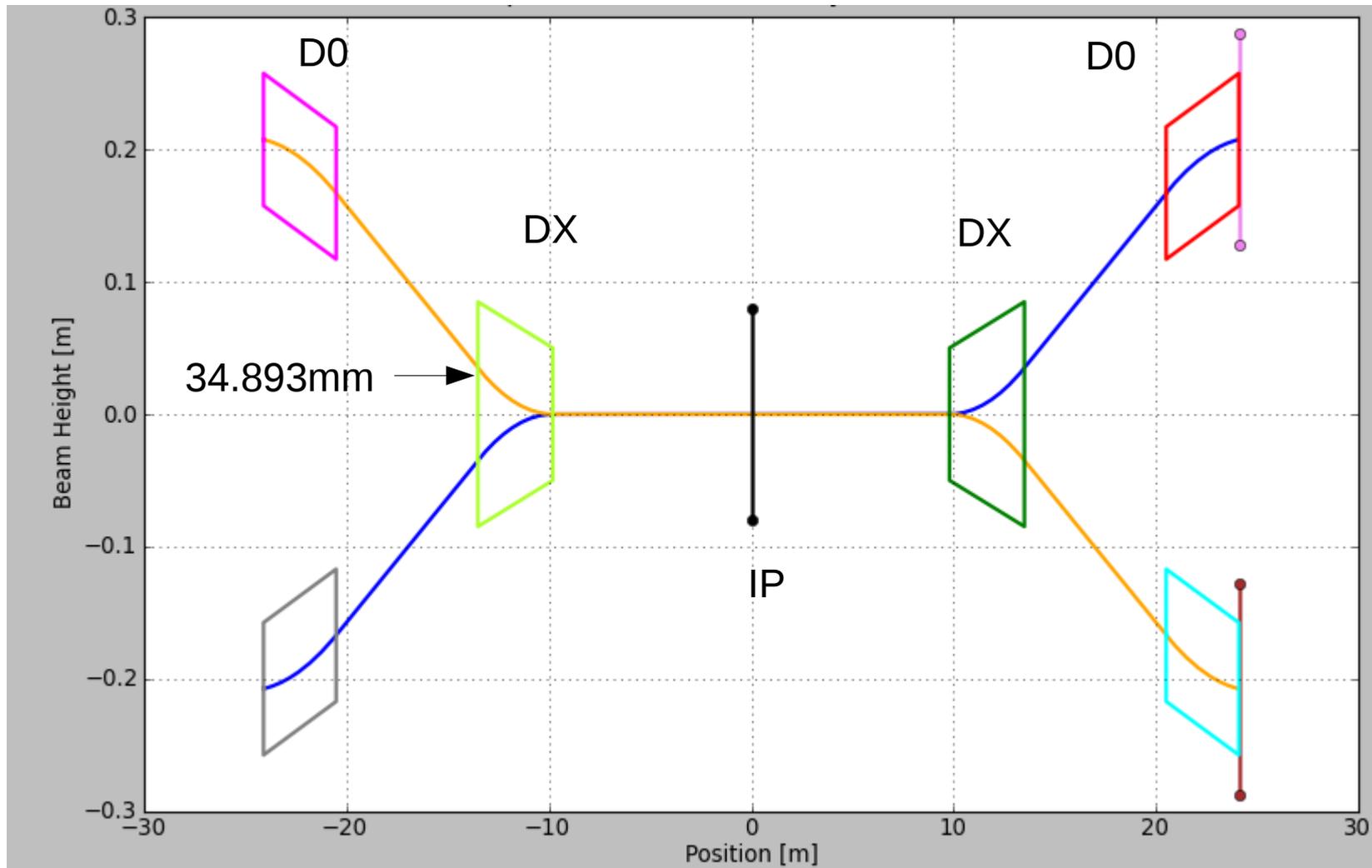


# DX Physical Aperture Measurement

Al, Chuyu, Mei, Steve, Yun

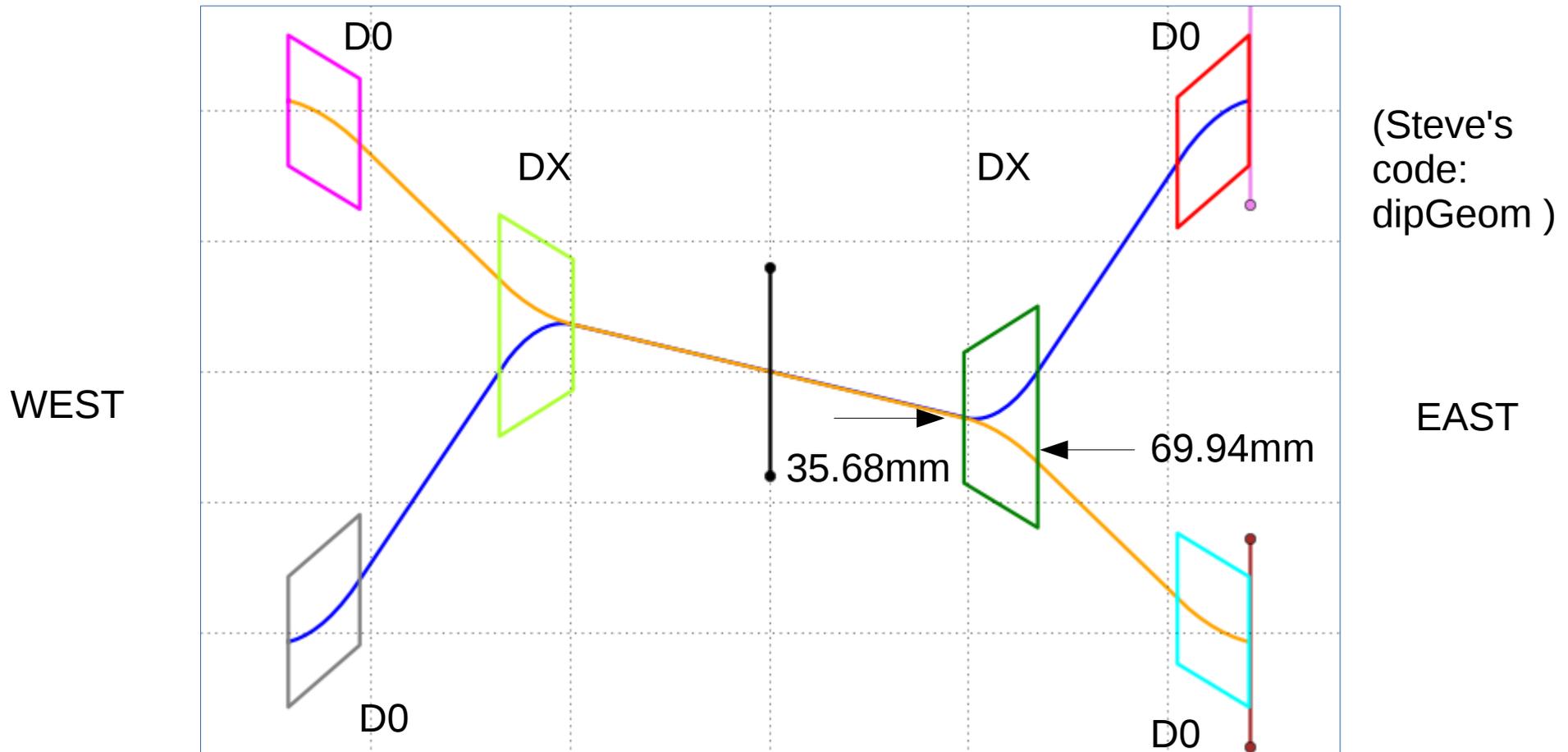
2014 RHIC APEX Workshop, 2014 Dec. 18, 2014

# Orbits between DX magnets in Normal Operation



- 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 **66.675mm** (instead of 68.326mm).

# Orbits between DXs for p-Au Operation



- 1) Beam orbits tilted by 3.581mrad(**3.64mrad**) w.r.t. beam pipe axis.
- 2) p beam: 35.68 and 0.15 mm on both ends of DX magnets.
- 3) Au beam: 35.68 and **69.94 mm** on both ends of DX magnets.

# Solution to DX Aperture Limitation

With DX physical aperture **66.675 mm**, clearly we do not have enough physical aperture in DX. Fortunately, DX magnet was designed to be able to move.

Decided DX movements in all IRs for 2015 p-Au run ( Chuyu )

	Sector	Distance (mm)	direction
move before pp	1	20	outwards
	2	20	inwards
	3	17.5	inwards
	4	17.5	outwards
move between pp and p-Au	5	25	outwards
	6	25	inwards
	7	25	inwards
	8	25	outwards
	9	20	outwards
	10	20	inwards
	11	20	inwards
	12	20	outwards

# The Goal of Beam Experiment

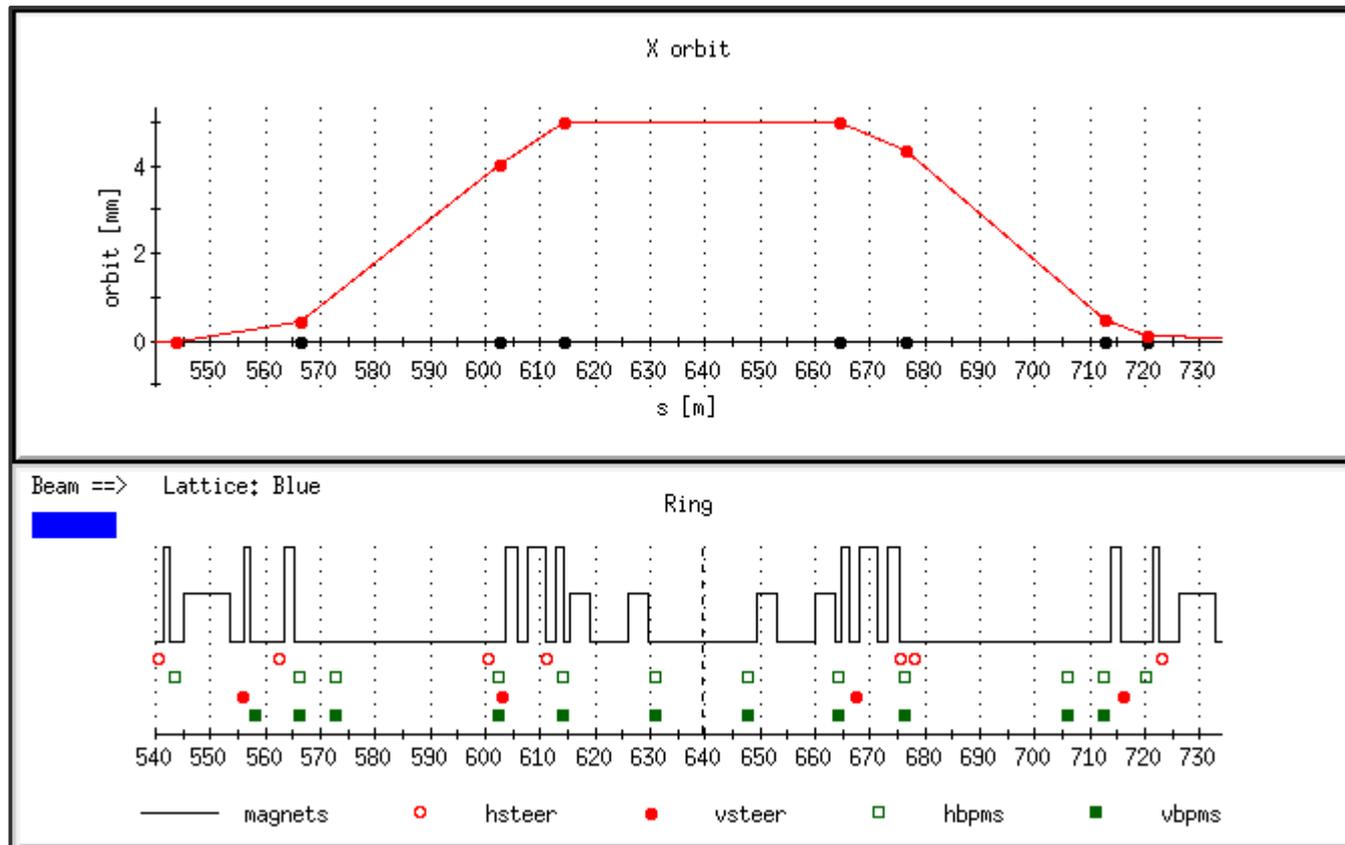
With 25 mm movement in IR6 and IR8, the beam center will be  $(66.675+25.0 - 69.94)=$  **21.74mm** off the beam pipe of DX exit.

## Through beam experiment:

- 1) Measure beam loss versus horizontal beam offset at DXs
  - method 1: using position bump across IR
  - method 2: using D0 and DX to tilt orbit between DXs
- 2) Determine safe beam clearance at DX magnets.

Our measurements mostly were done at injection energy.

# Method 1: Experiment Setup

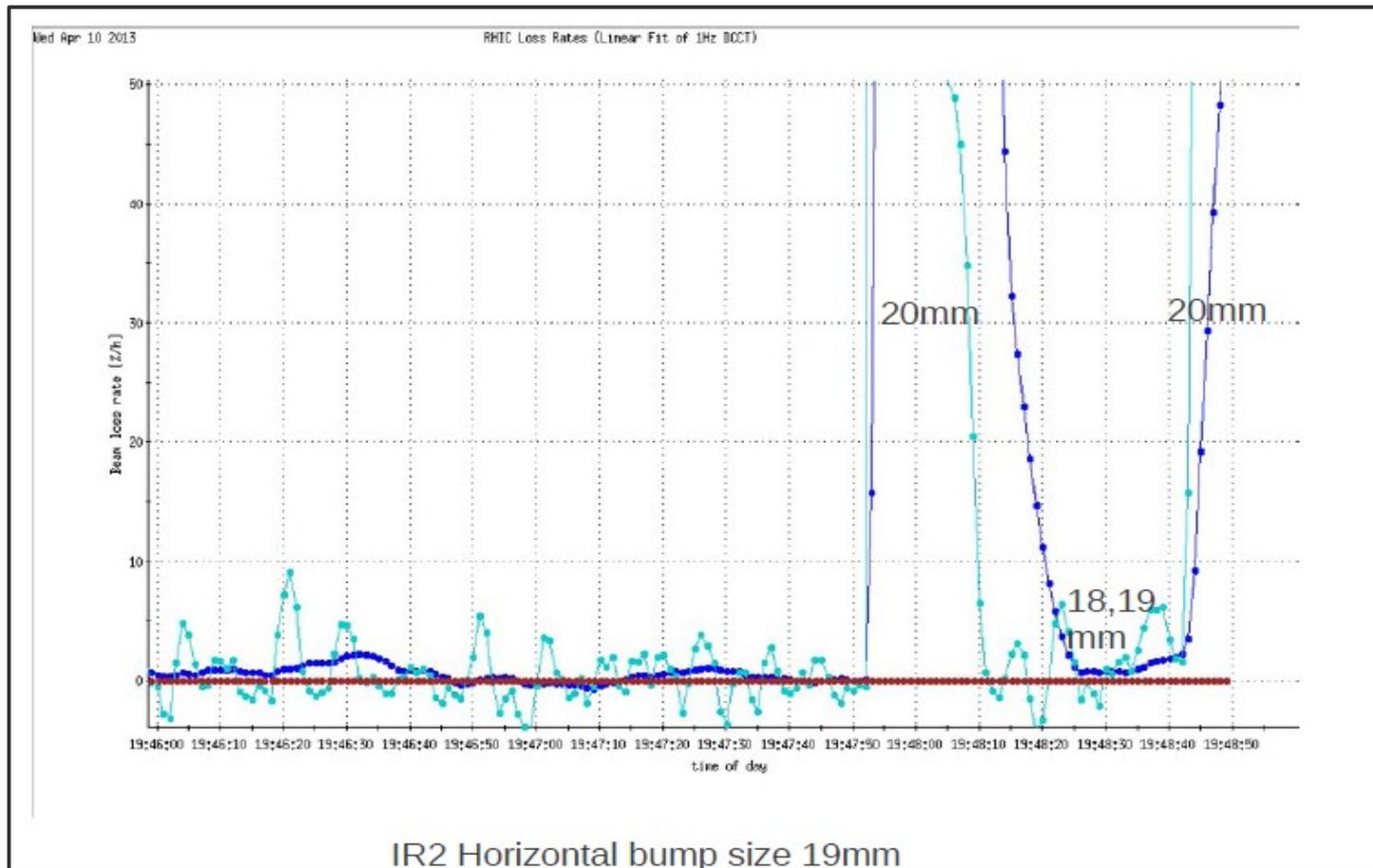


2013  
APEX

Au ion

4 horizontal dipole correctors used.

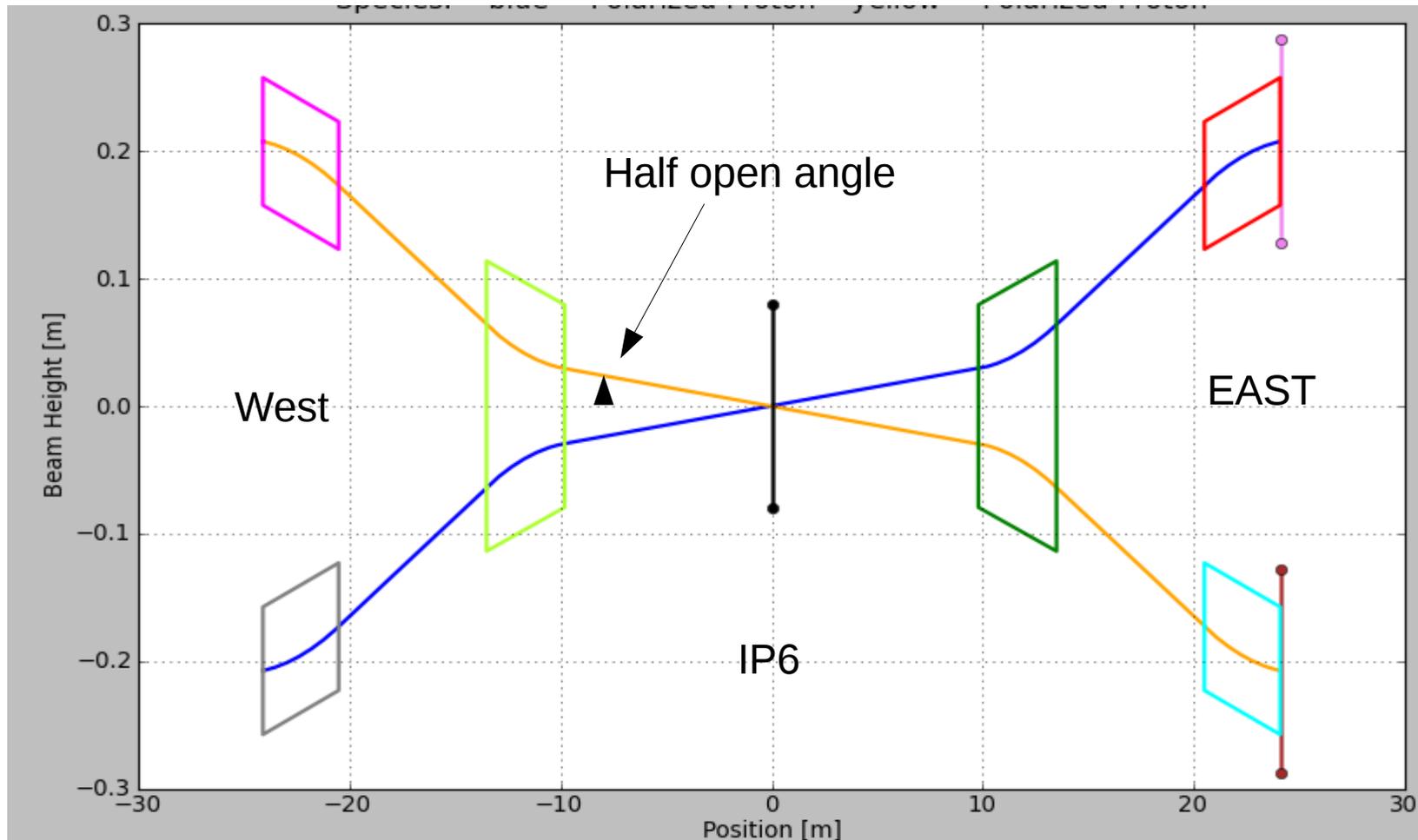
# Method 1: Results



	[ max bump amp. ]	[ offset to axis at DX exit ]	[ to DX physical aperture ]
IR2:	+19mm and -18mm	53.89 mm and -52.89mm	12.78 mm and 13.78mm
IR12:	+20mm and -18mm	54.89 mm and -52.89mm	11.78 mm and 13.78mm

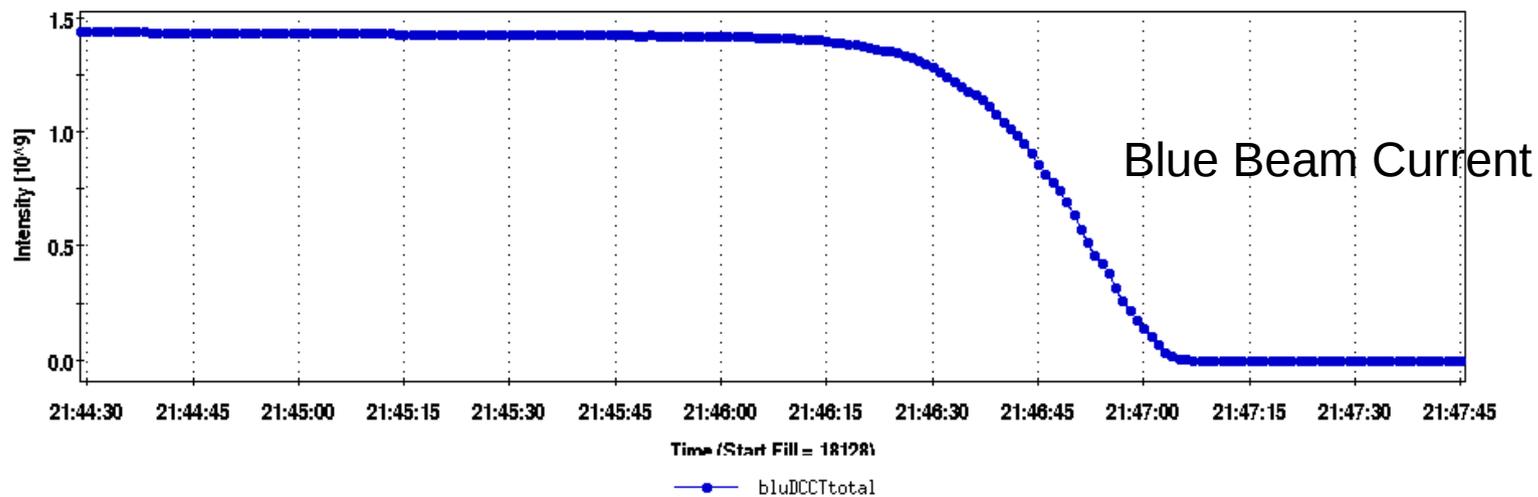
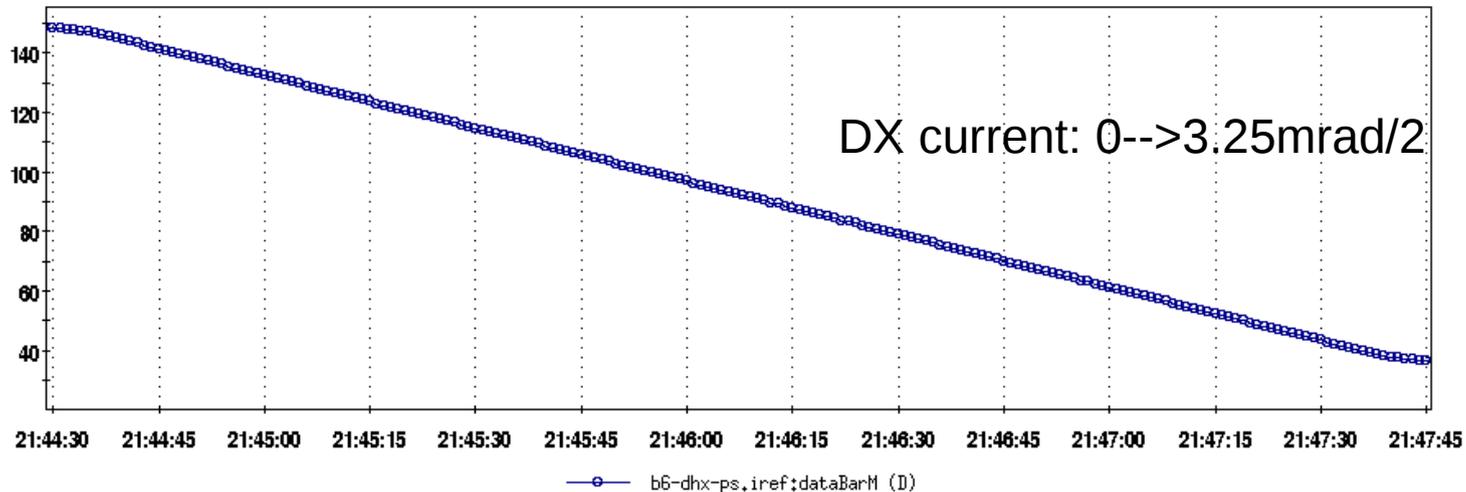
**If move DX by 25mm, the Au beam center will be 21.74mm (> 13.78mm) from DX aperture.**

# Method 2: Experiment Setup



We use D0 and DX to generate a CLOSED TILT ORBIT between two DXs. Above plot shows the beam orbits in the Blue and Yellow rings.

# Method 2: Experiment Procedure



2014 APEX  
Proton used

In experiment, slowly ramp D0, DX power supply current to determine at which current settings ( ->tilt angle) a visible beam loss takes place.

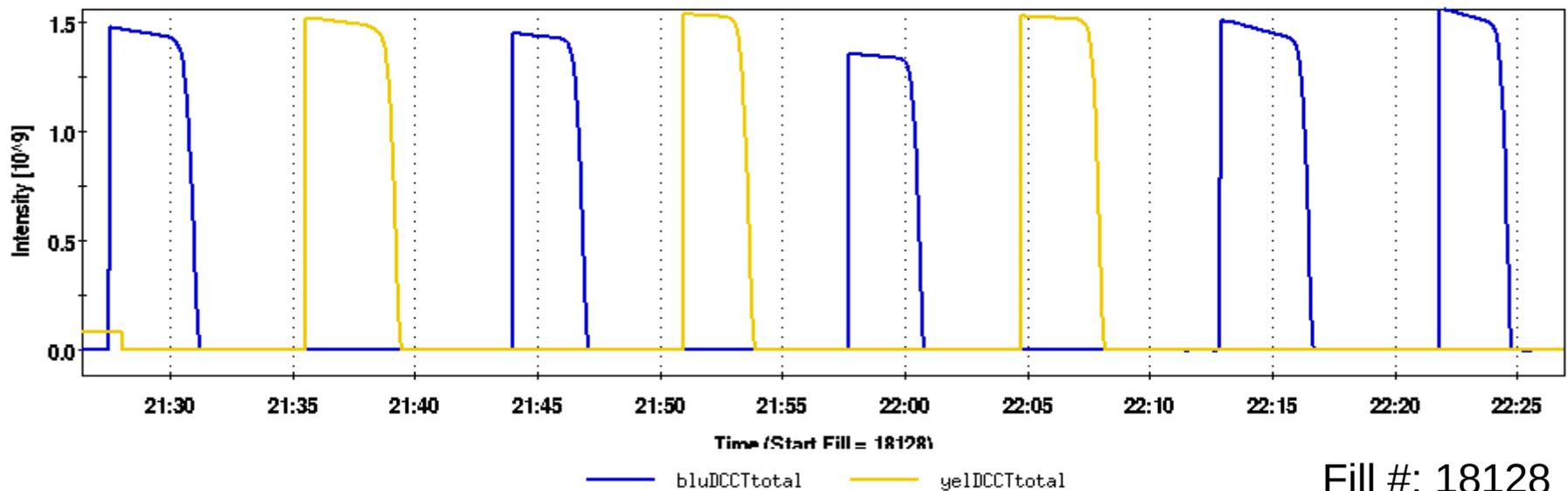
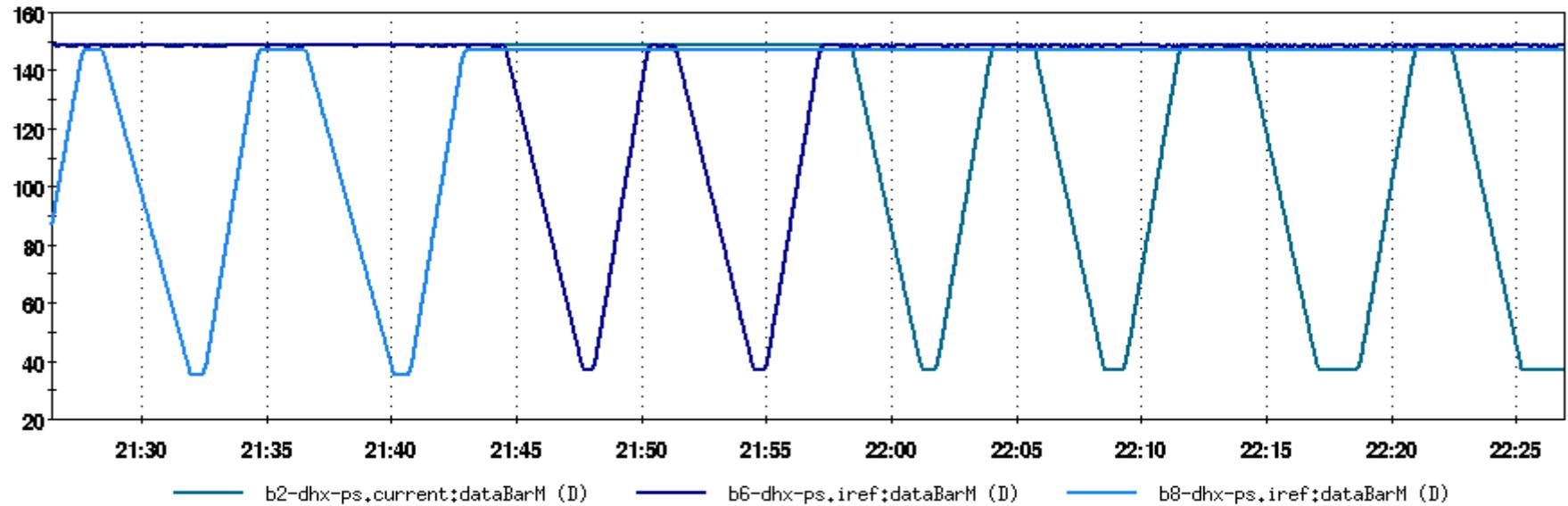
# Method 2: Data Taken

IP8

IP6

IP2

IP2



Fill #: 18128

# Method 2: Measurements

0 rad

3.25mrad/2

IR	DX Max Current (A)	DX Min Current (A)	Beam Loss begins (A)	Orbit Angle w.r.t. axis (mrad)
IR8	146.66	35.10	97 (B) 98 (Y)	1.45 (B) 1.42 (Y)
IR6	148.37	36.69	98 (B) 101(Y)	1.47 (B) 1.38 (Y)
IR2	148.87	37.12	93 (B) 97 (Y)	1.62 1.51

# Method 2: Data Interpretation (I)

1) With 1.38mrad half open angle, the beam center is 48.18mm from axis, or **18.50 mm** away from DX beam pipe.

2) Assuming at injection:

$$\text{Emit} = 12 \text{ Pi. ( IPM measurement ), } \gamma = 10.52$$

$$\text{Beta}_x \text{ at DX exit is: } 10 + 13.5 * 13.5 / 10 = 28.23\text{m}$$

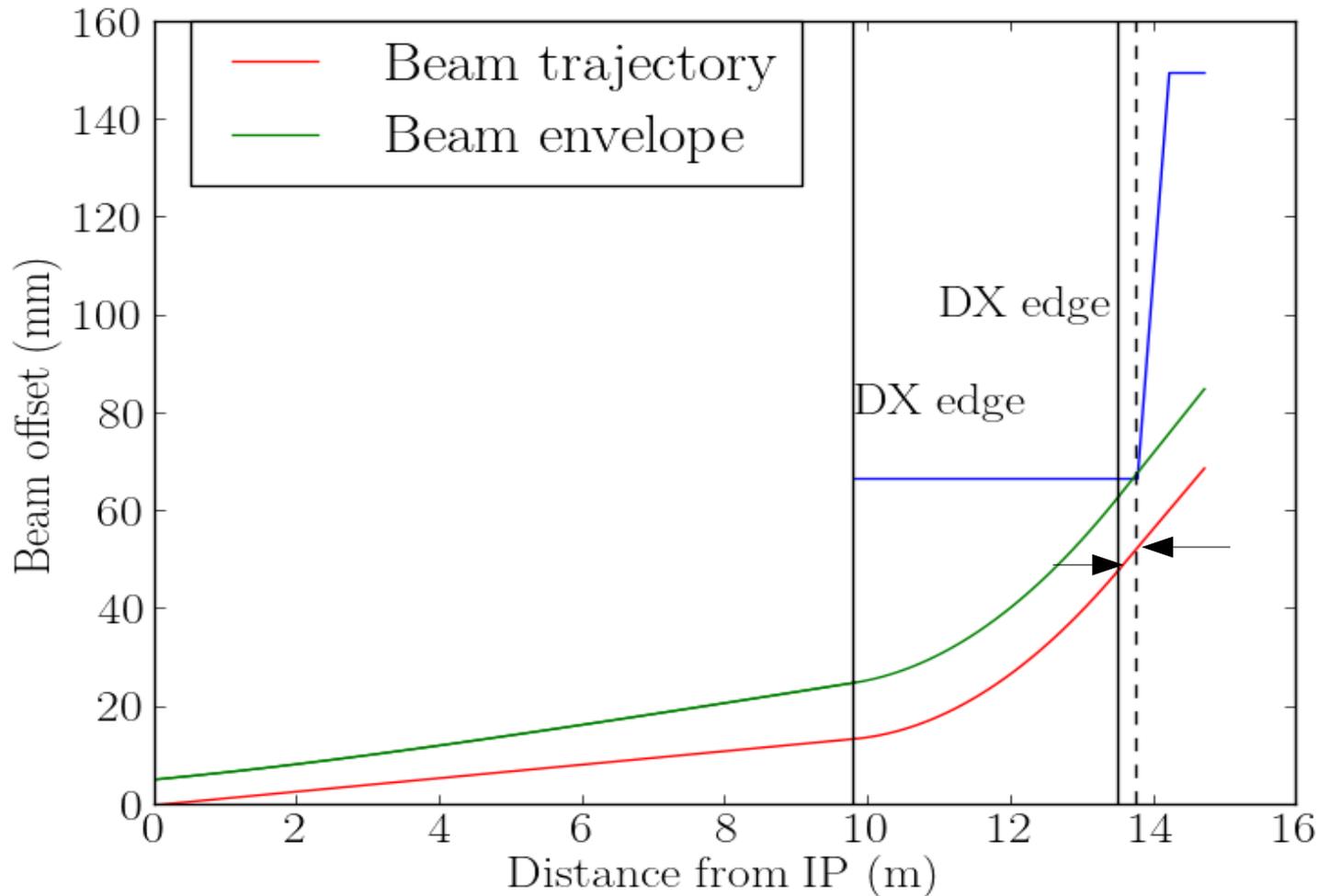
1 sigma beam size at **DX exit** is:

$$1 \text{ sigma} = 2.32 \text{ mm}$$

Beam center at 18.50mm from the beam pipe wall at DX :

$$18.50 / 2.32 = \mathbf{8.0 \text{ sigma} .}$$

# Method 2: Data Interpretation (II)



- 1) **New findings:** beam first scrape the pipe at ( 13.5mm + 10.3" inches) instead at DX exit (chuyu, dejan )
- 2) At 13.75m from IP6, with 1.38mrad half open angle, beam center offset is (48.18mm + 4.34mm) = 52.52mm. To DX pipe is  $(66.675-52.52)/2.34=$ **6.05 sigma**

# Summary

- 1) Two methods were used to measure physical aperture at DX magnets.
- 2) With Au beam at injection, beam had good lifetime until its center was less than 13.78 mm from the beam pipe at DX.
- 3) With proton beam at injection, beam had good lifetime with a maximum half open angle 1.38mrad, which means beam center is 18.50 mm from the beam pipe aperture at DX.
- 4) If translated to rms beam size, the beam clearance to the beam pipe at DX is around 6 sigma, instead of originally claimed 8 sigma.