

## **ASD Quarterly Bulletin** **April-June, 2017**

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Accelerator Systems Division provided excellent support for APS operation in 2017-1 achieving 145.5 hours of the Mean Time Between Faults (MTBF) and 98.8% of the Machine Availability. The beginning of the run 2017-2 was delayed by 24.5 hours because of the vacuum leak at a bellows in Sector 27. There is a high degree of confidence that the leak has developed from two dents that were there due to the impact from a box wrench. Several other developments and events took place in the first quarter of 2017 and are also highlighted here.

### **The Accelerator and Operations Group**

In preparation for installation of helical superconducting undulator (HSCU), AOP developed, tested and installed lattice with modified beta functions at Sector 7, analyzed expected beam-induced power load on HSCU test chamber and worked on preparing Physics Requirements Document. After HSCU test vacuum chamber was installed in May, AOP commissioned the chamber and performed test measurements.

AOP organized and supervised APS linac interleaving ACIS installation during the April/May shutdown. New program Linac Interleaving Control was developed for controlling the linac interleaving operation, Storage Ring top-up script also had to be modified to accommodate for new linac operating mode. APS linac is now ready for beam testing for interleaving operation.

The main accomplishment in the APS-U related efforts was the completion of the Preliminary Design Report (PDR). APS-U related simulation efforts were also continuing. Ion instability simulations for the 42 pm lattice were completed. It was shown that at least two bunch trains are needed to suppress ion instability. Also, a detailed BTS line design was developed, and new collimator configurations were studied. In addition, temperature tuning algorithm of cavities with relatively strong monopole HOMs was tested; results indicate that one would still need a longitudinal feedback system. Energy deposition process in the swap-out and beam dumps were also simulated.

In high-charge injector studies, it was found (using newly developed bunch length monitor) that the bunch length blowup in the PAR limits high charge injection into the booster. This effect was partially mitigated by carefully controlling the 12-th harmonic cavity detuning and phase as a function of bunch charge. A new booster orbit correction software was prepared, tested and installed in operation resulting in the improved orbit along the booster rump. A combination of two improvements allowed setting a new record of 11 nC booster charge.

In other developments, the transport line optics between the Laser Room and the Linac Tunnel was modified to reduce the spot size of the UV drive laser on the photocathode gun, which should result in lower beam emittance.

### **The Magnetic Devices Group**

#### **SCU Status**

Three 1.2-m long helical superconducting undulator (HSCU) magnet cores have been machined. Two cores have been wound with NbTi superconducting wire and one of the wound cores is impregnated with epoxy resin. The impregnated core is being tested in a vertical LHe bath cryostat. The detailed mechanical design of the Superconducting Arbitrarily Polarizing Emitter (SCAPE) magnet assembly has been completed. The drawing package has been sent out for quotations. Detailed design of a core impregnation mold is in progress. A search for an AC-optimized conductor for a fast-switching SCAPE is in progress. Both 18-mm period superconducting undulators are in continuous user operation.

### APS Planar Devices

A 2.3 cm period APS planar device has been studied extensively on the 3-meter bench in MM1. After mechanical and magnetic tuning, RMS phase error of 2.5 degree has been reached with operational gap changing from 8.6 mm to 30 mm. Trajectories of +/- 0.5 microns have been achieved. It meets the APS-U requirements. A new design, manufacture, assembly, and tuning procedure to optimize the device for production is in progress.

### DSC 1.72 cm Undulator

All components have been delivered. Magnets will be delivered by the second week of August. Assembly of the device has been planned. Deployment of the device has been scheduled for the September shutdown.

### APS-U

M1 prototype has been awarded to Danfysik. Q8 magnet from Stangenes has been delivered and inspection tests have been carried out. Q8 assembly from Dial has been completed. Initial measurement results are promising. M4 has been assembled and measurements are underway. New ID vacuum chamber/support stand/absorber design has been completed. Prototype procurement is in progress.

## **The Power Systems Group**

### Operations

During the startup, the Operations found that IK1 kicker in the storage ring had excessive time change between the top-up mode and the non-top-up mode, making it impossible to have a consistent injection efficiency in both modes. The problem was resolved after we replaced the thyatron.

P2IK kicker in PAR also is having more time jitter than it used to have. We are closely monitoring its condition. Since it will take several hours to replace the thyatron, we plan to replace it during the next shutdown if the time jitter does not affect the operations too much.

Started "global" installation of the new PLC in the storage ring raw power supplies. IT group completed the installation of twenty network switches required by the new PLCs. The electrician work for the 120VAC outlets was completed in Zone A. The procurement for the production quantity of the components for the new PLC has started and some of the parts have been received.

Held an in-group review of the design specs for the project of upgrading the control electronics in the interleaving power supplies. The design specs have been approved by Yine Sun and Jeff Dooling in terms of the operation parameters. The new design will consolidate the DSP and CANbus with an FPGA based controller with Ethernet interface. The schematic design has been completed and the PCB layout will start as soon as the PCB designer becomes available.

### APS Upgrade:

Completed the update to the Preliminary Design Report.

The preliminary designs for the APS-U power supplies and the power supply controllers are in progress. A preliminary design version of the fast corrector power supply has been constructed. The initial test shows that the required 10 kHz small signal bandwidth has been achieved. This version has multiple improvement over the R&D prototypes such as using a DCCT instead of a LEM to sense the current for better precision and stability, a second cooling fan for redundancy, consolidate PCB designs, and better internal layout and connections.

## **The RF Group**

### **General RF System Operation**

As of June 26th, the rf systems have experienced no beam loss related faults in runs 2017-1 and 2017-2.

Some injector downtime resulted because of an rf turn-on/conditioning issue with a waveguide window in L2. The system ultimately conditioned back to normal operation.

### **Linac-PAR**

All high-voltage cables in the Linac modulator systems were either reworked or replaced.

The end-of-line clipper diode was replaced in L6.

A new 500-watt linear driver amplifier, with bias gating capability to blank rf drive to support interleaving operation and PC gun operation, was installed at L3.

Construction of the prototype digital phase detector for the Linac is underway.

Reference line output ports were installed at all Linac rf systems to provide phase stability measurement capability using the digital phase detector.

One new S-ban pulsed klystron was received and tested at L6.

One old klystron was installed in L6 and evaluated for a return to service. This testing indicated that this klystron was not suitable to support operations.

A new driver amplifier was installed in the Fundamental PAR rf system #2.

RF Measurements were made on the PAR rf cavities in support of injector studies.

### **Booster-Storage Ring**

New wiring was installed to accommodate the relocation of the Booster extraction ion pump and cold cathode gauge controllers to A005.

Two defective thermocouple input modules were replaced in the Booster Extraction PLC interlock system.

A new matching transformer was installed at RF3.

The first new tuner motor driver system was installed at Sector 37/C1 for evaluation under beam conditions.

An intermittent 208/120VAC step-down transformer was replaced in the RF3 matching transformer cabinet.

New-design tetrode socket contact pins were installed at RF1.

Ground stick testing was completed at RF1-RF5.

### **350-MHz RF Test Stand**

Two new green tuners were installed in the test stand cavity for conditioning. One of the tuners failed during the conditioning process due to overheating of the piston fingerstock, which resulted in minor arcing damage to the test stand cavity. This is a repeat failure for this tuner, and it is under evaluation to determine the cause. The minor arcing damage to the cavity was repaired, and a second new tuner was successfully installed and conditioned

A new green storage ring coupler is presently undergoing conditioning.

### **Solid State RF Development**

Assembly of the 12kW cavity combiner system and related components is progressing. The combining cavity was fully assembled, followed by a successful test at the 100-watt power level

for rf leakage and losses. Construction and assembly of support electronics and hardware is also underway, including the 6-amplifier cold plate assembly, six 100-watt driver amplifiers, and the monitor/control PLC interlock system. Final assembly of the complete system is scheduled for the third week of July, followed by complete system rf testing in August and September.

### **The Diagnostic Group**

#### **BPM Sensitivity for the MBA Insertion Device (ID) Vacuum Chamber**

The bpm button configuration sensitivity is a geometric factor that is used to convert the measured signal to the distance from the electrical center of the bpm measured in mm. The sensitivities of the button BPMs are calculated using simulation and analytical methods and compared with ones in the 8 mm × 40 mm APS ID vacuum chambers. The “as-built” APS 4 mm diameter “double-buttons” (two on each button flange) could be used in the ID vacuum chambers of the MBA storage ring in either rotated or un-rotated configurations, shown in Fig. 1. The sensitivity is linear as long as the beam is not displaced too far from the bpm electrical center. The higher order polynomial corrections can be used to adjust the sensitivity far from the electrical center.

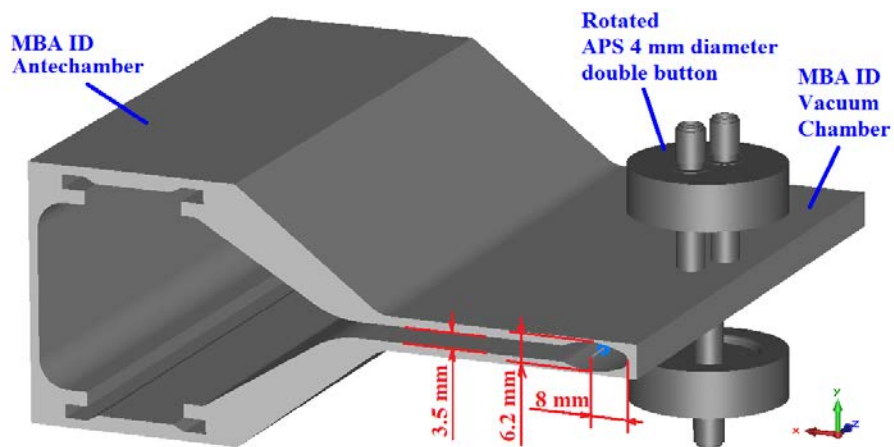


Figure 1: 4 mm diameter double-buttons installed in the MBA ID vacuum chamber shown in rotated configuration.