Run 15: Polarized Protons 100 GeV

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RHIC Retreat

8/14/2014

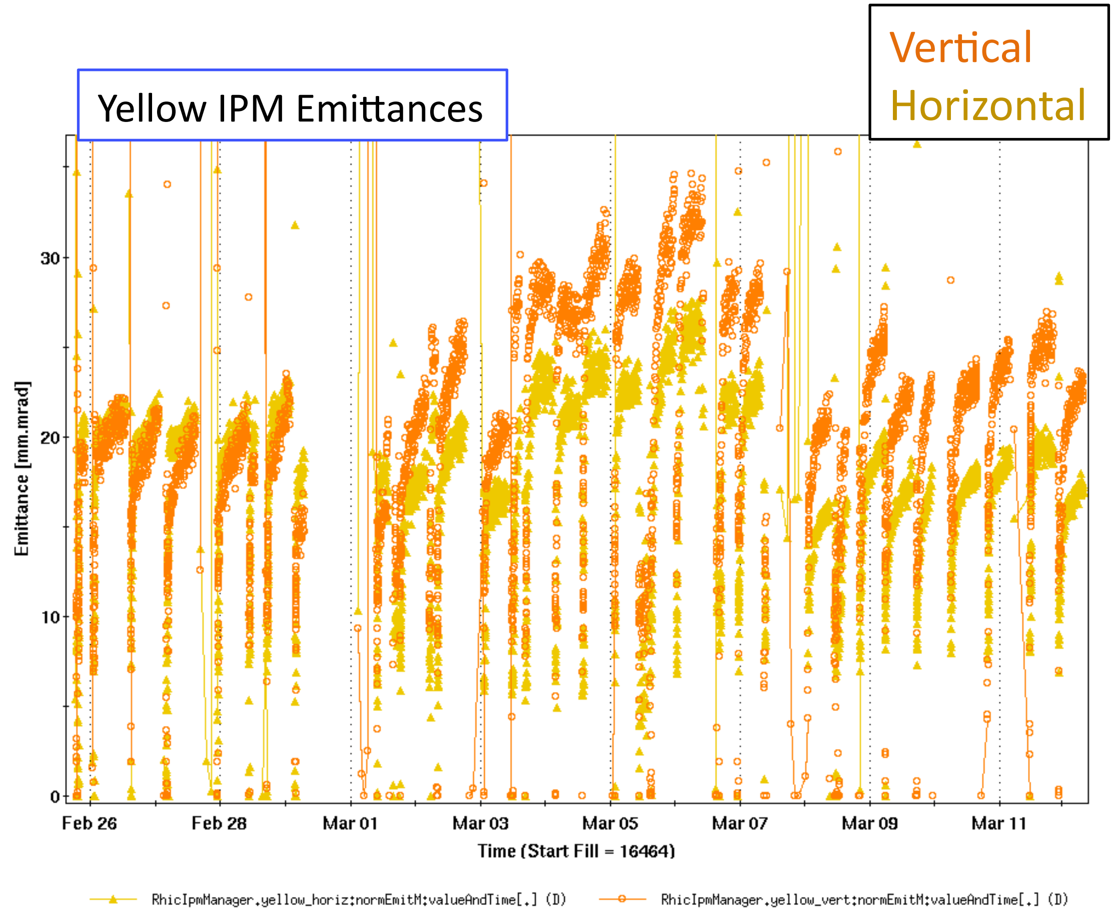
Last time on “100 GeV Protons”…

Longitudinal scraping being used to reduce beam loss during rebucketing at 100 GeV.

Moving to a vertical-only scraping scheme increased beam-beam tune spread, ΔQ_{bb}

Ran into the beam-beam limit:
- Transverse emittance blowup
- Increase in polarization decay
  - >2%/hr, compared to ~1%/hr nominal

Diminishing tune spread from beam-beam is exactly the goal of the electron lens



Feb 28-Mar 11, Run 12

E-lens Effort

1) E-lens proper (See earlier talk)

2) Lattice design for e-lens
   1) First tried (and abandoned) in Run13
   2) Reworked* using ATS principle for
      1) Improved nonlinear chrom
      2) Improved DA

3) Beam stability with e-lens/BBB damper development

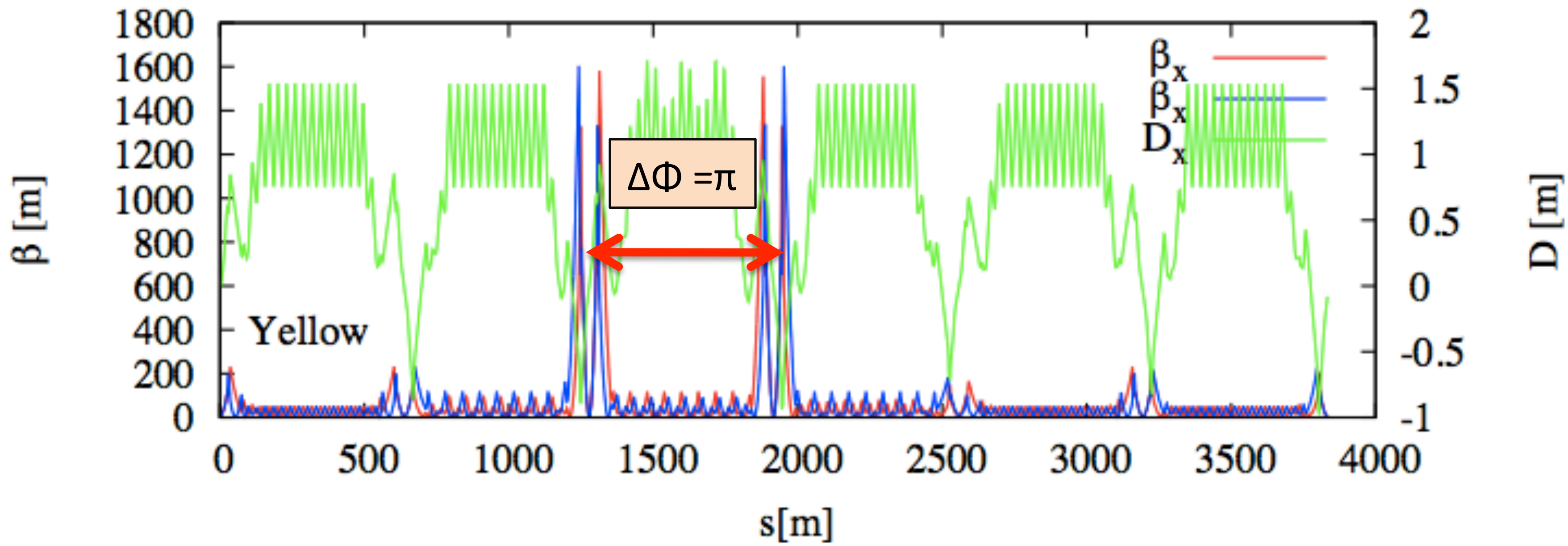
*S. White, W. Fischer, Y. Luo "Optics solutions for pp operation with electron lenses at 100 GeV" (C/AD Note)

E-lens Lattice Requirements

B* (IP6 and 8)	0.85 m	Same as Run 12, could push a little
B* (IP10)	Large as possible (20 m ?)	Beam stability with e-lens
$\Delta\Phi$ (per cell)	$\pi/2$	Nonlinear chrom comp
$\Delta\Phi$(Elens->IP6)	$k\pi$	E-lens kick
Injection γ_{tr}	Not near injection γ	Matching/stability
DA (on/off momentum)	Compare favorably to previous lattices	
Spin resonance strengths	Compare favorably to previous lattices	STILL NEEDS CHECKING!

*S. White, W. Fischer, Y. Luo "Optics solutions for pp operation with electron lenses at 100 GeV" (C/AD Note)

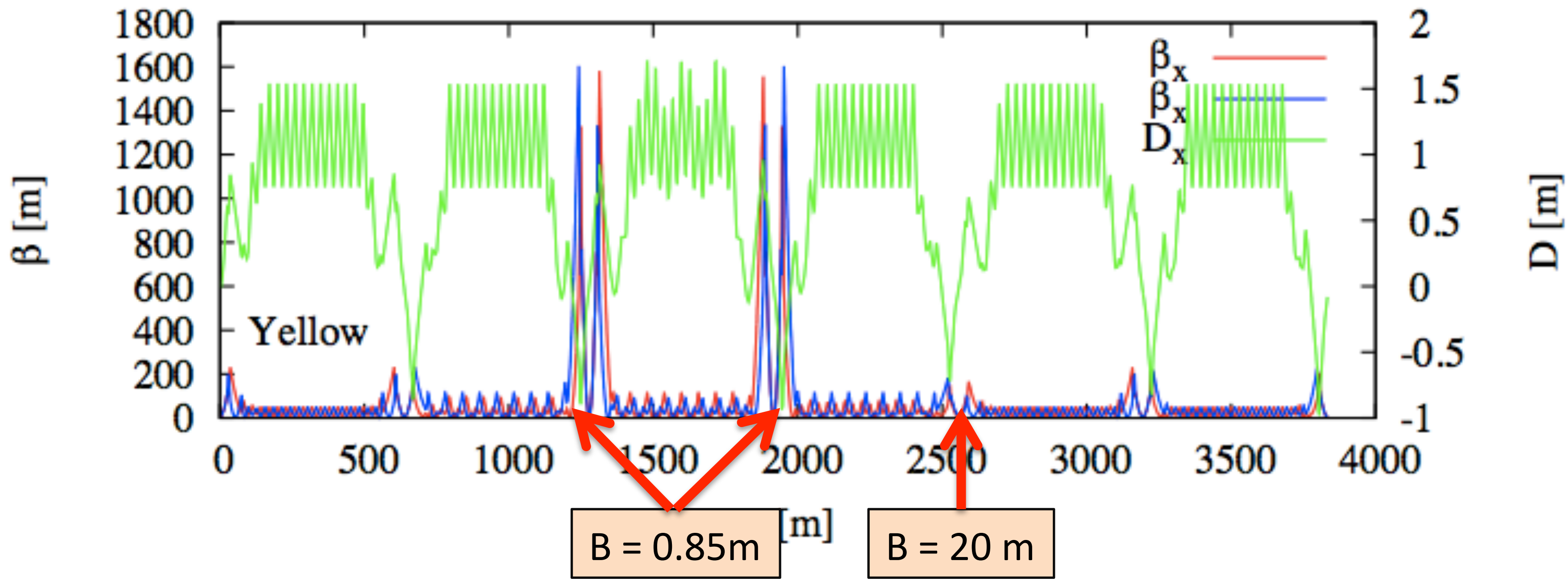
ATS Store Optics



ΔΦ/cell =π/2

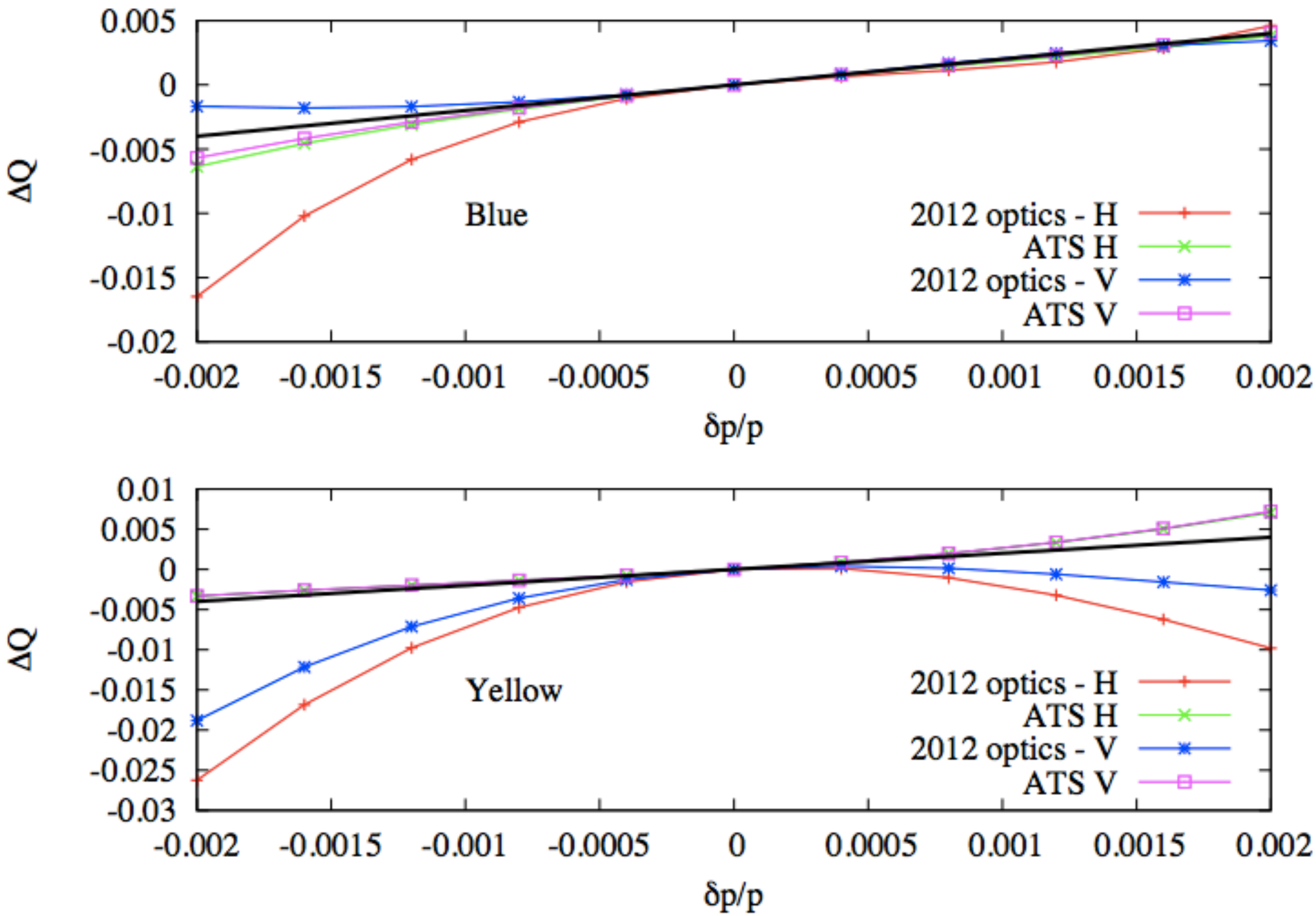
Integer tune increased (28,29)→(29,30):
Injection γ_{tr} refit to 23.5 (nominally 23.3)
Injection B* = 7.5 m (2/3 driving?)

ATS Store Optics



Lattice requires modification of Q-trim to make it bipolar

Nonlinear Chroms Improve



E-lens and transverse stability

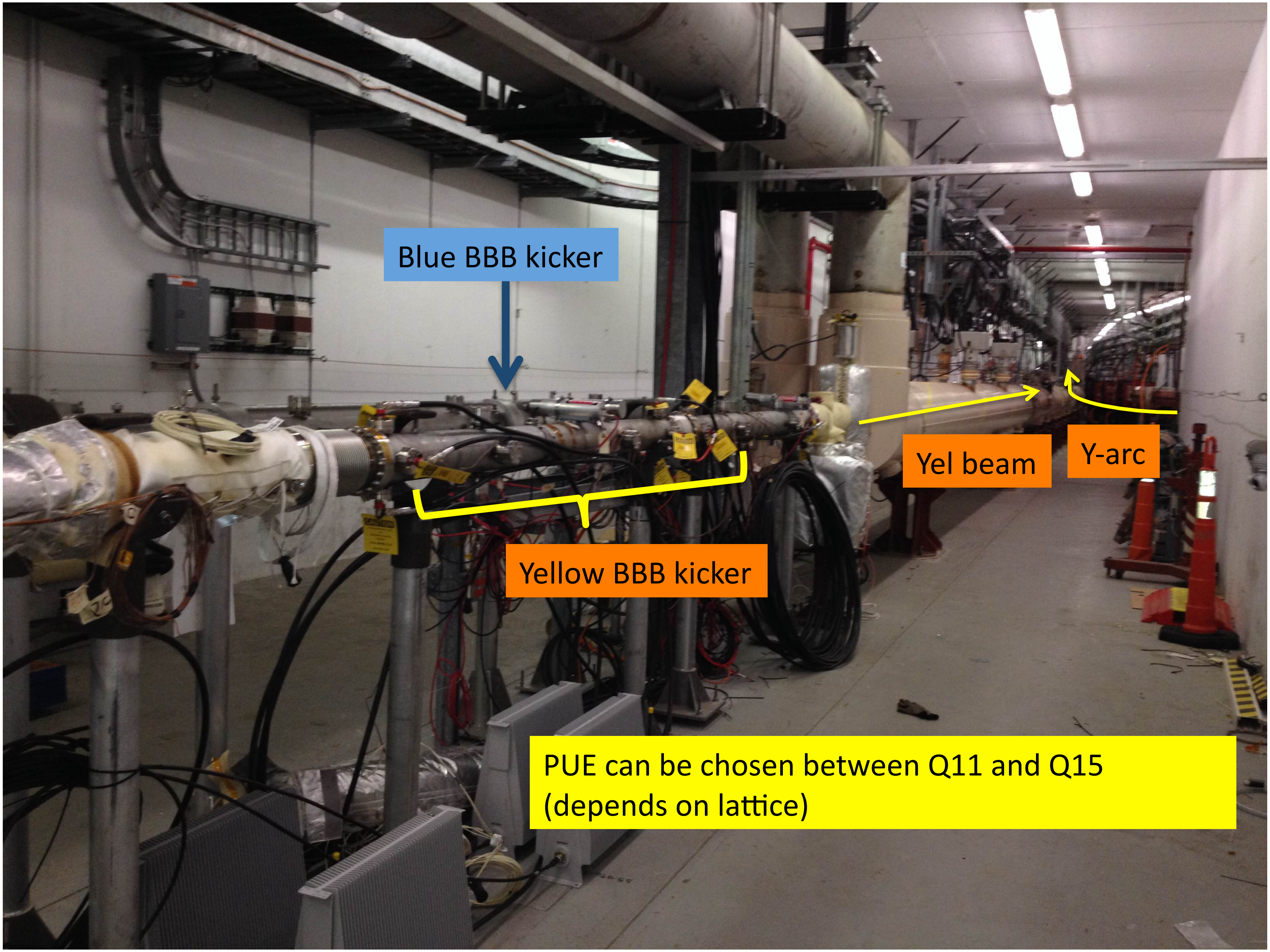
- E-lens presents a substantial impedance to the beam* , "transverse mode coupling instability" (think head-tail instability)
- Primary stabilizing force is the solenoidal field at the e-lens (pins the electrons)
- Additional stabilizing (against all coherent instabilities, including e-lens) to be provided by the transverse BBB damper.

$$B_{th} = 1.3 \frac{eN_p \xi_e}{r^2 \sqrt{\Delta Q Q_s}}.$$

B_{th} = min solenoid field for stability
r = beam radius (controlled via β*)

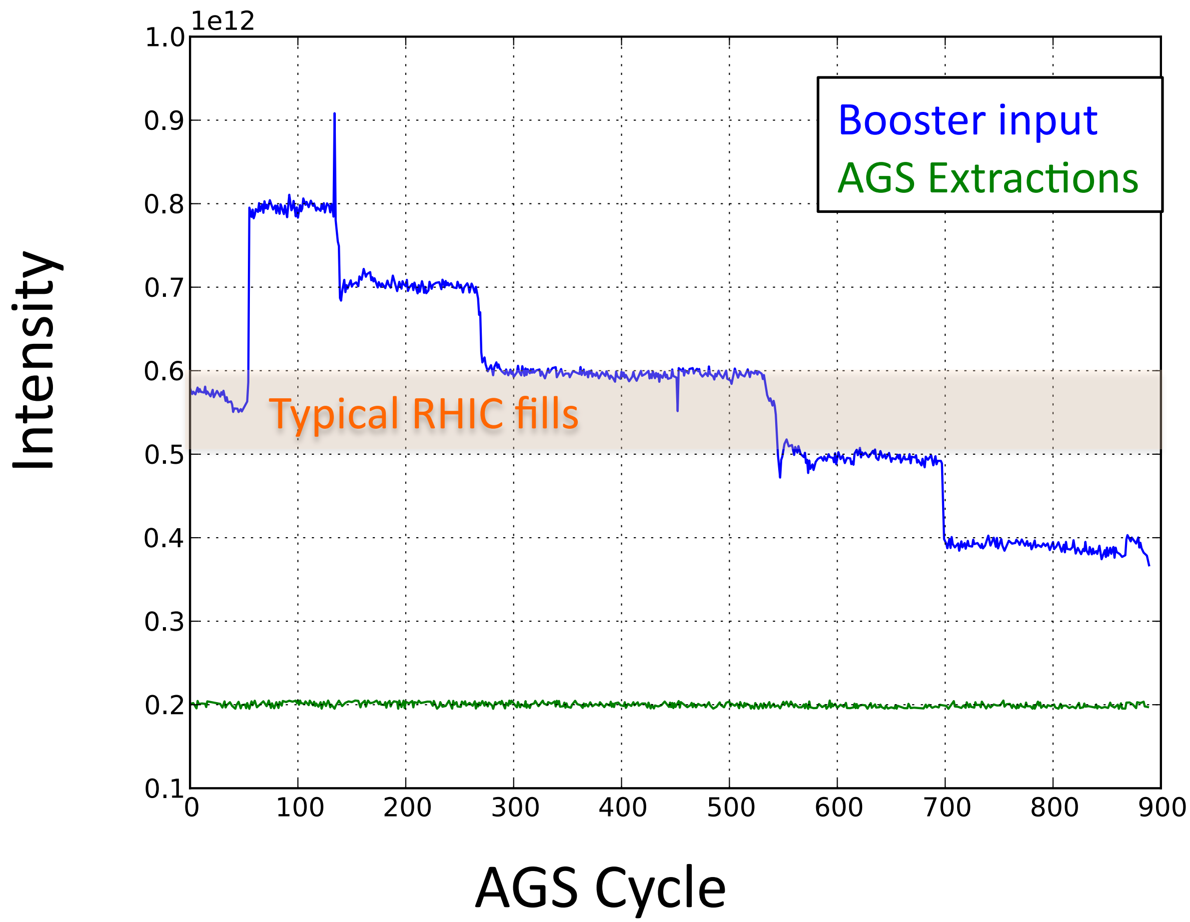
ΔQ = |Qx – Qy| (assumed to be 0.01, could be a problem)

*Burov et al, "Transverse beam stability with an 'electron lens'" Phys. Rev. E, Vol 59, Num 3 (1999)



Blue BBB kicker
Yel beam
Y-arc
Yellow BBB kicker
PUE can be chosen between Q11 and Q15
(depends on lattice)

So, RHIC will handle higher intensity… can the injectors deliver? (an important measurement from Run 14)



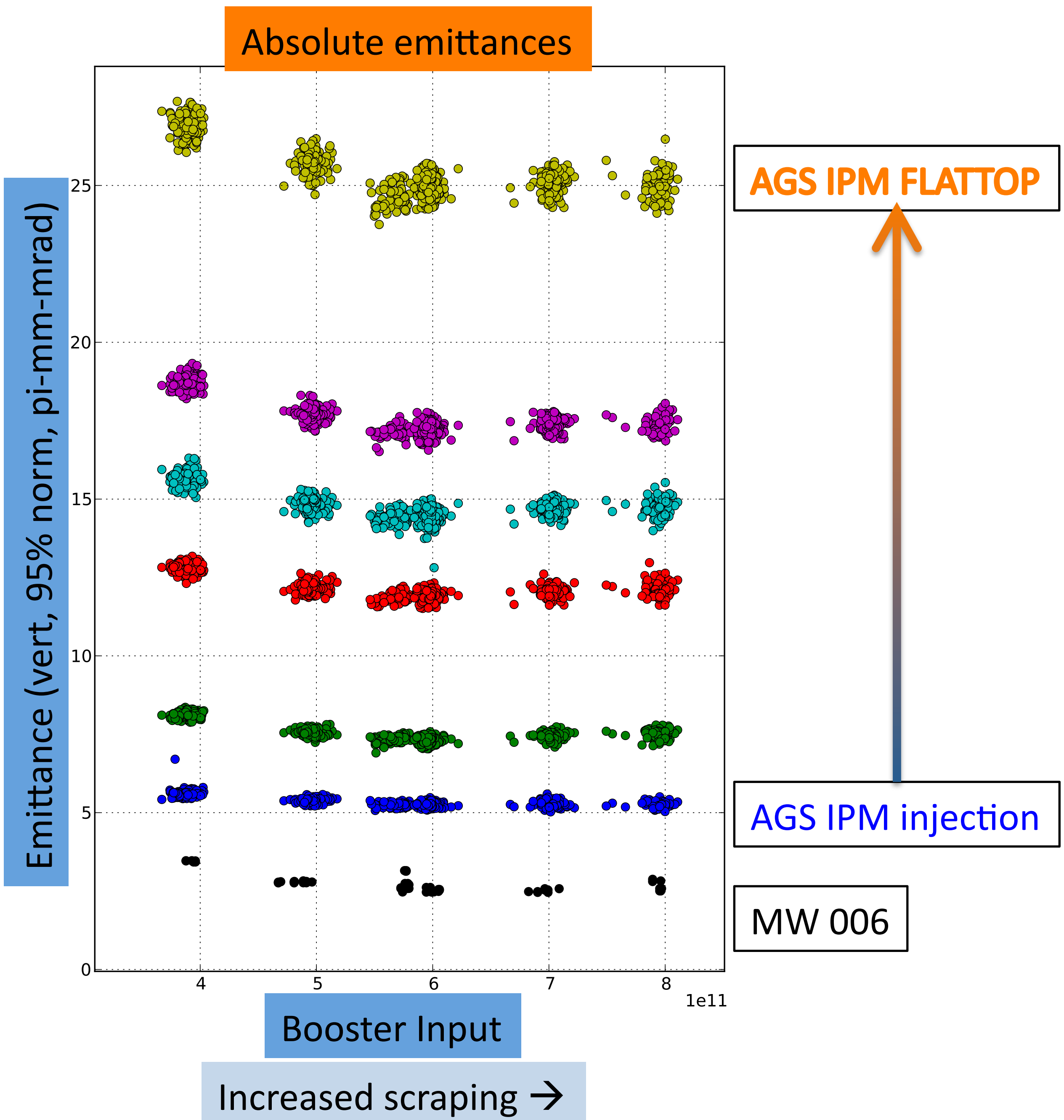
Change source temp to get different input

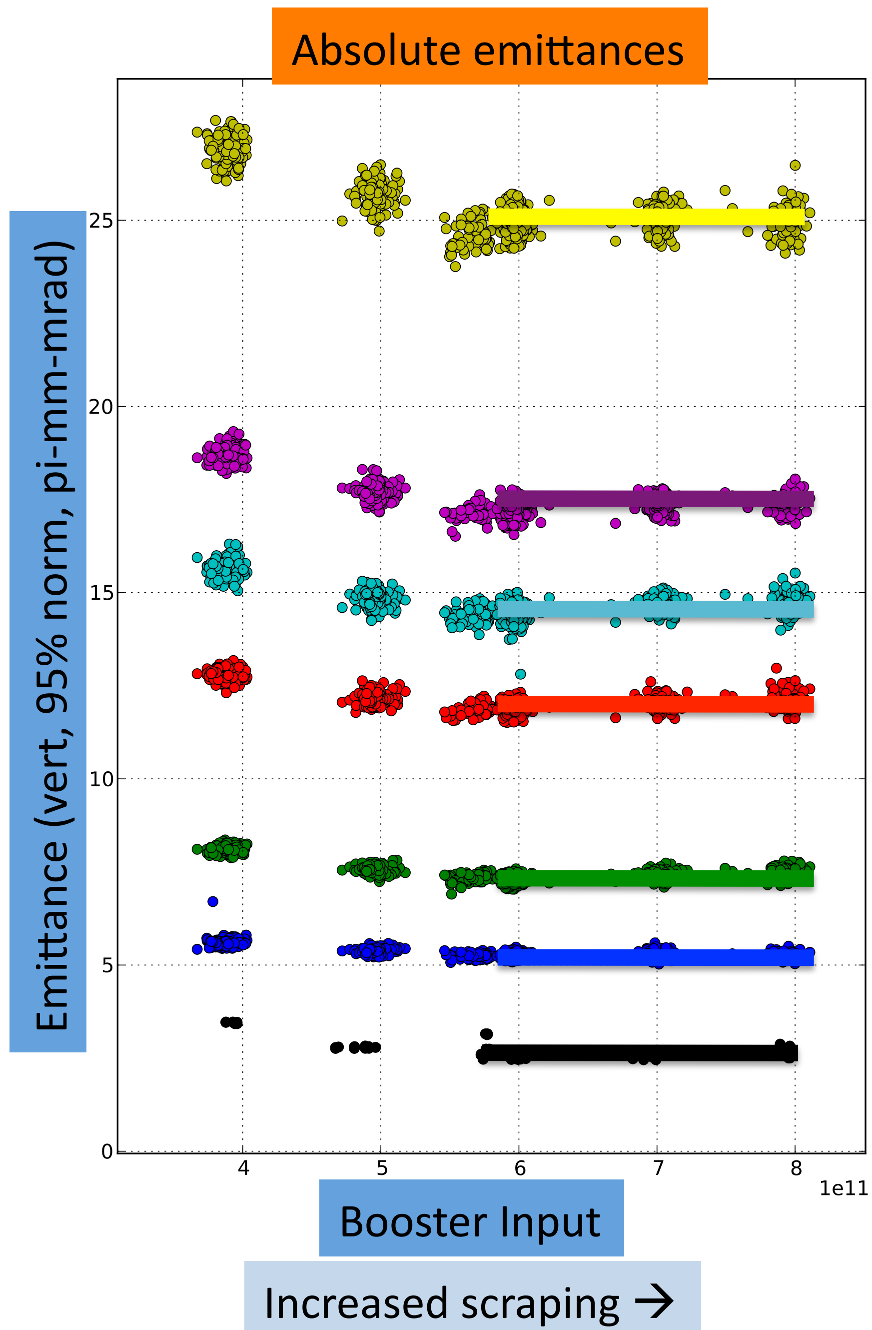
Adjust scraping to keep AGS extraction intensity constant

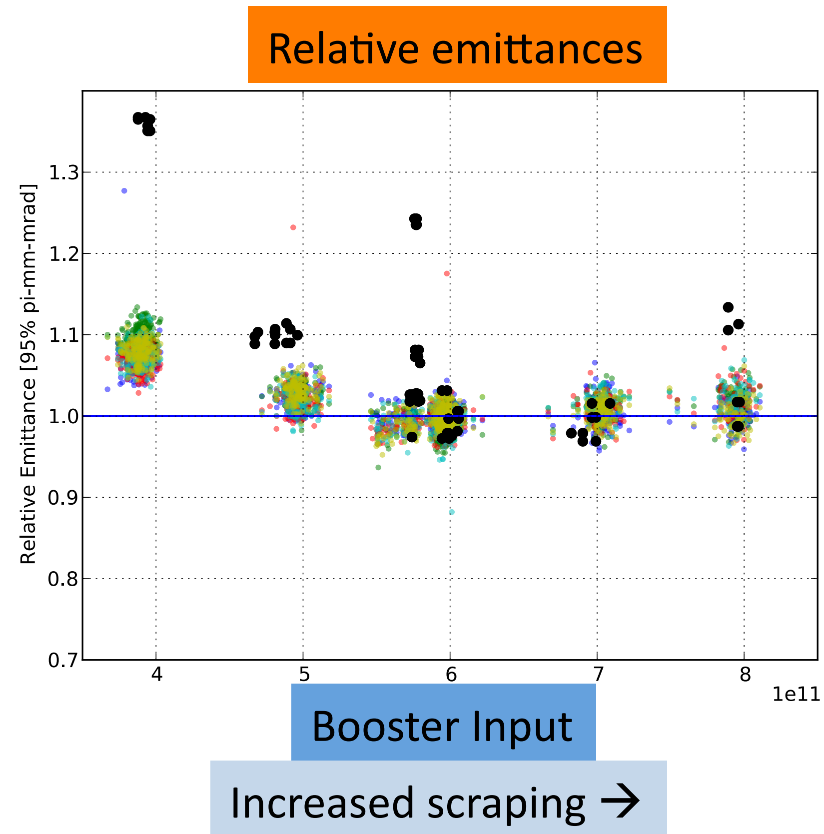
Measure emittances

Data cut:
AGS late = 2.0 +/- 0.05 e11

More scraping = lower emittance ???


Absolute emittances
Emittance (vert, 95% norm, pi-mm-mrad)
0
5
10
15
20
25
4
5
6
7
8
1e11
Booster Input
Increased scraping →
AGS IPM FLATTOP
AGS IPM injection
MW 006


Absolute emittances
Emittance (vert, 95% norm, pi-mm-mrad)
0
5
10
15
20
25
4
5
6
7
8
1e11
Booster Input
Increased scraping →


Relative emittances
Relative Emittance [95% pi-mm-mrad]
0.7
0.8
0.9
1.0
1.1
1.2
1.3
4
5
6
7
8
1e11
Booster Input
Increased scraping →

Booster emittance dilution

If we cannot get *brighter* beam from the more *intense* beam, then we lose (to say nothing of polarization)

- Possible cures (all aimed at space charge driven problems):
  - Second harmonic in RF (not two bunches, but flatter bunch)
  - Altered scraping scheme
    - Scrape earlier (pre blow-up), even just at injection (do not ever circulate in the Booster what we would scrape later)
  - Two bunches in the Booster, merge in the AGS (?!)

Booster emittance dilution

If we cannot get *brighter* beam from the more *intense* beam, then we lose (to say nothing of polarization)

Fixing this problem is crucial with or without the e-lens

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Conclusions

- The lattice is in really good shape
  - …and early
  - …and well-documented
  - …but needs to pass the spin test
  - …but the Devil is always in the ramp implementaion details
- E-lens driven improvements in figure of merit will only happen with a real improvement in the injectors (the Booster in particular)
- Important things I did not mention
  - eIPM: emittance understanding/preservation in AGS
  - 56 MHz: Is there are need for MD during pp?