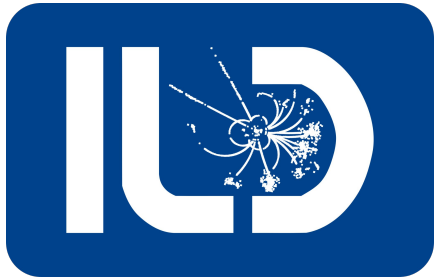
User report on the new Bhabha samples

ILD Analysis/Software Meeting

Jonas Kunath (LLR). 30.03.2022.



Laboratoire Leprince-Ringuet

ÉCOLE POLYTECHNIQUE

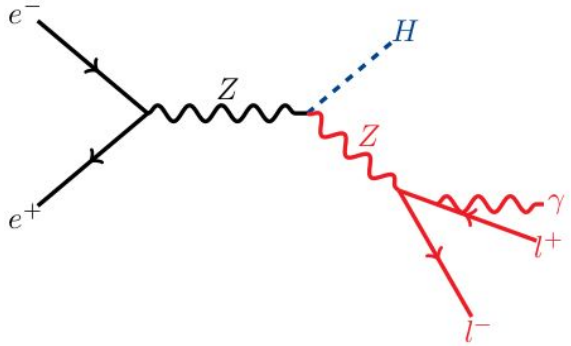
IP PARIS

Bhabha report- overview

My interest: Bhabha as background for the Higgstrahlung process at 250 GeV

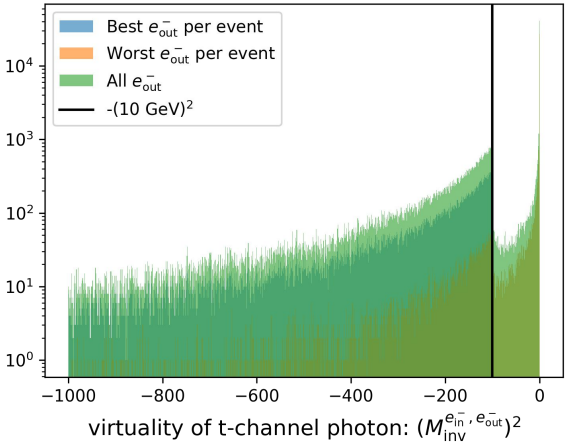
- Combined Higgs BR fit presentation

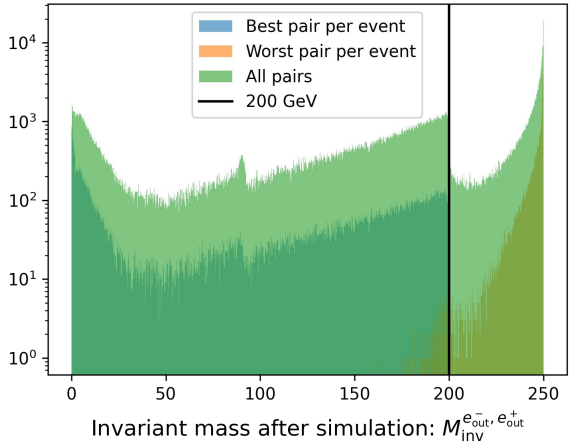
1. MC level distributions (general)
2. Higgsstrahlung-like Bhabha events

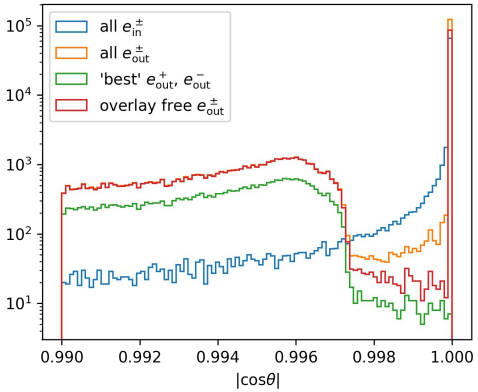


MCParticlesSkimmed

Generator level cuts

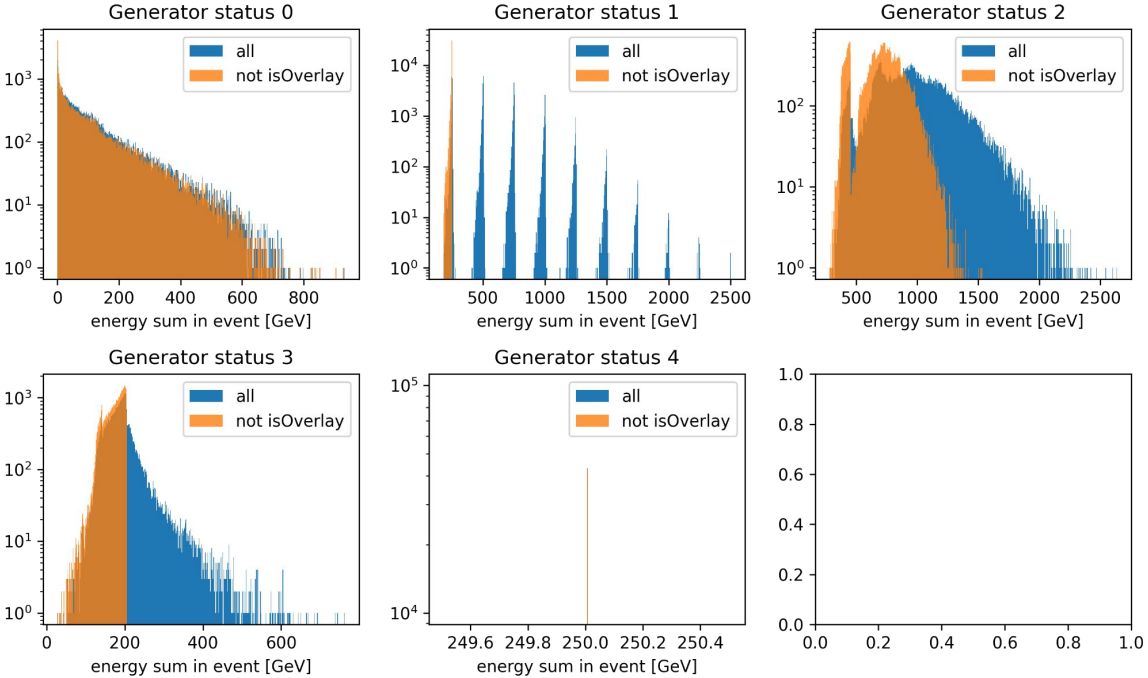






- Non-overlay electrons obey the cut (blue distribution)
- Additional electrons (overlay?) can lead to pair masses above threshold
- t-channel virtuality roughly translates to $|\cos\theta| < 0.997$

Energy sum in event



Meaning of the generator status

Adapted from LCIO docs

- **0**: Created in simulation
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- getGeneratorStatus()==1 is the (double counting free) set of particles passed to the detector simulation
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This would mean it is quite possible to have 2, 3, 4 times the nominal energy within an event?

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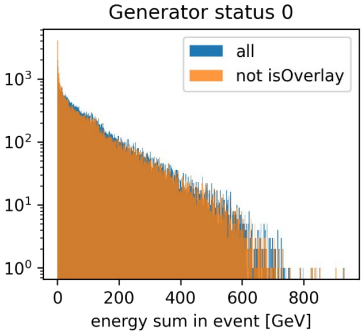

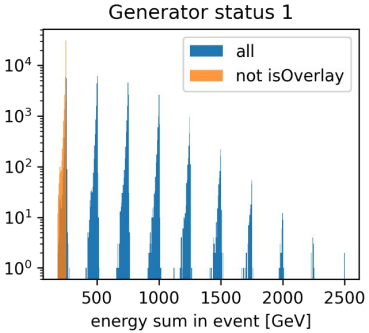

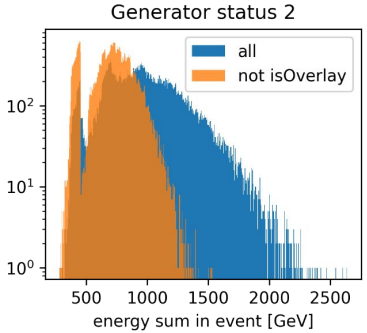

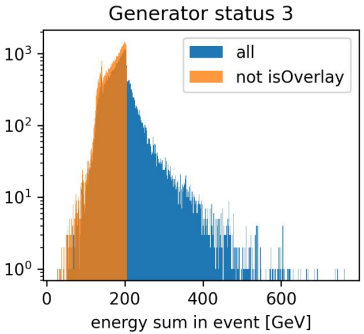

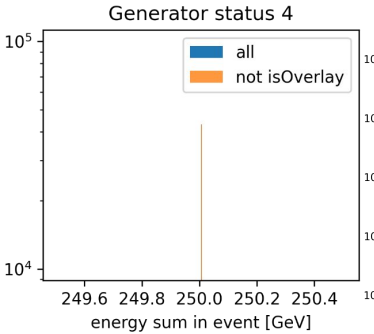

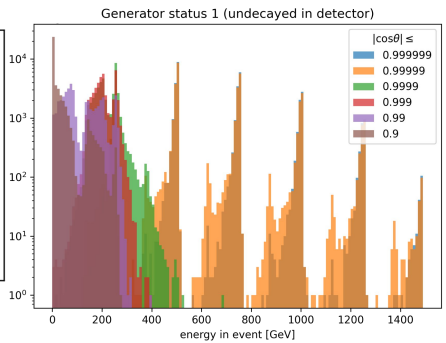

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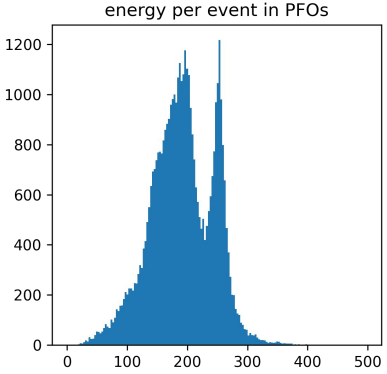

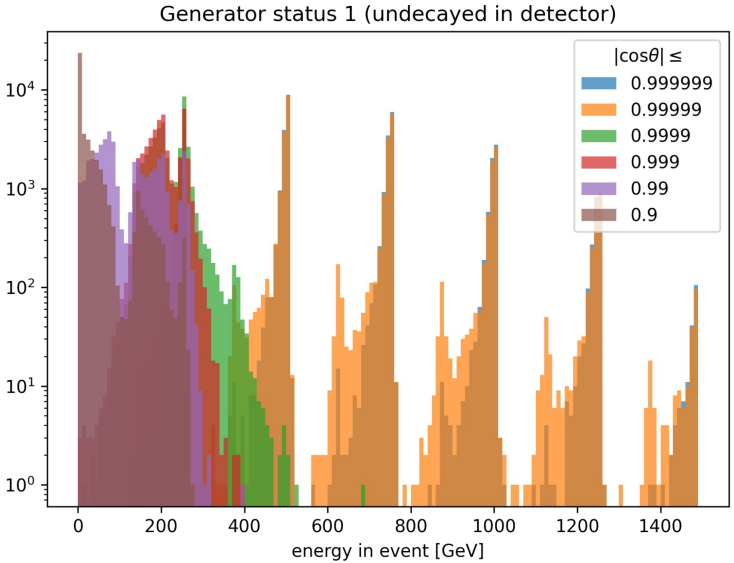

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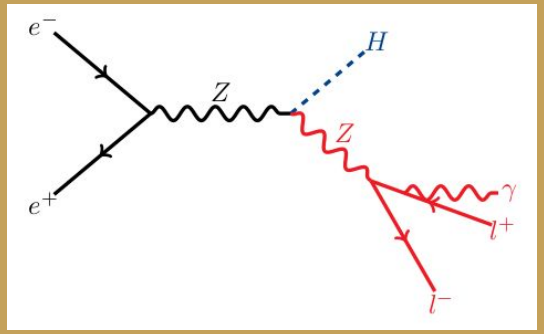
This would mean it is quite possible to have 2, 3, 4 times the nominal energy within an event?
Mostly at high |cosθ|. Not found in PFOs.

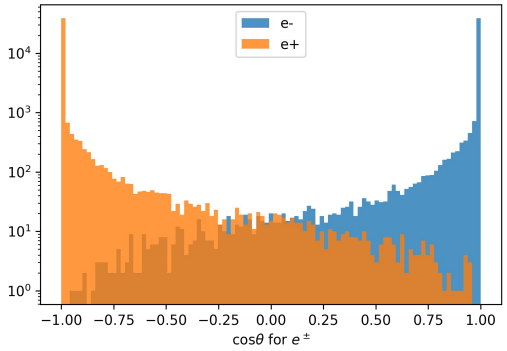


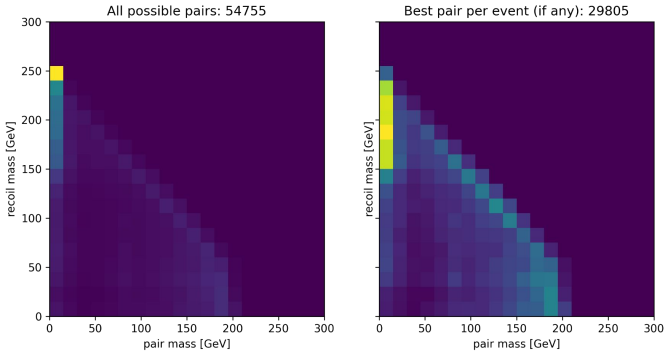
Higgsstrahlung-like PandoraPFOs

Higgstrahlung kinematic region

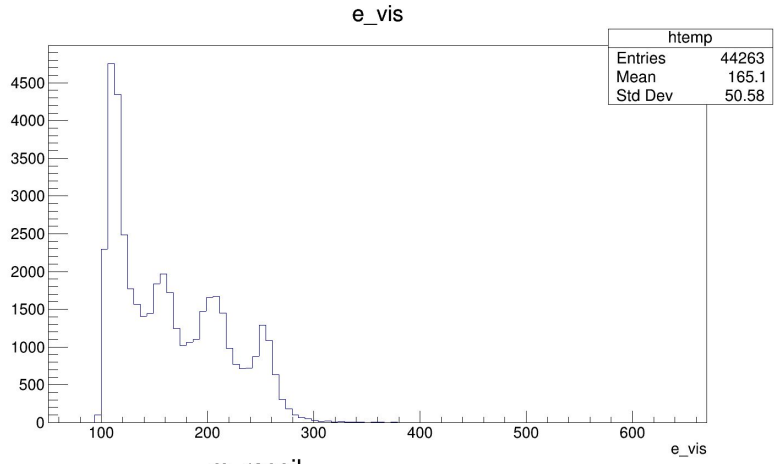
Most Bhabha events not relevant for Higgs studies. E.g.:

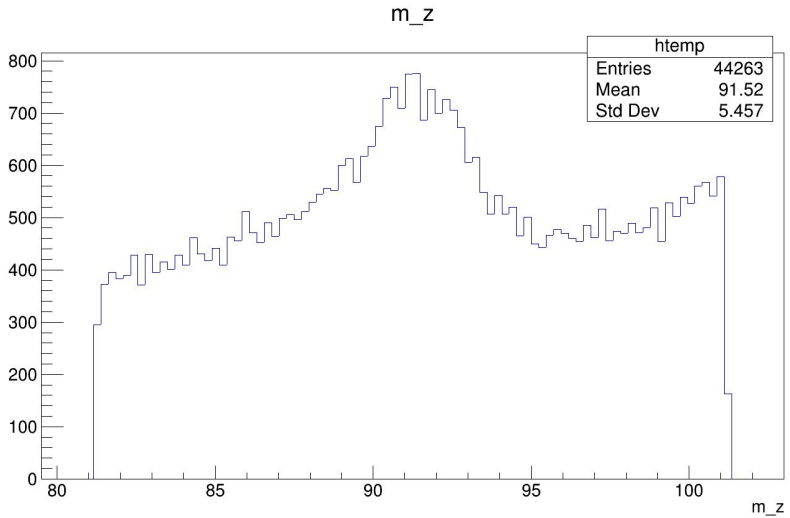
- 19M pure eLpR events
- 44k passing loose preselection (0.27%)
- 100 events after my current tight selection
  - each with weight 10/ab

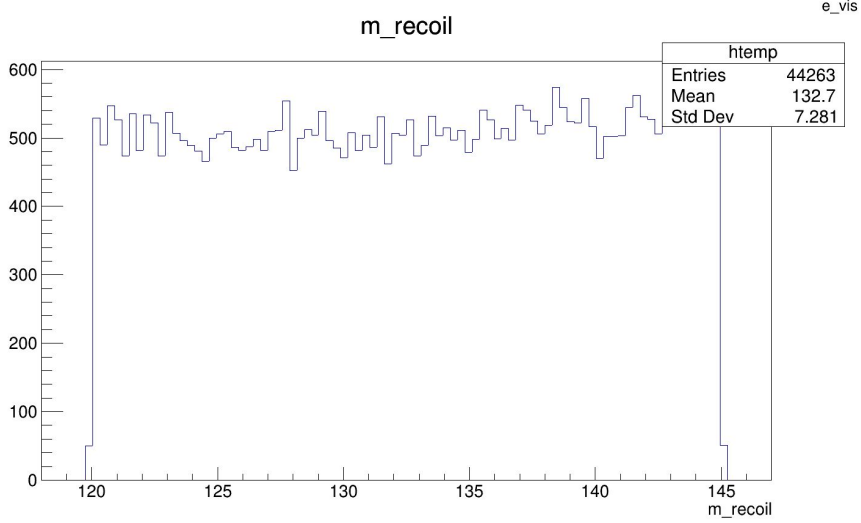




Higgstrahlung kinematic region





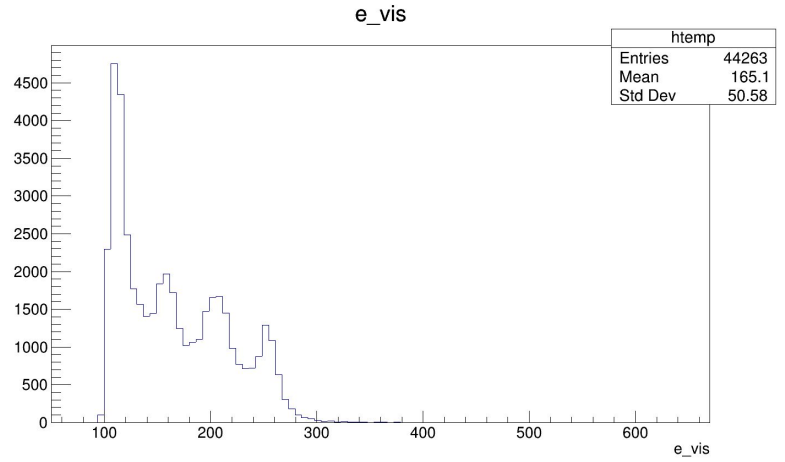


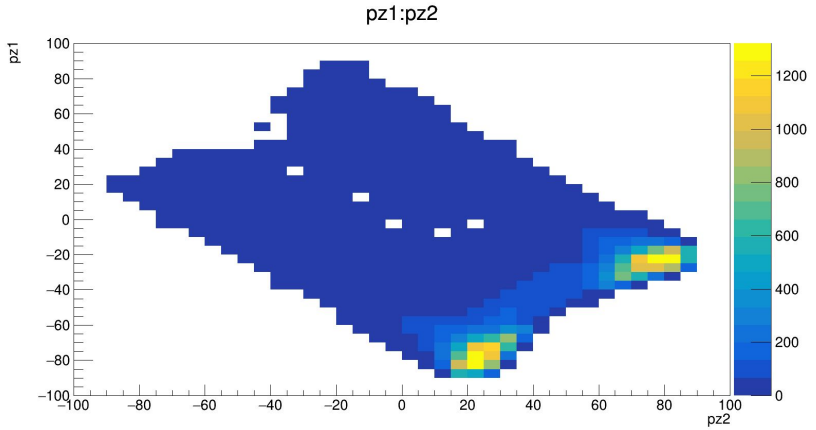
The energy peak structure

For Bhabha events in Higgsstrahlung region, we typically, have 2 prominent ISR photons, with roughly $E_\gamma \approx$(~50 GeV, ~100 GeV) respectively.

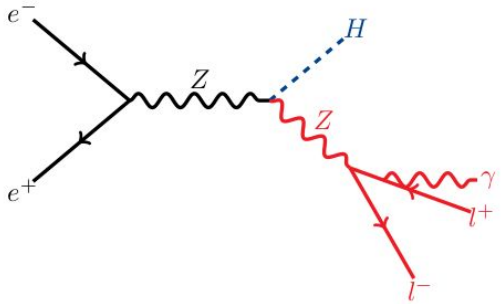
$E_{vis} \approx$

- 110 GeV: Both outside the detector volume
- 250 GeV: Both inside the detector volume
- 150 GeV, 200 GeV: Only one of them is detected





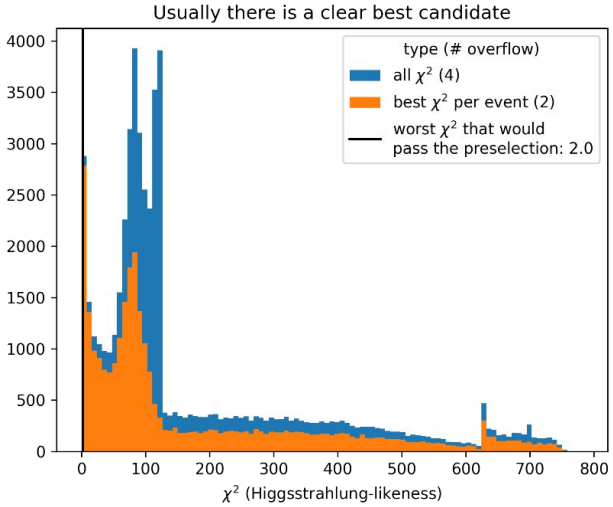
Summary

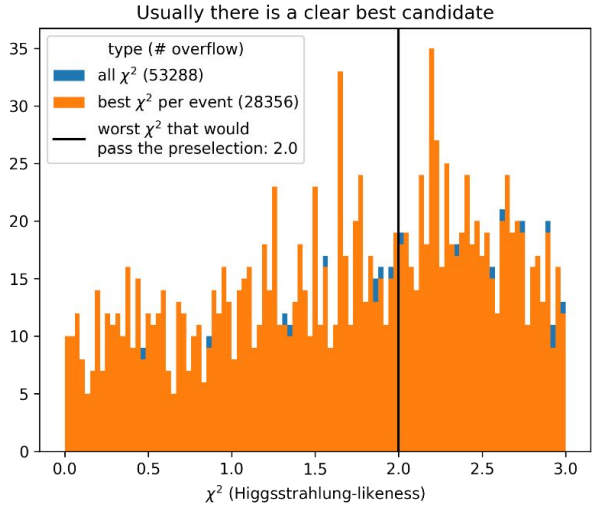


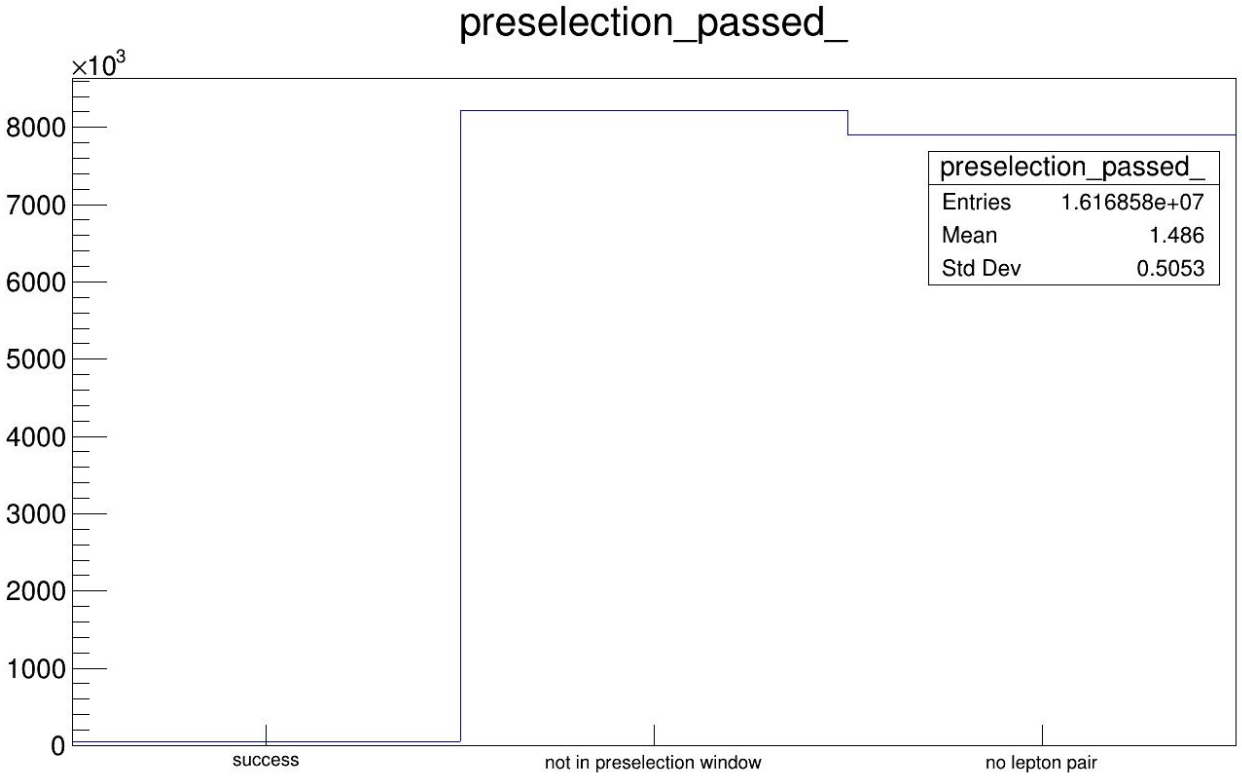
- Open question: Many events overlayed in MonteCarloParticlesSkimmed?
- Distributions as expected for tree-level Matrix elements
- For Higgs studies, tighter generator level cuts might have been preferable
- Web page with more details: https://llr.in2p3.fr/~kunath/eehiq

Backup

Preselection

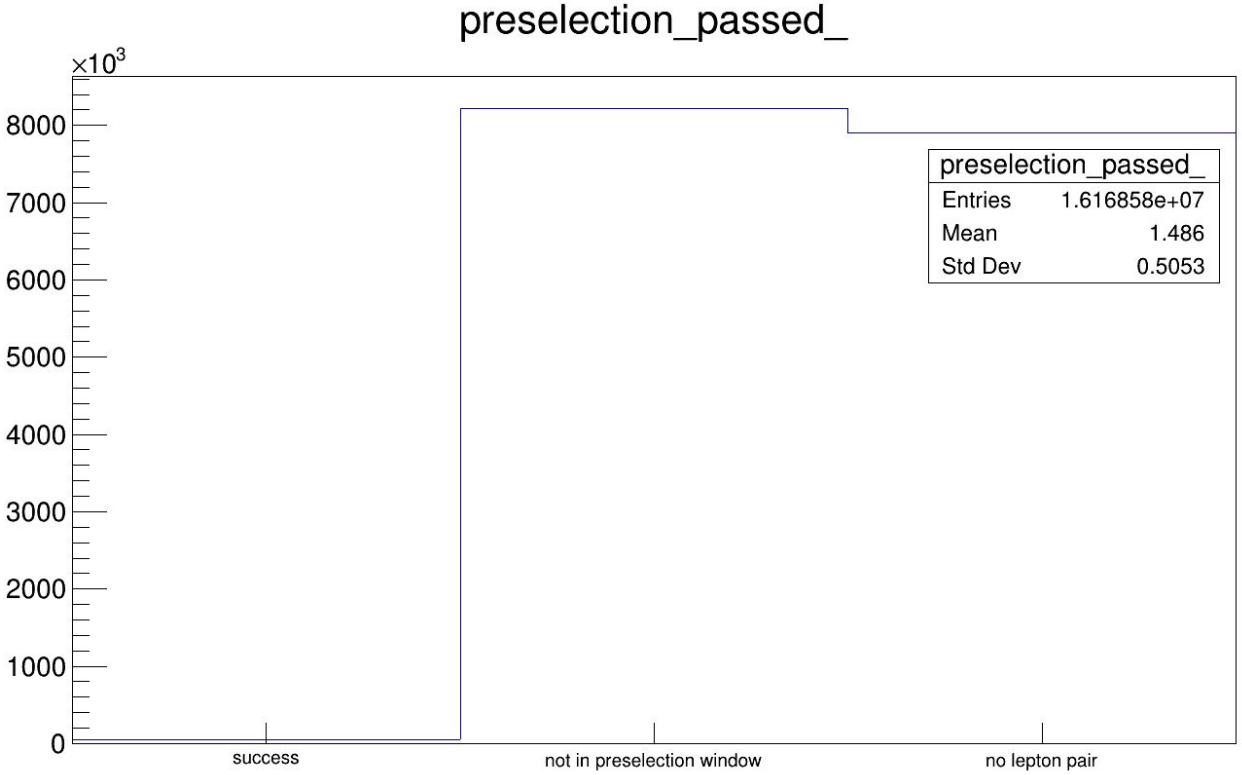

Usually there is a clear best candidate
type (# overflow)
all χ^2 (4)
best χ^2 per event (2)
worst χ^2 that would pass the preselection: 2.0
χ^2 (Higgsstrahlung-likeness)

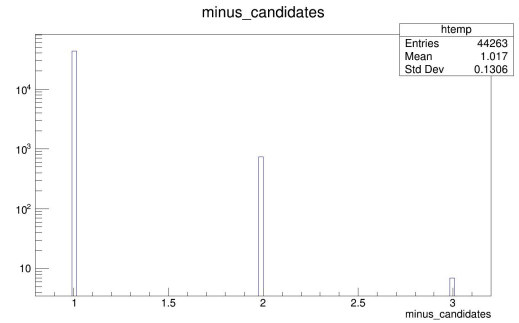

Usually there is a clear best candidate
type (# overflow)
all χ^2 (53288)
best χ^2 per event (28356)
worst χ^2 that would pass the preselection: 2.0
χ^2 (Higgsstrahlung-likeness)

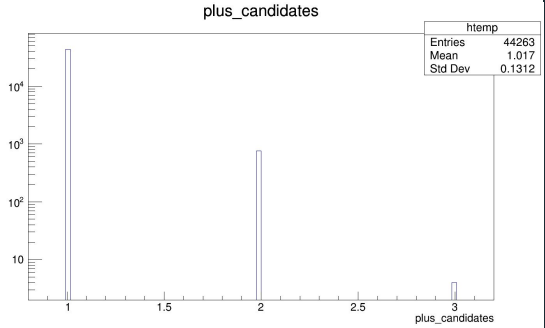


- Why so many events without IsolatedLepton pair?
- Chosen sample seems very broad (almost all outside preselection window)

All plots in this section are based on pure eLpR polarization. 100 fb simulated. 191M events available according to ELOG -> 10% simulated. Not sure why only 16M entries (not 19M). Might just be an issue with my batch job sending procedure. 44k events pass my first preselection(0.27%): 440 events/ifb luminosity. Only ~100 events (weight 10/ab) in classes after after tight preselection (down from 16M). C.f.: P_2f_l for e2e2H is based on ~500 events, weight 2/ab.







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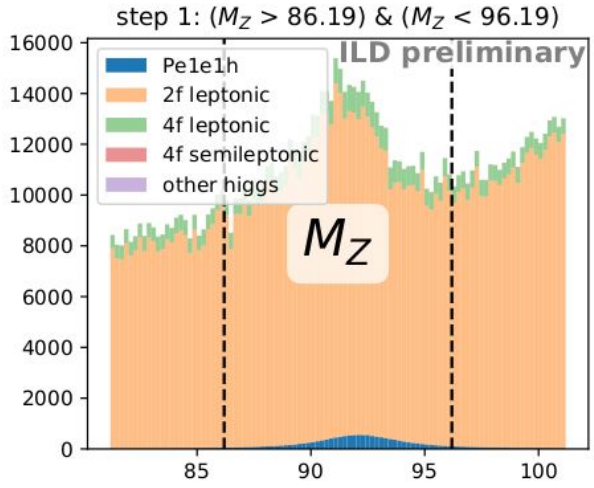
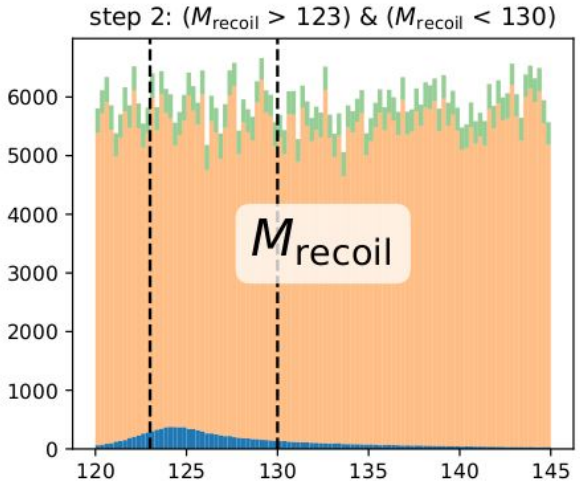
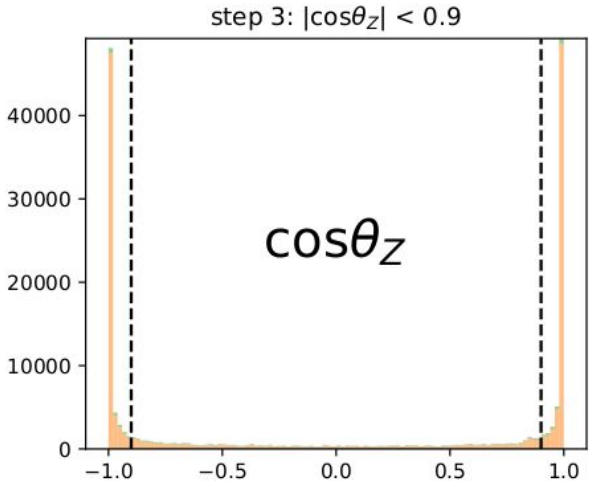
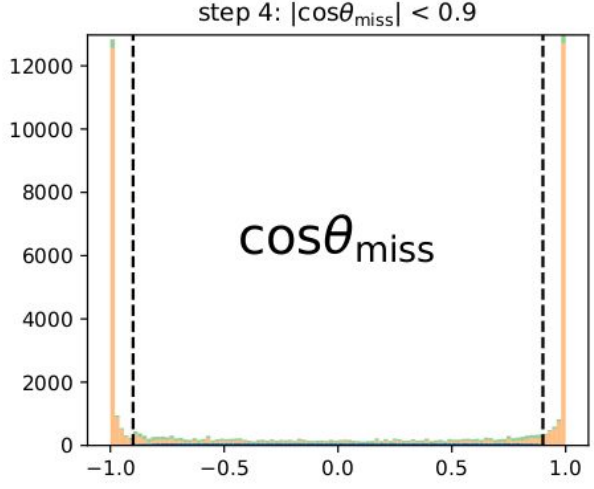
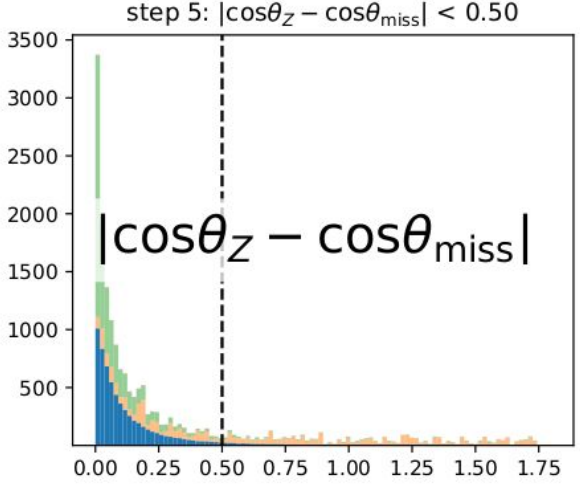
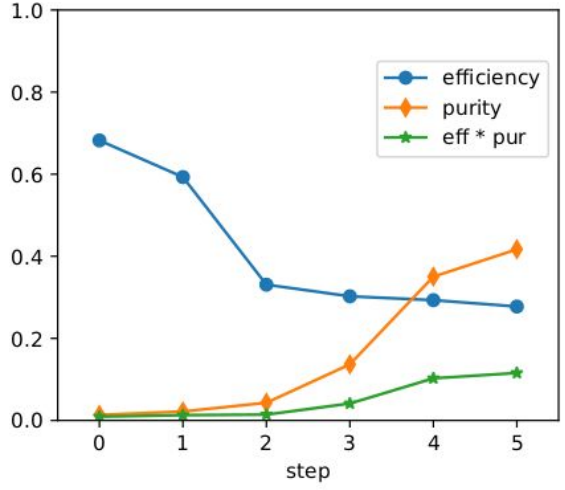

step 1: (M_Z > 86.19) & (M_Z < 96.19)
ILD preliminary
Pe1e1h
2f leptonic
4f leptonic
4f semileptonic
other higgs
M_Z

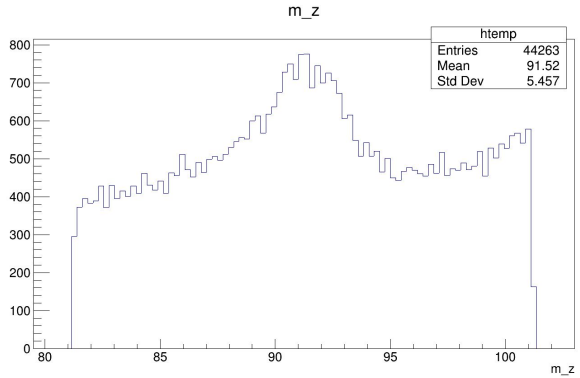

step 2: (M_{recoil} > 123) & (M_{recoil} < 130)
M_{recoil}

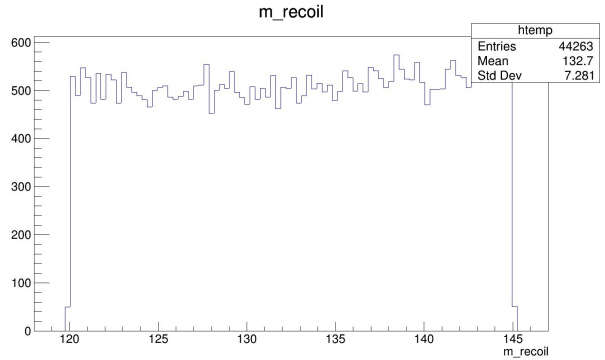

step 3: |cosθ_Z| < 0.9
cosθ_Z

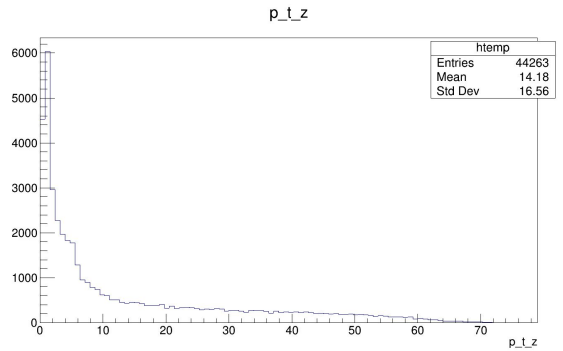

step 4: |cosθ_{miss}| < 0.9
cosθ_{miss}

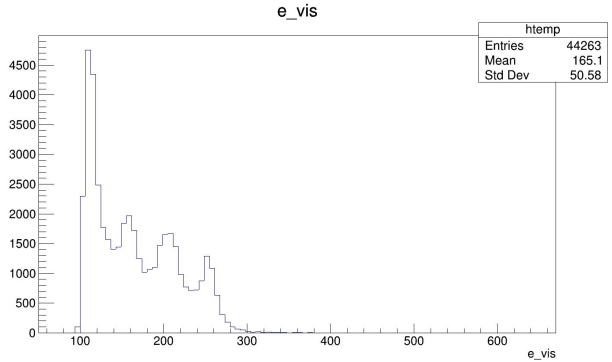

step 5: |cosθ_Z − cosθ_{miss}| < 0.50
|cosθ_Z − cosθ_{miss}|

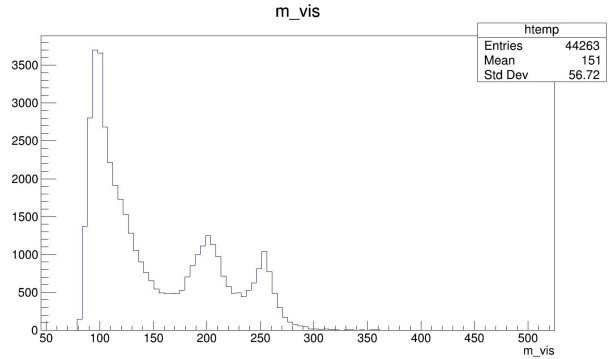

efficiency
purity
eff * pur
step

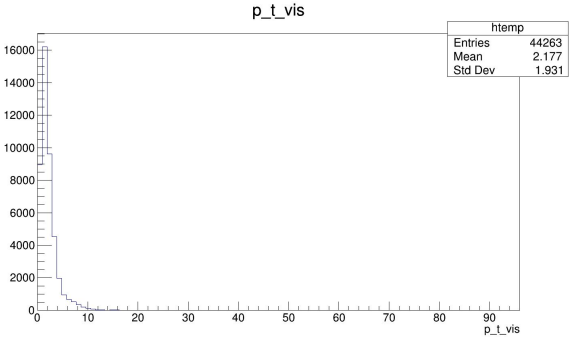




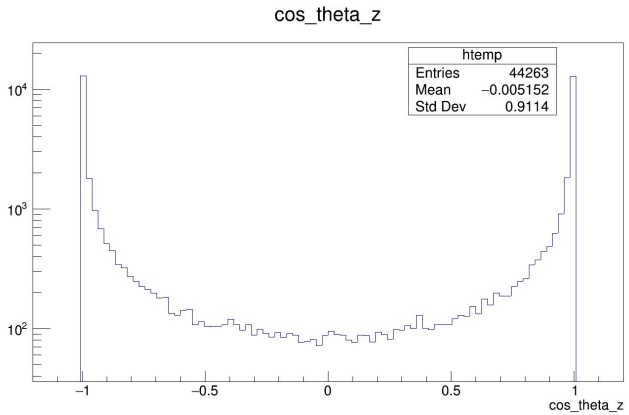


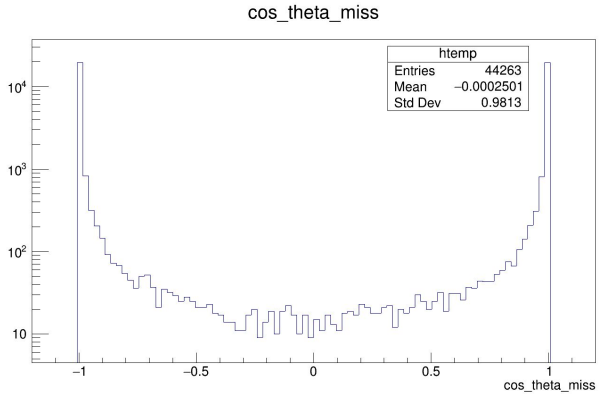


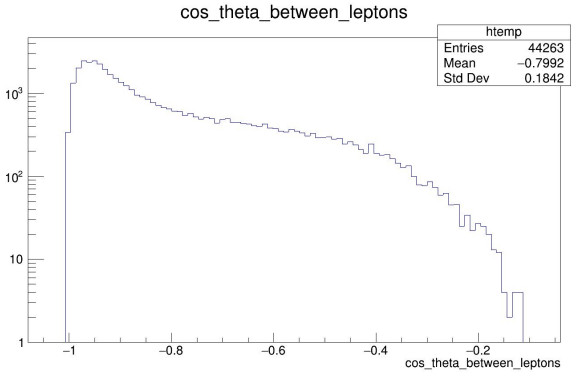


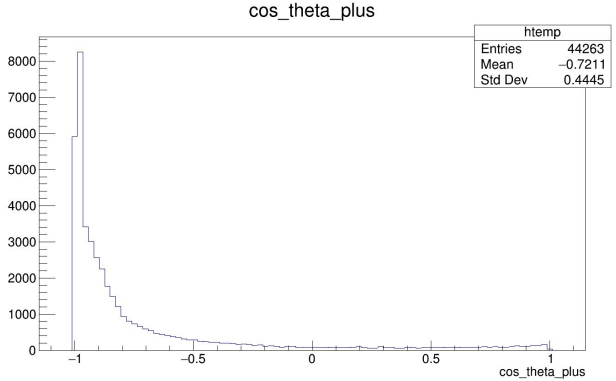


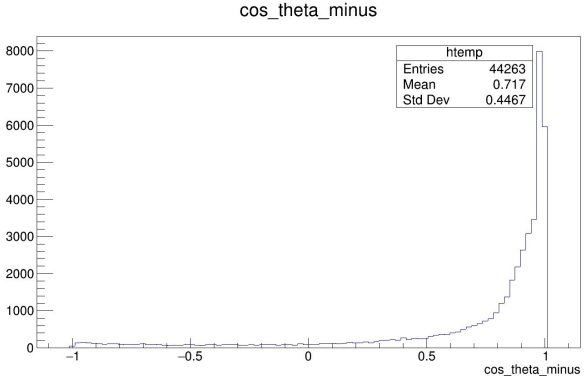
Variables built on e+e- pair that fakes a Z decay.
Second row: Variables built on full visible momentum.
Suspicious bump structure every 50 GeV in **visible** variables - to be checked on “Higgs part” of event



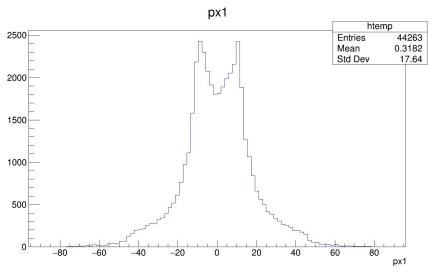


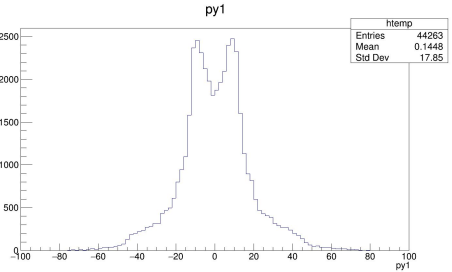


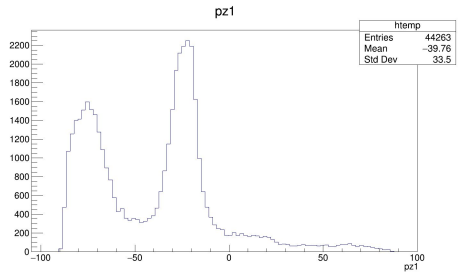


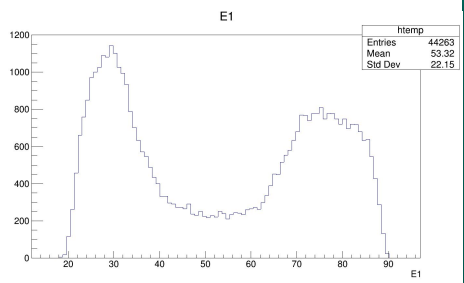


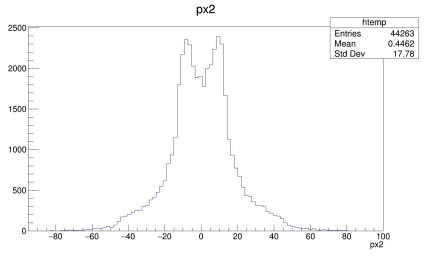
Angular distributions look fine.

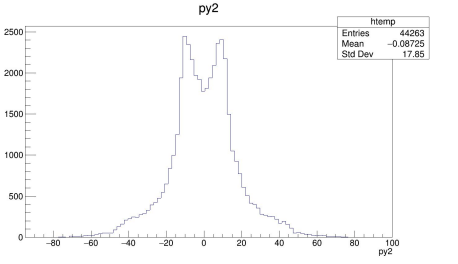


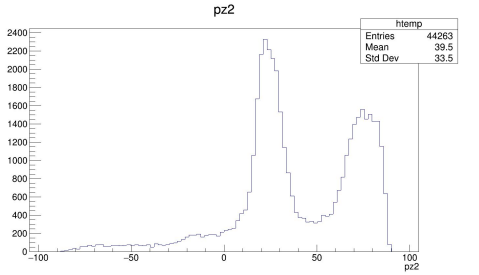


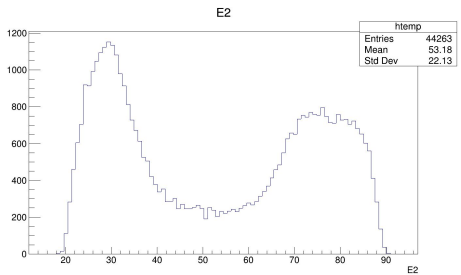


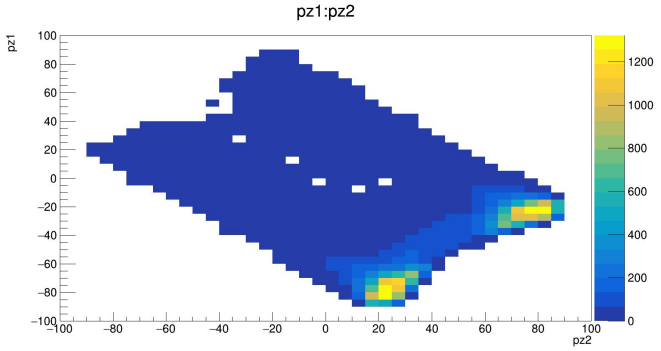






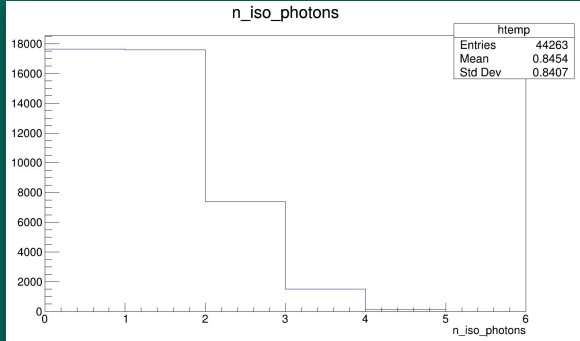


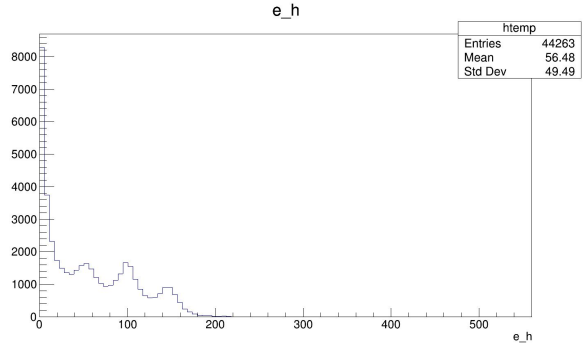


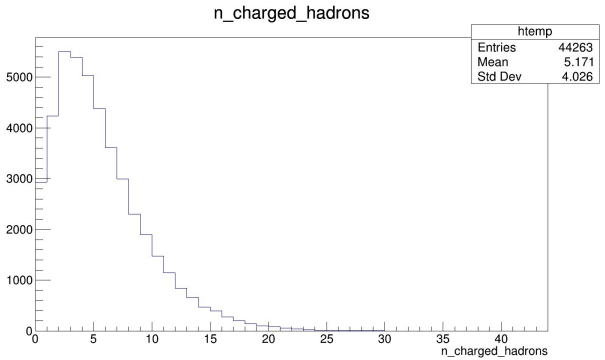


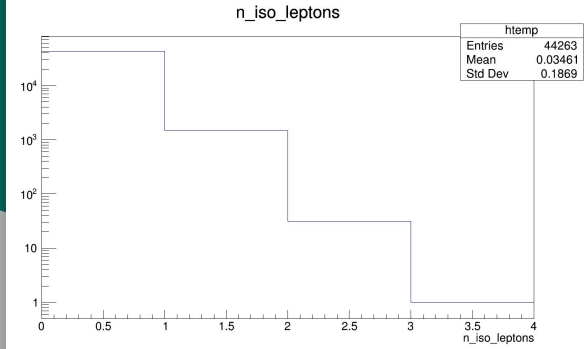
4-momenta of the electron and the positron that together fake a Z decay.

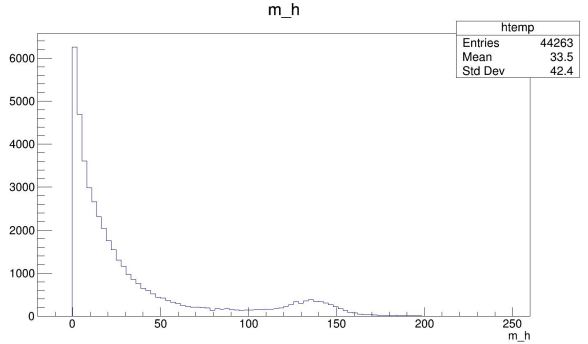
Higgs-like variables in Bhabha after preselection

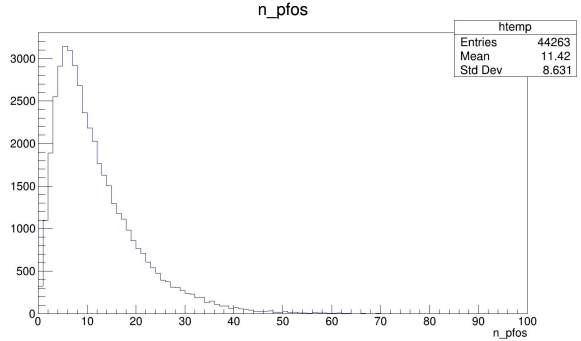








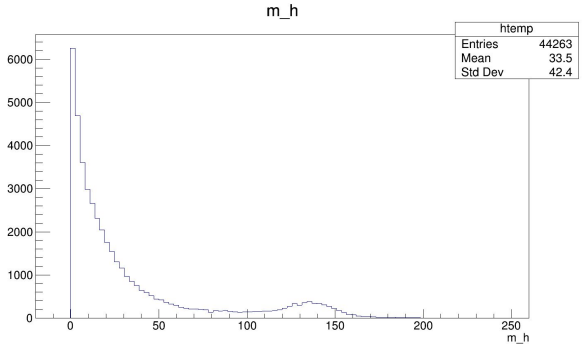


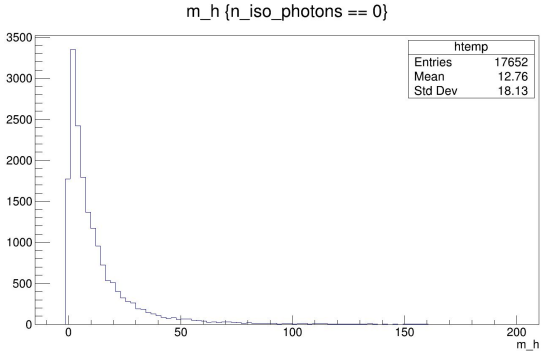


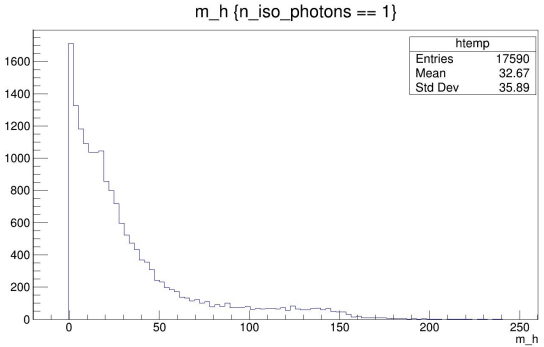
Let’s start looking into the “Higgs part”: Everything but the e+e- pair.

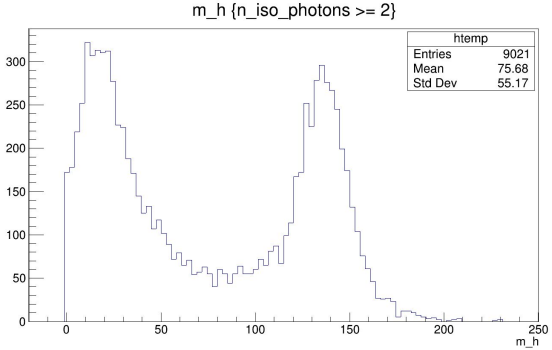
“Higgs mass”

High-mass bump when multiple ISR photon in detector volume.

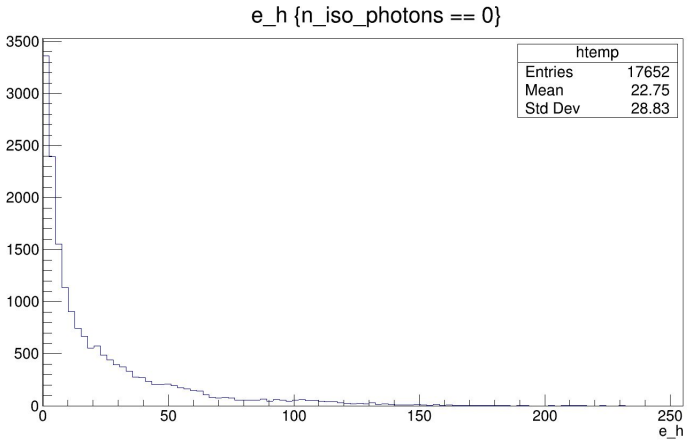


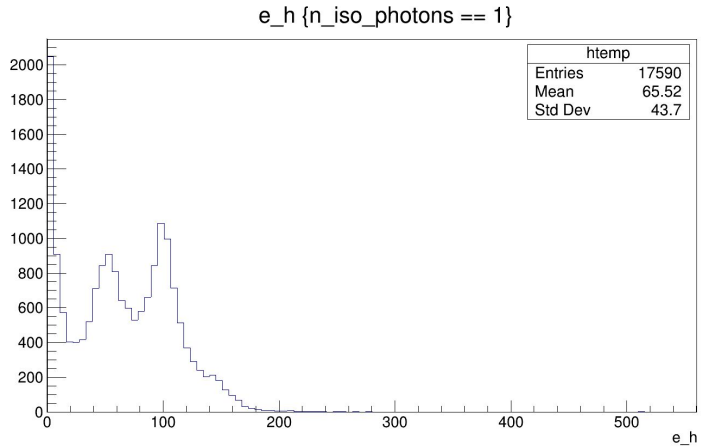


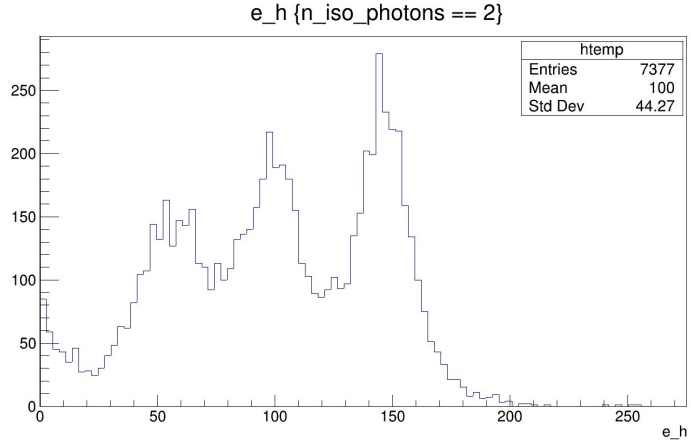


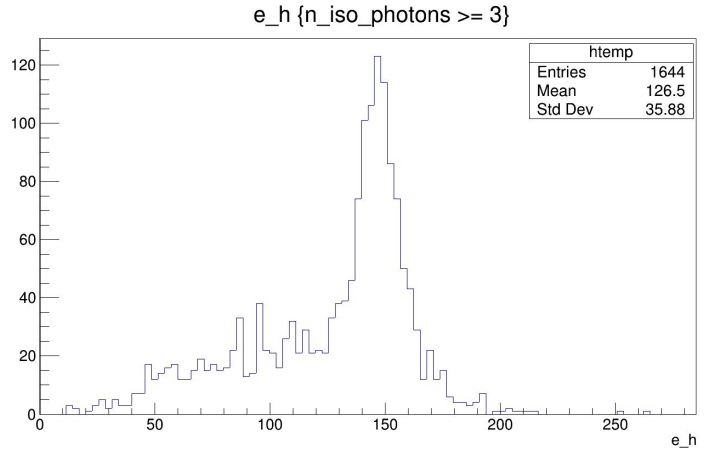


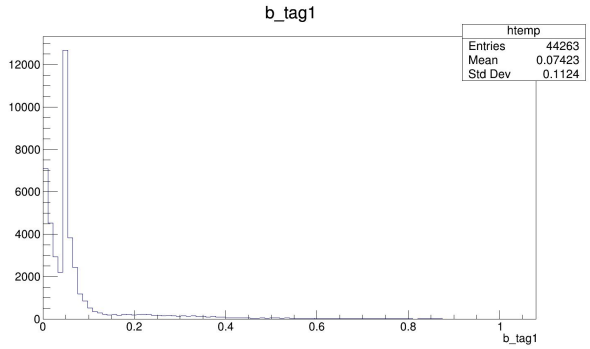
simple_event_vector->Draw(“m_h”, “n_iso_photons == 0”)

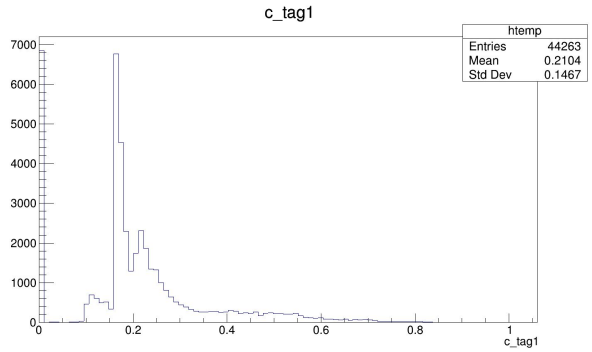

e_h {n_iso_photons == 0}
htemp
Entries 17652
Mean 22.75
Std Dev 28.83
e_h

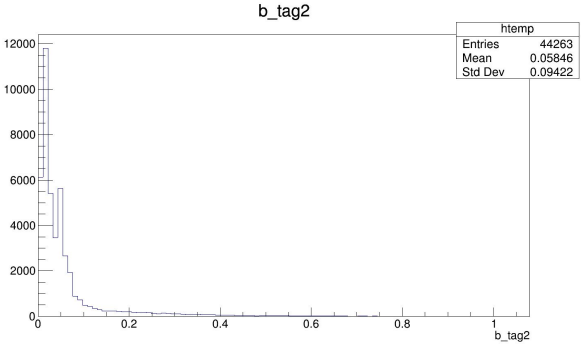

e_h {n_iso_photons == 1}
htemp
Entries 17590
Mean 65.52
Std Dev 43.7
e_h

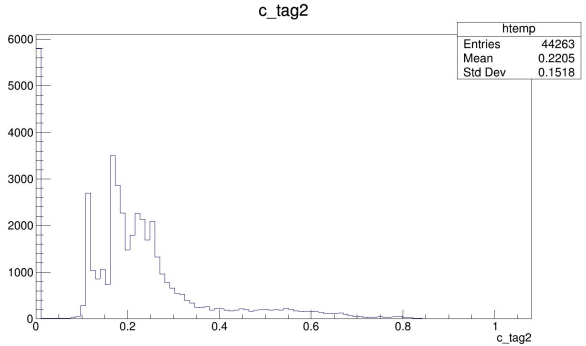

e_h {n_iso_photons == 2}
htemp
Entries 7377
Mean 100
Std Dev 44.27
e_h


e_h {n_iso_photons >= 3}
htemp
Entries 1644
Mean 126.5
Std Dev 35.88
e_h

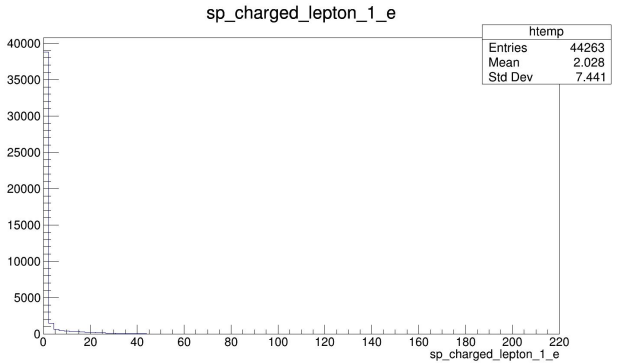


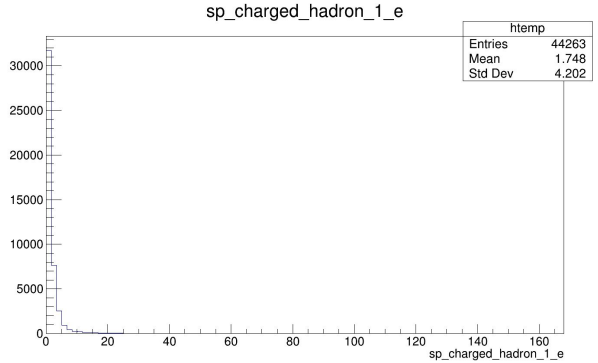


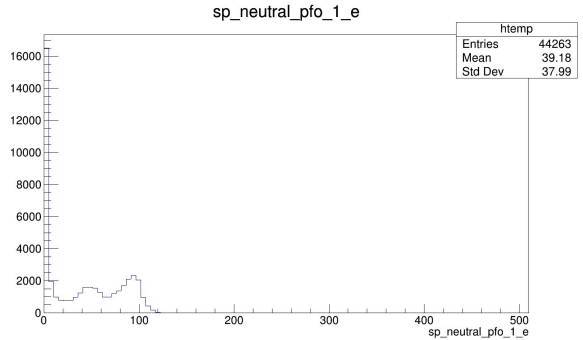


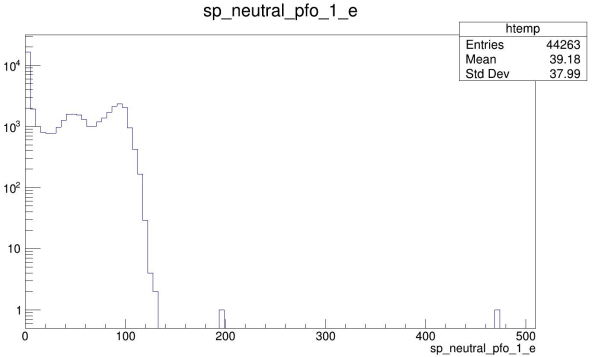


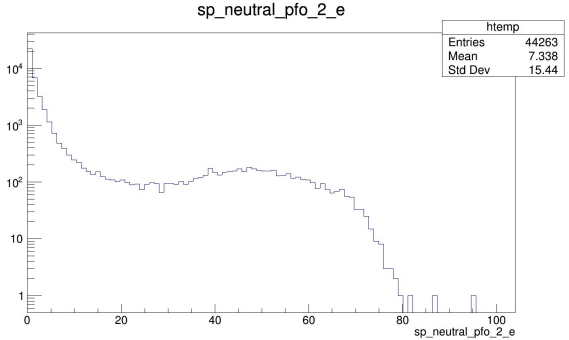
Flavor tagging shapes are rough. Expected? Algorithm is trained on Z→qq@91GeV. Here many “events” with almost no energy.











If there is any charged particles (apart from e+e- pair), they are almost exclusively at low energy.
It is common to find 1 high-energy neutral PFO (photon). Again, this has a bump structure.
More neutral PFOs are possible.