Dijet mass distributions in pp, p-Pb and Pb-Pb collisions

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February 25, 2021

Research achievement last year

- Jet fragmentation transverse momentum distributions in pp and p–Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV submitted to JHEP (https://arxiv.org/abs/2011.05904)
- Pseudorapidity distributions of charged particles as a function of mid- and forward rapidity multiplicities in pp collisions at $\sqrt{s} = 5.02$, 7 and 13 TeV submitted to EPJC (https://arxiv.org/abs/2009.09434)
- Long- and short-range correlations and their event-scale dependence in high-multiplicity pp collisions at $\sqrt{s} = 13$ TeV (https://arxiv.org/abs/2101.03110) submitted to JHEP
- A Fast Simulation Tool for Silicon-Pad Detectors (https://link.springer.com/article/10.3938/jkps.77.635) published in JKPS
- Momentum-kick model application to high-multiplicity pp collisions at $\sqrt{s} = 13$TeV at the LHC accepted in IJTP

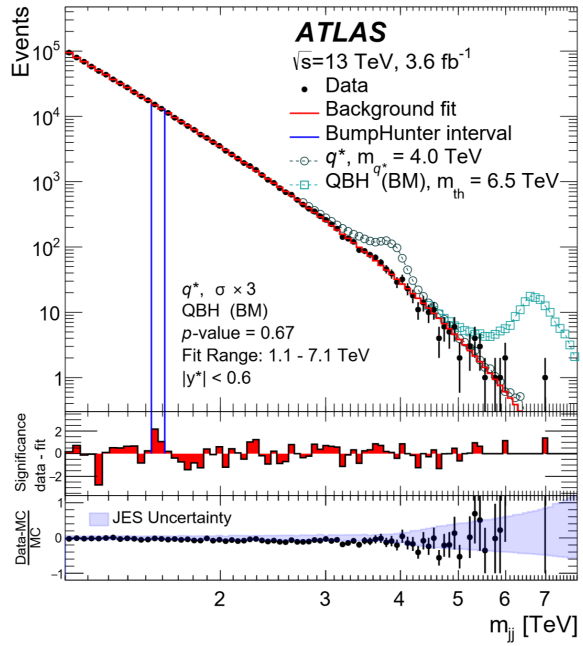
Researches ongoing this year

- Acting as Mult-PAG coordinator starting at last November with David
- Elliptical flow application to the ridge yield Junlee Kim
- Multiplicity dependence of $\Sigma(1385)^{\pm}$ and $\Xi(1530)^{0}$ production in pp collisions at $\sqrt{s} = 13$ TeV Bonghwi Lim
- Jet fragmentation dependence of jet fragmentation transverse momentum in pp and p–Pb with Jaehyeok Ryu
- p_{T}-cut pseudorapidity density in pp collisions with Dr. Bok to be submitted to EPJC
- Path-length dependence of I_{AA} in Pb–Pb collisions
- Dijet mass and acoplanarity (this talk)

Physics motivation

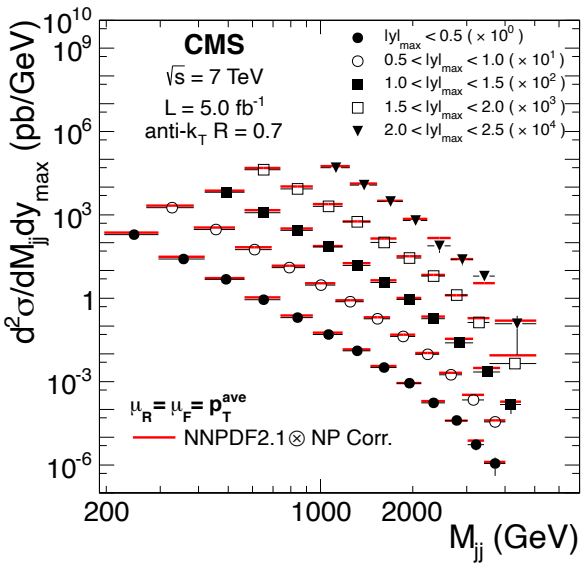
M_{jj} in pp collisions

- Good tool to probe a new Physics, $M_{jj}^2 = (p_{\text{leading jet}} + p_{\text{subleading jet}})^2$
- As the virtuality of the system gets larger for larger dijet mass, this is a good observable to see the modification of acoplanarity in dijet mass bins(▸ studied some time ago).



M_{jj} in p-Pb and Pb-Pb collisions

- Never measured so far
- a complementary to the dijet imbalance or asymmetry
- or better, measuring dijet asymmetry in terms of M_{jj} in long term?



[1] PLB 754 (2016) 302-322, PRD 87, 112002 (2013)

Data samples, kinematic and geometric cuts

1. Data samples

Type	$\sqrt{s}$ or $\sqrt{s_{\mathrm{NN}}}$	Period	Trigger	# of events
pp	5.02	LHC17p	INT7	380×10^6
pp	8	LHC12h	INT7	29.3×10^6
			EMCEJE	6.06×10^6
p-Pb, Pb-p	5.02	LHC13b, 13c	INT7	100×10^6
		LHC13d, 13e, 13f	EMCEJE	13×10^6
Pb-Pb	5.02	LHC15o	INT7	29.3×10^6

2. Track selection : Hybrid tracks for primary track selection
3. Jet reconstruction algorithm : anti-kt
4. Jet selection
   - charged jets in the TPC acceptance (EMCAL framework)
   - $p_{\mathrm{T}}^{\text{leading particle}} > 5$ GeV/c
   - R $= 0.4$
5. Dijet selection
   - $p_{\mathrm{T}}^{\text{leading jet}} > p_{\mathrm{T}}^{\text{sub-leading jet}} > 20$ GeV/c , $|\Delta\phi_{\mathrm{jj}} - \pi| < \frac{\pi}{2}$

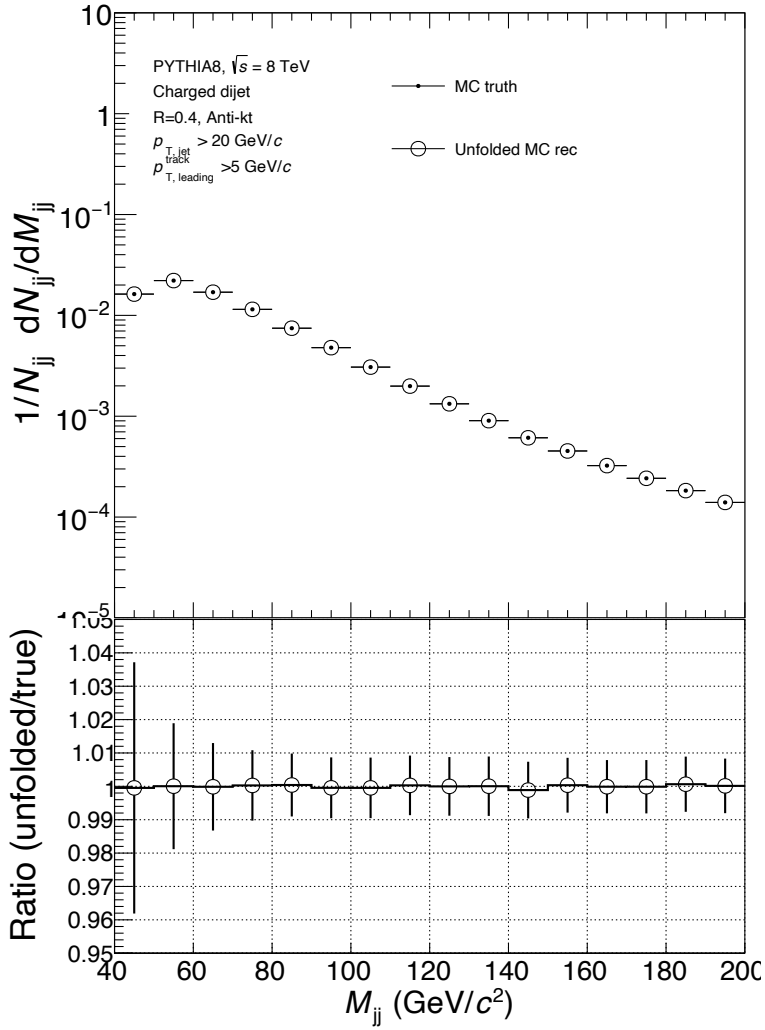
Detector efficiency correction

Detector efficiency and smearing effect

- Corrected by the unfolding method
- Package : RooUnfold
- Algorithm : Iterative, SVD

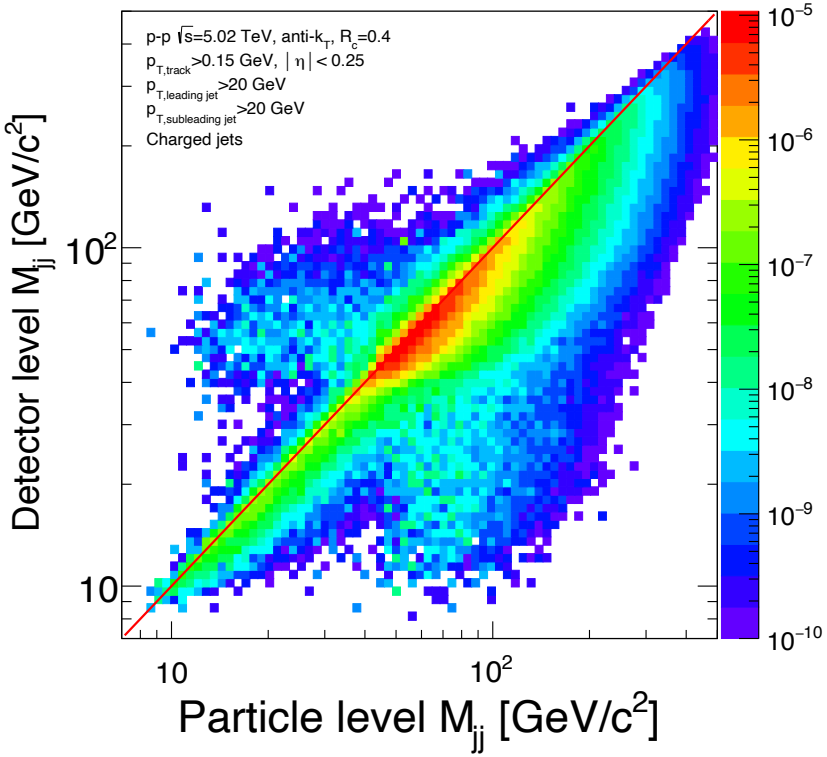
$$M_{\mathrm{jj}}^{\mathrm{corrected}} =$$

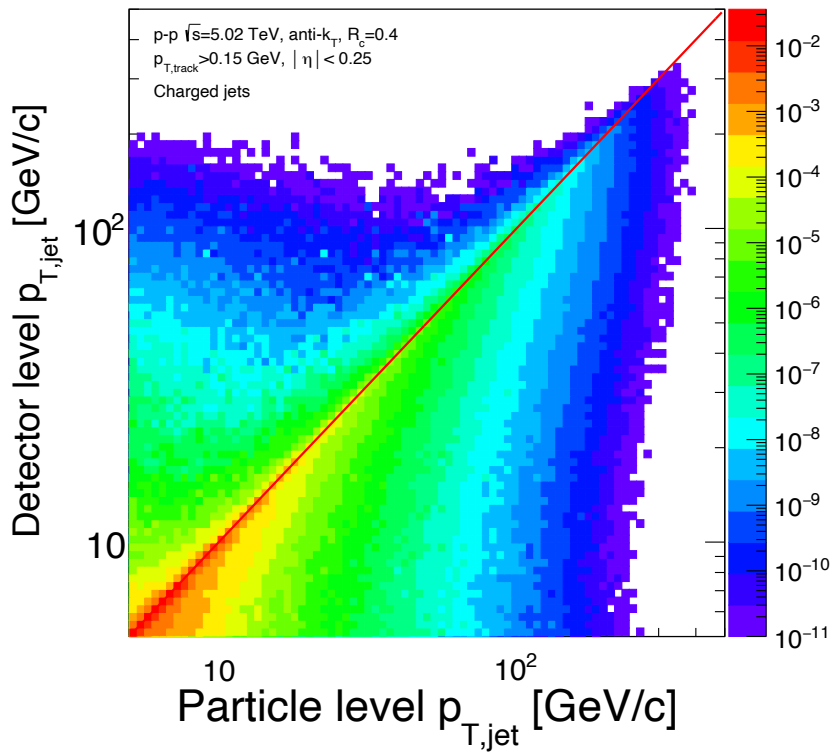
$$M_{\mathrm{jj}}^{\mathrm{raw}} \times \mathcal{R}(M_{\mathrm{jj}}^{\mathrm{mcrec}}, M_{\mathrm{jj}}^{\mathrm{mctrue}})$$



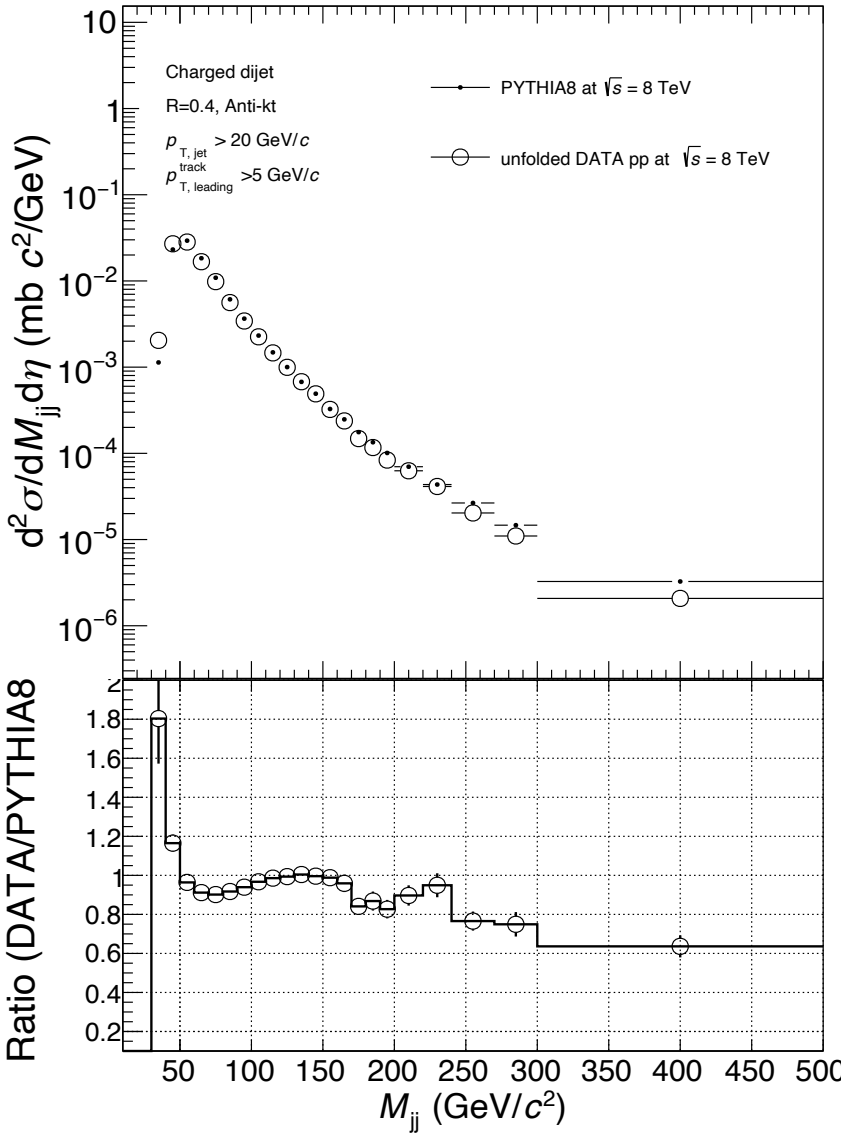
Closure test for the unfolding with MC samples

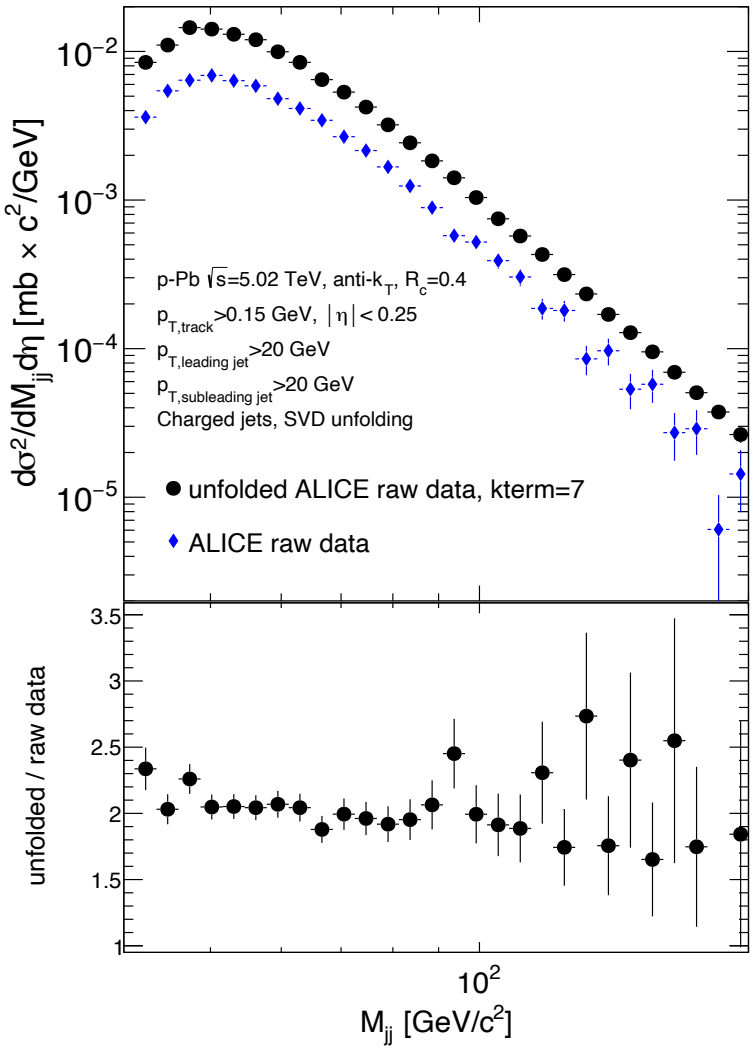
Unfolding matrices





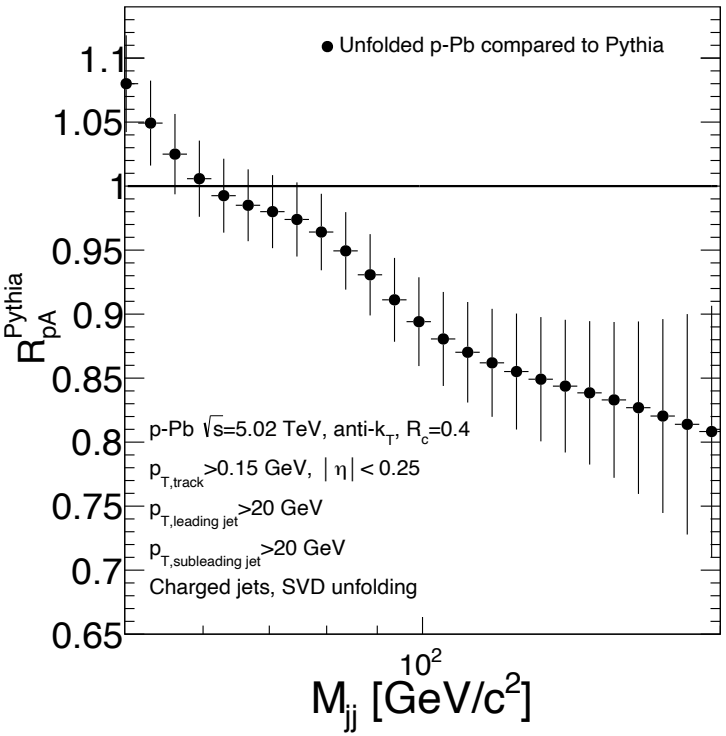
pp and pPb unfolded spectra

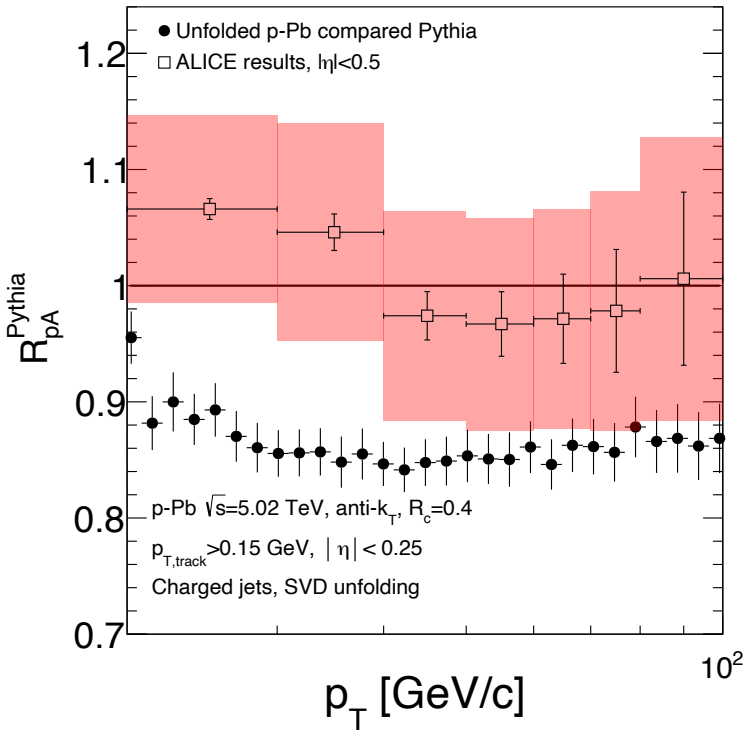




pPb R_{pA}^{PYTHIA}

$$R_{pA}^{PYTHIA} = \frac{\text{proton-lead yield}}{\text{PYTHIA yield} \times \langle N_{coll} \rangle}$$



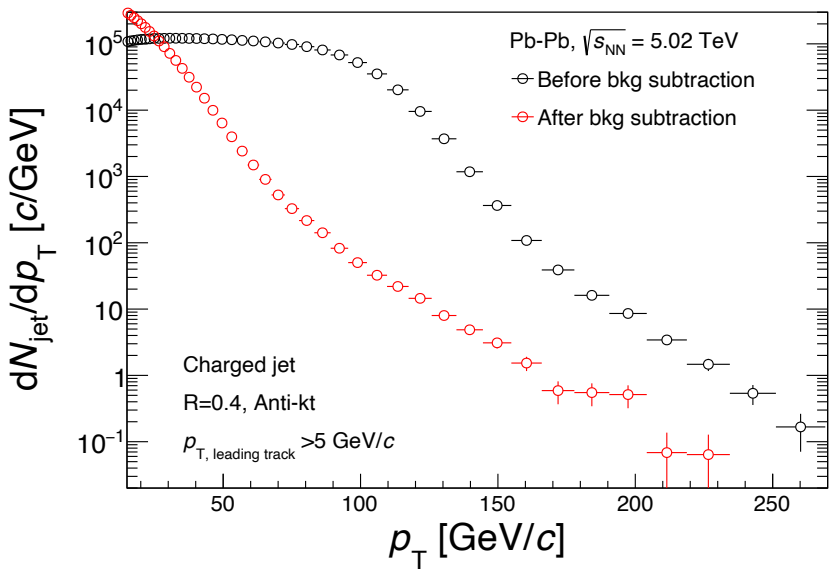


- M_{jj} : no modification in p-Pb collisions.
- p_T : similar 10-15% modifications once we use the Pythia reference instead of data.
- 5TeV pp reference is being studied.

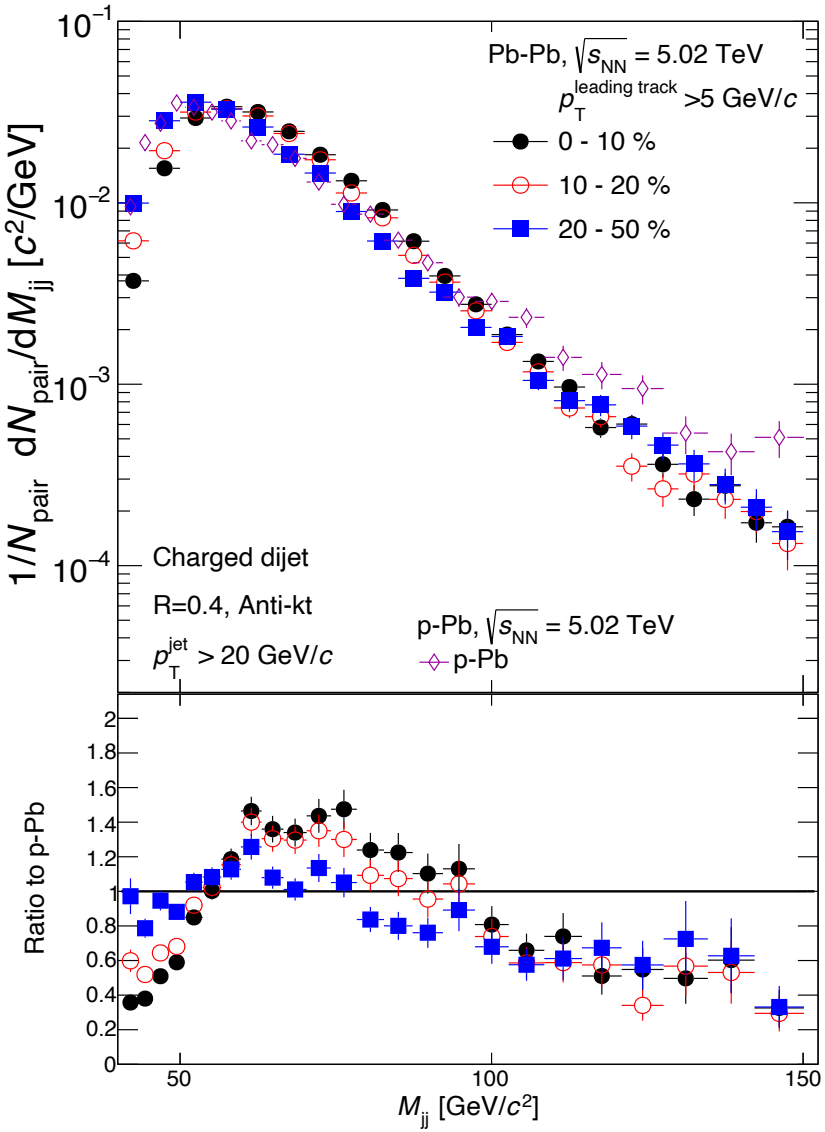
[1] http://urn.fi/URN:NBN:fi:jyu-201805072479(Oskari's MD thesis)

Background subtraction in PbPb

- Bkg densities are measured with kT cones by median
  - $p_{\mathrm{T,patch}} = \sum_{i \in \mathrm{patch}} p_{\mathrm{T,i}}$, $m_{\delta,patch} = \sum_{i \in \mathrm{patch}} (\sqrt{m_i^2 + p_{\mathrm{T,i}}^2} - p_{\mathrm{T,i}})$
  - $\rho = \mathrm{median}_{\mathrm{patches}} \{ \frac{p_{\mathrm{T,patch}}}{A_{\mathrm{patch}}} \}$, $\rho_m = \mathrm{median}_{\mathrm{patches}} \{ \frac{m_{\delta,\mathrm{patch}}}{A_{\mathrm{patch}}} \}$
- anti-kT jets are recalculated by this bkg density with kT cones
  - $p^{\mu}_{\mathrm{corr}} = (p^x - \rho A^x, p^y - \rho A^y, p^z - (\rho + \rho_m) A^z, E - (\rho + \rho_m) A^E)$



Dijet mass in heavy ion vs. proton–lead.



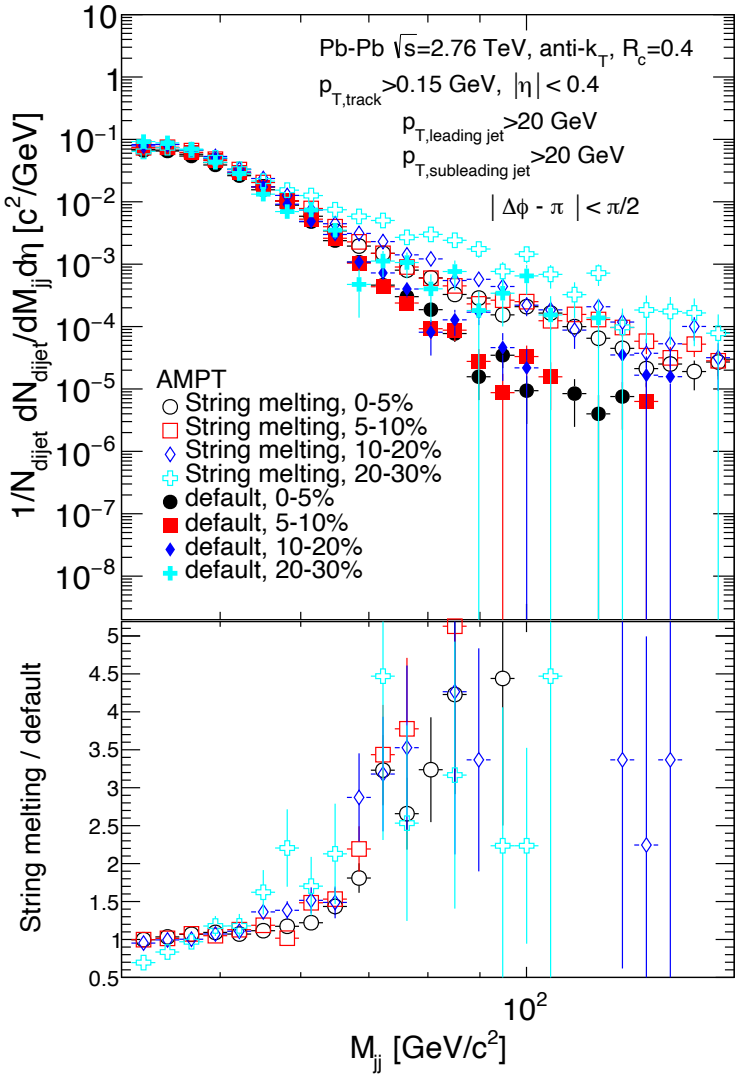
- Raw distributions show interesting modification over 100 GeV/c^2
- dijet mass suppression 0.6 w.r.t p-Pb collisions
- Correction is being prepared.

[1] http://urn.fi/URN:NBN:fi:jyu-201805072479(Oskari's MD thesis)

Summary

- Dijet mass distributions in pp and p–Pb are measured, systematic errors are being prepared.
- Raw M_{jj} in PbPb shows a suppression compared to pPb, correction in $M_{jj} > 100$GeV should be small ?
- Model comparisons, ▸ MARTINI and ▸ AMPT are being prepared.

AMPT calculations

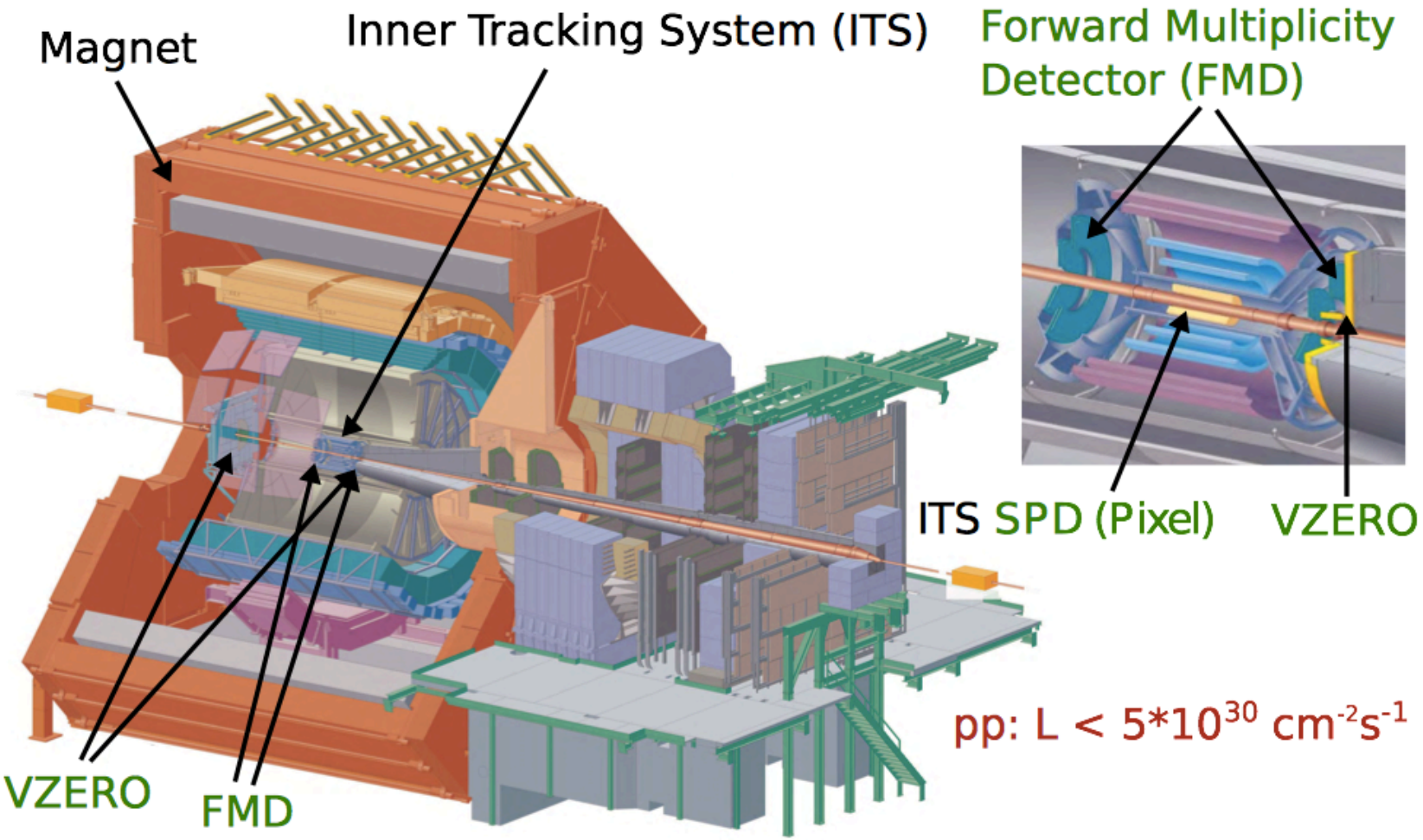


- M_{jj} from AMPT String Melting and default versions.
- Both calculations shows larger suppressions in more central collisions.
- The default version is steeper than the String Melting version in all centrality classes shown.

Thank You!!!

Backup

A Large Ion Collider Experiement

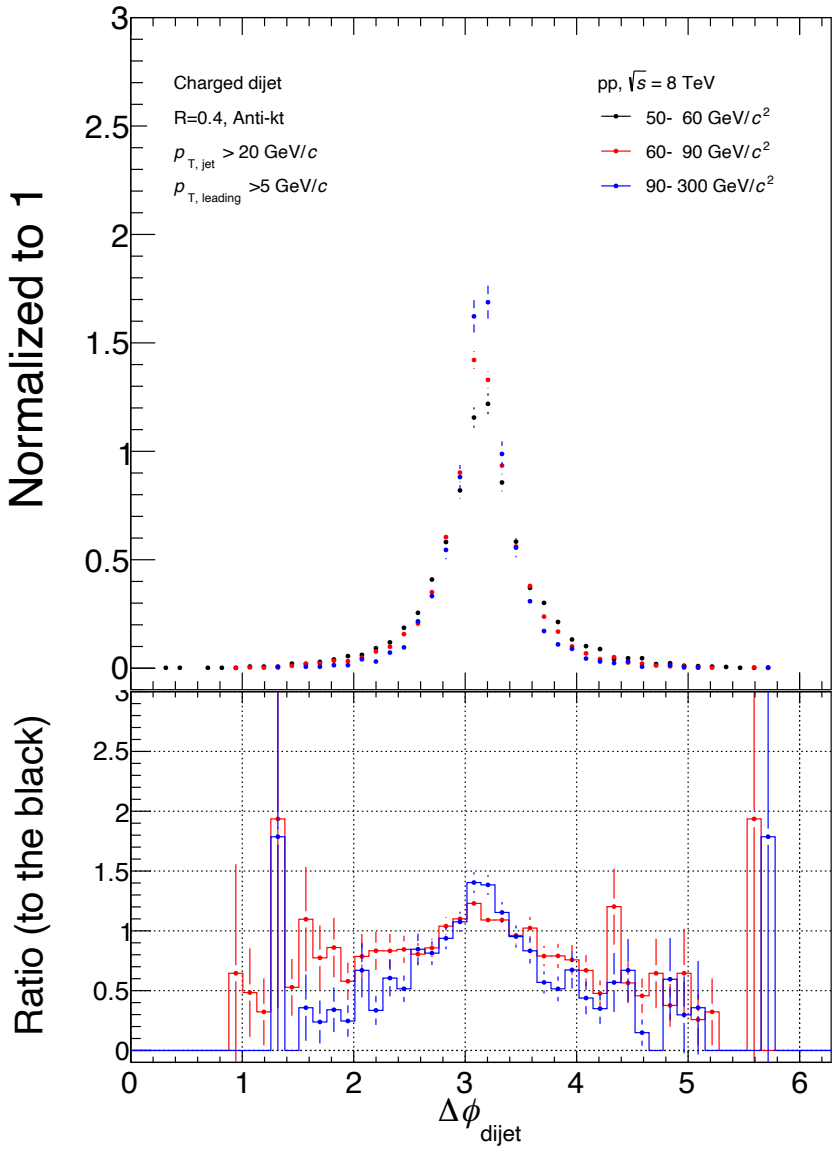


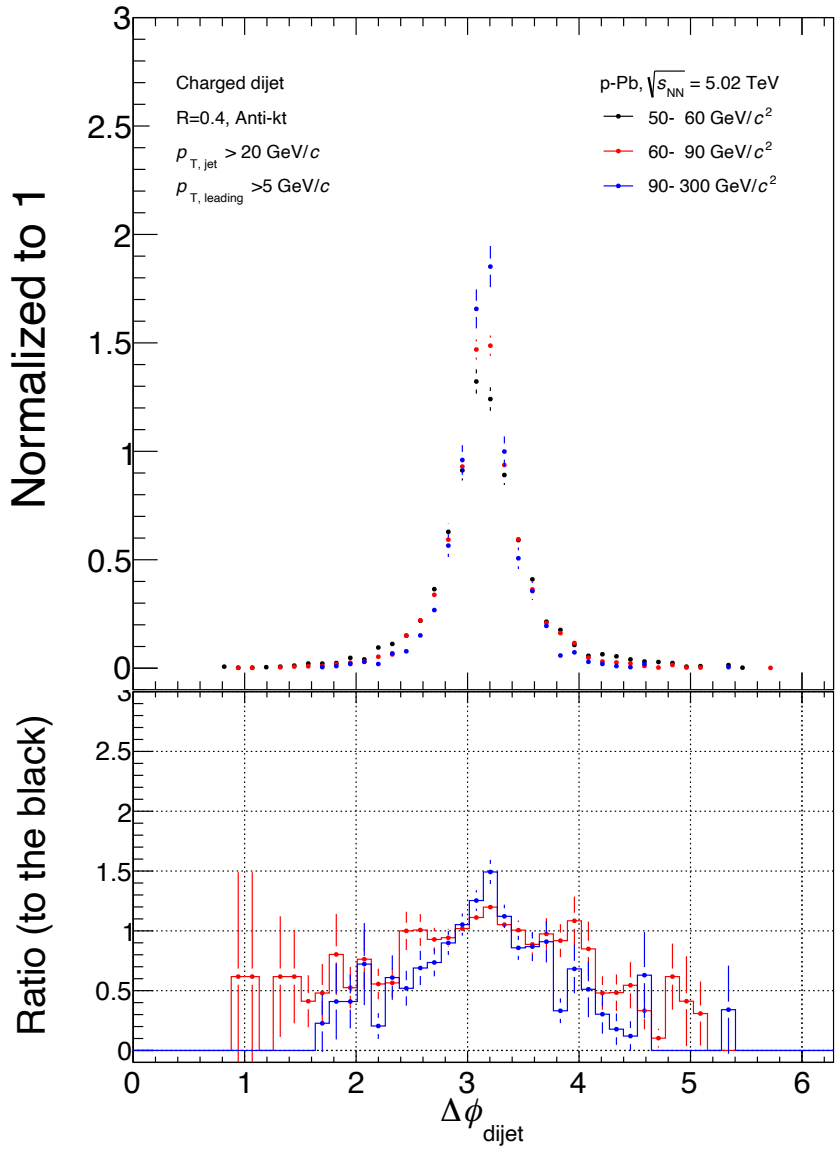
Motivation for dijet mass measurement

The goal of the dijet mass analysis in Pb-Pb collisions

- Dijets are mostly induced by $gg \rightarrow gg$ collisions
- Outgoing gluon jets lose their energy by the gluon Bremsstrahlung if they are slow to interact with the medium (increase of jet mass)
- Jet mass change gives an effect to dijet mass which is compensated by imbalance (k_{T}) between leading and sub-leading jets
- Many free parameters and they can be understood well by data-driven results

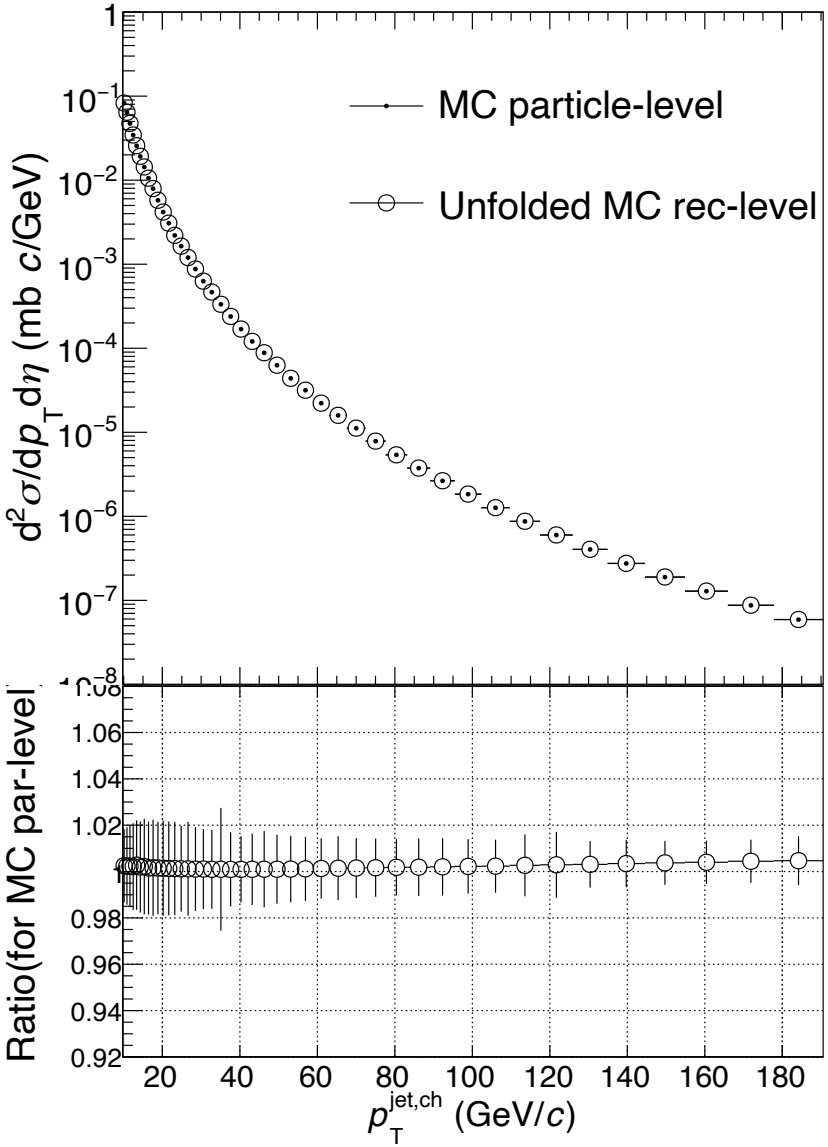
$\Delta\phi_{\text{dijet}}$ FOR PP AND P-PB COLLISIONS





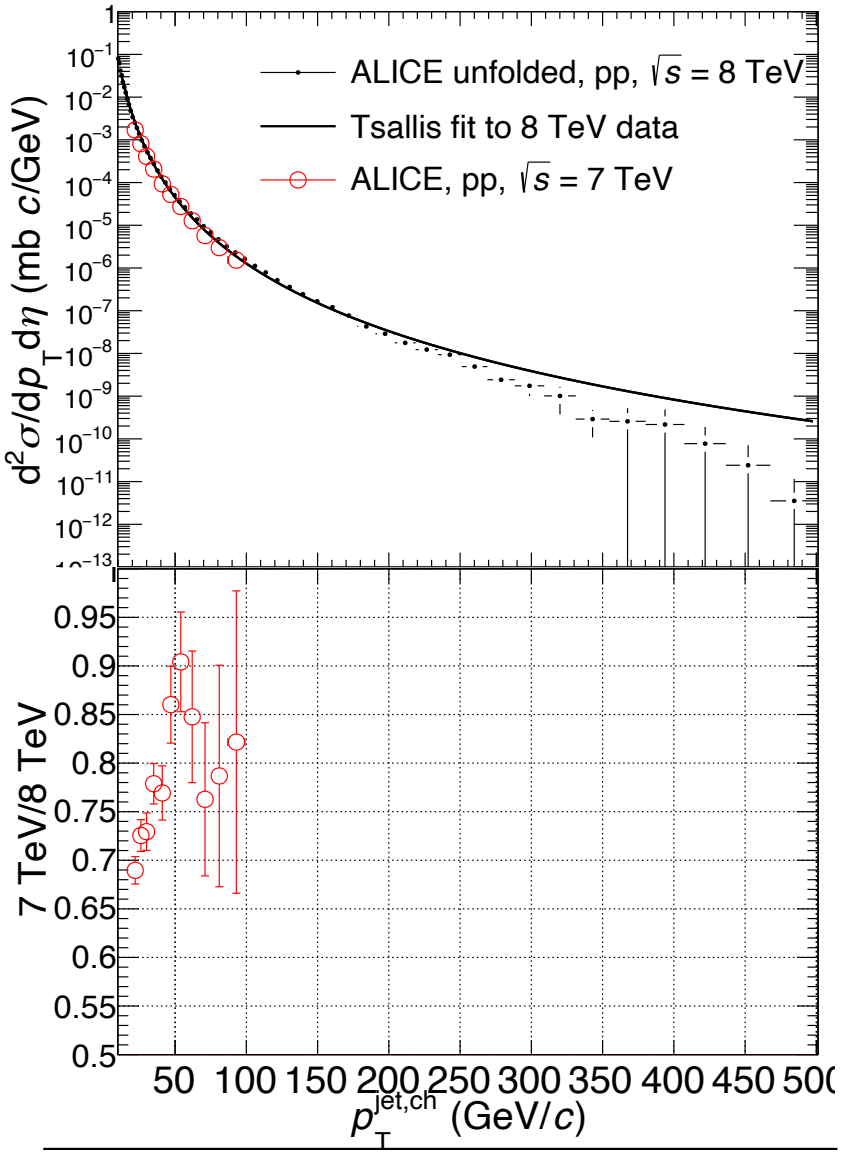
Unfolding - closure test

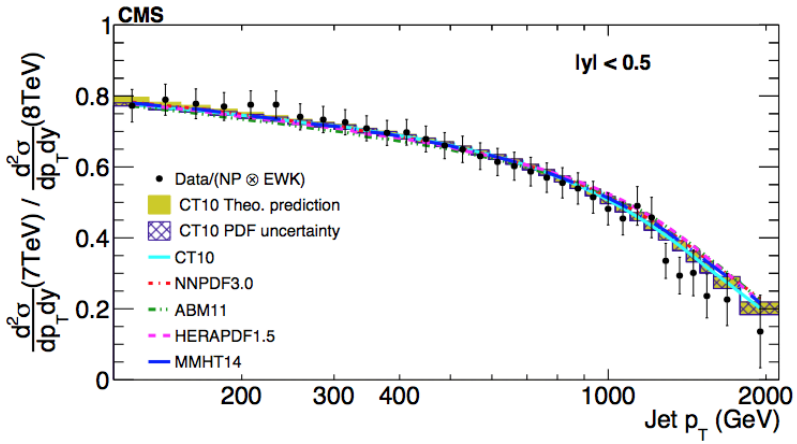
Detector efficiency is corrected by the unfolding method



- Package : RooUnfold
- Algorithm : Iterative(Bayesian)
- Regularization parameter : 4

Final result





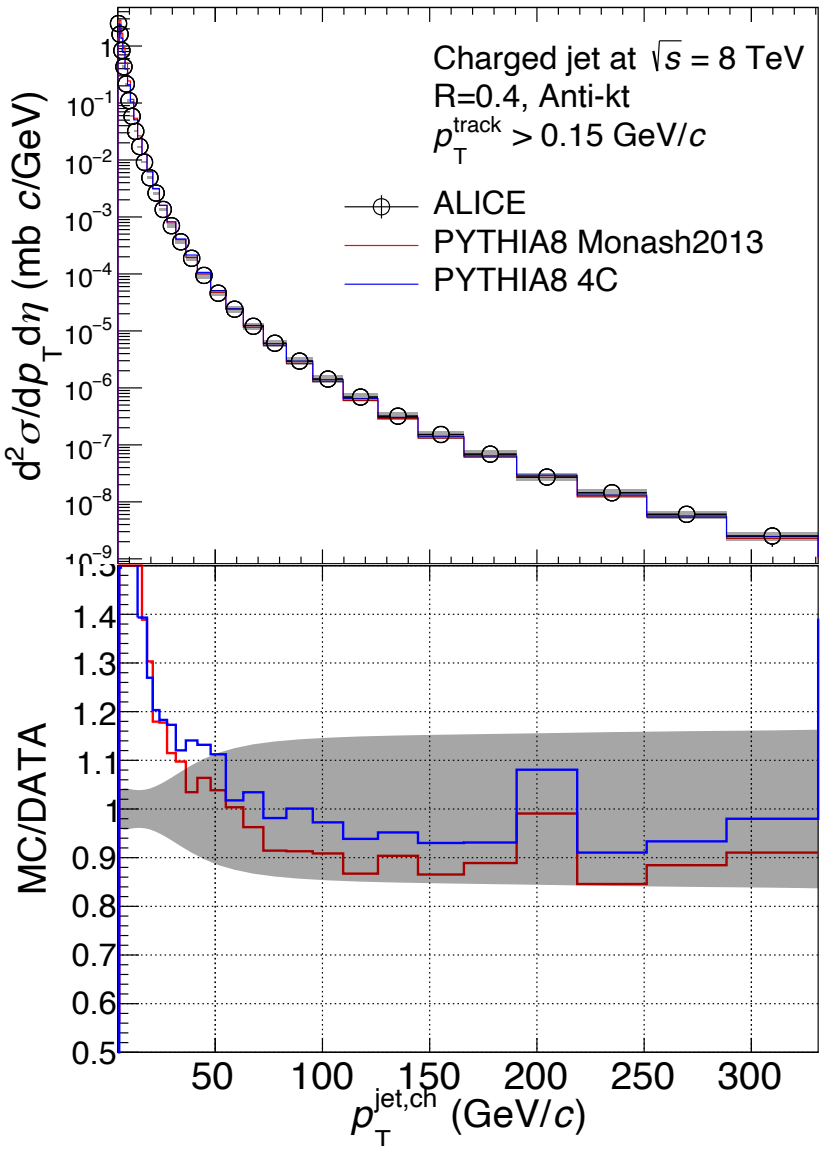
Ratio of CMS full jet spectra beteen 7 and 8 TeV[1]

- around 0.8
- support the new 8 TeV result

The new 8 TeV result extends to 300 GeV/c (7 TeV, 100 GeV/c)

[1] arXiv:1609.05331v2 [hep-ex] 4 Apr 2017

Final result v.s models



Systematic uncertainty

- INT7 to INEL normalisation : 2.95% (0.7718±0.0228 (2.95%))
- Unfolding : 3 %