Background light in T2K's OTR Monitor: Is it helium scintillation?

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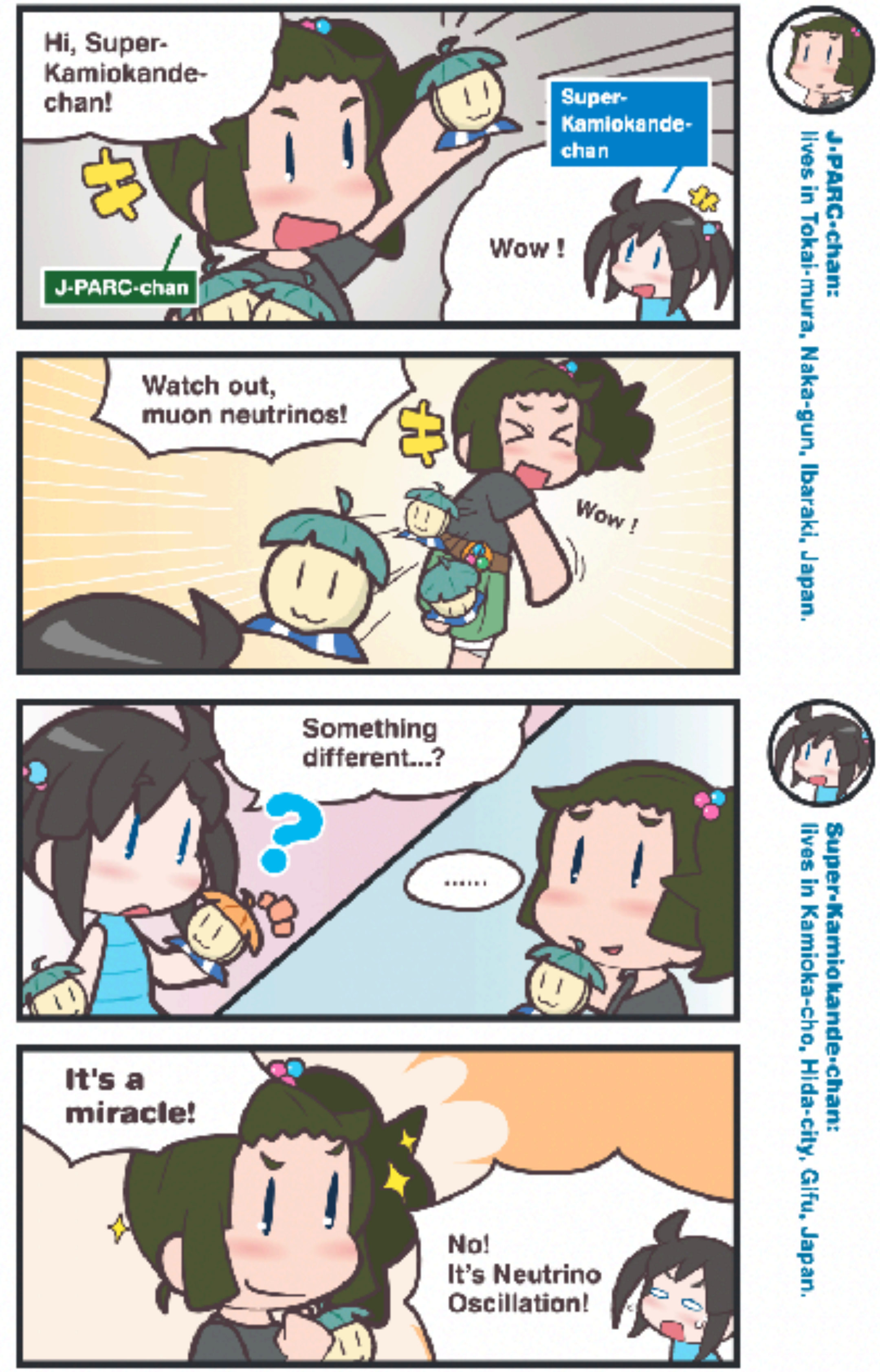
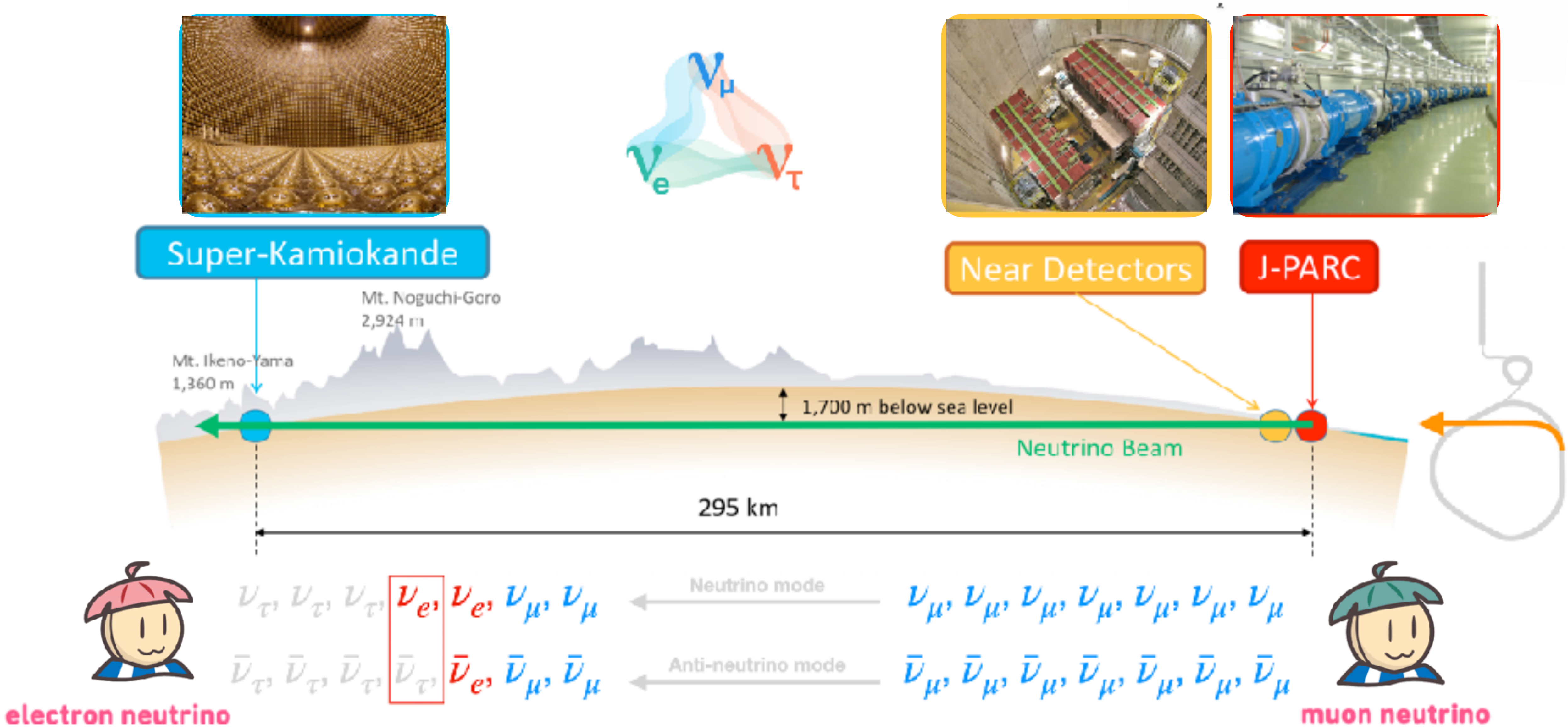


What is T2K ?

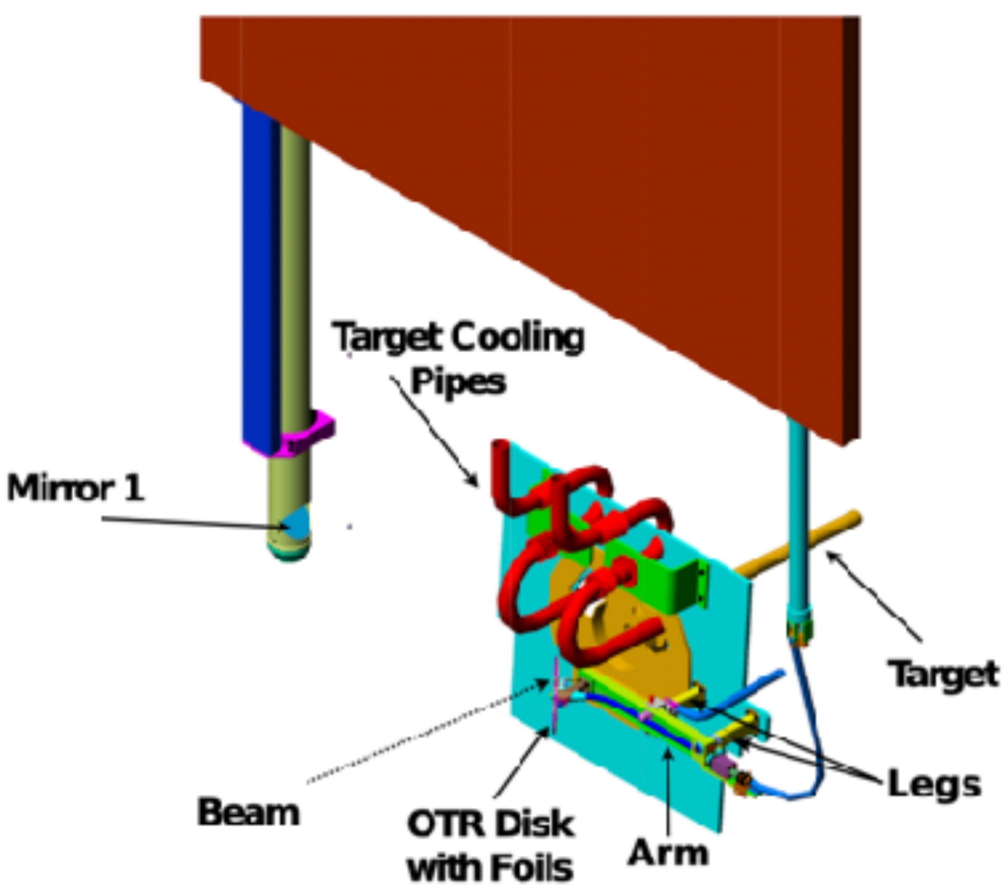
Long-baseline experiment studying neutrino oscillations.

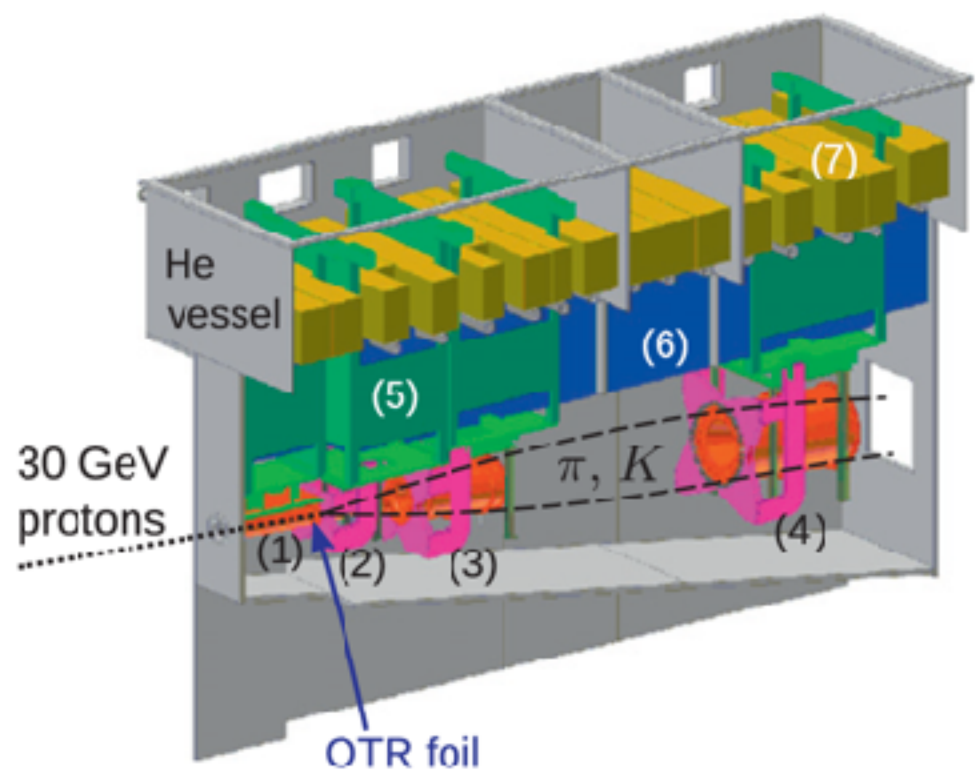


Difference in neutrino and anti-neutrino oscillation probability can help us answer questions about the nature of our universe: CP violation!

Neutrino beam

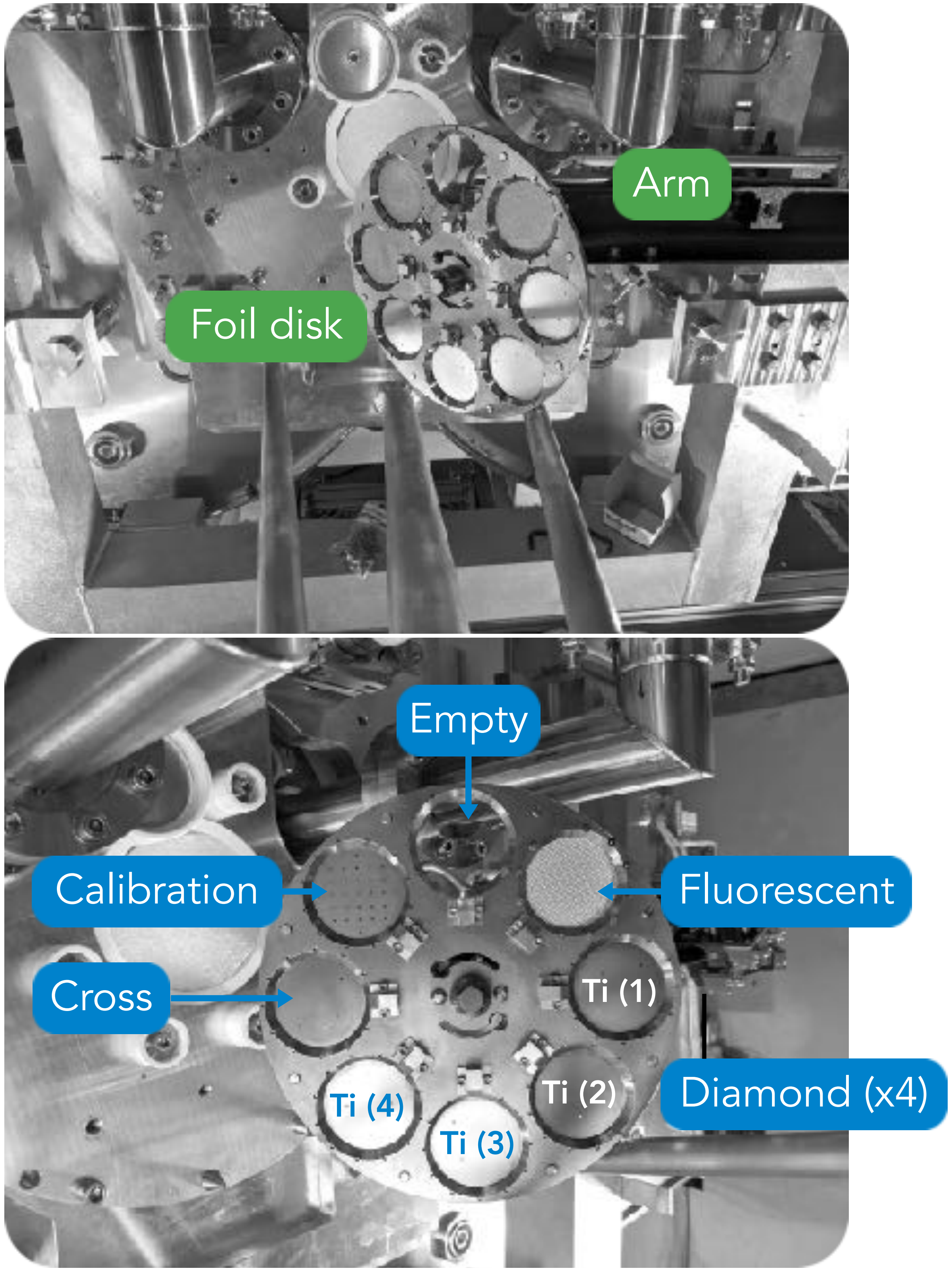
- 30 GeV protons produce π, K in 90 cm graphite target
- 3 magnetic horns selectively focus π^+, K^+ (or π^-, K^-) to produce ν_μ (or $\overline{\nu}_\mu$) in beam
- Essential to understand proton beam position to constrain neutrino energy spectrum → make this measurement with OTR





(1) Beam collimator
(2) Horn 1 & target
(3) Horn 2
(4) Horn 3
(5) Support modules
(6) Iron shielding
(7) Concrete shielding

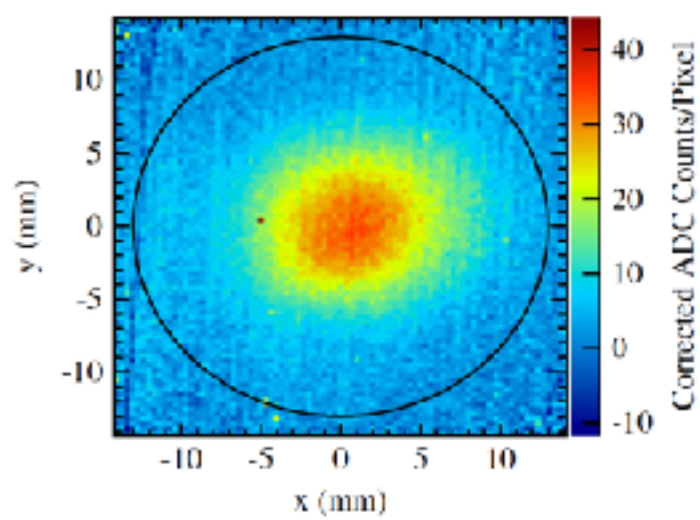
OTR monitor

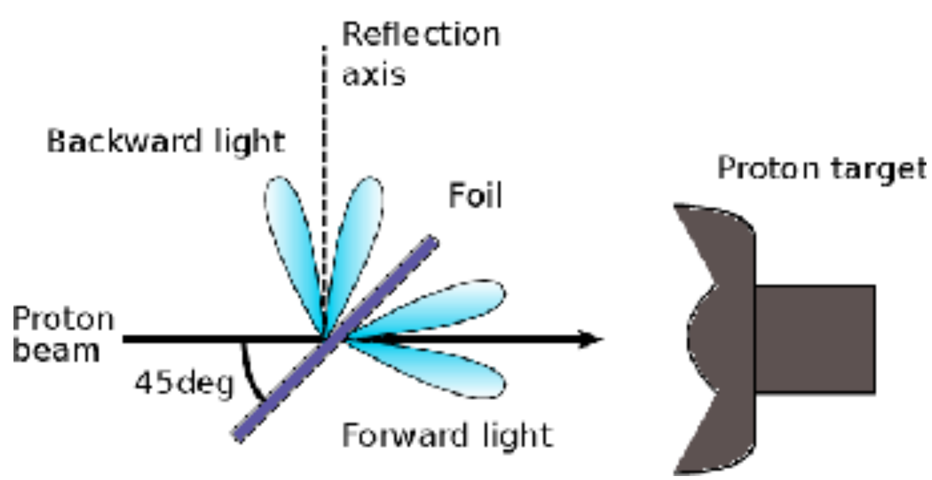


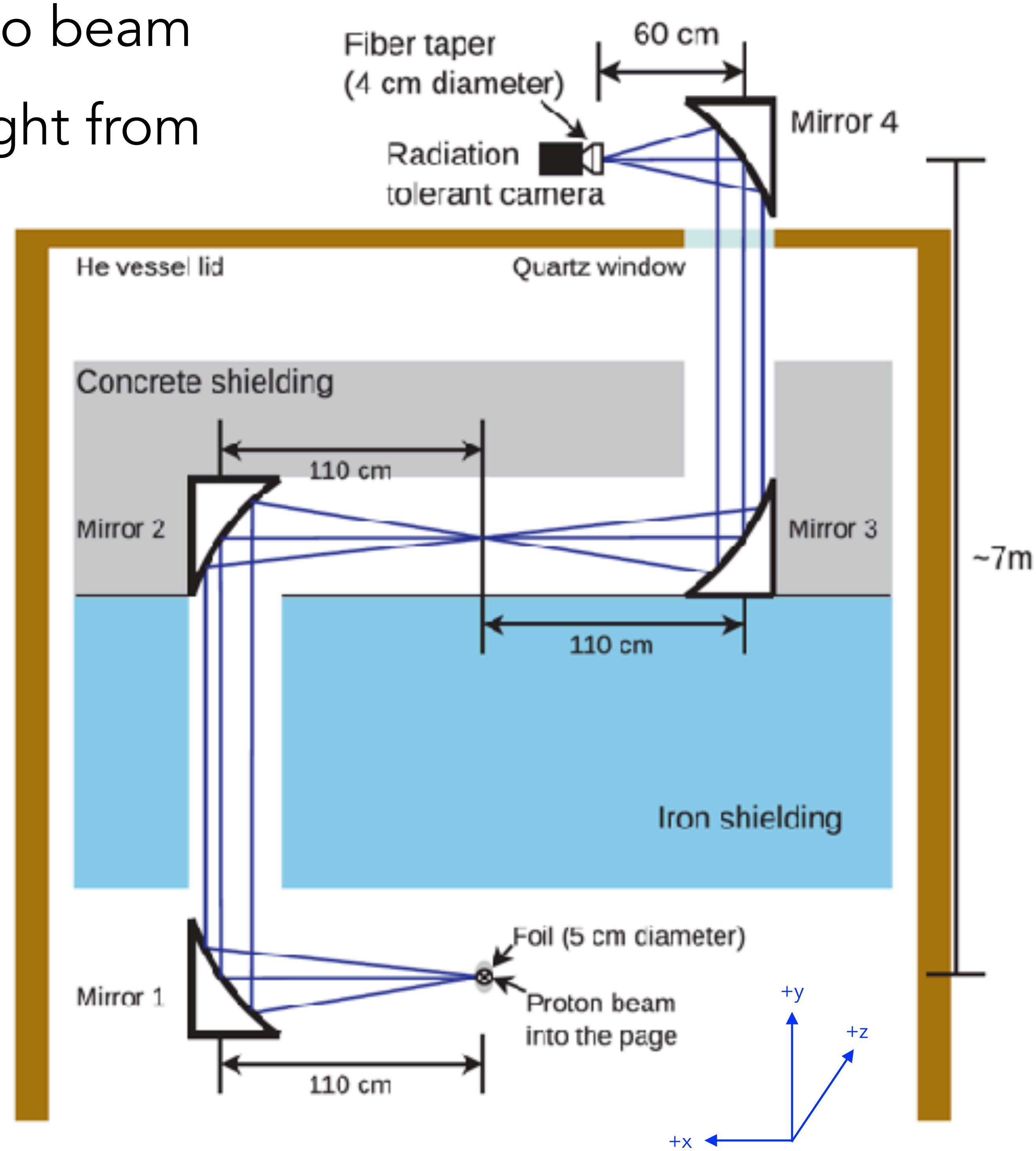
- Final proton beam monitor 30 cm before target, located in helium environment
- Use optical transition radiation (OTR) emitted as beam crosses Ti foil
- Ensure beam and target safety

OTR signal

- OTR light produced perpendicular to beam
- 4 parabolic mirrors transport OTR light from high → low radiation environment
- Signal captured by camera





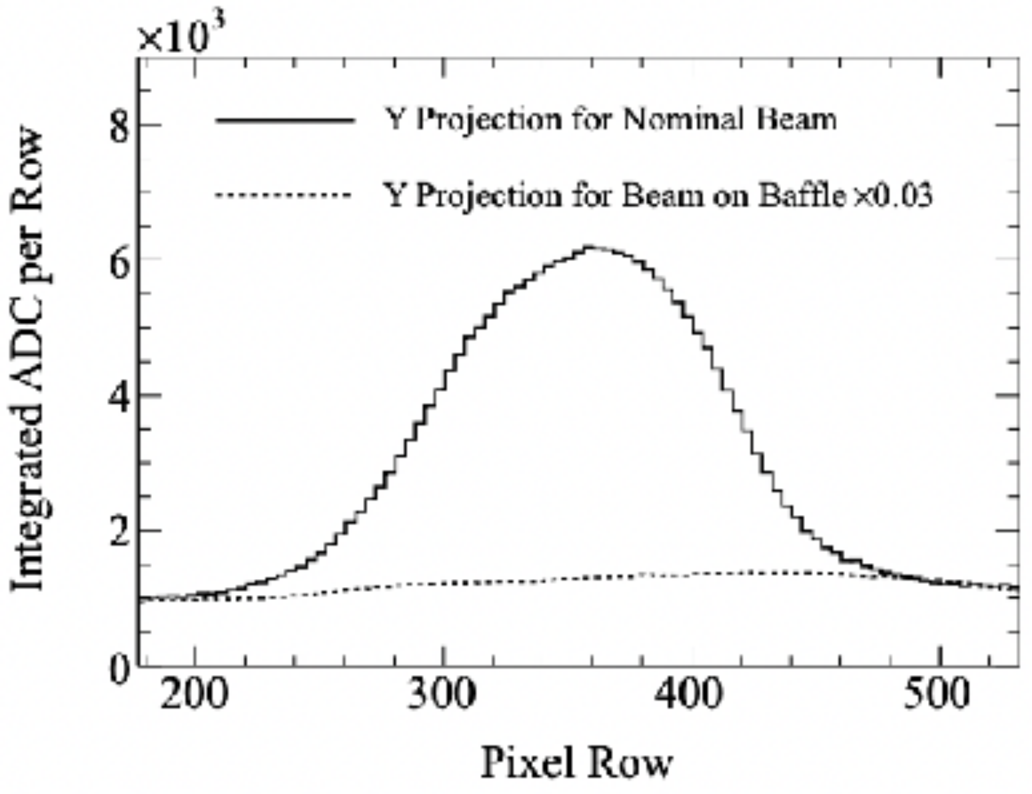


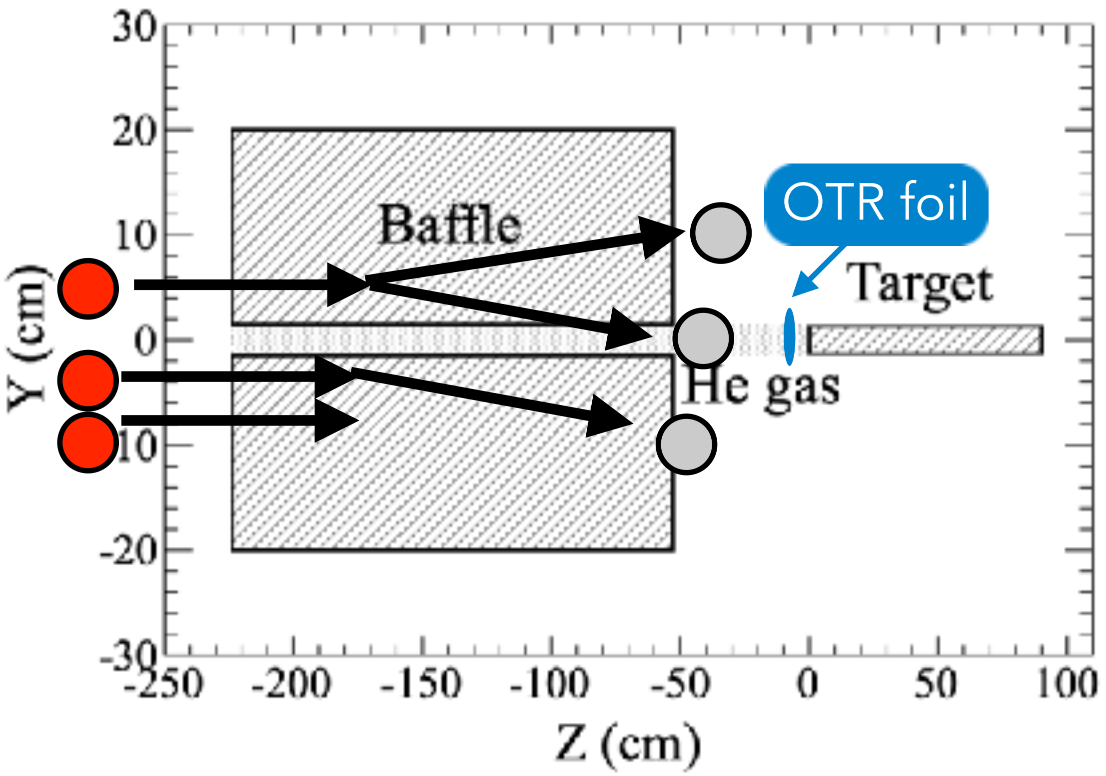
[1] https://doi.org/10.1016/j.nima.2012.11.044

OTR background light

Broad background contribution in OTR signal

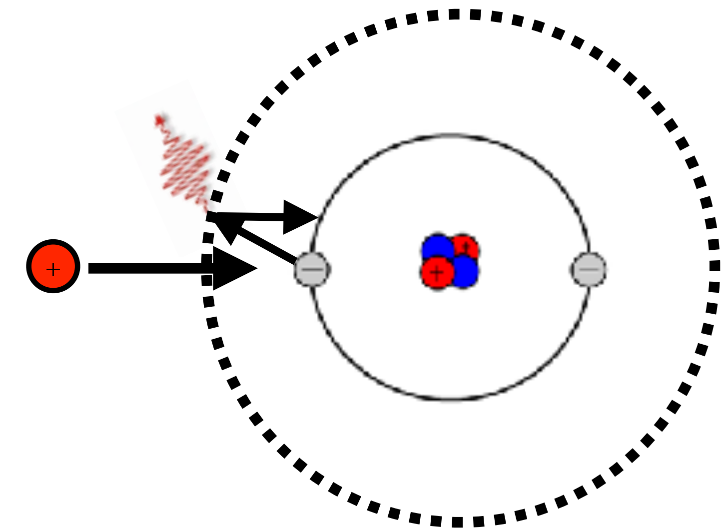
- Consistent with what we see when beam size is blown up so much of it is hitting baffle
- Even with nominal beam, still expect secondaries from beam tails hitting the baffle or backscattering from the target
- Necessary to understand to reduce systematic uncertainty in OTR measurement





Helium scintillation hypothesis

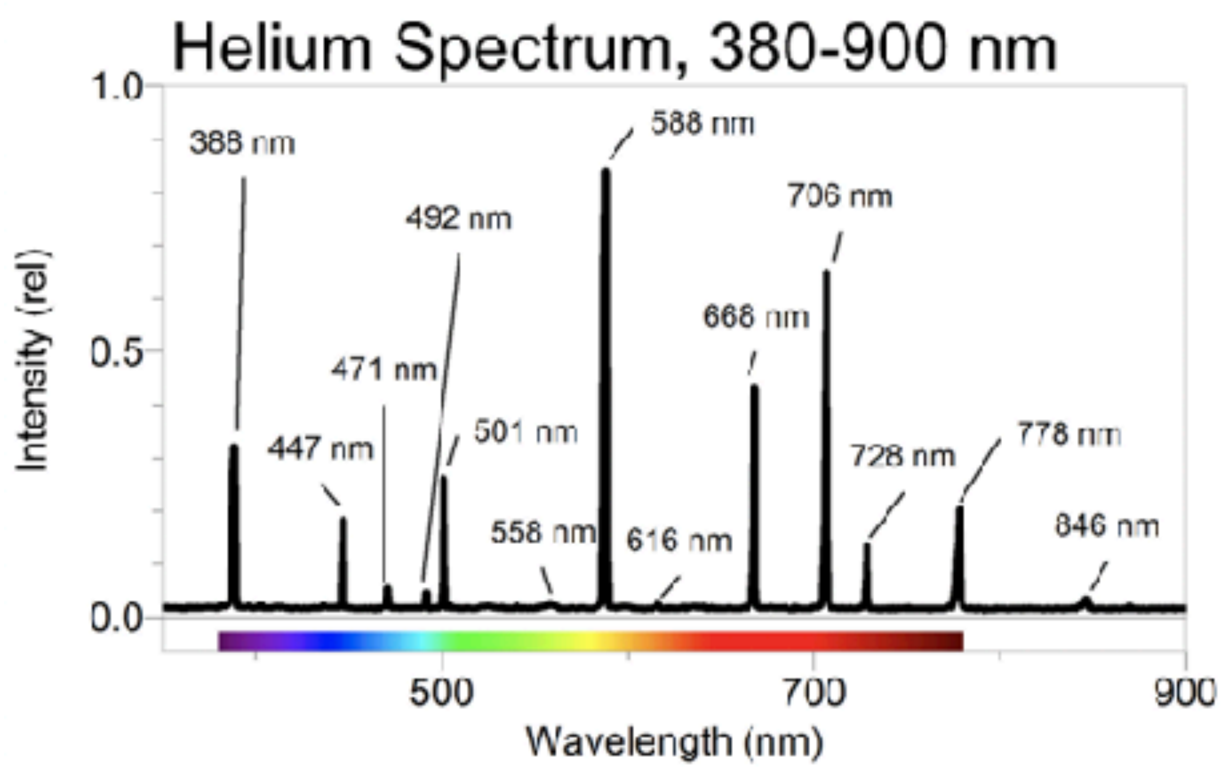
OTR operates in helium environment where charged particles can cause helium to scintillate

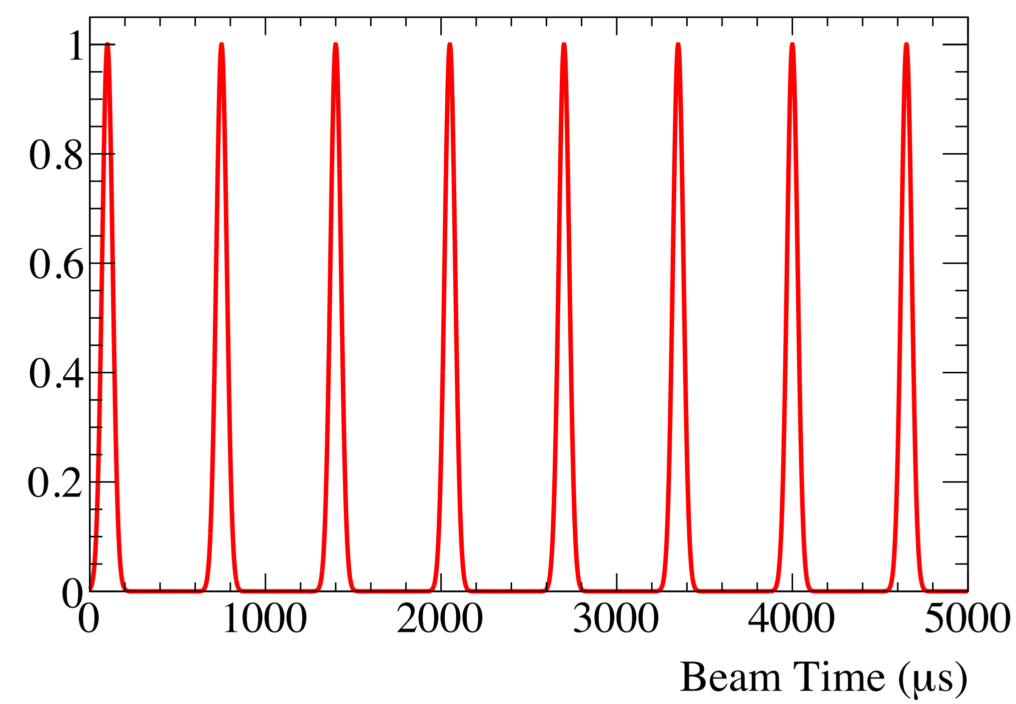


Confirm with timing (see talk by Félix)

- OTR signal is 30 — 50 ns wide, prompt
- He scintillation has lifetime of 68 ns —153 ns[2]

Or with optical wavelength[3]





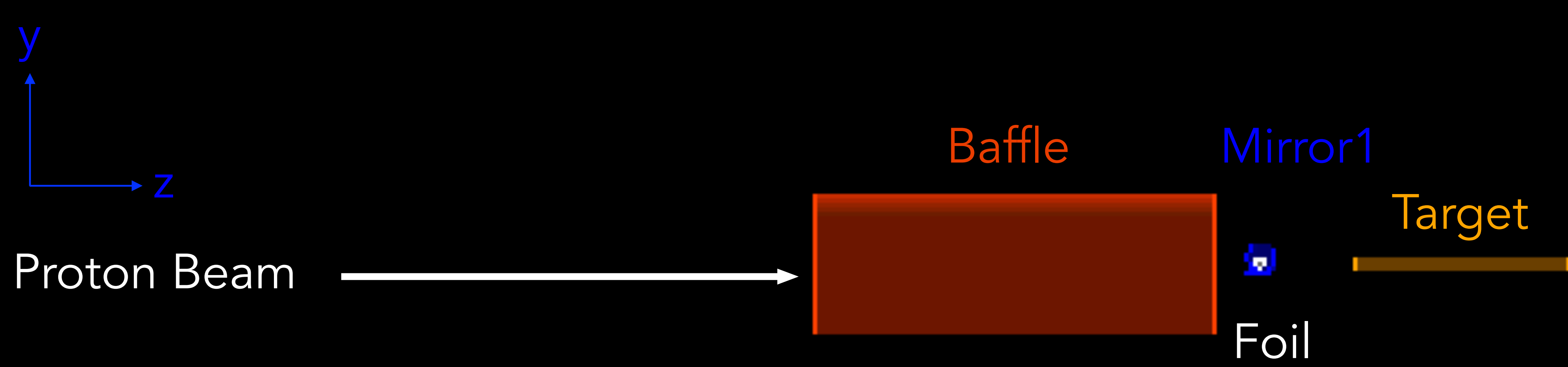
[2] https://doi.org/10.1098/rspa.1956.0058
[3] https://www.vernier.com/vernier-ideas/a-quantitative-investigation-of-the-helium-spectrum/

2 scintillation hypotheses

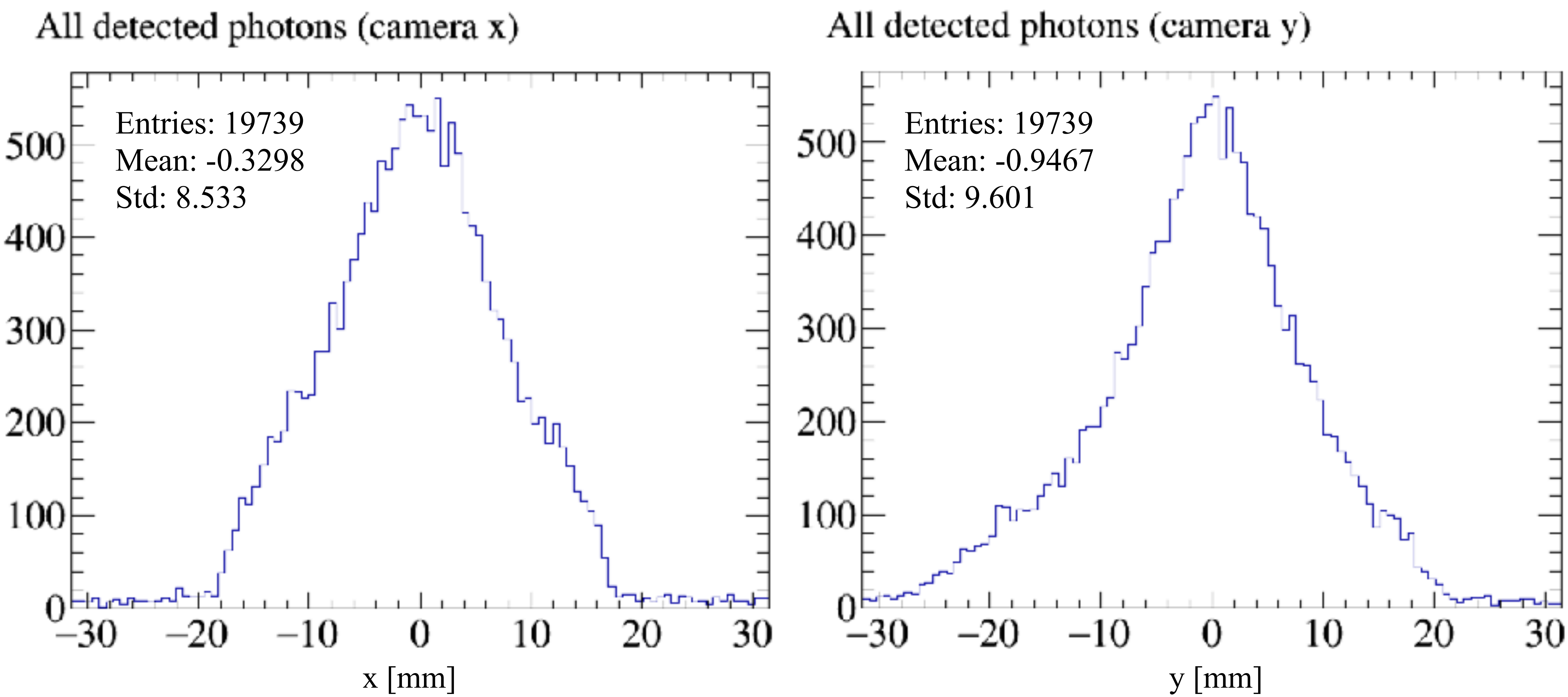
Primary: from proton beam

Secondary: from protons interacting with baffle which produces many charged particles (in particular low energy electrons) which can cause scintillation

> Use Geant4 simulations to understand what **spatial distribution** we expect to see from helium scintillation



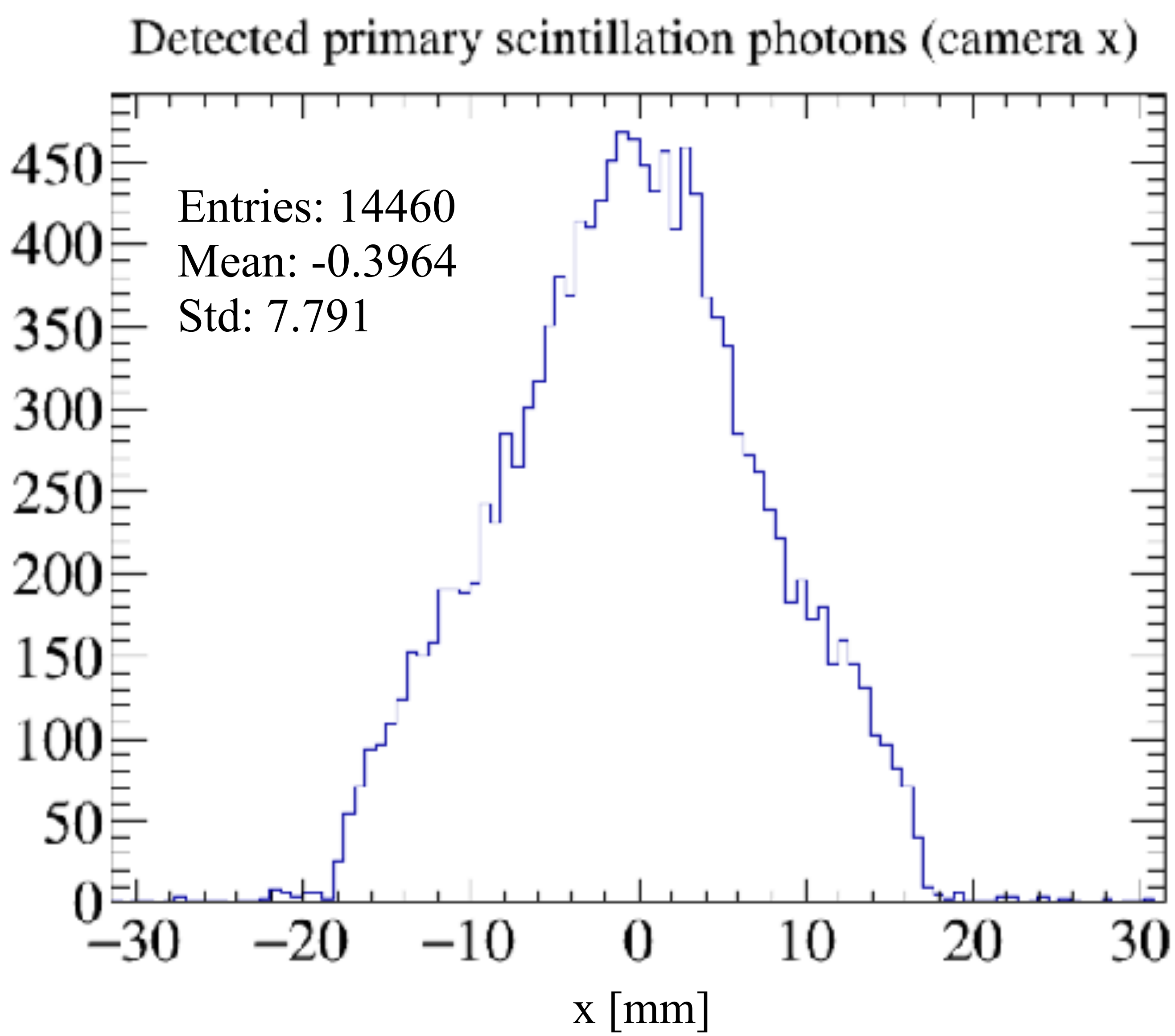
All scintillation photons at detection

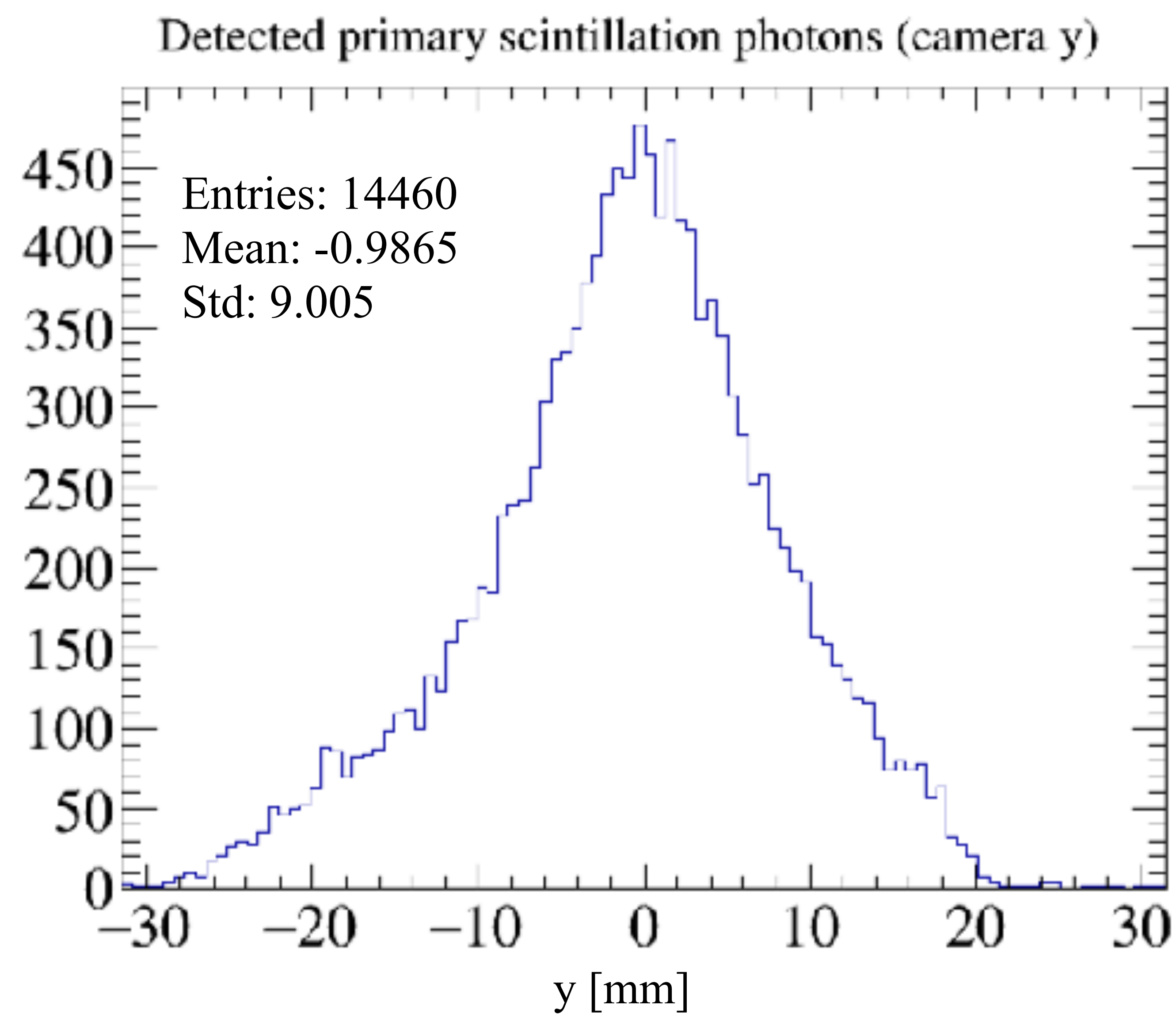


Detected primary scintillation

Accounts for most of background (73%)

Peaked distribution

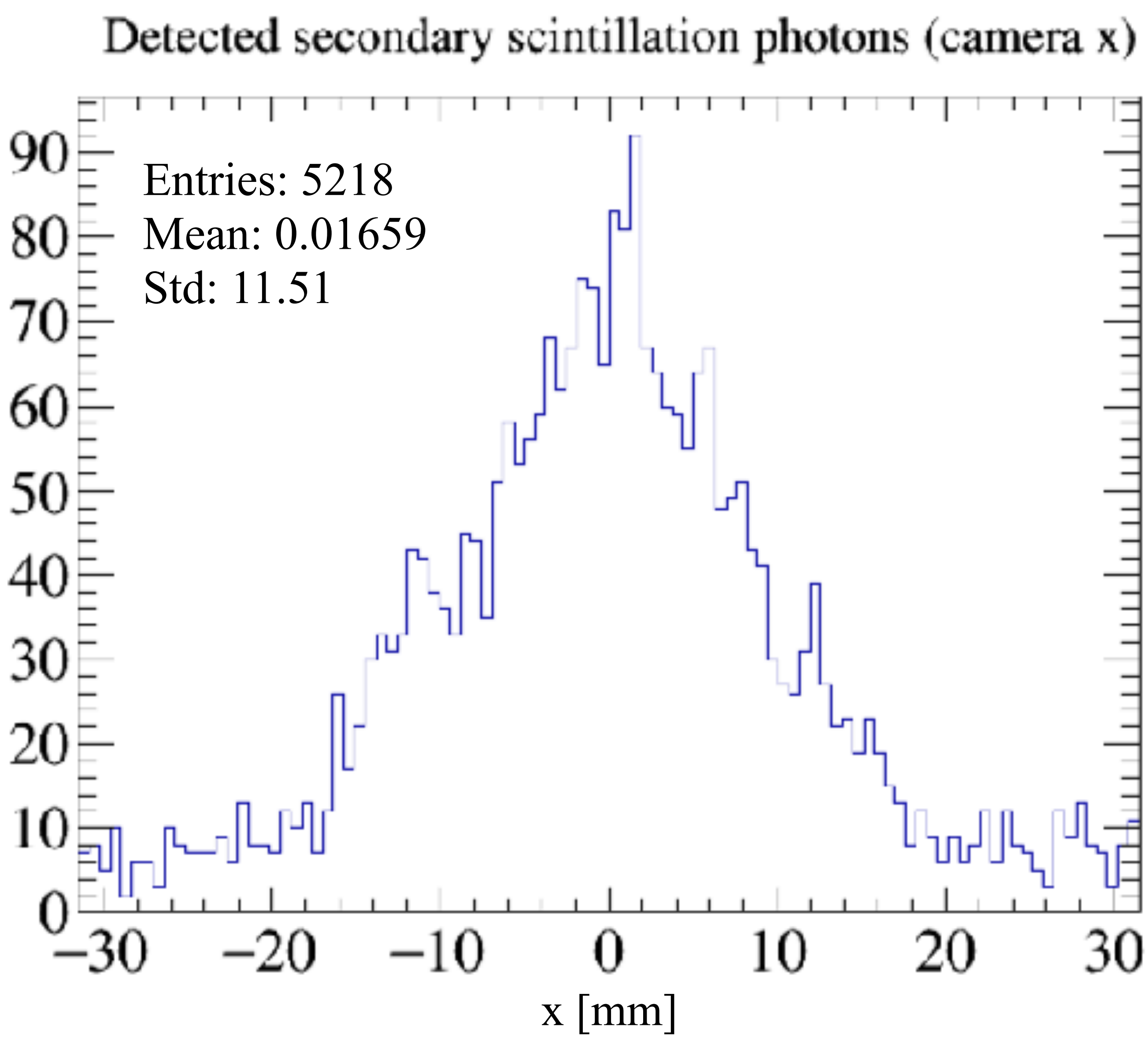


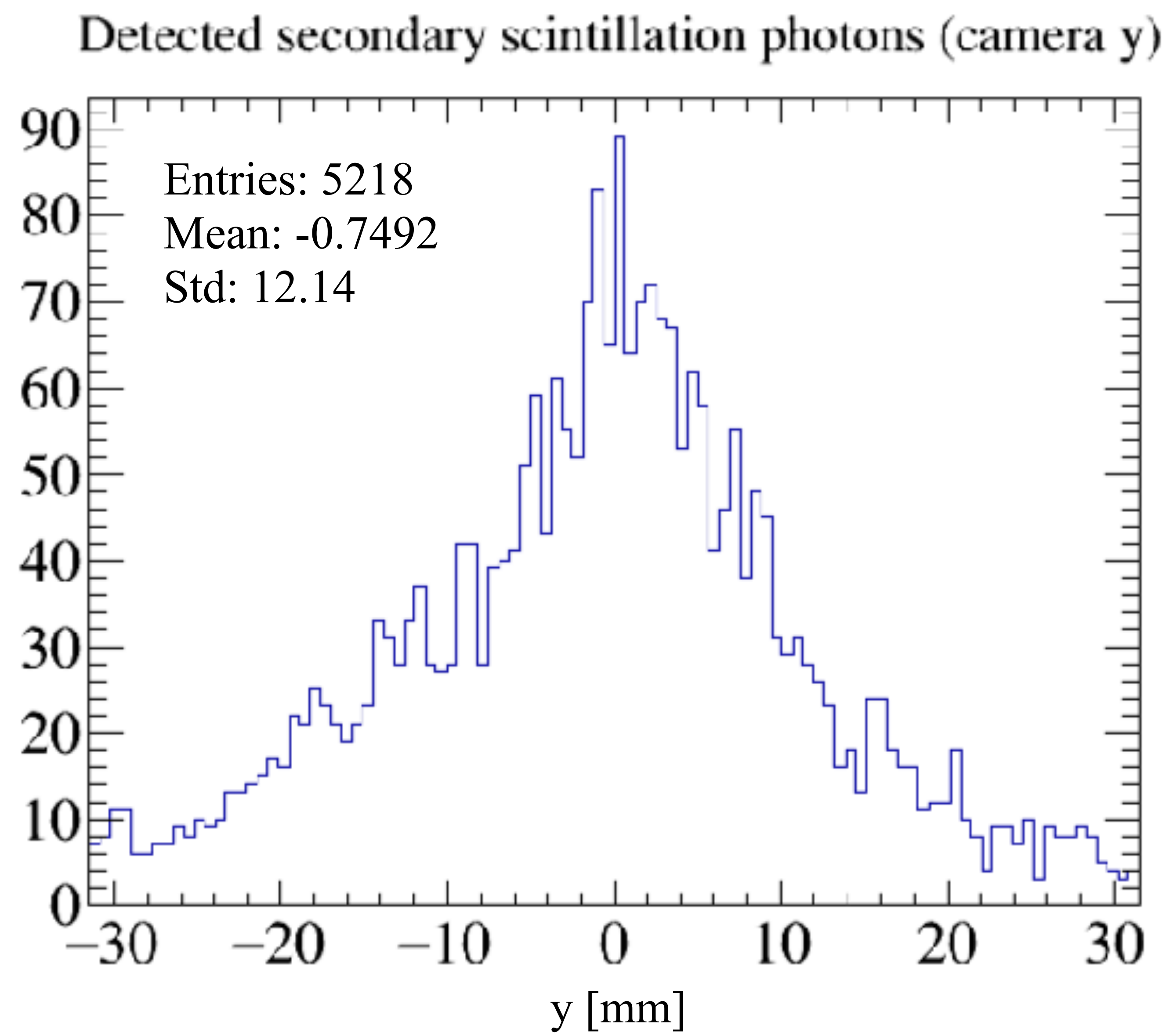


Detected secondary scintillation

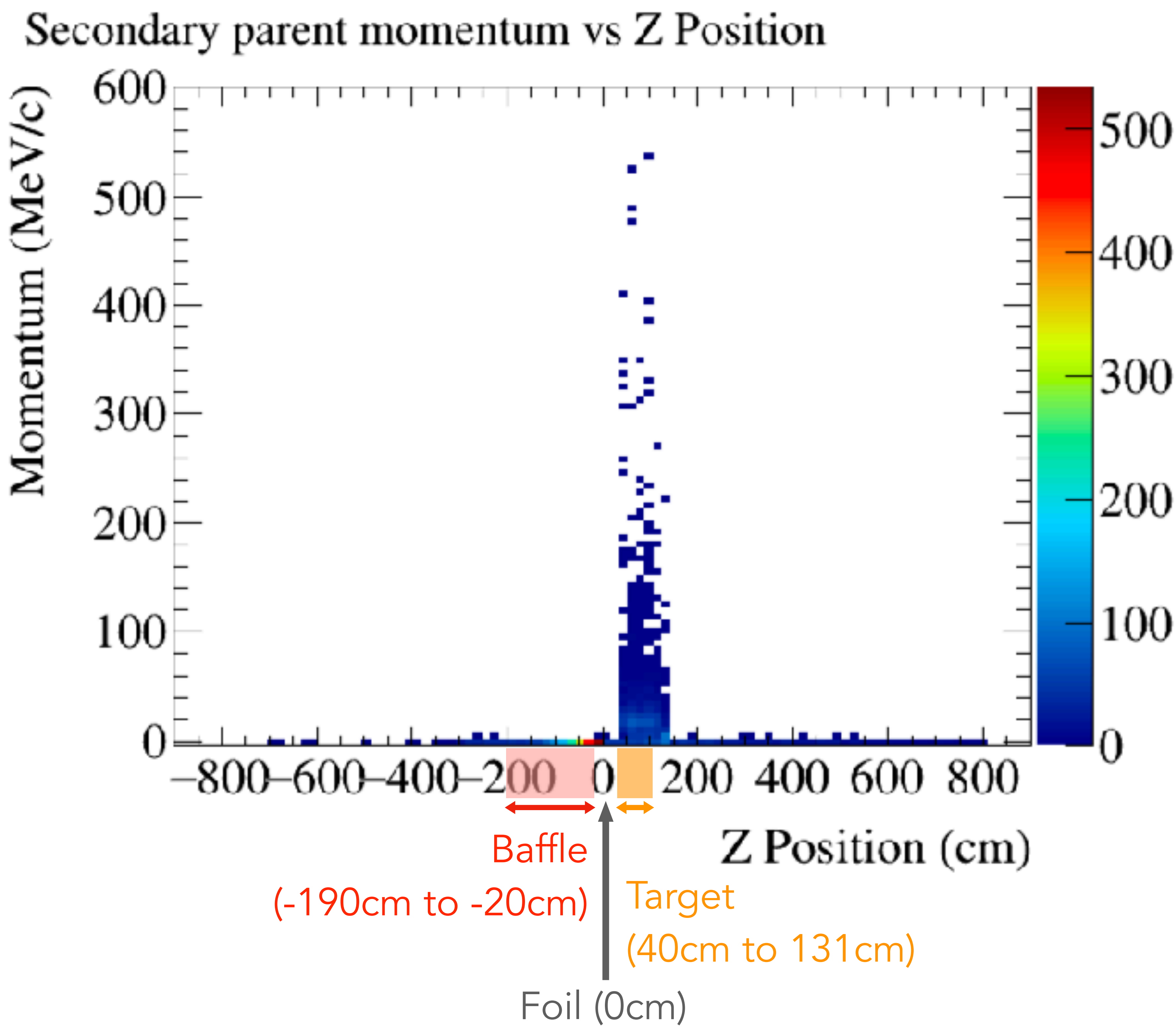
Accounts for less of background (26%)

Wider distribution



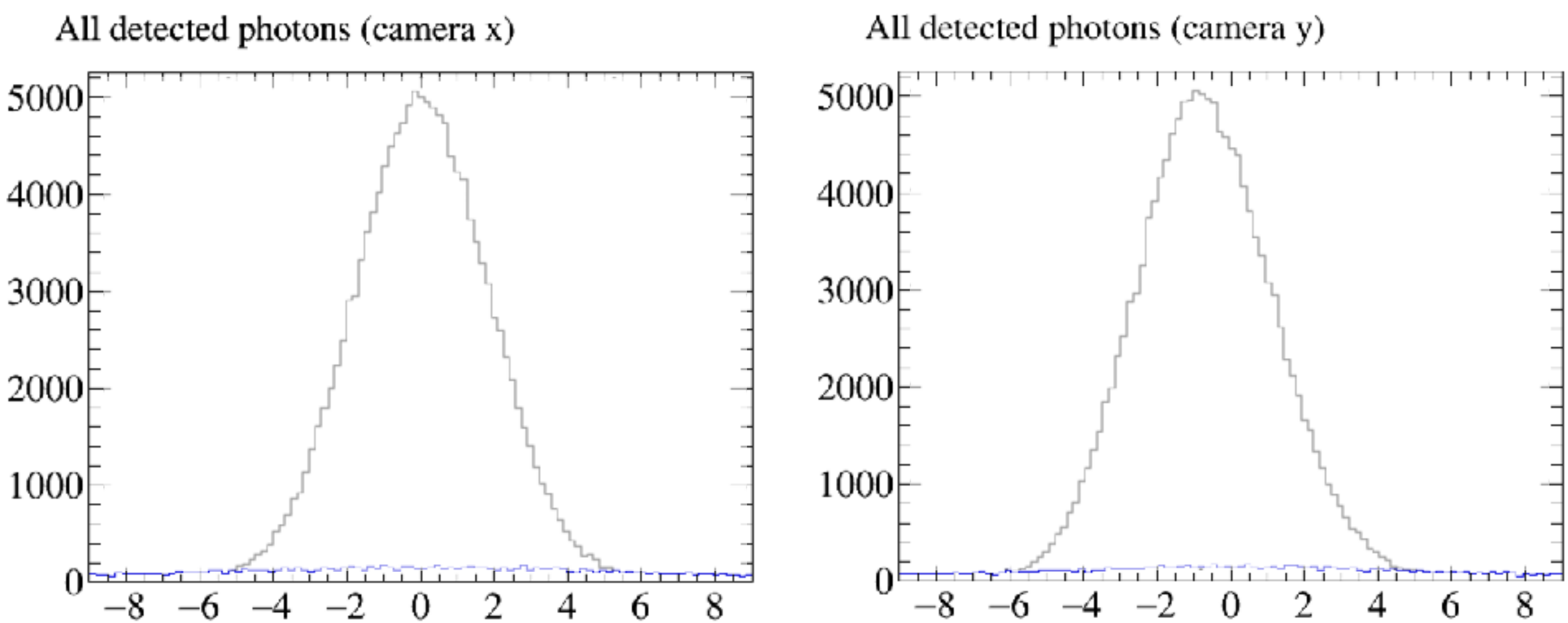


Energy of secondaries (electrons)



Comparison with OTR signal

We do see a broad background! But we need to think about normalization…



- OTR
- Scintillation background

Conclusions + next steps

Summary

- Primary scintillation does not appear to cause broad signal
- Broad component could be caused by scintillation from secondaries
- Looking at timing and wavelength dependence data would be illuminating!

Next

- Implement OTR in Geant4

Thank you!