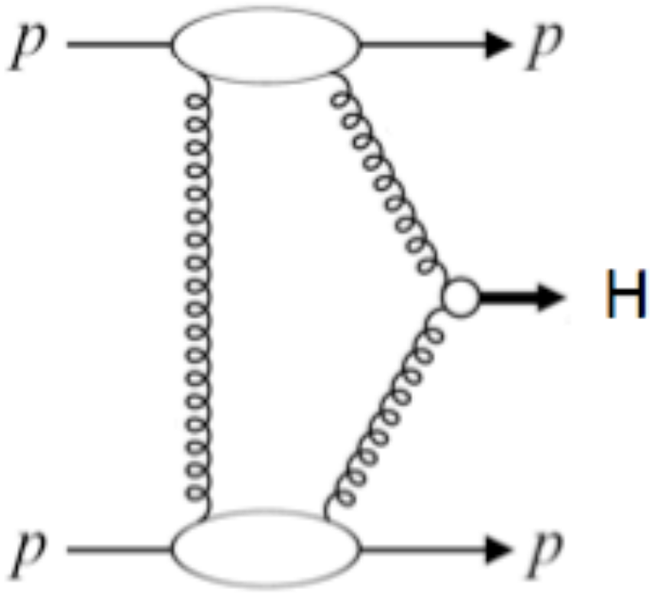
Diffraction discussion

- some lessons from TeVatron
- What and how do we want to measure ?
- how to define diffraction
- how to model diffraction
- how to relate diffraction at HERA with LHC

Exclusive production

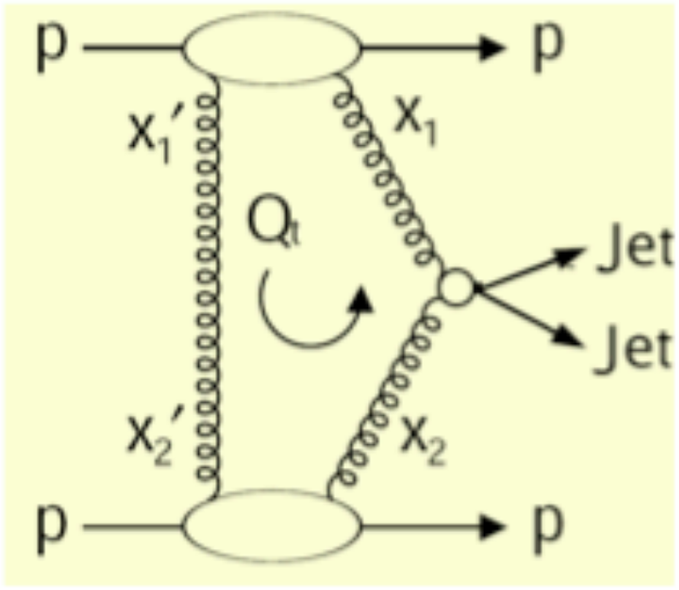


✓clean process

✓exclusive $b\bar{b}$ suppressed

Khoze Martin Ryskin: σ_H(LHC)~3 fb, signal/bkg~3 (if ΔM_{miss}=1 GeV)

Attractive Higgs discovery channel at the LHC



⇨much larger cross section

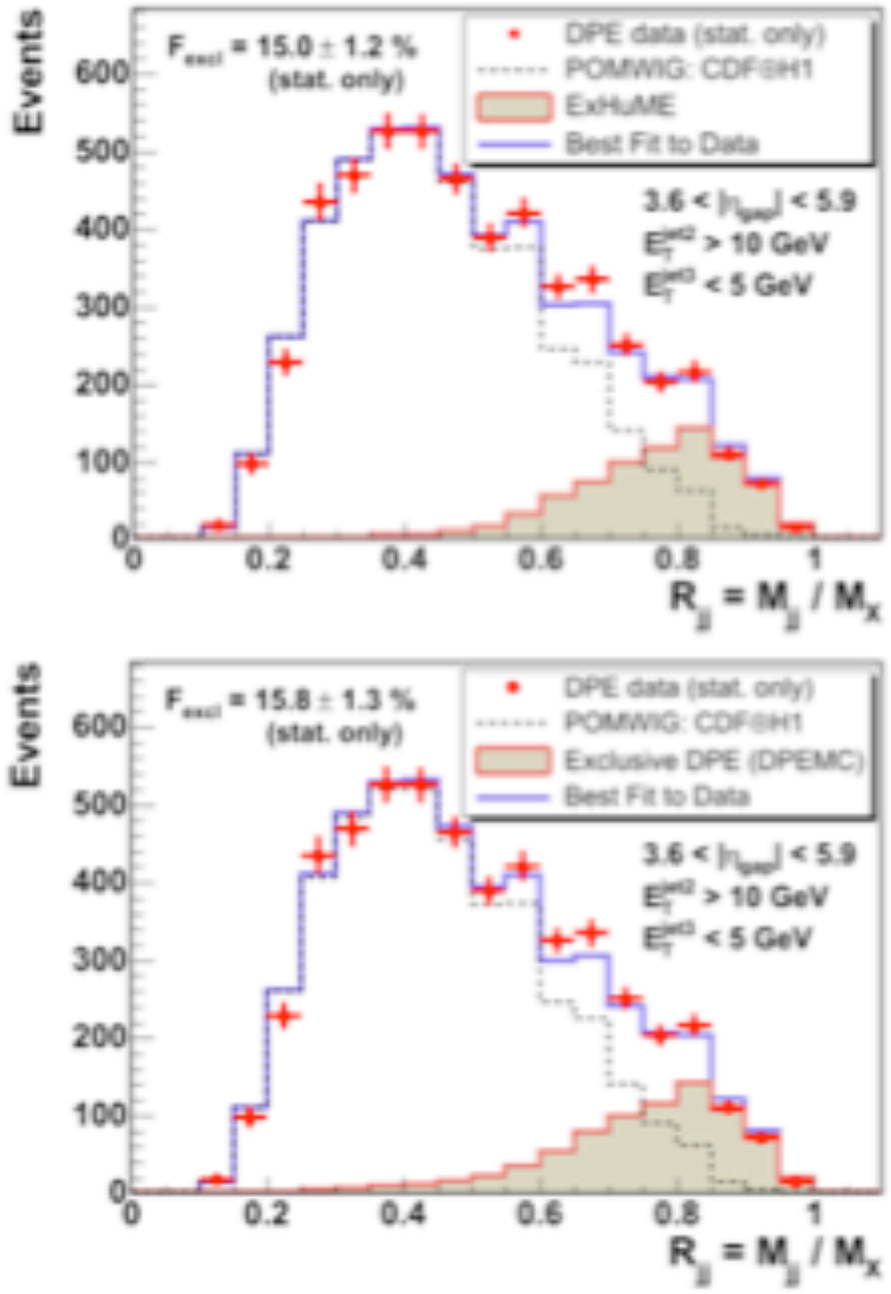
Goal:

- measure exclusive dijet production (if it exists)
- test/calibrate Higgs predictions at LHC

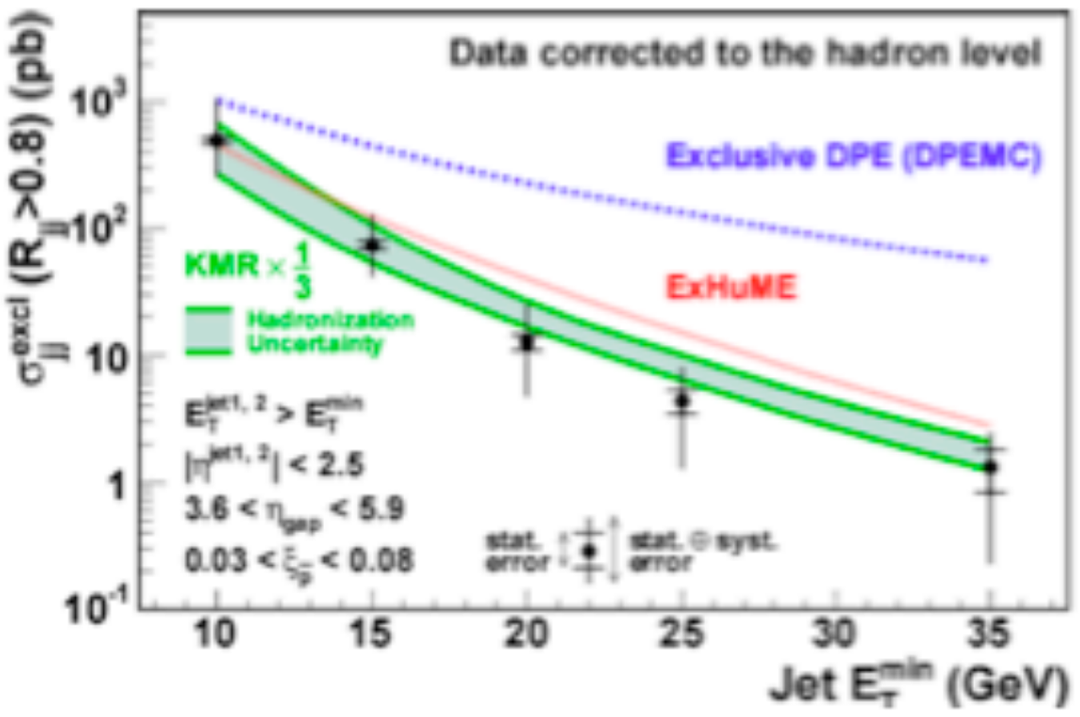
Michele Gallinaro - "CDF experimental results on diffraction" - MPI@LHC'08 - Perugia, Oct. 29, 2008 21

Exclusive dijet cross section

Phys.Rev.D77:052004,2008



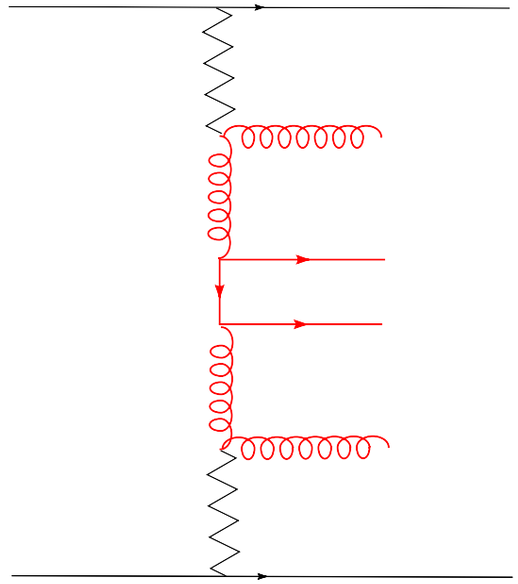
- R_{jj} shape described by MC based on two models (ExHuME, DPEMC)
- Cross section agrees with ExHuME
- Data favor KMR model (uncertainty ~factor of 3)

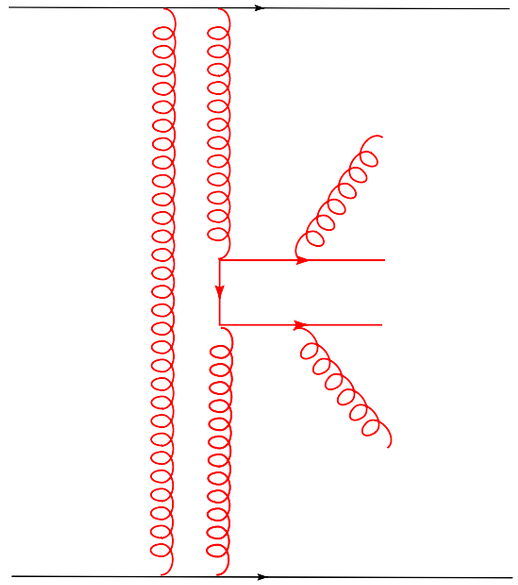


Michele Gallinaro - "CDF experimental results on diffraction" - MPI@LHC'08 - Perugia, Oct. 29, 2008 24

Questions on exclusive diffraction

- How sensitive is the Mx spectrum to details of hadronization and parton showering
  - final state parton shower
    - what about different parton showers?
  - how well is hadronisation done ?
    - what about differnet hadronsiation models ?
  - is it exactly like e+e-
  - what about qqg states - how are they different from a inital state radiated gluon ?

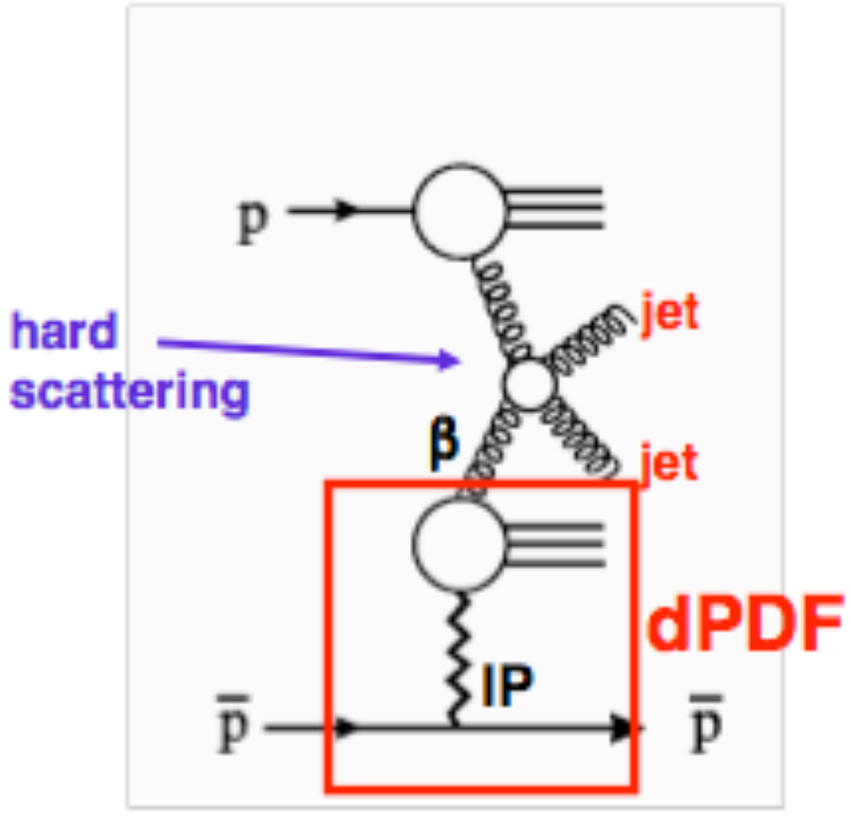


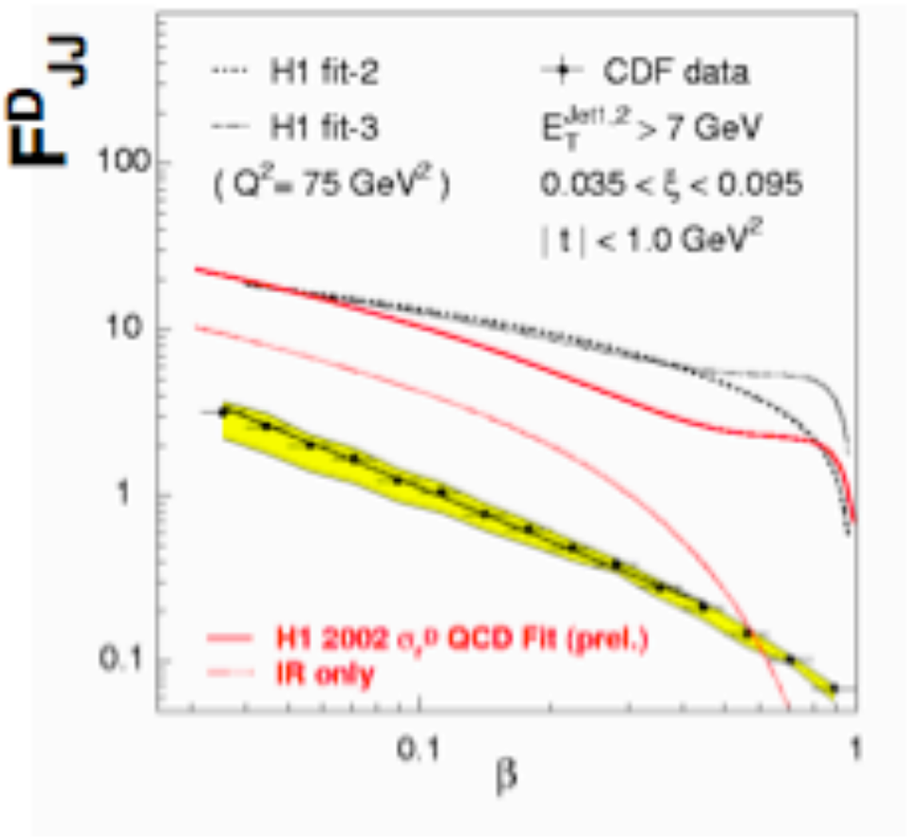


Factorisation breaking in $\bar{p}p$, pp

- **Factorisation theorem holds in diffractive ep scattering:**
  σ_{diffr} = σ(hard scatter) x (diffractive PDF) – cf talk by A. Solano

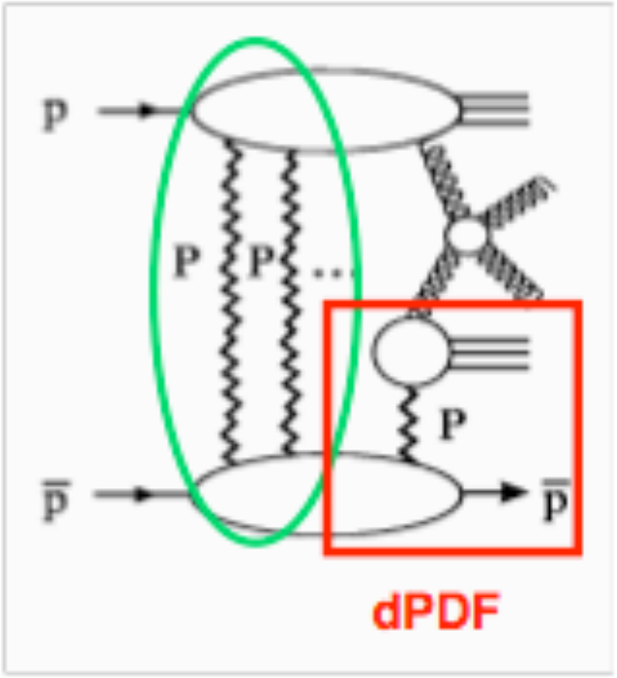
- **Factorisation does not hold in $\bar{p}p$, pp – cf talk by M. Gallinaro:**





Normalisation discrepancy (x10)
(lots more evidence available !)

Factorisation breaking in $\bar{p}p$, pp



Closely related to the underlying event

Factorisation broken at hadron colliders due to soft interactions/rescatterings among spectator partons
→ Fill rapidity gap & slow down outgoing p, $\bar{p}$
→ Hence suppress visible σ_{diffr}

Quantified by rapidity gap survival probability $\langle|S|^2\rangle$
σ_{diffr} proportional to $\langle|S|^2\rangle$

At Tevatron $\langle|S|^2\rangle \sim 0.1$, ie suppression by O(10)
compared to HERA – diffr. dijets/inclusive dijets ≈ 1%

At LHC: some consensus that $\langle|S|^2\rangle \sim 0.05$
i.e. diffr. dijets/inclusive dijets ≈fraction of %
but values of $\langle|S|^2\rangle$ between 0.004 and 0.23 proposed

In early LHC running no proton taggers available
Hence try selection via rap gap → Feasible ?

CMS forward hadron calorimeter (HF)

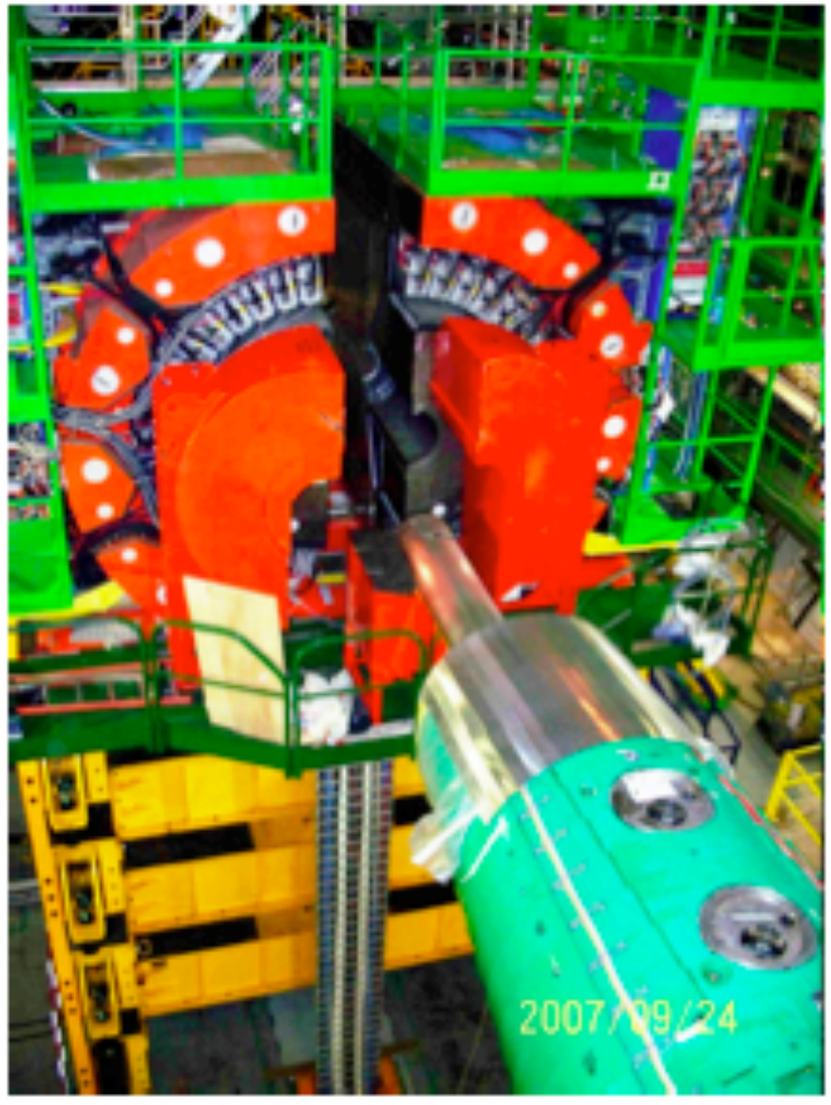
- $3<|\eta|<5$

- Located 11.2 m from the interaction point

- Steel absorbers and embedded radiation hard quartz fibers → fast collection of Cherenkov light

- Each HF module has 18 wedges in non-projective geometry with the quartz fibers running parallel to the beam axis along the length of the iron absorbers

- Long (1.65 m) and short (1.43 m) quartz fibers are placed alternately with a separation of 5 mm.

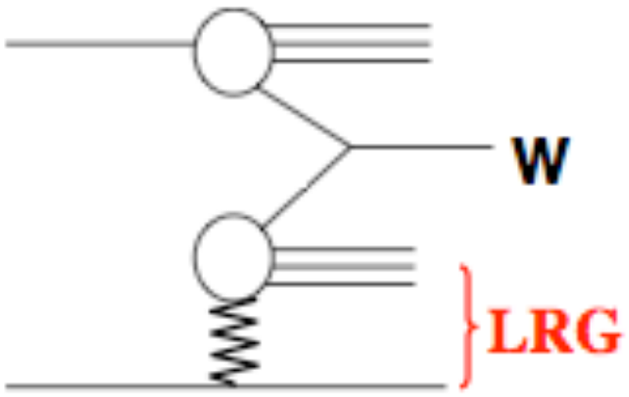


What and how do we want to measure ?

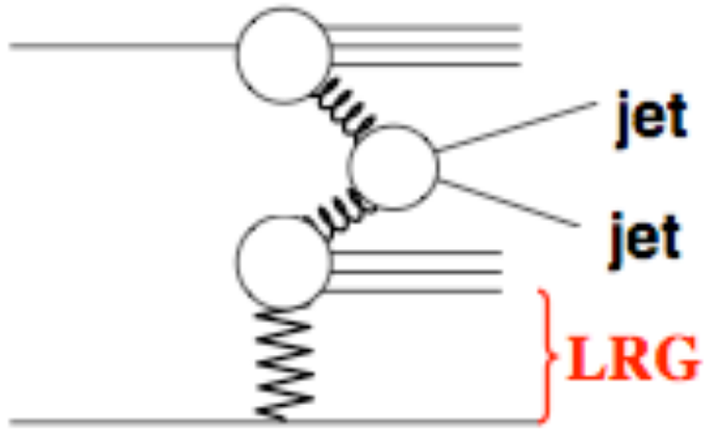
- Measure diffractive dijets, W, etc
- What is needed for this ?
  - data
  - MCs
  - estimate of systematic effects
    - experimental systematics
    - model uncertainties
      - simulation of diffraction
    - diffractive pDFF: LO vrs NLO
      - experience from HERA: the pdfs are not appropriate for use in MC ... since gluon dominance
    - secondary trajectories
    - pion exchange

Observing hard diffraction at LHC

CMS feasibility studies:



Single diffractive W production
(CMS PAS DIF-07-002)



Single diffractive di-jet production
(CMS PAS FWD-08-002)

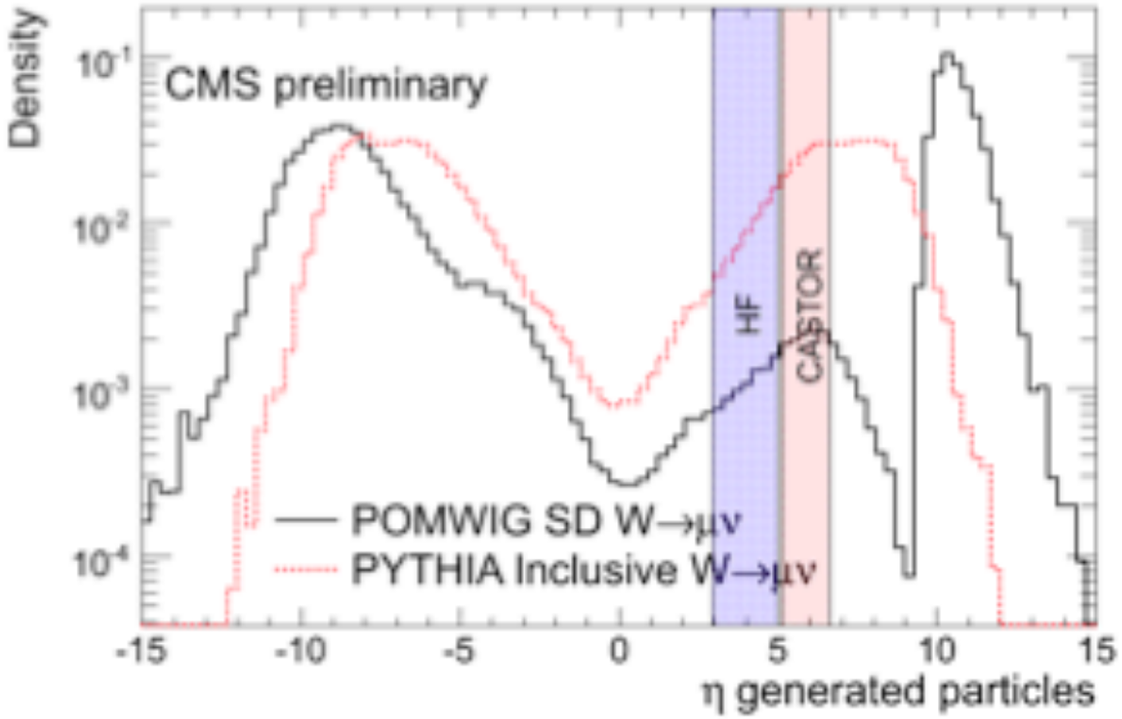
Available from https://twiki.cern.ch/twiki/bin/view/CMS/PhysicsResults

Assume:

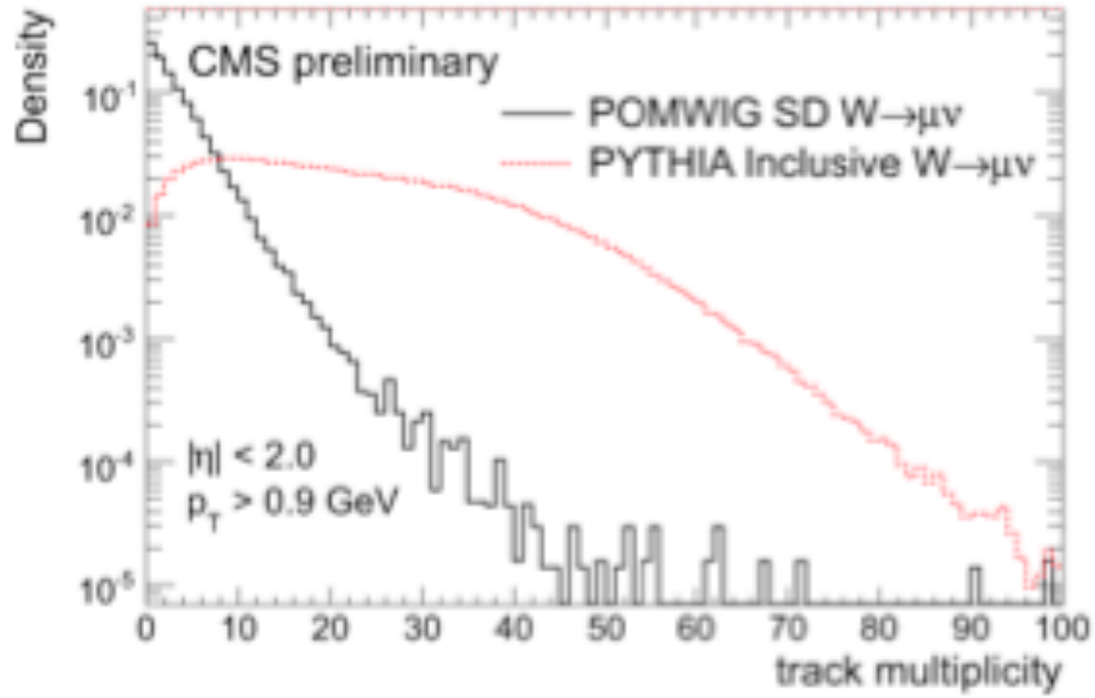
- **Rapidity gap survival probability: $\langle |S|^2 \rangle = 0.05$**
- **Diffractive PDF: NLO H1 2006 Fit B**
- **Inclusive PDF: CTEQ61**
- **No pile-up**
- **SD MC: Pomwig; non-diffr. generator: Pythia/Madgraph**
- **Complete simulation of detector, trigger & reconstruction (except CASTOR)**

Selection of SD events

GENERATED PARTICLES – ENERGY WEIGHTED
(diffractive sample with gap at positive η)



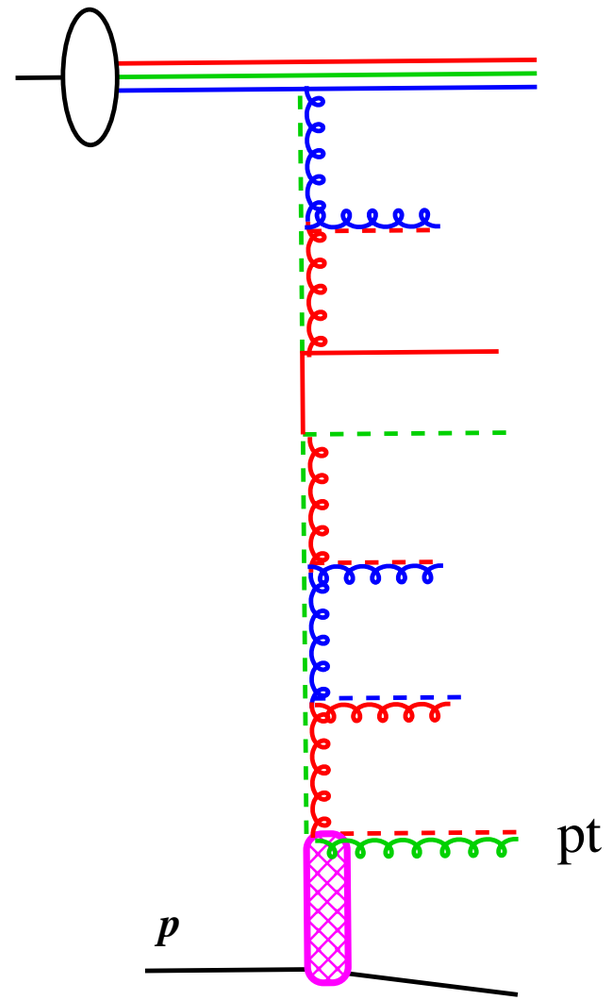
TRACK MULTIPLICITY IN CENTRAL TRACKER



- **Diffractive event candidates selected on the basis of multiplicity distribution in the central tracker, in the HF and/or CASTOR [in the gap side]**
- **Gaps not easy to see at LHC – may start at very large η**
- **Track multiplicity correlated to ξ (proton fractional momentum loss)**
- **"Gap side" defined as that with lower hadronic activity in the forward region**

Diffraction in pp

- Hard diffraction via diffractive pdfs as measured in DIS ep at HERA
- Questions:
  - how is diffraction defined ?
    - rapidity gap
    - Mx method
    - leading proton
  - how well do we understand the diffractive remnant ?
  - how well do we understand the parton shower ?



Diffraction and non-diffraction in pp

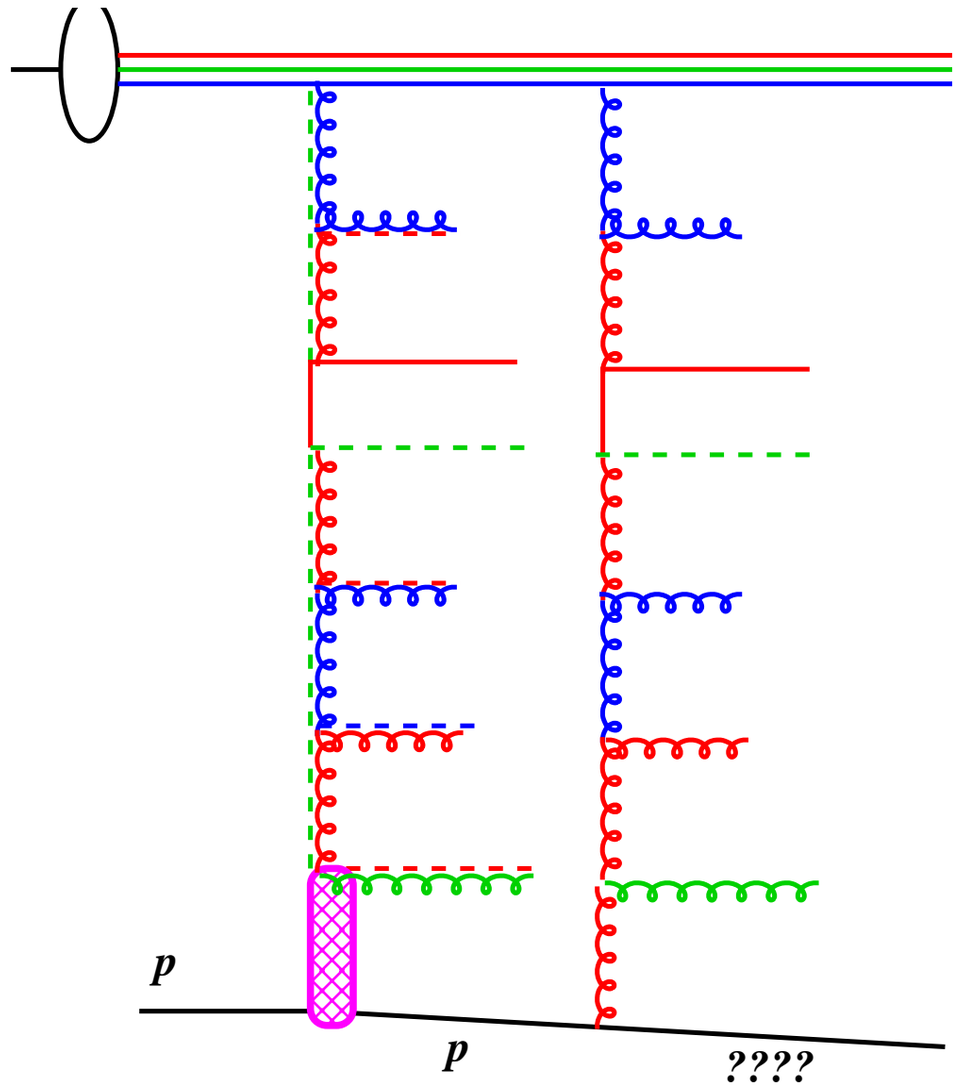
- Diffractive contribution is already implicitly included in parton densities.
- Inclusive di-jets include already diffractive di-jets
- How is it done in MC
  - in DIS we know how to do it:
  - calculate diffractive x-section

$$F_2(x,Q^2)^{non\ diff} = F_2(x,Q^2) - \int d\beta F_2^D(x_{pom},\beta,Q^2)\delta(x_{pom}\beta - x)$$

- But how can this be done in pp or γp
  - how do multiple interactions influence this ?
  - does it depend on the order ?
- Important for estimate from non-diffractive background

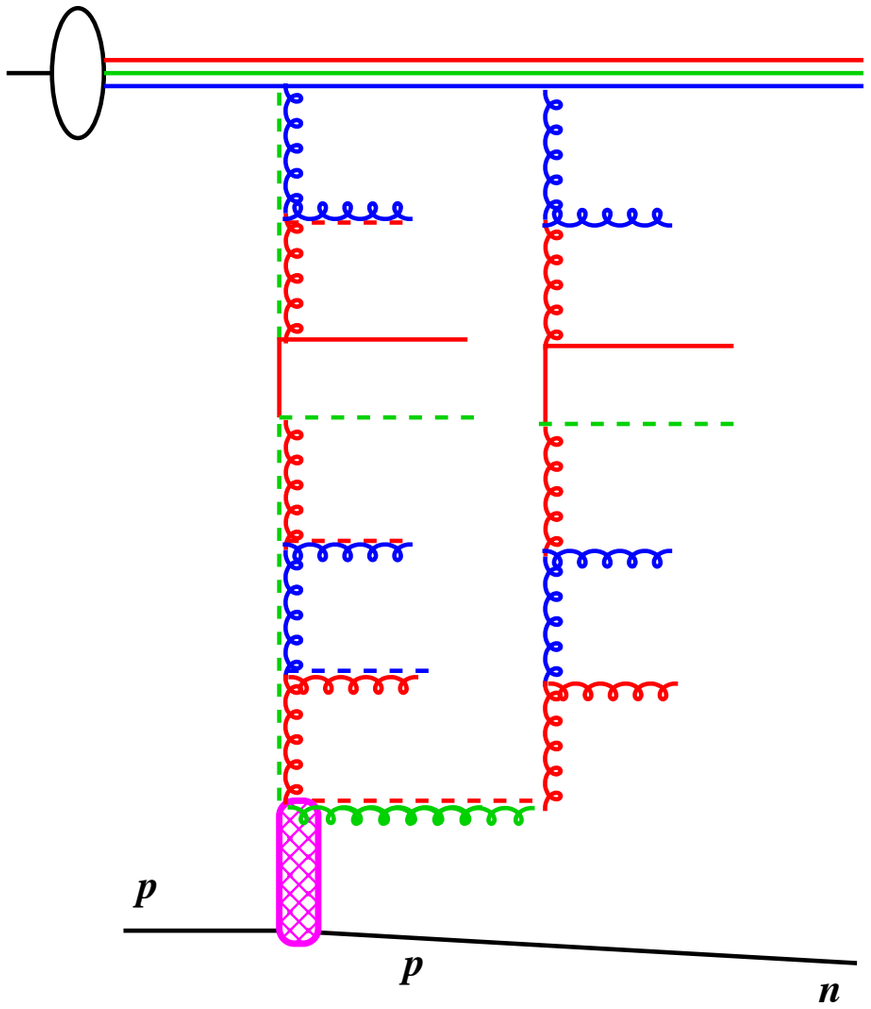
Origin of rescattering

- Where is rescattering happening ?
  - multi-parton scattering between remnant and leading proton
    - can be simulated, since secondary scattering happens on a proton ...
    - does it depend on the order of the scatterings:
      - 1st diffraction,
      - 2nd non-diffraction ?



Origin of rescattering

- Where is rescattering happening ?
  - multi-parton scattering between remnant and leading proton
    - changing leading baryon nature
  - multiparton scattering between remnants (of proton and pomeron) ?



- ☑ how to separate scattering between diffractive remnant and proton from scattering between both protons ?
- ☑ is there any difference in showering from inclusive and diffractive scattering ?

Conclusions

- how can we achieve a reasonable measurement ?
  - we need proper estimates for the systematics from the models
  - we need a appropriate definition of diffraction in terms ob hadronic final state observables
- how can we contribute ?
  - do we have the MCs ?
    - should we further develop and upgrade RAPGAP ?
    - what about NLO calculations (and simulation) of diffraction ?
    - how to obtain the proper corrections from hadron to parton level ?