QCD Prospects for ATLAS

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On behalf of the ATLAS collaboration

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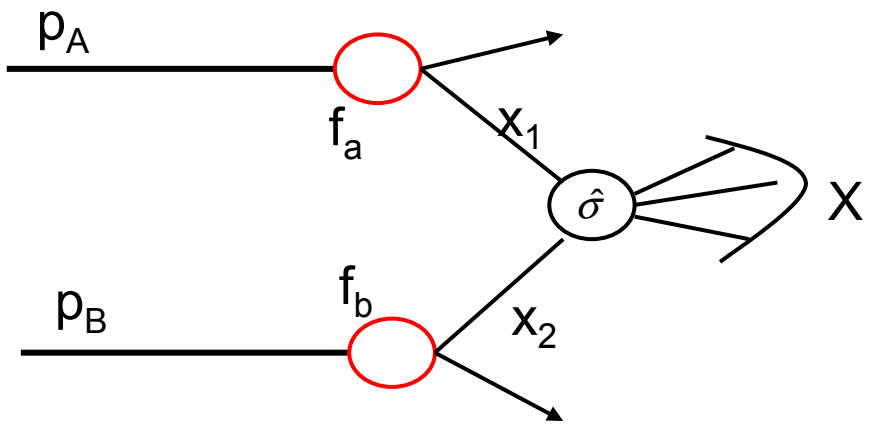
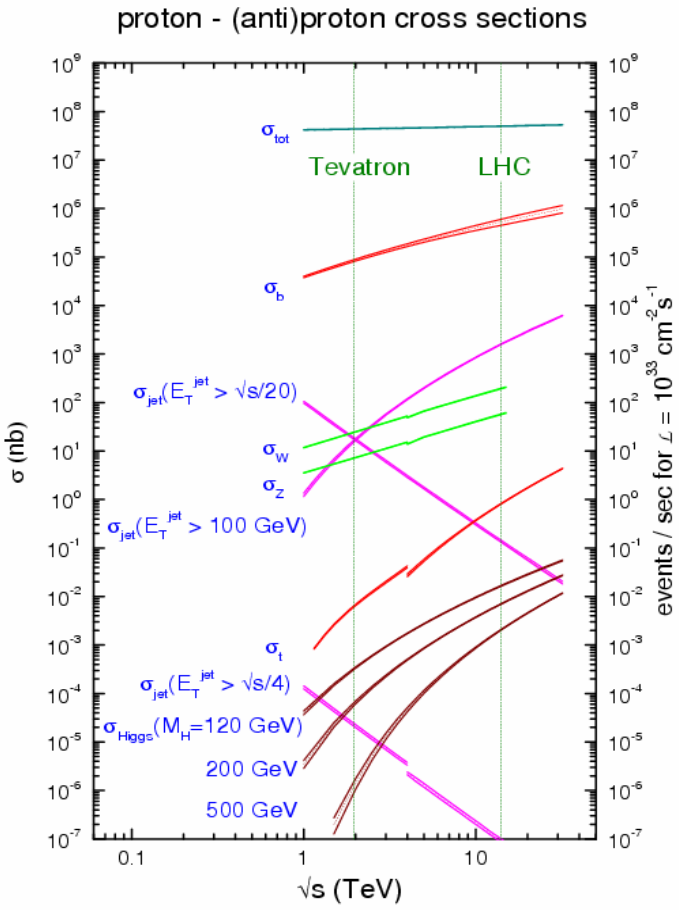
Cross Sections at LHC



$$\sigma = \sum_{i,j} \int dx_1 dx_2 \, f_i\left(x_1, \mu^2\right) f_j\left(x_2, \mu^2\right) \hat{\sigma}_{ij}\left(x_1, x_2, \alpha_s\left(\mu^2\right)\right)$$



Everything we do at LHC is QCD

Goals for QCD studies at LHC:

- Precision Tests of SM
- Input to understand BSM signal cross sections
- Input to understand background processes for searches

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Outline

- LHC & ATLAS
- Kinematic Space
- Examples for Physics Possibilities
  - Parton Densities
  - Jet Physics
  - Underlying Event

LHC

Schedule:
Now: Installation
2007: First Collisions (450 GeV x 450 GeV)
2008: High Energy (7 TeV x 7 TeV)
3 y. low lumi ($10^{33}cm^{-2}s^{-1}$ <=> 10 fb^{-1}/y.)
3 y. high lumi ($10^{34}cm^{-2}s^{-1}$ <=> 100 fb^{-1}/y)

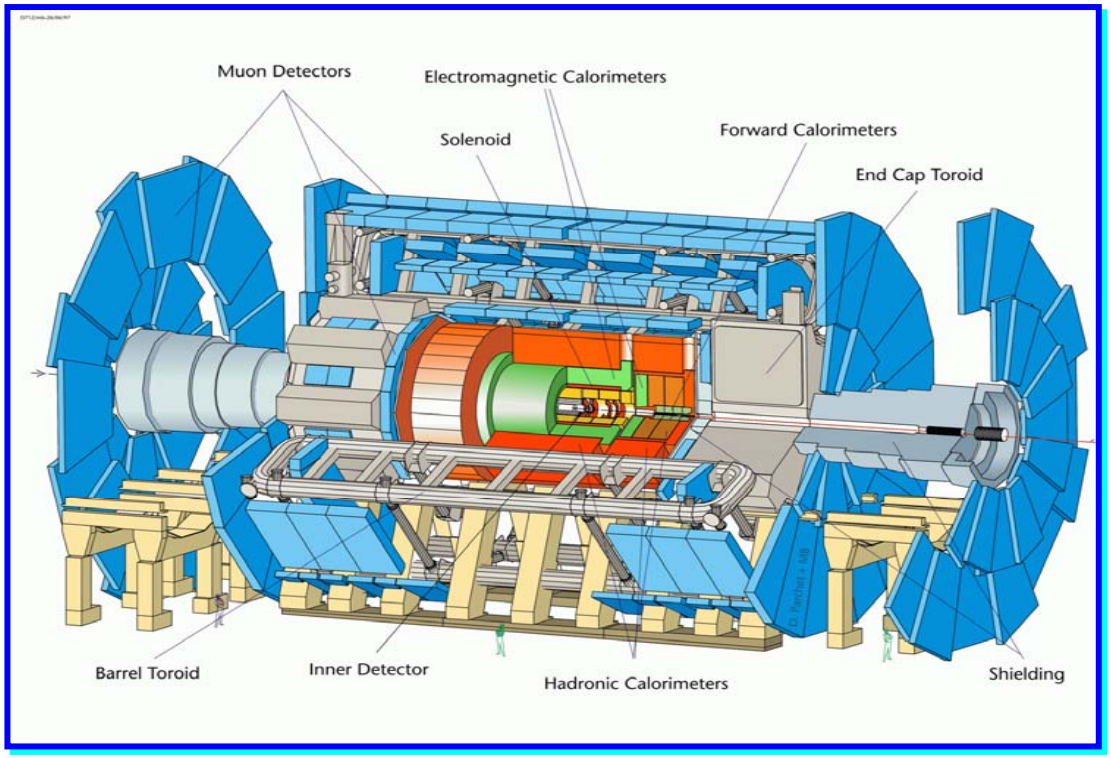
pp Interactions

$\sqrt{s} = 14$ TeV

L = 10^{34} $cm^{-2}s^{-1}$ (design)

Process	σ (nb)	Evts/year (10 fb^{-1})
Minimum Bias	10^8	~10^{15}
Inclus. Jets (p_T > 200 GeV)	100	~ 10^9
bb	5 10^5	~ 10^{12}
$W \rightarrow e\nu$	15	~ 10^8
$Z \rightarrow e^+ e^-$	1.5	~ 10^7
t t	0.8	~ 10^7
Dibosons	0.2	~ 10^6

ATLAS



Length ~45 m, height ~22 m, weight ~7000 tons

Inner Detector (2T solenoid, $|\eta| < 2.5$):

$$\sigma_{pt}/p_t = 0.05\% \times p_t(GeV) + 1\%$$

Calorimetry:

* electromagnetic $|\eta| < 3.2$:

$$\sigma_E/E = 10\%/\sqrt{E(GeV)} + 0.1\%$$

* hadronic $|\eta| < 4.9$:

$$\sigma_E/E = 50\%/\sqrt{E(GeV)} + 3\%$$

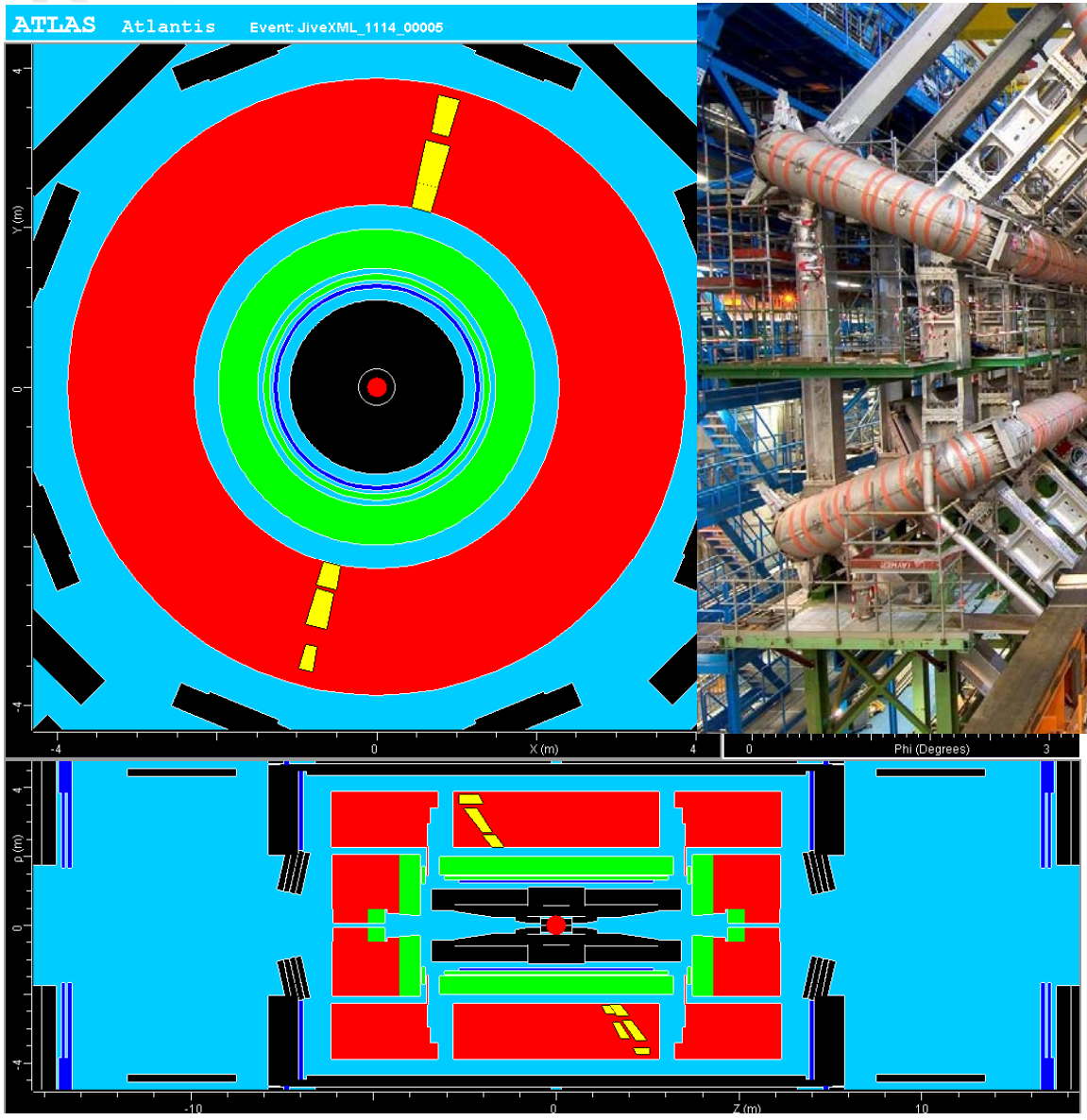
Muon system (~4T toroid, $|\eta| < 2.7$):

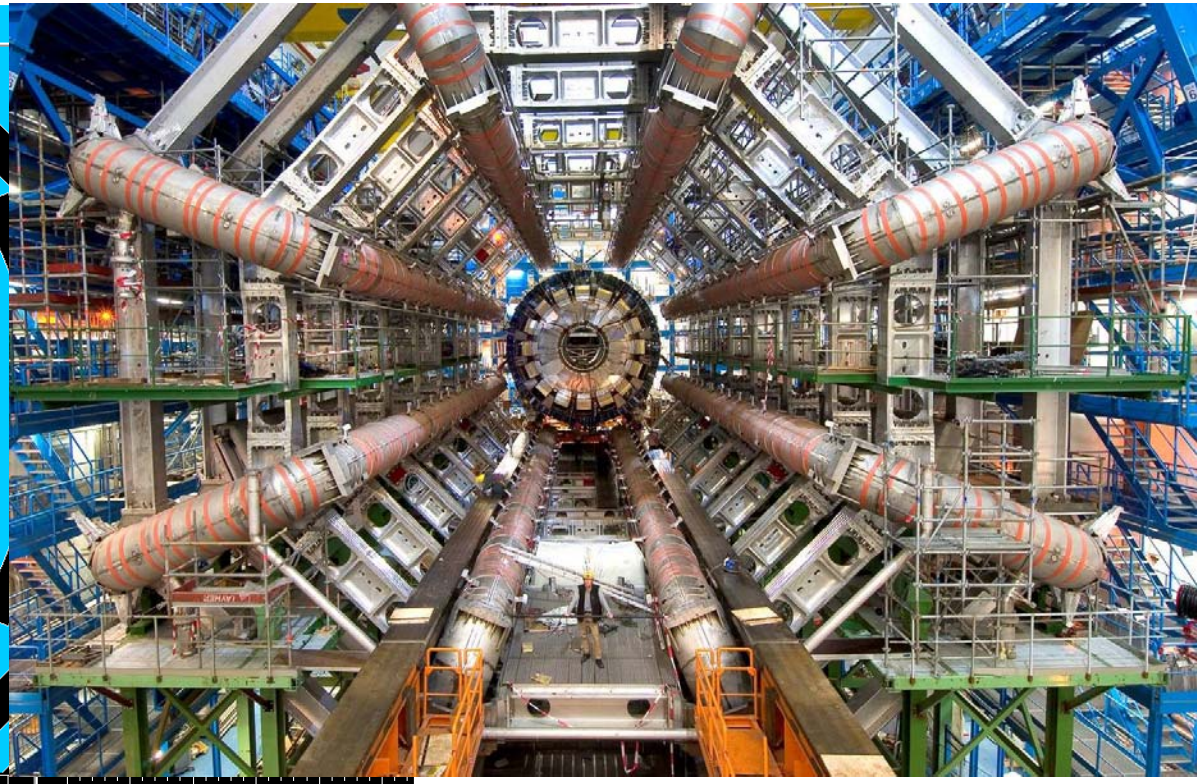
$$\sigma_{pt}/p_t = 10\% \text{ for } p_t(\mu) = 1 \text{ TeV/c}$$

Energy Scale Uncertainty: Electrons 0.1% (0.02%)
Jets 1%

-> Precision Device

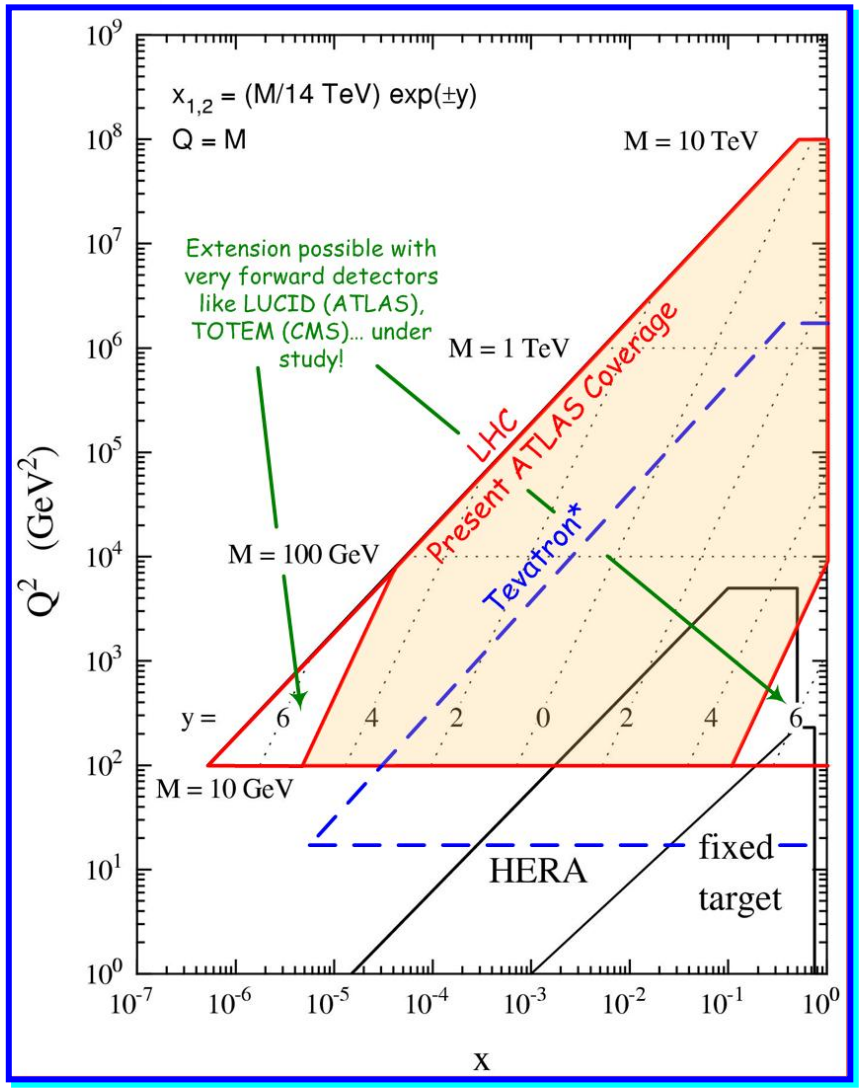
ATLAS

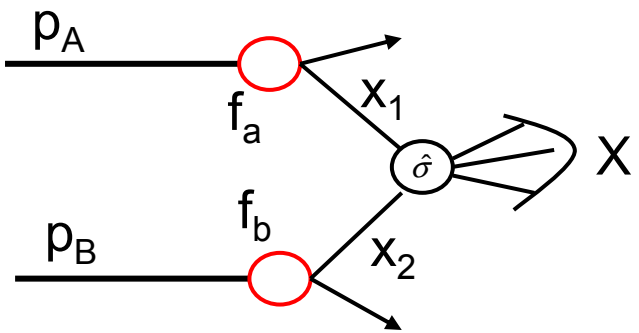




- „Data Taking" started (cosmic muon as seen by the calorimeter)
- construction & commissioning of components underway
- ATLAS will be ready in 2007

Kinematic Space





x – momentum fraction of participating parton
Q – Energy Scale of the hard interaction

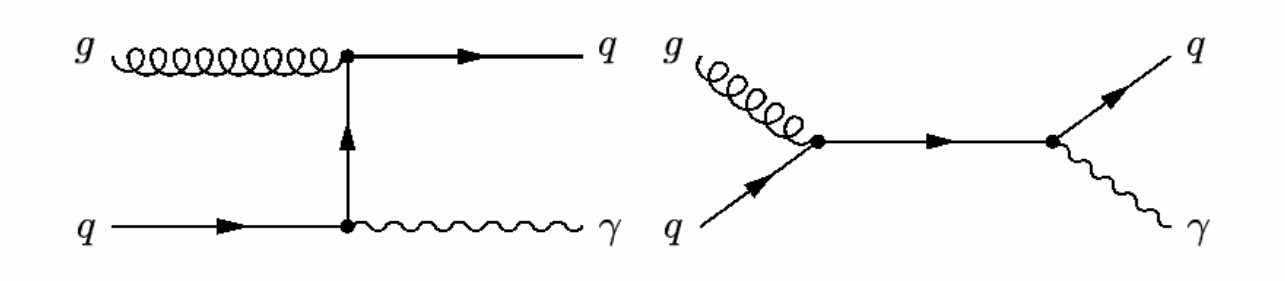
Large Mass range accessible

x-space almost covered by HERA
DGLAP -> prediction for LHC
-> check DGLAP at low x (higher orders needed?)
-> more precision at high x

How to constrain Pdf's?

- Vector Boson Production: Photons, W's, Z's
- Jets, heavy quarks, …

γ + jet:

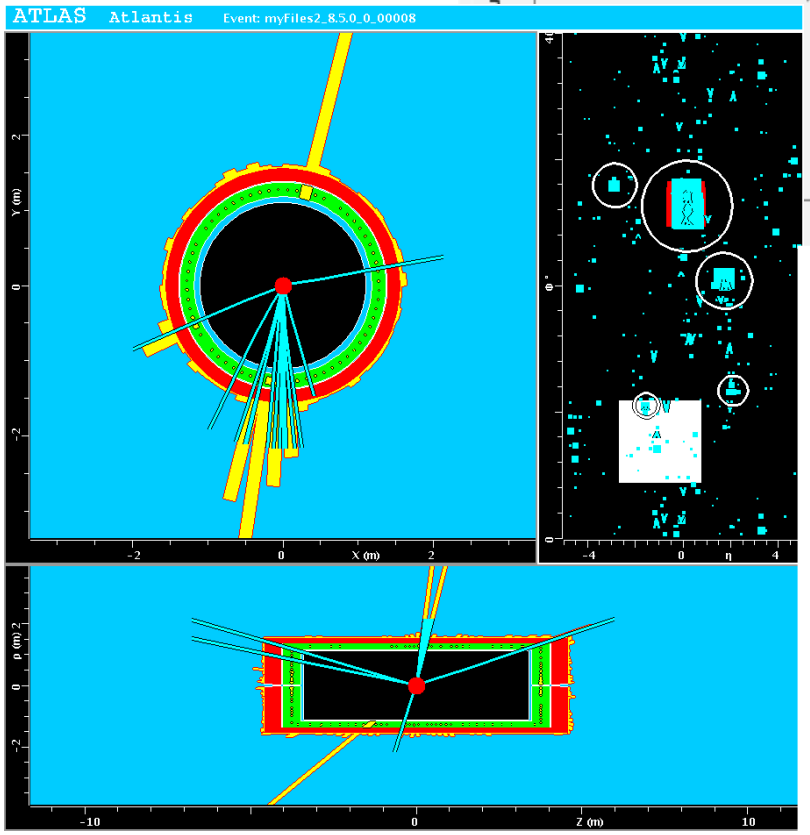


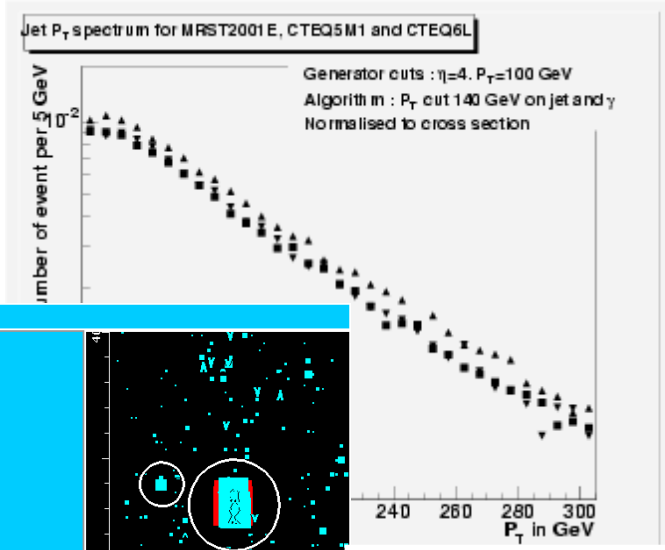
W-production: $\begin{cases} u\bar{d} \rightarrow W^+ \\ d\bar{u} \rightarrow W^- \end{cases}$ Z-production: $\begin{cases} u\bar{u} \rightarrow Z \\ d\bar{d} \rightarrow Z \end{cases}$

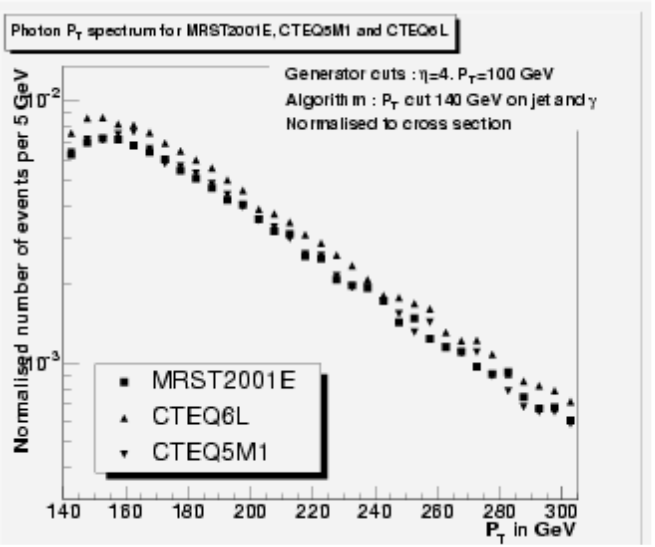
sea quark distributions driven by gluon
(main uncertainty for LHC x-sections)

Constraining PDF's using γ+jet

Simulated event

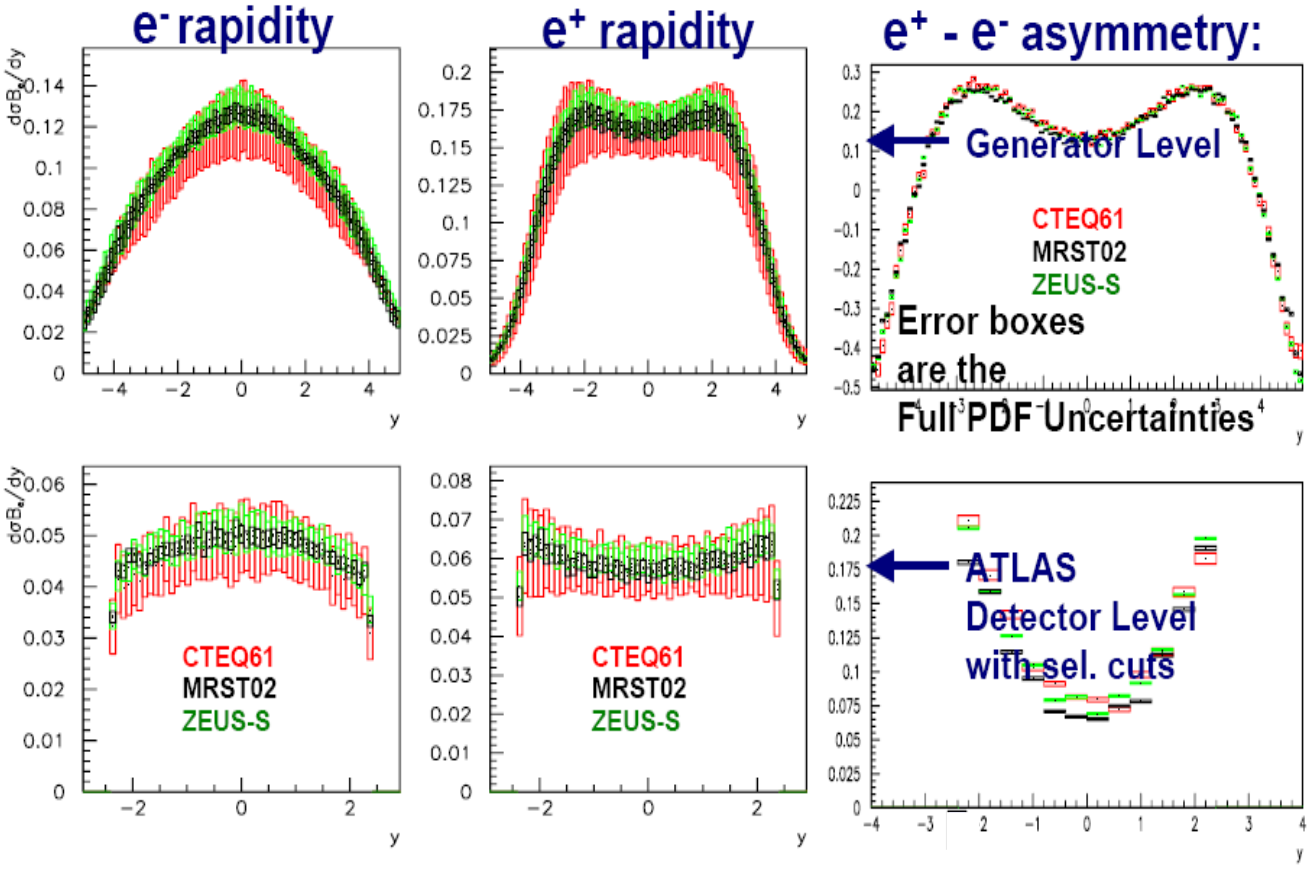






- sensitivity to PDF differences
  16-18% disagreement on γ and jet p_T distributions
- develop full analysis

W-> ev rapidity distributions



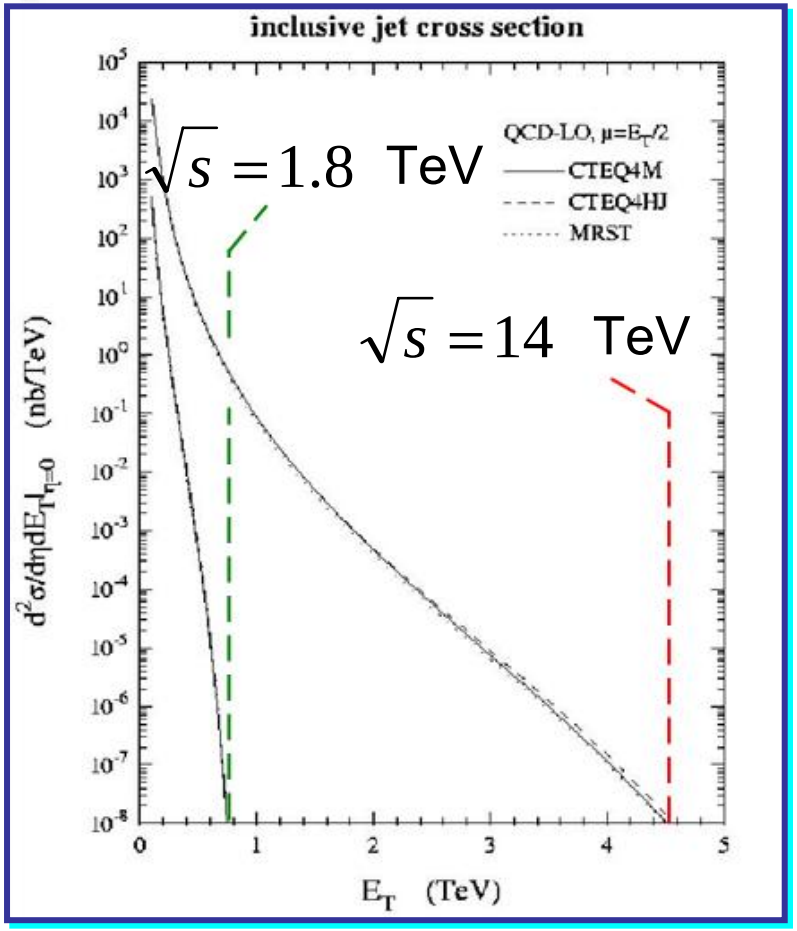
$$A(y) \equiv \frac{d\sigma/dy(e^+) - d\sigma/dy(e^-)}{d\sigma/dy(e^+) + d\sigma/dy(e^-)}$$

Asymmetry:
no sensitivity
-> benchmark

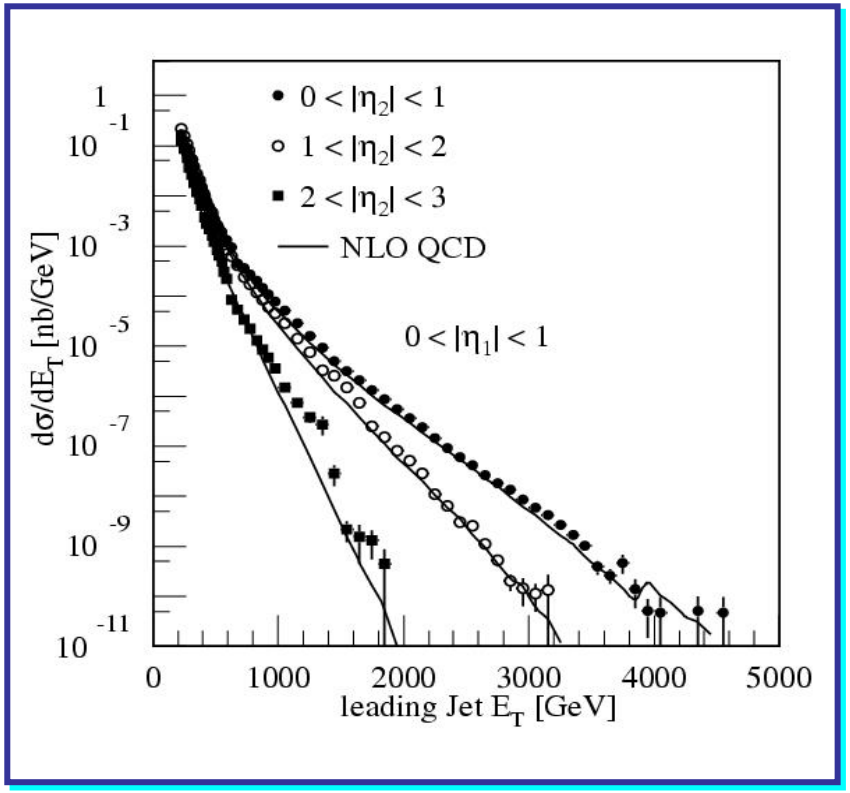
uncertainties: up to 9%
differences: up to 5%

statistics: plenty
systematics: goal 3.5%

Jet Physics

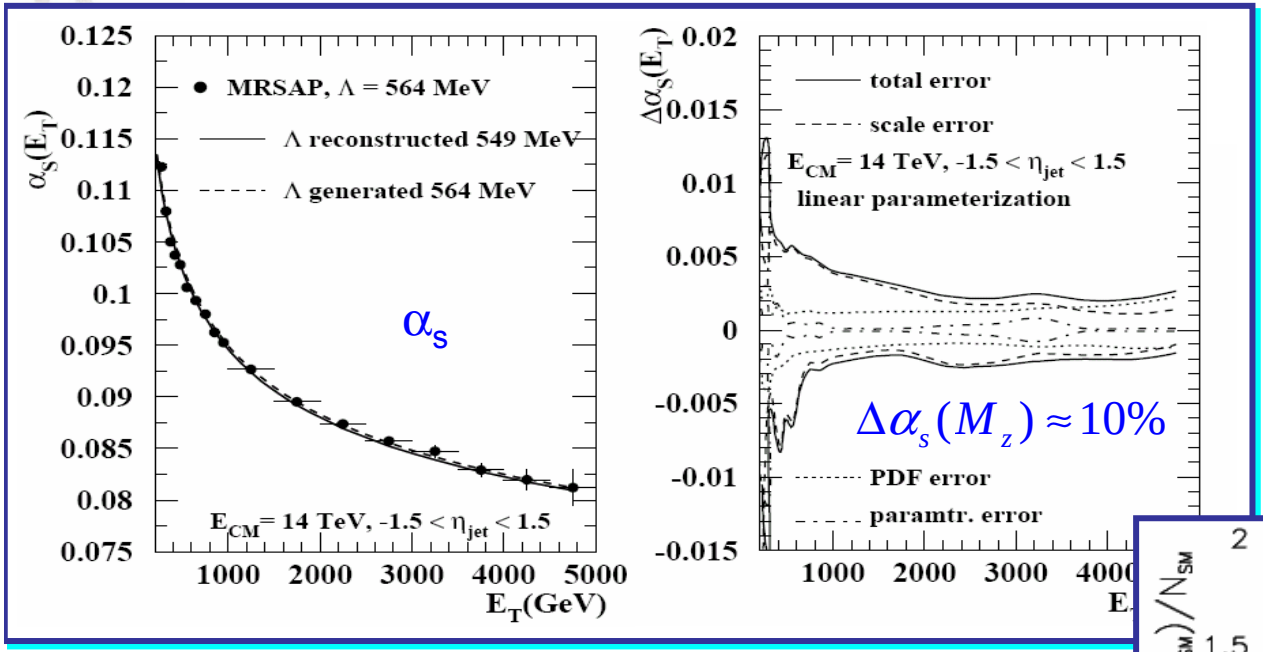


increase of phase space by factor 5



- precision tests at high scales
- differential dijets x-sections (E_T,η_1,η_2) give also constraints on PDFs

Jet Physics

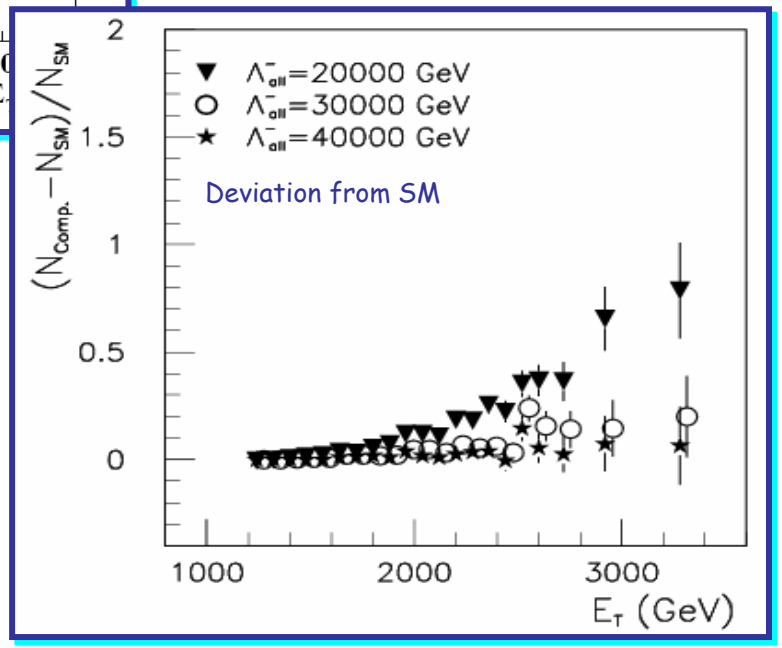


strong coupling constant

- Precision QCD tests at high scales E_T and small values of α_s
- No improvement of α_s (M_Z) expected

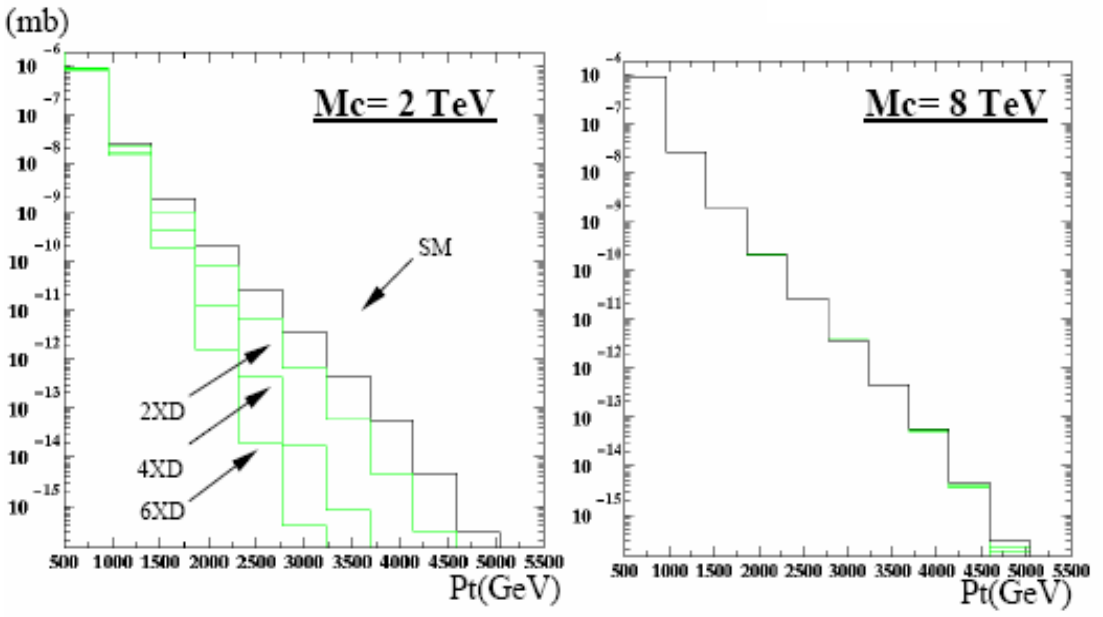
Compositness

Sensitivity up to scales of 40 TeV (300fb^{-1})



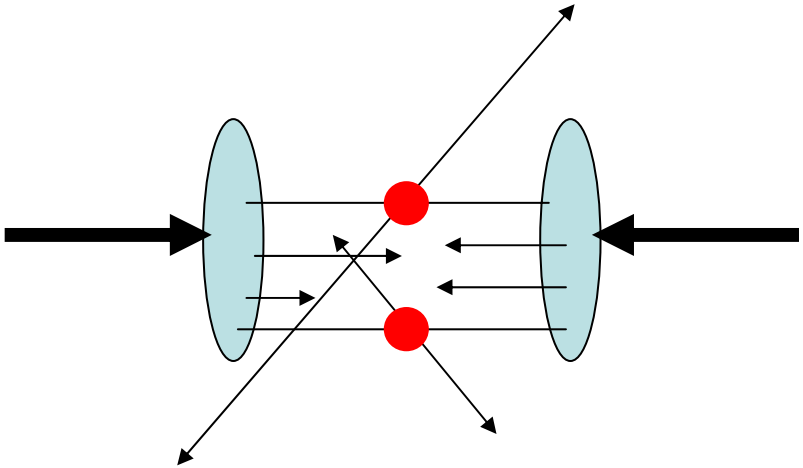
Parton Densities

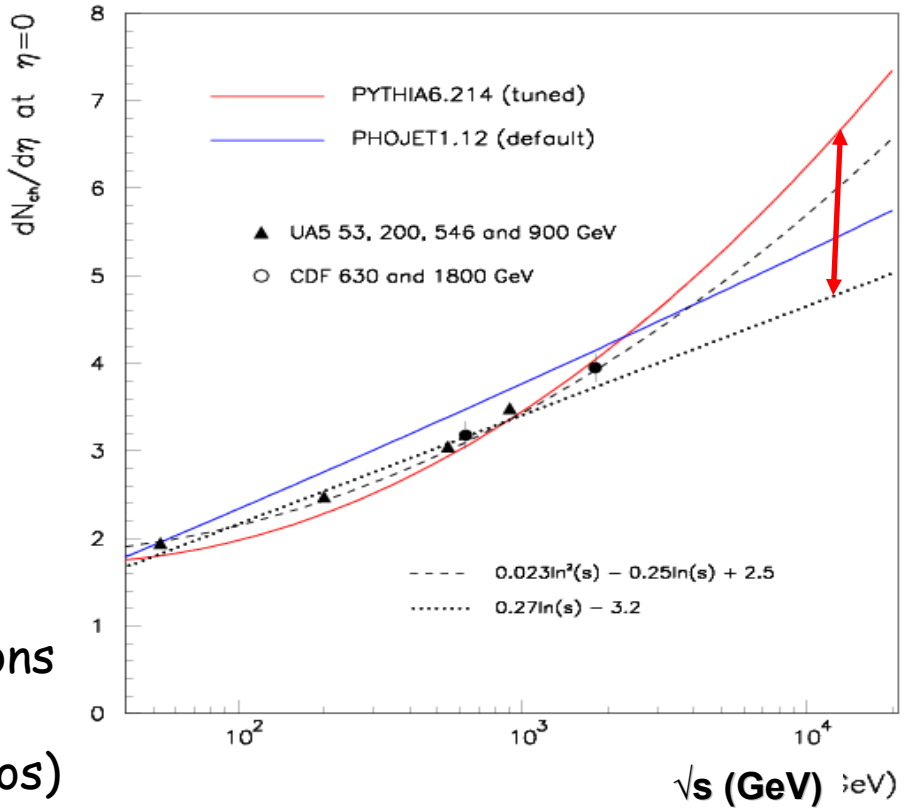
Impact of PDF uncertainties: Search for extra dimensions
(Dijet cross section)



- Extra Dimensions are masked behind PDF uncertainties (high-x gluon)
- Sensitivity: (Mc ~ 2 TeV)
  -> increase precision

Underlying Event

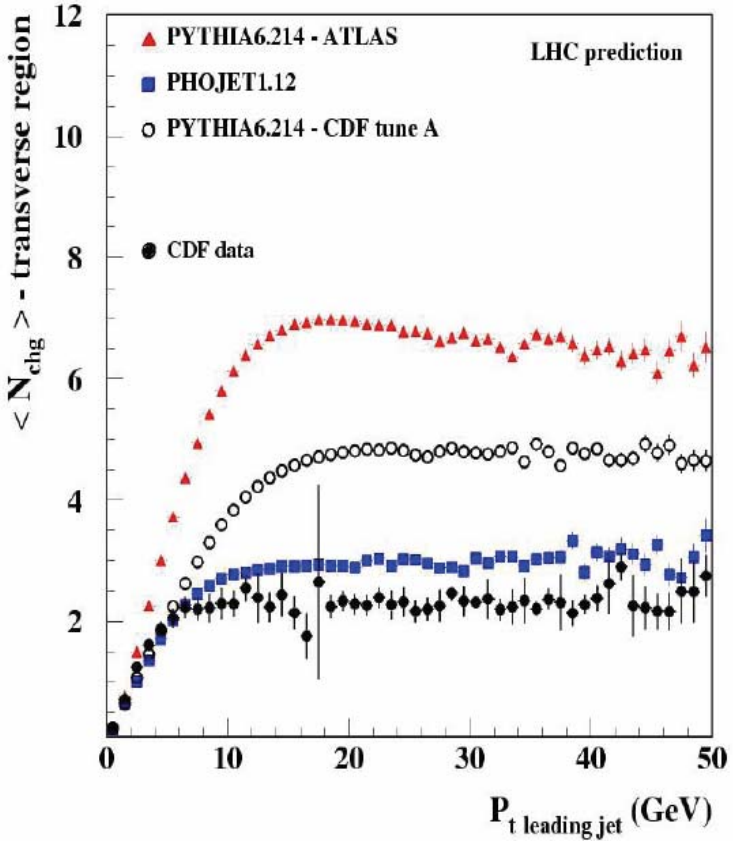


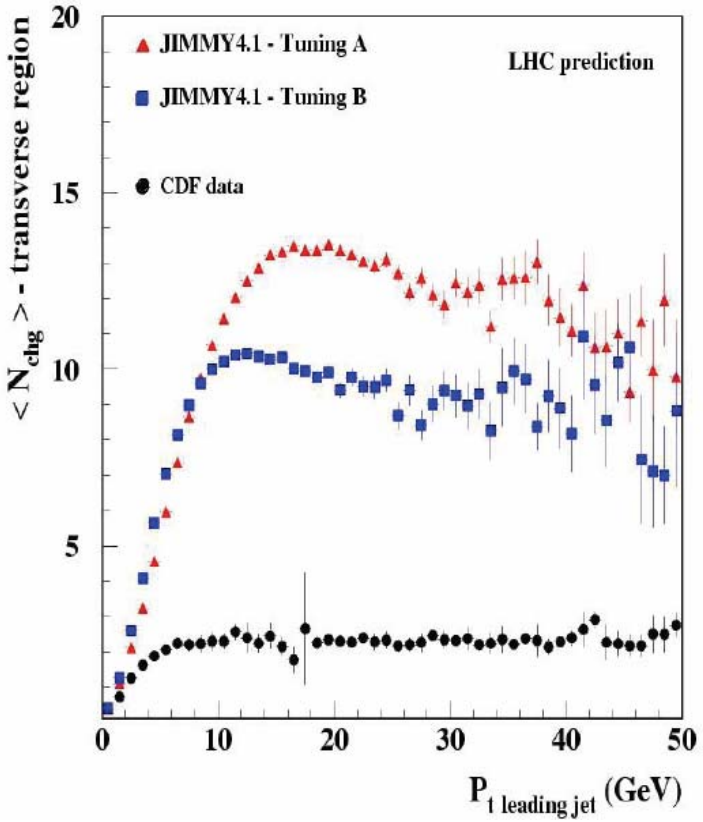


- Secondary interactions
- Additionally 23 inelastic interactions per bunch crossing
- Important for many searches (vetos)

-> Very important first measurement

Underlying Event





- Many models exist, tuned to Tevatron Data
- Large discrepancies when extrapolated to LHC energies

Possible Timeline

Depends on:

- machine development (increasing luminosity)
  - 1-2 fb^{-1}/y.
  - 3x10fb^{-1}/y.
  - 3x100fb^{-1}/y.
- detector understanding (increasing precision)
  - precision needs time and luminosity
  - calibration using data
  - (e.g. Z->ee, γ+jet production)

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Summary

- Possibility to test QCD at highest energies, smallest distances (smallest coupling constant) e.g. Jet cross sections, …
- Refinement of PDF knowledge
- Nonperurbative aspect (inelastic pp event structure)