CEBAF, et al., Accelerator Update

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The View from Inside

- Injector (and associated)
- Linacs
- Beam Switch-Yard
- Cryogenics
- Putting it all together
- The rest of the story: schedule and budget

Injector

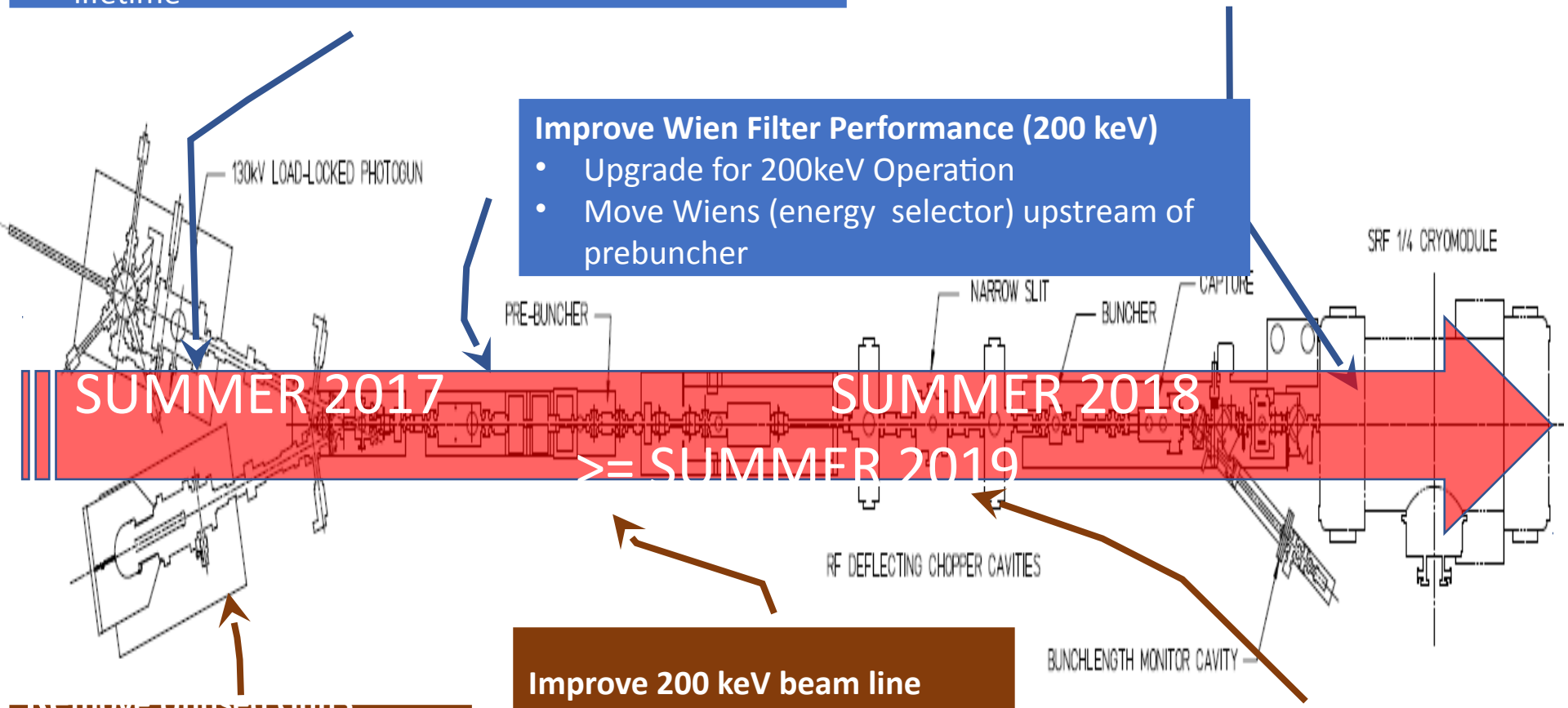
- 4-laser system support
- Cathode developments
- Updated gun HV permissive logic
- 200 keV gun capability, preparing for:
  - Upgrade cryounit
  - Wien spin rotator
- “Parity quality” is the driver
- Goal is to satisfy 'Møller experiment' needs

CEBAF Injector Upgrade : BIG Picture

Install Gun Capable of Higher Voltage (200kV)
- Stiffen beam against space charge repulsion => minimize beam loss
- Reduce number ions created by beam => increase lifetime

Replace 5/5 QCM with 2/7 BOOSTER
- Minimize RF deflection & X/Y coupling
- Eliminate capture to simplify setup

Improve Wien Filter Performance (200 keV)
- Upgrade for 200keV Operation
- Move Wiens (energy selector) upstream of prebuncher

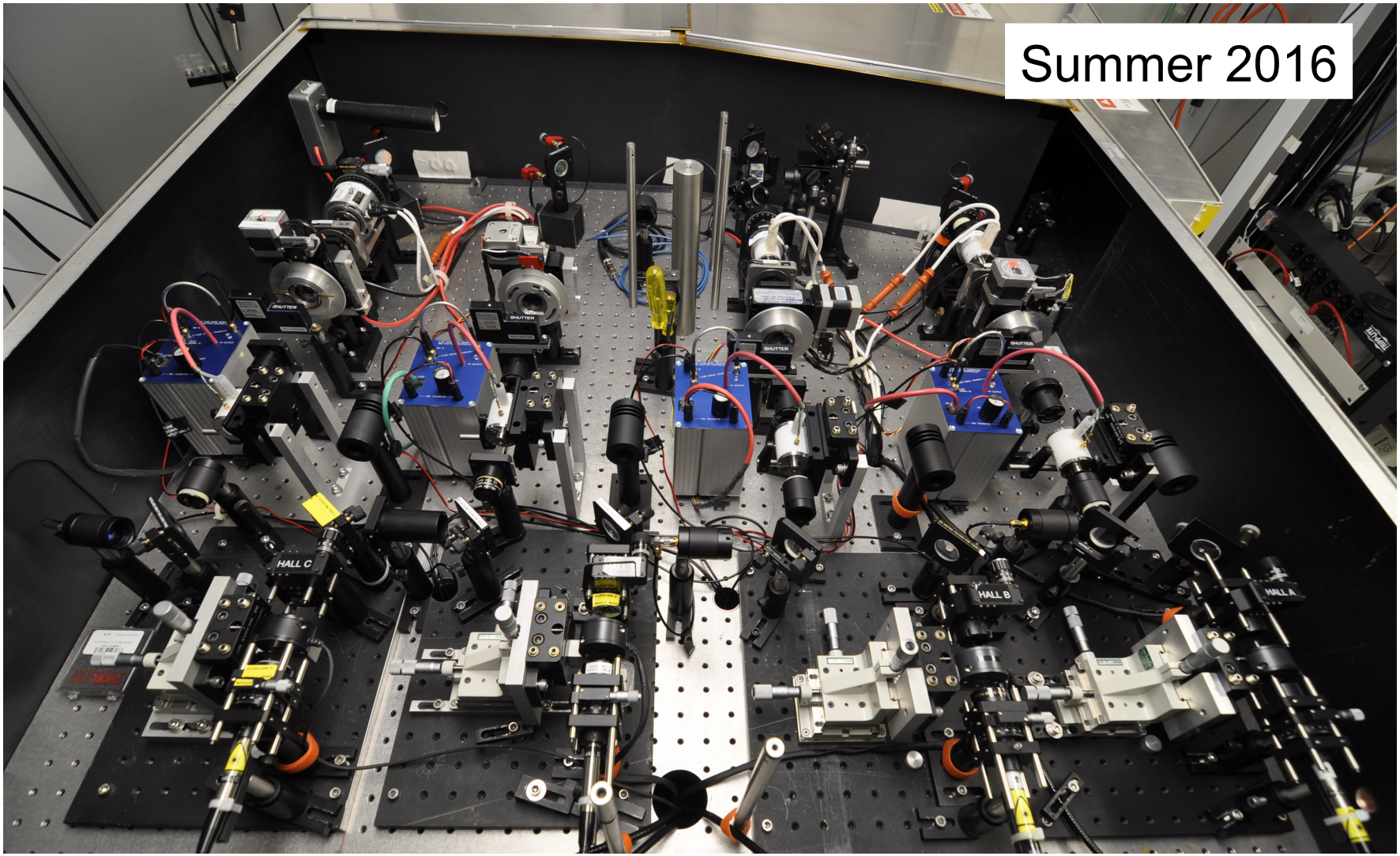


Remove Unused Guns
- Simplify controls/hardware
- Replacing w/ vacuum

Improve 200 keV beam line
- Improve beam line vacuum
- Improve ma

Upgrade Chopper
- ABCD independent apertures
- Improve alignment/controls

4-Hall Polarized Source Laser Table Rebuild



CEBAF 4-Hall Operations Begins Fall 2017

4 Hall Operations (also called D+3) begins this Fall

Condition	(D+2)	(D+3)
• Maximum number of halls receiving beam	3 halls	4 halls
• ABC Beam @ 5th pass (Hall D on)	499 MHz	249.5 MHz
• ABC Beam @ 5th pass (Hall D off)	499 MHz	499 MHz
• ABC Beam @ lower passes	499 MHz	**499 MHz**

4 Hall Preparations Completed ….so far

- ✓ Rebuild laser table w/ 4th laser and 4-beam combination
- ✓ Two beams @ 249.5 MHz share one 499 MHz “RF Chopping Bucket”
- ✓ 750 MHz separators for 5th pass ABC / D separation

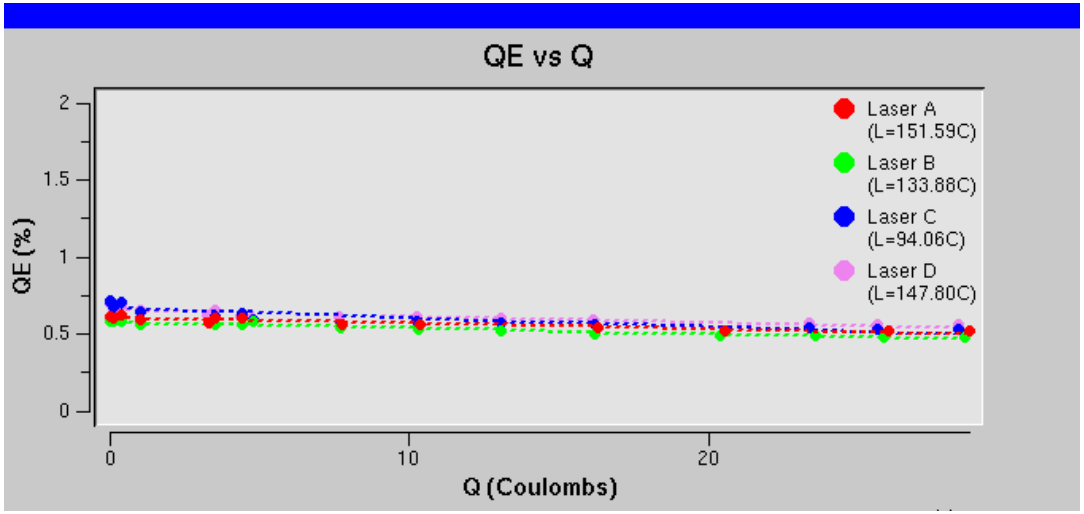
Source Operation

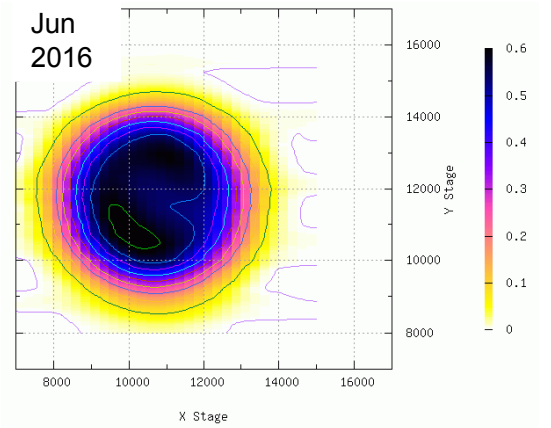
Spring/Fall 2016

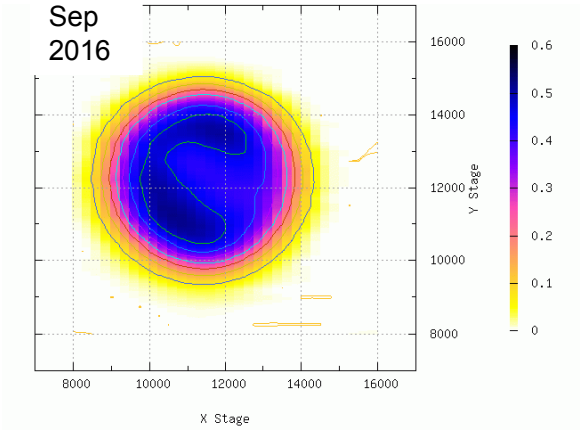
- SSL GaAs/GaAsP SVT #5756-4 (Polarization ~ 87%)
- No heat/activation over Summer 2016 / Winter 2017 SADS

Fall 2016

- Gun2 operating at -130 kV without any problems
- Charge lifetime >100C with average current 70-80 μA







Spring 2017

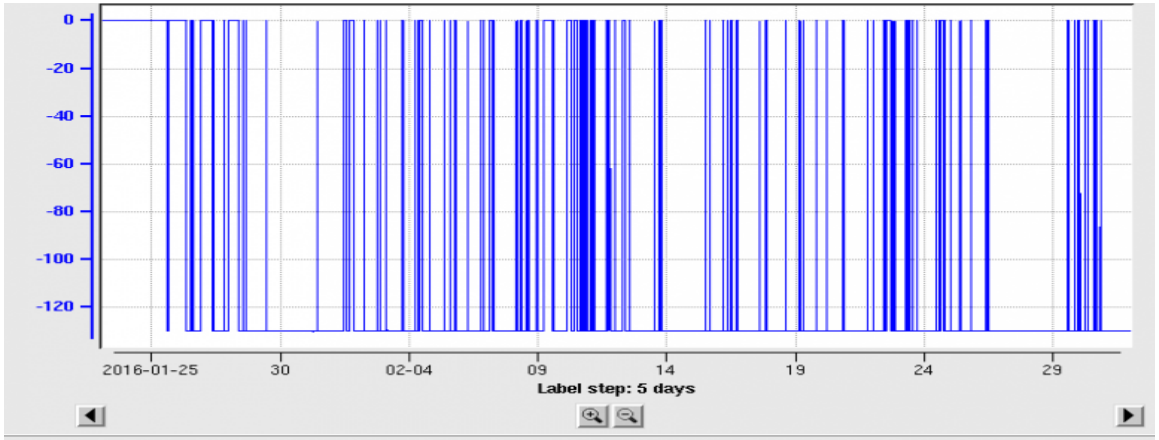
- Delivering up to 3 halls at a time (either 249.5 or 499 MHz)
- Hall A (Physics), Hall B (KPP), Hall C (KPP), Hall D (Physics)

PSS High Voltage Interface Upgrade

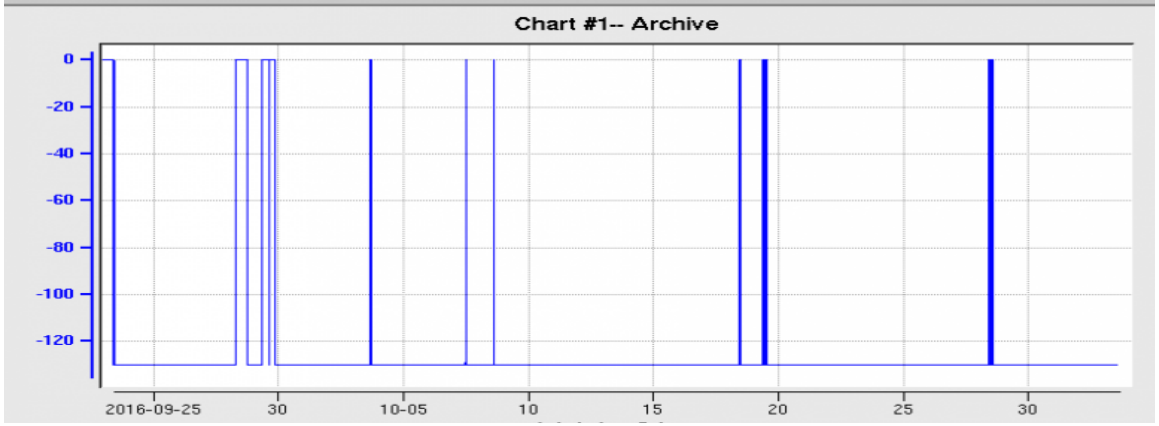
Fall 2016

- Historically Gun HV commensurate with PSS Beam Permit state => Off often!
- Gun HV power supply now remains ON when PSS = Power Permit
- Anticipate improved injector reliability and possibly increased charge lifetime

First 5 weeks of Spring 2016 Run (**before upgrade**)

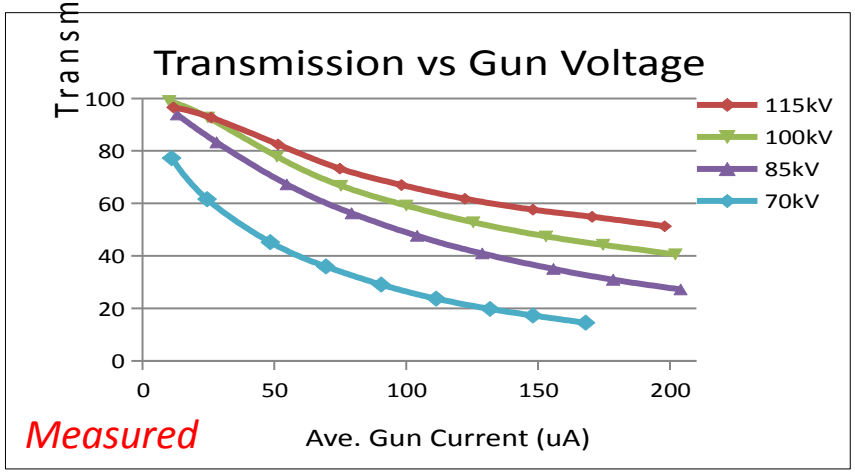


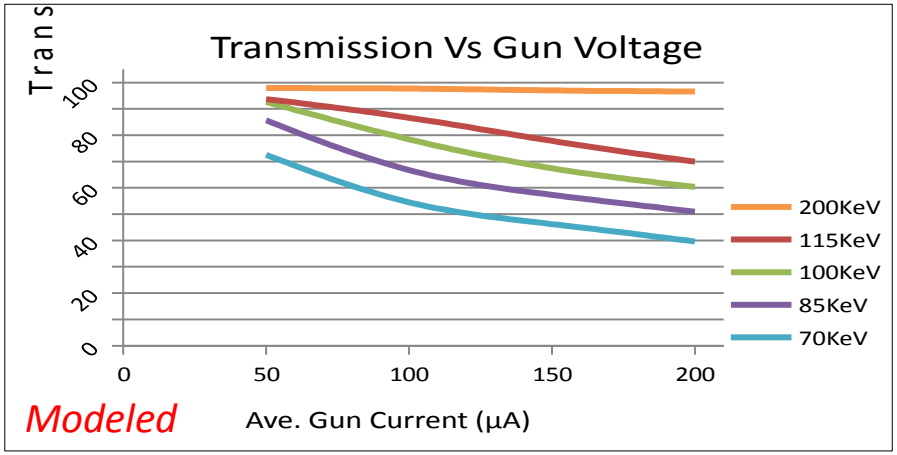
First 5 weeks of Fall 2016 Run (**after upgrade**)



Why a higher voltage gun?

- **Parity Quality Beam improves with better transmission**
  - Space charge repulsion drops as beam becomes more relativistic





- **Parity Quality Beam improves with more uniform Quantum Efficiency**
  - Electron impact ionization cross-section falls with increasing beam energy

Testing 200 kV Wien filter at UITF

Will test the 200 kV Wien characterization

- Existing Wien filters limited to about 150 keV beam
- Believe we can modify for 200 keV beam
- Barrel polished electrodes, successfully tested HV feed thru to 20kV
- Shop is fabricating new 20A coils Jay proposed (JLAB-TN-15-032)
- Small modification to magnet completed to accept new coils

Wien Upgrade for 100 deg precession			
Beam Voltage	*keV*	200.00	350.00
Integrated BL	*G-cm*	3993.86	6788.51
Magnet Current	*A*	15.36	26.11
Electric Field	*MV/m*	2.67	5.27
Electrode High Voltage	*kV*	20.05	39.56

Summary [injector topics]

CEBAF Operations

- Source is operating well, providing high polarization at 11 GeV
- On track for 4-Beam operations in Fall 2017, time will tell how easy this is.

Injector Upgrade

- Deliver and test 200 kV beam at CEBAF injector Summer 2017 SAD
- Test of 200 kV Wien filter, new QCM and higher voltage polarized gun at UITF
- Rebuild baked beamline with 2-Wien spin flipper Summer 2018 SAD

Parity Quality Beam Readiness

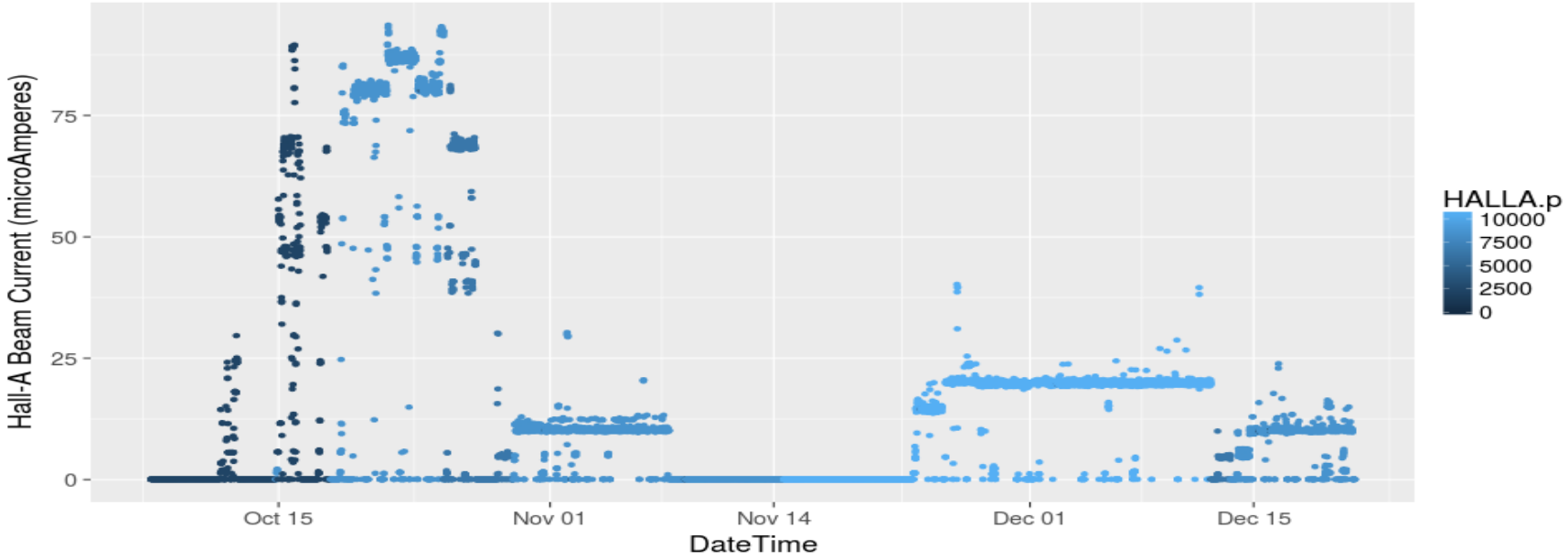
- Required specifications have been demonstrated
- We are ready to return to setting up and delivering PQB beams

Linacs and Accelerator Systems

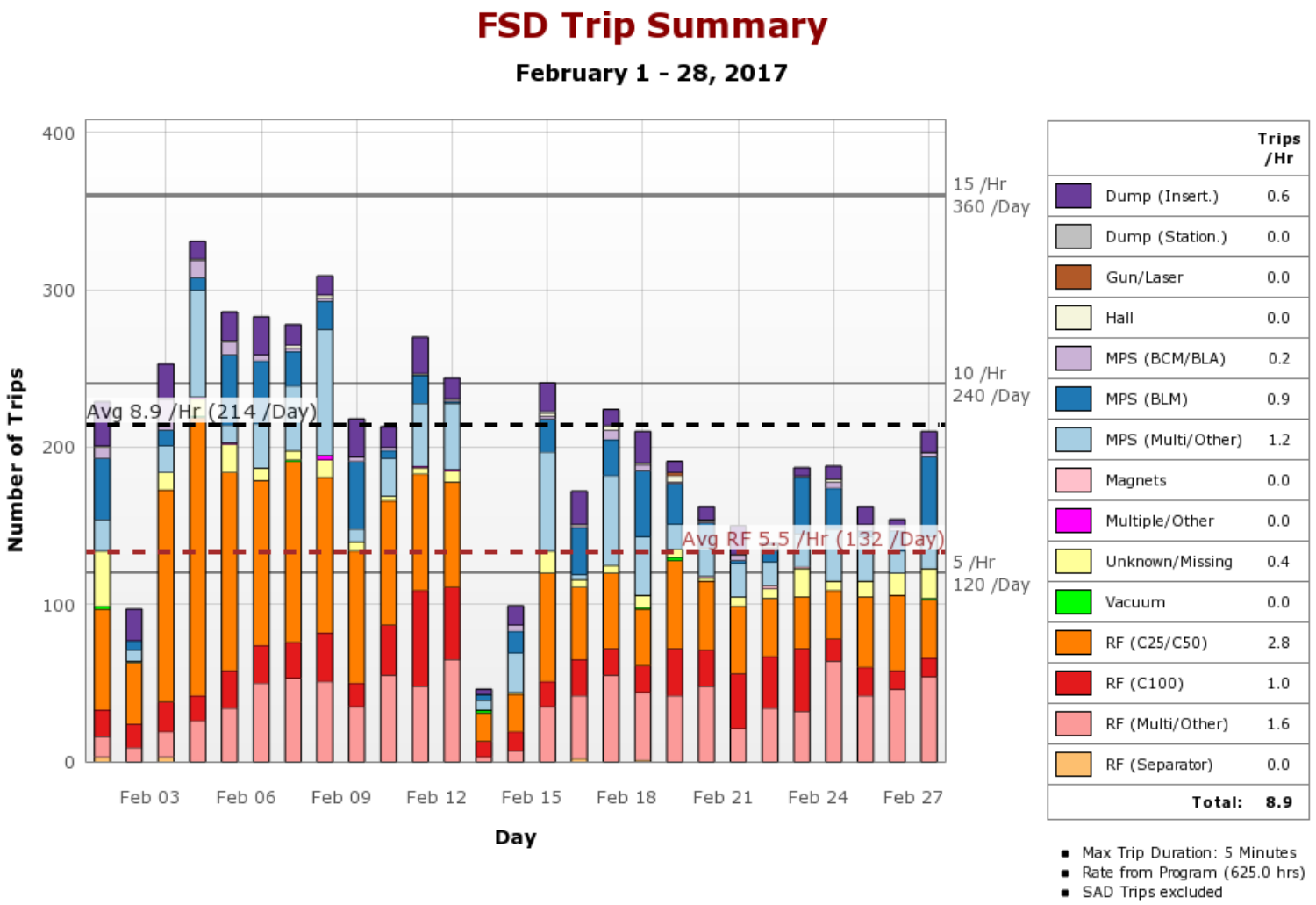
- Energy set to 4% below 12 GeV nominal value
  - Expect to hold at this energy (A. Freyberger 3/28/17)
- Trip rate is “acceptable”
- 750 MHz separators are operational
- We are learning how to operate the hardware
- We are learning where the limits are
  - Some things have broken
  - Some are being fixed
  - Some are being worked around
- Development of the accelerator continues
- Working at hardware limits eats 'clock time'

Fall 2016 Beam Operations

- 11 Weeks of Beam Operation, 2.1 GeV/pass
- **Hall-A completed scheduled portion of DVCS and GMP experiments**
  - Delivered up to 80 μA, ~700 kW
- Hall-D GlueX beamline setup for Spring 2017
- Litany of major issues (Arc7 PS, 5-pass RF Separator) resulted in a single-user program for most of the period.
- 2-Hall operations successfully executed during the final week.



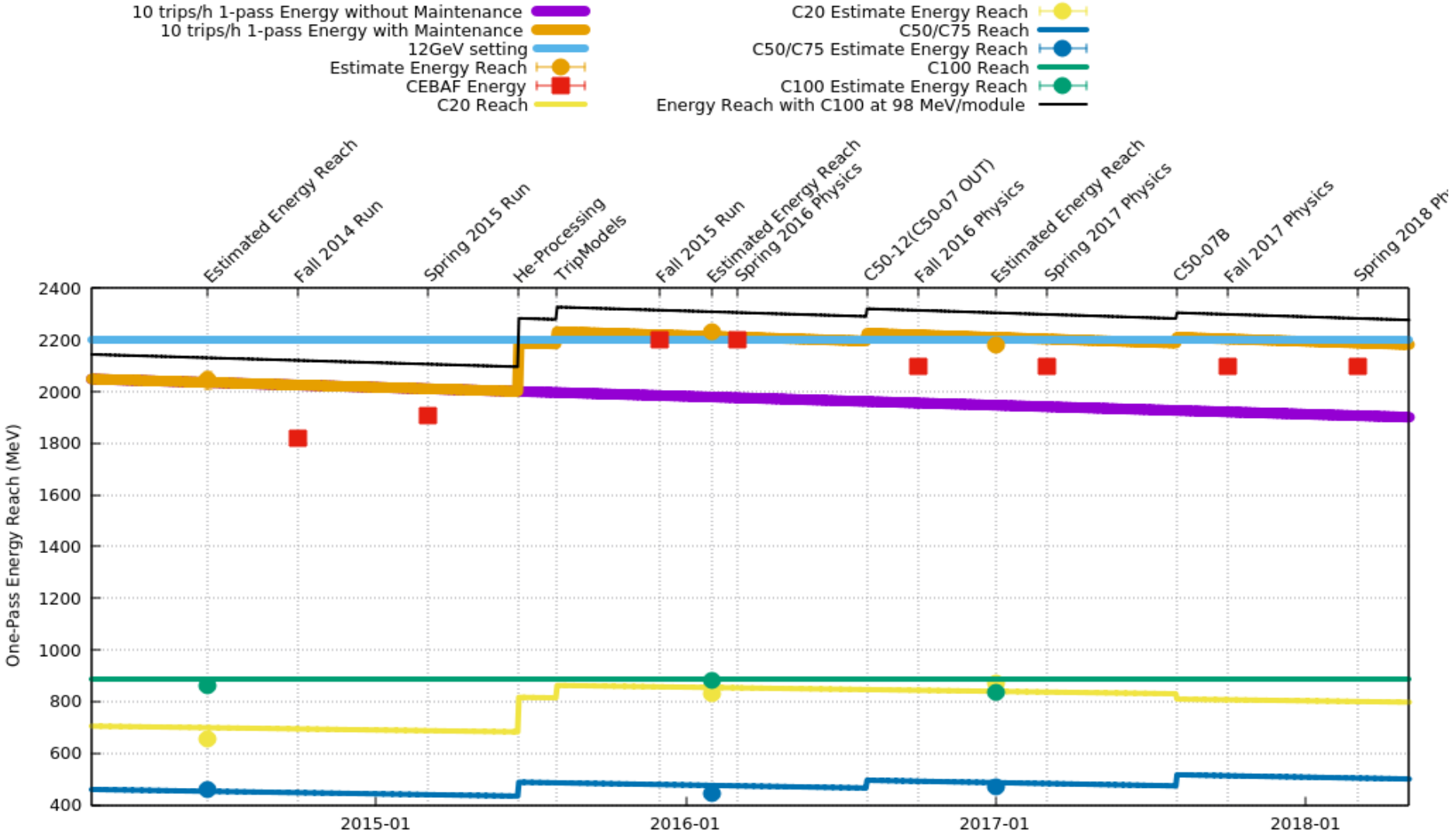
February 2017 FSD trips



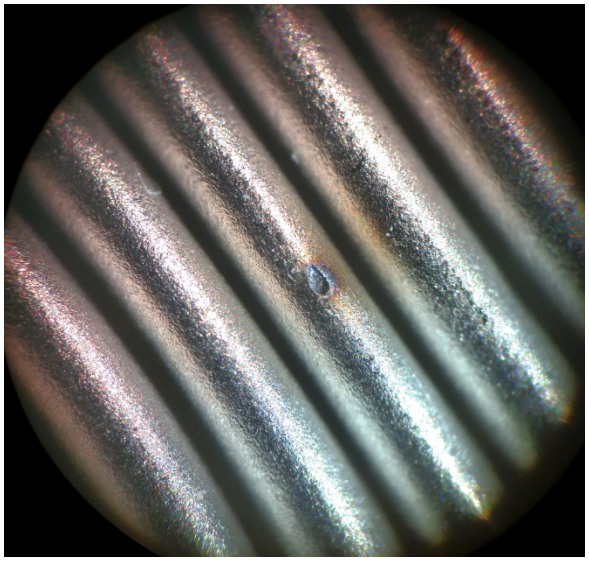
Fall 2016 RF Performance

- One pass energy gain set to 2.1 GeV/pass
  - 100 MeV/pass lower than 12 GeV design (-5%)
  - Availability during Spring 2016 Operations at 2.2 GeV/pass suffered due to lack of gradient margin.
- ~50 MeV/linac of gradient margin in Oct. 2016 (at 2.1 GeV/pass)
  - Program flexibility: by-passed troubled cavities in a few minutes and resume beam operations.
  - By Dec. margin was reduced to 25 MeV/linac due to by-passed cavities and other gradient reductions.
    - Most of this reduction ~~will be~~ [was] recovered during Jan. 2017 SAD

CEBAF Energy Reach



750 MHz Separator Leak



- Leak in tuner bellows associated with some discoloration
- Root cause of the leak still not identified
  - Bellows and near-by wall surface nominally at ground potential
  - No associated discoloration found on cavity wall

750 MHz Separators

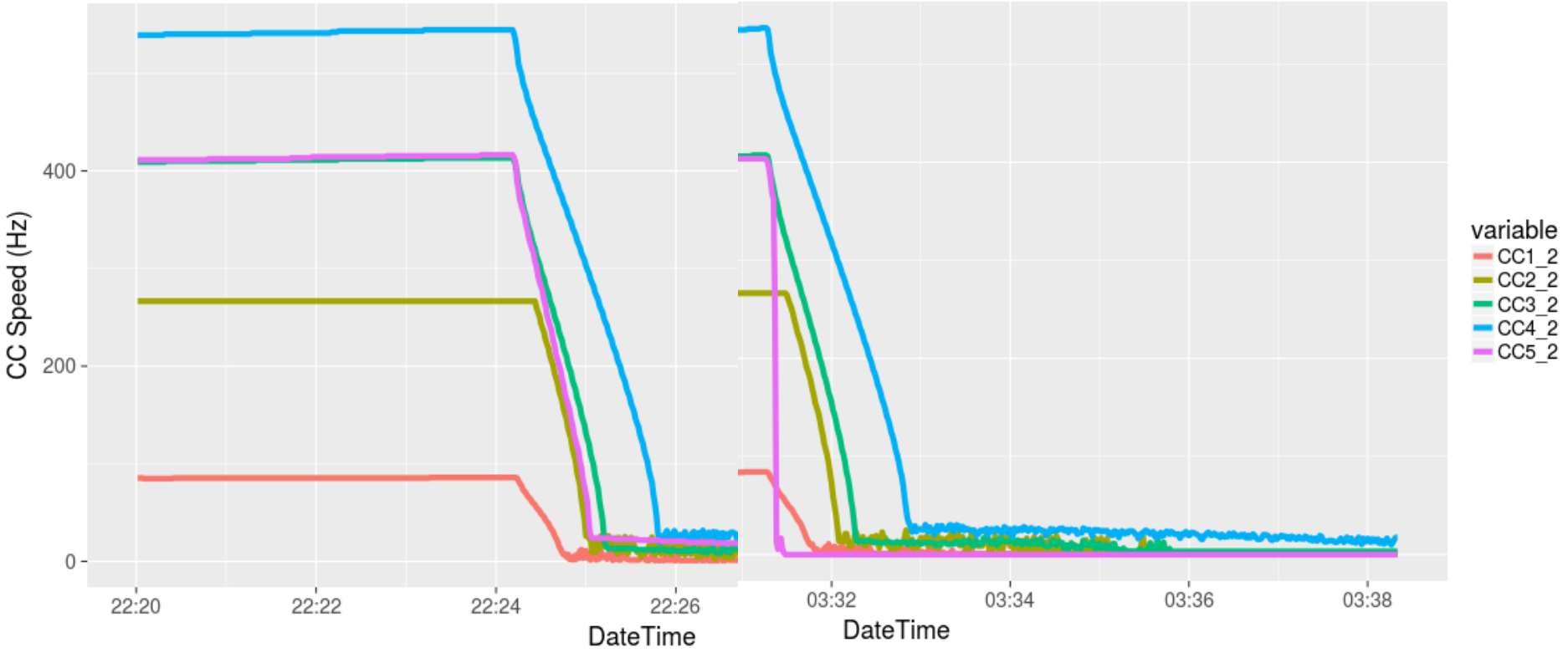
- Vacuum issue repaired (bellows punch-through)
- Separator system re-commissioned
- Improved system layout adds power margin
- Thermal control issues identified
- System is capable of continuous operation

Linac Systems Issues Summary

- RF Performance in Fall 2016 was very good
  - RF trips < 5 trips/h
  - C100 trips factor two less than Spring 2016
- Up 80 μA, 700kW delivered to Hall-A on 4th pass.
- Support two-hall operations on the last week.
- Month of Dec. had 80% overall availability
- 750 MHz separation improvement demonstrated (vacuum leak prevented further operation).
  - Root cause not as yet known
  - Repaired cavity ~~to be~~ [was] installed ~~today/tomorrow~~
- ...[750 MHz separators fully functional]
- [Unanticipated LCW pressure vulnerability to be fixed]

Cold Compressor Trip, fast spin-down

- Successive cold compressor trips ended in rapid deceleration of compressor 5 of cold box 2.
- Not initiated by power failure as earlier event



Compressor Condition Unknown

- Rapid deceleration -- another bearing failure?
- Attempts to levitate via controls unsuccessful
- Condition inspection awaits full SC2 warmup
- Options:
  - Repaired previously damaged CC4 can be installed
  - Run SC2 at lower load with 4-compressor stack

Options for Operation

- Run as usual if operational with 5-compressors in series
- Run asymmetric linacs ($E_{NL} > E_{SL}$) if SL CC impaired
  - Limitations on magnet network and aperture
  - Budgetary constraints during 12 GeV design narrowed options for asymmetric running with respect to 2006 test at NL:SL ratio 1.10:1
  - Estimated as-built limit: ~ 5% or less
  - Could be improved with small additional magnets.
- Present plan: run linacs at Spring 2017 total energy

Outlook

- CHL configuration uncertain for a few more weeks
  - Muliple back-up options feasible and under study
- Linac (SRF and other systems) performance improving
- 750 MHz separators back on-line
- Operational issues being solved
  - Energy gain per pass is improving
  - Revising ops procedures
  - Improving internal calibrations
- Budget and schedule?
  - We should all find out soon