The EMC Error Matrix
and
Beam Constraint Fitting

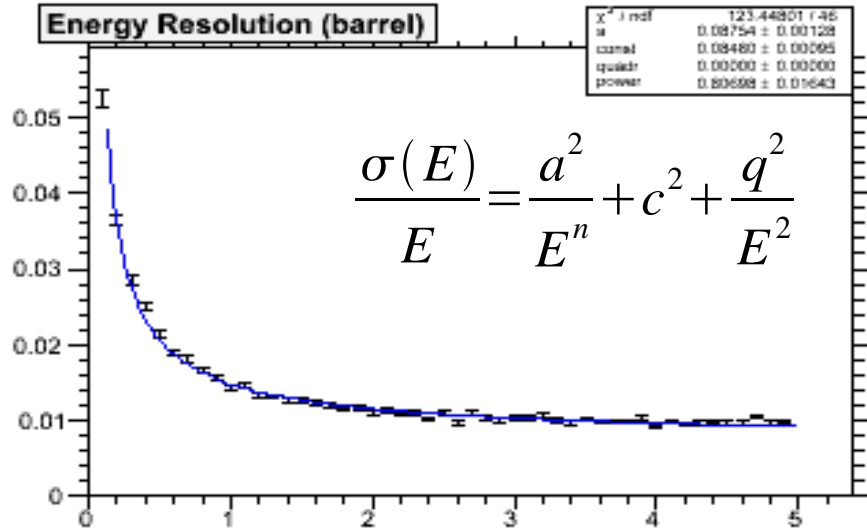M. Pelizäus

Physics Book and Desing Studies Meeting

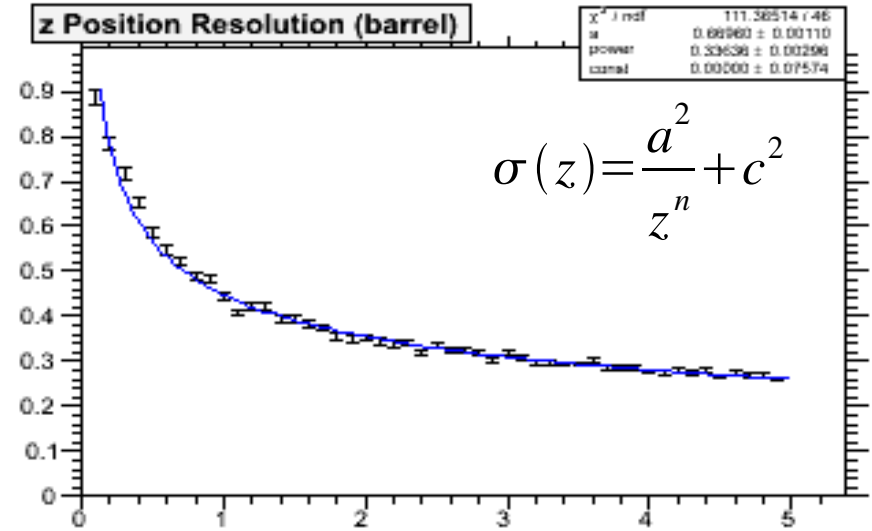Aug 27, 2007

Emc Error Matrix

- covariance matrices for neutral candidates mandatory for kinematic fitters in (E,px,py,pz) representation

- method

  ▸ estimate error σq of quantity q as standard deviation of the residual $\delta q = q - q_t$ distribution (q_t: genrated value)

  ▸ single photon events: from cluster position/energy measure in dependence of E

    – ($\sigma E, \sigma x, \sigma y$) for BW/FW cap and forward EMC (fixed z=100cm)

    – ($\sigma E, \sigma \phi, \sigma z$) for EMC barrel (fixed R=100cm)

    – parameterize $\sigma q(E) \rightarrow$ diagonal elements of covariance matrix

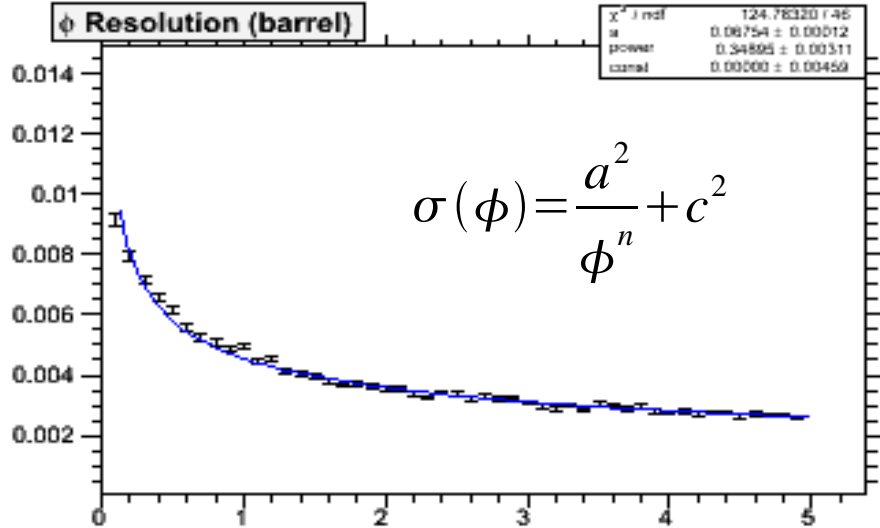 ▸ transfrom covariance to (E,px,py,pz) representation

Energy Resolution (barrel)

χ^2 / ndf	123.44801 / 46
a	0.08754 ± 0.00128
const	0.08480 ± 0.00095
quadr	0.00000 ± 0.00000
power	0.80698 ± 0.01643

$$\frac{\sigma(E)}{E}=\frac{a^2}{E^n}+c^2+\frac{q^2}{E^2}$$

z Position Resolution (barrel)

χ^2 / ndf	111.38514 / 46
a	0.66960 ± 0.00110
power	0.33636 ± 0.00296
const	0.00000 ± 0.07574

$$\sigma(z)=\frac{a^2}{z^n}+c^2$$

φ Resolution (barrel)

χ^2 / ndf	124.78320 / 46
a	0.08754 ± 0.00012
power	0.34895 ± 0.00311
const	0.00000 ± 0.00459

$$\sigma(\phi)=\frac{a^2}{\phi^n}+c^2$$

Energy Resolution (fwcap)

$$\frac{\sigma(E)}{E} = \frac{a^2}{E^n} + c^2 + \frac{q^2}{E^2}$$

x Position Resolution (fwcap)

$$\sigma(x) = \frac{a^2}{x^n} + c^2$$

y Position Resolution (fwcap)

$$\sigma(y) = \frac{a^2}{y^n} + c^2$$
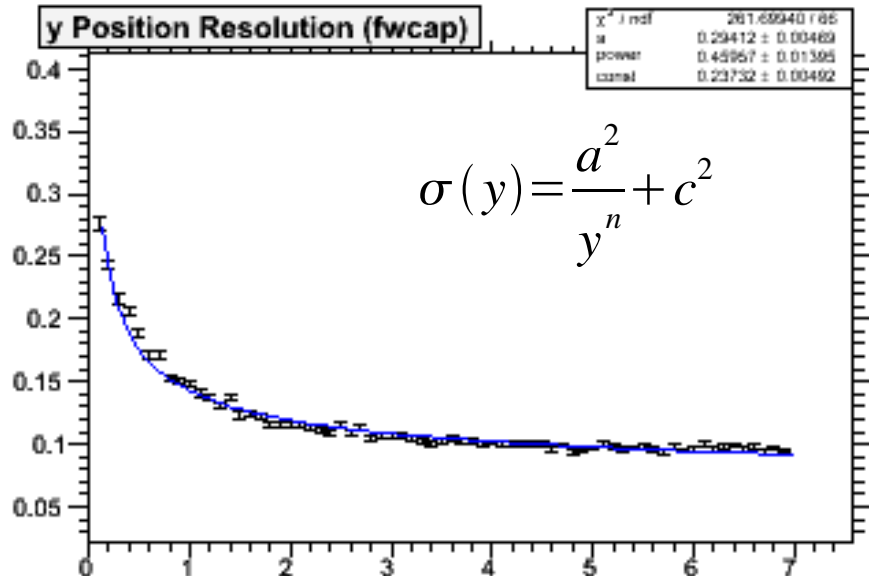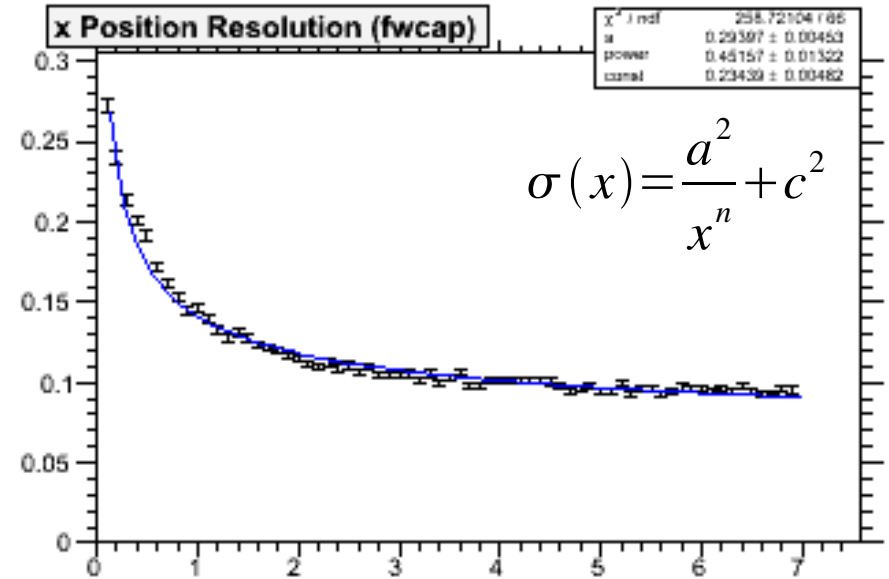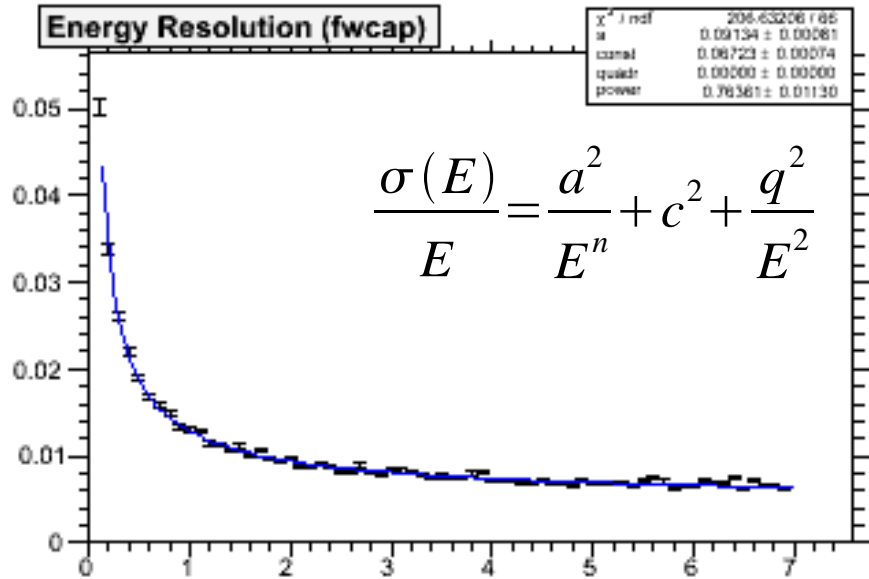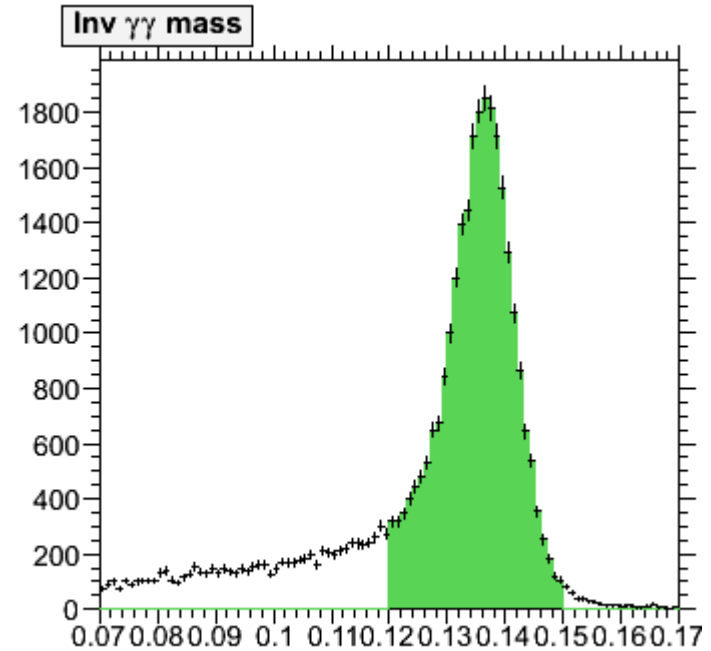
BW cap and forward EMC likewise

- kinematic fit for $\pi^0 \rightarrow \gamma\gamma$ (single pi0 evts)

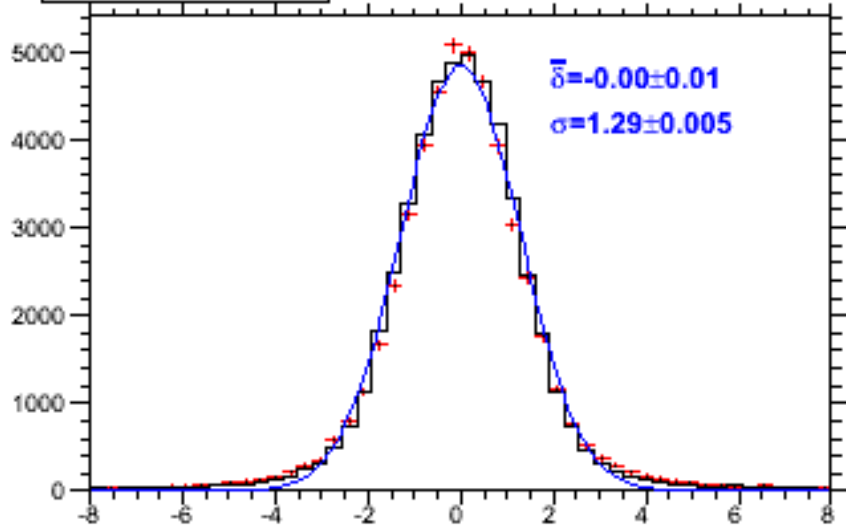 ▸ mass constraint

  ▸ beam spot constraint (vtx: IP+errors)

Inv γγ mass

- diagnostic:

  ▸ pull distributions for (E,px,py,pz) before and after fit

    – normal distribution expected

  ▸ vertex probability distribution

    – uniform distribution expected for converged fits
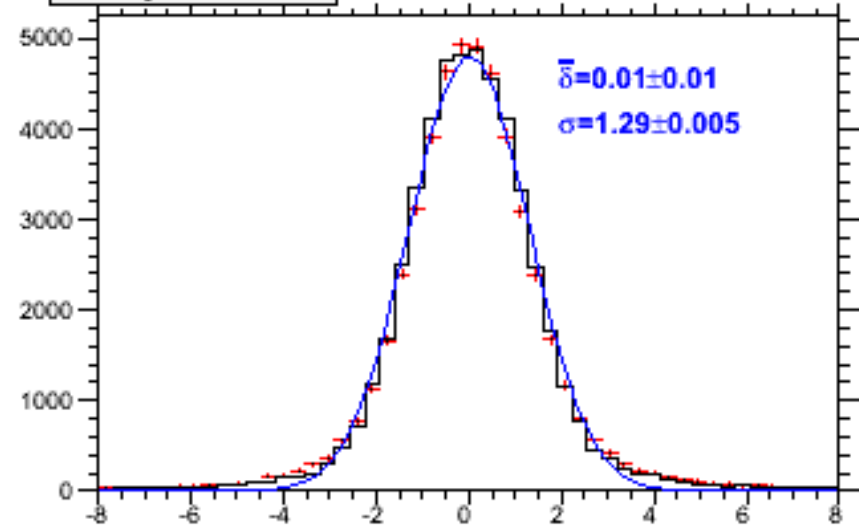
  ▸ repeat w/ 0.1 and 10 times the default energy error

before/after fit

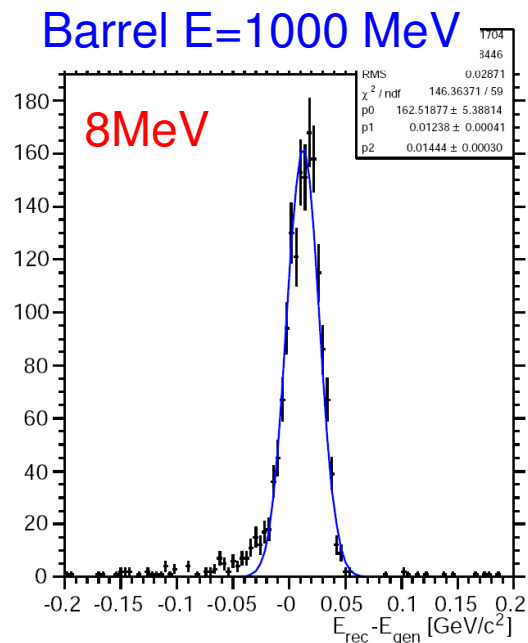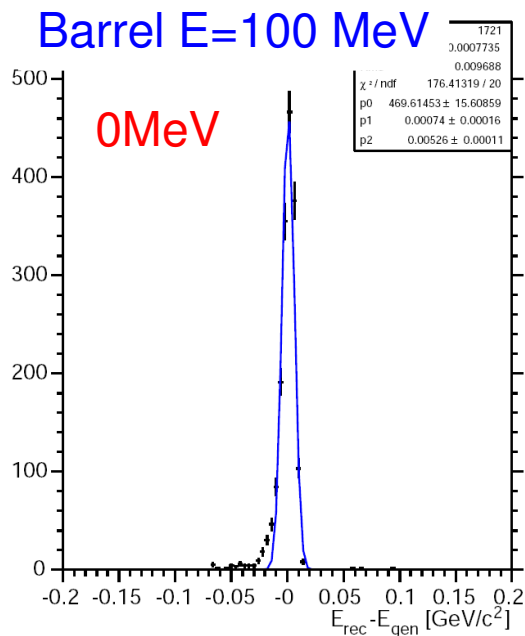# Pull distributions
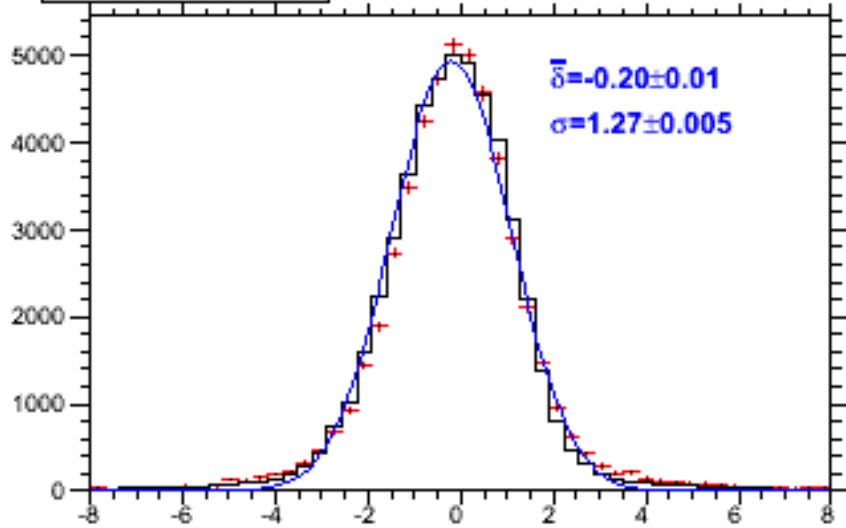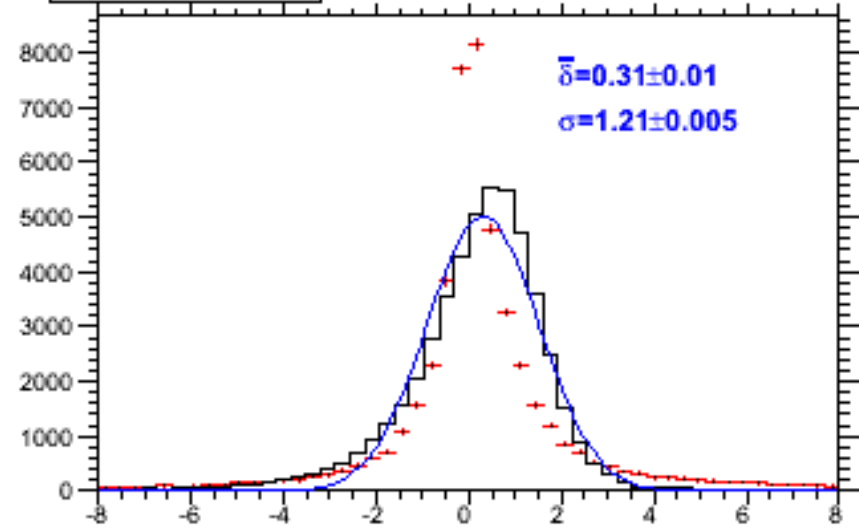
- pull for energy is shifted and to broad

  ▸ Px,Py,Pz pulls may be not problematic (σE propagates to σP!)

- explanaitions:

  ▸ σE is not Gaussian → underestimated width due to tail

  ▸ mean of σE distributions shifts w/ higher energy (calibaration)
    → σE distribution is smeared out
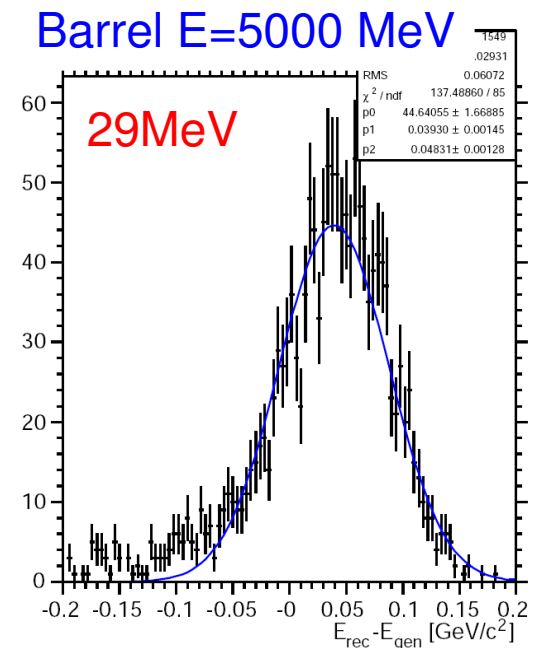
- probability distribution: slightly decreasing for p>20%

- shape non-distinguishable from shape obtained for underestimated σE

- σE is not overestimated

Probability

default σE
scaled 10xσE
scaled 0.1xσE
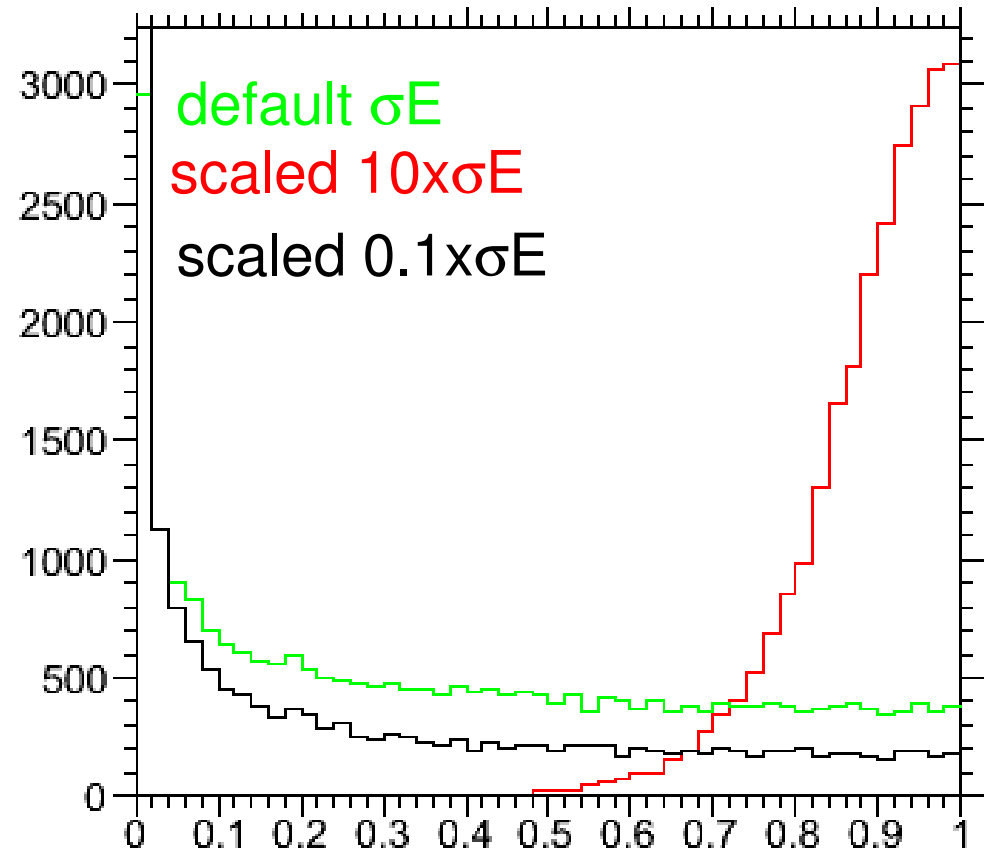
- current σE seems to be understimated

  ▸ better model to fit σE distribution (not Gaussian) or

  ▸ scale errors on energy

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- exclusive measurement of events (k particles) w/ precise knowledge of beam 4-momentum

  ▸ fit w/ constraints on beam momentum and total energy

  $$\vec{p}_b = \sum_k \vec{p}_k \quad \text{(3 constraints)}$$

  $$E_b = \sum_k E_k = \sqrt{\left(\sum_k \vec{p}_k\right)^2 + m_k^2} \quad \text{(1 constraint)}$$

- constraint was implemeted for TreeFitter for Babar's special use case $Y(4\mathrm{S}) \rightarrow B_{reco} \overline{B}_{tag}$

  ▸ few modifications made to use algorithm for $\overline{p}\, p \rightarrow X$

- Physics book analysis: $Y(4620) \rightarrow J/\psi\,\eta \quad (J/\psi \rightarrow e^+ e^-, \eta \rightarrow \gamma\gamma)$

- decay tree w/ charged and neutral candidates

  ▸ vertex of charged tracks is used as origin for $\eta \rightarrow \gamma\gamma$

  ▸ additional beam constraint improves resolution of resonances
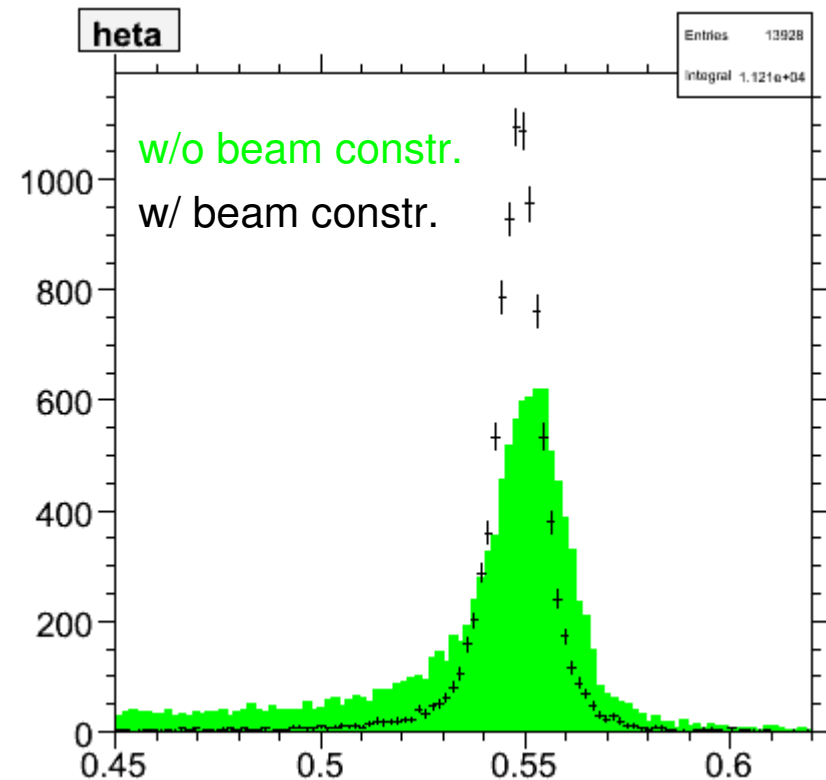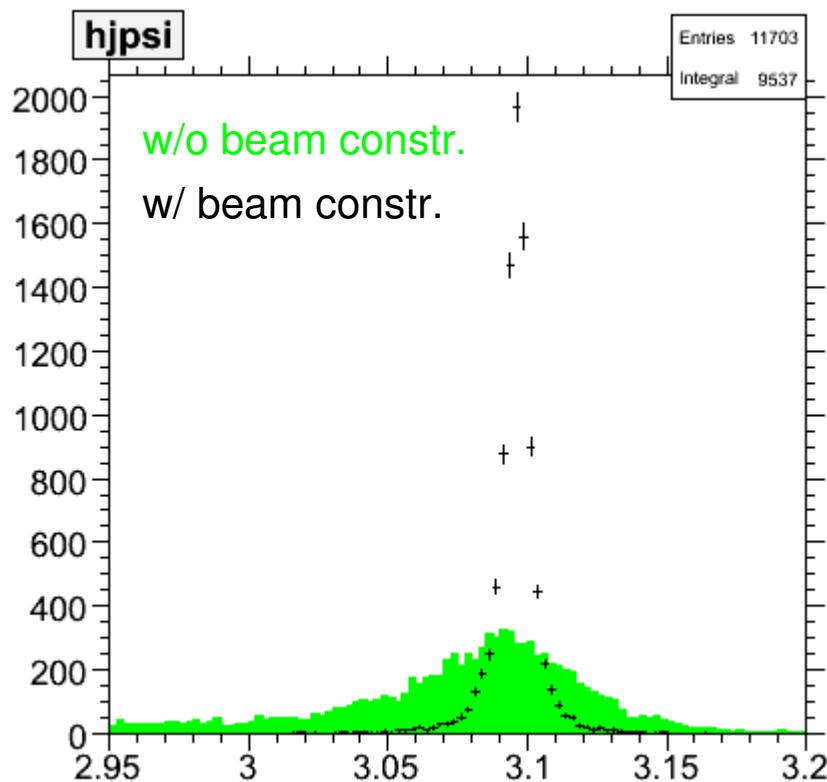
- fit probability p$_{fit}$ distribution

  ▸ looks ok: almost uniform for p>15%

  ▸ future use: background rejection, i.e. $\bar{p}\, p \rightarrow J/\psi + neutrals$

How to use
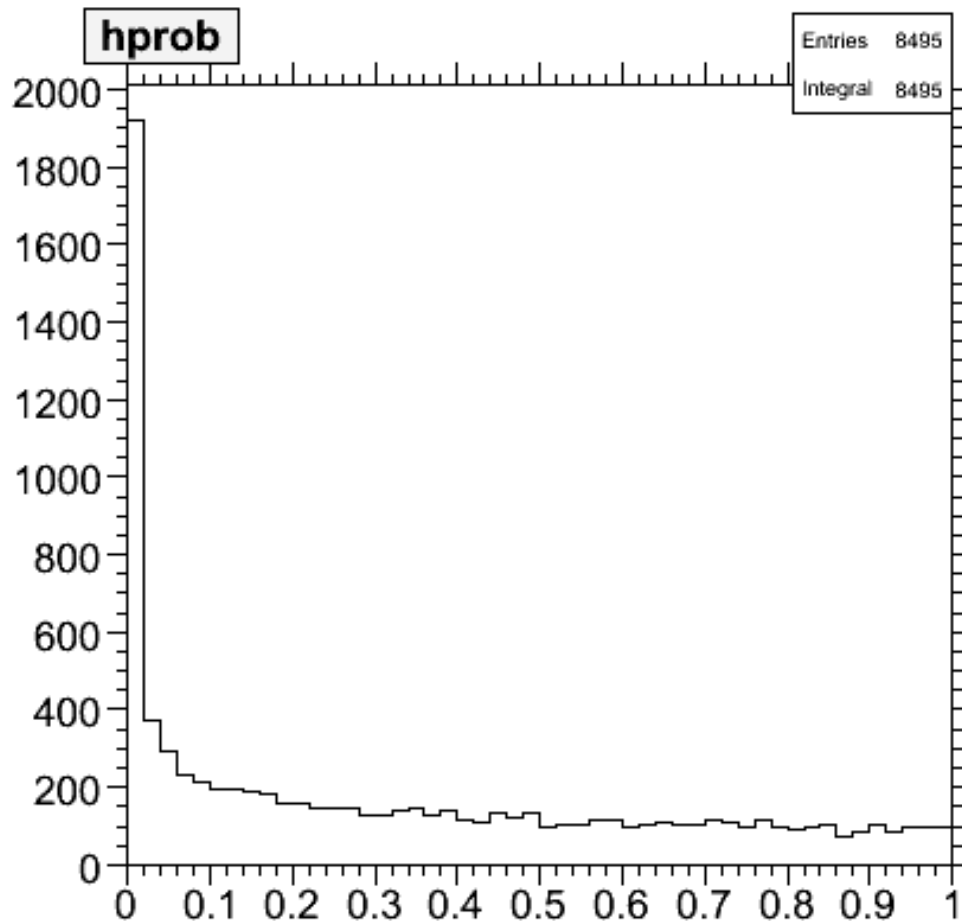
- beam constraint can be applied with SimpleComposition

```
mod talk FaiBuildEnv
  set pbarMomentum 8.6819                mandatory: set proper beam momentum
exit


mod clone SmpMakerDefiner JPsiEta
mod talk JPsiEta
  decayMode set "pbarpSystem -> J/psi eta"
  daughterListNames set JPsiToEE
  daughterListNames set etagg

  fittingAlgorithm  set "TreeFitter"

  fitConstraints set "Energy"
  fitConstraints set "Beam"            beam 4mom + beam spot (mandatory!)


  fitSettings  set "FitAll"
  fitSettings  set "UpdateDaughters"
exit
```

mandatory: set proper beam momentum

beam 4mom + beam spot (mandatory!)

caveat: apply to
- refit already fitted cands., e.g. J/Ψ→ee
- obtain fitted version of photon+electron candidates

- dump quantities to ntuple with BtaTupleMaker

```
mod clone BtaTupleMaker TupJpsiEta
mod talk TupJpsiEta
    listToDump set JPsiEta
    ntpBlockConfigs set "pbarpSystem  ppb     2 100"
    ntpBlockConfigs set "J/psi         jpsi    2 100"
    ntpBlockConfigs set "eta           eta     2 100"

    ntpBlockContents set "ppb   :  Mass Momentum Vertex VtxChi2"
    ntpBlockContents set "jpsi  :  Mass Momentum Vertex VtxChi2"
    ntpBlockContents set "eta   :  Mass Momentum Vertex VtxChi2"

    ntpAuxListContents set "jpsi : JPsiToEE : Uf : Mass"
    ntpAuxListContents set "eta  : etagg : Uf : Mass"
exit
```

- keyword VtxChi2 adds fit probability to ntuple, e.g. "ppbprob"

- store quantities of cands. before fit w/ ntpAuxListContents

  ▸ syntax: set <block> : <orig. list of cands.> : <prefix> : <list of quantites>

  ▸ extends to: jpsiUfMass, which is inv. mass of J/psi cands. in list "JpsiToEE"