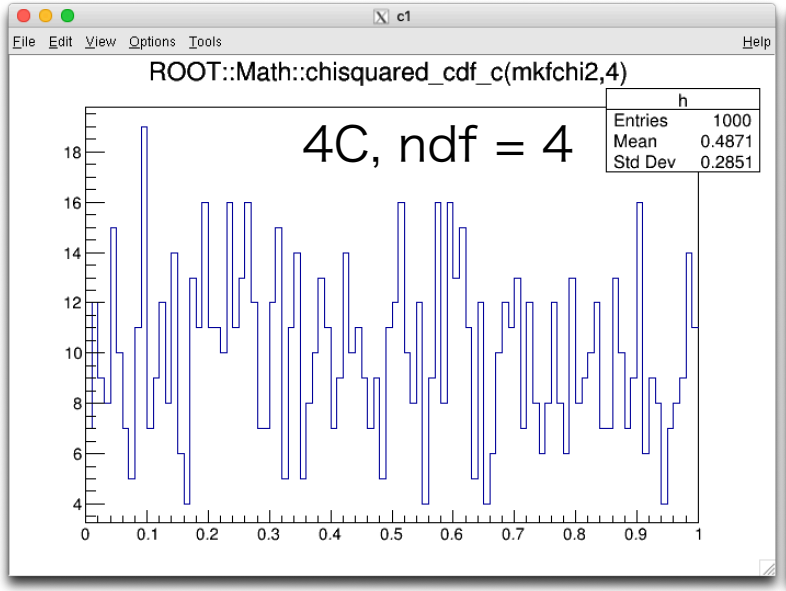
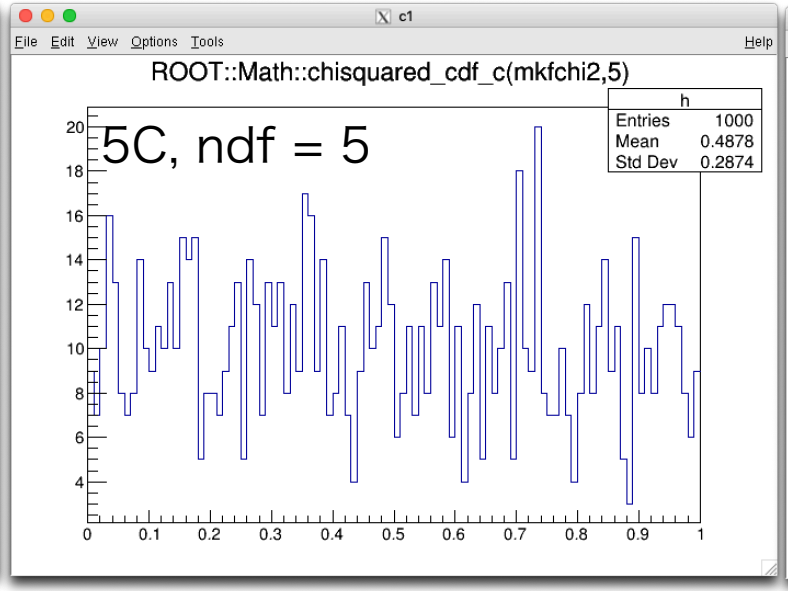
Asian Physics and Software meeting 2021.4.16

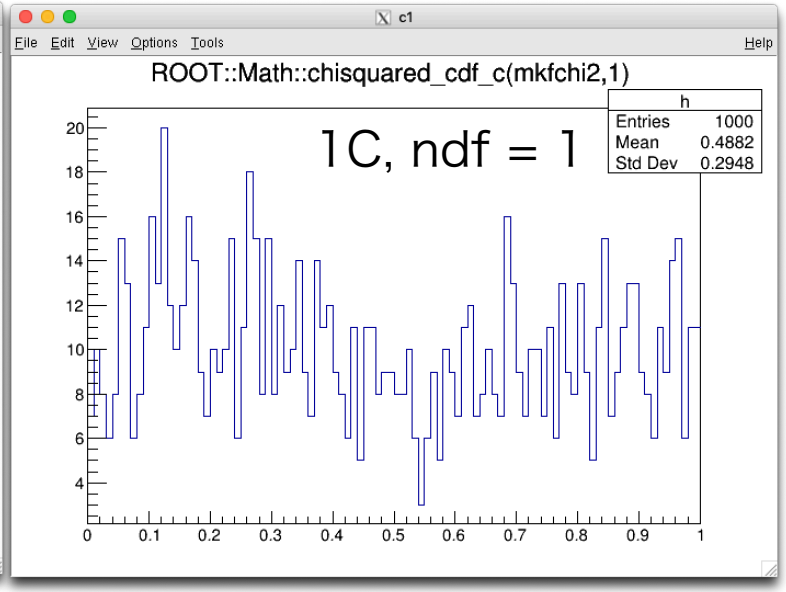
- Status reports:
  - Performed the fast simulation of kinematic fit for the check of the χ^2 outputs.
  - Try to generate ZH->μμbbbb sample at 250 GeV.
    - WHIZARD step is done based on ILC Analysis Workthrough.
    - Test of ddsim is in progress.
    - ? Which overlay bkg files should we use in the reconstruction phase?

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.

backup

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

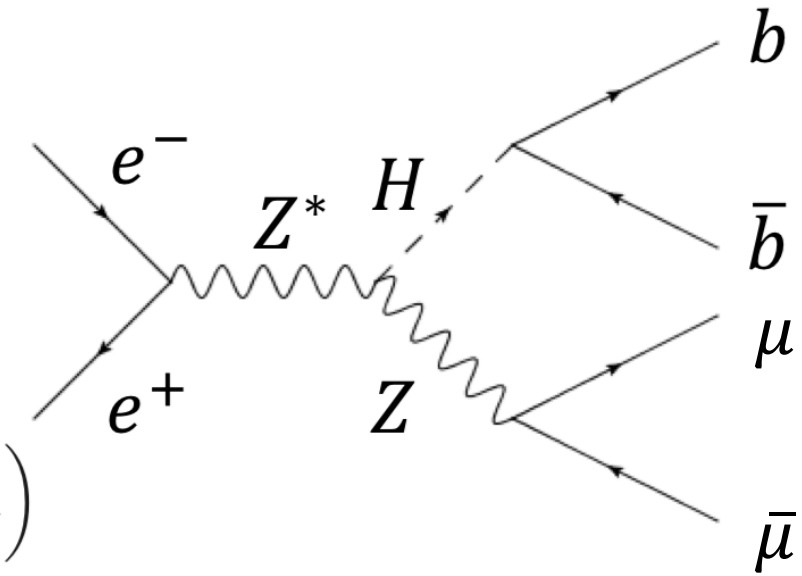
Fit Objects:

- 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)

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

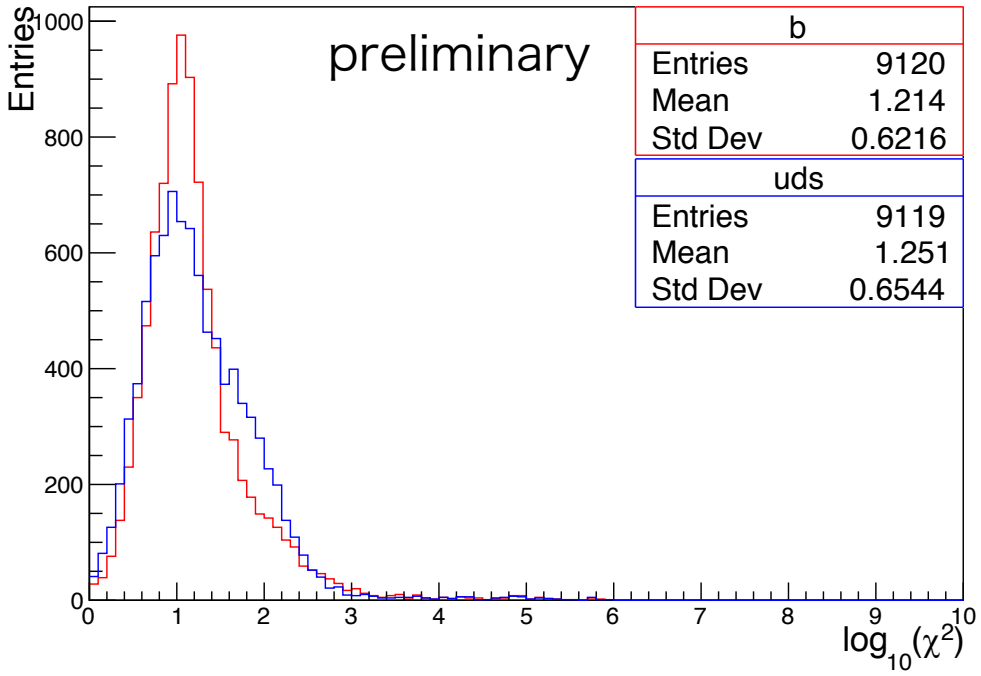
Constraints:

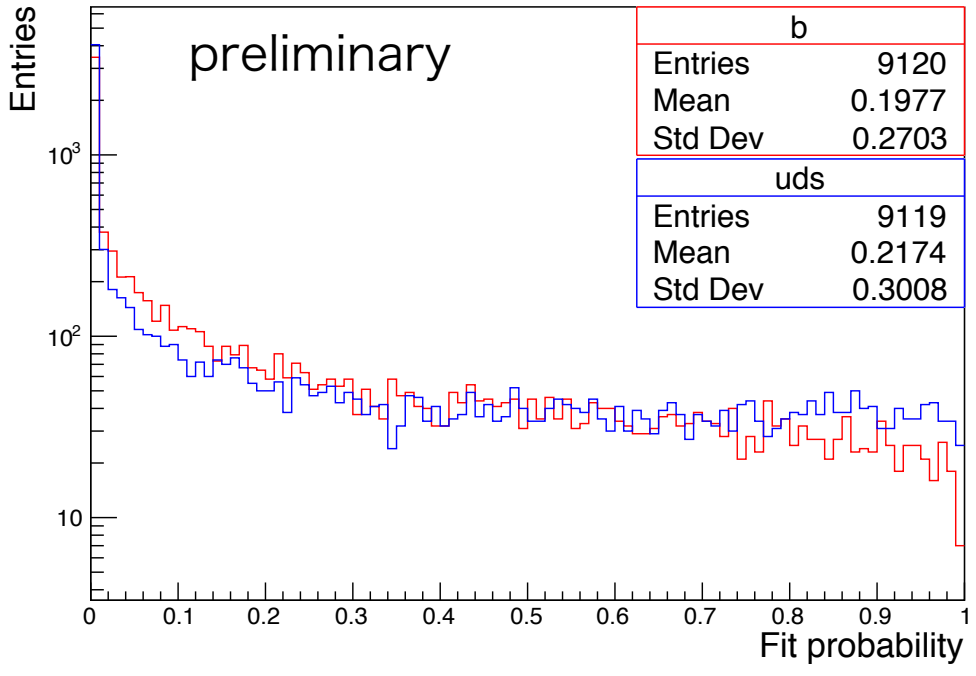
- Hard:
  - Total Energy/Px/Py/Pz for all FOs
  - Higgs mass = 125 GeV for 2 JFOs
- Soft:
  - Z mass w/ Breit-Wigner for 2 MFOs with mean 91.2 GeV and width 2.5 GeV



Fit Result: comparison of b/uds resolution

- We also obtained the result which use uds-jet resolutions.
- χ^2 is better for b-jet case.
- Fit probability flatness is slightly worse for b-jet case.
- A detailed check is in progress.





自由度と fit probability についての考察

- フィッティングの自由度: ndf = m - p
  - 一般的には “測定点の数(m) - パラメータの数(p)”
- χ^2とラグランジュ未定乗数項のみのシンプルな kinematic fit を考えると
  - m = p’ = パラメータの数 e.g. Ej, θj, ϕj, ... constraint なしでは測定点とパラメータの数は同じ
  - #constraint: c
  - p = p’ - c constraint によって実質的なパラメータ数が打ち消される
  - ndf = m - p = c
- fit probabilityについて
  - 0 付近が多い → 想定したχ^2分布より大きいχ^2が多い, テールの影響, 過小評価
  - 1 付近が多い → 想定したχ^2分布より小さいχ^2が多い, エラー or ndf を過大評価している
- μμbb fit で得た fit probability について
  - ndf = c = 5 とすると
    - 0 にピーク → テールが影響している, SCが悪化原因？
    - 他はフラット? → χ^2分布の形状自体は近い？
  - ndf = m - c = 8 とすると
    - 1 付近が若干増加 → ndf の過大評価？

fit probability

- χ^2分布から、fit probability を得られるようにした
  - fit probability:

$$P(\chi^2) = \int_{\chi^2}^{\infty} f(\chi'^2; \nu)\, d\chi'^2 = 1 - F(\chi^2; \nu)$$

    - フィットが適切に行えているかの指標になる, 適切であればフラットな分布
    - 自由度ν: nHardCostraint + nSoftConstraint <- SC の自由度はこれで正しい？