VCI 14TH VIENNA CONFERENCE ON INSTRUMENTATION

Si-PIN radiation detectors with low leakage current, thin incident window and large active area for Nuclear Physics applications.

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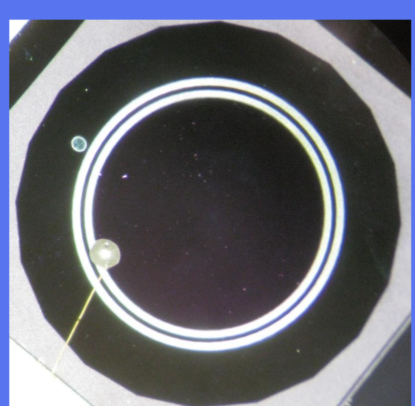
In many Nuclear Physics applications, low leakage current and thin incident window, often on both sides of the sensors, are mandatory characteristics for silicon radiation detectors.
Technologies of Si-PIN detectors for these applications have been developed at the National Center of Microelectronics (IMB-CNM, CSIC) of Barcelona (Spain). Shallow p+ and n+ layers and thin metal/passivation layers were incorporated in the devices as well as special attention has been paid during the the fabrication processes, aiming to achieve a leakage current of the order of 2 nA/cm^2·100µm in large area detectors. The technology and characterization of the fabricated devices are presented here.

Small area Si-PIN radiation detectors prototypes for a-particle spectroscopy

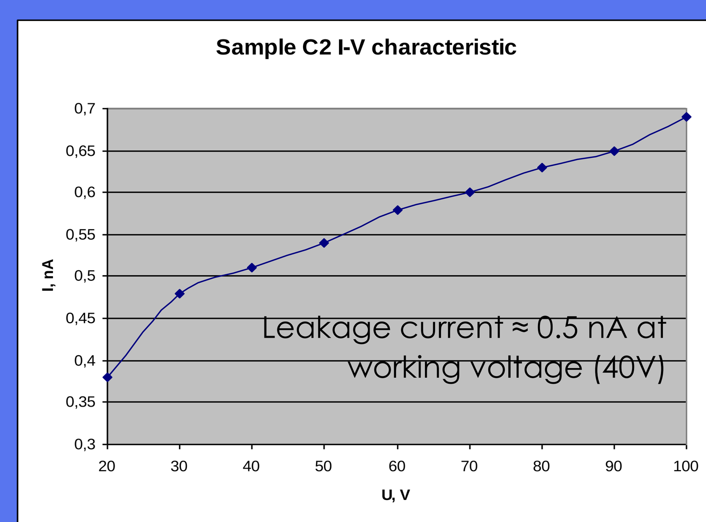
(fabricated at IMB-CNM, characterized at Baltic Scientific Instrumentation)

Application: a-particles spectroscopy

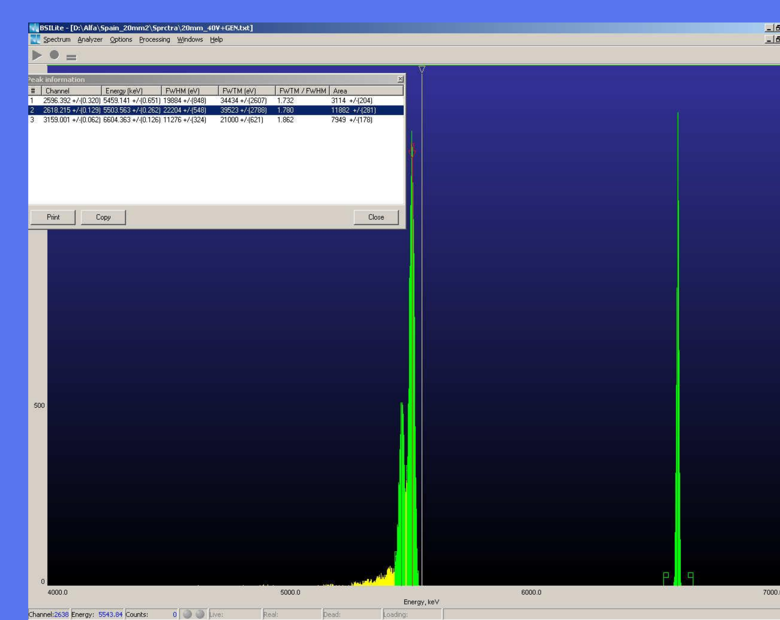


- Shape = circular
- Active area = 20mm^2
- Bulk = n-type FZ, ρ > 10 kΩ·cm, 300 µm thick
- Passivated hole on the metallization
- Passivation thickness = 600 nm (SiO_2+Si_3N_4)
- Shallow junction < 0.5 µm
- Leakage current < 1nA/cm^2·100µm

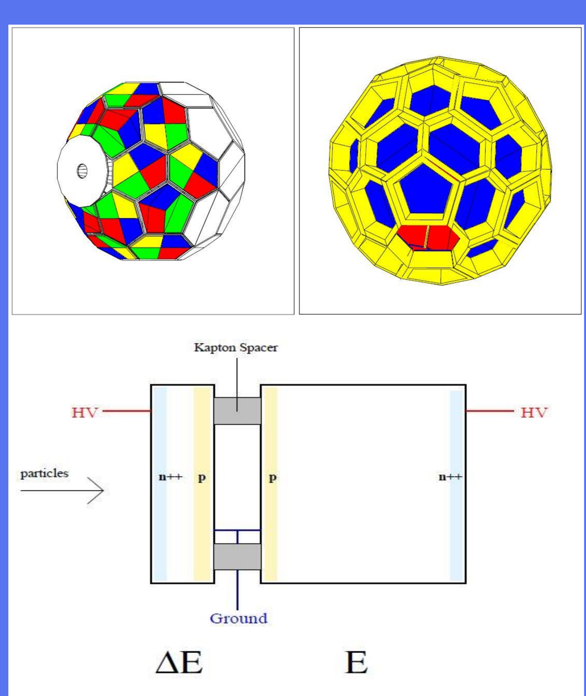
Different shapes and dimensions can be arranged



The testing of spectrometric characteristics was measured in a vacuum chamber. Vacuum was kept not less than 1*10^{-3} mm Hg. The isotope Pu-328 was used as irradiation source.
The irradiation source was placed to the detector on distance 3 mm. The bias voltage of the detector was 40V. The calculated energy resolution is 22.1 keV at energy 5499.07 keV.

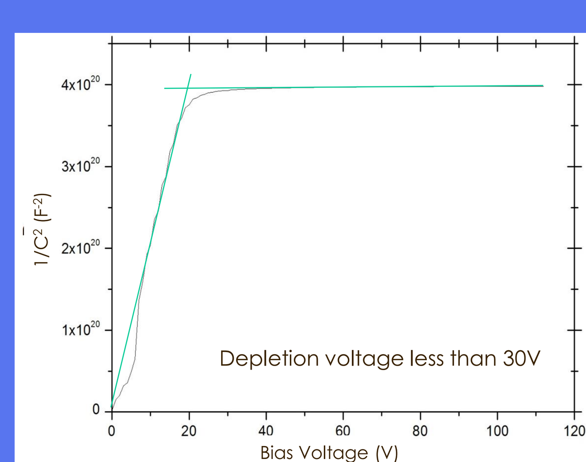


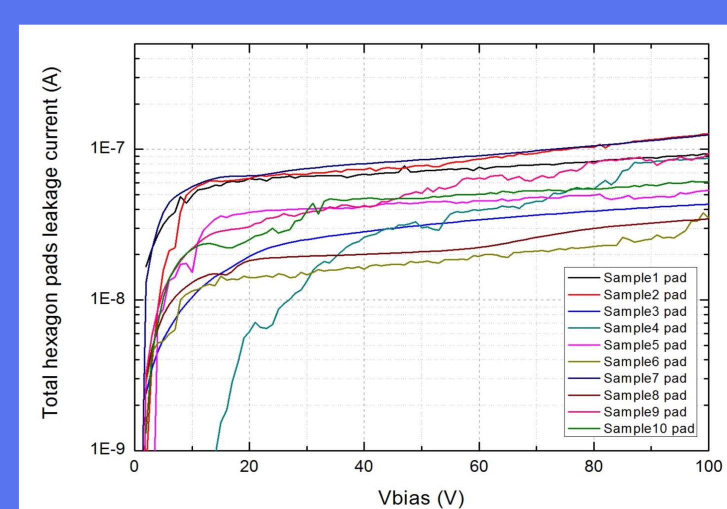
Large area Si-PIN radiation detectors for Nuclear Physics experiments (1)

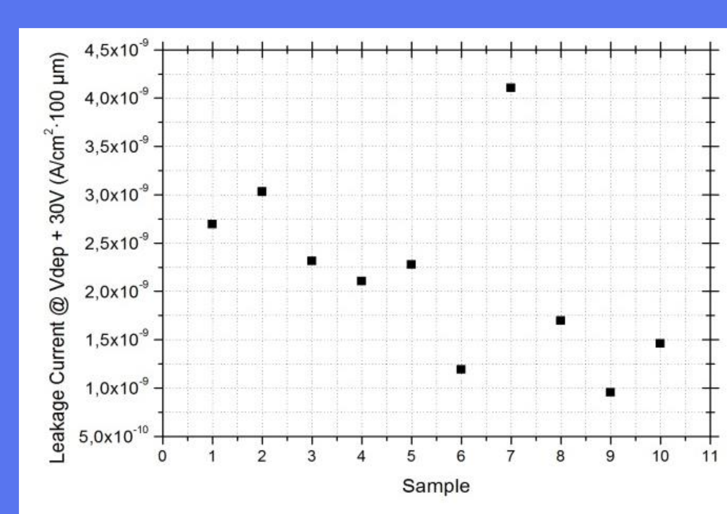


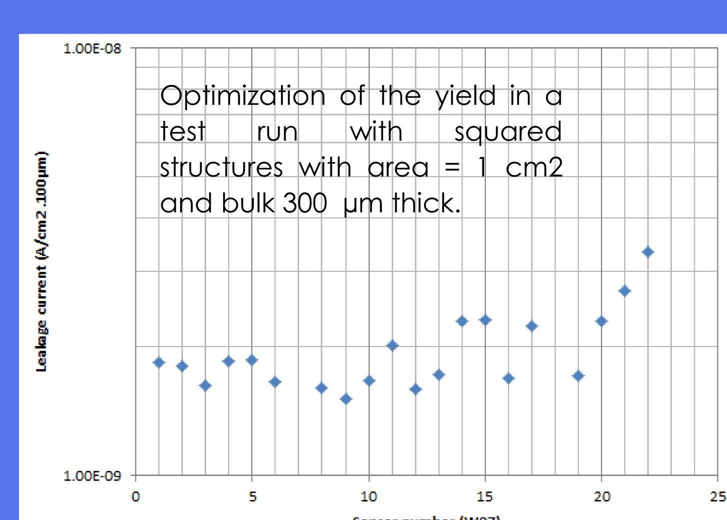
Application: Replacement of Euclides elements.
Si-ball EUCLIDES[1] (EUroball Charged Light particle Identification DEtector Sphere), is a 4pi detector array to detect emitted light charged particles in nuclear physics experiments. Coupled with the array of Compton-suppressed HPGe detectors GASP, that has been operating at the Laboratori Nazionali di Legnaro since 1992 provides the capability to perform a kinematical reconstruction of the trajectories of the recoiling nuclei through the detection of the evaporated light charged particles.

- Shape = hexagon divided in 4 trapezoidal pads
- Total active area = 9.11 cm^2
- Bulk = n-type FZ, ρ > 5 kΩ·cm, 200 and 1000 µm thick
- Rings = Extracting ring and guard ring
- Metallization = 230 nm
- Shallow p+ and n+ layers < 0.5 µm
- Leakage current < 4 nA/cm^2·100µm



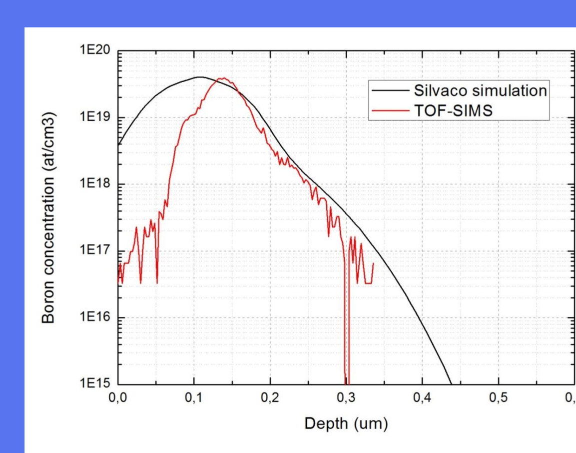




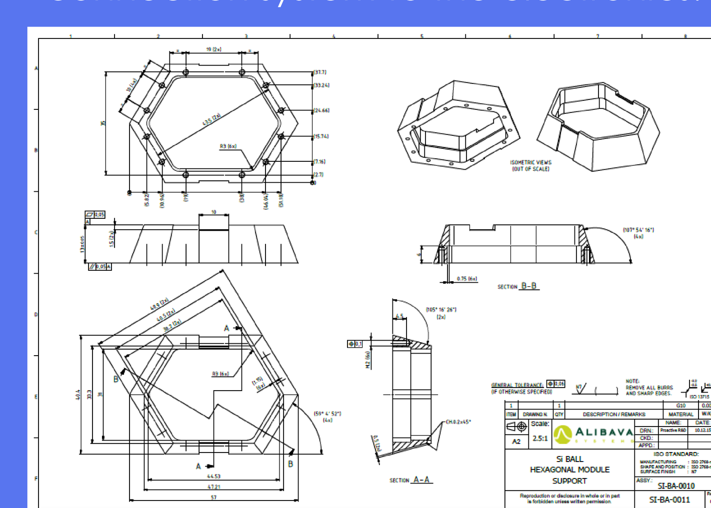


ΔE-layer (200 µm thick) characterization shows a total leakage current <90 nA at room temperature, at full depletion.

Shallow junction obtained with a Boron implant < 0.5 µm

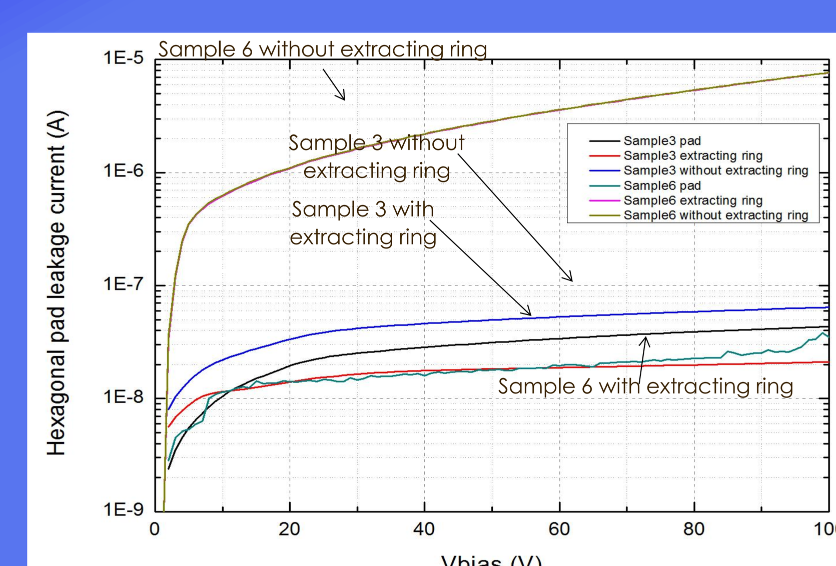


The devices of the E-layer (1000 µm thick) at the moment of presenting these results are being fabricated. Complete ΔE-E telescopes will be assembly by Alibava Systems, mounting them on mechanical supports and providing them with the connection system to the electronics.

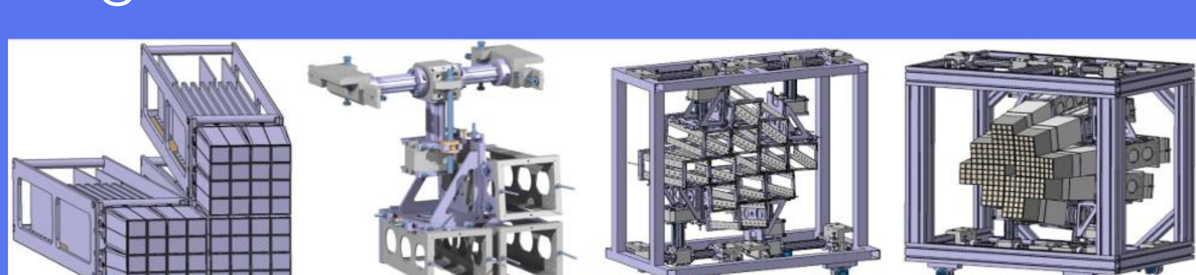


The importance of the extracting ring structure

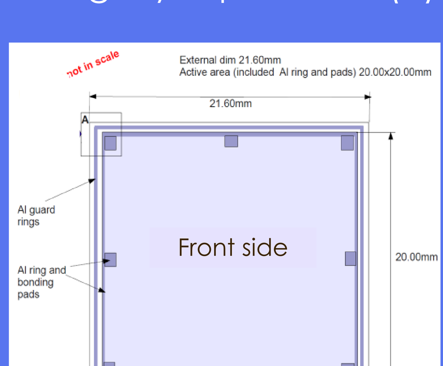
The extracting ring structure prevents the lateral extension of the active volume.
Its function is to extract the superficial leakage current as well as the bulk current originated in the lateral depleted volume outside the active volume.



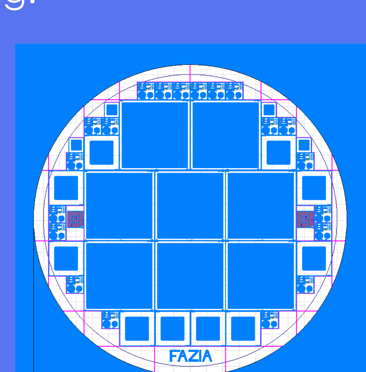
Large area Si-PIN radiation detectors for Nuclear Physics experiments (2)



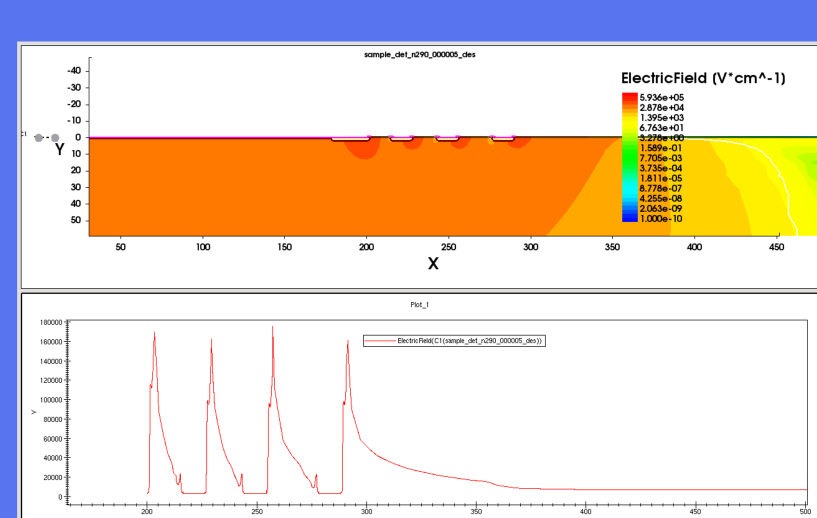
Application:
The European Fazia collaboration aims at building a new modular array for charged product identification to be employed for heavy-ion studies. The elementary module of the array is a Silicon-Silicon-CsI telescope, optimized for ion identification also via pulse shape analysis. The telescope (active area 20x20mm2) is made of two Silicon layers (300 and 500 µm thick, respectively) followed by a slightly tapered CsI(Tl) scintillator 100 mm long.

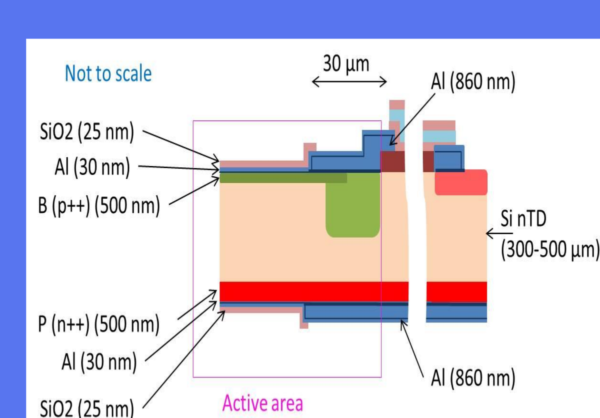


The layout of the detectors meets the specifications requested by the collaboration.



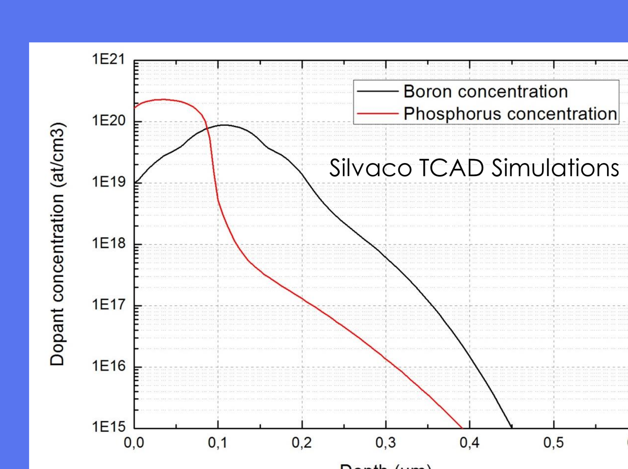
- Shape = squared
- Active area = 4 cm^2 single pad
- Bulk = n-type nTD, ρ ≈ 2 kΩ·cm, 300 and 500 µm thick
- Rings = Guard rings and edge protection structure
- Metallization = 30 nm thick on active area
- Passivation = 25 nm SiO_2 on the active area
- Shallow p+ and n+ layers < 0.5 µm
- Leakage current expected < 2nA/cm^2·100µm





Guard electrodes and an edge protection structure (deep implant around the active area) were incorporated to increase the breakdown voltage in order to apply high bias voltage for full depletion. High Electric Field peaks are equally distributed between the four terminations (edge protection structure + rings).

Shallow p+ and n+ layers are incorporated in the front and back side of the sensor as well as thin metal and SiO2 layers. Double metal technology has been used to fabricate metal pads for the connection with the electronics.



The devices are being manufactured

1 "Coupling of the GASP II array with the n-Ring and the EUCLIDES detectors", E.Farnea et al. LNL Annual report 2005.
2 "The european FAZIA initiative: a high-performance digital telescope array for heavy-ion studies", G. Casini et al. Journal-ref: 25th International Nuclear Physics Conference (INPC 2013), arXiv:1309.1336