



TOTEM - 2011

Evian, 13 December 2011

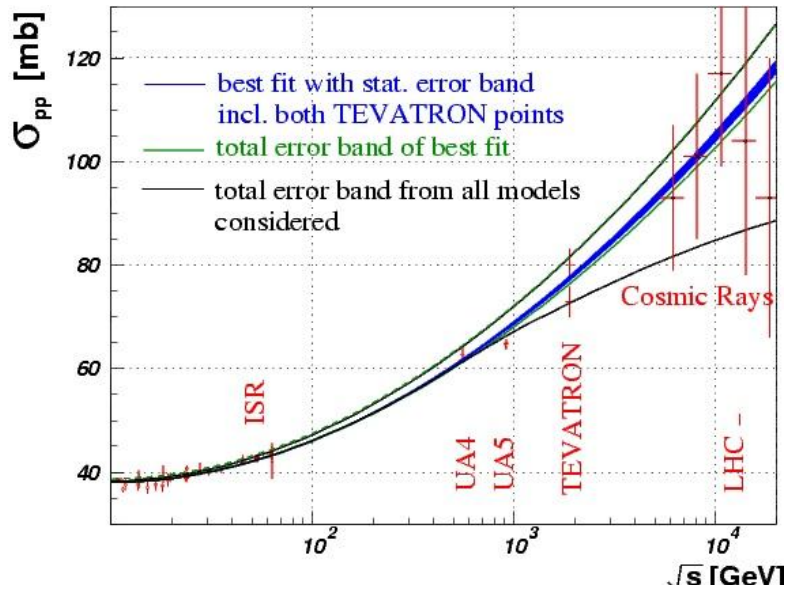
S.Giani

CERN – CH

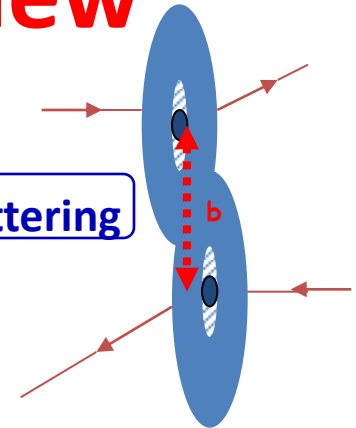
[on behalf of the TOTEM collaboration]

TOTEM Physics Overview

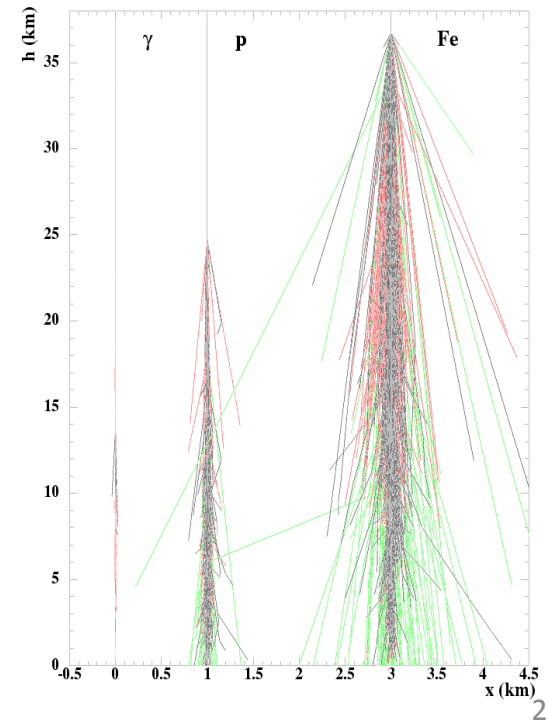
Total cross-section



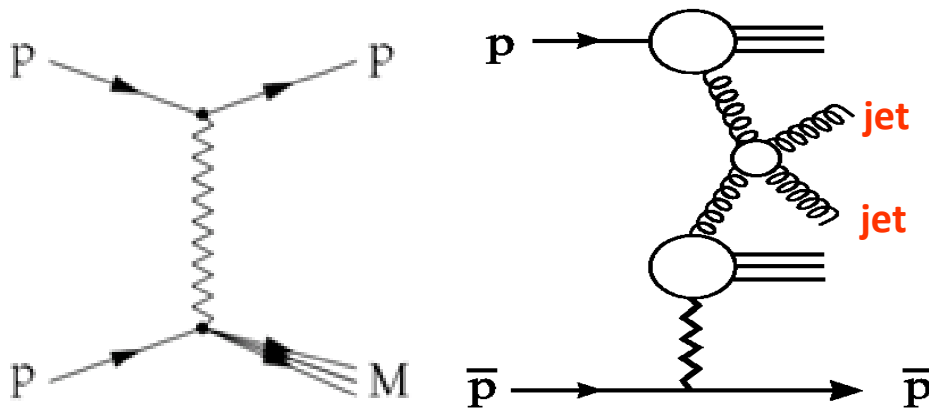
Elastic Scattering



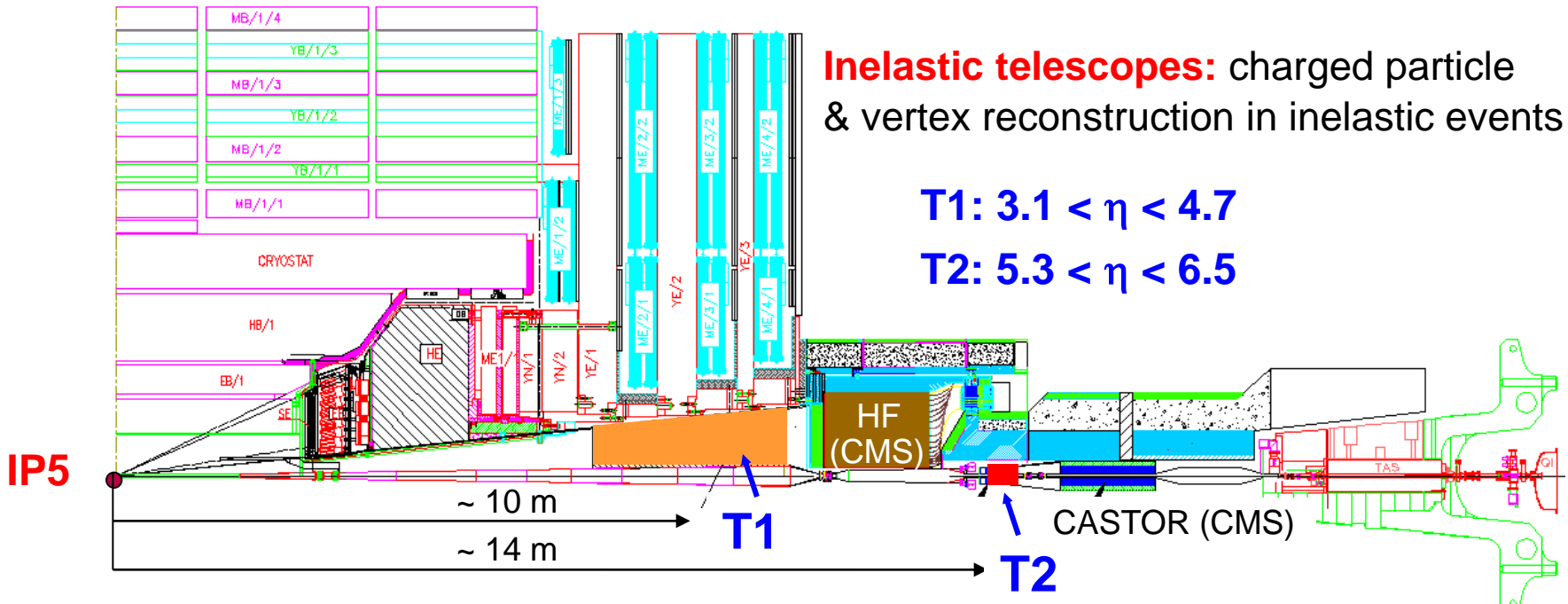
Forward physics



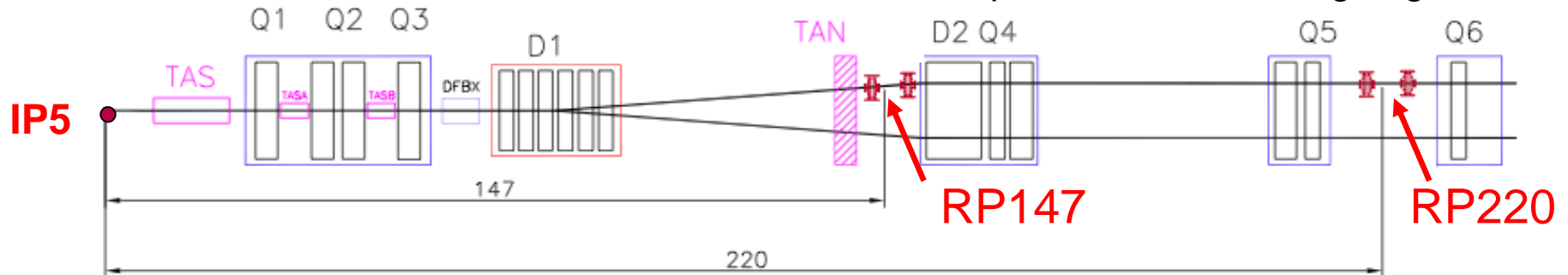
Diffraction: soft (and hard with CMS)

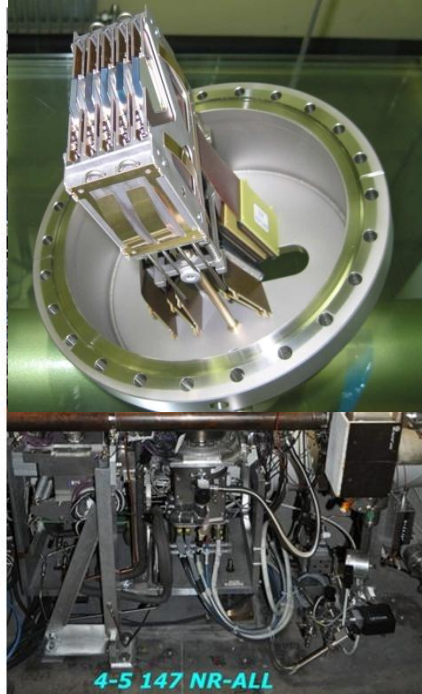
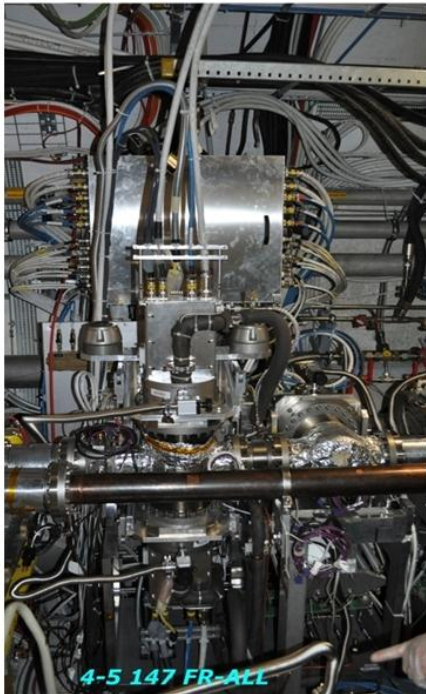
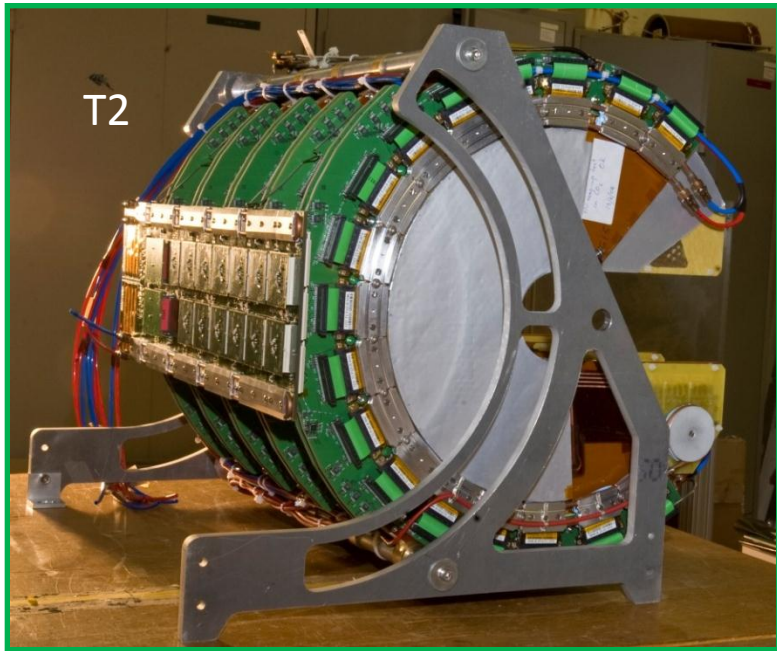


Experimental Setup @ IP5



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





Detectors

- T1 and T2 detectors are installed and fully operational
- 220 m Roman Pot Silicon detectors are fully operational
- 147 m Roman Pot detectors are installed and tested

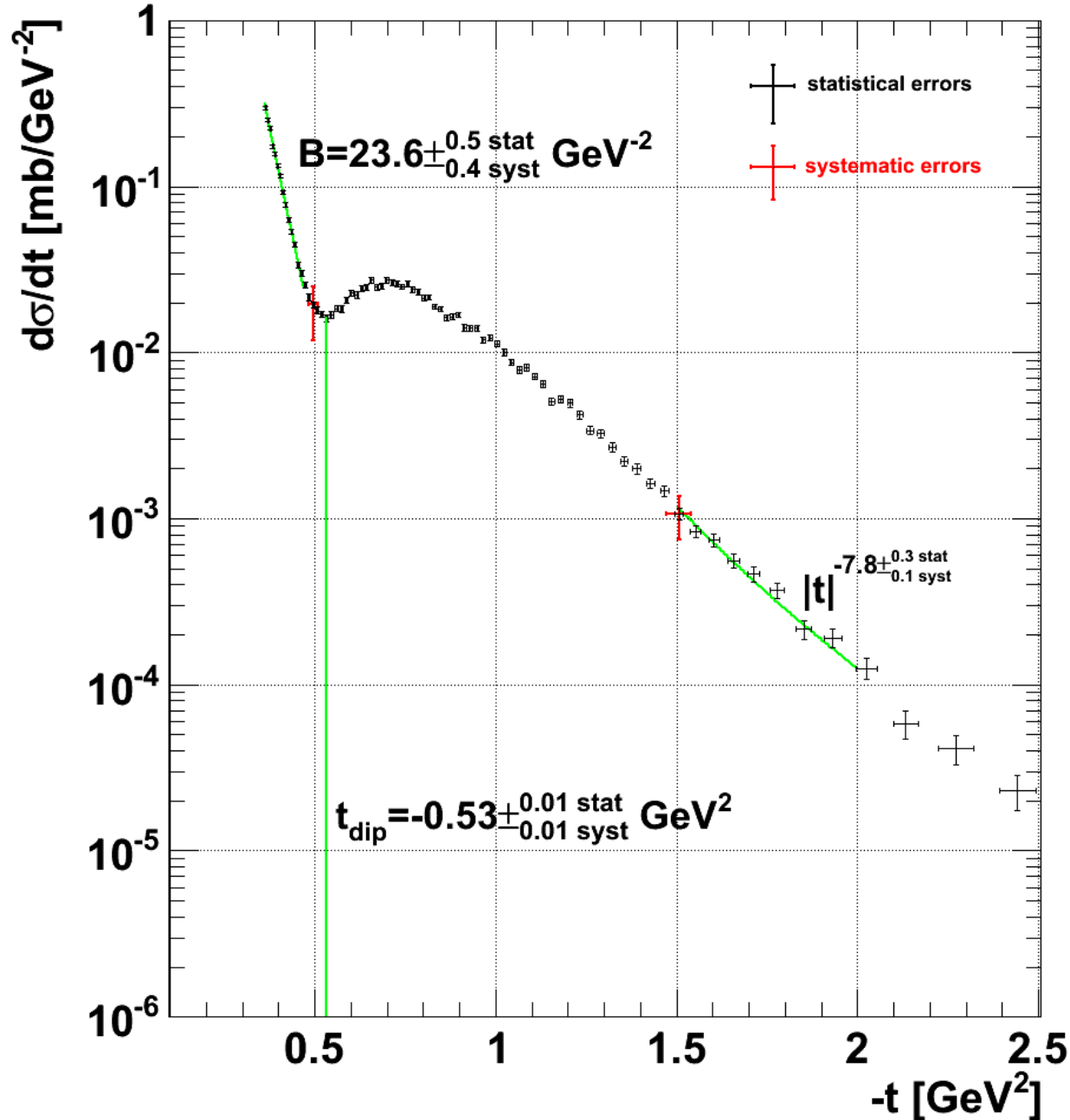
Runs & Data Statistics

Date	Detector configuration	β^* [m]	$\int L dt$ [nb ⁻¹]	Analysis
Oct 2010	RP at 7 σ ; T2 in readout	3.5	6.8	Elastic scattering 0.36 < t < 2.5 GeV ²
Sep/Oct 2010	RP at 18 σ	3.5	2300	Elastic scattering - large t (in progress)
May 2011	RP at 5 σ ; T1, T2 in readout	1.5	0.72	Alignment of 220m pots
June 2011	RP at 10 σ ; T1, T2 in readout	90	0.0017	Total cross section + elastic scattering 0.02 < t < 0.33 GeV ²
Aug/Sep 2011	RP at 5 σ ; T1, T2 in readout	90	beam lost	Alignment of RPs
18. Oct 2011	RP at 5 σ ; T1, T2 in readout	90		Several hours of data taking;

RP position (V) [sigma]	trigger schema	trigger on bunch	Run time [min]	Events	Integ. Lumi [ub ⁻¹]
6.5	RP_all_OR + T2 + BX	1950,2000,2050 2100, 2200, 2300	64.9	2.4E+6	1.6
6.5	RP_V_and + T2 + BX	all	13.4	5.8E+5	5.2
6.5	RP_all_and + T2 + BX	all	217.5	9.3E+6	77
5.5	RP_all_and + T2 + BX	all	50.7	1.9E+6	16
4.8	RP_all_and + T2 + BX	all	16.4	6.2E+5	4.9
		sum	363	1.5E+7	104

pp Elastic differential cross-section

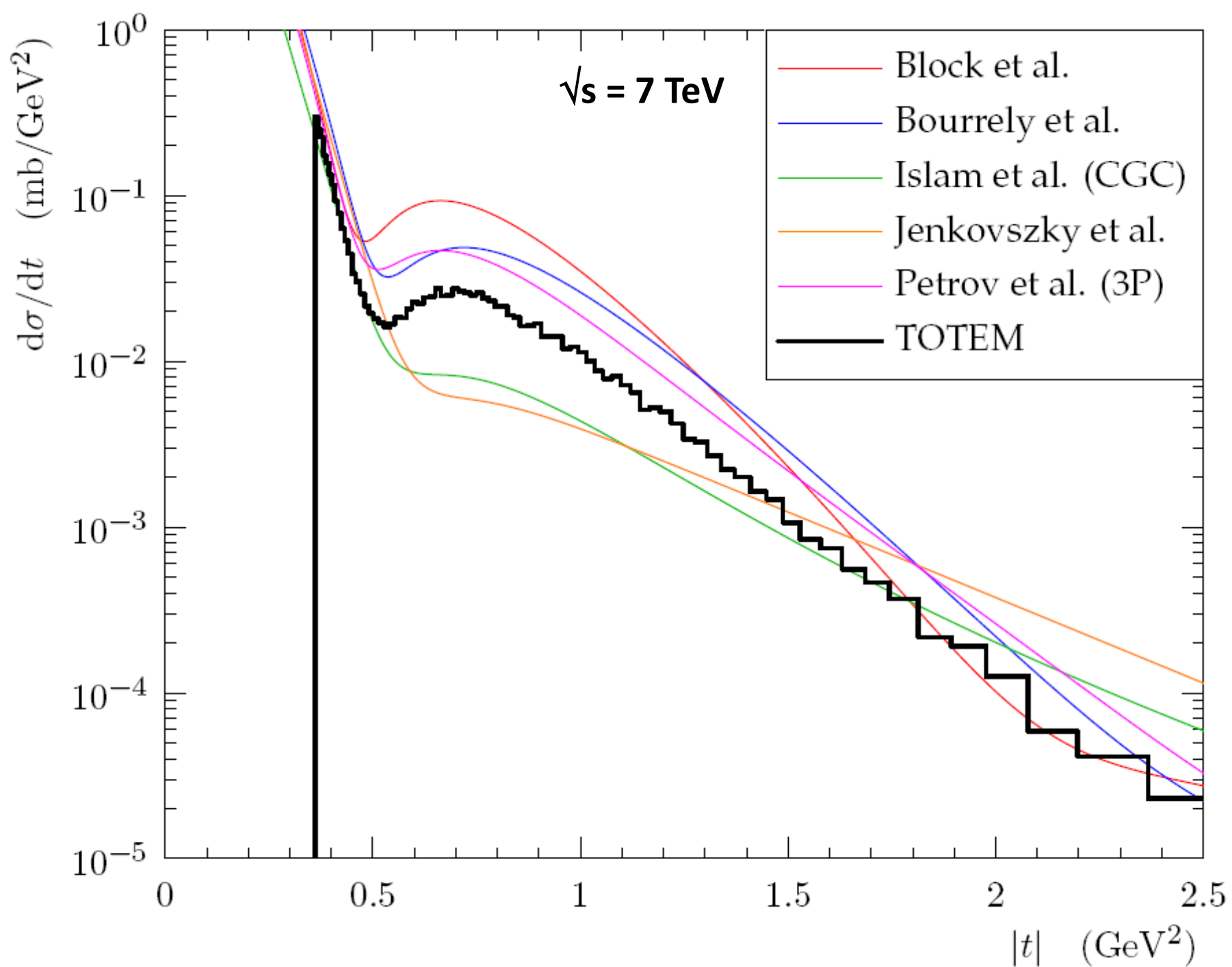
TOTEM



$\sqrt{s} = 7 \text{ TeV}$

RP @ 7σ

Oct 2010



Proton-proton elastic scattering at the LHC energy of $\sqrt{s} = 7$ TeV

THE TOTEM COLLABORATION

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^{7b} *Università degli Studi di Siena and Gruppo Collegato INFN di Siena, Italy.*

⁸ *CERN, Geneva, Switzerland.*

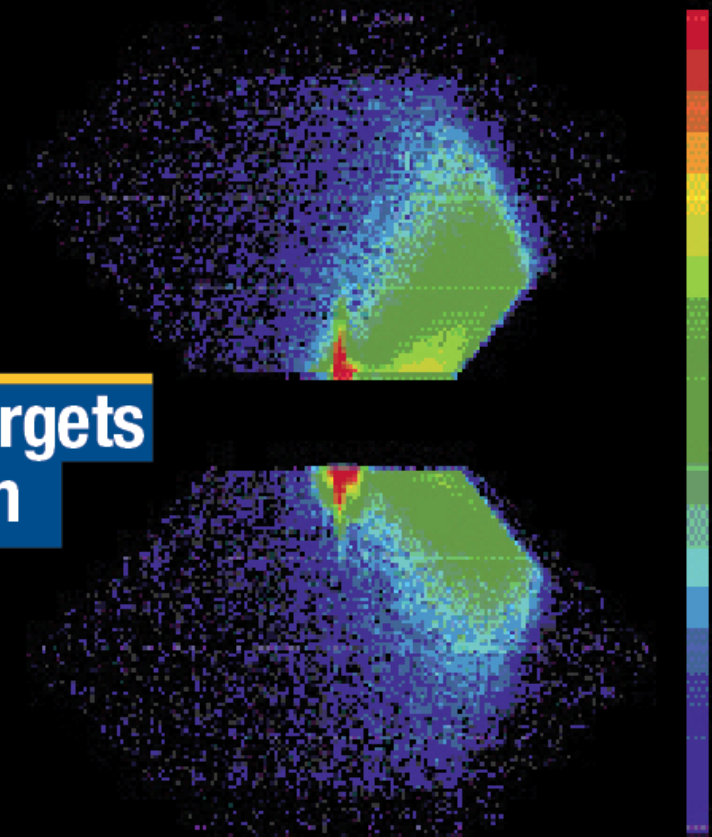
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CERN COURIER

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TOTEM targets the proton



EYEBROW

Strapline strapline
strapline strapline
strapline strapline
pXX

EYEBROW

Strapline str
strapline stra
strapline stra
pXX



HEADLINE IN CAPS

Strapline strapline
strapline strapline pXX

A special run: 1st run with the $b^* = 90$ m optics and RP insertion

June 2011



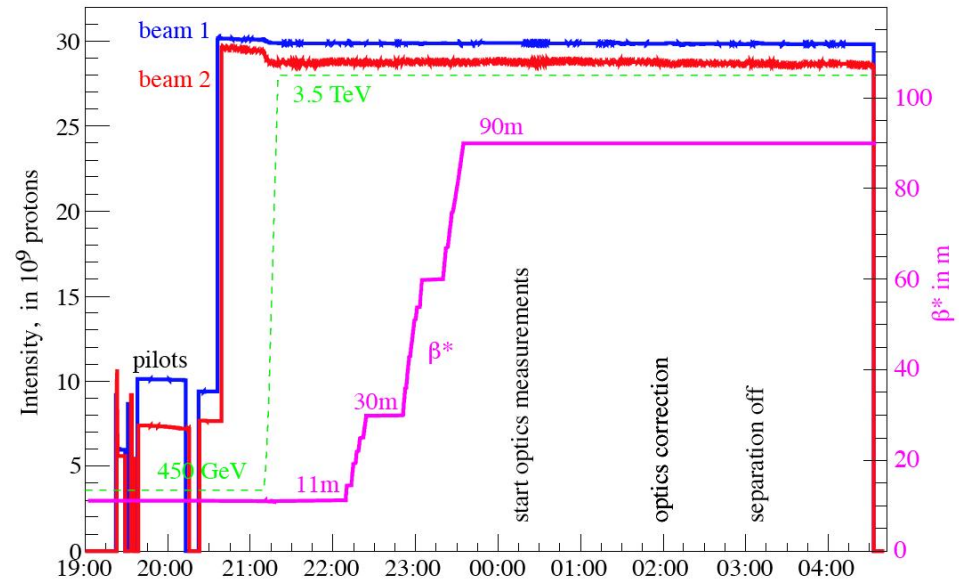
Evolution with time : intensity, energy, β^*



scheduled : 28/06/2011, beam for 90m from 20:00 - 04:00 Fill 1902

Un-squeeze from injection optics
 $\beta^* = 11$ m to 90m
[Helmut Burkhardt, Andre Verdier]
Request of TOTEM (2005)

Very robust optics with high precision

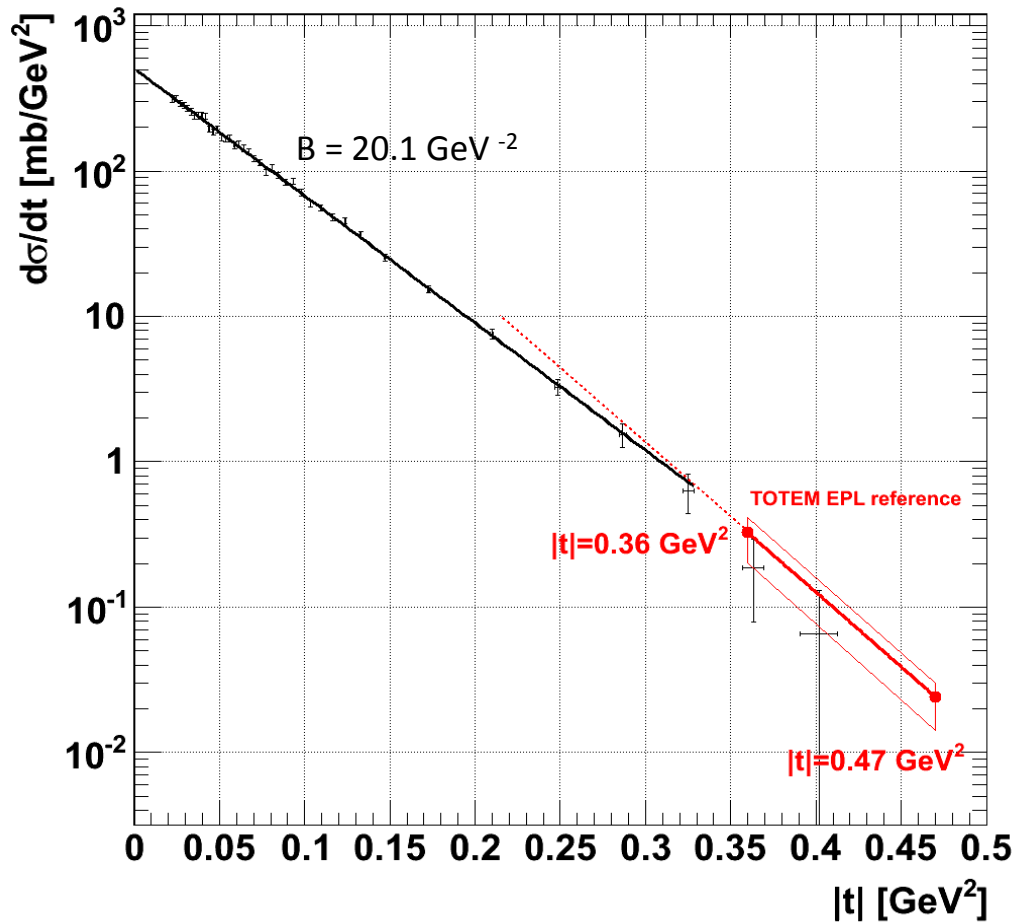


Fill 1902 Beam process SQUEEZE_HIGHBETA-90M_3.5TeV_IP1_IP5_LONG

- Two bunches with 1 and 2 x 10^{10} protons / bunch
- Instantaneous luminosity: $8 \times 10^{26} \text{ cm}^{-2} \text{ s}^{-1}$
- Integrated luminosity: $1.7 \mu\text{b}^{-1}$
- **Estimated pile-up: ~ 0.5 %**
- Vertical Roman Pots at 10σ from beam center
- Trigger rate : ~ 50 Hz
- Recorded events in vertical Roman Pots: 66950

At the end of machine development
0.5 hours data taking by TOTEM

TOTEM: pp Elastic Cross-Section



Exponential slope:

$$B|_{t=0} = 20.1 \text{ GeV}^{-2}$$

Extrapolation to $t = 0$:

$$\left. \frac{d\sigma}{dt} \right|_{t=0} = 5.037 \times 10^2 \text{ mb} / \text{GeV}^2$$

Integral Elastic Cross-Section

$$\sigma_{\text{EL}} = 8.3 \text{ mb}^{(\text{extrapol.})} + 16.5 \text{ mb}^{(\text{measured})} = 24.8 \text{ mb}$$

TOTEM: pp Total Cross-Section

Elastic exponential slope:

$$B|_{t=0} = (20.1 \pm 0.2^{(stat)} \pm 0.3^{(syst)}) \text{ GeV}^{-2}$$

Elastic diff. cross-section at optical point: $\left. \frac{dS_{el}}{dt} \right|_{t=0} = (503.7 \pm 1.5^{(stat)} \pm 26.7^{(syst)}) \text{ mb} / \text{ GeV}^2$

↓ Optical Theorem, $\rho = 0.14^{+0.01}_{-0.08}$

Total Cross-Section

$$S_T = \left(98.3 \pm 0.2^{(stat)} \pm 2.7^{(syst)} \left(\begin{array}{c} \pm 0.8 \\ \pm 0.2 \end{array} \right) \text{ (syst from } r) \right) \text{ mb}$$

TOTEM: pp Inelastic Cross-Section

$$\sigma_{el} = \left(24.8 \pm 0.2^{(stat)} \pm 1.2^{(syst)} \right) \text{ mb} \quad S_T = \left(98.3 \pm 0.2^{(stat)} \pm 2.7^{(syst)} \begin{array}{c} \pm 0.8 \\ \mp 0.2 \end{array} \begin{array}{c} (syst \text{ from } r) \\ \end{array} \right) \text{ mb}$$

Inelastic Cross-Section

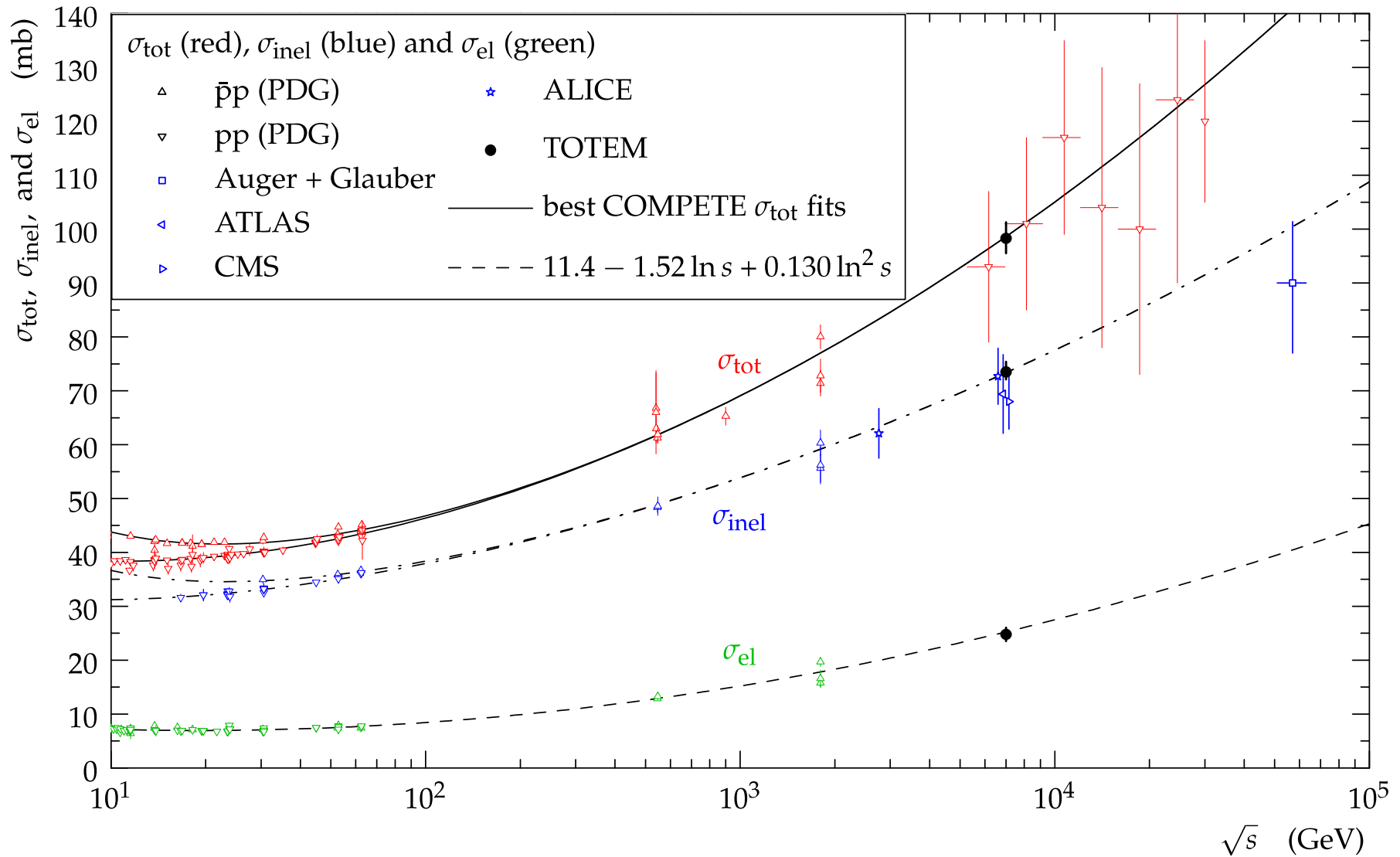
$$\sigma_{inel} = \sigma_{tot} - \sigma_{el} = \left(73.5 \pm 0.6^{(stat)} \begin{array}{c} +1.8 \\ -1.3 \end{array} \begin{array}{c} (syst) \\ \end{array} \right) \text{ mb}$$

$$\sigma_{inel} \text{ (CMS)} = (68.0 \pm 2.0^{(syst)} \pm 2.4^{(lumi)} \pm 4.0^{(extrap)}) \text{ mb}$$

$$\sigma_{inel} \text{ (ATLAS)} = (69.4 \pm 2.4^{(exp)} \pm 6.9^{(extrap)}) \text{ mb}$$

$$\sigma_{inel} \text{ (ALICE)} = (72.7 \pm 1.1^{(mod)} \pm 5.1^{(lumi)}) \text{ mb}$$

Total, Elastic, Inelastic Cross-Section





A LETTERS JOURNAL EXPLORING
THE FRONTIERS OF PHYSICS

OFFPRINT

**First measurement of the total proton-proton
cross-section at the LHC energy of $\sqrt{s} = 7$ TeV**

THE TOTEM COLLABORATION (G. ANTCHEV *et al.*)

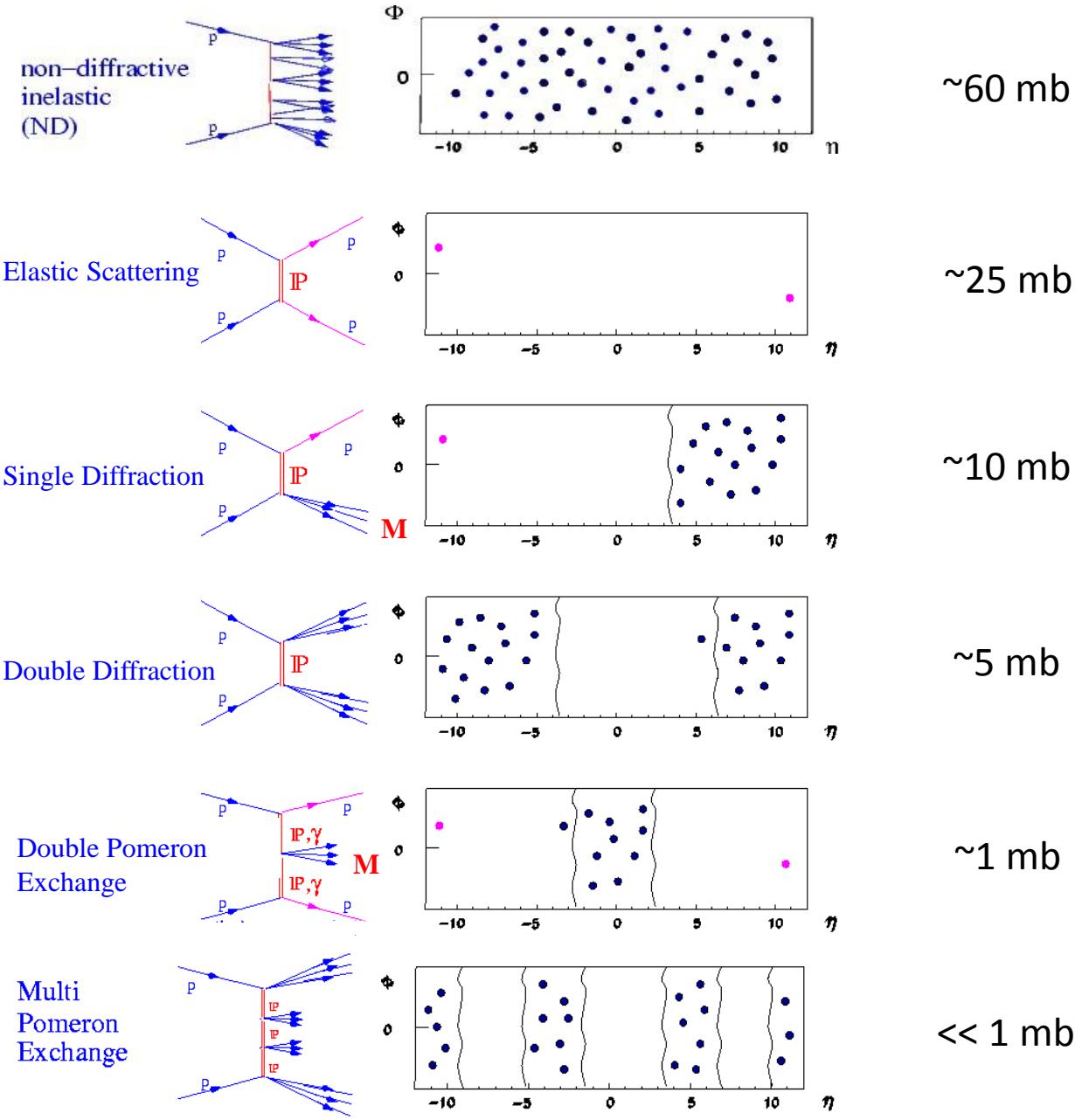
EPL, **96** (2011) 21002

Acknowledgments

- Special acknowledgments to the LHC team for their support and for the development of the 90m optics.
- Special acknowledgments to CMS for their collaboration and for providing TOTEM with the luminosity measurements.

Inelastic and Diffractive Processes ($\eta = -\ln \text{tg } \theta/2$)

All the drawings show soft interactions.
 In case of hard interactions there should be jets,
 which fall in the same rapidity intervals.

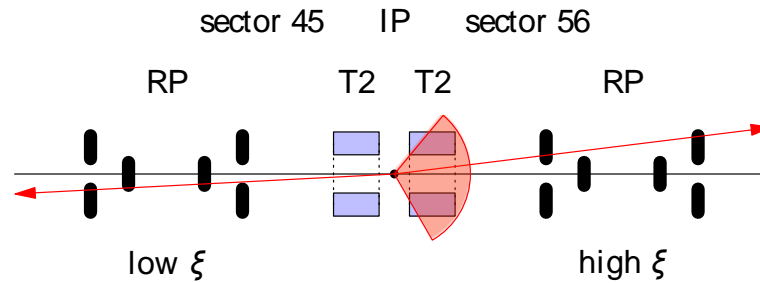


Measure $\sigma(M, \xi, t)$

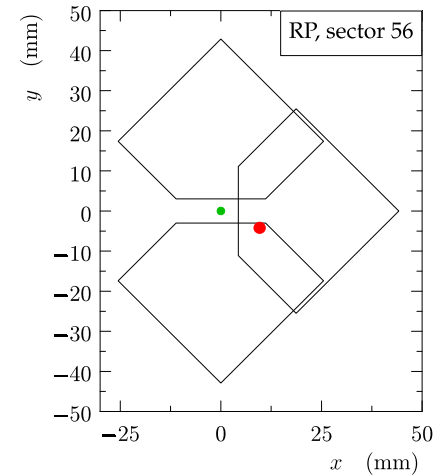
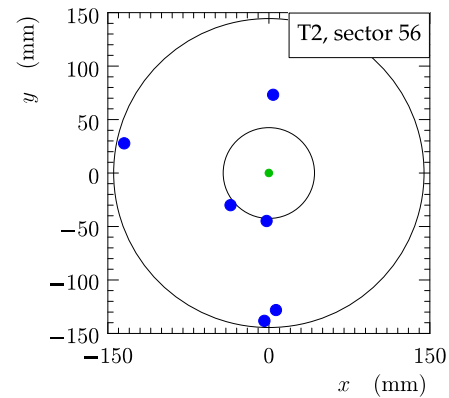
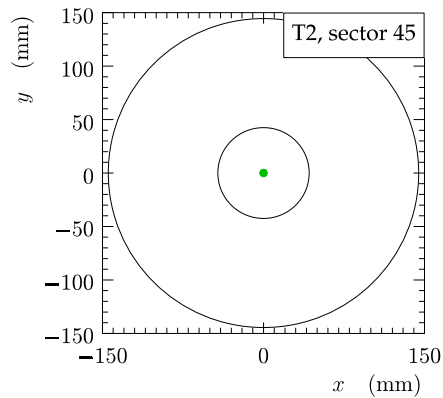
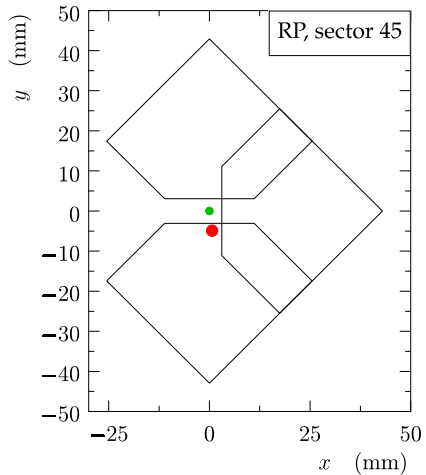
Diffractive scattering is a unique laboratory of confinement & QCD:
 A hard scale + hadrons which remain intact in the scattering process.

Double Pomeron Exchange (DPE)

correlation between leading protons and forward detector T2

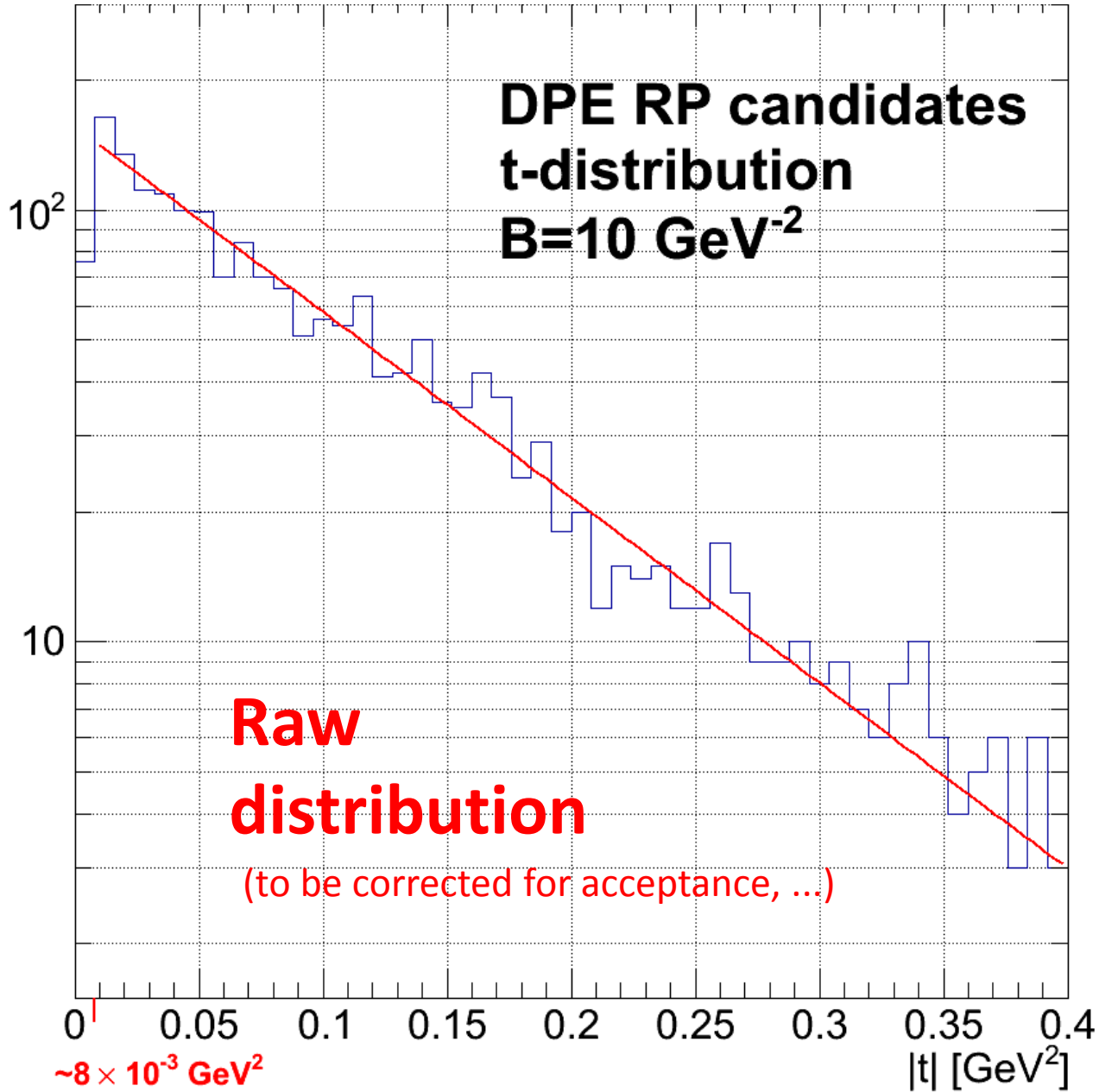


run: 37220007, event: 9904



Data Oct'11: DPE Cross-Section

Preliminary

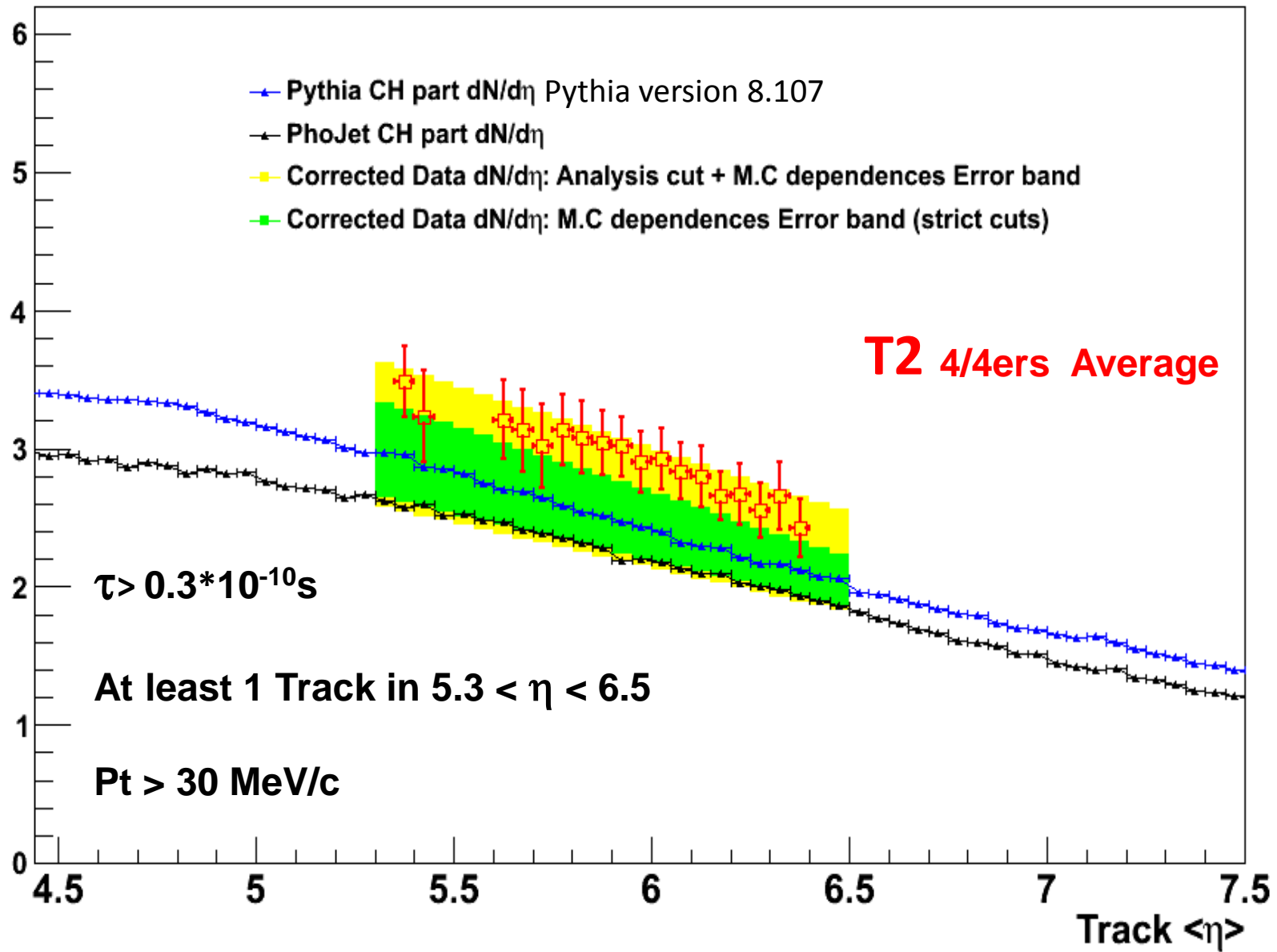


Distribution integrated on ξ

T2Corrected data and PhoJet/Pythia comparison

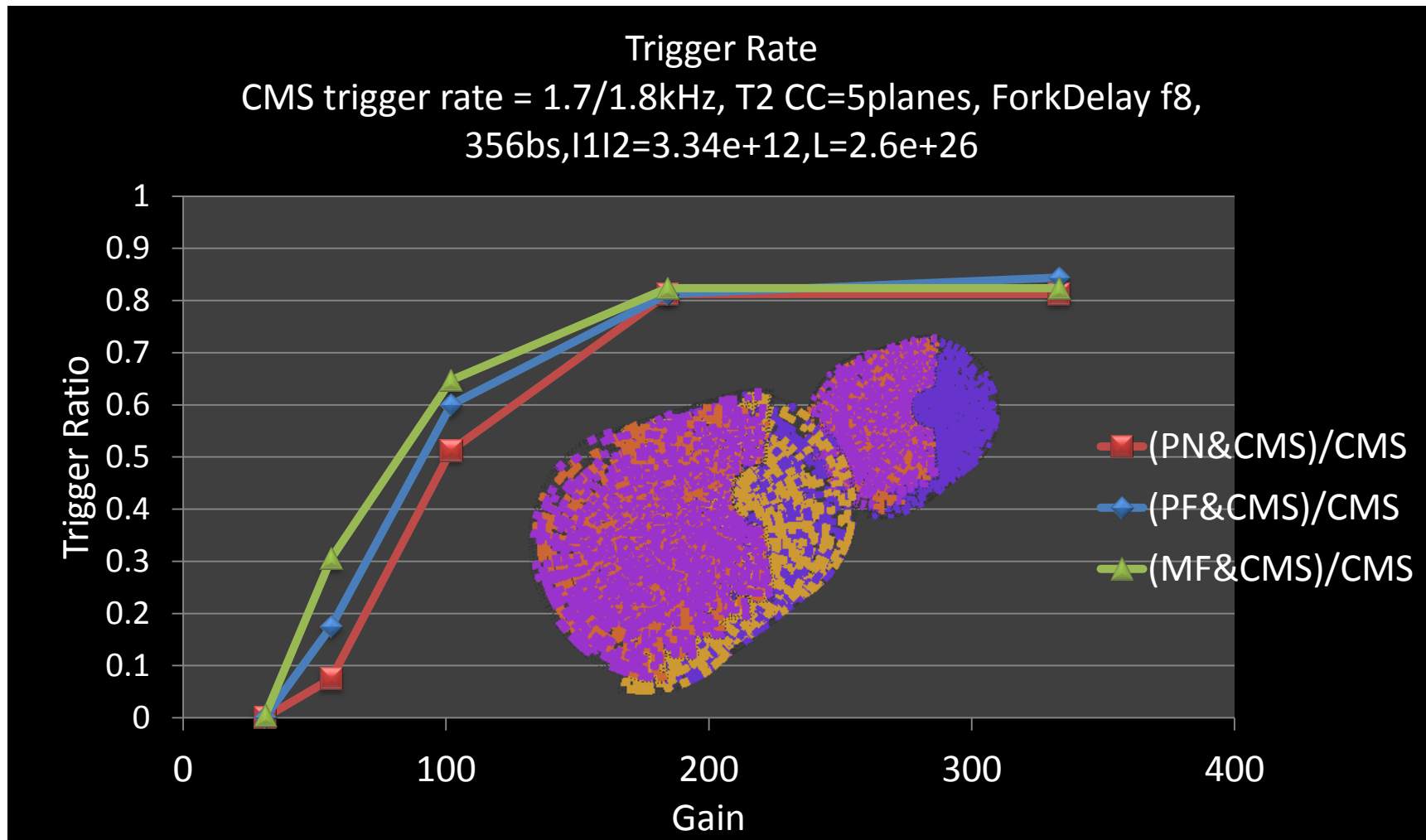
TOTEM
T2 :
dN/dη

To be published



Ions 2011: CMS + TOTEM joint data-taking

Trigger CMS >>> TOTEM



From Spring 2012: **Trigger TOTEM >>> CMS**