WG1 parallel session summary

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Alicia Calderon Tazon (CMS), Giovanni Marchiori (ATLAS)

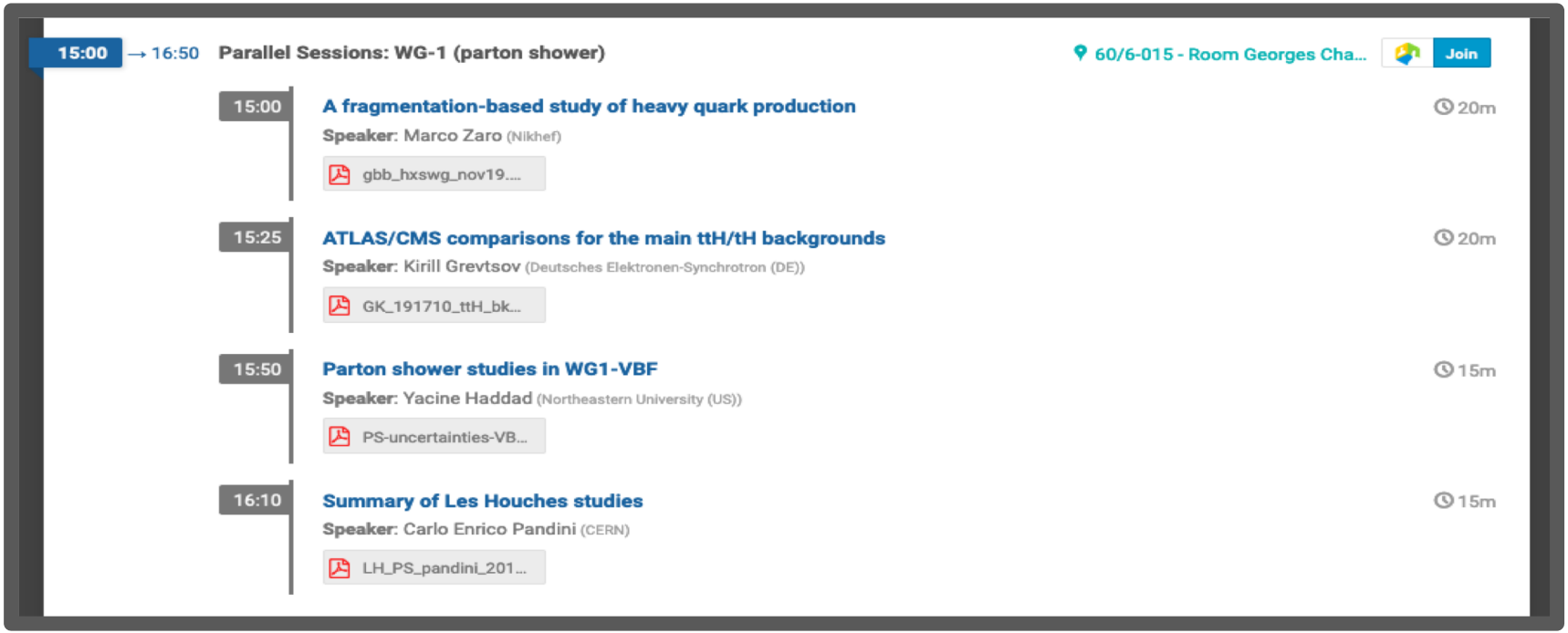
Intro

- WG1 parallel session dedicated to follow up on PS studies
- Main goal is to converge on an agreed procedure to estimate parton shower uncertainties.
- First dedicated meeting during last June. https://twiki.cern.ch/twiki/bin/view/LHCPhysics/PartonShowerUncertaintiesXSWG1
- We have a dedicated e-group: lhc-higgs-xsbr-ps@cern.ch .

  If you are interested please join it!

Overview

- Mixture of theoretical and experimental talks summarizing recent work.



Overview

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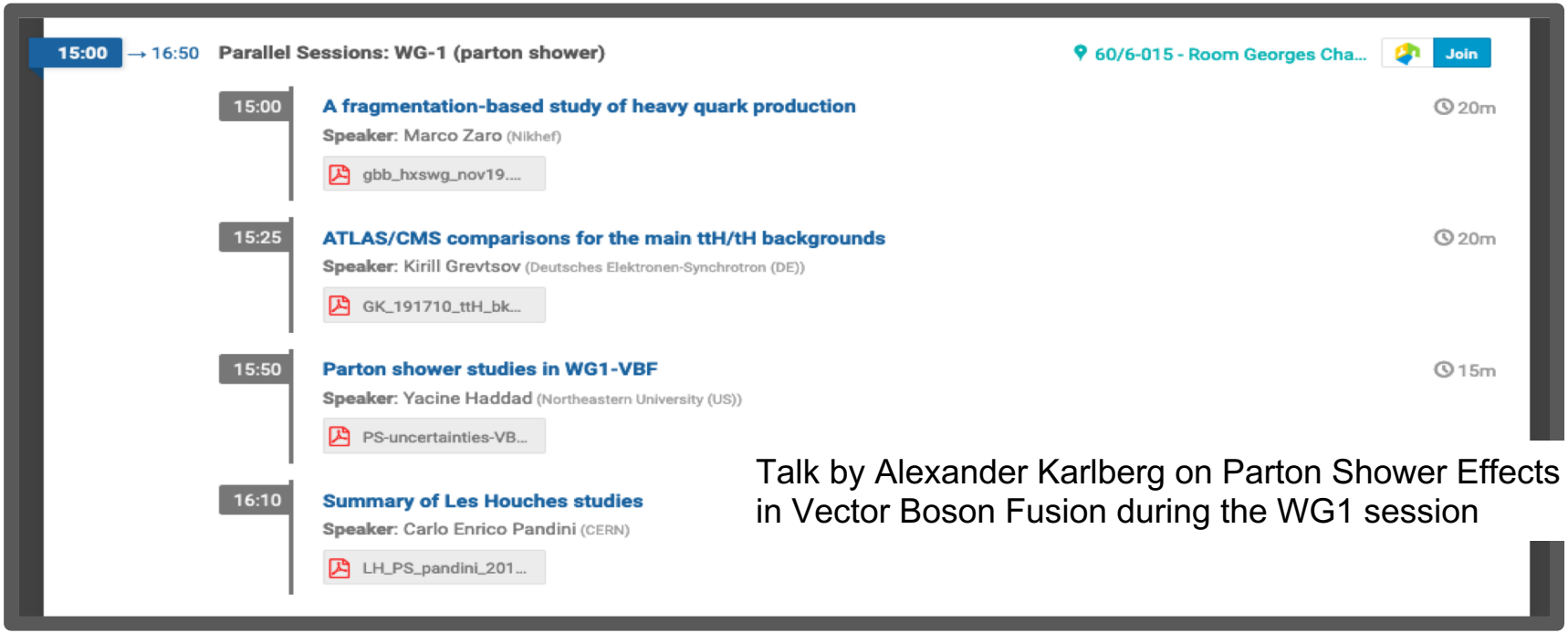


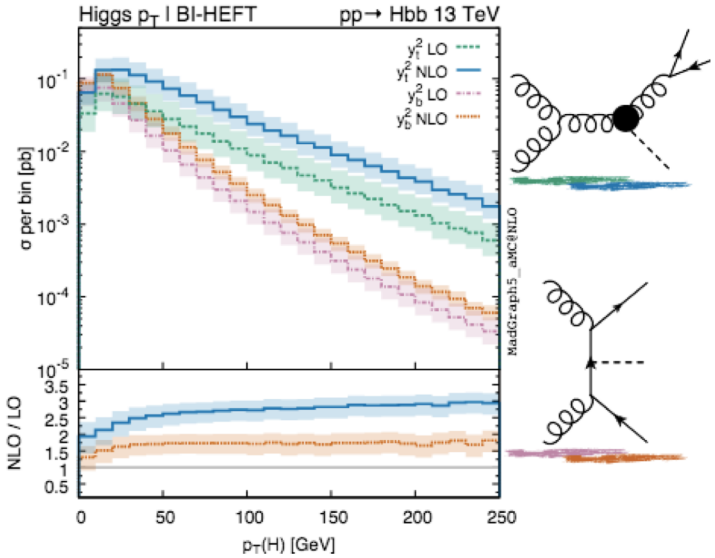
Talk by Alexander Karlberg on Parton Shower Effects in Vector Boson Fusion during the WG1 session

M. Zaro

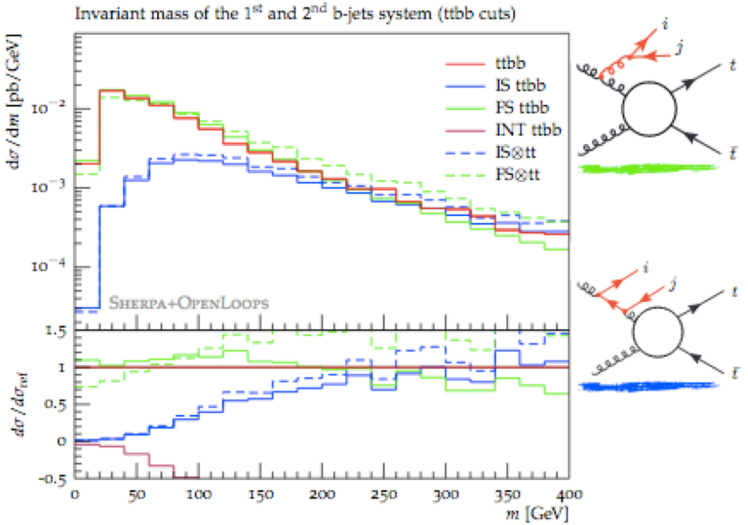
Fragmentation effects in g→bb

- Processes relevant for Higgs physics receive large contributions from topologies with final-state g→bb̄ splittings

On example is ggH+bb̄, which dominates Hbb̄ production
Maltoni, Deutschmann, Wiesemann, MZ, arXiv:1808.01660



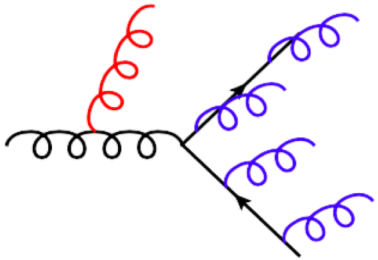
Another one is ttbb is one example: FS splittings dominant in most PS
Jezo et al, arXiv:1802.00426



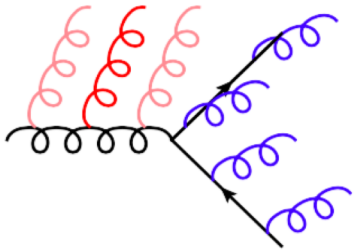
M. Zaro

Fragmentation effects in g→bb

- Is it appropriate to simulate these splittings at the matrix-element level?
- Important for Higgs analyses: ttbb background to ttH and bbH signal.



NLO+PS



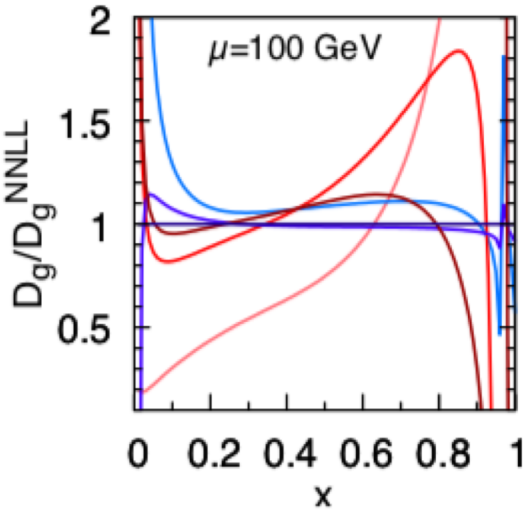
QCD evolution

Only one emission from parent gluon at NLO, additional radiation in NLO+PS only from b's

Extra radiation off parent gluon missing if b quarks generated at ME level, even at NLO+PS →How important is it?

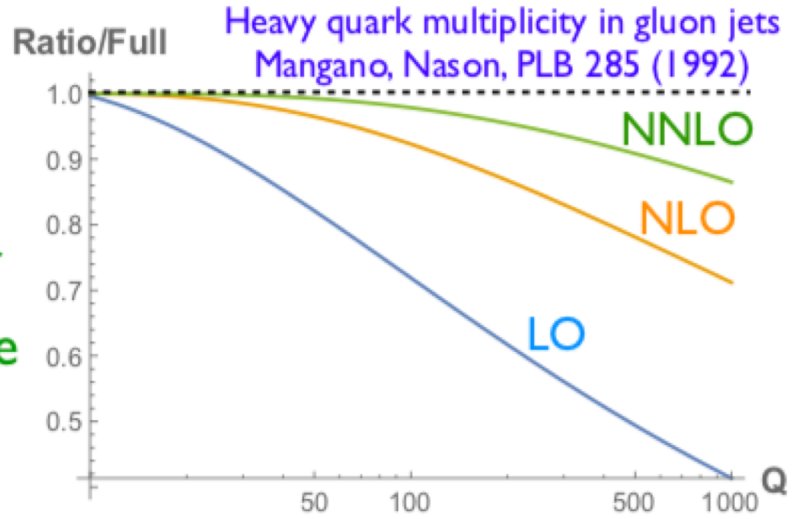
Importance can be assessed using fragmentation functions
Include colinear emissions at all-order resummation of $\log(\mu/m_b)$, here to NNLL

Exclusive vs. inclusive



Exclusive

Inclusive

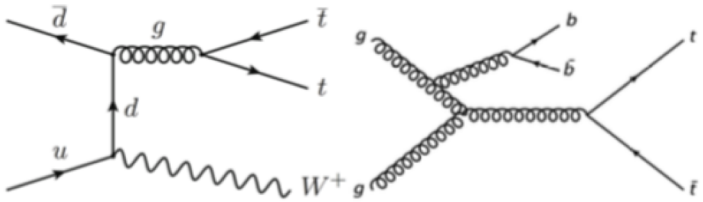


- NLO has large differences with resummed result
- Much better agreement at NNLO, largely due to extra radiation from parent gluon.
  - Suggests ttbb+jet good reference for ttbb
- Can this mis-modelling have effects on relevant observables?
- Previous results indicate much smaller differences inclusively.

K. Grevtsov

ATLAS and CMS backgrounds for ttH

- Monte Carlo generator comparisons of main background modelling for $t\bar{t}H$ analyses:
  - $ttH(bb)$: $t\bar{t}b\bar{b}$
  - $ttH(ML)$: $t\bar{t}W$



- Objective of this study:
  - Compare modelling and theory uncertainties in the relevant analysis regions
  - Define common theory uncertainties to be used for the full Run2 combination

- Content:
  - Samples ATLAS/CMS
  - Common fiducial phase space definition and observables
  - First very preliminary combined ATLAS+CMS distributions will be presented
    - $ttbb$
    - ttW

K. Grevtsov

ATLAS and CMS backgrounds for ttH

- • Nominal (ATLAS/CMS); ○ used to derive uncertainty in $ttH(bb)$; + part of this study;

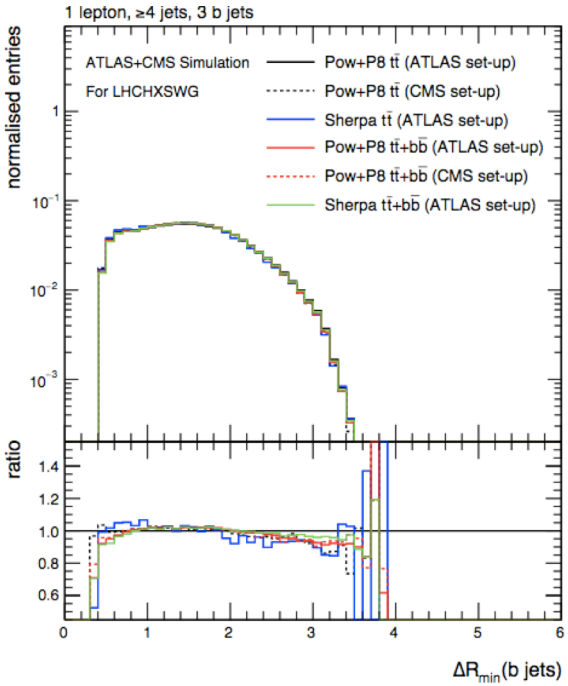
Exp	Proc	Gen	ME order	PS	PDF	Tune
•	$t\bar{t}$	Powheg v2	NLO	Pythia 8	5FS NNPDF3.0 NLO	A14
•	$t\bar{t}$	Powheg v2	NLO	Pythia 8	5FS NNPDF31 nnlo as 0118	CMS CP5
+	$t\bar{t}b\bar{b}$	Powheg-Box-Res	NLO	Pythia 8	4FS NNPDF3.0 NLO	A14
+	$t\bar{t}b\bar{b}$	Powheg-Box-Res	NLO	Pythia 8	4FS NNPDF31 nnlo as 0118 nf 4	CMS CP5
○	$t\bar{t}b\bar{b}$	Sherpa 2.2.1	NLO	Sherpa	4FS NNPDF3.0 NNLO	Sherpa def
○	$t\bar{t}$	Sherpa 2.2.1	0,1@NLO+2,3,4@LO	Sherpa	5FS NNPDF3.0 NNLO	Sherpa def

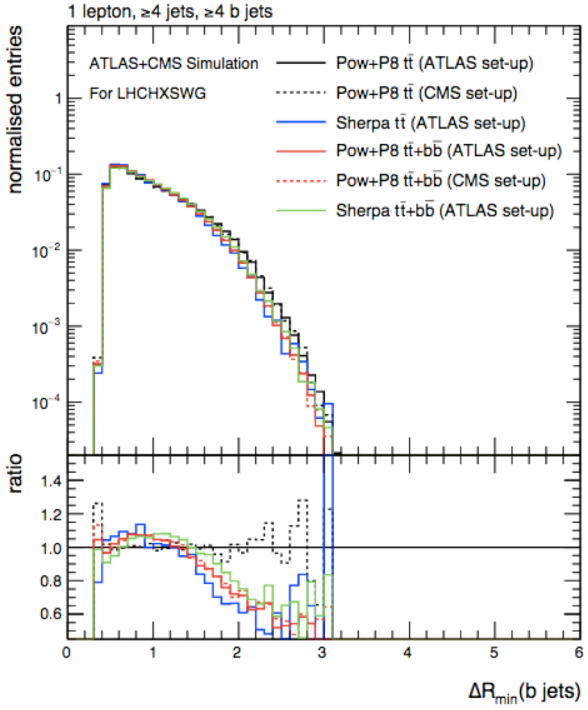
- Samples for ttW process: (• = Nominal; ○ = variation, ATLAS/CMS);

Exp	Generator	ME order	PS	PDF	Tune
•	Sherpa 2.2.1	MEPs@Nlo (0,1j@NLO+2,3@LO)	Sherpa	NNPDF3.0 NNLO	Sherpa default
•	MG5_aMC FxFx	NLO (0,1j@NLO+ 1,2j@LO)	Pythia 8	NNPDF3.0 NNLO	CMS TuneCUETP8M1
○	MG5_aMC	NLO (0j@NLO+ 1j@LO)	Pythia 8	NNPDF3.0 NLO	A14

K. Grevtsov

ATLAS+CMS combined: ttbb





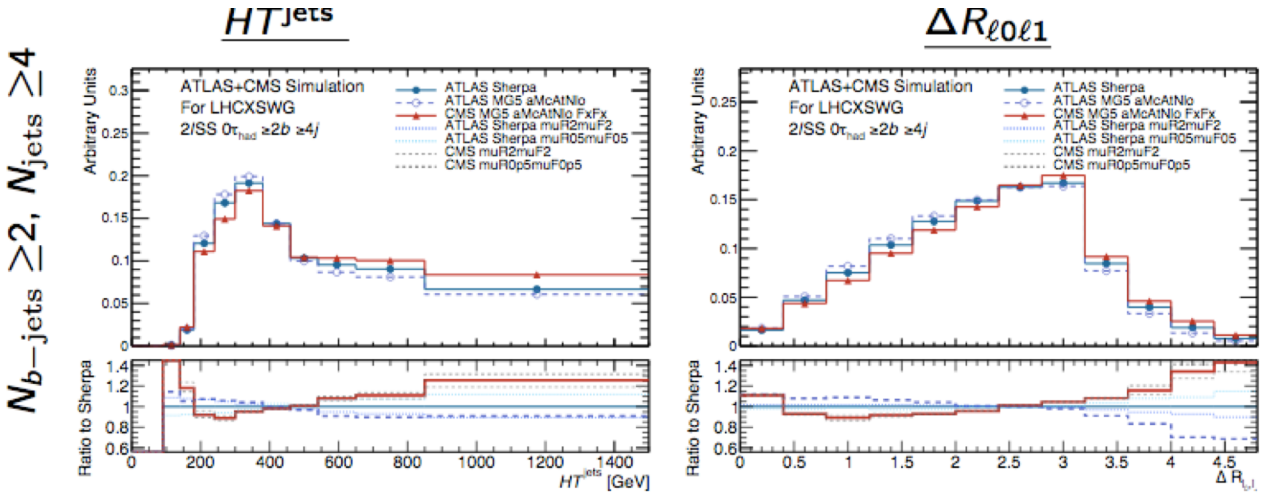
Relatively small uncertainties, fairly well understood

Significant differences observed between the PS and the ME calculations

More work needed (ongoing work in ttH subgroup)

K. Grevtsov

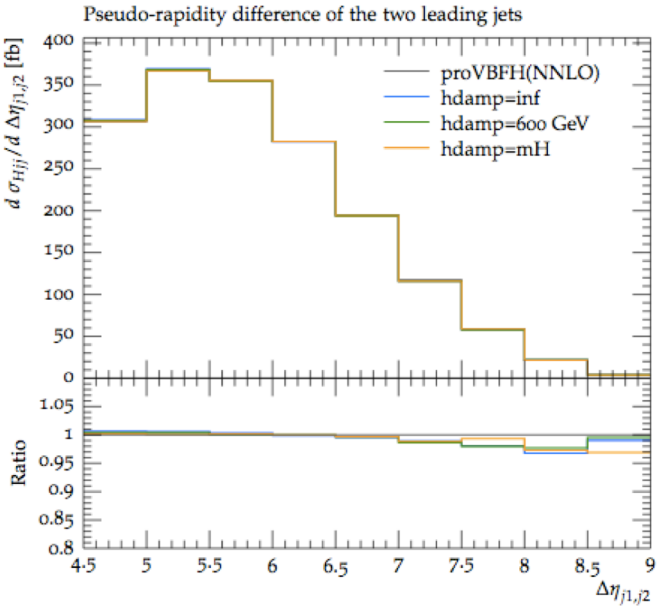
ATLAS+CMS combined: ttW



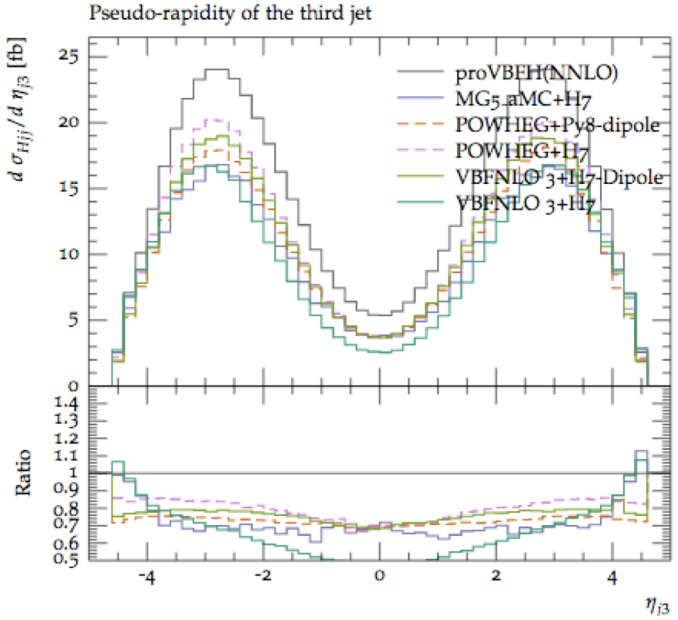
- Differences between three generators are within 20% and within the uncertainties of the scale variations of Sherpa
- The difference seen between ATLAS and CMS in these observables may point to a systematic difference
- Further validation is needed to ensure the two experiments are implementing exactly the same selection

A. Karlberg

Parton Shower Effects in VBF



VBF in-sensitive to NLO matching prescription (interfaced to PY8 with dipole recoil)



- Very sensitive to recoil scheme
- Dipole type recoil schemes (both PY8 and H7) give much better agreement with fixed order (NNLO)

Y. Haddad

Parton shower studies in VBF

- **HERWIG 7 Parton Shower and matching studies in VBF**
  - More details see Alexander's slides

[S. Plätzer, A. Karlberg and al.]

- **Pythia 8 Impact of PS variations on VBF observables using Automatic variations**
  - Impact of parton shower tune parameters
  - Exploring other shower paradigms: such as Dire and Vincia
  - Traitement of the uncertainties in measurement (correlation with hard process?)

[Y. Haddad, A. De Maria and al.]

- **Sherpa has implemented a fix for VBF-like process**
  - Will be public in the next releases of Sherpa
  - Similar studies as for H7 and Py8

[G. Singh Chahal and al.]

- **Comparison between different showers:**
  - Pythia8 (string) vs Herwig/Sherpa (Cluster)
  - Angular vs Dipole ….

[Y. Haddad, A. De Maria and al.]

A lot of projects -- let the VBF group know if you want to help!

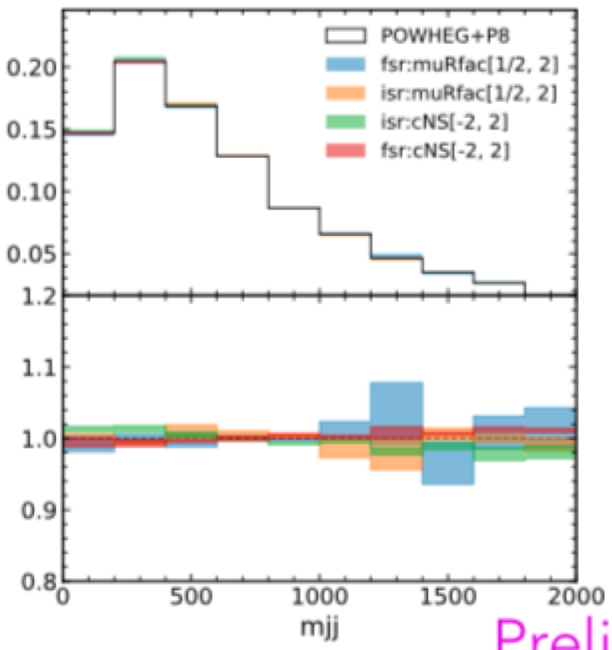
Yet to be done

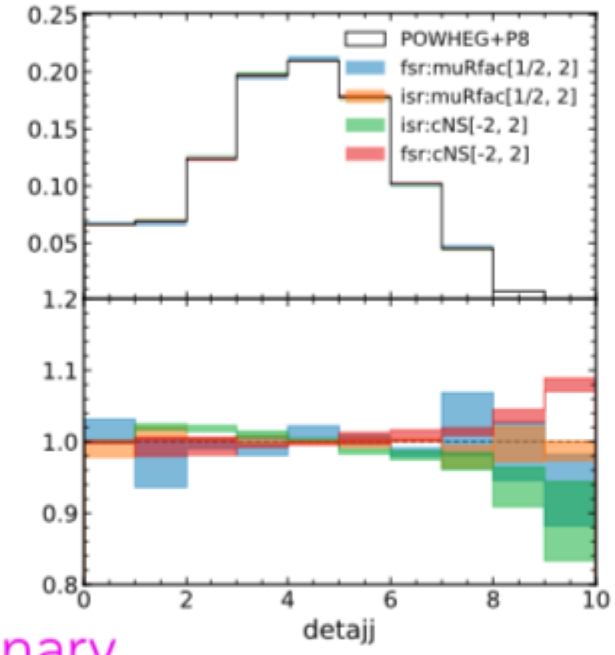
Ongoing

Y. Haddad

Example: automatic variations in Pythia8

POWHEG NLO + Pythia8 PS, with uncertainty estimation per Mrenna & Skands ‘16





Preliminary

Select events with at least 2 anti-kT jets with R=0.4 and pT(jet) > 30 GeV

Most variations at the 5-10% level

Should they be treated independently, or take envelope?

Synergy with Les Houches studies

- Heavy overlap with projects started this year - the more the merrier!
- Ambitious project with plenty of room for everyone:
  theory (MC authors) and experiment (feasibility for MC users).

Project #1: Theory Nomenclature for MC variations

- comprehensive **list of parameter variations** in General Purpose MC+PS
- **common naming convention** for variations across different tools / codes
- exact interpretation of "variation X", and which phenomena it influences
- **correlation** scheme among variations
- constraints / suggested ranges / "good practices" for each variation
- examples of set of MC variations relevant for different cases (possibly with plots)
  (e.g. QED shower for bare leptons, hadronization for small-R jets, MPI for large-R jets, etc.)

C. Pandini

Case studies

Project #2: Case Study of MC variations *(trying to apply Project #1 to a useful case:* ***ttbar****)*

- ttbar case study, 2-3 observables to be selected
- consider different central setups ("N-points") of {FO/matching/merging accuracy), PS model, NP model}
- for each setup define envelope of MC variations (~based on Project #1)
    1. **does it behave as expected?**
       (e.g. dependence on NP model in region dominated by hard physics, too large dependence on shower model, other signs of inconsistencies, ...)
    2. **does it overlap across central setups? if not, can we understand if it's expected?**

Going towards properly defining what we call "UEPS" uncertainty (at least for one test case)

Another case study along the same lines, with a Higgs focus, should be promoted by the LHCHXSWG; VBF seems a natural choice.