Status of ChDR experiment at ATF2

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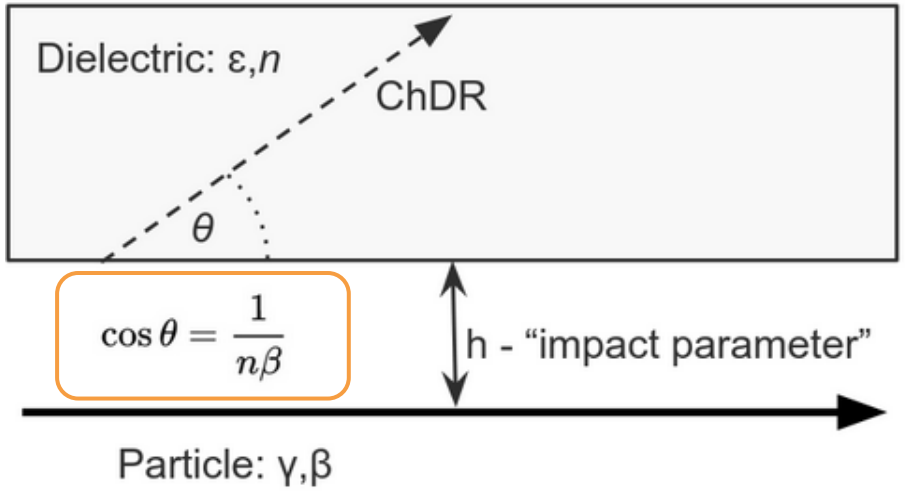
Cherenkov Diffraction Radiation (ChDR)

Def : Radiation emitted when a charged particle passes in the vicinity of the dielectric medium at speed greater than the phase velocity of the light in this medium.

Conditions:

- $\boldsymbol{\beta > 1/n}$ with n the refractive index of the material ($n = 2.1$ for SiO_2)
- $\boldsymbol{h \leq \gamma \lambda}$ with λ the wavelength of the observed radiation.

Ex : For a 1GeV e-beam at 550nm, $\mathrm{h} \approx 170\ \mu m$



=> **Requires small, high-gamma beams (potentially CLIC)**

Advantages for diagnostics:

- Non-invasive
- The radiation is emitted at a specific angle (usually large)

State of the art

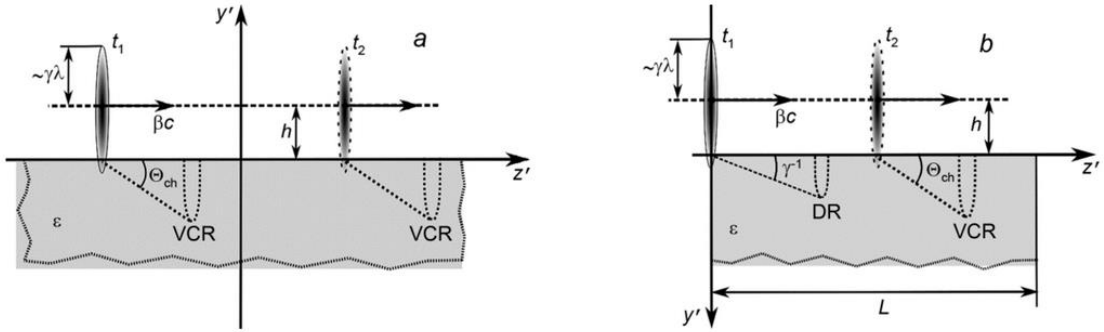
Experimental: ChDR has been observed in various settings :

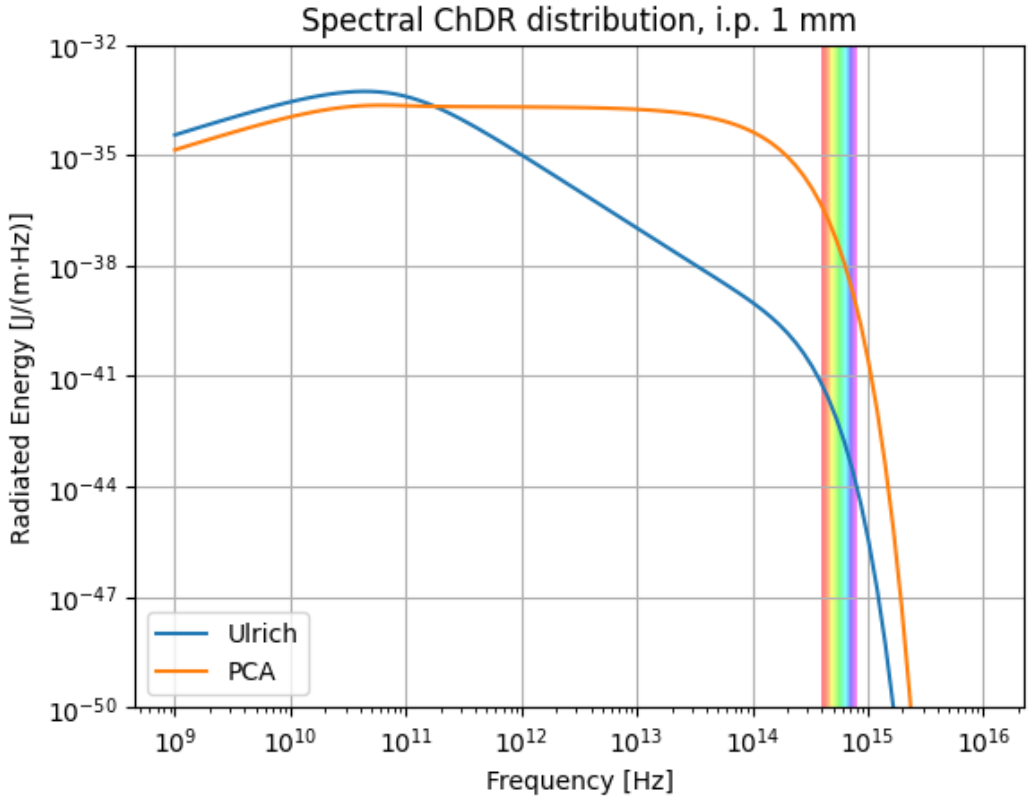
- CESR at Cornell University, USA (Phys. Rev. Lett. 121, 054802 (2018))
- Diamond Light Source, UK (Proceedings of IBIC2019, WEPP037)
- And more !

$E = 1.28GeV$
$h = 1mm$

Theoretical:

- Spectral distribution not well known
- Two models with **widely** different predictions





Stationary models

- B.M. Bolotovskii, Sov. Phys. Usp. 4 781, 1962
- Ulrich, Z. Physik 194, 180–192, 1966
- H. A. Olsen and H. Kolbenstvedt, Phys. Rev. A, 21, 1980

Non-stationary model (Polarization Current Approach)

- Karlovets, D.V., Potylitsyn, JETP Lett. 90, 326, 2009

2023 Study at ATF2

Goal : Measure the absolute light yield to validate the non-stationary model

Why ATF ? Small beam size (μm) and high $\gamma = 2560$
=> Possibility to measure in incoherent regime (visible photons)

Setup

- In horizontal plane
- Non-nominal beam parameters ($\sigma_x = 50\mu m$)

Method :

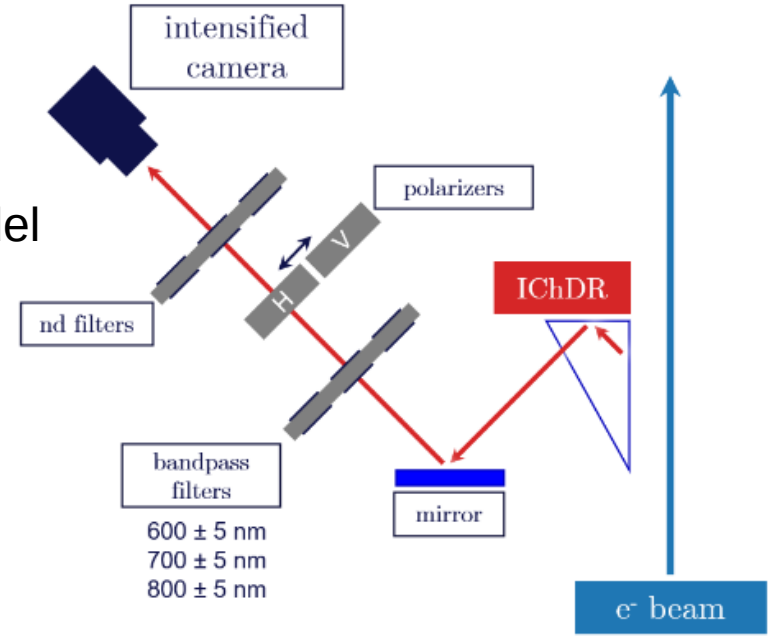
- Measure of absolute light yield (photon-counting)
- Different dependence on frequency between ChDR and direct Cherenkov radiation

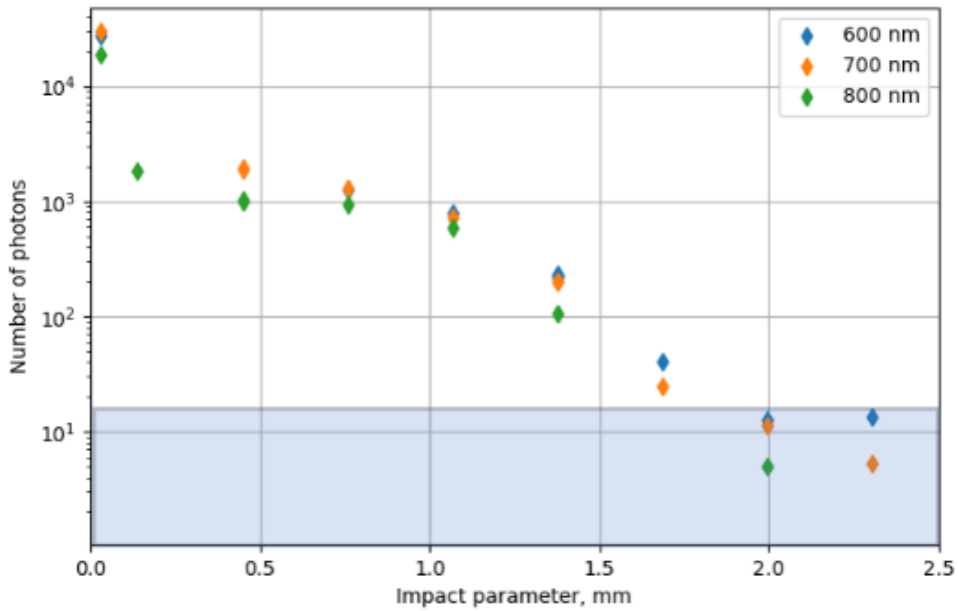
Results :

- None of the expected behaviors

Possible explanations :

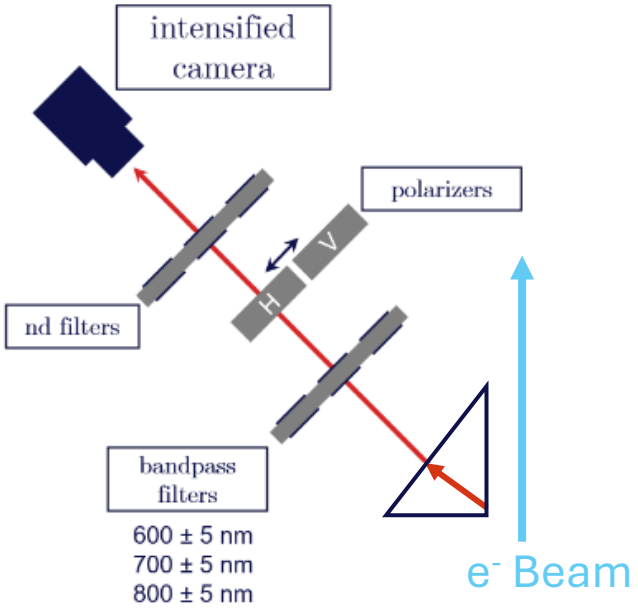
- Signal strongly polluted
- Possibly by radiator-halo interactions
- Parasitic synchrotron radiation

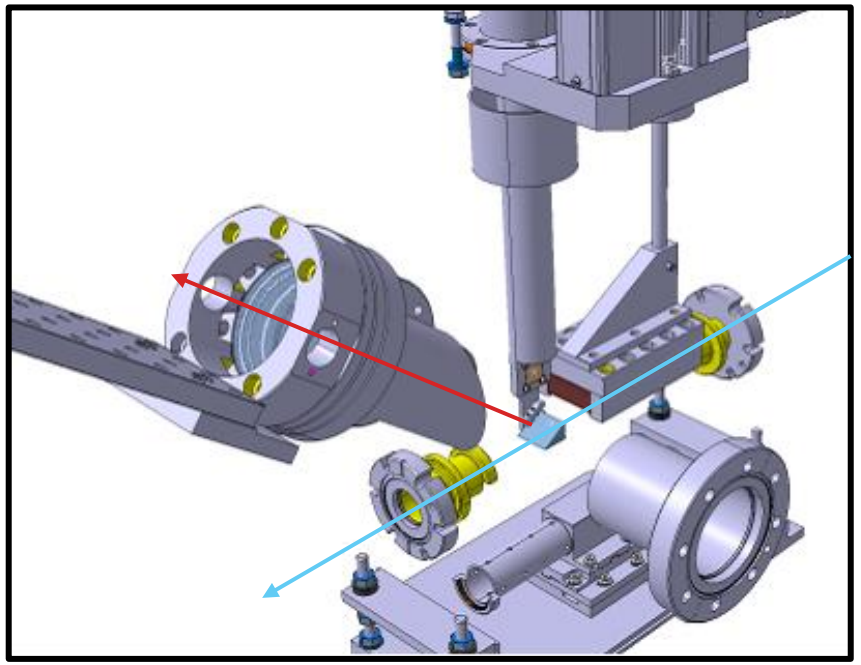


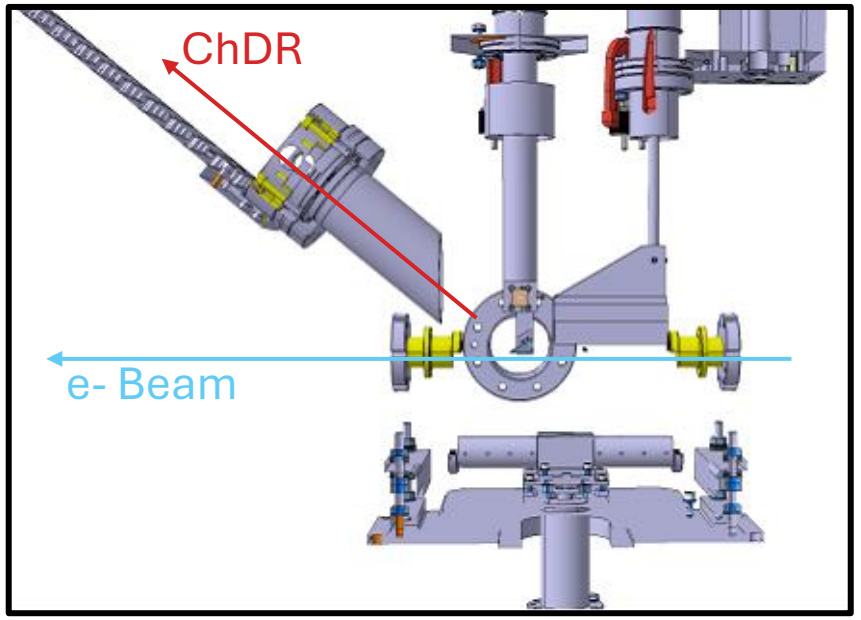


Improvements

- New vacuum chamber with vertical viewport
- Nominal beam parameters ($\sigma_y = 0.26\mu m$)
- Reuse existing sub-systems
- Reverse prism orientation
- More reliable actuator system
- Tungsten Halo-shield/Collimator



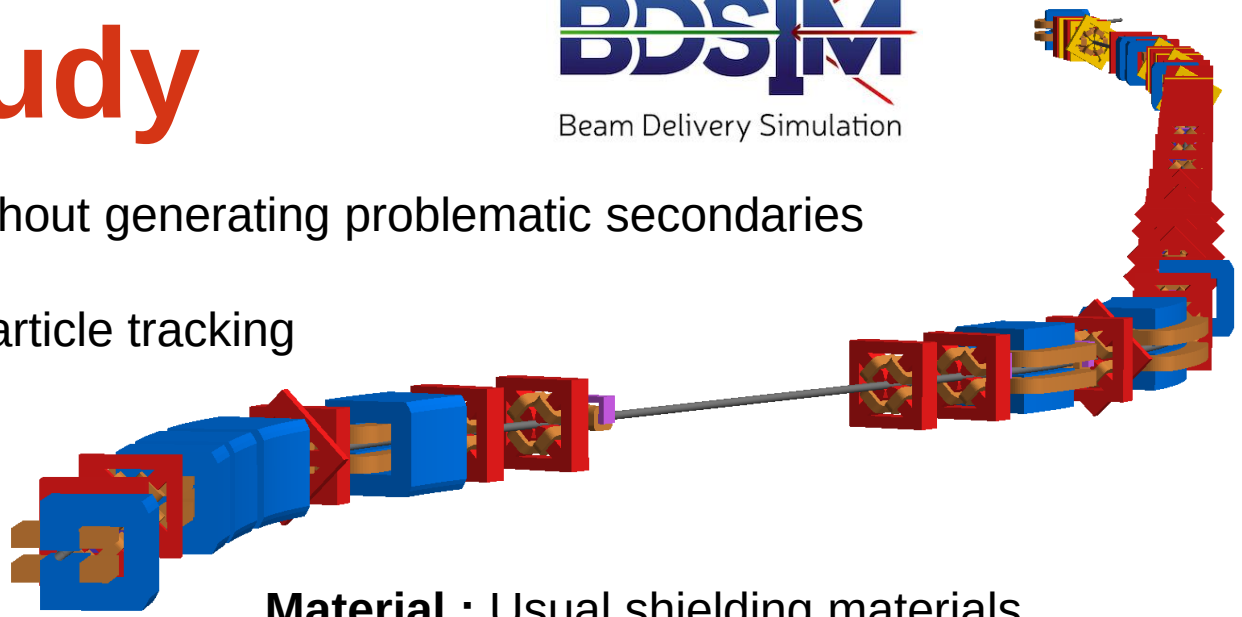


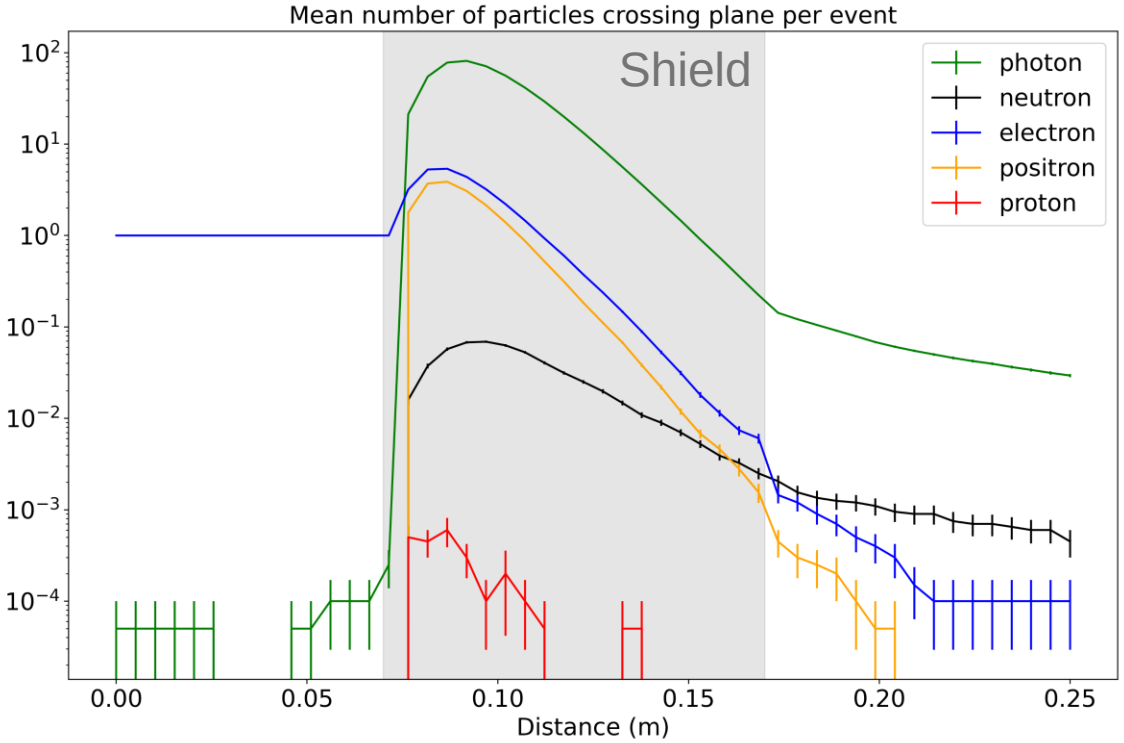


Halo Shielding Study

Goal : Shielding the radiator from halo particles without generating problematic secondaries

Simulation tool : BDSIM combines Geant4 and particle tracking



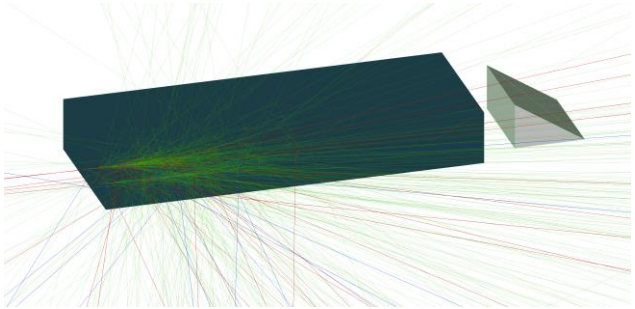


Material : Usual shielding materials

- Lead or Tungsten
- Has to be easily available

Dimensions : Has to fit in the chamber (10cm length max)

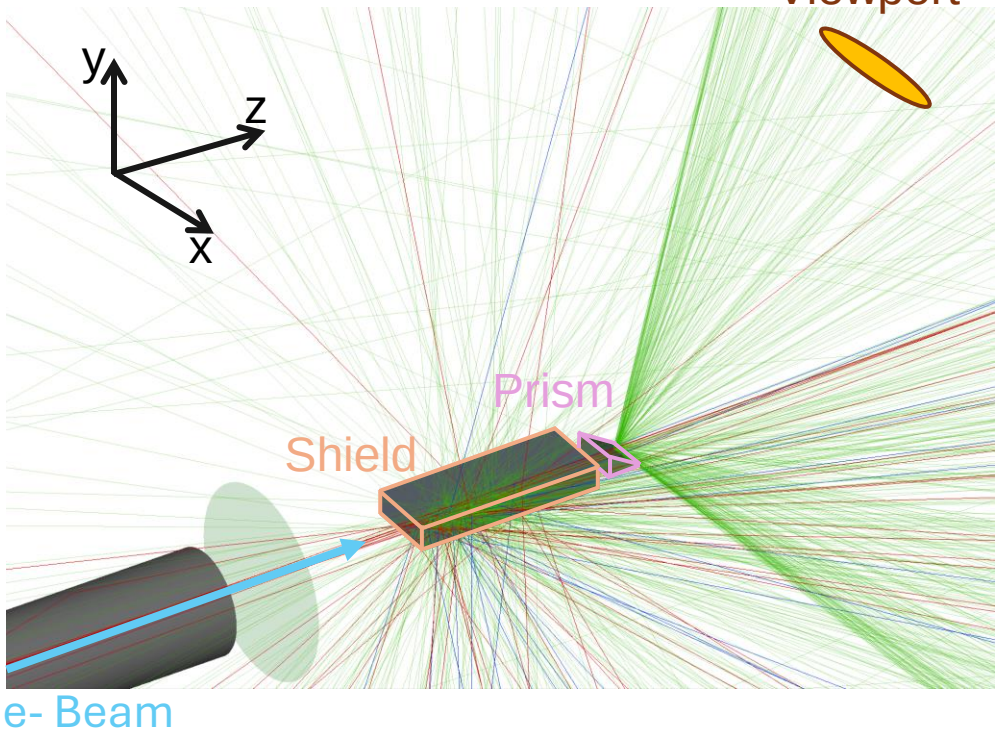
Weight : Actuator can support max 10kg

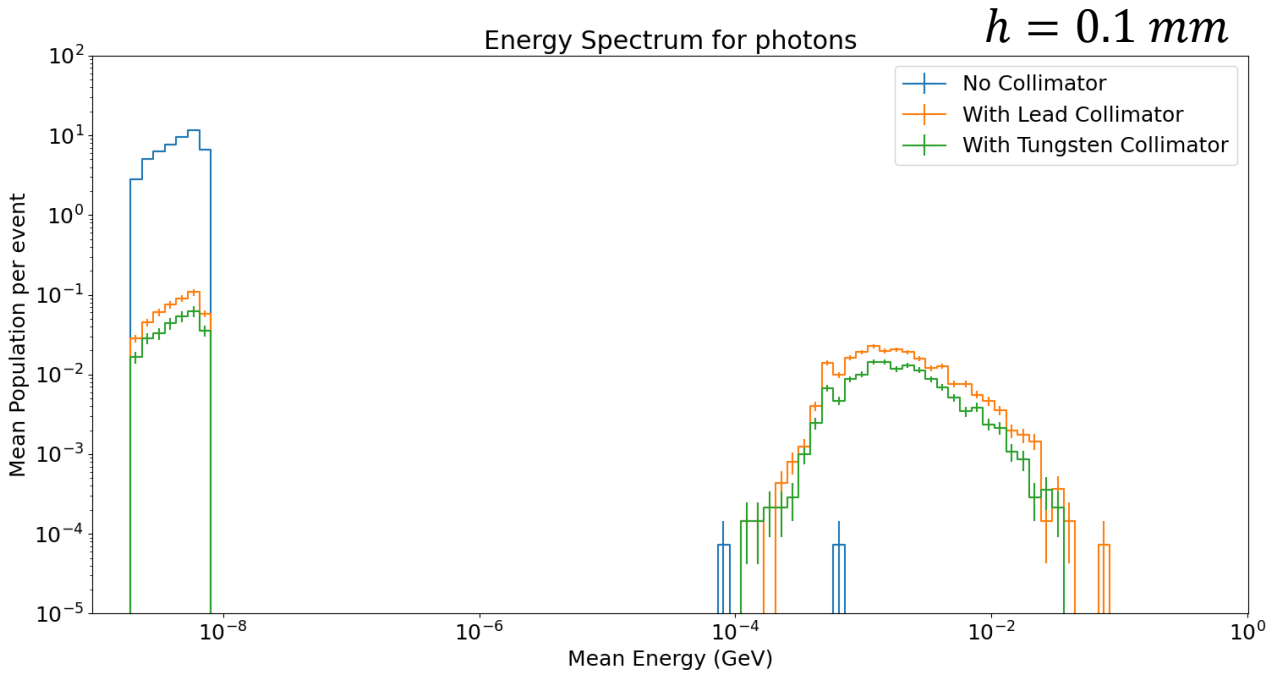


Halo Shielding Study

Beam Delivery Simulation

Goal : Shielding the radiator from halo particles without generating problematic secondaries





- Tungsten is more effective than lead
- 100x reduction in optical photon count with shield
- But creation of γ-rays at the detector

Work in progress… Need for better halo model

Conclusion :

- ChDR is a promising tool for **non-invasive longitudinal measurements**
- However, our **theoretical understanding is incomplete**
- Experimental tests have been successful at verifying properties of ChDR but not the absolute light yield in optical region.
- **In 2025**, a new test campaign is being pursued **with improved halo-shielding and geometry**
  - Preparatory tests in **Feb-March** at ATF
  - Delivery of new chamber expected in April at CERN
  - Data taking in **Summer** at ATF

Thank you for your attention !