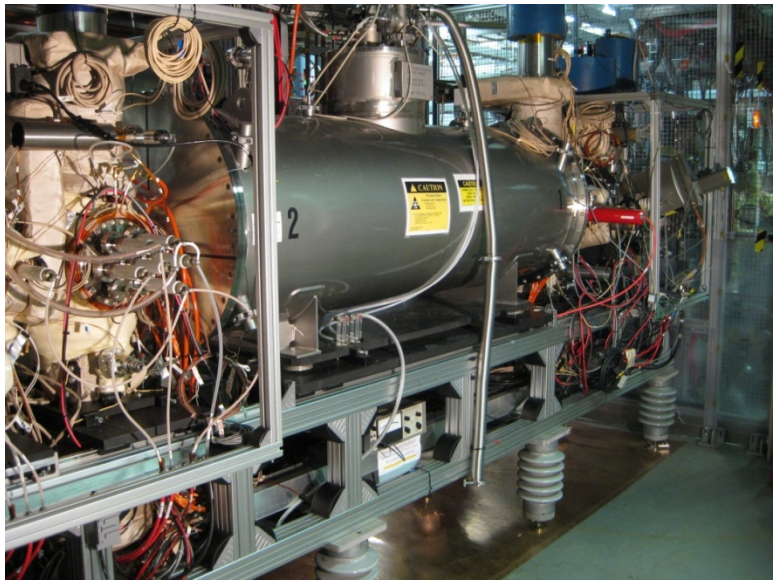
Status of EBIS

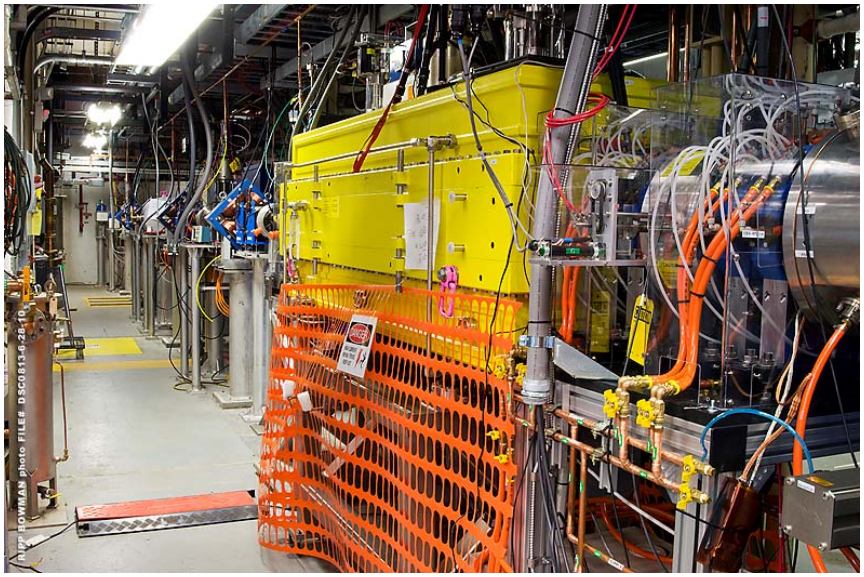
J. Alessi

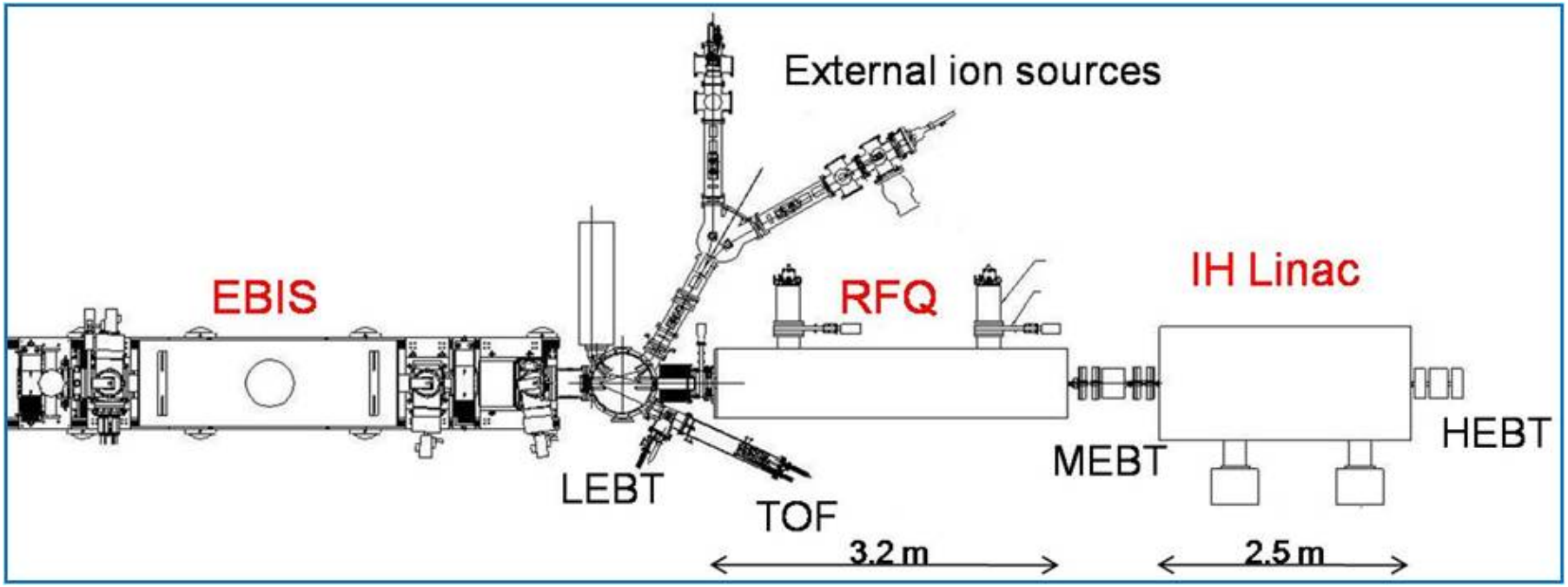
Performance – operation for NSRL

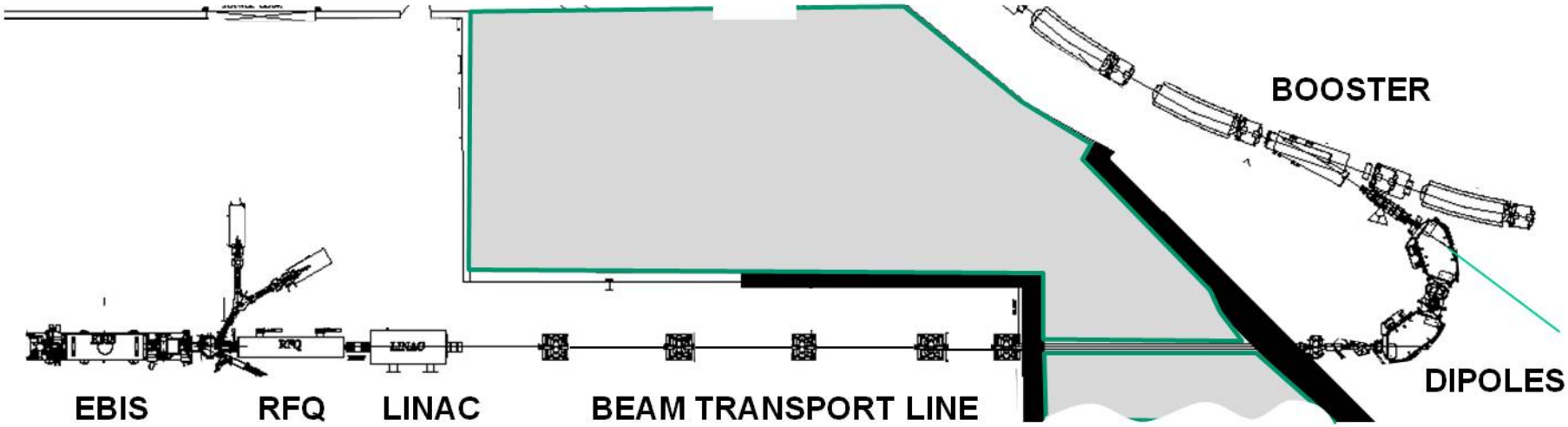
Intensity – status

Plan for reaching full intensity






External ion sources
EBIS
RFQ
IH Linac
HEBT
MEBT
LEBT
TOF
3.2 m
2.5 m


BOOSTER
DIPOLES
EBIS
RFQ
LINAC
BEAM TRANSPORT LINE

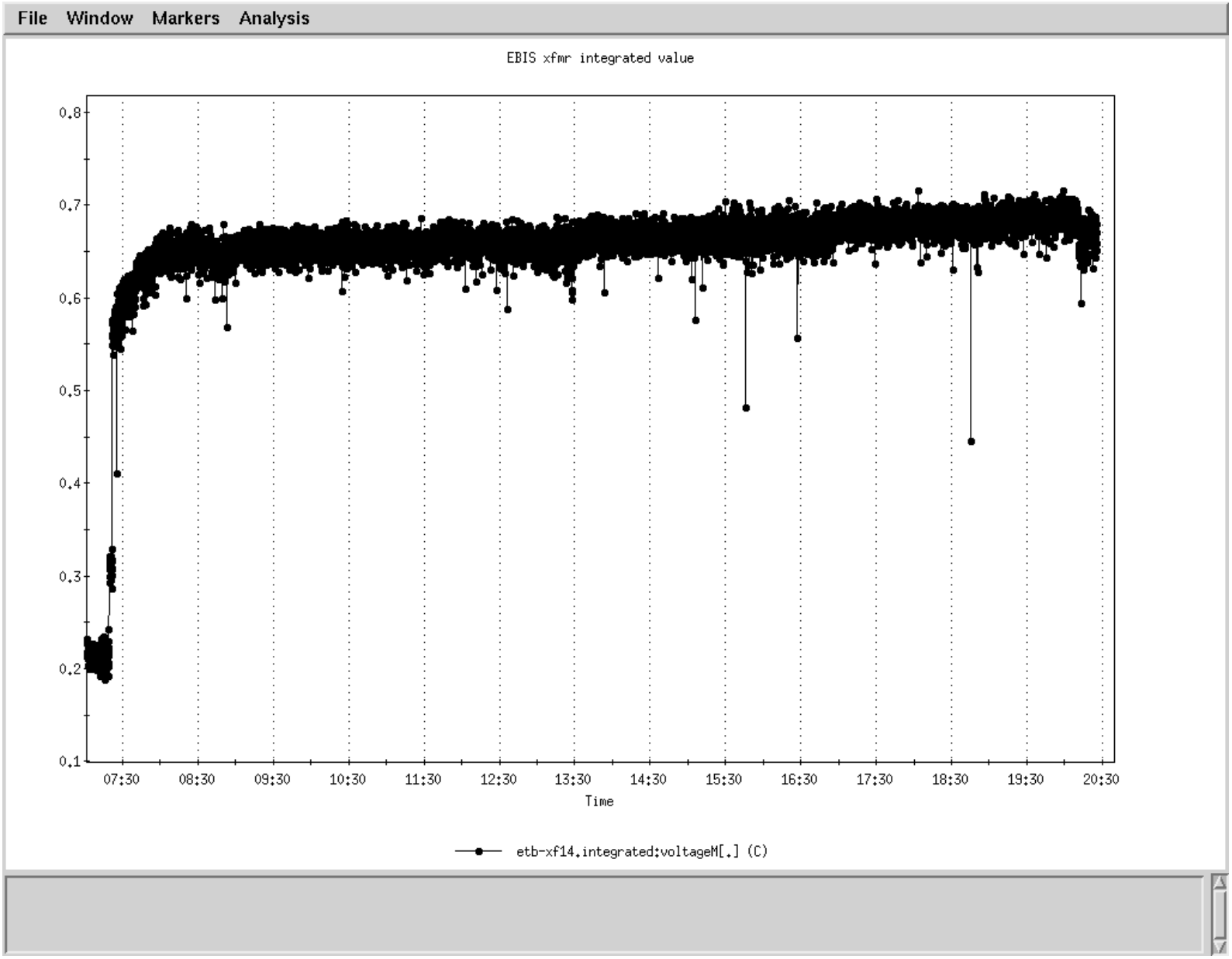
EBIS Status

- EBIS operated ~ 6 days/ week, 12-16 hours/day, from ~ March through June
    - Delivering beam to NSRL, and working on Au intensity for RHIC
- Ran 38 days for NSRL biology experiments
    - Delivered Fe, He, Ne, Ar, Ti beams
    - No downtime
    - Excellent stability (eventually got to where it ran for days without any adjustments)
- The superconducting solenoid has been operating in persistent mode for >1 year
- All RF systems and transport magnets ran 24/7 for ~ 4 months
- All EBIS, rf system, and transport magnet settings are very reproducible

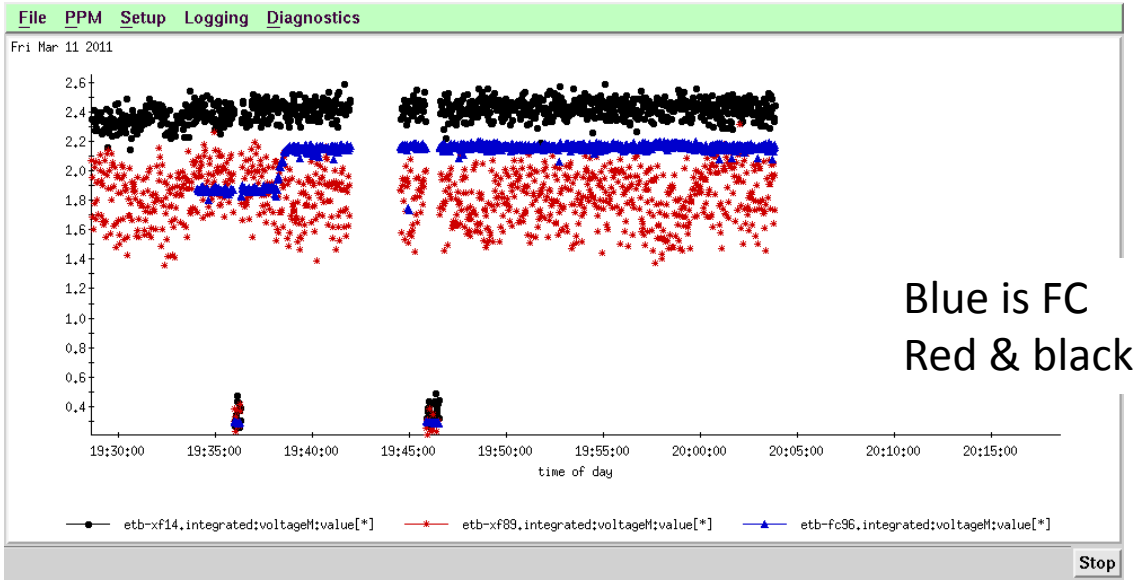
Although operation for NSRL took time away from Au beam development, this was a very valuable shakedown of all systems, and improvements with NSRL beams translated directly to Au as well.

Because of the operational demands, and since we had demonstrated the scaling of intensity with electron current on Test EBIS, we made the decision to operate EBIS at the ~5A level, and concentrate on improvements to efficiencies.
(we have operated with ion output at up to 6.85A, and electron beam at up to 8A; we will work up the electron current during the summer shutdown).

Fe to NSRL – 13 hours without a missed pulse (a few at reduced intensity)

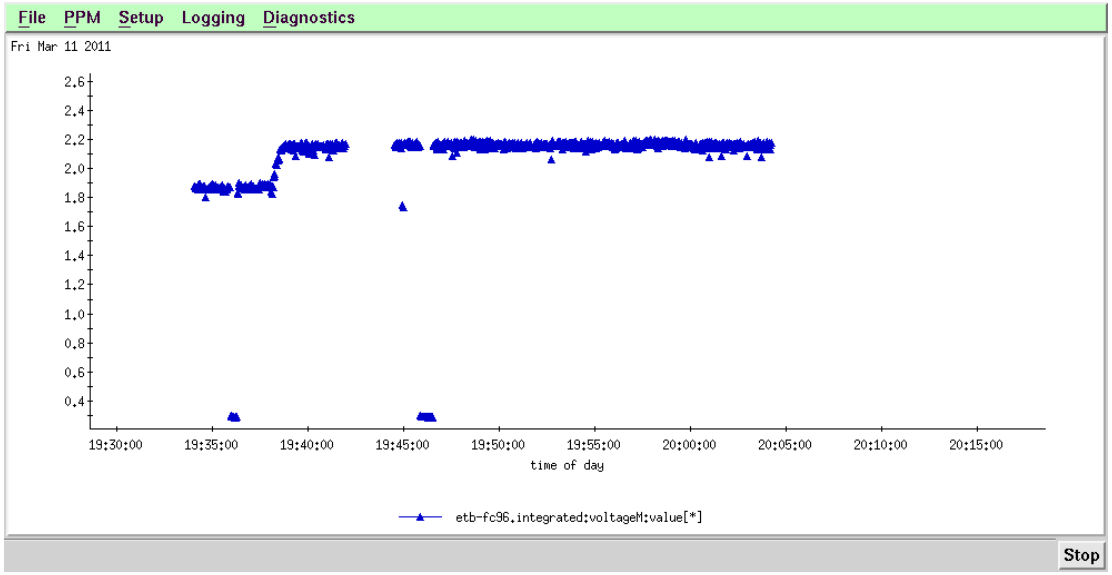


Beam is stable – fluctuations are much less than it looks on the transformers



Blue is FC

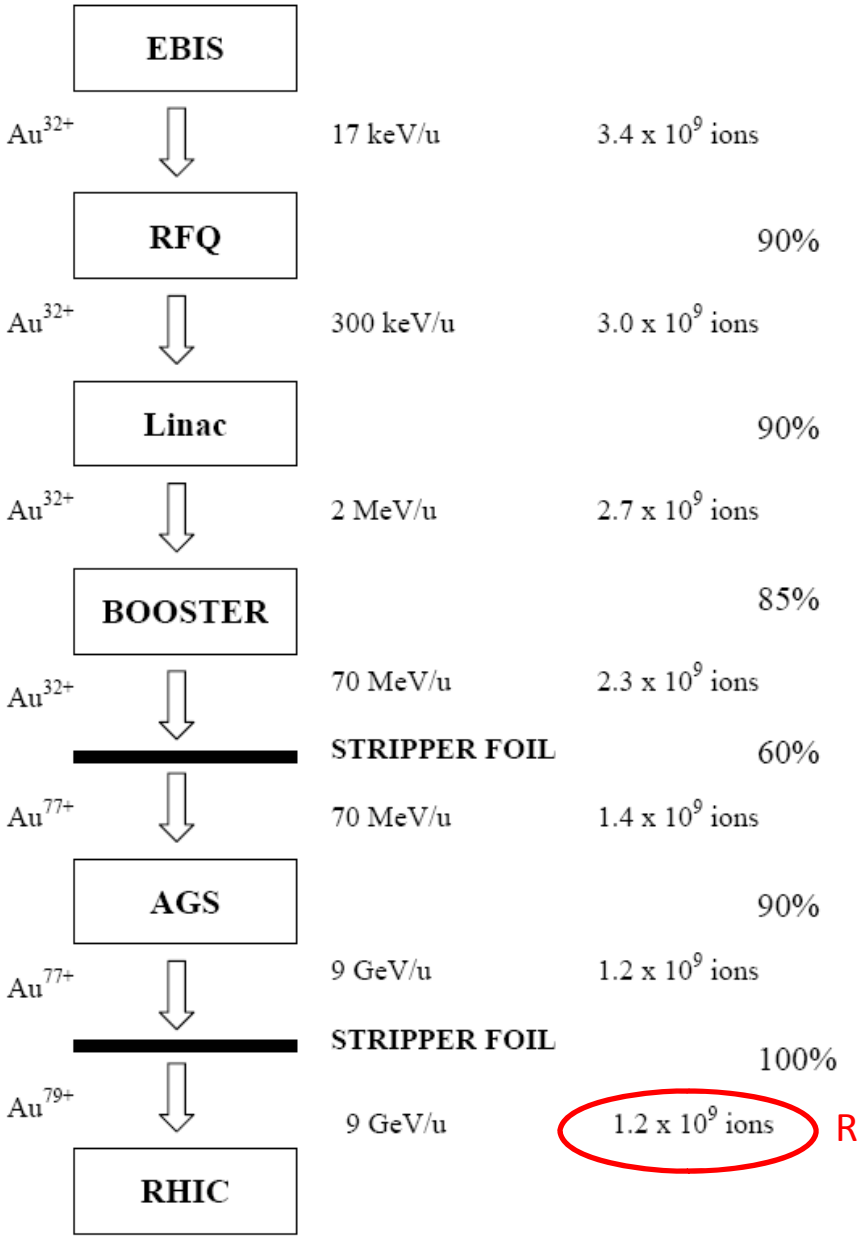
Red & black are transformers



Project CDR – September, 2005
(10 A electron beam)

Au Intensity

5A
Expected / Actual



1.35e9 / 1.35e9 ✓

1.15e9 / 0.65e9 (56% of expected)

Combined, need factor of ~2.3
(excluding 5A→ 10A)

RHIC now needs ~ 30% more here….

Booster late / Booster input

(from Kip's note summarizing measurements)

He 2+	41%
Ar 11+	42%
Ti 18+	40%
Fe 20+	38%
Au 32+	48%
(Tandem Au 31+	46%)

Because with EBIS we have only few-turn injection, we expected the Booster efficiency to be better than from Tandem

Is the EBIS input emittance too large?

EBIS beam emittances

Design value was ~0.17 π mm mrad, normalized, rms at Booster input

After RFQ/MEBT (measured with slit-collector):

He = 0.13 π mm mrad

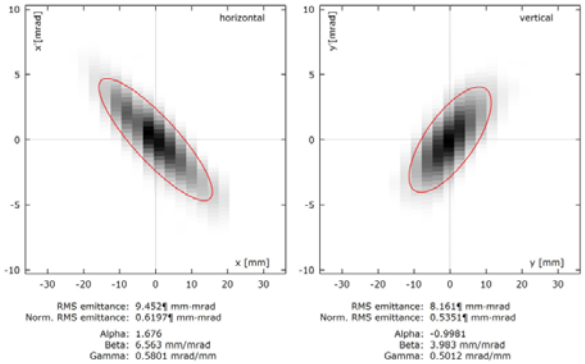
Au = 0.19 π mm mrad

Emittances in ETB, calculated from measured profiles
(profiles still contain multiple charge states at that location)

He 2+ 0.6 π mm mrad, normalized, rms

Fe 20+ 0.34 π mm mrad

Au 32+ 0.7 π mm mrad



ETB, measured with pepperpot

He 2+ 0.68 π mm mrad

Fe 20+ 0.54 π mm mrad

Au 32+ 0.58 – 0.65 π mm mrad

Is there excessive emittance growth through the linac?

Misalignments; coupling; improper rf tune

Inflector "acceptance" is ~ 29 π mm mrad = 1.9 π mm mrad, normalized

With an rms emittance of 0.6 π mm mrad, ~ 80% can fit within the inflector acceptance (*ignoring* additional constraint of matching to Booster, and effect of coupling)

reduce emittance to 0.4 → 91%; regap inflector at 0.6 → 96%; doing both → 99%

Performance (Au^{+32})

The Au intensity measured at Booster input is at the design value for the 5A electron beam

- we think there are still further gains to be made through improvements in beam matching, steering.

The efficiency from Booster input to full energy is ~56% of the design value (but ~matches Tandem efficiency)

- the emittance entering the inflector is larger than expected (may need further upstream optimization)
- further tuning of the match into Booster (additional quad and steerer to be added)

The energy spread of the beam in Booster and the emittance out of Booster appear to be as expected.

All beam species act very similar.
Same efficiency at lower intensity.

Plan to reach full intensity

EBIS:

•Run EBIS through the summer - increase electron beam to 10A

Electron gun electrode correction (did this week)

Recently added time-of-flight measurements of charge state distributions - will aid optimization

Collector ps passtube to eliminate voltage droop

Transport:

•Add the ability to steer the beam between the RFQ and linac (presently 4 quads, 1 buncher, and *no* steering)

•Beam emittance studies at the output of linac (pepperpot is working)

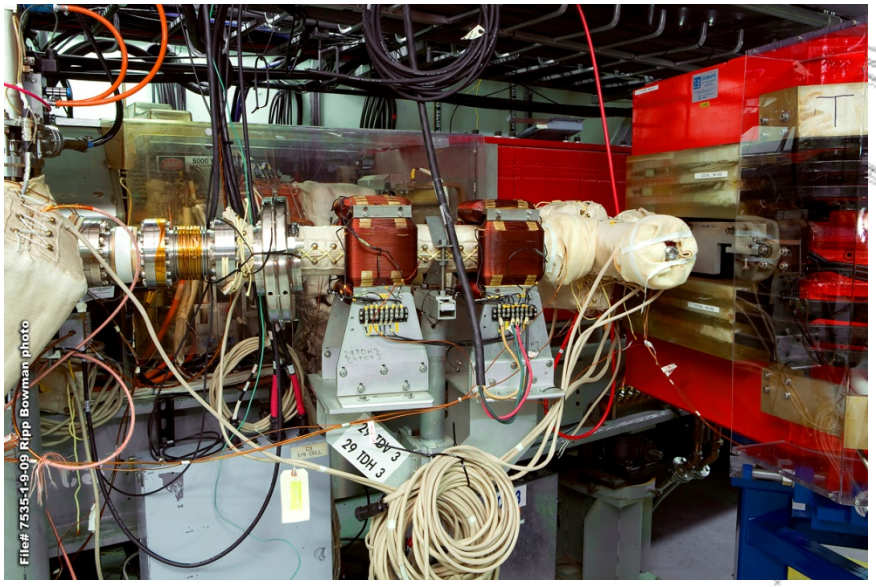
•Resurvey the beamline (?)

Matching into Booster:

•Add a quadrupole and steerer at the Booster input (provisions were made to do this as part of the EBIS Preinjector design, and the magnets already exist)

•Increase the inflector gap?? (from 17 mm to 24 mm ~ doubles the acceptance)

Bunch merge??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29 IDH 3
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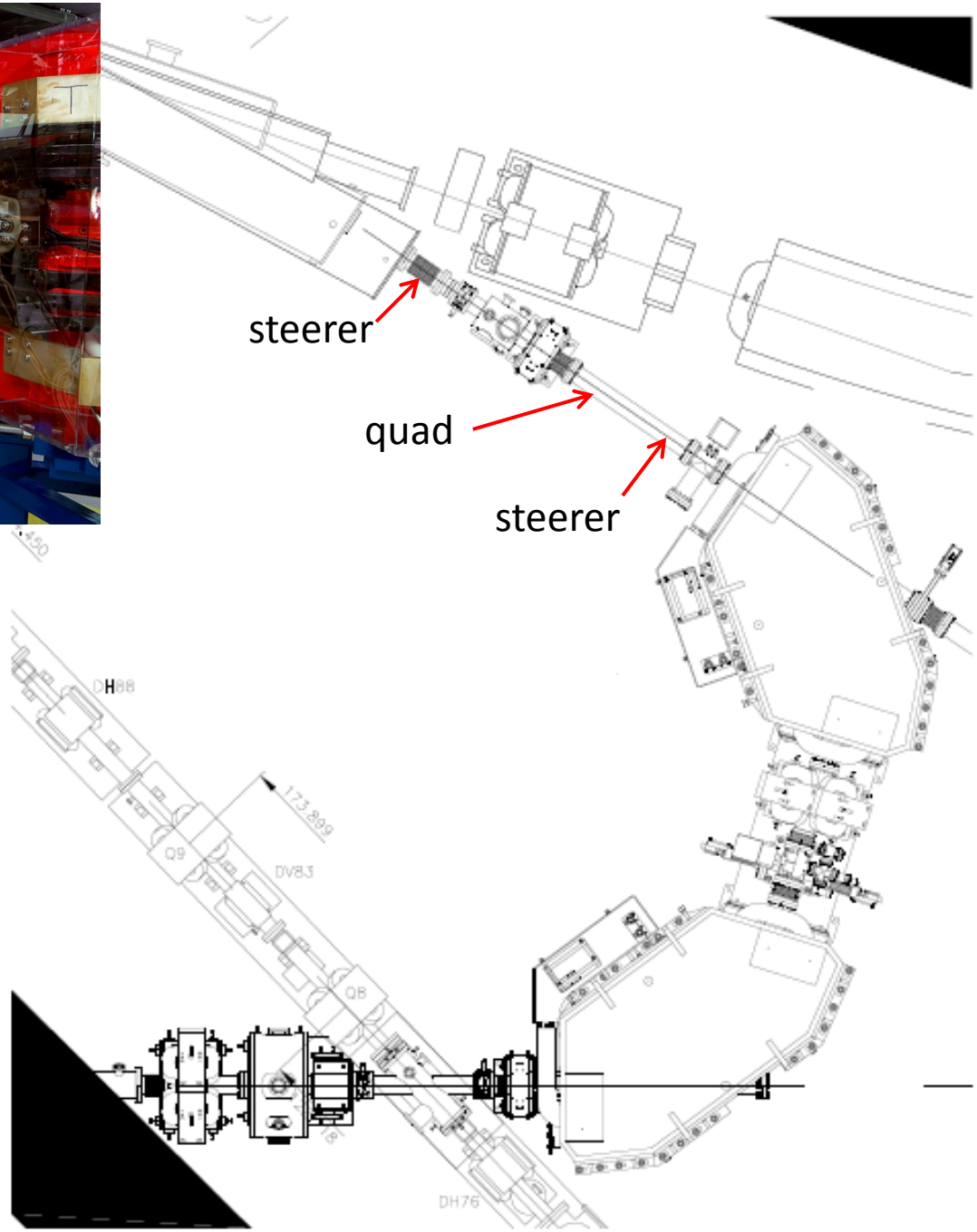
steerer
quad
steerer
DH88
Q9
DV83
QB
DH76

Summary

Since CD-4 last September, we made ~ 5 x improvement in intensity, plus big improvements in stability and reliability.

Beams for NSRL were very successful. Stable. Reliable. Scaling worked well for different species.

Total charge out of EBIS is exceeding the design value (we hope to use this excess to meet the increased requirements).

Transmissions are poorer than what we ultimately expect to achieve in several places (LEBT, linac, inflector). The overall factor of ~4.6 still needed probably won't come easy…….

<u>Very busy "shutdown"</u>–

- Push to 10A
- Beam emittance studies
- Maintenance on EBIS vacuum, ps's, rf systems, etc.
- Improvements to ion injection lines to reduce gas flow
- Add quad & steerer at Booster input
- Develop new beams – U, Cu for RHIC; Si, C, O for NSRL
- Work on establishing "routine" PPM and 5 Hz operation
- Beams for NSRL from late September to Thanksgiving
- Work towards unattended operation
- Operational Readiness Review