FLASHGuard Project: Particle Physics Technology to Transform Cancer Treatment

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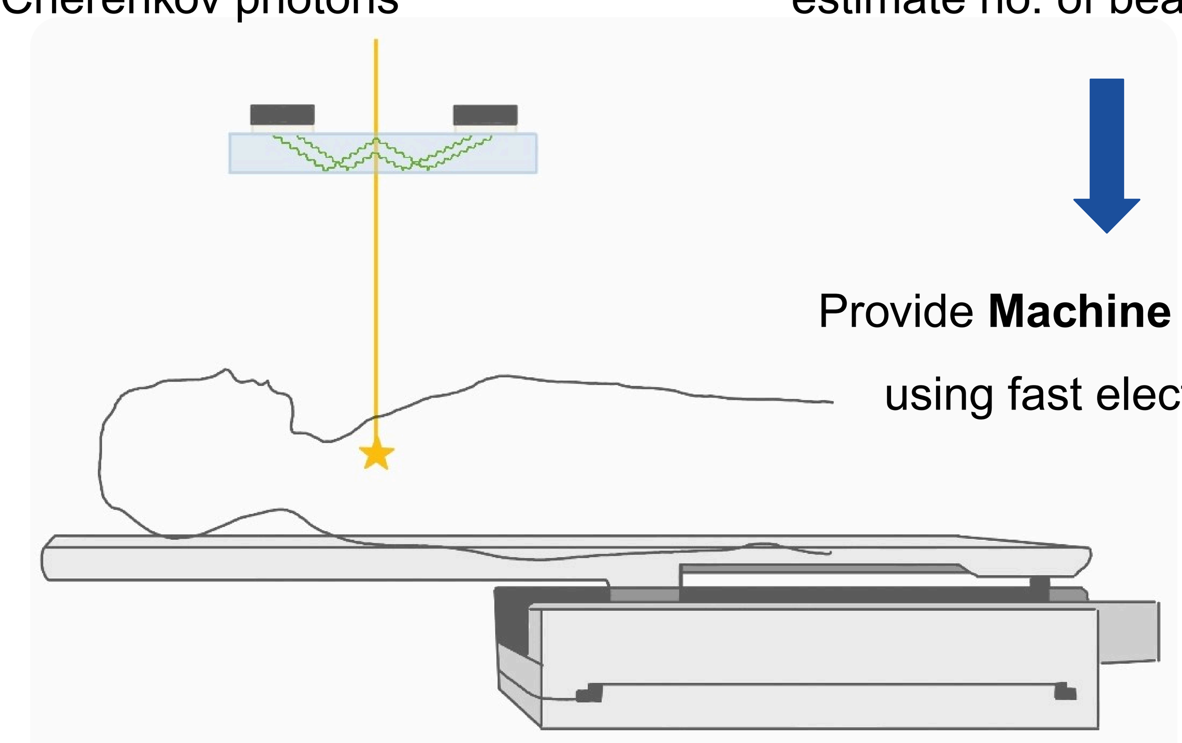
Introduction

- FLASH Radiotherapy (FLASH-RT): emerging, highly promising radiotherapy modality; delivers radiation at **ultra-high dose rates** (UHDR), at several orders of magnitude higher than conventional RT [1].
- FLASH-RT effect spares healthy tissue while maintaining tumor control [1].
- Photon, electron, proton and heavy ions beams can be used [2][4][5].
- **Real-time beam monitoring is a challenge** [1][2].
- Key requirements for device: **high temporal resolution with timely feedback** to the machine, **absence of saturation effects**, **minimal impacts on beam** and **reduced footprint** [1][2].
- Cherenkov Effect detectors hold great promise [2][3].
- This effect occurs when a charged particle transverses a medium with a velocity greater than light, emitting optical photons promptly (~ps).

Concept

Thin radiator (~mm) in beamline to produce Cherenkov photons → **Photodetector** to detect them and estimate no. of beam particles ↓ Provide **Machine Feedback** using fast electronics



Project Achievements

- **August 2024:** Patent PT 119369 submitted.
- **December 2024:** Preliminary report on Patent; Presentation at FRPT, Rome, Italy.
- **May 2025:** International Advisory Committee established.
- **June 2025:** Lab2Market@Técnico 2025 Winners.
- **July 2025:** Patent Internationalization under PCT agreement.

Conclusions

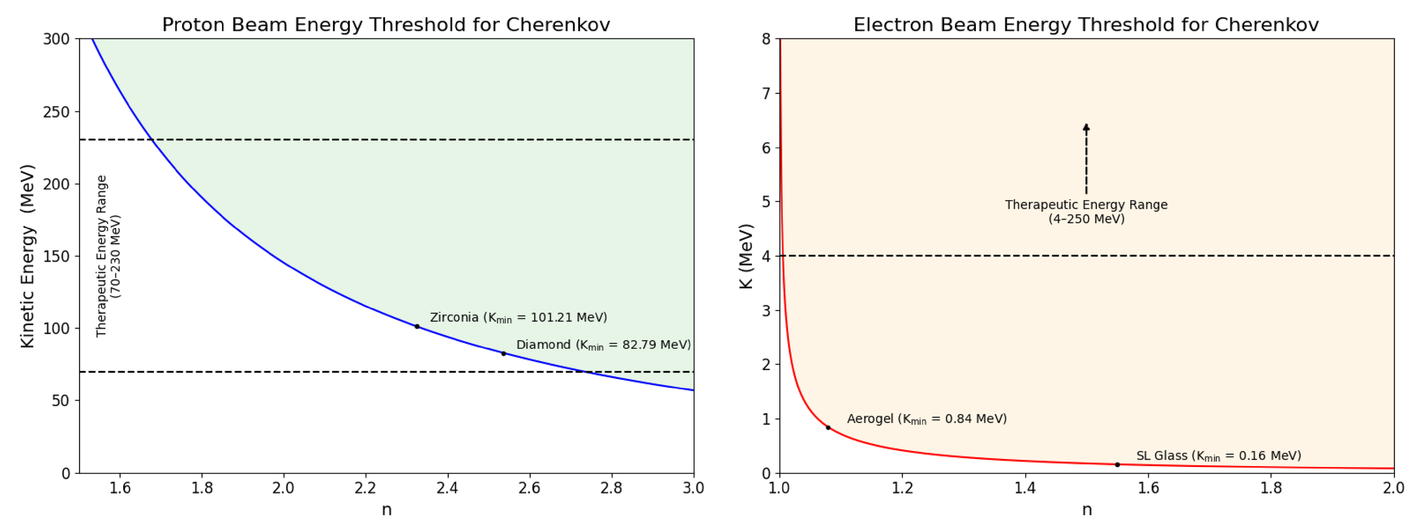
- We presented a **novel approach for beam monitoring for FLASH-RT**, addressing a critical challenge in the clinical transfer of this emerging therapy.
- We propose a **Cherenkov radiator, coupled to fast photodetectors**, intended to measure beam flux and applicable to all charged particles.
- Our device fulfils all the needed requirements: **high temporal resolution, providing sub-microsecond feedback to the machine; radiation hardness; absence of saturation effects and minimal impacts on the particle beam**.
- **This project has been recognised through various means**, validating the concept and the work of the team.

Methods

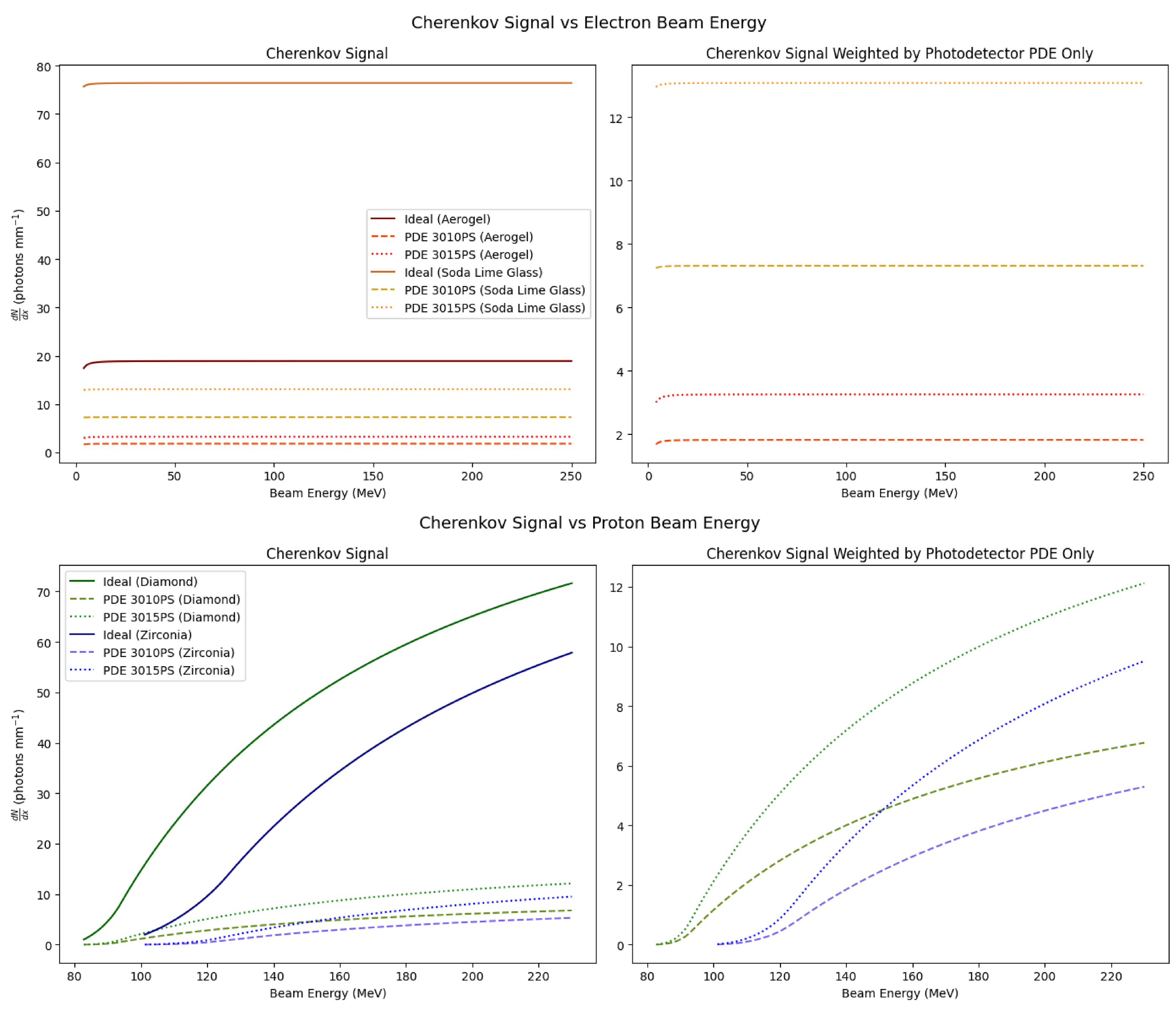
- Radiator material necessary characteristics: **suitable refractive index**, **transparency to the emitted light**, **minimal perturbation to the beam**.
- From analytical theory we get: **range of refractive indices that allow Cherenkov emission** for typical charged particle energies in radiotherapy.
- For selected materials: we computed the **expected photon yield** per particle, weighted by the **efficiency of a Silicon Photomultiplier** (SiPM), and estimated the **expected disturbance to the beam.**
- Preliminary **Geant4 simulations** confirmed: **linearity** between the number of particles in the beam and the number of emitted Cherenkov photons, the **minimal impact of the radiator** on the beam's properties.
- **Laboratory tests ongoing** with a preliminary prototype, designed to assess the feasibility of the concept.

Results

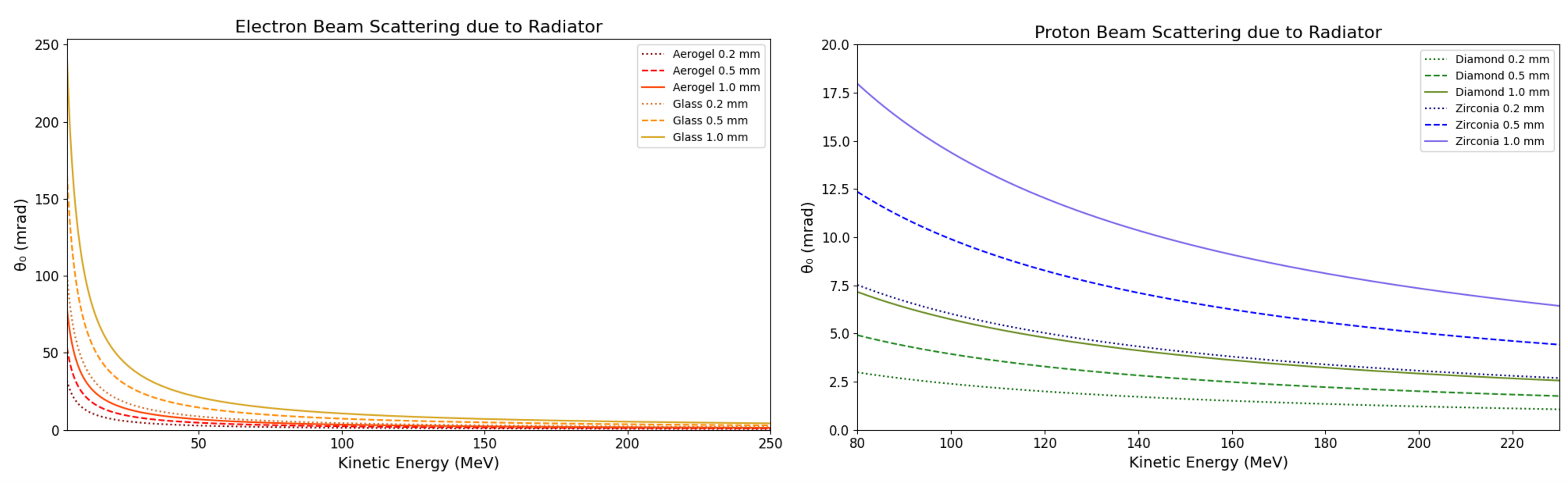
- Minimum energy threshold for Cherenkov radiation emission for proton (left) and electron beams (right)



- Cherenkov Signal vs Electron (top) and Proton (bottom) Beam Energy for Aerogel and Soda Lime Glass, weighted with SiPM PDE



- Electron (left) and Proton (right) Beam Scattering due to Radiator for various thicknesses



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