LNS Users Meeting

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Multidisciplinary irradiation beam lines

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Outline

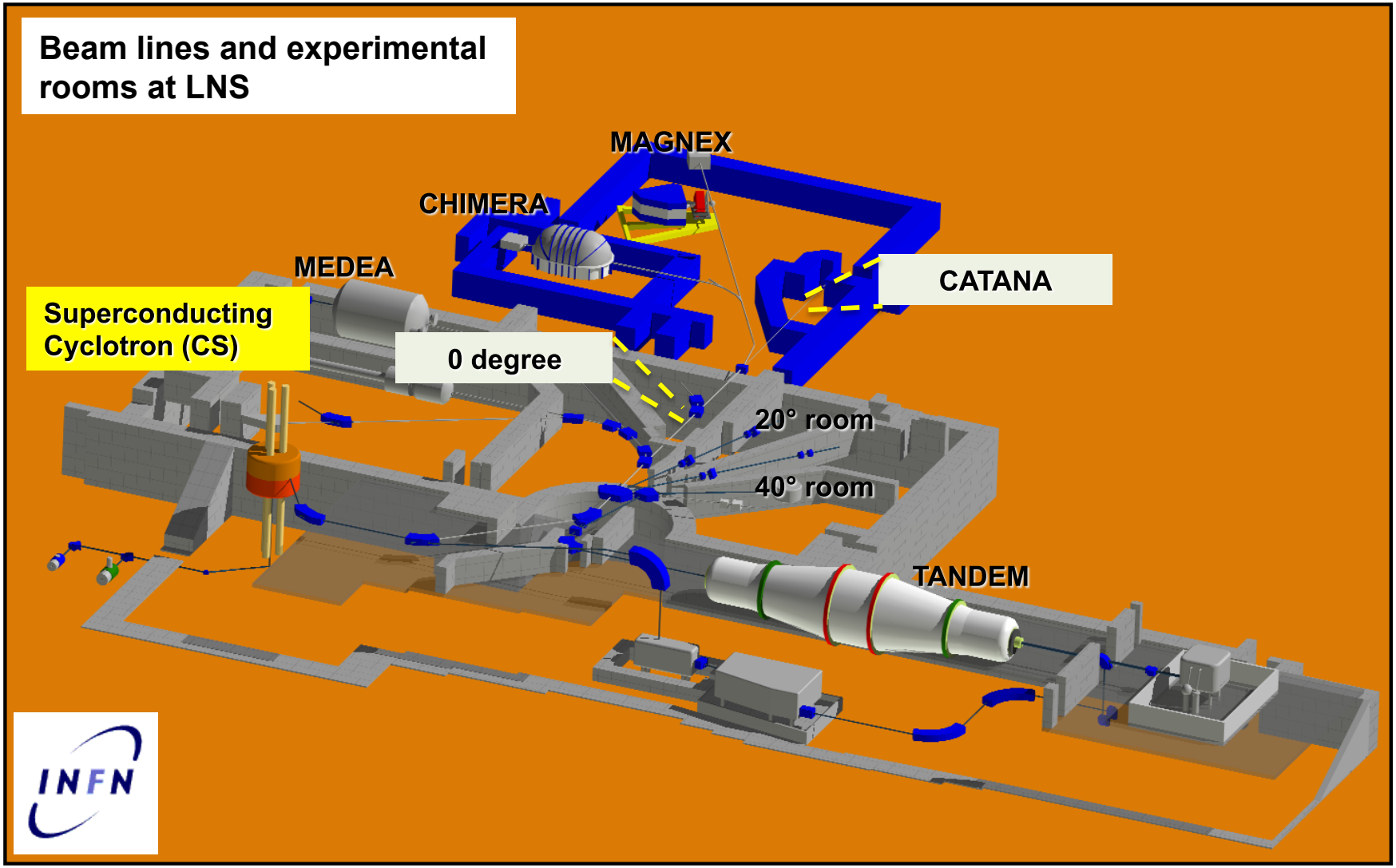
- Multidisciplinary beam lines
  - CATANA beam line
  - 0 degree beam line
- Beam monitoring and characterization
  - Lateral spread
  - On-line monitoring of the beam
  - Dose distribution measurements
- Radiobiology
  - Cell positioning
  - Motorized irradiation device
  - Cell growth laboratory
- User requirements

Multidisciplinary beam lines at INFN-LNS

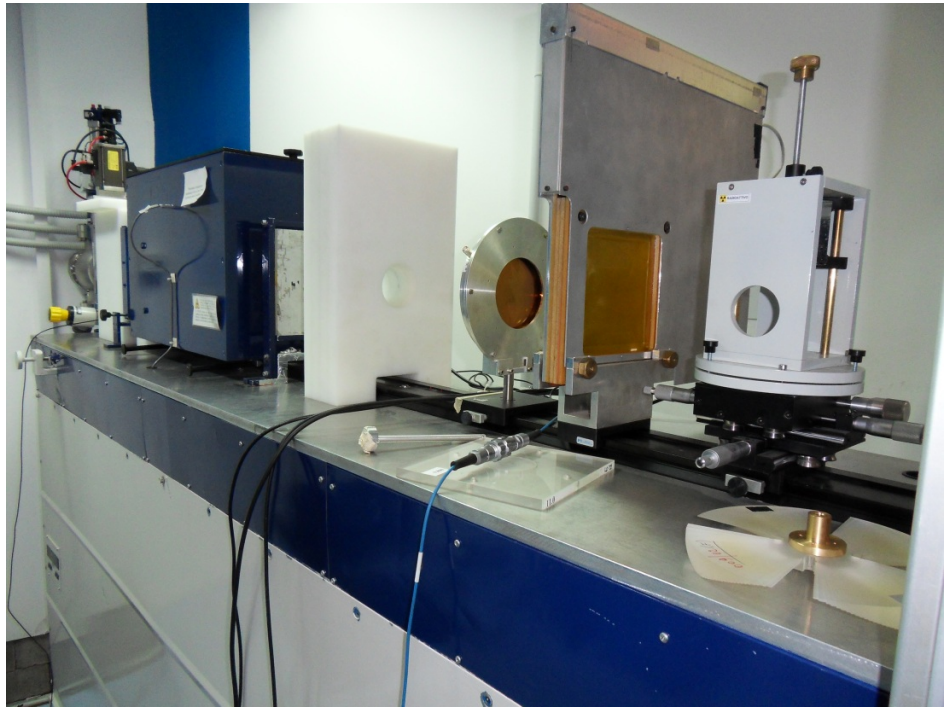
Two rooms are available at LNS for multidisciplinary activities irradiations:

- CATANA beam line (clinical proton beams at 62 MeV)
- 0 degree beam line (protons and light ions up to 80 AMeV)

both equipped with detectors for beam diagnostics and dose monitoring.



CATANA beam line



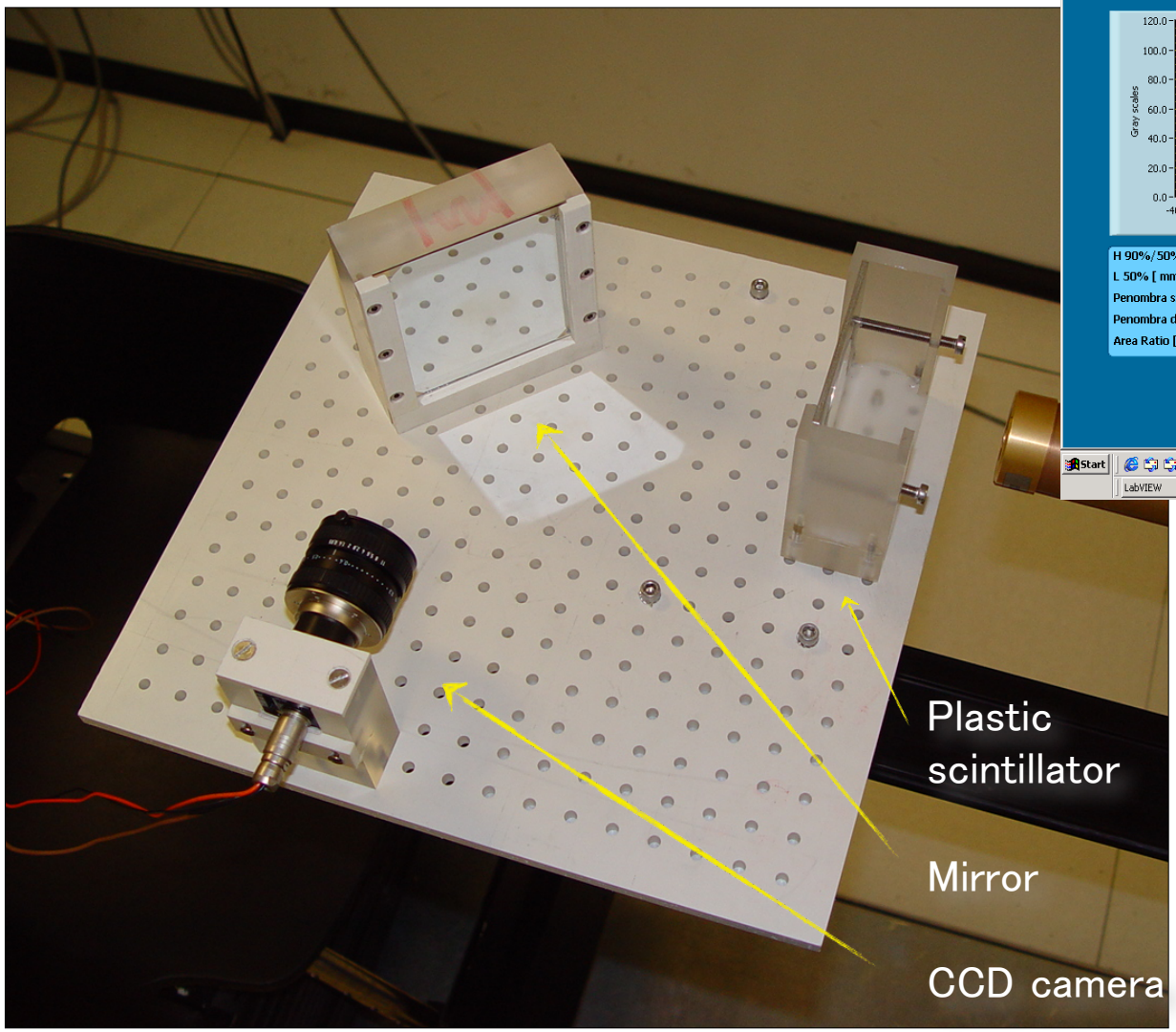
- Mainly dedicated to proton irradiation (eye melanoma treatments)
- Double scattering system for lateral spread → homogeneity ≈ 3%
- Collimated beams 1 m 35 mm
- *In-air* only
- Dosimetry and radiobiology experiments
- Energy passively degraded
- Fixed elements limiting some applications:
    - Fluence not maximised
    - High level of homogeneity but no point-like spot size
    - Radiation protection issues during the patient treatments may limit beam current

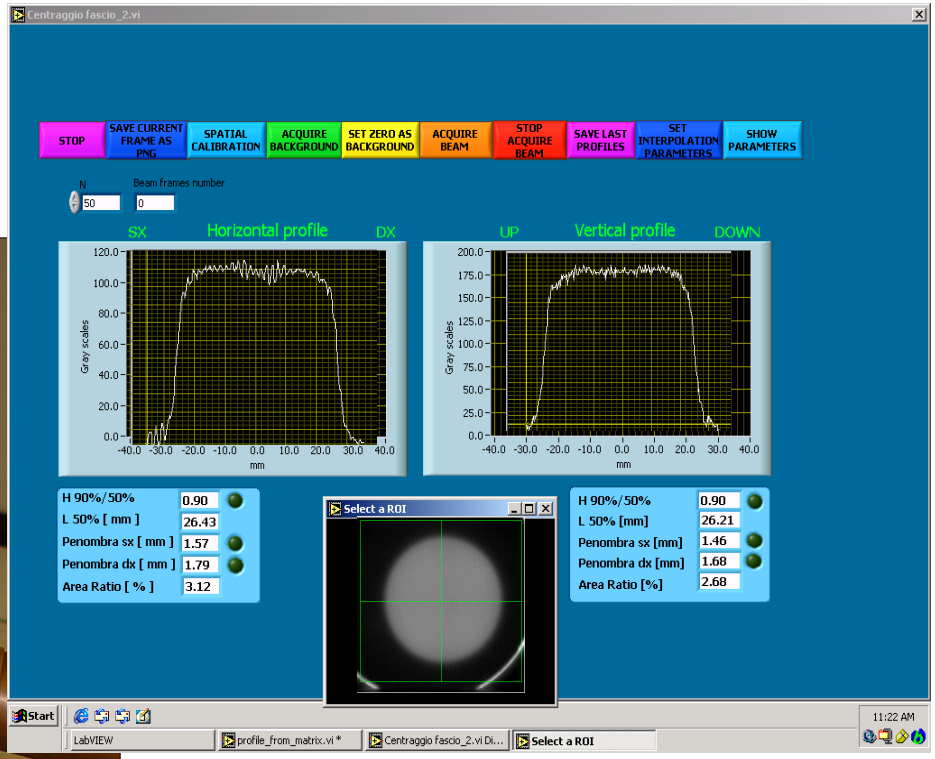
0 degree beam line

- Transported beams:
  p, He, C, O, Ne, Ar, Kr, Xe, …
- Relative and absolute dosimetry
- Certified beam line for ESA experiment by the MAPRAD Group.
- Mainly dosimetry and radiobiology *in-air i*rradiation but also possibility to use vacuum chambers

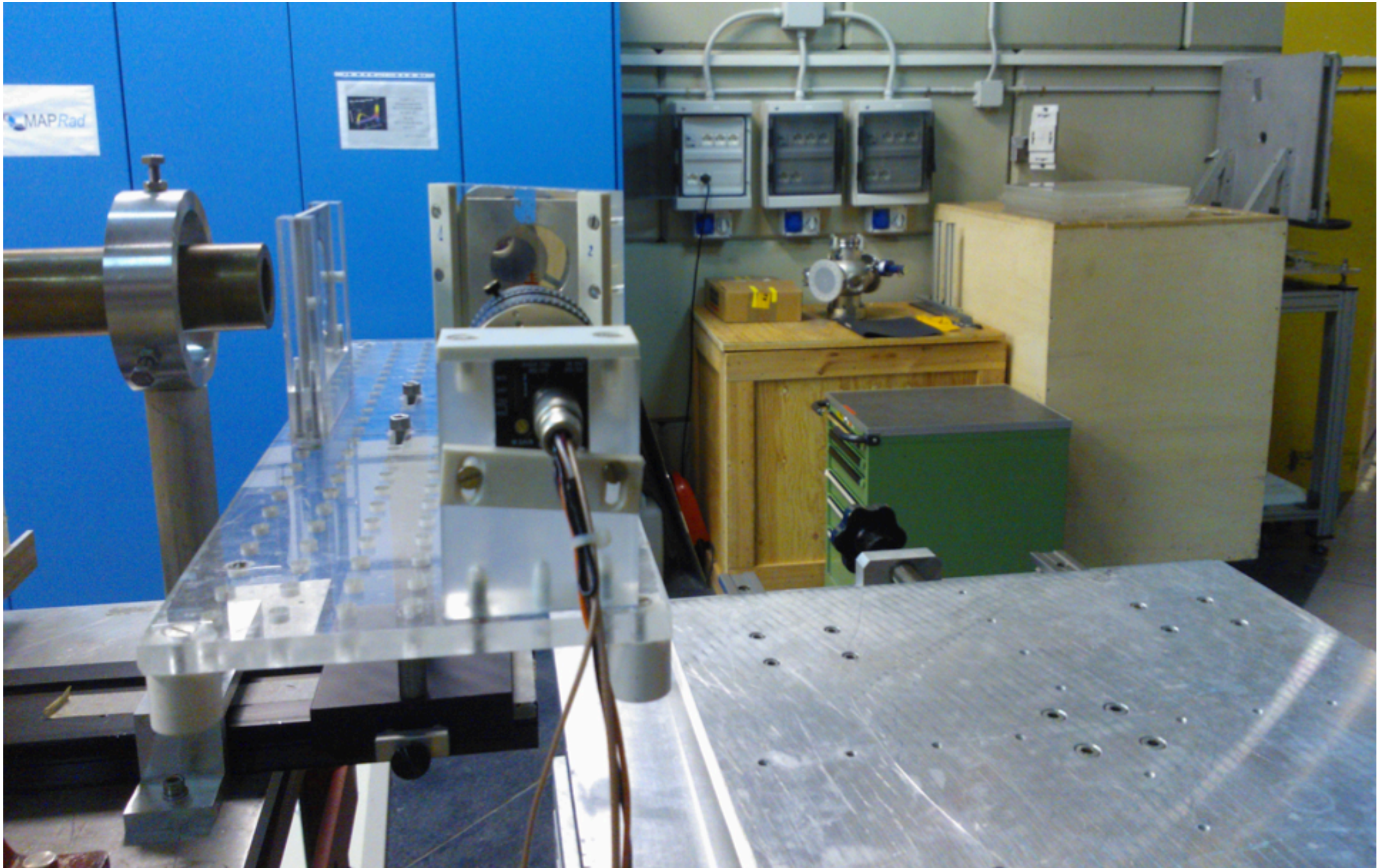
- Fast and easy positioning systems
- No particular constrain from fixed elements but ....
  - Homogeneity ≈ 15% (non focalized beams)
  - Experiment MUST be carefully scheduled to ensure the quality of alignment
  - One day of stop is needed if alignment and dosimetric system are removed

Lateral spread monitoring

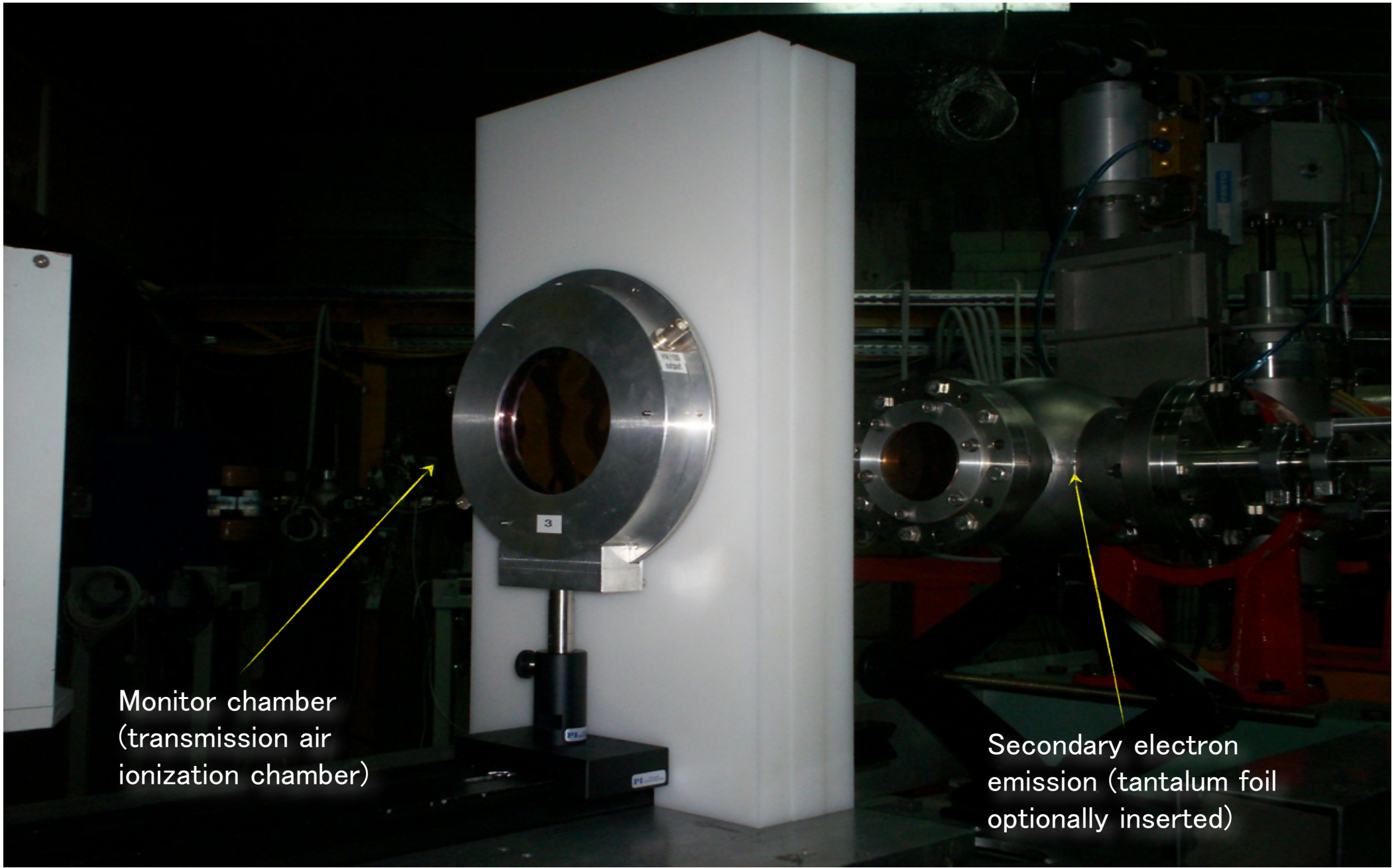




New setup for beam monitoring

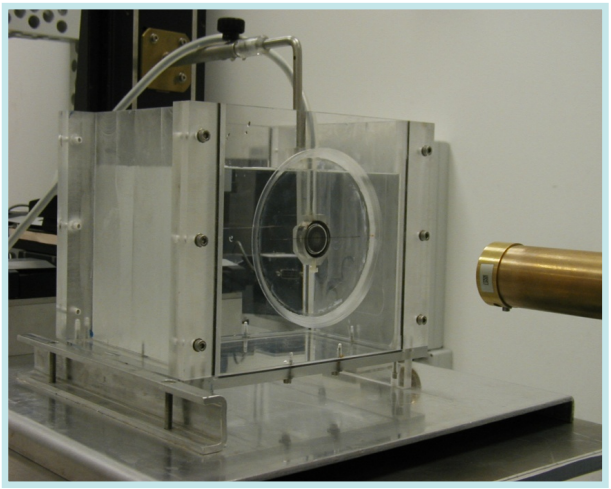


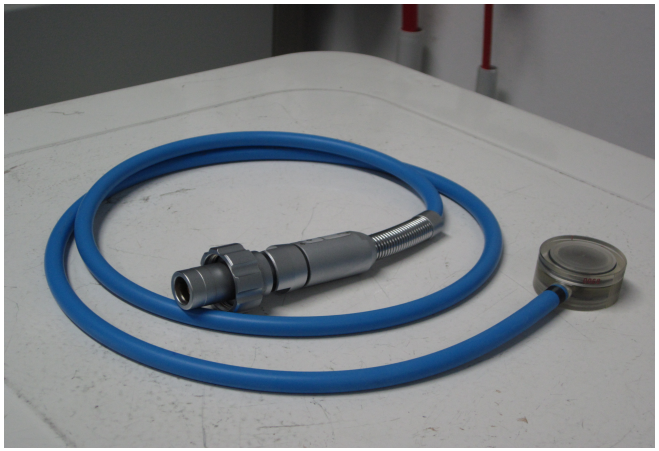
On line beam monitoring



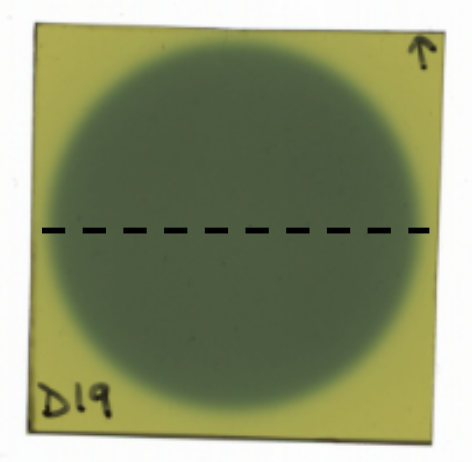
Dose distributions measurements

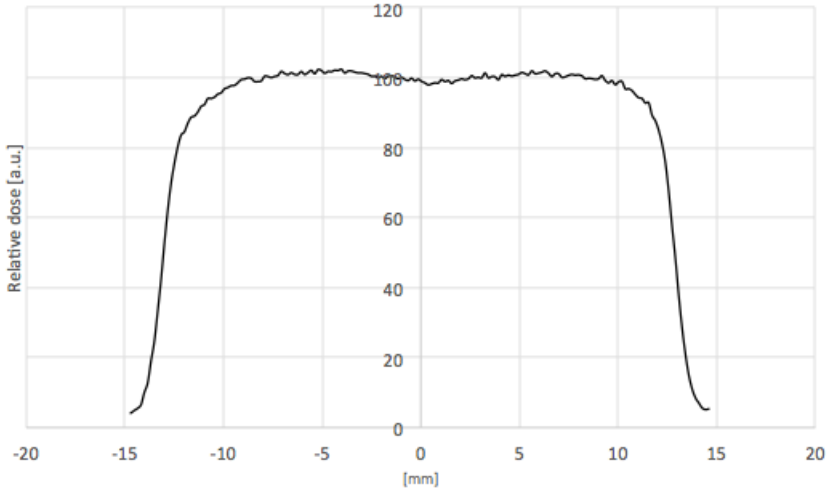
✓ Reference absolute dosimetry in a water phantom using plane-parallel PTW Markus ionization chamber, calibrated according to IAEA code of practice.



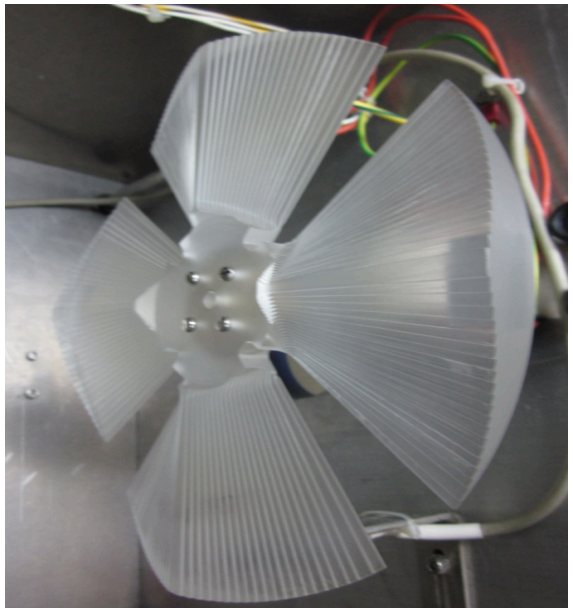


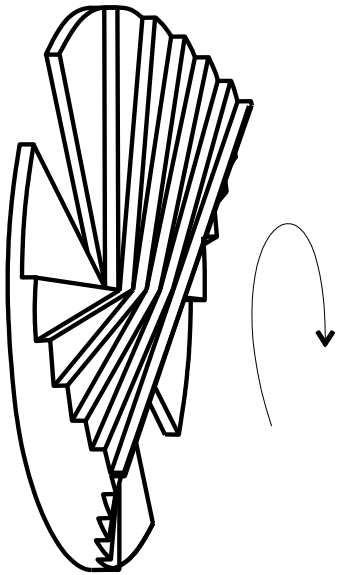
✓ Lateral dose distribution checked with radiochromic films (EB3, HD-V2)

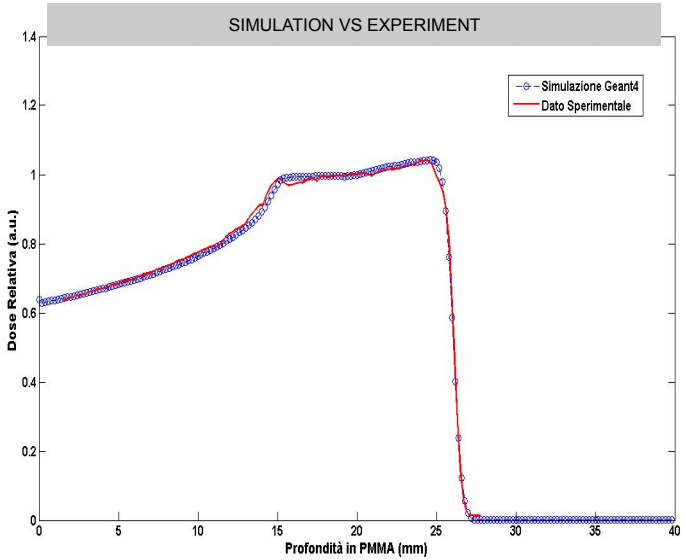


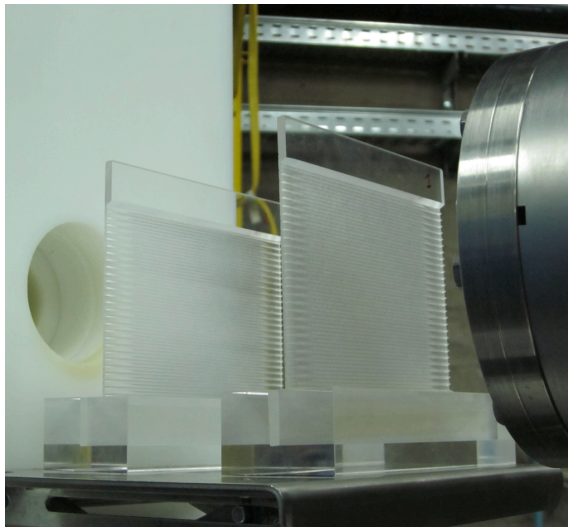


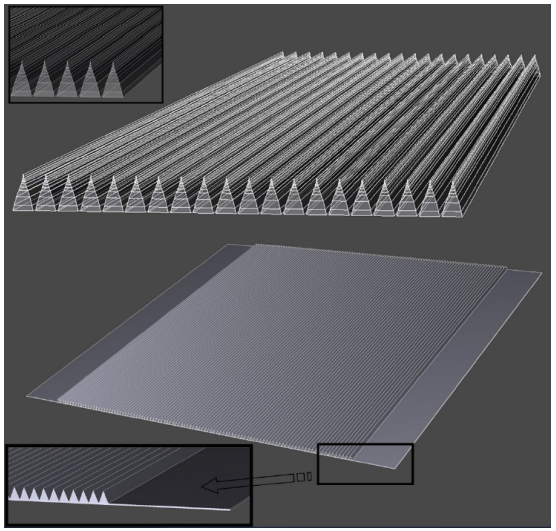
Longitudinal dose distributions

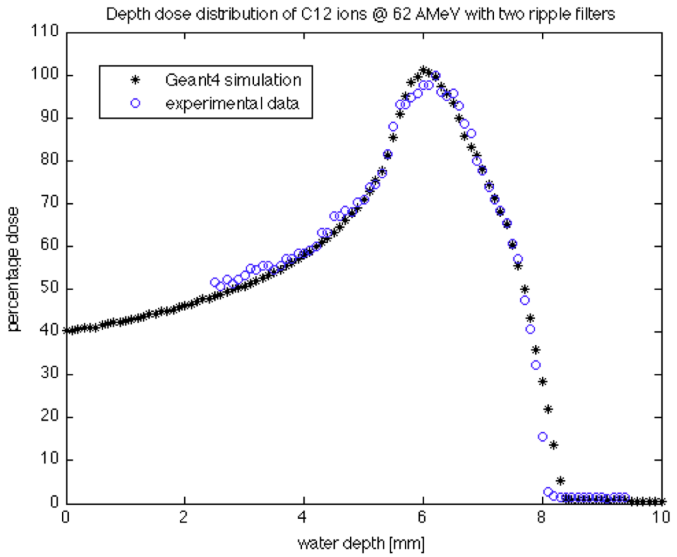




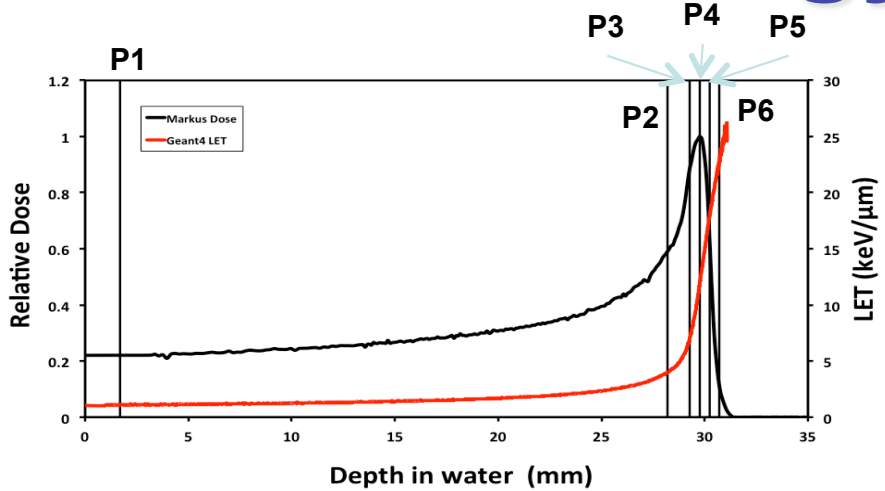




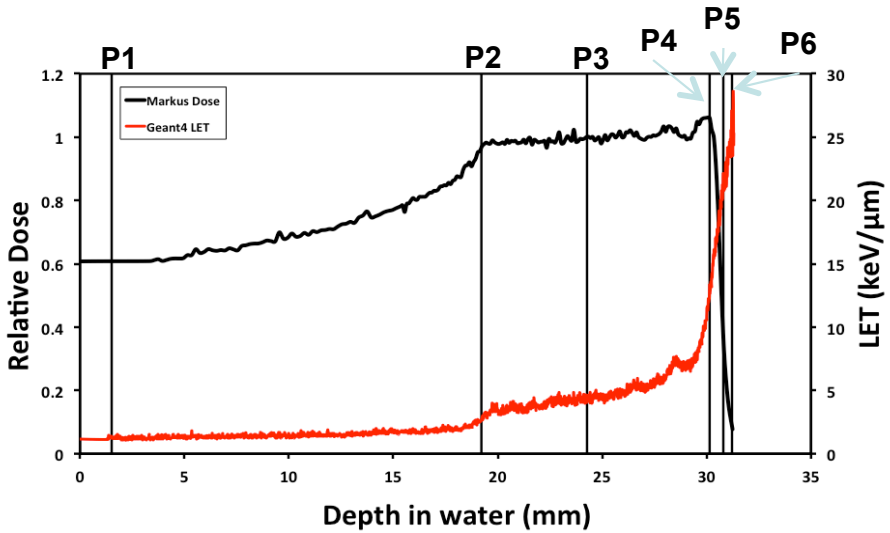




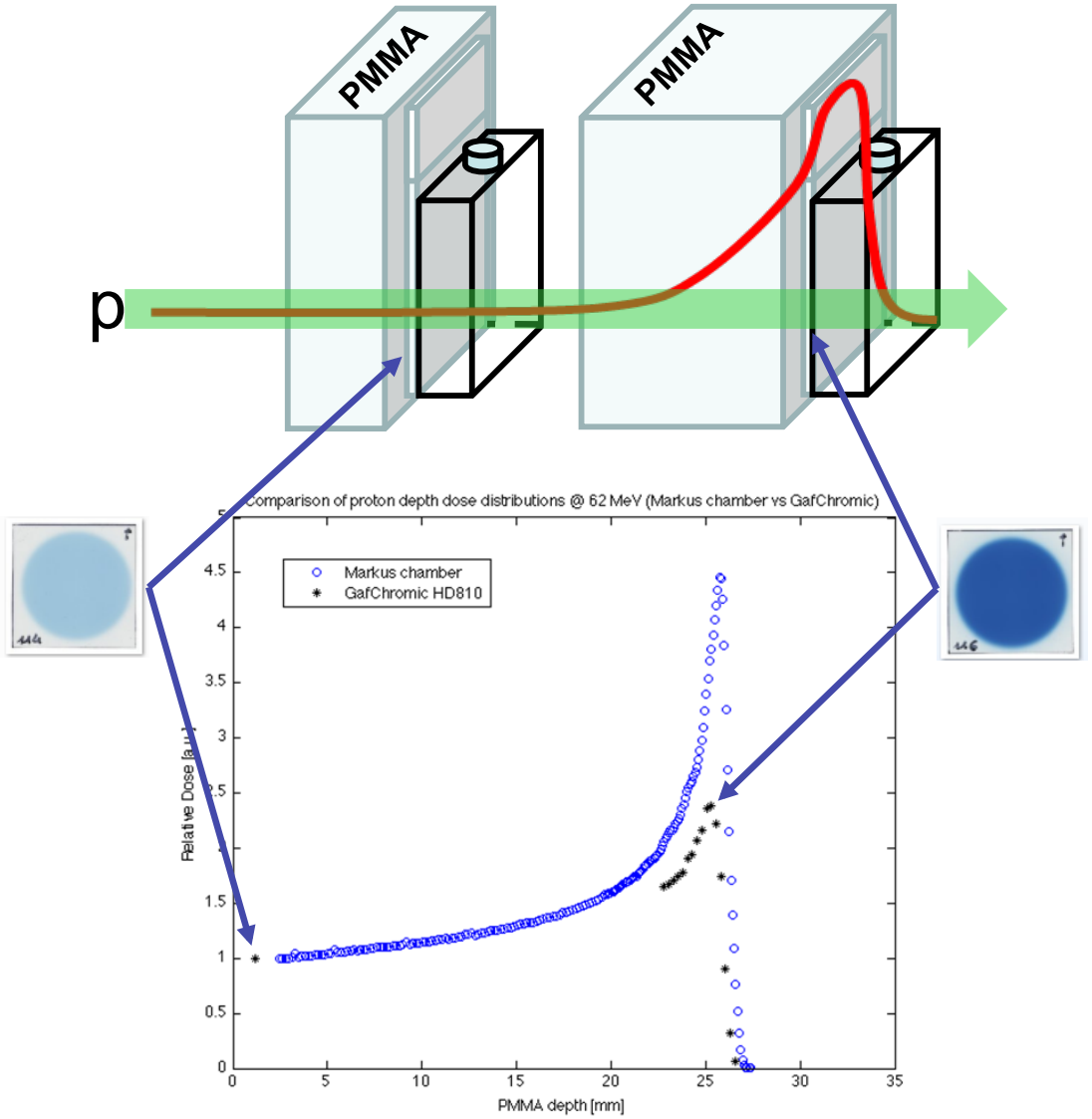
Radiobiology: cell positioning



	P1	P2	P3	P4	P5	P6
Depth water [mm]	1.38	20.23	24.59	27.69	29.48	30.08
LET [keV/µm]	1.2	2.6	4.5	13.4	21.7	25.9



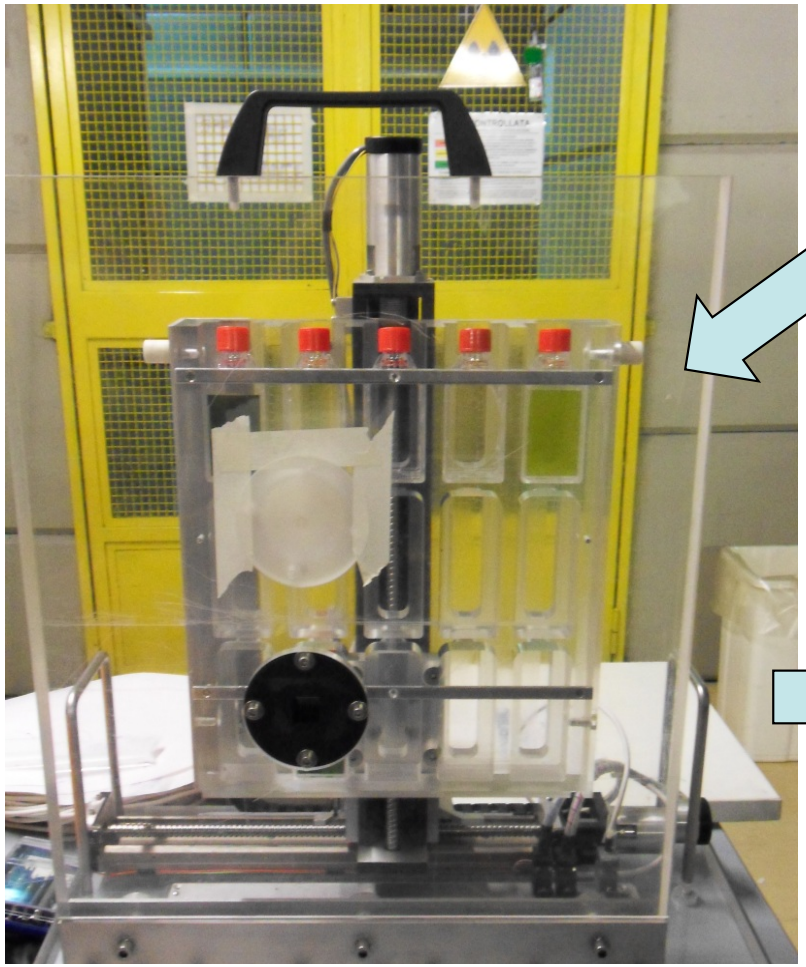
	P1	P2	P3	P4	P5	P6
Depth water [mm]	1.38	27.42	29.21	29.8	30.7	31.29
LET [keV/µm]	1.11	4.0	7.0	11.9	18.0	22.6

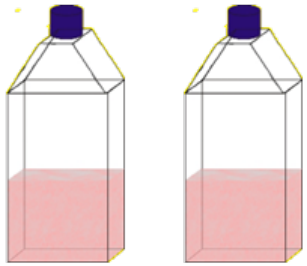


50 µm positioning accuracy achieved by combining relative dosimetry (Gafchromic films) and secondary standard dosimetry (Markus Chamber)

Radiobiology: irradiation device

Irradiation positions are typically along the pristine or spread out Bragg peak





- Motorized system with 100 um precision
- Remotely controlled
- Interfaced with beam control system

Dose and LET distributions are obtained by numerical simulations (GEANT4)

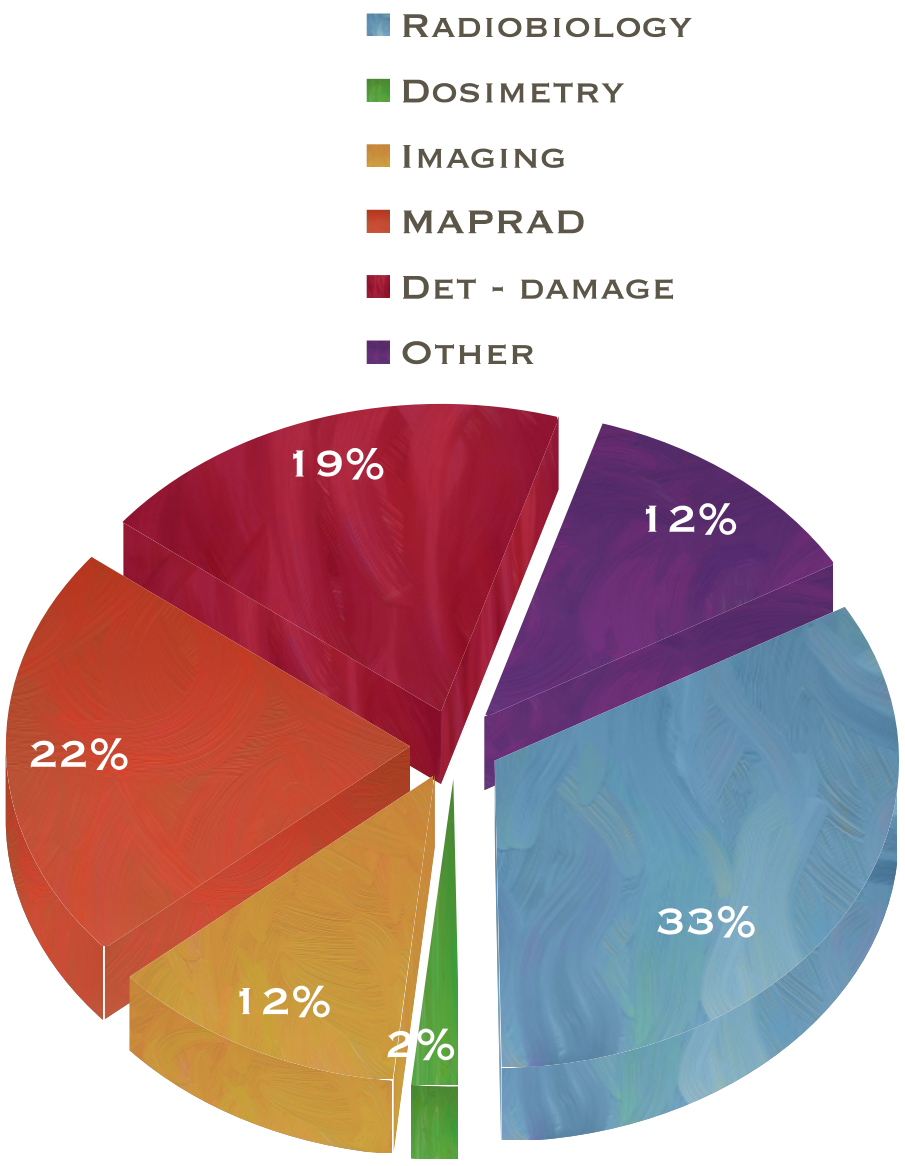
Radiobiology: cell growth laboratory

- New laboratory (larger and more equipped than the previous one)
- Fully equipped with the basic system for a biological analysis
    - Extractor fan
    - Centrifuge
    - Incubators
    - Sterilizer
    - Microscope
- A limited set of chemicals can be also provided under direct request of the User Group
- Mainly dedicated to the external Users preparing the experiments
- Open to any LNS researcher
- Now not critical the overlapping of several groups

BTU for multidisciplinary activities (2012)

BTU of CS beams:
- 34% Nuclear Physics
- 26% CATANA
- **40% Applications**

- Radiobiology 33%
- Detectors for absolute/relative dosimetry 2%
- Detectors for imaging 12
- MAPRAD 22%
- Test of nuclear physics detectors/damage 19%
- Others 12%



More than 20 groups

Users requirements

- [x] Dosimetry accuracy:
  - [x] < 2% for proton beams at CATANA beam line
  - [x] < 15% for light ion beams at 0 deg beam line
- [x] Possibility of spread-out Bragg peak also at 0 deg beam line
- [x] On line measurements of beam lateral homogeneity
- [ ] Precise fluence measurements and contamination characterization
  - [ ] At the moment indirect measurement for high currents
  - [ ] Transmission chamber often used for relative measures
- [x] Faster and more precise motorized system for cell sample irradiation
- [x] Accurate protocol for checking the cell sample position
- [x] Larger spaces for radiobiology and post experiment cell survival analysis
- [x] Cabling connection outside/inside the exp. room
- [x] New ones ???

Thanks for your attention