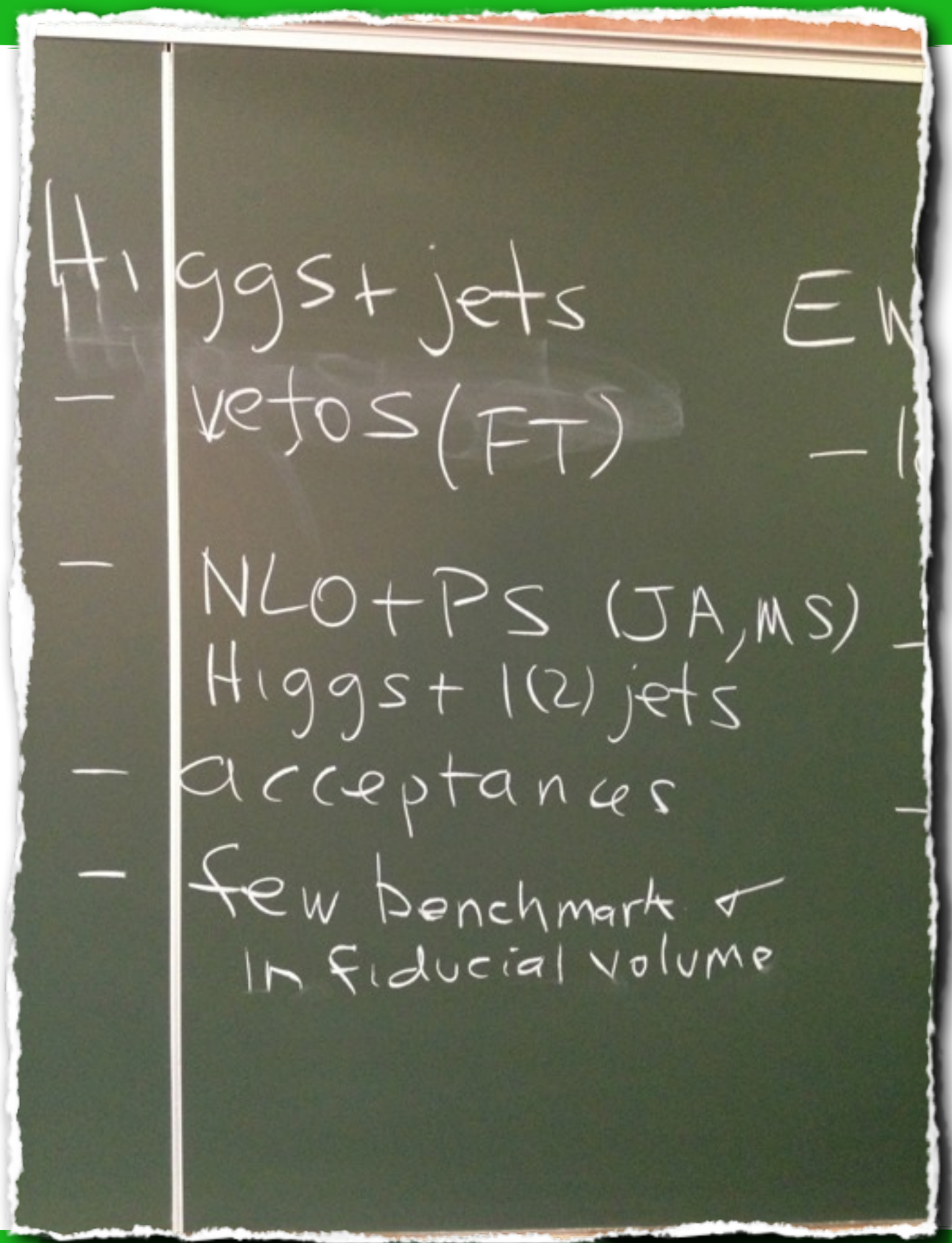
Tools & MC summary

Convenors: Jon Butterworth, Frank Krauss

Jets contact person: Gregory Soyez
MCNLO contact person: Keith Hamilton

Apologies for any overlap with preceding talks / omissions

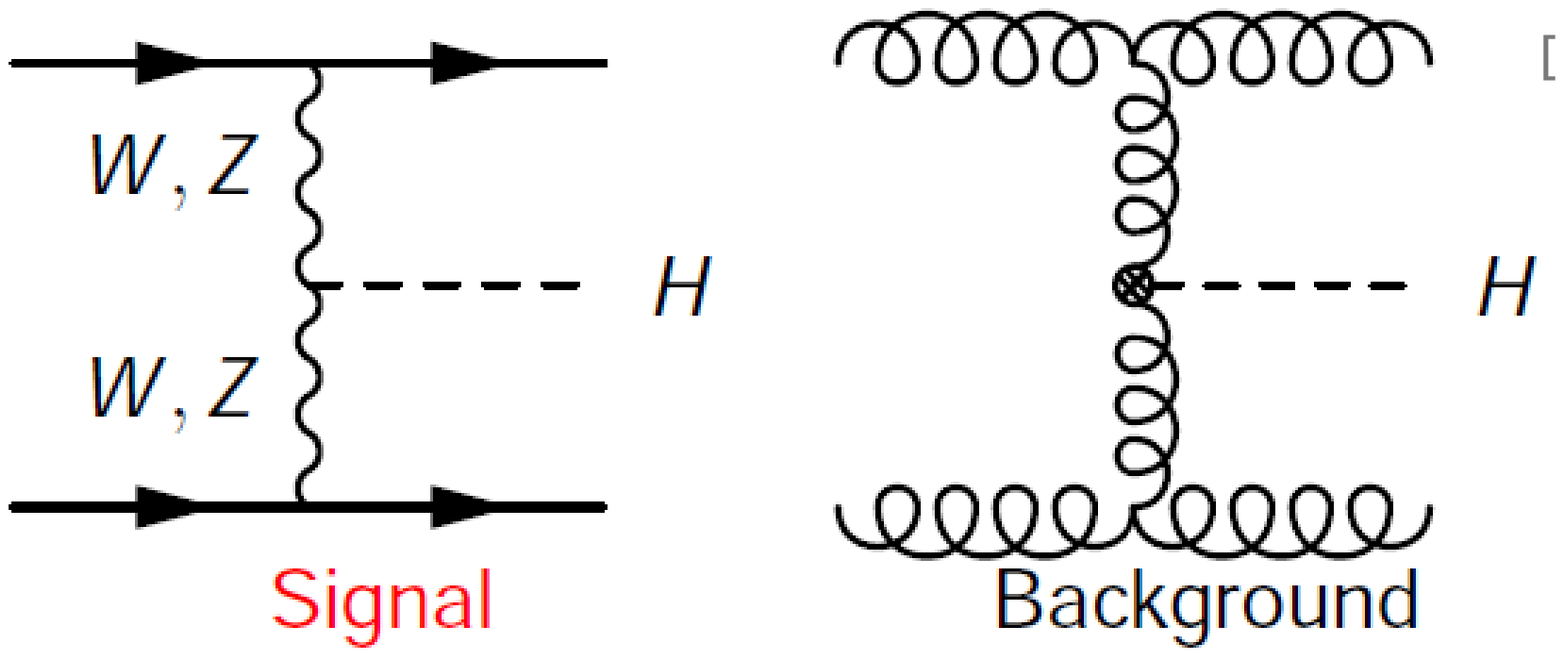

Higgs+jets
vetos (FT)
NLO+PS (JA,MS)
Higgs+1(2) jets
acceptances
few benchmark
in fiducial volume

Higgs + jets

- Popular topic with interesting discussions

Higgs + jets

- Significant ~irreducible bkg^{d} to VBF H is gg → H+jets



[© Jeppe Andersen]

- Estimate gluon fusion contamination in VBF Higgs prod^{n}
- What's the uncertainty?
- Altogether a v. complicated multi-layered problem ...

Higgs + jets

- It's characterised by a lot of physical scales:

$$p_\perp(j_1), p_\perp(j_2) > 25 \text{ GeV (anti-kt, } R = 0.4, \eta < 5)$$

$$m_{jj} > 400 \text{ GeV}, \Delta_y > 2.8$$

$$p_\perp(j_3) > 20\text{GeV}$$

$$m_H$$

- And in the Monte Carlos also other unphysical ones

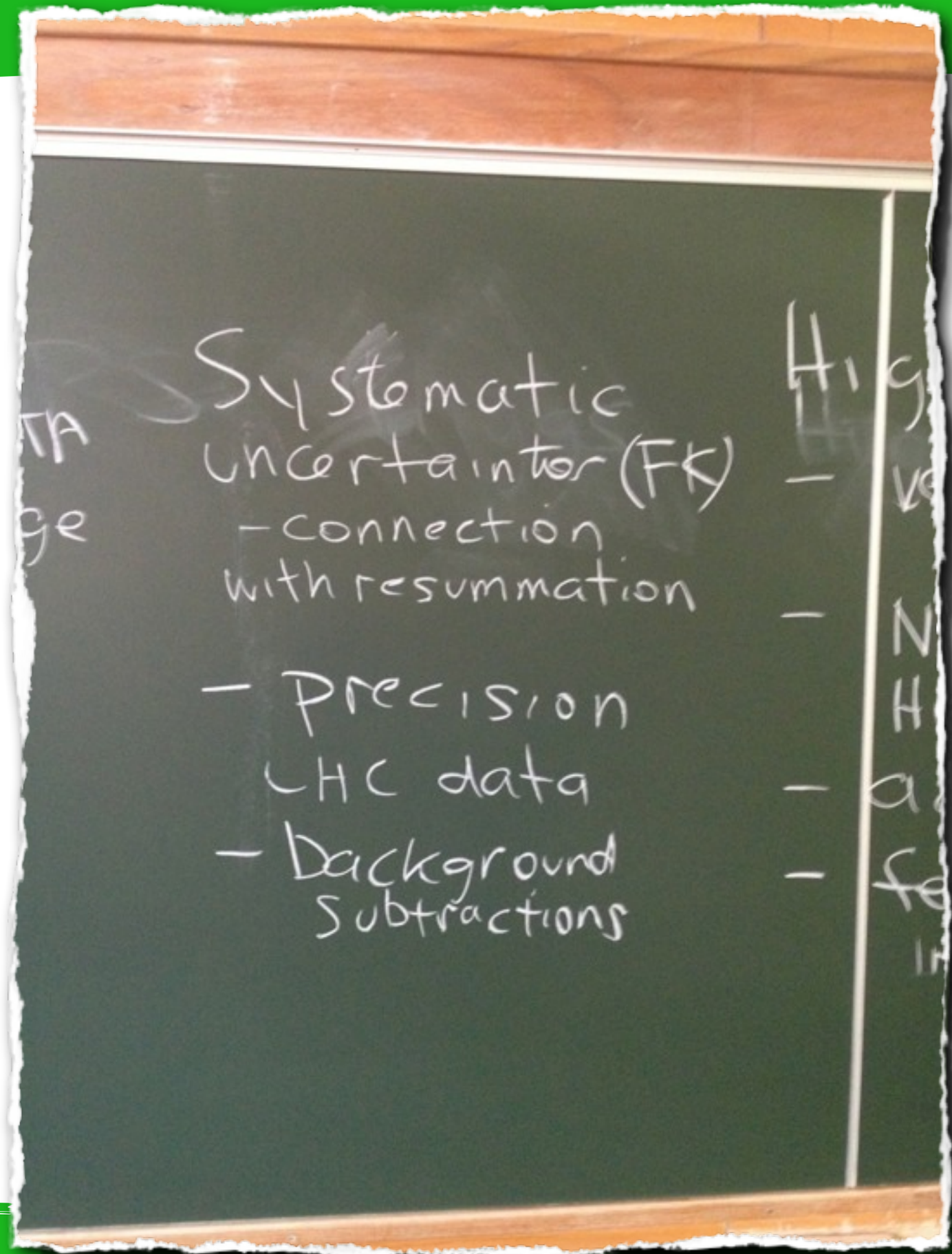
$$\mu_R \quad \mu_F \quad \mu_Q \quad Q_{\text{cut1}} \quad Q_{\text{cut2}}$$

- Probes a funny region of phase space [large m_{jj} Δy]

- Complicated colour, resum 3rd jet, shwr matching, &c &c

Higgs + jets

- Very complicated but with very rich physics content
- Start study w. latest MCs HEJ, UMEPS, UNLOPS, MEPS@NLO
  [coordinators: Jeppe Andersen, Marek Schönherr]
- Assess systematics in the methods
- Develop solid understanding of differences, rather than descriptive
- Comprehensive write-up planned for proceedings


Systematic
uncertainties (FK)
- connection
with resummation
- Precision
LHC data
- Background
subtractions

MC systematic uncertainties: scale var. in PS

- Shift in baseline accuracy of MCs in last 10+ yrs mandates they also spit out uncertainty reflecting it

- Are we doing things the ‘right’ way when doing scale variations in PS and NLO+PS Monte Carlo?

- Typically scale in the hard matrix elements only is varied

- Scale in the Sudakov form factor isn’t touched

MC systematic uncertainties: scale var. in PS

- Vary scale in α_S in the Sudakov form factor by $^1/_2$,1,2, as in fixed order - breaks NLL accuracy

  [for cases where the Sudakov is NLL accurate]

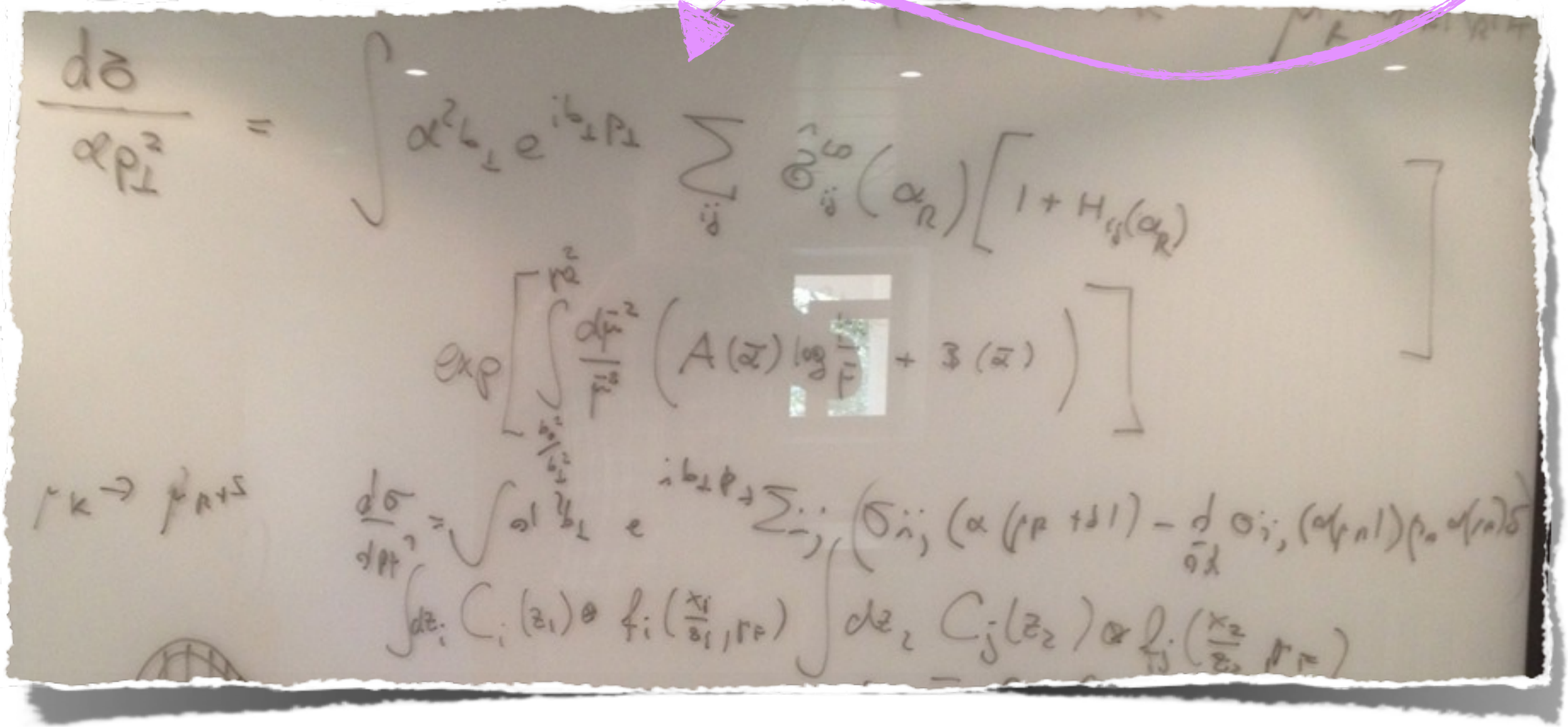
- Problem routinely dealt with in dedicated resummation calculations since forever ...

- How to propagate solution to fully-excl NLO+PS event generators now being thought about

- Dedicated calculat^{n}s are obs-specific, specialised, regularly formulated in conjugate space: how to realise in gen. excl. probabilistic algorithm? Not obvious

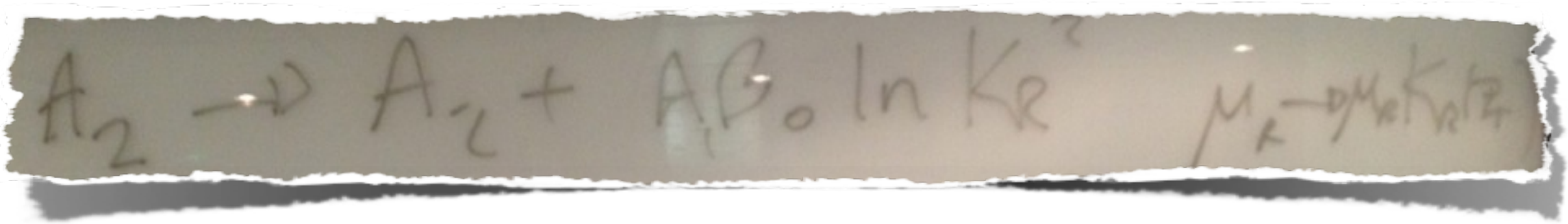
MC systematic uncertainties: scale var. in PS

- Discussions: Frank K with expert input from de Florian, Forte, Monni, Tackmann & company
- Take, as a guide, CSS-like scale variat^{n} and try to translate to the PS MC algorithm



MC systematic uncertainties: scale var. in PS

- Beginnings of simple practical prescript^{n} emerge
- Fully correlated scale variation of μ_R, μ_F in matrix element and partons shower
- Implement μ_R compensation term in shwr Sudakov exponent



[factor multiplying 1/1-z]; preserves $\alpha_S L^2$, $\alpha_S L$ bits

- μ_F variation as naive expectation
- Investigate profile of μ_R rescaling w.r.t splitting p_T
- Investigate correspondence w. SCET approaches

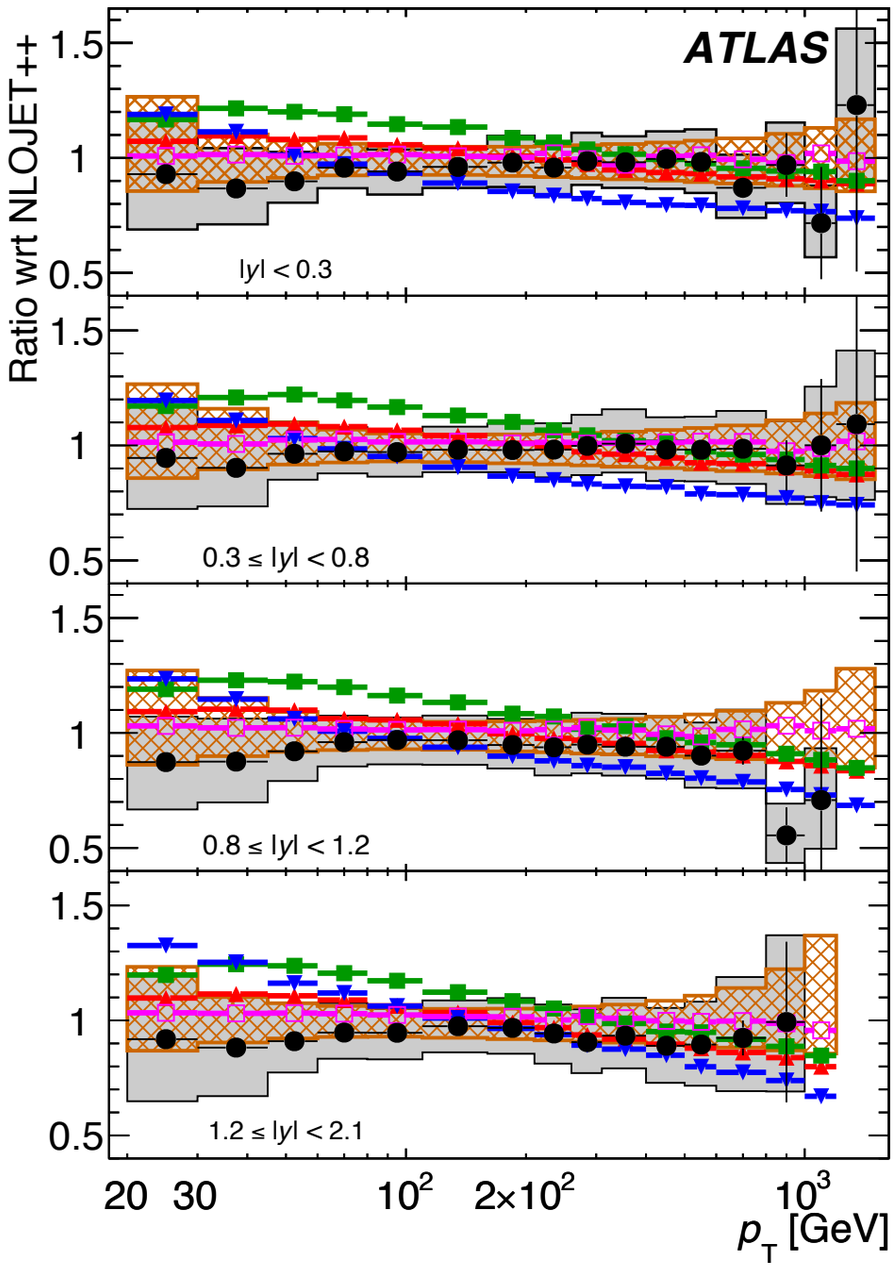
MC systematic uncertainties: Jet production

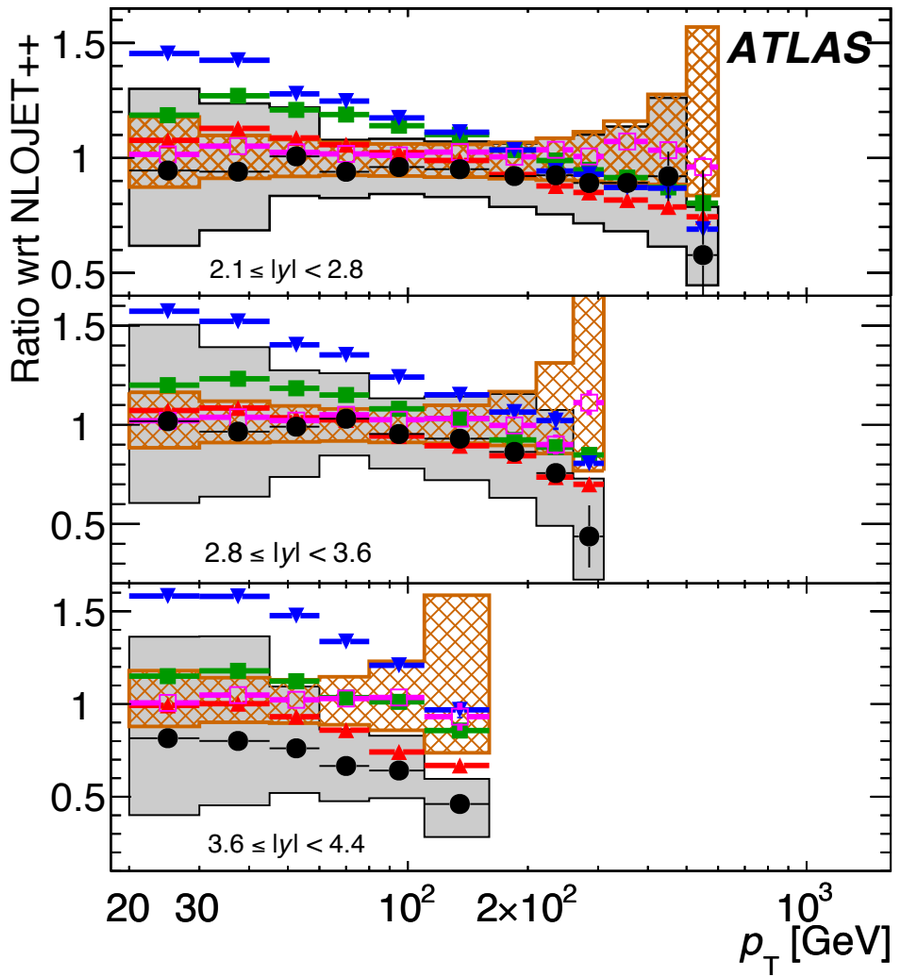
Jets: NLO+PS vs NLO vs LHC Data.

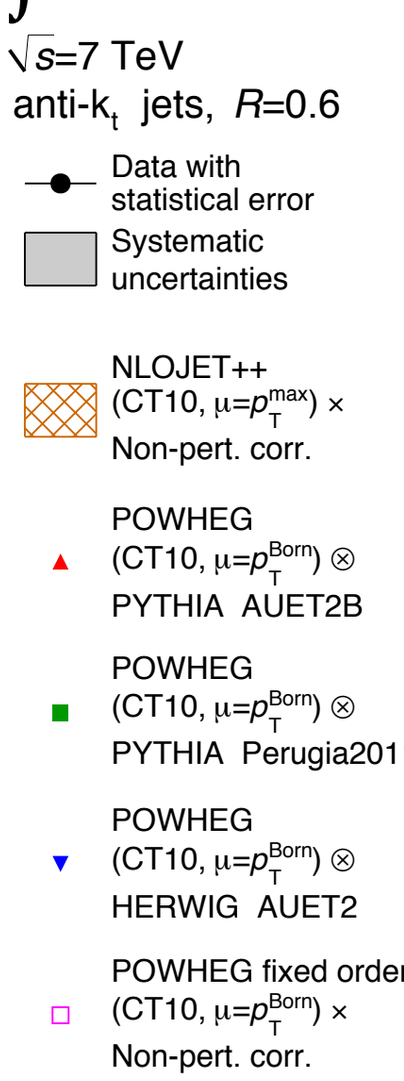
MC systematic uncertainties: Jet production

- We kept it simple & stuck mainly w. the inc. jet xsec
- The hydrogen atom [of jet physics]
- You would like to be able to understand well what you see here in approaching more complicated processes.
- Andy Buckley, Klaus Rabbertz, Simon Plätzer, Frank K & Marek, Leif Lönnblad, Stefan Prestel.

MC systematic uncertainties: Jet production



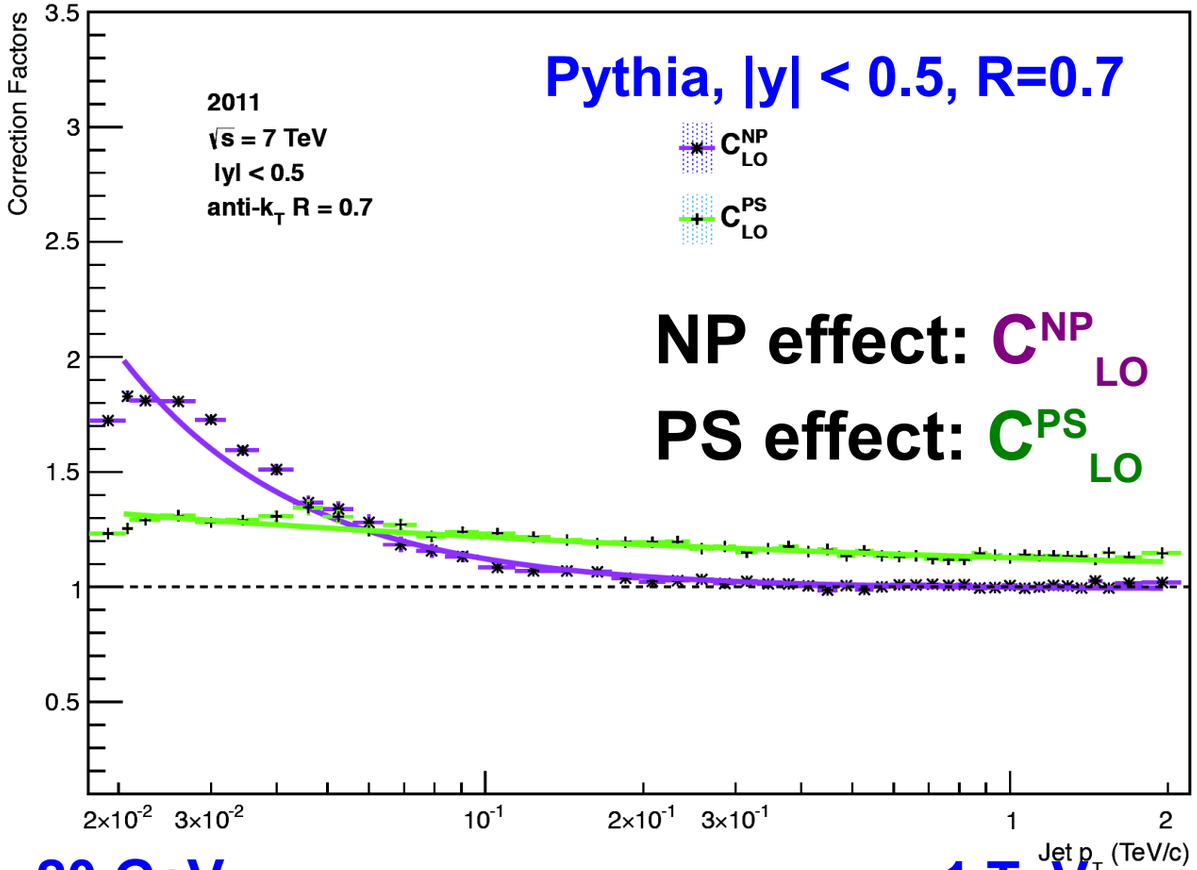




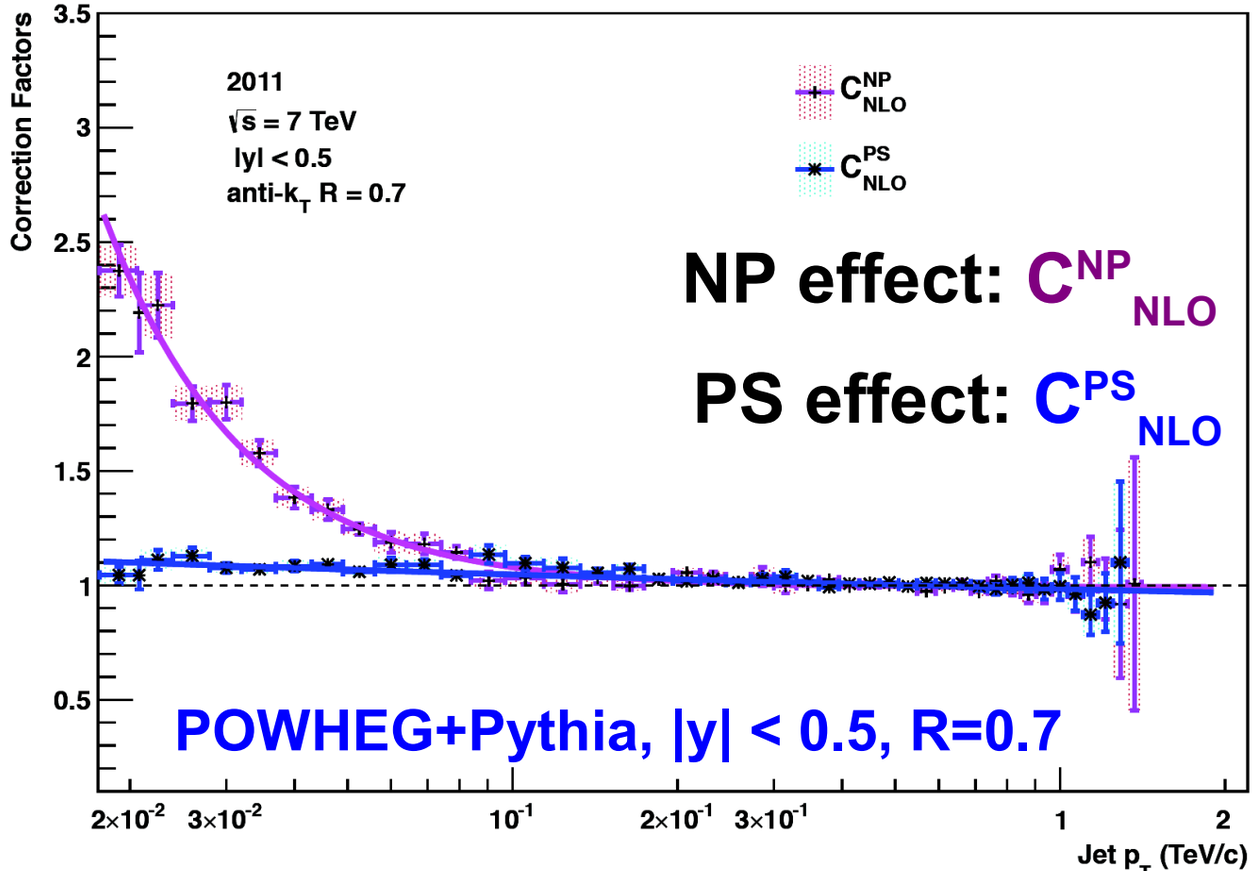
- What are the new tools saying & does it make any sense?

MC systematic uncertainties: Jet production

- Rabbertz et al. make contact between non-perturbative correction factors as used for NLOJET++ predictions [ATLAS theory default] and contribution from non-perturbative phases of the evt. gen. in Powheg+Pythia



20 GeV 1 TeV

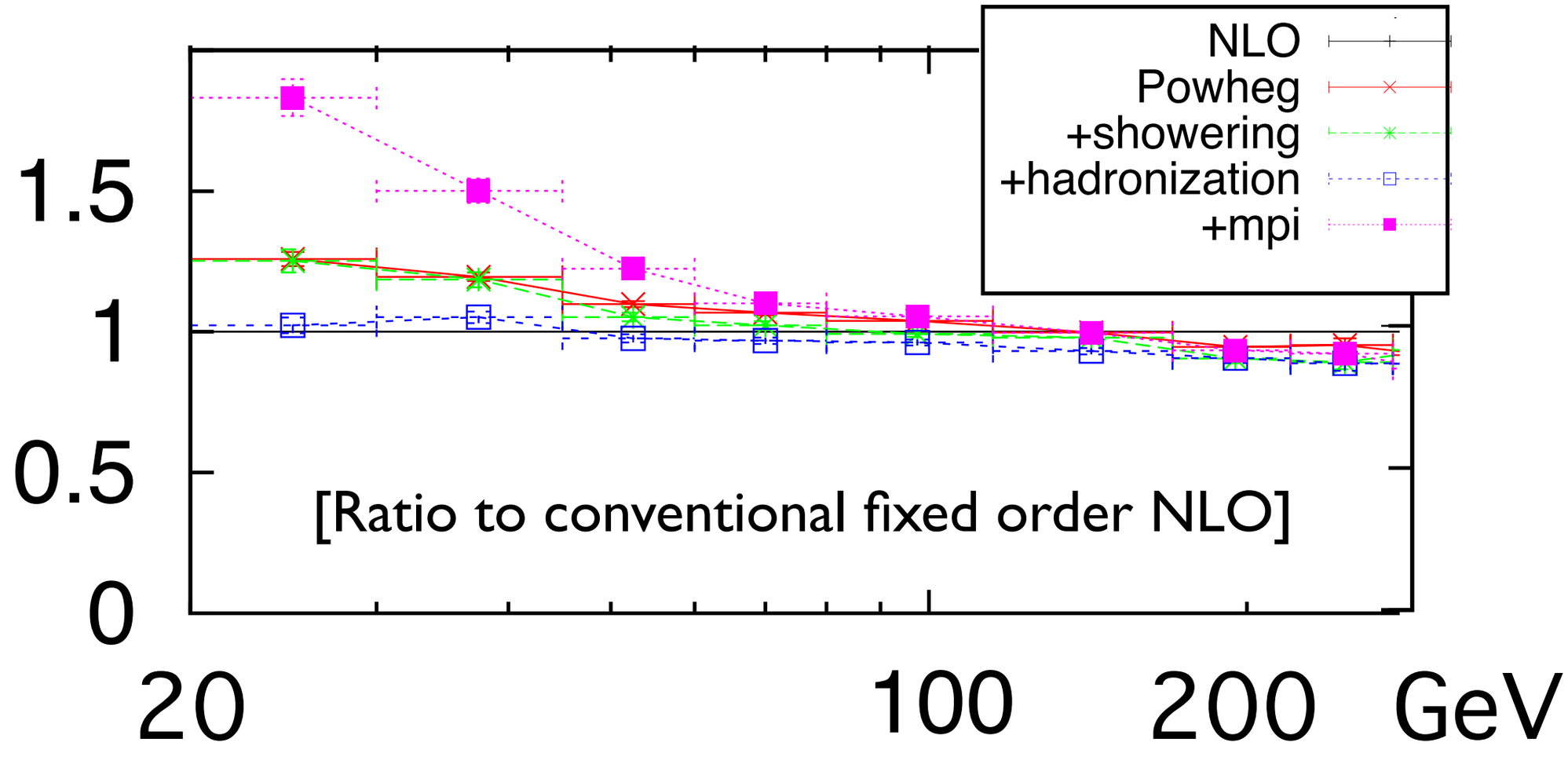


20 GeV 1 TeV

- LARGE corrs from hadr. & MPI. contribution [up to factor ~2] in <u>both</u> Pythia & Powheg+PYTHIA at low p_T

MC systematic uncertainties: Jet production

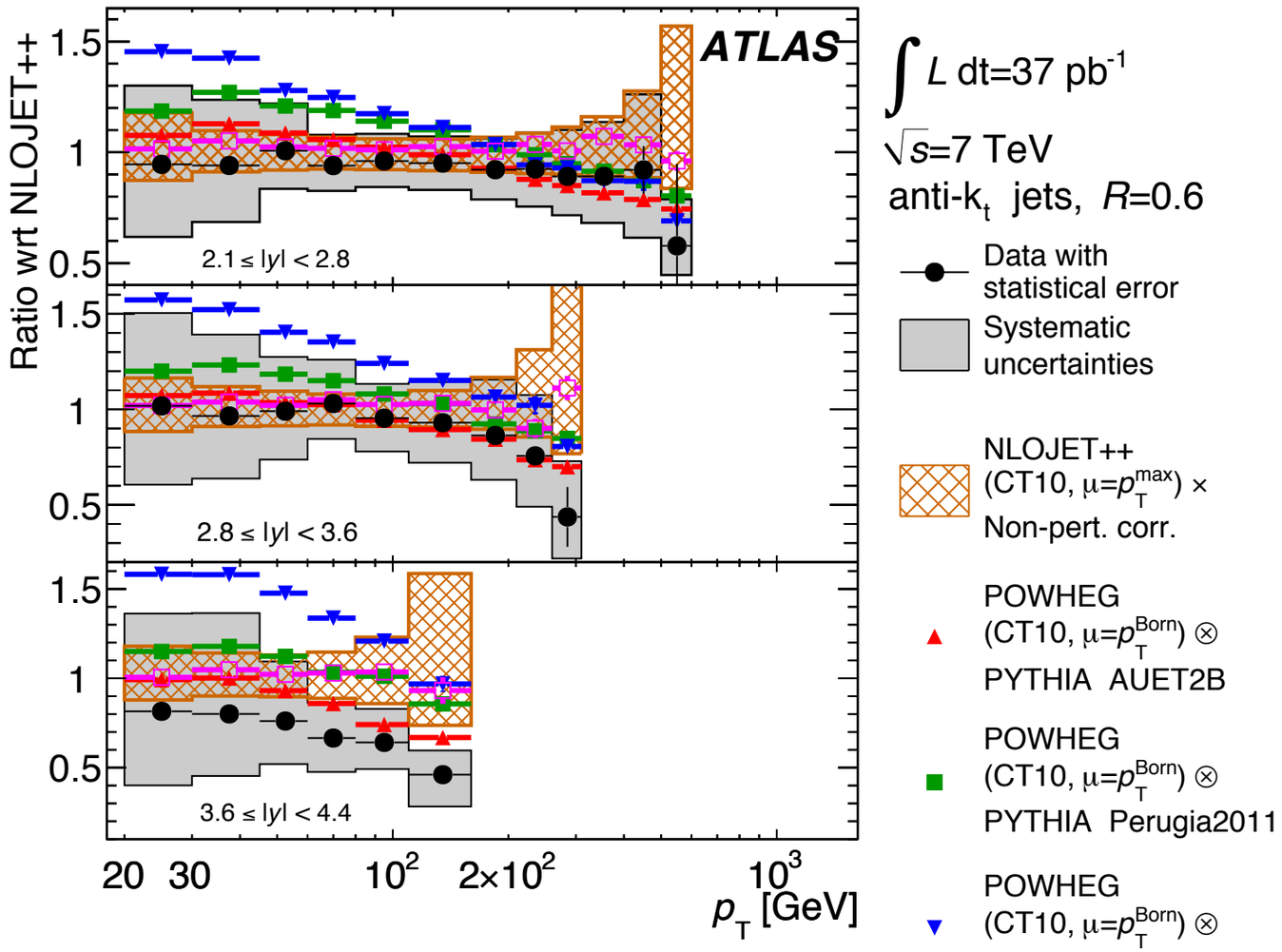
- Same qualitiative & quite similar numerical behaviour as quick and dirty study from ~1-2 years ago [KH] comparing to ATLAS analysis (despite different R, R=0.7 ➡ R=0.6 and y, |y|<0.5 ➡ |y|<0.3):



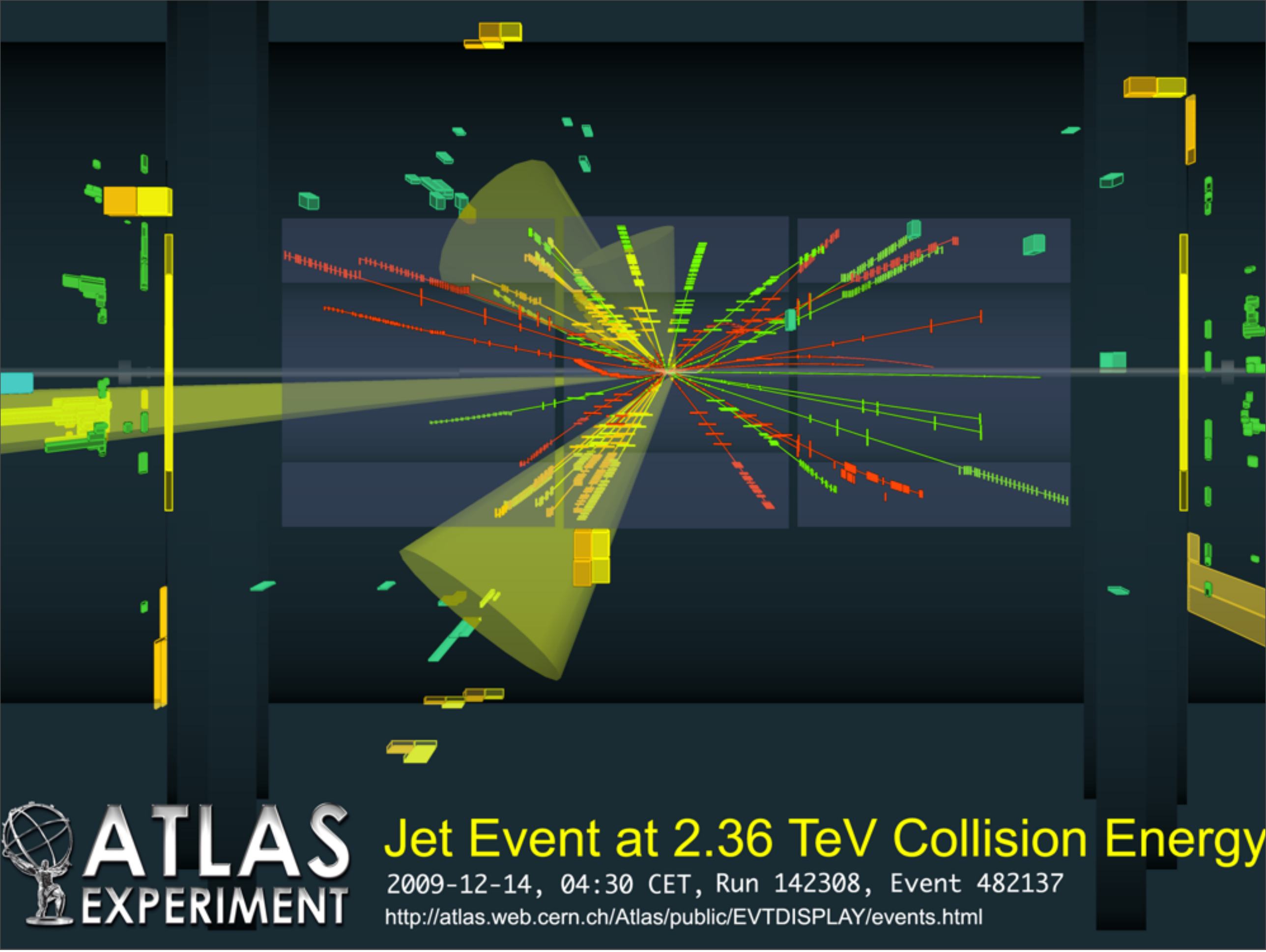
- Agreement / disagreement < ~50 GeV due to tuning / lack-of-tuning of, in particular, for R>=0.6, the U.E.

MC systematic uncertainties: Jet production

- NLO+PS high p_T fwd jets don't agree great with data but seem to do better than F.O. NLO.
- F.O. NLO prob. only LO accurate for high p_T & high rapidity - inc. jet. spectrum there due to soft[er] forward jets in association with v.hard central dijets



- Consistent with large μ_R, μ_F dep in NLOJET++
- Expect NLO+PS to do a bit better [seems to]
- Gap between Powheg+HW & Powheg+PY too big? Missing truncated shwr?


ATLAS
EXPERIMENT
Jet Event at 2.36 TeV Collision Energy
2009-12-14, 04:30 CET, Run 142308, Event 482137
http://atlas.web.cern.ch/Atlas/public/EVTDISPLAY/events.html

MC systematic uncertainties: Jet production

- Low p_T bins strongly affected by MPI for R>=0.6
  - NLO+PS jets should benefit from dedicated [MPI] tune
- Insightful to evaluate NLO+PS predictions at each stage of the event generation process [tells you when to worry and when to worry less] & it's cheap to do it
  - F.O. NLO, hardest emission, + shower, + hadronizat^n, + MPI
- Fully assess NLO+PS systematics: μ_R, μ_F uncertainty, shower veto scale uncertainty [in Powheg downwards only w.r.t default], shower tunes &c ...

MC systematic uncertainties: Jet production

- Bear in mind when NLO is of course not “NLO for everything” but for some observables it’s only LO

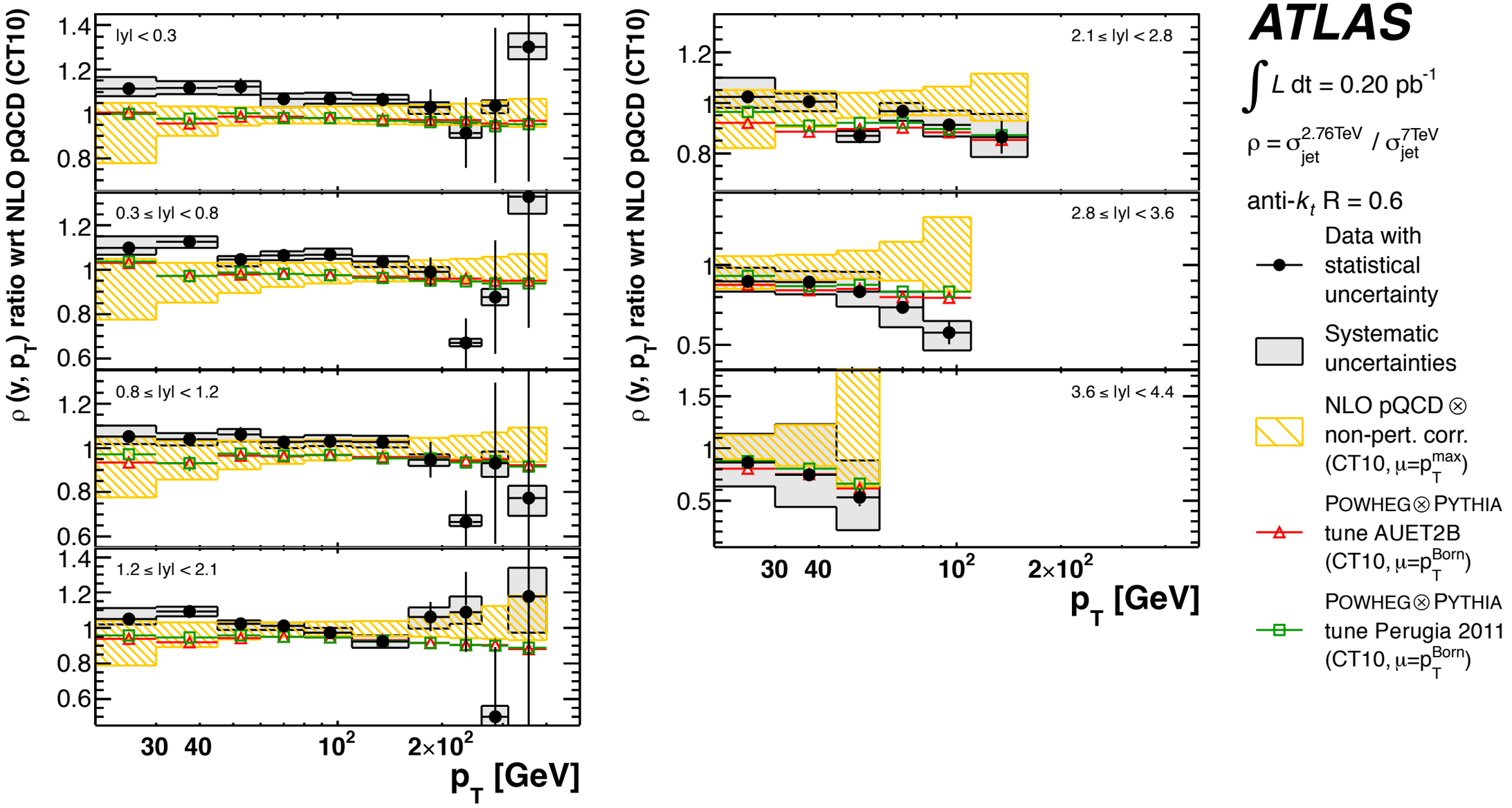
  - How do contributions from leading, next-to-leading, next-to-next-to-leading jet p_T ’s etc stack up in data to give the inc. jet. p_T in the various rapidity windows? [check for possible “LO-ness”]

  - Analogous question maybe interesting for H+jets too?

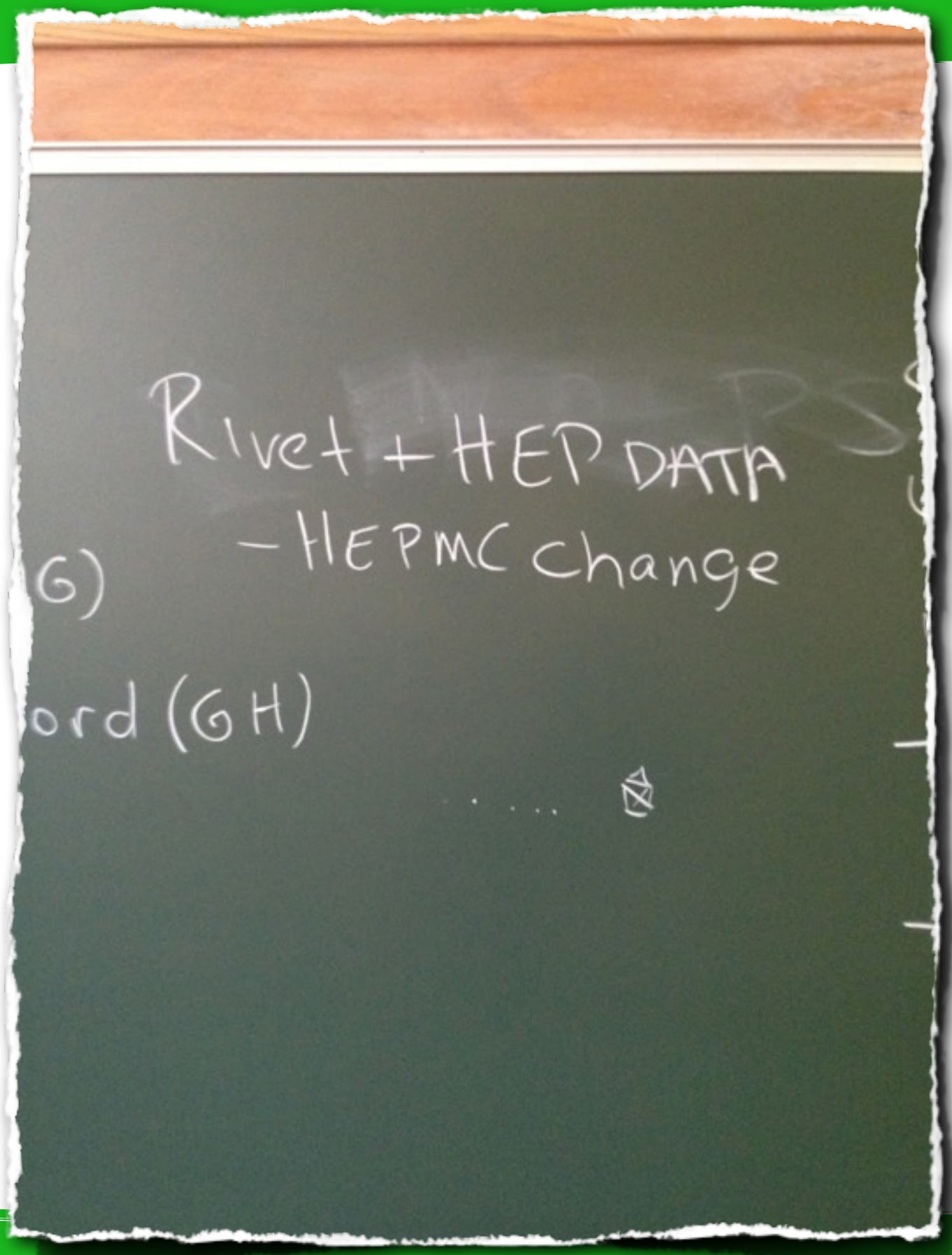
- Not sure if neglect of truncated shwr explains PY vs HW diffs in predict^{n}s at high Ys. Can’t rule it out but it’s surely too small an effect to account for diffs on its own. N.P. + UE tuning seem more likely suspects

MC systematic uncertainties: Jet production

- Comparative tools study initiated at LH [Krauss et al] to investigate such issues further, make recommendatⁿs
- Meanwhile, latest ATLAS jets study shows nice[r] agreement



- Trend should continue as analysts + authors continue to exchange and consolidate experience & understanding


Rivet + HEP DATA
- HEPMC change
G)
ord (GH)

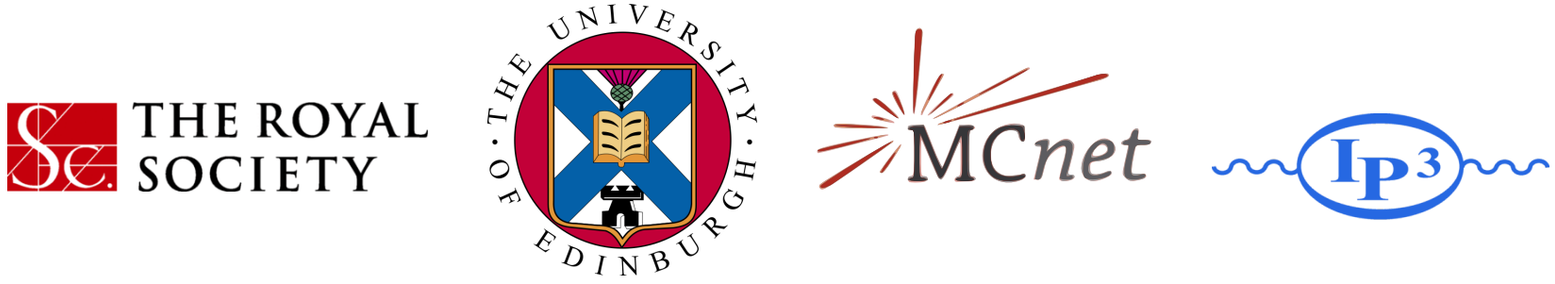
Rivet and enhancing it

- Last Tuesday we had an introductory Rivet tutorial

Rivet tutorial

Andy Buckley, Hendrik Hoeth

Les Houches 2013



- V.useful for all uninitiated in particular those participating in LH studies using Rivet e.g. H+jets

- Thanks to Andy and Hendrik! -

Rivet and enhancing it

- Rivet has more than proved itself as a universal, versatile and powerful analysis and validation tool.

- Discussions centred on extending Rivet to include multiple weight histogramming
  - Primarily for purposes of producing uncertainty band
  - Also with a view to analysing correlated sequences of events i.e. “conventional” NLO computations [e.g. BH]

- Don’t forget to contribute your analysis!

Andy Buckley, Hendrik, Frank K, Jon B et al

HepMC Event Record - GenVertex

- GenVertex: would like to distinguish e.g. MPIs from hard scattering

- Identify signal vertex e.g. for reweighting studies, heavy flavour overlap removal

- Facilitated by identifying each particle with a GenVertex by a code

Andy Buckley, Hendrik, Frank K, Jon B et al

HepMC Event Record - GenVertex

- GenVertex:id()
  - 0 undefined [e.g. B.W. mom. reshuffling.]
  - 1 Signal process [ME]
  - 2 Secondary scatters [partonic]
  - 4 shower
  - 3 hard decay [t,W,H,...]
  - 5 hadronisation [primary hadrons in FS]
  - 6 hadron decays / tau decays
  - 10-99 even more undefined

Andy Buckley, Hendrik, Frank K, Jon B et al

HepData

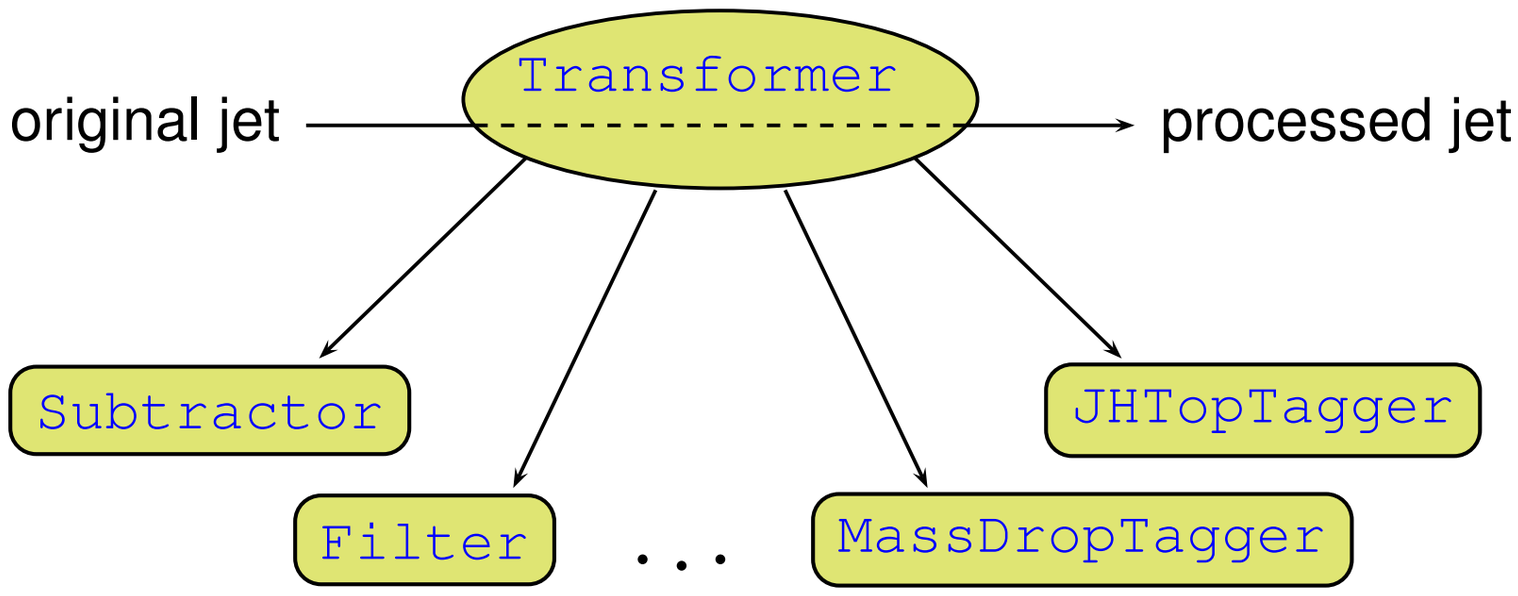
- Extensions and improvements for Hepdata
  - non-histogram data!
    - correlation / error matrices [get into Rivet]
    - +/- excursions for each systematics [get into Rivet]
  - linked to Rivet analyses
- Search facility upgrade [keywords etc]
- Auto-entry, [auto-] formatting ...
- Facility to export / import to Rivet

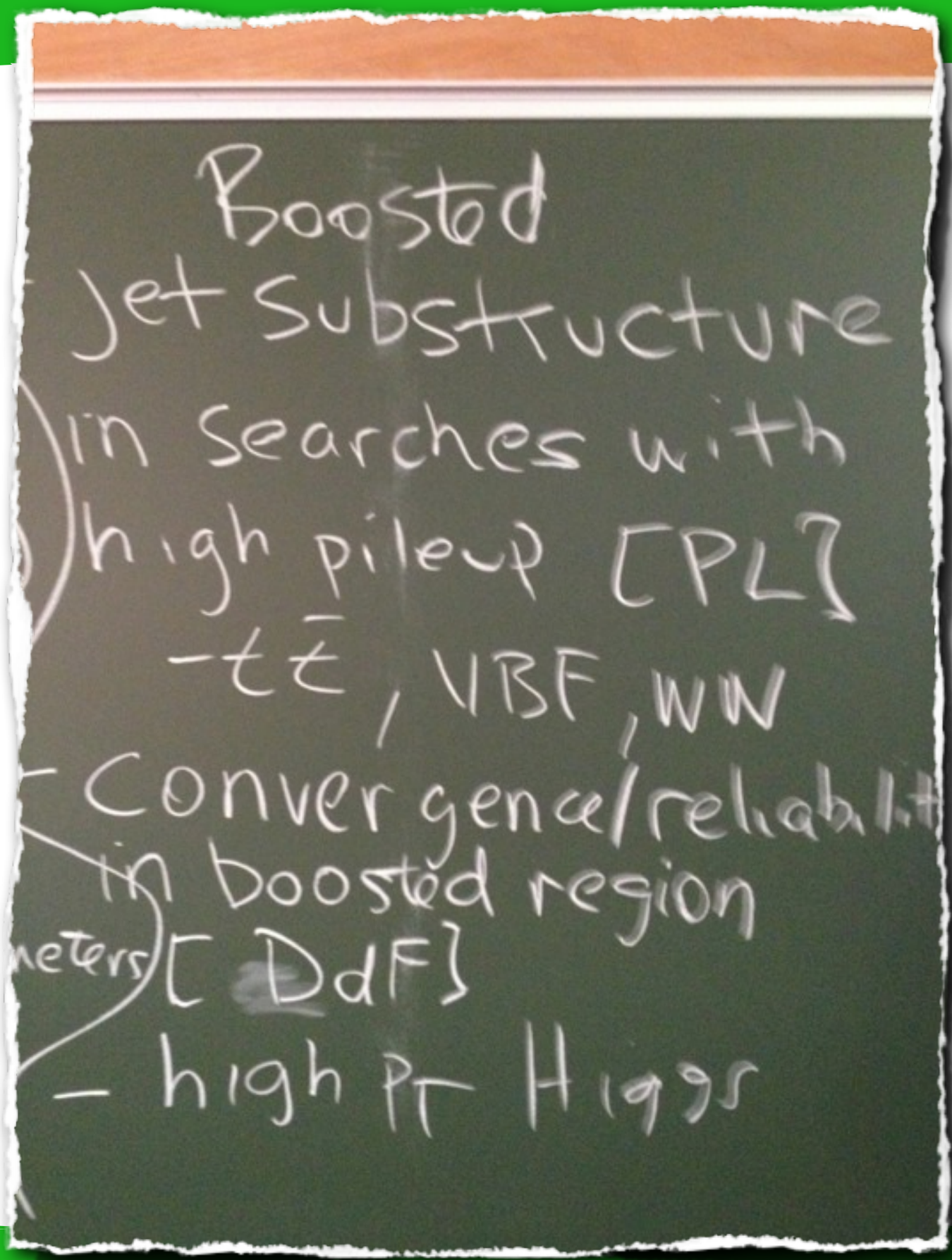
Andy Buckley, Hendrik, Frank K, Jon B et al

FastJet

- FastJet needs no introduction

- Tutorial on FastJet v3
- Tonnes of stuff for high-wire jet substructure gymnastics




Boosted
Jet Substructure
in Searches with
high pileup [PL]
-tt, VBF, WW
- Convergence/reliabilit
in boosted region
[DdF]
- high Pt Higgs

Jet substructure & high pile up

- "Grooming" is becoming popular jet-substructure tools to clean jets (from the UE) in boosted searches

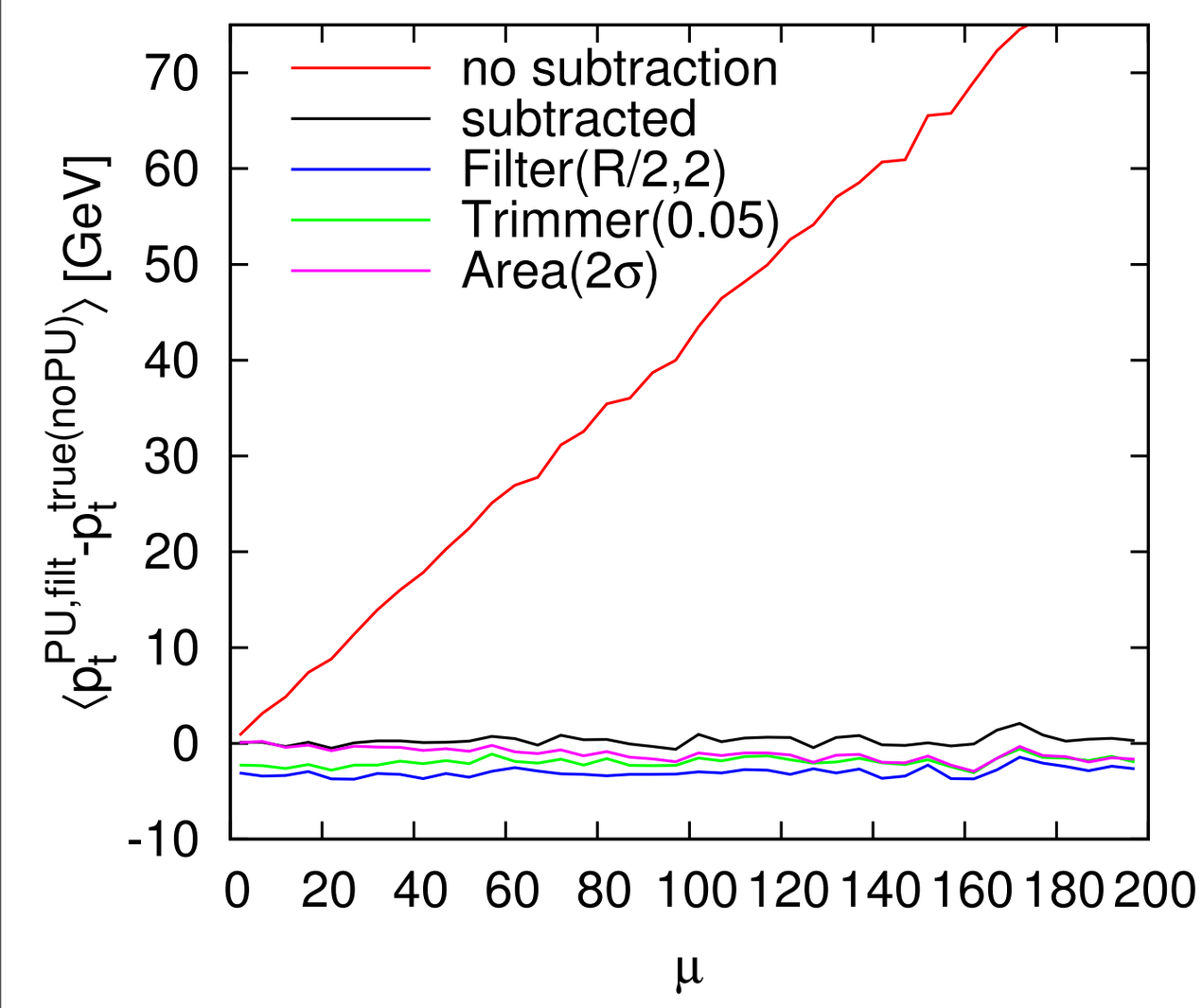
- Idea: re-cluster the jet into subjets and keep only some of the subjets: filtering, trimming, "area-trimming" [NEW]

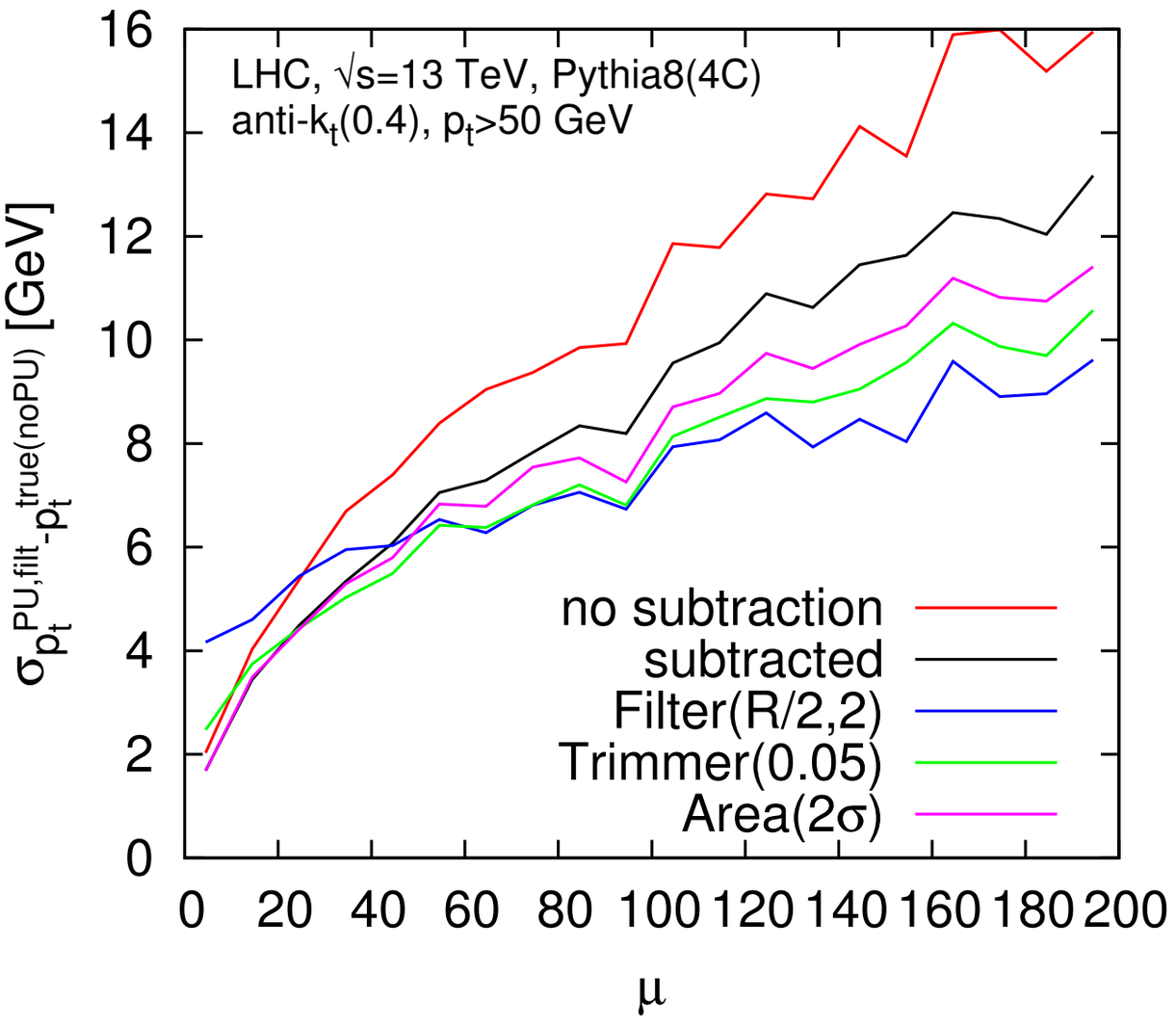
- Our goal: study these in the presence of pileup
  - test robustness of these techniques with pileup (*)
  - check potential resolution improvement for "regular jets" (non-boosted, non-fat) at high pileup

- Notes:
  - ATLAS did similar tests on data up to 15 vertices [ATLAS-CONF-2012-066]
  - Analysis framework and event samples produced for these studies

Dijet

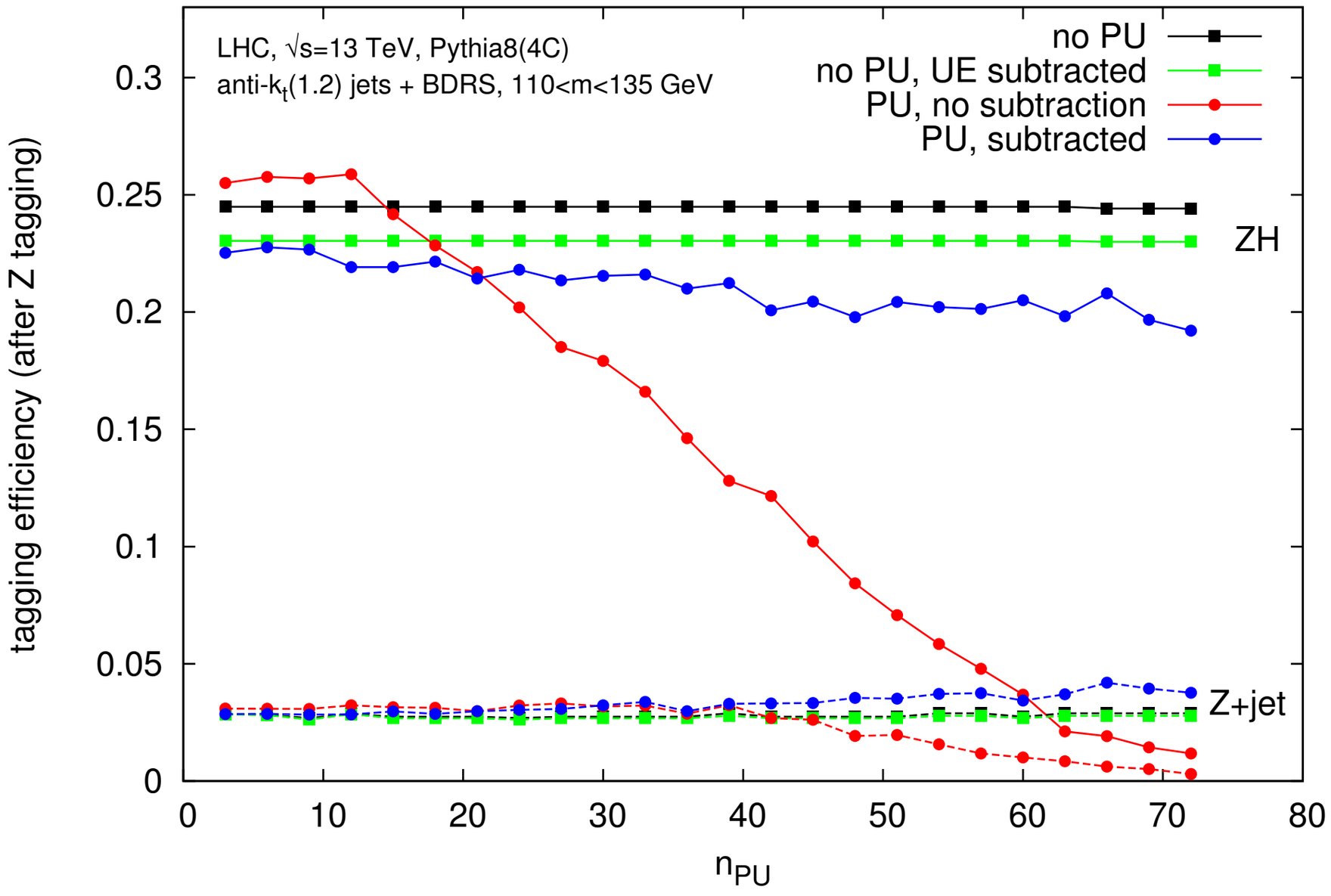
- Pileup fluctuations impact jet resolution .... problematic for low-p_T jets
- Make scan up to very high pileup of how grooming could reconstruct the jet p_T with a better resolution





Boosted Higgs

- Check the robustness of boosted Higgs->b bbar
  - using BDRS tagging [including filtering]
  - with or without noise subtraction



Boosted Higgs

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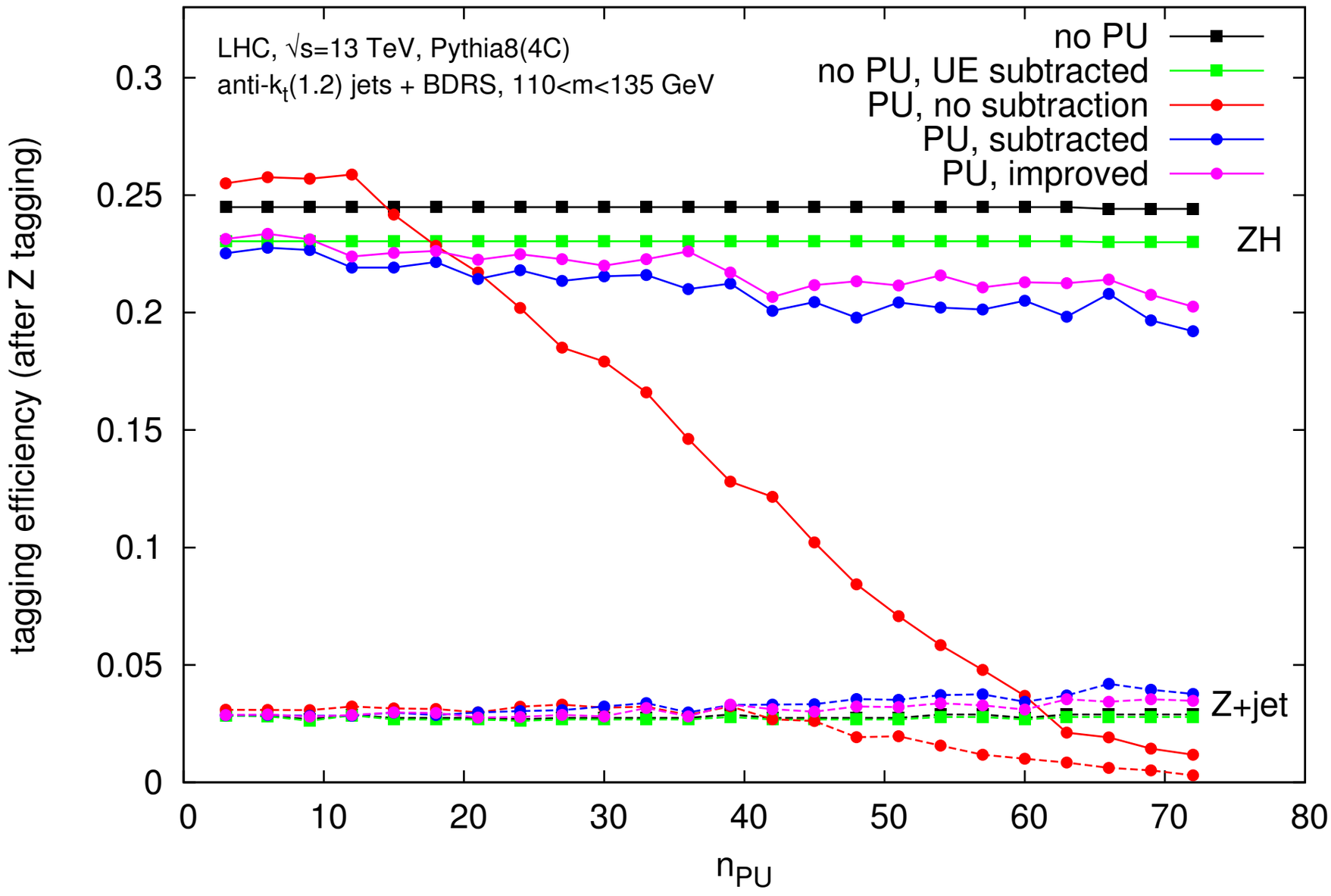

  - better understanding allows for improvement

Jet substructure - Roadmap for proceedings

- Generic intro:
  - framework [Peter, Gregory, Andy]
  - event samples [Paolo, Peter, Nicola, Maria-Vittoria]
  - check agreement with ATLAS substructure data [Andy]

- High-PU, low-p_T jets
  - grooming & resolution improvement [Gregory]
  - pileup (fake) jets v. real jets [Peter]
  - VBF at high PU [Nicola]

- Boosted searches:
  - HZ using “BDRS” [Gregory, Paolo]
  - ttbar tagging [Nicola]

Better stop already ...

Thanks to the [great] organisers!

Thanks to the convenors ...

Special thanks to Joey for catalysing a lot of the discussion & stimulating a lot of the projects.

Thanks to the participants for the expertise and good company

KH remembers Sadie Blair [née Hamilton] 11/1931 - 06/2013