



Trento Institute for
Fundamental Physics
and Applications

Possibility of Total Ionizing Dose Effects measurements for LHC experiments elements in a medical facility: the TIFPA-INFN experience

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MOTIVATION

Total Ionizing Dose (TID) effects damage studies, performed with x-ray irradiation, are required measurements for solid state particle sensors and electronic control systems qualification in all the LHC present experiments and future upgrades.

Some of these irradiation studies can be performed not only in facilities explicitly built for this mission⁽¹⁾, but also in medical/biophysical research facilities equipped with x-ray irradiation stations with tungsten anode satisfying some required conditions:

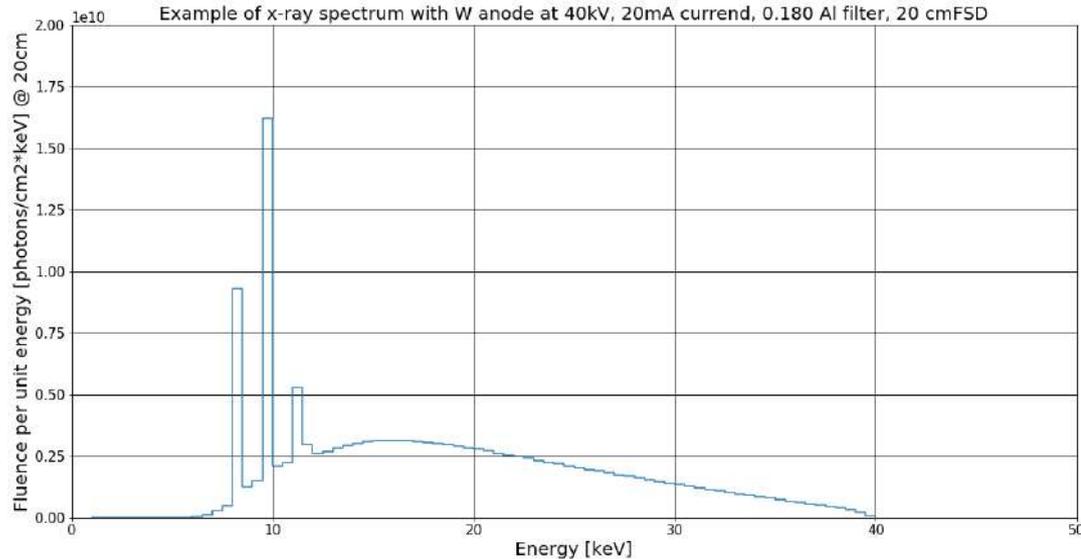
- 1) the x-ray tube voltage can be set to 30-40 kV
- 2) irradiation filter can be changed with a thin 0.100-0.200 mm Al filter.

These 2 conditions allow to use the L lines tungsten emission peaks (energy 7-12 keV). Verification of these condition can be done with a specific simulation software, like the SpekPy software toolkit.

If a calibrated diode is not available, delivered TID dose measurement (Si dose or SiO₂ dose) can be performed using medical/biophysical devices like Farmer Chamber or Markus chamber, only after a direct comparison of the chamber read-out with a calibrated diode read-out. The chamber/diode dose ratio measurements cannot be extrapolated outside the measured Tube parameters conditions.

Preliminary studies and measurements

SiPM Radiation Field simulation with the the SpekPy* software toolkit:



Considered tube configuration:
tungsten anode, 0.8mm Be window;
40kV anode tension, 20mA current, 0.180 mm Al filter,
20 cm FSD target position.

(*) <https://doi.org/10.1016/j.ejmp.2020.04.026>

In order to use the PTW Farmer Chamber dose measurement system, preliminary comparison framer chamber vs calibrated diode read-out were performed in the Padova INFN x-ray station using exactly the planed SiPM radiation field. In this way was evaluated the read-out ratio farmer chamber dose/Si dose .



Final considerations

The TIFPA-INFN center is equipped with a x-ray tungsten irradiation station optimized for medical/biophysical irradiation: 195kV, 5mA current, 3mm Al filter and PTW Farmer Chamber Dose measurement system.

After a filter replacement, the station was used for SiPM TID studies at 40kV and 20mA current. The x-ray spectrum of the new tube configuration was checked using simulations realized with the SpekPy toolkit. The ratio chamber dose/ diode dose (Si dose) was evaluated performing PTW Farmer Chamber dose measurements in the Padova INFN x-ray irradiation station. In these conditions a 10Mrad irradiation was successfully performed in 3 working days performing also SiPM characterizations at different irradiation dose levels.

Data analysis on the SiPM characterization is ongoing and will be included in the Anna Rita Altamura PhD thesis (in preparation).

In this set-up configuration the x-ray uniform spot is quite large: 4.5 cm radius and can be used for other LHC experiment elements TID characterization studies requiring total dose of the order of 1-50 Mrad, for example electronic elements and sensors located far from the interaction point.

Thanks for your attention!

And contact me for any other question!

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Back-up slides

Documentation

See also the following presentations

ICHEP 2020 Conference: ICHEP2020: #677

Benedetto Di Ruzza

Proton and x-ray irradiation of silicon devices at the TIFPA-INFN facilities in Trento (Italy)

<https://indico.cern.ch/event/868940/contributions/3815732>

16th (Virtual) "Trento" Workshop on Advanced Silicon Radiation Detectors

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Ionizing and Non-Ionizing Energy Loss irradiation studies with 70-230 MeV protons at the Trento Proton Therapy Center

<https://indico.cern.ch/event/983068/contributions/4223200>

WEBLINKS

Trento Institute for Fundamental Physics and Applications (**TIFPA**): <https://www.tifpa.infn.it/about-tifpa>

TIFPA Activity Reports: <https://www.tifpa.infn.it/contacts/downloads>

TIFPA Trento Proton Beamline: <https://www.tifpa.infn.it/sc-init/med-tech>

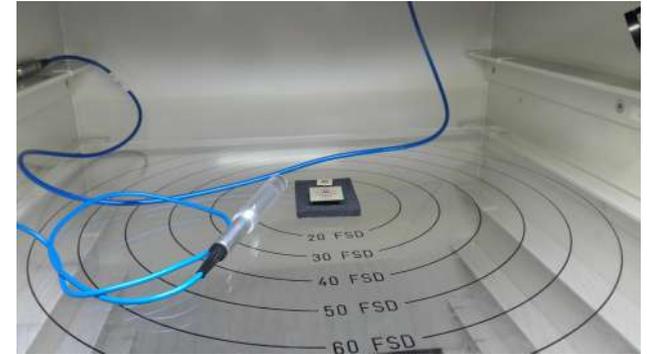
Bruno Kessler Foundation (**FBK**): <https://www.fbk.eu/en>

TIFPA-INFN X-Ray station

X-Ray cabinet



PTW Farmer Chamber (left)
with SiPM (right)



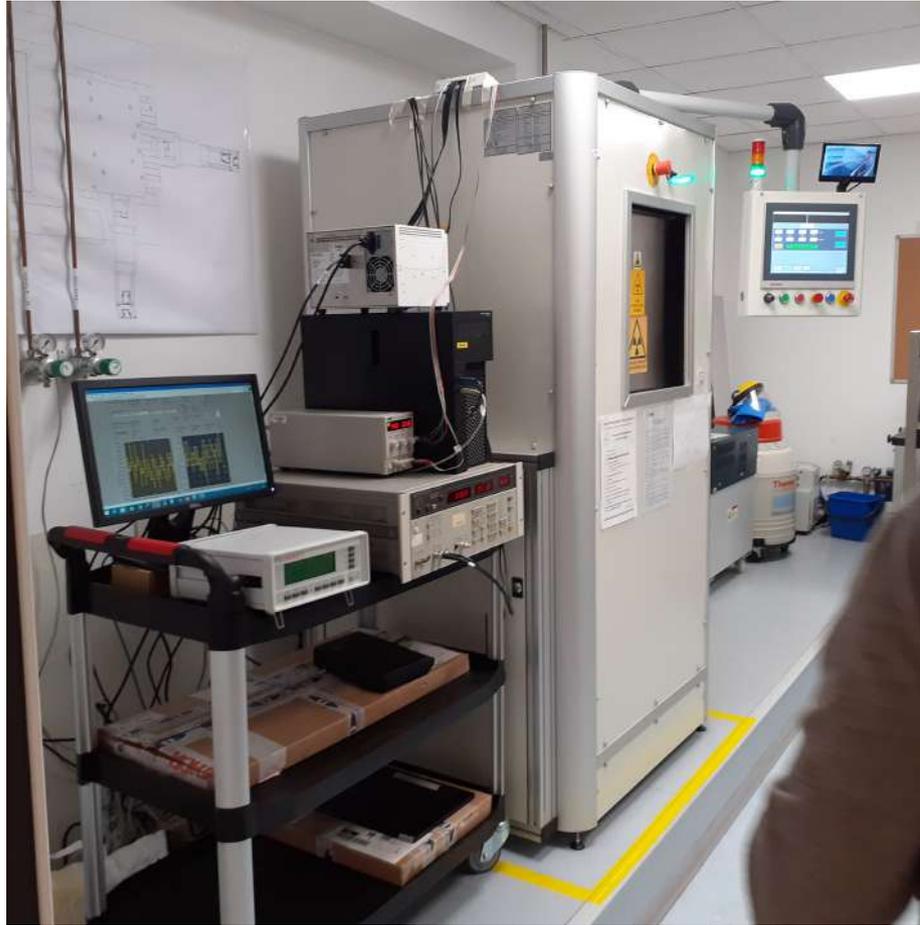
Tube detail



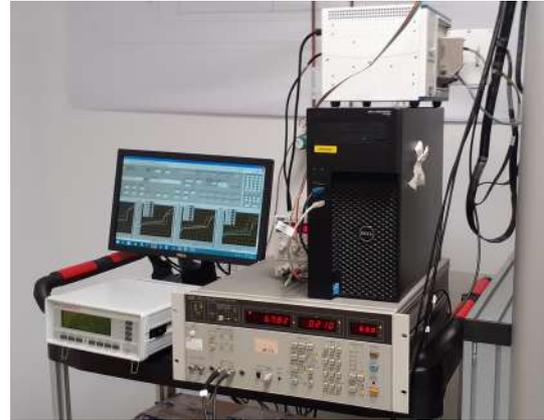
PTW Electrometer



FBK SiPM Irradiations



Overview of the irradiation set-up



SiPM online characterization system (FBK)



Farmer chamber and SiPM support (FBK)

Abstract:

Total Ionizing Dose Effects tests and measurements are crucial requirements for solid state particle sensors and electronic control systems qualification in all the LHC present experiments and future upgrades.

These measurements can be performed not only in facilities explicitly built for this mission, but with some wisdom, also in medical or biological research facilities when some minimum requirements are present. In this poster will be shown the planification and realization of SiPM x-ray irradiations for TID measurements realized in the italian TIFPA-INFN Trento Center laboratory.

In detail will be described the minimum flexibility required by the x-ray irradiation set-up, by the dose measurement system, the irradiation pianification and realization.

Finally will be presented the limitations observed in these measurements, how can be minimized and the final results.