Several developments and events took place in the first quarter of 2016 and are highlighted here.

The Accelerator and Operations Group

AOP rolled out the web-based steering request system for APS users. Though the steering activity in the MCR on the first day of the run was quite heavy, the new system was a success. The work is ongoing on the next step which will involve automated user steering bypassing MCR. The first tests with one beamline during machine studies were successful (with support from Controls group).

AOP also continued preparations for the installation of the helical SCU in the storage ring. The lattice with reduced beta function in sector 7 was successfully tested during machine studies; heating of the device due to beam effects was calculated and provided to the design engineers; work on beam tracking using field maps is ongoing.

The main recent achievement of the team working on APS injectors is filling the storage ring with the beam generated by the photocathode gun. The injection efficiency from booster to storage ring was 60%. Presently, the gun can provide about 0.3 nC per pulse which is enough for injection in 324-bunches mode but is still slightly lower then what is required for 24-singlets top-up operation.

AOP group members also helped to plan the upgrade of the PAR vacuum system, which involved replacing the ion pumps and vacuum gauges, and installing two RGAs. Measurements of the upgrade effects on the PAR vacuum and beam parameters is ongoing.

Optimization of APS Upgrade lattice is ongoing. A major development was achieved in simulation of collective effects for the Upgrade. When studying these effects in the lattices designed for injection with accumulation, it was found that collective effects make accumulation very difficult in any lattice, it was also shown that even during on-axis injection the collective effects can drive transverse oscillations that lead to beam losses. By modifying the photon absorber design to reduce its impedance and by employing a modest feedback system, it was shown that particle losses for on-axis injection can be largely eliminated in both the 67 pm and 41 pm lattice designs. The results were presented at the Topical Workshop on Impedance, Instabilities, and Collective Effects, and to the Lattice Review Committee.

The abort kicker designed to protect superconducting undulators from quenching during beam dumps is now in operation. It was observed that the kicker does not always perform as intended, and SCU's still quench during some beam dumps. AOP analyzes kicker's performance as number of beam dumps accumulates.

Among other things, an invited presentation on APS reliability program was given at the NSLS-II reliability workshop; an increase of the canting angle for ID4 to 400 microradians was approved as well as the introduction of the same 400 microradians canting angle at ID2; various software modifications and developments were performed that simplify some machine tunings and also support other groups' efforts.

The Diagnostic Group

Mechanical Motion System Testing in Sector 27

Performance of the mechanical motion sensing system monitoring the insertion device vacuum chamber at the sector 27-ID source point has been validated with the high-power Grazing-Incidence Insertion Device (GRID) x-ray beam position monitor located in the 27-ID beamline

front end. This is a significant milestone on the way to demonstrating 1-micron rms stability over a one- week time period.

Using heaters affixed to the upstream and downstream chamber supports (near where rf bpms are mounted), the height of the chamber can be controlled using the MMS capacitive proximity sensors together with a simple EPICS control program. The particle beam was constrained to move along with the chamber by orbit feedback control using the P0 rf bpm readbacks on electron beam position. Fig. 1 shows the layout. With the electron beam locked vertically at the P0 bpms, the Xray beam moves if the vacuum chamber moves. For this experiment, various ID gap values were used.

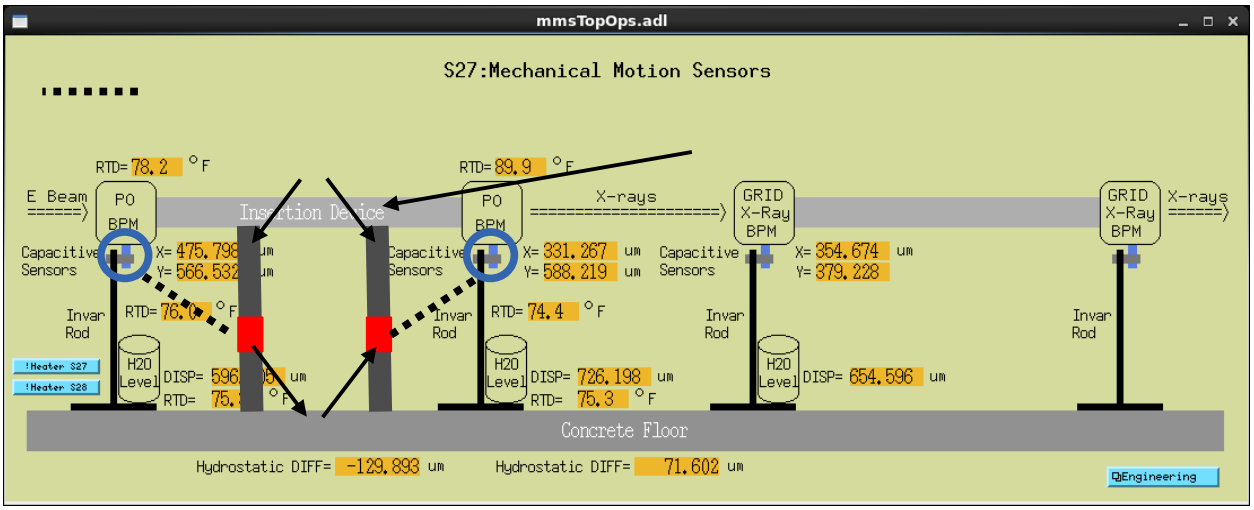

Fig. 1. Layout of sector 27 mechanical motion system components used in the experiments. Each support is fitted with heater tape. When activated the supports are lengthened or shortened depending on how much heat is applied. A feedback system is employed to maintain the vertical position of the vacuum chamber containing the P0 bpms using the capacitive position sensors shown in blue. Downstream of the insertion device, is the GRID Xbpm used to record the Xray beam position during the experiment.

Figure 2 demonstrates the correlation between capacitive sensor readbacks and x-ray beam position. The scaling factors between motion of the source and GRID x-ray beam position readbacks agree with expectations. The ripples are a consequence of chamber water temperature fluctuations. During the experiment, orbit feedback kept the beam position locked at the P0 rf bpms. This experiment shows that to correct for mechanical motion of the bpms, one can subtract a measured mechanical offset from the bpms position reading. This result is important for maintaining the long term stability of the Xray beam for the APS upgrade (specified as 1 μm from 100 seconds to 7 days at the ID P0 bpms).

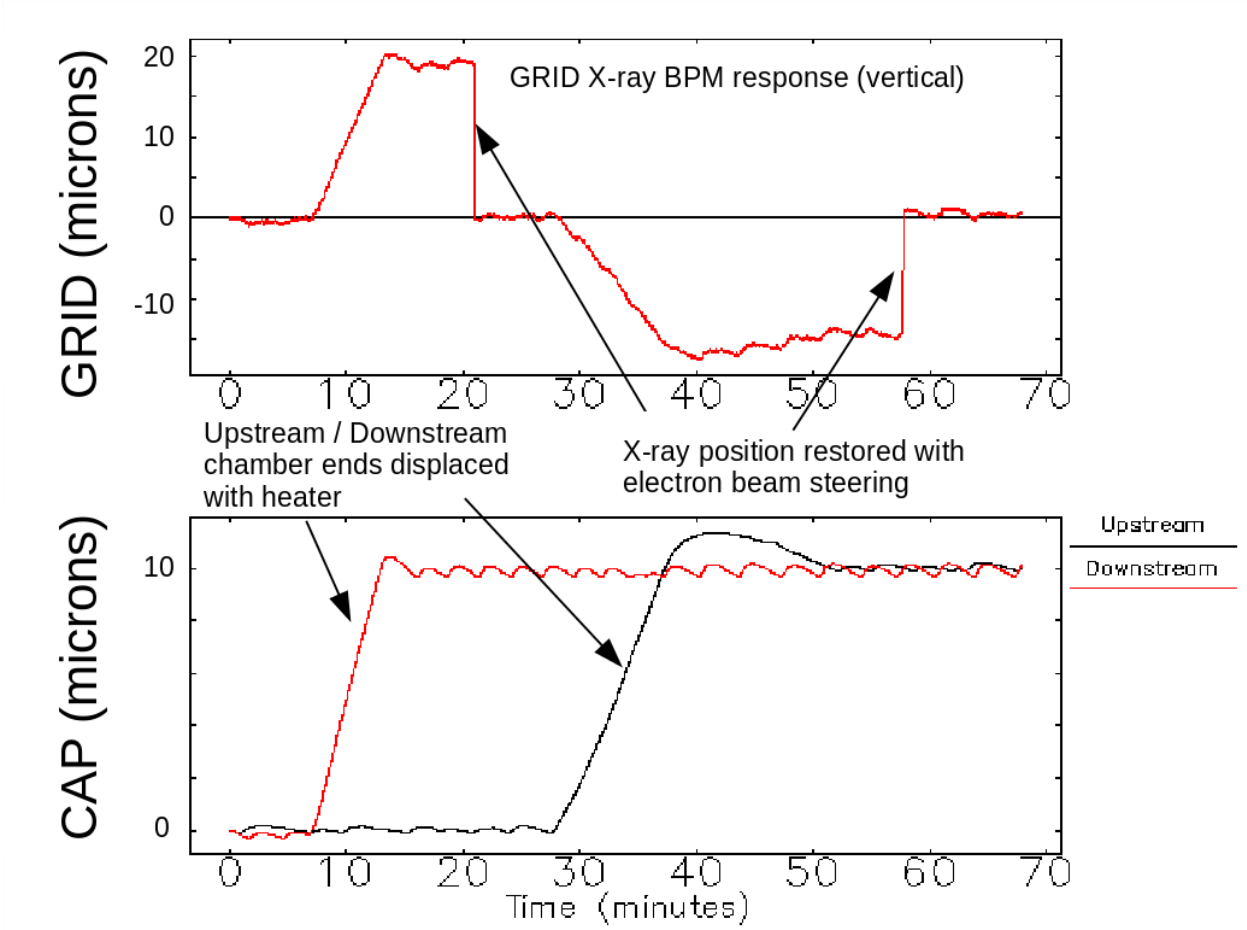

Fig. 2. Top plot shows the x-ray position measured by GRID Xbpm as a function of time in minutes. The bottom plot shows when 10 microns displacements of the upstream and downstream ID vacuum chamber ends took places.

The Magnetic Devices Group

During January, 2016 shutdown per XSD request 5.5-cm undulator at Sector 2 has been replaced with the 3.3-cm period undulator. A newly installed device has been tuned to compensate the loss of 250 Gauss in the effective field. This device was in operation for full 20 years since 1995. New 1.08-m long SCU magnet with the period of 1.8-cm has been fabricated at the APS SCU facility. This magnet will replace short 0.34-m SCU magnet at Sector 6 at this Fall shutdown. The Nb_3Sn SC undulator magnet built by LBNL has been assembled and tested in the APS cryostat. Unfortunately this magnet was unable to reach specified excitation current of 800A. The maximum achieved current, limited by quenches, was 530A. The SCU has been disassembled and Nb_3Sn magnet has been shipped back to LBNL. The design of the conceptually new cryostat for the APS helical superconducting undulator (HSCU) was completed and reviewed. The procurement package for the cryostat is under preparation. The handover meeting for the horizontal gap vertically polarizing undulator (HGVPU) took place on March 17 with the participation of LCLS-II and LBNL staff. The device is shipped to SLAC and documentation has been transferred to LCLS-II and LBNL.

The Power Systems Group

There has been only one power supply related beam loss so far. The faulty power supply was tested on the bench and no definitive fault found. The power supply was returned to operations a week ago. Fifty-two storage ring quadrupole magnet power converters were upgraded with new IGBTs and associated hardware in this quarter so far. Six more will be upgraded by the end of the quarter.

The unipolar power supply development for APS-U achieved a milestone by completing the report for the evaluation of the commercial high performance power supplies. Two commercial power supplies, a current regulated power supply from Danfysik and a voltage regulated power supply from TDK-Lambda plus an external current regulator from BiRa, were evaluated. Both power supplies performed very well with a current stability well below 10 ppm (part per million).

The first prototype fast corrector power supply has been assembled and tested. It has achieved a 10 kHz bandwidth with an ideal 16.5 mH load. The following is a picture of the power supply under test.

The RF Group

General RF System Operation

As of 3/23/16, the rf systems have experienced no trips or downtime during run 2016-1.

Linac-PAR

Linac accelerating structure #008 was successfully straightened and installed in L2AS1. Accelerating structure #016 has been fully tuned and is ready for installation at L2AS2 during the April-May 2016 maintenance shutdown. In preparation for installation of the T-cavity during the April-May 2016 shutdown, all related waveguide components were installed in the Linac gallery and tunnel and conditioned to nominal rf power levels.

The high gradient s-band HGS cavity was installed in the ITS, and the waveguide system from L6 to the ITS was conditioned to nominal rf power levels.

Work on several hardware upgrades was ongoing, including construction of an interface chassis needed for installation of a new 500-watt Linac driver amplifier, assembly of a spare Vector Detector Module, installation of new envelope detector modules to provide additional rf measurement capabilities at L2 and in support of T-cavity testing. Construction of the automated envelope detector module calibration setup was completed. PFN capacitors were replaced with new units at L4, thereby completing this upgrade in all Linac modulators.

Twenty-four new Linac focus magnet power supplies have been received and tested. Three of the new power supplies were installed in L6, and preparations are underway to install three more in L3 during run 2016-1. One new Linac klystron is awaiting resolution of a manufacturer warranty issue, and an order has been placed for a second new klystron.

Network analyzer measurements were made on both PAR rf cavities to gather performance data for the APS Upgrade effort. Construction of hardware necessary to complete the PLC upgrade to the second Harmonic PAR rf amplifier is underway. This upgrade is scheduled for installation during the April-May 2016 maintenance shutdown.

Booster-Storage Ring

Replacement of the damaged matching transformer at RF1 was completed on February 10th. The system was tested with beam on February 16th, and returned to normal service.

Continued progress on chassis backplane design and circuit card alignment has been made on the design of the first production prototype rf cavity tuner motor controller, which is intended to replace the existing obsolete tuner motor controllers used in the 352-MHz rf systems.

350-MHz RF Test Stand

The first of three EEV klystrons received from Los Alamos is being prepared for installation into the rf test stand for testing and re-tuning to the APS operating frequency. Collector water adaptor pipes were fabricated and installed, and leveling jacks were ordered. Initial testing at 350.0MHz to validate general operating condition will be attempted before the start of the April-May 2016 maintenance shutdown.

Storage ring tuner ANL-28 was successfully conditioned to 100 kW cw in the rf test stand.

Solid State RF Development

A second prototype 352-MHz amplifier was constructed and tested. It repeated the general performance of the first prototype, producing 1.77kW cw output power at 70% efficiency. Work on creating production drawings for the 12 kW cavity combiner is underway, and procurement of hardware to build the first-article combiner is expected to start during the first week of April. Testing of nanobonding techniques to replace conventional soldering processes used in solid state amplifier construction is ongoing.

Multi-Purpose Amplifier Conversion to L-Band

Work continues on converting the Multi-Purpose Amplifier (MPA) to L-band operation for providing rf power to test the harmonic cavity input coupler for the APS Upgrade. The cause of a failure of the MPA high voltage power supply is presently under investigation. Repairs to the power supply were successfully completed, and the system is again operational and undergoing tests.

ANL Open House

Preparations for setting up the RF Group demonstration booth for the ANL Open House are underway. The rf cavity tuning demonstration unit has been checked out, and is being prepared for relocation to the RF Group display area.