Report from the DESY MC Group

A. Knutsson (DESY),

4th Annual Workshop of the "Physics at the Terascale"
December 1-3, Dresden

Outline

- News from Herwig++ related work at DESY
- News from the CASCADE MC generator
- Assorted projects

HERWIG++ activities related to DESY

Herwig++ & related MC activities @ DESY

- General purpose MC event generator
- Angular ordered showers
- Cluster hadronization
- Hard LO ME, some NLO ME (POWHEG) + matching with showers
- UE model

Co-Author **Simon Plätzer** started at DESY(Hamburg) a few weeks ago.

M. Bähr, et al, **Herwig++ Physics and Manual, Eur.Phys.J.C58:639-707,2008**

Herwig++ & related MC activities @ DESY

Overview of:

- Dipole Parton Showers
- NLO Matching
- Subleading $1/N_c$ effects

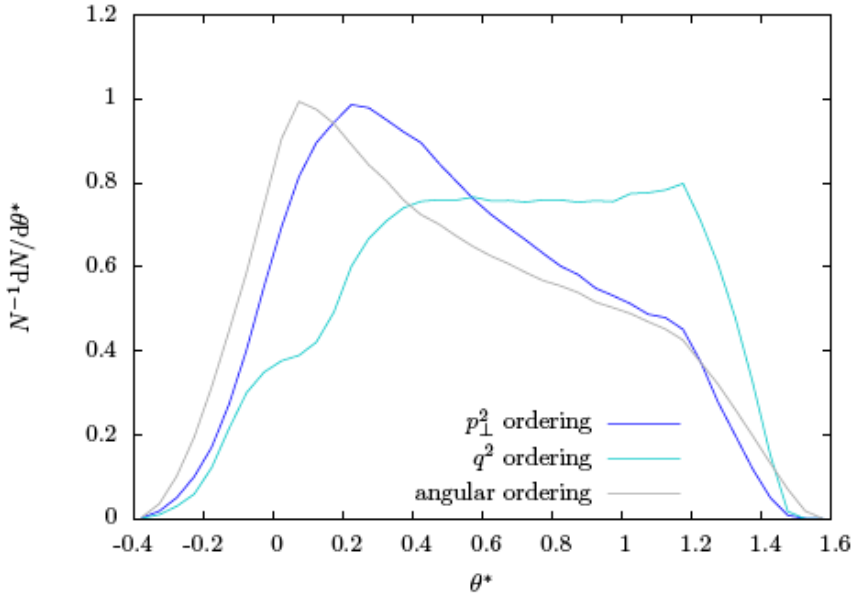
Not covered:

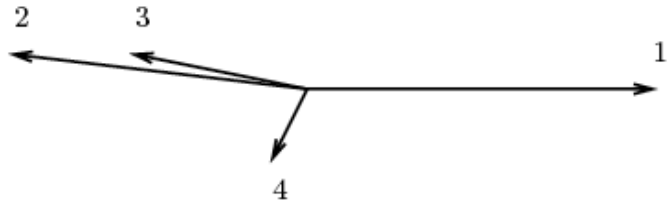
- Calculational Formalism for Showers and Matching $\rightarrow$ NNLO?
- General Herwig++ Development and User Support

Herwig++ & related MC activities @ DESY

In-depth analysis of CS-type dipole parton showers. [S. Plätzer & S. Gieseke, 0909.5594]

- Sudakov anomalous dimensions? → OK with $p_\perp$ ordering
- Coherence? → OK with $p_\perp$ ordering, e.g. $\theta^* = \theta_{24} - \theta_{23}$





- New physical prescription for initial state radiation

Herwig++ & related MC activities @ DESY

Dipole Showers and NLO Matching: Recent developments.

[S. Plätzer & S. Gieseke, in preparation]

- New dipole shower prescription as add-on module to Herwig++
- Provided along with 'Matchbox'
  - Automated dipole subtraction
  - Automated setup of POWHEG and MC@NLO-type matching
- Validated for simple processes: e^+e^-, DIS, DY
- Focus on interfaces to existing NLO codes
  - VBFNLO
  - ...

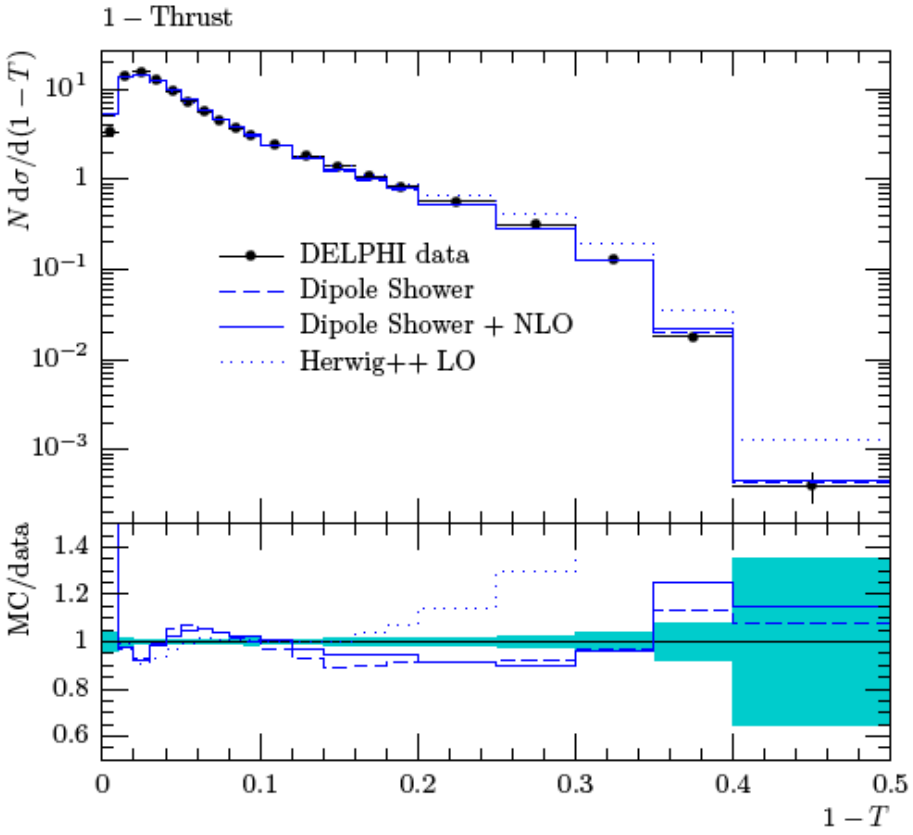
[DESY ↔ Karlsruhe, together with Ken Arnold]

Herwig++ & related MC activities @ DESY

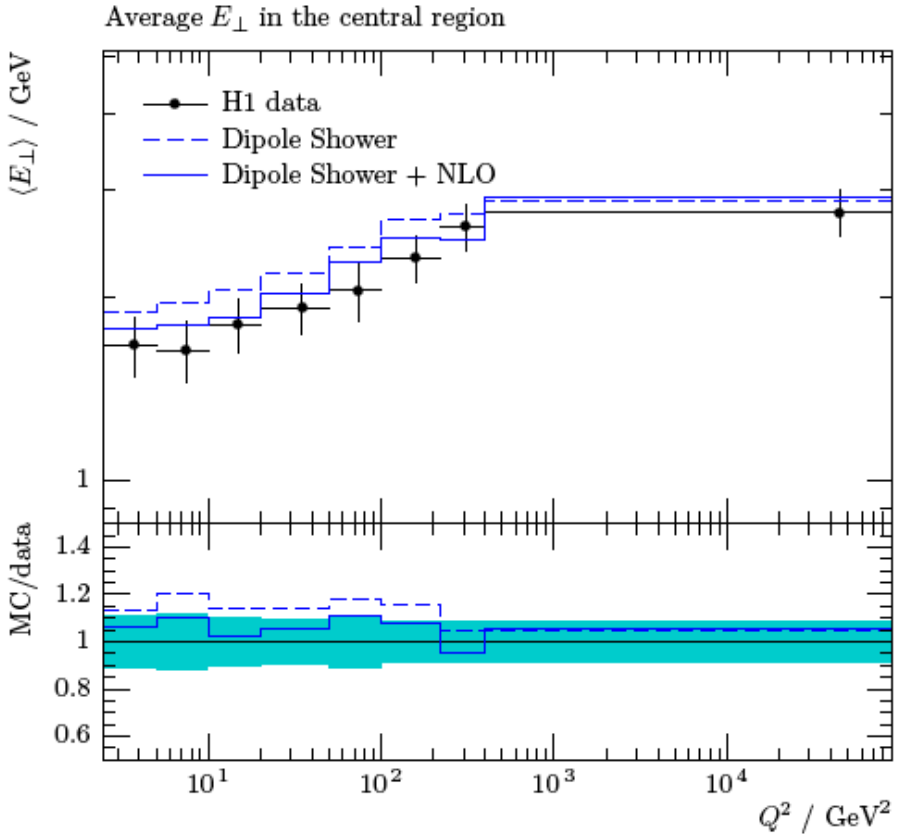
Some highlights from our dipole shower + NLO framework.

[S. Plätzer & S. Gieseke, in preparation]

Thrust @ LEP



Average $E_\perp$ @ HERA



Herwig++ & related MC activities @ DESY

Subleading $1/N_c$ effects.

[DESY ↔ Karlsruhe, together with Malin Sjödahl]

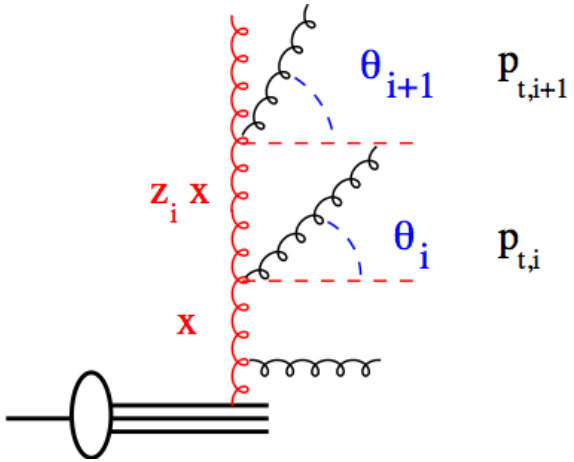
- Try to quantify the role of the large-N_c limit
- Supplement dipole shower to cope with full colour correlations
  - C++ code for dealing with colour tensor basis and amplitudes
  - New Monte Carlo techniques for non-positive definite splitting kernels
- About to produce first results

New developments in CASCADE

CASCADE

- **Monte Carlo event generator based on kt-factorization.**
  Off-shell MEs with initial and final state parton showers and hadronization.

- **Unintegrated PDFs are defined at some starting scale and evolved to higher scales by emissions of gluons according to the *CCFM* evolution scheme.**
  Angular ordering of emitted gluon (color coherence). No explicit k_t-ordering.



- **CCFM is usually referred to as the bridge between DGLAP and BFKL.**

- **New release of the CCFM based Monte Carlo generator CASCADE version 2.2.03 – Recently published online:**
  `EPJ C, DOI: 10.1140/epjc/s10052-010-1507-z`

- **Recent development: New matrix elements included, unintegrated quarks+ME, improved understanding of HQ by comparison to Tevatron data, new fits of uPDFs (using the fitting program PROFFIT).**

New Matrix elements in CASCADE

- heavy quarks

$g^*g^* \rightarrow Q\bar{Q}$ → New studies of heavy quark production in CASCADE comparison to Tevatron data.
H. Jung, M. Krämer, A.V. Liptatov, N. Zotov, arXiv:1009.5067v2

$g^*g^* \rightarrow J/\psi g$

$g^*g^* \rightarrow \chi_c$ NEW

$g^*g^* \rightarrow \chi_b$

$g^*g^* \rightarrow \Upsilon g$

- Gauge boson & Higgs

$g^*g^* \rightarrow h$

$g^*g^* \rightarrow Z + Q\bar{Q}$

$g^*g^* \rightarrow W + q_i q_j$

$qg^* \rightarrow Zq$ NEW

- QCD processes – forward jets

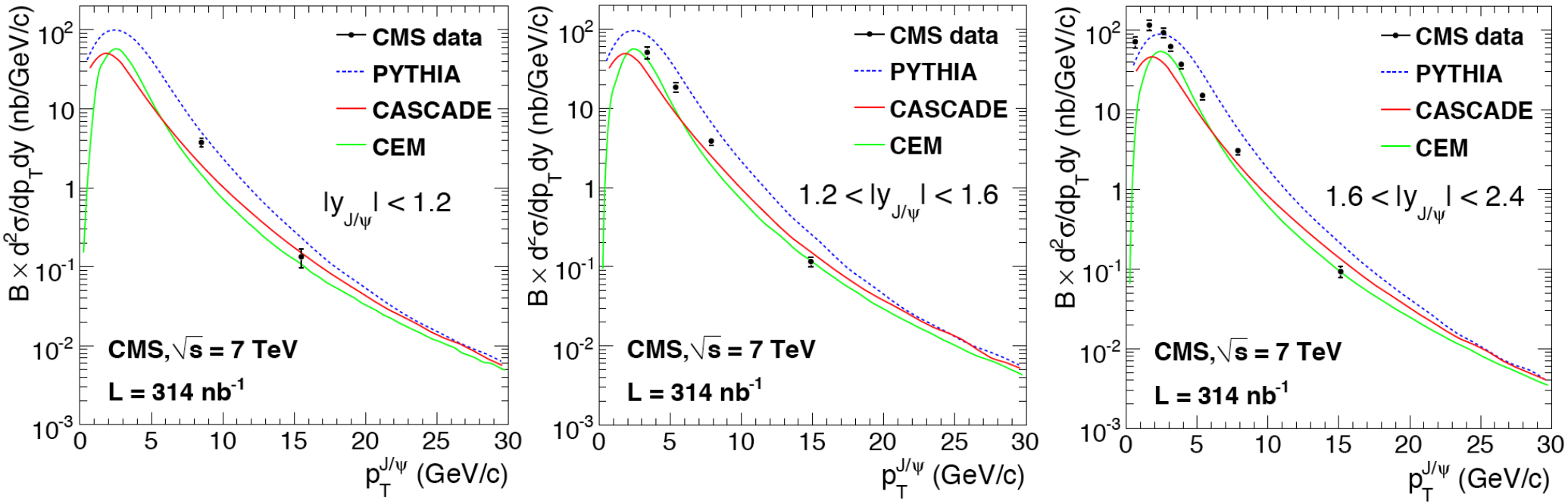
$g^*g^* \rightarrow q\bar{q}$

$qg^* \rightarrow qg$ NEW

$gg^* \rightarrow gg$

J/Psi production in CASCADE

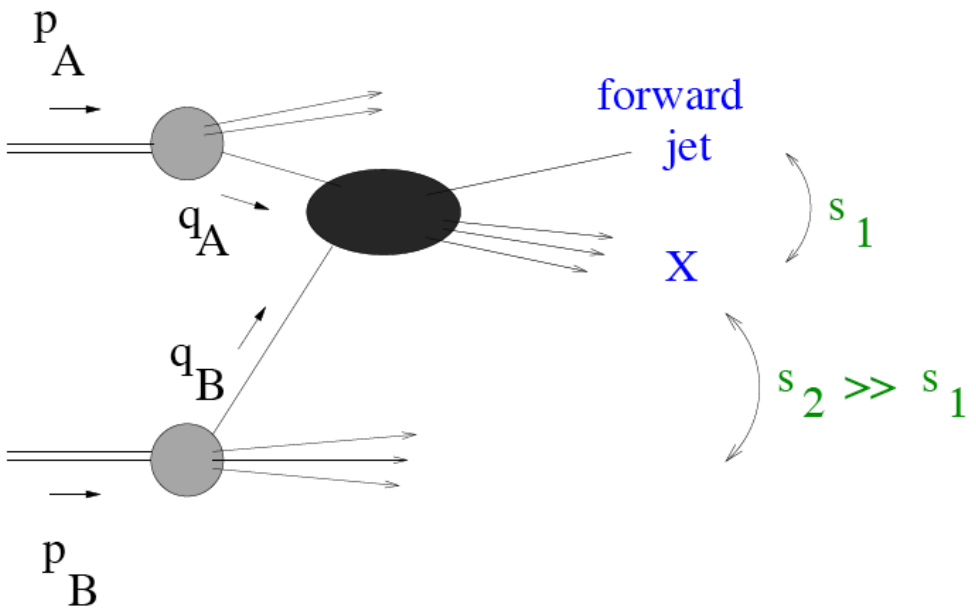
New matrix elements for J/Psi production.
Cascade compared to CMS data of prompt J/Psi production.
Included in "CMS Collaboration, arXiv:1011.4193, submitted to EPJ C".



- CASCADE describes data at medium/high pt, and is in competition with PYTHIA and CEM at low pt.

Forward jet production in CASCADE

- Before only unintegrated gluons (i.e. indirectly also sea quarks) in CASCADE.
- Valence quarks expected to be relevant for LHC. For example high Pt production:



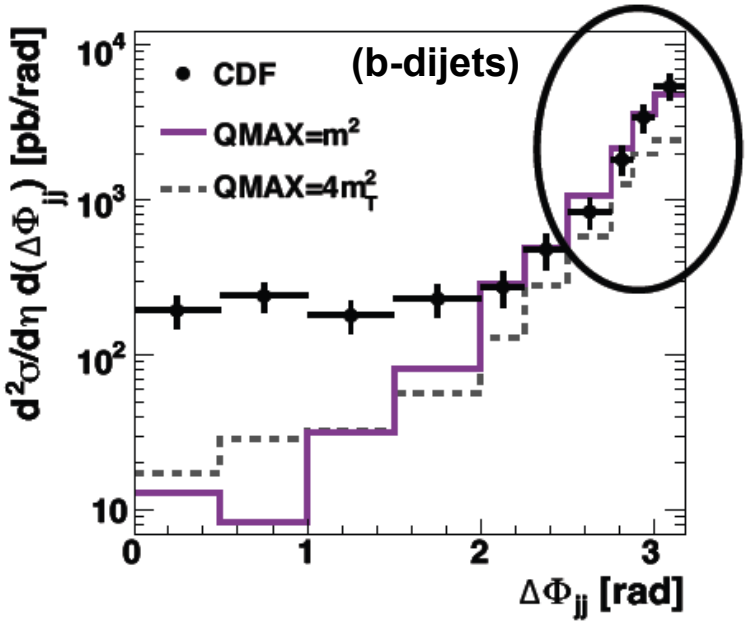
Two scale process. With relevant physics for both $x \to 0$ and $x \to 1$.

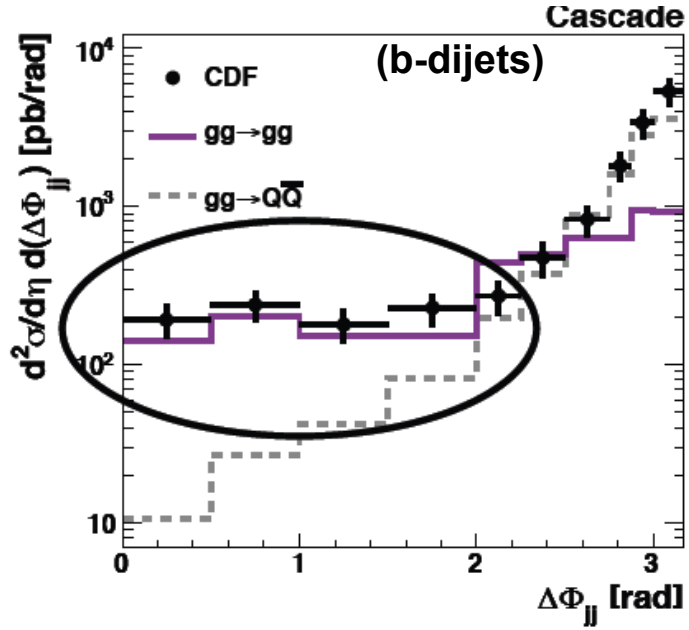
Quarks (and MEs) implemented in CASCADE.
The k_t dependent quark PDF is taken from derivated CTEQ5.1.

M. Deak, F. Hautmann, H. Jung, K. Kutak, JHEP 09, 121 (2009). 0908.0538
+ new paper in preparation with detailed studies

Heavy Quark production i CASCADE

- *Heavy Flavour Production at Tevatron and Parton Shower Effects*
  H. Jung, M.Krämer, A.V. Lipatov, N.Zotov
  arXiv:1009.5067v2



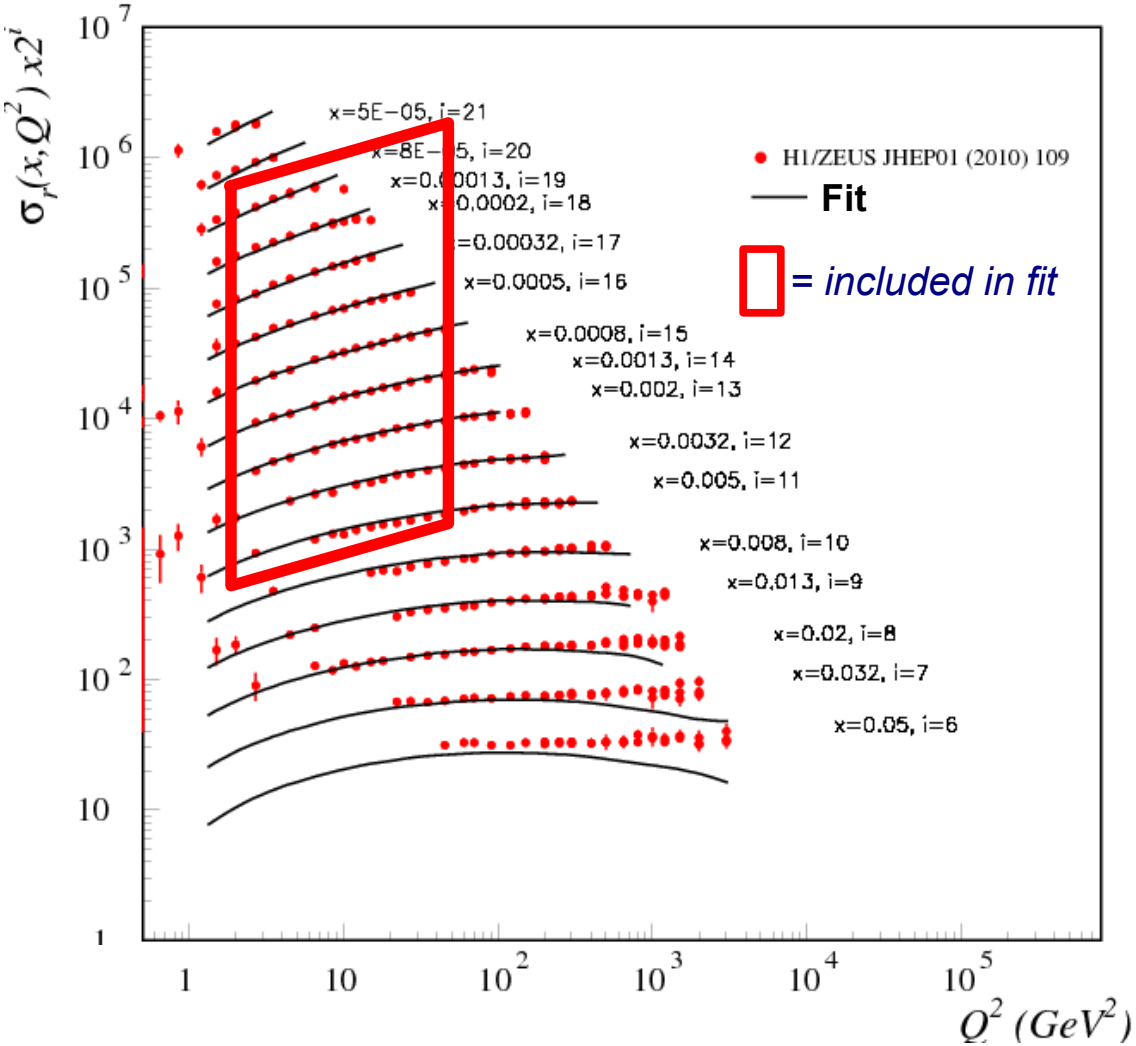


- variation of the final state parton shower scale ⟶ description of peak in dphi
- include gg*→ gg ⟶ description of tail in dphi
  M.Deak, F.Hautmann, H.Jung, K.Kutak, JHEP0909 : 121, 2009

CDF Run II Preliminary, PhD. Thesis S. Vallecorsa

Mira Krämer 1

Fits of uPDF



New uPDF fits to the combined high precision HERA data (H1+ZEUS).

With only 3 fitted parameters the **non-collinear gluon gives a decent description at low x and Q2 region**.

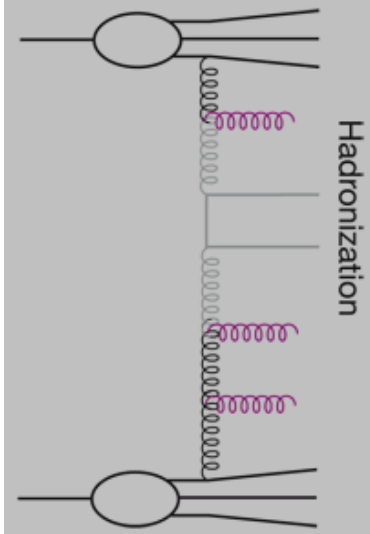
However, Chi2/ndf=2.5 for the fit.
Room for improvements:
Include quarks, improve non-Sudakovs, etc.

Used fitting program PROFFIT and improved parameterization
Bachetta, Knutsson, et al EPJC,70 (2010) 503

The uPDF online plotter

CCFM PHYSICS

Home | About CCFM | Online Plotting of uPDFs | Online Plotting of F2 | Cascade | Publications | Contact



ONLINE PLOTTING OF UPDFS

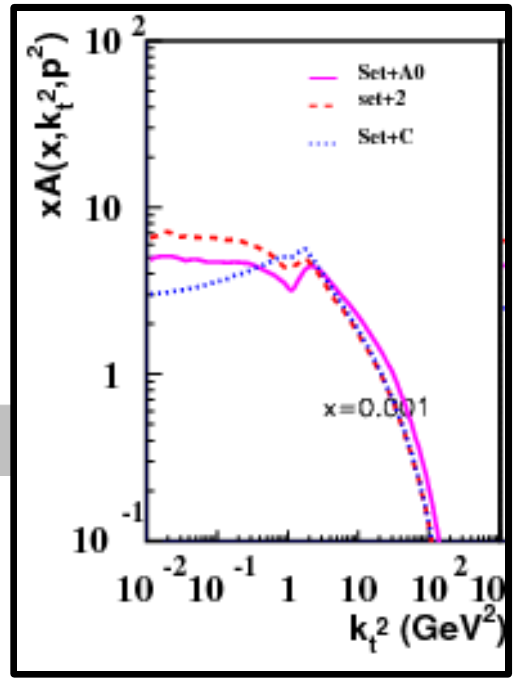
Using the form below you can calculate, in real time, values of xA(x,kt,p) for any of the uPDFs. You can also generate and compare plots of xA(x,kt,p) vrs x and vrs kt**2 at any p for up to 4 different parton types or PDFs.

xmin = 0.0001 xmax = 0.8 p**2 = 100 GeV**2

in case a collinear PDF is used (option dPDF, Bluemlein): 10041

1	☑	gluon	Set A0	scale-factor 1.0
2	☑	gluon	set 2	scale-factor 1.0
3	☑	gluon	Set C	scale-factor 1.0
4	☐	gluon	Set A0	scale-factor 1.0

Make the Plot/Calculation | Reset the Form



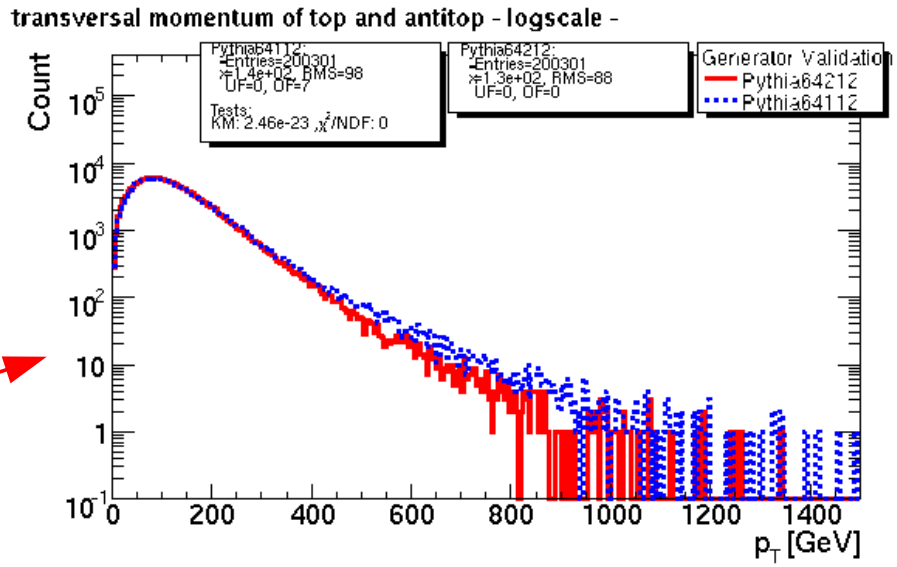
- Possibility to plot uPDFs online, and also compare MC and F2 data
- Link made public soon (keep an eye on http://www.terascale.de/mc)

Assorted projects

The HepMCAnalyser Tool

HEPMC Analyser Tool: a tool for *generator validation and comparisons*

- **Easy to implement generator MC studies**
- **Used for validation of the Genser (Generator Service) library at LHC**
- **Example: Validation of PYTHIA – predictions for top-anti top pair transverse momentum**



New release – v3.4 (last week):

- **Will be used by GENSER in order to do regression tests of the generator libraries (provided for all Collaborations).**
- **Compatible with newer HepMC versions**
- **Alpgen supported**

And more...

http://hepmcanalysistool.desy.de

HepMC Analysis

Sebastian Johnert, Judith Katzy, Jan Kotanski, Sebastian Piec, et al

Alpgen + Pythia in ATLAS

Slide from Liza Mijovic

Joint effort of the Analysis Center at DESY with the LHC Physics Center at CERN.

Alpgen + Pythia in a nutshell:

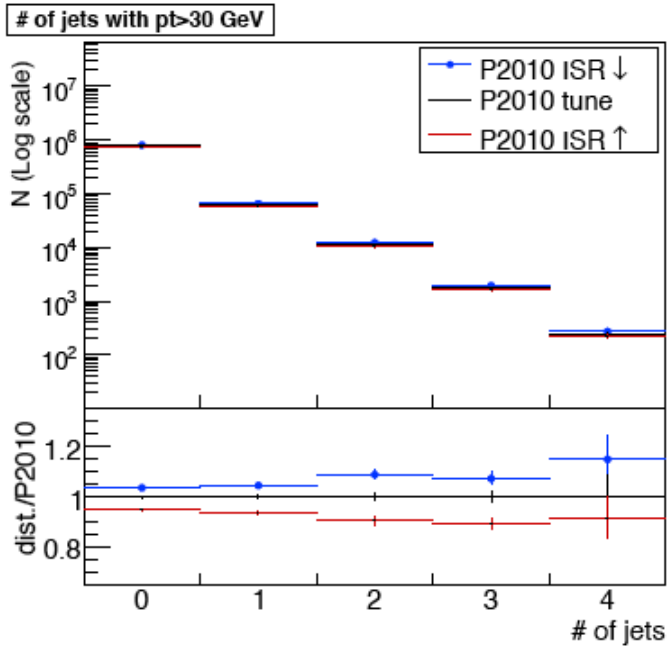
- **Alpgen:** hard process,
- **Pythia:** PS and hadronization,
- **Alpgen+Pythia:** MLM matching of the hard process and PS partons.

Alpgen + Pythia Project Goal:

- achieve **optimal performance** of Alpgen+Pythia for the LHC (should be useful for both ATLAS and CMS).
- **Free model parameters will be tuned in order for the generator(s) to describe the data; Alpgen+Pythia tuning requires a separate effort from Pythia standalone tuning** (at least for some param.-s).

Example of an Alpgen+Pythia effect we've explored:

- different effects of increasing/decreasing Pythia **I**nitial **S**tate **R**adiation activity for Pythia standalone and Alpgen+Pythia;
- Pythia stand.: **ISR ↓ ⇒ less jets; ISR ↑ ⇒ more jets**
- **Alpgen+Pythia: vice-versa**
  (see Figure: Alpgen+Pythia, W+jets, 7 TeV.)
- **Turns out to be a legitimate effect when only PS parameters are varied.**
- **Ongoing work: asses which/how Alpgen and Pythia parameters should be varied simultaneously/consistently.**



For more information please:

- see presentations at W+jets workshop @ Durham[1] and/or contact the people involved: Ben Cooper, Judith Katzy(DESY), Michelangelo Mangano, Andrea Messina, Liza Mijović(DESY), Peter Skands.

[1] http://www.ippp.dur.ac.uk/Workshops/10/Vjets (Thursday and Friday sessions)

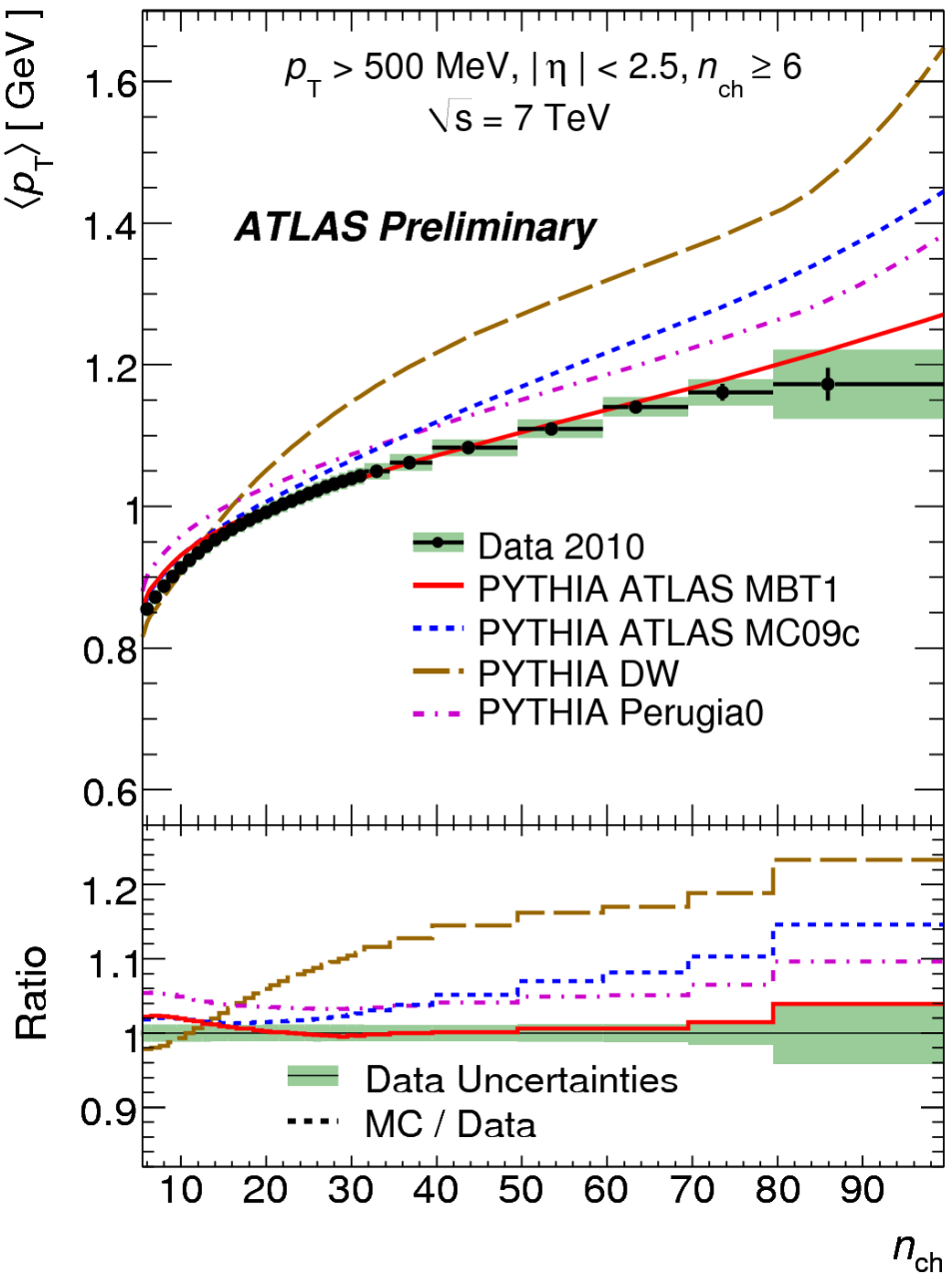
ATLAS related work 2

ATLAS-CONF-2010-031

- Tuning of Pythia6 (only non-diffractive component) using Professor tool
- MPI parameters, matter overlap distribution, colour reconnection parameters
- dedicated measurement of charged particle multiplicities in diffraction reduced phase-space ($N_{ch} \geq 6$, $p_T > 500$ MeV)
- in addition: ATLAS and CDF UE data

- first tune to 0.9 and 7 TeV LHC data
- significant improvement in description of minbias data

- **Details in talk by M. Warsinsky in QCD & EW parallel session**



CMS related work

- **Tuning within CMS. MC group at DESY involved in preparations, and later also in the tuning itself.**
- **Currently: Implementation of Rivet in CMS-software and start up of using it within the collaboration. Essentially done.**
- **Next step: Implementation of tuning tool(s).**
- **Involves also: Coding of Rivet routines for CMS.**

MC studies for 2 particle correlations ("the Ridge")

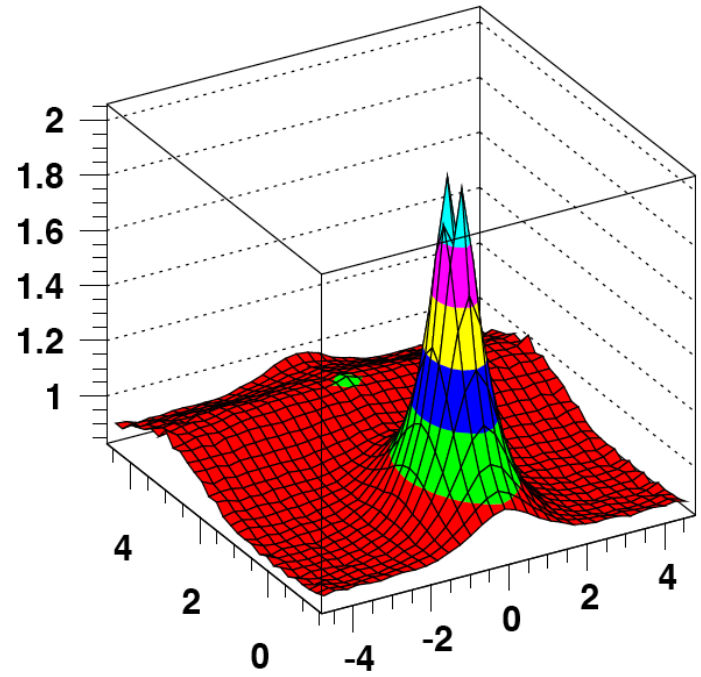
- We are performing MC studies of the 2 particle correlation measurement from CMS.

- In collaboration with Antwerp University (Pierre van Mechelen).

- Please see https://www.wiki.terascale.de/index.php/Ridge

  - Correlation plots for ~40 different Pythia tunes (A. Grebenyuk).

  - Rivet analyses routine (A. Knutsson).



Summary

- **HERWIG++:**
  Simon Plätzer recently started at DESY
  New development in dipole showers + NLO matching.
  Studies of $1/N_c$ effects.

- **CASCADE:**
  New MEs implemented, Unintegrated quarks implemented, New fits of uPDF,
  Web interface for plotting uPDFs

- **Experiment specific MC projects:**
  Tuning activites at ATLAS and CMS.
  "Pythia with Alpgen" implementation in ATLAS

- **Several other projects**, e.g. studies of the Ridge effect in 2 particle correlations.

- **PhD and Master students are welcome to DESY and the MC group to work within out projects, e.g. tuning or improved fits of uPDF.**

- **Please also see http://www.terascale.de/news/analysis_centre_studentships/ for 2-3 month studentship at the Analysis Center at DESY (Hamburg or Zeuthen). Not only Monte Carlo.**

Back ups

New MC generator development at DESY

Validation parton shower against QCD When, for a particular process, one knows the summation of large logarithms in full QCD, then it is of significant interest to investigate whether a given shower algorithm produces matching results. To do this, one needs to derive the corresponding summation in the shower model, deriving the appropriate evolution equation for the observable in question from the general evolution equation for the shower algorithm.

From shower equation

$$\frac{d}{dt}(x,q|\mathcal{U}(t,t')|M_2) = (x,q|[\mathcal{H}_I(t)-\mathcal{V}(t)]\mathcal{U}(t,t')|M_2)$$

Z. Nagy and D. Soper: **JHEP 0905:088,2009** **JHEP 1003:097,2010**

to DGLAP

No approximation and assumptions. Only algebraic manipulations.

$$\frac{d}{dt}D_q(t,t',x) = \int_x^1 \frac{dz}{z}P_{qq}(z)D_q(t,t',x/z) + \mathcal{O}(e^{-t})$$

- We have shown that all the parton shower algorithms correctly reproduce the evolution of the energy distribution of an final state parton (DGLAP). This is an very inclusive quantity and it provides very little control on the parton shower algorithms. *We need more exclusive tests!*
- We have shown that a virtuality ordered parton shower (*Z. Nagy and D. Soper:* **JHEP** 0709:114) can sum up correctly the large logarithms of the Drell-Yan pT distribution at NLL level. We have found that the showers based on Catani-Seymour factorization fail even at LL level.
- We are working on a general validation procedure and a general shower scheme that can provide a unified theoretical framework for the further MC developements.

Implemented in new MC generator at DESY. Work in progress...

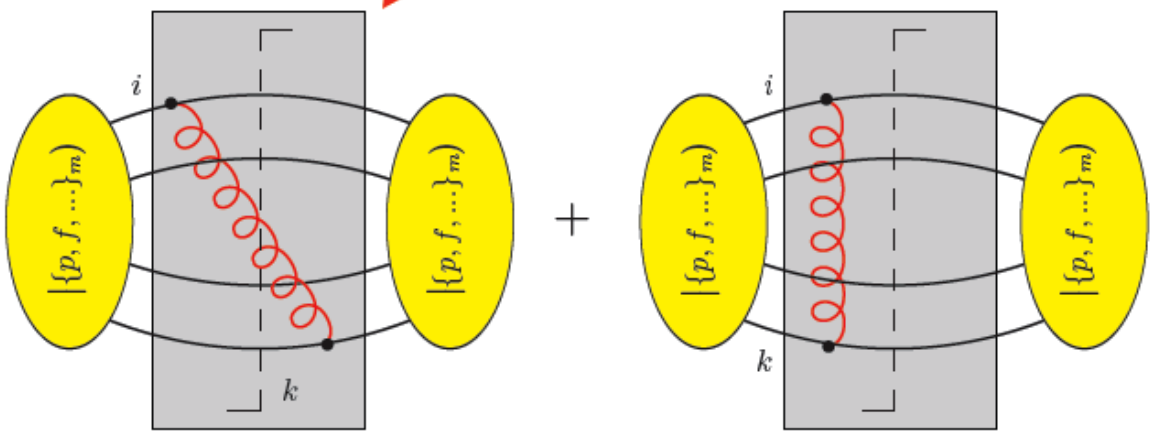
Slide by Zoltan Nagy

New MC generator development at DESY

Parton shower with quantum interference The current parton shower programs are based on simple probabilistic picture. This is possible because of additional, rather non-systematic approximations such as spin averaging, leading color approx., explicit angular ordering. This approximation could work for a certain class of the observables but in the general case we have to systematically treat the quantum correction in the parton shower.

Parton shower is a time ordered exponential of the splitting operators.
These are operators in the color and spin space:

$$\mathcal{U}(t,t') = \mathbb{T}\exp\left(\int_{t'}^{t} d\tau \left[\mathcal{H}_I(\tau) - \mathcal{V}(\tau)\right]\right)$$



Z. Nagy and D. Soper: JHEP 0709:114 (2007)
JHEP 0803:030 (2008)
JHEP 0807:025 (2008)

- From simple estimates we know that even the very subleading color correction can be five times bigger than the leading color contribution.
- Coloumb gluon effect ➠ Super leading logarithms, diffraction at perturbative level
- It is important to have full control over the soft contributions otherwise one can easily misidentify them as underlying event contributions.
- In heavy flavor (top, SUSY, BSM) physics the soft gluon corrections are the leading QCD contributions.
- Usually the electroweak decays are spin dependent. ➠ Important spin correlations.

Implemented in new MC generator at DESY. Work in progress...

Slide by Zoltan Nagy