Triggers for displaced decays of long-lived neutral particles in the ATLAS detector

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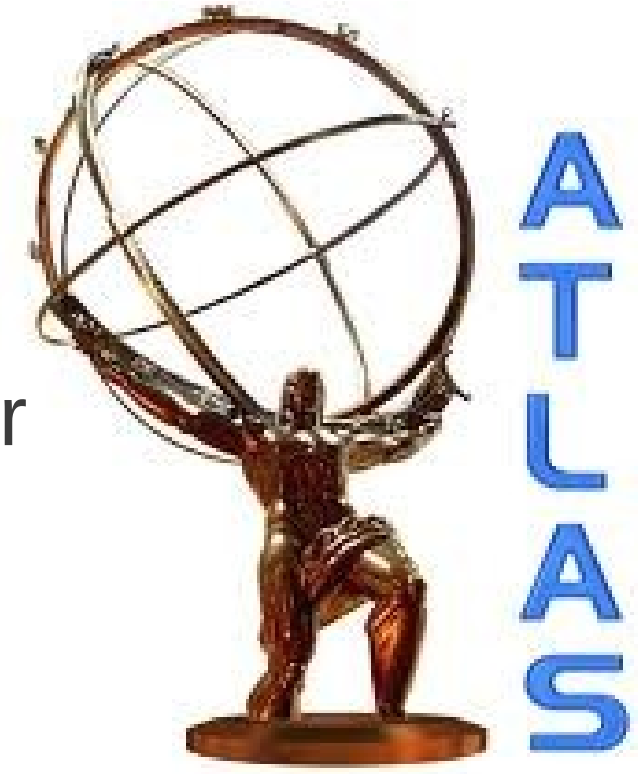
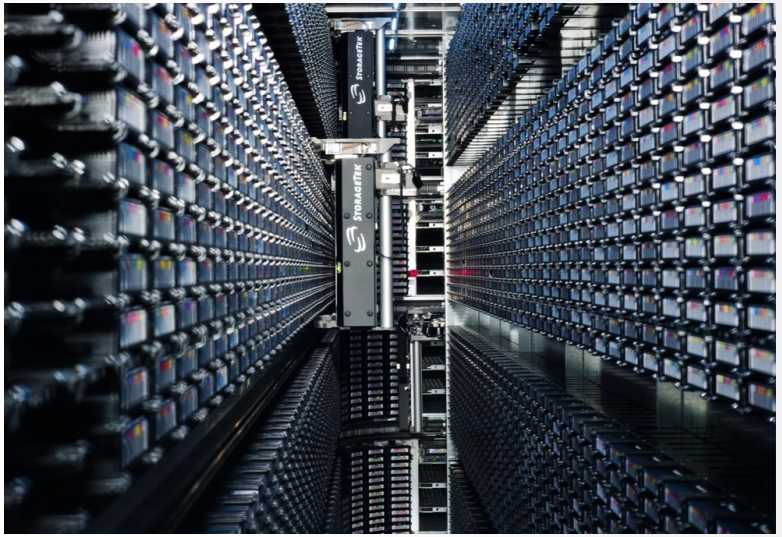


Outline

- Triggers – what are they for?
- ATLAS triggers – how do they work?
- Long living neutral particles and the Hidden Valley theories
- Special triggers for long living neutral particles
- Conclusion

Triggers – what are they for?

ATLAS – at full performance:

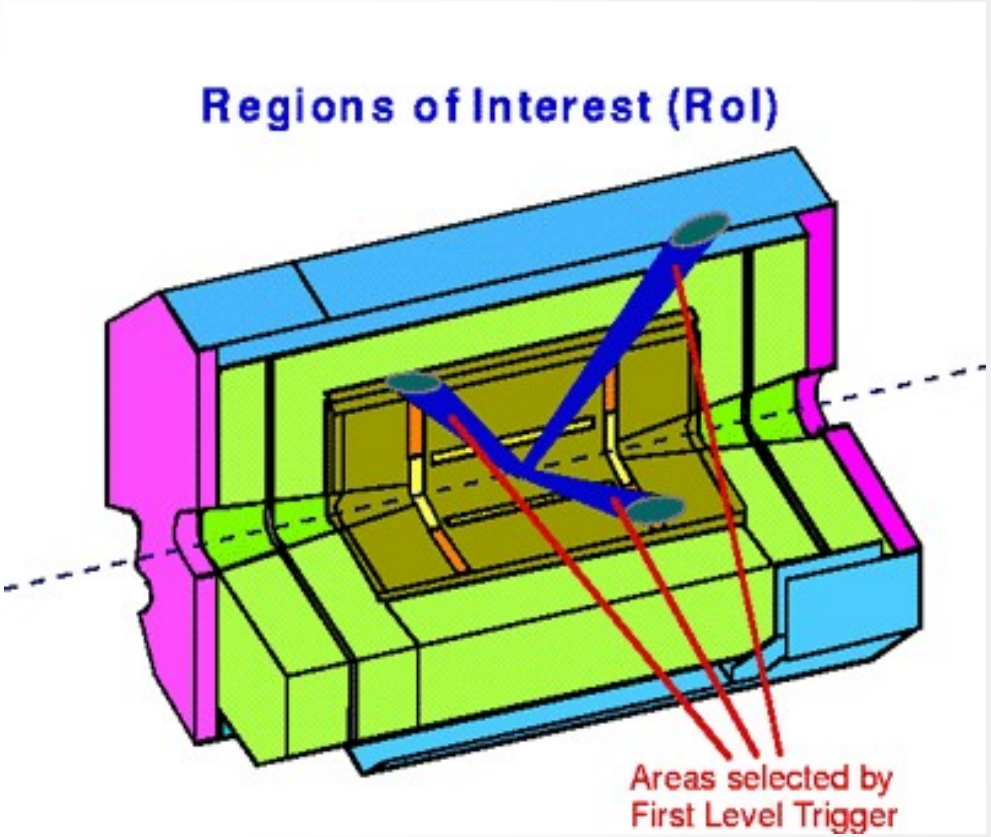


- ~ 40 000 000 collisions and 1 billion events per second → 1 petabyte of raw data per second
- CERN Data Center ~ 100 petabytes – full in 2 minutes!
- only 1 event from 10 000 000 is interesting
- but... we need to find it, definitely in 2 minutes ;) → objective for the *trigger system*

Triggers in the ATLAS experiment

L1 – hardware based system
• 2 μs to analyze

L2 and *Event Filter* – software oriented (processor farms, offline)
• 10 ms to analyze
• information from all detectors
• matching inner tracks
• event reconstruction...

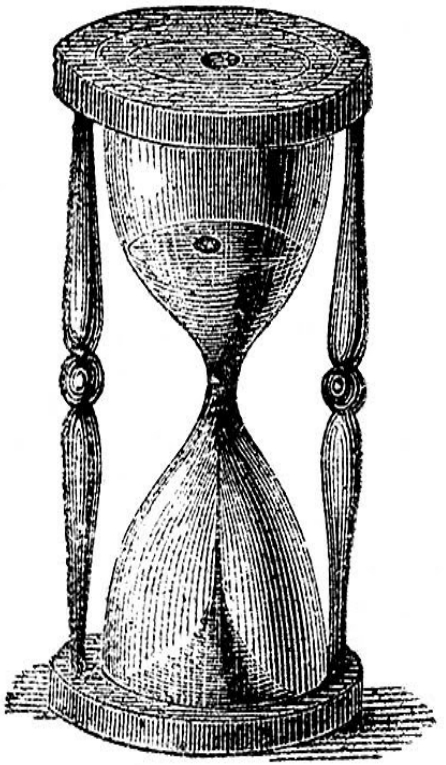


Common triggers include signal from the tracker → might be a problem for some neutral particles!

Long living neutral particles

Long living neutral particles...

- proper lifetime ~ 0.1 – 20 meters
- beyond SM theories – MSSM, inelastic dark matter, Hidden Valley scenarios...
- neutral particles – no track in the inner detector → with the usual triggers we would refuse these events

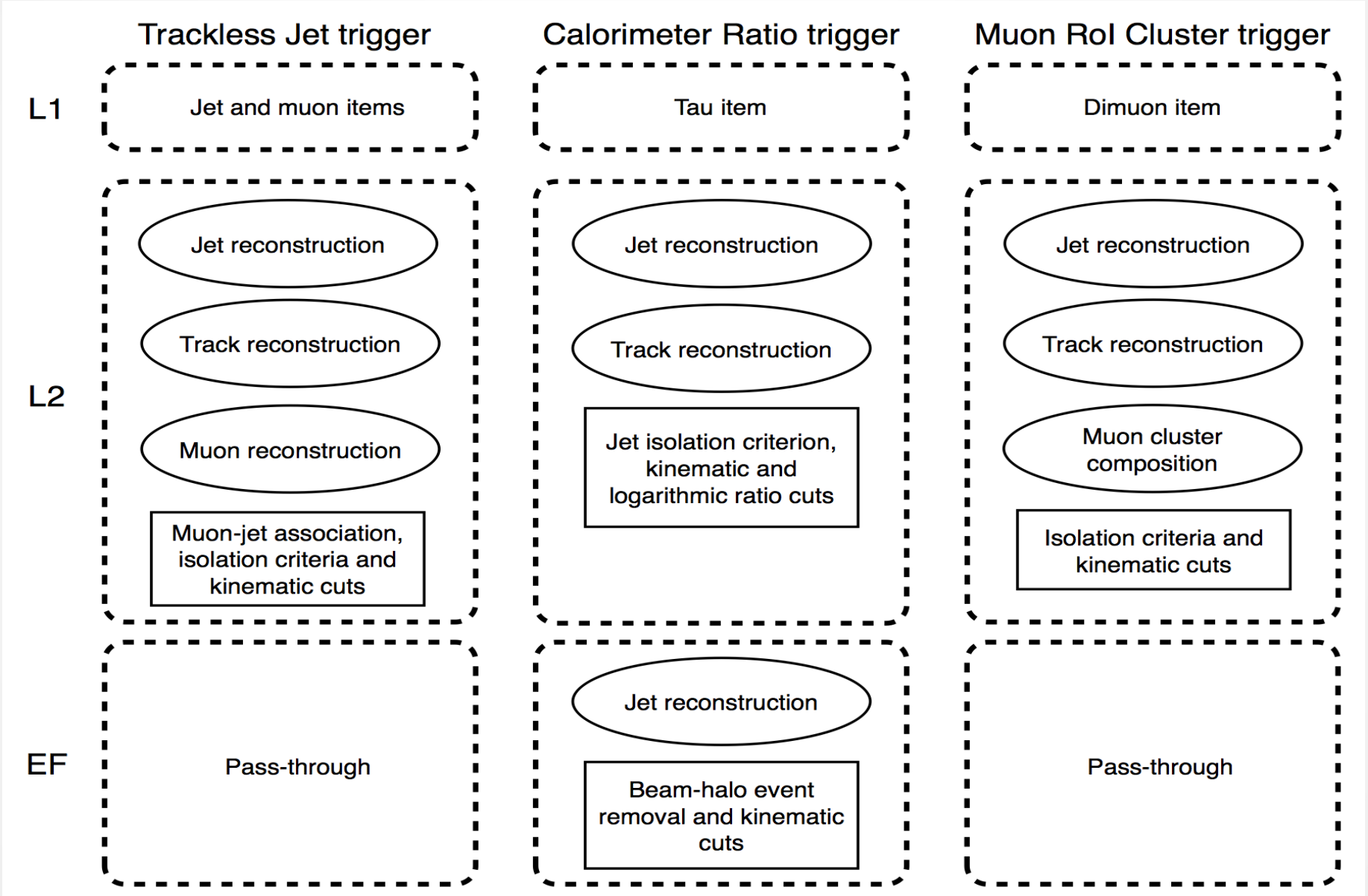


Hidden Valley theories

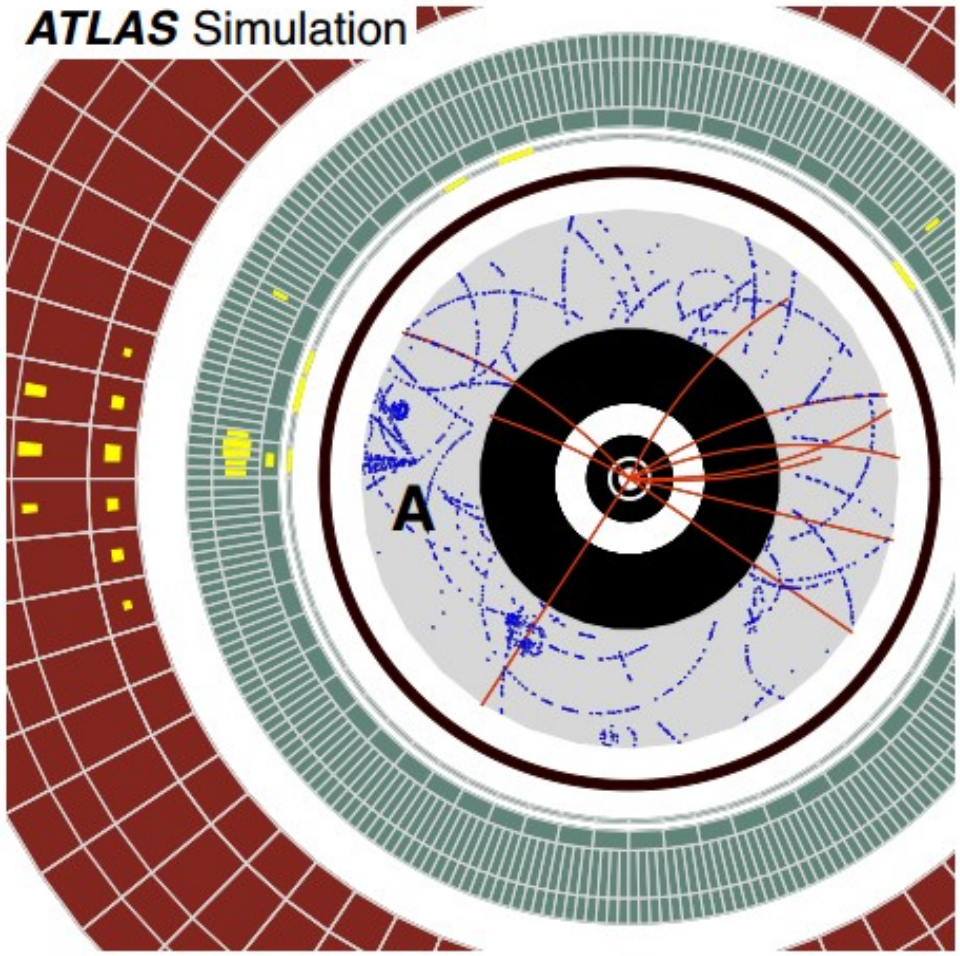
Hidden Valley:

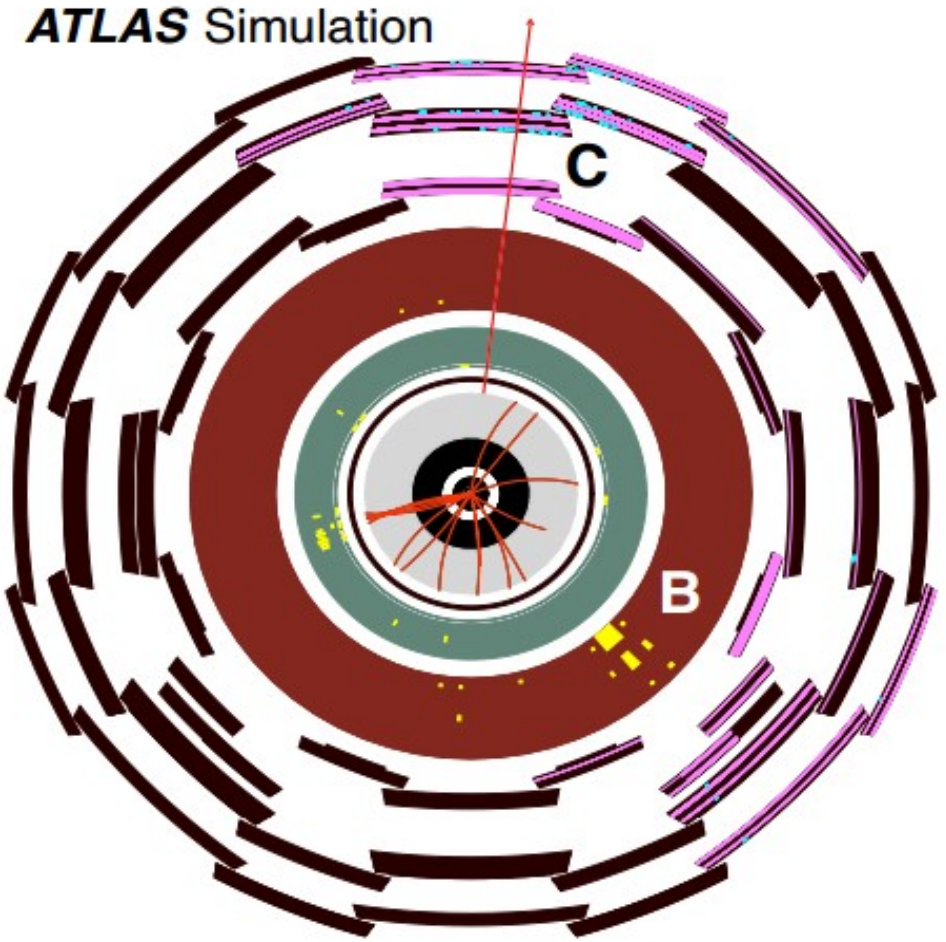
- hidden area with relatively light particles
- accesed via a communicator particle (e.g. Higgs)
- benchmark for this study – Higgs decay to π_v with mass 10, 20 and 25 GeV
- π_v decays to heavy fermions, mostly into $b\bar{b}$

Special triggers



Special triggers



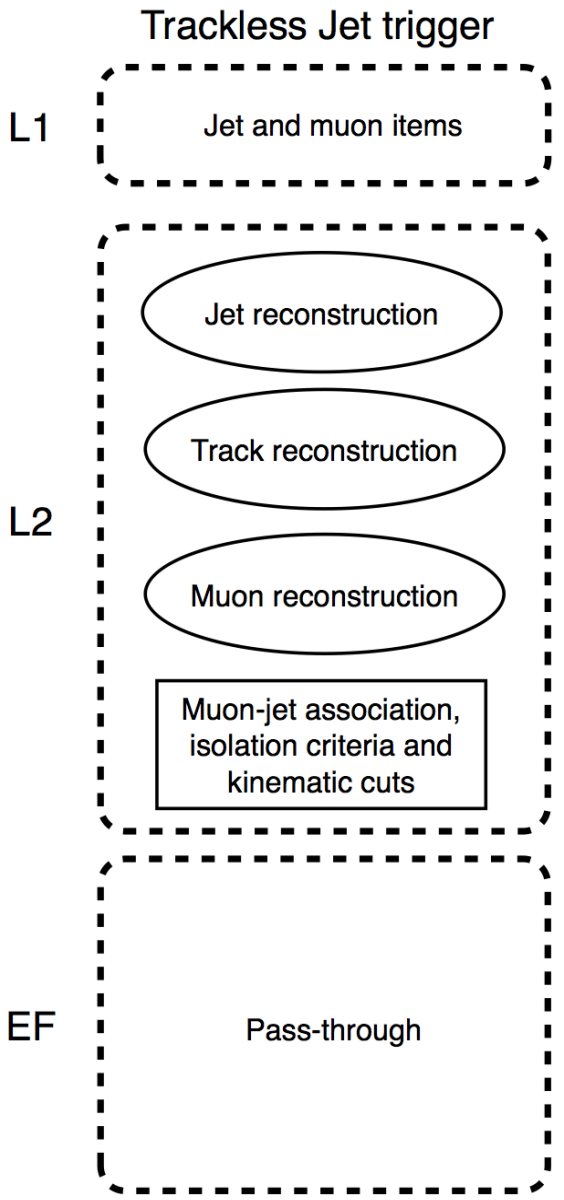


Trackless Jet trigger

- π_v decays in the ID/ECal
- 40% of these events contain a muon; the L1 trigger rejects some multi-jet background
- muon should be close to the jet axis:

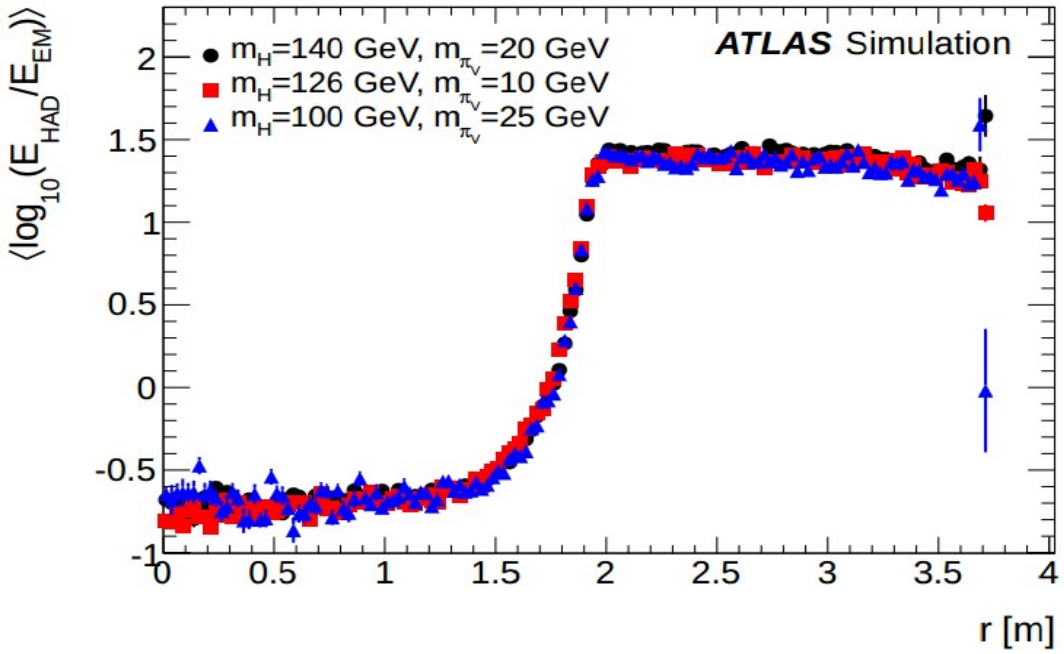
$$\Delta R = \sqrt{(\Delta\eta)^2 + (\Delta\varphi)^2} \leq 0.4$$

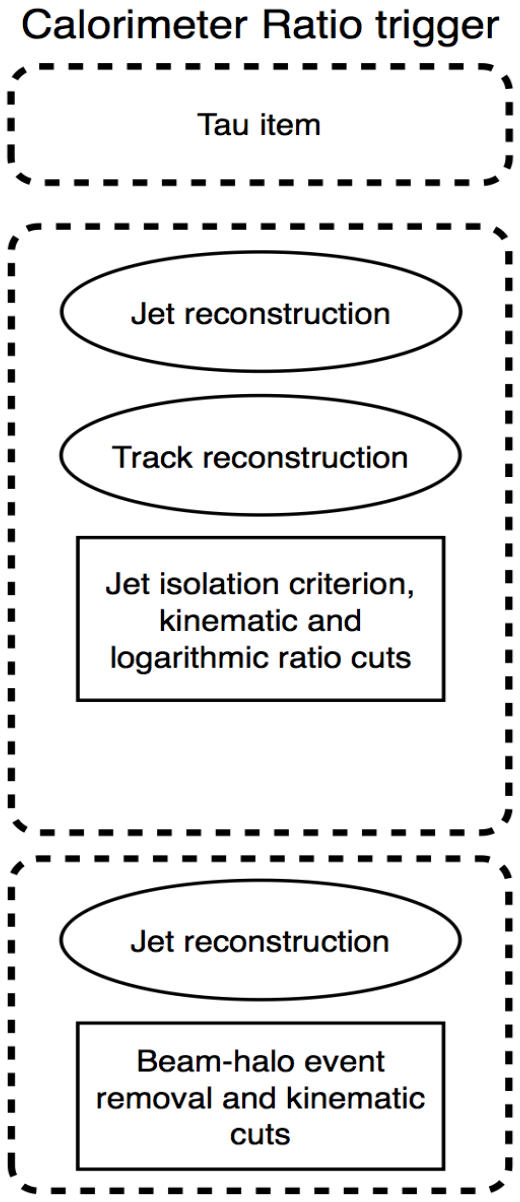
- no ID track within 0.2x0.2 in $\Delta\eta \times \Delta\varphi$ of jet axis



Calorimeter Ratio trigger

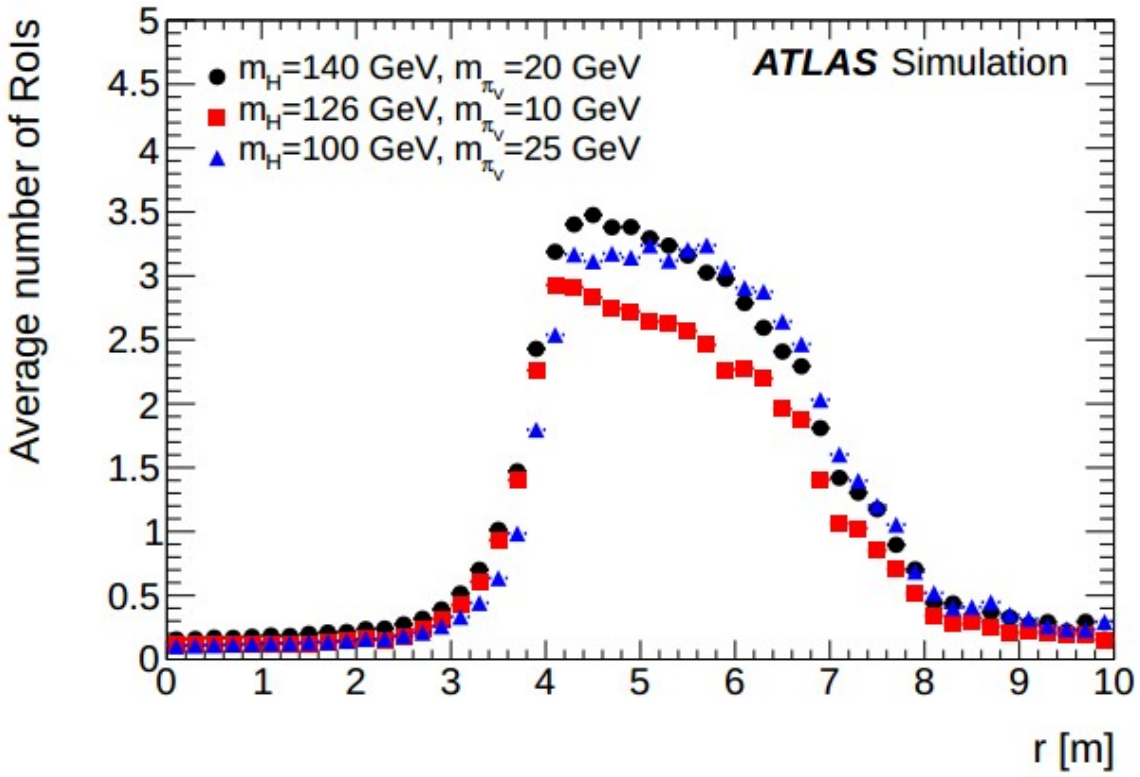
- π_v decays in ECal/HCal
- narrow jets (tau like)
- anomalous E_{HAD}/E_{EM} value
- no ID track within 0.2x0.2 in $\Delta\eta x\Delta\varphi$ of jet axis
- muon bremsstrahlung in HCal is a potential background

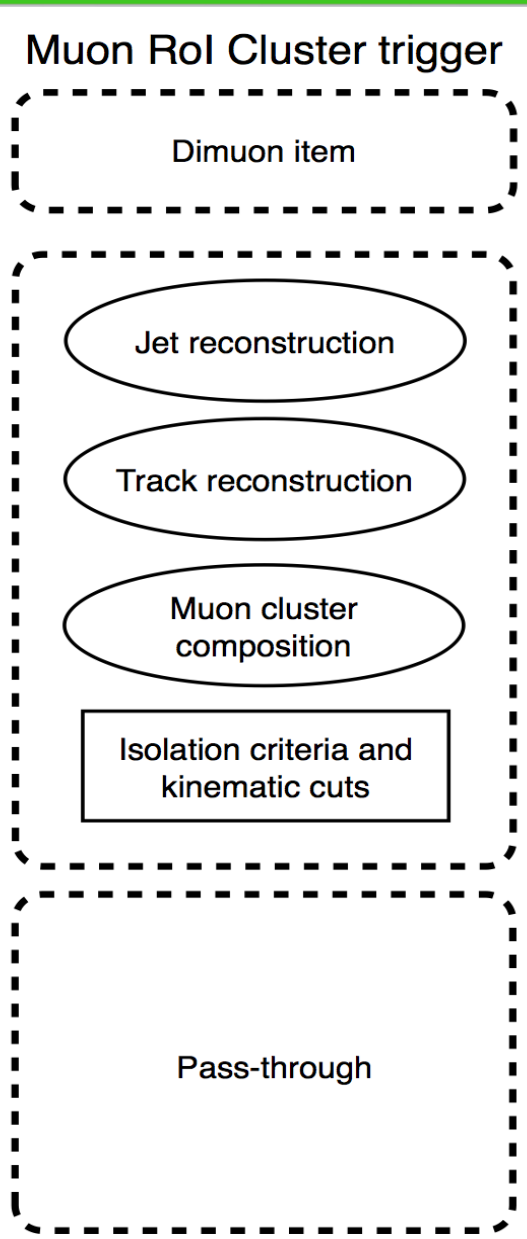




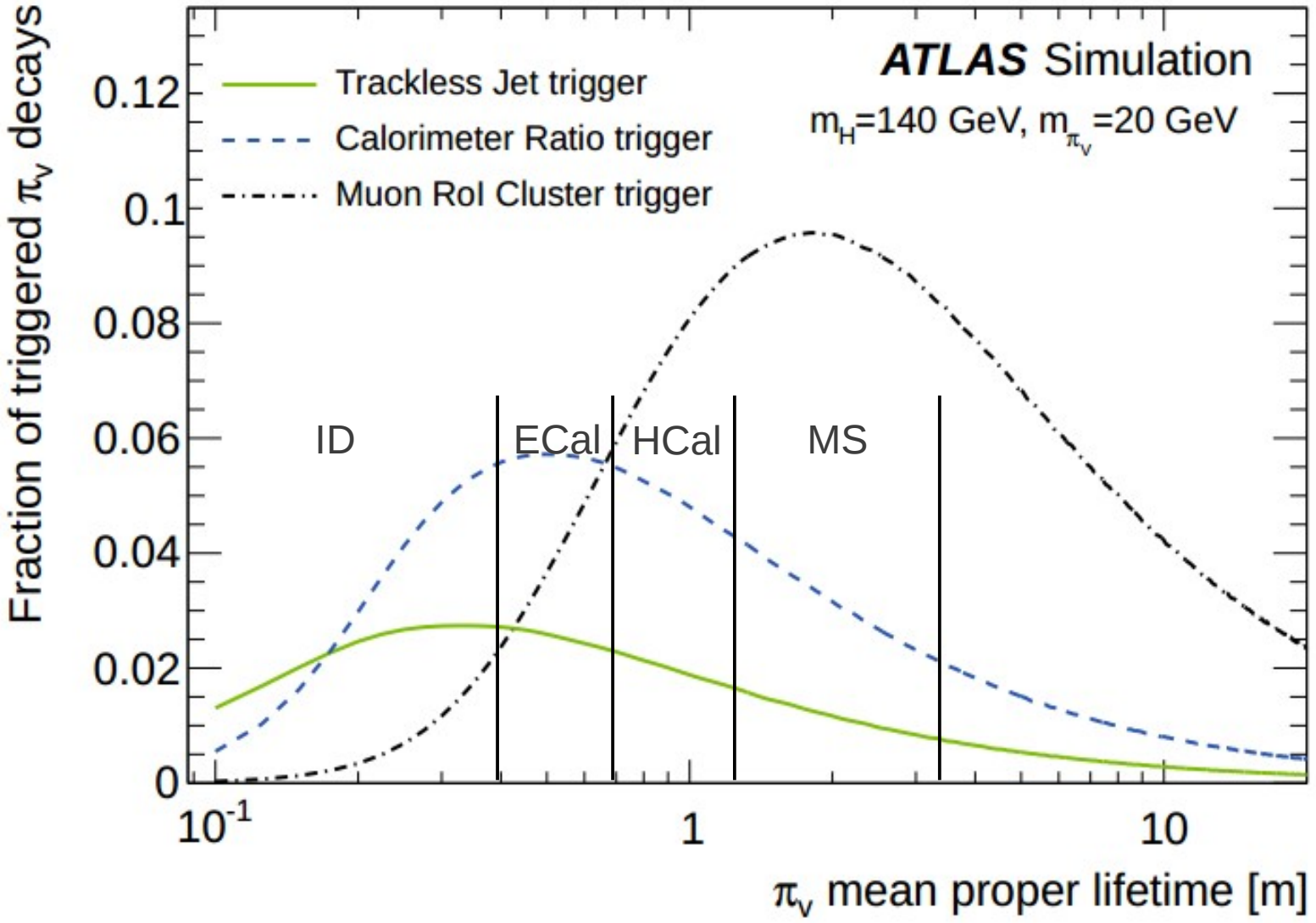
Muon RoI cluster

- π_v decays in the outer HCal or MS
- clusters of muon RoIs
- Isolated from calorimeter jets ($\Delta R \leq 0.7$), and ID tracks ($\Delta R \leq 0.4$)





Performance



Summary

- some beyond SM models predict long-living neutral particles
- standard ATLAS trigger would not be able to recognize them – special triggers were developed and studied, the Hidden Valley theory was used as a benchmark
- estimated fraction of triggered π_v particles is between 2% and 10% for a mean proper lifetime in the range 0.1 m – 20 m