

## Total, elastic and inelastic cross section at 7 TeV

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#### **On behalf of the TOTEM collaboration**.

La Thuile 28-2-2012



## **The Totem Detectors**









### **P-P Elastic Cross Section measurement**





#### **Kinematics correlations and background subtraction**







## Acceptance corrections



Correction of  $\theta_y^*$  dist. for missing 'corners' of acceptance

Correction for missing  $\varphi$  accept.: Correction =  $2\pi$  / accepted  $\varphi(t)$ Near edge region to be removed



The data where taken in a special run oct 30 2010. The 220m pots where inserted at  $7\sigma$  from the beam.  $\beta^*=3.5m$ 



| Time        | Events                | Eff. DAQ | Eff. trigger | Luminosity             |
|-------------|-----------------------|----------|--------------|------------------------|
| Oct 30 2010 | 5.48* 10 <sup>6</sup> | 0.99     | 0.995        | 6.187 nb <sup>-1</sup> |

### **Elastic scattering – from ISR to Tevatron**



- · depth of minimum changes  $\rightarrow$  shape of proton profile changes
- depth of minimum differs between pp, p<sup>-</sup>p  $\rightarrow$  different mix of processes

TARGET PROTON

PROTON BEAM

TOTEM

x1

 $x10^{-2}$ 

 $x10^{-4}$ 

 $x10^{-6}$ 

x10<sup>-8</sup>

x10<sup>-10</sup>

3

|t| [GeV2]

3.5



### **Proton Proton Elastic Cross Section**





#### **P-P Cross Section and Models Comparison**







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## Low t elastic cross section measurement



 $\beta^* = 90m$  $L_y \sim 260 m$  $L_x \sim 0-3 m$ 



Protons x-y Raw distribution



## $\Theta_{\rm x}$ and $\Theta_{\rm y}$ correlations of both arms





## Elastic differential cross section

**Exponential slope:** 

 $B\Big|_{t=0} = 20.1 \,\mathrm{GeV}^{-2}$ 





**Integral Elastic Cross-Section** 

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



## **Cross-Section Formulae**

Optical Theorem: 
$$\sigma_{TOT}^2 = \frac{16\pi (hc)^2}{1+\rho^2} \cdot \frac{d\sigma_{EL}}{dt}\Big|_{t=0}$$

Using luminosity from CMS: 
$$\frac{d\sigma_{EL}}{dt} = \frac{1}{L} \cdot \frac{dN_{EL}}{dt}$$

ρ from COMPETE fit: 
$$ρ = 0.14^{+0.01}_{-0.08}$$

$$\sigma_{TOT} = \sqrt{19.20 \,\mathrm{mb}\,\mathrm{GeV}^2 \cdot \frac{d\sigma_{EL}}{dt}}_{t=0}$$

$$\sigma_{TOT} = \sigma_{EL} + \sigma_{INEL}$$

# **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:

$$\frac{d\sigma_{el}}{dt}\Big|_{t=0} = (503.7 \pm 1.5^{(stat)} \pm 26.7^{(syst)}) \text{mb} / \text{GeV}^2$$

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

#### **Total Cross-Section**

$$\sigma_{T} = \left(98.3 \pm 0.2^{(\text{stat})} \pm 2.7^{(\text{syst})} \left[\begin{smallmatrix} +0.8\\ -0.2 \end{smallmatrix}\right]^{(\text{syst from }\rho)}\right) \text{mb}$$

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$$\sigma_{\rm el} = \left(24.8 \pm 0.2^{(\rm stat)} \pm 1.2^{(\rm syst)}\right) \text{mb} \qquad \sigma_{T} = \left(98.3 \pm 0.2^{(\rm stat)} \pm 2.7^{(\rm syst)} \left[\begin{smallmatrix}+0.8\\-0.2\end{smallmatrix}\right]^{(\rm syst from }\rho)\right) \text{mb}$$

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

$$\begin{split} \sigma_{\text{inel}} & (\text{CMS}) &= (68.0 \pm 2.0^{(\text{syst})} \pm 2.4^{(\text{lumi})} \pm 4.0^{(\text{extrap})}) \text{ mb} \\ \sigma_{\text{inel}} & (\text{ATLAS}) = (69.4 \pm 2.4^{(\text{exp})} \pm 6.9^{(\text{extrap})}) \text{ mb} \\ \sigma_{\text{inel}} & (\text{ALICE}) &= (72.7 \pm 1.1^{(\text{mod})} \pm 5.1^{(\text{lumi})}) \text{ mb} \end{split}$$

A new direct analysis, based on the inelastic telescopes data, is almost completed and leads to a measurement of the inelastic cross-section which is highly consistent with the one presented here



## **Total, Elastic, Inelastic Cross-Section**



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Charged particle dN/d $\eta$  measurement in the pseudorapidity range 5.3<  $\eta$ <6.4

- In 2011 the T2 detector has been used to evaluate the charged tracks density.
- The runs used for this purpose where low luminosity runs to avoid the pileup.
- The detector sit after a large amount of material from the vacuum chamber and most of the analysis work has been devoted on the evaluation of the fraction of primary tracks.





# Charged particle $dN/d\eta$





# Track density compared with central measurements

 $dN/d\eta$  data from ALICE, ATLAS, CMS, LHCb, TOTEM



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## Conclusions

- The TOTEM experiment has performed the total and elastic P-P cross section at 7 TeV measurement using the Roman Pots placed at 220m from IP5.
- The measurement is done using the CMS estimation of Luminosity
- The inelastic cross section is currently under evaluation directly using the inelastic detector T1 and T2 and is in agreement with the value estimated by subtraction
- The direct measurement of the total cross section using the luminosity independent method is almost finalized.
- The inelastic detector allowed us to estimate the charged track density at large pseudorapidity values.



# Backup



# **Systematics and Statistics**

- $t: \pm [0.6:1.8]$ %<sup>syst optics</sup>  $\pm <1$ %<sup>align.</sup>  $\pm [3.4:11.9]$ %<sup>stat (before unfolding)</sup>
- do/dt: ±4% syst lumin; ±1% syst (acc.+eff.+backg.+tag) ±0.7% syst unfold.
- $B: \pm 1\%^{stat} \pm 1\%^{syst from t} \pm 0.7\%^{syst from unfolding}$
- $d\sigma/dt_{(t=0)}$  : ± 0.3%<sup>stat</sup> ±0.3%<sup>syst (optics)</sup> ±4%<sup>syst lumin</sup> ±1%<sup>syst (acc.+eff.+backg.+tag)</sup>
- $\int d\sigma/dt : \pm 4\%^{\text{syst lumin}} \pm 1\%^{\text{syst (acc.+eff.+backg.+tag)}} \pm 0.8\%^{\text{stat extrap.}}$
- $\sigma_{\text{TOT}}$ : (+0.8% -0.2%)<sup>syst  $\rho$ </sup> ± 0.2%<sup>stat</sup> ±2.7%<sup>syst</sup> = (+2.8%-2.7%)<sup>syst</sup> ± 0.2%<sup>stat</sup>
- $\sigma_{\text{EL}}$  : ±5%<sup>syst</sup> ±0.8%<sup>stat</sup>
- $\sigma_{\text{INEL}}$  : (+2.4%-1.8%)<sup>syst</sup> ± 0.8%<sup>stat</sup>



## Secondary tracks evaluation

