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FCC trigger rate estimation

Plans and status

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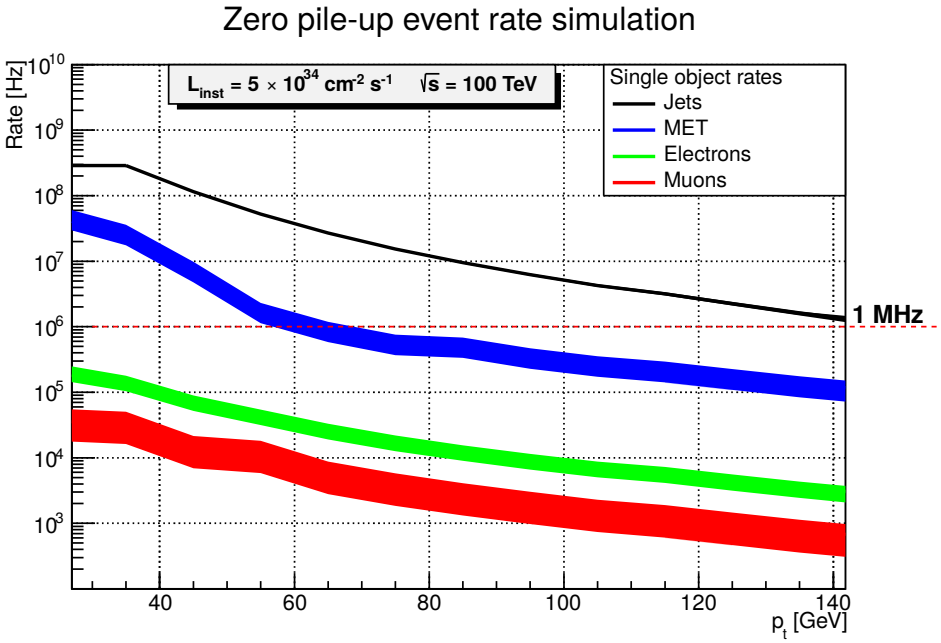
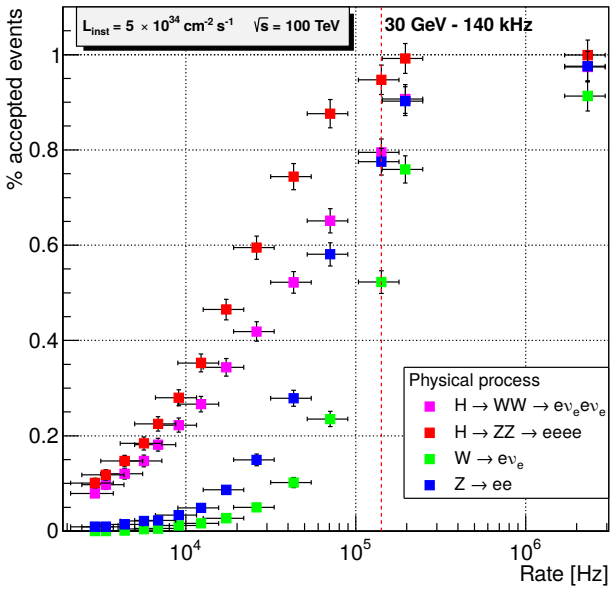
Introduction

- How can we determine the readout architecture of a FCC-hh detector?
- We need to know:
  - Raw data rates from the various sub-detectors
  - Trigger rates
- Different assumptions can be made on the trigger architecture
- In this talk, we will look at the trigger rate estimation

Rate estimation at FCC-week

- At the FCC-week we have presented a first estimation of the trigger rates
  - Link to the slides of the talk





- We are now working on a more solid and general method to estimate trigger rates at FCC

Goal of our study

- Finding a consistent parametrisation of CMS level-1 trigger (L1T) to simulate trigger-level objects based on generator-level ones
  - E.G. pt resolution
  - Extrapolate it to FCC
    - Some parameters might be assumed constant, some of them might need some re-working
- Perform an estimation for muon, electron, photon, jet, and MET rate
- Modelling and estimating rates for trigger architectures with and without tracker, for comparison
  - Focussing on tracker-less architecture at the moment

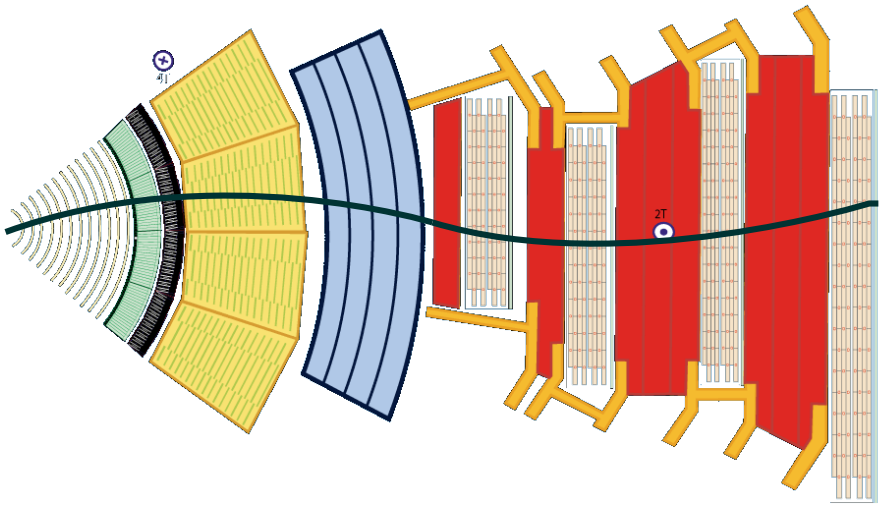
Strategy

- We consider the main contributions to each object rate
  - For instance, real hadron jets are expected to be the main contribution to trigger-level jets
- Corresponding trigger objects are generated by applying a smearing to the generator-level objects originating it
  - Parametrisation is obtained by matching generator-level objects to trigger level ones
  - For instance, trigger-level jets can be obtained from generator-level ones by applying a smearing
  - We employ CMS full-simulations to compute those parameters
    - We will need CMS collaboration approval to show our input data
- Validity of the parametrisation is ensured through closure tests on object distributions and trigger rates

Muons (1/3)

What are the main contributions to the muon trigger rate?

1. Muons from prompt quark decays (b and c)



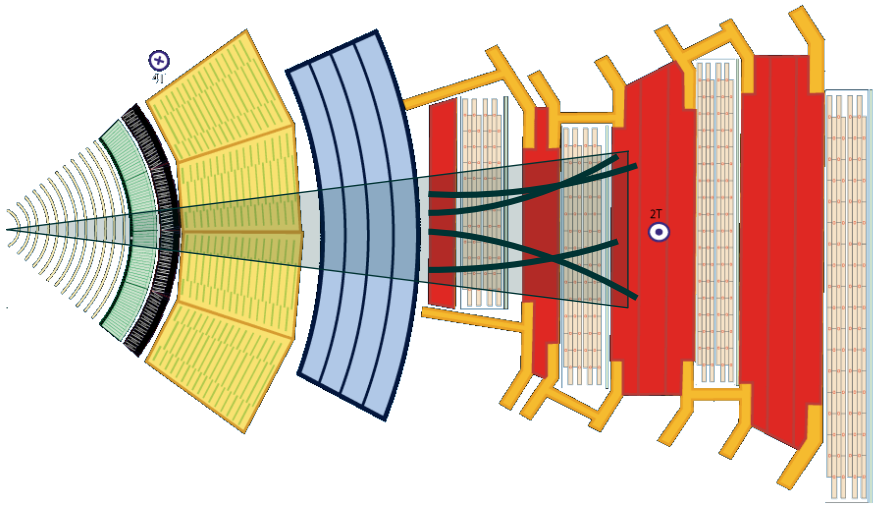
Mainly in the high-pt region

- L1T Muons obtained in Delphes simulation by smearing generator-level muons
- Parameters computed from gen-muon and L1T-muon pairs in CMS full-sim
- Parameters we are interested in:
  - Resolution as a function of pt and eta
  - Acceptance as a function of pt and eta

Muons (2/3)

What are the main contributions to the muon trigger rate?

2. Jet punch-through



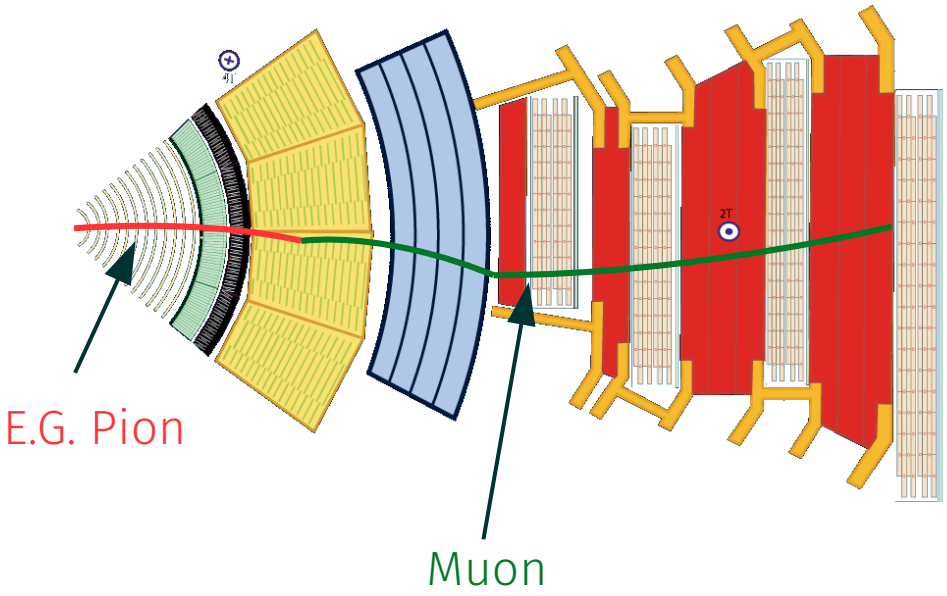
Mainly in the low-pt region

- L1T-muon obtained in Delphes simulation from gen-jets
- Parameters obtained from L1T-muon and gen-jet pairs in CMS full-sim
- Parameters we are interested in:
  - Punch-through probability as a function of jet pt and eta
  - L1T-muon pt distribution as a function of jet pt and eta
- Detector-dependant

Muons (3/3)

What are the main contributions to the muon trigger rate?

3. Non-prompt in-flight decay of particles

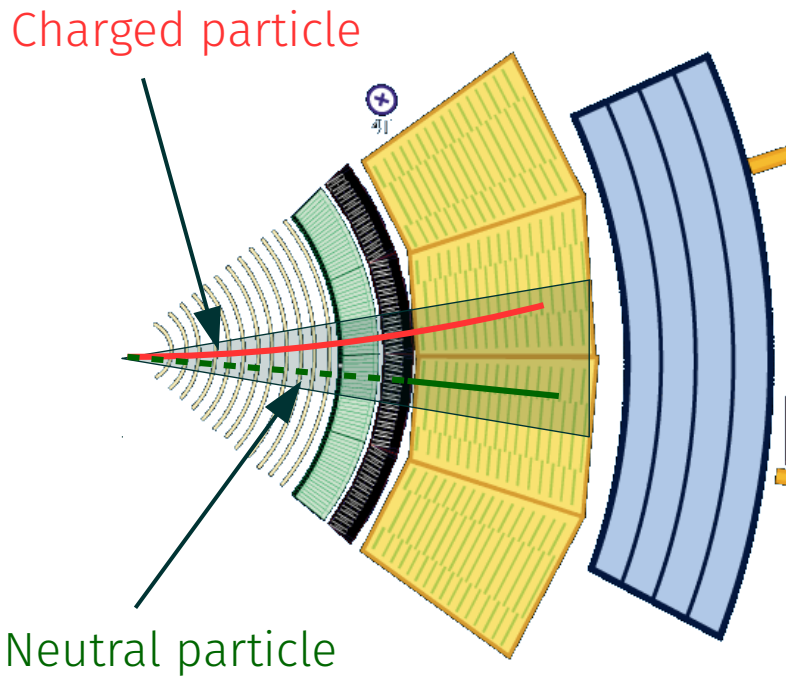


- Generate in-flight decays and smear the decay muon in Delphes
- Parameters we are interested in:
  - Resolution as a function of pt, eta, and vertex position
  - Acceptance as a function of pt, eta, and vertex position
- Will be looking at this process only after prompt muon and punch-through have been considered
  - Might be negligible

Electron and photons

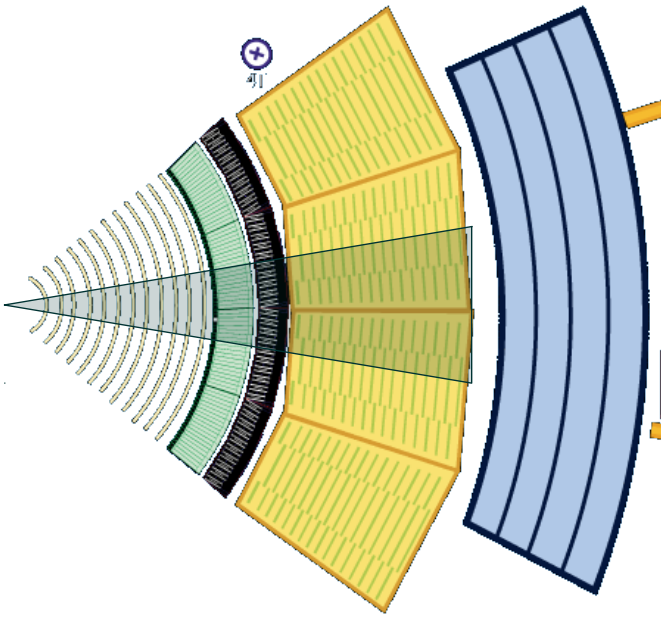
What are the main contributions to the electron and photon trigger rate?

Charged and neutral particles from hadronic jets



- Obtained in Delphes simulation from gen-jets
- Parameters computed from L1T-electron/photon and jet pairs in CMS full-sim
- Parameters of interest:
  - Probability that a jet will originate a trigger-level e/gamma, based on the jet pt and eta
  - Based on the jet pt and eta, distribution of the generated objects
- In a tracker-less trigger electrons and photons contribute to the same rate

What are the main contributions to the jet trigger rate?



Hadronic jets

- L1T-jets obtained in Delphes simulation by smearing generator-level jets
- Parameters computed from gen-jet and L1T-jet pairs in CMS full-sim
- Parameters we are interested in:
  - Resolution as a function of pt and eta
  - Acceptance as a function of pt and eta

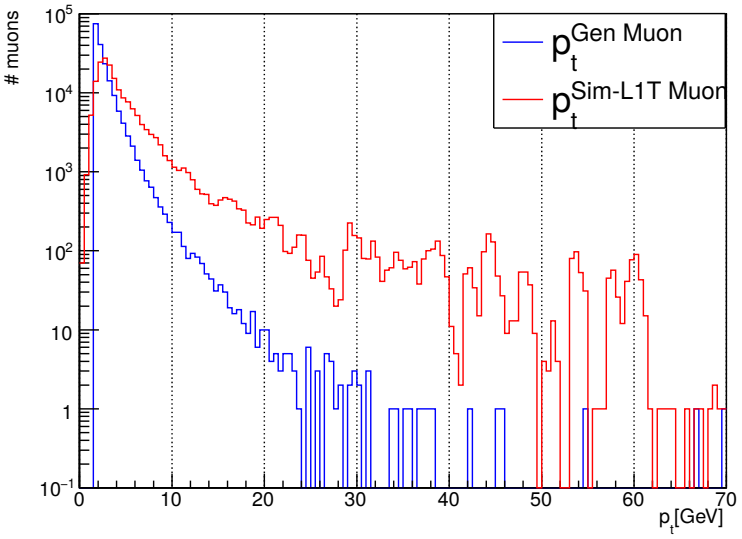
Status

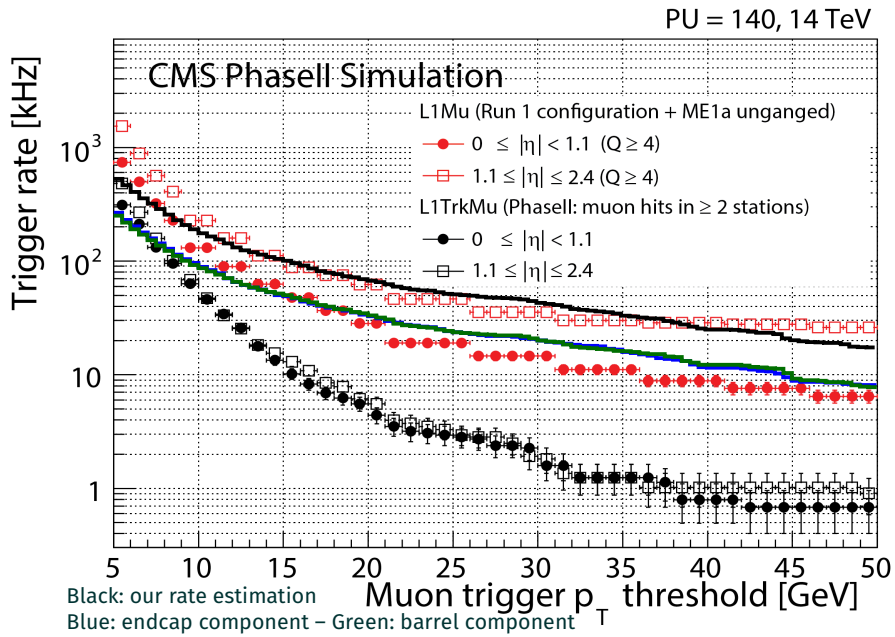
Overview

- Muons:
  - **Prompt decays**: initial parametrisation and trigger rate has been obtained
  - **Punch-through**: first look to muon-jet pairs
  - **In-flight decays**: not yet started (might not be necessary)
- Electrons and photons, initial parametrisation obtained and first look at the trigger rate
- Jets, first look to jet-genjet pairs

A look at the muon trigger rates at PU 140

- Trigger rate obtained from smearing generator-level muons (SimL1TMuon) in pile-up 140 events produced in FCCSW has been compared against CMS public results [1]
- First estimation shows we are headed in the right direction
  - Interesting match between the rates in the 15-35 GeV region
  - Below 15 GeV: probably jet punch-through becomes dominant
  - Above 40 GeV: not clear if some other physical process is contributing to the rate
  - We need to introduce the eta dependency in our parametrisation





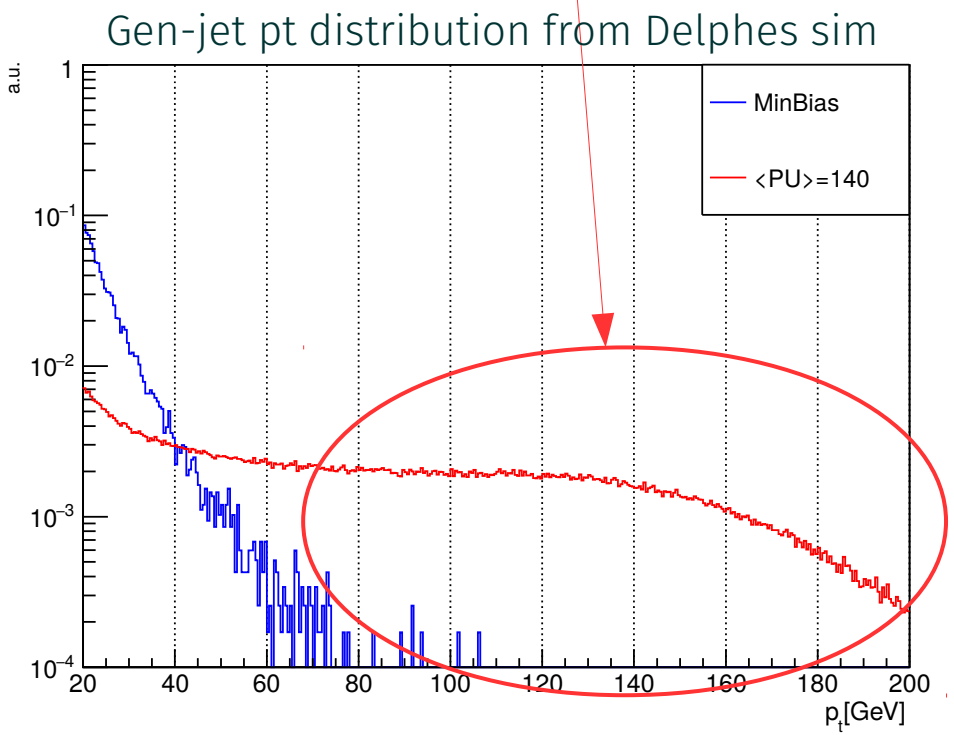
Black: our rate estimation
Blue: endcap component – Green: barrel component
(they overlap in most of the range)

[1] https://cds.cern.ch/record/2020886, page 202

Electron and photon trigger

- Rates at PU 140 are too high
- **Problem:** Momentum of the gen-jets in Delphes gets shifted towards high-pt as the pile-up increases
  - This affects L1T-jets, punch-through and every other estimation based on gen-jets

This causes rate over-estimation at high-pt



Is this a known issue?
How do the analysis groups approach the jets at high pile-up?

Plans

- Resolve issue with gen-jets
- Obtain parametrisation for punch-through muons
- Consider CMS Phase-2 trigger (i.e. w/ tracker)
- Extrapolate to FCC
  - Acceptance is known
  - Trigger pt resolution can be estimated from known offline resolution estimates
  - Punch-through? Can we try to scale from CMS by the material budget?
  - Can we take E/Gamma probability from CMS?
- Include the parametrisation in the Delphes card

Conclusions

- We have presented a plan to estimate trigger rate via parametrisation obtained from CMS
- First parametrisation of trigger muons has been obtained and agrees reasonably well with CMS Run-1
- Parametrisation of electrons, photons, jets, and punch-through muons is delayed due to a feature of gen-jets in FCCSW
- Next step is to obtain parameters from CMS Phase-2 (inc. Tracker) and extrapolate to FCC
- Input from ATLAS would be interesting
- Our expected schedule:
  - Finalise CMS parameterisation by mid November (and obtain approval)
  - First FCC rates by early December

Backup

Applying the smearing

- Once this curves have been obtained, an hit-and-miss Montecarlo has been applied to compute from generator-level muon momentum a trigger-level muon (called SimL1T Muon) momentum distributed in the same way as in CMS L1T:
  1) The delta pt distribution is first normalised by dividing it by the number of entries
  2) A pair of values (x, y) is generated
  3) If y is lower than the content of the histogram bin at the x, that x is added to gen-level muon momentum to obtain a L1T muon momentum
  4) If not, a new pair is generated until 3) is verified