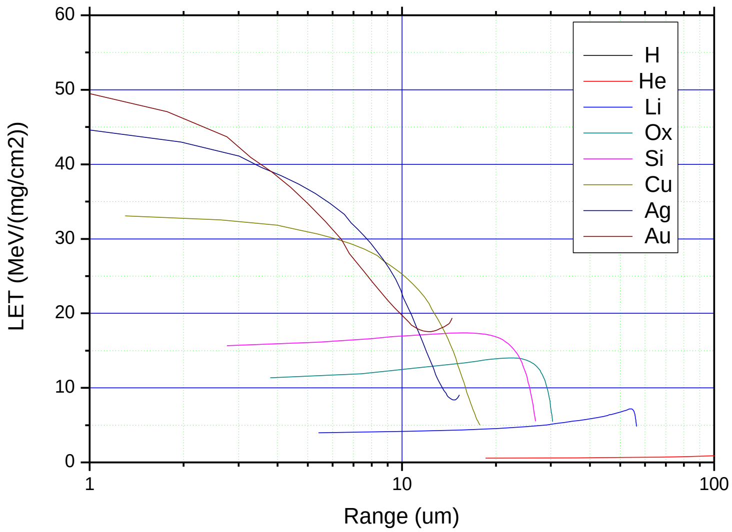
Irradiation of eletronic devices

In collaboration with FEI (K. Cline, R.B.B. Santos, S. Gimenez) and CTI (J.A. de Lima, L. E. Seixas Junior, W. Melo) researchers. The study of ionizing radiation effects on materials used in electronic devices is of great relevance for the progress of global technological development and, particularly, it is a necessity in some strategic areas in Brazil [1]. Electronic circuits are strongly influenced by radiation and the need for IC´s featuring radiation hardness is largely growing to meet the stringent environment in space electronics. On the other hand, aerospace agencies are encouraging both scientific community and semiconductors industry to develop hardened-by-design components using standard manufacturing processes to achieve maximum performance, while significantly reducing costs. To understand the physical phenomena responsible for changes in devices exposed to ionizing radiation several kinds of radiation should then be considered, among them heavy ions, alpha particles, protons, gamma and X-rays. Radiation effects on the integrated circuits are usually divided into two categories: Total Ionizing Dose (TID), a cumulative dose that shifts the threshold voltage and increases transistor's off-state current; Single Events Effects (SEE), a transient effect which can deposit charge directly into the device and disturb the properties of electronic circuits [2]. TID is one of the most common effects and may generate degradation in some parameters of the CMOS electronic devices, such as the threshold voltage oscillation, increase of the sub-threshold slope and increase of the off-state current. The effects of ionizing radiation are the creation of electron-hole pairs in the oxide layer changing operation mode parameters of the electronic device. Indirectly, there will be also changes in the device due to the formation of secondary electrons from the interaction of electromagnetic radiation with the material, since the charge carriers can be trapped both in the oxide layer and in the interface with the oxide. In this work we will investigate the behavior of MOSFET devices fabricated with different geometries, using heavy ion and proton beams. First tests were done using the 1.7 MV 5SDH tandem Pelletron accelerator of the USP Physics Institute with a proton beam of 2.6 MeV. Nevertheless, it is necessary to use heavy ion beams such as ^{28}Si, ^{37}Cl and ^{107,109}Ag in the energies produced by the Tandem 8MV Pelletron accelerator and the new Linear Accelerator (under construction) to achieve the high values of Linear Energy Transfer specified in standards used to characterize the electronic devices. For next year we plan to investigate Single Event Effects in the electronic devices varying the LET, using for that different projectiles like ^{28}Si, ^{35}Cl, ^{107}Ag, ^{197}Au.

LET simulation

Ion beams in Si

(Maximum energy in Pelletron)



Ion	Energy (MeV)
Li	**32**
O	**70**
Si	**90**
Cl	**100**
Cu	**100**
Ag	**100**
Au	**100**

Figure 2: LET simulation (TRIM code) for projectiles using typical conditions in Pelletron accelerator.

[1] Duzellier, S., “Radiation Effects on Electronic Devices in Space”, Aerospace Science and Technology 9, pag. 93-99, 2005.
[2] Barnaby, H.J., “Total-Ionization-Dose Effects in Modern CMOS Technologies”, IEEE Transactions on Nuclear Science, vol. 53, n° 6, 2006.

Relação dos experimentos planejados:

1. Tests with several electronic devices
A) Luiz Carlos Seixas, Marcilei A.G. da Silveira, Salvador Gimenez e Saulo Finco (CTI +FEI) - Dispositivos e componentes eletrônicos robustos à radiação: Transístores com novas geometrias + Circuitos robustos à radiação
B) Marcilei A.G. Silveira e aluno (FEI) – microcontrolador RISC
C) Marcilei A. G. Silveira, Felipe Cunha, Felipe Leite (FEI) - Tests in p- and n-MOSFET devices to investigate the physical mecanisms related to defects induced by próton beam (external beam)

2. SEE tests using heavy ion beam in ADCs from Texas instruments
ATLAS collaboration
respons: Marco L Leite - LIP: Laboratório de Instrumentação e Partículas
Acquisition system available. Tests with gama rays (1.25 MeV) were completed.: External beam ^{28}Si and protons 15 MeV

3. Irradiation of FPGA with prótons and heavy ion beams
A) Fabian Vargas + Juliano Benfica (PUC-RS) – Xilinx Spartan3E + Xilinx Virtex3
B) Fernanda L Kastensmidt (UFRGS) – 28 nm Xilinx Zynq 7000
C) Saulo Finco (CITAR Collaboration) – MicroSemi ProAsic3

4 . SAMPA
ALICE (A Large Ion Collider Experiment) is one of the four major experiments at the particle accelerator LHC (Large Hadron Collider) installed in the European laboratory CERN (European Organization for Nuclear Research). The management committee of the LHC accelerator has just approved a program of updates for this experiment. Among the upgrades planned for the coming years of the ALICE experiment is to improve the resolution and tracking efficiency maintaining the excellent particle identification ability and allowing the study of rare probes that can increase significantly our understanding of nuclear matter. In order to achieve such goal, it is necessary to update the read-out electronics from several systems in the ALICE experiment, like the Time Projection Chamber detector (TPC) and the Muon Tracking Chambers (MCH). The TPC detector is the main device of the central barrel of the ALICE experiment for tracking and identification of charged particles, while the MCH allows the measurement of muons in the forward direction. The main required modification is the creation of a new ASIC (Application Specific Integrated Circuit) that will be installed in the front-end electronics of these detectors with the aim of amplifying, converting and filtering the signal generated by these devices. The High Energy Physics and Instrumentation Center (HEPIC) from the Nuclear Physics Department and the Laboratório de Sistemas Integráveis (LSI) from Escola Politécnica da USP have the entire responsibility of the design, simulation, prototyping, experimental testing, validation and manufacturing of this new ASIC that will work in the new conditions imposed by the LHC, with lower power consumption compared with the previous version of the chip. One of the main requirements of this new ASIC is to cope with the radiation induced by LHC in the ALICE environment. Therefore, it is mandatory to perform several tests with this device in order to qualify it for usage under such environment.
Responsible: Marcelo Munhoz + Alice collaborators

LABORATÓRIO ABERTO DE FÍSICA NUCLEAR

PAC 2016

Proposal	N°
Title: **Irradiation of electronic devices**	
Responsable: **Nemitala Added**	e-mail: **nemitala@if.usp.br**
Participants **N. Added, M.H. Tabacniks, N.H. Medina, M.A.G. Silveira, Vitor Aguiar, Fernando Aguirre, bolsistas de IC + Grupo do projeto CITAR (CTI, INPE, AEB, IEAv)**	
Spokeperson: **Nemitala Added**	e-mail: **nemitala@if.usp.br**
Telephone: 3091-6824	Skype:
Number of days for experiment:	36 days
Period planned for the experiment (are the setup ready for beam time?): Experiment can be performed tomorrow	

Technical information

Ion source			Accelerator			Experimental Area	
Beam	Cathode	$I_{mínima}$	V_{min}	V_{max}	Bunched beam?	Beam line	Target
Several		300 nA	6,5	7,5	n	0, 30B	several

Other relevant/needed information:
3 days each month