Vector Bosons, Jets and soft QCD

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St. Dittmaier, Th. Gehrmann, K. Rabbertz, J. Kuehn

LHC-D SM working group summary

FSP 101 ATLAS

Session overview

Session I

title	presenters
Observation and Measurement of Vector Boson Production in ATLAS	GOEBEL, Martin
Measurement of W and Z Boson Production with Muons in CMS	GUETH, Andreas
Cross-section Measurement for Z Production in pp Collisions at ATLAS	WOLLSTADT, Simon
Measurement of Z->mumu gamma cross section with first CMS data at LHC	Mr. HINDRICHS, Otto
Determination of the forward-backward asymmetry in pp --> gamma*/Z+X with ATLAS	KöNIG, Sebastian
Measurement of pp --> Zb(b), Z --> mumu at LHC with CMS	Ms. HERACLEOUS, Nata
Measurement of Vector Boson + Jets Production with ATLAS	BLUMENSCHEIN, Ulla BIERWAGEN, Katharina
Jet Energy Calibration with Z(--> mumu) plus Jet Events in CMS	HAUTH, Thomas
4-Loop anomalous dimensions	Dr. ROGAL, Mikhail

Session II

title	presenters
Jet Production Cross-Section in pp Collisions with ATLAS	RUTHMANN, Nils
Inclusive Jet pT Cross Section with CMS	STOBER, Fred
Alpha_s determination via the differential 2-jet rate with ATLAS	Mr. LICHTNECKER, Markus
The automisation of the POWHEG method and its consistent combination with CKKW matching in Sherpa	SCHOENHERR, Marek
The Quark and Gluon Form Factor to Three Loops in Massless QCD	Dr. HUBER, Tobias
Tuning of MinBias and the Underlying Event with ATLAS	Dr. WARSINSKY, Markus
Measurement of J/Psi --> mumu and Y(1S) --> mumu cross sections with first CMS data	BERANEK, Sarah
Study of the Underlying Event at ATLAS	SCHMITT, Christopher
Effects of Multi-Parton-Interactions and Pile-up	SCHNEIDER, Markus

17 Talks

8 Atlas
6 CMS
3 Theory

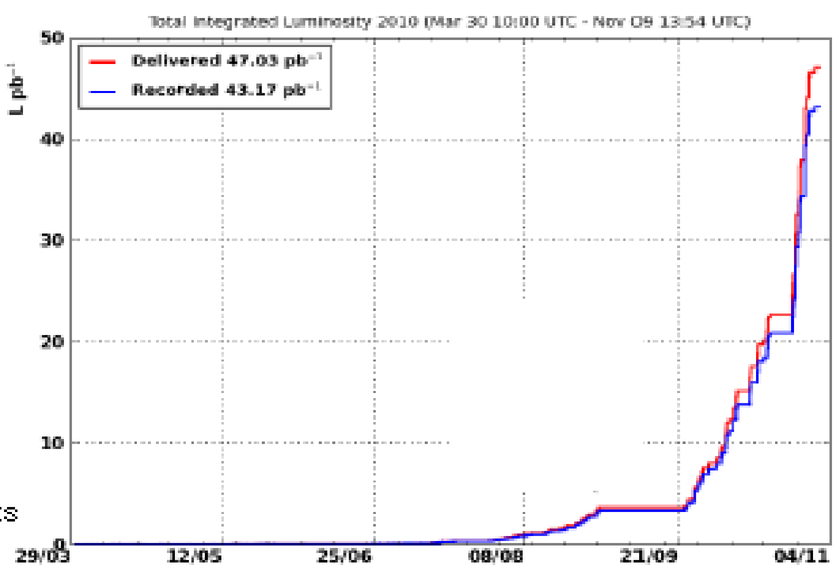
CERN parking

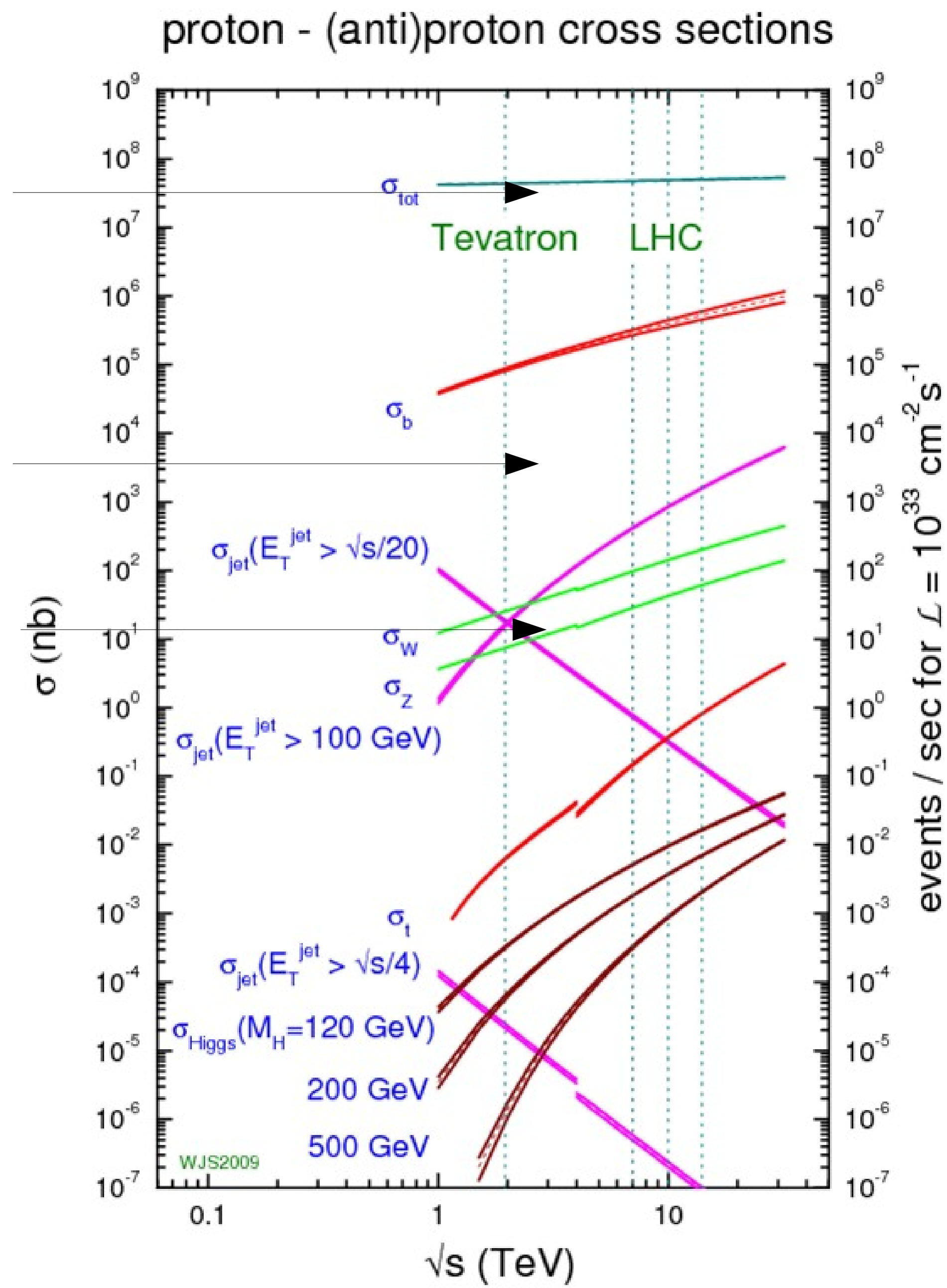
A lot of experimental talks using this year data set; some of them that new, that not everything could be shown.

Intro

Experimental talks concentrate on 3 Topics:

- Soft QCD (MinBias, UE, MPI)
- Jet Physics
- Vector Bosons (W/Z)

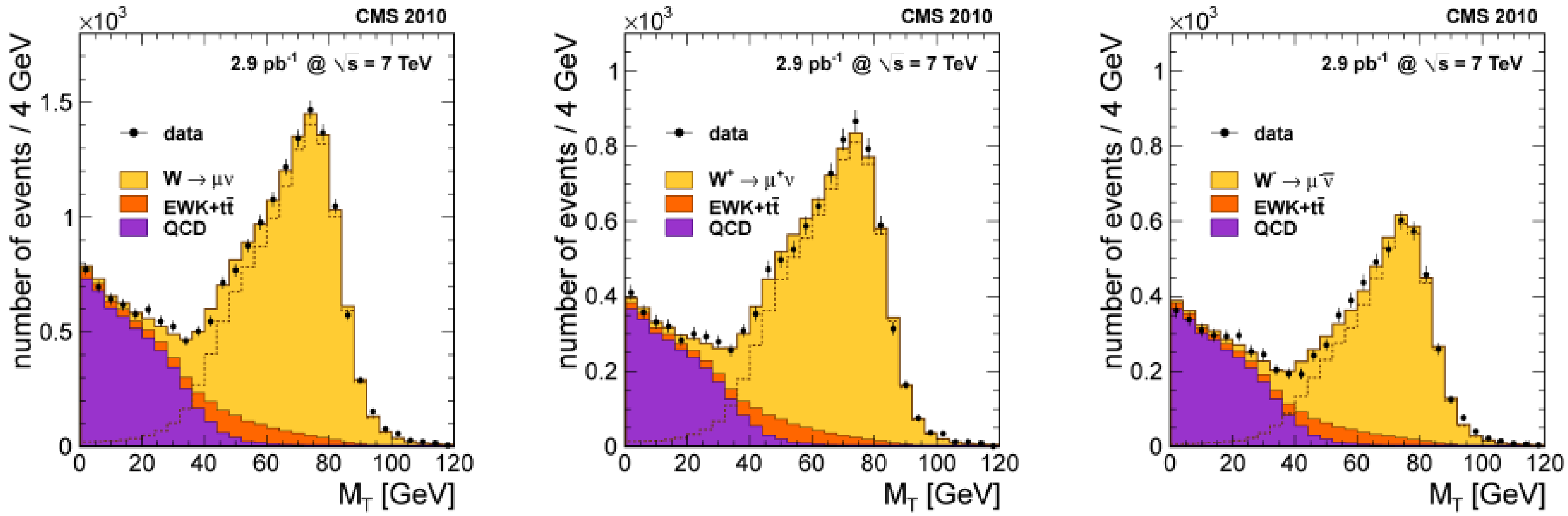




Vector Bosons (W/Z)

Andreas Güth

Asymmetric production of W^+/W^-: $\frac{\sigma(W^+)}{\sigma(W^-)} = 1.433 \pm 0.026(\text{stat.}) \pm 0.054(\text{syst.})$.



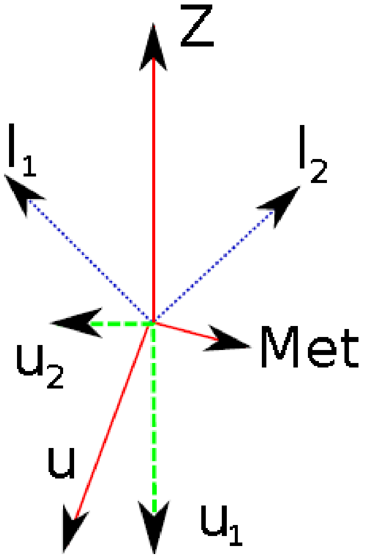
- Cross sections from fits to M_T with an EWK template (MC, corrected), scaling with N_W, and the QCD template (data), scaling with N_{QCD}.
- Recoil modeling used to improve signal MC shape (see below).

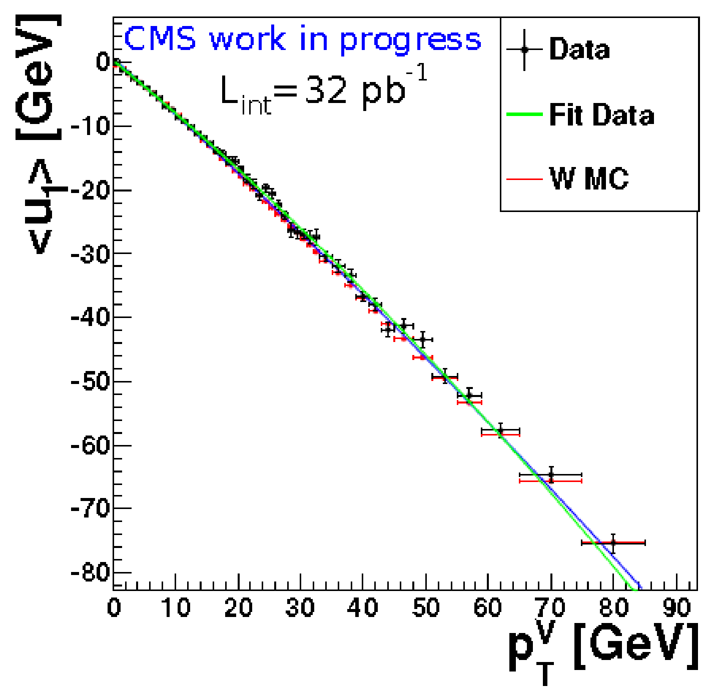
$W \rightarrow \mu\nu$ Cross Section Result FEWZ: 10.44 ± 0.52 nb (FEWZ)

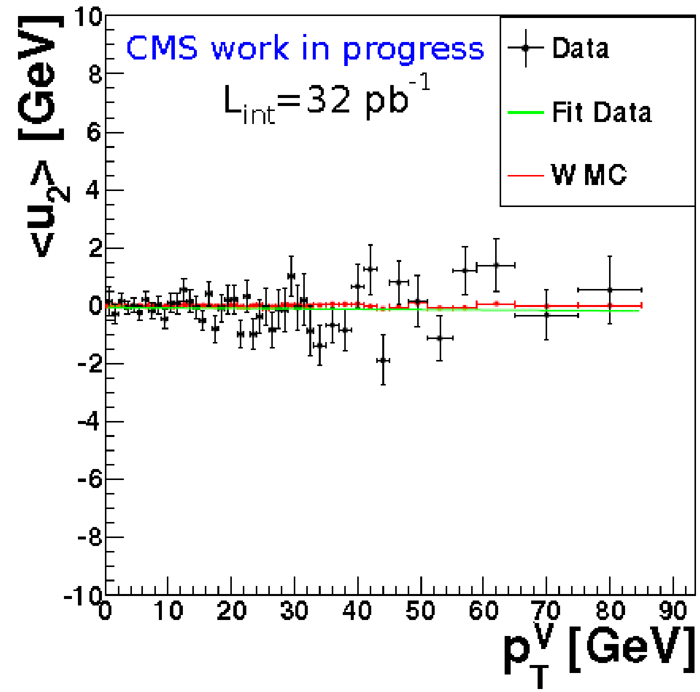
$\sigma_W \cdot \text{BR}(W \rightarrow \mu\nu) = 9.922 \pm 0.090(\text{stat.}) \pm 0.307(\text{syst.}) \pm 1.091(\text{lumi.})$ nb

Hardronic Recoil modeling

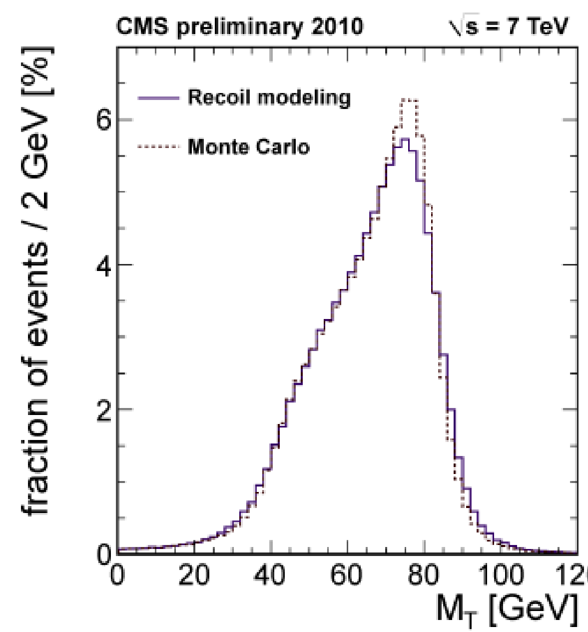
Andreas Güth







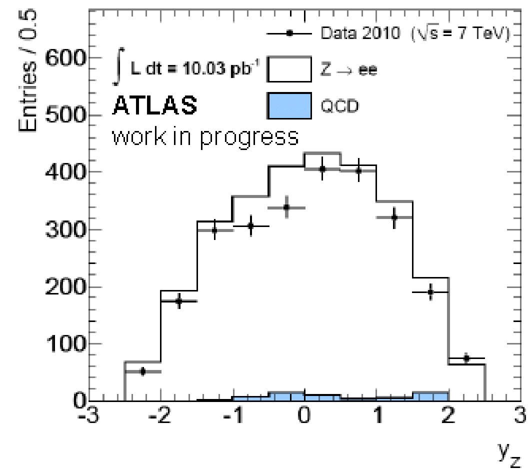
- Data driven methode to improve recoil modelling in W events
- Use Z events and measure recoil parallel and perpedicular of Z
- Effect on X section small (0.4% but better modelling of M_T)

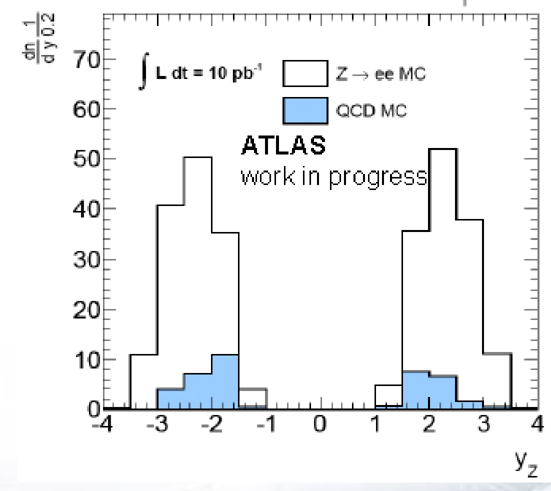


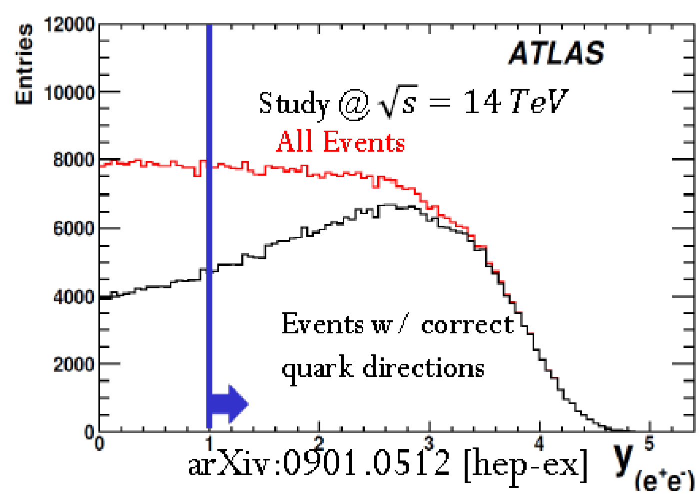
Forw. Elec. for Xsection/A_{fb} Zee(Atlas)

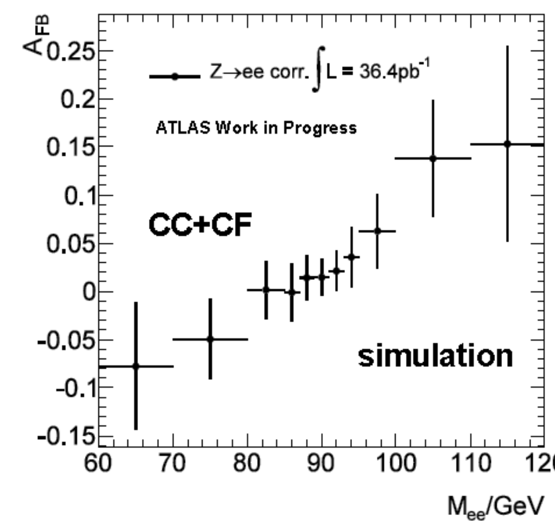
Simon Wollstadt Sebastian König

- Forwards electronen good to increase rapidity acceptace for Z bosons
- For Cross section measurement:
  - bigger acceptance
  - PDF sensitifity
- Essentiell for forward backward assymetry:
  - Big chance to get the correct direction of the quark (quark should have bigger X as anti quark)



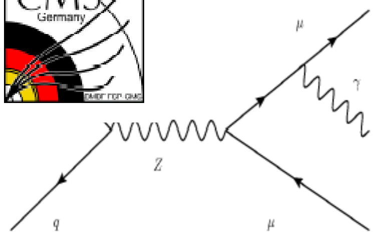




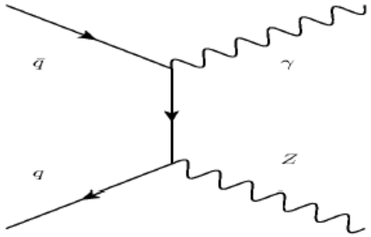


Z(mmg)

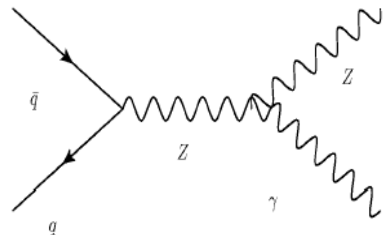
O. Hindrichs (RWTH 1B)



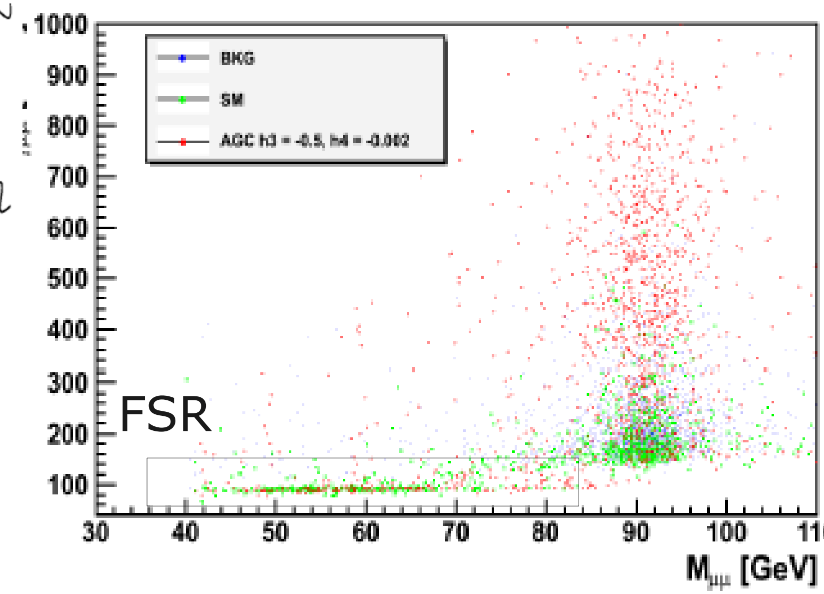
SM see last part



SM



Not allowed in SM



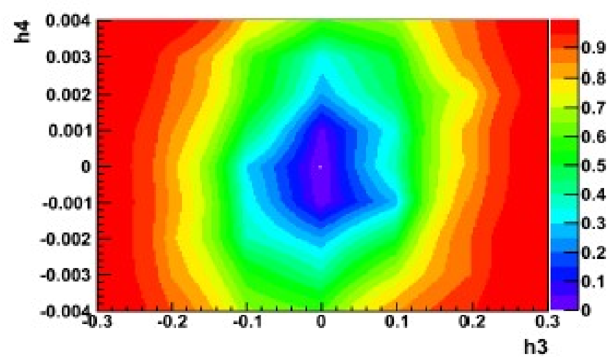
- Measurement of two muon plus photon final state:
  - FSR: low $M_{\mu\mu}$
  - $M_{\mu\mu\gamma} \sim M_Z$

$\sigma_{FSR} = 9.9 \pm 0.6(stat.) \pm 0.4(eff.) \pm 1.0(lumi.)$ pb

No official CMS result.

Monte-Carlo prediction: 10 pb

  - Anourmalous couplings produce additional events with high



Results are very preliminary

Limits form CDF(95 % CL):

-0.083 $< h_3 <$ 0.083

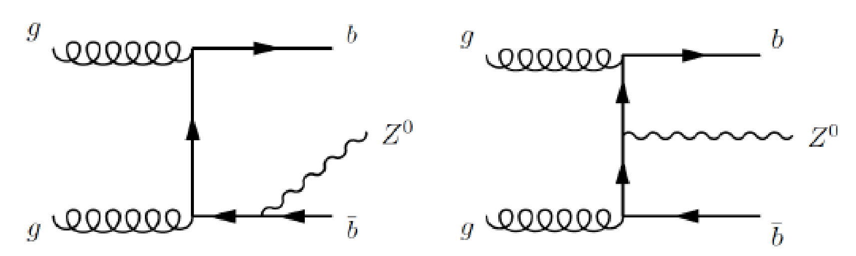
-0.0047 $< h_4 <$ 0.0047

No official CMS results.

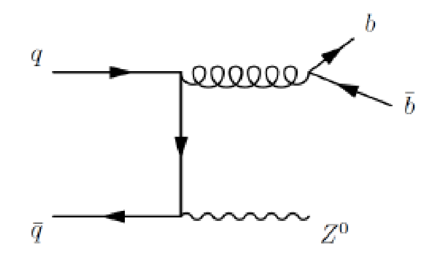
Zbb

Natalie Heracleous,

$gg \to Z^0 b\bar{b}$



$q\bar{q} \to Z^0 b\bar{b}$

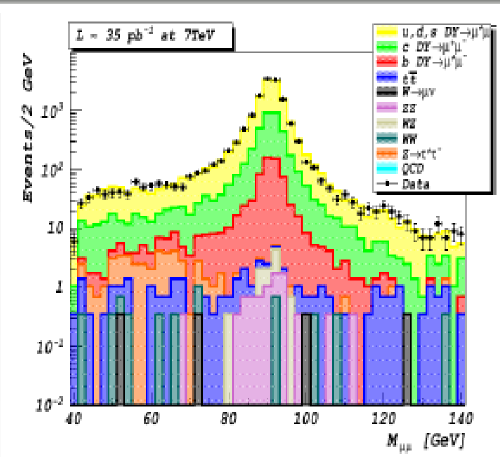


Candidates

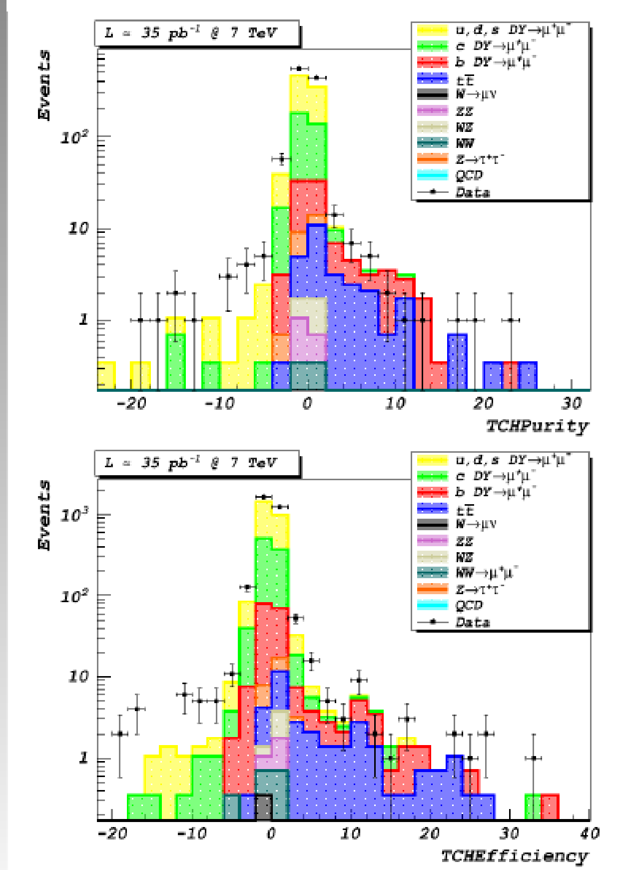
- $Z^0 \to \mu^+\mu^-$:
  Mass window:
  60 GeV< $M_{\mu\mu}$ <120 GeV

  Observed: 14315 ± 120,
  MC: 14017 ± 118

Invariant Mass



TCHP & TCHE



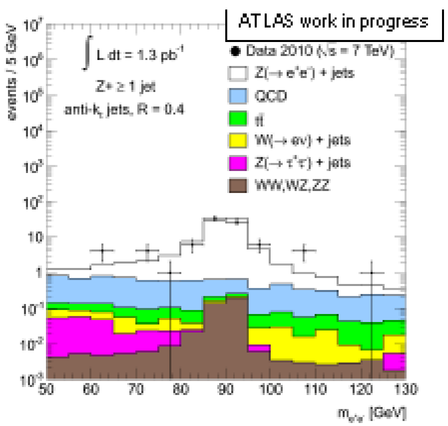
Analysis using 35 pb^{-1} data

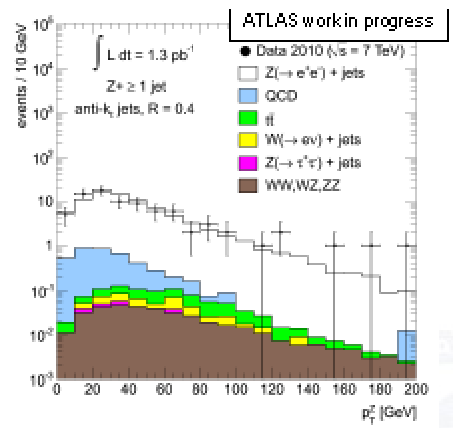
Result shortly for finalization

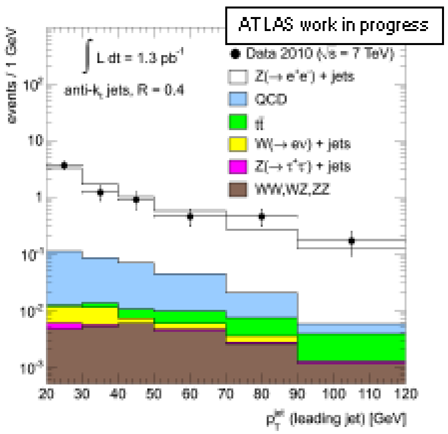
Z+jet

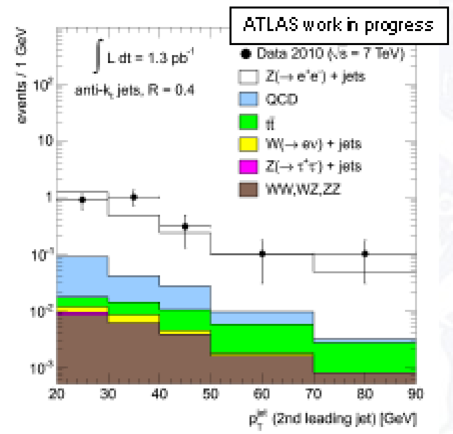
K. Bierwagen

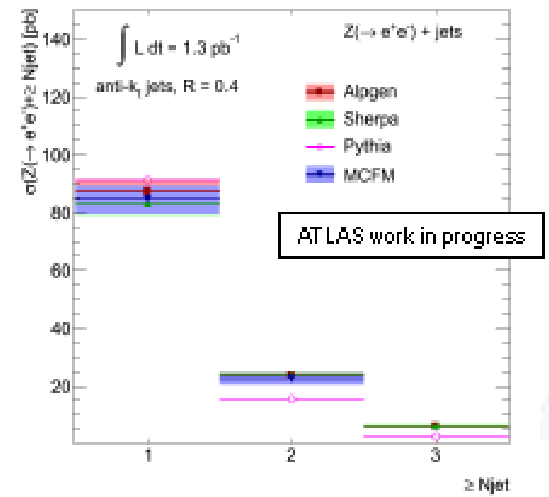
Detector level → Particle jet level

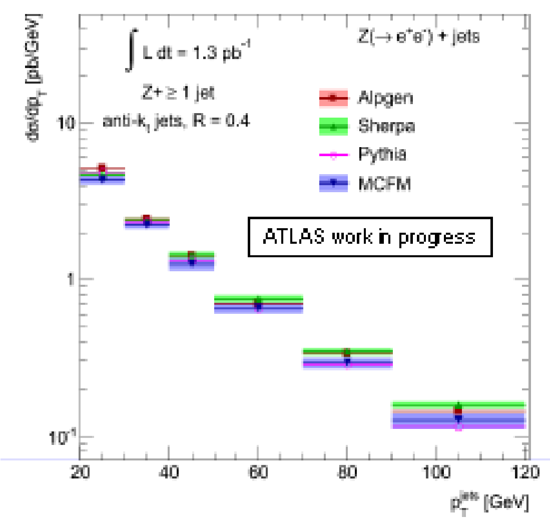






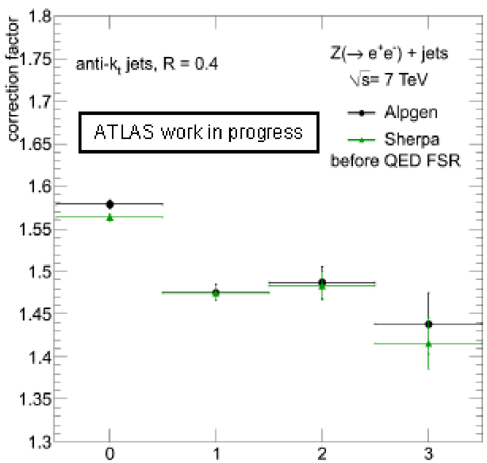


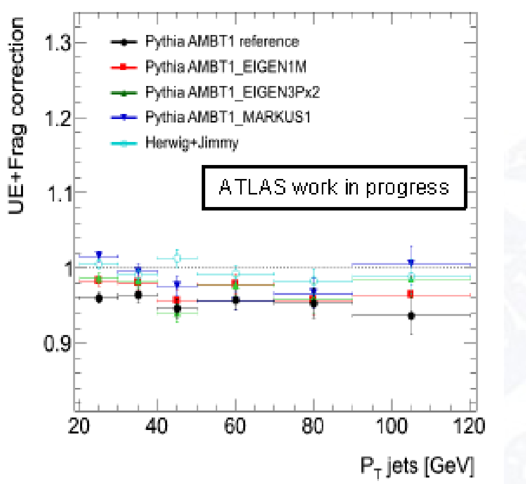




Z+jet unfolding

K. Bierwagen





Uncertanties

Statistics

JES, JER,
lepton reco & ID + triger

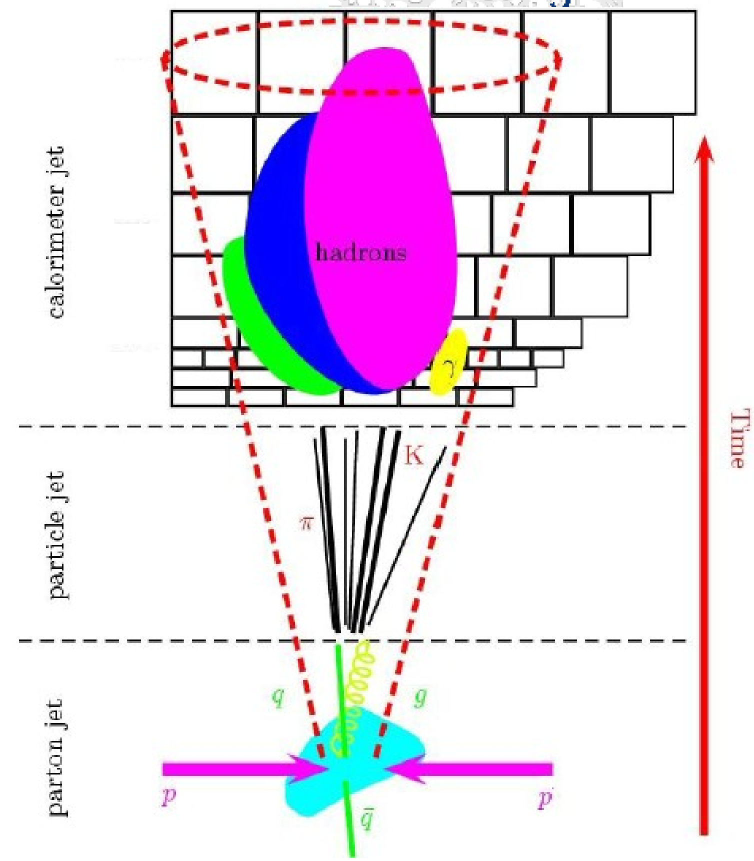
Non-perturbative effects
(UE, fragmentation)

PDF, α_s

Detector level (data)

Hadron level

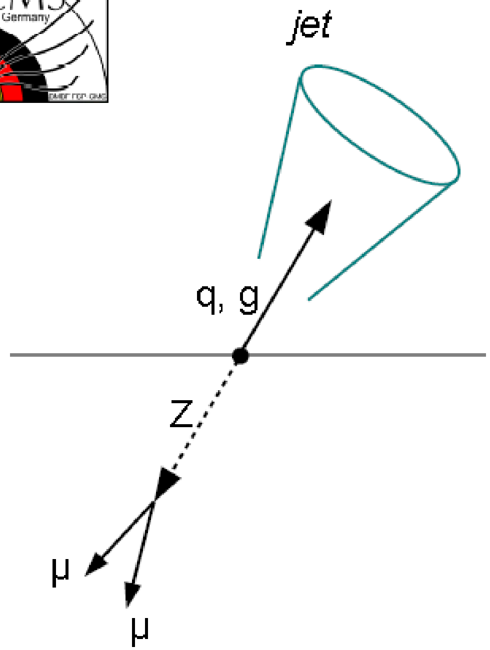
Parton level (MCFM)



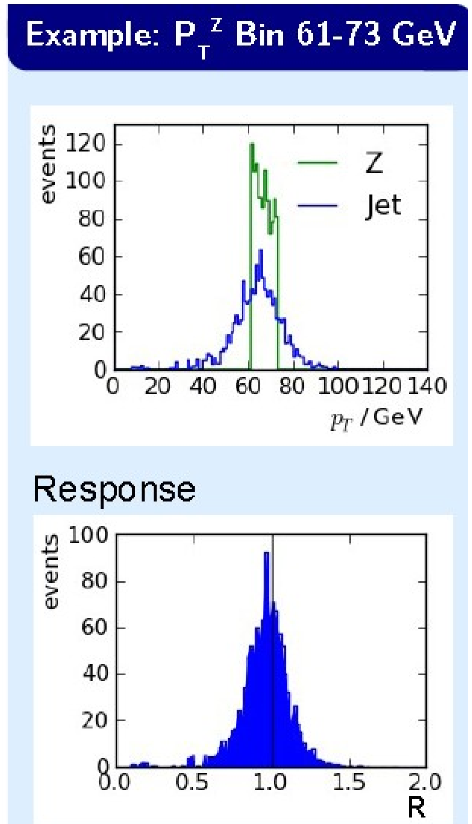
Results will be fully corrected to particle state as well as theoretical prediction for comparison

First results: bin-to-bin, bayesian method in preparation

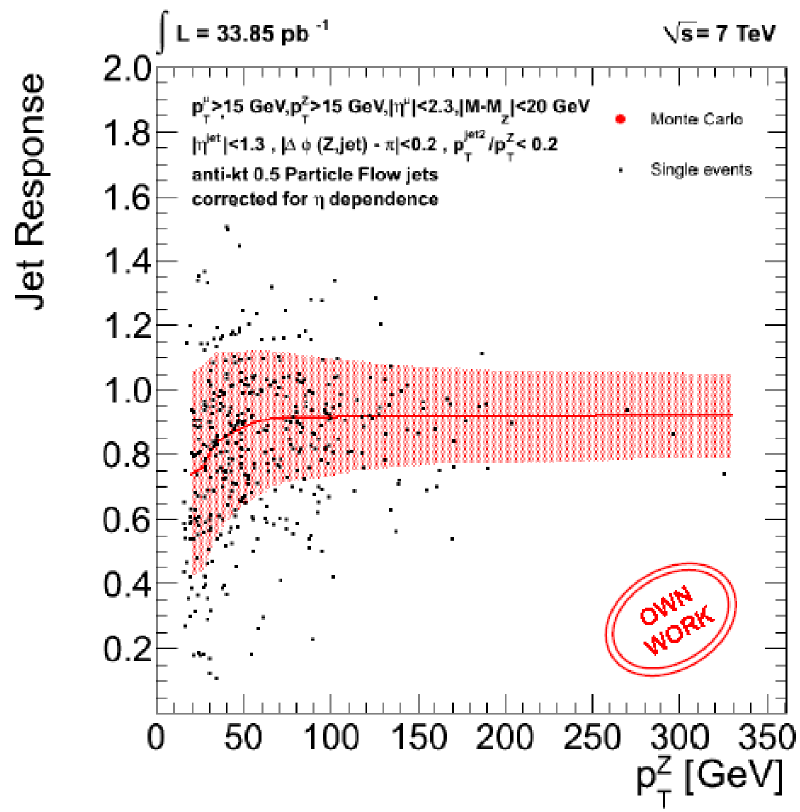
Z for jet response correction



$$R_P = \frac{p_T^{jet}}{p_T^{part}} \sim R = \frac{p_T^{jet}}{p_T^{Z}}$$



Thomas Hauth

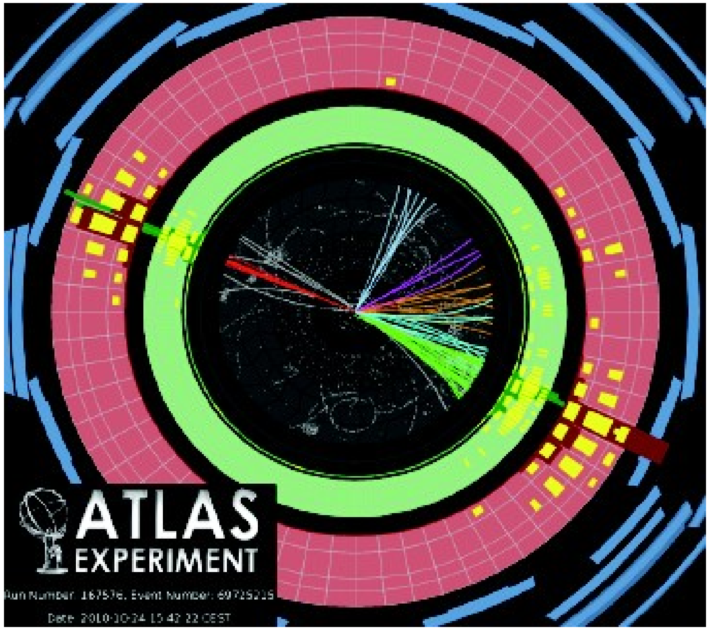


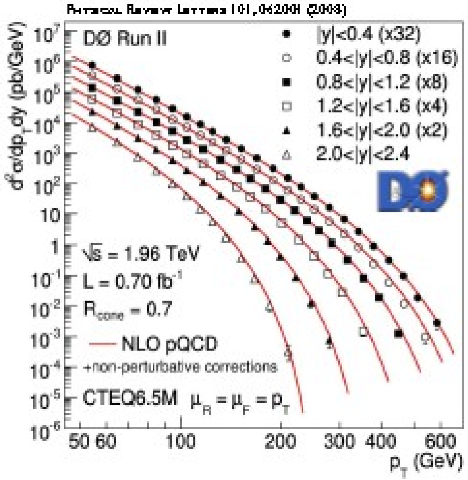
Methode to get the absolut calibration of the jet energy scale

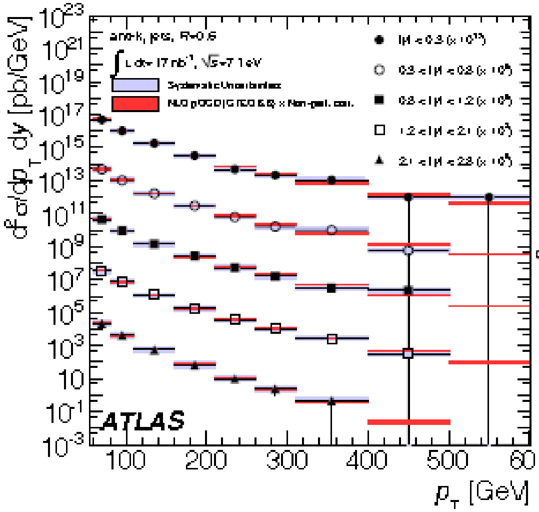
Using $p_t(Z)$ to model the response of the jet

Nils Ruthmann Fred Stober

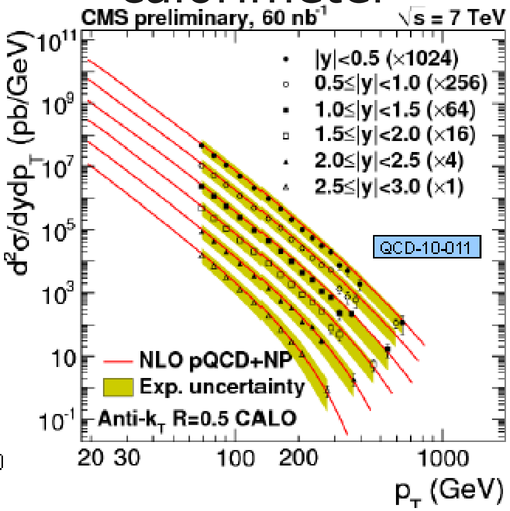
- Huge cross section → early measurement
- Access to
  - A_s
  - PDF
  - New physics



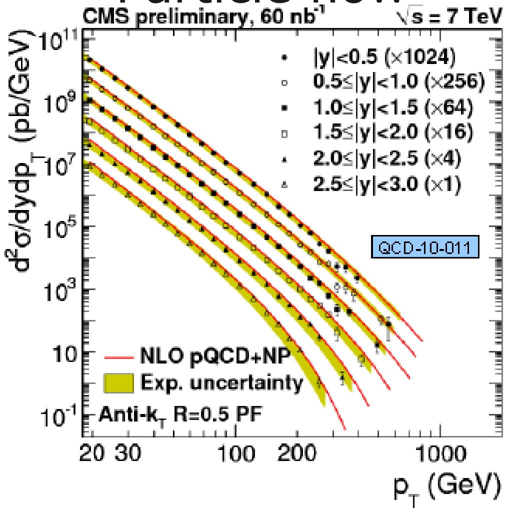




calorimeter



Particle flow

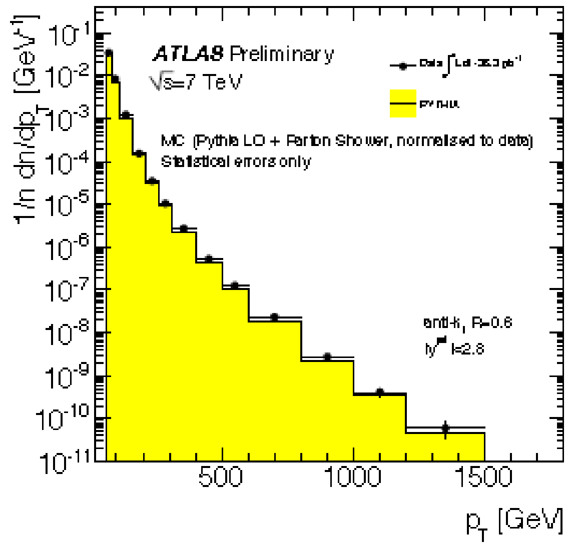


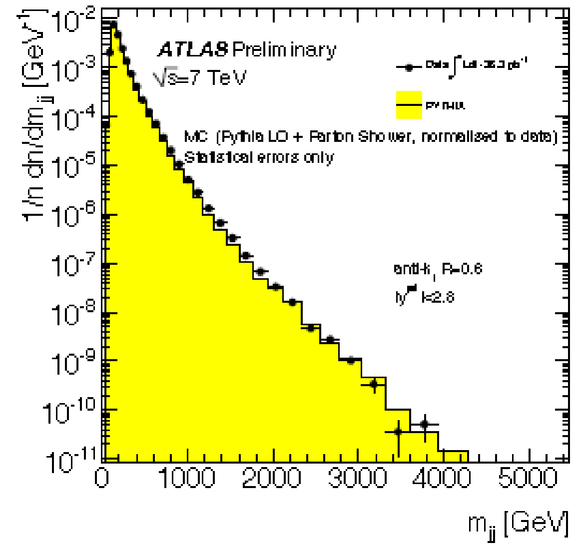
Jets

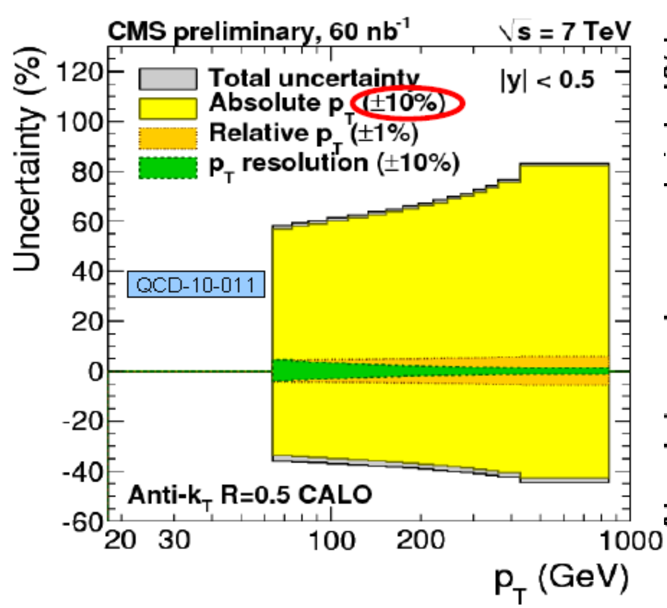
Nils Ruthmann Fred Stober

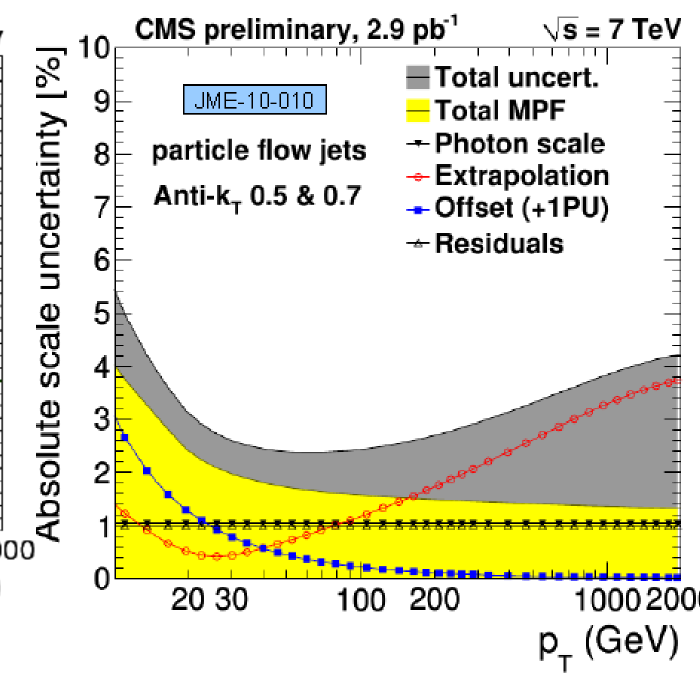
Paper out with $\int \mathcal{L}dt = 17nb^{-1}$, the full 2010 sample contains $\int \mathcal{L}dt = 36pb^{-1}$

- Full 2010 data set should increase range to ~ p_T=1500 GeV
- Dominating error (absolute scale) will get much smaller



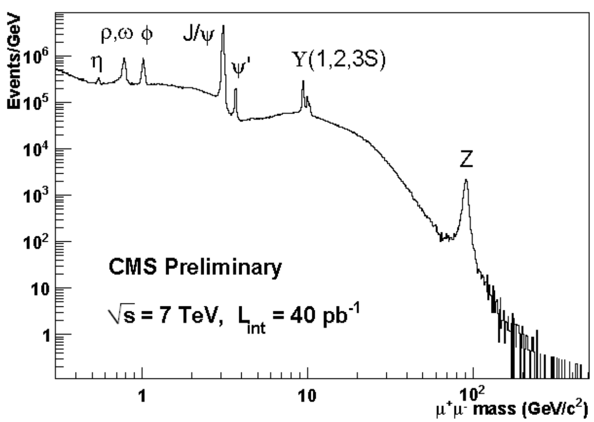


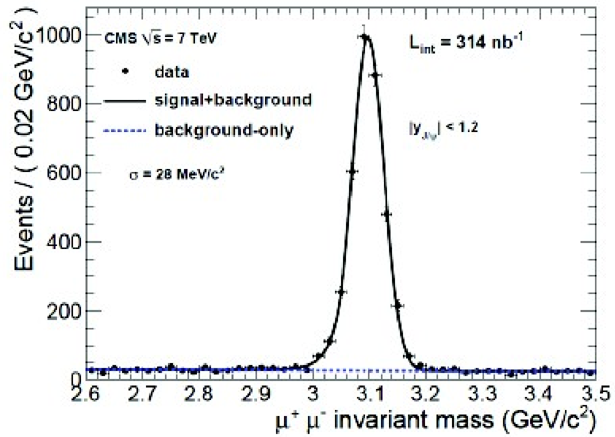


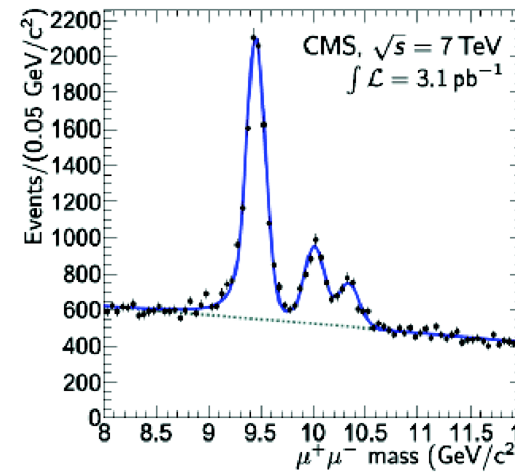


J/Ψ and ϒ

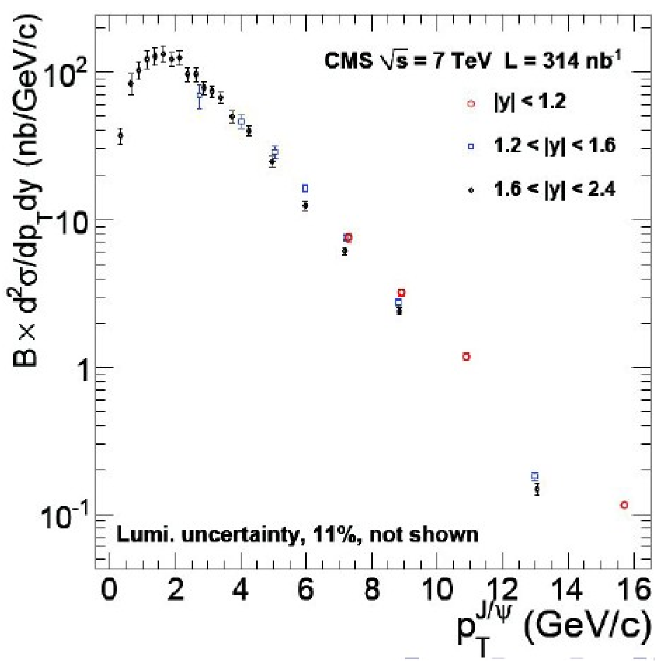
Sarah Beranek

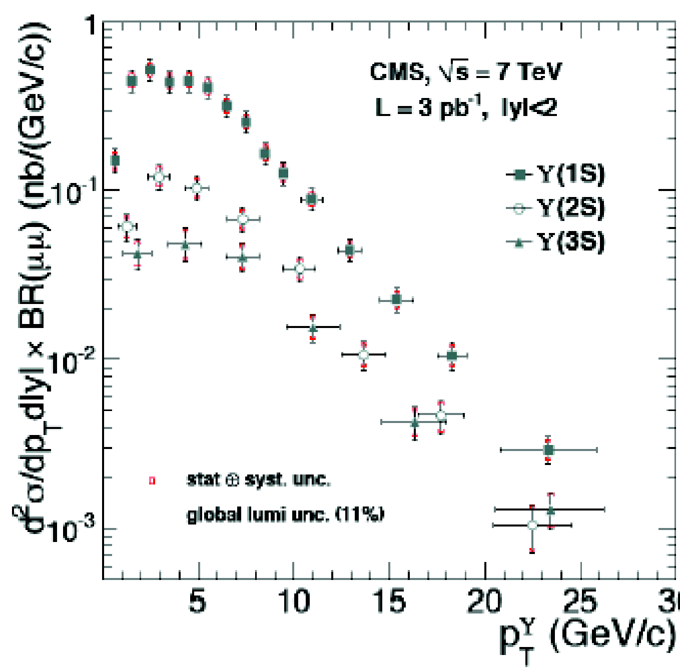






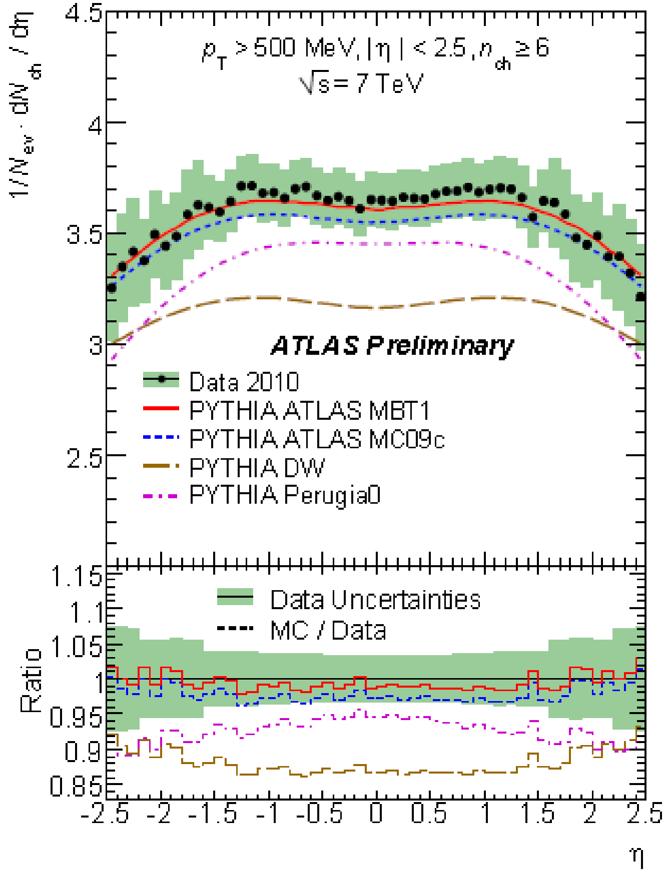
- CMS result on di-muon pairs
  - J/Ψ
  - ϒ
- CMS also sensitive to η

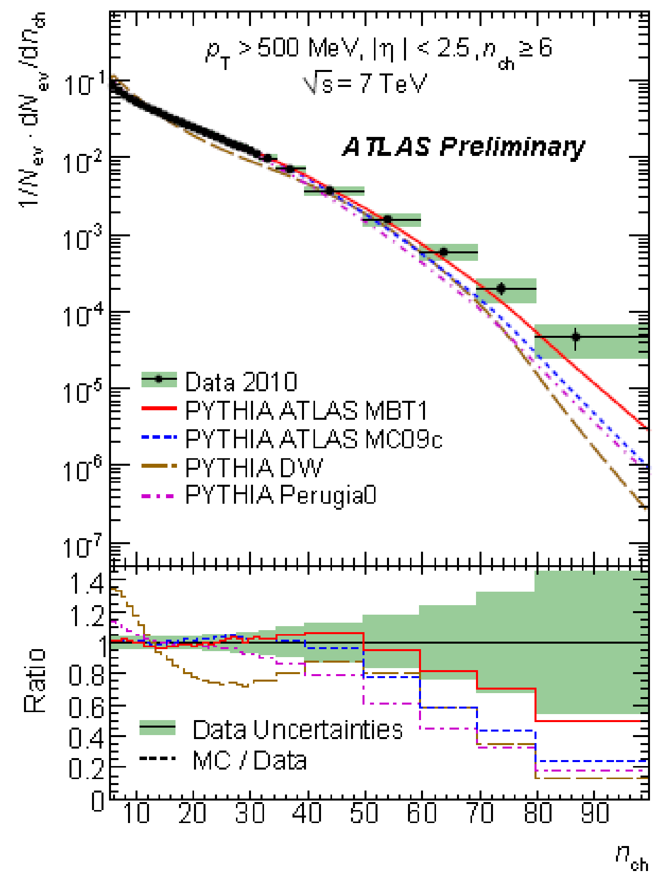




MinBias Tuning

Markus Warsinsky,





- Atlas Minimum Bias data: only corrected for detector effects
- AMBT1: Minimum Bias tune using ATLAS Minimum Bias data with reduce diffractive phase space, CDF and ATLAS UE data
- Tuning done with professor tool, Similar agreement at 900 GeV

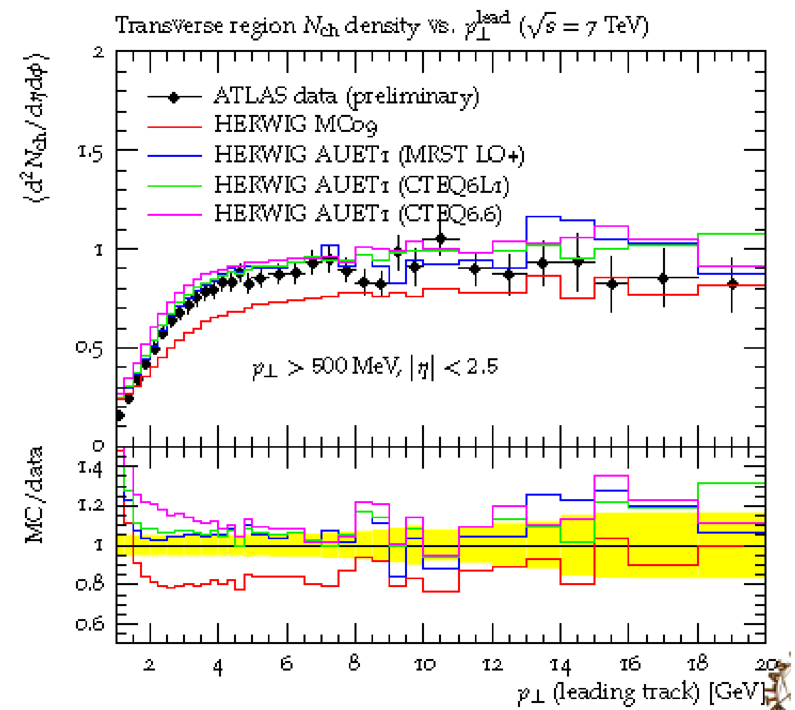
MinBias/UE Tuning

Markus Warsinsky,

Atlas Underlying Event Tune 1 (AUET1)

- family (different PDFs) of tunes of HERWIG/JIMMY to ATLAS UE data
- includes also CDF data, but ATLAS-centric
- improvement of UE description
- more detail in ATL-PHYS-PUB-2010-014

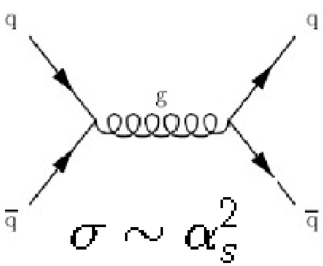
ATLAS UE, N_{ch}/p_T^{sum} density in transverse region, $\sqrt{s} = 7$ TeV

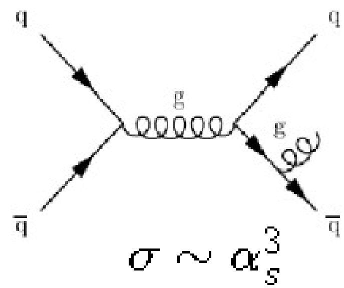


$\Rightarrow$ clear improvement of UE description!

α_s with differential 2 jet rate

Markus Lichtnecker



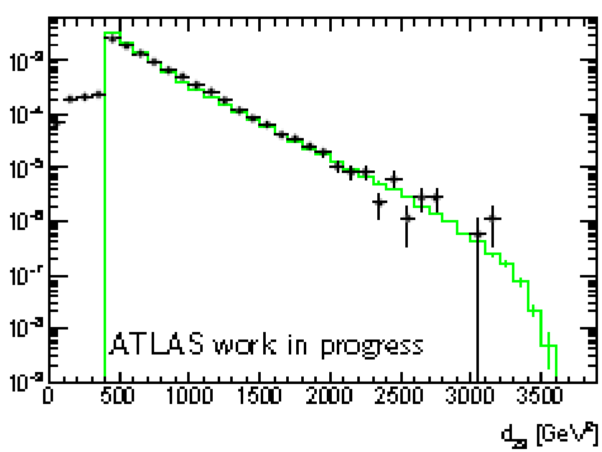


$$D_{23} = \frac{1}{N} * \frac{\Delta N(Q^2)}{\Delta d_{23}} =$$

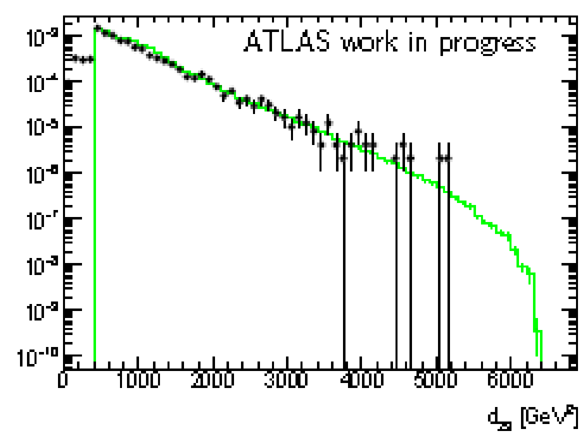
$$\frac{\Delta A(d_{23}, Q^2)}{\Delta d_{23}} * \alpha_s(Q^2) + \frac{\Delta B(d_{23}, Q^2)}{\Delta d_{23}} * \alpha_s^2(Q^2)$$

- Using kt algorithm an d_{23} (swich from 3 to 2 jets)
- Fitting born and NLO part of NLOJET++ calculation

$p_T : 40 - 60 GeV$



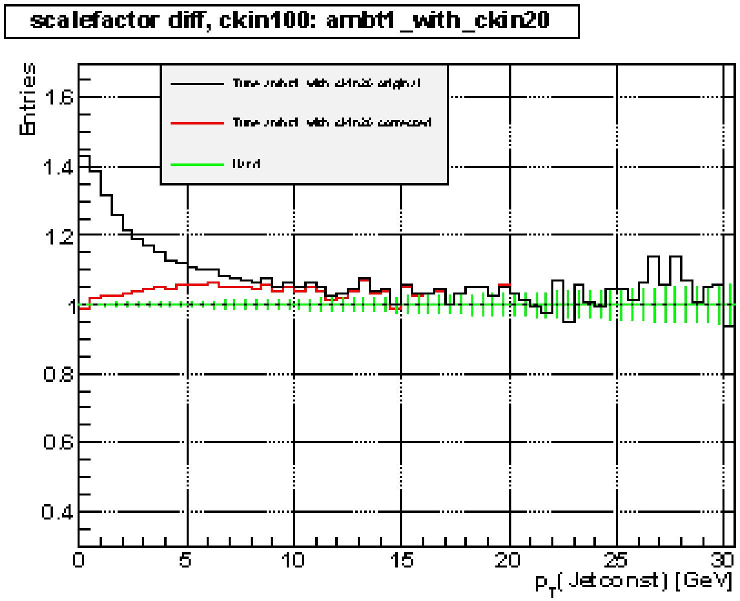
$p_T : 60 - 80 GeV$

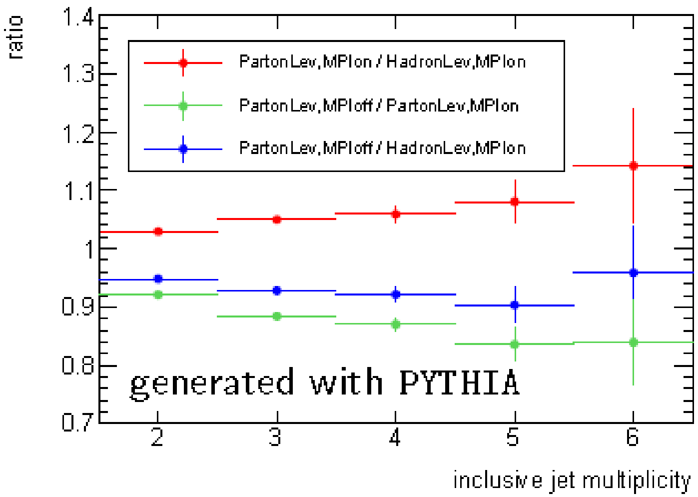


UE, MPI and pile up corrections

Christopher Schmitt:

- Correction for UE effect by weighting every jet constituent





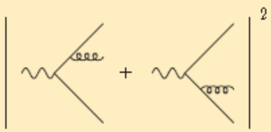
Markus Schneider:

- Study of MPI (plot) and Pile up reduction using JVF cut

Marek Schönherr,

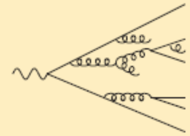
Approaches to real emission corrections

Matrix Element



- + **Exact** to fixed order
- − Perturbative series breaks down due to **large logarithms**

Parton Shower



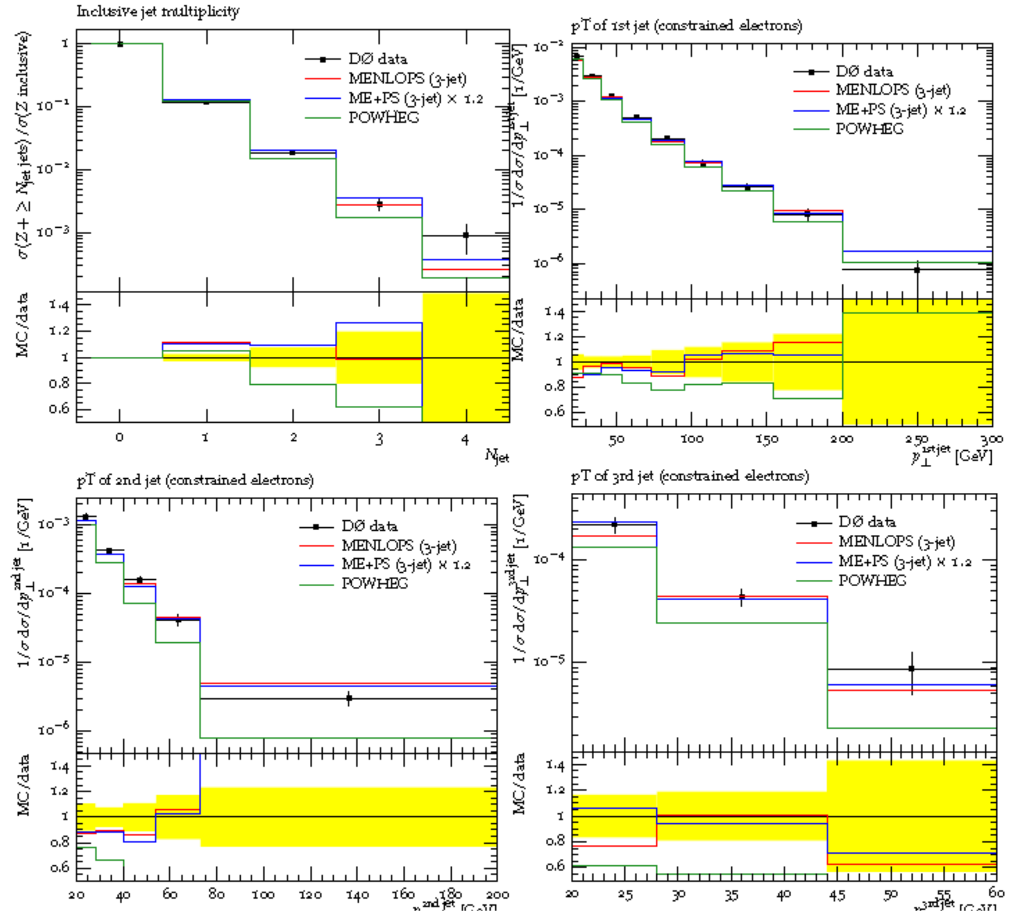
- + Resums logarithms to **all orders**
- − Only **approximation** to real emission ME

Combine Advantages ⇒ ME⊗PS

- avoid double-counting by dividing phase space ⇒ Q_{cut}
- **ME** to describe **hard radiation**, **PS** for **intrajet evolution**

Multijet Merging with NLO MEs – MENLOPS

$$\langle O \rangle = \int \mathrm{d}\Phi_B\, \bar{B}(\Phi_B) \Big[\bar{\Delta}(t_0)\, O(\Phi_B) + \underbrace{\overbrace{\int \mathrm{d}\Phi_{R|B} \frac{R(\Phi_R)}{B(\Phi_B)} \bar{\Delta}(t)\, \Theta(Q_{\text{cut}} - Q)\, O(\Phi_R)}^{\text{POWHEG domain}} + \int \mathrm{d}\Phi_{R|B} \frac{R(\Phi_R)}{B(\Phi_B)} \Delta(t)\, \Theta(Q - Q_{\text{cut}})\, O(\Phi_R)}_{\text{ME domain}} \Big]$$



- ME⊗PS works well for shapes, but needs K-factor
- POWHEG reproduces NLO cross section and shape of first emission, but additional hard jets at LL only
- MENLOPS combines ME⊗PS and POWHEG
  ⇒ NLO cross accuracy in core process
  ⇒ multijet observables as in ME⊗PS

4-loop anomalous dimension

Mikhail Rogal

- Self-consistent NNNLO analysis of **DIS**: 3-loop *Wilson Coefficients* and 4-loop *anomalous dimensions*

  KNOWN:

  Wilson Coeff. $\sim$ up to 3-loops for *all* values of spin Moch, Vermaseren, Vogt'05
  Anom. dim. $\sim$ also up to 3-loops for *all* values of spin Moch, Vermaseren, Vogt'04 (also some polarized results Vogt, Moch, M.R., Vermaseren'08)
- The higher loops calculations: to *decrease theoretical errors* in analysis of **DIS** ($\mapsto$ PDF)
- to get 4-loop anomalous dimensions is enough to calculate UV part of 4-loop tadpoles
- Using the *Asymptotic Expansion* and the R-operation it is possible to reduce initial task by at least 1 loop
- At the moment we have program that computes some 3-loop diagrams with scalar, spinor and gluon propagators.
  This is a prototype of future **ZFOUR** program

Quark/Gluon Formfactor for 3 loop in massless qcd

Tobias Huber

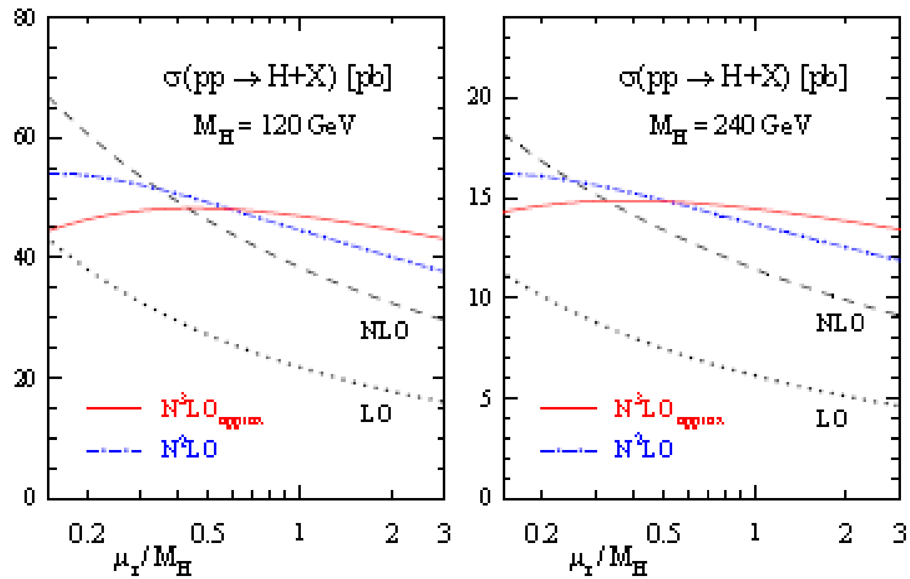
- We computed the quark and gluon form factors to three loops in massless QCD
- Calculation requires dedicated computer algebra tools for generation, reduction, and computation of master integrals
- Result is given as linear combination of 22 master integrals
- The three-loop result is also available through to $\mathcal{O}(\epsilon^2)$
- Together with $\mathcal{O}(\epsilon^6)$ of one- and $\mathcal{O}(\epsilon^4)$ of two-loop form factors, the stage is set for the four-loop calculation

- Gluon form factor
  - Higgs-production: $gg \to H$

[Dawson '91; Djouadi,Graudenz,Spira,Zerwas '91-'93]
[Harlander,Kilgore '01-'02; Catani,de Florian,Grazzini '01]
[Anastasiou,Melnikov '02; Ravindran,Smith,van Neerven '03]
[Anastasiou,Melnikov,Petriello '05; Moch,Vogt '05]

  - N^{3}LO without finite term
  - $\sigma_{\text{tot.}}$ approximated to $\mathcal{O}(1\%)$ by $\sigma_{\text{tot.}}^{m_t\to\infty}$ up to $M_H \approx 2m_t$

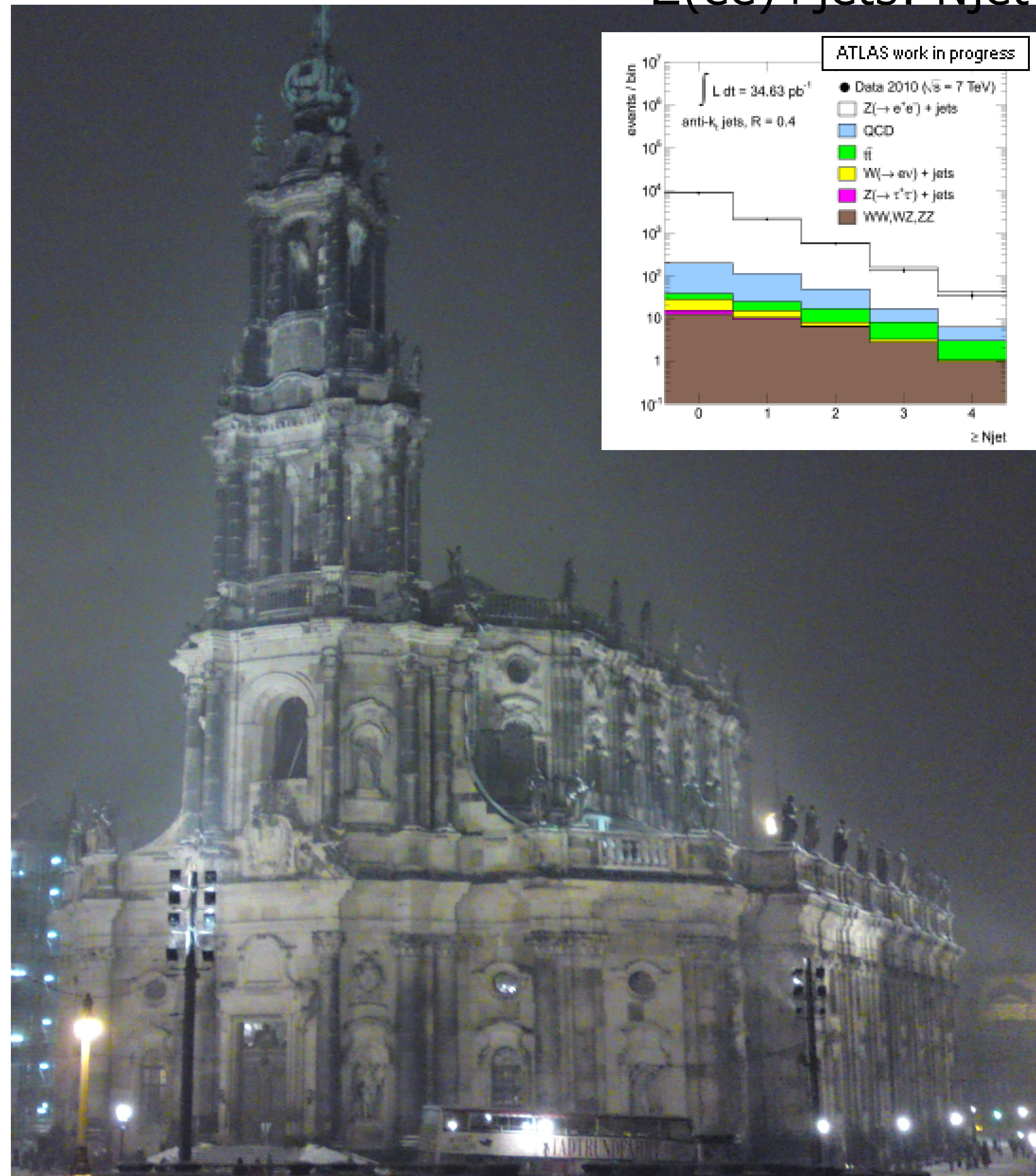
[Krämer,Laenen,Spira '96, see also e.g. Harlander,Ozeren '09]
[Pak,Rogal,Steinhauser '09; Anastasiou,Bucherer,Kunszt '09]



Summary

- LHC: 40 pb^{-1} luminosity at 7 TeV delivered
- CMS and ATLAS: very successful data taking in 2010
  - Many SM results at 7 TeV compared to expectations, no discrepancies observed so far
  - German students heavily involved in data analysis; most talks showed their work in progress
- Spring conferences: Updates for the full data set expected

Z(ee)+jets: Njet



Theory

- Mein auto

Summary

Track Counting:

- Order tracks by the signed impact parameter significance $S_{d0}=d_0/\sigma_{d0}$
- Count tracks exceeding certain threshold of S_{d0}
- Ask for minimal number of tracks with this requirement
- Essential: good description of 1^{st} , 2^{nd} and 3^{rd} highest S_{d0} distribution