Particle source and targets
Lines of research

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Particle source and targets

- Accelerator need specific devices to **produce** particles
  - Sources must be used to produce “beam” of particles
- Can be source of charged or neutral particles.

- Particles are produced from **interaction in matter**
  - i.e. photocathodes
  - Strong interplay with condensed matter physics
  - Secondary particles sources (fixed target experiments)
  - Collimators, septa, etc.

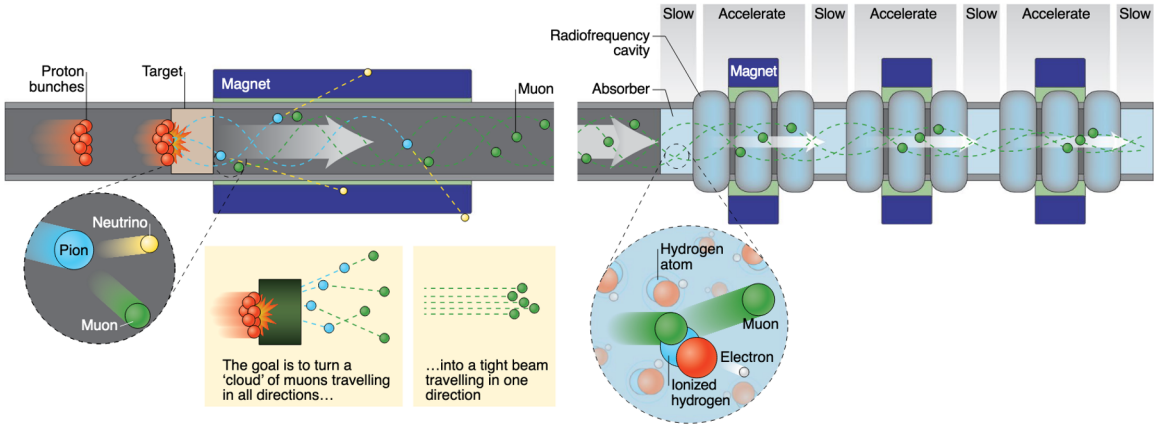
Muon collider

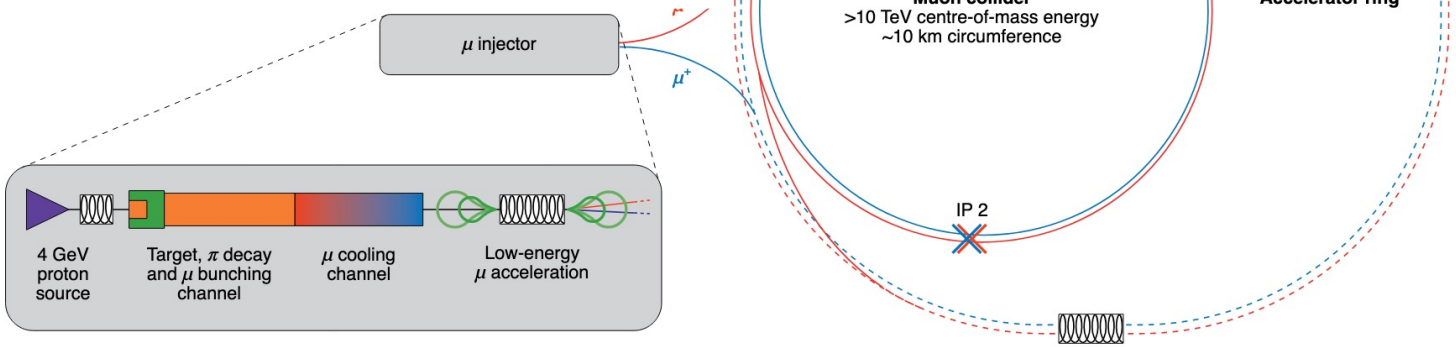
Long, K.R., Lucchesi, D., Palmer, M.A. *et al.*
Muon colliders to expand frontiers of particle physics. *Nat. Phys.* **17,** 289–292 (2021).

International MUON Collider Collaboration

R&D to design it (L= 10^{35}cm^{-2} s^{-1} , sqrt(s)= 10 TeV

Production of muons, must be a lot and with small emittance (*cooling*)



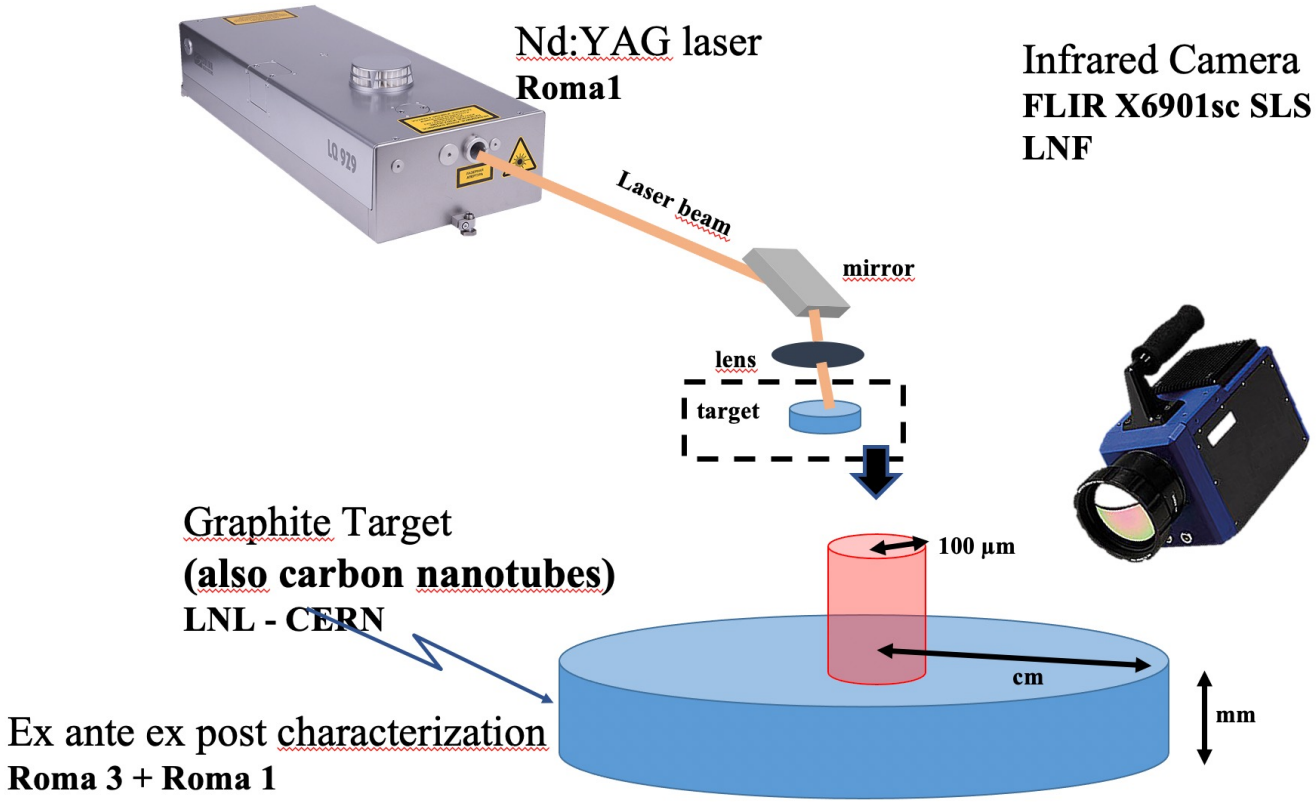


Cesarini, G., Antonelli, M., Anulli, F. *et al.* . *Int J Thermophys* **42,** 163 (2021).

Target Thermo-physics characterization

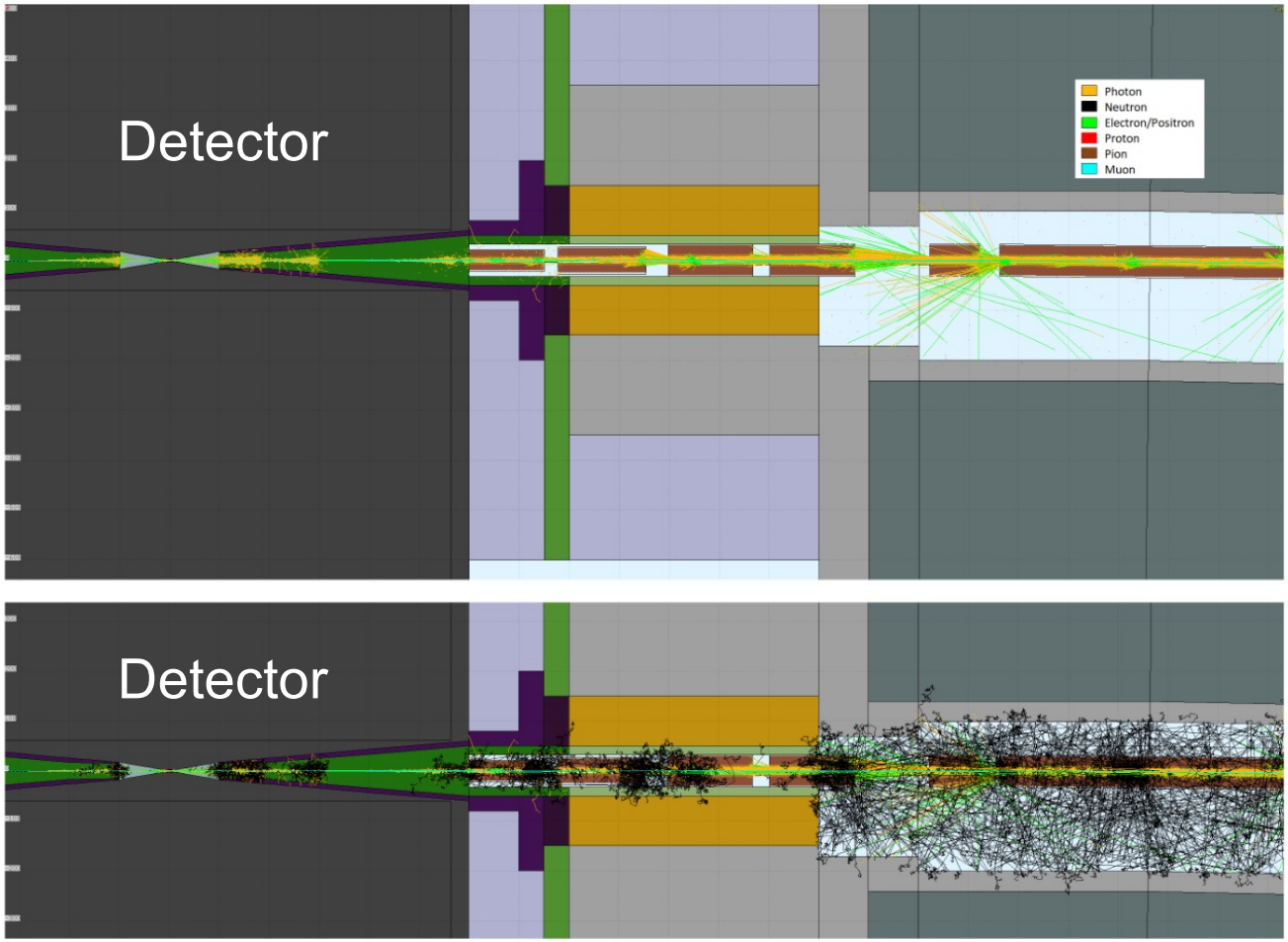
- INFN, **RD_MUCOLL** group (within the Muon collider international collaboration)

  – Study option of producing muons from positron (LEMMA)
    - Test beam at CERN
  – Study thermal properties for high power class target



F.Collamati et al https://inspirehep.net/literature/1864142

Machine detector interface

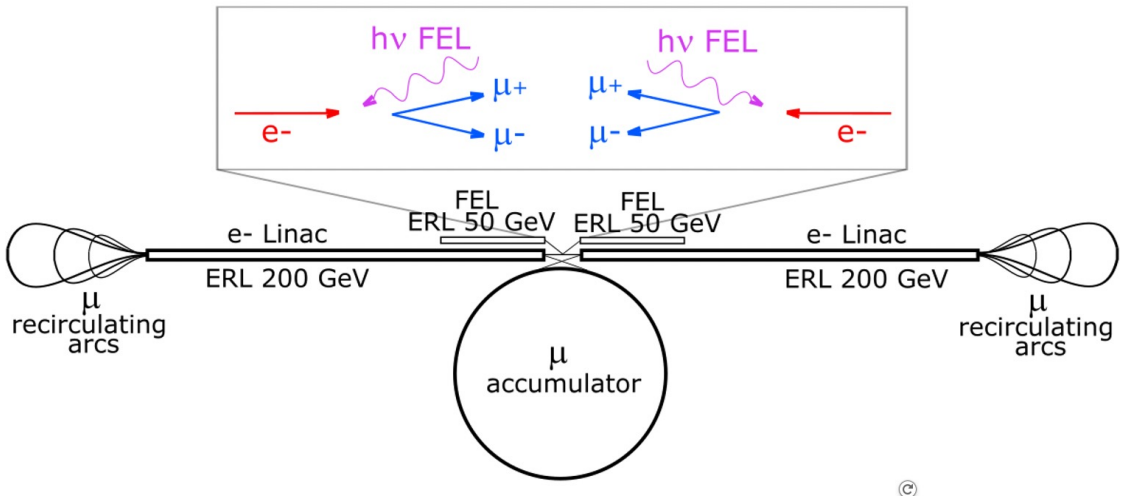


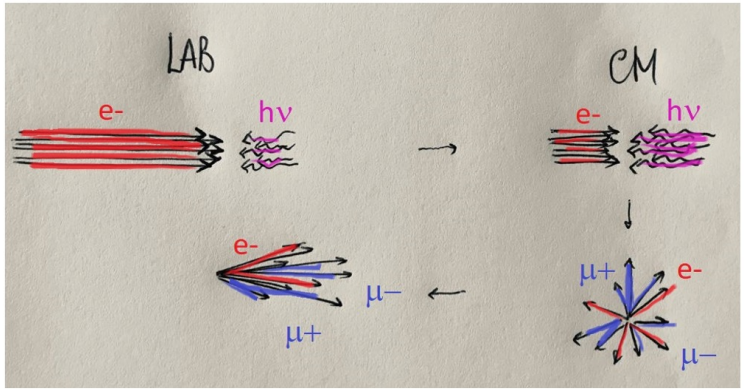
- Muon decays can represent a threat for the detector
- Design the Interaction region (simulation)

Muon production with photons

C. Curatolo and L. Serafini, arXiv:2106.03255v1

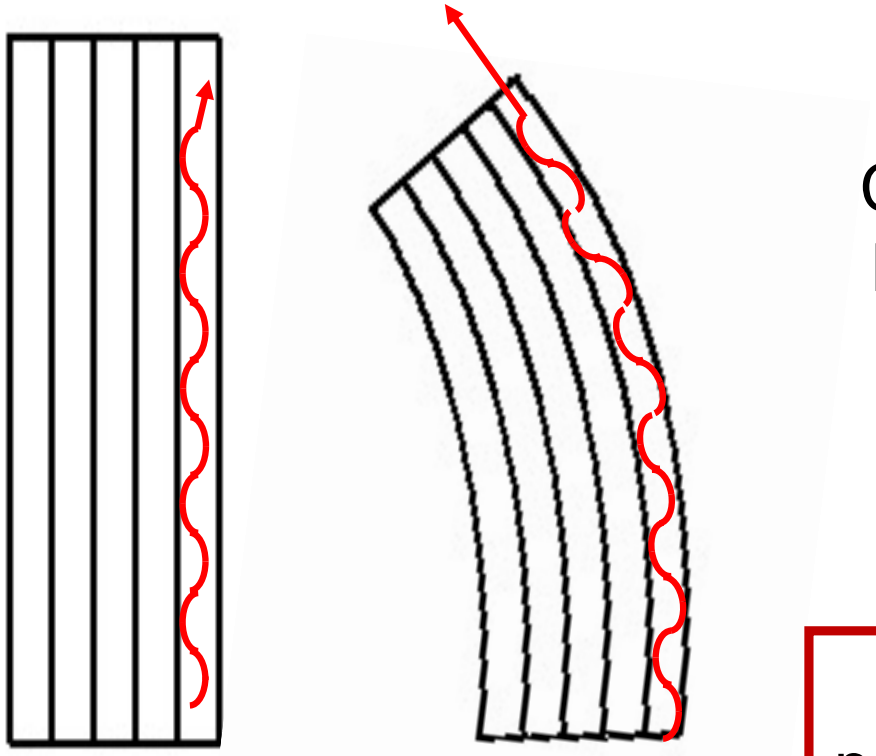
- Recently proposed





X-ray photons (150 keV) against 200 GeV electrons

Coherent interaction in crystals

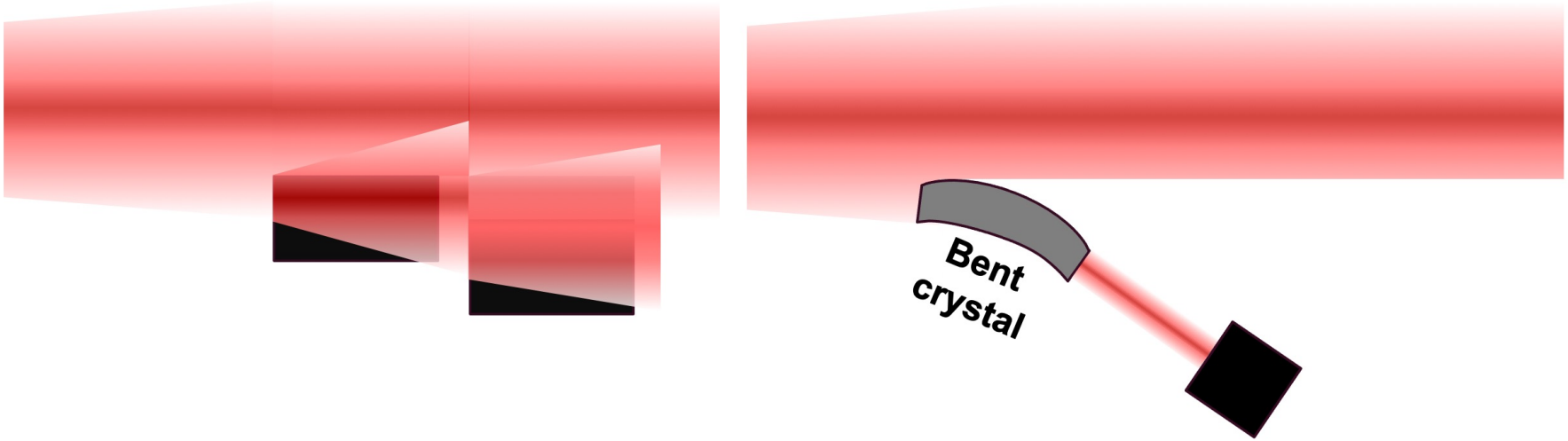


Channeling of a charged particle beam in a bent crystal results in steering of its trajectory

Bent crystals can be used in particle accelerators as collimators or as extraction elements

Crystal collimation

- Collimators in accelerators remove unwanted particles
- Crystal can concentrate losses and improve cleaning



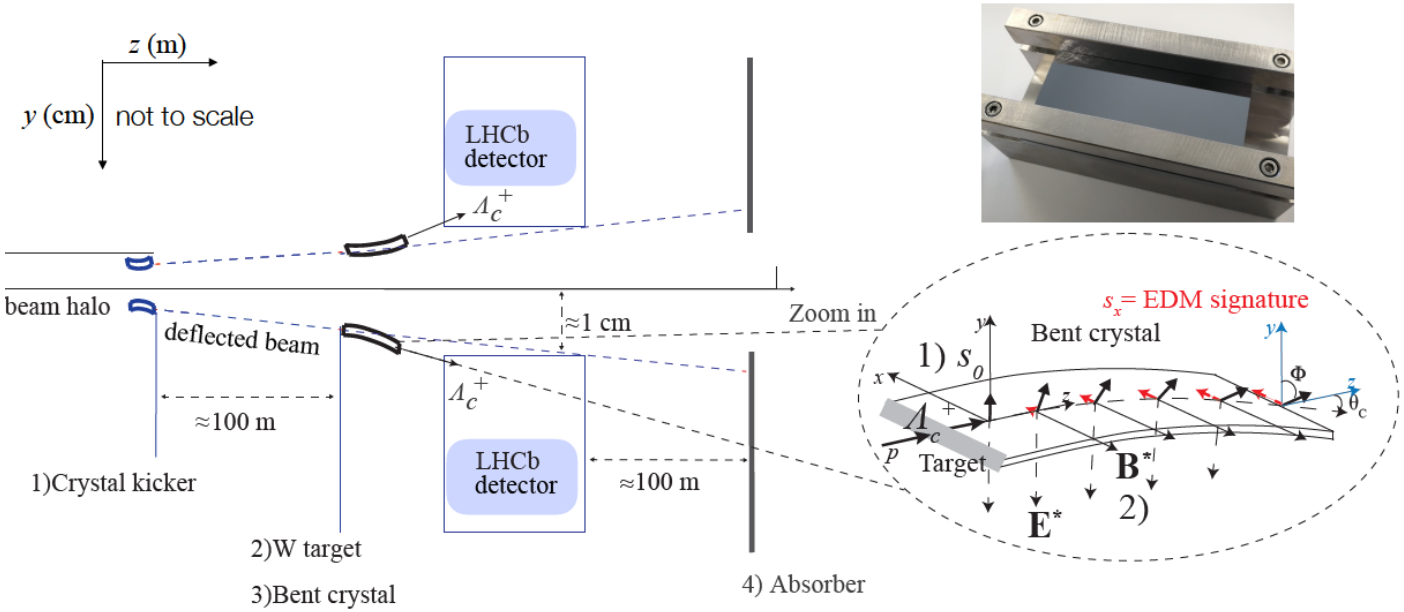
- UA9 demonstrated it at the SPS and the LHC
- Now studying **beam extraction** with crystals

A. Mazzolari et al., *Eur.Phys.J.C* 78 (2018) 9, 720

Magnetic and electric dipole moments of baryons

Novel fixed-target experiment at LHC for charm baryons

- EDM/MDM from spin precession of channeled baryons in **bent crystals**

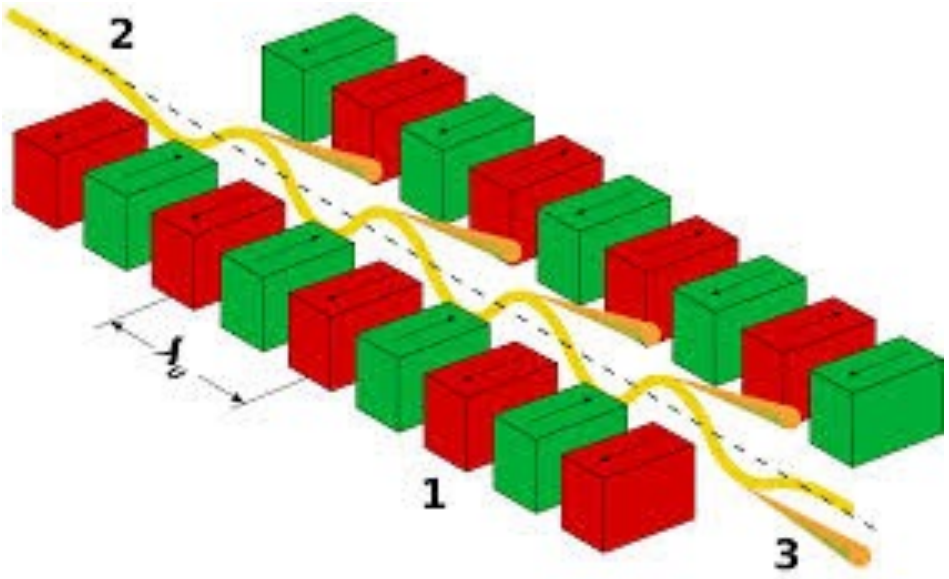


p extraction Λ_c^+ polarised production channeling spin precession event reconstruction

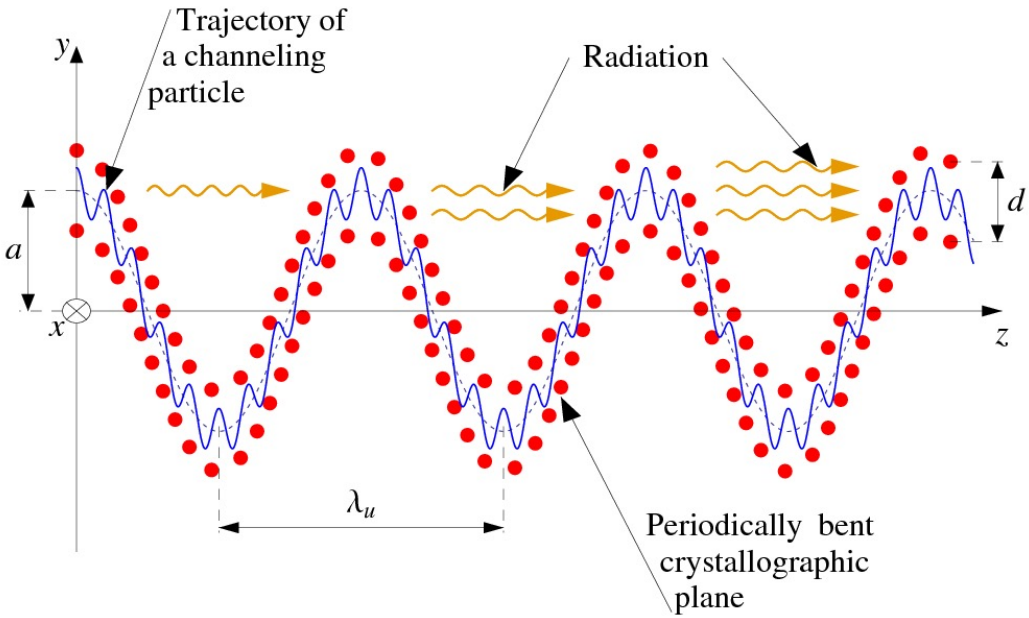
- CERN Physics Beyond collider Fixed target WG

A crystalline undulator

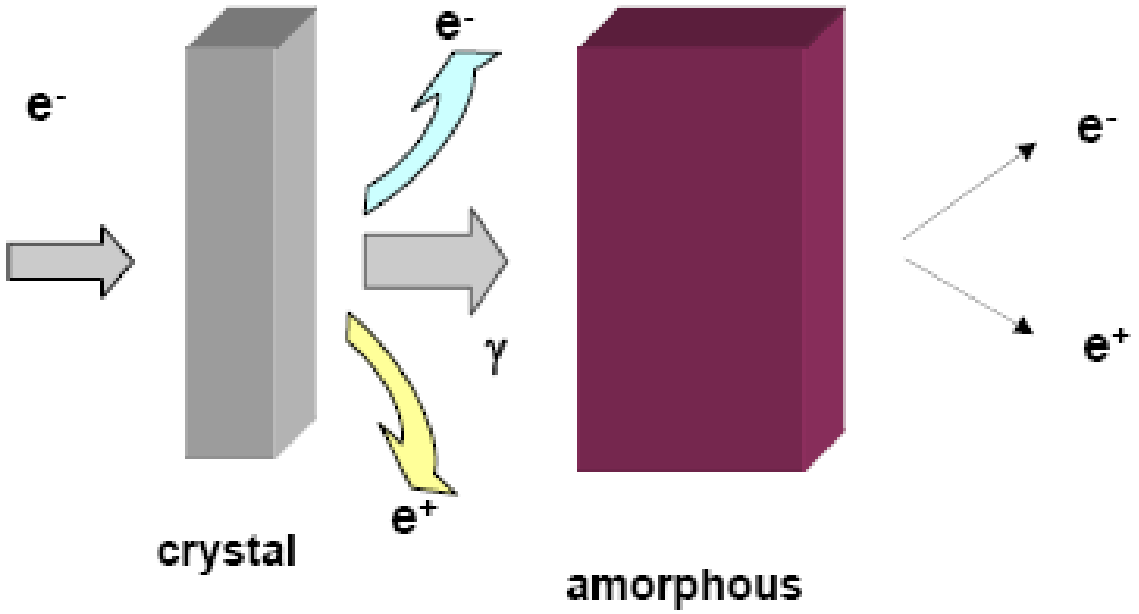
A classical scheme: FEL



Innovation: crystalline undulator



Innovative Positron sources



- Use **oriented crystal** to produce larger yield photon to be converted

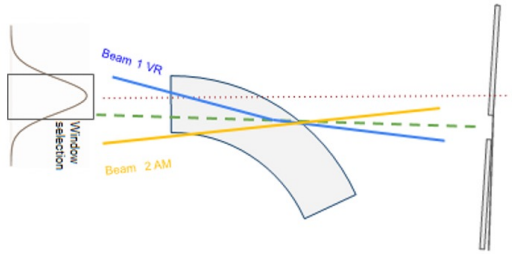
Under study for FCC positron source

Beam merging with crystals

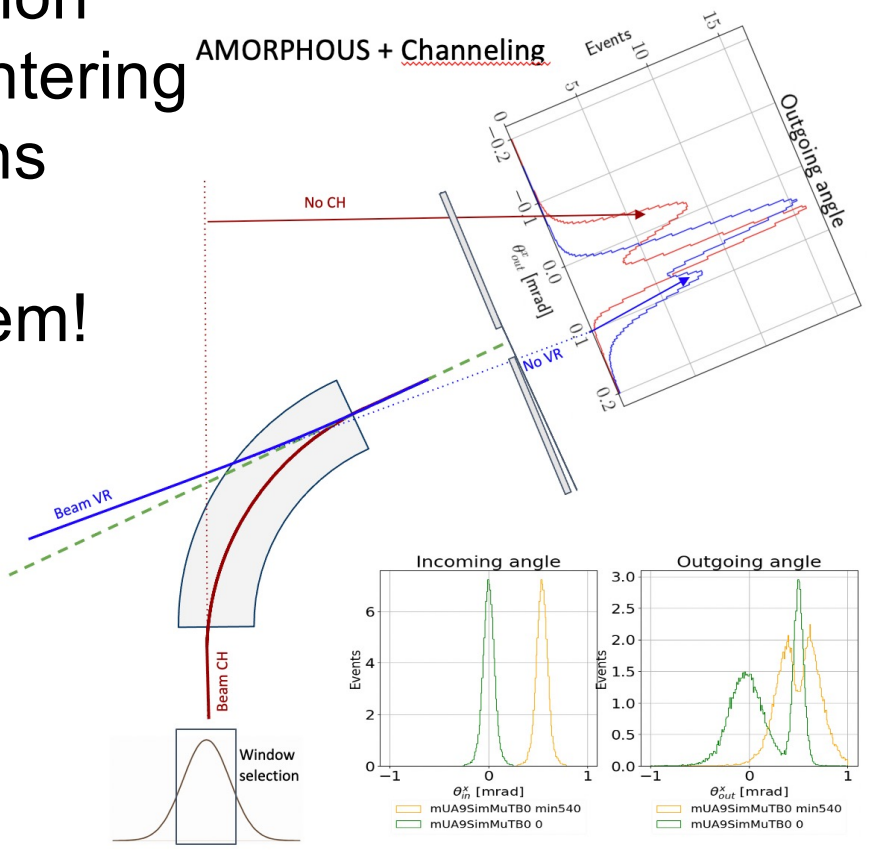
Use different coherent interaction phenomena to merge beam entering crystals from different directions

Violation of the Liouville theorem!

AMORPHOUS + Volume Reflection

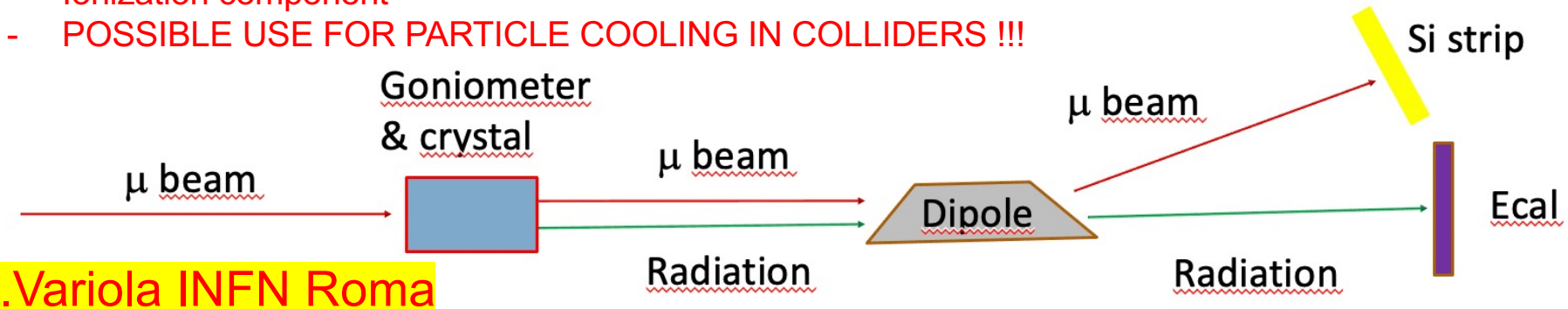


AMORPHOUS + Channeling



Experiments at CERN of crystal characterization

- Extracted lines of SPS (North Area)
  - Measure of the muon energy losses:
  - Radiative component
  - Ionization component
  - POSSIBLE USE FOR PARTICLE COOLING IN COLLIDERS !!!



A.Variola INFN Roma

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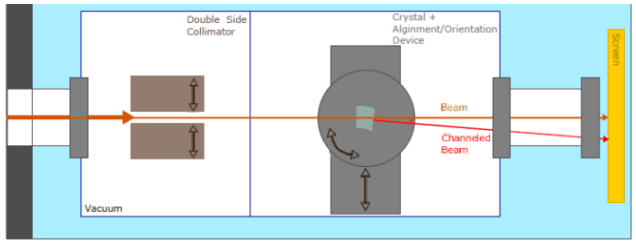
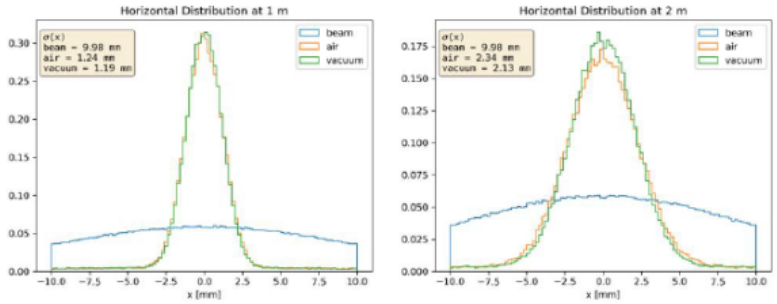
EXPERIMENT @ CNAO: PROTONS AND IONS AT LOW ENERGY In CRYSTALS--> FUNDAMENTAL TEST FOR CRYSTALS IN MEDICAL SCIENCE.

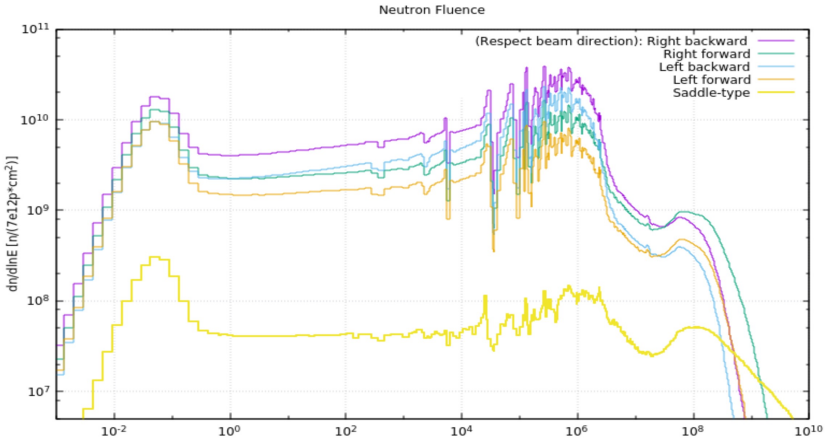
- Collimator gap (1mm vs 2mm)
- Energy (120 vs 400 A MeV)
- Single vs double collimator (2 set of 25 mm long jaws, 50 cm apart)
- Vacuum vs air

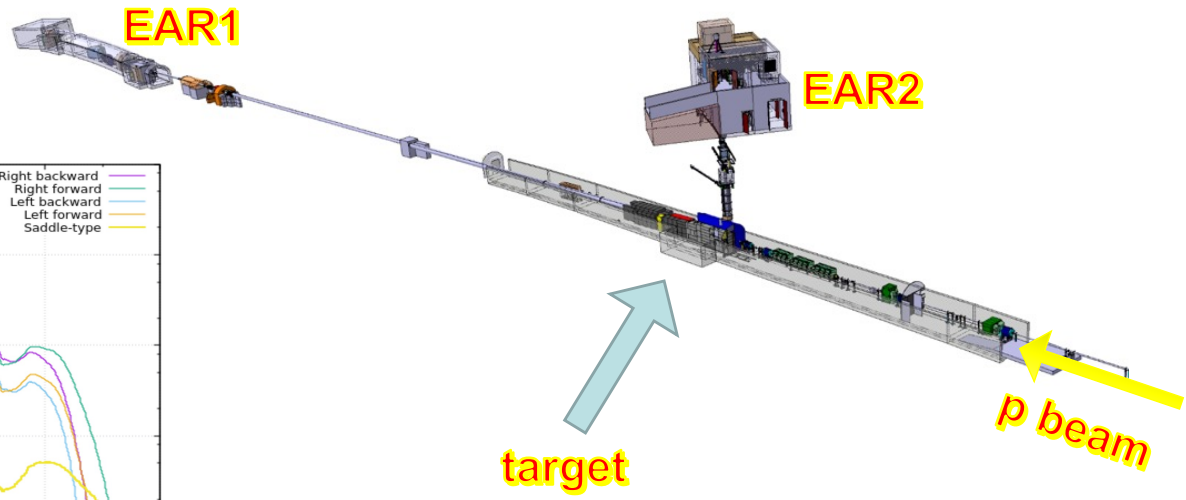




The CERN nTOF neutron production facility

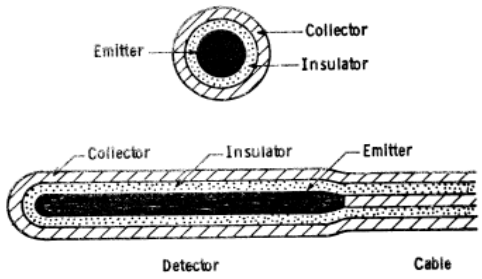
- The **nTOF experiment at CERN** exploits the 20 GeV PS proton beam interaction with a **lead target**, to produce neutrons by **spallation**.
- Neutron spectrum close to the target has a wide **energy spectrum up to hundred MeV** and a long tail down to thermal neutrons

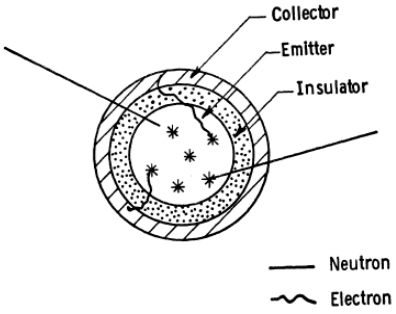


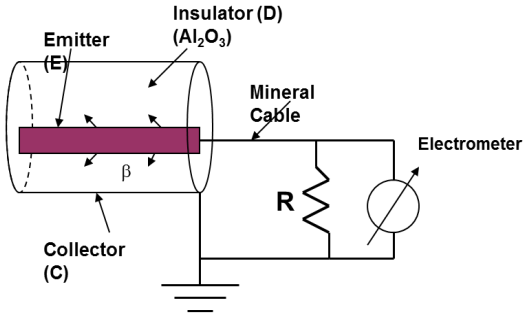


Self Powered neutron detector for fast neutrons

- **Self Powered (Neutron) Detectors** (SPNDs) are **rugged miniature** devices used for **fixed in-core reactor monitoring** both for safety purposes and neutron and gamma flux mapping.operate **without any bias voltage**







Design and commissioning of SPND at CERN

Particle production, particle interaction, particle monitoring

- Many and diverse opportunites for PhD projects

- Interplay between condensed matter physics, material science and accelerator physics extremely interesting
- International collaborations with activities mainly at CERN