Status report

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29/June/2021

Analysis of 100 events

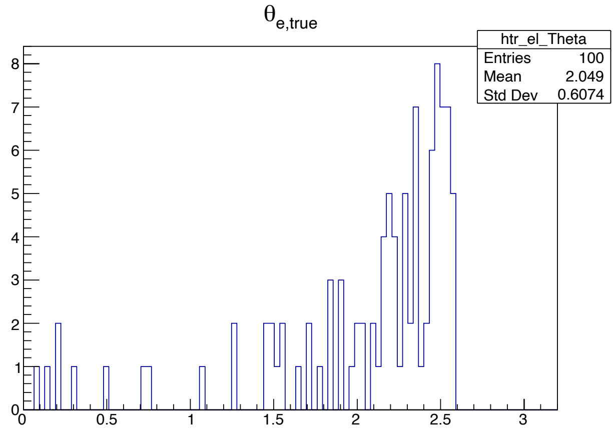
- NC, 18x275, Q^2>100 GeV^2, after **detector simulation**
  - Run on 22/June. (Any recent update is not included.)
  - Using Ralf's analysis module (SIDIS), in order **to fill the eta values of calorimeter clusters.**
    - Default simulation:

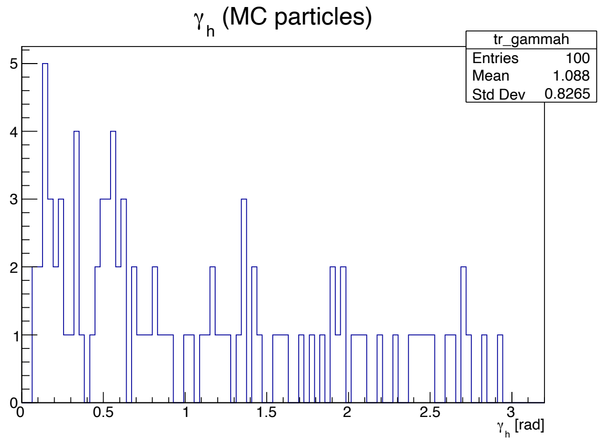
      Eta of calorimeter clusters are set to -10000, as they look for event vertex position, which are unavailable.
    - Eta values are set with vertex=(0,0,0)

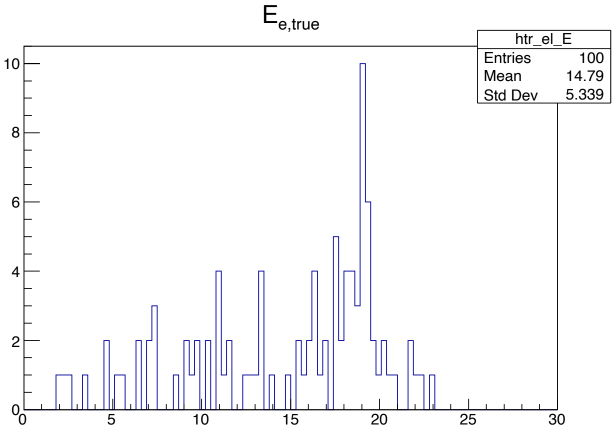
- Look into calorimeter clusters.
  - Matching to truth electron → electron candidate
  - Kinematic reconstruction using calorimeter energies.

Truth distributions

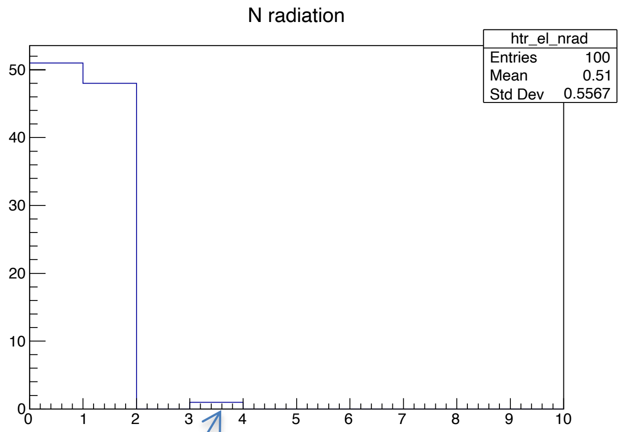
- Based on HEPMC particle information.
- γ_h is calculated from MC particles from all the proton side.
  - In QPM, γ_h corresponds to the polar angle of scattered quark.

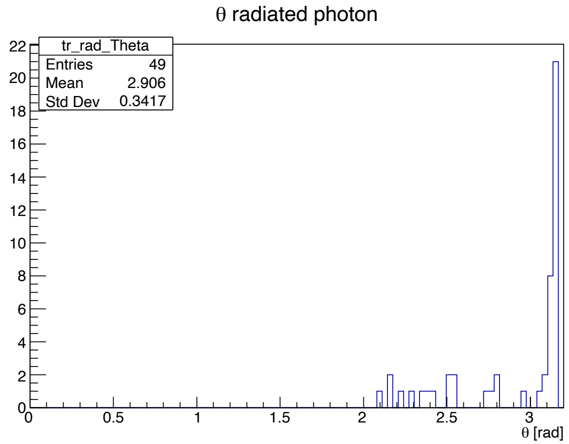


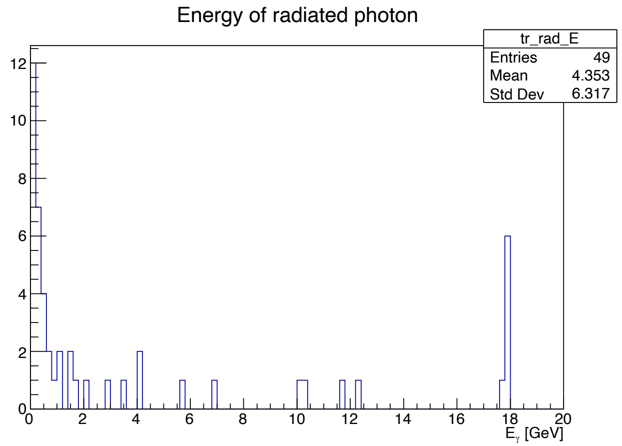




Radiative photons (Truth)





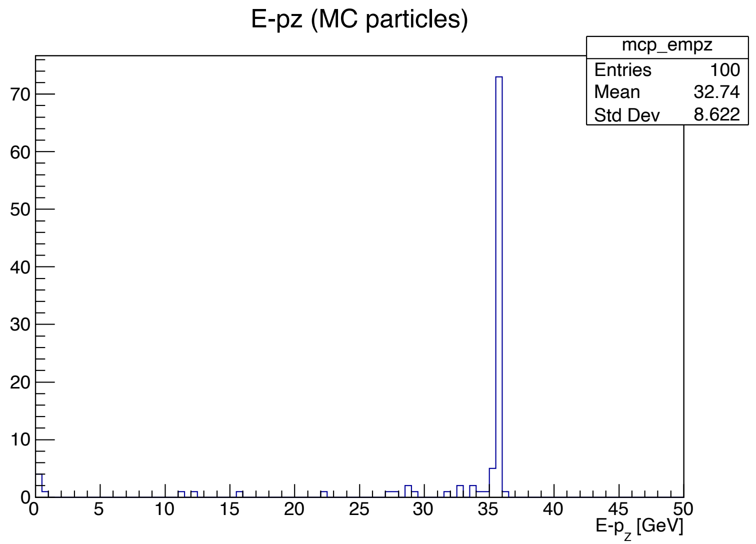


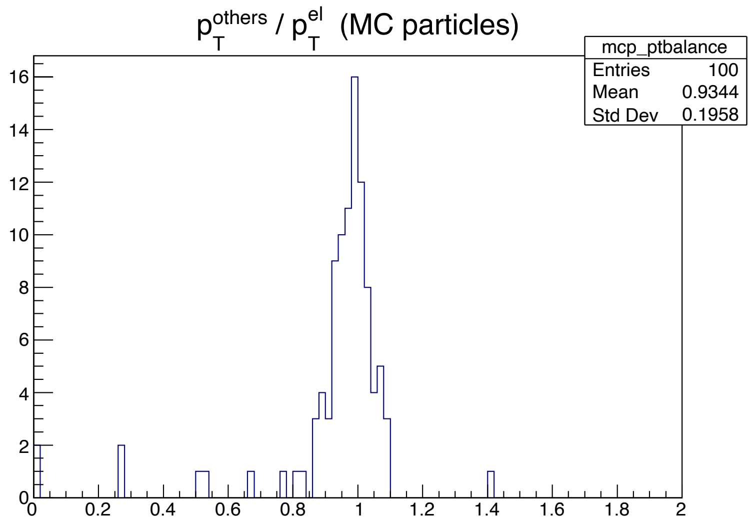
This one is not yet understood. It contains particles with hepmc status=1 (final state particle) but PDG ID = 2 (u-quark) and 90 (MC internal)??

- Half of events have real photon emission.
- Peak at θ~π is seen.
  - ISR photon
- Some photons are quite hard.

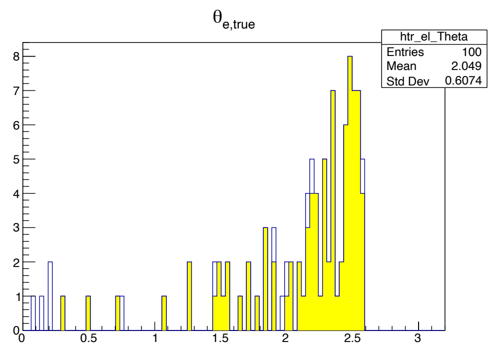
Pre-selection based on truth particles

- This is to analyse events with good event property.
  - $\Sigma(E\text{-}p_Z) > 25$ GeV, where sum runs over all the MC particles in $-3.5<\eta<3.5$.
  - $0.6 < p_T^{others}/p_T^{el} < 1.4$, where "el" is for electron and "others" are for all other MC particles including radiative photons.





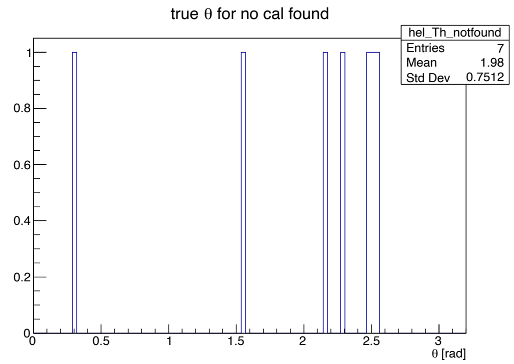
If all the scattered particles are in the detector, $\Sigma(E\text{-}p_Z)$ should be $2E_e^{beam}$. $E\text{-}p_z\sim0$ for particles going along with proton beam direction.



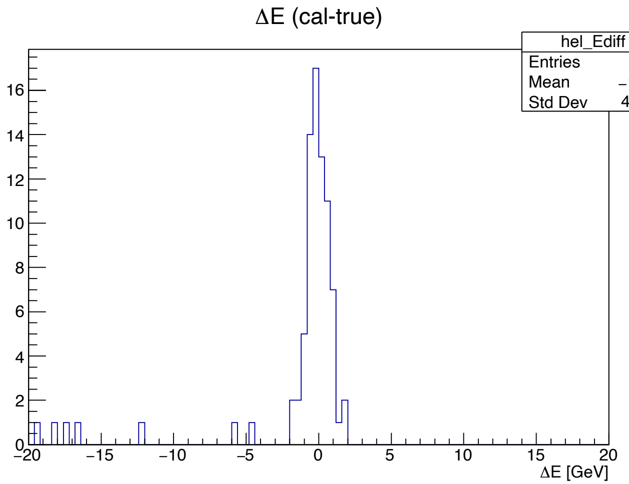
88 events passed the preselection

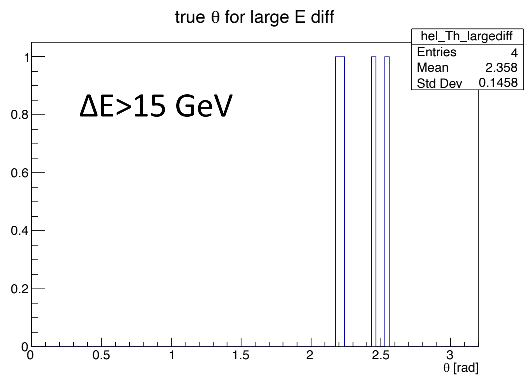
Electron matching to calorimeter clusters

- Calorimeter clusters in a (η, ϕ) cone of 0.1 from the truth electron are considered as electron candidates.
  - 7 events fails matching.
    - All of them have a radiated photon.
    - 2 events (θ=0.32, 1.54) have candidates but failed matching.
    - Others don't have good candidate clusters.



  - A few events show large energy difference between the candidate and truth electron.
    - These events don't contain clusters with E>10 GeV, while $E_{e,\ truth}$~18 GeV.





Need more statistics to understand electrons/clusters in the rear side.

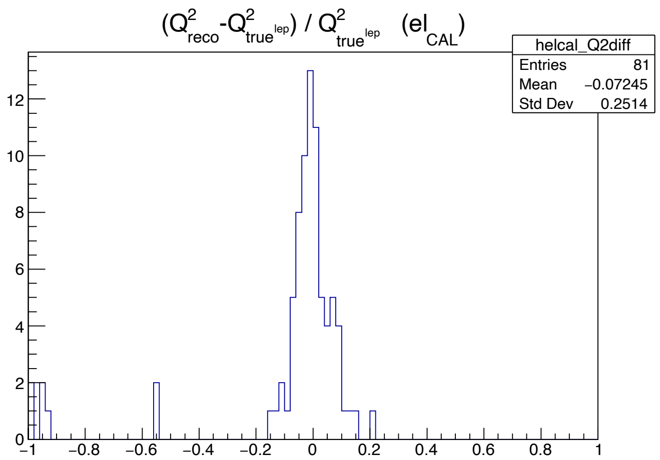
Electron method vs true leptonic kin. variables

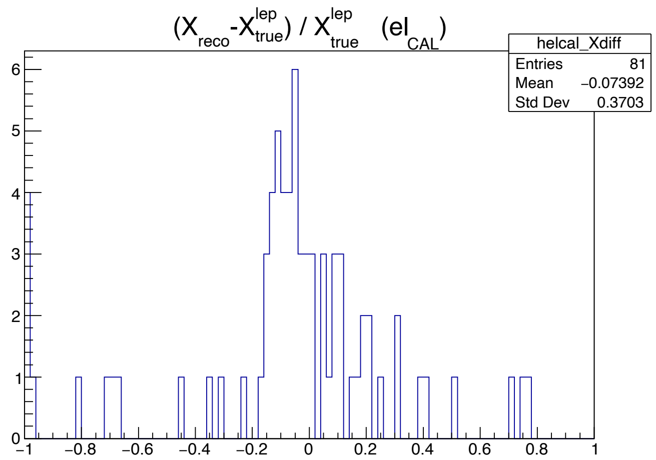
- Truth is taken from DJANGOH generator.
- Electron method is applied for found electron candidates, i.e. calorimeter clusters.
  - Not bad as a first trial.

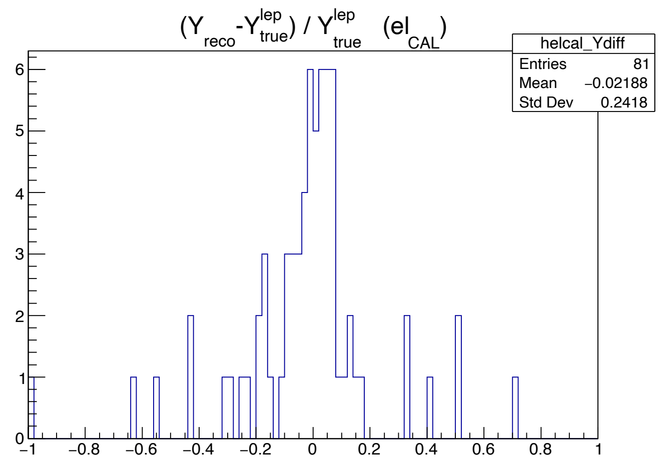
$$y_{el} = 1 - \frac{E'_e}{2E_e}(1 - \cos\theta_e)$$

$$Q^2_{el} = 2E_e E'_e (1 + \cos\theta_e)$$

E_e: electron beam energy
E'_e: scattered electron energy
θ_e: scattered electron angle







Hadron variables

- Hadron side variables:

$$\delta_h = \sum_h (E - p_z)_i \quad p_{T,h} = \sqrt{\left(\sum_h (p_{x,i})\right)^2 + \left(\sum_h (p_{y,i})\right)^2}, \quad \cos\gamma_h = \frac{p_{T,h}^2 - \delta_h^2}{p_{T,h}^2 + \delta_h^2},$$

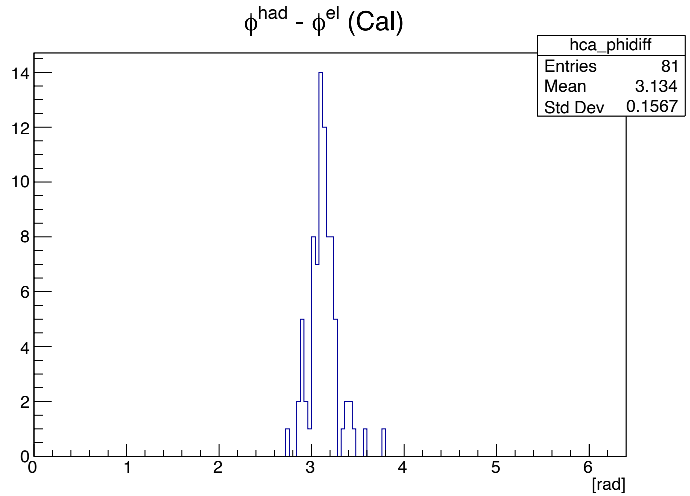
  Σ_h runs over all particles in the final state except the scattered electron.

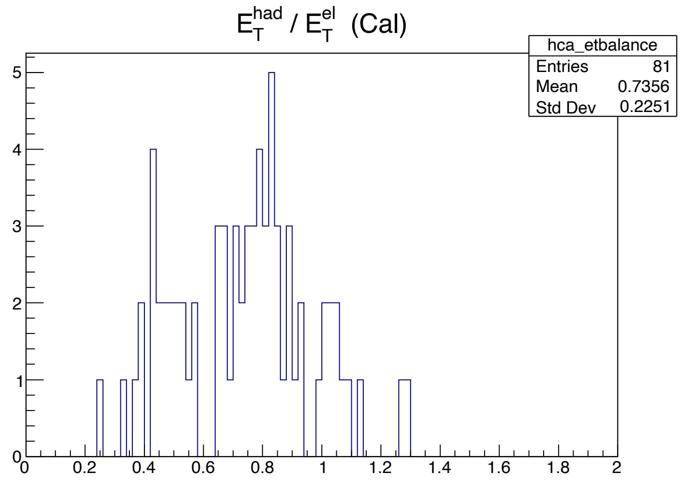
- Reconstruction:
  - e.g. ZEUS experiment
    - Σ_h runs over calorimeter energy deposits, using **calorimeter clusters**.
      - Noise suppression → Clustering → Energy correction (e.g. DM)
      - "Backsplash" rejection: Rejection of secondary particles from a high energy particles hitting the forward CAL or beam pipe.
      - Invariant mass of the clusters are set to the pion mass
  - Today
    - Use all the calorimeter clusters, neglecting mass.

    → Will provide worst reconstruction. (Can be considered as poorest case.)

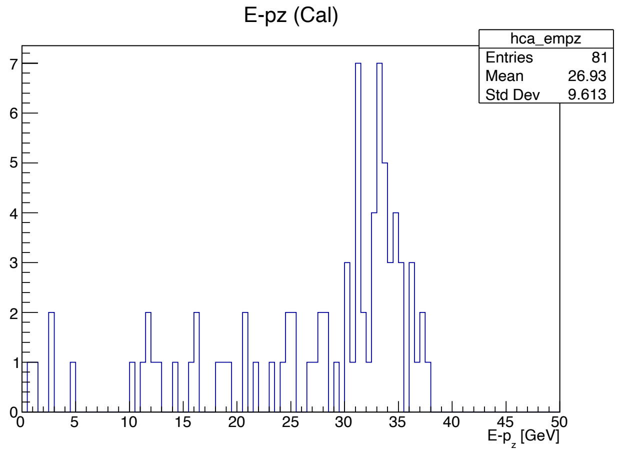
Event properties

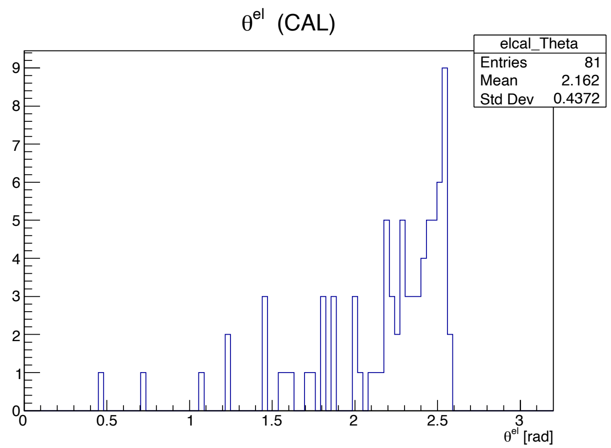
- Balance between electron clusters and hadron clusters

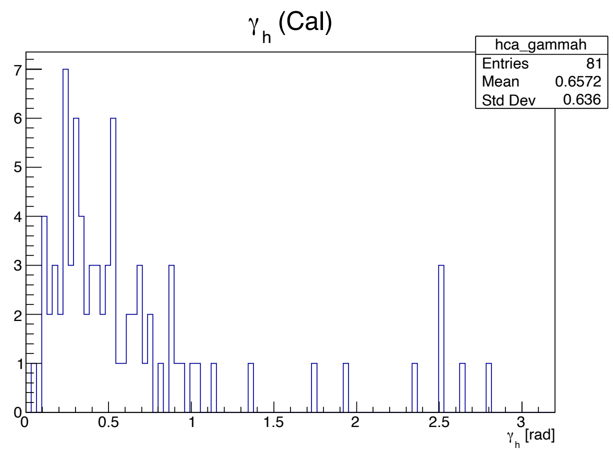




- Event properties

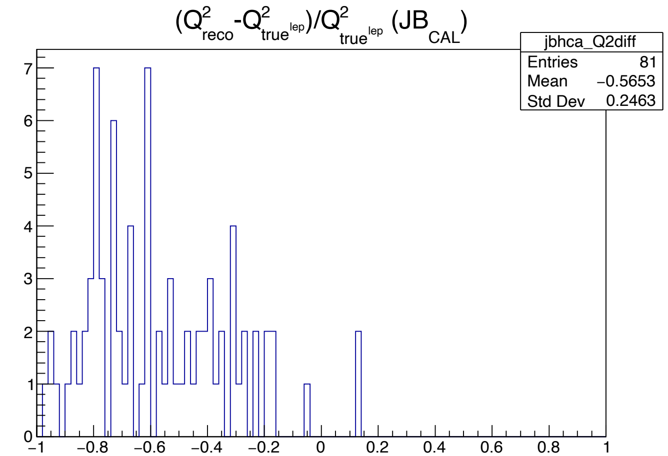






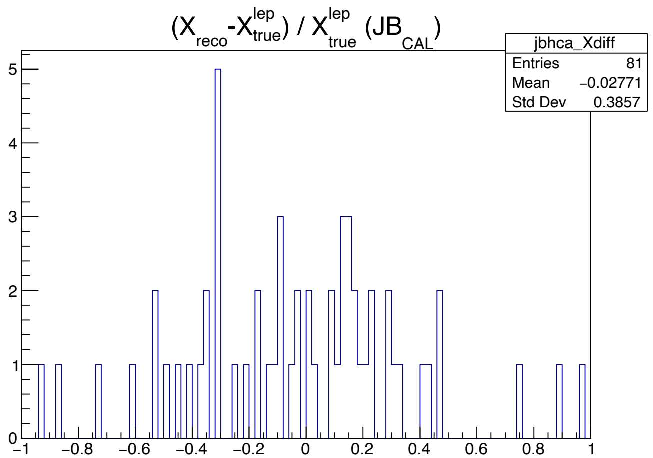
JB method vs true leptonic kin. variables

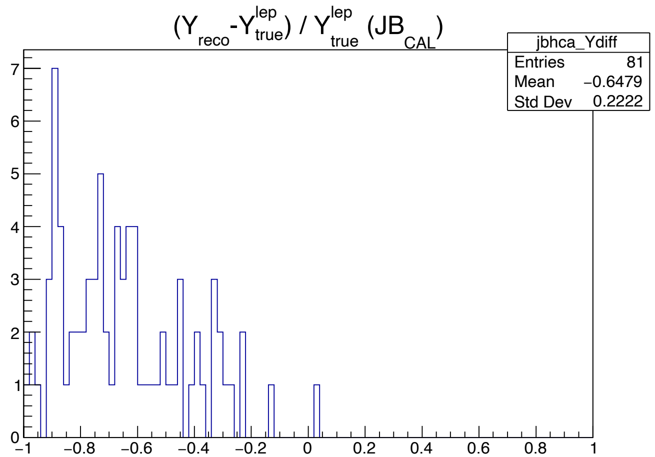
- Expected to have bad resolution.
- Bias is seen even for y.
  - Could be reconstructed δ_h is too small.
    - Need to improve how to use calorimeter clusters.



$$y_{JB} = \frac{\delta_h}{2E_e}$$

$$Q^2_{JB} = \frac{p^2_{T,h}}{1 - y_{JB}}$$





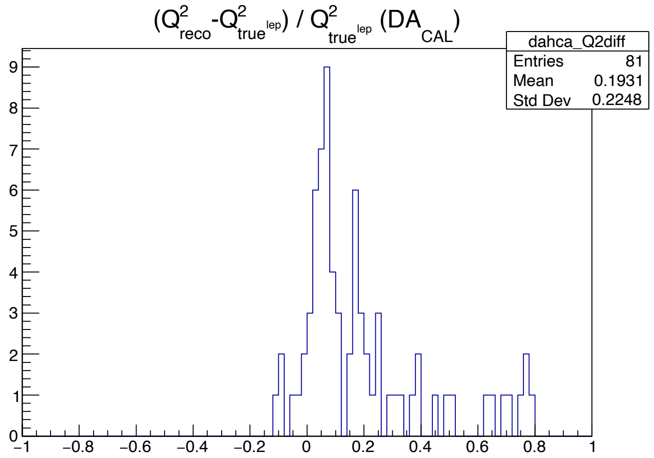
DA method vs true leptonic kin. variables

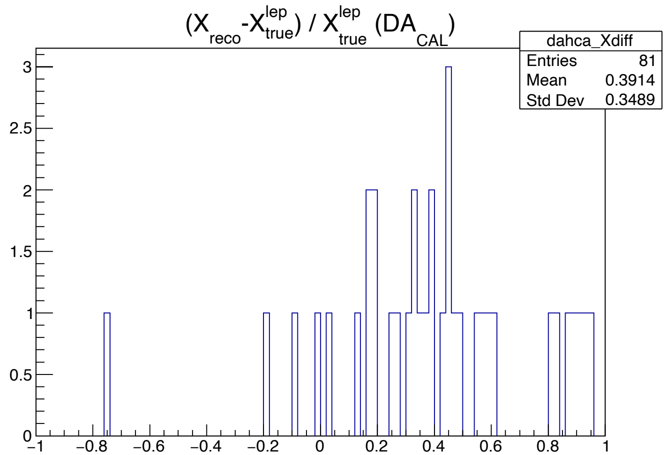
- DA method

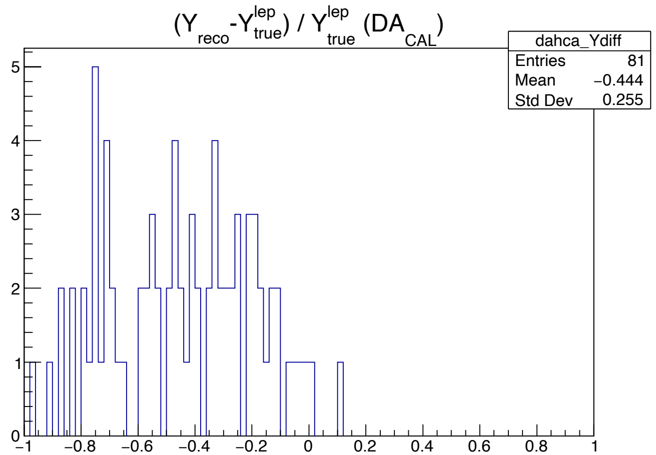
$$Q^2_{DA} = 4E_e^2 \frac{\sin\gamma_h(1+\cos\theta_e)}{\sin\gamma_h + \sin\theta_e - \sin(\gamma_h+\theta_e)}$$

$$x_{DA} = \frac{E_e}{E_p}\frac{\sin\gamma_h + \sin\theta_e + \sin(\gamma_h+\theta_e)}{\sin\gamma_h + \sin\theta_e - \sin(\gamma_h+\theta_e)}$$

$$y_{DA} = \frac{\sin\theta_e(1-\cos\gamma_h)}{\sin\gamma_h + \sin\theta_e - \sin(\gamma_h+\theta_e)}$$







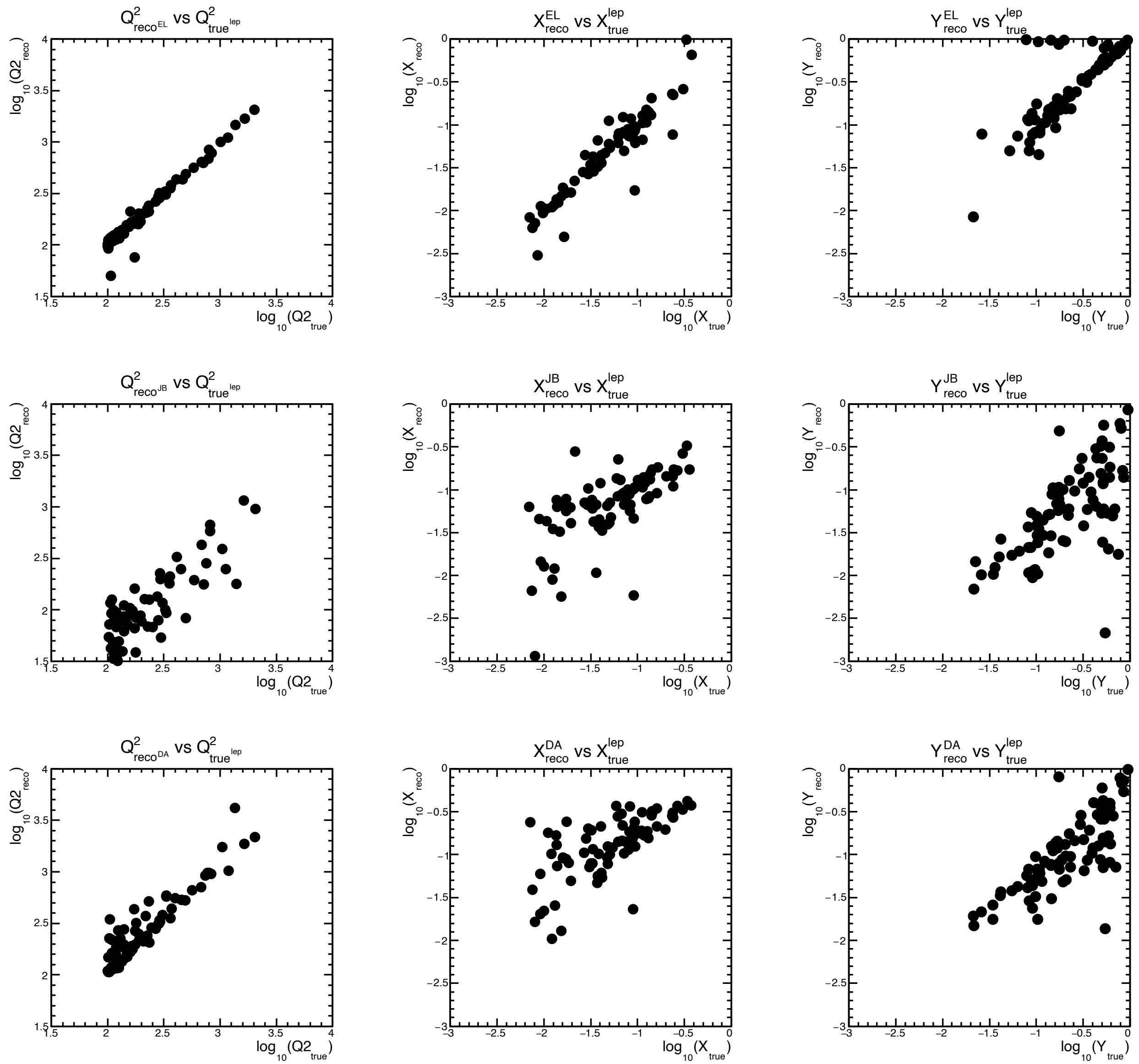
- Poor reconstruction of γ_h gives biased x_{DA} and y_{DA}.

Summary plot

EL

JB

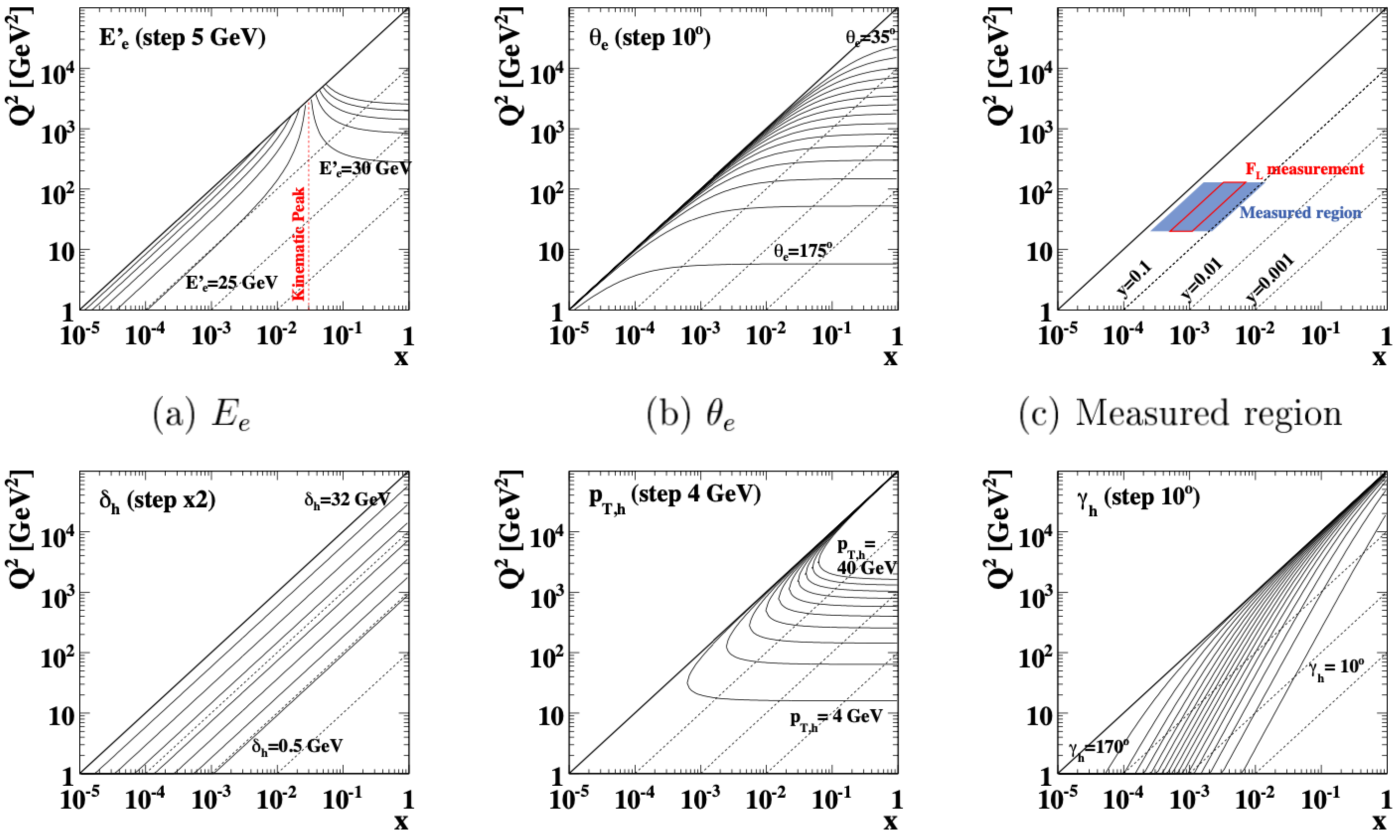
DA



Next step:

- Consider better treatment of calorimeter clusters.
  - Cluster mass
  - Rejection of noise clusters.
- Also learn how to make use of truth information of clusters.

Backup: HERA Kinematic plane



(a) E_e (b) θ_e (c) Measured region

(d) δ_h (e) $p_{T,h}$ (f) γ_h

Electron method

Use E_e and θ_e →

Good at low x, low Q^2

Worse x determination at high x.

JB method

Use δ_h and $p_{T,h}$ →

Reasonable estimation at low y

DA method

Use θ_e and γ_h →

Better at high Q^2

Worse at high y