Report on jet reconstruction at Muon Collider

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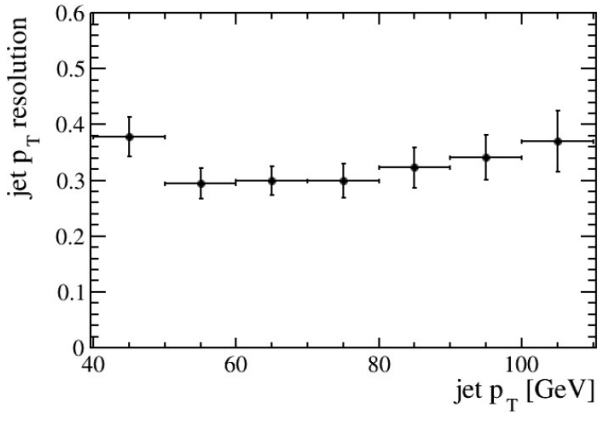
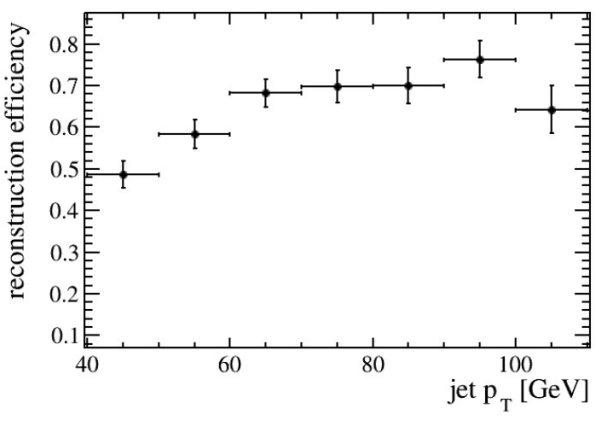
Outline

- Jet reconstruction with calorimeter
- Missing energy
- Jet reconstruction with particle flow
- Jet tagging and identification
- Next steps

Where we were before ILCSoft





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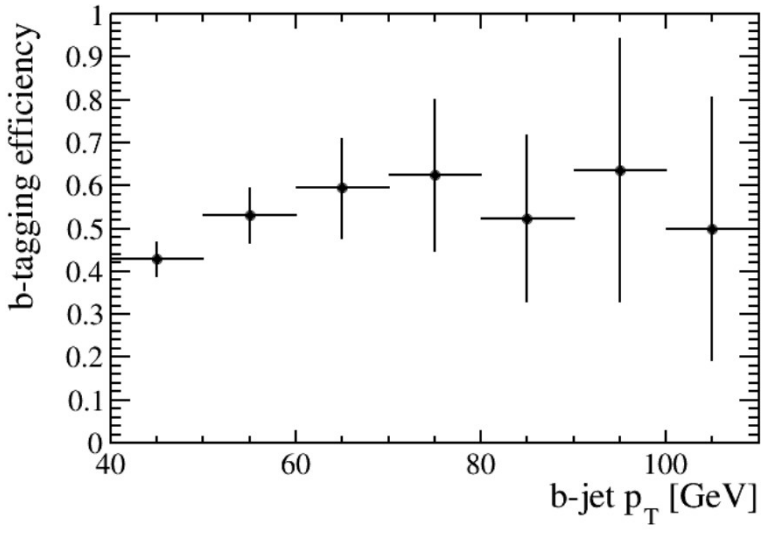
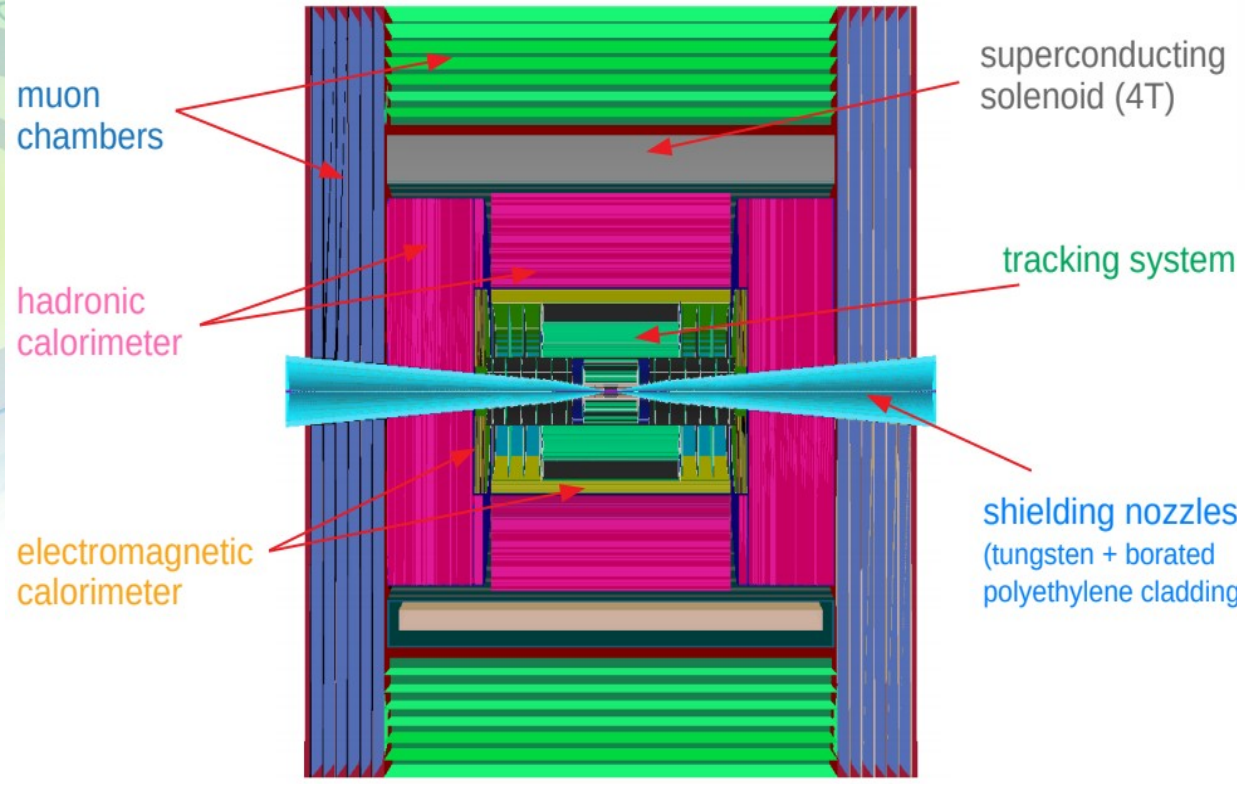


Full characterization of the b-jet performance in the presence of the beam-induced background (BIB)

Not optimized, but we demonstrated that Physics is doable

Design a detector at $\sqrt{s}$ = 1.5 TeV



Vertex Detector (VXD)
- 4 double-sensor barrel layers 25x25μm²
- 4+4 double-sensor disks ”

Inner Tracker (IT)
- 3 barrel layers 50x50μm²
- 7+7 disks ”

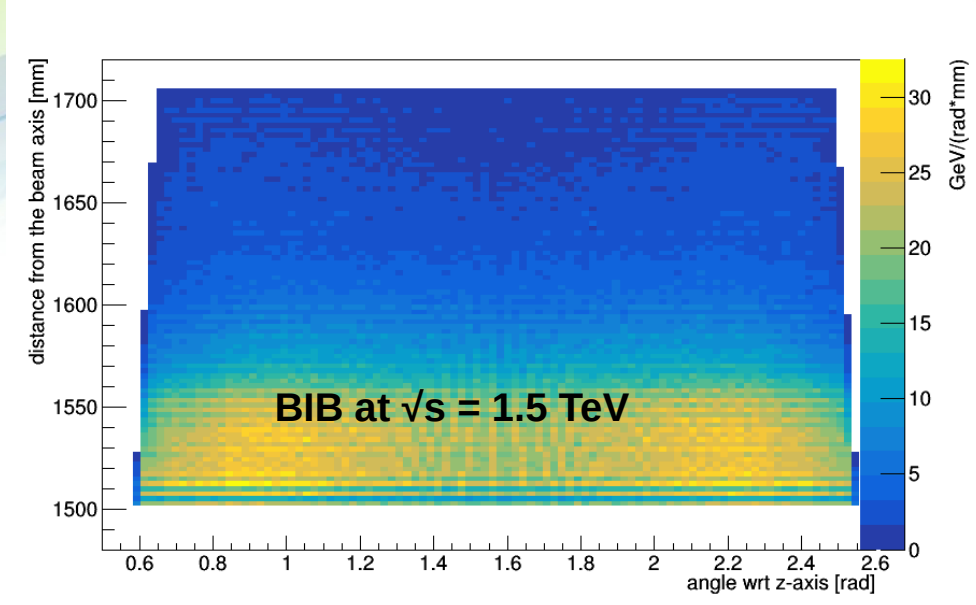
Outer Tracker(OT)
- 3 barrel layers 50x50μm²
- 4+4 disks ”

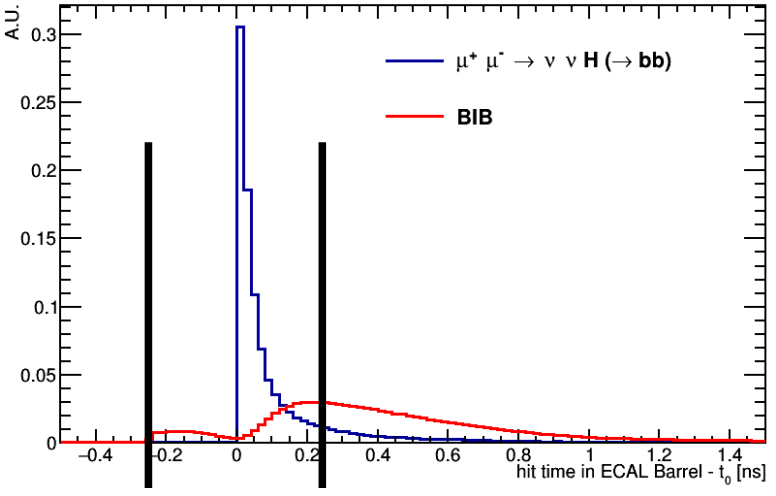
Electromagnetic Calorimeter (ECAL)
- 40 layers W absorber and silicon pad sensors, 5x5 mm²

Hadron Calorimeter (HCAL)
- 60 layers steel absorber & plastic scintillating tiles, 30x30 mm²

BIB subtraction in calorimeter

- An aggressive acquisition time window is set: ±0.25 ns.
- $\overline{E}$ and σ are calculated in bins of θ (angle with respect to the beam axis) and R (distance from the beam axis) from the BIB distribution.

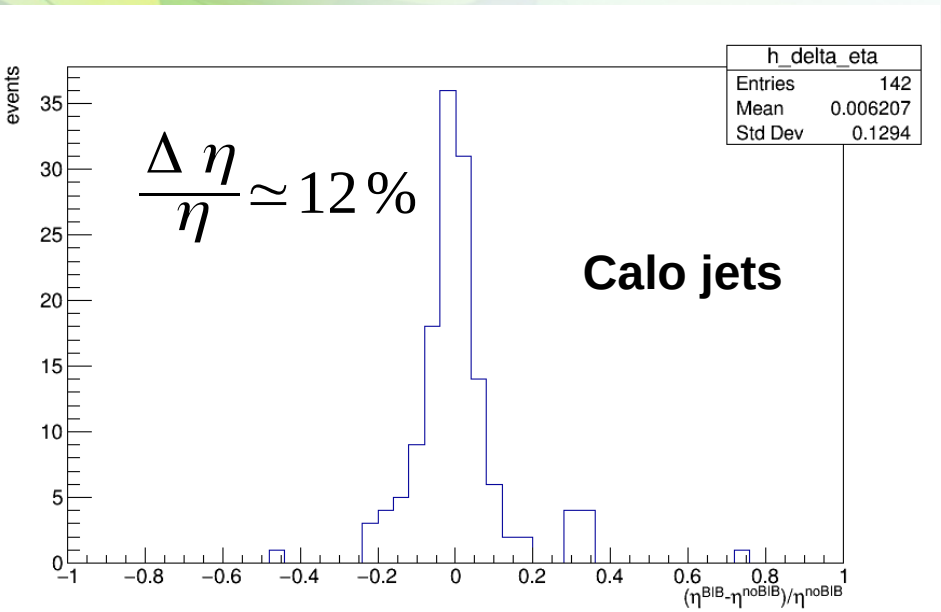




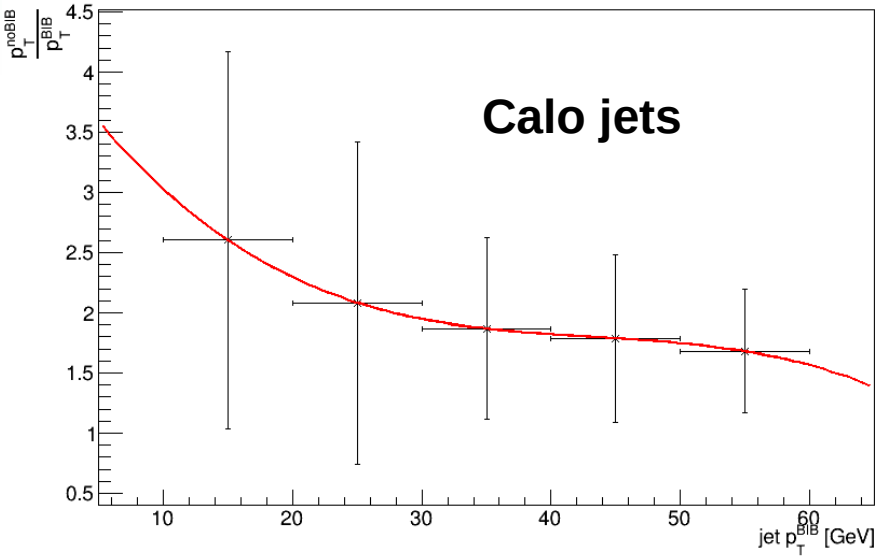
- A hit is accepted if $E>\overline{E}+2\sigma$.
- The energy of the accepted hit is corrected: $E \rightarrow E - \overline{E}$.
- The PandoraPF algorithm is used for clustering.

Jet reconstruction with calorimeter

- Jets are clustered starting from calorimeter clusters with the kt algorithm (R=0.7).
- Tests have been performed with HH(→bbbb) events.



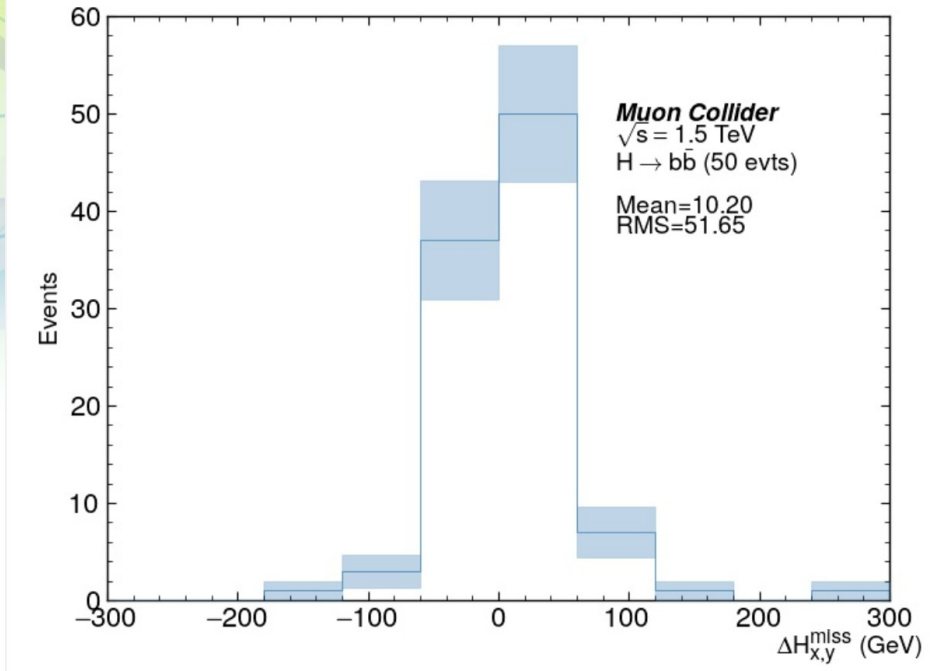
Ratio btw p_T of the jet without BIB (and no subtraction) and p_T of the jet with BIB

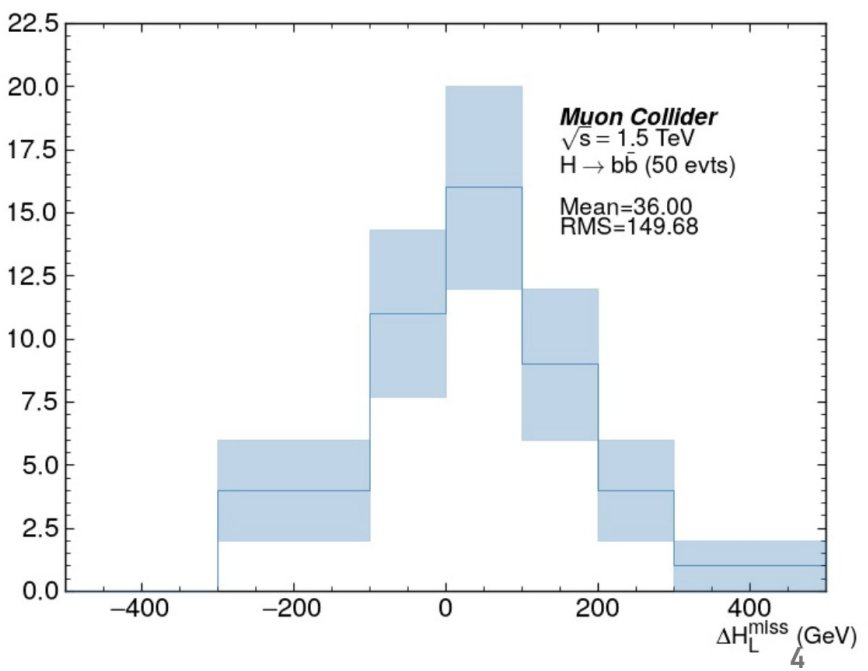


- More than half of the energy is lost with subtraction.
- After applying a Jet Energy Correction, p_T resolution is 30% (compatible with IlcRoot).

Missing energy

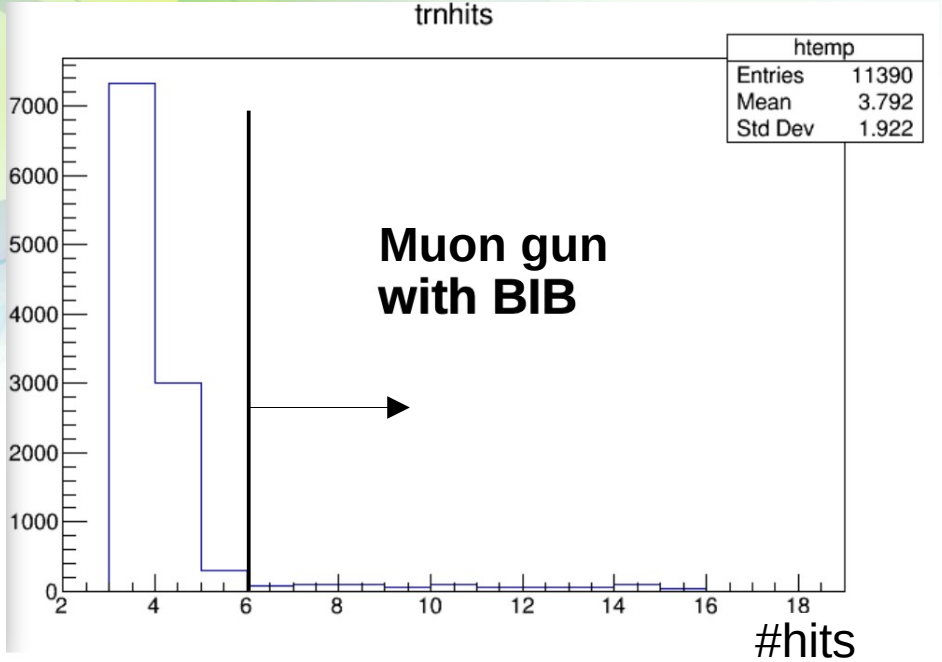
- The calorimeter-jet configuration has been considered for studies on the **missing energy measurement**.
- $\Delta H^{miss} = H^{miss}_{BIB} - H^{miss}_{noBIB}$ → calculated in the transverse and longitudinal plane.
- Preliminary studies show that the measurement in the transverse plane is more procise.

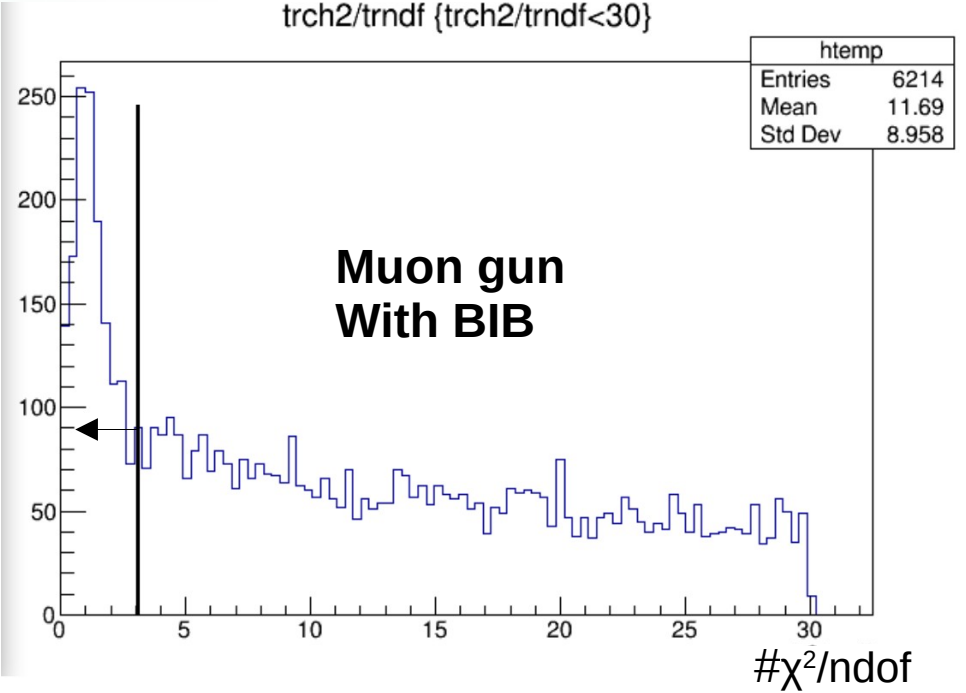




Track selection for Particle Flow inputs

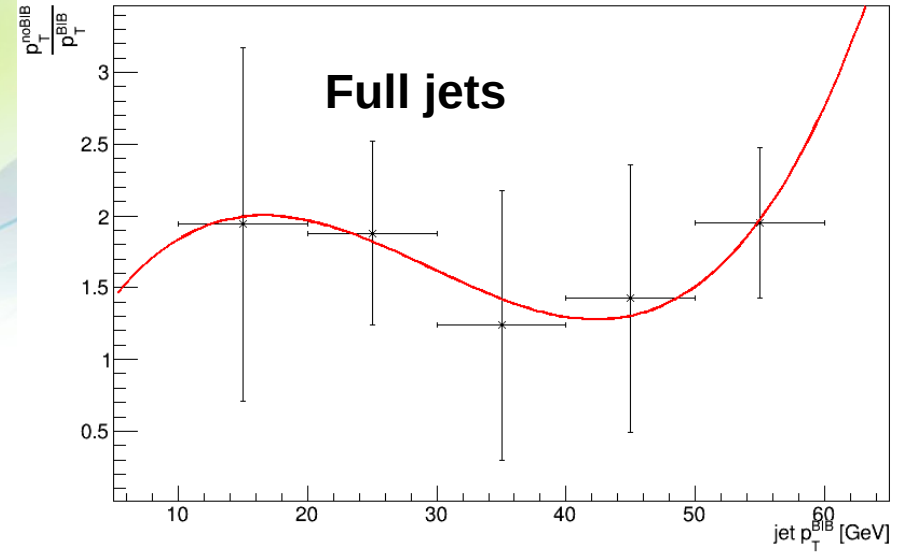
- We have to deal with the tracking combinatorial.
- Cuts on the number of hits and χ^2/ndof of the tracks could be applied to remove most of it.

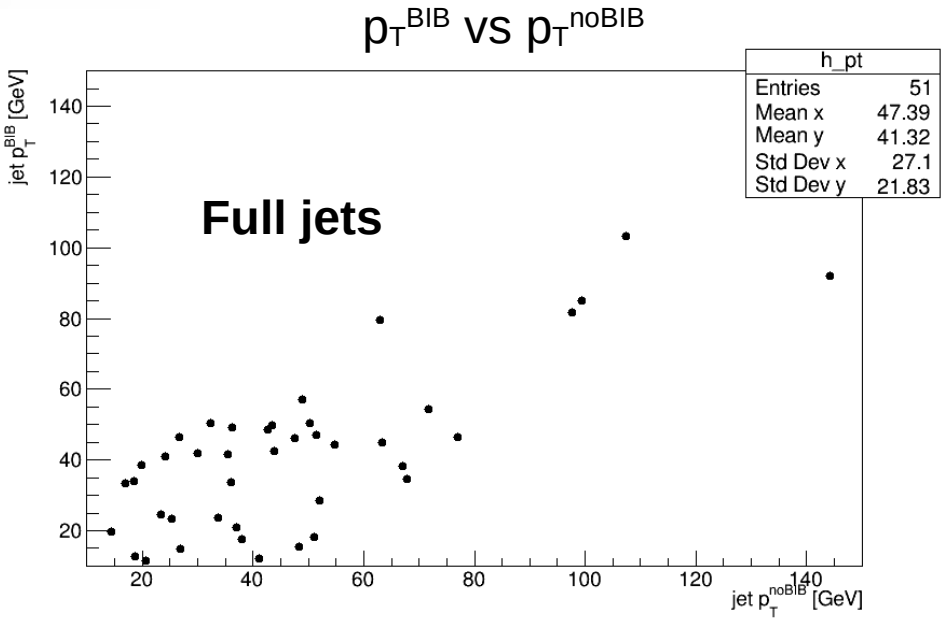




Full jet reconstruction (tracks + clusters)

- Full particle flow algorithm (PandoraPF) with tracks and calorimeter clusters (with BIB subtraction). Jet clustering with kt and R=0.7.
- **Tested with few events: 20 HH(→bbbb) events, not enough to assess the performance.**

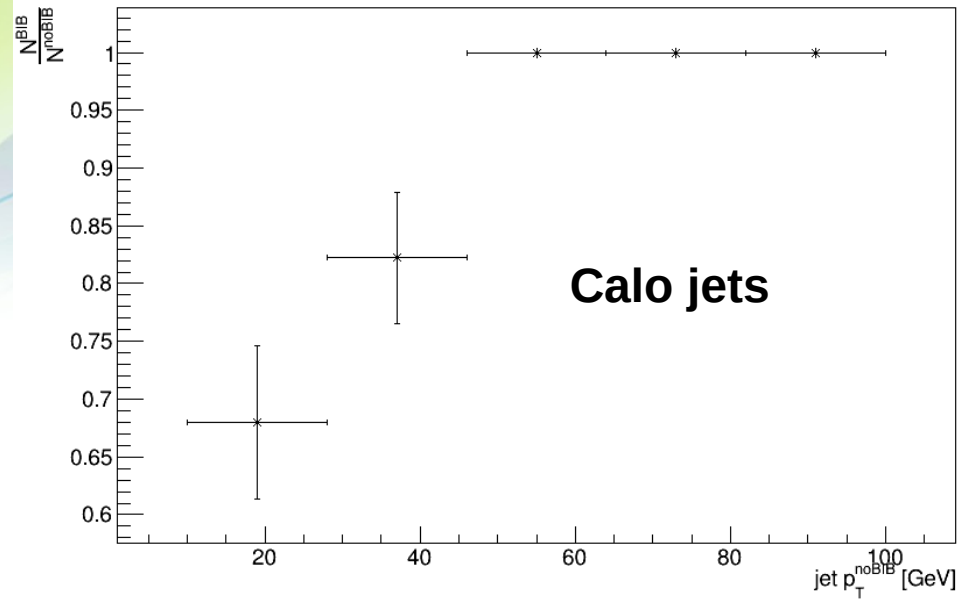


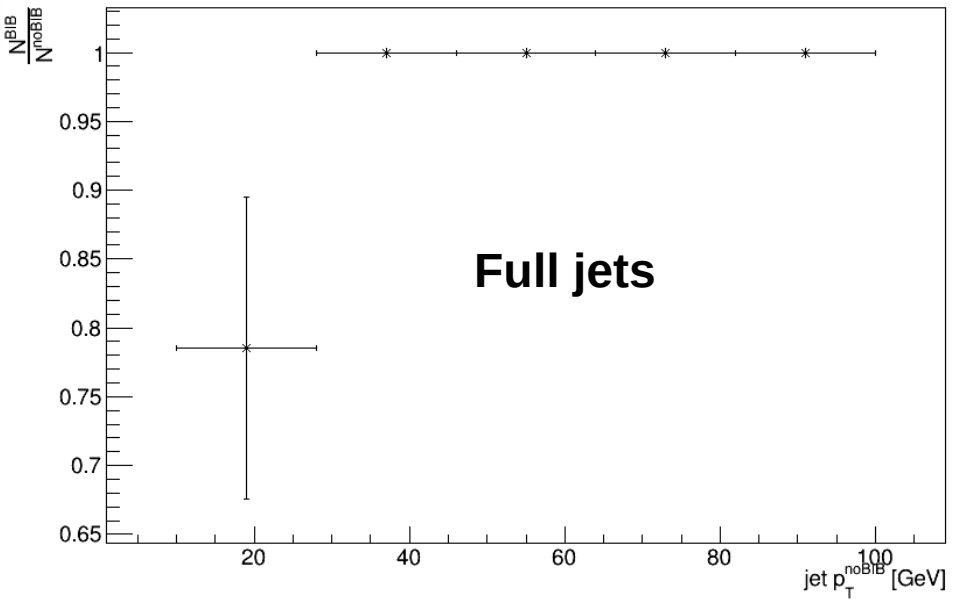


- About 1/3 of the energy is lost (to be compared with ½ of energy lost in calorimeter only reco)

Full jet reconstruction

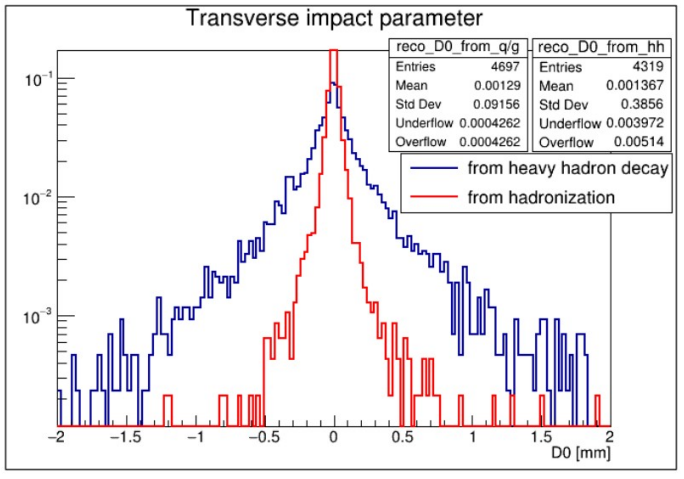
- Ratio of the number of jets reconstructed with and without BIB → $\mathbf{N^{BIB}/N^{noBIB}}$
- The statistics is still low, but it may be possible to recover low p_T jets with the full reco.

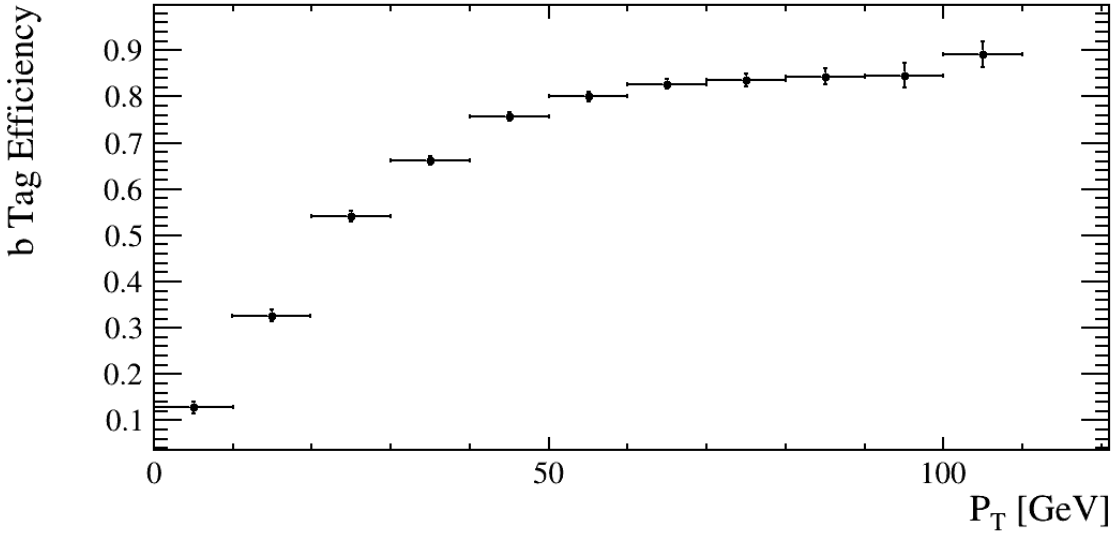




Jet identification

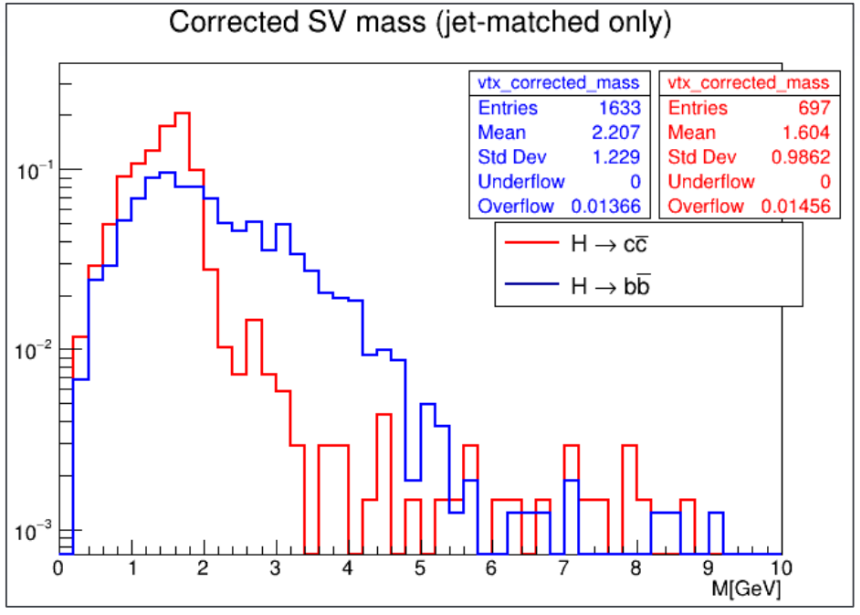
- Secondary vertex algorithm from LCFIPlus processor.
- **At least for now it is tested without the BIB** (we are still working on dedicated simulations).
- Further studies on light mis-tag rate are also necessary.

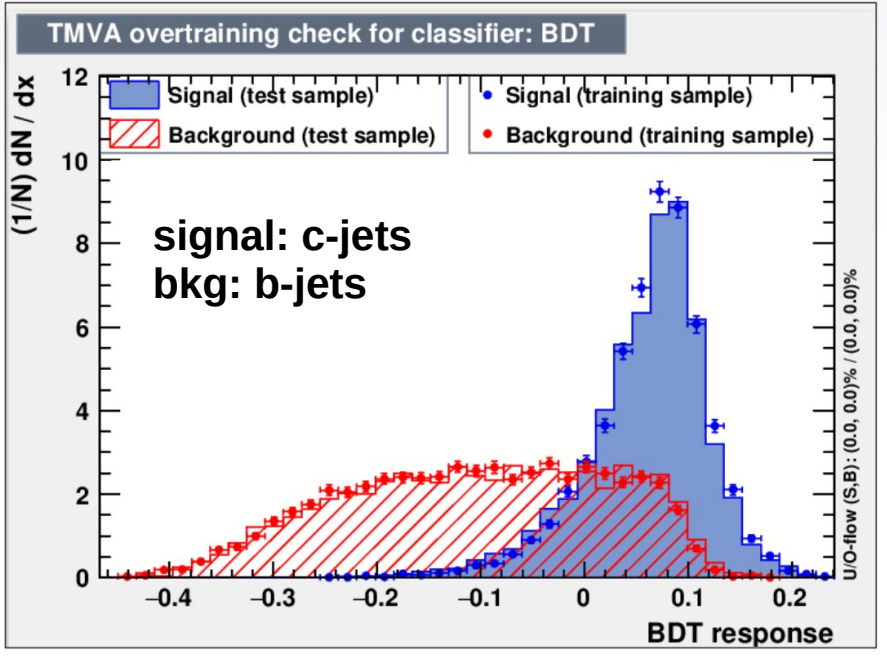




Jet identification

- On-going studies on b vs c discrimination: MVA technique with SV-related observables in input.
- Further studies will be performed on b/c vs light jets discrimination.



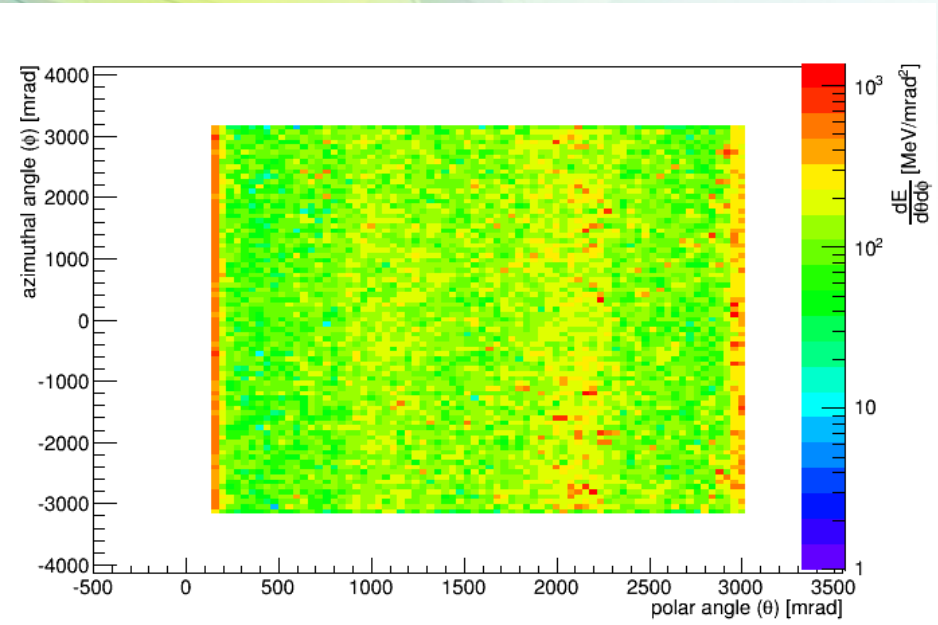


Plan for jet reconstruction

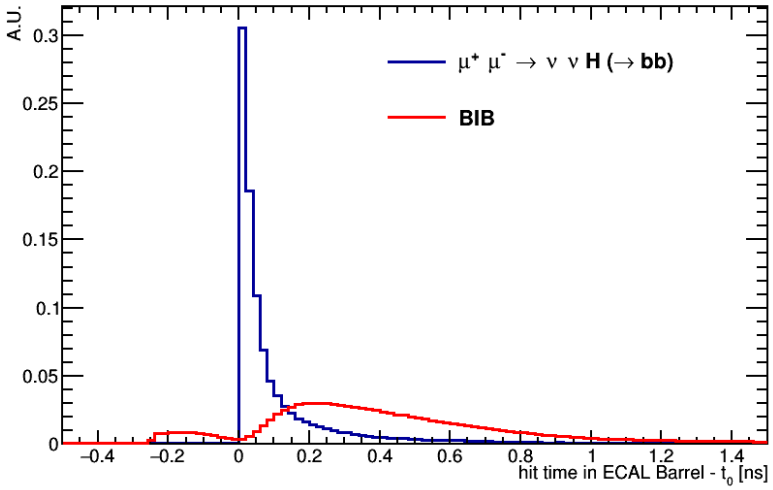
- **The goal is to obtain the complete characterization of the jet performance in the presence of the BIB:** jet efficiency and fake rate, jet energy resolution, tagging efficiency and mistag.
- As you have seen the machinery is already in place.
- We have already generated **inclusive b, c and light dijet samples** with Pythia 8 in six p_T(b/c/light)+p_T(b/c/light) bins: [0,40], [40,80], [80,120], [120,160], [160,200], [200,∞] GeV.
- Simulations are on-going.
- **The bottleneck will be the tracking: we need a proper tracking configuration!**
- **For sure we can do more sophisticated things than these, but consider that this work is the secondary activity of a very limited number of people.**

Backup

Background in calorimeter



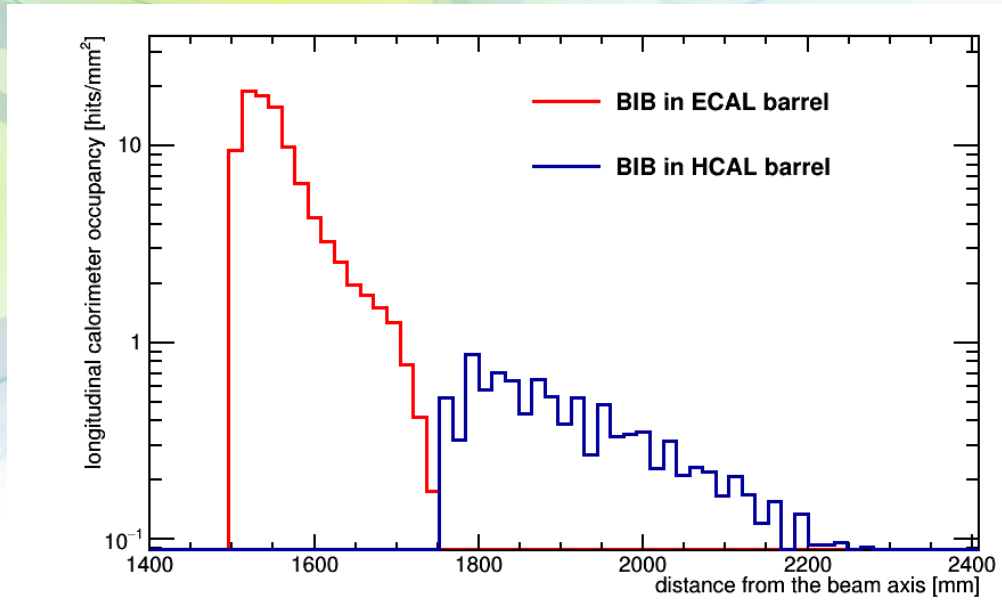
The background is **diffused**



Part of the background is **asynchronous with respect to the signal**

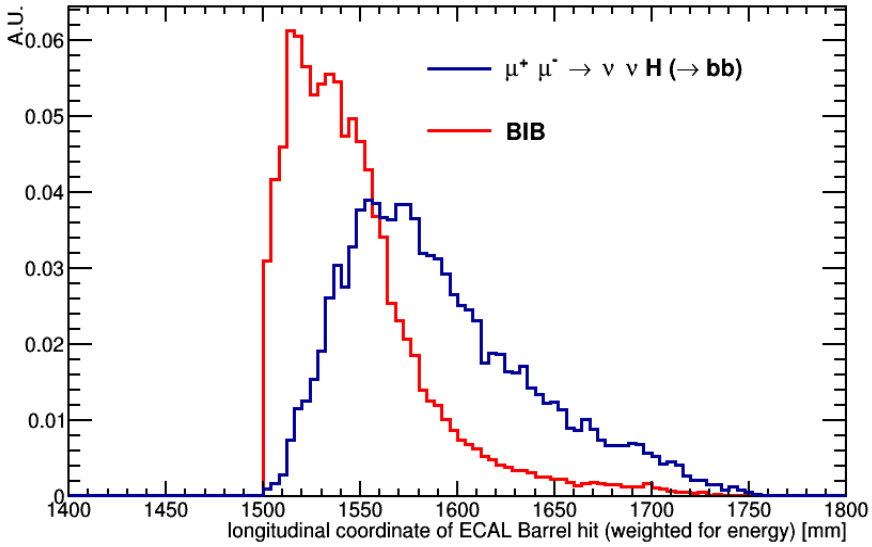
Background in calorimeter

Calorimeter Occupancy



Low occupancy in HCAL

ECAL barrel longitudinal coordinate

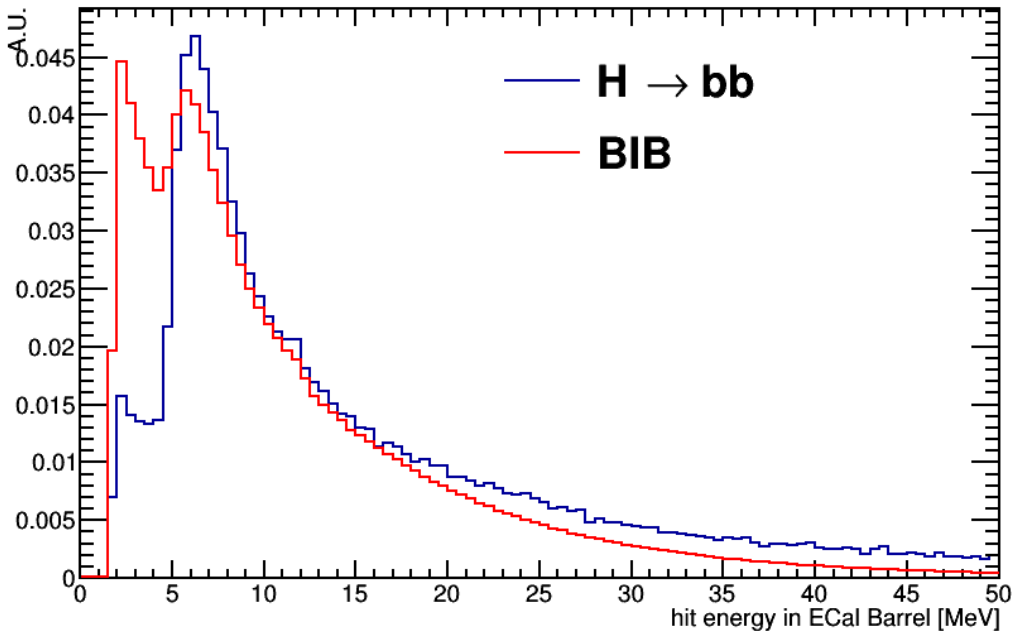


Longitudinal calorimeter segmentation can be exploited to reconstruct showers and reject the BIB

Goal

- Test the calorimeter digits selection used in past studies (ILCroot with Dual Readout calorimeter) in the current framework (ILCsoft) and with the CLIC calorimeter.
- If decent results are obtained, the algorithm can be optimized for better performance
- The algorithm goes as follow:
  - the calorimeter is divided into several regions;
  - in each region the digits released by the BIB are considered, the mean (<E>) and the standard deviation (σ) are calculated;
  - for signal+BIB reconstruction, if the digit energy $E > \overline{E} + 2\sigma$, then it is selected;
  - the energy of the selected digit is corrected: $E^{cor} = E - \overline{E}$

Digit energy



- Average digit energy for BIB is 11 MeV.
- Average digit energy for H→bb is 15 MeV (withouth BIB).
- The overlay of H→bb+BIB produce an average digit energy between 20 and 30 GeV for digits that contains both signal and BIB.
- Calculated thresholds are in the range between 10 and 40 MeV depending on R and θ.

SV-tagging parameters

Parameters	PV	SV
Min D_0 [mm]	0.	0.
Max D_0 [mm]	0.2	5.
Max Z_0 [mm]	0.5	5.
TrackMinVdxFtdHits	2	4
Min P_T [GeV]	Default (0)	0.8