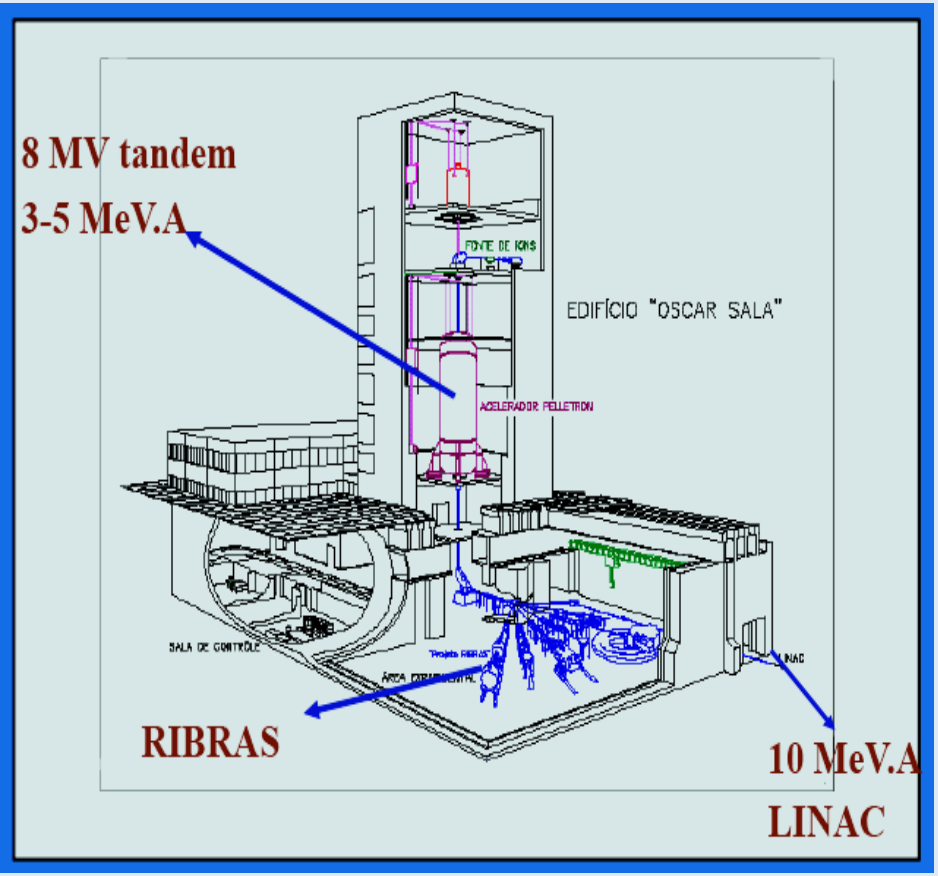
Recent results and upgrades in the Nuclear Physics Laboratory (LAFN) of the University of São Paulo

The Nuclear Physics Laboratory (LAFN) of the University of São Paulo



Facilities: 8MV Pelletron Tandem Accelerator since 1975

Several beamlines:

1. **Radioactive Ion Beams in Brasil (RIBRAS)**
2. **Large multipurpose scattering chamber**
3. **Special beam line for applications**
4. **Enge Split-Pole magnetic spectrometer**
5. **HPGe array with miniball for particle detection- SACI-PERERE**

Open Laboratory of Nuclear Physics (LAFN)

- About 60-70 users, including staff members, pos-docs, graduate students and external users.
- Project Advisory Committee (PAC)
- Basic nuclear physics activities: mainly nuclear reactions with stable or radioactive projectiles
- Applications: Irradiation of electronic devices
- Techniques for cultural heritage study and collaboration with Brazilian museums

RIBRAS - Radioactive Ion Beams in Brasil

First RIB facility in the Southern Hemisphere, installed in2004

Two superconducting solenoids: radioactive ion beam production : ^{6}He, ^{8}Li, ^{7}Be, ^{8}B, ^{10}Be, ^{17}F
Typical intensities: 10^{4} - 10^{6} pps

Prevision of up-grades at RIBRAS:

The use of **new gamma detectors (LYSO) insensitive to neutrons and to magnetic fields**, which are present close to the solenoids.
This will open new possibilities in reaction measurements.

The use of the **Neutron Wall**, a large position sensitive neutron detector with an obsolete electronics. The purchase of new electronics will put the Neutron wall in excellent conditions. Neutron-charged particle detection in coincidence to exclusive break-up measurements of radioactive nuclei (^{6}He, ^{8}Li, ^{10}Be etc)

Scientific program at RIBRAS

Past and Present

Elastic scattering:

(only first solenoid)

- $^{6}He + ^{9}Be, ^{27}Al, ^{51}V, ^{58}Ni, ^{120}Sn$
- $^{7}Be + ^{27}Al, ^{51}V$
- $^{8}Li + ^{51}V, ^{8}B + ^{27}Al$
- $^{8}Li, ^{7,9,10}Be$ on ^{12}C
- $^{8}Li + ^{9}Be, ^{58}Ni, ^{120}Sn$

Present and future

(two solenoids) → $^{8}Li + p, ^{6}He + p$

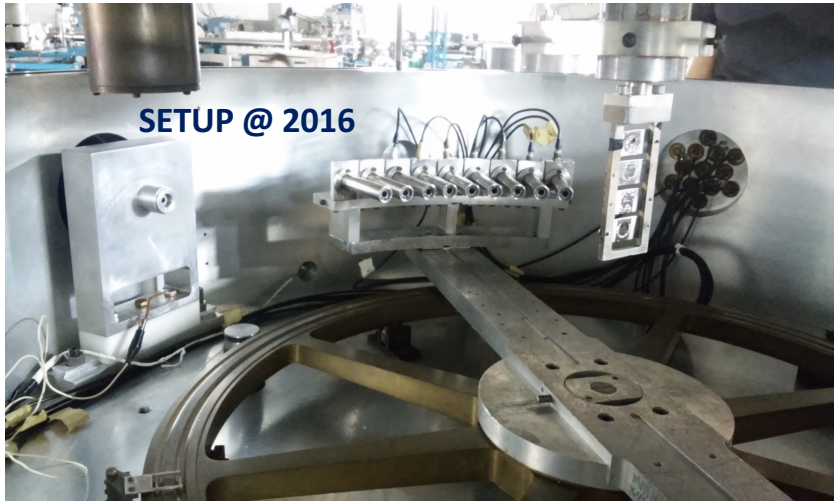
Transfer reactions: $^{8}Li(p,\alpha)^{5}He$, $^{8}Li(p,d)^{7}Li$, $^{8}Li(p,p)^{8}Li$, $^{7}Be\ (^{9}Be, ^{7}Be)\ ^{9}Be$

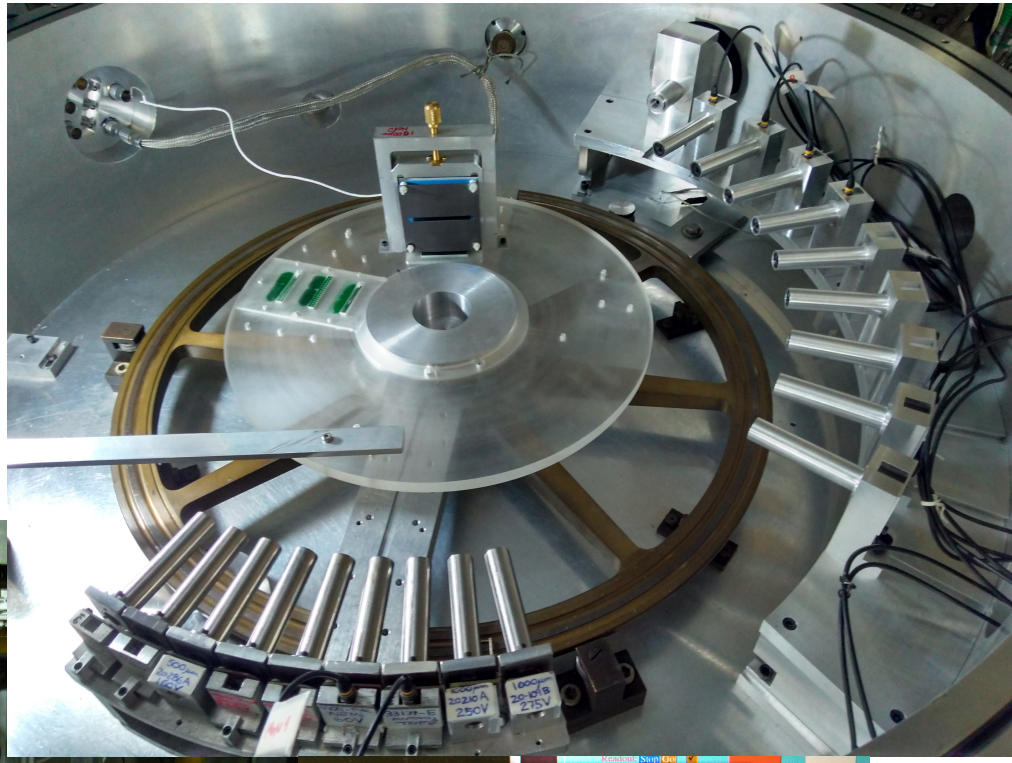
Break-up reactions

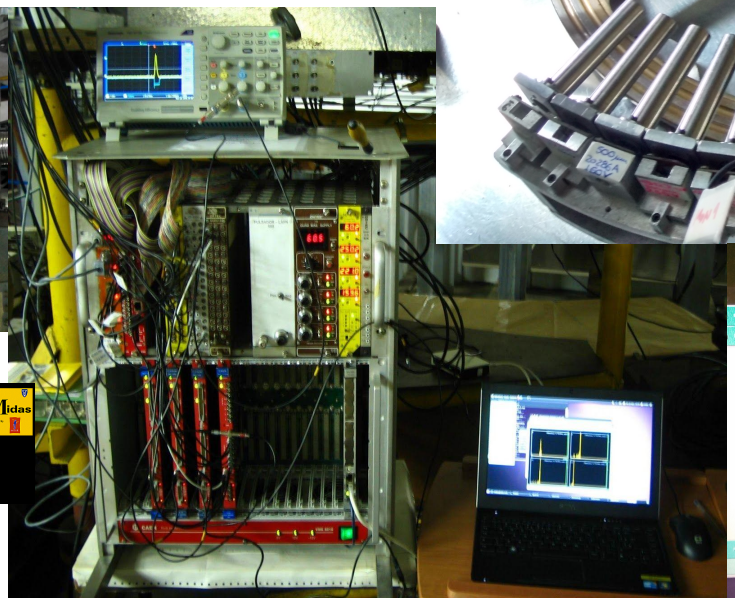
Inelastic scattering

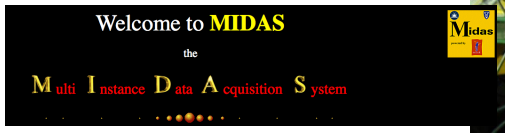
Fusion reactions

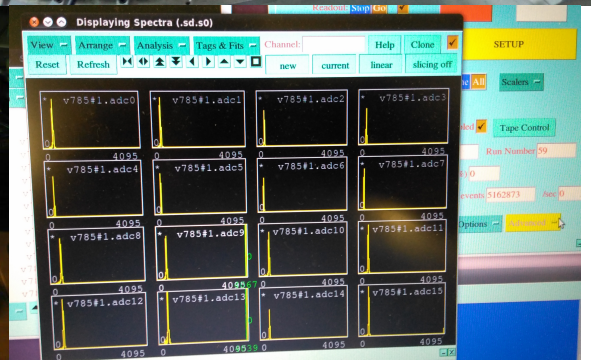
GRIPe - multipurpose scattering chamber 30B



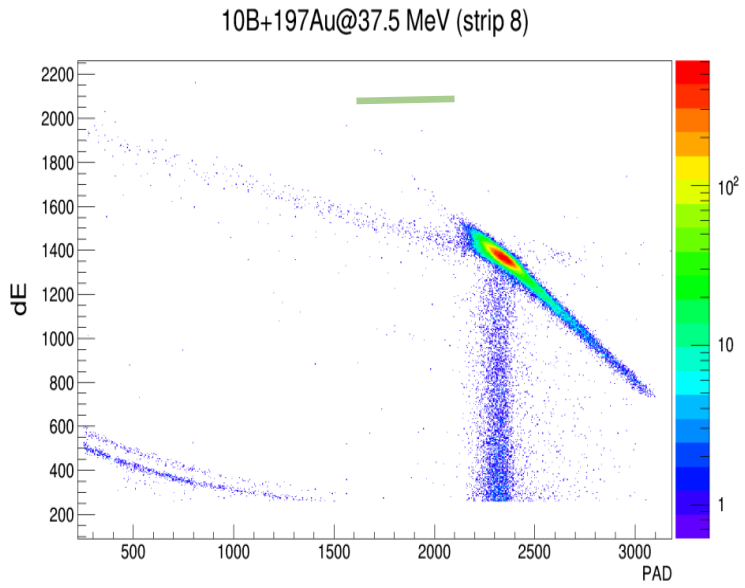


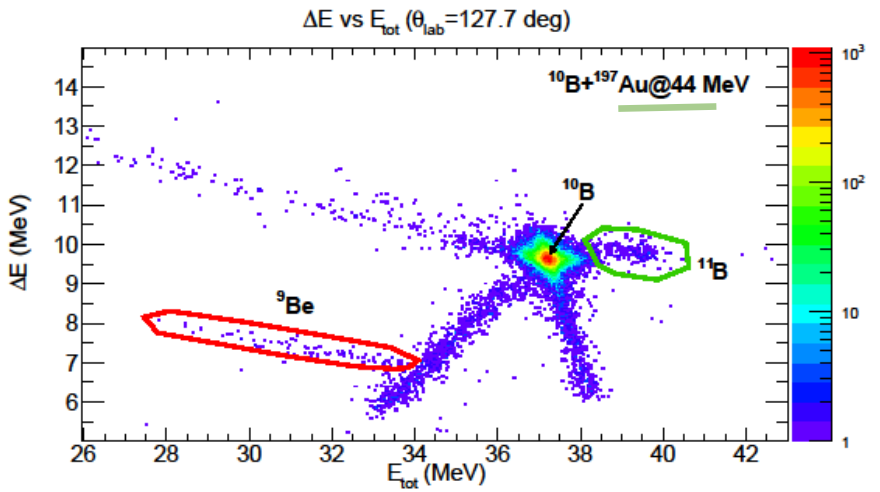


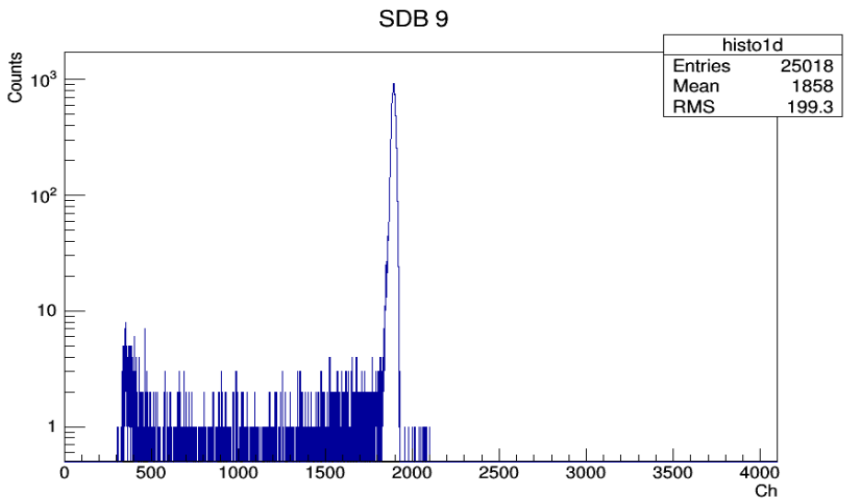


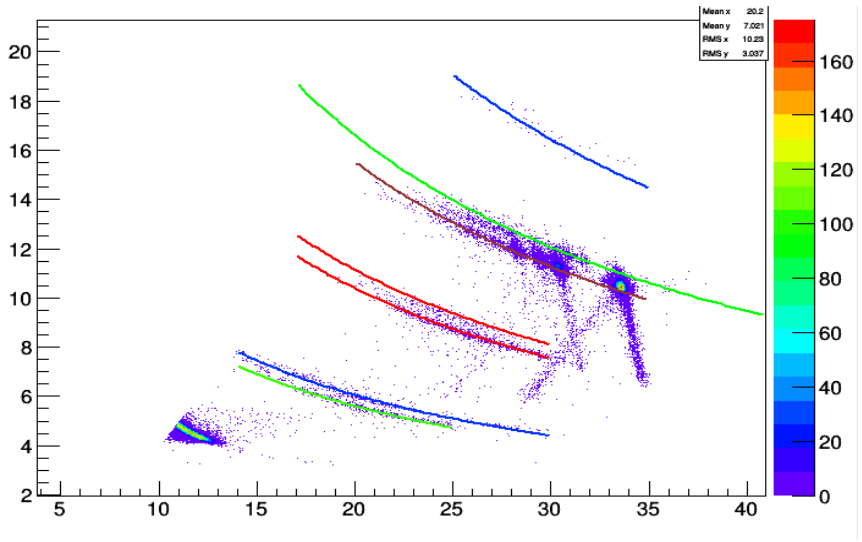


Recent results – experimental campaingn involving weakly bound projectiles









Nuclear Spectroscopy with Light Ions Group

Instituto de Física da Universidade de São Paulo

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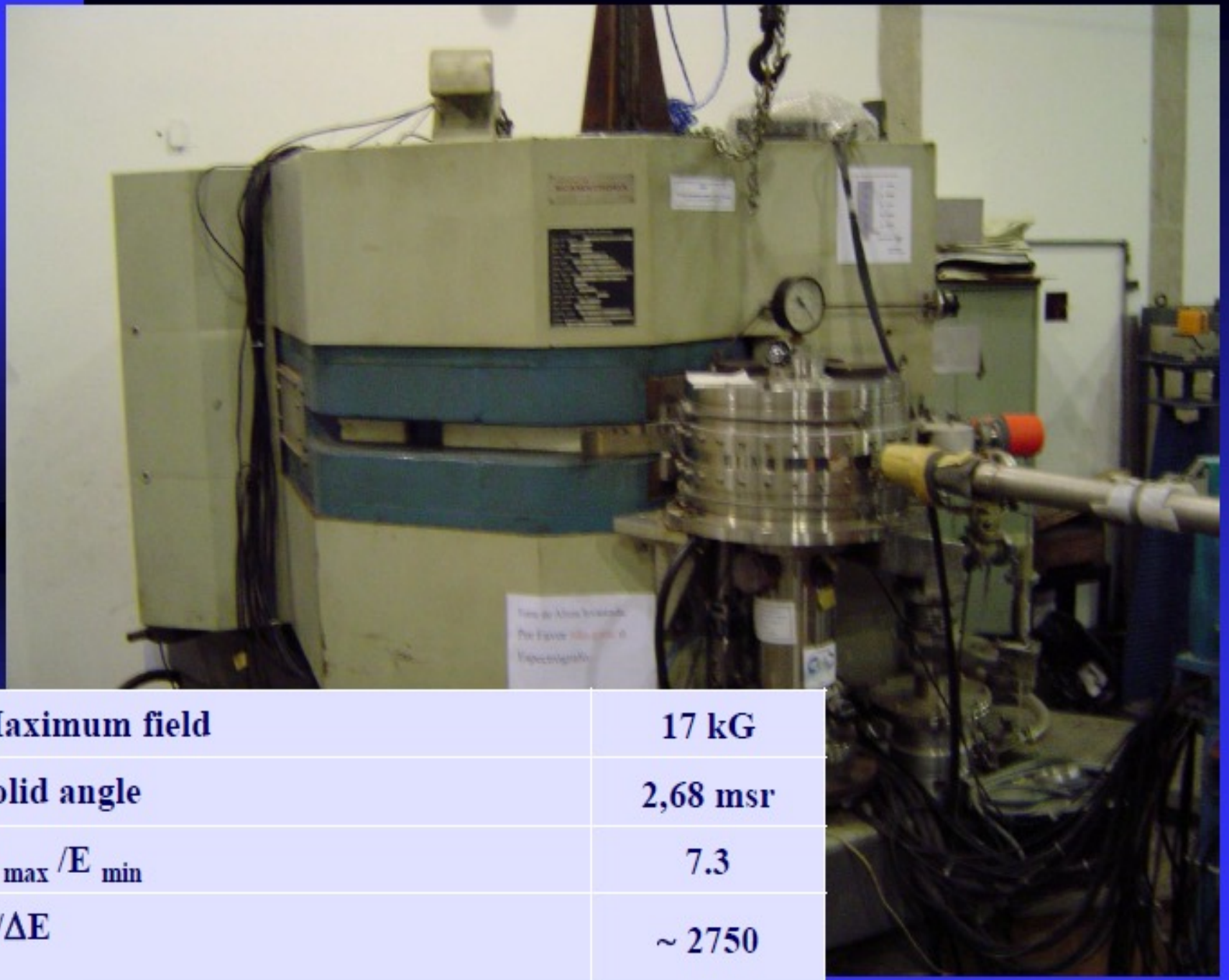
Cleber Lima Rodrigues (IFUSP)



Maximum field	**17 kG**
Solid angle	**2,68 msr**
E_{max}/E_{min}	**7.3**
$E/\Delta E$	**~ 2750**

- Inelastic scattering of 28.0 MeV ^{6}Li exciting the first quadrupole state in ^{70,72,74,76}Ge
- No B(IS2) values had been previously reported.

Gamma-ray spectroscopy group

IFUSP

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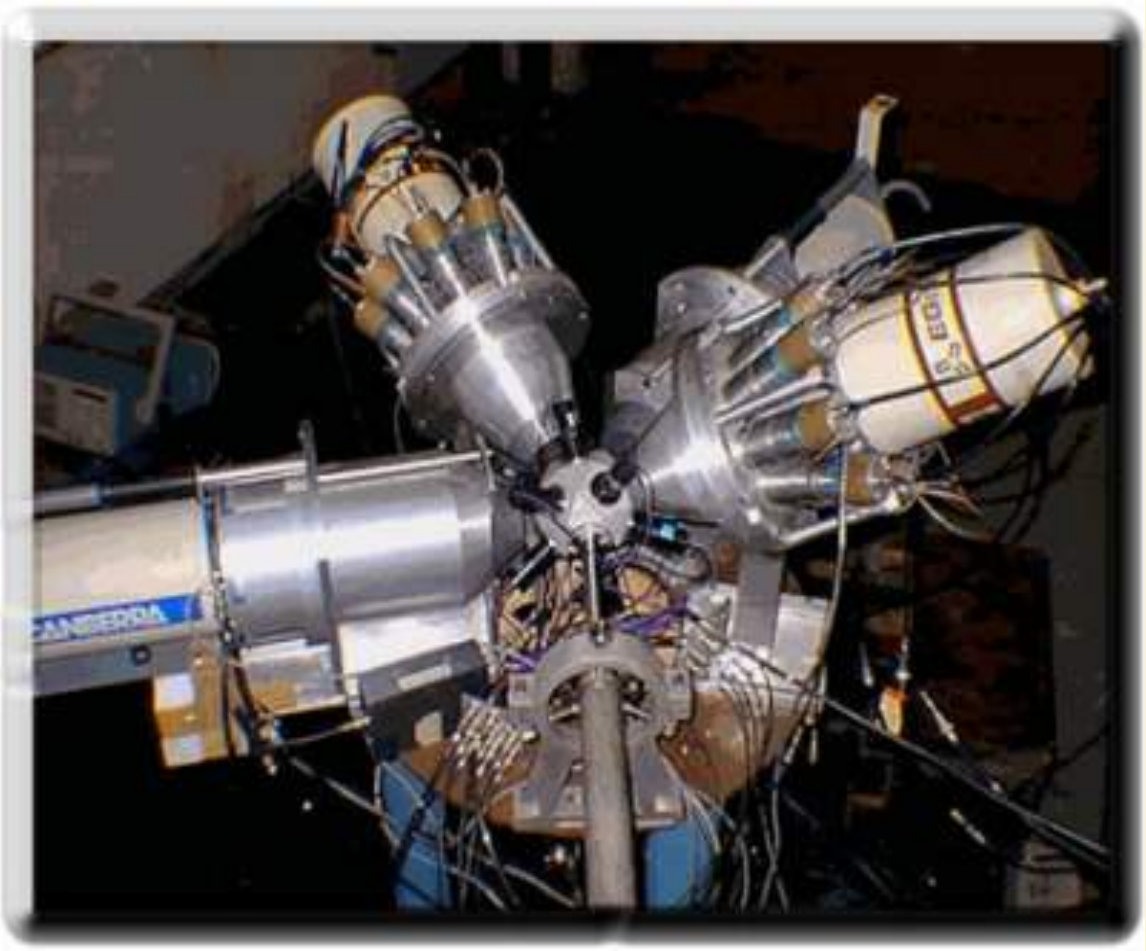
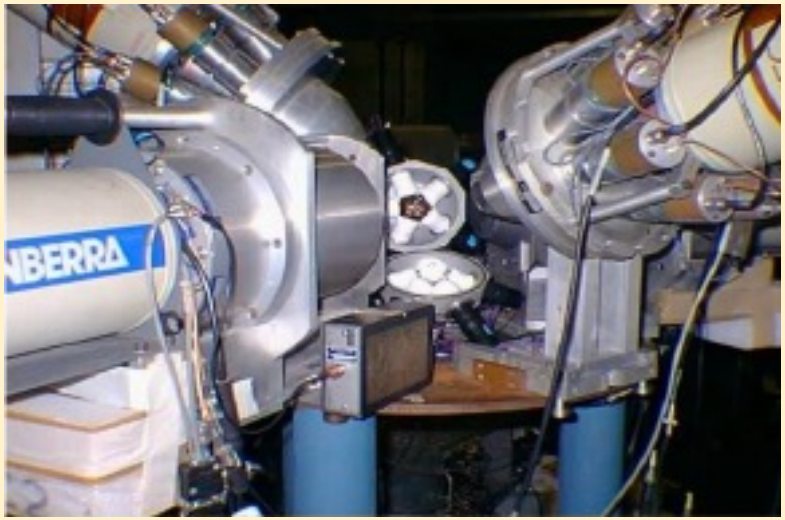


Sistema **A**ncilar de **Ci**ntiladores-**P**equeno **E**spectrometro de **R**adiação **E**letromagnética com **R**ejeição de **E**spalhamento - **SACI-PERERE**

Figure of Brazilian Folklore

4 HpGe detectors (2og 60% 2 of 20%) with BGO Compton suppressors.

Mini-ball of 11 ΔE-E plastic phoswich scintillator (76% of 4π) particle detectors



Use of the Pelletron Accelerator for Applications

Radiation Effects in Electronic Devices

N.Added

N. H. Medina

V.A.P. Aguiar

Instituto de Física da Universidade de São Paulo

SAFIIRA SYSTEM

SistemA de Feixes Iônicos para IRradiações e Aplicações

All the Electronic Devices May Suffer from Radiation Effects

Space Environment
Ground High Radiation Environment

Particle and electromagnetic radiation
Ionizing and non-ionizing dose

Degradation of:
Micro-electronics, micro-processors,
solar cells, optical components, semiconductor detectors,
front-end electronics, cabling, etc

Causing: System shutdowns
Circuit damage
Data corruption, etc

Human beings can also be influenced by radiation effects: astronauts, airplane crew, passengers, patients, personnel, etc.

Single Event Effects

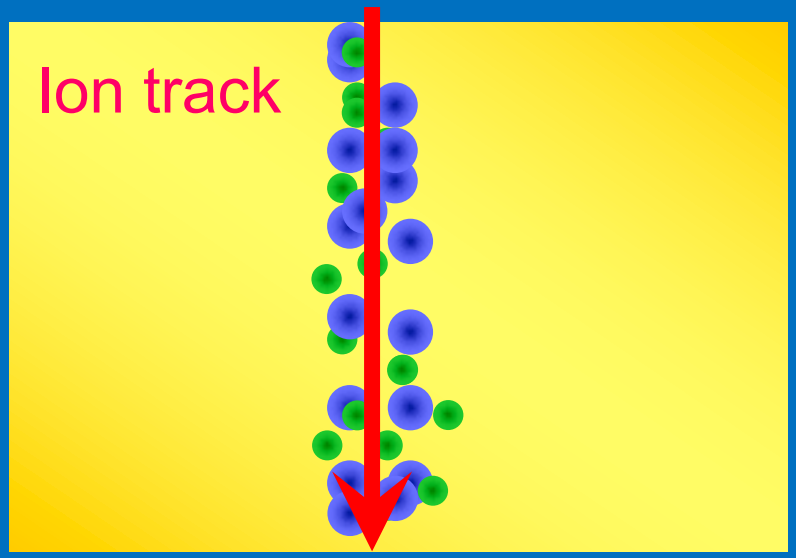
Charge generation

- An ionizing particle generates a track of electron-hole pairs in semiconductors (Silicon) and dielectrics (SiO_2)
- The number of generated carriers is proportional to the particle **Linear Energy Transfer (LET)** (MeV/mg/cm^2)

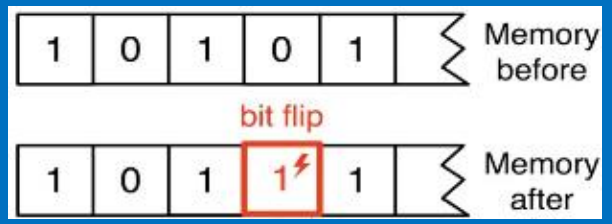
(Energy / e-h pair: **3.6 eV in Si, 17 eV in SiO_2**)

Units: 1 rad = 100 erg/g

1 Gy = 1 J/kg = 100 rad



Nondestructive Effects



Single event upset (SEU)

e.g. memory bit-flip (logic error)

Single event transient (SET)

A transient effect (voltage/current pulses) which may provoke a SEU

Single event functional interrupt (SEFI)

Logical malfunction in programmable devices

Destructive Effects

Single event latch-up (SEL)

high current flux overheated power transistors,
affecting *e.g.* CMOS devices

Single event gate rupture (SEGR)

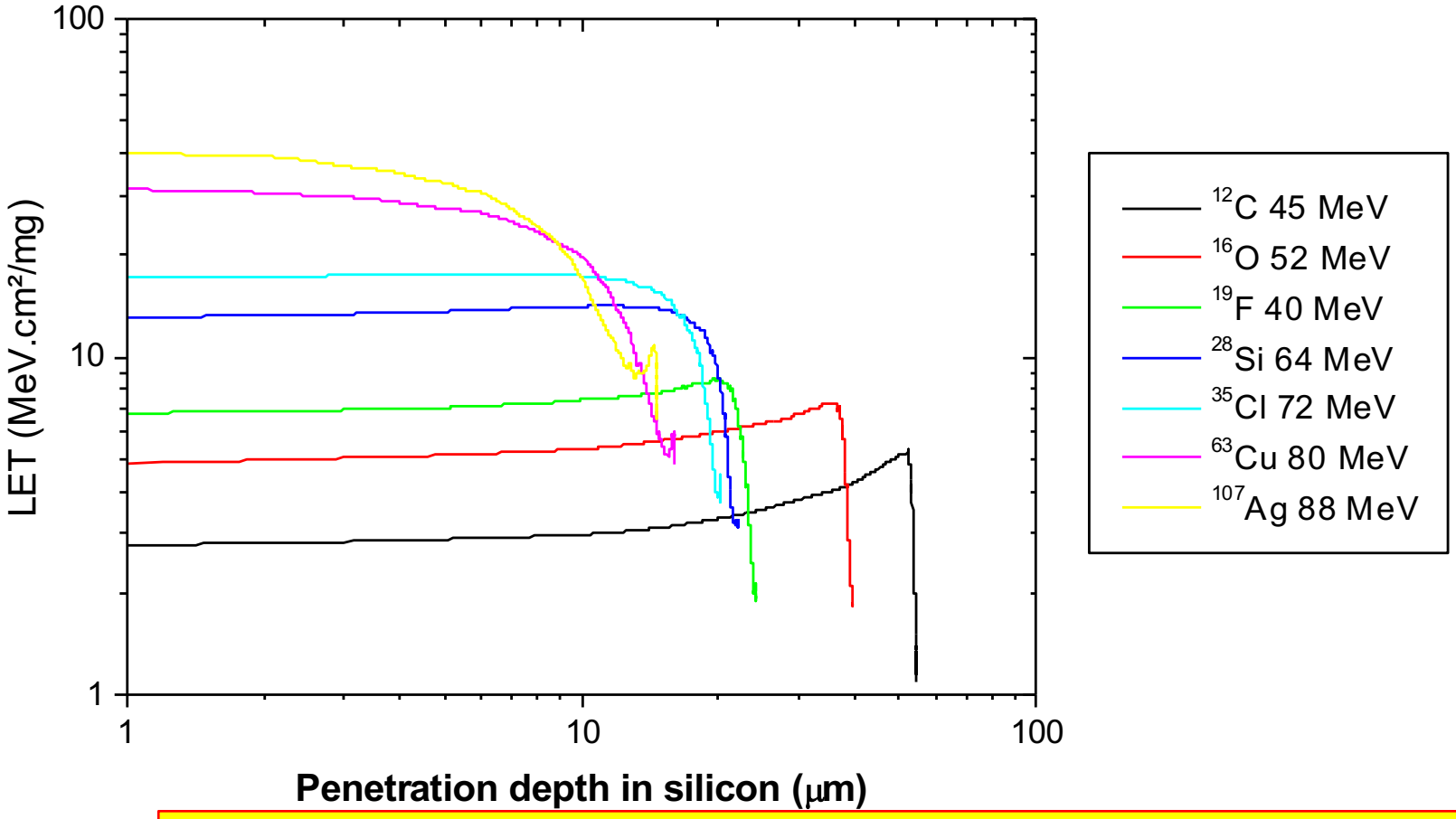
dielectric breakdown of the oxide layer of a MOSFET

Single event burnout (SEB)

Similar to SEL. The high current damage irreversibly ,
e.g. power MOSFET

Linear Energy Transfer (LET)

Energy per depth (**1 MeV/mg/cm^2 ≈ 0.01 pC/μm**)

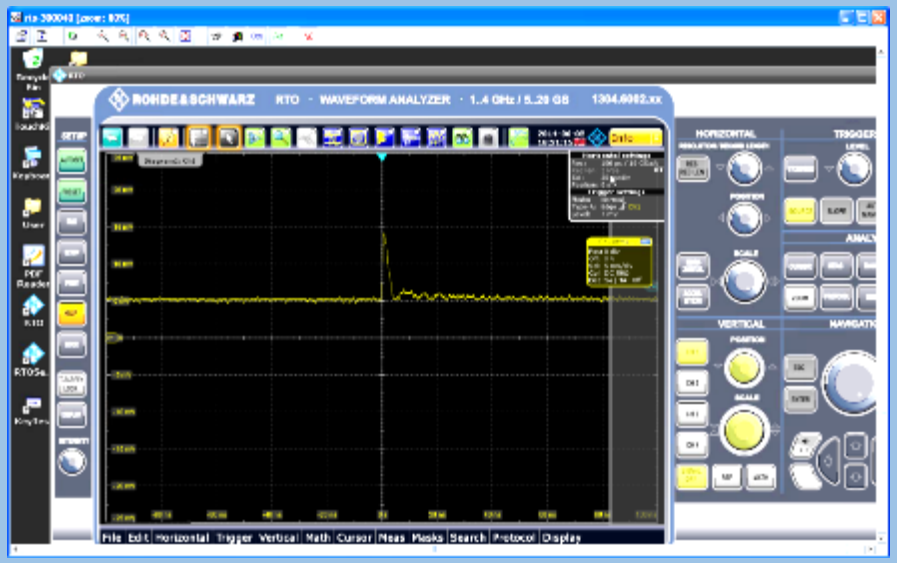


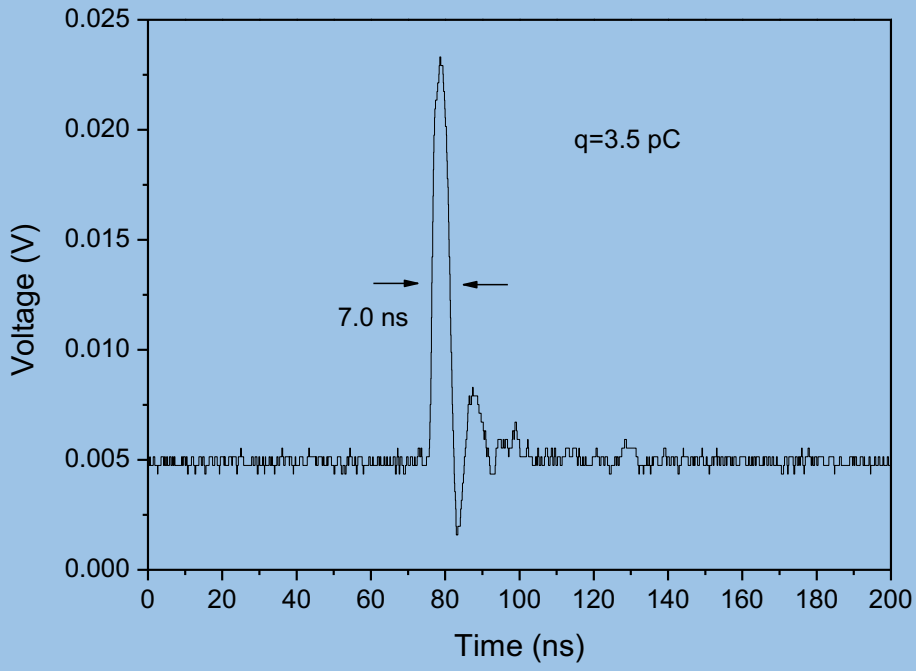
LET as a function of the depth in silicon for the heavy ions available in the 8 UD Pelletron accelerator.

SEU measurements in a p-channel MOSFET transistor (3N163) USP-FEI Collaboration

SEU signal observed with an oscilloscope due to ^{35}Cl heavy ion beam at 75 MeV.

V_G = -0.13 V
V_{DS} = -4.5 V





Sampling rate 5 Gsamples/s 1-GHz Rohde & Schwarz RTO1012 scope

SUMMARY

We have presented the activities in basic and applied experimental nuclear physics with the Pelletron accelerator.

Nowadays we do not have well defined groups, people are collaborating in different projects, involving stable and radioactive beams.

We still have an active research program, with several students, external users and international collaborations