DESY PDF Meeting
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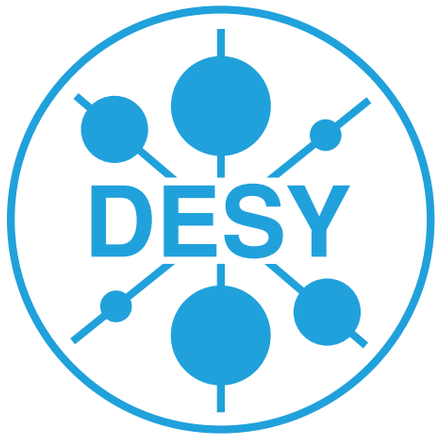
ATLAS Top Physics and PDFs



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PDFs at Hadron Colliders

- For many people (including myself): PDFs are tools
  - Important (but rather unexciting) input to theory calculations and MC
  - Have to work out of the box with a common interface → LHAPDF
  - PDFs should come with a prescription for determination of uncertainties
- Strategies for (re-)discovery physics (now top; later Higgs, SUSY, …)
  - Goal: get results out quickly (there's competition from the other side of the ring…)
  - Aim for the best-understood analysis, not (necessarily) the best-performing
  - Uncertainties: attack the largest ones first/only → how good is good enough?
  - If PDFs are important here → make the case, otherwise people won't bother
- Strategies for precision physics (top after 2011/2)
  - Few-percent effects will become important at some point → be prepared
  - Infuse knowledge of improved PDFs early and using the right channels
  - Again: make the case

A Little History

- Tevatron top physics:
  - CDF: main generator for $t\bar{t}$ signal events still Pythia 6.216 with CTEQ5L PDFs, various other setups and PDF reweighting for cross-checks
  - DØ: using ALPGEN $t\bar{t}$+jets with CTEQ6L
  - Both: slowly moving to MC@NLO (CDF: with CTEQ5M or MRST02)
  - Published PDF uncertainties usually among the smaller ones (typically < 1–2%)
  - Reasons: lack of person power? lack of PDF expertise? inertia?
    → all of the above, but also: still good enough for most top physics!
- ATLAS before the data taking era: “CSC Book” studies (until 2008)
  - Scenario: 14 TeV CMS energy, 10 fb^{-1} or more
  - Default PDF set: CTEQ6M for NLO, CTEQ6L1 for LO
  - PDF uncertainties on signal usually among the smaller ones, e.g. 3% for top cross section and many properties
  - PDF uncertainties on backgrounds may be larger (but certainly not larger than scale uncertainties in LO MC)
    → prefer data-driven determination of these backgrounds

ATLAS Top Group: Current Status

- Current MC production for the ATLAS top group:
  - Full set of 7 TeV samples for 2010/2011 data-taking period
  - $t\bar{t}$ signal generated with MC@NLO or POWHEG, interfaced to HERWIG/Jimmy (and PYTHIA in the case of POWHEG)
  - Single top signal generated with MC@NLO + HERWIG/Jimmy
- Top group uses ATLAS-wide PDF defaults, currently:
  - For NLO step (and HERWIG parton shower for MC@NLO): CTEQ6.6 (before: CTEQ6M)
  - For all LO MC generators: LO* PDFs (MRST2007lomod)
    → improved K factor and $q\bar{q}$ to gg ratio w.r.t. old default (CTEQ6L1)
  - Underlying event re-tuned for new LO* PDFs

ATLAS Top Group: Current Status

- Current feeling about PDFs (after discussion with the conveners)
  - Top group is consumer of PDFs, won't constrain PDFs in the next few years → usually follow recommendations of MC group
  - Lots of interactions with other groups (e.g. Higgs) → need consistent MC samples
  - Established procedures to estimate PDF uncertainties based on PDF reweighting
  - Top mass (e.g. from cross section) may be the first to get sensitive to PDF uncertainties (if other uncertainties cancel) → 2011 at the earliest
  - A few specialists study PDF effects, e.g. relevance of low-x gluon PDF for underlying event (UE) → soft jets may affect JES, b-tagging, lepton isolation, …
- PDF reweighting method:

$$w(x_1, x_2, Q^2) = \frac{f_1^{\text{new}}(x_1, Q^2) \cdot f_2^{\text{new}}(x_2, Q^2)}{f_1^{\text{old}}(x_1, Q^2) \cdot f_2^{\text{old}}(x_2, Q^2)},$$

  - Caveat: changes PDFs for hard process but does not change UE and parton shower → not the full picture

Changing Something in ATLAS…

- ATLAS
  - Large collaboration: inertia, but lots of people to work on issues
  - Consistency of published results: decide on, and stick to, standards
- Scenario I: all DESY grad students use HERA PDFs from tomorrow
  - Need to rely on private MC production → huge effort; however, results cannot be used for any public result (ATLAS policy)
- Scenario II: make the case for improved PDFs and use the right channels
  - Approach conveners of MC group and physics groups that aim for precision measurements: Standard Model, Top after 2011/2
  - Consider all implications → MC underlying event tunes, MC-based calibrations (e.g. JES) have to be redone, probably much more
  - Give presentations (in the MC group) that make the case, like “current evaluation of PDF error too optimistic, PDFs are becoming the dominant systematic uncertainty in a certain (relevant) kinematic regime for process *X* after *Y* fb^{-1}, …”
  - Ideally: this push comes from PDF community as a whole, not just a single group

What can be done now?

- PDFs are not too high up on the top group's priority list right now, but some things could start now (and a few people are interested)
- Improve standard description of how PDF uncertainties are evaluated
  - Typical recipe today: for the default PDF (CTEQ) add differences between error PDFs in quadrature, combine with difference to second PDF (MSTW)
  - Done by PDF reweighting (generating new MC each time would take too long)
  - Various caveats: no error PDFs sets for LO PDF, second PDF choice is ad-hoc, …
  - Are there better methods? Which "second PDFs" should be checked (not too many!)? How should the errors be treated? What about differences in α_S?
- Request test samples with different PDFs
  - Is it worth the effort (now)? Which PDFs with which priority? How much can be learned compared to PDF reweighting?
  - E.g. $t\bar{t}$ NLO step can be done at DESY for MC@NLO or POWHEG
- Start discussions with the right people in the experiments…

Some Thoughts from the MC Convener

- Discussion with ATLAS MC group convener: J. Katzy (DESY)
- Collection of PDF related issues from the ATLAS MC group
  - Next round of changes to MC production will be driven by the first 7 TeV data
  - NLO PDFs cannot be used for underlying event (LO contributions from soft QCD must be canceled by LO PDF)
  - Some more recent LO and NLO generators (e.g. Pythia8, Herwig++, POWHEG): different PDFs for matrix element and underlying event → LO* still necessary?
  - New prescription for PDF uncertainty treatment desirable → proposals?
- Maximizing the impact of DESY's PDF expertise
  - Quick change of default PDF for ATLAS MC production unlikely → anyway: small impact compared to many other possible changes, use of LO MC, …
  - More interesting for PDF community: provide PDF input for theory calculations to be superimposed on the physics results of the paper (cross sections etc.)
  - Show strength of HERAPDFs in the physics processes where they perform best
  - Provide comparisons of PDFs for standard processes to show width of variations