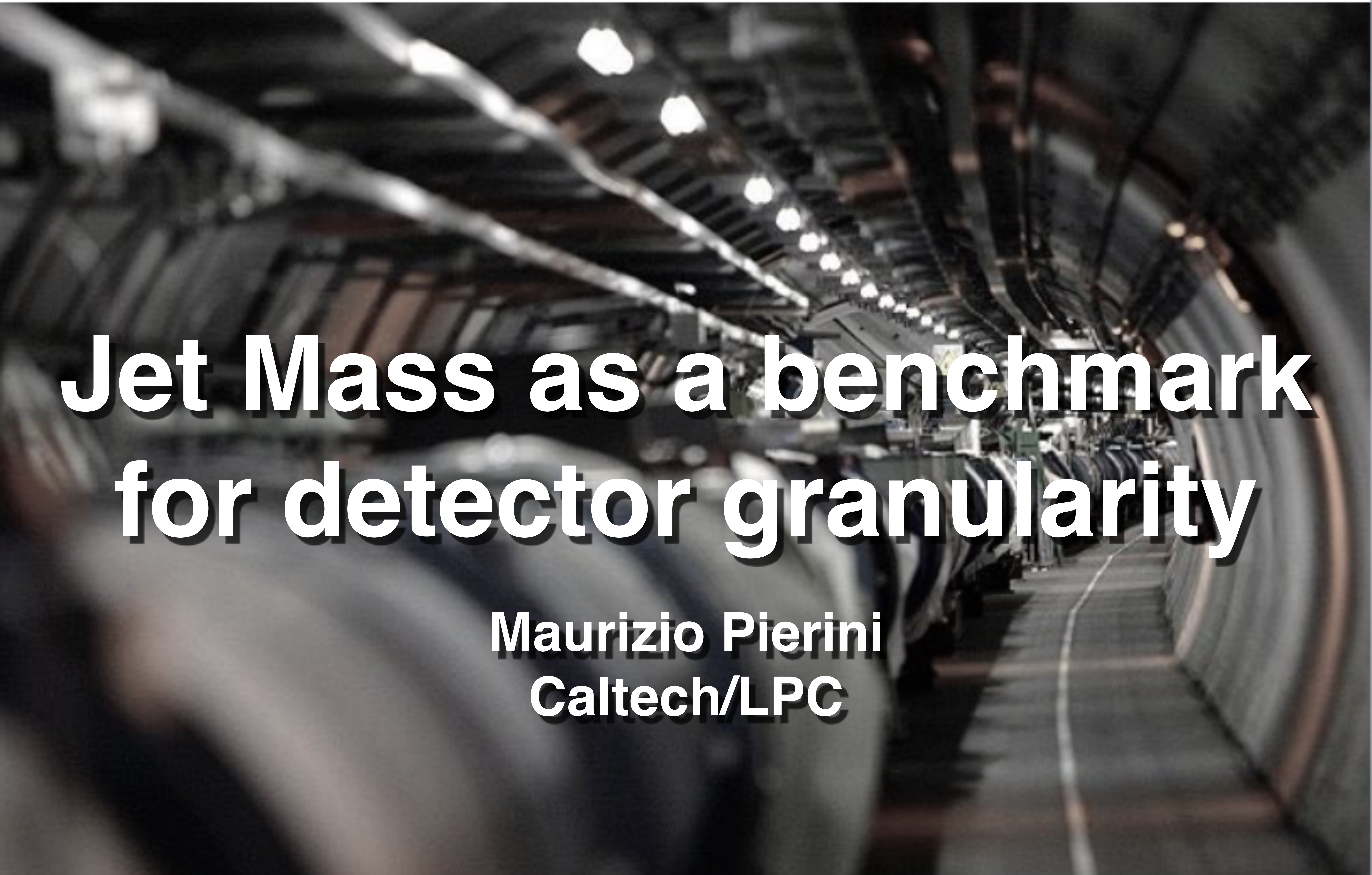
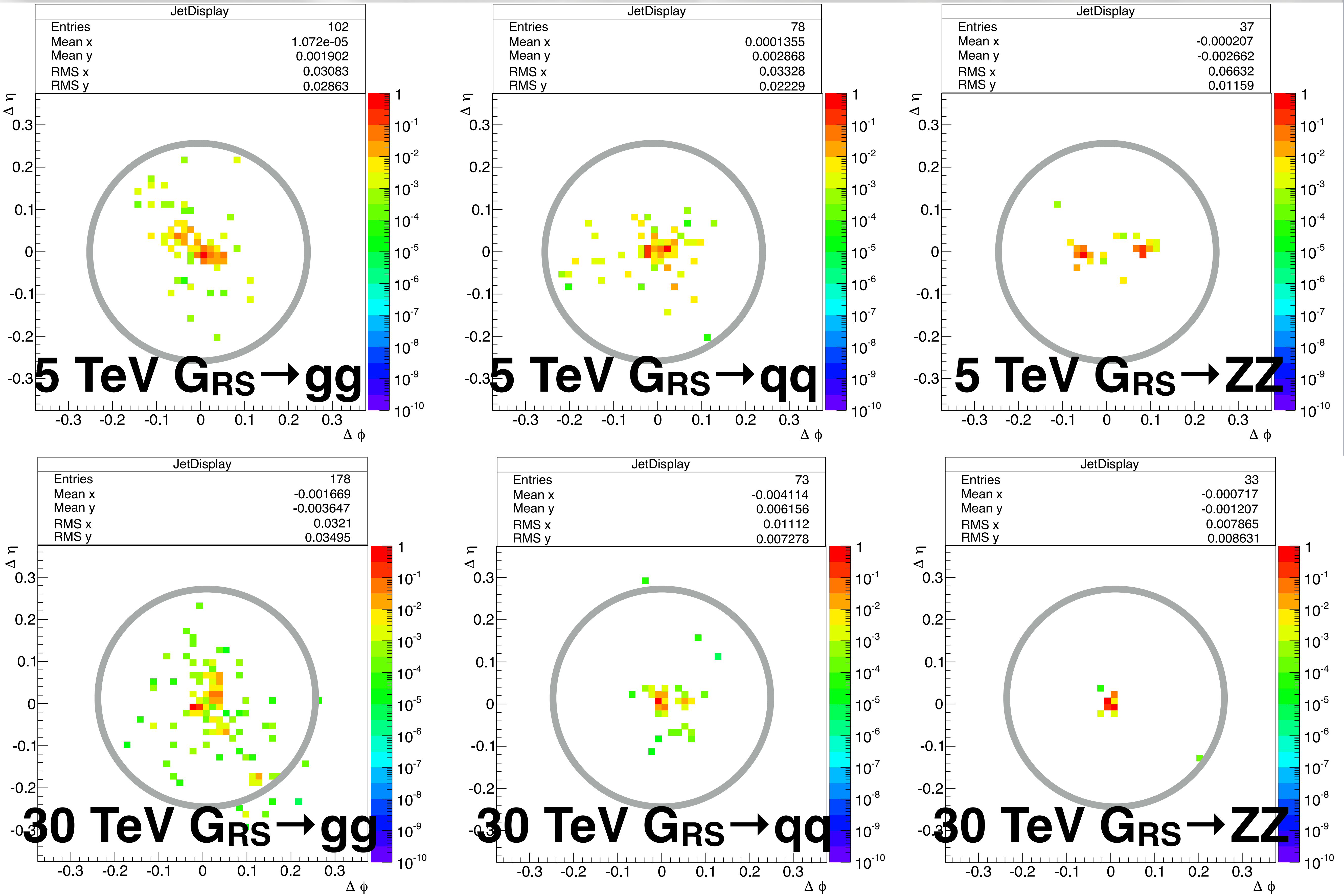


Jet Mass as a benchmark for detector granularity

Maurizio Pierini
Caltech/LPC

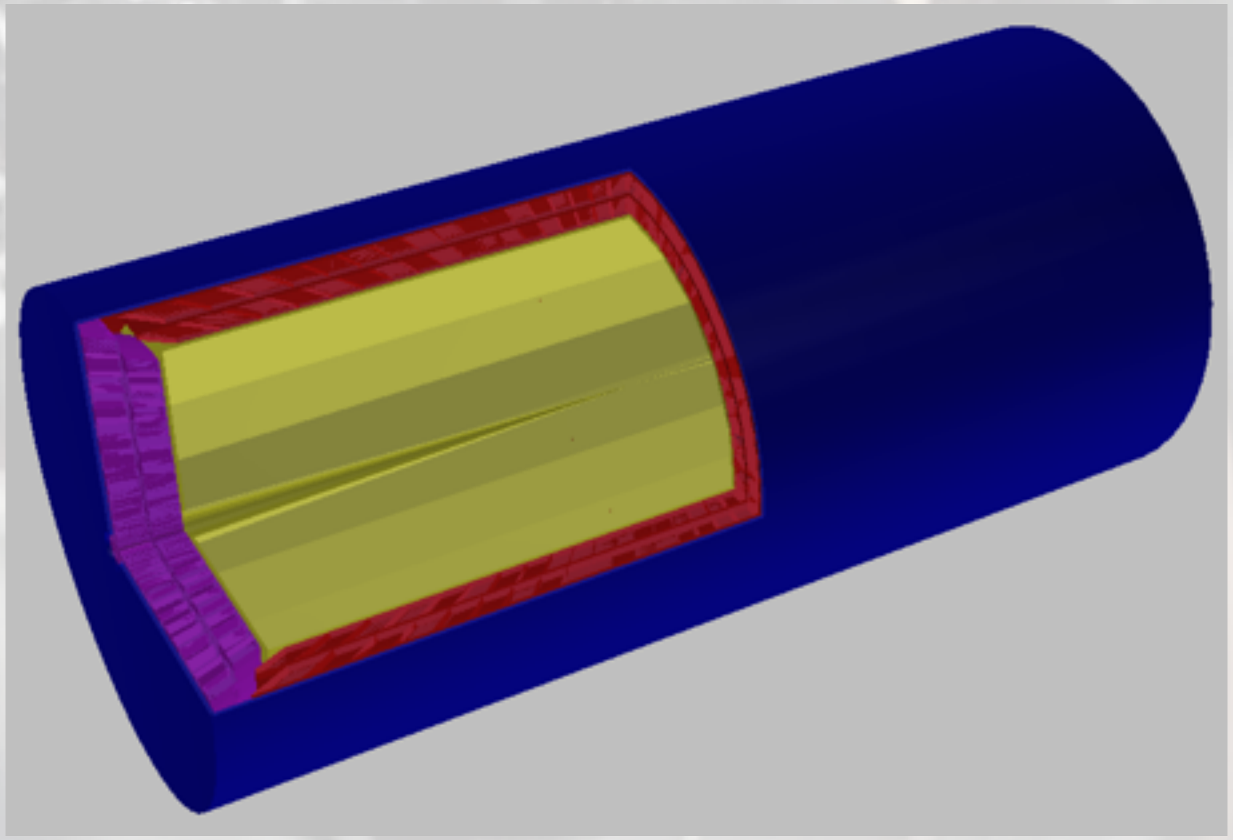
Substructure as granularity benchmark



Event Reconstruction

- RS Graviton G→ZZ→4q events generated with PYTHIA
- Events saved in HepMC format and processed through Delphes
- The template FCChh card provided with Delphes taken as default

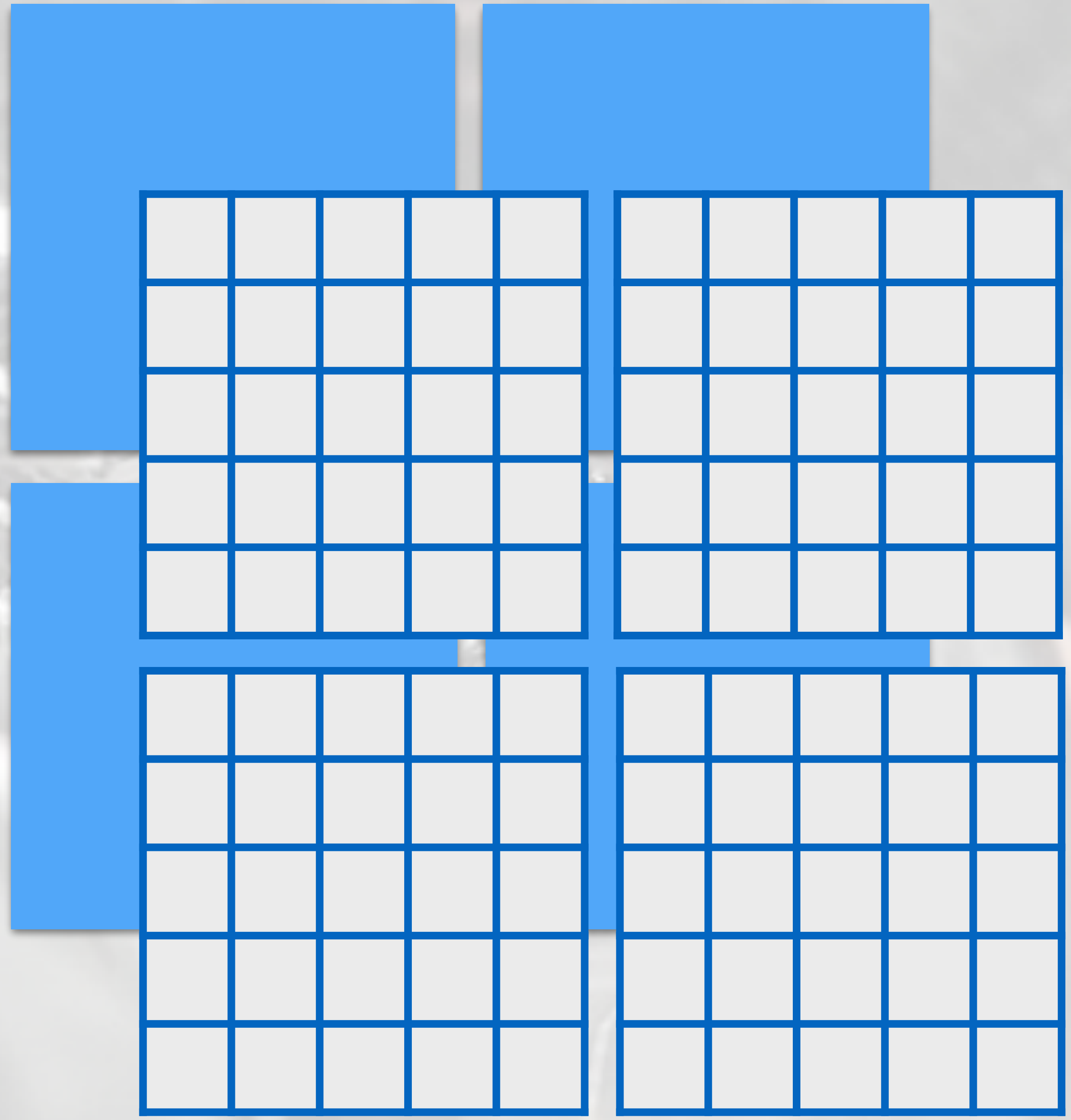
  ✓ Inner Magnetic field B= 6 T
  ✓ Inner detector radius 2.6 m
  ✓ Tracking ~ LHC detectors
  ✓ ECAL performances ~ CMS
  ✓ HCAL performances ~ ATLAS



- Granularity modified to study performances vs granularity
  - x 1/2 cell size, keeping the same HCAL/ECAL ratio
  - x 2 cell size, keeping the same HCAL/ECAL ratio

Three granularity scenarios

- **Basic**
  - Δφ X Δη in ECAL: 0.5° x 0.01
  - Δφ X Δη in HCAL: 2.5° x 0.05
- **X2 (BIGGER) cell size**
  - Δφ X Δη in ECAL: 1° x 0.02
  - Δφ X Δη in HCAL: 5° x 0.1
- **X1/2 (SMALLER) cell size**
  - Δφ X Δη in ECAL: 0.25° x 0.005
  - Δφ X Δη in HCAL: 1.25° x 0.025

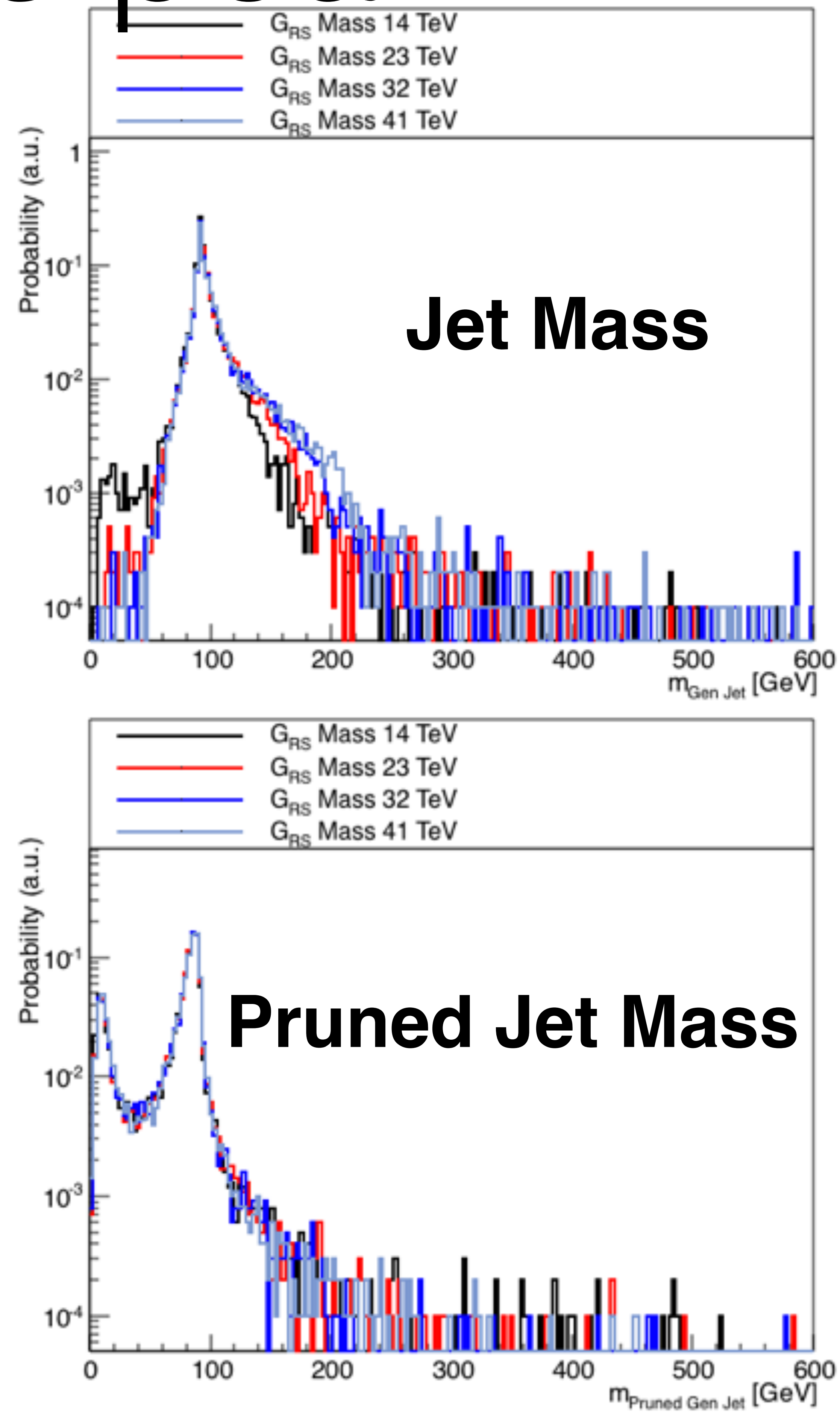


FIXED ratio in Δφ X Δη

1 HCAL cell =
5x5 ECAL cells

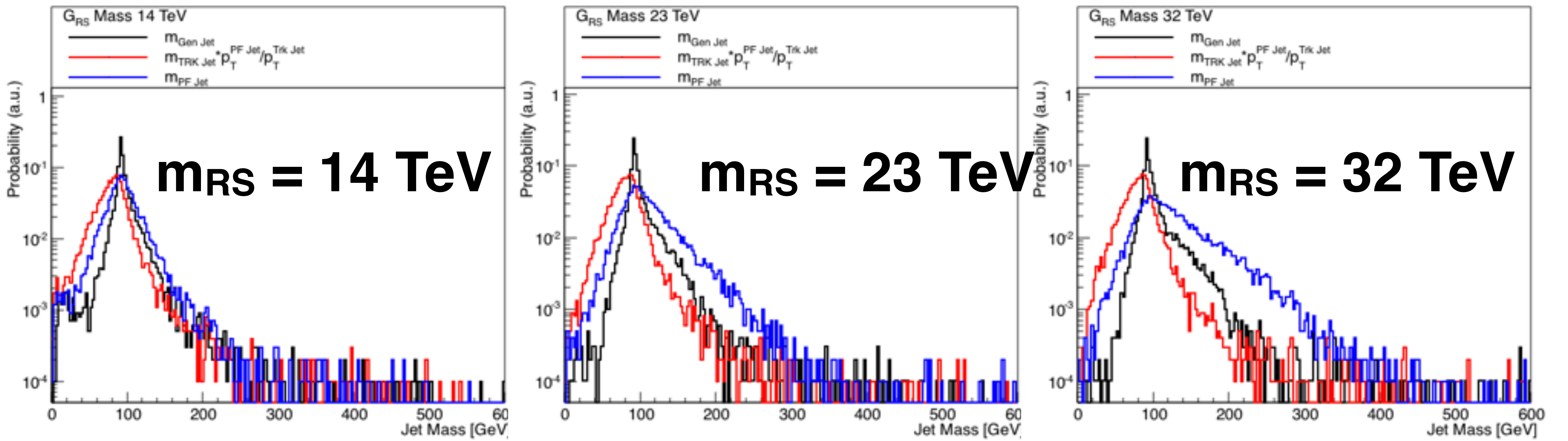
The Jet Mass peak

- Plain jet mass
  - QCD quantity for bkg (not the real jet mass)
  - it is affected by PU (not simulated here)
- Pruned jet mass
  - closer to the mass of the parton initiating the jet showering
  - more robust vs PU
  - two-peak structure with narrower tails
- At gen level, distributions stable vs mass
- At reco level (next slides) worse resolution at large masses



Detector effect: Jet Mass

- At small mass values, the reconstructed masses are not far from the gem-level distribution
  - (rescaled) Track-based mass narrower
  - PF-based mass centred in the right place
- For larger masses, detector granularity becomes an issue
  - (rescaled) Track-based mass stable
  - PF-based mass developed a tail for large values



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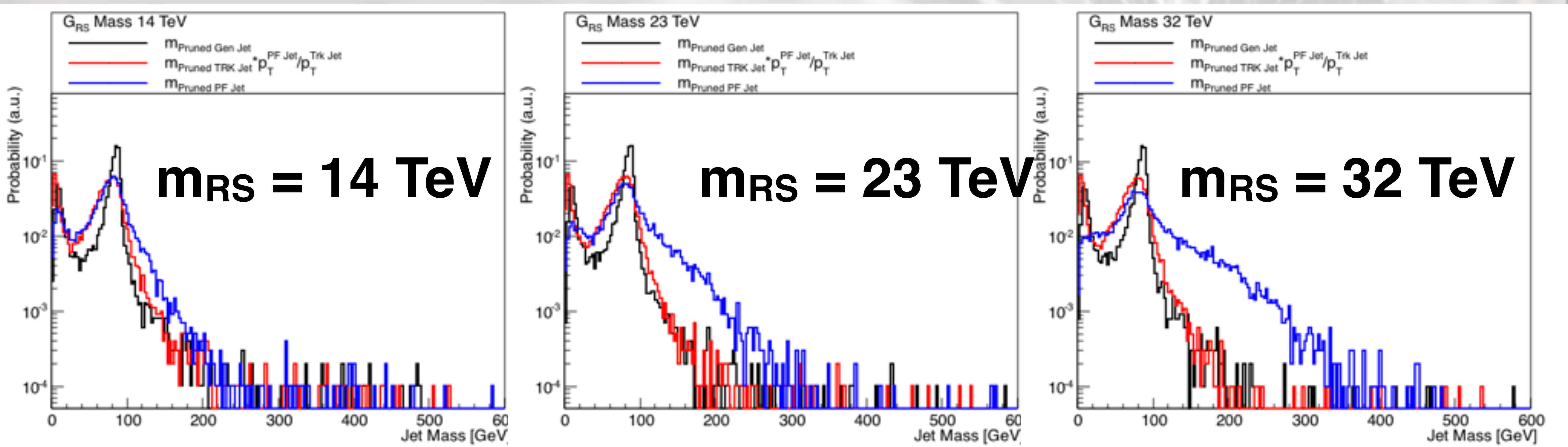
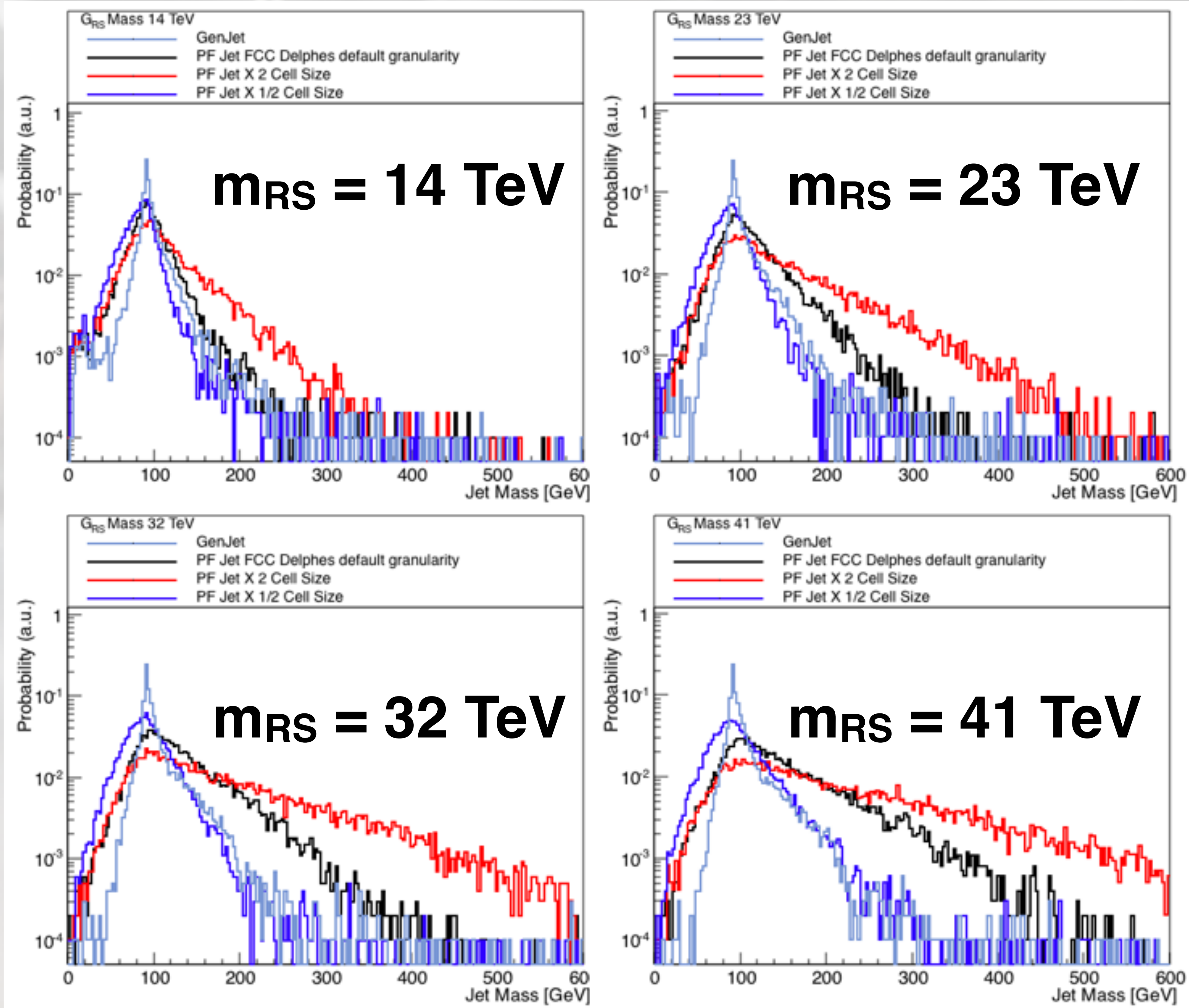


Granularity effect: Jet Mass

- The red shows what can go wrong with insufficient granularity
- The blue shows that 1/2 reduction of granularity wrt Delphes default is a minimum
- More granular detector scenarios to be studied in the future



Granularity effect: Pruned Jet Mass

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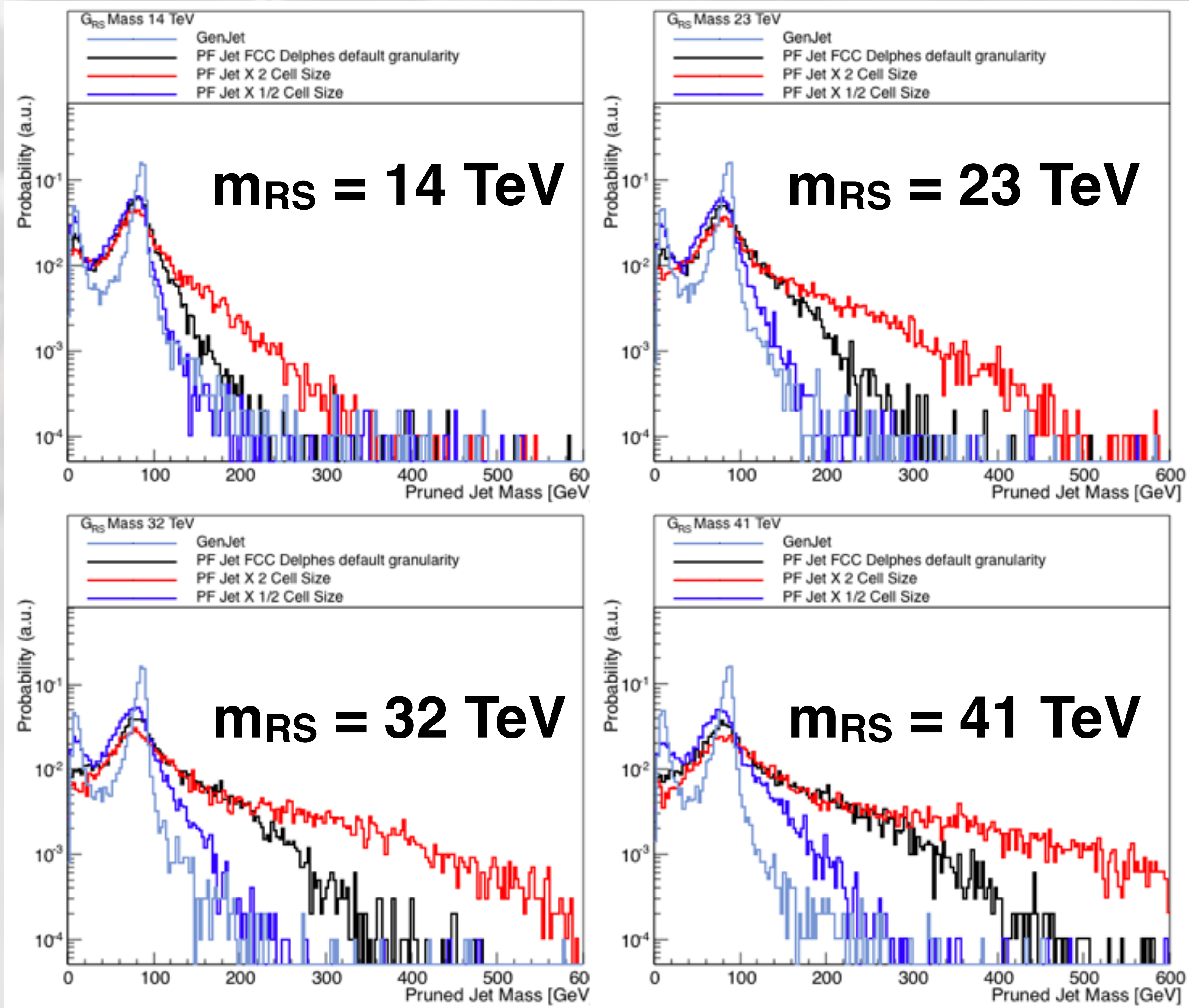


Summary

- Established a baseline to benchmark a given granularity design with substructure-related reconstruction
- Need to complete the study with mode granularity scenarios
- Need to add PU simulation, to see the deterioration in resolution it implies
- With this respect, a groomed-jet mass is more robust but more complicated (need to deal with multi-modal distributions)
- Feedback/suggestions/comments are welcome

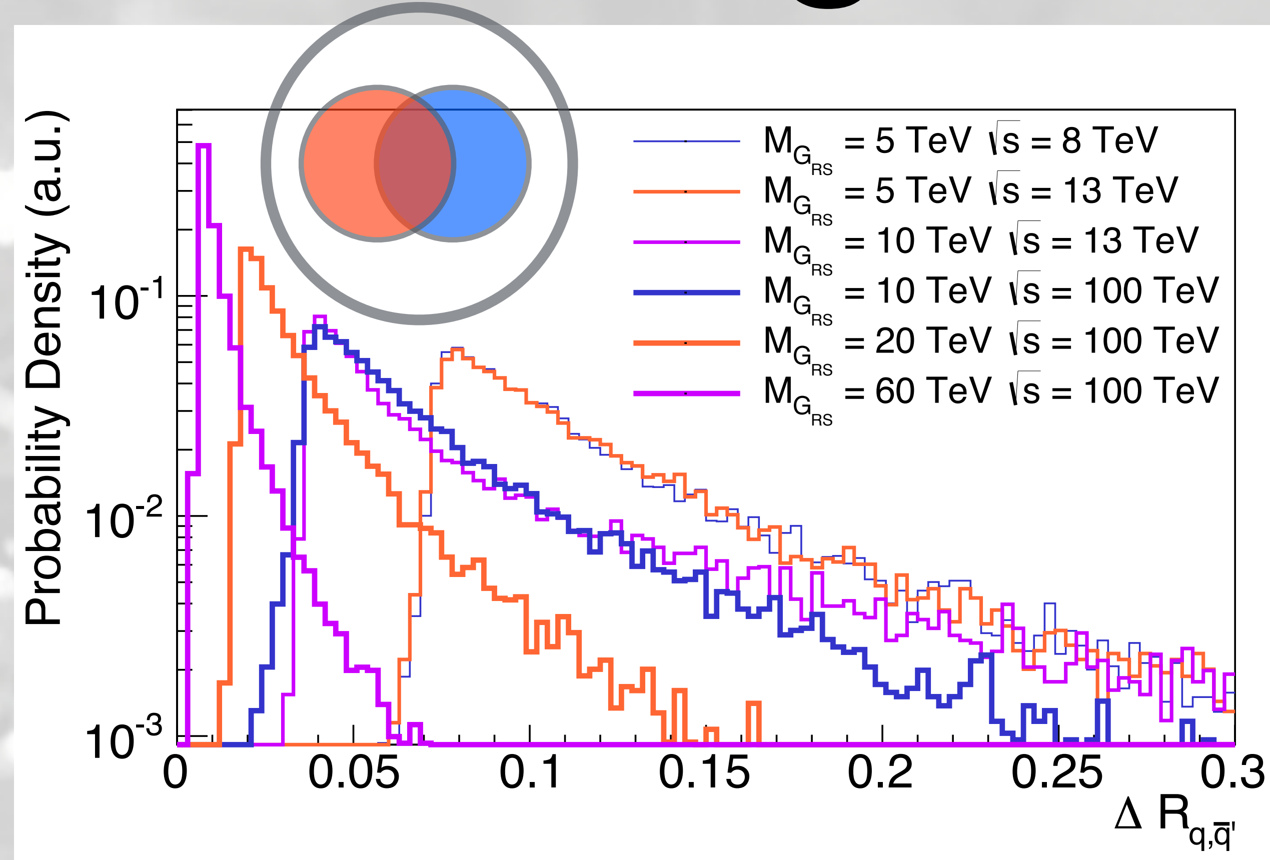

Backup

Event Generation

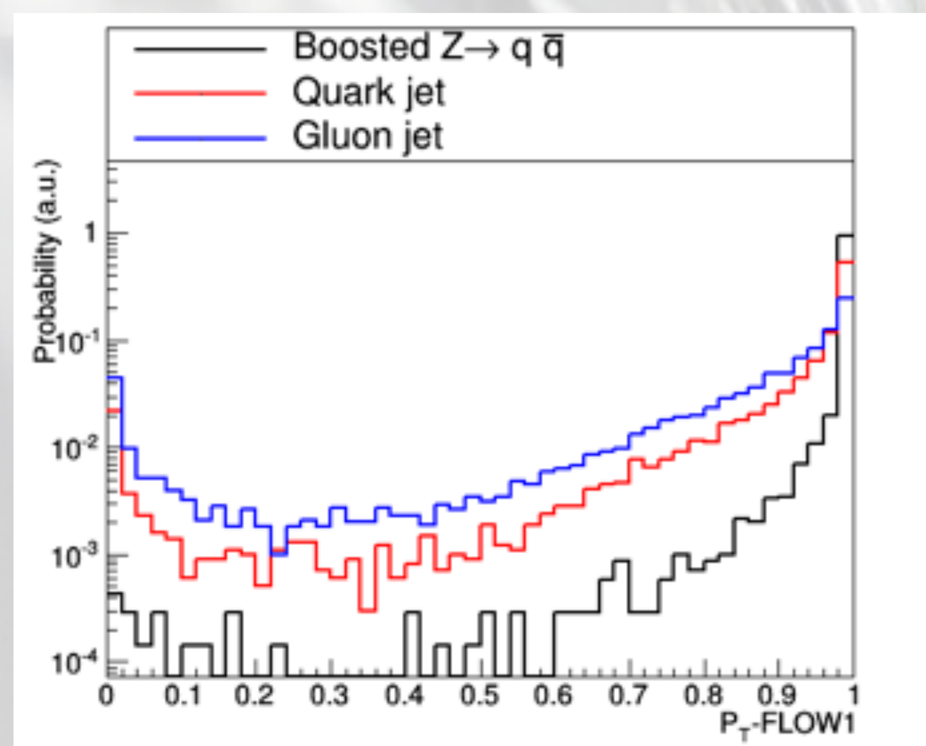
- PYTHIA8 for event generation and parton shower
- RS Graviton to ZZ used as signal benchmark
  - only hadronic Z decays
- RS Gravitons to gg and qq used as background sample
  - Not the real background (many more multijet events)
  - Same kinematic as signal jets
  - All discrimination from jet substructure (worst case scenario)

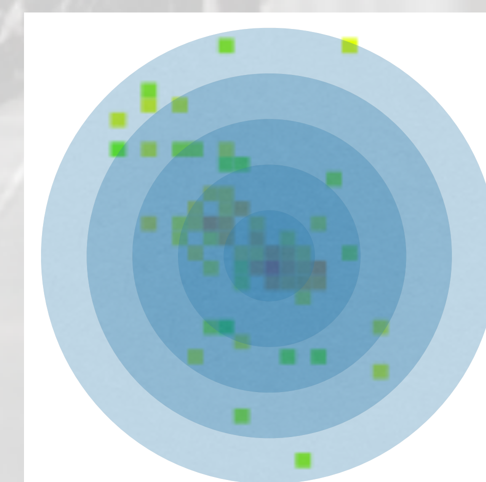
V-tagging: Two Strategies

- **At small masses**, look for two subjets inside the jet
  - granularity requirement dictated by subjet separation



- **At large masses**, look for jets with all particles at centre
  - granularity dictated by how collimated the jet is

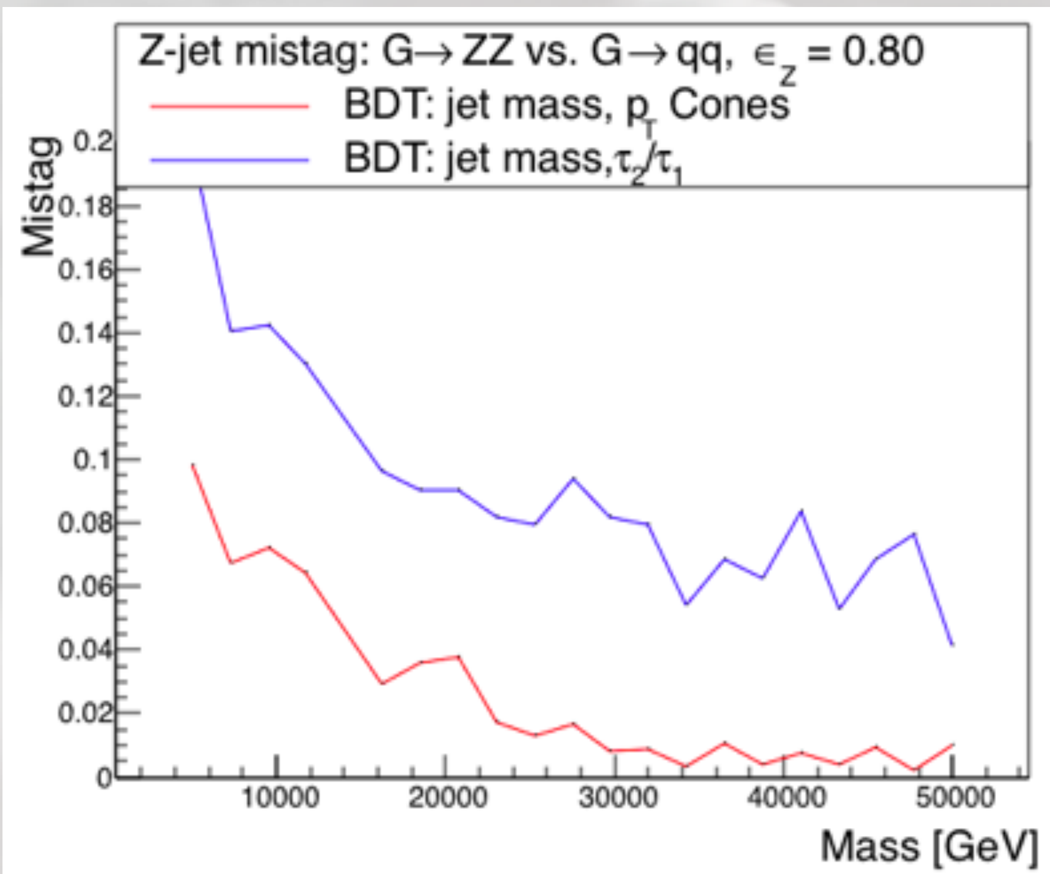


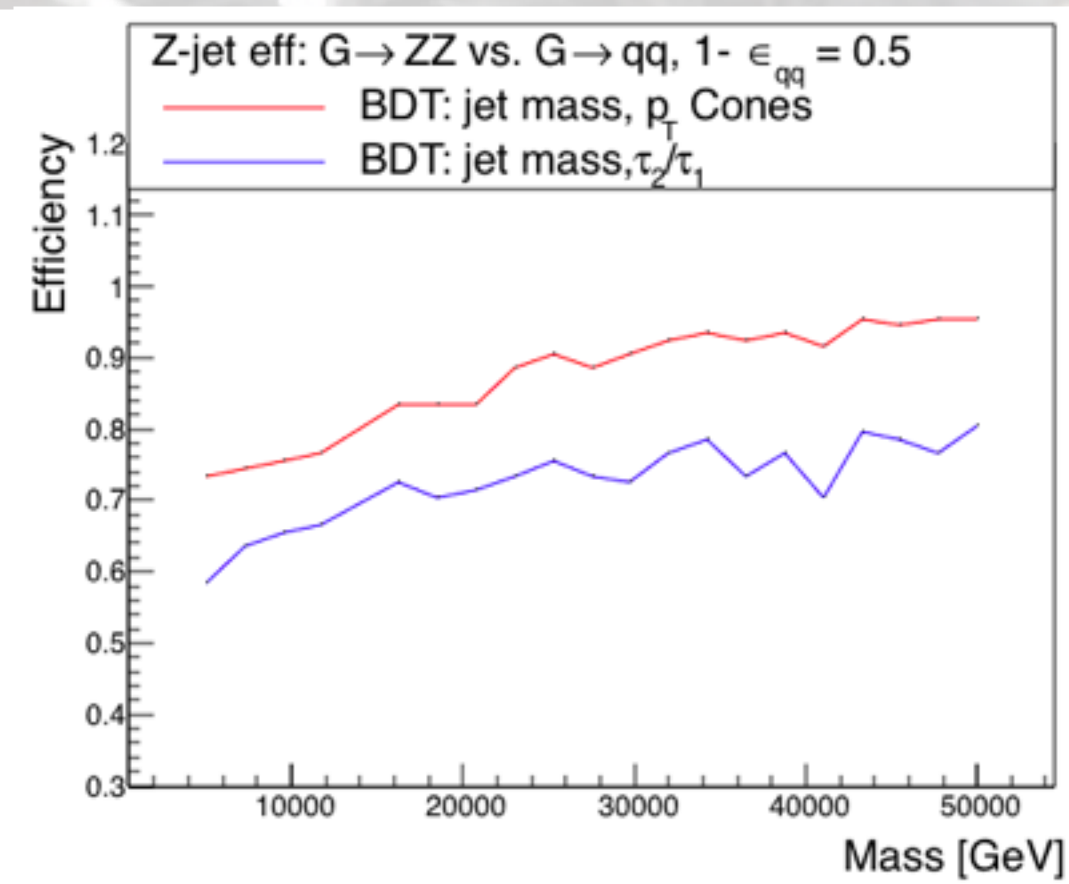


$$P_T\text{-}FLOW^i = \frac{\sum_{p \in C_i} \left|\vec{P}_T^{\,p}\right|}{\left|\vec{P}_T^{\,JET}\right|}$$

Performances vs mass

- Evaluate performances at GEN level
  - VERY preliminary: no detector effects, no pileup
  - Events selected with $70<m_j<100$ GeV (plain jet mass used)
  - Using BDT to combine mass with substructure (τ_2/τ_1 or pT flow cones)





- Result suggests that the requirement in granularity could be relaxed
  - To be confirmed with realistic environment (and LHC Run II data)
  - Granularity problem remains: the width of the mass peak depends on angular resolution → a cleaner benchmark? [TO DO NEXT]