Diffraction
Report II - WG4

Forward protons at LHC

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DESY
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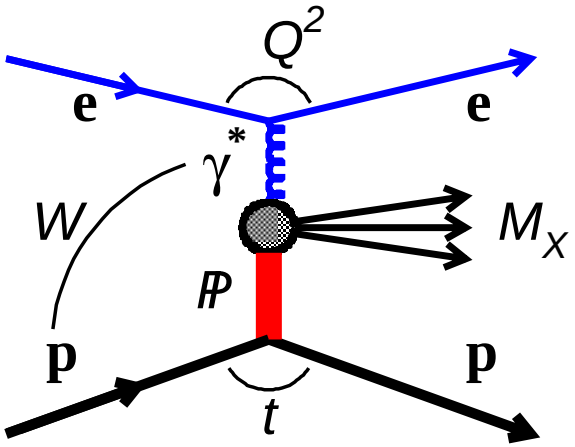
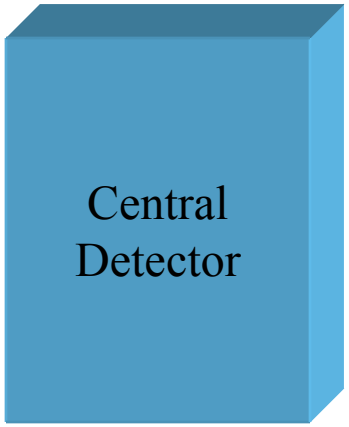
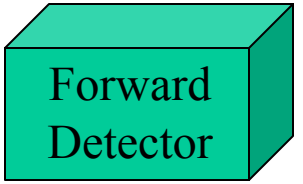
HERA-LHC Workshop

Forward protons at HERA



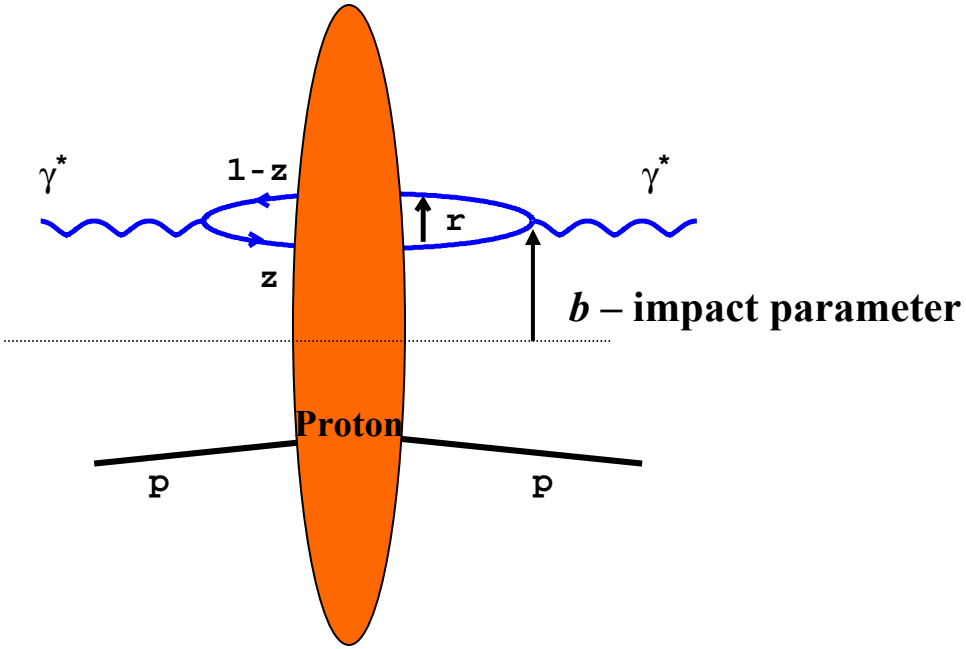




diffractive t – distributions in DIS processes at HERA are connected to basic QCD dynamics BFKL, BK equations ….

in focus of several theory groups

Impact Parameter Dipole Model



$$\sigma_{tot}^{\gamma^* p} = \int d^2\vec{b}\, d^2\vec{\hat{r}} \int_0^1 dz\, \Psi(Q^2, z, \vec{r})^* \sigma_{q\bar{q}}(x, r^2, b) \Psi(Q^2, z, \vec{r})$$

$$\frac{d\sigma_{qq}(x,r)}{d^2 b} = 2 \cdot \left\{ 1 - \exp\left(-\frac{\pi^2}{2 \cdot 3} r^2 \alpha_s(\mu^2) x g(x, \mu^2) T(b) \right) \right\}$$

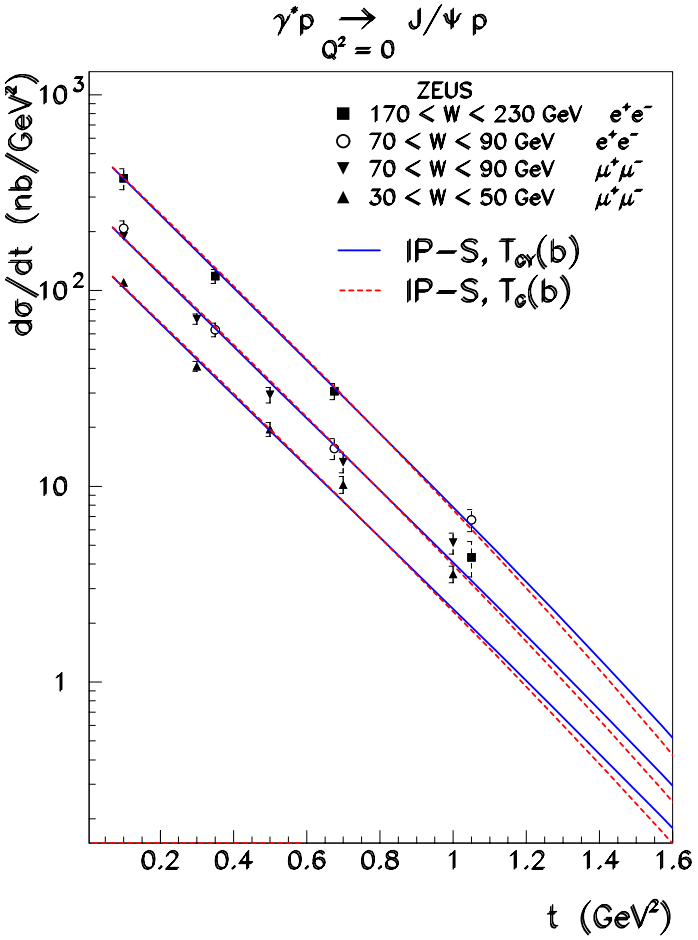
$$T(b) = \frac{1}{2\pi B_G} \exp\left(-b^2/2B_G\right)$$

T(b) **- proton shape**

t-dependence of the diffractive cross sections determines the *b* distribution

$t = -\vec{\Delta}^2$ $\quad\vec{\Delta}$ - transv. momentum (2-d) $\quad\vec{b}$ - impact parameter (2-d)

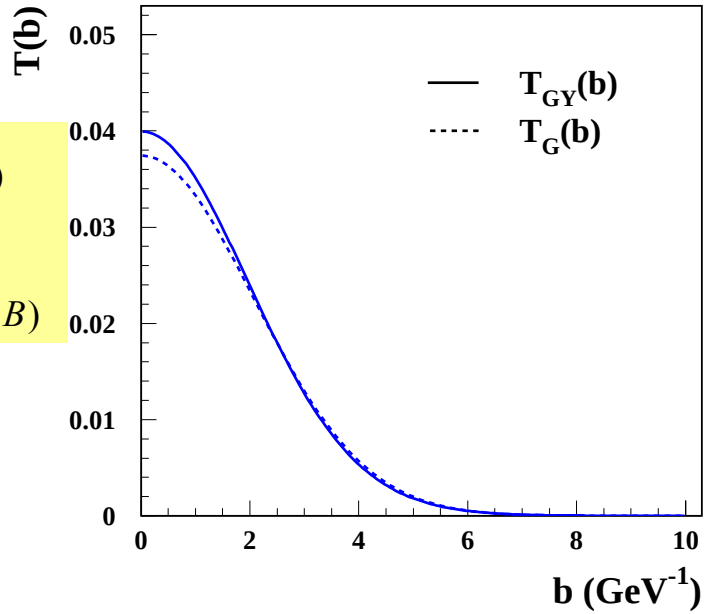
$$\frac{d\sigma_{VM}^{\gamma^* p}}{dt} = \frac{1}{16\pi}\left|\int d^2\vec{r}\int d^2b e^{-i\vec{b}\vec{\Delta}}\int_0^1 dz\Psi_{VM}^*(Q^2,z,\vec{r})\; 2\left\{1-\exp\left(-\frac{\pi^2}{2\cdot 3}r^2\alpha_s xg(x,\mu^2)T(b)\right)\right\}\Psi(Q^2,z,\vec{r})\right|^2$$



$$\frac{d\sigma^{diff}}{dt} \sim \exp(B\cdot t)$$

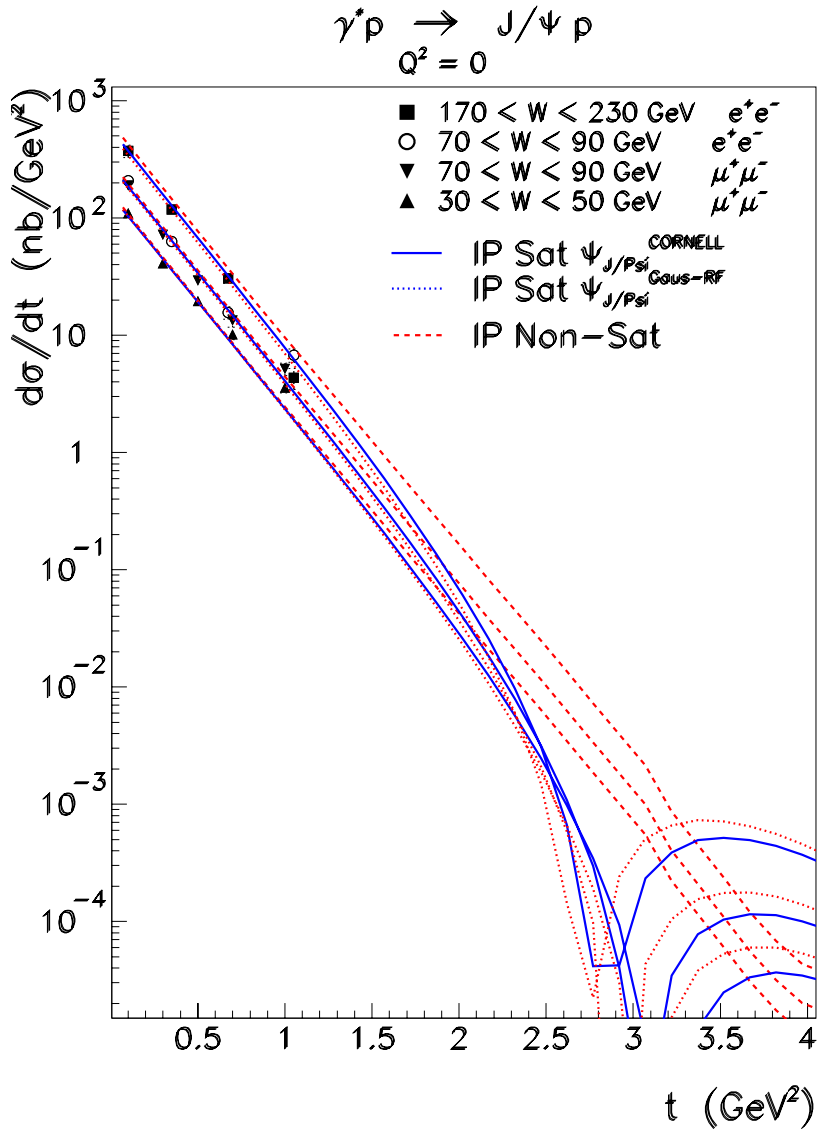
$$\Rightarrow$$

$$T(b) \sim \exp(-\vec{b}^{\,2}/2B)$$

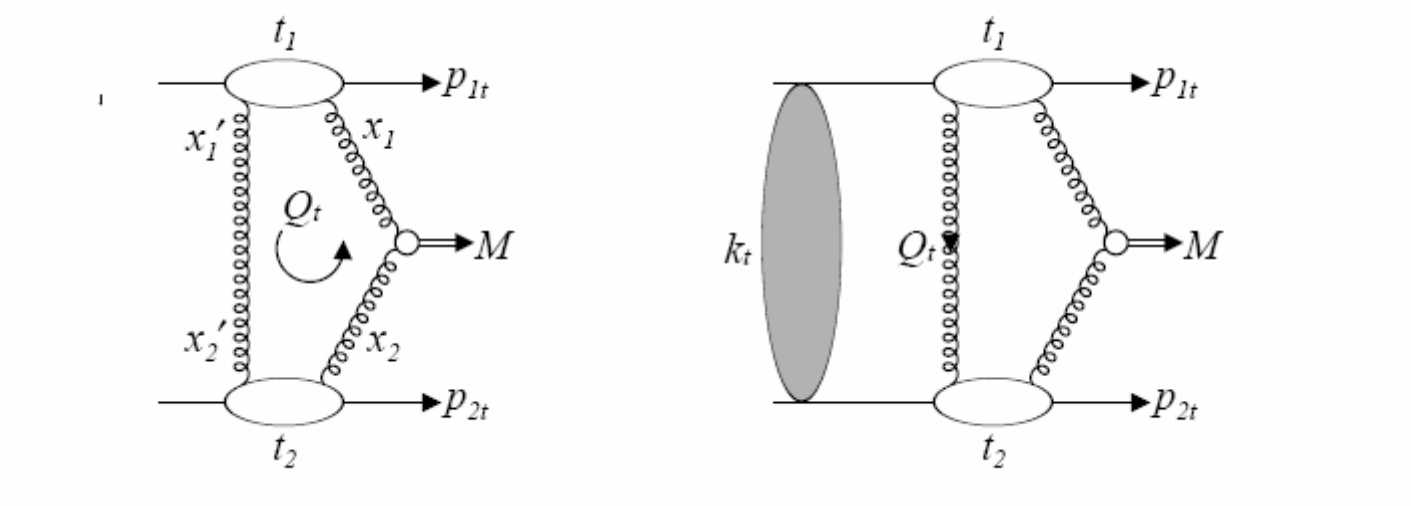


$$T_G(b) \propto \exp(-\vec{b}^{\,2}/2B_G) \qquad B_G = 4.25\ \text{GeV}^2$$

$$T_{GY}(b) \propto \int d^2b' \exp(-(\vec{b}-\vec{b}')^2/2w_G)K_0(b'/w_E)$$


$\gamma^* p \rightarrow J/\Psi\, p$
$Q^2 = 0$
$d\sigma/dt$ (nb/GeV^2)
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
0.5
1
1.5
2
2.5
3
3.5
4
t (GeV^2)
170 < W < 230 GeV e^+e^-
70 < W < 90 GeV e^+e^-
70 < W < 90 GeV $\mu^+\mu^-$
30 < W < 50 GeV $\mu^+\mu^-$
IP Sat $\Psi_{J/Psi}^{CORNELL}$
IP Sat $\Psi_{J/Psi}^{Gaus-RF}$
IP Non−Sat

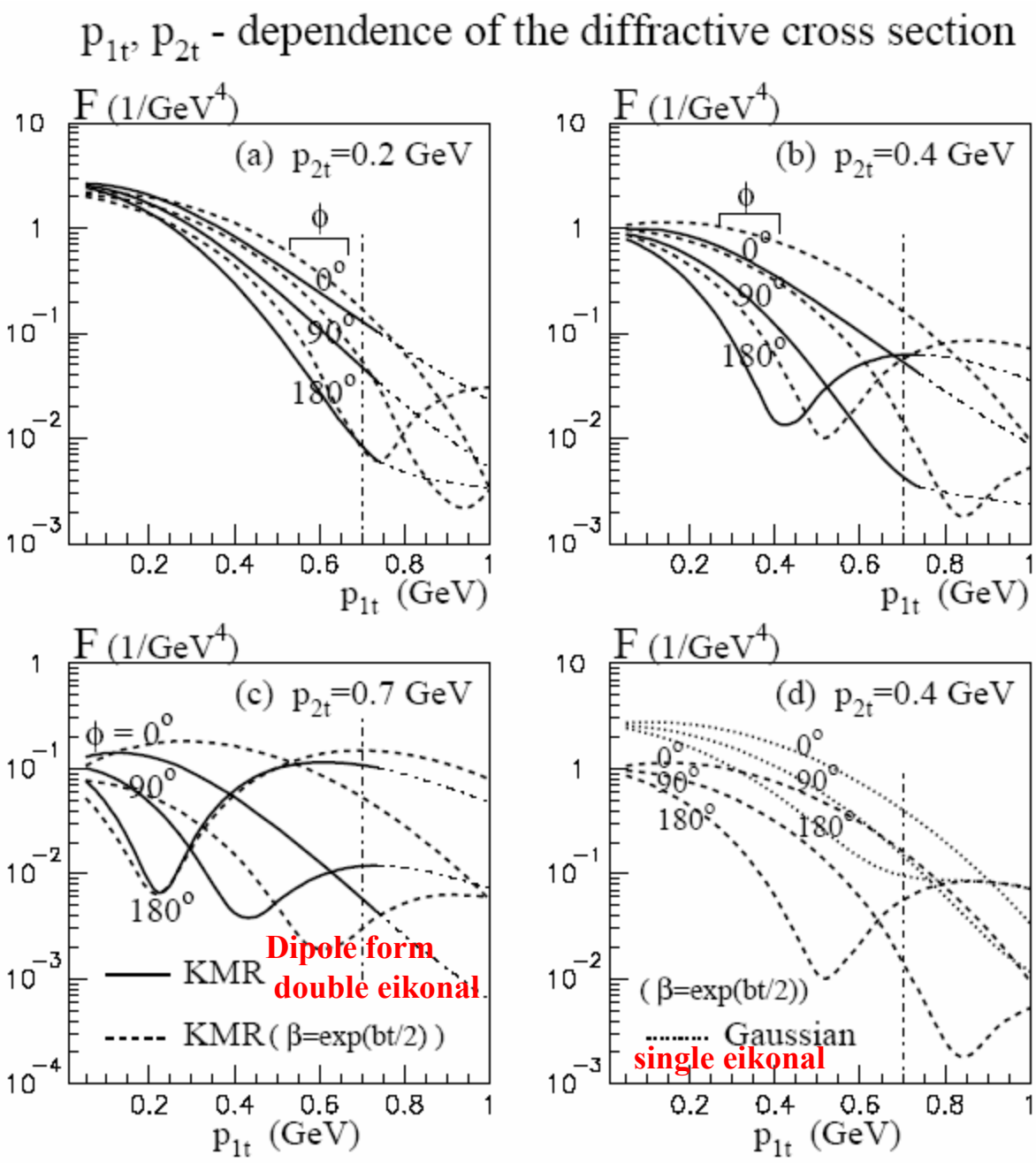
Forward protons at LHC



$$S^2 = \frac{\int M^2(s,b) e^{-\Omega(s,b)} d^2b}{\int M^2(s,b) d^2b}$$

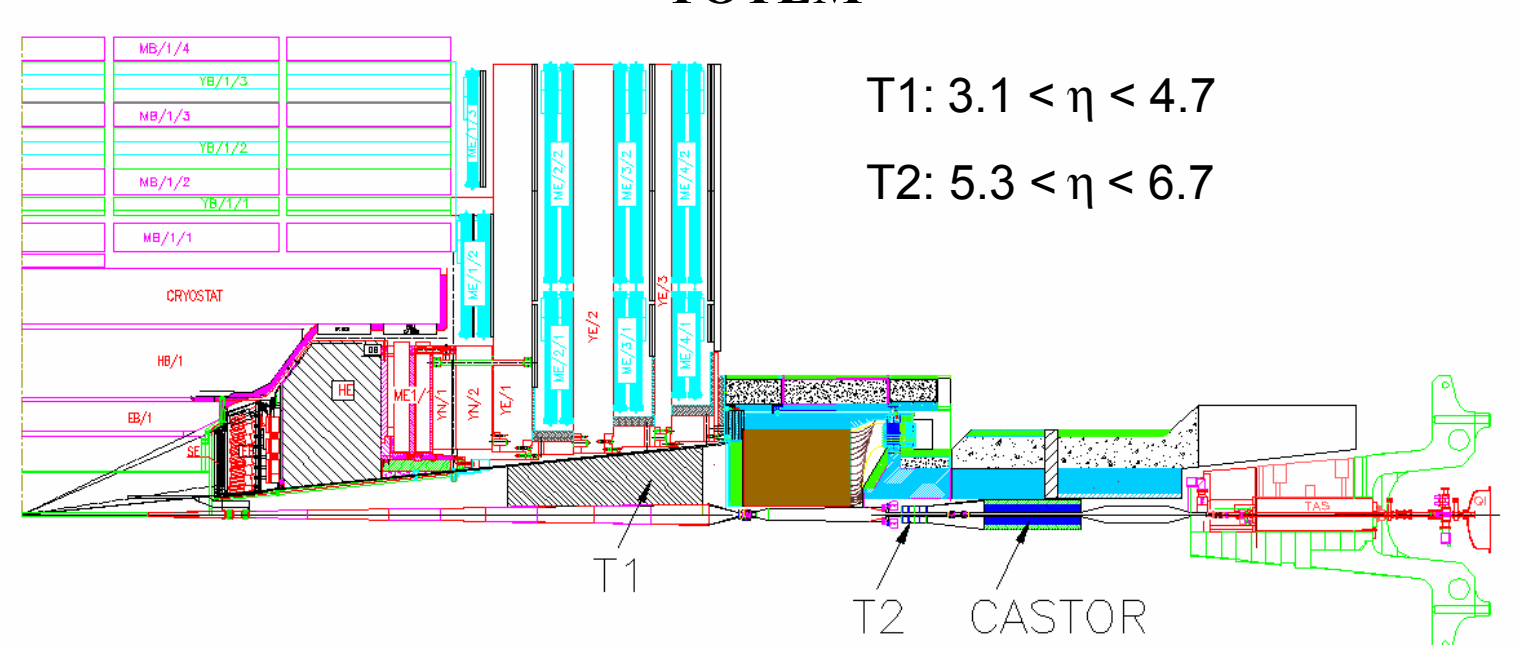
$$\left.\frac{d\sigma}{dt_1 dt_2}\right|_{ppM} = \int M^2 e^{-\Omega(s,b)} e^{i\vec{b}\vec{\Delta}} d^2b$$

$$t_1 = -(\vec{\Delta} - \vec{p}_{1t})^2 \qquad t_2 = -(\vec{\Delta} + \vec{p}_{2t})^2$$



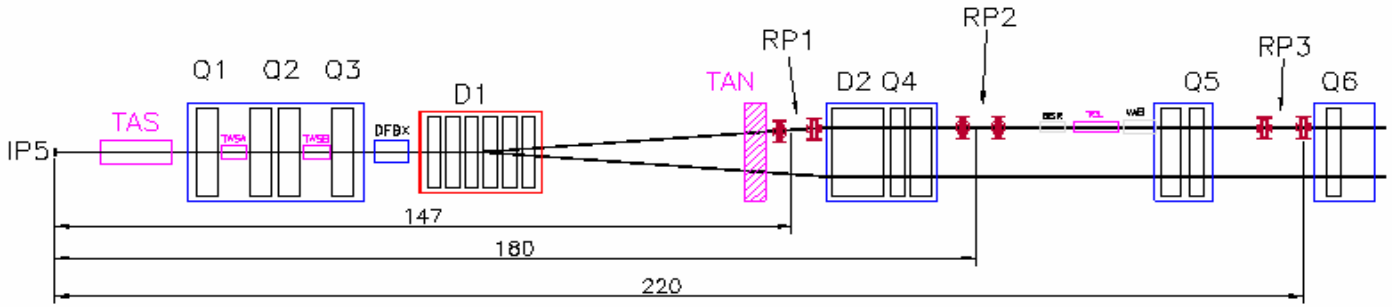
Khoze
Martin
Ryskin

TOTEM



T1: $3.1 < \eta < 4.7$

T2: $5.3 < \eta < 6.7$



$$L\sigma_{tot}^2 = \frac{16\pi}{1+\rho^2} \times \left.\frac{dN}{dt}\right|_{t=0}$$

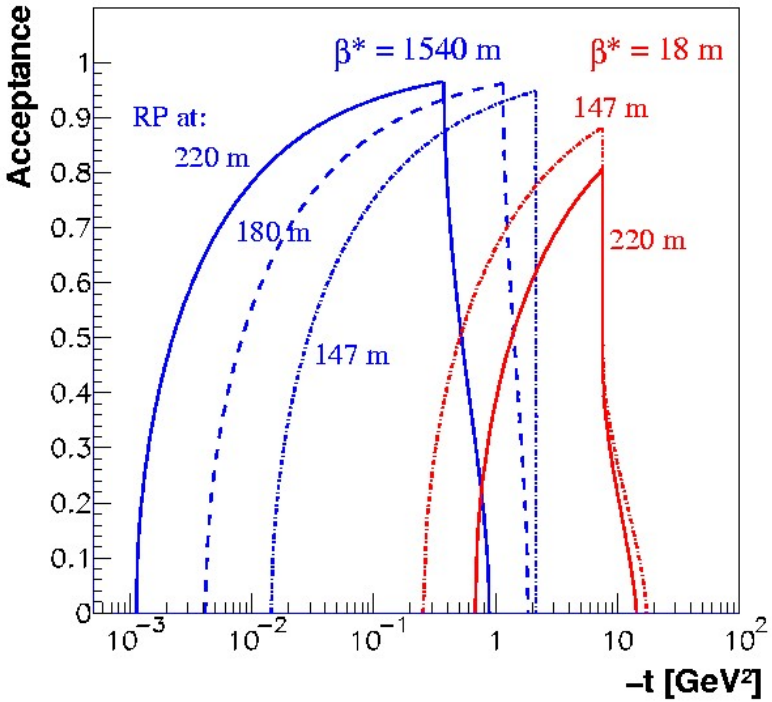
$$L\sigma_{tot} = N_{elastic} + N_{inelastic}$$

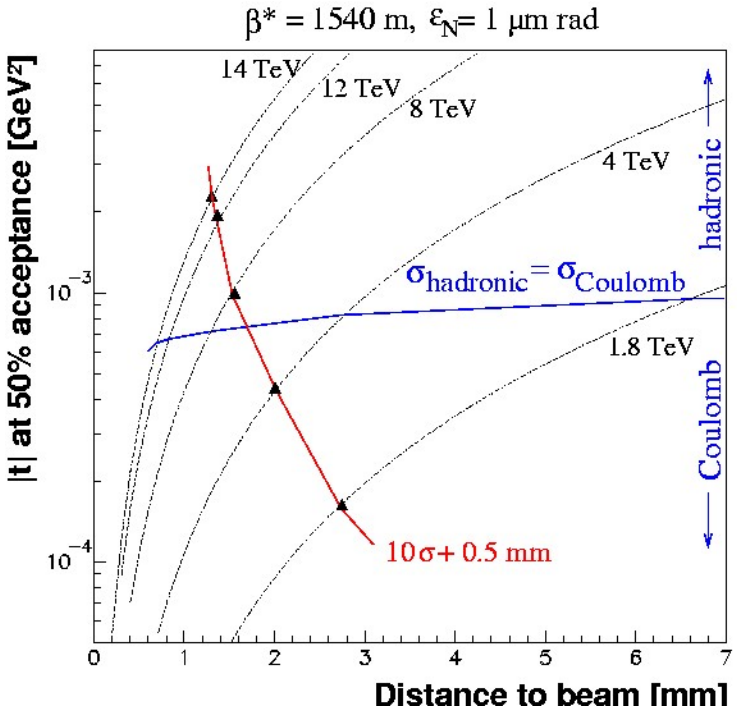
Optical Theorem

$$\sigma_{tot} = \frac{16\pi}{1+\rho^2} \times \frac{(dN/dt)\big|_{t=0}}{N_{el} + N_{inel}}$$

TOTEM

elastic scattering: t-Acceptance

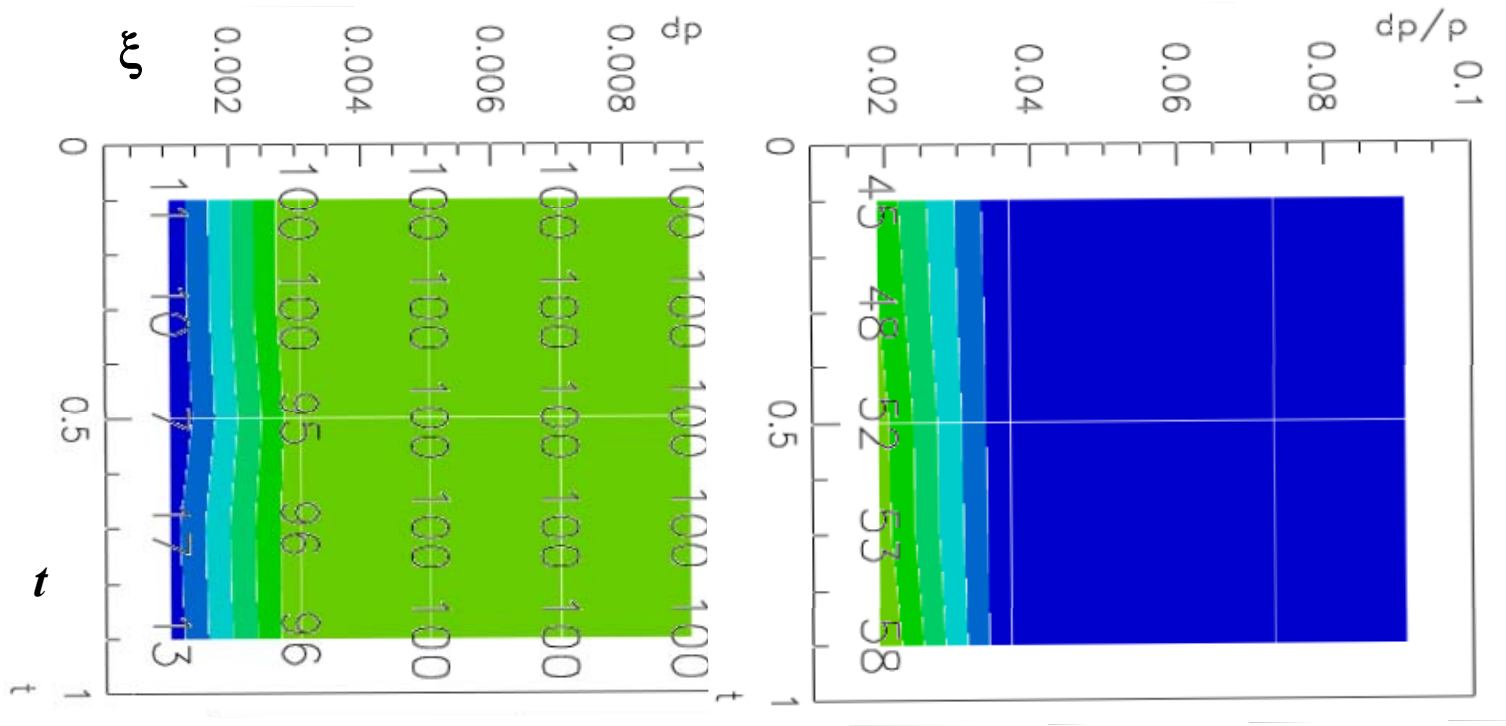




Region	$\|t\|$ [GeV]^2	Running Scenario
Coulomb region	$\leq 5\times10^{-4}$	[lower s, RP closer to beam]
Interference, ρ meas.	$5\times10^{-4} \div 5\times10^{-3}$	[as above], standard β* = 1540 m
Pomeron exchange	$5\times10^{-3} \div 0.1$	β* = 1540 m
Diffractive structure	$0.1 \div 1$	β* = 1540 m, 200 - 400 m
Large $\|t\|$ – perturb. QCD	$1 \div 10$	β* = 18 m

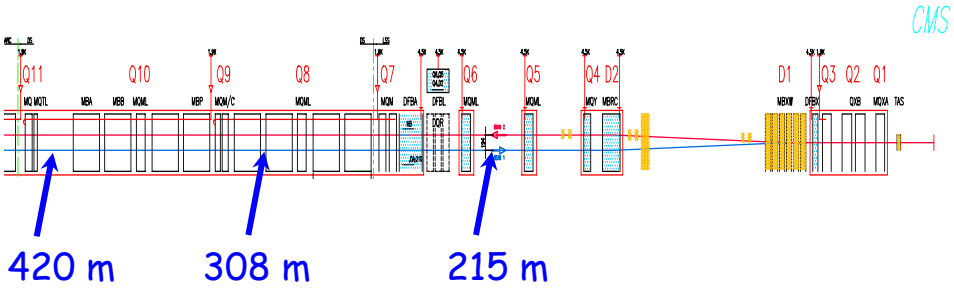
Studies of the acceptance in t and ξ, high luminosity, β*=0.5m, detectors at 420m from IP

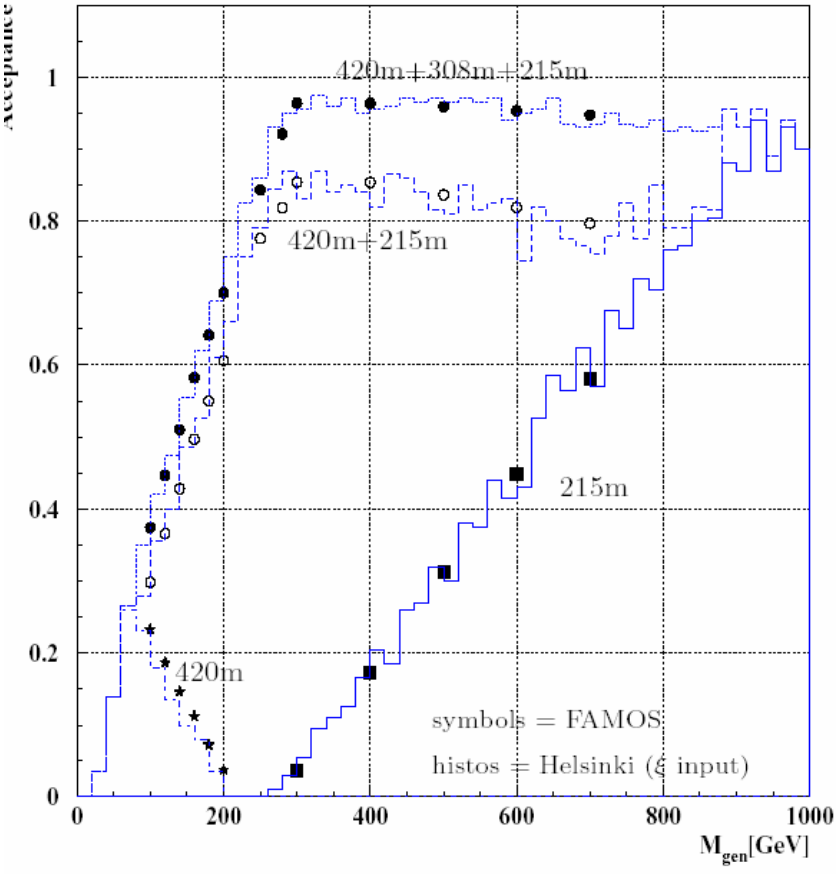
A. Sobol



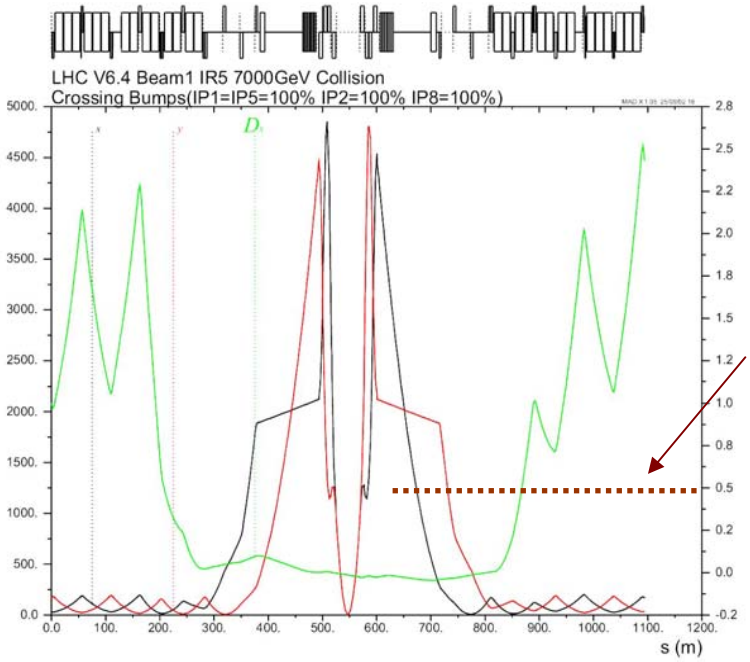
Good acceptance, *t* -measurement well above 1 GeV^2 feasible!

Acceptance at $\beta^* = 0.5$ m





horizontal offset = $\xi \cdot D_x$



To get $\xi \sim 0.005$ proton ($M \sim 70$ GeV) 2.5mm from beam (10σ) pots must be > 250 m from IP

-> cold region, & level 1 trigger not possible

Helsinki group

Possibility of modifying the LHC cryostat at about 400m from the IP is studied (UK groups) – can the detector be warm and fit between the beam pipes?

Dedicated expert meeting is planned for November 04
to transfer know-how (of detector calibration and alignment)
between HERA and LHC communities

Summary

Measurement of diffractively scattered protons at LHC is challenging but technically possible

Optimization of Forward Detectors is in progress

Measurement of forward protons should allow the determination of survival probabilities for diffractive processes from LHC data alone

⇒Precision QCD study in transverse plane
⇒Diffractive Higgs

Thanks to my co-conveners for help in preparing this talk