Delphes card discussion

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CERN

Dedicated Meeting on Aug 20th

DELPHES Card discussion

Thursday 20 Aug 2020, 16:00 → 18:00 Europe/Zurich

16:00 → 16:20 **Delphes overview** 20m
Speaker: Michele Selvaggi (CERN)
delphes_muon.pdf

16:20 → 16:40 **Lessons from CLIC** 20m
Speaker: Ulrike Schnoor (CERN)
UlrikeSchnoor_2020...

16:40 → 17:00 **Lessons from Muon Collider detector simulation** 20m
Speaker: Donatella Lucchesi (Universita e INFN, Padova (IT))
MuonColl-det.pdf

17:00 → 17:20 **Lessons from the FCC-hh** 20m
Speaker: Michele Selvaggi (CERN)
lessons_fcchh.pdf

17:20 → 17:40 **Discussion** 20m
Speaker: Michele Selvaggi (CERN)
discussion_delphes...

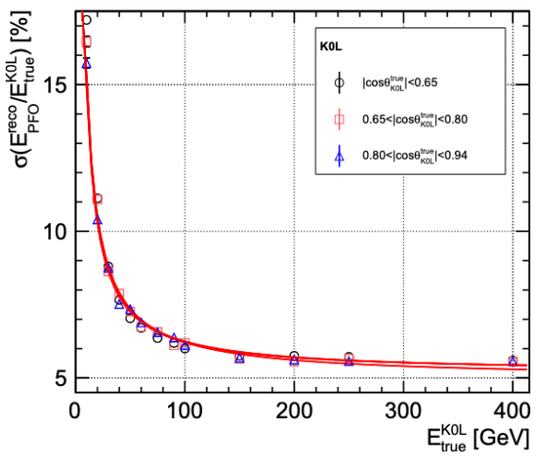
Ulrike Schnoor

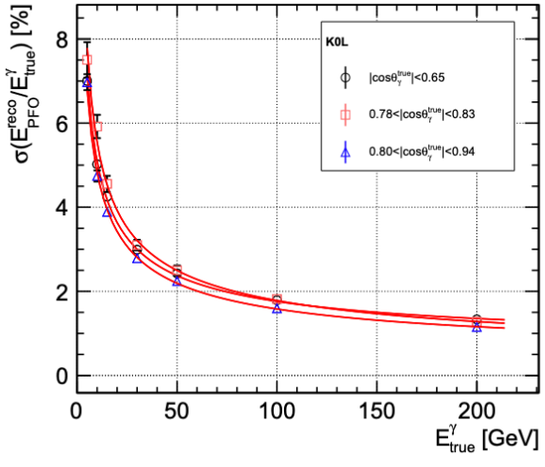
Introduction: DELPHES card for CLICdet

- Implementation based on existing performance studies in full simulation

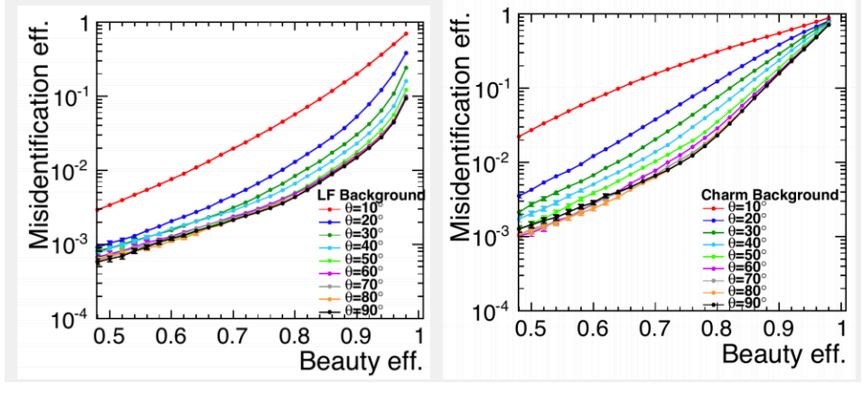
→ Goal: performance close to the full simulation performance (more realistic than optimistic)

- Specific to the CLICdet card implementation:
  - Added Lepton Collider jet algorithm (VLC) and exclusive jet clustering based on FastJet plugin
  - Multiple sets of jet observables for N=2,...,6 jets in the card
  - Effects of beam-induced background → different cards for the three energy stages
- Validation for certain processes and observables
- Feedback from studies in which it was used (in particular on isolation)





calorimetry



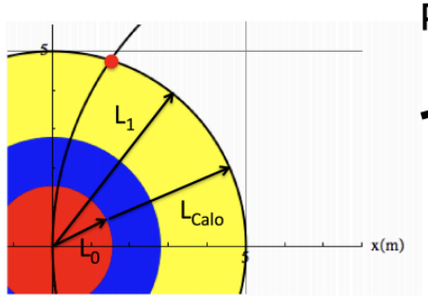
b-tagging

FCChh Det

MS

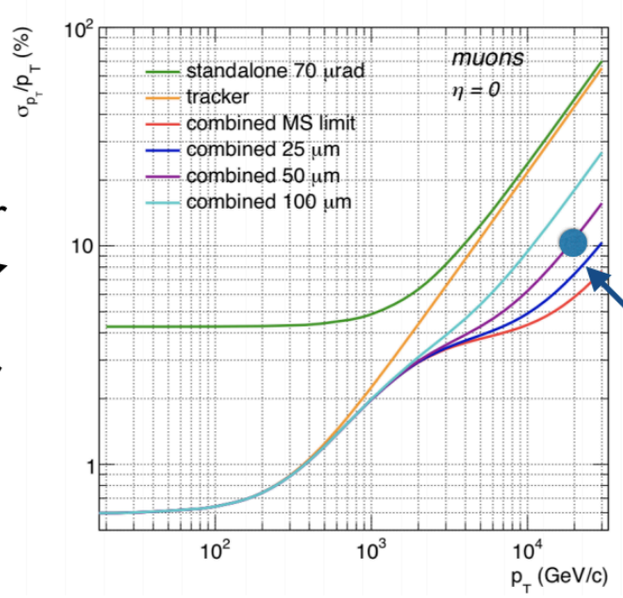
Desired physics reach → Desired Detector performance → Optimize detector design

e.g. Z' →μμ



pen & paper

W. Riegler formulae

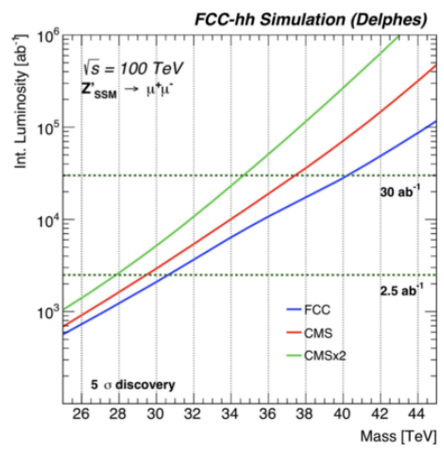


σ_p/p = 10% @20 TeV

Delphes

- pT = 4 GeV muons enter the muon system
- pT = 5.5 GeV leave coil at 45 degrees

- Standalone muon measurement with angle of track exiting the coil
- Target muon resolution can be easily achieved with 50 μm position resolution (combining with tracker)
- Good standalone resolution below |η| < 2.5

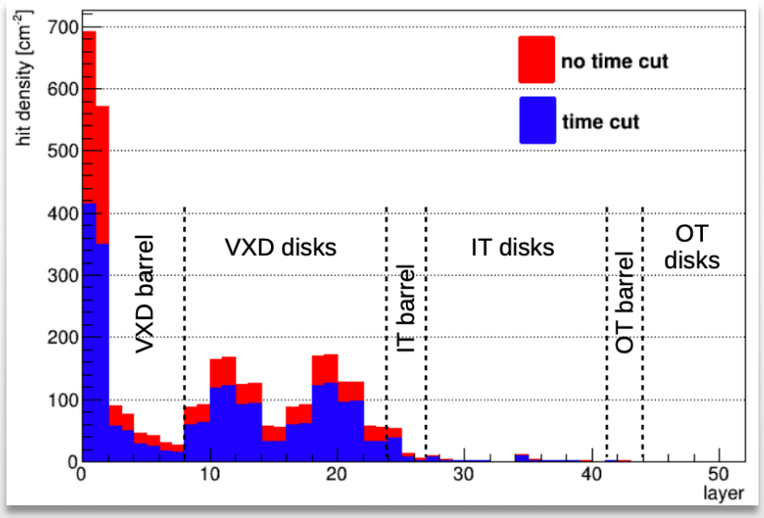


Donatella Lucchesi

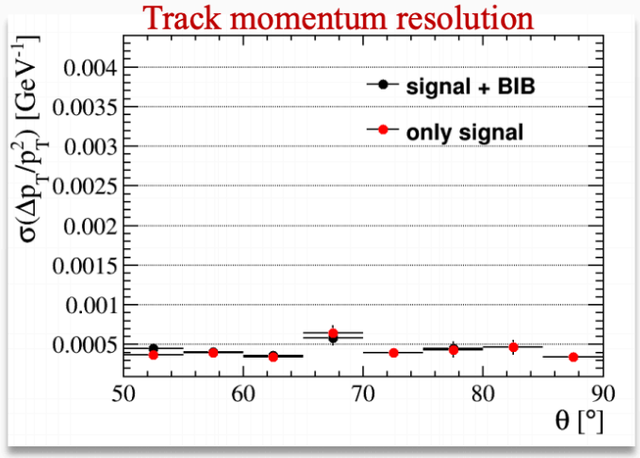
Tracking performance at $\sqrt{s}$ =1.5 TeV

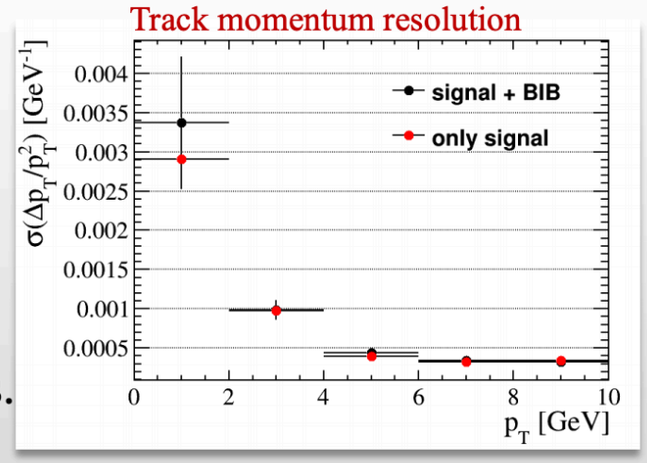
L.Sestini M. Casarsa N. Bartosik L. Buonincontri

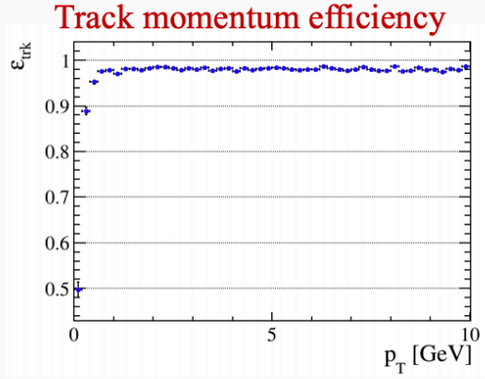
Effects of beam-induce background can be mitigated by exploiting “5D” detectors, i.e. including timing.



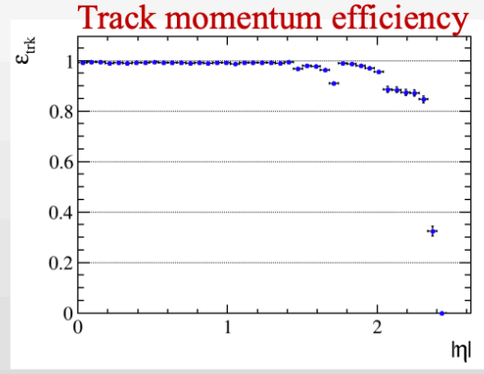
- Simplified digitization: position + time smearing. Realistic digitization in progress.
- Double-layer based BIB rejection in progress.



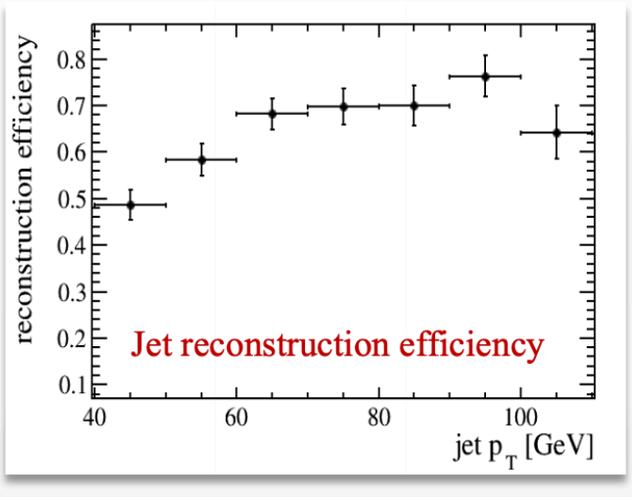


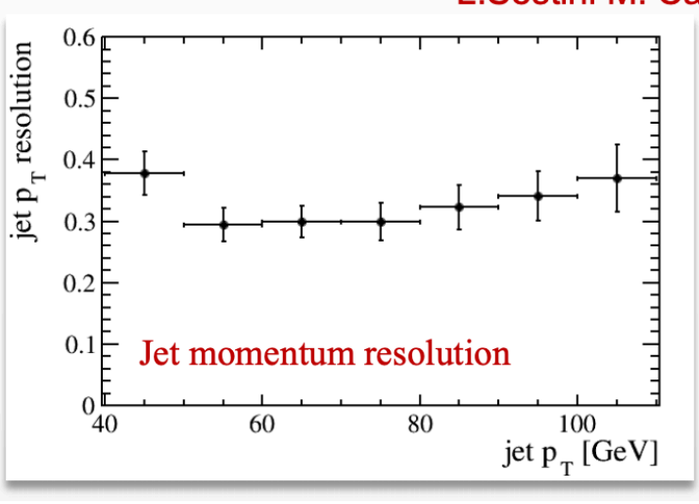


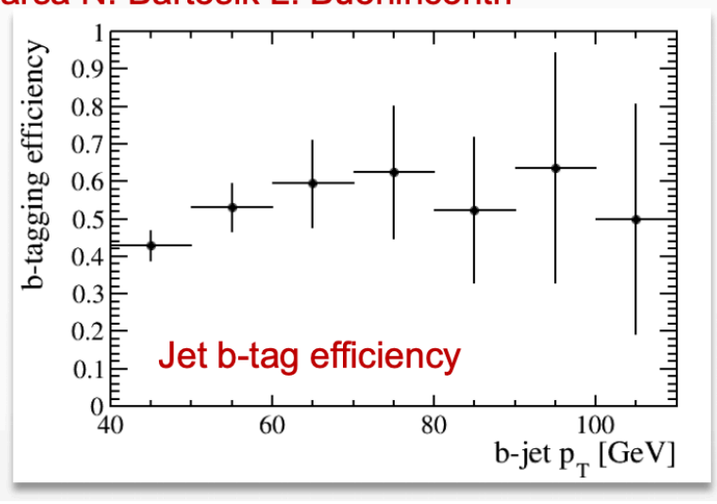
Signal=muon gun



L.Sestini M. Casarsa N. Bartosik L. Buonincontri

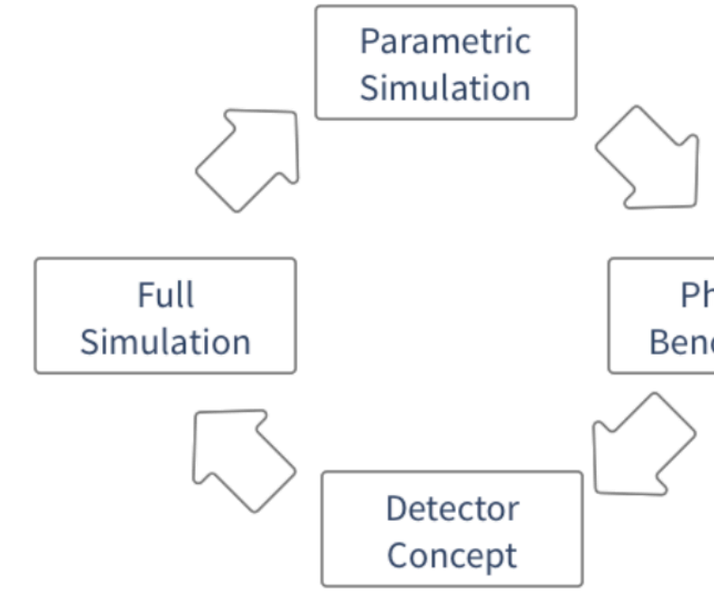






Philosophy

- **Goal** of the Delphes card (and physics studies):
  - define a target for the detector performance (free of BIB)
  - study benchmark physics channels with target performance
  - study impact of physics of variations of detector performance around nominal
  - iterate on detector design



- Delphes task force is to come up with a **v0 Delphes card** in ~ 2 weeks time scale

Philosophy

- The interest in the TH/pheno community is to **assess the physics reach at the highest possible energies** sqrt(s) = 10, 14, 30 TeV

  (at any rate, such a detector would perform great also at 1.5, 3 TeV)

- Need to be able to reconstruct: mu, ele, jets, tops, V up to p_T = **15 TeV**
  - μ μ → μ μ , e e , j j, t t~ (hadronic) ,V V (hadronic)
  - μ μ → EW-inos, stops → SM

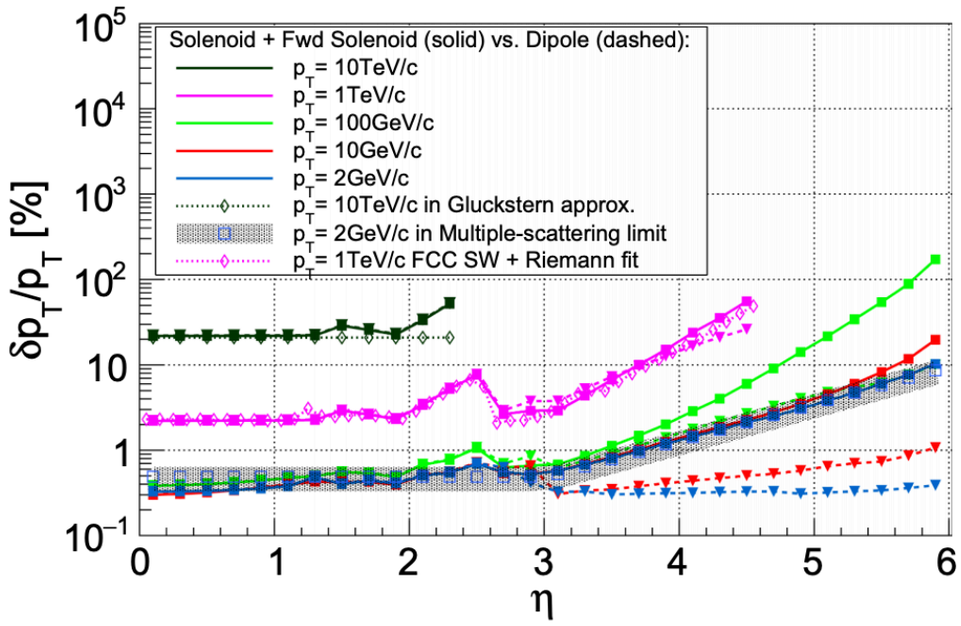
With many respects, the constraints from physics at high p_T are going to be similar to those of the FCC-hh and CLIC (also easier to start from existing detector concept)

Simple proposal: resolutions

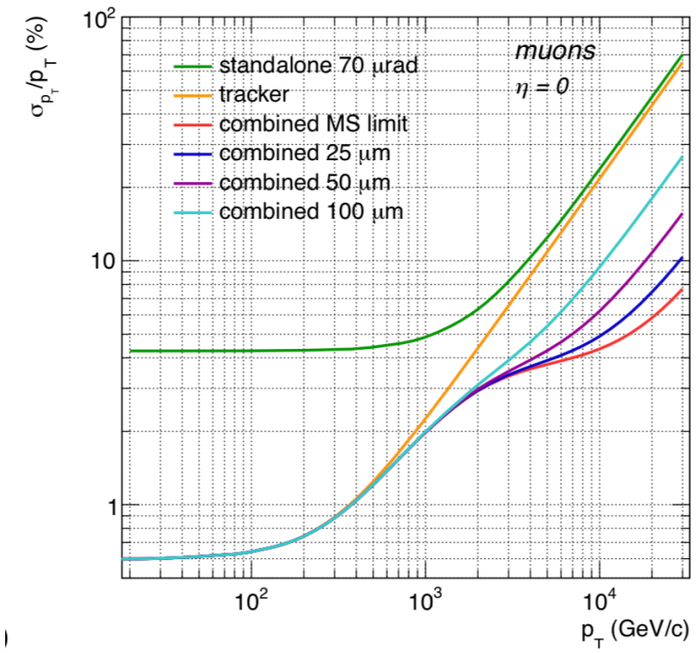
Resolutions:

- **B field** = 4T
- **Tracks** and **muons** :
  - from FCC-hh (for multi-TeV performance)
- **Calorimetry**:
  - ECAL: MuColDet / CLICdet single photon
  - HCAL: MuColDet / CLICdet: single pion / KL

Tracks



Muons



Simple proposal: reconstruction

Reconstruction:

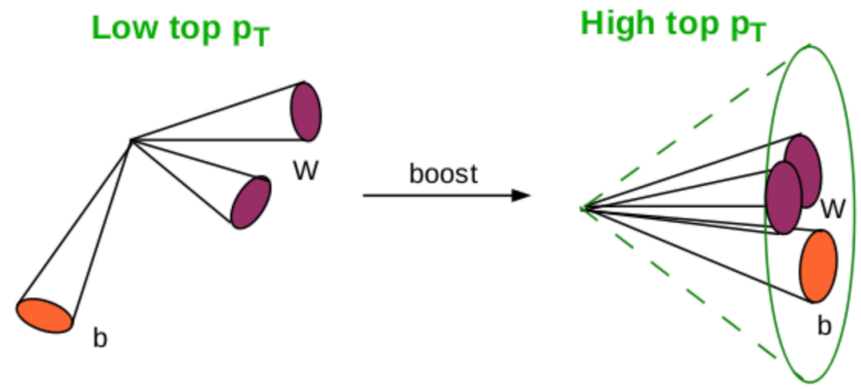
- **Particle-Flow**: Delphes
- **DenseTrackFiltering:** Delphes
- **Jets (Valencia)**:
  - Exclusive jet clustering (CLICdet)
    - R=0.5, 0.7 … 1.5
      - N=2.3 .. 6
  - Inclusive R=0.5, 0.7, … 1.5
  - option to go lower in R=?
    - W(pT = 15 TeV) contained in 0.01 jet !
  - add jet substructure!

```
############
# Jet finder VLC
############
#R05 N2
module FastJetFinder FastJetFinderVLC_R05_N2 {
    #  set InputArray Calorimeter/towers
    set InputArray EFlowFilter/eflow

    set OutputArray VLCjetsR05N2

    # algorithm: 1 CDFJetClu, 2 MidPoint, 3 SIScor
    set NJets 2
    set ExclusiveClustering true
    set JetAlgorithm 9
    set ParameterR 0.5
    set Beta 1.0
    set Gamma 1.0

    set JetPTMin 20.0
}
#R05 N3
module FastJetFinder FastJetFinderVLC_R05_N3 {
    set InputArray EFlowFilter/eflow
    set OutputArray VLCjetsR05N3
    set NJets 3
    set ExclusiveClustering true
    set JetAlgorithm 9
    set ParameterR 0.5
    set Beta 1.0
    set Gamma 1.0
    set JetPTMin 20.0
}
#R05 N4
```



$\Delta R = 2m/p_T$

Simple proposal: efficiencies

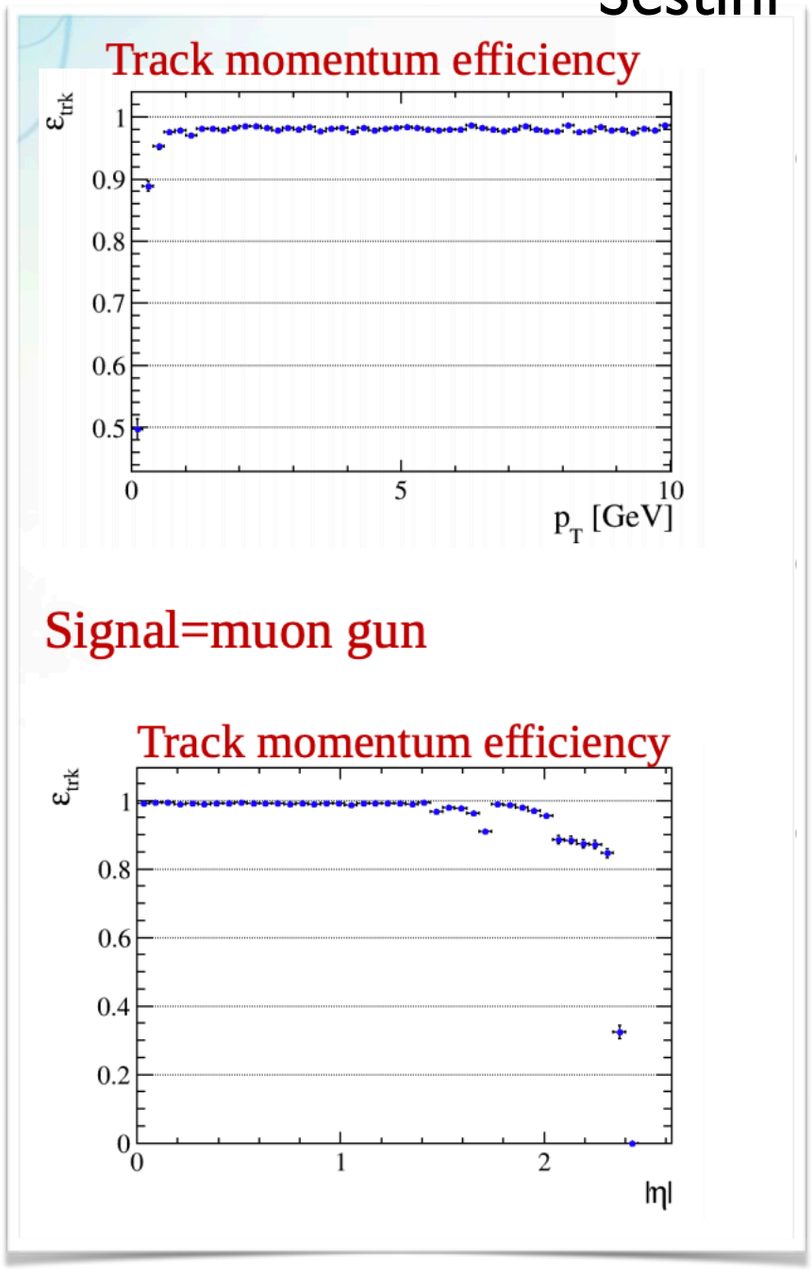
Efficiencies:

- **Tracking, Muon:** MuonColDet
  - Rapidity acceptance:
    - $|\eta| < 2.5, 3$?

- **Electrons, Photons:** CLICdet
  - > 90% at high pT

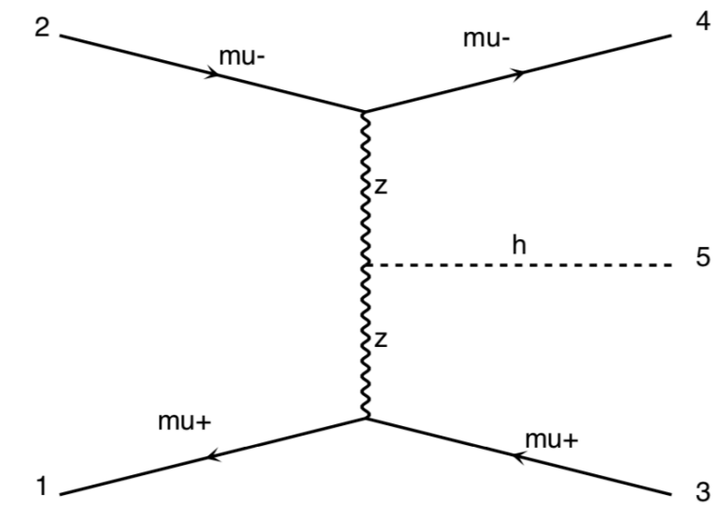
- **HF tagging:** CLICdet / FCChh?
  - CLIC efficiency seems low for hadronic taus (simple iso algo)

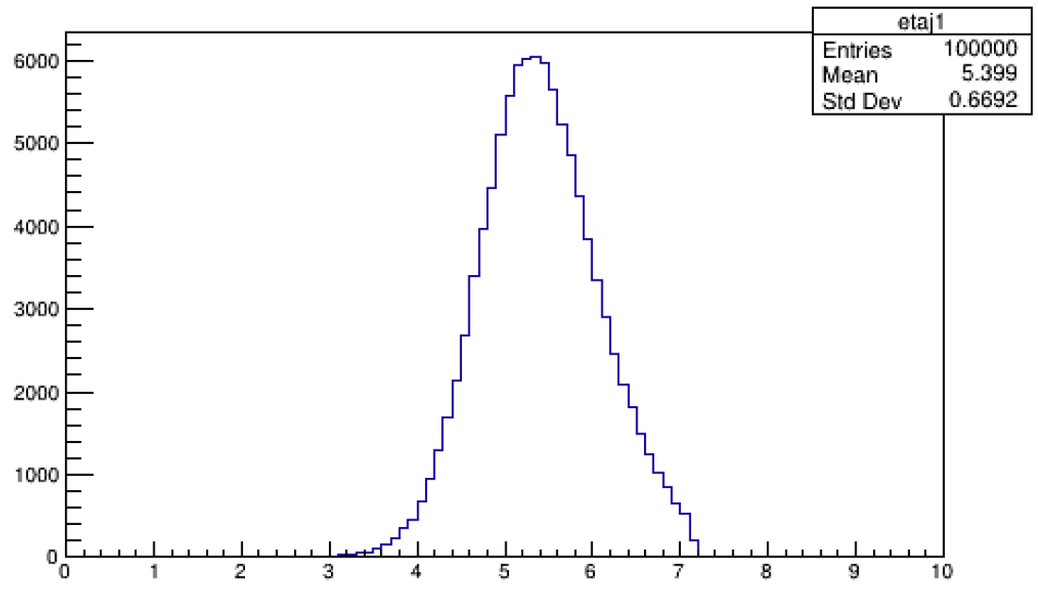
Sestini



Simple proposal: Fwd collection

- Forward **Muon collection:**
  - dedicated collection to avoid confusion
  - **energy resolution ? 10-20%**





most forward muon |η|

Muon Collider card

```
#####################################
# Order of execution of various modules
#####################################

set ExecutionPath {
    ParticlePropagator
    TrackMergerProp

    DenseProp
    DenseMergeTracks
    DenseTrackFilter

    ChargedHadronTrackingEfficiency
    ElectronTrackingEfficiency
    MuonTrackingEfficiency

    ChargedHadronMomentumSmearing
    ElectronMomentumSmearing
    MuonMomentumSmearing
```

```
#####################################
# Muon Collider Detector TARGET model
#
# Michele Selvaggi michele.selvaggi@cern.ch
# Ulrike Schnoor ulrike.schnoor@cern.ch
#
#
# !!! DISCLAIMER !!!
#
# The parameterisation of the Muon Collider
# has to be intended as a target performance.
# This has not been validated by full simulation.
# Very similar to CLIC performance, added DenseTrackFilter
#
# Comments:
#   - fix: angle param in DenseTrackFilter
#   - fix: add FWD muon collection
#   - what to do with Eta acceptance?
#       - for now everything reduced at 2.5
#   - add jet substructure to valencia jets ?
#   - added R02 jets
#   - added electron misId for taus, and make flat eff
#
```

- Evolving prototype can be found here:
  - https://github.com/delphes/delphes/blob/master/cards/delphes_card_MuonColliderDet.tcl
  - https://github.com/delphes/delphes/tree/master/cards/MuonCollider
- Missing:
  - Forward muon collection for now
  - Jet Substructure
  - Validation

Comments

- The performance that will be encoded in the Delphes muon collider card is to be intended as a **“target” performance** for the highest possible energy

However (disclaimer):

- Nothing will be written in stone, should be intended as a **moving target**
- Users should **explore variations around target performance** to assess sensitivity of physics reach as a function of particular detector choices, and impact of beam induced background