Prospects for Diffractive and Forward Physics at the LHC

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on behalf of the CMS/TOTEM Collaboration

CERN/LHCC 2006-039/G-124
CMS Note-2007/002
TOTEM Note 06-5

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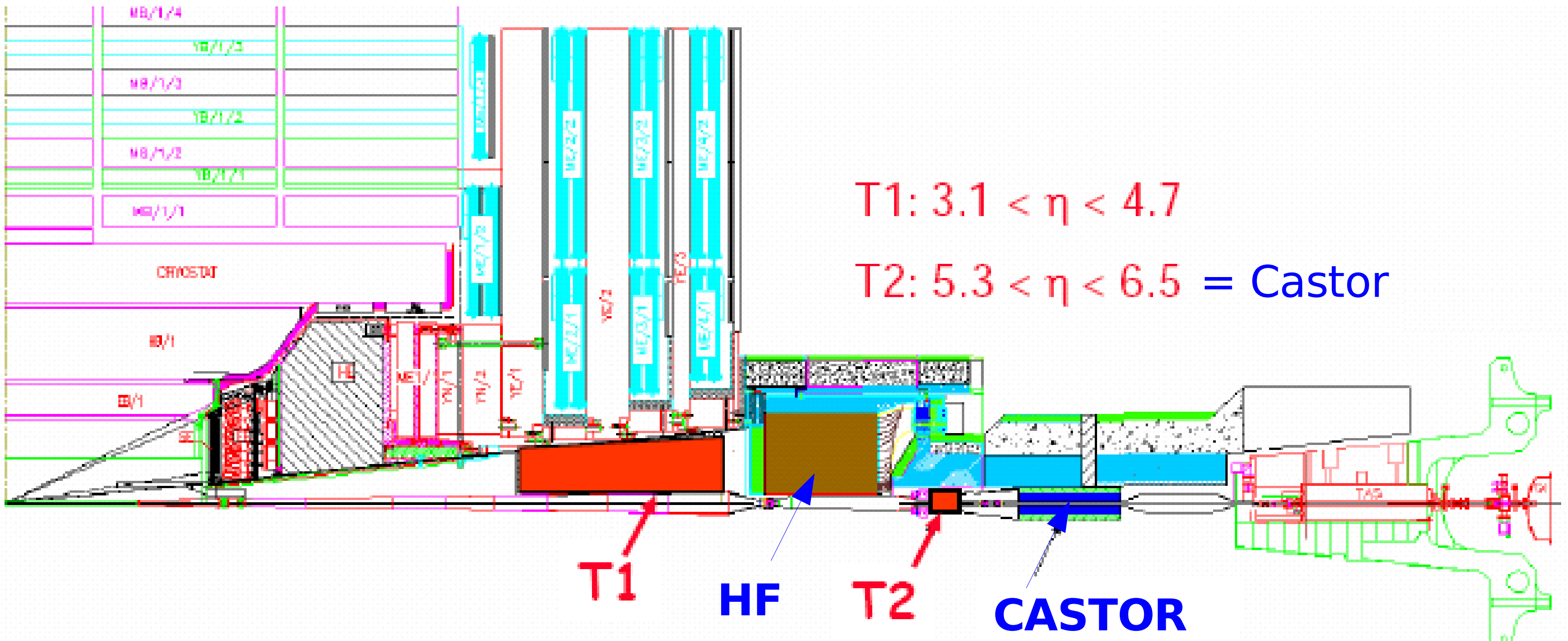
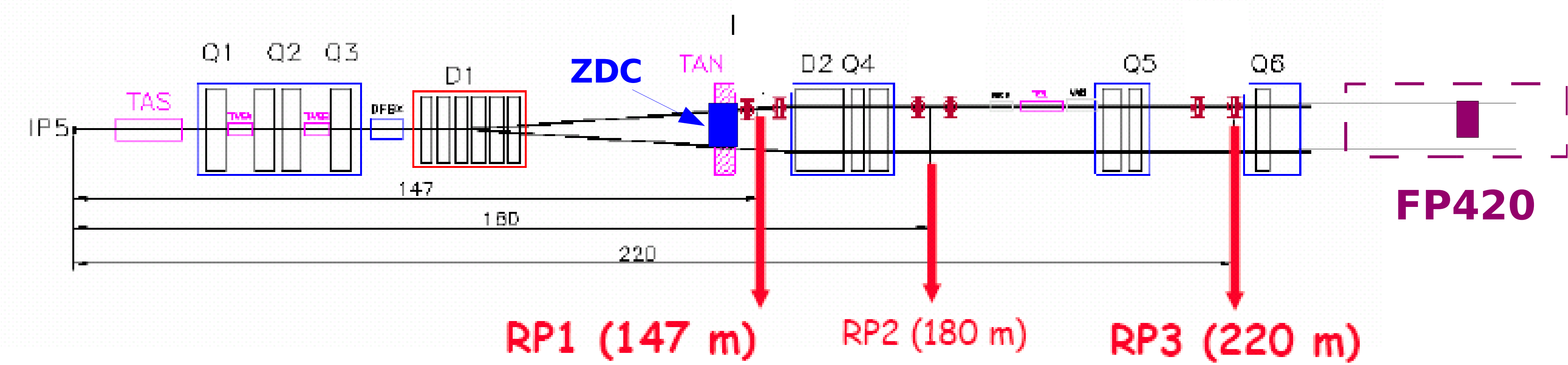
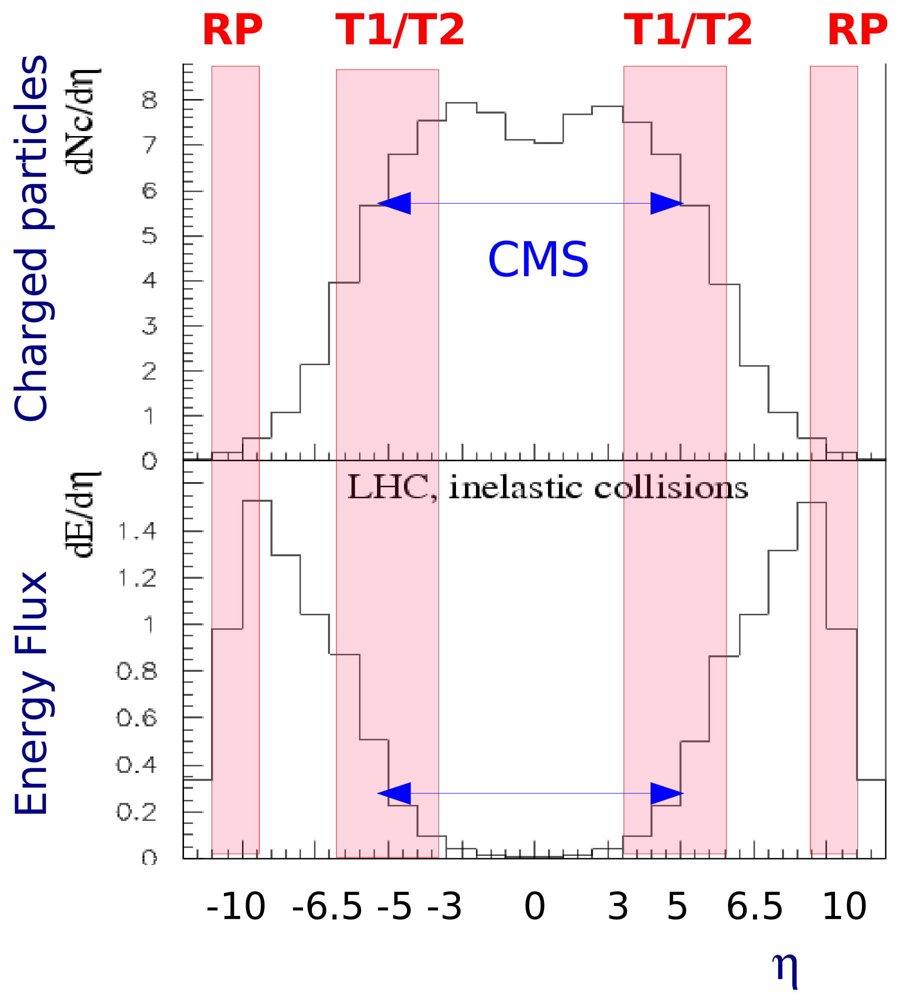
Experimental apparatus





CMS/TOTEM common physics program

Largest coverage in pseudorapidity & proton detection on both sides



Physics menu

Low Luminosity ($\leq 10^{32}$ $cm^{-2}s^{-1}$): low & high β^*

- Measure inclusive SD and DPE cross sections:
    - t, M_X dependence
    - Study of topology e.g. rapidity gap
- Measure semi-hard SD and DPE:
    - Onset of jet activity
- Muller-Navelet dijets
- Forward Drell-Yan
- Validation of Cosmic Ray generators

High Luminosity ($> 10^{32}$ $cm^{-2}s^{-1}$) : low β^*

- Measure SD and DPE in presence of hard scales (dijets, vector bosons, heavy quarks): dPDF, GPD

- $\gamma\gamma$ and γp phyics

High Luminosity ($> 10^{33}$ $cm^{-2}s^{-1}$) : low β^*

- Discovery physics in central exclusive production
    - SM or MSSM Higgs, other exotic processes

Contents of the common document

Includes important experimental issues in measuring forward and diffractive physics but not an exhaustive physics study

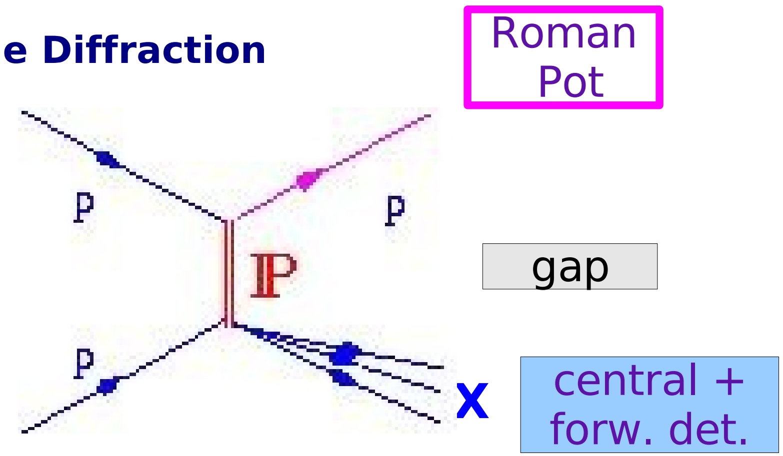
- Detailed studies of acceptance & resolution of the forward proton detectors
- Trigger
- Background
- Reconstruction of kinematic variables

Several exemplary processes are studied in detail

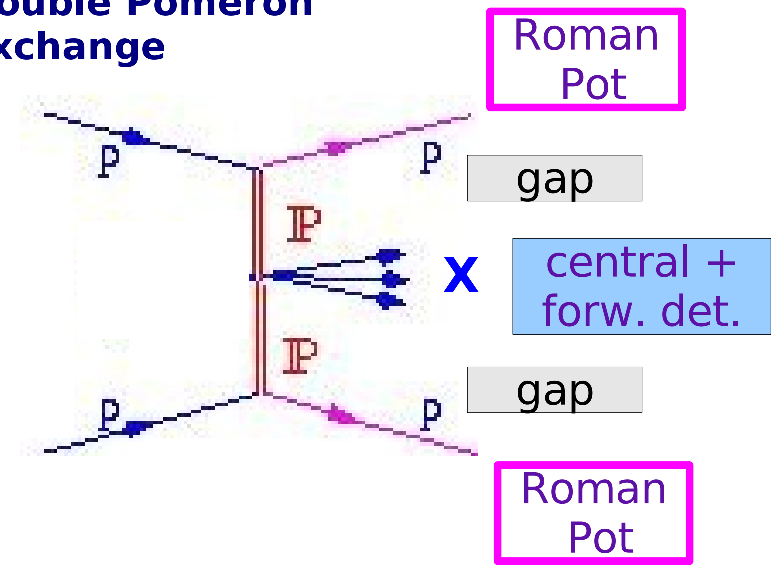
An important milestone in the collaboration between the two experiments

Diffraction: Physics Motivation

Single Diffraction



Double Pomeron Exchange



X=anything : dominated by soft physics

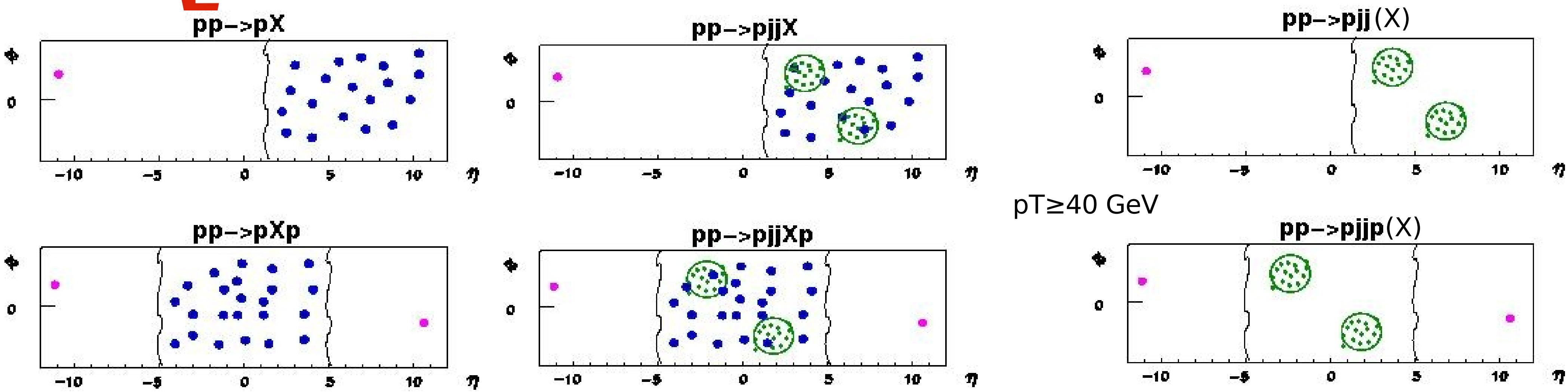
- **Measure fundamental quantities of soft QCD:**
  SD and DPE inclusive cross sections, their s, t, M_X dependences are fundamental parameters of non-perturbative QCD.

- **Contributes to the pile up.**

X includes jets, W's, Z's, Higgs (!): hard processes calculable in pQCD

- **Give info on proton structure (dPDFs and GPDs), QCD at high parton densities, multi-parton interactions, discovery physics**

Running scenario



soft diffraction | (semi)-hard diffraction | hard diffraction/exclusive processes

Cross section ← → Luminosity

σ	mb	μb		nb
L (cm^{-2} s^{-1})	10^{28}	10^{30}	10^{32}	10^{34}
β (m)	1540	90	2	0.5
	TOTEM runs		Standard runs	

The accessible physics depends on : luminosity

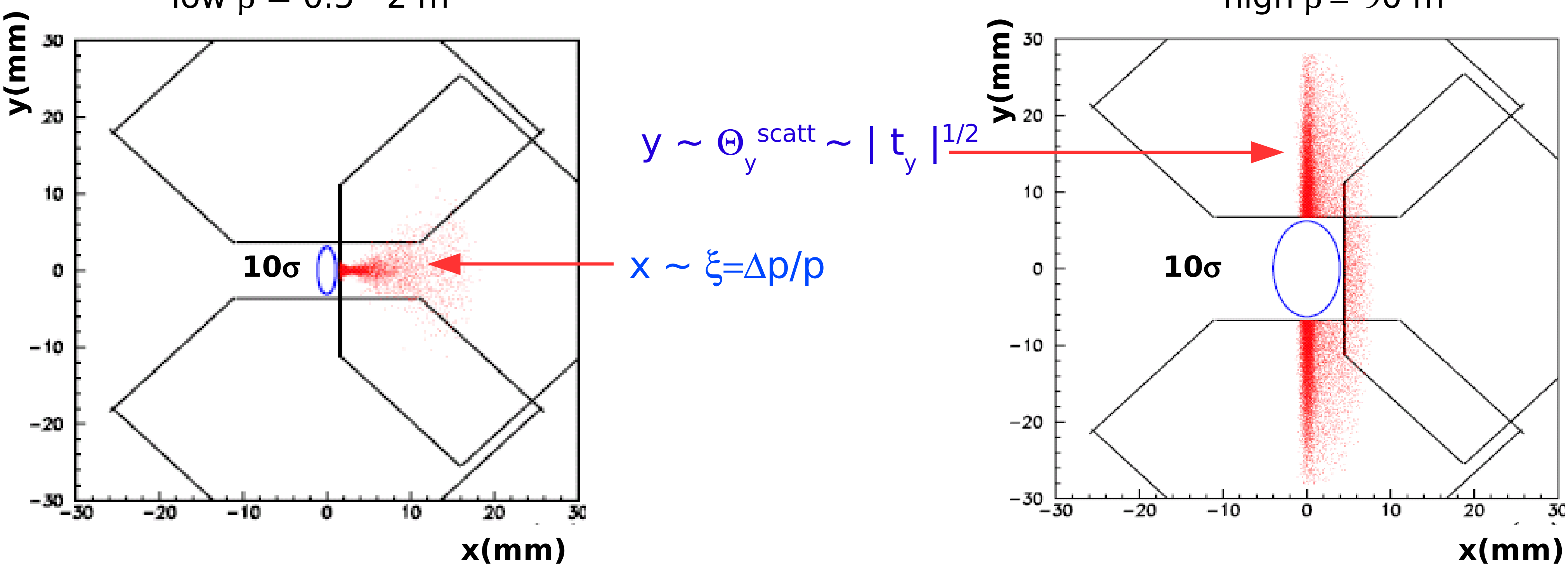
β (different proton acceptance)*

Measurement of Forward Protons: the principle

Diffractive protons : hit distribution @ RP220

low β = 0.5 - 2 m

high β = 90 m

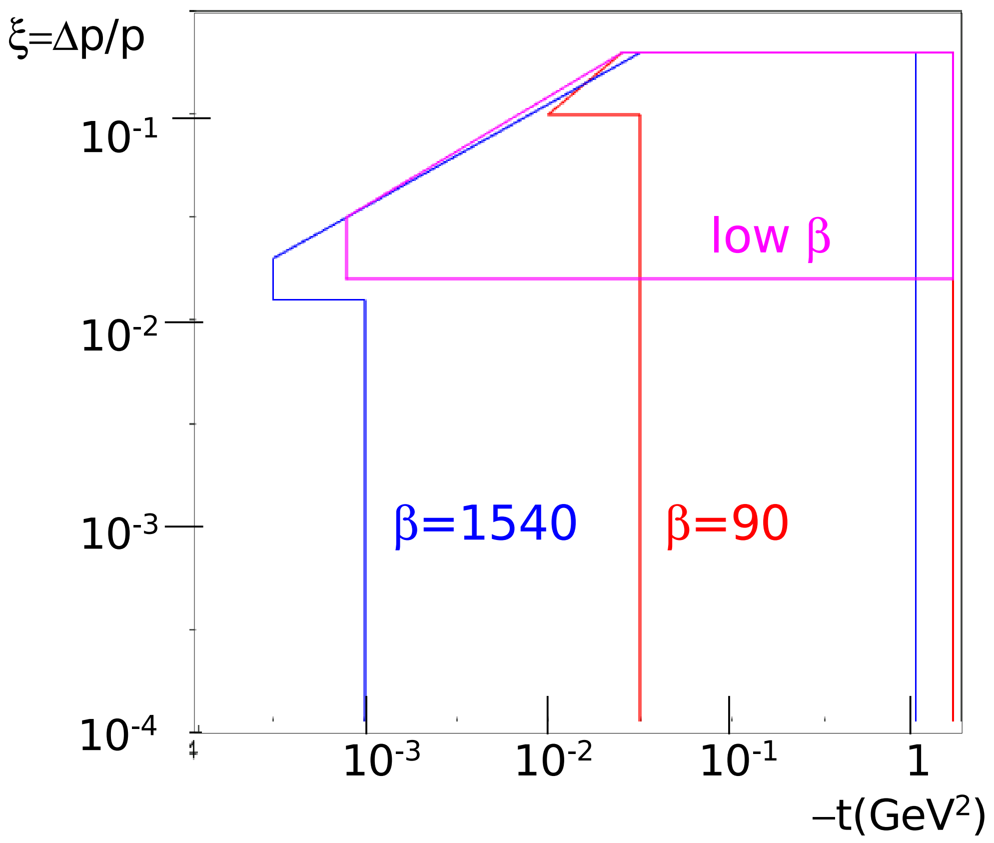


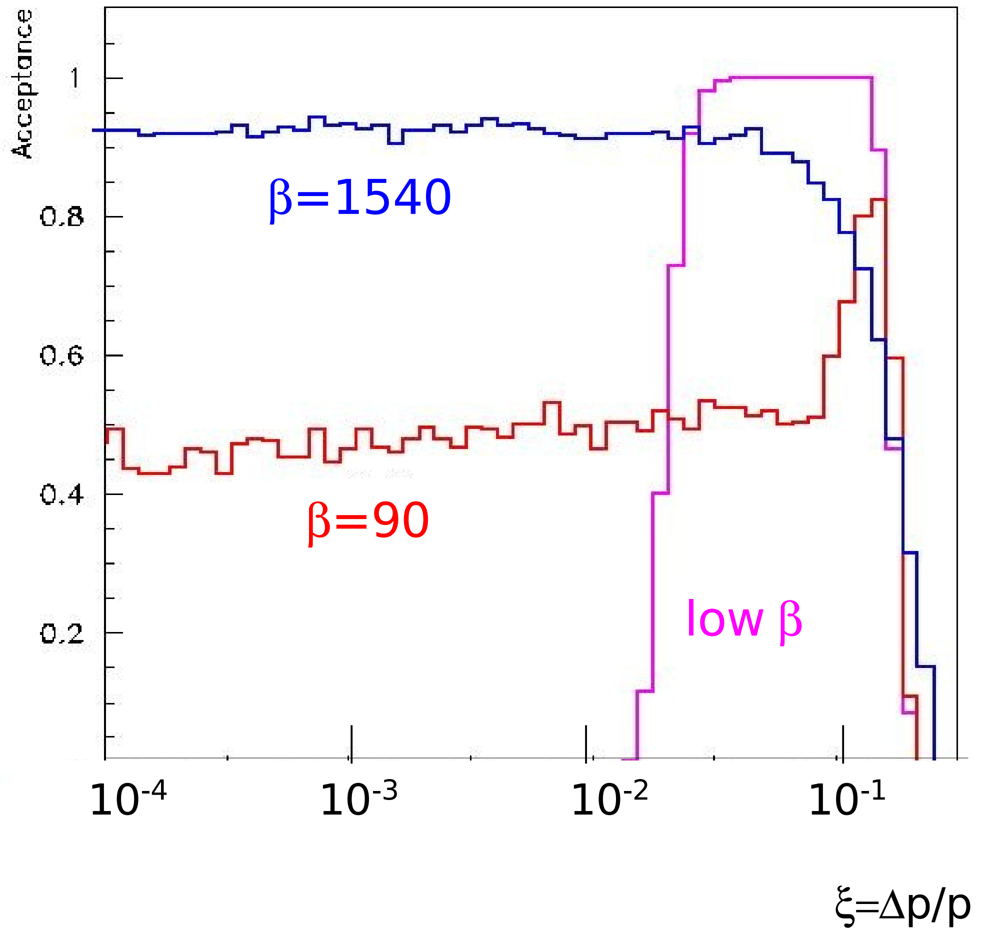
Detect the proton via:

its momentum loss (low β)

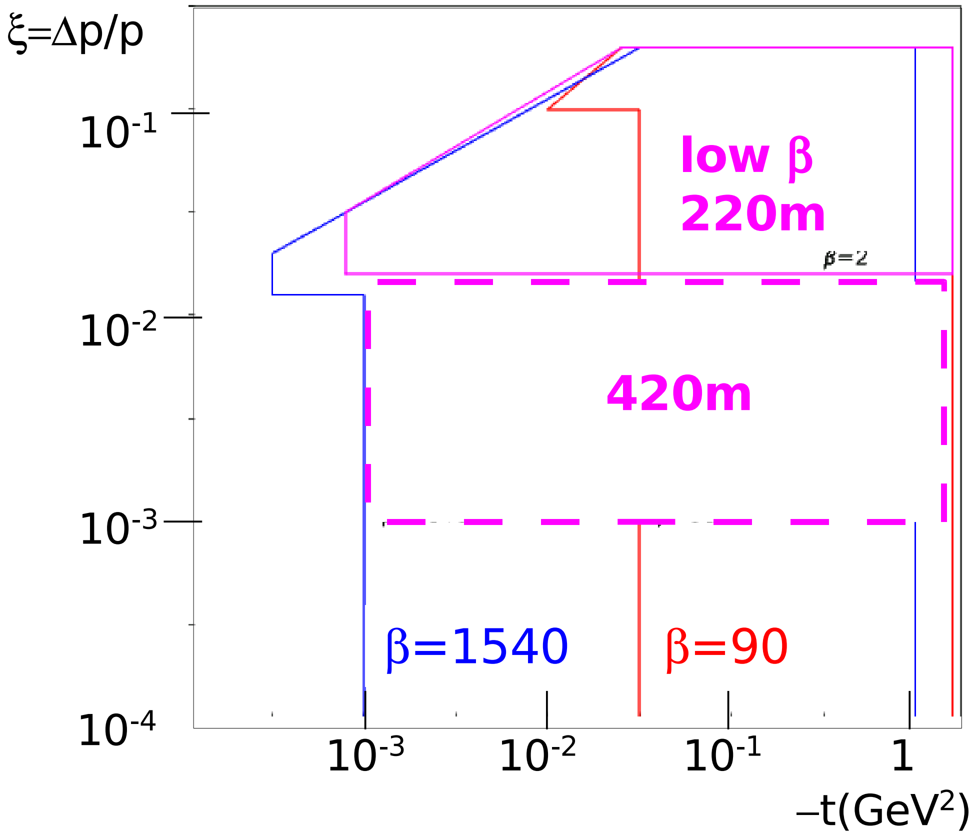
its transverse momentum (high β)

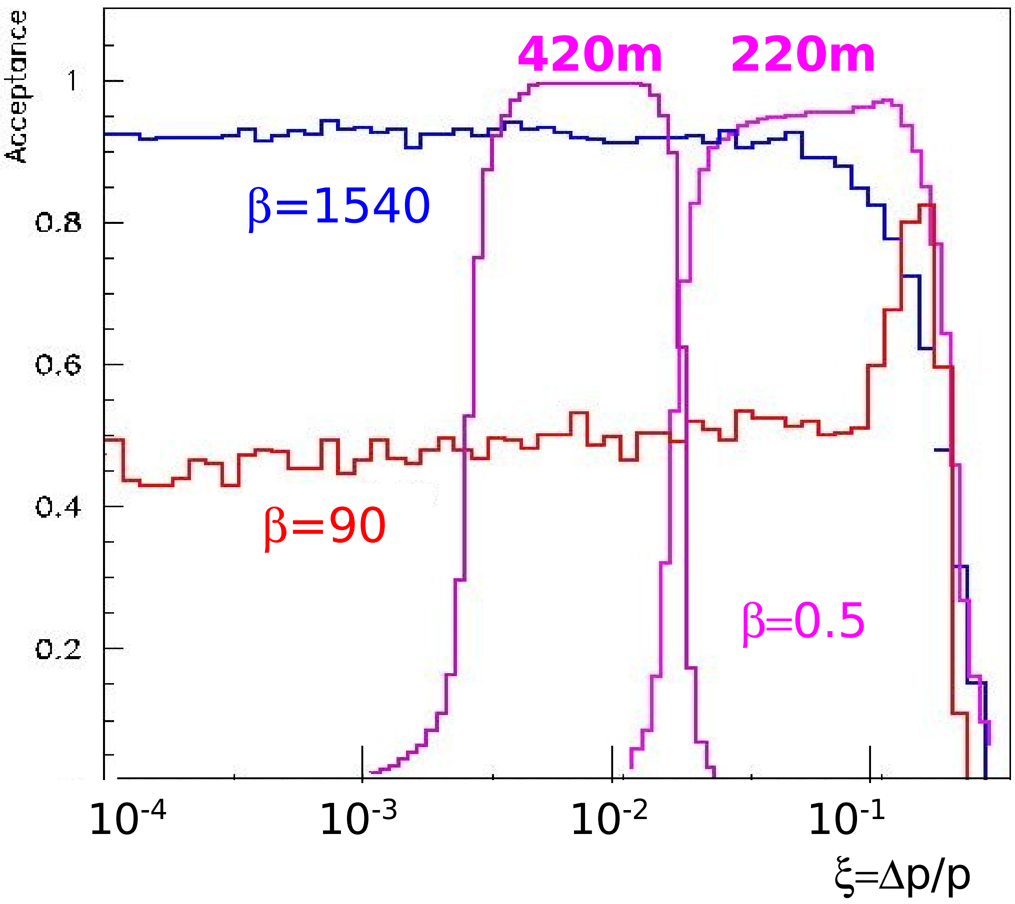
Measurement of Forward Protons: Acceptance (@220m)





Measurement of Forward Protons: Acceptance





Measurement of Forward Protons: momentum resolution (low β)

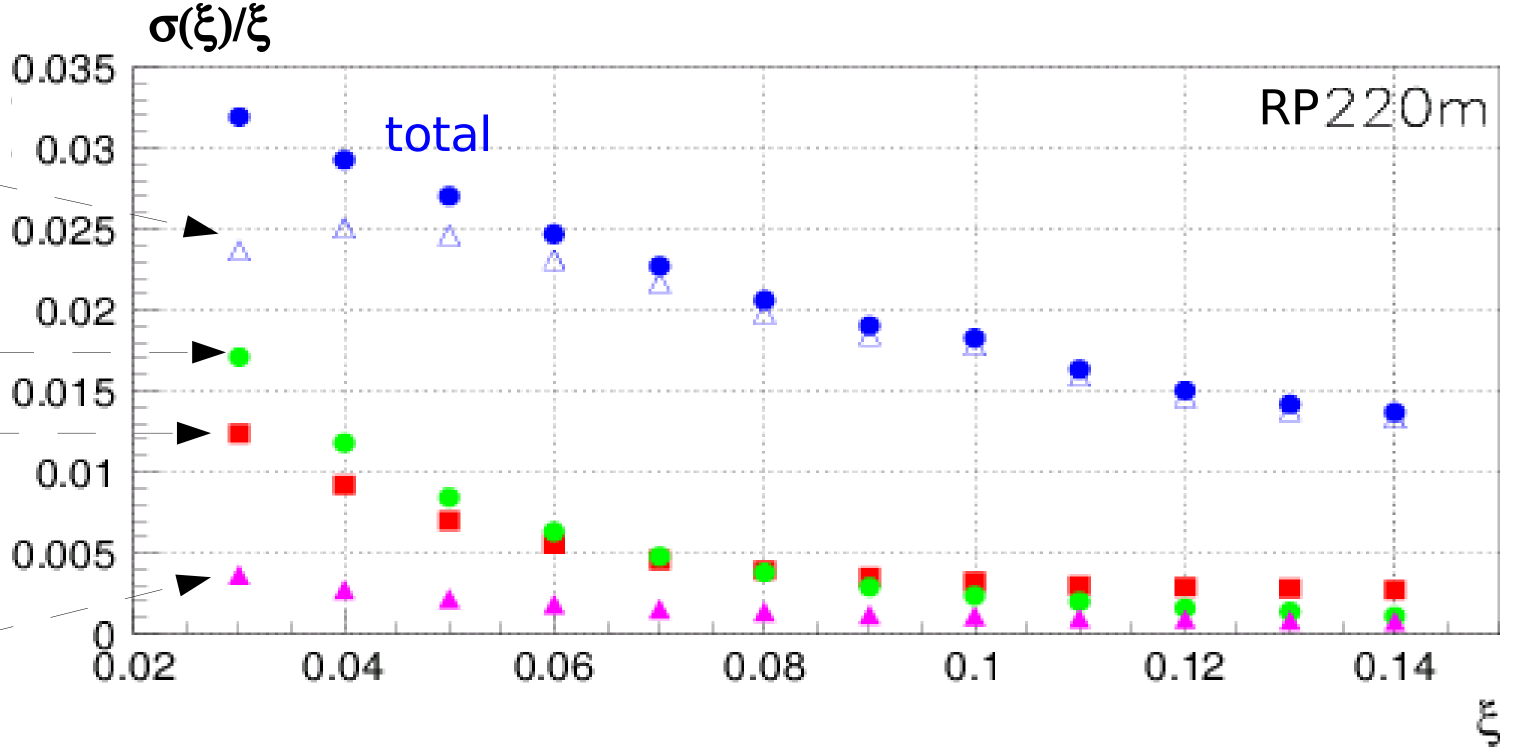
Individual contribution to the resolution:

Detector resolution (10μm)

Beam position res. (50μm)

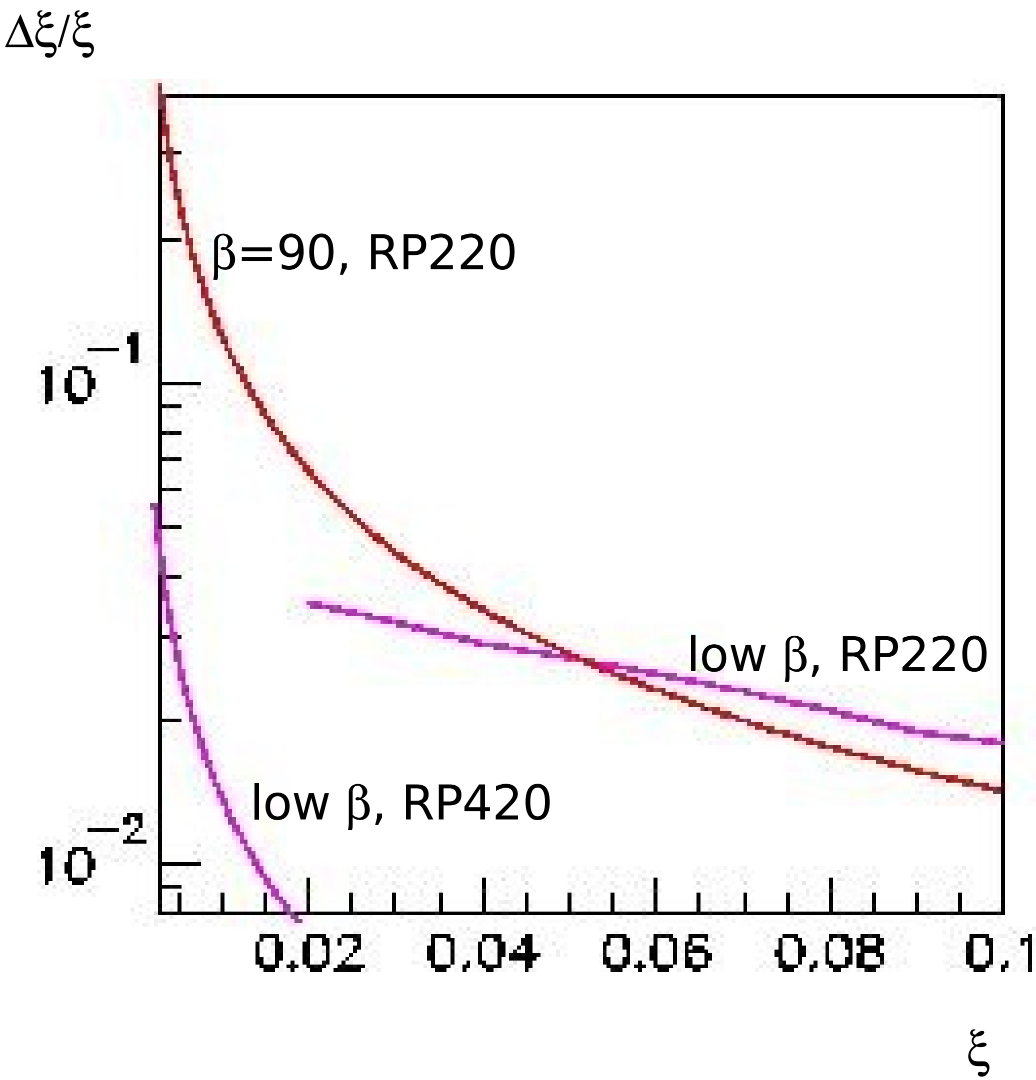
Vertex smear. (10μm)

relative beam energy spread (10^{-4})



Studies available also for β=1540, 90, all RP stations

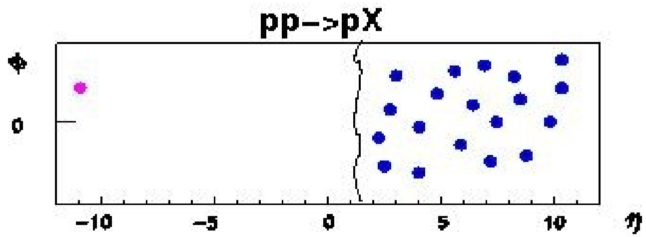
Measurement of Forward Protons: momentum resolution

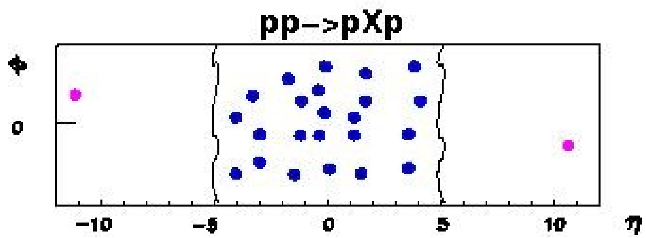


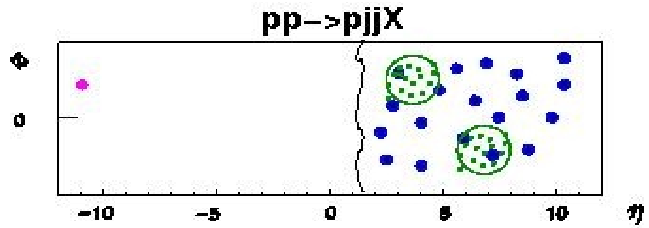
Assumption on Trigger Rates

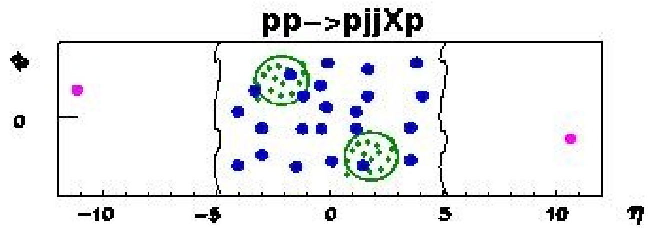
		L1(kHz)	HLT/tape (Hz)
	CMS	100	100
	TOTEM	~2	~2000
Common runs	CMS/TOTEM	~2	100
	CMS/TOTEM	1	1

Trigger rates





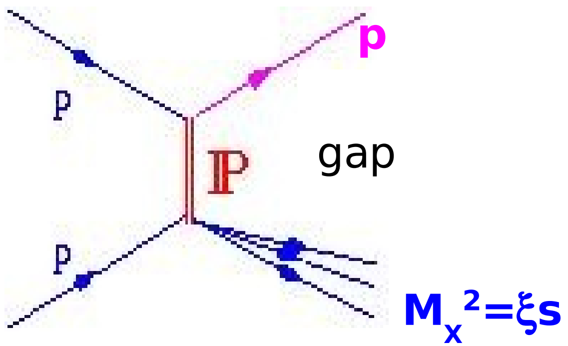




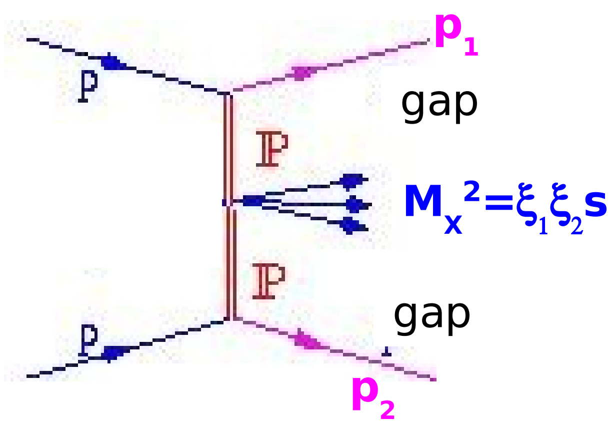
	σ	L $=10^{30}$ β=90 m	L $=10^{32}$ β=2m
		Estimated Rates (Hz) [acceptance corrected]	
1 p T1/T2	14 mb	6000	140×10^3
2p T1/T2	1 mb	200	3.5×10^3
1p T1/T2 jet(s)	1μb (p_T^{jet}>20 GeV)	0.2	
	30nb (p_T^{jet}>50 GeV)	0.01	0.5
2p T1/T2 jet(s)	60nb (p_T^{jet}>20 GeV)	10^{-3}	
	1.5 nb (p_T^{jet}>50 GeV)		0.03

Diffraction at low luminosity (<10^{32} cm^{-2} s^{-1}) soft diffraction

Single Diffraction



Double Pomeron Exchange



Inclusive cross sections and their *t*, M_x dependence

Topology of the events

Measure ξ and central Mass via:

- proton(s)
- rapidity gap relation $\Delta\eta=-\ln\xi$
- calorimeters

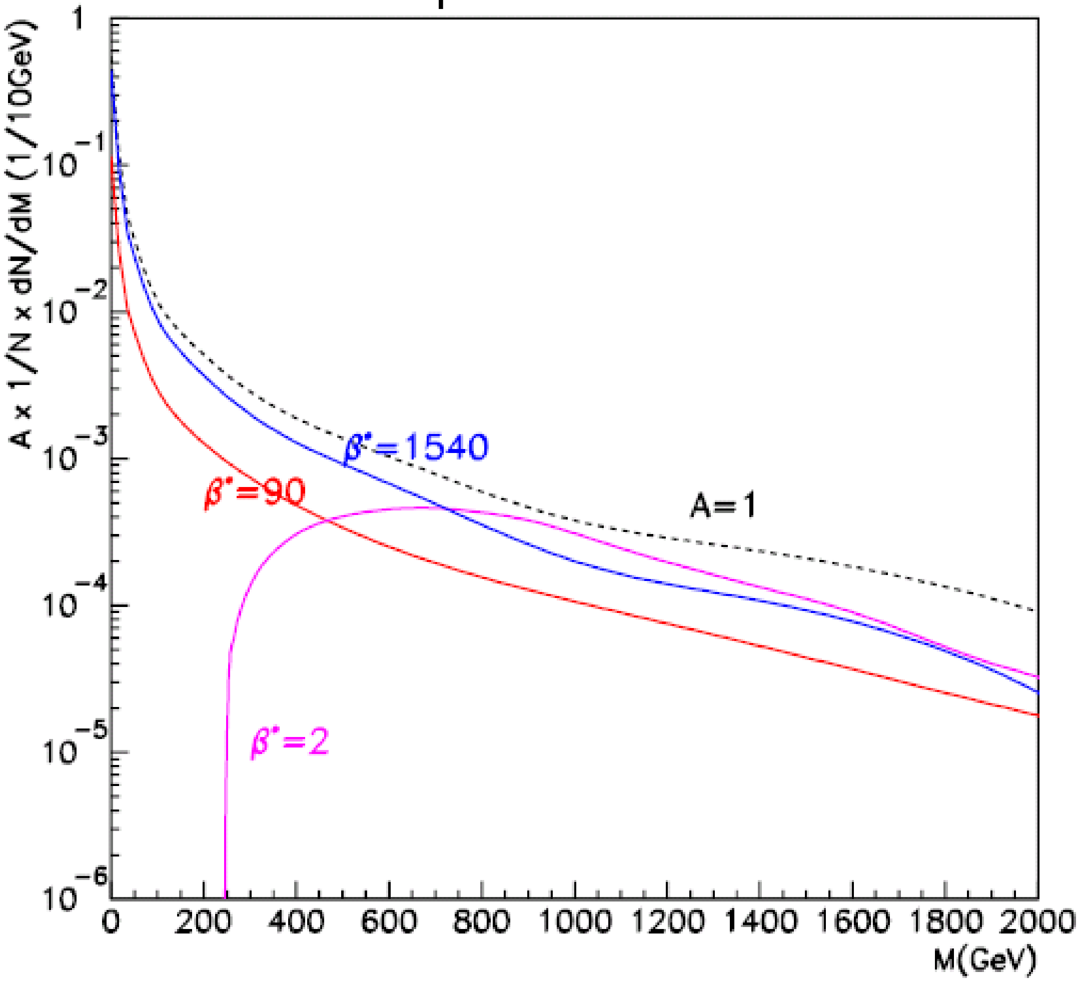
$$\xi=\sum_i E_T^i \exp(\mp\eta_i)/\sqrt{s}$$

Wide range t, ξ acceptance with special optics

These processes contribute to the pile-up at high luminosity

Diffraction at low luminosity: soft diffraction (DPE)

Differential Mass distribution, acceptance corrected



Number of event collected in a few days

β=90m $\int Ldt = 0.3\ (pb^{-1})$:

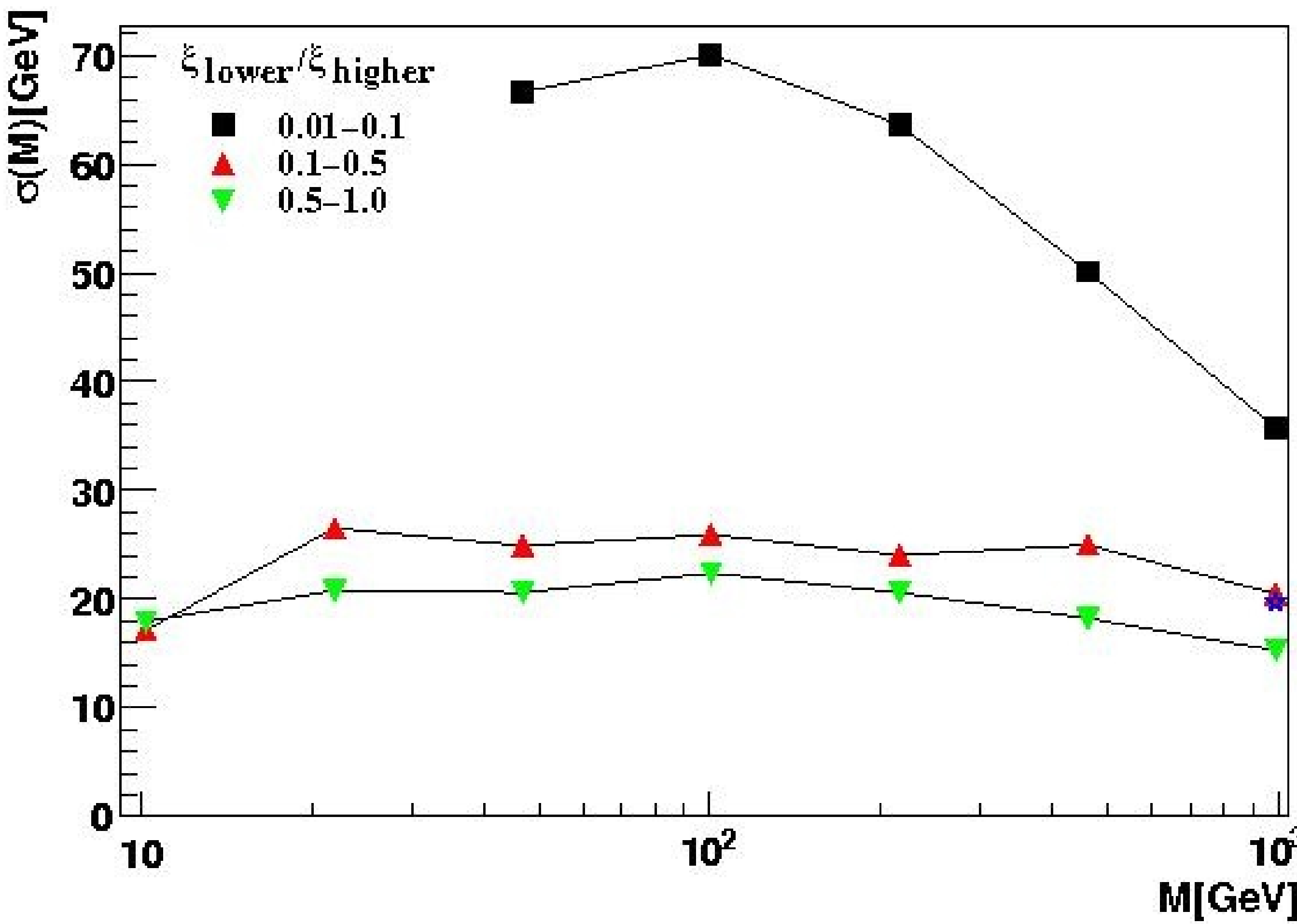
1<M<2000 GeV   N ~ 6×10^7

β=2m $\int Ldt = 10 (pb^{-1})$:

M>300 GeV   N ~ 10^8

Diffraction at low luminosity:
DPE Central Mass Resolution

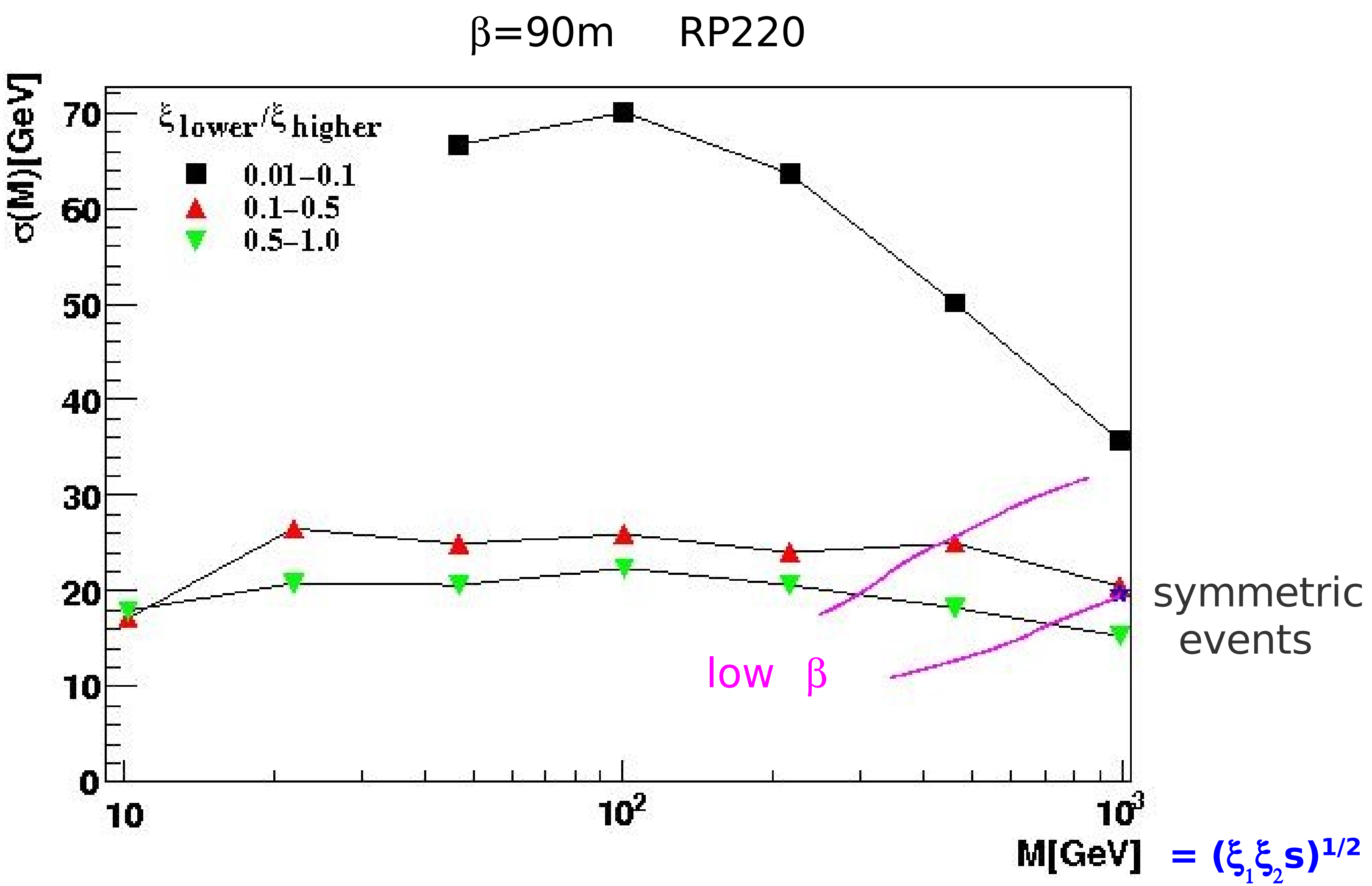
β=90m RP220



symmetric events

$= (\xi_1 \xi_2 s)^{1/2}$

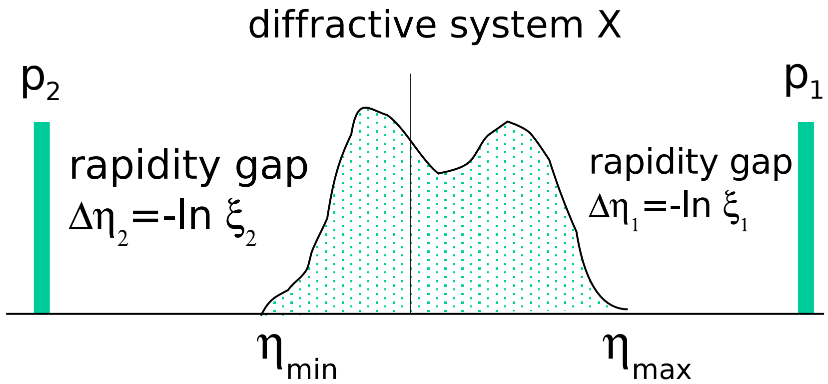
Diffraction at low luminosity: DPE Central Mass Resolution

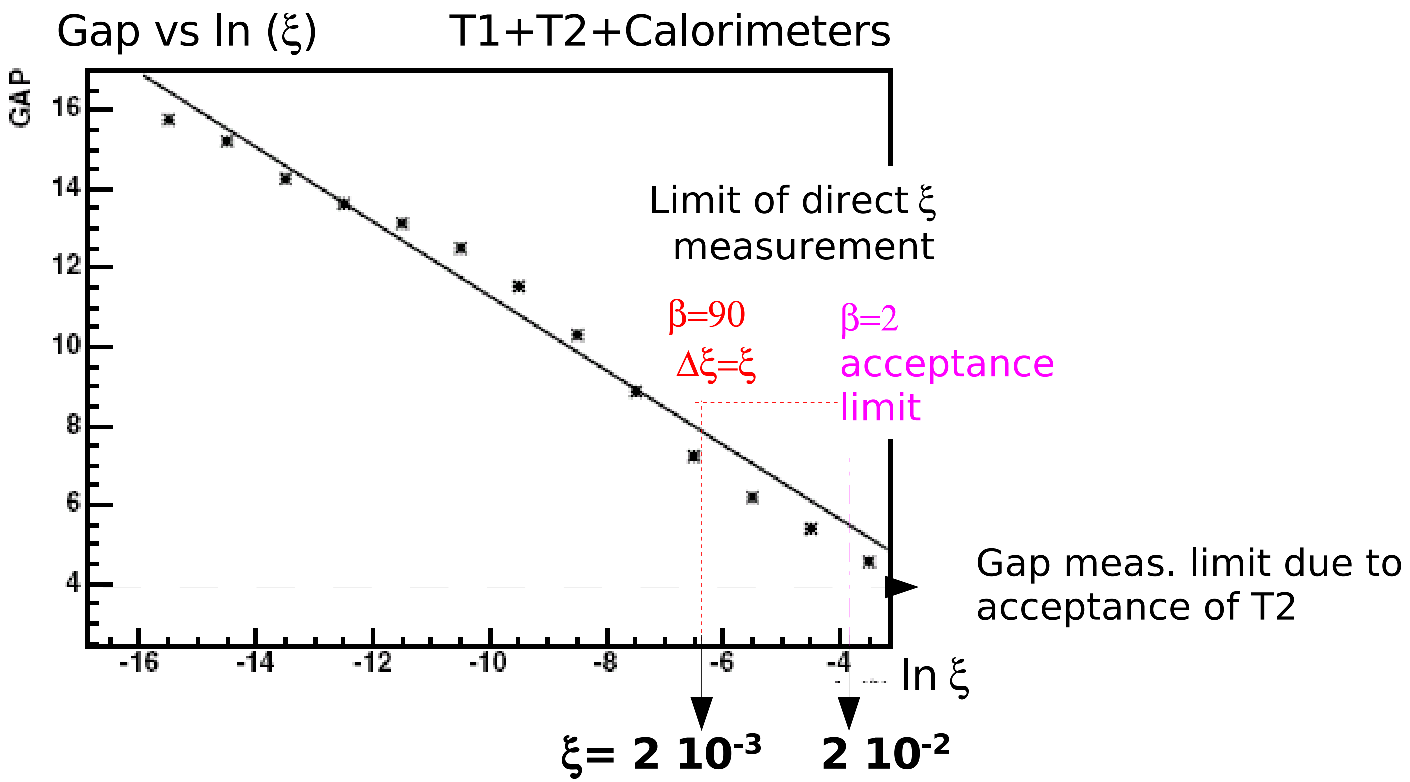


Diffraction at low luminosity: rapidity gaps

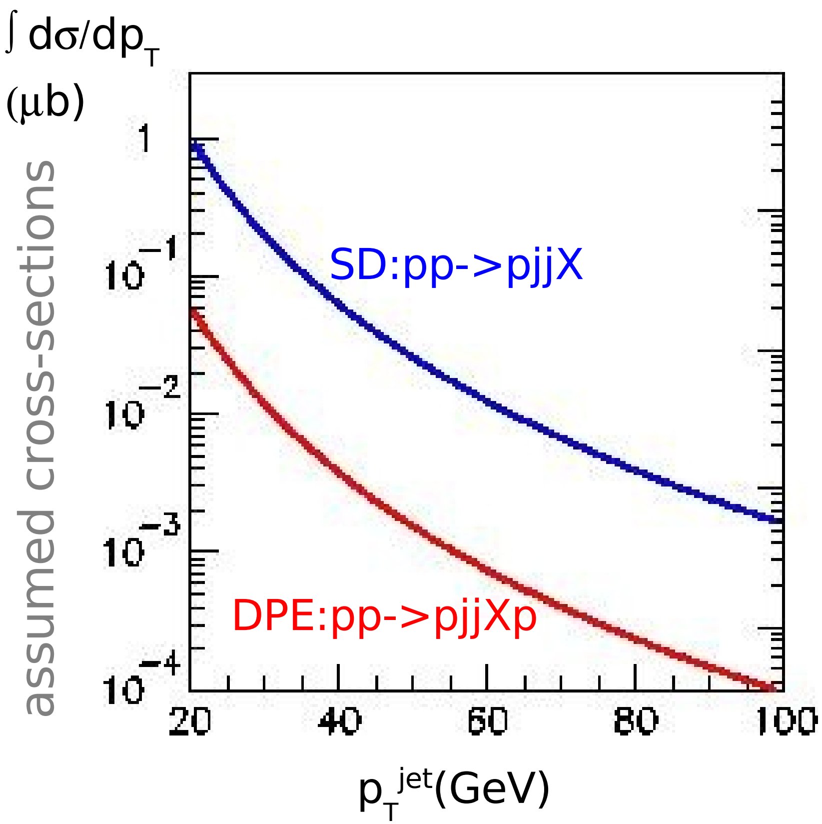
Measure ξ via rapidity gap: $\Delta\eta = -\ln \xi$

Achieved precision: $\sigma(\xi)/\xi \sim 80\%$





Diffraction at low luminosity: semi-hard diffraction



N event collected [acceptance included]

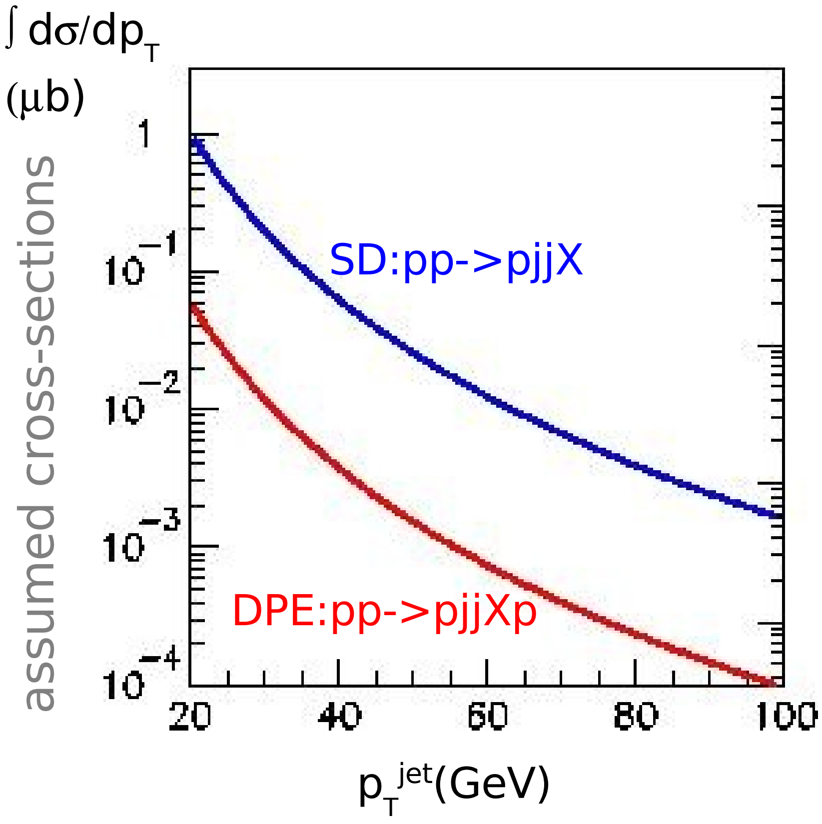
β=90 $\int Ldt$ = 0.3 (pb^{-1})

SD:	pT>20 GeV	$6x10^4$
DPE:	“	2000

β=2 $\int Ldt$ = 100 (pb^{-1})

SD:	pT>50 GeV	$5x10^5$
DPE:	“	$3x10^4$

Diffraction at low luminosity: semi-hard diffraction



Measure the cross sections and their *t, M_X, p_T^{jet}* dependence

Topology of the events:
for example exclusive vs inclusive jet production

In addition to the previous methods, ξ and central mass can be determined from calorimeter information:

$\xi = \sum_i E_T^i e^{\mp\eta^i}/\sqrt{s}$ $\sigma(\xi)/\xi \sim 40\%$

Summary (Part I)

Important experimental issues have been addressed in the common document:

Detailed studies of acceptance & resolution of the forward proton detectors for all scenarios

Machine induced background (not discussed, see document)

Physics reach:

Already at low luminosity diffractive processes, from low masses up to a few TeV, can be measured

The topology of the events can be studied and correlated with the forward proton

At medium luminosity the onset of jet activity in diffractive events can be investigated

Part II is now presented by M. Grothe