LLRF2023 Abstract list

Id	Accepted type	Category	Title	Content	Speaker	Primary authors (affiliation)	Co-Authors (affiliation)
54	Oral	Lab talk	LLRF challenges and developments at CERN	In this overview talk I will report on the recent achievements at CERN and the challenges for LLRF that are being studied for future colliders and the high luminosity upgrade at CERN. This also includes the experience with COTS components and some of the initiatives started at CERN in the area of AI and machine learning in our field. I will also report on some of the CERN initiatives to further foster collaboration with other laboratories to meet our future challenges.	Wolfgang Hofle	Wolfgang Hofle (CERN)	
8	Oral	Lab talk	DESY lab talk	Overview of the latest LLRF developments at DESY. This includes a short report on XFEL and FLASH operation and new development at test facilities.	Julien Branlard	Julien Branlard (DESY)	
28	Oral	Lab talk	Lab Talk - Fermilab	An update on the various projects at Fermilab including PIP-II, Muon g-2, Mu2e and LBNF	Philip Varghese	Philip Varghese (Fermilab)	
10	Oral	Lab talk	Overview of JLAB LLRF activities- Lab Talk	The presentation will provide an overview of the most relevant LLRF developments at Jefferson Lab, including the Electron-Ion Collider (EIC) and the Proton Improvement Plan II (PIP-II).	Tomasz Plawski	Tomasz Plawski (Jefferson Lab)	Ramakrishna Bachimanchi (Jefferson Lab); Mannuel Diaz (Jefferson Lab); Curt Hovater (Jefferson Lab); James Latshaw (Jefferson Lab)
110	Oral	Lab talk	LBNL lab talk	This presentation covers highlights of LLRF activities at LBNL.	Qiang Du	Qiang Du (Lawrence Berkeley National Laboratory)	
96	Oral	Lab talk	SLAC lab talk	This presentation covers highlights of LLRF activities at SLAC.	Alessandro Ratti	Andy Benwell (SLAC); Alessandro Ratti (SLAC)	
108	Oral	Lab talk	Lab talk – progress of the proton power upgrade low-level RF development at the Spallation Neutron Source	The Proton Power Upgrade Project (PPU) for the Spallation Neutron Source (SNS) at Oak Ridge National Laboratory is nearing completion. This project will double the proton beam power capability from 1.4 MW to 2.8 MW with 2 MW beam power available to the first target station and an additional 800 kW available for the future second target station. As of July 2023, seventeen of the new µTCA.4 low-level RF (LLRF) systems have been installed and are currently supporting 1.7 MW beam operation. As with any new development, some issues have been discovered and changes implemented. This talk presents highlights of the installation, a few of the solutions developed to correct issues, recent operational experience, and plans for the completion of the LLRF portion of the PPU project	Mark Crofford	Mark Crofford (Oak Ridge National Laboratory)	J. Ball; J. Graham; M. Martinez; M. Musrock; S. Whaley
111	Oral	Lab talk	SSRF lab talk	This presentation cover highlights of LLRF activities at SSRF	Yubin Zhao	Yubin Zhao (Shanghai Advanced Research Institute	
25	Oral (invited)	System and Operation	LLRF system for the Fermilab PIP-II superconducting LINAC	PIP-II is an 800 MEV superconducting linac scheduled to start the installation and commissioning phase in 2025. The LLRF system design is in the final design review phase this year and will enter the production phase next year. The PIP-II project is an international collaboration with various partner labs contributing subsystems. The LLRF system design for the PIP-II Linac is presented and the specification requirements and system performance in various stages of testing are discussed.	Philip Varghese	Philip Varghese (Fermilab)	Shrividhyaa Sankar Raman (Fermi National Accelerator Laboratory); Hitesh Shukla (Fermilab)
21	Oral	System and Operation	Design and operation of the new digital LLRF system for CAFe SC linac	The superconducting radio frequency(SRF) linac of Chinese ADS front-end demo(CAFe) facility was built by Institute of Modern Physics(IMP) to demonstrate the feasibility of a 10-mA high power continuous-wave proton beam for the CiADS project. In order to achieve the strict requirements of the facility, which require extremely low beam loss levels for 10 mA high intensity beam, the phase and amplitude stability of superconducting cavity must be less than ±0.1° and ±0.1% respectively. The new FPGA based digital low-level RF control system (LLRF) was designed to stabilize the RF power and phase in the accelerating cavities of the CAFe linac and compensate the beam loading effects, ultimately maintaining beam stability. The new adaptive learning control function and highly automated operation software were developed, which were the key to the demonstration of the 10 mA CW high power beam. The new digital LLRF system is fully commissioned and transitioned to operation. We will review the update of the LLRF system for CAFe in this talk.	Zheng Gao	Zheng Gao (Institute of Modern Physics)	Yuan He (IMP); guirong huang (IMP); qiu feng; Zhenglong Zhu; Qi Chen (IMP); jinying ma; Chengye Xu (IMP); Xinghao Ding (IMP)

Id	Accepted type	Category	Title	Content	Speaker	Primary authors (affiliation)	Co-Authors (affiliation)
51	Oral	System and Operation	Present status of J-PARC Linac LLRF system	In the low-level radio-frequency (LLRF) control system J-PARC Linac, the digital feedback and feedforward (DFB and DFF) system plays an important role in stabilizing the output beam momentum by achieving a high-precision cavity electric field. The twenty-four 324 MHz DFB and DFF systems were upgraded to a new system using a MTCA board in 2020-2021. The increased degrees of freedom in the system made it possible to implement a high-precision adaptive beam loading compensation system. During the modification of the system, monitoring has been enhanced to check the set values and save waveforms automatically and regularly. In addition, various applications of automatic adjustment of parameters have been developed, making it possible for anyone to easily carry out adjustments. Recently, we have developed an interlock control system that automatically acquires and analyses waveforms of interlock events, processes them systematically and statistically, and stores the data on a MySQL server. In addition, a Mattermost server has been used to write records of parameter changes and program errors. In this presentation, the current LLRF system of the advanced J-PARC Linac will be introduced.	Kenta Futatsukawa	Kenta Futatsukawa (High Energy Accelerator Research Organization (KEK))	
56	Oral	System and Operation	The HL-LHC LLRF project	In the framework of the High Luminosity LHC project (HL-LHC), crab cavities (CC) will be installed on both sides of the LHC interaction point (IP) 1 (ATLAS experiment) and point 5 (CMS experiment) to restore an effective head-on collision and minimize the geometric luminosity loss which arises from the crossing angle. Two crab cavities will be installed on each side of the IPs for each beam for a total of sixteen cavities. The stringent requirements of the low level RF (LLRF) for crab cavities will be briefly described along with the architecture of the LLRF system and of the RF feedback. The LLRF system will be much inspired from the former SPS LLRF upgrade put in operation in 2021, including the use of the MicroTCA platform, a digital deterministic links for synchronization (the so-called White Rabbit), and a constant clock frequency for the sampling and processing.	Gregoire Hagmann	Gregoire Hagmann (CERN)	Philippe Baudrenghien (CERN); Arthur Spierer (CERN)
92	Oral	System and Operation	Status of the LCLS-II SRF accelerator	The SLAC National Accelerator Laboratory has completed the installation and checkout of a RSF linac for the LCLS-II, an ultra-bright Free Electron Laser. The LCLS-II is composed of 296 SRF cavities plus 2 NC cavities, each with its own LLRF control system and dedicated RF amplifier. At the time of this abstract submission, beam transport through the soft X-Ray undulators is imminent and first light from the LCLS-II facility is highly inticipated. This LCLS-II status talk will briefly describe the SRF linac, the RF system, and discuss SRF commissioning of the LCLS-II linac.	Andy Benwell	Andy Benwell (SLAC); Sebastian Aderhold (SLAC); Daron Chabot (SLAC); JING CHEN (SLAC National Accelerator Laboratory); Jorge Diaz Cruz (SLAC); Dan Gonnella (SLAC); Sonya Hoobler (SLAC); Richard Kelly (SLAC); Andre McCollough (SLAC); Janice Nelso (SLAC); Mark Petree (SLAC); Alessandro Ratti (SLAC); Lisa Zacarias (SLAC); Brian Chase (FNAL); Ramakrishna Bachimanchi (Jefferson Lab); Curt Hovater (Jefferson Lab); Larry Doolittle (LBNL); Gang Huang (LBNL); Shreeharshini Dharanesh Murthy (Lawrence Berkeley National Laboratory); Carlos Serrano (LBNL); Keith Penney	

Id	Accepted type	Category	Title	Content	Speaker	Primary authors (affiliation)	Co-Authors (affiliation)
47	Oral	System and Operation	Drift observations and mitigation in LCLS-II RF	The LCLS-II RF system physically spans ~700m and has strict requirements -- on the order of 20 fs -- on the phase stability of the accelerating RF fields in its SRF linac. While each LLRF rack is crudely temperature-stabilized, the weather inside the service building as a whole is usually compared to a tin shack in the California sun. A phase-averaging reference line is the primary system deployed in support of the phase stability goals. There are other, secondary subsystems (SEL phase offset, and determination of cavity detuning) that are also sensitive to RF phase drift. We present measurements of phase shifts observed in the overall RF system, and how diagnostics are able to sense and correct for them during beam operations.	Shreeharshini Murthy	Andy Benwell (SLAC National Accelerator Laboratory); Daron Chabot (SLAC National Accelerator Laboratory); Jing Chen (SLAC National Accelerator Laboratory); Larry Doolittle (Lawrence Berkeley National Laboratory); Bo Hong (SLAC National Accelerator Laboratory); Sonya Hoobler (SLAC National Accelerator Laboratory); Shreeharshini Dharanesh Murthy (Lawrence Berkeley National Laboratory); Janice Nelson (SLAC National Accelerator Laboratory); Chengcheng Xu (SLAC National	
86	Oral	System and Operation	LCLS-II-HE LLRF	Abstract The LCLS-II-HE project is a high energy upgrade of the existing LCLS-II superconducting LINAC at SLAC which will increase its baseline energy from 4 GeV to 8 GeV. A new LINAC section L4 will be added with 23 new high gradient cryomodules, 184 SRF cavities, tested to a mean gradient of 22 MV. The LLRF system to control the new cavities will be comprised of 46 HE LLRF rack systems, each outfitted with an updated version of the LCLS-II LLRF system. While average cavity gradient is increased in the new cryomodules, the LLRF field control requirements will remain the same as LCLS-II, i.e., RF regulation within 0.01%, 0.01 deg rms amplitude and phase and resonance control regulation of the cavity frequency < 1Hz. With rich experience from LCLS-II, we present the incorporated lesson learned, planned updates and progress of HE LLRF. *Authors: Jing Chen, Andy Benwell, Jorge Diaz, Andre McCollough, Sonya Hoobler, Larry	Jing Chen	Andy Benwell (SLAC); JING CHEN (SLAC National Accelerator Laboratory); Jorge Diaz Cruz (SLAC); Larry Doolittle (LBNL); Sonya Hoobler (SLAC National Accelerator Laboratory); Andre McCollough (SLAC); Shreeharshini Dharanesh Murthy (Lawrence Berkeley National Laboratory)	
94	Oral	System and Operation	Flat gateware architecture for low level RF control	FPGA gateware is the core component for the accelerator low level control system. A flatten architecture is introduced in this paper to improve the system modularity and so improve the code maintainability. This code architecture utilizes the new capability introduced in the system verilog, such as interface and alias to realize the design goal. A series of python and tcl scripts are developed to simplify the streamline operation from giga transceiver module implementation, verilog header generation, register/memory name and address handling as well as the iostandard/package pin assignments etc. The architecture is preliminary bench tested with the LCLS-II LLRF system and the compatibility is analyzed.	Gang Huang	Gang Huang	Larry Doolittle (LBNL)
83	Oral (invited)	Measurement and Control	Digital low level optical control for multidimensional coherent laser combining	Recently, we have demonstrated new methods to actively stabilize multi-way laser coherence states in the dimensions of time, space and spectrum, so that we can effectively combine many laser beams into one in each dimension. This can be considered a set of LLRF exercises, where the carrier is 200 THz. This paper summarizes many of our technical approaches and milestones, from optical physics modeling, to FPGA based feedback control platform, to machine learning pattern recognition methods and experimental demonstration results. This technique paved the way for building high power lasers that have many applications, such as driving the laser plasma Wakefield accelerator, manufacturing, and many more.	Qiang Du	Qiang Du (Lawrence Berkeley National Laboratory)	Larry Doolittle (LBNL); Dan Wang (LBNL); Russell Wilcox (LBNL)

Id	Accepted type	Category	Title	Content	Speaker	Primary authors (affiliation)	Co-Authors (affiliation)
30	Oral	Measurement and Control	Approach to calibrate beam phase using steady-state RF forward signal under closed-loop operation	We propose a new algorithm for calibrating the beam phase that utilizes the steady-state RF forward signal (Vf) in closed-loop operation, which overcomes the difficulties associated with measuring the beam phase using RF transients in open-loop operation in high-intensity proton accelerators. The new algorithm calibrates the beam phase by comparing the steady-state Vf vector before and after the beam. We validated the calibration results of this algorithm against BPM measurements in two different experimental setups (the CAFe facility at the Institute of Modern Physics and the European Spallation Neutron Source), finding excellent agreement between the two methods in both facilities. Additionally, we investigated the feasibility of using beam-induced RF transient signals in closed-loop operation to obtain the beam phase. Our paper offers a more accessible and practical method for calibrating beam phases in high-intensity proton accelerators.	Rihua Zeng	Rihua Zeng (European Spallation Source)	Feng Qiu (Professor, Institute of Modern Physics); Chengye Xu (Institute of Modern Physics); jinying ma (Institute of Modern Physics); zheng gao; Shihui Wei (South China Normal University)
45	Oral	Measurement and Control	High-precision RF-voltage measurements using longitudinal phase-space tomography in the CERN PSB and SPS.	Precisely determining the gap voltage and phase in an RF cavity is essential for the calibration of the LLRF feedbacks. Following the conventional approach, measured RF power is converted into gap voltage, assuming a given shunt impedance. However, power and impedance evaluations can both have large uncertainties. Alternatively, the voltage can be obtained precisely with a complementary technique based on longitudinal phase-space tomography. From a set of bunch profiles, tomography reconstructs the bunch distribution in the longitudinal phase-space. The quality of the reconstruction strongly depends on the RF voltage and therefore allows to derive its absolute value. In this paper we describe the tomography-based voltage measurements performed in the CERN PSB and SPS, where this method allowed to detect significant voltage errors for the main RF systems. After applying the correction factors in the LLRF, 1% accuracies were reached. We report here also the remarkable results achieved by using this technique to calibrate the voltage of the SPS higher-harmonic cavities at 800 MHz, as well as their relative phases with respect to the 200 MHz cavities.	Danilo Quartullo	Simon Albright (CERN); Heiko Damerau (CERN); Giulia Papotti (CERN); Danilo Quartullo (CERN)	
97	Oral	Measurement and Control	Variational autoencoders for noise reduction in industrial LLRF systems	Industrial particle accelerators inherently operate in much dirtier environments than typical research accelerators. This leads to an increase in noise both in the RF system and in other electronic systems. Combined with the fact that industrial accelerators are mass produced,, there is less attention given to optimizing the performance of an individual system. As a result, industrial systems tend to under perform considering their hardware hardware capabilities. With the growing demand for accelerators for medical sterilization, food irradiation, cancer treatment, and imaging, improving the signal processing of these machines will increase the margin for the deployment of these systems. Our work is focusing on using machine learning techniques to reduce the noise of RF signals used for pulse-to-pulse feedback in industrial accelerators. We will review our algorithms, simulation results, and results working with measured data. We will then discuss next steps for deployment and testing on an industrial system.	Jonathan Edelen	Jonathan Edelen (RadiaSoft LLC)	Jorge Diaz Cruz (SLAC); Auralee Edelen (SLAC); Joshua Einstein-Curtis (RadiaSoft LLC); Christopher Hall (RadiaSoft LLC); Morgan Henderson (RadiaSoft LLC)
42	Oral	Measurement and Control	Digital direct RF feedback for beam loading reduction at ALBA	A direct RF feedback loop has been implemented in the digital LLRF of ALBA aimed to reduce the effective impedance of the RF cavities and so, reduce the beam loading effects. A sample of the cavity voltage signal is added to the PID loop generated signal with adjustable gain and phase shift. The resulting signal is then feed back to the amplifier by means of a DAC and an up-conversion stage. Taking advantage of this digital implementation, the phase and amplitude of both the PID and the direct RF feedback control signals can be easily monitored and adjusted to match desired feedback loop gain. The result of this digital loop is the effective reduction of the longitudinal cavity impedance seen by the beam, and therefore of the tune shift due to beam loading. This method has been implemented and validated at ALBA reaching a direct RF feedback gain Af=1, thus reducing the cavity impedance seen by the beam, and therefore the tune shift, by a factor 2. Conceptual design of the feedback loop, adjustment of the cavities, and synchrotron tune measurements are presented in this contribution confirming the effectiveness of the digital implementation of a direct RF feedback loop.	Pol Solans	Pol Solans (ALBA-CELLS Synchrotron)	

Id	Accepted type	Category	Title	Content	Speaker	Primary authors (affiliation)	Co-Authors (affiliation)
17	Oral	Measurement and Control	An Intra-pulse feedforward algorithm for improving pulsed microwave stability	During the pulsed operation of the linear accelerator in DCLS (Dalian Coherent Light Source), we found a strong correlation between the klystron modulator's high voltage and the klystron output microwave, with noticeable jitter among adjacent microwaves. Therefore, we propose an intra-pulse feedforward algorithm and implement it in LLRF (Low-Level Radiofrequency) systems. This algorithm assumes that the transfer model of the microwave system is linear within a small range of work points and measures the transfer coefficient of the microwave between the LLRF and klystron. For each pulsed microwave of the klystron output, the LLRF system first calculates the vector deviation between the initial measurement within its pulse and the target. The deviation will be compensated in the LLRF excitation so that the jitter in the later part of the pulsed microwave is suppressed. Experiments have shown that this algorithm can effectively suppress the jitter among adjacent microwaves, e.g., improving the amplitude and phase stability (RMS) from 0.12%/0.2° to 0.09%/0.06°. This algorithm can also be applied to other accelerators operating in pulsed modes.	Jinfu Zhu	Jiawei Han (Institute of Advanced Science Facilities, Shenzhen); Jinfu Zhu (Institute of Advanced Science Facilities, Shenzhen); Hongli Ding (Dalian Institute of Chemical Physics, Chinese Academy of Sciences (CAS)); Haokui Li (Dalian Institute of Chemical Physics, Chinese Academy of Sciences (CAS)); Xiwen Dai (Institute of Advanced Science Facilities, Shenzhen); Jiayue Yang (Institute of Advanced Science Facilities, Shenzhen); Weiqing Zhang (Institute of Advanced Science Facilities, Shenzhen)	
29	Oral	Measurement and Control	LLRF upgrade status at the KEK Photon Factory 2.5 GeV ring	In 2023, we will replace the LLRF system for the KEK-PF 2.5 GeV ring. The new system is composed of digital boards such as eRTM, AMC, and μRTM, based on the μTCA.4 standard. For our application, development time and cost were minimized by customizing the LLRF technologies developed for the SPring-8 and J-PARC. In our system, we adopted the non-IQ direct sampling method for RF detection. We set the sampling frequency at 8/13 (307.75 MHz) of the RF frequency, where the denominator (13) is the divisor of the harmonic number (312) of the storage ring. This allows us to detect the transient variation of the cavity voltage that is synchronized with the beam revolution. To compensate the voltage variation, we implemented a feedforward technique. These functions will be useful in a double RF system for KEK future synchrotron light source. Production of the new system was complete and we are in the offline testing phase. From July to October, the new system will be installed in the KEK-PF 2.5 GeV ring RF system and various adjustments using klystrons and cavities will be performed. In this presentation, we introduce our new system and report the upgrade status.	Daichi Naito	Daichi Naito (KEK)	Arata Motomura (KEK); Shogo Sakanaka (KEK); Takeshi Takahashi (KEK); Naoto Yamamoto (KEK)
5	Oral	Measurement and Control	Digital LLRF feedbacks development, implementation and test at KEK LUCX facility	High Demand for stability, accuracy, reproducibility and monitoring capability were placed on accelerators LLRF systems, because of fundamental and applied experimental requirements. Meanwhile, availability of FPGA boards became better during last two decades. Nowadays, it is possible to implement FPGA based LLRF feedback using boards with low-bandwidth ADC&DAC (down-conversion technique).There are two options to implement feedback into the LLRF system. The first option employs external I/Q demodulator, I/Q signals digitization, phase and amplitude calculation, PI feedback, I/Q modulation and RF signal regeneration. This approach does not require an expensive, highly stable slave oscillator or slave signal generator to down-convert picked-up signals from RF cavity.The second option is almost the same, but I/Q demodulator is implemented into the FPGA logic. Both approaches were implemented and tested at KEK LUCX facility. This report presents	Konstantin Popov	KONSTANTIN POPOV (High Energy Accelerator Research Organization (KEK))	ALEXANDER ARYSHEV (High Energy Accelerator Research Organization (KEK)); NOBUHIRO TERUNUMA (High Energy Accelerator Research Organization (KEK))

Id	Accepted type	Category	Title	Content	Speaker	Primary authors (affiliation)	Co-Authors (affiliation)
48	Oral	Measurement and Control	Implementation of the on-line RF amplitude and phase calibration for vector sum control	The RF field's quality in particle acceleration significantly affects beam properties. Controlling and measuring the field as observed by the beam is crucial, but only indirect measurements are usually available. In many RF accelerators, a single RF source drives multiple cavities to reduce costs. The individual cavity fields are probed and combined to regulate the vector sum. Errors in gradient and phase calibration create a discrepancy between the observed vector sum and the measured vector sum stabilized by the RF control system, leading to energy spread, especially with microphonics. The standard calibration method measures small beam-induced transients in the cavity, requiring RF field stability, particularly forward power. Active cavity field regulation during measurements is excluded, limiting normal operation. This paper presents a new method that calibrates the RF field to the beam under normal conditions, especially in feedback mode, by fitting the beam to the cavity equation for accurate calibration estimation.	Mariusz Grecki	Mariusz Grecki (DESY)	
91	Oral (invited)	Timing	Performance summary of the ESS phase reference line	The Phase Reference Line (PRL) of the European Spallation Source (ESS) is a passive system based on a single 1-5/8" coaxial rigid line installed at the tunnel ceiling above the beamline. It is supported by temperature and gas pressure control systems with active electronics installed in the ESS Klystron Gallery Hall. The length of the PRL is around 580 meters. The system is temperature stabilized (+/-0.1 deg C) and includes an inner-line gas pressure stabilization to assure synchronization accuracy. The PRL was designed to distribute 352 MHz and 704 MHz reference frequencies from a Master Oscillator to 56 tap points in the tunnel. Each tap point has several (3 or 6) signal outputs, giving 294 of the total output number. The system was installed, and the power level and phase drift performance was tested recently. This contribution covers the summary of the PRL project, including the performance test results.	Krzysztof Czuba	Krzysztof Czuba (WUT)	Paweł Jatczak (Warsaw University of Technology); Morten Jensen (European Spallation Source); Anirban Krishna Bhattacharyya (European Spallation Source); Radosław Papis (Wawrsaw University of Technology); Dominik Sikora (Warsaw University of Technology)
103	Oral	Timing	RF reference distribution and operation experiences in PAL-XFEL	XFELs require high-end timing synchronization in a femtosecond time scale, which is related to the short electron bunch length, phase space stability, and diagnosis of those. In the experiment side, the timing error of optical femtosecond laser pulses is also better to be less than their pulse duration for their time-correlation measurement. PAL-XFEL has been operated since 2016 based on coaxial RF distribution and ultralow phase noise DROs, which gives less than 1 femtosecond jitters. The drift can be managed using a beam-based feedback for the stable lasing condition. For the experimental lasers, a commercial optical links with phase stabilization and a home built Sagnoc PLL system has been utilized.	Chang-Ki Min	Chang-Ki Min (PAL, POSTECH)	Myunghoon Cho (PAL, POSTECH); Hoon Heo (PAL, POSTECH); Jinyul Hu (PAL, POSTECH); Seonghoon Jung (PAL, POSTECH); Heung-Sik Kang (PAL, POSTECH); Changbum Kim (PAL, POSTECH); Gyujin Kim (PAL, POSTECH); Inhyuk Nam (PAL, POSTECH); Chi Hyun Shim (PAL, POSTECH); Dong Cheol Shin (PAL, POSTECH); Haeryong Yang (PAL, POSTECH)
	Oral	Tutorial	Machine learning		Annika Eichler	Annika Eichler (DESY)	
70	Oral (invited)	Hardware	Upgrade of the fast analogue intra-pulse phase feedback at SPARC_LAB	SPARC_LAB is a facility designed for the production of FEL radiation and the exploration of advanced acceleration techniques using a high brightness electron photo-injector. Specifically, particle-driven plasma wakefield acceleration (PWFA) necessitates exceptional beam stability, in order to minimize the jitter between the driver and witness beams. This requirement directly translates into RF phase jitter minimization, since a velocity bunching (RF compression) working point is employed at SPARC_LAB for acceleration. In the past, a fast intra-pulse phase feedback system has been developed to stabilize the klystron RF pulse. This allowed to reach a phase stability of S-band power units (both driven by PFN modulators) below 50 fs rms. However, in order to meet the more stringent requirements of PWFA scheme, some upgrades of this feedback system have been recently carried out. A prototype has been tested on a C-band klystron driven by a solid-state modulator, in order to investigate the possibility for an additional improvement resulting from the inherently more stable power source. In this paper the preliminary measurement results obtained at SPARC_LAB will be reviewed.	Luca Piersanti	Luca Piersanti (Istituto Nazionale di Fisica Nucleare - Laboratori Nazionali di Frascati)	Marco Bellaveglia (Istituto Nazionale di Fisica Nucleare - Laboratori Nazionali di Frascati); Alessandro Gallo (Istituto Nazionale di Fisica Nucleare - Laboratori Nazionali di Frascati); Beatrice Serenellini (Istituto Nazionale di Fisica Nucleare - Laboratori Nazionali di Frascati); Simone Tocci (Istituto Nazionale di Fisica Nucleare - Laboratori Nazionali di Frascati)

Id	Accepted type	Category	Title	Content	Speaker	Primary authors (affiliation)	Co-Authors (affiliation)
99	Oral	Hardware	Progress in LLRF system development for Korea-4GSR	The Korean 4th Generation Storage Ring (4GSR) aims to generate an ultra-low emittance beam of 58 pm rad with a beam energy of 4 GeV and a beam current of 400 mA. Currently, the construction of this facility is underway, with plans for commissioning by the end of 2027. The RF system of the 4GSR consists of 10 normal conducting cavities and associated RF systems, including a high-power RF source, Low-Level RF (LLRF) system, and ancillary equipment. This paper provides an overview of the 4GSR RF system, presents the current status of its development, and focuses on the design of the LLRF system for digital feedback control.	Yong-Seok Lee	Yong-Seok Lee (Pohang accelerator laboratory)	Bonghyuk Choi (Pohang accelerator laboratory); Myunghwan Chun (Pohang accelerator laboratory); Taekyun Ha (Pohang accelerator laboratory); Youngdo Joo (Pohang accelerator laboratory); Jeong-Hoon Kim (Pohang accelerator laboratory); Mujin Lee (Pohang accelerator laboratory); In-Soo Park (Pohang accelerator laboratory); Sehwan Park (Pohang accelerator laboratory); In-Ha Yu (Pohang accelerator
38	Oral	Hardware	Preliminary design of scalable hardware integrated platform for LLRF application	In this paper, the SHIP4LLRF (Scalable Hardware Integrated Platform for LLRF) based on 6U VPX-standard was designed preliminarily, which includes 6U mother board and two HPC FPGA mezzanine cards (FMCs). The ADC and DAC FMC is based on ADS54J60 from TI and LTC2000Y-16 form ADI, respectively. The mother board is based on Xilinx's KU060, which also features 64-bit DDR4 SDRAM, QSFP and USB3.0 interfaces. Each FMC connector is assigned 58 pairs of LVDS standard IOs and 8 pairs of GTH serial lanes. Besides, the mother board is equipped with the self-developed ZYNQBee2 module based on ZYNQ7010 for slow control such as EPICS. All ADC/DAC raw data in each SHIP4LLEF is compressed lossless without triggering and transmitted to the process board. A scalar quantization method which is in development is used for lossless compression of ADC raw data, the process board will decompress the ADC data and perform a digital algorithm to measure the amplitude and phase of the high frequency signal. This design is scalable for testing and upgradability, meanwhile, the trigger-less data transmission enable this system participate in both local (rack-scale) and accelerator-wide communication networks.	Tao Xue	Haoyan Yang (Tsinghua University); Jianmin Li (Tsinghua University); Jingjun Wen (Tsinghua University); Liangjun Wei (Tsinghua University); Lin Jiang (Tsinghua University); Qiutong Pan (Tsinghua University); Tao Xue (Tsinghua University); Xiaowei Guo (Tsinghua University); Yinong Liu (Tsinghua University)	
	Oral	Tutorial	Timing and synchronization		Krzysztof Czuba	Krzysztof Czuba (WUT)	
67	Oral (invited)	SRF Controls	Initial test results of an SRF cavity field and resonance controller based on dynamic mode decomposition	Field and resonance control of superconducting radio frequency (SRF) cavities are often implemented as independent control loops. A control loop for amplitude and phase uses the power amplifier signal as the control signal and a separate loop for resonance control uses a piezo tuner. Traditional proportional-integral (PI) loops are implemented for field control, whereas more elaborate techniques, including active noise cancellation, are implemented for resonance control. This paper presents a novel approach that can effectively stabilize amplitude and phase by only using the piezo actuator, keeping the power amplifier output level constant. For this purpose, we have designed a model predictive controller (MPC), based on the dynamics of a cavity model developed using dynamic mode decomposition (DMD). We have implemented the proposed controller on a LCLS-II LLRF system, and here we present the initial test results and performance of the system using cold SRF cavities.	Jorge Diaz Cruz	Jorge Diaz Cruz (SLAC)	Faya Wang (SLAC)
7	Oral	SRF Controls	RF-energy saving initiative at the European XFEL	In an effort to reduce the power consumption linked to RF operation of the European X-ray free electron laser (EuXFEL), the klystron high voltage is no longer kept constant but shaped to minimize the regulation overhead over the RF pulse. This intra-pulse dynamic change of the high power gain demands an adaptation of the low-level RF drive to stabilize the klystron signal in amplitude (up to a factor of 2) and in phase (over 360 deg.). Combining this approach with an efficient use of the rise- and fall-time of the klystron high voltage pulse, energy saving up to 30% were demonstrated at EuXFEL. This contribution presents the RF control challenge and its LLRF solution, illustrated by the experimental implementation at EuXFEL.	Julien Branlard	Julien Branlard (DESY)	

Id	Accepted type	Category	Title	Content	Speaker	Primary authors (affiliation)	Co-Authors (affiliation)
59	Oral	SRF Controls	Experimental results using a Modified ADRC control algorithm for Microphonics Reduction in SRF cavities	In this work, the experimental results obtained with a new type of disturbance rejection algorithm control, the Modified ADRC (MADRC) algorithm applied to a 9-cell tesla-type SRF cavity are presented. The cavity is located in the HobiCat test bench of the Helmholtz-Zentrum Berlin. The main advantage of the MADRC controller is the addition of a new control element for increasing the stability range of the closed-loop system, which is designed by loop shaping techniques. The methodology can be applied in the presence of time-delay, in this case introduced by the piezoactuator. Another advantage of the approach is that can be combined with feedforward controllers. In general, the stochastic nature of microphonics and the relatively large delay of piezoelectric actuators reduce the stability margin of feedback systems and, therefore, the disturbance reduction capability is quite limited. In this work, the experimental results showing the improvement in the disturbance reduction obtained with the new MADRC approach are shown.	Elejaga Ander	Josu Jugo (University of the Basque Country UPV/EHU); Elejaga Ander (University of the Basque Country UPV/EHU); Pablo Echevarria Fernandez (Helmholtz Zentrum Berlin)	
11	Oral	SRF Controls	Superconductor LLRF control system for CSNS-II LINAC	China Spallation Neutron Source(CSNS) beam power will upgrade to 500 kW(CSNS-II), energy gain of H- linac will up to 300 MeV from 80 MeV using about 48 superconductor cavities. LLRF is an important device for controlling the amplitude and phase of the SRF cavity field to be less than ± 0.3% and ± 0.3 °, as well as maintaining resonance stability. By the way ,quench detection and similar interlocking of SRF cavity and rf power source are also crucial.The development progress and results of LLRF are introduced.	Zhexin Xie	Zhexin xie (ihep/csns)	ZhenCheng Mu; Kai Guo; Maliang Wan; Bo Wang; Hexin Wang
75	Oral	SRF Controls	LLRF algorithm for superconducting cavities in SHINE	A LLRF cavity control system has been designed in Shanghai High Repetition Rate XFEL and Extreme Light Facility (SHINE) project to ensure its rf field stability. The system employs non-IQ sampling and uses two driven modes in amplitude /phase control, namely, the Self-excited Loop (SEL) and the Generator Driven System (GDR). Additionally, each cavity is tuned with a Piezo actuator and a slow stepper motor. Moreover, the measurement and compensation of microphonics have been considered. In the test, we have detected a potential source of disurbances at 50Hz and we attempt to suppress it. The LLRF control algorithm is currently being optimized, and this paper provides an overview of its design and development.	Xuefang Huang	xuefang huang (Shanghai Advanced Research Institude, Chinese Academy of Saiences)	hongru jiang (Shanghai Advanced Research Institute, Chinese Academy of Sciences); hailong wu; hong wu; kai xu (Shanghai Advanced Research Institude, Chinese Academy of Sciences); wenfeng yang; zhigang zhang (Shanghai Advanced Research Institute, Chinese Academy of Sciences); xiang zheng (Shanghai Advanced Research Institute, Chinese Academy of Sciences)
112	Oral	IQ award	Unleashing the full potential of LLRF algorithm: enhancing stability, reliability, and automation in RF systems	This presentation showcases groundbreaking advancements in Low-Level Radio Frequency (LLRF) control systems. These include the innovative application of disturbance-observer control for precise beam energy spread control, leveraging prior knowledge of the beam profile to develop an FPGA-based real-time iterative learning control system for suppressing beam-induced RF transient instabilities, proposing a novel cross-talk calibration algorithm for accurate beam synchronous phase calibration, and developing a real-time digital filter with robustness to field emission-induced burst noise to improve machine reliability and performance. These advancements represent significant breakthroughs in the LLRF community and contribute to the overall enhancement of accelerator systems.	Feng Qiu	Feng QIU (Feng Qiu, Professor, Institute of Modern Physics)	
57	Oral	Tutorial	Modelling control loops in beam dynamics simulations	In an increasing amount of cases, a precise description of beam motion in synchrotrons requires modelling control loops alongside with collective effects. The contribution shows the generic methods, implemented in the Beam Longitudinal Dynamics simulation suite BLonD, to include global and/or local control loops in beam dynamics simulations. Furthermore, it details the implementation of CERN-specific LLRF models and their application in recent studies.	Helga Timko	Helga Timko (CERN)	

Id	Accepted type	Category	Title	Content	Speaker	Primary authors (affiliation)	Co-Authors (affiliation)
41	Oral	Other	Model in the loop verification for multi-cavity LLRF control systems	Accelerating RF field controls for Free-Electron Lasers FLASH and EuXFEL are based on driving multiple superconducting cavities with a single klystron. The realization of the control loop is distributed into several FPGAs. Open loop verification of each subsystem is straightforward but closed loop performance analysis is challenging. Detailed performance evaluation and regression testing are crucial for a sustainable Continuous Integration (CI) environment. Hardware Description Language (HDL) simulators are the core tools for digital design verification; and especially with the use of mainstream methodologies, functional coverage can be achieved efficiently. Nevertheless, the numerical analysis capabilities are limited in HDL with respect to high-level programming languages. This fact highlights the fundamental necessity of co-simulation which also enables software integration inherently. An ongoing effort for Model in the Loop (MIL) verification for the LLRF control systems of FLASH and EuXFEL, aims to evaluate the algorithm performance on CI of firmware and software, in conjunction with the models of hardware components and the superconducting RF accelerator structures.	Burak Dursun	Burak Dursun (Deutsches Elektronen-Synchroton DESY)	Andrea Bellandi (Deutsches Elektronen-Synchroton DESY); Julien Branlard (DESY); Lukasz Butkowski (Deutsches Elektronen-Synchroton DESY); Cagil Gumus (Deutsches Elektronen-Synchroton DESY); Max Herrmann (Deutsches Elektronen-Synchroton DESY); Martin Hierholzer (Deutsches Elektronen-Synchroton DESY); Sven Pfeiffer (Deutsches Elektronen-Synchroton DESY); Christian Schmidt (Deutsches Elektronen-Synchroton DESY)
24	Oral	Other	LANSCE low level RF resonance control water system upgrade	The LANSCE accelerator at Los Alamos National Laboratory (LANL) has been in service for 50 years. Efforts to update and modernize crucial systems, many of which are original, are ongoing. This paper reports on refurbishment of the Low-Level Radio Frequency (LLRF) Resonance Control Water System (RCWS) for the half mile long Cavity-Coupled LINAC (CCL). RCWS controls resonance frequency of the cavities by controlling the temperature of the cooling water delivered to each of 44 accelerator modules. Of the 44 modules making up the CCL, 20 have had their RCWS upgraded. The old hardware was completely removed, and new components were installed, including water pumps, mix tanks, valves, thermistors, and plumbing. This paper describes the design of the new system, material selection, installation, technical challenges, and improved performance compared to original system.	Anju Poudel	Anju Poudel (Los Alamos National Laboratory)	Jacob Medina (Los Alamos National Laboratory); James Ohara (Los Alamos National Laboratory)
4	Poster	Measurement and Control	Python-EPICS RF conditioning automatic control system in the Spallation Neutron Source	The SNS RFTF is used for RF conditioning to prepare RF structures such as ceramic windows and couplers for charged-particle accelerator installation and operation, involving high-power RF fields and heating to improve performance and remove impurities. A Python-based EPICS control system software and some hardware updates were developed to automate and optimize the conditioning process, with real-time monitoring of RF levels, temperature, and vacuum pressure. The CS-Studio (Phoebus) user interface were utilized to develop a GUI for user-friendly operation, adjusting parameter, and data collection. The system utilizes the High Power Protection Module (HPM) for interlocks from the vacuum and arc detection. The system has improved the efficiency and accuracy of conditioning at the SNS RFTF to ensure proper, and safe processes before installation and operation in LINACs. This presentation introduces the RF conditioning system update by software developments and hardware upgrades made in the SNS RFTF and utilization of the system for the proton power upgrade (PPU) projects in the SNS.		Sung-Woo Lee (Oak Ridge National Laboratory)	Mark Crofford (Oak Ridge National Laboratory); Yoon Kang (Oak Ridge National Laboratory); Kay Kasemir (Oak Ridge National Laboratory); John Moss (Oak Ridge National Laboratory); George Toby (Oak Ridge National Laboratory)
6	Poster	Measurement and Control	Measurement uncertainty in the RF system control of a particle accelerator	When talking about microwave/RF power system in Particle Accelerator, we usually refer to amplitude, phase and frequency stability as key indicators, whether these indicators are given by our self-made LLRF system or the results given by third-party standard measuring instruments. Not only that, when measuring some specific microwave parameters of the system, such as the QValue of the cavity, some active and passive microwave devices, it is also possible to use self-made LLRF or third-party standard instruments, whether using standard or customized as measurement tools, when giving conclusions, uncertainty should be introduced to characterize the discrete characteristics of these results and possible true values, so as to improve the recognition of our measurement methods and results, and enhance the credibility		RONG LIU (Beijing Normal University)	

Id	Accepted type	Category	Title	Content	Speaker	Primary authors (affiliation)	Co-Authors (affiliation)
9	Poster	Measurement and Control	Approach to calibrate cavity forward and reflected signals using LLRF system for continuous wave-operated cavities	Precise measurements of the cavity forward (Vf) and reflected signals (Vr) are essential for characterizing other key parameters such as the cavity detuning and forward power. In practice, the accuracy of these measurements is impacted by the crosstalk between the forward and reflected channels. DESY proposed an algorithm for calibrating Vf and Vr based on the cavity differential equation for pulsed RF system, and we verified the validity and pract*emphasized text*icability of this approach for the Chinese ADS front-end demo superconducting linac (CAFe) facility. This approach requires cavity voltage (Vc) changing over time to establish a complete differential equation. However, for a CW operated RF system, Vc signal is almost constant over time thanks to the LLRF system’s high gain feedback control. As a result, it is difficult to locate the optimal calibration factors using DESY’s algorithm. Therefore, we offer an alternative algorithm to determine the calibration factors using the CW waveforms during a nominal RF shutdown event. The effectiveness of the proposed algorithm was demonstrated on the CAFe facility that operated in CW mode.		jinying ma; feng qiu (Institute of Modern Physics, Chinese Academy of Sciences.); zheng gao (Institute of Modern Physics, Chinese Academy of Sciences.); guirong huang (Institute of Modern Physics, Chinese Academy of Sciences.)	
12	Poster	System and Operation	Tests at 2K of the beta 0.35 Spoke Cryomodule prototype with the MTCA.4-based Low Level RF System prototype for the MYRRHA R&D	Within the framework of the first phase of MYRRHA (Multi-purpose hYbrid Research Reactor for High-tech Applications) project, as known as MINERVA, IJCLab was assigned with the development of a fully functional Spoke cryomodule prototype development,which was tested at 2K. This prototype integrates two superconducting single spoke cavities, the RF power couplers and the Cold Tuning Systems associated. On the control side, a MTCA.4-based Low Level Radio Frequency (LLRF) system prototype and the Software/EPICS developments have been realized by IJCLab and the SCK•CEN in partnership with the company IOxOS Technologies. The final version of the global system and the results of the tests at 2K are presented, along with future projections.		Philippe Della Faille (SCK.CEN); Christophe Joly (IJCLab (IN2P3/CNRS))	Sylvain Berthelot (IJCLab (IN2P3/CNRS)); Sébastien Blivet (IJCLab (IN2P3/CNRS)); Jean-Luc Bolli (IOXOS technologies); Frédéric Bouly (LPSC (IN2P3/CNRS)); Olivier Bourrion (LPSC (IN2P3/CNRS)); Frédéric Chatelet (IJCLab (IN2P3/CNRS)); Nicolas Gandolfo (IJCLab (IN2P3/CNRS)); Iván García-Alfonso (IOXOS technologies); Cédric Gaudin (IOXOS technologies); Yolanda Gomez-Martinez (LPSC (IN2P3/CNRS)); Cédric Lhomme (IJCLab (IN2P3/CNRS)); Guillaume Mavilla (IJCLab (IN2P3/CNRS)); Gilles Olivier (IJCLab (IN2P3/CNRS)); Matthieu Pierens (IJCLab (IN2P3/CNRS)); Hervé Saugnac (IJCLab (IN2P3/CNRS)); Damien Tourres (LPSC (IN2P3/CNRS)); Mickael Vanderlinden (SCK.CEN); Jean-François Yaniche (IJCLab (IN2P3/CNRS))
13	Poster	Measurement and Control	Design of the digital LLRF system for TRIUMF ISIS buncher	The ISIS buncher system at TRIUMF operates at frequencies of 23MHz, 46MHz, and 4.6MHz. The 23MHz and 46MHz signals drive two buncher cavities, while the 4.6MHz signal drives the 5:1 selector. The previous analog-digital hybrid system has been replaced with a new digital LLRF system due to occasional drifts in the setpoints of the control loops during operation. The reference signal for the LLRF system is obtained from the pickup signal of the cyclotron's cavity, ensuring that all frequencies are synchronized with it. In the event of a spark occurring in the cyclotron's cavity, the LLRF system may lose its reference signal. To address this, a phase-locked loop with a track and hold function is designed to maintain the frequency when the reference signal is absent. The 4.6MHz frequency is derived by dividing the 23MHz reference signal frequency by 5. Designing the divide-by-5 circuitry posed specific challenges in a binary system. The LLRF system is built upon TRIUMF's versatile digital LLRF hardware system, with firmware optimized specifically for the ISIS buncher system. This paper will delve into the details of the system.		Xiaoliang Fu (TRIUMF)	Thomas Au (TRIUMF); Ken Fong (TRIUMF); Ramona Leewe (TRIUMF); Qiwen Zheng (TRIUMF)

Id	Accepted type	Category	Title	Content	Speaker	Primary authors (affiliation)	Co-Authors (affiliation)
14	Poster	System and Operation	Low-level radiofrequency system upgrade for the Dalian Coherent Light Source	DCLS (Dalian Coherent Light Source) is an FEL (Free-Electron Laser) user facility at EUV (Extreme Ultraviolet). The primary accelerator of DCLS operates at a repetition rate of 20 Hz, and the beam is divided at the end of the linear accelerator through Kicker to make two 10 Hz beamlines work simultaneously. In the past year, we have completed the upgrade of the DCLS LLRF (Low-Level Radiofrequency) system, including setting the microwave amplitude and phase for two beamlines based on event timing, optimizing the microwave stability, and generating microwave excitation with the arbitrary shape of amplitude and phase. We added two special event codes and a repetition rate division of 10 Hz in the event timing system and set the microwave amplitude and phase by judging the event code in LLRF. The amplitude and phase stability of the microwave was improved with an intra-pulse feedforward algorithm. In addition, we have also generated microwave excitation with arbitrary amplitude and phase shapes to meet the dual beam operation in the future. Detailed information on functions or algorithms will be presented in this workshop.		Hongli Ding (Dalian Institute of Chemical Physics, Chinese Academy of Sciences (CAS)); Jinfu Zhu (Institute of Advanced Science Facilities, Shenzhen); Haokui Li (Dalian Institute of Chemical Physics, Chinese Academy of Sciences (CAS)); Jiawei Han (Institute of Advanced Science Facilities, Shenzhen); Xiwen Dai (Institute of Advanced Science Facilities, Shenzhen); Jiayue Yang (Institute of Advanced Science Facilities, Shenzhen); Weiqing Zhang (Institute of Advanced Science Facilities, Shenzhen)	
15	Poster	Hardware	Dual frequency master oscillator generation and distribution for ALS and ALS-U	The ongoing work to upgrade ALS to ALS-U demands strict RF requirements such as low jitter and low spurs frequency reference to meet its accelerator and science goals. A low phase noise dual frequency Master Oscillator (MO), where the two frequencies are related by a fractional ratio of 608/609 and flexible divide by four frequency outputs has been consolidated into a single chassis. Optical fiber clock distribution system has been selected over the old coax system used in ALS to distribute these signals to various clients across the facility, providing high electrical isolation between outputs and therefore lower phase errors. A Xilinx FPGA ties the MO chassis together by providing a RS-485 interface to monitor and control the system. The new system aims to deliver phase-continuous frequencies with a phase noise (integrated RMS jitter) from 1 Hz to 1 MHz of less than 200 femtosecond per output. This paper will discuss the design, implementation, performance and installation of the new MO generation		Shreeharshini Dharanesh Murthy (Lawrence Berkeley National Laboratory); Angel Jurado (Lawrence Berkeley National Laboratory); Qiang Du (Lawrence Berkeley National Laboratory); Benjamin Flugstad (Lawrence Berkeley National Laboratory); Michael Betz	
16	Poster	System and Operation	Performance of FPGA controllers in ISAC-1 accelerator chain	The LLRF of four of TRIUMF's ISAC-1 accelerator cavities have been replaced by 2 FPGA based system. These are 2 Drift Tube Linacs and 2 bunchers, nameley DTL4, DTL5, HEBT11 and HEBT35. The operating frequencies of these cavities 11.76 MHz, 35.36 MHz for the bunchers and 106.08 MHz for the DTLS, with the RF power ranges from 1.5 kW and 13 kW for the 2 bunchers to more than 20 kW for the DTLs. These LLRF uses internal phase locked loops for frequency generation and synchronization, feedback control using Amplitude/Phase regulations. The FPGAs also have internal stepper motor controller for resonance control. Various modes of resonance control are possible, including phase comparison and minimum seeking slide-mode control. Operational performances including frequency generation, amplitude and phase noises, tuning speeds, compatibility to original remote controls, are reported.		Ken Fong (TRIMUF)	Thomas Au (TRIUMF); X Fu (TRIUMF); Ramona Leewe (TRIUMF); QW Zheng (TRIUMF)

Id	Accepted type	Category	Title	Content	Speaker	Primary authors (affiliation)	Co-Authors (affiliation)
18	Poster	Measurement and Control	A low-delay reference tracking algorithm for microwave measurement and control	In FEL (Free-Electron Laser) accelerators, LLRF (Low-Level Radiofrequency) systems usually deploy feedback or feedforward algorithms requiring precise microwave measurement. The slow drift of the clock allocation network of LLRF significantly impacts the measured microwave phase, thereby affecting the stability of the closed-loop operation. The reference tracking algorithm is used to eliminate the measurement drift. The conventional algorithm is to perform phase and amplitude demodulation on the synchronous reference signal from the main oscillator and subtract the reference phase in other measurement channels. The demodulation is usually based on the CORDIC, which requires approximately 16 clock cycles in FPGA (Field Programmable Gate Arrays). This paper uses the multiplication of complex numbers, which only requires four clock cycles of computational delay and achieves phase subtraction point by point. Nevertheless, it causes irrelevant amplitude noise to overlap and may increase the amplitude measurement noise. This reference tracking algorithm is suitable for control algorithms with low-delay requirements of microwave measurement.		Jinfu Zhu (Institute of Advanced Science Facilities, Shenzhen); Hongli Ding (Dalian Institute of Chemical Physics, Chinese Academy of Sciences (CAS)); Haokui Li (Dalian Institute of Chemical Physics, Chinese Academy of Sciences (CAS)); Jiawei Han (Institute of Advanced Science Facilities, Shenzhen); Xiwen Dai (Institute of Advanced Science Facilities, Shenzhen); Jiayue Yang (Institute of Advanced Science Facilities, Shenzhen); Weiqing Zhang (Institute of Advanced Science Facilities, Shenzhen)	
19	Poster	Software	The microwave amplitude and phase setting based on event timing for the DCLS	The primary accelerator of DCLS (Dalian Coherent Light Source) operates at a repetition rate of 20 Hz now, and the beam is divided at the end of the linear accelerator through Kicker to make two 10 Hz beamlines work simultaneously. For the simultaneous emission FEL of two beamlines, the beam energy of the two beamlines is required to control independently, so we need to set the amplitude and phase of each beamline. This paper implements a microwave amplitude and phase setting function based on event timing. We upgrade the EVG/EVR event timing system and LLRF (Low-Level Radiofrequency) system. Two special event codes and a repetition rate division of 10 Hz are added to the event timing system, and we can set the microwave amplitude and phase by judging the event code in LLRF. We ultimately perform the microwave triggering at a repetition rate of 10 Hz for each beamline and validate this function through beam experiments.		Jinfu Zhu (Institute of Advanced Science Facilities, Shenzhen); Hongli Ding (Dalian Institute of Chemical Physics, Chinese Academy of Sciences (CAS)); Haokui Li (Dalian Institute of Chemical Physics, Chinese Academy of Sciences (CAS)); Jiawei Han (Institute of Advanced Science Facilities, Shenzhen); Xiwen Dai (Institute of Advanced Science Facilities, Shenzhen); Bo Xu (Dalian Institute of Chemical Physics, Chinese Academy of Sciences (CAS)); Lei Shi (Institute of Advanced Science Facilities, Shenzhen); Jiayue Yang (Institute of Advanced Science Facilities, Shenzhen); Weiqing Zhang (Institute of Advanced Science Facilities, Shenzhen)	

Id	Accepted type	Category	Title	Content	Speaker	Primary authors (affiliation)	Co-Authors (affiliation)
20	Poster	Software	Implementation of microwave with arbitrary amplitude and phase for the DCLS	In many experiments, the simultaneous emission of multiple wavelengths of FEL (Free-Electron Laser) is significant. For the pulsed-mode FEL facility, we must accelerate multiple electron beams in one microwave pulse, and they may be in different amplitudes and phases in the acceleration field. Therefore, we implement a microwave excitation, whose amplitude and phase have arbitrary shapes in LLRF (Low-Level Radiofrequency) system. We generate a microwave pulse with step-shaped amplitude and phase for dual beam operation in DCLS (Dalian Coherent Light Source). The microwave system of the primary accelerator has four pulsed LLRF devices, which output excitation to drive four solid-state amplifiers and then excite two 50 MW and two 80 MW klystrons, respectively. Due to the limited bandwidth of the klystron, the burst phase or amplitude of the step-shaped pulse may cause the excitation ring, so we generate a microwave excitation with a smooth step-shaped pulse by a sigmoid function. Preliminary experiments have shown that this step-shaped microwave can be used for the DCLS dual beam operation.		Haokui Li (Dalian Institute of Chemical Physics, Chinese Academy of Sciences (CAS)); Jinfu Zhu (Institute of Advanced Science Facilities, Shenzhen); Hongli Ding (Dalian Institute of Chemical Physics, Chinese Academy of Sciences (CAS)); Jiawei Han (Institute of Advanced Science Facilities, Shenzhen); Xiwen Dai (Institute of Advanced Science Facilities, Shenzhen); Jiayue Yang (Institute of Advanced Science Facilities, Shenzhen); Weiqing Zhang (Institute of Advanced Science Facilities, Shenzhen)	
22	Poster	Measurement and Control	Measuring and control equipment on the RFSoC for Hobicat facility	Controlling SRF cavities in CW mode in the presence of mechanical disturbances, as well as in the presence of noisy detectors, makes control still a challenge. Internal cavity features such as Lorentzian forces are well understood and predictable, but also make control difficult. An inexpensive solution for compact accelerators that can accommodate many algorithms simultaneously on a single board at an affordable price is RFSoC. Their analog circuits are not yet accurate. Nevertheless, a significant reduction in development time can be achieved through an integrated architecture, as well as development tools available on the market. The following will present the RFSoC control hardware with a focus on basic functions, implemented primarily as a firmware solution. The scope of functions is as follows: VNA measurements to determine resonator quality factor and S-parameters, PLL, control in the presence of noisy detector data, and adaptive RF/piezo control. The results of their tests on the Hobicat test facility will be shown.		Pablo Echevarria Fernandez (Helmholtz Zentrum Berlin); Axel Neumann (Helmholtz Zentrum Berlin); Andriy Ushakov (Helmholtz-Zentrum Berlin)	
26	Poster	Timing	PIP-II beam pattern generator upgrade using an SoCFPGA	A prototype beam pattern generator for the PIP-II Linac was tested with beam during the PIP2-IT testing a couple of years ago. This system used Labview as a user interface and for some of the digital signal processing along with the pattern generation performed on an external server. A new design using a COTS sourced SOCFPGA and a DAC board offers the advantages of low hardware and development cost. The pattern generation, digital signal processing and the interface to an external EPICS server are integrated onto the ARM processor of the FPGA. The system design is described and the test results are presented.		Hitesh Shukla (Fermilab)	Shrividhyaa Sankar Raman (Fermi National Accelerator Laboratory); Philip Varghese (Fermilab)
27	Poster	Measurement and Control	Closed loop testing of microphonics algorithms using a cavity emulator	An analog crystal filter based cavity emulator is modified with reverse biased varactor diodes to provide a tuning range of around 100 Hz. The piezo drive voltage of the resonance controller is used to detune the cavity through the bias voltage. A signal conditioning and summing circuit allows the introduction of microphonics disturbance from a signal source or using real microphonics data from cavity testing. This setup is used in closed loop with a cavity controller and resonance controller to study the effectiveness of resonance control algorithms suitable for superconducting cavities.		Shrividhyaa Sankar Raman (Fermi National Accelerator Laboratory)	Hitesh Shukla (Fermilab); Philip Varghese (Fermilab)
31	Poster	Hardware	Design of the LLRF control system for MA cavity at CSNS RCS	The China Spallation Neutron Source (CSNS) beam power was successfully reached 125 kW with a low beam loss in February 2022. In order to increase beam power, during the summer in 2022, we employ magnetic-alloy (MA) cavity in the rapid cycling synchrotron (RCS). It is a wideband cavity (Q=2) , allows the second harmonic rf (h= 4)operation, with the existing ferrite cavity to realize the dual-harmonic acceleration. The second harmonic (h=4) is used for the bunch shape control and alleviating the space charge effects. We design of the low level RF(LLRF) control system for MA cavity, in this paper, We describe the system design and implementation, and the preliminary test results.		Yang Liu (Institute of High Energy Physics); Xiang Li (Institute of High Energy Physics); Jian Wu (Institute of High Energy Physics)	

Id	Accepted type	Category	Title	Content	Speaker	Primary authors (affiliation)	Co-Authors (affiliation)
32	Poster	Measurement and Control	Simulation of muti-harmonic adaptive feedforward control for magnetic alloy cavity	The upgrade plan of the China Spallation Neutron Source aims to enhance the beam power from 100 kW to 500 kW. To achieve this, the plan involves incorporating three new magnetic alloy cavities while maintaining the existing system to enable double harmonic acceleration. As a consequence of the increased current intensity, the beam loading effect will be significantly amplified in multiple harmonics, presenting a considerable challenge for the low-level RF control system of the magnetic alloy cavity. To address this challenge, an adaptive feedforward algorithm has been developed to enable optimal control in multiple harmonics. In addition, comprehensive simulations of the algorithm have been successfully conducted to validate its		Xiang Li (Institute of High Energy Physics); Yang Liu (Institute of High Energy Physics)	
35	Poster	Software	A Python-based LLRF algorithm library	Many common algorithms are used in LLRF applications or testing software. Implementing these algorithms as a library with widely used computer languages is attractive to share knowledge within the LLRF community and avoid duplications in development. This poster reports the progress of implementing an LLRF algorithm library in Python, a popular language used in LLRF high-level applications and beam controls. The following algorithms are implemented: cavity parameters and model identification, RF system calibration, RF signal demodulation, RF controller design and analysis, noise analysis, and RF system simulation. The library is in the form of general routines with interfaces adaptable to different data formats and accelerator machines. The routines can be directly used in Python-based software, such as the Python-EPICS-based soft IOC automating the operation of an RF station. We also demonstrate the library with data from actual or simulated RF systems.		Zheqiao Geng (Paul Scherrer Institut)	Radoslaw Rybaniec (Paul Scherrer Institut)
36	Poster	Hardware	Digital upgrade of the low energy beam transport resonance control system	For the Los Alamos Neutron Science Center (LANSCE) at Los Alamos National Laboratory (LANL), the incremental upgrades of the legacy low level radio frequency (LLRF) equipment continue. The Low Energy Beam Transport (LEBT) LLRF control systems, including the resonance control system, will be upgraded to a modern, digital system during the 2024 maintenance period. The current resonance control system of the LEBT is original to the LANSCE accelerator from 1972. This paper will describe the technical requirements for the resonance control system of the LEBT and the additional features of the digital system for the upgrade. A discussion of the technical challenges associated with the upgrade is included.		Paula Van Rooy (Los Alamos National Laboratory)	Aaron Archuleta (Los Alamos National Laboratory); Lawrence Castellano (Los Alamos National Laboratory); Sung Il Kwon (Los Alamos National Laboratory); Colton Marchwinski (Los Alamos National Laboratory); Mark Prokop (Los Alamos National Laboratory); Phillip Torrez (Los Alamos National
37	Poster	Measurement and Control	Online identification algorithm for mathematical model of RF cavity system based on FPGA	The mathematical model of a RF system incorporates crucial characteristic parameters of the RF cavity, including cavity bandwidth, resonant frequency, and LFD factors. This mathematical model is crucial for cavity performance evaluation and optimization of control algorithms. The network analyzer is usually used for measuring the scattering parameters of the RF system and subsequently constructing mathematical models. However, its measurement steps are tedious and fail to identify the system model online. Therefore, we have developed a sweeping algorithm in the LLRF system. This sweeping algorithm simulates the operational principles of a network analyzer, which can achieve the cavity system model online identification. The sweeping algorithm has been verified on a superconducting cavity of the CAFe accelerators. The measurement result using the proposed sweeping algorithm is in accordance with those obtained via a network analyzer. Furthermore, this algorithm successfully measures the distortion curve of cavity frequency response caused by Lorentz force detuning. Finally, we discuss the influence of LFD variation on the measurement of the critical cavity parameters.		Zhenglong Zhu (Institute of Modern Physics)	Zheng Gao (Institute of Modern Physics); Feng Qiu (Institute of Modern Physics); Shihui Wei (Institute of Modern Physics); jinying ma (Institute of Modern Physics)

Id	Accepted type	Category	Title	Content	Speaker	Primary authors (affiliation)	Co-Authors (affiliation)
39	Poster	System and Operation	Commissioning of CW digital low-level RF for 50 MHz cyclotrons at PSI	In the long-term project frame of the HIPA (High Intensity Proton Accelerator) RF systems, the replacement of analogue LLRF from the decades 1980 with a digital system is ongoing. This new digital LLRF system will be used the first time in HIPA for beam operation with a new cavity in autumn 2023. The tuning system, with hydraulic aggregate and valve actor for the plunger, is working in closed loop. Regulated operation is keeping the cavity on resonance under all changing environmental conditions. The tuning system controls two independent plungers for the same cavity, which are used in different operation schemes. Phase detection between the accelerating voltage and RF input Power acts as the input to the tuning loop. Phase error Offset, fixed position control, independent plunger tuning and position offset offers the variety of operation scenarios. The RF system is working with amplitude and phase regulation to maintain the precision and performance of the accelerating field. For the start-up sequence and also for the operation of the system there are various exception handling procedures implemented. This poster shows the first test results at the Injector-II/Resonator 2		Matthias Stoll (Paul Scherrer Institut)	Karina Ambrosch (Paul Scherrer Institut); Mario Jurcevic; Benoit Stef
40	Poster	System and Operation	HIAF-bring magnetic alloy loaded RF system design and testing	High Intensity heavy-ion Accelerator Facility (HIAF) is a major scientific and technological infrastructure project of the 12th Five Year Plan in China. It will be the heavy ion beam device with the highest pulse current intensity in the world. HIAF has the characteristics of fast ramping, high current and high energy. It puts forward high index requirements for the RF system of synchrotron. HIAF-Booster Ring RF system mainly consists of four parts: magnetic alloy (MA) loaded cavity, high-power broadband RF amplifier, high-precision digital low-level RF (LLRF) system and computer controller. The LLRF system is designed based on the VPX platform. On above basis, the first low-frequency, broadband, oil cooled MA loaded RF system in China has been successfully developed. The cavity voltage achieved 66kV (gradient > 30kV/m) within the frequency range of 0.29 to 2.1MHz, harmonic suppression > 23dBc, amplitude stability $\lvert\triangle A/A\rvert \leq 1\%$, phase stability $\lvert\triangle\varphi\rvert \leq 1°$.		Zhe Xu (Institute of Modern Physics, Chinese Academy of Sciences); Yan Cong (Institute of Modern Physics, Chinese Academy of Sciences)	Peng Jin (Institute of Modern Physics, Chinese Academy of Sciences); Ruifeng Zhang (Institute of Modern Physics, Chinese Academy of Sciences); Shilong Li (Institute of Modern Physics, Chinese Academy of Sciences); Xin Fu (Institute of Modern Physics, Chinese Academy of Sciences); Xiaodong Han (Institute of Modern Physics, Chinese Academy of Sciences)
43	Poster	Hardware	New development of X-band LLRF for PAL-XFEL Linearizer	Current X-band LLRF for PAL-XFEL has been operated reliably for about 8 years. However, the RF jitter and drift values of the LLRF were relatively big. Therefore, new development of X-band LLRF was initiated a few years ago. Current X-band LLRF in operation had been designed in direct- or single-conversion method between X and IF bands. The new X-band LLRF was designed to run in dual or two step conversion among X, S and IF bands to minimize development efforts by redeveloping only converter between X and S bands and by reusing S-band LLRF. The new LLRF showed about 2 times better values in jitter and drift at lab test. The new LLRF is expected to be installed and verified in July 2023.		Jinyul Hu (PAL, POSTECH)	Chang-Ki Min (PAL); Soung Soo Park (PAL, POSTECH); Sang-Hee Kim (PAL, POSTECH); Yong Jung Park (PAL, POSTECH); KwangHoon Kim (PAL, POSTECH); Seonghoon Jung (PAL, POSTECH); Donghyun Na (PAL, POSTECH); Changbum Kim (Pohang Accelerator Laboratory); Hoon Heo (PAL, POSTECH)
49	Poster	System and Operation	Status upgrade on the BESSY-II LLRF modernization and future plans	BESSY-II synchrotron light source at Helmholtz Zentrum Berlin, has been in operation for almost 25 years and it is not expected that its successor, BESSY-III will be ready for user operation until the second half of the next decade. This fact makes necessary several modernization measures to keep BESSY-II competitive until then. One of these measures is the replacement of the old analogue LLRF control system with modern, state-of-the-art mTCA.4 crates running the so-called "single cavity control". In order to test the new systems, a test stand has been set up, comprising a HOM-damped BESSY cavity, a 80kW SSA, a MPS PLC, a motor driver and a mTCA.4 chassis. Provided a successful operation of the teststand, the system will be stepwise deployed to drive the booster and storage ring cavities. It is also planned to introduce 3rd harmonic cavities operating at 1.5GHz in the following years, so the hardware adaptations are currently being commissioned.		Pablo Echevarria Fernandez (Helmholtz Zentrum Berlin); Axel Neumann (Helmholtz Zentrum Berlin); Andriy Ushakov (Helmholtz-Zentrum Berlin)	

Id	Accepted type	Category	Title	Content	Speaker	Primary authors (affiliation)	Co-Authors (affiliation)
50	Poster	System and Operation	Insights and conclusions from operating the CERN Linac4 LLRF system	The CERN Linac4 accelerator, completed in 2017, achieved a significant milestone when it was connected to the Proton Synchrotron Booster (PSB) in December 2020, enhancing its operational capabilities. This paper provides an overview of Linac4's parameters and RF layout, emphasizing key aspects of its design. It focuses on the identification and resolution of operational issues encountered during the initial operations, providing insights into the implemented corrective measures. Additionally, the paper highlights the potential for future advancements, including the exploration of longitudinal painting techniques, which may soon be applied in the Linac4 system for improved beam manipulation and optimization.		Philippe Baudrenghien (CERN); Bartosz Bielawski (CERN); Robert Borner (CERN)	
52	Poster	Hardware	Status of the beam control renovation of the Proton Synchrotron at CERN	The Proton Synchrotron (PS) at CERN is equipped with 25 RF cavities in the frequency range from 0.4 MHz to 200 MHz. The present beam control driving the RF systems is based on multiple sub-parts, dedicated to the different beam types covering almost four orders of magnitude in intensity. While featuring large flexibility, the current platform suffers from obsolescence and reproducibility issues due to the mix of analogue and digital hardware. A new beam control system, implementing radial, phase and synchronization feedback loops in a single hardware platform is therefore under development. It will match or improve upon the current capabilities and performance of the existing LLRF. Additionally, the new beam control system will profit from past developments in the other injectors at CERN, enabling the re-use of hardware, firmware and software components.		Diego Barrientos (CERN)	Heiko Damerau (CERN); Alexandre Lasheen (CERN); Nathan Pittet (CERN); Benjamin Woolley (CERN)
53	Poster	Hardware	Development and commissioning of a bunch-by-bunch phase measurement module for the CERN super proton synchrotron beam-based loops	The accurate measurement of bunch-by-bunch phase is of utmost importance for optimizing beam control and performance in the CERN Super Proton Synchrotron. We present the development and commissioning of Low-Level RF modules designed for this purpose. The phase module utilizes a high-speed 5 Gsps ADC and a wideband pick-up system to monitor individual bunches. A pipelined FFT processing technique, coupled with a numerically controlled oscillator (NCO) locked to the accelerating RF, generates a beam synchronous phase signal (200Msps). This signal is transmitted over 10 Gbps serial links to the beam loops module. Notably, the beam loop module can receive data streams from up to three pick-up processing chains and seamlessly switch between them during a machine cycle. This combination of features proves particularly valuable for scenarios such as slip-stacking, where two beams are independently controlled within the same ring, and for fixed target ions, where an amplified pick-up is employed after de-bunching. The implementation of the module on Ultrascale+ MPSoC and MicroTCA platform is presented, along with commissioning results.		Arthur Spierer (CERN)	Philippe Baudrenghien (CERN); Robert Borner (CERN); Gregoire Hagmann (CERN)
55	Poster	System and Operation	Digital LLRF system for SESRI Proton and Heavy Ion Accelerator Complex Injector	A 300 MeV proton and heavy ion accelerator complex has been designed and constructed by the Institute of Modern Physics for the space environment simulation and research infrastructure (SESRI) project. The linac injector of the accelerator complex is based on normal-conducting rf structures. It consists of an RFQ, a buncher, three DTLs, and two debunchers. The requirements for the rf field stabilities are ±1% in amplitude and ±1 degree in phase during flat-top. To satisfy these requirements, we developed a 108.48 MHz digital low-level RF system based on FPGA and compact PCI bus. This paper will present the design, implementation, and		Ruifeng Zhang (Institute of Modern Physics , CAS)	Zhe Xu (Institute of Modern Physics , CAS); Yan Cong (Institute of Modern Physics , CAS); Shilong Li (Institute of Modern Physics , CAS); Xiaodong Han (Institute of Modern Physics , CAS); Ruihuai Zhou (Institute of Modern Physics , CAS)

Id	Accepted type	Category	Title	Content	Speaker	Primary authors (affiliation)	Co-Authors (affiliation)
58	Poster	Software	Signal processing architecture of the next generation LLRF systems at PSI	LLRF systems play a crucial role in the efficient operation and control of particle accelerators. At the Paul Scherrer Institute (PSI), advanced LLRF systems are being developed to meet the demands of upcoming facility upgrades, including Swiss Light Source (SLS) and High Intensity Proton Accelerator (HIPA). In this contribution, we present the signal processing architecture designed for these next-generation LLRF systems. Always and independent of the machine or operation type, digital LLRF systems share the same key functions: Data acquisition (DAQ), RF actuation and feedback control. In addition, some management and automation features including exception handling and state control are required. Finally, LLRF systems typically interoperate with others systems, such as timing and machine protection. As an example architecture implementation, we present the design of the SLS-2 500 MHz LLRF, which is intended for CW and pulsed RF operation. The LLRF features are divided into different architecture layers, including programmable logic, embedded software, and the high level control system. Where applicable, re-usable and universal library elements are used.		Radoslaw Rybaniec (Paul Scherrer Institut)	Alexander Dietrich (Paul Scherrer Institut); Roger Kalt (Paul Scherrer Institut); Benoit Stef (Paul Scherrer Institut)
60	Poster	Measurement and Control	DAQ for JLAB legacy analog LLRF systems	The Computer Automated Measurement and Control (CAMAC) system is a modular instrumentation bus that was originally developed in the 1970s and is widely used for the LLRF control of C20/C50 Cryomodule at JLab. Due to the serial bus limitations, real time analysis of RF control signals is severely inhibited. To address this, a new Artix FPGA based Data Acquisition Chassis has been developed and can measure key RF controls signals up to a rate of 25k samples/sec. This allows users to analyze and debug problems in real time by viewing waveforms of RF signals (a real time virtual oscilloscope) which has the ability to freeze the buffer when a beam trip condition exists. This new DAQ makes it possible to collect and analyze data from these legacy RF systems, which helps troubleshoot problems in real time.		Ramakrishna Bachimanchi (Jefferson Lab); Curt Hovater (Jefferson Lab); James Latshaw (Jefferson Lab (JSA)); Tomasz Plawski (Jefferson Lab)	
61	Poster	Measurement and Control	The fast RF interlock system for CAFe II linac	The CAFe II is upgraded from Chinese ADS Front-end demo facility, it's a superconducting radio frequency(SCRF) linac to accelerate the proton or heavy ion for nuclear physics research. The facility aims to synthetic superheavy elements which demand high beam availability, therefore, the new fast RF interlock system has been developed to meet the reliability requirements for long-term operation of superconducting cavities, the system is required to immediately turn off the RF drive of cavity when fault event occurs. The fast RF interlock system was designed to detect fault conditions by monitoring cavity and coupler vacuum, coupler temperature, and arc events in coupler. All interlock signal connections were designed as optical fiber connections in the new RF interlock system, and the protection logic was implemented in the FPGA which has an embedded processor to support remote monitor and control. The new fast RF interlock system has been successfully tested and is running on line, the response delay was tested to be		Zongheng Xue (Institute of Modern Physics)	
62	Poster	Hardware	Operation of a LLRF system for RAON low energy LINAC	Recently the test and installation of superconducting cavities and the cryomodules of the low energy linear accelerator part (SCL3) of a heavy ion accelerator, RAON have been finished. The commissioning of the low energy linac had been proceeded from 2022 autumn in Daejeon, Korea by Institute for Rare Isotope Science (IRIS) in Institute of Basic Science (IBS). The purpose of this accelerator is the generation of rare isotope by ISOL (Isotope Separation On-Line) and its acceleration for the nuclear physics experiment. The operating RF frequency for SCL3 are 81.25 MHz and 162.5 MHz. Every cavity can be controlled independently for the flexibility to accelerate the various A/q ions. The development, evaluation and installation of the digital LLRF based on the FPGA technology have been finished in 2022. The self-excited loop (SEL) and the generator-driven-resonator (GDR) algorithm are implemented and they were tested in the SRF test facility. In this presentation the status and preliminary operation experience of RAON LLRF controller will be described.		Hyojae Jang (Institute for Basic Science); Youngkwon Kim (IBS); Yoochul Jung (IBS)	

Id	Accepted type	Category	Title	Content	Speaker	Primary authors (affiliation)	Co-Authors (affiliation)
63	Poster	System and Operation	Upgraded bunch length monitoring system for CEBAF	The existing bunch length monitoring system was designed and installed more than thirty years ago. This system measures the beam induced signal from a 5.988 GHz cavity. This phase is compared to a reference signal using a double balanced mixer/phase detector. The data are acquired using a Computer Automated Measurement and Control (CAMAC) system for bunch length determination and analysis. This system can only measure one such signal at a time. Upgraded system has three downconverters to measure signals from three cavities simultaneously and an FPGA based system acquires and displays the phase information in EPICS for analysis. This poster describes the architecture and the implementation details of the new		Ramakrishna Bachimanchi (Jefferson Lab); Tomasz Plawski (Jefferson Lab)	
64	Poster	System and Operation	Testing of the BARC LLRF and RFPI systems for the PIP-II Linac	The PIP-II project is an international collaboration with various subsystems developed by partner labs. The LLRF and RFPI systems developed at BARC are being tested with cold cavities at the Fermilab STC facility. Complete systems for the 325 MHz and 650 MHz cavities will be tested and validated. The test results and performance of these systems are presented.		Hitesh Shukla (Fermilab)	Shrividhyaa Sankar Raman (Fermi National Accelerator Laboratory); Philip Varghese (Fermilab)
65	Poster	System and Operation	A Hybrid architecture for the LLRF system of the Fermilab Mu2e project	The LLRF system for the Mu2e project uses the same primary LLRF hardware as the Muon g-2 experiment that has been running for the past five years. The SSA and RF cavity for the capture of the 2.5 MHz beam bunches in the delivery ring are located about a mile away from the LLRF controller. A local FPGA controller chassis is used to digitize the cavity signals and to co-ordinate the beam transfer manipulations. The system architecture is described and the results of the initial testing presented.		Shrividhyaa Sankar Raman (Fermi National Accelerator Laboratory)	Hitesh Shukla (Fermilab); Philip Varghese (Fermilab)
66	Poster	Measurement and Control	FPGA Implementation of the digital low level RF control system for the LANSCE low frequency buncher cavity	As part of the modernization of the Los Alamos Neutron Science Center (LANSCE), a digital low level RF (DLLRF) control system for the 16.67 MHz Low frequency buncher (LFB) is designed and is implemented on a Field Programmable Gate Array (FPGA). In this paper, the newly designed DLLRF control system of the LANSCE LFB and its performance verified on the cavity simulator are addressed. Since the LANSCE accelerator provides both H^+ and H^- beams that have different pulse types varying in timing and current size, the DLLRF control system of the LFB cavity requires to handle the beam type dependent multiple amplitude/phase set points, and corresponding controllers. Furthermore, in contrast to the deployed DLLRF control systems of 201.25 MHz Drift-Tube Linac (DTL), since the LFB RF frequency 16.67 MHz is subharmonic of 201.25 MHz reference, the DLLRF control system uses direct sampling, non-I/Q digital signal processing for the demodulation. For the modulation, FIR filter based Digital Hilbert Transformer (HT) is implemented to generate quadrature signals.		Sungil Kwon (Los Alamos National Laboratory)	Aaron Archuleta (Los Alamos National Laboratory); Lawrence Castellano (Los Alamos National Laboratory); Colton Marchwinski (Los Alamos National Laboratory); Mark Prokop (Los Alamos National Laboratory); Phillip Torrez (Los Alamos National Laboratory); Paula Van Rooy (Los Alamos National Laboratory)
68	Poster	Hardware	A digital RF control system design for the 2GeV FFA accelerator 1:4 down-scale cavity	A high energy and high current isochronous proton accelerator has been extensively studied at the China Institute of Atomic Energy. A down-scale system has been built to evaluate the feasibility of this accelerator's 15 RF systems, including a 1:4 scaled cavity, a 200kW tetrode tube amplifier, and a digital RF control. This new RF control system uses high-speed ADCs to direct sample the RF signals and implements digital algorithms to achieve amplitude/phase measurement and control. The amplitude and phase-controlled RF signal is generated by the numerical oscillator inside the FPGA and amplified by the high-power amplifier to drive the downscale cavity. This room-temperature cavity has two tuning systems. One uses mechanical deformation, and the other regulates the inlet water temperature to stabilize the resonance. A self-excited loop is preferred from a systematic point of view to test the latter. In the LLRF controller design, a clock distribution network is included to synchronize the ADC, the DAC, and the FPGA for this purpose, contributing more flexibility. The progress will be reported in this		Zhiguo Yin (China institute of atomic energy)	Xiaoliang Fu (TRIUMF)

Id	Accepted type	Category	Title	Content	Speaker	Primary authors (affiliation)	Co-Authors (affiliation)
69	Poster	System and Operation	Upgrade of the SPARC_LAB LLRF system and recent X-band activities in view of EuPRAXIA@SPARC_LAB project	SPARC_LAB is a high-brightness photoinjector developed for FEL and research on novel acceleration techniques. It has been in operation at LNF since 2005. It is made of a newly designed brazeless 1.6-cell S-band RF gun, two SLAC type S-band and one C-band accelerating structures. Recently, a plasma chamber was installed to study beam-driven plasma acceleration schemes. During fall 2023, a major upgrade of the entire low level RF (LLRF) system will take place to consolidate and improve performance in terms of amplitude, phase resolution and stability. The original analog S-band and the digital C-band LLRF systems will be replaced by commercial, temperature-stabilized, FPGA-controlled digital LLRF systems manufactured by Instrumentation Technologies. In parallel, there is a growing interest in X-band LLRF at LNF due to the EuPRAXIA@SPARC_LAB project. This project aims to build an FEL user facility driven by an X-band linac at LNF in the coming years. To test X-band RF structures and components, a high-power test stand named TEX has been installed and commissioned. The TEX LLRF system, based on a commercial S-band system with a dedicated up/down-converter stage, will be also discussed.		Luca Piersanti (Istituto Nazionale di Fisica Nucleare - Laboratori Nazionali di Frascati)	Marco Bellaveglia (Istituto Nazionale di Fisica Nucleare - Laboratori Nazionali di Frascati); Alessandro Gallo (Istituto Nazionale di Fisica Nucleare - Laboratori Nazionali di Frascati); Beatrice Serenellini (Istituto Nazionale di Fisica Nucleare - Laboratori Nazionali di Frascati); Simone Tocci (Istituto Nazionale di Fisica Nucleare - Laboratori Nazionali di Frascati)
71	Poster	SRF Controls	Status update of continuous wave and long pulse tests on XM46.1 and X3M2	The foreseen European XFEL High Duty Cycle upgrade requires driving the accelerator either in Continuous Wave or in Long Pulse mode of operation. In the Long Pulse mode of operation, the duty factor of the RF pulses is higher than 5% as opposed to the actual value of 1.4%. Therefore it is required to adapt the control system to operate with the new pulse parameters and, at the same time, preserve an RMS stability of the accelerating field of 0.01% in amplitude and 0.01° in phase. In the injector, where the maximum accelerating gradients will be realized, the accelerating cavities will operate at 20 MV/m with a loaded quality factor in the order of 6e7. Therefore tests with similar gradients, conducted at the CryoModule Test Bench on XM46.1 are presented along with RF stability measurements. Additional tests on the 3.9 GHz third harmonic module X3M2 are presented as well. The current third harmonic module used at European XFEL lacks piezoelectric tuners. Therefore the tests are crucial to determine whether a modification of the cryomodule is required.		Andrea Bellandi (Deutsches Elektron-Synchrotron)	Serena Barbanotti (Deutsches Elektron-Synchrotron); Julien Branlard (DESY); Denis Kostin (Deutsches Elektron-Synchrotron); Ruediger Onken (Deutsches Elektron-Synchrotron); Jacek Sekutowicz (Deutsches Elektron-Synchrotron)
73	Poster	System and Operation	Diamond digital low level RF	The first version of digital low level RF (DLLRF) for the Diamond Light Source storage ring and booster was developed with ALBA Synchrotron. Six systems have been built so far. Two of them are in routine operation controlling two normal conducting HOM-damped cavities in the Diamond storage ring. A third system is being used for cavity testing in the RF test facility. The fourth system has been deployed to control the second normal conducting booster cavity. The fifth DLLRF system has been deployed for the third normal conducting RF cavity in storage ring. A new DLLRF system based on SIS8300-KU with RTM has been developed and tested in the last few years. The linac version with arbitrary waveform generator mode was tested successfully to generate flat top pulse from SLED at high power in the linac. The high-power pulse accelerated electron beam to 68 MeV in just one accelerating structure. DLLRF for passive harmonic cavity is		Pengda Gu (Diamond Light Source)	
74	Poster	Software	Software design and implementation of the SHINE LLRF system	This report presents the design and implementation of the SHINE LLRF system software. The software architecture is designed in a layered approach, consisting of two layers. The lower layer is responsible for low-level control of individual sites, specifically for each cavity. It implements EPICS IOC (Input/Output Controller) on the Zynq platform to handle various operating scenarios including normal operation, equipment maintenance, and fault handling. The software offers system status monitoring, parameter measurement and calibration, parameter optimization, cavity conditioning, and fault handling.The upper layer is the management software that oversees all the sites and implements collaborative logic between them. It monitors the status of all the sites and handles any faults that may occur. It also includes fault analysis capabilities for troubleshooting purposes.With this software architecture, the system can effectively manage and monitor multiple sites, allowing for coordinated		Zhigang Zhang; Yubin Zhao (Shanghai advanced research institute. CAS); xuefang huang (Shanghai Advanced Research Institude, Chinese Academy of Saiences); hongru jiang; hailong wu; hong wu; kai xu; wenfeng yang; shenjie zhao; xiang zheng	

Id	Accepted type	Category	Title	Content	Speaker	Primary authors (affiliation)	Co-Authors (affiliation)
76	Poster	Hardware	LLRF hardware design in SHINE	Shanghai HIgh repetition rate XFEL aNd Extreme light facility (SHINE) is 8GeV、CW mode FEL facility. The length of LINAC is 1.2km. The 5.2kW SSA will drive the 1.3GHz SC, In LINAC, there are single cavity cryomodule with two high power couplers, ABBA injector cryomodule, 75's 1.3GHz standard cryomodules, two 3.9GHz harmonic cryomodule. The RF amplitude and phase requirement of one cryomodule are 0.01% and 0.01deg respectively. This presents will introduce SHINE status up to now and the LLRF hardware design.		Xuefang Huang (Shanghai advanced research institute. CAS); Kai Xue (Shanghai advanced research institute. CAS); Wenfeng Yang (Shanghai advanced research institute. CAS); Zhigang Zhang (Shanghai advanced research institute. CAS); Yubin Zhao (Shanghai advanced research institute. CAS); Xiang Zheng (Shanghai advanced research institute. CAS)	
77	Poster	Hardware	Status of DLLRF system development for Soleil-II Project	Under SOLEIL upgrade project, the Low Level Radio Frequency (LLRF) system will be redesigned from an analog to a digital system which has better flexibility and provides easier maintenance. Derived from a 1.3 GHz project, a compact Digital-LLRF system is under development based on the MicroTCA plateform. With Frequency Adaptation Interface, it can be easily implemented in different systems. This will be reported here.		rajesh sreedharan	
78	Poster	System and Operation	MTCA.4 based LLRF control system for the J-PARC MR	The J-PARC Main Ring (MR) is a high intensity proton synchrotron that accelerates protons from 3 GeV to 30 GeV. Its output beam power for fast extraction reached 515 kW, corresponding to $2.66₩times10^{14}$ protons per pulse, in April 2021, and studies and hardware upgrades are underway to achieve higher beam intensities. We observed longitudinal coupled bunch instabilities (CBI) above 450 kW due to the beam loading effect. The CBI causes beam loss during acceleration and large momentum fluctuations in the extracted beam. Beam loading compensation for a wider range of harmonics is required for the acceleration of high intensity proton beams with CBI suppressed. The FPGAs on the original digital low-level RF (LLRF) control system are obsolete and difficult to maintain. Therefore, we developed the new LLRF control system based on MTCA.4 platform. The multi-harmonic vector RF voltage control function was implemented in the system to suppress the beam-induced wake voltages in the RF cavity. We achieved the acceleration of the proton beam with the new LLRF control system in 2023. In this presentation, we present the system configuration and the preliminary commissioning results.		Yasuyuki Sugiyama (KEK)	Fumihiko Tamura (Japan Atomic Energy Agency); Masahito Yoshii (KEK)
79	Poster	Software	DLLRF controller for superconducting third harmonic cavity by developed at SSRF	The superconducting third harmonic cavity which has developed in Shanghai Synchrotron Radiation Facility (SSRF) has passed tests. A digital low level radio frequency (DLLRF) controller has been developed and achieved the goal of stretching beam cluster and improving beam life. The controller based on a Field-Programmable Gate Array (FPGA) board and a front-end board which adjust the stepper motor and piezoelectric ceramic. When the state is in top-up mode over 120mA, the amplitude stability has improved form ±5% with open loop to less than ±1% with close loop, the voltage of piezo has varies smoothly and stably within 120V, and the beam life has improved more than doubled.		Zhigang Zhang; Yubin Zhao; Xuefang Huang (Shanghai Advanced Research Institute, Chinese Academy of Saiences); Xiang Zheng (Shanghai advanced research institute. CAS); Yan Wang (Shanghai Advanced Research Institute); Kai Xu (Shanghai Advanced Research Institute, Chinese Academy of Sciences); Hongtao Hou (Shanghai Advanced Research Institute, Chinese Academy of Sciences)	

Id	Accepted type	Category	Title	Content	Speaker	Primary authors (affiliation)	Co-Authors (affiliation)
80	Poster	Software	Control software design based-on EPICS and CS-Studio for HEPS booster RF system	High Energy Photon Source is a 6 GeV fourth-generation synchrotron light source currently under construction in Beijing, China. It consists of a 500 MeV electron linear accelerator, a booster ring, a storage ring, and multiple beamlines. In the booster, three 499.8 MHz normal-conducting cavities have been installed in the tunnel with each driven by a 100 kW solid-state power amplifier. A digital LLRF system is used to regulate the RF field inside the cavity. PLC is used for slow signal acquisition (such as temperature, water flow-rate, and etc), while fast acquisition for RF signals is implemented with a new data acquisition system. The RF operator interface is in-house developed by using CS-Studio to monitor and control the RF system and its components such as LLRF systems, SSAs, cavities, etc. A total number of ~10000 PVs from all six RF stations are collected by the EPICS IOCs and subsequently stored via the EPICS Archiver Appliance. The design of the control software and the operator interface for the HEPS booster		Dongbing Li	Jian Li (IHEP, CAS); Haiying Lin (IHEP, CAS); Yuanli Luo (IHEP, CAS); Qiang Ye (IHEP, CAS); Pei Zhang (IHEP, CAS); qunyao wang (institue of high energy physics , chinese academy of sciences)
81	Poster	SRF Controls	Development of 499.8 MHz RF control system for HEPS booster ring	High Energy Photon Source (HEPS) is a 6 GeV fourth-generation synchrotron light source currently under construction in Beijing, China. Three sets of 499.8 MHz RF systems have been installed in the HEPS booster and commissioned, while six sets of RF systems will be installed eventually. The RF system needs to ramp the RF voltage from 2 MV to 8 MV to realize the beam energy ramp from 0.5 GeV to 6 GeV. The RF control system has been developed and successfully commissioned in the HEPS booster. The system mainly includes digital Low-level RF system, RF interlock system, data acquisition system and an EPICS database. Both the low-level system and the interlock system used Xilinx's zynq-7000 series FPGA which comes with a versatile Processing System (PS) integrated with a highly flexible and high-performance Programmable Logic (PL) section. In this paper, we describe the architecture of the RF control system under development, the implemented functions, and the commissioning results.		Dongbing Li; Jian Li (IHEP, CAS); Haiying Lin (IHEP, CAS); Pei Zhang (IHEP, CAS); qunyao wang (IHEP, CAS)	
82	Poster	Measurement and Control	A custom multi-channel RF distribution module for FLASH2020+ RF reference generation system	The new RF phase reference generation system was designed and installed to ensure proper and reliable operation of the linac upgraded in the FLASH2020+ program. It synthesizes ultra-stable and ultra-low phase noise RF signals at 9, 108, 1300, and 1517 MHz frequencies. These signals are then routed via coaxial cables to all the system endpoints along the linac. This task required the development of a custom high-power, multi-channel RF distribution module. The contribution presents the designed distribution box that delivers RF reference signals in over 40 channels and provides constant monitoring and diagnostics of the signals, module status, and connected RF loads status. The presented devices have been installed for over a year in the FLASH facility and proved the reliable work and outstanding parameters.		Maciej Urbański (Institute of Electronic Systems, Warsaw University of Technology)	Julien Branlard (Deutsches Elektronen-Synchrotron DESY); Krzysztof Czuba (Institute of Electronic Systems, Warsaw University of Technology); Bartosz Gąsowski (Institute of Electronic Systems, Warsaw University of Technology); Paweł Jatczak (Institute of Electronic Systems, Warsaw University of Technology); Frank Ludwig (Deutsches Elektronen-Synchrotron DESY); Heinrich Pryschelski (Deutsches Elektronen-Synchrotron DESY); Katharina Schulz (Deutsches Elektronen-Synchrotron DESY)
84	Poster	SRF Controls	Introduction of a digital LLRF system at the STF vertical test stand at KEK	The main goal of the superconducting radio frequency (SRF) group at KEK is the development and research of 1.3 GHz SRF cavities. The performance of the prepared cavities is measured within a vertical cryostat, which is operated at the Superconducting RF Test Facility (STF) at KEK. Until now the required RF is controlled by an about 30-year-old analog system. We are in the process of replacing it in collaboration with DESY with a state-of-the-art MicroTCA.4-based LLRF system, which allows continuous wave (CW) operation controlled by a self-excited loop		Mathieu Omet (KEK)	Hayato Araki (KEK); Julien Branlard (DESY); Lukasz Butkowski (DESY); M. Hoffmann (DESY); Patrick Nonn (DESY); Kenssei Umemori (KEK)

Id	Accepted type	Category	Title	Content	Speaker	Primary authors (affiliation)	Co-Authors (affiliation)
85	Poster	Other	Concept of the real-time monitoring system for the ESS phase reference line	The Phase Reference Line (PRL) of the European Spallation Source (ESS) is a system that distributes 352.21 MHz and 704.42 MHz reference signals from Master Oscillator (MO) in Klystron Gallery (KG) to LLRF and Beam Instrumentation (BI) systems over the machine in the tunnel. It is a 580 m long system based on a 1-5/8" coaxial rigid line installed in the tunnel. Due to radiation, the system is an entirely passive structure, and possible diagnosis during the accelerator operation is an issue. This contribution covers the design concept of a real-time PRL performance monitoring system. The system will base on active optic links measuring PRL phase performance with the assistance of reflectometer links. Reflectometers with Ethernet interface for real-time phase change measurements in cables routed through STUBs. Active optical links for PRL performance monitoring in the ESS Klystron Gallery. The assumed measurement accuracy is better than 0.1 degrees.		Dominik Sikora (Warsaw University of Technology)	Anirban Krishna Bhattacharyya (European Spallation Source); Krzysztof Czuba (Institute of Electronic Systems, Warsaw University of Technology); Paweł Jatczak (Institute of Electronic Systems, Warsaw University of Technology); Morten Jensen (European Spallation Source); Radoslaw Papis (Warsaw University of Technology)
87	Poster	Hardware	Piezo driver for spoke and elliptical cavities of ESS project linac production and installation status	The MTCA.4 based piezo driver has been proposed and developed by the LUT-DMCS engineers as a Polish in-kind to the ESS project. The driver is capable to drive two independent channels dedicated to a single piezo tuner in a single cavity. It has been designed to work for elliptical resonators (M-Beta and H-Beta) with 0 to 200 V output voltage range. Additionally, it can be reconfigured to work in any bipolar or asymmetric range between -190 to 190 V. That is why it will be installed also for the spoke accelerating structures of the same linac. The current contribution presents the latest status of the piezo driver production and installation in the ESS accelerator. Results from the hardware evaluation and initial tuning performance achieved at the Test Stand 2 facility are discussed too.		Wojciech Cichalewski (LUT-DMCS)	Dariusz Makowski (LUT-DMCS); Aleksander Mielczarek (LUT-DMCS); Perek Piotr (LUT-DMCS); Anders Svensson (ESS); Radoslaw Tomala (LUT-DMCS)
88	Poster	Hardware	Status of the PEG in-kind contribution to the ESS LLRF systems integration and installation	The Polish Electronic Group (PEG) is currently in the final stage of the Polish in-kind project realization. This endeavor is dedicated to the chosen modules of LLRF system design and production, LLRF system integration, and installation in the dedicated ESS accelerator infrastructure. This contribution describes the latest achievements in the LLRF system integration and installation for the M-Beta and H-Beta sections. The status and plans for the final production of MTCA.4 modules like Piezo RTM driver, LO RTM, RTM carrier AMC card are discussed as well.		Wojciech Cichalewski (LUT-DMCS); Krzysztof Czuba (WUT-ISE); Jarosław Szewinski (NCNR Poland)	Konrad Bartoszek (NCNR-Poland); Piotr Bartoszek (NCNR-Poland); Maciej Grzegrzolka (WUT-ISE); Kacper Klys (LUT-DMCS); Krzysztof Kostrzewa (NCNR-Poland); Tomasz Kowalski (NCNR-Poland); Dariusz Makowski (LUT-DMCS); Aleksander Mielczarek (LUT-DMCS); Piotr Perek (LUT-DMCS); Igor Rutkowski (WUT-ISE); Dominik Rybka (NCNR-Poland); Radoslaw Tomala (LUT-DMCS)
89	Poster	Hardware	New RFPI system for the PIP-II accelerating structures	The cryomodule or cavity data like vacuum status, helium level, RF leakage level, field emission probe signal and others can be important indicators of potentially hazardous conditions for the RF operation of the superconducting structures. That is why the dedicated system (RF Protection Interlock - RPFI) has to closely monitor all sensitive parameters and drop the permission for RF operation instantaneously when a possible fault situation occurs. The new design of such an RFPI system has been proposed by LUT-DMCS team. This system is dedicated to the PIP-II accelerating structures. The modular design and interlock logic realization by the SoC (system on Chip) module are the main driving factors for this development. Such an approach provides not only a fast reaction to upcoming faults but also wide flexibility in the input signal sets and protection logic configuration and implementation. This contribution describes the proof of concept prototype design and evaluation as well as the full signal count prototype ongoing efforts.		Piotr Amrozik (LUT-DMCS); Brian Chase (FermiLab); Wojciech Cichalewski (LUT-DMCS); Elvin Harms (FermiLAB); Grzegorz Jablonski (LUT-DMCS); Wojciech Jalmuzna (LUT-DMCS); Rafal Kiełbik (LUT-DMCS); Kacper Klys (LUT-DMCS); Rafal Kotas (LUT-DMCS); Pawel Marciniak (LUT-DMCS); Niral Patel (FermiLab); Bartosz Pekoslawski (LUT-DMCS); Wojciech Tylman (LUT-DMCS); Philip Varghese (FermiLab)	

Id	Accepted type	Category	Title	Content	Speaker	Primary authors (affiliation)	Co-Authors (affiliation)
90	Poster	Hardware	LLRF controls of the S-band transverse deflector cavity for LCLS-II	The S-Band Transverse Deflector Cavity (STCAV) is a diagnostic tool to measure the absolute electron bunch length and beam quality in the LCLS-II Injector at the SLAC National Accelerator Laboratory. The cavity is installed in the diagnostic beamline which receives samples of the main beam at 120 Hz or less, where measurements such as slide emittance and slice energy spread can be performed. The STCAV requires a short burst of RF at 2856 MHz with a power of 400 kW or less. This burst will be provided by the LLRF control system driving a Solid-State Amplifier (SSA) and klystron supplied by ScandiNova Systems AB. The LLRF control system is based on Advanced Telecommunications Computing Architecture (ATCA) platform which has been adopted for many 2856 MHz RF systems at SLAC. In these systems, the 2856 MHz reference is derived from the same base reference used by the 1300 MHz LCLS-II RF, and the LCLS-II timing system will be used. The system architecture and its features will be described in		Nicholas Ludlow (SLAC National Accelerator Laboratory)	
93	Poster	SRF Controls	FW/SW framework for SRF cavity active resonance control	Relater to the high precision active motion controller based on ML, we are going to describe the CI/CD pipeline for testing and deploying the FPGA FW and embedded SW for the Xilinx uBlaze processor that is in use at SLAC. We also introduce the different option to accelerate the SW using HLS flow to target FPGA FW blocks that replace the non performing code. Latest part is to describe the porting from of the XILINX uBlaze processor to the RISC-V architecture and design the CI/CD pipeline to obtain the same results with the open source architecture.		Jorge Diaz Cruz (SLAC); Alessandro Ratti (SLAC)	Andy Benwell (SLAC); Larry Doolittle (LBNL); Shreeharshini Dharanesh Murthy (Lawrence Berkeley National Laboratory); Faya Wang (SLAC); maurizio donna (SLAC National Accelerator Laboratory)
95	Poster	Hardware	LLRF system considerations for a compact, commercial C-band accelerator using the AMD Xilinx RF-SoC	This work describes the LLRF and control system in use for a novel accelerator structure developed for a compact design operating in C-band developed by SLAC, with collaboration from RadiaBeam and RadiaSoft. This design is a pulsed RF/pulsed beam system that only provides minimal monitoring for control of each two-cavity pair. Available signals include only a forward and reflected signal for each pair; such a design requires careful consideration of calibration and power-on routines, as well an understanding of how to correct for disturbances caused by the entire RF signal chain, including a new SSA, klystron, and distribution system. An AMD Xilinx RF-SoC with a separate supervisory computer is the LLRF system core, with on-board pulse-to-pulse feedback corrections. This work presents the current status of the project, as well as obstacles and manufacturing plans from the viewpoint of developing for larger-volume manufacturing.		Jonathan Edelen (RadiaSoft LLC); Joshua Einstein-Curtis (RadiaSoft LLC)	Ronald Augustsson (RadiaBeam Technologies, LLC.); Amiari Diego (RadiaBeam Technologies, LLC.); Morgan Henderson (RadiaSoft LLC); Bo Hong (SLAC National Accelerator Laboratory); Gurhar Khalsa (RadiaSoft LLC); Matt Kilpatrick; Zenghai Li (SLAC National Accelerator Laboratory); Chao Liu (SLAC National Accelerator Laboratory); Julian Merrick (SLAC National Accelerator Laboratory); Emilio Nanni (SLAC National Accelerator Laboratory); Larry Ruckman (SLAC National Accelerator Laboratory); Alexander Smirnov (RadiaBeam Technologies, LLC.); Sami Tantawi (SLAC National Accelerator Laboratory); Seiji Thielk (RadiaBeam Technologies, LLC); Fengrui Zuo (SLAC National
98	Poster	Hardware	Technical design considerations on the low level RF system for KOREA 4-GSR booster	The 4th Generation storage Ring (4GSR) as the second large synchrotron light source in Korea was launched from 2021. It features < 100 pm rad emittance, about 800 m circumference, 4 GeV electron-beam energy, full energy booster injection, and more than 40 beamlines. The booster synchrotron RF system will be designed and manufactured so that up to 1nC charge per bunch injected from the linear accelerator are stably incident on the storage ring every 0.5 seconds by increasing the energy from 200MeV to 4GeV.The performance goals for the booster are derived from the beam acceptance requirements for the storage ring including an RF acceptance of 4.051% We discuss the techniques and design of what is considered the booster synchrotron low -level RF system, including cavity field control, data acquisition, diagnostics, etc., to reliably and efficiently accelerate electron beams from 200MeV to 4GeV. In this report, the design study of the Low Level RF system is presented along with the technical proposals and design summary to be applied to the manufacture of the booster low-level RF system.		Inha Yu (Pohang Accelerator Laboratory. POSTECH)	Bonghyuk Choi (Pohang accelerator laboratory); Myunghwan Chun (Pohang accelerator laboratory); Yong-Seok Lee (Pohang accelerator laboratory)

Id	Accepted type	Category	Title	Content	Speaker	Primary authors (affiliation)	Co-Authors (affiliation)
101	Poster	Measurement and Control	RF measurement in SHINE cavity and cryomodule test stands	Vertical test stands(VTS) and cryomodule test facilities(HTF) have been built in SHINE cryomodule assembly and test hall(ATH). 633 TESLA type super conducting cavities and 75 cryomodules should be tested on these test stands. RF measurement and some result will be shown.		Shenjie Zhao (Shanghai Advanced Research Institute)	Xuming Liu (Shanghai Advanced Research Institute); Chen Luo (Shanghai Advanced Research Institute); Xiaohan Ouyang (Shanghai Advanced Research Institute); Yuechao Yu (Shanghai Advanced Research Institute)
102	Poster	System and Operation	Development status of LLRF system for KOMAC	A 100-MeV proton accelerator has been developed, and the beam service started at the Korea Multi-purpose Accelerator Complex (KOMAC) in July 2013. The accelerator consists of a 50-keV proton injector, a 3-MeV radio-frequency quadrupole (RFQ) and a 100-MeV drift tube linacs (DTLs). Total 9 pulsed klystrons with 1.6 MWpeak are used to provide RF power to the cavities with 350 MHz of operating frequency. As the demand for high intensity beam service increased, the feedforward controller was implemented to mitigate the heavy beam loading effect. This paper introduces the concept of a feedforward controller for KOMAC as well as the experimental results performed in low-level RF (LLRF) teststand and 100-MeV linac. In addition, a LLRF system for a newly developed 200-MHz RFQ, based on non-IQ sampling techinque will be presented briefly.		Hae-Seong Jeong (KAERI, KOMAC)	Han-Sung Kim (KAERI, KOMAC); Jae-Ha Kim (KAERI, KOMAC); Hyeok-Jung Kwon (KAERI, KOMAC); Young-Gi Song (KAERI, KOMAC)
113	Poster	SRF Controls	The LCLS-II-HE SRF gun development	The SLAC National Accelerator Laboratory is undergoing an upgrade to its newest accelerator the LCLS-II. The upgrade consists of installation of 23 new high gradient cavity cryomodules and a Low Emittance Injector (LEI) design both of which will extend the photon energy reach of the LCLS-II accelerator. The SRF gun has a target gradient of 30 MV/m, will produce a target bunch charge of 100 pC, and will operate under CW conditions with a bunch repetition rate of 928.6 kHz. The nominal cavity design frequency is 185.7 MHz, which is the same as the existing NC LCLS-II gun cavity. Thus, it makes sense to adapt the existing LCLS-II LLRF gun control hardware with the LCLS-II SRF firmware and software suite. A description of this effort, and the extra challenges of this merged LLRF system will be presented.		Andy Benwell (SLAC)	JING CHEN (SLAC National Accelerator Laboratory); Daron Chabot (Stanford Linear Accelerator Laboratory (SLAC)); Larry Doolittle (LBNL); Qiang Du (Lawrence Berkeley National Laboratory); Sonya Hoobler (SLAC National Accelerator Laboratory); Curt Hovater (Jefferson Lab); Gang Huang; James Latshaw (Jefferson Lab (JSA)); Andre McCollough (SLAC); Alessandro Ratti (SLAC)
120	Poster	System and Operation	A CPCI based LLRF system for proton CT	A new proton CT(PCT) facility will be built in Shanghai Ruijin Hospital. The main structure of the proton CT includes a high gradient proton LINAC, a compact 360 degree gantry and a proton imaging platform. In the proton LINAC, 16 S band proton accelerating tube were used to increase the energy from 230 MeV to 350 MeV. To provide a more accurate and stable Radio-Frequency(RF) control, a CPCI based Low-Level Radio-frequency(LLRF) control system was developed. In this paper, we introduce the LLRF control system both in firmware and software, which contains the front frequency conversion board with vector modulation RF output, the		Chengcheng Xiao (Shanghai Synchrotron Radiation Facility)	Wencheng FANG (Shanghai Synchrotron Radiation Facility); Yiming XU (Shang Advanced Research Institude, Chinese Academy of Sciences)
121	Poster	System and Operation	Implementation of flat-top output pulse of RF pulse compressor for SXFEL	The adaptive control-based low-level radio frequency (LLRF) algorithm was developed for the two bunch operation of the Shanghai Soft-X-ray Free Electron Laser Facility (SXFEL), needing to generate flat-top radio frequency (RF) power pulses at the output of an RF pulse compressor. The adaptive algorithm optimized for the compressor system can achieve a better convergence rate and domain. The algorithm has already modulated the flat-top-accelerating gradient in the SXFEL's RF cavity, and the energy of the electrons accelerated at the field's different longitudinal locations is within 0.8% (rms) of the mean value. This study presents the algorithm's theory, and		Yiming Xu (Shang Advanced Research Institude, Chinese Academy of Sciences)	Wencheng FANG (Shanghai Synchrotron Radiation Facility); Chengcheng XIAO (Shang Advanced Research Institude, Chinese Academy of Sciences)