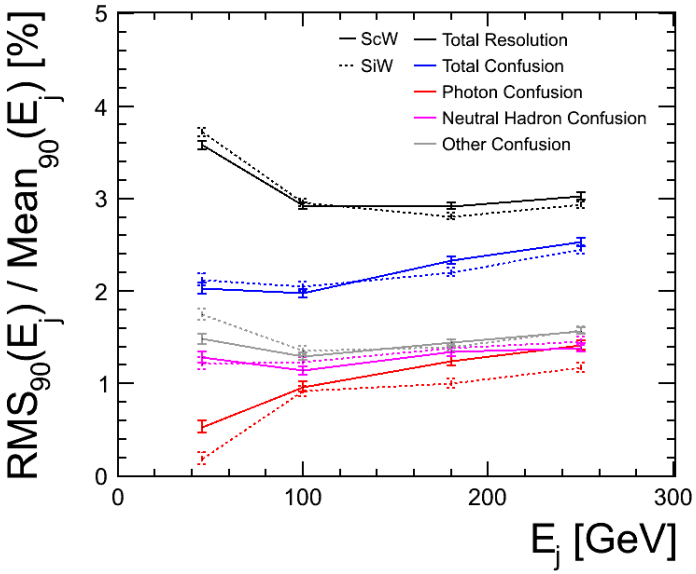
Cluster Uncertainties
- a basis for discussion -

ILD sw/ana meeting, June 17 2015

Jenny List

What ?

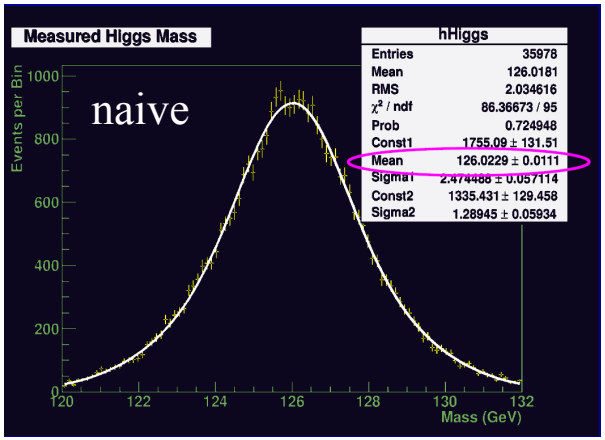
- Particle flow, "1st order":
  - very successful reconstruction of jet energy
  - jet energy resolution 3-4%
  - but: JER averaged over all jets!
- Particle flow, "2nd order":
  - exploit the full power of PFlow by assigning jet-by-jet uncertainties following PFlow paradigm:

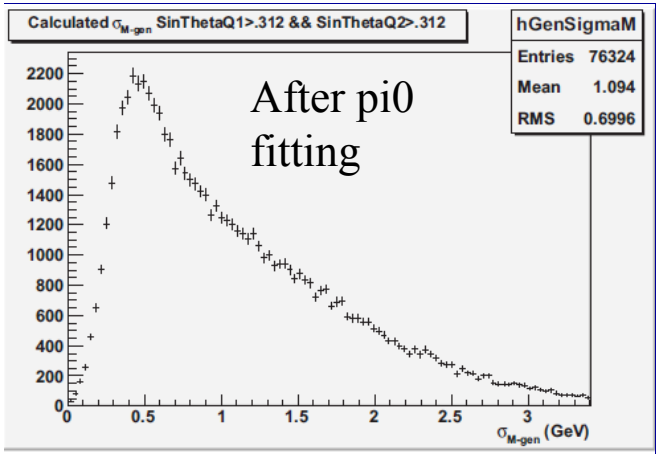


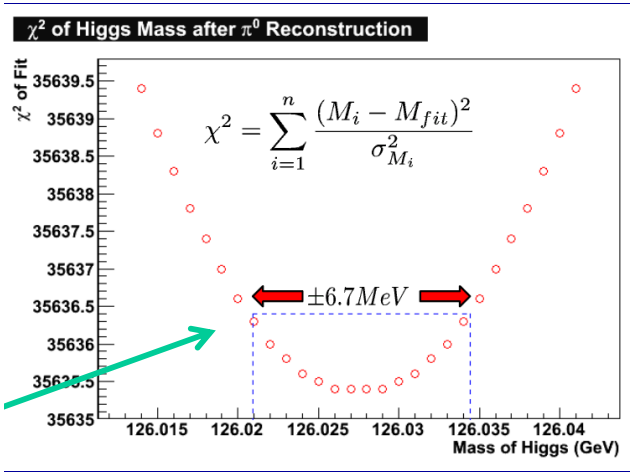
$$\sigma_{jet} = f_{charged}\,\sigma_{track} \text{ "+" } f_{photon}\,\sigma_{ECal} \text{ "+" } f_{neut.had.}\,\sigma_{HCal} \text{ "+" } \sigma_{confusion}$$

Why?

- the neutral hadron fraction varies considerably
- jets with small neutral hadron fraction are better measured!
- E.g. G. Wilson: Higgs mass reco with event-by-event error knowledge (and pi0 fitting)







How?

Tricky part!

$$\sigma_{jet} = f_{charged}\,\sigma_{track} \text{ “+” } f_{photon}\,\sigma_{ECal} \text{ “+” } f_{neut.had.}\,\sigma_{HCal} \text{ “+” } \sigma_{confusion}$$

Reconstruction flow of a jet:

- calorimeter hits
- form **Clusters**
- combine w tracks to **PFOs**
- combine to **Jets**

=> at which level should confusion enter error calculation?

Measured in calo

PFlow Algorithm (Pandora)

Jet Algorithm

Increasing confusion

Proposal

- Clusters:
  - estimate uncertainties **purely from calorimetric measurement**
  - no attempt to take into account confusion
- PFOs:
  - track uncertainty for charged PFOs
  - cluster uncertainty for neutral PFOs
  - confusion?
    - conceptionally: to be discussed - eg for neutrals based on distance to next charged? Based on Pandora reclustering? ....? Or not at all at this stage?
    - **pragmatically: no confusion for now, see where it get's us!**
- Jets:
  - obvious place to try to add confusion
  - still needs work and discussion to find a good approach!
  - having the unconfused cluster / PFO uncertainties will be a prerequisite to study this

EVENT::Cluster – my assessment

- Properties:
  - virtual float getEnergy () const =0
    Energy of the cluster. filled
  - virtual const float * getPosition () const =0 Position of the cluster.
    filled
  - virtual float getTheta/Phi () const =0
    Intrinsic direction of cluster at position: Theta /Phi
    not filled?
- Uncertainties:
  - virtual float getEnergyError () const =0
    Returns the error on the energy of the cluster. not filled
  - virtual const EVENT::FloatVec & getPositionError () const
    Covariance matrix of the position (6 Parameters).
    not filled
  - virtual const EVENT::FloatVec & getDirectionError () const
    Covariance matrix of the direction (3 Parameters).
    not filled

Proposal for First Steps

- add energy error to EVENT::Cluster
- assign uncertainties for energy / position
  - based calorimetric measurement
  - depending on $E_{cluster}$ (add theta, phi dependency later?)
  - evaluate "brute force" with particle gun
  - compare with testbeam (beware of different support structures etc)
- fill instrinsic direction (cluster main axis) and its uncertainty – again particle gun...
- clusters are created by Pandora – natural place to fill these quantities
- however resolutions:
  should be proposed from / discussed with Calice

EVENT::ReconstructedParticle

- virtual const FloatVec & getCovMatrix () const =0
  Covariance matrix of the reconstructed particle's 4vector (10 parameters).
- currently not filled
- Tino Calancha is working on filling this for charged PFOs from track covariance matrix
- Straight forward to extend to neutral PFOs – if we had the cluster uncertainties!

Discussion

- your comments?
- other opinions?
- wild protest?
- better ideas?
- volunteers?