Radiation Hardness and Annealing Strategies for SiPMs of the Terzina Telescope on-board the NUSES space mission

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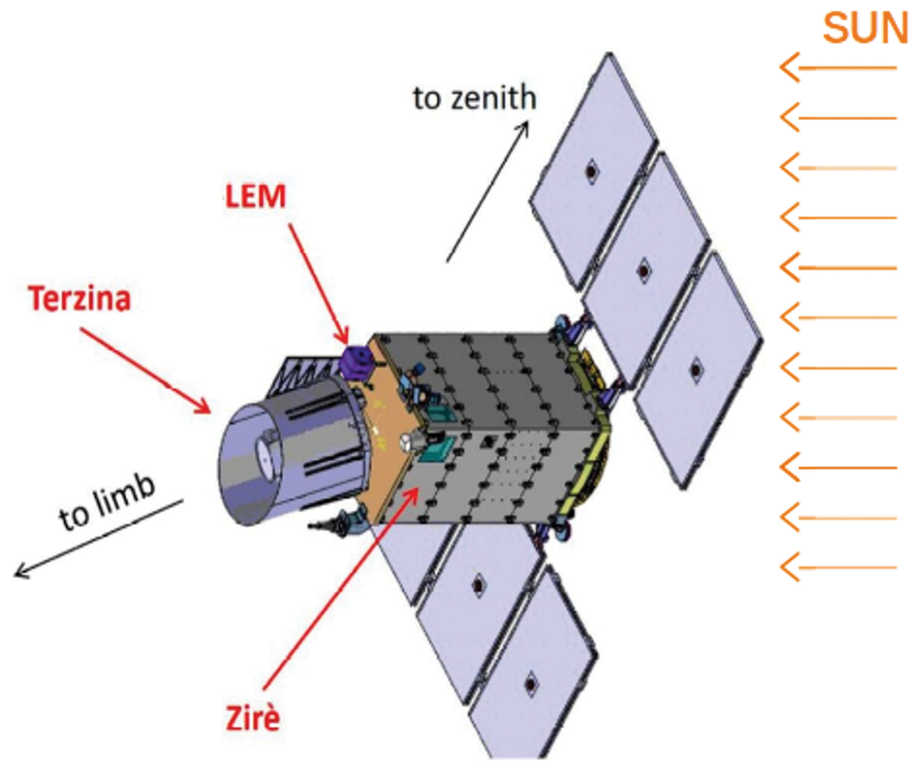
on behalf the NUSES collaboration

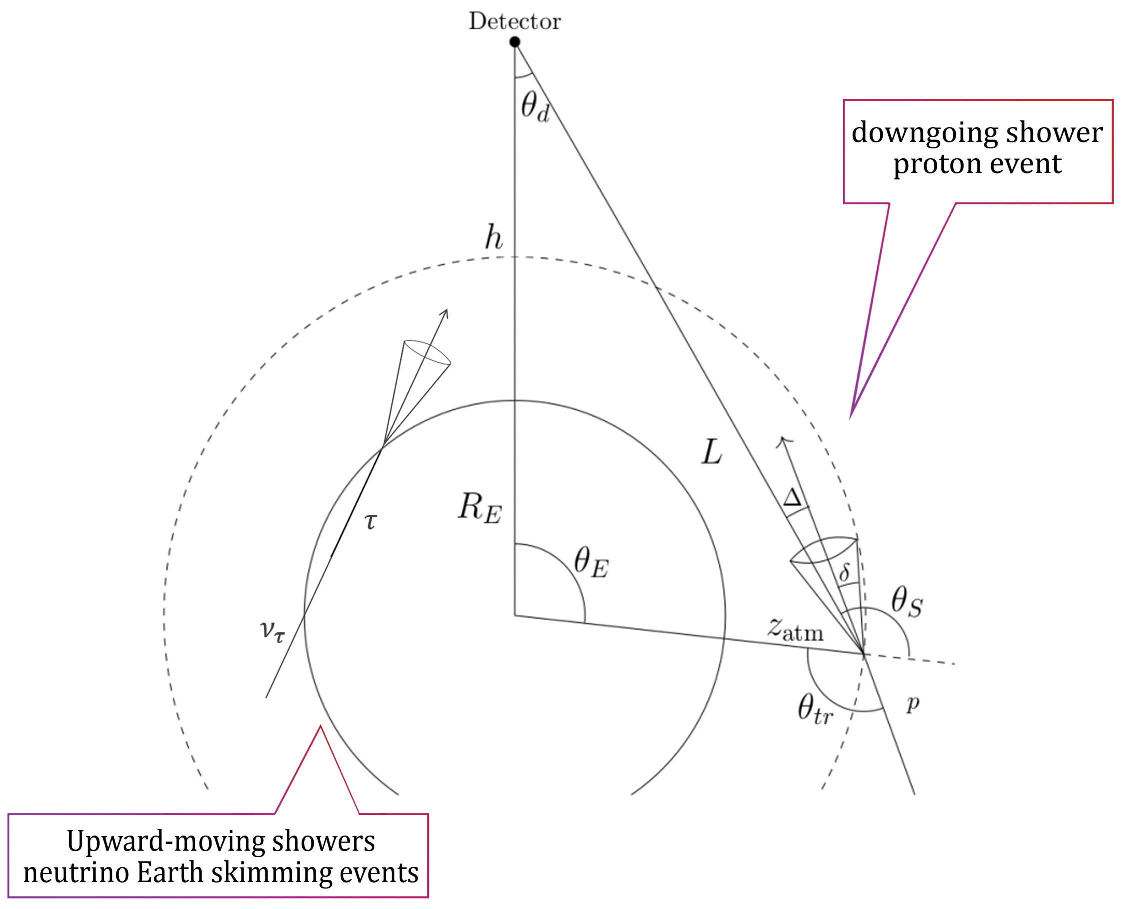
1. NUSES mission

- Lifetime 3 years
- Sun-synchronous orbit
- Low Earth orbit, initial altitude 535 km
- Two payloads: ZIRE and TERZINA



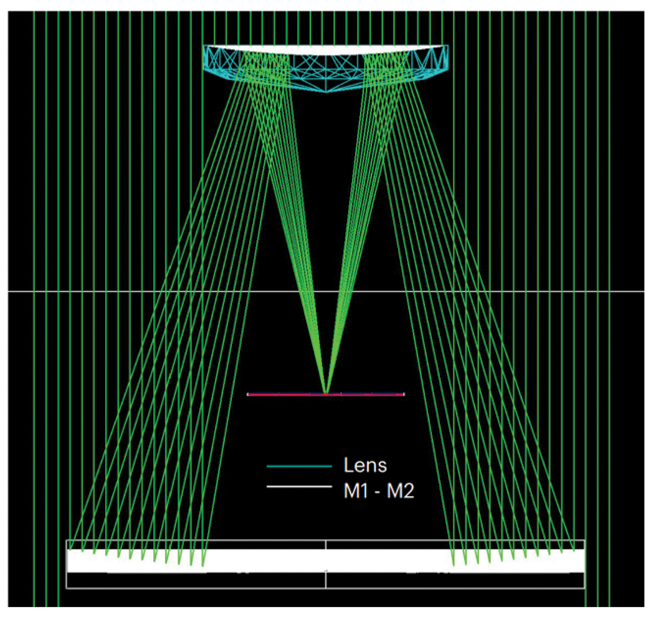
2. Terzina target events

- 1st observation of Cherenkov light emitted by atomospheric showers from space!
- upgoing and downgoing Extensive Air Shower

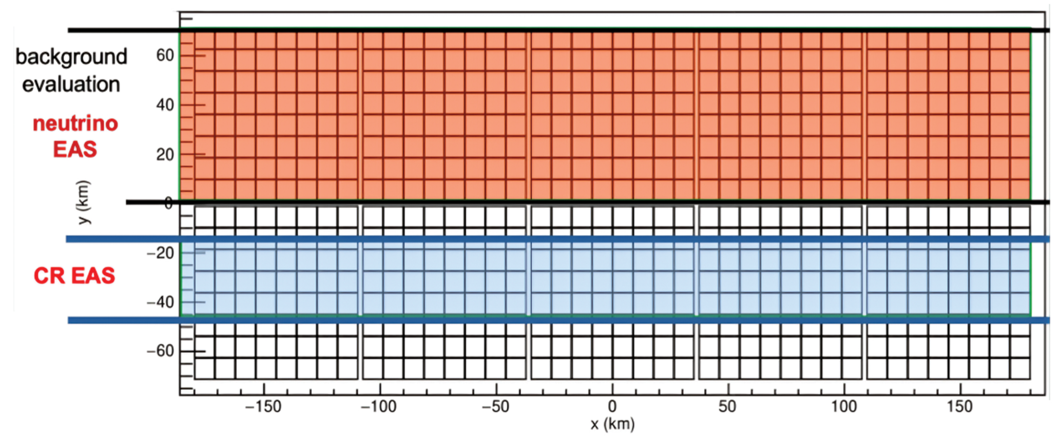


3. Terzina detector

- Schmidt-Cassegrain optical system
- Camera Field of View ~ 7.2° x 2.88° (40 x16 pixels)

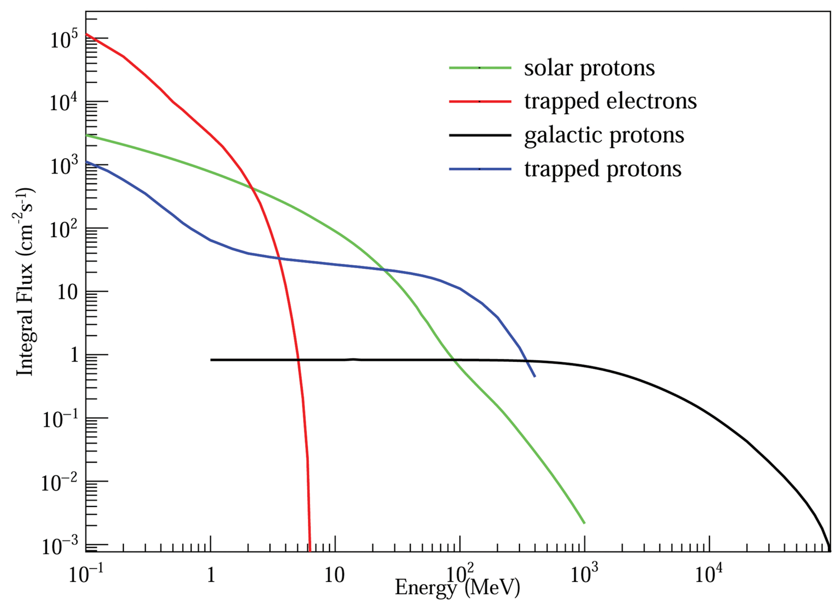


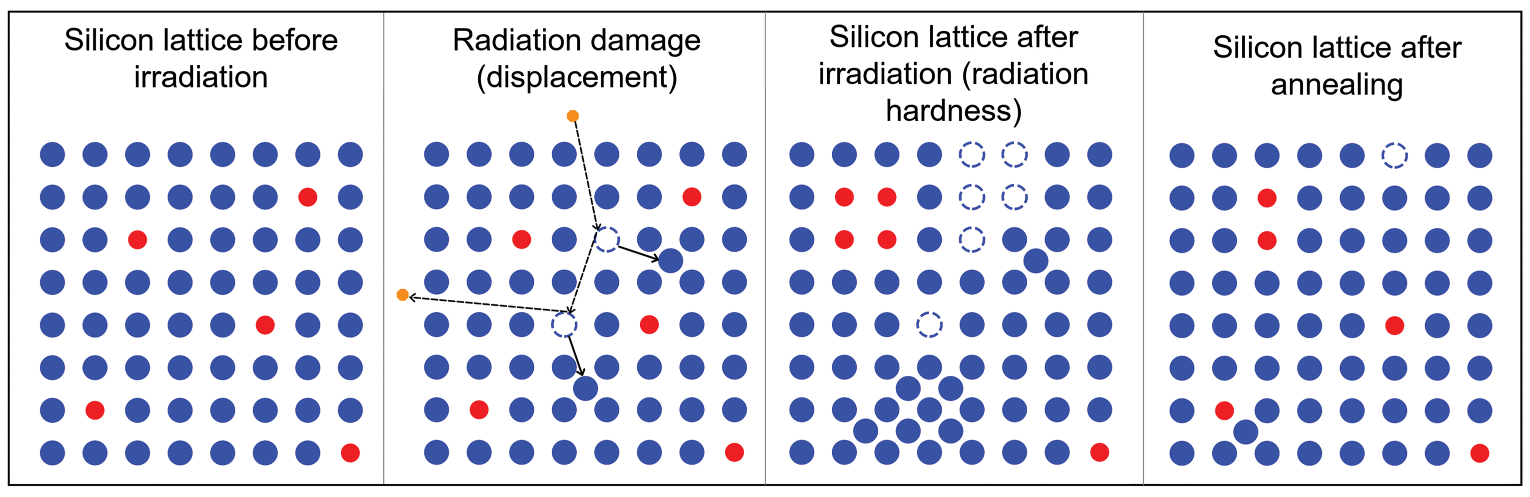
- 2 x 5 = 10 tiles (24.9 x 24.9 mm^2)
- each 8 x 8 pixels (3 x 3 mm^2)
- sensitive area for each pixel = 6.58 mm^2



4. Radiation background, radiation damage and annealing

- No atmospheric shield
- Radiation background on the telescope



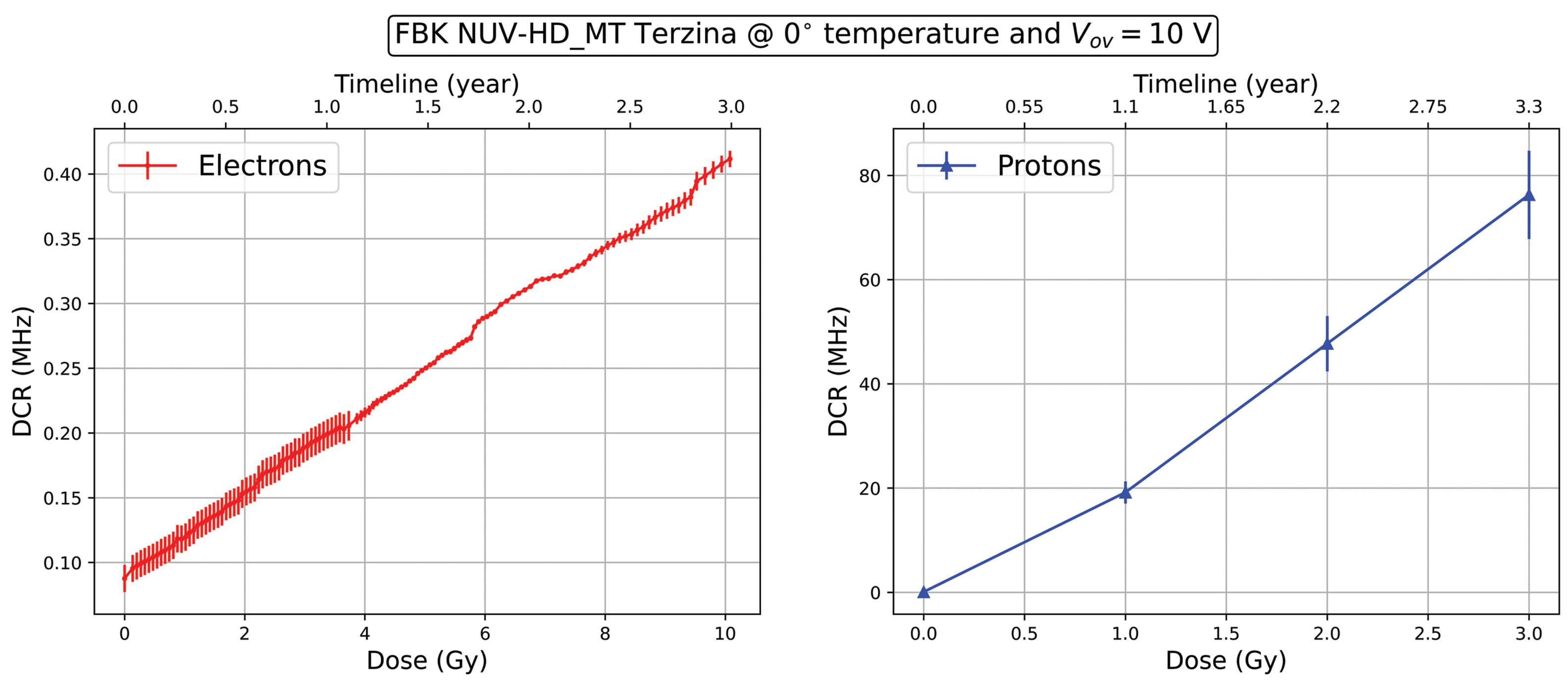


- Radiation damage increase the Dark Count Rate
- Mitigation: by heating them; measuring efficiency of treatment at temperature comparable to the power consumption

5. Measurements and results

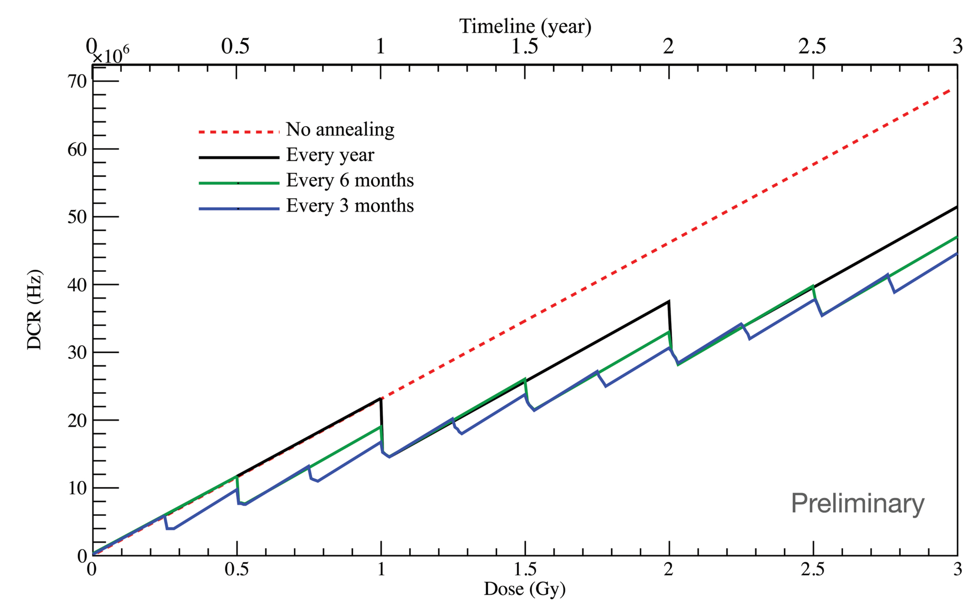
IV measurement done at temperature of 22.0°c for two irradiation cases:

- **Proton irradiation:** 50MeV proton beam (3cm diameter) with ~3% uniformity
- **Electron irradiation:** β-source strontium-90, up to 2.2MeV



Inferred DCR per pixel for Terzina SiPMs sensitive area from IV measurement during the irradiation

$$\mathrm{DCR}(10\ \mathrm{ov}, \mathrm{dose}) \propto \frac{I(10\ \mathrm{ov}, \mathrm{dose})}{\mathrm{Gain}.\,q.S^*} \cdot \frac{\text{Sensitive area}}{T_{\text{factor}}}$$



Different annealing cycles for the total DCR change during satellite lifetime

INFN Istituto Nazionale di Fisica Nucleare
FBK Fondazione Bruno Kessler
ASI Agenzia Spaziale Italiana
ThalesAlenia Space a Thales / Leonardo company
GSSI Gran Sasso Science Institute School of Advanced Studies Scuola Universitaria Superiore

Université de Genève
Faculté des Sciences
Département de Physique Nucléaire et Corpusculaire

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