Facilities for in-beam detector tests at INFN LABEC accelerator

Massimo Chiari / *I.N.F.N. Firenze*

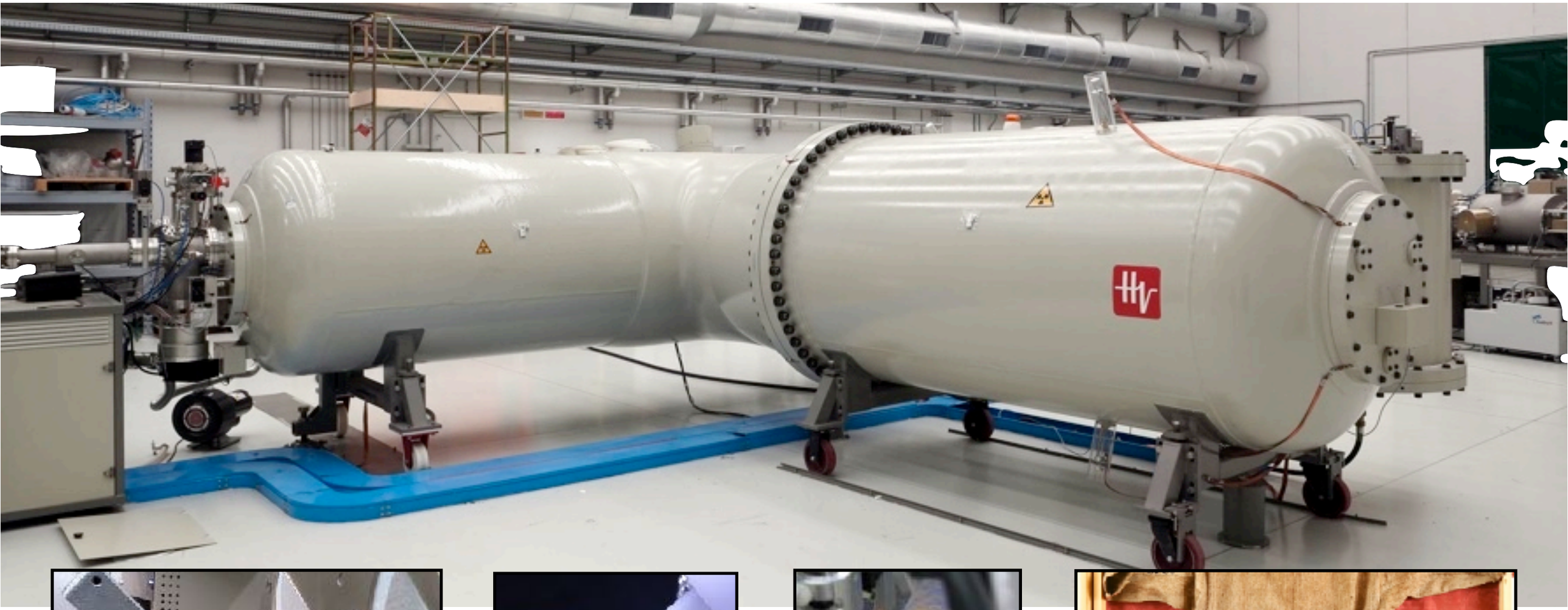
chiari@fi.infn.it

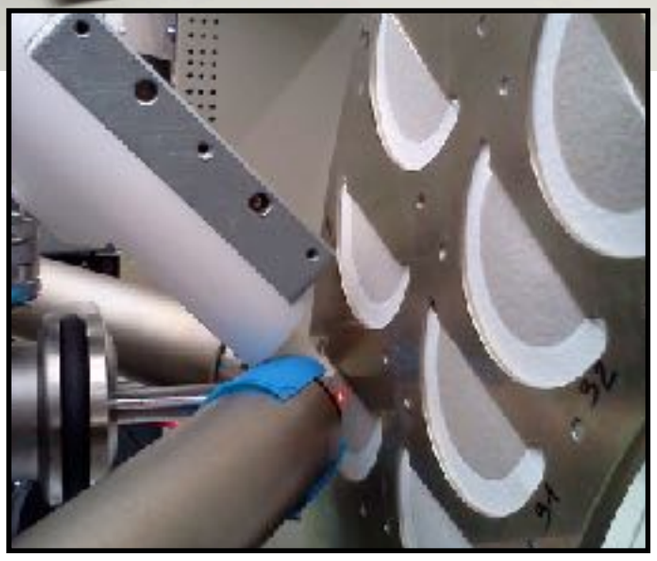
max0068

GRIT 2019
9-11 October 2019, GGI, Florence (Italy)

INFN LABEC
Istituto Nazionale di Fisica Nucleare
Laboratorio di tecniche nucleari per l'Ambiente e i Beni Culturali

LABEC, Laboratory of Nuclear Techniques for the Environment and Cultural Heritage

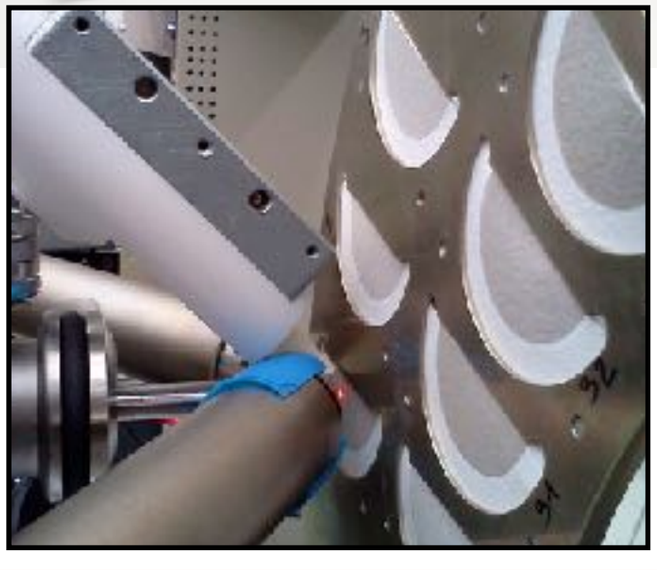




LABEC, Laboratory of Nuclear Techniques for the Environment and Cultural Heritage

ION BEAM ANALYSIS

elemental analysis
thin films
depth profiling
imaging
ambient pressure



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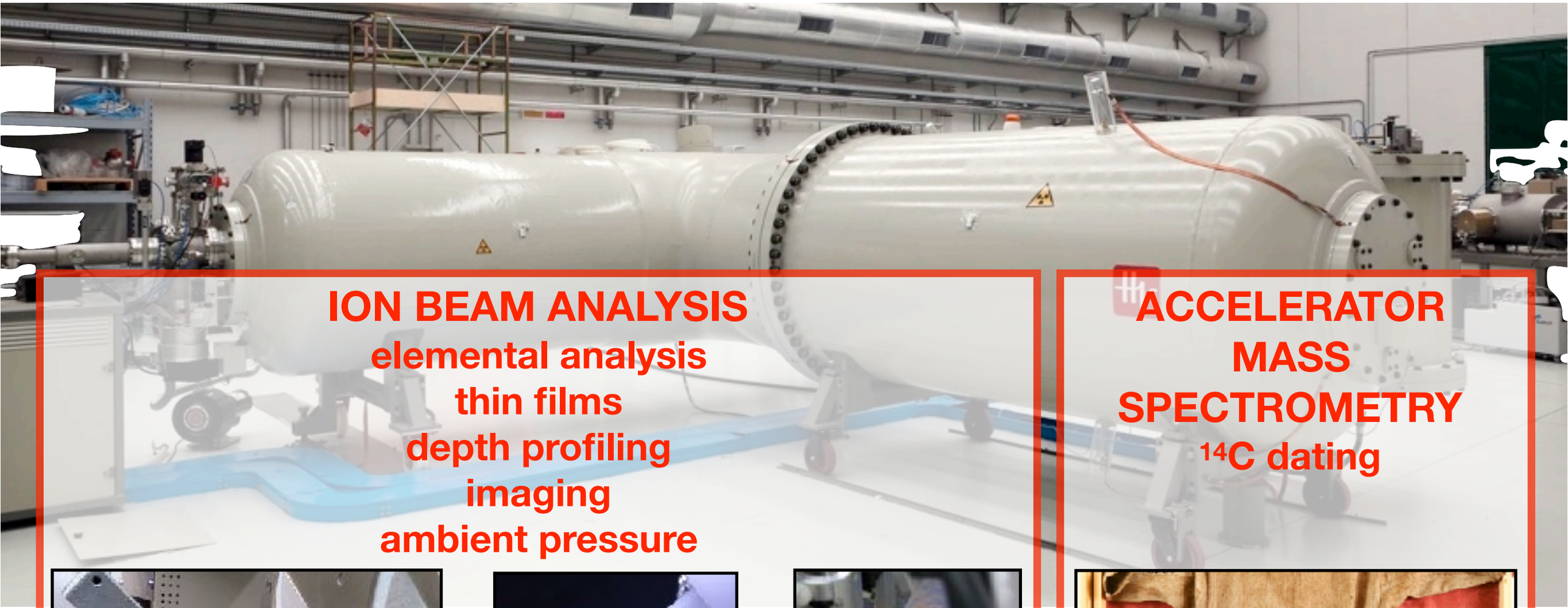

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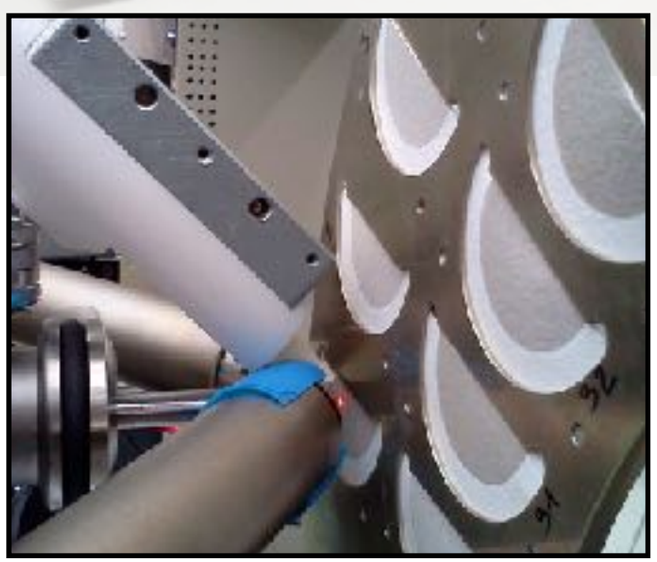
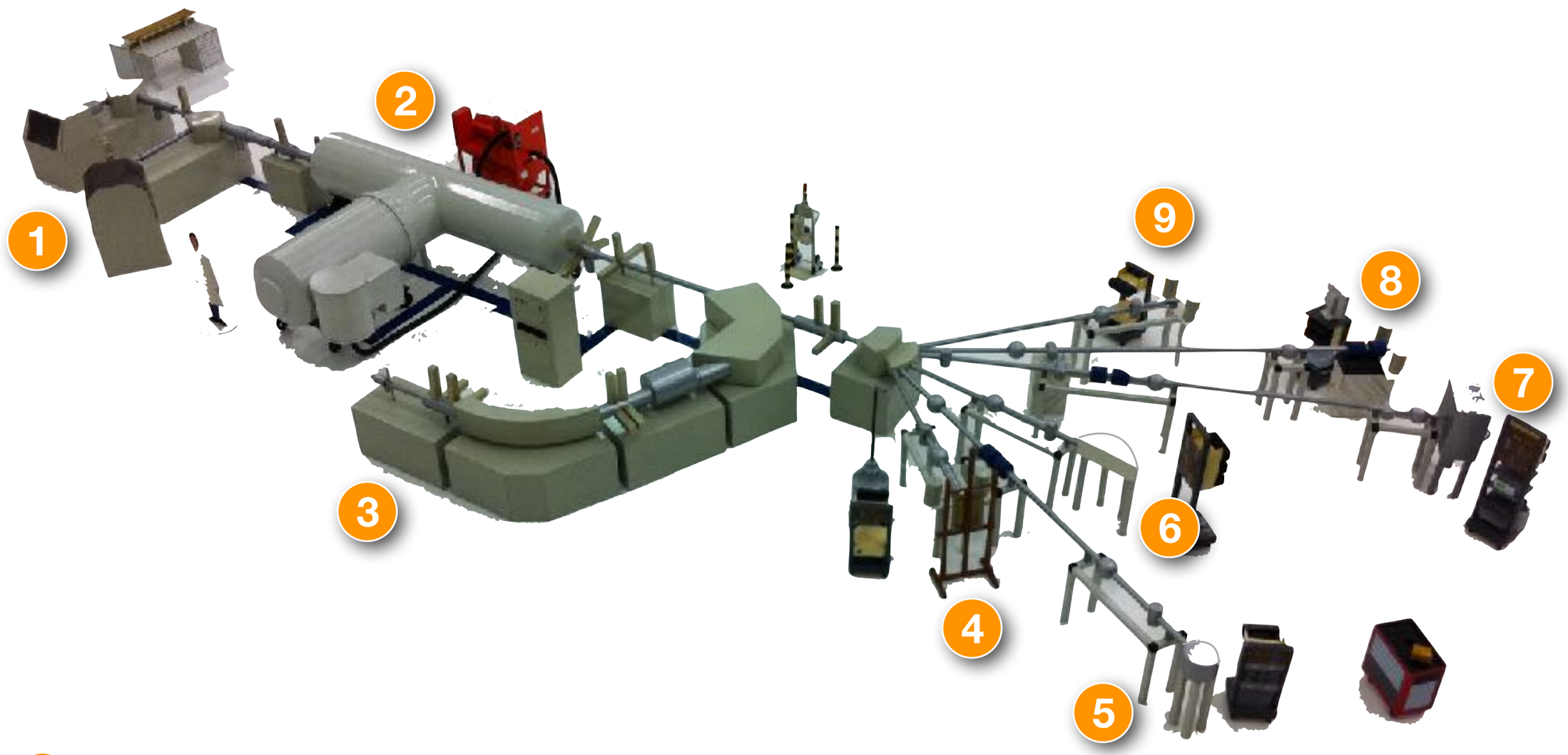


ACCELERATOR MASS SPECTROMETRY

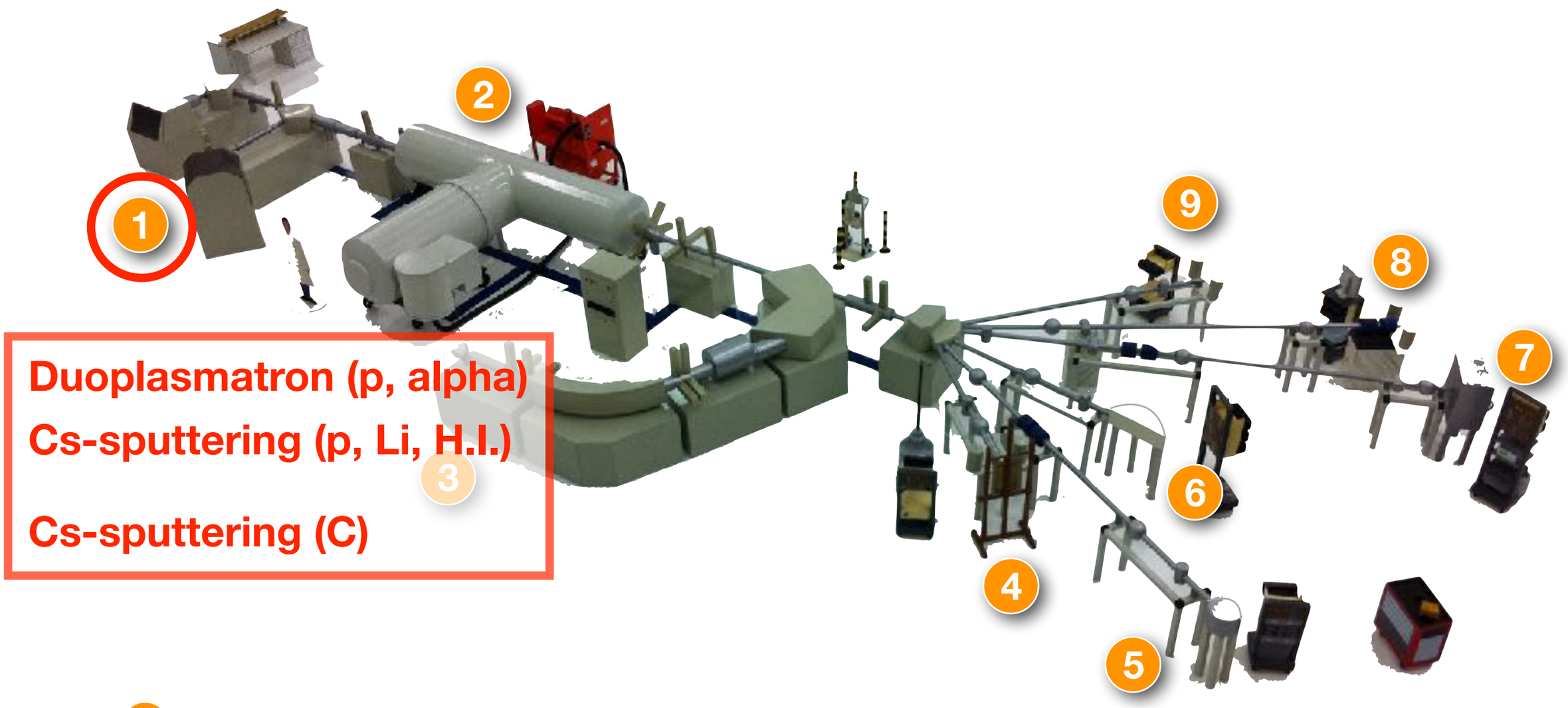
^{14}C dating

The INFN LABEC laboratory in Florence



1. Ion sources
2. 3MV Tandetron accelerator
3. AMS beamline
4. External beam (cultural heritage)
5. IBA scattering chamber
6. Irradiation beamline (in progress)
7. Pulsed beam (DEFEL)
8. External microprobe
9. External beam (aerosol)

The INFN LABEC laboratory in Florence



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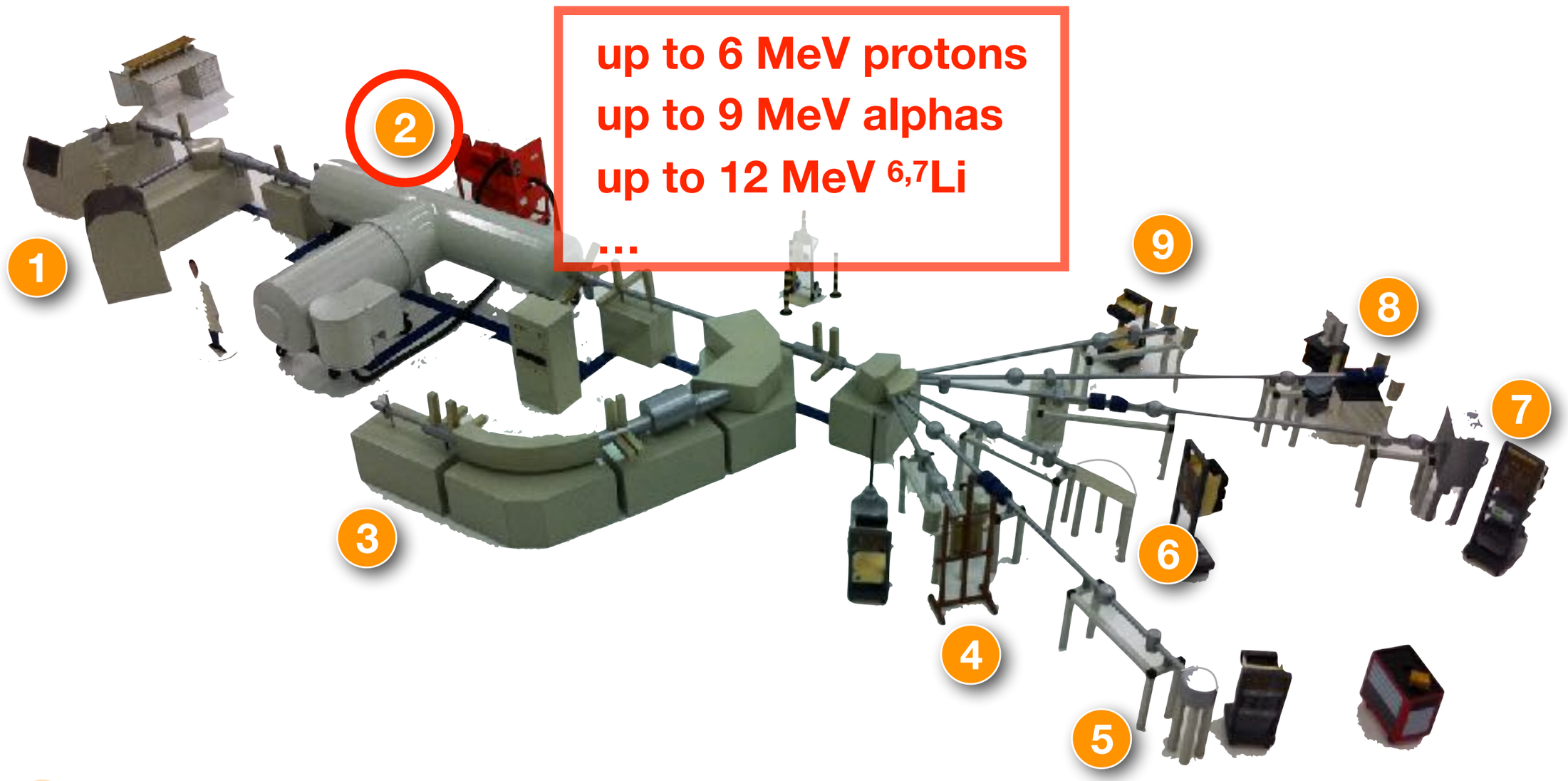

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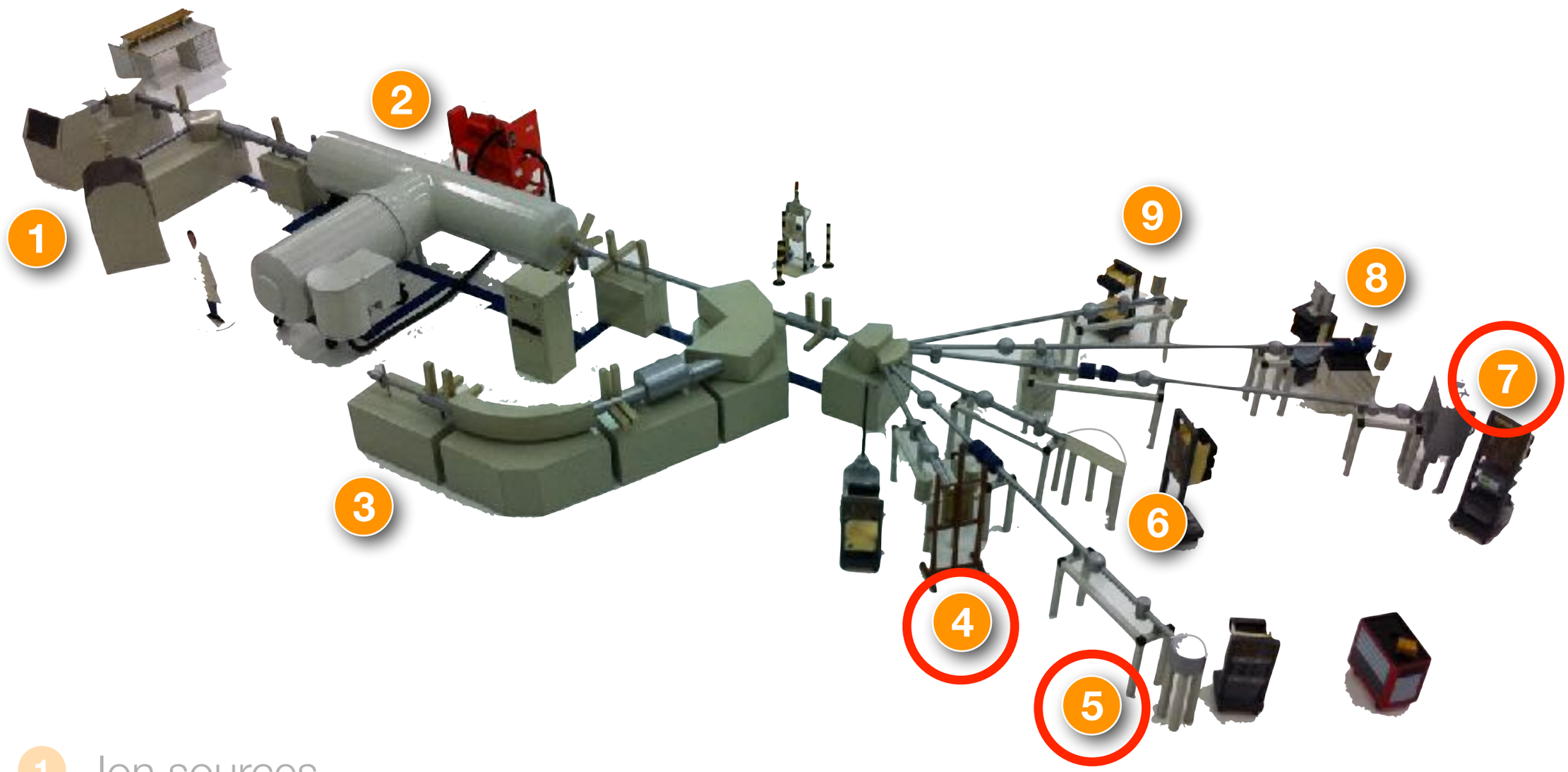

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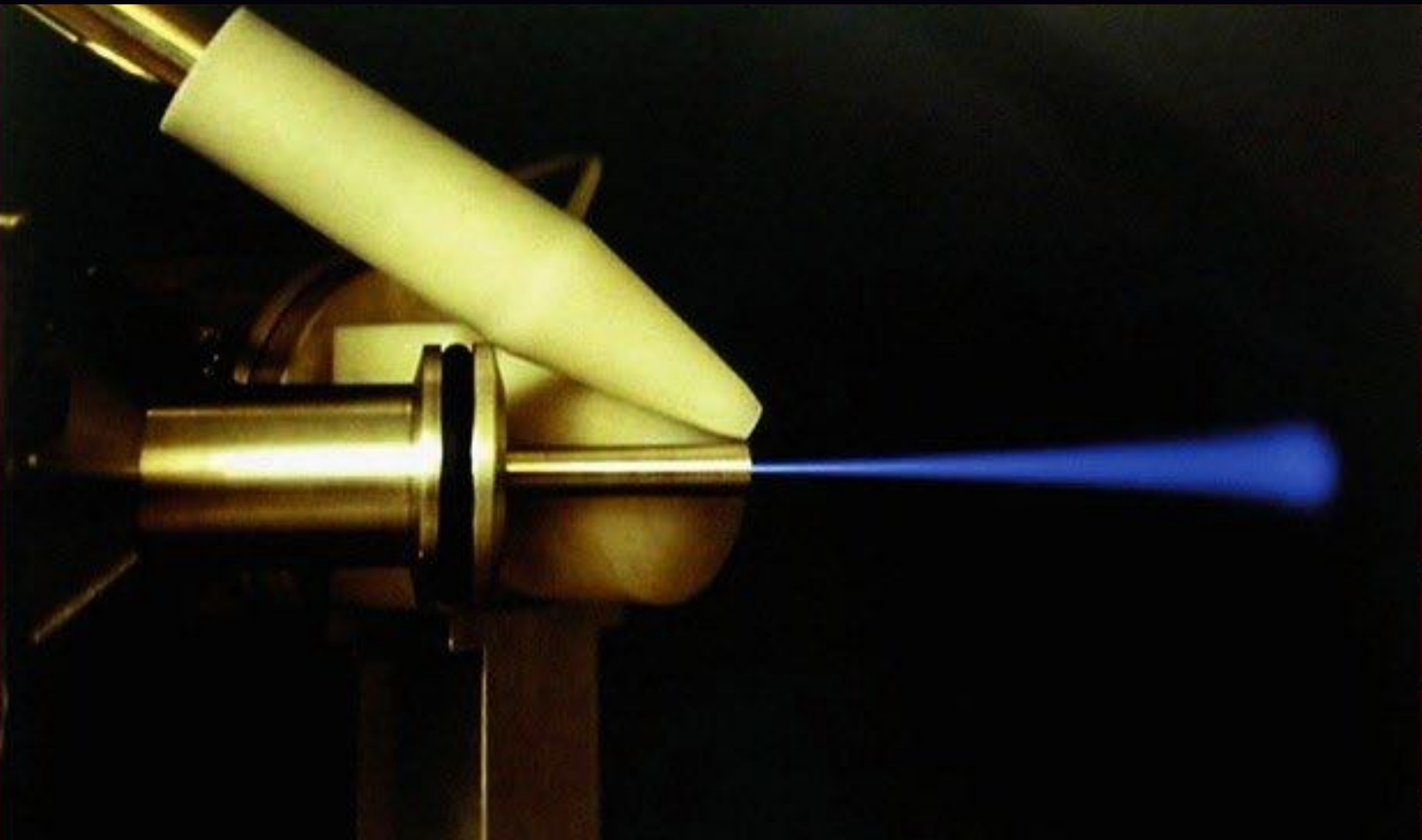
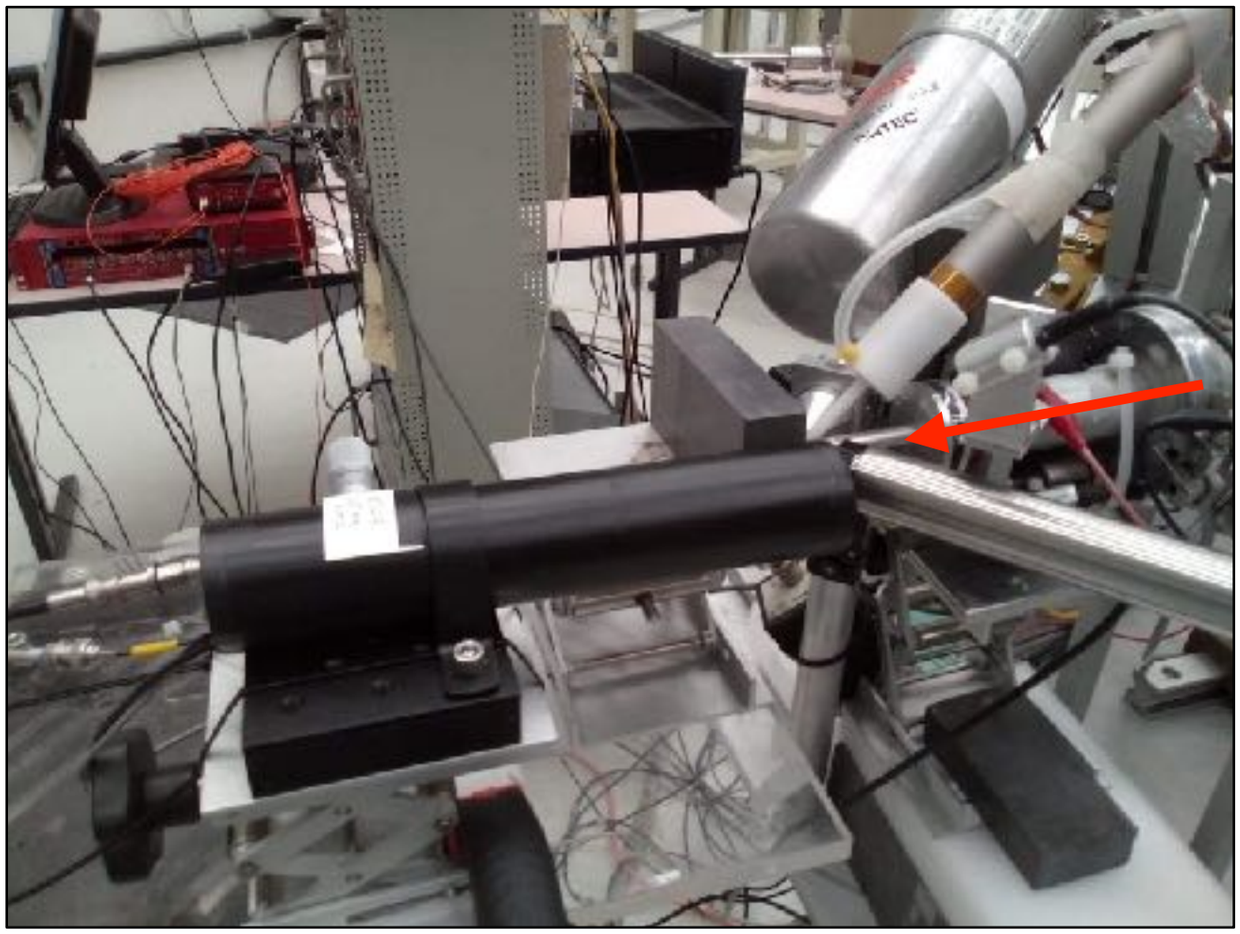
Proton beam extract into ambient pressure



LNL/TIFPA

Ion beam measurements: @LABEC

Tests of scintillation yield in low current conditions of organic scintillators
@LABEC facility (INFN, Sez. di Firenze)



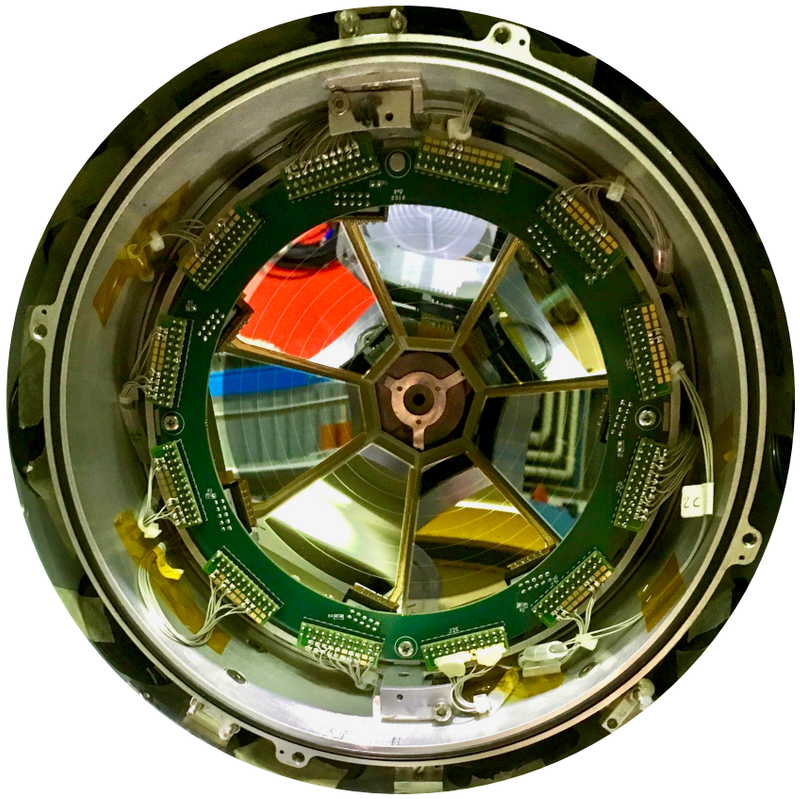
H^+ Beam energy: 5 MeV
Current 0.5 fA (very low)
Spot size 0.25×0.25 mm^2
Fluence ≈1.6×10^6 p/cm^2 s

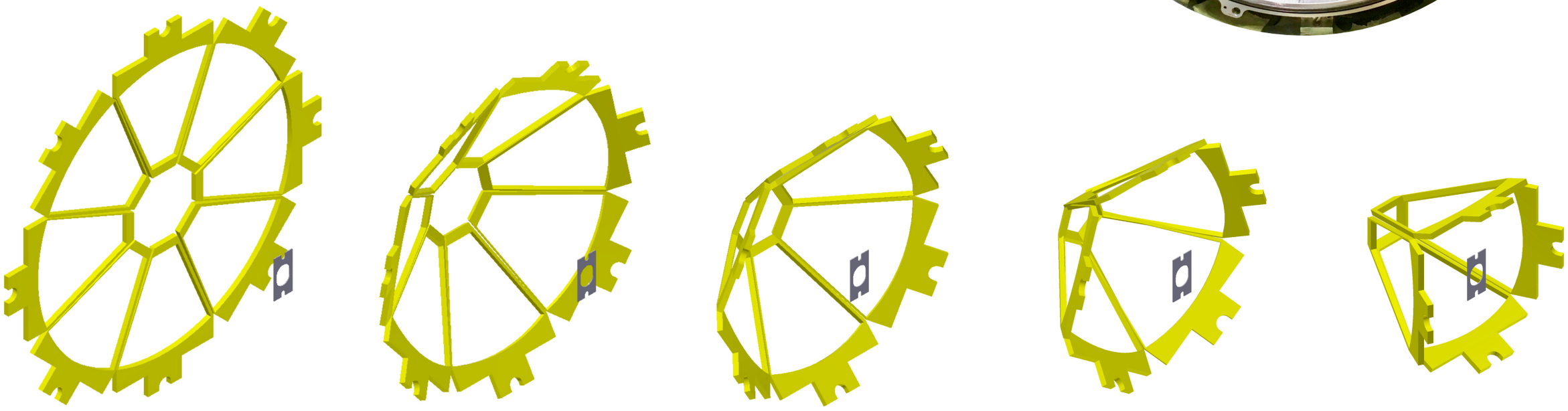
Operation in air

courtesy of B. Fraboni, UniBO & INFN BO

SPIDER: the Silicon PIe DEtectoR

- Modular silicon detector array for low-energy Coulomb excitation measurements
- Composed by independent sectors, 8 strips + guard ring
- Detector thickness ~ 300 μm, dead layers ~ 50 nm in the junction (front) side and ~ 350 nm in the ohmic (rear) side
- Cone configuration (7 sectors) at backward angles: 8.5 cm from the target ⟹ ΔΘ = 37.4°, Ω/4π = 17.3%



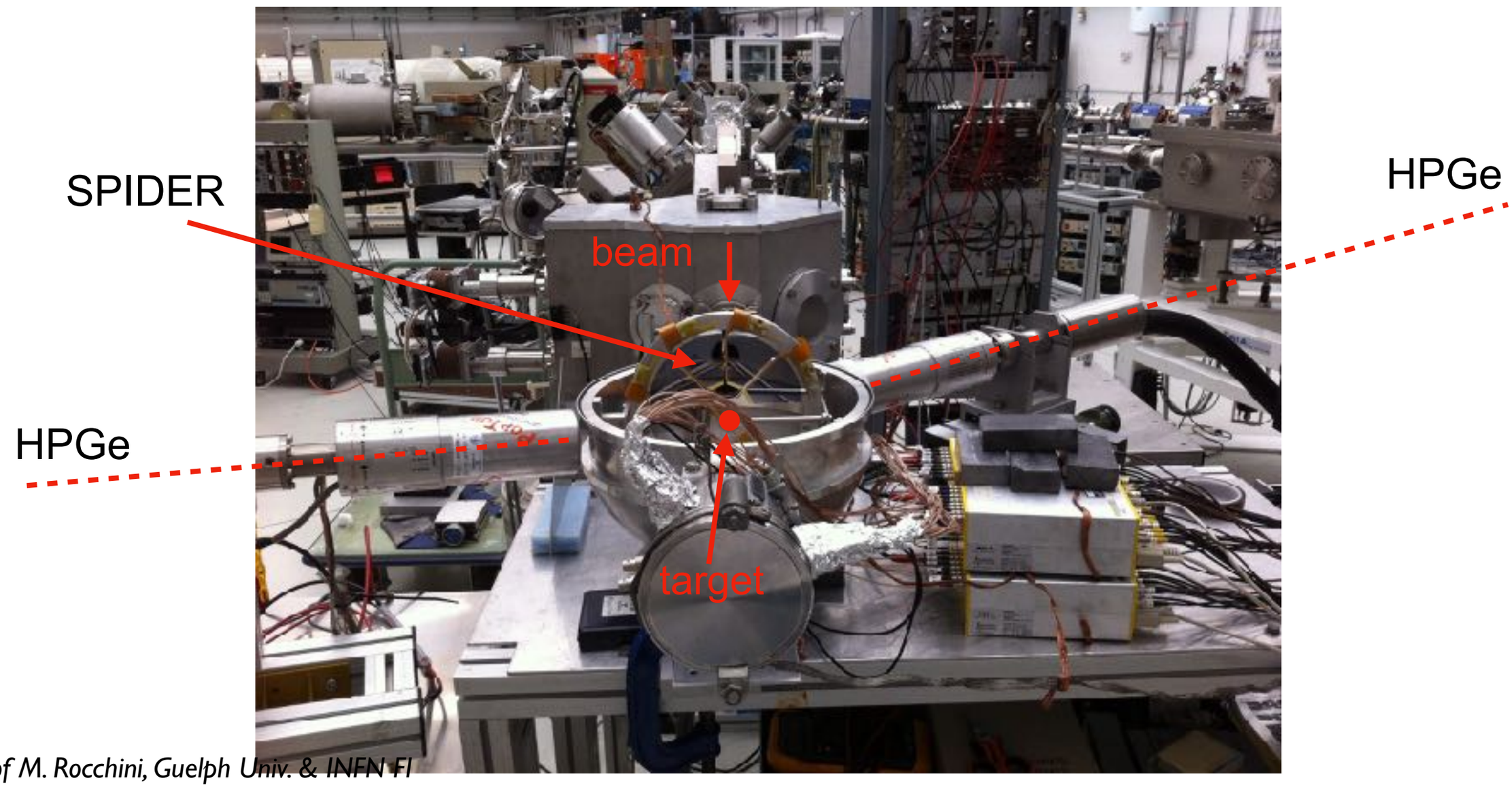


N_d = 8 N_d = 7 N_d = 6 N_d = 5 N_d = 4

courtesy of M. Rocchini, Guelph Univ. & INFN FI

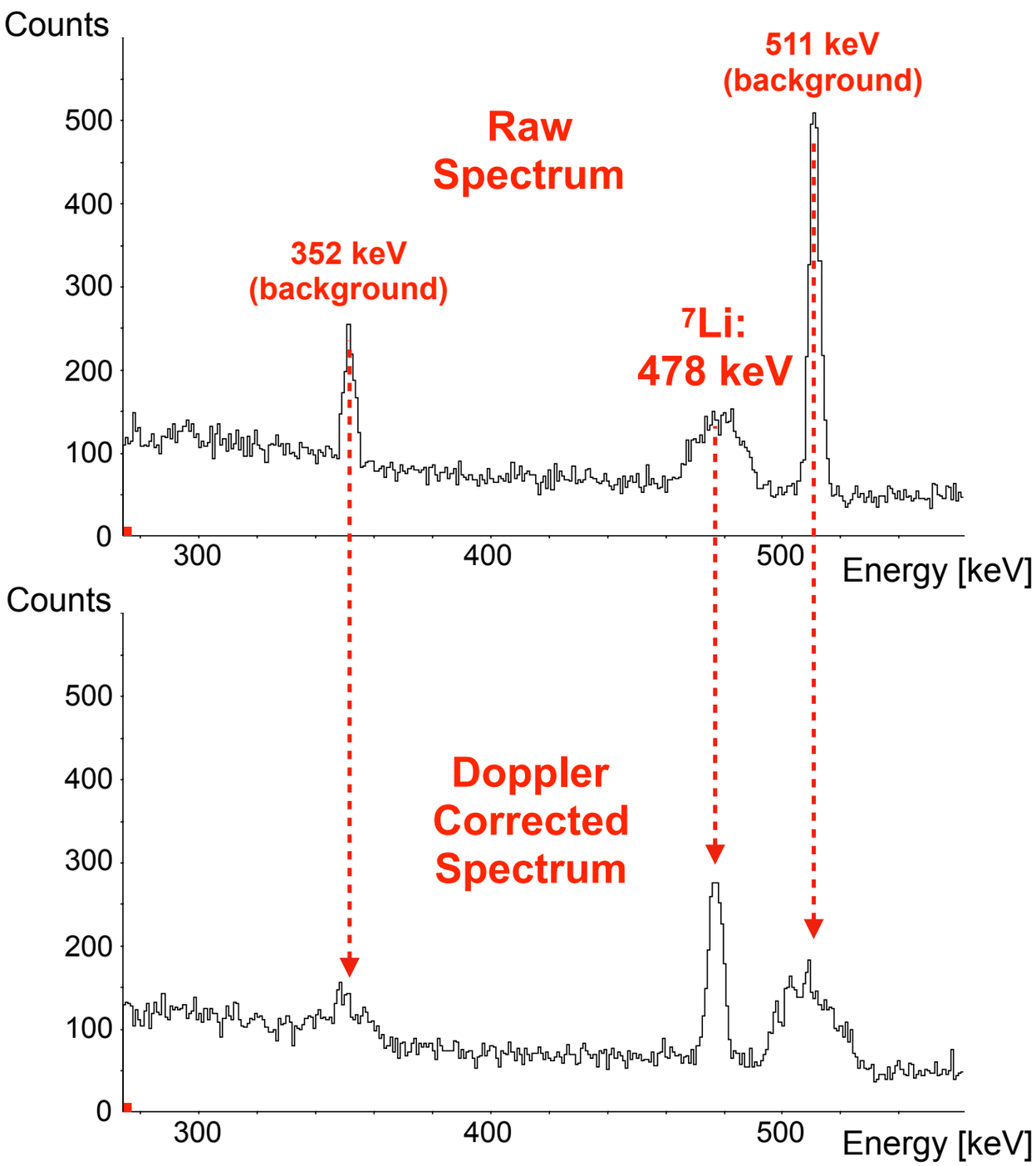
SPIDER: first in-beam commissioning

- ^{7}Li @ 6 MeV on 0.5 mg/cm^2 ^{27}Al target (Coulex safe energy @ 180° = 6.35 MeV)
- 4 SPIDER sectors (backward angles) + 2 HPGe detectors
- 31 h of beam time (intensity ~1 pnA)

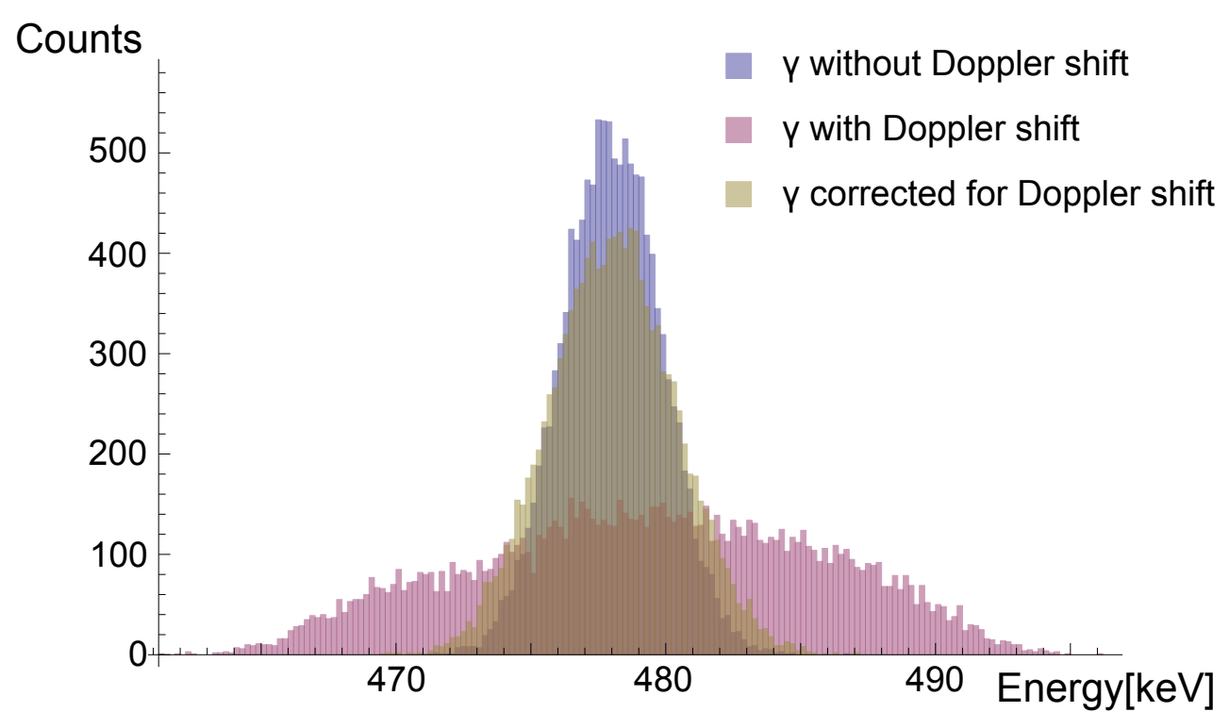


courtesy of M. Rocchini, Guelph Univ. & INFN FI

SPIDER: test of doppler correction capabilities and Monte Carlo simulations



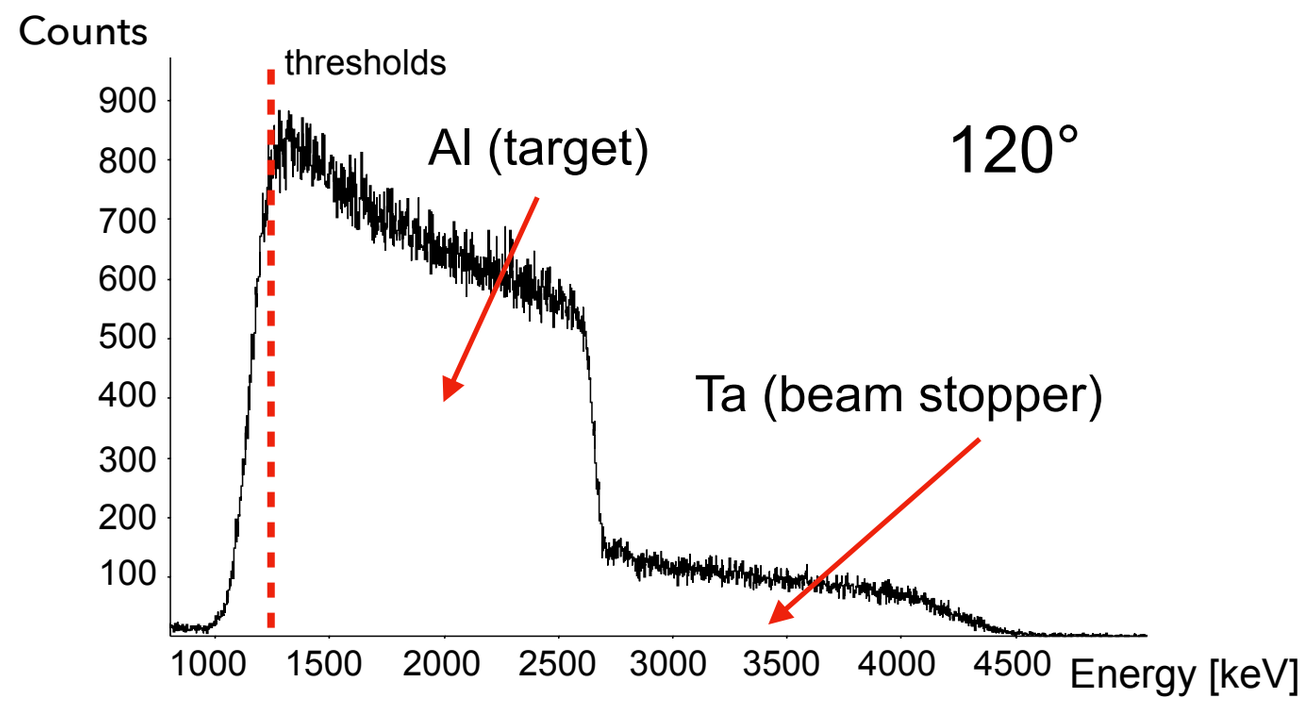
- Gamma spectra: 478 keV from the first excited state ($1/2^- \rightarrow 3/2^-$)
- Random coincidences: natural background
- Doppler correction: from FWHM = 18.4 keV to FWHM = 5.7 keV (HPGe intrinsic FWHM @ 478 keV = 4.3 keV)
- Simulations: FWHM after Doppler correction = 5.3 keV



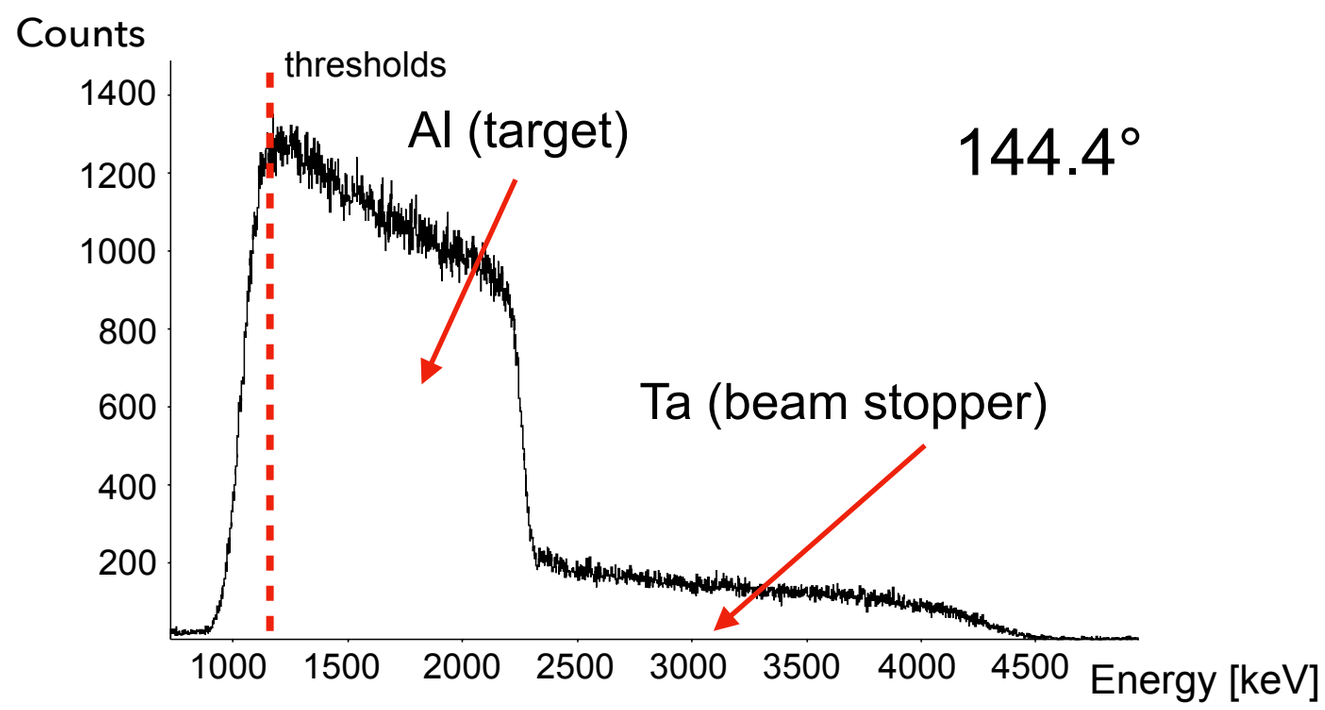
courtesy of M. Rocchini, Guelph Univ. & INFN FI

SPIDER: particle energy spectra

- Several SPIDER strips acquired in single mode
- Backscattered protons at different angles (from ~ 120° to ~150°)
- Measurement of the in-beam energy resolution and kinematic reconstruction



After the LABEC commissioning SPIDER has been used @ LNL as an ancillary device of GALILEO for Low-energy Coulomb excitation measurements.
3 experiments have been successfully performed, 2 are approved and will be soon scheduled. Several LoI for the use of the detector with AGATA and SPES @LNL have been presented.

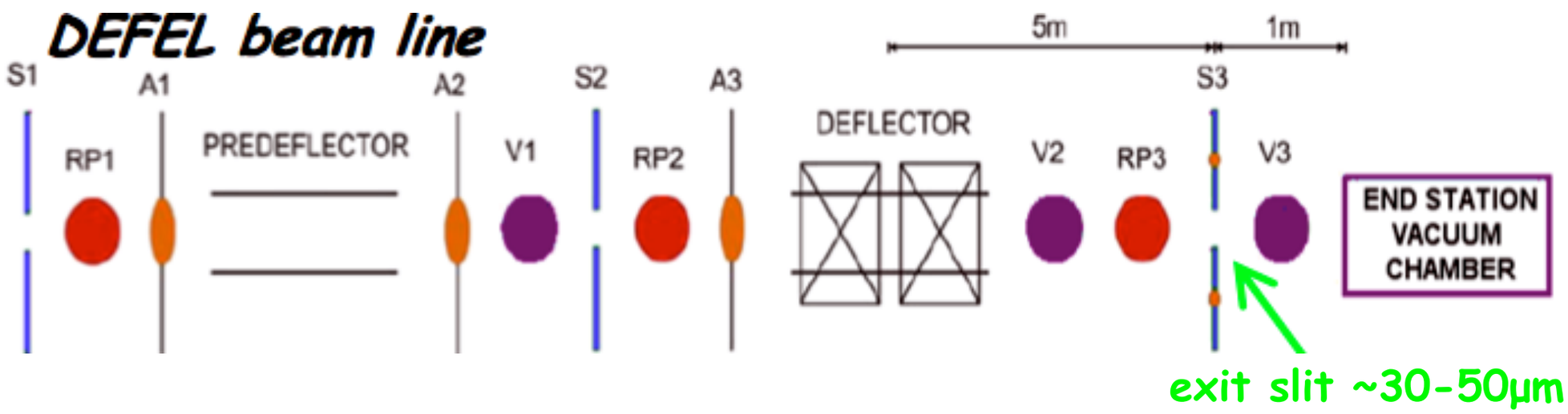


courtesy of M. Rocchini, Guelph Univ. & INFN FI

Pulsed beam line facility DEFEL

Pulsed beam facility (DEFEL) for irradiation of devices and tests of large area detectors with a wide range of ions and with even ultra-weak doses

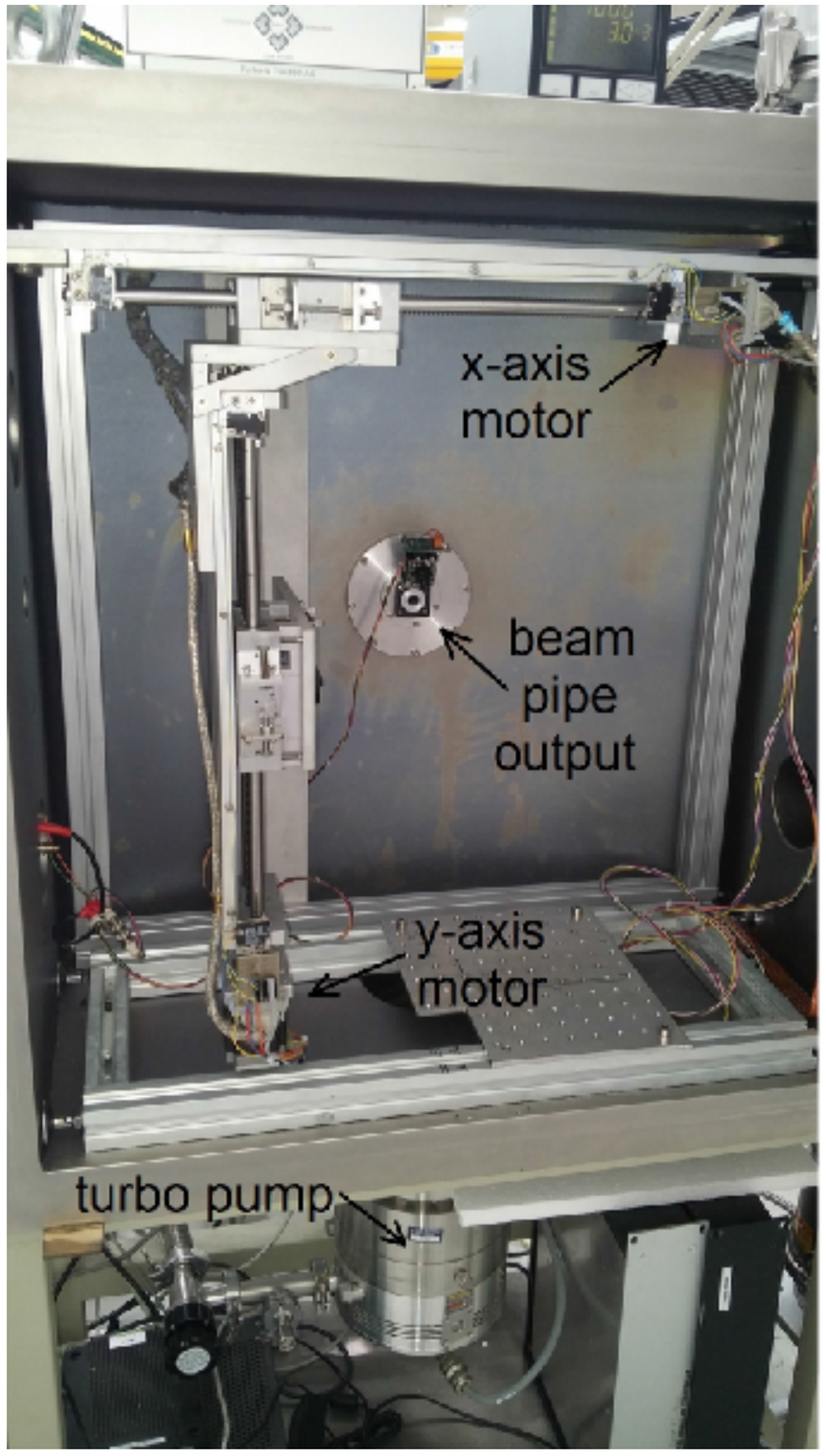
Fast electrostatic chopper deflects the beam across a slit to generate bunches of monoenergetic (even single) ions

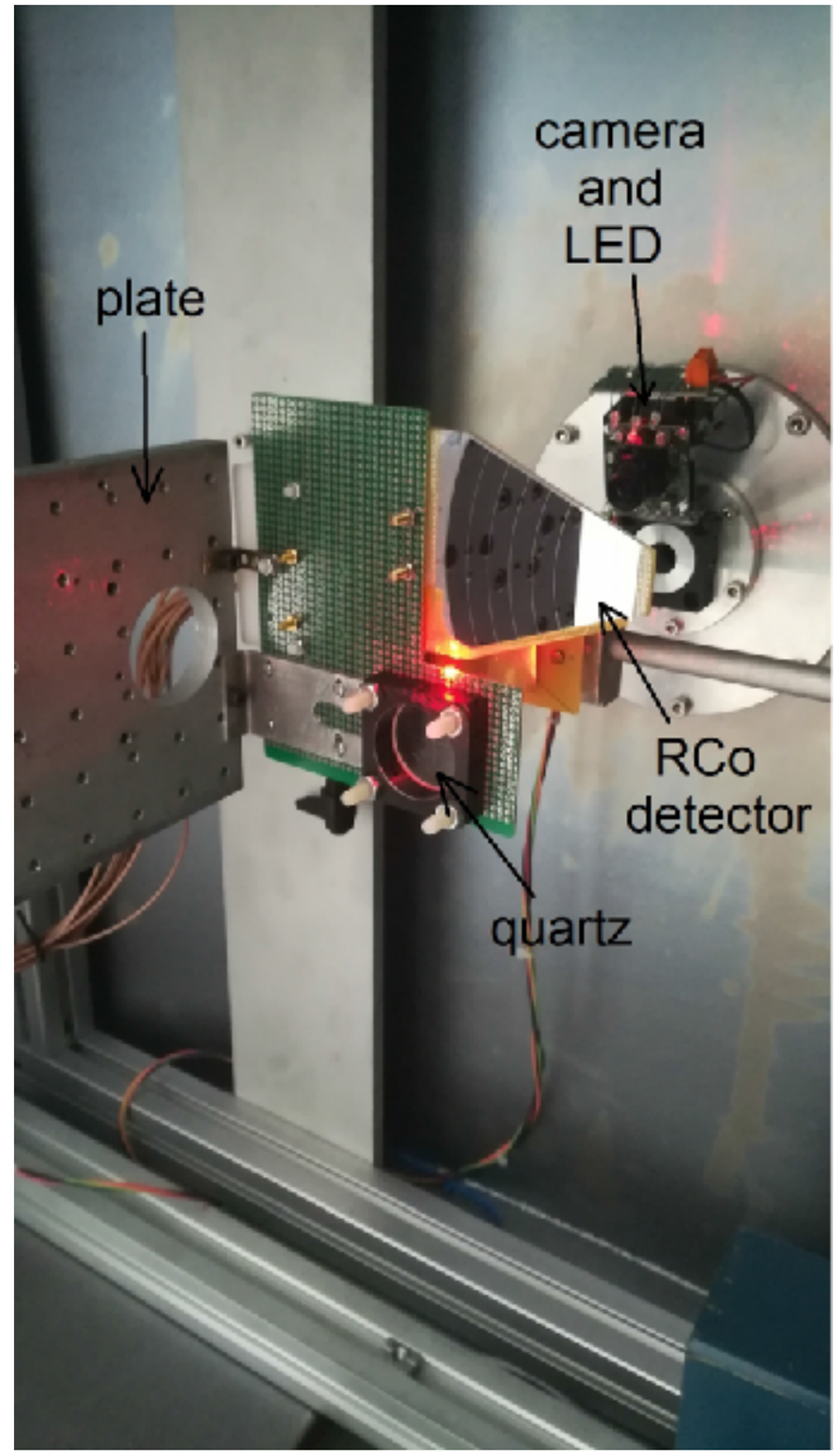


Pulsed beam characteristics:

- *beam spot:* few tens μm
- *ions:* from p to O
- *density:* from single ion to a few thousand ions per bunch
- *repetition rate:* from single shot to a few kHz

Detector resistivity maps and study of border effects



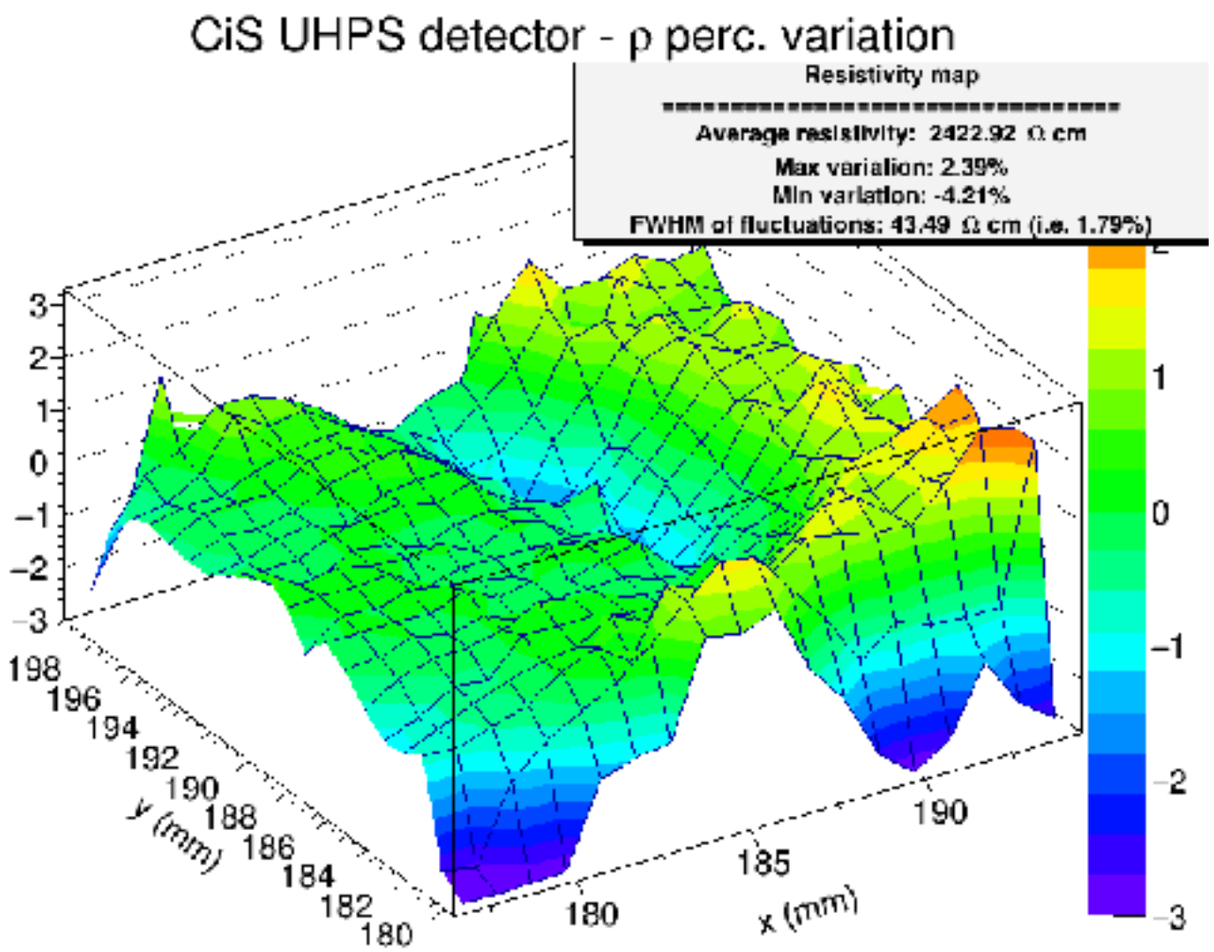


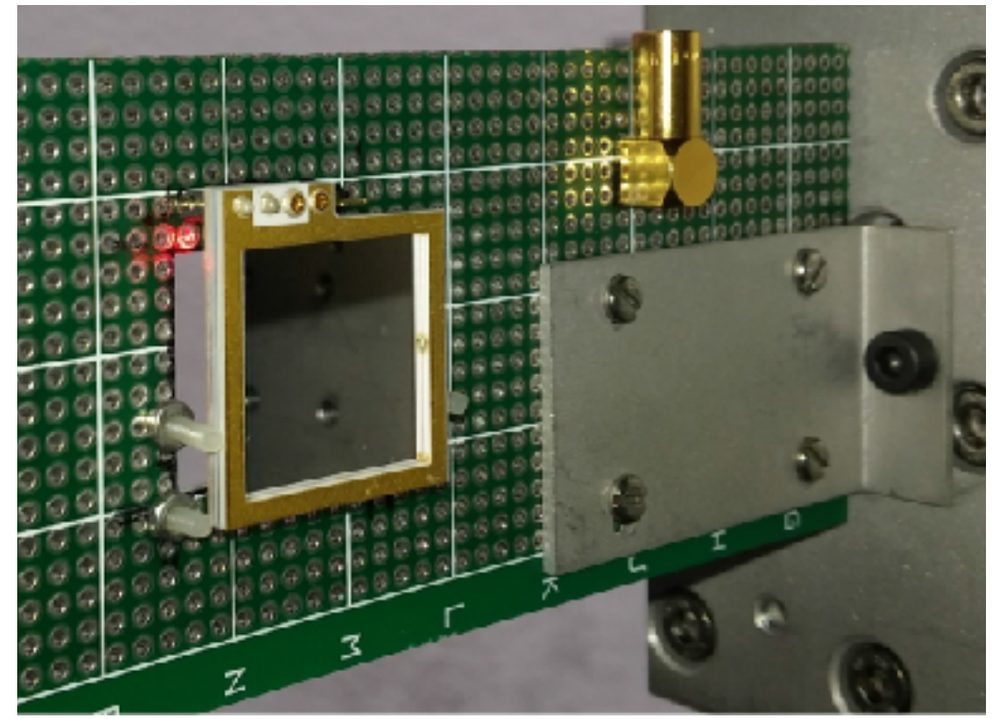
courtesy of C. Ciampi, UniFI & INFN FI

Resistivity maps

- Tests carried out on Si detectors of known characteristics, with reasonable results

Si UHPS (Ultra High Purity Silicon) detector 20x20 mm² at high uniformity, realized for FAZIA -> variations < 5%





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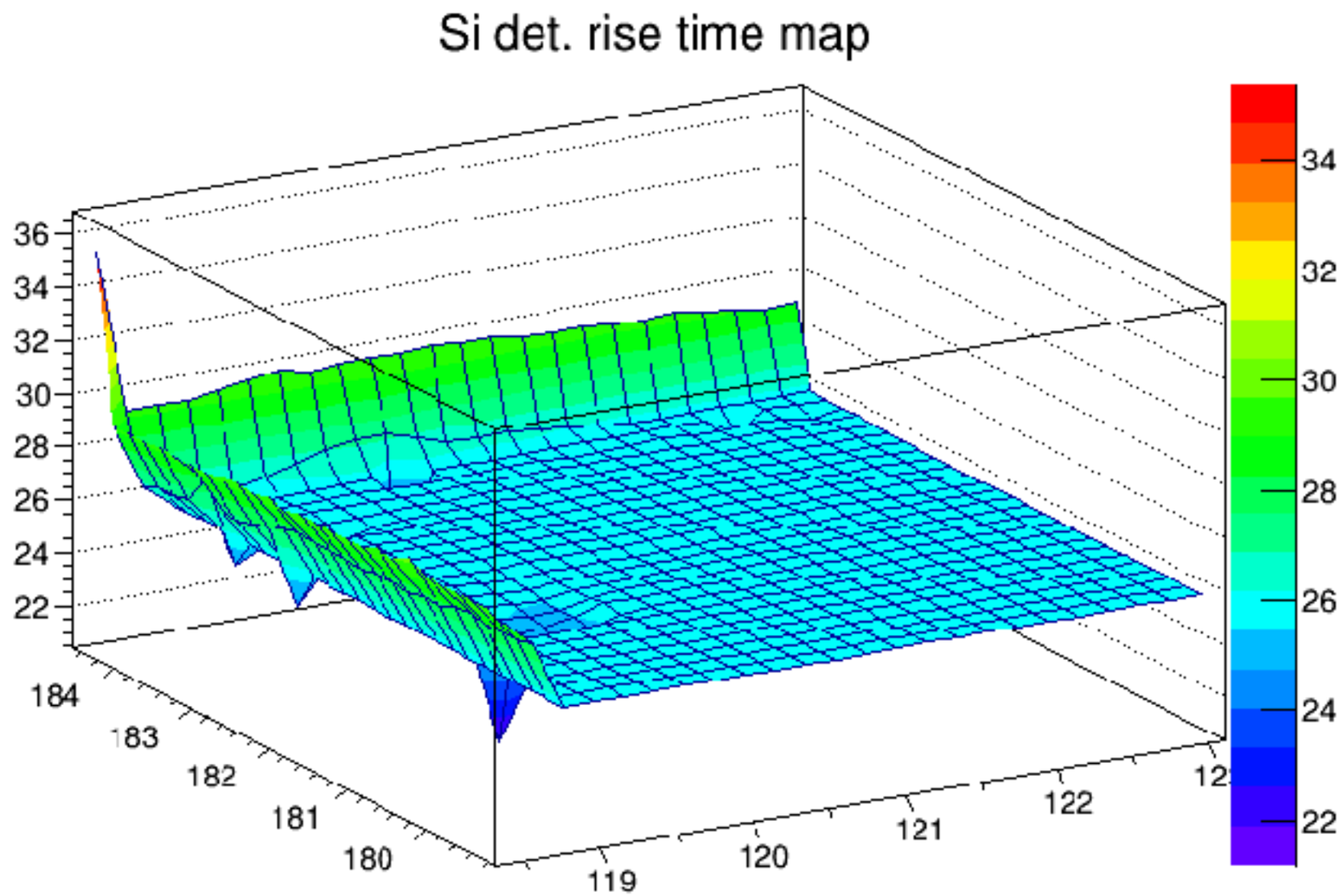
Study of border effects

- Hamamatsu silicon detector (300 μm thick): increase of the mean rise time of signal on the borders



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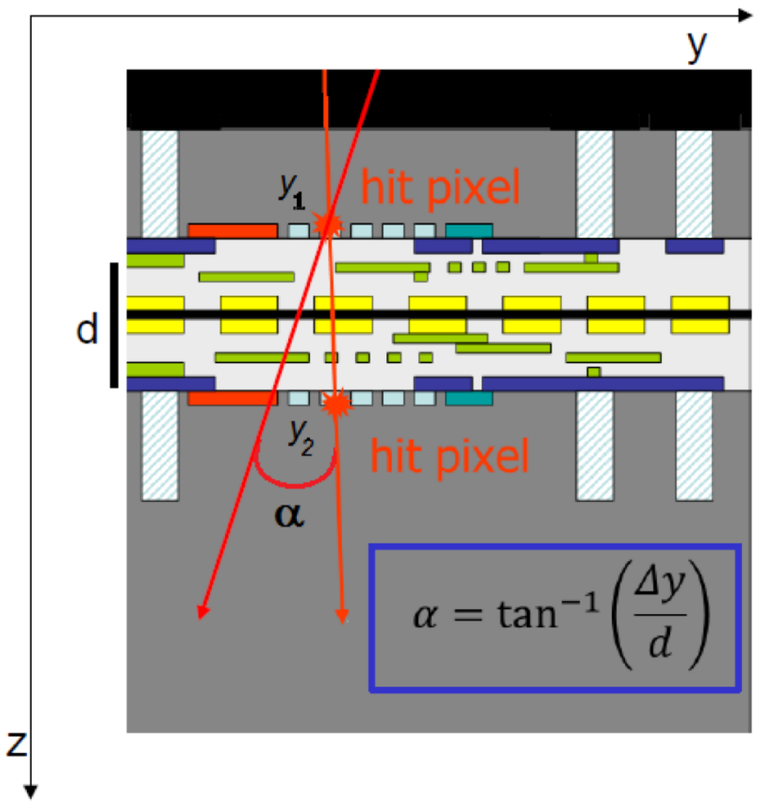
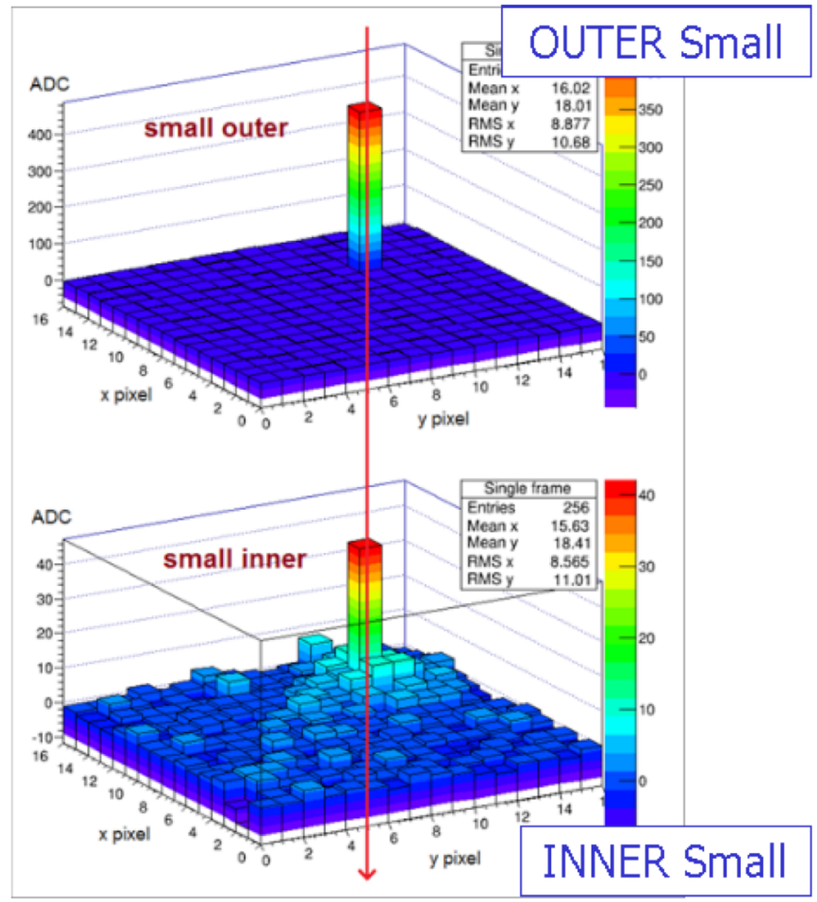
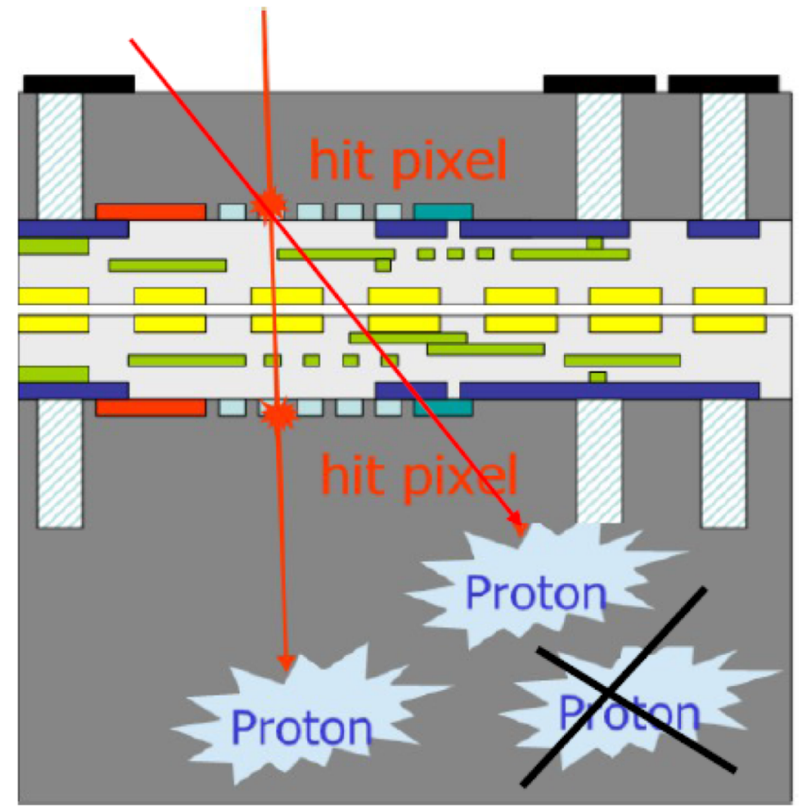
3D stacked CMOS Active Pixel Sensors (VIPIX)

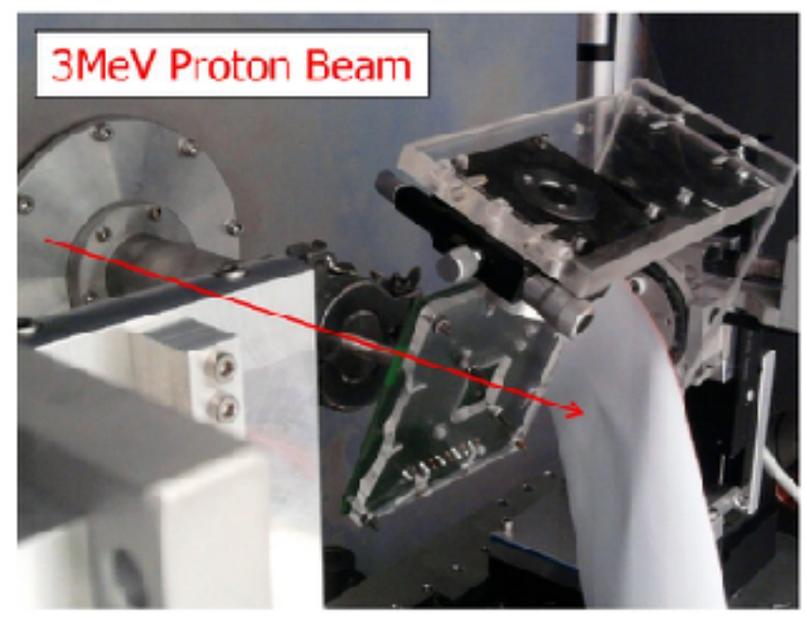


d = 8 μm
pixel size = 10x10 μm



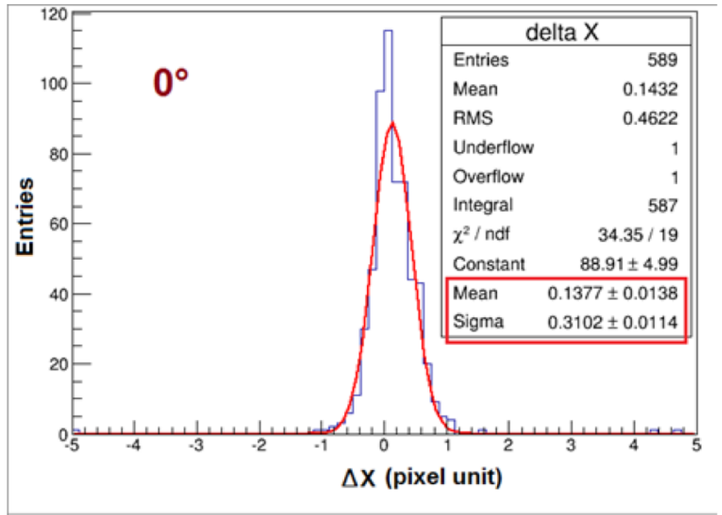


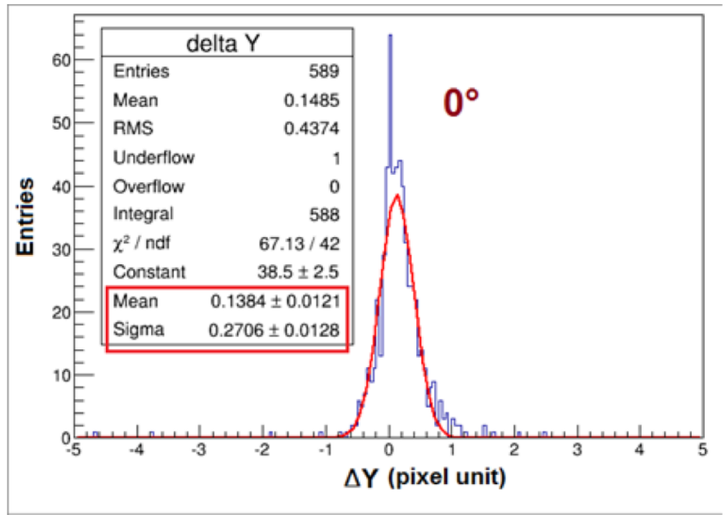
DEFEL beamline
3 MeV protons (2.5 MeV considering the energy loss in air)

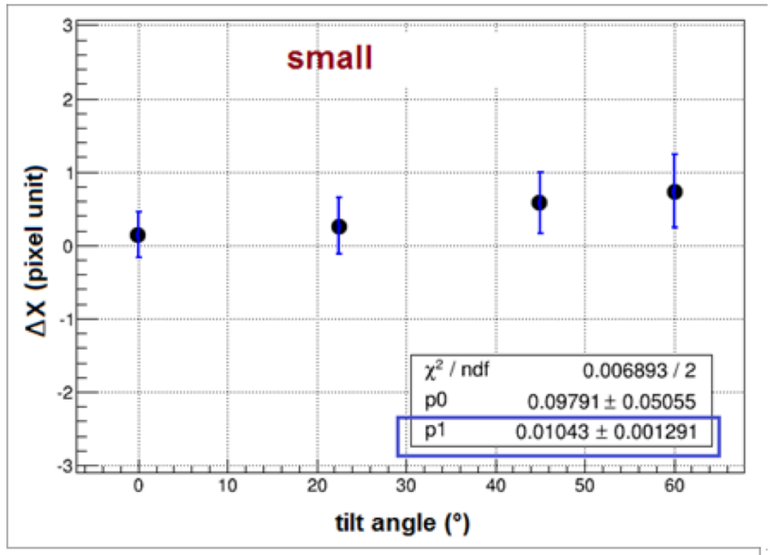


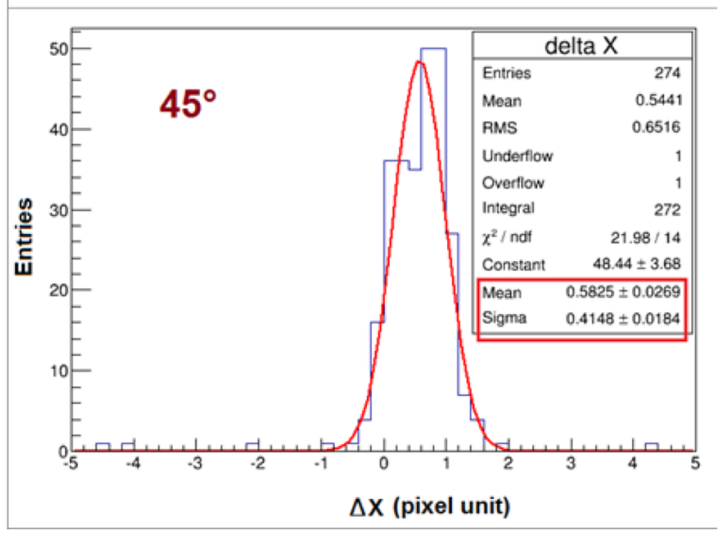
courtesy of L. Servoli, INFN PG

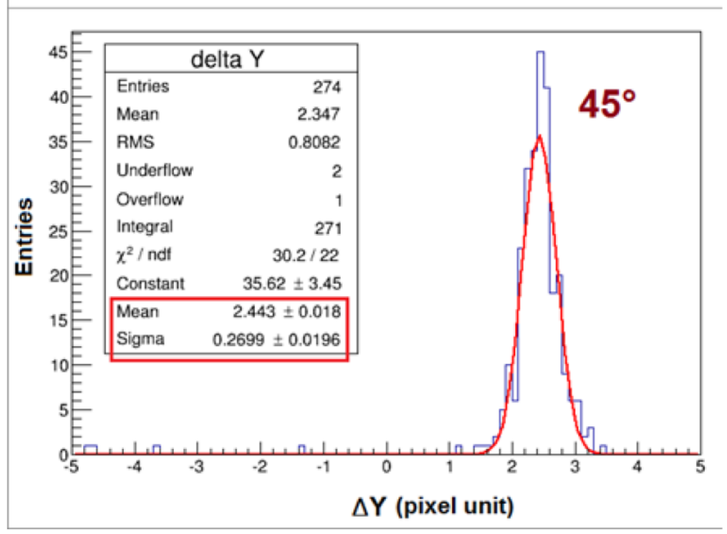
Results

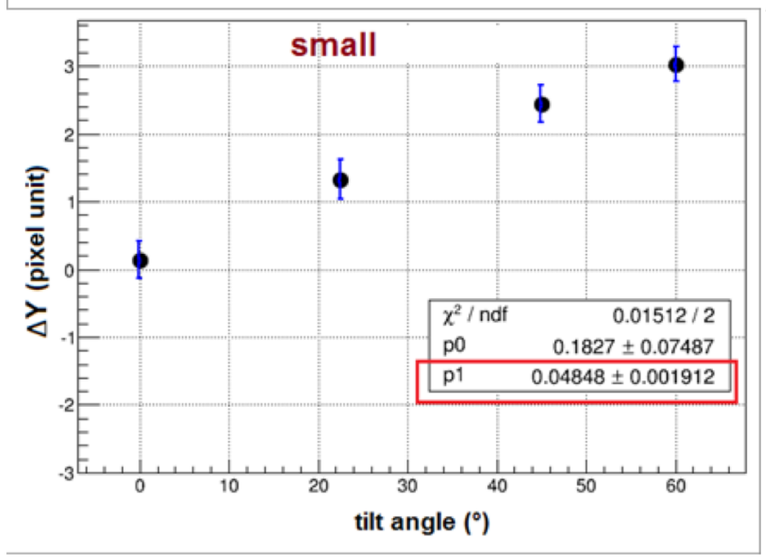












We observe the variation of Δy vs incidente angle while Δx ~ stable

courtesy of L. Servoli, INFN PG

Transnational access to LABEC

- The H2020 project RADIATE “Research and Development with Ion Beams - Advancing Technology in Europe” offers TNA to European ion beam laboratories
- 1000 hours of TNA will be offered at INFN LABEC in 2019-2022
- RADIATE’s main target group are users working in EU member states and associated states. A user is only eligible for beam time in a different country than the country of employment
- The user have to submit a proposal to RADIATE’s proposal submission system, RADIATE GATE (https://gate.hzdr.de/user/)