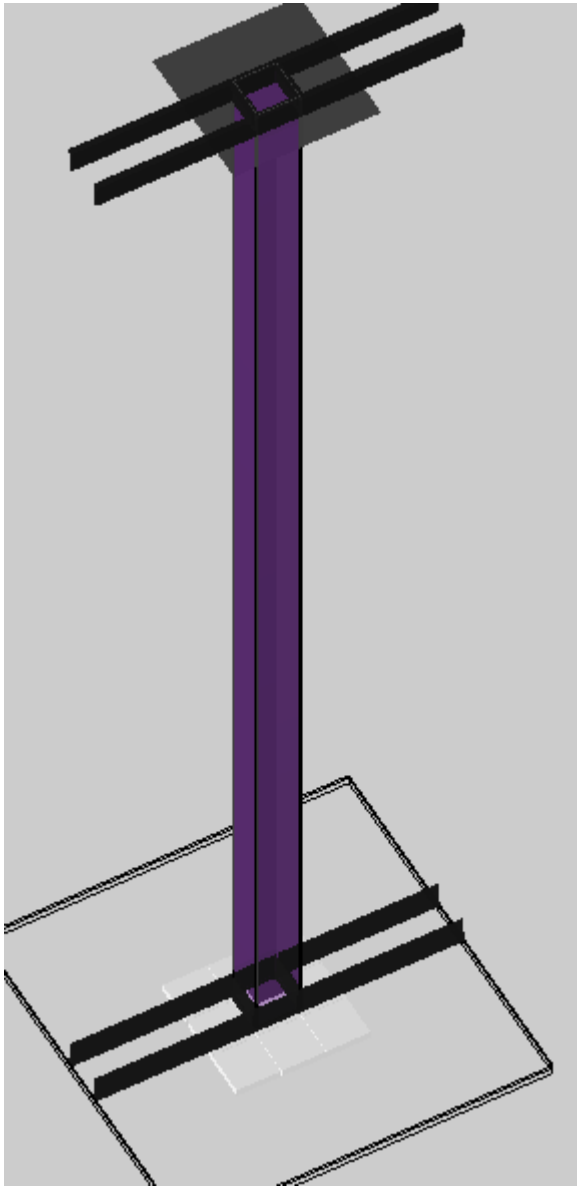
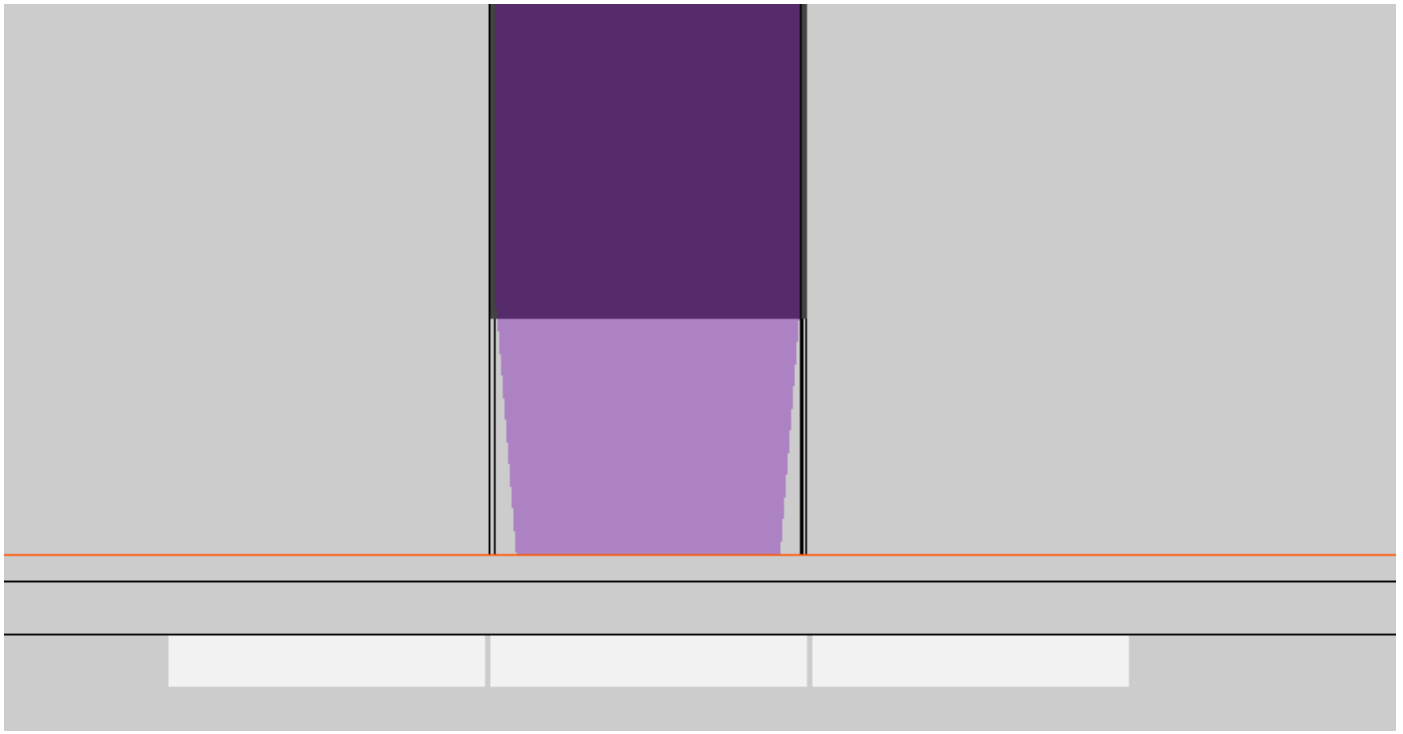
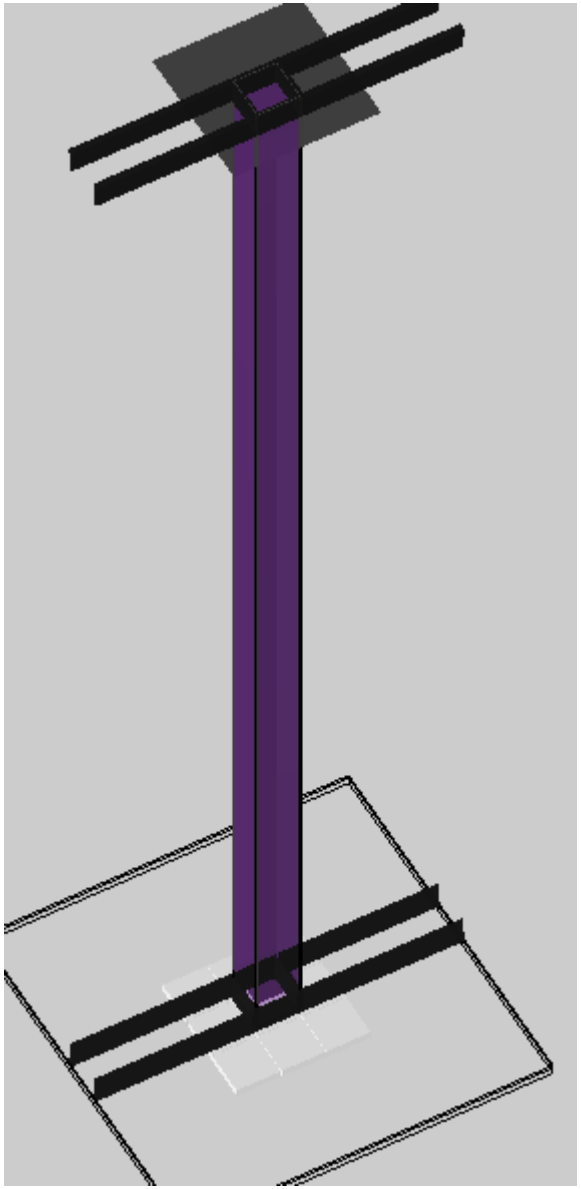
Scintillator Optimization Study

- Goal is to finalize the exact shape of the scintillators
- Required for final quotes on scintillator production
- Required as input for the module grid design
- Scintillator production should start next year



Method



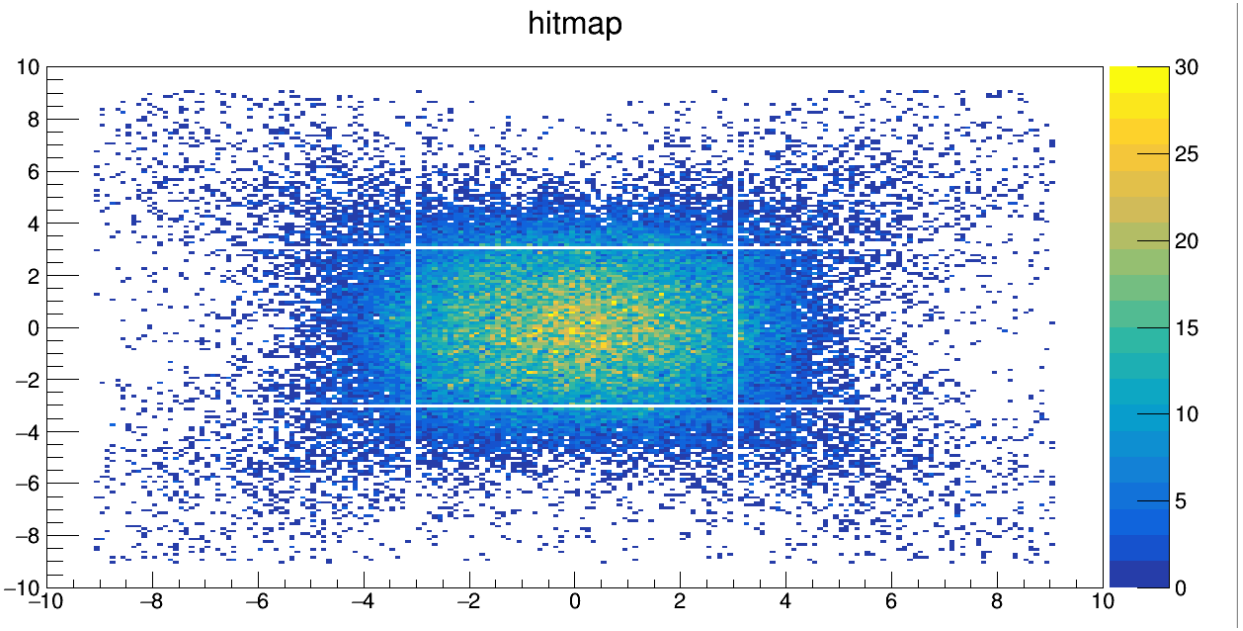


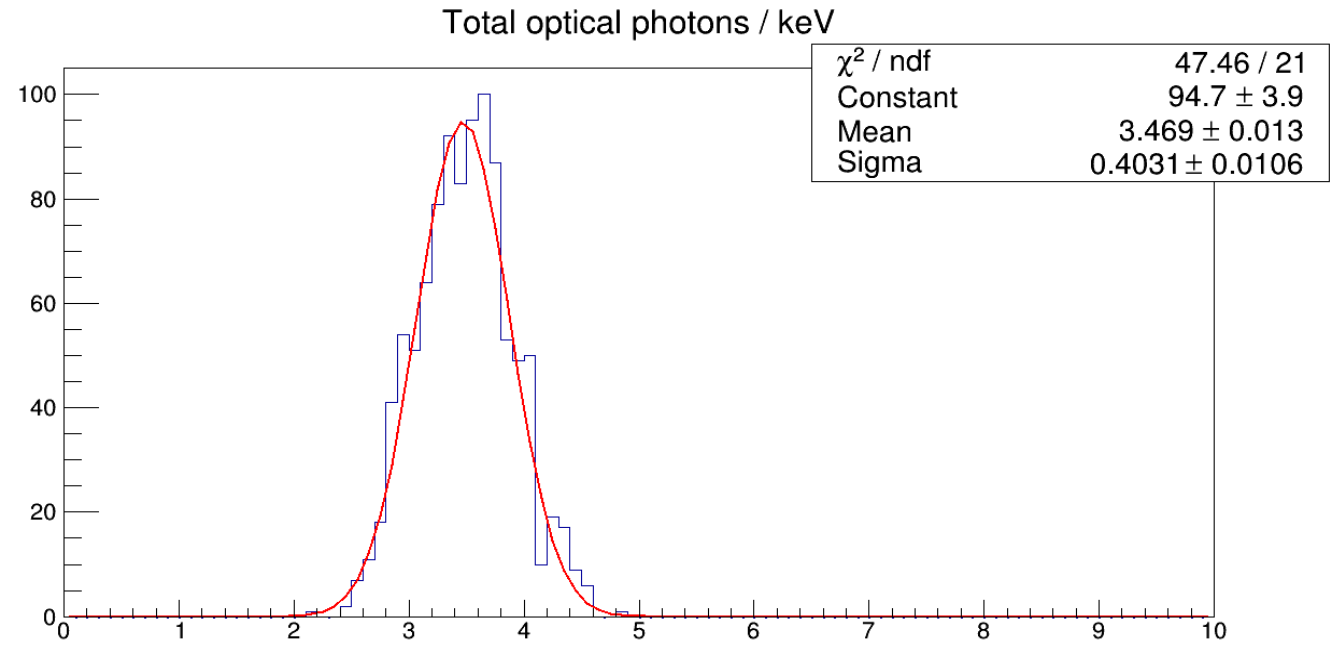
- Optical simulations based on the old POLAR ones with:

- Scintillator
- Reflective foil (vikuiti)
- Photon detector (SiPM or PMT)
- Glass window
- Optical pad
- Grid

+ all optical properties

Check if it works for POLAR setup





- We see the optical cross talk (through glass window and optical pad)

- Total number of optical photons reaching the PMT is 3.45 / keV

- Matches old simulations

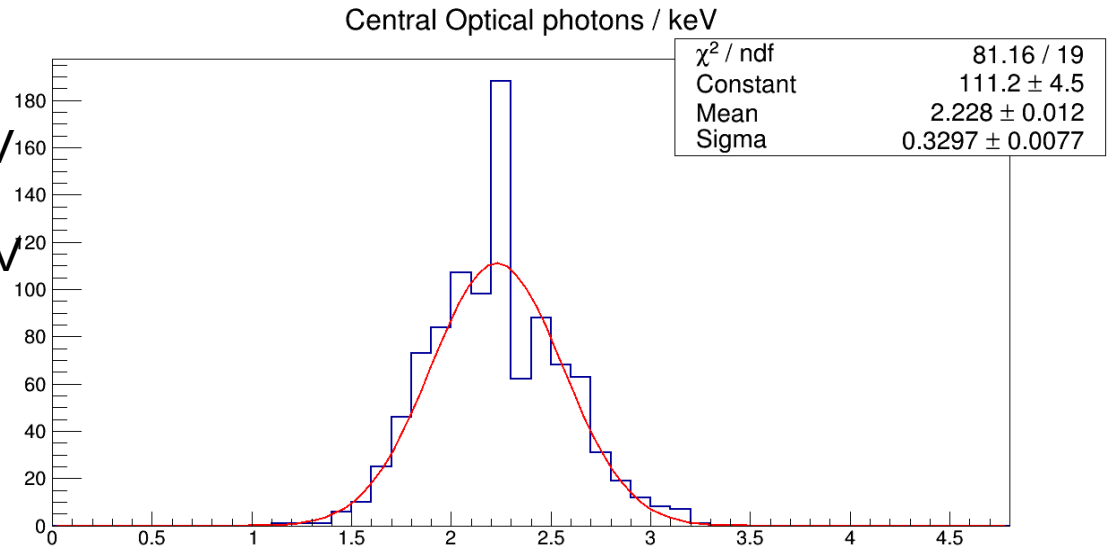
Cross talk in POLAR

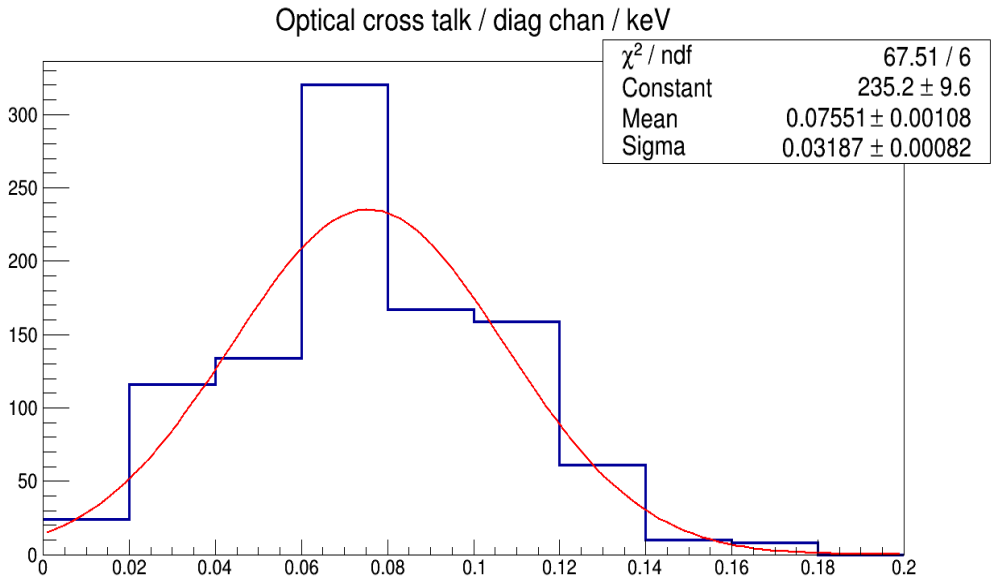
- Central channel gets 2.2 opt. photons/ keV

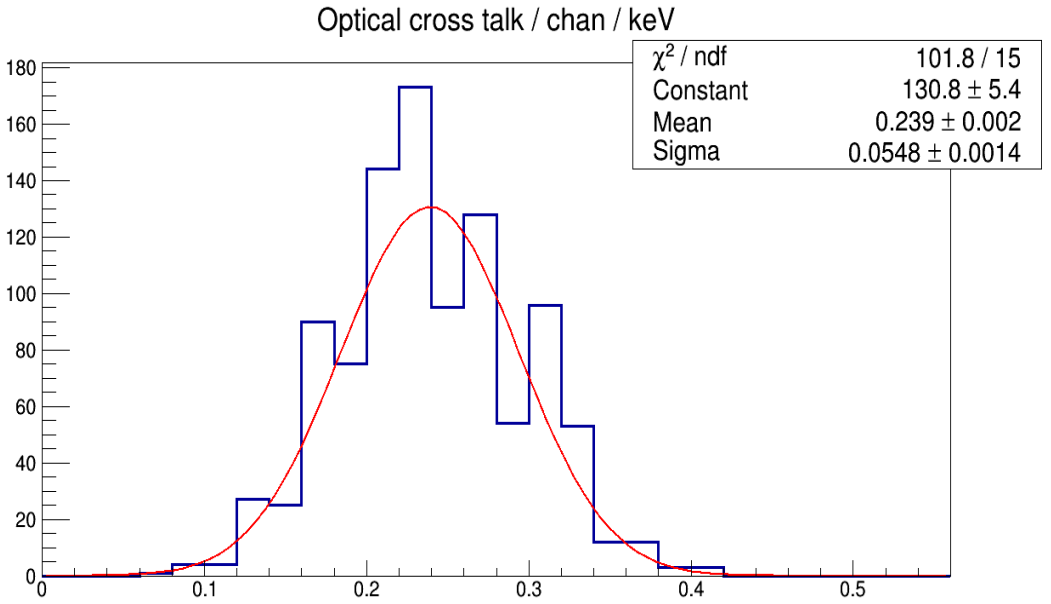
- Direct neighbours get 0.24 opt. photons/ keV

- Corner neighbours get 0.08 opt. photons/keV

(matches results from POLAR)







Position dependency

- Difference in light yield between top and bottom of ~3%

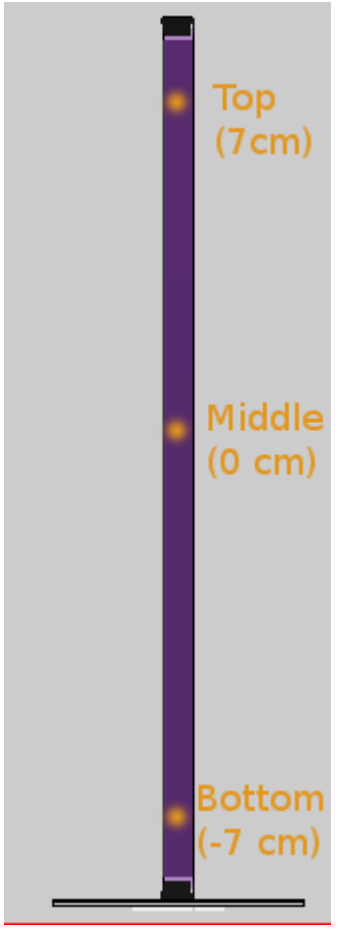
- During beam tests we could not reach the level of precision to check this

- Should ideally be minimized

Constant	126.9 ± 5.2
Mean	1.952 ± 0.010
Sigma	0.2913 ± 0.0074

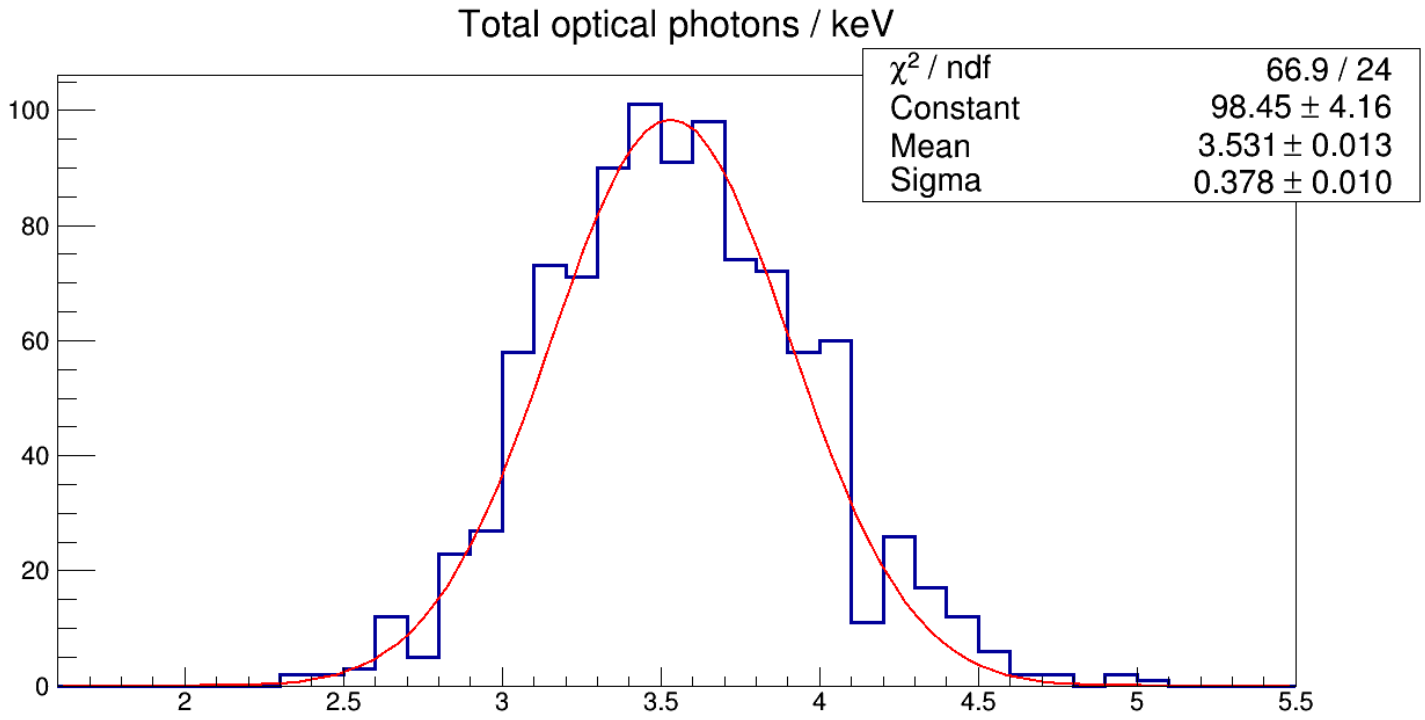
Constant	127.5 ± 5.5
Mean	2.006 ± 0.010
Sigma	0.2919 ± 0.0082

Constant	125.7 ± 5.5
Mean	2.022 ± 0.010
Sigma	0.2955 ± 0.0086



Simple POLAR-2 design

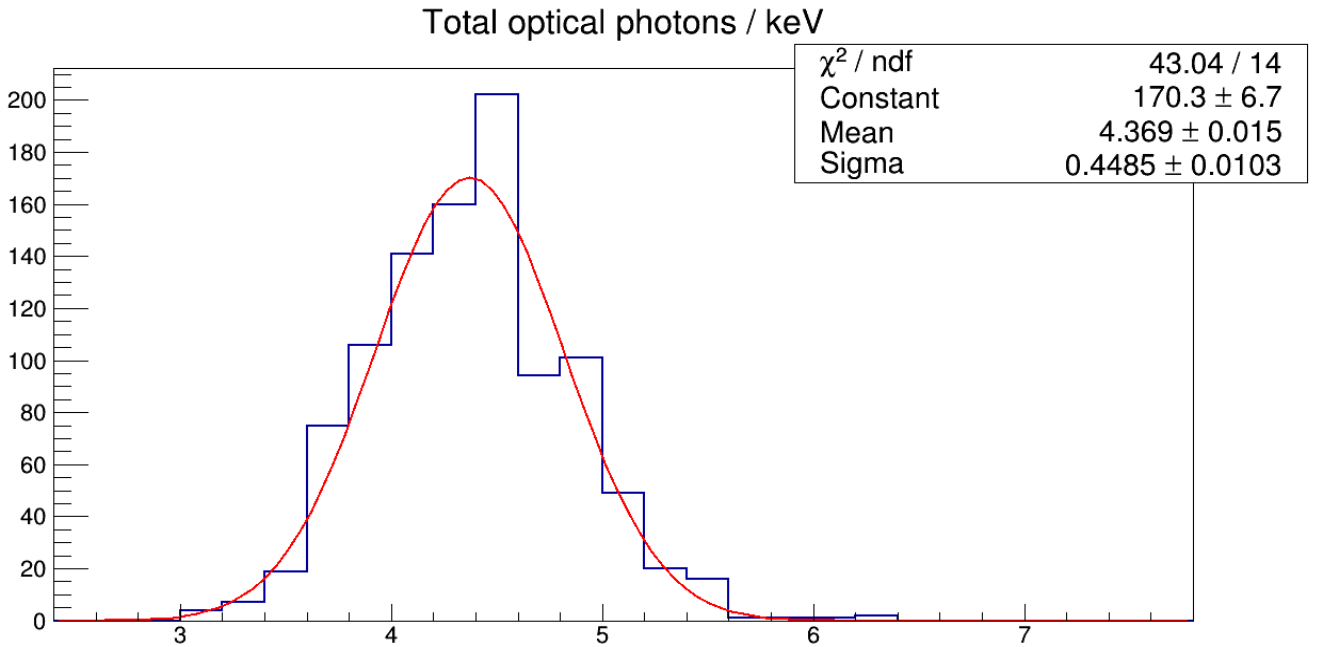
First design:
- Keep everything equal about the scintillator
- Remove glass window
- Replace optical pad with 0.1 mm thick glue
- Refractive index of glue similar to that of the SiPM (can change things by ~5%)
- 3.5 optical photons / keV
- Total cross talk ~0.4% (note that we will have some cross talk due to wrapping)



Optimization design

- Removing top truncation (would simplify design a bit), increases position dependency (~10%)
- Also reduces light yield by 5%
- Main improvement can be made by changing the truncation size, maximize contact area with SiPM
- Discussions with Franck → minimum we can do is 0.4 mm

- Improves light yield to 4.4 opt. photons / keV → gives us 2 p.e. / keV (aim is threshold of ~4 p.e.)
 - Less light loss since we remove one layer
- Cross talk of 0.2%



POLAR-2 position dependency

- Less truncation means more position dependence...

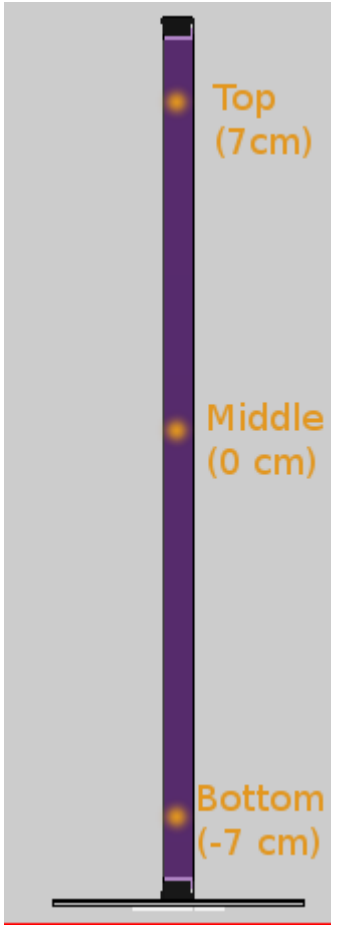
- Now around 4.5% between top and bottom

- This can be put into the response as long as we perform very detailed measurements of this effect (can be done with sources quite easily)

Constant	73.36 ± 3.11
Mean	4.214 ± 0.016
Sigma	0.4769 ± 0.0125

Constant	75.94 ± 3.10
Mean	4.373 ± 0.016
Sigma	0.4606 ± 0.0108

Constant	69.61 ± 2.90
Mean	4.418 ± 0.017
Sigma	0.4851 ± 0.0120



Conclusions

- Next step is optimizing the length for signal to noise
- Requires full POLAR-2 simulations
- Will use typical GRB for signal (check for different angles)
- Will use standard bg spectra as input for background (detailed background model is not available and will take months to do this)
- Most likely we will not gain much from this exercise (order of ~%)
- Will send proposal for grid design to Franck so he can check for production
- After fixing the length we can ask for new quotes from manufacturers