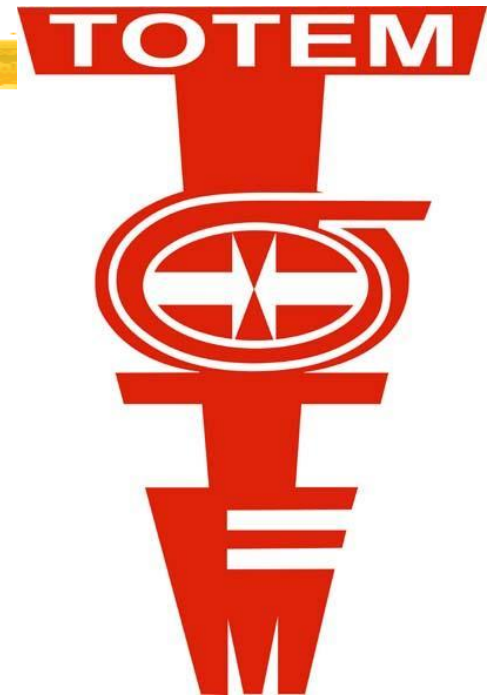


First Data from the TOTEM experiment at LHC

**F.S. Cafagna, INFN Bari
on behalf of the TOTEM
Collaboration**



TOTEM Physics goals

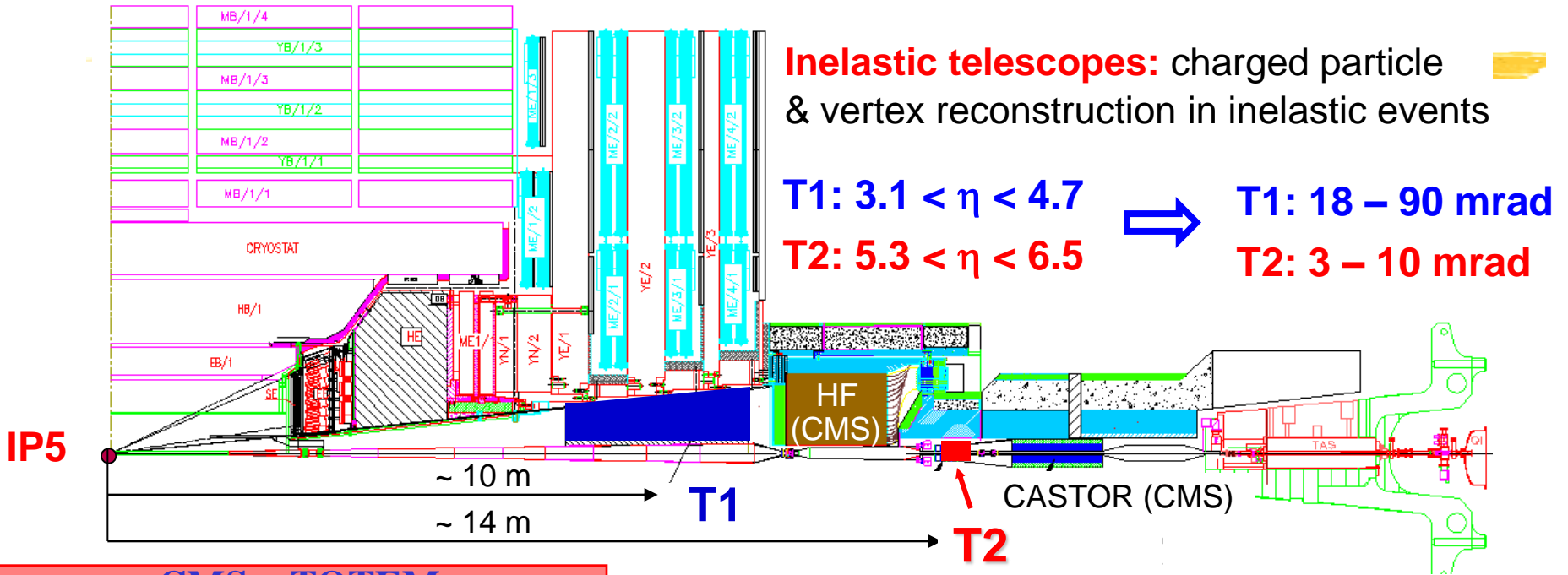
● TOTEM

- $\sigma_{\text{TOT}}^{\text{pp}}$ with a precision $\sim 1\text{-}2\%$, simultaneously measuring:
 - N_{el} down to $-t \sim 10^{-3} \text{ GeV}^2$
 - N_{inel} with losses $< 3\%$
- Elastic pp scattering in the range $10^{-3} < |t| \sim (p\theta)^2 < 10 \text{ GeV}^2$
- Soft diffraction (SD and DPE)
- Particle flow in the forward region (cosmic ray MC validation/tuning)

● TOTEM & CMS

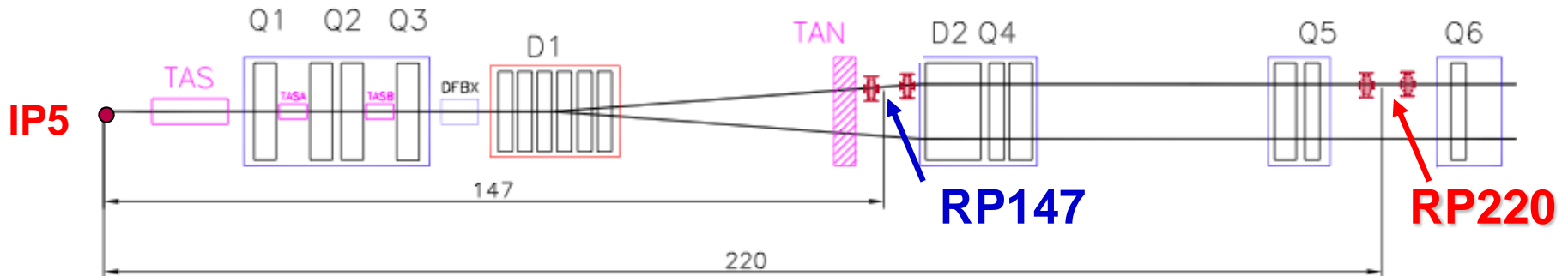
- Soft and hard diffraction in SD and DPE (production of jets, bosons, h.f.)
- Central exclusive particle production
- Low-x physics
- Particle and energy flow in the forward region

Experimental Setup @ IP5



CMS + TOTEM
 unprecedented η coverage

Roman Pots: measure elastic & diffractive protons close to outgoing beam



Roman pots

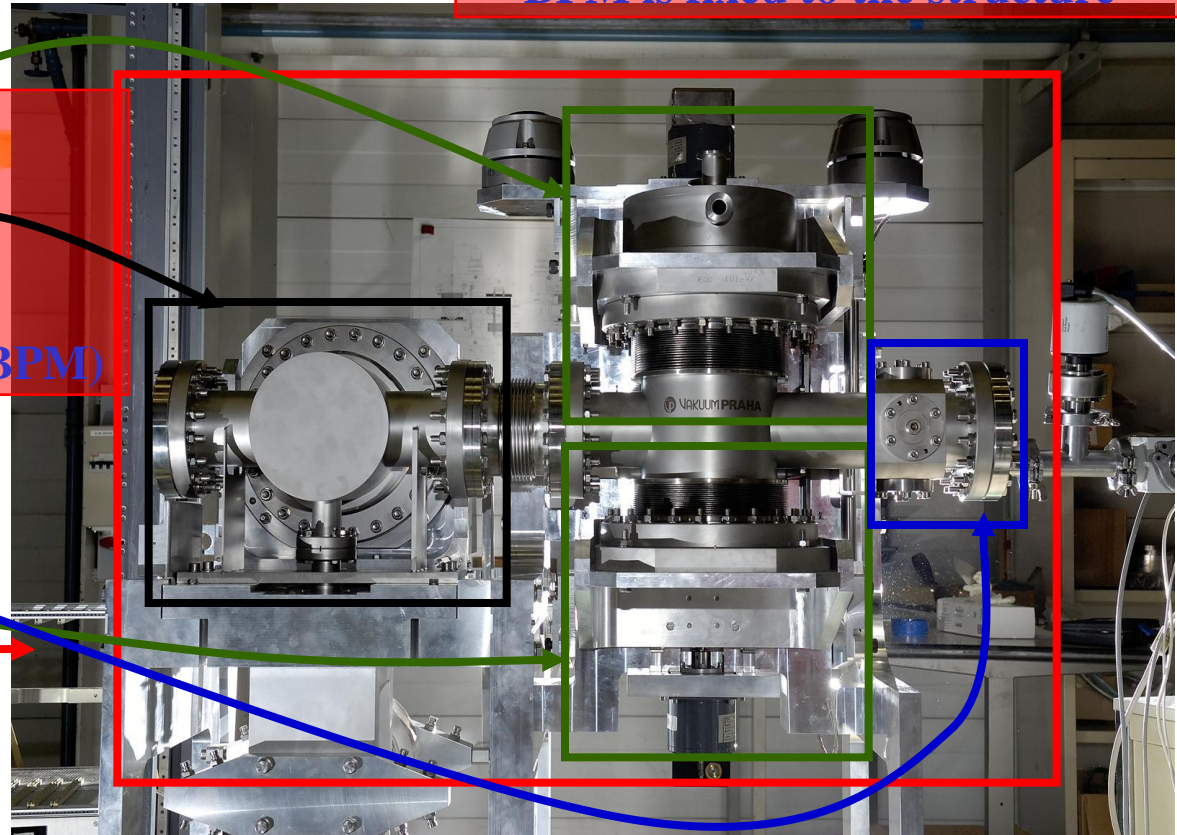
BPM is fixed to the structure

One RP station:

- 2 units

One unit:

- 2 vertical pot
- 1 horizontal pot
- 1 Beam Position Monitor (BPM)



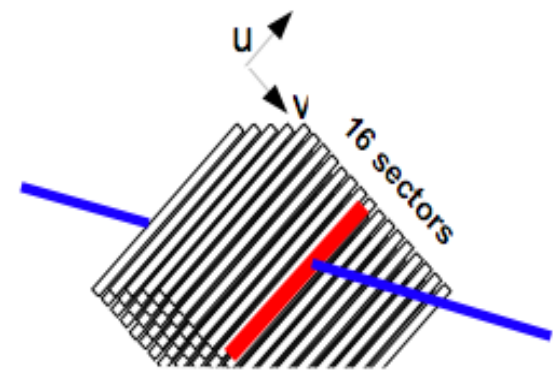
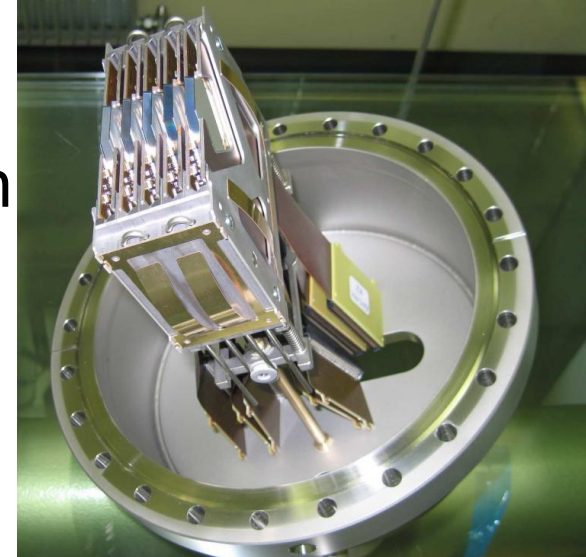
- All 12 Roman Pots at ± 220 m from IP5 are operational (data with active triggers)
- RP147 detector assemblies to be installed in winter technical stop.
- Until June: data were taken with RP220 in retracted position.

Roman Pots

One pot:

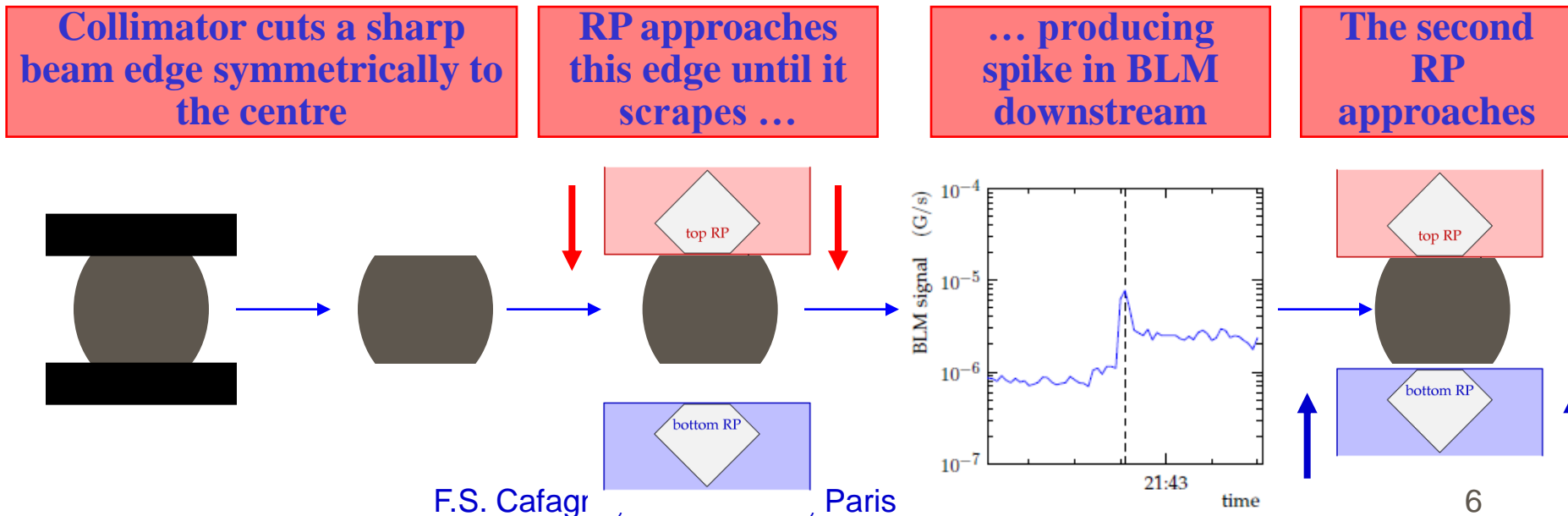
- 10 edgeless Si detectors
- Arranged in 5 planes (u & v views)

- Motor and interlock system commissioned
 - Run with the beam in retracted position
 - Measurement of beam latency parameters
 - Trigger commissioning
 - DAQ commissioning
 - Track reconstruction
- Insertion and alignment in sectors 4-5 & 5-6 @ 450GeV
- Trigger:
 - 3 out of 5 planes inclusive
 - Monitor via scalers
 - More restrictive triggers in progress



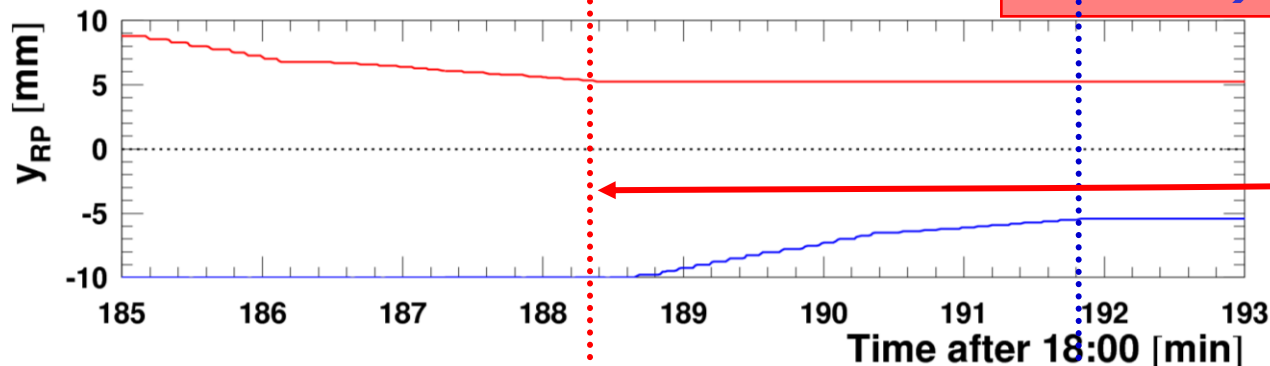
RP alignment w.r.t. the Beam Centre

- Alignment is the central problem of Roman Pot measurements:
 - Done at 450 GeV on the 25th of June
- LHC collimation system produces sharp beam edges:
 - used to align Roman Pots and to determine the centre of the beam
 - same procedure as collimator setup
- When both top and bottom pots “feel” the edge:
 - they are at the same number of sigmas from the beam centre as the collimator
 - the beam centre is exactly in the middle between top and bottom pot

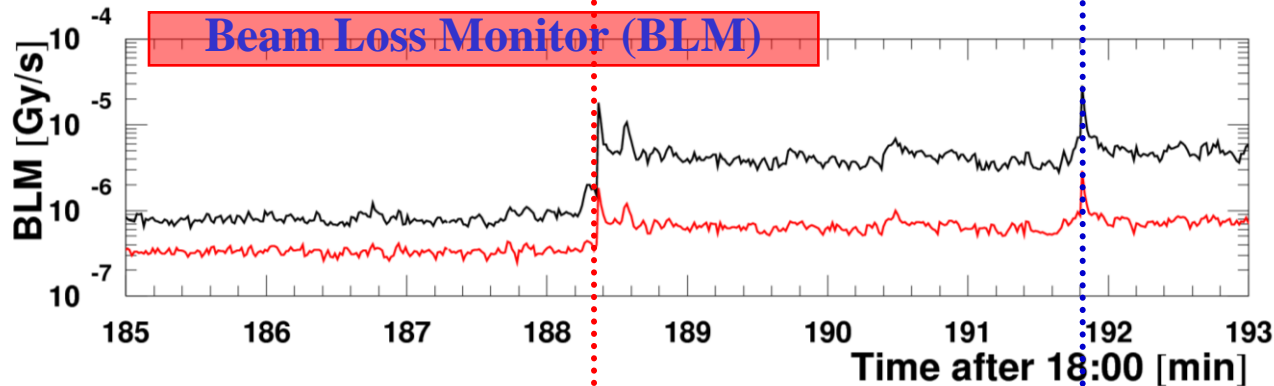


RP alignment @ 450 GeV

Start with primary collimator at 4.9σ
→ beam edge at 4.9σ

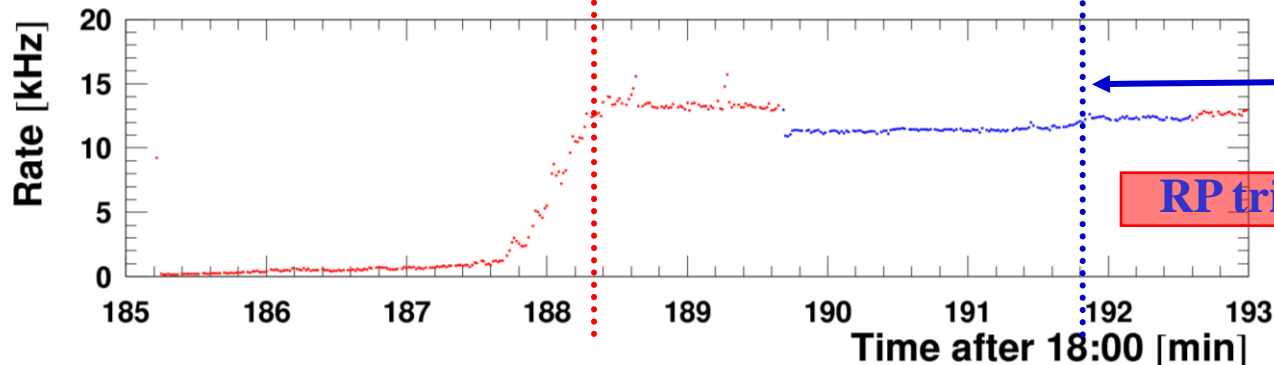


RP 4-5 (-220m)
Near - TOP @ 4.9σ



RP approach
(in $\geq 100\mu\text{m}$ steps)

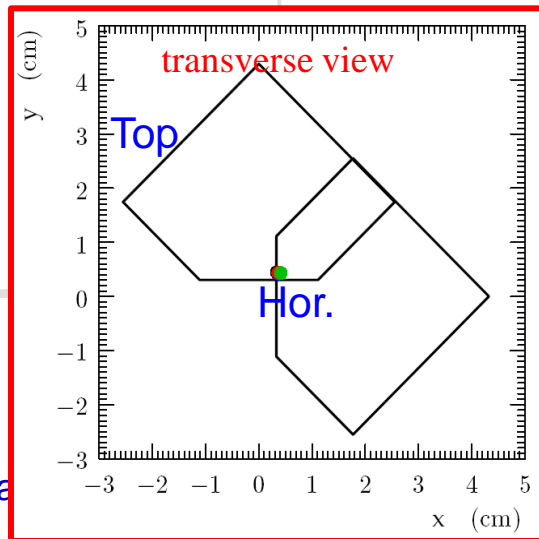
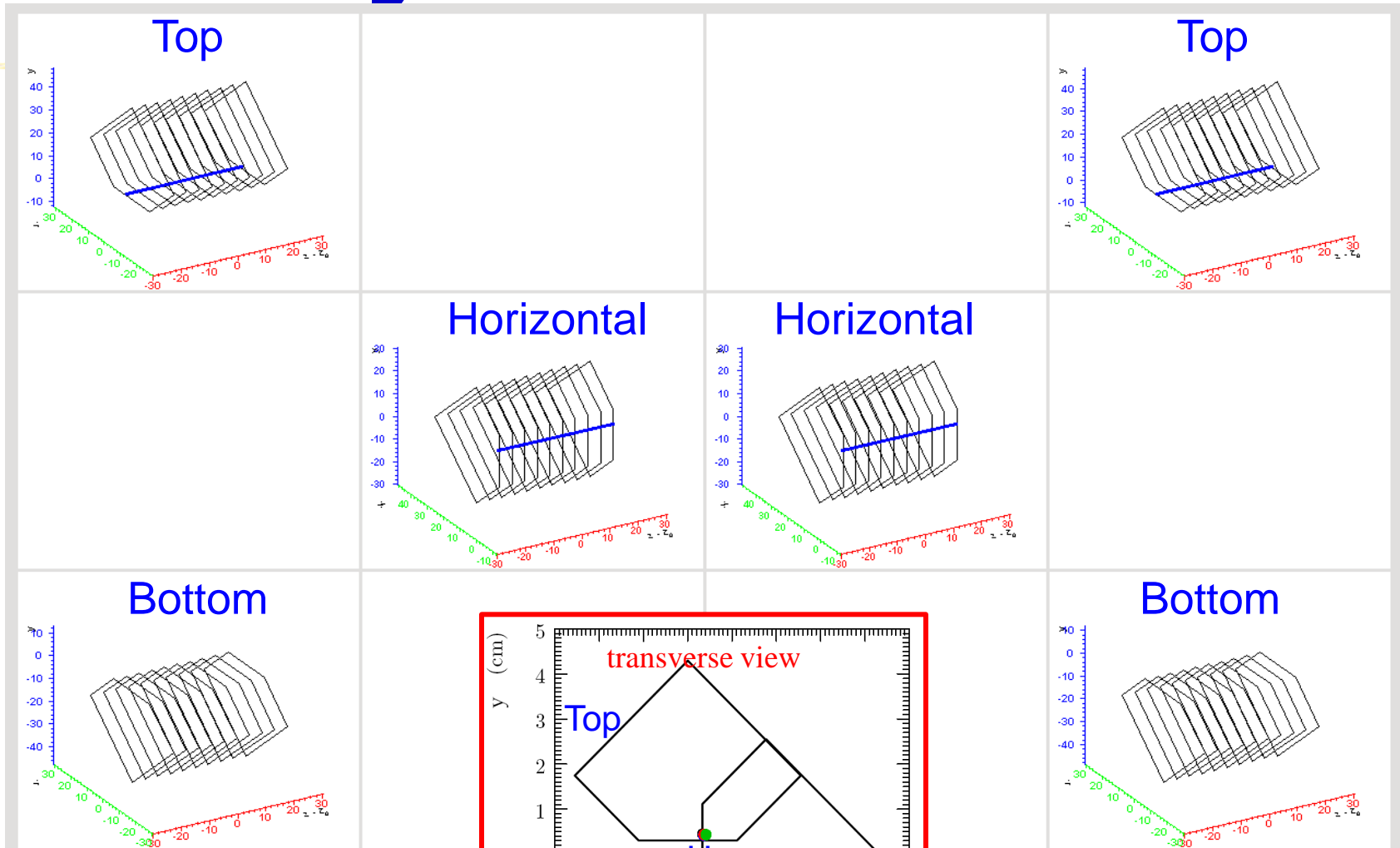
BLM @ 221 m
BLM @ 225 m



RP 4-5 (-220m)
Near-BOTTOM @ -4.9σ

RP trigger rate

A Single Track Event in RP

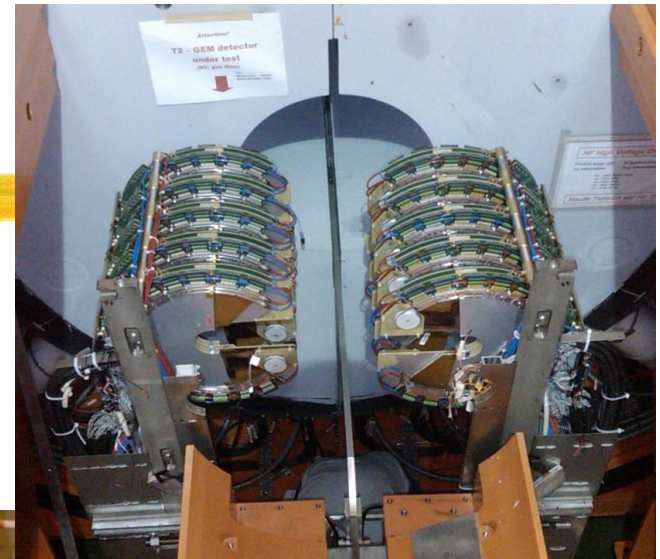
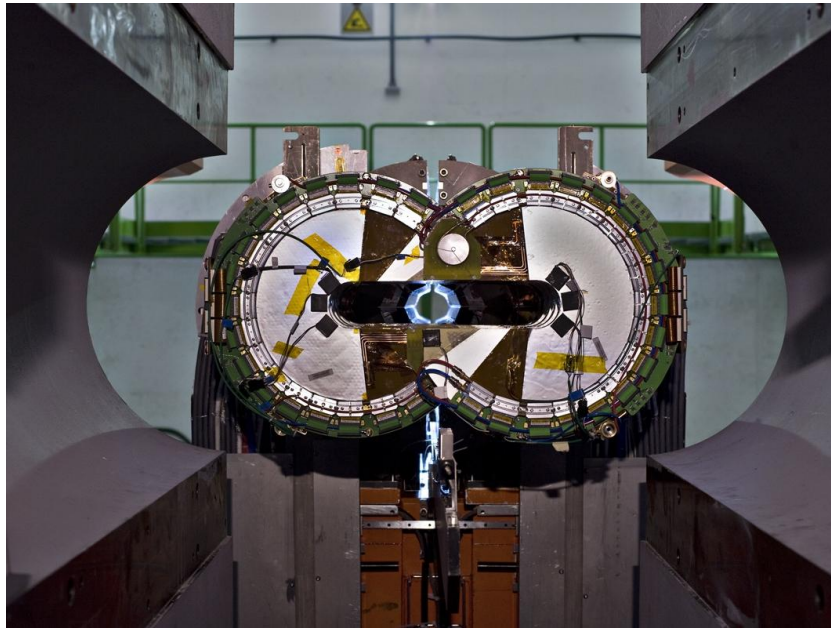


Near

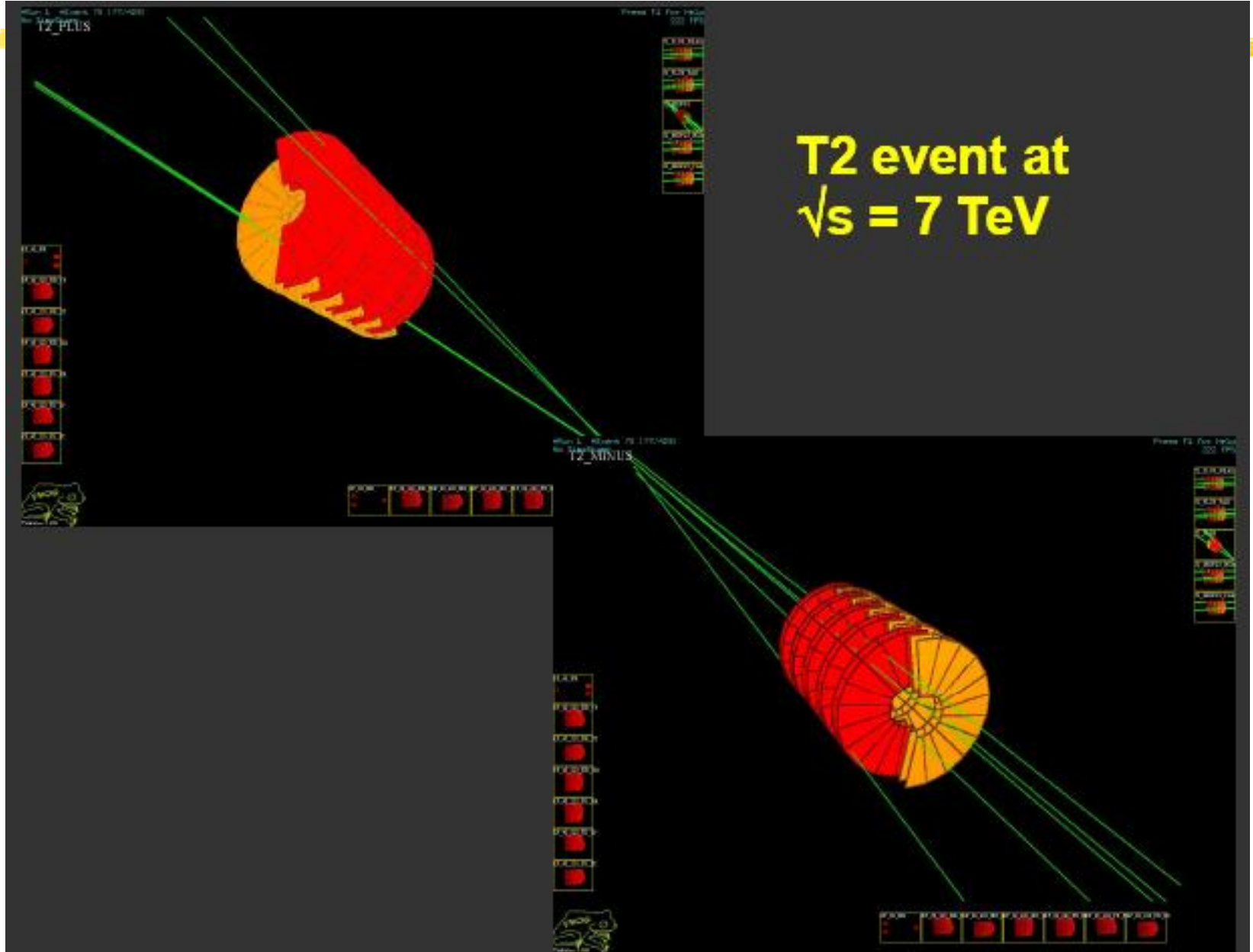
Far

T2 Detector

- All T2 GEM chambers on both sides of IP5 installed and operational (data & trigger)

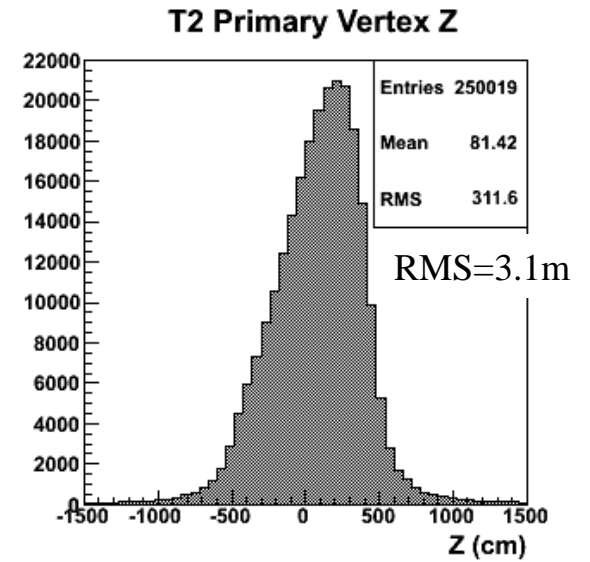
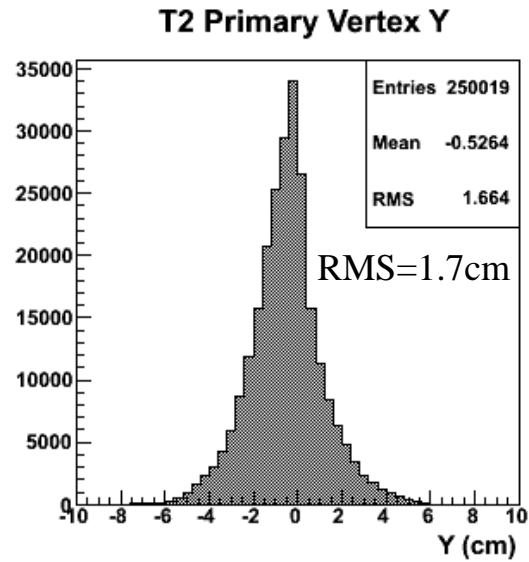
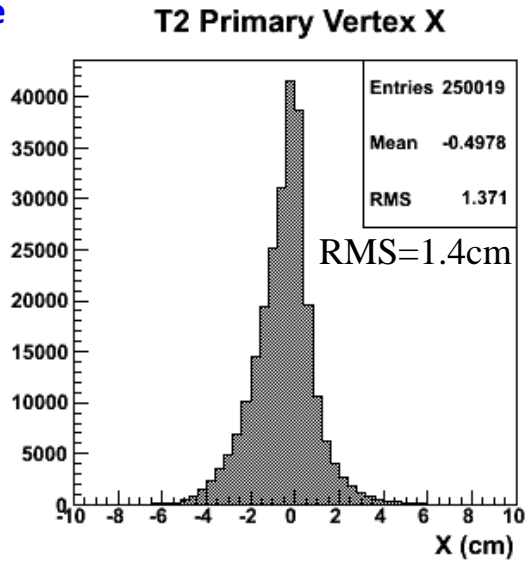


T2 event @ 7TeV

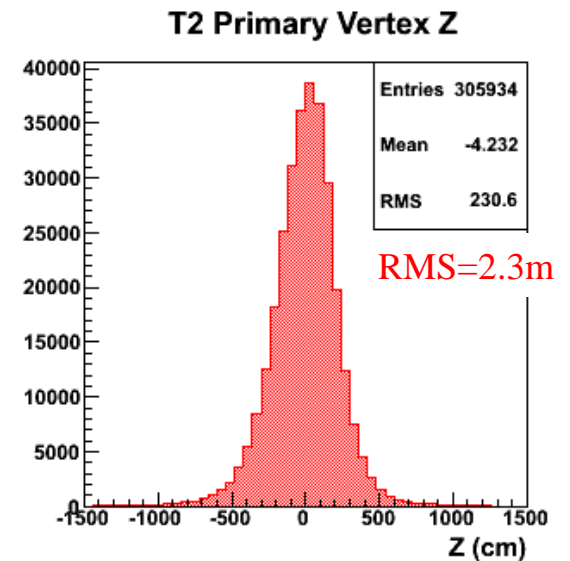
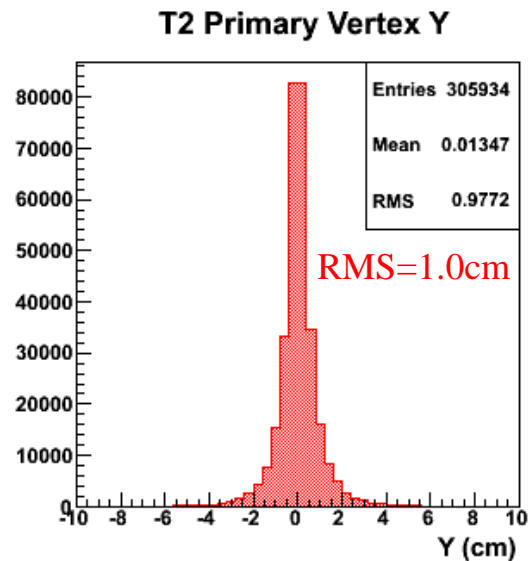
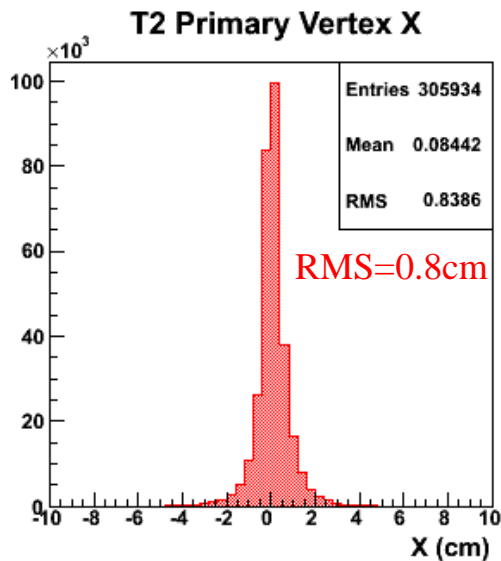


T2 alignment

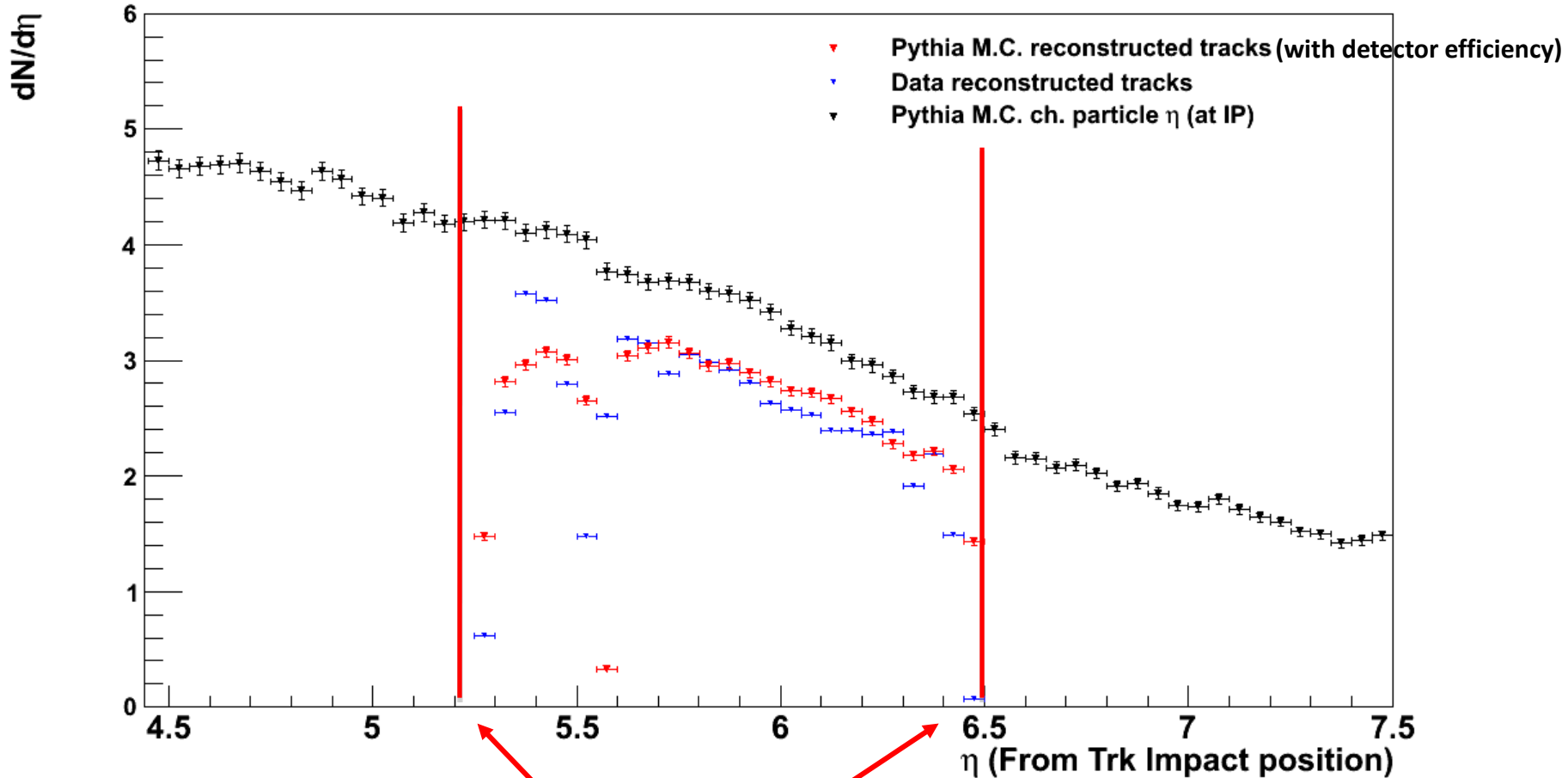
Before



After



T2: Preliminary η Distribution

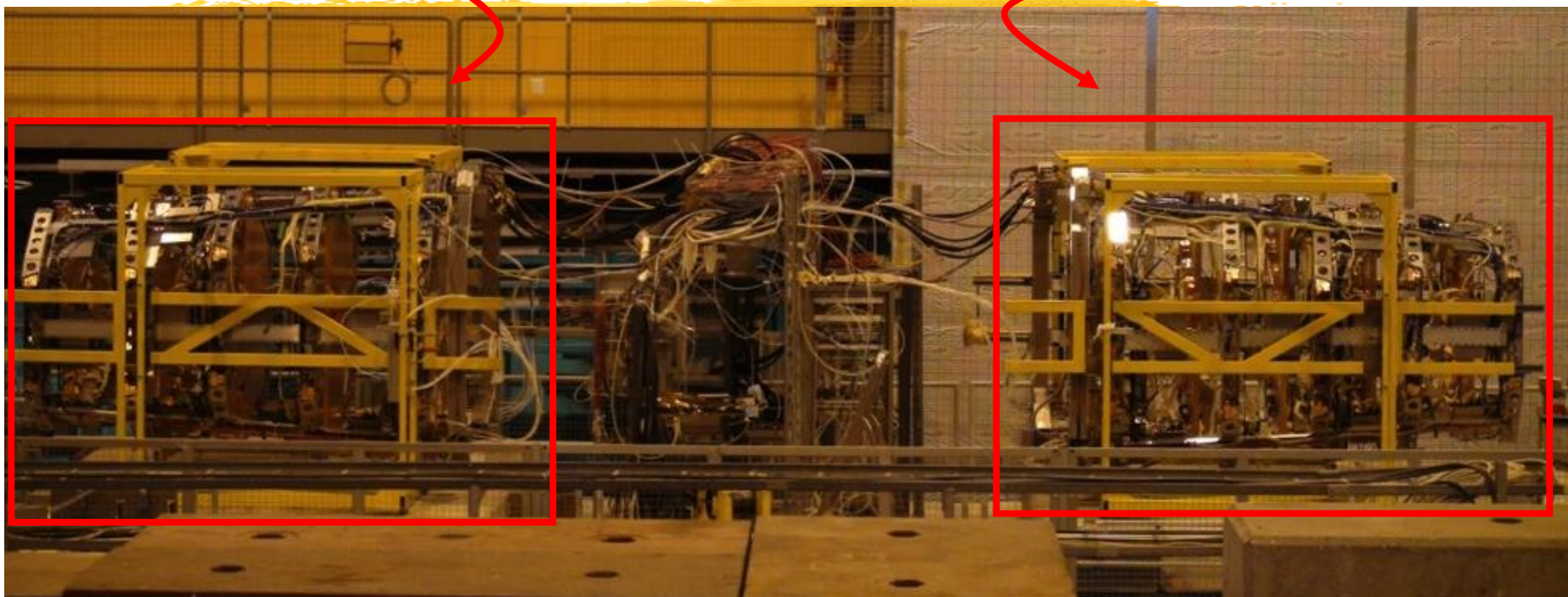


T2 η acceptance

T1 detector

3rd – 4th quarters

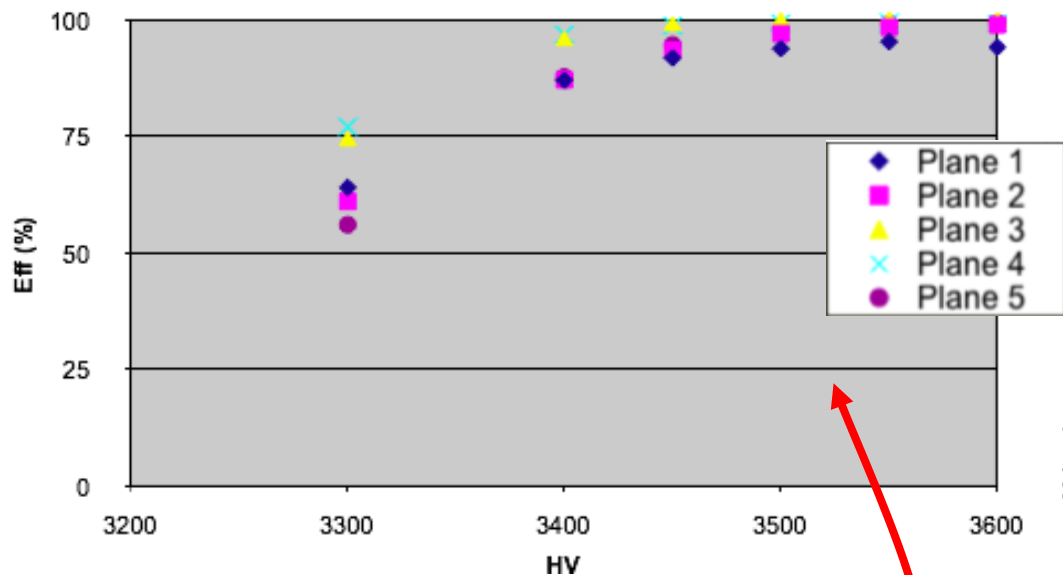
1st – 2nd quarters



- Both arms are completely assembled and equipped in the test beam line H8.
- Successfully tested with pion and muon beams in May – June

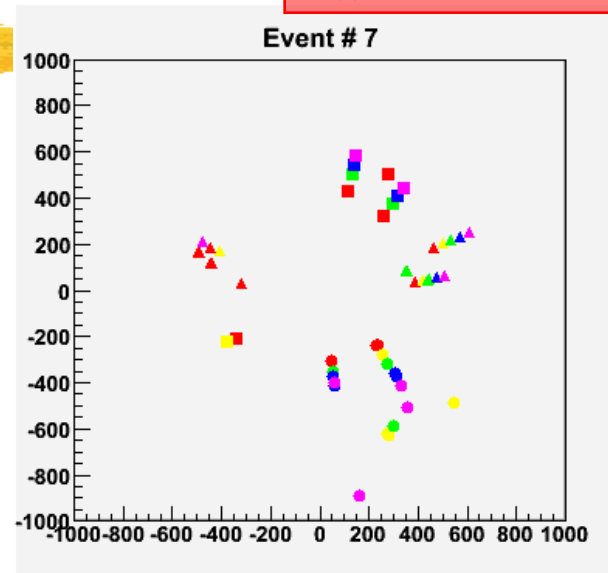
Both telescope arms ready for installation

T1 data in H8: pions & muons

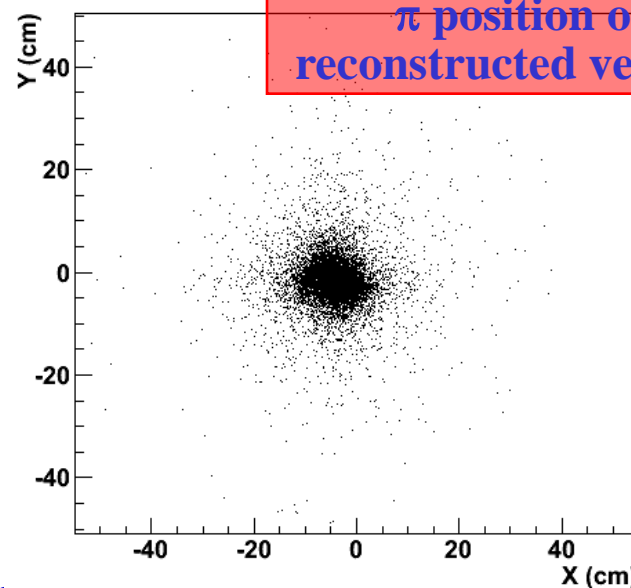


Cathode Strip Chamber (CSC)
efficiencies with μ
(triple coincidences)

π reconstructed hits



π position of
reconstructed vertices



Physics plans

- Physics at $\sqrt{s} \approx 7$ TeV with low β^* (= 2 - 5 m) optics:
 - forward charge particles studies with T2
 - large $|t|$ elastic scattering
 - high mass SD & CD
- Physics at $\sqrt{s} \approx 7$ TeV with short $\beta^* = 90$ m runs:
 - early measurement of σ_{tot} @ 5-6 %
 - elastic scattering in wider $|t|$ range ($|t| > 0.015$ GeV²)
 - SD & CD @ any M
 - classification of inelastic events:
 - inelastic rates
 - process dependent forward charged multiplicity

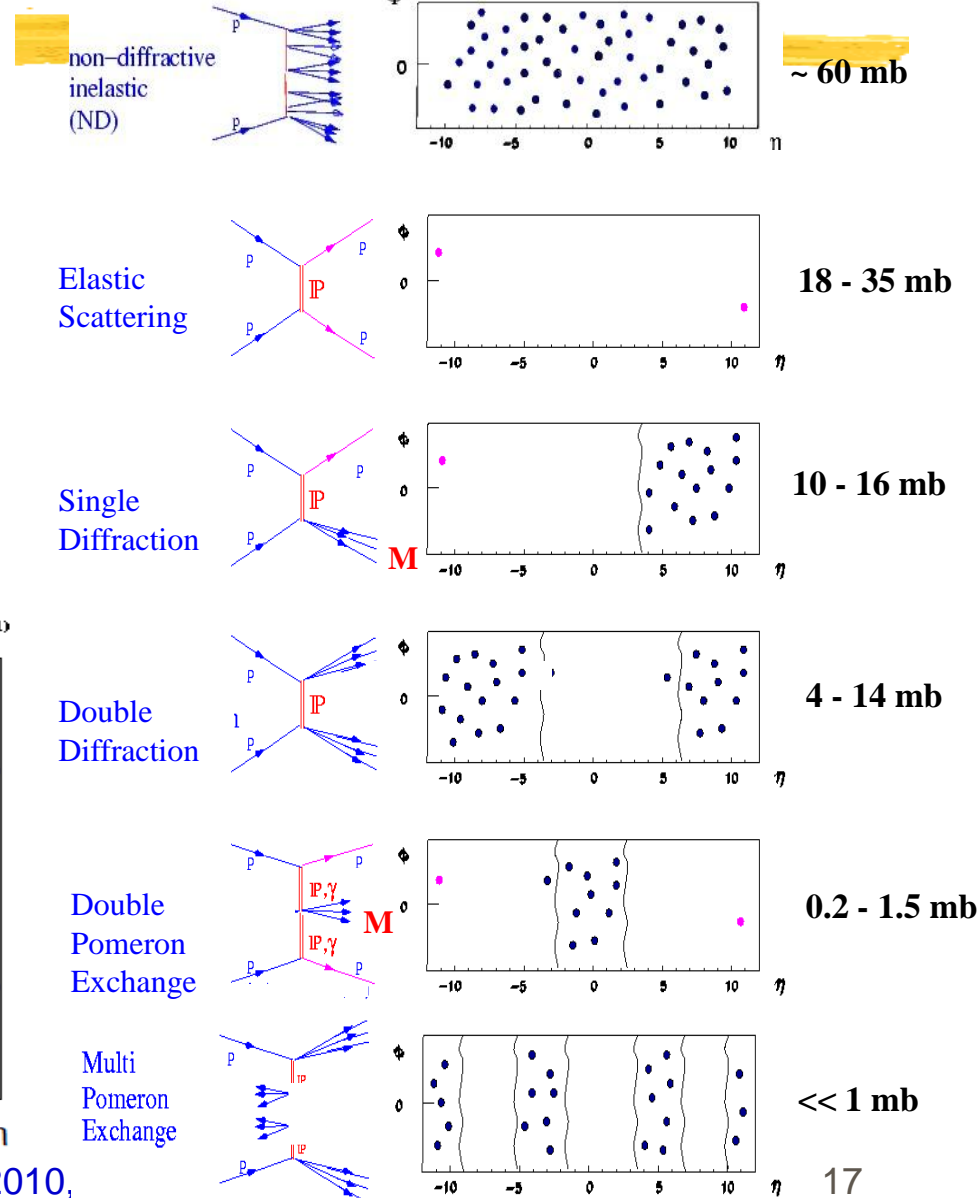
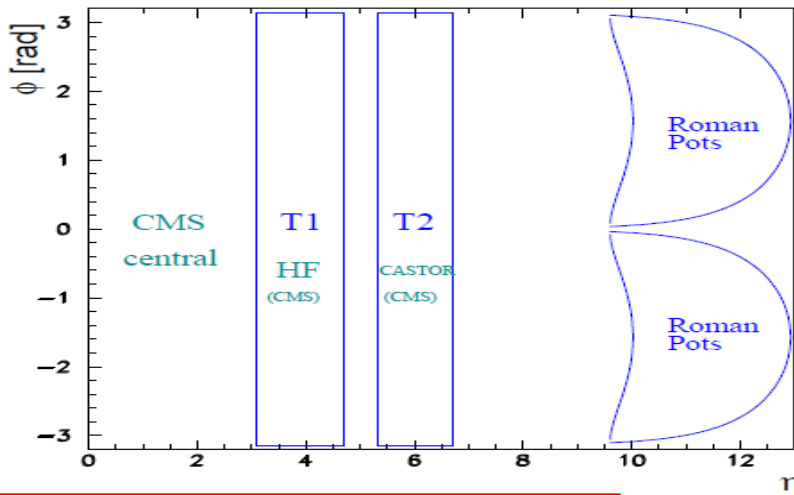
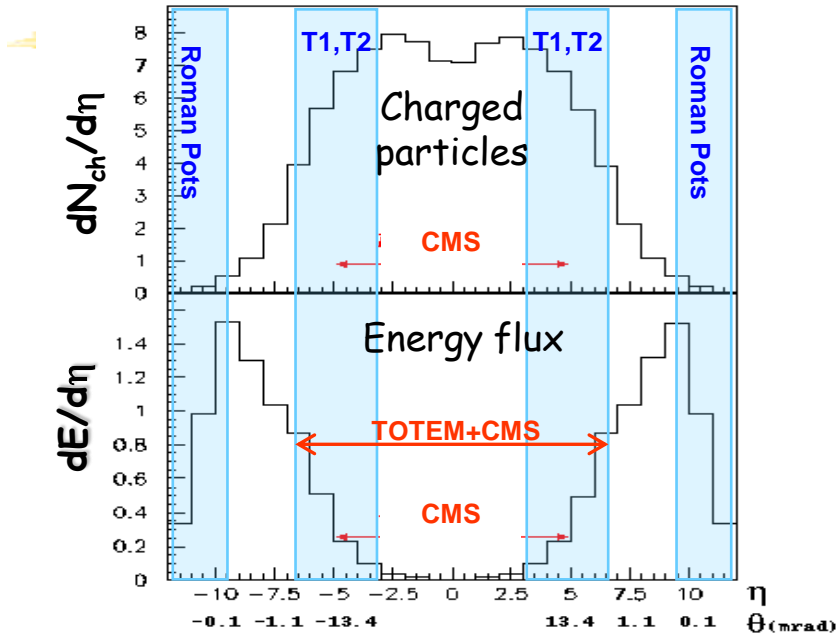
THANKS !!!

Spares

A thick, horizontal yellow brushstroke with a textured, painterly appearance, spanning most of the width of the slide below the title.

Event Topology & η coverage

LHC, inelastic collisions

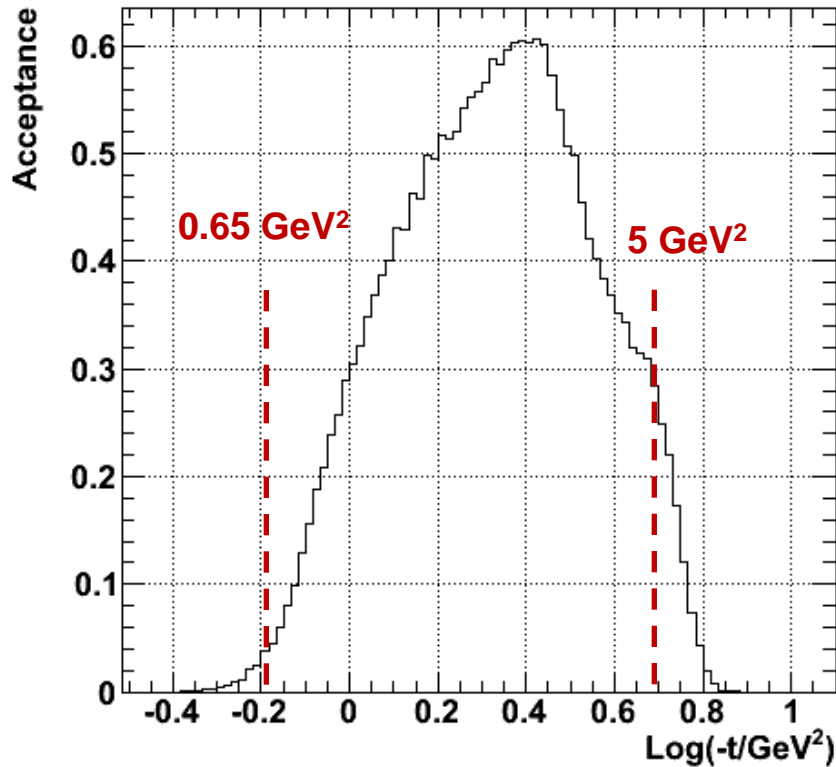


CMS + TOTEM
unprecedented η coverage

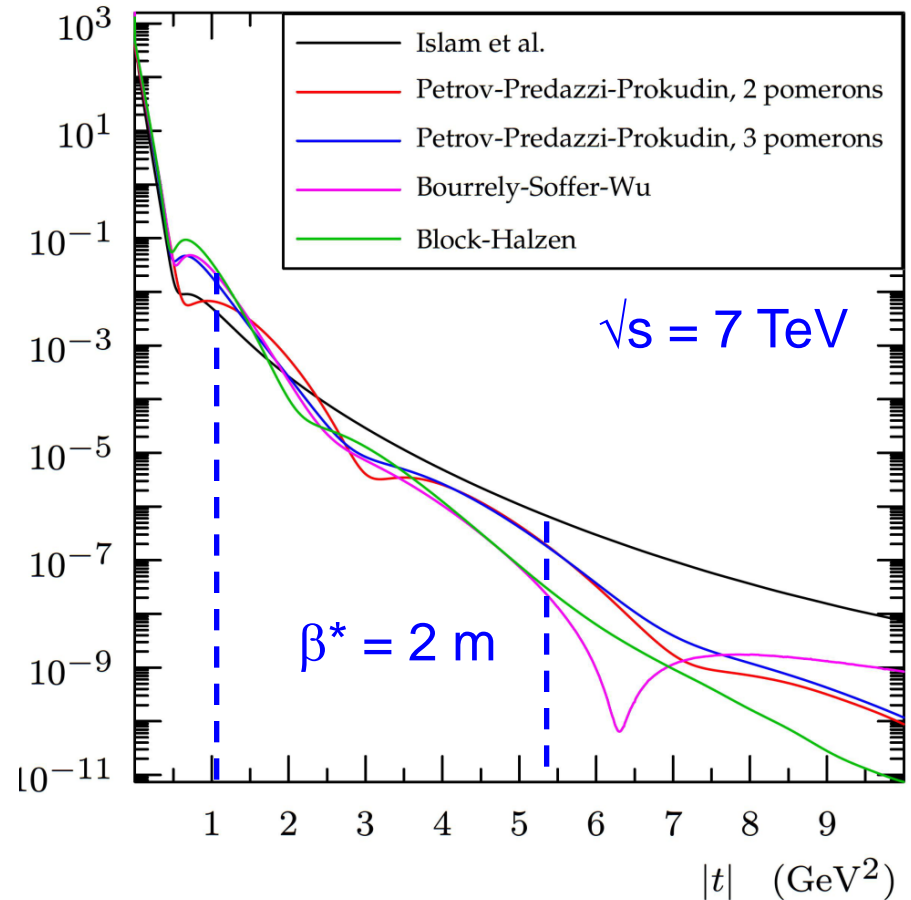
F.S. Cafagna, ICHEP 2010,

Elastic protons, $\sqrt{s} = 7 \text{ TeV}$, $\beta^* = 2 \text{ m}$, RP220

elastic protons @ RP220



elastic cross section



e.g. PPP3, 3 pomeron model: $\sigma_{\text{acc}} \approx 4 \mu\text{b}$

Acceptance & rates $\sqrt{s} = 7 \text{ TeV}$ & $\beta^* = 2 \text{ m}$

RP @ $10 \sigma_{\text{beam}} + 0.5 \text{ mm}$

β^* [m]	Process	RP accepted σ [mb]	Accepted rate @ $L = 5$ $\cdot 10^{30} / \text{s} \cdot \text{cm}^2$ [Hz]**	<Events/bx> @ $L_{\text{bx}} = 10^{25}$ /s·cm ² ***	Acceptance range in t [GeV ²] or ξ [%]
2	Elastic scattering (PPP3*)	0.004	20	0.00004	$\sim 0.6 < t < \sim 5$
2	SD, Pythia	2.4	12k	0.024	$0.02 \leq \xi \leq 0.2$
2	CD, Phojet	0.05	250	0.0005	$0.02 \leq \xi \leq 0.2$
2	Min bias, Pythia	60	300k	0.6	$N_{\text{track}, T2} \geq 1$

* PPP3: Petrov-Predazzi-Prokudin model, 3 pomeron

** $N_{\text{bunch}} = 43$, $N_{\text{p/bunch}} = 5 \cdot 10^{10}$ & $\beta^* = 2 \text{ m} \Rightarrow L_{\text{bx}} = 10^{25} \text{ cm}^{-2}$

Large $|t|$ elastic scattering @ low β^*

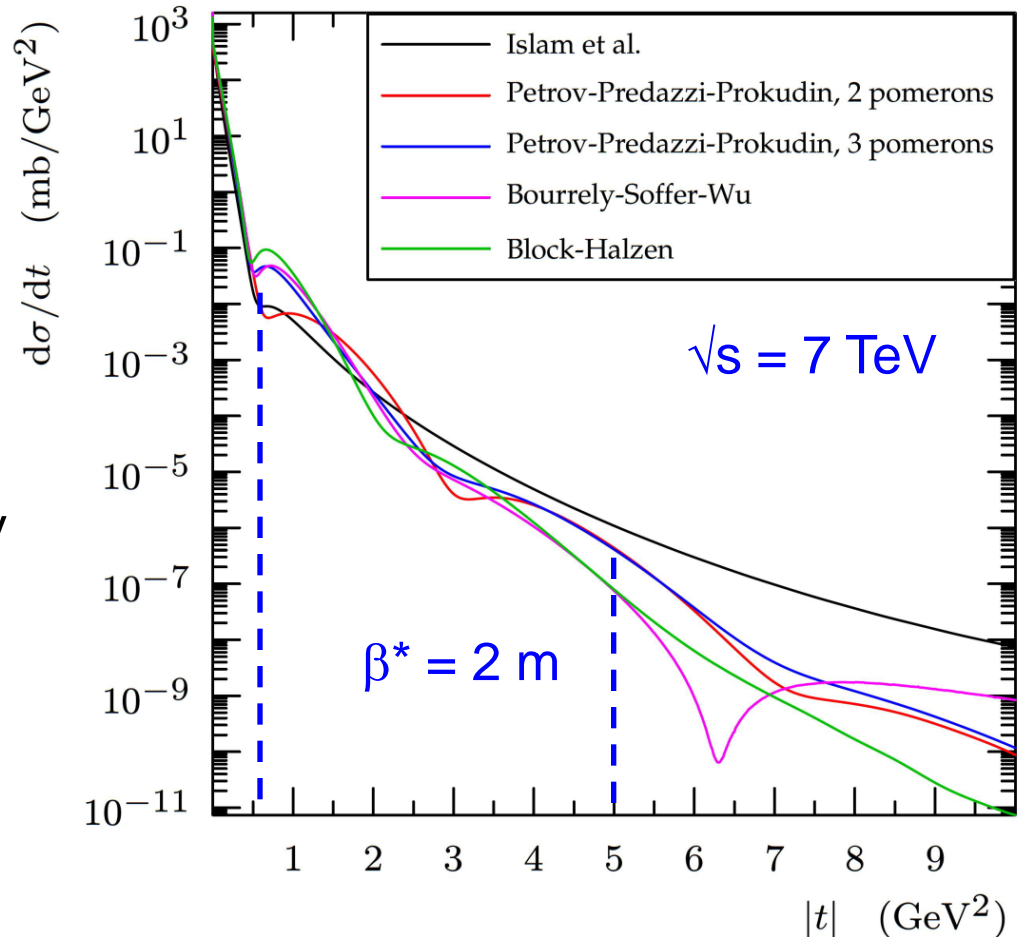
elastic p's in top & bottom vertical RP's on each side

trigger: $RP_{\text{vert},45}$ & $RP_{\text{vert},56}$
rate \sim few 10 Hz (RP @ $10\sigma_{\text{beam}}$)
 $\beta^* = 2$ m, $N_b = 43$ & $N_p/b = 5 \times 10^{10}$)

At larger $|t|$ σ several order of magnitude smaller (\sim mHz) \Rightarrow dedicated long runs with vertical pots at largest possible luminosity

$$\sigma(|t|) = 0.1 - 0.5 \text{ GeV}^2 (\propto \sqrt{|t|})$$

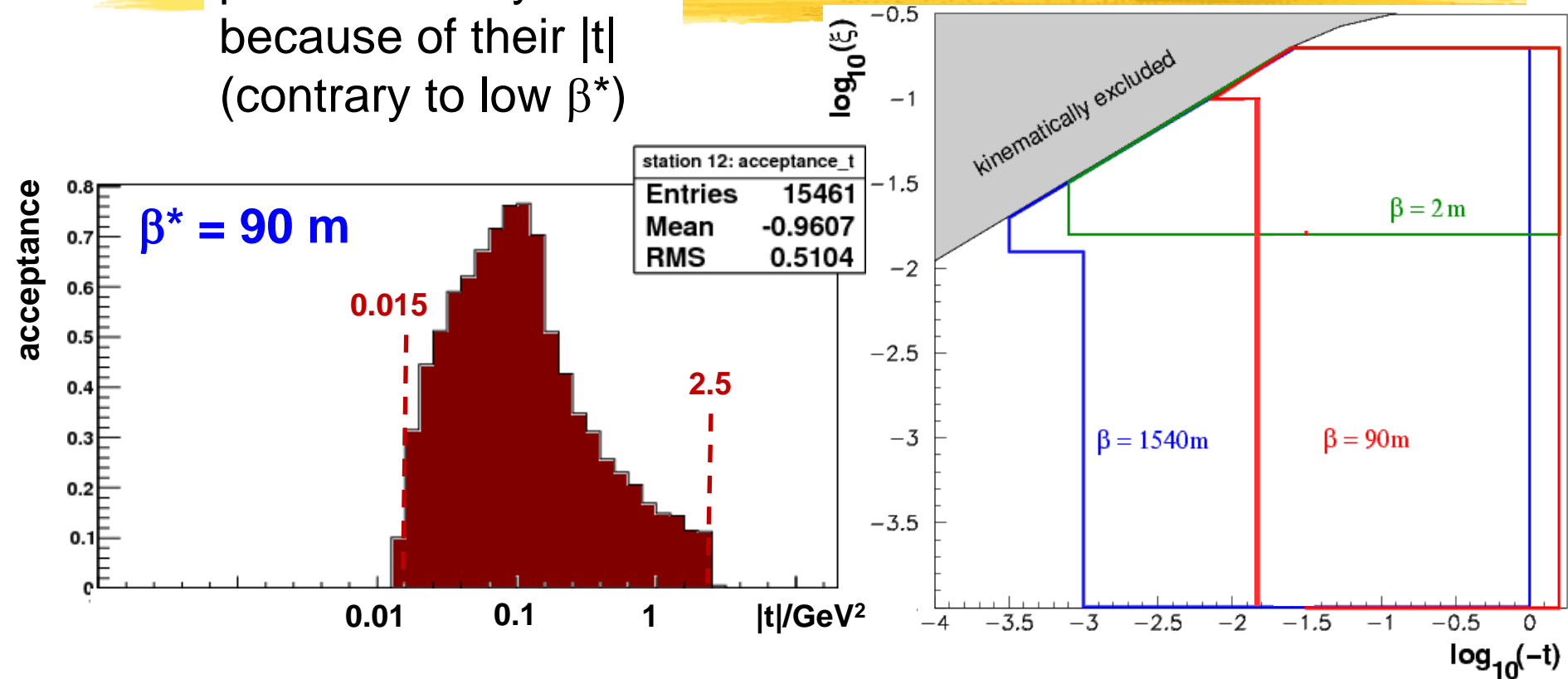
elastic cross section



Physics with $\beta^* = 90$ m

protons mainly seen because of their $|t|$ (contrary to low β^*)

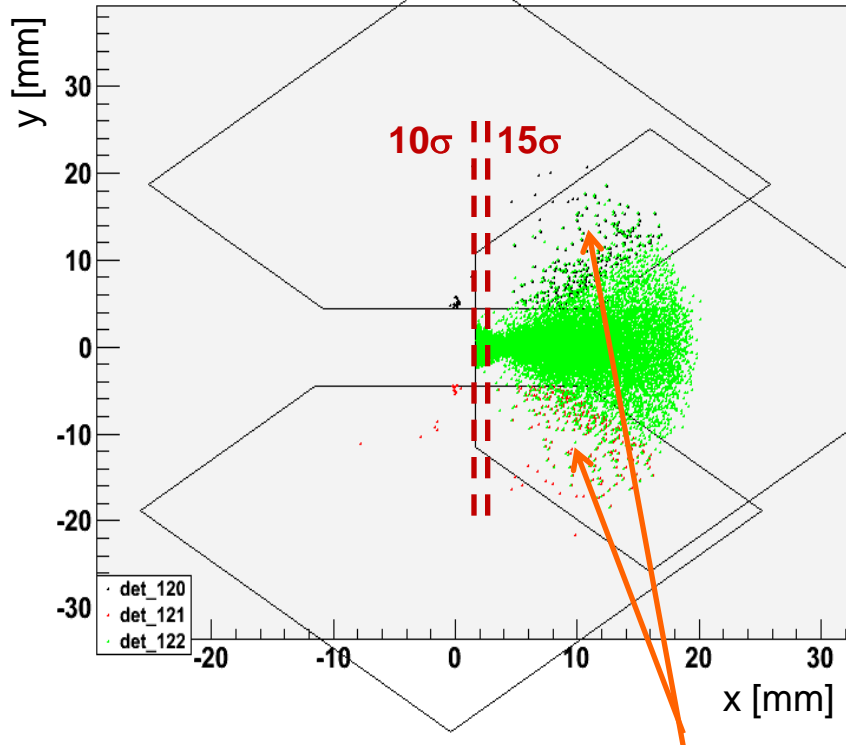
acceptance for RP220



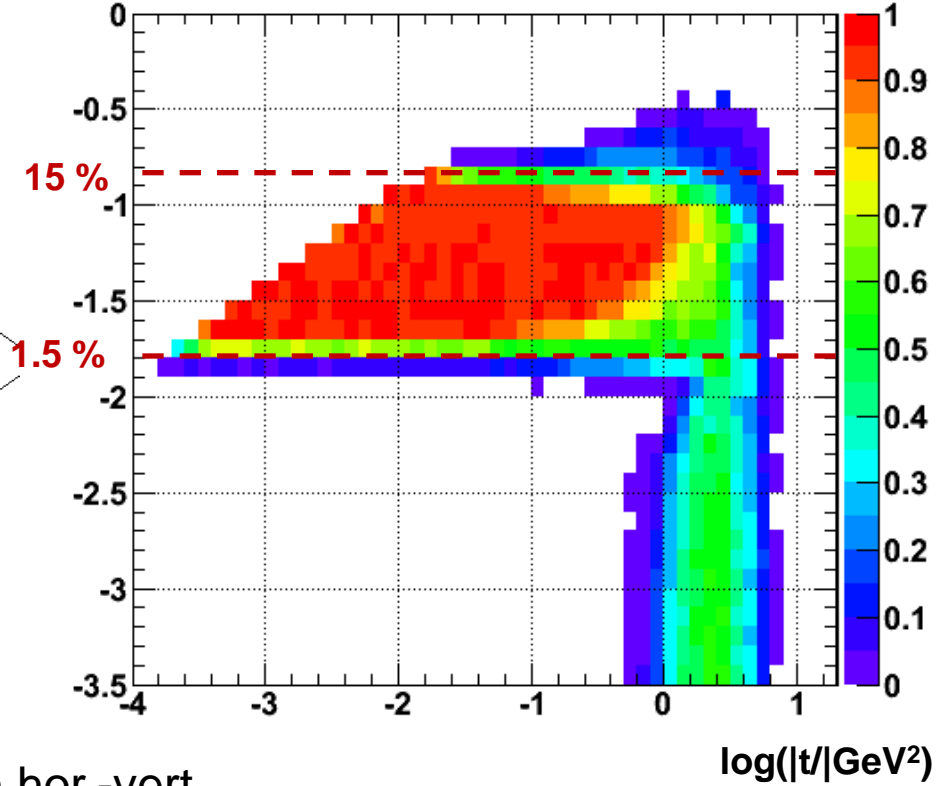
- Total cross section measurement at $\pm 5 - 6$ %
- Elastic scattering: $0.015 < |t| < 2.5$ GeV²
- Soft diffraction: all M - 65 % of diffractive protons seen
- Classification of inelastic events: rates & multiplicity

Diffractive protons, $\sqrt{s} = 7 \text{ TeV}$, $\beta^* = 2 \text{ m}$, RP220

SD protons @ RP 220



RP 220 acceptance



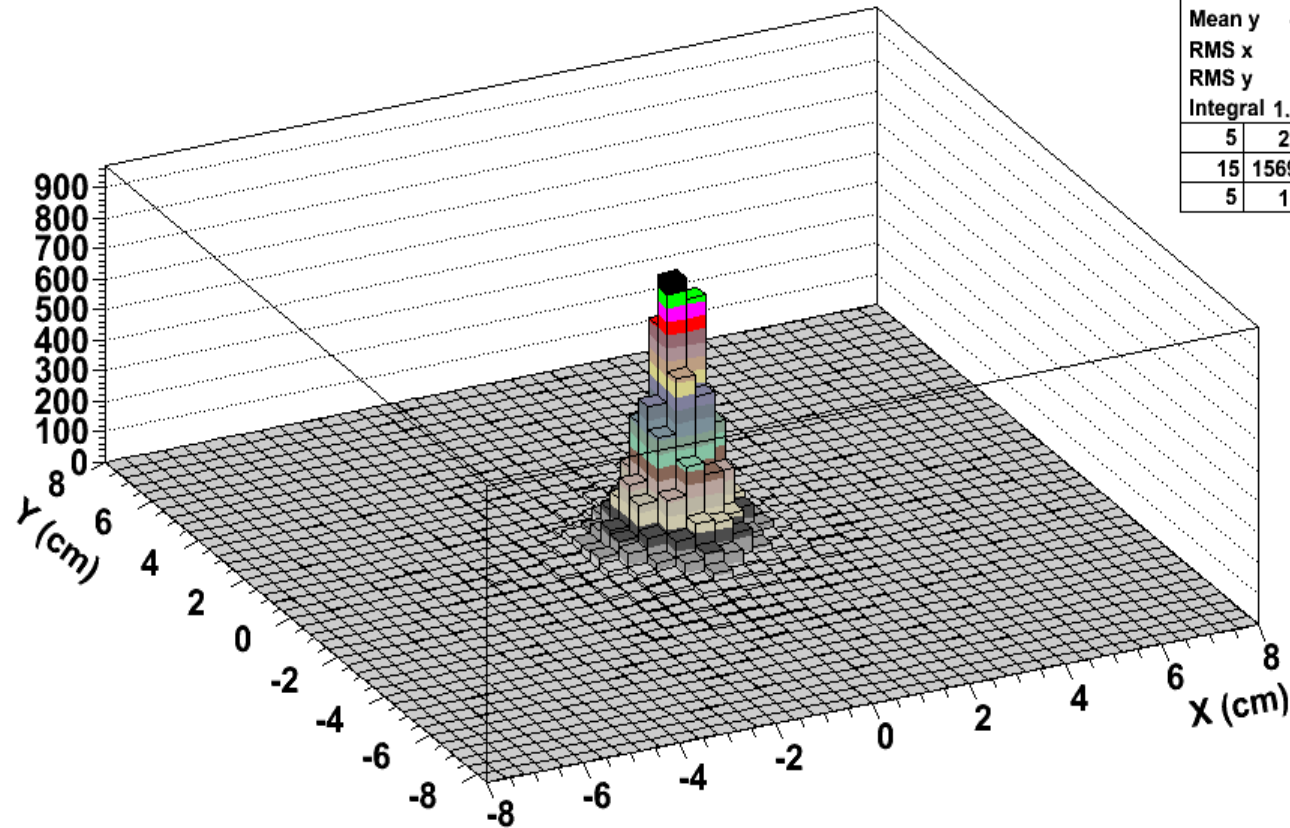
0.02 mb of tracks both in hor.-vert.

Pythia SD: $\sigma_{\text{acc,sd}} \approx 1.2 \text{ mb} (\times 2) / \sigma_{\text{sd}} \approx 13.7 \text{ mb}$

Phojet CD: $\sigma_{\text{acc,cd}} \approx 0.05 \text{ mb} / \sigma_{\text{cd}} \approx 1.33 \text{ mb}$

T2 Data

Vertex X-Y



Vertex X-Y_RZ		
Entries	15777	
Mean x	-0.0986	
Mean y	-0.2014	
RMS x	1.087	
RMS y	1.24	
Integral	1.57e+04	
5	23	6
15	15697	10
5	13	3