



Final Presentation
1/22

R Peterson-Hall, 10/13/15

Introduction

First Task - Fit $H \rightarrow \gamma\gamma$
signal

Second Task - Data/MC
Analysis of Vertex
Reconstruction Accuracy

Conclusions

Programming Skills
Analysis Techniques and
Statistics
Experimental Physics
Research Experience -
Software
Life Experience

Final Presentation UM CERN Research Semester

Rebecca Peterson-Hall

University of Michigan, Ann Arbor

December 10, 2015



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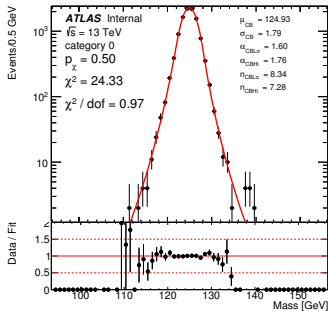
- Programming Skills
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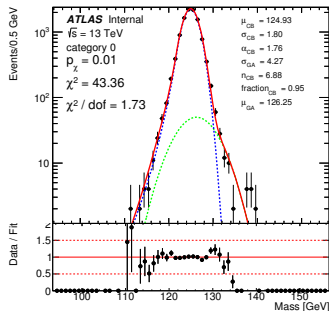
- Data fit with Double Sided Crystal Ball
 - Function has six fit parameters: σ , μ , α_{low} , n_{low} , α_{high} , n_{high}
 - If $(m_{\gamma\gamma} - \overline{m_{\gamma\gamma}})/\sigma < -\alpha_{low}$, use low CB parameters
 - If $(m_{\gamma\gamma} - \overline{m_{\gamma\gamma}})/\sigma > \alpha_{high}$, use high CB parameters
- Data fit with Crystal Ball Gaussian
 - Function has seven parameters: σ_{CB} , μ_{CB} , α_{CB} , n_{CB} , σ_{GA} , μ_{GA} , $fraction_{CB}$
 - Sum of Crystal Ball and Gaussian is weighted according to parameter $fraction_{CB}$
- Conclusion
 - For every production mode, resolution of the Double Crystal Ball is better than resolution of Crystal Ball in CBGA
 - In addition, the χ^2 statistics are also better for DCB in each production mode
- SigParam Class - Tool used for fitting
 - Uses RooFit to fit Double CB, CBGA, 3 \times GA, Voigt, CBVoigt, etc.



Double CB:



CB + Gaus:





VBF Signal Fit

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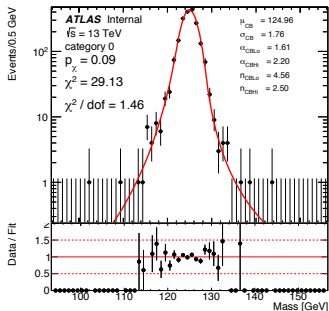
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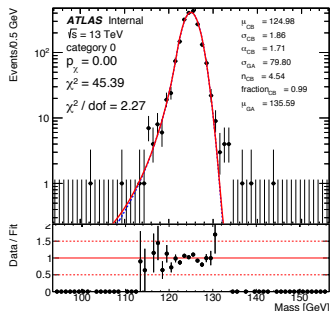
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Double CB:



CB + Gauss:





Resolution Table Across Production Modes

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Resolution			
Production Mode	$\sigma_{DoubleCB}$	$\sigma_{CB, CBGA}$	$\sigma_{Gaus, CBGA}$
ggF	1.79	1.80	4.27
VBF	1.76	1.86	79.80
ZH	1.79	1.85	69.99
WH	1.85	1.94	30.10
ttH	1.81	1.85	78.97



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■ Selections Used

- Tight Photon ID, standard cuts on η , $p_T > 150\text{GeV}$
- With MxAODs produced by Chiara (big thank you!) only one photon is saved, so by default are using the highest p_T photon
- We want the $\Delta\phi$ distribution between this photon and the vertex (i.e. the tracks attached to the vertex) to peak at π

■ Photon Vertex Helpers and Photon Pointing Tool - Tools Used

- PV Helpers selects the "hardest" vertex from the container of vertices in the event, which is the vertex with tracks attached that have the highest sum p_T
- PPT gives the z coordinate of the vertex location that the calorimeter "points" to, it does this for converted and unconverted photons separately

■ Methods Used

- z_{vertex} is the z coordinate of the hardest vertex
- z_{pointing} is the z coordinate reconstructed from data in the calorimeter, $z_{\text{pointingError}}$ is the error associated with this value
- Same for z_{conv} except that this z coordinate is only reconstructed for photons with Si hits, meaning it converts before the calorimeter



Example: Unbinned Data Results

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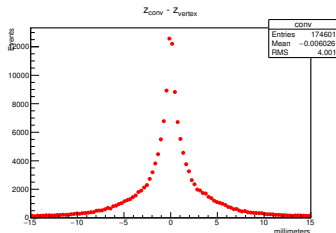
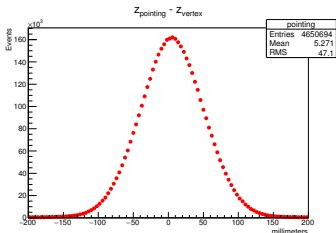
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$z_{\text{pointing}} - z_{\text{vertex}}$ compared to $z_{\text{conv}} - z_{\text{vertex}}$ in Data

- Pointing distribution is Gaussian as expected
- Converted photon pointing distribution isn't Gaussian, aim was to see its shape





Example: Binned Data Results

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$z_{pointing} - z_{vertex}$ compared to $z_{conv} - z_{vertex}$ binned by p_T in Data

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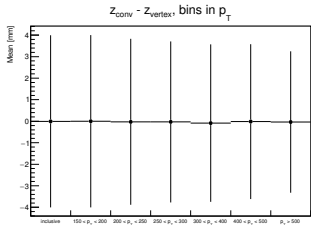
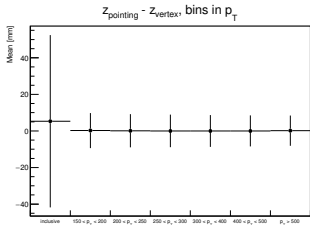
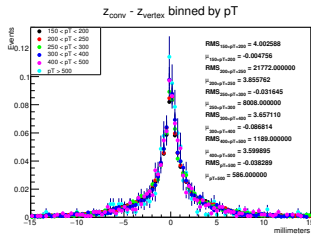
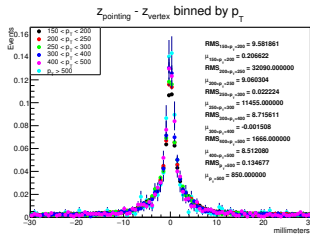
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Example: Binned Data Results with Error Correction

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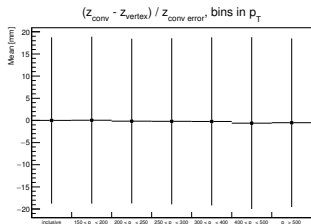
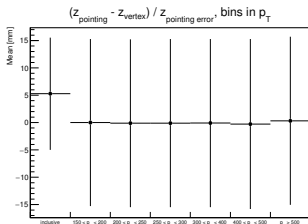
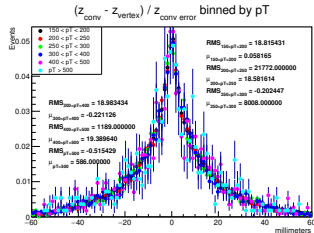
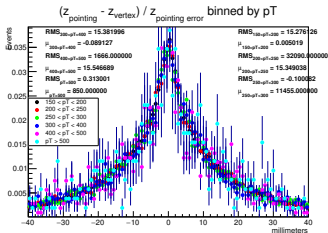
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$z_{pointing} - z_{vertex} / z_{pointingError}$ compared to $z_{conv} - z_{vertex} / z_{convError}$ binned by p_T in Data





Example: Binned Data Results

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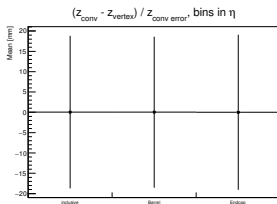
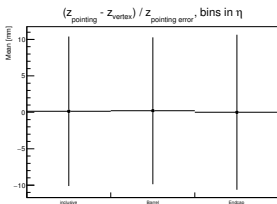
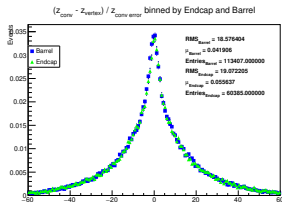
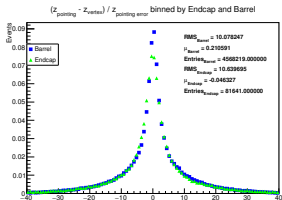
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$z_{\text{pointing}} - z_{\text{vertex}} / z_{\text{pointing error}}$ compared to $z_{\text{conv}} - z_{\text{vertex}} / z_{\text{conv error}}$ binned by η in Data





Example: Binned Comparison of Sherpa and Pythia MC with Data Results

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MC Comparison of $Z_{pointing} - Z_{vertex} / Z_{pointingError}$ and $Z_{conv} - Z_{vertex} / Z_{convError}$ binned by η

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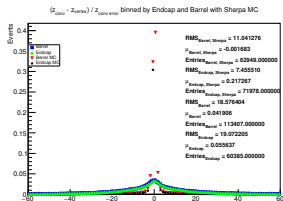
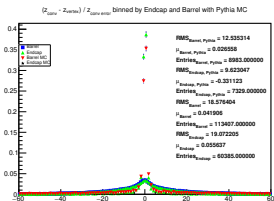
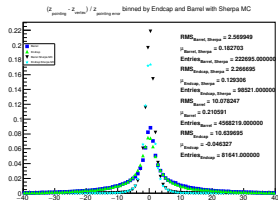
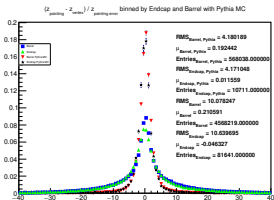
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Example: Binned Pythia Results

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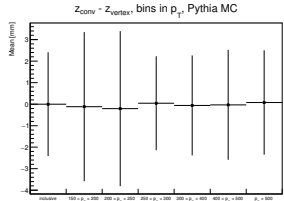
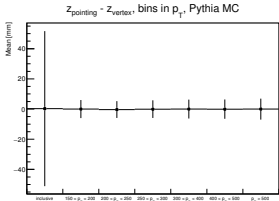
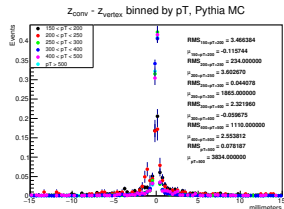
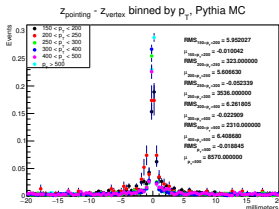
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Pythia MC Results for $z_{pointing} - z_{vertex}$ and $z_{conv} - z_{vertex}$ binned by p_T





Example: Binned Sherpa Results

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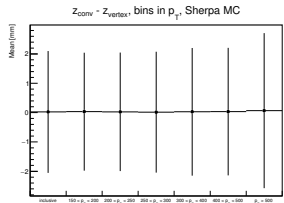
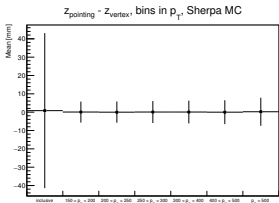
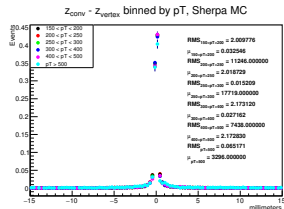
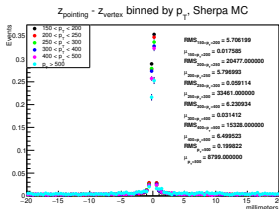
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Sherpa MC Results for $z_{pointing} - z_{vertex}$ and $z_{conv} - z_{vertex}$ binned by p_T





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Programming Skills Acquired and Honed

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Life Experience

- Learned a lot about C++, like new data structures, use of pointers, interface with ROOT
- Learned ROOT, especially worked on aesthetic/statistical manipulation of histograms
- Much more comfortable with Terminal commands and bash





Improvements in Analysis Techniques and Statistical Methods

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Life Experience

- How to assess goodness of fit - use of p-values and χ^2 statistics
- Learned about different fitting functions - for example the crystal ball
- How to use the parameters of a fit to evaluate quality, what specific parameters mean when doing a comparison of fits
- How to make a summary plot with mean and RMS





Expanded Perspective on the world of Experimental Physics Research

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Life Experience

- Explored option for post graduation, physics grad school and especially experimental physics analysis
- Saw what software analysis would be like, potentially what I could do as a PhD student
- Worked with PhD students, professors and postdocs





Gains in Life Experience

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Life Experience

- Took on more responsibility working a job, instead of doing 10-15 hours of research a week on top of classes
- Worked as part of a team, worked with deadlines
- Lived in a country which doesn't speak English, worked with people of varied cultural backgrounds





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Thanks for a great semester!