
Polarization Is
Magic II
The Hidden Craft

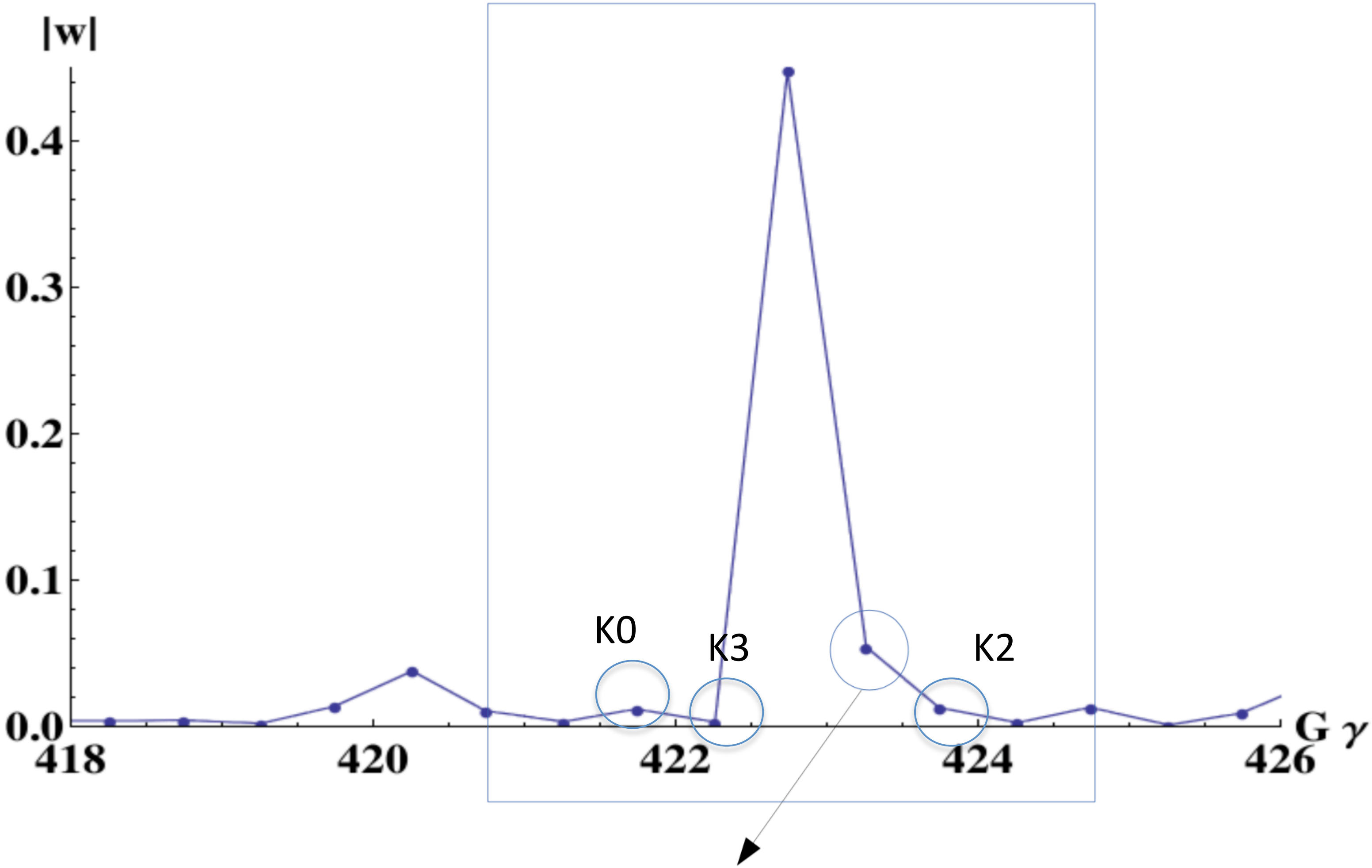
Preparation for FY17 pp run

- Requirements for Run:
  - Energy 255 GeV
  - E-lens phase advance between IP's 8 and 10.
  - Luminosity leveling
  - Transverse Polarization
- Differences from FY13 run:
  - No PHENIX
  - No orbit offset through STAR
  - No Rotators (no rotator ramp)

E-lens phase advance vs. Polarization

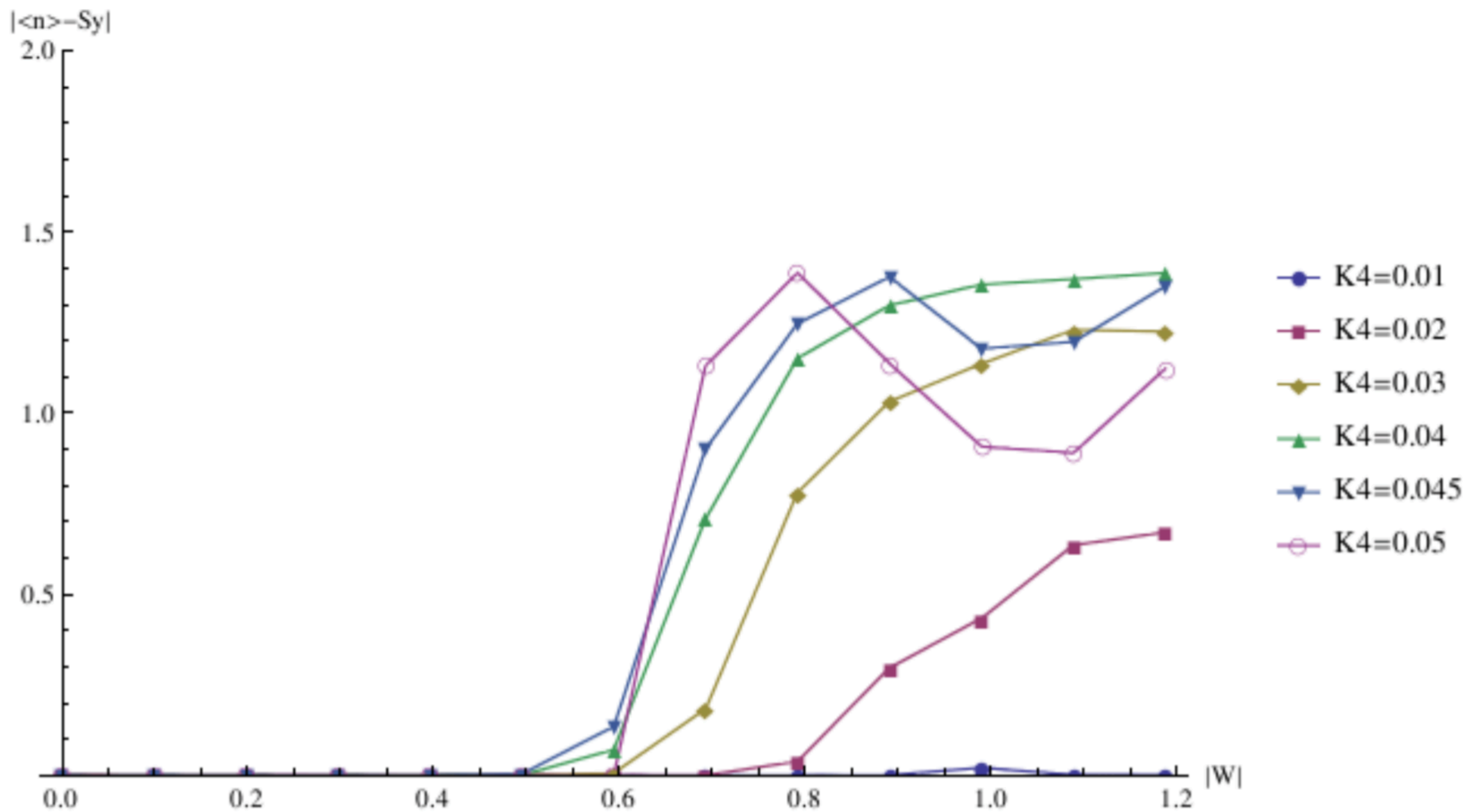
- On Ramp losses at the three strongest resonances yield a total of ~ 10-20% loss depending on emittance:
  – Larger nearby resonances made these losses worse for the old e-lens lattice.
  – Theoretical work suggests these losses can be mostly eliminated by reducing these smaller resonance < 0.01 magnitude at 10PI mm-mrad
- Simulations of store Polarization lifetime show that it can suffer due to higher low level resonances.

Analysis of FY12 lattice Crossing 393+NU resonance

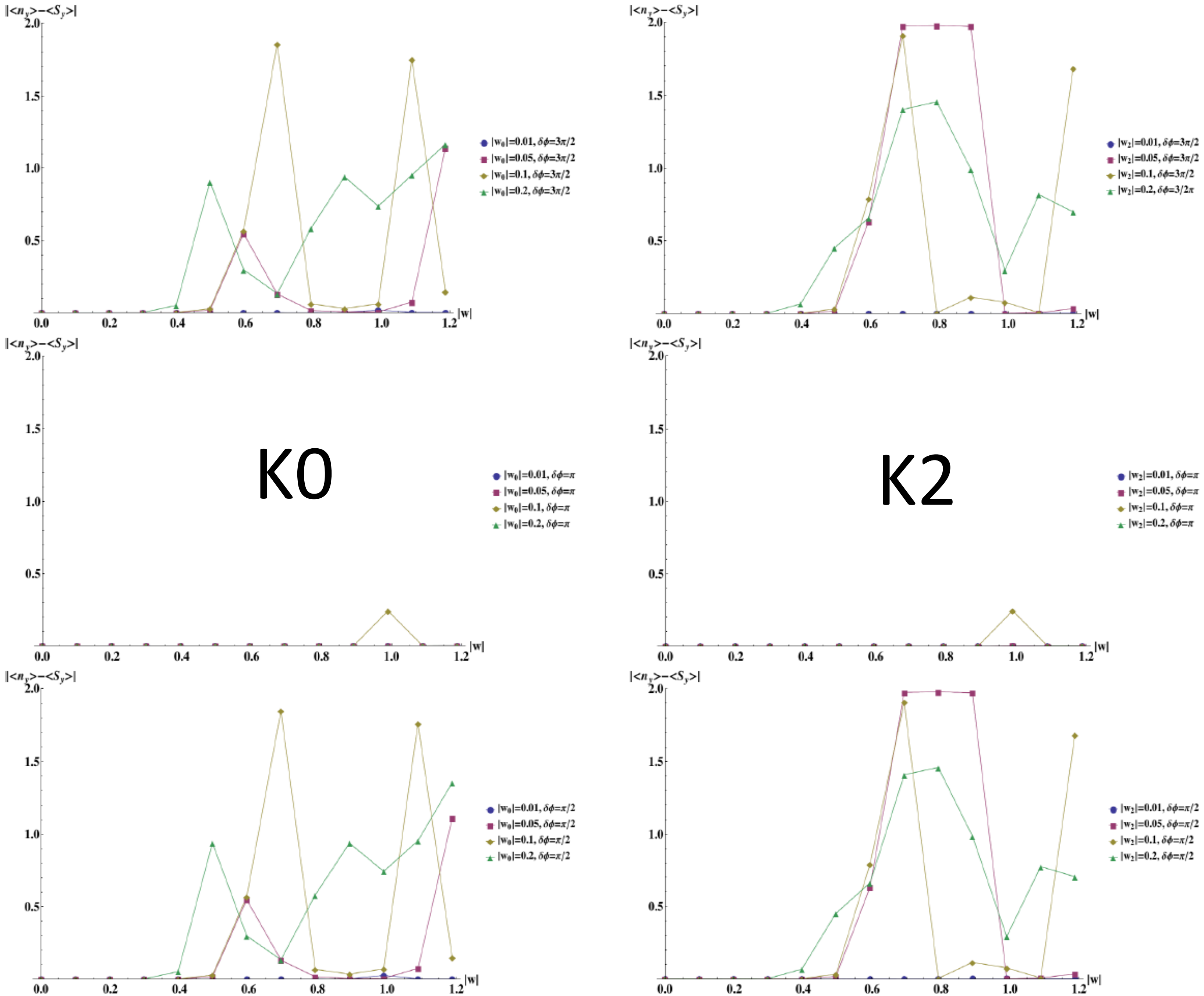


K4=423.325 largest nearby resonance.

K4 seems singular in determining polarization aperture.



Lattice independent tracking with 5 resonance from FY12 varying K4=423.325 strength


|<n_y>−<S_y>|
|w|
|w_0|=0.01, δφ=3π/2
|w_0|=0.05, δφ=3π/2
|w_0|=0.1, δφ=3π/2
|w_0|=0.2, δφ=3π/2
|w_2|=0.01, δφ=3π/2
|w_2|=0.05, δφ=3π/2
|w_2|=0.1, δφ=3π/2
|w_2|=0.2, δφ=3/2π
K0
|w_0|=0.01, δφ=π
|w_0|=0.05, δφ=π
|w_0|=0.1, δφ=π
|w_0|=0.2, δφ=π
K2
|w_2|=0.01, δφ=π
|w_2|=0.05, δφ=π
|w_2|=0.1, δφ=π
|w_2|=0.2, δφ=π
|w_0|=0.01, δφ=π/2
|w_0|=0.05, δφ=π/2
|w_0|=0.1, δφ=π/2
|w_0|=0.2, δφ=π/2
|w_2|=0.01, δφ=π/2
|w_2|=0.05, δφ=π/2
|w_2|=0.1, δφ=π/2
|w_2|=0.2, δφ=π/2

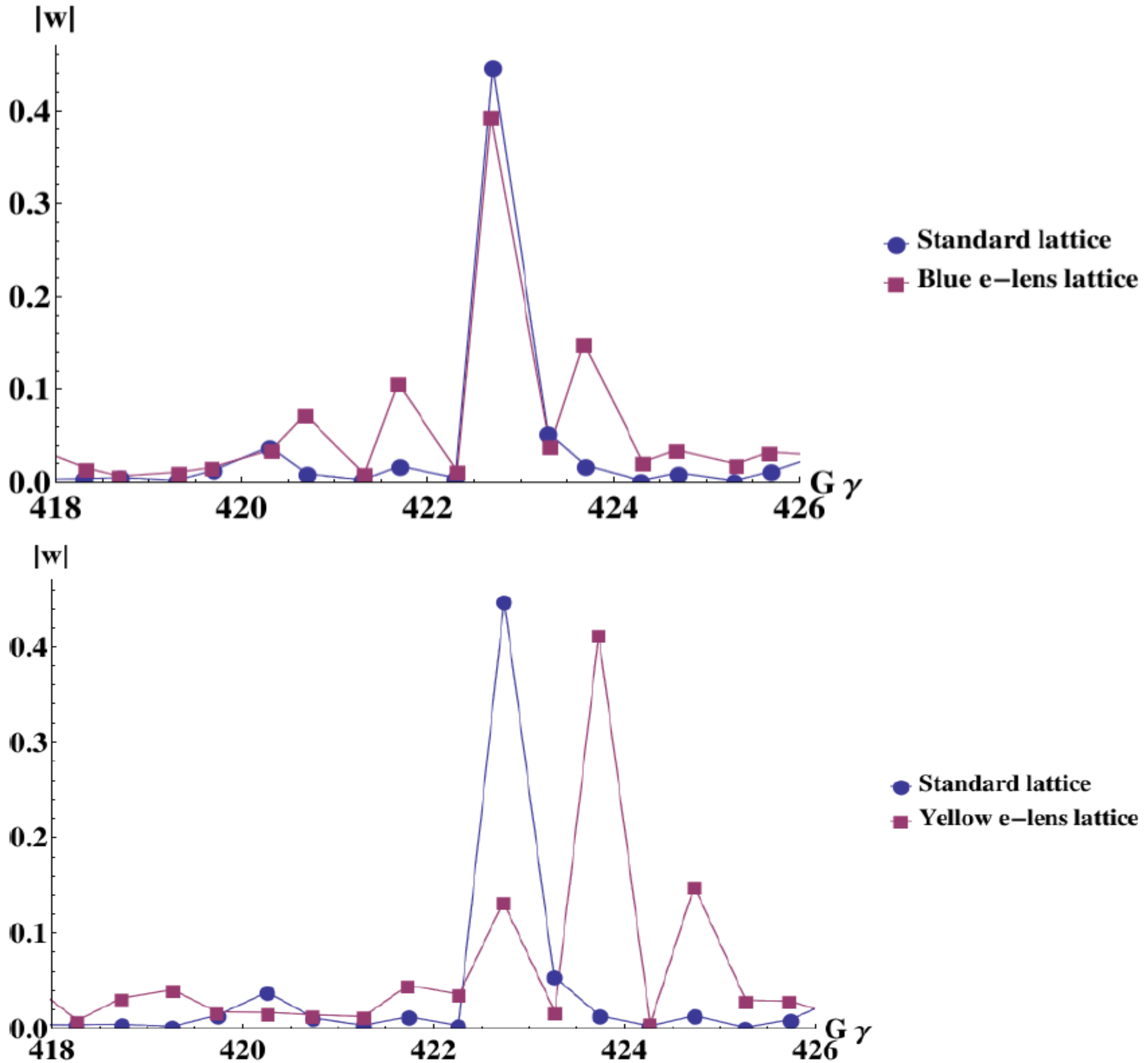


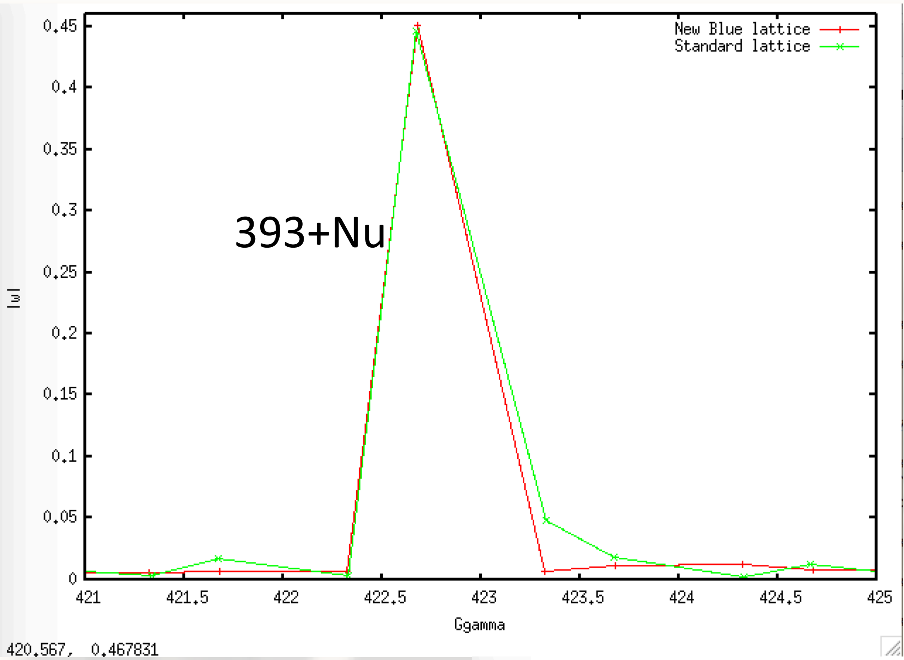
FIG. 1. Comparison of the Blue (top) and Yellow (bottom) e-lens intrinsic resonance strengths with standard RHIC lattice for $393 + \nu_y$

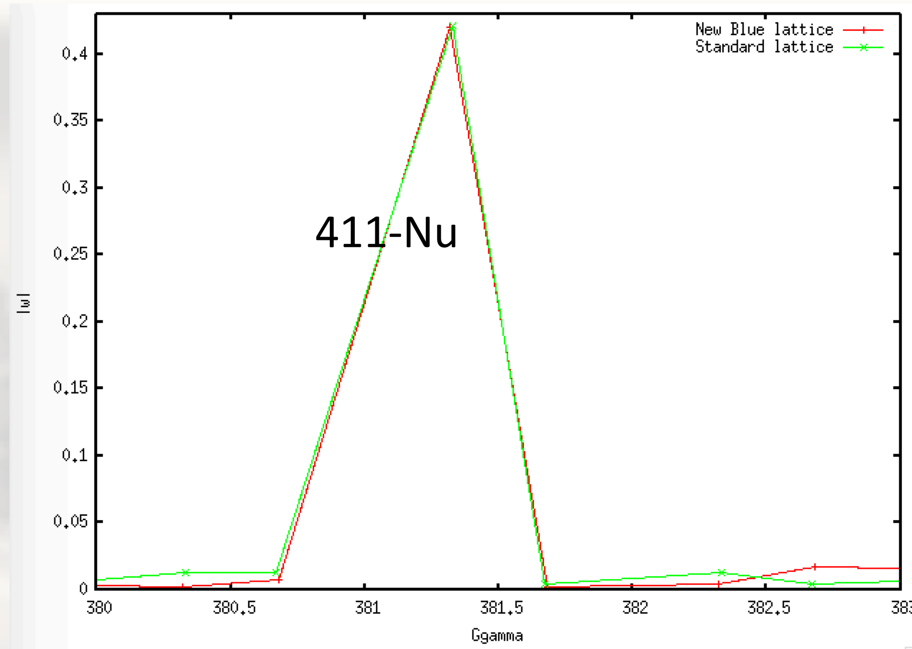
Challenges designing e-lens lattice

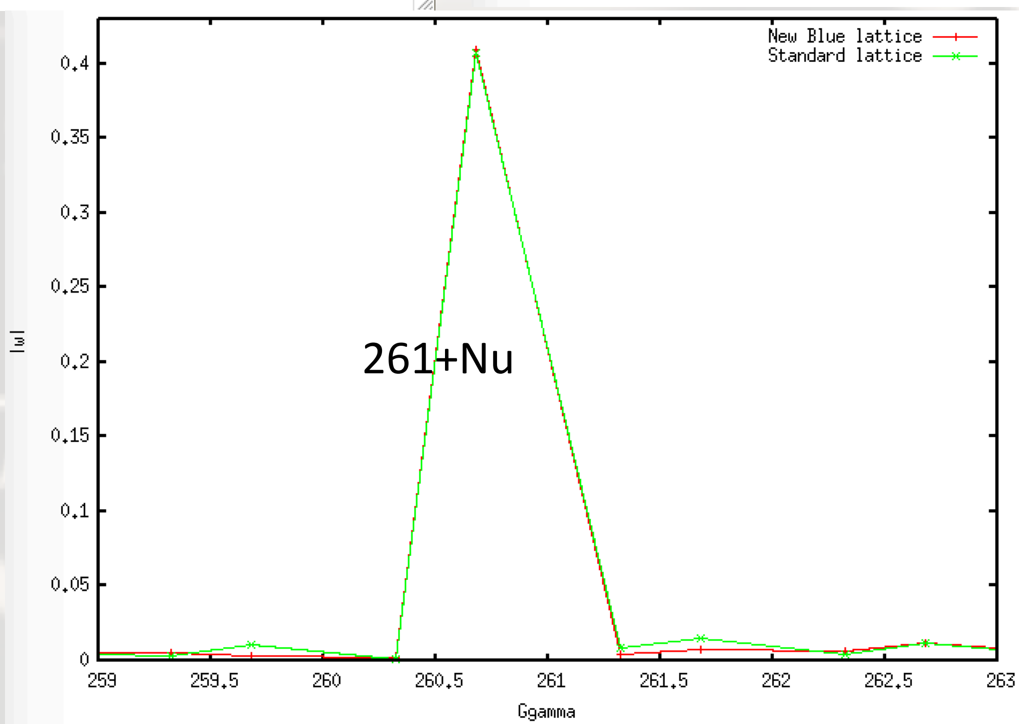
- For Blue lattice on the ramp, we have solutions which minimize the neighboring spin resonances using the standard lattice with standard integer tunes.
- The old e-lens lattices all used integer tunes higher or lower than the standard lattice.
  - We could not yet find a good solution for the neighboring resonances using the higher tunes in Blue (what was used at 100 GeV in FY15)
  - We did manage to modify the Blue standard lattice with standard tunes to achieve the appropriate phase advance
    - However this required larger beta functions in the arc between IP8 and IP10. We are currently testing this lattice for DA to see how it performs
  - The yellow standard lattice is already very close to the appropriate phase advance necessary for e-lens. So we have developed a solution which keeps the beta functions nearly unchanged. We also are in the process of testing this solution for DA performance.

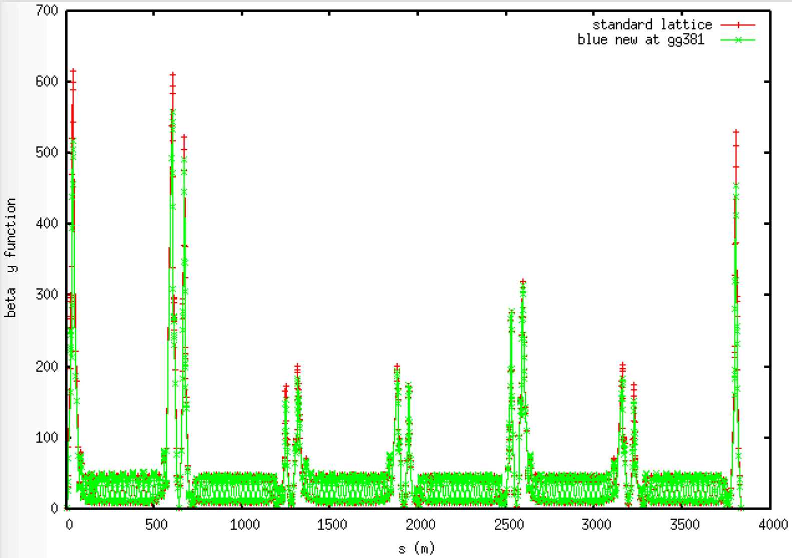
Tentative Solution

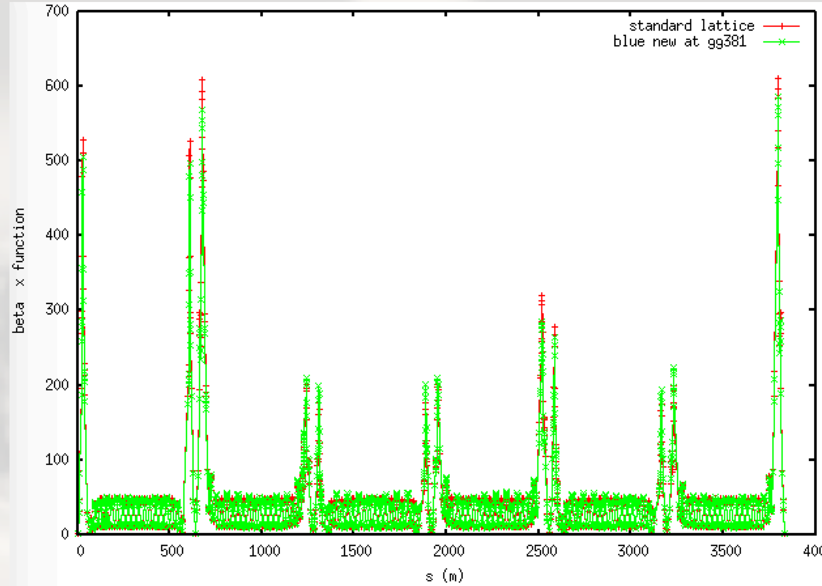
- We have both Blue and Yellow stored lattice which seem to meet our requirements and live at the original standard lattice tunes.
- We also have solutions for these tunes on the ramp which should minimize polarization losses.
- Since they are both in the same tune space we hope that we can ramp from one to the other configuration without too much trouble.

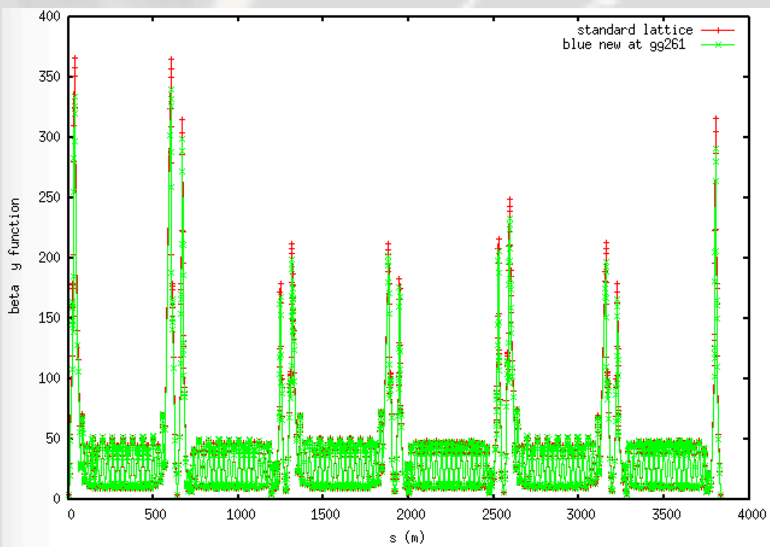

393+Nu
New Blue lattice
Standard lattice
|ω|
Ggamma
420.567, 0.467831

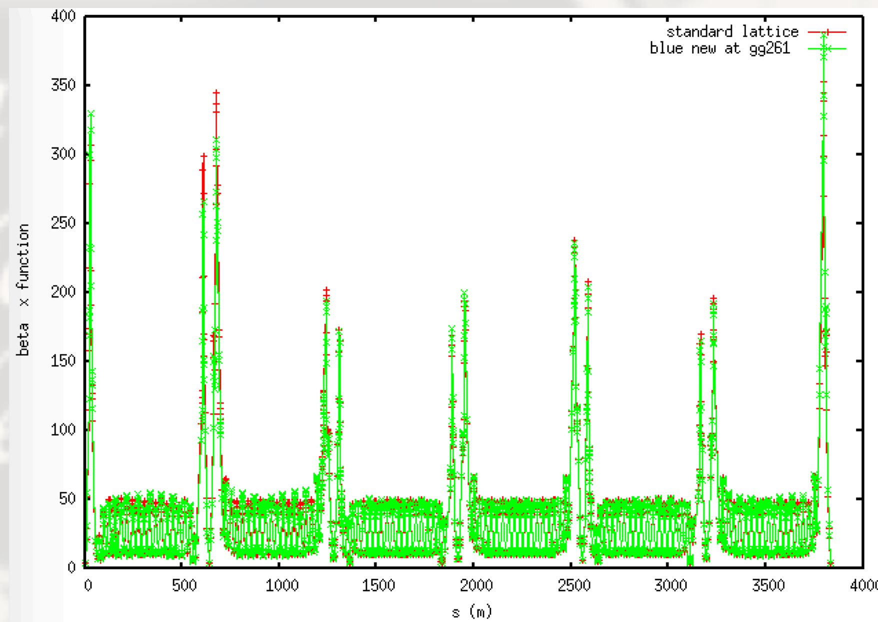

411-Nu
New Blue lattice
Standard lattice
|ω|
Ggamma

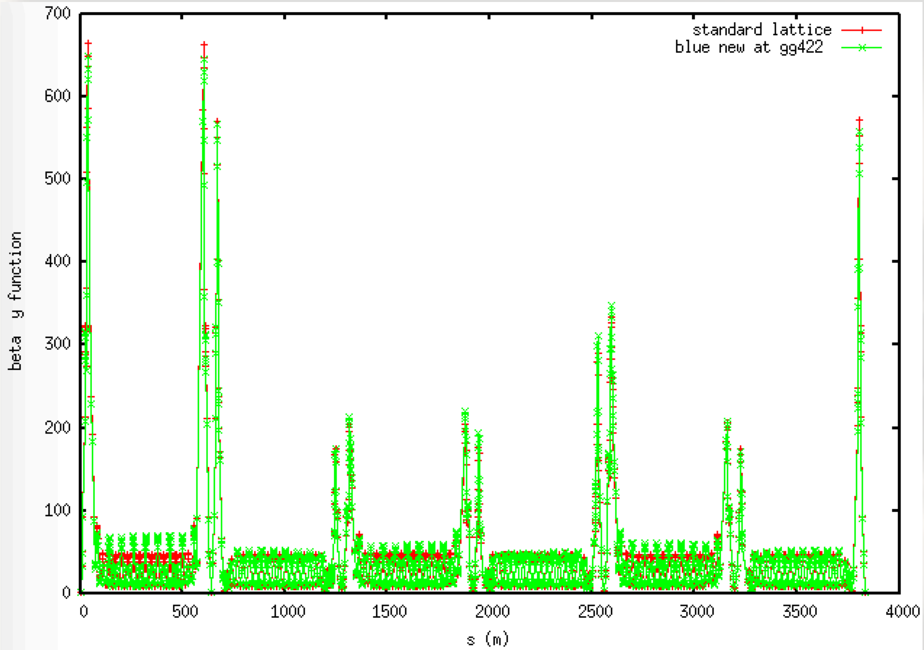

261+Nu
New Blue lattice
Standard lattice
|ω|
Ggamma

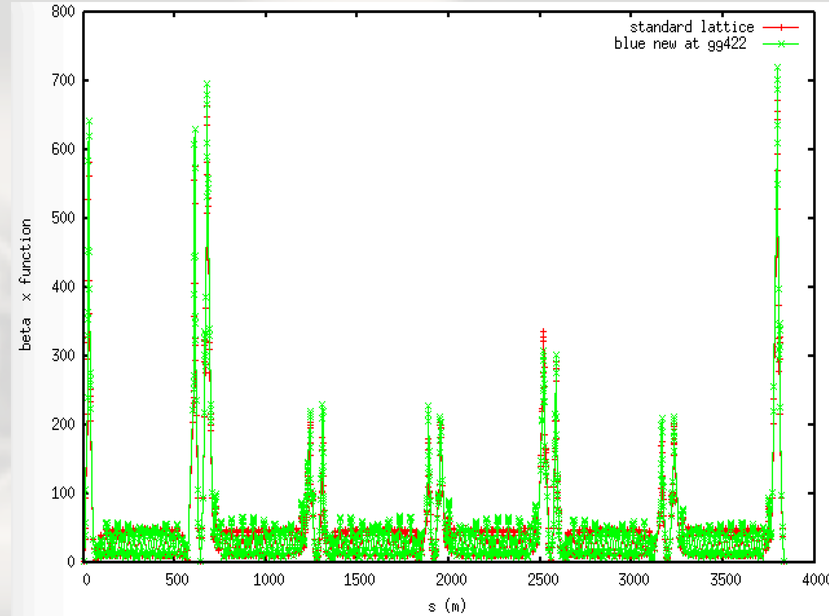

standard lattice
blue new at gg381
beta y function
s (m)

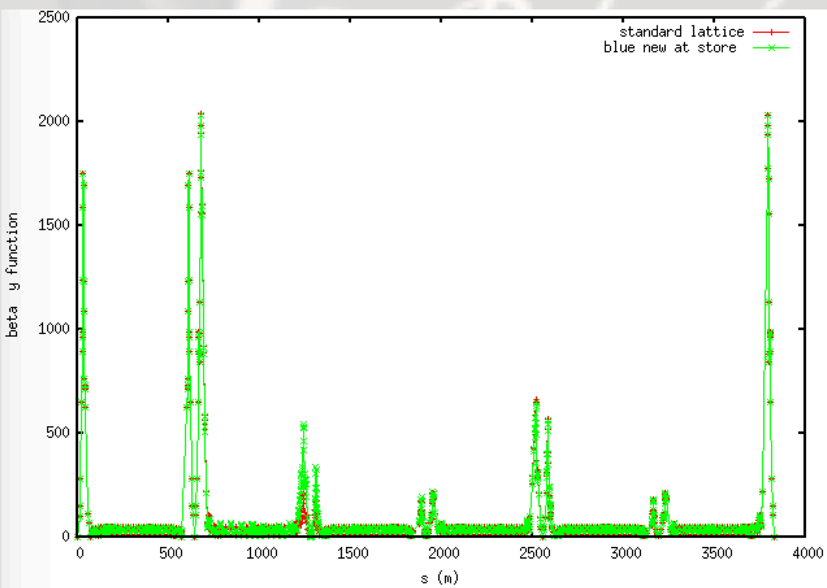

standard lattice
blue new at gg381
beta x function
s (m)

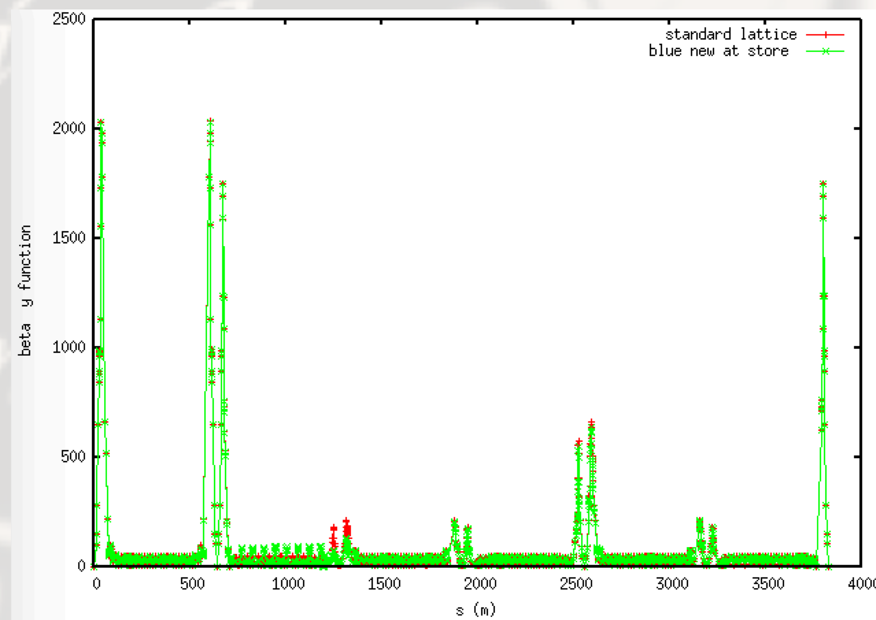

standard lattice
blue new at gg261
beta y function
s (m)


standard lattice
blue new at gg261
beta x function
s (m)


standard lattice
blue new at gg422
beta y function
s (m)
0
100
200
300
400
500
600
700
0
500
1000
1500
2000
2500
3000
3500
4000

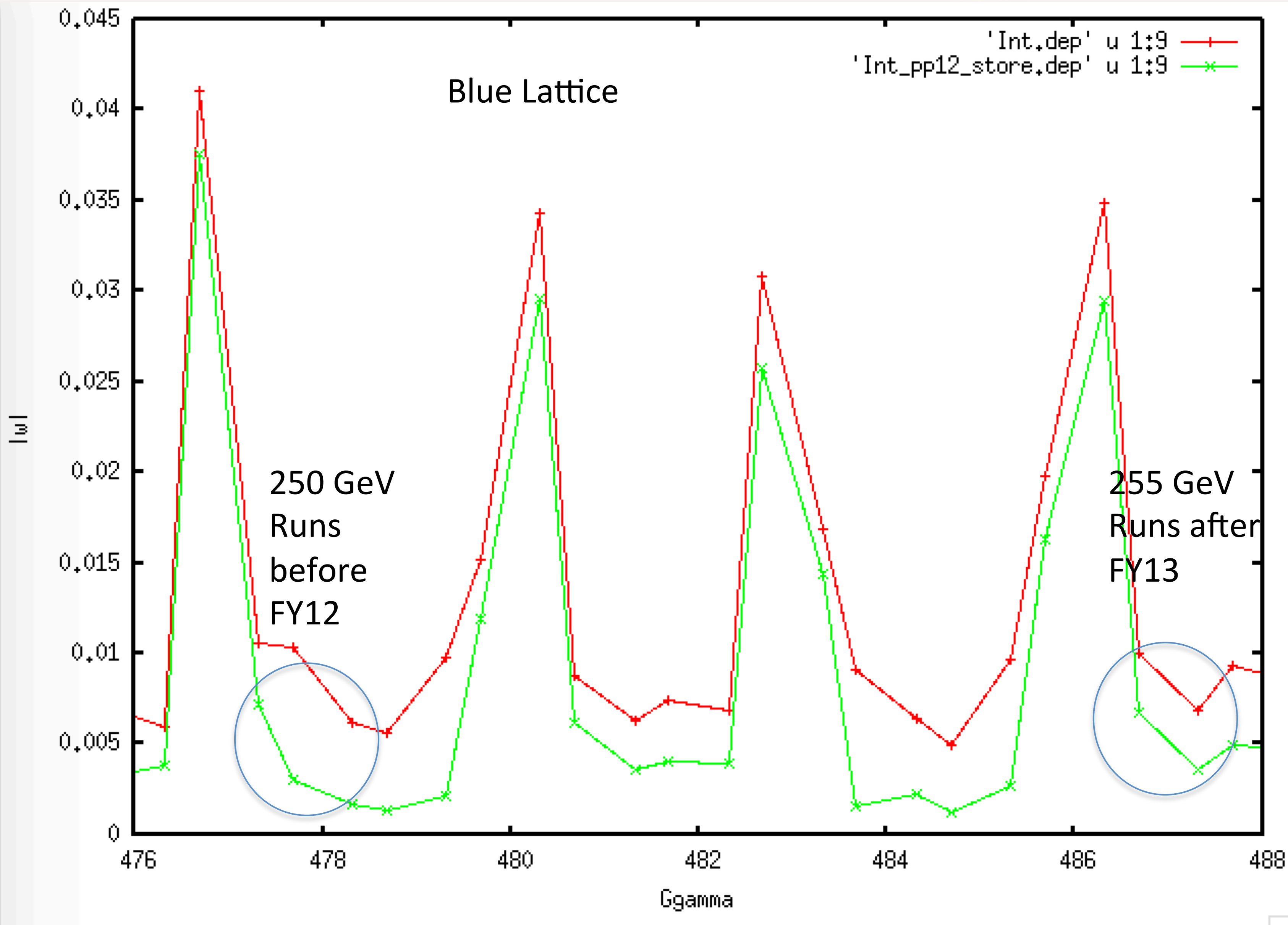

standard lattice
blue new at gg422
beta x function
s (m)
0
100
200
300
400
500
600
700
800
0
500
1000
1500
2000
2500
3000
3500
4000


standard lattice
blue new at store
beta y function
s (m)
0
500
1000
1500
2000
2500
0
500
1000
1500
2000
2500
3000
3500
4000

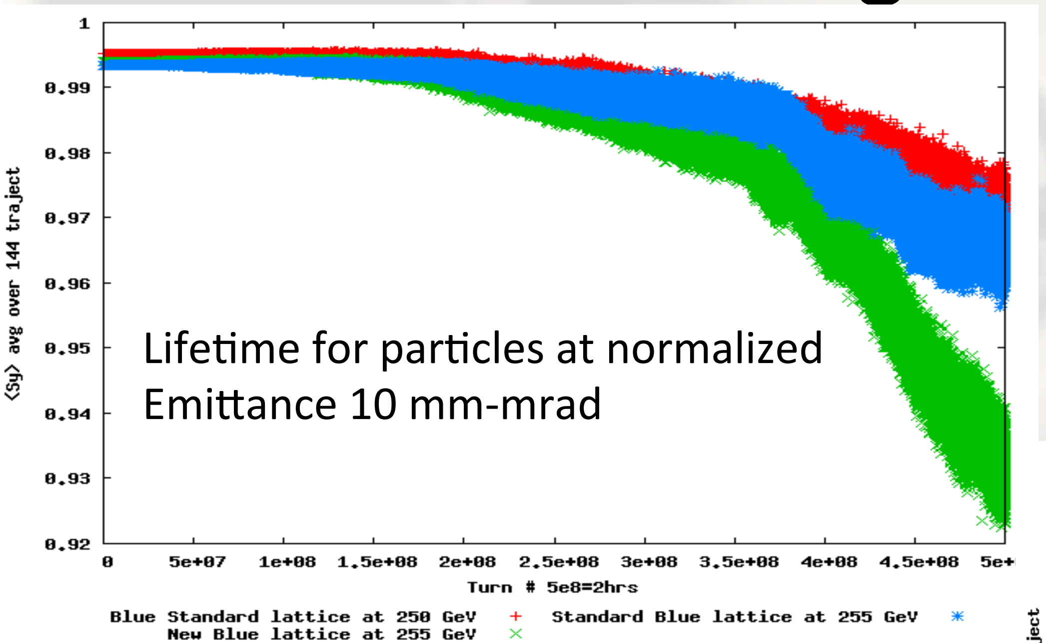

standard lattice
blue new at store
beta y function
s (m)
0
500
1000
1500
2000
2500
0
500
1000
1500
2000
2500
3000
3500
4000

Polarization Lifetime issues

- Recent Simulation work has demonstrated the importance of the strength of the nearest spin resonance to lifetime.
- However for the Blue with e-lens phase advance at the standard lattice tunes, so far, I don’t have solution which makes the intrinsic resonance the same or better at energies around 250-255 GeV
- Yellow the situation is better we are about the same.

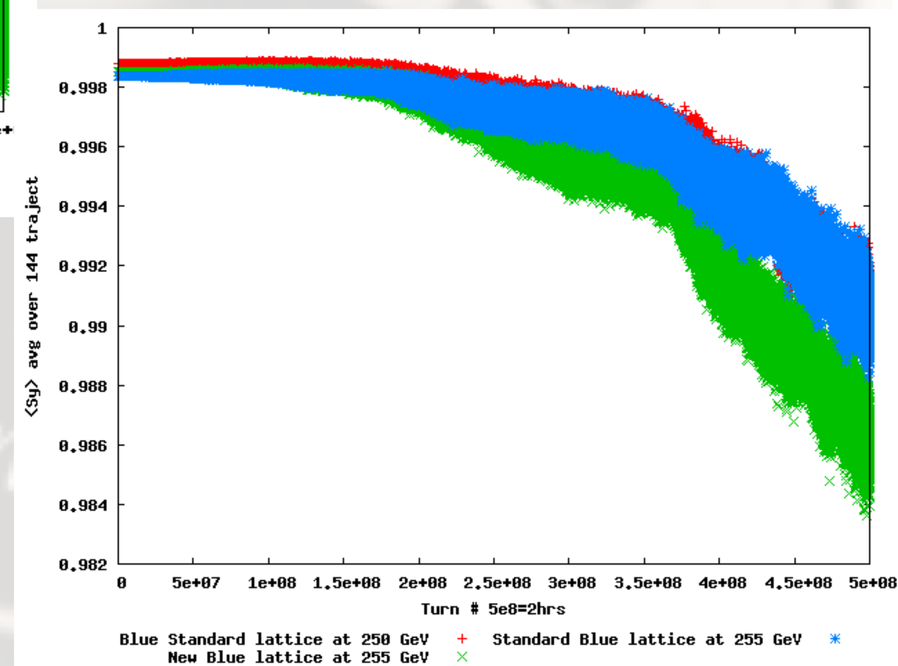

Blue Lattice
'Int.dep' u 1:9
'Int_pp12_store.dep' u 1:9
250 GeV
Runs
before
FY12
255 GeV
Runs after
FY13
|ε|
Ggamma
0
0.005
0.01
0.015
0.02
0.025
0.03
0.035
0.04
0.045
476
478
480
482
484
486
488

Resonance Strength and Pol. Lifetime

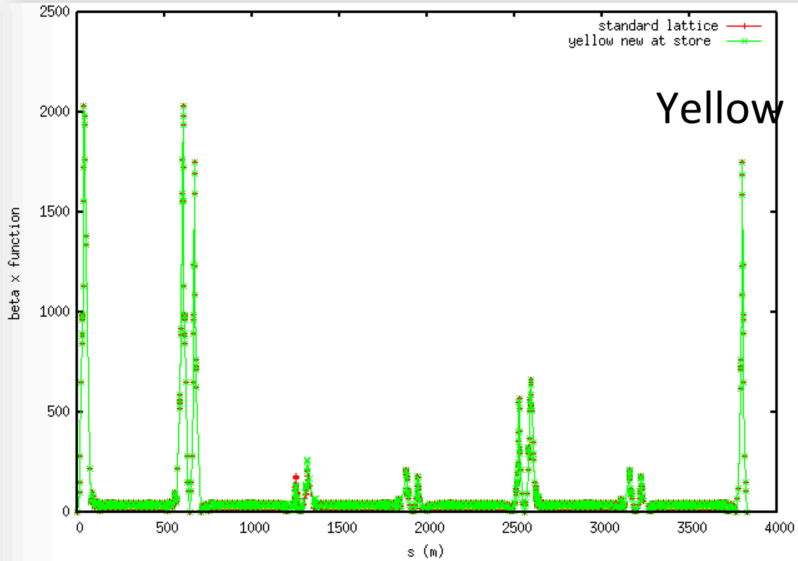


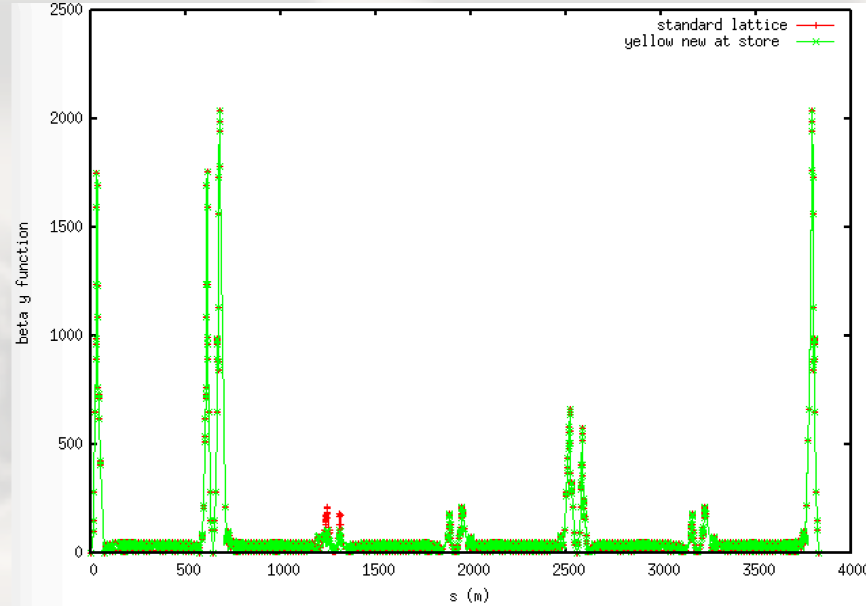
Lifetime for particles at normalized Emittance 10 mm-mrad

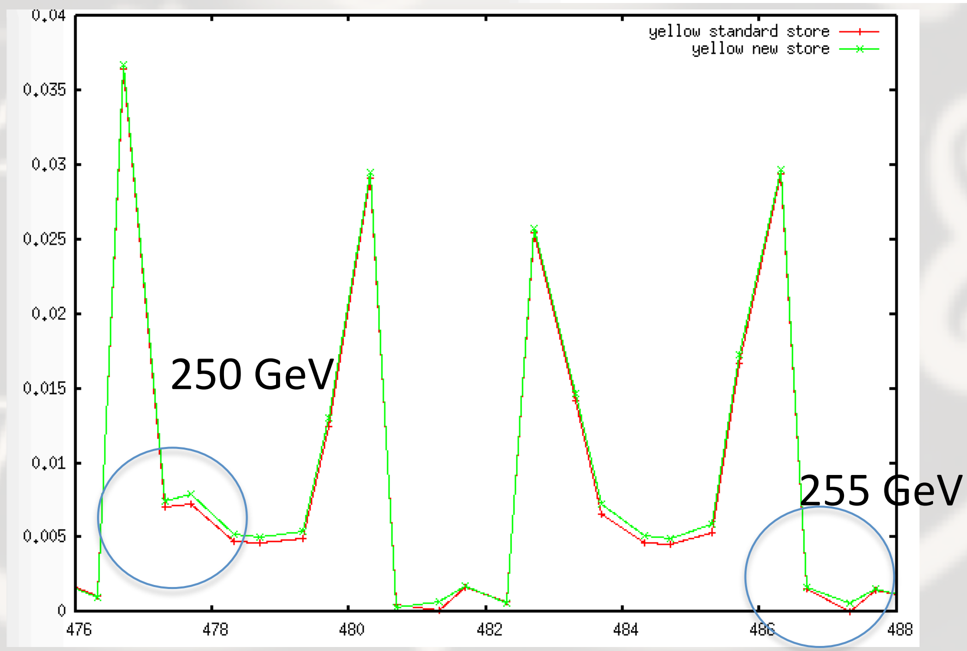
Lifetime for particles at normalized Emittance 2.5 mm-mrad



Yellow lattice





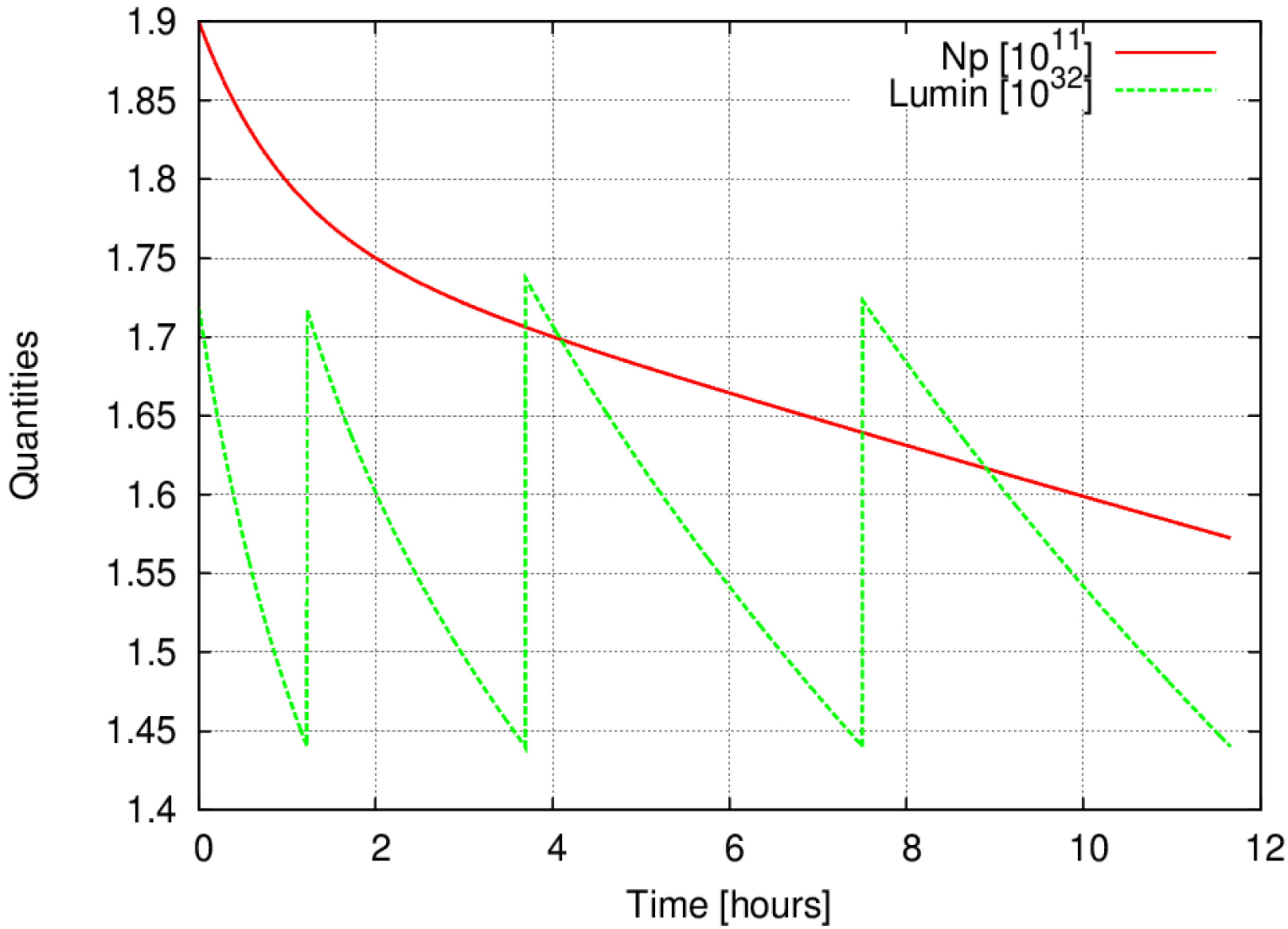


Luminosity Leveling

- STAR requires ZDC rates between 385-315kHz which translates in lumi of 1.76-1.44e32 cm^-2 s^-1
- Three approaches to achieve this:
  - Offset collisions → bad impact on polarization sampled since best beam in the bunch center
  - Dynamic Beta squeeze→ Yun has estimated we can get away with only two squeezes over a 7 hour store. (from 1 to 0.8 to 0.6)
  - Design lattice with ‘great’ lifetime

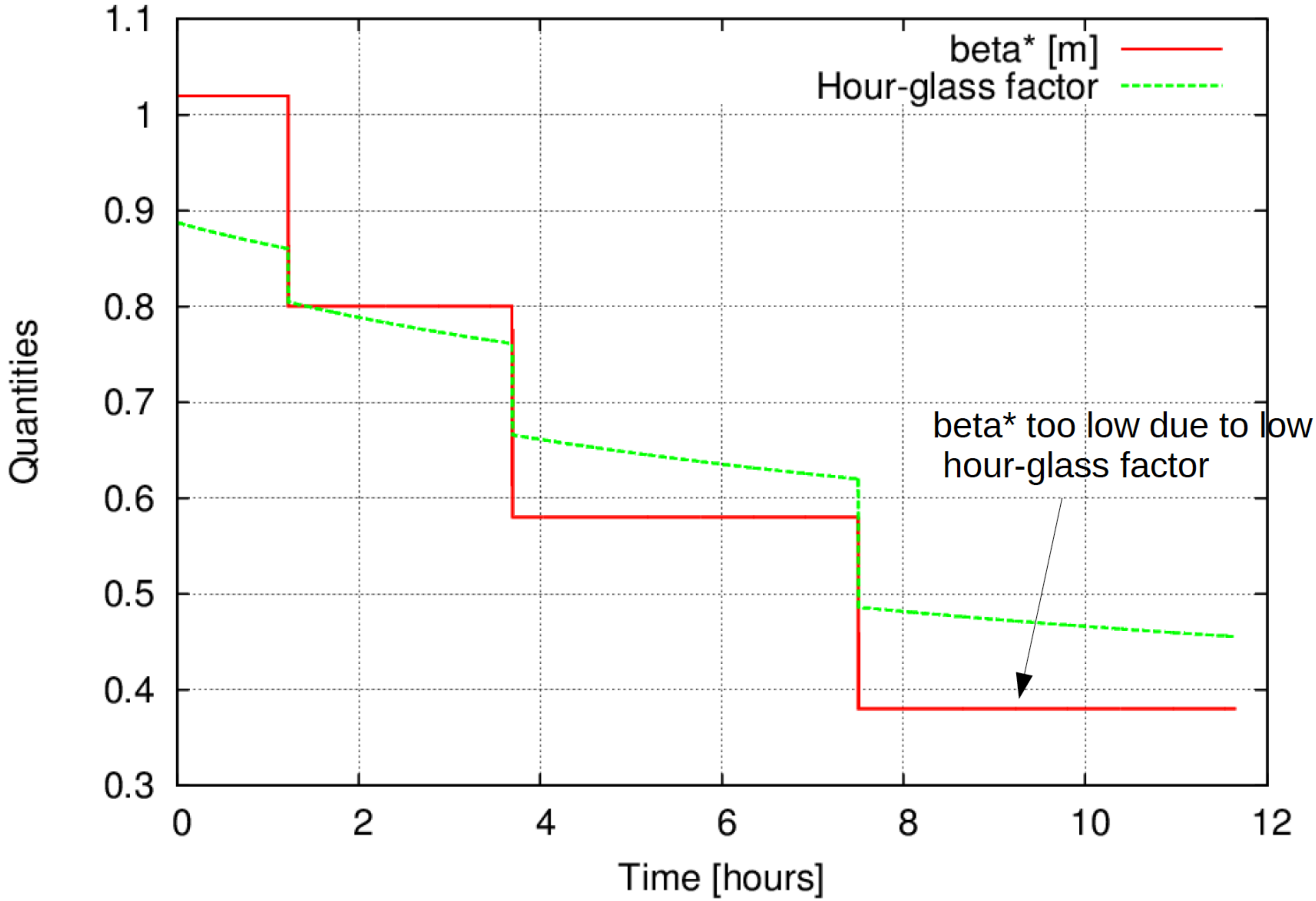
Courtesy Yun Luo

Case I : initial Np=1.9e11



Assuming `Np= Np0 *( 0.07 *exp(-t/1.0) + 0.93 *exp(-t/100.) )`

Courtesy Yun Luo



Conclusion

- We are closing in on a final stored lattice and designs for the three important stones, gg260,gg381 and gg422.
  - Next we need to check the DA and Pol. Lifetime results for the stored lattice
  - Design Ramp trajectory to move from injection through stones to stored solution.
- We have several strategies to handle luminosity leveling
- We are optimistic that if we can successfully suppress the neighboring resonances that we might be able to eliminate polarization losses on the ramp for even the large emittance bunches.

Thanks

- Guillaume Robert-Demolaize, Yun Luo
- Also: Chuyu Liu, Wolfram Fischer, Vincent Schoefer, Elke Aschenauer.