High mass diffraction at the LHC

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Tev4LHC 2005, October 20-21, Fermilab

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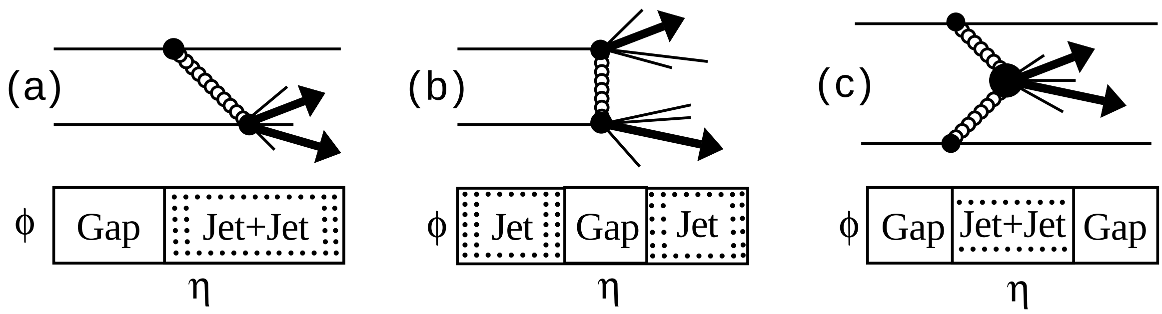
Contents:

- Inclusive diffraction at the Tev. LHC
- Exclusive standard model and SUSY Higgs production: S/B
- W, top and stop production cross section and mass
- Look for exclusive events at the Tevatron?

Diffraction at Tevatron/LHC

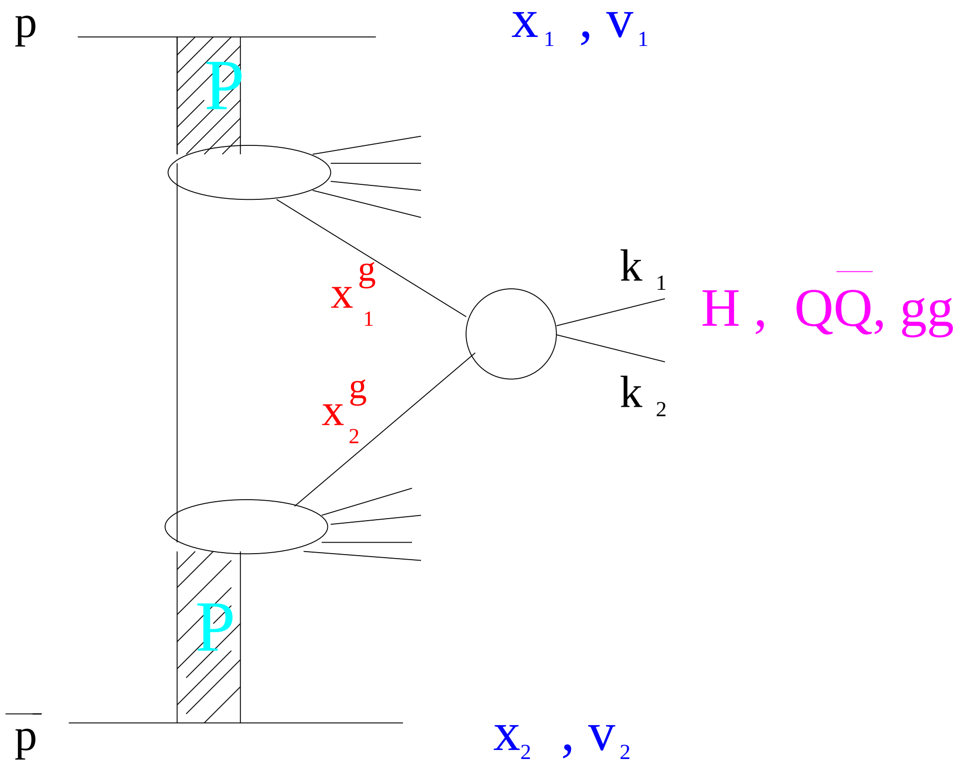


Kinematic variables

- 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

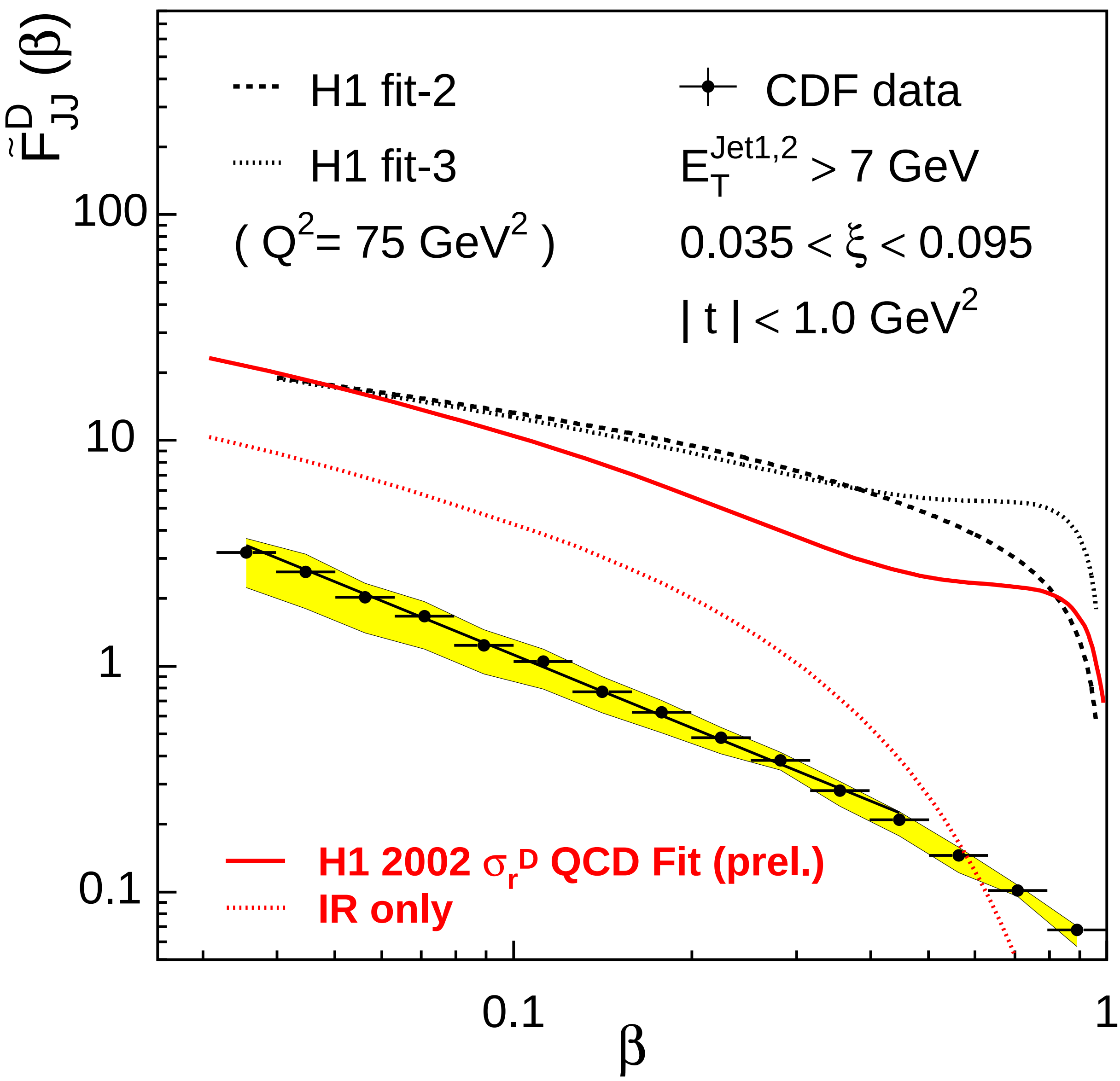
"Inclusive" models

"Inclusive" models: Take the hadron-hadron "usual" cross section convoluted with the parton distributions in the pomeron



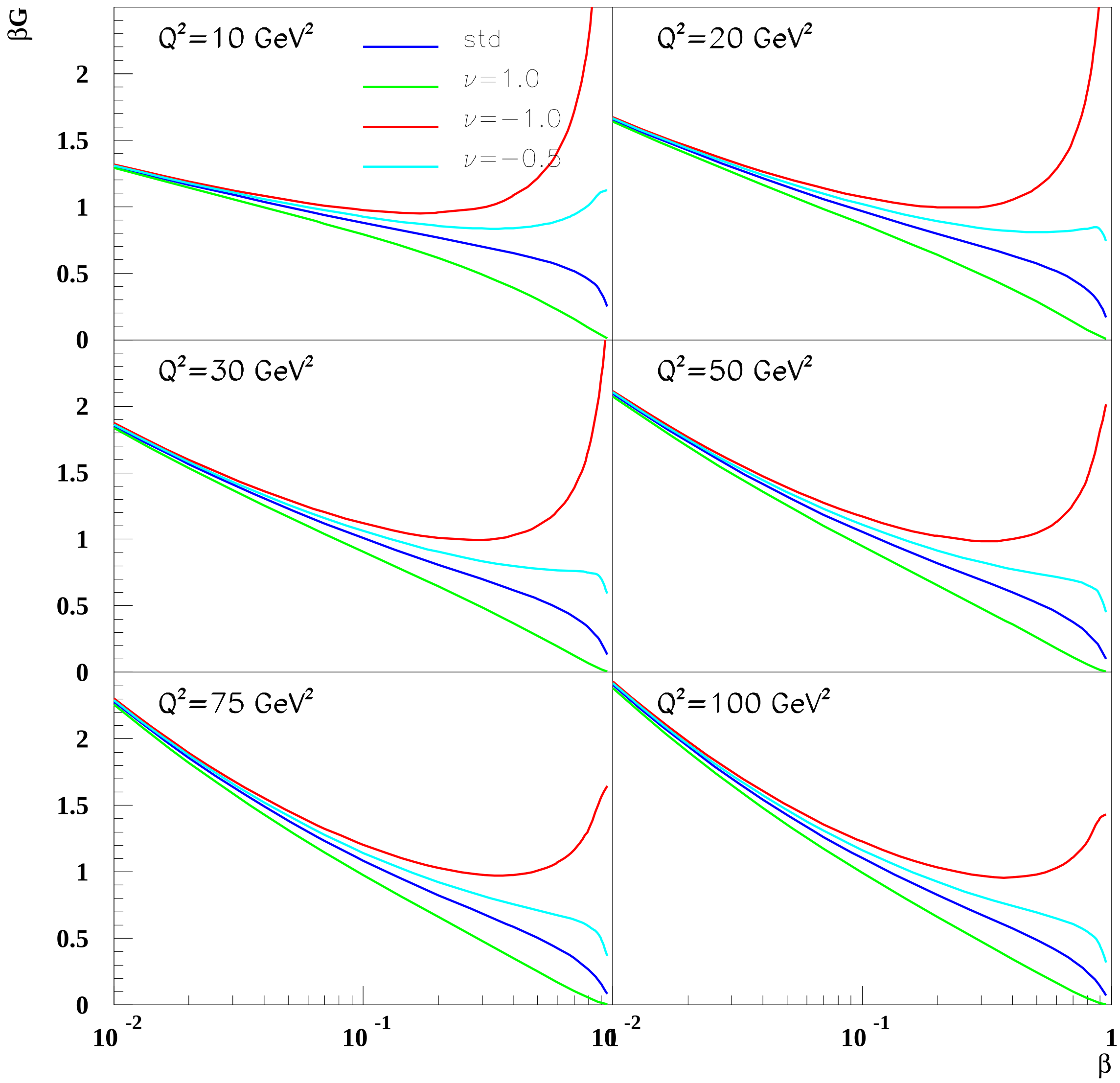
Extraction of xG in pomeron from CDF data

Comparison of xG in pomeron from H1 (full red line) compared to CDF measurement: Difference in normalisation, shapes similar



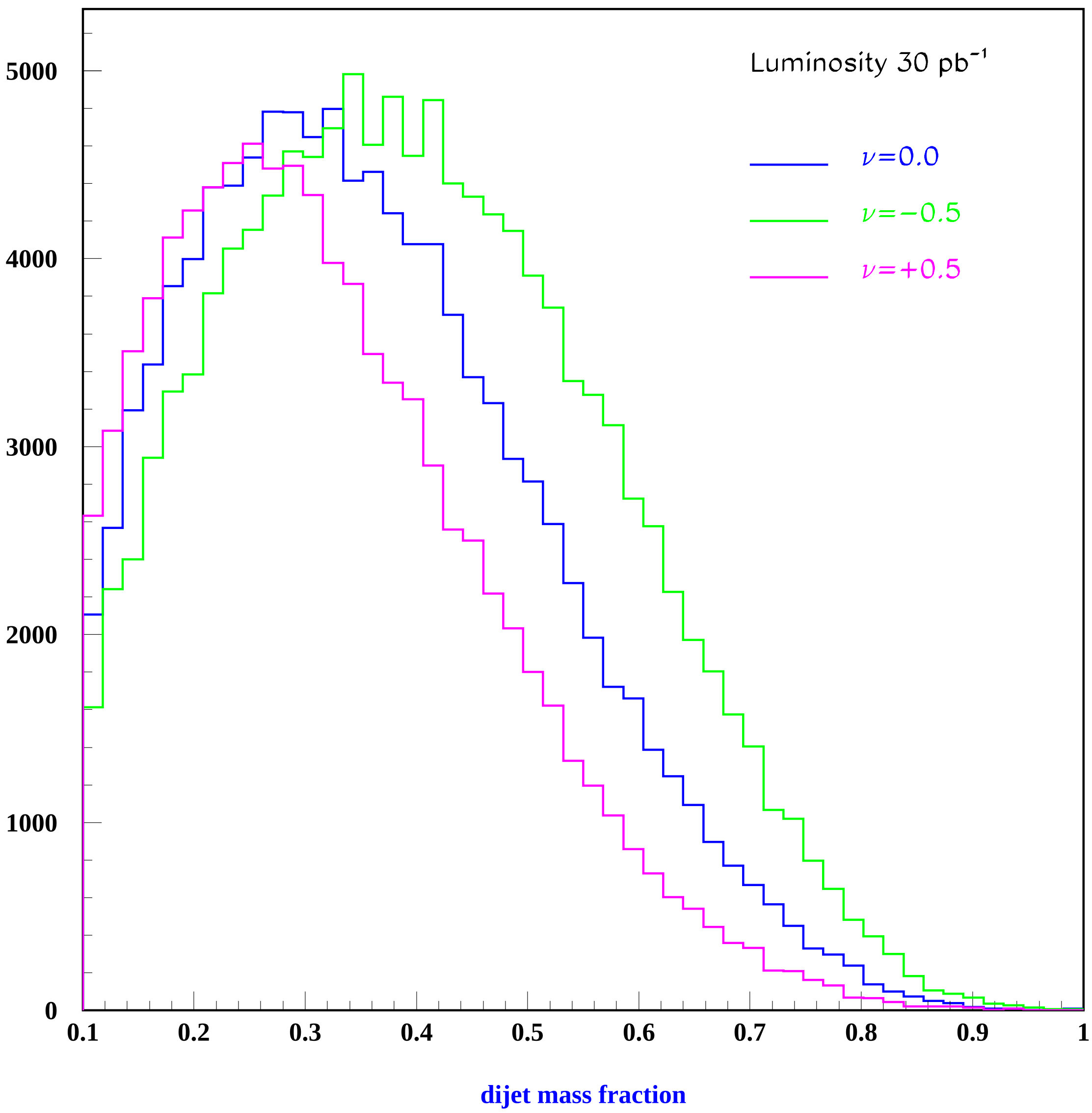
Uncertainty on high β gluon

Uncertainty on gluon density at high β: multiply the gluon density by $(1-\beta)^{\nu}$



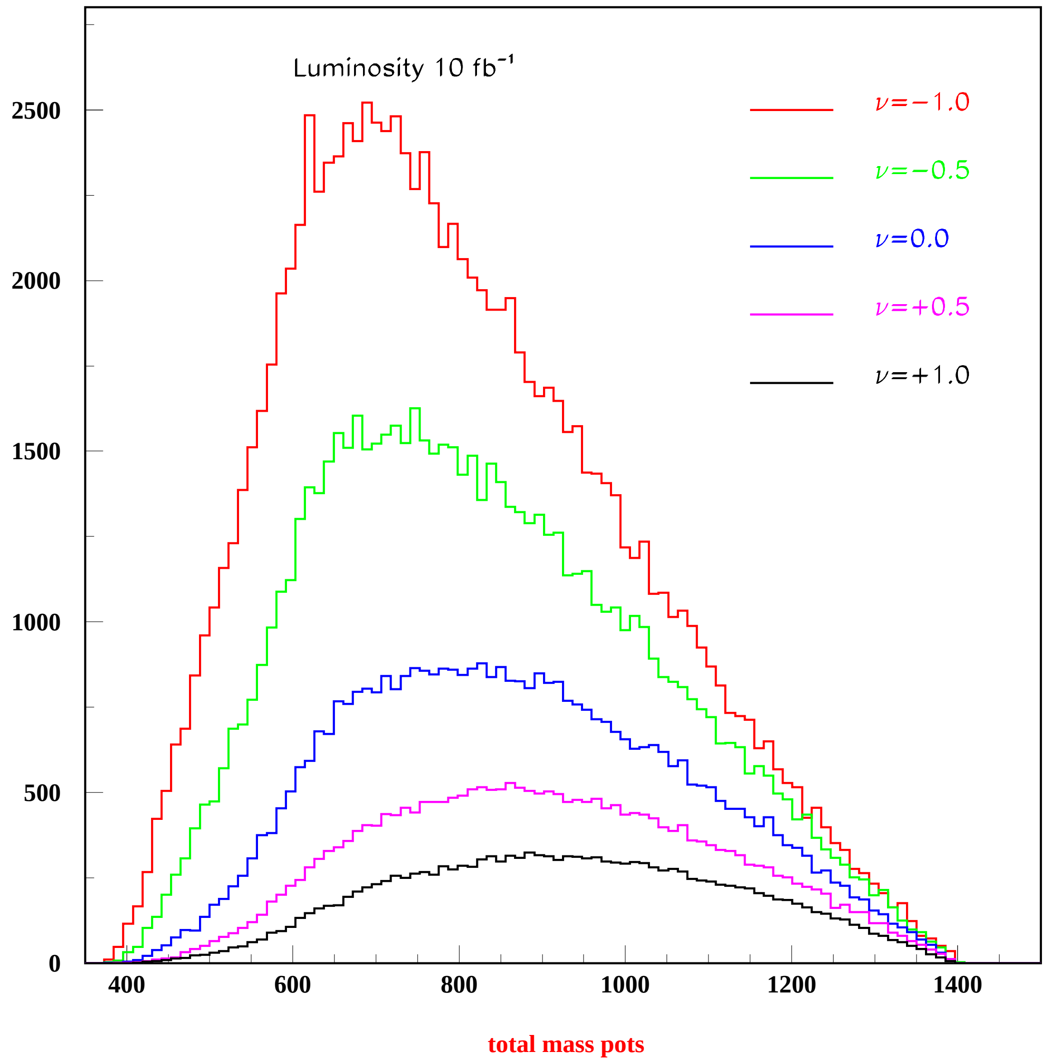
Dijet mass measurement

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

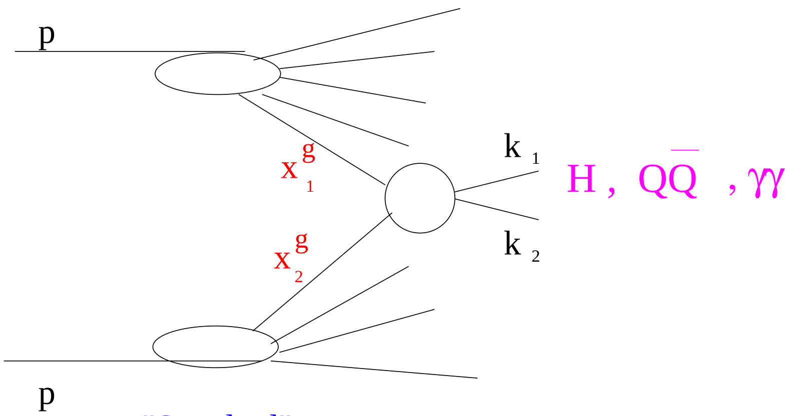


$t\bar{t}$ inclusive events

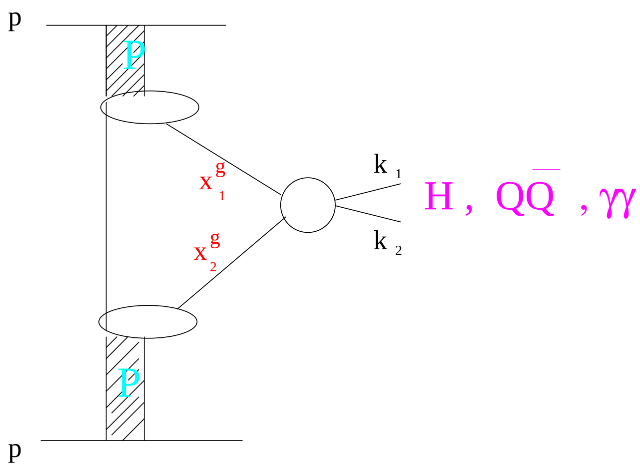
Idea: Measure the diffractive mass produced in $t\bar{t}$ events at the LHC ($M = \sqrt{\xi_1 \xi_2 S}$): high sensitivity on high-β gluon



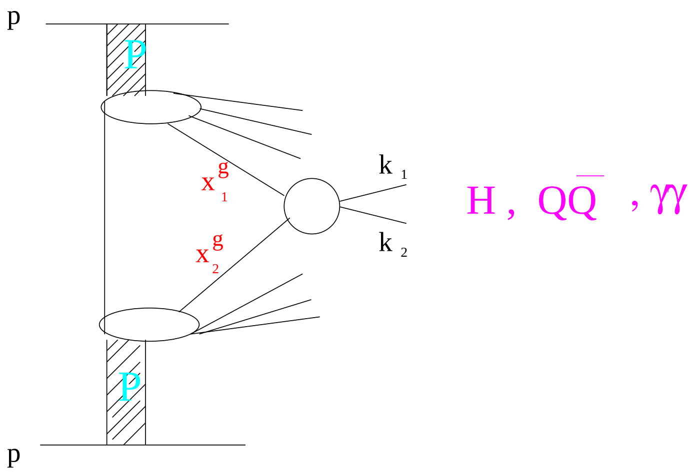
“Exclusive models”



"Standard"



"Exclusive "

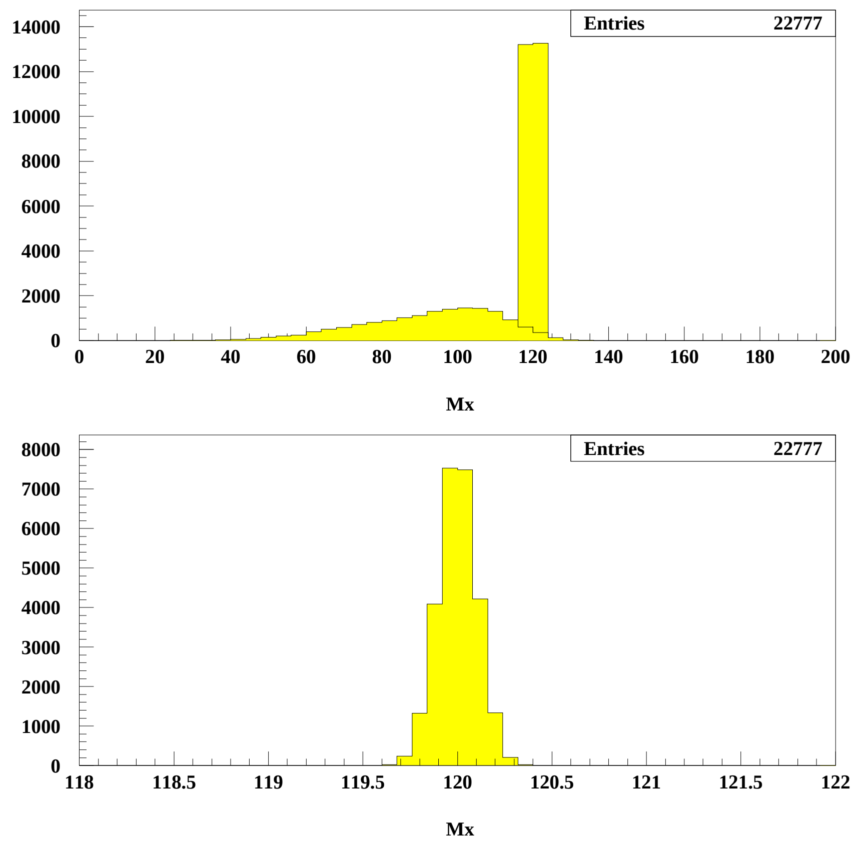


"Inclusive"

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

Advantage of exclusive Higgs production?

- Good Higgs mass reconstruction: fully constrained system, Higgs mass reconstructed using both tagged protons in the final state ($pp \to pHp$)
- $M_H = \sqrt{\xi_p \xi_{\bar{p}} S}$
- No energy loss in pomeron "remnants"

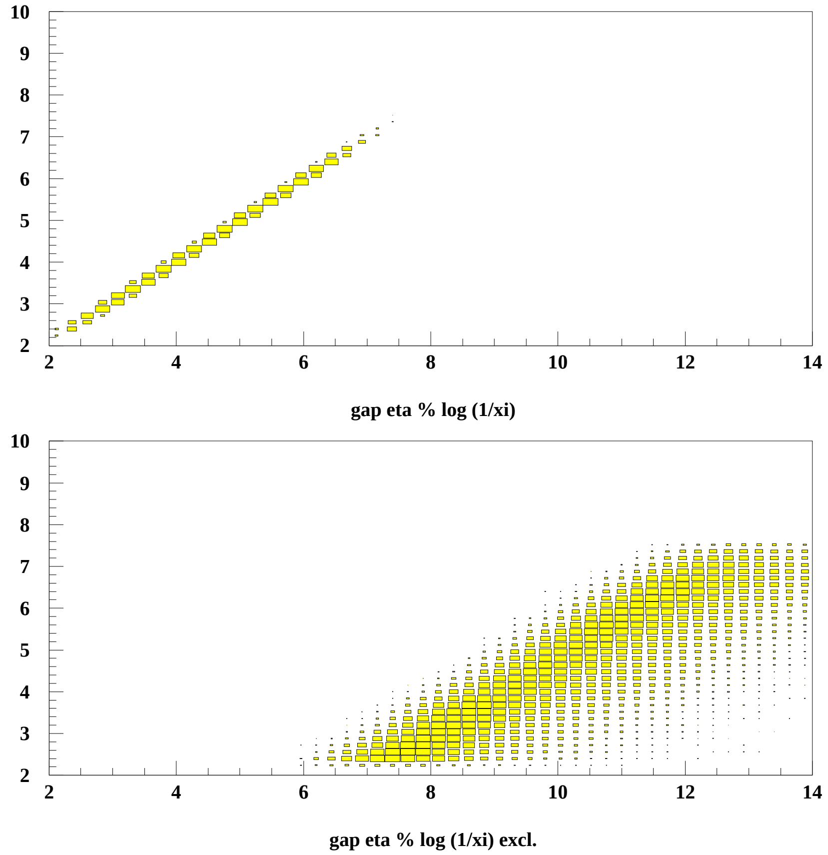


DPEMC Monte Carlo

- 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

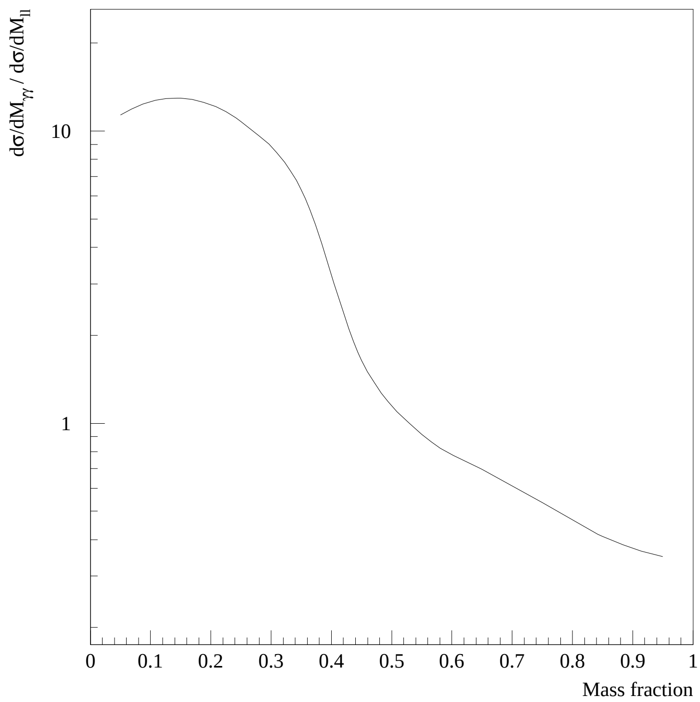
Existence of exclusive events

Correlation between size of rapidity gap and $log 1/\xi$ for inclusive and exclusive (or quasi-exclusive) events: Gap is between jet and proton for exclusive events



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 ($gg \to \gamma\gamma$ ok, $gg \to l^+l^-$ direct: impossible)
- Change of slope of ratio if exclusive events exist
- Other method: ratio b-jets / all jets,

“Exclusive” production at the LHC

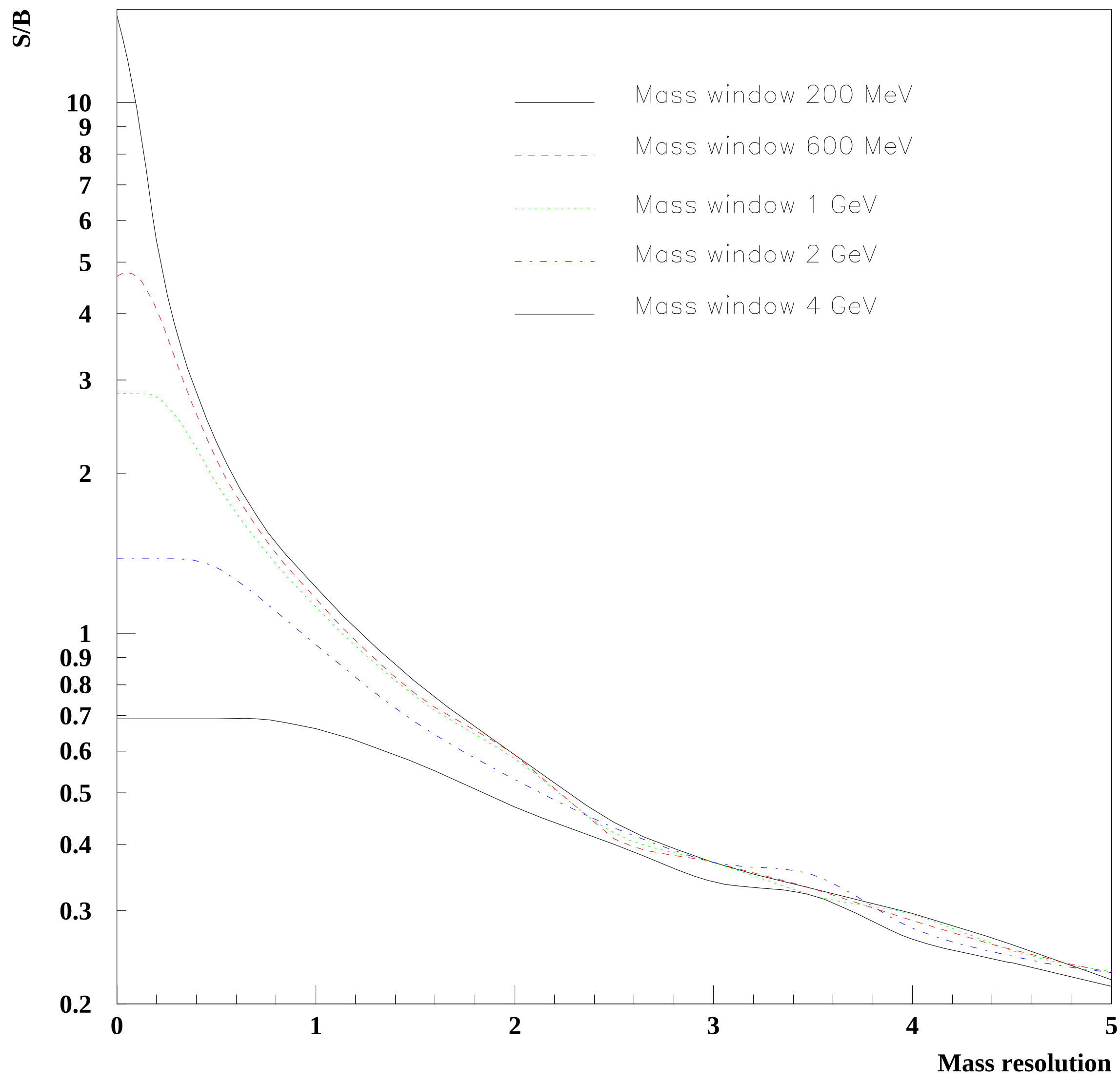
- Higgs decaying into $b\bar{b}$: study S/B
- Exclusive $b\bar{b}$ cross section (for jets with $p_T > 25$ GeV): 2.1 pb
- Exclusive Higgs production (in fb)

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

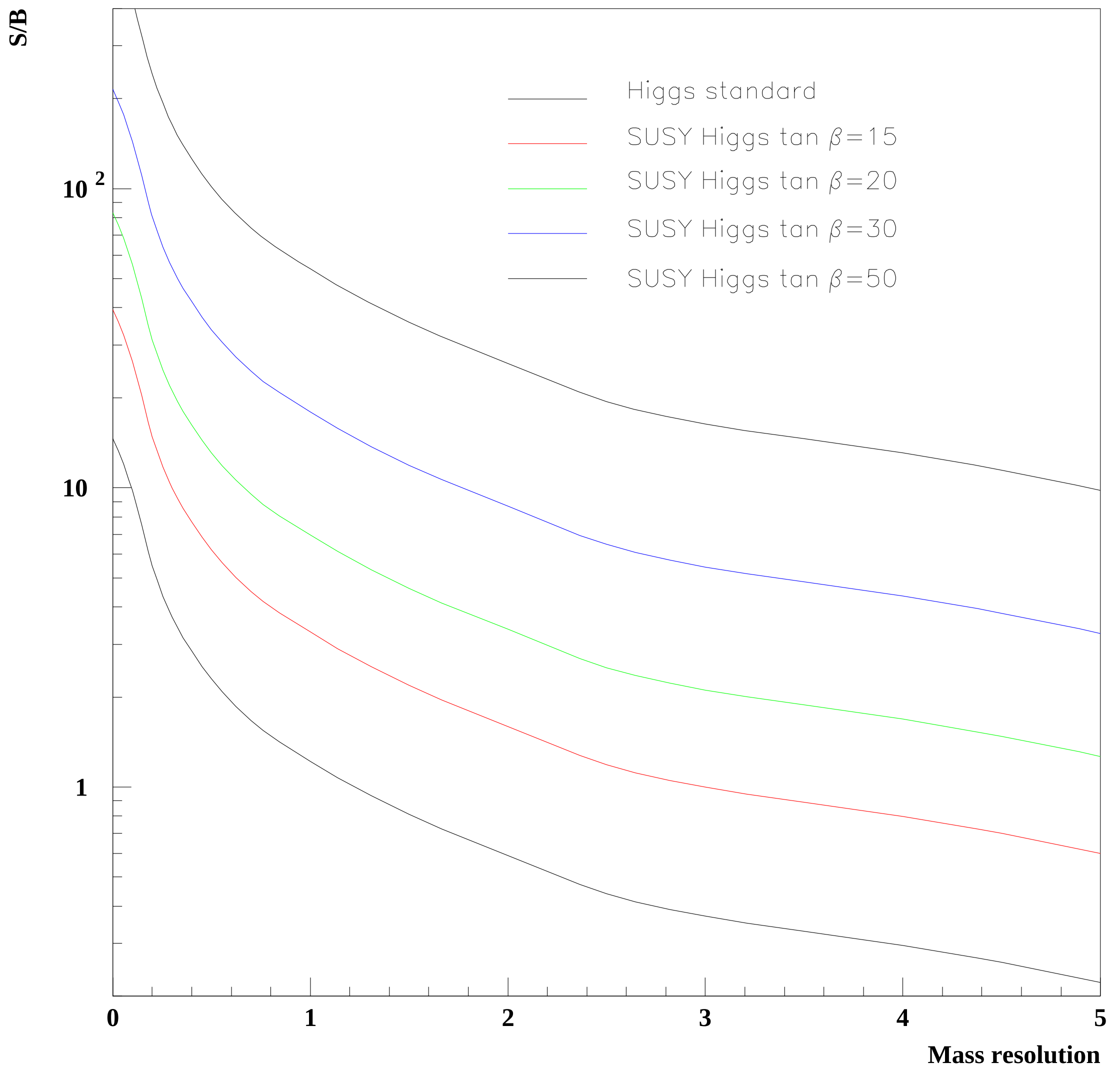
Signal over background: standard model Higgs

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

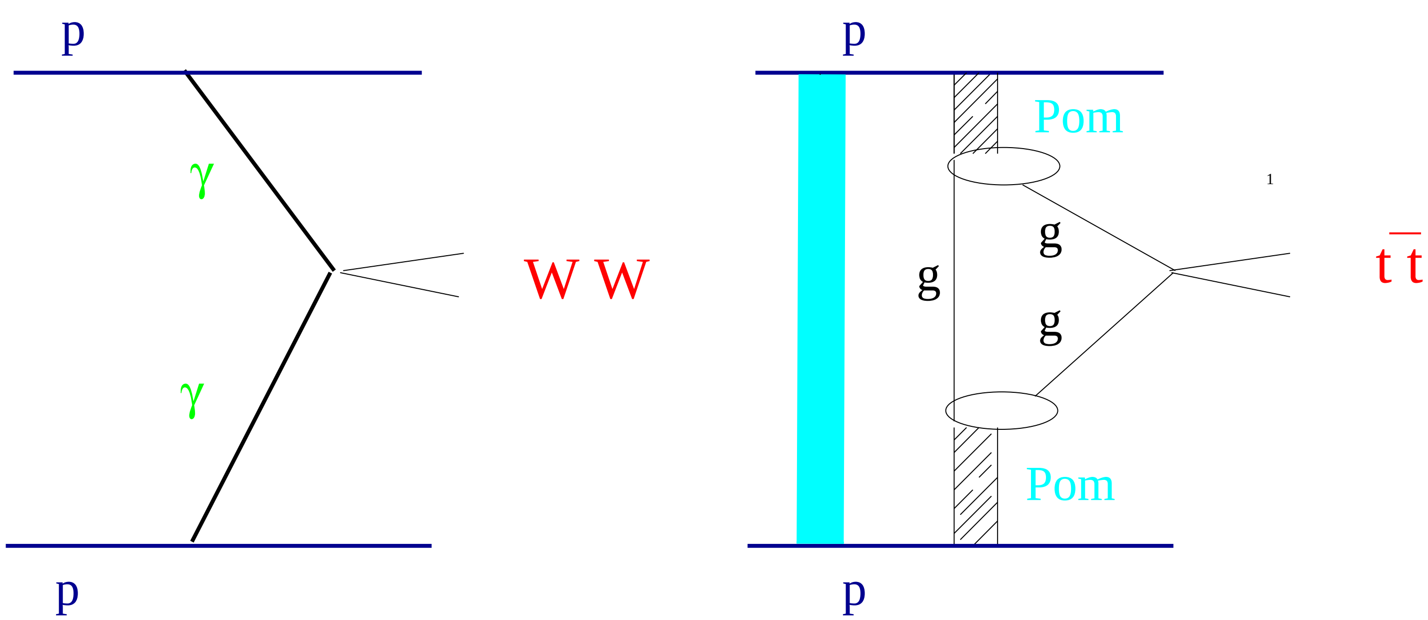


Diffractive SUSY Higgs production

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

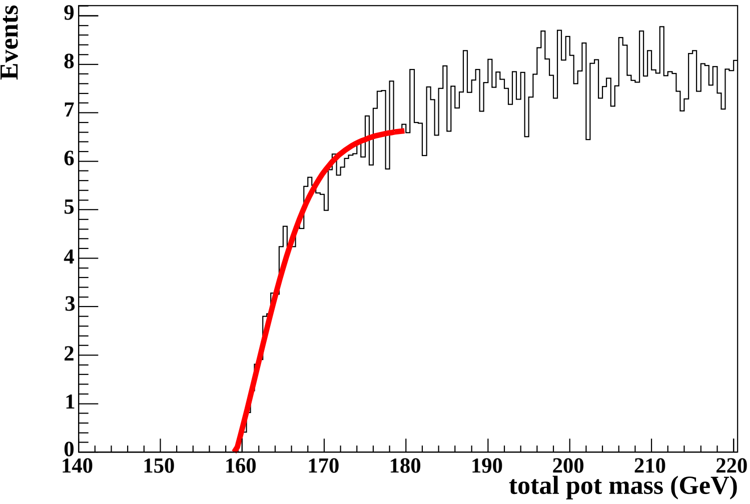


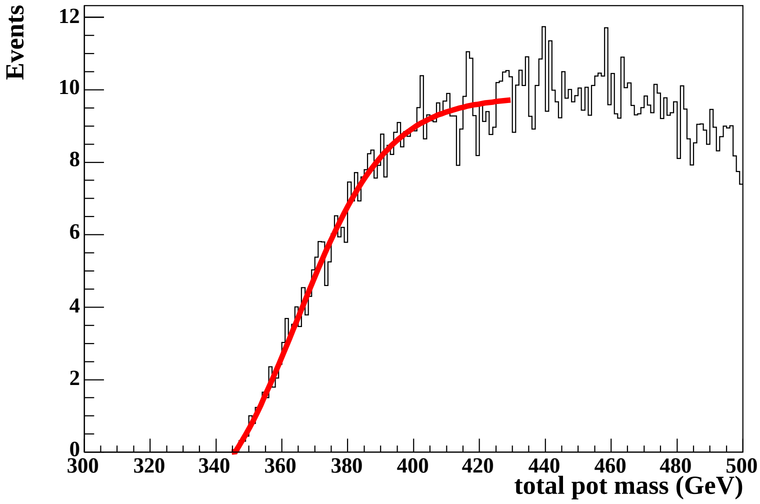
W, top and stops



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

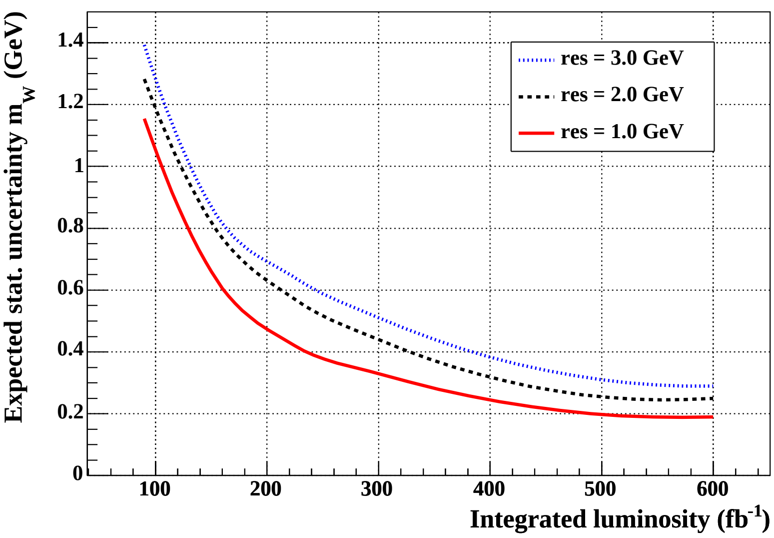
Top and W events

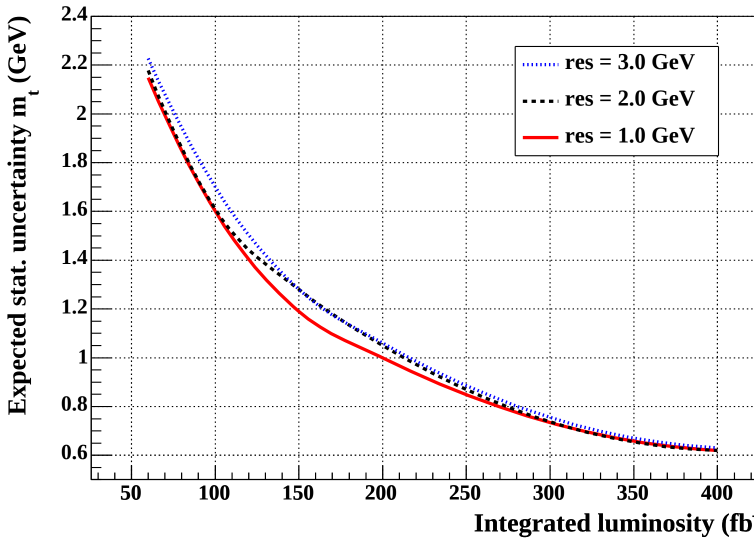




- W boson cross section and acceptance: $\sigma \sim$ 56 fb, pots at 420 m needed, about 60%
- Top quark cross section and acceptance: $\sigma \sim$ 40 fb, pots at 220 m, about 85%
- Reconstruct the W and top mass using the threshold scan method: Fit the increase of the cross section at threshold

Resolution on W and top masses

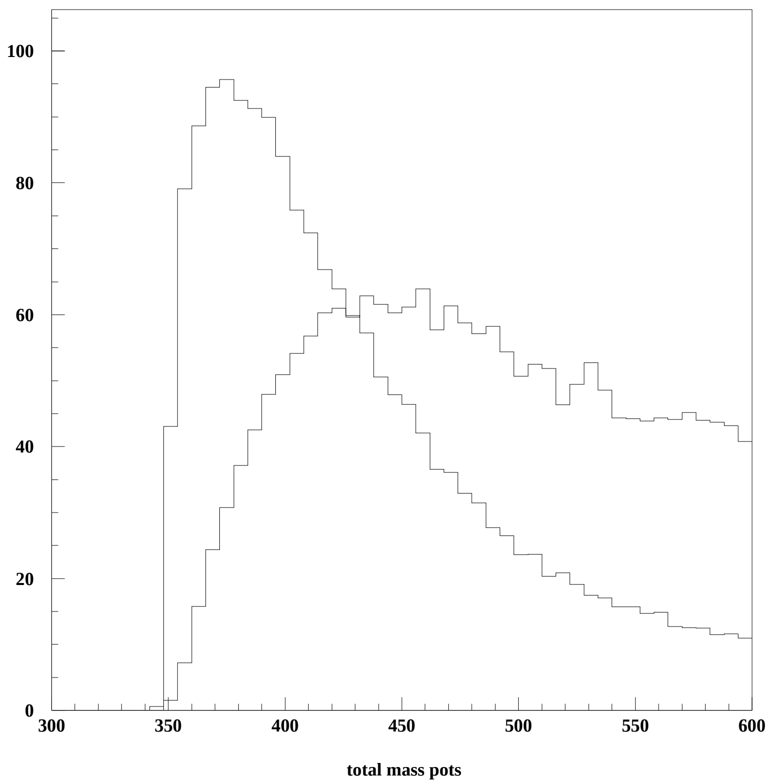




- 2 methods uaed to reconstruct the top mass: histogram: (compute χ^2 between number of events in bins in MC and data for the same lumi), turn-on fit: fit the turn-on point of the missing mass distribution at threshold
- W mass resolution: $\sim$ 400 MeV, not competitive, but allows to calibrate (align)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

Top and stops

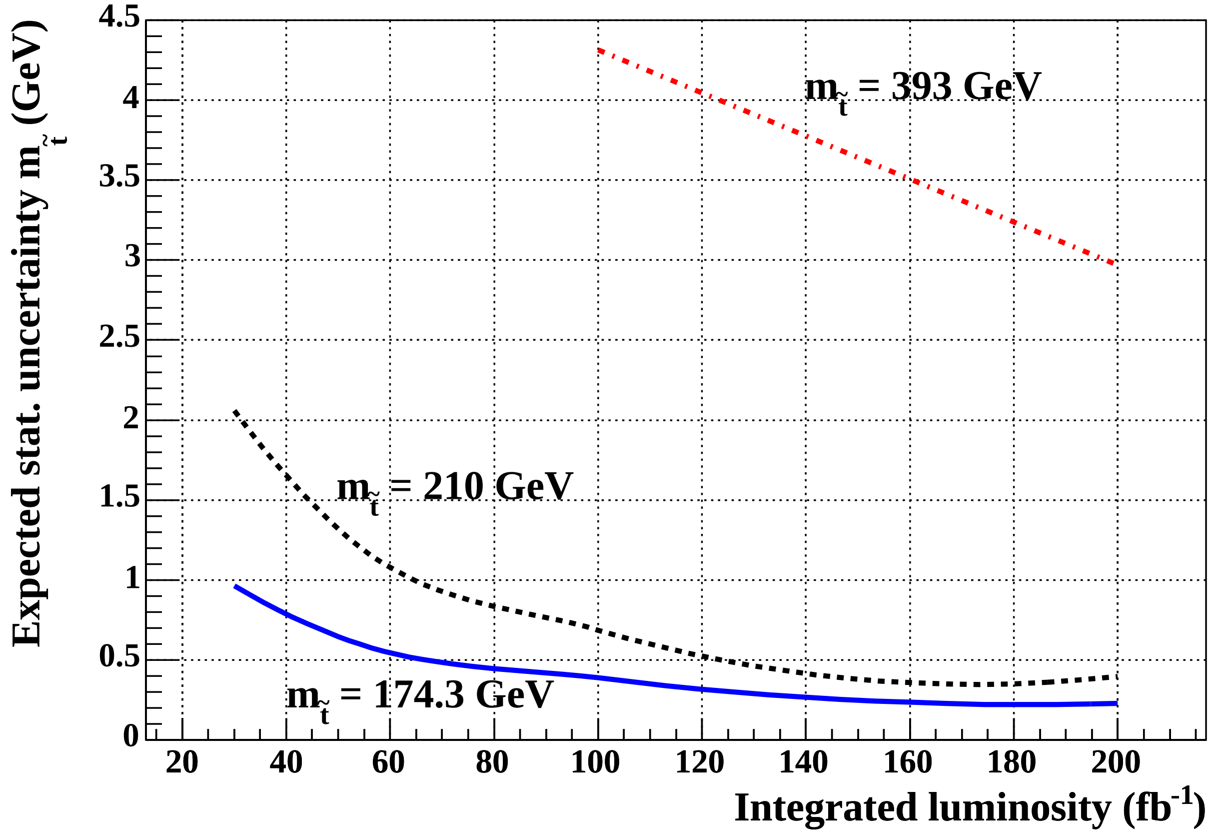
- Cross section for a stop mass of 250 GeV: $\sigma_{tot} = 8$ fb, $\sigma_{acc} = 6$ fb
- Possibility to distinguish between top and stop even if they have about the same mass: using the differences in spin (as an example: $m_{\tilde{t}} = m_{top}$)
- Very fast turn-on for stops



Resolution on stop mass

Resolution on stop mass by using roman pot detectors with a resolution of 1 GeV $\rightarrow$

Resolution better than 1 GeV at high lumi!



Conclusion

- Study of inclusive events (the only events which are existing for sure): determination of gluon at high β, search for SUSY events (or any resonance) when dijet background is known

- Exclusive events still to be observed in particular at the Tevatron

- Exclusive Higgs: Signal over background: ~ 1 if one gets a very good resolution using roman pots (better than 1 GeV), enhanced by a factor up to 50 for SUSY Higgs at high $tan\beta$

- QED WW pair production: cross section known precisely, allow to calibrate prescisely the roman pot detectors

- Diffractive top, stop pair production: possibility to measure top and stop masses by performing a threshold scan with a precision better than 1 GeV (same idea as linear collider, without ISR problem),