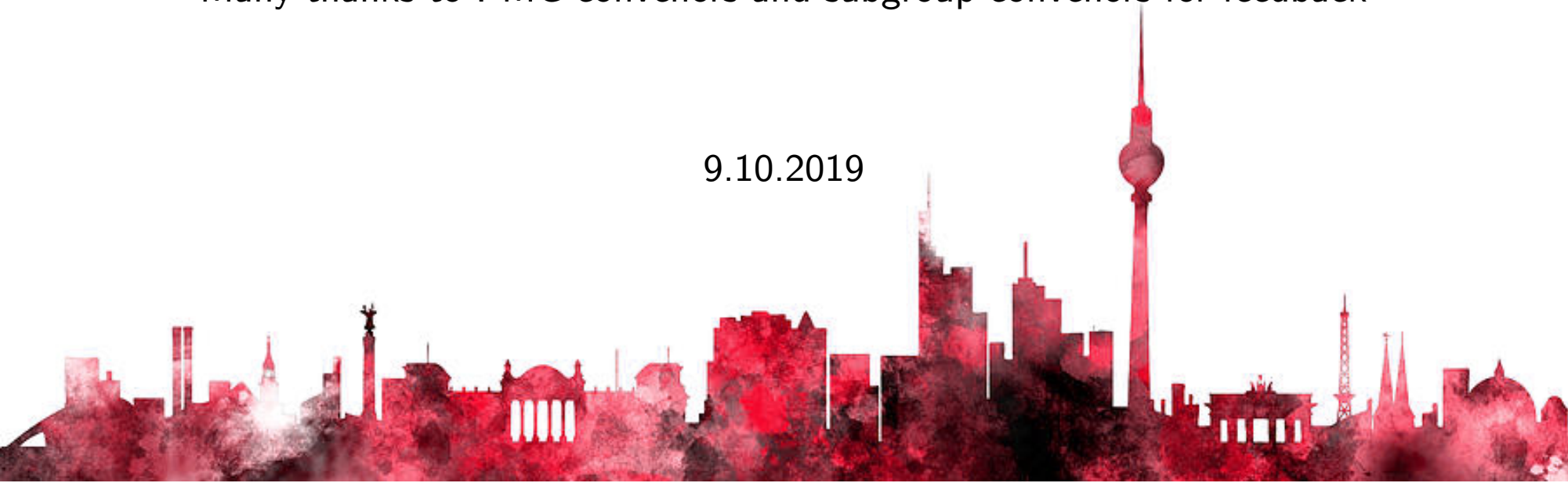
Report from the Physics Modelling Group

Jan Kretzschmar (on behalf of PMG)

ATLAS Week Berlin

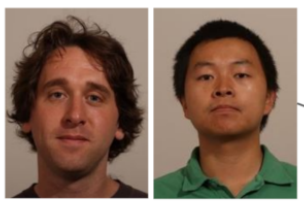
Many thanks to PMG convenors and subgroup convenors for feedback

9.10.2019



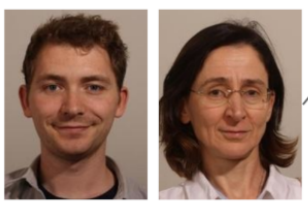
Physics Modelling Group TWiki

- MC Generators – indispensable for every ATLAS analysis
- PMG the place to work on improved setups and receive help with usage
- Structure of the Group:

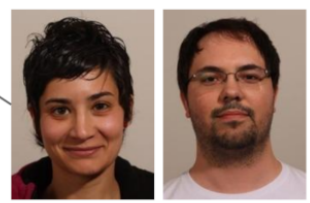


Thur 16:00

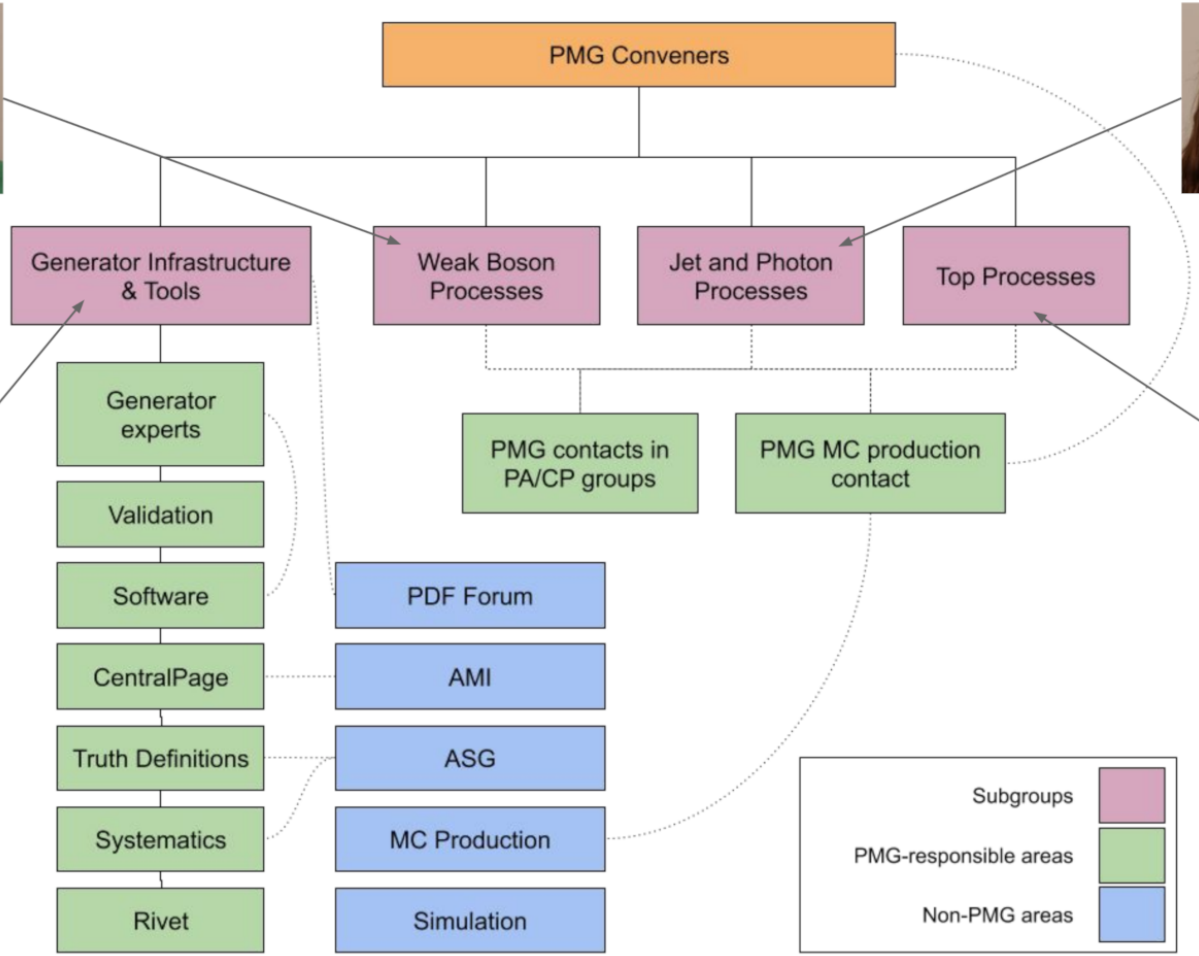
Thur 11:00



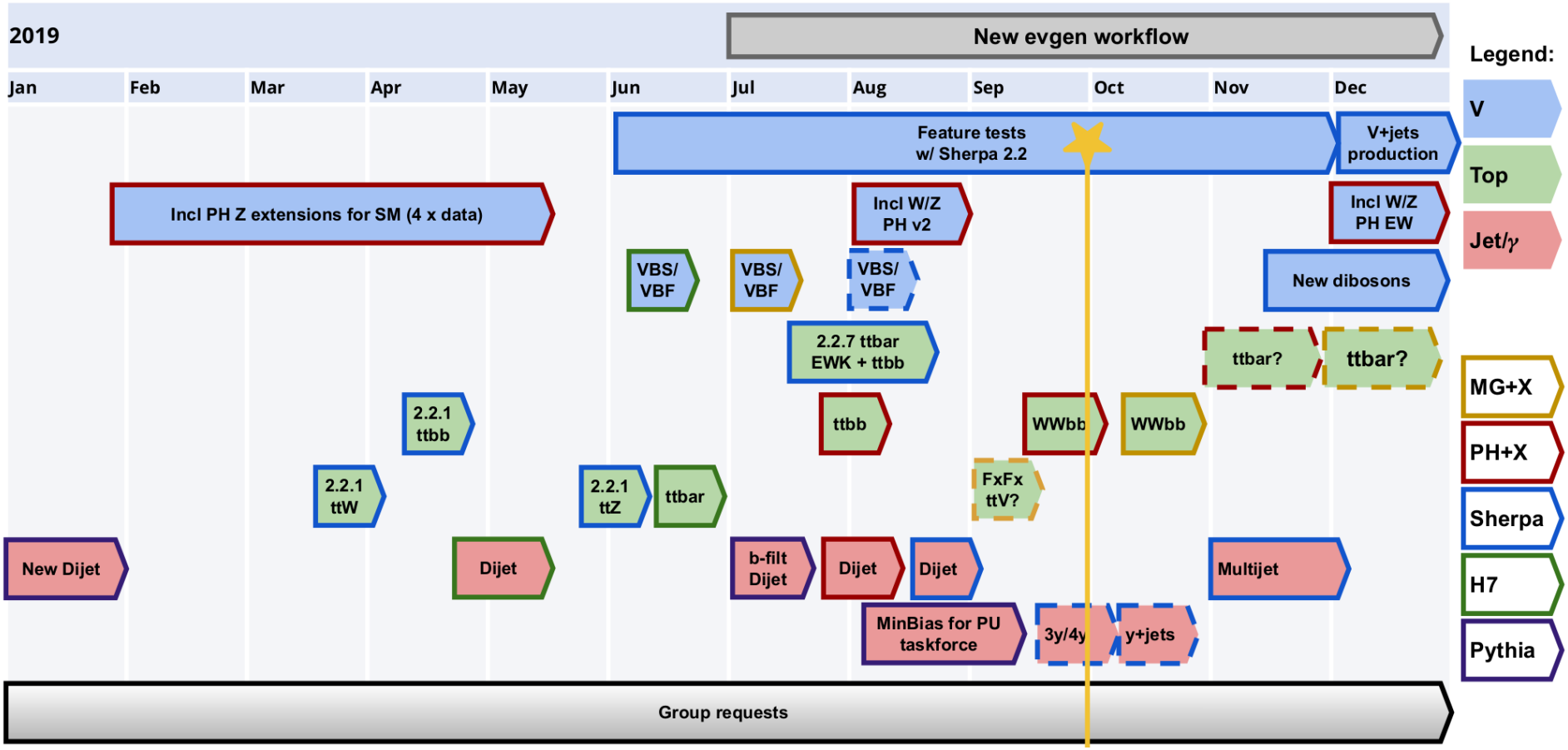
Fri 15:00



Thur 14:00

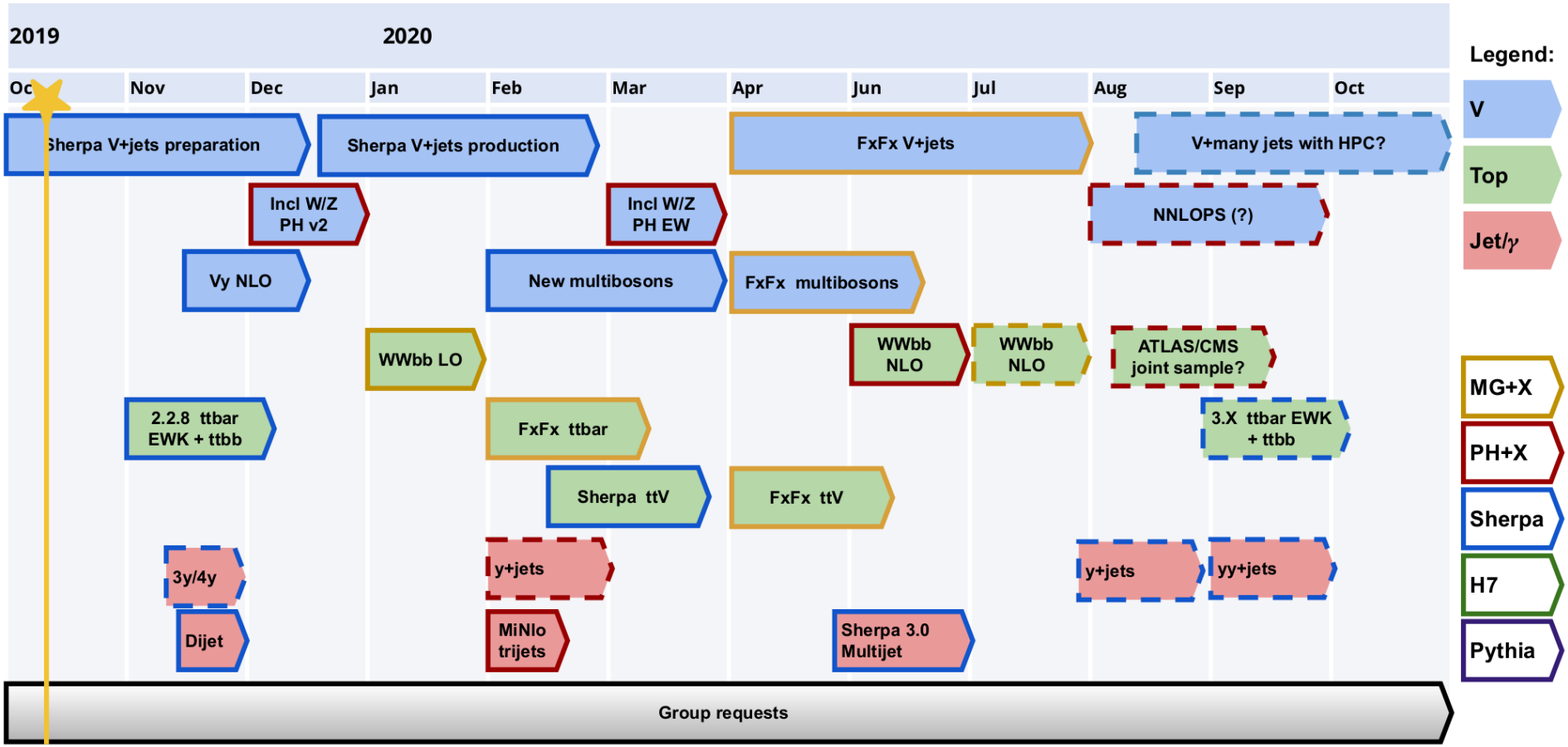


MC Production: Past Planning



- Very successful production, so far in 2019 $\sim$ 20B events
- Setting up new bulk-sample productions generally a challenge – several samples in validation phase

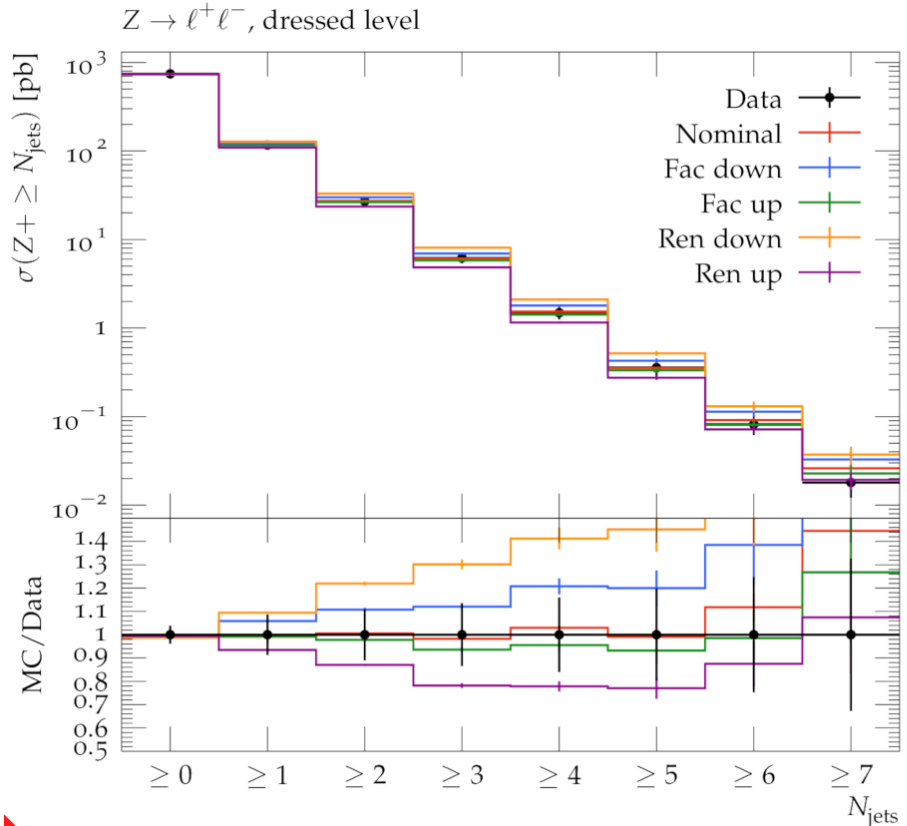
MC Production: Future

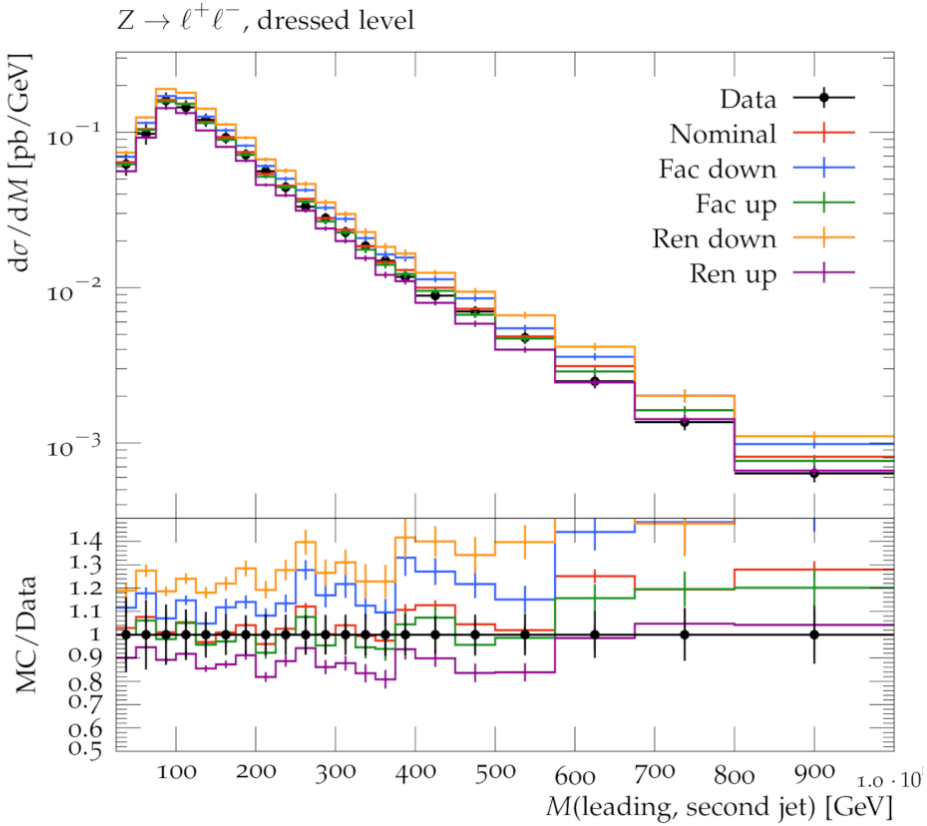


- Expecting a busy year 2020
- Make sure you make any requests you know of today as soon as possible
- Together with Sim@P1 available should have enough resources to produce not only new baseline samples, but also alternative configurations

V+jets (Sherpa)

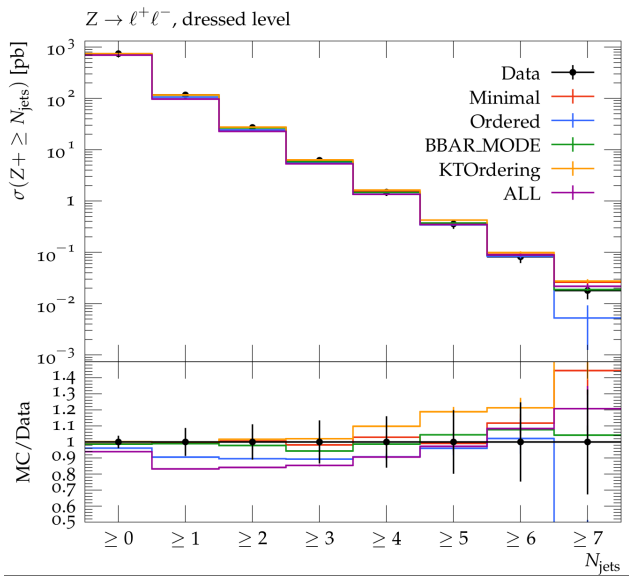
- Major effort to upgrade our bulk Sherpa V+jets sample to Sherpa 2.2.8 with many new features: validation advanced, AFII Z+jets test sample exist
- Technical improvements: optimised scale makes event generation by factor $2-3$ faster (for same physics), reduce negative weight fraction from 18% $\rightarrow$ 14% (saves 30% sim+reco CPU + storage)
- Physics improvements: coherent variation in ME+PS scales, NLO EW corrections, m_{jj} data/MC slope reduced, fusing with 4FS $Z + bb$ possible

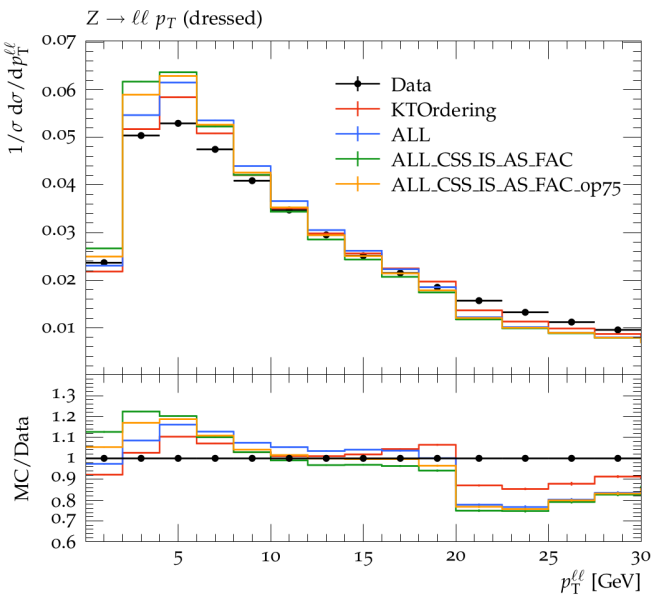


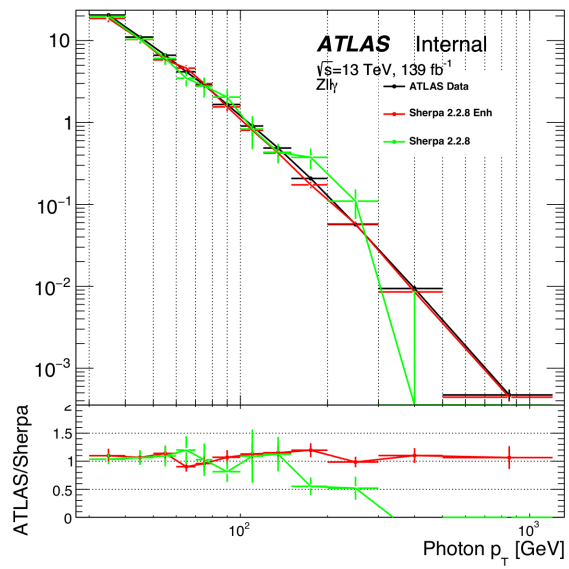


V+jets and $V\gamma$+jets (mostly Sherpa)

- "KTOrdering" configuration was beneficial for m_{jj}, but introduces new features → likely to go with the "minimal" configuration
- Finalisation of setup: aim to replace the `MAXPTVHT` slicing by phase-space biasing (`Enhance_observable`)
- $V\gamma$+jets: setting up NLO sample using `Enhance_observable` in $p_{T,\gamma}$ without the slicing issues encountered before



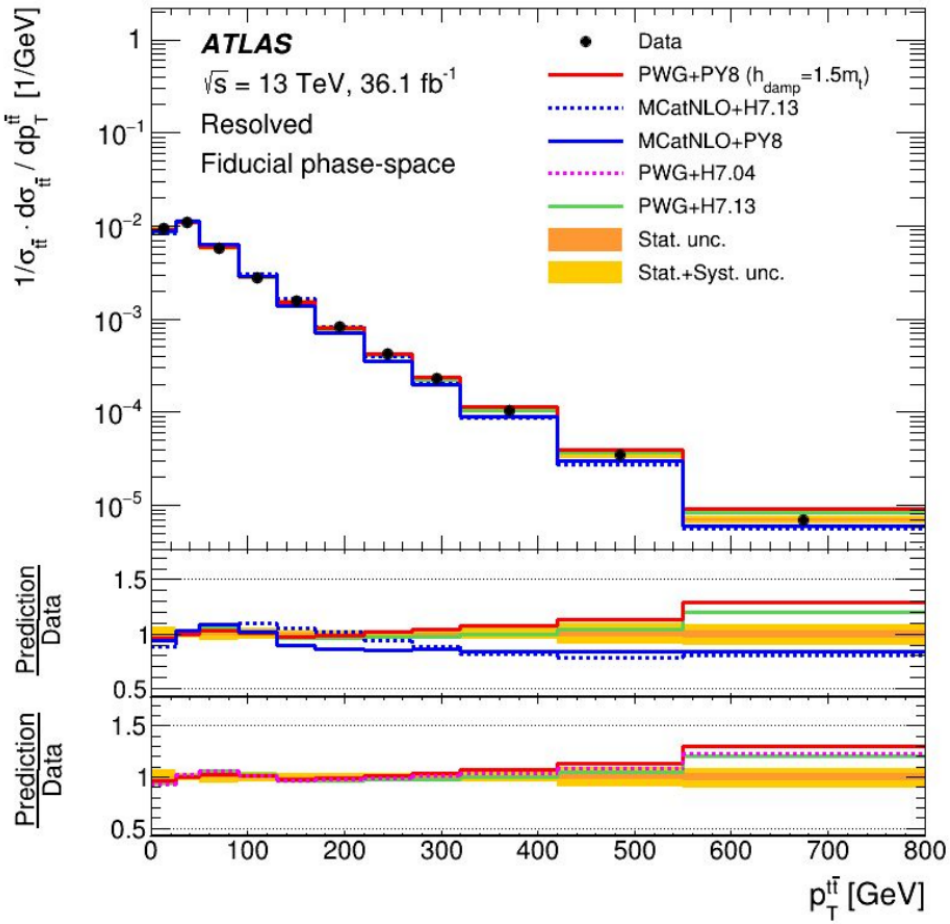


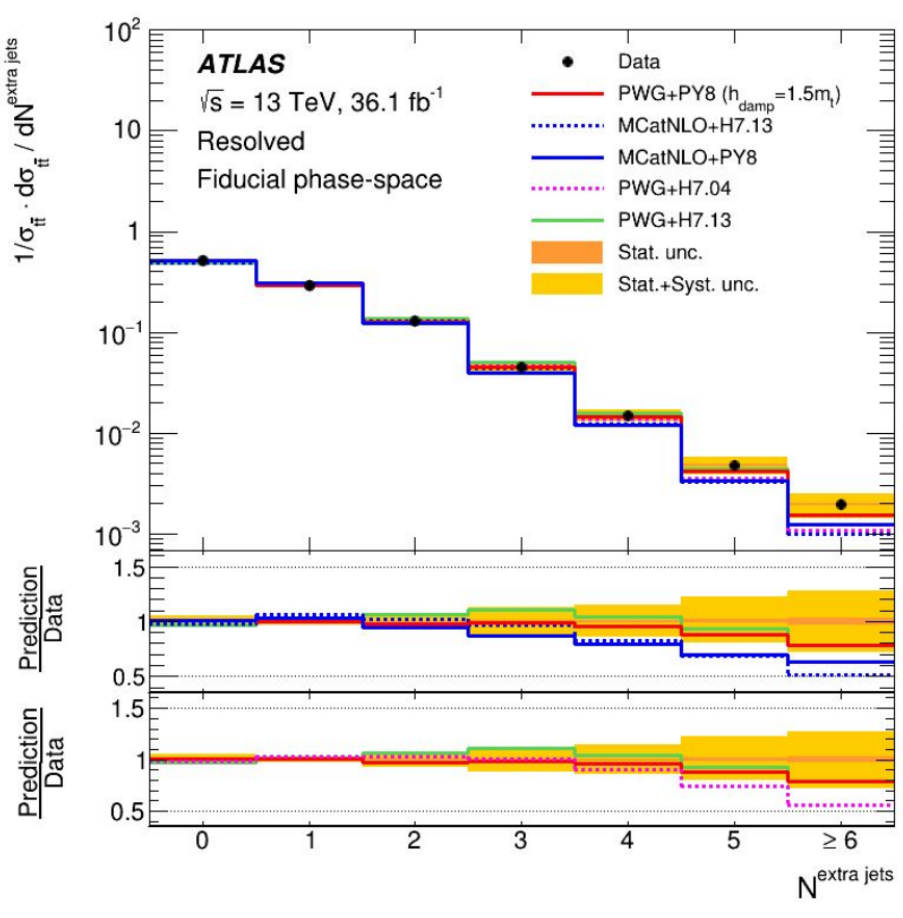


- V+jets alternatives:
  - MadGraph FxFx (up to 2 or 3 jets at NLO), considered also UNLOPS or Herwig7 MatchBox but technical issues and $\sim 40\%$ negative weights
  - Powheg with NLO EW, MiNNLO, Geneva

Top samples

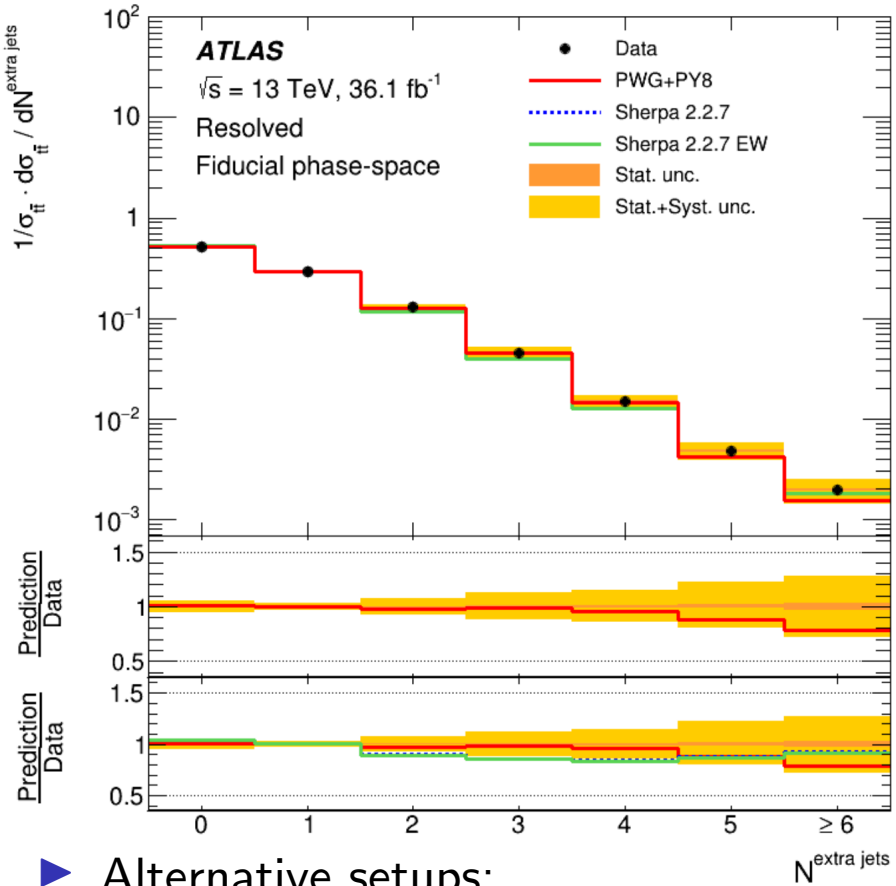
- Variety of new samples with Herwig 7.1.3 (also with different matching schemes and shower algorithms) that improve in modelling over older Herwig 7.0.4

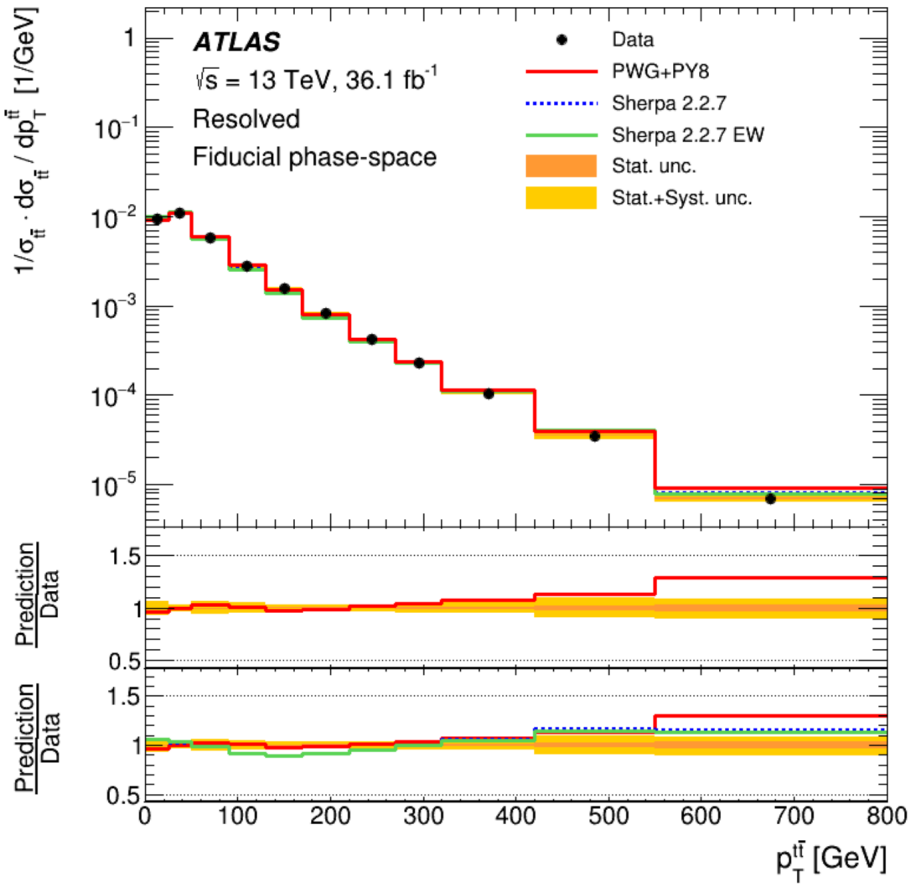




Top samples

- No multileg $t\bar{t}$+jets sample in MC16 so far, but converged on good Sherpa setup, meanwhile produced set of Sherpa 2.2.8 validation samples to gather feedback before going for production



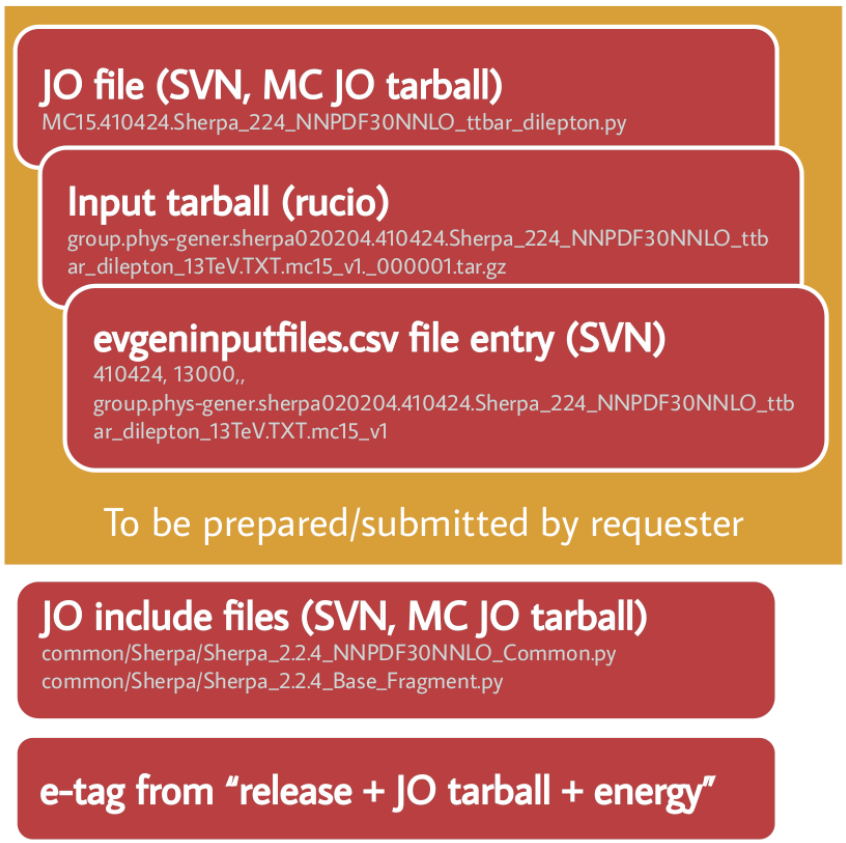


- Alternative setups:
  - FxFx $t\bar{t}$+jets
  - WWbb@NLO with Powheg and aMC@NLO: includes all offshell effects and removes ambiguity in separation of $t\bar{t}$ vs. tW real correction (DR/DS)

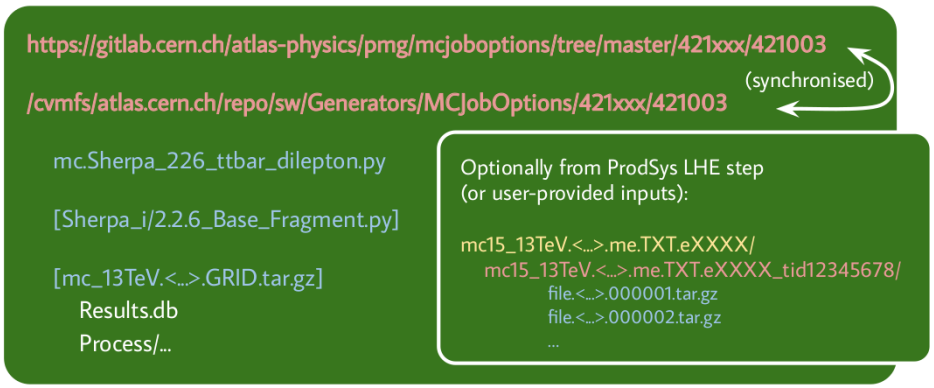
Workflow for Event Generation

- EVGEN migrated from rel. 19 & svn to rel. 21 & git
  - Most generators re-validated in rel. 21
  - Required for any new samples
- Setting up new workflow to improve automated checks during setup phase

Current structure:



New structure:



- Everything needed for one sample goes into a single cvmfs directory
- Use merge requests in GitLab for JO submission
- JO consistency checks in GitLab CI
- Automatic Athena test run with 1 event

Central Page

twiki.cern.ch/twiki/bin/view/AtlasProtected/CentralMC16ProductionList

Top

SingleTop

RareTop

V+jets

Zinc_ll samples

Zjets_ll samples

Baseline sliced

Sherpa_221_NN30NNLO_Zee_Mll10_40_MAXHTPTV

Sherpa_221_NN30NNLO_Zmm_Mll10_40_MAXHTPTV

Sherpa_221_NN30NNLO_Ztt_Mll10_40_MAXHTPTV

Sherpa_221_NNPDF30NNLO_Zee_MAXHTPTV — Evts = 255419100, σ[nb] ≈ 4.5905E-01, ε ≈ 4.2960E-01

Datasets found : 14 — Use % for wildcarding — Filter — Export

mc15_13TeV.364127.Sherpa_221_NNPDF30NNLO_Zee_MAXHTPTV1000_E_CMS — Evts = 3919700, σ[nb] ≈ 1.4875E-04, ε ≈ 1.0000E+00 — jobOption

mc15_13TeV.364126.Sherpa_221_NNPDF30NNLO_Zee_MAXHTPTV500_1000 — Evts = 11739800, σ[nb] ≈ 1.8092E-03, ε ≈ 1.0000E+00 — jobOption

- New dynamic page based on AMI technology – metadata directly available
- Work ongoing to also display EVNT and AOD information
- Samples categorised with 4 levels of “hashtags”
- Do not be afraid to give feedback and report errors in classification

Documentation

- Occasionally PMG releases PUB notes with detailed documentation of (new) sample setups, see Public results page

- New document with example descriptions and references for use in ATLAS publications:
  - Compiled version on CDS https://cds.cern.ch/record/2678867 – feedback/corrections welcome
  - Link to git repository
  - Detailed physics and content review in last months – **ready for use**
  - Will be integrated into ATLAS Latex package soon, so editors can easily integrate this into their papers
  - To be updated frequently with newly produced samples

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2 Single-boson processes

In the following paragraphs, the setup of the current ATLAS single-boson baseline samples are described. Details on the full process configuration are given in the PUB note [5]. In the case of Sherpa samples, a minimal description of built-in systematic uncertainties is also given.

2.1 Sherpa (MEPS@NLO)

2.1.1 QCD V+ jets

Samples

The descriptions below correspond to the samples in Table 1.

DSID range	Description
364100-364113	Zmumu
364198-364203	Zmumu (Mll10-40)
364359,364362,364281	Zmumu (Very low mass)
364114-364127	Zee
364204-364209	Zee (Mll10-40)
364358,364361,364282	Zee (Very low mass)
364128-364141	Ztautau
364210-364215	Ztautau (Mll10-40)
364282,364360,364363	Ztautau
364142-364155	Znunu
364156-364169	Wmunu
364170-364183	Wenu
364184-364197	Wtaunu
364216-364229	Z,W→ e,mu,tau (high p_T)

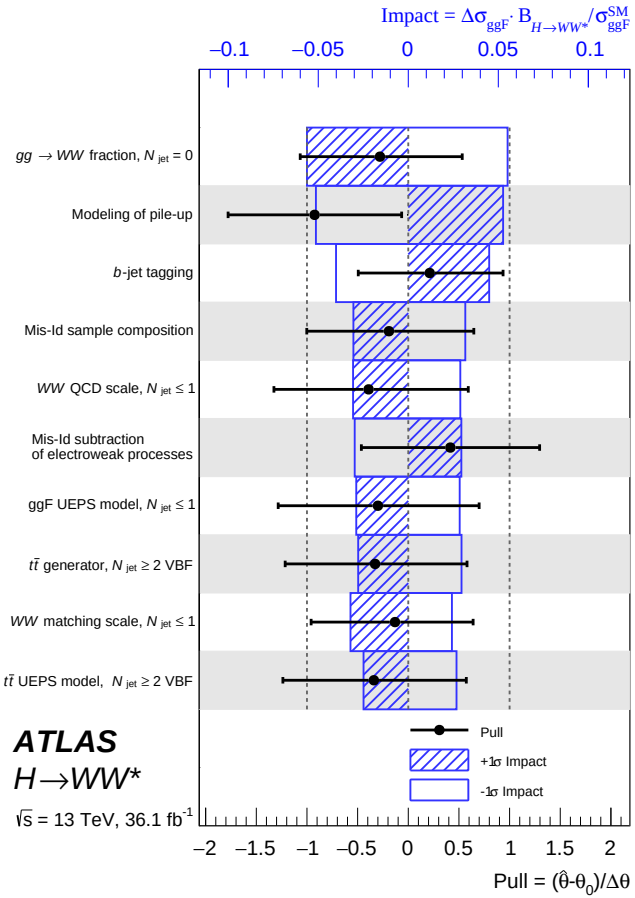
Table 1: V+jets samples with Sherpa

Short description

The production of V+jets is simulated with the Sherpa v2.2.1 [6] generator using NLO-accurate matrix elements for up to two jets, and LO-accurate matrix elements for up to four jets calculated with the Comix [7] and OpenLoops [8, 9] libraries. They are matched with the Sherpa parton shower [10] using the MEPS@NLO prescription [11–14] using the set of tuned parameters developed by the Sherpa authors. The `NNPDF3.0nnlo` set of PDFs [15] is used and the samples are normalised to a next-to-next-to-leading order (NNLO) prediction [16].

Theory uncertainties — and usage in fits

- "Standard recipes" documented on on subgroup TWiki pages, see general prescriptions and process-specific links from main PMG page
- Reminder on PMGSystematicsTool:
  - Currently able to combine variations directly from on-the-fly-weights or ROOT-format inputs
  - Extension to systematics through other samples in progress
- Theory-related uncertainties by now leading in many ATLAS analyses, important to remember that some are educated guesses and should not be over-interpreted
  - E.g.: using "scale variations" or Pythia/Herwig differences to construct correlated uncertainties (and constrain them) can be problematic
  - Lively discussion in September P&P week: following up and aim to conclude at December Workshop with more concrete recommendations



Other ongoing work in GIT

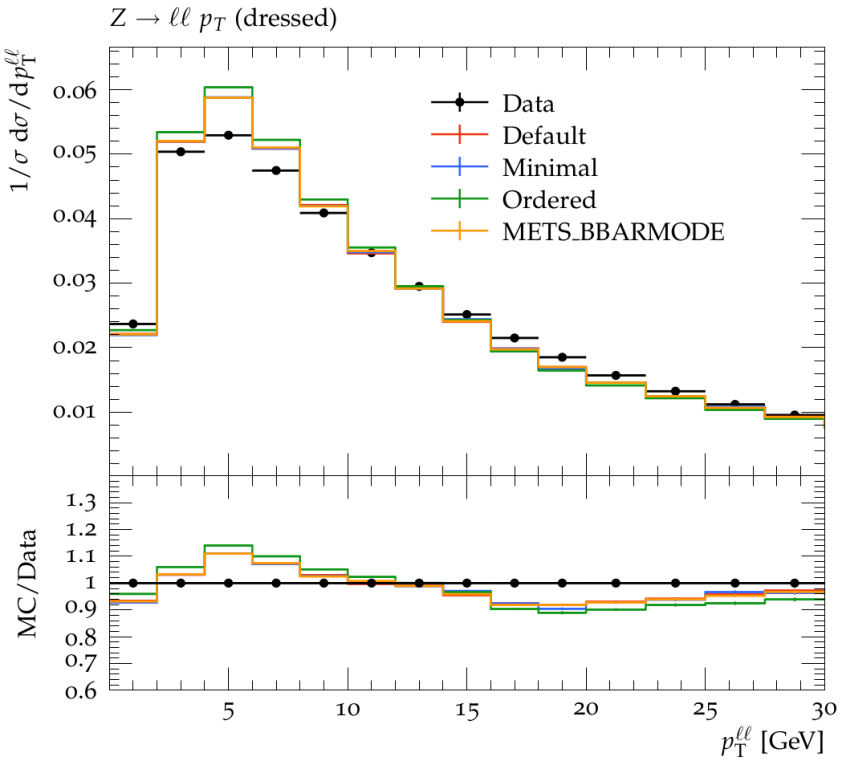
- PMGTruthWeightTool is now integrated into the AthAnalysis Systematics workflow
- Ongoing effort to review definition of truth objects following recommendations of 2014 Truth Particle Workshop to reduce generator dependence
- Effort to parametrise uncertainties which are not currently stored as OTF weights: could eventually lead to reduced processing time if we don't need to reconstruct so many alternative samples
- Ongoing effort to synchronise OTF eight names across generators - recent progress with MadGraph

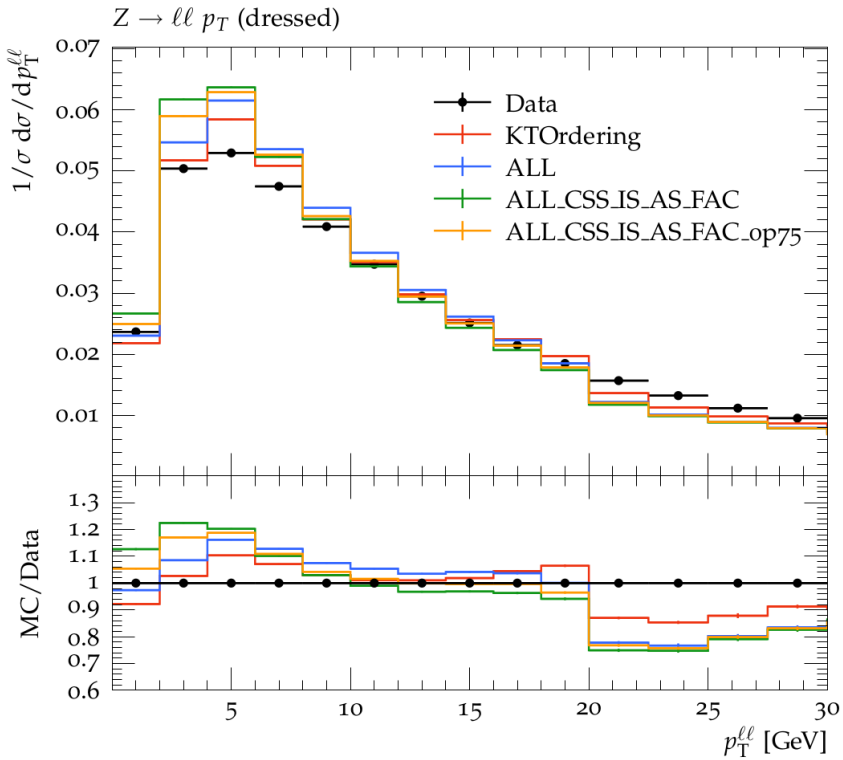
Conclusion

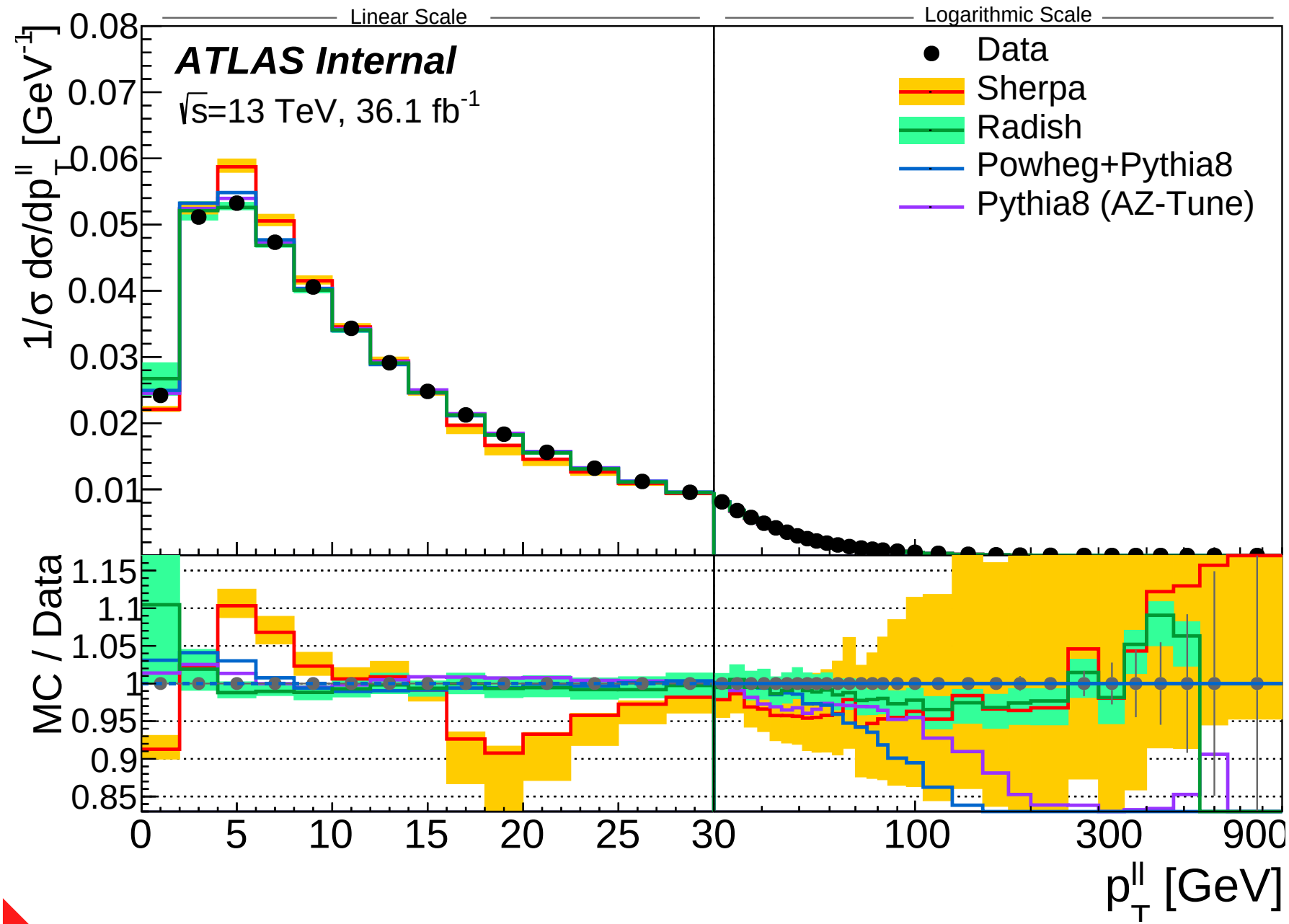
- Modern MC generators and knowledge on usage essential for measurements and searches — join the efforts!
- Successful production and/or converging on new setups for V+jets, $t\bar{t}$, multijets...
- Ease life of analysers through documentation and tools
  – so you have more time to think how to deal best with theory uncertainties

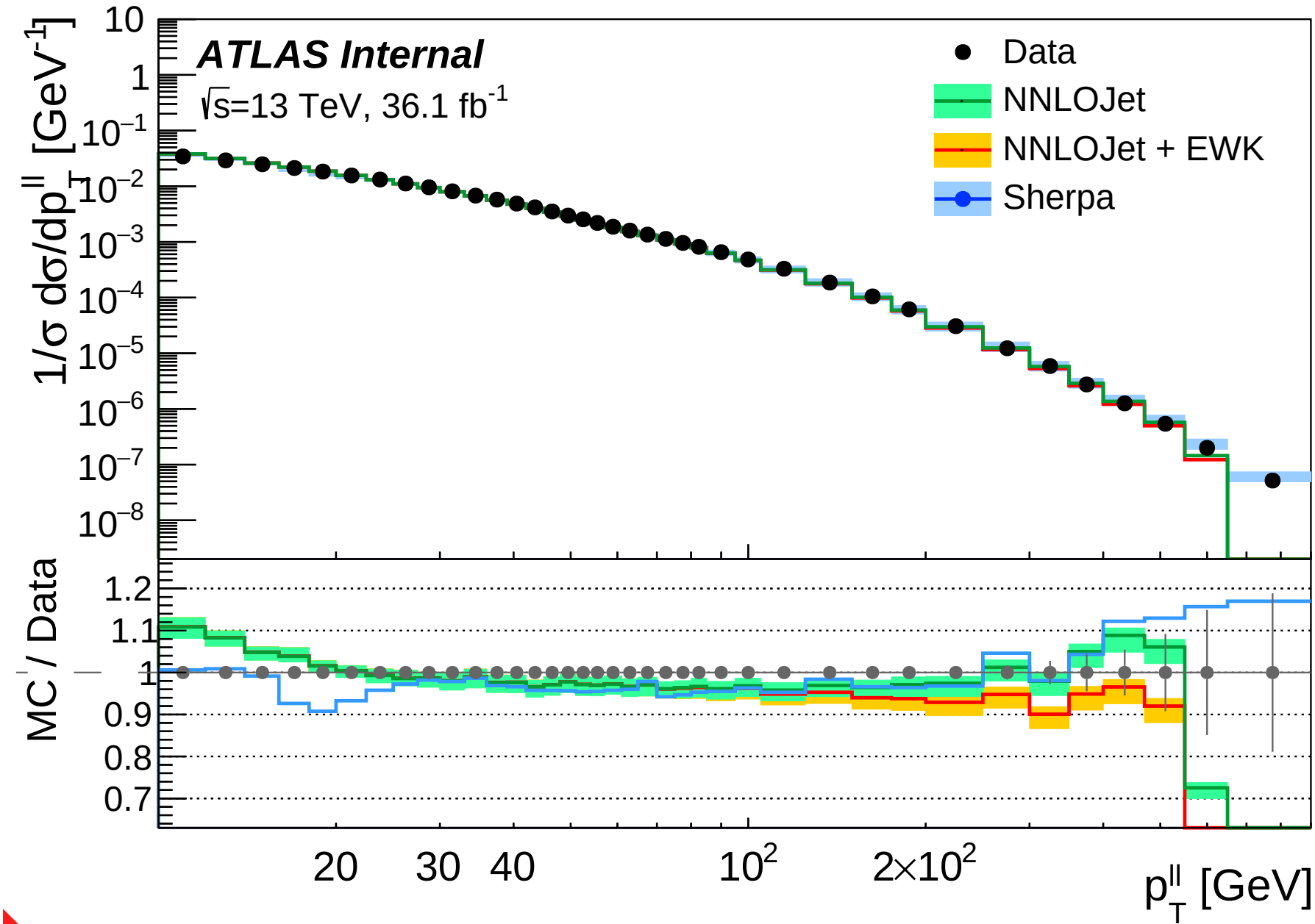
Backup

$p_{T,\ell\ell}$


$Z \to \ell\ell$ p_T (dressed)
$1/\sigma\ \mathrm{d}\sigma/\mathrm{d}p_{\mathrm{T}}^{\ell\ell}$
Data
Default
Minimal
Ordered
METS_BBARMODE
MC/Data
$p_{\mathrm{T}}^{\ell\ell}$ [GeV]


$Z \to \ell\ell$ p_T (dressed)
$1/\sigma\ \mathrm{d}\sigma/\mathrm{d}p_{\mathrm{T}}^{\ell\ell}$
Data
KTOrdering
ALL
ALL_CSS_IS_AS_FAC
ALL_CSS_IS_AS_FAC_op75
MC/Data
$p_{\mathrm{T}}^{\ell\ell}$ [GeV]


Linear Scale
Logarithmic Scale
ATLAS Internal
√s=13 TeV, 36.1 fb-1
Data
Sherpa
Radish
Powheg+Pythia8
Pythia8 (AZ-Tune)
1/σ dσ/dp_T^ll [GeV^-1]
MC / Data
p_T^ll [GeV]


ATLAS Internal
√s=13 TeV, 36.1 fb-1
Data
NNLOJet
NNLOJet + EWK
Sherpa
1/σ dσ/dp_T^ll [GeV^-1]
MC / Data
p_T^ll [GeV]
10
1
10^-1
10^-2
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
1.2
1.1
1
0.9
0.8
0.7
20
30
40
10^2
2×10^2

Short-term Improvements for $t\bar{t}$

- Despite improvements during Run2, modelling of $t\bar{t}$ a major issue for many analyses ($\rightarrow$ talks by A. Knue and J. Kempster on Monday)
- NLO+PS "matching uncertainty" aMC@NLO+Pythia8 vs. Powheg+Pythia8: spuriously large due to different Pythia8 shower settings
- Move to aMC@NLO+Herwig7 vs. Powheg+Herwig7
- Explore splitting ISR/FSR shower uncertainties by physical processes: $g \rightarrow gg$, $g \rightarrow q\bar{q}$, $g \rightarrow Q\bar{Q}$, $q \rightarrow qg$ etc.