A first look to Hbb and Hcc using Jet Lifetime Probabilities

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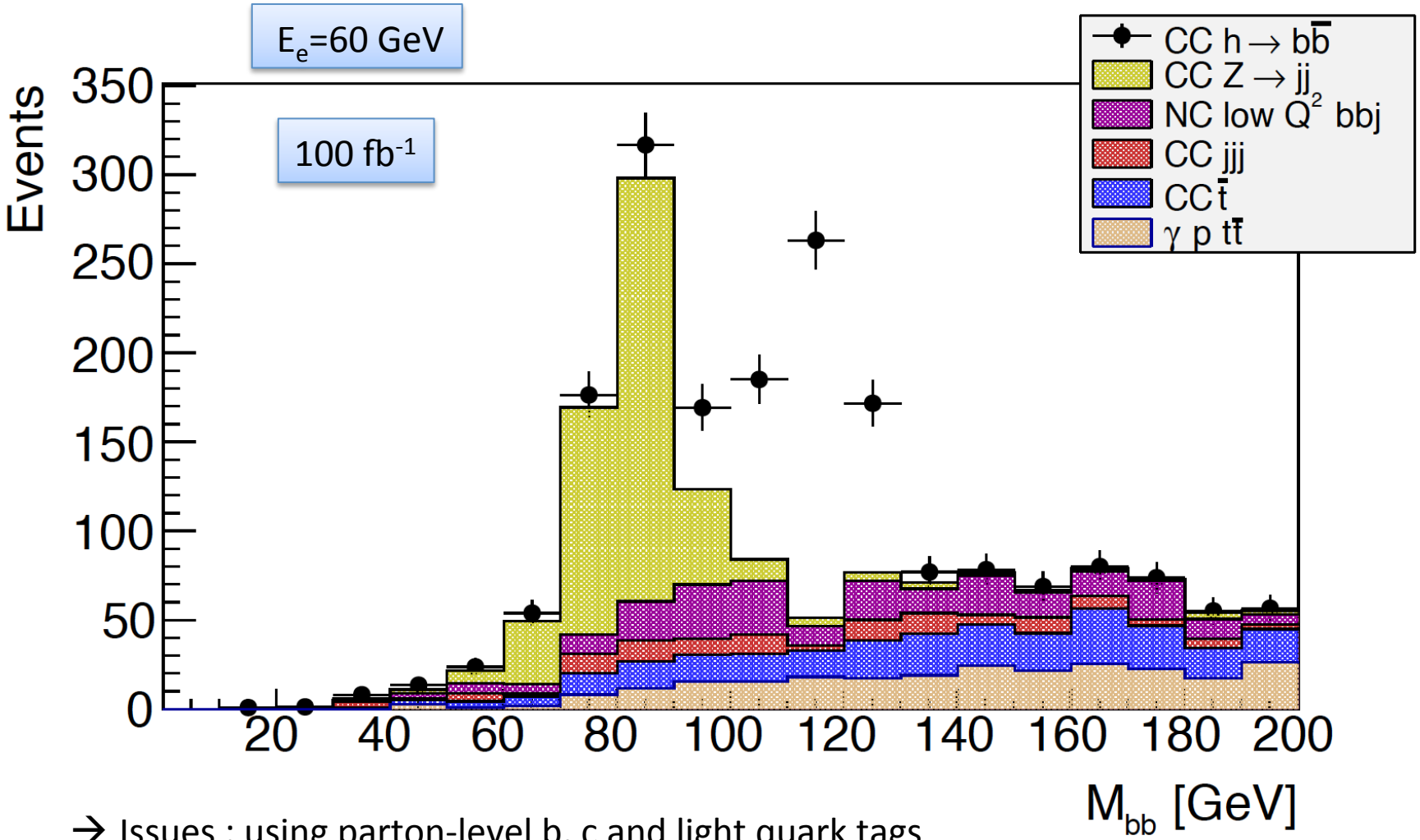
ICHEP14 poster $H \to b\bar{b}$ results

[P=-0.8, BR=0.577]



→ Issues : using parton-level b, c and light quark tags

→ using PGS which is hard to control and to modify

→ a parton-tag will not be trusted for Hcc ➔ use a real experimental method!

New approach

- use Delphes and start to design more an 'own' detector using the existing generated Pythia samples (c.f. part of Ellis Master thesis) → rerun delphes only

- get a flavour tagging that also may work for Hcc, i.e. using jet lifetime probabilities, c.f. D0 Note 4158, June 10, 2003

➔ **joint determination of Hcc and Hbb** as done with real data (if no charm-tag via D mesons is used), e.g. as used by D0 experiment

- understand new Delphes features : understand and activate vertex resolution and signed impact parameter distributions

→ add genuine flat b and c-tagging based on parton information for cross checks only

→ understand generated jets for the first time!

We started a big research program to go thru the various steps, only a few, more recent results are shown here.

Basic setup

60 GeV x 7000 GeV

100 fb^{-1}

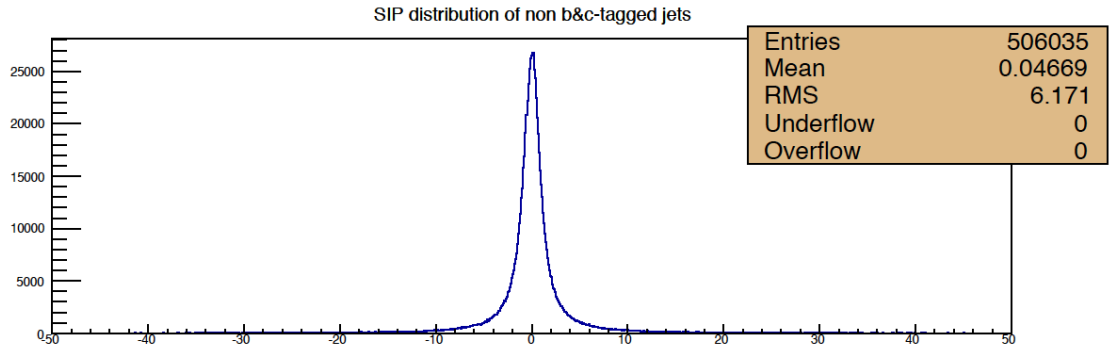
- CMS-like detector, B=3.8 T
- generated jets with anti-kt R=0.9 (we tested also R=0.5)
- for generated and reconstructed jets : optional flat b and c-tagging up to eta=5 and pTjet>5 GeV based on partons
- add vertex resolution of 5 mu for pT>5 GeV and 10 mu for pT<5 GeV (taken from FCC-ee) : to be checked and improved
- elmag resolutions : taken about factor 2 worse than FCC-ee : to be checked and improved
- add a fine 'LheC' calorimeters of 0.025 x 0.025 in eta and phi (discussion with Max, 252 phi and 400 eta cells)
- charged particle tracking up to eta=4 (in accordance with planned CMS upgrades), taken from FCC-ee
- tracking and electron ID efficiencies set to 1

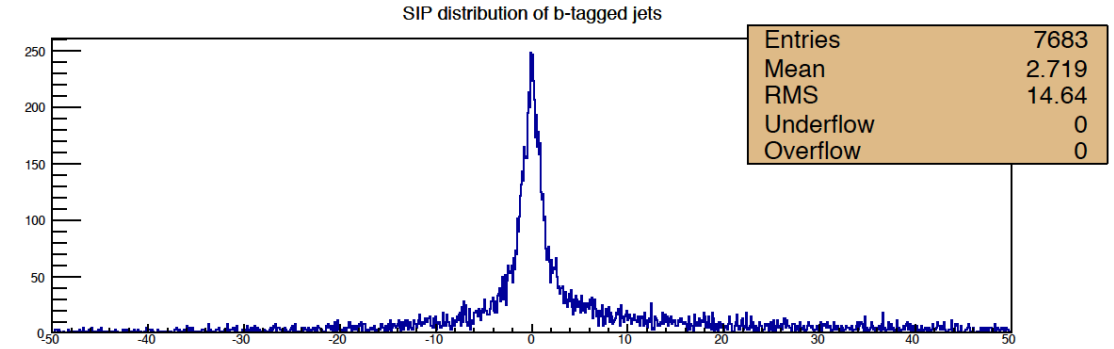
CCjjj : Signed impact parameter

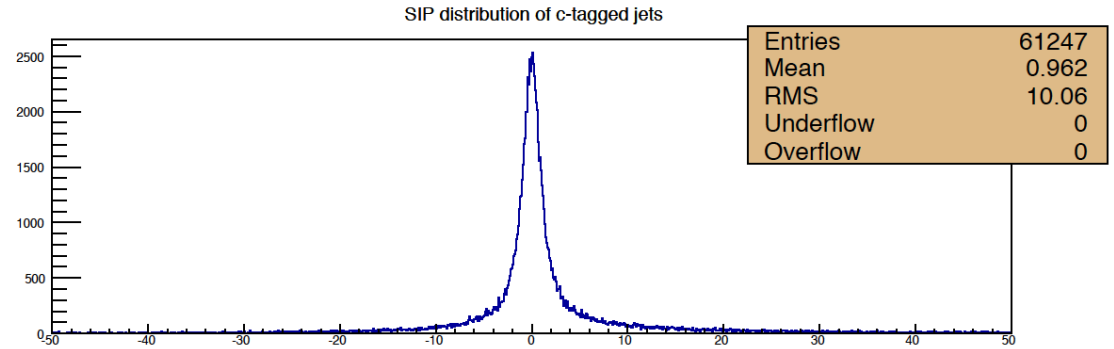
light quarks
and gluons
➔ used for an unbiased track probability (no top, no higgs in CC jj sample), isotropic distributions for all flavours
➔ **triple Gaussian fit of *SIP***

b-tagged
distribution
➔ used for cross checks

c-tagged
distribution
➔ used for cross checks







Track lifetime probability

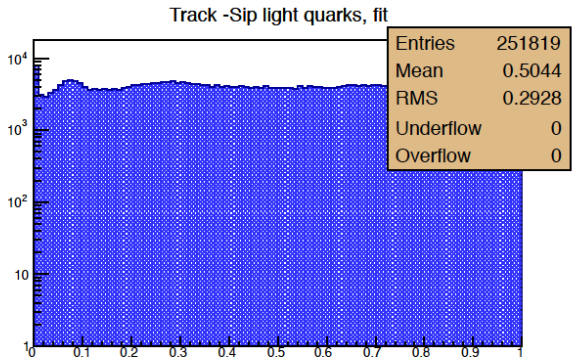
$$\mathcal{P}_{trk}(\mathcal{S}_{IP}) = \frac{\int_{-30}^{-|\mathcal{S}_{IP}|} \mathcal{R}(s)ds}{\int_{-30}^{0} \mathcal{R}(s)ds},$$

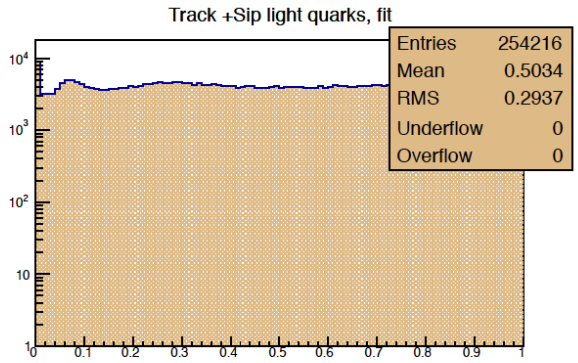
light quarks
and gluons
➔ **fast integration of triple Gaussian fit of *SIP***

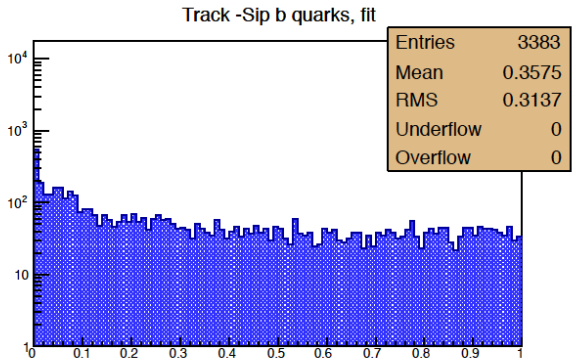
b-tagged
distribution
➔ used for cross checks

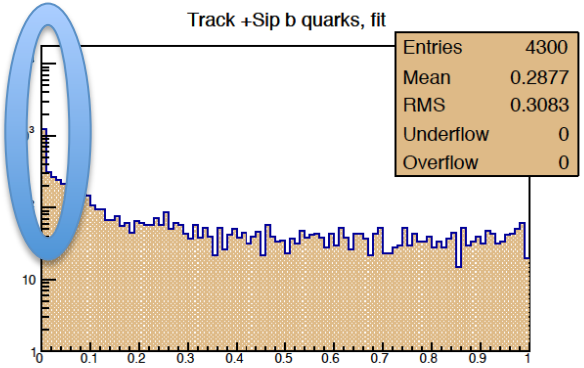
c-tagged
distribution
➔ used for cross checks

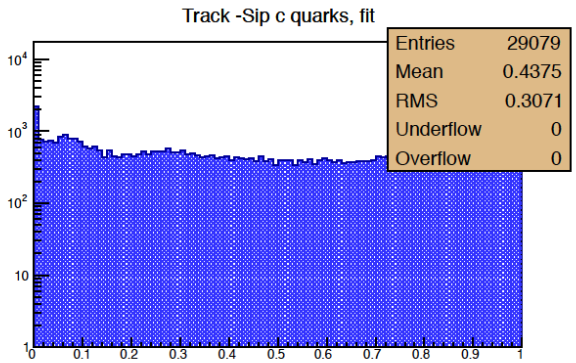
HFL tracks have a very low light track probability as expected.

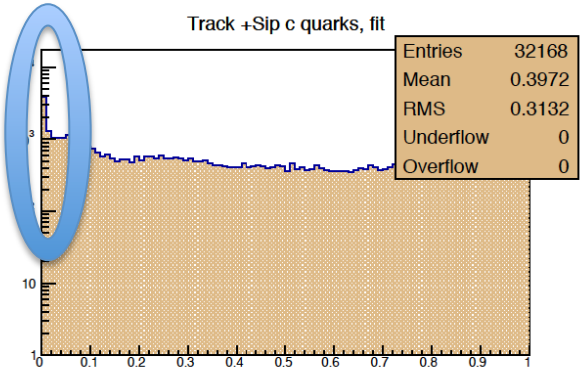












Jet lifetime probability

Then all N^{+}_{trk} (N^{-}_{trk}) tracks in the jet, with a positive (negative) IP significance, can be used to compute a jet lifetime probability $\mathcal{P}^{+}_{jet}$ ($\mathcal{P}^{-}_{jet}$) [4]:

$$\mathcal{P}^{\pm}_{jet} = \Pi^{\pm} \times \sum_{j=0}^{N^{\pm}_{trk}-1} \frac{(-\log \Pi^{\pm})^{j}}{j!} \quad \text{with} \quad \Pi^{\pm} = \prod_{i=1}^{N^{\pm}_{trk}} \mathcal{P}_{trk}(\mathcal{S}^{IP>0}_{IP<0}) \; . \tag{5}$$

Using light quark distributions in denominator, and SIP of track in numerator

$$\mathcal{P}_{trk}(\mathcal{S}_{IP}) = \frac{\int_{-30}^{-|\mathcal{S}_{IP}|} \mathcal{R}(s)ds}{\int_{-30}^{0} \mathcal{R}(s)ds} \; ,$$

The Multi-step procedure at a glance:

1) obtain the SIP of tracks of the jet (NEW code!! using TREF arrays)

2) determination of track lifetime probilities

3) determination of the jet lifetime probabilities based on track lifetime probabilities

➔ ***tracks in jets with deltaR<0.5***

4) define a Pjet+ cut for heavy flavour tagging to get b and c-like jets at ONCE

Jet lifetime probabilities

light quarks
and gluons

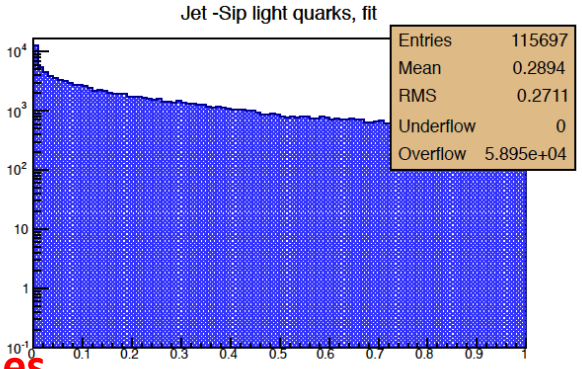
➔ **determination of the jet lifetime probabilities based on track lifetime probabilities**

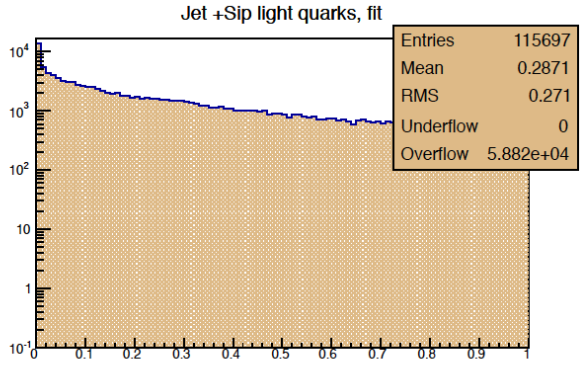
➔ ***tracks in jets with deltaR<0.5***

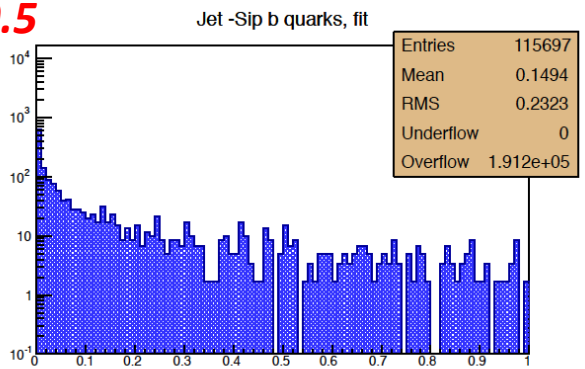
b-tagged
distribution
→ used for cross checks

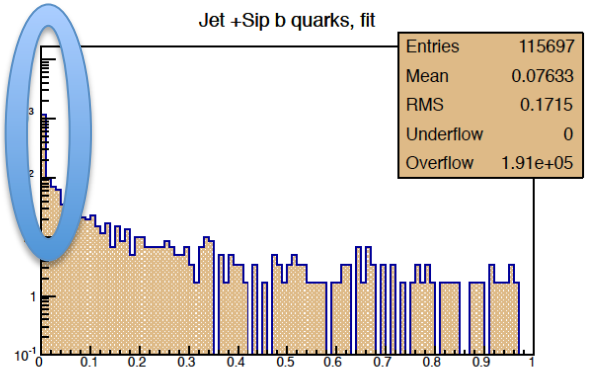
c-tagged
distribution
→ used for cross checks

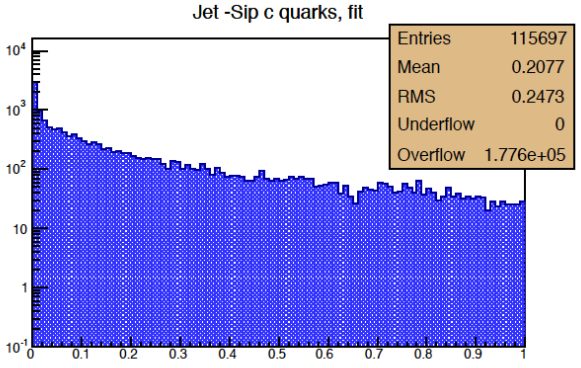
<u>HFL jets</u> have a very low light jet probability as expected.

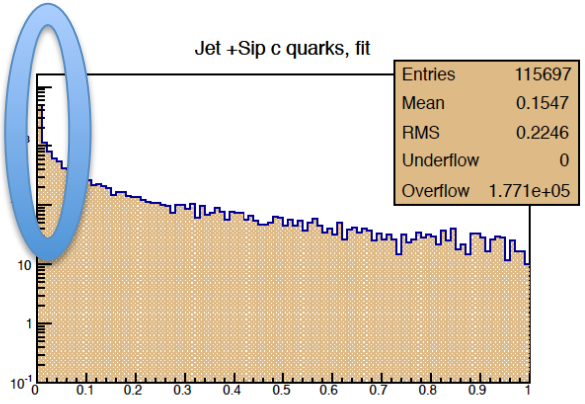




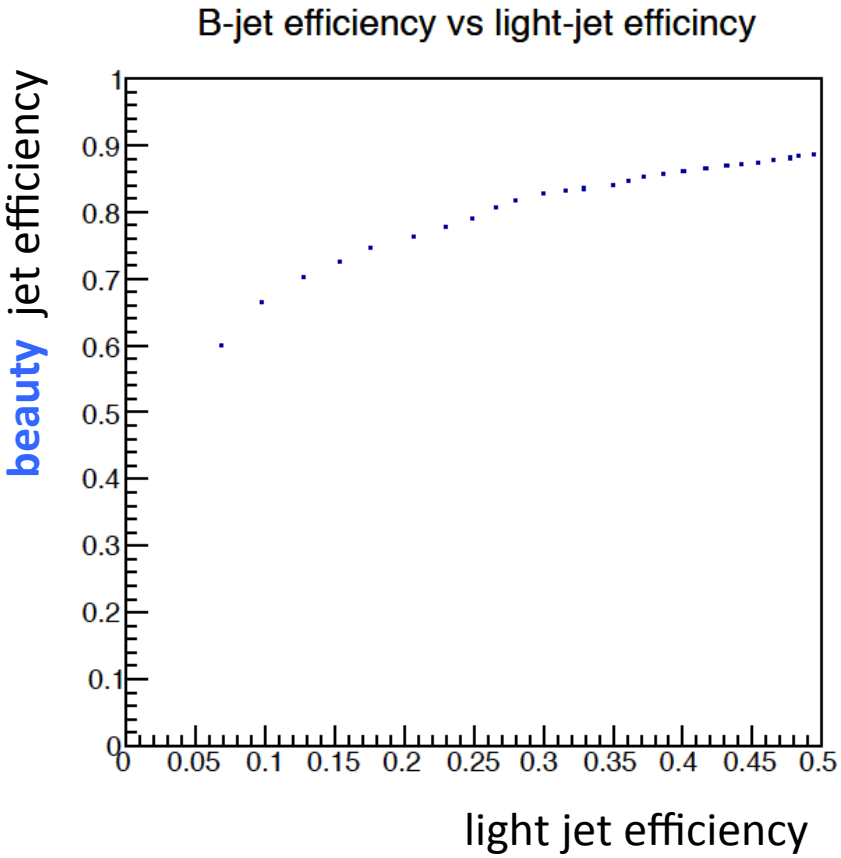


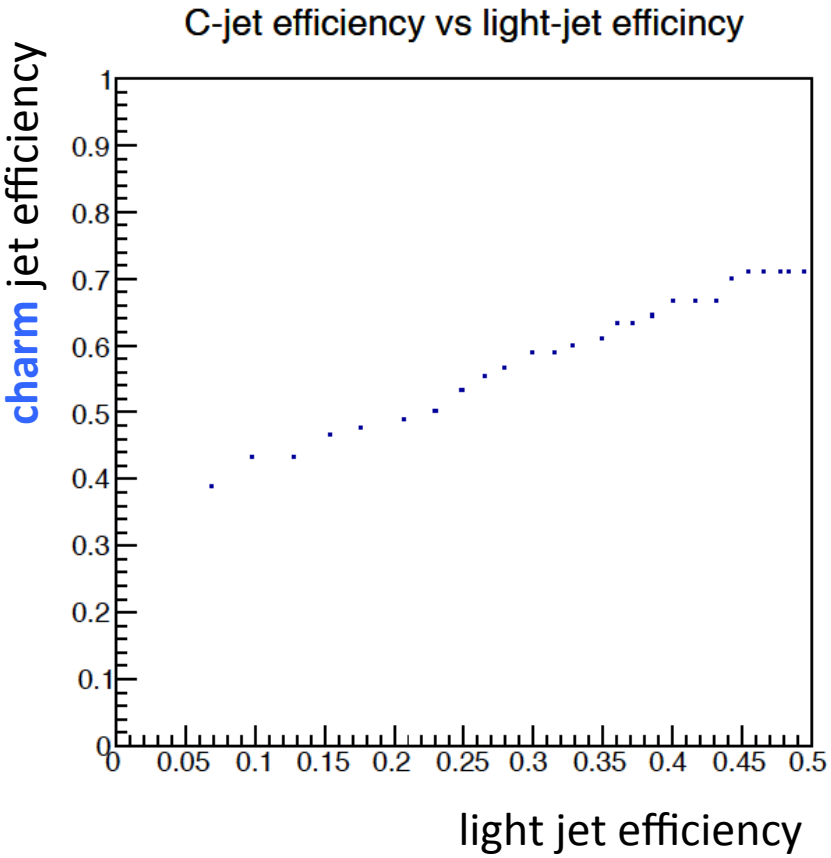






HFL tagging efficiency

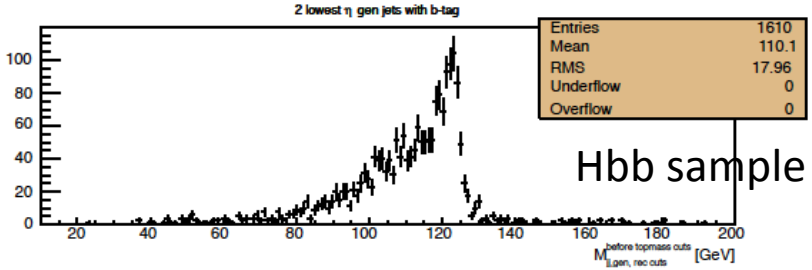




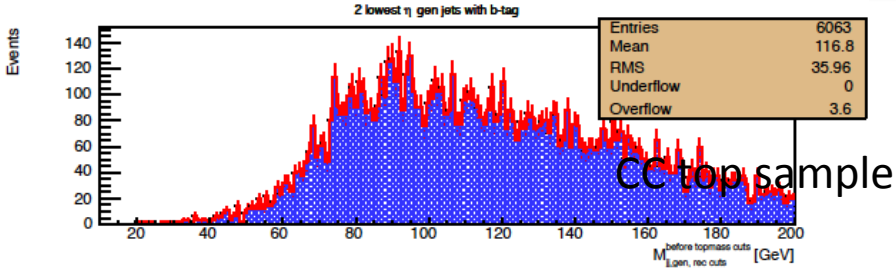
→ 2 dimensional efficiency plot → B-tag efficiency is 60% but light jet efficiency is 5% still with this 'detector' setup

→ each value determined using plots on previous slide ➔ test cuts with Pjet+<0.02 (0.01)

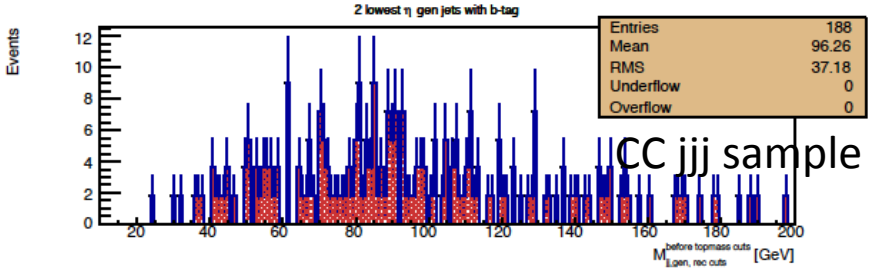
First results : *generated* jets genuine *beauty* tagged after reconstructed cuts



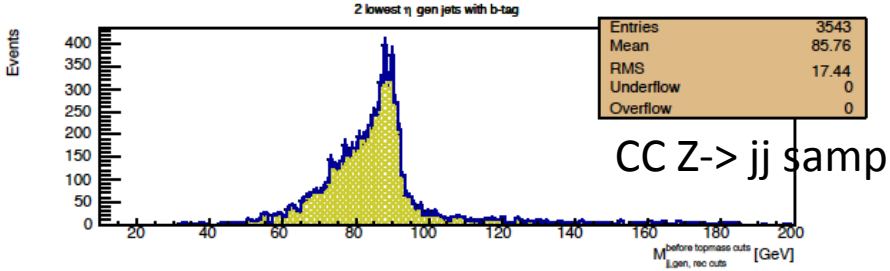
Hbb sample



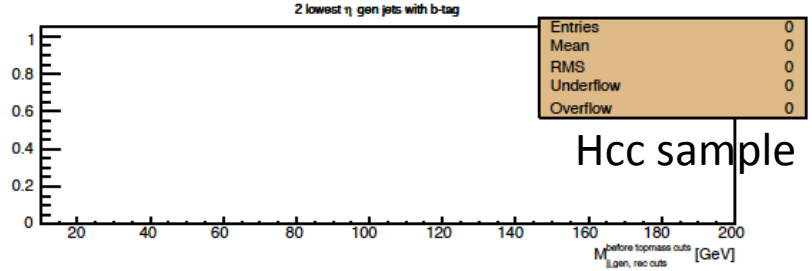
CC top sample



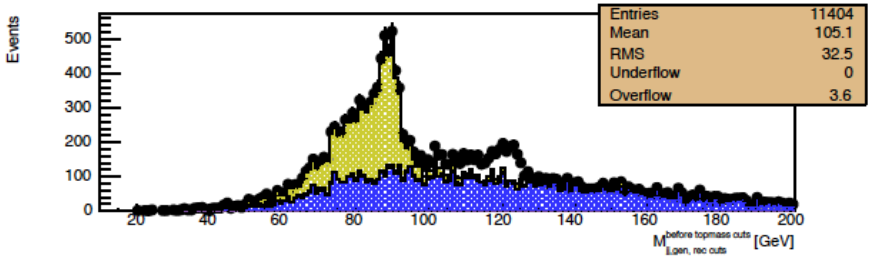
CC jjj sample



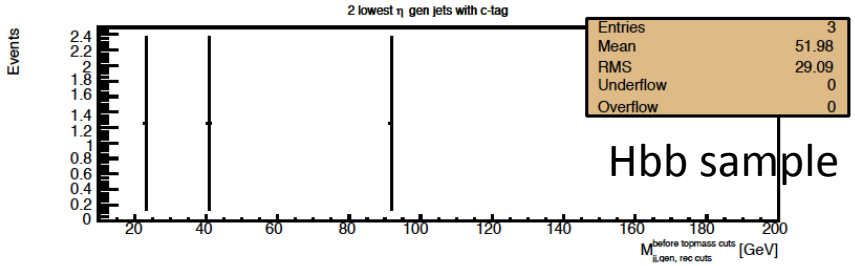
CC Z-> jj sample



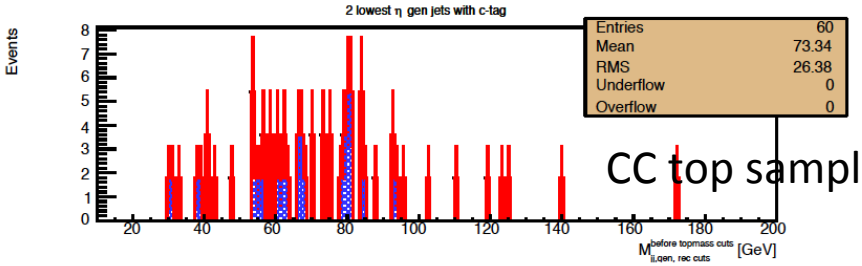
Hcc sample



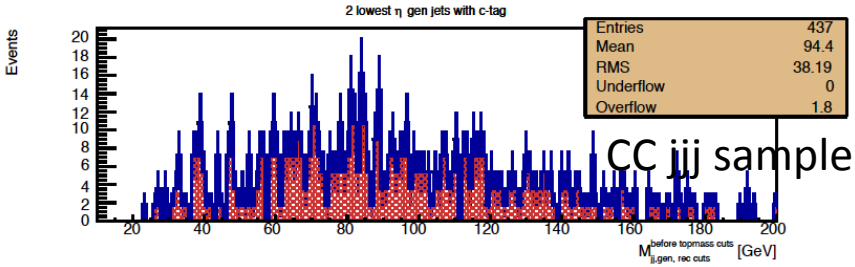
First results : *generated* jets genuine *charm* tagged after reconstructed cuts



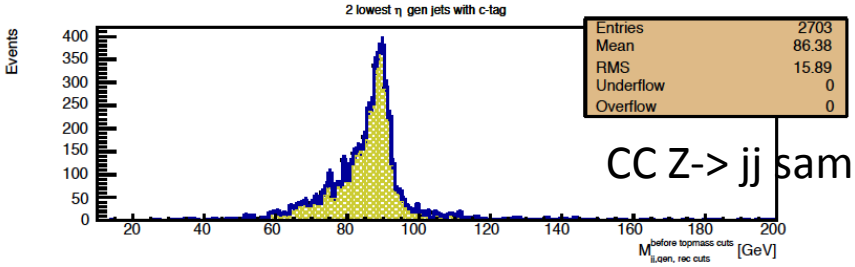
Hbb sample



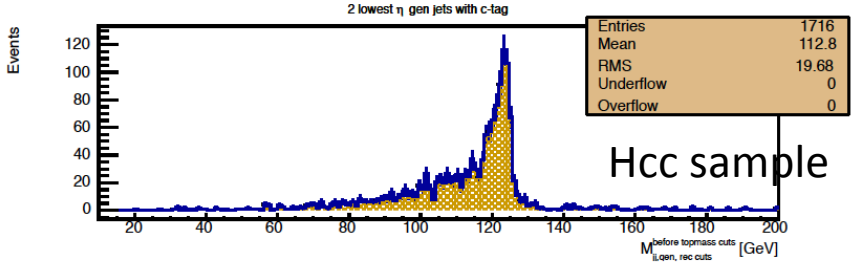
CC top sample



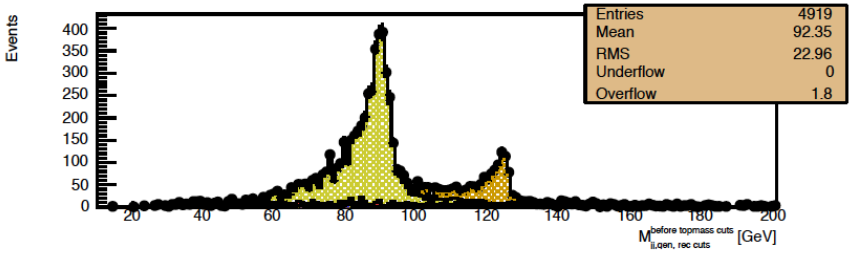
CC jjj sample



CC Z-> jj sample

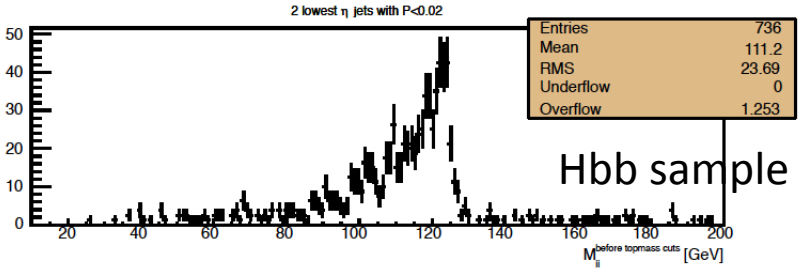


Hcc sample

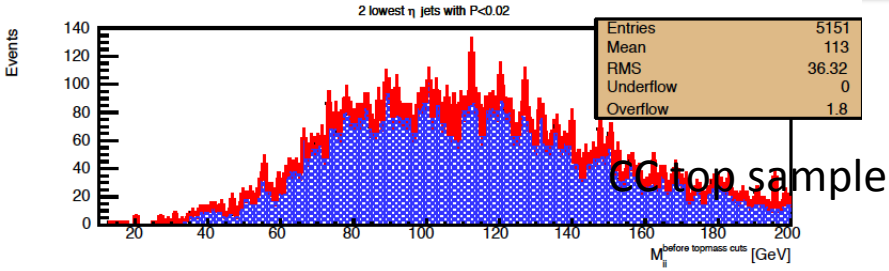


First results : reconstructed jets

Pjet+<0.02 after basic kin. cuts (no anti-top yet)

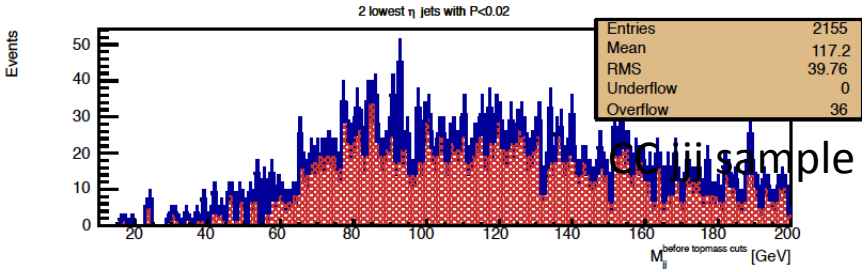


Hbb sample

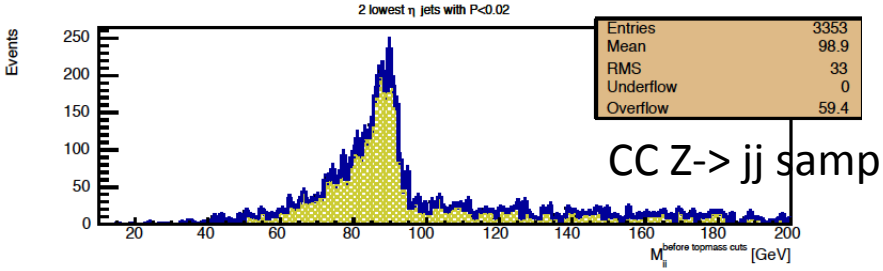


CC top sample

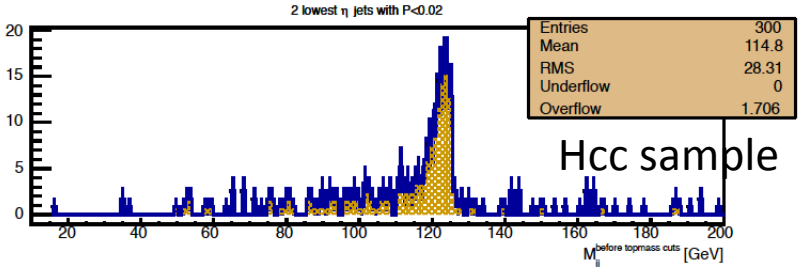
Plots for e polarisation of -0.8.
Hbb and Hcc corrected to HDECAY BR
scale(Hbb) = 1.253
scale(Hcc) = 0.853
Note Hcc BR is 0.06119 in MG5, but real BR is 0.029 only.



CC jj sample



CC Z-> jj sample



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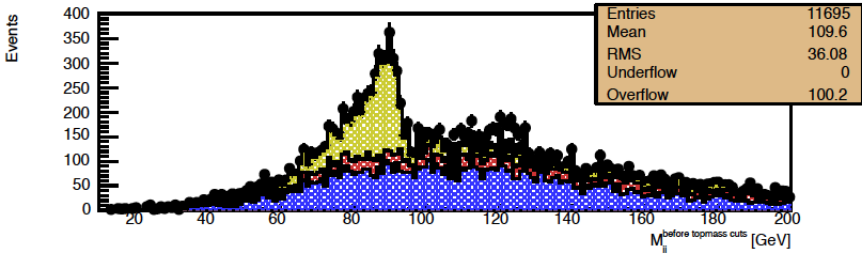

Next steps

- New powerful chain established to study realistic b and c-tagging using displaced vertices (signed impact parameters) and jet lifetime probabilities

- Offers a big potential to investigate relation between vertex and tracker performance and signal selections using a real data driven method as used by modern HEP experiments.

- Beautiful task for a PhD or PostDoc.