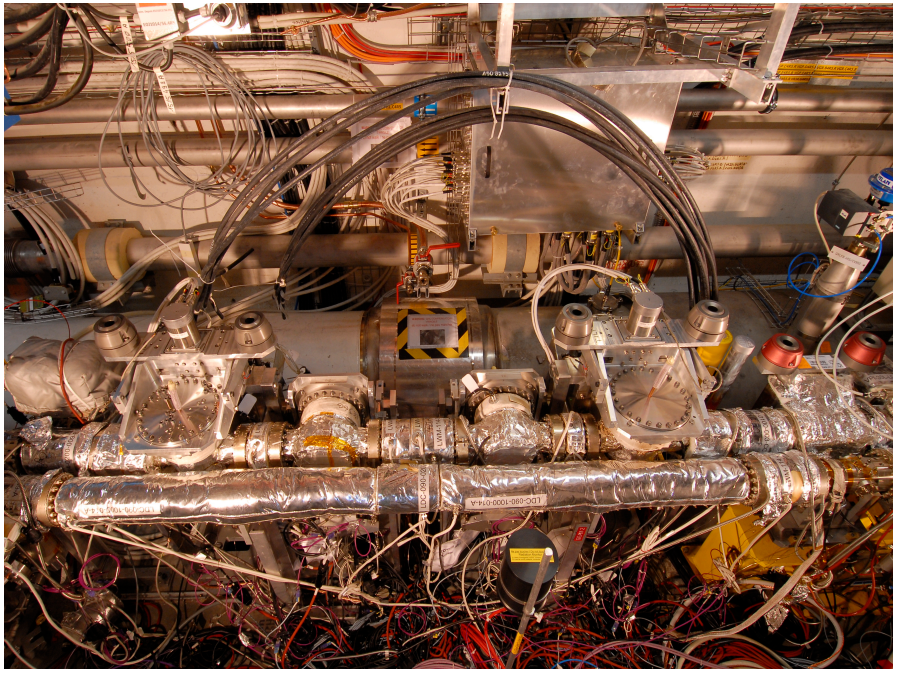
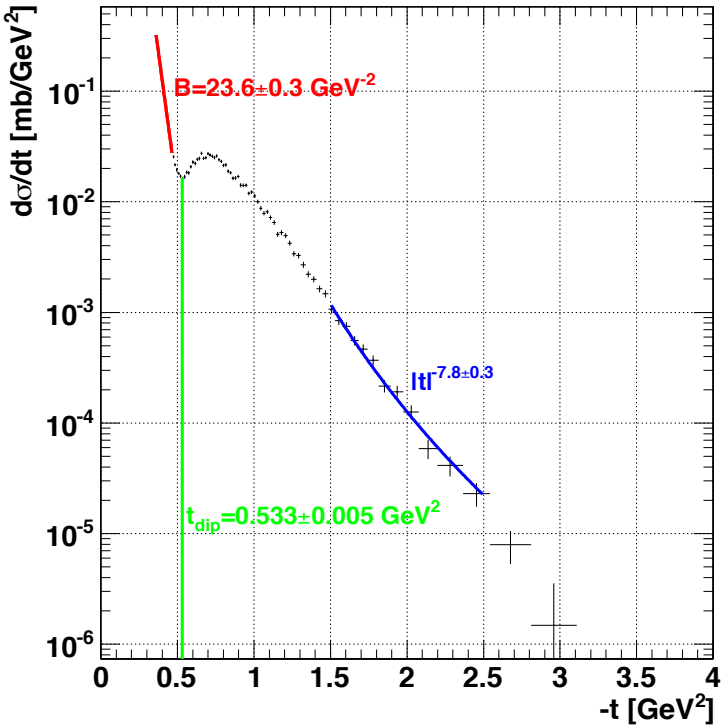
Status of the TOTEM Experiment and Latest Results

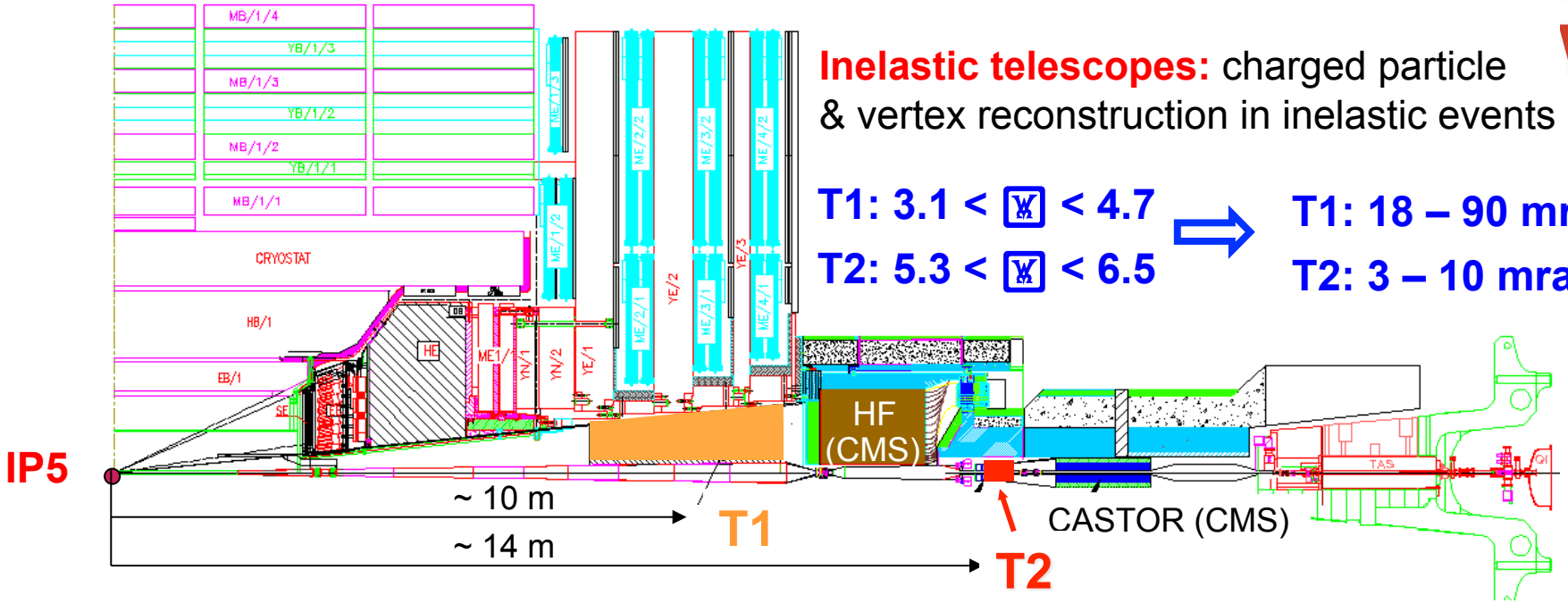




Karsten Eggert
on behalf of the TOTEM Collaboration

EleventhWorkshop on Non-Perturbative Quantum Chromodynamics
l'Institute d'Astrophysique de Paris
June 6-10, 2011

Experimental Setup @ IP5



Inelastic telescopes: charged particle & vertex reconstruction in inelastic events

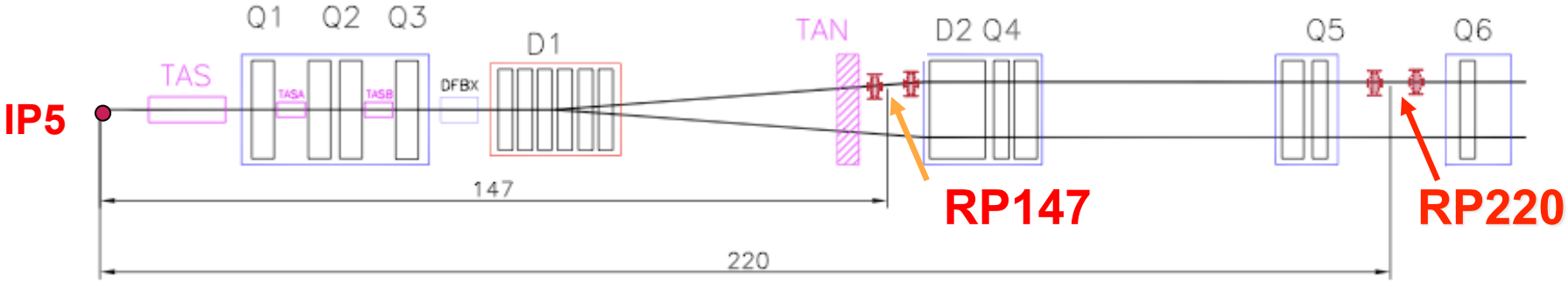
T1: 3.1 < η < 4.7

T2: 5.3 < η < 6.5

⇒ **T1: 18 – 90 mrad**

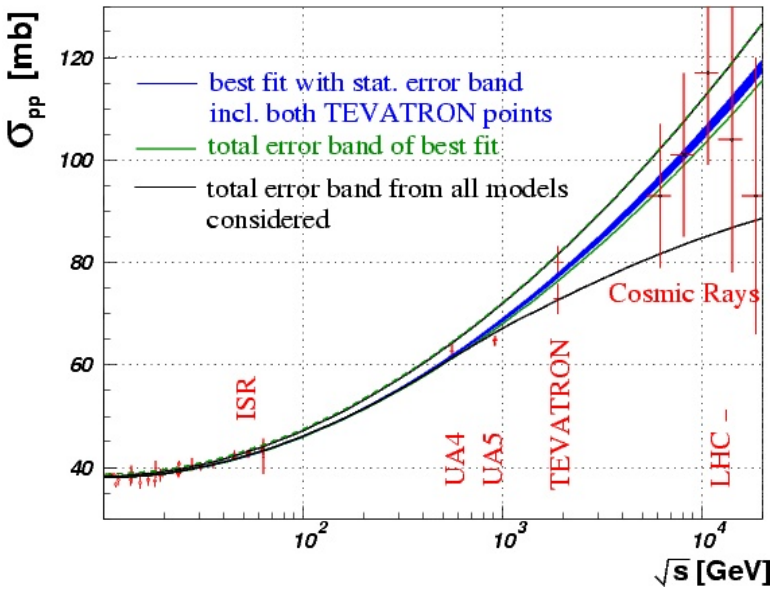
T2: 3 – 10 mrad

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

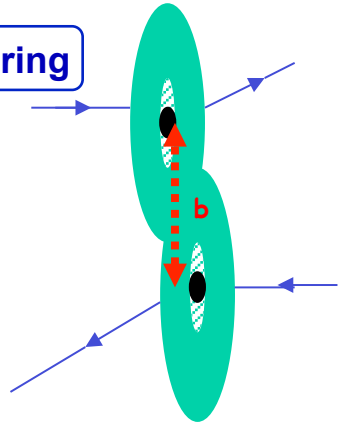


TOTEM Physics Overview

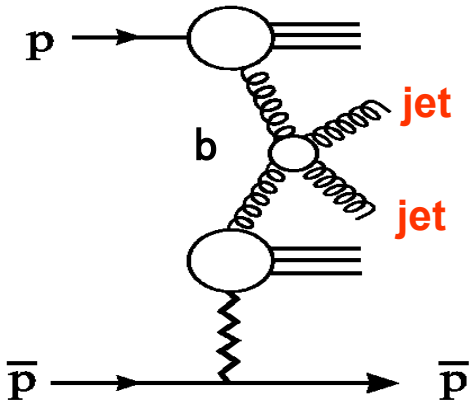
Total cross-section



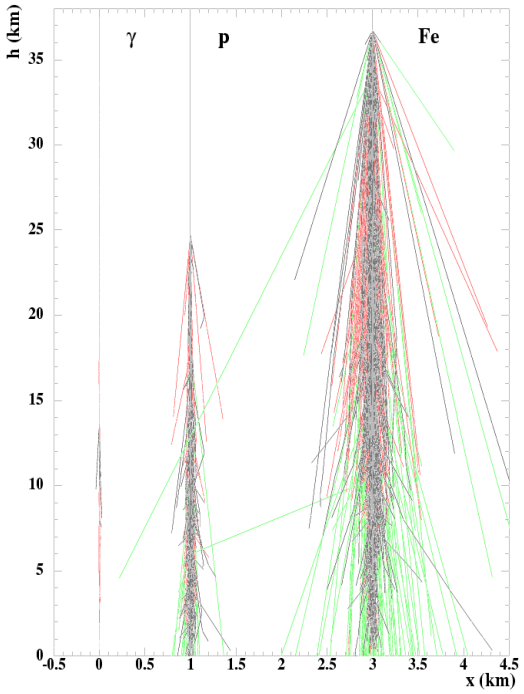
Elastic Scattering



Diffraction: soft and hard

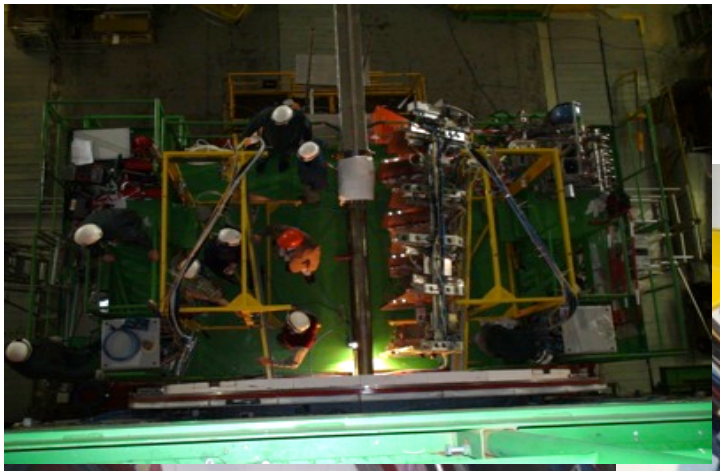


Forward physics

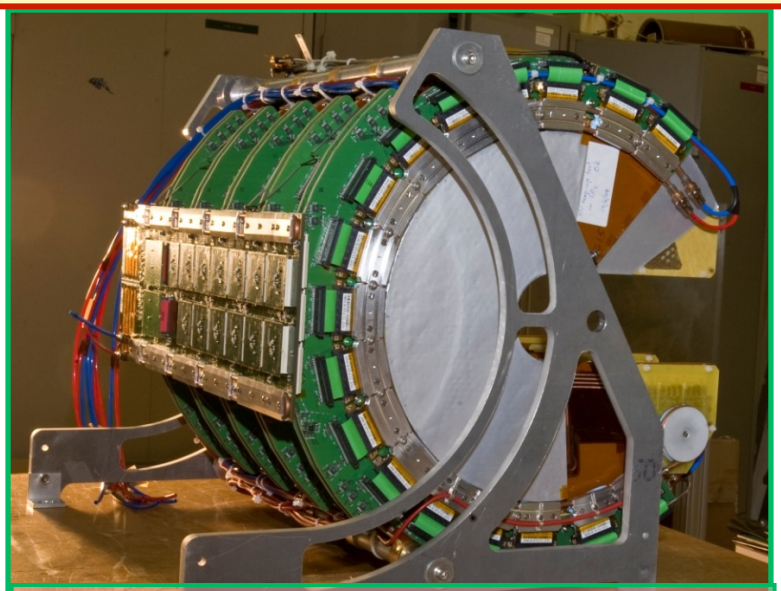


T1 Installation

In January 2011 the T1 detector has been inserted in the end-cap of CMS



Installation of half T2 Telescope



Half a telescope assembled in lab

Installation

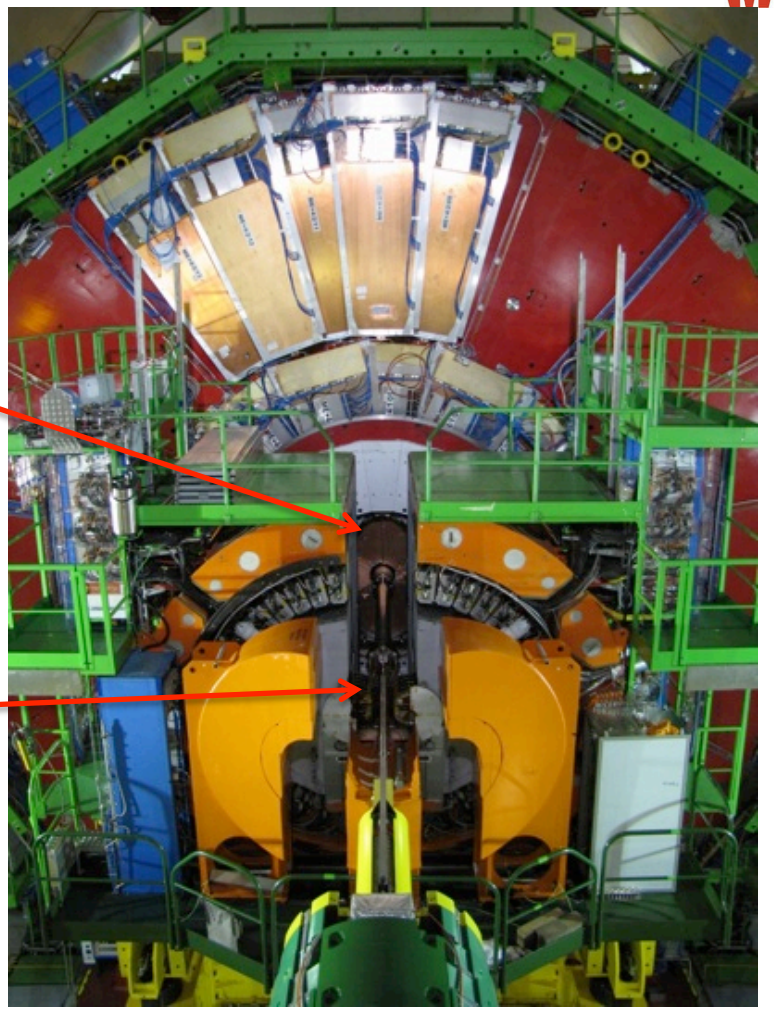
All Inelastic Detectors T1 and T2 were installed

T1 detector

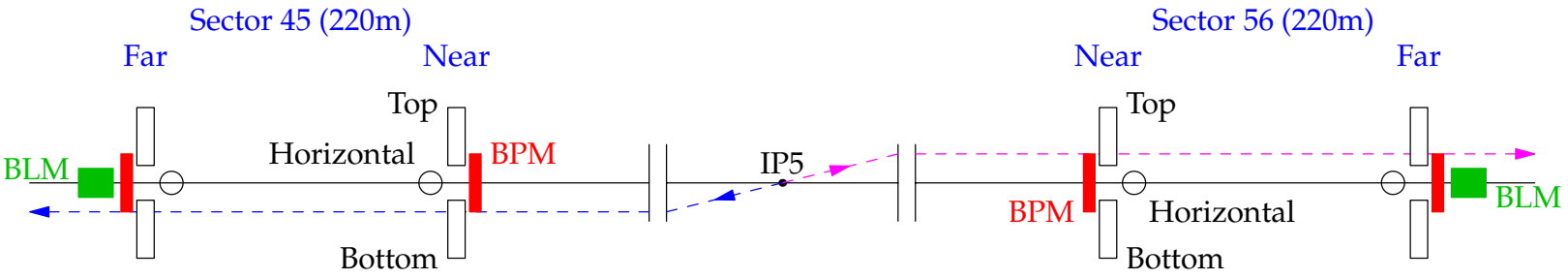
5 planes of CSC chambers

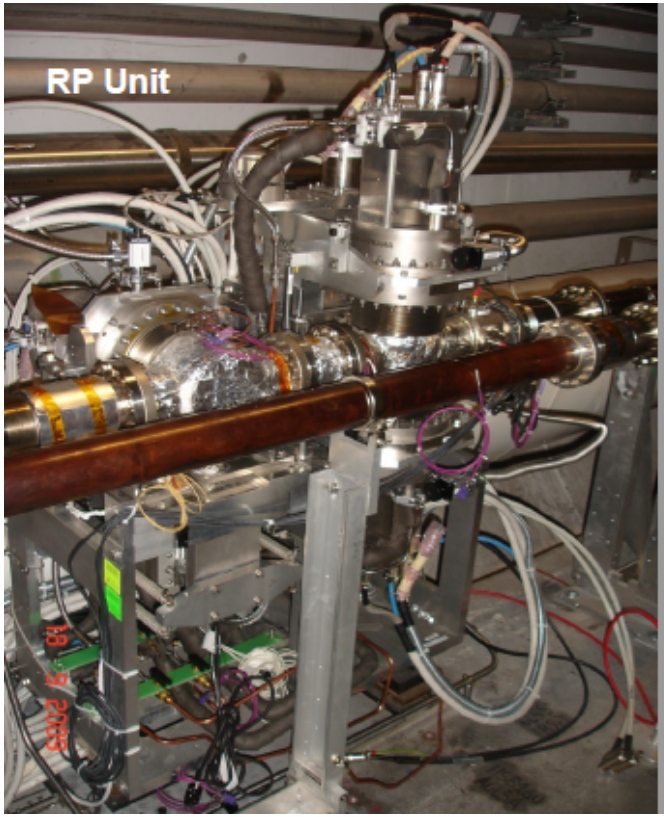
T2 detector

10 planes of GEM chambers



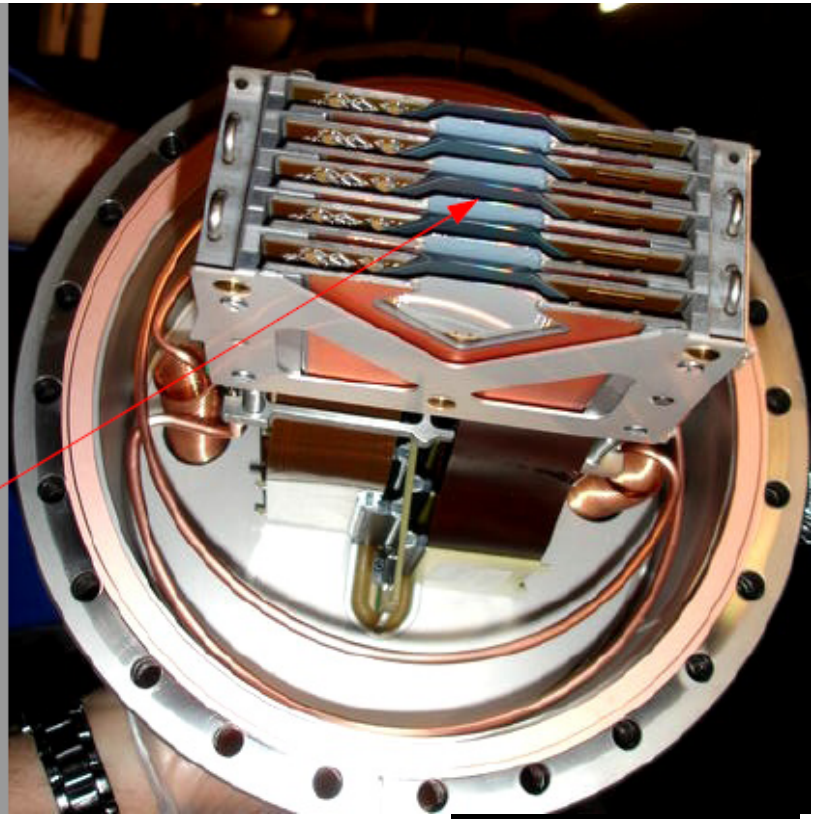
The Roman Pot System at 220 m and 147 m

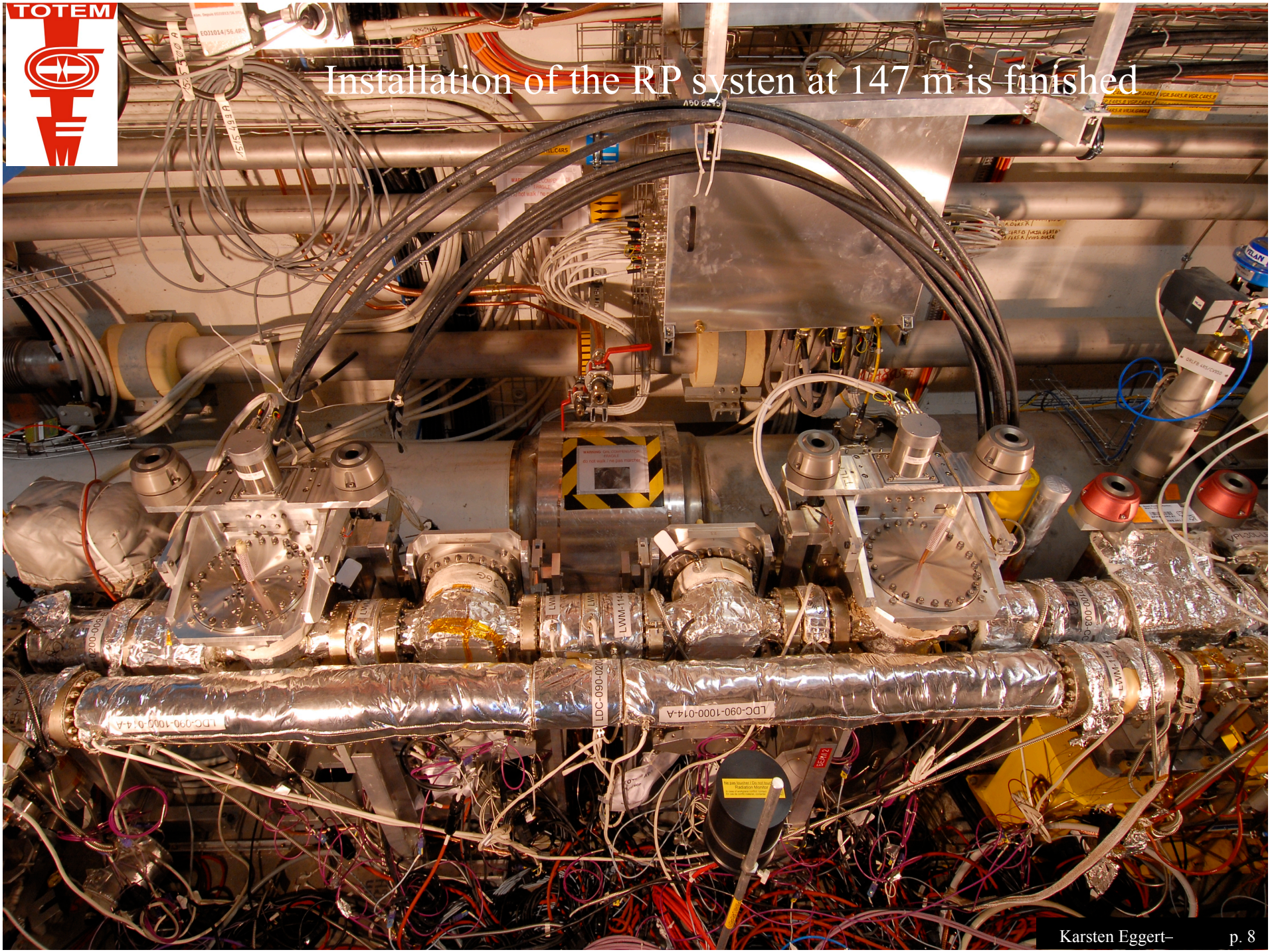




4 Stations
→ 2 Units
→ 3 pots
1 BPM
(Beam Position Monitor)

Edgeless Silicon Detectors



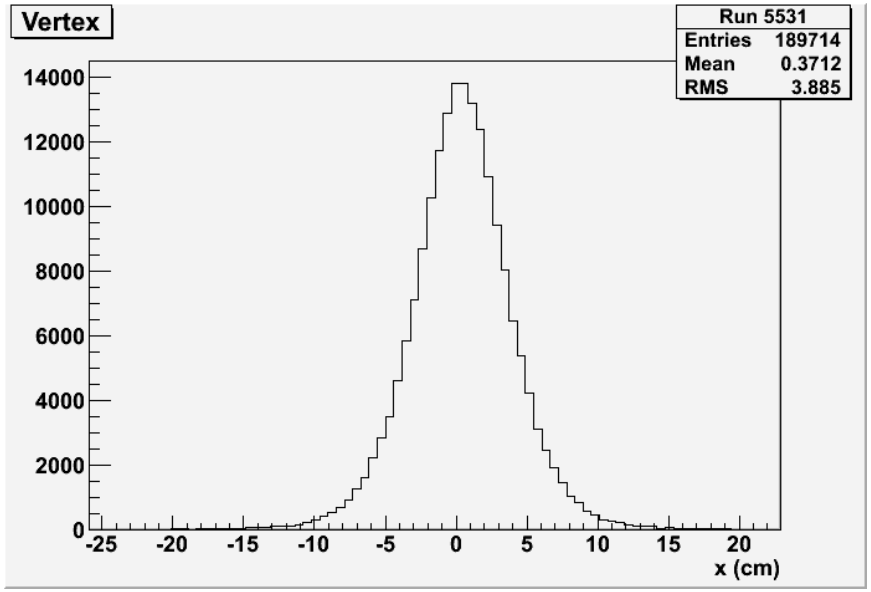

TOTEM
Installation of the RP systen at 147 m is finished
LDC-090-1000-014-A
LWM-114
Karsten Eggert–
p. 8

The TOTEM experiment is completely installed

- All Roman Pots at 147 and 220m are installed
- T1 detectors are installed on both sides
- T2 detectors are installed on both sides
- Trigger system based on all detectors is running
- DAQ is running with an event rate capability of 1 kHz
- Special runs with dedicated β^* and bunch structures are prepared

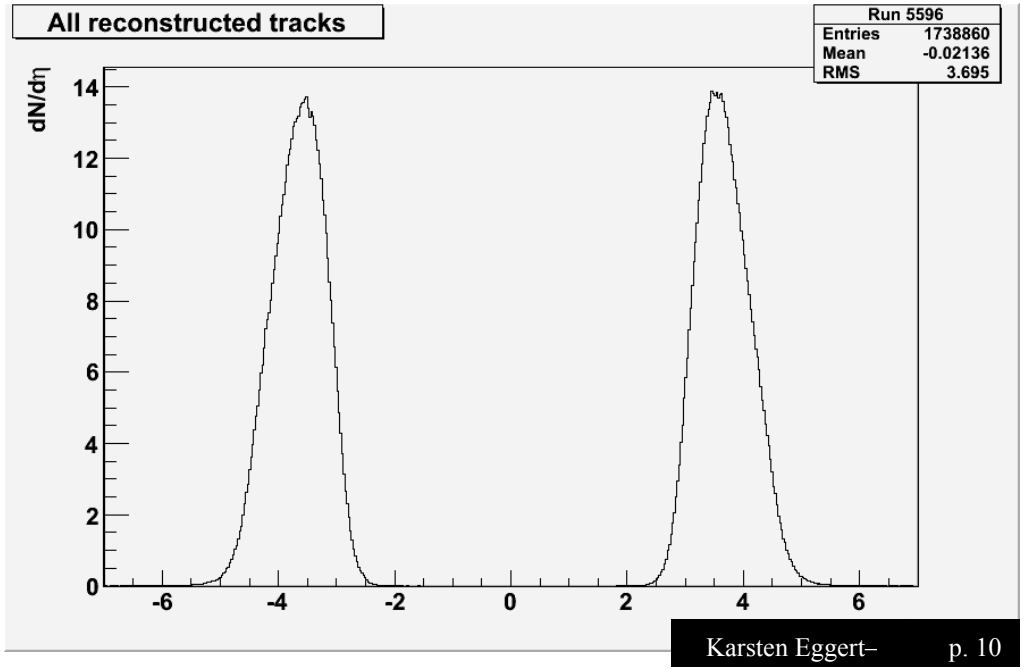
Preliminary dN/dh results (T1)

Vertex reconstruction



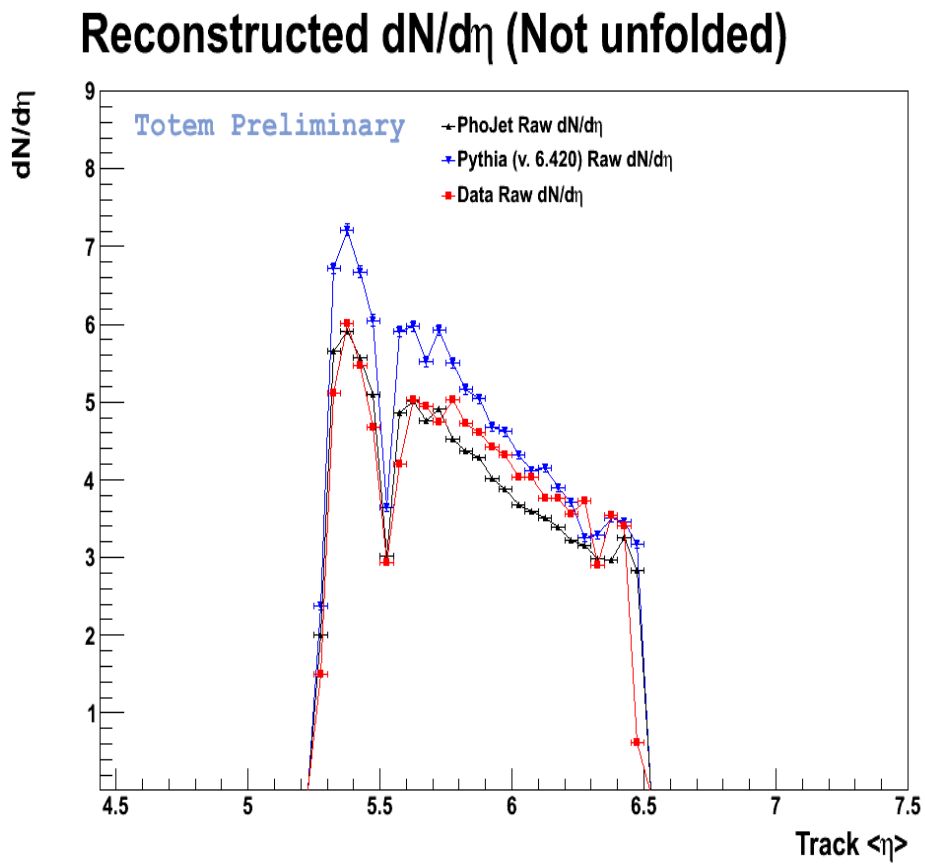
Vertex reconstruction is effected by the CMS magnetic field

h distributions



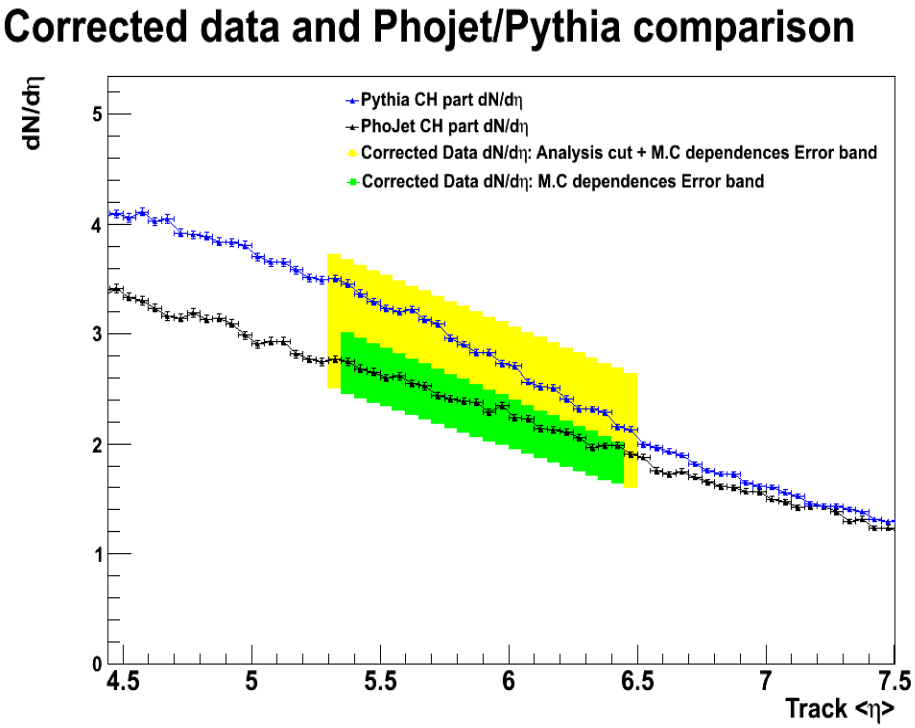
Preliminary dN/dh results (T2)

Raw data



Unfolded data

Green band after vertex cuts



Low luminosity runs only

Elastic pp scattering

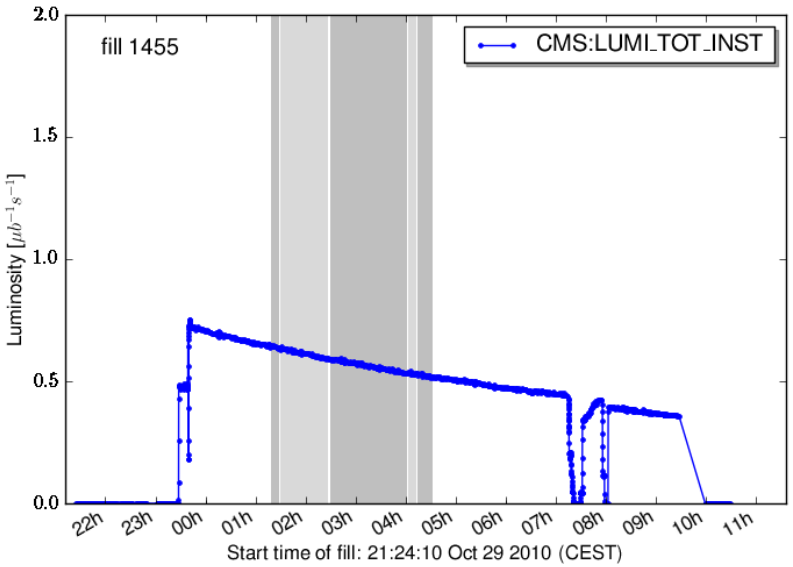
Several runs were taken during 2010

with different distances of the Roman pots to the beam center

The 7 s runs were analyzed.

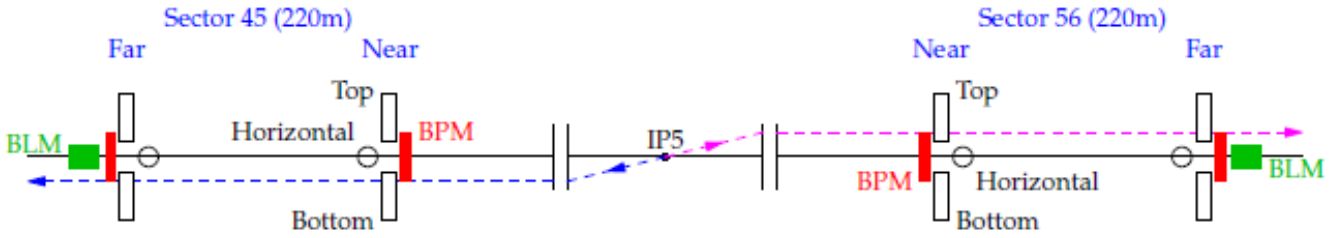
The 18 s runs with a total luminosity of ~3.8 pb^{-1} will follow soon

Luminosity



25 s	1.5 nb^{-1}
20 s	185 nb^{-1}
18 s	3867 nb^{-1}
7 s	9.5 nb^{-1}

Cuts and data reduction

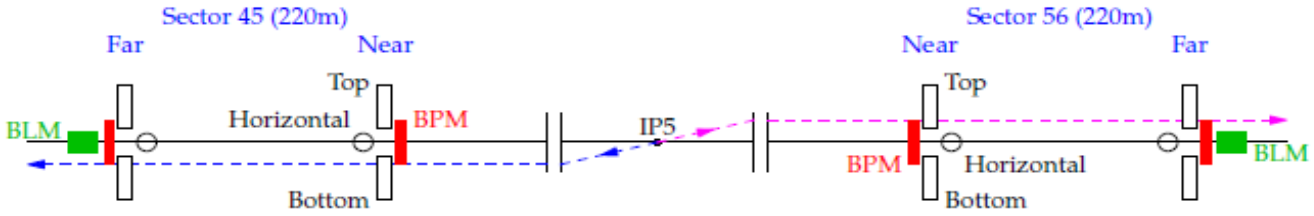


- Topology
  - near and far units
  - diagonals
- Low |[illegible]| selection (3σ)
  - $|x_{RP,45}|<3\sigma_x$ @ $L_{x,45}=0$
  - $|x_{RP,56}|<3\sigma_x$ @ $L_{x,56}=0$
  - corr. $y_{RP216,45}$ [illegible] $y_{RP220,45}$
  - corr. $y_{RP216,56}$ [illegible] $y_{RP220,56}$
- Elastic collinearity (3σ)
  - $\theta_{x,45}^*$ [illegible] $\theta_{x,56}^*$
  - $\theta_{y,45}^*$ [illegible] $\theta_{y,56}^*$

Intergrated luminosity : 6.2 nbarn^{-1}

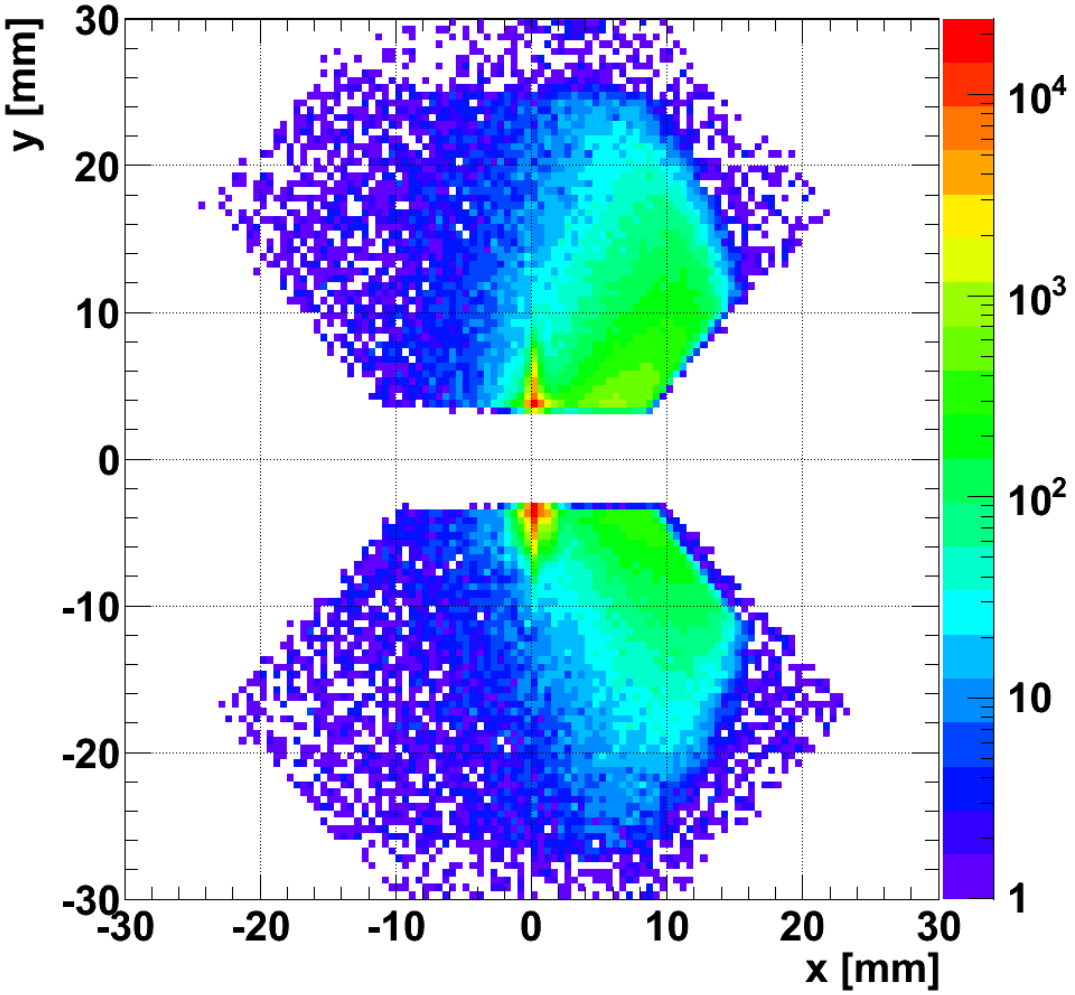
Total triggers	5.28M
Reconstructed tracks & elastic topology	293k
Low |[illegible]| selection	70.2k
Collinearity cuts	66.0k

Proton tracks of a single diagonal (left-right coincidences)



Sector 56

Sector 45



$t = -p^2 q^2$

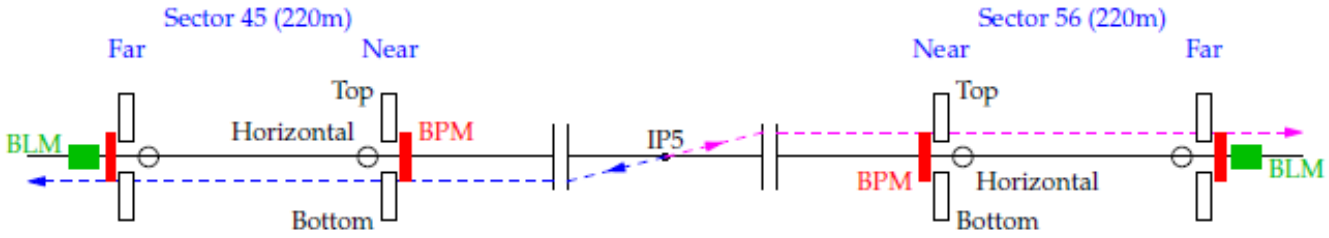
$x = Dp/p$

$y = L_y Q_y$

$x = L_x Q_x + x D$

$L_x \sim 0$

Cuts and data reduction



- Topology
  - near and far units
  - diagonals
- Low $|\not{W}|$ selection (3σ)
  - $|x_{RP,45}|<3\sigma_x$ @ $L_{x,45}=0$
  - $|x_{RP,56}|<3\sigma_x$ @ $L_{x,56}=0$
  - corr. $y_{RP216,45}$ $\not{W}$ $y_{RP220,45}$
  - corr. $y_{RP216,56}$ $\not{W}$ $y_{RP220,56}$
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  - $\theta_{x,45}^{*}$ $\not{W}$ $\theta_{x,56}^{*}$
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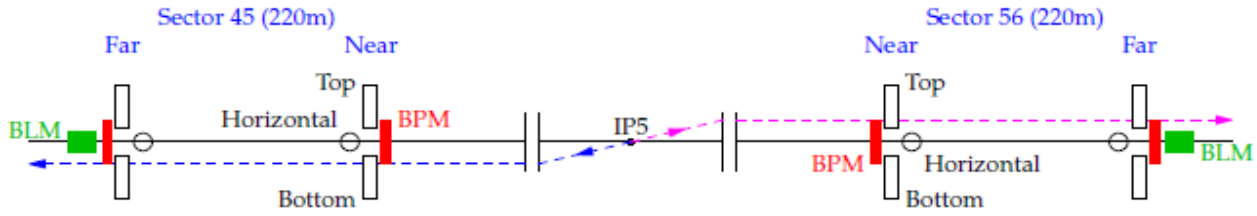
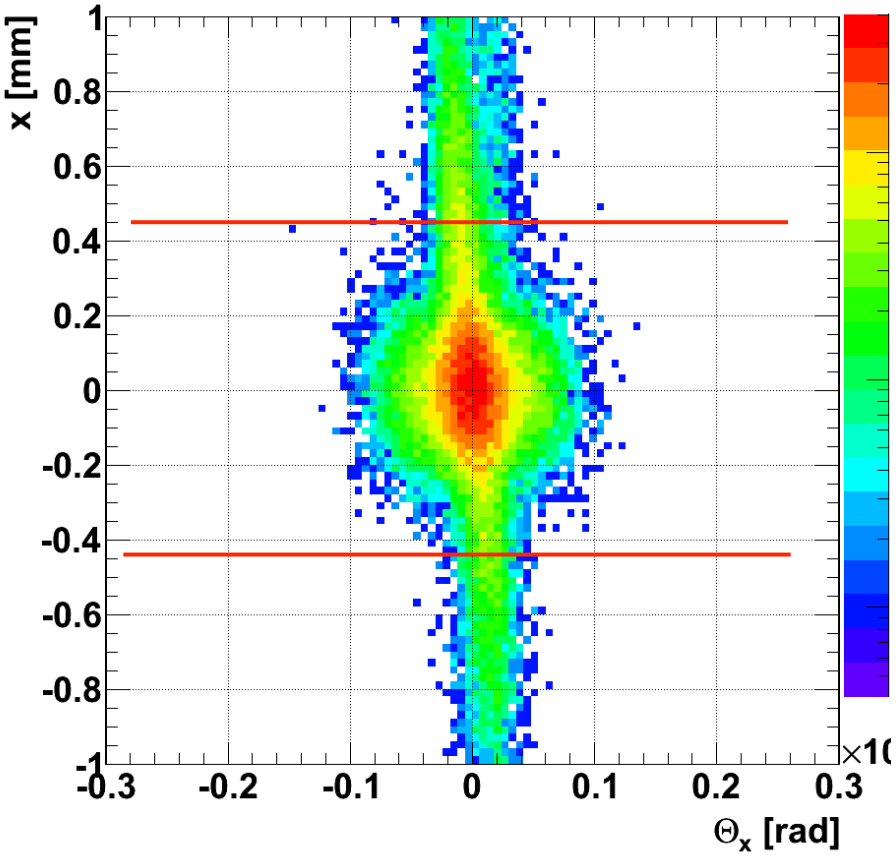
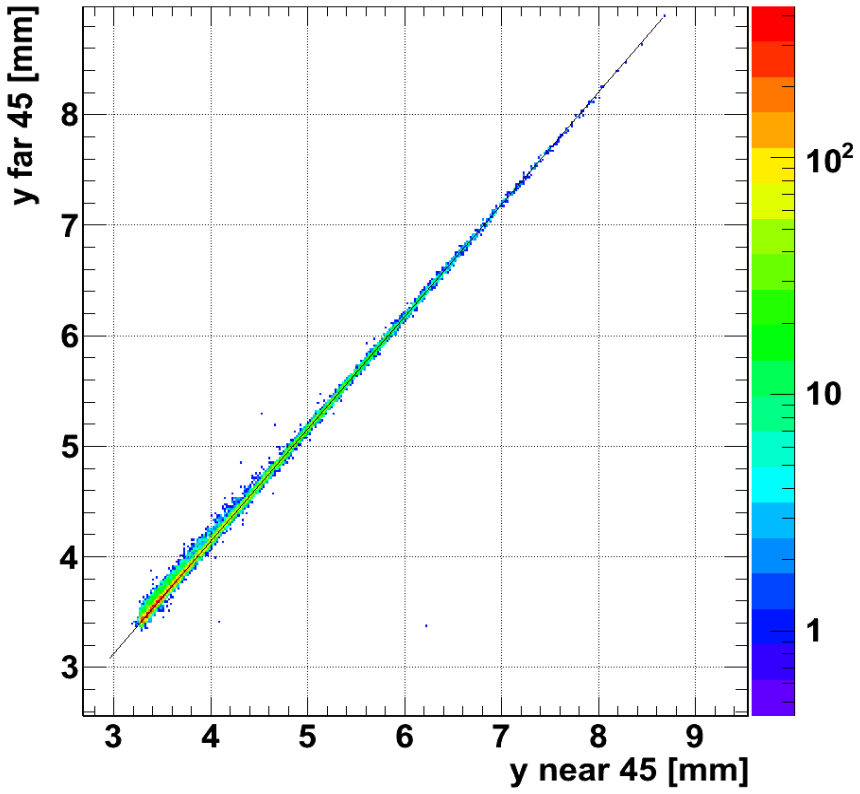
Low ξ = Dp/p cuts





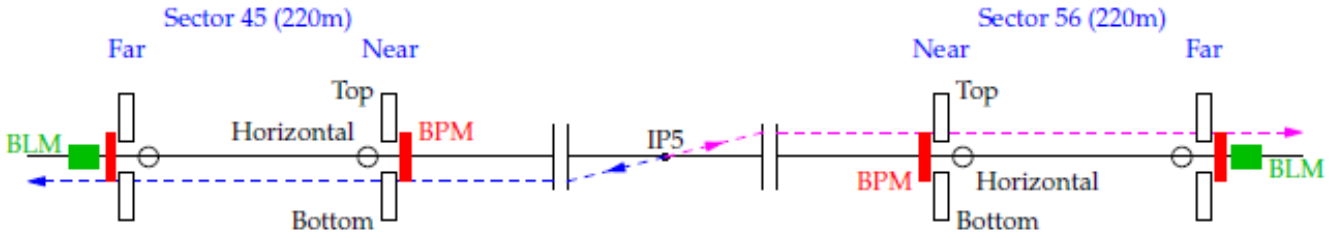


$|x| < 3\sigma_x$ @ $L_x = 0$

$y_{RP\ near,45}$ ξ $y_{RP\ far,45}$

(dLy/ds ξ 0)

Cuts and data reduction



- Topology
  - near and far units
  - diagonals
- Low |[illegible]| selection (3σ)
  - $|x_{RP,45}|<3\sigma_x$ @ $L_{x,45}=0$
  - $|x_{RP,56}|<3\sigma_x$ @ $L_{x,56}=0$
  - corr. $y_{RP216,45}$ [illegible] $y_{RP220,45}$
  - corr. $y_{RP216,56}$ [illegible] $y_{RP220,56}$
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  - $\theta_{x,45}^*$ [illegible] $\theta_{x,56}^*$
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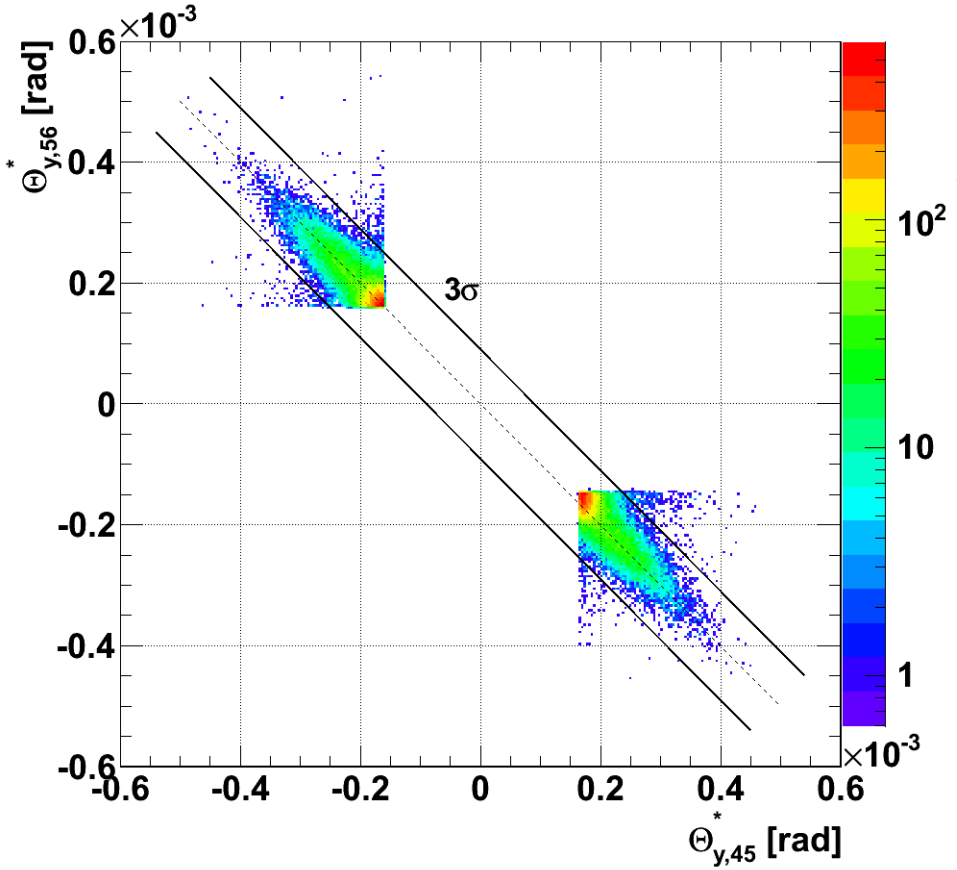
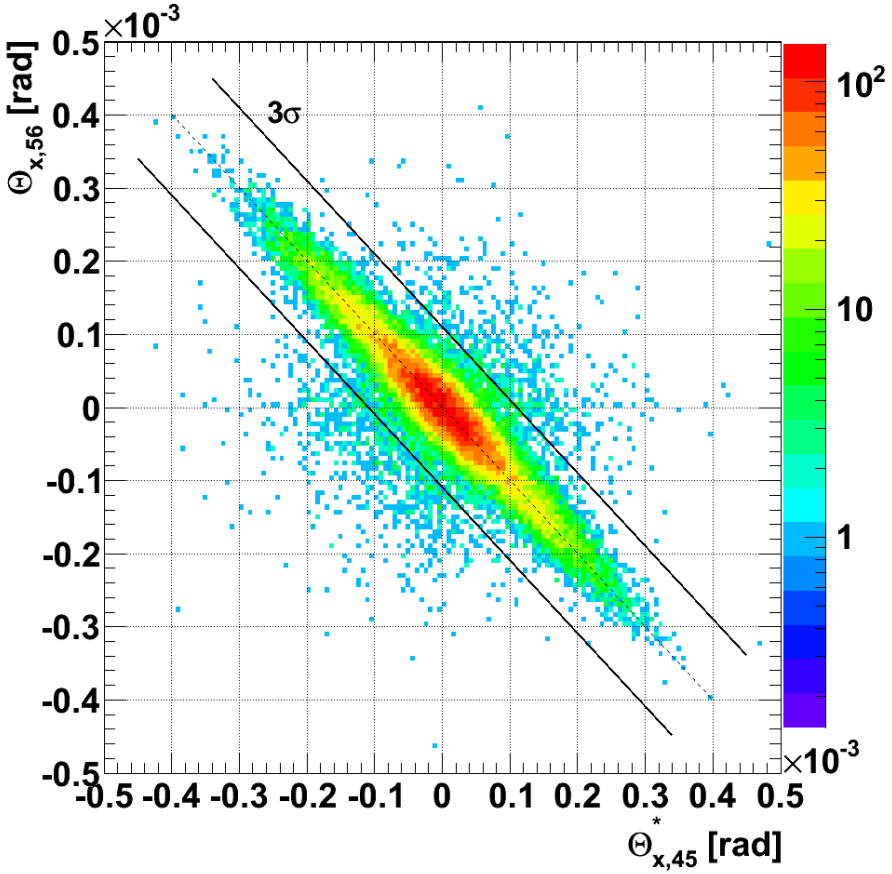
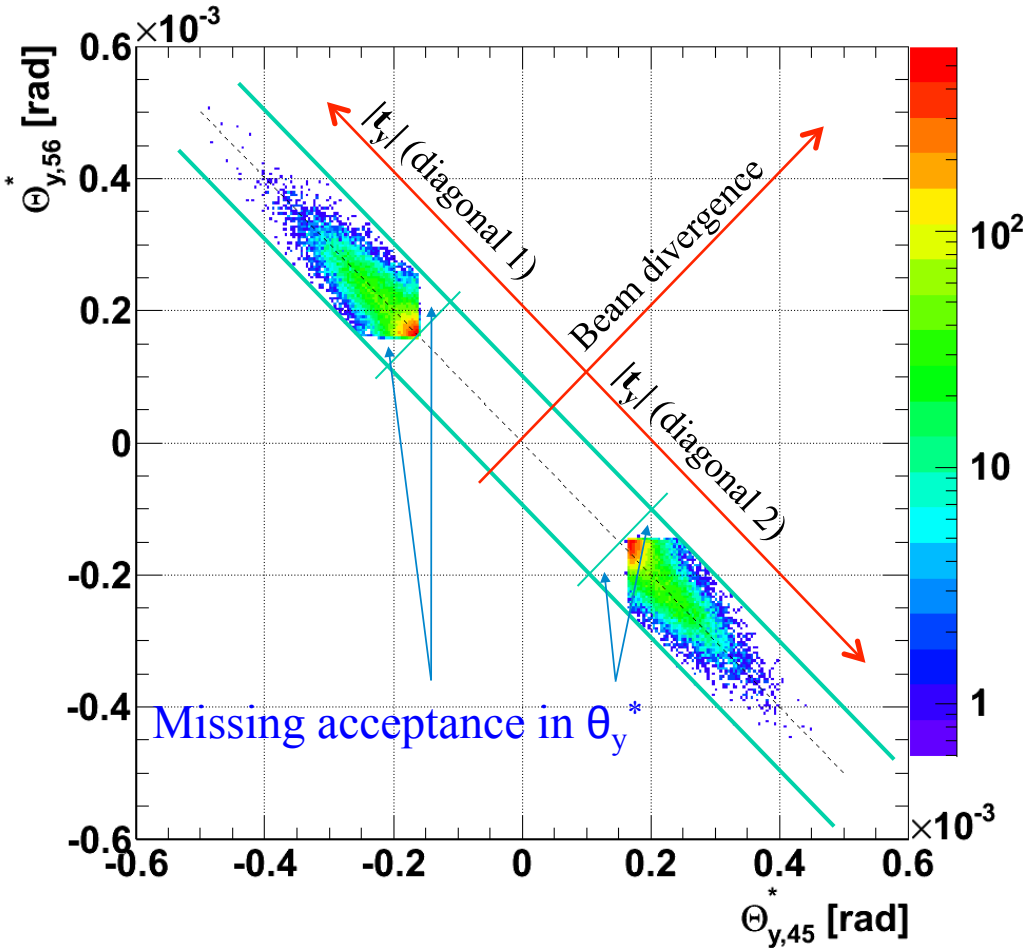
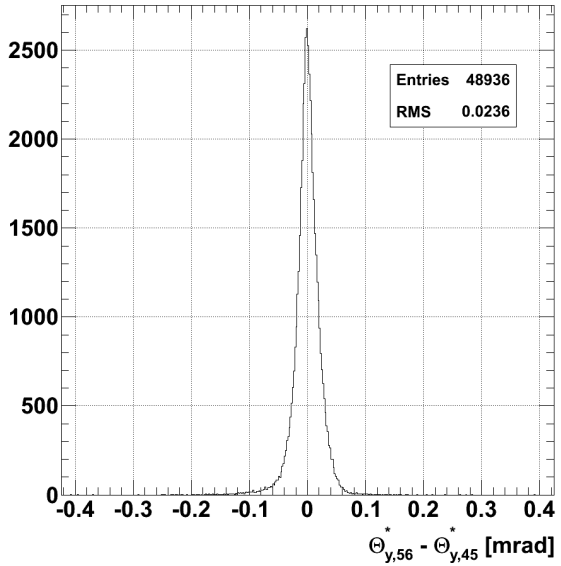
Elastic collinearity cuts

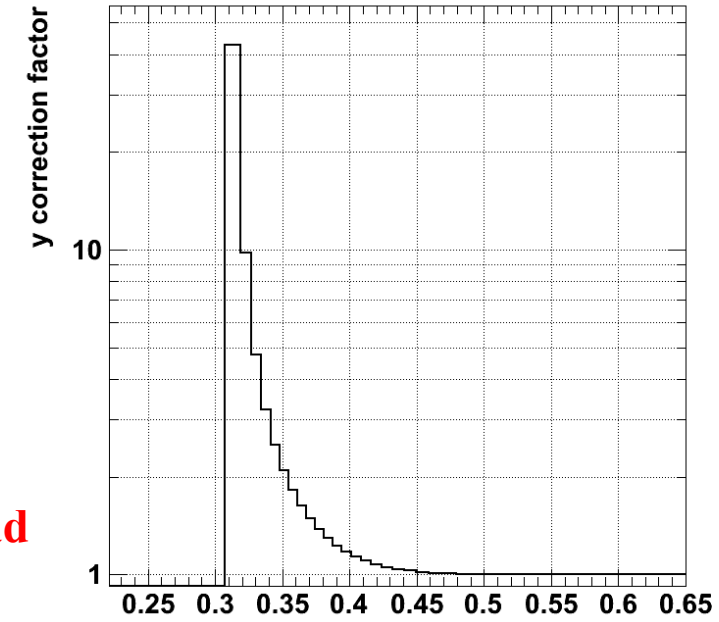




y-acceptance corrections and resolution



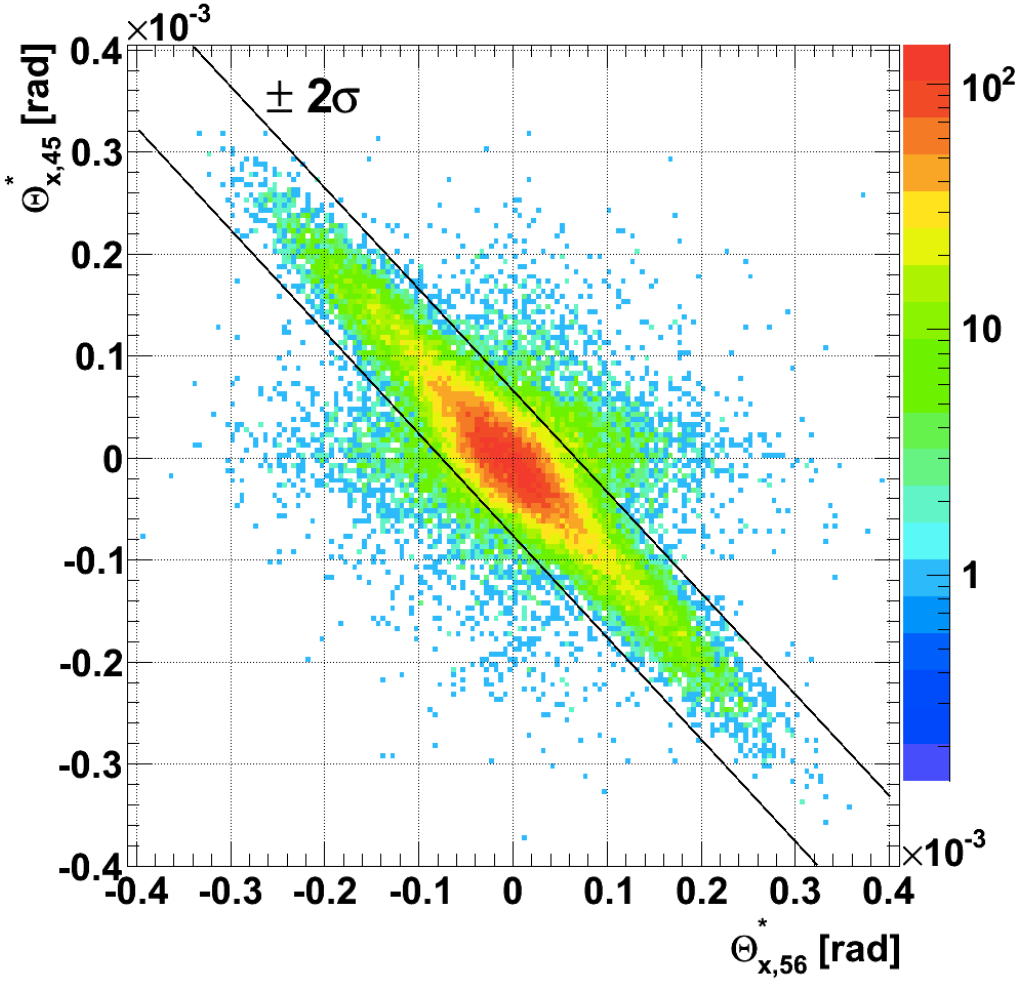


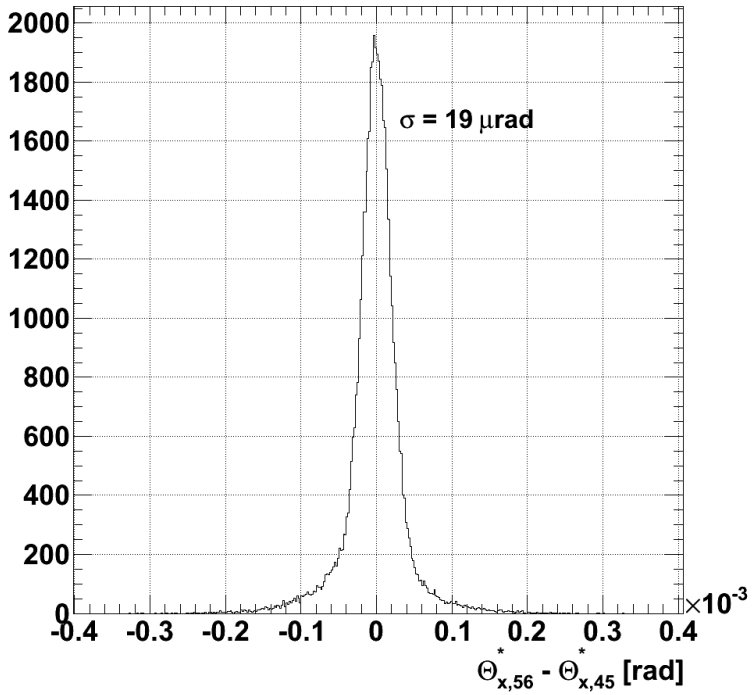


Width in agreement with beam divergence of 17 mrad

Collinearity in q_x

Low x, i.e. |x| < 0.4 mm and 2s cut in Dq_y^*

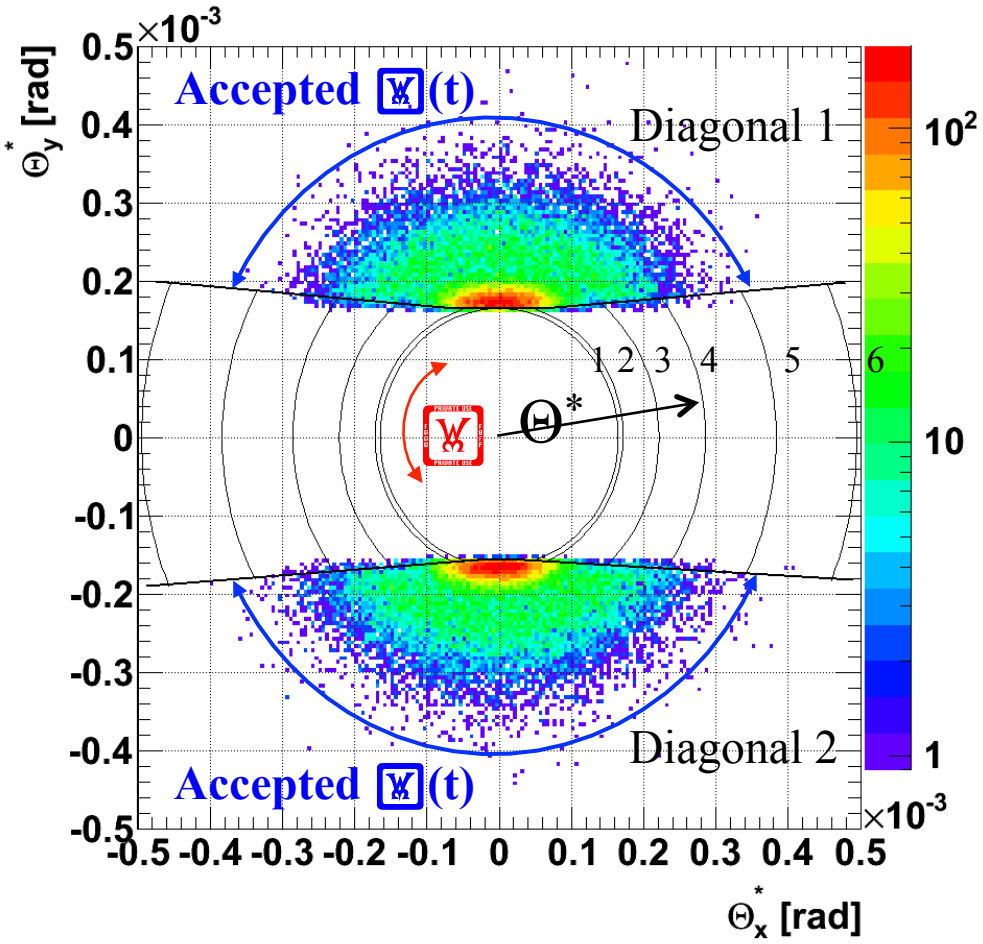




Compatible with the beam divergence

Q_x is measured with 5m lever arm spectrometer

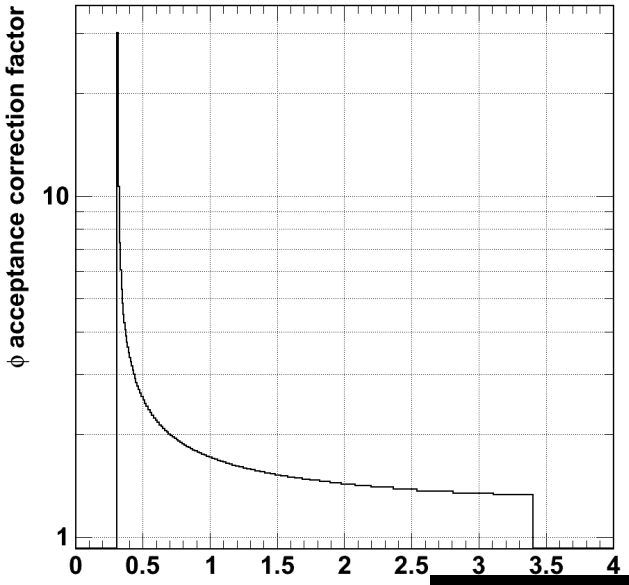
φ-acceptance correction



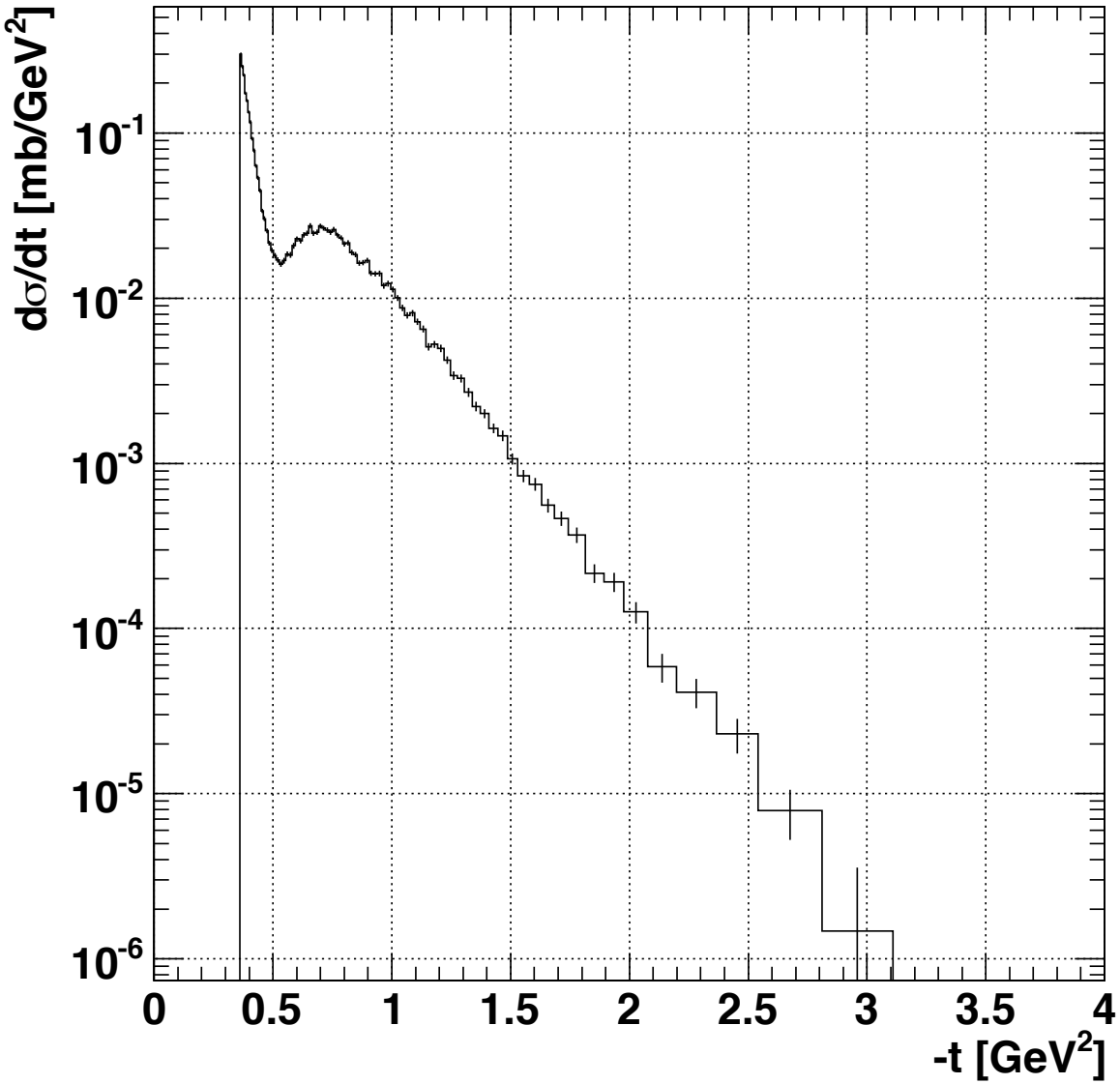
Critical at low t-acceptance limit

Total φ-acceptance correction

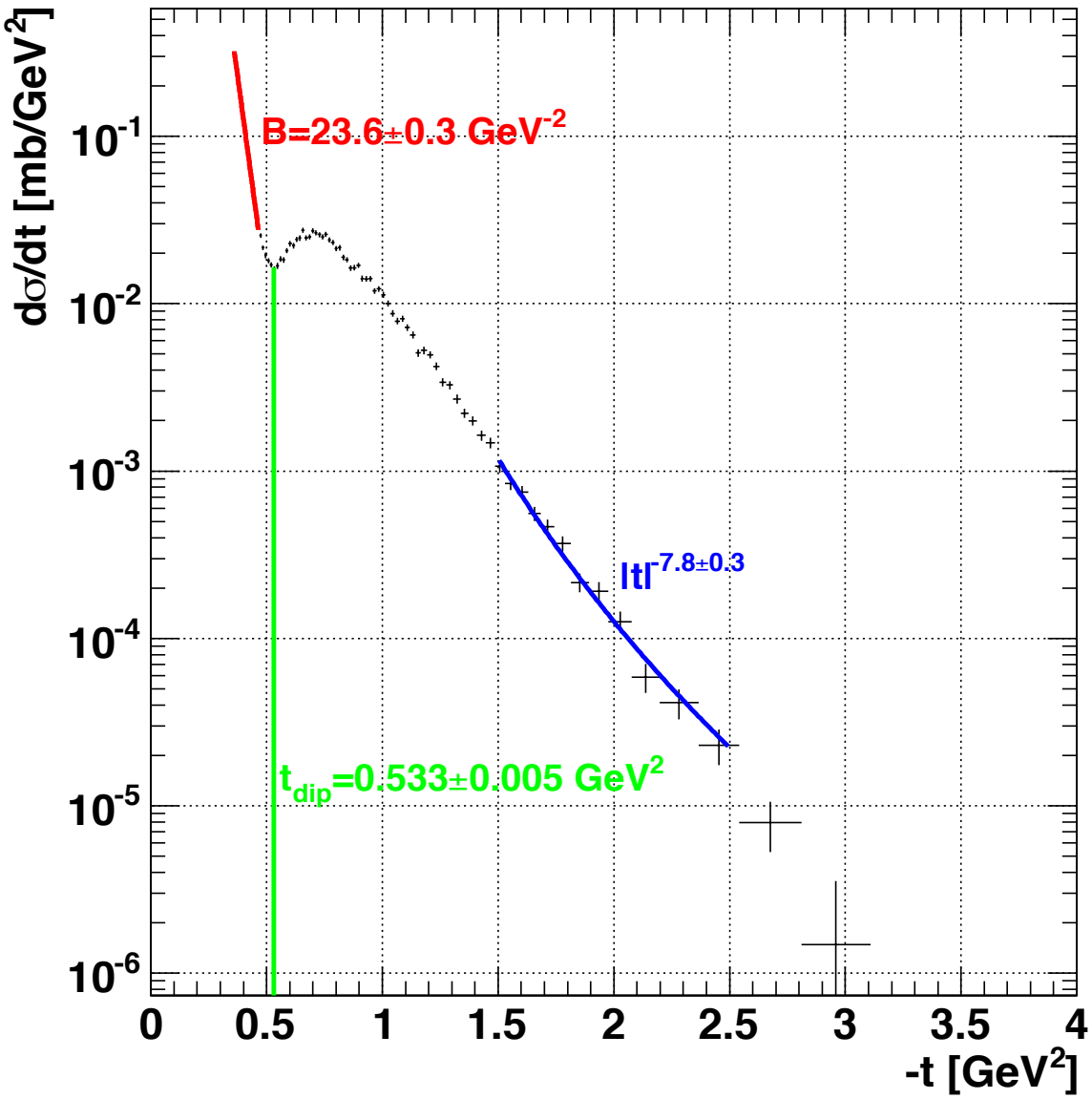
No.	t [GeV²]	Θ* [rad]	Accepted φ (2 diag.) [°]	φ accept. correct. factor
1	**0.33**	1.65E-04	38.6	**9.3**
2	**0.36**	1.71E-04	76.4	**4.7**
3	**0.60**	2.21E-04	162.5	**2.2**
4	**1.00**	2.86E-04	209.8	**1.7**
5	**1.80**	3.83E-04	246.3	**1.5**
6	**3.00**	4.95E-04	269.0	**1.3**



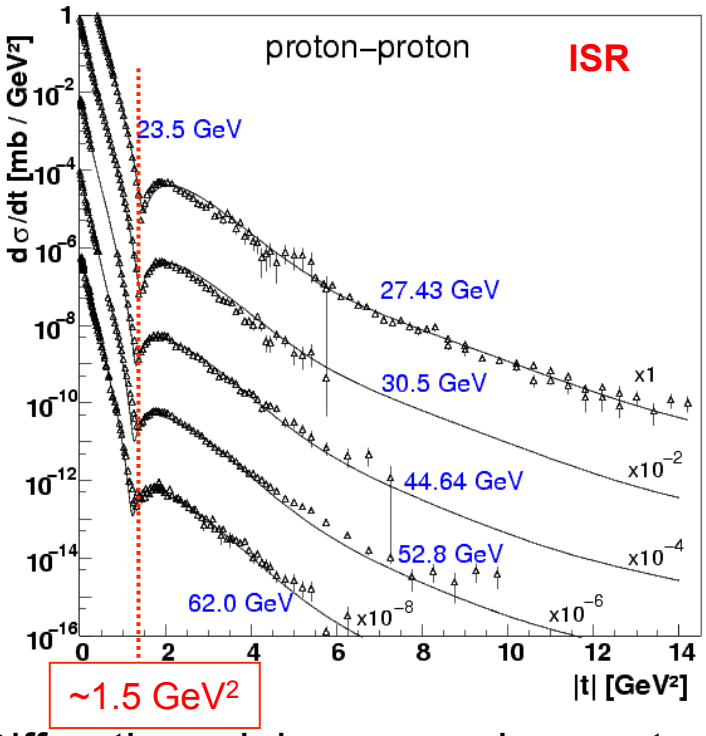
Final result: Differential pp cross-section

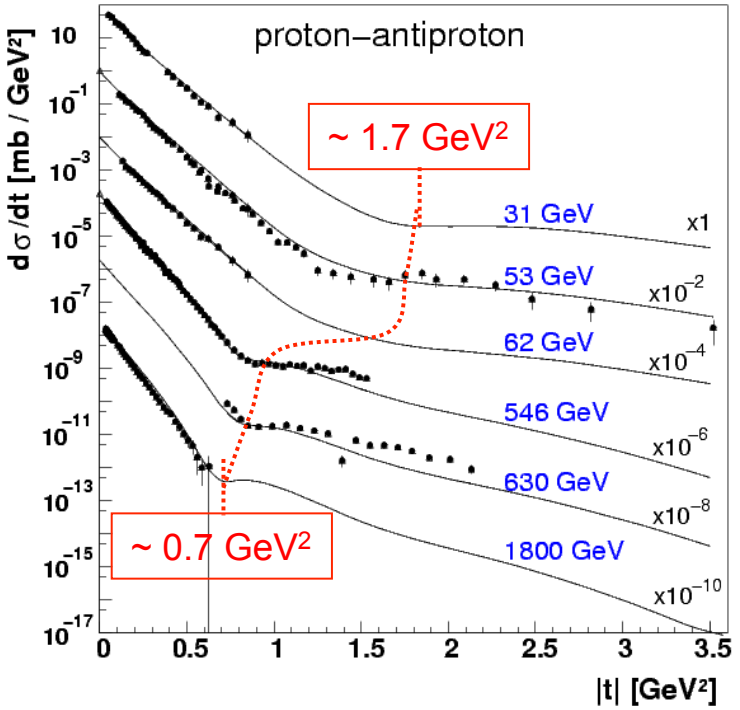


Parameters

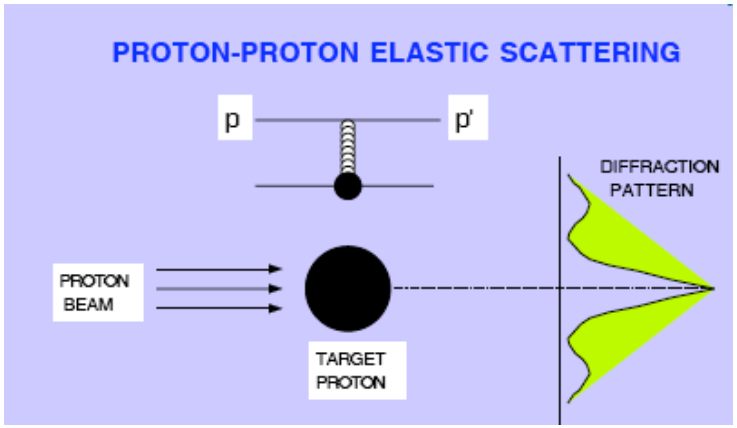

dσ/dt [mb/GeV²]
10⁻¹
10⁻²
10⁻³
10⁻⁴
10⁻⁵
10⁻⁶
B=23.6±0.3 GeV⁻²
|t|^-7.8±0.3
t_dip=0.533±0.005 GeV²
0
0.5
1
1.5
2
2.5
3
3.5
4
-t [GeV²]

Elastic Scattering - from ISR to Tevatron



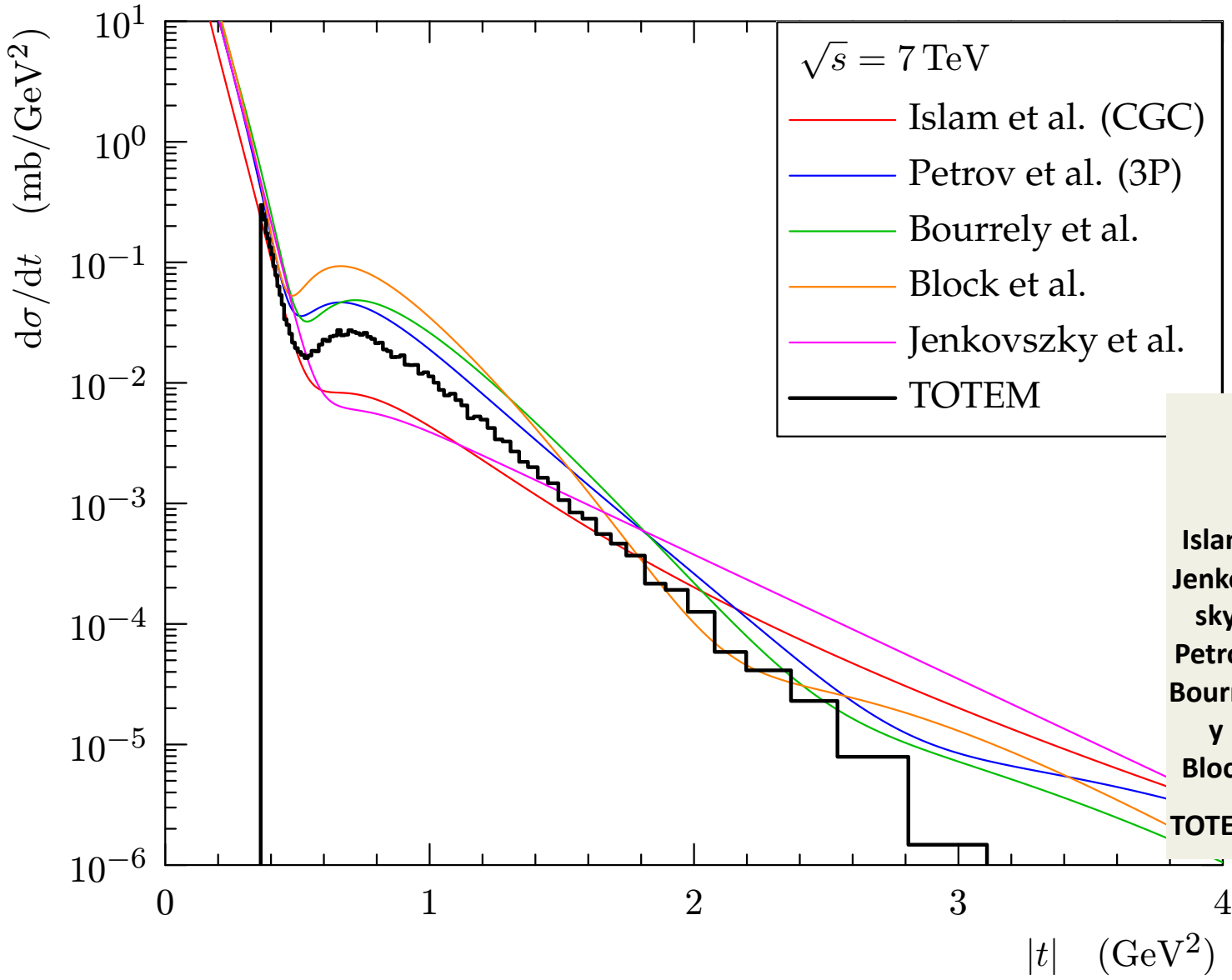


Diffractive minimum: analogous to Fraunhofer diffraction: $|t| \sim p^2\, q^2$



- exponential slope B at low |t| increases
- minimum moves to lower |t| with increasing s
  → interaction region grows (as also seen from s_{tot})
- depth of minimum changes
  → shape of proton profile changes
- depth of minimum differs between pp, p^-p
  → different mix of processes

Comparison with models



	B (t=-0.4 GeV^2)	t_{DIP}	t^{-x} [1.5–2 GeV^2]
Islam	20.2	0.60	5.0
Jenkovsky	20.1	0.72	4.2
Petrov	23.3	0.51	7.0
Bourrely	22.0	0.54	8.4
Block	25.3	0.48	10.4
TOTEM	23.6 ± 0.3	0.53 ± 0.01	7.8 ± 0.3

Outlook

The 18 s runs with a total luminosity of ~3.8 pb^{-1} will be analyzed soon

Gain in statistics ~ 500 for $2.5 < |t| < 4$ GeV^2

Commissioning with b* = 90 m has started and runs are expected summer 2011

lower accessible limit $|t| > 10^{-2}$ GeV2 will allow:

extrapolation to $|t|=0$

determination of B and elastic pp scattering cross-section

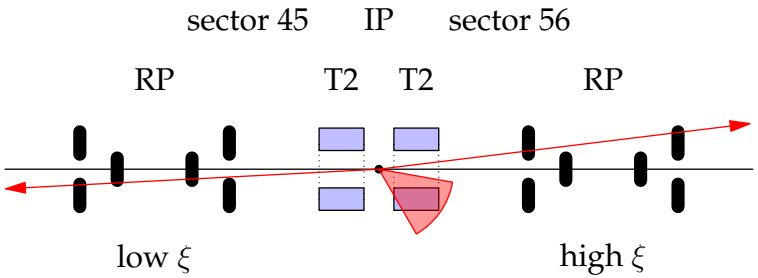
total cross-section measurements

Start extensive studies of diffractive processes:

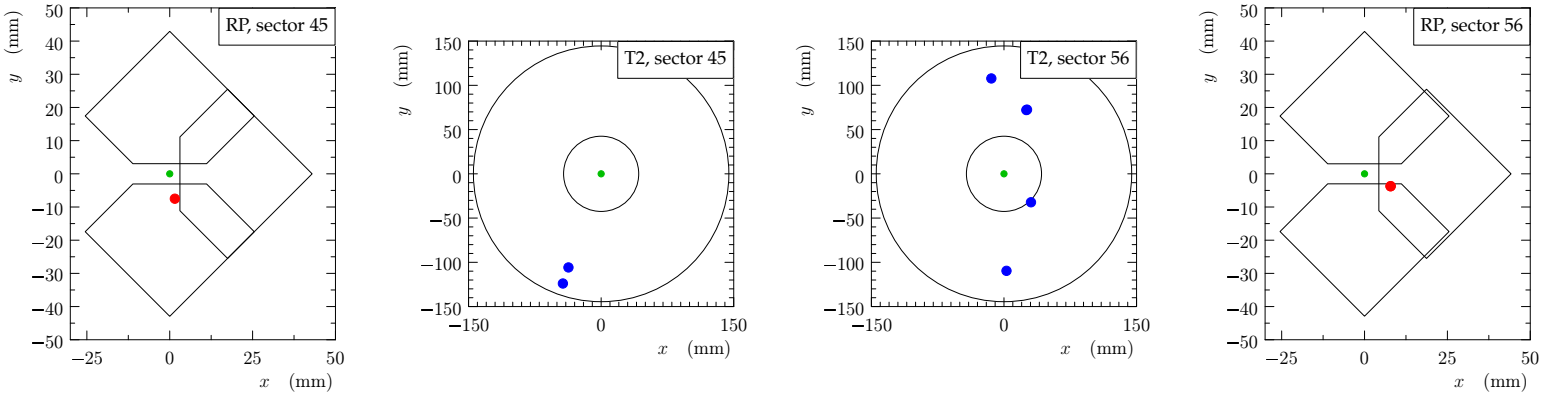
Double Pomeron exchange

Single Diffraction

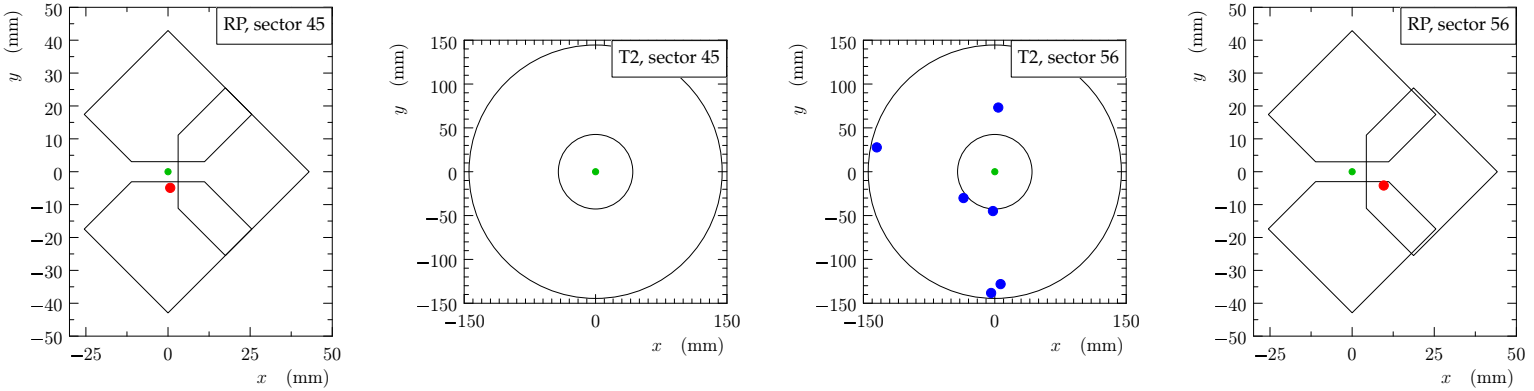
Double Pomeron Exchange



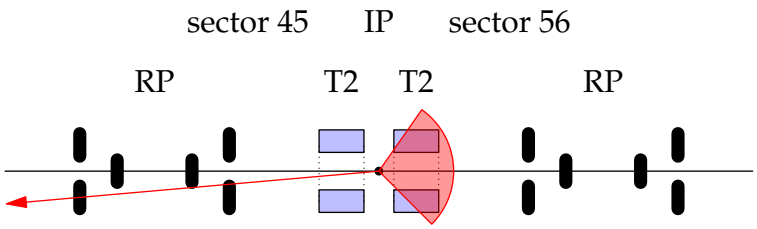
run: 37250009, event: 14125



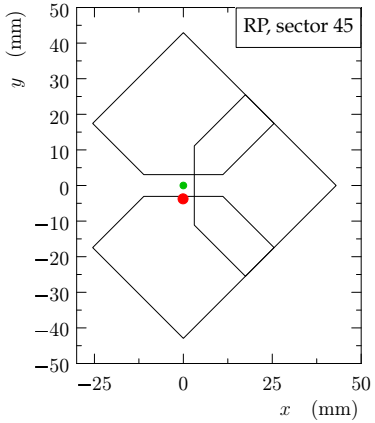
run: 37220007, event: 9904

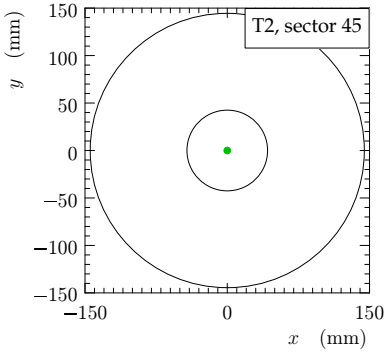


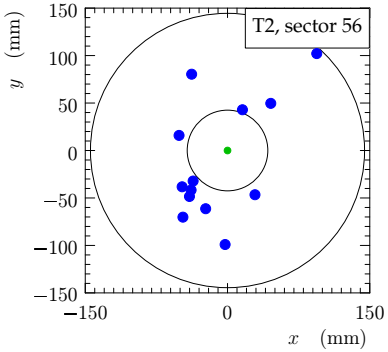
Single diffraction low x

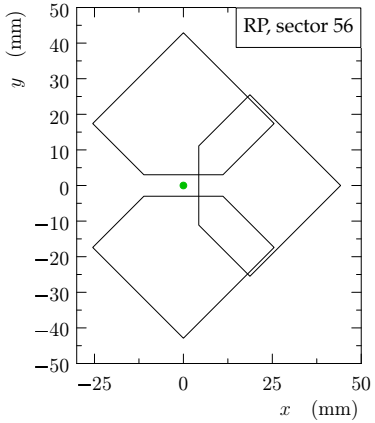


run: 37280003, event: 3000

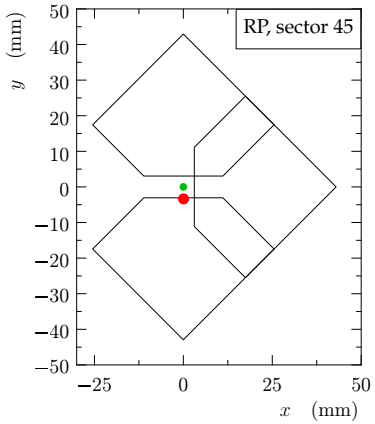


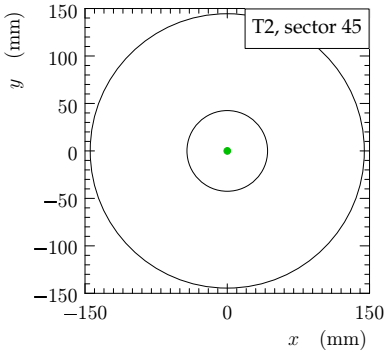


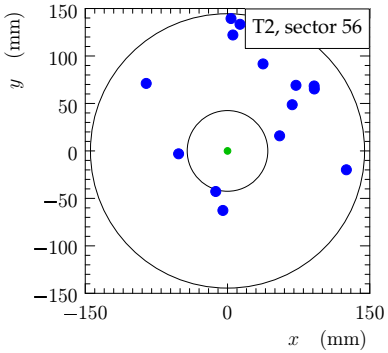


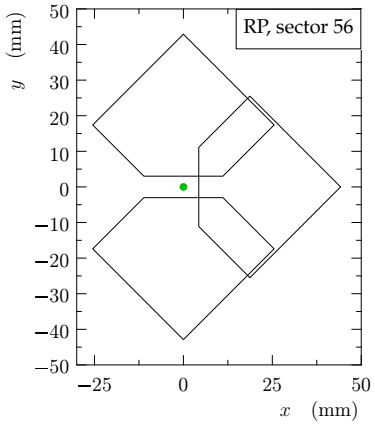


run: 37280004, event: 22784

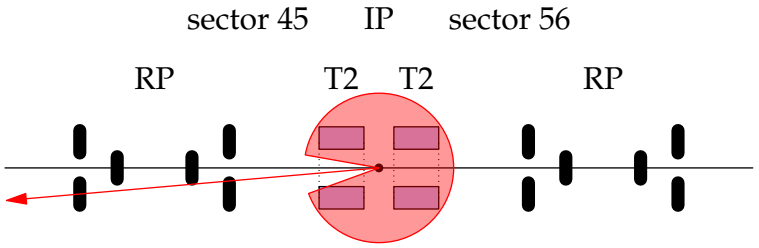




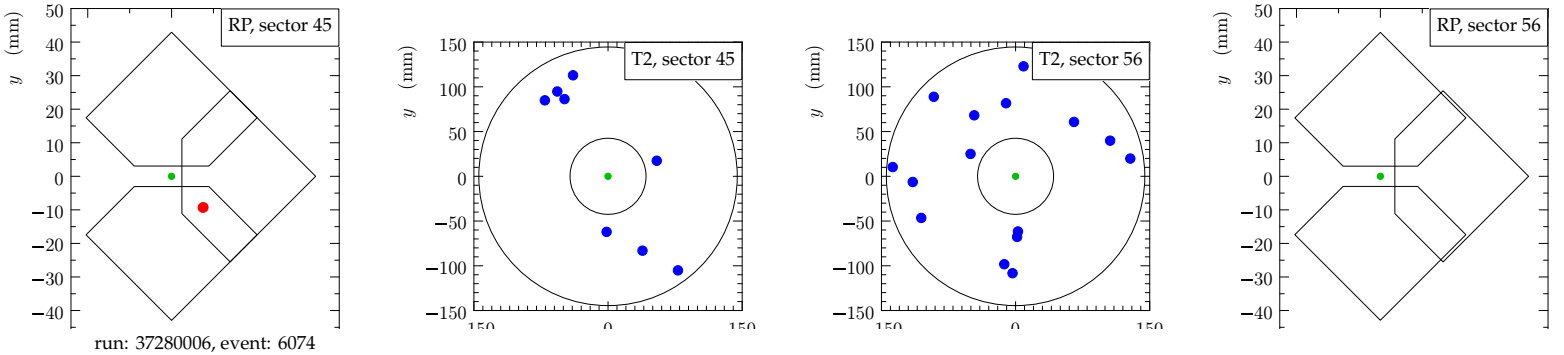




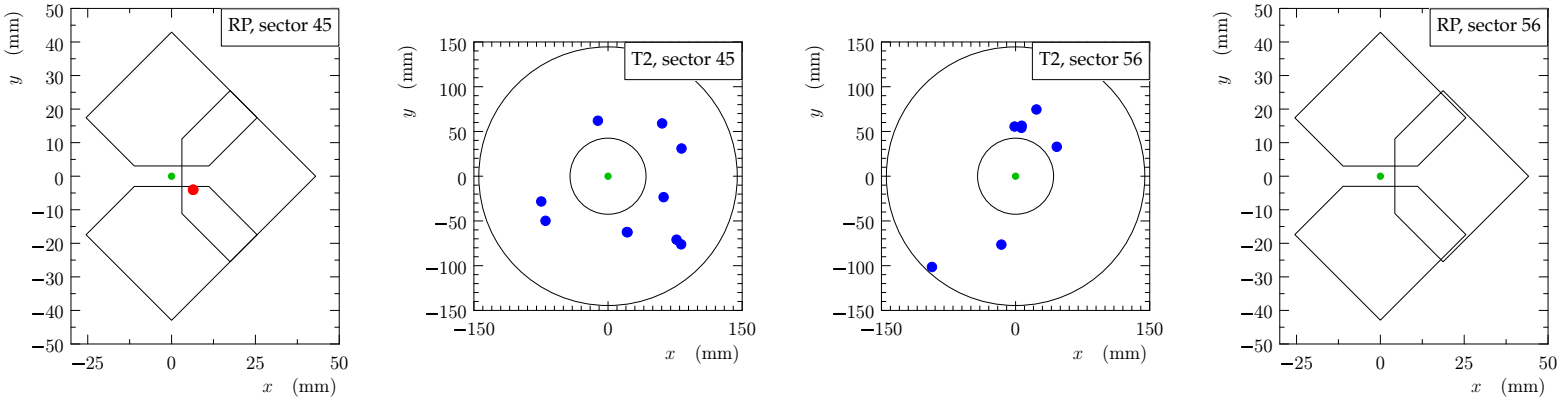
Single diffraction large x



run: 37280006, event: 9522



run: 37280006, event: 6074



The TOTEM Collaboration

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Università di Genova and Sezione INFN, Genova, Italy

University of Helsinki and HIP Helsinki, Finland

End

Collimation-Based Roman Pot Alignment w.r.t. the Beam Centre

Alignment is the central problem of Roman Pot measurements

LHC collimation system produces sharp beam edges

→ used to align Roman Pots and to determine the centre of the beam

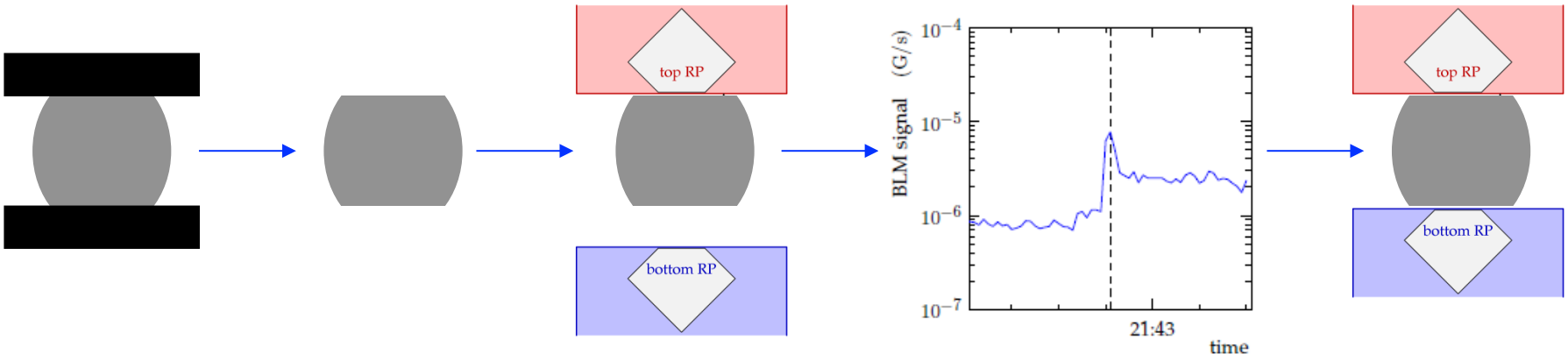
(same procedure as collimator setup)

Collimator cuts a sharp beam edge symmetrically to the centre

RP approaches this edge until it scrapes

produces spike in Beam Loss Monitor downstream

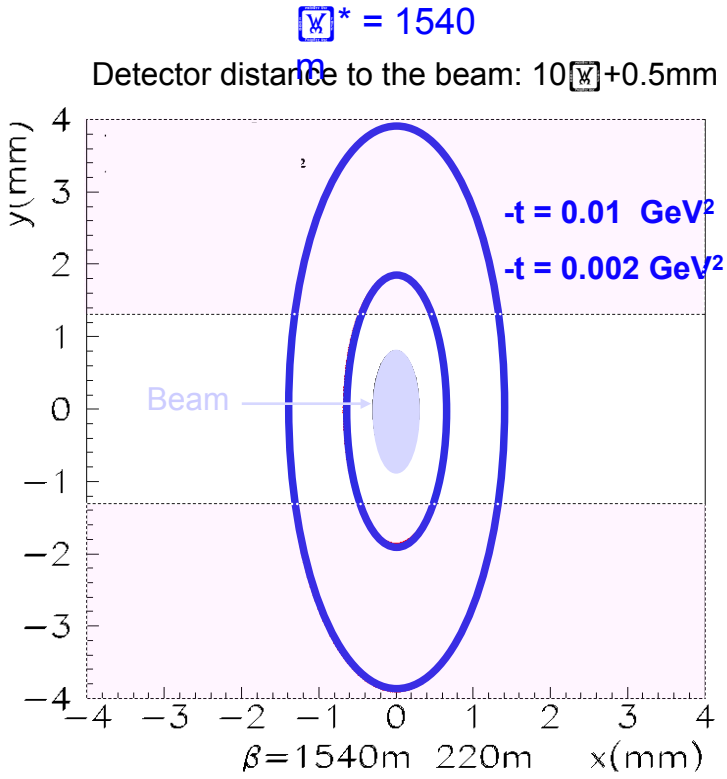
second RP approaches

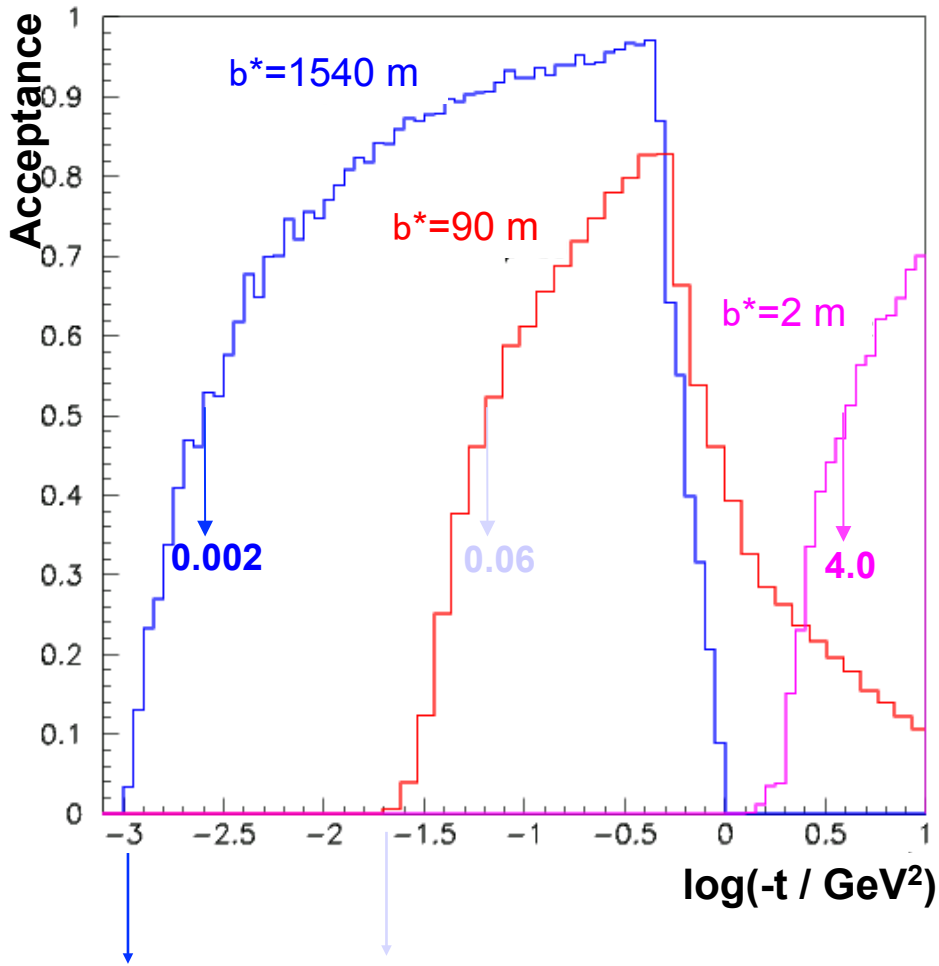


When both top and bottom pots "feel" the edge:

- 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

Elastic Scattering Acceptances
β* = 1540 90 2 m

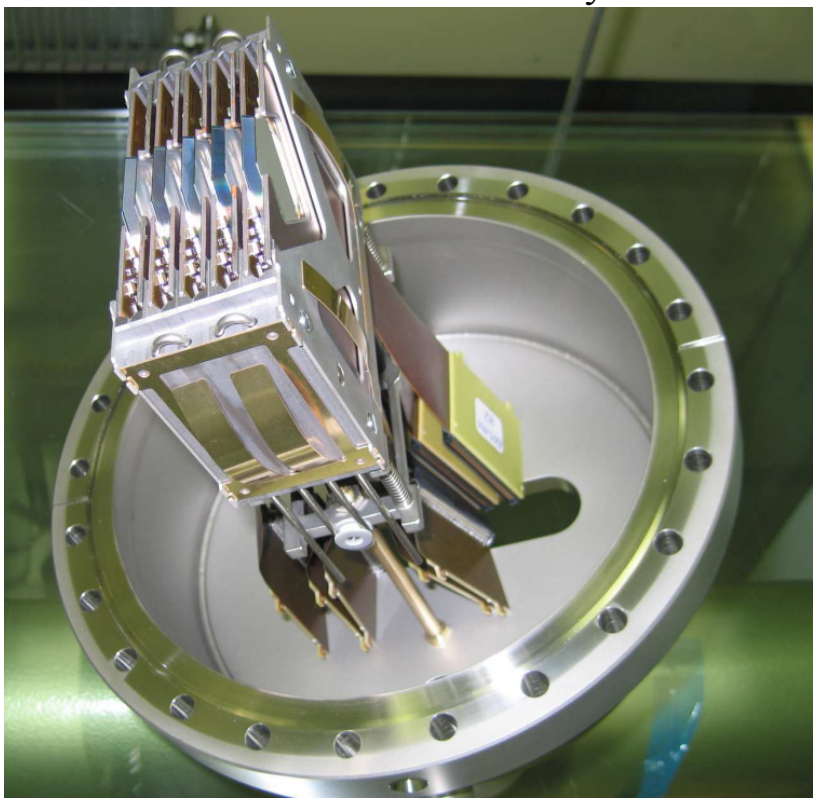


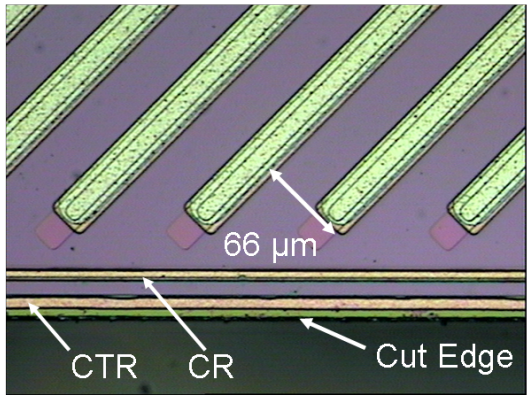


Detector distance 1.3 mm 6 mm

Roman Pot System

Roman Pot detector assembly





All 12 Roman Pots at ±220 m from IP5 are operational: delivering data with active triggers.

All 12 Roman Pots at ±147 m from IP5 are operational.

Overview 2010

30.03.	first T2 run: tracks seen	
April	T2 commissioning with beam, RP comm. in garage position, bunch-crossing trigger	
21.04.	first tracks in RPs in garage position, active trigger	
15.05.	first T2 data with squeezed optics	b* = 2m 2 b., 2e10 p/b
25.06.	RP beam-based alignment	450 GeV, b* = 11m 1 b., 3e10 p/b later 9e10 p/b
04.07.	first T2 data with nominal bunches	b* = 3.5m, 1e11 p/b (nom.)
13.−14. 07.	RP insertion to 30 s in stable beams	8 nom. b.
15.07.−04.08.	RP insertion to 25 s (V) and 30 s (H) in stable beams	8 – 16 nom. b.
09.08.	partial RP beam-based alignment	3.5 TeV, 1 nom. b.
11.08.	RP loss map measurement to qualify 20 s settings	
18.08.	first RP insertion to 20 s (V) and 25 s (H)	16 nom. b.

1.5 nb^{-1}
first 2 elastic candidates

Overview 2010 (continued)

24.-26. 08.	RP insertions to 20 s (V) and 25 s (H)	16 nom. b.	184.6 nb^{-1}
21.09.	RP beam-based alignment and run at 7 s	1 nom. b.	0.88 nb^{-1}
28.09. -28.10.	RP insertions to 18 s (V) and 20 s (H)	93 – 348 nom. b.	3867.1 nb^{-1}
30.10.	special run: RPs inserted to 7 s (V) and 16 s (H) pileup-free data for T2 (trigger on pilot) common run RP + T2	1 pilot b. (1e10) + 4 b. x 7e10 p/b.	8.6 nb^{-1}

Total:

25 s	1.5 nb^{-1}
20 s	185 nb^{-1}
18 s	3867 nb^{-1}
7 s	9.5 nb^{-1}