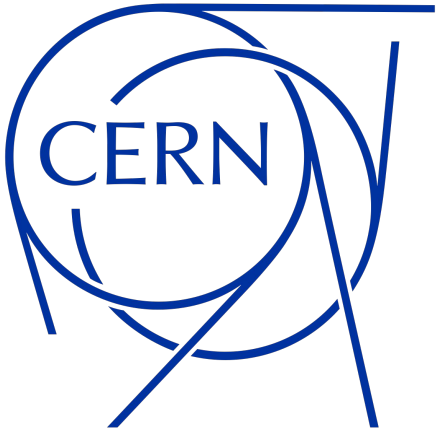


ATF2 incoherent Cherenkov diffraction radiation monitor status and plans

Kacper Lasocha, Thibaut Lefevre, Stefano Mazzoni, Benjamin Moser, Chiara Pasquino, Andreas Schloegelhofer, CERN

Pavel Karatev, RHUL

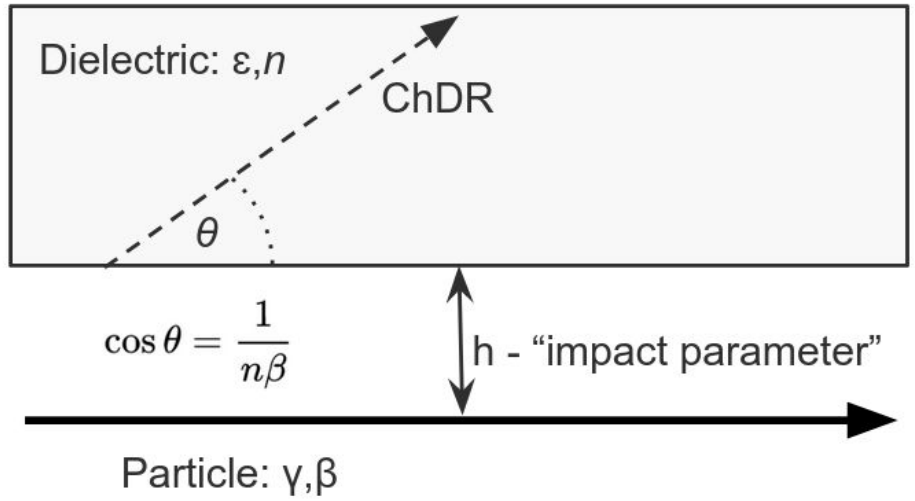
Renjun Yang, CSNS

Alex Aryshev, KEK

2024 International Workshop on Future Linear Colliders, 10.07.2024

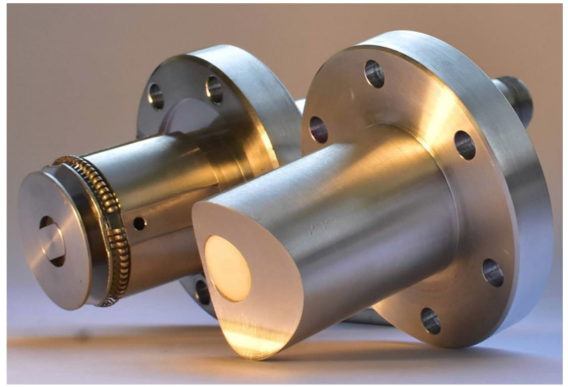
Cherenkov diffraction radiation

The electric field of ultra-relativistic charged particles passing in the vicinity of a dielectric radiator produces photons by the Cherenkov mechanism.



Relatively old concept; proposed by L. Mandelstam during the doctoral defense of P. Cherenkov (1940). Considered however only for **h** in order of few wavelengths (**h ~ λ**).

Later theoretical results moved the ***effective radius*** to **γλ**, what revealed the potential of applying ChDR for non-invasive beam diagnostics of high-energy beams.

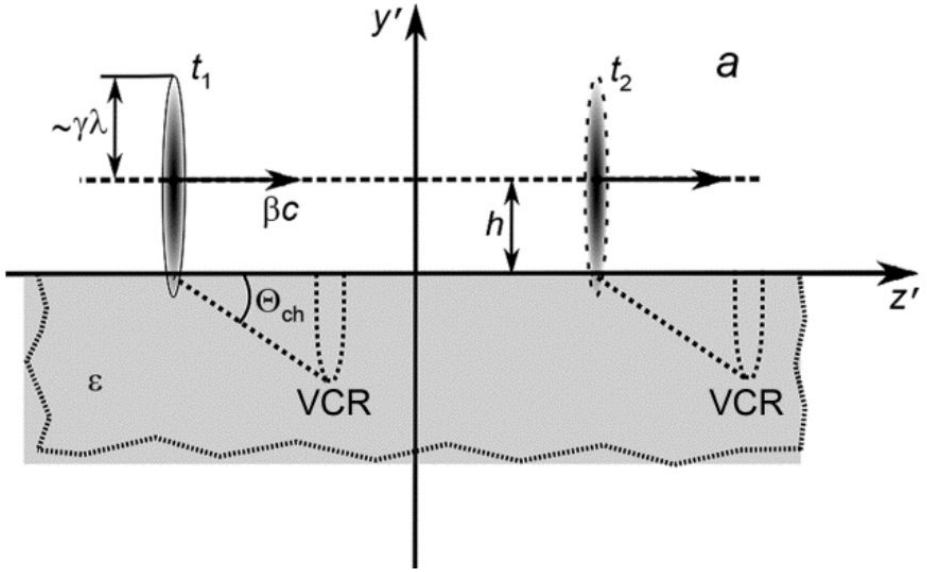


ChDR pickup

ChDR theoretical models

Assumptions taken on the shape and edges of the radiator divide ChDR models into two groups. The change of the considered geometry significantly differs the radiation yield.

Stationary models



Non-stationary models

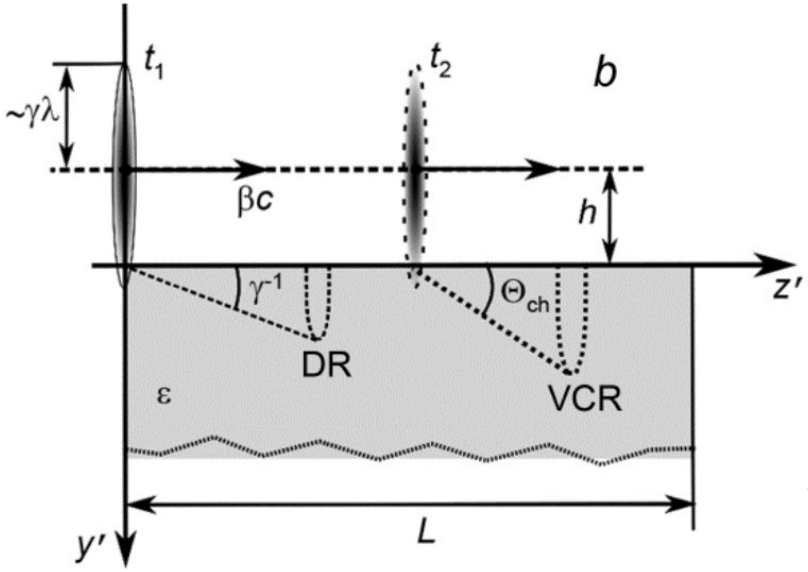
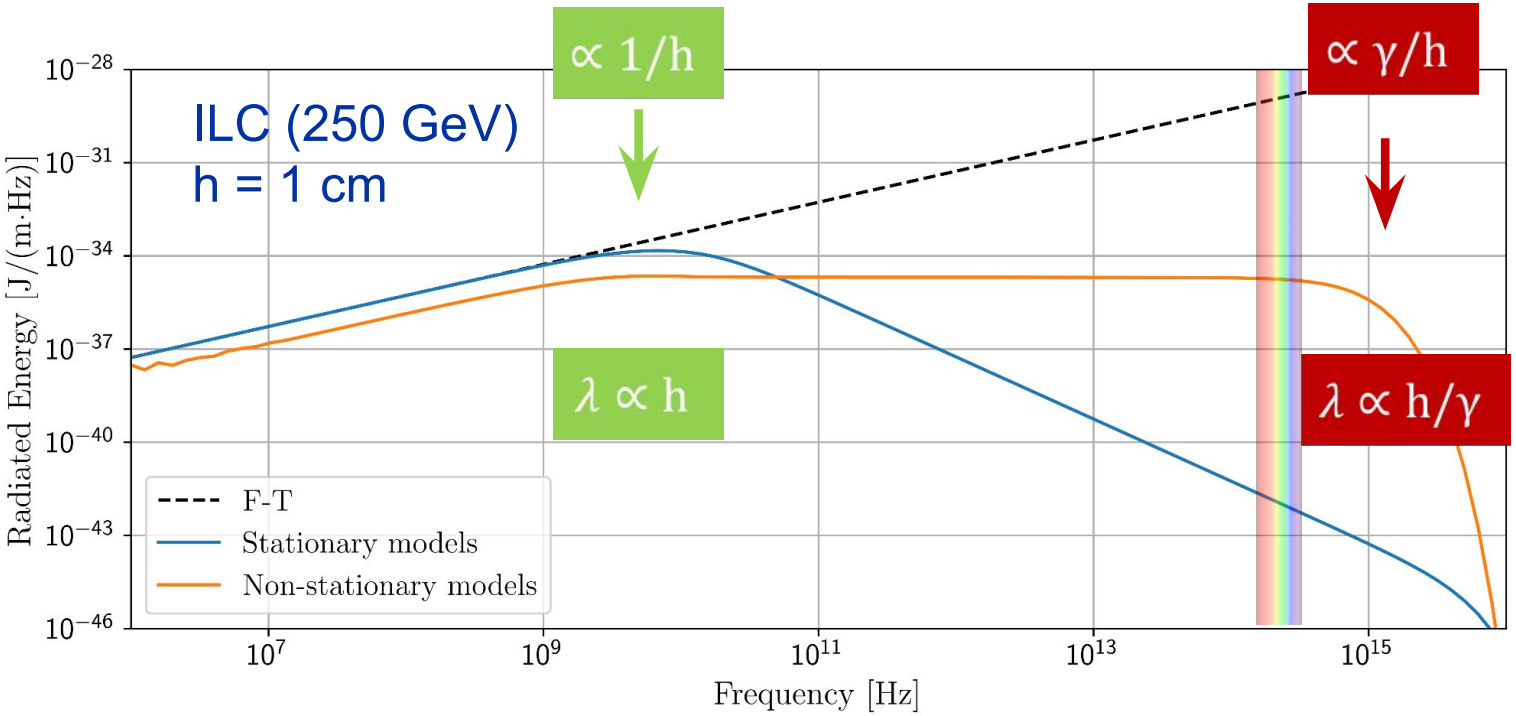


Diagram: A. Potylitsyn, *Russ Phys J* 62, 2187–2193

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

4. Karlovets, D.V., Potylitsyn, JETP Lett. 90, 326 (2009).

ChDR light yield

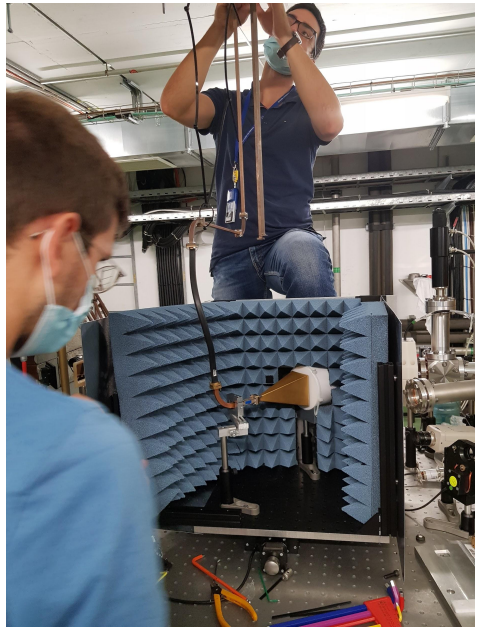


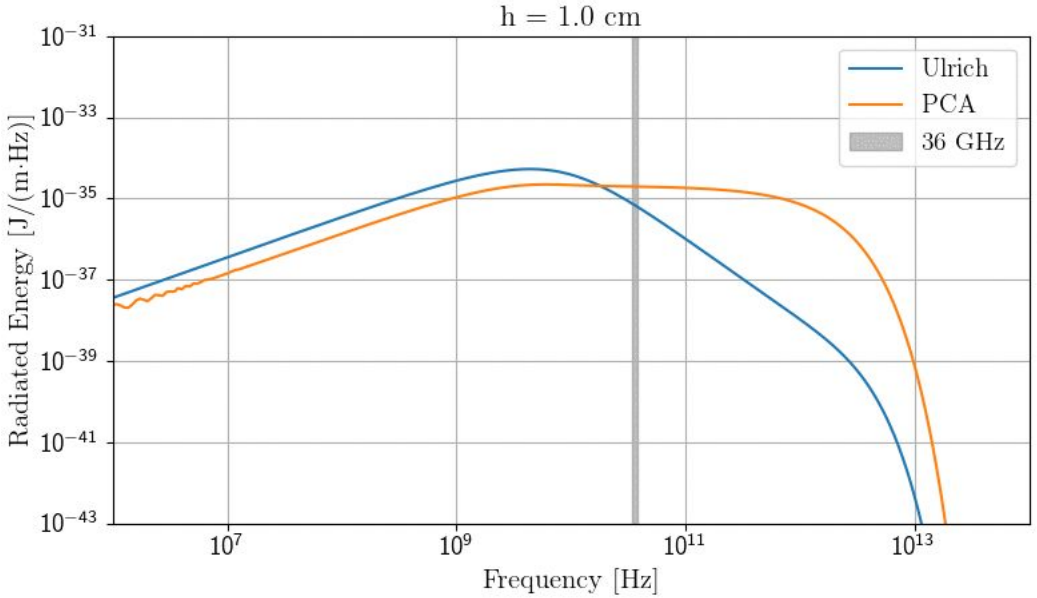
ChDR has a potential for longitudinal diagnostics for high energy future colliders (CLIC, ILC, FCCee), but models predict large differences in photon yield (up to γ^2).

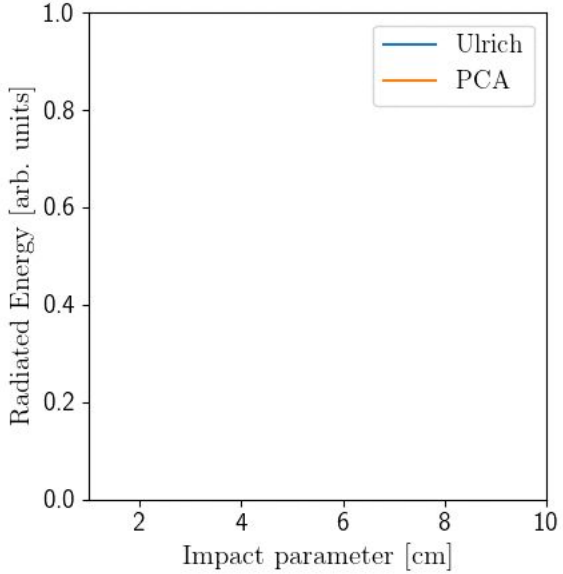
The absolute incoherent ChDR yield was never yet measured.

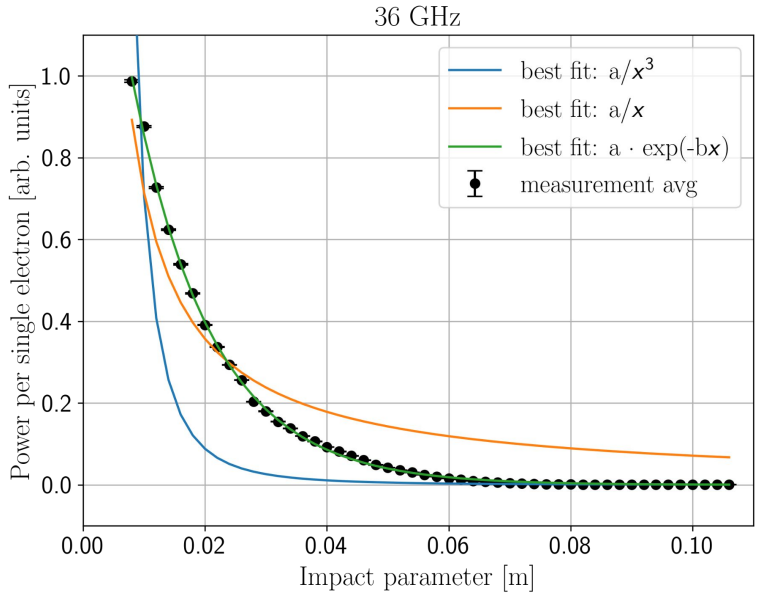
Coherent ChDR light yield

- **Tests in CLEAR in 2021-2022 (100-200 MeV e-, 30/36 GHz). Test in full coherent regime.**
- **Results did not support neither Ulrich or PCA models, consistently in between**
- **Coherent regime: large yield but large wavelengths: diffraction, angular acceptance.**



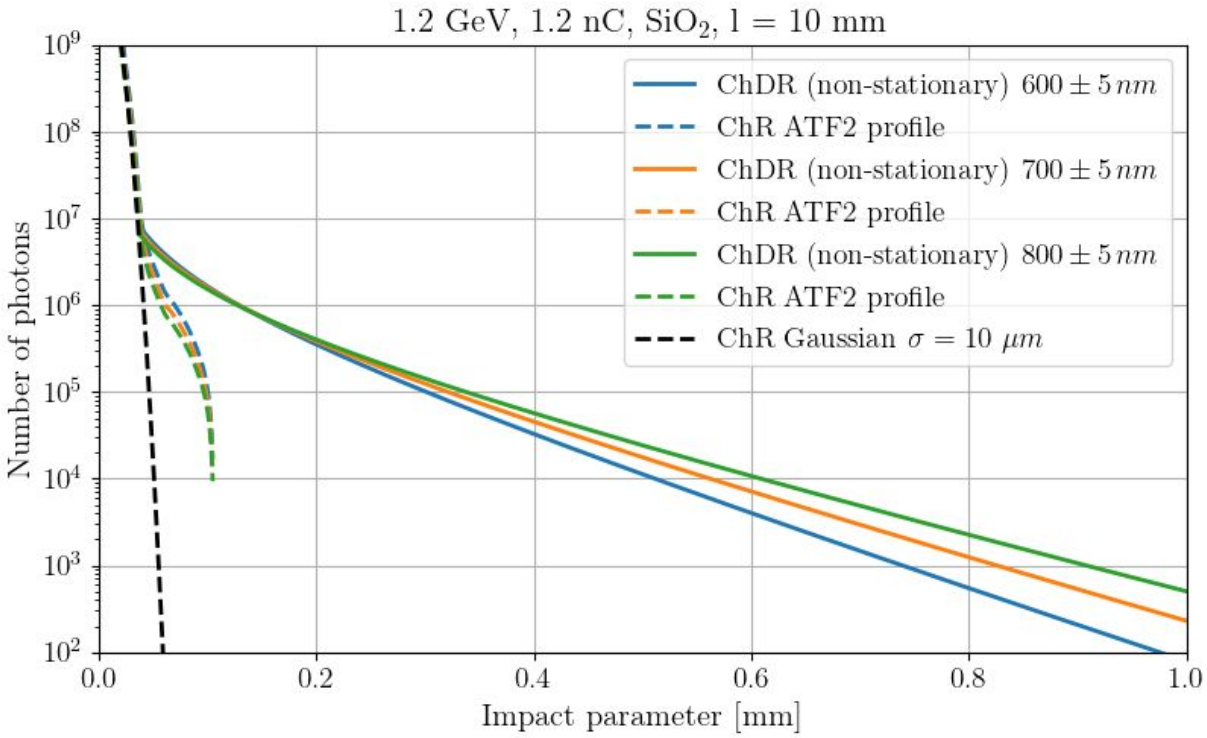




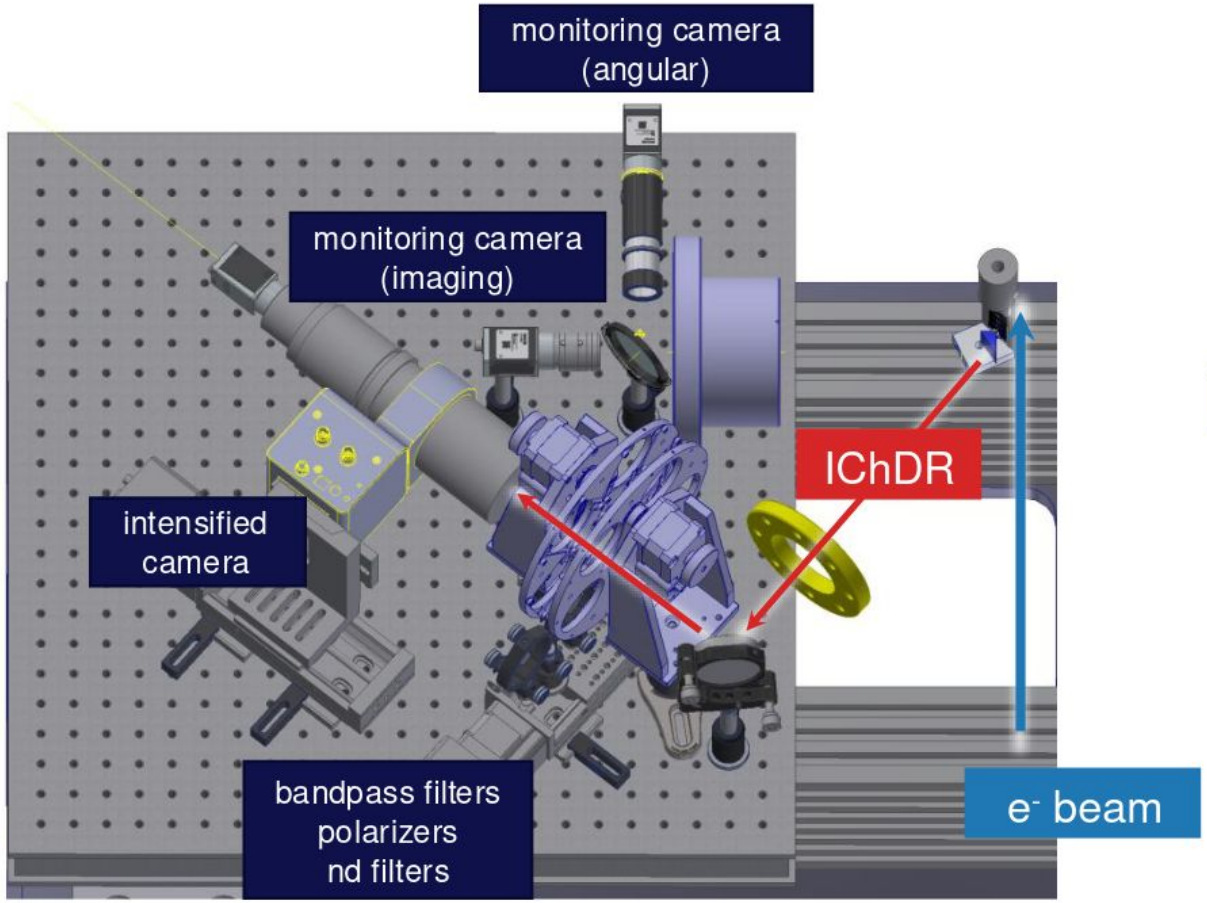


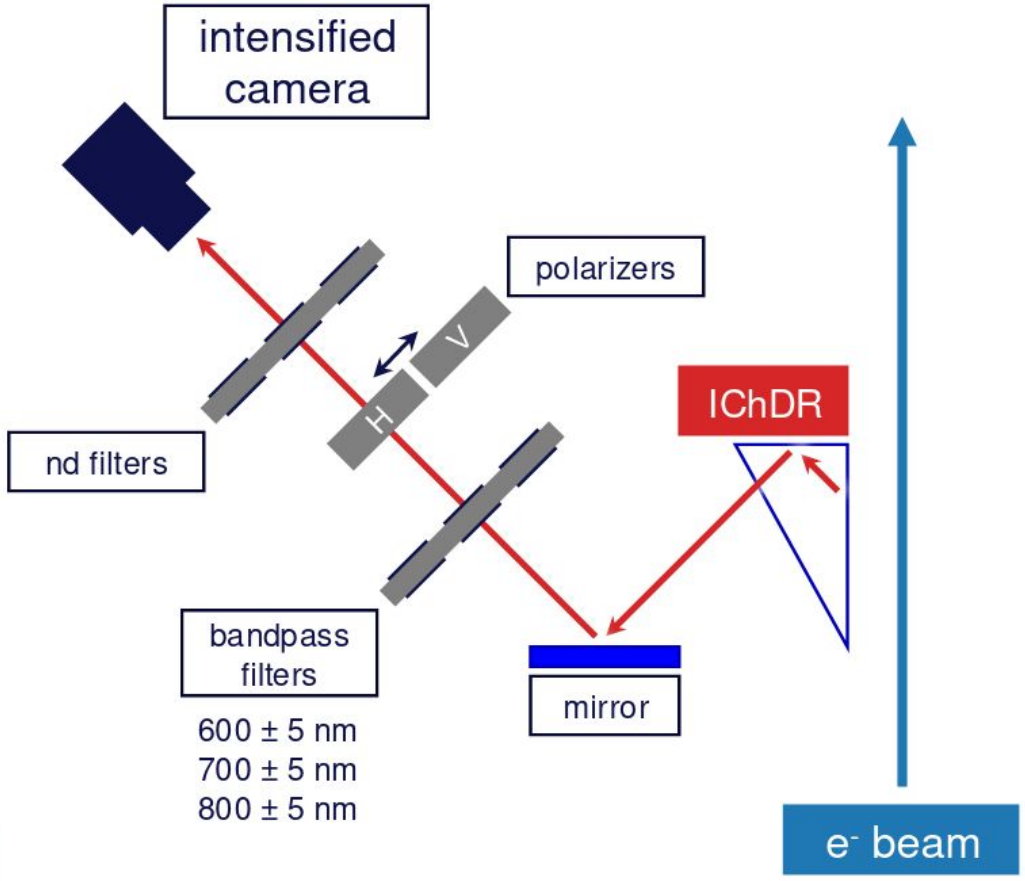
Incoherent optical ChDR yield at ATF2

- **Incoherent visible ChDR offers advantages:**
  - acceptance angle does not depend on impact parameter
  - ‘easy’ absolute detection (visible photons)
  - signal can be used for fast longitudinal profile measurement (streak, single photon TDC,…)
- **…but requires high γ! In clear case, to measure optical ChDR (700 nm) one needs to be as close as 200 um**
- **Need large(r) γ and small beam: ATF2. Accurate halo estimation is mandatory!**



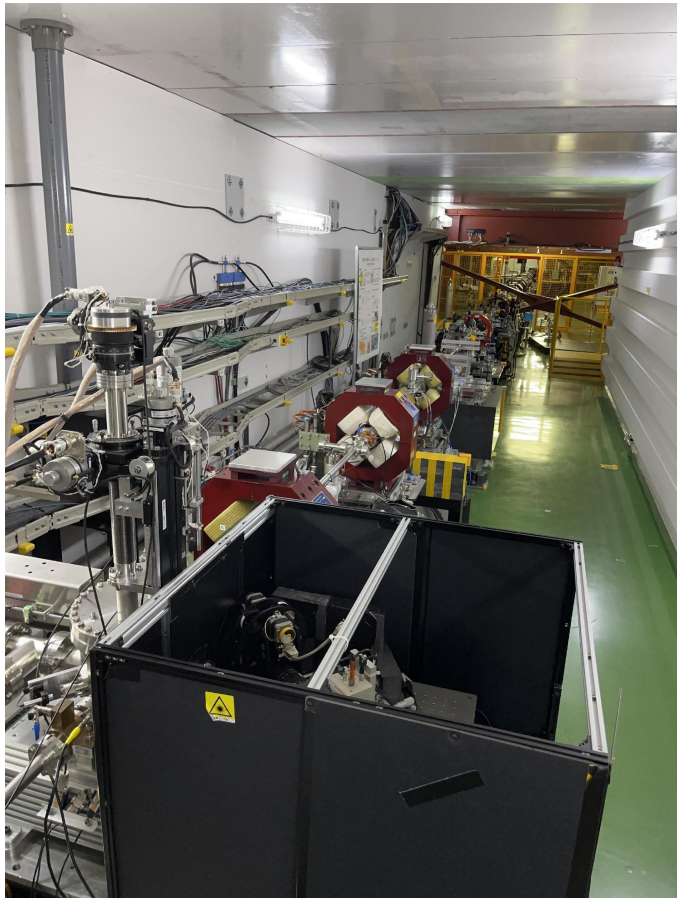
Incoherent ChDR at ATF2 - setup

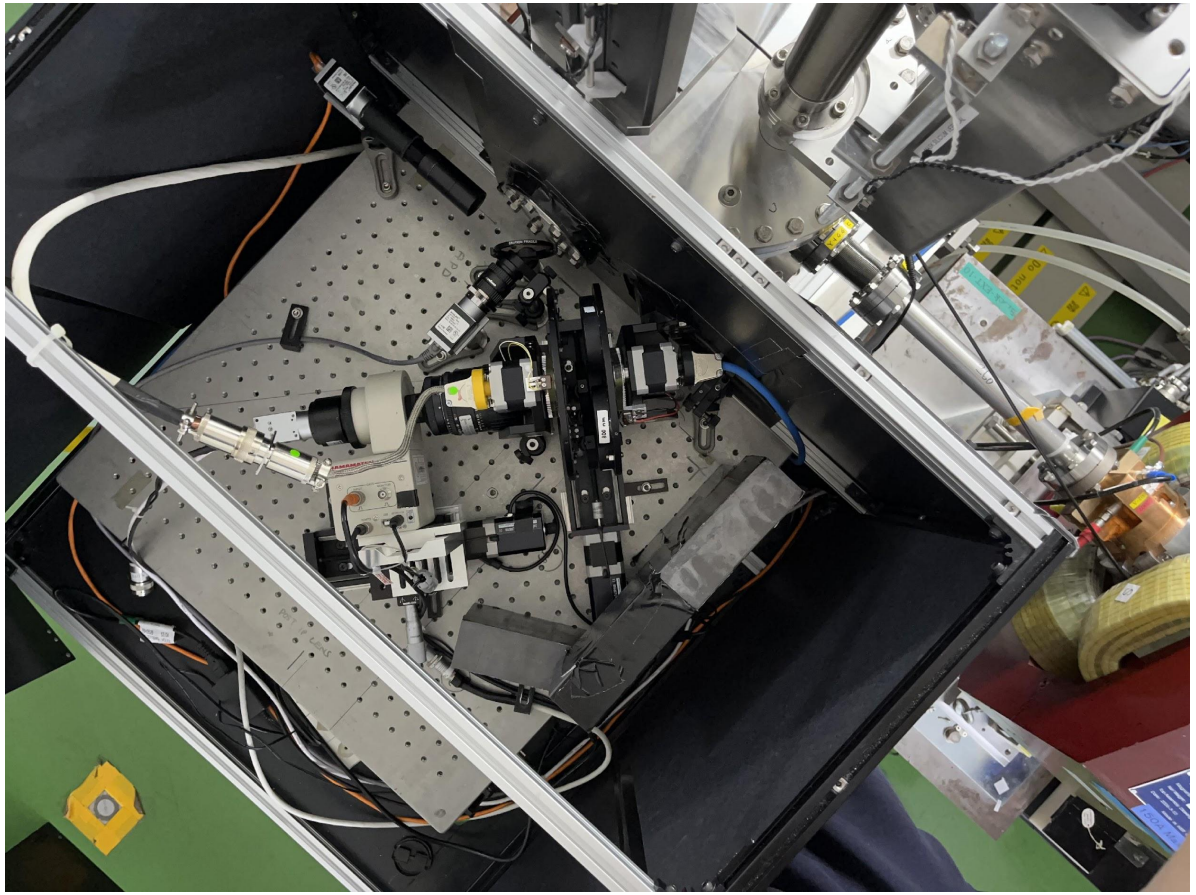




Distance to target: 51 cm

Incoherent ChDR at ATF2 - setup

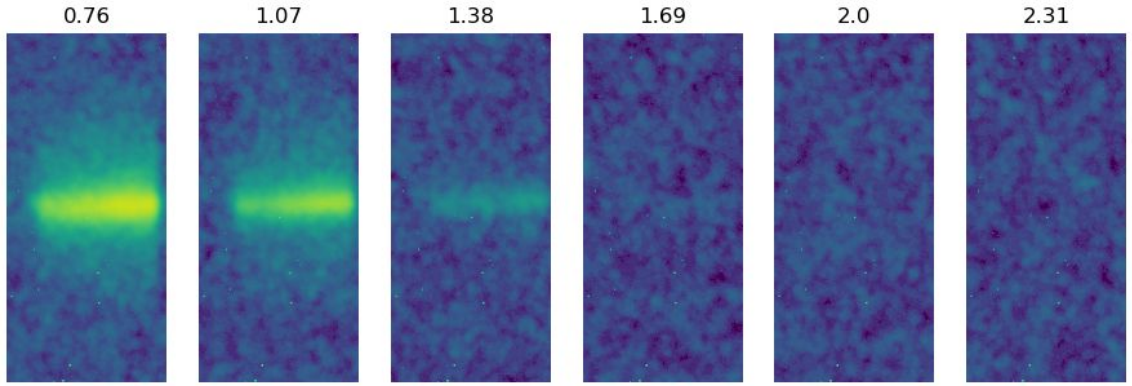




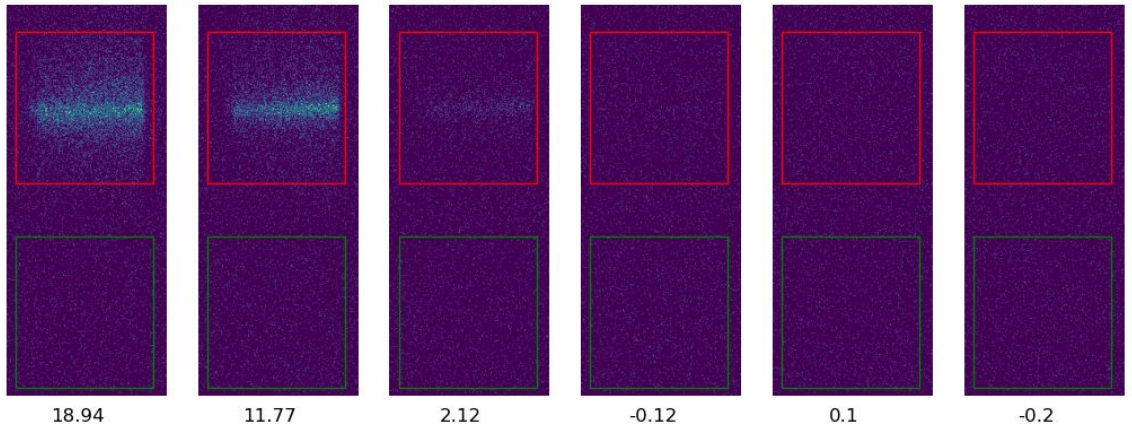
Summary of 2023 tests

Integrated images

Impact parameter



Photon counting



Number of Photons

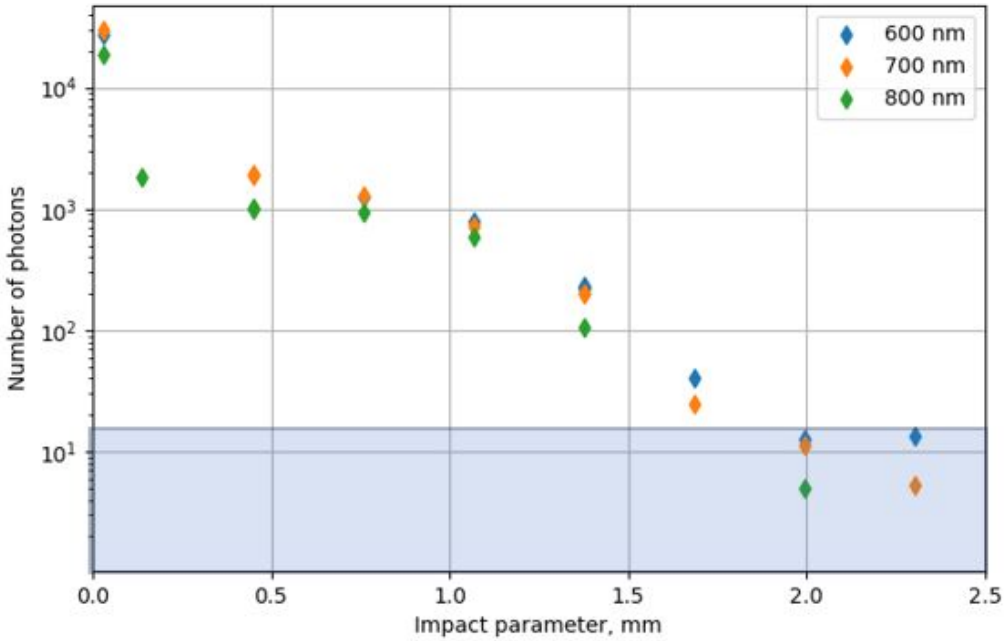
20 different distances/bandpass filter
500 images per position

Normalized for bunch charge

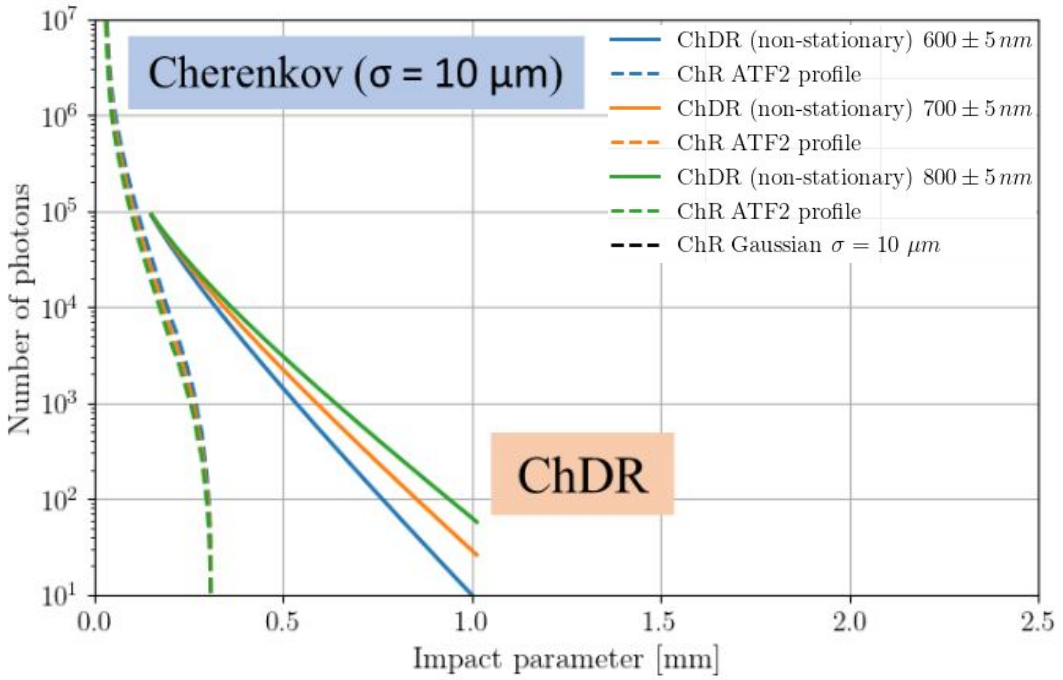
Signal

Background

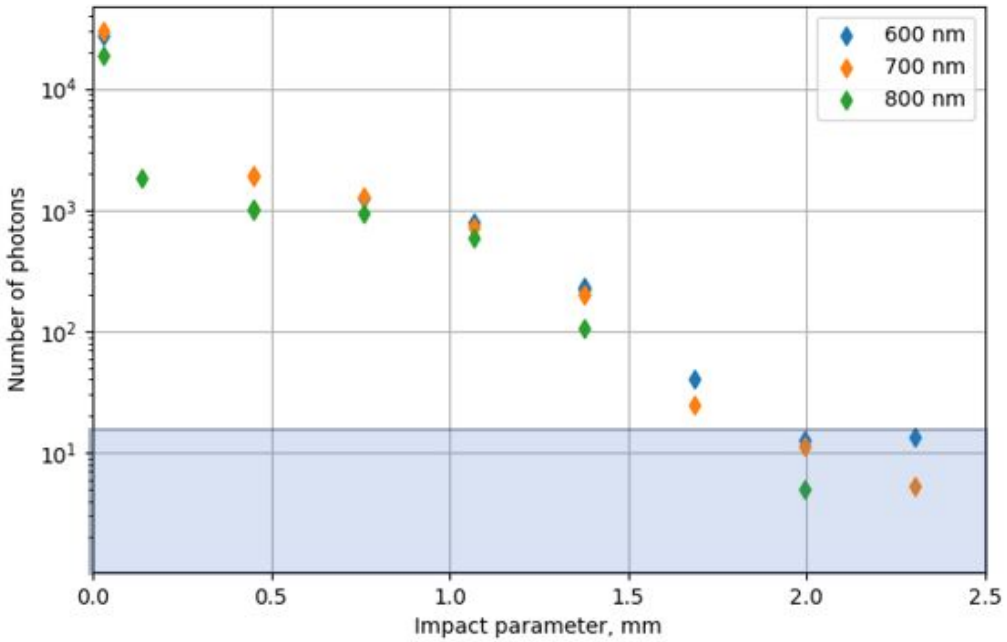
Summary of 2023 tests



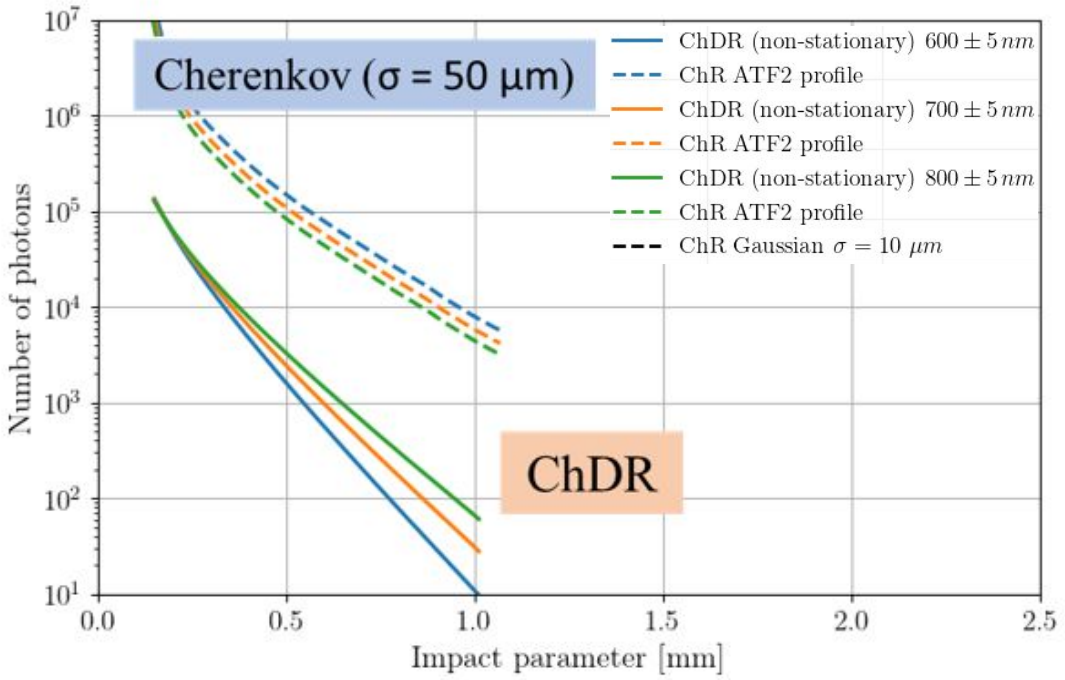
1.0 GeV, 150 pC



Summary of 2023 tests

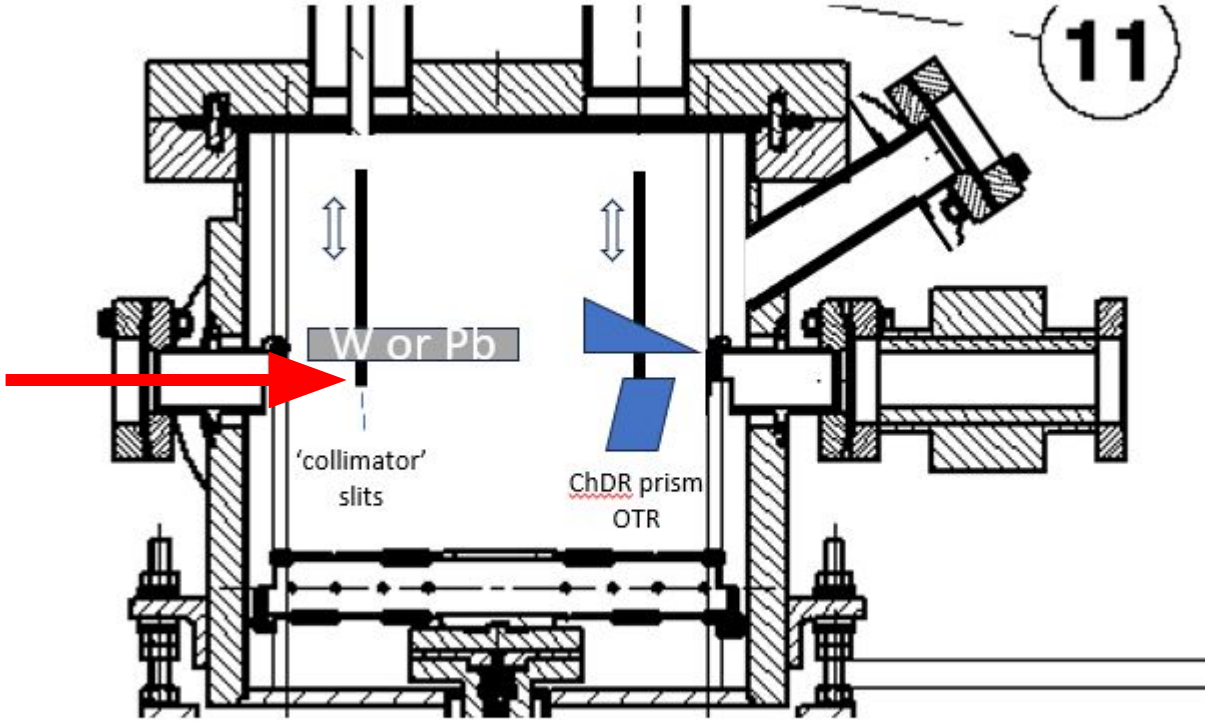


1.0 GeV, 150 pC



Signal mixed with the Cherenkov radiation produced by halo particles

Planned upgrade of ChDR setup



- **Preserve most of existing design; actuators, support, replacement chamber,**
- **Replace the chamber and add 45 degree forward view-port in the <u>vertical plane</u>**
  - At ATF2, the vertical beam size, and consequently halo, is significantly smaller than the horizontal
  - Additional exclusion of synchrotron radiation,
- **Introduce a collimator in front of the radiator**
  - Preliminary FLUKA simulations showed factor of 10^6 intensity reduction using 1x1x4 cm Tungsten absorber

Summary

- **Incoherent ChDR can be source for beam diagnostics for future high energy colliders, but a realistic radiation model is still not known.**
- **First attempts at ATF2 to verify the existing theories were not conclusive**
  - Setup not adapted to ChDR complicates the analysis,
  - The highly populated halo introduces a strong background.
- **Preliminary studies show a possible new setup design that would allow better noise rejection.**
- **The preparation for the upgrade include**
  - New set of simulations with the realistic halo distribution and the target shielding,
  - Upgraded setup design, with a vertical viewport.
- **The aim is the installation and a new measurement campaign in 2025.**

home.cern