G.A. 101046458

CLS TECHNOLOGY WP3 REPORT

Vincenzo Guidi
University of Ferrara
vincenzo.guidi@unife.it

Istituto Nazionale di Fisica Nucleare

Università degli Studi di Ferrara

Università degli Studi di Padova

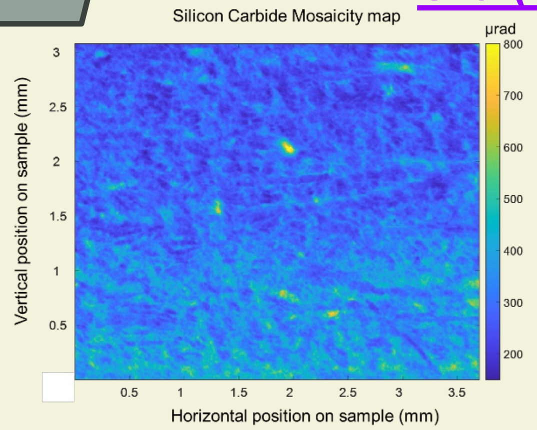
Objective 3.1
DIAMOND Light source results

diamond

see Rébecca Dowek's talk

LCs

SiC (W and Ir)

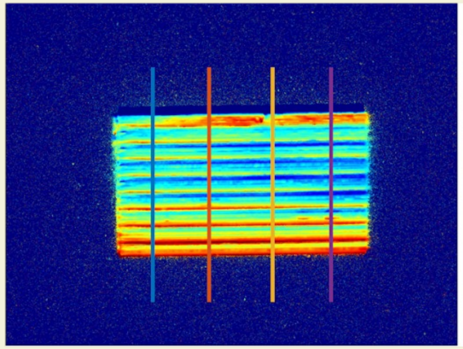


Bulk quality of **W** and **Ir** samples cannot be investigated via X-ray diffraction, due to the high absorption of the materials.

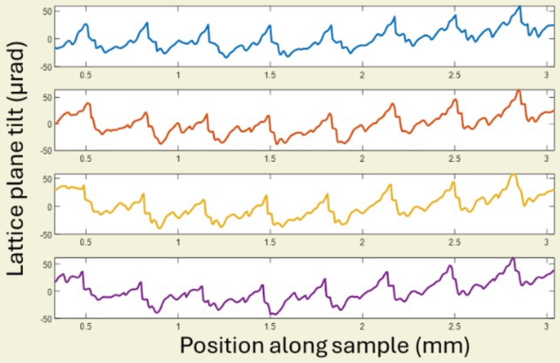
PBCs

PBC-Si-G1

2d map for plane tilt



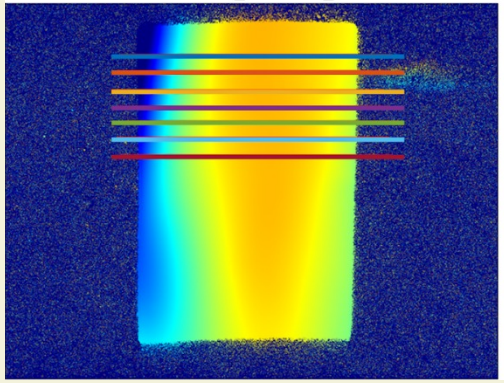
Profile map for map tilt



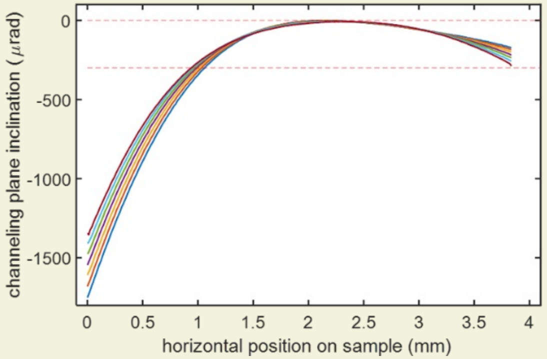
BCs

BC-Si-QM1

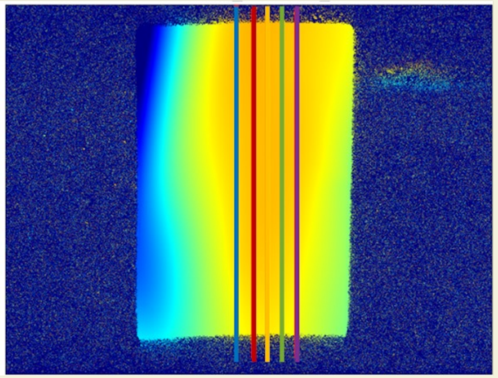
2d map for channeling planes inclination



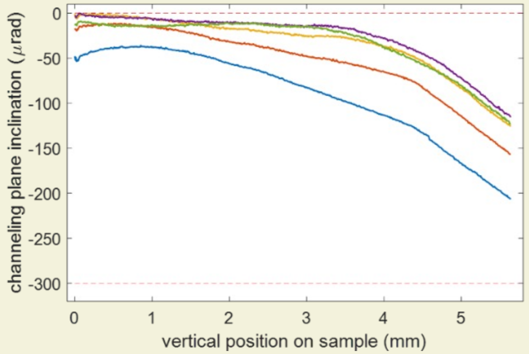
Profile map for channeling planes inclination



2d map for channeling planes inclination



Profile map for channeling planes inclination



Objective 3.5

Channeling experiments with electrons and positrons in LC, BC and PBC crystals.

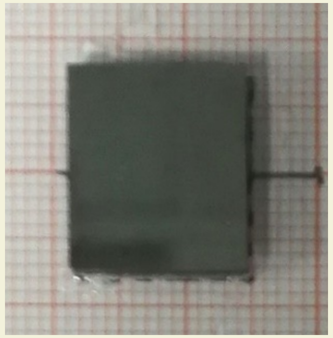
$e^{\pm}$ @ (1-10) GeV

CERN PS (Geneva, Switzerland)

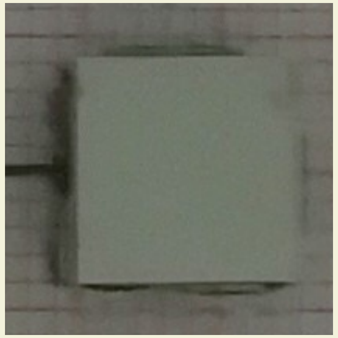
August 2023 CERN PS experiment goals

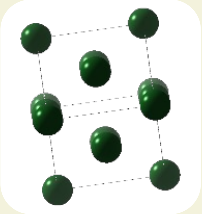
- Test linear crystals with new materials at high-Z (Ir and W – see WP4);
- Full Characterization of PS e+ beam to evaluate the possibility to test in 2024/25 BC and PBC crystals;
- Evaluate the possibility to work under vacuum or with He bag (to reduce MS in air), which is necessary to test in future BCs and PBCs of low-Z material and of thinner thickness;
- After characterization of the positron beam, we are planning to perform a Geant4 simulation of the experimental setup to understand which detector could be used to measure the gamma-ray peak of **CU** without being blinded by the harder channeling/bremsstrahlung radiation spectrum.

New Materials for linear crystals light sources



Material: **Tungsten** (2x15x13x mm)
channelling Axis: <111> (most efficient)
Axial potential: 1 keV
$\theta_C \approx 0.6\, mrad$ ~ beam divergence
Lattice structure: Body Centered Cubic (BBC, space group #229)
Thickness: 2 mm (0.6 of W X0)





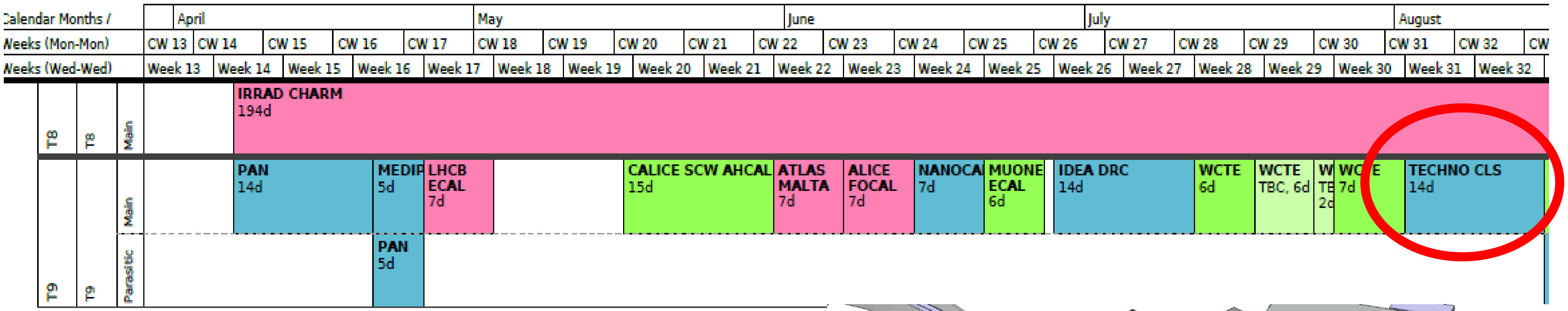
Material: **Iridium** (1x7x8 mm)
channelling Axis: <110> (most efficient)
Axial potential: 1 keV
$\theta_C \approx 0.6\, mrad$ ~ beam divergence
Lattice structure: Face Centered Cubic (FCC, space group # 225)
Thickness: 1 mm (0.3 of Ir X0)

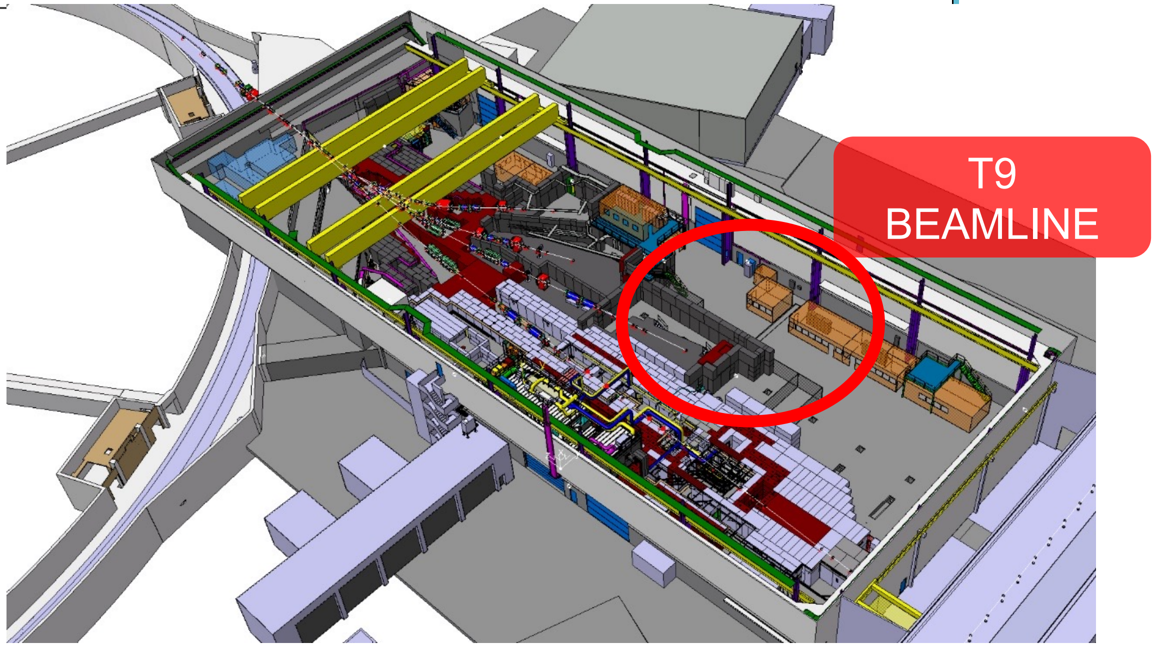
Channelling radiation tested at T9 the extracted beamline of
PS at CERN with multi-GeV electrons

Strong axial potential → huge radiation enhancement

Experiment at CERN
PS extracted lines (East Area) in August 2023

East Area Schedule v1.4.0 :: Beamlines T8, T9, T10, T11 & nToF :: Status 2023-06-16 19:00 UTC



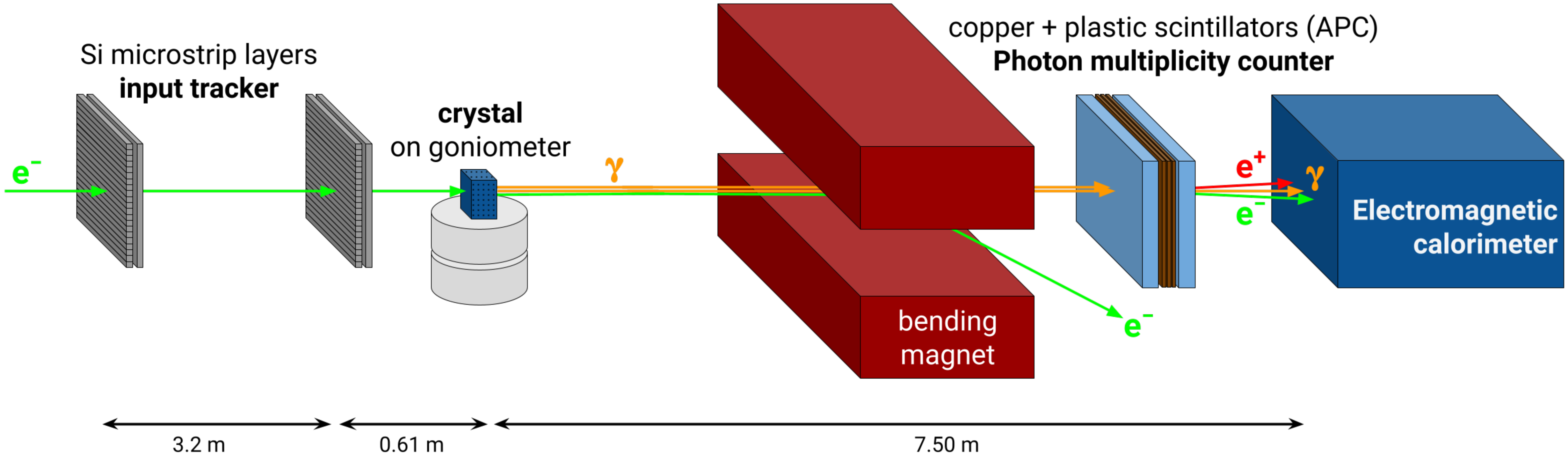


Preparation of the experiment

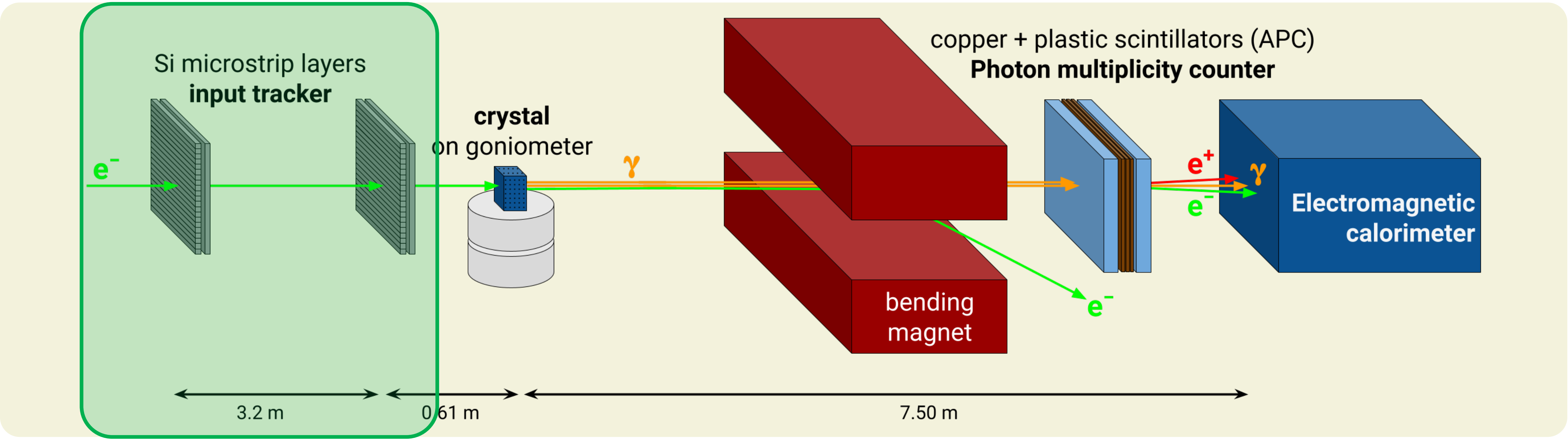
Provided by the INFN Milano Bicocca team – Erik Vallazza & Michela Prest

Electron and positron beams at

- CERN PS at **5-10 GeV/*c***

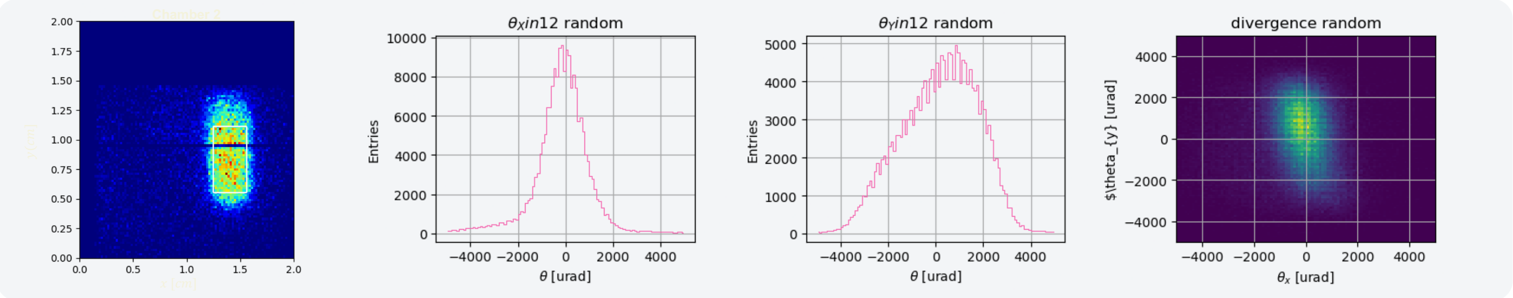


The setup



Input stage

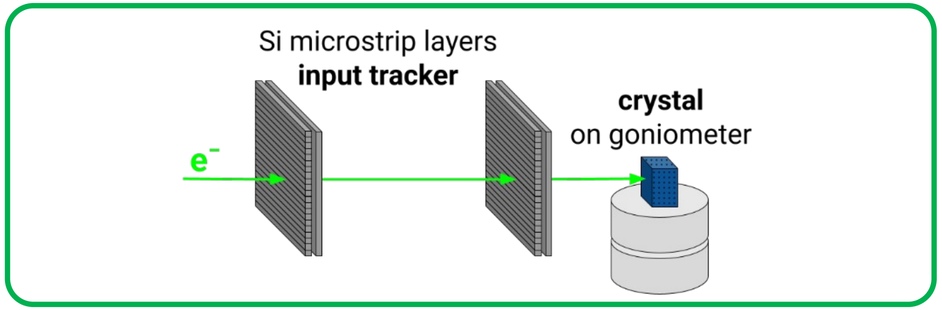
Reconstruct track and impinging angle on the crystal



The setup input stage

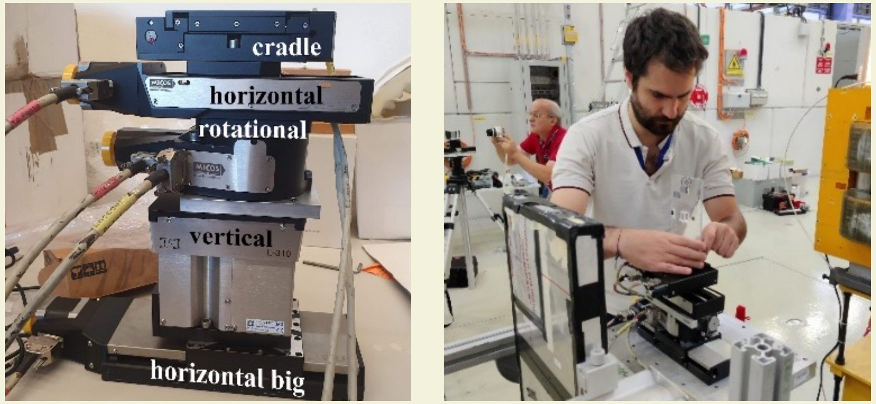
Input tracker

~2×2 cm^2 *xy* double-sided Si microstrip sensors, with an overall ~10 μm single-hit resolution.
Self-triggering on strip to select the proper area.

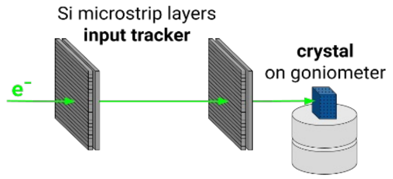


Goniometer from LNL & UNIPD

Fine-grained, remote-controlled movements along x, y, θ_x and θ_y with ~5 μm/μrad resolution.



The setup **the beams**

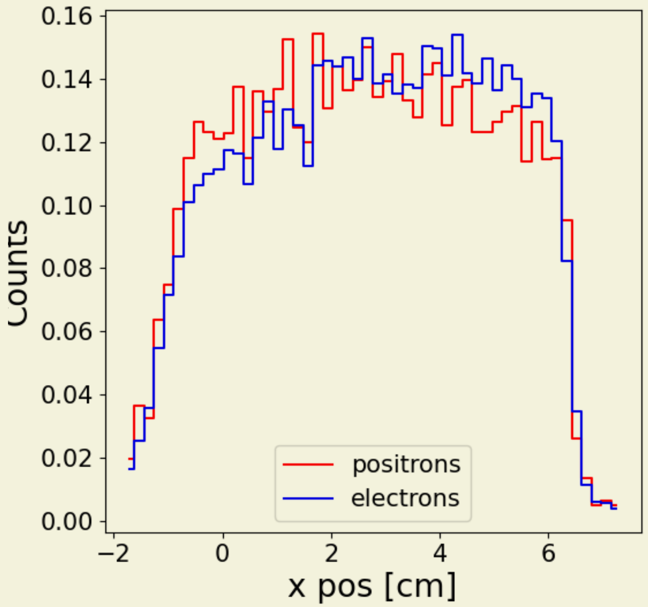


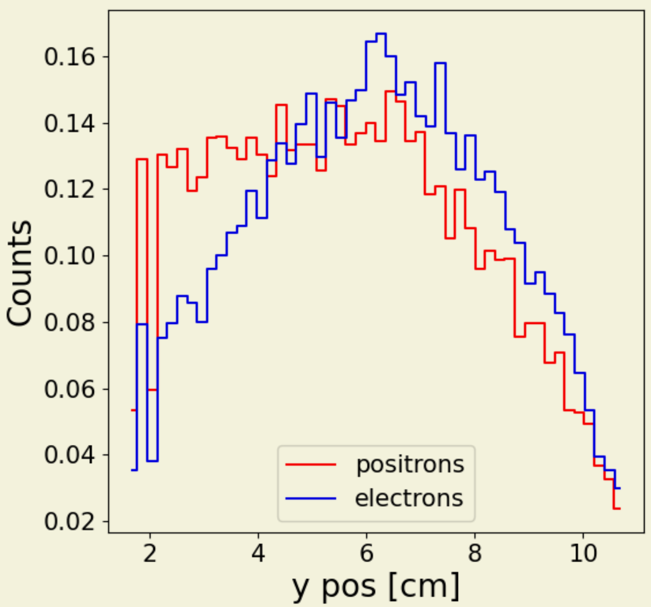
LCs

Beam distributions
(electron/positron beam, 6 GeV)

Rate
- $10^2/10^3$ particles/spill
- Spill duration 400 ms
- 4-6 spills per minute

The quality of the beam can be improved removing the upstream Cerenkov detectors and working in vacuum



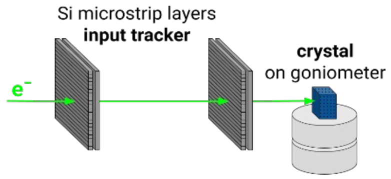


Cons

The beams are secondary and tertiary

→ Čerenkov detector needed

The setup **the beams**

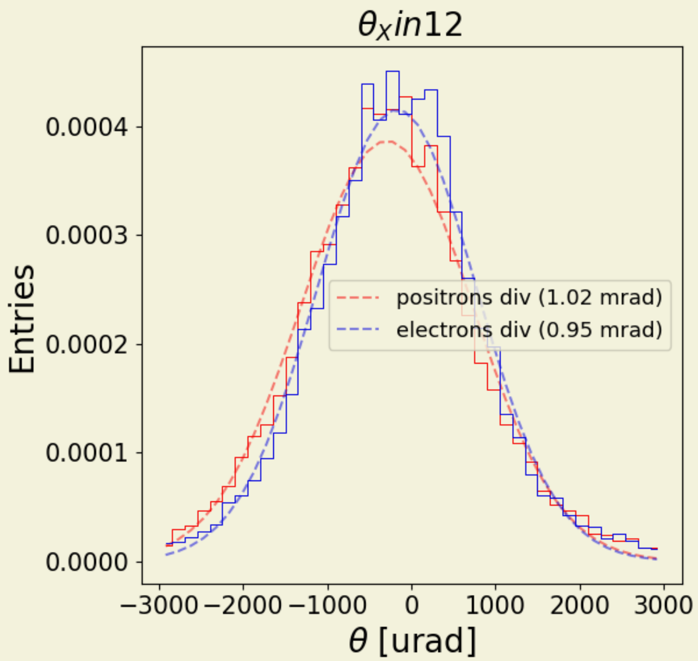


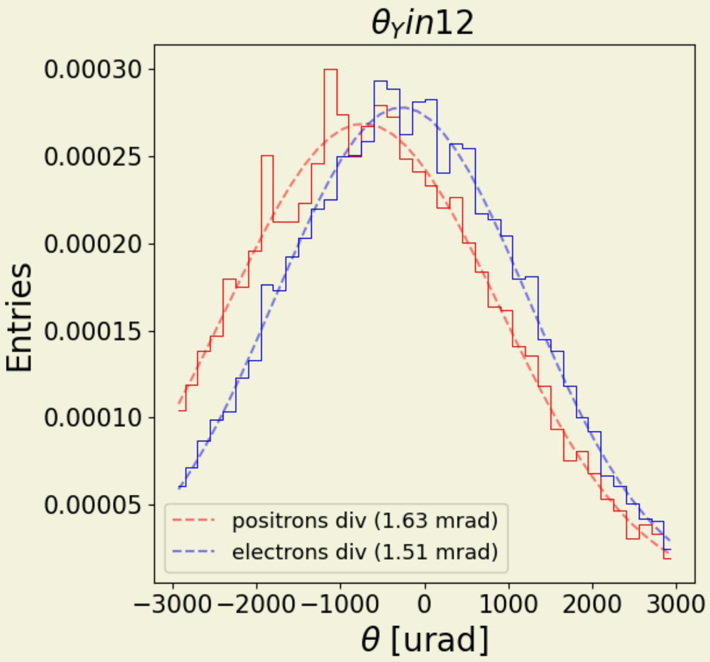
Beam distributions
(electron/positron beam, 6 GeV)

Rate
- $10^2/10^3$ particles/spill
- Spill duration 400 ms
- 4-6 spills per minute

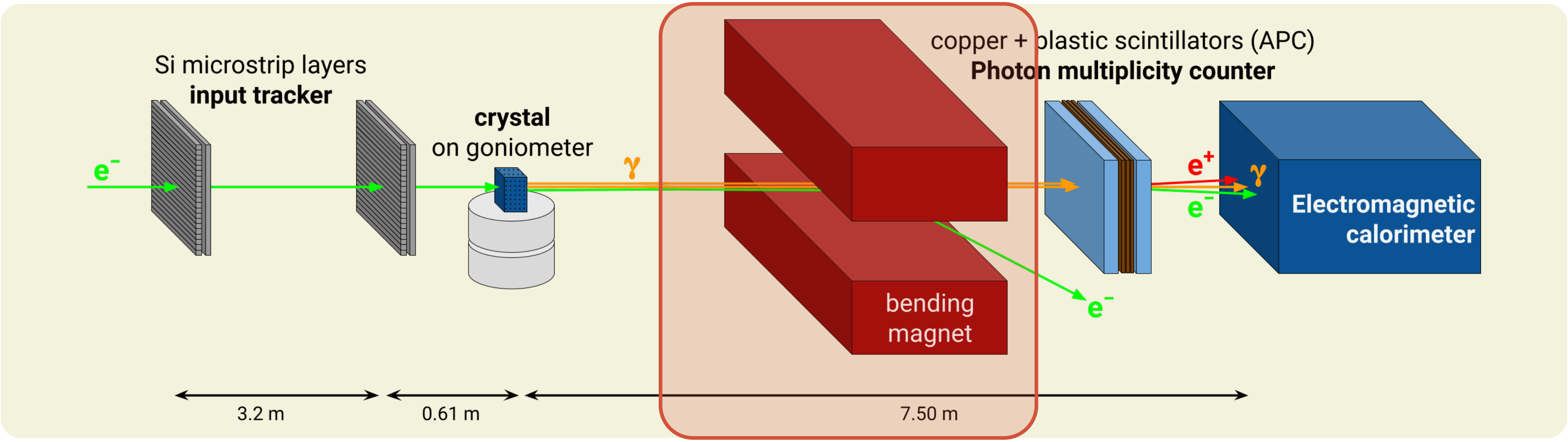
Cons
The beams are secondary and tertiary
→ Čerenkov detector needed

The quality of the beam can be improved removing the upstream Cerenkov detectors and working in vacuum



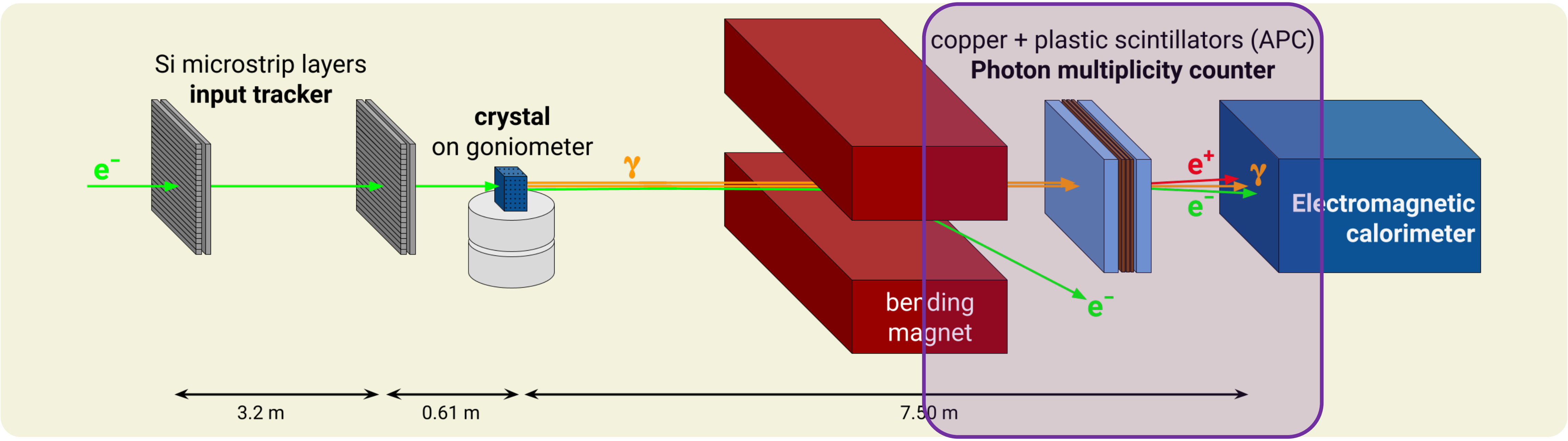


The setup



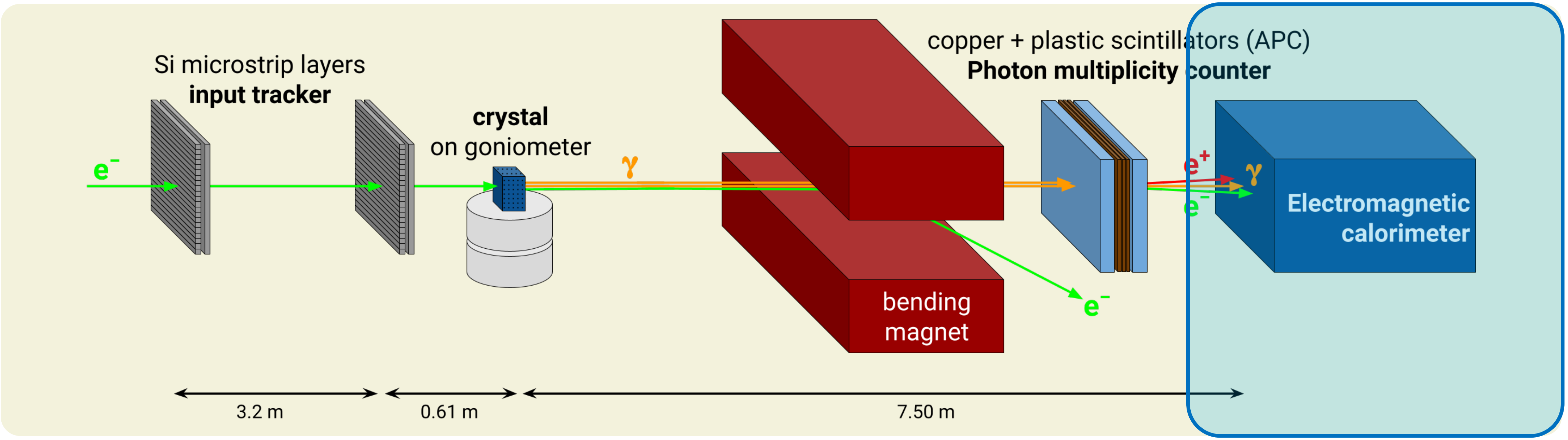
Magnet
Select only the photons

The setup



APC + Cu converter
Photon mutiplicity counter

The setup



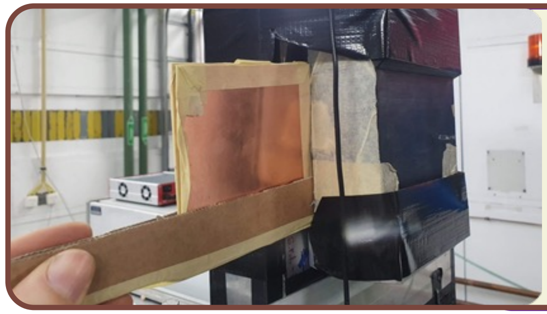
Radiated energy loss
calorimeter signal

The setup output stage

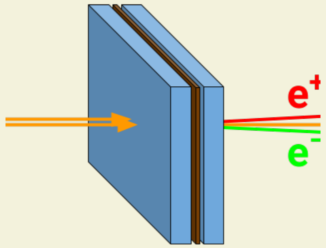
An **Active Photon Converter (APC)** based on plastic scintillators and thin layers of copper for photo conversion

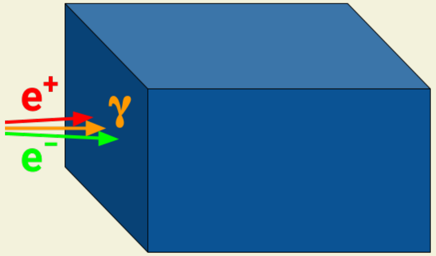
Different **calorimeters** can be exploited:

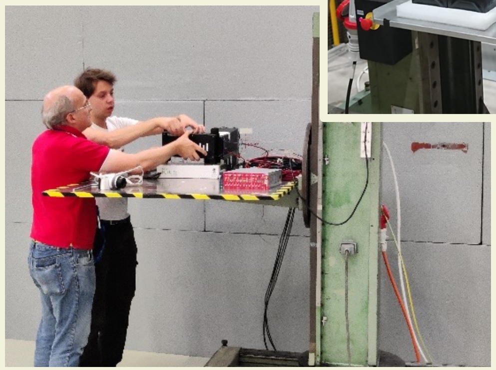
- 3×3 matrix of PWO blocks from the CMS endcap, SiPM-based readout
- **(OPAL) Pb glass blocks read out by PMTs**
- 3×3 matrix of BGO blocks, PMT-based readout



Active Photon Converter (APC)



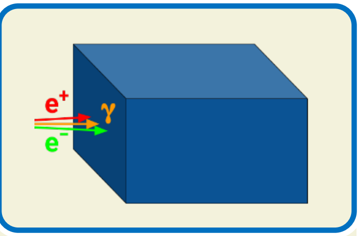


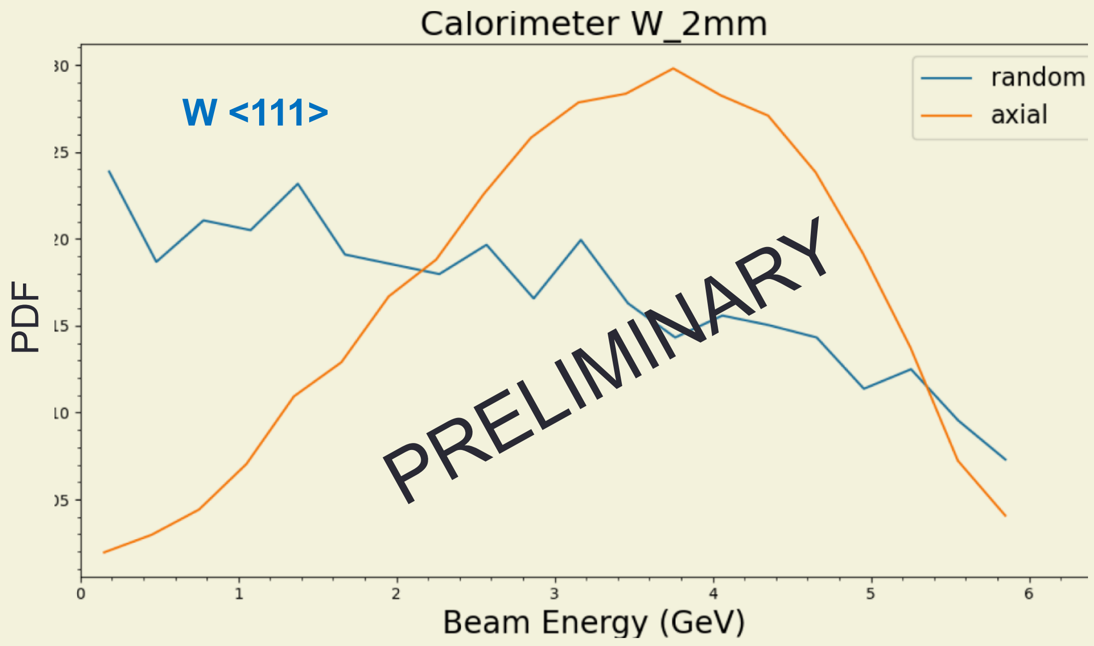


Lead glass calorimeter

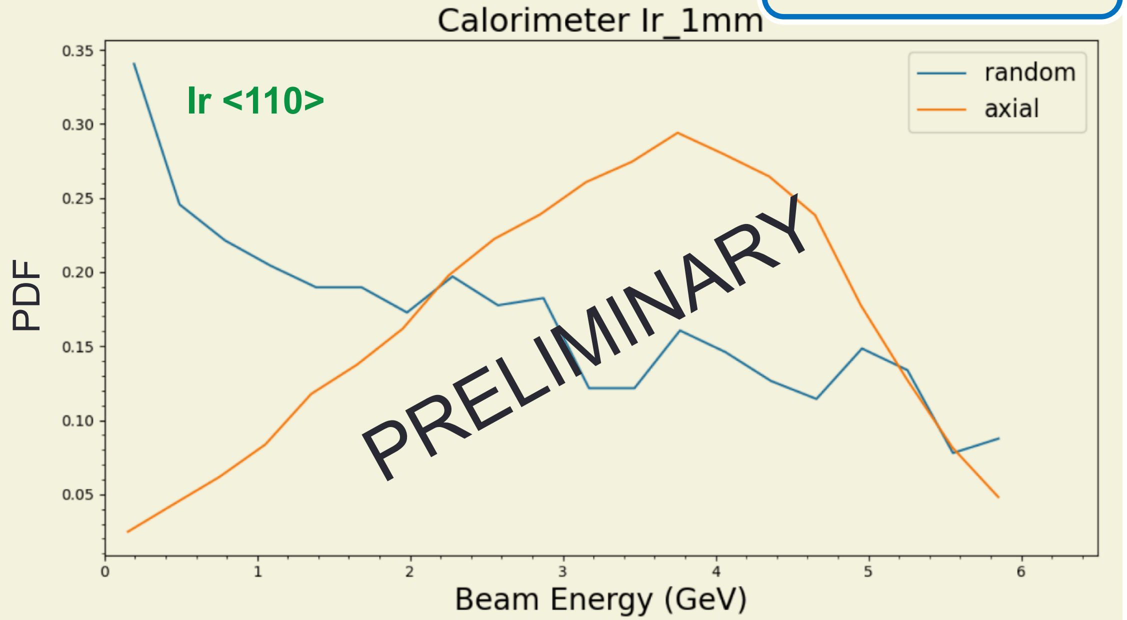
The setup output stage: **radiated energy loss**

For both the **2 mm long W** **and** **1 mm long Ir** aligned along the **<111> axes** and the **<110> axes,** respectively, the radiative energy loss distribution **peaks above 3.5 GeV**, while for **random orientation it vanishes** as typical for Bremsstrahlung





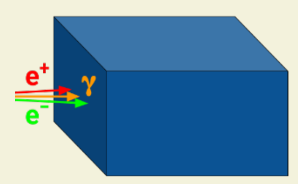
+ 41.6 % mean value in axial orientation

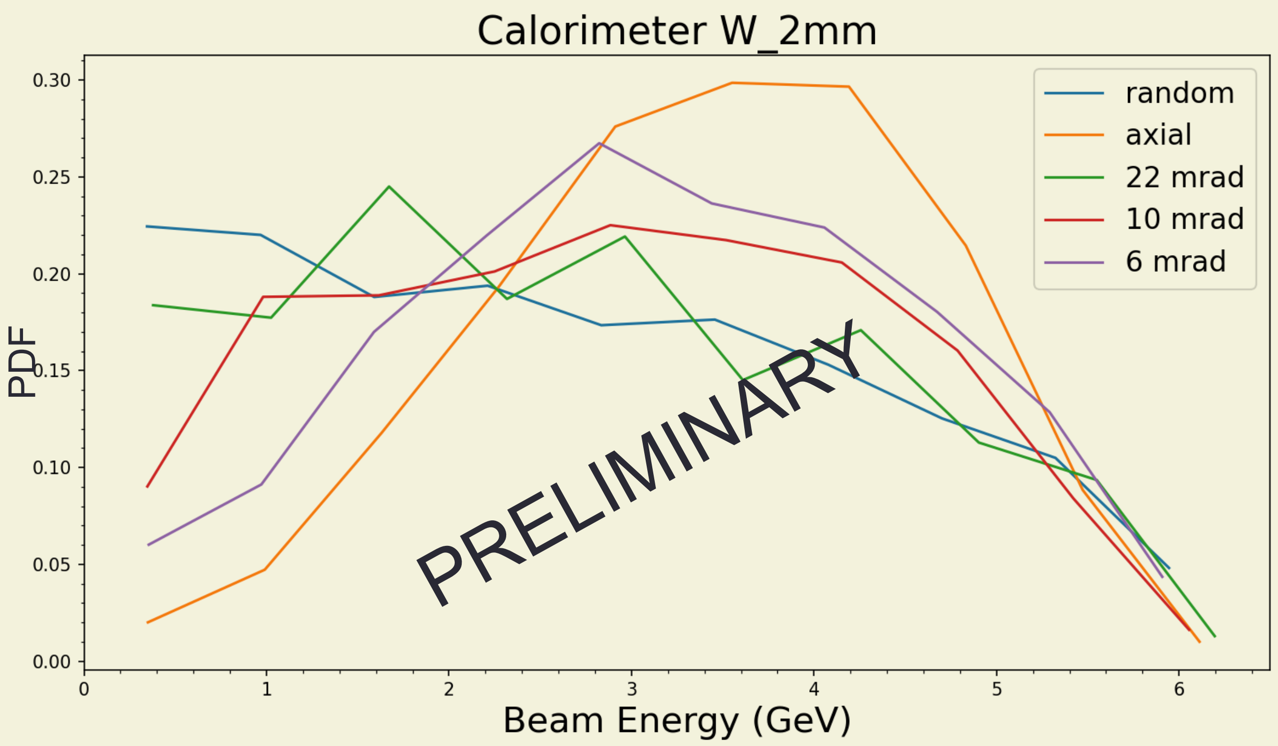


+ 40.9 % mean value in axial orientation

The setup output stage: **radiated energy loss**

For both the **2 mm long W** **and** **1 mm long Ir** aligned along the **<111> axes** and the **<110> axes,** respectively, the radiative energy loss distribution **peaks above 3.5 GeV**, while for **random orientation it vanishes** as typical for Bremsstrahlung

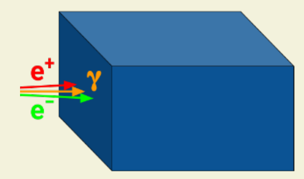


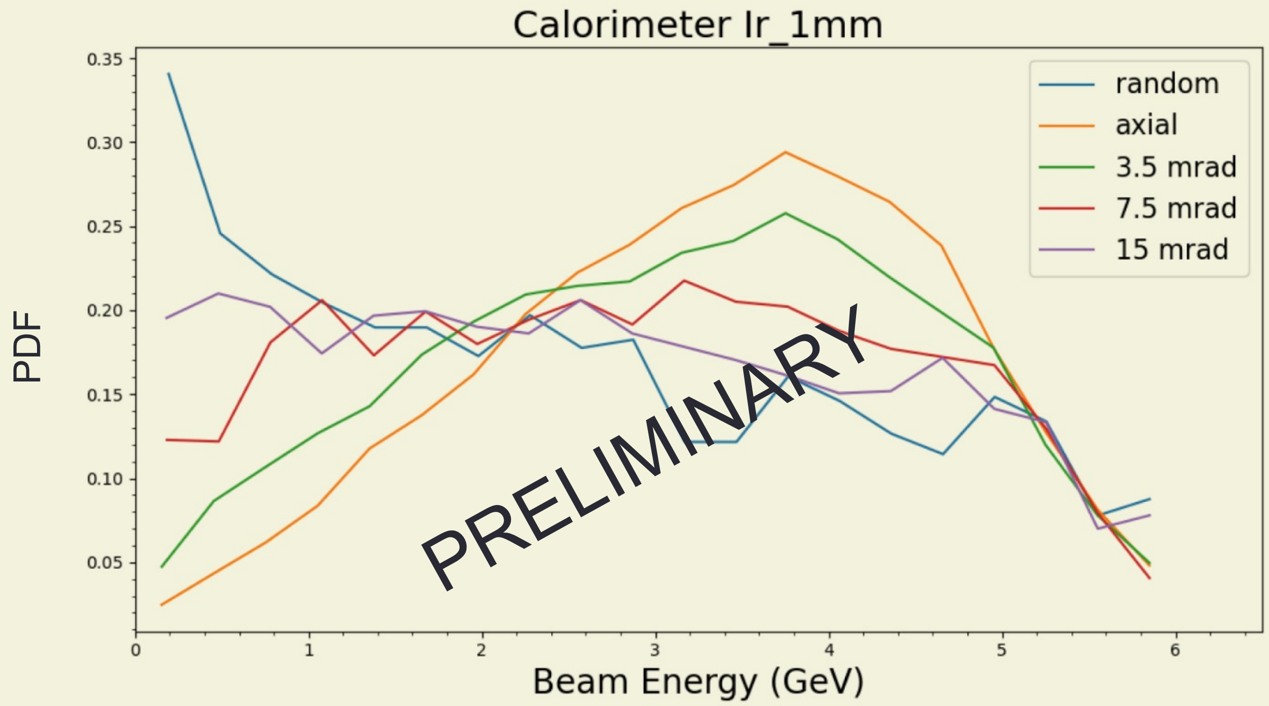


We observed continuous transition from random to aligned mode with the axis, extending **10 mrad, i e much wider the critical angle for axial channeling.**

The setup output stage: radiated energy loss

For both the **2 mm long W** **and 1 mm long Ir** aligned along the **<111> axes** and the **<110> axes,** respectively, the radiative energy loss distribution **peaks above 3.5 GeV**, while for **random orientation it vanishes** as typical for Bremsstrahlung





We observed continuous transition from random to aligned mode with the axis, extending **15 mrad, i e much wider the critical angle for axial channeling.**

August 2023 CERN PS experiment goals

- Test linear crystals with new materials at high-Z (Ir and W – see WP4); DONE
- Fully Characterize the PS e+ beam to evaluate the possibility to test in 2024/25 BC and PBC crystals; DONE
- Evaluate the possibility to work in vacuum or with He bag (to reduce MS in air), which is necessary to test in future BCs and PBCs of low-Z material and of thinner thickness; DONE
- After the characterization of the positron beam, we are planning to perform a Geant4 simulation of the experimental setup to understand which detector could be used to measure the gamma-ray peak of **CU** without being blinded by the harder channeling/bremsstrahlung radiation spectrum. ONGOING

Conclusions and future plans

- Precious information has been achieved about gamma-ray generation in LC when interaction assisted by coherent interaction under axial or quasi-axial mode.
- Important implications for next-generation high-intensity positron sources
- Future tests of BCs and PBCs featuring submillimeter width are deemed impractical at CERN PS
- **More suitable beamlines would be the CERN SPS external lines,** which offer 20-120 GeV positrons with millimeter-scale width and small divergence, suitable for TECHNO-CLS.
- **We have applied for beam time in there for the third year of TECHNO-CLS.**

Possible other future facilities for channeling experiment with positron beams

MAMI Facility
range 300-550 MeV

POSITRONS

See Werner Lauth's talk

...In future FACET-II @ SLAC
if e+ upgrade will be carried out

THANK YOU FOR YOUR ATTENTION!