DØ Forward Proton Detector Alignment

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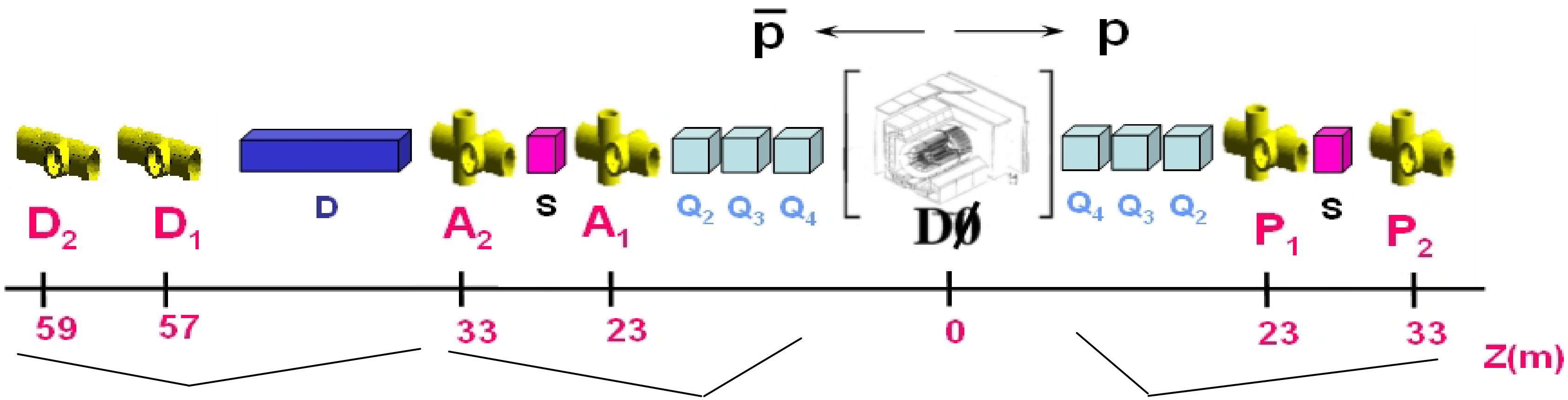
DØ Forward Proton Detector

FPD: a series of momentum spectrometers that make use of accelerator magnets in conjunction with position detectors along the beam line.

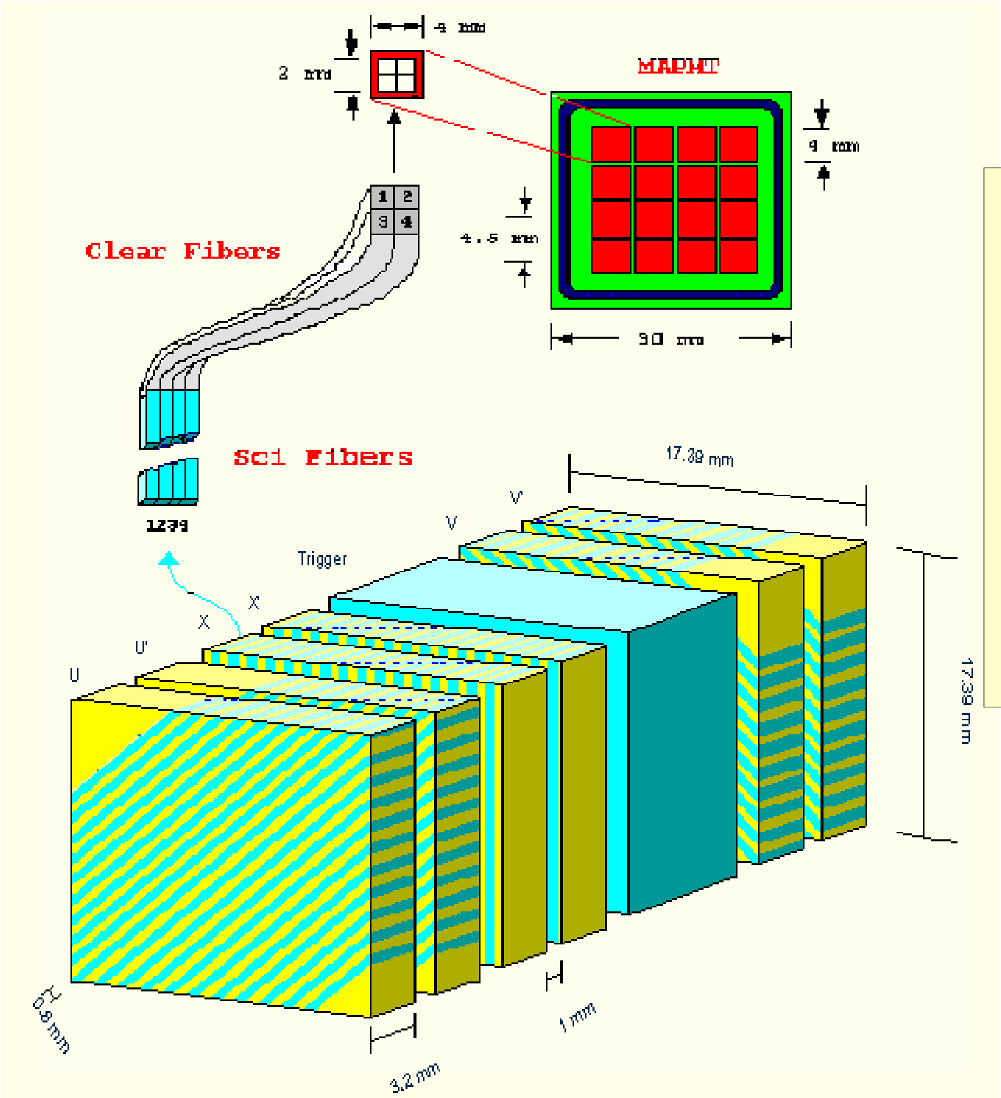


- **Dipole Spectrometer**
- inside the beam ring in the horizontal plane
- use **dipole magnet** (bends beam)

- **Quadrupole Spectrometers**
- surround the beam: up, down, in, out
- use **quadrupole magnets** (focus beam)
- also shown here: **separators** (bring beams together for collisions)

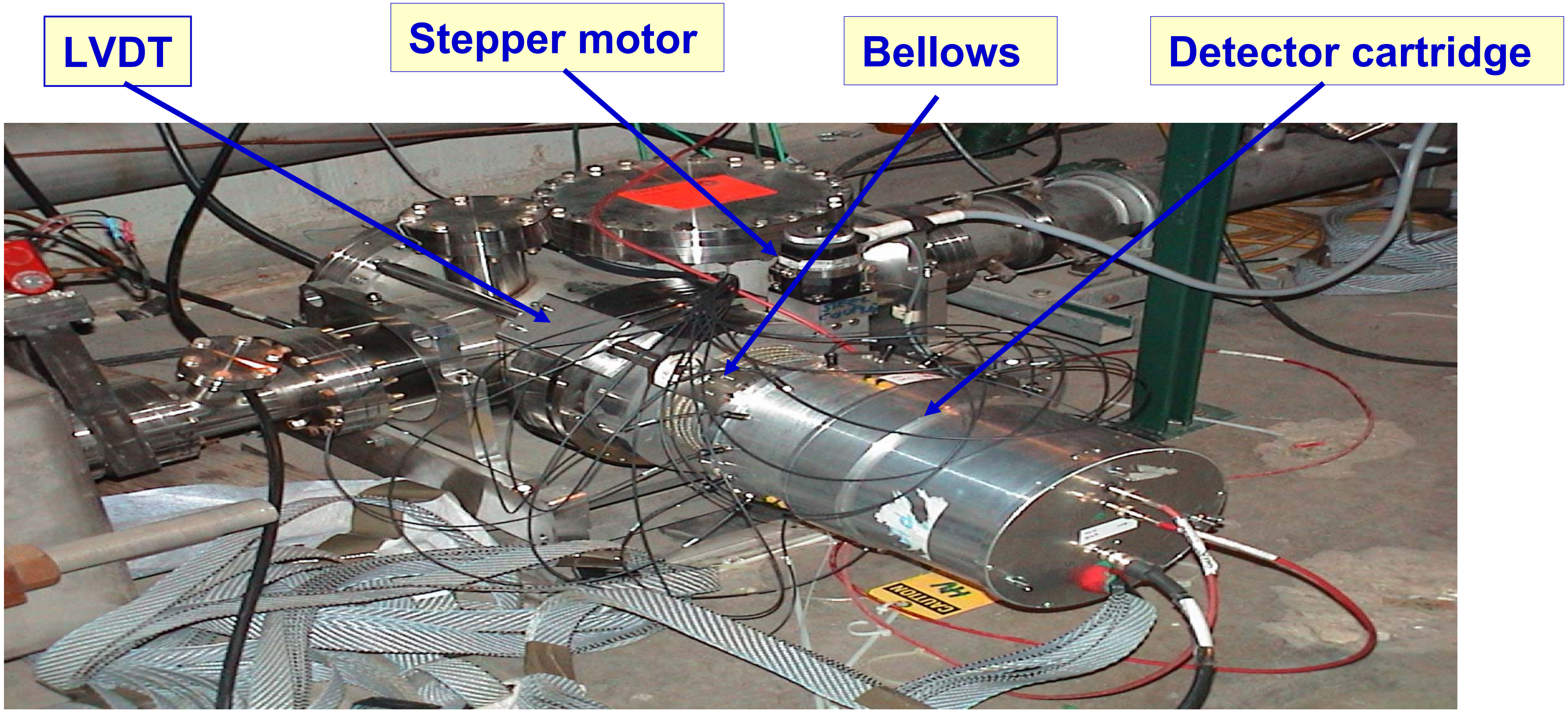
A total of 9 spectrometers composed of 18 Roman Pots

The Detector



- Six scintillating fiber planes (u,u',x,x',v,v').
- Fibers are squared with 800 µm side.
- (') planes offset by 2/3 fiber
- **80 µm theoretical resolution**
- 4 fibers/channel
- 112 channel/detector
- 7 MAPMTs/detector (H6568)
- Total # channels = 2016

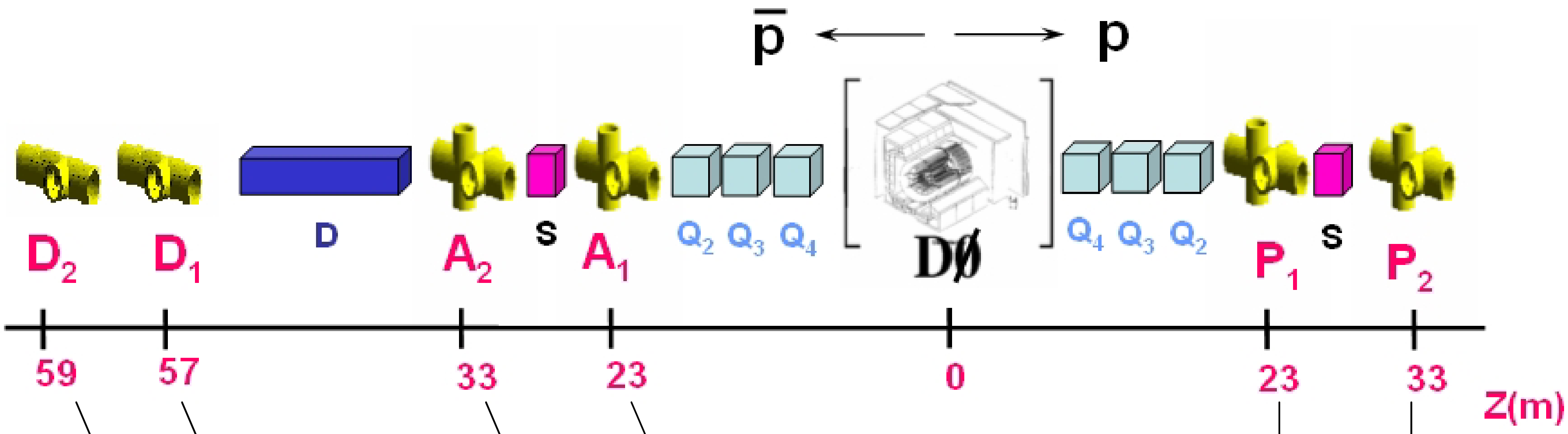
A photo with a dipole pot installed



• **All 18 roman pots are already installed and fully operational.**

• **The distance the pot moves is determined with a LVDT and with the number of turns of the stepper motor (both of them calibrated previously).**

FPD EFFECTIVE LENGTHS



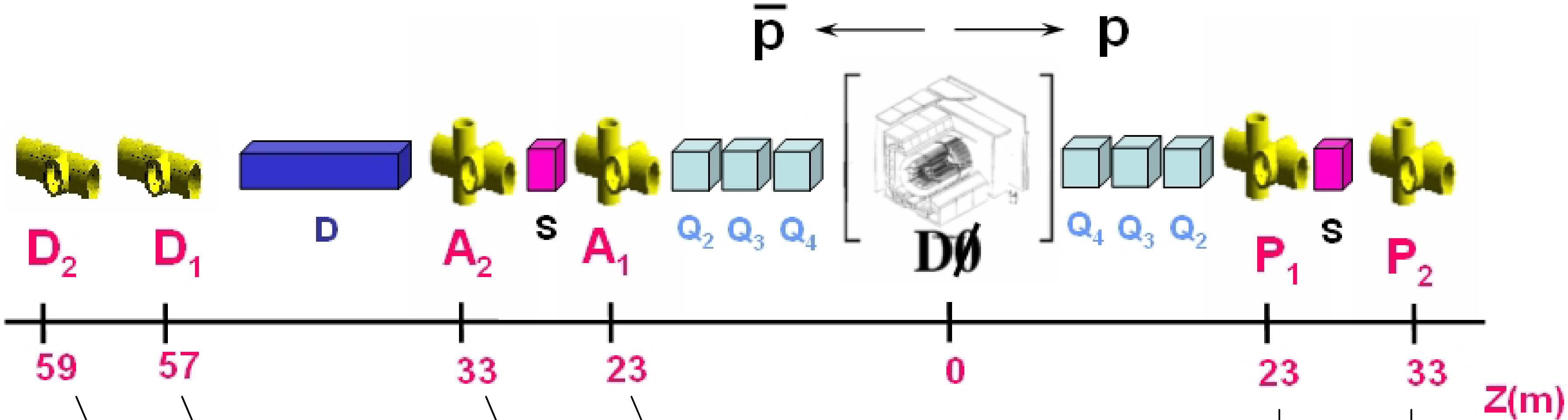
	D2	D1
Leffx (m)	7.4	8.2
Leffy (m)	1.8	2.4

	A2	A1
Leffx (m)	16.2	19.3
Leffy (m)	8.4	10.8

	P1	P2
Leffx (m)	10.8	8.4
Leffy (m)	19.3	16.2

FPD BEAM WIDTHS

(20π emmitance)



	D2	D1
σ_x (mm)	0.7	0.8
σ_y (mm)	0.2	0.3

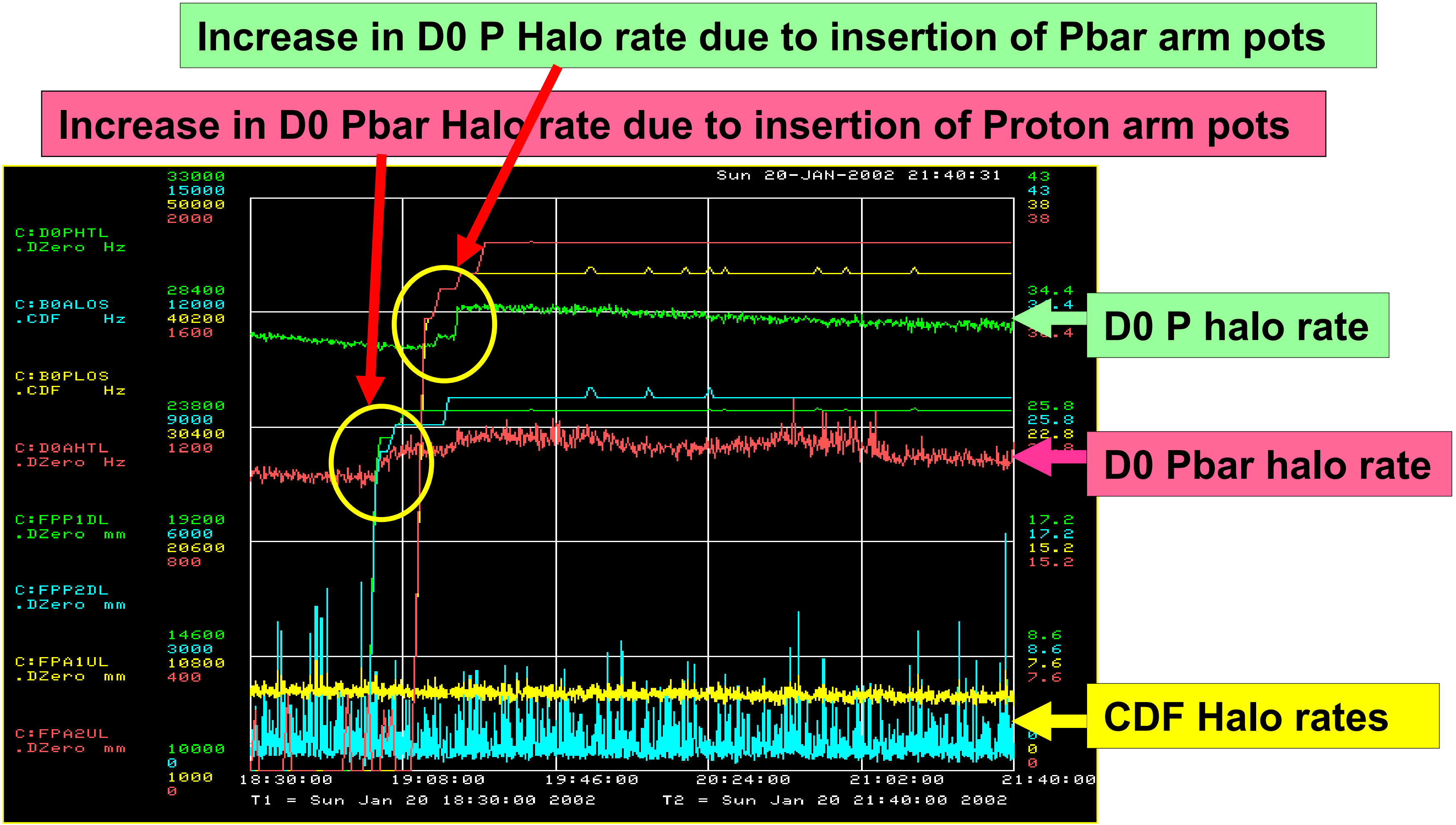
	A2	A1
σ_x (mm)	1.6	1.9
σ_y (mm)	0.8	1.1

	P1	P2
σ_x (mm)	1.1	0.8
σ_y (mm)	1.9	1.6

DØ Roman pot insertion

Pots are inserted until they touch beam halo.

Maximum increase in D0 beam halo rate < 20 %.



Detector Position

- **Several measurements in each pot are performed to obtain the position of the bottom of the detector respect to the ideal beamline when the pot is at home position:**

1. Distance from bottom of the pot to the home position.
2. Thickness of the bottom of the pot.
3. Location of home position with respect to a tooling ball (located on the pot stand.)
4. Distance between the ideal beam line and the tooling ball.

- **We subtract the pot displacement from the home position to obtain the distance between ideal beam line and bottom of the detector.**
- **The location of each fiber with respect to the bottom of the pot is determined for the ideal geometry.**
- **The deviation between actual and ideal fiber positions can be determined for each detector using track residuals.**
- **Offset of real beam position and ideal beamline is determined using elastic events.**

Alignment using scintillation counters

- RATE = ERATE + IRATE

  IRATE should be proportional to collision rate.
- Send Pots to Prestablished positions according to beam conditions.

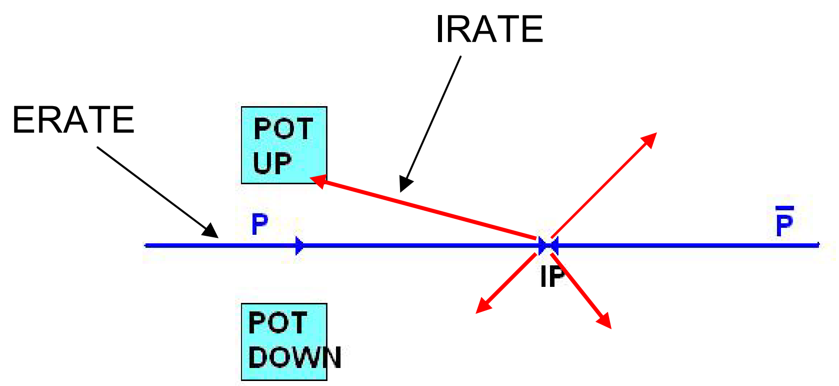
LIMITING FACTOR FOR POT INSERTION:

Either Proton halo or Pbar halo or total pot rate

- Once positions have been reached we symmetrise pots according to IRATEs.

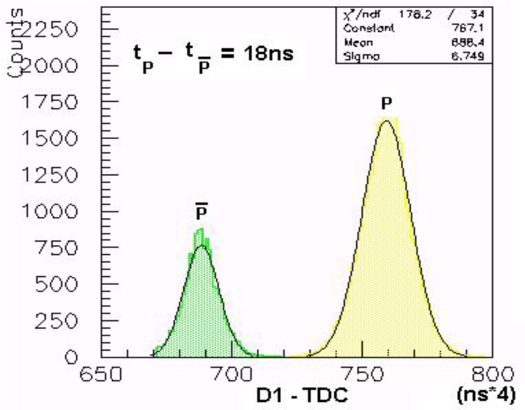
AFTER POT INSERTION:

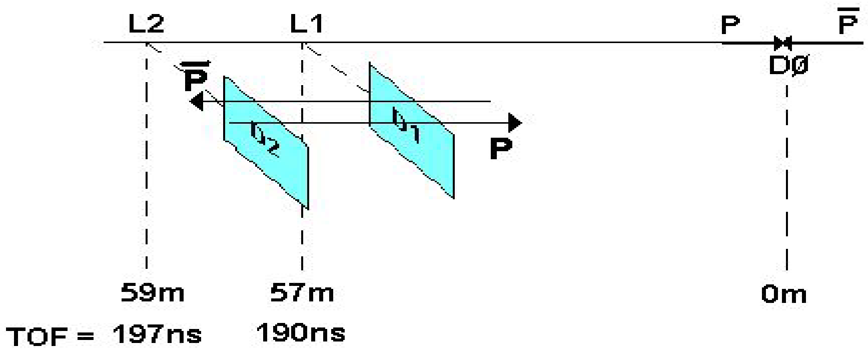
$$X_{BEAM} = (X_{OUTER} + X_{INNER})/2$$
$$Y_{BEAM} = (Y_{UP} + Y_{DOWN})/2$$

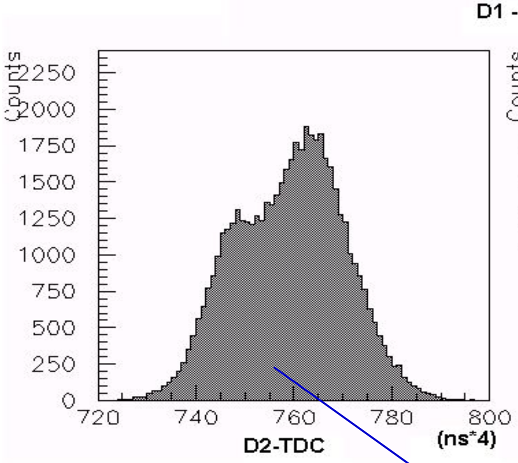


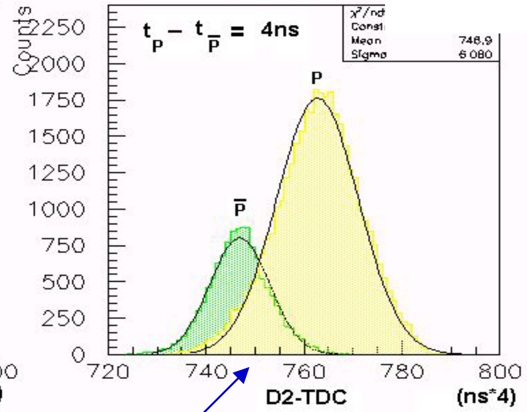
TRIGGER SCINTILLATORS TDCs

TDC information can be used to determine the Z position.









We can differentiate the peaks in D2 using D1

From TDCS :

18ns = (396ns – L1/c) – L1/c

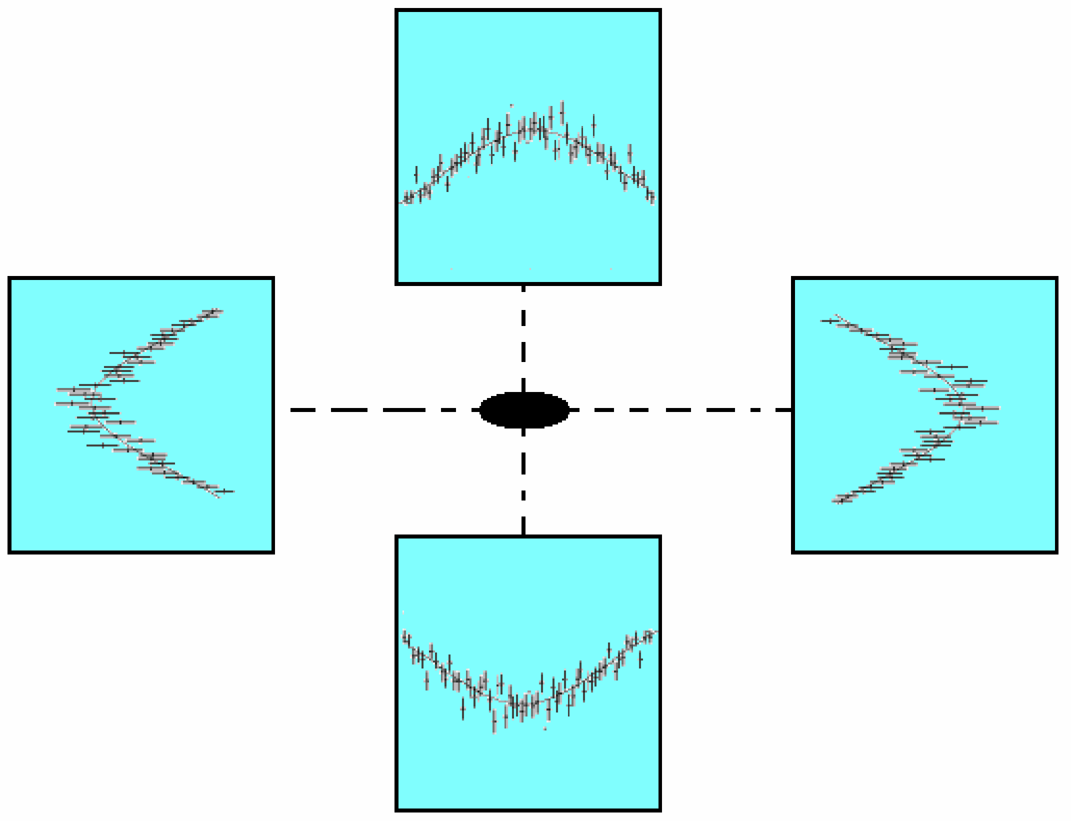
4ns = (396ns – L2/c) – L2/c

→ **L1 = 56.7 m; L2 = 58.8 m**

Tevatron Lattice:

L1 = 56.5m; L2 = 58.7m

Alignment using elastic events



- X beam position from Vertical pots.
- Y beam position from horizontal pots

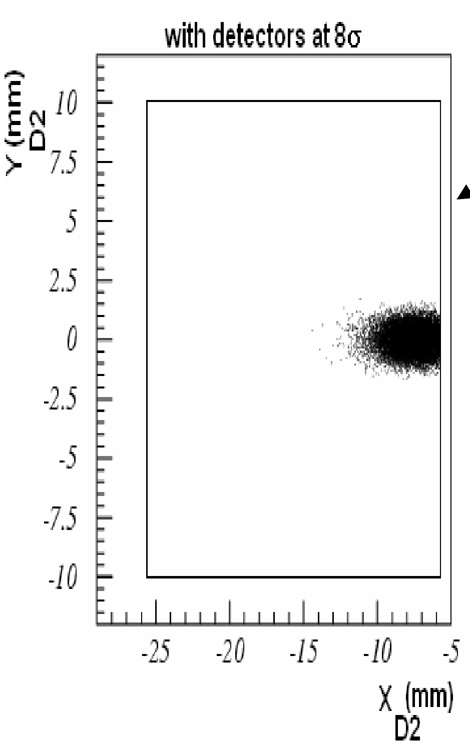
Elastic Trigger

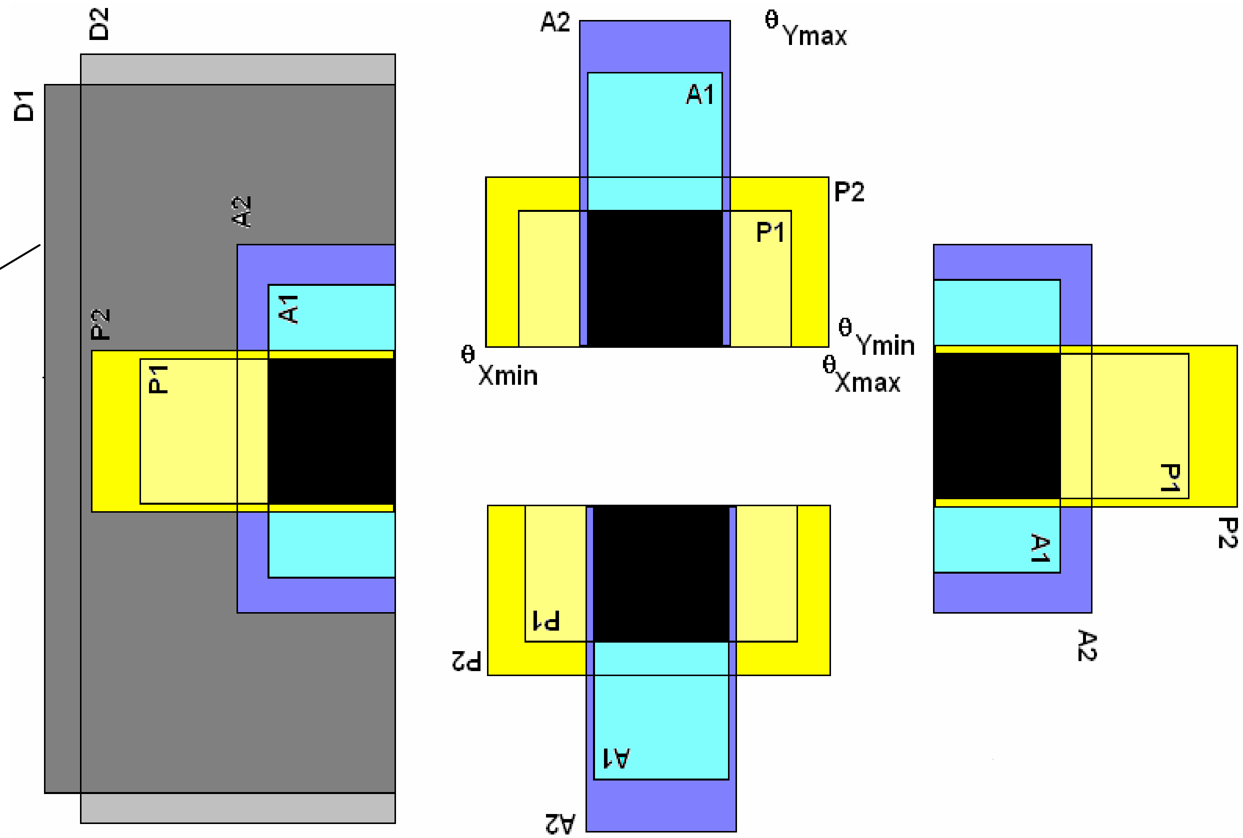
1. Make a tight elastic trigger in hardware:
   (A1U.A2U.P1D.P2D + A1D.A2D.P1U.P2U
   + A1O.A2O.P1I.P2I + A1I.A2I.P1O.P2O)
   & veto on Luminosity counters
2. In software select for each detector its corresponding trigger term and apply TDC cuts.
3. Convert fiber information to detector X,Y coordinates
4. Transform detector X,Y coordinates to X,Y ideal beam position coordinates.
5. Only use region with common angular coverage (see next slide).
6. Fit a gaussian to dN/dY from horizontal pots and a gaussian to dN/dX from vertical pots.

Angular coverage for elastic events

Black region is the common angular coverage for detectors in the trigger (assuming all detectors located at same sigma value from beam):

MC Elastics in D2:

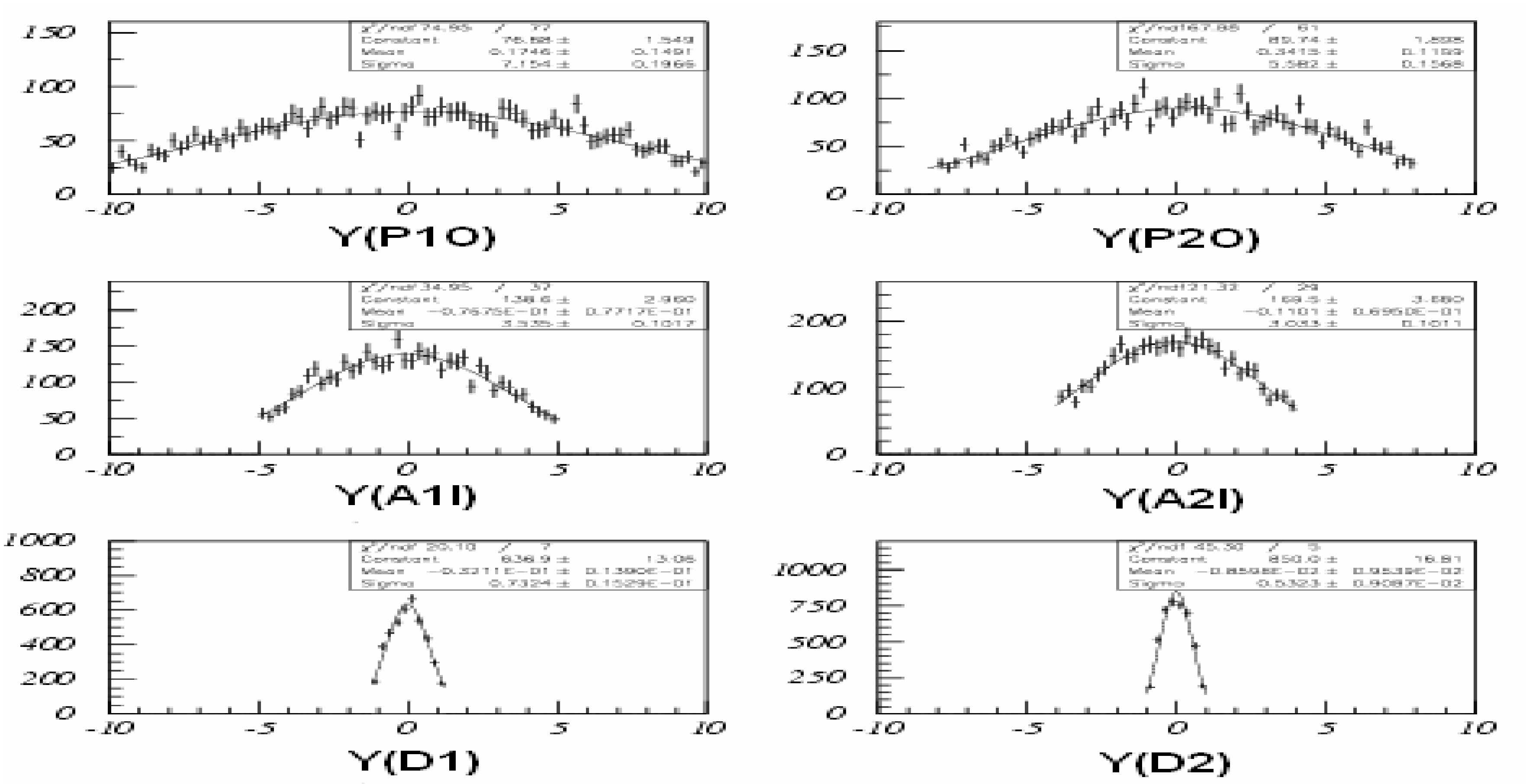




Horizontal Pots

5000 MC elastic events are shown in the plots.

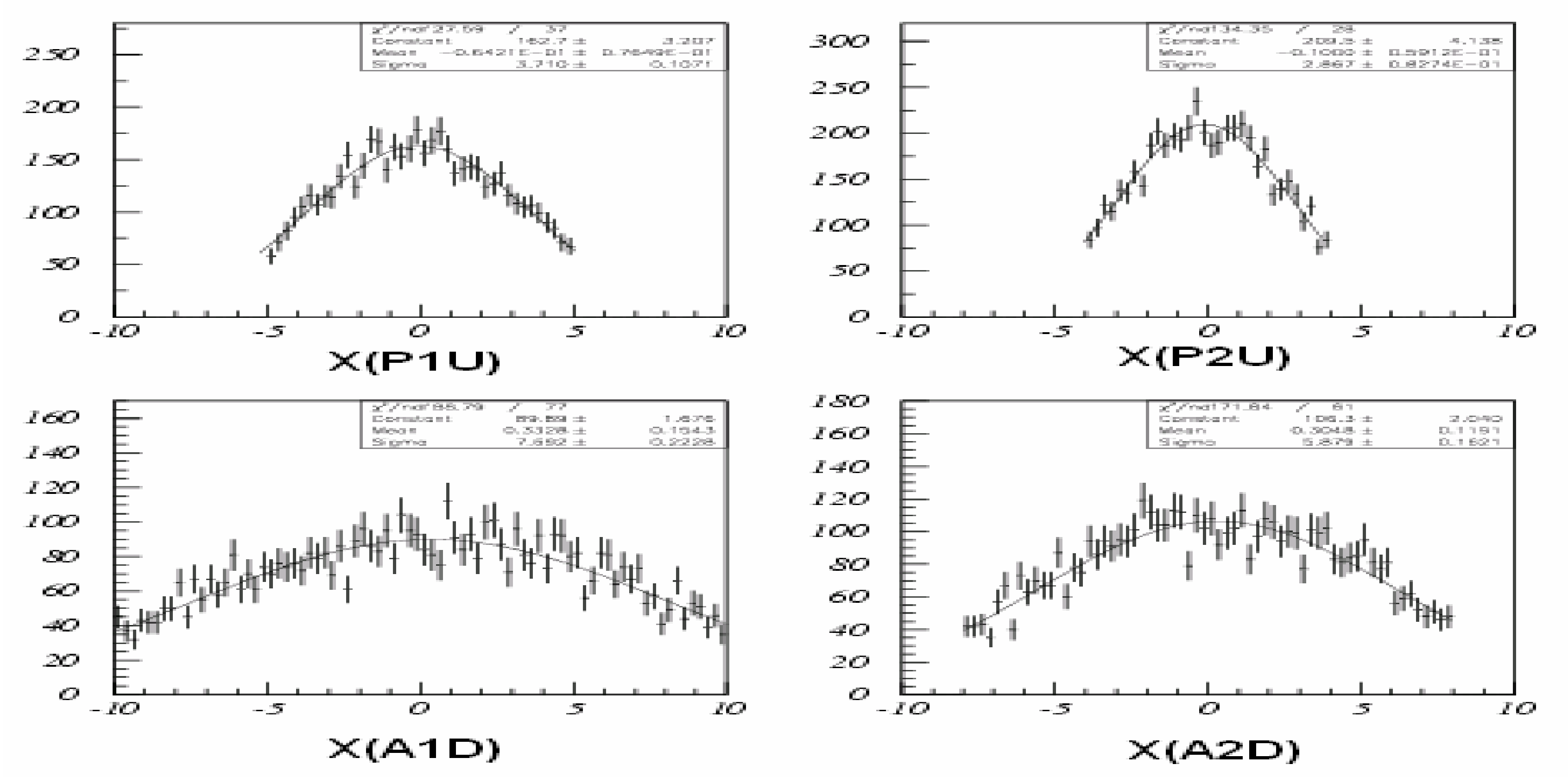
An uncertainty in the beam position less than 120 μm is obtained for all pots except for P1 where an uncertainty of 150 μm is obtained.



Vertical Pots

5000 MC elastic events are shown in the plots.

An uncertainty in the beam position less than 120 μm is obtained for all pots except for A1 where an uncertainty of 150 μm is obtained.



Conclusions

The plan we are pursuing to align FPD roman pots requires:

1. Use of Scintillation counters to simmetrise opposite side pots around the beam.
2. Use of X,Y coordinates from elastic events to determine beam position respect to ideal beam line.