Segment Efficiencies and Dead Layers

Heather Crawford (LBNL)

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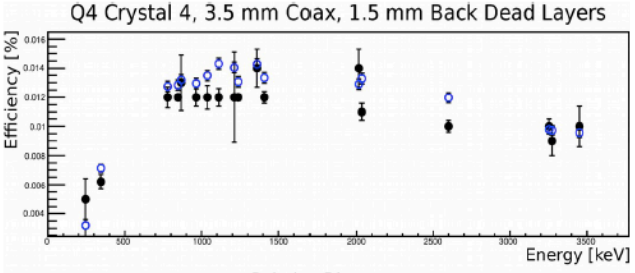
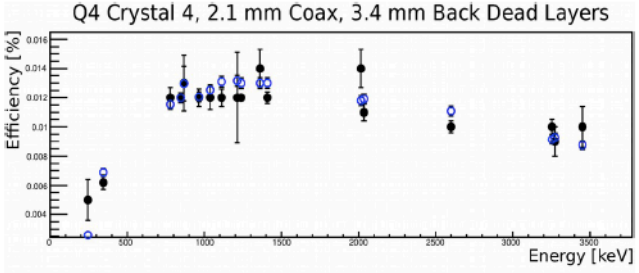
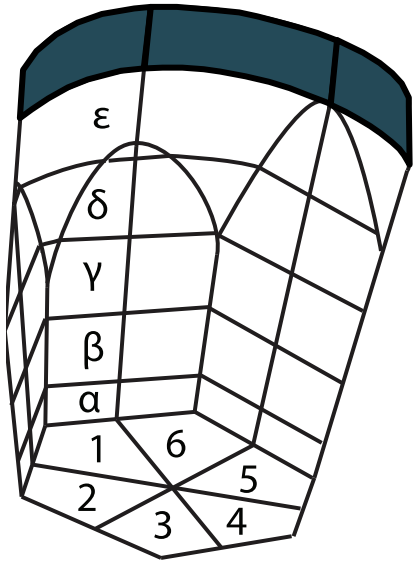
Detector Rear Dead Layers







- Efficiency measurements, requiring a signal in the rear layer (rear 1.2cm) of the crystals can be compared to simulation, analyzed in the same way
- Shape of efficiency curve proves sensitive to rear dead-layer thickness

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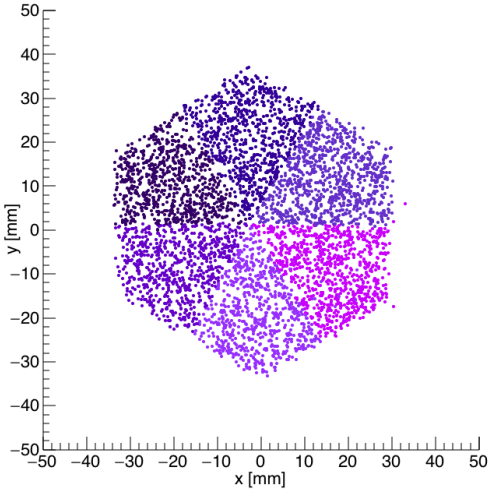
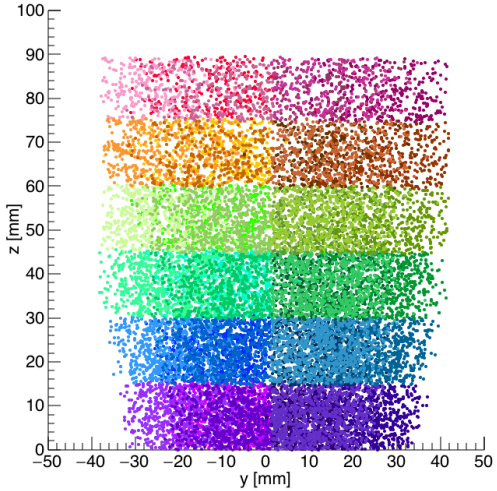
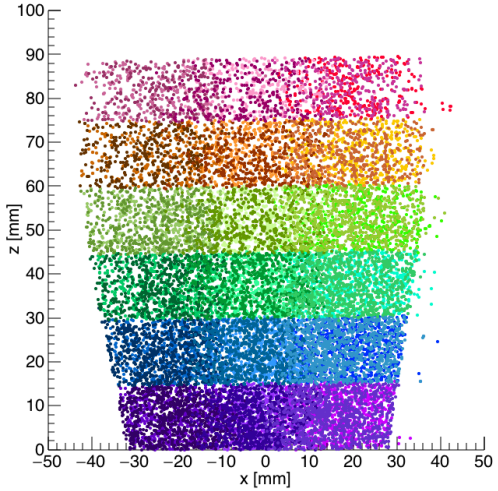
“Enhanced” Simulation

Toward a More Realistic Description







- GEANT4 includes realistic crystal geometries but does not have the correct segmentation
- Introduces challenges in accurately applying concepts such as position resolution etc. – realistic description would require us to maintain the definition of net segment correctly

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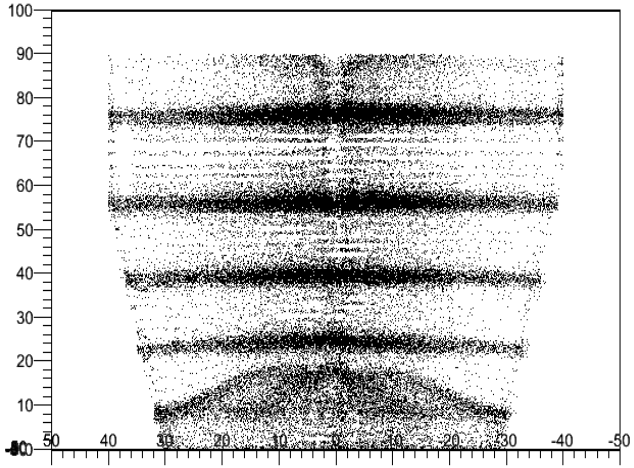
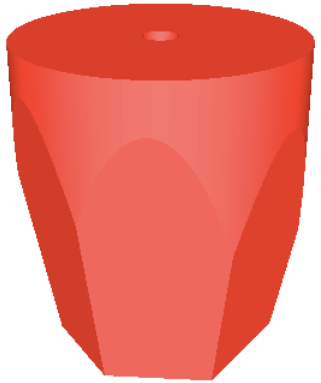
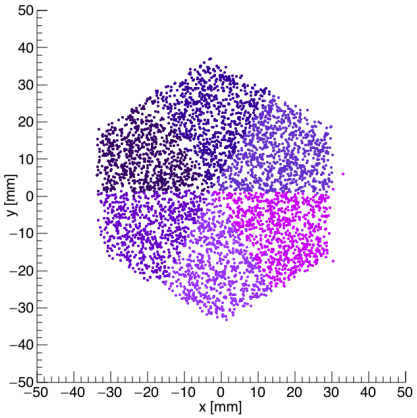
Improving Segment Boundary Descriptions

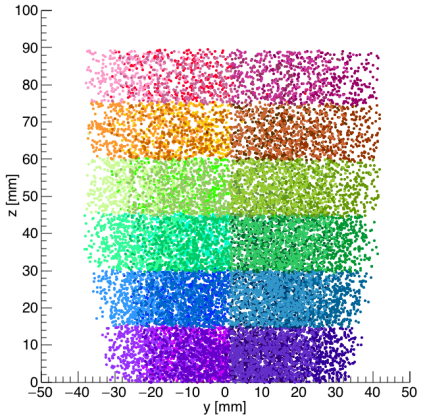


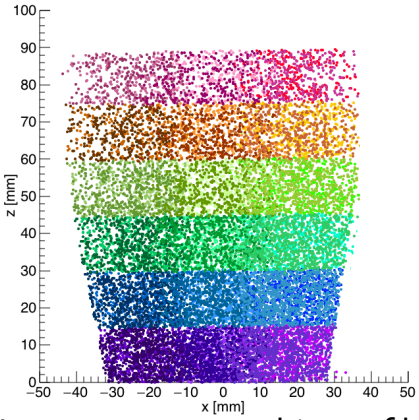


- GEANT4 includes realistic crystal geometries but does not have correct segmentation
- We use the basis grid points to define the correct segmentation in Z (as a function of X, Y) and phi
- Directly reproduce detector crystal geometry (A and B type) in ROOT, to constantly check that no operation puts interaction points outside the physical crystal volume

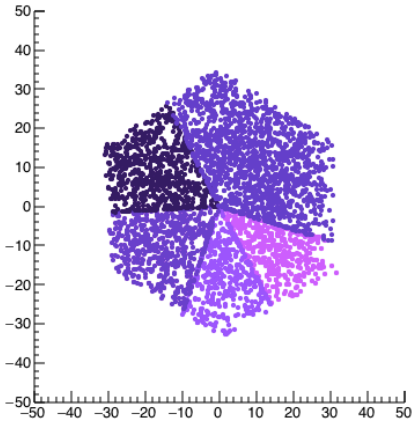
Improving Segment Boundary Descriptions

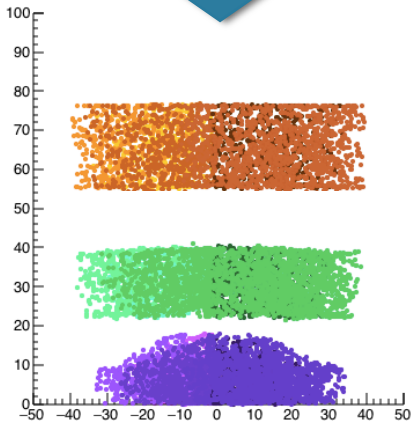


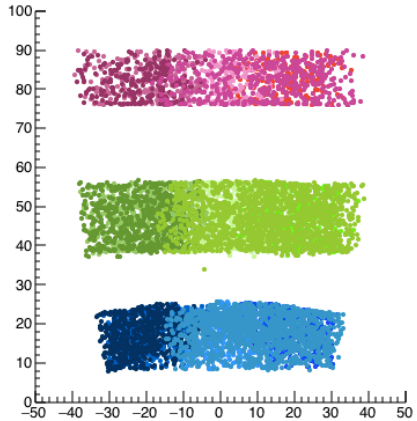




- 5% of points were removed (out of bounds)
- 49% of segments were modified







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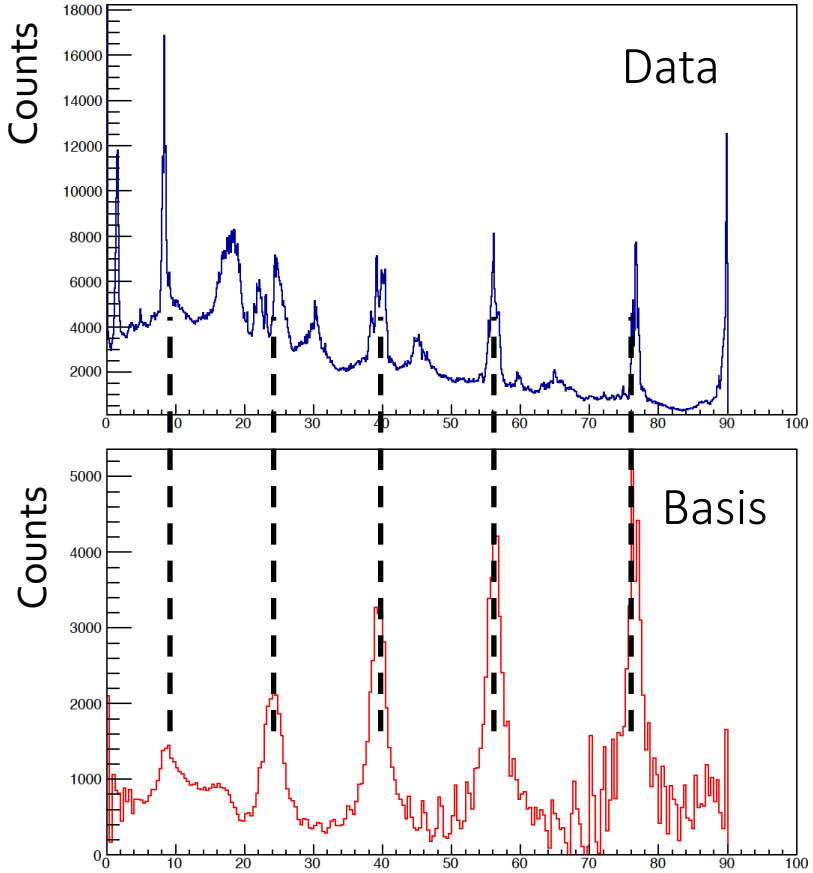
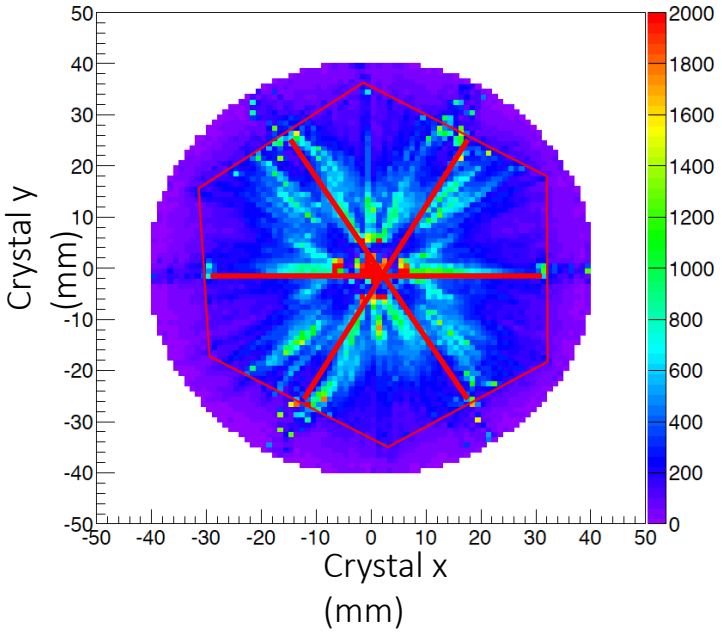
Decomposition Basis and Errors



- Similarity in basis point distributions and data (x,y,z) distributions suggests using density of grid points to weight likelihood for altered interaction point positions



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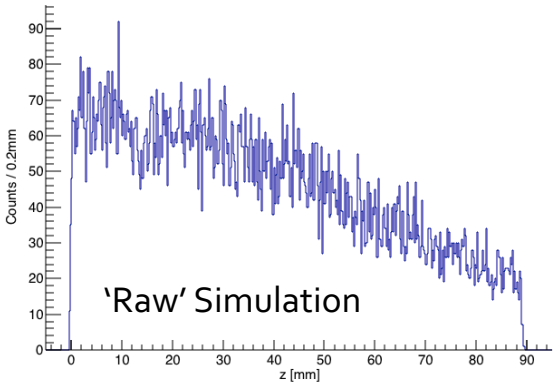
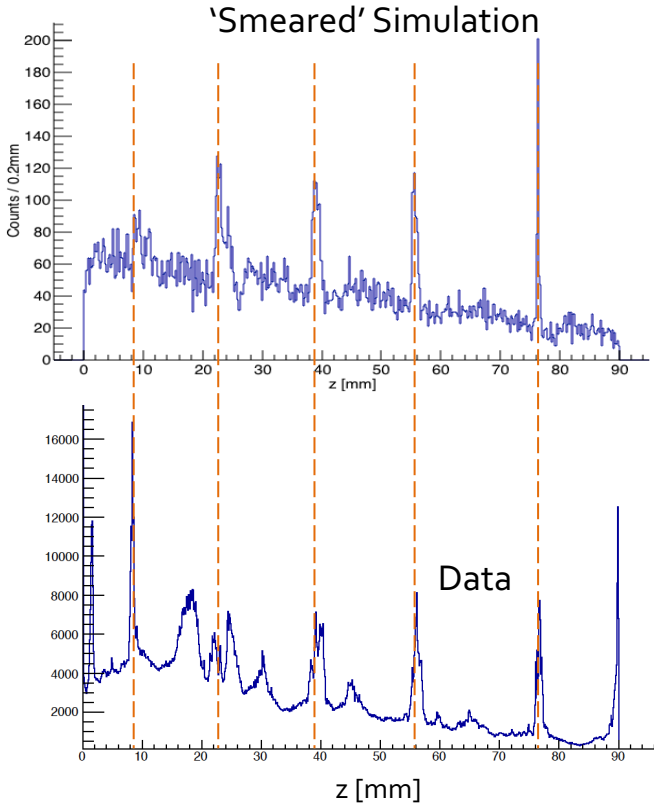
Converging Toward Data



$$\sigma_{x,y,z}(E) = A \times \sqrt{(1/E)} + B$$

$$\sigma_{x,y,z}(100\ \text{keV}) = 4\ \text{mm}$$

$$\sigma_{x,y,z}(1000\ \text{keV}) = 2\ \text{mm}$$



- With realistic segments, interaction point distributions naturally move toward reproducing data more readily
- Application of an energy-dependent position resolution smearing to the simulated data, while requiring no change to the segment ID naturally results in "clumping" of lower-energy points near segment boundaries

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Segment Efficiencies

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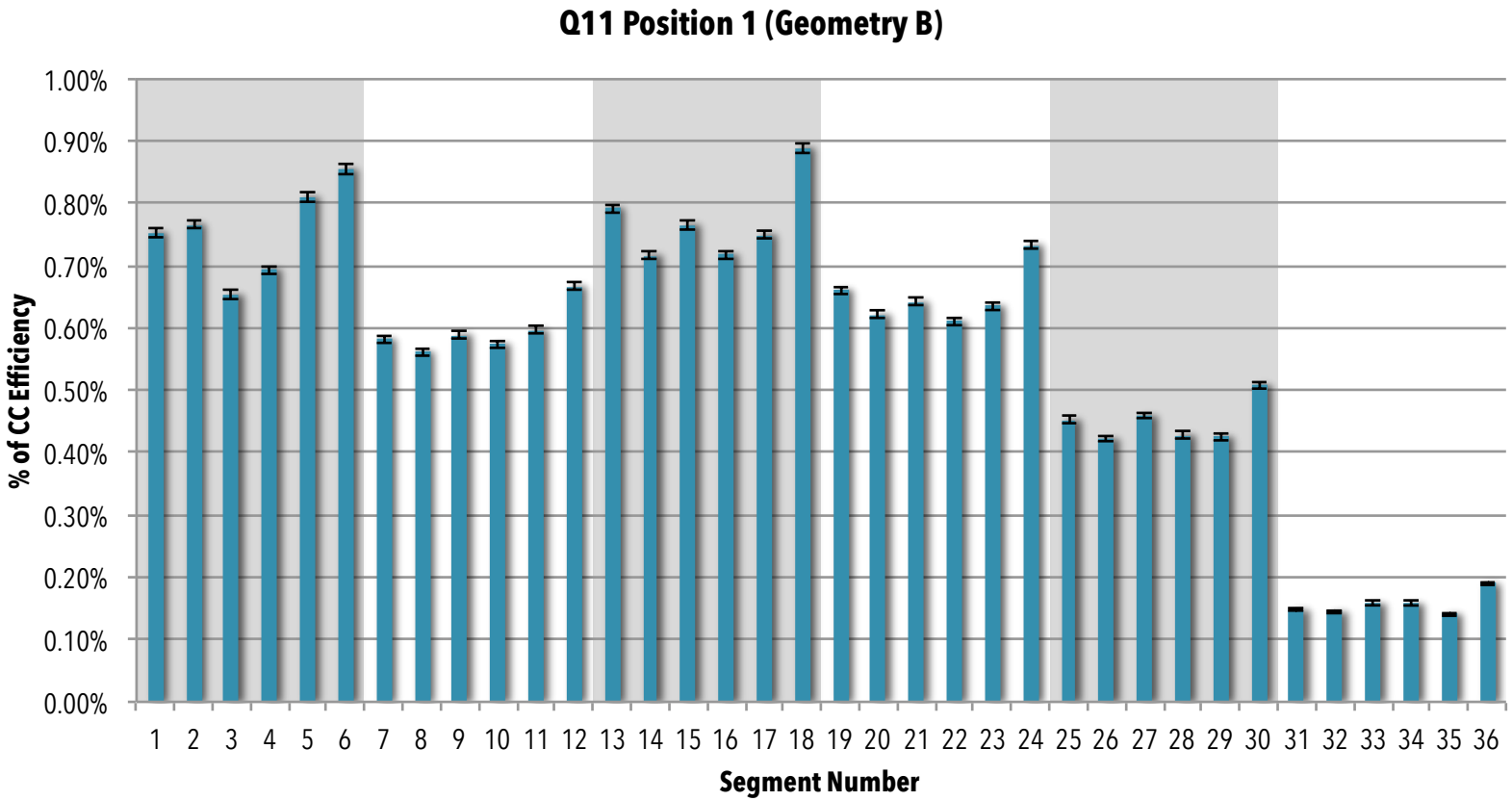
Segment Efficiency (% of CC)



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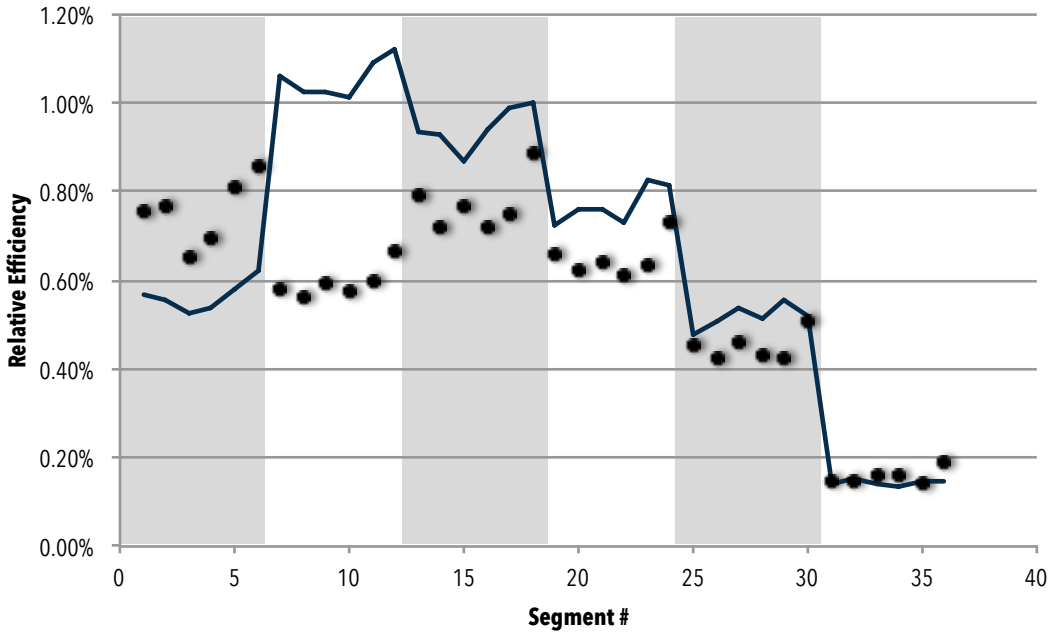
"Standard" Simulation



- 1.5 mm back dead layer + 3.5 mm coaxial dead layer
- Flat segment slices at 8, 14, 16, 18 and 20

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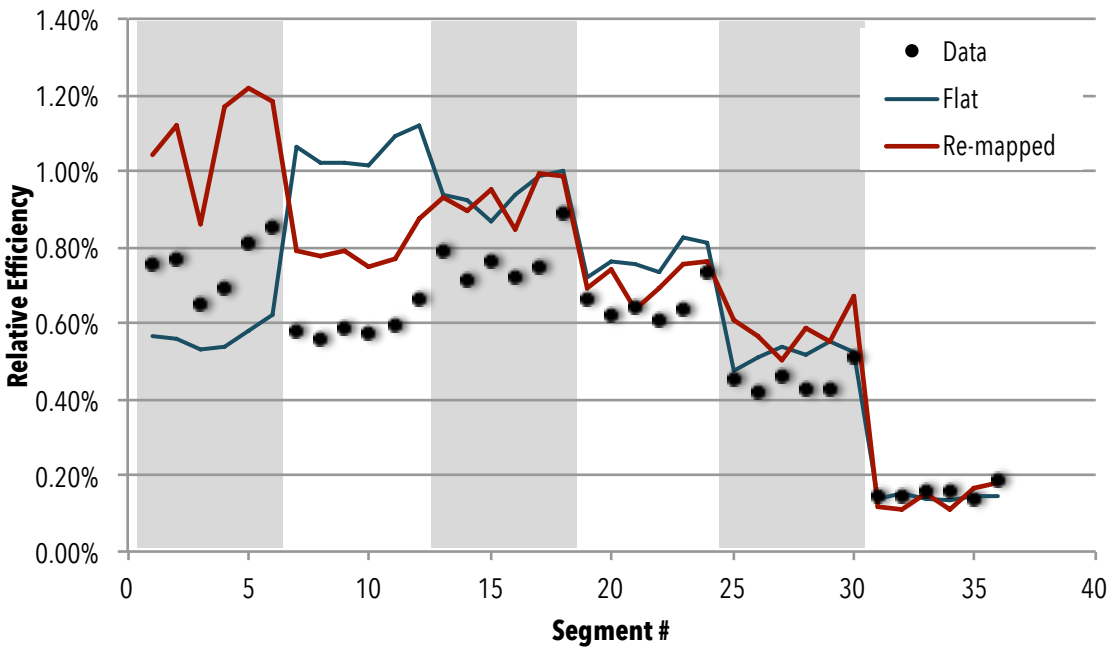
Remapped Simulation



- 1.5 mm back dead layer + 3.5 mm coaxial dead layer
- Mapped to realistic segment boundaries (all changes to layer #)
- Shape of distribution for segment efficiencies correct

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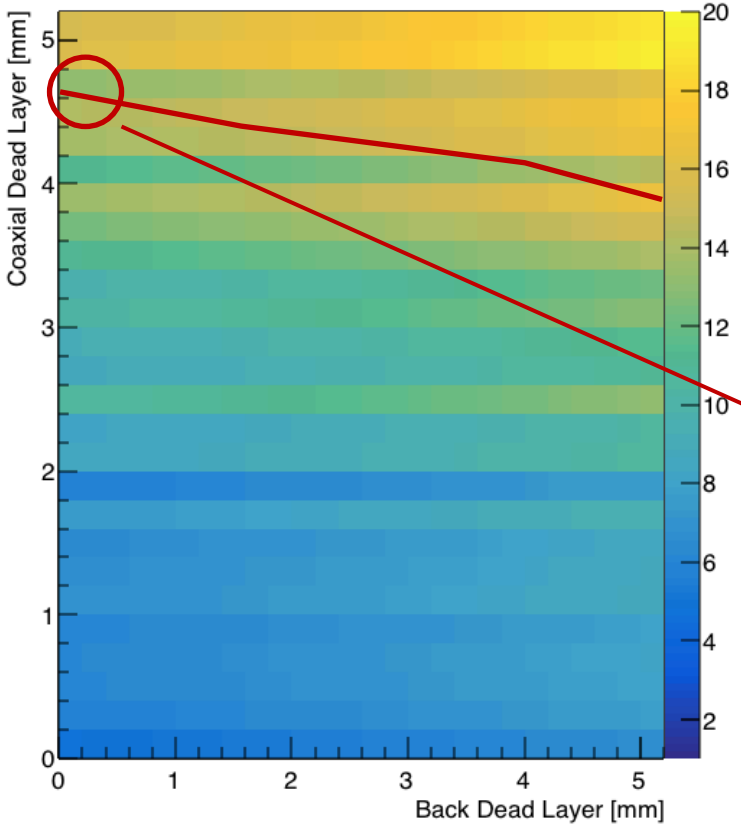
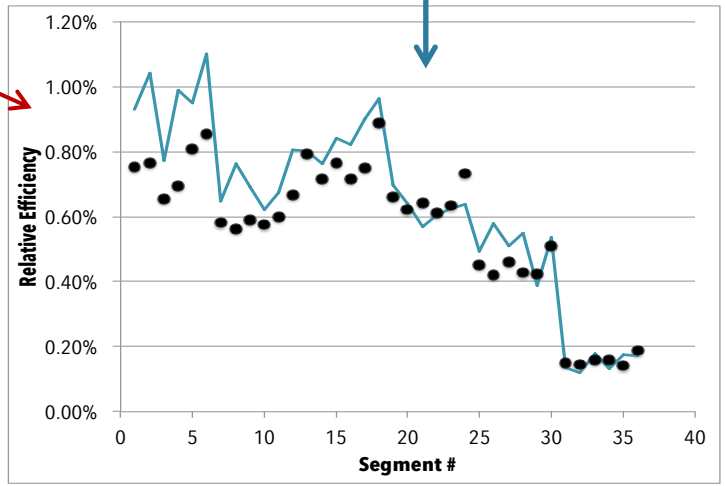
Remapped Simulation



- Vary dead layers and optimize χ^2 of difference in segment-by-segment relative efficiencies
- Best "fit" for lower dead layers (coaxial and back)



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Still Under Development…

- There is no consistent description of overall crystal efficiency and segment partial efficiencies – for both crystal geometries A and B
    - Suggestive of additional losses – outer surface area effective dead layer?

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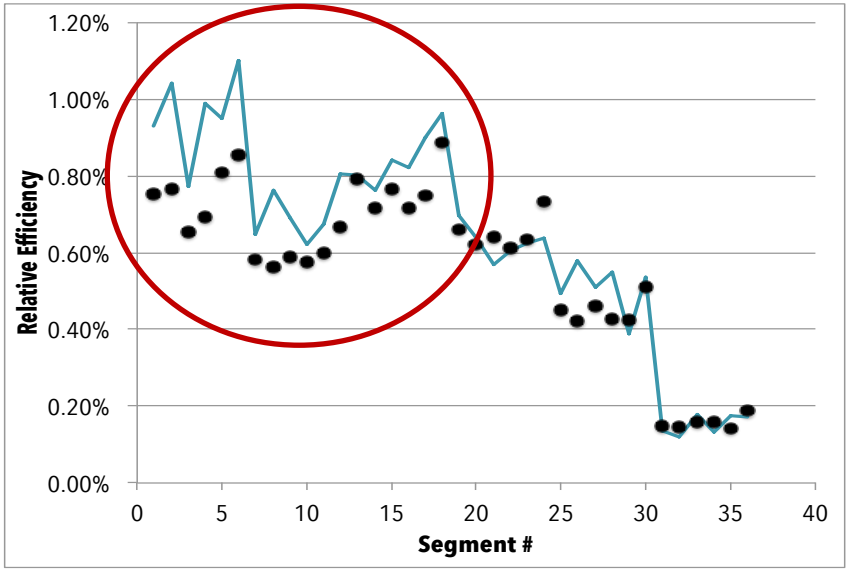

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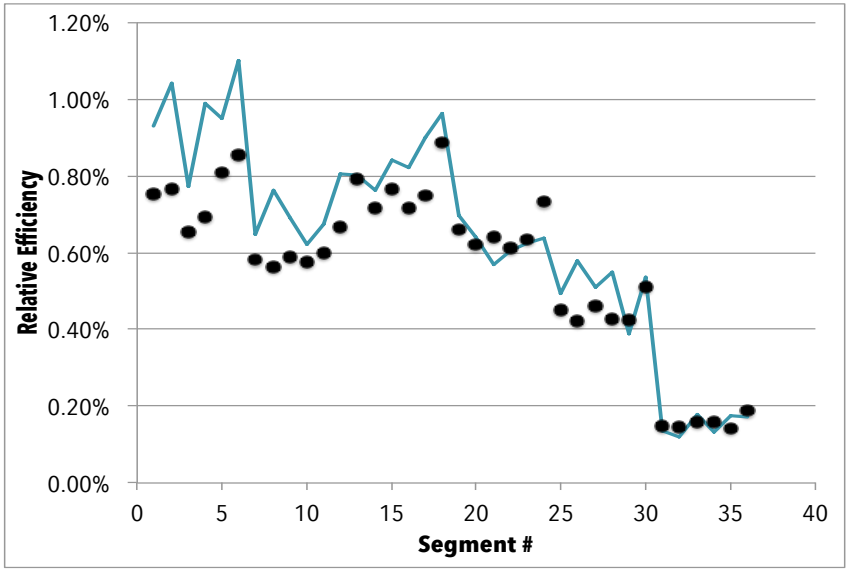
Still Under Development…

- There is no consistent description of overall crystal efficiency and segment partial efficiencies – for both crystal geometries A and B
  - Suggestive of additional losses – outer surface area effective dead layer?
  - Exploring addition of outer surface dead layer – combine optimizing segment and total efficiencies to fit crystal-by-crystal for most accurate description



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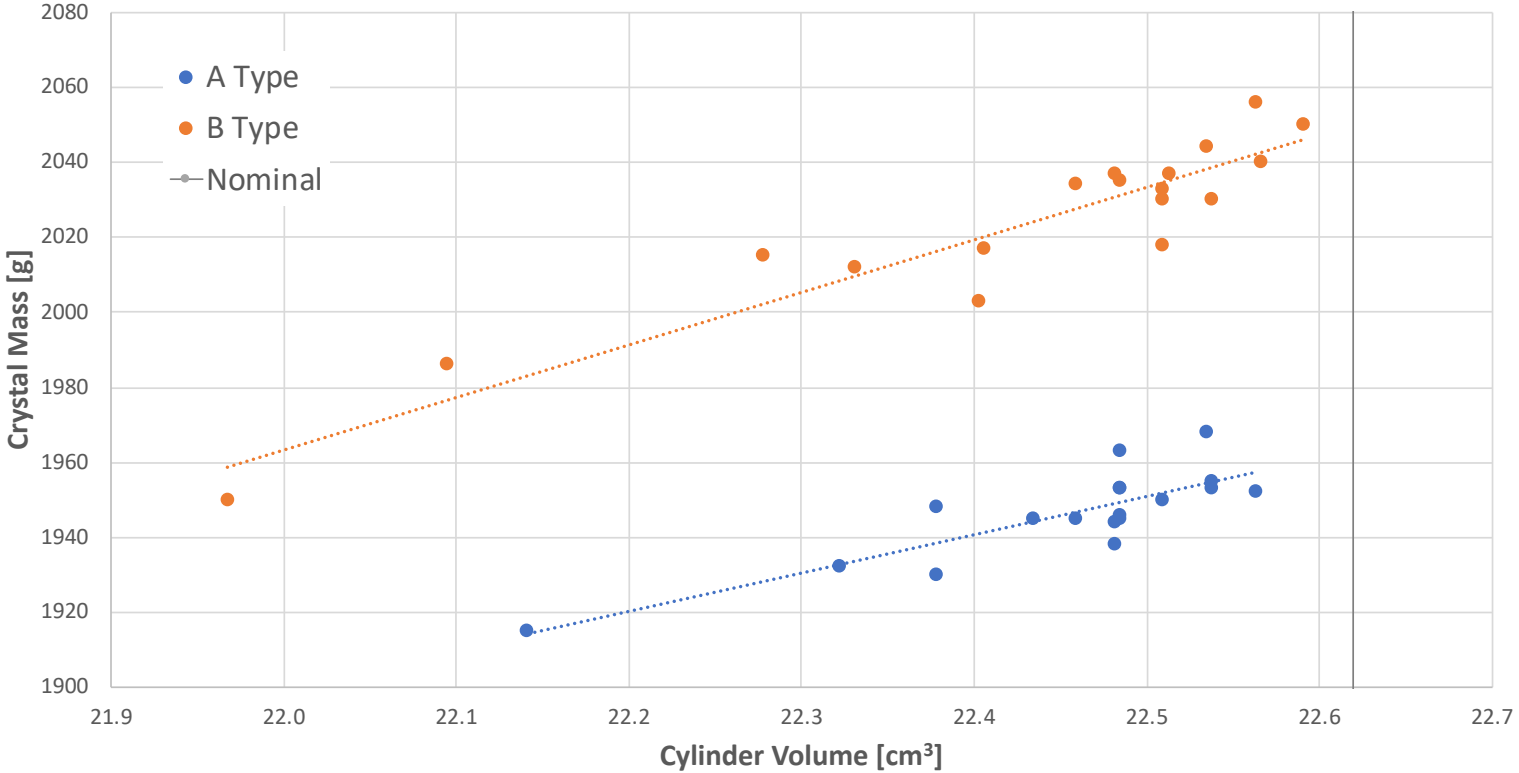
Variation Between Crystals



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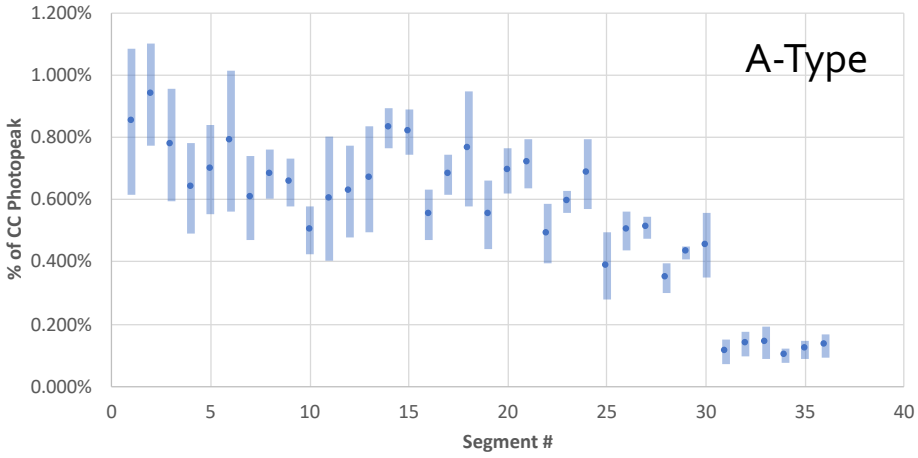

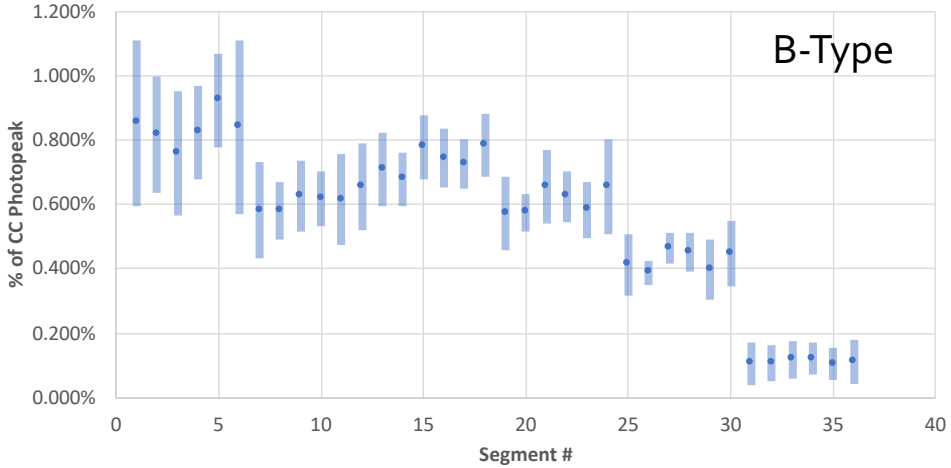

- Variation of relative segment efficiencies between crystals is at ~20% level
- Fully realistic simulation requires 120 independent crystal dimensions / dead layers

- Parameters ***can be*** determined from flood field data – iterative between simulation and field calculations

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Segment Efficiencies & Dead Layers

- UCGRETINA GEANT4 simulation package has become an all-inclusive package for both physics analysis and GRETINA performance benchmarking
- Detailed scanning measurements are continuing to refine the subtleties of detector geometry

- More "realistic" simulations are currently being reached by post-processing of GEANT4 outputs
  - Realistic segments and energy-dependent smearing provide path forward to better agreement with P/T and polarization
  - Method to investigate partial energy loss near boundaries and surfaces etc.
  - Segment efficiencies within specific layers can constrain dead layers (rear, coaxial and outer surface?)

Acknowledgements

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& Richard Chen (UCBerkeley)

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THANK YOU!

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