SM BENCHMARKS – SUBGROUP REPORT

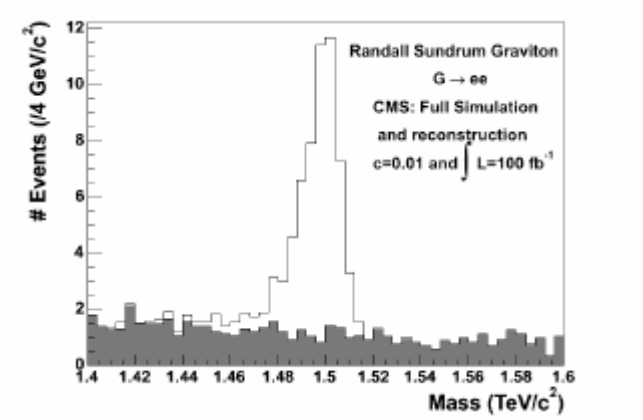
Topics and people involved:

- Di-lepton and di-photon final states: BSM signals as excesses in precision SM observables (Samir, Catherine, Csaba, Guillaume, Louis)
- PDF uncertainties: standard vs (Sudakov) resummed PDFs (Lorenzo, Fred, Gennaro, Samir)
- EW corrections: large, may be reduced by real W/Z radiation and decay (Stefano, Joey, Csaba, Samir, Stefan)
- Precision SM shapes: comparisons among codes for Higgs/DY pT/eta spectrum (Peter, Stefano, Csaba, Steffen, Gennaro, Lorenzo, Samir, Nicolas, Stefan)
- Generic analyses: optimal experiments and optimal observables (Witek, Nicolas)

Talks and slides at http://agenda.cern.ch/fullAgenda.php?ida=a052819

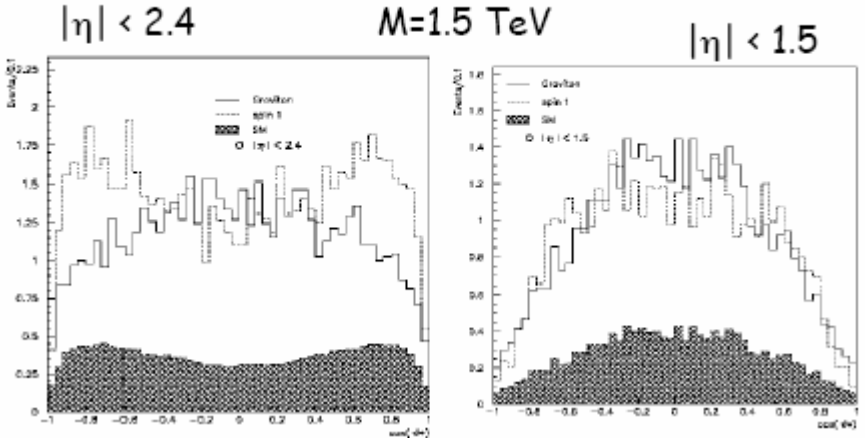
Search for very massive resonances in the di-e channels

Full Simulation and Reconstruction chain of CMS (CMSIM & ORCA without pile-up):



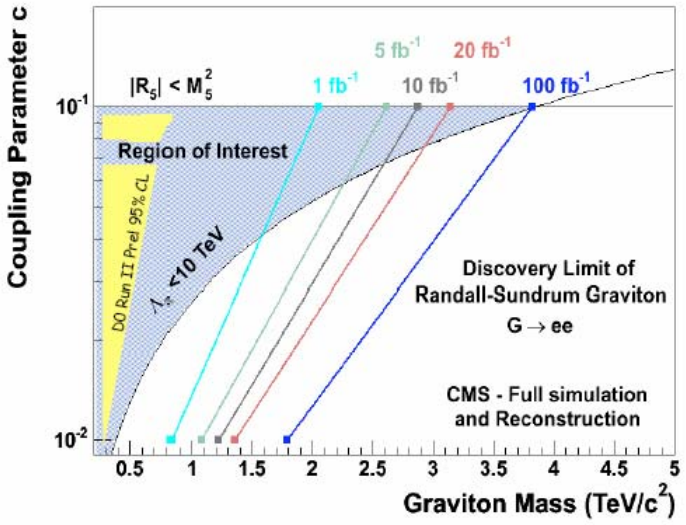
Angular Distribution

Analysis with fast simulation (CMSJET)



⇨ Need to do the study with the full simulation and reconstruction chain of CMS

Discovery potential of CMS



Plan for action:

- Validate angular study with full CMS simulation
- Extend analysis to di-photon case (Samir, ATLAS)
- Precision analysis of SM di-photon noise (Csaba): needed for case of unfavourable G masses/couplings !
- Similar exercise for Higgs (Guillaume and Louis)

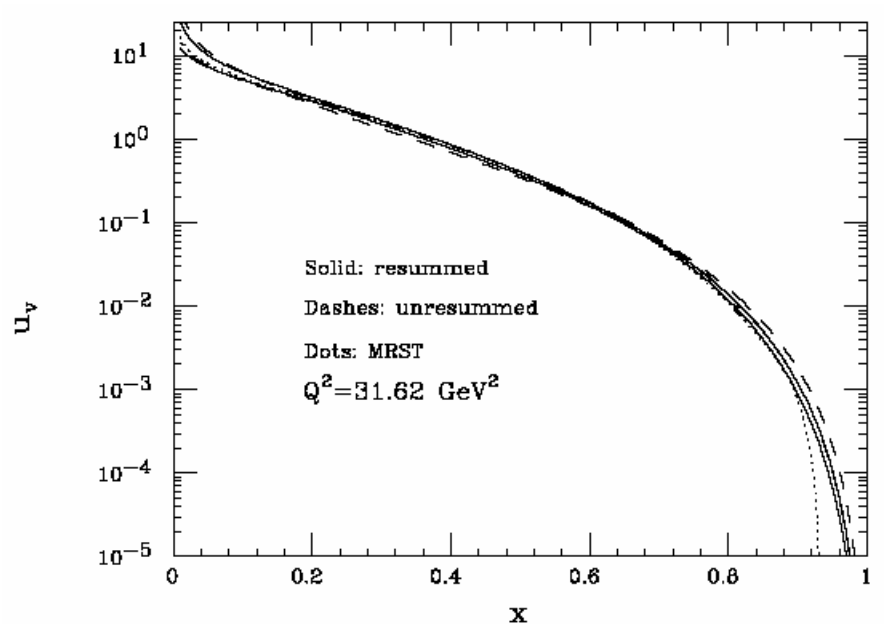
Soft gluon resummation

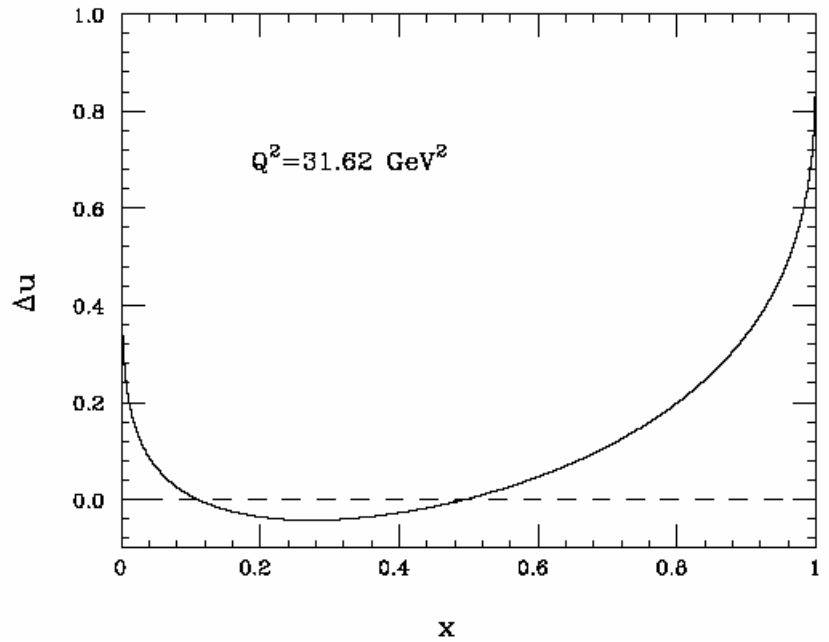
Extending the range of perturbative QCD

- Soft and collinear gluons generate *large logarithms* in QCD cross sections near kinematic thresholds.

$$\text{DIS} \longrightarrow \alpha_s^n \log^{2n-1}(1-x)/(1-x)$$

- Soft and collinear logarithms can be computed to all orders and they *exponentiate* in moment space.
  $\sum_k \alpha_s^k \sum_p^{2k} c_{kp} L^p \rightarrow \exp\left[L g_1(\alpha_s L) + g_2(\alpha_s L) + \alpha_s g_3(\alpha_s L) + \ldots\right]$
- Resummation *extends the range* of perturbation theory
  $\alpha_s L^2 \ll 1 \longleftrightarrow \alpha_s \ll 1$
- Resummation reaches beyond perturbation theory
  finite order $\longrightarrow$ resummation $\longrightarrow$ power corrections



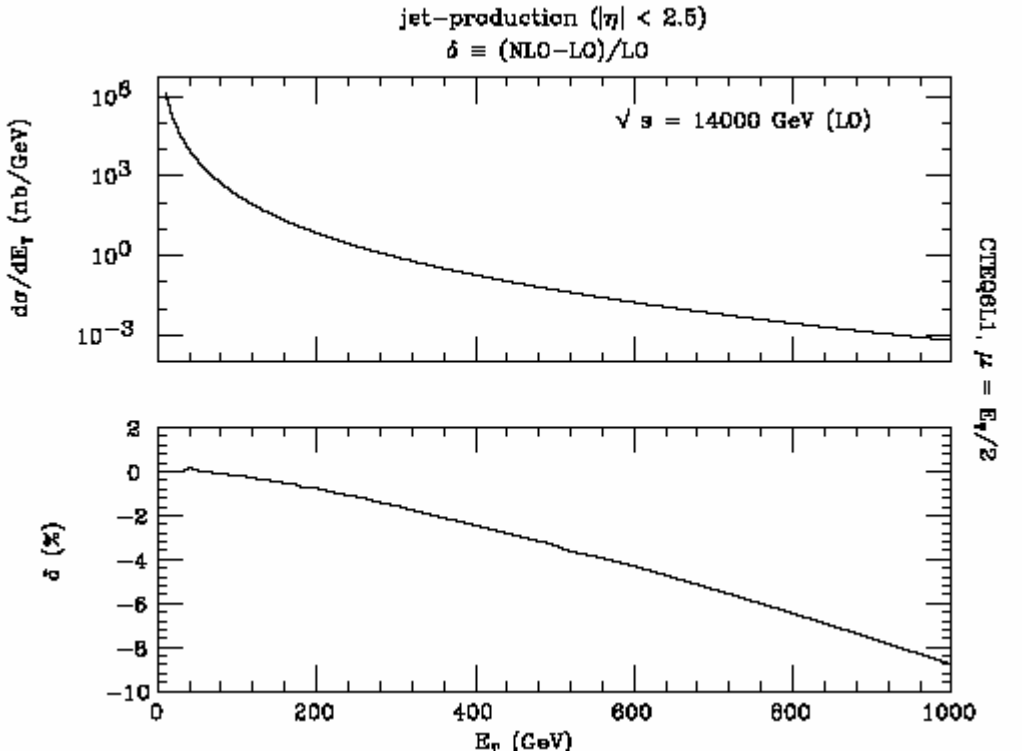


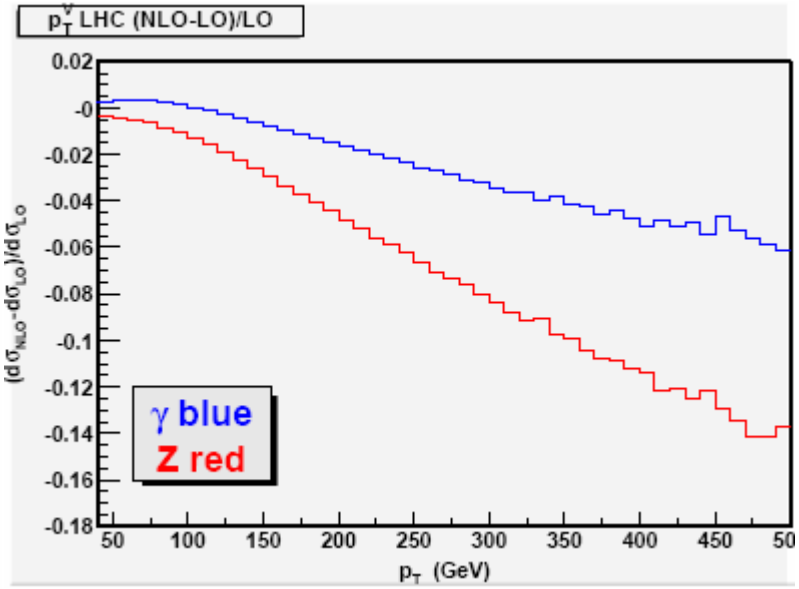
A fully consistent *global resummed fit* is not yet possible
but realistically *achievable*

Workshop goal (Lorenzo, Gennaro, Fred, Samir): **look at the impact of resummation in the high-x quark distributions on some real cross section.**

1) Fred to provide resummed `fit' (maybe using ad interim K-factor/powers)
2) Lorenzo & Gennaro to assess systematics in `NLO PDFs + NLO cross section', `resummed PDFs + NLO cross section' and `resummed + resummed'
3) Samir keen to investigate Drell-Yan production at high-mass

EW corrections to TeV scale hadronic observables: large weak log^2(s/M^2)

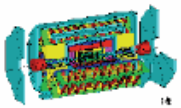




* Philosophy so far: compute only virtual part, assume real W/Z radiation resolvable
* Naïve assumption may need to be rectified, to include real (positive) effects:

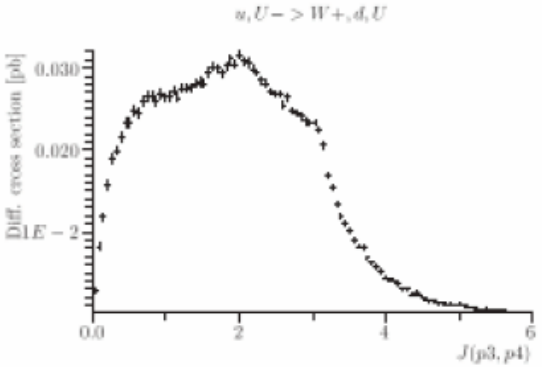
1) Some (negligible) amount of events with W/Z decay products outside detector
2) Data samples may contain W/Z decayed inside jet

Action: Joey generated CompHEP events with branching q->qV to study DeltaR

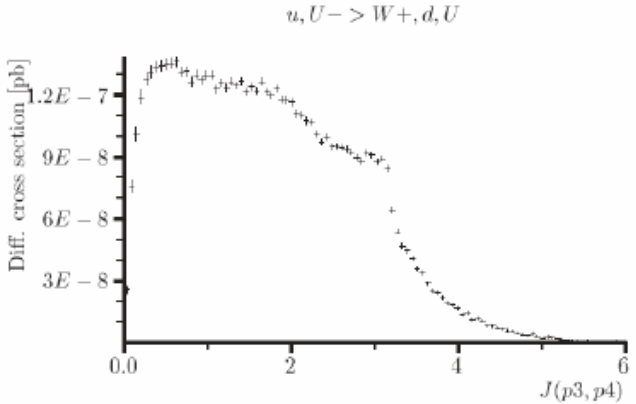


W emission off of quark line

400 GeV at the Tevatron



3 TeV at the LHC



and to run such events through PYTHIA looking at W's and Z's embedded in high pT jets, finally run them through CDF event simulation to see how well these W/Z could be picked out at detector level. Also investigate pT>350 GeV jet data sample directly.

Samir to do similarly for ATLAS (MC events), including di-lepton events

Watch this space …

Precision SM Shapes

Assessing the state of the art for Z & h spectra at hadron colliders

Gieseke, Melnikov, Mrenna, Nadolsky, Skands, Moretti,
Magnea, Balazs, Ferrag, Bartalini, Zametti, Kauer, Krasny

- NNLO fully diff results available for h, NLO for Z+jet. NN(N?)LL also available.
- But tools are either:
  - LO + (real) NLO + parton showers (Herwig, Pythia)
  - NLO + parton showers (MC@NLO)
  - LO + (real) NNNN...LO + parton showers (Sherpa, Patriot, Ariadne)
- Need to assess tools: what to use where, how good are they?
- Shapes & K-factors

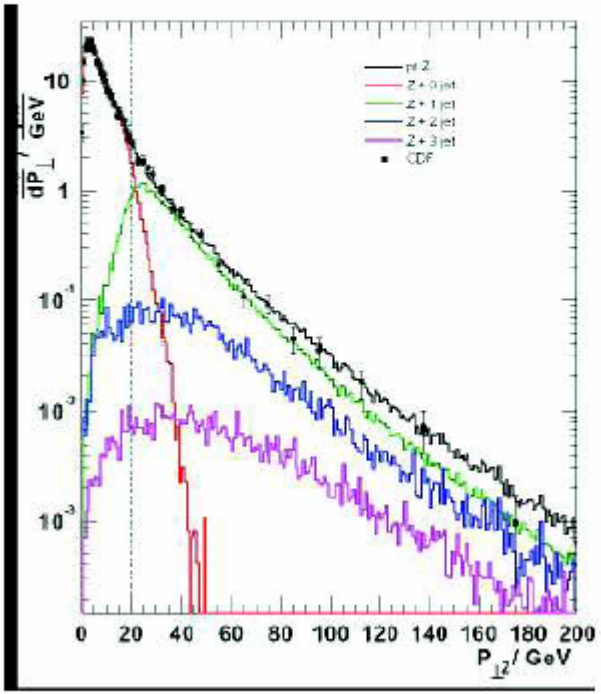
Will Study Z & h + jets production, producing comprehensive comparisons

Need contacts from:
- MC@NLO
- Ariadne
- Sherpa

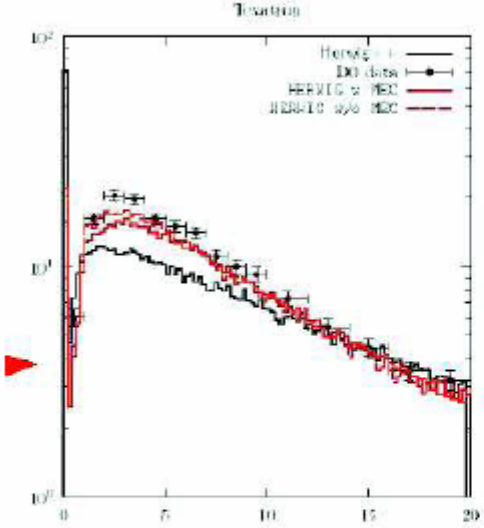
Precision SM Shapes

Assessing the state of the art for Z & h spectra at hadron colliders

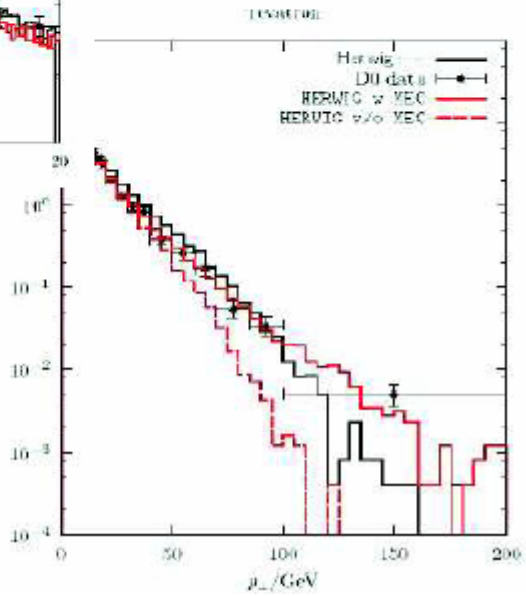
EXAMPLES



DY: Sherpa



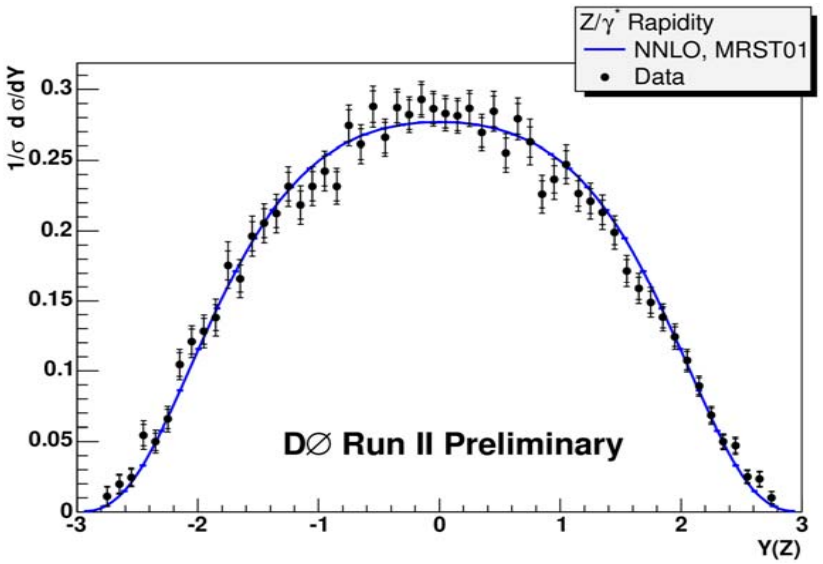
DY: Herwig, Herwig++

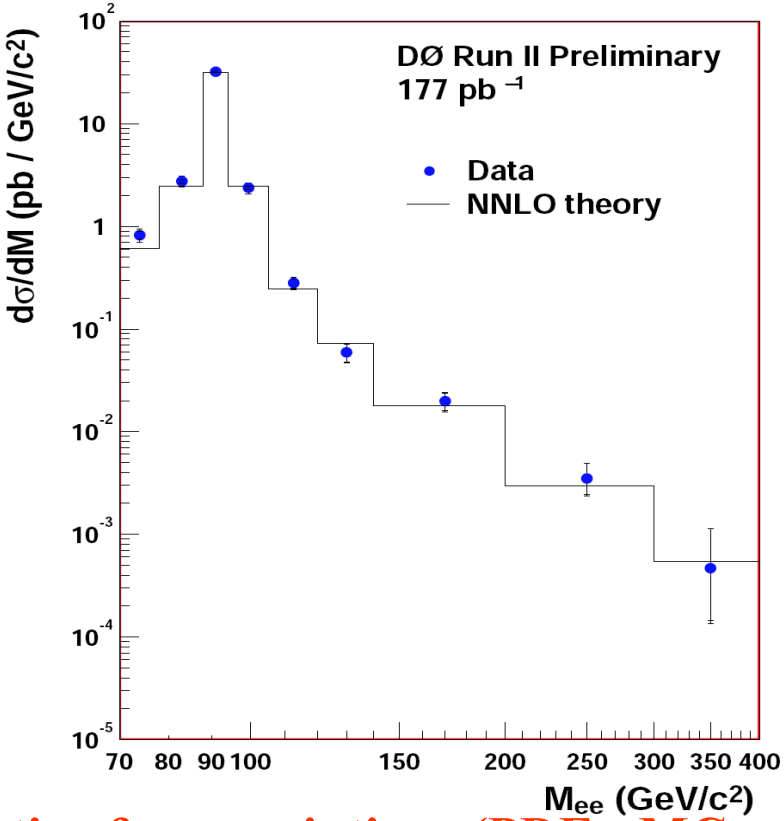


N1 SANITARY APPLIANCES/FITTINGS

AVOID:
Overnight water flushing on an automatic urinal flushing system must be avoided
Taps that can be left running
Taps running at full bore full pressure, if nor required
Taps that require pressure boosting pumps
Inadequate showers that people would retrofit with a power shower (PYTHIA)

CONSIDER:
A good high flow shower so to avoid retrofitting power shower (HERWIG)





Further topics:

1) Better understanding of modelling uncertainties & prescriptions (PDFs, MC based acceptance other than LO vs NLO vs NNLO vs resummed)

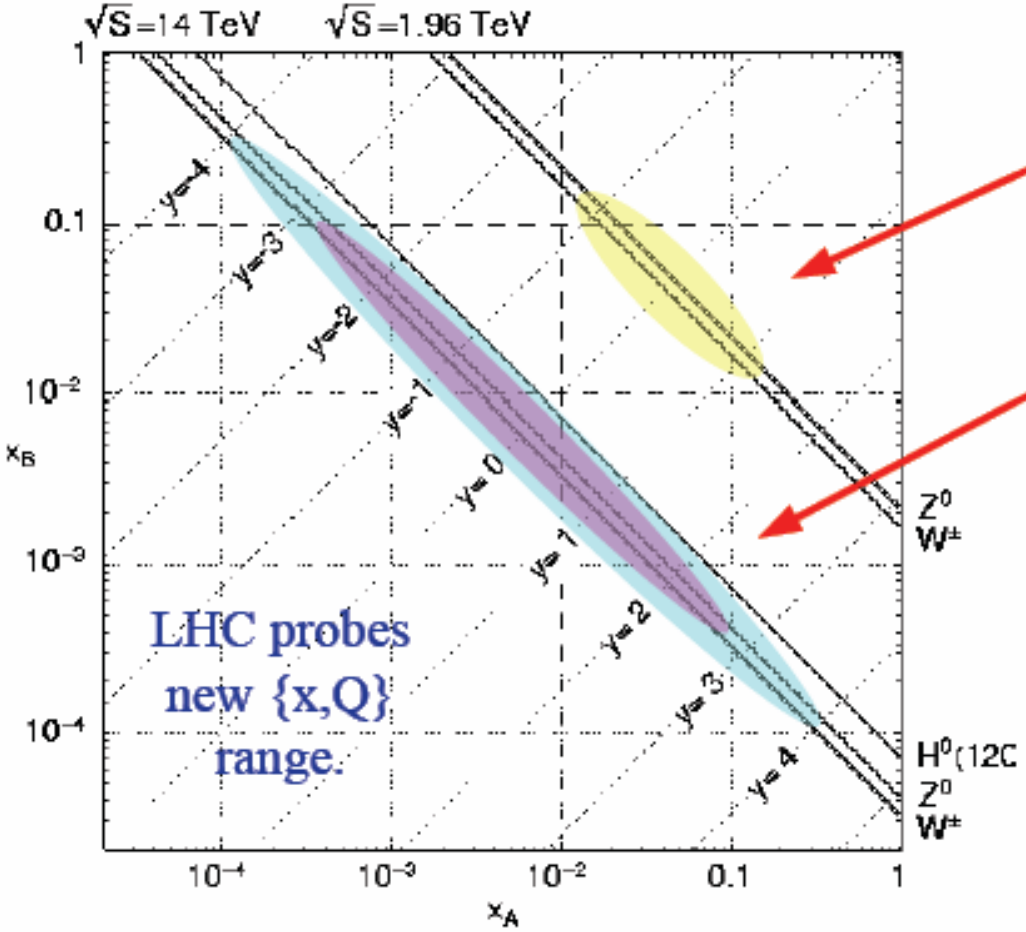
2) Systematic comparison of Tevatron results (ie, data) with state of the art generators and calculations

3) Extend comparison to other spectra, including rapidity and invariant masses (ie, decay products of vector boson)

What is relative uncertainty for W / Z / Higgs Production

Kinematics of boson production

$$\sigma = f(x_A) f(x_B) \hat{\sigma}$$



LHC probes new {x,Q} range.

This is the region of present measurement

This is the region we need at LHC

Requires extrapolation in {x,Q}

New Uncertainties Possible

x range for Tevatron

x range for LHC

HERA observed new effects at small-x

Berge, Nadolsky, Olness, Yuan, hep-ph/0410375.

Uncertainties at small-x can effect W/Z production at LHC

Results in q_T broadening:

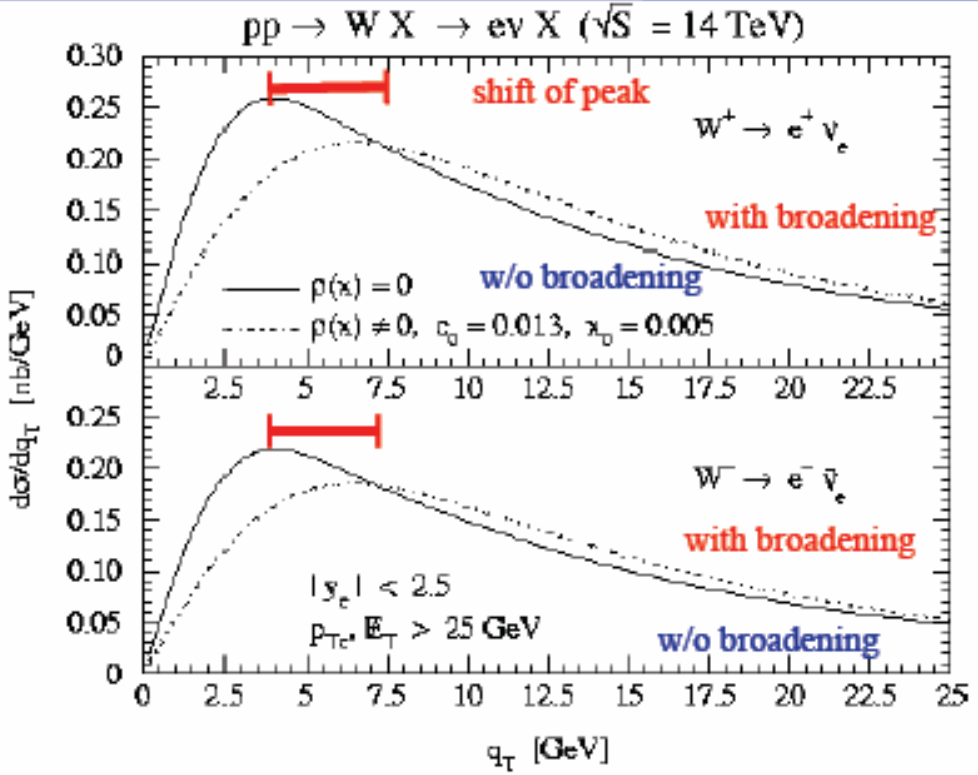
Shift of distribution

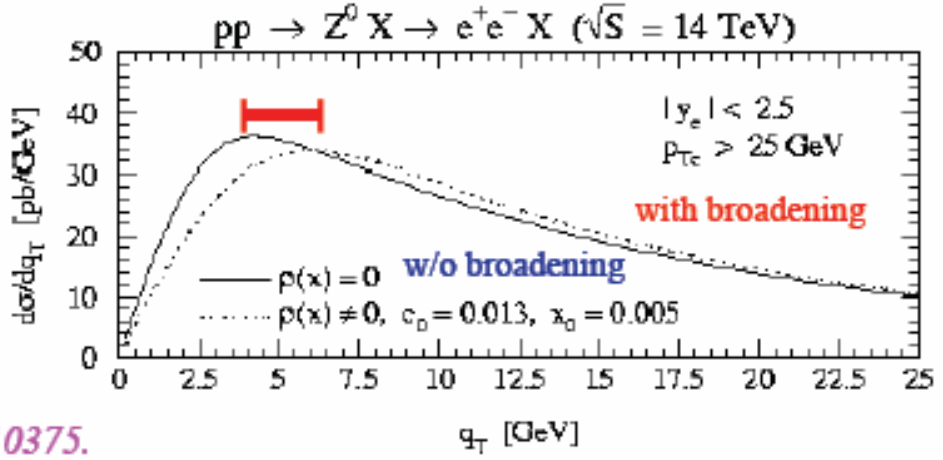
Shift of normalization

This will effect M_W measurement at both Tevatron and LHC

Tevatron can look for this effect by measuring forward W and Z production

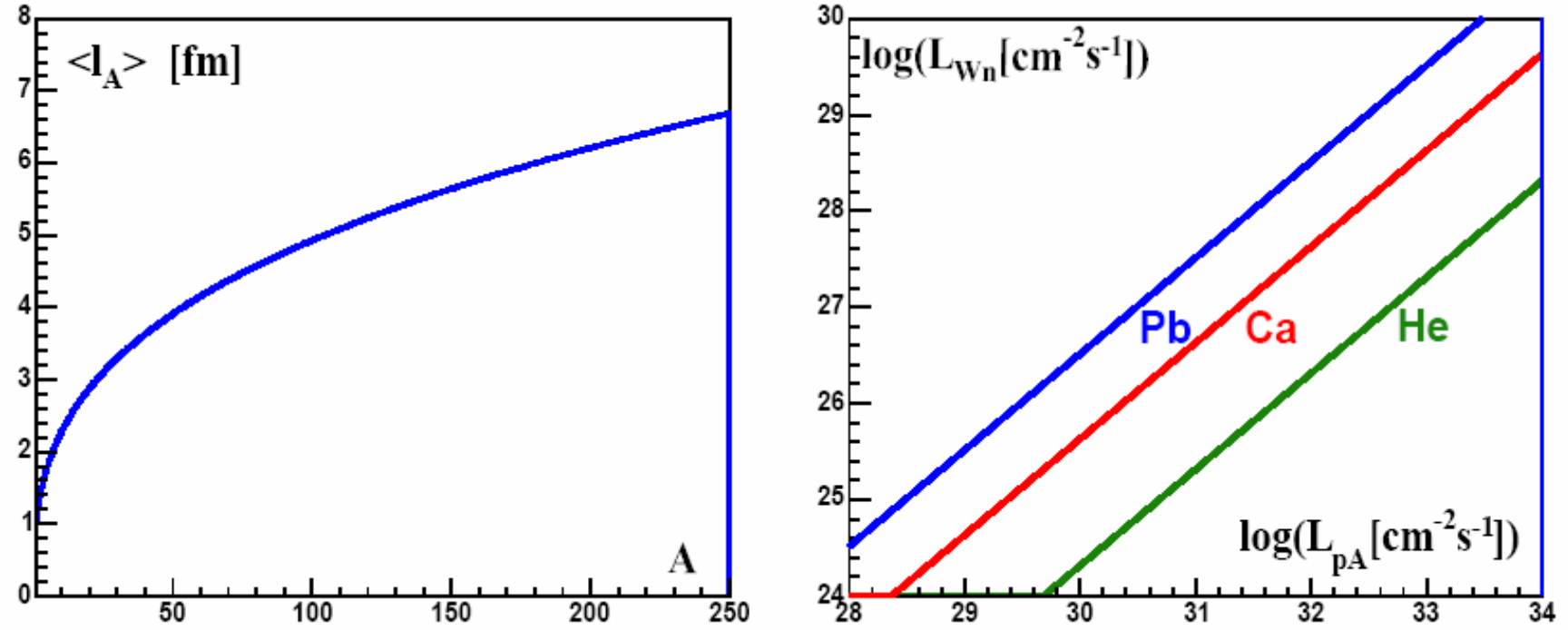
These uncertainties are not acceptable for "benchmark" processes





Berge, Nadolsky, Olness, Yuan, hep-ph/0410375.

For W-bosons produced by the valence quarks of the nucleus *the average path -length* ***of W boson in nuclear matter and the corresponding*** *W-n luminosity* ***can be directly calculated***



Note: the sample of N events in which the W-boson traveled the total distance $l_A(N) = \sum_{i=1,N} l_A(i)$ is, in the limit of large N, equivalent to the sample of N events in which each produced W-boson traveled the distance $\langle l_A \rangle$

The achievable luminosity of the electron-ion (PIE) collider at the LHC

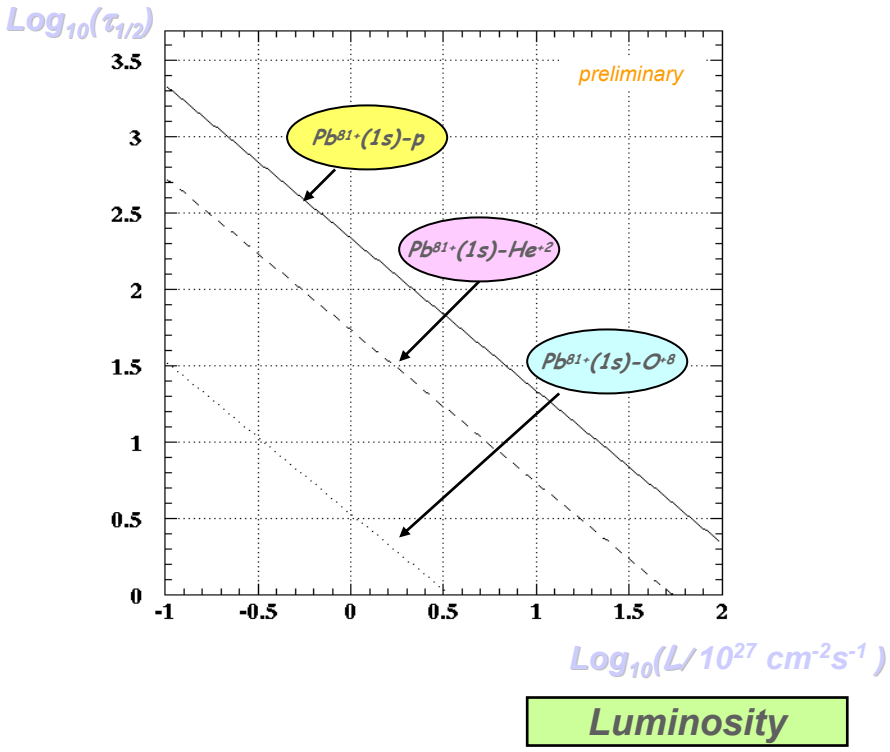
Constraints:

Electrons must be attached to the highest Z ions (e.g. Pb, Au)

The beam of partially stripped ions can collide only with the proton or the fully-stripped light-ion beams

The machine vacuum should not be worse than predicted for the IP-s (Rossi, Hillertet, LHC report 674 (2003)

Beam life-time

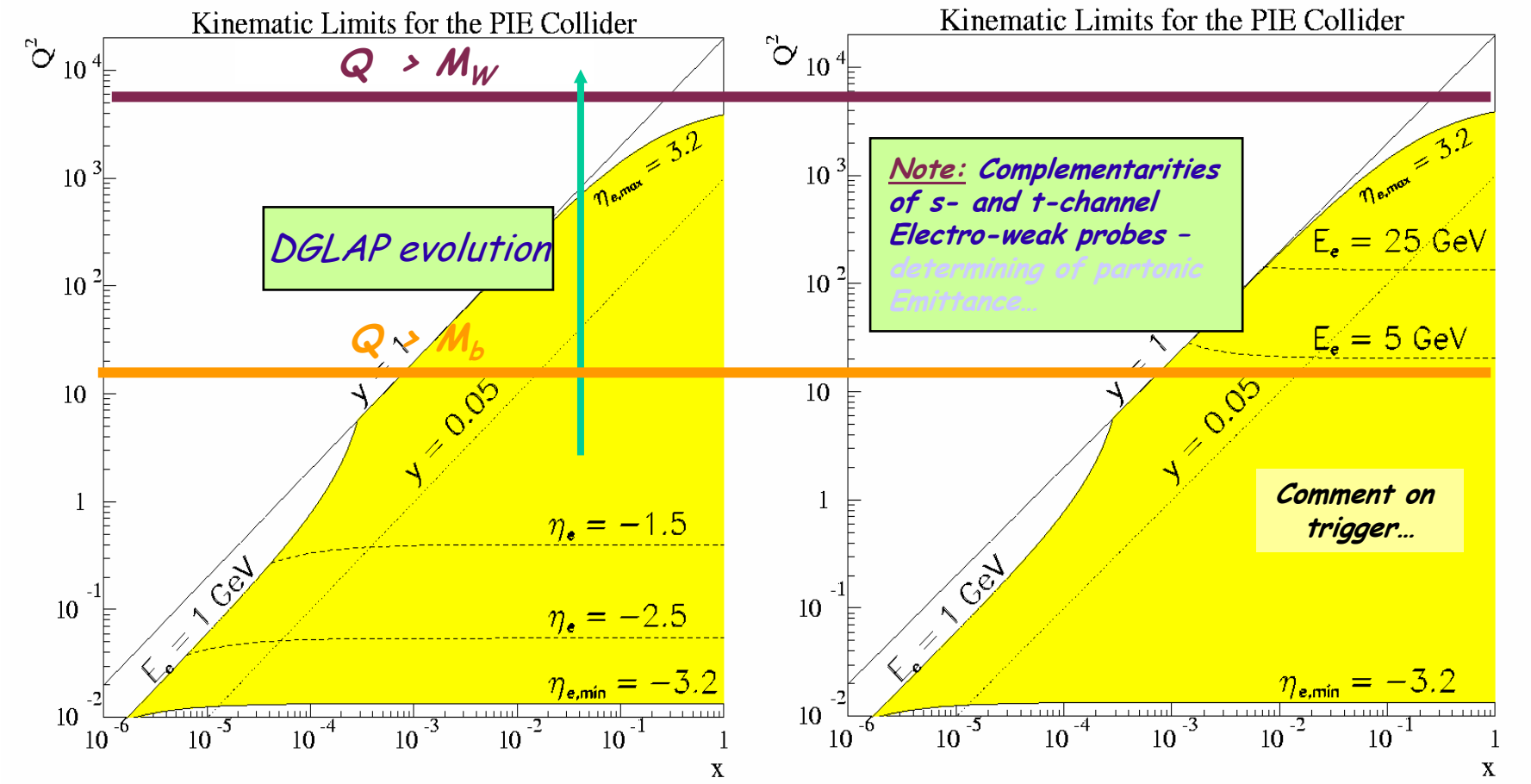


Luminosity

Allowed collision schemes: e.g. $Pb^{81+}(1s)$-p, $Pb^{81+}(1s)$-He^{+2}, $Pb^{81+}(1s)$-O^{+8}

Achievable luminosities: (e.g. for $Pb^{81+}(1s)$-p - **0.4 x 10^{29} $cm^{-2}s^{-1}$**)

Kinematical domain
at the LHC using parasitic electron beam



Note: *The ep luminosity used in the first measurement of the Structure Function F_2 at HERA for ($10<Q2<60$ GeV^2) – could be collected in 6 days of the Pb^{81+}-p collision runs at LHC*

Backup Slides

A case for resummed PDF's

Phenomenology

- Resummation justifies including *more* data in PDF fits.
  $W^2 \sim Q^2(1-x) \longrightarrow$ close to resonance region

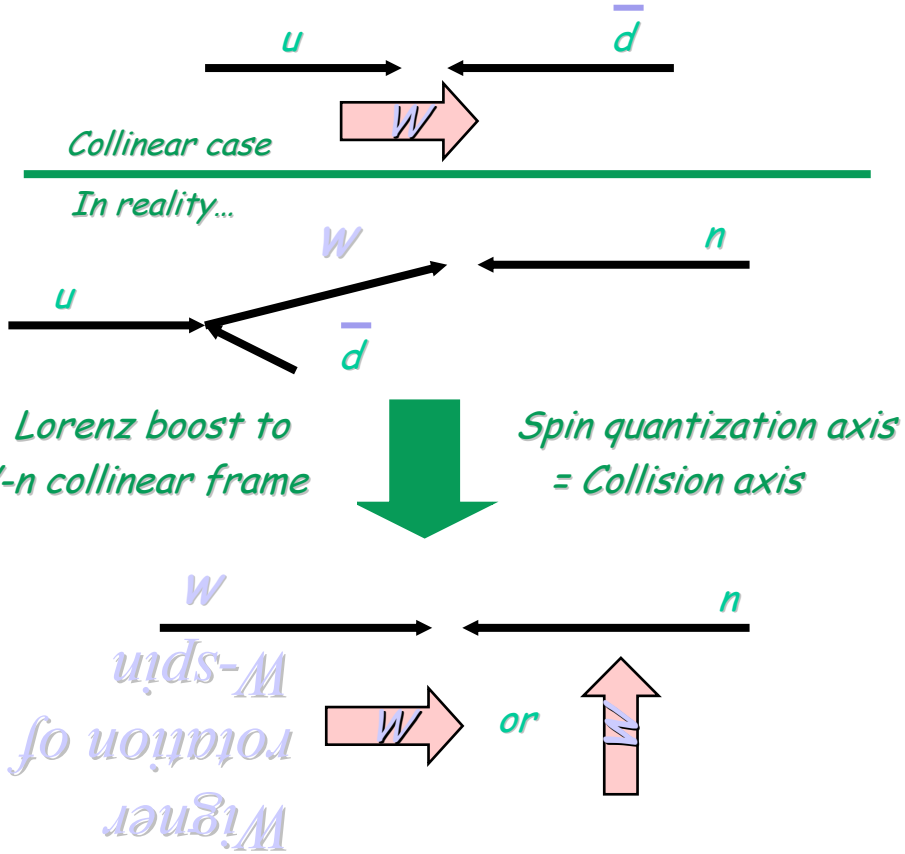
- Large-x quarks influence large-x gluons and smaller-x partons via *sum rules* and *evolution*.
  Q^2 evolution of partons at x_0 determined by partons at $x > x_0$.

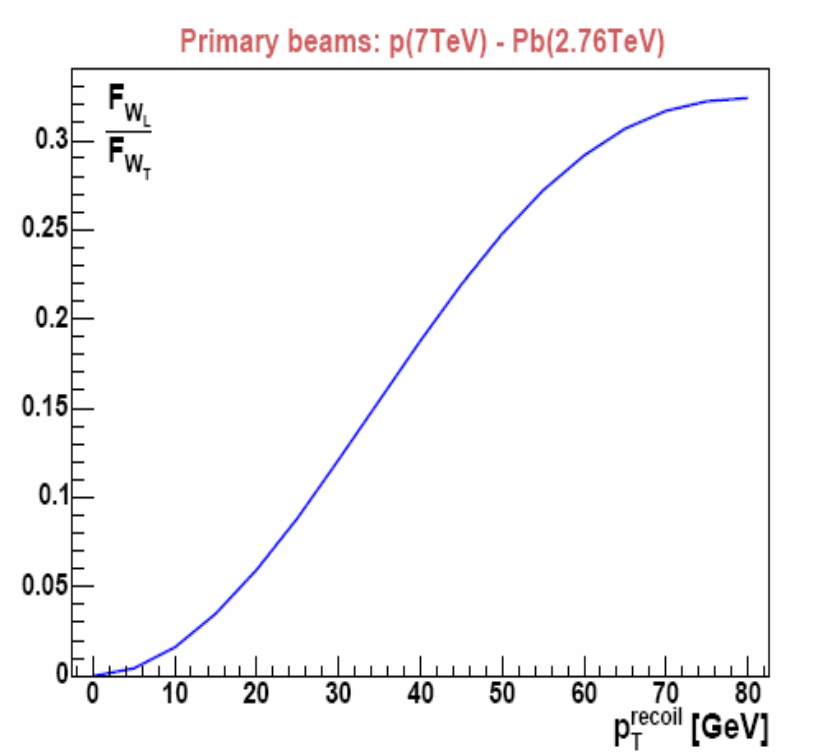
- Light Higgs@LHC (made at small x) should not be *unique* focus: large-x is *new physics* region.

  t-channel exchange of heavy particles?
  High-E_T jets?

Longitudinal polarization of W-beams at the LHC

Longitudinal polarization is driven by the transverse momentum of quarks annihilating into W-boson





… Controlled experimentally by choosing the transverse momentum of the W-recoil …