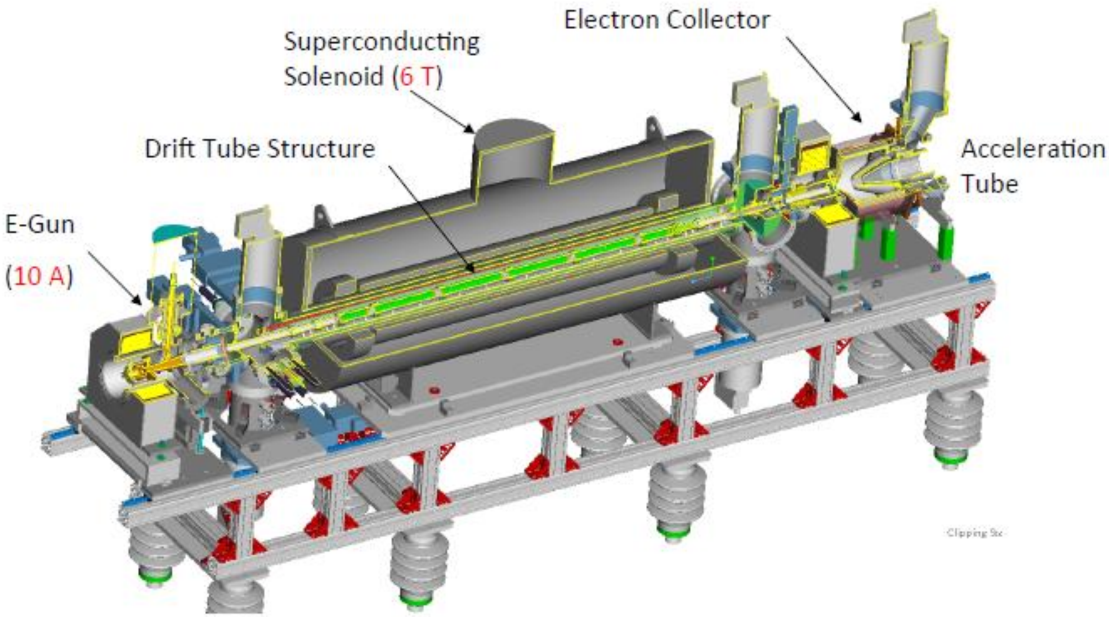
Session IV: Preparations for Next Runs & Project Reports

- EBIS
- Stochastic Cooling
- 56 MHz Cavity
- New Instrumentation
- RHIC Polarization Plan
- Spin Flipper
- E-Lens
- Low energy cooling
- p-A Collisions

EBIS Jim Alessi

Fifteen different beams used to date.

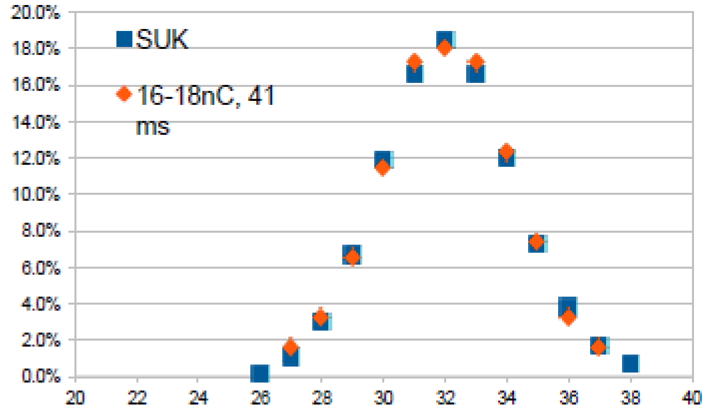
Electron Beam Ion Source (EBIS) – produces high charge state heavy ions



Provided U-U and Au-Cu for 2012 RHIC run
Some ions for NSRL starting in 2011; all NSRL ions in 2013

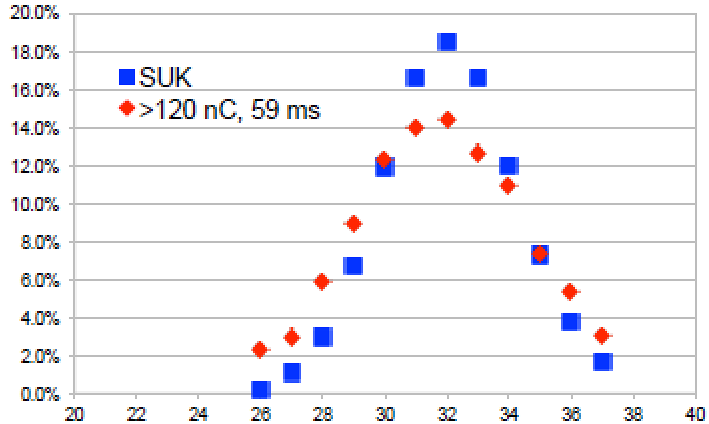
- He-3 2+ AGS
- He-4 1+, 2+ NSRL
- C 5+ NSRL
- O 6+ NSRL
- Ne 5+ NSRL
- Si 11+ NSRL
- Ar 11+ NRSL
- Ti 18+ NSRL
- Fe 20+ NSRL
- Cu 11+ RHIC
- Kr 18+ NSRL
- Xe 27+ NSRL
- Ta 38+ NSRL
- Au 32+ RHIC & NSRL
- U 39+ RHIC

EBIS
Au yields

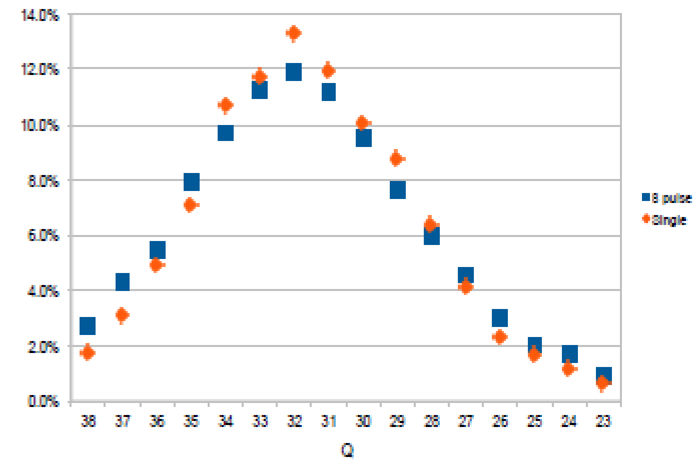


Au ions - measured charge state distributions (orange), vs. calculated (blue, R. Becker code), which assumes 100% overlap of ions with electron beam

Test at reduced charge - measured distribution matches calculated



Normal running at >50% of capacity gives ~14% in desired charge state vs. 18.5% calculated.



1 pulse/5 seconds vs. 8 pulse, 5 Hz burst every 5 seconds – Au^{32+} reduced to ~12%

12% vs. 18.5% = 65% of design

Code used in design did not include effect of ions outside core of electron beam. Reduced e- flux near edges leads to lower average ionization.

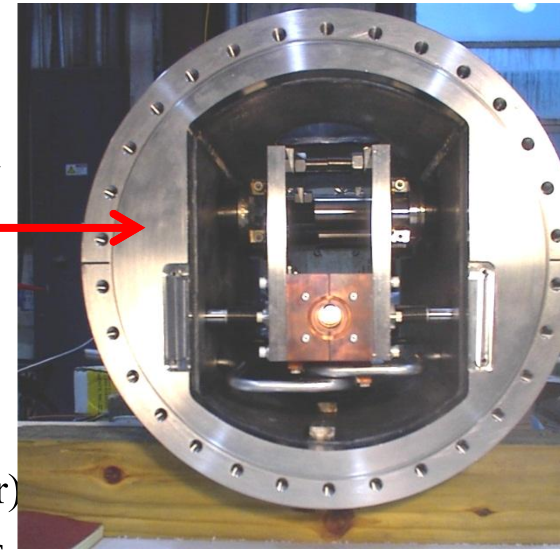
EBIS Summary

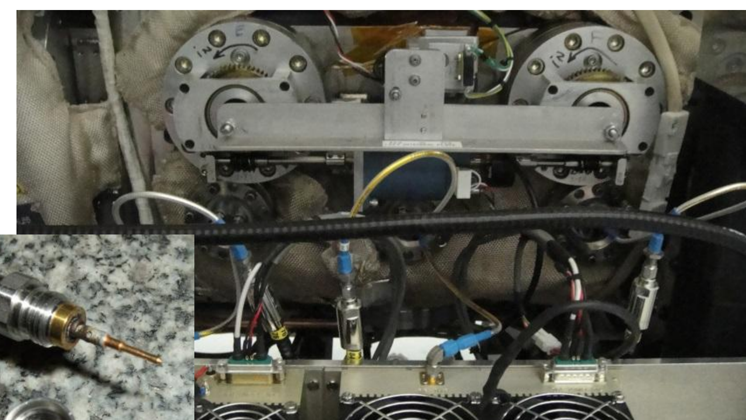
- Many species, good running for NSRL
- No jump in intensity, but we haven't given up hope
- LIS coming this year for at least some beams
- Polarized He-3 and advanced electron gun R&D in progress

Stochastic Cooling **Mike Brennan**

Motivation

- Reliability of kickers
  - Longitudinal kickers are made from retrofitted kicker tanks from Tevatron
  - Problems have occurred
    - **Motion mechanism**
      1. Stuck bearings in vacuum
      2. Stepper motors/encoders (“slip detected” error)
      3. Reproducibility of cavity resonant frequencies
    - **Vacuum leaks**
      - Water cooling line, and bellows
      - Rf vacuum feedthrus
      - Thermocouple vacuum feedthrus
    - **Coax cable over heating**
    - **Power amplifier failures**





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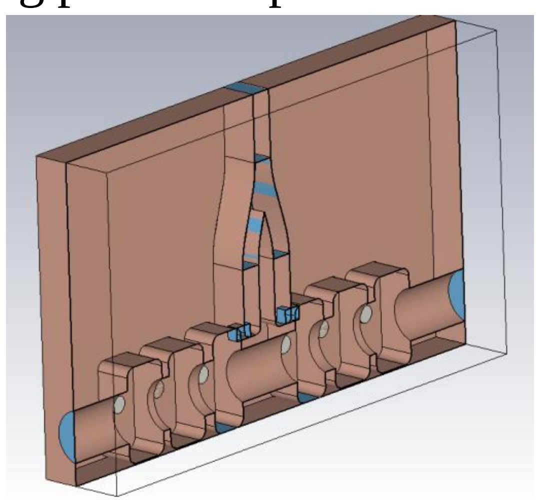
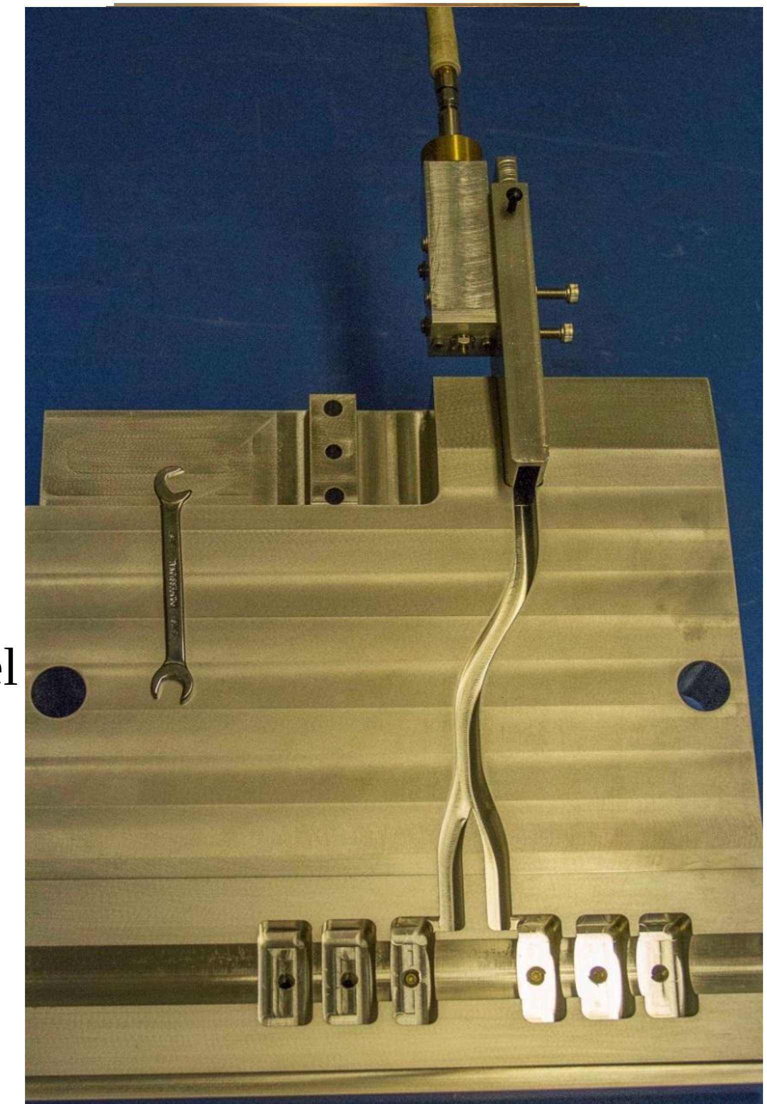
Six-Cell Cavity Kickers

- 6-cell cavities, higher R/Q (don't have to shoehorn into Tevatron tanks)
- No bearings in vacuum
  - Scissors type motion for opening cavities
    - Used for vertical and horizontal kickers
    - Binary motion mechanism (open or closed)
  - Flexi-hinge (no sliding surfaces)
  - No springs (more below)
- Waveguide power feeds (no coax cables in vacuum)
- Use all existing power amplifiers and low-level electronics





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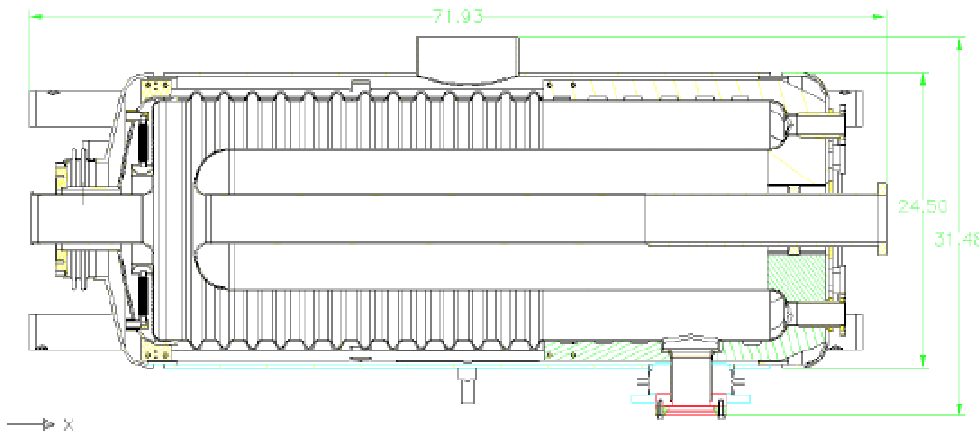
Status

- Yellow keyhole pickup was installed and operated during the proton run FY13
- Blue keyhole pickup will be installed this shutdown
- Kicker production is underway. First vacuum tanks have arrived. First set of cavities have been built and are being tuned. RF vacuum feedthrus are on hand. Small components, hinges, brackets, etc. are now coming from the shops.
- Fast switches for the pickups are on order. Control electronics are being designed
- Microwave link LO upgrade is in progress. Most parts are on hand. We'll do a test with one link next month (using spare parts if needed)
- Software work is "ramping up"

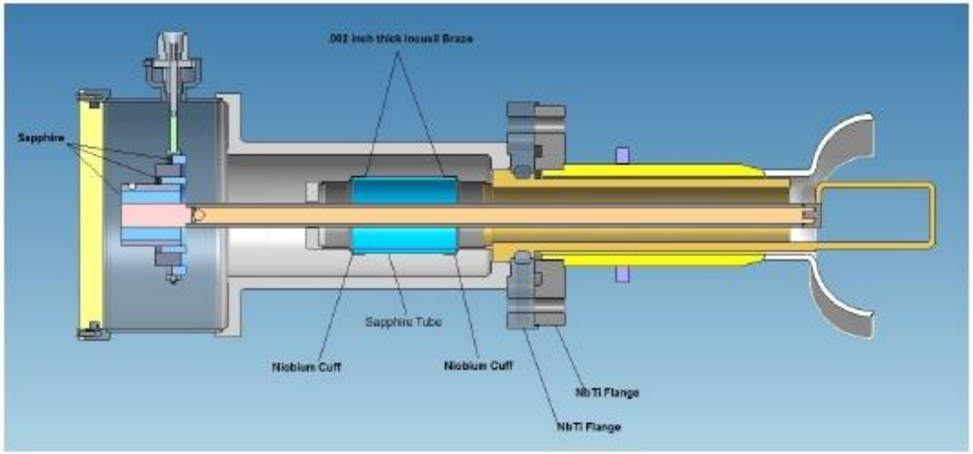
56 MHz Cavity Sergey Belomestnykh

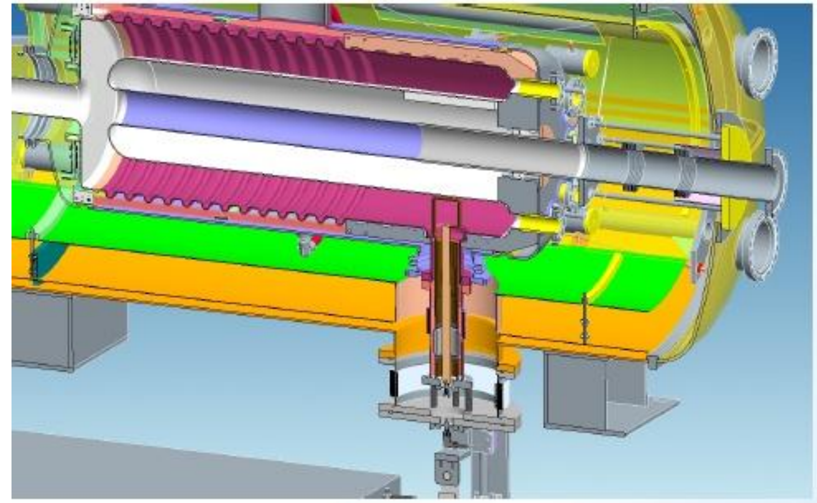
56 MHz cavity



- The purpose of this Quarter Wave Resonator (QWR) is to provide a larger RF bucket (5 times larger than that of 197 MHz cavities) for ions, which should result in higher luminosity of RHIC by: direct adiabatic capture from 28 MHz system, better preservation of longitudinal emittance, elimination beam spillage in satellite buckets, improving luminosity by allowing shorter beta function at the IP.
- This is a "storage" cavity, that is it does not have large tuning range to follow the large frequency change during acceleration from injection energy to energy of experiment and is turned on only after that for re-bucketing.
- One 56 MHz cavity will serve both RHIC rings. It will be the first superconducting RF system in RHIC.

V_{acc}	2.0 MV
Stored energy	140 J
R/Q	80.5 Ohm
Geometry factor	33.5 Ohm
Operating temperature	4.4 K
Q_0 at low fields (assuming R_{res} = 10 nOhm)	3.0×10^9
Q_0 at 2 MV	2.4×10^9
P_{cav} at 2 MV	20.7 W
Q_L	4×10^7
Available RF power	1 kW
Coarse tuning range	25.5 kHz
Coarse tuning speed	3.7 kHz/s
Tuning sensitivity (stepper motor)	17 kHz/mm
Fine tuning range	60 Hz
Tuning sensitivity (piezo)	0.06 Hz/V
LF detuning at 2 MV	-132 Hz
Frequency sensitivity to He bath pressure	0.282 Hz/mbar
Peak detuning due to microphonic noise	1 Hz



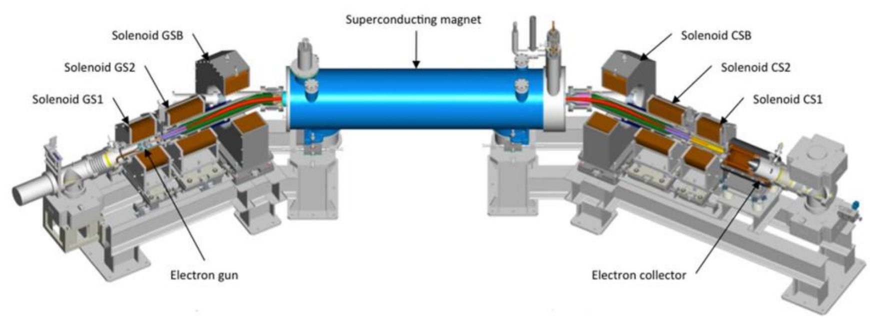


Summary

- 56 MHz cavity fabrication and processing is complete
- Vertical test of the cavity is in progress
- Cryostat fabrication is progressing well, many components are fabricated and dry-fitted
- The most critical components for the project at the moment are HOM couplers and FD
- Current schedule allows installation for Run-14 and everybody is working hard to make this happen

RHIC Retreat 2013
New Instrumentation

Outline



- **E-Lens:**
  - **Profile measurements – YAG Screen & Pin Hole**
  - **Ion Clearing Electrodes**
  - **E-Lens BPMs and Calibration**
  - **Back-Scattered Electron Detector**
  - **RHIC Bunch-by-Bunch Monitors -> covered by R. Hulsart**
  - **Gated BTF measurements**
- **High Current RHIC Operations:**
  - **Linac Laser Profile Monitor – New Laser**
  - **Abort kicker Thermocouples**
  - **BPM Thermocouples**
  - **RHIC Bunch-by-Bunch Transverse Damper -> covered by K. Mernick**

Toby Miller, Friday 14:30, July 26, 2013

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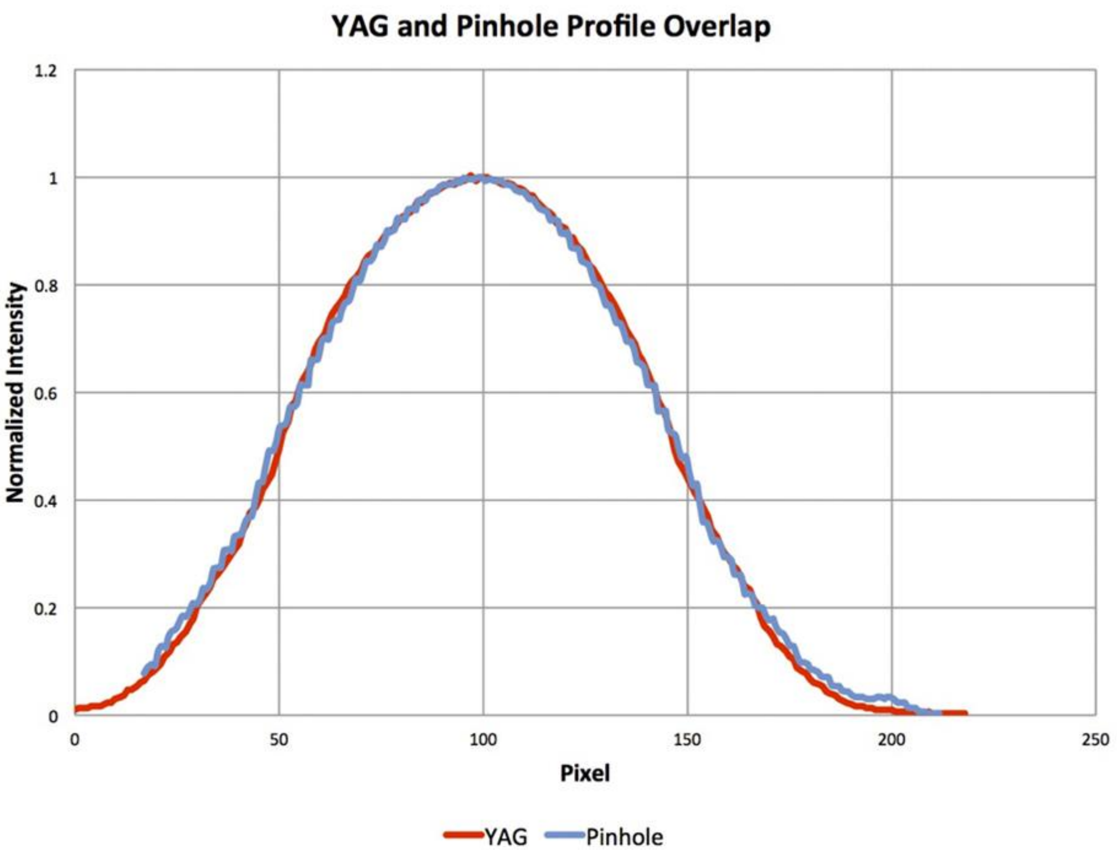
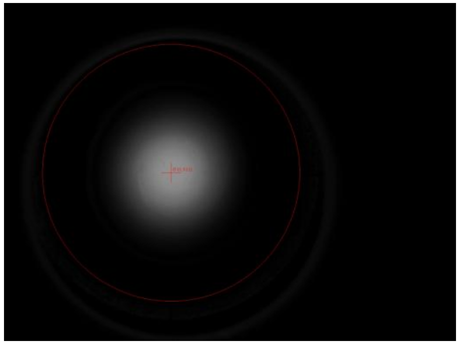
E-Lens Profile Measurements – YAG & Pin Hole

YAG – PinHole Agreement

Comparison of Normalized Data from
YAG Image & Rendered Image* of PinHole Scan



YAG image:
70mA beam **



Rendered PinHole image:
210mA beam, 100x100pts

* Smoothing algorithm applied during rendering of scan data into image file.

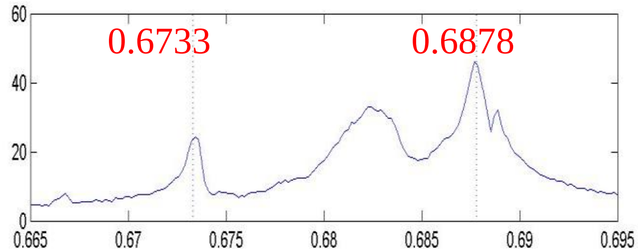
** E-Lens Test Bench data showed YAG profile to scale linearly with beam current.

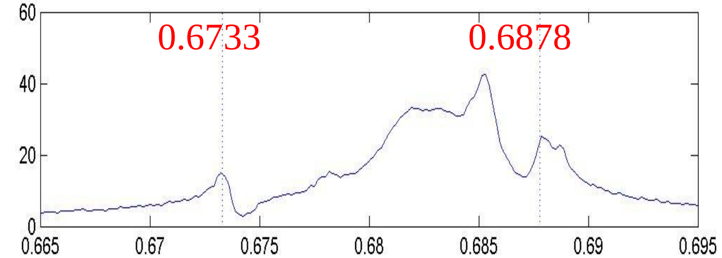
Gated BTF measurements

Preliminary

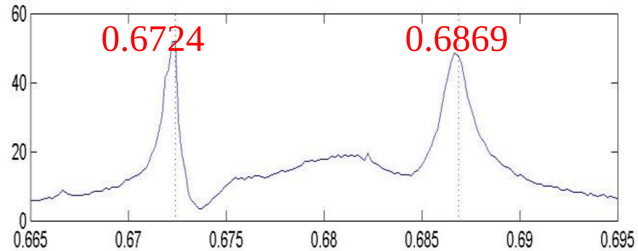
BLUE vertical | YELLOW vertical

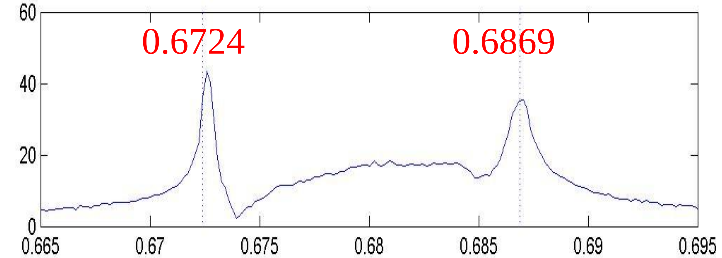
bunches with 1 collision



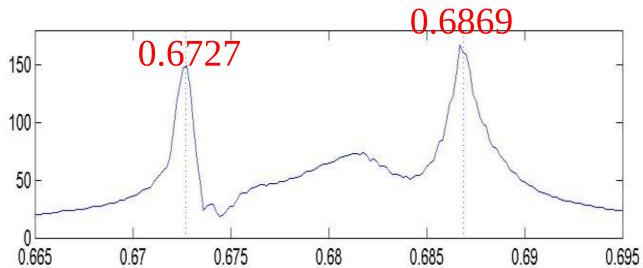


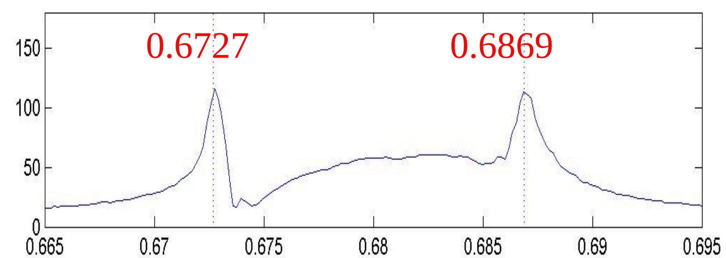
bunches with 2 collisions





all bunches (no gating)





tune | tune

Bunch synchronous measurements of beam parameters is another critical tool for the parasitic commissioning of E-Lens.

C. Dawson, M. Wilinski, K. Mernick, M. Minty

Polarization Improvement: Mei Bai

- Increase polarization transmission efficiency of acceleration
  - At current working point
    - Explore techniques to reduce the strong intrinsic spin resonance strength at high energy
    - Spin tracking to verify the relevance of horizontal tune
    - Maintain small beam emittance including injector chain
  - Explore near-integer working point
    - Weaker and less snake resonances
    - The only location that both luminosity and polarization prefer at the same time

Further Polarization Improvement

- Avoid polarization loss during rotator ramp
  - Need the parameterization of spin rotator configuration as function of its current. This is critical for modeling/understanding the spin tune and resonance driving term change during the rotator ramp(work progress)
  - Optimize the beam's big fours
    - tunes/chromaticity for rotator ramp, i.e. close to 2/3 resonance like energy ramp?
    - Orbit distortion
    - Coupling, including local coupling
    - RUN 13 shows it is beneficial to postpone the re-bucketing towards the end of rotator ramp
  - NEED polarization measurement at the beginning of rotator ramp

Further Polarization Improvement

- Maximize distance between store working point and snake resonance at **$5Q_y=Q_{spin}+1$** for good polarization lifetime
  - 3rd order orbital resonance correction at store to increase more room for tune spread
  - E-lens to shrink the beam-beam tune spread
  - Tight control of local orbit at IP where pair of spin rotator is present

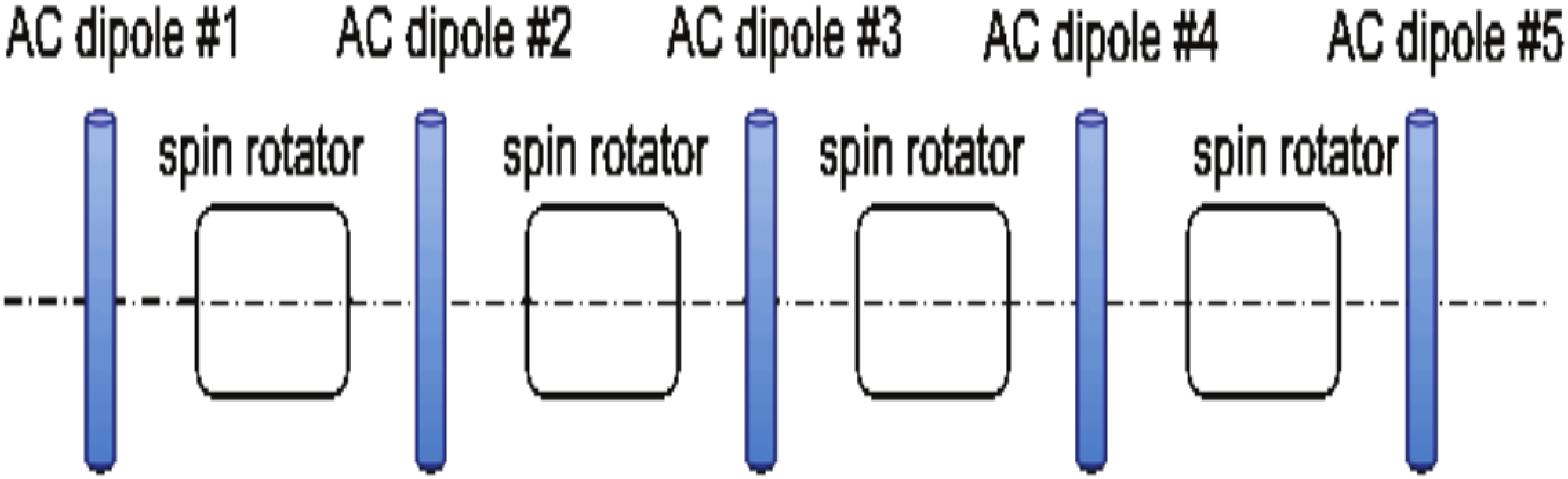
- Improve spin dynamics diagnostics
  - Non-destructive spin tune measurement
    - Key words: driven spin coherence
  - accurate and robust polarimetry.
    - **Significant target lifetime is crucial especially for the coming high intensity operation, as well as spin dynamics studies as well as post run data analysis !!!**

Spin Flipper Commissioning Jorg Kewisch

- The spin should be flipped to eliminate systematic errors in the detectors
- This is in addition to the alternating helicity already used in RHIC
- Ideal would be a snake that can be turned on and off for one revolution. Not practical
- We use a resonant spin rotation to flip the spin
- The spin flipper tune is swept through the spin tune resonance.

$$P_f = \left(2 \cdot \exp\left(-2\pi|\varepsilon_k|^2/\alpha\right) - 1\right) P_i$$

Spin Flipper Layout



Use two closed 3 bumps oscillating near/through the spin tune.

Phase difference in 3 bumps allow to distinguish between Q and 1-Q.

Conclusion

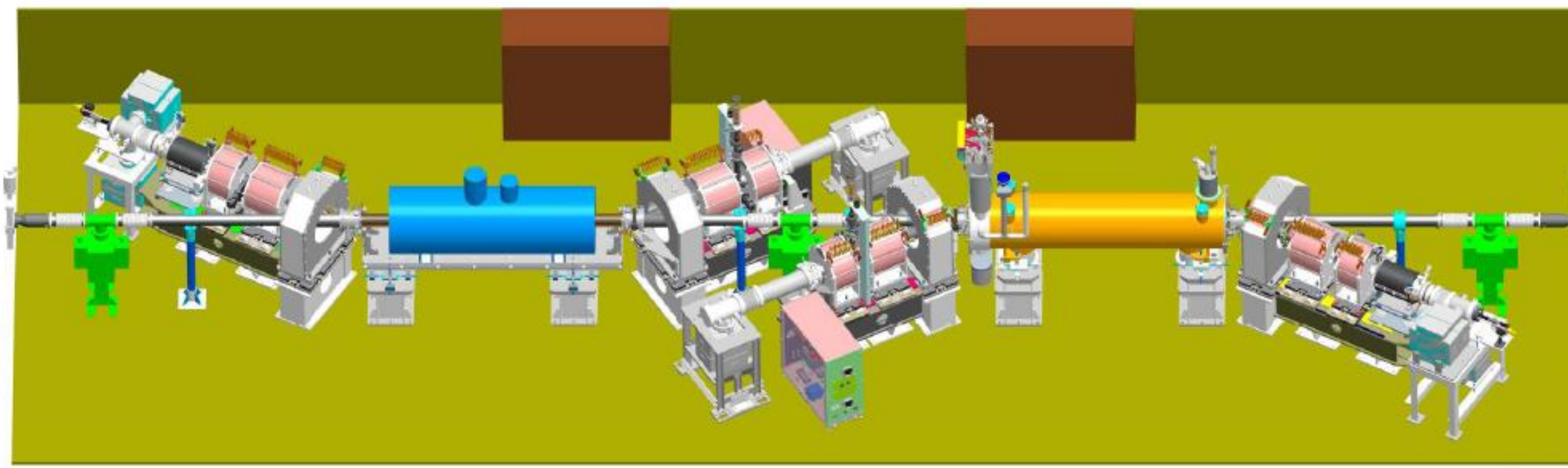
- The elimination of the mirror resonance works (within the accuracy of the measurement). Bump closure works and may be improved with better instrumentation
- Spin flipping is quite sensitive to the spin tune chromaticity due to the unbalance dispersion slope at the two snakes
- Spin flipping also requires excellent spin tune stability from store to store
- The strategy for future spin flipper commissioning is to first establish spin tune meter capability by measuring driven coherent spin precession. Need to measure amplitude of spin precession at 2+ drive frequencies.

RHIC Electron Lens Commissioning

Xiaofeng Gu

Z. Altinbas, M. Anerella, D. Bruno, M. Costanzo, W.C. Dawson, A.K. Drees, W. Fischer, B. M. Frak, D.M. Gassner, K. Hamdi, J. Hock, L.T. Hoff, A.K. Jain, J. Jamilkowski, R. Lambiase, Y. Luo, M. Mapes, A. Marone, R. Michnoff, T. Miller, M. Minty, C. Montag, S. Nemesure, W. Ng, D. Phillips, A.I. Pikin, S.R. Plate, P. J. Rosas, J. Sandberg, P. Sampson, L. Snydstrup, Y. Tan, R. Than, C.W. Theisen, P. Thieberger, J. Tuozzolo, P. Wanderer, and W. Zhang

26 July 2013, Brookhaven National Lab.



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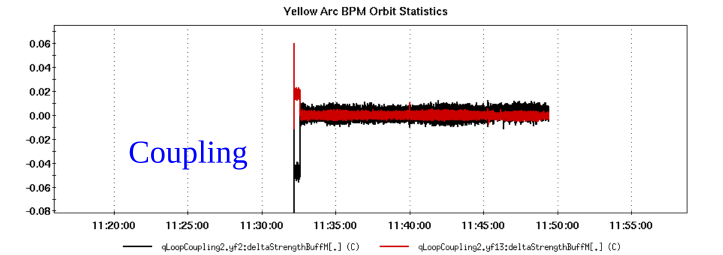
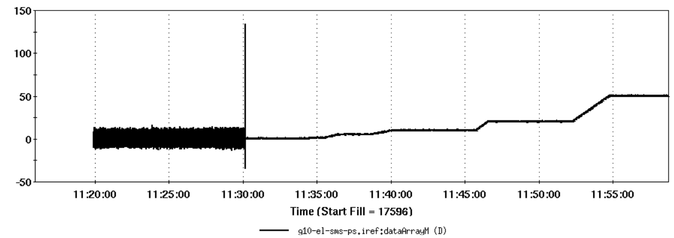
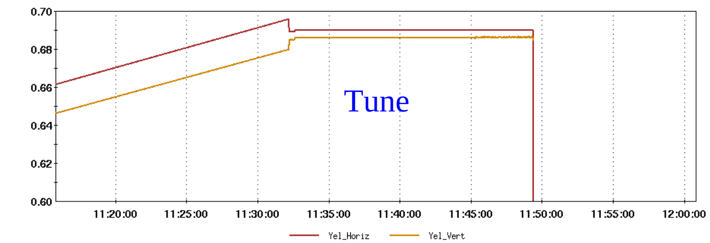
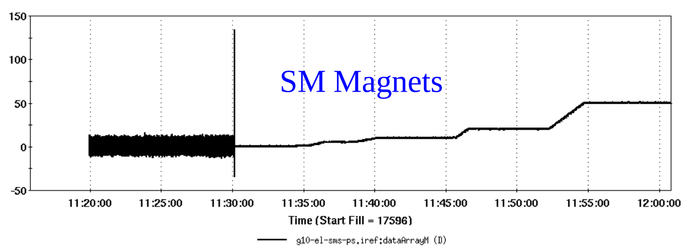
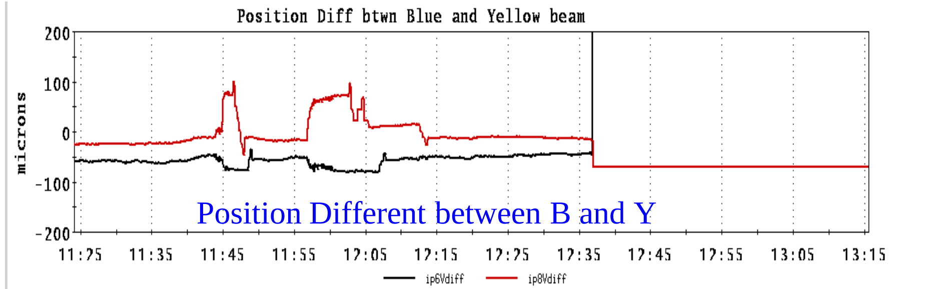
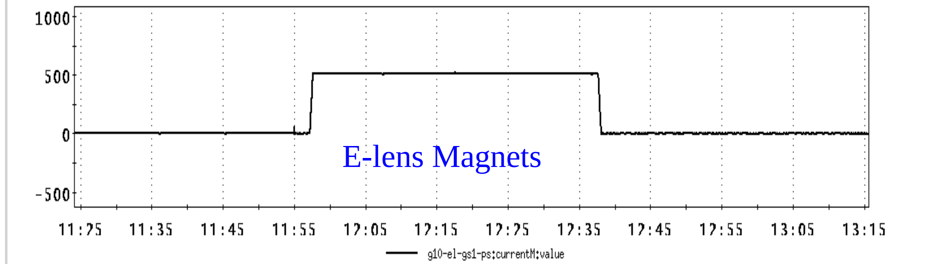


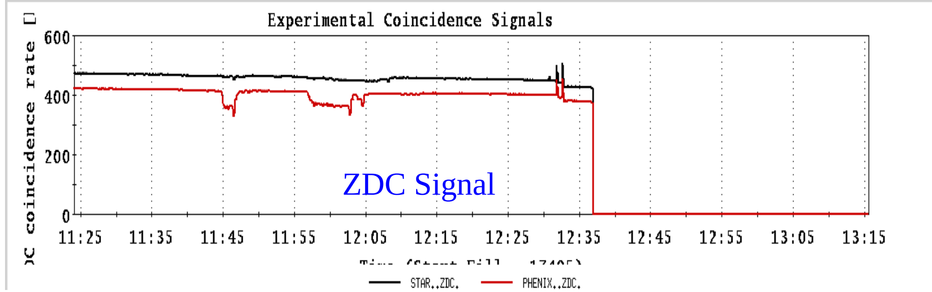












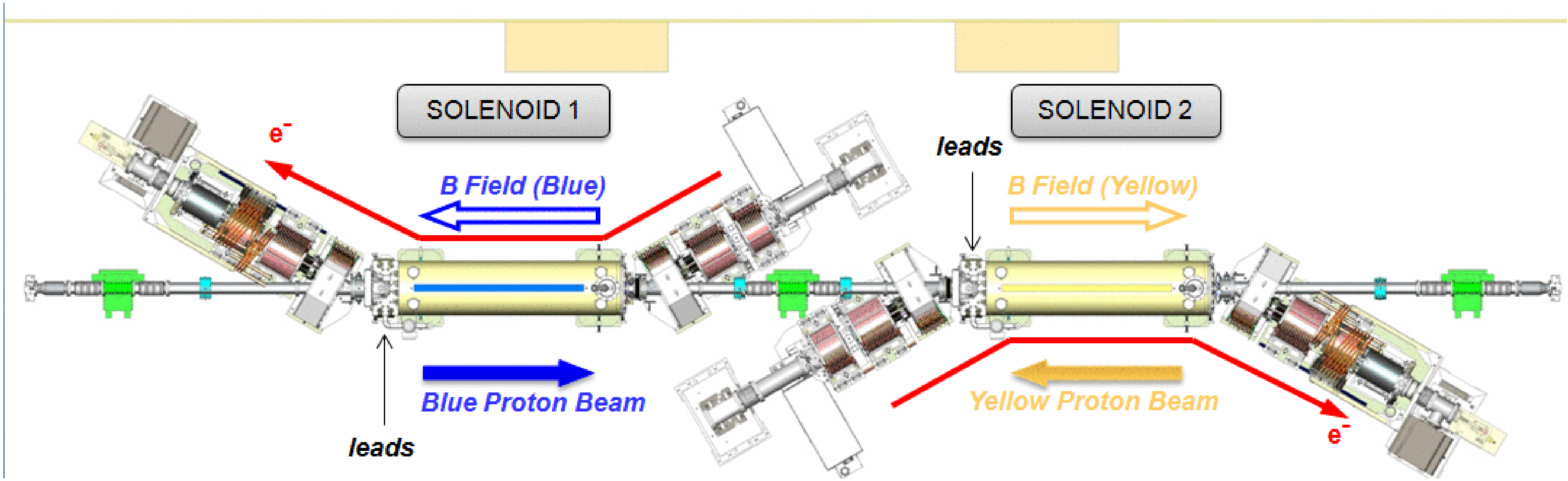
Superconducting solenoid had little effect on tune and coupling at 10% current.

E-Lens warm magnet has little effect on closed orbit. Well with feedback range.

Summary

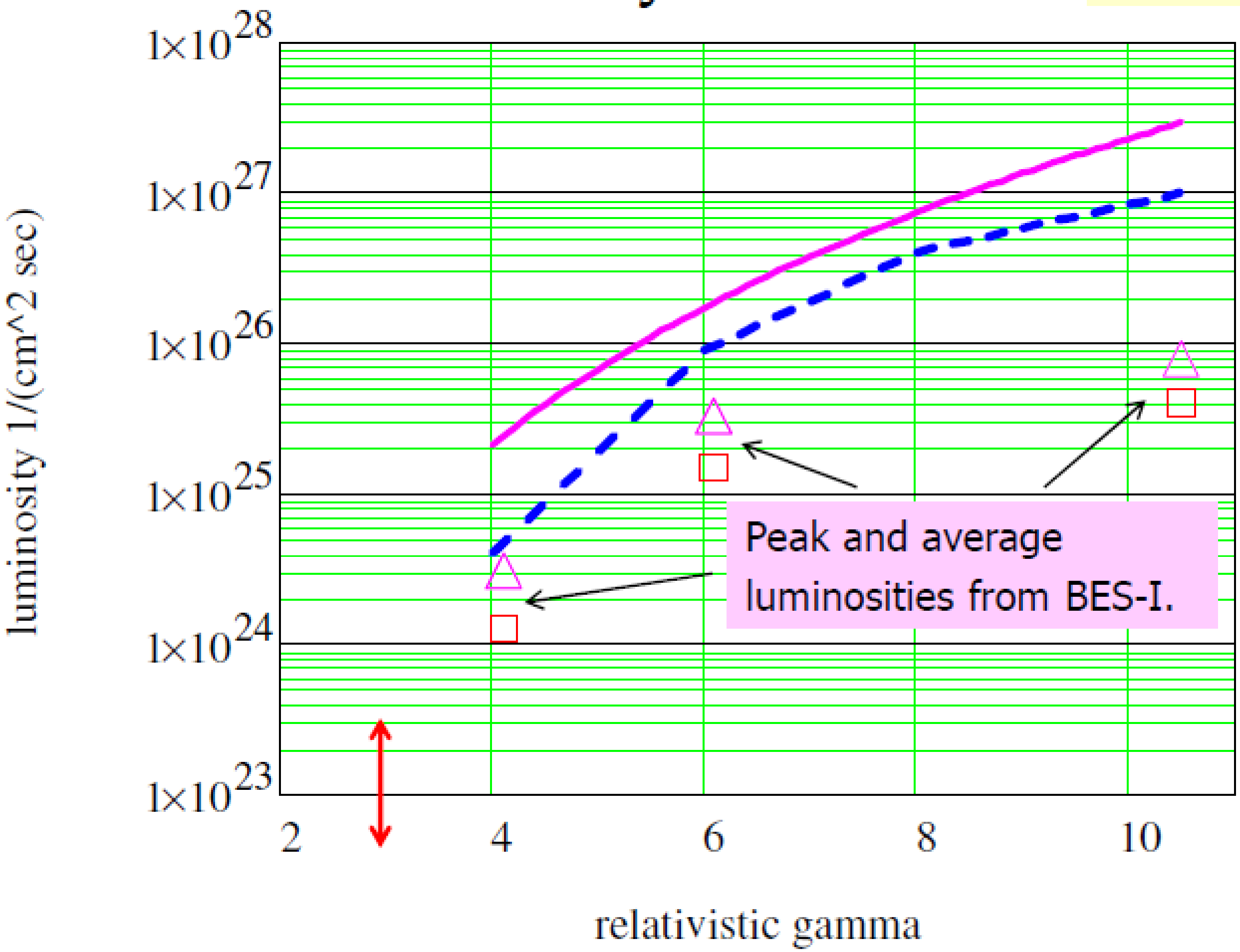
1. One e-lens hardware and software are tested, except collision detector. Reliability was tested for short time (over 14hours).

2. Solenoid #1 and #2 were horizontal tested. Solenoid #2 field straightness was measured. Both of them will be measured again in tunnel.



Luminosity projection for present 28 MHz and new 4.5 MHz RF system

C-A/AP/481 (April 2013)



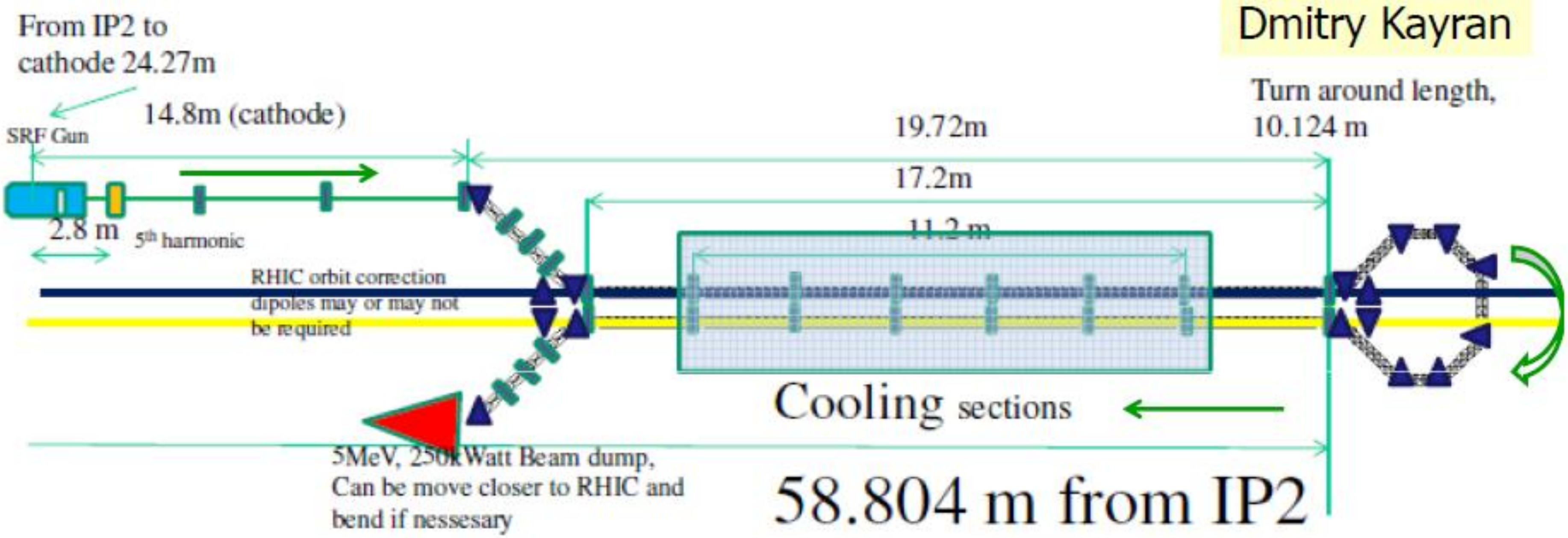
Expected improvement with electron cooling:

Blue-dash line: possible luminosity improvement with present limitations and 28 MHz RF.

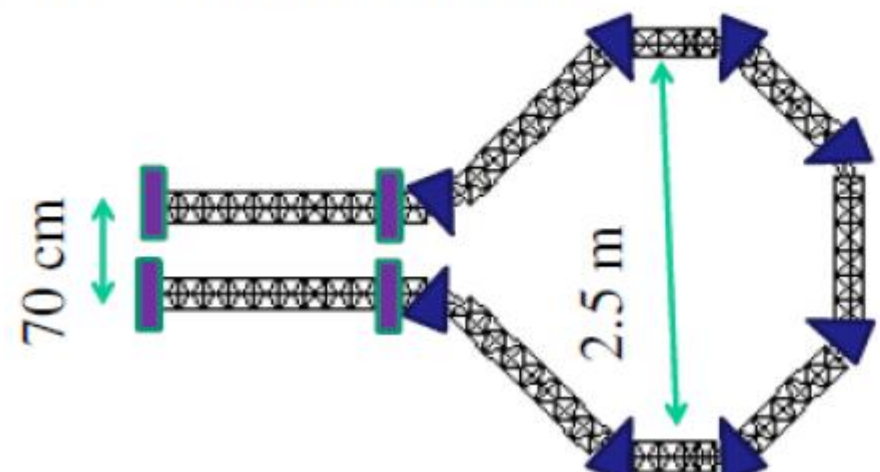
Magenta: maximum possible improvement if limitations are mitigated by using longer bunches (with new RF system)

LEReC schematic layout

Dmitry Kayran



- HTS Solenoid inside gun cryomodule
- Solenoids, (20 cm effective length)
- 45 degrees chevron magnets (30 cm length)



Summary

1. Electron cooling can provide significant luminosity improvement for low-energy RHIC operation.
2. Present electron cooler design is based on SRF gun bunched beam cooling. Electron accelerator is similar to CEC PoP accelerator and will use the same cryo system developed at IP2.
3. New low-frequency RF system (4.5 MHz) is being planed for low-energy RHIC operation with electron cooling, to maximize potential luminosity gains and provide good beam lifetime.

- Implementation of electron cooling for RHIC operation at low energies is expected to take about 4 years.

Thank you.

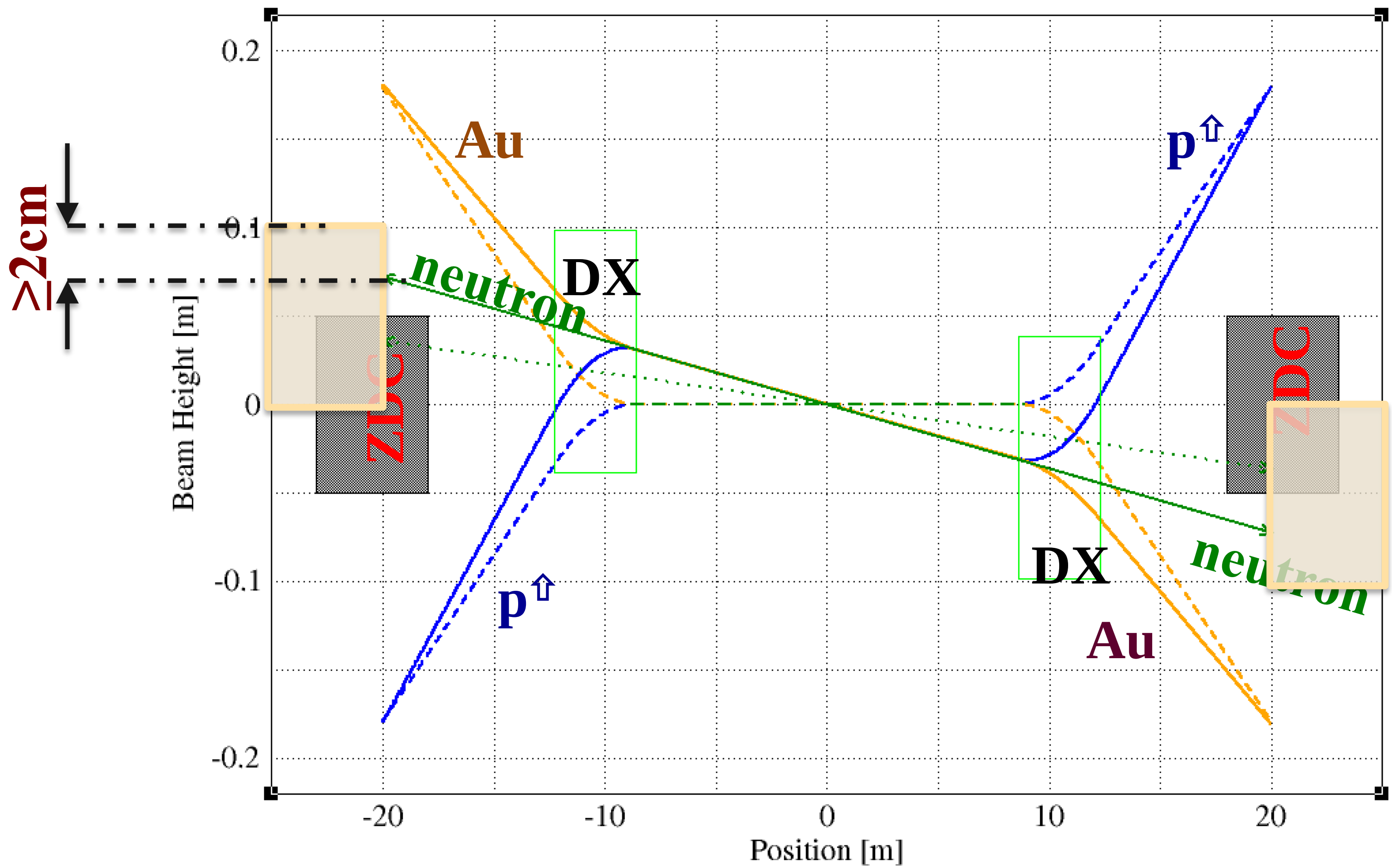
RHIC Asymmetric Collisions
Mei Bai, Steve Tepikian

	# of bunches	Ions/bunch [10^9]	Beta* [m]	Emittance [um]	L peak [cm^{-2} s^{-1}]	L week [nb^{-1}]
Run 2003	55	110d /0.7Au	2	13/25	$7x10^{28}$	4.6
Run 2008	95	100d /1.0Au	0.85	15/20	$13.5x10^{28}$	40
Run 2012	111	4.0 Cu/ 1.3 Au	0.7	24.5/7.0	$120x10^{26}$	3.5

- Deuteron Au collision was first established in 2003. And it was found the best way is to have equal frequency between the two species to avoid beam-beam modulation
- Cu Au collision was established in 2012. Cu beam suffered emittance blown up at transition due to instability, which limited the bunch intensity at store as well as peak luminosity

Machine changes

- DX magnets need to move.
- Divergence angle of neutrons is about +-1mrad, which has a spread in x of about +-2cm around the beam trajectory → need to move ZDCs



Path Forward towards p+A collision at RHIC

- During coming ion run
  - Repeat non-colliding DX aperture scan at injection with proper crossing angle verify that ~4.5\sigma clearance between beam and pipe in good for lifetime. And at the same time study
- Design of DX as well as DX-D0 pipe movement are in working progress to allow enough aperture for DX and minimum ZDC acceptance
- Current shieldings at both IPs need to be rearranged to yield enough space for the move of DX as well as DX-D0 pipe. A. Pendzick is leading the efforts on finding the effective way
- At the end of RUN14, exercise the movement of DX magnet and DX-D0 pipe. if possible, with cold.