ProtoDUNE-SP Attenuation Update

Monte Carlo

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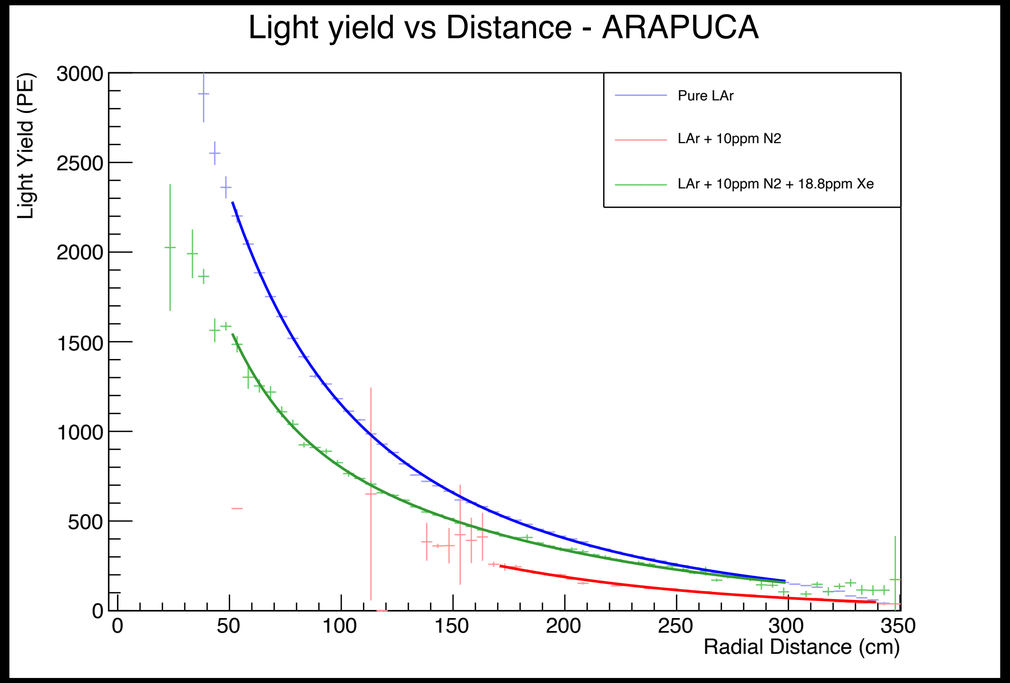
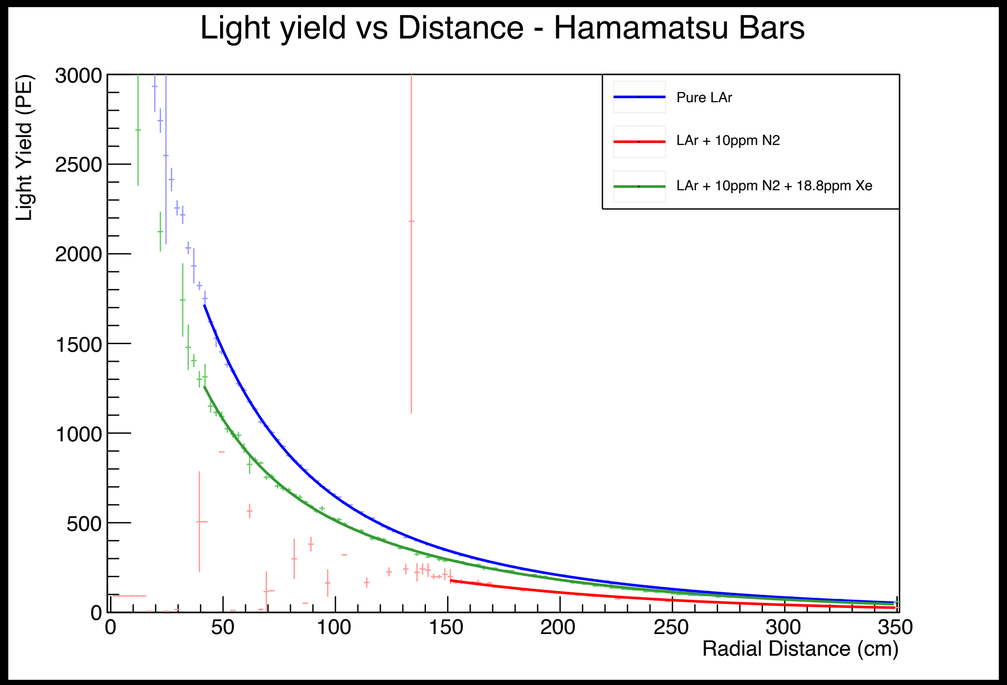
Update

- Monte Carlo tracks generated with position/momentum from the data tracks
  - Create 1:1 MC to data track
- Run through light reconstruction process
- Transverse distance calculated from true MC start/end position
  - not reconstruction (data uses pandora)


Light yield vs Distance - ARAPUCA
Light Yield (PE)
Radial Distance (cm)
Pure LAr
LAr + 10ppm N2
LAr + 10ppm N2 + 18.8ppm Xe


Light yield vs Distance - Hamamatsu Bars
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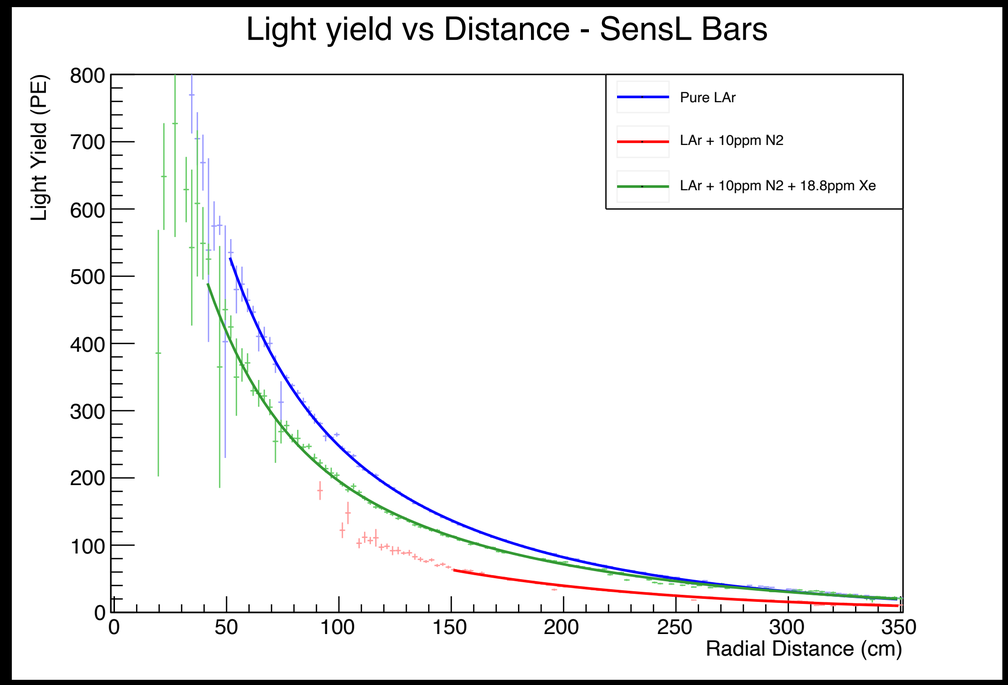
Light yield vs Distance - SensL Bars
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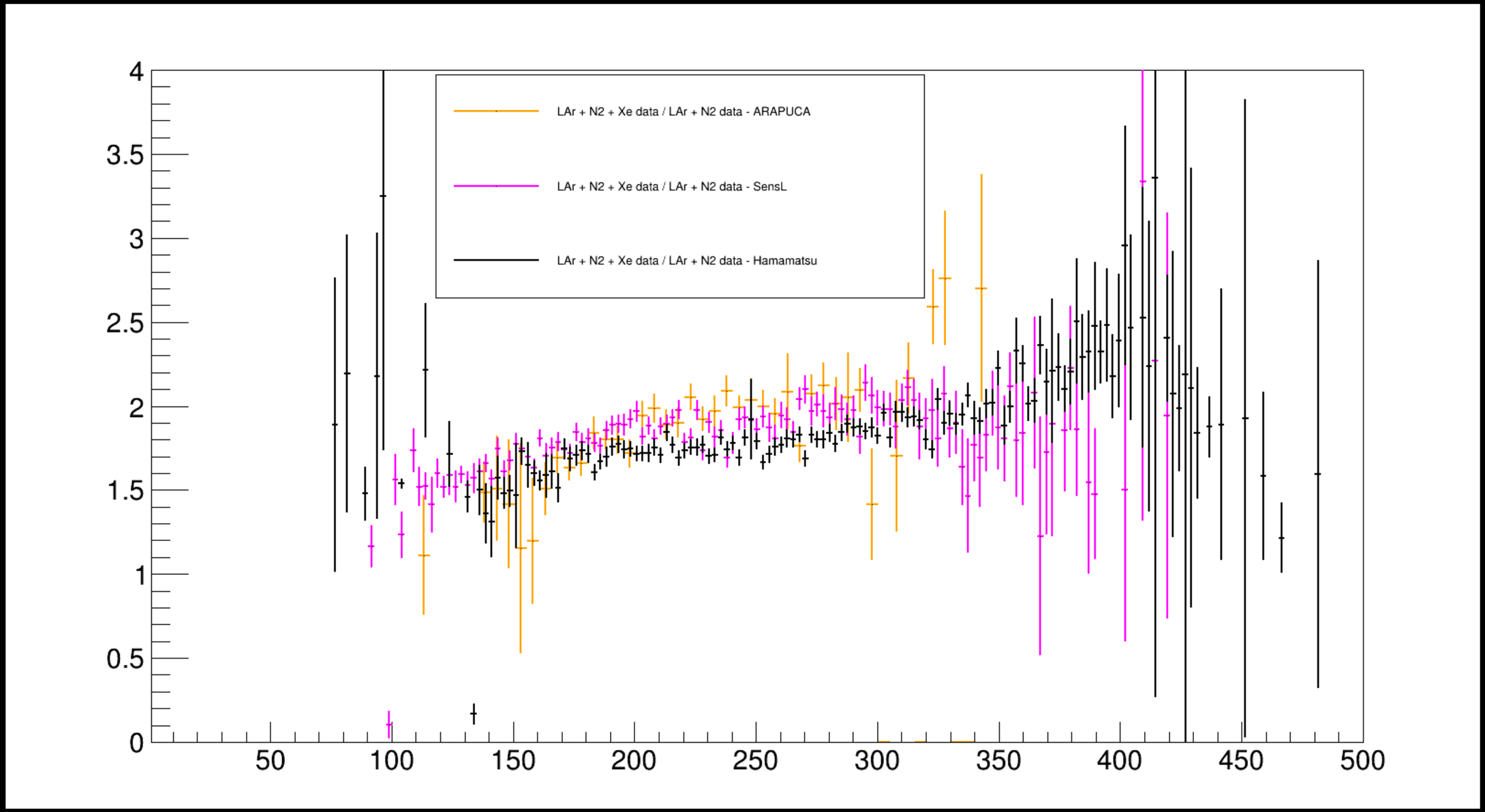
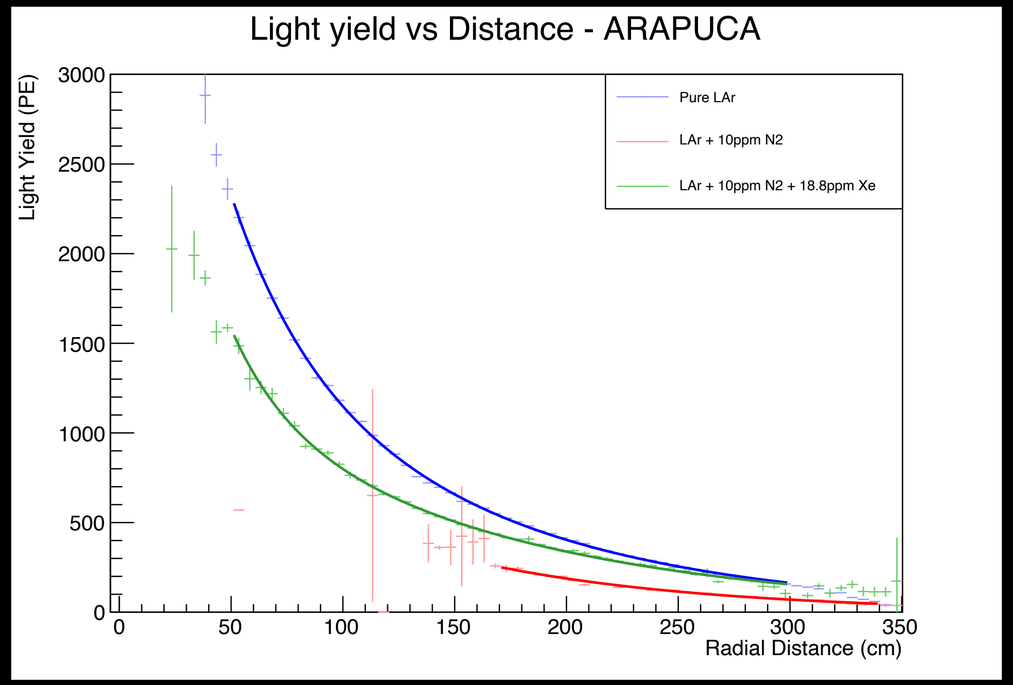
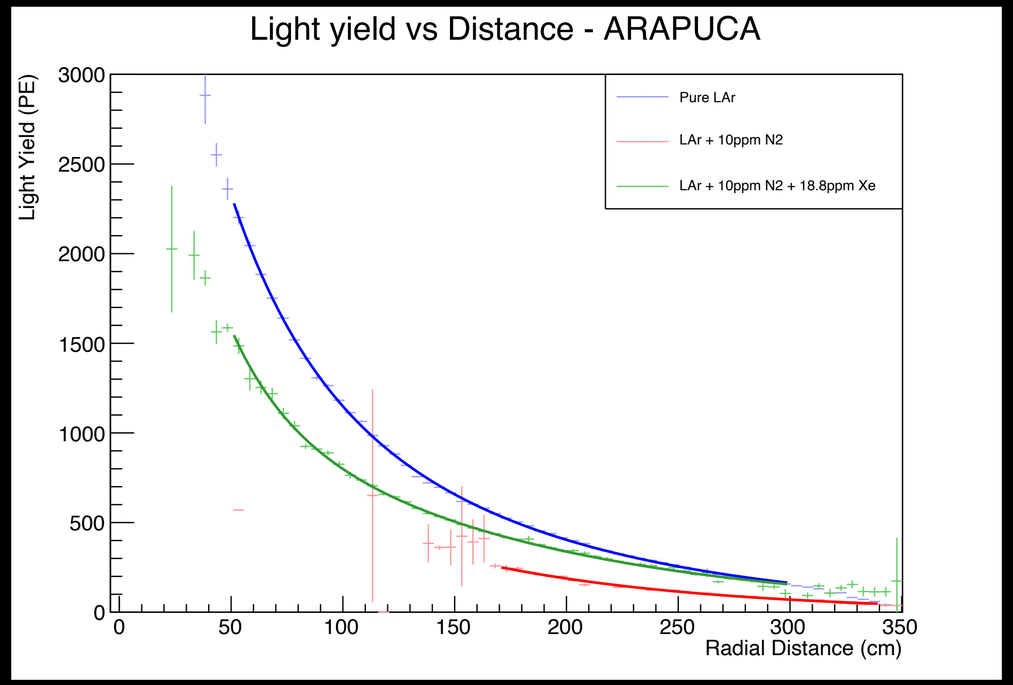

LAr + N2 + Xe data / LAr + N2 data - ARAPUCA
LAr + N2 + Xe data / LAr + N2 data - SensL
LAr + N2 + Xe data / LAr + N2 data - Hamamatsu
0
0.5
1
1.5
2
2.5
3
3.5
4
50
100
150
200
250
300
350
400
450
500



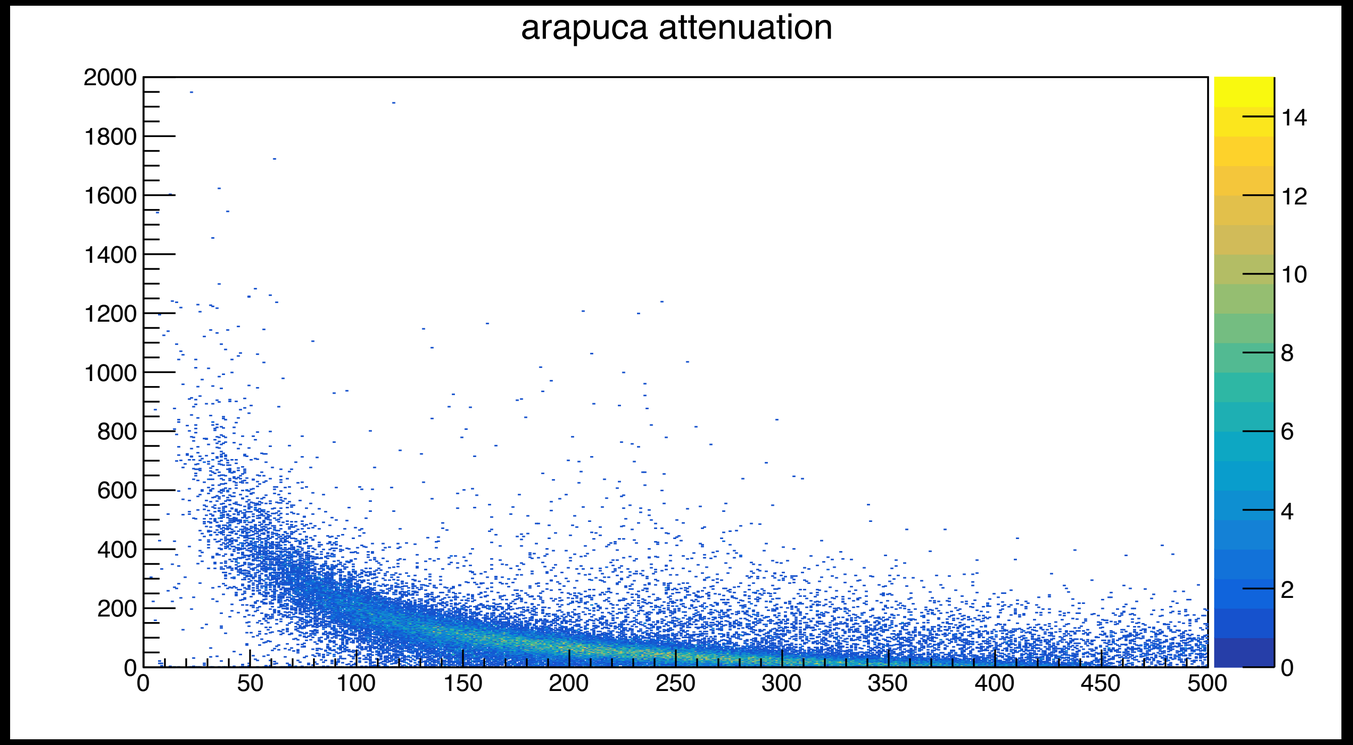
- Show upper and lower bounds of light yield
  - TPC matched tracks (>99.9% purity)
  - Distance dependent light yield measurement (<10cm resolution
- Show strong increase in light yield
  - Fully counteracts loss due to nitrogen at far distances
  - Recovers almost all light at close distances
- Indicates we can learn more by utilizing all PDS systems in ProtoDUNE-SP

Additional info

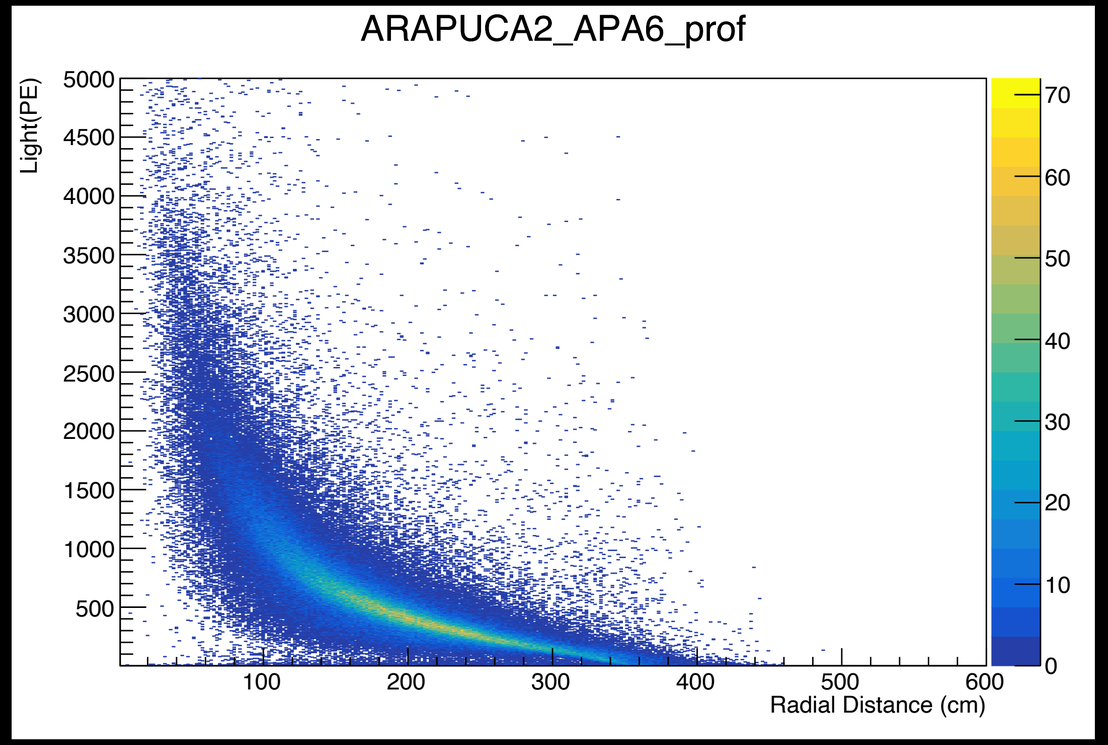


- Currently have 3 subsets of waveforms
  - 75cm, 125 cm, 200 cm from APA
  - see this talk for more analysis on this
  - Can be used in similar benchmarking ways as light yield
- Some plans to extend this analysis to have more time granularity
  - Remove cuts on distance as well.

Full MC Sample

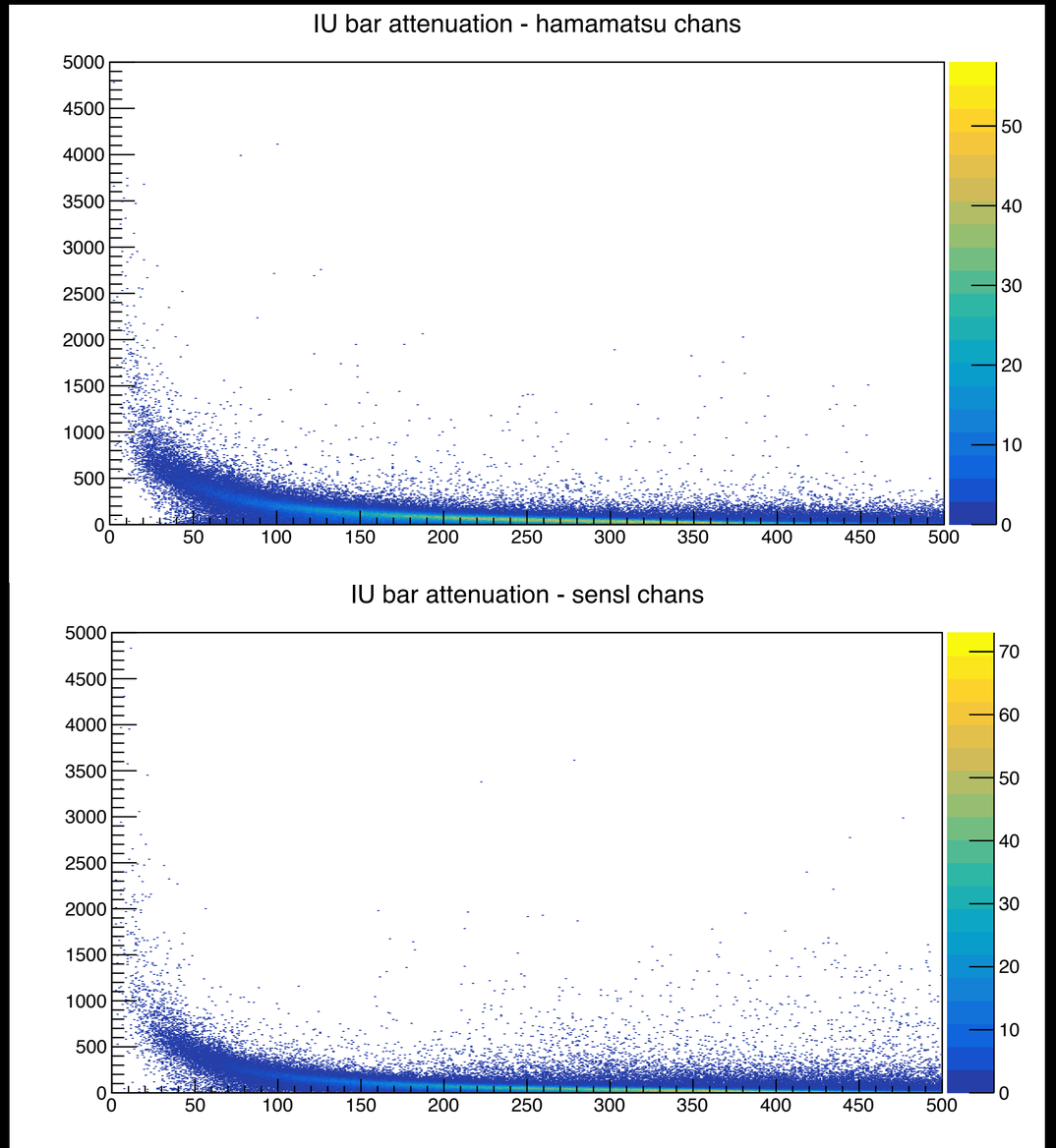


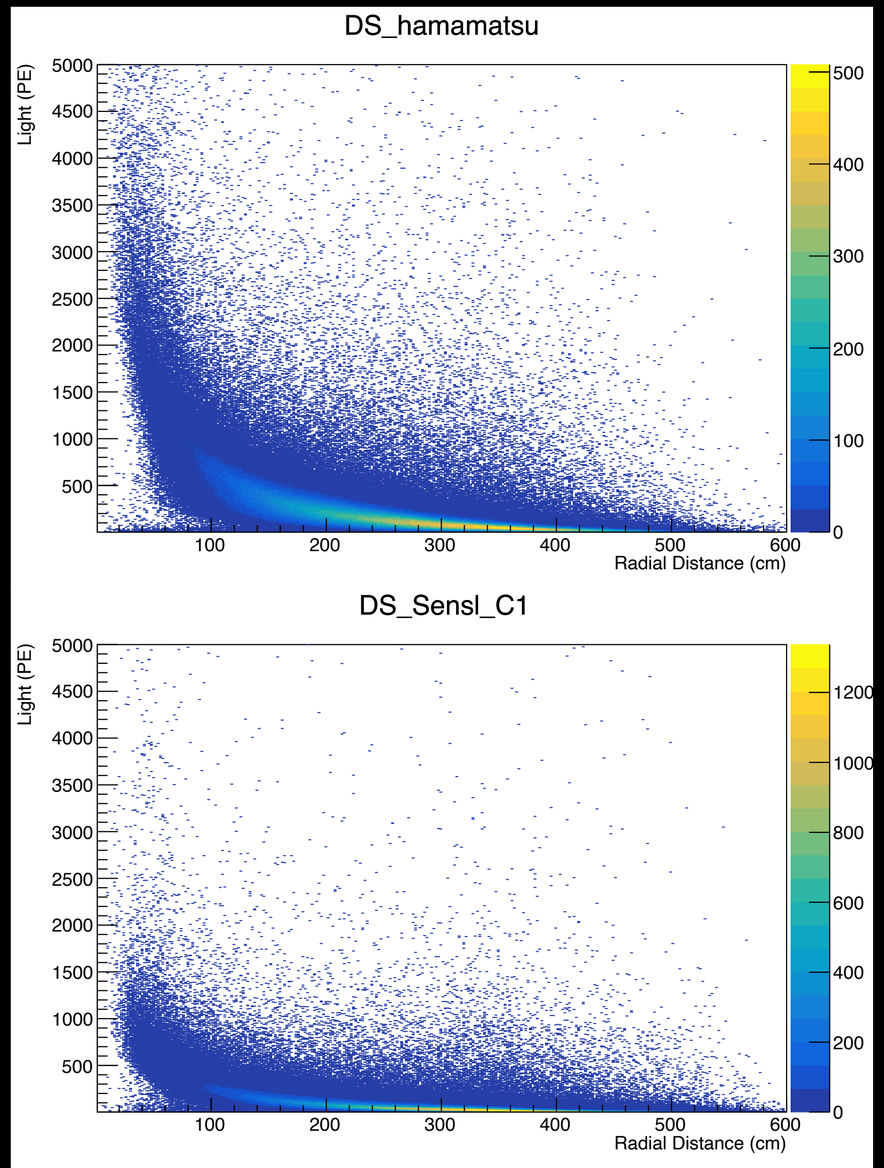
99cm Rayleigh Scattering Monte Carlo



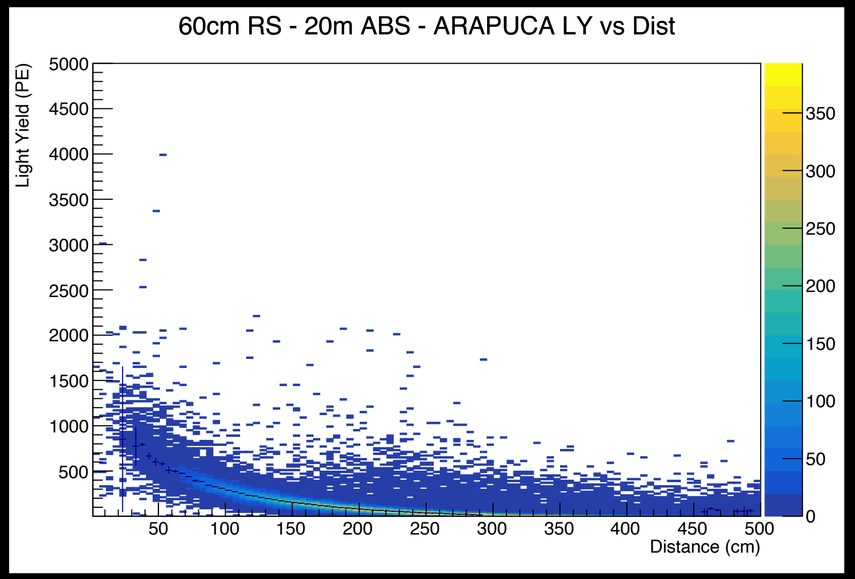
Data

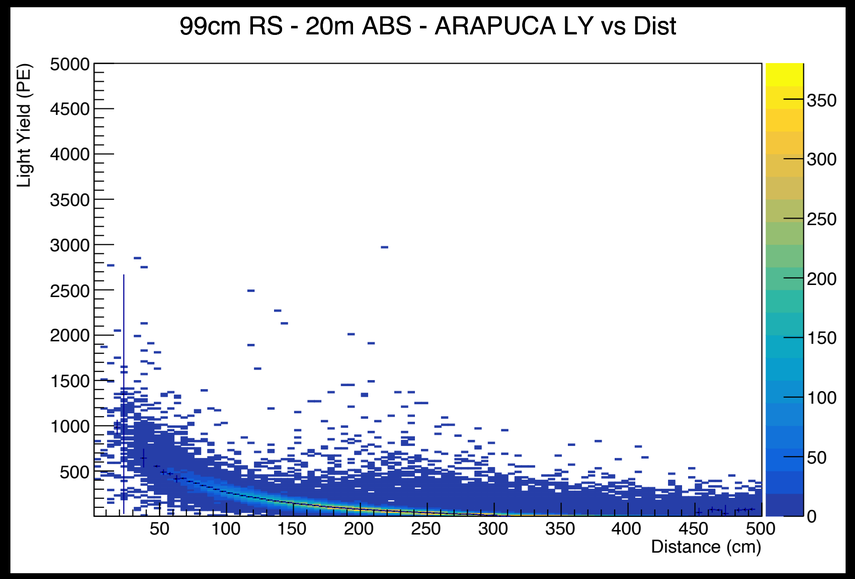
Full MC Sample

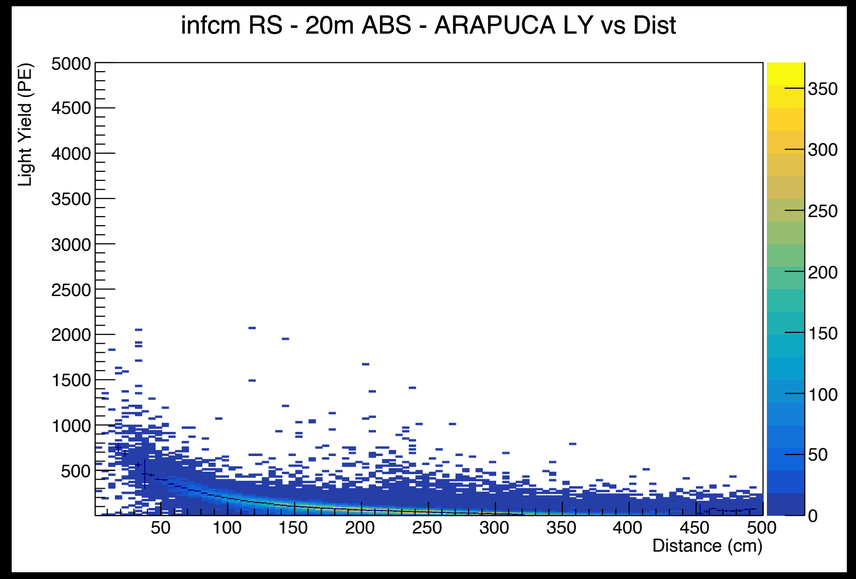


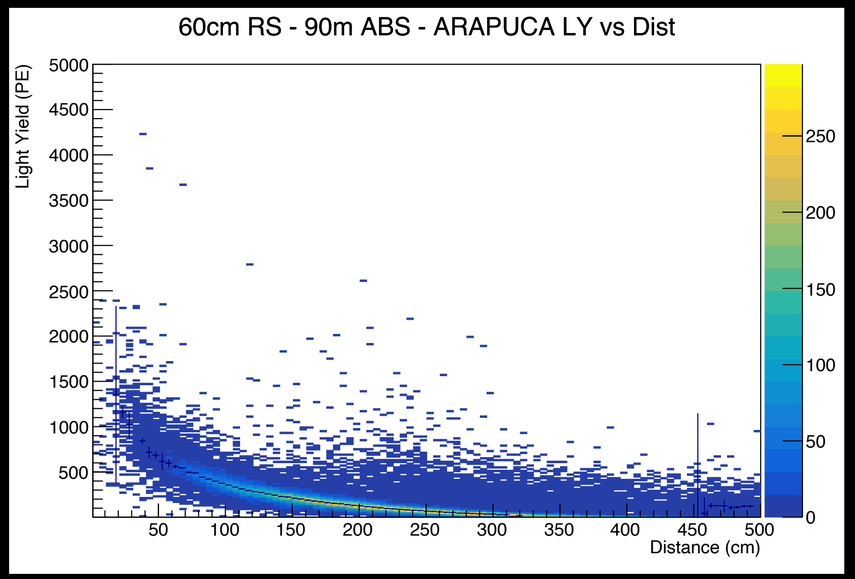


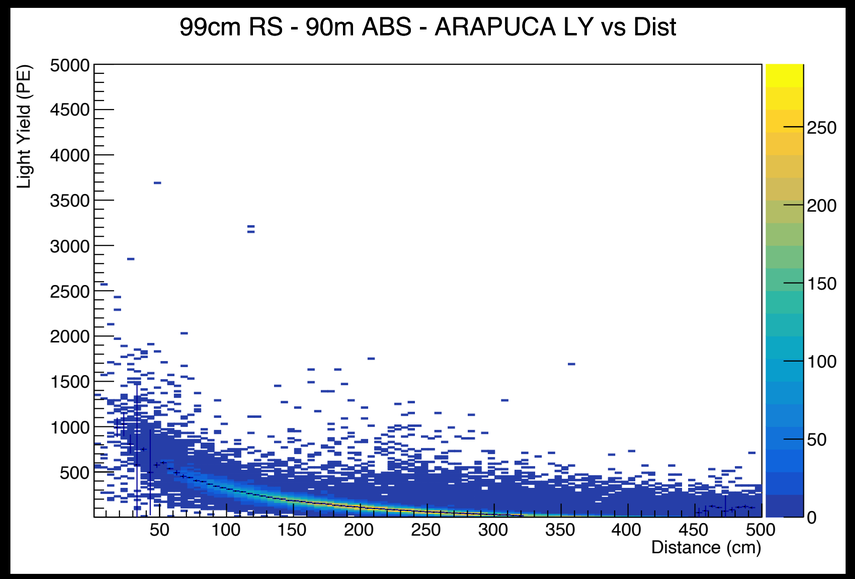
Monte Carlo Samples

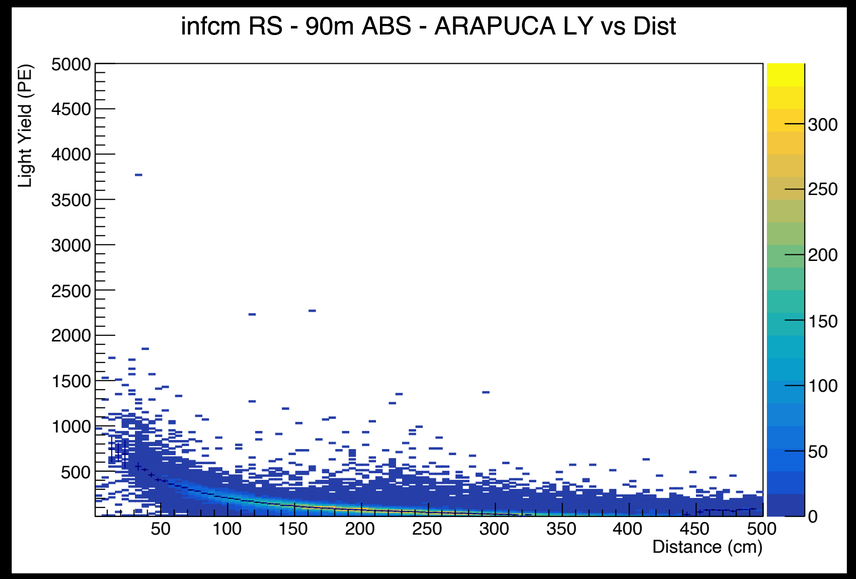


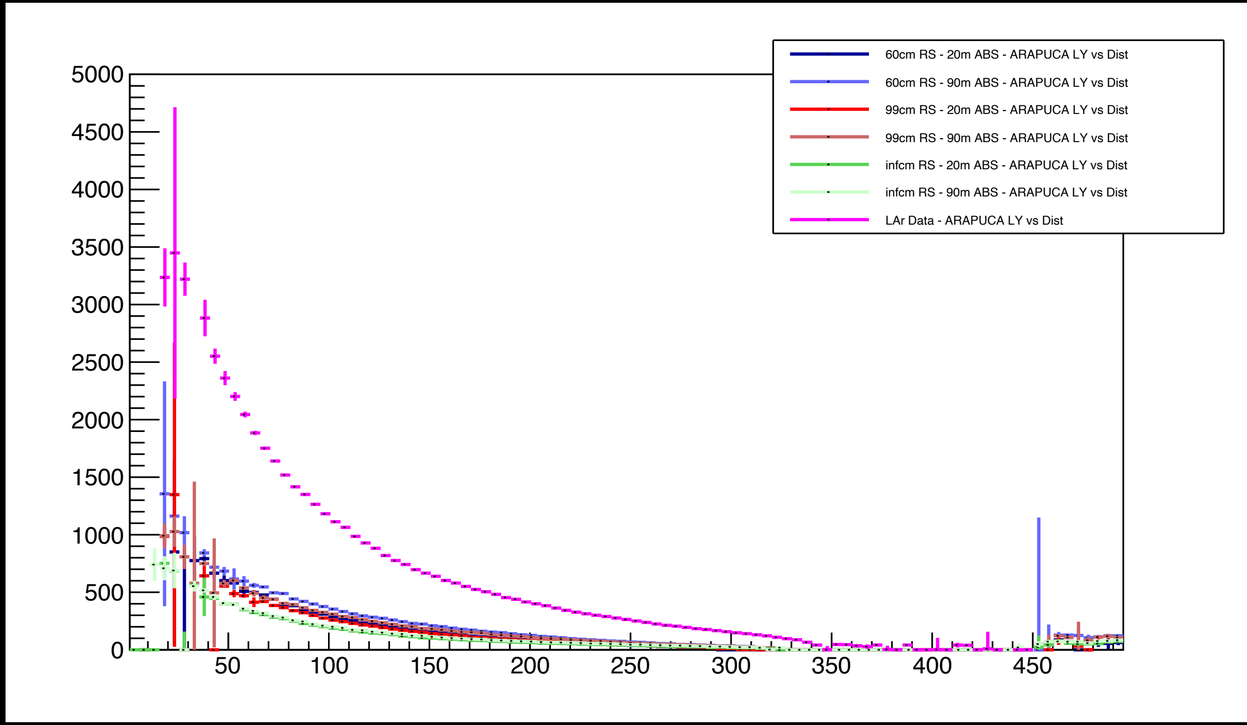


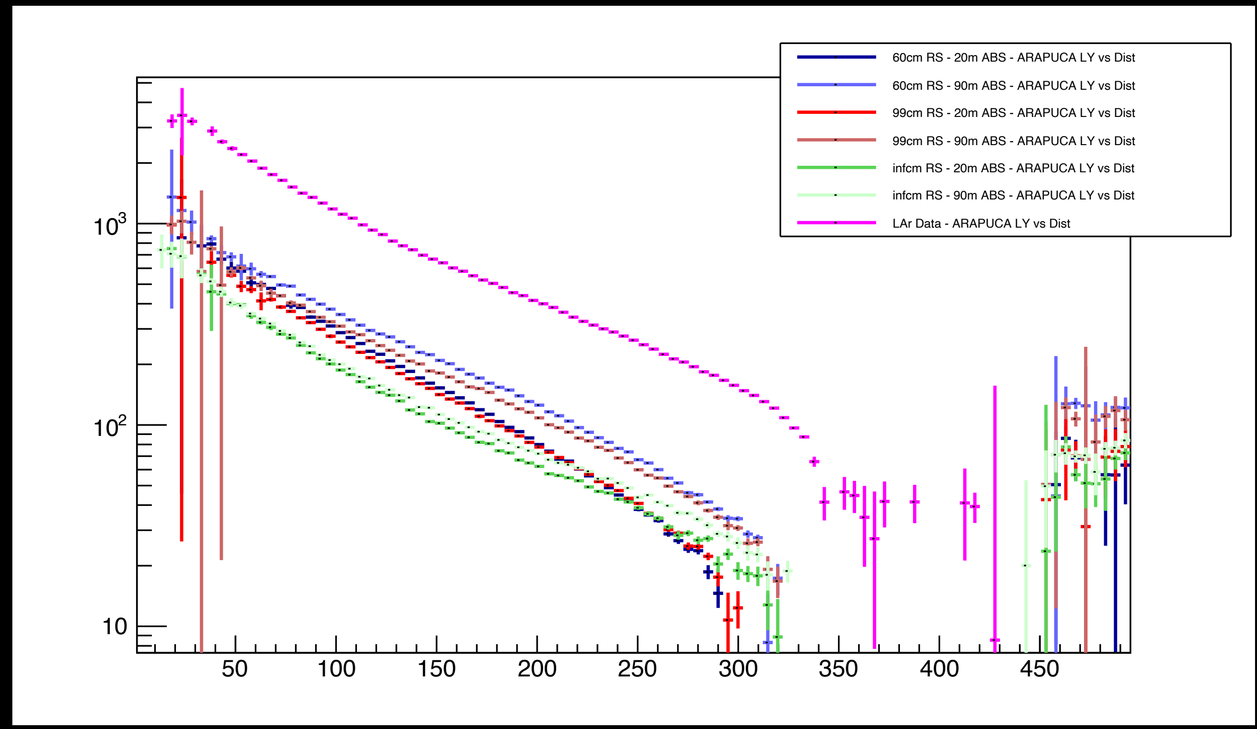









60cm RS - 20m ABS - ARAPUCA LY vs Dist
60cm RS - 90m ABS - ARAPUCA LY vs Dist
99cm RS - 20m ABS - ARAPUCA LY vs Dist
99cm RS - 90m ABS - ARAPUCA LY vs Dist
infcm RS - 20m ABS - ARAPUCA LY vs Dist
infcm RS - 90m ABS - ARAPUCA LY vs Dist
LAr Data - ARAPUCA LY vs Dist
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
50
100
150
200
250
300
350
400
450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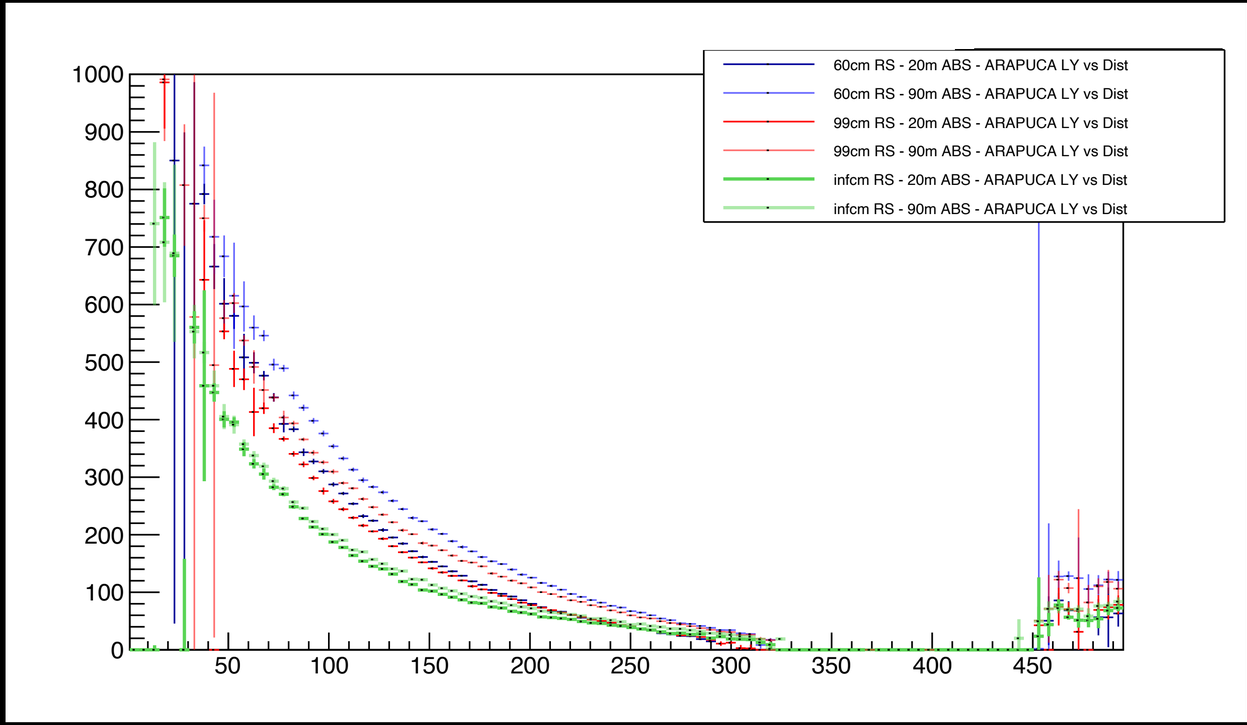
99cm RS - 90m ABS - ARAPUCA LY vs Dist
infcm RS - 20m ABS - ARAPUCA LY vs Dist
infcm RS - 90m ABS - ARAPUCA LY vs Dist
LAr Data - ARAPUCA LY vs Dist
10^3
10^2
10
50
100
150
200
250
300
350
400
450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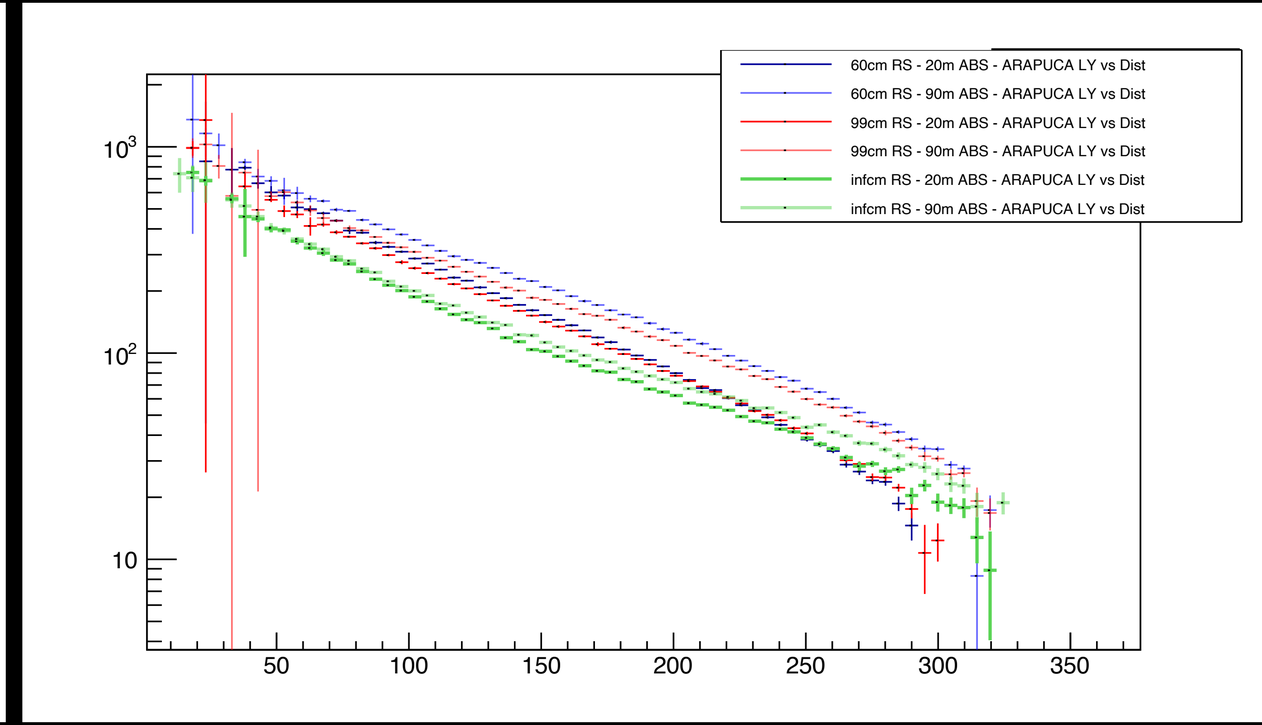
infcm RS - 20m ABS - ARAPUCA LY vs Dist
infcm RS - 90m ABS - ARAPUCA LY vs Dist
1000
900
800
700
600
500
400
300
200
100
0
50
100
150
200
250
300
350
400
450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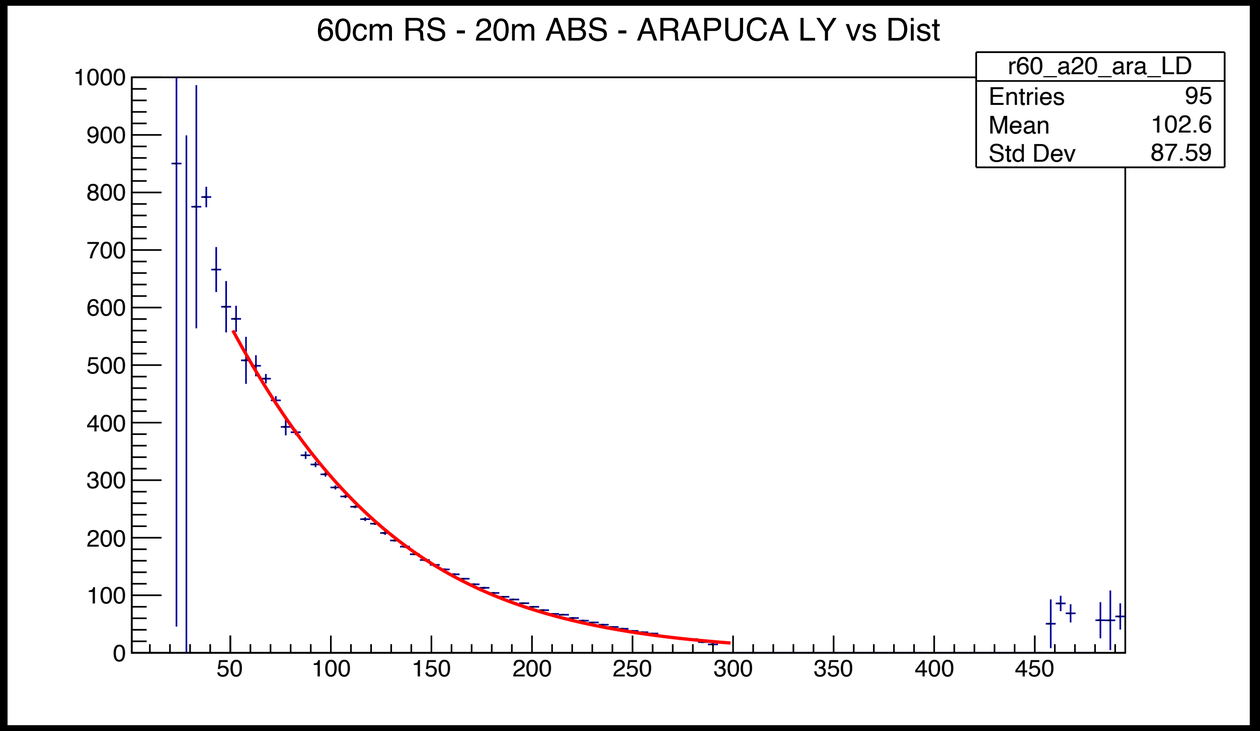
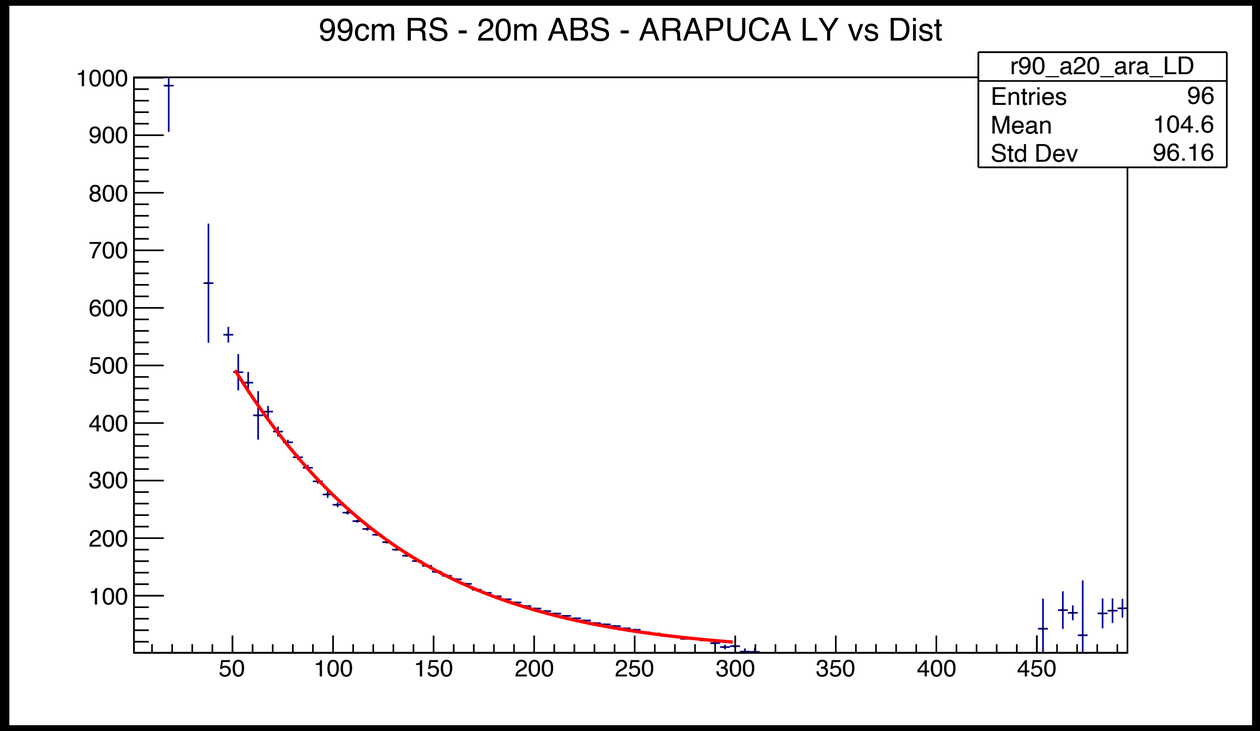
10^3
10^2
10
50
100
150
200
250
300
350

Double Exponential fit example

Monte carlo





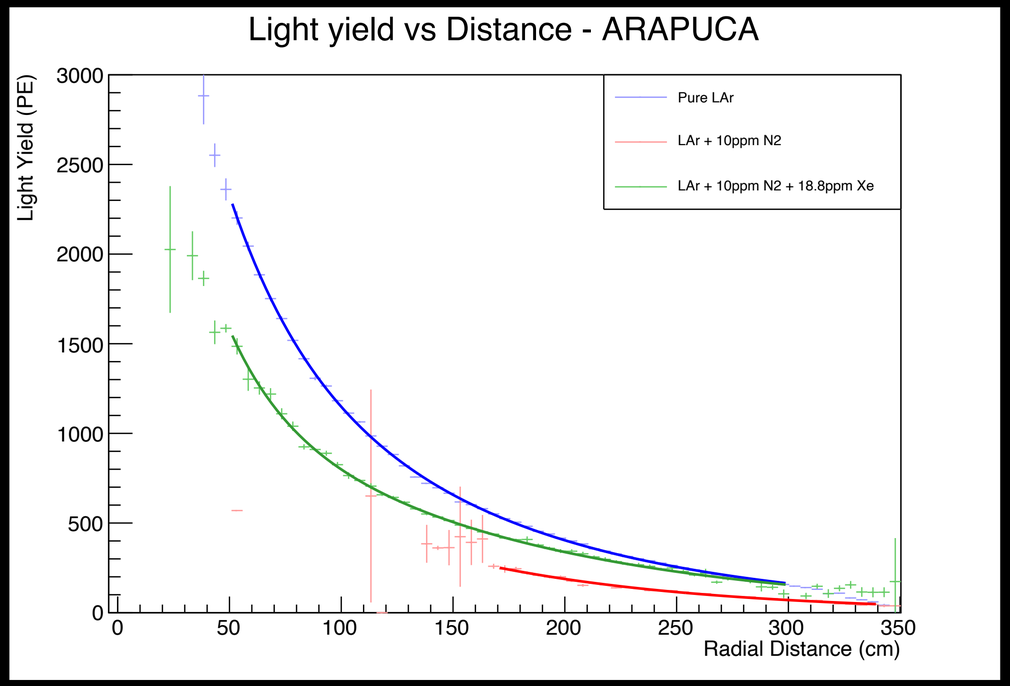
- Good agreement, as with data
- Simulation results in similar shape as data

What can you do with these MC Samples?

- How does data compare to each simulation?
  - What does that tell us about Rayleigh Scattering, absorption, geometry……
- How do the simulations compare to each other?
  - What does this tell us about data?
  - Can we infer anything about the RS of Xenon?
- Create a database of different RS attenuation curves to match to
  - More curves = better fit = smaller error on rayleigh scattering measurement

Conclusions

- Libraries show decrease in light yield as nitrogen concentration increases
- Libraries seem consistent with expectations
  - Some issues (known and unknown) to work with/around
- Xenon libraries next
  - Slightly more technically challenging
  - How to model Xe + N2 + Ar in one simulation
- Some other possibilities to extend this analysis structure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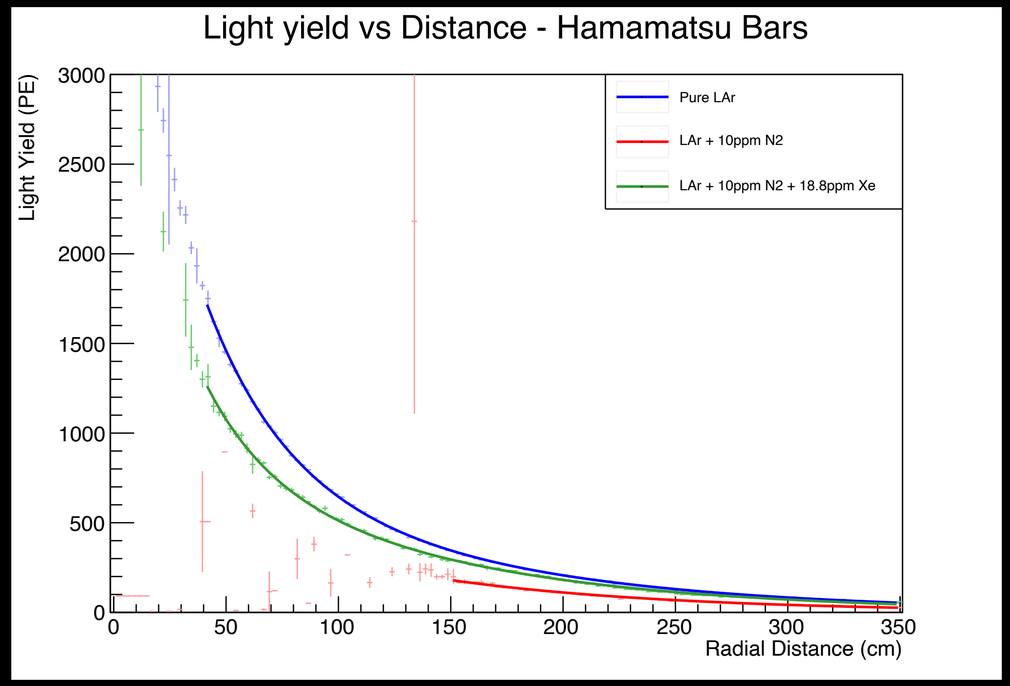
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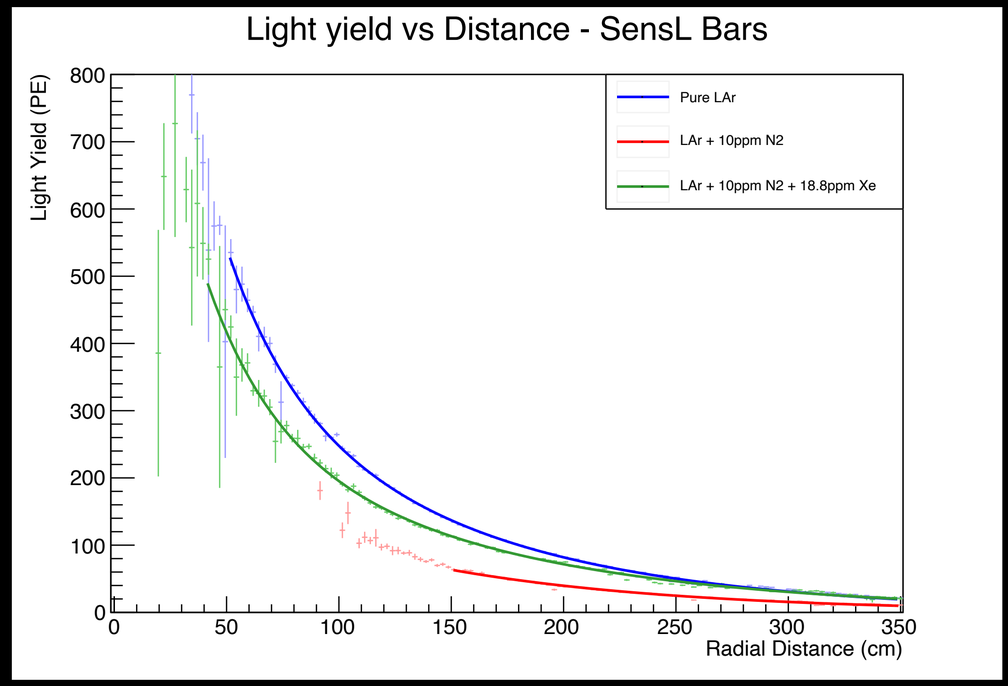
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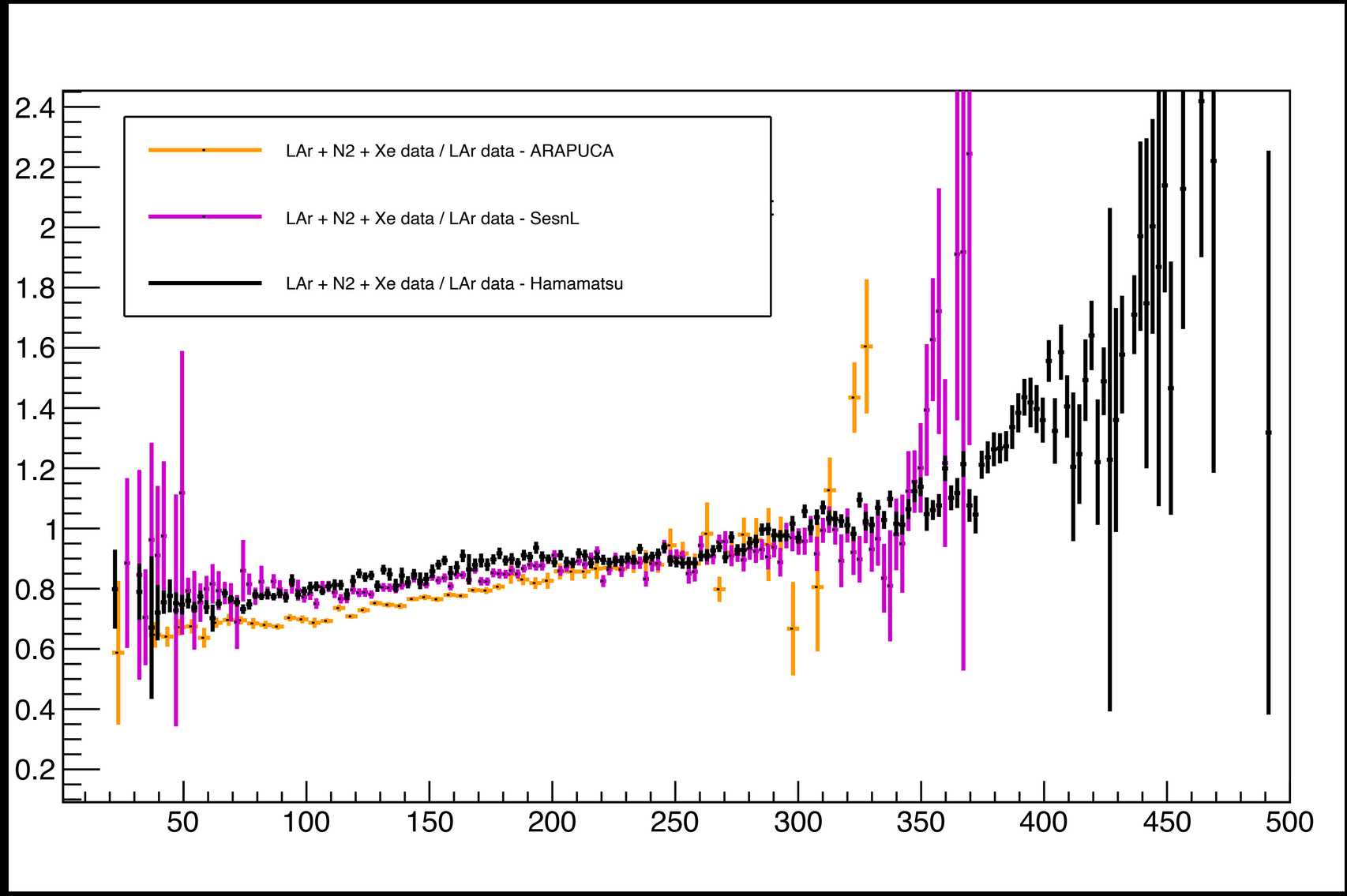
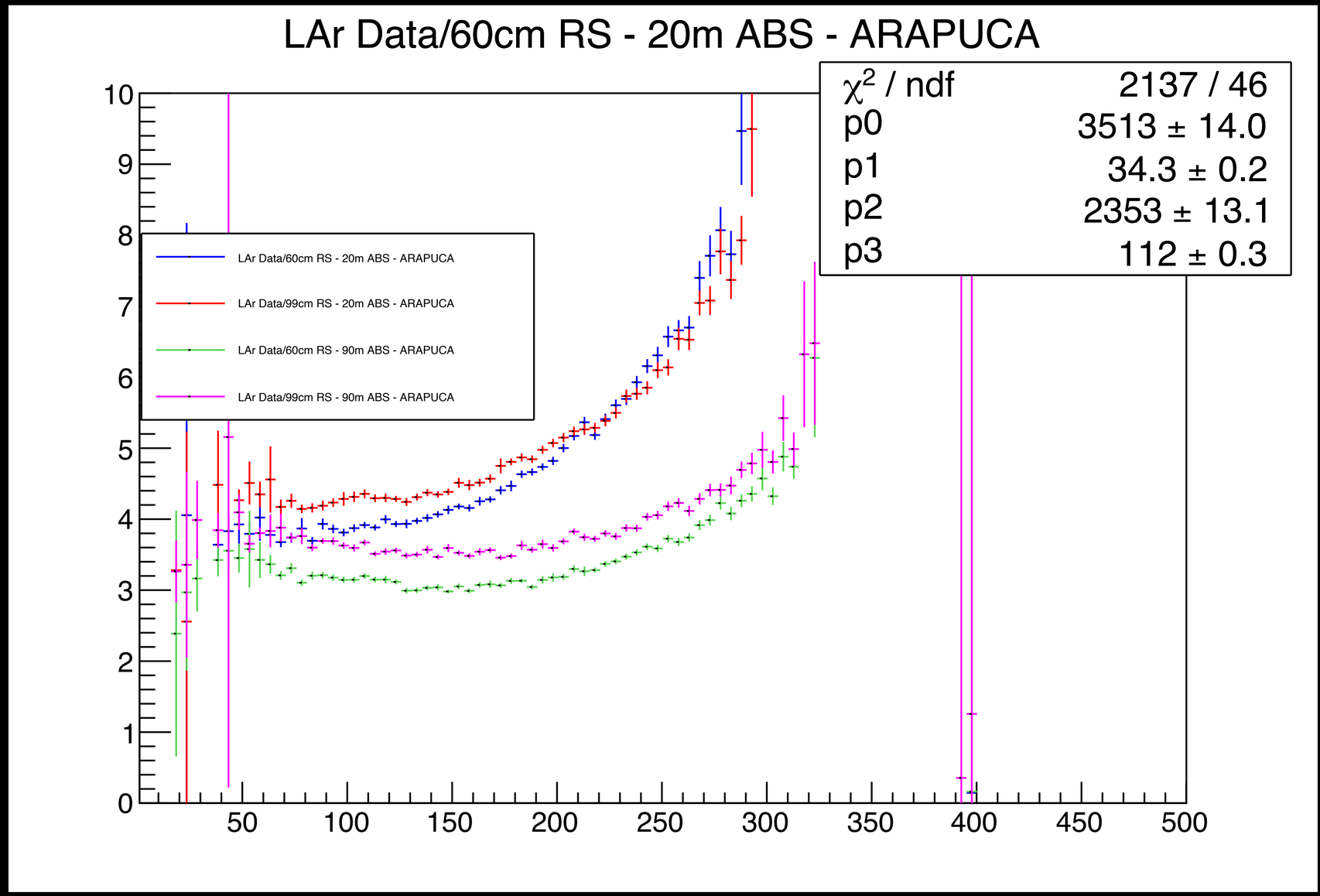
Backups

- ratio of Xe / LAr data



Backups

- ratio of data/ simulation
- LAr Data
- 60 & 90 cm RS at 20 & 90 m Abs
- ARAPUCA



Backups

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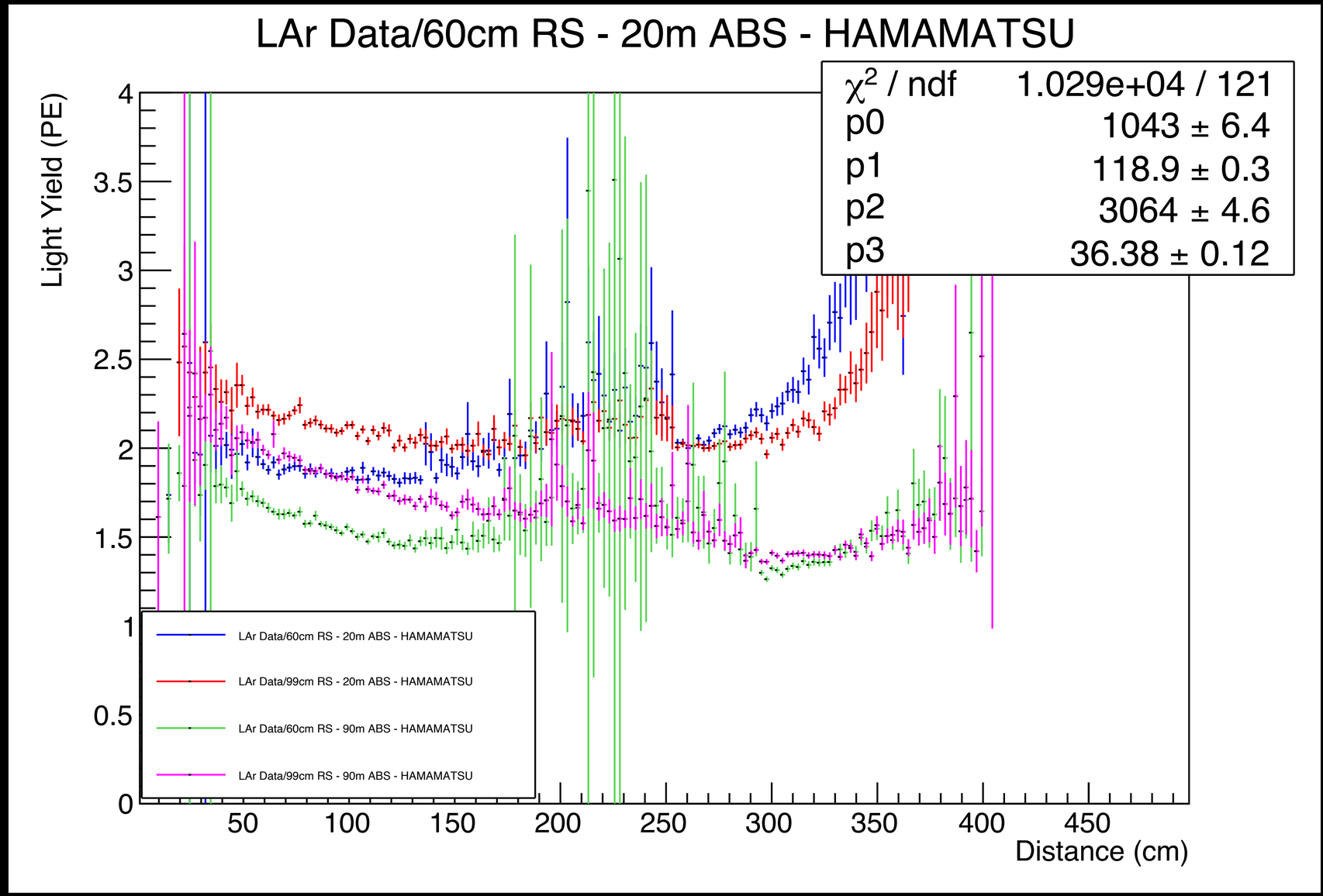
- 60 & 90 cm RS at 20 & 90 m Abs
- Hamamatsu IU bars



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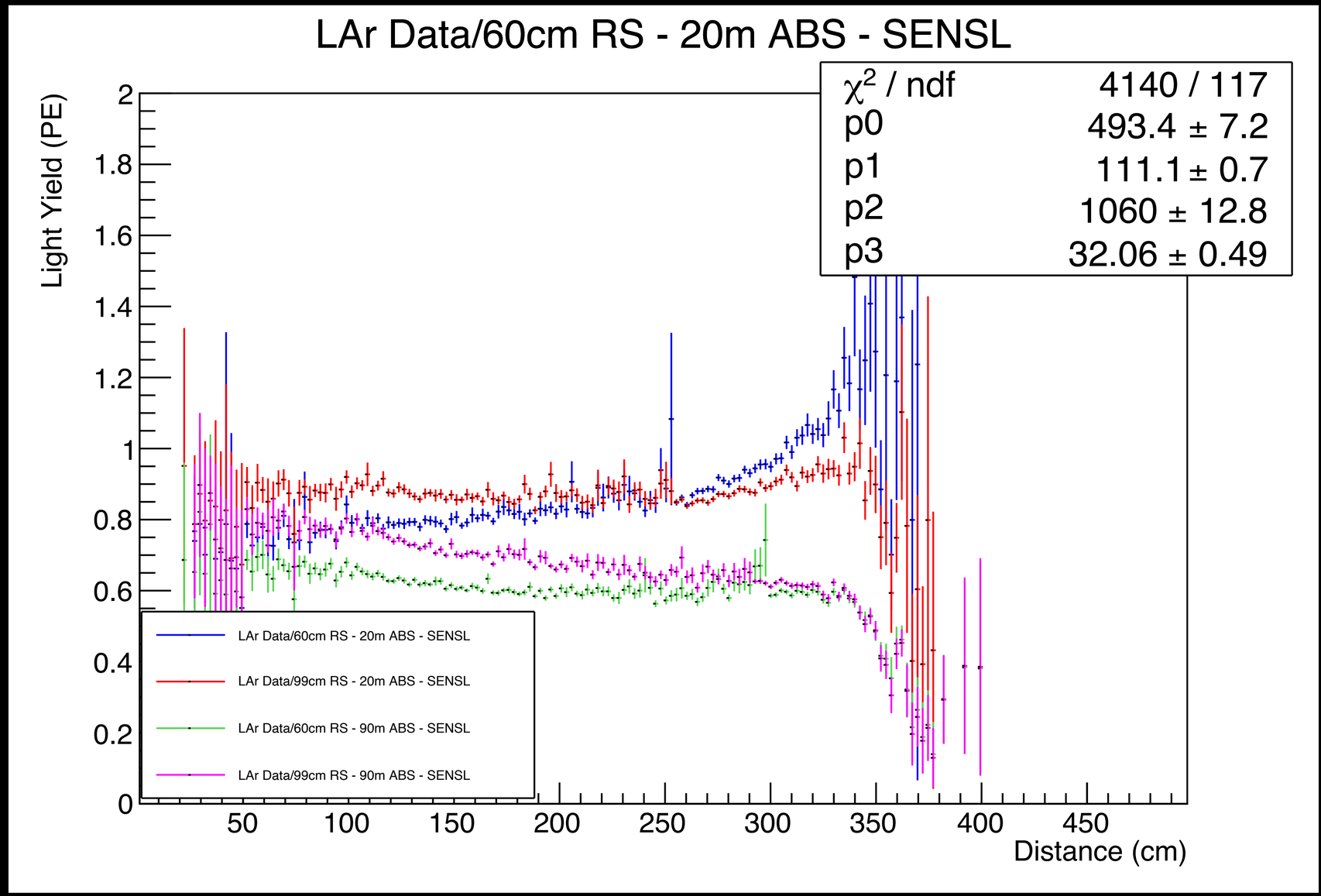
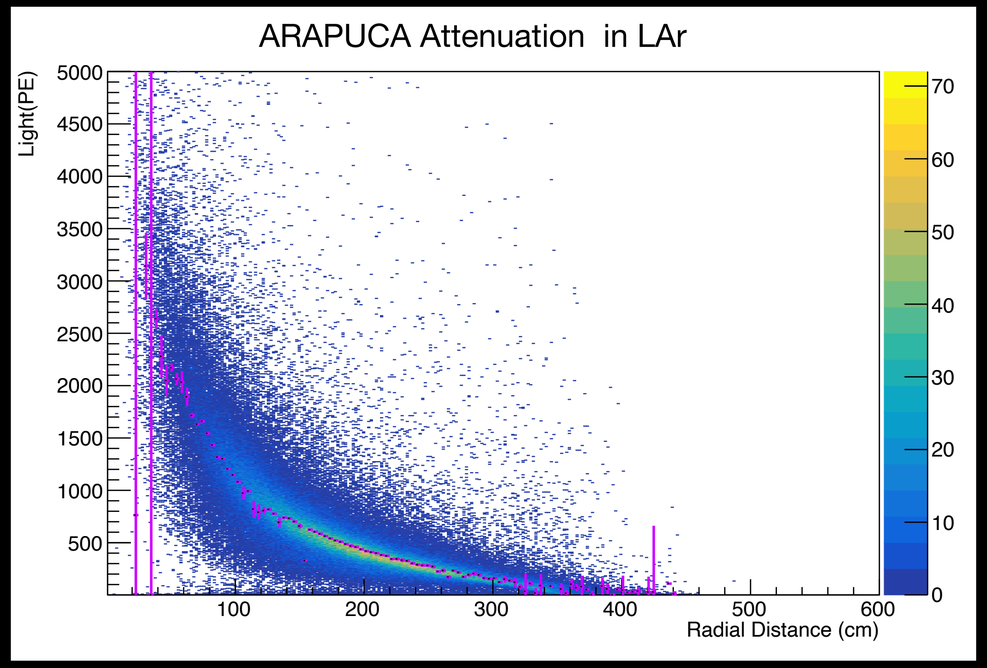
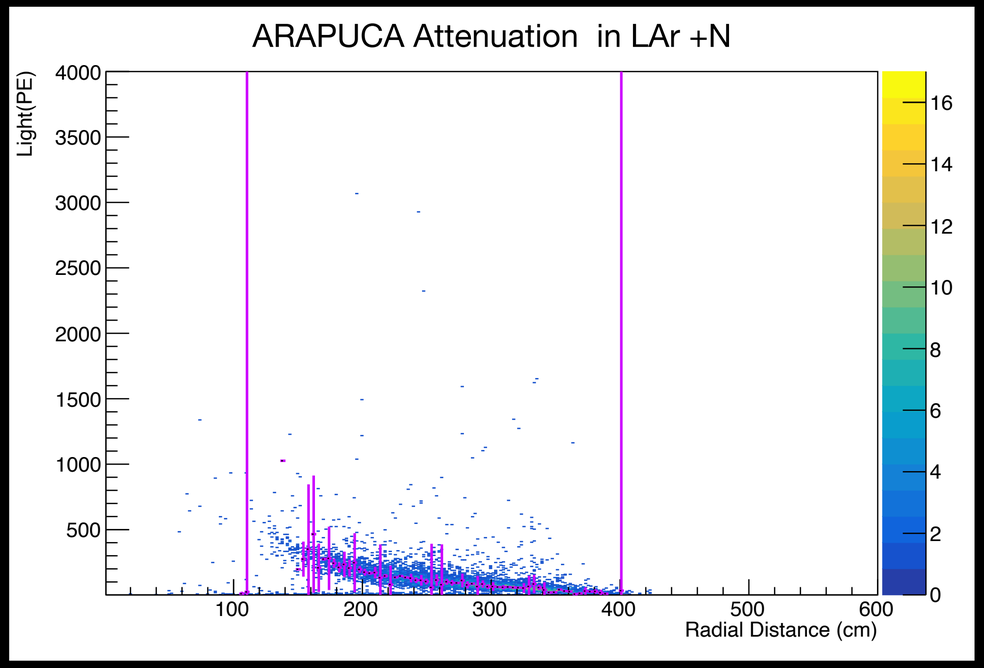
- 60 & 90 cm RS at 20 & 90 m Abs
- SensL IU Bars

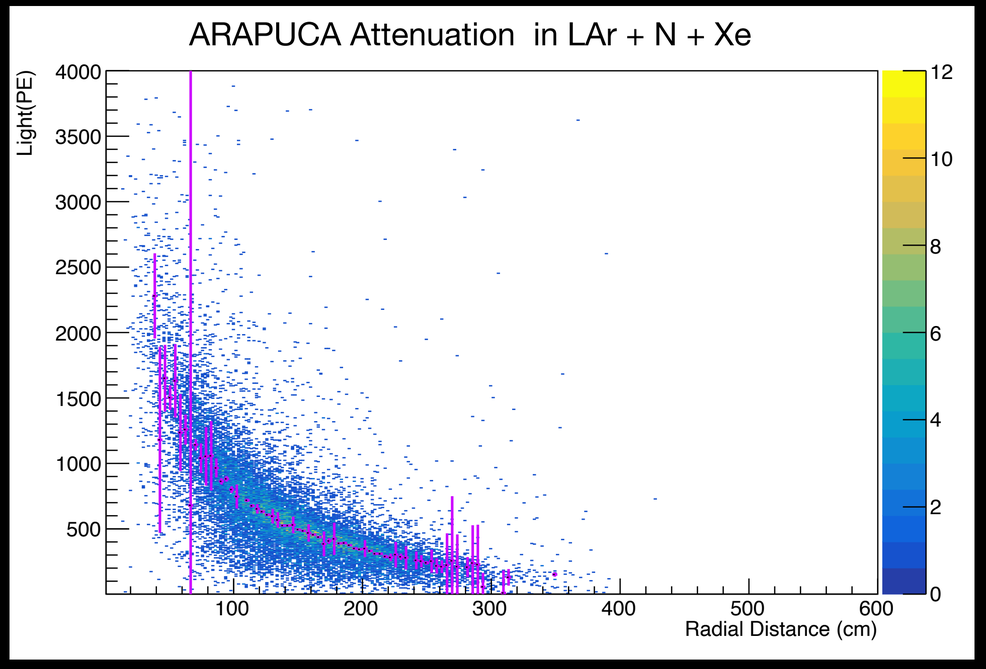



ARAPUCA Attenuation in LAr
Light(PE)
Radial Distance (cm)

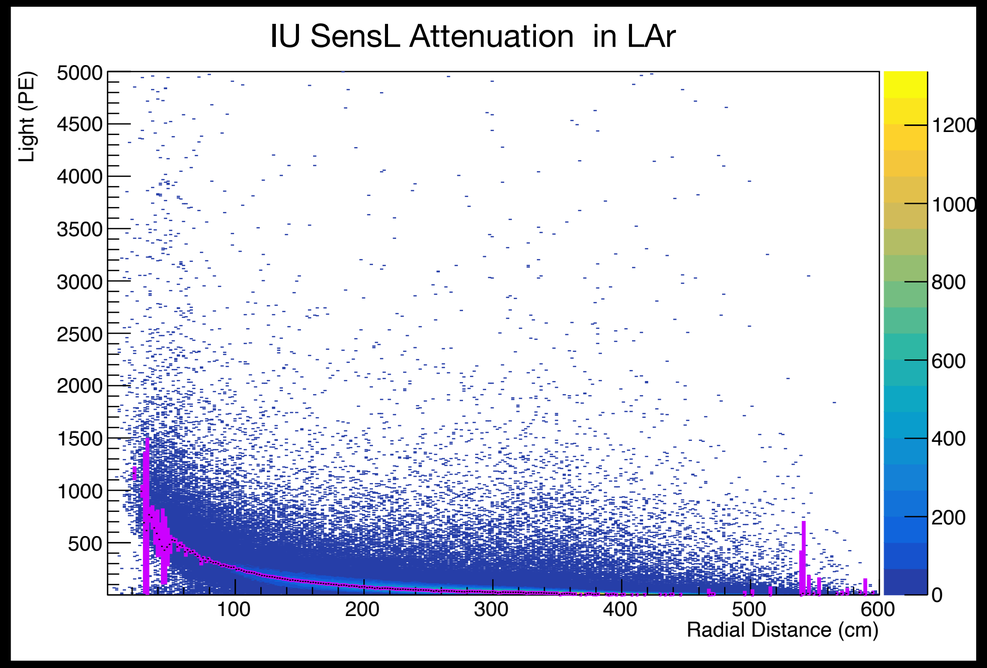
+N


ARAPUCA Attenuation in LAr +N
Light(PE)
Radial Distance (cm)

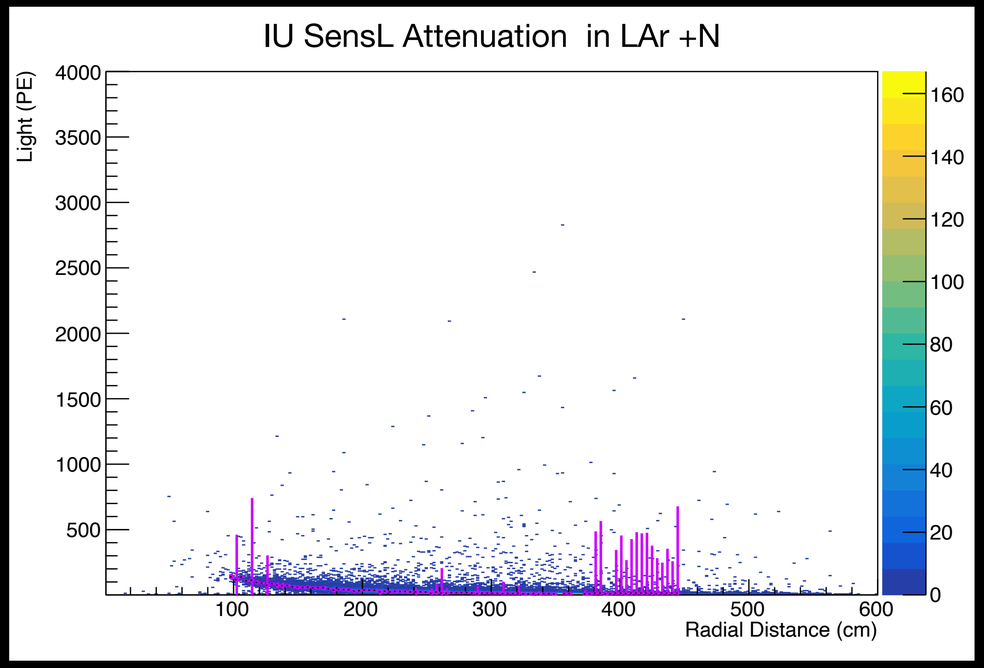
+Xe

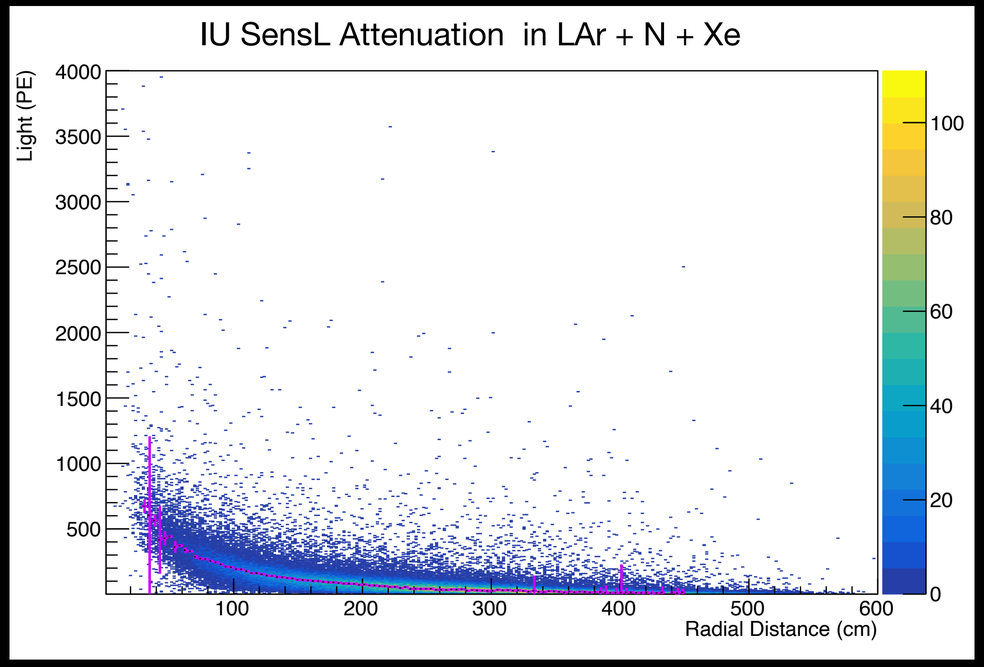

ARAPUCA Attenuation in LAr + N + Xe
Light(PE)
Radial Distance (cm)

IU DSLG w/ SensL-C1 Attenuation Plots



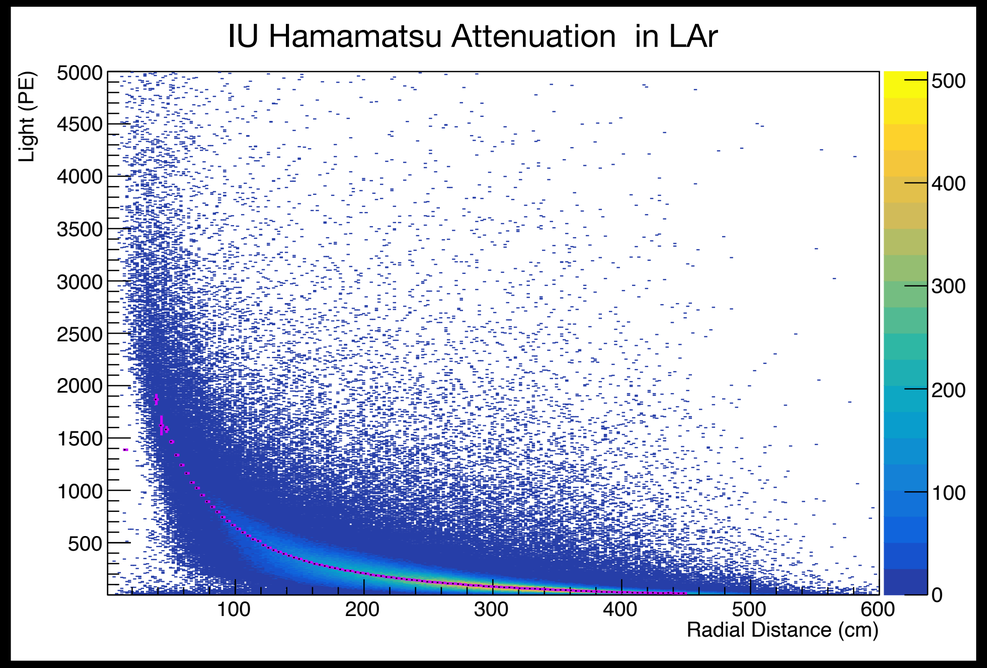
+N



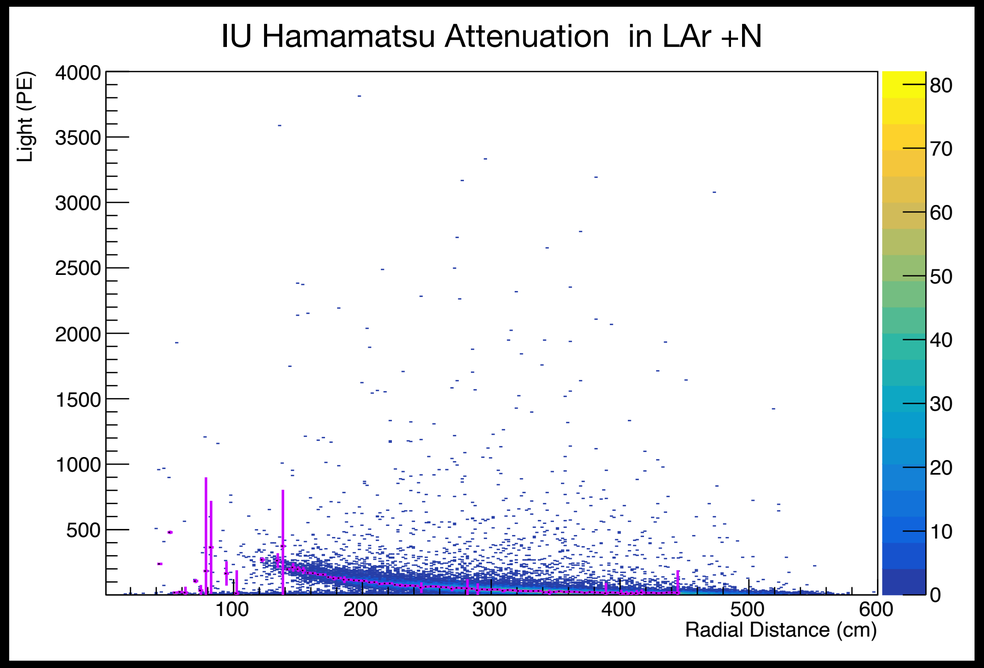


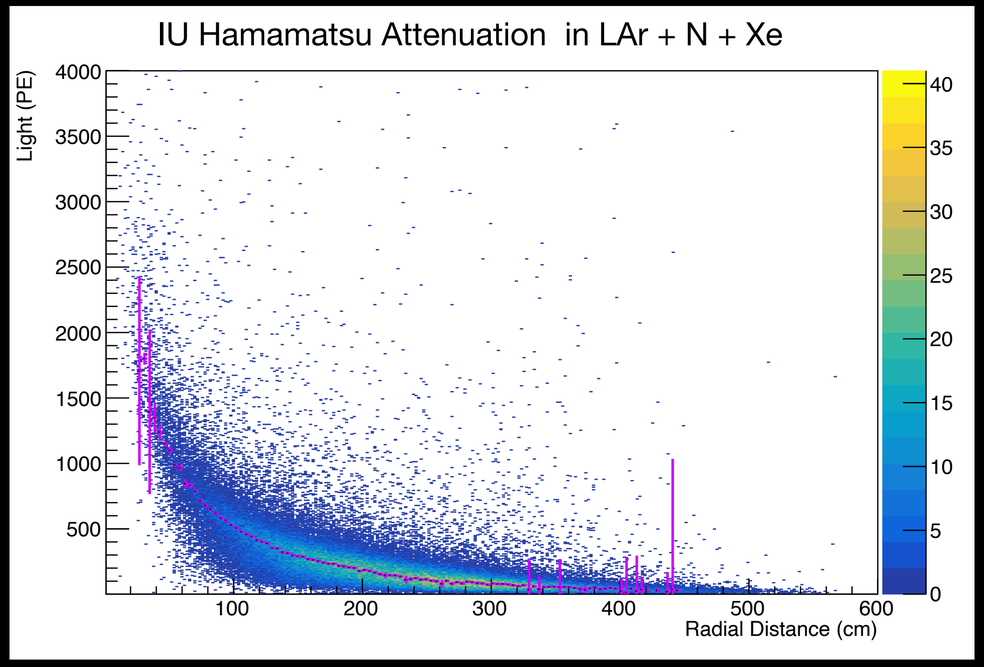
+Xe

IU DSLG w/ Hamamatsu Attenuation Plots



+N





+Xe