Recent Progress in Muon Collider Lattice Design

Pavel Snopok, Carol Johnstone, Al Garren

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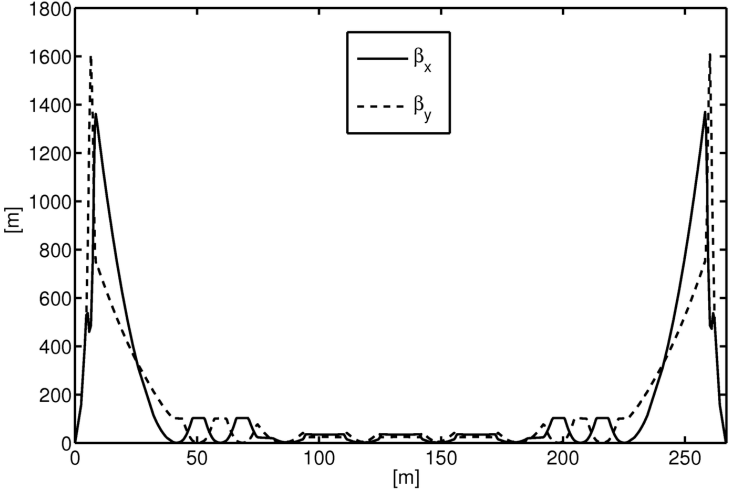
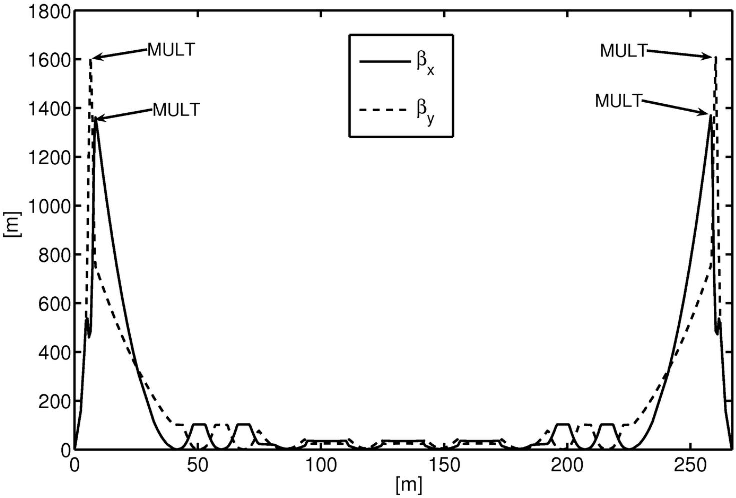
Where it all started



DA aperture studies and optimization



The idea behind the 750 × 750 GeV

Design a lattice for the storage ring that fits the Tevatron Main Ring tunnel with all its bends and straights.

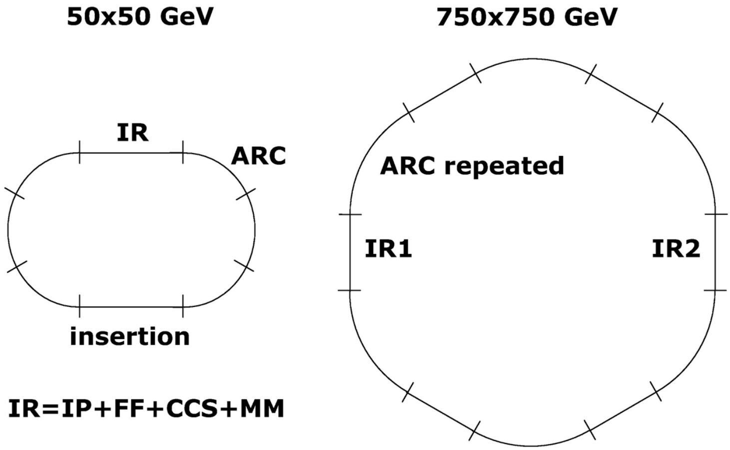
We use 50% dipole packing fraction, which results for the arclength of 5.85 km (6.28 km - 432 m of straights) in the dipole field of 5.3 T.

At 750 GeV the magnet strengths are reasonable, in fact, the ultimate energy might be up to 1 × 1 TeV.

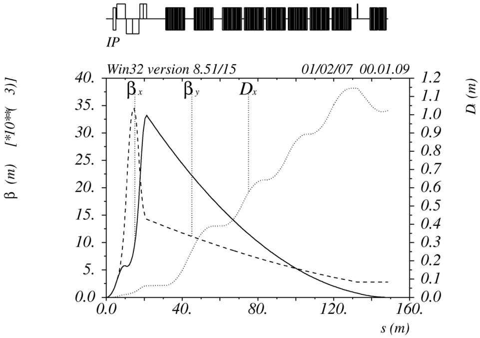
From 50 GeV to 750 GeV

- We use the 50 $\times$ 50 GeV lattice as a baseline, and scale its components to 750 GeV (next slide);
- 50 $\times$ 50 GeV is a highly optimized lattice with a very high dipole packing fraction (70%), for the 750 $\times$ 750 GeV lattice we currently use 50% dipole packing fraction;
- the 750 $\times$ 750 GeV design shares most of the advantages with its "little brother".

Lattice details

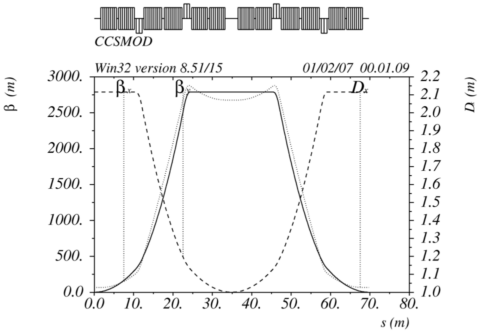


Final Focus



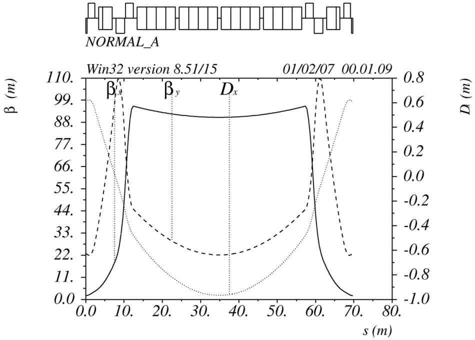
- Three strong superconducting quadrupoles forming the FF Telescope;
- Bend starts at 35 meters, so the FF system fits the Tevatron footprint (not quite finished at the moment).

Chromatic Correction Section



- Large β ratio $\Rightarrow$ clean chromatic correction, minimal cross correlation;
- The sextupoles are π phase advance apart $\Rightarrow$ no second order geometric aberrations;
- Repetitive symmetry + transfer map unity $\Rightarrow (x|\delta\delta) = 0$.

Arc module



- Flexible Momentum Compaction module provides negative momentum compaction values compensating for the positive momentum compaction generated by the CCS;

Parameter Comparison for Various Designs

	4/1.5 TeV	1.5 TeV	100 GeV
β^* [mm]	3	10	40
l^* (IP to quad) [m]	4	5.5	4.5
peak β [km]	145	35	1.4
IR quad aperture [cm]	10	10	10
Poletip field [T]	12	9	8
$\epsilon_N(95\%)$ [mm mrad]	$841\pi/315\pi$	1306π	2176π
$\Delta p/p(95\%)[\%]$	.01-.08	$\geq$ .018-.144	$\geq$ .036-.288
$\xi_x(IR+CCS)$	-1500	-456	-53
$\xi_y(IR+CCS)$	-2000	-645	-73
α_{IR}	3.6×10^{-4}	1.0×10^{-3}	3.0×10^{-2}
IR length [m]	1300	506	137
α_{arc}	-2.1×10^{-3}	-9.3×10^{-3}	-9.5×10^{-2}
Arc length [m]	187	70	31

Advantages

- Lattice is isochronous $\Rightarrow$ prevents bunch length change, important for controlling the hour-glass effect;
- $\beta^* = 1$ cm $\Rightarrow$ hour-glass is less of the effect;
- Smaller apertures (as compared to the 3 mm lattice);
- Smaller chromaticities $\Rightarrow$ weaker chromatic aberrations, larger momentum acceptance;
- Larger dynamic aperture.

Disadvantages

$$L \propto \frac{1}{\beta^*}$$

$\beta^* = 3$ mm $\Rightarrow$ hour-glass reduction $\eta_A = 0.76$, disruption enhancement $f_D = 1.5$.
Overall, $H_D = \eta_A f_D = 1.14$. For $\beta^*_{new} = 1$ cm we have $\eta_A \rightarrow 1, f_D \rightarrow 1, \Rightarrow$

$$\left(\frac{L_{old}}{L_{new}}\right)_{eff} = 1.14\frac{\beta^*_{new}}{\beta^*_{old}} = 3.8$$

- Luminosity for $\beta^* = 1$ cm is 3.8 times smaller as compared to the $\beta^* = 3$ mm;
- Lots of work to make sure the lattice matches the footprint of the Tevatron.

The loss of luminosity can be compensated by the increased momentum aperture and using the 2 IRs in the ring.

Next steps

- Put the ring together;
- Make sure the ring matches the Tevatron footprint;
- Study and optimize the DA, momentum compaction for the ring;
- Work on the scraping section, injection, extraction.