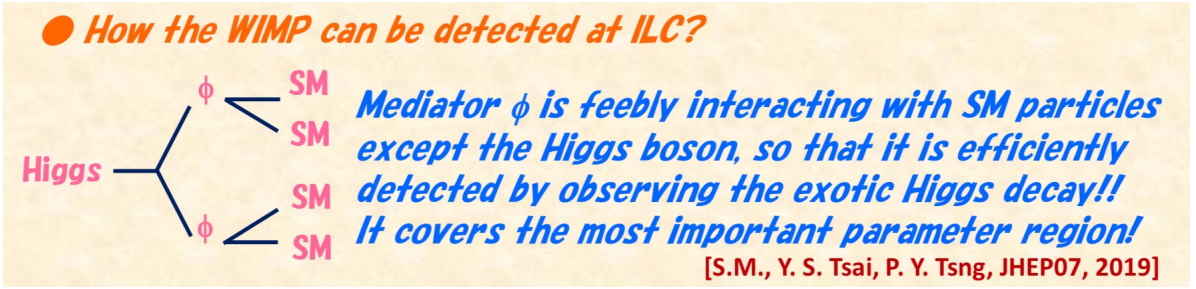
Asian Physics and Software meeting 2021.6.11

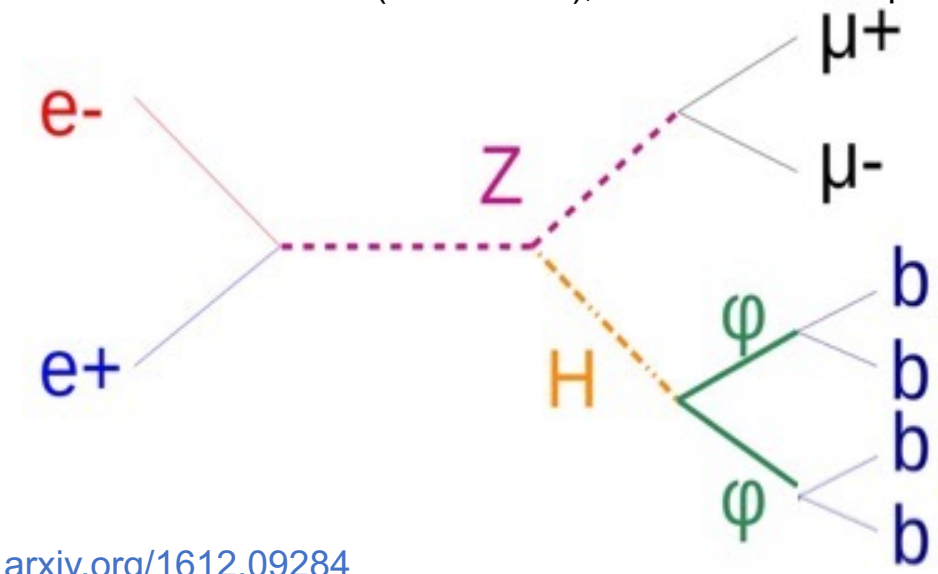
- Status reports:
  - Target process: ZH->μμφφ->μμbbbb at 250 GeV
    - Sample generation
      - The model “THDM(_CKM)” has some bugs in process description and ghzz value, so I try to replace it with “MSSM(_CKM)”.
    - Fast analysis
      - IsolatedLeptonTagging and LCFIPlus are applied as the basic reconstruction.
      - Signal and main background are compared quickly.

ZH->μμφφ->μμbbbb at 250 GeV

- Motivation:
  - Higgs exotic decay (H->φφ->bbbb)
  - To apply b-jet kinematic fitter
- Setup:
  - WHIZARD 2.8.5
  - mφ: 15, 20, 30, 40, 50, 60 [GeV]
  - 20,000 events for each mφ, polarization{ (-0.8,+0.3), (+0.8,-0.3) }
  - Official setting(mc-2020), √s = 250 GeV
- Status:
  - ✓ Sample preparation
    - Generate WHIZARD sample and some check at MC level
    - Simulate with DDSim, Reconstruct with MarlinStdReco
  - ☐ Fast analysis
    - IsolatedLeptonTagging, JetClustering (4-jet)
  - ☐ Test fitting
  - ☐ Detailed analysis



S. Matsumoto(Kavli IPMU), ILC summer camp 2020



arxiv.org/1612.09284

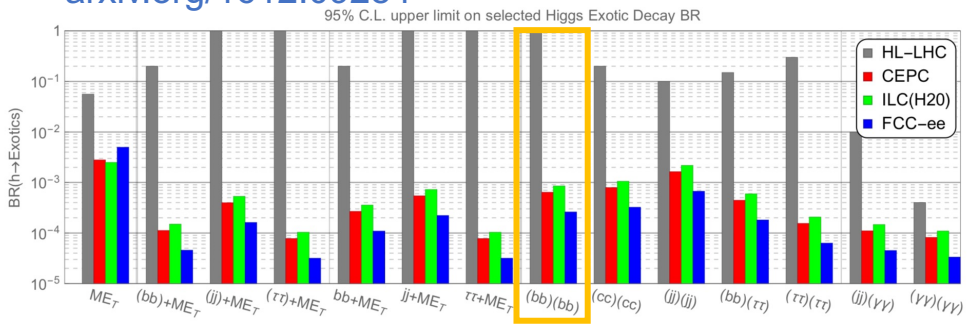
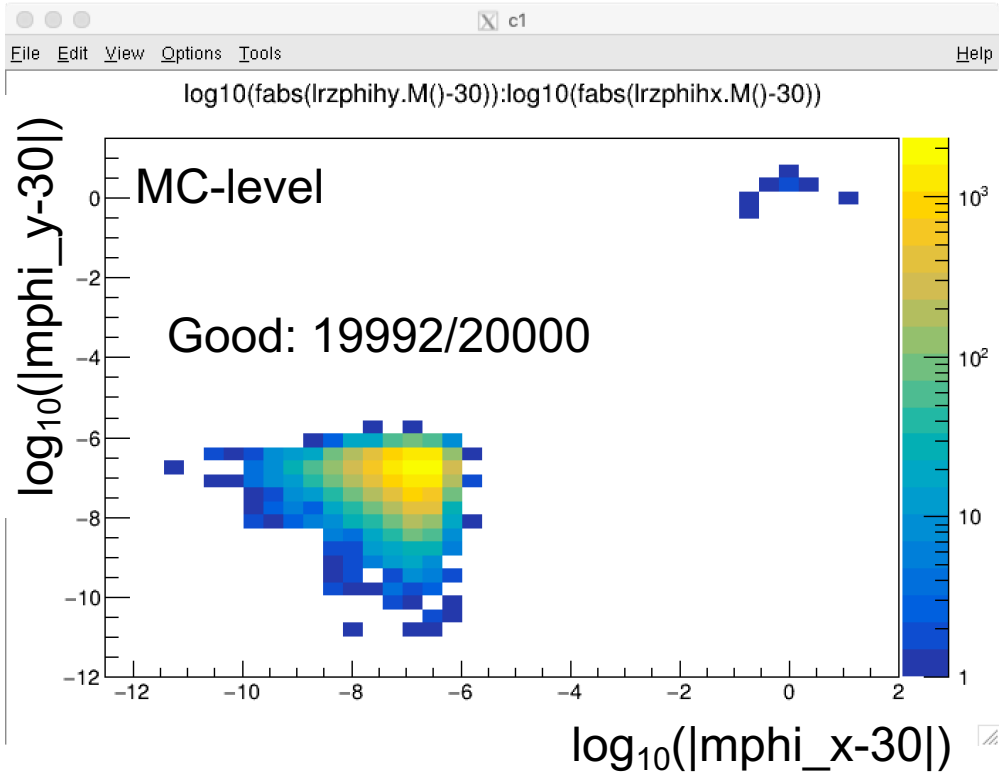
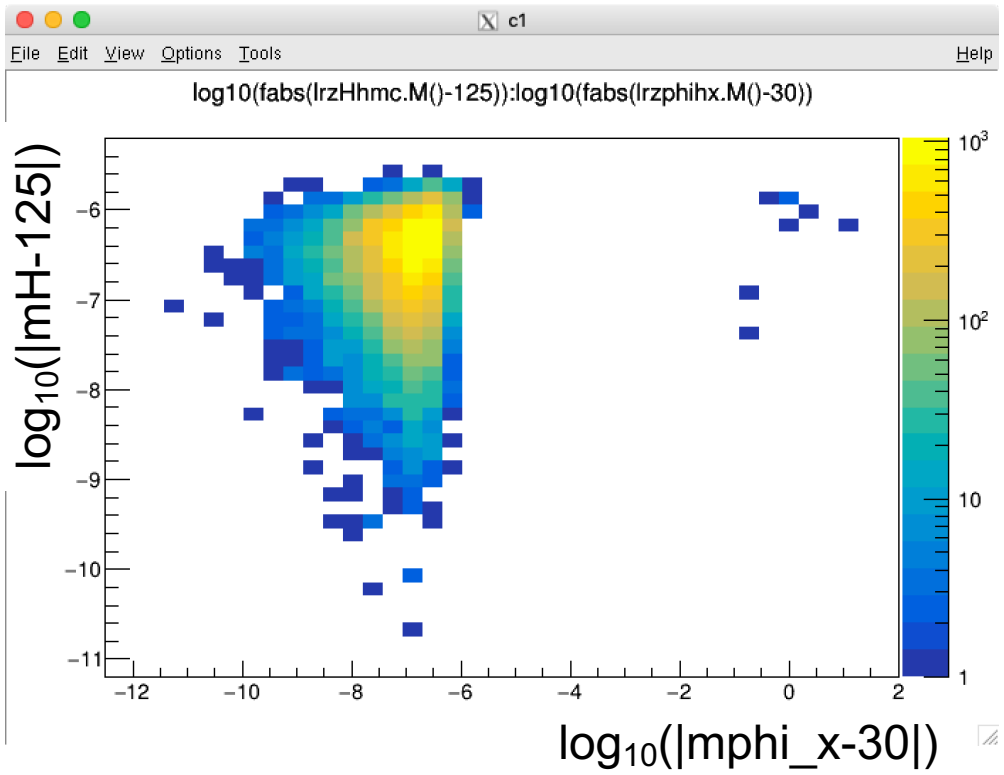


Fig. 12. The 95% C.L. upper limit on selected Higgs exotic decay branching fractions at HL-LHC, CEPC, ILC and FCC-*ee*. The benchmark parameter choices are the same as in Table 3. We put several vertical lines in this figure to divide different types of Higgs exotic decays.

mumuh_phiphi_4b_MSSM_CKM





- mb ≠ 0
- mphi = 30 GeV
- α = -π/4
- tanβ = 1

Φ	g_u	g_d	g_V
SM H	1	1	1
MSSM h	$\cos\alpha/\sin\beta$	$-\sin\alpha/\cos\beta$	$\sin(\beta-\alpha)$
MSSM H	$\sin\alpha/\sin\beta$	$\cos\alpha/\cos\beta$	$\cos(\beta-\alpha)$
MSSM A	$1/\tan\beta$	$\tan\beta$	0

MC production: Whizard

- model: THDM_CKM

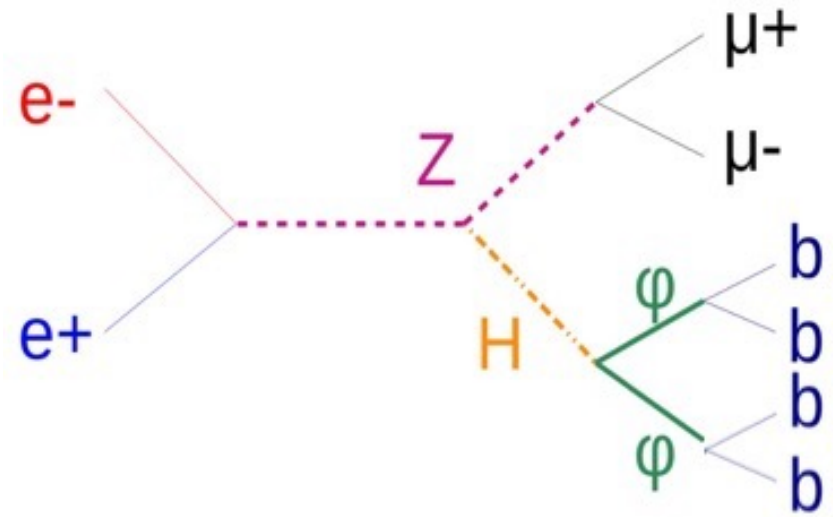
  Note: There are some bugs so MSSM_CKM may be better.

- process description:

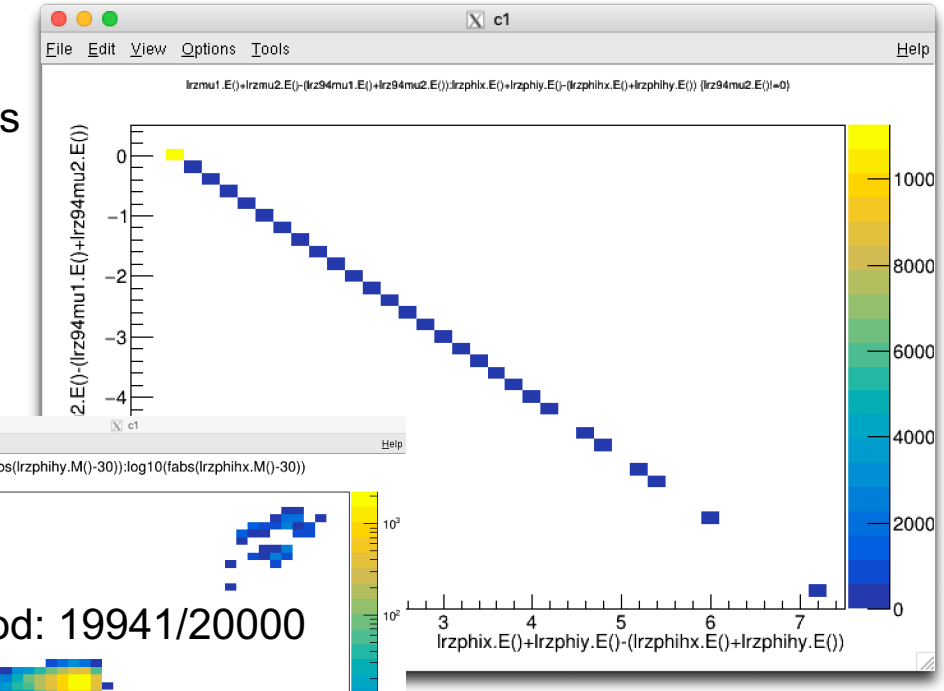
  "e-", "e+" => "mu+", "mu-", "h0" { $restrictions = "1+2~Z && 3+4~Z" },
  h0 => "H0", "H0" (unstable), H0 => b, "b~" (unstable)

- parameters
  - αs = 1.e-6
  - ms = mc = mb = 0 GeV
  - H0 = φ, mH0 = 30 GeV, wH0 = 4.1 MeV
  - Yd_33 = 1.0

- issues
  - There are some momentum exchanges between phis and muons.



$\Delta E_{\mu s}$

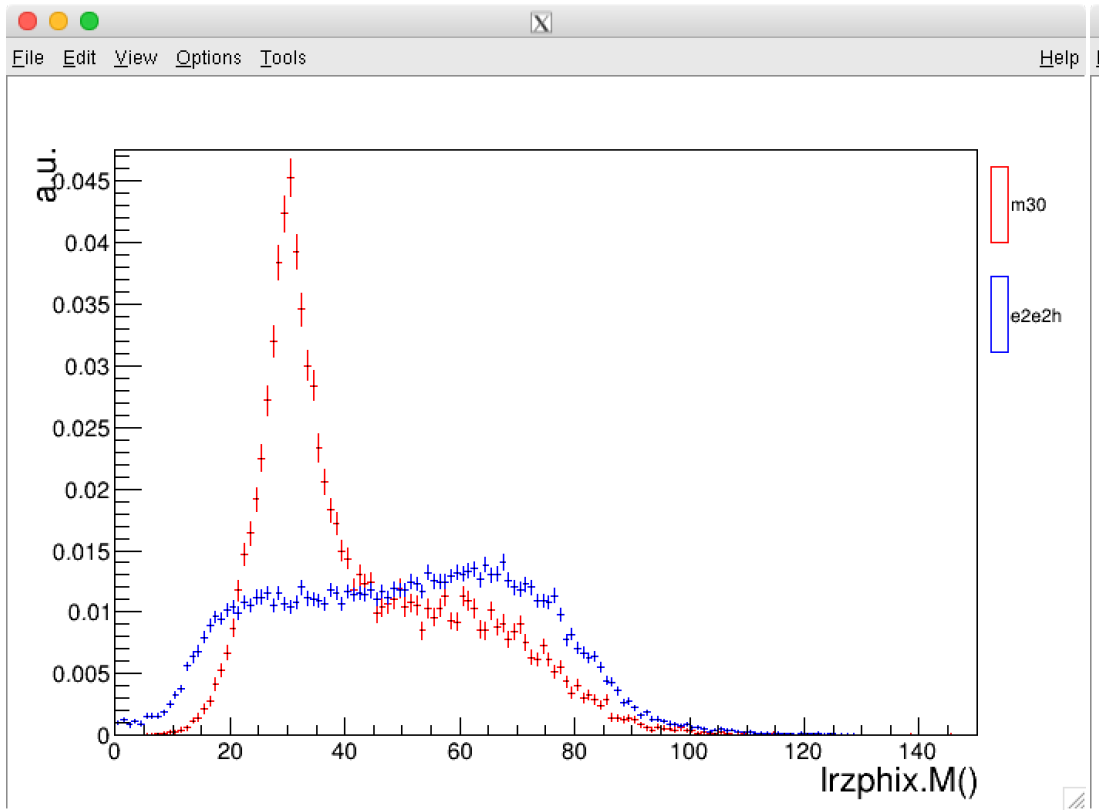


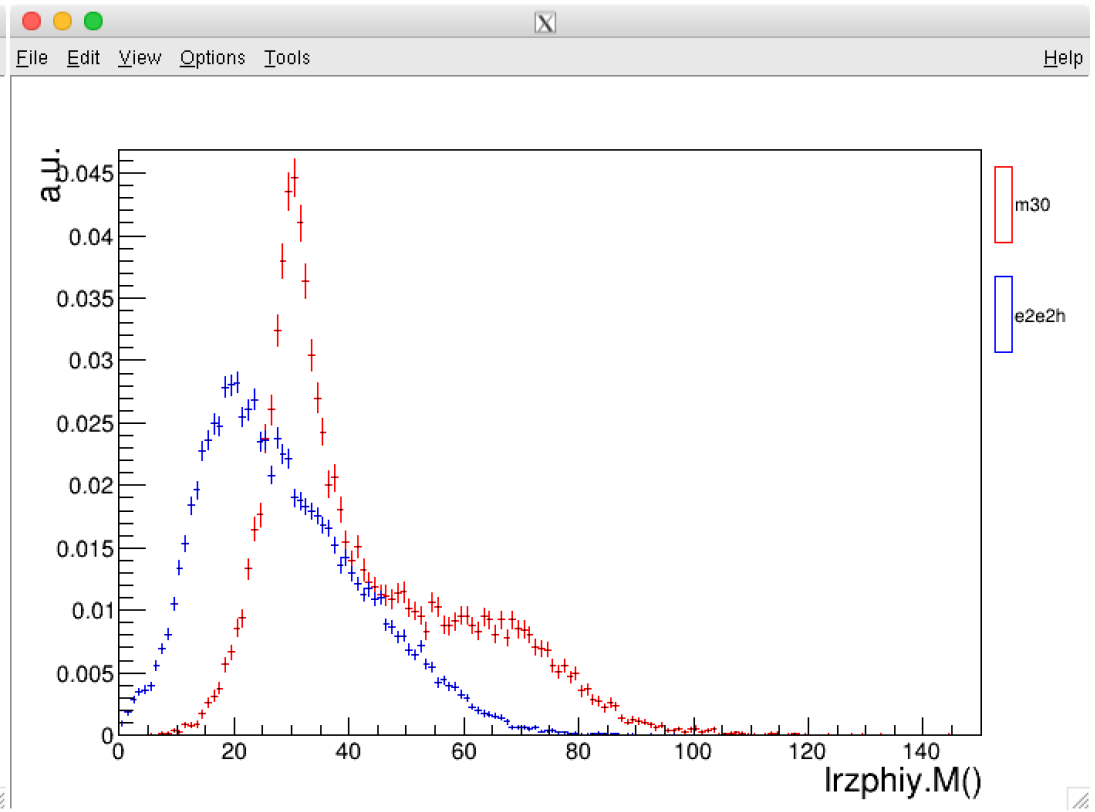
$\Delta E_{\varphi s}$

Fast Analysis of hφφ

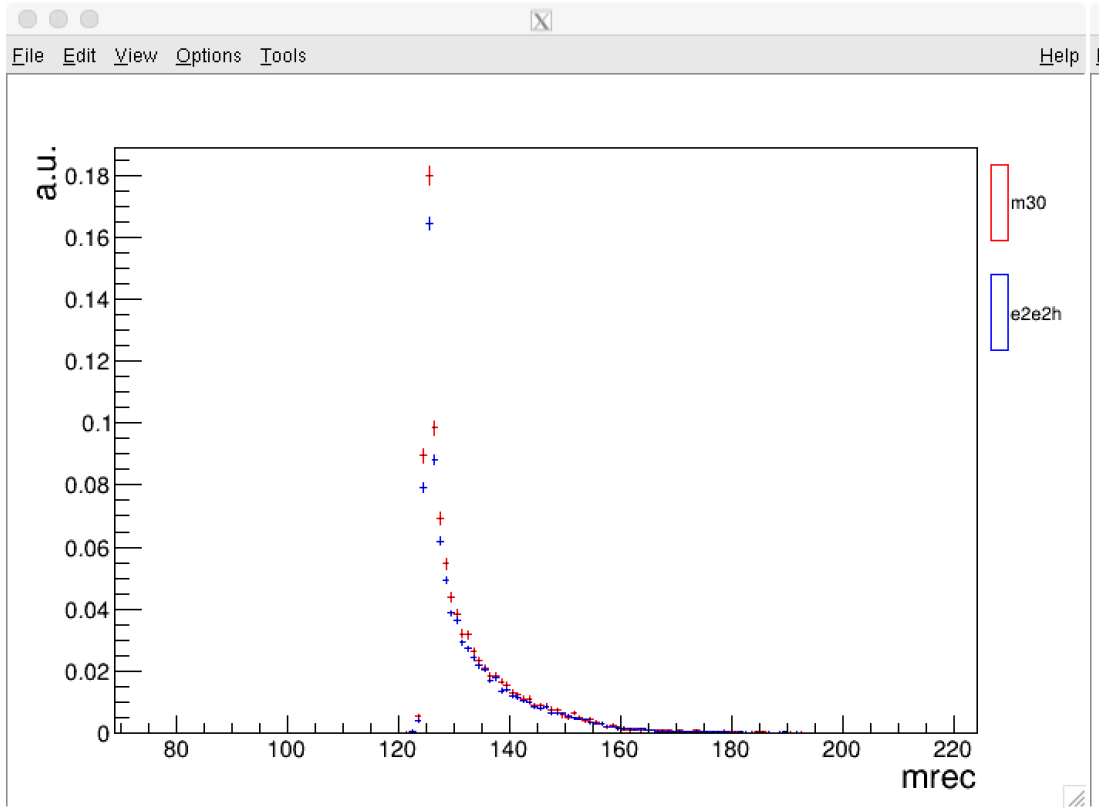
- Samples
  - m30 (THDM_CKM) for signal
    - nGen = 20,000
    - nIsoLep = 2 -> 18,736 (93.68%)
  - e2e2h for background
    - nGen = 42,000
    - nIsoLep = 2 -> 35,814 (85.27%)
  - Pol: (-1, +1)
- Basic analysis
  - IsolatedLeptonTagging
    - require nIsoLep = 2
  - LCFIPlus
    - Jet clustering: forced to 4 jets
    - Flavor tagging
  - Jet pairing
    - m12 = m34
- Basic variables
  - lrzphix/y
  - lrzjx1/x2/y1/y2
  - lrzH, lrzZ
  - mrec
- To do
  - Event selection
  - Overlay removal, cheat
  - Optimize processor parameters

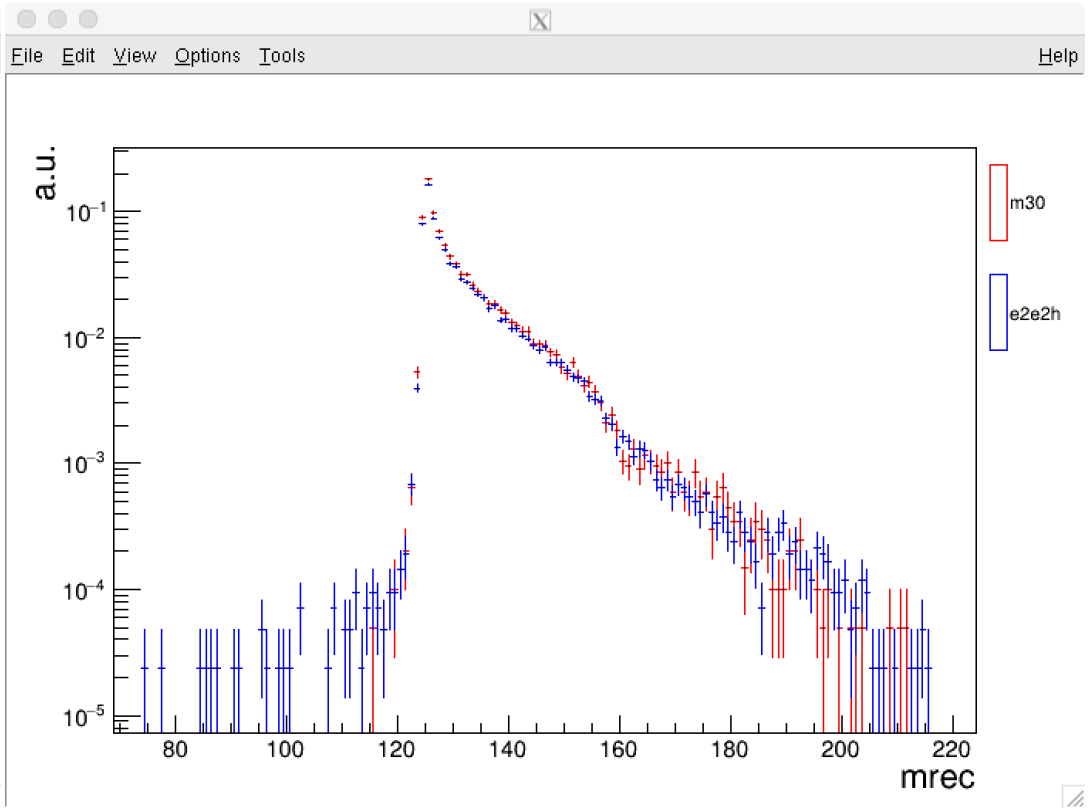
Fast Analysis of hφφ



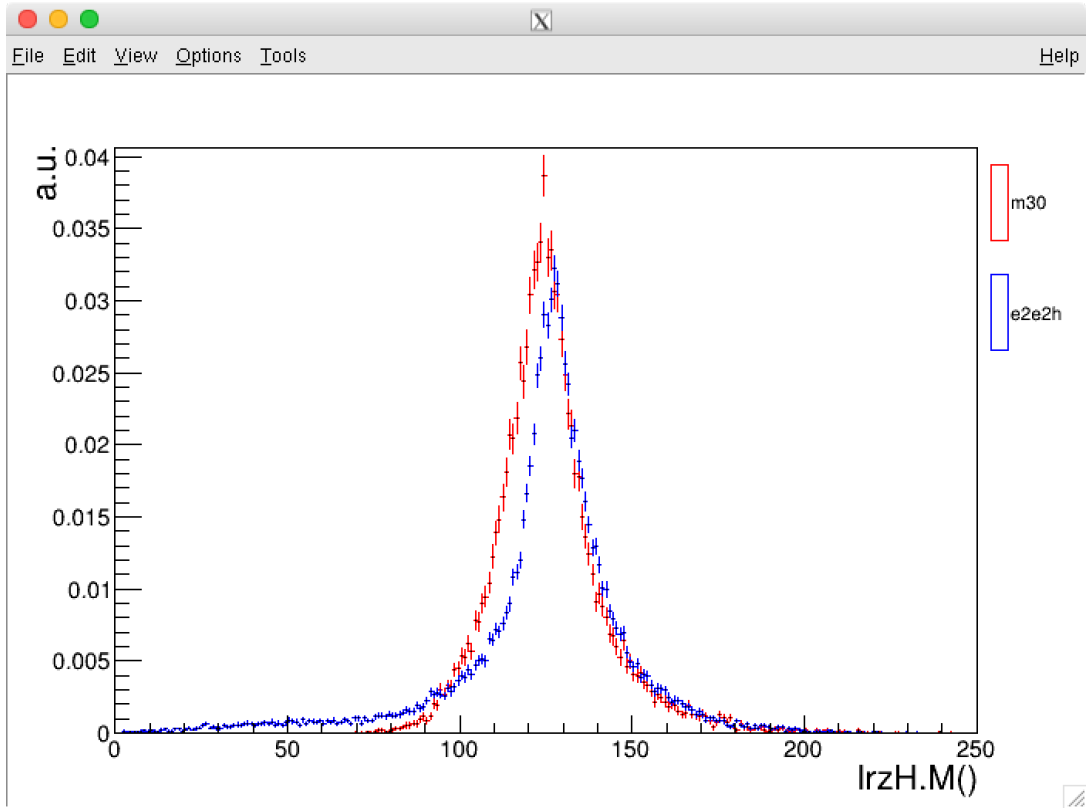


Fast Analysis of hφφ

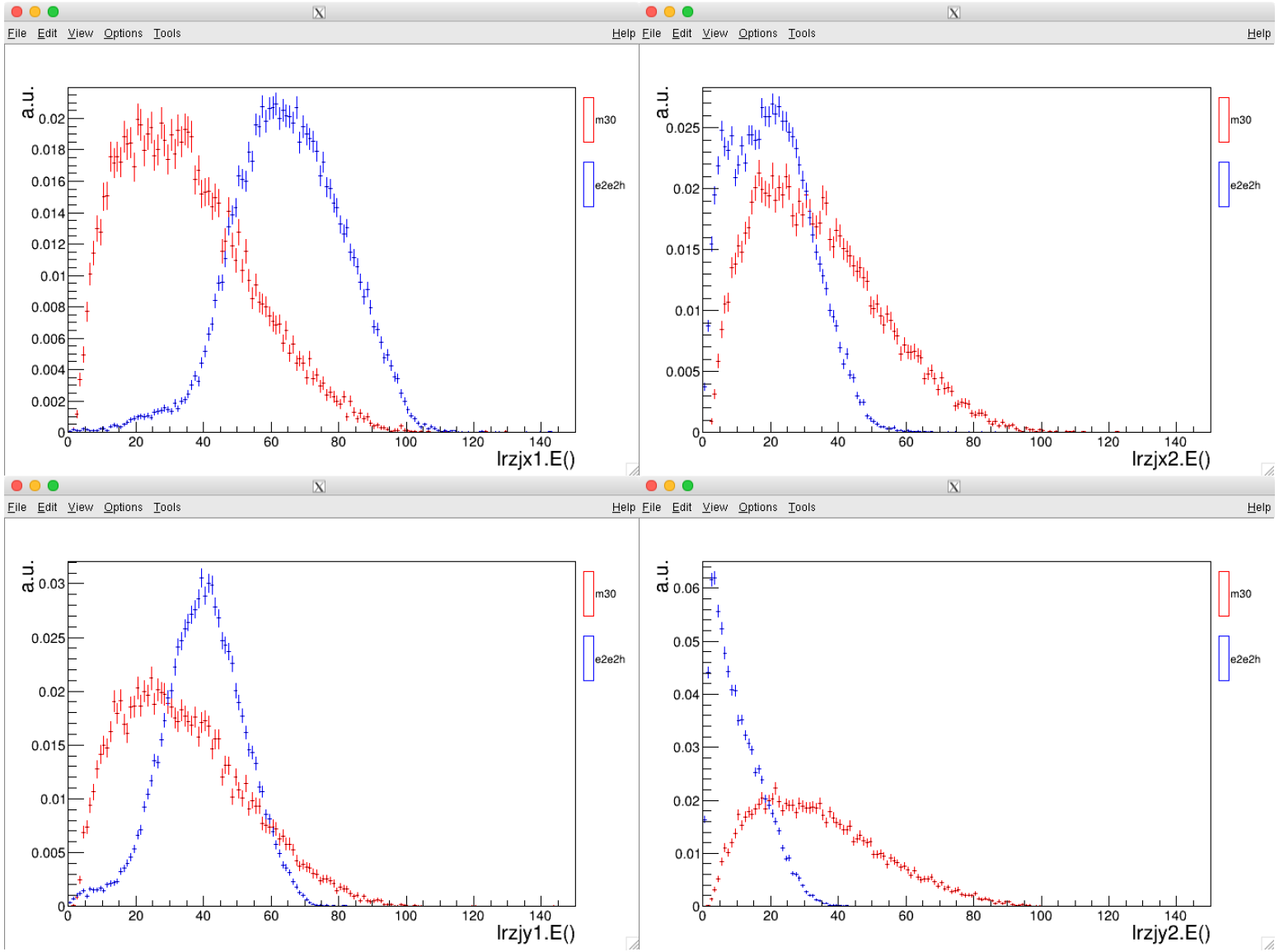




Fast Analysis of hφφ



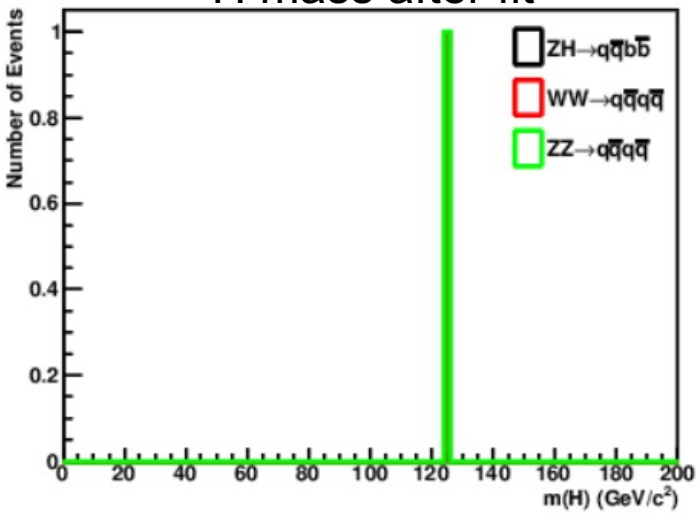
Fast Analysis of hφφ



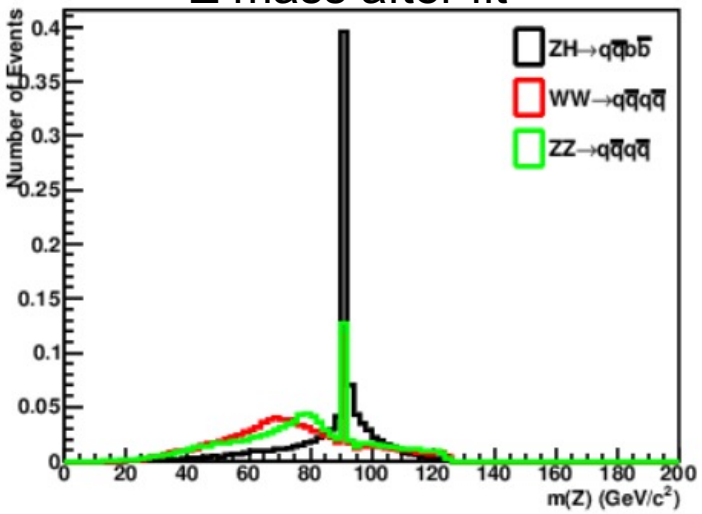
backup

Test process: e^+e^- -> ZH -> qqbb

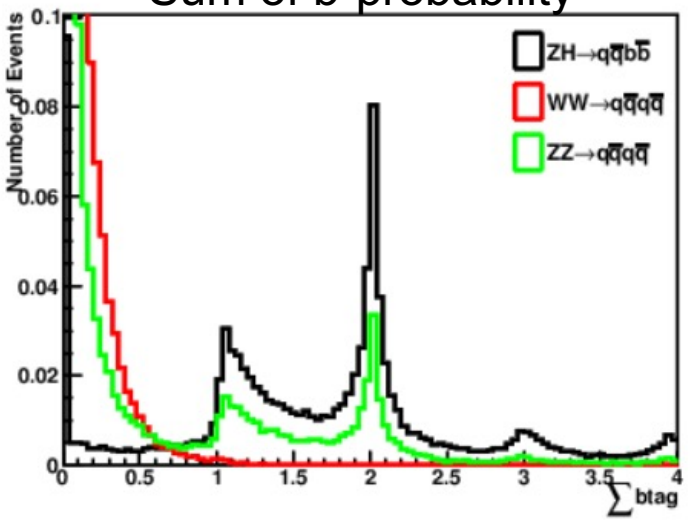
H mass after fit



Z mass after fit

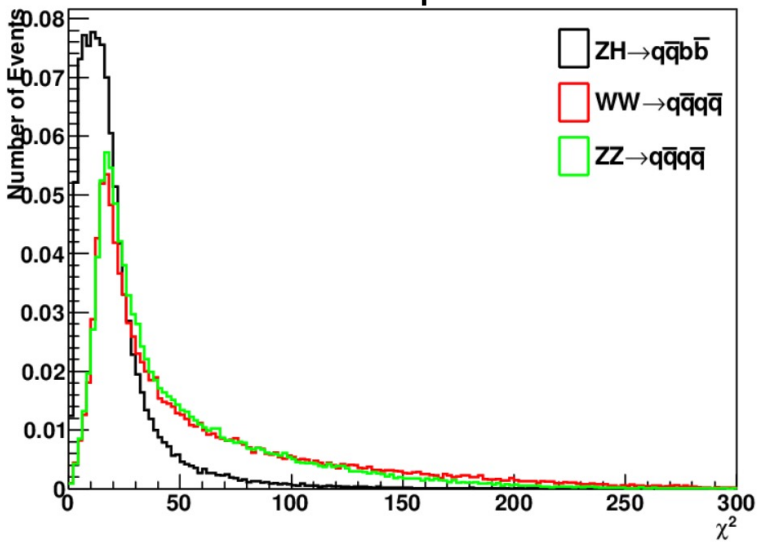


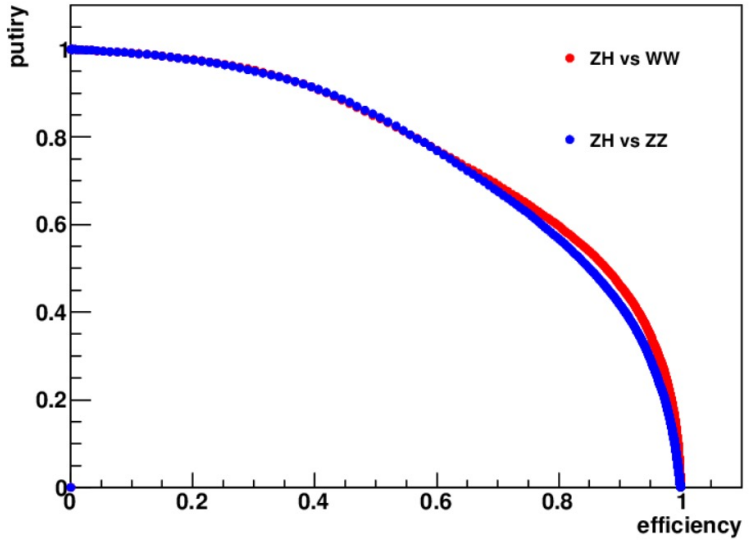
Sum of b-probability



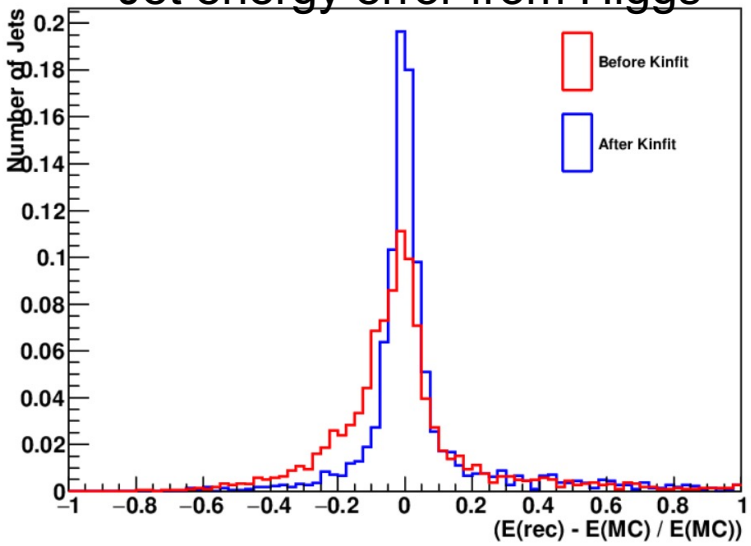
Test process: e^+e^- -> ZH -> qqbb

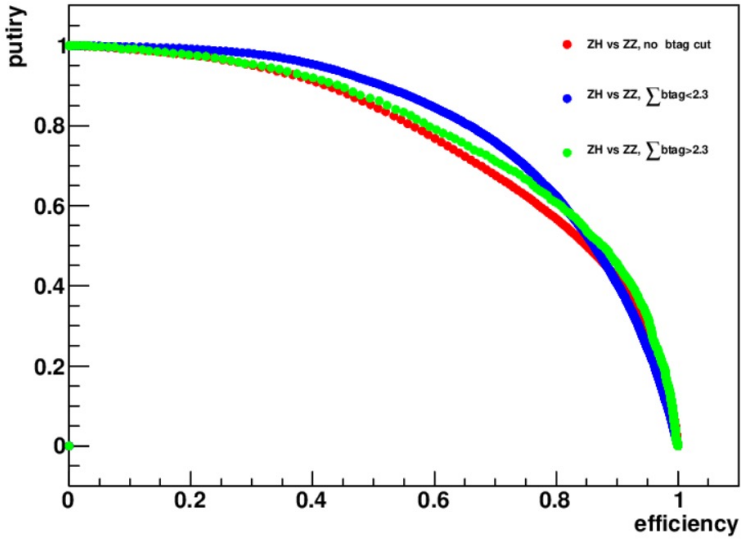
Chi-square



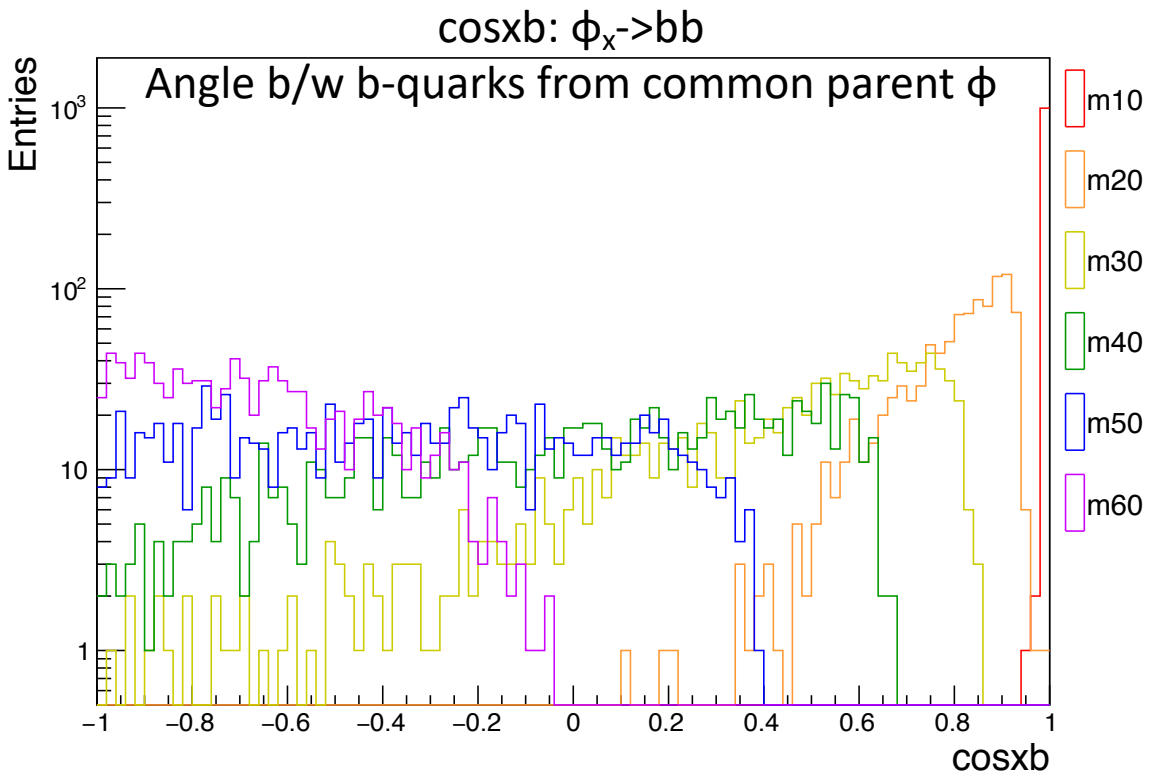


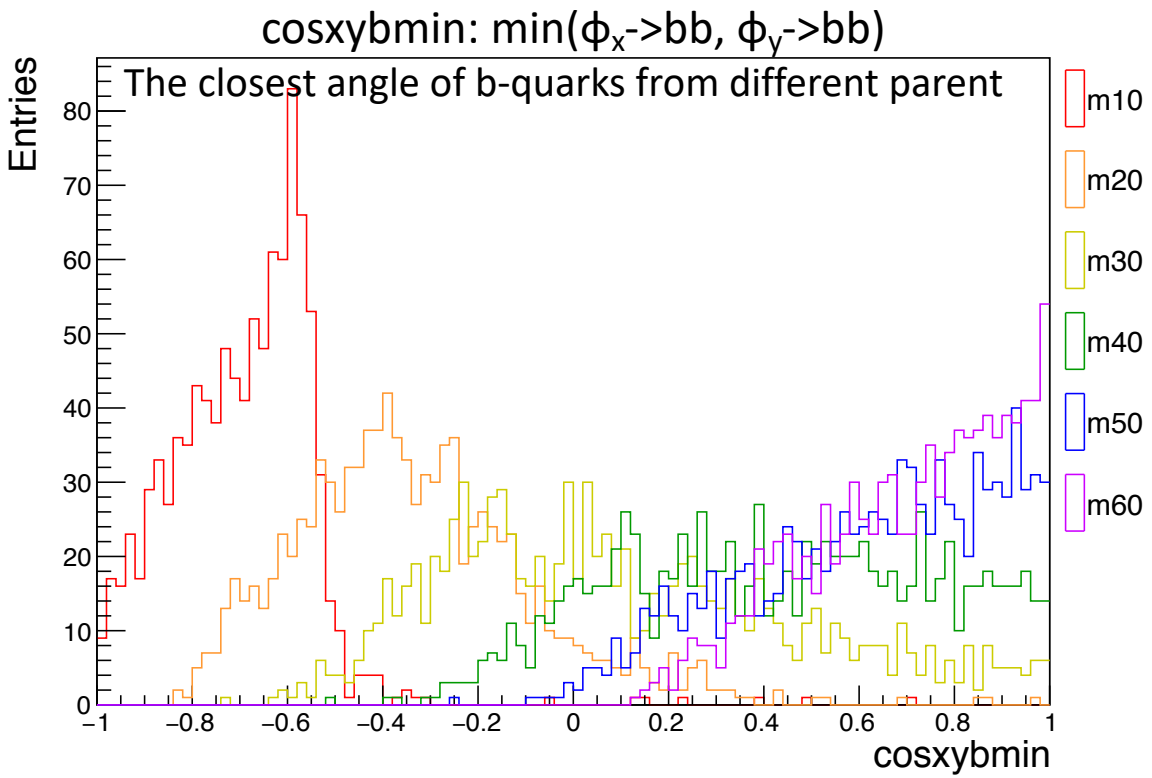
Jet energy error from Higgs





MC-level check: b-quark angle





- The lighter mϕ, the easier to separate ϕs and the more difficult to separate b-quarks decayed from a common ϕ.
- We expect that the LCFIPlus vertexing is effective to separate the b-jets.
- Note: The case of m10 (i.e. mϕ = 10 GeV) is not enough to generate 4 B-hadrons.

MC-level check: MC-jet

w/o Boost
w/ Boost
↖ $\cos\theta_{x1}$
↗ $\cos\theta_{x2}$
↙ E1 – E2
↘ $\cos\theta_{hel}$