DX magnet Aperture Scan

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Motivation

1) In the future p-Au collision, the beam orbit will be tilted between two DX magnets.

2) Take a look of beam parameters at store:

p in Blue Ring →

blue	yellow
Direction	1
Select Species	p
Proton from Tandem	
Charge State	1
Harmonic	360
Bρ [T-m]	358.638298946
γ	114.594861222
Momentum [GeV/c/n]	107.517057174
Energy [GeV/n]	107.521151118
Equalize RF Frequency	

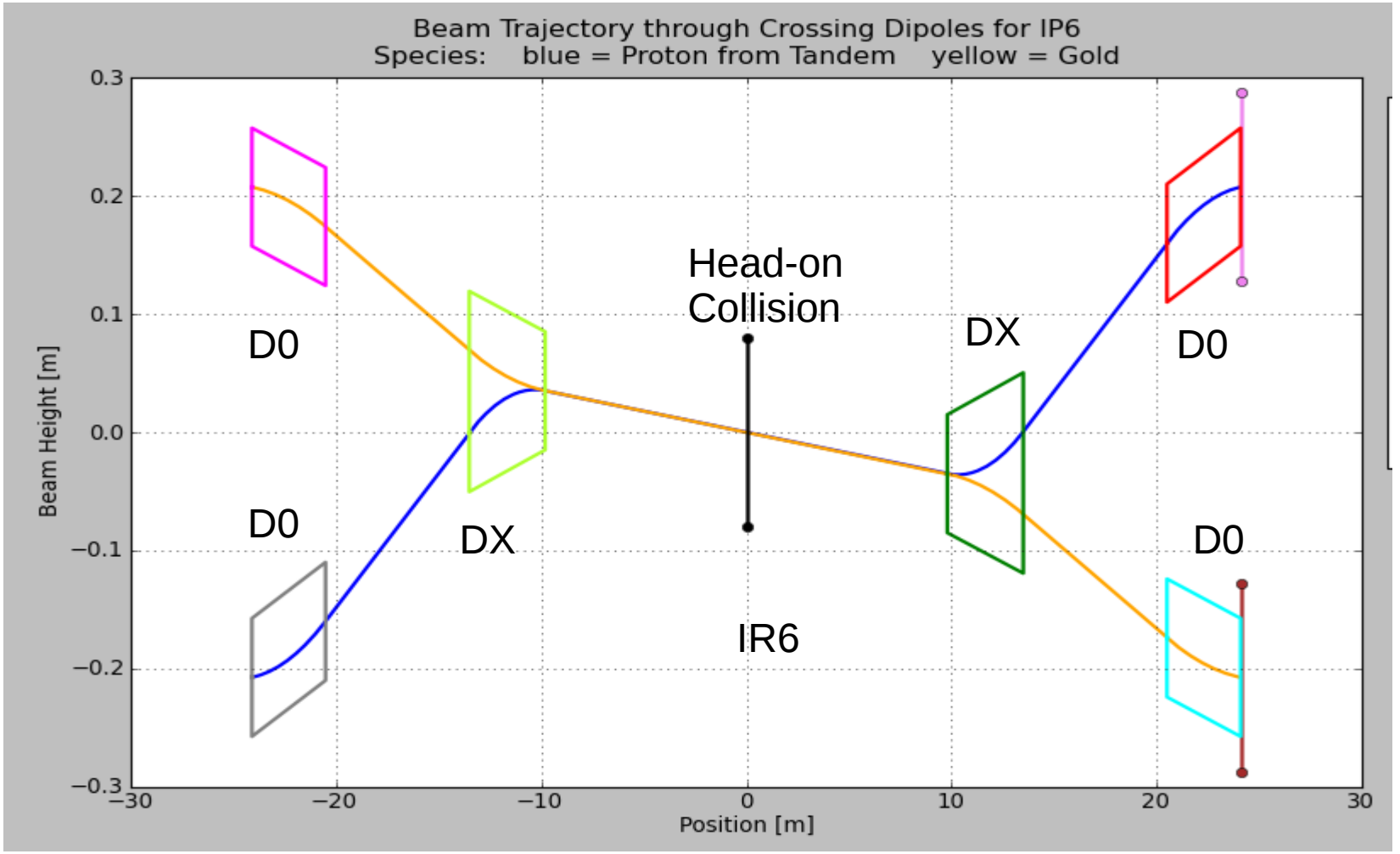
blue	yellow
Direction	-1
Select Species	Au
Gold	
Charge State	79
Harmonic	360
Bρ [T-m]	831.763013235
γ	107.396089451
Momentum [GeV/c/n]	99.9956648664
Energy [GeV/n]	100.0
Equalize RF Frequency	

← Au in Yellow Ring

Requirement: same revolutionary or RF frequencies for both beams

Orbits in the Collisional IRs

WEST

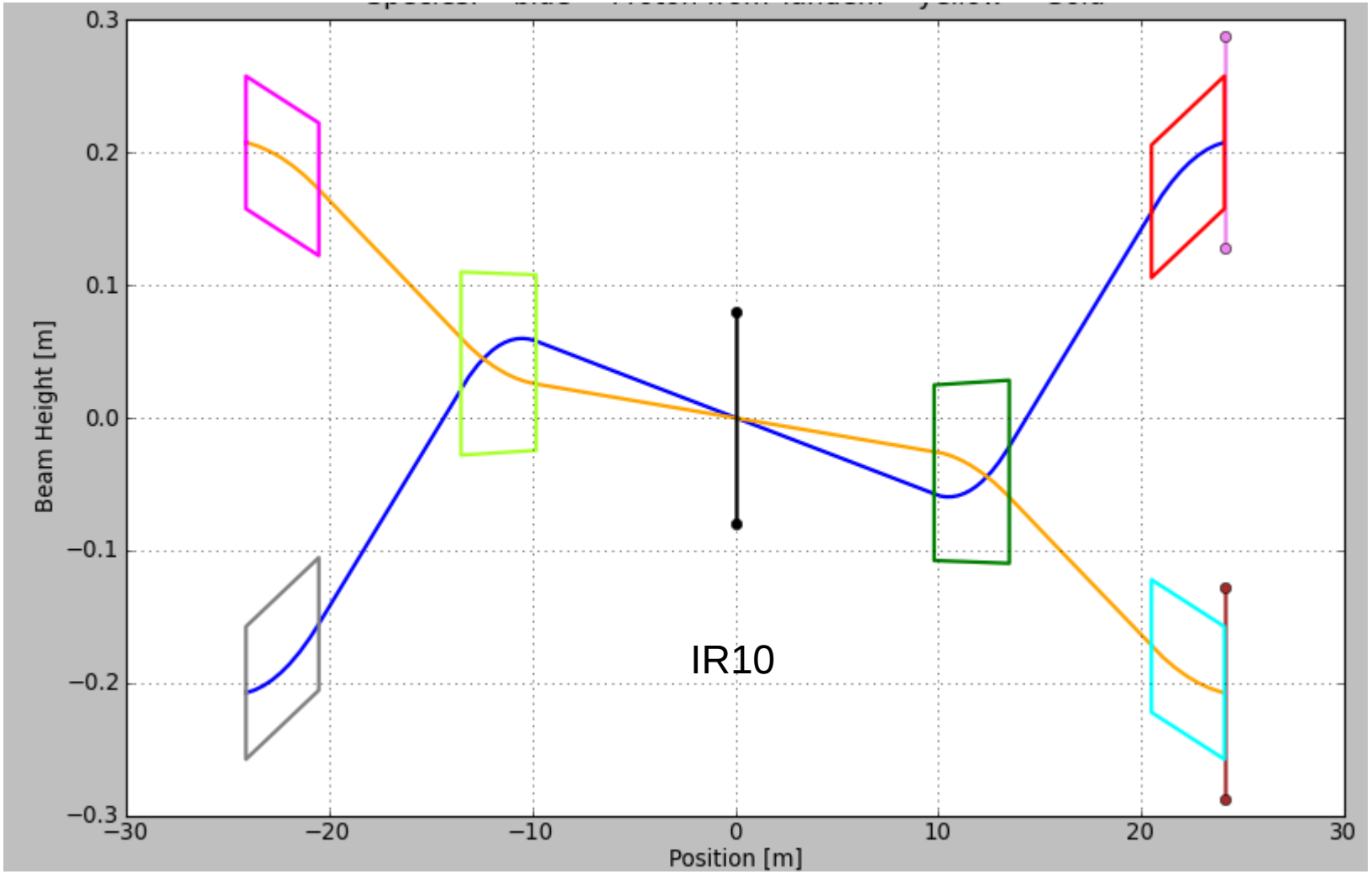


EAST

1) Beam oribts tilted by 3.581mrad w.r.t. The beam pipe axis.
2) p beam: 35.09 and 0.424 mm on both ends of DX magnets.
3) Au beam: 35.09 and 69.303 mm on both ends of DX magnets.

Orbits in Non-collisional IRs

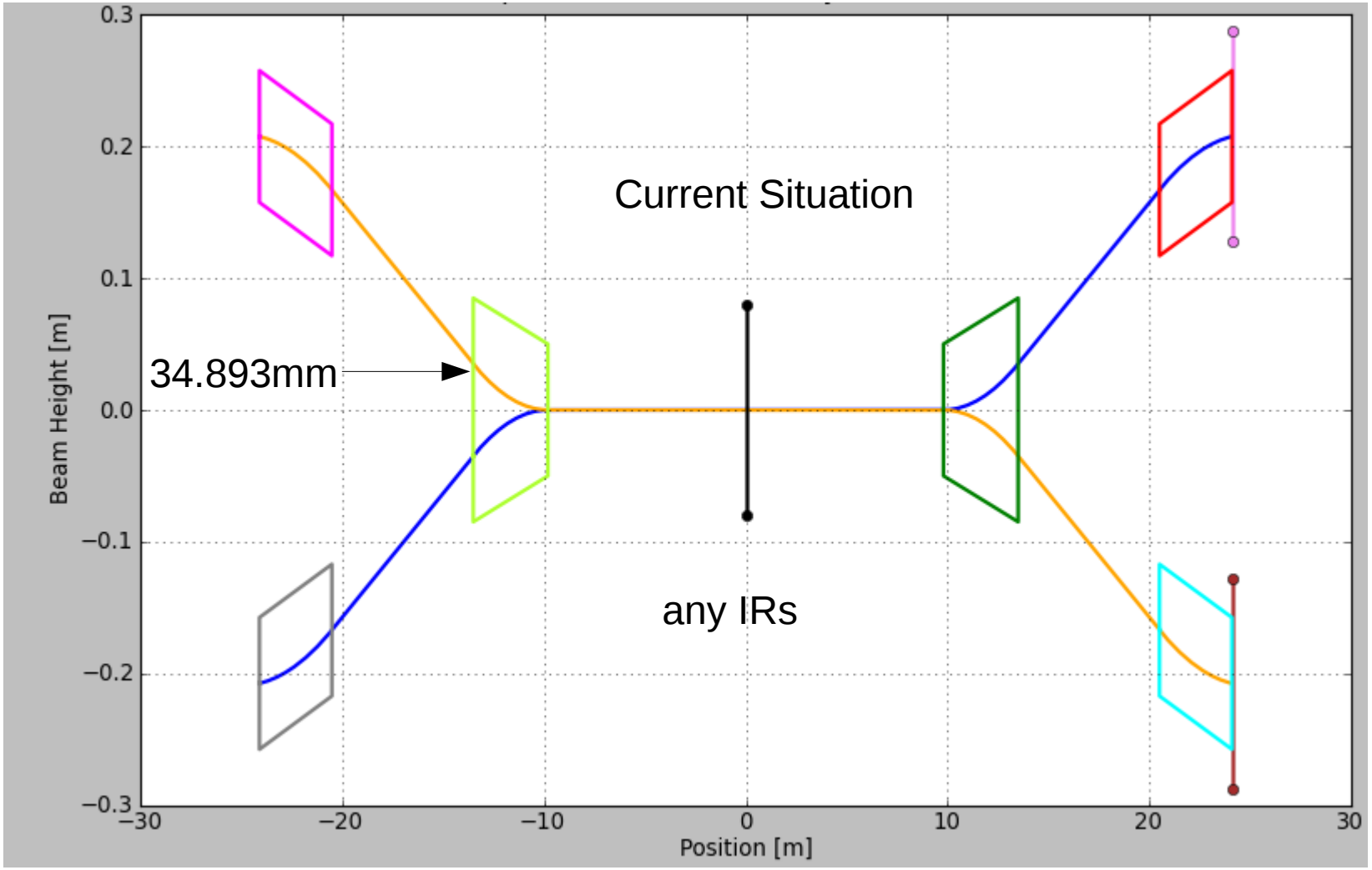
South



North

1) Blue Orbit tilted by 5.887mrad; Yellow orbit tilted by 2.587mrad.
2) p beam: 57.688 and 21.776 mm on both ends of DX magnets.
3) Au beam: 25.348 and 59.793 mm on both ends of DX magnets.

DX Physical Aperture



1) For the same species and energies, no orbit tilt between DX magnets.
2) At exit of DX magnets, orbits offset by 34.893mm from the pipe axis.
3) The physical aperture at DX magnets is 68.326mm.

One Solution

1) At store: Au beam orbit offset by 69.3 mm at collisional IRs
p beam orbit offset by 57.7 mm at non-collisional IRs

2) With DX physical aperture 68.326mm, clearly we do not have enough physical aperture in DX.

3) Fortunately, DX magnet was designed to be able to move.

One solution is to move DX magnet horizontally by 25 mm away from the beam pipe axis.

Therefore, the beam center will be at least (68.326+25 – 69.3) = 24.026mm away from the beam pipe of DX.

Beam-Stay-Clear (BSC)

1) Since the beam is Gaussian Distribution, we also need some distance between beam center and pipe wall.

2) Beam Stay Clear (BSC):

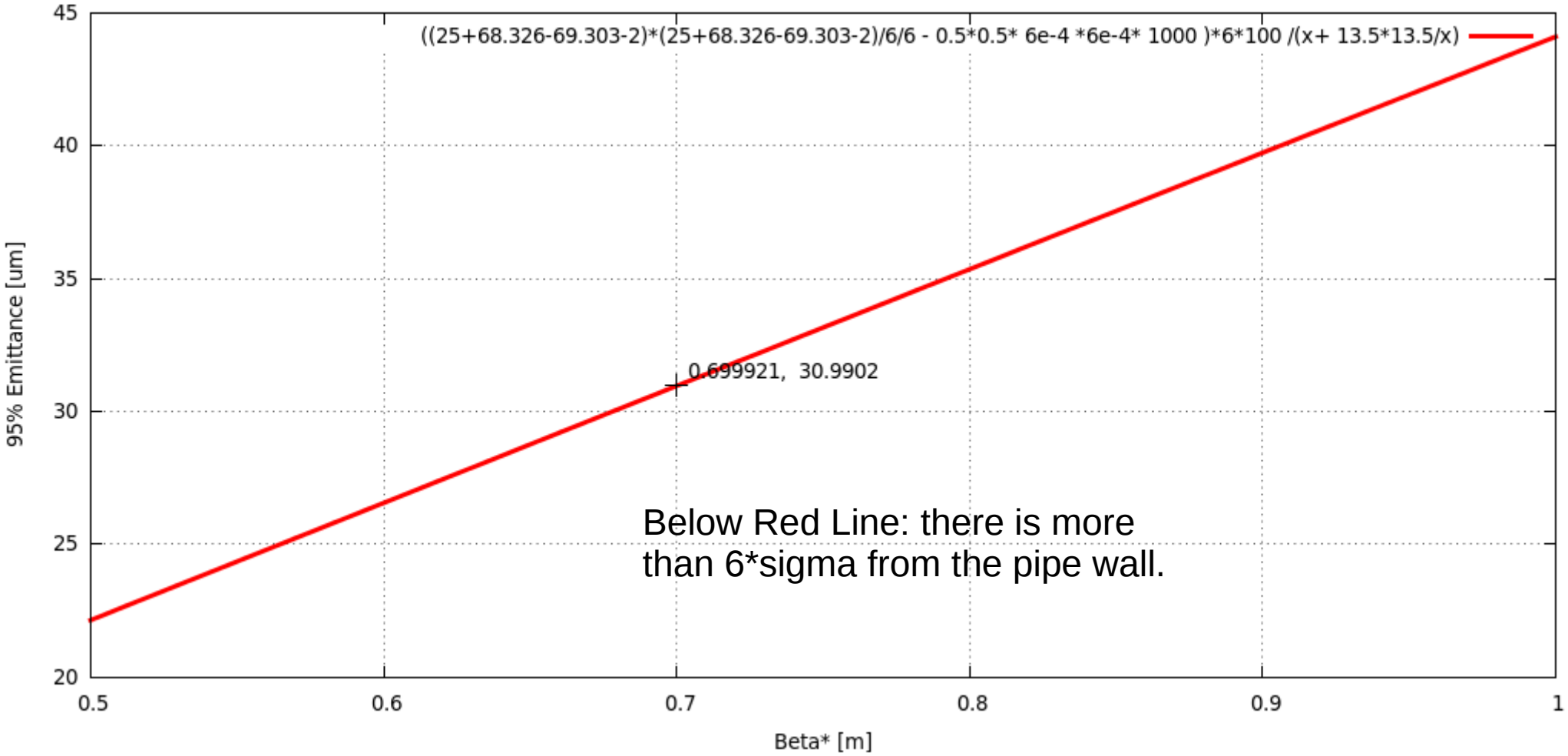
BSC = 6* sigma + Xcod

Sigma = Sqrt [Emit_rms * Beta + Dx * (dp/p)rms]
(dp/p)rms = 4.2e-4 for proton, 6e-4 for Au at 100GeV
Horizontal dispersion at DX, Dx ~ 0.5m

Xcod = 2 mm (depending on Al's magic)

Physical Aperture Limit at Store

Mainly from the Yellow beam at collisional IRs IR6 and IR8



For beta*=0.7m as we ran in 2012, if emit < 30um, P.A. Is larger than 6 sigma.

Physical Aperture Limit at Injection

1) Beam Energies at proton injection plateau:

proton →

blue	yellow
Direction	1
Select Species	PP
Polarized Proton	
Charge State	1
Harmonic	360
Bρ [T-m]	79.3667745
γ	25.3786244712
Momentum [GeV/c/n]	23.7935604109
Energy [GeV/n]	23.8120530698

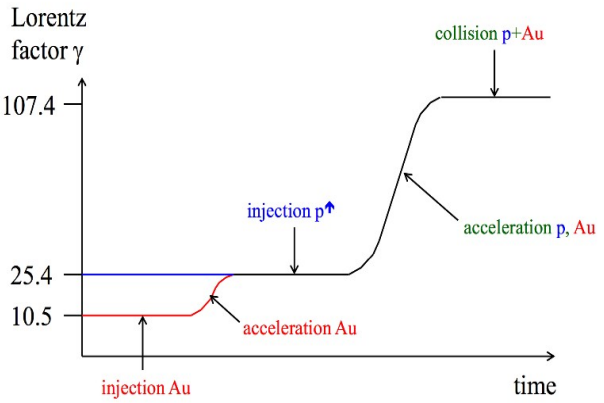
blue	yellow
Direction	-1
Select Species	Au
Gold	
Charge State	79
Harmonic	360
Bρ [T-m]	195.702985918
γ	25.2875836144
Momentum [GeV/c/n]	23.5276754097
Energy [GeV/n]	23.5460934786

← gold

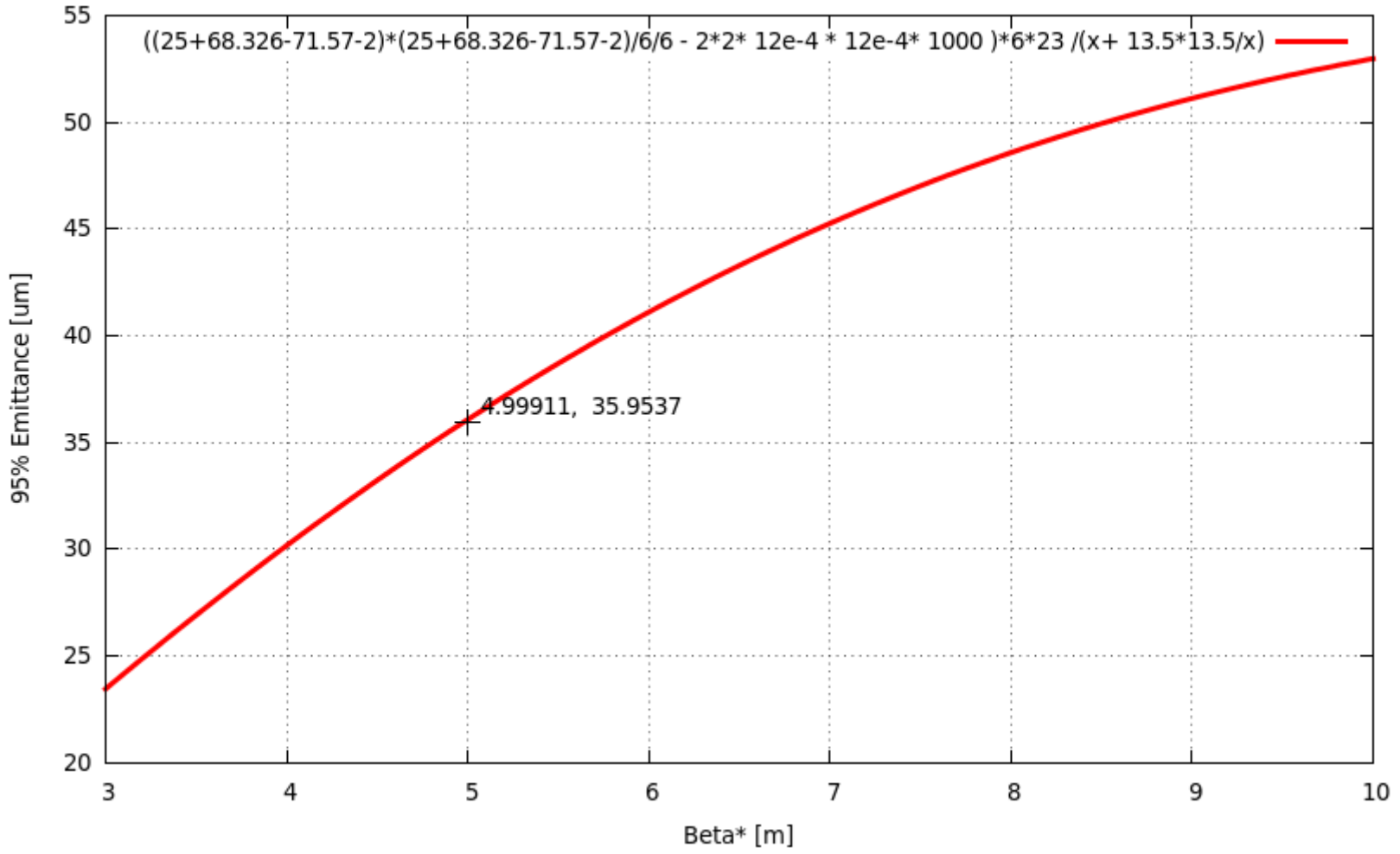
2) Orbits at the proton injection energy:

Offset at two end of DX magnets (unit : mm)

	Collisional IRs	No-collisional IRs
P:	37.34 / 1.79	60.252 / 24.294
Au	37.34 / 71.57	28.050 / 62.447



3) The physical aperture limit at injection

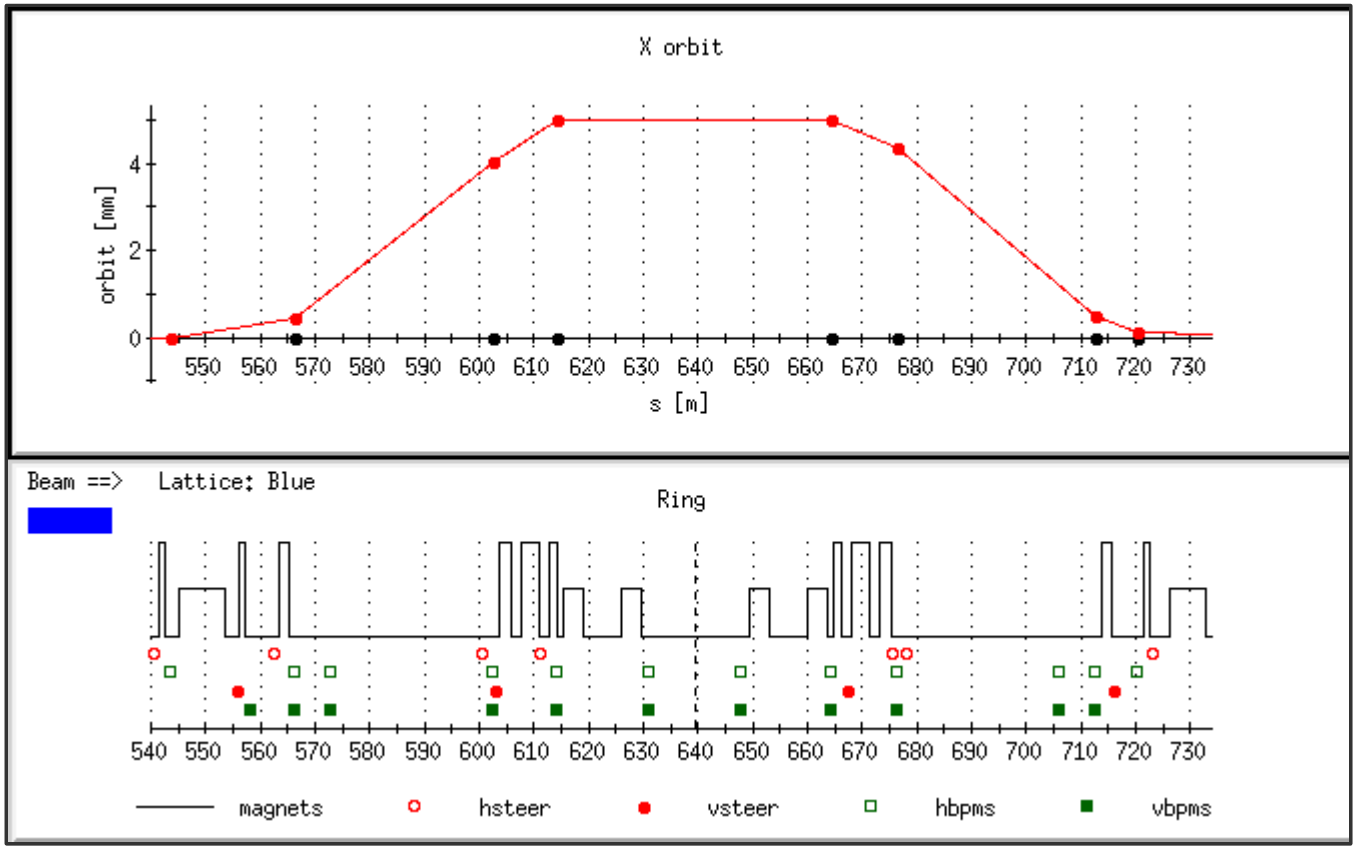


Below the red line, there is at least 6 sigmas away from the pipe wall.

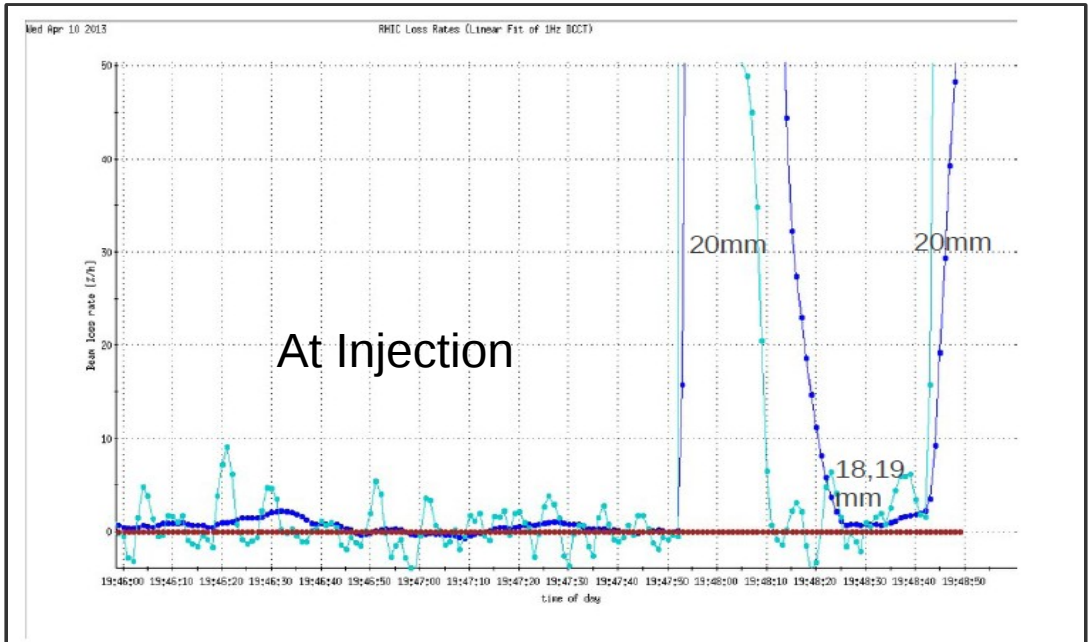
Previous DX P.A. Scan Exp.

1) Goal: Check how close the beam can stay close to the pipe wall for DX magnets

2) Experiment Setup: Generate an orbit position bump across one IR with 4 horizontal dipole correctors to record beam loss.



Results from Previous Exp.



IR2 Horizontal bump size 19mm

1) IR 12 Measurement:

Maximum orbit bump: +20mm / -18 mm

Considering the reference orbit offset at DX exit: 35 mm,

==> **Maximum measured beam center offset : 55 mm / -53 mm.**

2) IR 2 Measurement;

Maximum orbit bump : + 19 mm / -18 mm

Considering the reference orbit offset at DX exit: 35 mm

==> **Maximum measured beam center offset : 54 mm / -53 mm.**

Summary of experiment:

- The beta*s at IP12 and IP2 are 10.31m and 10.07m. The beta at the exit of DX is (28+/-0.2)m.
- One transverse rms beam size (1 sigma) was 1.66mm, with 15 um 95% transverse emittance.
- The beam pipe radius at DX is 68.326mm. There were (68-54) = 14mm from the beam center to the wall, which corresponds ~8.5 sigmas.

New Idea to Scan DX P.A.

1) Complication in previous experiment

Position bump covers whole IR section, can't distinguish the aperture limit is from DX or D0 or even triplets.

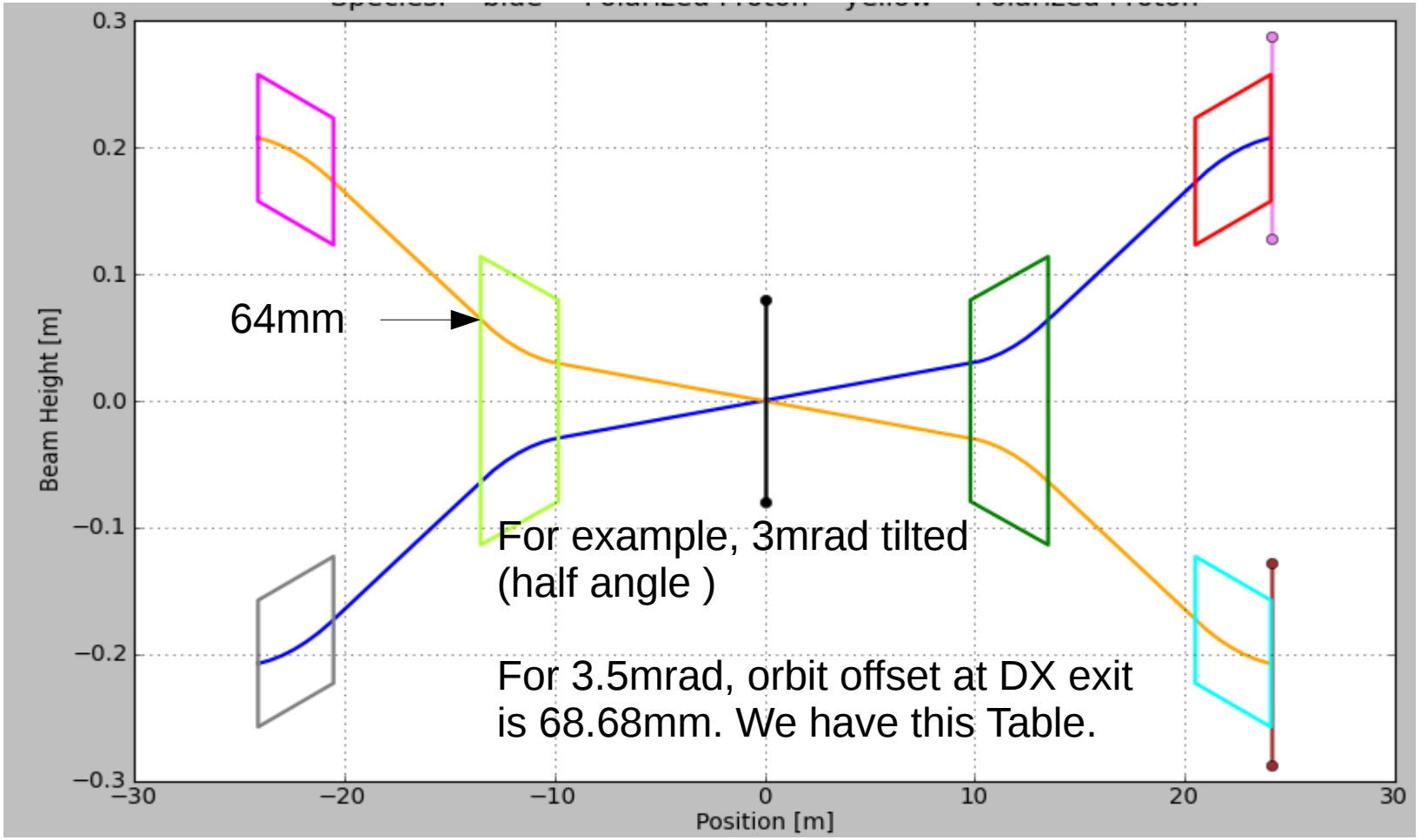
2) New Idea:

Directly modify DX and D0 strengths to generate a more realistic orbit tilt between two DXs, while with little orbit change in D0 and no orbit leakage out of D0.

Steve provides such a fitting program to calculate DX and D0 strengths with a given tilt angle.

Experiment Plan

1) Calculate settings of DX and D0 for a tilt angle or a known orbit offset at DX exit.
2) Set these strengths into machine and measure the beam decay.
3) Increase the angle until a huge beam loss is observed.
4) Determine the minimum distance between the beam center and the pipe wall offline.



Beam Time Requirement

Beam experiment time:

2 hours at injection

Careful preparation required:

Need consult Don and Al how to ramp DX and D0 power supplies to the experiment values.

(Actual DX strengths will be smaller than normal situation).