



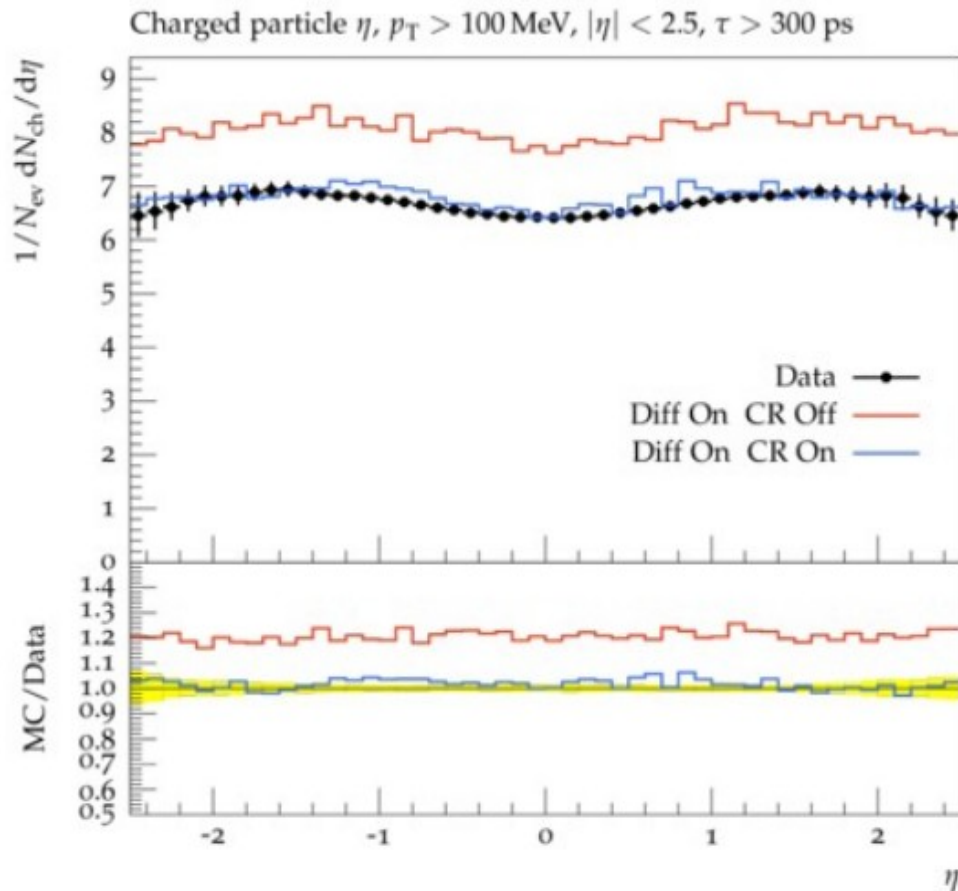
Monte Carlo session: summary for discussion

MPI@LHC 2017 conference
Stefan Gieseke, Paolo Gunnellini

(KIT, DESY)

Monte Carlo tutorial

- **By setting the diffraction and colour reconnection On and Off, we have seen the various cases and interesting results.**
- **Our all thanks to Organizers, Stefan and Deepak Kar for giving us an opportunity to learn about MC generator production and their applications.**



MANY THANKS TO YOU
FOR TAKING PART TO
THE TUTORIAL AND
PRODUCING THESE
NICE RESULTS

GENERATORS + RIVET
ARE POWERFUL TOOLS
THAT CAN BE
EASILY USED

Inputs for discussion

- What is the priority list for the MC developers?
- Experiments should start to use the new models (both for pp and heavy-ion collisions)..We have many data at 13 data already!
 - Looking at the inside of the jets: large room for improvement..any suggestion for observables?
- Experiments started (already since some years) to use at matched generators (higher-order matrix elements + PS/UE simulation): ongoing discussion for best combination of PDF set/UE parameters..what is best?
 - Performance of generators (and tunes) in high multiplicity regimes..is it satisfactory?

**Thanks a lot for the very
nice workshop and
looking forward to next
MPI@LHC**

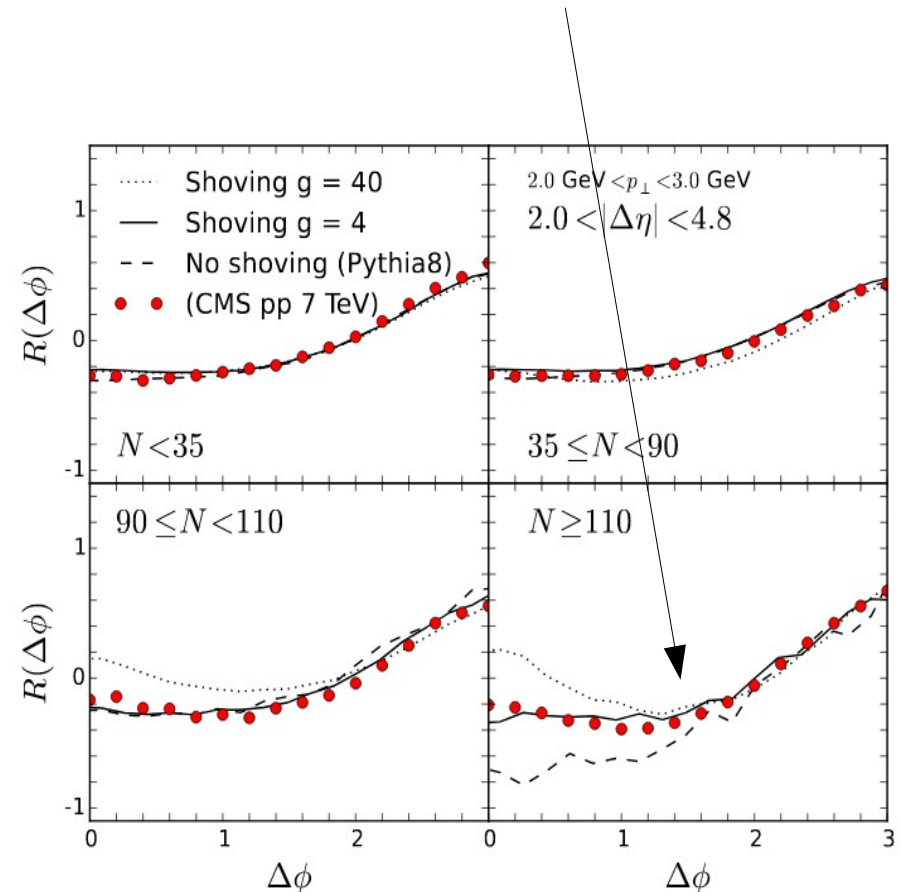
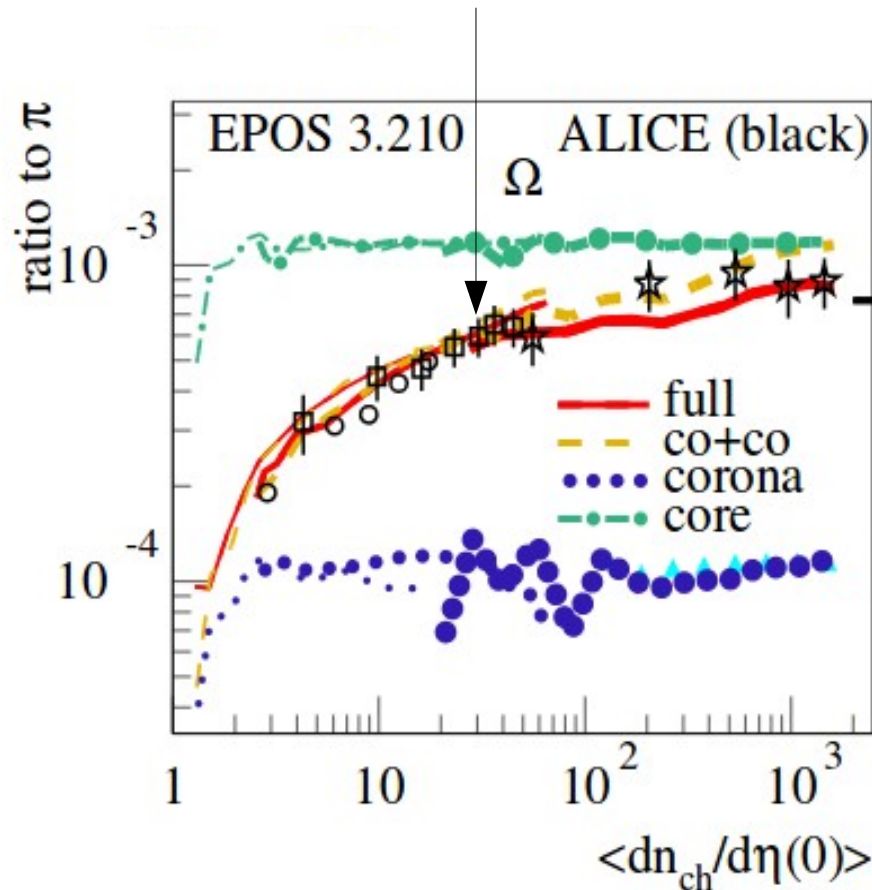


Development of Monte Carlo event generators

GOAL (among all): improving the models on description of charged hadron multiplicities and ridge

PYTHIA8: rope hadronization and string shoving model

EPOS: core-corona model

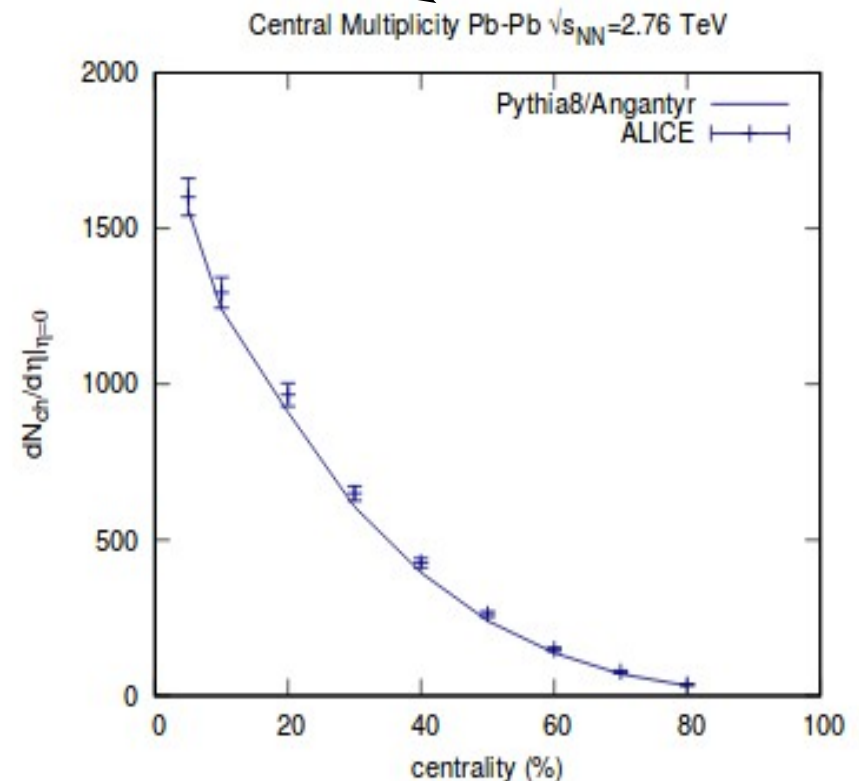
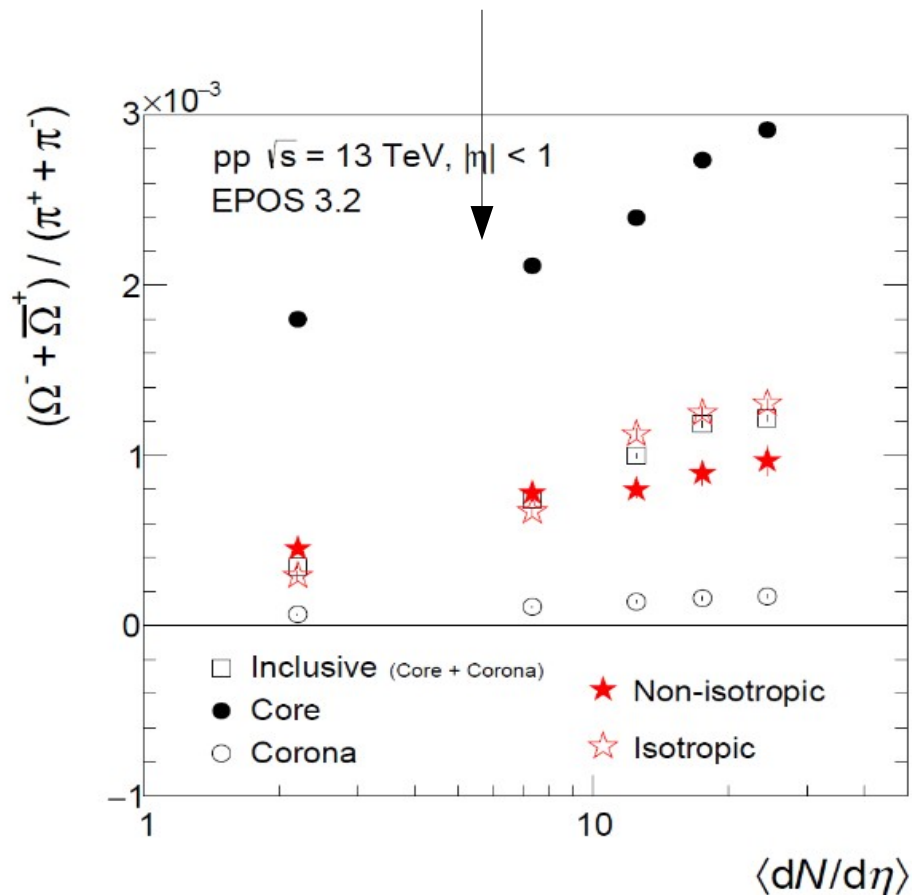


Development of Monte Carlo event generators

GOAL (among all): improving the models on description of charged hadron multiplicities and ridge

PYTHIA8: heavy-ion collisions available

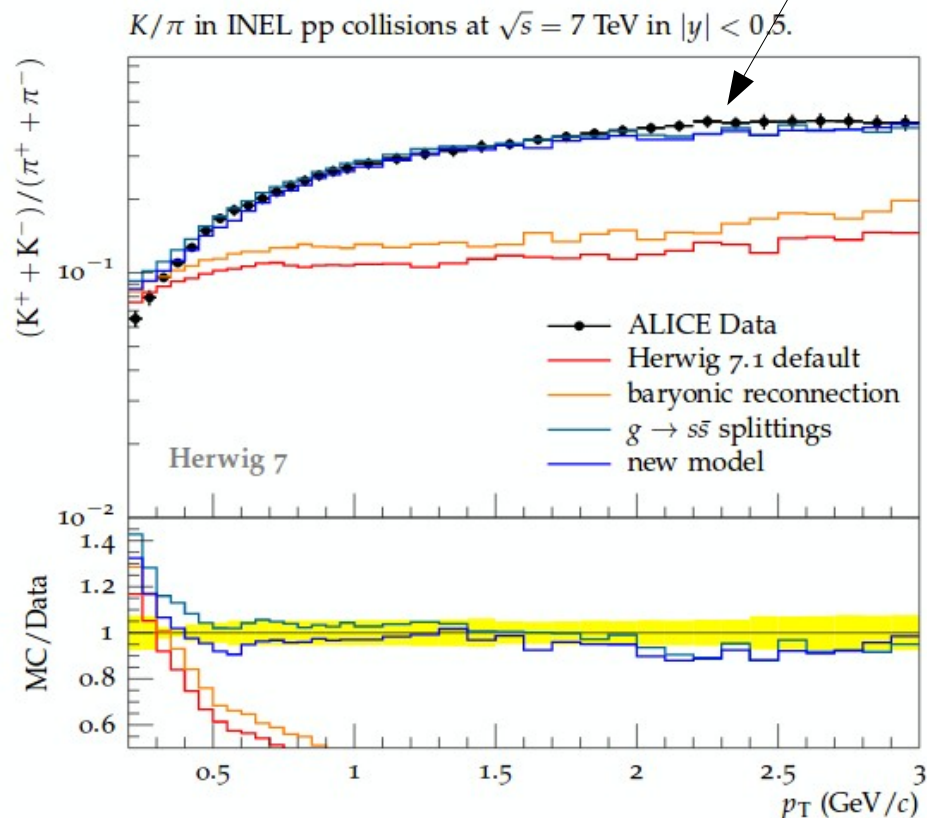
EPOS: core-corona model



Development of Monte Carlo event generators

GOAL (among all): improving the models on description of charged hadron multiplicities and ridge

HERWIG7: powerful soft-physics model and colour reconnection baseline



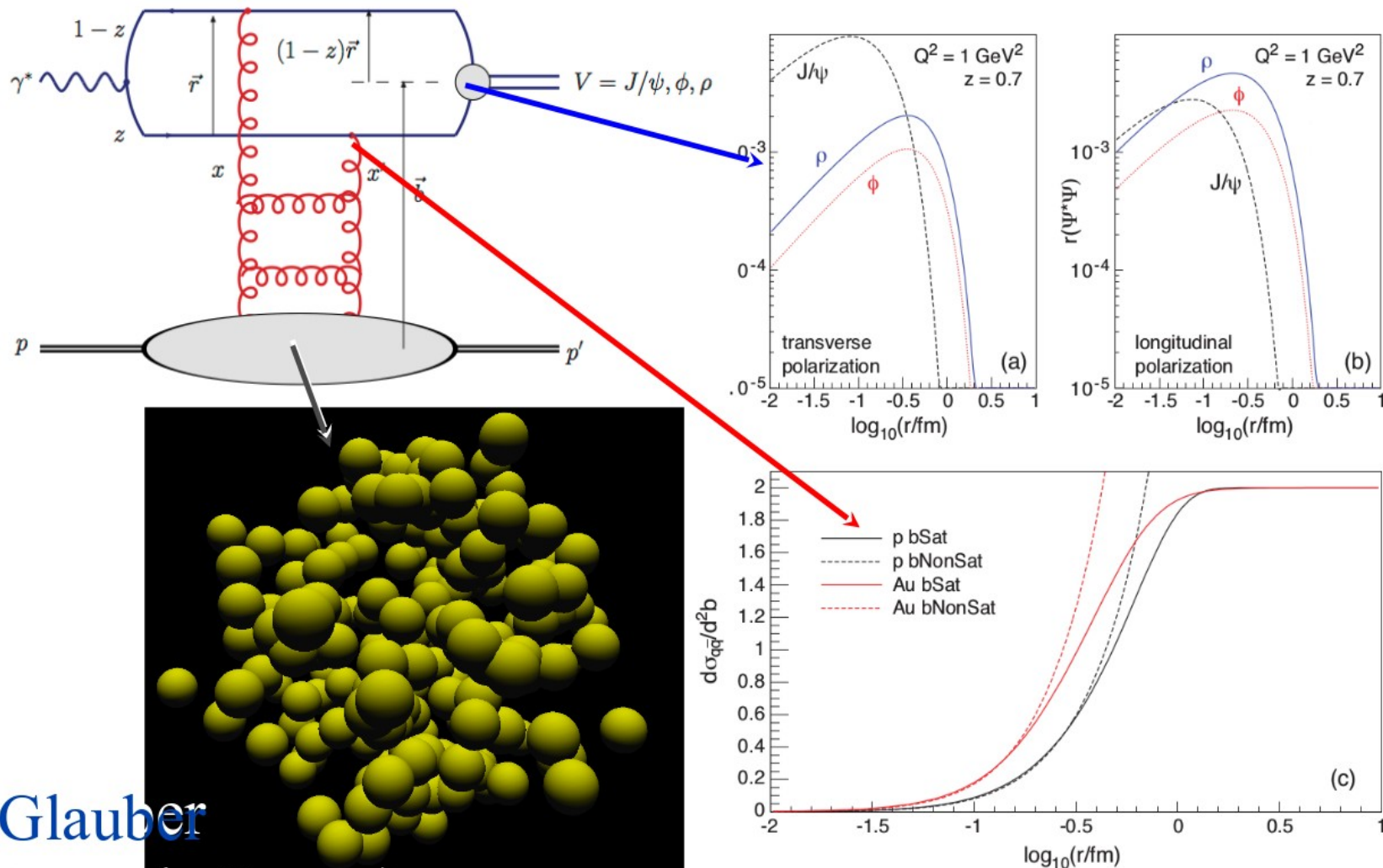
Nice interplay between experimental and theory community \rightarrow data drive the improvement of the models

Ball is on the experiments now for using these new models!

Development of Monte Carlo event generators

SARTRE: looking at the future!! EIC project

Sartre dipole model with Glauber bSat and bNonSat



Glauber
(Woods-Saxon)

Last year – this year (collaboration status)

- Monte Carlo activities in ALICE
 - Tuning generators in LHCb
 - Monte Carlo tuning for MPI from ATLAS data
 - Monte Carlo development and tuning with CMS
-
- QCD Monte-Carlo model tuning studies with CMS data at 13 TeV
 - Studies of Monte Carlo modelling of Jets (ATLAS)
 - Studies of Top Quark Monte Carlo Modelling (ATLAS)
 - Tuning of color reconnection models with CMS data at 7 and 13 TeV
 - CMS underlying event and double parton scattering tunes
- + MC tutorial

Less represented by collaborations but broader range of topics:

- Parton shower and underlying event simulation matched to higher-order matrix elements
- Colour reconnection model investigation
- Description of double parton scattering observables within available MC generators
- Jet and jet substructure description
- **MC tutorial (with student's presentation!)**

Tuning Monte Carlo event generators

Experiments want their data to be well described!

→ **Good description of soft physics but not only..**

..most of the analyses use parton shower (PS) and underlying event (UE) simulation matched to higher-order matrix elements



HOT TOPICS:

- optimization of merging/matching options
- PDF choice for PS/UE (if kept as LO, not the same as for matrix element calculation)

Sherpa: UE tune with NNLO PDF set

Herwig: UE tune with NLO PDF set

Pythia8: UE tune with LO PDF set



What to do?

Tuning Monte Carlo event generators

Simon Plaetzer

PDF Philosophy: General Requirements

PDF in the shower needs to match the one in the hard process.

- May not be numerically significant in all cases, but merging extremely good at probing such inconsistencies (lessons learned from alphas).

PDF in the hard process is constrained by hard process accuracy.

- In our case this is NLO, at least.

PDF for beam remnant handling and MPI should best be chosen LO for the sake of a physical small- x gluon.

- We do make this choice, independent of the hard process. Tuning performed with this set.

Tuning Monte Carlo event generators

Torbjörn Sjöstrand, <http://home.thep.lu.se/~torbjorn/pdfdoc/pdfwarning.pdf>

- **Strict use of LO PDF sets in UE tunes:**
 - They have a clear physics interpretation
 - They have the correct behavior at small x

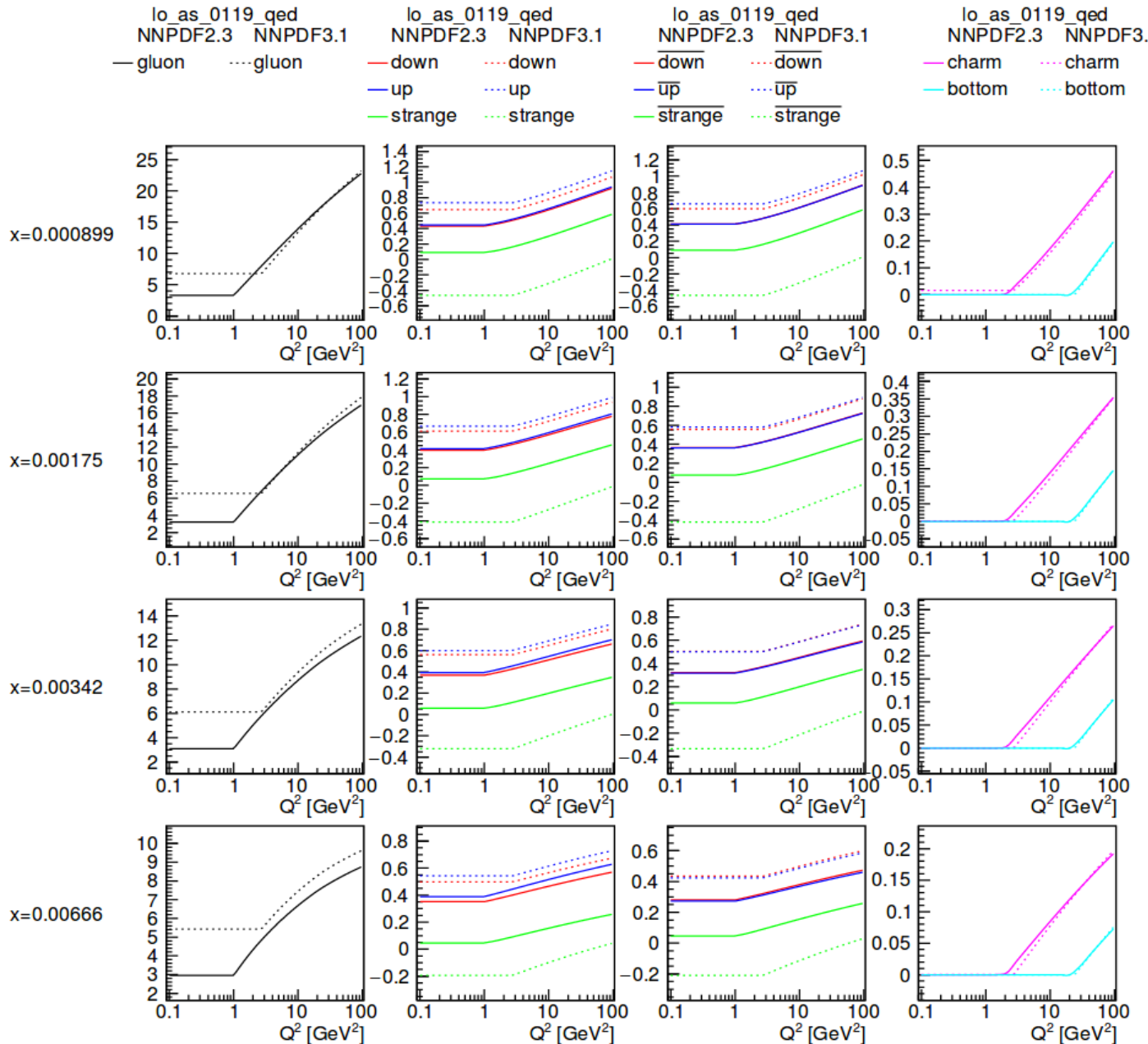
- **In contrast, NLO (NNLO) PDF sets have no probabilistic interpretation and are not definite positive + possible inconsistencies with splitting kernels in the PS**

- **Tunes with NLO (NNLO) show a larger amount of MPI and a very different energy extrapolation**

P.S. Nothing is forbidden but guidelines are quite clear

Tuning Monte Carlo event generators

Radek Zlebick



Some of the (new) LO PDF sets also show negativity in some regions of the phase space

(no ForcePositive option)

This might also affect the UE description (and the tune)

NLO and NNLO PDF sets are often sometimes “less” negative

Exploring new non-perturbative models

Experiment	m_{top} [GeV]	Error due to CR	Reference
World comb.	173.34 ± 0.76	310 MeV (40%)	arXiv:1403.4427
CMS	172.22 ± 0.73	150 MeV (20%)	CMS-PAS-TOP-14-001
D0	174.98 ± 0.76	100 MeV (13%)	arXiv:1405.1756

CR is one of the **dominant systematics in top mass measurements**

Tunes available for the QCD-based and gluon-move models implemented in PYTHIA 8 performed by ATLAS and CMS

- feedback to the MC authors about models from comparisons to non-published observables at 13 TeV
 - more reliable and physical estimation of the colour reconnection model uncertainties

Jet substructure and pulls in generators

Jet pulls in top events – Conclusion from Lily Asquith (ATLAS)

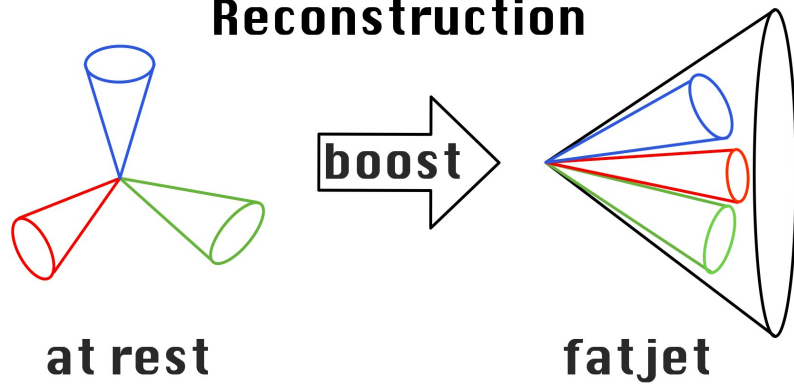
Baseline Powheg+Pythia8 gives *worst* description of θ variable for W daughters.
No generator describes all distributions.

Need for improvement...

What happens inside a jet?

Crucial observables for understanding parton evolution/hadronization

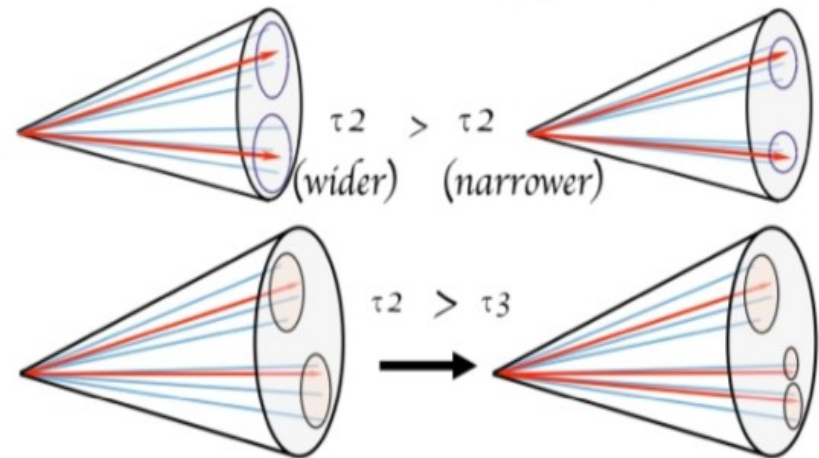
Reconstruction



Detection of boosted objects (searches, high-pT region) strongly relies on jet substructure, e.g. N-subjettiness

N-subjettiness variables

$$\tau_N = \frac{\sum_i^n p_{(t,i)} \min(\Delta R_{(i,1)}, \Delta R_{(i,2)} \dots \Delta R_{(i,n)})}{\sum_i^n p_{(t,i)} R}$$



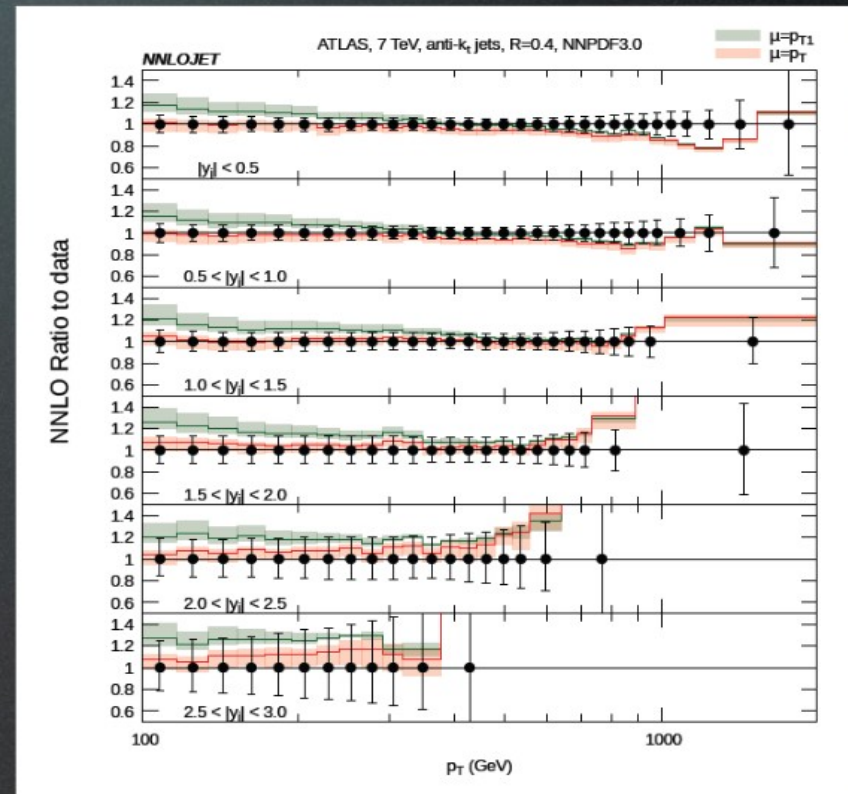
$$\tau_{ij} = \tau_i / \tau_j$$

Scale Choice

Inclusive jets measurement

arXiv:1705.08205

- Difference between choosing leading jet p_T or inclusive jet p_T
- What should be the right choice?
- Should it depend on the kinematics or topology of the event?
- Relevant for PDF fit



13

Suggestions for experiments?

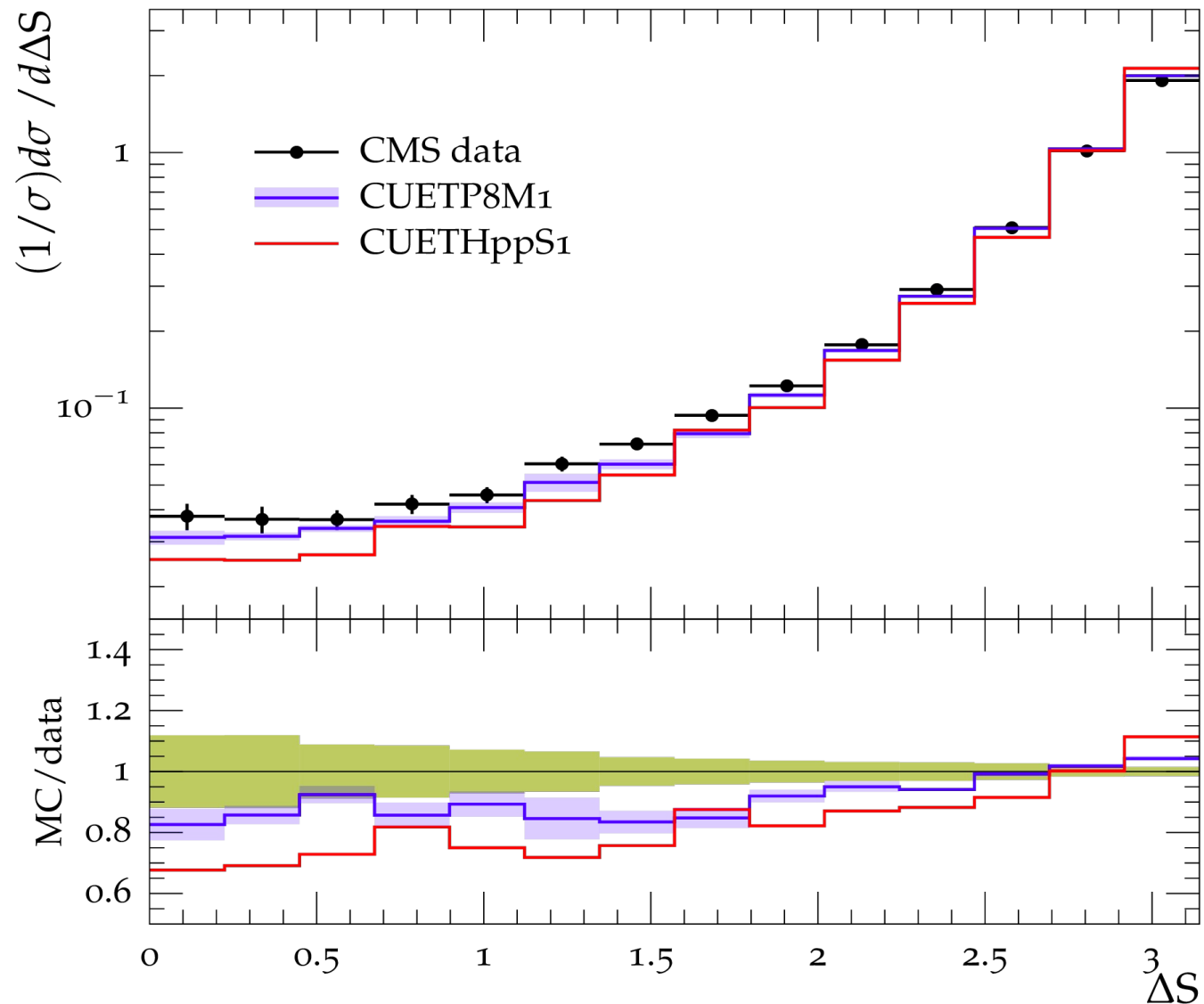
Compare data with both scale calculations?

16

Double parton scattering description

EPJC 76 (2016) 155

Normalized ΔS in $pp \rightarrow 4j$, $\sqrt{s} = 7$ TeV



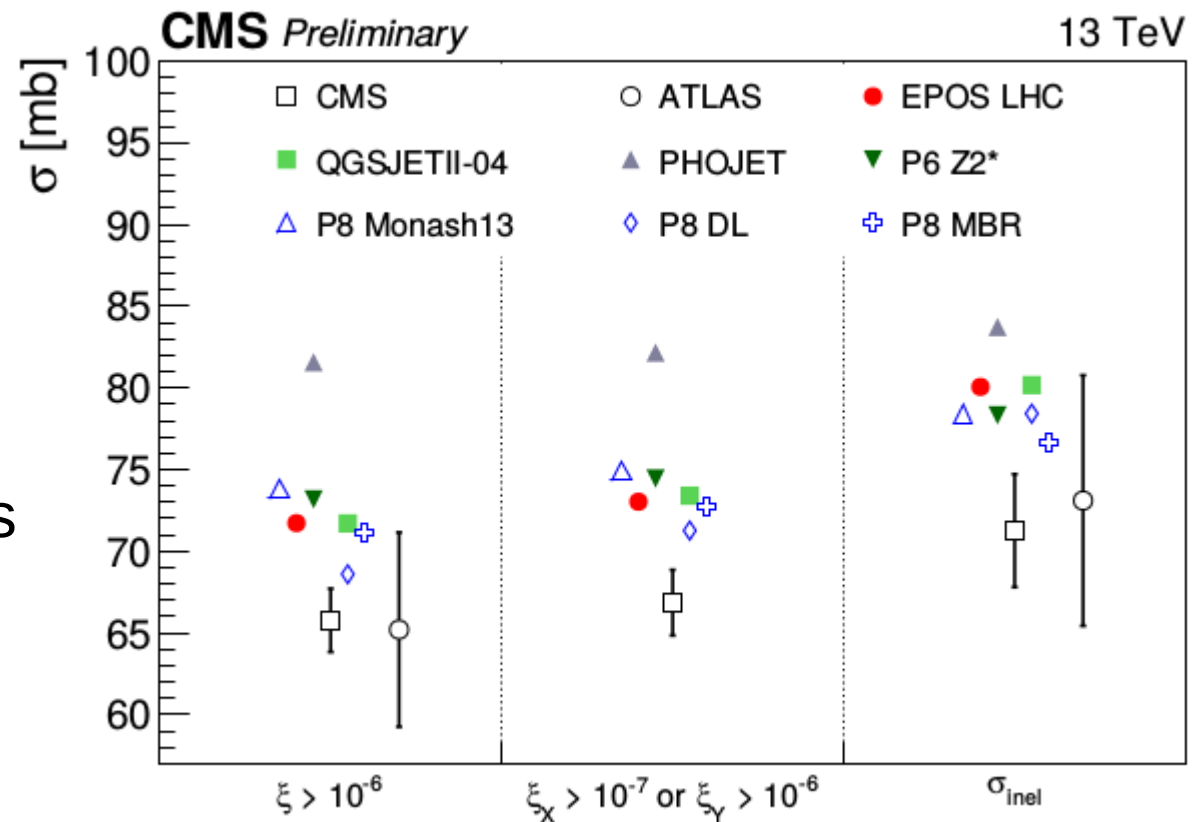
Models have troubles
on describing
UE and DPS
differential distributions

Extrapolation of MPI
contributions from soft
to hard regime is quite
rough

Need to add
correlations in
models/generators

Tuning Monte Carlo event generators

Inelastic cross sections measured for different selections, compared to different generators, tunes and diffraction models



Very difficult to describe both absolute and differential diffractive cross sections by any Monte Carlo generator

→ **But crucial aspect to model pile-up!**