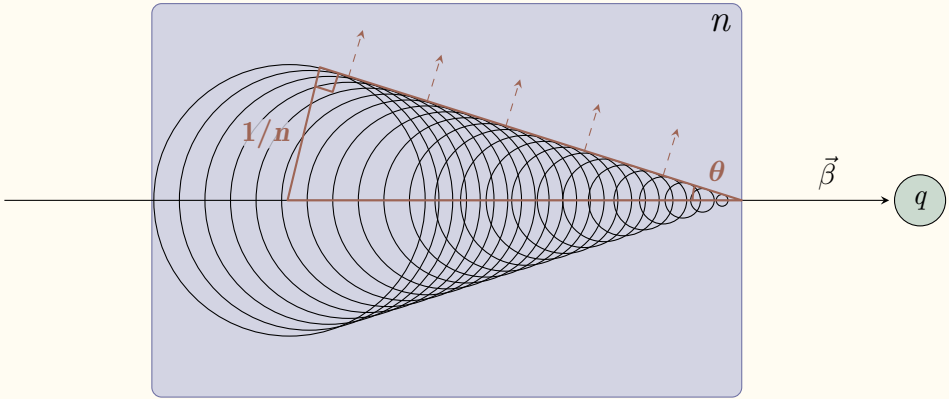
IMPERIAL

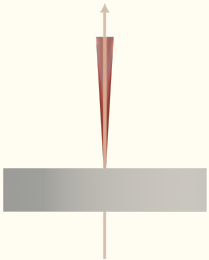
Novel Cherenkov Radiators

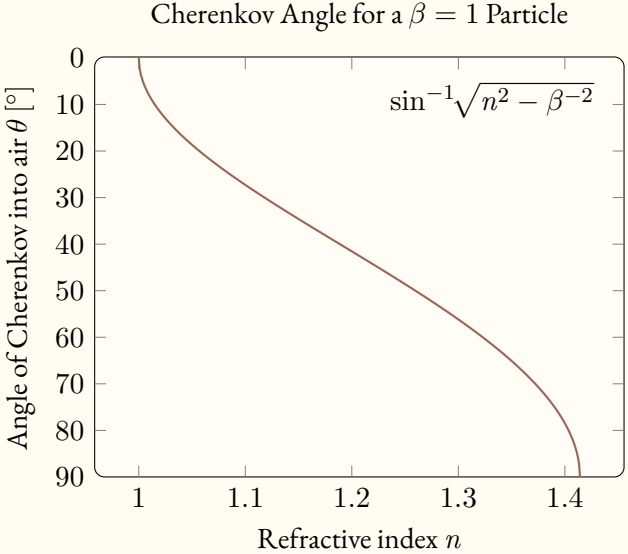
Henry Linton

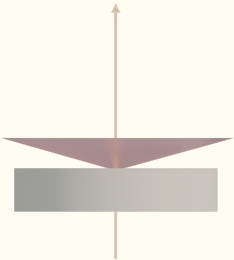
Cherenkov Theory



Cherenkov Theory





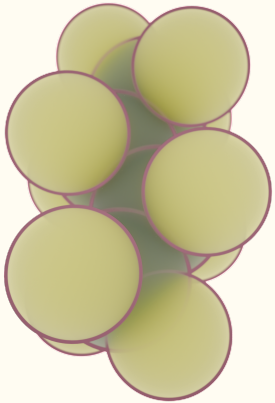


Cherenkov Detectors

The Problem With C_4F_{10}

- The Cherenkov detectors in LHCb have traditionally used Fluorocarbon Gasses as their radiating medium
- Refractive index of $n = 1.0014$.

- C_4F_{10} as used in RICH1, has $\sim$ $6000\times$ greater global warming potential than CO_2
- Buying and selling C_4F_{10} was banned by the EU in 2014.



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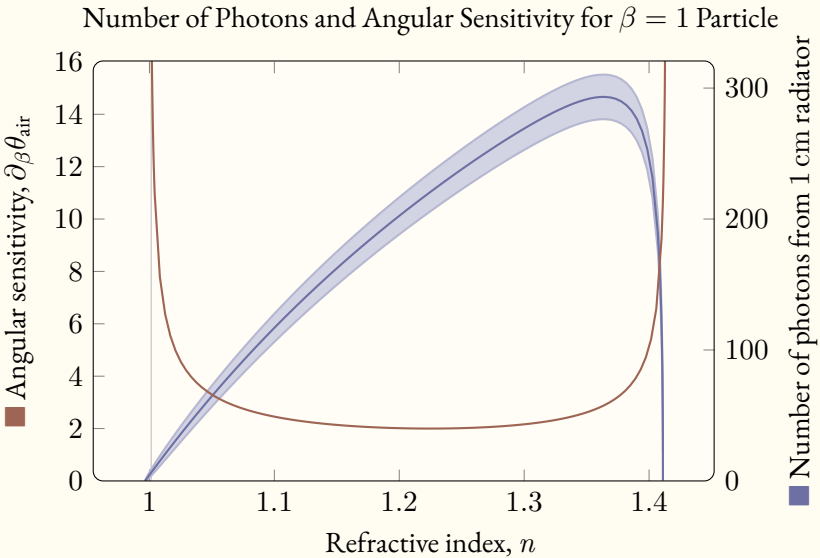
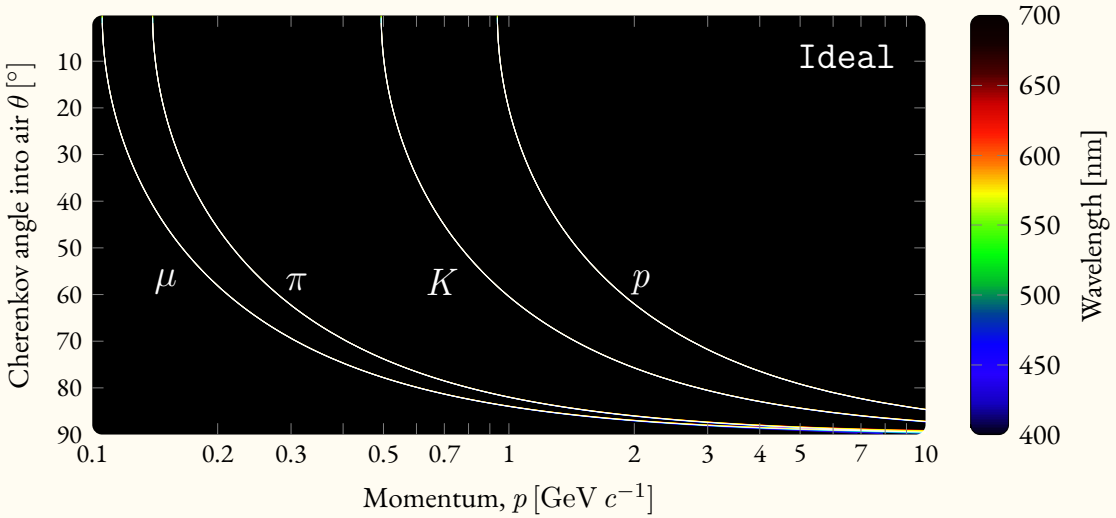
Glass Instead of Gas



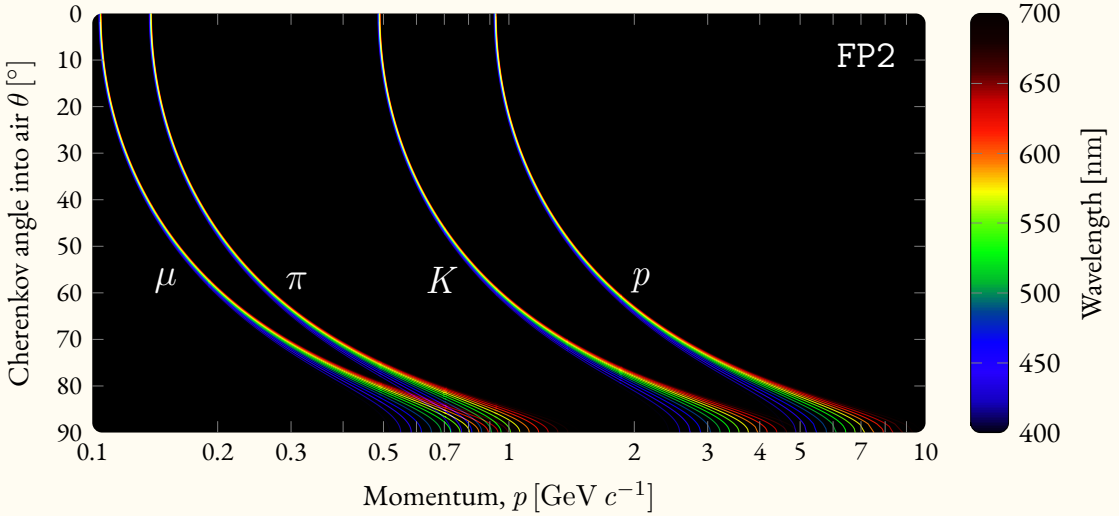
Predicted Particle Separation: Ideal Glass



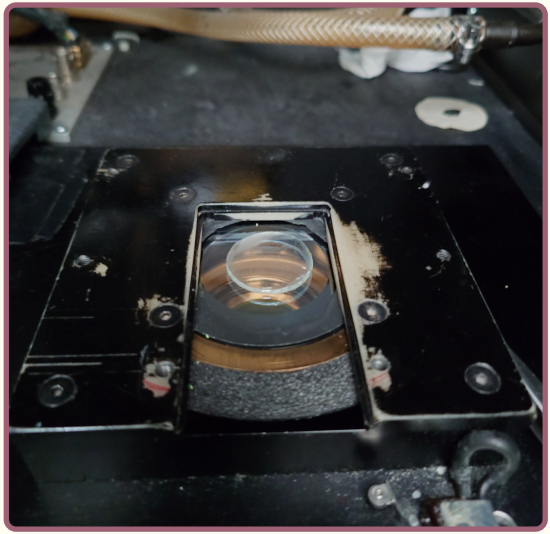
Anyone Want To Get A Glass Later?

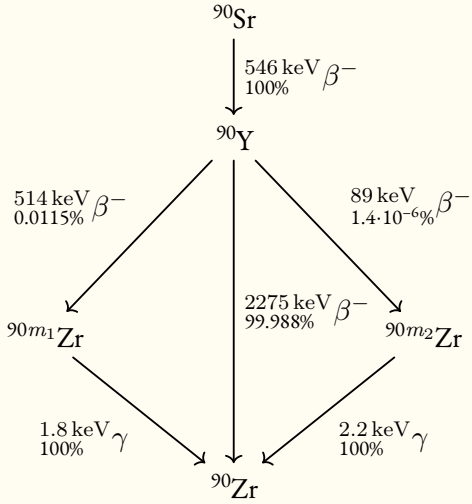
№	n	∅	↕
FP1	$\sqrt{2.076}$	40 mm	5 mm
FP2	$\sqrt{2.025}$	40 mm	5 mm
FP3	$\sqrt{2.079}$	25 mm	5 mm
FP4	$\sqrt{2.016}$	25 mm	2 mm

Predicted Particle Separation: FP2



Scintillation





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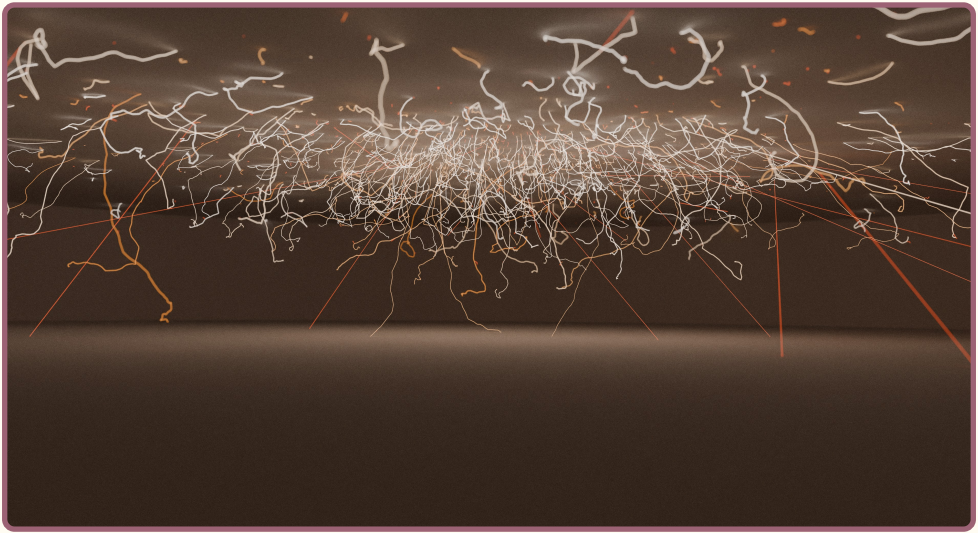
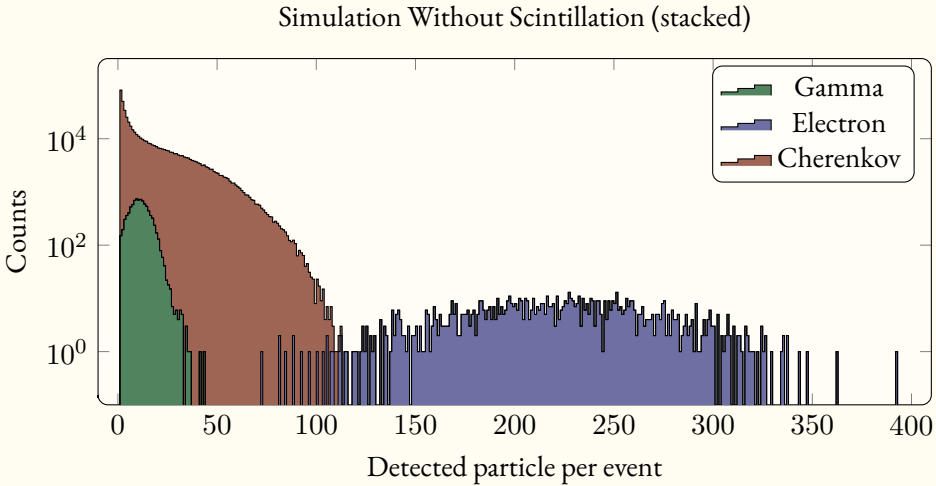
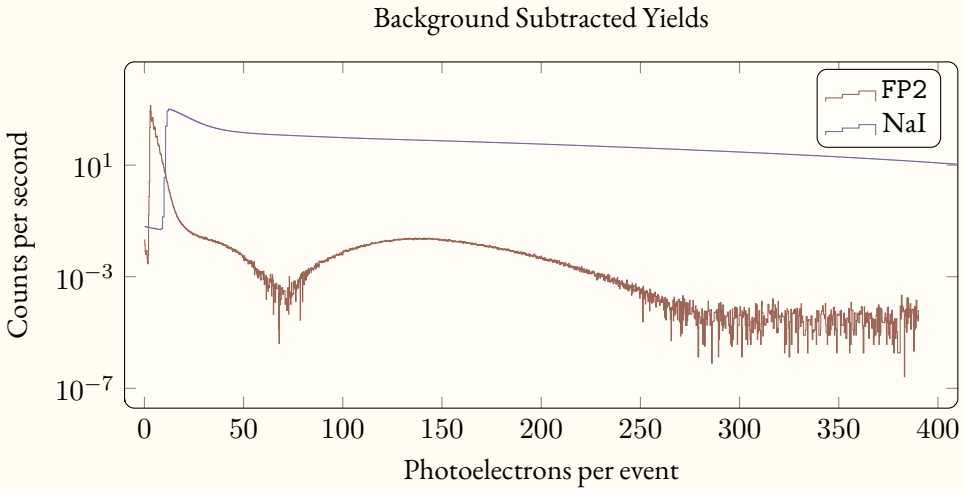
Scintillation



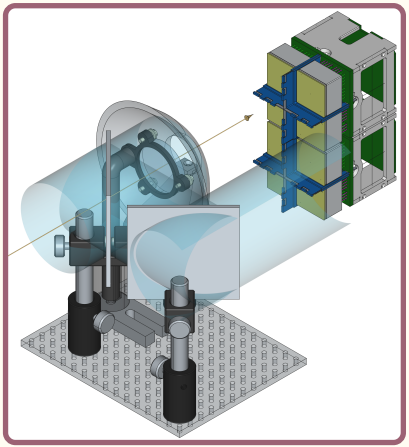
Scintillation Simulation

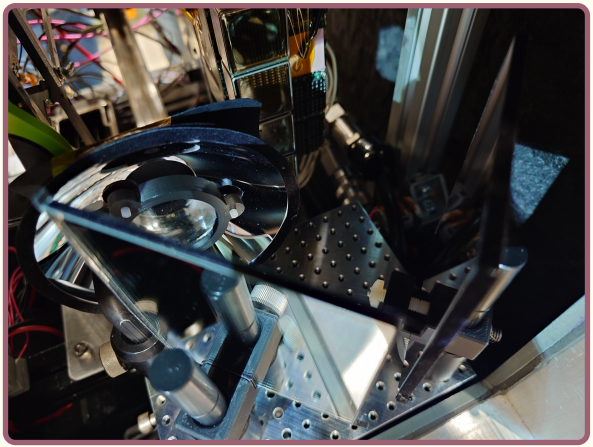


Scintillation Real

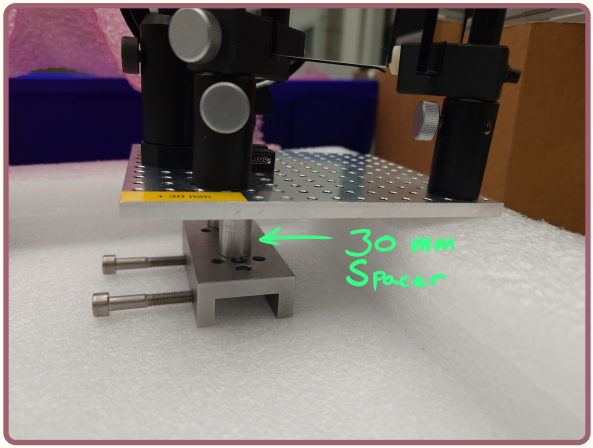


Testbeams

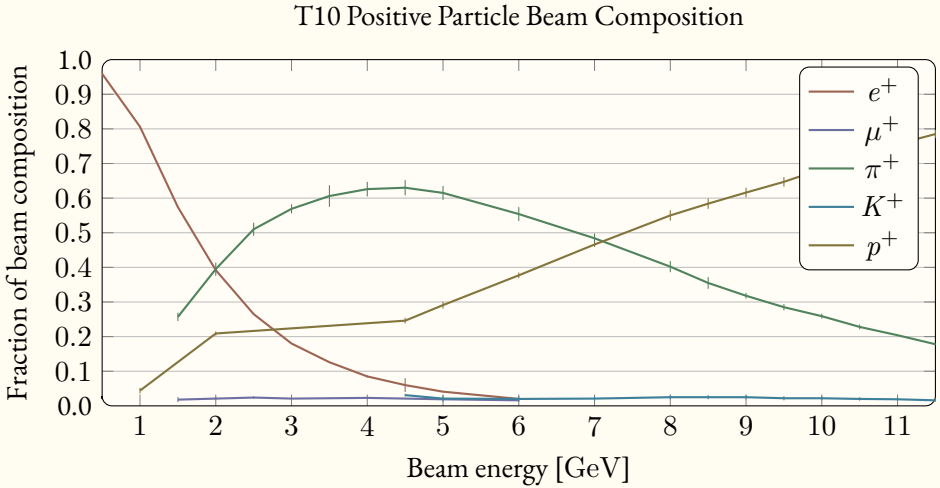




Testbeams



Testbeam composition



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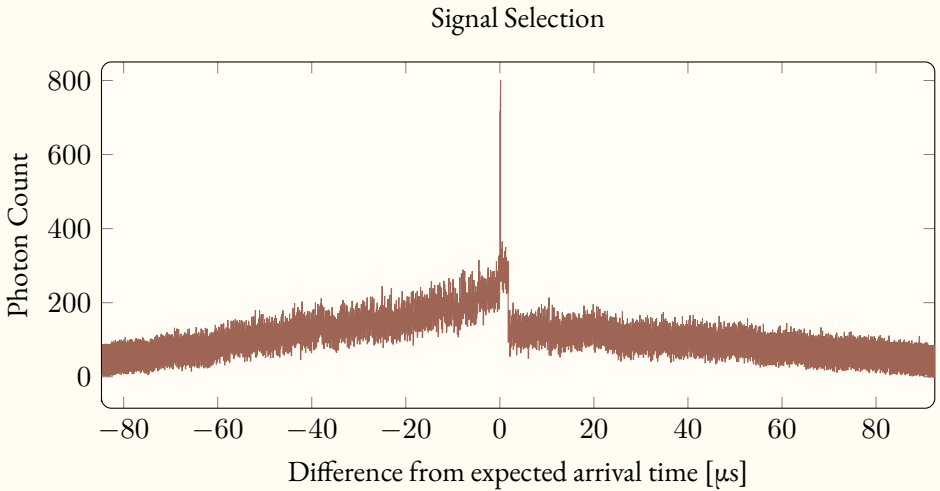
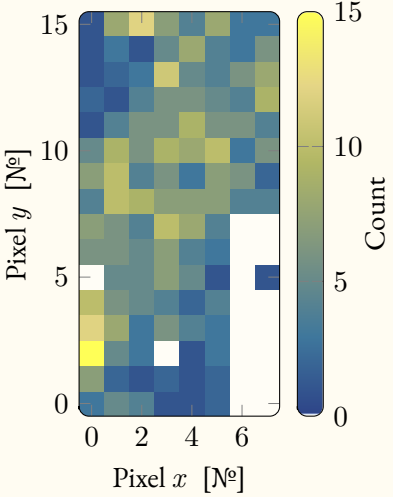
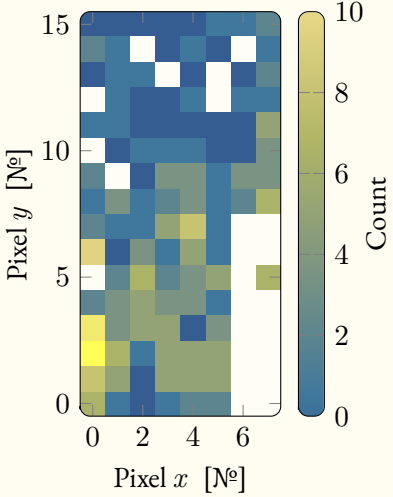

Signal Selection
Photon Count
800
600
400
200
0
−80
−60
−40
−20
0
20
40
60
80
Difference from expected arrival time [μs]

Testbeams

Run 3031, 2 GeV
Sample in UP position

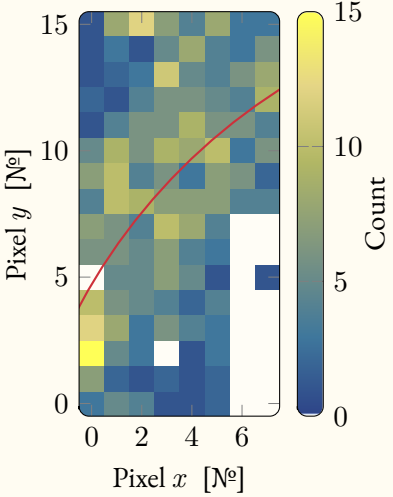


Run 3051, 2 GeV
Sample in DOWN position

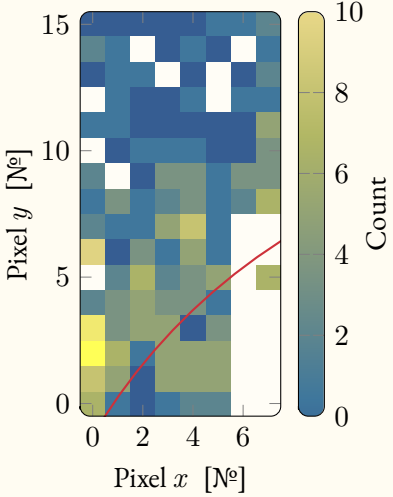


Testbeams and Overly Suggestive Circles

Run 3031, 2 GeV
Sample in UP position



Run 3051, 2 GeV
Sample in DOWN position



Summary

- Environmental and supply issues with C_4F_{10} promp the search for its replacement as a Cherenkov radiator.
- I propose using a glass.
- Samples have been produced.
- and they generate Cherenkov light.
- and the distribution *seems* to be consistent with what we expect.
- Work is ongoing to further characterise the samples
  (Dispersion and Radiation testing are in the works)

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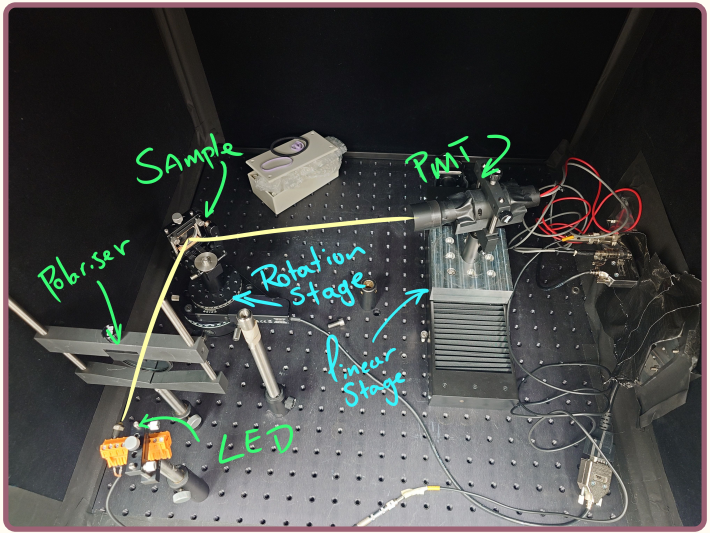
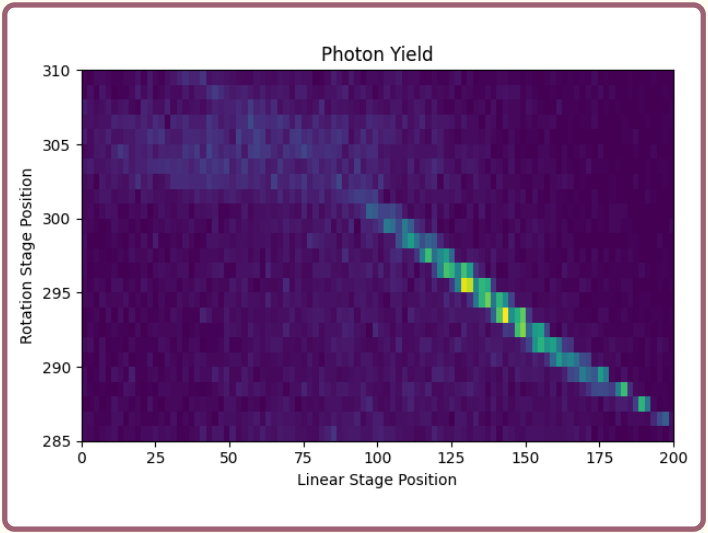
Backup Frames

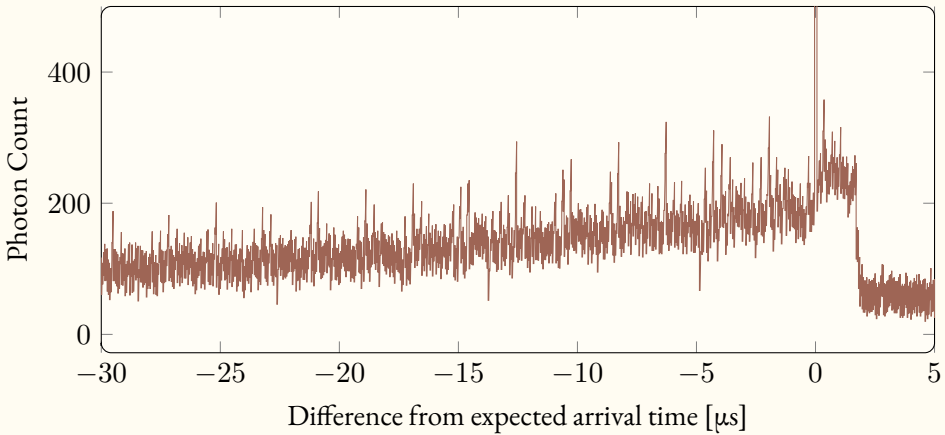
Ongoing: Dispersion



Ongoing: Dispersion

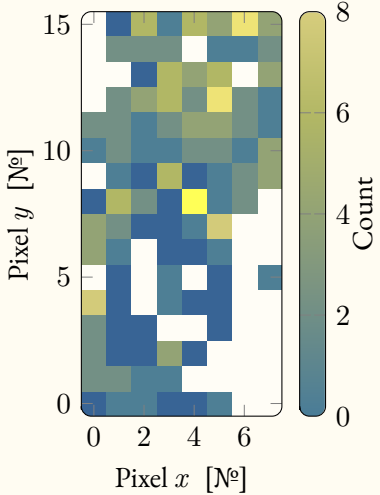


Testbeams

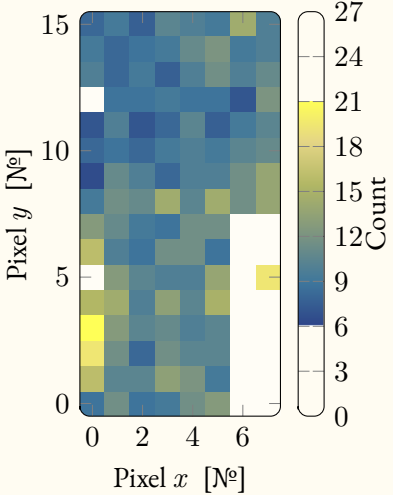

Photon Count
400
200
0
−30
−25
−20
−15
−10
−5
0
5
Difference from expected arrival time [μs]

More Testbeams

Run 3032, 5 GeV
Sample in UP position

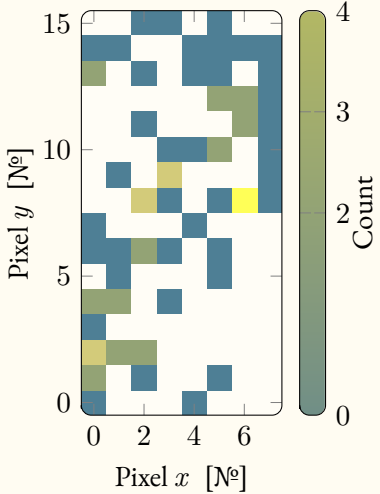


Run 3054, 5 GeV
Sample in DOWN position

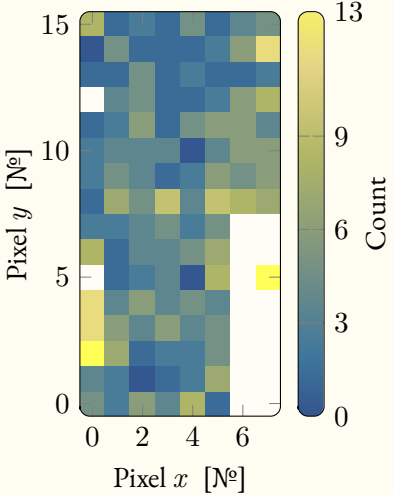


More Testbeams

Run 3047, 7 GeV
Sample in UP position



Run 3060, 7 GeV
Sample in DOWN position



Cherenkov Theory

Cherenkov radiation is emitted with an angle

$$\cos\theta_{\text{Ch}} = \frac{1}{n\beta} \quad .$$

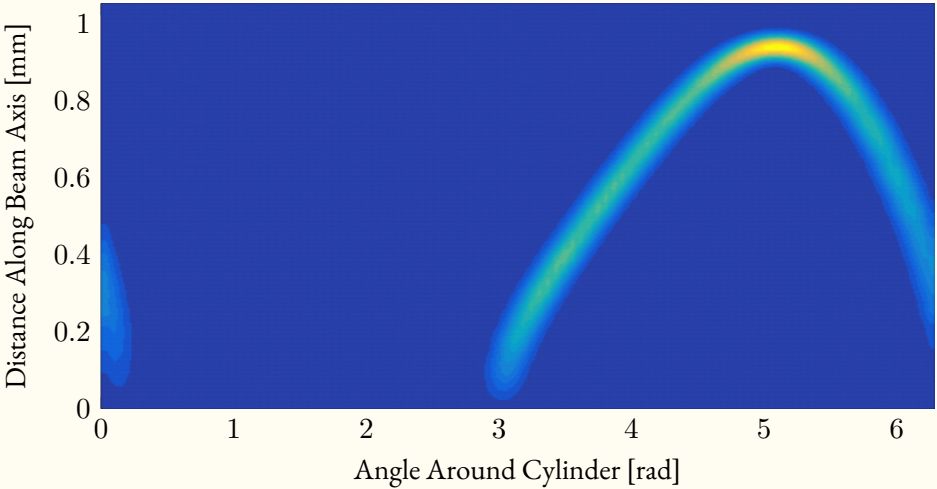
However it must escape the radiating medium into air. For this we use Snell's law.

$$n_{\text{air}} \sin\theta_{\text{air}} = n \sin\theta_{\text{Ch}} \quad .$$

Assuming $n_{\text{air}} = 1$, Arrange for $\sin\theta_{\text{air}}$

$$\sin\theta_{\text{air}} = \sqrt{n^2 - \beta^{-2}} \quad .$$

Distribution of Photons from off-axis particles



References

[1] S. Solomon, *Climate Change 2007: The Physical Science Basis: Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, I. P. on Climate Change and I. P. on Climate Change, Eds. Cambridge ; New York, 2007, 996 pp., ISBN: 978-0-521-88009-1.

[2] *Regulation (EU) No 517/2014 of the European Parliament and of the Council of 16 April 2014 on fluorinated greenhouse gases and repealing Regulation (EC) No 842/2006 Text with EEA relevance*, 16th Apr. 2014. Accessed: 27th Mar. 2026. [Online]. Available: http://data.europa.eu/eli/reg/2014/517/oj.

[3] B. Johnston et al., *BradyAJohnston/MolecularNodes: V4.5.12*, Zenodo, 17th Mar. 2026. DOI: 10.5281/zenodo.19072617.

[4] S. K. Basu and E. A. Mccutchan, 'Nuclear Data Sheets for A = 90,' *Nuclear Data Sheets*, vol. 165, pp. 1–329, 1st Mar. 2020, ISSN: 0090-3752. DOI: 10.1016/j.nds.2020.04.001.

[5] M. van Dijk et al., 'Particle production and identification for the T10 secondary beamline of the CERN East Area,' *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms*, vol. 569, p. 165 907, 1st Dec. 2025, ISSN: 0168-583X. DOI: 10.1016/j.nimb.2025.165907.