ZHH Channel
First Attempt with LCFI Package

SiD Benchmarking meeting
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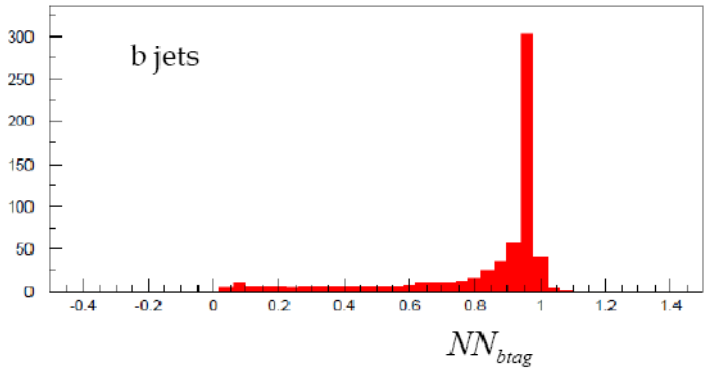
Higgs self-coupling analysis

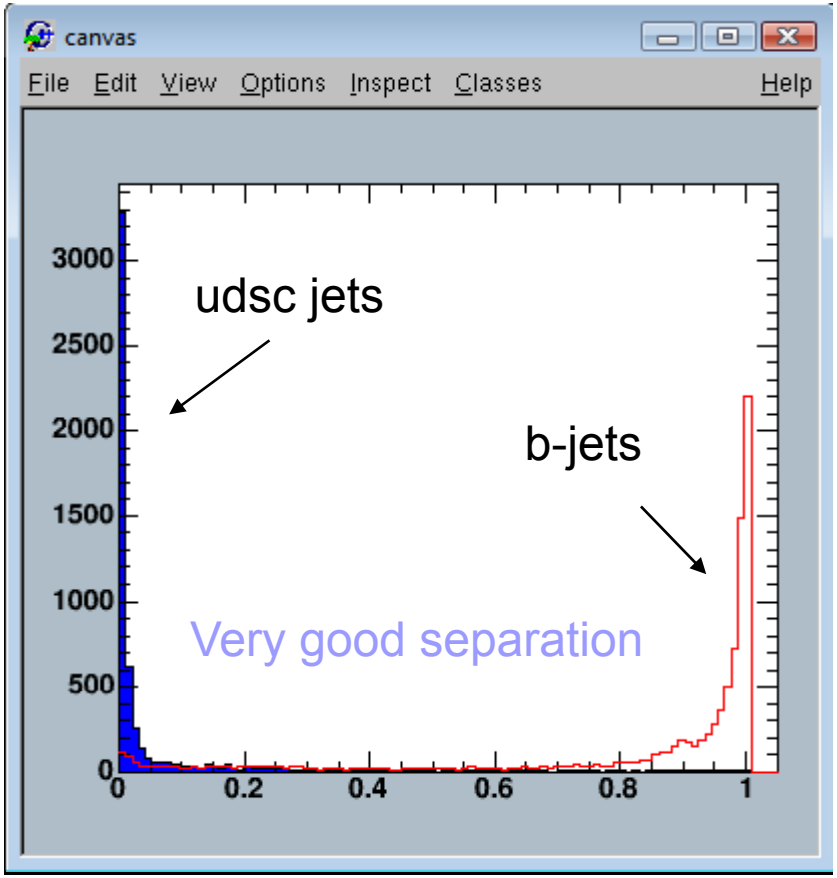
- We started to work on ZHH analysis using the LCFI vertexing package.
- First steps:
  - Take SiD FastMC simulations
    - ZHH signal and tt (tbW) background so far.
    - Gluon radiation seems to be on.
  - Pass them to LCFI vertexing package.
    - Enforce six jets to be found by the jet finder.
  - Follow Tim's analysis and reproduce plots.
- No particular event selection yet
  - except ZHH forced to decay into bbbbqq state.
- No jet energy smearing, nor extra track parameter smearing
  - taken as it is on FastMC slcio files.

Neural Net Outputs

Tim's net

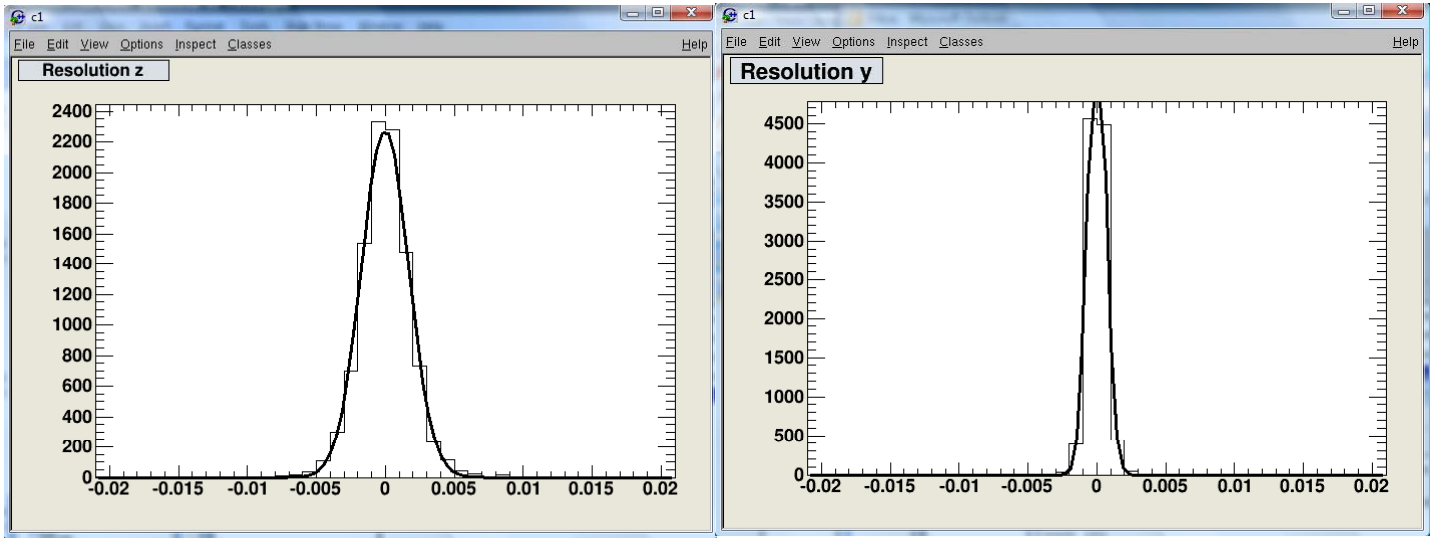


LCFI



Primary Vertex Reconstruction

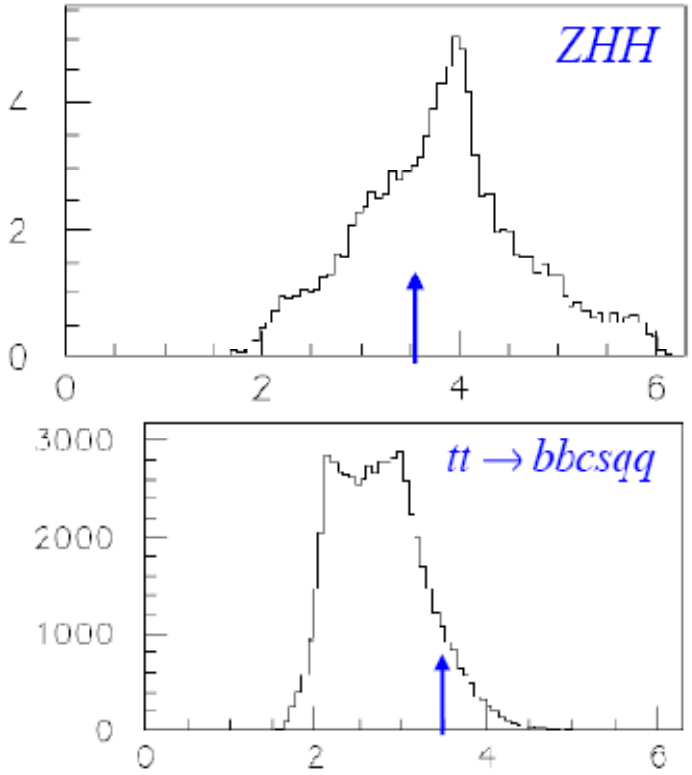
- Too perfect
  - 2um in z-direction
  - <0.8 um in x-y plane
  - Vertex resolution pulls are nice Gaussians with σ ~ 1.1 for all x,y and z



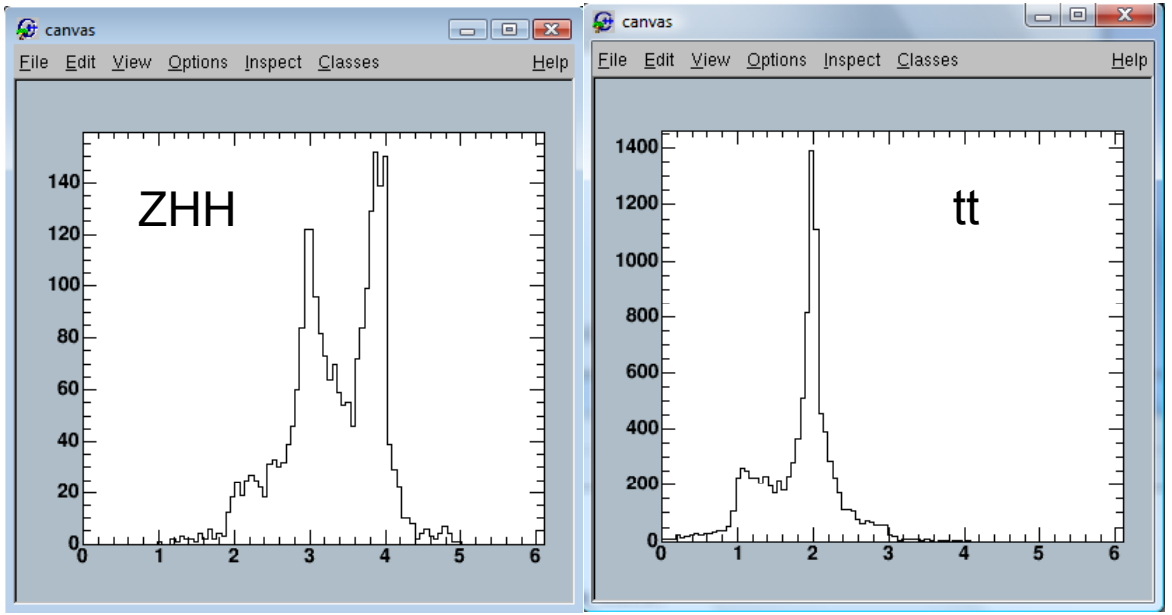
It is FastMC (no material effects) – how are the track parameters smeared?

Sum of neural net outputs for all jets

Tim's net



LCFI

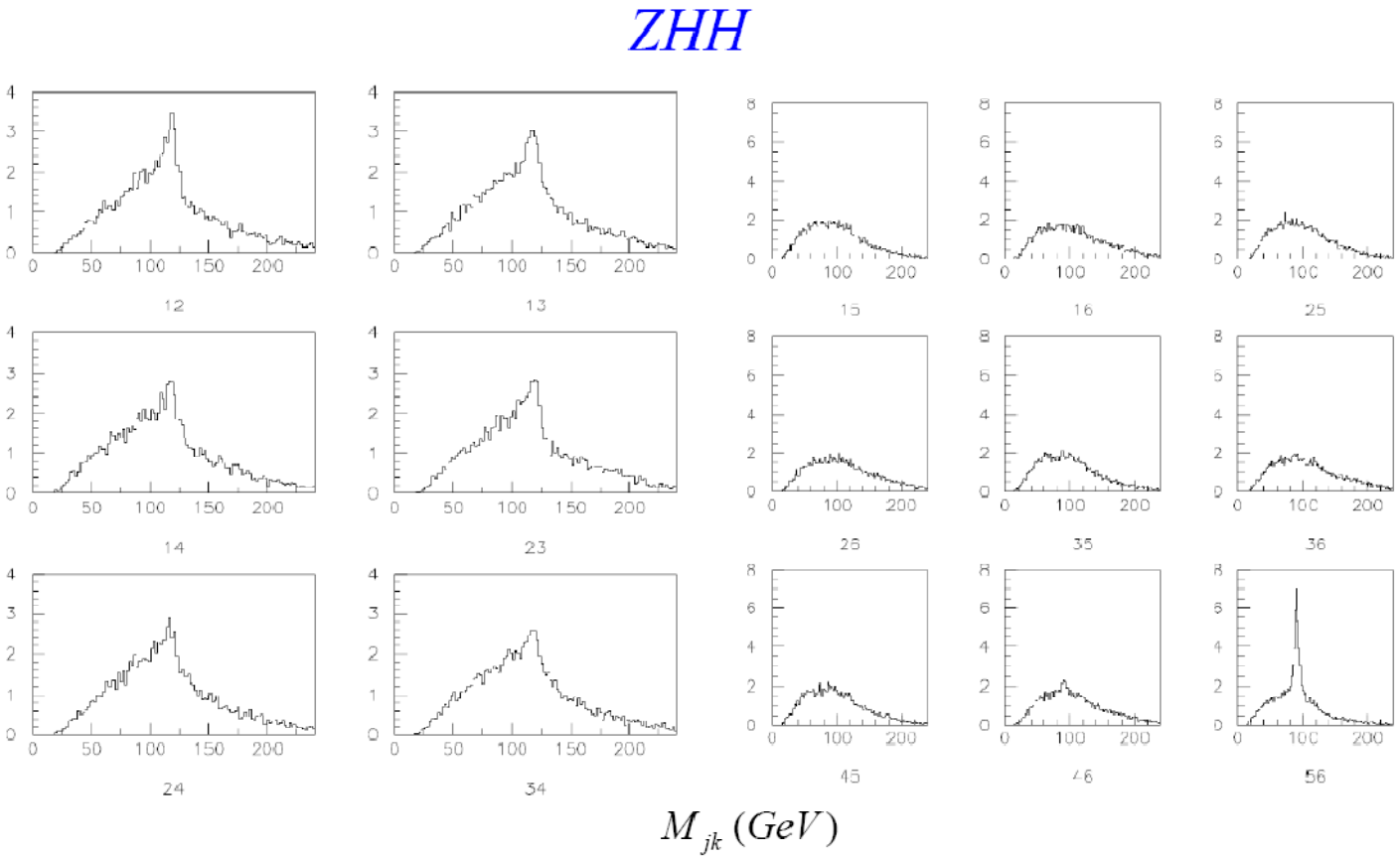


Rather different shapes. LCFI has more binary behaviour.

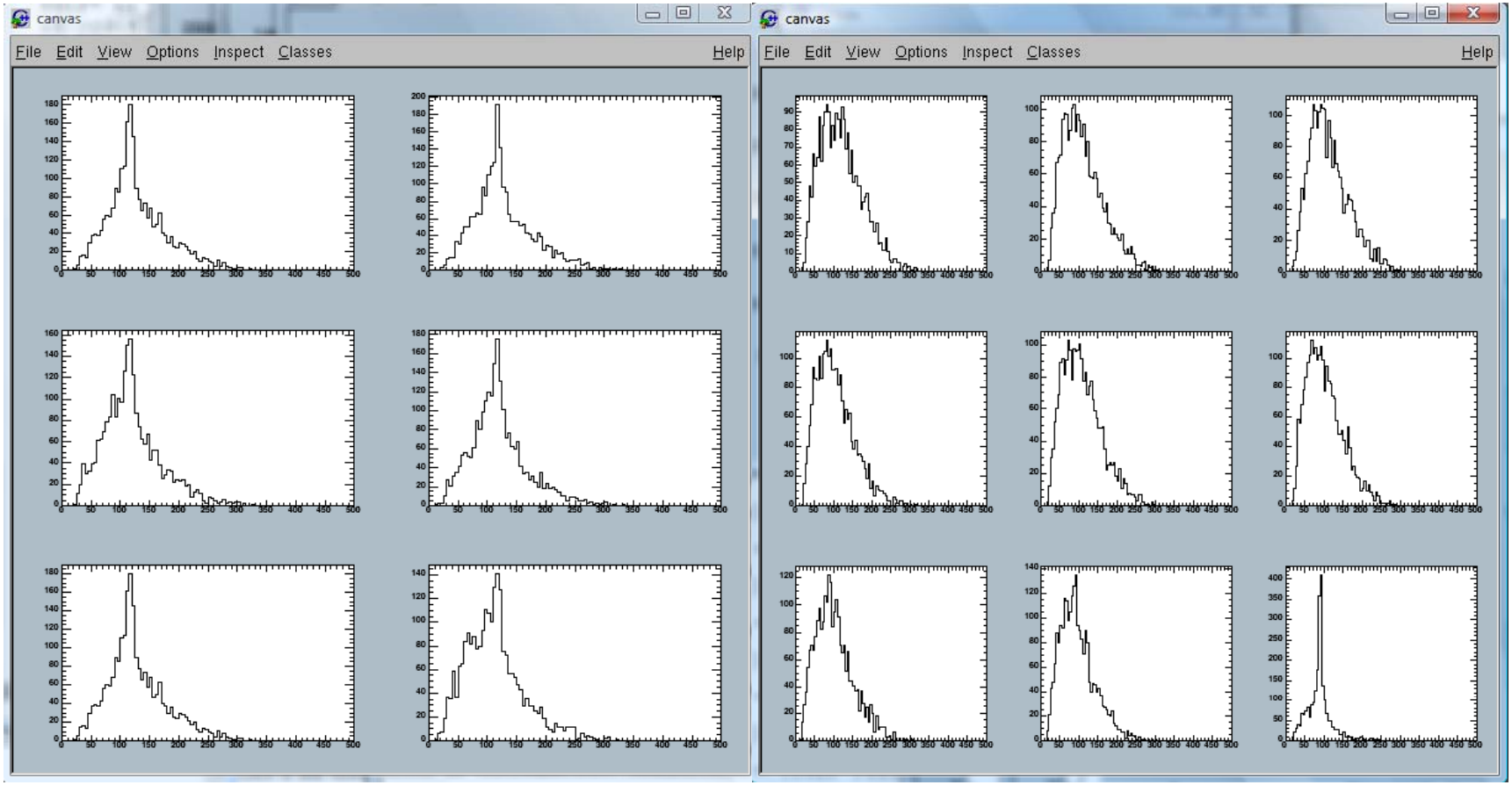
Invariant masses

- Jets ordered according to their tagging NN output
  - most b-like comes first

Tim's plots



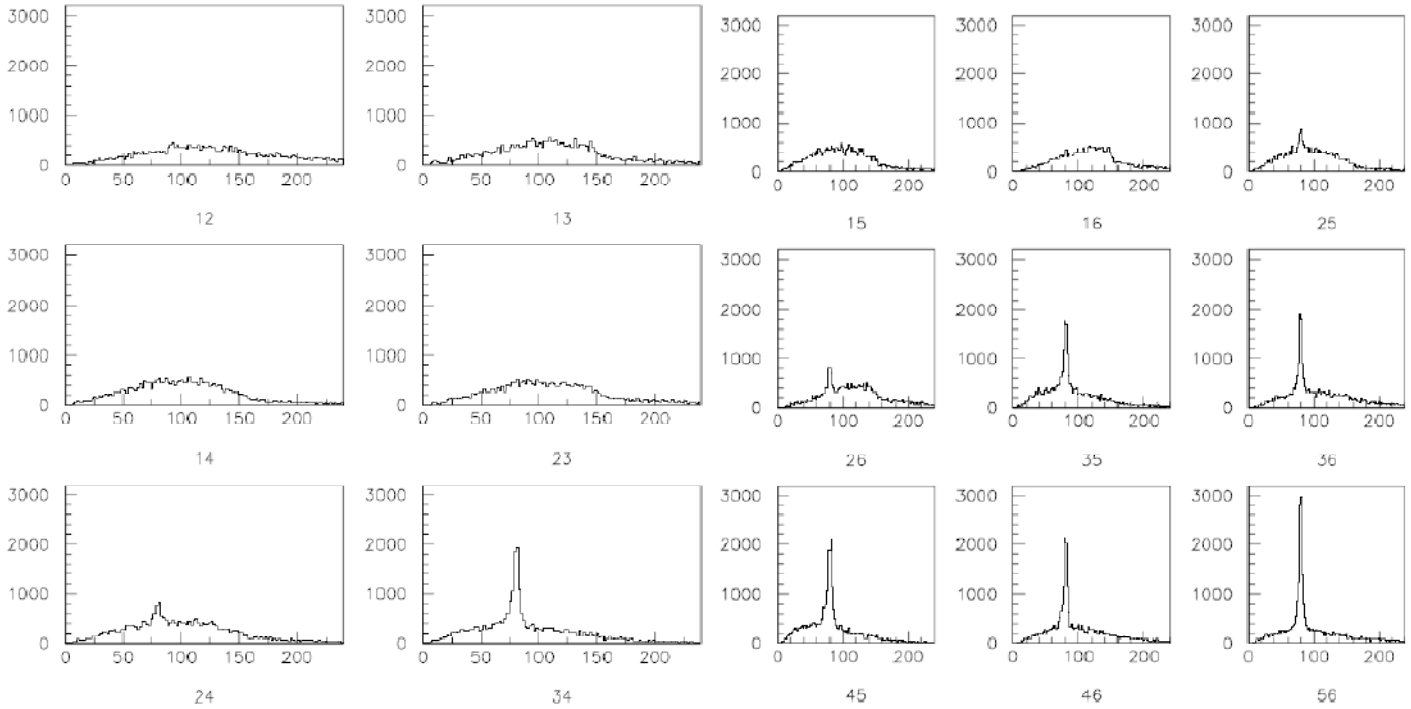
LCFI vertexing package – the same ordering as on the previous slide



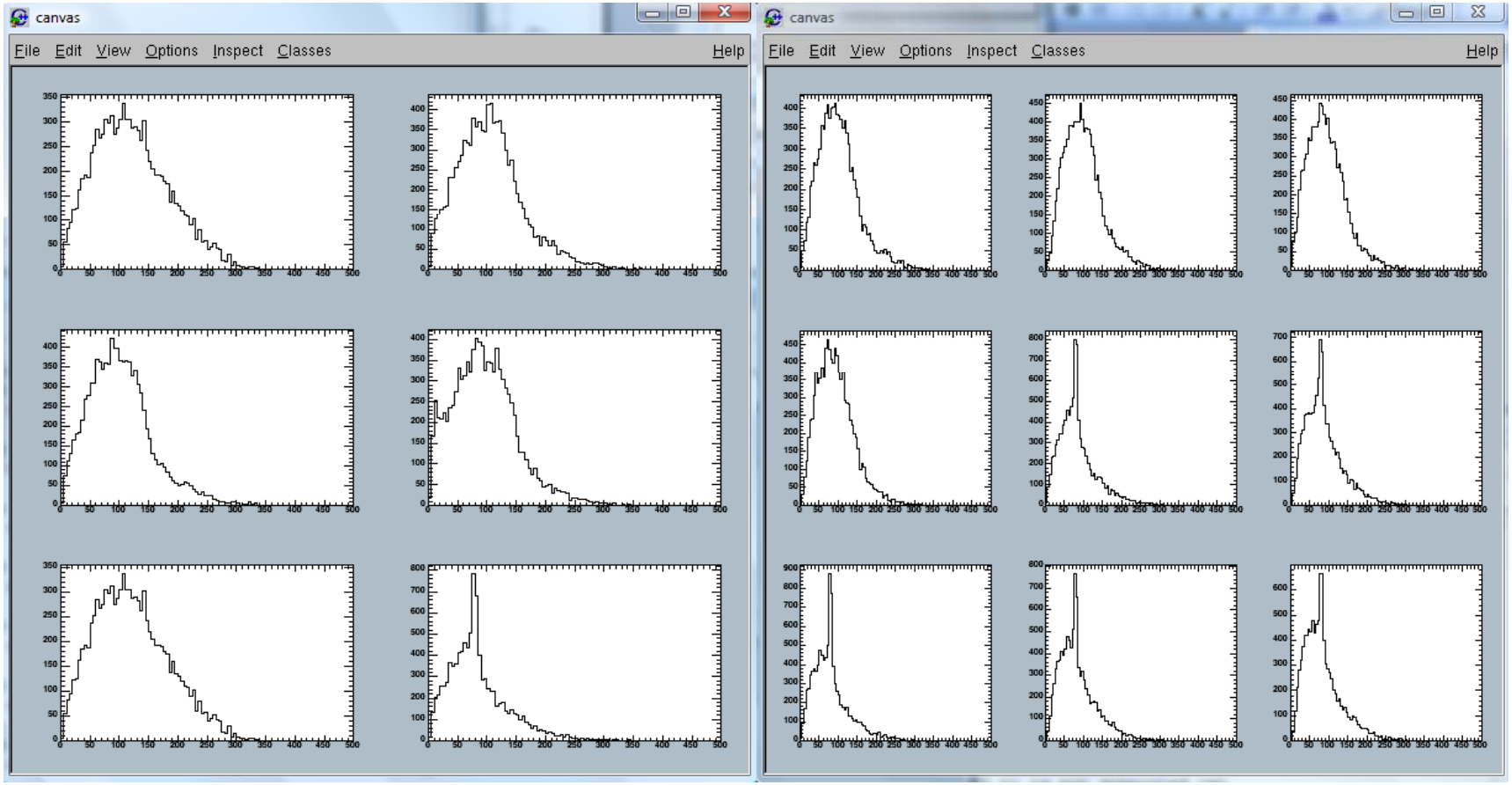
More or less consistent with Tim (note the y-scale is not fixed).

Higgs and Z peaks clearly visible where expected.

$t\bar{t}$



LCFI vertexing package – the same ordering as on the previous slide



Compared to Tim's plots there are differences.
Note we do not do any event selection yet.

Next steps

- Clarify a couple of things with Tim
  - Energy smearing, vertex resolution, other backgrounds, …
- Performance plots
  - To understand differences in NN tagging performances
  - mistag efficiency versus tag efficiency (rather than purity vs. eff)
- Further steps:
  - Add event cuts.
  - Add jet energy smearing.
  - Add remaining backgrounds.
  - Train NN to separate signal from background.
  - Calculate cross section precision and thus self-coupling error.
  - Use PPFA instead of FastMC.
  - Investigate usability of the vertex charge information.

backups

ZHH Preselection

Require:

$$|\cos\theta_{thrust}| < 0.95$$

$$thrust < 0.85$$

$$P_{tot}(z) < 50 \text{ GeV}$$

$$M_{thrust\_hemisphere} > 110 \text{ GeV for at least 1 thrust hemisphere}$$

$$N_{isolated\ leptons} = 0$$

$$6 \le N_{jets} \le 8$$

$$N_{chrg\ tracks} \ge 35$$

$$E_{jet}(photons)/E_{jet}(total) < 0.8 \text{ for all 6 jets}$$