# Impulse approximation limitations to the (e,e'p) reaction on $^{208}$Pb identifying correlations and relativistic effects in the nuclear medium

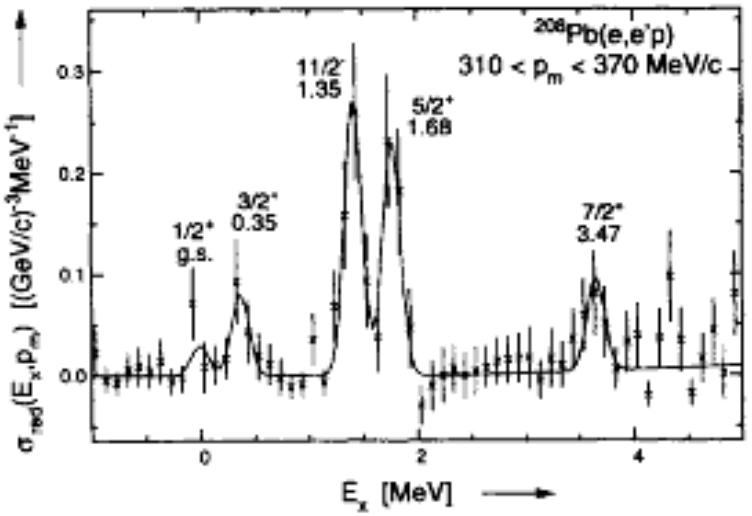
December 12, 2007

# Goals of the experiment

Use $^{208}$Pb, a doubly magic, complex nuclei, a textbook case for the shell model. Measure $^{208}$Pb(e,e'p)$^{207}$Tl cross sections at true quasieleastic kinematics and at both sides of q. This has never been done before for A>16 nucleus.

Study low lying states in $^{207}$Tl:

| $g.s$ | $3S_{1/2}$ |
|---|---|
| 0.351 | $2d_{3/2}$ |
| 1.348 | $1h_{11/2}$ |
| 1.683 | $2d_{5/2}$ |
| 3.470 | $1g_{7/2}$ |




- Quasielastic kinematics: $X_B = 1$, $q = 1GeV/c$, $\omega = 0.433GeV/c$
- Determine momentum distributions: $0 < p_{miss} < 500MeV/c$
- Determine $A_{TL}$ by measuring cross sections on either side of $q$

# Improving the optics database (Method I)

The database is equivalent to a matrix T that transforms the focal plane coordinates in scattering coordinates

$$\vec{Y} = T \cdot \vec{X}, \quad \vec{Y} = \begin{pmatrix} DP \\ \Theta \\ \Phi \\ Y \end{pmatrix}, \quad \vec{X} = \begin{pmatrix} x \\ y \\ \Theta \\ \Phi \end{pmatrix}$$

To make a change on the database means to find a new matrix $T'$ that gives a new set of values:

$$\vec{Y'} = T' \cdot \vec{X}$$

Then taking $\vec{X} = T^{-1} \cdot \vec{Y}$ we get

$$\vec{Y'} = F \cdot \vec{Y}$$

Essentially we only deal with the calculated scattering coordinates. Then we can find $T'$ by $T' = F \cdot T$

# Improving the optics database (Method II)

Express $F = 1 + \delta F$. This leads to

$$\vec{Y}' = Y + \delta F \cdot \vec{Y} = \vec{Y} + \delta(\vec{Y})$$

To see what this means consider momentum:

$$DP' = DP + \delta F \cdot \vec{Y} = DP + \delta(DP) = DP + P(DP, \Theta, \Phi, Y)$$

where $P(DP, \Theta, \Phi, Y)$ is a polynomial expression.

# Improving the optics database (Method II)

Because $DP \rightarrow DP'$ then the missing energy $E_{miss}$ will also change as such:

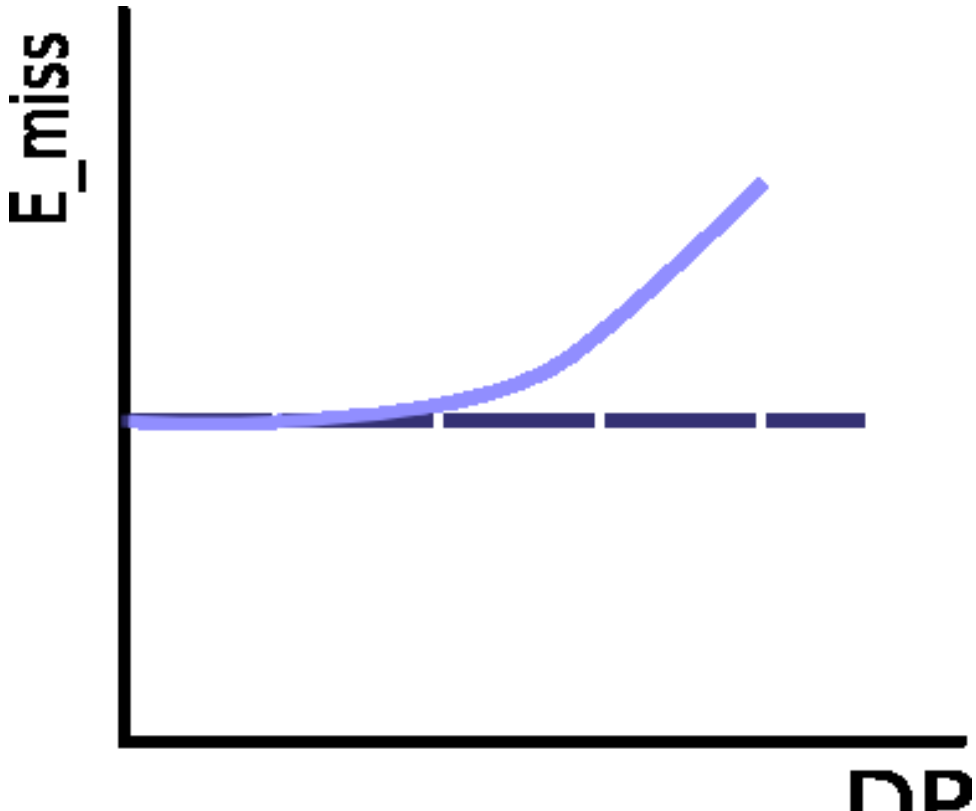
$$E_{miss}(DP') = E_{miss}(DP + \delta(DP)) = E_{miss}(DP) + \partial\frac{E_{miss}}{\partial(DP)}\delta(DP) = E_{miss}(DP) + A(DP, \Theta, \Phi, Y)$$

So an optimization involves finding he empirical polynomial $A(DP, \Theta, \Phi, Y)$ in scattering coordinates. Finally we calculate:

$$\delta(DP) = \frac{E'_{miss} - E_{miss}}{\partial\frac{E_{miss}}{\delta(DP)}}$$

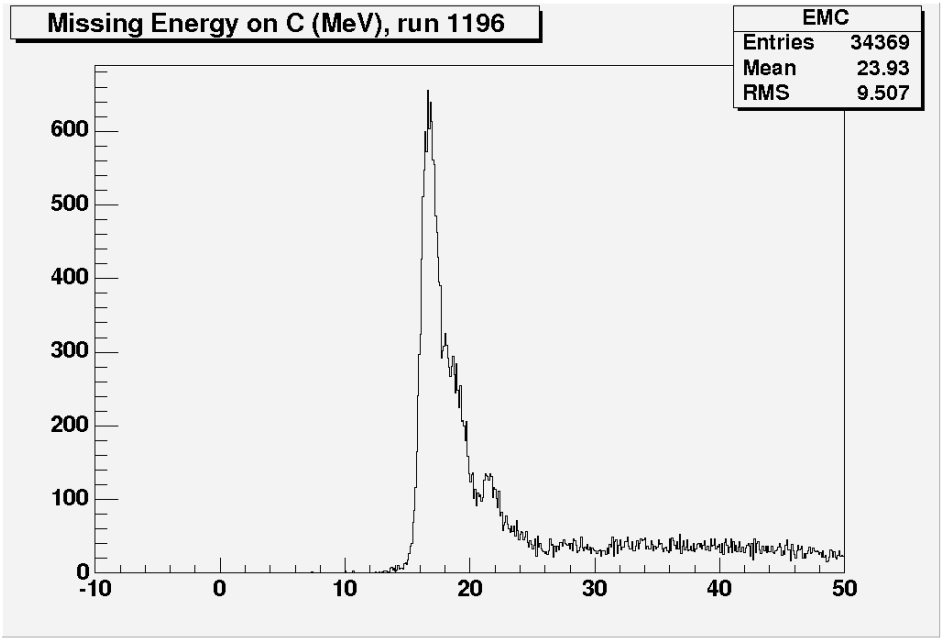
# Improving the optics database (Method II)

The process is to plot $E_{miss}$ as a function of one of the calculated scattering coordinates $DP, \Theta, \Phi, Y$ and empirically find a polynomial that will make $E_{miss}$ independent of the calculated scattering coordinate.

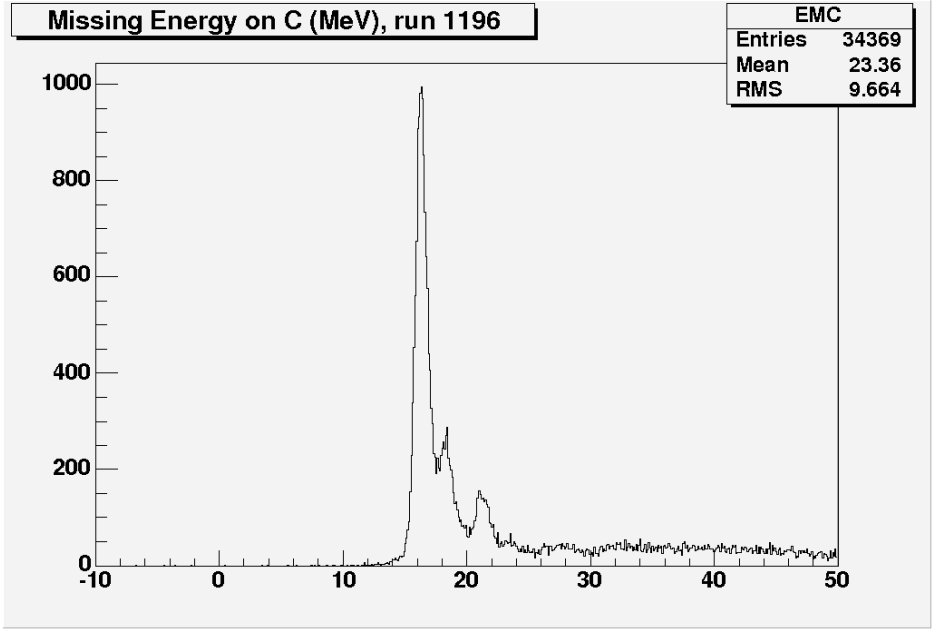


# Optimization Results

$^{12}$C(e,e'p)$^{11}$B Missing Energy. About 1 MeV resolution.



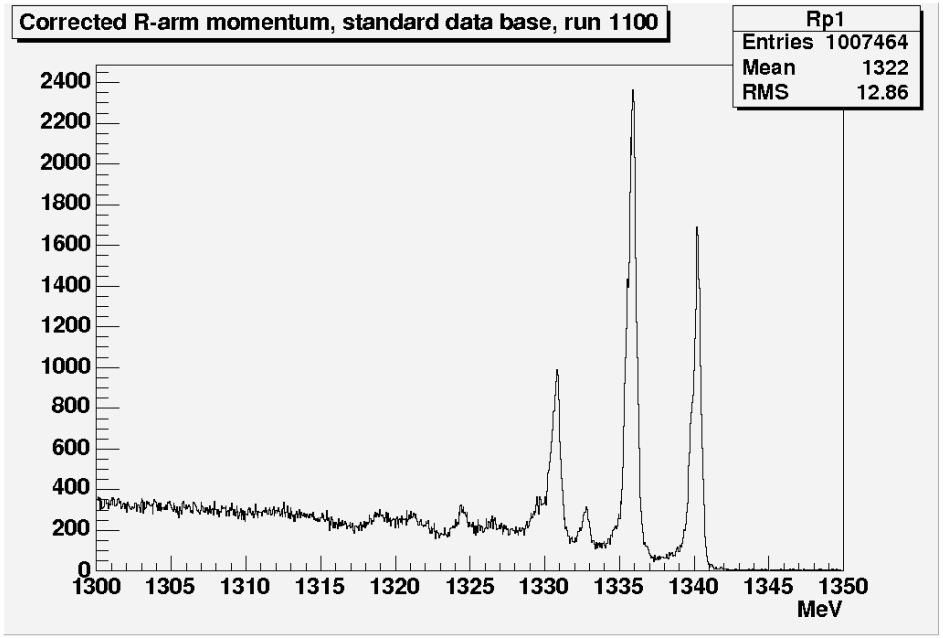

Old Database



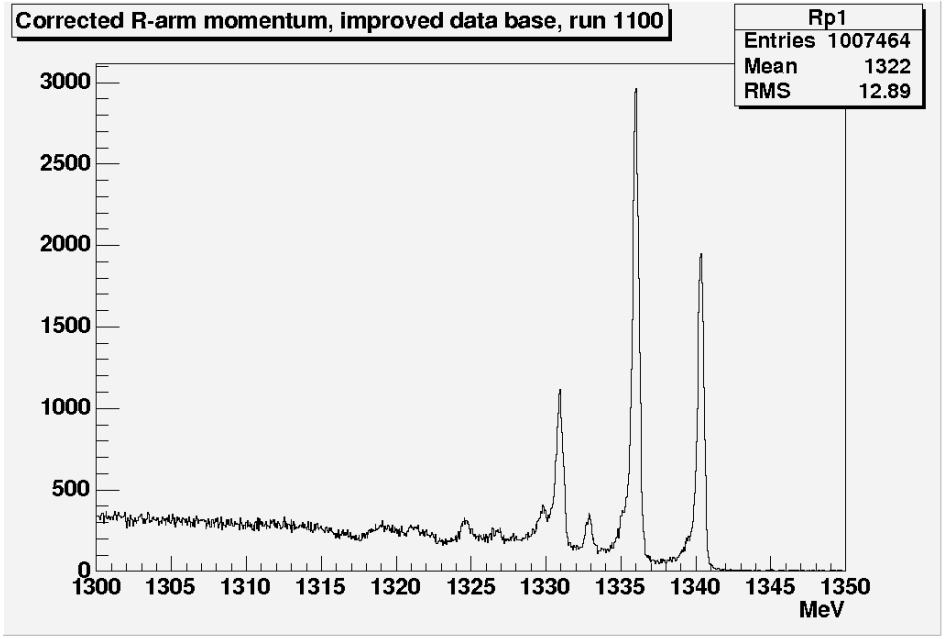

Improved Database

# Optimization Results

## Elastic Right Arm



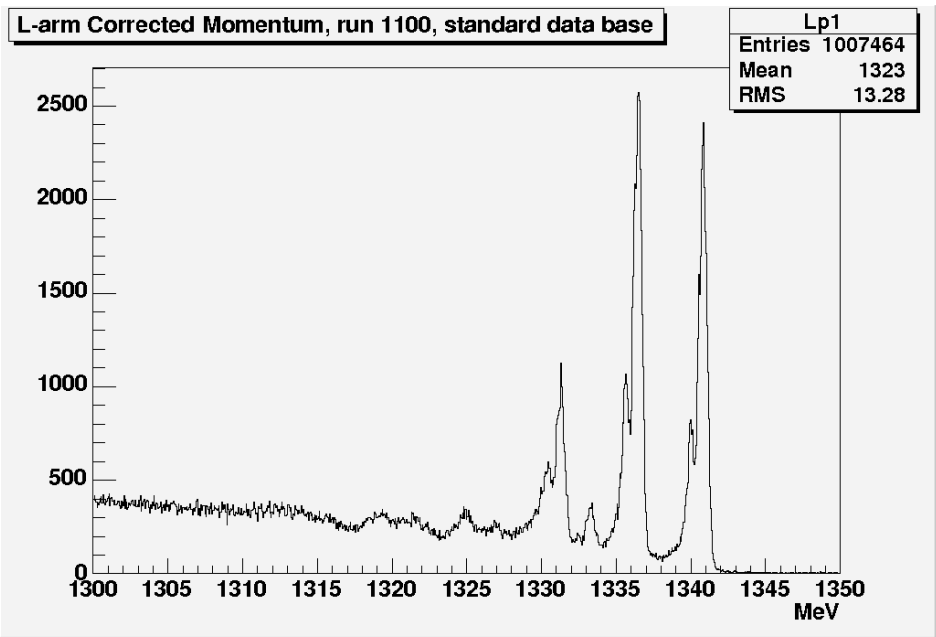

Old Database




Improved Database

# Optimization Results

## Elastic Left Arm

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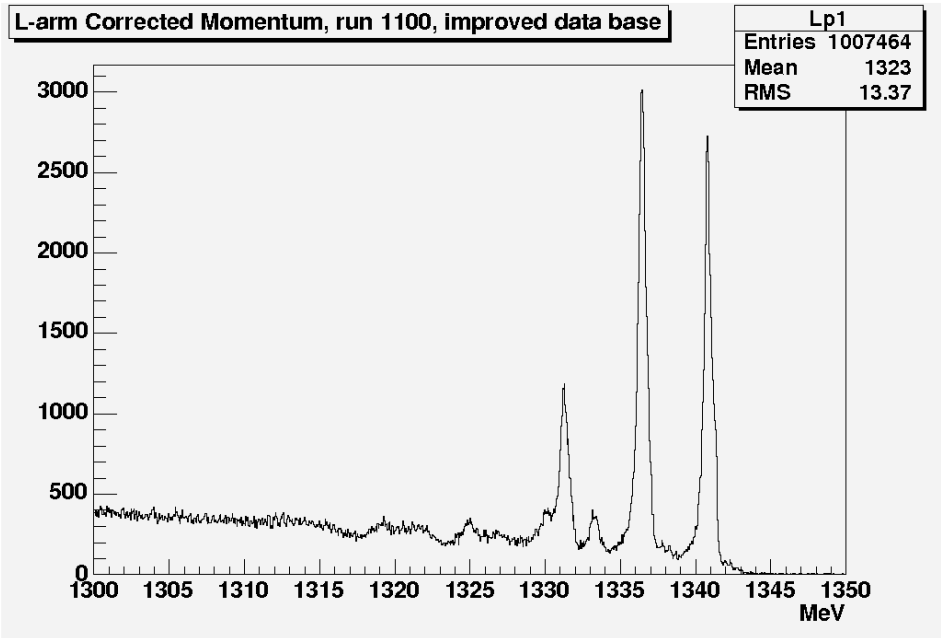
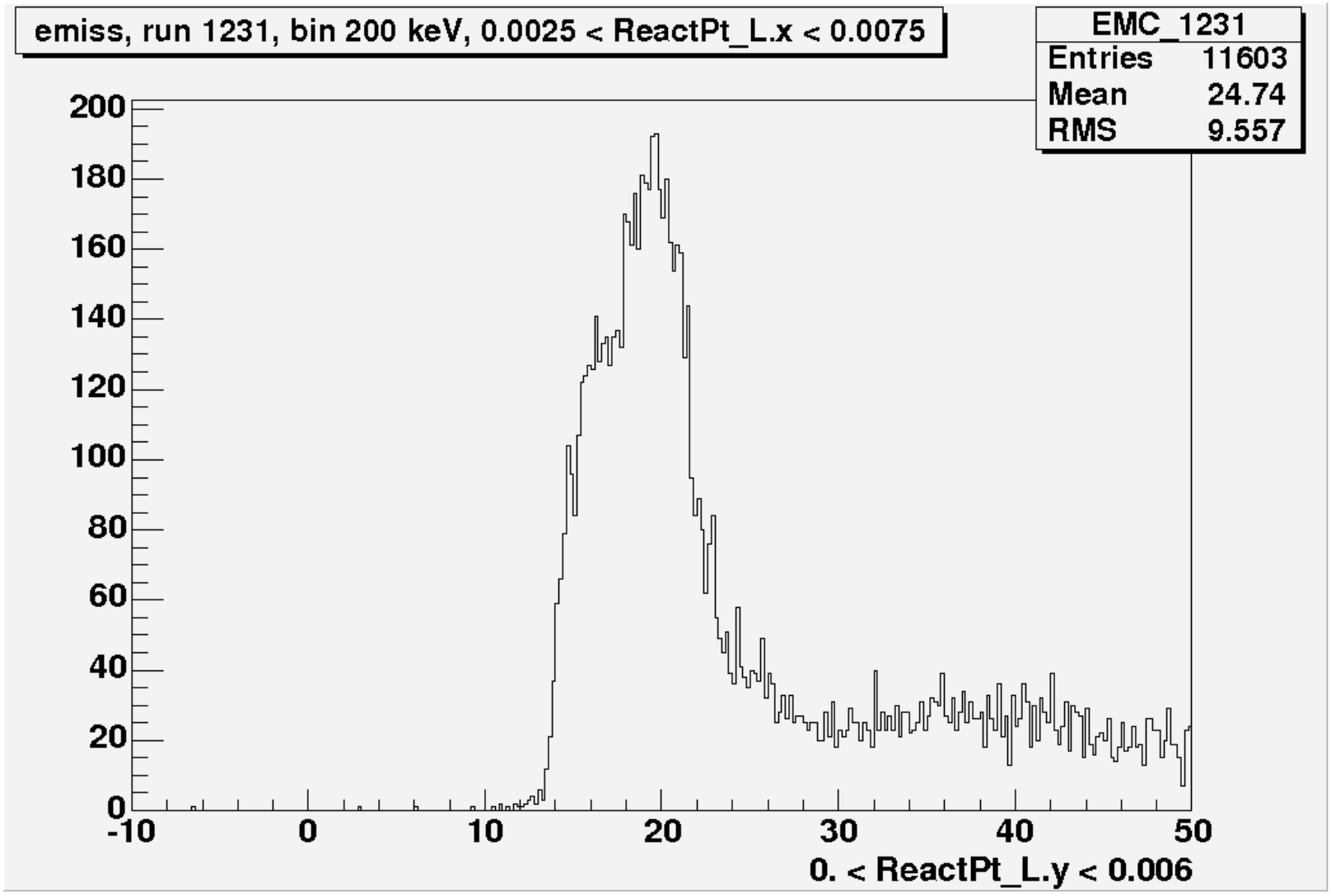
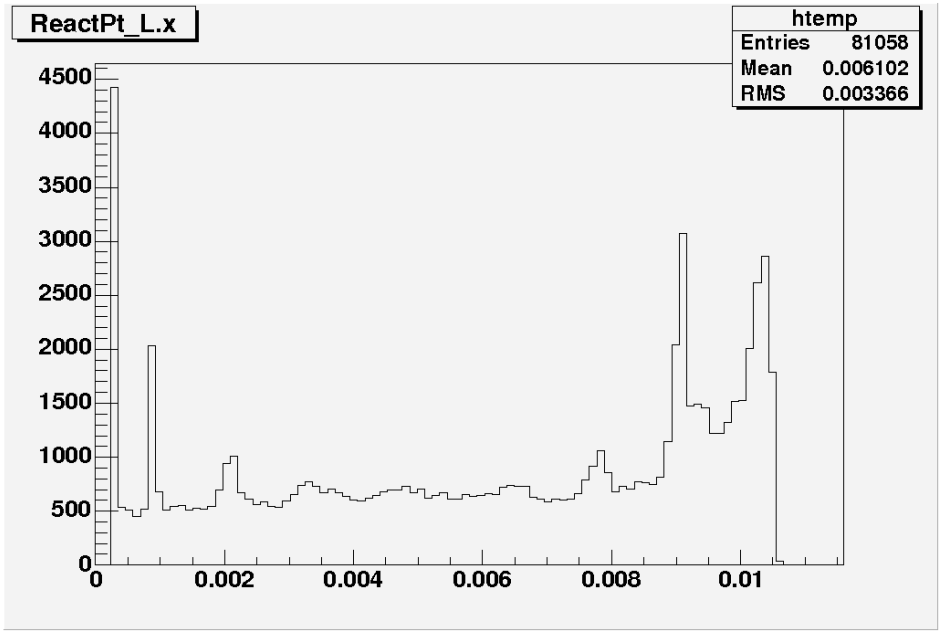


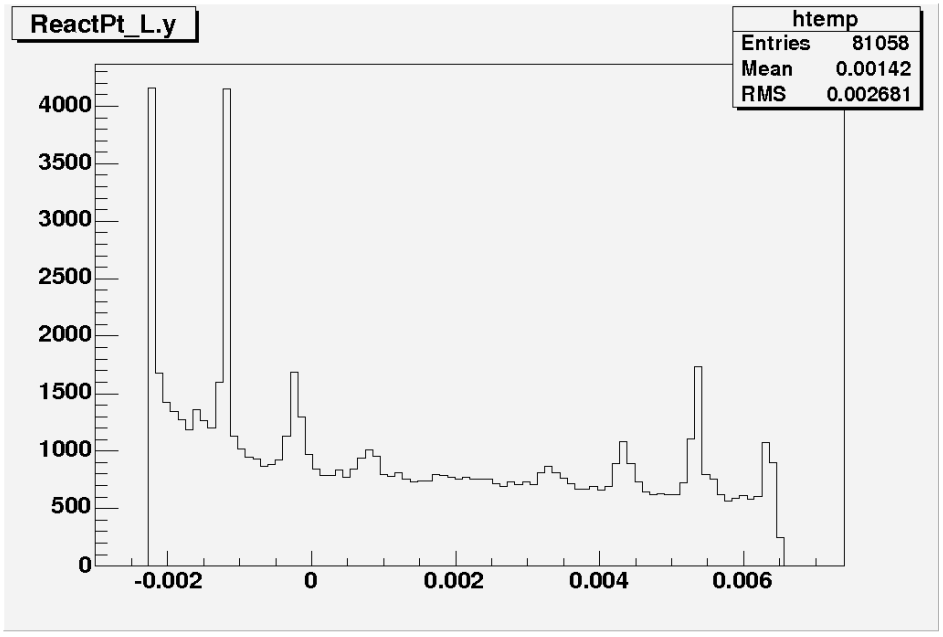

Improved Database

# Uncorrected Carbon Spectra

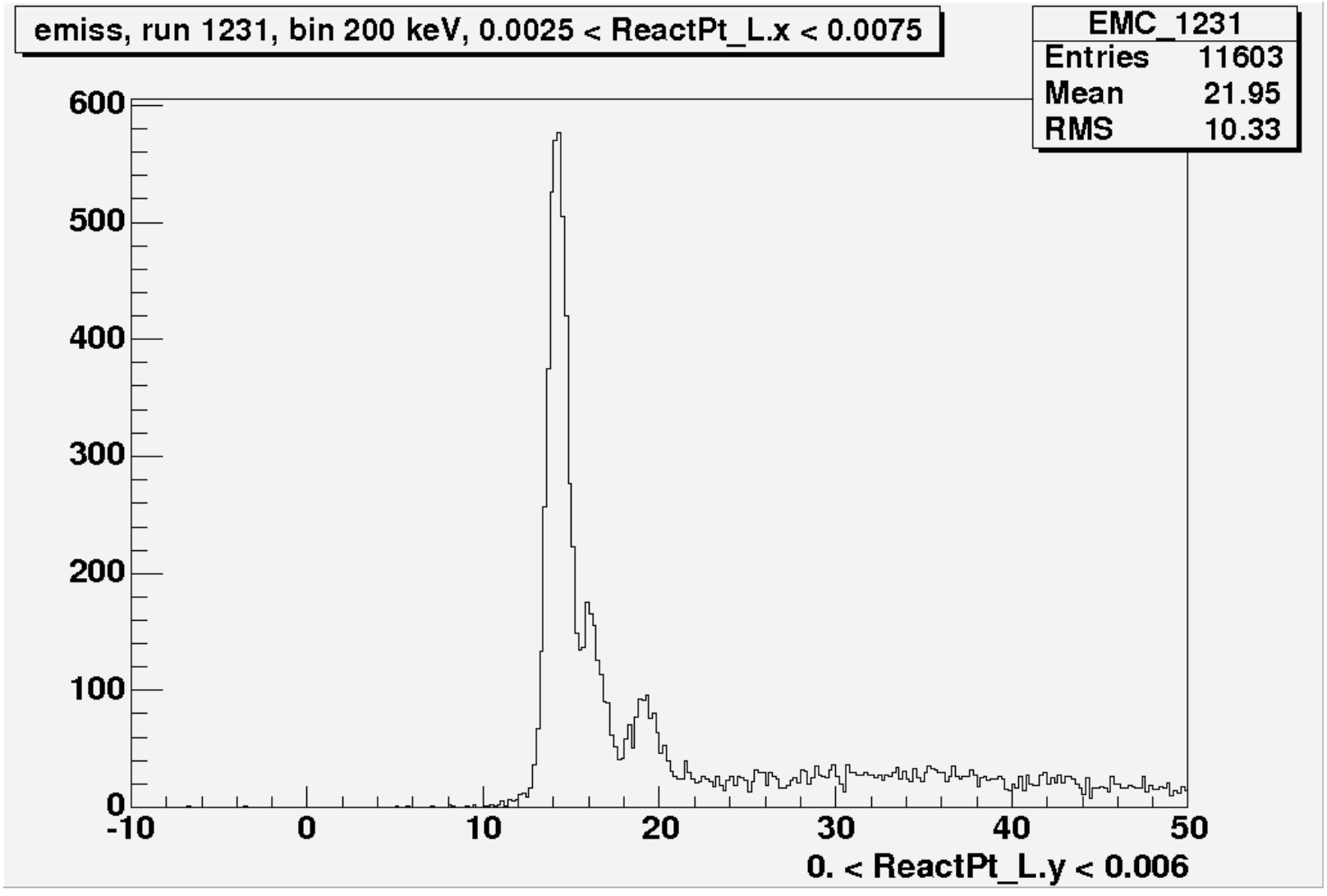


# Problems with Raster

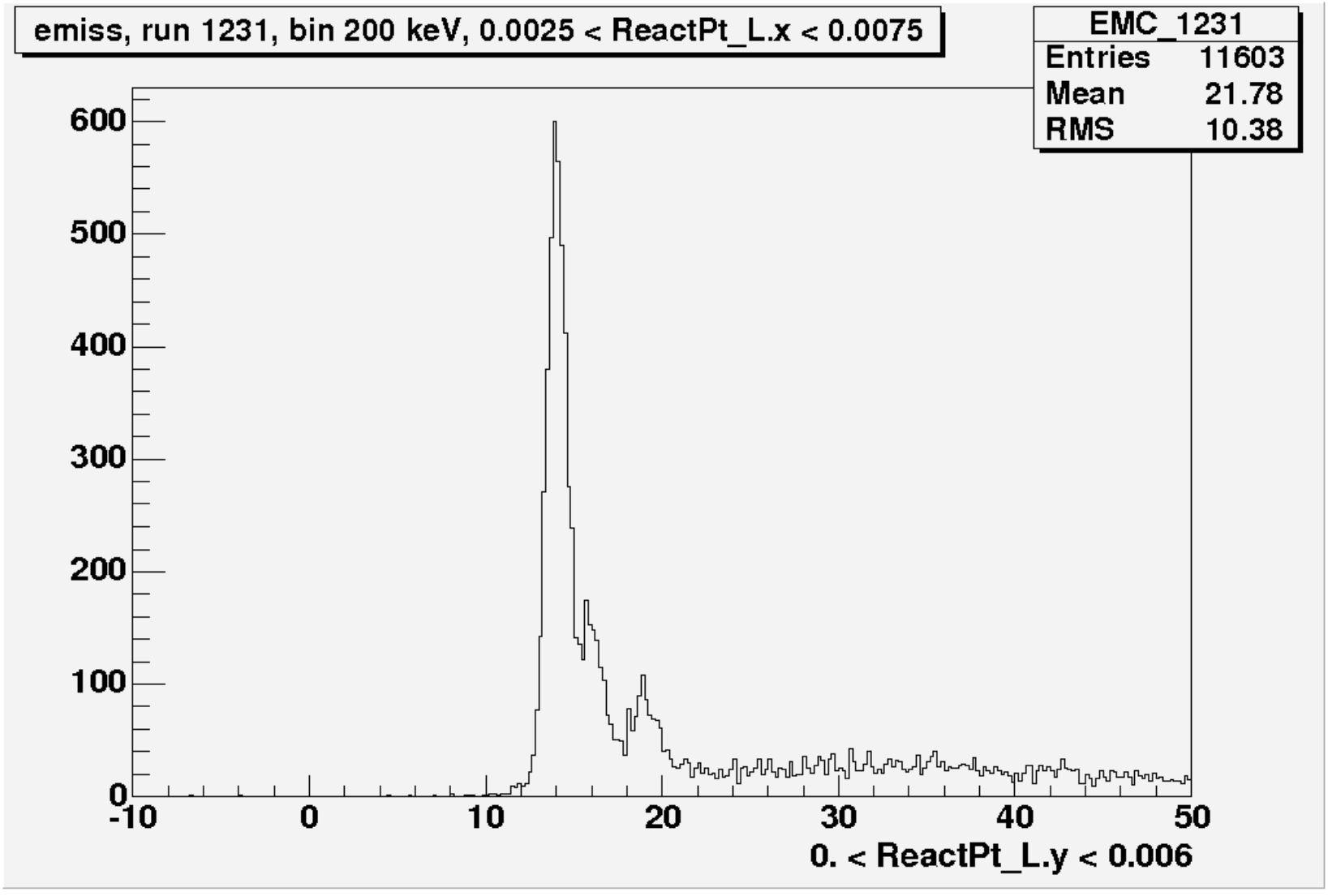


# First order raster corrections



# Second order raster corrections

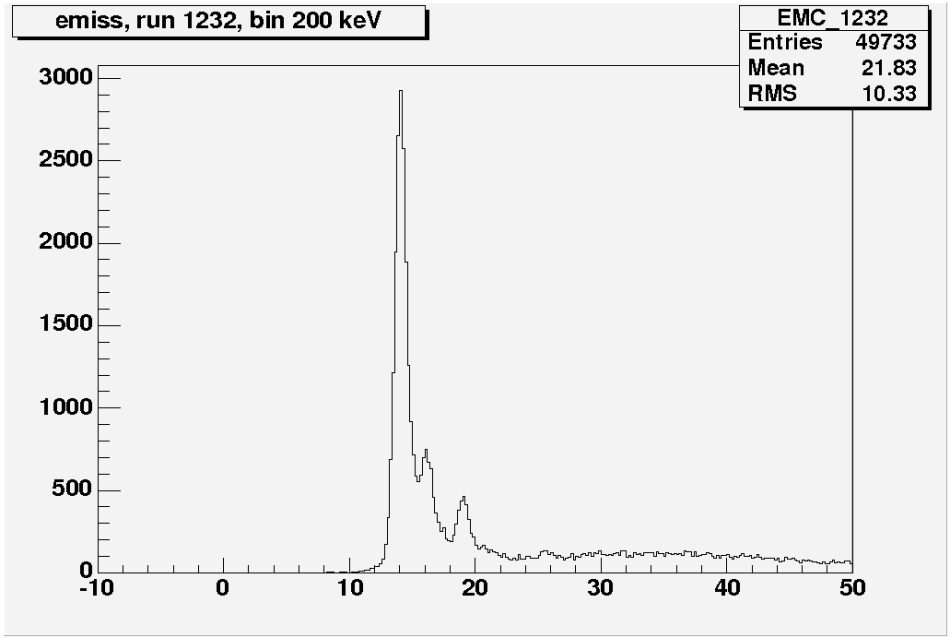


# Second order raster corrections

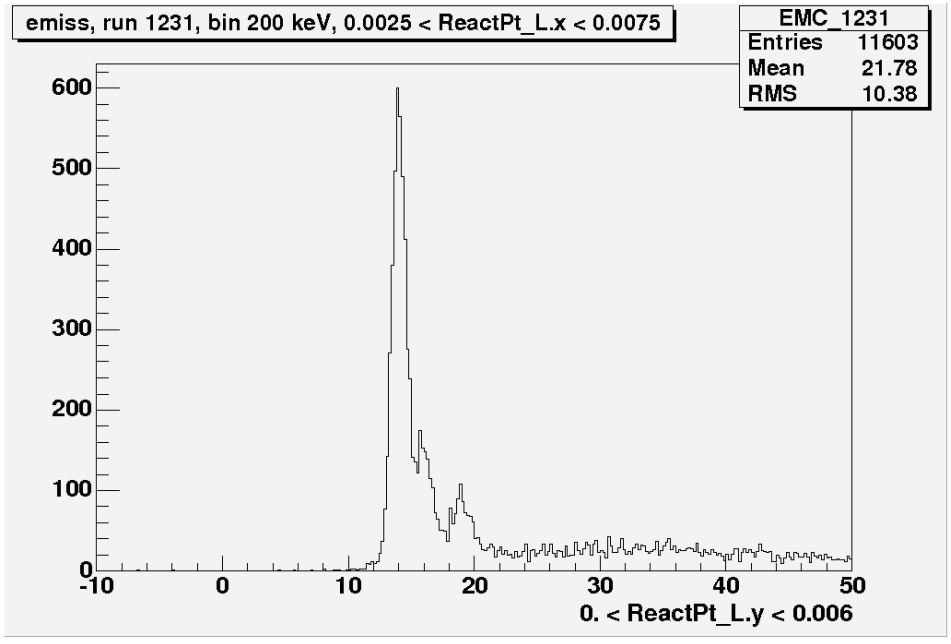
Currently ANALYZER does not consider second order raster corrections. As such a correction formula must be added to the missing energy as given by ANALYZER.

# Kinematics #2 Carbon target

Raster correction formula: $-1194 ReactPointL_y - 17560 ReactPtL_y^2$

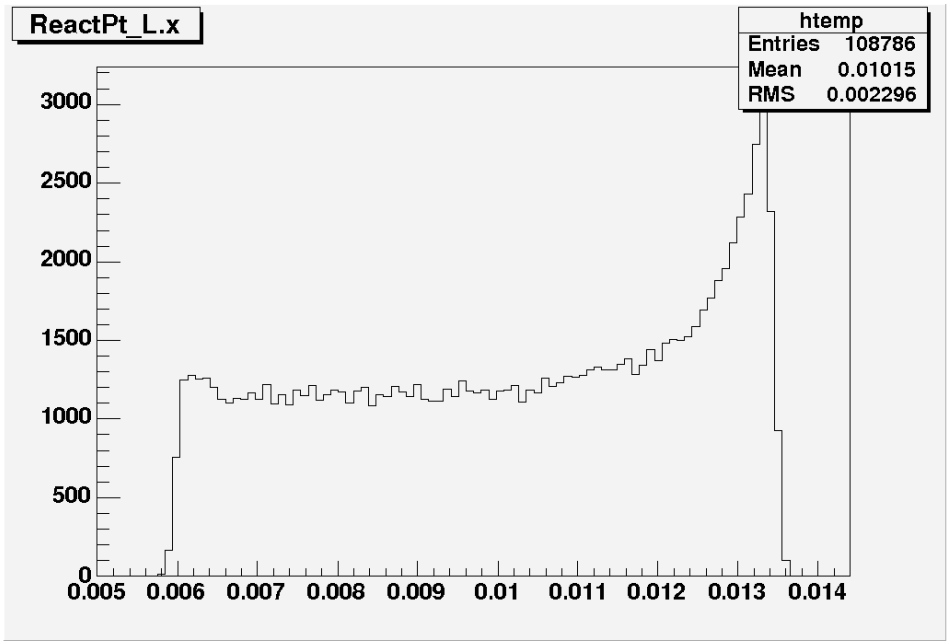


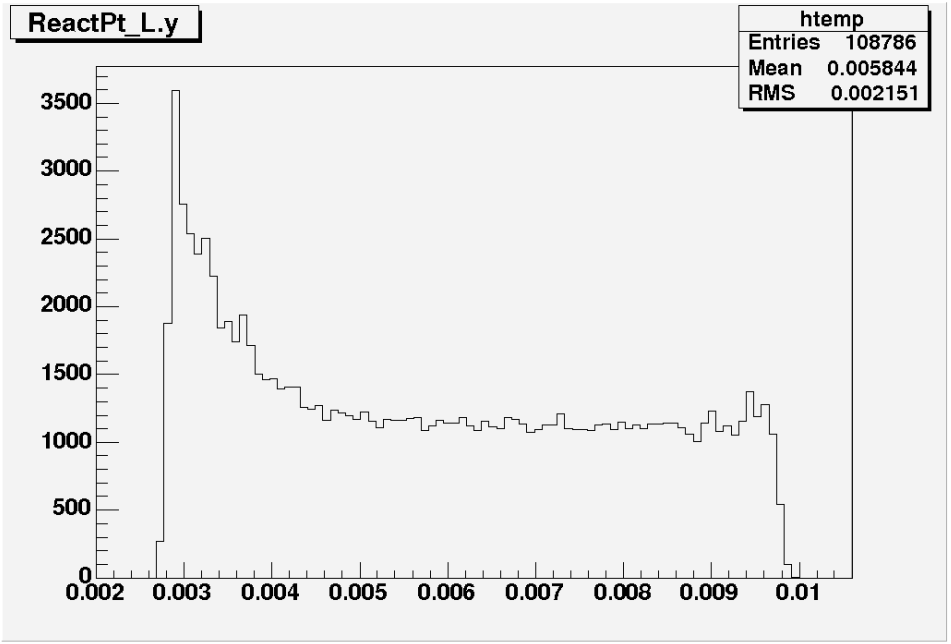

Run 1232
Raster OFF
FWHM 1 MeV



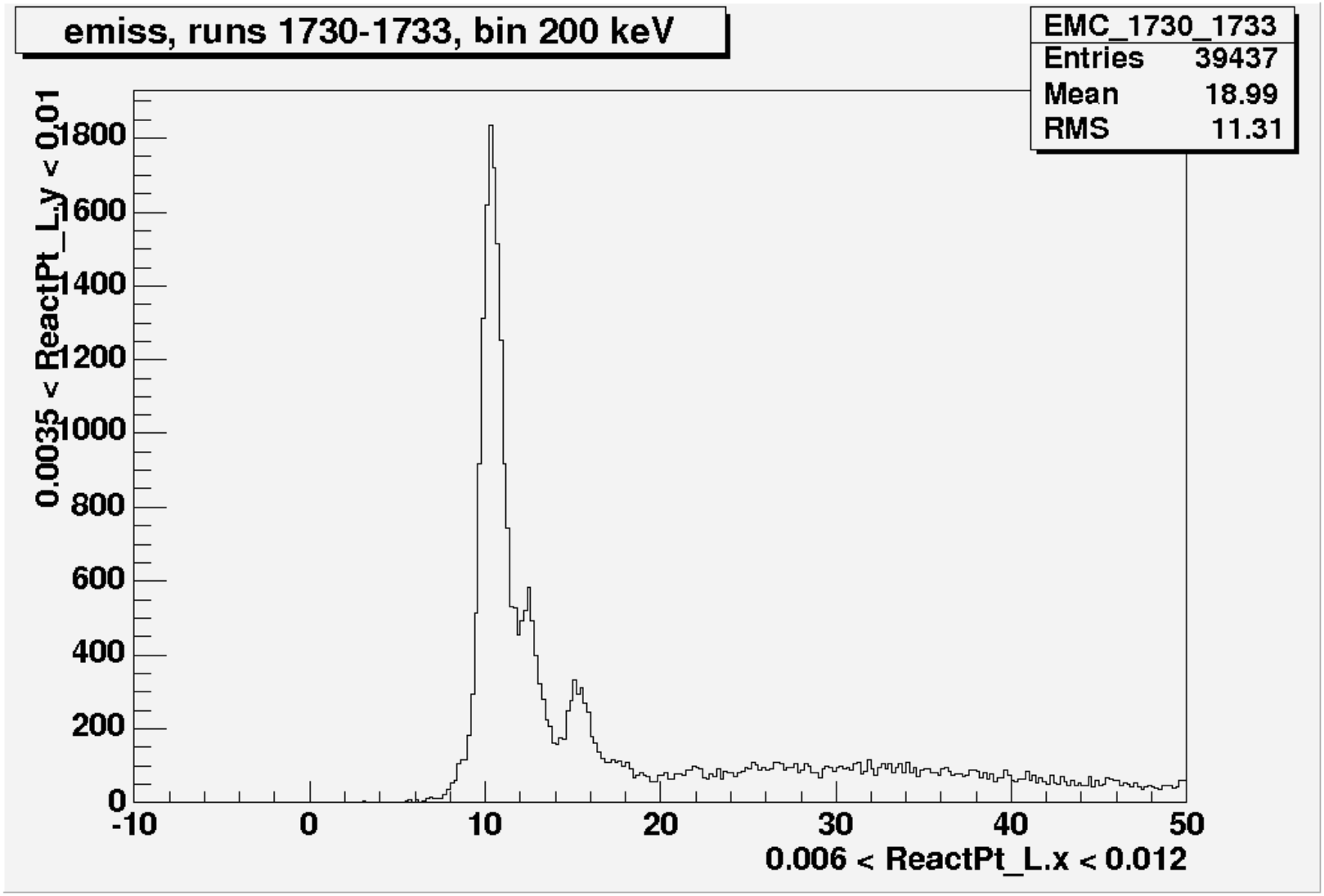

Run 1231
Raster ON
FWHM 1 MeV

# Raster working correctly

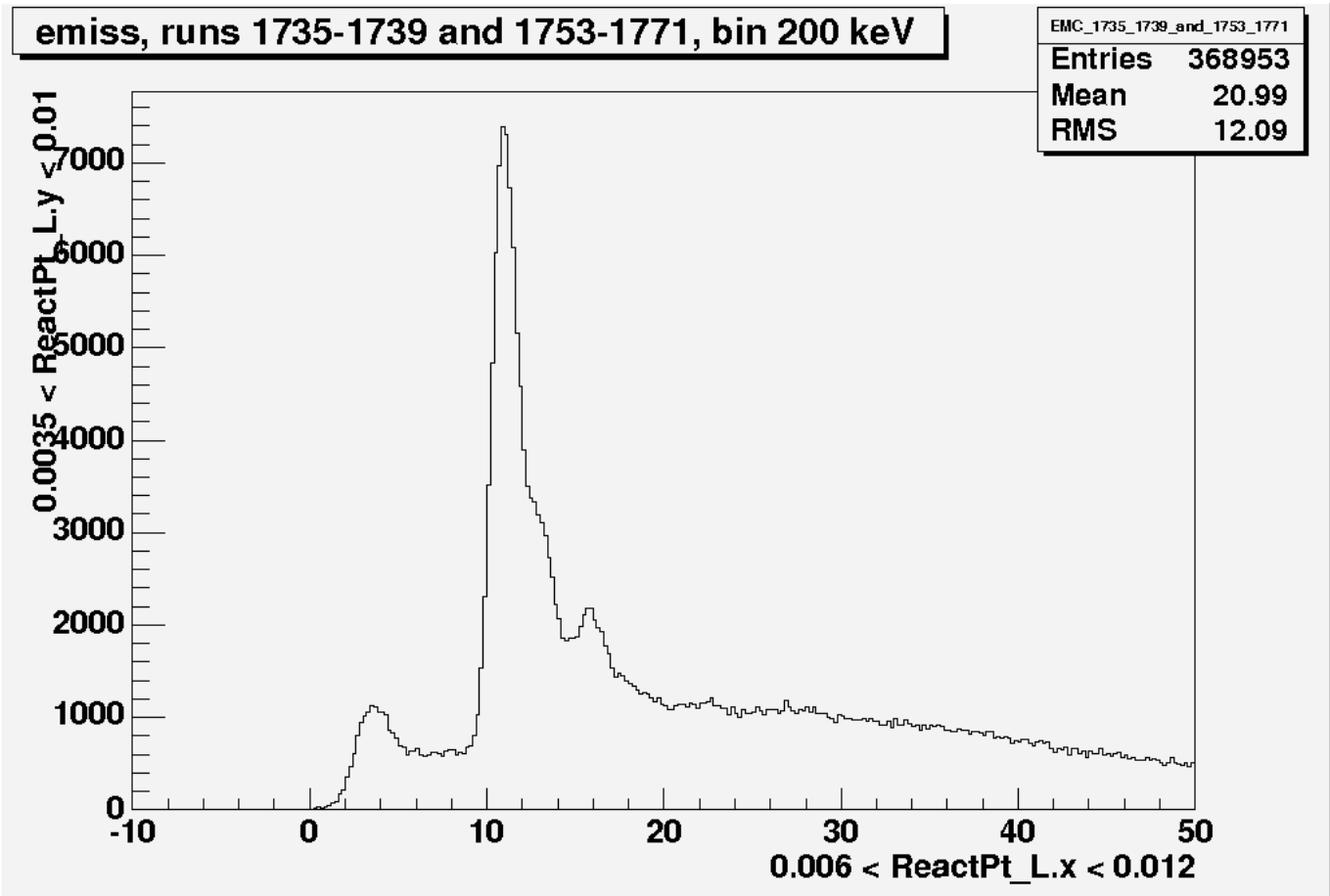


# Kin #2 runs 1730-1733 on carbon target



# Kin #2 runs 173501739 and 1753-1771 on lead target




Raster correcting formula is: $-1147 ReactPtL_y - 17050 ReactPtL_y^2$

# Summary

- Optics database was improved
- Raster correction should be made to 2nd order to improve resolution
- With tight cut on acceptance and no raster the resolution is 850keV on carbon as predicted by GEANT.