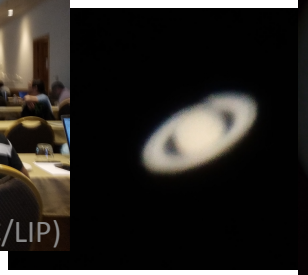
HADRONIC CALIBRATION WORKSHOP 2019

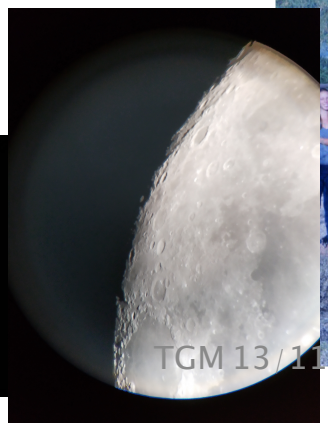
R. Gonçalo (U.Coimbra/LIP)

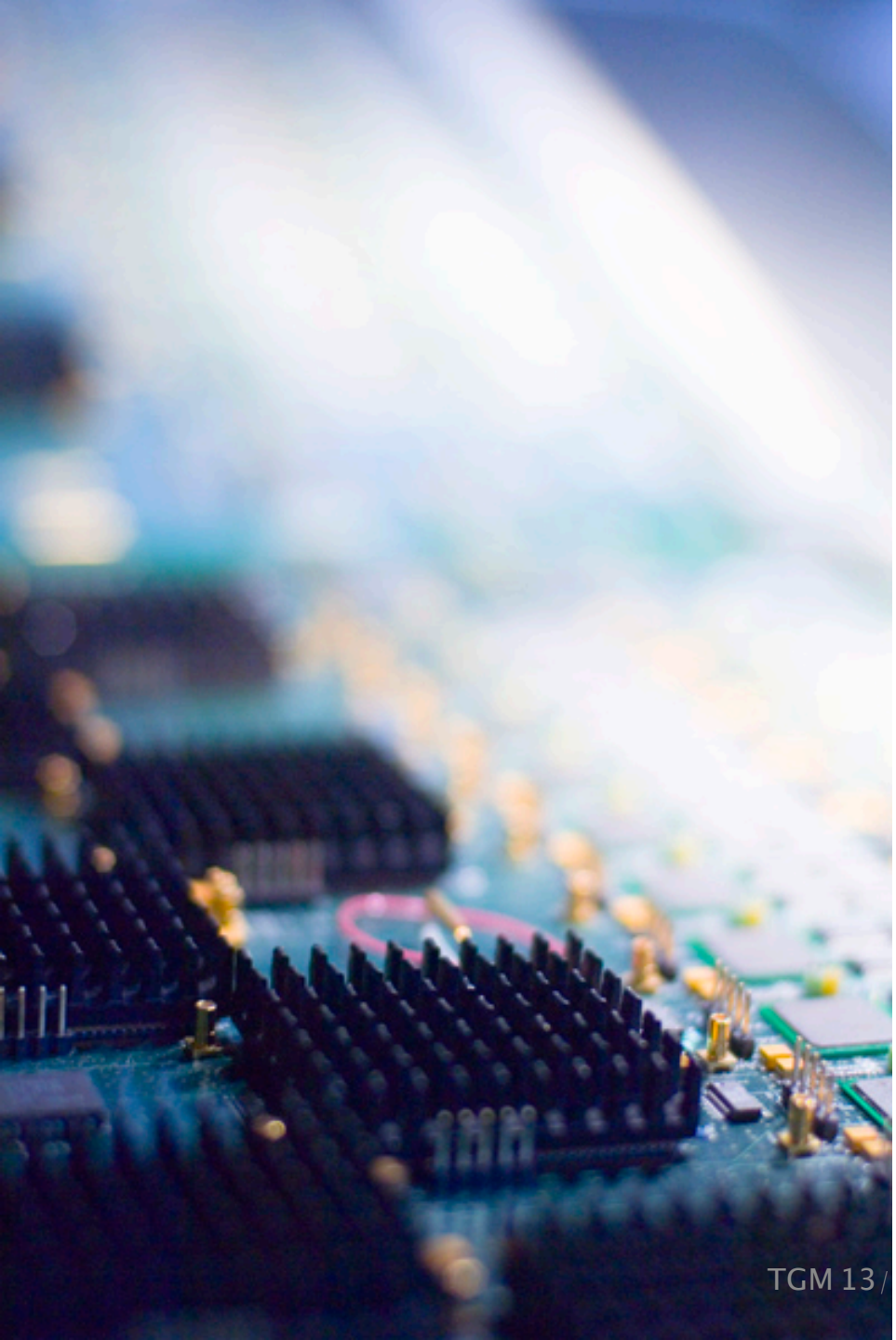
Cofinanciado por:

Hadronic Calibration Workshop

- Annual workshop of the Jet/ETmiss group and related activities
- Format:
  - Contributions submitted to each session by physics and CP groups throughout ATLAS
  - Summarised in presentations by session conveners in order to generate debate
  - Trigger sessions since 2014 – was instrumental in jet trigger strategy for early Run 2
  - This year convened by **Ben Carlson**, **Kenji Hamano**, **RG**
  - Always a lively and interesting workshop!
- This year in Tucson, Arizona:
  - 231 contributions
  - 149 items to follow up on (Jet/MET conveners)
  - 84 participants
  - 37.5 hours of talks
  - 12 hours of coffee break and lunch chats
  - Stargazing session with local astronomer
  - Great karaoke session! ☺

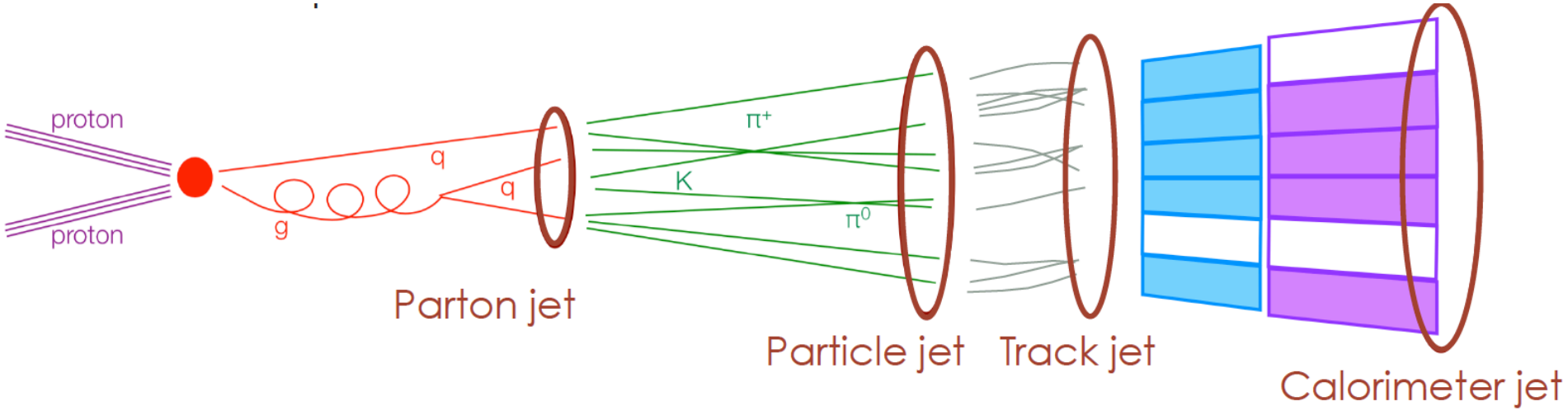






The Jet and MET Triggers

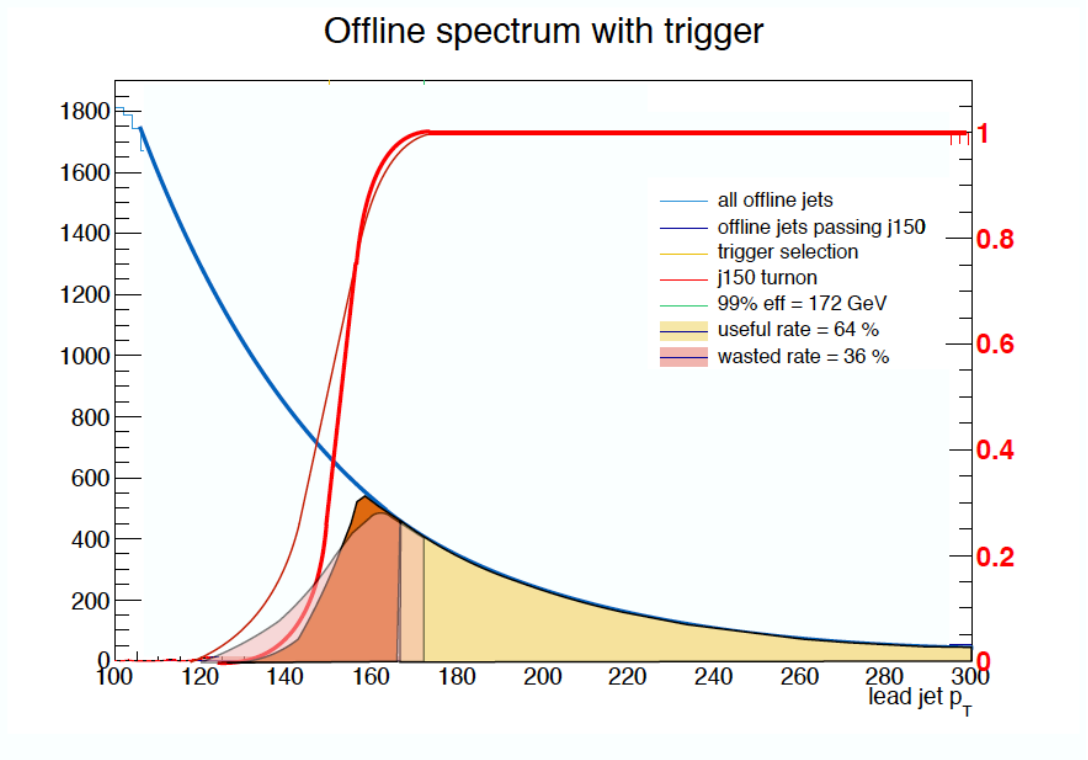
Jet and MET are not usual triggers



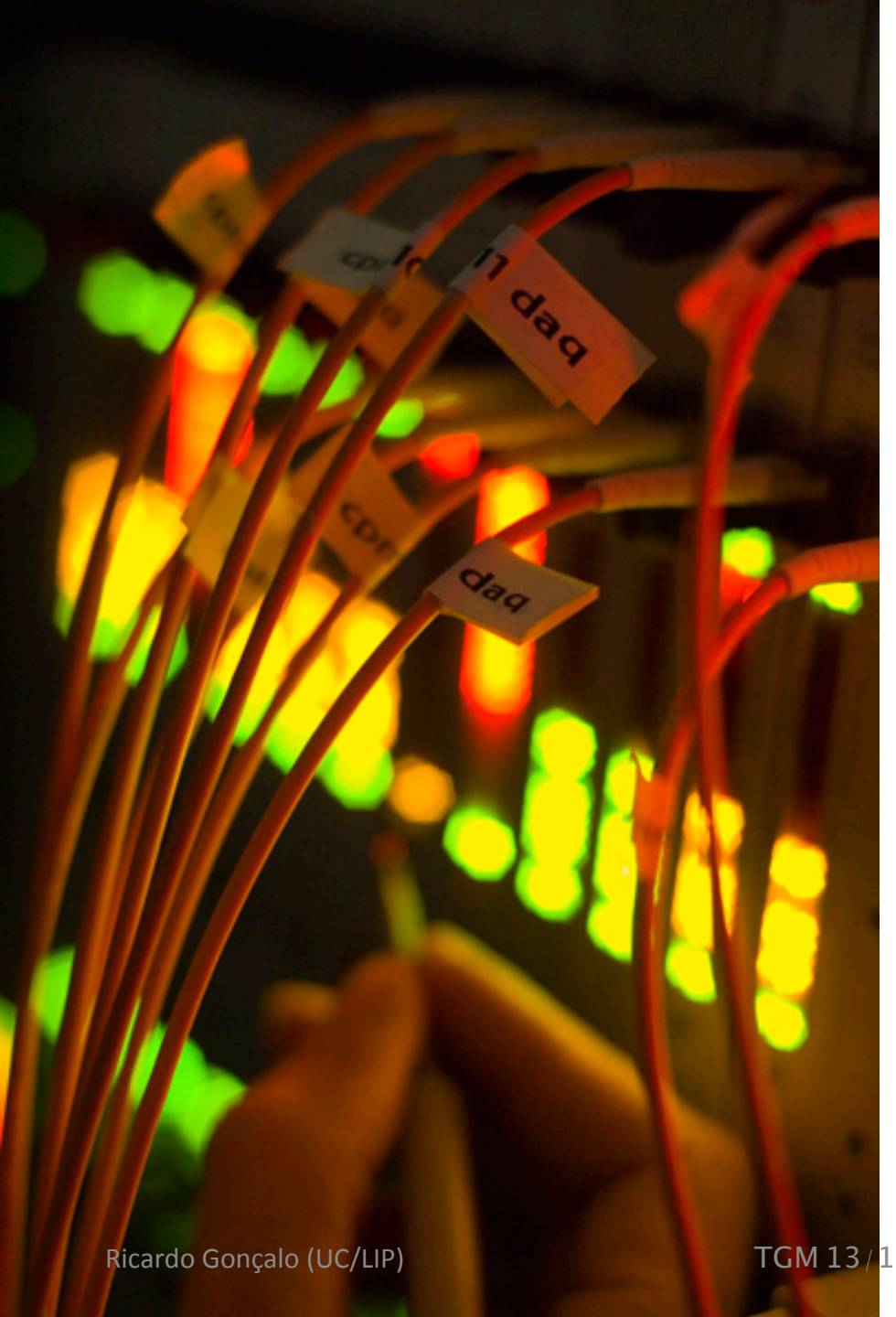
- Usual game is to trigger on **distinctive objects**
  - E.g. electron trigger: play with identification selection to improve purity
- Jet and MET are different:
  - MET needs **all** reconstructed objects
  - Jets are **defined** by jet algorithm – **extended** objects which depend on **QCD**
  - All events have jets and MET ≠ 0: cut on phase-space (**resolution is essential**!)
  - Then clean up false positives: pileup jets, fake MET

Effect of Resolution

- Emulate j150
- Jet selection based on phase space cuts
- Resolution is essential!
- Resolution is wrt offline

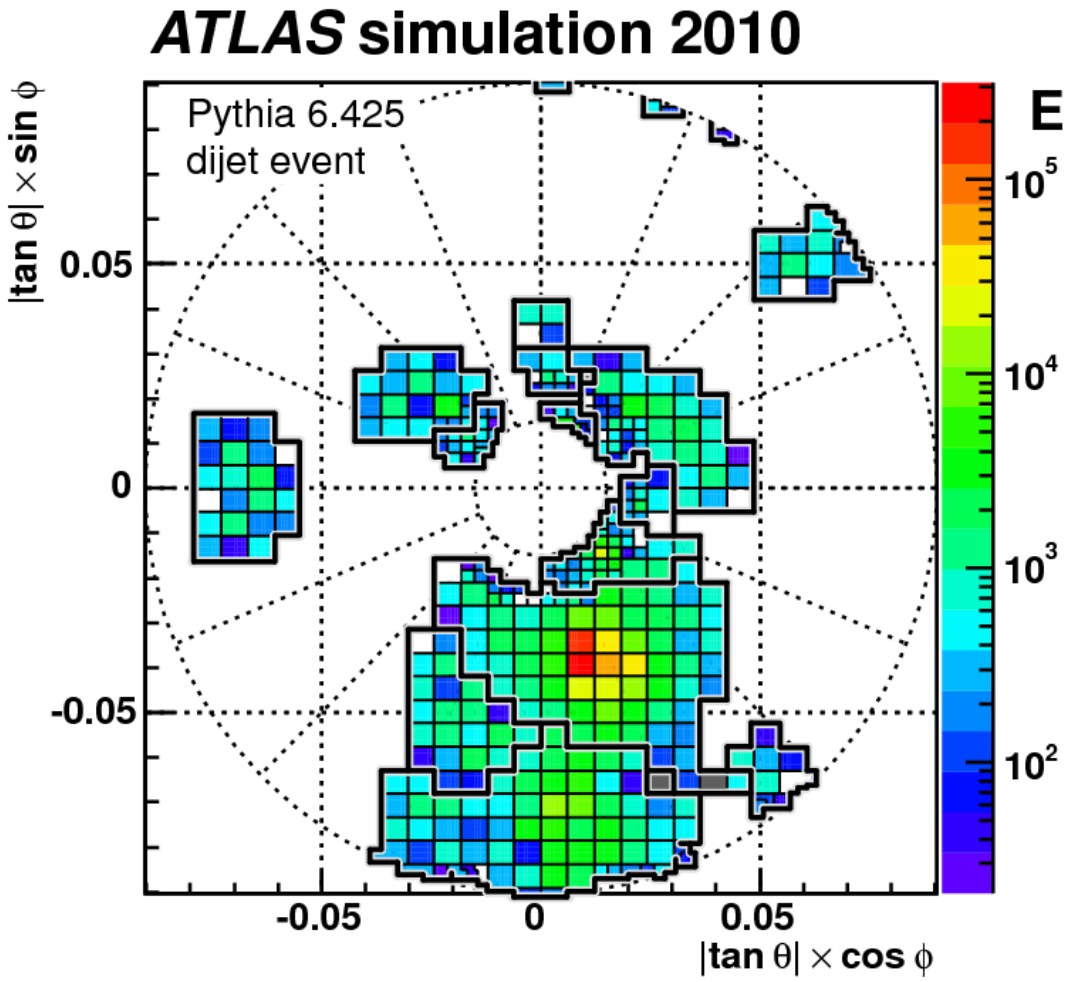


Plots from Will Kalderon:[Jet trigger overview in HCW2018]



JET / MET INPUT OBJECTS

Basic objects: TopoClusters

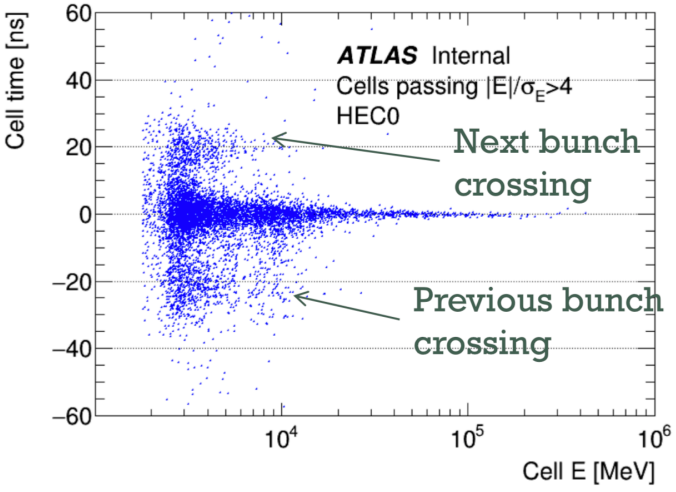


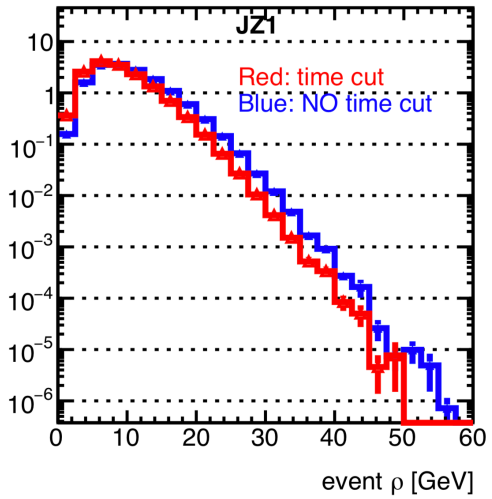
- Seed cells with large energy / noise: E/n > 4
- Expanded to neighbouring cells with E/n > 2
- Layer of neighbouring cells added (E/n > 0)

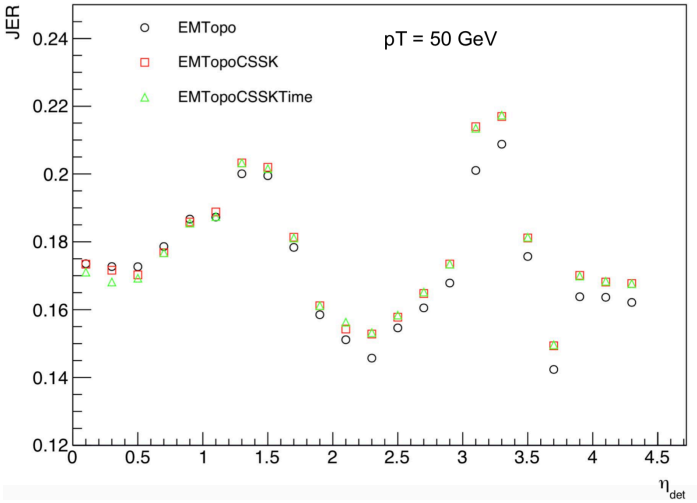
See talk by Dilia Maria Quintero

Pileup suppression of Jet/MET inputs

- Cluster/cell timing cuts and other methods being investigated to suppress pileup at the input level
- Some features still not understood:
  - Improvement for central jets (Constit.Subtraction+SoftKiller) seems reversed at high η
  - Improvements also reversed for Pflow jets
- But potential gains in pileup stability and energy resolution, especially at low-p_T



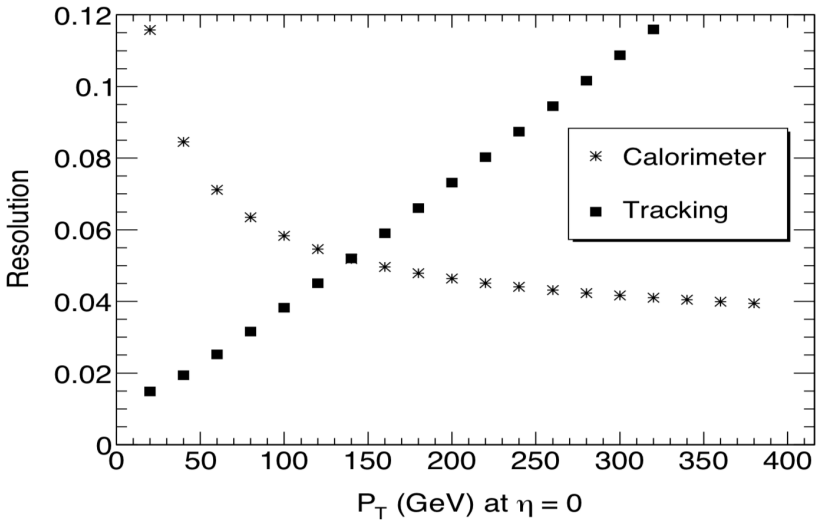


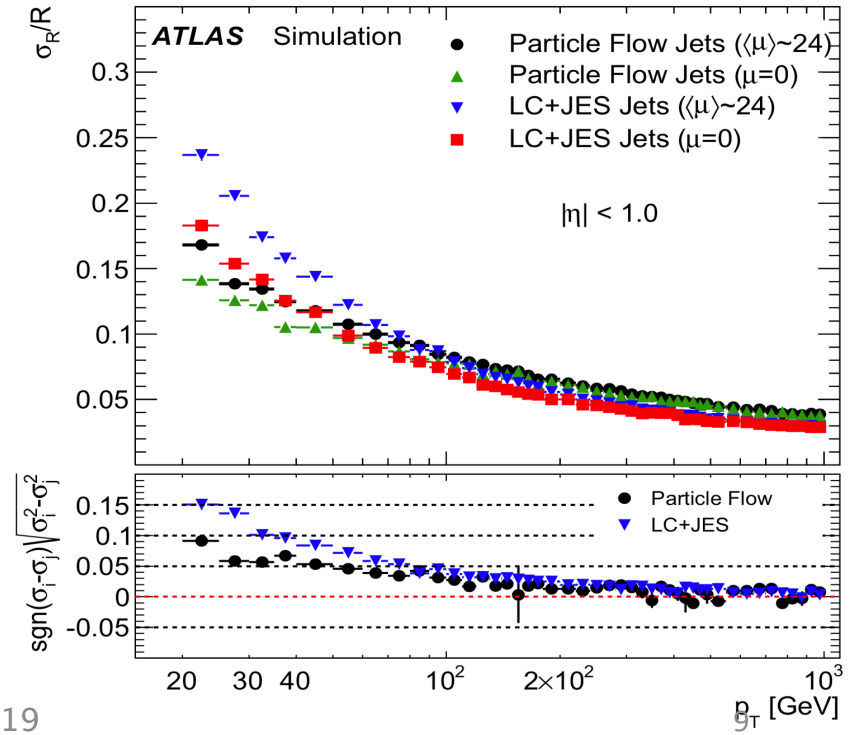


See talk by Jennifer Roloff and Pablo Rivandeneira

Particle Flow

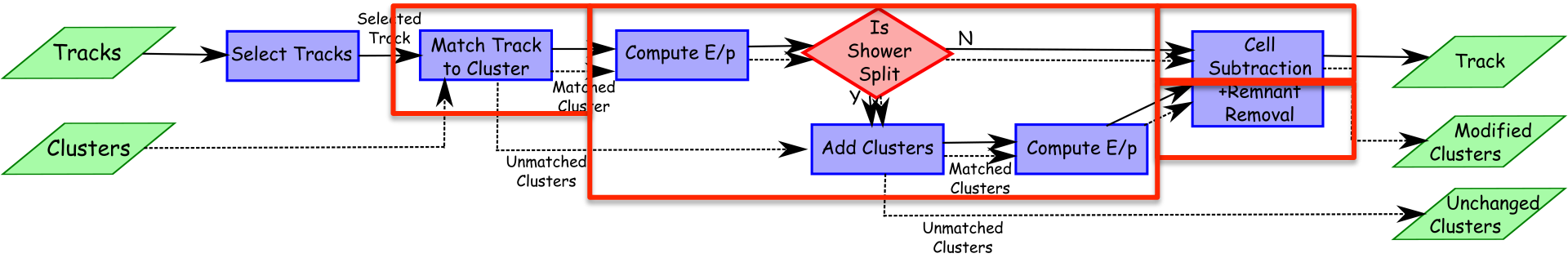
- Calorimeter and tracker provide complementary information
- Tracker:
  - Charged particles only
  - Better angular resolution
  - Pileup discrimination built in
  - Better efficiency and momentum resolution at low p_T
- Calorimeters:
  - Both neutral and charged particles.
  - Better energy resolution at high p_T
- Alternative approaches to TopoClusters
  - Particle Flow (PFO) – Good for low p_T
  - Track Calo Clusters (TCC) – for high p_T
  - Unified Flow Objects (UFO): try to get best of both



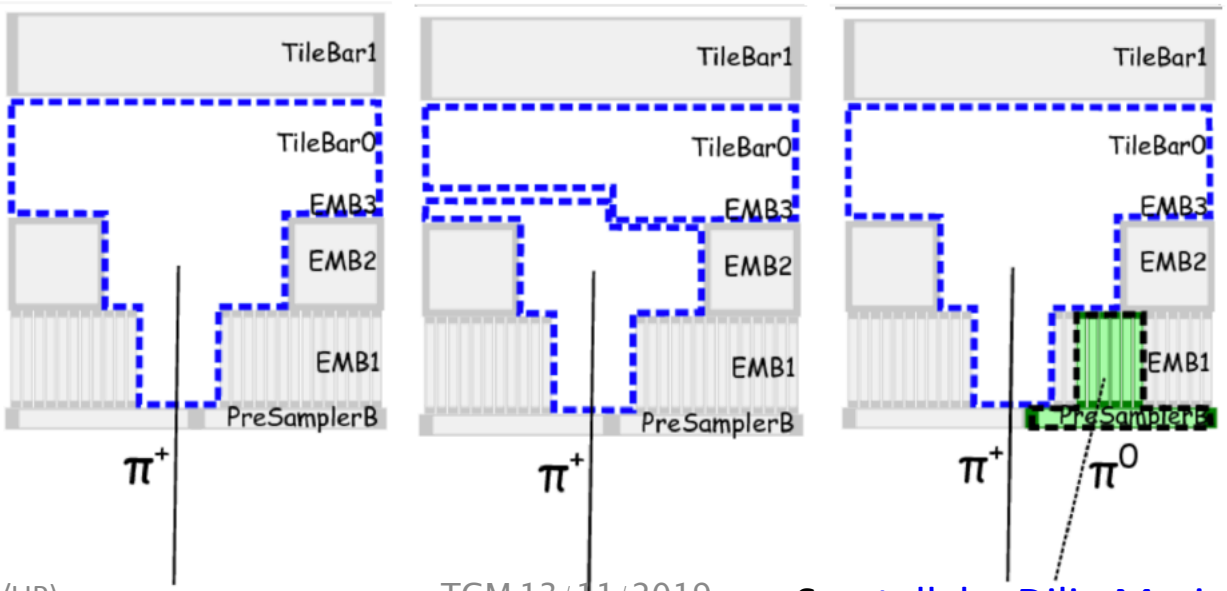


Eur. Phys. J. C 77 (2017) 466

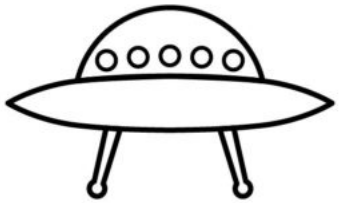
Particle Flow Objects



- Subtract calorimeter energy deposits that match an extrapolated track
  - Main thing is to avoid double counting of energy in tracks and clusters
  - At the end we have: tracks (charged particles), remaining clusters (neutrals)

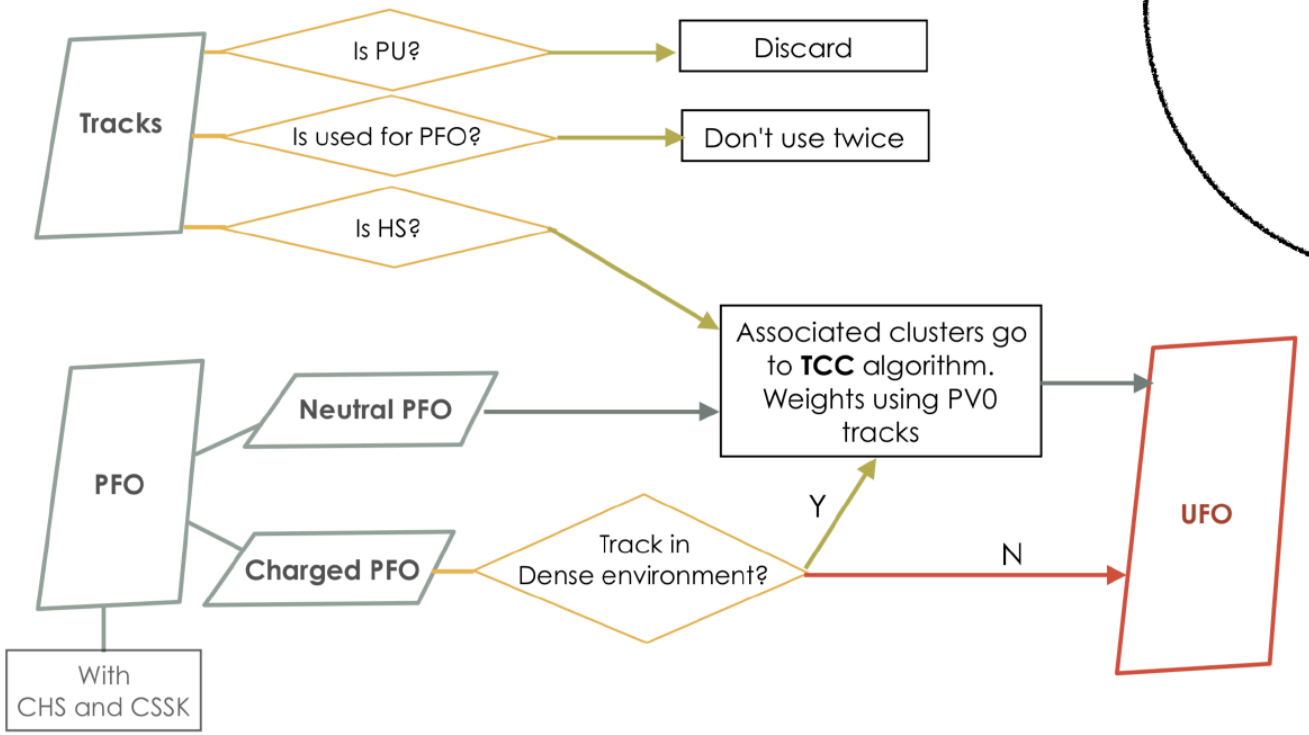


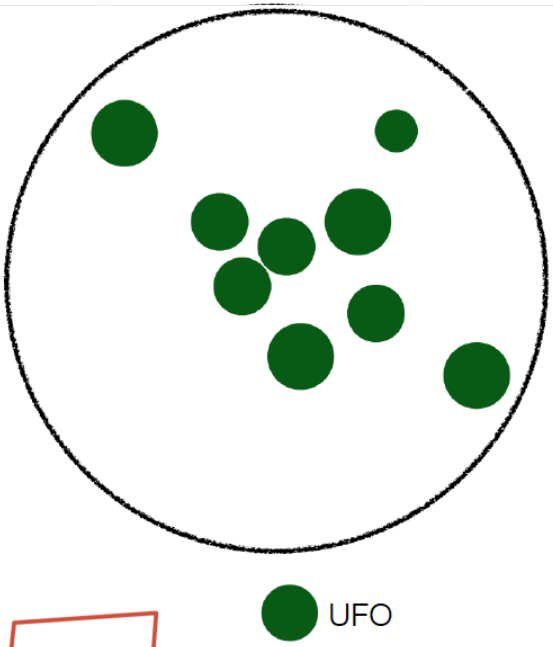
See talk by Dilia Maria Quintero



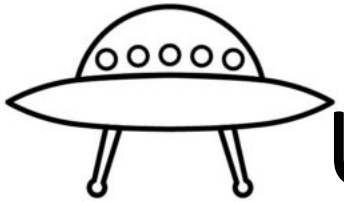
Unified Flow Objects (UFOs)

UFO merges PFO and TCC inputs, aiming to obtain a better and mo
stable performance in a wide pT range.



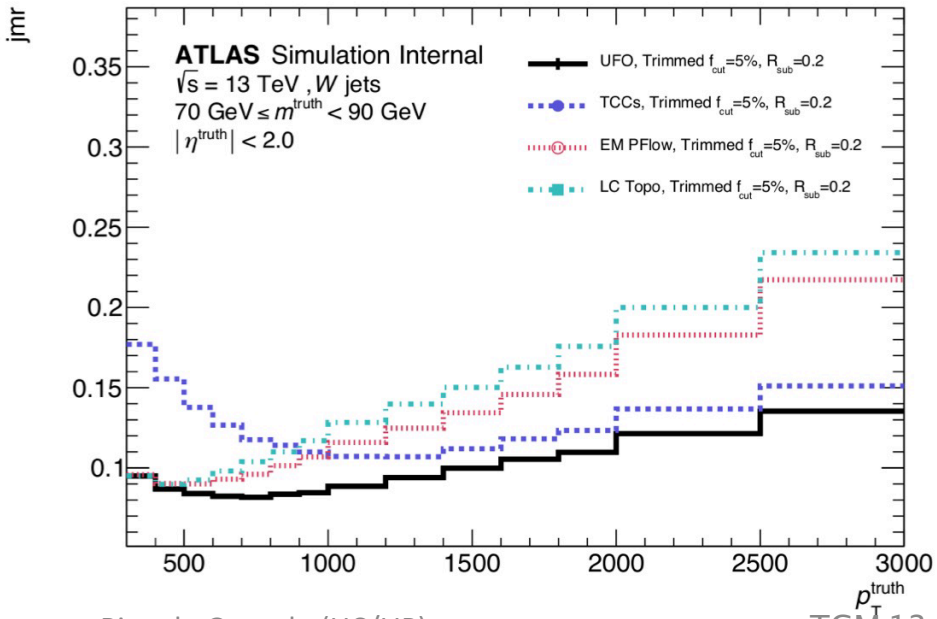


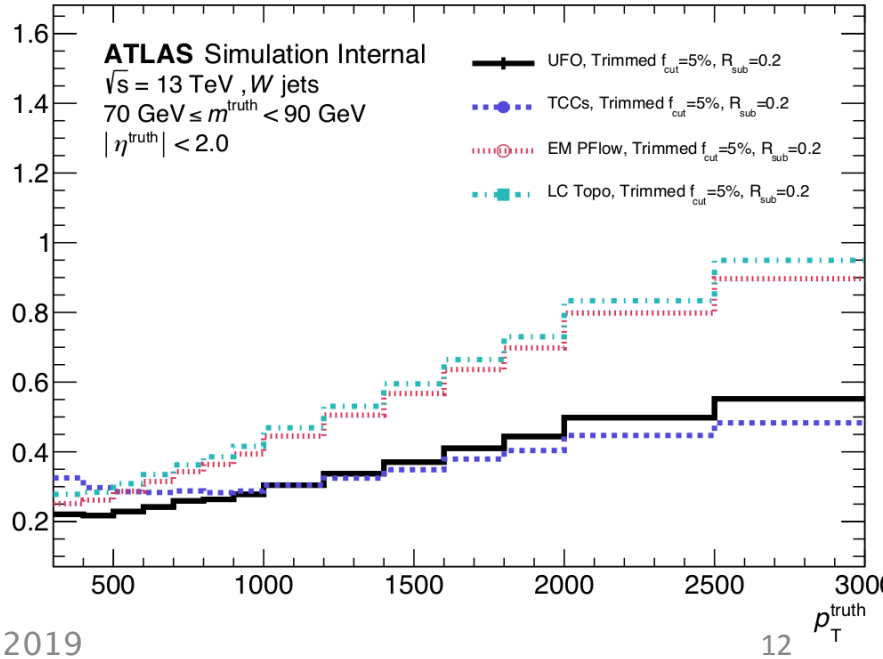
See talk by Dilia Maria Quintero



Unified Flow Objects (UFOs)

- PFlow already default for small-R jets
- Good UFO performance for large-R jets
  - UFOs will be default for substructure/large-R jets
  - Less relevant on short term for small-R
- Need to understand performance to decide on uses in trigger
  - See talk by TJ in Jet Trigger meeting

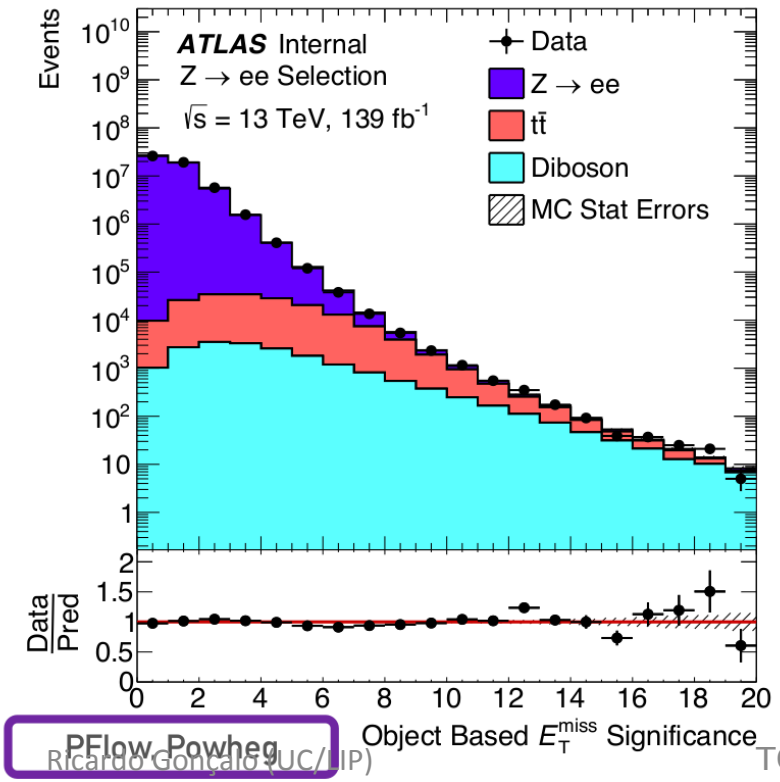


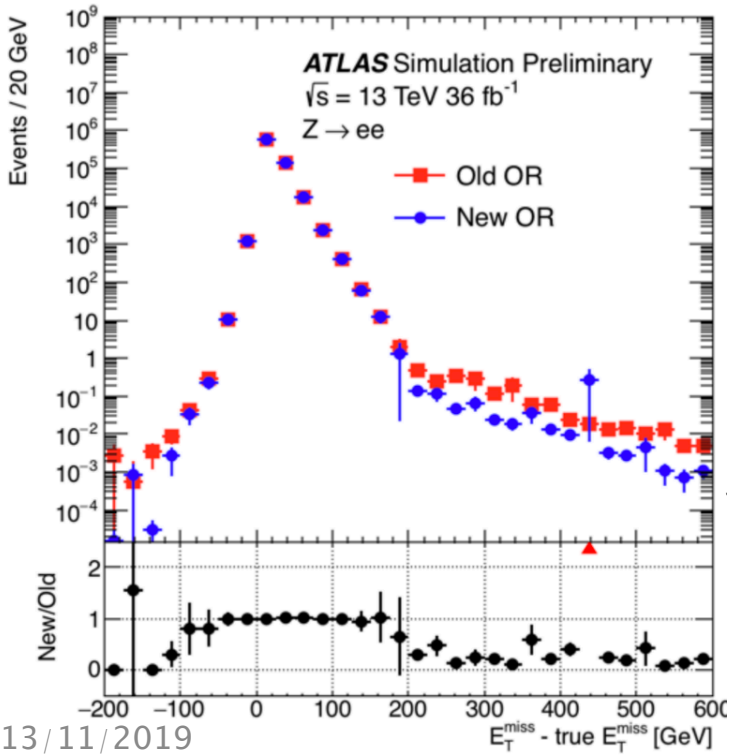


Missing ET

Offline

- MET signicance is increasingly used and working well
- Overlap removal in MET: Electron/photon/jet ambiguity resolution lead to improvements





Trigger vs Offline MET

- Offline: object-based algorithm using: $e^{\pm}$, γ, μ, τ and jets + Soft Term
- Trigger: use calo cells, TopoClusters, Jets
- 3 basic algorithms × pileup mitigation methods
  - 9 algorithms are being considered for Run3

Run2 name	Run3 name	Base	Track based pileup mitigation	Non-track based pileup mitigation
cell	cell	cell	n/a	n/a
n/a	cellPufit	cell	n/a	pufit
tc_lcw	tc	topoclusters	n/a	n/a
pufit	tcPufit	topoclusters	n/a	pufit
n/a	tcPufitCVF	topoclusters	CVF	pufit
trktc	tcVSSK	topoclusters	(CVF) - no need?	Voronoi Subtraction, SoftKiller
mht	mht	jets	n/a	n/a
n/a	mhtPufit	jets	JVT (or RpT)	pufit
trkmht	mhtTST	jets	JVT, Track Soft Term	n/a

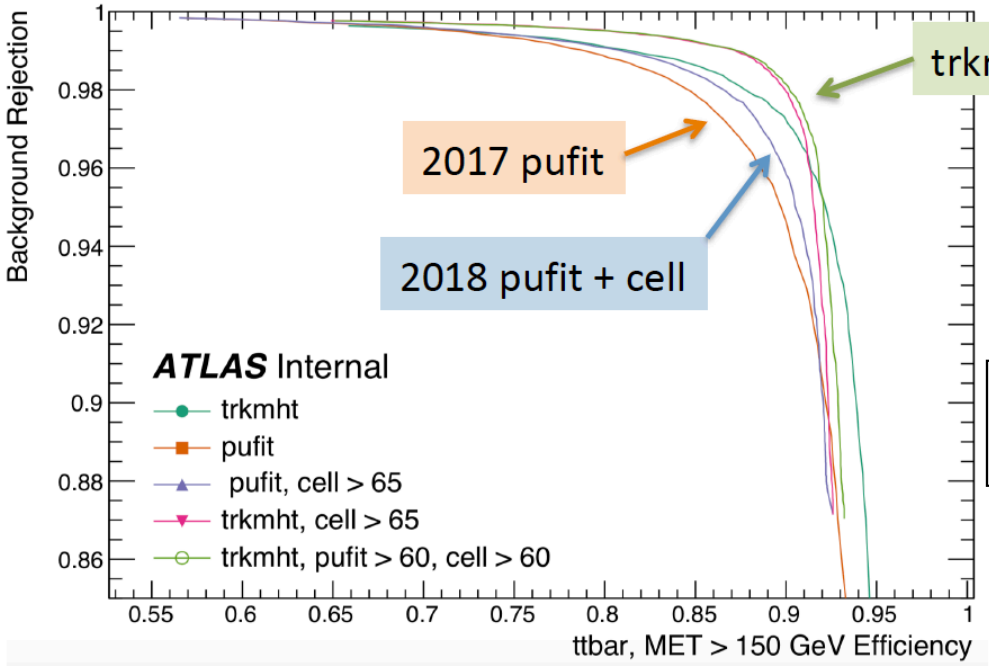
PFlow object (PFO) based algorithm?

Red: Main, Blue: Support, Green: Experimental

See talk by Kenji Hamano

Trigger
Algorithm Combination for Run3

- This is based on Run2 algorithms.



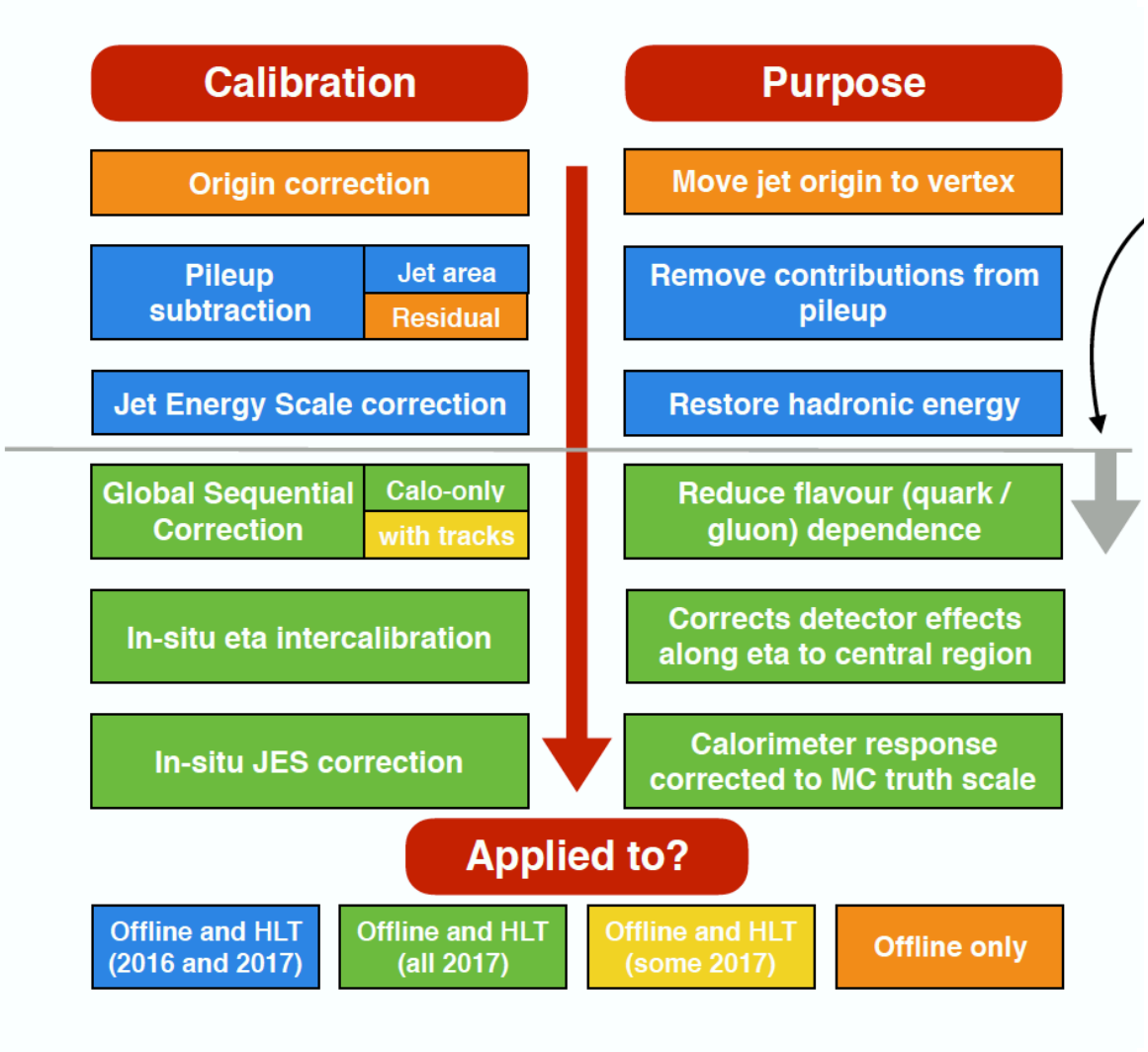
Thresholds are optimized to give the best performance

- Combination of cell + pufit + trkmht gives the best performance.
- Need to redo the study based on Run3 algorithms.

See talk by Kenji Hamano

Jet Trigger Calibration

Ingredients of jet calibration



Start with offline calibration

Use tracks whenever possible

From 2017: used tracking in jet triggers used for b-tagging chains

Ideal World

- Full-scan tracking at the HLT would mean:
- No complicated RoI-based tracking
  - All triggers would have tracking, not just b chains
- PFlow available for all thresholds
  - Better match with offline jets
  - Less rate wasted with migrations from below the threshold
- Pileup suppression with JVT
  - Less rate wasted from pileup effects
- Latest developments in Jiri's talk last week

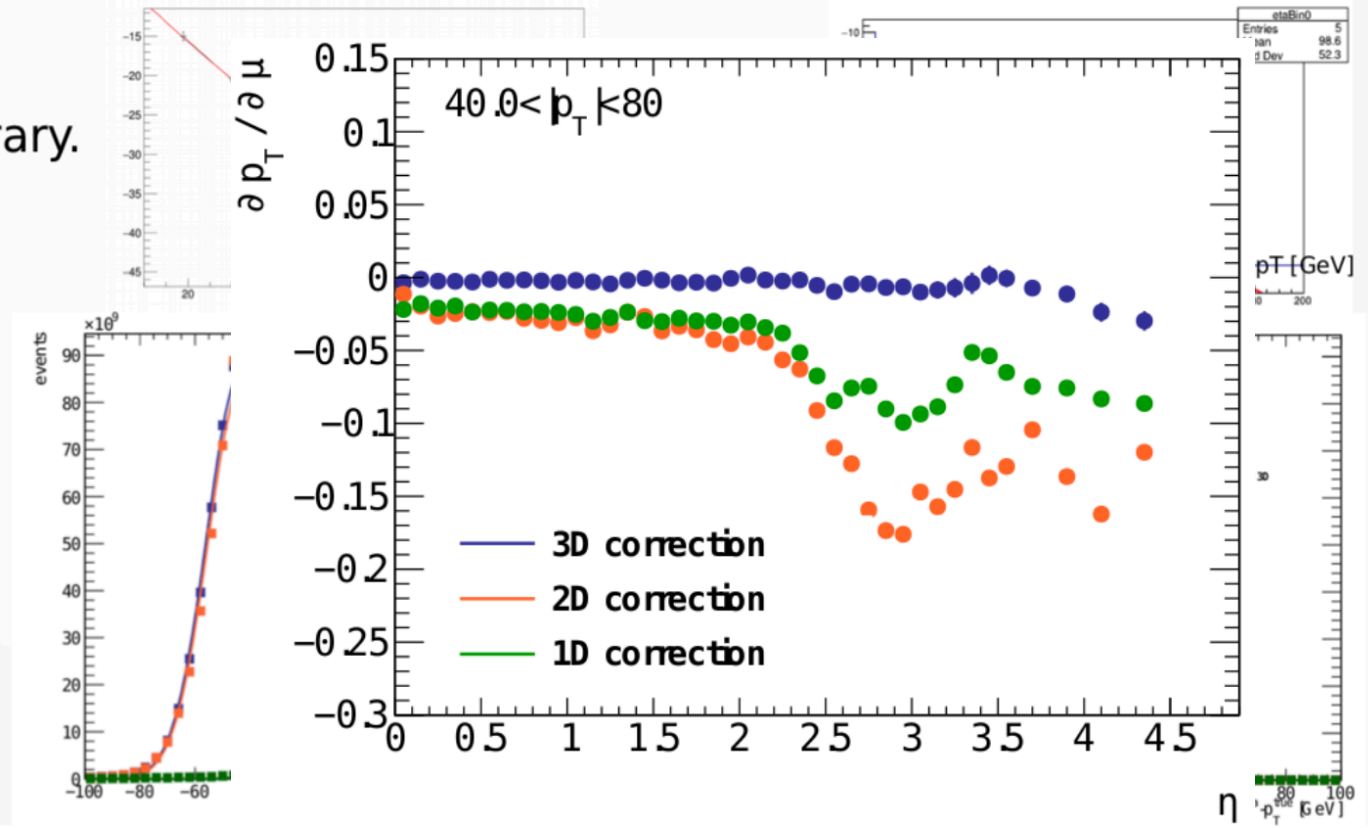
See Ben's contribution in HCW2019

Residual pileup subtraction

$$p_{\mathrm{T}}^{\mathrm{corr}} = p_{\mathrm{T}}^{\mathrm{reco}} - \rho \times A - \alpha \times (N_{\mathrm{PV}} - 1) - \beta \times \mu,$$

3D correction -<pT(area)-pTtrue>(eta,pT,NPV,mu) + <pT(area)-pTtrue>(eta,pT)

- Modeling of pT distribution is arbitrary.
- Uncertainty on the modeling



See talk by Jennifer Roloff and Pablo Rivandeneira

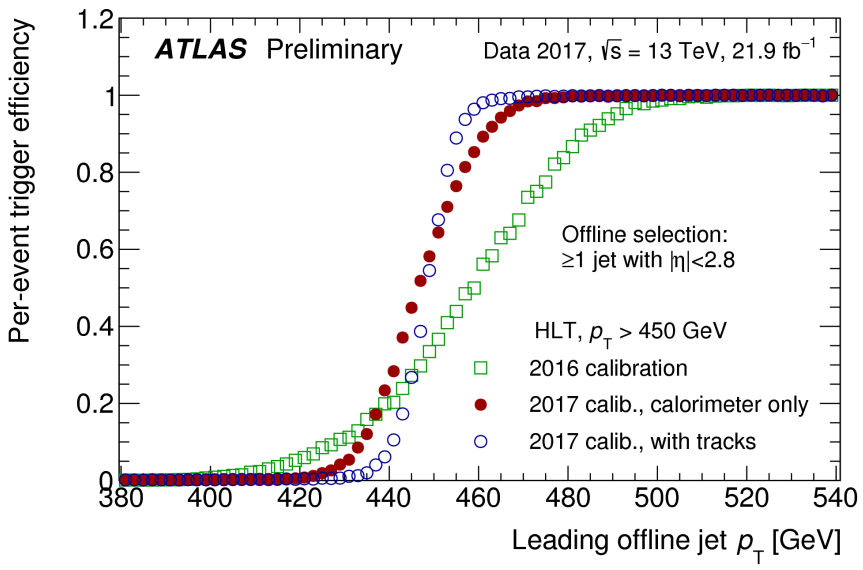
Jet Trigger Performance in Run 2

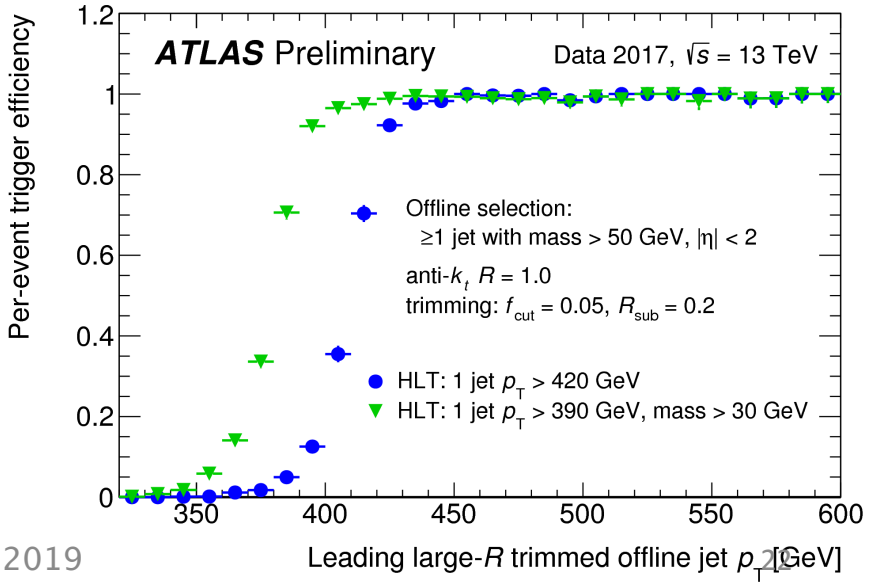
2017 Performance

- See ATL-DAQ-PUB-2018-002

- Single-jet trigger with different calibrations
  - 2016 calibration
  - 2017 calorimeter-only calibration
  - 2017 calibration plus GSC and in-situ corrections
- Better jet resolution!

- HLT large-R single-jet triggers
  - $|\eta| < 2.0$
  - jet mass > 50 GeV



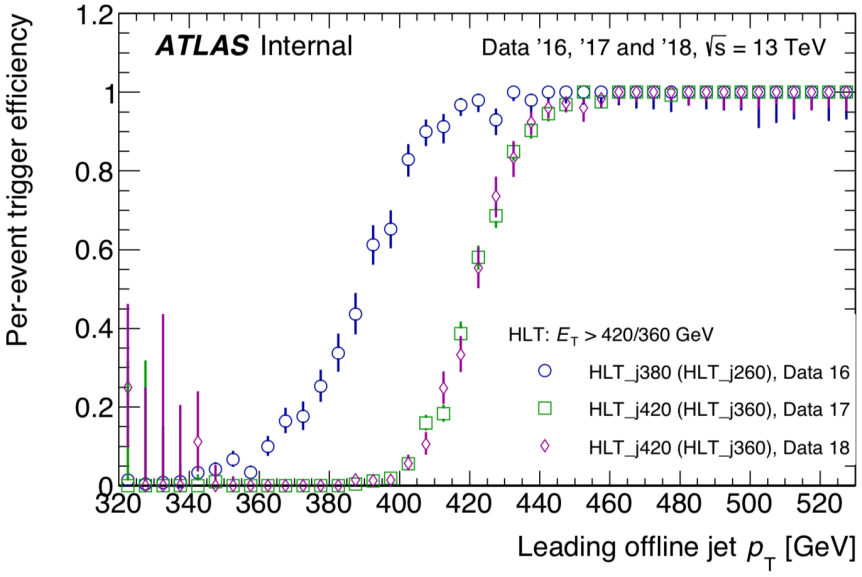


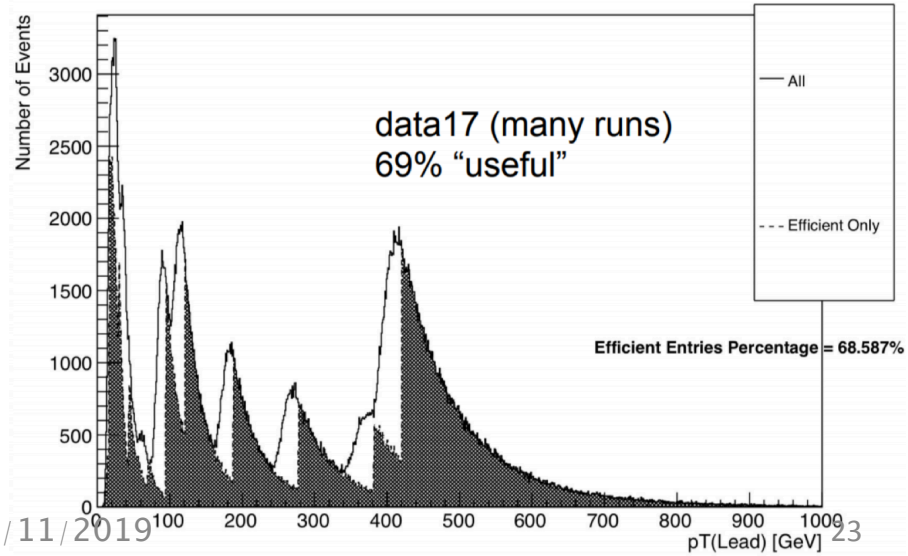
Latest updates

- Preliminary plots
  - Work in progress; not full stats

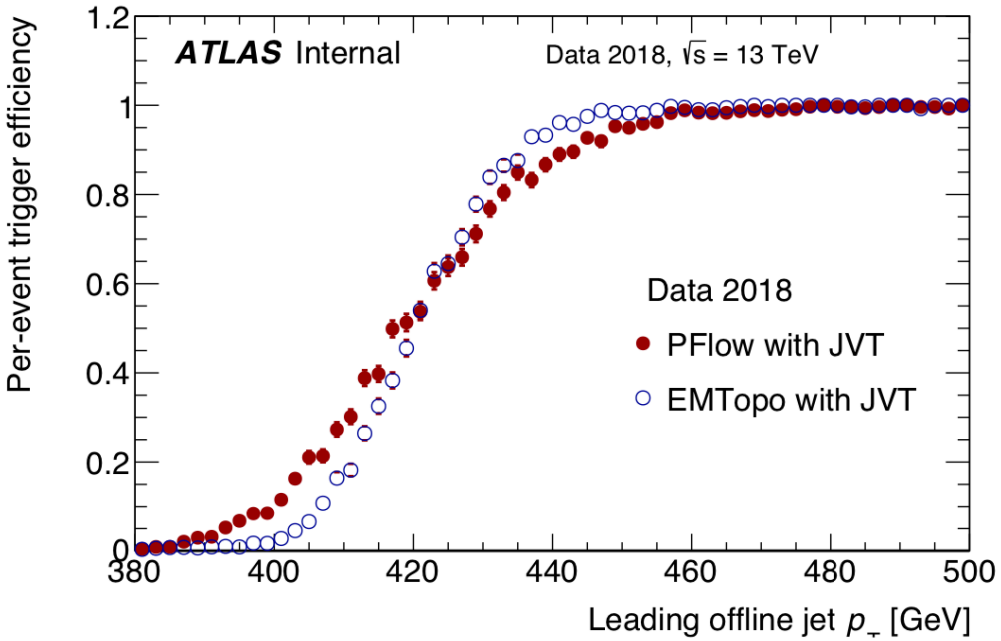
- Lowest unprescaled single jet turn-on
- 2016 data
- NOTE: your latest calibration doesn't exist when trigger is running...
- 2017 and 208
  - Updated JES
  - Added GSC
  - Added in-situ correction

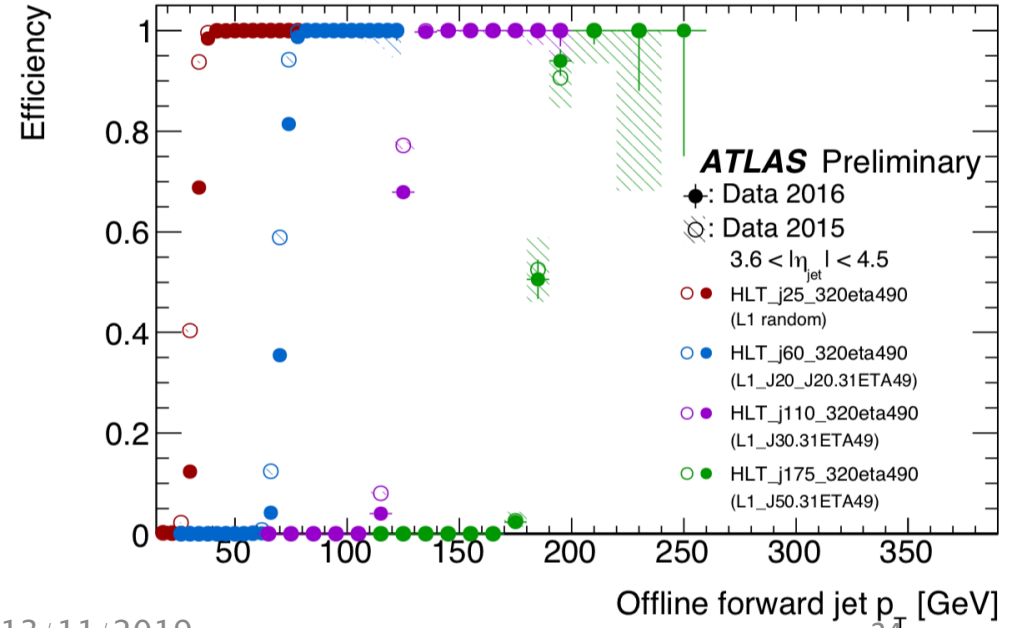
- Impact of HLT calibration: (shaded: >99% efficiency)
- Efficiency increased from 51% (2015) to 69%





- EMTopo trigger jets plotted vs offline EMTopo or Pflow
  - Note: x-axis is either EMTopo or PFlow
- For completeness: forward jets





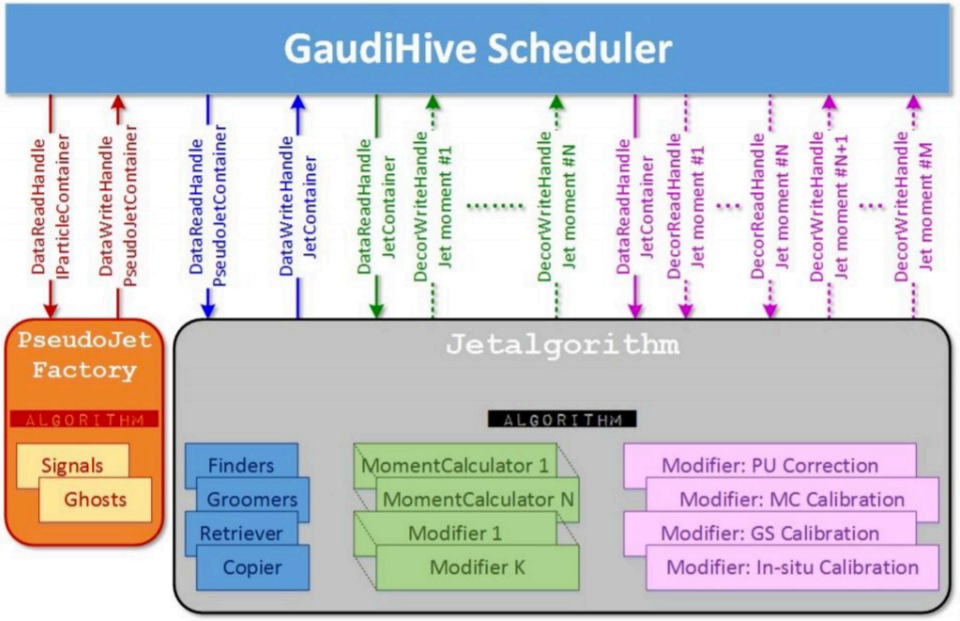

B-W Green 1 has been destroyed.
Cannon recharge at maximum rate.
3 3
0
EJECT
GUN: Talon 4
SHD 136% HULL 100% SYS 100%
E L S
1:54
50%
THROTTLE
B-W: Green 2
DIST 1.60
SPEED

SOFTWARE

Software for Run 3

- Replacing JetRecTool with new, simpler JetAlgorithm
  - To replace JetRecTool's convoluted internal logic and use
  - Run a IJetProvider (new interface) to either build jets or grab existing ones.
  - Run all IJetModifiers (existing interface), including moment calculation, calibrations, etc
- Entirely new configuration system for both jets and MET

- Currently have multiple particle ow EDM classes:
  - PFO, original TCC, TCC schema evolved for UFO
- Will harmonize this with a single particle flow EDM class, with links to tracks and/or clusters

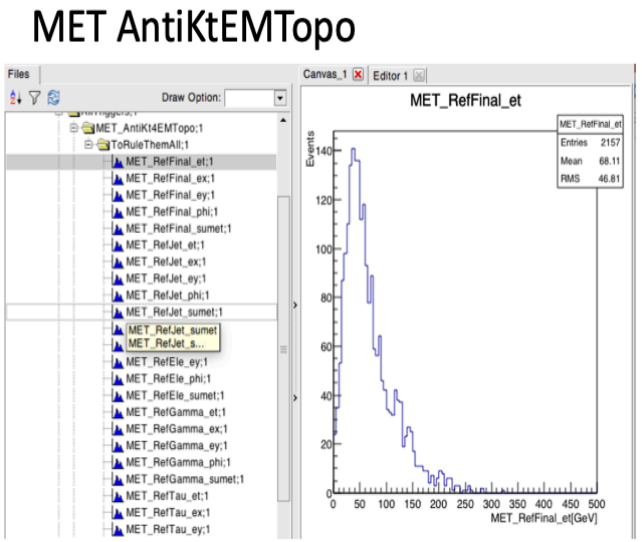


See talk by Bill Balunas

JET / MET MONITORING AND VALIDATION

Monitoring and Validation

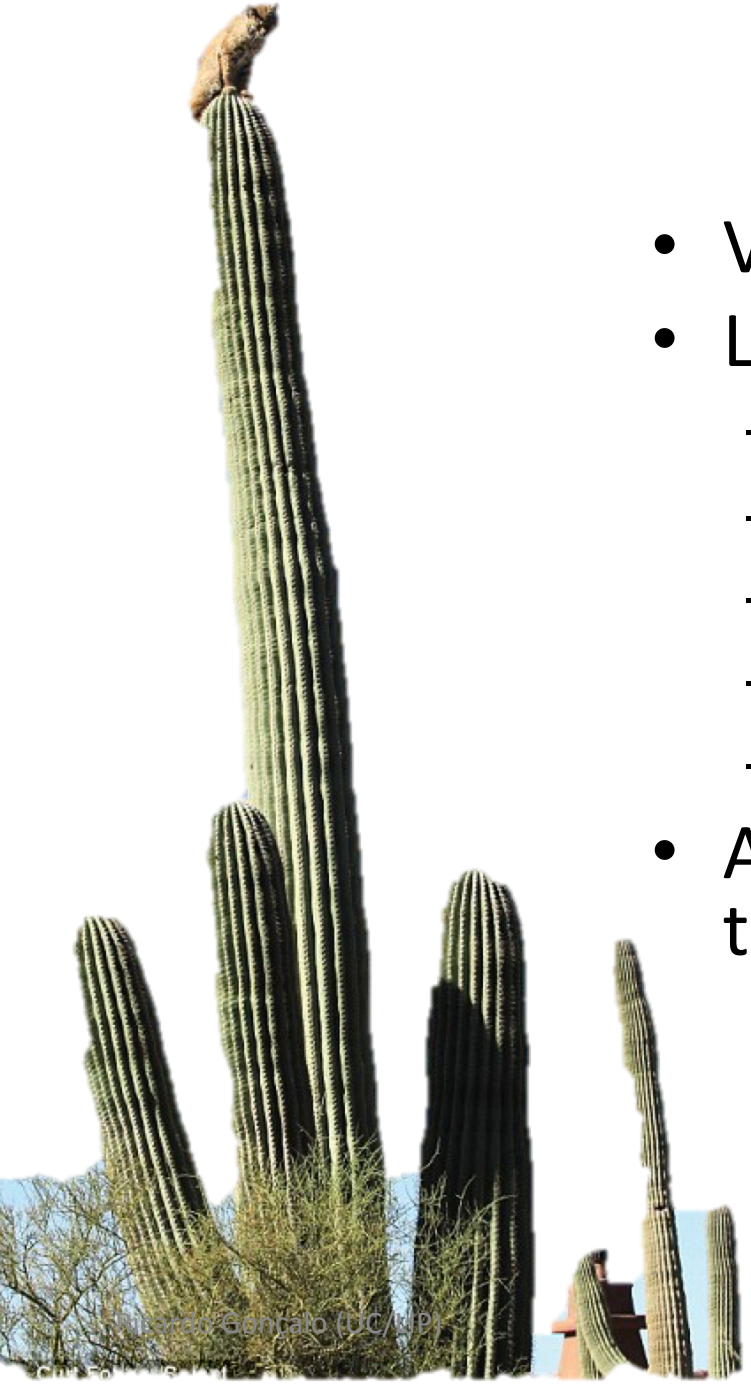
- Data quality monitoring for Run 3:
  - New AthenaMT compatible monitoring framework
  - JetEtmiss & calo combined monitoring software being re-written for new framework
    - Covering Jets, MET, Calo, and Pflow
  - Ideas on automating monitoring with Machine Learning
    - Train on defects,
    - Use ML to pre-label new data



- Validation:
  - Opinion was that there is room for improvement!
  - Plans/ideas, e.g. testing configs, using articial jets to cover phase space
  - Plans to develop testing framework based on unit tests

- **Good** cross talk between offline and trigger in these areas!

See talks by Lee Sawyer, P-A Delsart, GalenGledhill



Conclusions

- Very interesting workshop!
- Lots going on in Jet/MET group
  - Software and EDM changes
  - Pileup suppression in inputs
  - New calibration techniques
  - DQ using machine learning
  - etc
- Also very healthy interaction with trigger

Backup

Tracks in the jet trigger(*)

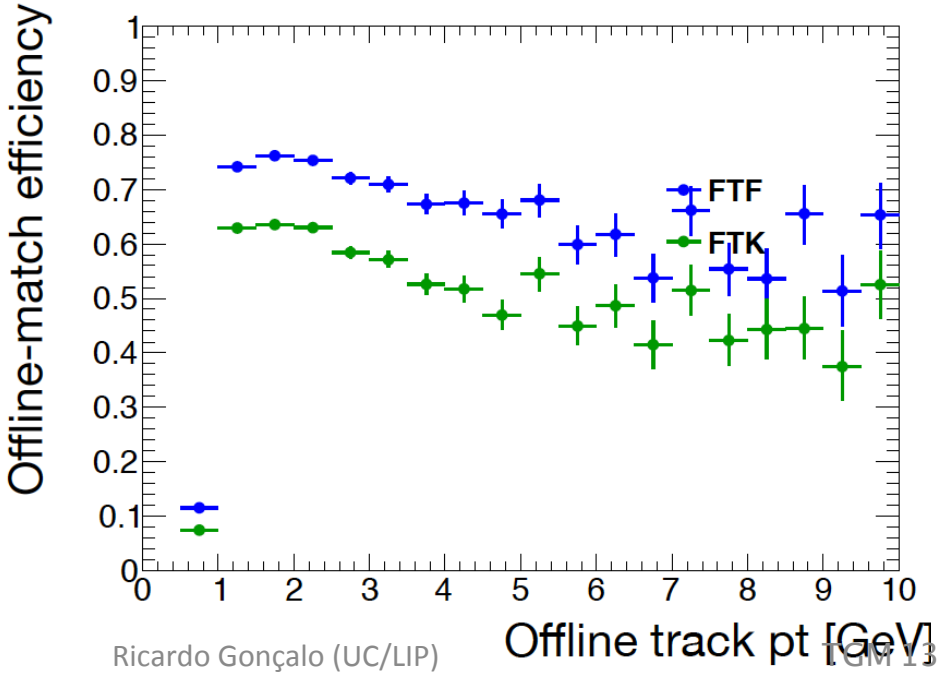
(*) In an FTK-less world

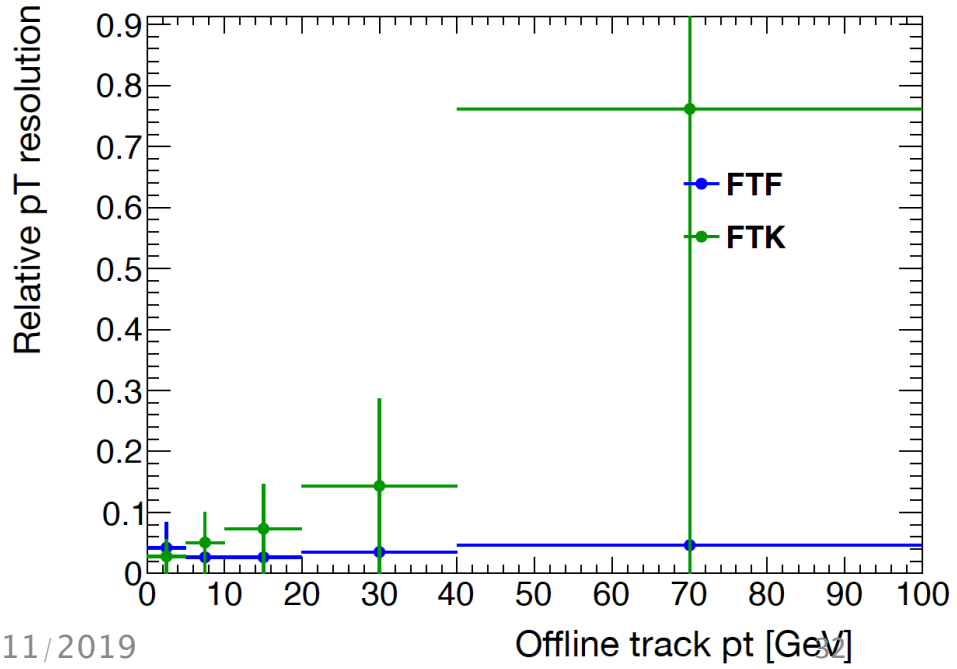
TJ Khoo

FTK vs FTF comparison

- Took 21.3 AOD sample with FTF & FTK tracks (ART test)
- Match tracks to offline with min deltaR cut of 0.01
  - Good enough, no overlaps
- Applied 500 MeV pT cut and TightPrimary WP
- Compare resolution and efficiency for FTF and FTK (non-refit)
- Resolution is width of Gaussian (fitted to +/- 2 sigma)

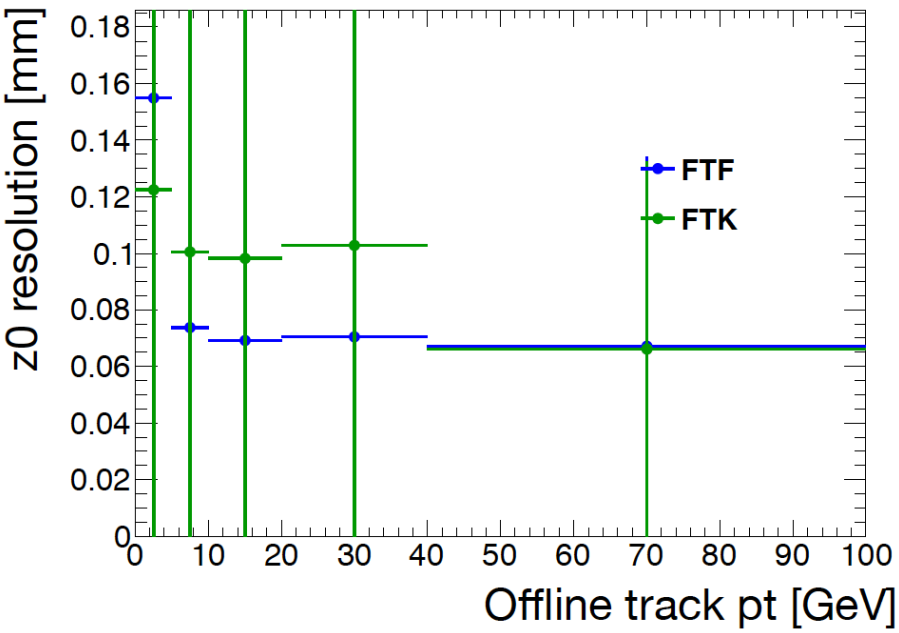
Rate wrt no JVT	JVT>0.15
HLT_j15	81%
HLT_j45	85%
HLT_4j15	13%
HLT_2j45	45%
HLT_4j45	76%
HLT_6j45	68%

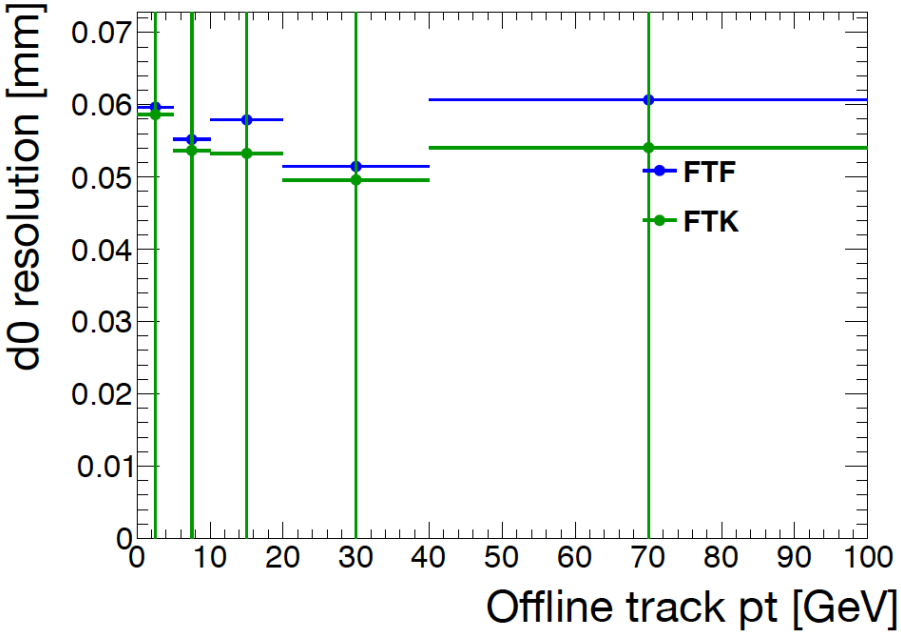




FTK vs FTF comparison

- Performance of **these** FTF tracks seems better than FTK benchmark
  - Except resolutions at very low p_T
  - And have not checked fake rate
- BUT: this version of FTF takes 5s/event
  - Not only tracks, also need vertexing algorithm
  - Goal is 1s/evt but compatible with FTK performance ; currently 5s/evt





Tracking scenarios

- First: need a better assessment of PFlow performance with HLT tracks
  - Initial results from 2016, but raised questions recently
  - Need to establish that the HLT PFlow gives us a significant benefit over pure calo triggers.

- Baseline procedure would be:
  1. Run HLT fast-tracking (re-optimised for speed, performance similar to FTK)
  2. Run PFlow with HLT tracks & clusters
  3. Run PFlow jet-finding

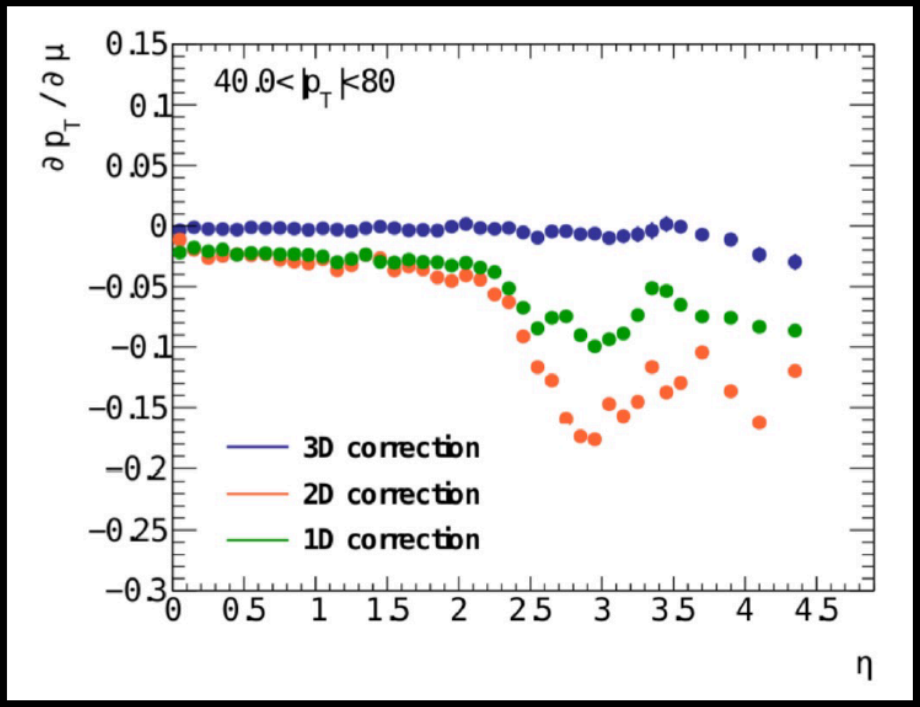
- Plan B (if we get decent FTF track performance but fail CPU constraints):
  1. Build jets from topoclusters for pre-filtering (no track GSC)
  2. Run HLT fast-tracking (reoptimised for speed, performance similar to FTK)
  3. Run PFlow with HLT tracks & clusters
  4. Run PFlow jet-finding

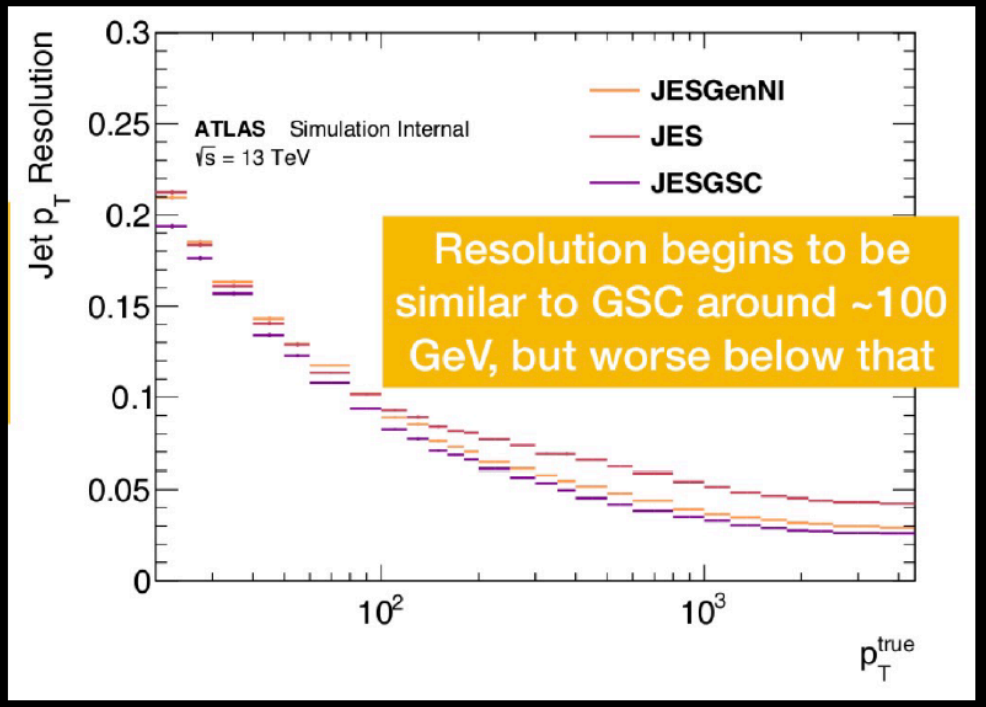
- Plan C (if PF still worth it but plans A and B fail CPU constraints):
  1. Do tracking only in RoIs around jets (a la current b-jet tracking) with low enough thresholds to build vertices and achieve some pileup suppression

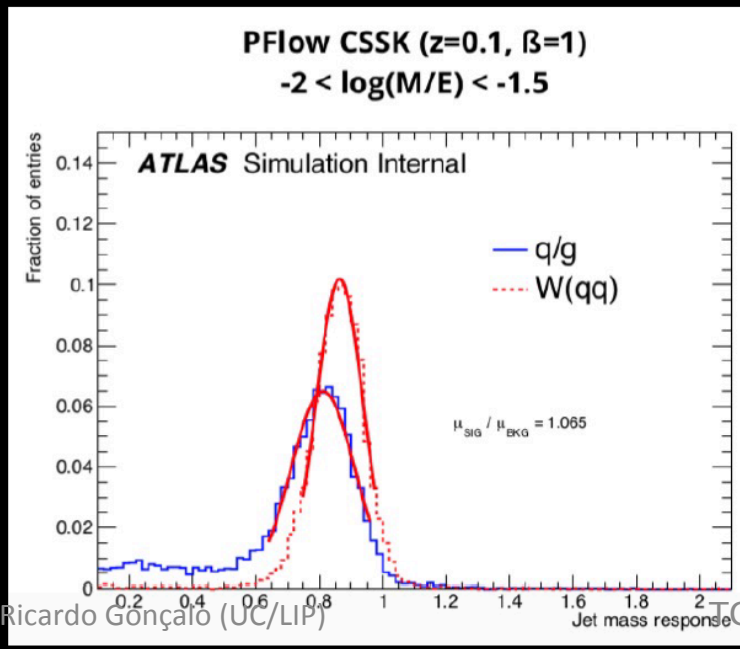
Slides by TJ in Jet Trigger meeting

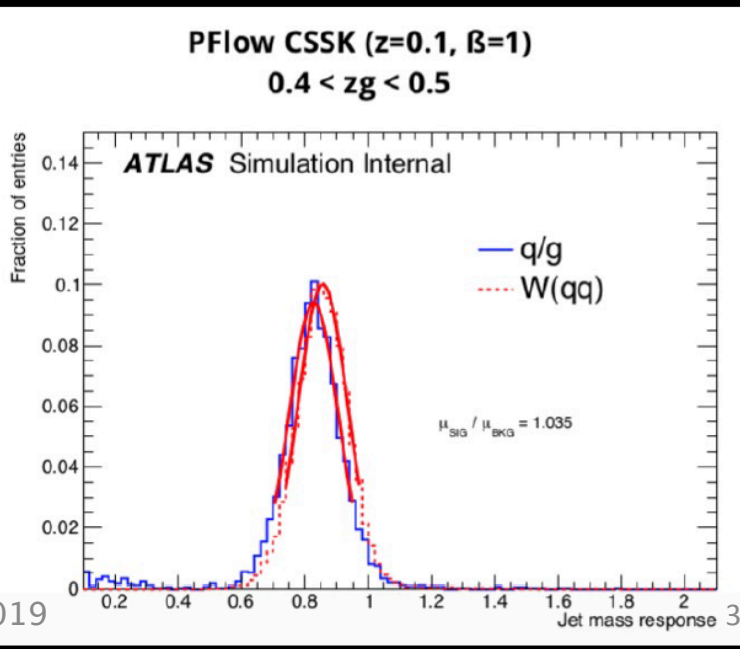
Jet calibration

- Precision recommendations in MCJES stages, some new methods being tried:
  - 3D pileup corrections — look very good
  - GenNI/ML calibration — combine MCJES with GSC
    - Not certain to converge: may revert to GSC
  - Different variables for JMS calibration to reduce topology-dependence
- Should we wait a bit for a decision to avoid duplicating effort with a different method?
- Note: no guarantee that Run 2 precision == Run 3 baseline


40.0< p_T <80
$\partial p_T / \partial \mu$
η
3D correction
2D correction
1D correction


ATLAS Simulation Internal
√s = 13 TeV
JESGenNI
JES
JESGSC
Jet p_T Resolution
p_T^{true}
Resolution begins to be similar to GSC around ~100 GeV, but worse below that

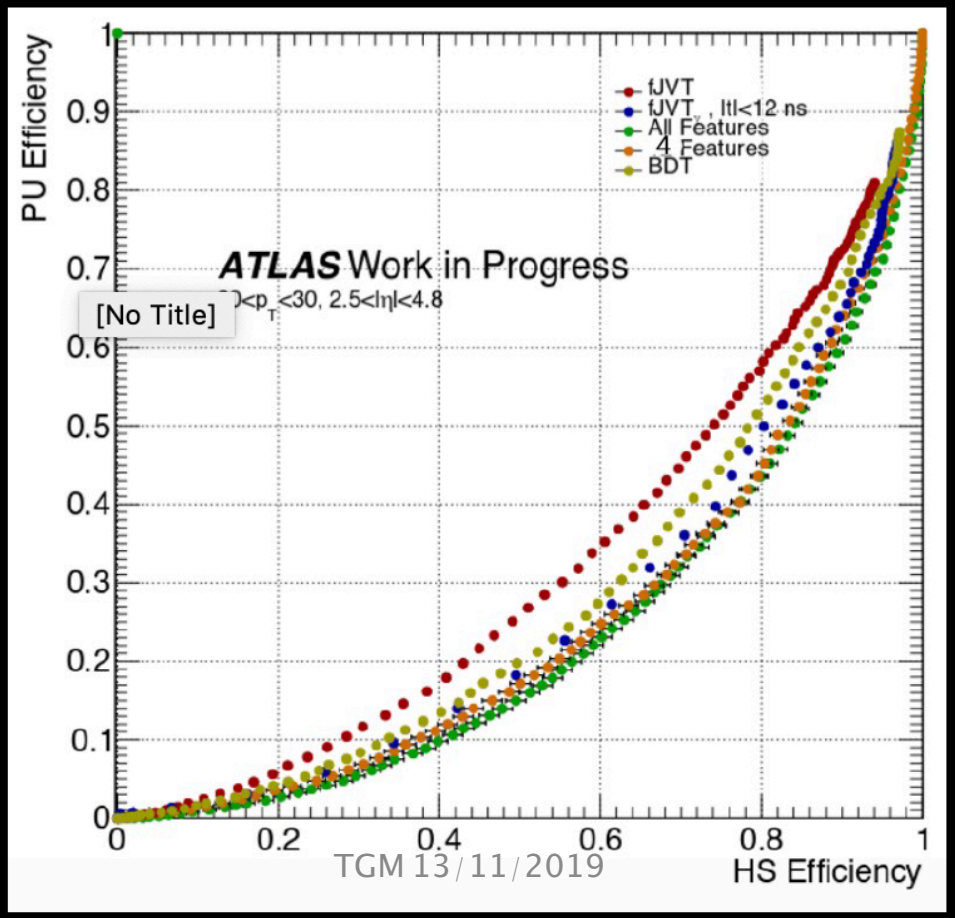

PFlow CSSK (z=0.1, ß=1)
-2 < log(M/E) < -1.5
ATLAS Simulation Internal
q/g
W(qq)
μ_{SIG} / μ_{BKG} = 1.065
Fraction of entries
Jet mass response


PFlow CSSK (z=0.1, ß=1)
0.4 < zg < 0.5
ATLAS Simulation Internal
q/g
W(qq)
μ_{SIG} / μ_{BKG} = 1.035
Fraction of entries
Jet mass response

Jet tagging

- Q/G and substructure taggers at this point probably still not baseline for trigger, unless analyses want to push
- Two ML methods for JVT trained, slight gains
  - Probably insignificant rate reduction for trigger, but important in terms of efficiency
- Have not (yet) looked at fJVT, needs lots of tracking for limited rejection. Methods improving esp with towers
  - Something to look at for 2022?

Algorithms	JVT loose Efficiency=0.97		JVT medium Efficiency=0.92		JVT tight Efficiency=0.85	
	Cut (JVT >)	PU Rejection	Cut (JVT >)	PU Rejection	Cut (JVT >)	PU Rejection
JVT (Run 1)	0.295	0.915	0.828	0.956	0.955	0.964
KNN_V2	0.170	0.916	0.640	0.961	0.870	0.968
MLP_V4	0.525	0.931	0.904	0.966	0.953	0.973



Tracking

- Suggestion that fullscan tracking is irrelevant for L1_J100 and seeded HLT triggers, use regional to save CPU
  - Not clear — TLA, b-tagging, other applications may want tracks at least for lower pt jets
- Probably an optimisation to be done by menu
- FullScan is still easiest technically — needs implementation/integration ASAP (esp PFlow)
  - Solve regional problem as 2nd priority

News Summary

- New unified EDM: a single particle flow EDM class, with links to tracks and/or clusters

- Data quality monitoring:
  - Automating with machine learning techniques
  - Using artificial jets to cover phase space in tests

- ETC... (to be completed)