APEX Workshop 2012

Lattice Design

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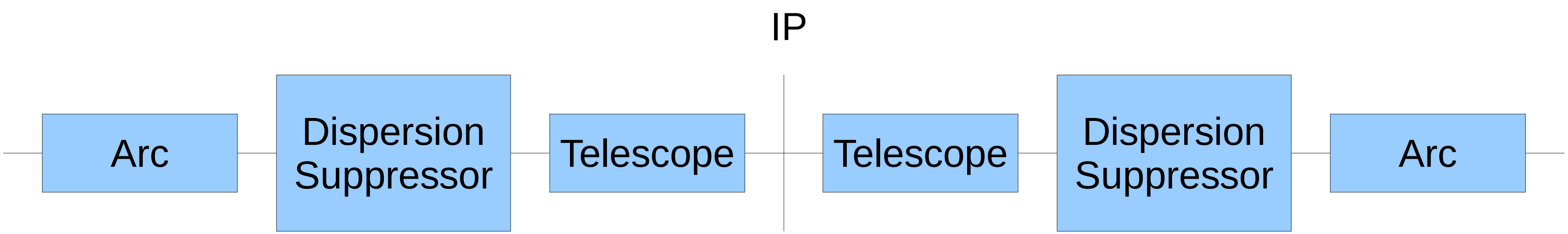
Lattice Design

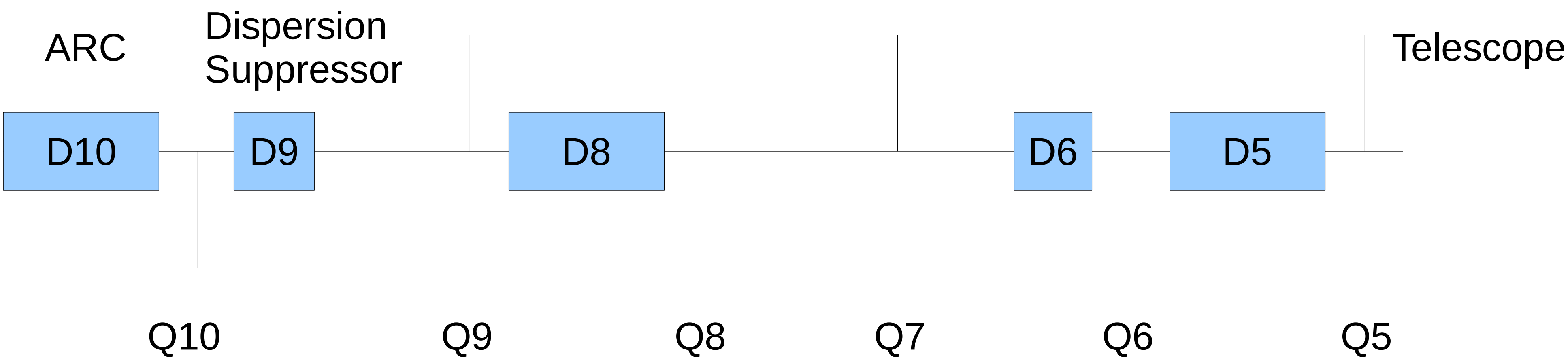
- RHIC IR
  - Dispersion Suppressor
  - Telescope
- Optics Fitting
  - Independent IR approach
  - Full Ring approach
- E-Lens
- PP2PP
- Summary

RHIC IR



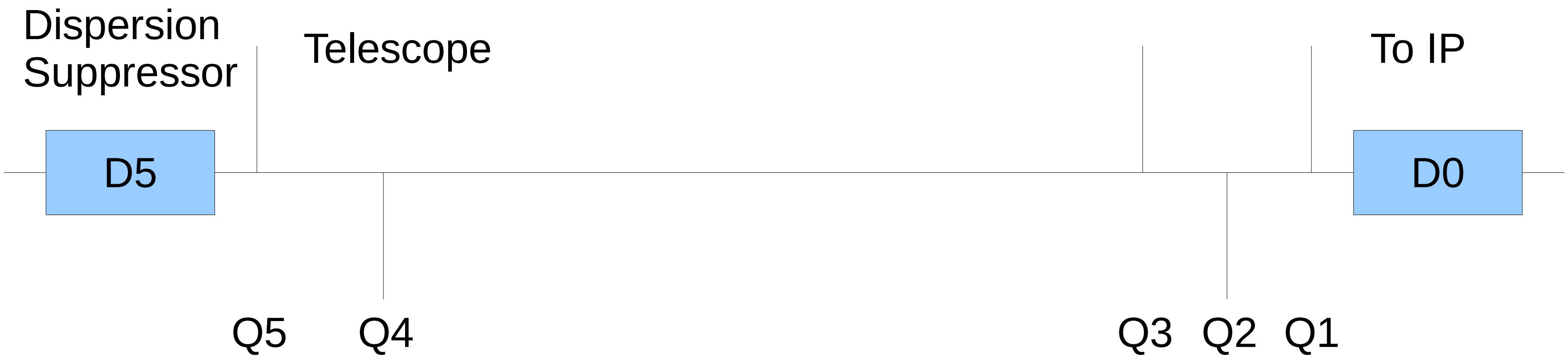
- Design the dispersion suppressors first
  - Use shortened and/or missing magnets in FODO cells
  - Determines the geometry of the ring
    - May be necessary if designing for an existing tunnel
  - For anti-symmetric optics, the suppressor must work for DOFO cells as well

RHIC IR



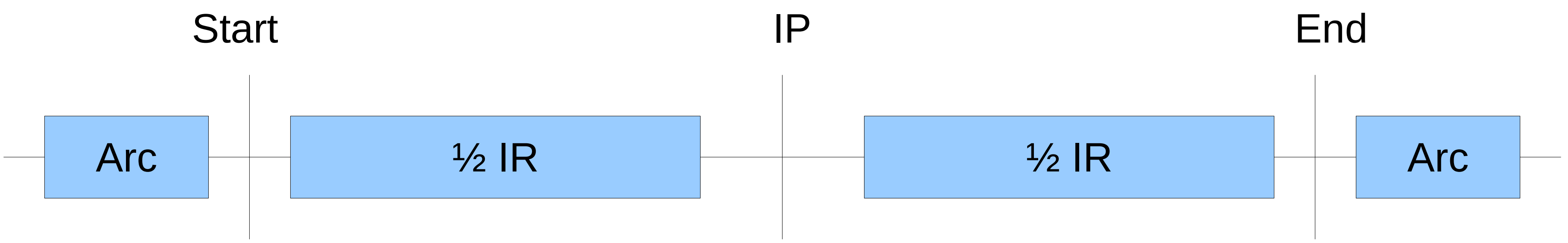
- The RHIC dispersion suppressor
  - Two short dipoles and an ARC dipole
- Varying the dipole lengths/positions changes the dispersion with negligible effect on the twiss functions.
- Drift spaces for: Injection kickers, septum, snakes, etc.

RHIC IR



- The telescope typically consists of a doublet and a triplet
  - Used to change the β* to small (or large) values
- The arcs are standard FODO cells with bending magnets
- Large warm drift space for: Rotators, Instrumentation, RF cavities, Beam dump, etc.

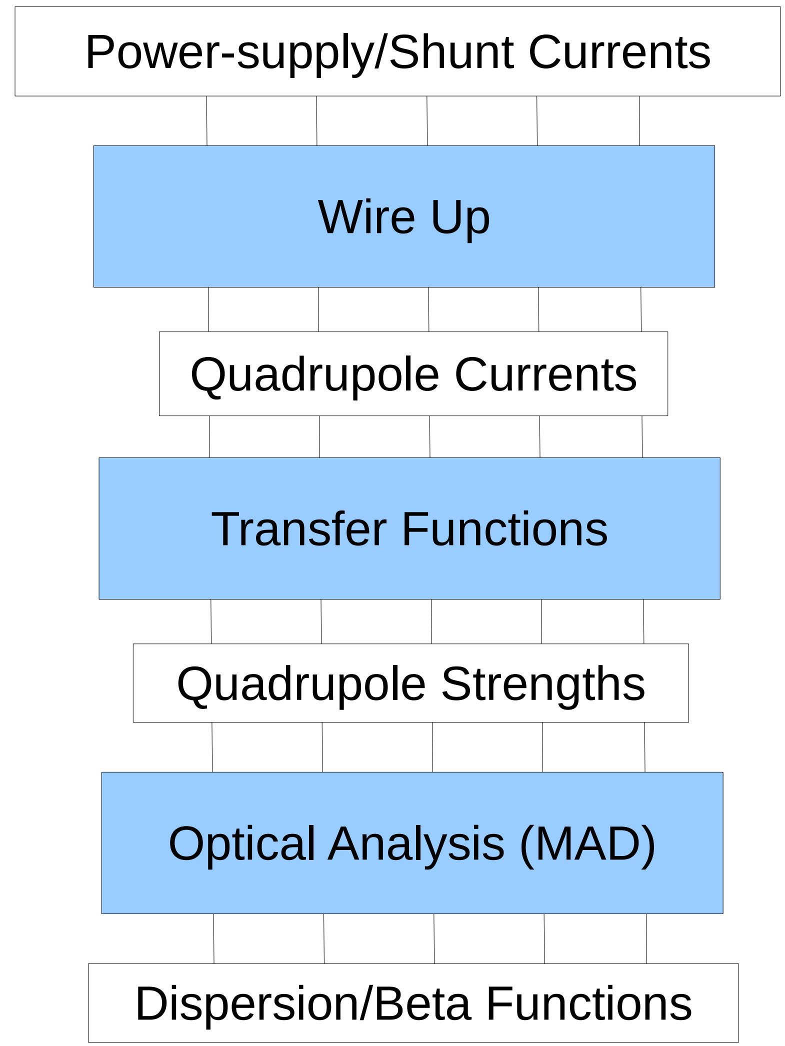
Optics Fitting



- Change the quadrupoles to adjust β*, Dispersion, etc.
- Constraints for each IR
  - Constrain **IP** to be the β*s of choice (6 constraints)
  - Constrain **End** to match to the Arc (6 constraints)
- Additional constraints: β_{max}, machine tunes, PP2PP, etc.
- Fit to within the power supply limits.
- Fit as beam line, one super-period and/or use full ring.
- Programs: MAD8, MADX, OpticsDesigner and OpticsDesigner2

Optics Fitting

- Set the Power-supply/Shunt currents to get desired optics
  - Use an Optimizer to find the currents
  - Desired optics functions are the constraints
- Changing optics with beam (squeeze)
  - Requires smooth changes to the currents
- Weakest point: Magnet transfer functions



Optics Fitting

- Independent IR approach
  - Advantages
    - Build new ramps with different β* without refitting optics
    - Faster fitting of optics
  - Disadvantages
    - Uses same solution for all IRs
    - Blue and Yellow optics maybe different (perhaps due to mismatch)
    - Power supply limits can be exceeded due to fitting conditions being different from the final ramp
    - Can't take advantage of more power supply head room at the lower energies

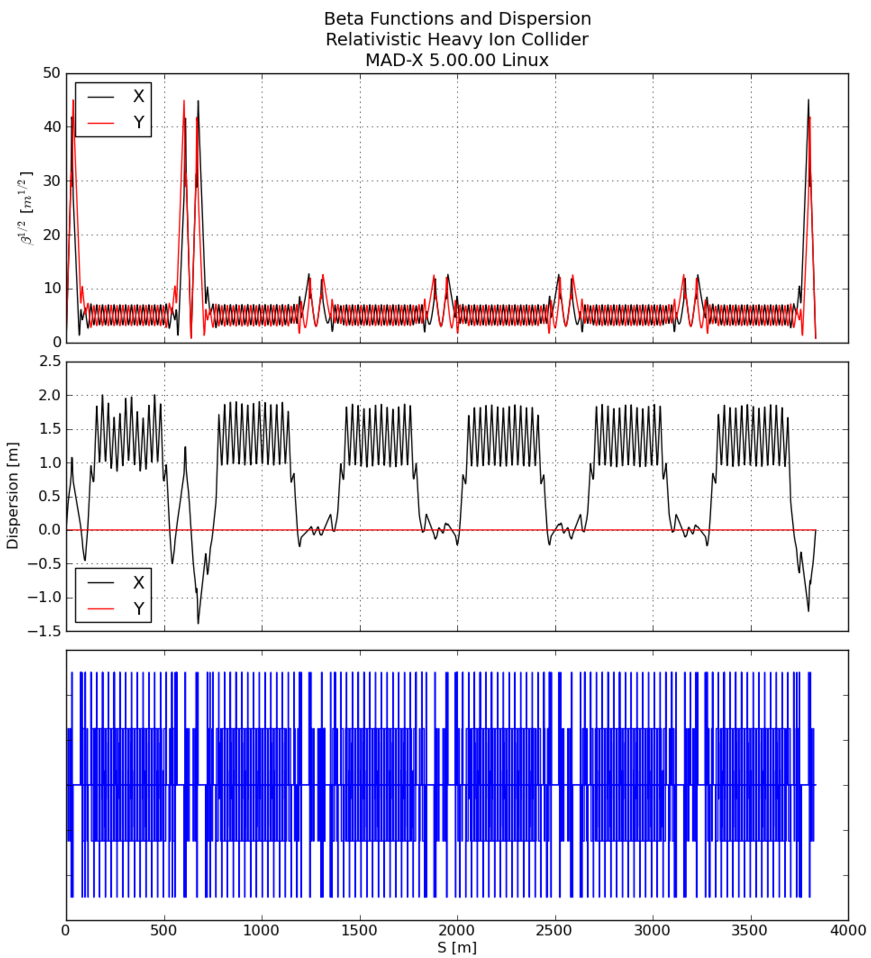
Optics Fitting

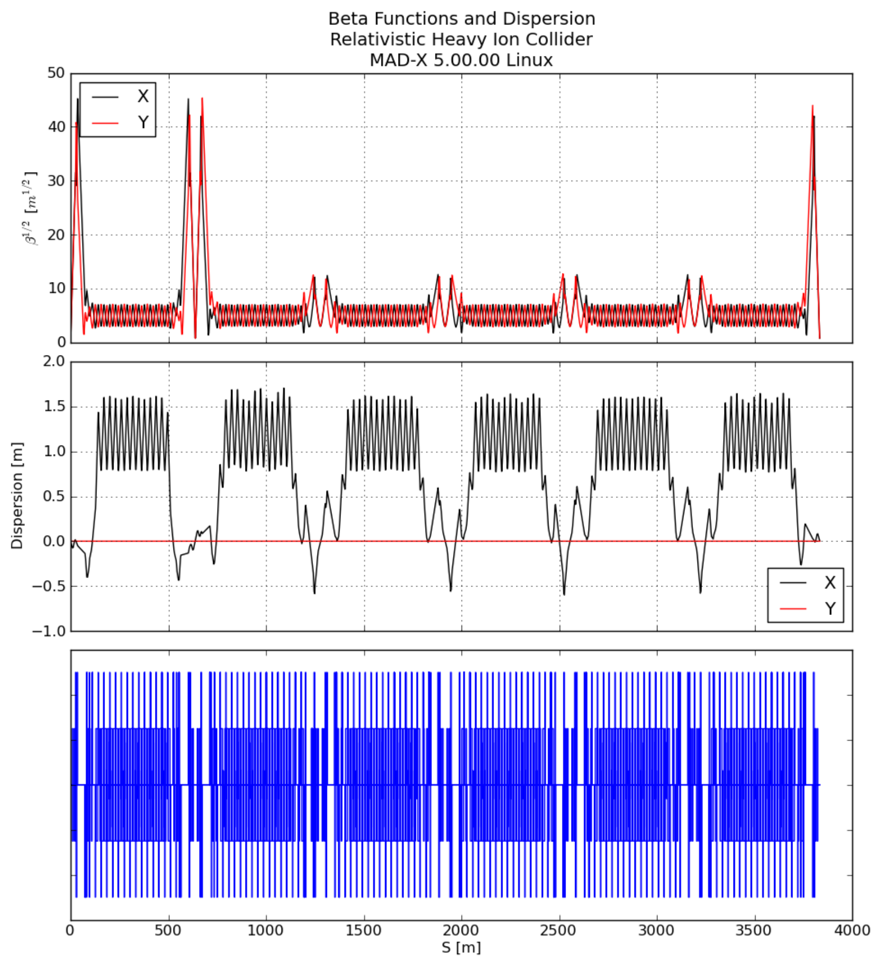
- Full ring approach
  - Advantages
    - Fits as final ramp
    - Provides more power supplies for fitting
    - Can have different solutions for each IR
  - Disadvantages
    - Takes much longer to fit
    - Must be refit whenever β* changes are requested
    - Larger number of free variables are harder for the optimizer
    - May make it harder to keep current changes smooth due to additional inter dependencies between free variables

E-Lens

- The goal is for higher intensity proton beams
- Phase constraint between IP8 (Phenix) and IP10 (e-Lens)
- Different tunes in the rings for achieving the phase constraints
  - Blue: Q = (27.69, 29.68)
  - Yellow: Q = (29.69, 30.68)
- Two additional shunt supplies to adjust phase per ring
- Must use full ring approach for fitting
- β^* = 0.65 meters at IP6 and IP8

E-Lens


Beta Functions and Dispersion
Relativistic Heavy Ion Collider
MAD-X 5.00.00 Linux
X
Y
Dispersion [m]
S [m]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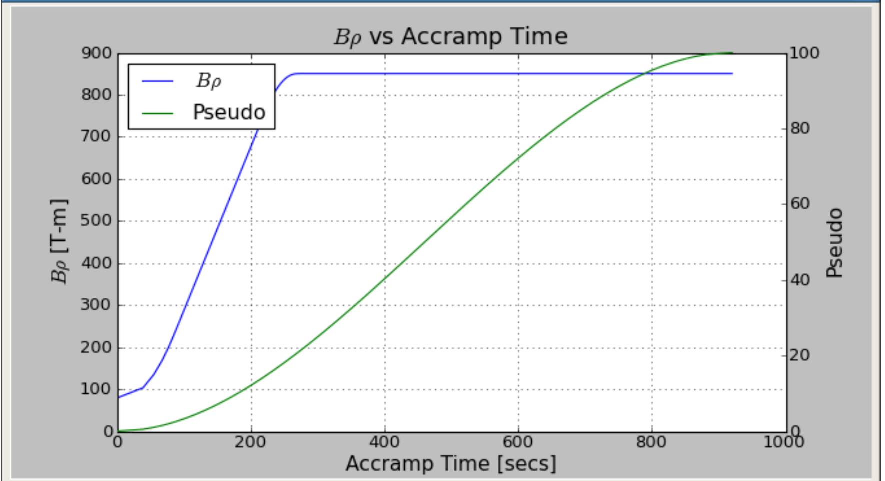
E-Lens

Bρ Ramp

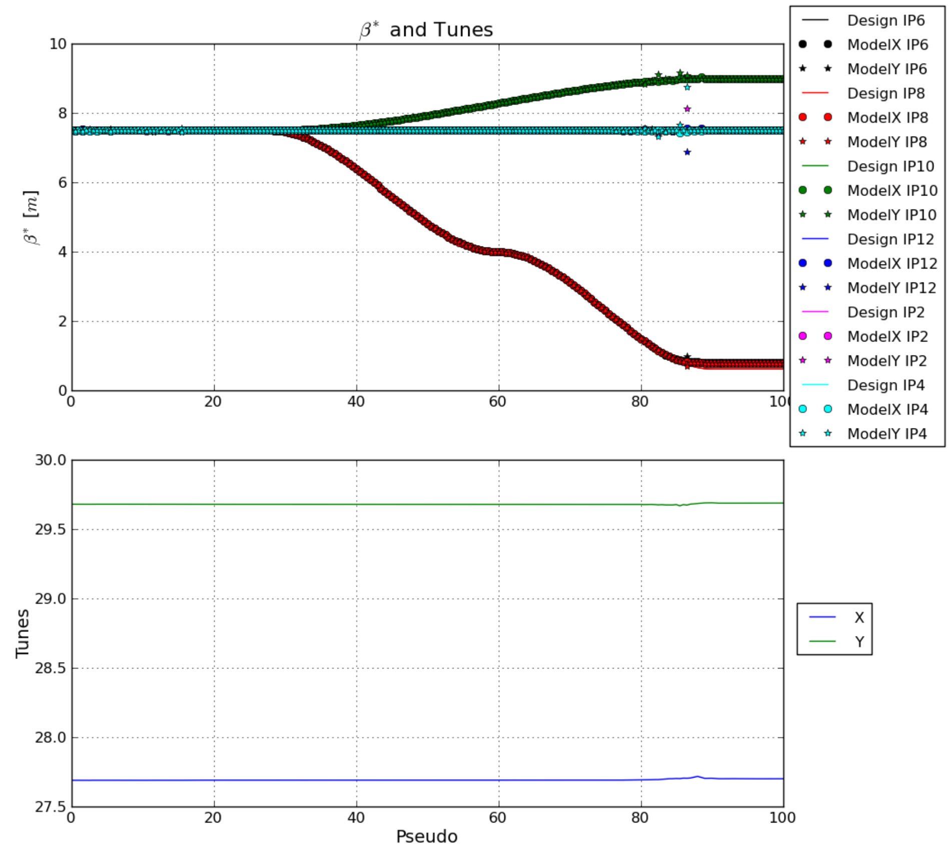


Name	Type	Time [sec]	A[0] [T-m]	A[1] [T-m/sec]	A[2] [T-m/sec^2]	A[3] [T-m/sec^3]
T0	Constant	0.000000	79.366775	0.000000	0.000000	0.000000
T1	Cubic	16.000000	79.366775	0.000000	0.000000	0.000533
T2	Quadratic	64.000000	81.548076	0.408994	0.025562	0.000000
T3	Cubic	8.000000	212.426190	3.680947	0.025562	-0.001065
T4	Linear	126.269444	242.964416	3.885444	0.000000	0.000000
T5	Cubic	13.000000	733.577270	3.885444	0.000000	-0.001060
T6	Quadratic	34.000000	781.759531	3.348095	-0.041335	0.000000
T7	Cubic	13.000000	847.812079	0.537349	-0.041335	0.001060
T8	Constant	645.730556	850.140590	0.000000	0.000000	0.000000

Bρ [T-m]	*Injection*	79.3667745	*Store*	850.140589585
Total Time [sec]	*Flattop*	274.269444444	*Ramp*	920.0
Peak Ramp Rate [T-m/sec]		3.88544398831		

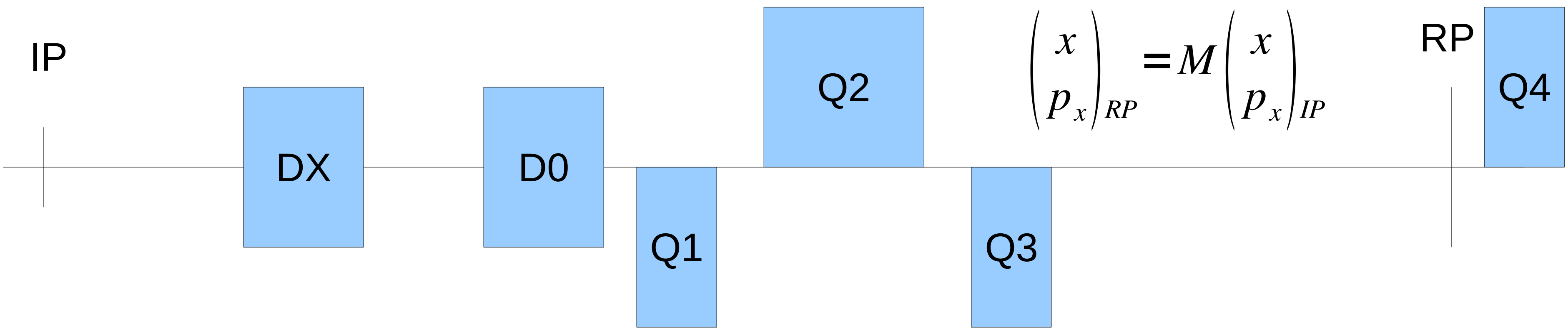
Injection Bρ | Store Bρ | Peak Ramp Rate | Ramp Time | Flattop Time

OK | Cancel



PP2PP

PP2PP – Coulomb (Elastic) scattering experiment

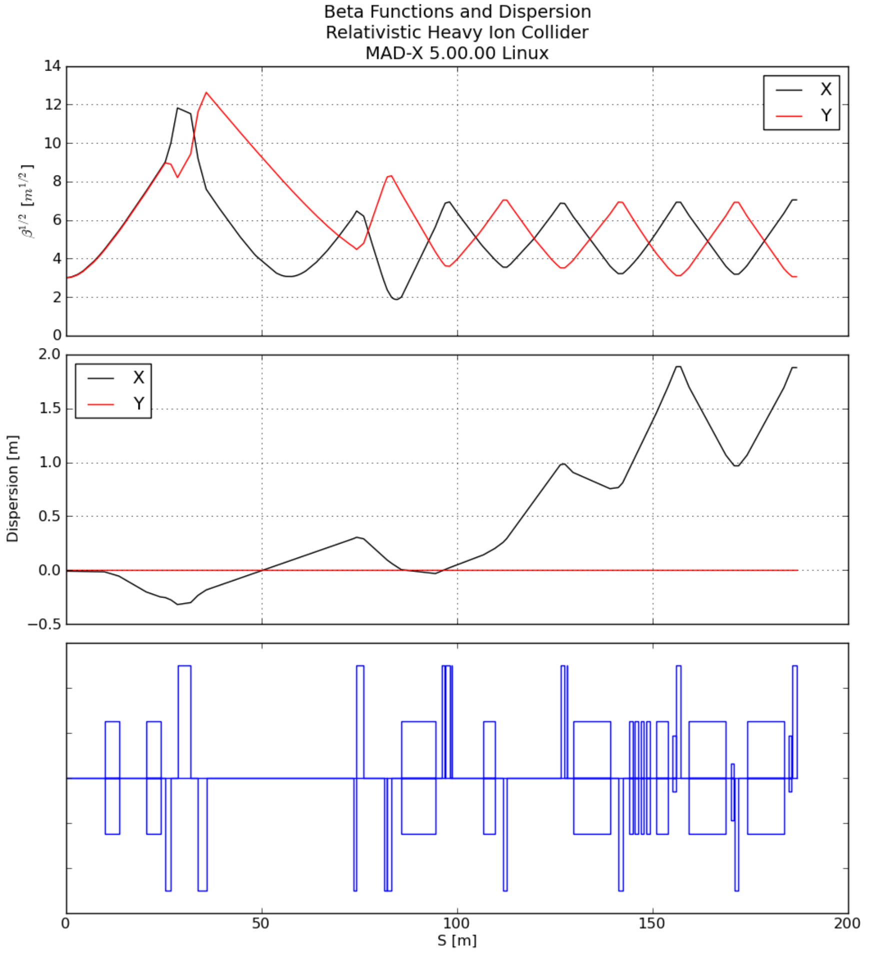


$$\begin{pmatrix} x \\ p_x \end{pmatrix}_{RP} = M \begin{pmatrix} x \\ p_x \end{pmatrix}_{IP}$$

$$M = \begin{bmatrix} a_{11} & L_{eff} \\ a_{21} & a_{22} \end{bmatrix} = \begin{bmatrix} \sqrt{\frac{\beta_{RP}}{\beta_{IP}}}(\cos(\Psi) + \alpha_{IP}\sin(\Psi)) & \sqrt{\beta_{IP}\beta_{RP}}\sin(\Psi) \\ \frac{(1+\alpha_{IP}\alpha_{RP})\sin(\Psi) + (\alpha_{IP} - \alpha_{RP})\cos(\Psi)}{\sqrt{\beta_{IP}\beta_{RP}}} & \sqrt{\frac{\beta_{IP}}{\beta_{RP}}}(\cos(\Psi) - \alpha_{RP}\sin(\Psi)) \end{bmatrix}$$

$$a_{11} \approx 0 \quad \Rightarrow \quad \Psi = \frac{\pi}{2} \quad \Rightarrow \quad L_{eff} = \sqrt{\beta_{IP}\beta_{RP}}$$

PP2PP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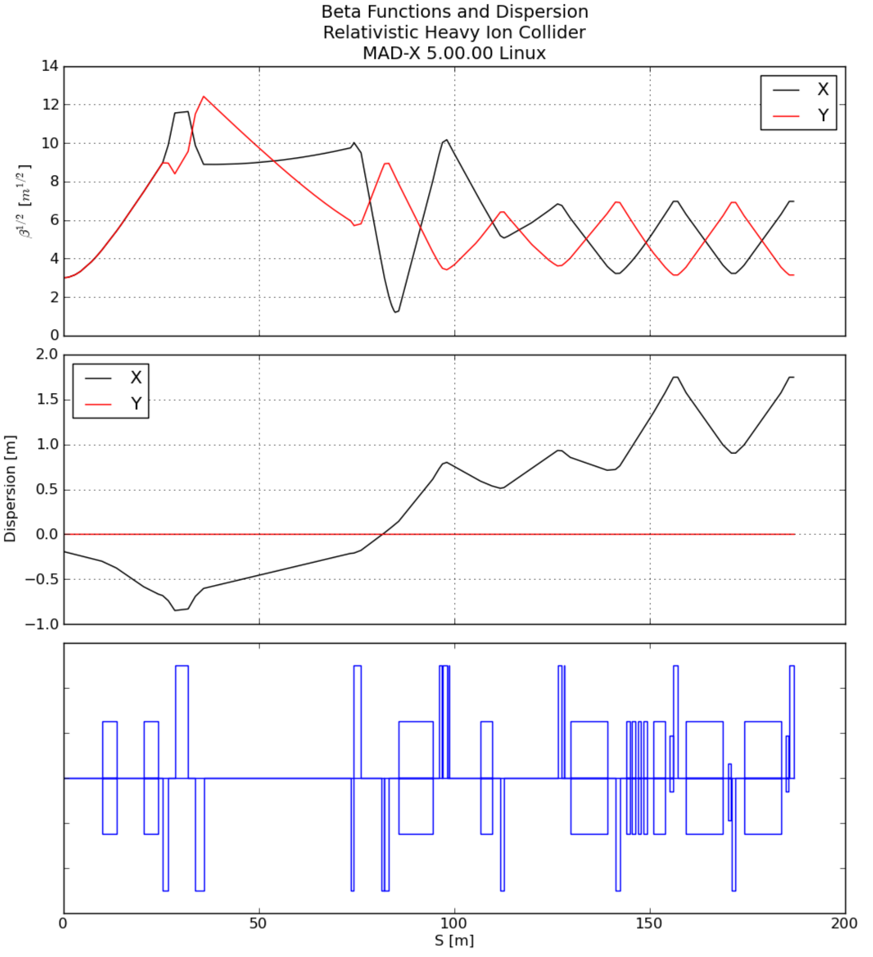
$\beta^{1/2}$ [$m^{1/2}$]
Dispersion [m]
X
Y
S [m]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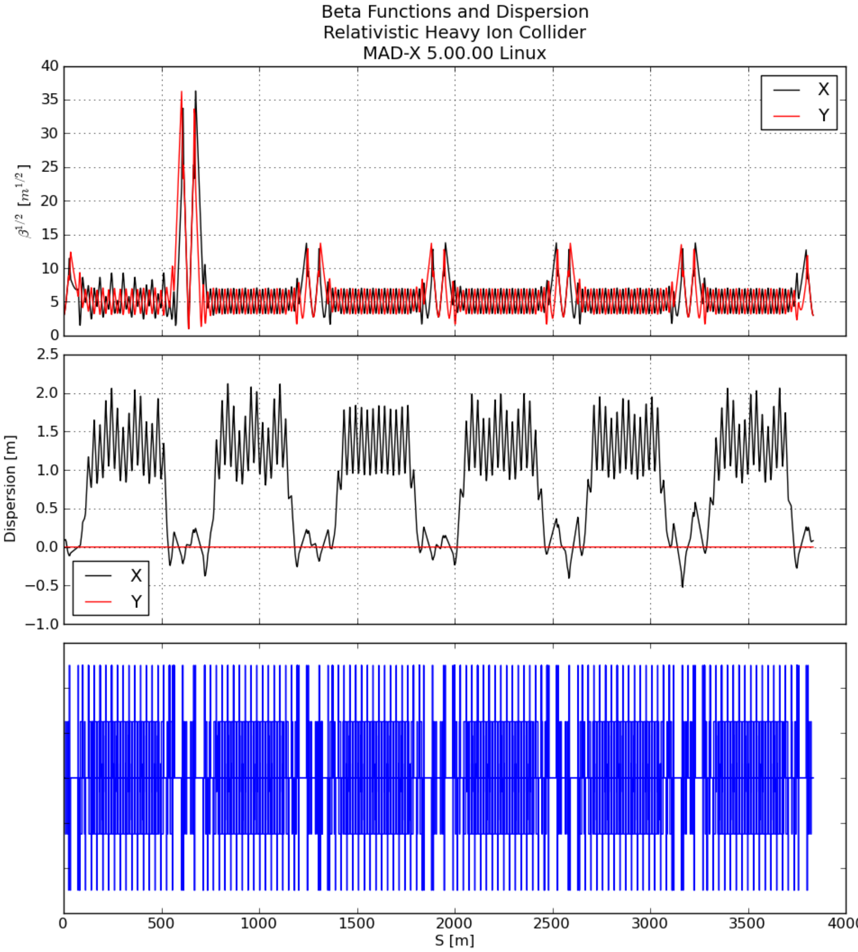
$\beta^{1/2}$ [$m^{1/2}$]
Dispersion [m]
X
Y
S [m]

PP2PP

255GeV at Store



Summary

- Description of RHIC lattice design
- Discuss optics fitting methods
- Progress of the E-Lens ramp
- Progress with the PP2PP ramp