Solutions for the absolute dosimetry of pulsed, high-rate proton beams

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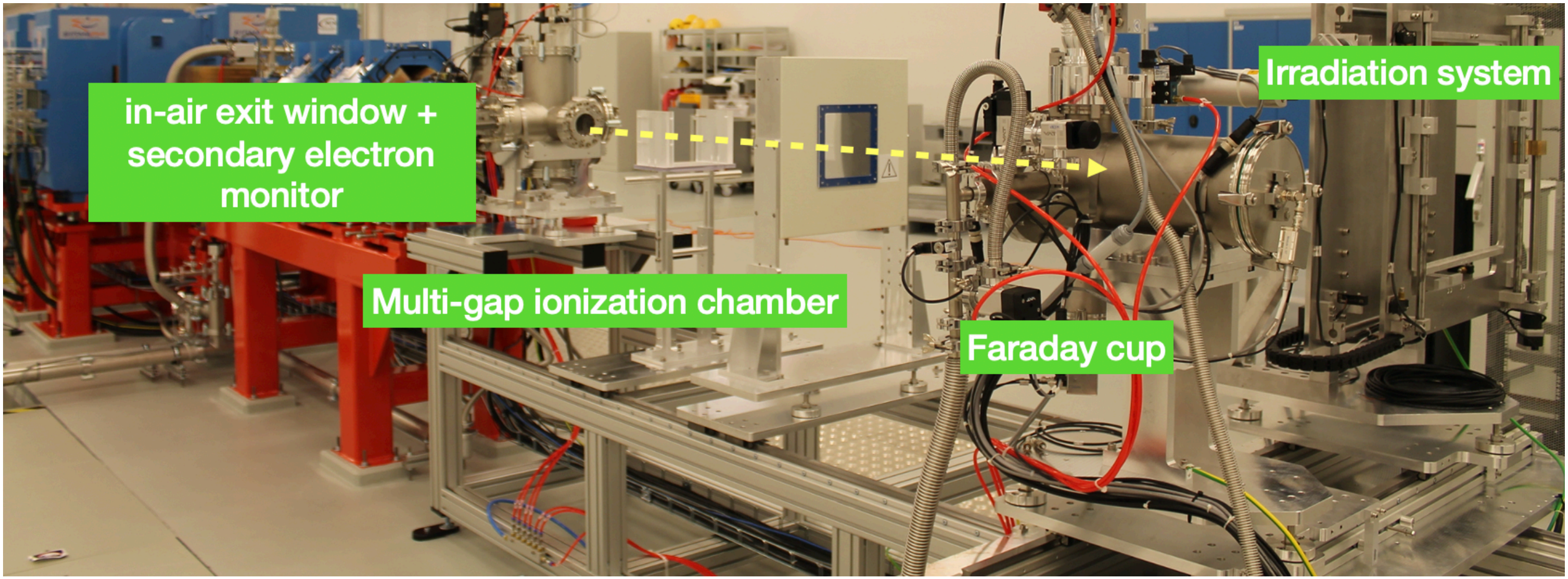
Outline

- Dosimetric approaches @ELI Beamlines
  - Faraday Cup
  - Secondary Emission Monitoring
  - Multi Gaps ionization chambers

- Experimental test @LNS-INFN
  - Setup
  - Preliminary results

Dosimetric approaches @ELi Beamline

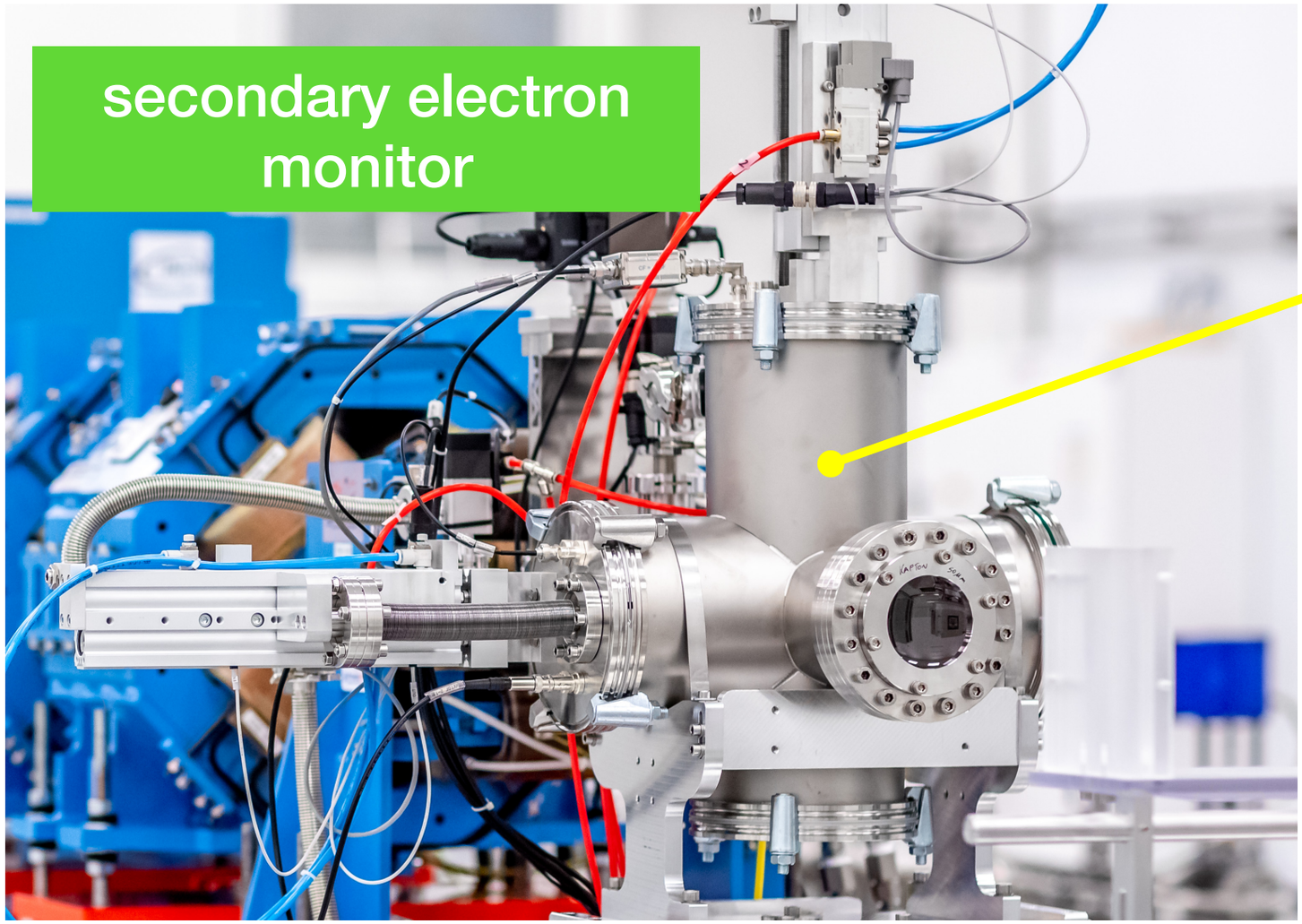


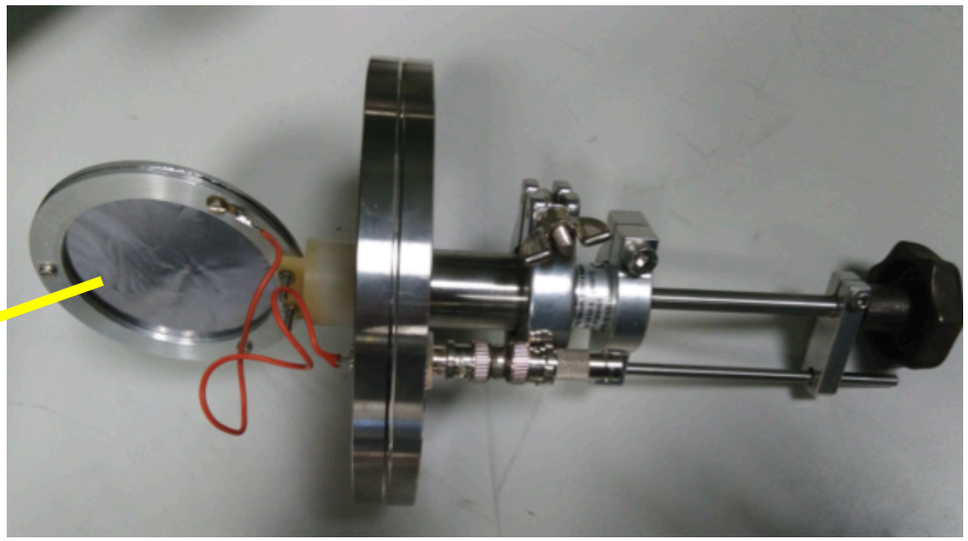
Faraday cup in a special design for absolute dosimetry

Dual gap ionisation chamber for ion recombination correction

Radiochromic films and plastic detector for spectroscopy(first phase, low-energy)

Secondary Emission Monitoring

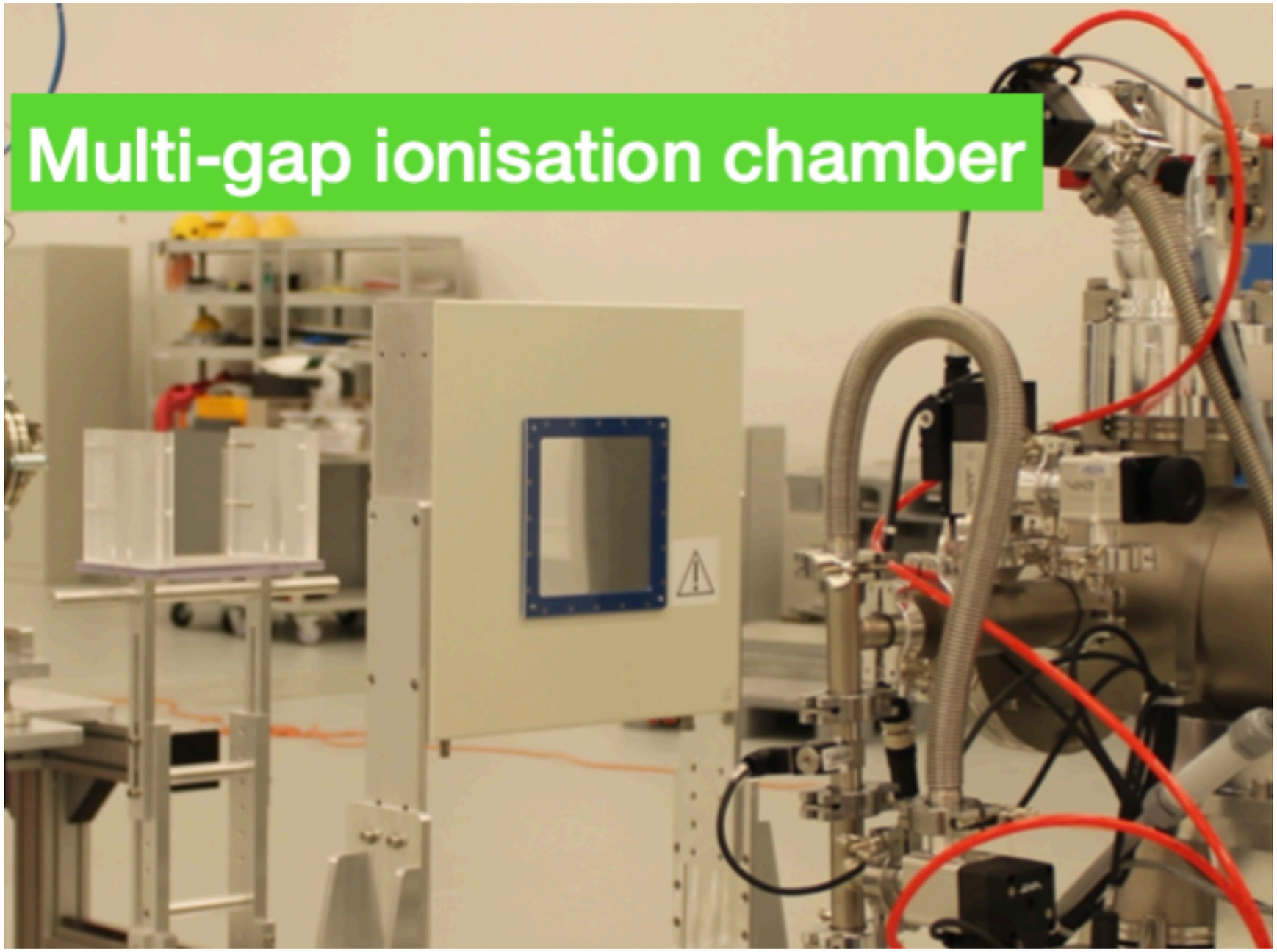




15 um Tantalum foil;

- Time Of Fligth configuration
- Charge integration for normalisation purposes
- Scattering foil for beam diffusion

MGs Ionization Chamber

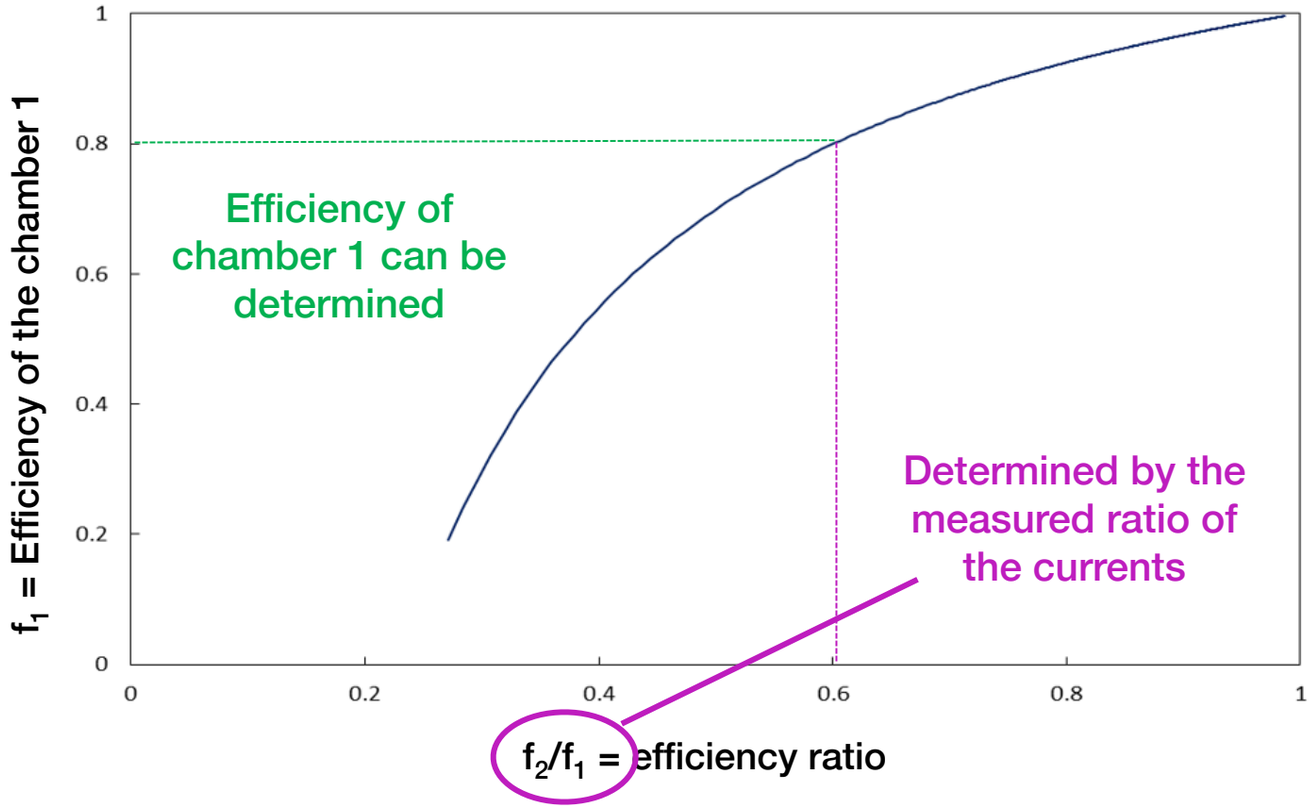


- Innovative prototype for real-time monitoring the dose delivered shot-by-shot onto the user sample at ELIMED
- Two adjacent IC, gaps of 5 mm and 10 mm, independently biased
- Maximum applied voltage ±1000 V and ±2000 V, respectively
- Anode: thin layers of 5 µm of copper and 2 µm of nickel, deposited on a 25 µm layer of kapton
- Cathode:12 µm-thick layer of aluminized mylar
- 420 × 420 × 100 mm^3 aluminum box

Supplied by DE.TEC.TOR. Devices & Technologies Torino Srl, Italy

MGs Ionization Chamber

When extremely high-flux beams of the order of $10^{12} - 10^{14}$ protons/s and $10^{7} - 10^{9}$ protons per pulse, with a pulse duration of around 10 µs are considered, the technological usage limit of traditional ionization chambers is reached. The recombination phenomena become very significant and then a reliable measurement correction in needed.



Boag-Wilson Theory

$$f = \frac{2}{1 + \sqrt{1 + \frac{2}{3}\xi^2}} \quad \text{with} \quad \xi = m\sqrt{n_0}\left(\frac{d^2}{V}\right)$$

where

m is a constant involving the recombination effect and the mobilities

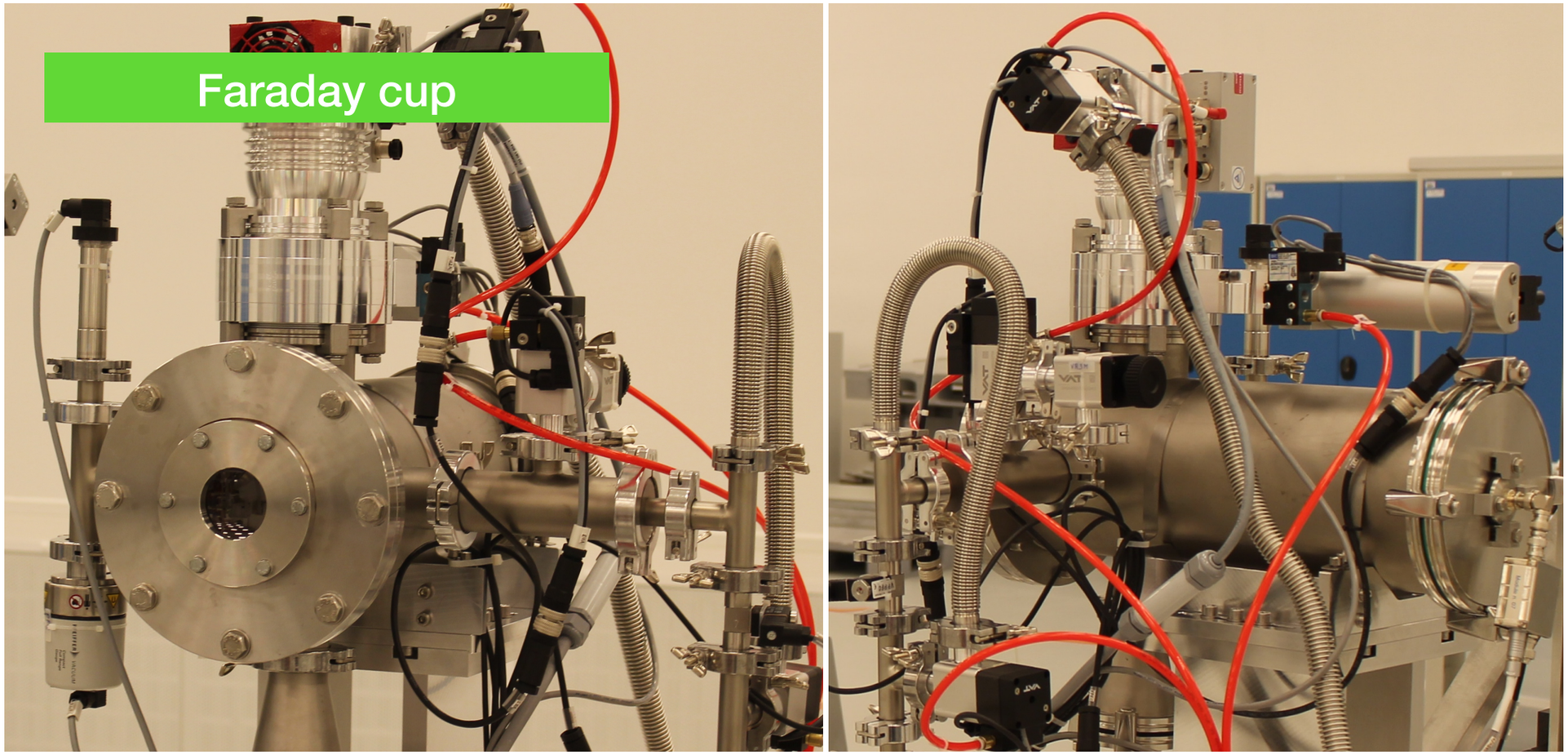
n_0 is the volumetric ionization density [C/cm3s]

d is the gap between anode and cathode [cm]

V is the applied voltage [V]

Once the voltage is set, this curve does not depend on the beam energy

Faraday Cup



The cylindrical symmetry of the electric field provided by the external electrode is broken due to the presence of the internal one.

The resulting effect is a strongly asymmetric electric field, characterized by a significant transversal component able to maximize the deflection of the secondary electrons generated by both the entrance window and the cup.

Experimental set-up @INFN-LNS

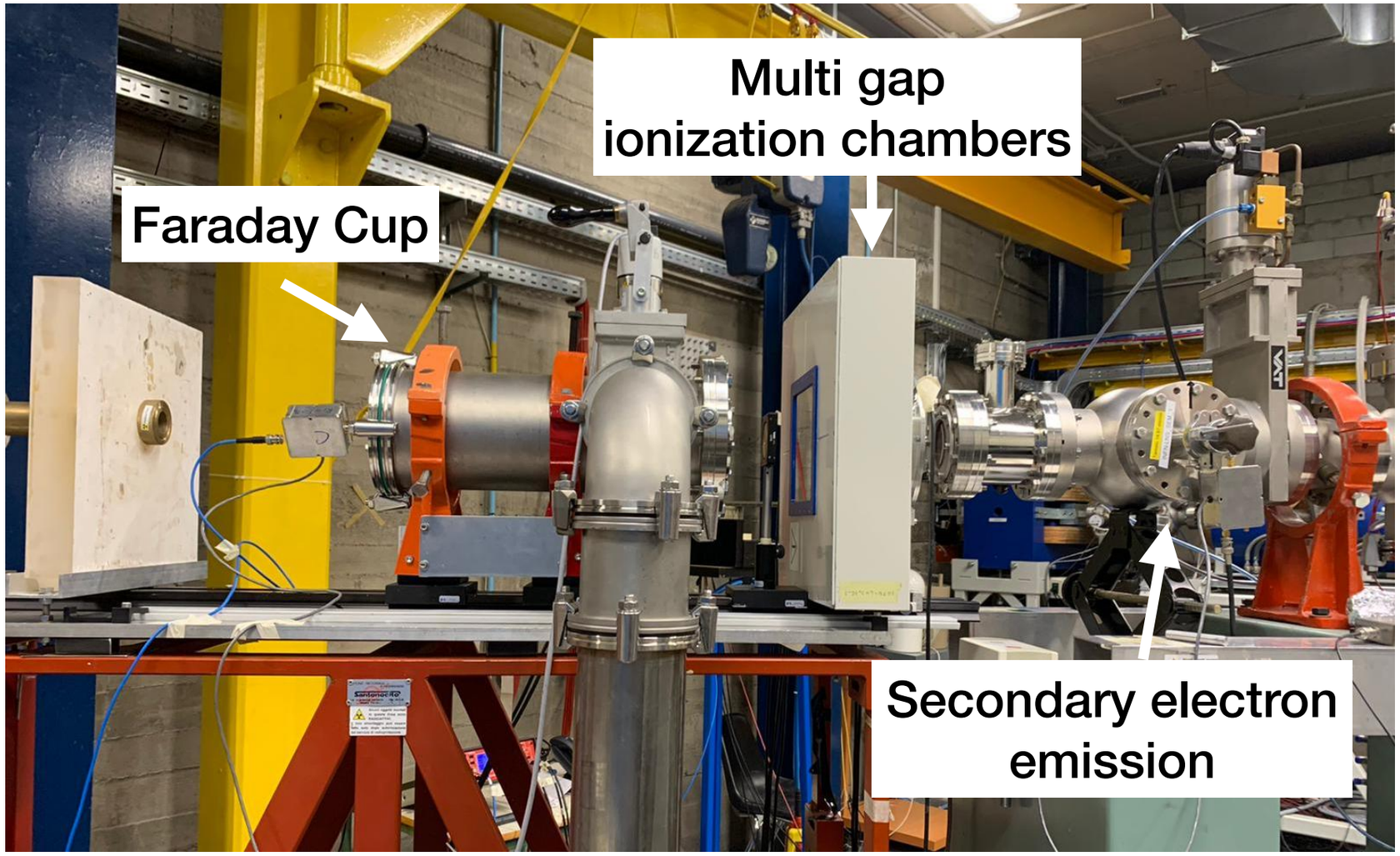
Zero Degree Exp room

proton 62 MeV

Beam current: 1 - 50 nA

Shot time: 10ms - 200ms

Beam Collimator: 1x1cm²



Results: Faraday Cup

Results: MGs Ionization Chamber

Thanks for listening