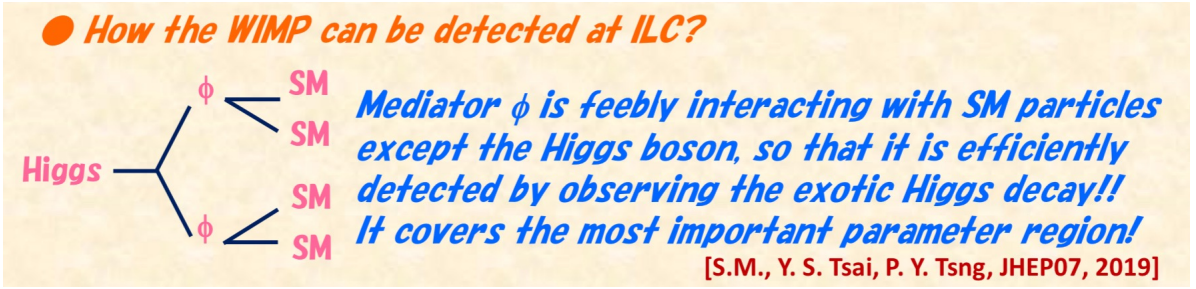
Asian Physics and Software meeting 2021.4.30

- Status reports:
  - Try to generate ZH->μμbbbb sample at 250 GeV.
    - Go to next page.

ZH->μμφφ->μμbbbb at 250 GeV

- Target:
  - BR(H->φφ)
  - 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
  - mc-2020, √s = 250 GeV
    - rv02-02-01.sv02-02-01.mILD_l5_o1_v02.E250(_SetA)
- Status:
  - Test of 1st sample generation was done.
    - Generate whizard sample based on ILC Analysis Workthrough
    - Simulate with DDSim, Reconstruct with MarlinStdReco
      - Thanks to Miyamoto-san, Ono-san, Daniel, Junping
  - Some check of generator setups for consistency with mc-2020
    - Mass of s/c/b is set to 0 GeV.
    - All the particles except higgs are polarized.
    - BS/ISR/FSR settings: `($circe2_file = "/home/ilc/tianjp/generator/PostDBD/whizard2/250_SetA_ee024.circe")`
    - Default mass cut, and so on.



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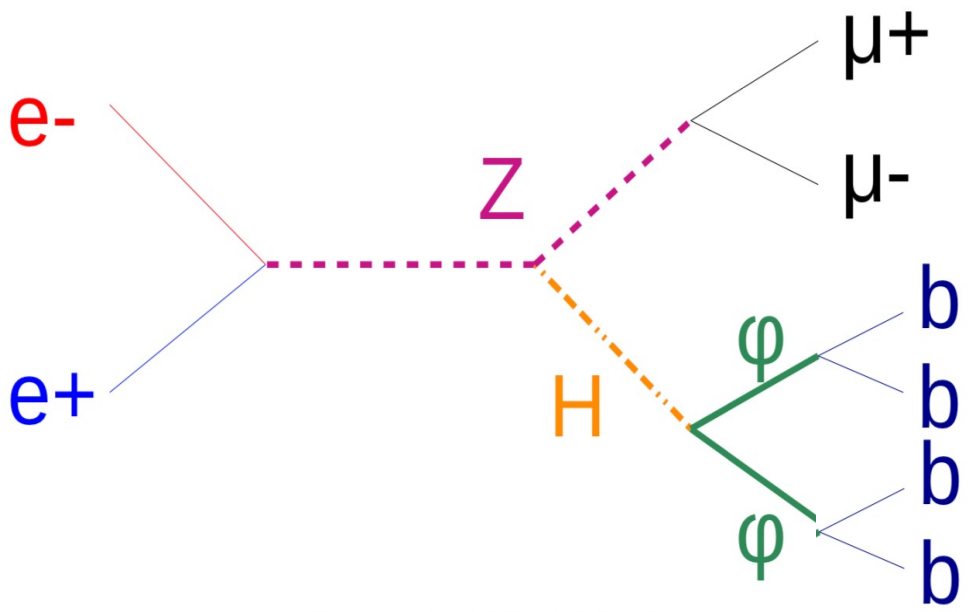


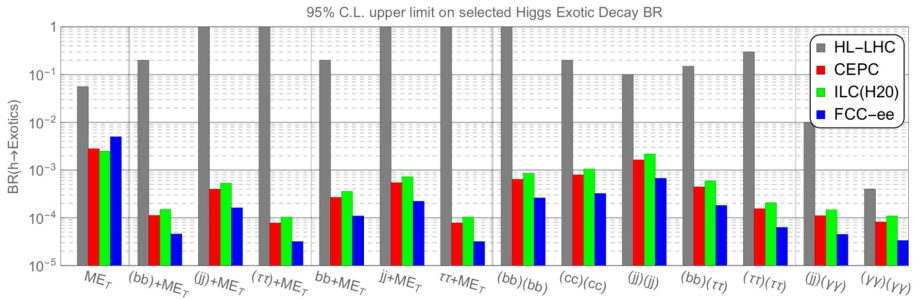


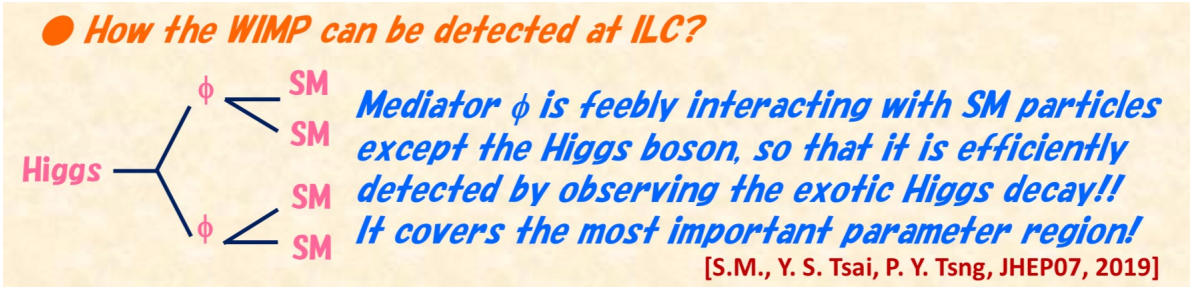
Fig. 12. The 95% C.L. upper limit on selected Higgs exotic decay branching fractions at HL-LHC, CEPC, ILC and FCC-*ee*. The benchmark parameter choices are the same as in Table 3. We put several vertical lines in this figure to divide different types of Higgs exotic decays.

ZH->μμφφ->μμbbbb at 250 GeV

- Questions for WHZARD:
  - Which model should we use for this process?
    - mc-2020: SM_CKM
    - 1st test: 2HDM_UFO https://feynrules.irmp.ucl.ac.be/wiki/2HDM
      - We use “h2” as φ.
    - Default THDM_CKM is similar to SM_CKM, but H0->bb is not available.
  - In mc-2020, why the b-quark mass appears as a few GeV even if we set “mb=0” in the input sindarin?
    - I understand that the decay of higgs is described by PYTHIA in mc-2020.
    - Currently I describe this process as follows;

      process mumubbbb = "e-" , "e+" => "mu+", "mu-", "h2", "h2" { $restrictions = "3+4~Z && 5+6~h1" }

      process h2dec = h2 => "b" , "b~"
  - Are there any other points to check?



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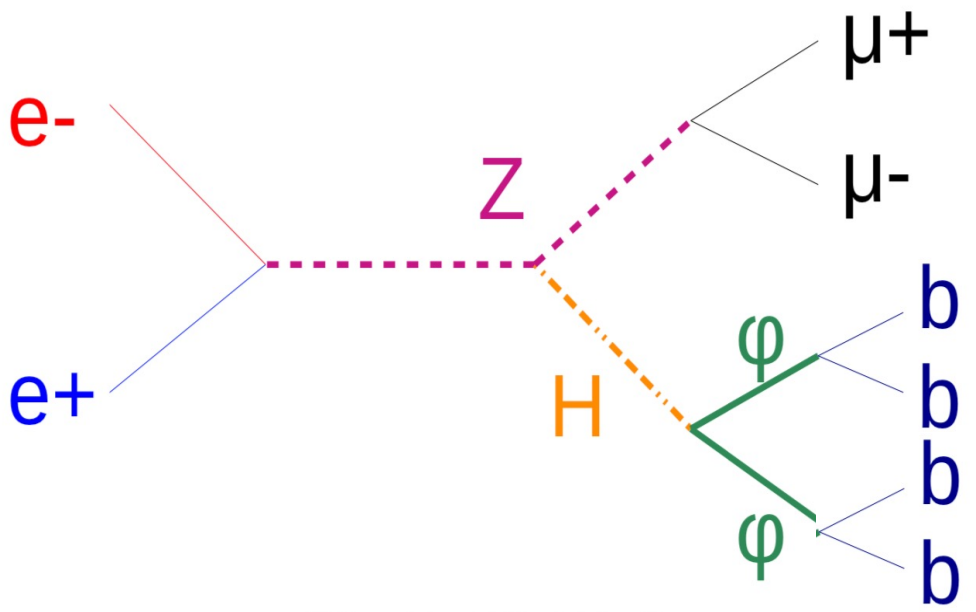

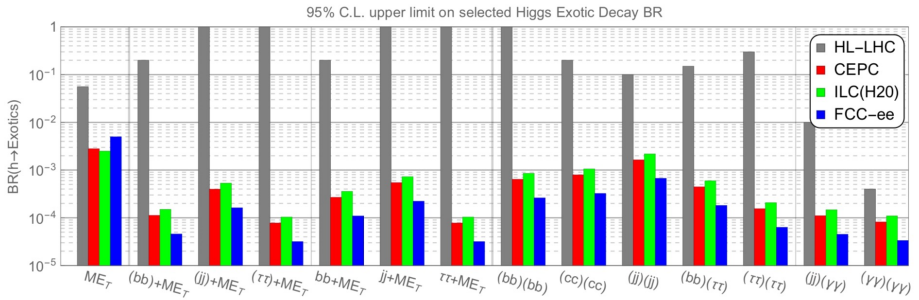

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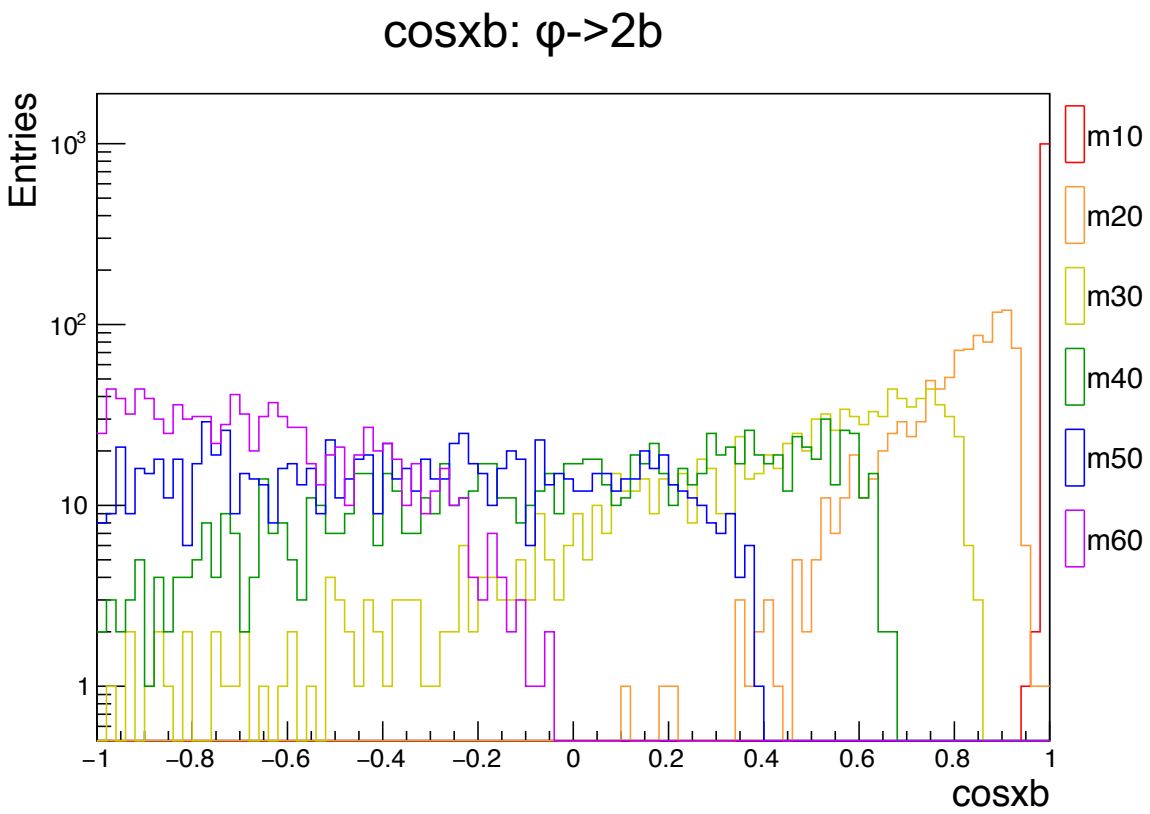
backup

b クォーク間の角度

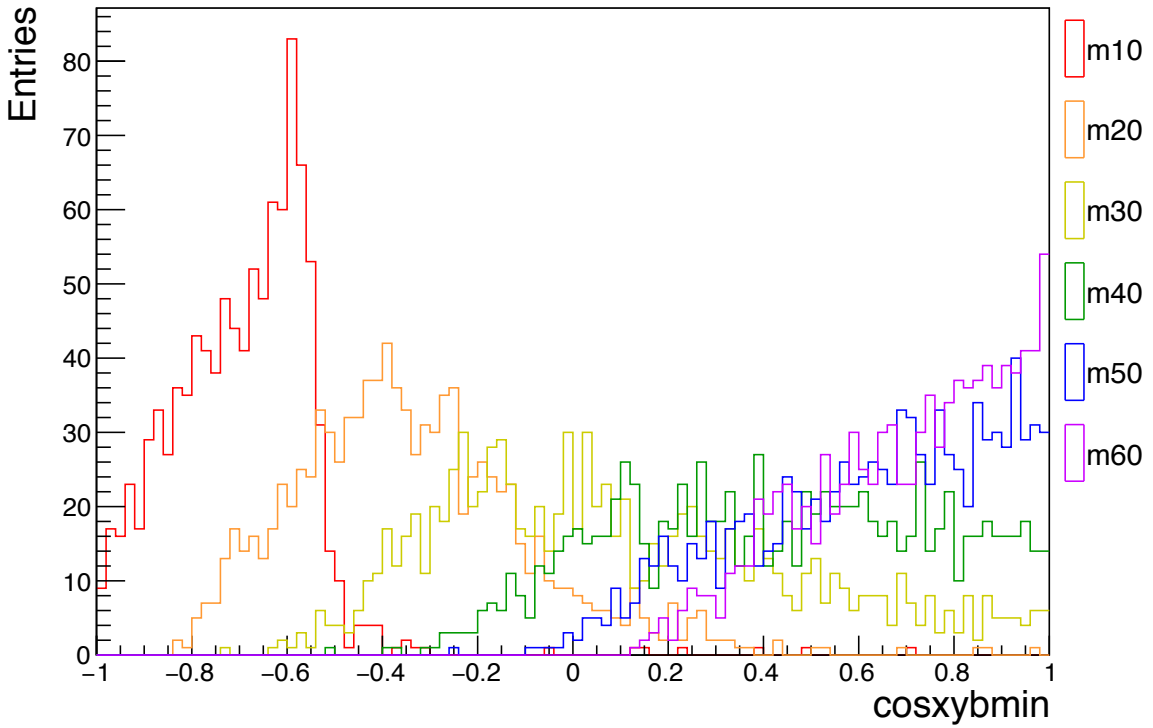


- クォーク間の角度が小さい領域
  -> vertex 2つのジェットになる
  -> まずは LCFIPlus が効果的か
  - (double b-tag も可能性あり)

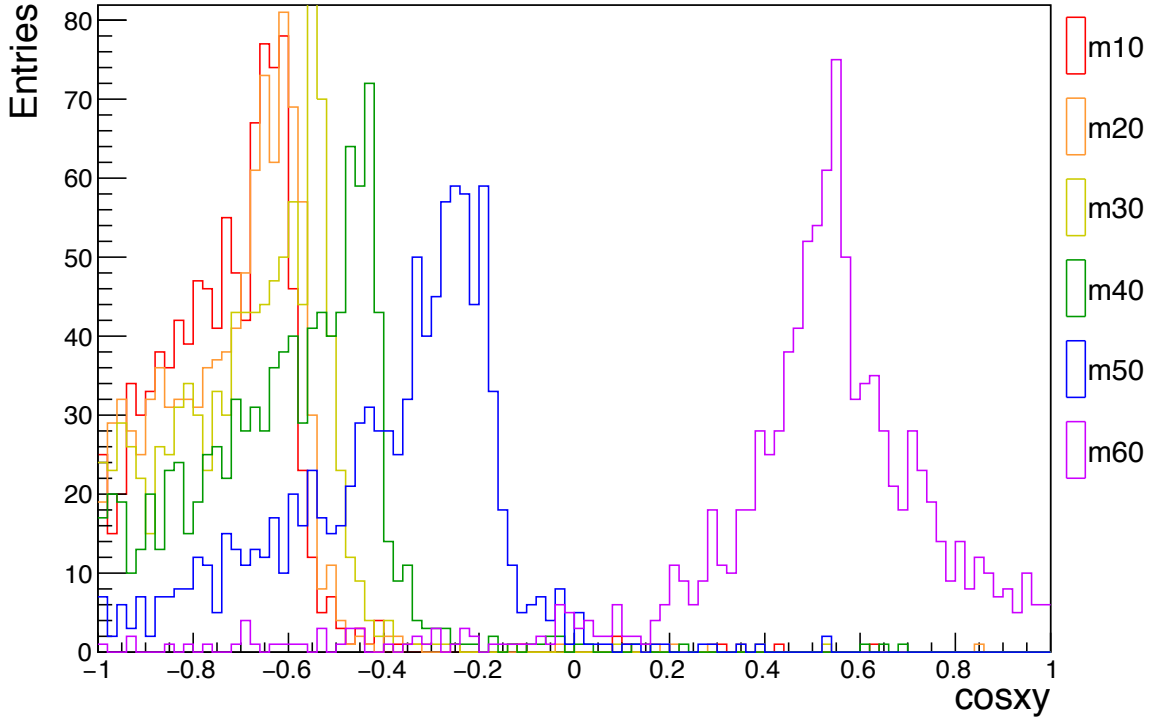
- 候補: m15, 20, 30, 40, 50, 60, (62.5, 11)
  - m10 だと Bハドロンが4つできない
  - 優先度
    - {30}, {15,60}, {のこり}
    - 理論ペーパーに合わせる

b クォーク間の角度

cosxybmin: 親が異なるbのペアで角度が最小のもの



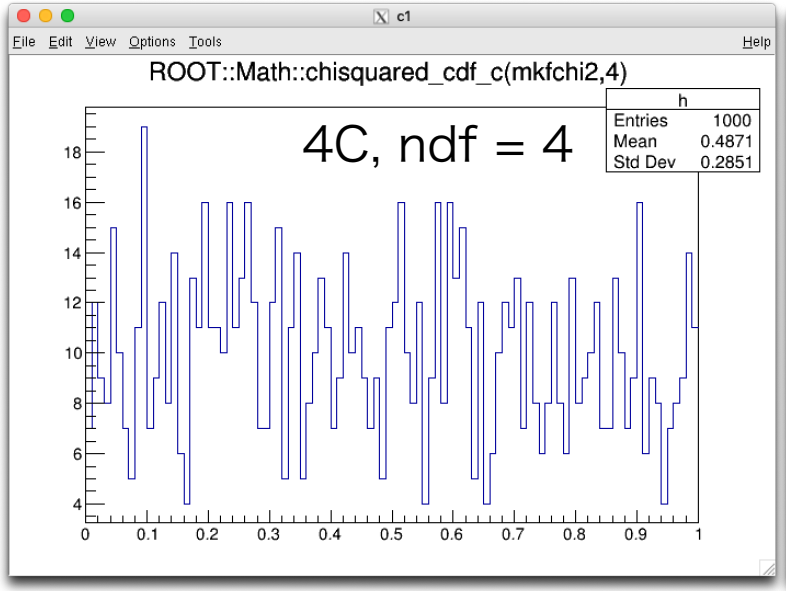
(参考) cosxy: φ(35), φ(36) の間の角度

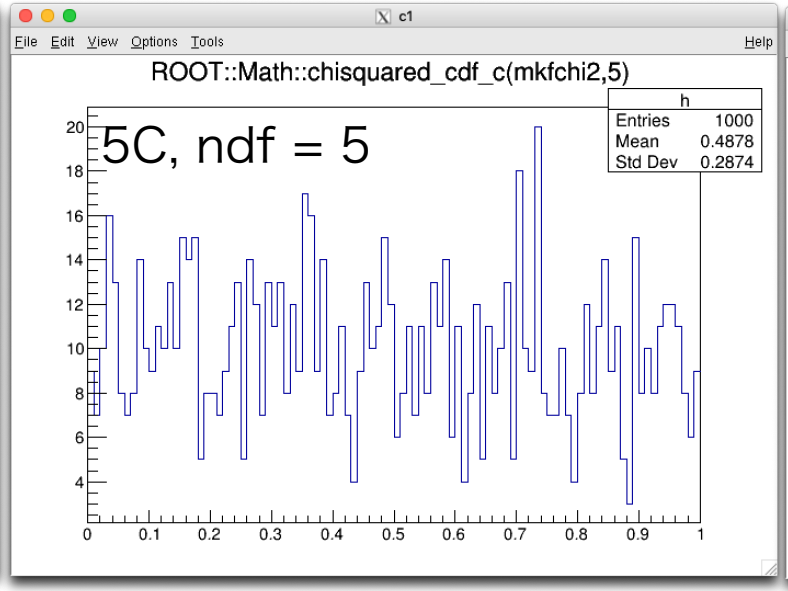


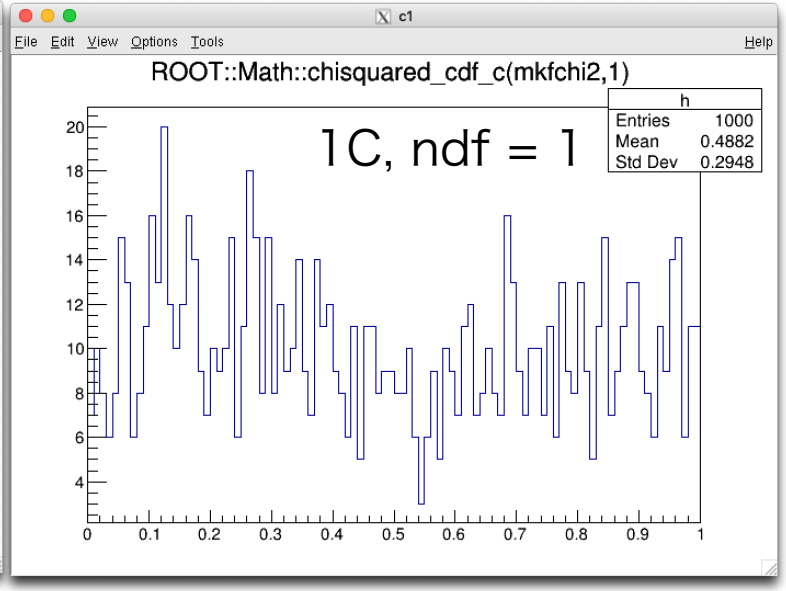
- m60 でも LCFIPlus による分離が期待できる

Test of χ^2 and degrees of freedom

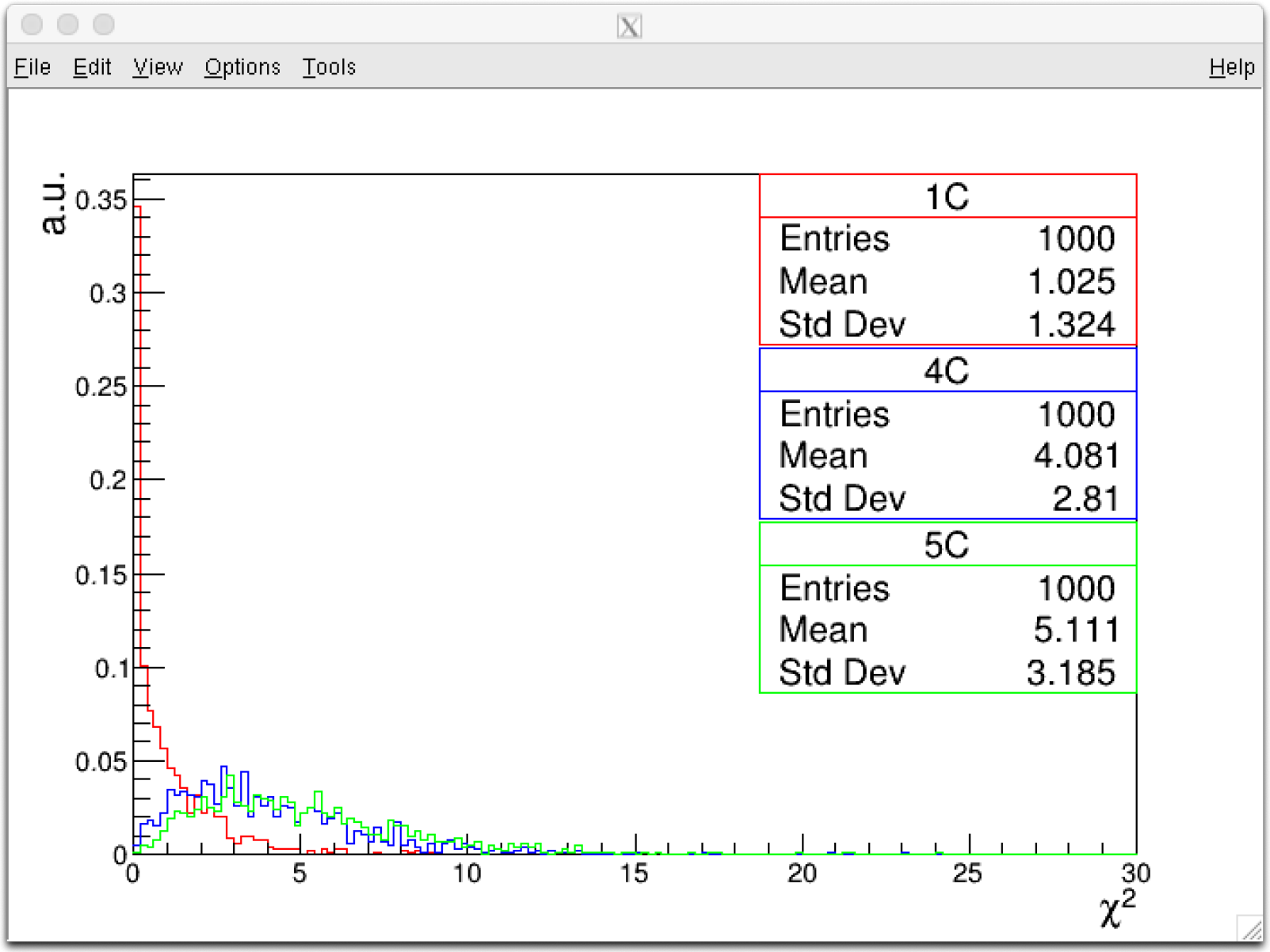
- Fast simulation
  1. Generate pseudo samples of ZH -> 4 particles which parameters {E, θ, φ} have Gaussian errors;
     σ_E = 1 [GeV], σ_θ = 0.1[rad.], σ_φ = 0.1[rad.]
  2. Perform the kinematic fit under the 4 jets assumption which parameter errors are Gaussian above.
  3. Estimate the degrees of freedom from the χ^2 distribution when each constraint is applied;
     4C: Energy momentum, 5C: Energy momentum & Higgs mass, 1C: Energy
- Results: fit probability

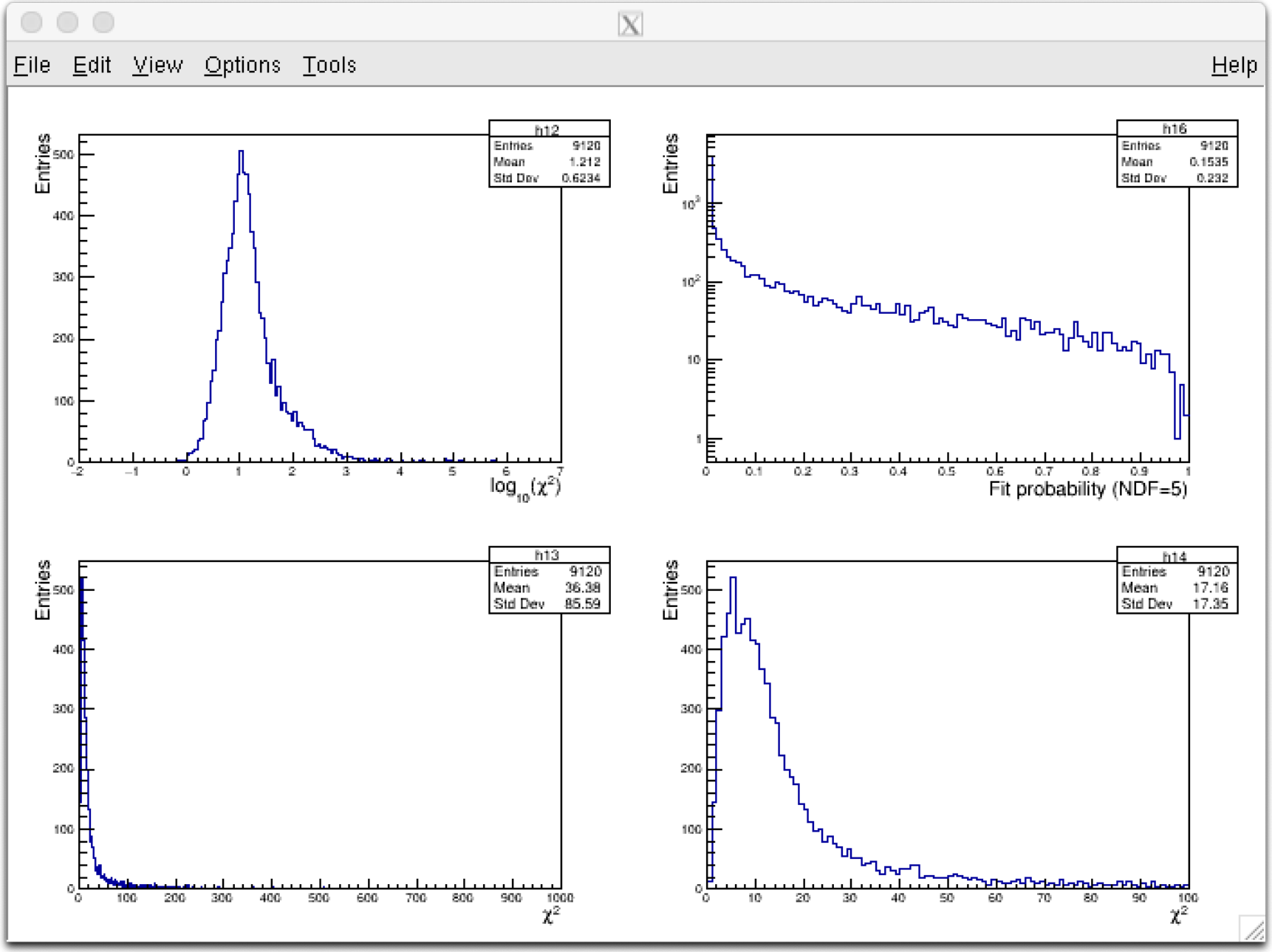






The χ^2 distributions show that the d.o.f. equals the number of constraints.
Our kinematic fitter evaluates the χ^2 output correctly in the simplest case.


File Edit View Options Tools Help
a.u.
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0 5 10 15 20 25 30
χ^2
1C
Entries 1000
Mean 1.025
Std Dev 1.324
4C
Entries 1000
Mean 4.081
Std Dev 2.81
5C
Entries 1000
Mean 5.111
Std Dev 3.185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h12
Entries 9120
Mean 1.212
Std Dev 0.6234
Entries
log10(χ2)
h16
Entries 9120
Mean 0.1535
Std Dev 0.232
Entries
Fit probability (NDF=5)
h13
Entries 9120
Mean 36.38
Std Dev 85.59
Entries
χ2
h14
Entries 9120
Mean 17.16
Std Dev 17.35
Entries
χ2

Setup of kinematic fit for e^+e^- -> ZH -> μμbb

Fit Objects:

- JetFitObject (JFO) x 2
  - parameter: (E, θ, φ) with b-jet resolution
    E: Crystal Ball, θ: Gaus, φ: Gaus
  - $\text{mass}^{\text{fit}} \equiv E^{\text{fit}}/E^{\text{meas.}} \times \text{mass}^{\text{meas.}}$
  - Resolutions are adjusted by (E, cosθ) for each jet
- MuonFitObject (MFO) x 2
  - parameter: (Pt, θ, φ) with Gaussian error from track parameters
- ISRPhotonFitObject
  - parameter: Pz (E_{max} = 31.5 GeV)

$$\mathcal{P}\left(p_{\mathrm{z},\gamma}\right) = \frac{\beta}{2E_{\max}} \cdot \left|\frac{p_{\mathrm{z},\gamma}}{E_{\max}}\right|^{\beta-1} \qquad \beta = \frac{2\alpha}{\pi}\left(\ln\frac{s}{m_{\mathrm{e}}^2} - 1\right)$$

Constraints:

- Hard:
  - Total Energy/Px/Py/Pz for all FOs
  - Higgs mass = 125 GeV for 2 JFOs
- Soft:
  - Z mass w/ Breit-Wigner for 2 MFOs with mean 91.2 GeV and width 2.5 GeV