Update on calorimeter hits selection

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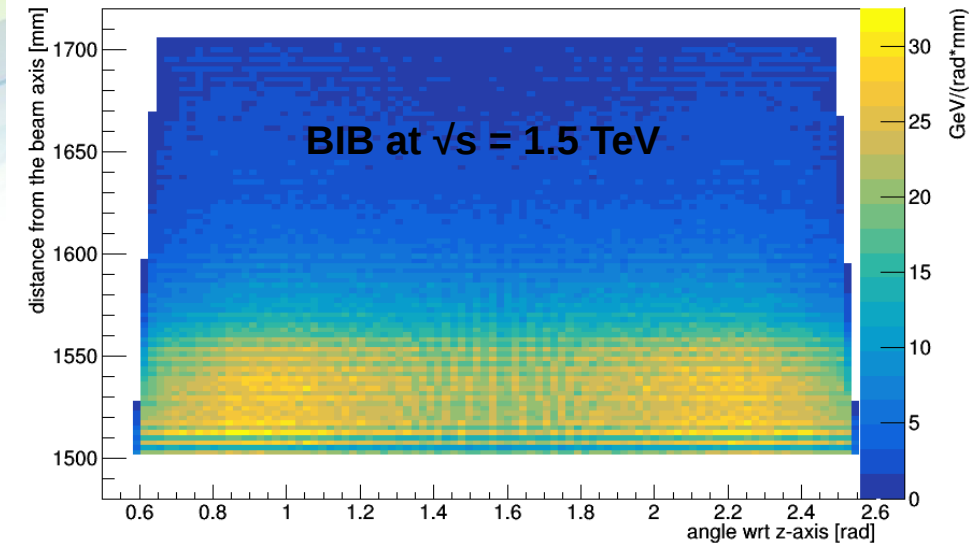
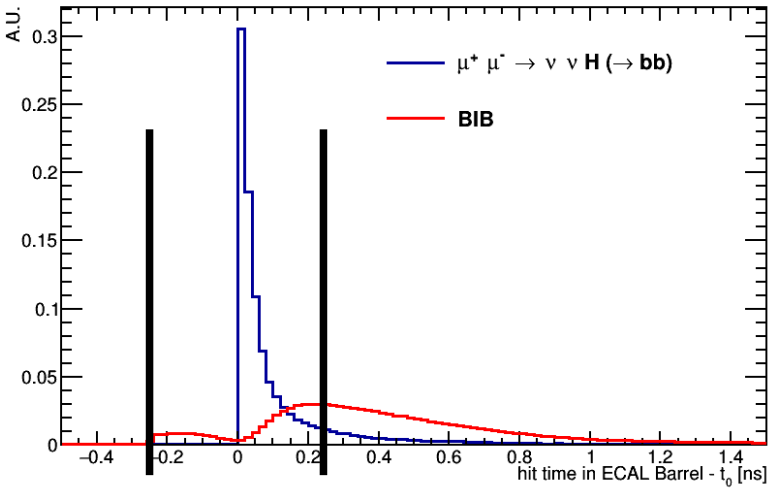
Goal

- 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: $E^{cor} = E - \overline{E}$

Implementation

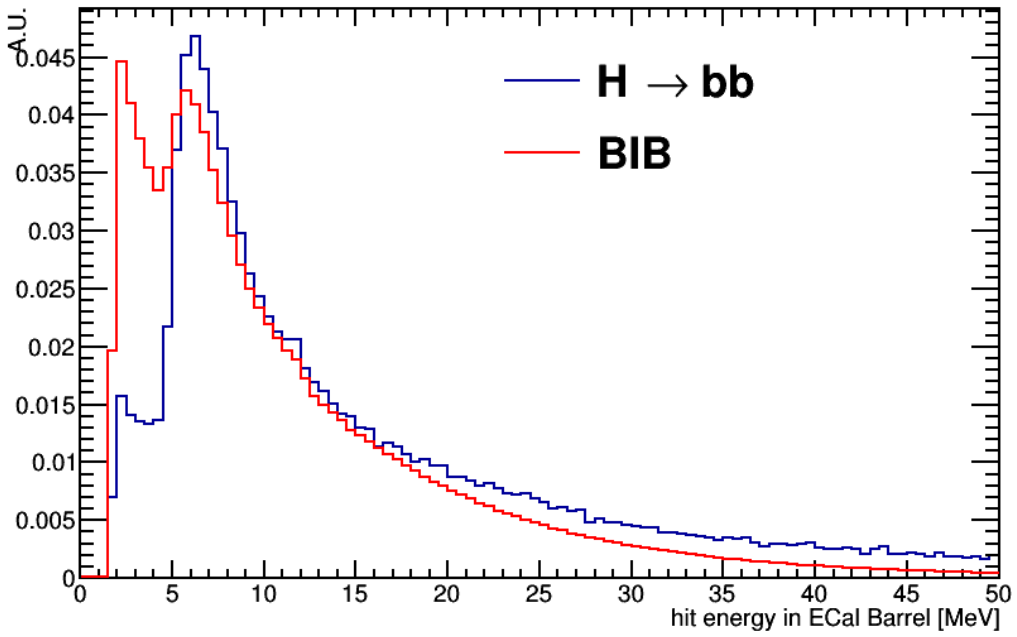
- An aggressive acquisition time window is set: ±0.25 ns.
- The digit selection has been implemented directly in the digitizer processor.





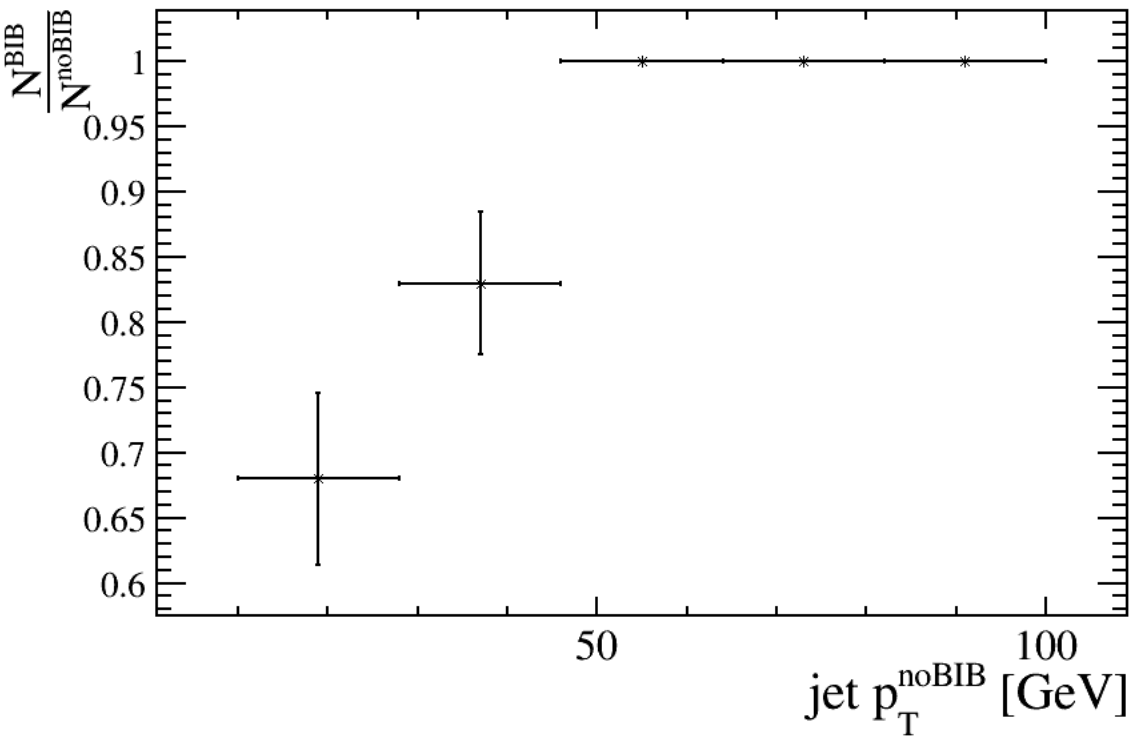
- $\overline{E}$ and σ are calculated in bins of θ (angle with respect to the beam axis) and R (distance from the beam axis)
- As first test thresholds are applied just to the ECAL barrel. ECAL endcaps are not considered. HCAL digits are all accepted.

Digit energy



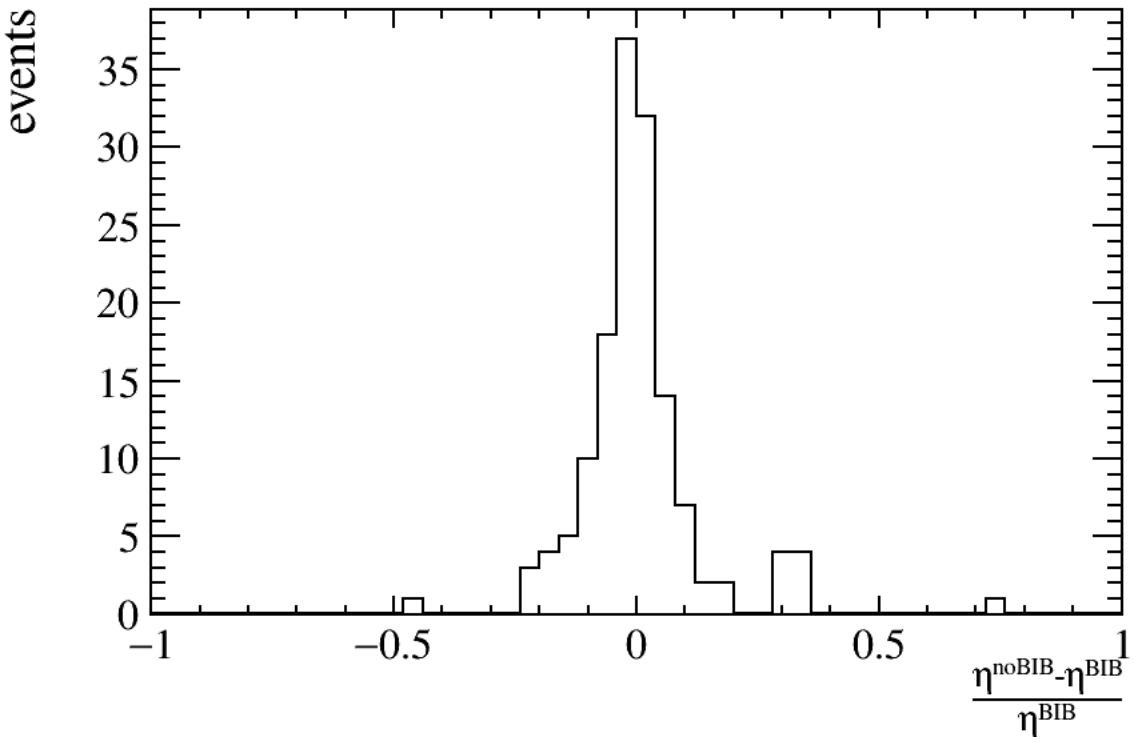
- Average digit energy for BIB is 11 MeV.
- Average digit energy for H→bb is 15 MeV (withouth BIB).
- The overlay of H→bb+BIB produce an average digit energy between 20 and 30 GeV for digits that contains both signal and BIB.
- Calculated thresholds are in the range between 10 and 40 MeV depending on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

Jet reconstruction with calorimeters



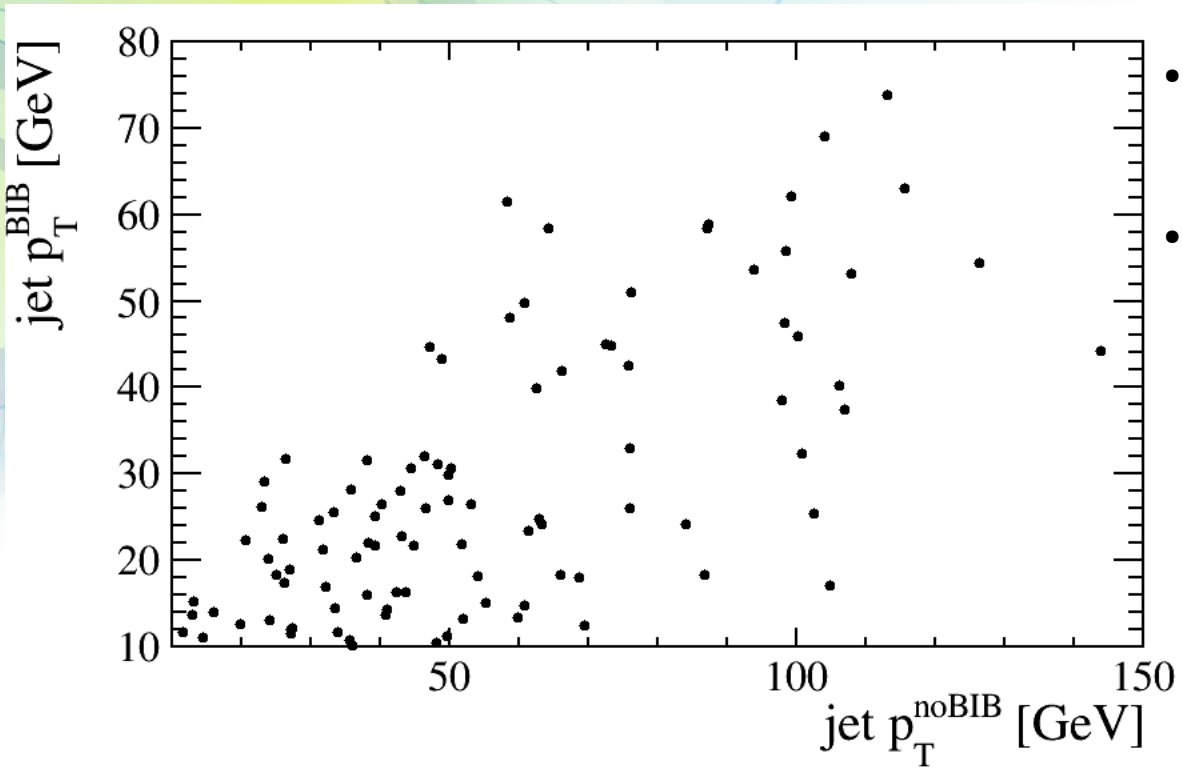
- The PandoraPF and kt algorithms are used for jet reconstruction, using just selected calorimeter hits.
- Sample used is H → bb + BIB.
- 50 events have been reconstructed (the same BIB bunch crossing have been overlayed).
- ~5 days of CPU time, 40-50 GB of RAM constantly used.
- On average 5.2 jets per event have been reconstructed. Without BIB we have 3.8 jets per event.
- Jets reconstructed with and without BIB are matched in the (η,φ) space for comparison.

Jet direction



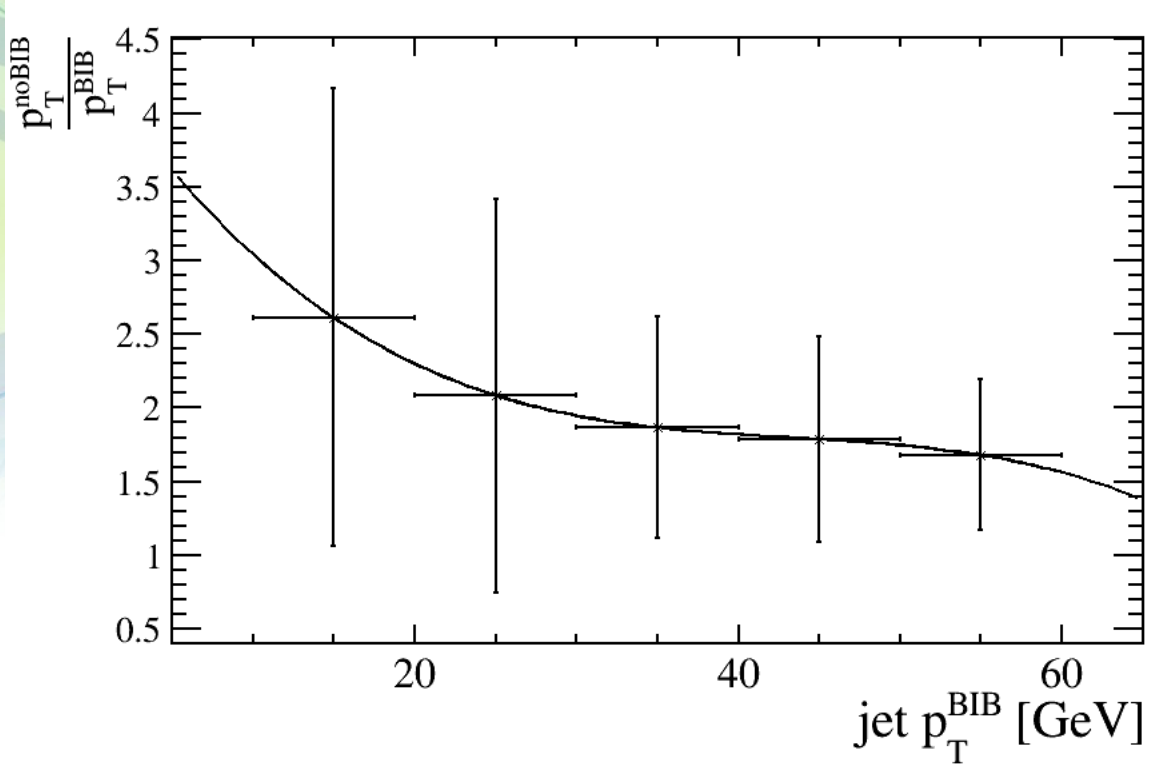
- Jet direction seems properly reconstructed.
- The BIB introduces a 13% degradation of η.

Jet transverse momentum



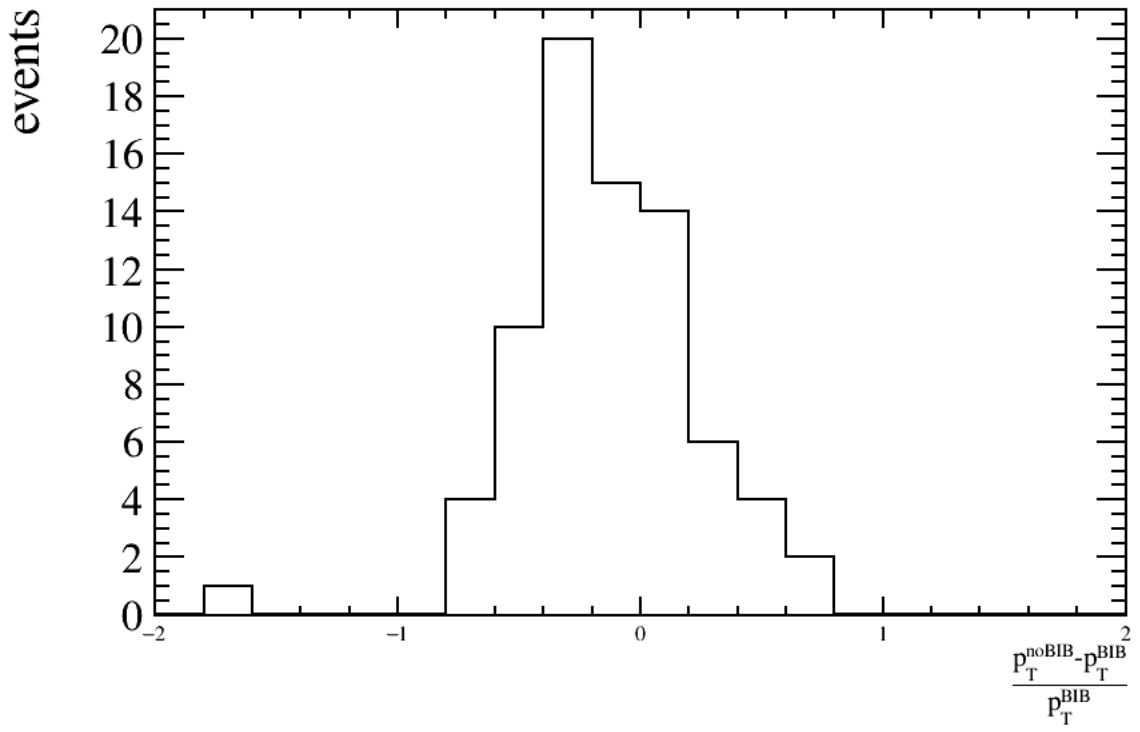
- Transverse momentum reconstruction is more difficult.
- A correlation between the jet pT with BIB an without BIB exists

Jet transverse momentum scale



- Points are the mean of p^{noBIB}_T/p^{BIB}_T, error bars the standard deviations.
- Almost half of the transverse momentum of the jet is lost with the selection algorithm

Jet transverse momentum degradation



- Jet p_T in the presence of BIB can be corrected with the scale factors.
- Corrected jet p_T can be compared with the jet p_T without BIB.
- The transverse momentum degradation is 37% for p_T>40 GeV.
- The situation looks better at higher p_T, but we don't have enough statistics to make a clear statement.

Conclusions and Perspectives

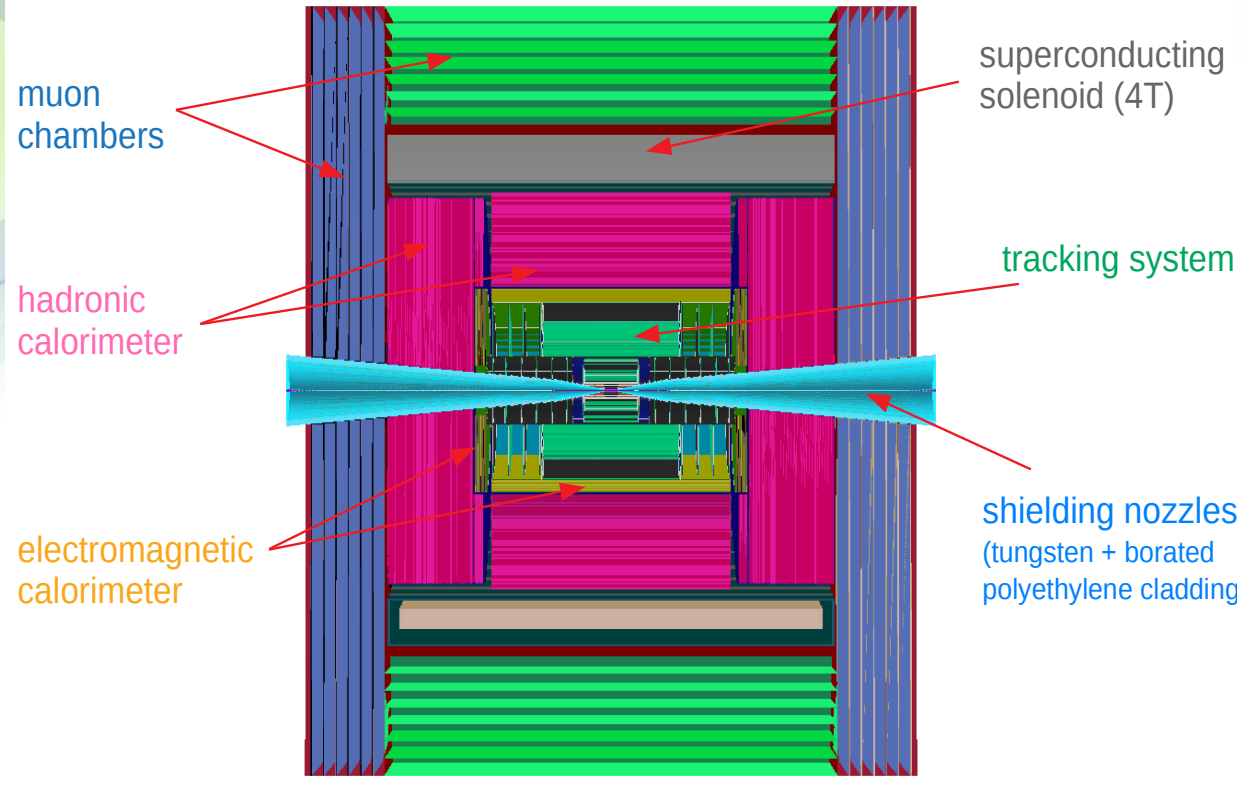
- What we obtained is compatible with the past results from the old framework.
- We can use this configuration as starting point for improvements.
- For now there is no “tuning” on the cuts.
- We are trying an approach similar to SoftKiller to determine a set of thresholds.

Backup

Design a detector at √s = 1.5 TeV

For detector studies we are currently using **ILCSoft**, which will be part of the common software for future colliders → Key4hep

Modified version of CLIC detector: we included two nozzles, we adapted the forward tracking station to them, we modified the Vertex detector geometry



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

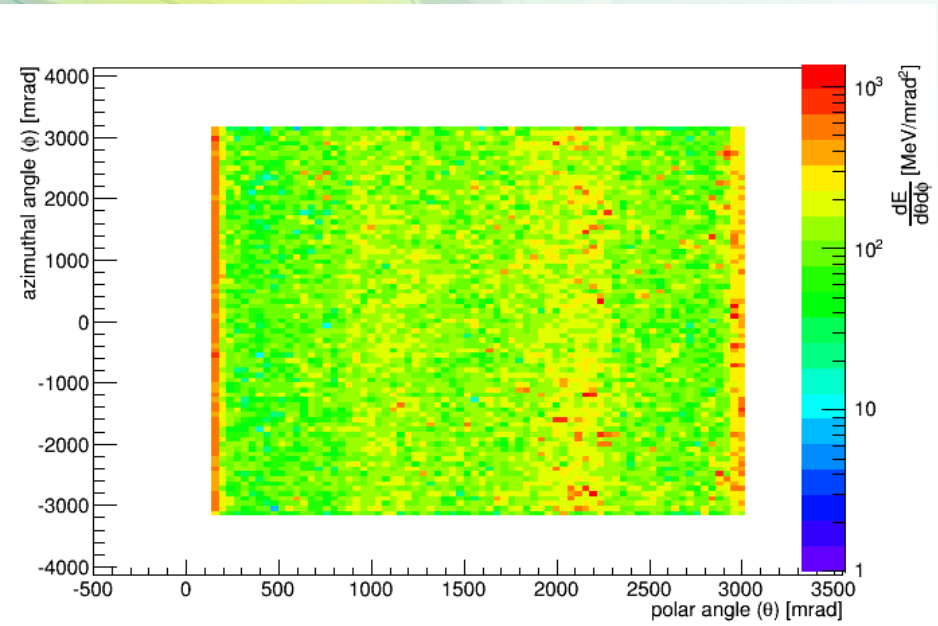
Inner Tracker (IT)
- 3 barrel layers 50x50μm²
- 7+7 disks ''

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

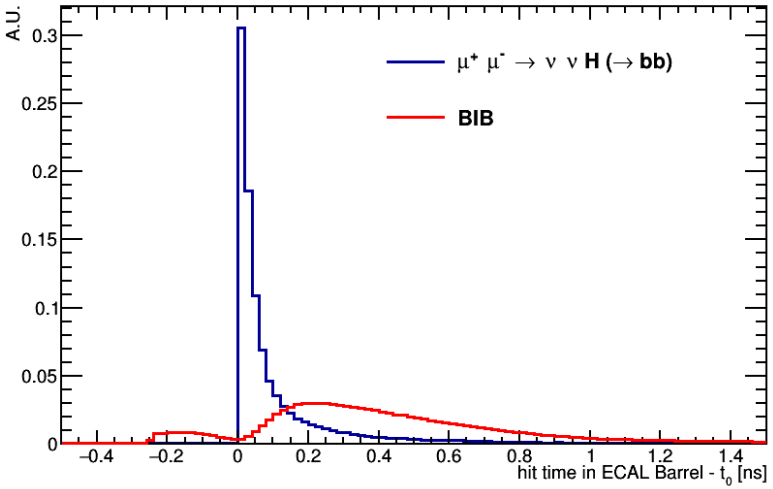
Electromagnetic Calorimeter (ECAL)
- 40 layers W absorber and silicon pad sensors, 5x5 mm²

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

Background in calorimeter



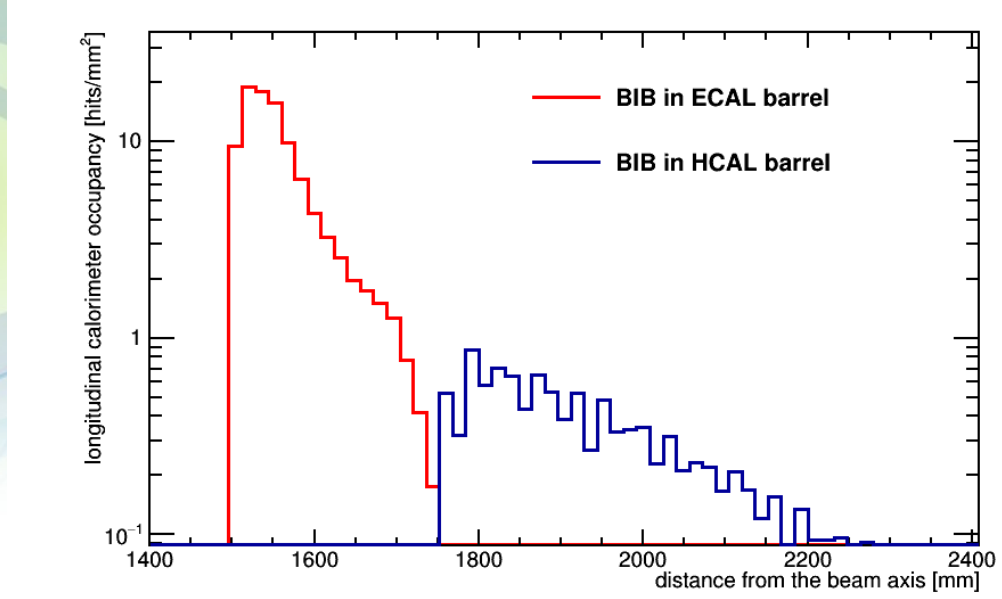
The background is **diffused**



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

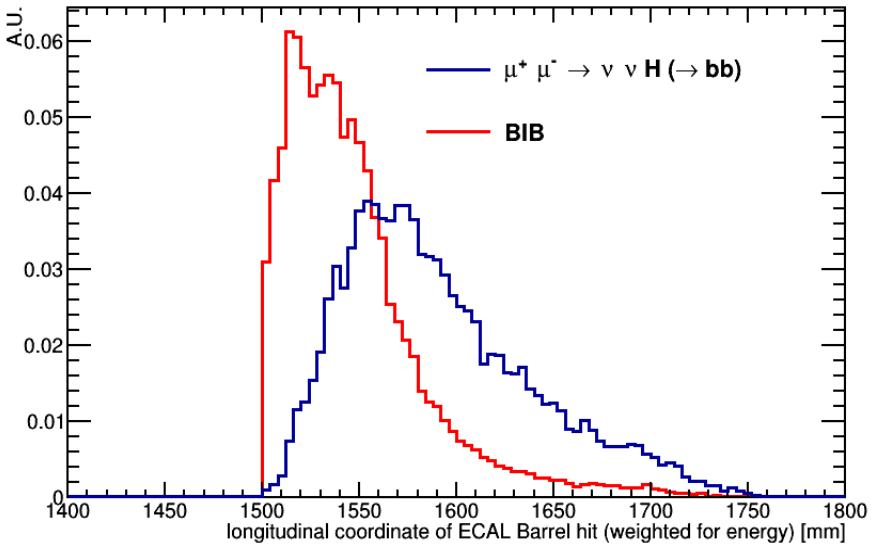
Background in calorimeter

Calorimeter Occupancy



Low occupancy in HCAL

ECAL barrel longitudinal coordinate



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