Hard diffraction at HERA, Tevatron and LHC

Christophe Royon
DAPNIA-SPP, CEA Saclay

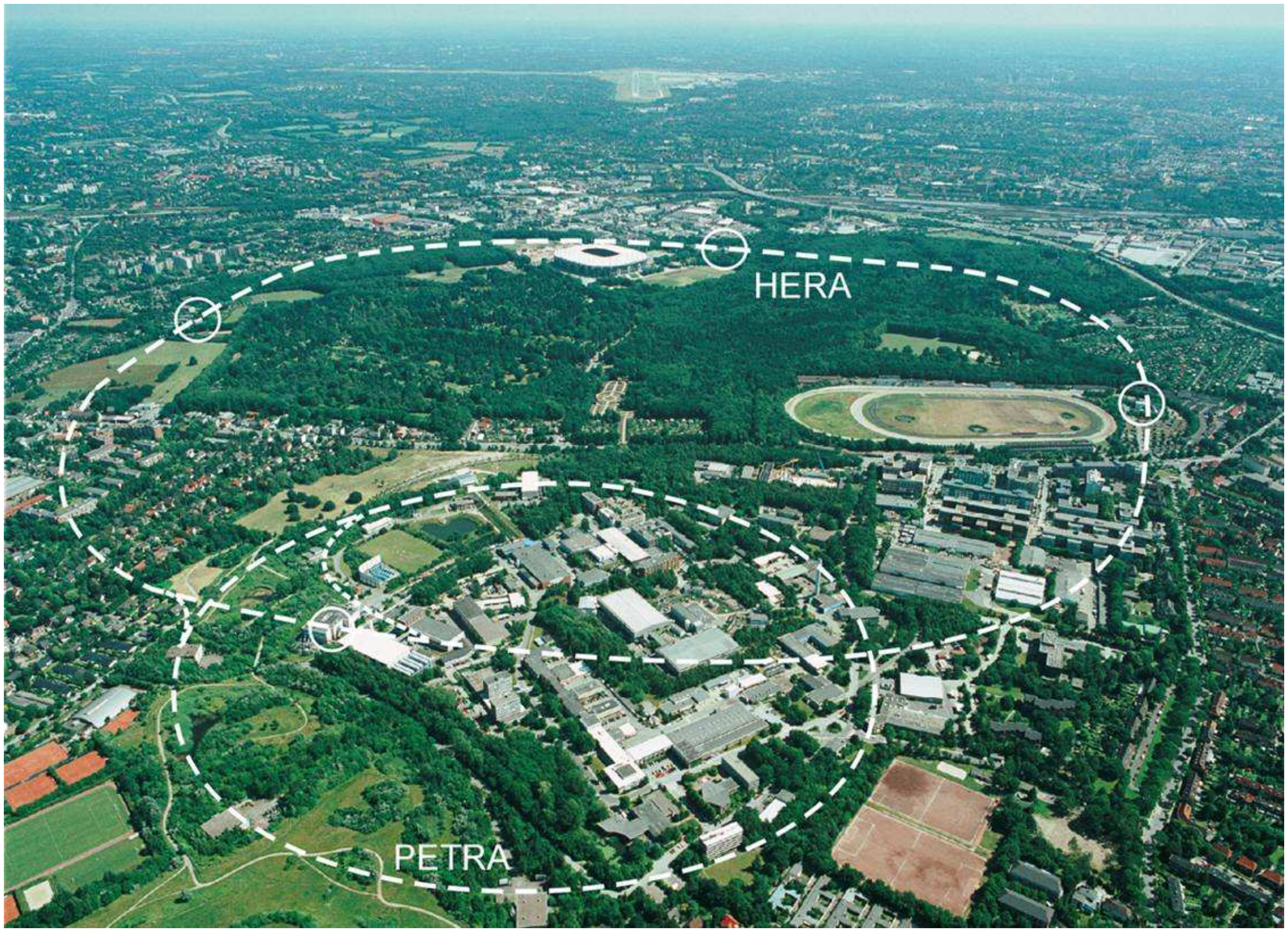
Zakopane Summer School 2006

Contents:

- What is diffraction? (experimental definition)
- Diffraction at HERA
- Diffraction at Tevatron and factorisation breaking
- Prospects at the LHC

The HERA accelerator

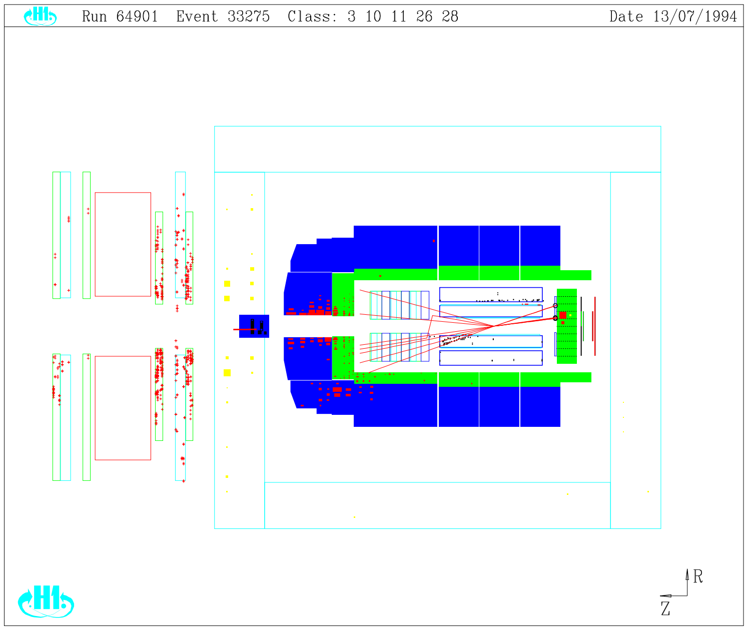
- HERA accelerator: ep, E_e= 27.5 GeV, E_p= 920 GeV
- Standard event: QCD event $ep \to eX$

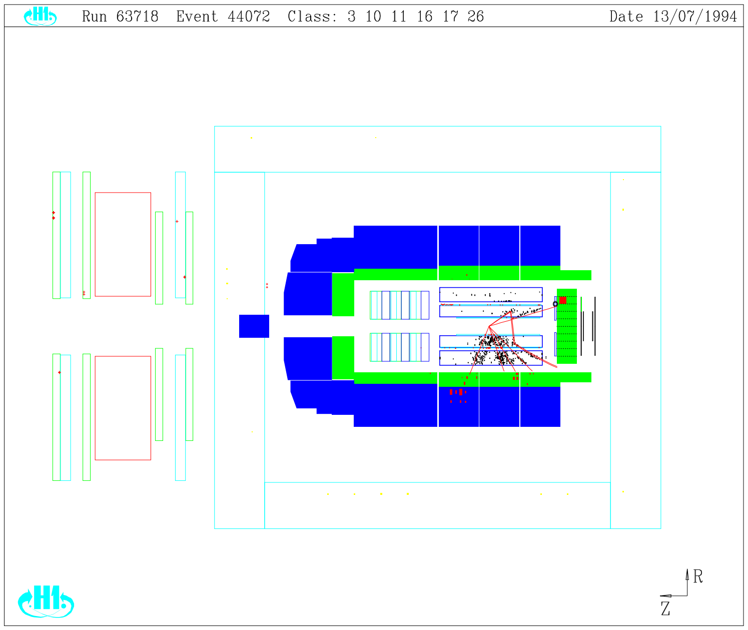


Diffraction at HERA

- Typical DIS event: part of proton remnants seens in detectors in forward region (calorimeter, forward muon...)
- HERA observation: in some events, no energy in forward region, or in other words no colour exchange between proton and jets produced in the hard interaction
- Leads to the first experimental definition of diffractive event: rapidity gap in calorimeter

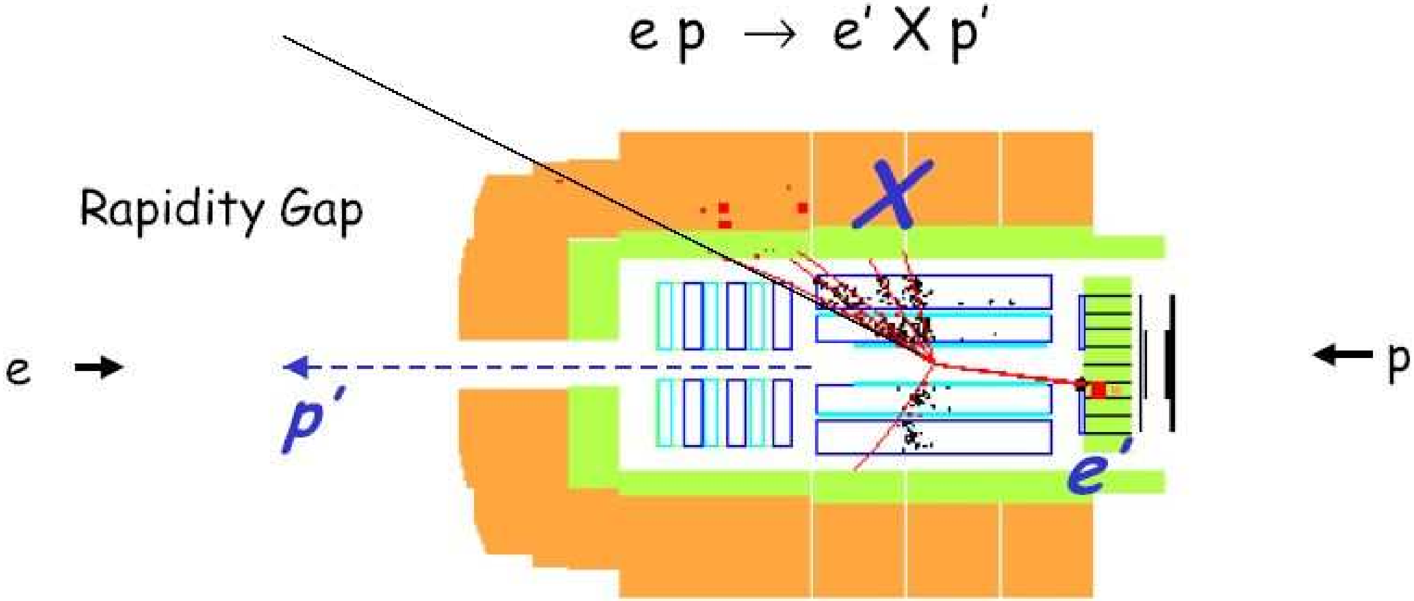
DIS and Diffractive event at HERA





How to see diffractive events at HERA (I)?

- Require a rapidity gap ($\eta = log(tan\theta/2)$) where θ is the polar angle) in the proton direction
- Method used by H1 (and ZEUS) collaboration: $3.3 < \eta < 7.5$
- Does not insure that the proton is intact after interaction (proton dissociation), but represents a limit on mass of the produced object: $M_Y < 1.6 GeV$
- Advantage: large acceptance in the diffractive kinematical plane

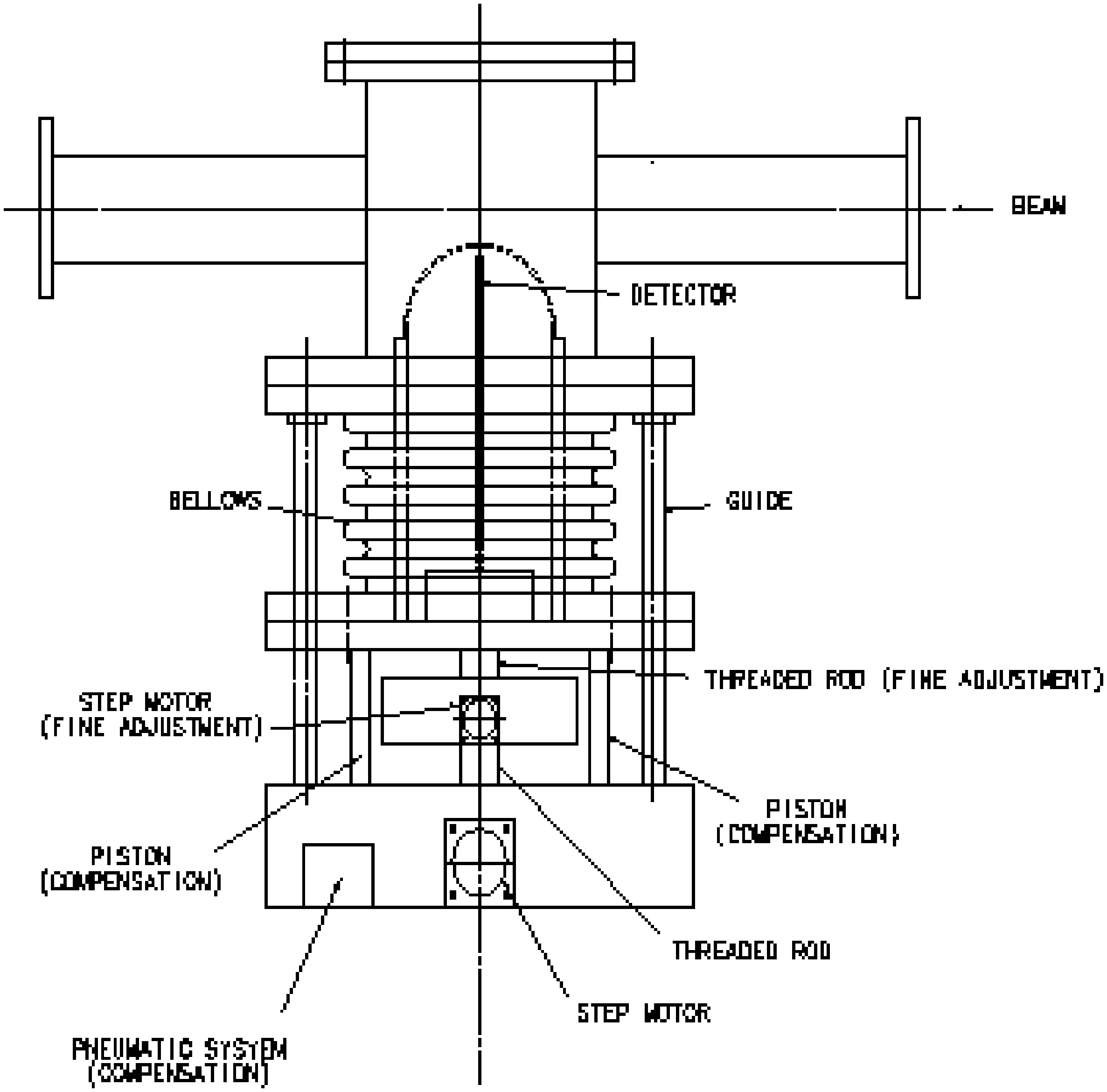


How to see diffractive events at HERA (II)?

- Second natural idea: tag scattered proton in the final state
- The proton loses a small fraction of its energy and is thus scattered at very small angle with respect to the beam direction
- Detection of these scattered protons: dedicated detectors called roman pots which can go close to the beam (when beam is stable) and located far away from the interaction point
- Inconvenient: limited acceptance in diffractive kinematical variables

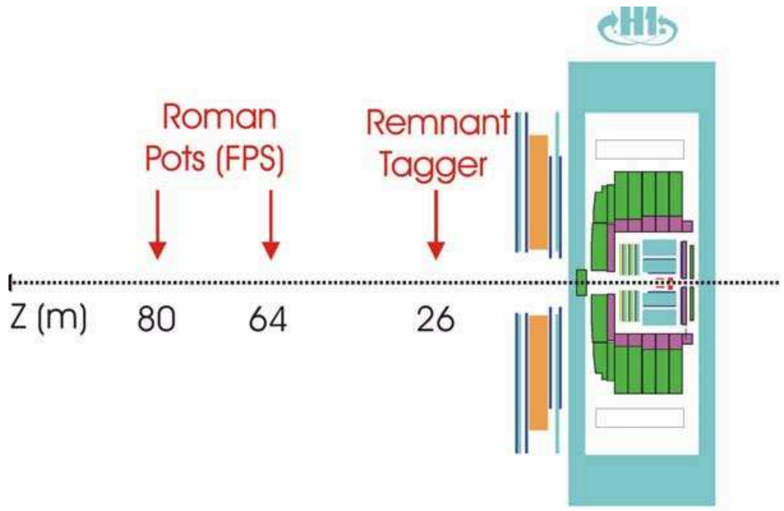
Scheme of a roman pot detector

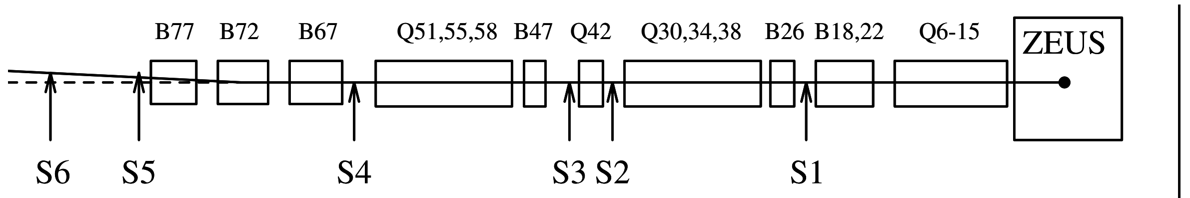
Scheme of roman pot detector



How to see diffractive events at HERA (II)?

Scheme of roman pot detectors from H1 and ZEUS (H1: VFPS at about 200m)



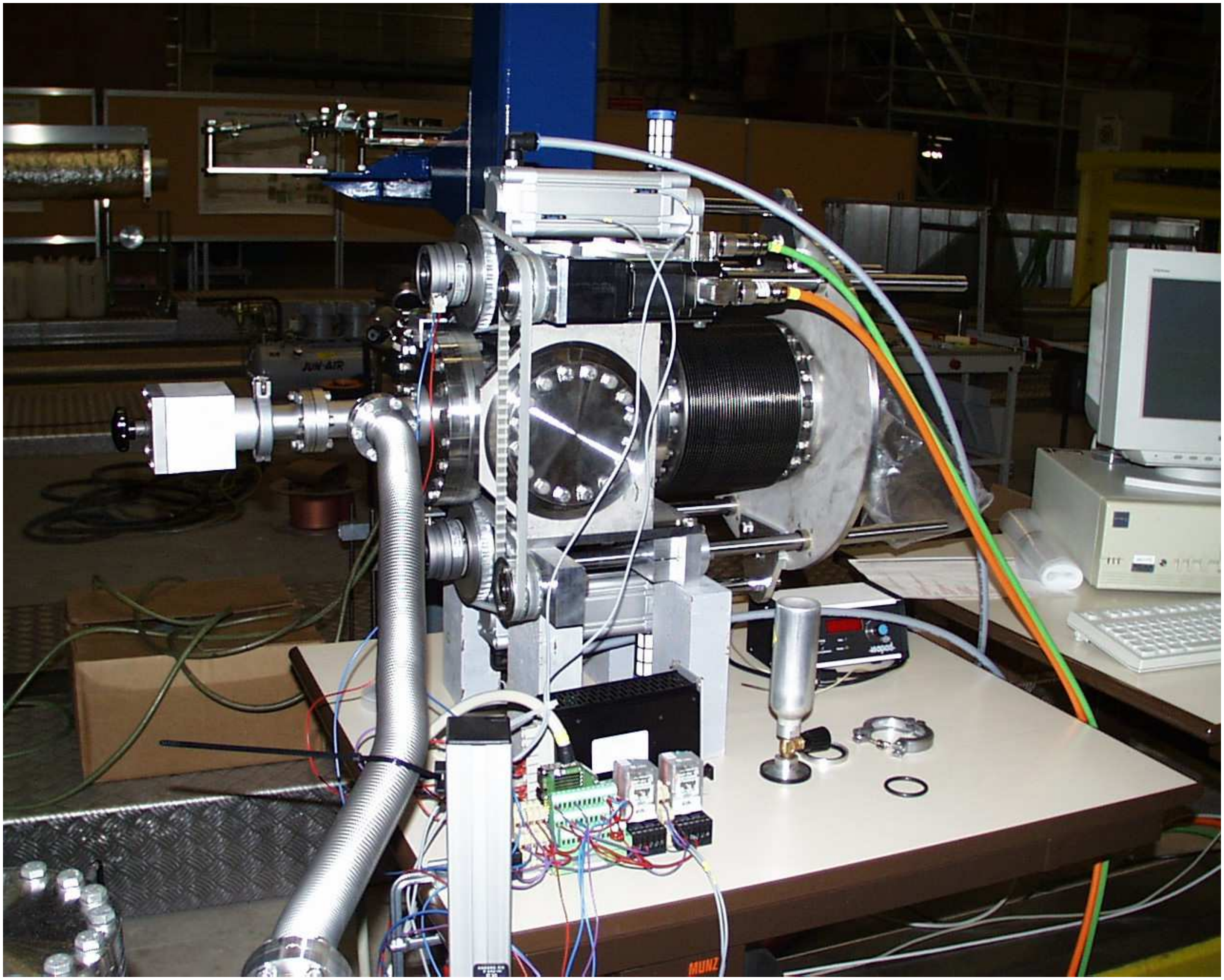


Leading Proton Spectrometer

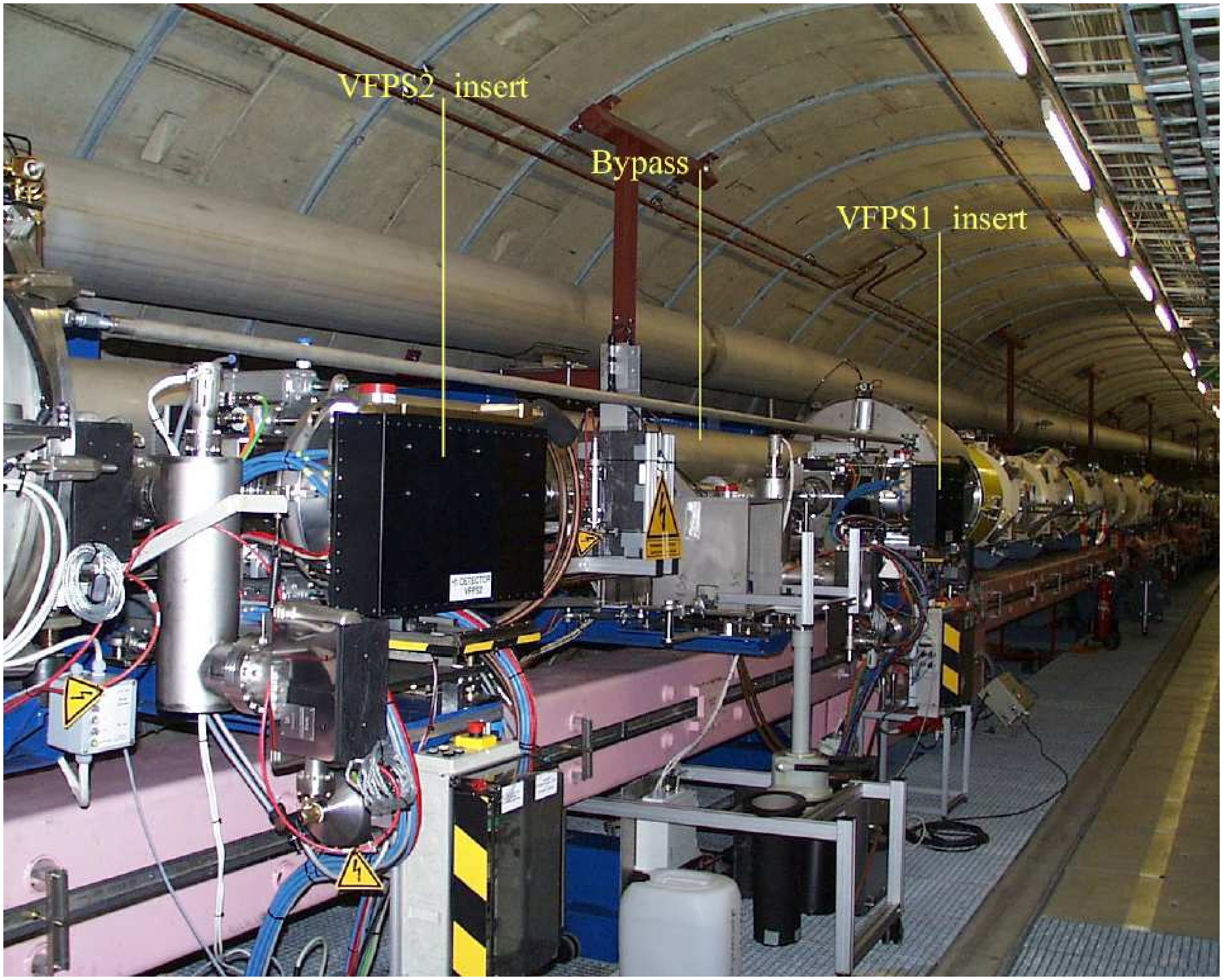
. silicon μstrips (6 stations)

. $\sigma_{x_L} < 1\%$, $\sigma_{p_T} \sim 5$ MeV

H1 roman pots



H1 roman pot detector

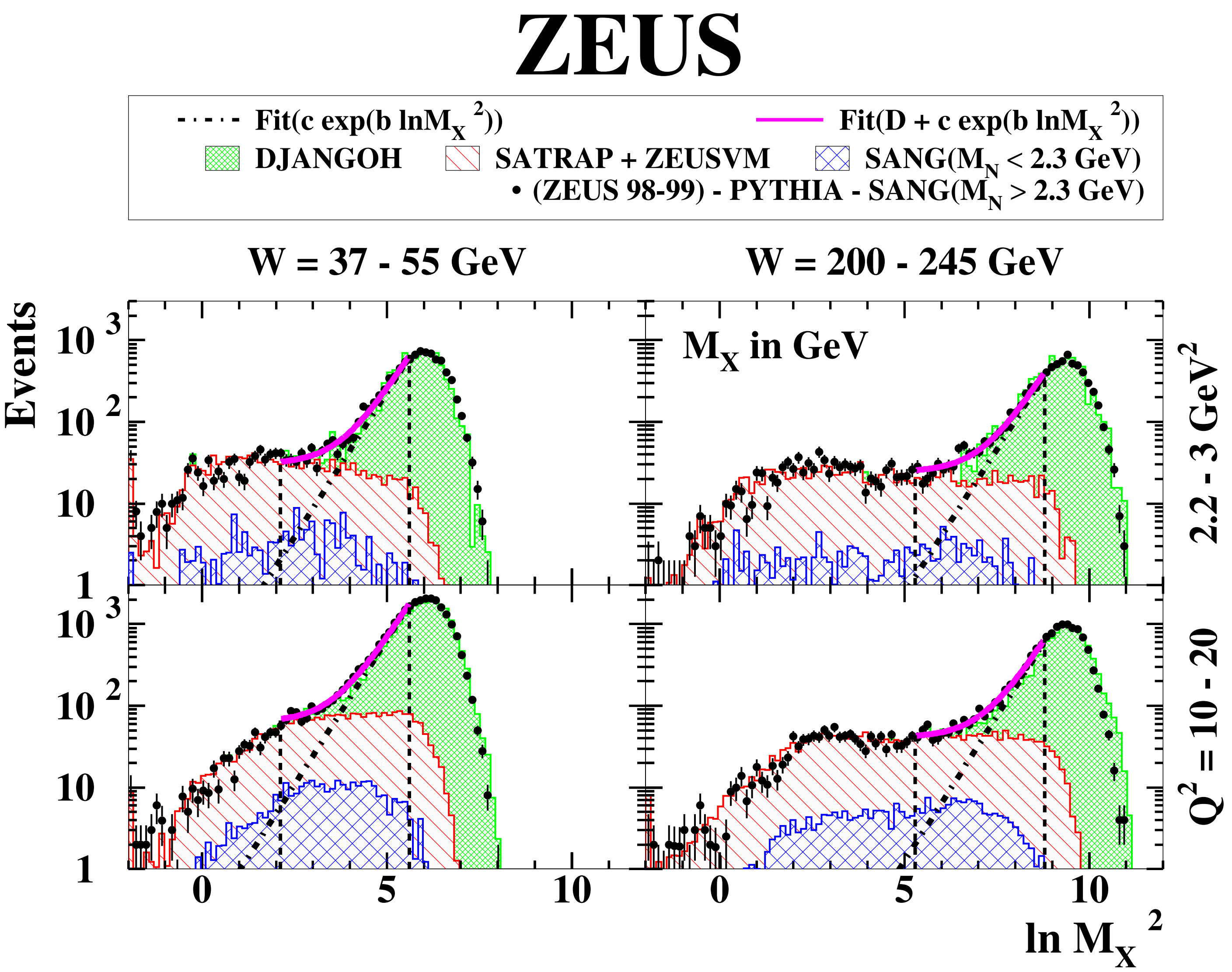


How to see diffractive events at HERA (III)?

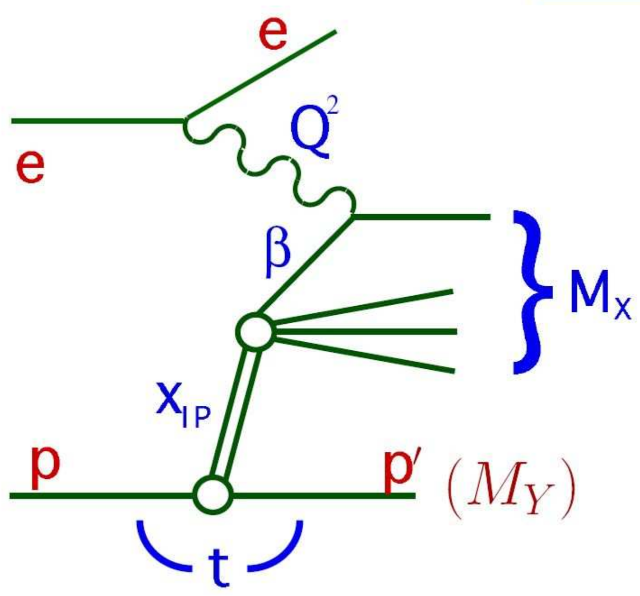
- M_X method used by ZEUS: different behaviour in $\log M_X^2$ for diffractive and non diffractive events where M_X is the mass produced in the interaction
- $$\frac{d\sigma_{diff}}{dM_X^2} = \left(\frac{s}{M_X^2}\right)^{\alpha-1} = cte \;\; if \;\; \alpha \sim 1$$
- Diffractive component exponentially suppressed (not perfectly theoretically justified):

$$\frac{d\sigma}{dM_X^2} = D + c\exp(b\log M_X^2)$$

How to see diffractive events at HERA (III)?



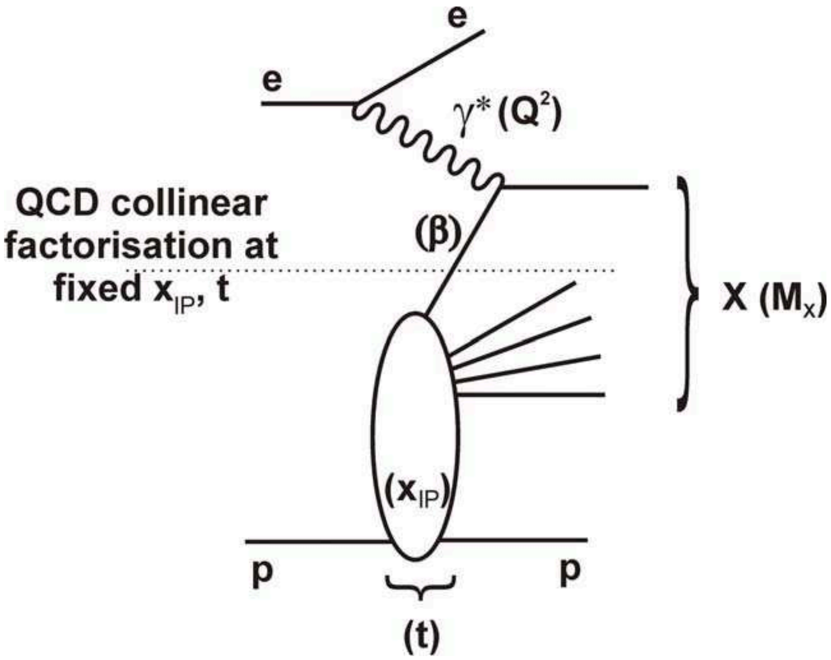
Diffractive kinematical variables

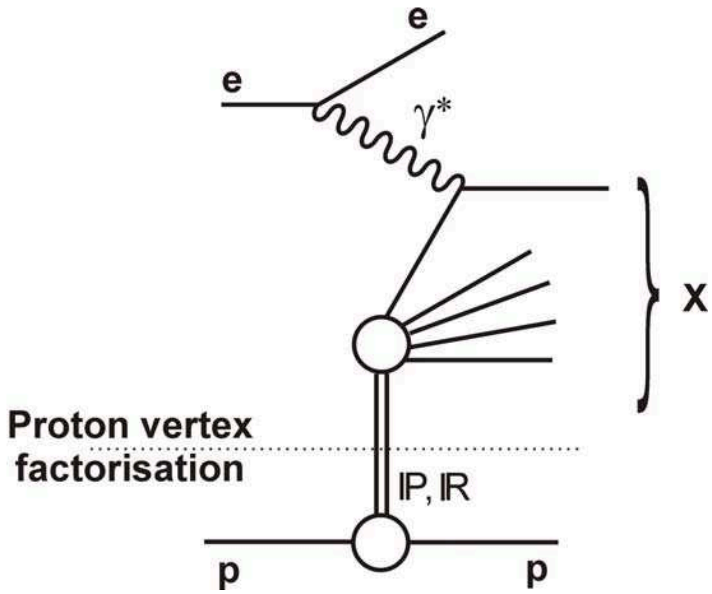


Invariant mass of the diffractive final state

- Momentum fraction of the proton carried by the colourless object (pomeron): $x_p = \xi = \frac{Q^2+M_X^2}{Q^2+W^2}$
- Momentum fraction of the pomeron carried by the interacting parton if we assume the colourless object to be made of quarks and gluons: $\beta = \frac{Q^2}{Q^2+M_X^2} = \frac{x_{Bj}}{x_P}$
- 4-momentum squared transferred: $t = (p - p')^2$

Diffractive factorisation





- QCD hard scattering collinear factorisation at fixed x_P and t (Collins):
  $d\sigma(ep \to eXY) = f_D(x, Q^2, x_P, t) \times d\hat{\sigma}(x, Q^2)$
- Proton vertex factorisation: factorises the (x_P, t) and the (x, Q^2) dependences,
  $f_D(x, Q^2, x_P, t) = f_P(x_P, t) f(\beta = x/x_P, Q^2)$

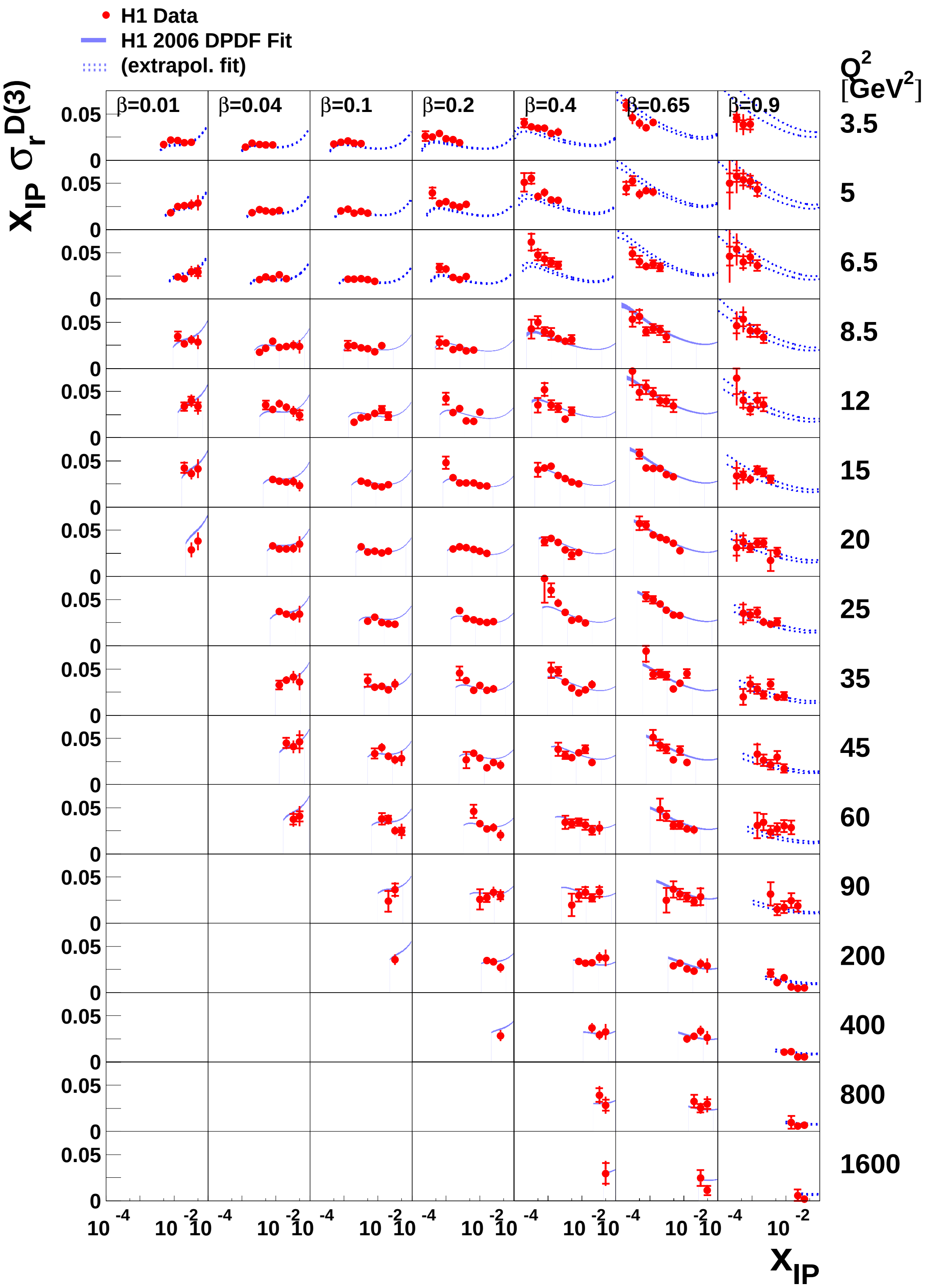
Measurement of the diffractive structure function F_2^D

- Measurement of the diffractive cross section using the rapidity gap selection over a wide kinematical domain in (x_P, β, Q^2)
- Definition of the reduced cross section:

$$\frac{d^3\sigma^D}{dx_P dQ^2 d\beta} = \frac{2\pi\alpha_{em}^2}{\beta Q^4}\left(1 - y + \frac{y^2}{2}\right)\sigma_r^D(x_P, Q^2, \beta)$$

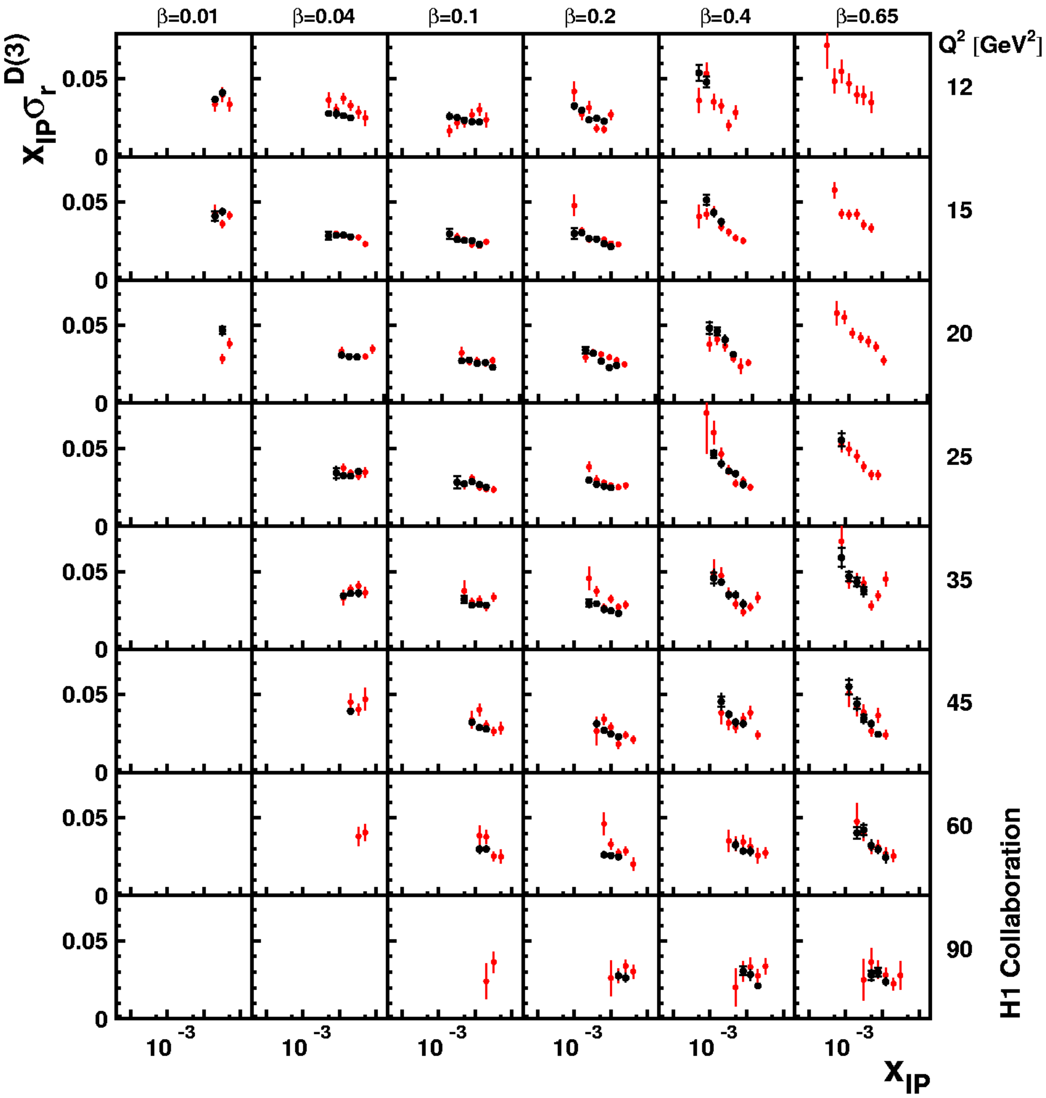
- As an example: H1 data

Measurement of the diffractive structure function F_2^D



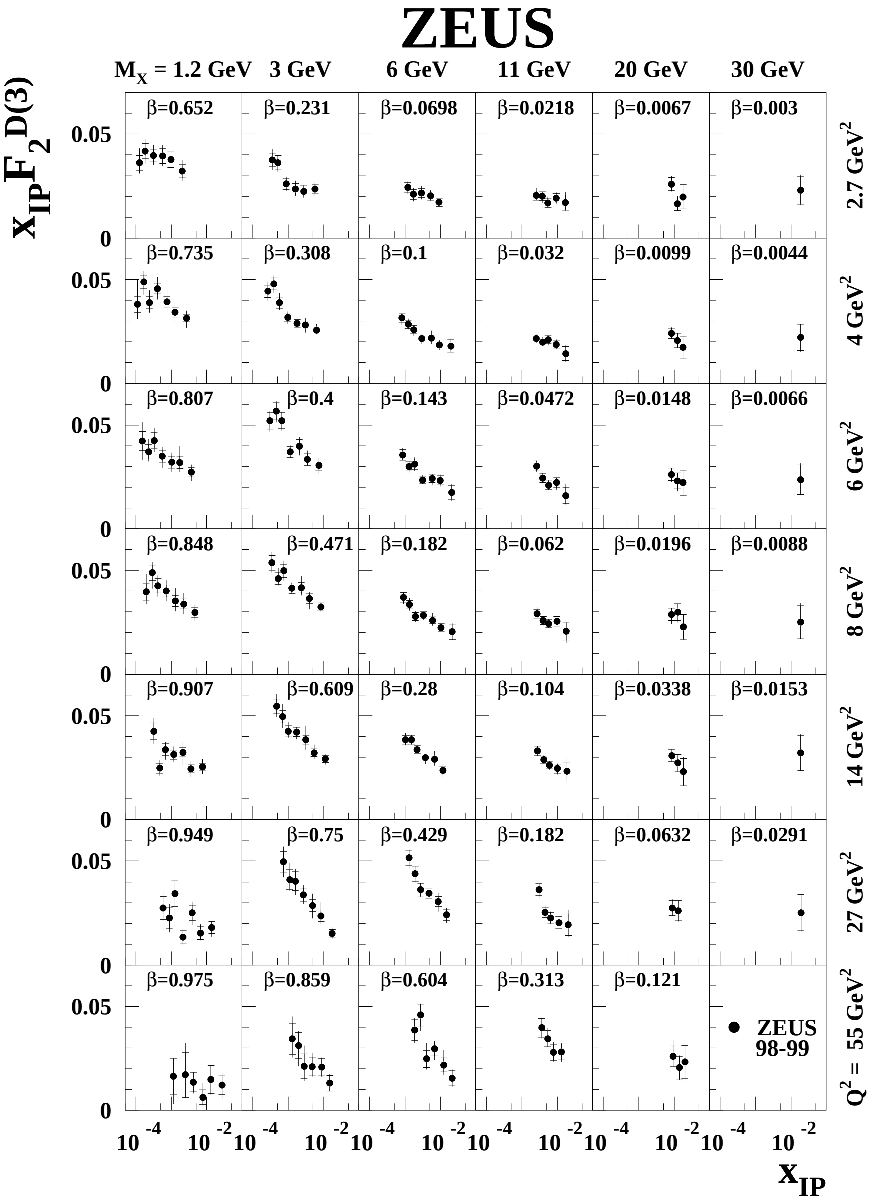
Measurement of the diffractive structure function F_2^D

Measurement using 1999-2000 data compared with 1997 data: better statistics (6 times more accumulated), good agreement between both sets



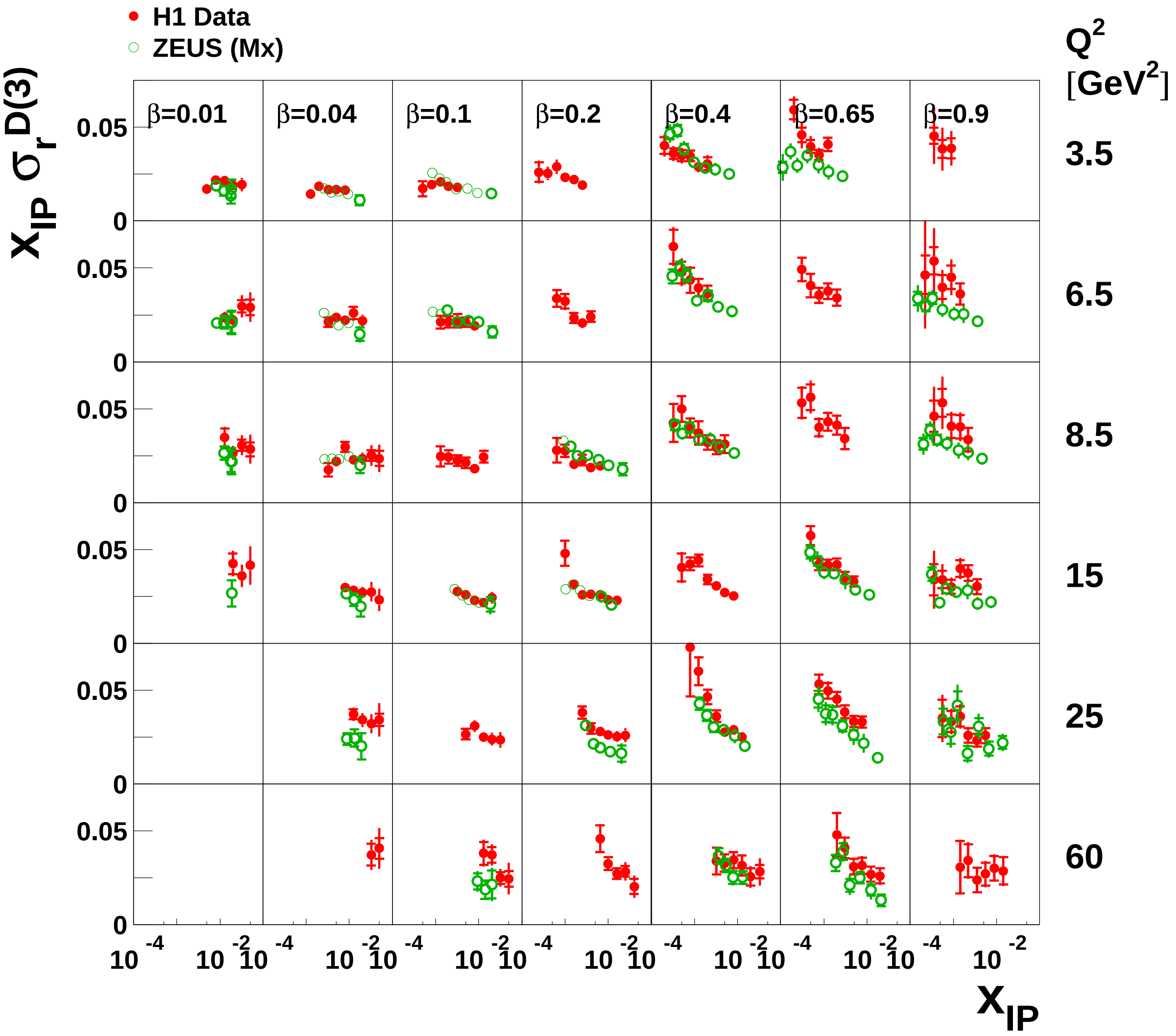
Measurement of the diffractive structure function F_2^D

- Measurement performed by ZEUS using the "M_X method"
- Good agreement with rapidity gap method?



Measurement of the diffractive structure function F_2^D

- Comparison between the rapidity gap and M_X methods
- Good agreement between both methods within errors



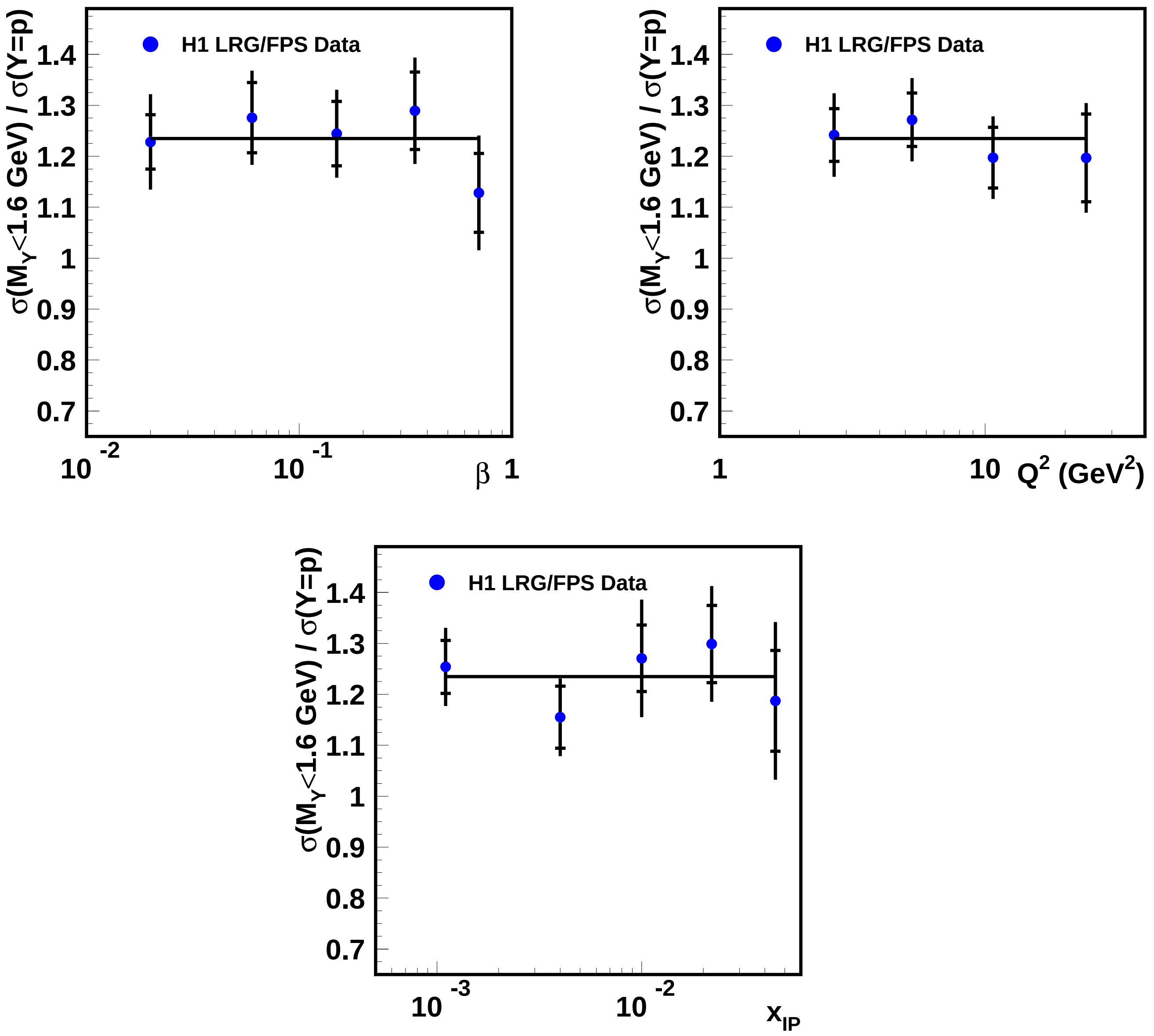
Measurement of the diffractive structure function F_2^D

- Comparison between rapidity gap and proton tagged method in roman pot detector: no direct comparison possible because of proton dissociation included in rapidity gap measurement
- Compute the ratio of rapidity gap and forward proton spectrometer measurements:

$$\frac{\sigma(M_Y < 1.6 GeV)}{\sigma(Y = p)} = 1.23 \pm 0.03(stat) \pm 0.16(syst)$$

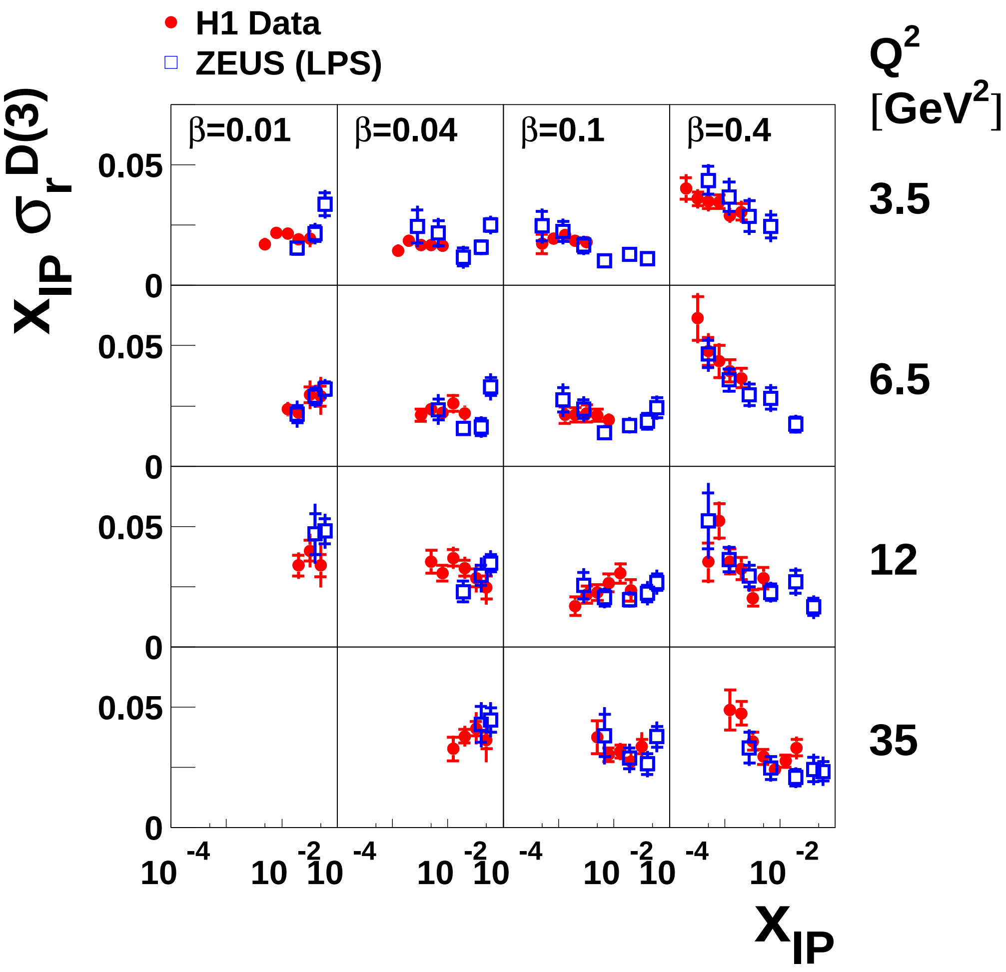
- Ratio independent of kinematical variables within errors

Measurement of the diffractive structure function F_2^D



Measurement of the diffractive structure function F_2^D

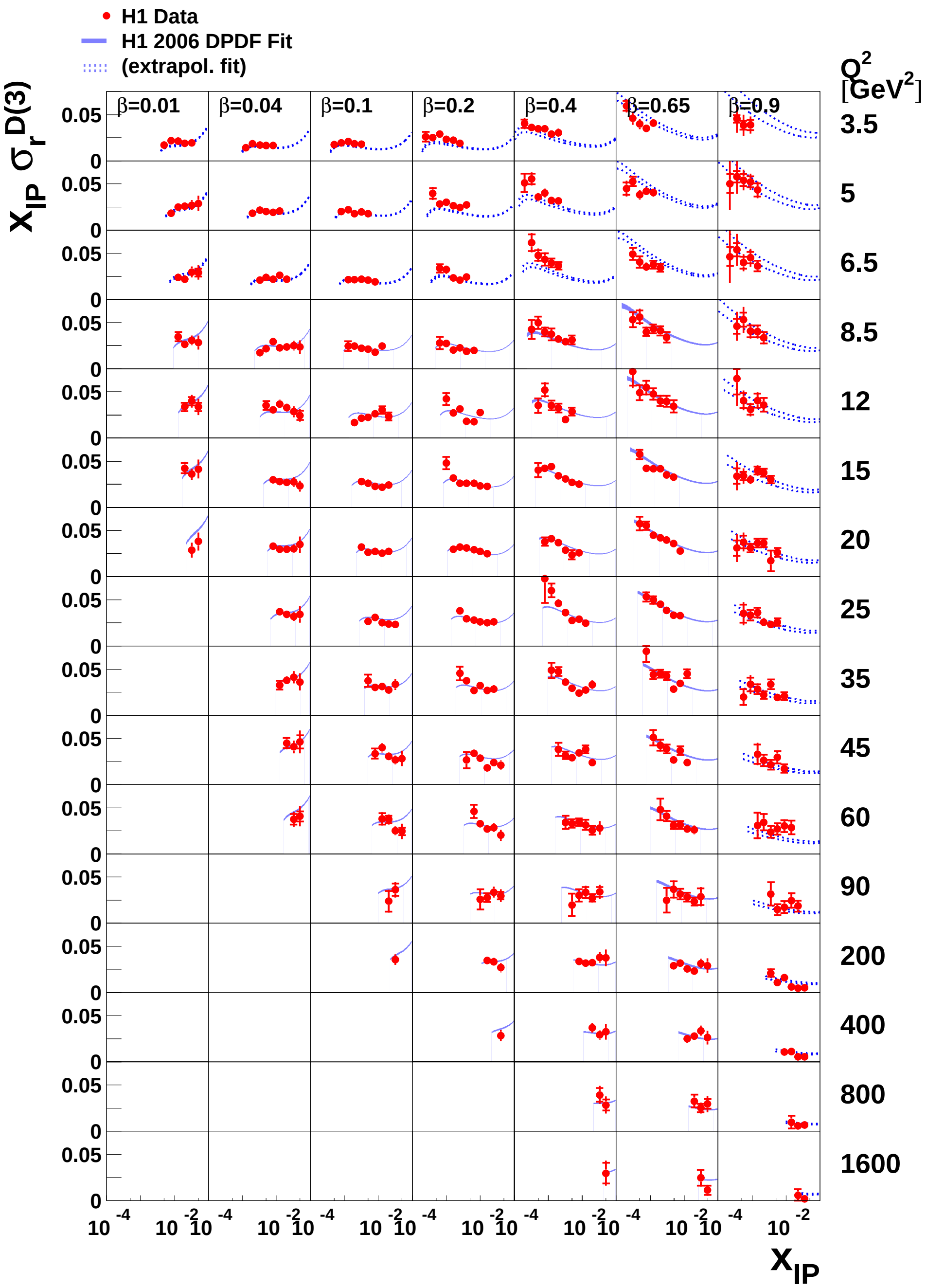
- Comparison between H1 rapidity gap method corrected for dissociate protons and ZEUS roman pot detector method: good agreeement
- Comparison also performed between H1 and ZEUS forward proton detectors: good agreement



Pomeron and reggeon?

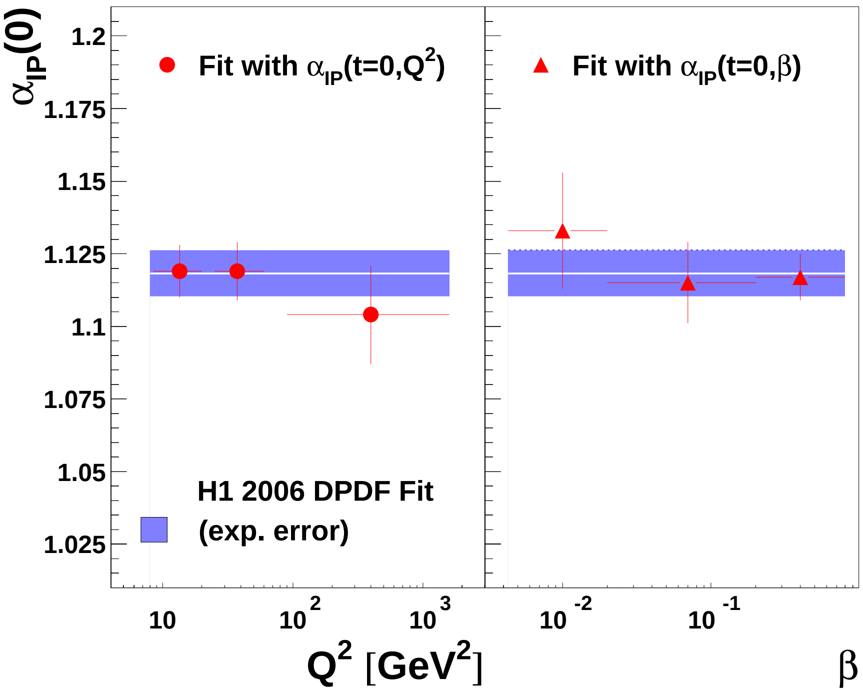
- $\sigma_r \sim f_p(x_P) F_2^D(\beta, Q^2)$, f (flux) predicted by Regge theory
- Consequence: the x_P dependence should factorise from the (β, Q^2) one
- Not observed experimentally (H1): secondary exchanges, assume 2, Pomeron and Reggeon
- NB: Reggeon contribution described by the pion structure function with an exponent $\alpha_R = 0.5$, not much constrained by data

Pomeron and reggeon?



Measurement of the pomeron exponent α_P

- $\sigma_r \sim f_p(x_P) F_2^D(\beta, Q^2)$, f (flux) predicted by Regge theory: $f(x_P, t) = \frac{e^{Bt}}{x_P^{2\alpha_P(t)-1}}$ with $\alpha_P(t) = \alpha_P(0) + \alpha' t$
- t dependence obtained from forward proton spectrometer measurements: $\alpha' = 0.06^{+0.19}_{-0.06}$ GeV^{-2}, $B_P = 5.5^{+0.7}_{-2.0}$ GeV^{-2} (H1)
- Measurement of $\alpha_P(0)$ using rapidity gap and M_X method data and Q^2 and β dependence



Extraction of the parton densities in the pomeron (H1)

- Assume pomeron made of quarks and gluons: perform QCD DGLAP fits as for the proton structure function starting from xG and xq distributions at a given Q_0^2, and evolve in Q^2 (the form of the distributions is MRS like)

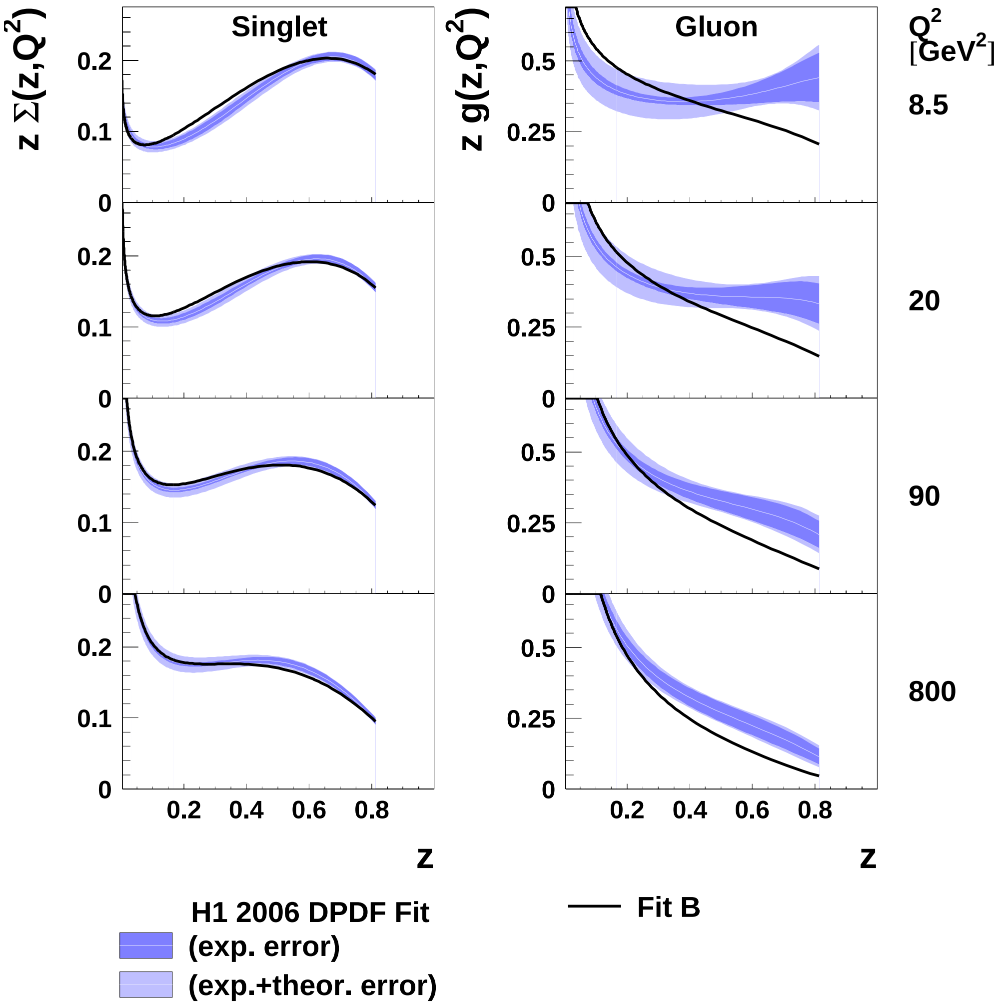
$$\begin{aligned} \beta q &= A_q \beta^{B_q} (1-\beta)^{C_q} \\ \beta G &= A_g (1-\beta)^{C_g} \end{aligned}$$

- At low β: evolution driven by $g \longrightarrow q\bar{q}$, at high β, $q \longrightarrow qg$ becomes important
- Take all data for $Q^2 > 8.5$ GeV^2, $\beta < 0.8$ to be in the perturbative QCD region and avoid the low mass region (vector meson resonances)

$$\frac{dF_2^D}{d\log Q^2} \sim \frac{\alpha_S}{2\pi} \left[P_{qg} \otimes g + P_{qq} \otimes \Sigma \right]$$

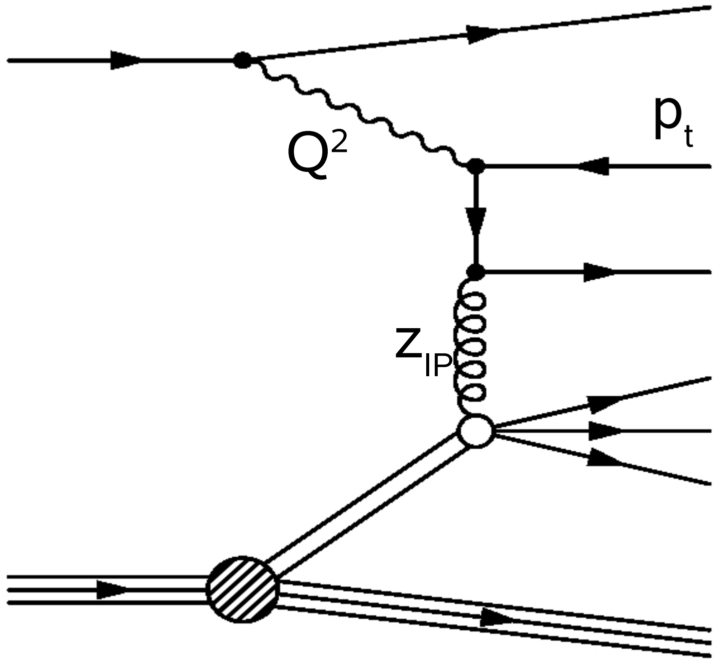
Parton densities in the pomeron (H1)

- Extraction of gluon and quarks densities in pomeron: gluon dominated
- Gluon density poorly constrained at high β (imposing $C_q = 0$ leads to a good fit as well, Fit B)
- What about description of final states?



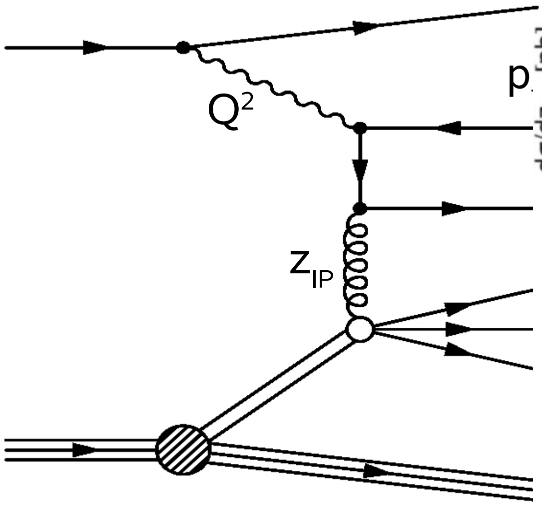
Diffractive dijet production (H1)

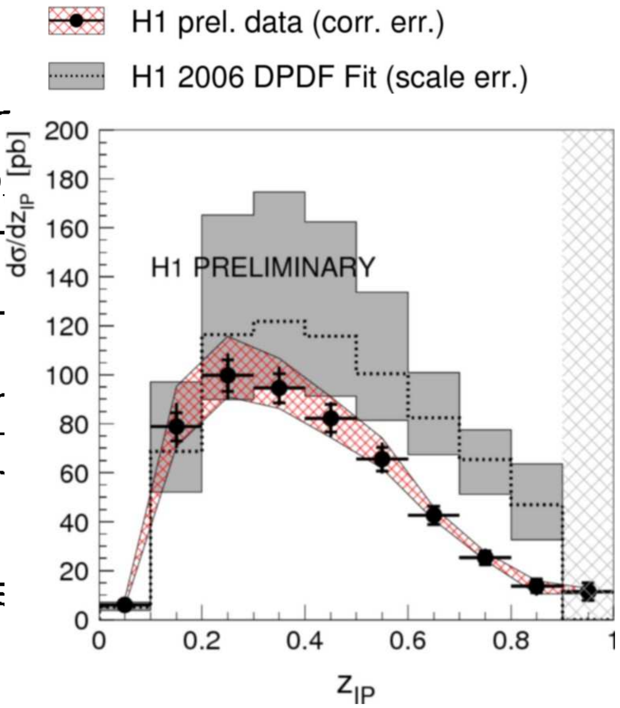
- Idea: Use dijet data to further constrain the gluon density in the pomeron
- Compare dijet data with expectation from QCD fit

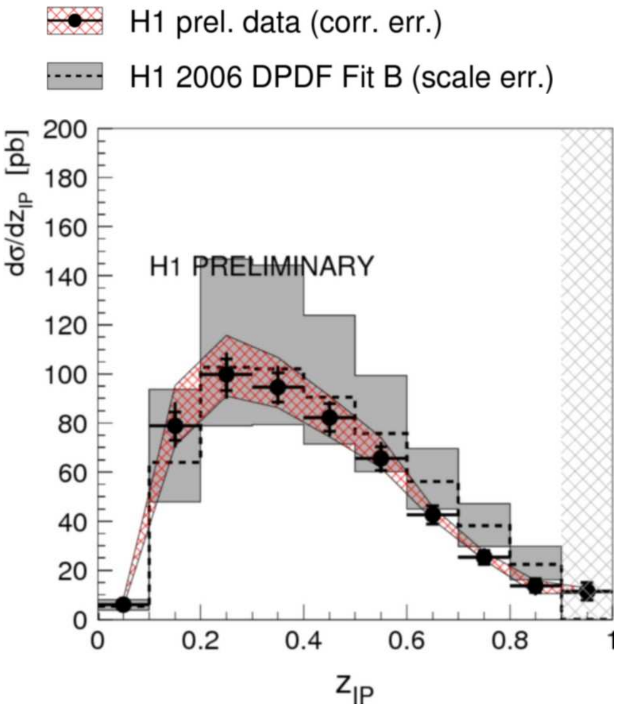


Diffractive dijet production (H1)

- Comparison between jet cross section measurements and QCD fit expectations
- "Standard" QCD fits lead to too high cross sections
- Take F_2^D and dijet cross section data to obtain new QCD fits, and parton density in pomeron

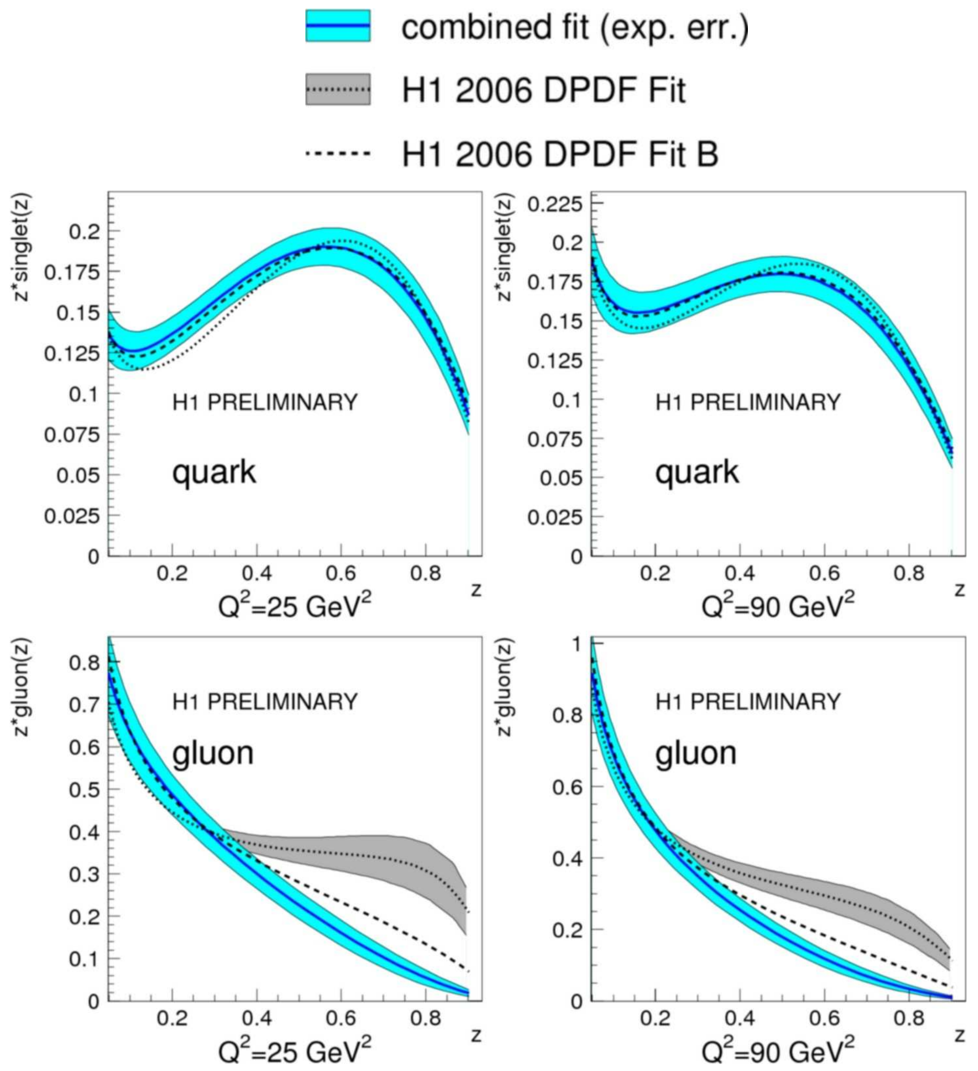






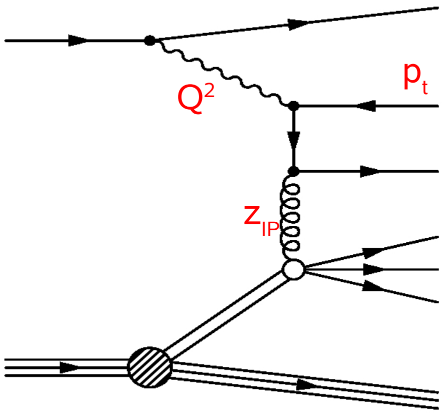
Parton densities in pomeron (H1)

- New parton densities using both F_2^D and dijet data
- Gluon density at high β more constrained and closer to fit B

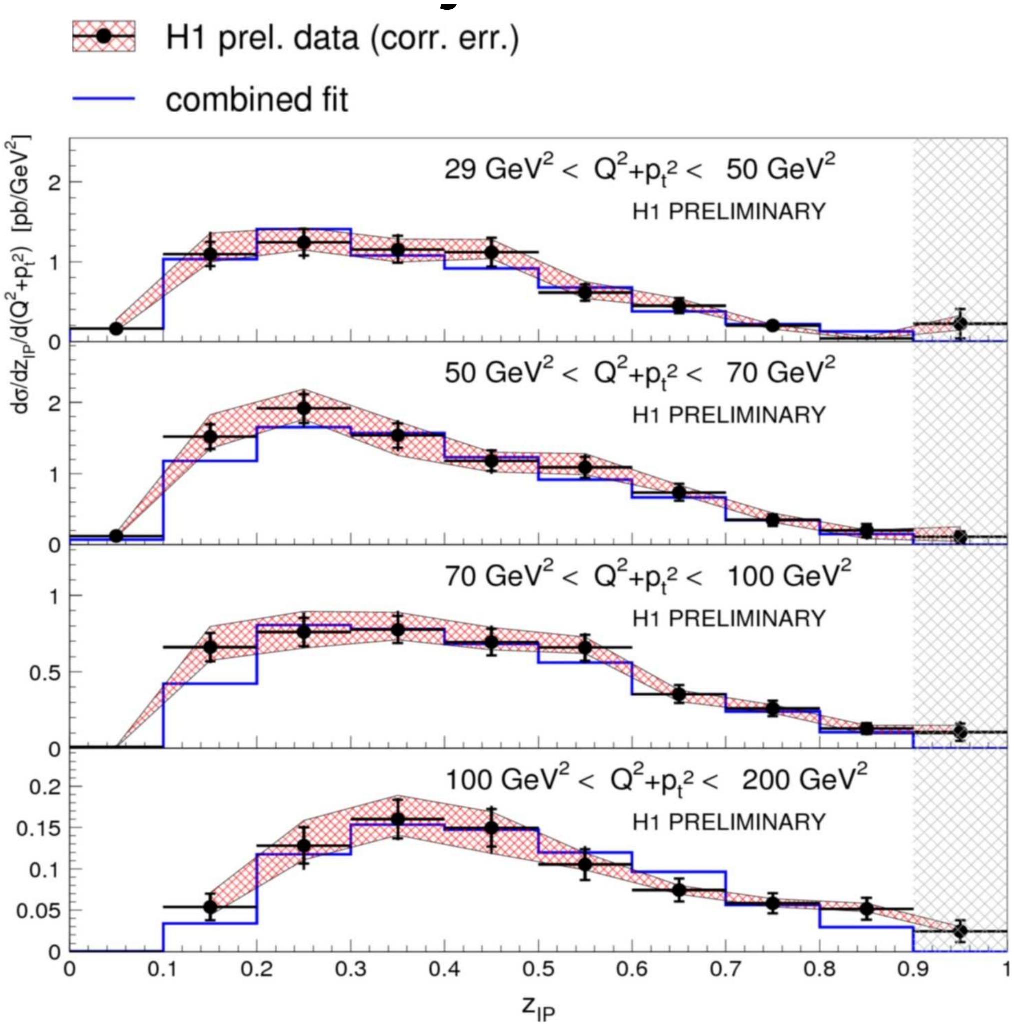


Comparison with jet cross sections (H1)

- Comparison between new QCD fit and jet cross sections
- Good agreeement found



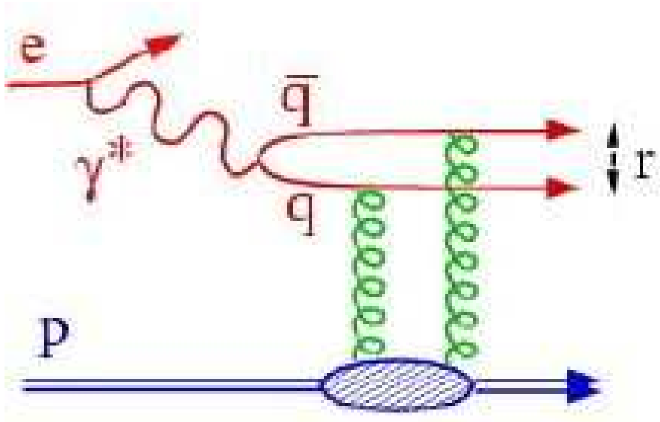
factorization confirmed

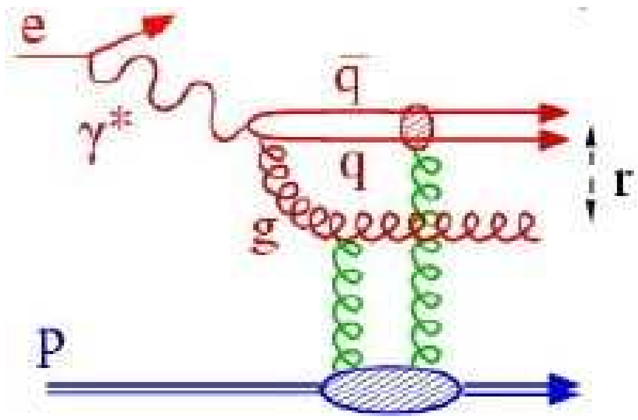


Two gluon models

- Two gluon model: Different kind of model to describe diffractive data (see also dipole model, saturation models...)
- Pomeron purely perturbative (2 gluon ladder)
- Q^2, β dependence predicted, x_P dependence given by dipole distribution, and x_P dependence does not factorise
- No concept of diffractive PDFs

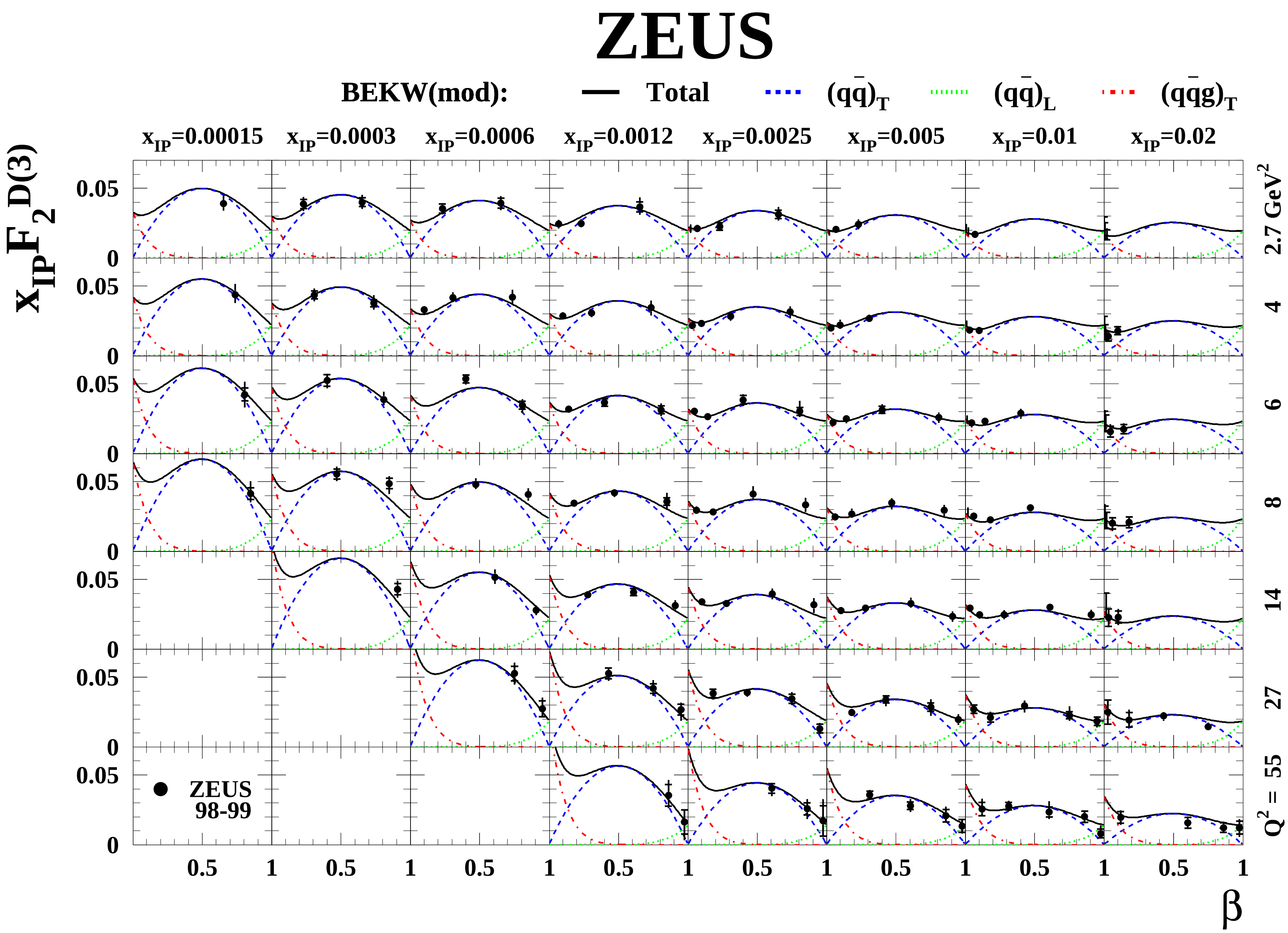
$$x_{\mathbb{P}} F_2^{D(3)} = c_T \cdot F_{q\bar{q}}^T + c_L \cdot F_{q\bar{q}}^L + c_g \cdot F_{q\bar{q}g}^T$$





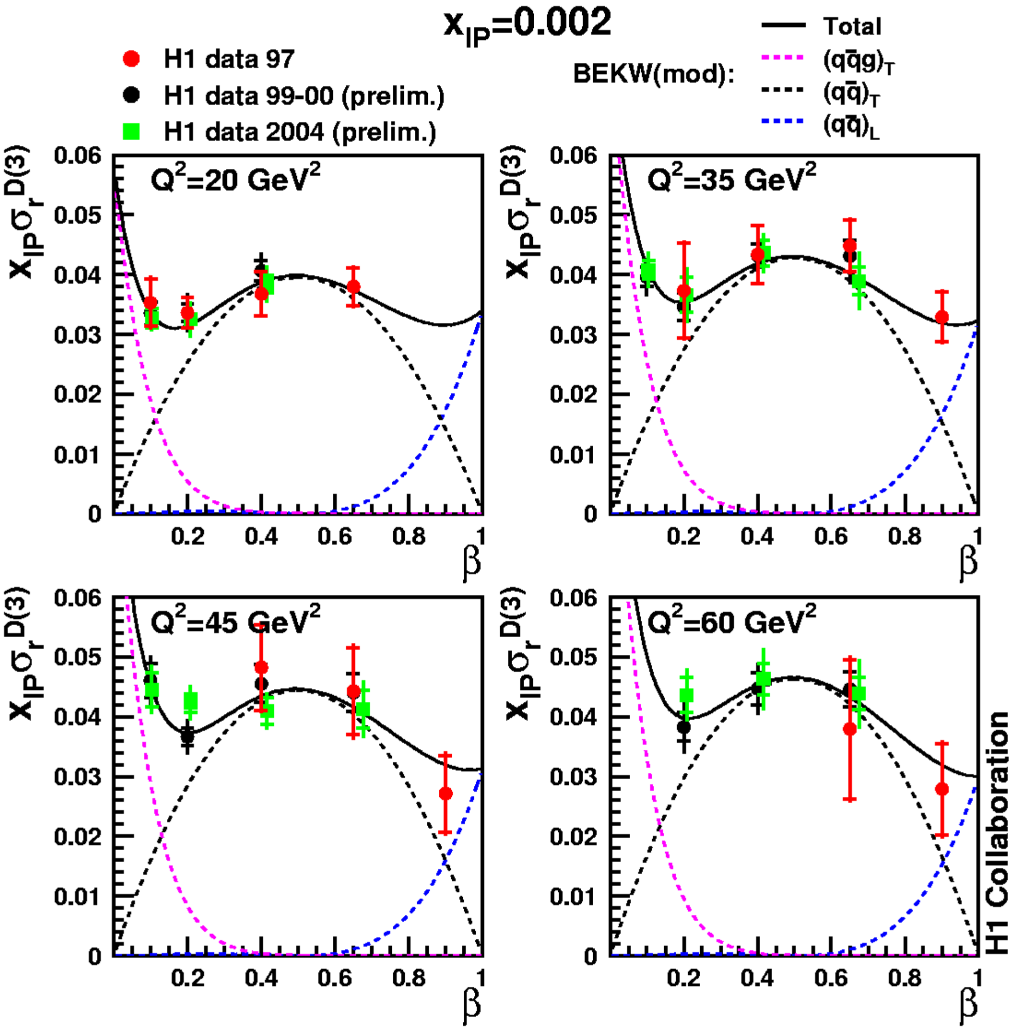
Two gluon models (ZEUS data)

ZEUS data (M_X method) compared to two gluon models



Two gluon models (H1 data)

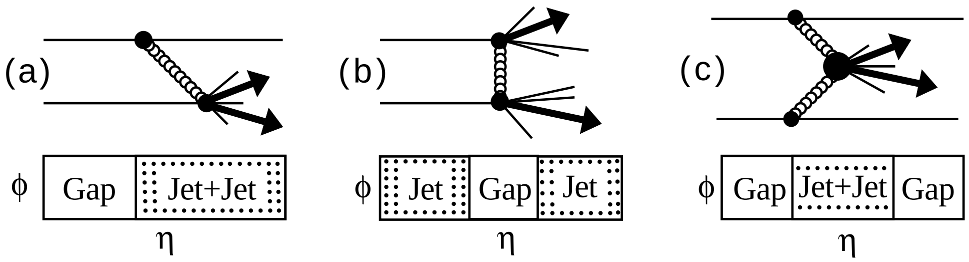
- Good description of all H1 data: all H1 data, 672 points, $\chi^2 = 1.26/\text{point}$
- F_L dominating at high β, qqg at low β, and qq at medium β



Diffraction at Tevatron

- Tevatron: $p\bar{p}$ collider, $\sqrt{S} = 1.96$ TeV, 2 experiments DØ and CDF
- Luminosity accumulated of the order of 1.2 fb^{-1} per experiment

Diffraction at Tevatron/LHC

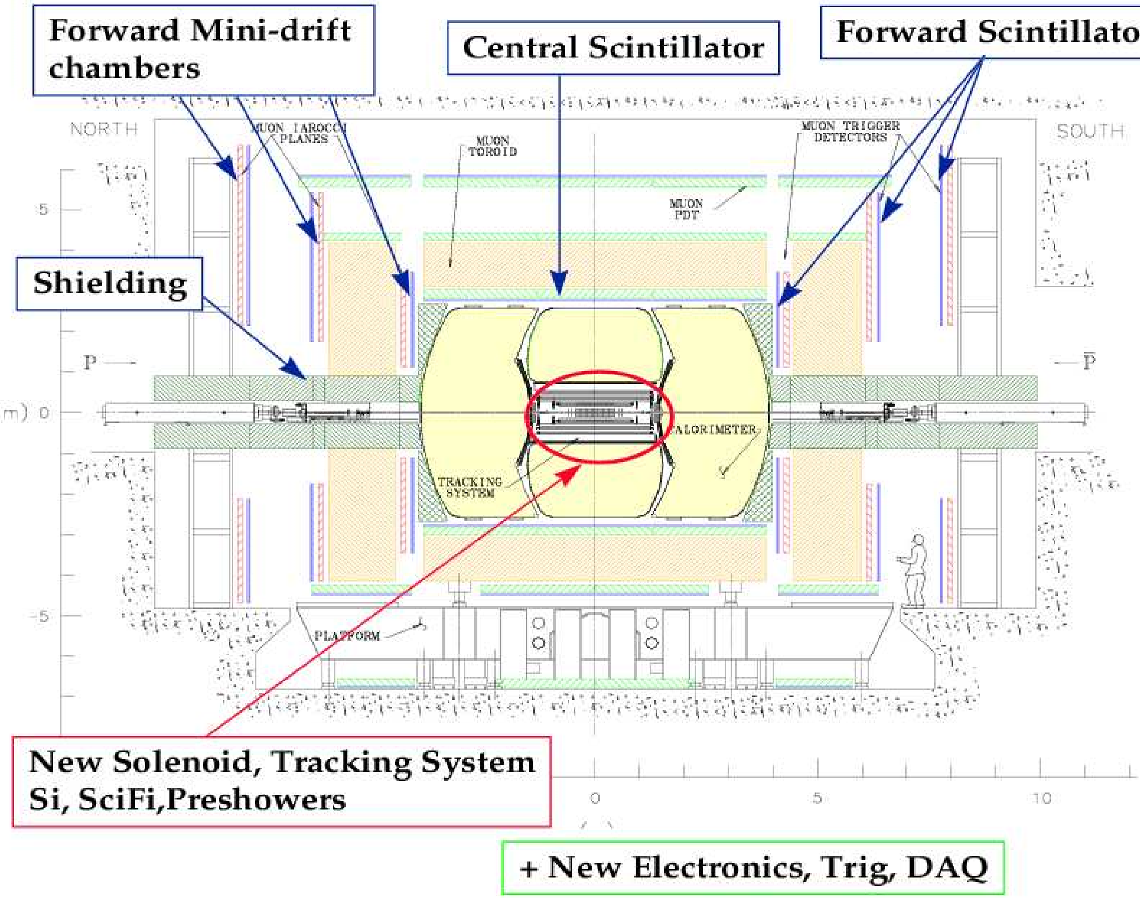


Kinematic variables

- t: 4-momentum transfer squared
- ξ_1, ξ_2: proton fractional momentum loss (momentum fraction of the proton carried by the pomeron)
- $\beta_{1,2} = x_{Bj,1,2}/\xi_{1,2}$: Bjorken-x of parton inside the pomeron
- $M^2 = s\xi_1\xi_2$: diffractive mass produced
- $\Delta y_{1,2} \sim \Delta\eta \sim \log 1/\xi_{1,2}$: rapidity gap

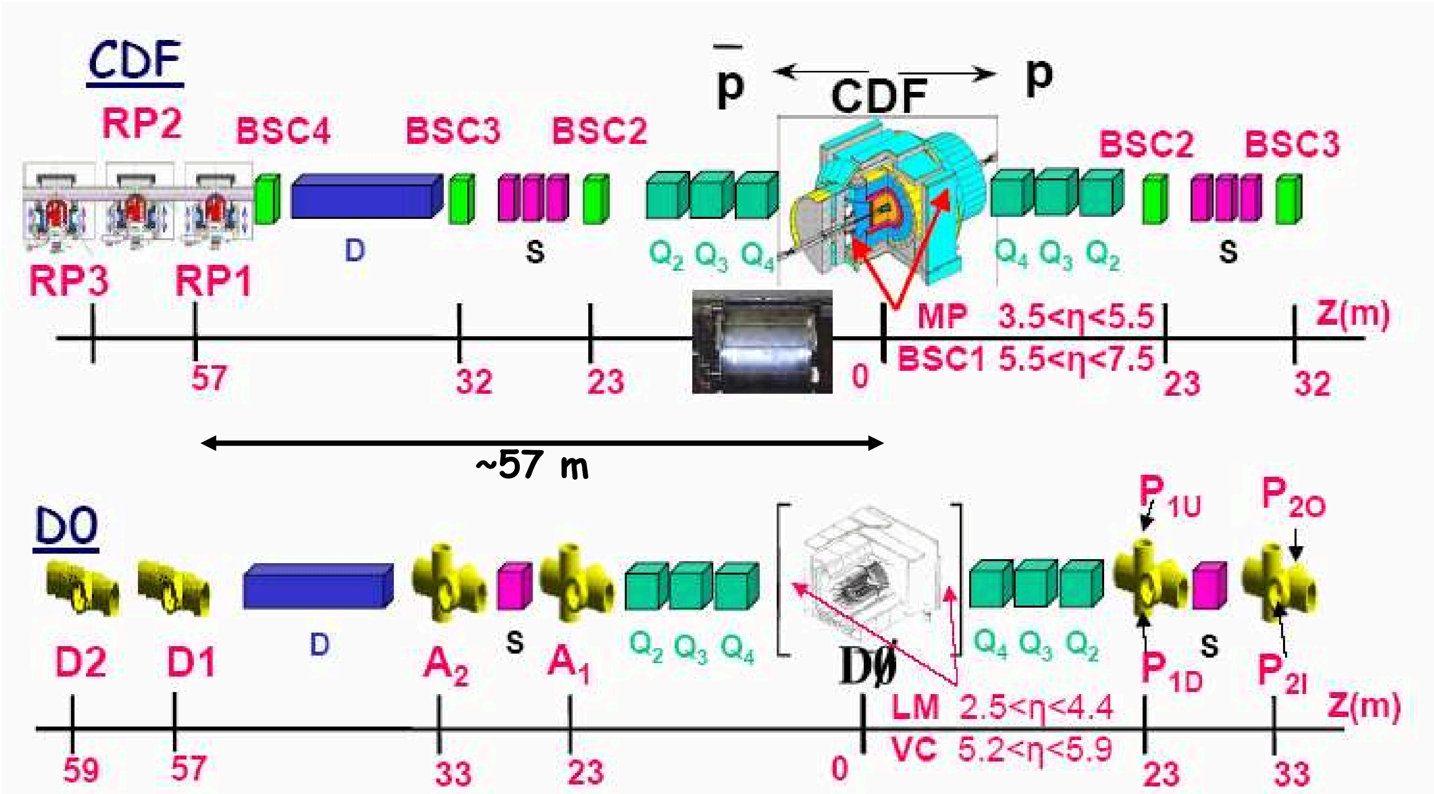
How to find diffractive events at the Tevatron

- First method: Use the rapidity gap technique defined in calorimeter
- Second method: Tag p and/or $\bar{p}$ in final state

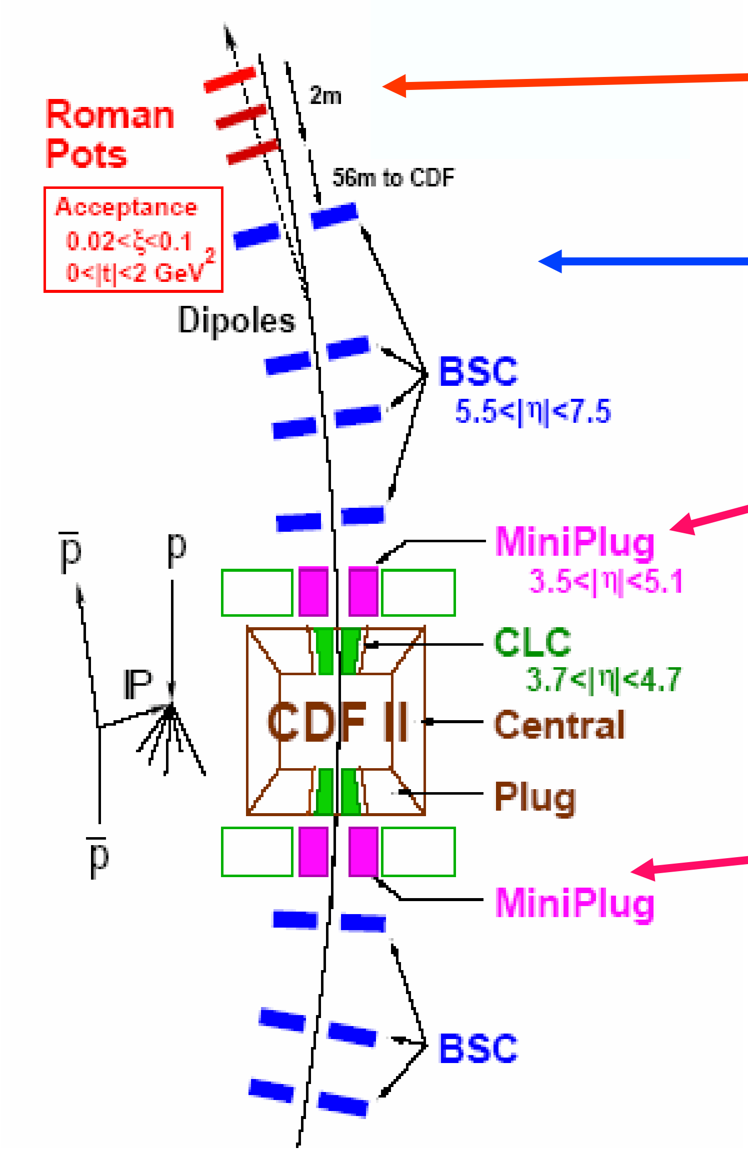


Forward Detectors (DØ and CDF)

- CDF: "dipole" roman pots on $\bar{p}$ side only
- DØ :"Roman pot" detectors on each side (p and $\bar{p}$)

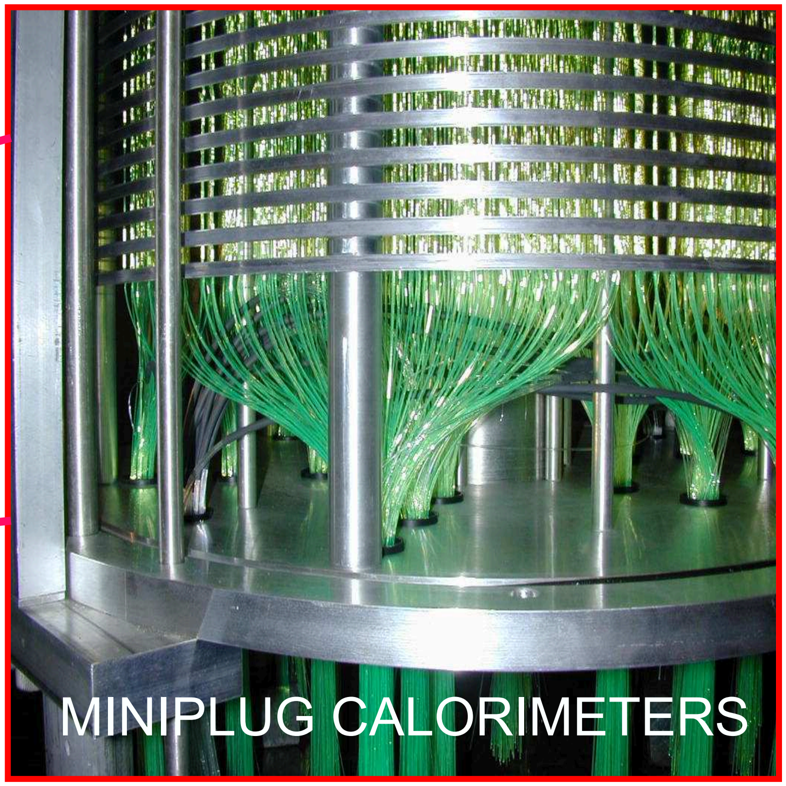


Forward Detectors (CDF)

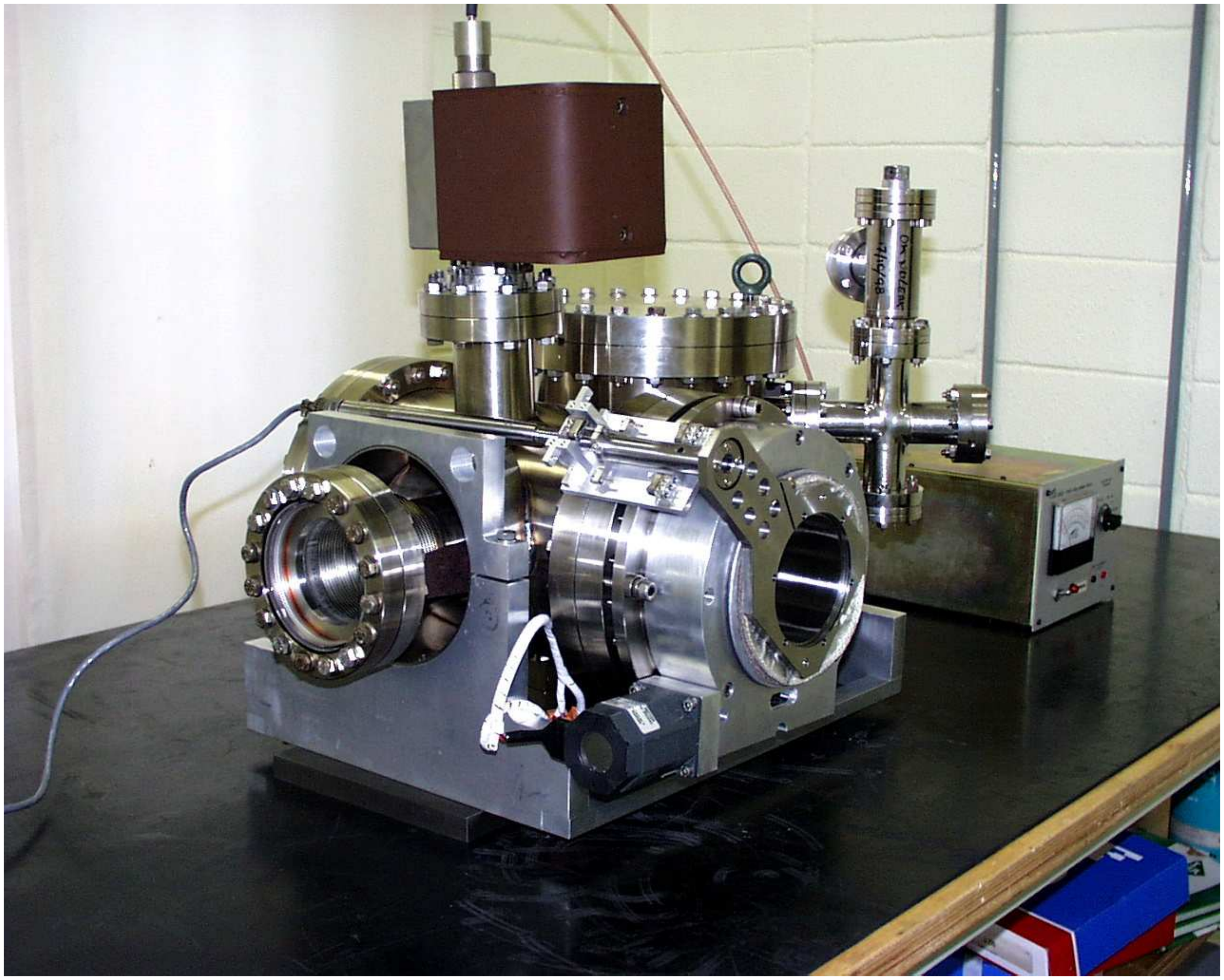


ROMAN POT DETECTORS

BEAM SHOWER COUNTERS: used to reject ND events



Forward Detectors (DØ)

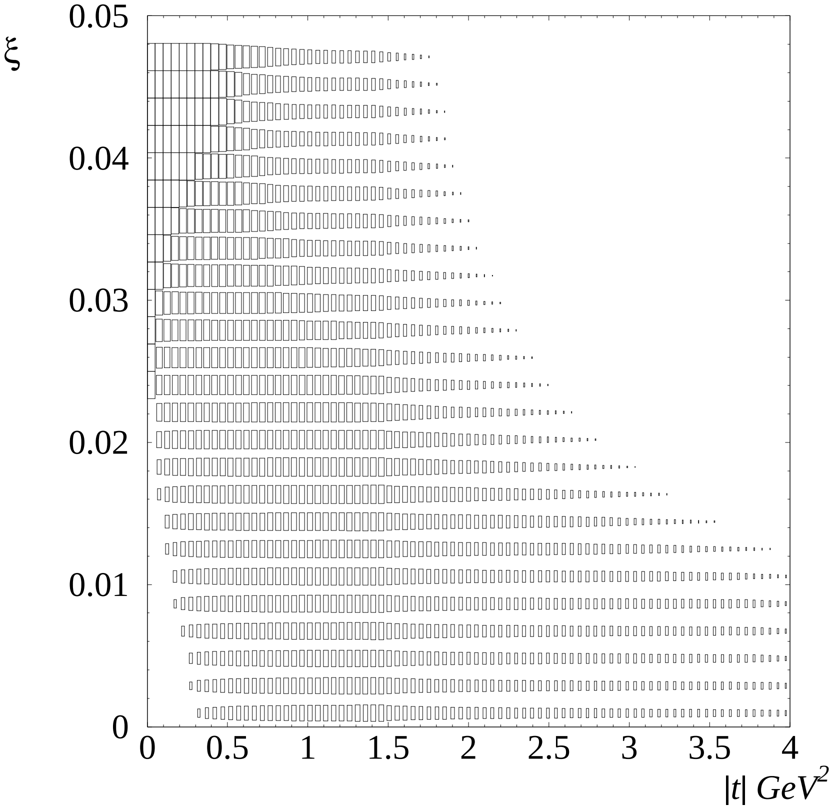


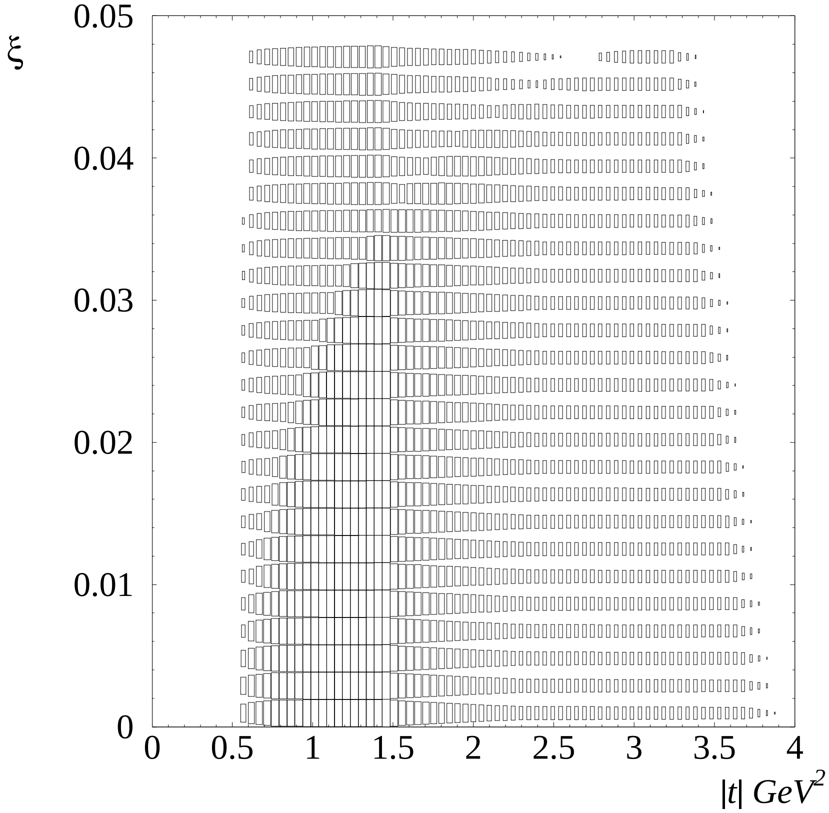
Forward Detectors (DØ): tunnel

Forward Detectors (DØ)

FPD acceptance

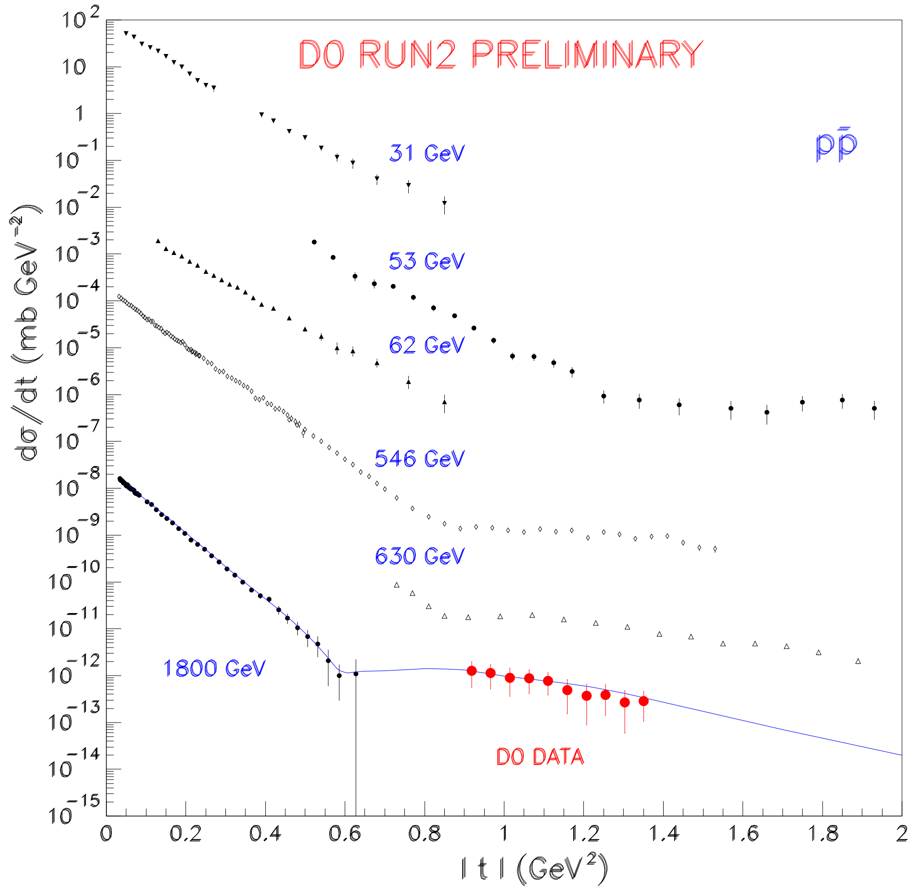
dipoles: acceptance at small t, medium ξ, quadrupole: higher t, small ξ





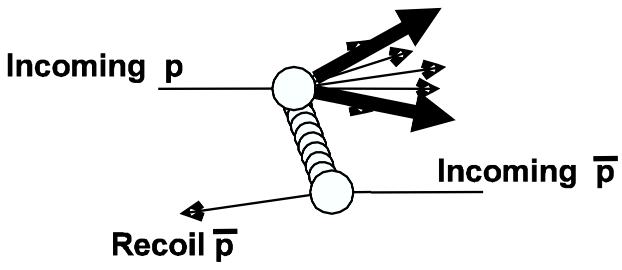
Elastic events

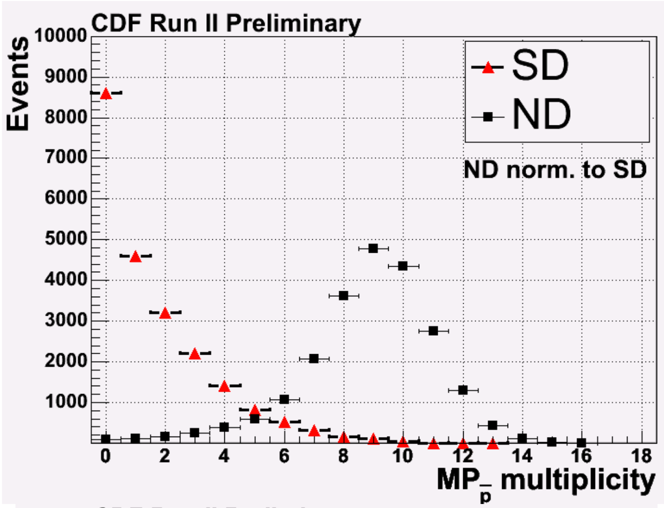
Measurement of the t-slope of the elastic cross section (FPD commissioning)



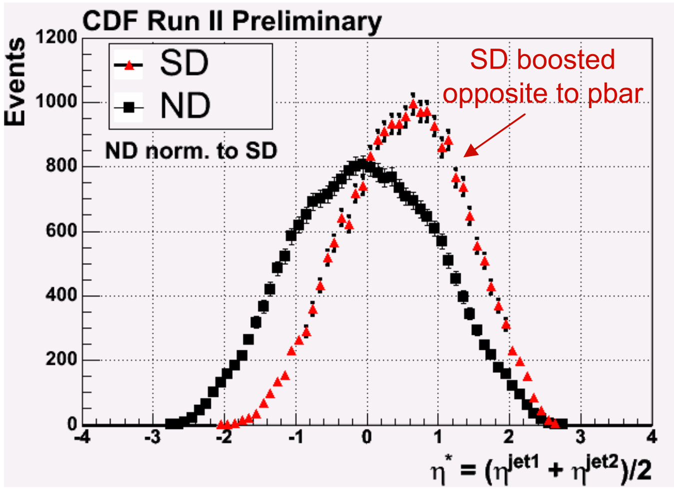
Kinematic properties for diffractive events

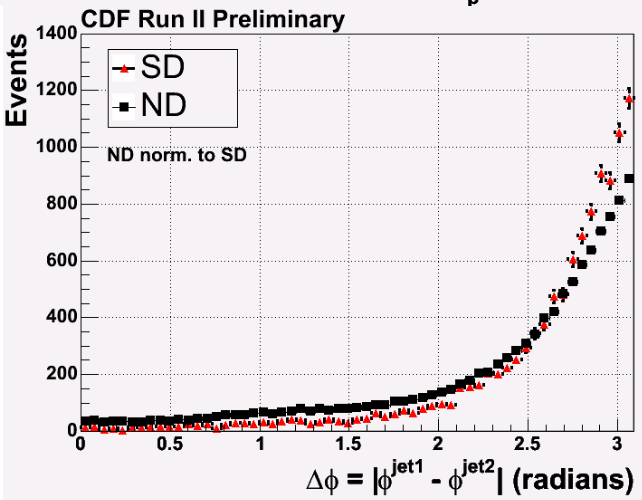
- Compare kinematic properties of single diffractive/non diffractive events when a $\bar{p}$ is tagged
- Diffractive events show less QCD radiation: events more back-to-back





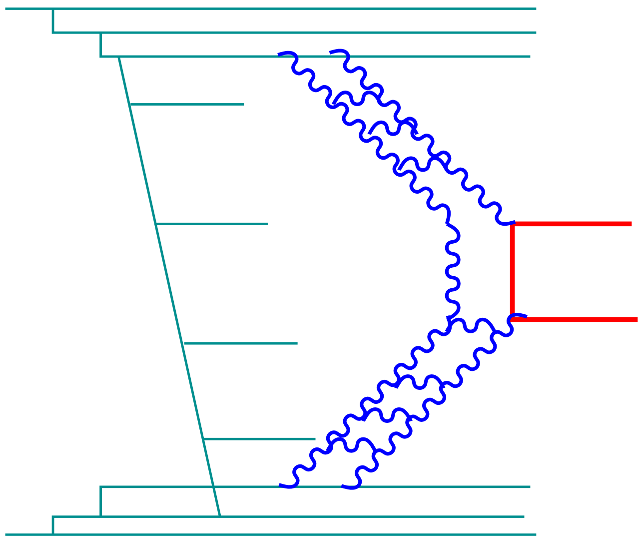
compare ND and SD



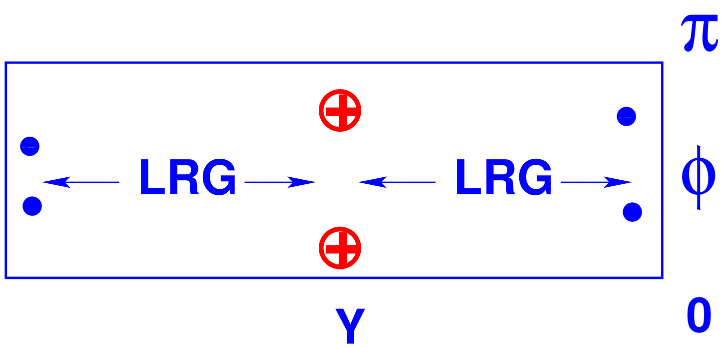


Factorisation at Tevatron?

- Is factorisation valid at Tevatron? Can we use the parton densities measured at HERA to use them at the Tevatron/LHC?
- Factorisation is not expected to hold: soft gluon exchanges in initial/final states
- Survival probability: Probability that there is no soft additional interaction, that the diffractive event is kept



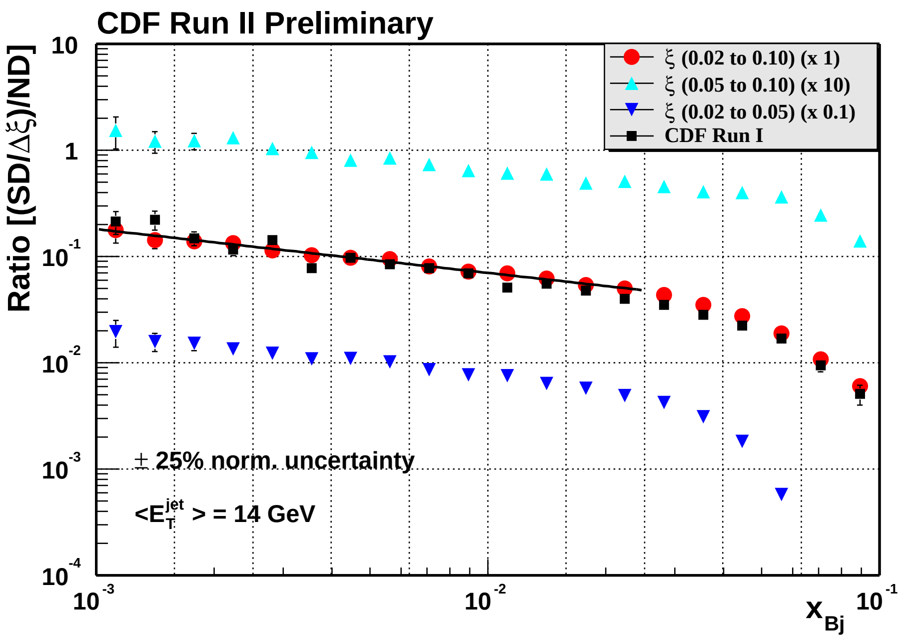
a)

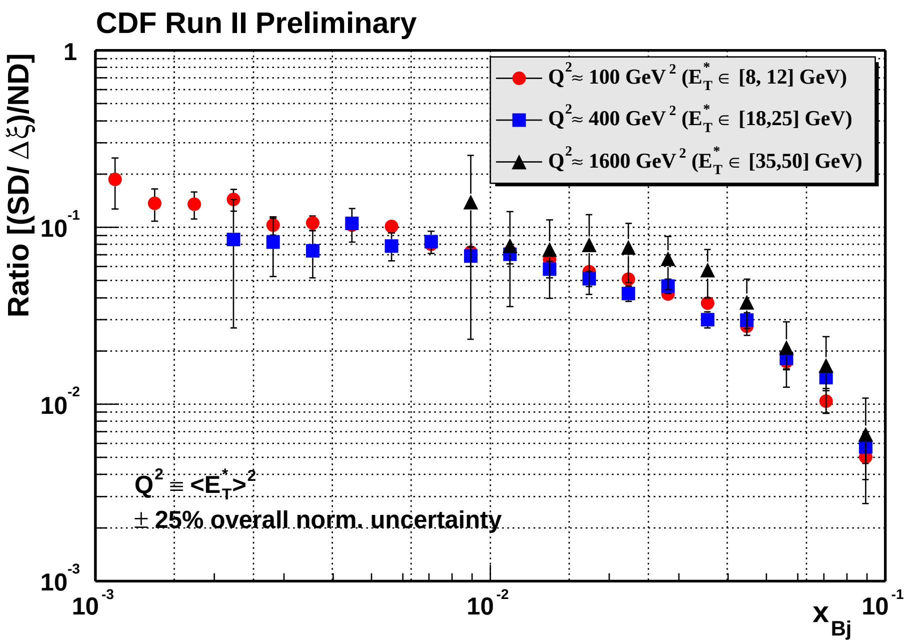


b)

Factorisation within CDF data?

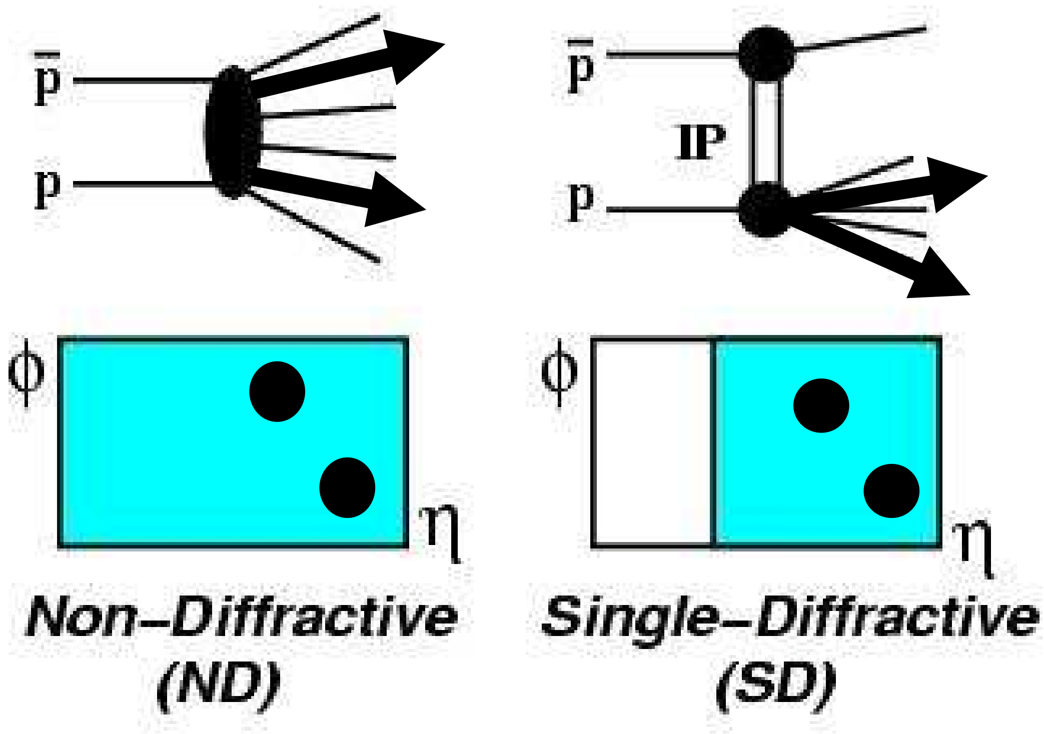
Same x and Q^2 dependence for different kinematical domains
$\longrightarrow$ Factorisation holds





Extraction of xG in pomeron from CDF data

Extraction of gluon in pomeron using diffractive jet rate in CDF data

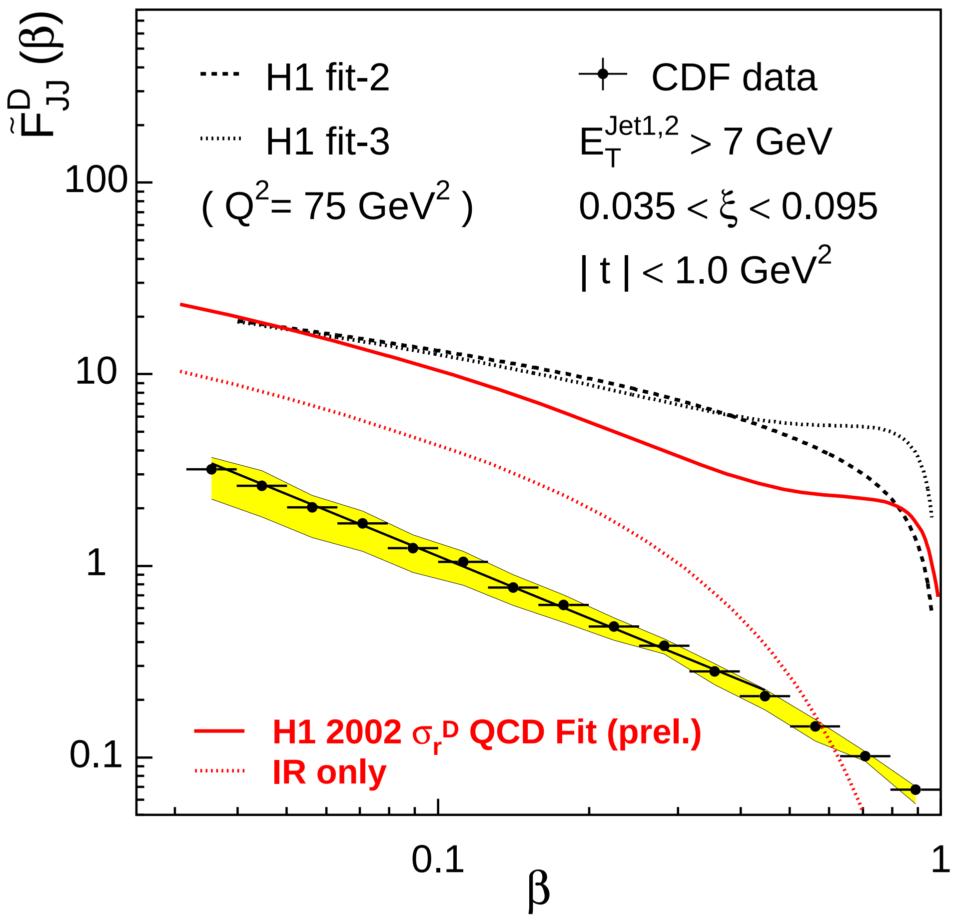


$$R(x_{Bj}) \equiv \frac{\mathrm{Rate}_{jj}^{SD}(x_{Bj})}{\mathrm{Rate}_{jj}^{ND}(x_{Bj})}$$

$$\Rightarrow \quad \frac{F_{jj}^{SD}(x_{Bj})}{F_{jj}^{ND}(x_{Bj})}$$

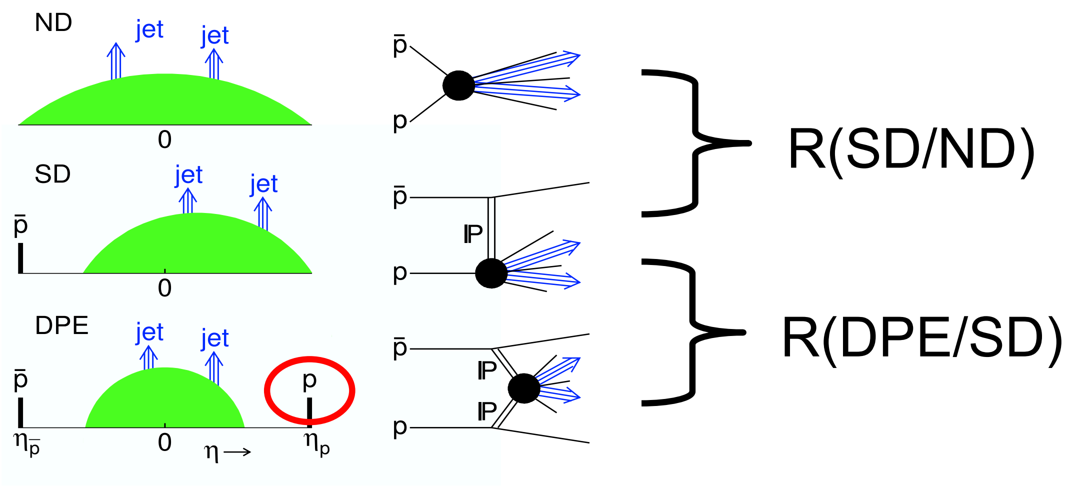
Extraction of xG in pomeron from CDF data

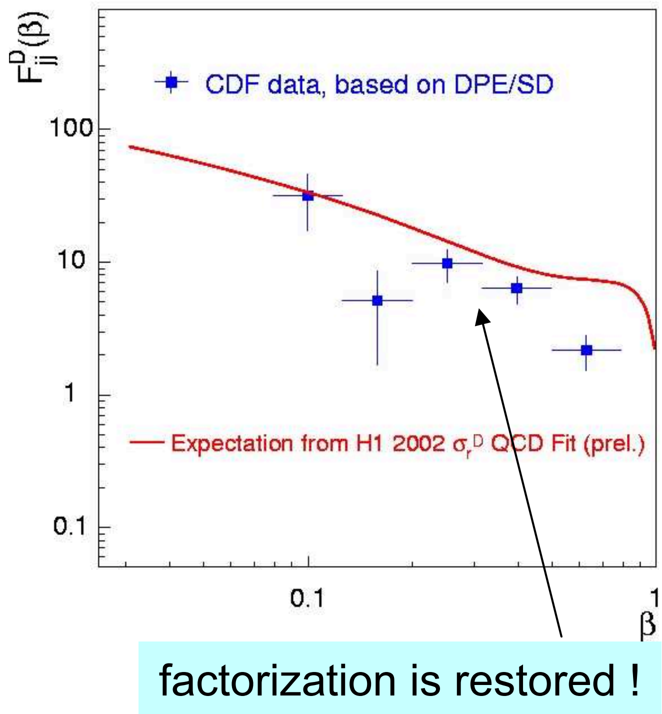
- Measurement of the dijet diffractive cross section leads directly to diffractive structure function: $\frac{\sigma_{jj}(SD)}{\sigma_{jj}(ND)} = \frac{F^D_{jj}}{F_{jj}}$
- Comparison of xG in pomeron from H1 (full red line) compared to CDF measurement:
- Difference in normalisation, shapes similar



Factorisation breaking at Tevatron

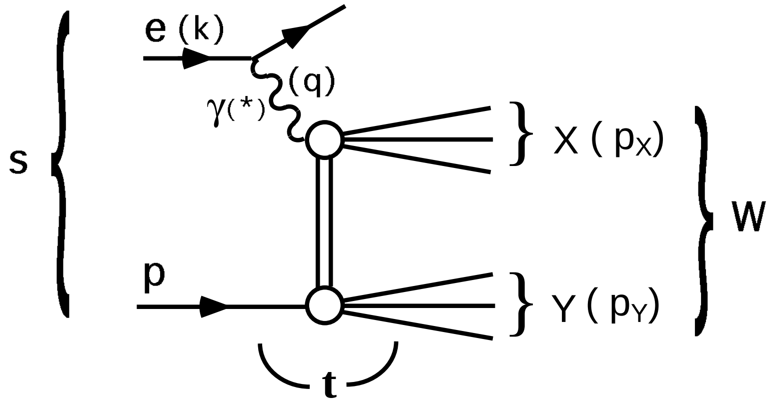
- No factorisation between HERA and Tevatron: survival probability of 0.1 at Tevatron
- Factorisation between double pomeron exchange and single diffraction?
- Is the survival probability a constant or does it depend on kinematic variables? Can we test it at Tevatron?

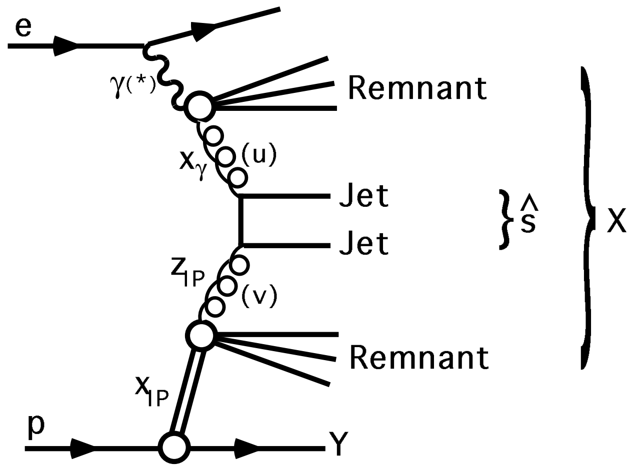




Survival probability studies in H1

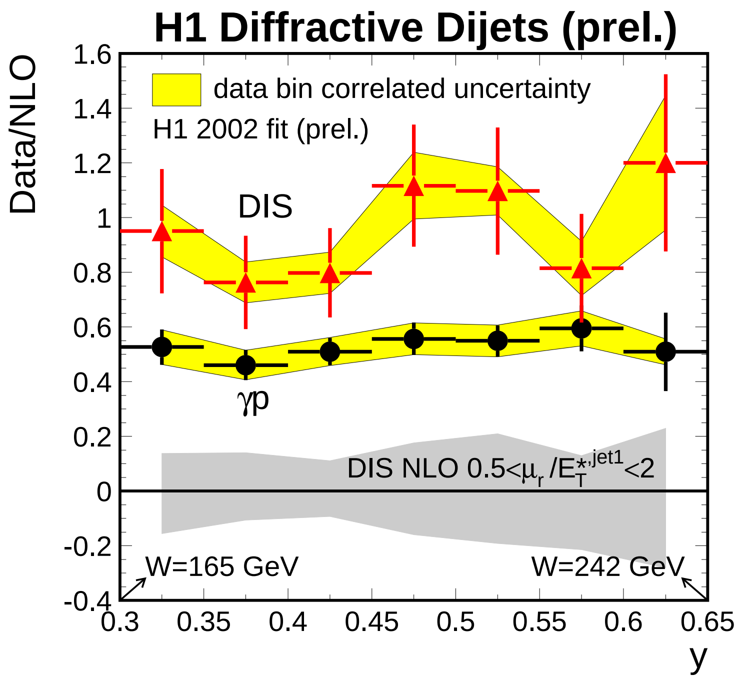
- Find a process where we have diffractive hadron-hadron interaction at HERA: look in resolved photoproduction events
- Look for the proportion of diffractive events and check if it is different from DIS





Survival probability studies in H1

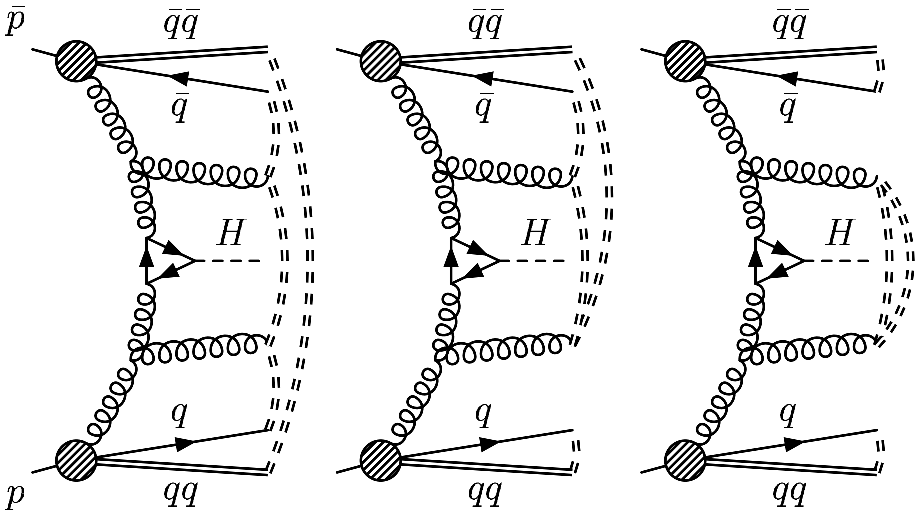
Normalised cross section for the diffractive production of 2 jets in γp



Conclusion: Factor 0.5 needed between DIS and γp data! Evidence for survival probability effects, different from Tevatron.

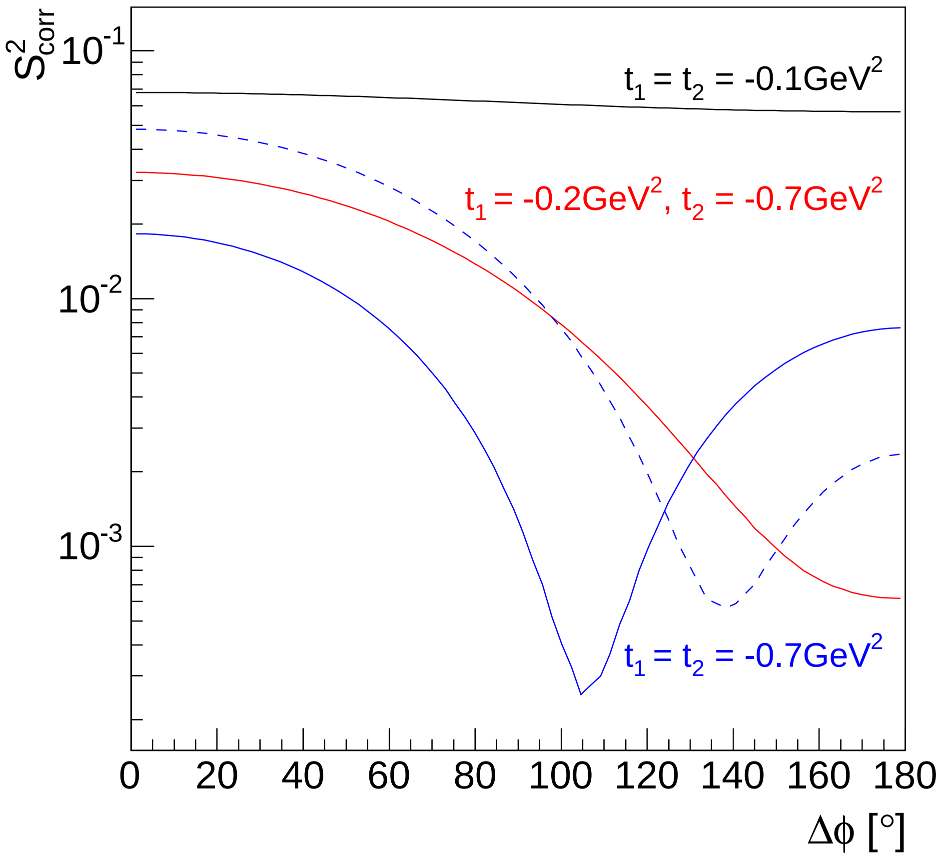
A parenthesis: Soft Colour Interaction Models

- A completely different model to explain diffractive events: Soft Colour Interaction (R.Enberg, G.Ingelman, N.Timneanu, hep-ph/0106246)
- Principle: Variation of colour string topologies, giving a unified description of final states for diffractive and non-diffractive events
- No survival probability for SCI models



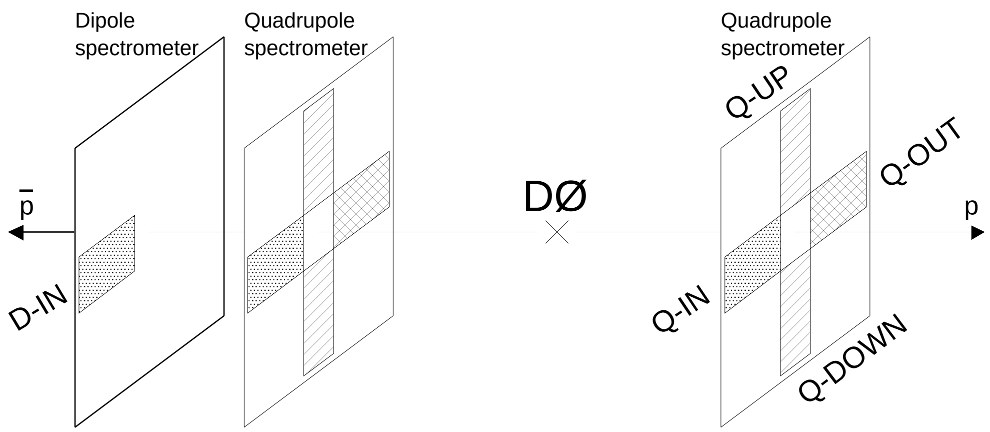
$\Delta\Phi$ dependence of survival probabilities

Survival probability strongly $\Delta\Phi$-dependent where $\Delta\Phi$ is the difference in azimuthal angles between p and $\bar{p}$



Forward Proton Detector in DØ

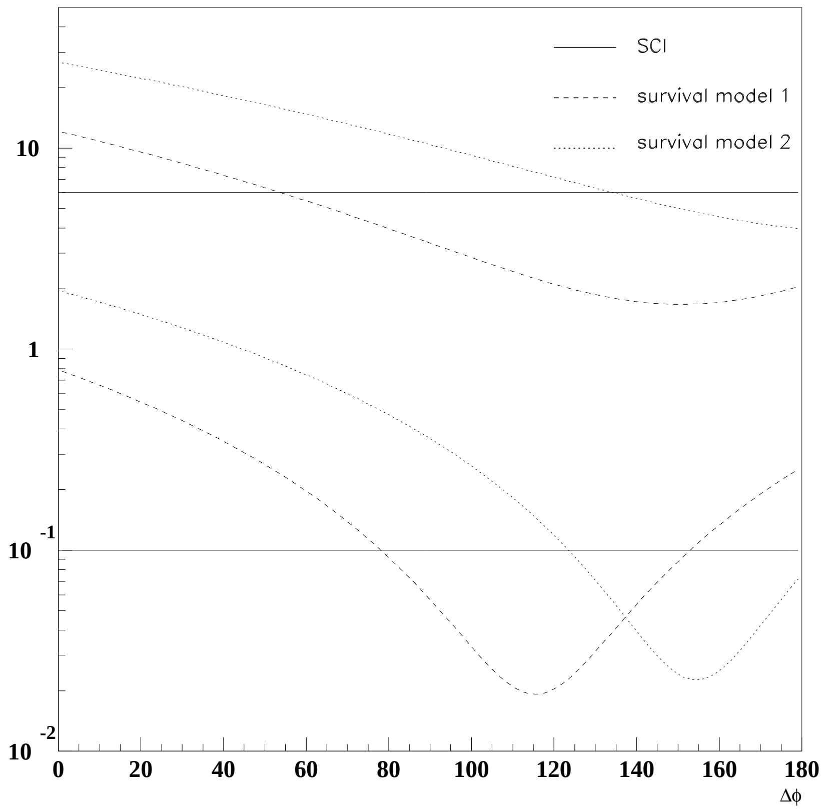
Forward Proton Detector (FPD) installed by DØ allowing to measure directly $\Delta\Phi$



Possibility to combine D-IN with quadrupole on the other side, or two quadrupole detectors (Q-UP and Q-UP, or Q-UP and Q-DOWN...)

Results

Relative $\Delta\Phi$ dependence for SCI and pomeron-based models (upper plots: ($|t_p| > 0.6$, $|t_{\bar{p}}| > 0.1$ GeV^2, lower ones $|t_p| > 0.5$, $|t_{\bar{p}}| > 0.5$ GeV^2)



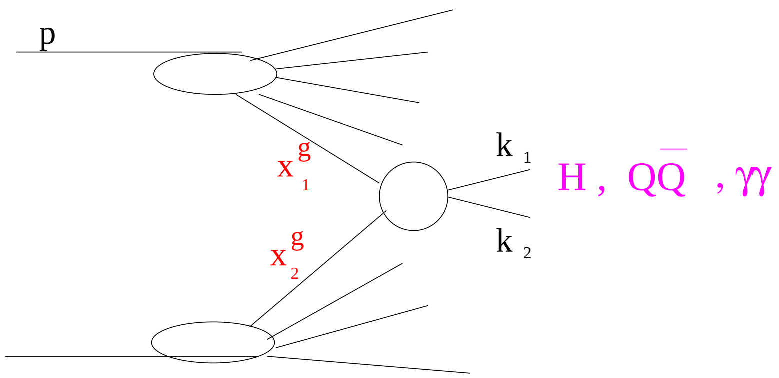
Possible measurement at DØ

- Diffractive cross section ratios in different regions of $\Delta\Phi$ at the Tevatron
- same side: $\Delta\Phi < 45$ degrees, opposite side: $\Delta\Phi > 135$, middle: $45 < \Delta\Phi < 135$ degrees;
- 1st measurement: asymmetric cuts on t (dipole and quadrupole), 2nd measurement: symmetric cuts on t (quadrupole on both sides)
- Possible to distinguish between SCI and pomeron-based models, and test the survival probabilities

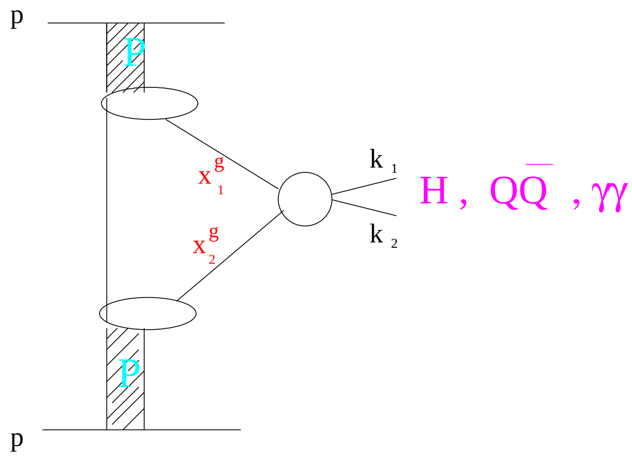
Configuration	model	middle/same	opp./same
Quad. + Dip.	SCI	1.3	1.1
	Pom.	0.36	0.18
Quad. + Quad.	SCI	1.4	1.2
	Pom.	0.14	0.31

Look for exclusive events at the Tevatron

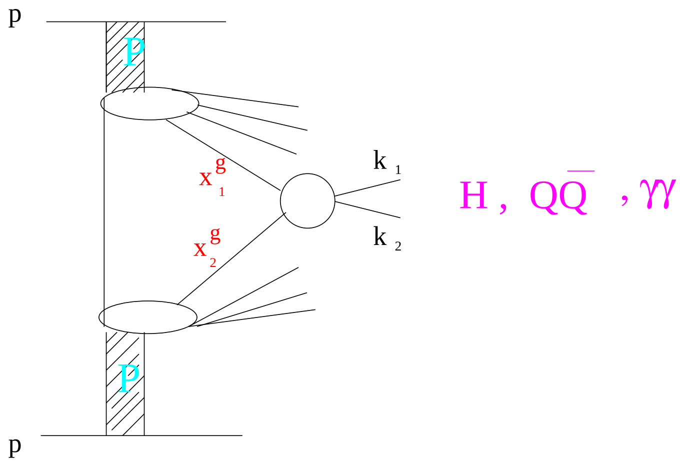
- "exclusive" events: events without pomeron remnant
- The full available energy is used in the hard interaction
- Interesting for LHC...



"Standard"



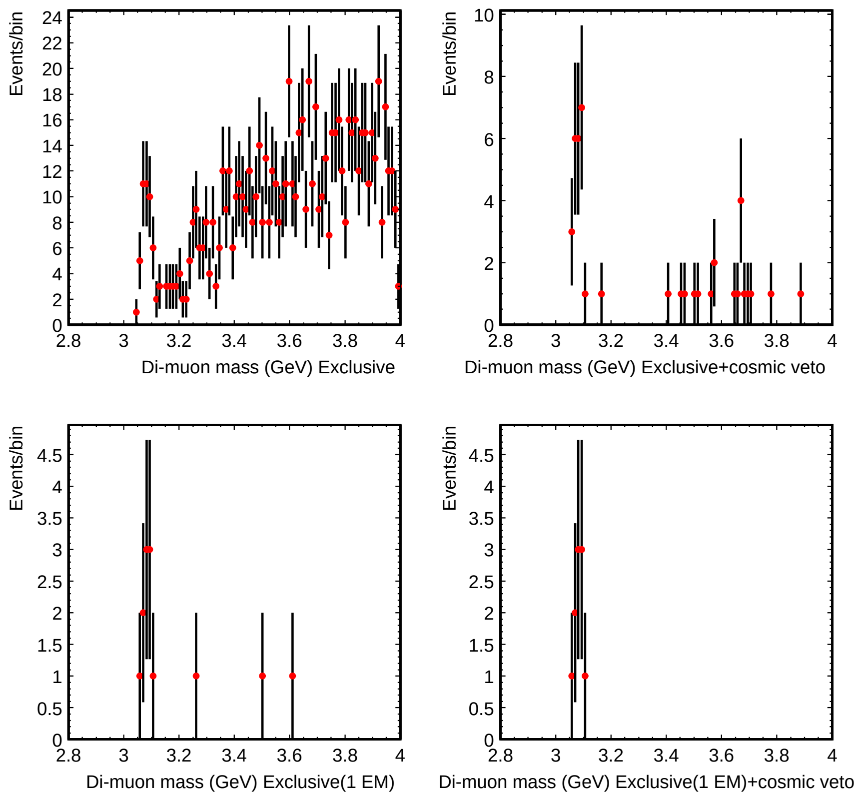
"Exclusive "



"Inclusive"

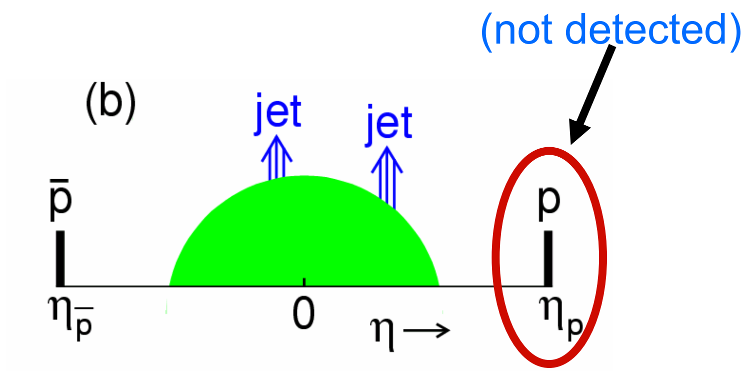
Exclusive χ_c production at CDF

- Look for events with two muons and two rapidity gaps ($\chi_C^0 \rightarrow J/\Psi\gamma \rightarrow \mu^+\mu^-\gamma$)
- Problem of cosmics contamination

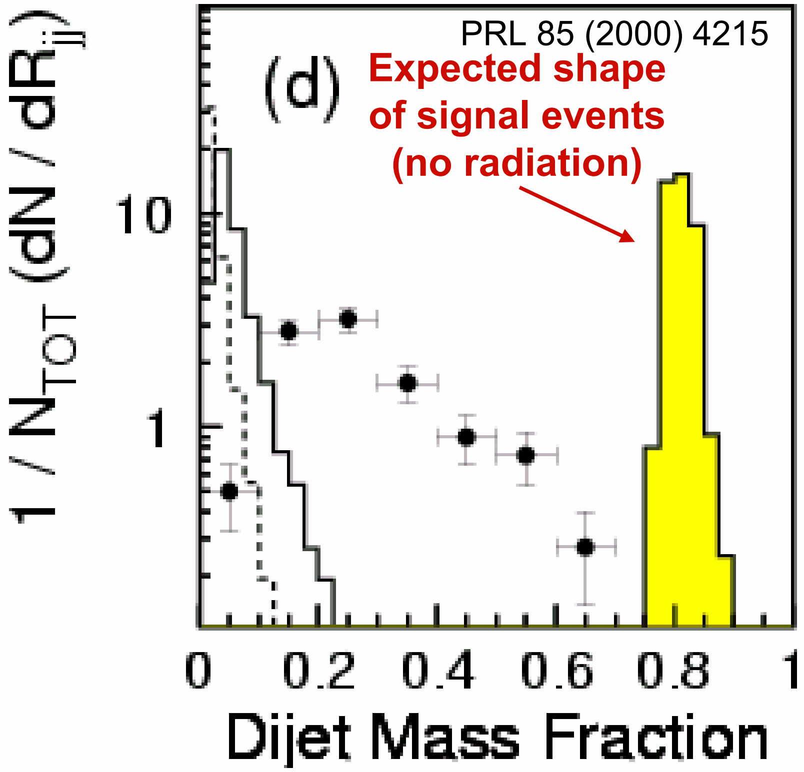


Look for exclusive events at the Tevatron

- measurement of the dijet mass fraction
- Expect a peak towards one if exclusive events exist

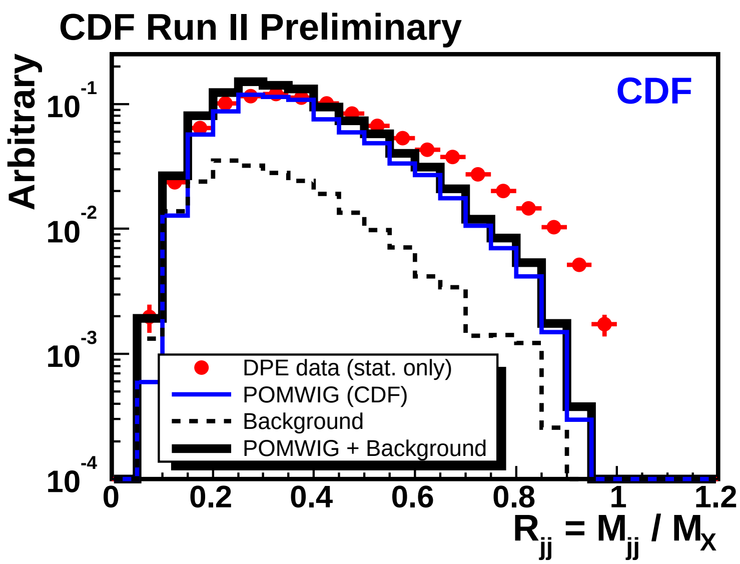


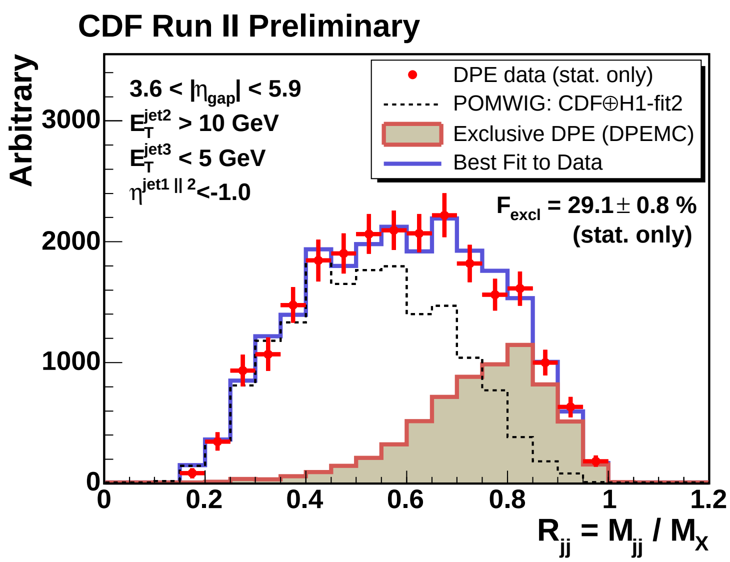
Mass fraction: $R_{jj} = \dfrac{M_{jj}}{M_x}$



Look for exclusive events at the Tevatron

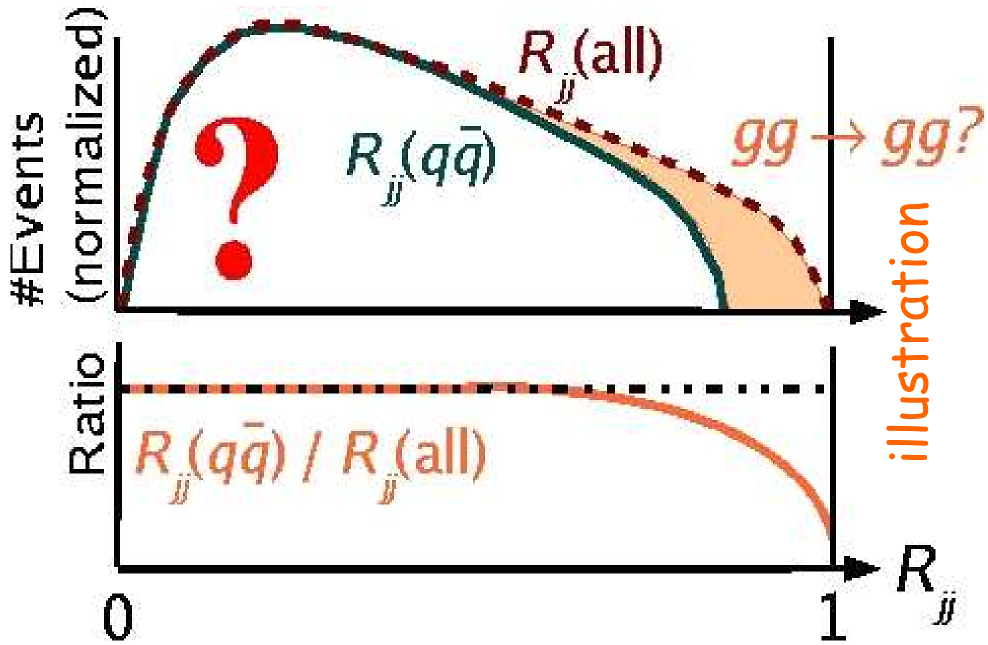
- Select events with two jets only, one proton tagged in roman pot detector and a rapidity gap on the other side
- Observable: dijet mass fraction, close to 1 (within detector resolution) for exclusive events
- Comparison with POMWIG Monte Carlo using H1 gluon density in pomeron and DPEMC for exclusive signal
- Will be interesting to see the effect of new H1/ZEUS PDFs in pomeron on these results





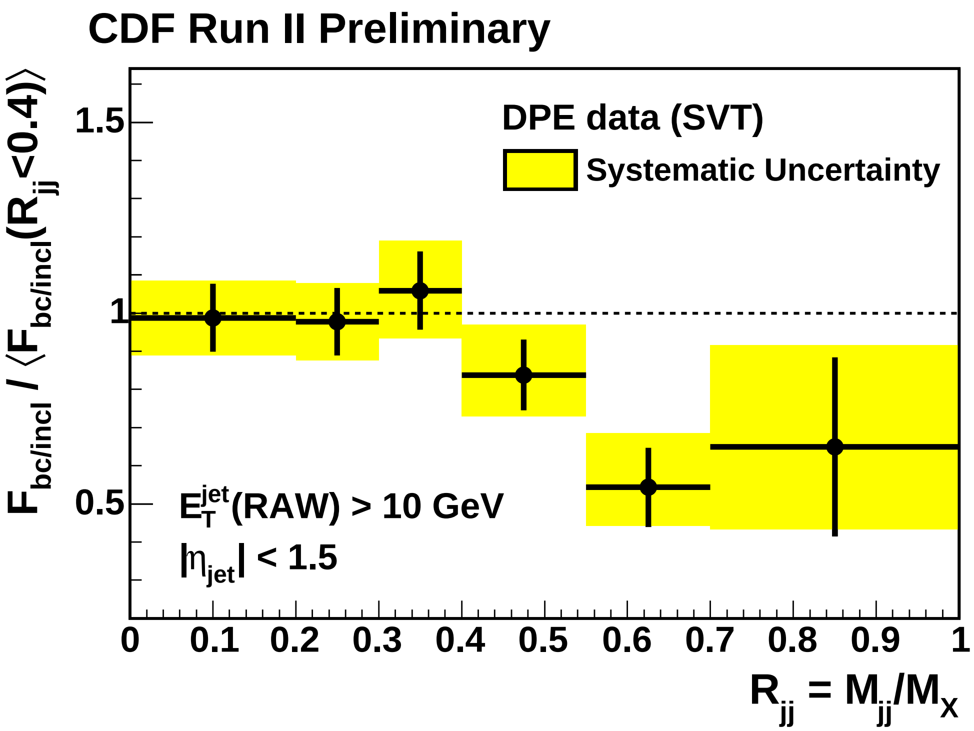
Search for exclusive events (CDF)

- Look for exclusive events in $b\bar{b}$ events production:
- If exclusive events exist the ratio of b jet events should be smaller at high dijet mass faction since exclusive b jet production is suppressed



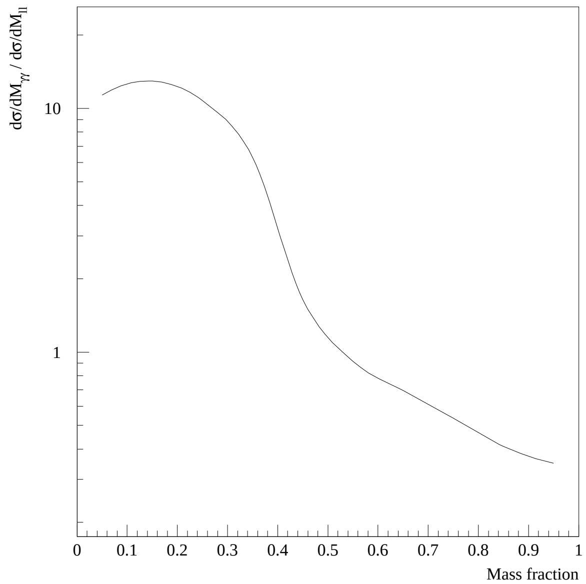
Search for exclusive events (CDF)

- Look for exclusive events in $b\bar{b}$ events production:
- The ratio of b jet events tends to be smaller at high dijet mass faction, needs more stats



Existence of exclusive events

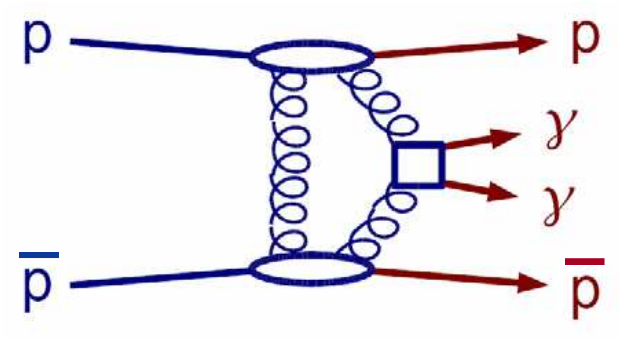
Test of the existence of exclusive events



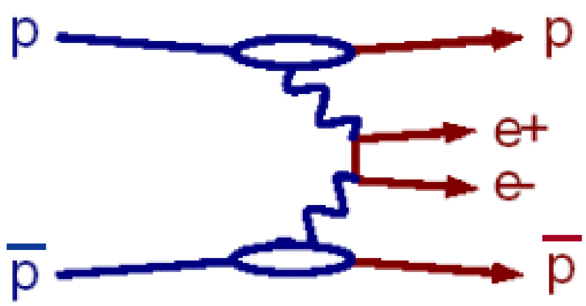
- Dilepton and diphoton cross section ratio as a function of the diphoton/dilepton mass: no dilepton event for exclusive models ($gg \rightarrow \gamma\gamma$ ok, $gg \rightarrow l^+l^-$ direct: impossible)
- Change of slope of ratio if exclusive events exist

Search for exclusive diphotons (CDF)

- Look for diphoton events: very clean events (2 photons and nothing else), but low cross section (nothing means experimentally nothing above threshold..., quasi-exclusive events contamination)
- Look for dilepton events: produced only by QED processes, cross-check to exclusive $\gamma\gamma$ production



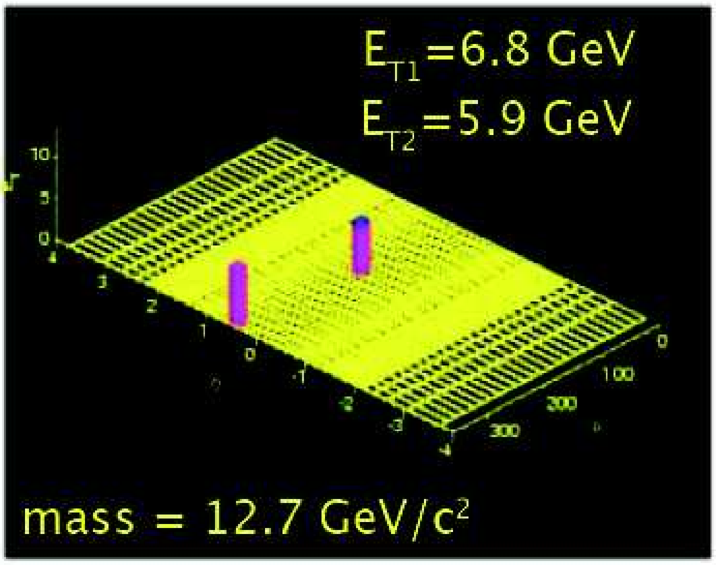
$p\bar{p} \to p \quad \gamma\gamma + \bar{p}$

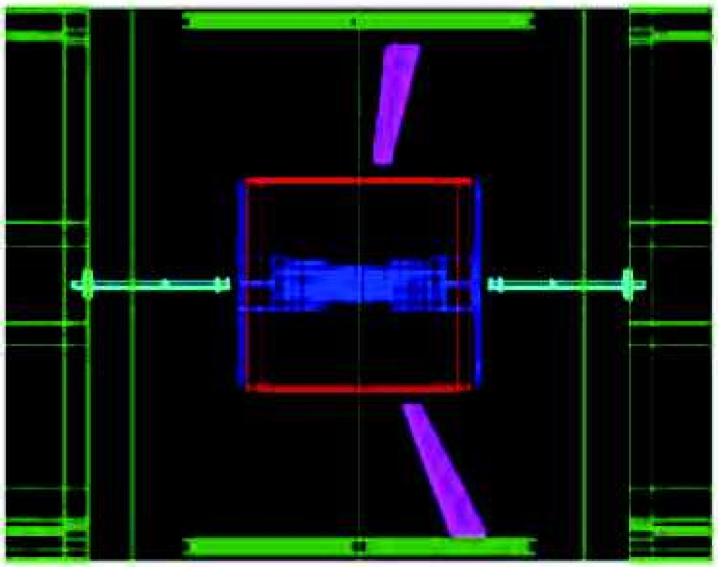


QED process: cross-check to exclusive $\gamma\gamma$

Search for exclusive diphotons (CDF)

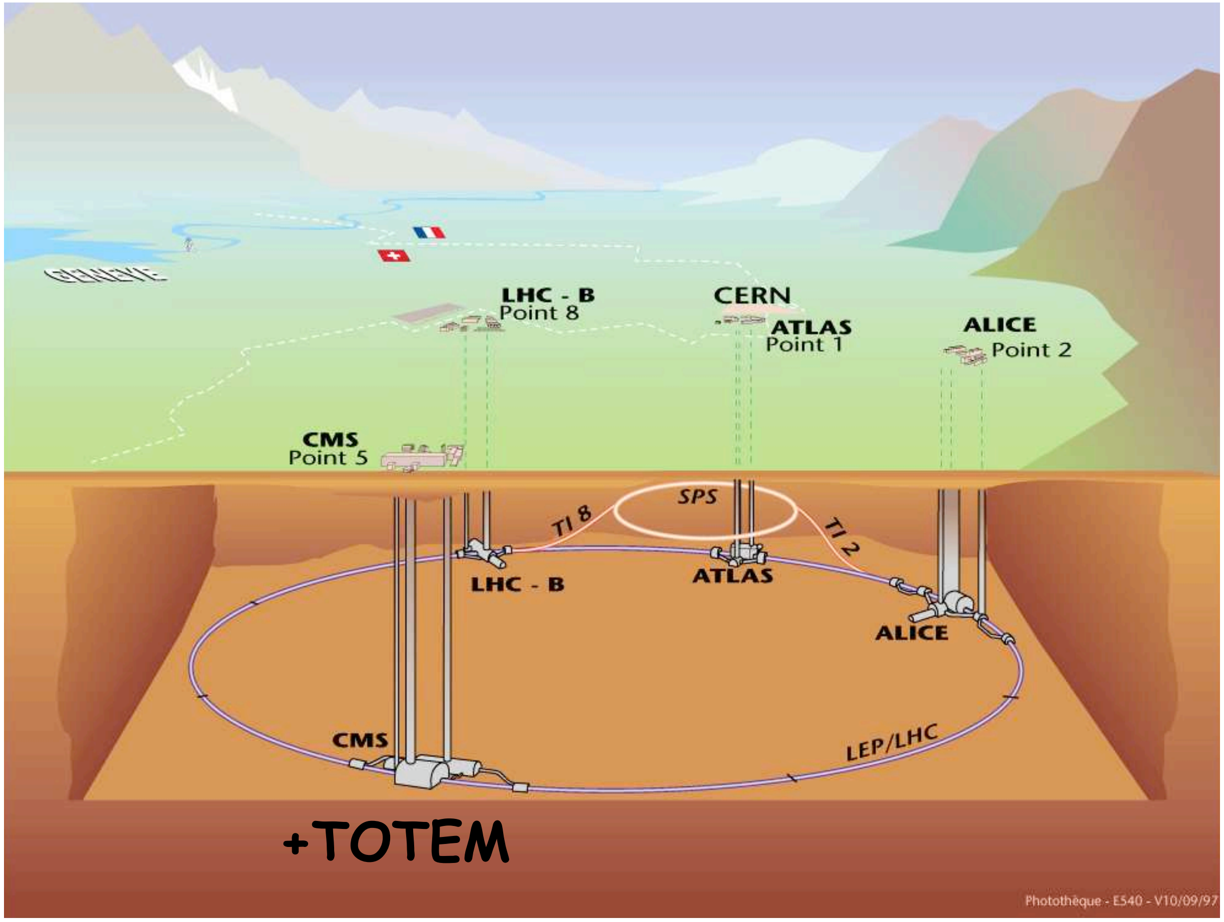
- Look for exclusive diphoton or dilepton production, dominated by QED events (photon exchanges) and not from pomeron exchanges
- Cross section for e^+e^- exclusive production: $N_{candidates} = 16^{+5.1}_{-3.2}$, $N_{background} = 2.1^{+0.7}_{-0.3}$ (mainly dissociation events) in 46 pb^{-1}
  $\sigma = 1.6^{+0.5}_{-0.3}(stat) \pm 0.3(syst)$ pb
- Cross section for $\gamma\gamma-$ exclusive production: $N_{candidates} = 3^{+2.9}_{-0.9}$, $N_{background} = 0^{+0.2}_{-0.0}$ (mainly dissociation events) in 46 pb^{-1}
  $\sigma = 0.14^{+0.14}_{-0.04}(stat) \pm 0.03(syst)$ pb





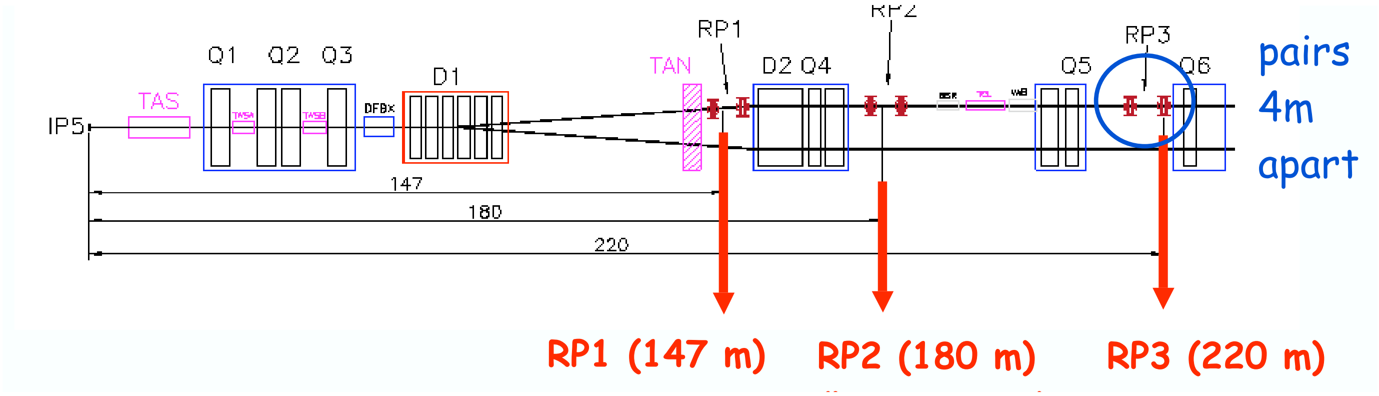
Diffraction at the LHC

- LHC, $\sqrt{S} = 14$ TeV, allows to reach a completely new kinematical domain, 2 experiments involved in diffraction: ATLAS, CMS-TOTEM
- Diffractive selection: as for the Tevatron, rapidity gap selection at low luminosity (25 interactions expected at the same time at the highest luminosity, will kill the gaps)
- Measurements of hard diffraction and elastic cross sections



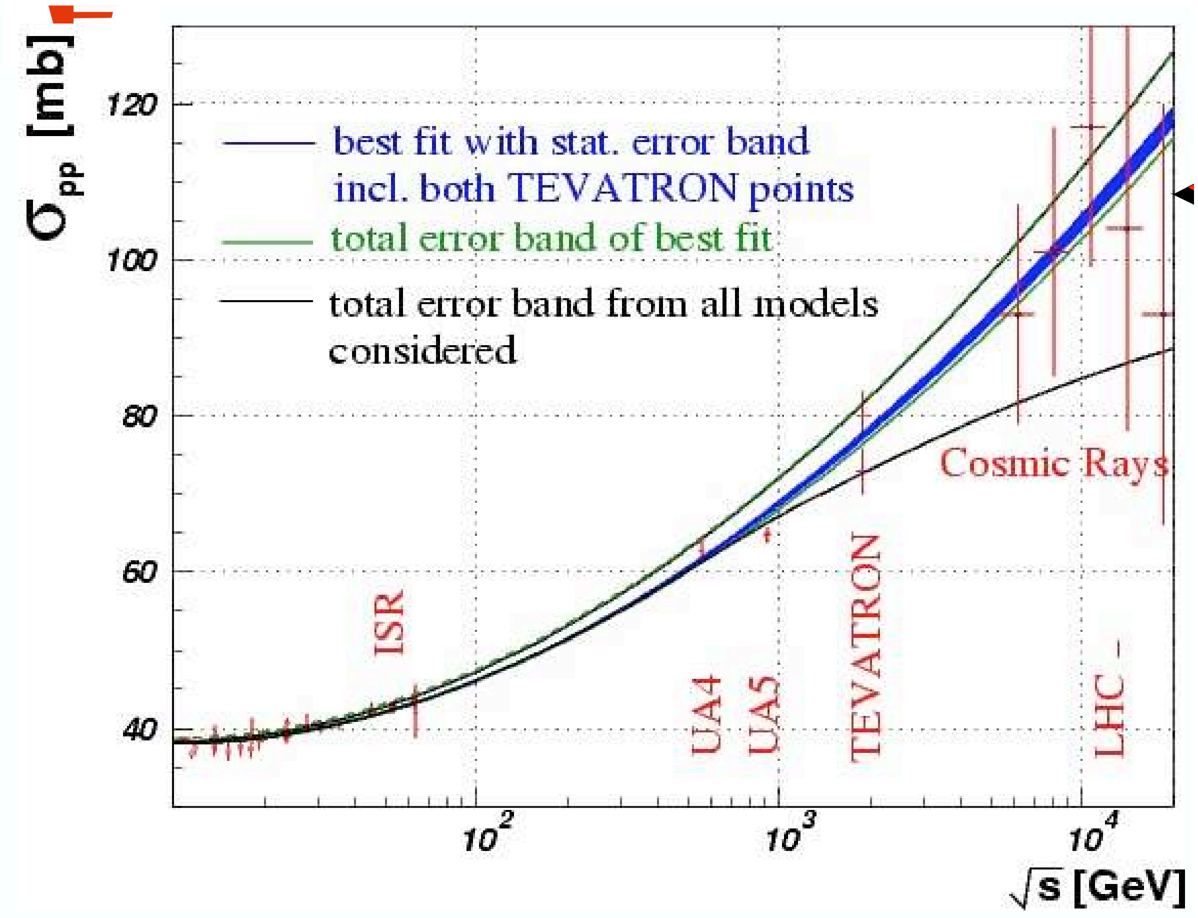
Soft physics at the LHC: Roman pots in TOTEM/ATLAS

- Roman pots in TOTEM located at 147 m, 220 m
- Roman pots in ATLAS located at 240 m
- Possibility to measure the total cross section at the LHC with a special LHC lattice at low luminosity



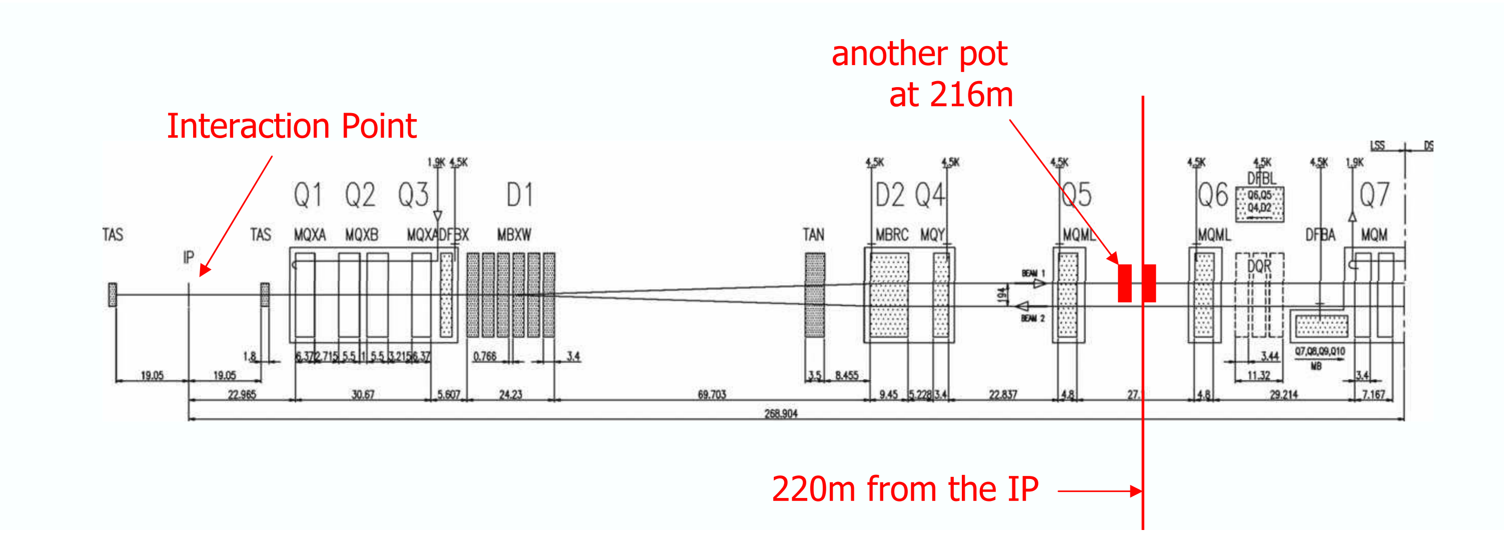
Measurement of the total cross section

- Measurement of the total cross section at the LHC
- Also important for luminosity measurements

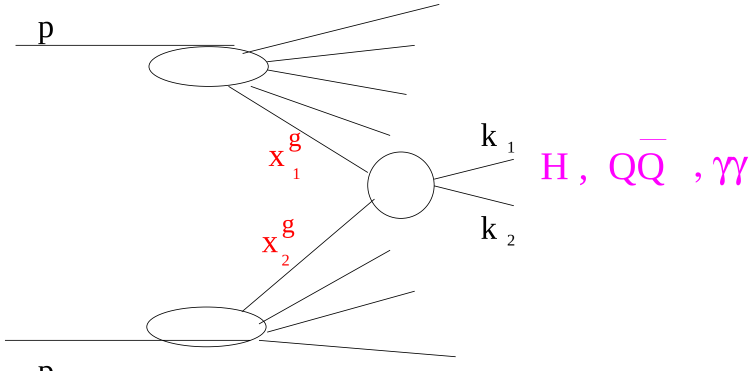


Hard diffraction at LHC

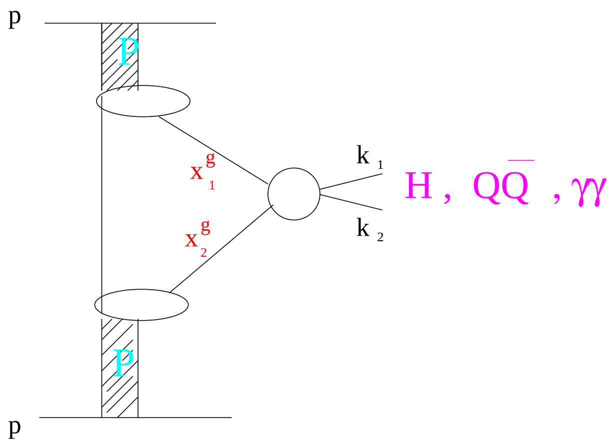
- Two projects of roman pot detectors at the LHC at high luminosity: 220m and 420 m (both for CMS and ATLAS)
- Projects under study, to be installed in 2008-2009



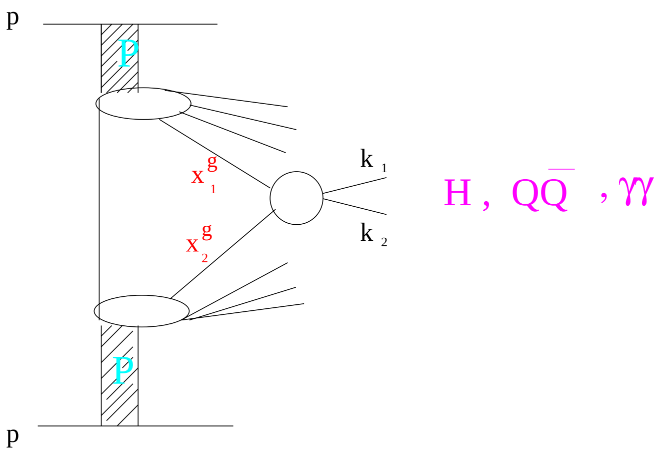
“Exclusive models”



"Standard"



"Exclusive "

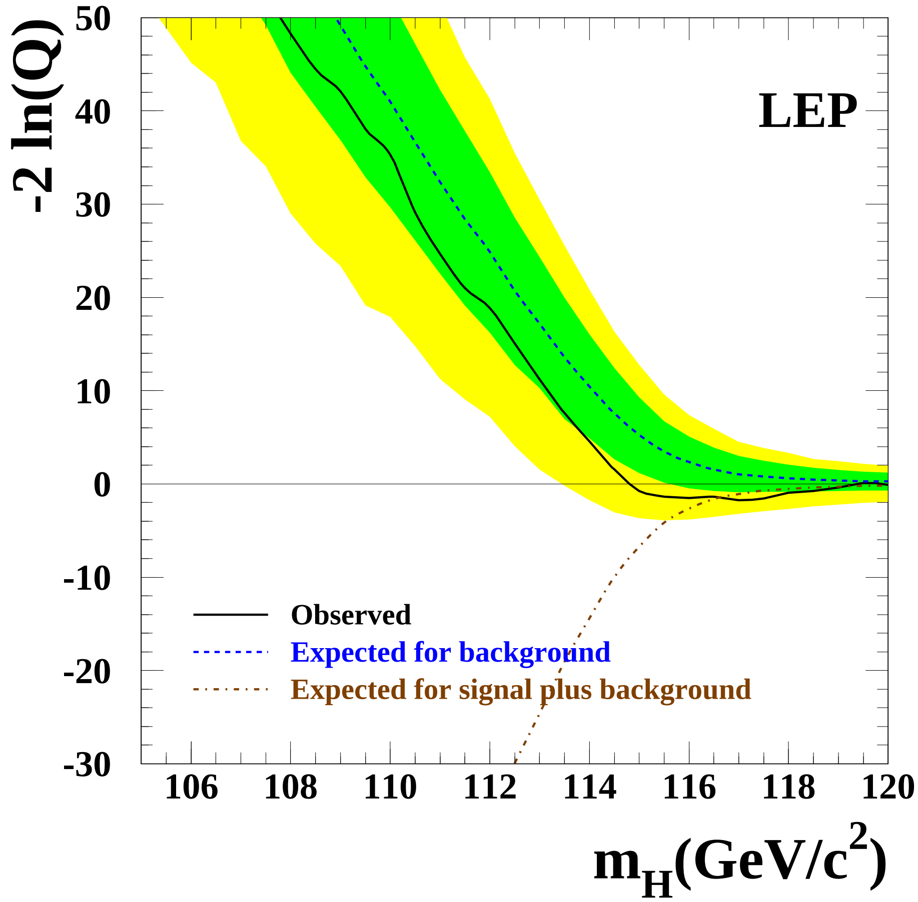


"Inclusive"

All the energy is used to produce the Higgs (or the dijets), namely $xG \sim \delta$

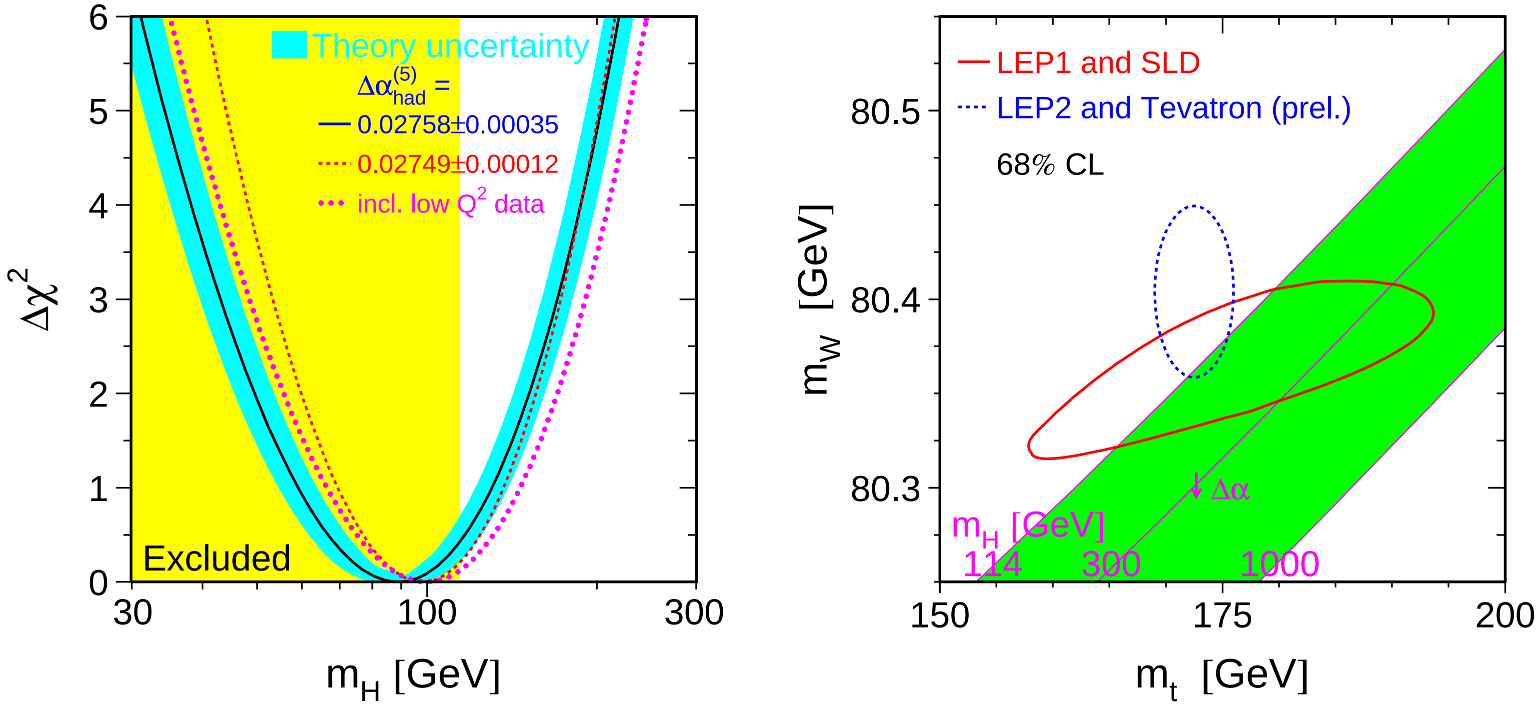
LEP limits on Higgs mass

Limit on Higgs mass: 114.4 GeV

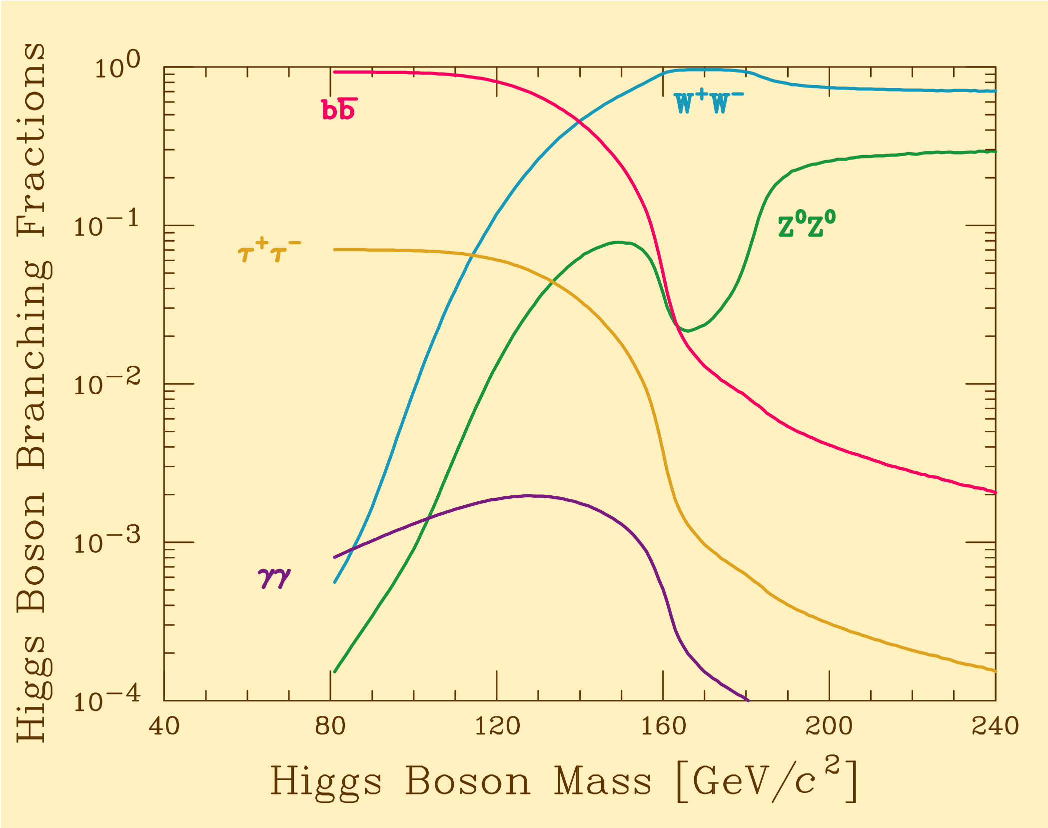


Electroweak fits and mass of Higgs boson

- Use new M_{top}, width of W boson from Tevatron and LEP, and mass of W from LEP
- $M_{Higgs} = 89 + 42 - 30$ GeV (68% CL), and < 175 GeV at 95% CL



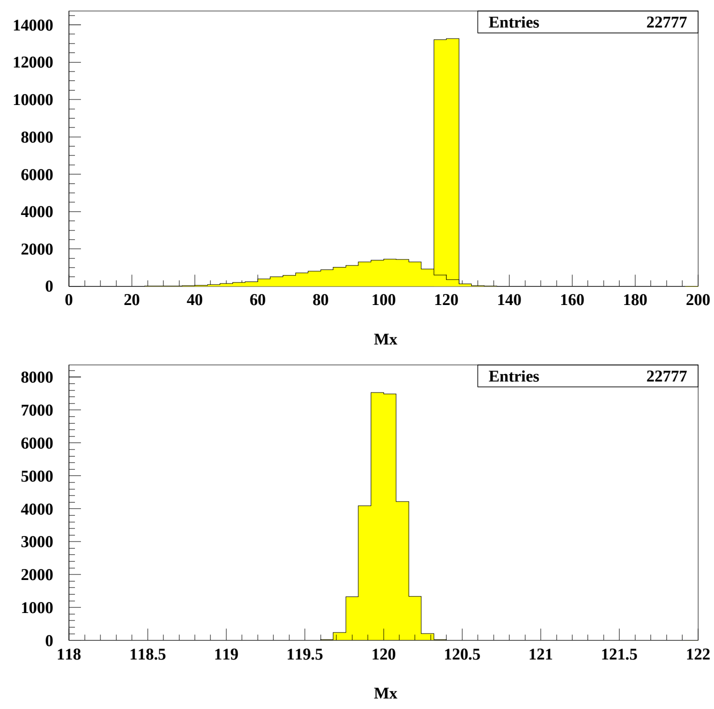
SM Higgs decay



Low masses: $b\bar{b}$ and $\tau\tau$ dominate
High masses: WW dominates

Advantage of exclusive Higgs production?

- Good Higgs mass reconstruction: fully constrained system, Higgs mass reconstructed using both tagged protons in the final state ($pp \to pHp$)
- $M_H = \sqrt{\xi_p \xi_{\bar{p}} S}$
- Contamination to the exclusive Higgs signal due to the tail of inclusive events: important to know the tail of the inclusive distributions at high β

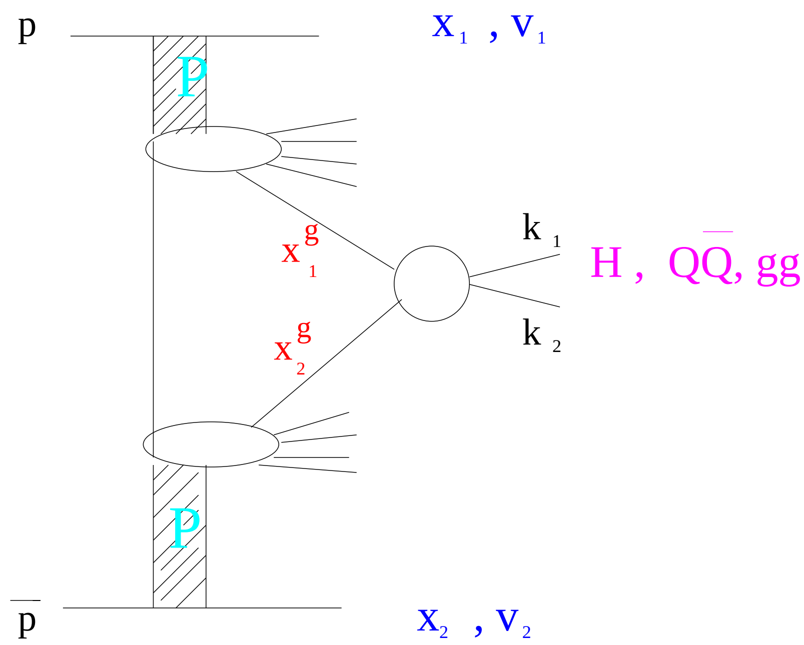


DPEMC Monte Carlo

- DPEMC (Double Pomeron Exchange Monte Carlo): New generator to produce events with double pomeron exchange http://boonekam.home.cern.ch/boonekam /dpemc.htm, hep-ph/0312273
- Interface with Herwig: for hadronisation
- Exclusive and inclusive processes included: Higgs, dijets, diphotons, dileptons, SUSY, QED, Z, W...
- DPEMC generator interfaced with a fast simulation of LHC detector (as an example CMS, same for ATLAS), and a detailled simulation of roman pot acceptance
- Gap survival probability of 0.03 put for the LHC i

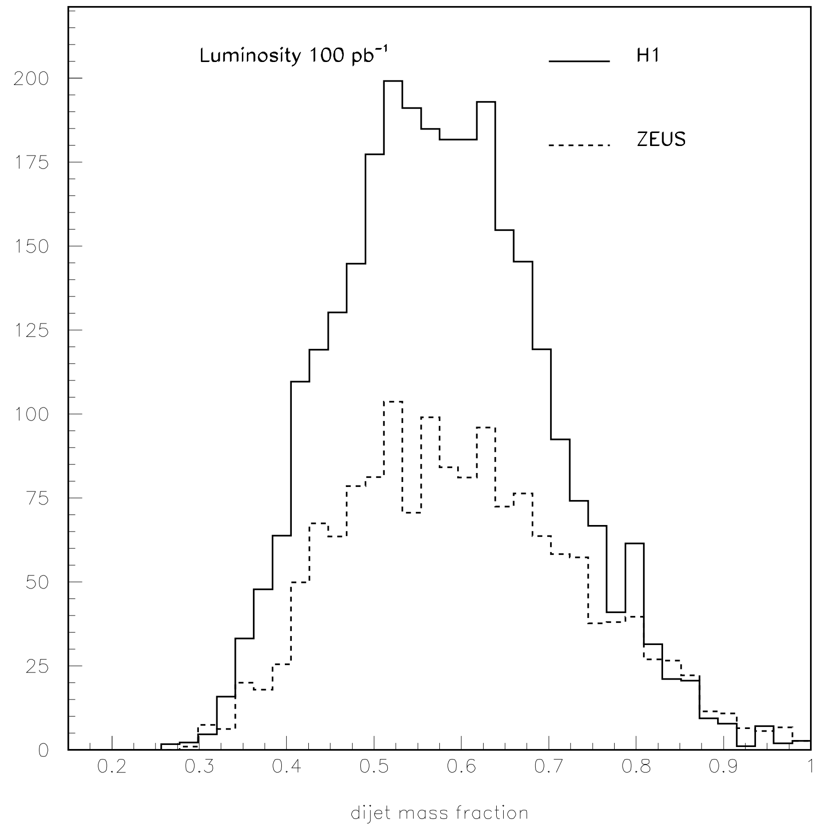
How to make predictions for diffraction at the LHC

- "Inclusive" models: Take the hadron-hadron "usual" cross section convoluted with the parton distributions in the pomeron
- Take shape of H1 measurement of gluon density
- Normalisation coming from survival gap probability
- Inclusive cross sections need to be known in detail since it is a direct background to search for exclusive events



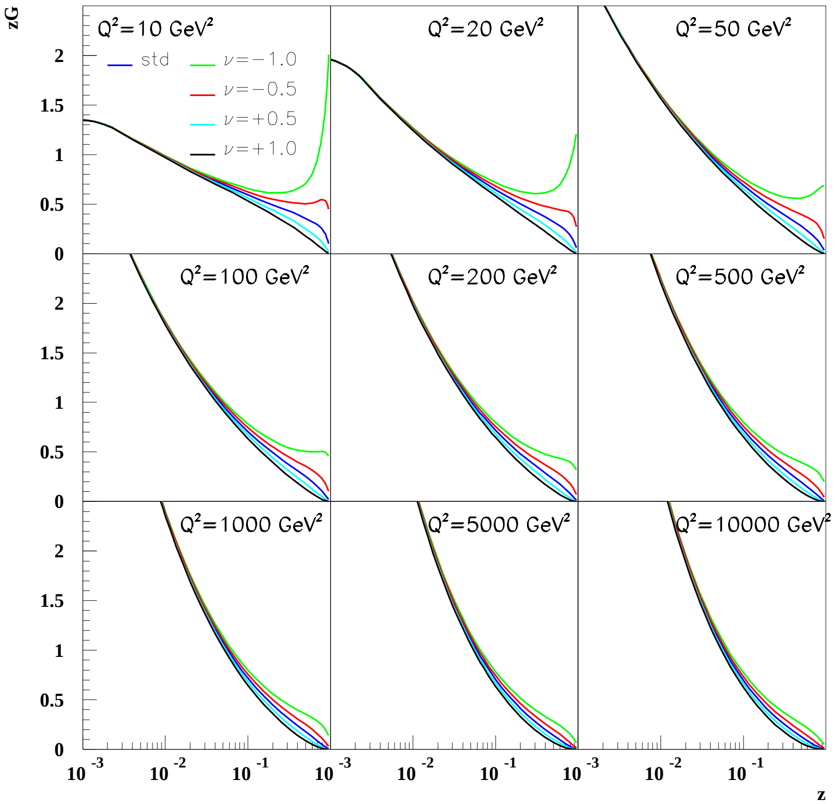
Contrain better xG using Tevatron measurements

- Possible measurement of the dijet mass fraction at the Tevatron sensitive to gluon density
- Request two jets of 25 GeV and a $\bar{p}$ tagged in the DØ dipole roman pot detector as an example



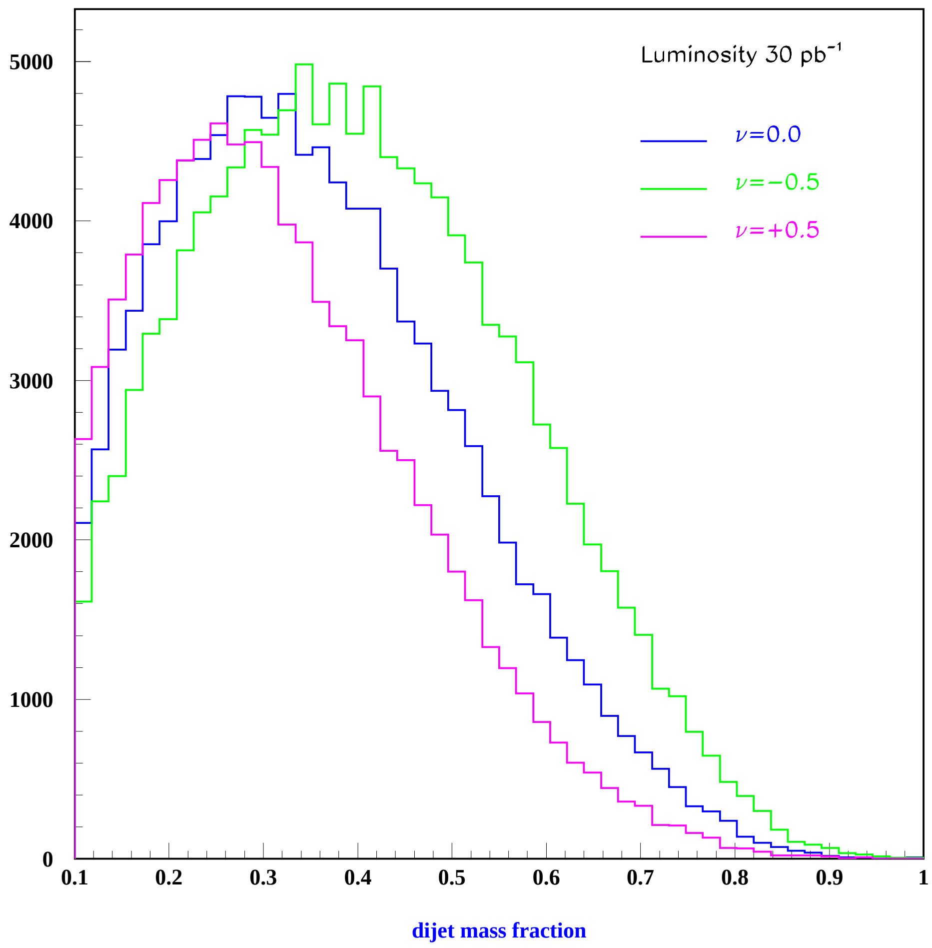
Uncertainty on high β gluon

- Important to know the high β gluon since it is a contamination to exclusive events
- Experimentally, quasi-exclusive events indistinguishable from purely exclusive ones
- Uncertainty on gluon density at high β: multiply the gluon density by $(1-\beta)^{\nu}$ (fit: $\nu = 0.0 \pm 0.6$)



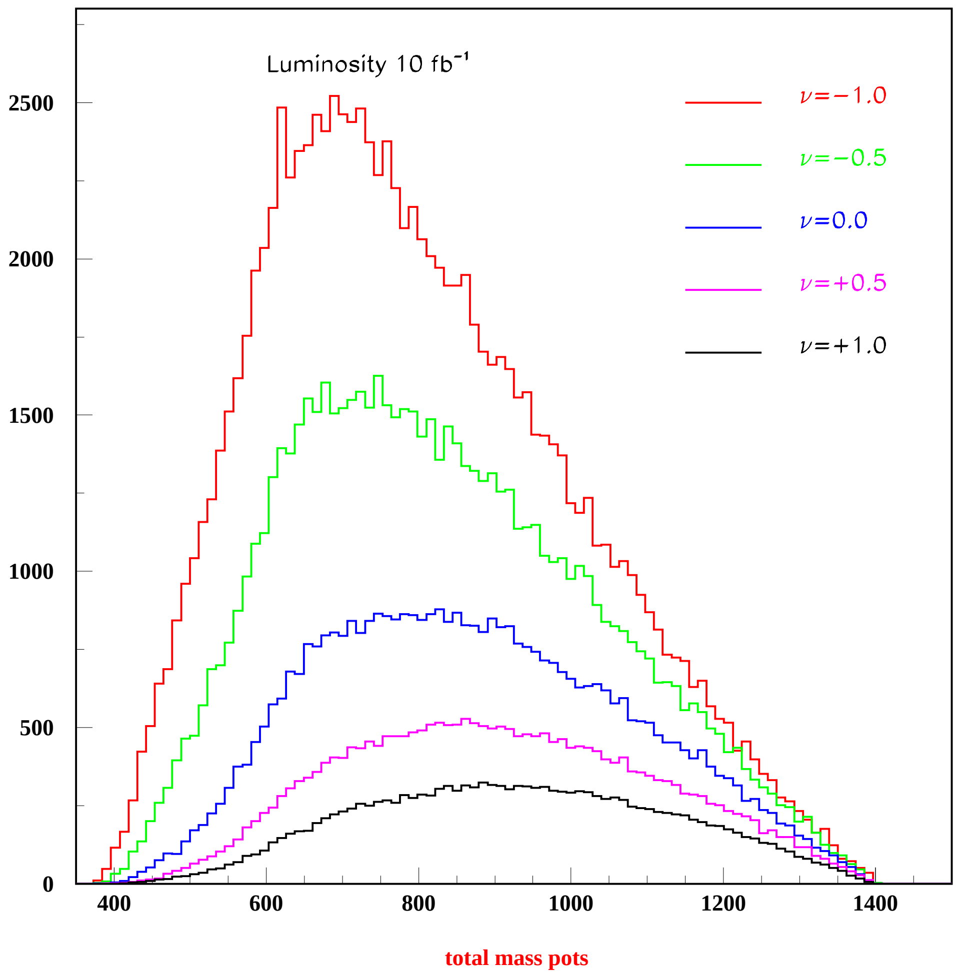
Dijet mass measurement

Measure the dijet mass distribution at the Tevatron or the LHC: dependent on high-β gluon



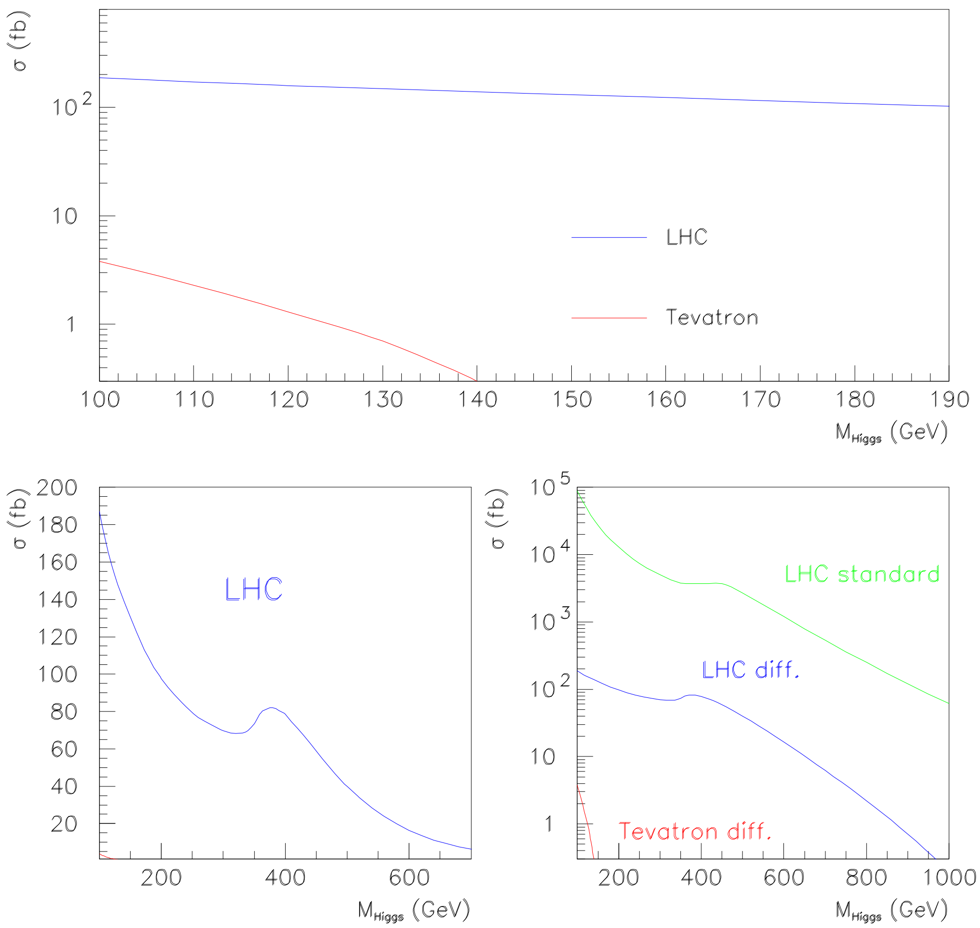
$t\bar{t}$ inclusive events

Idea: Measure the diffractive mass produced in $t\bar{t}$ events at the LHC ($M = \sqrt{\xi_1 \xi_2 S}$): high sensitivity on high-β gluon



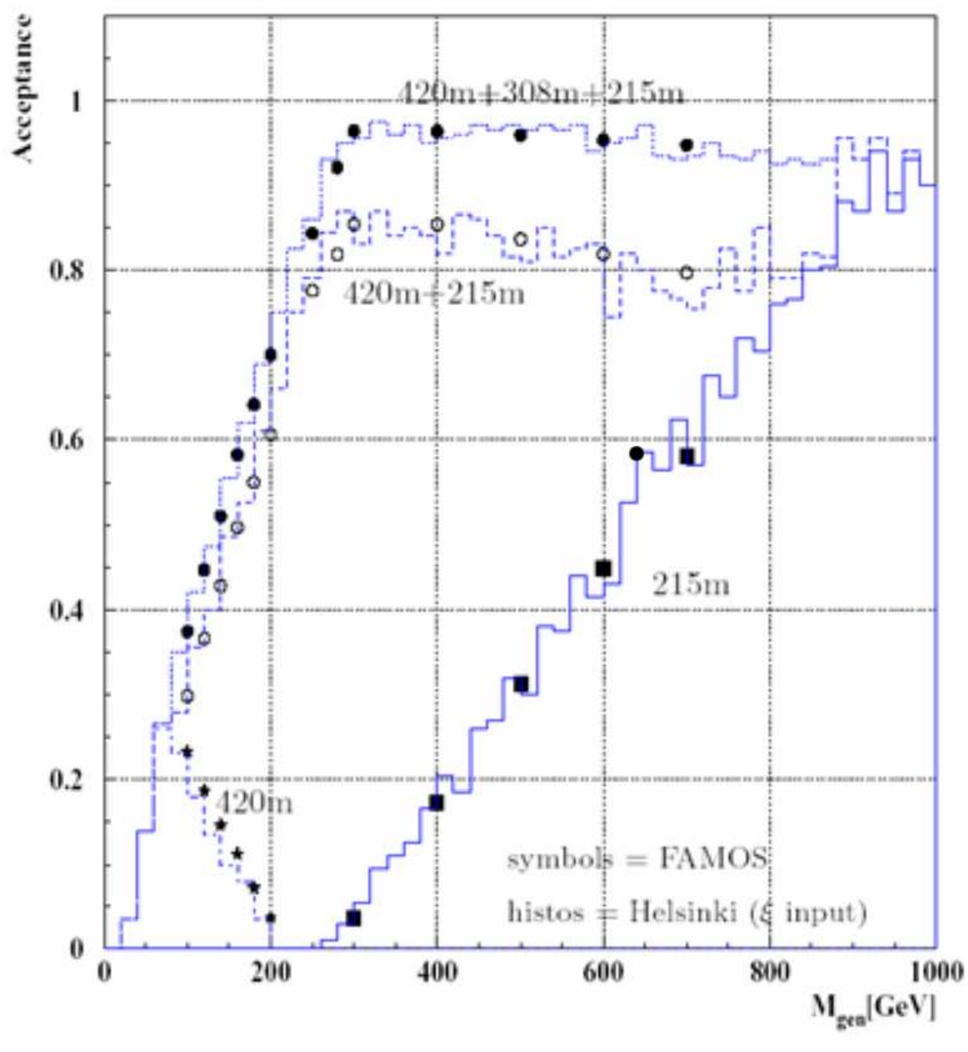
Inclusive Higgs mass production

Large cross section, but mass poorly reconstructed since part of the energy lost in pomeron remnants ($M = \sqrt{\xi_1 \xi_2 S}$ ~Higgs + remnant mass)

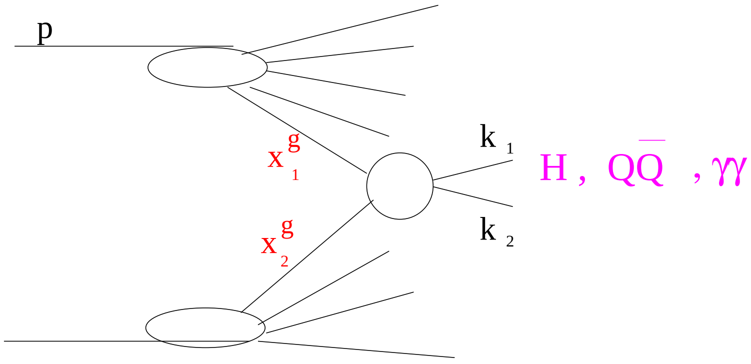


Roman pot acceptance at the LHC

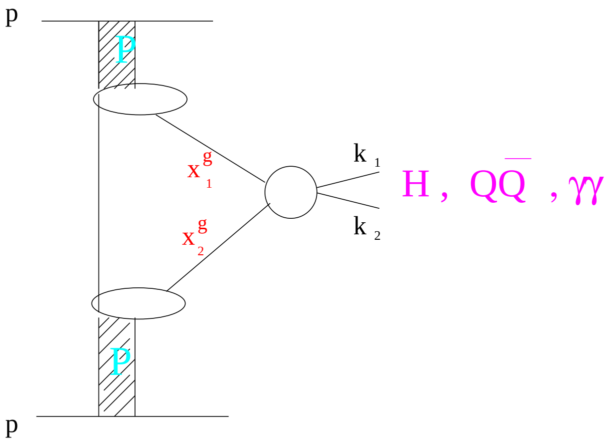
- Roman pot acceptance in ξ and t for CMS/TOTEM
- Roman pot acceptance slightly better for ATLAS, goes down to a Higgs mass of 120 GeV



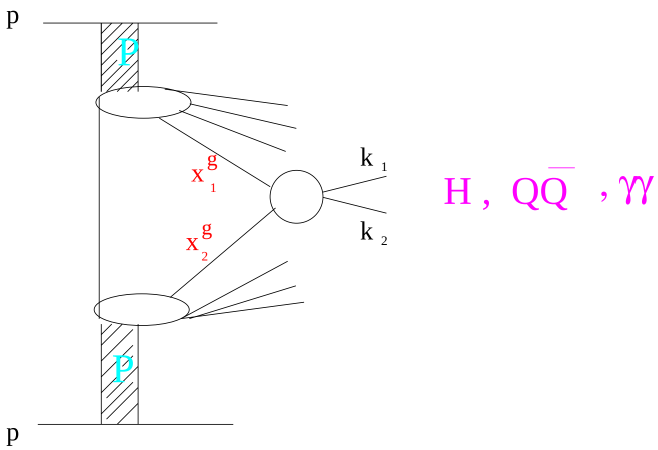
Reminder: “Exclusive” Higgs production



"Standard"



"Exclusive "

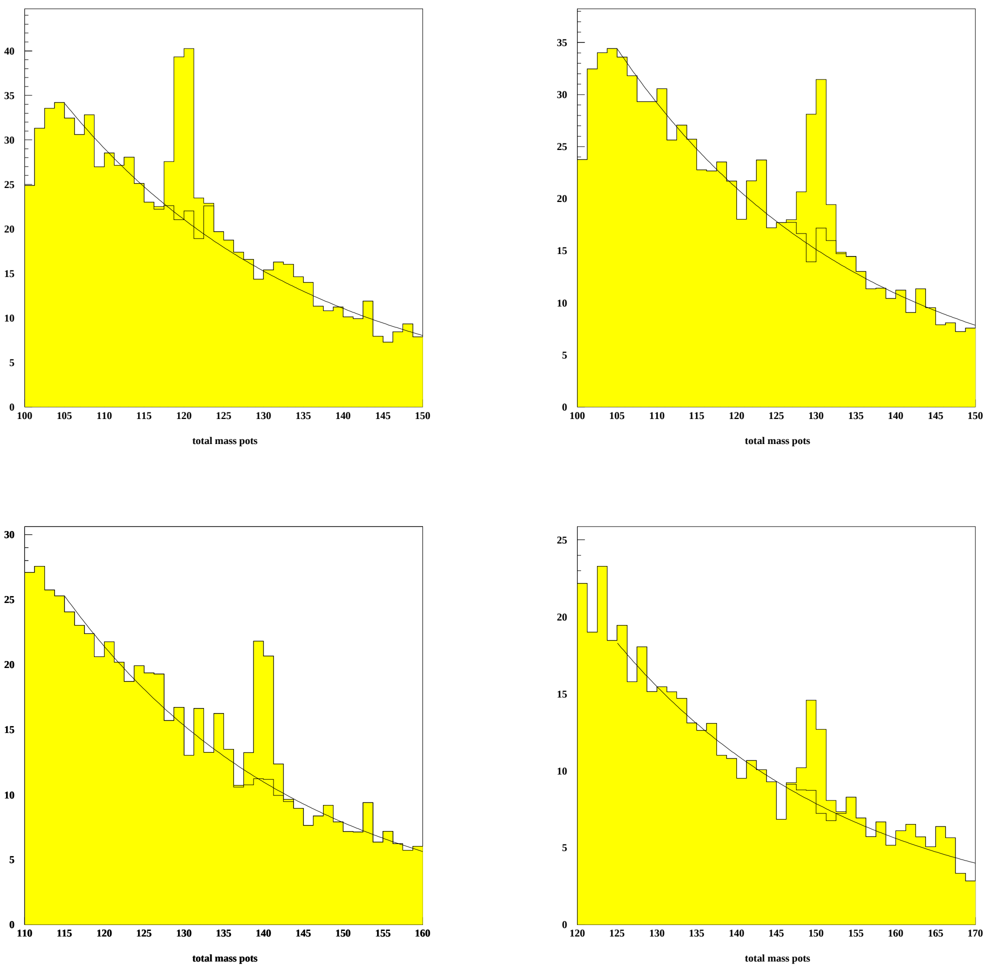


"Inclusive"

All the energy is used to produce the Higgs (or the dijets), namely $xG \sim \delta$

Signal and background

Signal and background for different Higgs masses for 100 fb^{-1}



"Exclusive" production at the LHC

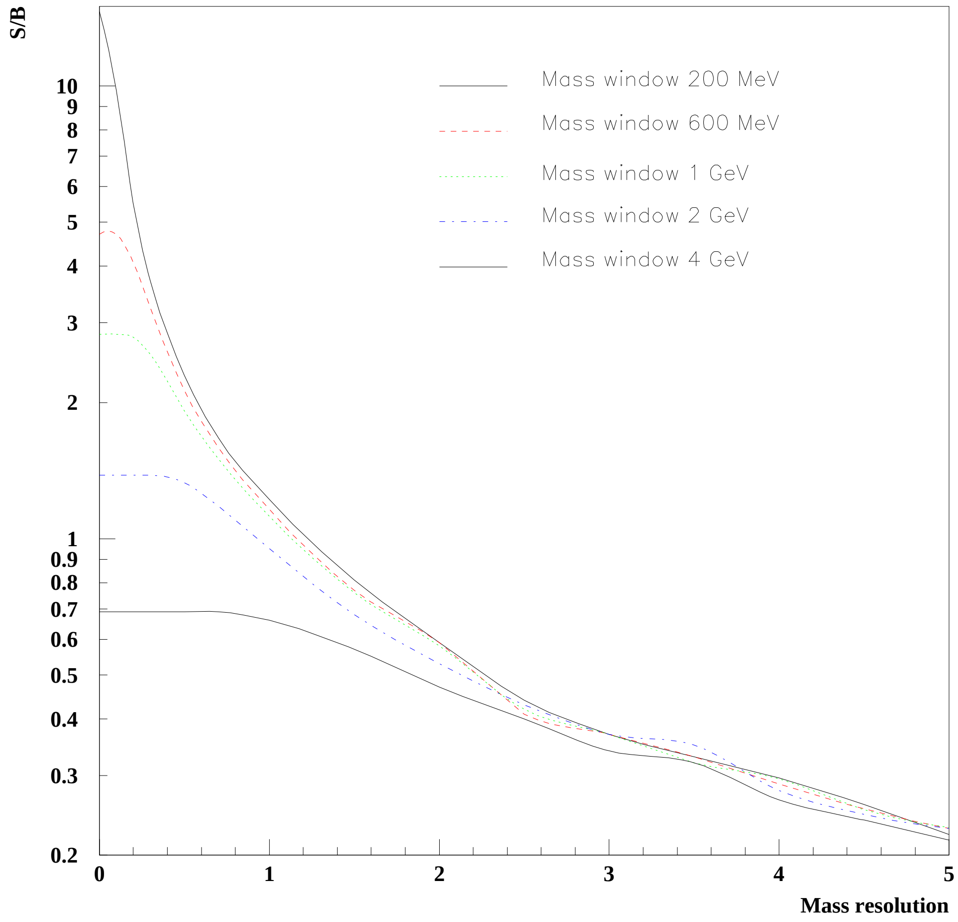
- Higgs decaying into $b\bar{b}$: study S/B
- Exclusive $b\bar{b}$ cross section (for jets with $p_T > 25$ GeV): 2.1 pb
- Exclusive Higgs production (in fb)

M_{Higgs}	σ (fb)
120	3.9
125	3.5
130	3.1
135	2.5
140	2.0

- NB: a survival probability of 0.03 was applied to all cross sections

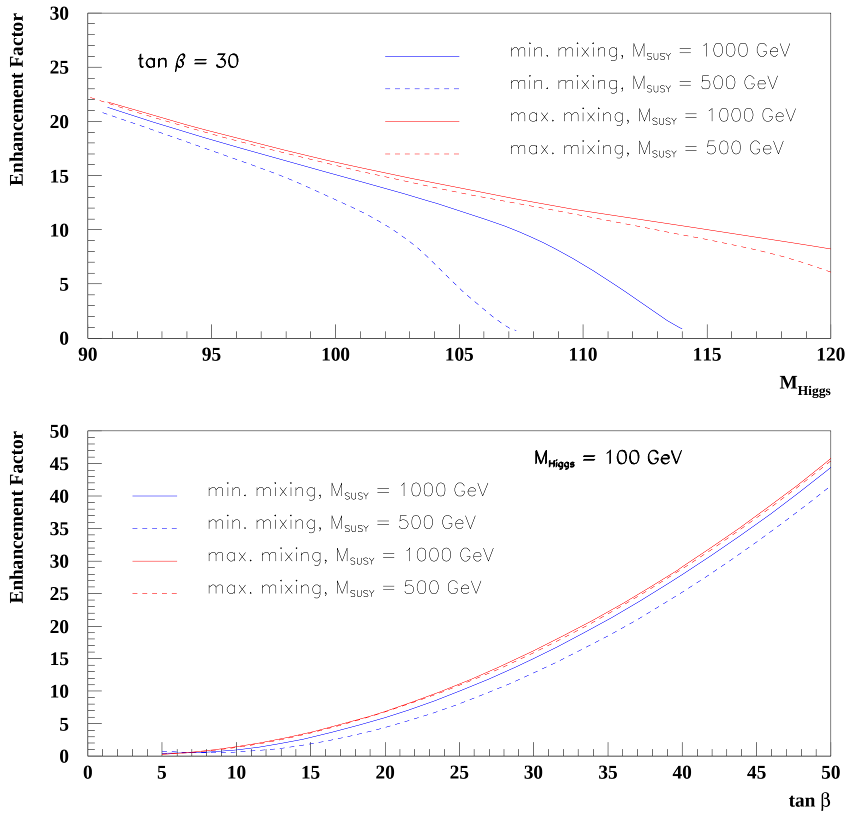
Signal over background: standard model Higgs

For a Higgs mass of 120 GeV and for different mass windows as a function of the Higgs mass resolution



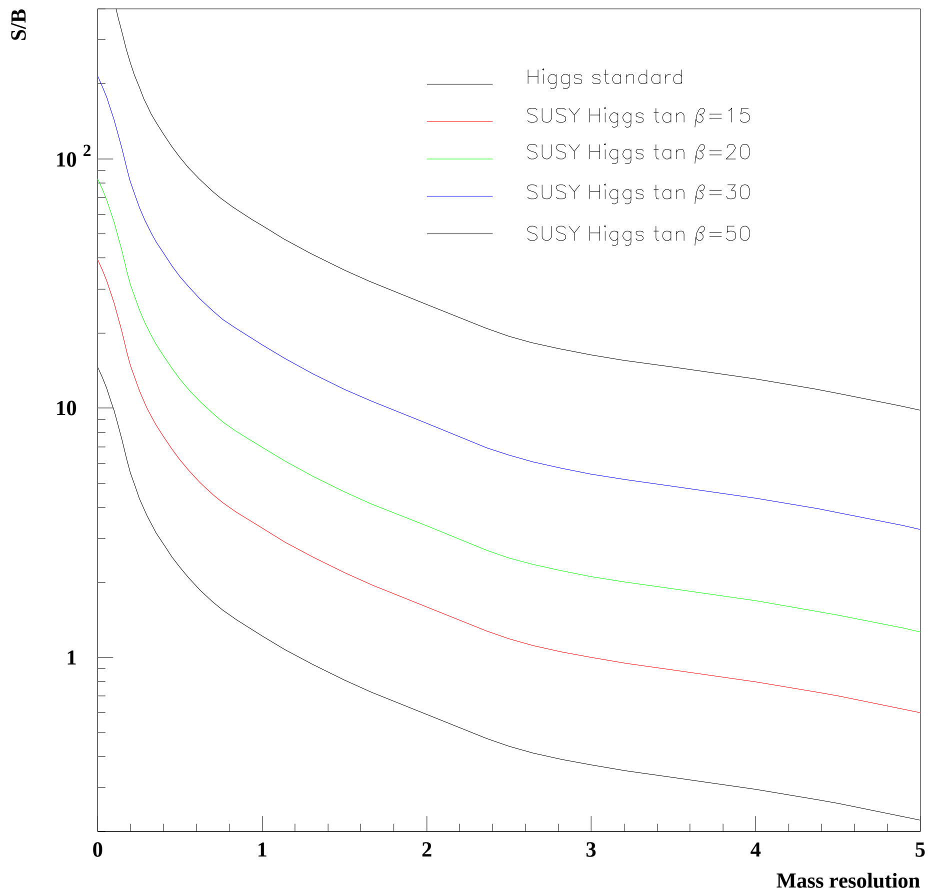
Diffractive SUSY Higgs production

- High $\tan\beta$: top and bottom loops to be considered, enhance the cross section by up to a factor 50
- (worth looking into Higgs decaying into $b\bar{b}$ since branching ratio of Higgs decaying into $\gamma\gamma$ smaller at high $\tan\beta$, standard search in $\gamma\gamma$ does not benefit from the increase of cross section)

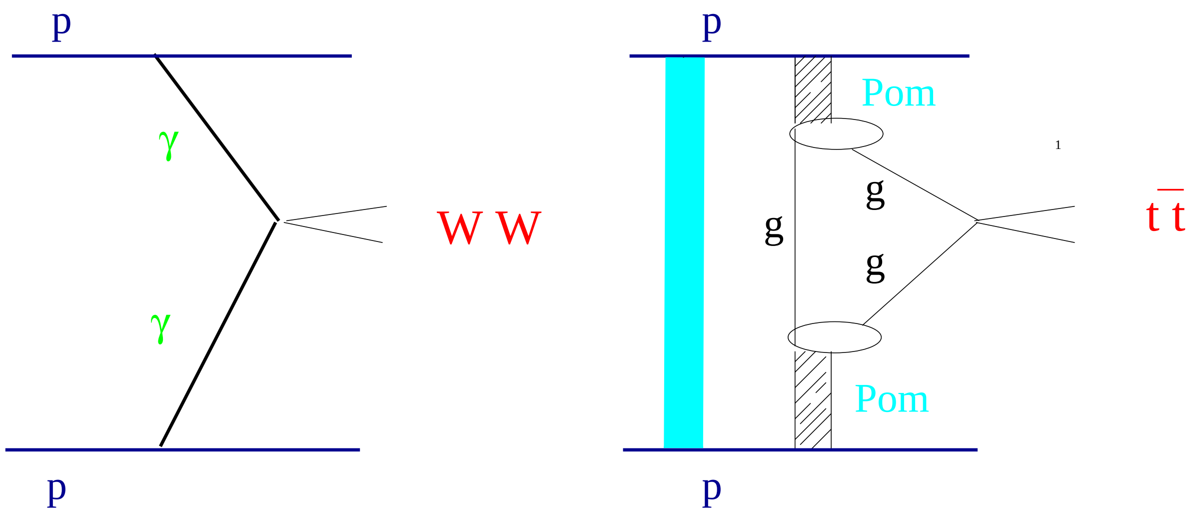


Diffractive SUSY Higgs production

At high $\tan\beta$, possibility to get a S/B over 50 (resp. 5.) for 100 (resp.10) fb^{-1}!

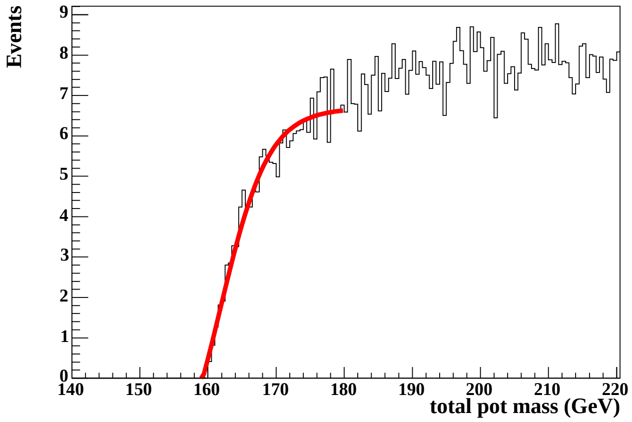


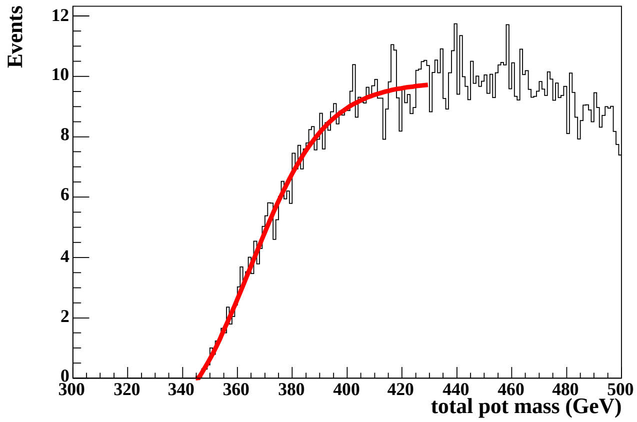
W, top and stops



All the energy is used to produce the W, top (stop) pairs: W: QED process, cross section perfectly known, top: QCD diffractive process

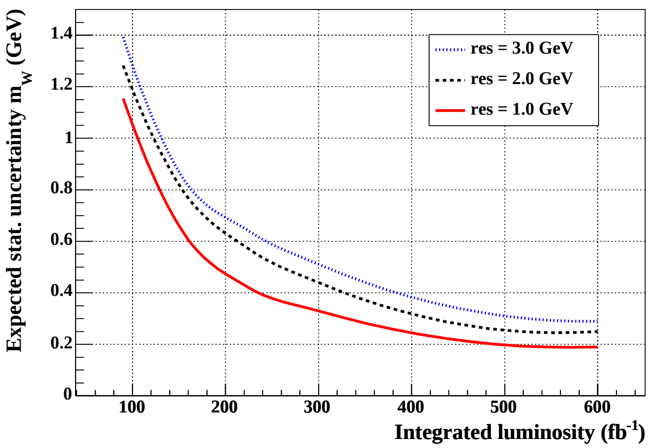
Top and W events

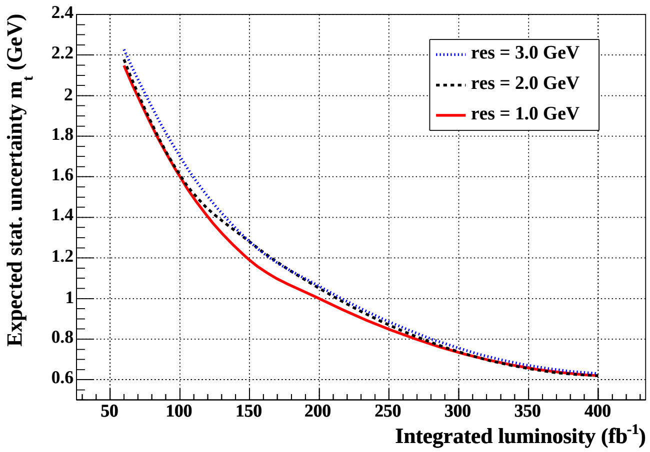




- W boson cross section and acceptance: $\sigma \sim 56$ fb, pots at 420 m needed, about 60%
- Top quark cross section and acceptance: $\sigma \sim 40$ fb, pots at 220 m, about 85%, model dependent
- Reconstruct the W and top mass using the threshold scan method: Fit the increase of the cross section at threshold

Resolution on W and top masses





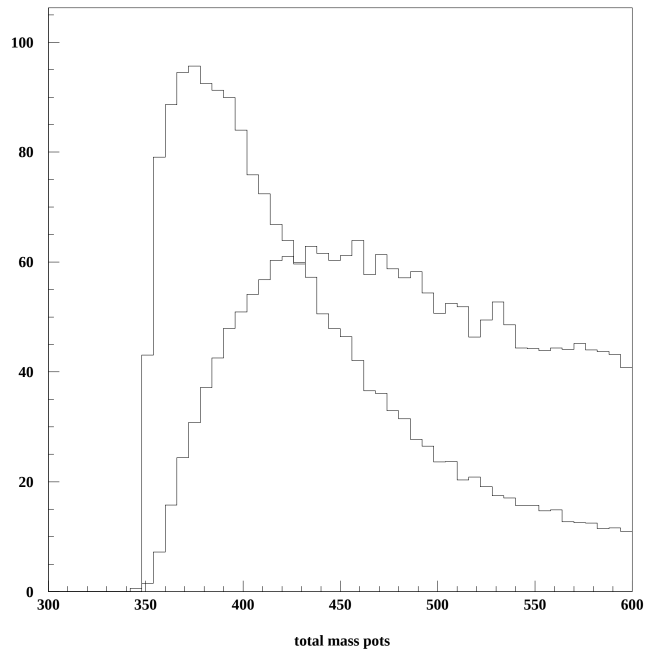
- 2 methods uaed to reconstruct the top mass: histogram: (compute χ^2 between number of events in bins in MC and data for the same lumi), turn-on fit: fit the turn-on point of the missing mass distribution at threshold
- W mass resolution: $\sim$ 400 MeV, not competitive, but allows to check the roman pot alignment very precisely
- Top mass resolution: $\sim$ 1 GeV, competitive measurement provided the corss section is high enough

Sensitivity on photon anomalous coupling

- WW production cross section perfectly known (QED)
- Any anomalous coupling between γ and W will reveal itself in a modification of the production cross section, and by different anbgular distributions
- The WW production cross section is proportional to the 4th power of the γW coupling $\rightarrow$ GOOD SENSITIVITY
- Quantitative studies in progress

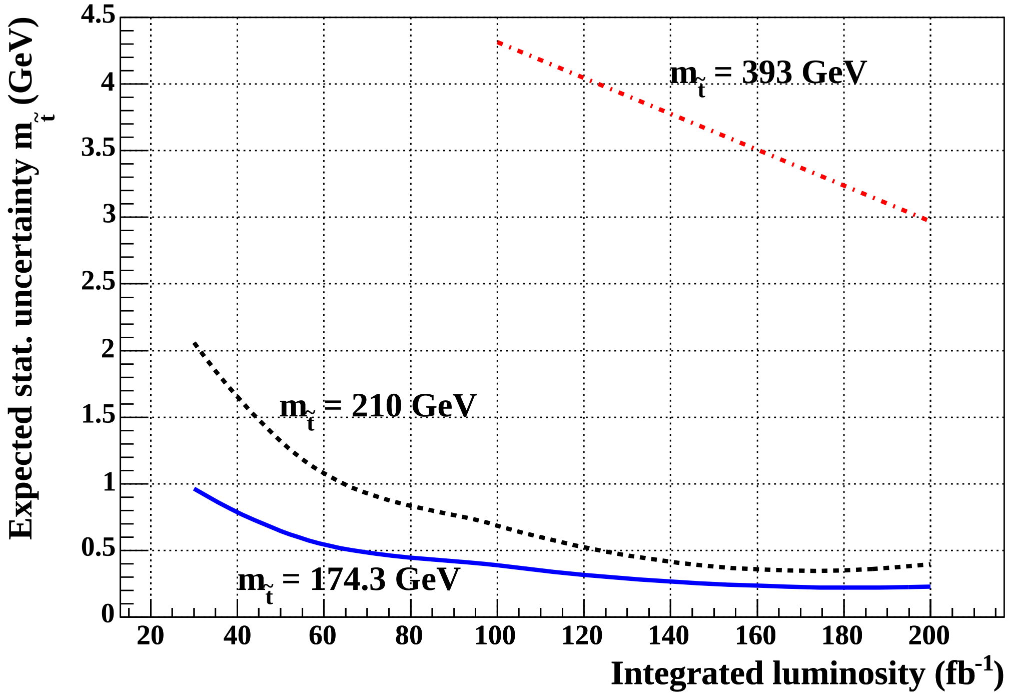
Top and stops

- Cross section for a stop mass of 250 GeV: $\sigma_{tot} = 8$ fb, $\sigma_{acc} = 6$ fb
- Possibility to distinguish between top and stop even if they have about the same mass: using the differences in spin (as an example: $m_{\tilde{t}} = m_{top}$)
- Very fast turn-on for stops



Resolution on stop mass

Resolution on stop mass by using roman pot detectors with a resolution of 1 GeV → Resolution better than 1 GeV at high lumi!



Conclusion

- Diffraction at HERA: many results given, extraction of quark and gluon densities in pomeron, dipole model, diffractive jet production (NB: not all results given, many additional results on vector meson production for instance
- Diffraction at Tevatron: Factorisation breaking between HERA and Tevatron, look for exclusive events
- Diffraction at the LHC: measurement of total cross section, hard diffraction program under study (new detectors for CMS and ATLAS), production of Higgs, tops, stops... under study