



**Istituto Nazionale di Fisica Nucleare
LABORATORI NAZIONALI DI LEGNARO**

Education and outreach using LNL accelerators' complex

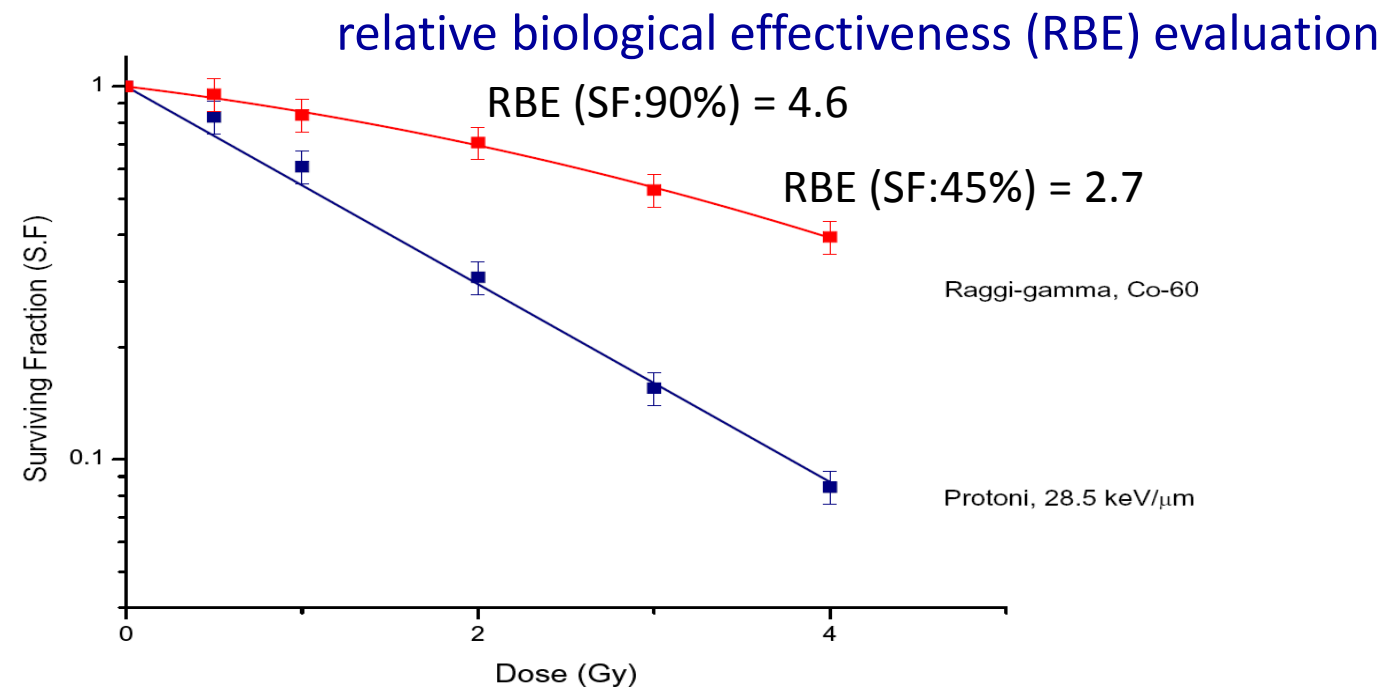
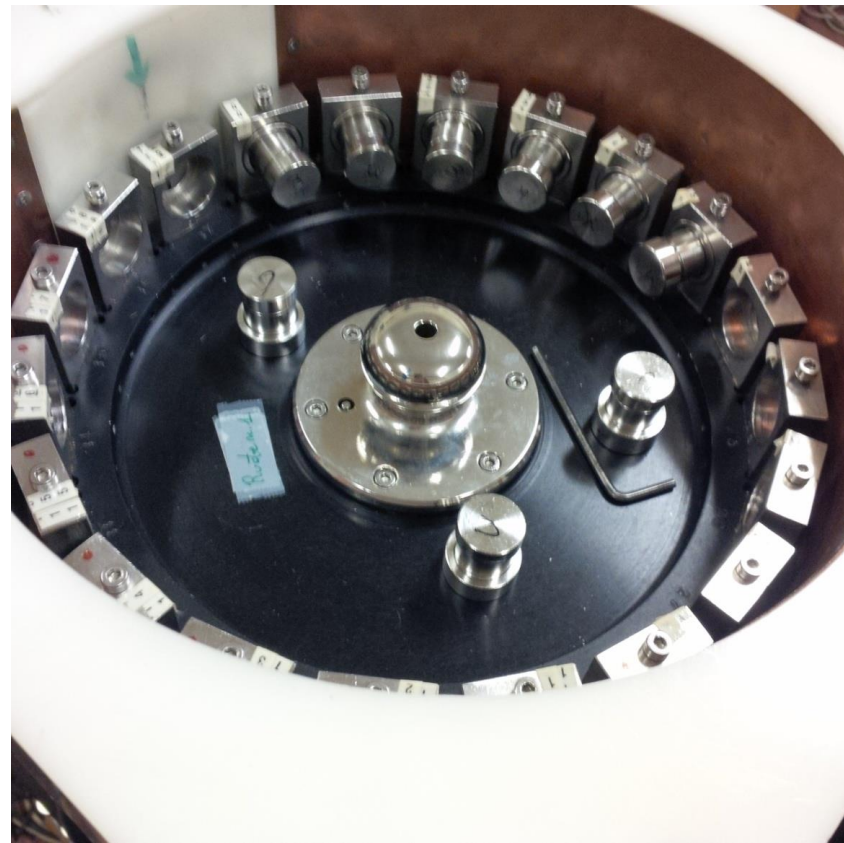
LNL User Community Annual Meeting

Andrea Gozzelino

Referente locale Comitato Coordinamento Terza Missione (CC3M)

Stage @ CN

Radiobiology
Radiobiology line – continuous proton beam at 3.1 MeV

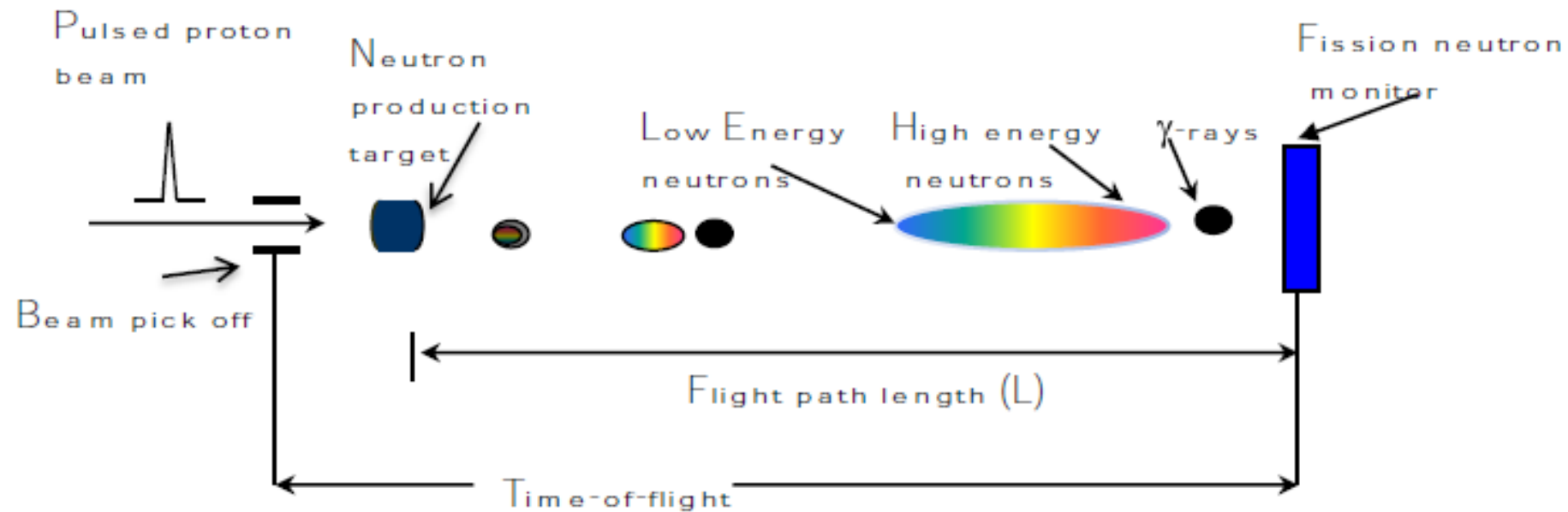


PUBLIC:
Students at high school
(last year of the cycle)

Stage @ CN

Neutron spectra measurements with time of flight technique
beam line 0° - pulsed proton beam at 2 MeV

$$E_{cin} = \frac{1}{2}mv^2 \qquad v = \frac{\Delta s}{\Delta t}$$

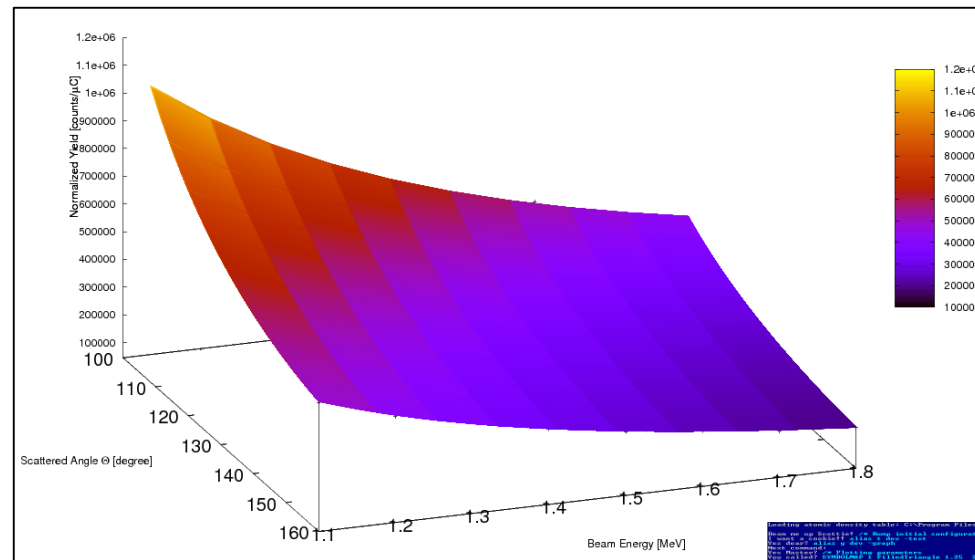
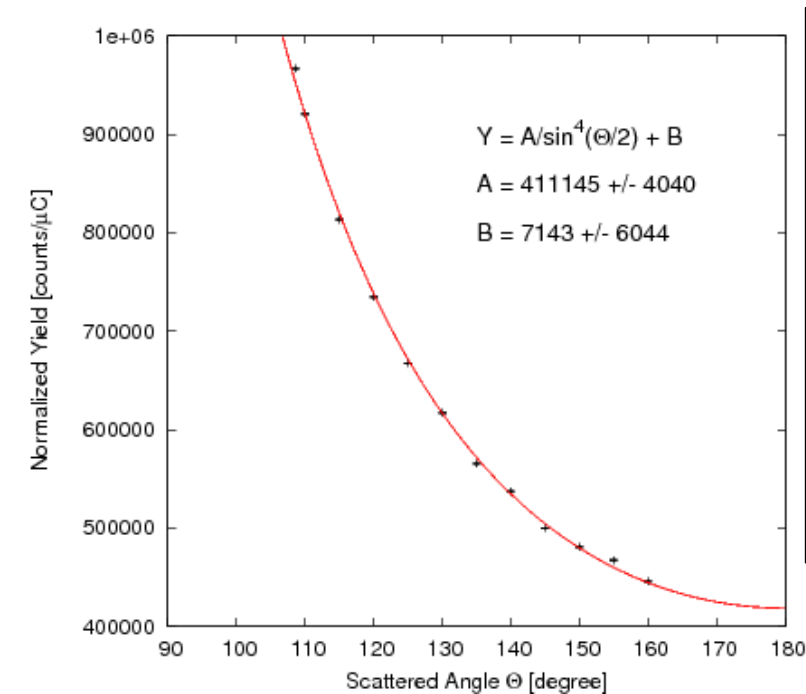


$$\text{Neutron TOF} = \frac{72.3 L}{\sqrt{E_n}} \quad (\text{non-relativistic}) \qquad \gamma\text{-ray TOF} = \frac{L}{c} \quad c \text{ is velocity of light}$$

PUBLIC:
Students at high school
(last year of the cycle)

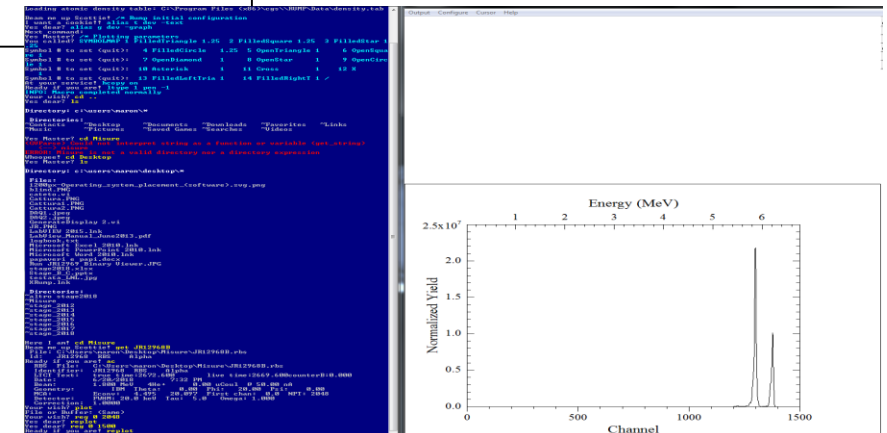
Stage @ AN2000

Rutherford's experiment + Informatics and experimental physics
beam line 60° - Rutherford Backscattering with continuous α beam at different energies



PUBLIC:
Students at high school
(last year of the cycle)

In other editions (not 2018):
Cultural Heritage applications (PIXE)
Environment applications
beam line 0° - continuous proton micro beam



Students on shift @ AN2000

Cultural Heritage applied physics – Experiment ALCHIMIA (INFN Torino)

10 students at high school Liceo Artistico Modigliani in Padua stay one afternoon in the AN2000 control room during data taking beam line 0° with continuous proton micro beam

We will repeat the experience in 2018-2019 scholar year.

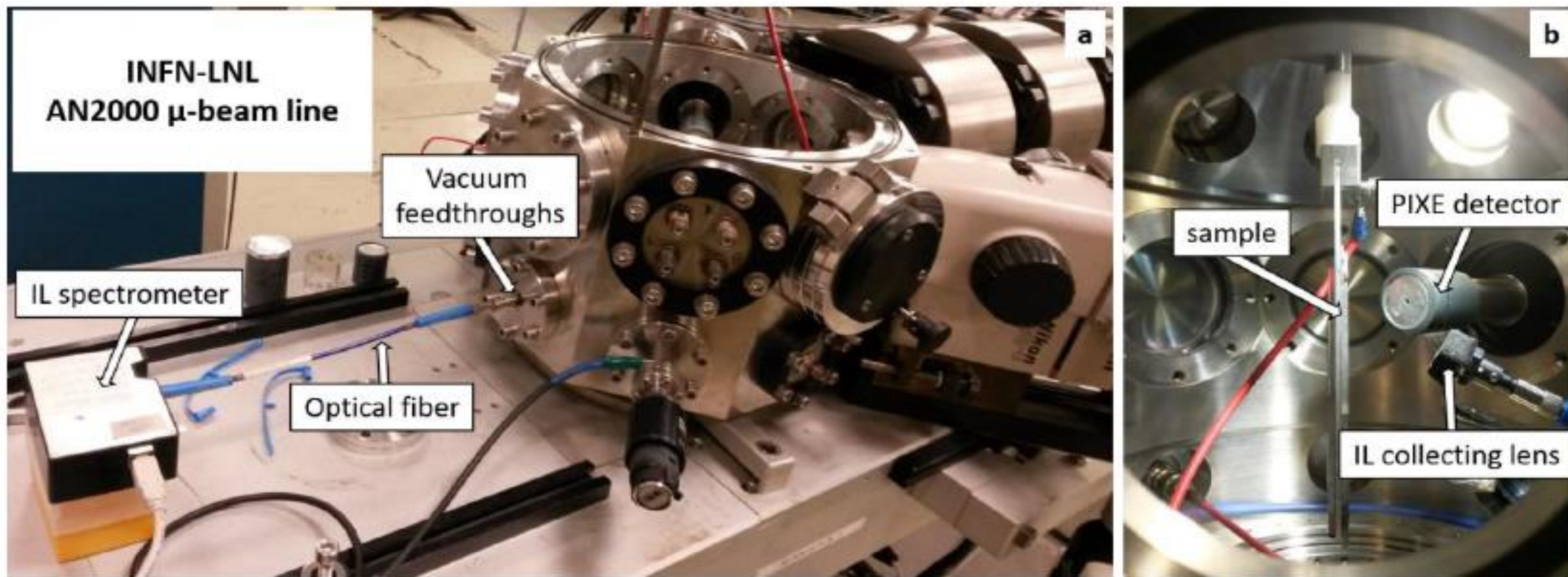


Fig. 1. a) the microbeam line with the installed IL setup; b) the internal part of the vacuum chamber with the IL collecting lens.

Teachers' update

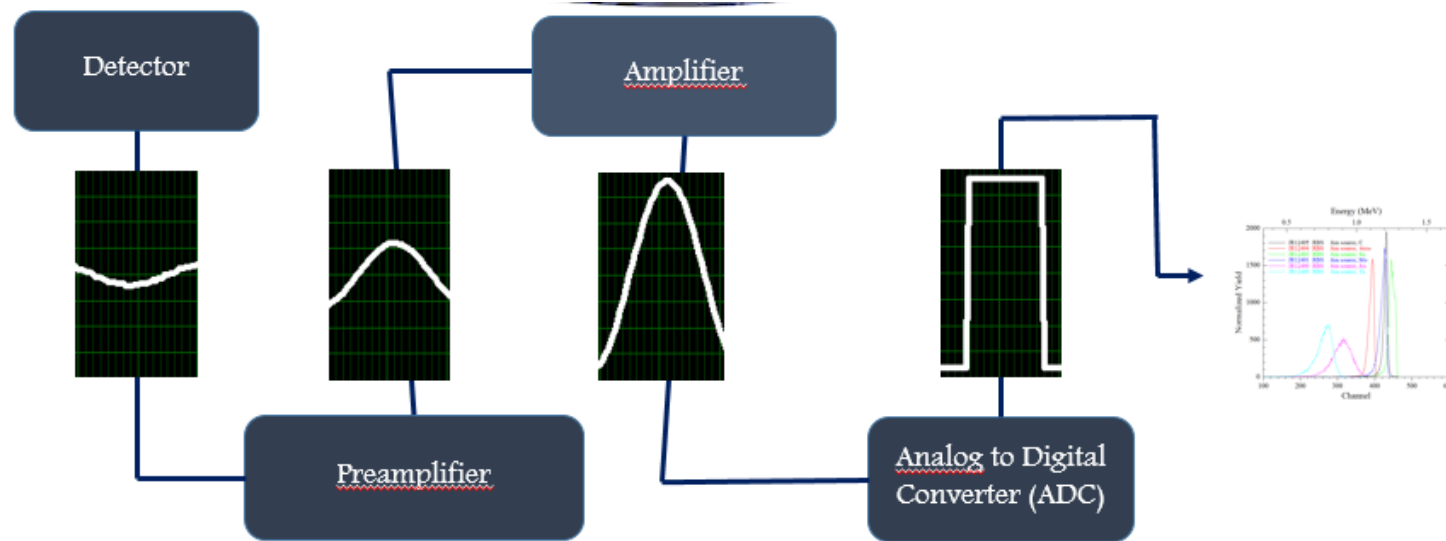
PUBLIC:

Teachers at high school in area mathematics-physics-informatics-electronics

Detectors – Calibration with sources

Experimental box of GALILEO

Experimental line -30° in hall II



PUBLIC of Programma INFN per Docenti (PID):

Teachers at high school in area mathematics-physics-informatics-electronics
national school founded by CC3M

32 teachers selected by committee

first period @ LNL November 12-16, 2018

Site: <https://agenda.infn.it/conferenceDisplay.py?ovw=True&confId=16331>

Laboratory 3: Radiobiology @ CN

Experiments of irradiation of cell cultures with proton beams provided by the Van De Graaff CN accelerator: physical and dosimetric characterization of the beams of radiation used; measures of radiation induced damage in in vitro cells as a function of dose and type of radiation, in terms of cell survival (death) and DNA damage.

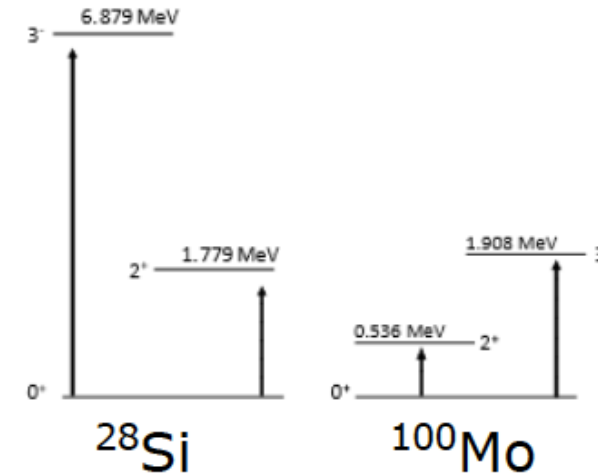
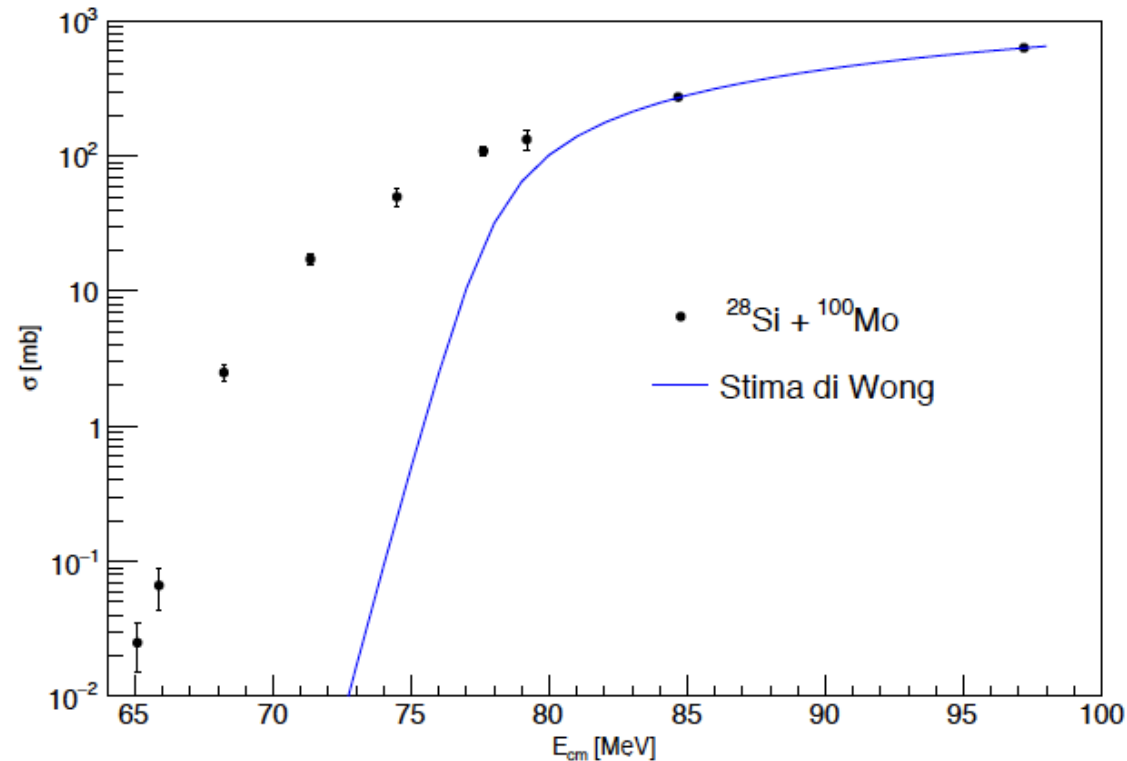
Laboratory 4: Cultural Heritage technique @ AN2000 (PIXE)

Measurement of trace elements present in artefacts or stones (lapis lazuli).

Education of master students I

Experiment conducted by first-year students of the master's degree in physics at the University of Padua in the course 'Advanced techniques of nuclear physics' with publication of an article on the Annual Report of the LNL. TANDEM accelerator, PISOLO experimental apparatus in room II

Measurement of Heavy-Ion Fusion Cross Section:
study of the quantum tunneling effect in complex systems

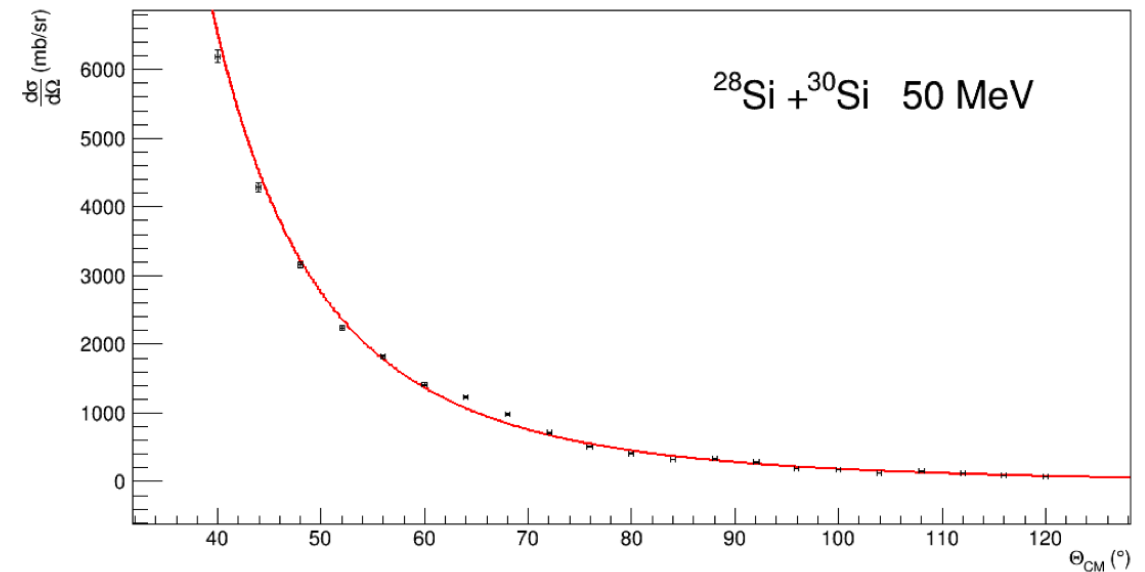
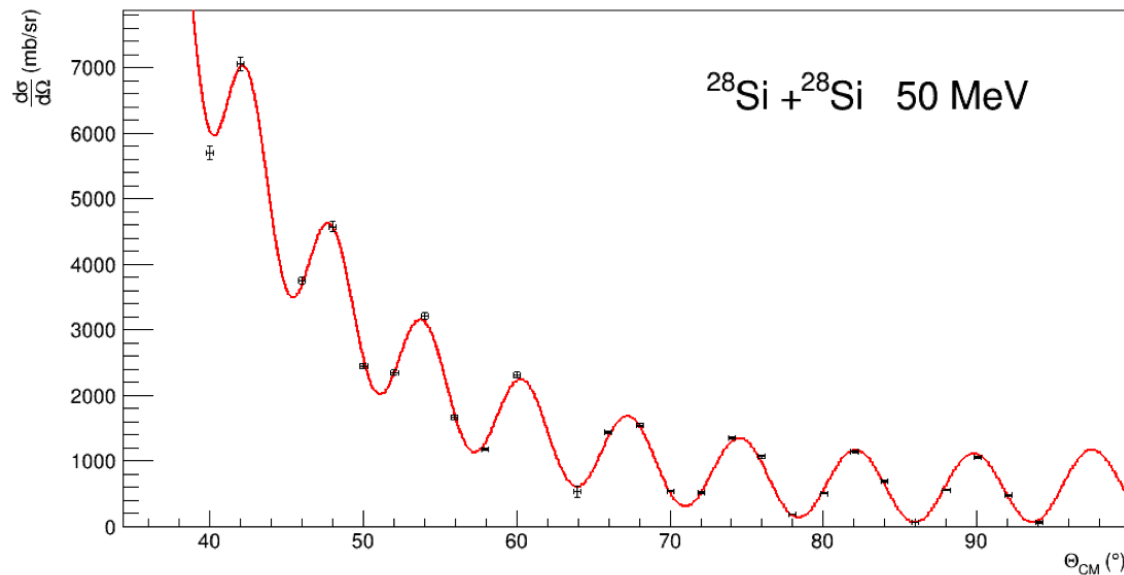


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Education of master students II

Experiment conducted by first-year students of the master's degree in physics at the University of Padua in the course 'Advanced techniques of nuclear physics' with publication of an article on the Annual Report of the LNL. TANDEM accelerator, PISOLO experimental apparatus in room II

Measurement of the Mott scattering cross section between identical particles:
indistinguishability of particles and particle-wave dualism



G. Montagnoli, A. Stefanini

Master students' measurements



Measurement of sub-barrier heavy-ions fusion cross section

The measurement is a verification of the quantum tunnelling effect in complex systems. To perform the experiment it is necessary to define the physical quantities to be measured and to prepare the set-up that has to be optimized on the basis of calculations or simulations. The preliminary work consists in learning how to use the detectors and their associated electronics. In this phase the students will handle vacuum and data acquisition techniques and will perform laboratory tests with an alpha source. The solid angle and the efficiency of the set-up will be determined. The fusion cross section will be measured using the particle beams delivered by the Tandem accelerator of LNL, by detecting fusion evaporation residues at various energies and/or angles. The results will be compared to theoretical predictions by means of simple calculations.

Measurement of the Mott scattering cross section

The measurement is a verification of the indistinguishability of identical particles and of the particle wave duality. To perform the experiment it is necessary to define the physical quantities to be measured and to prepare the set-up that has to be optimized on the basis of calculations or simulations. The preliminary work consists in learning how to use the detectors and their associated electronics. In this phase the students will handle vacuum and data acquisition techniques and will perform laboratory tests with an alpha source. The elastic cross section will be measured using the particle beams delivered by the Tandem accelerator of LNL, at several scattering angles by means of solid state detectors. The results will be compared to theoretical predictions of Mott scattering.

G. Montagnoli, A. Stefanini

Conclusions



- CN and AN2000 decisively support the third mission activity at LNL with more than 5 days (each) of measurement per year. The calendar of the machines must be compatible with the school timetable and the availability of the tutors.
- TANDEM strongly supports the educational activities for master students in physics at the University of Padua.
- The third mission and didactic are objectives on which the laboratories of Legnaro, and in general the INFN, point.
- **GUIDED TOURS: at least one accelerator and one experimental room are included in the itinerary of each visit.**

Thank you very much!