dRICH Material Property Table Updates

Christopher Dilks
dRICH Meeting
15 June 2023

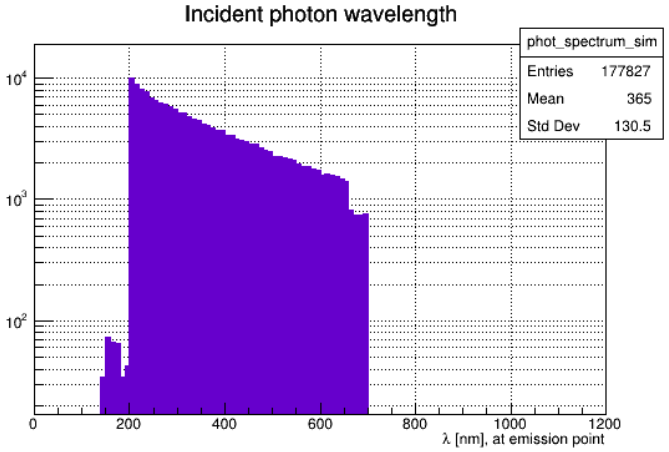
Common Optical Properties Class

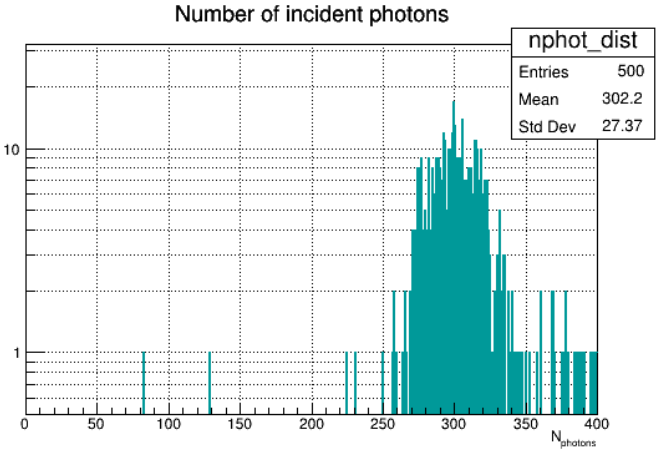
```
/*
 * g4dRIChOptics class hierarchy
 * -----------------------------
 * original authors: E. Cisbani, A. Del Dotto, C. Fanelli
 * source: git@github.com:cisbani/dRICh.git
 * -> adapted for usage in EPIC
 */
```

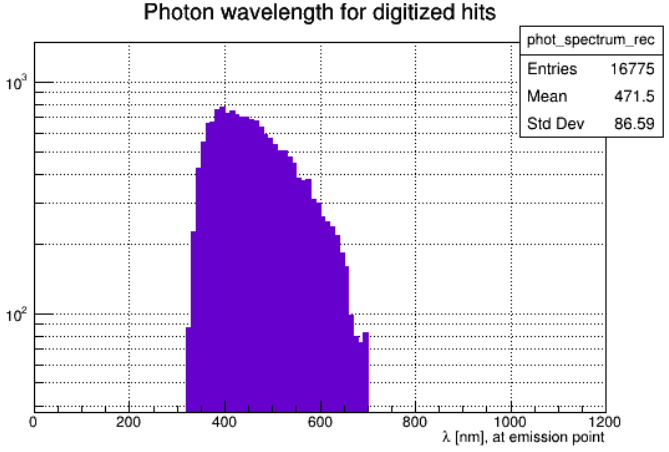
- Base class g4dRIChOptics with derived classes specific for each dRICH component
- Common class for defining dRICH material properties
  - Used in ATHENA, ECCE, and ePIC
  - Connection to DD4hep → dump XML tables
- Contains ***parameterizations*** of material properties, and/or ***experimental data points***
  - There is generally dependence on quantities such as density or threshold

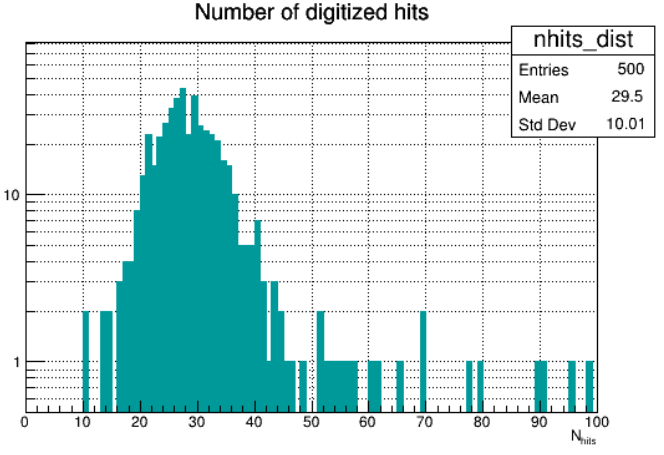
Documentation and Usage Guide
https://github.com/eic/drich-dev/blob/main/doc/material_tables.md

Photon Spectra and Multiplicity







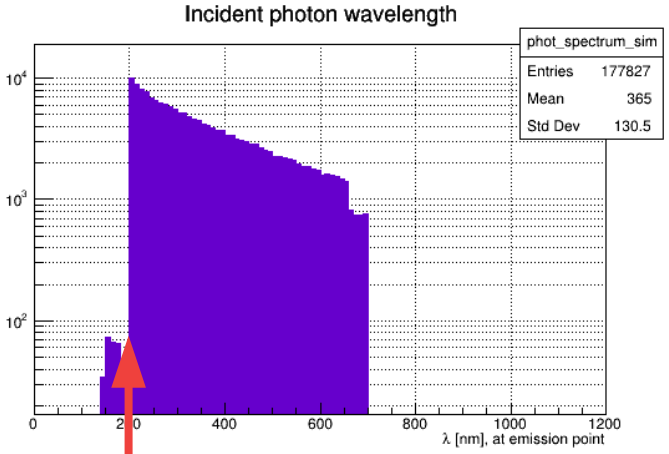


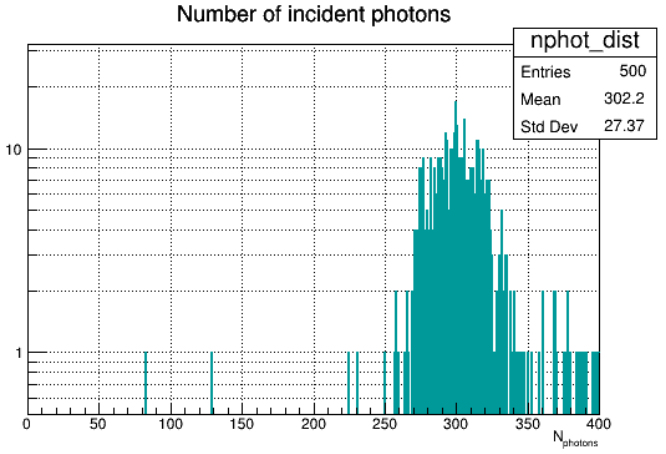
- This is <u>prior</u> to any changes presented in today's slides
- This is the version for production 23.6

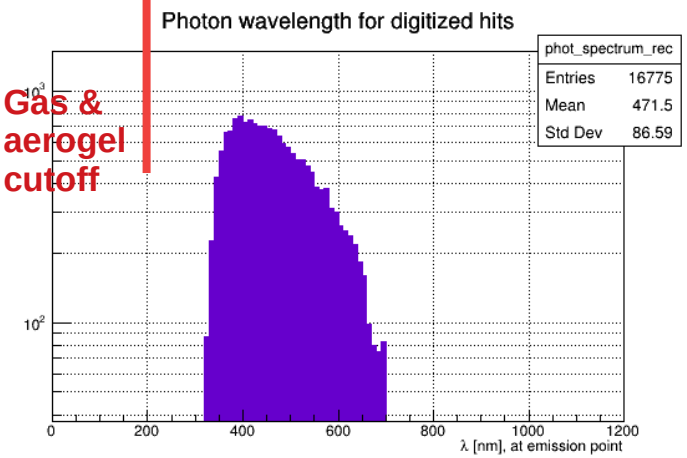
Multiplicities:

- **~300 photons**
- **~30 raw hits**

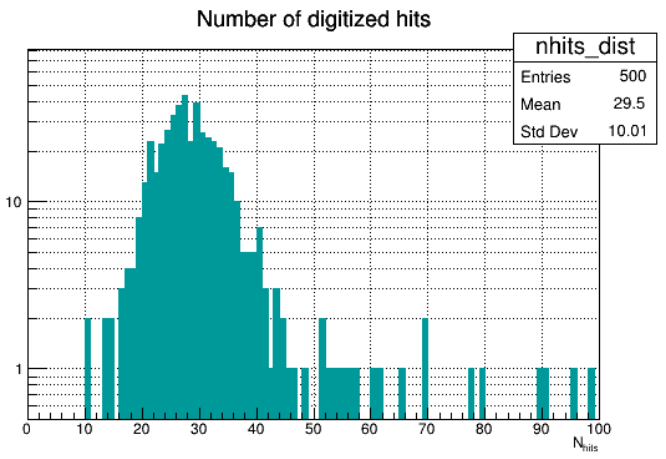
Photon Spectra and Multiplicity







Gas & aerogel cutoff



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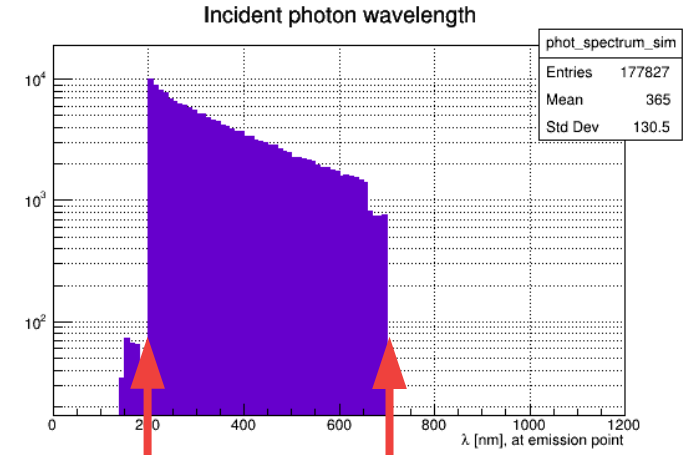
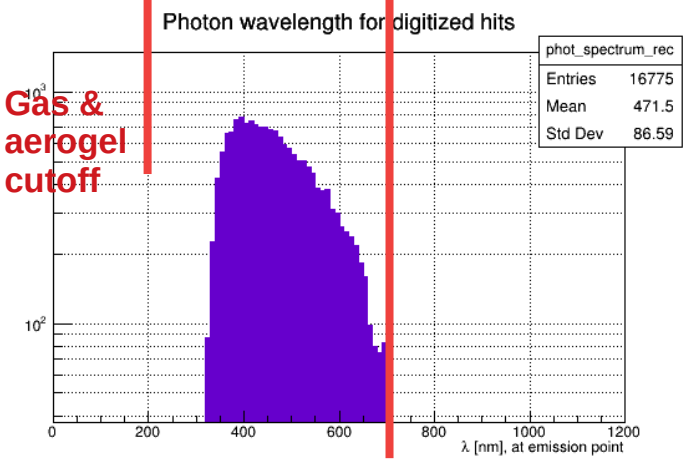
Cutoffs in the material property tables induce cutoffs in the photon spectrum

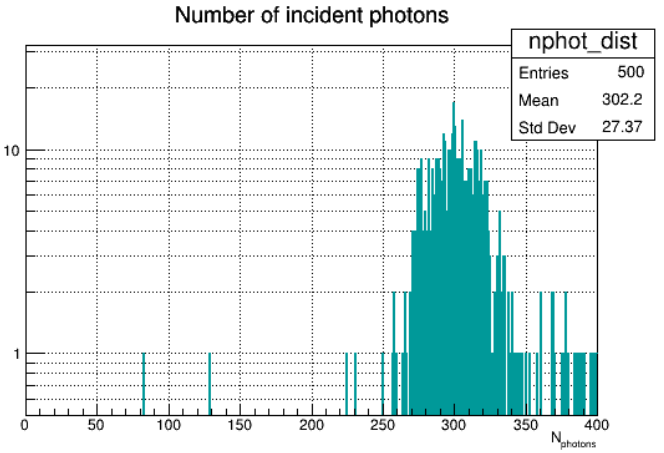
Photon Spectra and Multiplicity

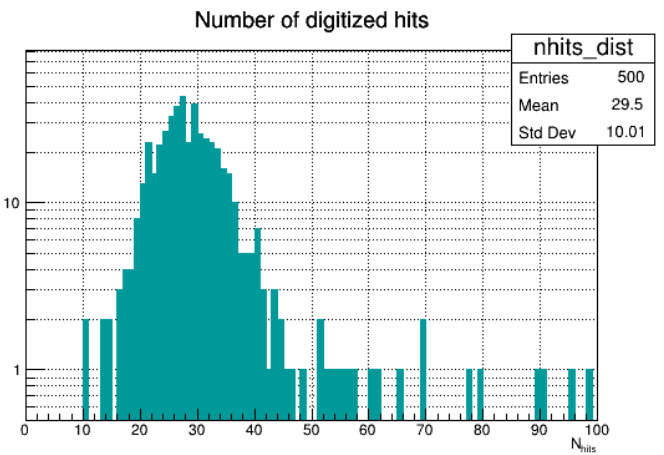




Gas & aerogel cutoff

Gas cutoff





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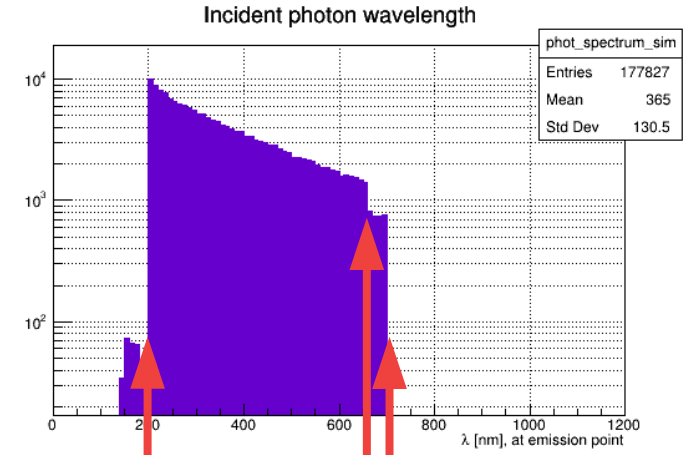
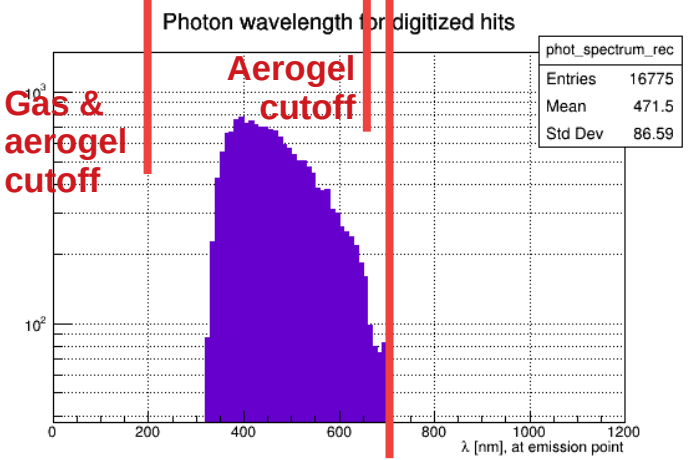
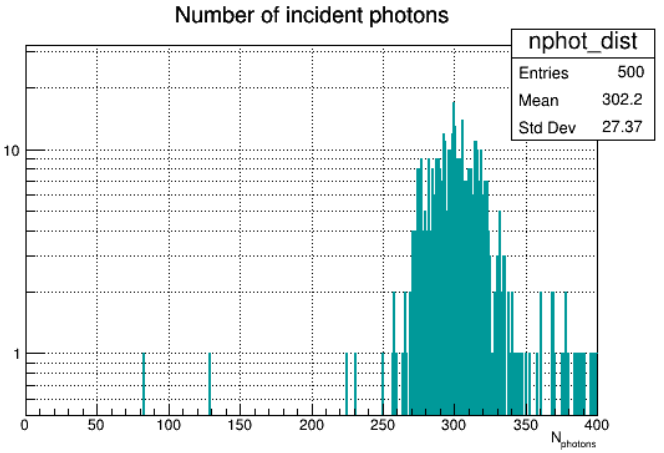


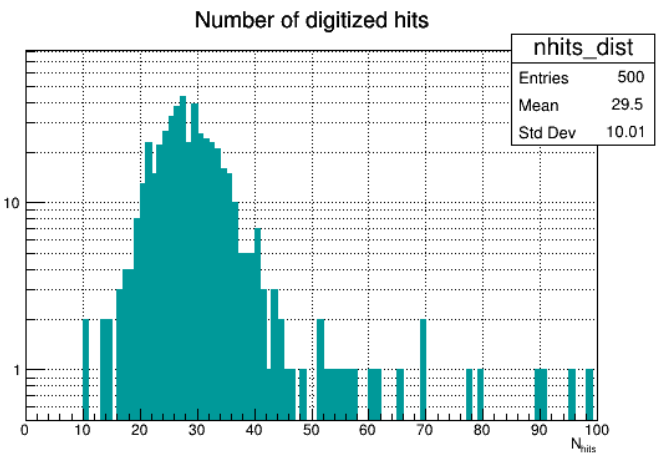


Gas & aerogel cutoff

Aerogel cutoff

Gas cutoff





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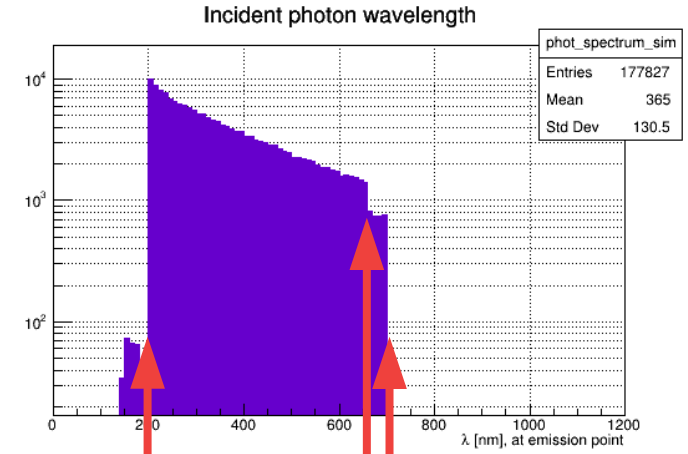

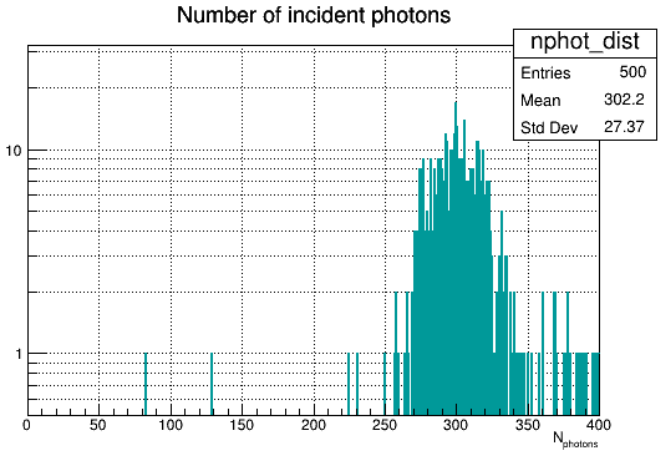

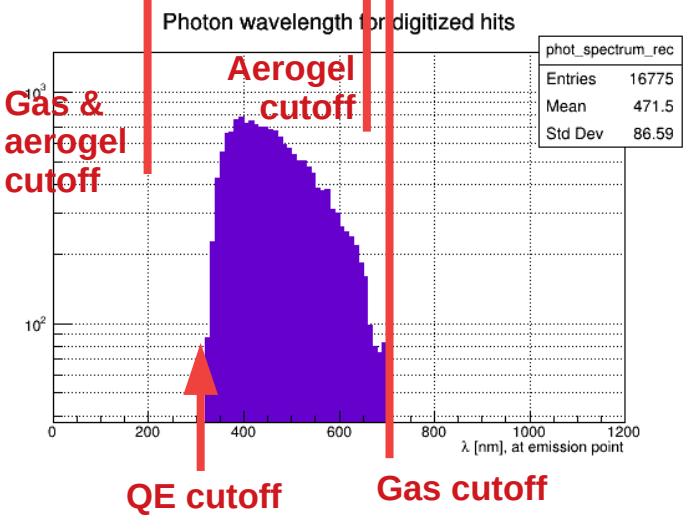

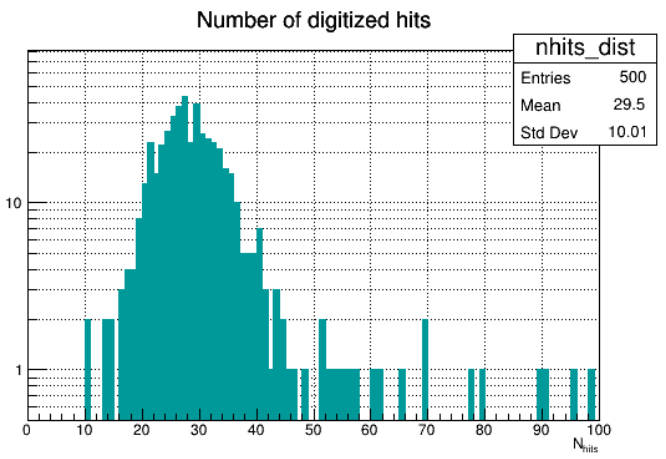

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Multiplicity Per Radiator

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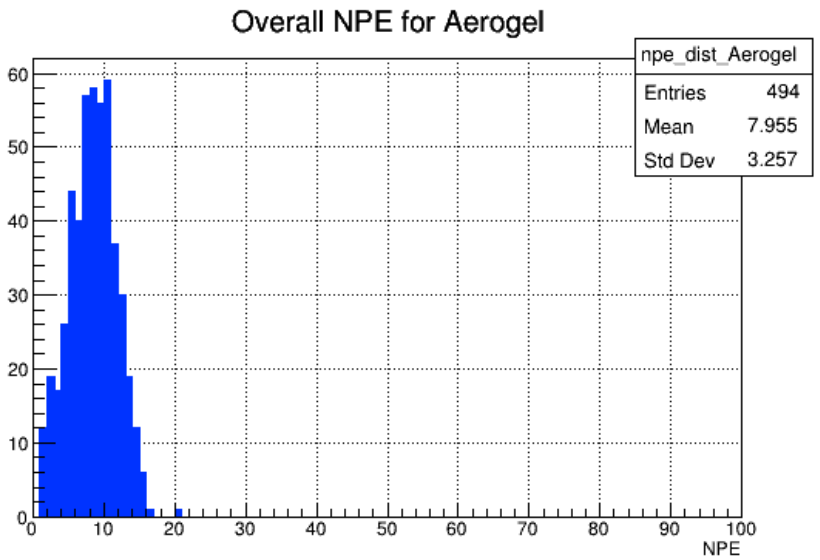
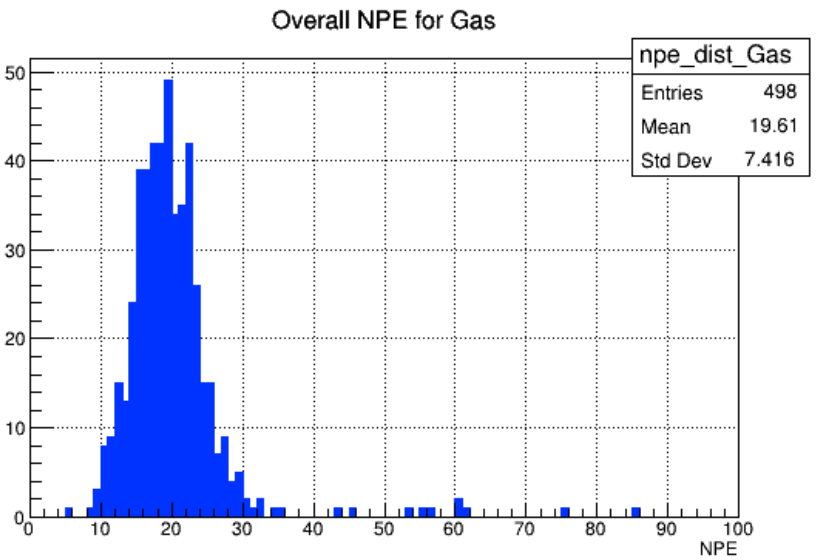
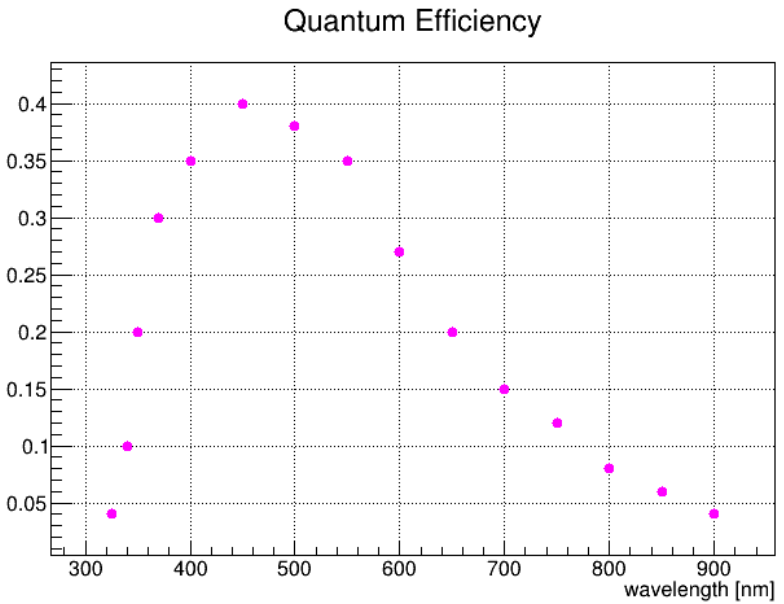




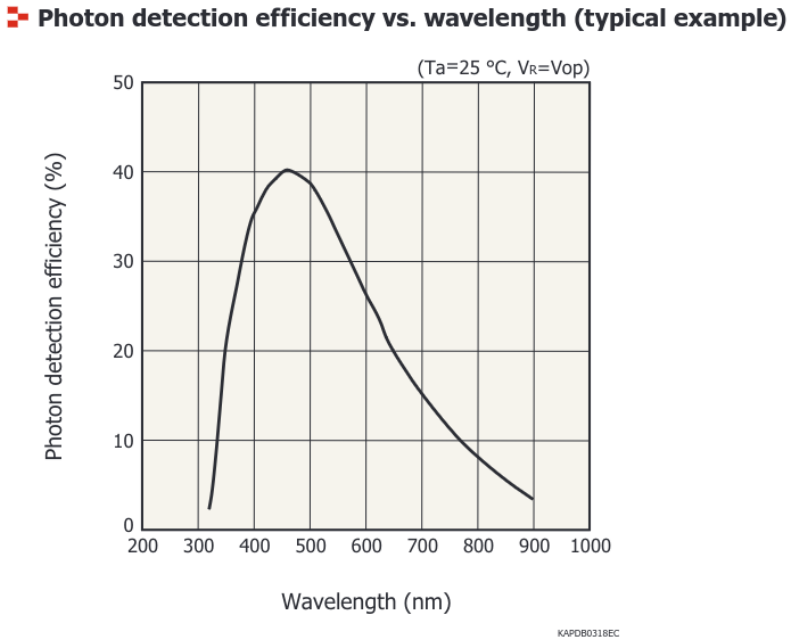
Sensor Quantum Efficiency

~300 – 1000 nm

Model in EICrecon (***not*** in epic, since QE is applied in reconstruction)

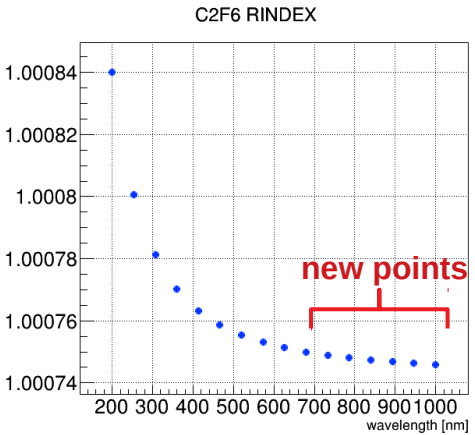


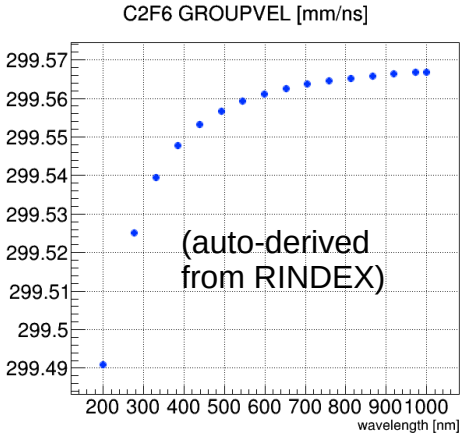
From S13361-3050NE-08 SiPM datasheet

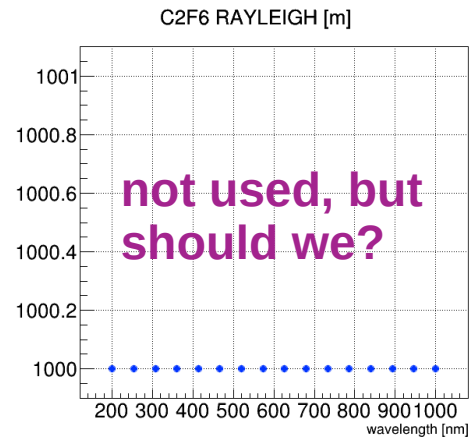


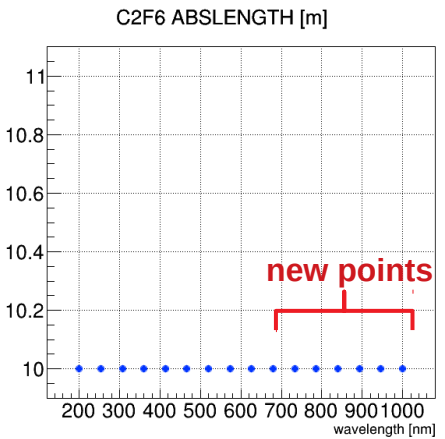
C_2F_6

- Source: Sellmeier formula + density correction (see class for details)
- Can easily extend wavelength range
  - **UPDATE: Extended from 200-700 nm range to 200-1000 nm**

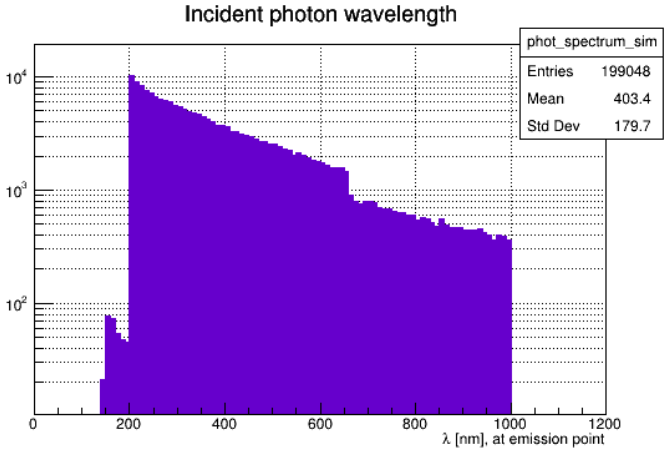


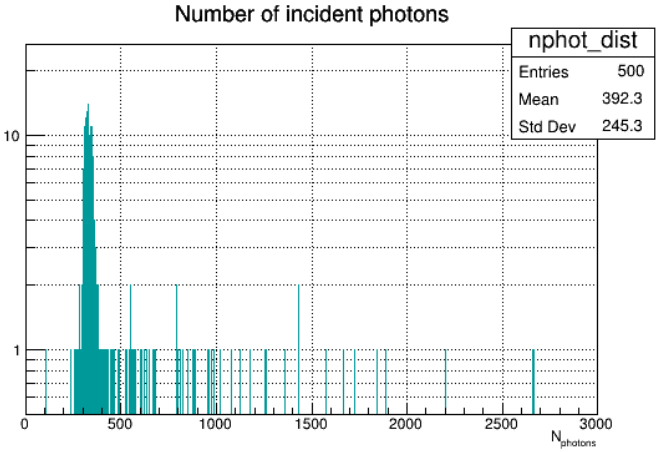


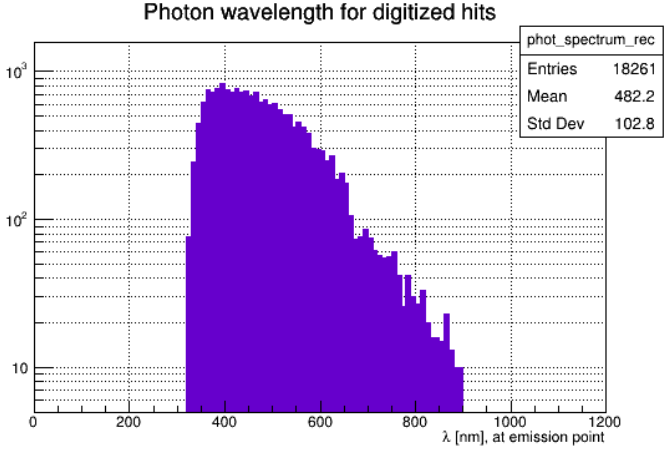


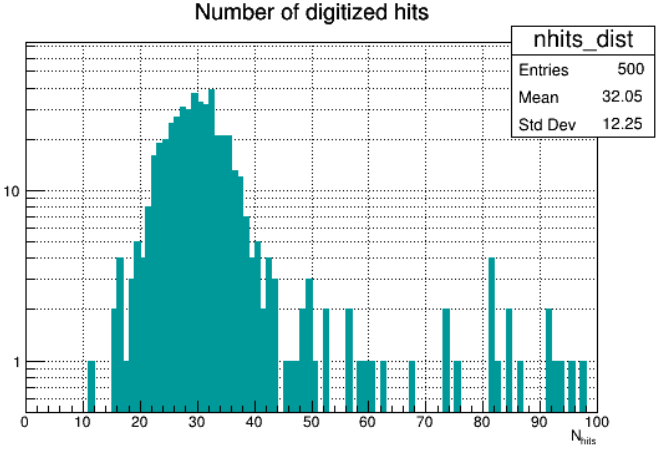


Photon Spectra and Multiplicity









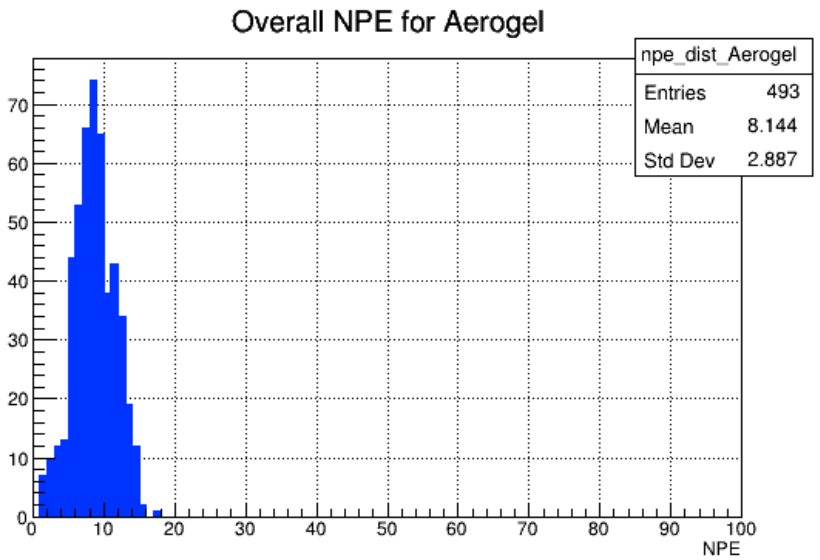
- After extending C2F6 range
- More photons from gas, with wavelength > 700 nm

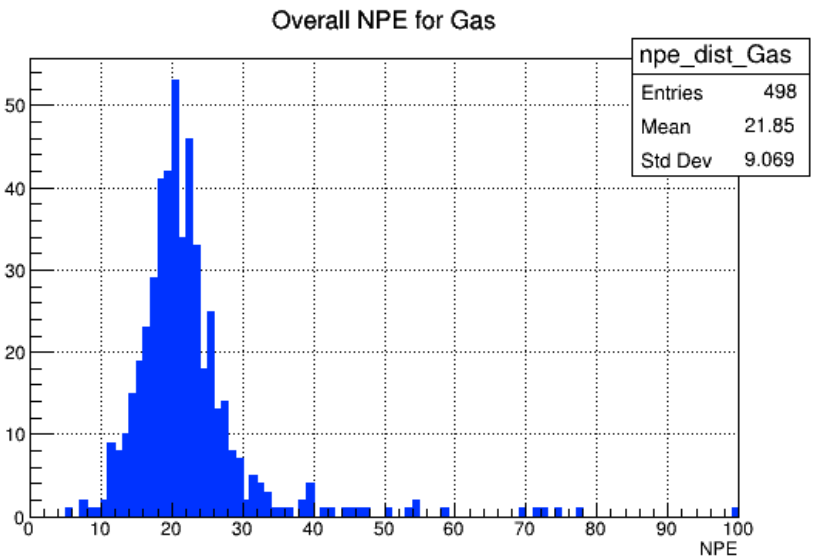
Multiplicities:

- **~390 photons**
- **~32 raw hits**

Multiplicity Per Radiator

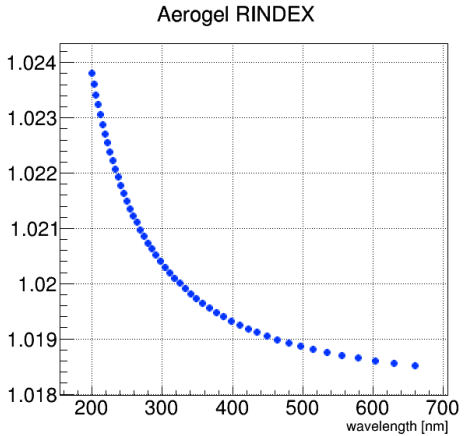
- After extending C2F6 range
- More photons from gas, with wavelength > 700 nm

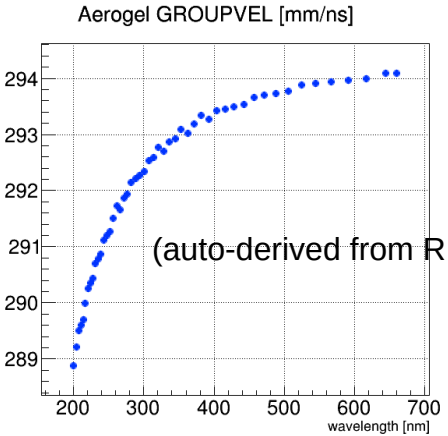




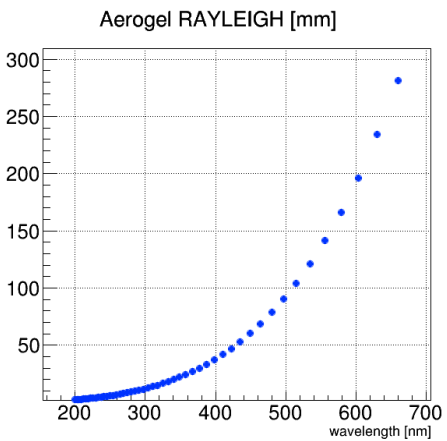
Aerogel

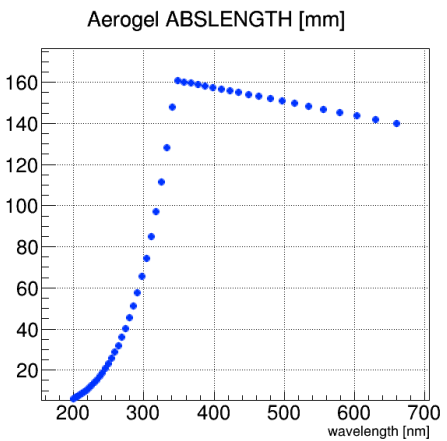
- Source: experimental data points from CLAS12, rescaled by Alessio/GEMC
  - Alternatives parameterizations available (Vorobiev, Sellmeier)
- ISSUE: stops at 660 nm
- Since based on data, **need to fit and extrapolate**



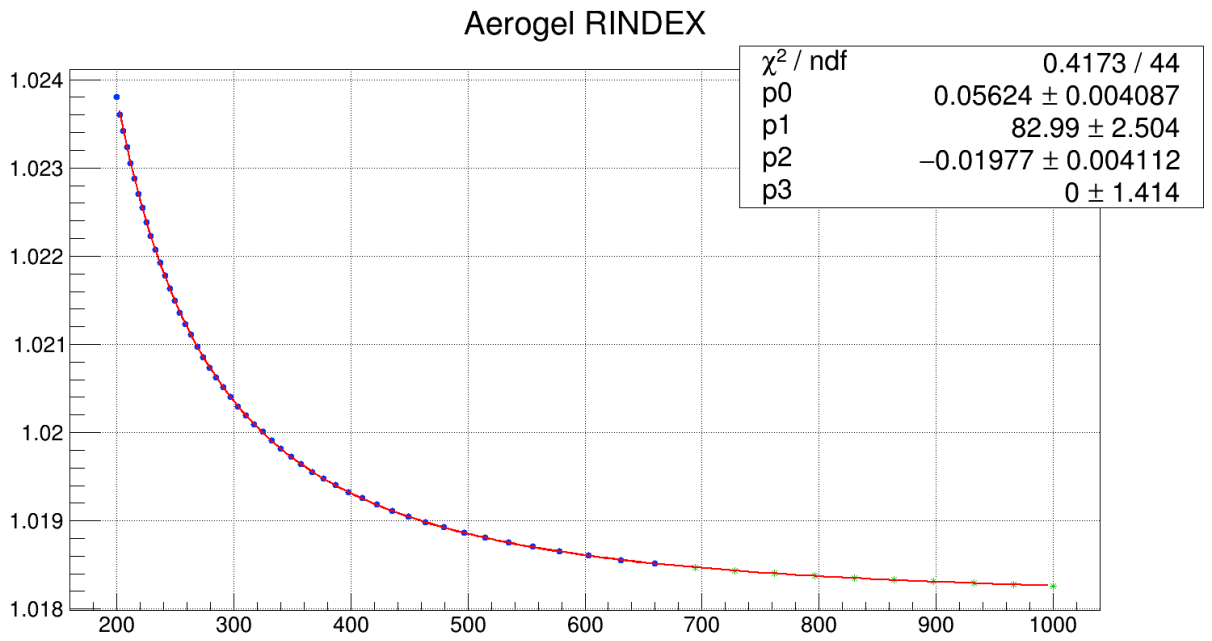


(auto-derived from RINDEX)





Aerogel: Extrapolation of Material Properties



Fit to 2nd order Sellmeier function

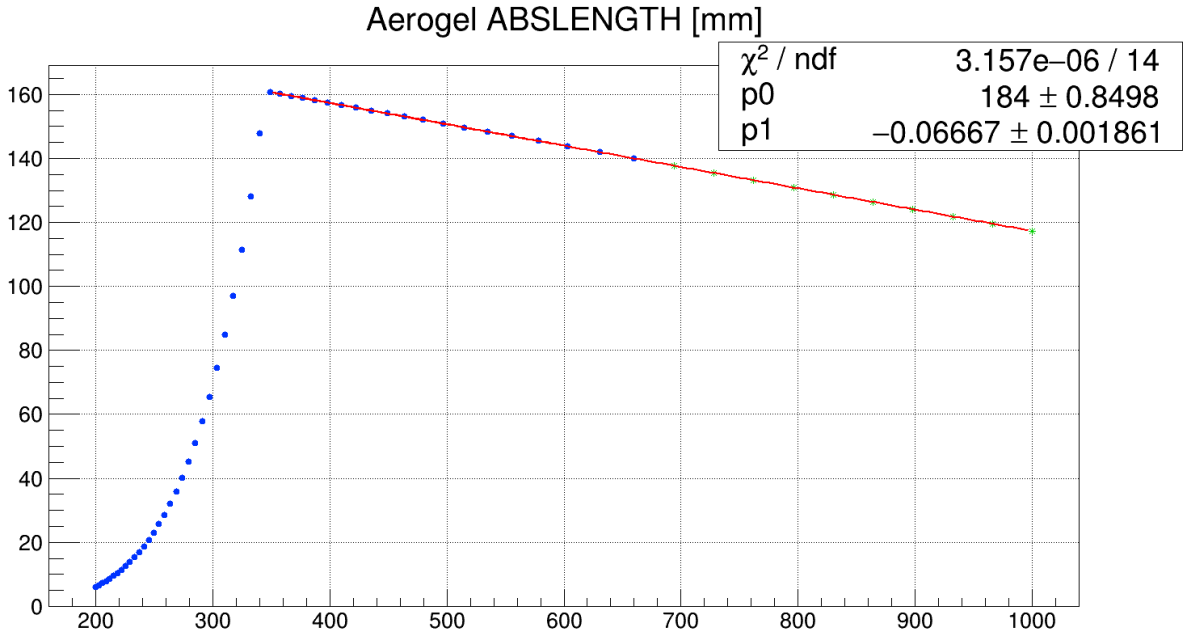
$$n^2(\lambda) = 1 + \frac{p_0\lambda^2}{\lambda^2 - p_1^2} + \frac{p_2\lambda^2}{\lambda^2 - p_3^2}$$

- The fit goes through the data points nearly perfectly
  - (ignore the χ^2, I added some small, fake error bars to "help" the fit)
- 10 additional points added

• data points

∗ extrapolated points

Aerogel: Extrapolation of Material Properties



Linear Fit for λ>350 nm

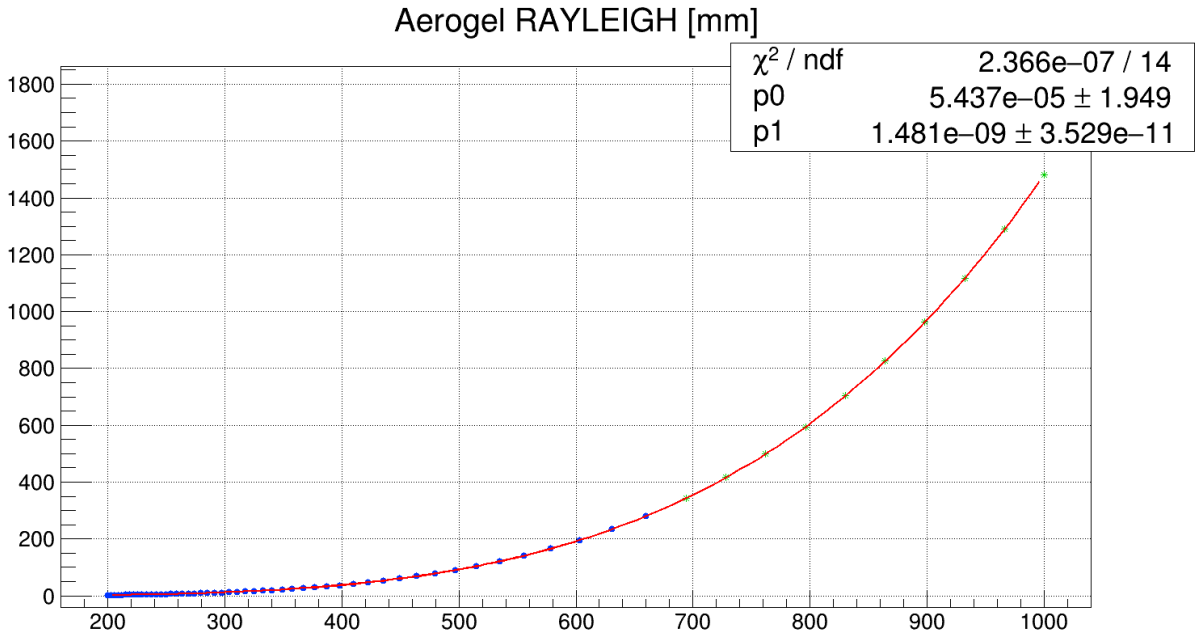
$$A(\lambda) = p_0 + p_1\lambda$$

- The fit goes through the data points nearly perfectly
  - (ignore the χ^2, I added some small, fake error bars to “help” the fit)
- 10 additional points added

● data points

∗ extrapolated points

Aerogel: Extrapolation of Material Properties



Fit to λ^4 dependence

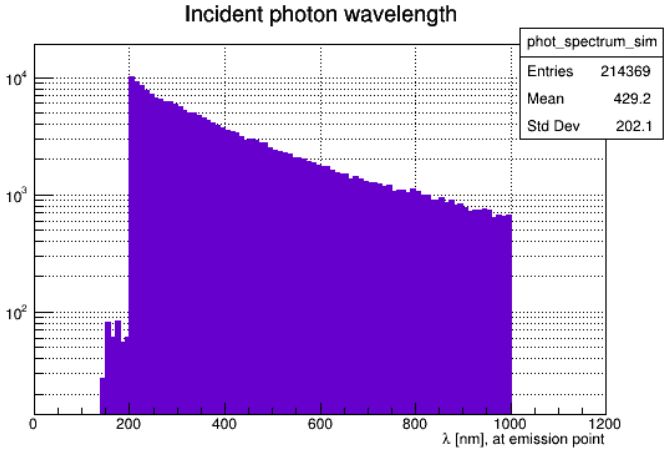
$$R(\lambda) = p_0 + p_1\lambda^4$$

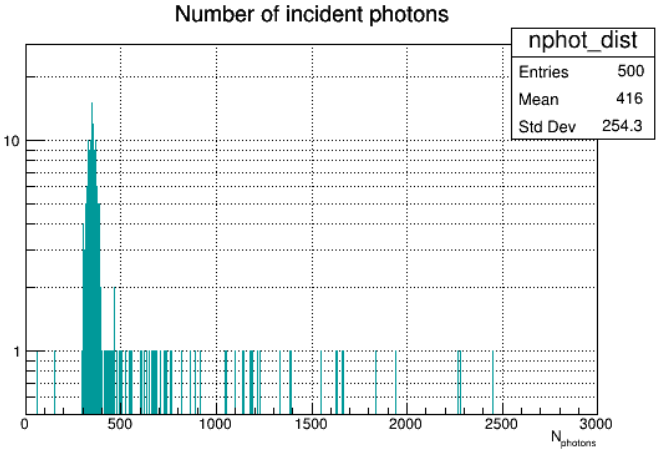
- The fit goes through the data points nearly perfectly
  - (ignore the χ^2, I added some small, fake error bars to “help” the fit)
- 10 additional points added

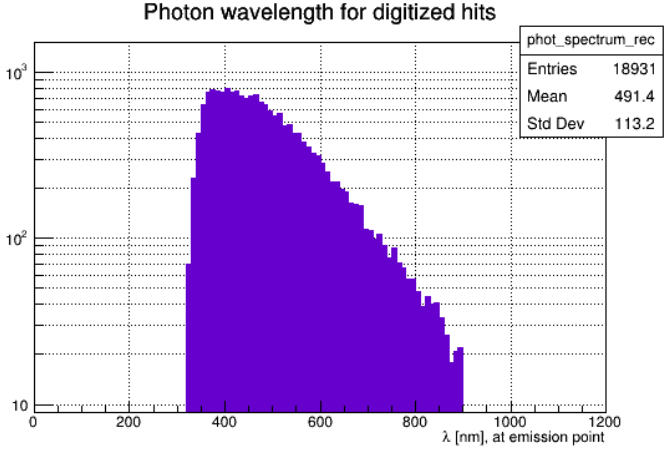
• data points

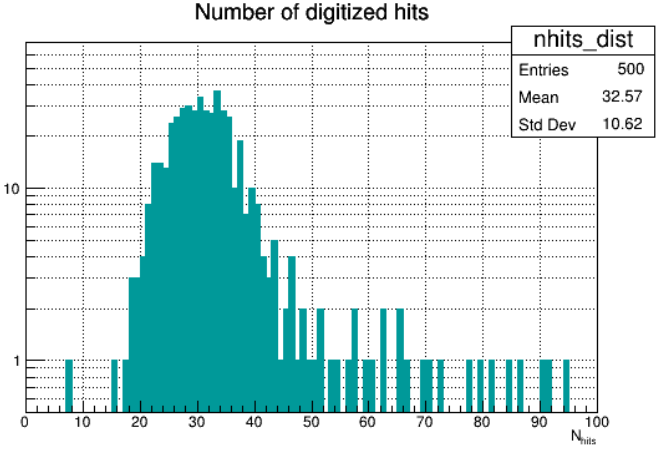
∗ extrapolated points

Photon Spectra and Multiplicity







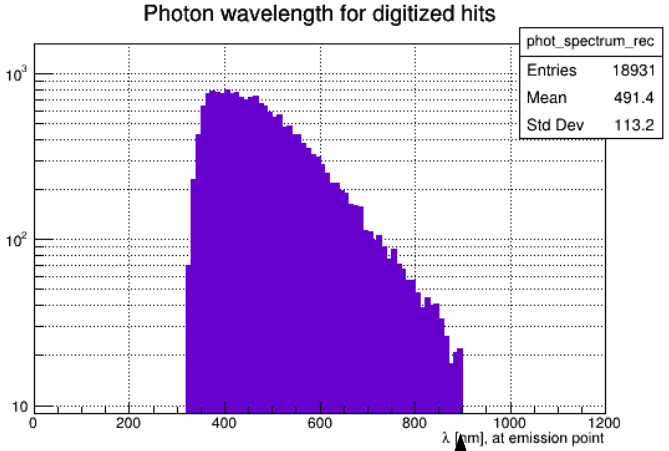


- After extending the Aerogel range
- More photons from aeogel, with wavelength > 660 nm
- Incident photon spectrum looks cleaner

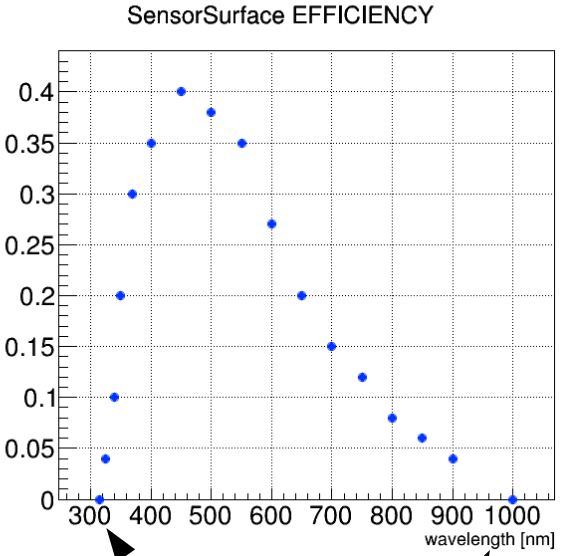
Multiplicities:

- **~416 photons**
- **~33 raw hits**

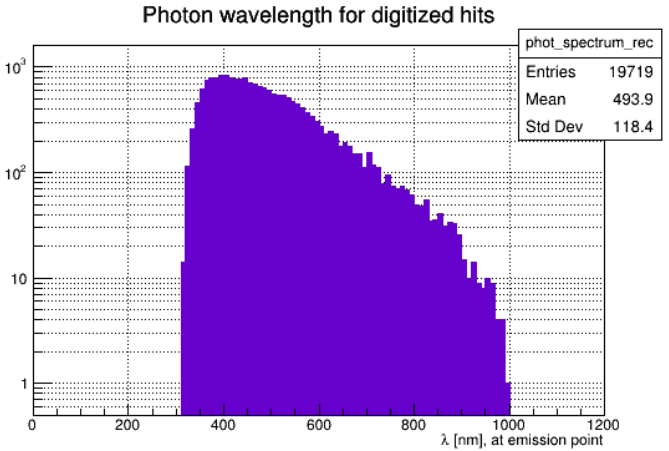
Photon Spectra: a closer look



still not happy with this small cutoff…



… so I added these endpoints

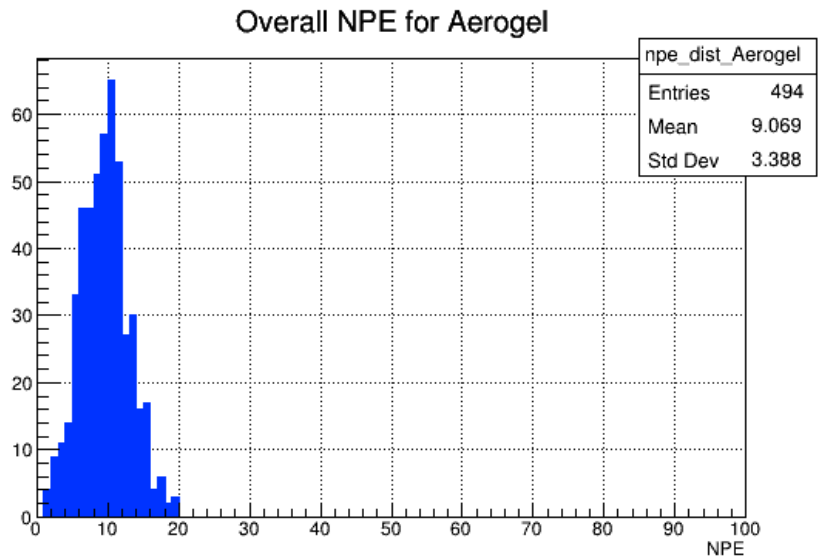


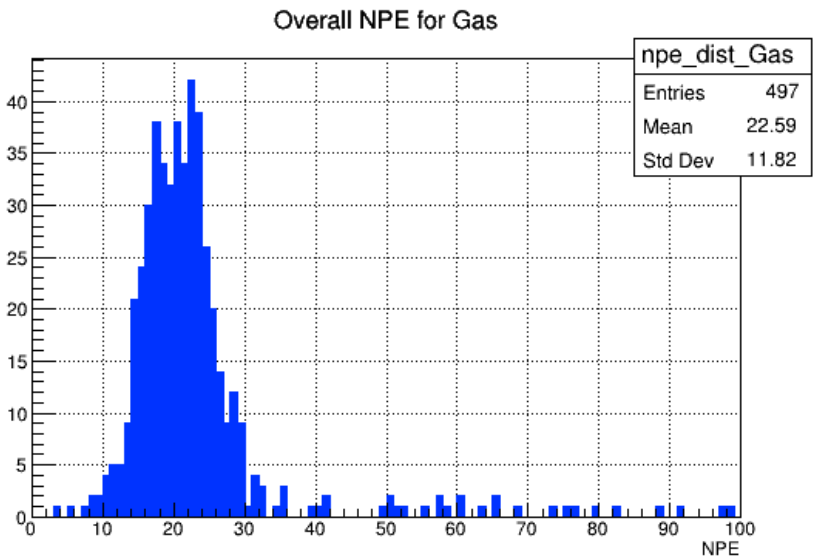
Result: a smoother roll-off, more consistent with QE curve (note the vertical axis scale change)

Multiplicity Per Radiator

9 photons from aerogel, compared to 8 from before

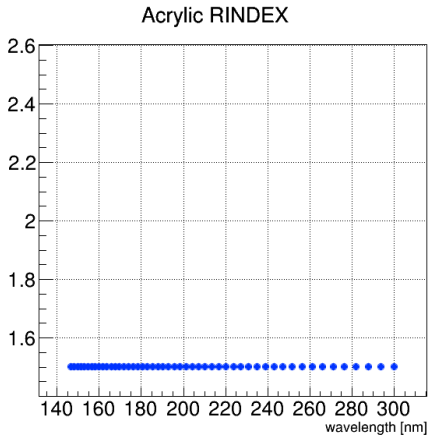
this is a 12.5% increase

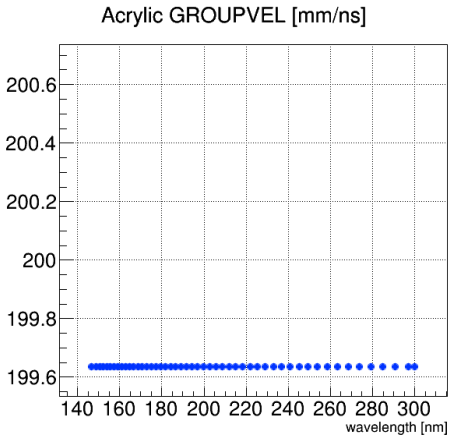


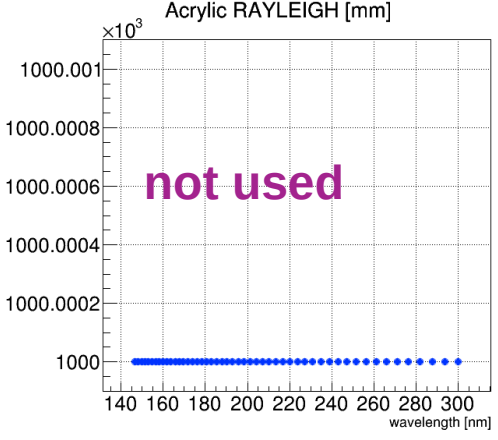


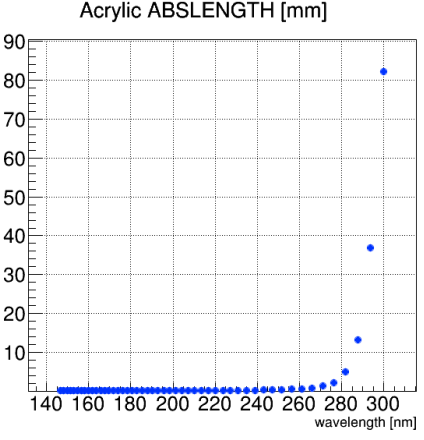
Acrylic Filter

- Source: not clear in g4dRIChOptics
- Threshold set to 300 nm
- Doesn't seem like we need to extrapolate this; I tried disabling the filter and there was no effect at wavelengths greater than 300 nm





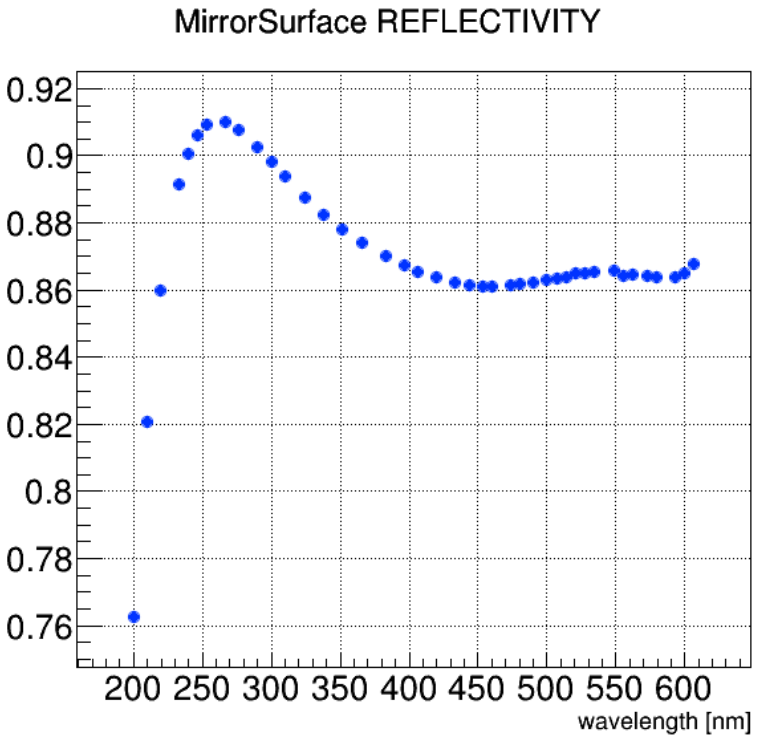




Mirror Surface

- In g4dRIChOptics: Reflectivity of $AlMgF_2$ coated on thermally shaped acrylic sheets, measured by AJRP, 10/01/2012

Reflectivity In g4dRIChOptics:



In ePIC, we currently use constant 0.9 reflectivity

More Undefined Properties and Concerns

- Things with *no* properties defined: surfaces
  - Aerogel surface: none defined
  - Acrylic filter surface: none defined
  - Sensor surface: defined
    - No property tables, but uses “glisur” model, “polished” finish, and “dielectric_dielectric” type
  - Mirror surface: defined
    - 90% constant reflectivity is the only property table
    - Uses “unified” model, “polished” finish, and “dielectric_metal” type
- Concerns
  - Mirror volume material is acrylic, same as filter
  - Sensor volume material is AirOptical
  - Rayleigh scattering tables