APEX Workshop 2013

He^3–Au in RHIC and possible studies

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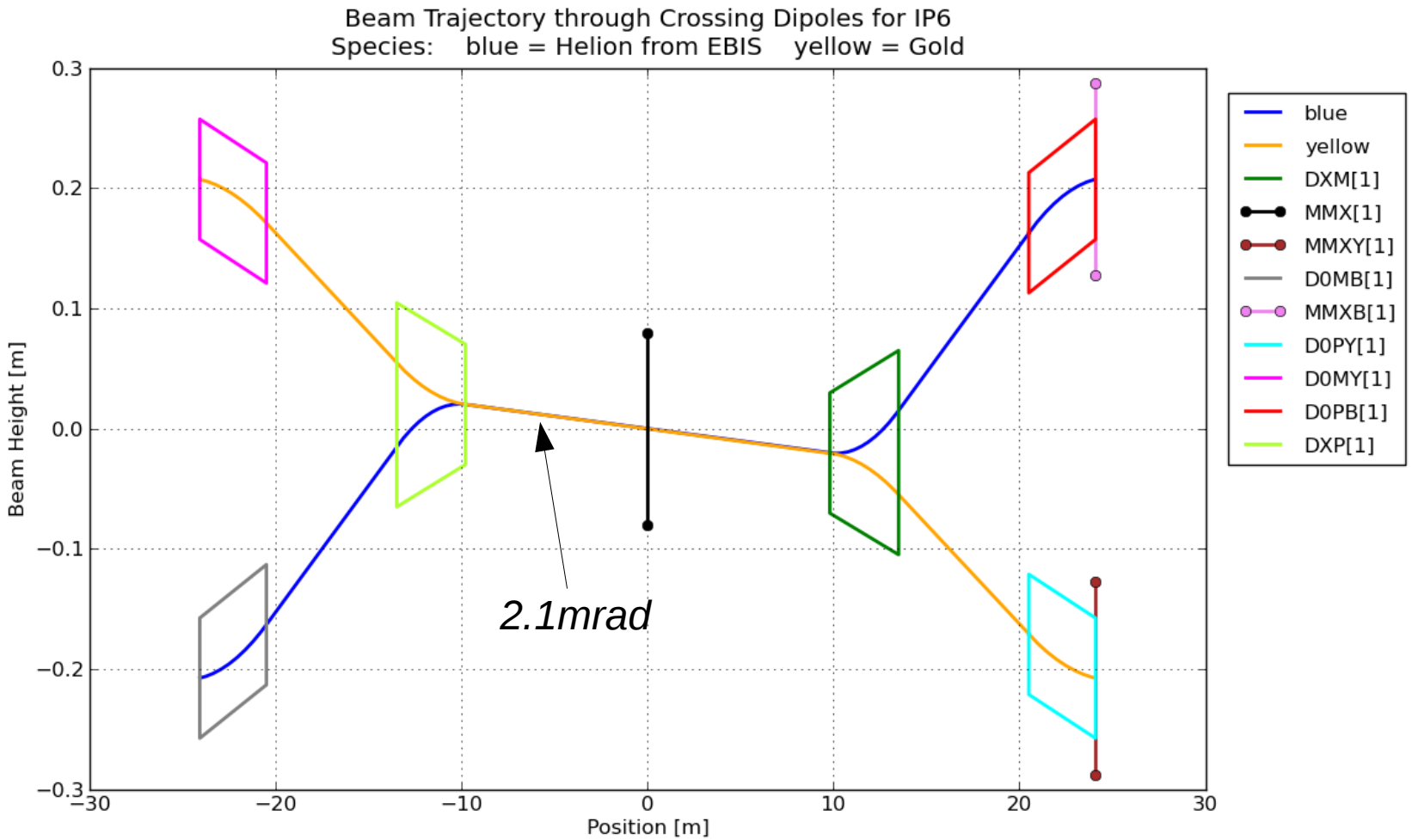
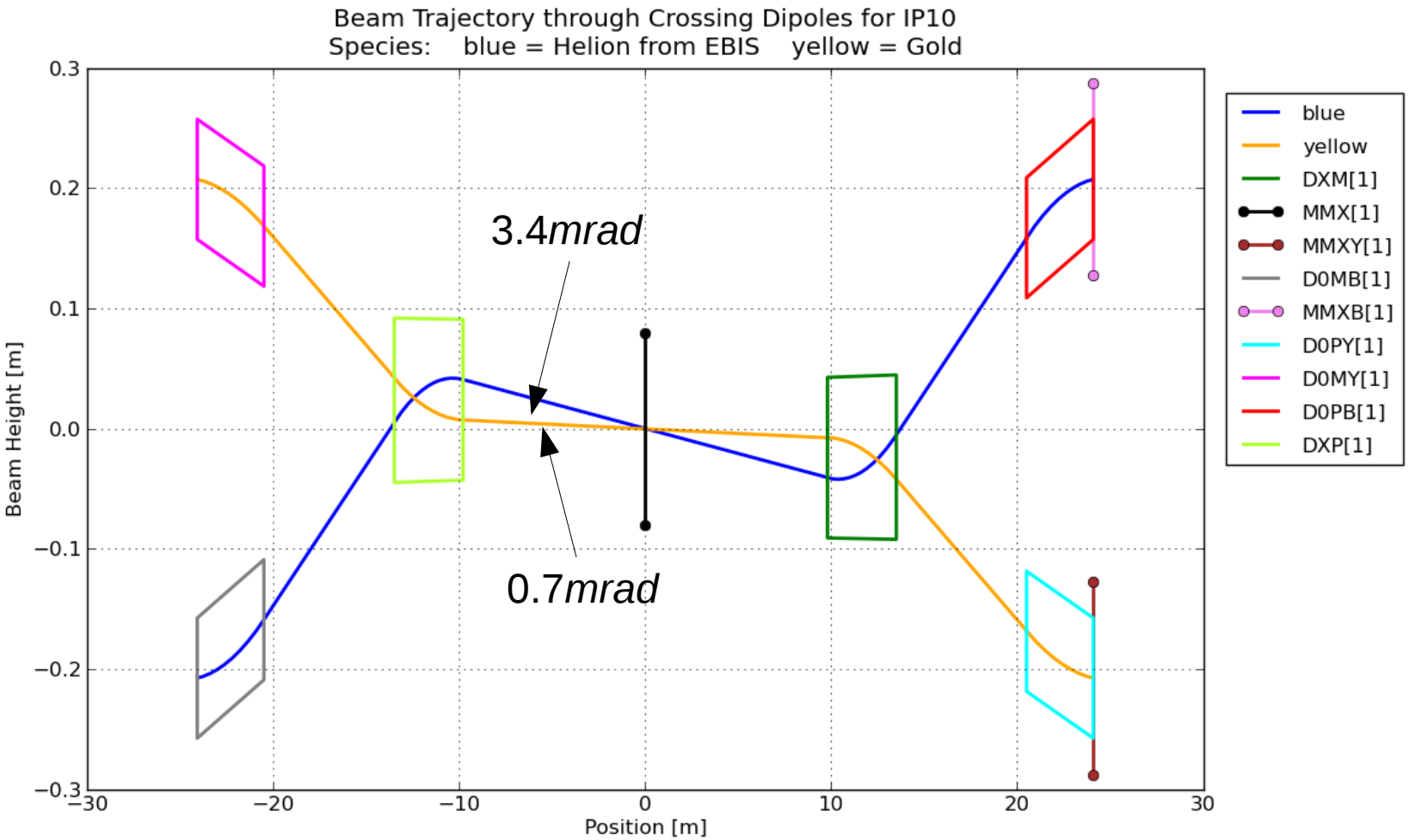
He^3–Au Colliding IRs



He^3–Au Non-Colliding IRs



Run-14 (He^3–Au)

- No shift in the DX magnets
  - DX magnets have a 68.3 *mm* aperture.
- Injection Bρ: He^3 → 52.032 *T-m* (10.44 *GeV/nucleon*) and Au → 86.0 *T-m* (10.38 *Gev/nucleon*)
  - May need a mini-ramp with Au before He3 is injected
- Store Bρ: He^3 → 521.814 *T-m* (104.3 *GeV/nucleon*) and Au → 831.763 *T-m* (100.0 *Gev/nucleon*)
- Non-zero crossing angle at non-colliding IRs
  - Aperture: center trajectory of 42.0 *mm* (crossing angle ≈ 3.4 *mrad*)
- Zero crossing angles at the colliding IRs
  - Non-zero at injection (Need to check if the DX-D0 shunt supplies change polarity during the ramp as the angle is ramped to zero)
  - Aperture: 54.8 *mm* center trajectory for Au. Possible?

Run-15 (He^3–Au)

- In IP6 and IP8 the DX magnet is to be moved about 15 to 25 *mm*
  - Both IPs will be set to zero-crossing angles.
- The CeC wiggler will be added to the IP2 in the summer of 2014
  - The wiggler has an aperture limitation with non-zero crossing angles.
  - IP2 DX magnets may be moved as well.
    - In this case, IP2 will be set to zero-crossing angle

Ramping (He^3–Au)

- The beams are accelerated with locked frequency RF cavities
- Choose energies to match the frequency at injection and store.

The frequencies for the Blue and Yellow beams as a function of accramp time:

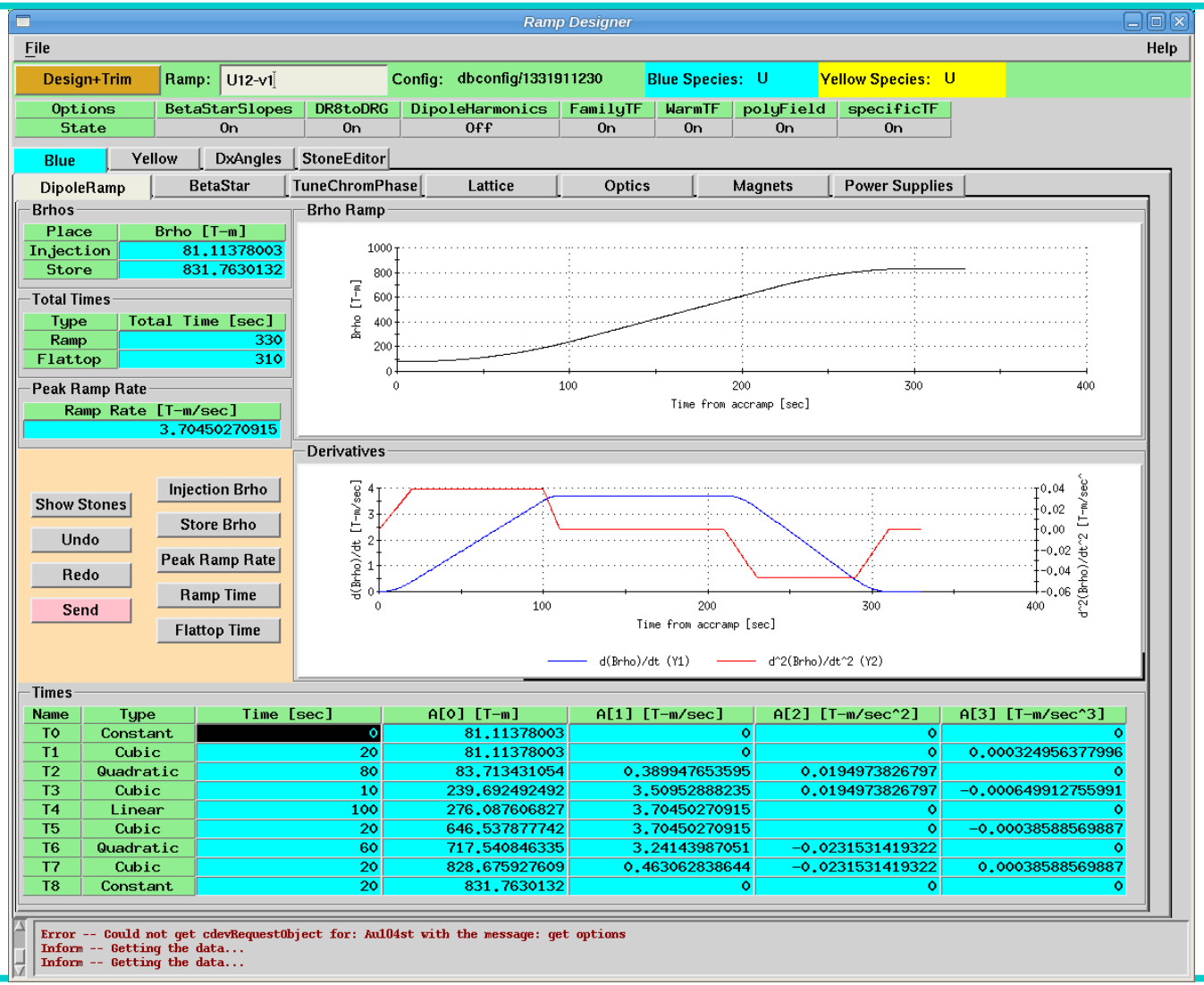
$$f_B(t)=h_B\frac{c\beta_B(t)}{C_B(t)},\qquad f_Y(t)=h_Y\frac{c\beta_Y(t)}{C_Y(t)},\qquad \Delta f(t)=f_B(t)-f_Y(t)=c\left[h_B\frac{\beta_B(t)}{C_B(t)}-h_Y\frac{\beta_Y(t)}{C_Y(t)}\right]$$

Yellow beam with frequency deviation:

$$\frac{\Delta p}{p}(t)=\gamma^2\left[\frac{\Delta f(t)}{f_Y(t)}+\frac{\Delta R_Y(t)}{R_Y(t)}\right]$$

$$\frac{\Delta p}{p}(t)=0\quad\rightarrow\quad \Delta R_Y(t)=\frac{C_Y(t)}{2\pi}\left[1-\frac{h_B\beta_B(t)C_Y(t)}{h_Y\beta_Y(t)C_B(t)}\right]\approx\frac{C_Y(t)}{2\pi}\left[1-\frac{\beta_B(t)}{\beta_Y(t)}\right]$$

Ramping (He^3–Au)



Name	Type	Time [sec]	A[0] [T-m]	A[1] [T-m/sec]	A[2] [T-m/sec^2]	A[3] [T-m/sec^3]
T0	Constant	0	81.11378003	0	0	0
T1	Cubic	20	81.11378003	0	0	0.000324956377996
T2	Quadratic	80	83.713431054	0.389947653595	0.0194973826797	0
T3	Cubic	10	239.692492492	3.50952888235	0.0194973826797	-0.000649912755991
T4	Linear	100	276.087606827	3.70450270915	0	0
T5	Cubic	20	646.537877742	3.70450270915	0	-0.00038588569887
T6	Quadratic	60	717.540846335	3.24143987051	-0.0231531419322	0
T7	Cubic	20	828.675927609	0.463062838644	-0.0231531419322	0.00038588569887
T8	Constant	20	831.7630132	0	0	0

Ramping (He^3–Au)

He3Au-ramp-prelim2.ues -- Unequal Species

Crossing Angles

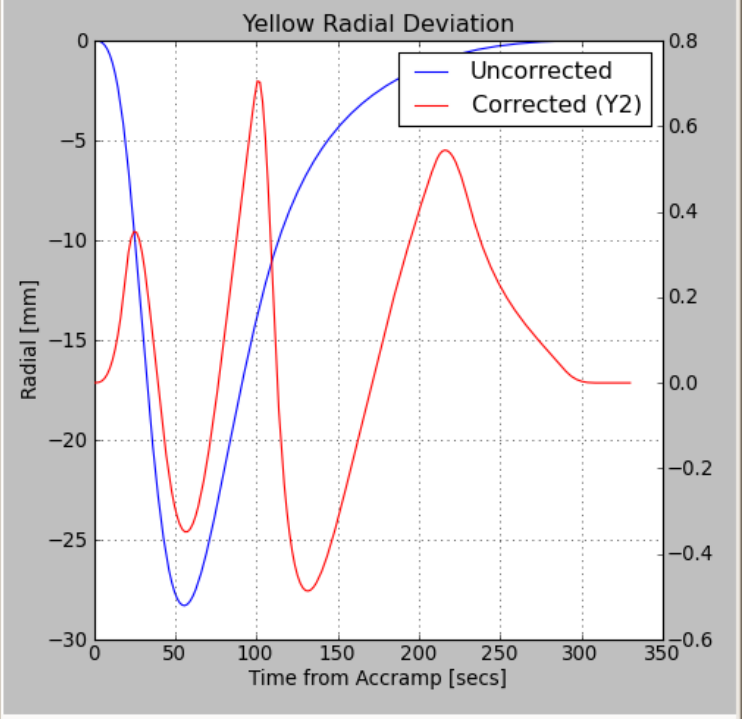
	IP6	IP8	IP10	IP12	IP2	IP4
Injection Angles [rad]	-0.00342	0.00342	-0.00342	0.00342	-0.00342	0.00342
Store Angles [rad]	0.0	0.0	-0.003434	0.003434	-0.003434	0.003434

Ramps

	Blue		Yellow	
Species	He3		Au	
	Uncorrected	Corrected	Uncorrected	Corrected
T0: Constant [secs]	0.0	0.0	0.0	0.0
T1: Cubic [secs]	20.0	20.0513888889	20.0	19.9486111111
T2: Quadratic [secs]	80.0	81.0638888889	80.0	78.9361111111
T3: Cubic [secs]	10.0	10.0111111111	10.0	9.98888888889
T4: Linear [secs]	100.0	101.9625	100.0	98.0375
T5: Cubic [secs]	20.0	20.0111111111	20.0	19.9888888889
T6: Quadratic [secs]	60.0	58.4513888889	60.0	61.5486111111
T7: Cubic [secs]	20.0	18.4486111111	20.0	21.5513888889
T8: Constant [secs]	20.0	20.0	20.0	20.0
Flattop Time [secs]	310.0	310.0	310.0	310.0
Ramp Time [secs]	330.0	330.0	330.0	330.0
Ramp Rate [T-m/sec]	2.31840567349	2.30330050031	3.68038889648	3.70467266152
Injection Bρ [T-m]	Fit Bρ	52.0322711532	Fit Bρ	86.0
Store Bρ [T-m]	Fit Bρ	521.814473413	Fit Bρ	831.763013235

Re-Display | Zero Corrections | Fit Timing | Open | Save

Round to 720Hz | ---- Ready ----



Unpolarized He^3 Studies

- DX Aperture Limit
  - Redo this experiment with an angle bump (Yun Luo)
- IBS → Beam emittance growth of He^3
- Stochastic cooling rates
- E-cloud with He^3
- Space charge tune shifts
- Beam-beam studies
- Dynamic aperture
- Transition Instability

Unpolarized He^3 Studies

- Linear Optics/ORM
  - Optics correction
  - Dynamic β* squeeze (or unsqueeze)
- Nonlinear Chromaticity
  - 1/3 or 2/3 resonance and correction
- Collimator studies
- ...

Polarized He^3 Studies

- He^3 and protons have different magnetic properties
  - W. W. Mackay, "Prospects for Acceleration of Deuterons and Helions", C-A/AP/#296, 2007
    - "polarized ^{3}He should be achievable in RHIC up to 167 *GeV/nucleon*"
      - He^3 energy in He^3-Au is about 104 *GeV/nucleon*
  - $a = G = g/2 - 1$
    - 1.7928 for protons and -4.1840 for He^3 (about 2.3 time larger than protons)
- Implications:
  - Good
    - Less current is needed in the snake magnets for He^3
    - AGS partial snakes will be stronger
  - Bad
    - The depolarizing resonance strengths are stronger
    - There are many more depolarizing resonances

Polarized He^3 Studies

- CNI Polarimeter studies
  - Compare with PJET measurements
  - Measure the analyzing power
- Snake settings
  - Tune scan for best polarization
- Polarization profile
- Beam profile using the polarimeter targets
- Rotator settings
- Spin flipper studies

Summary

- AGS has accelerated unpolarized He^3 to flattop (Keith Zeno)
- In run-15 we plan to move the DX magnets
  - This is for a p-Au run. Will benefit a He^3-Au run.
- Many studies with unpolarized He^3 can be performed.
- A polarized He^3 source is desired
  - Expected in the summer of 2015 (probably optimistic)
- Polarized He^3 through the Booster, AGS and the AtR line needs development.
- There are many interesting studies with polarized He^3.