Hard Diffraction at LHC

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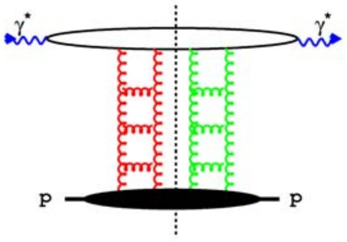
DESY

SM-Workshop
Zeuthen, 24th of October 2006

Outline

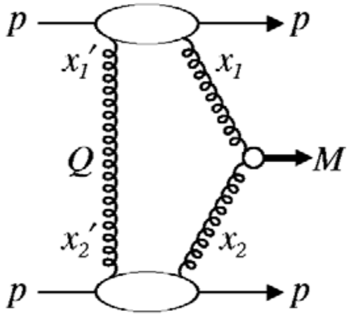
Short review of Hard Diffraction at HERA at small x



Transition to pp collisions

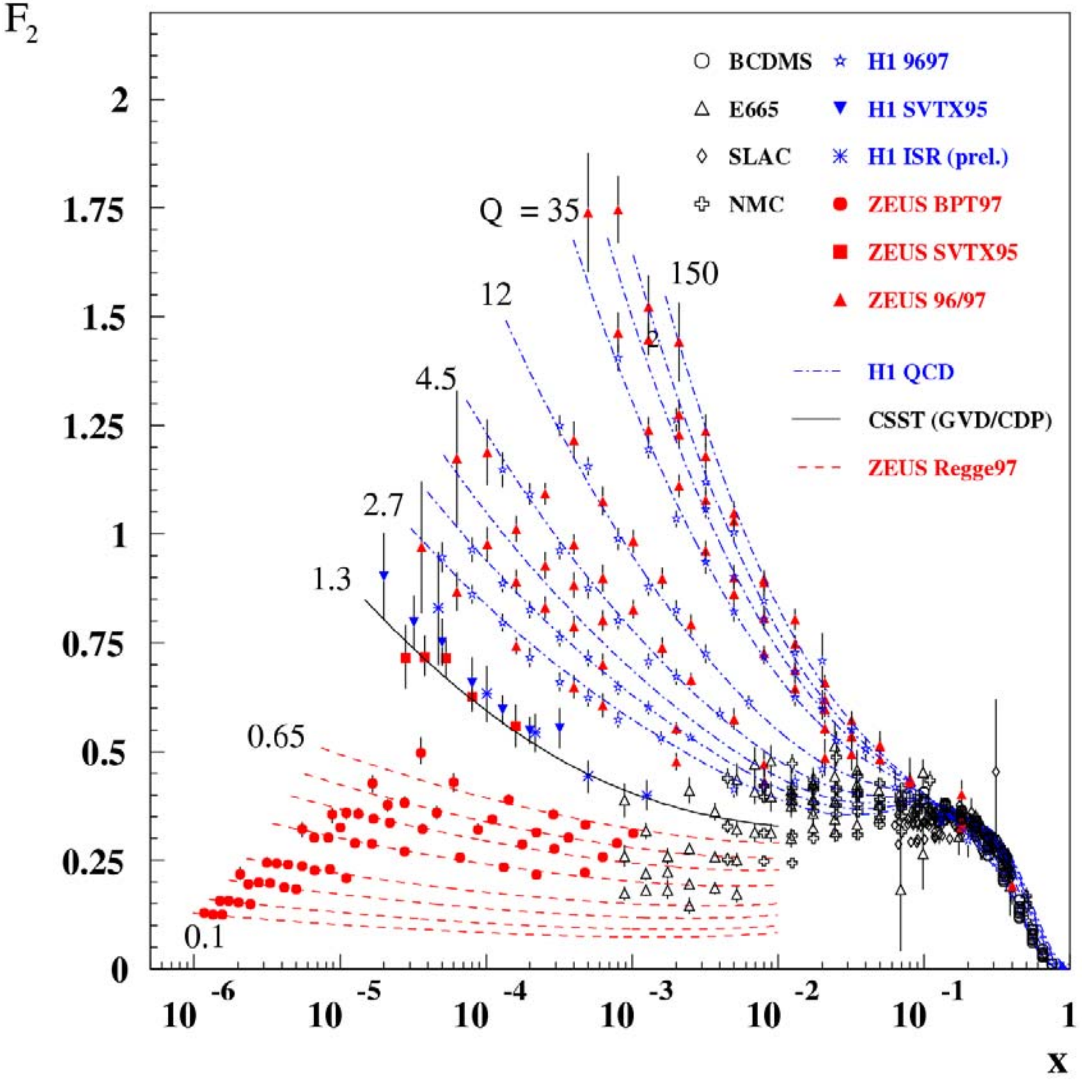
Hard diffraction at LHC at small x

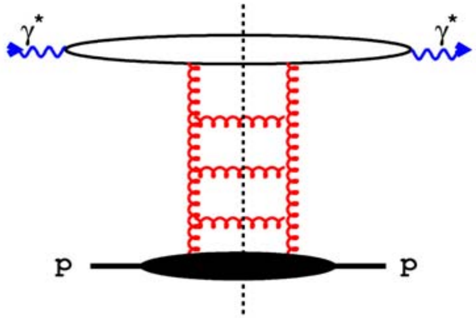
- Exclusive Jets
- Higgs
- Calibration Reactions



Forward Protons at 420m Project - FP420

Tevatron results





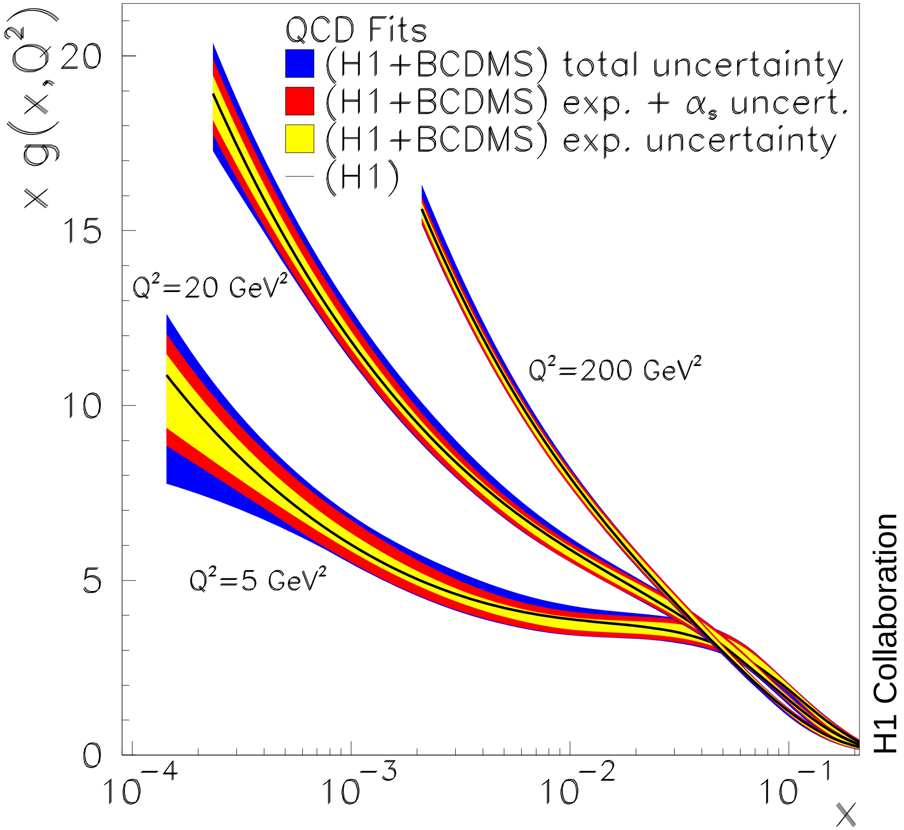
$$\sigma_{tot}^{\gamma p} = \frac{1}{W^2} Im A_{el}(W^2, t = 0)$$

$$F_2(x,Q^2) = \frac{Q^2}{4\pi^2 \alpha_{em}} \cdot \sigma_{tot}^{\gamma^* P}(W,Q^2) \qquad x \approx \frac{Q^2}{W^2}$$

F_2 is dominated by single ladder exchange

ladder symbolizes a QCD evol. process
(DGLAP or others)

Gluon density

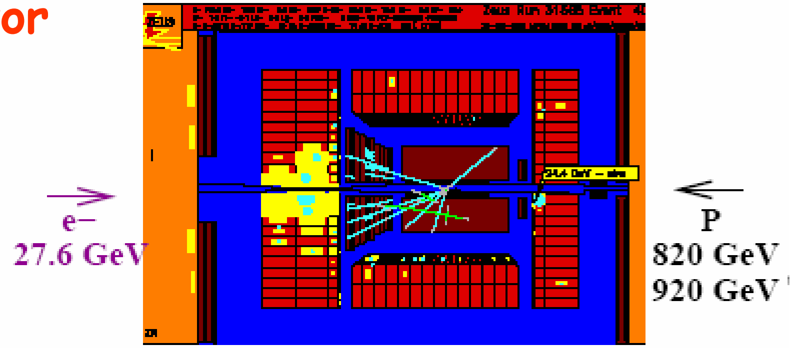


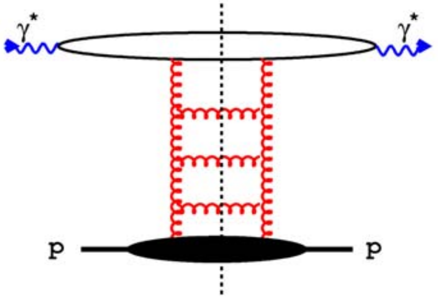
Gluon density dominates F_2 for x < 0.01

Diffractive Scattering

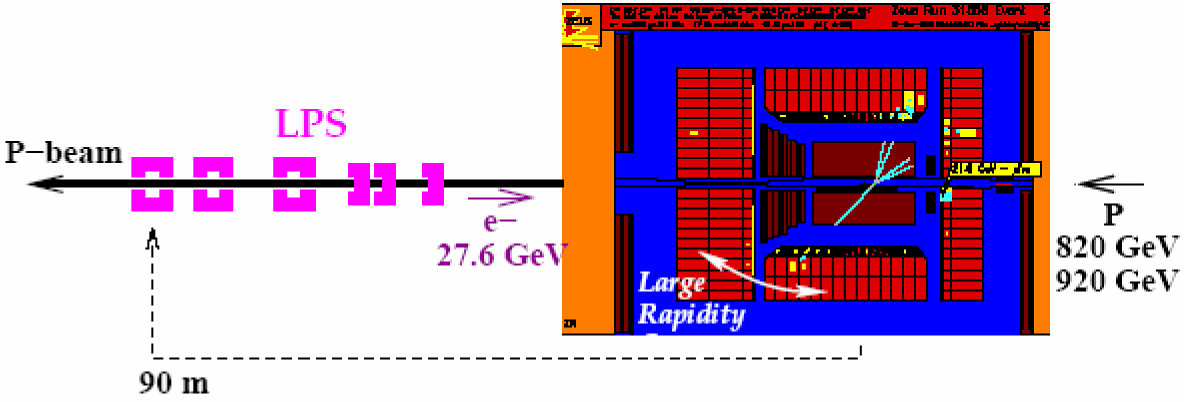
Non-Diffractive Event

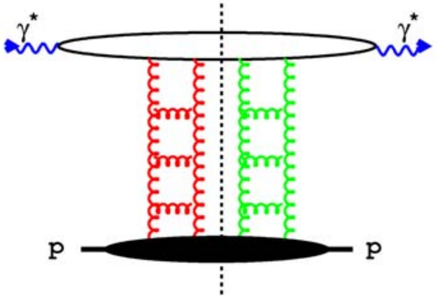
ZEUS detector





Diffractive Event



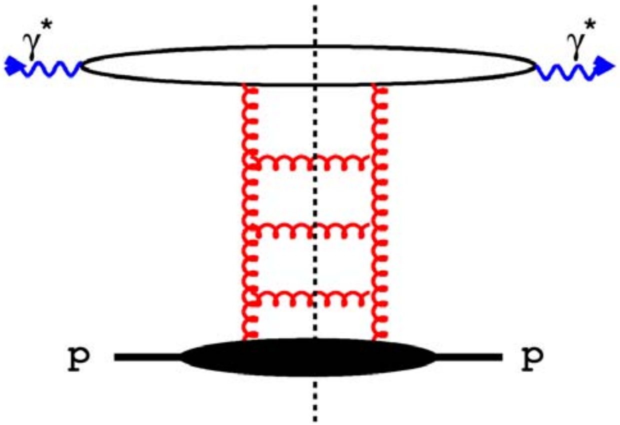


M_X - invariant mass of all particles seen in the central detector

t - momentum transfer to the diffractively scattered proton

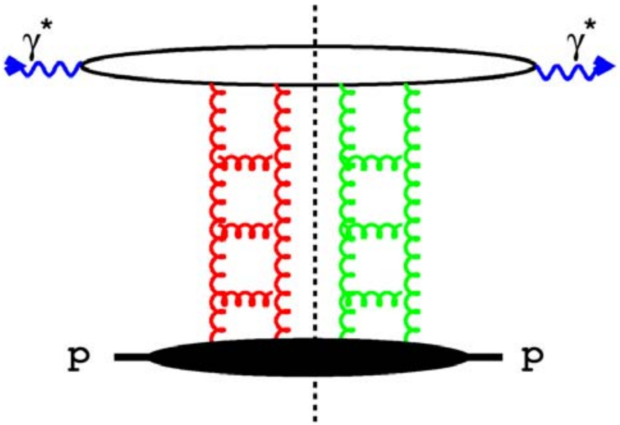
t - conjugate variable to the impact parameter

Observation of diffraction indicates that single ladder may not be sufficient
(partons produced from a single chain have exponentially suppressed rap. gaps)



Inclusive DIS

Optical T



Hard Diffraction

Dipole Models

equivalent to LO perturbative QCD for small dipoles

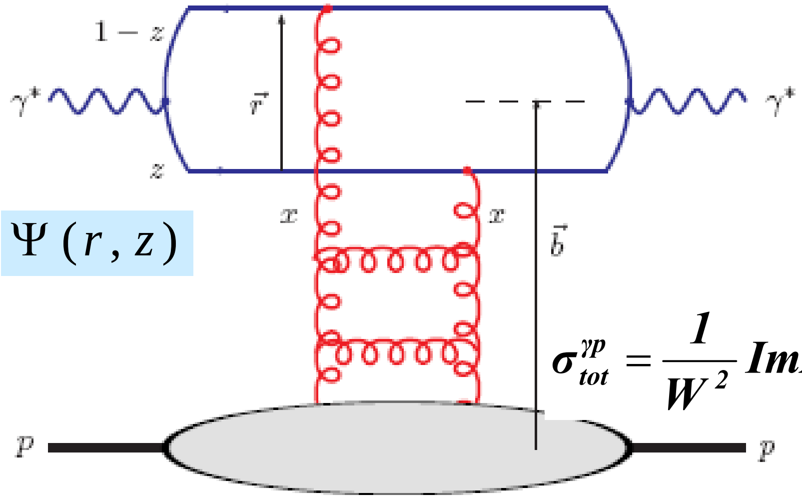
Glauber
Mueller

Dipole XS $$\frac{d\sigma}{d^2b} = 2(1-\exp(-\Omega/2)) = \Omega - \Omega^2/4 + ...$$

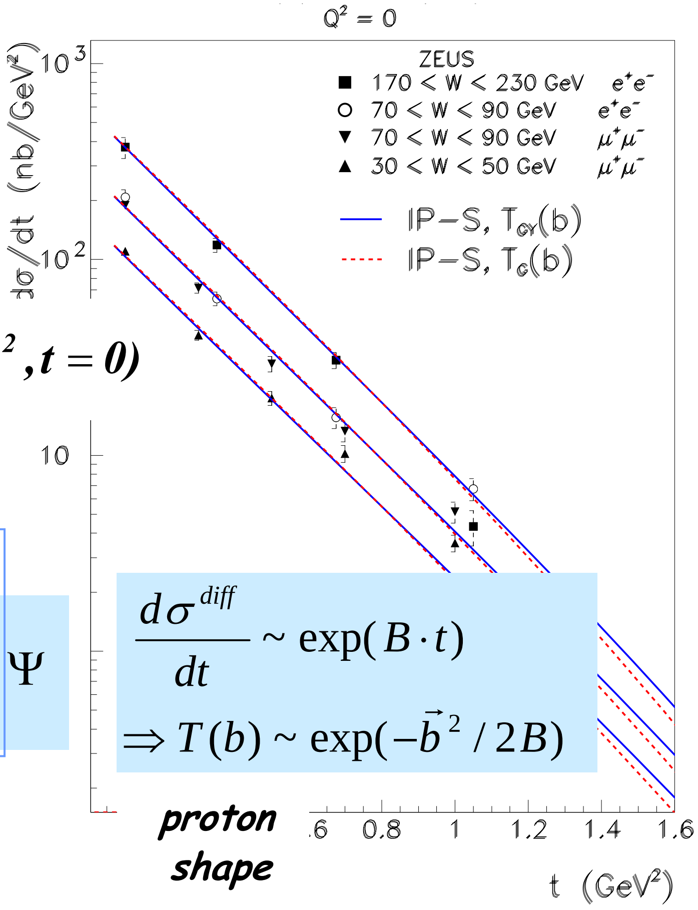
Dipole Models

equivalent to LO perturbative QCD for small dipoles

GBW - Golec-B, Wuesthoff
BGBK - Bartels, Golec-B, Kowalski
KT - Kowalski, Teaney
KMW - Kowalski, Motyka, Watt



$$\sigma_{tot}^{\gamma p} = \frac{1}{W^2} Im A_{el}(W^2, t = 0)$$



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

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

proton shape

Glauber Mueller

$$\sigma_{tot}^{\gamma^* p} = \int d^2\vec{r} \int_0^1 dz \int d^2 b \Psi^* \cdot 2\left\{1 - \exp\left(-\frac{\Omega}{2}\right)\right\}\Psi$$

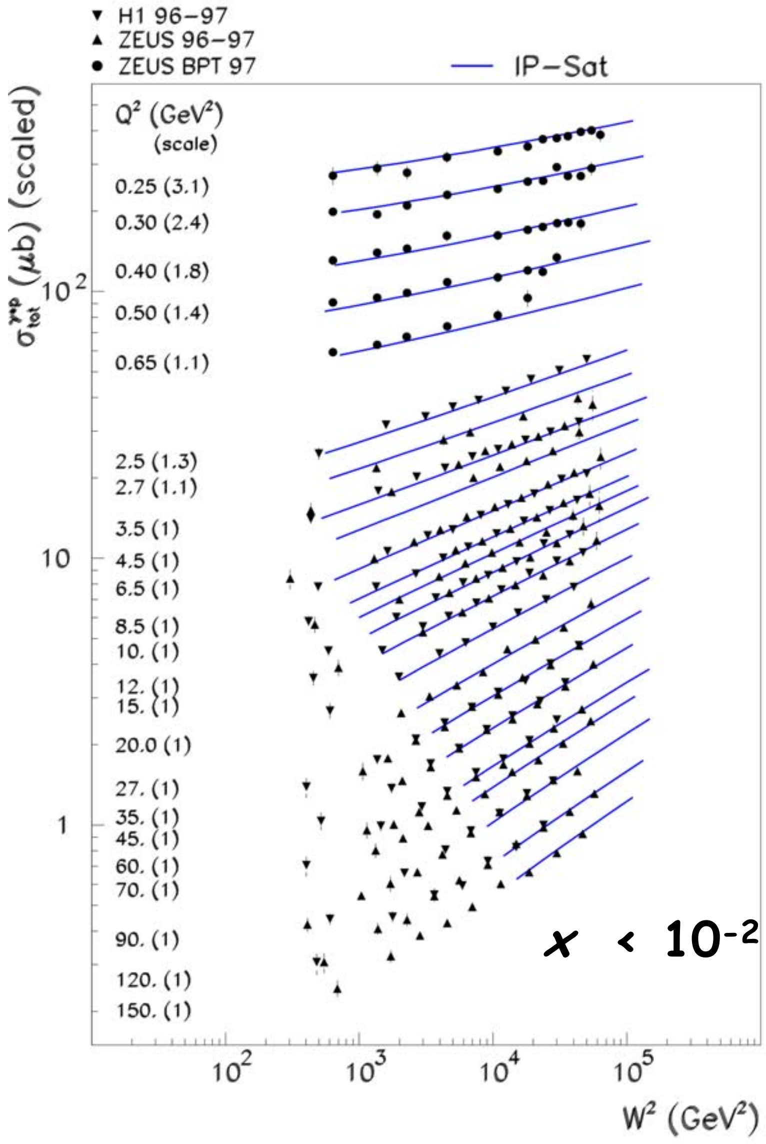
$$\Omega = \frac{\pi^2}{N_C} r^2 \alpha_s(\mu^2) x g(x, \mu^2) T(b)$$

$$\frac{d\sigma_{VM}^{\gamma^* p}}{dt} = \frac{1}{16\pi} \left| \int d^2\vec{r} \int d^2 b e^{-i\vec{b}\cdot\vec{\Delta}} \int_0^1 dz \Psi_{VM}^* \ 2\left\{1 - \exp\left(-\frac{\Omega}{2}\right)\right\}\Psi \right|^2$$

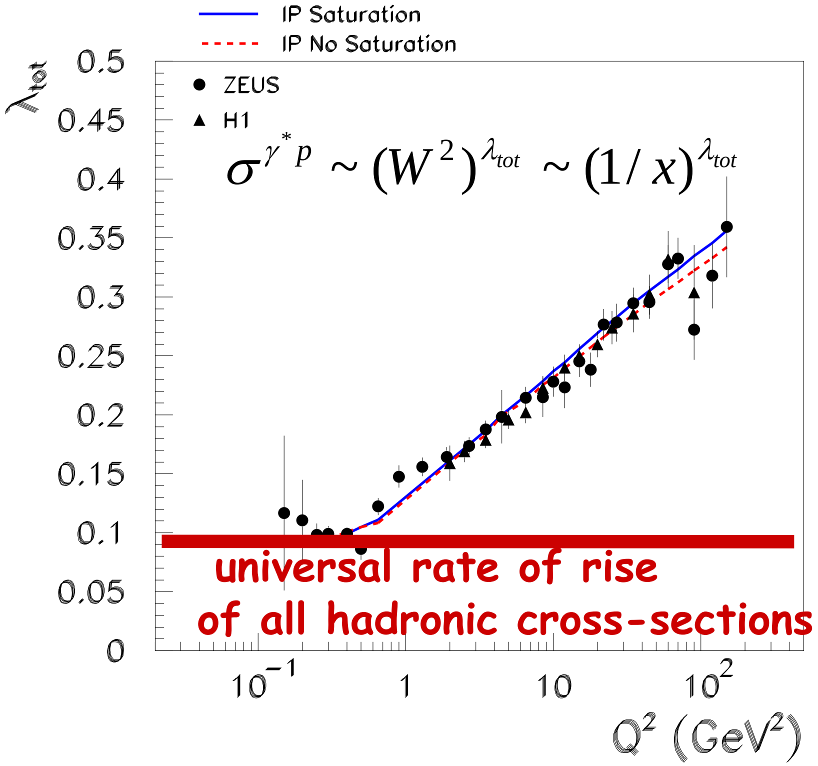
Total γ^*p cross-section

KT

KMW



$x < 10^{-2}$



$$\sigma^{\gamma^* p} \sim (W^2)^{\lambda_{tot}} \sim (1/x)^{\lambda_{tot}}$$

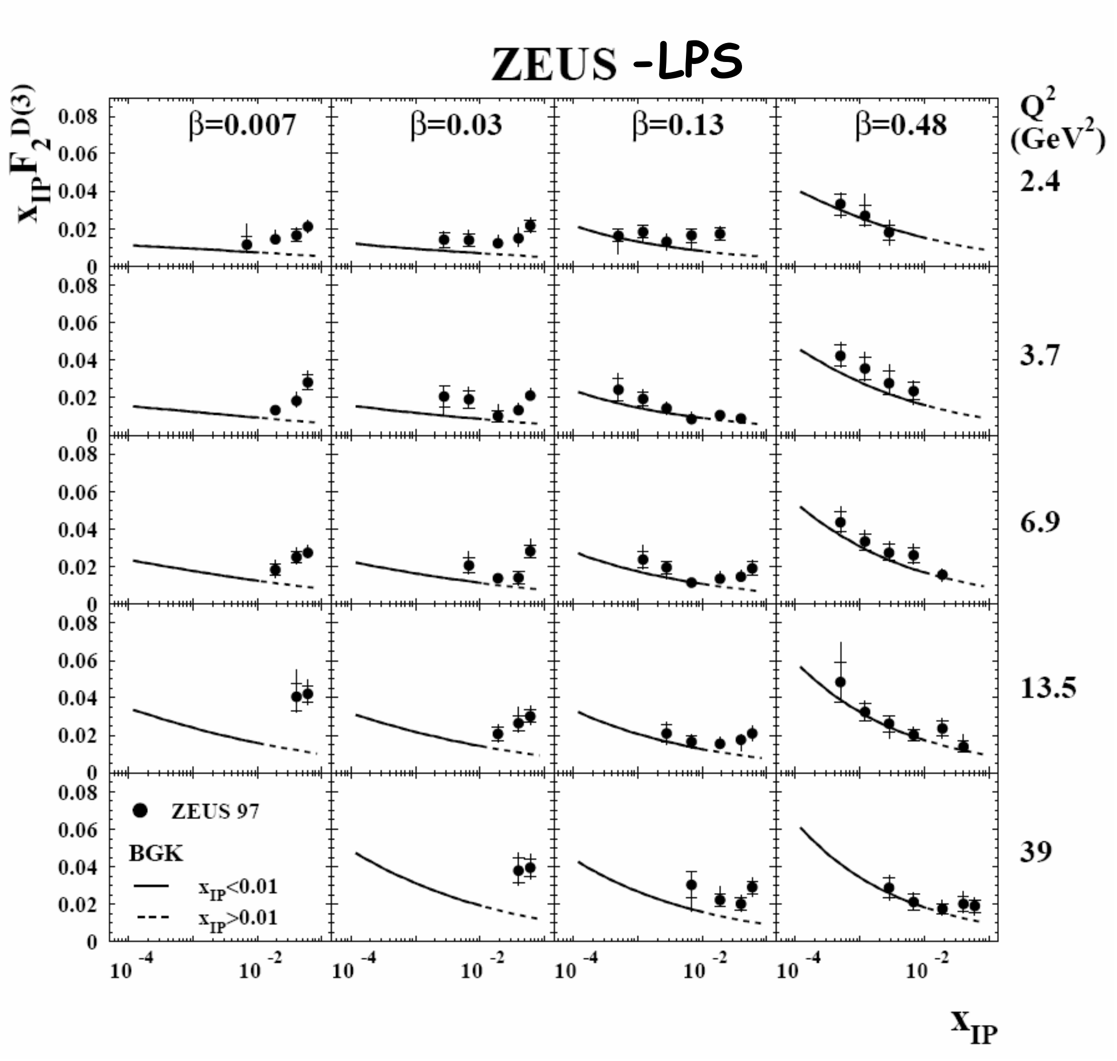
universal rate of rise of all hadronic cross-sections

$$\mu^2 = \frac{C}{r^2} + \mu_0^2$$

$$xg(x, \mu_0^2) = A_g \left(\frac{1}{x}\right)^{\lambda_g} (1-x)^{5.6}$$

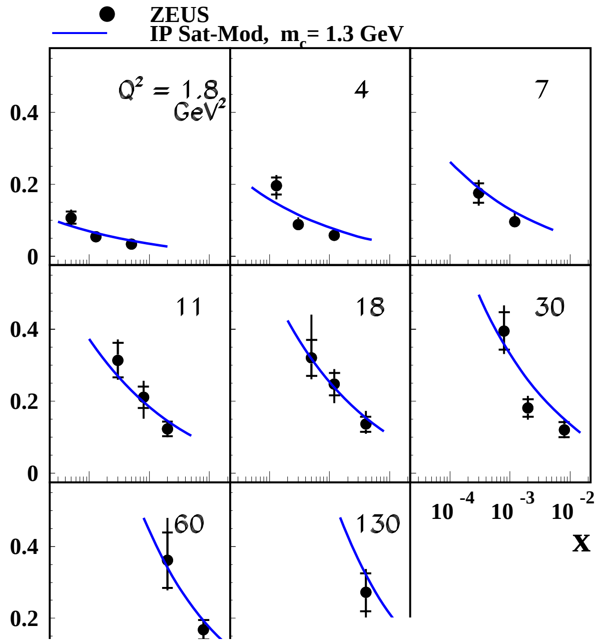
from fit to σ_{tot} predict σ^{diff}
GBW, BGBK, ….

Inclusive Diffraction



KT

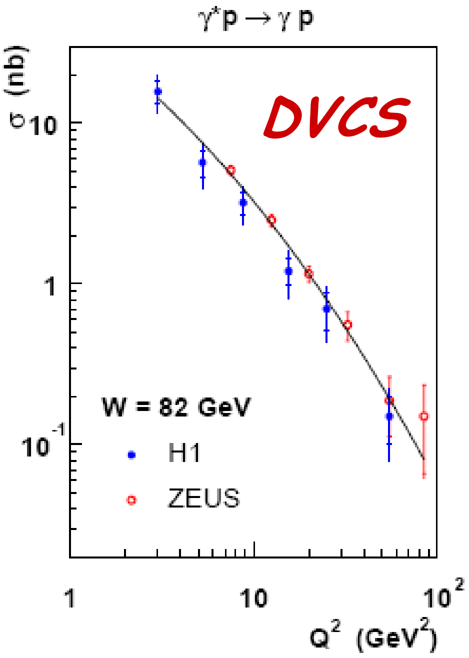
$F_2^{\,c}$

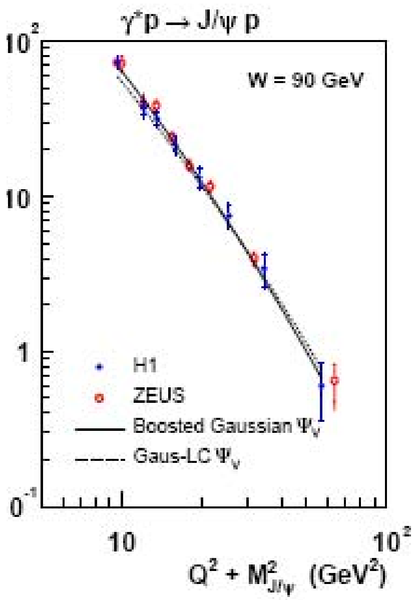


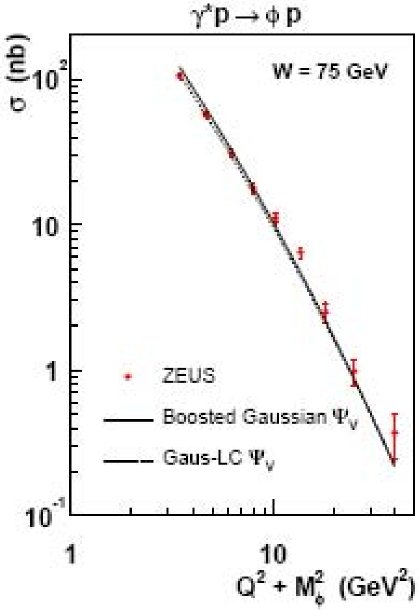
Dipole cross section determined by fit to F_2 →

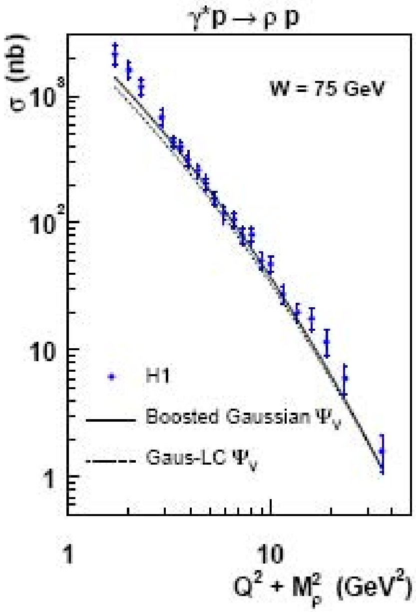
Simultaneous description of many reactions

Vector Mesons



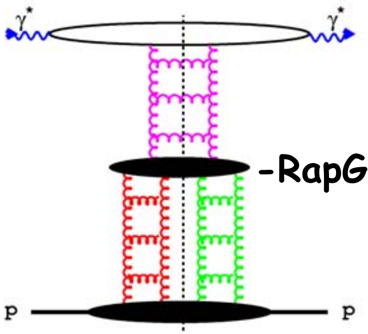




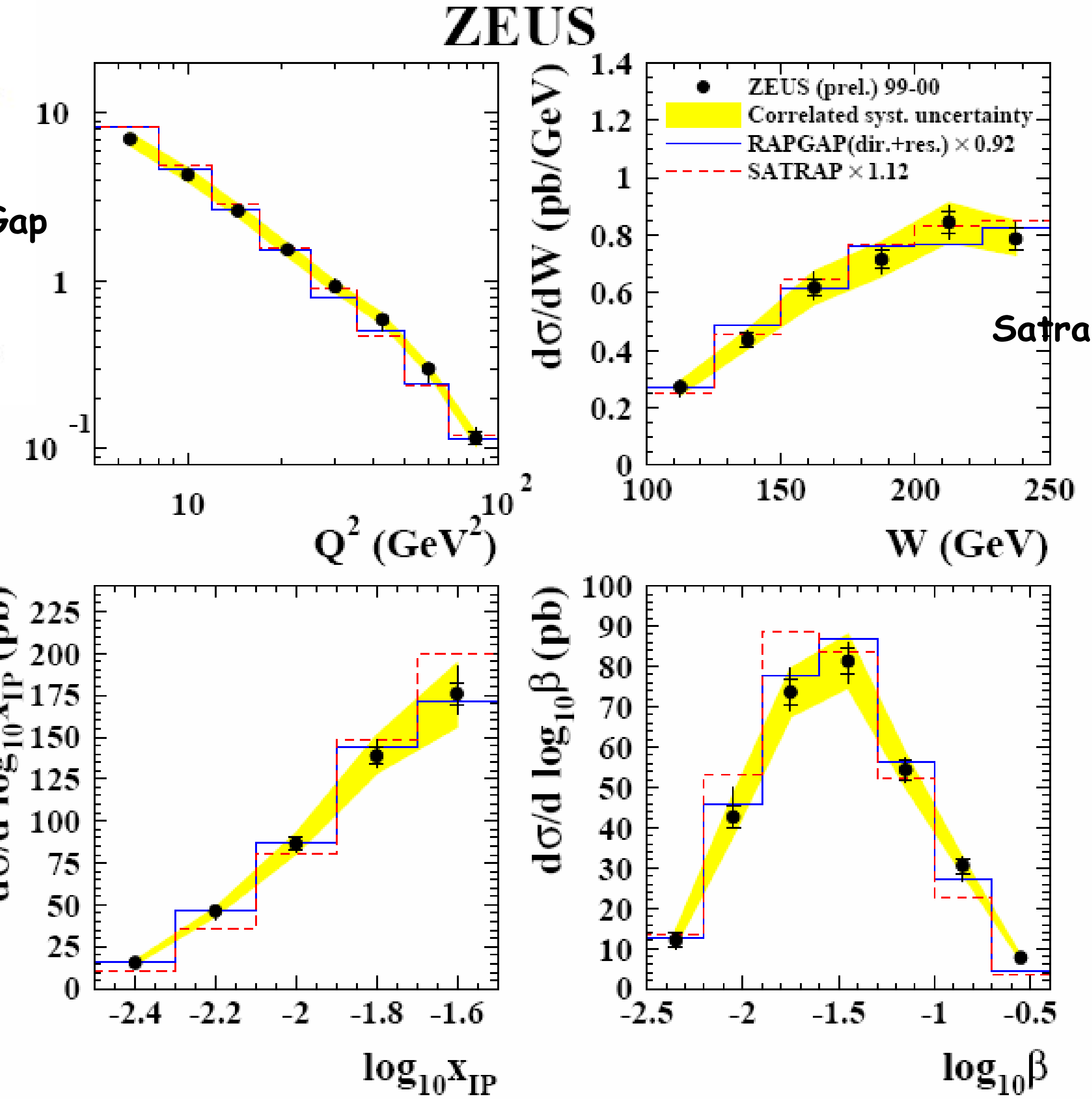


Diffractive Di-jets

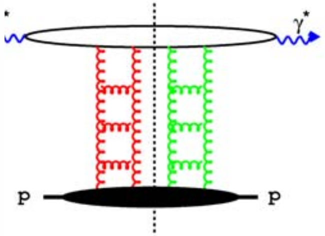
$Q^2 > 5$ GeV^2



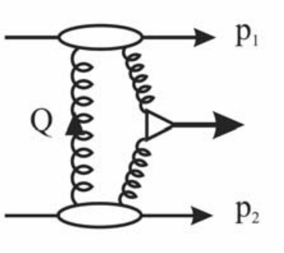
-RapGap



Satrap

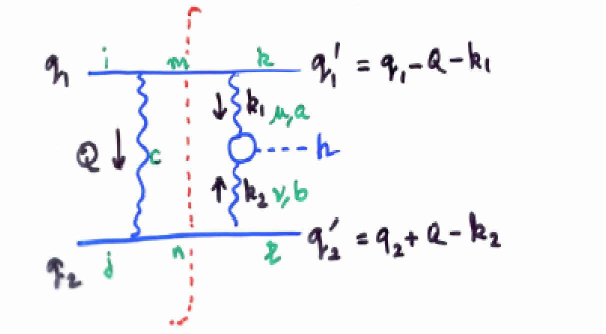


KMR Calculation of the Exclusive Diffractive Process



**Khoze
Martin
Ryskin**

$qq \to q + H + q$



q -> Proton

$$\frac{d\sigma}{dy_H} \simeq \frac{1}{256\pi \underline{\underline{b}}^2} \frac{\alpha_s^2 G_F \sqrt{2}}{9} \left[\int \frac{d^2 Q_\perp}{Q_\perp^4} \underline{\underline{f(x_1, Q_\perp^2)}} \; \underline{\underline{f(x_2, Q_\perp^2)}} \right]^2$$

$$f(x_i, Q_\perp^2) = \frac{\partial G(x_i, Q_\perp^2)}{\partial Q_\perp^2} \quad (x_i = \alpha_i)$$

Dominant uncertainty: KMR estimate factor of 2-3.

assuming $f \sim (Q^2)^\gamma$

$$Q \sim \frac{M_H}{2} \exp\left(- \frac{2\pi}{N_c \alpha_s} \frac{\left[\frac{n}{2} - 1 - 2\gamma \right]}{2} \right)$$

$\alpha_s = 0.2$, $M_H = 100$ GeV, $n = 4$, $\gamma = 0.2$

→ $\boxed{2 \text{ GeV}}$

Power of Q_T, 6 for pseudo-scalar

Divergent: controlled by Sudakov

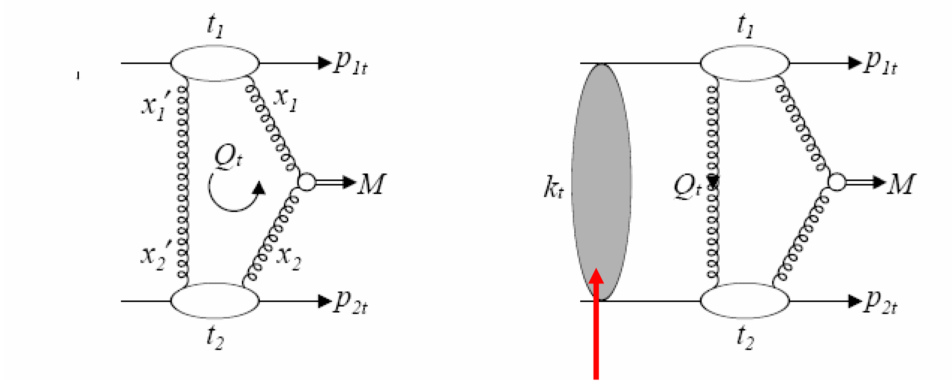
As $Q_T \to 0$ so the screening gluon fails to screen and $P_T \approx 0$ emission is allowed. Hence e^{-S} vanishes faster than any power of Q_T.

exponentiating generates a factor in amplitude of

$$\exp(-S) = \exp\left(- \frac{C_A}{\pi} \int_{Q_T^2}^{\frac{1}{4} M_H^2} \alpha_s \frac{dP_T^2}{P_T^2} \int_{P_T}^{M_H/2} \frac{dE}{E} \right) \quad \leftarrow \text{double logs}$$

B. Cox based on Jeff Forshaw

Survival Probability S^2



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

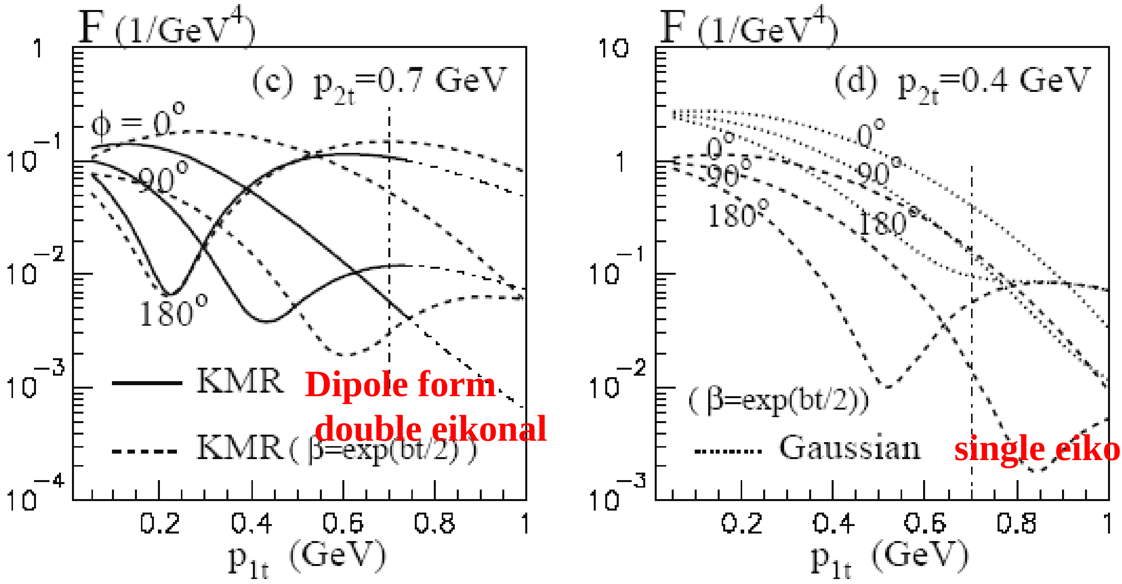
Soft Elastic Opacity

$$F(\vec{p}_{1t},\vec{p}_{2t}) = \frac{\beta^2(t_1)\beta^2(t_2)}{<S^2>\pi^2/b_0^2}S^2(\vec{p}_{1t},\vec{p}_{2t})$$

t – distributions at LHC

Effects of soft proton absorption modulate the hard *t* – distributions

t-measurement will allow to disentangle the effects of soft absorption from hard behavior



Dipole form

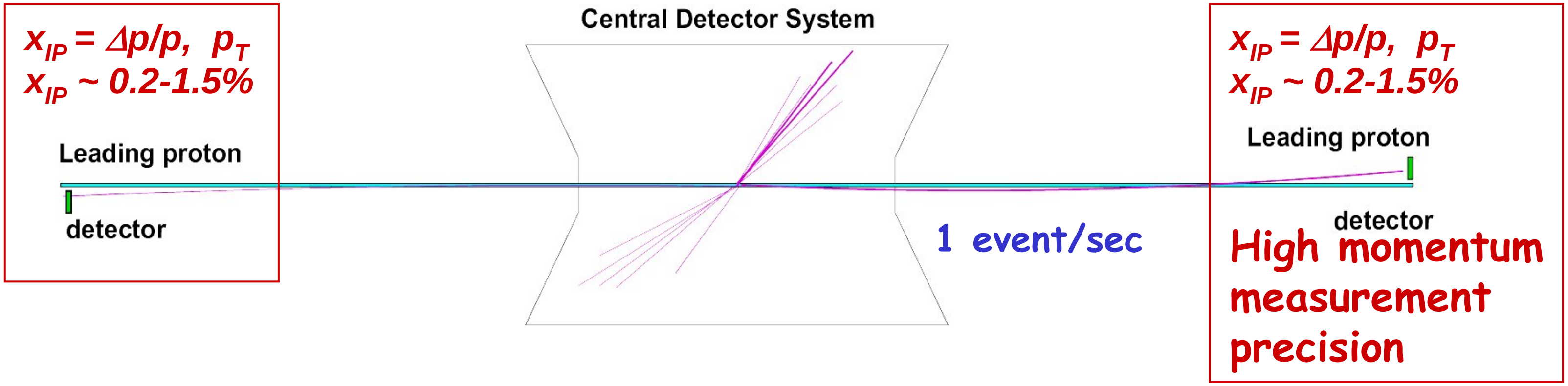
double eikonal

single eikonal

Khoze
Martin
Ryskin

Exclusive Double Diffractive Reactions at LHC

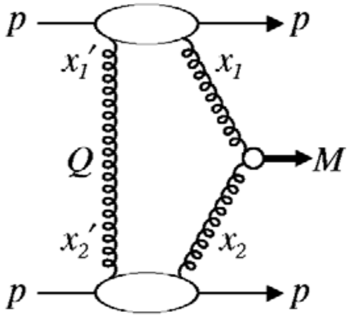
$x_{IP} = \Delta p/p,\ p_T$
$x_{IP} \sim 0.2\text{-}1.5\%$



$x_{IP} = \Delta p/p,\ p_T$
$x_{IP} \sim 0.2\text{-}1.5\%$

1 event/sec

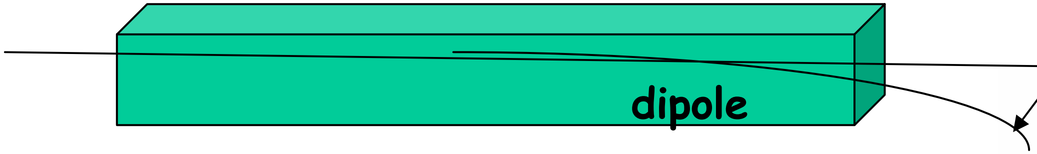
High momentum measurement precision



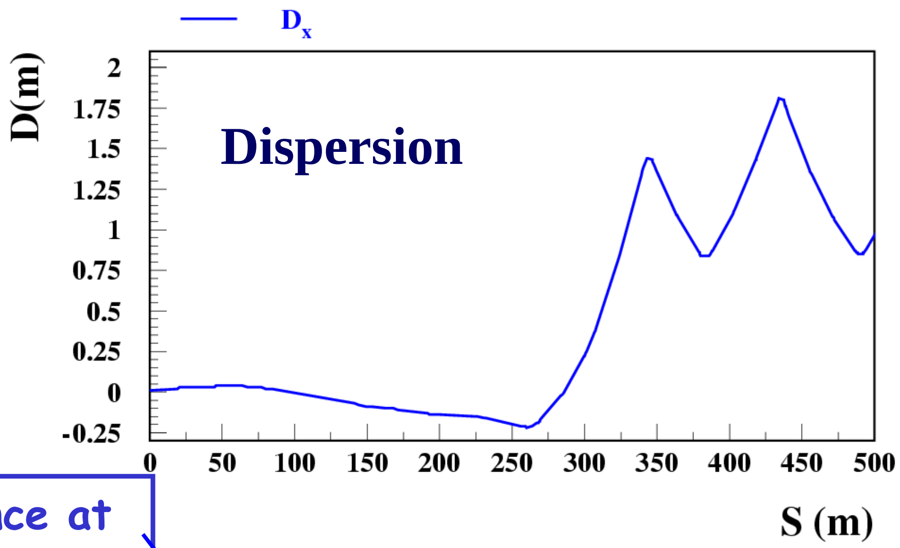
low *x* *QCD* reactions (KMR)

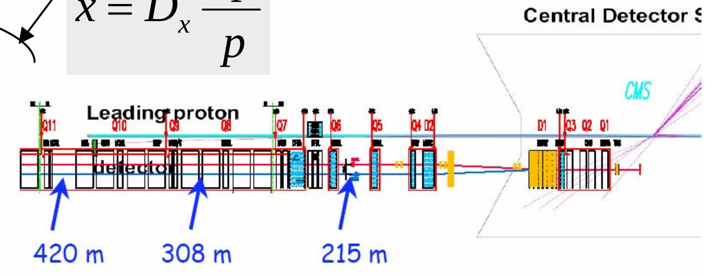
pp => pp + $g_{Jet}\, g_{Jet}$ $\sigma \sim 1$ nb for M(jj) ~ 50 GeV
$\sigma \sim 0.5$ pb for M(jj) ~ 200 GeV
$\eta_{JET}| < 1$

pp => pp + Higgs $\sigma \sim$ O(3) fb SM (inclusive ~ 20 pb)
~ O(100) fb *MSSM*



$$x = D_x \frac{\Delta p}{p}$$



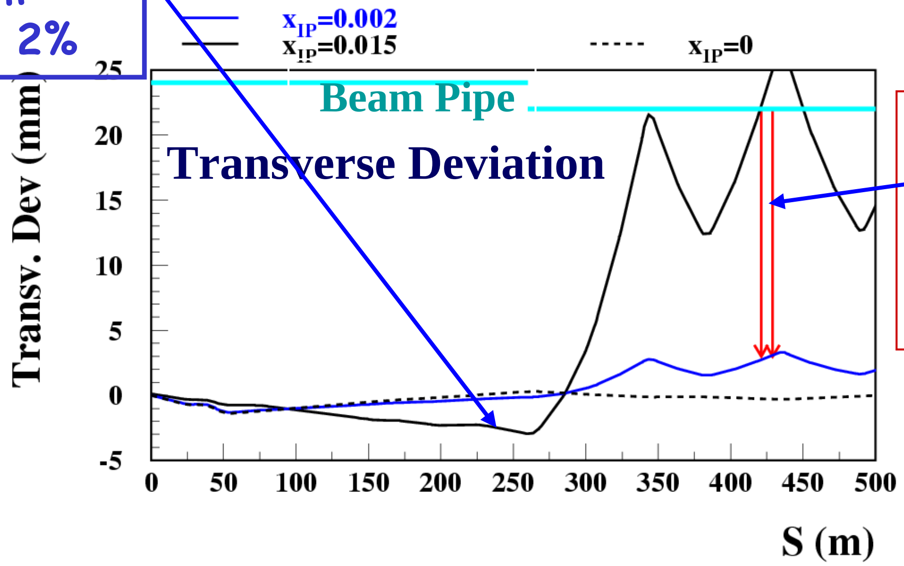


At 420 m

$$\frac{\Delta p}{p} = 0.01 \quad \Rightarrow \quad x = 1.5\,\text{cm}$$

$$\frac{\Delta p}{p} = 0.001 \quad \Rightarrow \quad x = 1.5\,\text{mm}$$

acceptance at 220/240m
x_{IP} ~ 1 - 2%



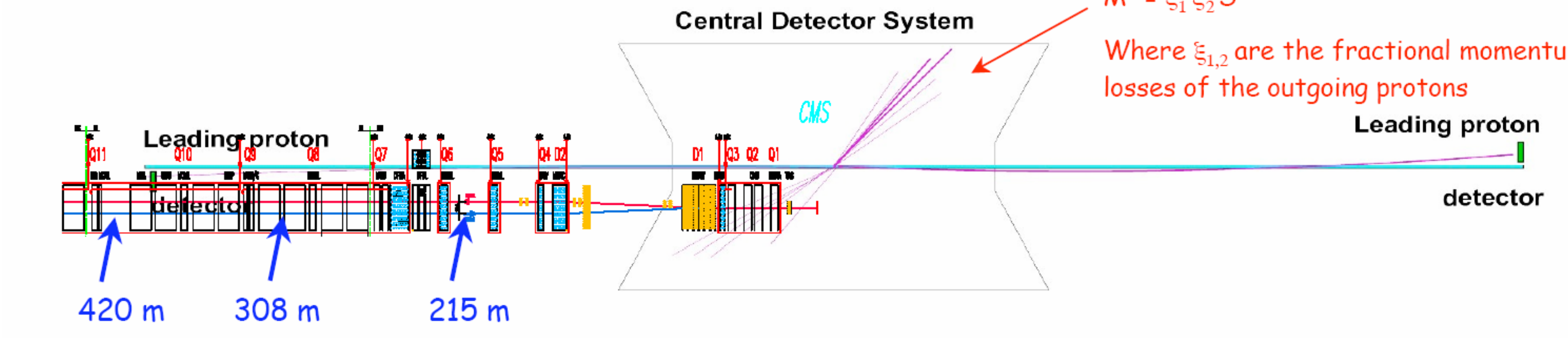
Detector

closest approach
12 σ ~3mm

acceptance at 420m
x_{IP} ~ 0.2 - 1.5 %
t from 0 to ~10 GeV^2

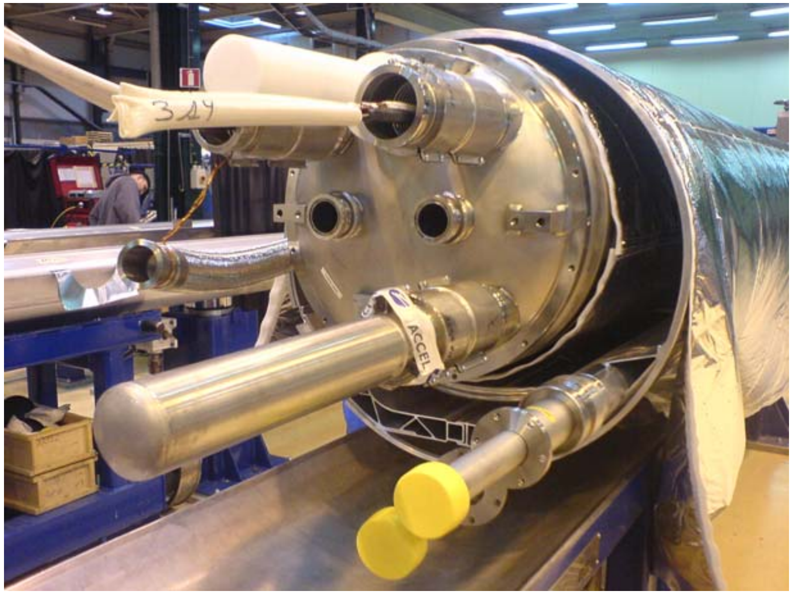
deflection of protons due to main magnets
→
stability against beam tuning effects

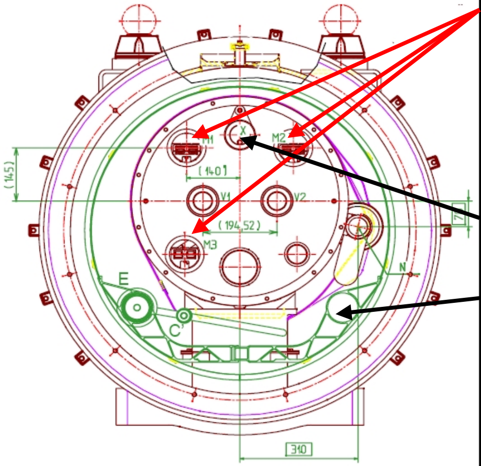
The 420m region at the LHC



$M^2 = \xi_1 \xi_2 S$

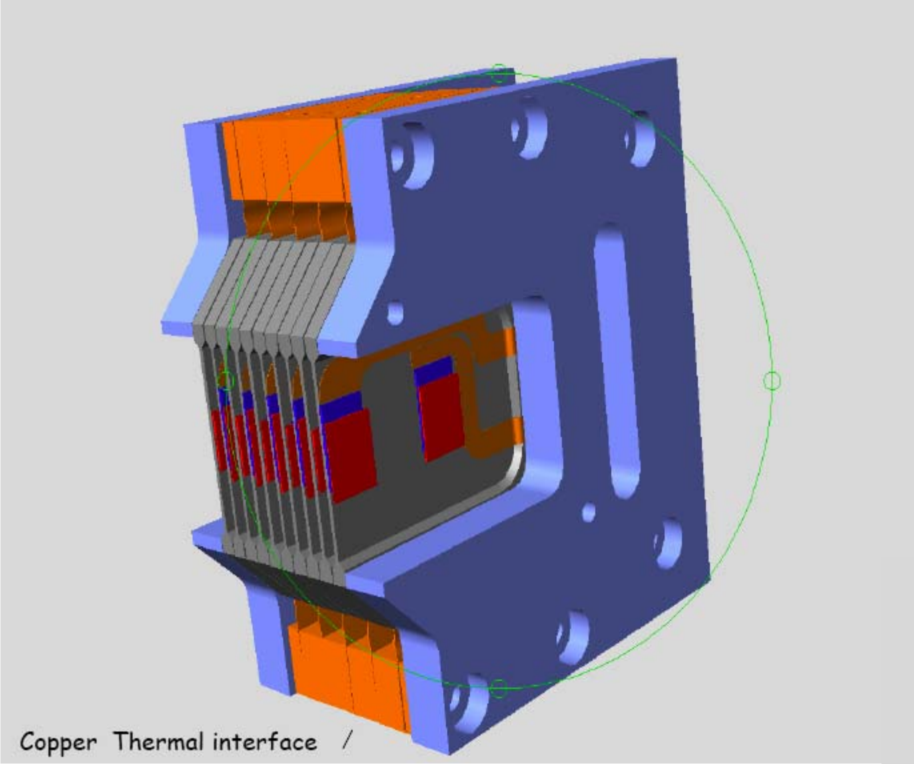
Where $\xi_{1,2}$ are the fractional momentum losses of the outgoing protons





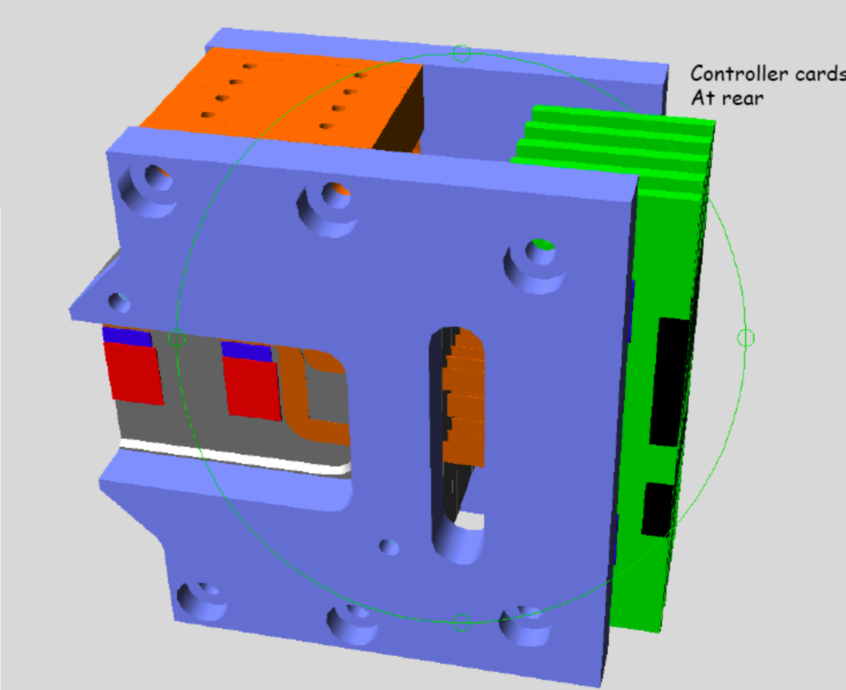
Line	T(K)	$\varnothing_i - \varnothing_e$(mm)
M1,M2,M3 Bus-bars	1.9	80-84
N Auxiliary bus-bars	1.9	50-53
X Heat exchanger	1.8	54-58
E Thermal shield	50-65	79-86
C' Supports posts and beam screens	4.6	15-17.2
V1,V2 He jackets	1.9	50-53 66-70

FP420 Silicon Detector Stations



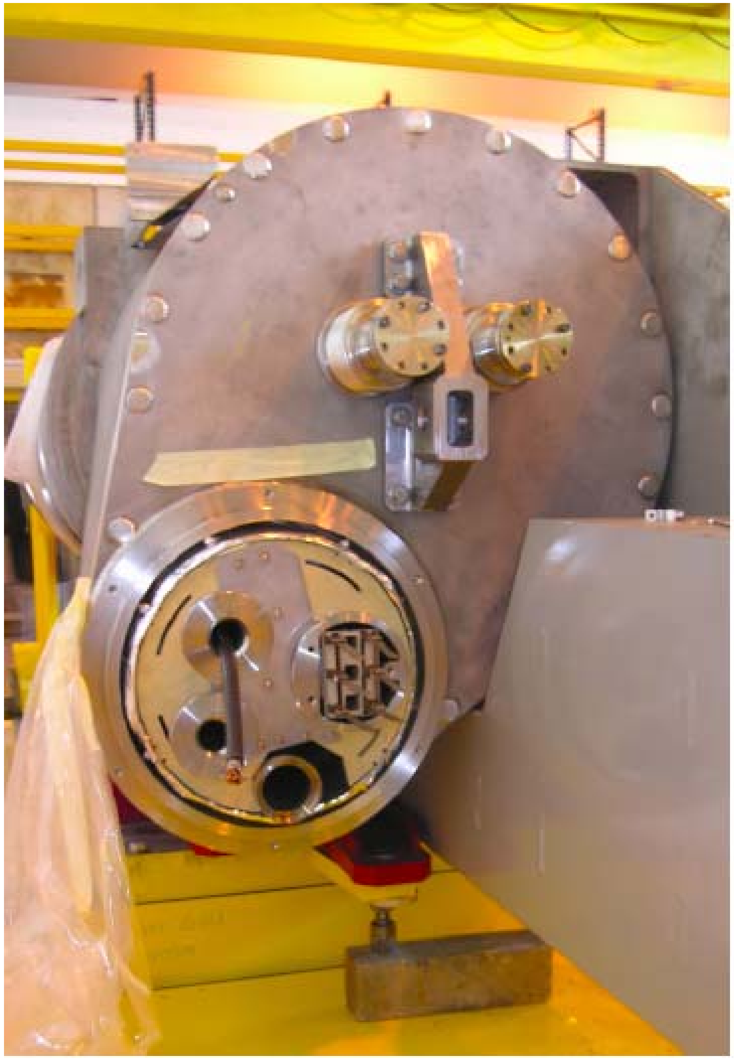
Brunell

Manchester / Mullard Space Sci. Lab



QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

DFB Arc Termination Modules

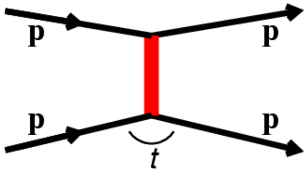


Background Reactions

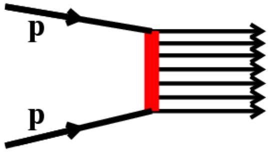
Main limits on the beam lifetime at LHC is due to strong interactions $\sigma_{tot} \sim O(100)$ mb

$$(L = 10^{34}\ \text{cm}^{-2}\ \text{sec}^{-1}) \cdot (\sigma = 100 \cdot 10^{-3} \cdot 10^{-24}\ \text{cm}^2) = 10^9\ \text{events/sec}$$

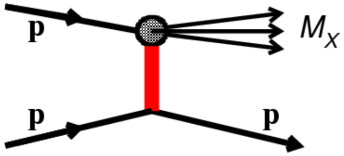
Beam lifetime $2808 \cdot 1.15 \cdot 10^{11} / (2 \cdot 10^9 \cdot 3600) \sim$ **O(40) hours**



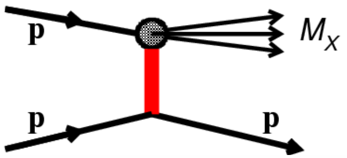
Elastic scattering – $\sigma_{el} \sim O(30)$ mb



Inclusive scattering – $\sigma_{inc} \sim O(50)$ mb



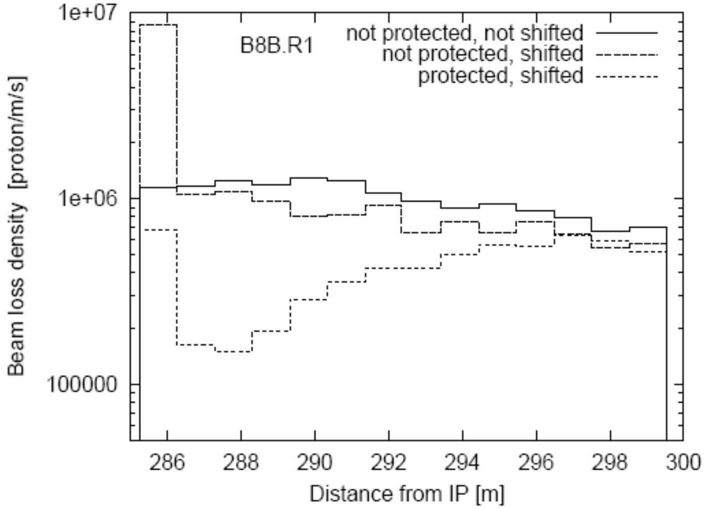
Proton dissociation – $\sigma_{el} \sim 2\ O(10)$ mb for $x_{IP} \sim 1 - 30\ \%$
Main source of the machine background. Leads to a rate of $O(10^8)$ forward protons/sec. Attention!!! It is above the magnet quench limit of $8\ 10^6$ protons/m/sec

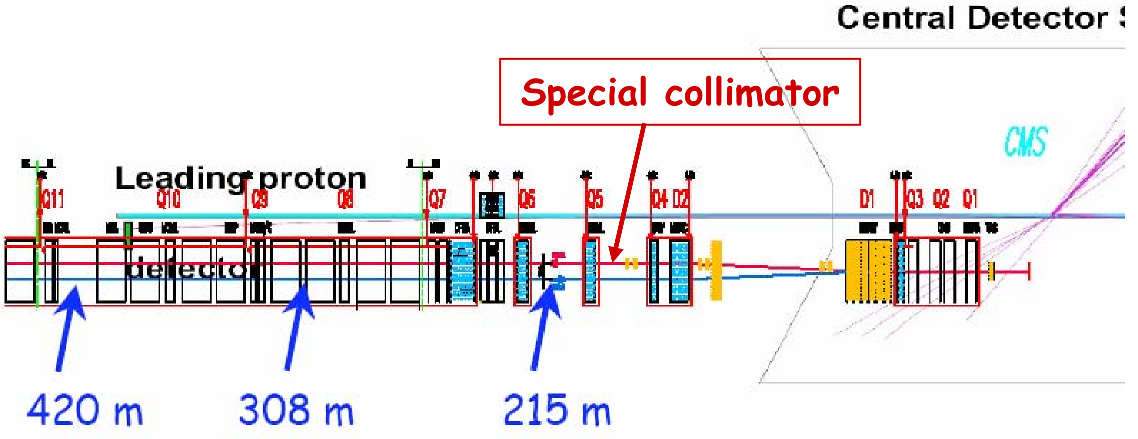


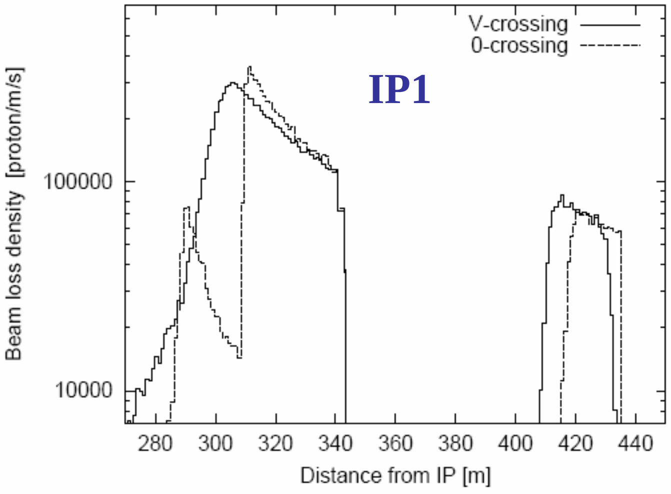
Machine background from proton dissociation reactions

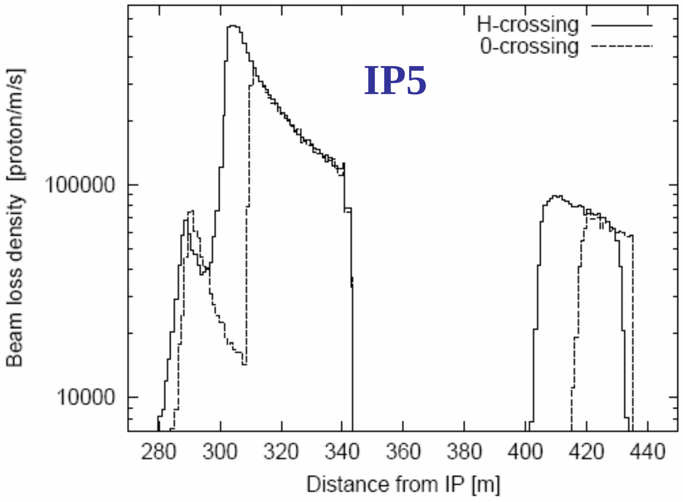
LHC Project Note 240, 208

I. Baishev, J.B. Jeanneret, G.R. Stevenson

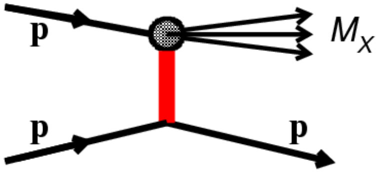






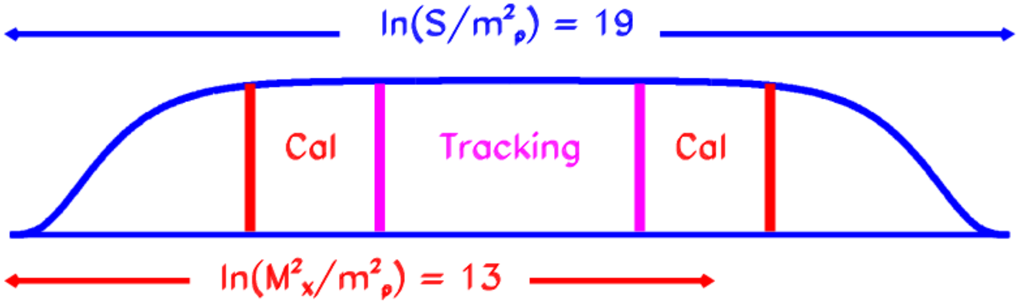


Physics background from proton dissociation reactions

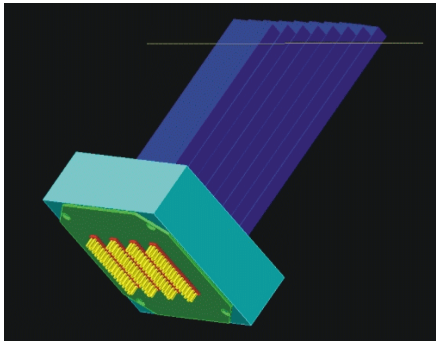


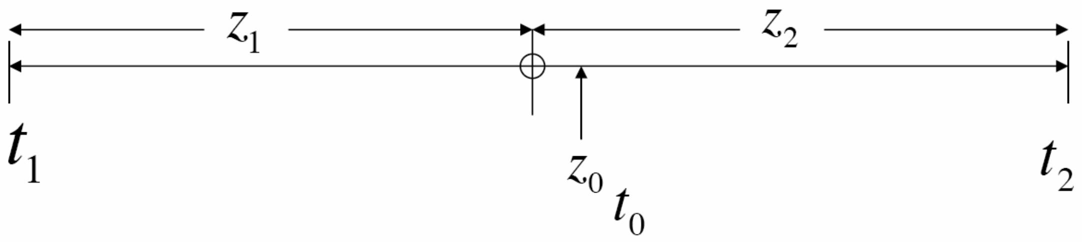
420 m detector sees protons with x_{IP} ~ *0.2 – 1.5 %* and σ_{dis} ~ 3 mb ~
At luminosity of 10^{34} s^{-1} cm^{2} there will be ~3 10^{7} protons/sec
~ *1 proton per bunch crossing*

However, these protons are produced in a *soft interaction* together with a particle cloud of a mass M_X ~ *700 - 1700 GeV*. Such a large mass cannot escape undetected in the central detector.



FP420 Fast timing Detectors





$$t_1 - t_0 = \frac{c}{|z_1| + z_0}\ ; \quad t_2 - t_0 = \frac{c}{|z_2| - z_0}$$

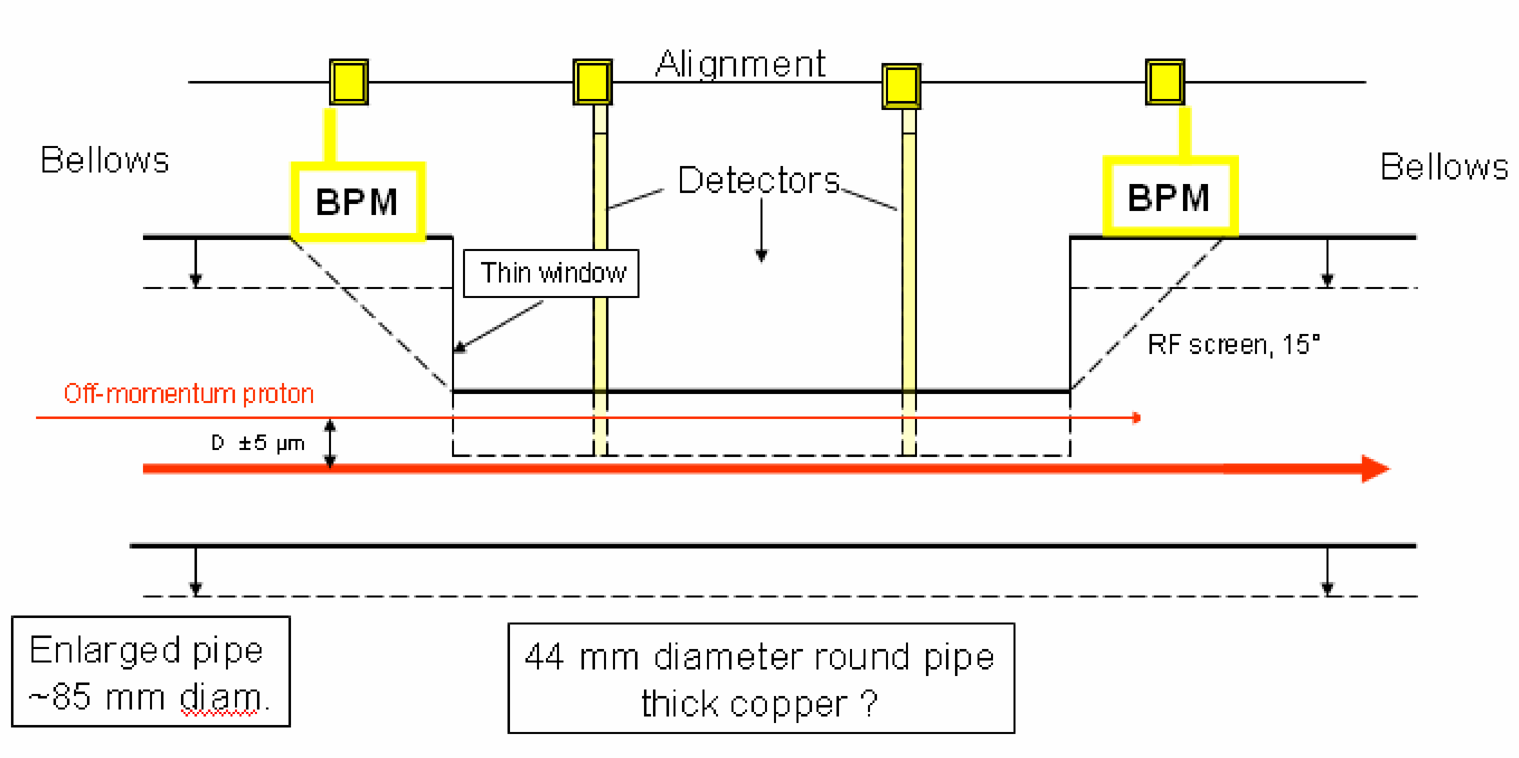
($|z_i|$ are distances but z_0 is signed)

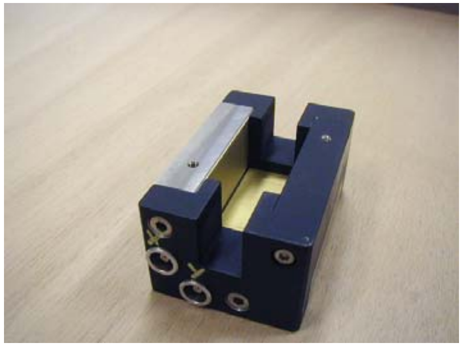
Stating the obvious, but ➡ $$z_0 = \left(\frac{c}{2}\right) \times \left(\frac{1}{t_1 - t_0} + \frac{1}{t_2 - t_0}\right)$$

if $z_1 = z_2$

- 1% events at LHC have diffractive proton track in FP420
- @ 2 x 10^{33} cm^{-2}s^{-1}, 7 interactions / bunch crossing
- -> 30% of FP420 events have an additional track
- Matching mass and rapidity of central system removes large fraction of these
- Of the remaining, 97.4% rejected by fast timing detectors with 10ps timing resolution (2.1 mm) .

FP420 alignment



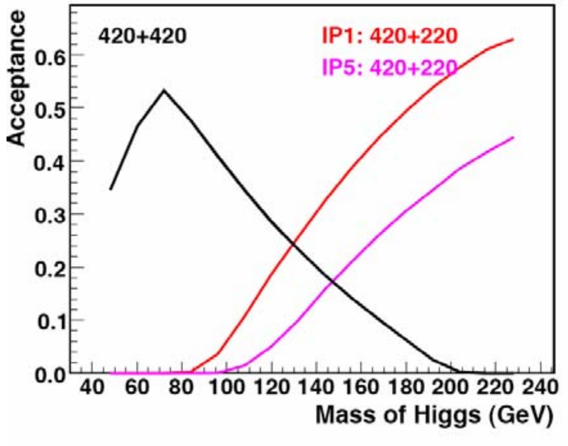


5 μm will be possible - test bench under construction at CERN

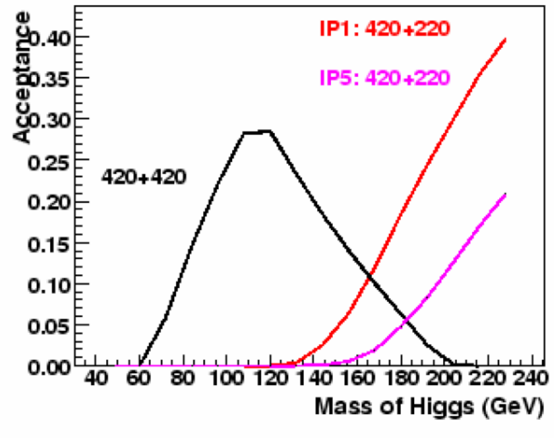
Intrinsic Higgs mass resolution: ~ 5μm/1.5cm ~ 3 x10^{-4}

Helene Mainaud-Durand, CERN

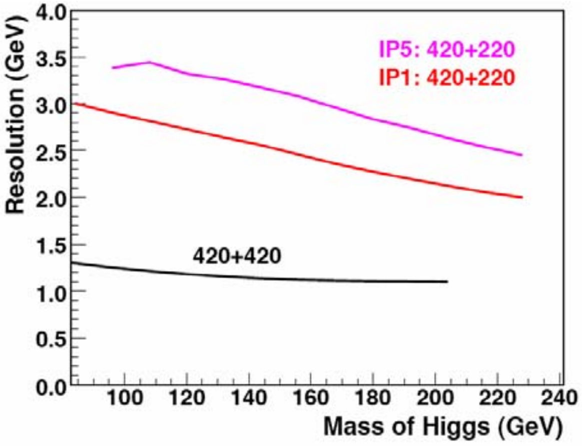
FP420 Acceptance and Resolution

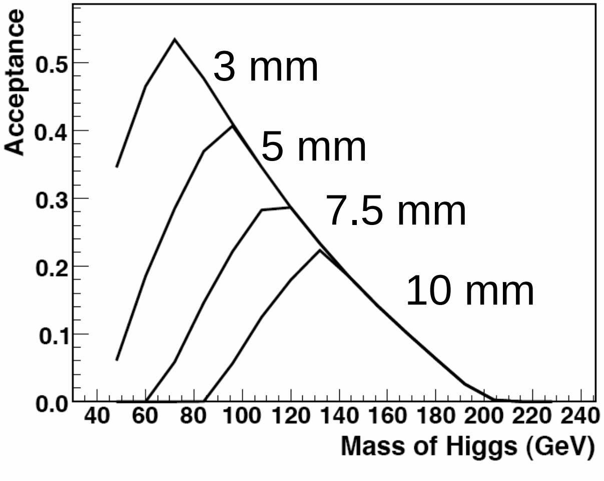


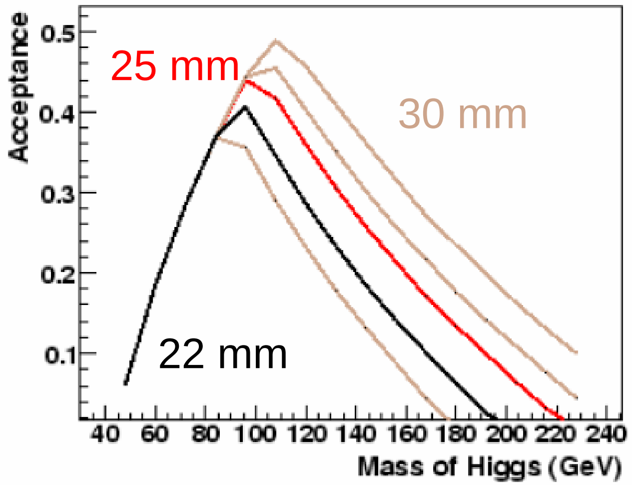
3 mm + 3 mm



7.5 mm + 3 mm







MB apertures

Plots : P. Bussey using ExHuME / FPTrack

Precise measurement of the Higgs Mass

New Physics in Diffraction?

J. Ellis, HERA-LHC Workshop

Higher symmetries (e.g. Supersymmetry) lead to existence of *several* scalar, neutral, *Higgs states*, H, h, A . . . . Higgs Hunter Guide, Gunnion, Haber, Kane, Dawson 1990

In MSSM *Higgs x-section* are likely to be much *enhanced* as compared to Standard Model (tanβ large because $M_{Higgs} > 115$ GeV)

CP violation is highly probable in MSSM → all *three* neutral Higgs bosons have *similar masses* ~120 GeV →

can ONLY be RESOLVED in DIFFRACTION

Ellis, Lee, Pilaftisis Phys Rev D, 70, 075010, (2004) , hep-ph/0502251

Correlation between *transverse momenta* of the tagged *protons* give a handle on the CP-violation in the Higgs sector

Khoze, Martin, Ryskin, hep-ph 040178

FP420 Physics Highlights

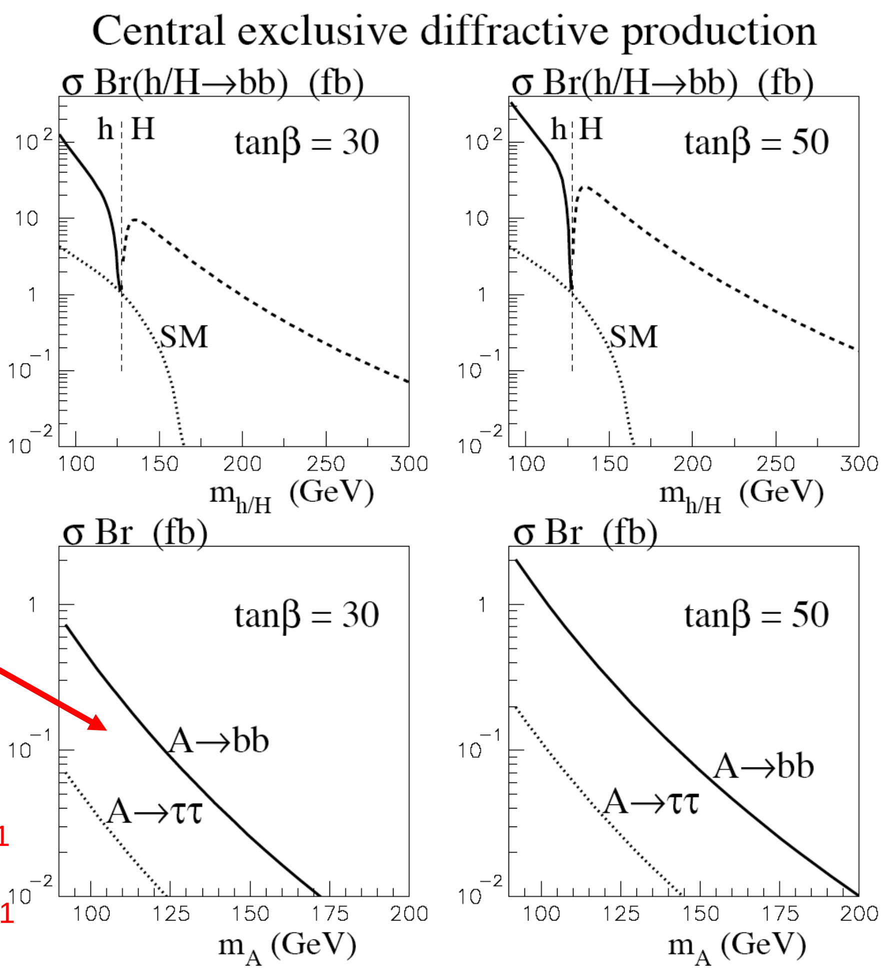
The intense coupling regime is where the masses of the 3 neutral Higgs bosons are close to each other and tan β is large

$\gamma\gamma, WW^{\star}, ZZ^{\star}$ suppressed

$gg \rightarrow \phi$ enhanced

0^{++} selection rule suppresses A production:

CEDP 'filters out' pseudoscalar production, leaving pure H sample for study


Central exclusive diffractive production

M_A = 130 GeV, tan β = 50

M_h = 124 GeV : 71 signal / 10 background in 30 fb^{-1}

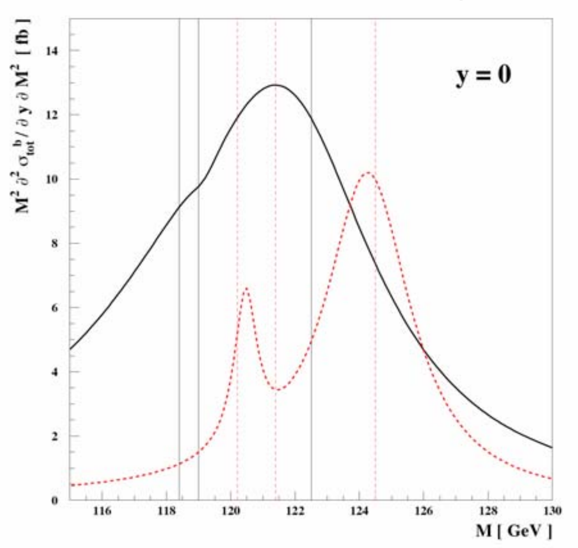
M_H = 135 GeV : 124 signal / 5 background in 30 fb^{-1}

M_A = 130 GeV : 1 signal / 5 background in 30 fb^{-1}

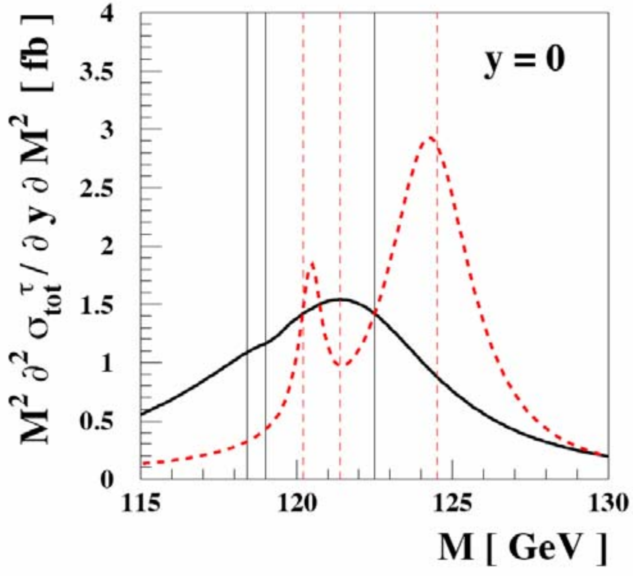
Well known difficult region for conventional channels, tagged channel may well be the discovery channel, and is certainly a powerful spin/parity filter

CP violation in the Higgs Sector

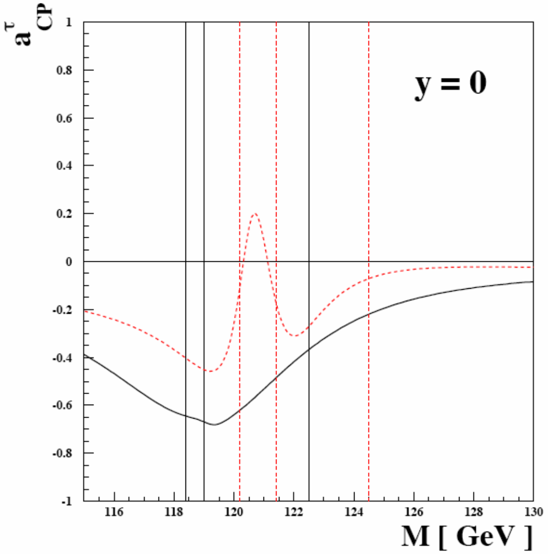
bb decay



ττ decay



ττ decay

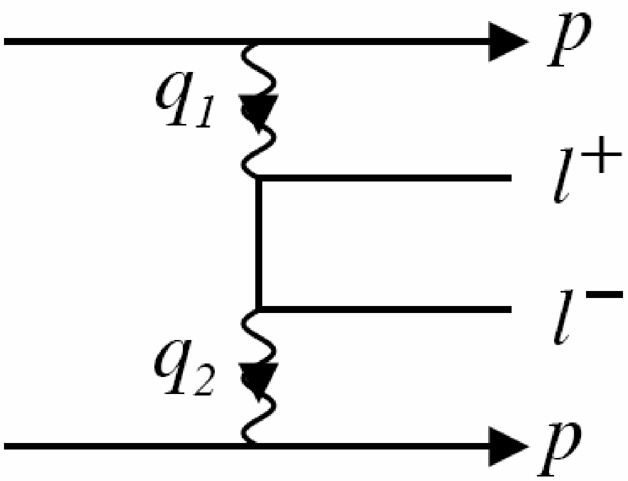


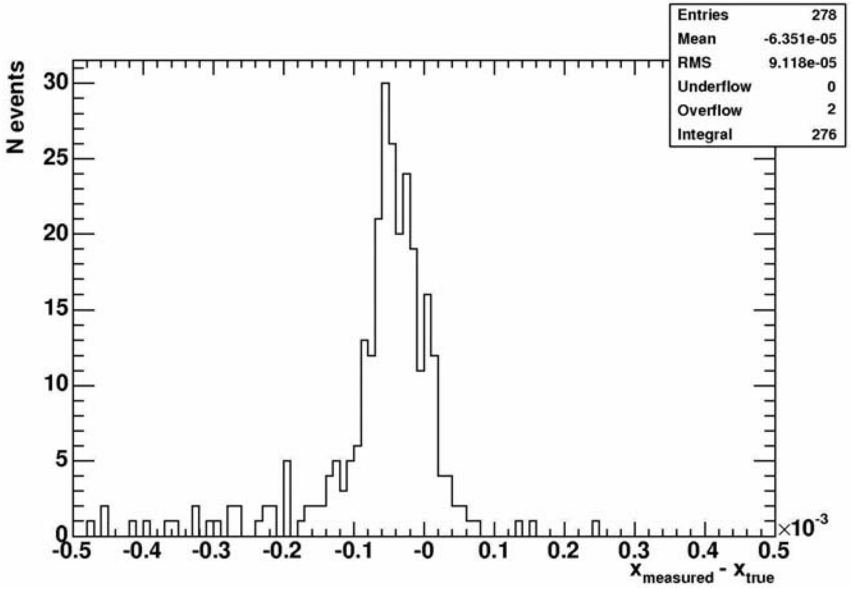
This example shows that exclusive double diffraction may offer unique possibilities for exploring Higgs physics in ways that would be difficult or even impossible in inclusive Higgs production. In particular, we have shown that exclusive double diffraction constitutes an efficient CP and lineshape analyzer of the resonant Higgs-boson dynamics in multi-Higgs models. In the specific case of CP-violating MSSM Higgs physics discussed here, which is potentially of great importance for electroweak baryogenesis, diffractive production may be the most promising probe at the LHC.

J. Ellis et al hep-ph/0502251

Louvain

FP420 alignment





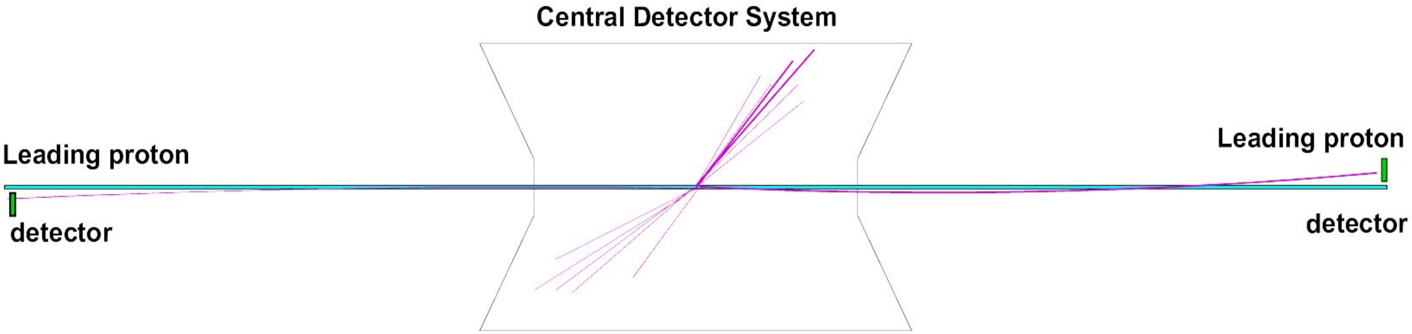
- @ 1 x 10^{33} cm^{-2} s^{-1} expect ~ 100 $\mu^+\mu^-$ events / fill with standard trigger thresholds

- Simulations (Louvain) indicate precision is better than necessary (theoretical limit is LHC beam energy uncertainty , σ_0 = 0.77 GeV ~ 50 microns)

(also $\gamma\gamma WW$, $M_{\gamma\gamma} > 200$ GeV, $\sigma \sim 100$ fb -> very high sensitivity to anomalous quartic couplings)

Diffractive Trigger

Example: central exclusive diffractive jet-jet system, $|\eta_{JET}| < 1$



Rapidity Gap Trigger - effective up to luminosity of 0.5×10^{33} cm^{-2} sec^{-1}
ATLAS L1: no hits in the end-caps, $2 < |\eta| < 4$, threshold ~1 GeV in p_T
~6 particles/ per unit of rap expected with $p_T > 1$ GeV (Pythia)
suppression factor O(10^{11})

Veto on LUCID - suppression factor O(10^3)

Physical importance: clean source of gluon jets
X-section closely related to diffractive Higgs

Diffractive Trigger

Example: diffractive Higgs production in CMS
(INFN investigation)

Up to 20% of bb Higss decay events can be saved with μ triggers of the central detector at all luminosities,
WW(*) channels have high trigger efficiency.

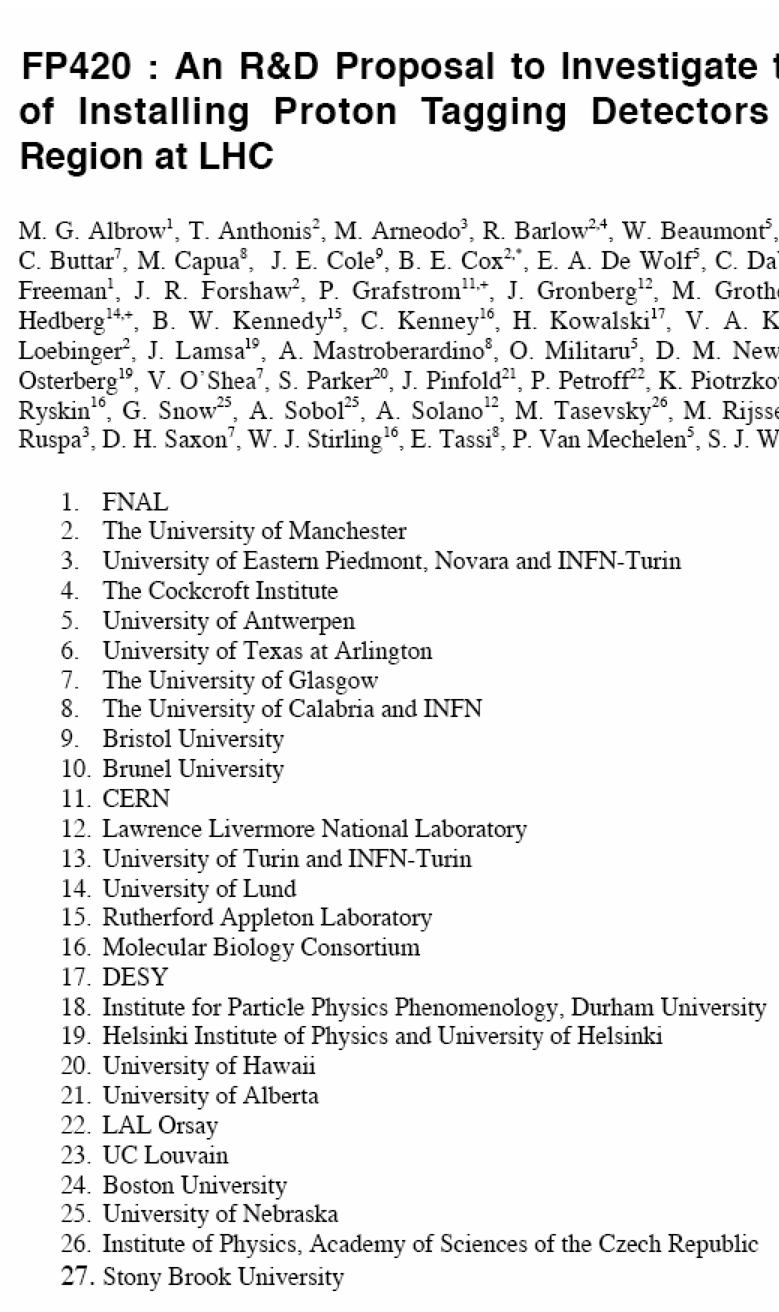
Rapidity Gap Trigger - effective up to luminosity of ~ 10^{32}

Trigger Tag at 220m + topological cuts - effective up to luminosity of $2\text{x}10^{33}$ (CMS)

Trigger with 420m counters require increase in latency from 3 to 4 μs

remark about ATLAS
220/240m counters more effective in the IP1 than in IP5 region

FP420 Collaboration



FP420 : An R&D Proposal to Investigate the Feasibility of Installing Proton Tagging Detectors in the 420m Region at LHC

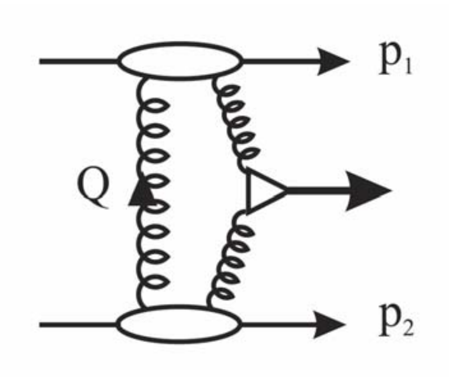
M. G. Albrow[1], T. Anthonis[2], M. Arneodo[3], R. Barlow[2,4], W. Beaumont[5], A. Brandt[6], P. Bussey[7], C. Buttar[7], M. Capua[8], J. E. Cole[9], B. E. Cox[2,*], E. A. De Wolf[5], C. DaVia[10], A. DeRoeck[11,*], J. Freeman[1], J. R. Forshaw[2], P. Grafstrom[11,+], J. Gronberg[12], M. Grothe[13], G. P. Heath[9], V. Hedberg[14,+], B. W. Kennedy[15], C. Kenney[16], H. Kowalski[17], V. A. Khoze[18], Y. Liu[5], F. K. Loebinger[2], J. Lamsa[19], A. Mastroberardino[8], O. Militaru[5], D. M. Newbold[9,15], R. Orava[19], K. Osterberg[19], V. O'Shea[7], S. Parker[20], J. Pinfold[21], P. Petroff[22], K. Piotrzkowski[23], J. Rohlf[24], M. G. Ryskin[16], G. Snow[25], A. Sobol[25], A. Solano[12], M. Tasevsky[26], M. Rijssenbeek[27], L. Rurua[5], M. Ruspa[3], D. H. Saxon[7], W. J. Stirling[16], E. Tassi[8], P. Van Mechelen[5], S. J. Watts[10]

1. FNAL
2. The University of Manchester
3. University of Eastern Piedmont, Novara and INFN-Turin
4. The Cockcroft Institute
5. University of Antwerpen
6. University of Texas at Arlington
7. The University of Glasgow
8. The University of Calabria and INFN
9. Bristol University
10. Brunel University
11. CERN
12. Lawrence Livermore National Laboratory
13. University of Turin and INFN-Turin
14. University of Lund
15. Rutherford Appleton Laboratory
16. Molecular Biology Consortium
17. DESY
18. Institute for Particle Physics Phenomenology, Durham University
19. Helsinki Institute of Physics and University of Helsinki
20. University of Hawaii
21. University of Alberta
22. LAL Orsay
23. UC Louvain
24. Boston University
25. University of Nebraska
26. Institute of Physics, Academy of Sciences of the Czech Republic
27. Stony Brook University

"The panel believed that this offers a unique opportunity to extend the potential of the LHC and has the potential to give a high scientific return." - UK PPRP (PPARC)

R&D now fully funded : £500k from UK (Silicon, detector stations, beam pipe + LHC optics and cryostat design),
$100k from US (QUARTIC),
€100k Belgium (+Italy / Finland) (mechanics)

!!!
Detectors at 420m are in the process of becoming an official ATLAS Upgrade Program



Summary

Central system produced in exclusive hard diffraction reactions is, to a good approximation, 0^{++} . A new states produced with proton tags has therefore know quantum numbers.

- CP violation in the Higgs sector shows up directly as azimuthal asymmetries
- Proton tagging may be the discovery channel in certain regions of the MSSM
- Tagging the protons means excellent mass resolution irrespective of the decay products of the central system
- Diffractive LHC ~ Gluon Collider – pure gluon jets

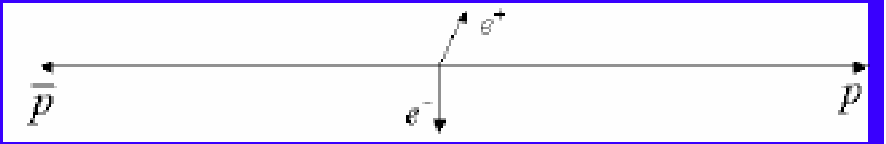
- ATLAS Upgrade Program in 420m region is in preparation

CDF II Preliminary

CDF Blessed this morning!

10 GeV $< M_{\gamma\gamma} <$ 20 GeV

Exclusive e^+e^- pairs



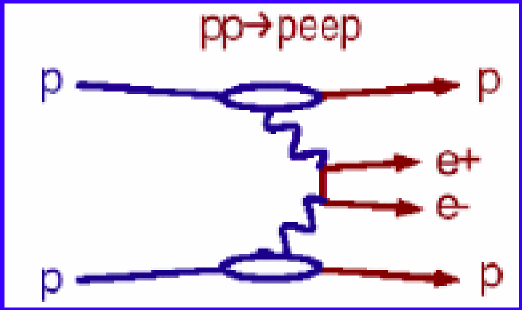
16 events observed

Estimated background $= 2.1^{+0.6}_{-0.3}$

(mostly p-dissociation)

$\sigma_{MEAS.} = 1.6\ ^{+0.5}_{-0.3}$ (stat) $\pm\, 0.3$ (syst) pb

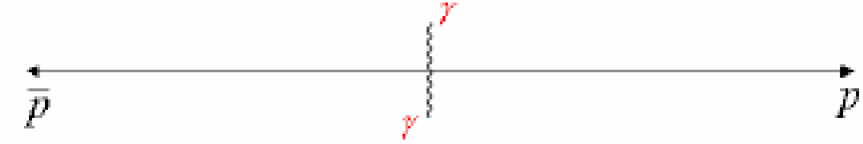
Poisson Prob. $= 3\times10^{-8} \approx 5.5\sigma$



QED: LPAIR Monte Carlo

$\sigma_{\mathrm{QED}} = (1.711 \pm 0.008)$ pb

Exclusive $\gamma\gamma$ pairs



3 events observed

Estimated background $= 0.0\ ^{+0.3}_{-0.0}$ events

(p-dissociation, exclusivity, fakes)

$\sigma_{MEAS.} = 0.14\ ^{+0.14}_{-0.04}$ (stat) $\pm\, 0.03$ (syst) pb

Poisson Prob.$(0.3 \rightarrow \geq 3) = 3.6\times10^{-3}$

(conservative)

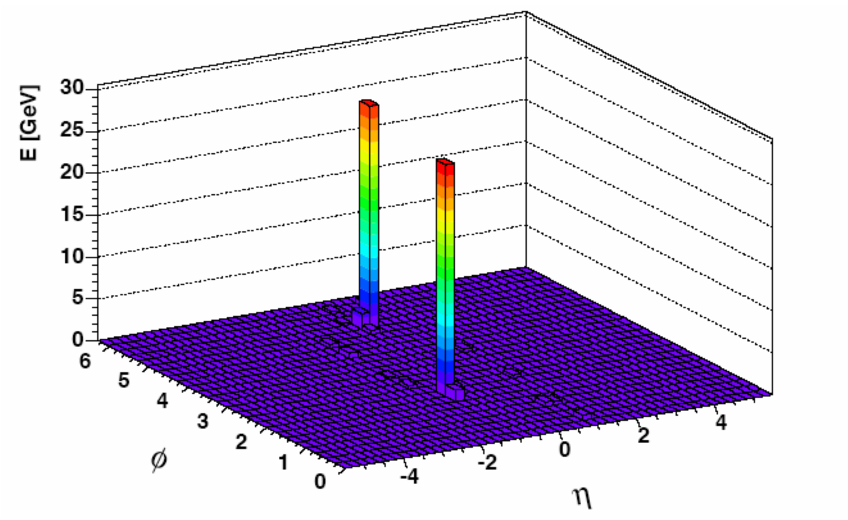
KMR (Durham) prediction $= 0.04 \times\!\div (3\text{-}5)$ pb

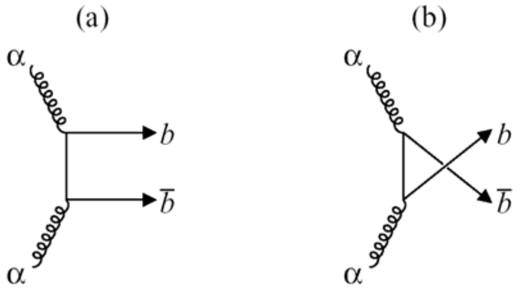
Note : $\sigma_{MEAS} \approx 2\times10^{-12}\, \sigma_{INEL}$!

It means exclusive H must happen (if H exists) and probably $\sigma \sim 10$ fb within factor ~ 2.5.

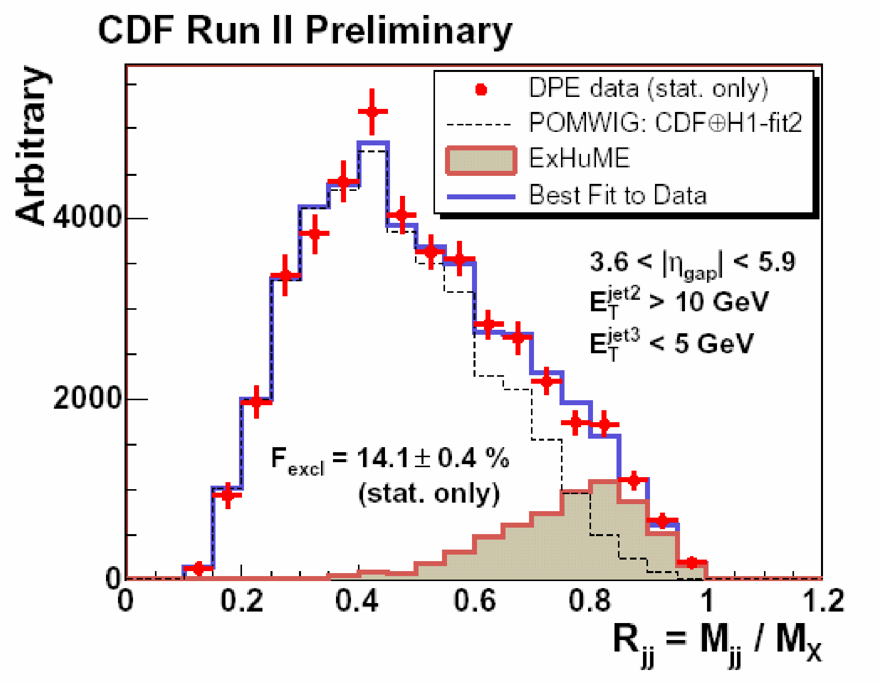
σ higher in MSSM

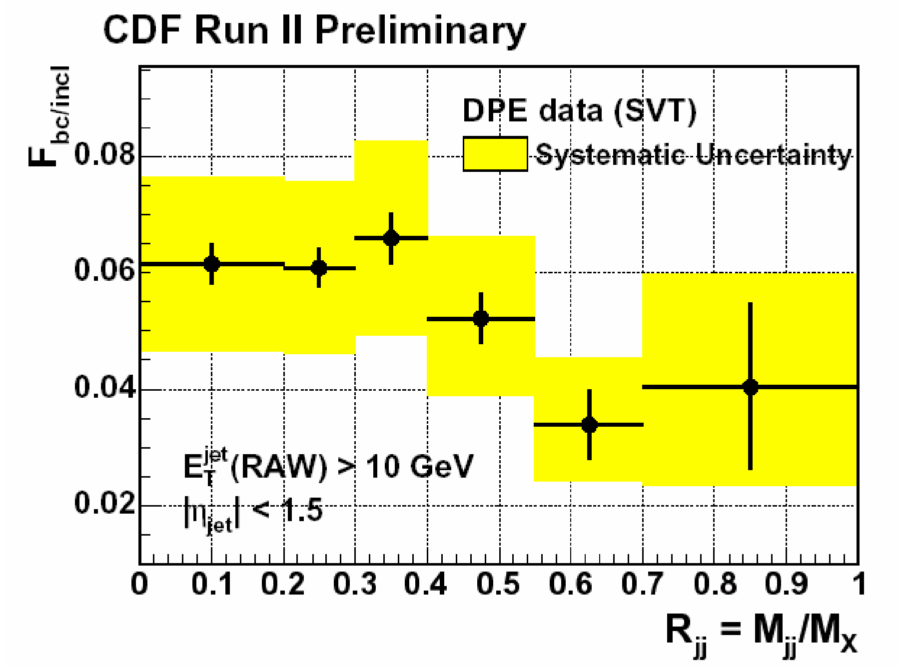
Evidence for Exclusive Production





J_Z=0 -> for colour singlet bbar production, the born level contributions of a) and b) cancel in the limit m_b -> 0





Coasted Beam Optics

x - transverse deviation from the beam position

x' - transverse angular deviation

Transport Matrix
(from text books)

$$\begin{pmatrix} x \\ x' \\ \xi \end{pmatrix} = \begin{pmatrix} \sqrt{\frac{\beta}{\beta_0}}(\cos\Psi + \alpha_0 \sin\Psi) & \sqrt{\beta\beta_0}\sin\Psi & D \\ \frac{(\alpha_0 - \alpha)\cos\Psi - (1+\alpha_0\alpha)\sin\Psi}{\sqrt{\beta\beta_0}} & \sqrt{\frac{\beta_0}{\beta}}(\cos\Psi - \sin\Psi) & D' \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} x_0 + 0 \\ x_0' + \theta \\ \xi_0 - x_{IP} \end{pmatrix}$$

observation point

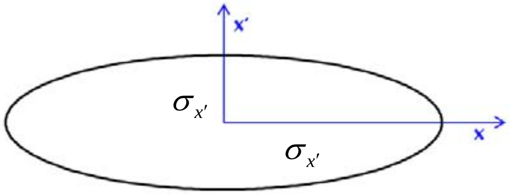
interaction point

e.g. P.Schmueser in CERN 94-01

β-amplitude function, Ψ-phases, D-dispersion can be obtained from the LHC Optic Webpage

Coasted beam optics is considerably easier to handle than ray tracking in MAD

x , x' are moving on
Phase Ellipse



$\alpha \neq 0$

$$\sigma_x = \sqrt{\varepsilon\beta_x} \qquad \sigma_{x'} = \sqrt{\frac{\varepsilon(1+\alpha_x^2)}{\beta_x}}$$

LHC High Luminosity Optics

Interaction point

$$\beta_x = \beta_y = 0.55\,\mathrm{m} \qquad \varepsilon_N = 3.75\,\mu\mathrm{rad}\cdot\mathrm{m}$$

$$\sigma_x = \sigma_y = \sqrt{\varepsilon\beta} = 16.6\,\mu\mathrm{m} \qquad \varepsilon = \varepsilon_N / \gamma$$

$$\sigma_{x'} = \sigma_{y'} = \sqrt{\frac{\varepsilon(1+\alpha^2)}{\beta}} = 30.2\,\mu\mathrm{rad}$$

=> p_T~ 200 MeV

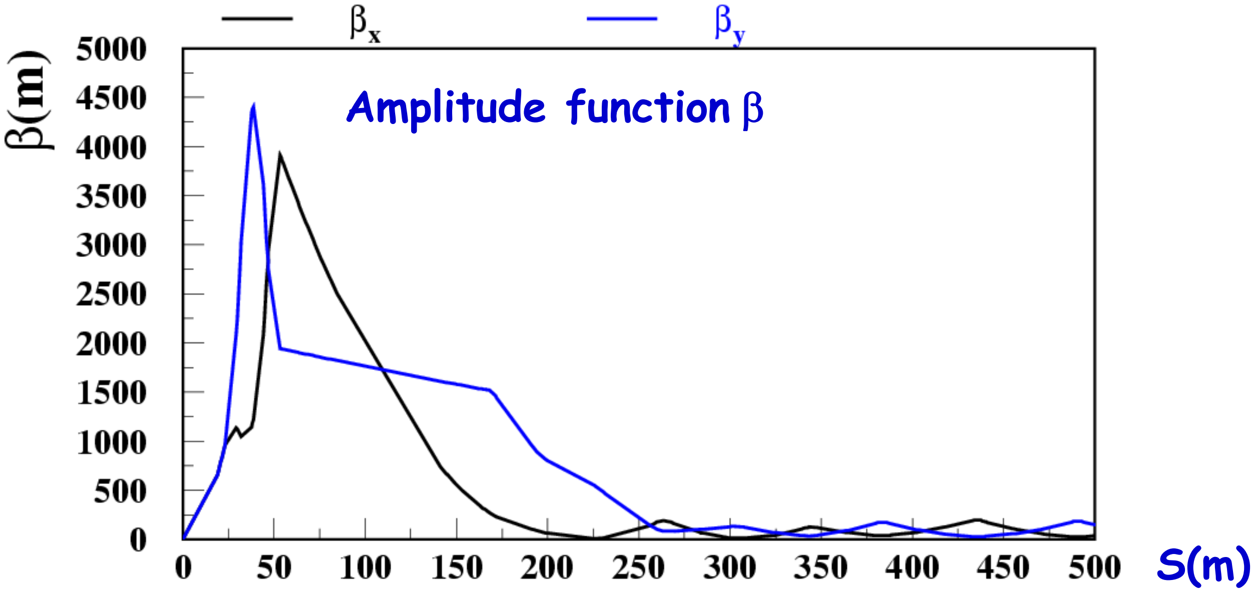
420 m point

$$\beta_x = 130\,\mathrm{m} \qquad \beta_y = 50\,\mathrm{m}$$

$$\sigma_x = 250\,\mu\mathrm{m} \qquad \sigma_y = 160\,\mu\mathrm{m}$$

$$\sigma_{x'} = 4.5\,\mu\mathrm{rad} \qquad \sigma_{y'} = 4.5\,\mu\mathrm{rad}$$

LHC HL Optics: transverse deviations are magnified, angular deviations are diminished



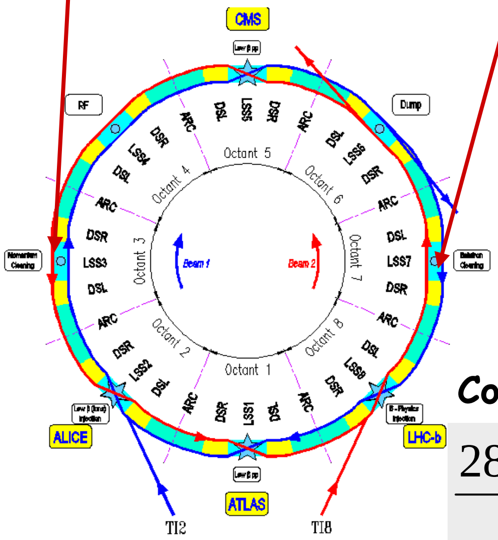
Beam Halo background from beam-beam tune shift

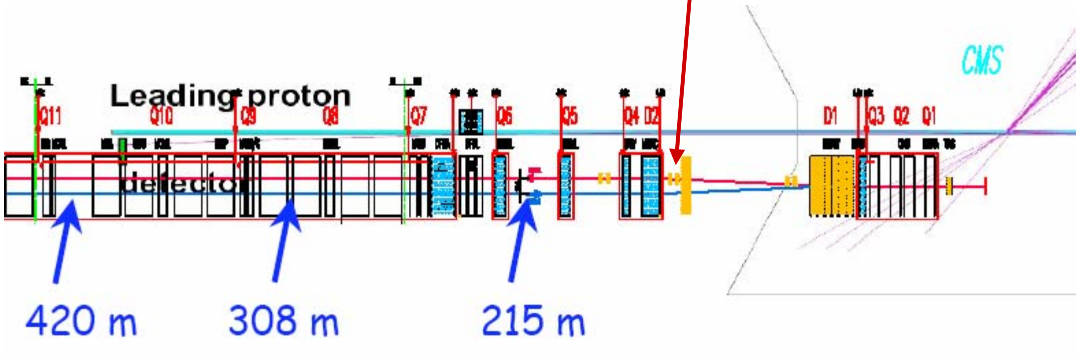
In bunch-bunch collision the particle of one bunch see the other bunch as a nonlinear lens.
Focusing properties are changing => protons of large amplitude
are getting out of tune after many crossings

Estimate of the proton loss: # protons / beam lifetime (40h)

Primary and secondary collimators
beam scratched to 6 and 7 σ

New tertiary collimators





Collimator cleaning inefficiency after 10 σ ~ 4 10^{-4}

$$\frac{2808\cdot 1.15\cdot 10^{11}\cdot 0.63\cdot 4\cdot 10^{-4}}{40\cdot 3600}=0.5\cdot 10^{6}\ \text{protons/sec}$$

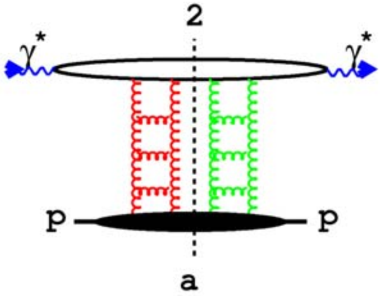
1 beam halo proton per ~80 bunches at the top luminosity
Presumably even considerably smaller in the 420m region,
in the shadow of the incoming collimator, after D2 (R. Assmann)

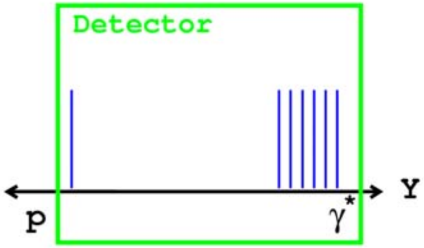
Multiple Interactions and Long Range Correlation

2-Pomeron exchange in QCD

Final States (naïve picture)

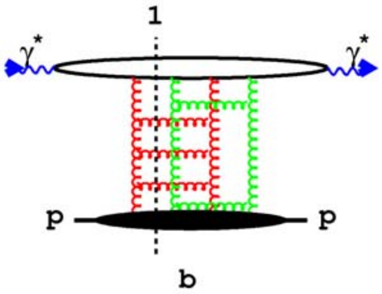
0-cut

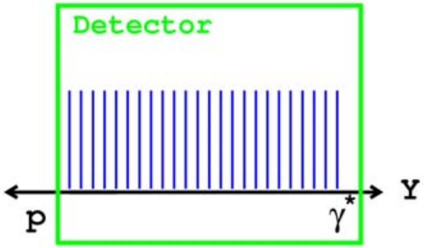




Diffraction

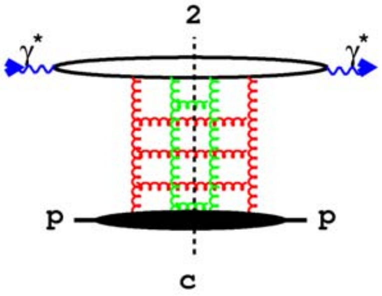
1-cut

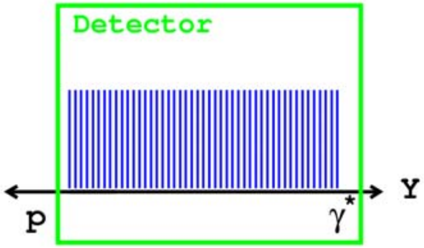




<n>

2-cut





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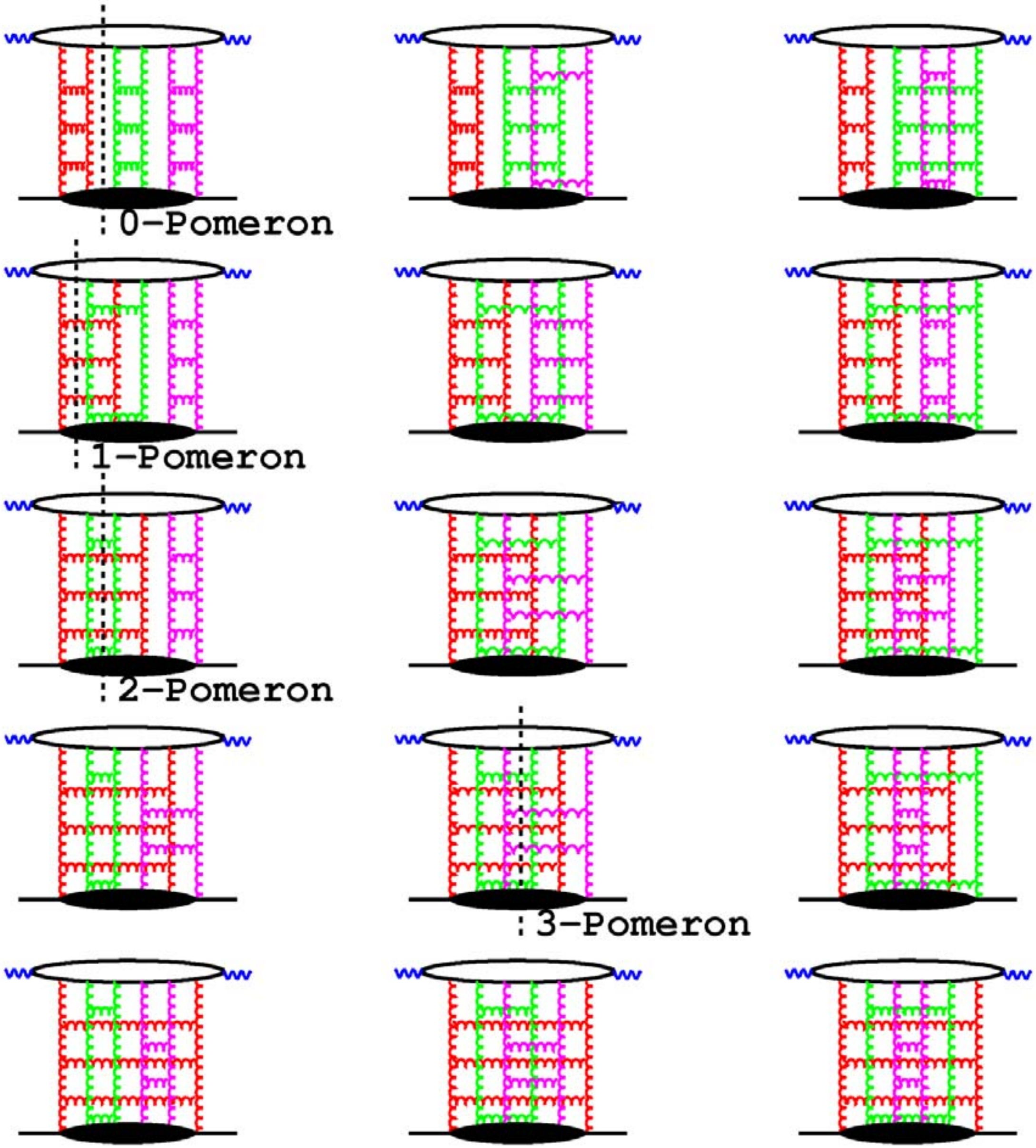
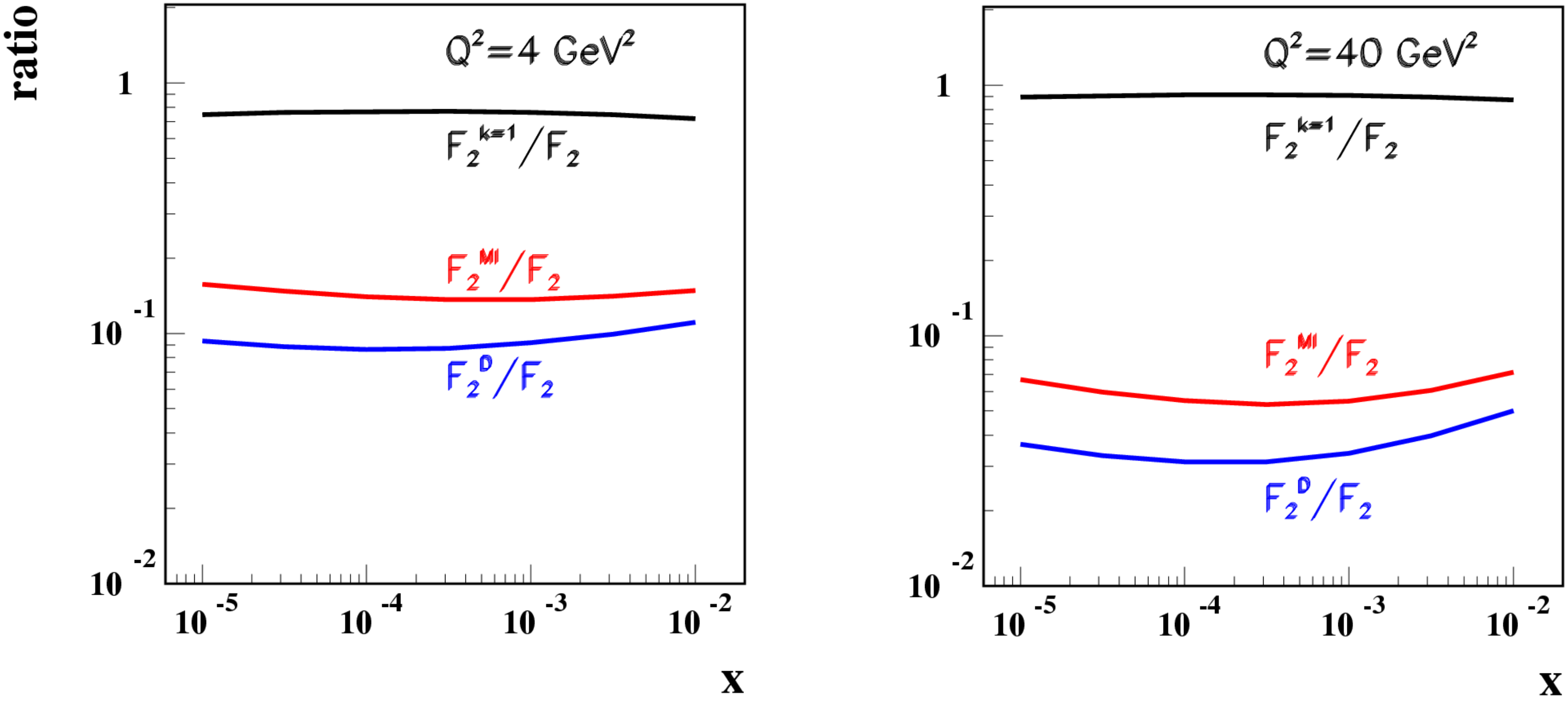
QCD diagrams



AGK rules in the Dipole Model

$$\frac{d\sigma_k}{d^2b} = \frac{\Omega^k}{k!}\exp(-\Omega)$$

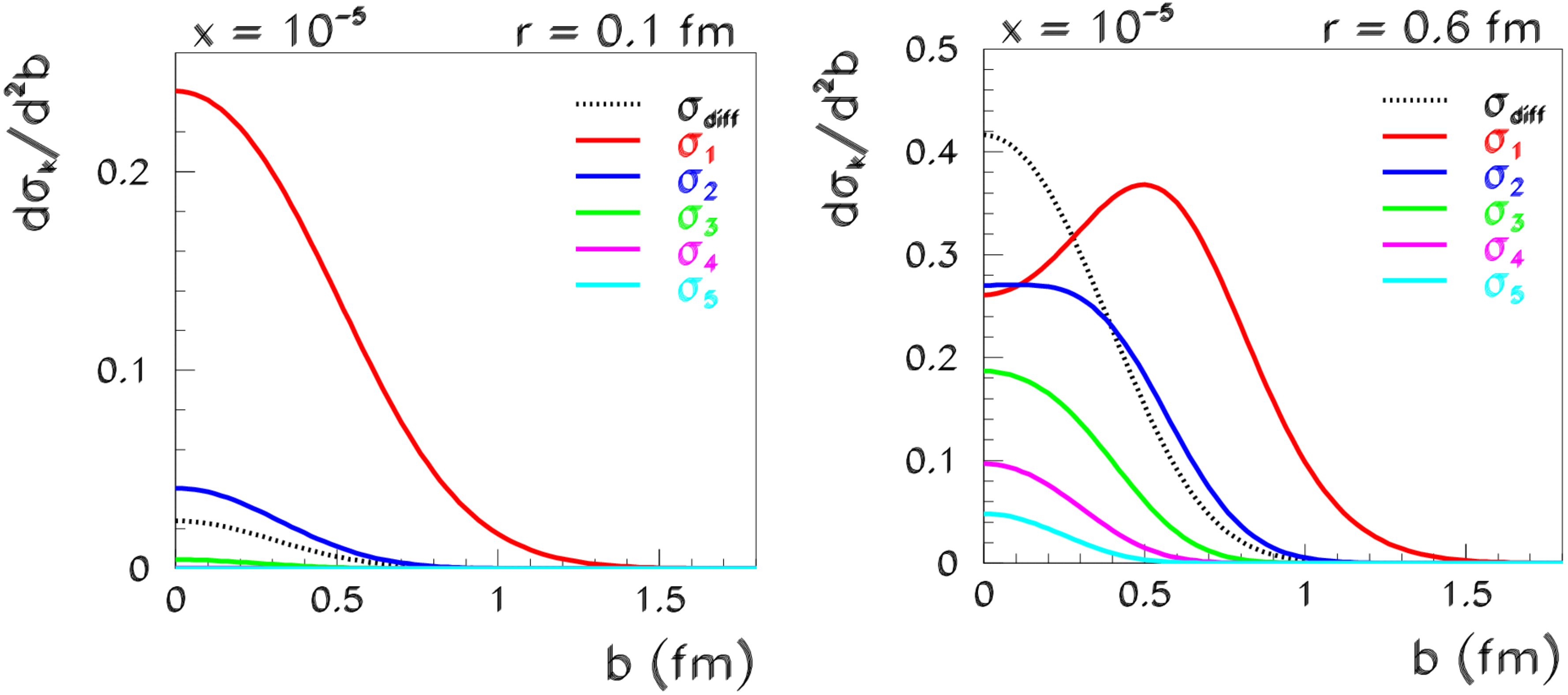
$$\Omega = \frac{\pi^2}{N_C} r^2 \alpha_s(\mu^2) x g(x,\mu^2) T(b)$$



Note: AGK rules underestimate the amount of diffraction in DIS

$$\frac{d\sigma_{qq}}{d^2b} = 2 \cdot \left\{1 - \exp(-\frac{\Omega}{2})\right\}$$

$$\frac{d\sigma_k}{d^2b} = \frac{\Omega^k}{k!}\exp(-\Omega)$$



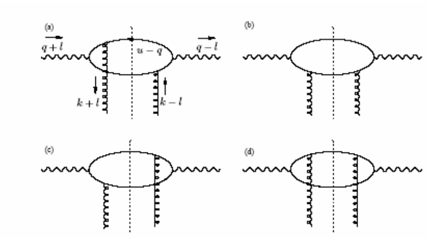
$$\Omega = \frac{\pi^2}{N_C} r^2 \alpha_s(\mu^2) xg(x,\mu^2) T(b)$$

Description of the size of interaction region B_D

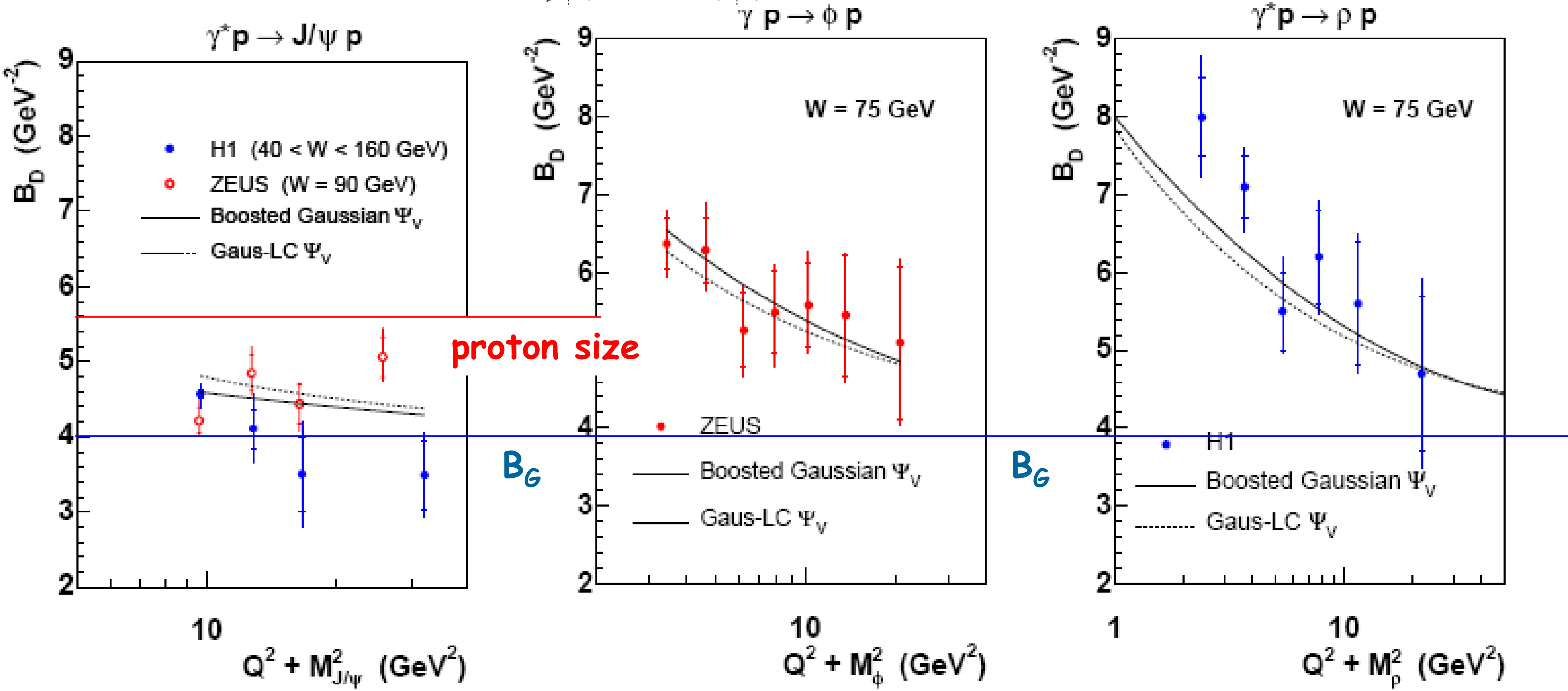
$$\frac{d\sigma^{diff}}{dt} \sim \exp(B_D \cdot t) \qquad \Rightarrow T(b) \sim \exp(-\vec{b}^{\,2}/2B_G)$$

Modification by Bartels, Golec-Biernat, Peters

$$e^{i\vec{b}\cdot\vec{\Delta}} \rightarrow e^{i(\vec{b}+(1-z)\vec{r})\cdot\vec{\Delta}}$$



KMW



EDMS Nr: 771549
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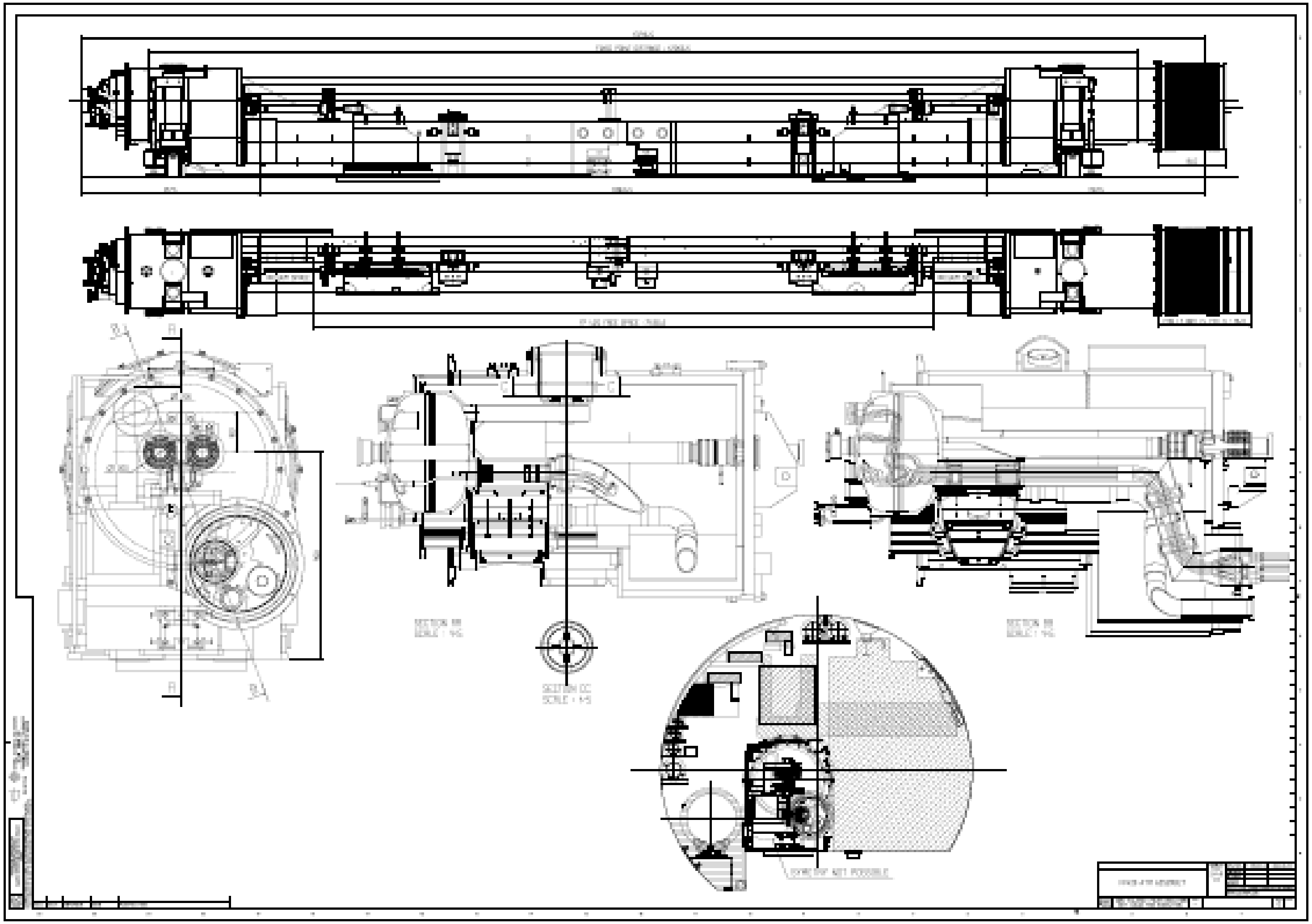
Utilisation des modules ATM pour le Projet FP420

T. Renaglia

Résumé

Le but de cette note est de résumer les premières caractéristiques de l'intégration de 2 modules ATM pour le projet FP420 (voir note technique EDMS n° 743628) ainsi que la liste des problèmes découverts à ce jour sur l'utilisation de ces modules dans sa nouvelle fonctionnalité.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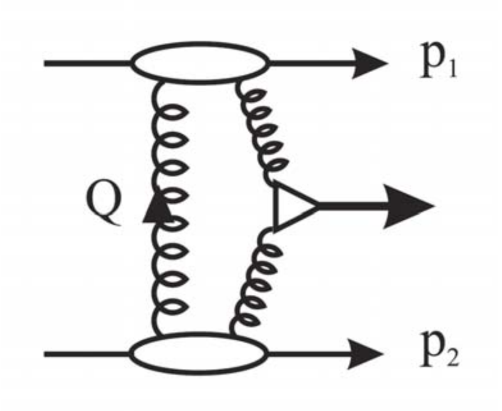
SYMMETRY NOT POSSIBLE

Computation of Diffractive Processes at LHC

Khoze – Martin - Ryskin Approach



$$\sigma = L \cdot \hat{\sigma}$$

$$M^2 \frac{\partial L}{\partial y \partial M^2} = S^2 L^{exclusive}$$ **Gluon Luminosity**

$$L^{exclusive} = \left(\frac{\pi}{(N_c^2 - 1)b} \int \frac{dQ_t^2}{Q_t^4} f_g(x_1, x_1', t, Q_t, \mu)\, f_g(x_2, x_2', t, Q_t, \mu) \right)^2$$

f_g unintegrated (skewed) gluon densities

obtained from low-x data of HERA

gg ->Jet+Jet

$$\frac{d\hat{\sigma}}{dt} \approx \frac{9}{4} \frac{\pi \alpha_s^2}{E_T^4}$$

gg -> Higgs

$$\hat{\sigma}_{Higgs} \propto \Gamma_{Higgs}$$

$$f_g(x, x', t, Q_t, \mu) = \beta(t) \cdot R_g \cdot \frac{\partial}{\partial \ln Q_t^2} [\sqrt{T(Q_t, \mu)} \cdot xg(x, Q_t^2)]$$

$$T(Q_t, \mu) = \exp\left(- \int_{Q_t^2}^{\mu^2} \frac{\alpha_S(k_t^2)}{2\pi} \frac{dk_t^2}{k_t^2} \int_0^{k_t/(\mu + k_t)} z P_{gg}(z) dz \right)$$

$$f_g(x_1, x_1', t, Q_t, \mu) = \beta(t) f_g(x_1, x_1', t = 0, Q_t, \mu) \qquad b(t) = \exp(Bt/2)$$

Note: *xg(x,.)* drive the rise of *F_2* at HERA and Gluon Luminosity decrease at LHC