

Attenuation Analysis Update

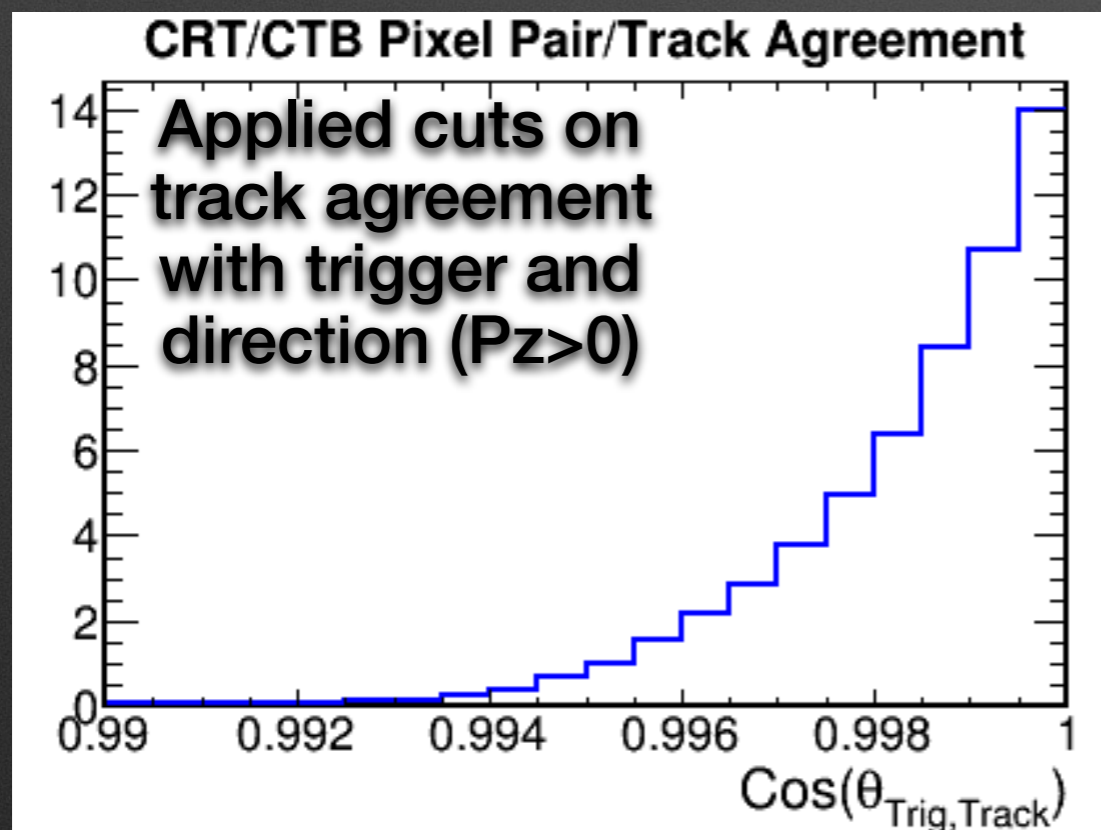
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ProtoDUNE DRA**

Introduction & Method Refresh

- Can temporally coordinate all three ProtoDUNE-SP subsystems using the CTB triggered by the CRT on cosmic muons.
- An upstream and downstream muon pixel pair is necessary for the trigger to fire (time difference of 60 ns).
- Comparison of reconstructed track position and orientation to CRT pixel centers confirms trigger and selects track.
- Photons are collected over the entire event and integrated over the entire single track.

Dataset & Cuts

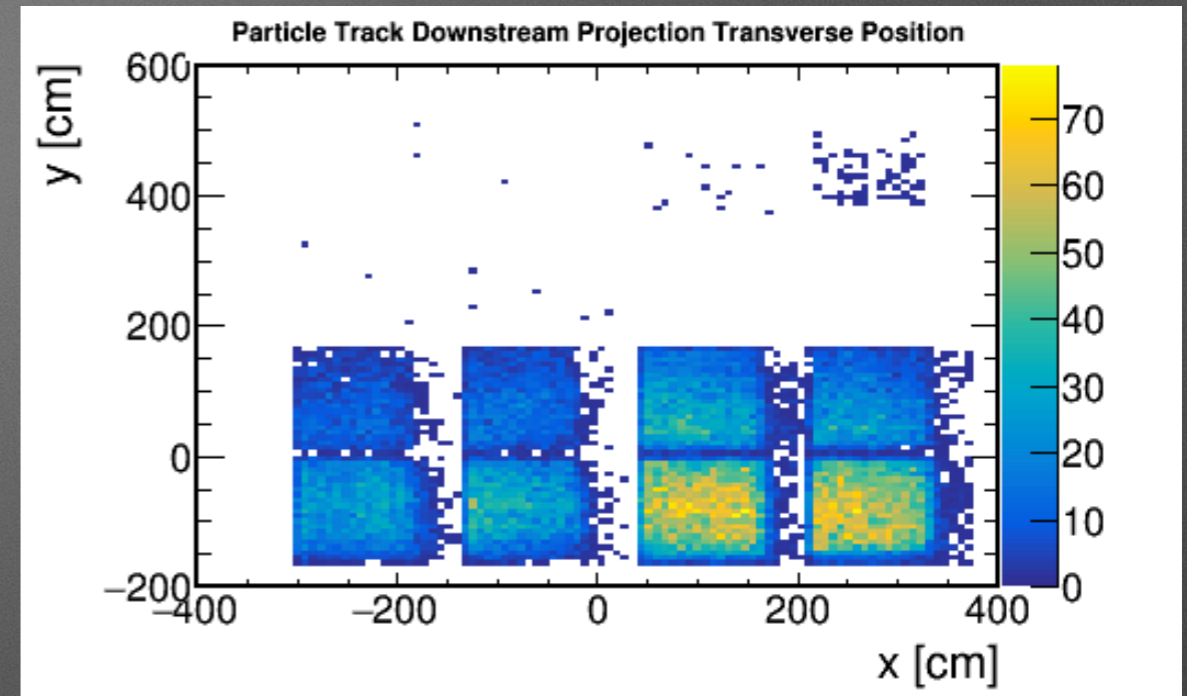
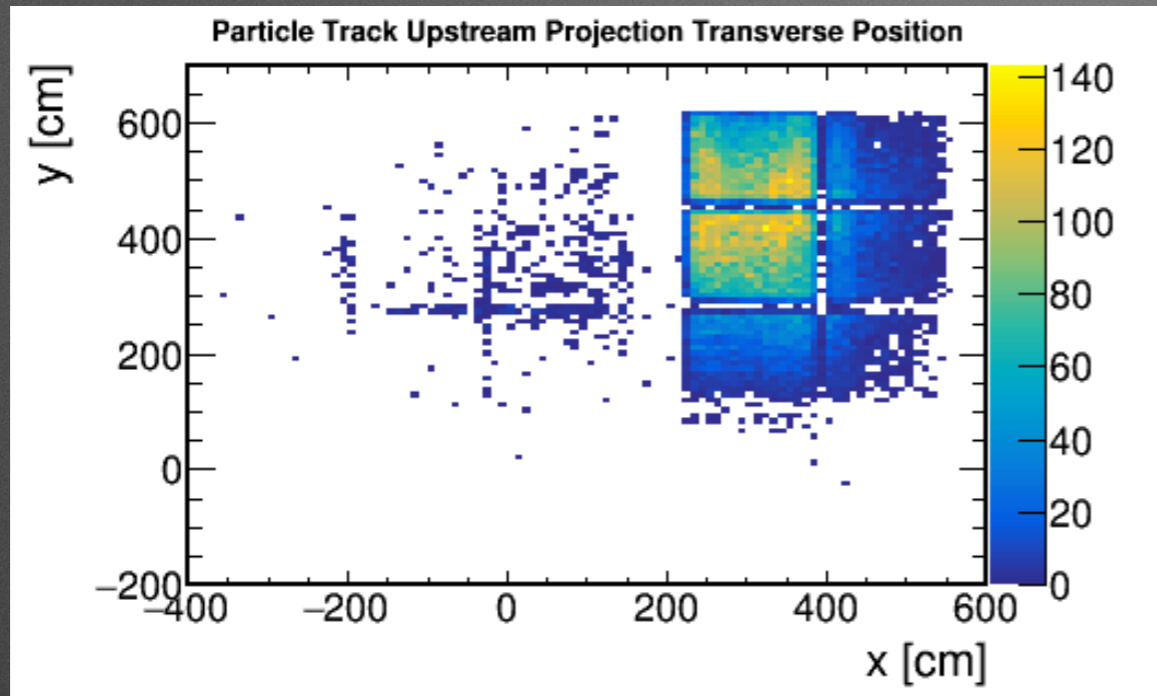
- This is latest TPC/Pandora and SSP processed data!
- Slight geometry change in PDS photon detectors
- Used the runs from the chart, ~1.13 million events



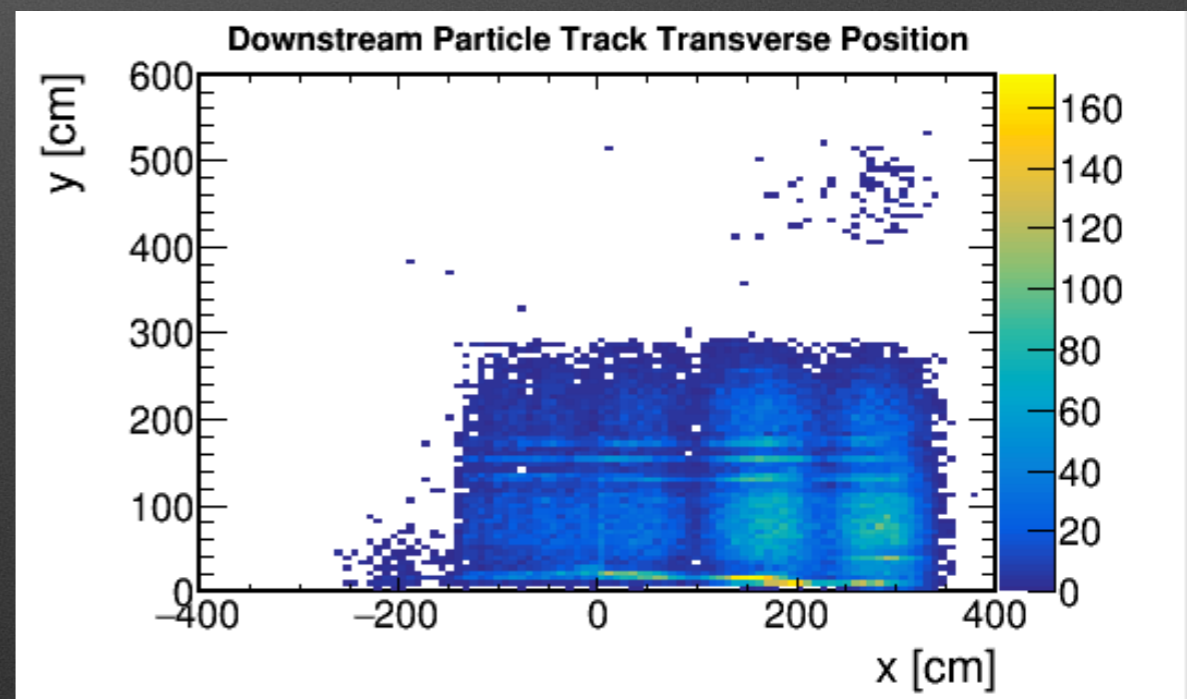
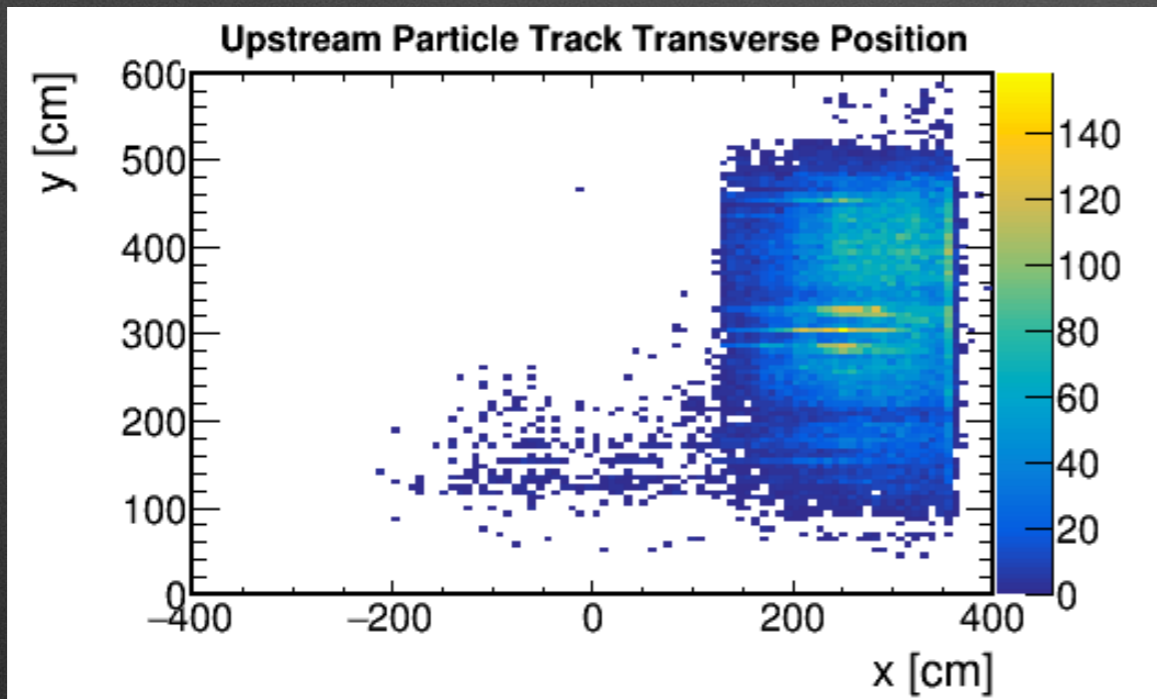
RUN	DATE	SIZE (FILES)
5785-5786	11/5/18	2,202
6120	12/10/18	1,530
6191	12/11/18	1,493
6696,6698,6700	2/7/2019	2,373
6776	2/12/2019	476
6812	2/14/2019	1,413
6834-6838	2/19/2019	4,251
6856	2/20/2019	2,049
6872-6874	2/21/2019	2,536

Track Characteristics

Projection to CRT



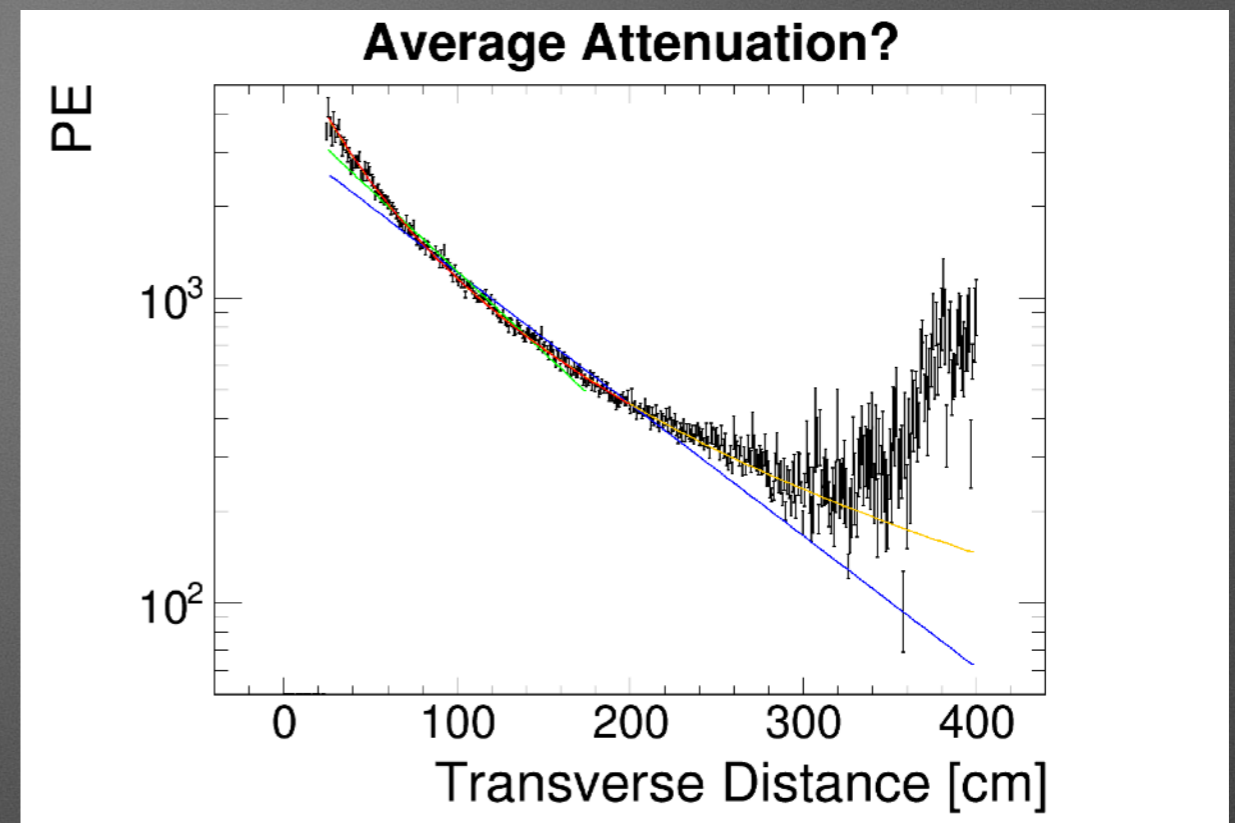
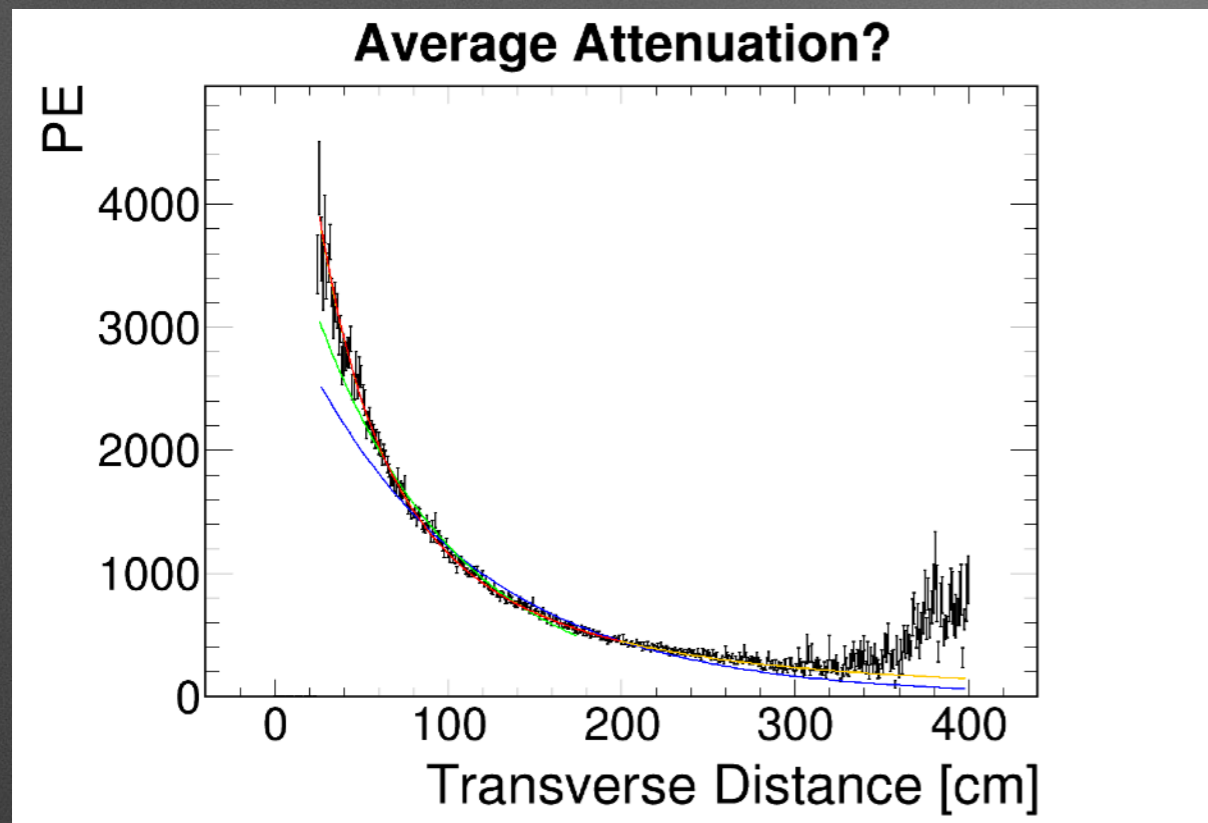
TPC Face



Upstream

Downstream

Attenuation Estimates?



Chi²/NDF ~ 184/149

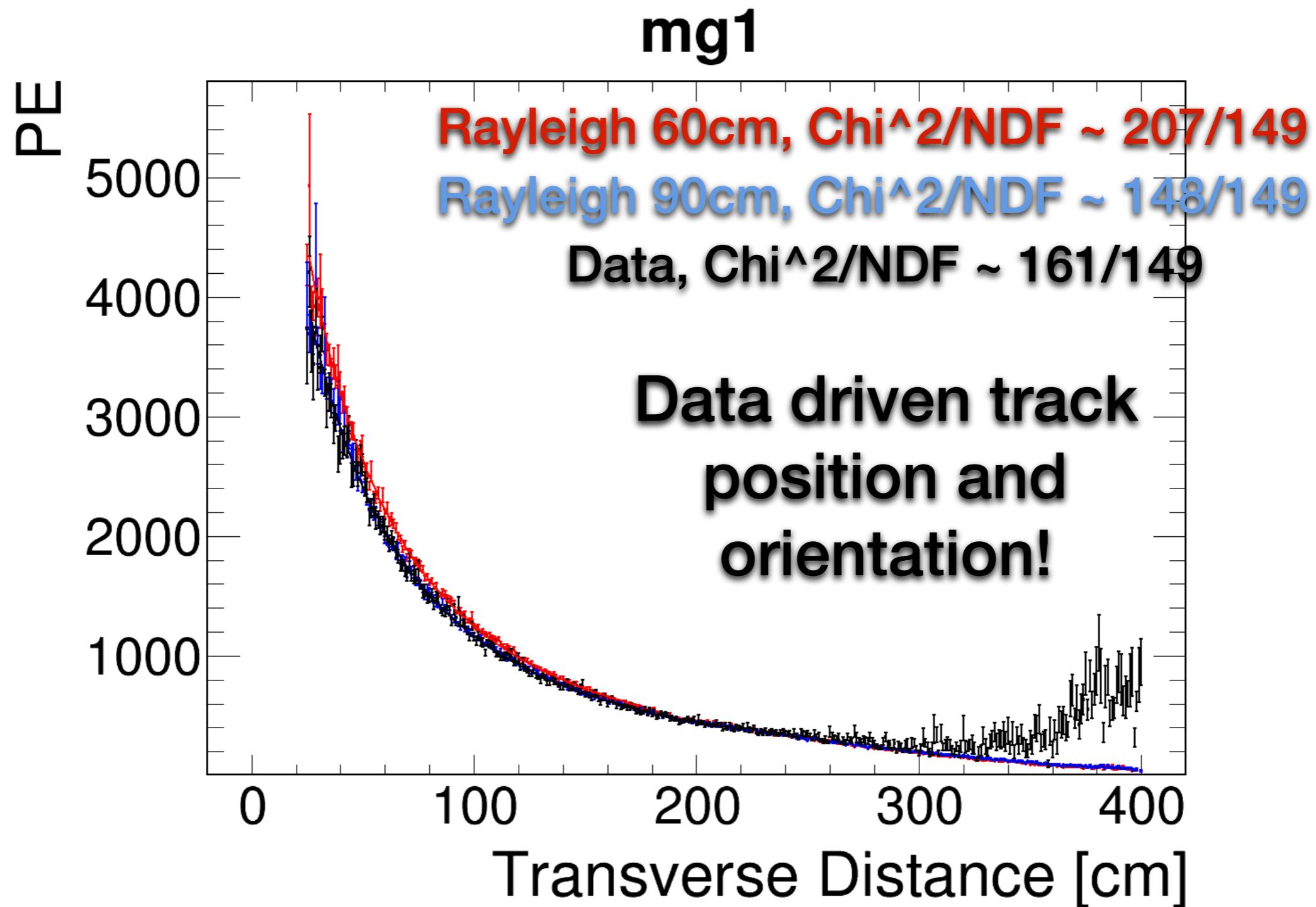
Chi²/NDF ~ 979/374

Chi²/NDF ~ 602/149

Chi²/NDF ~ 3,333/374

- Exponential no longer fits! Relationship goes like r^{-2}
No longer clear what value maps to attenuation-like measurement!

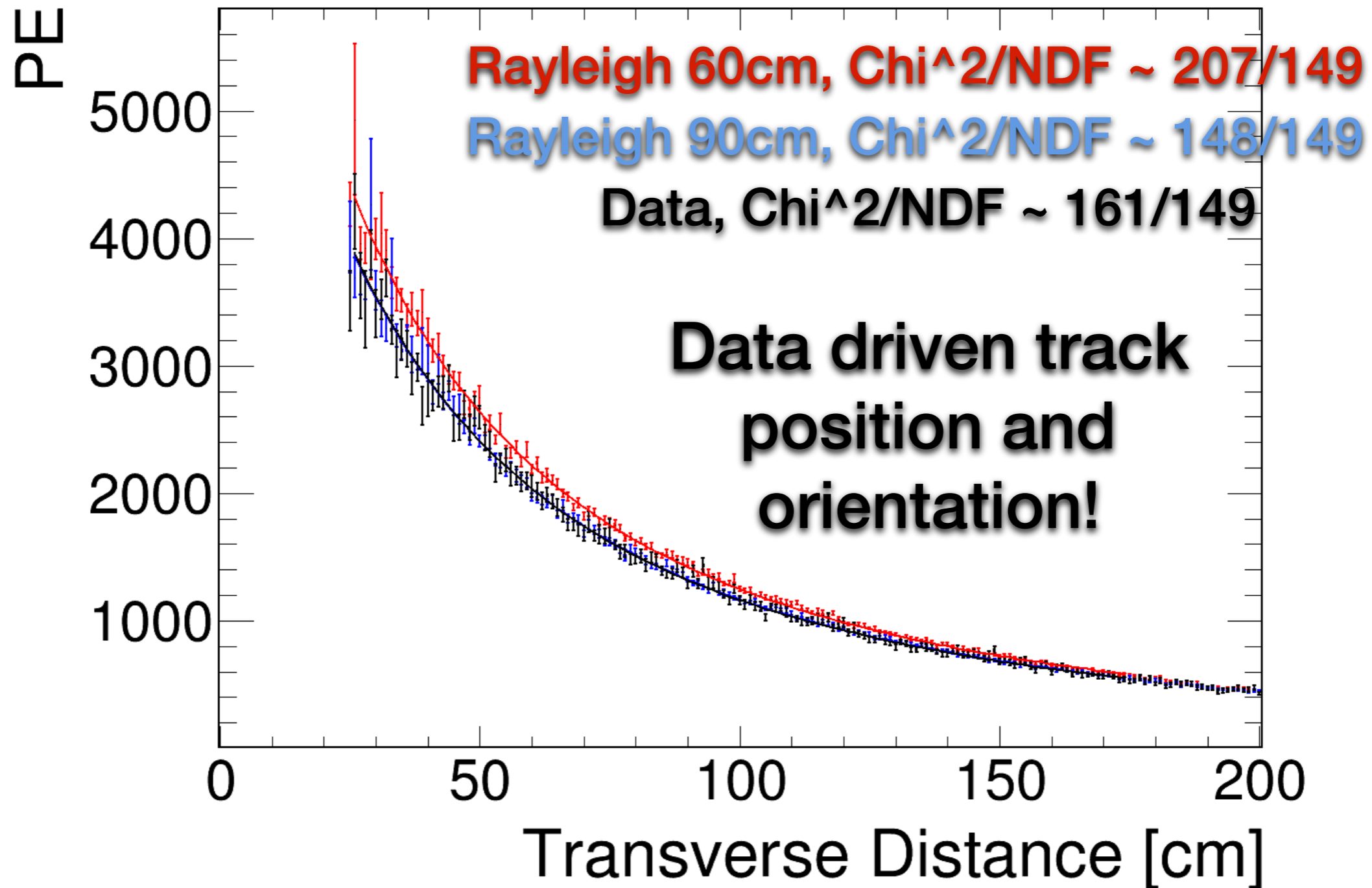
Comparison to Simulation



- Very good agreement when fit from [25cm, 175cm], fit fails above there, why?

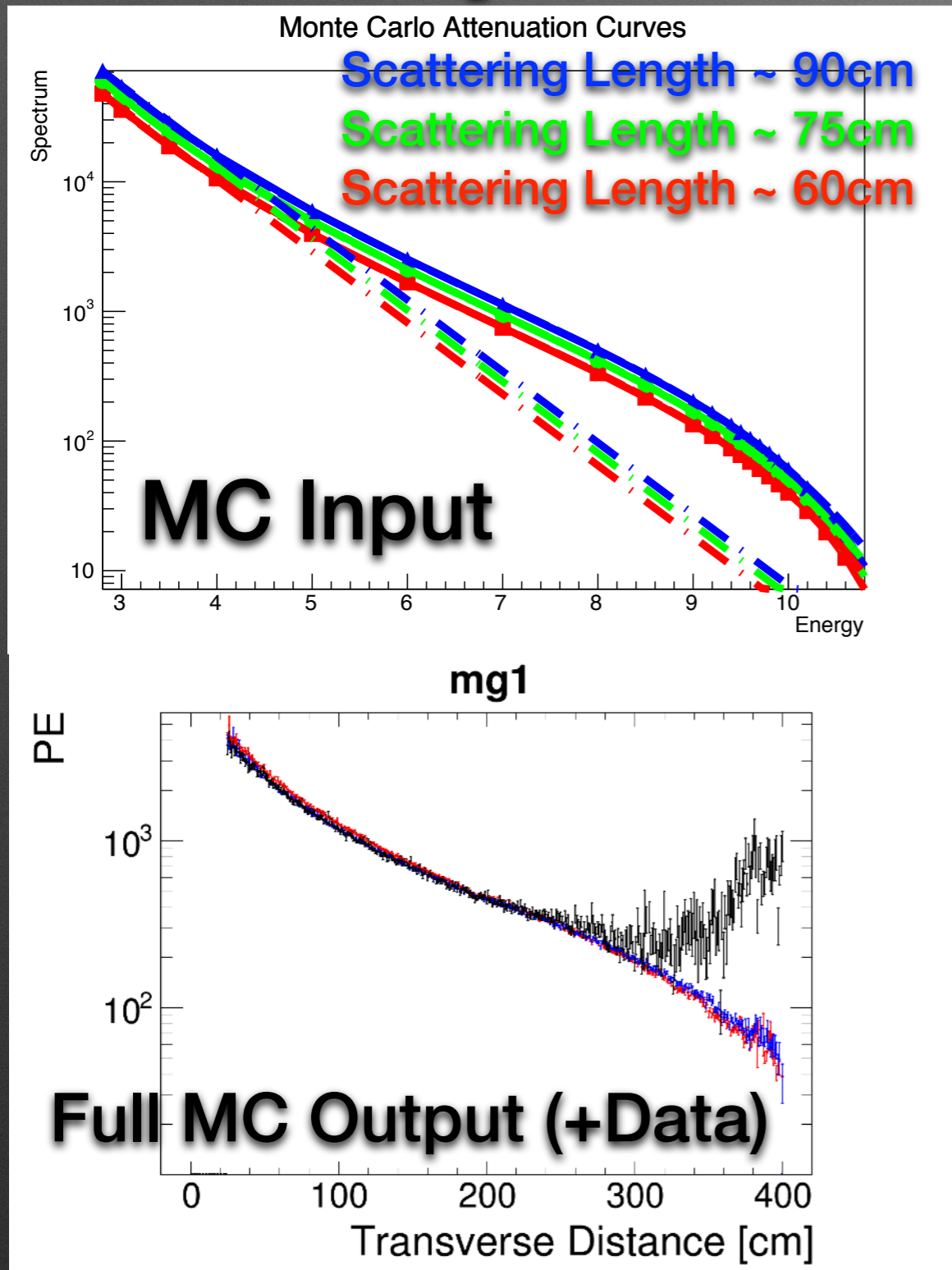
Comparison to Simulation

mg1

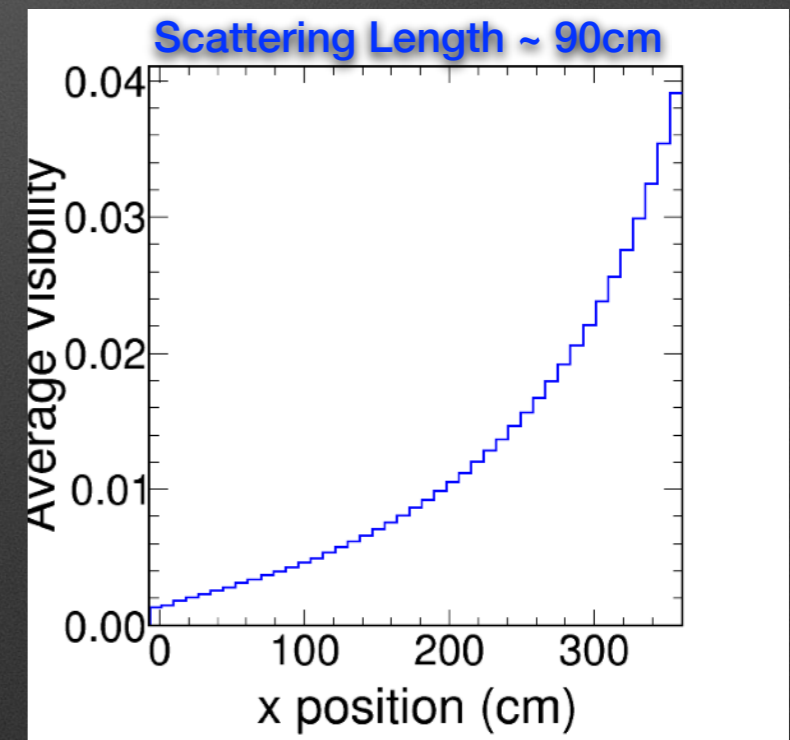
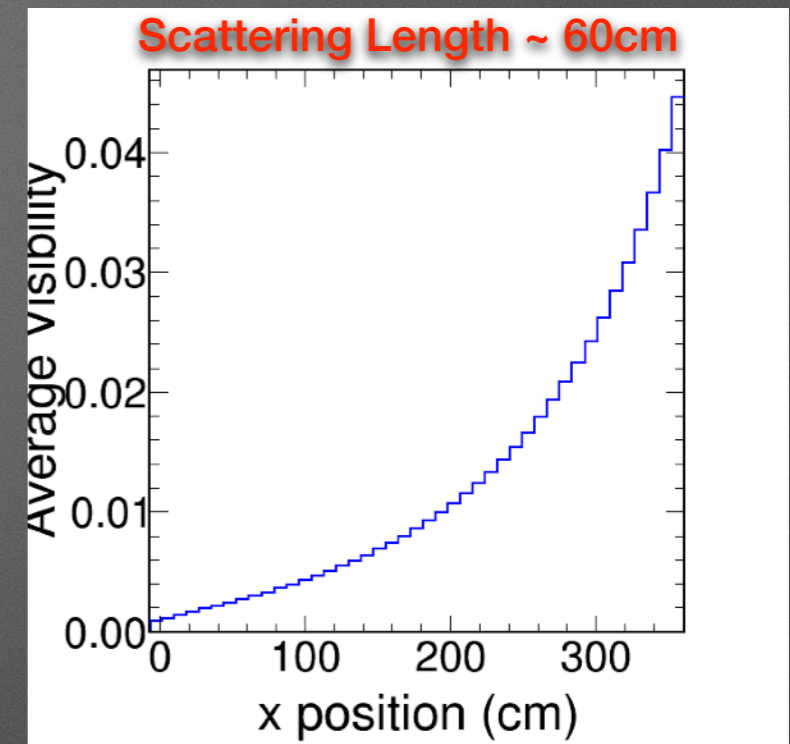


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Comparison to Simulation



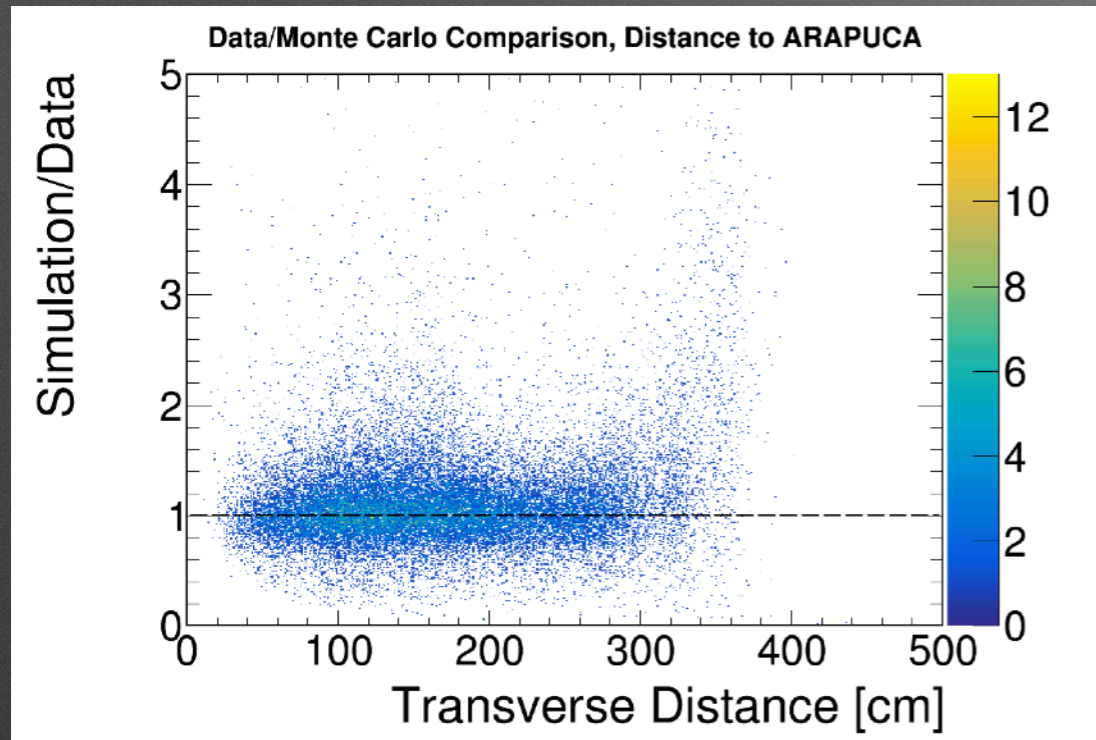
Intermediate Step - Light Library



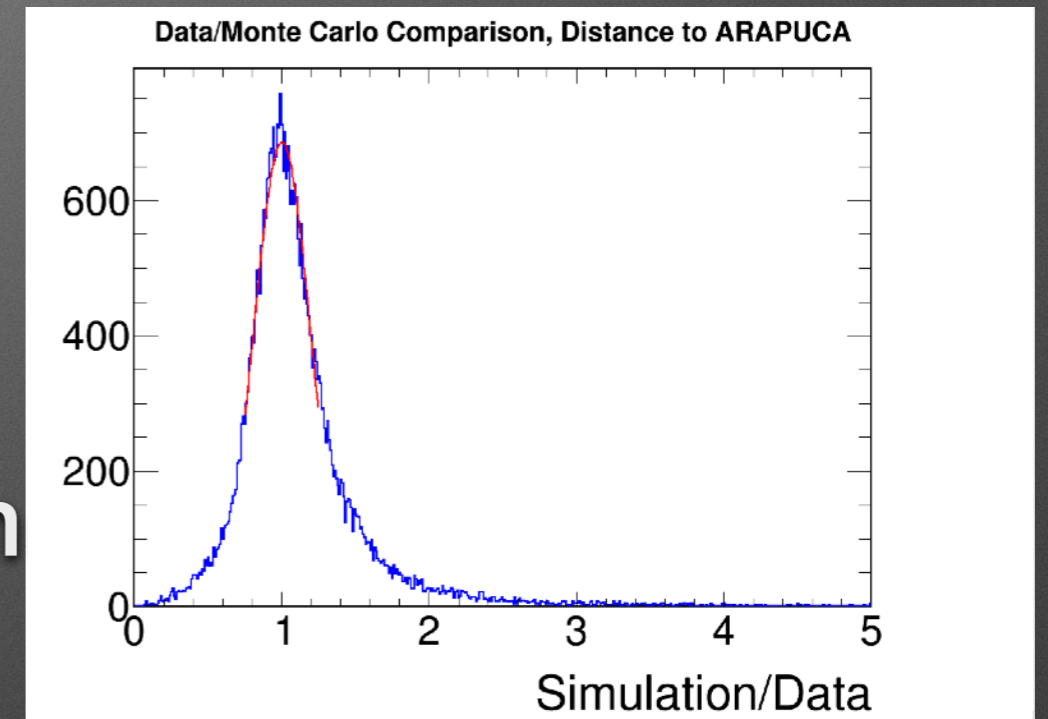
In the simulation, Rayleigh scattering only becomes apparent at distances greater than 2 meters, maxes out at ~5% effect at 3 meters!

Comparison with Simulation

- Can we resolve this 5 percent difference with cleaned up far distance tracks?



Projection



```
FCN=75.111 FROM MIGRAD    STATUS=CONVERGED    70 CALLS    71 TOTAL
                        EDM=3.31291e-09    STRATEGY= 1    ERROR MATRIX UNCERTAINTY    2.0 per cent
EXT PARAMETER
NO.   NAME      VALUE      ERROR      STEP      FIRST
 1   Constant  6.86463e+02  5.93682e+00  1.75892e-02  -3.20289e-06
 2   Mean      1.00259e+00  1.71361e-03  -6.34522e-07  -6.25522e-03
 3   Sigma     1.88543e-01  2.48730e-03  -1.36236e-05  1.76722e-02
```

- Data and simulation agree (after normalization and with tails) but event-by-event difference is almost 19%!

Conclusions

- New geometry, reconstruction, and fit strategy *significantly* improves agreement between data and simulation!
- Attenuation measurement is significantly more difficult given increase in precision and change in fit strategy.
- Resolving power of data is currently ~ 4 times less than the physical difference in light due to scattering.
- Why? Possibly due to angle on cosmic muons and imperfections in PDS geometry. Eager to get to improved data and simulations!

