

ITC-irst

Institute for Scientific and Technological Research

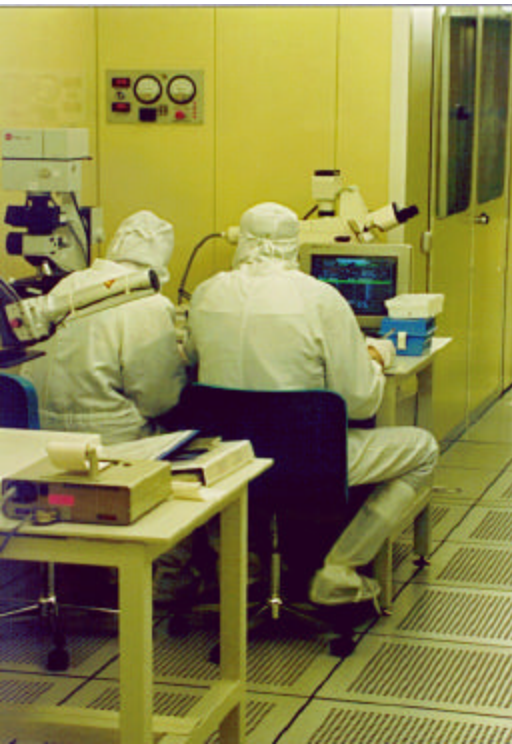
Trento - Italy

<http://www.itc.it/>

ITC-irst is part of Istituto Trentino di Cultura (ITC)

- **Founded in 1976**
- **Dimensions:**
 - **Full time researchers: 180**
 - **Technical support: 25**
 - **PhD students, consultants 50**
- **Competences:**
 - **Information Technology**
 - **Physical-Chemical analysis of Surfaces**
 - **Microsystems**

Researchers: 30
Technicians: 18
PhD students: 5



The division designs and realises *silicon microsystems*, particularly:

- sensors for **bio-medical** and environmental applications;
- micro-electro-mechanical systems (**MEMS**) for industrial and consumer applications;
- **electro-optical microsystems** for vision and non-destructive measurements;
- **radiation detectors**.

Microfabrication Facility

Microfabrication Facility 250sq.m class 10 + 250sq.m class 100; 4 inch

Equipment: Ion implanter;
11 furnaces ;
Mask Aligner;
Sputter metal deposition;
Dry etching: Al, SiO₂, poly and Si₃N₄;
Dicing Saw and ball bonder.



Clean Room Staff: 4 researchers, 12 operators

Simulation and design tools: Tanner tools, SILVACO and ISE-TCAD

Testing Lab. : Manual probe station (Karl Suess PM8);
Automatic probe station (Electroglas 2001 CX) for double-sided detectors;
Parametric test (HP4062UX, HP4145B, HP4280A, HP4192A, Keithley 2410)

Research Activities on Silicon Radiation Detectors at IRST

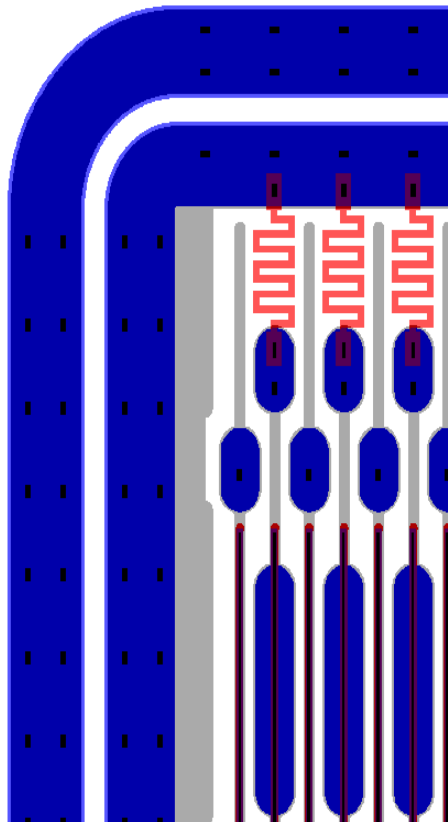
M. Boscardin, G.-F. Dalla Betta, P. Gregori, C. Piemonte,
G. Pucker, S. Ronchin, M. Zen, N. Zorzi

production and research activities
on detectors are carried on in parallel

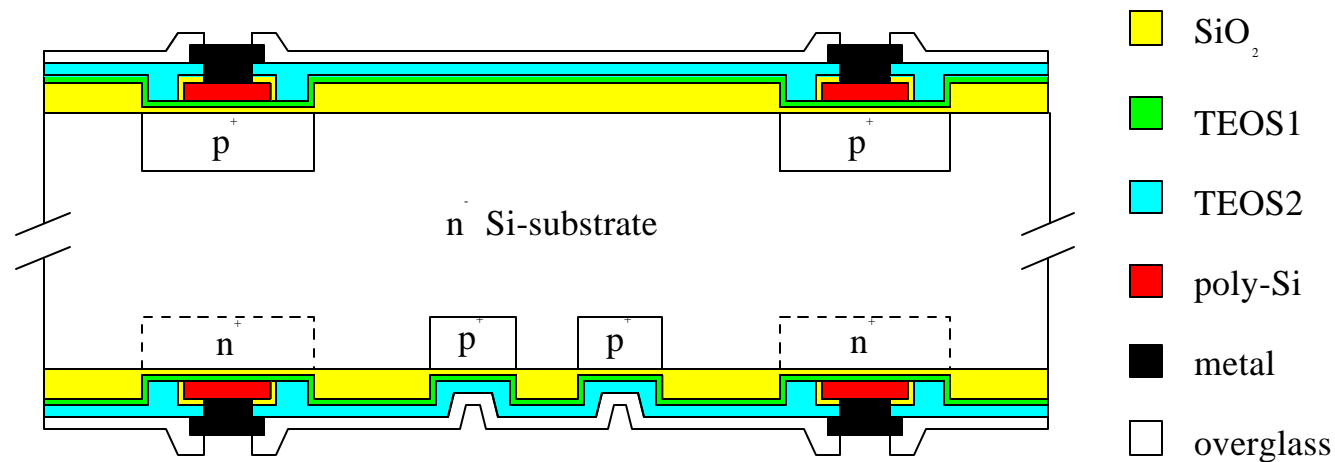
- Microstrip detectors for: AMS tracker and ALICE - ITS
- Pixel detectors for medical imaging
- Microstrip detectors with integrated front-end electronics
- Radiations hard devices
- Custom devices for industrial applications

<http://mis.itc.it/PROGETTI/SRD/srd.html>

Layout of CMS-like detectors



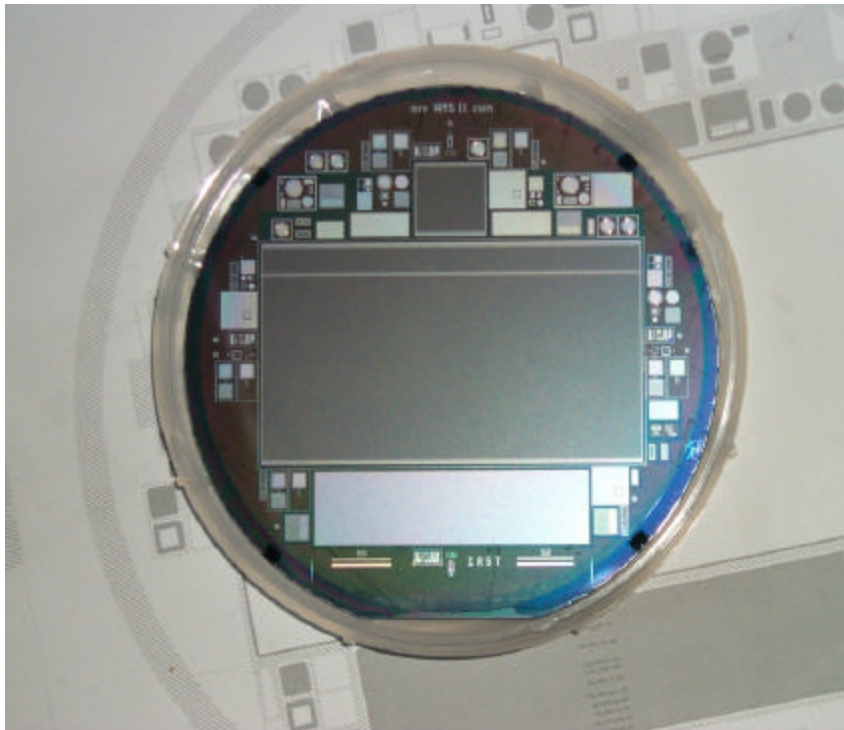
Double sided detectors with integrated poly-Si bias resistors and coupling capacitors



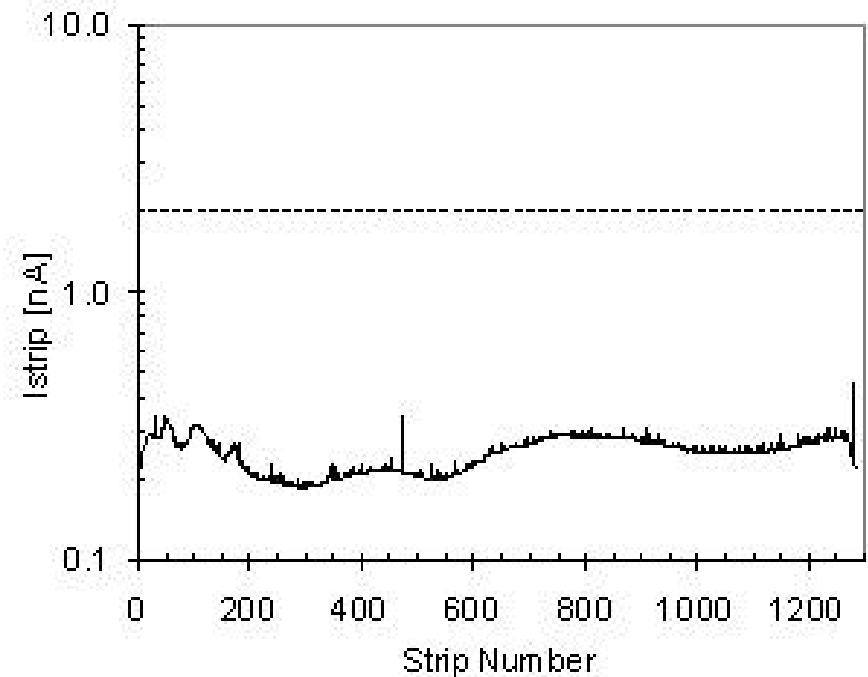
Development of a fabrication technology for double-sided AC-coupled silicon microstrip detectors, NI MA 460, pp. 306-315, 2001

AMS microstrip detectors

- The production of 400 detectors has been recently accomplished and delivered to the AMS organization.



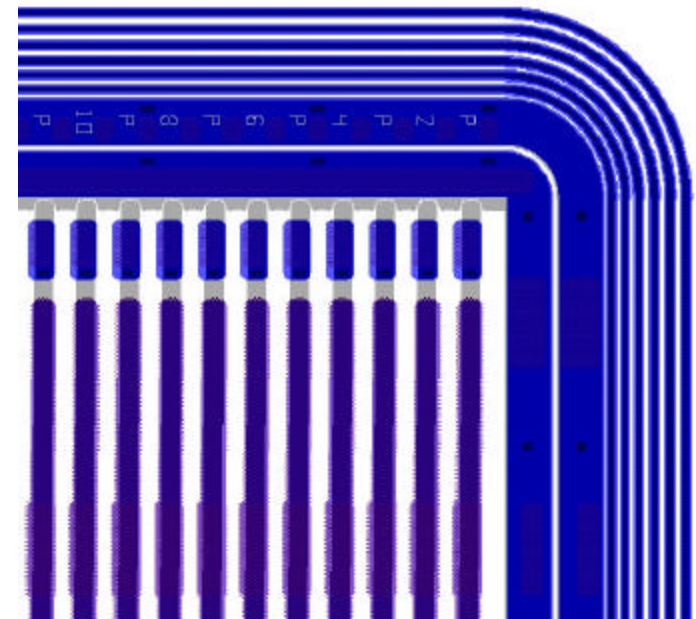
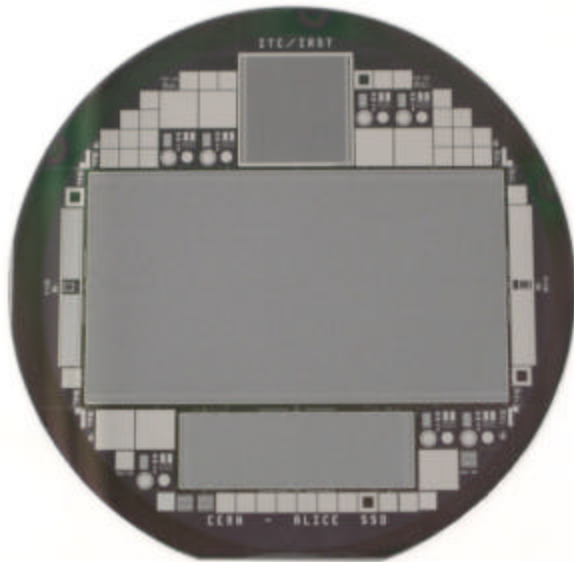
A photograph of a silicon wafer with an AMS microstrip detector



A typical leakage current scan

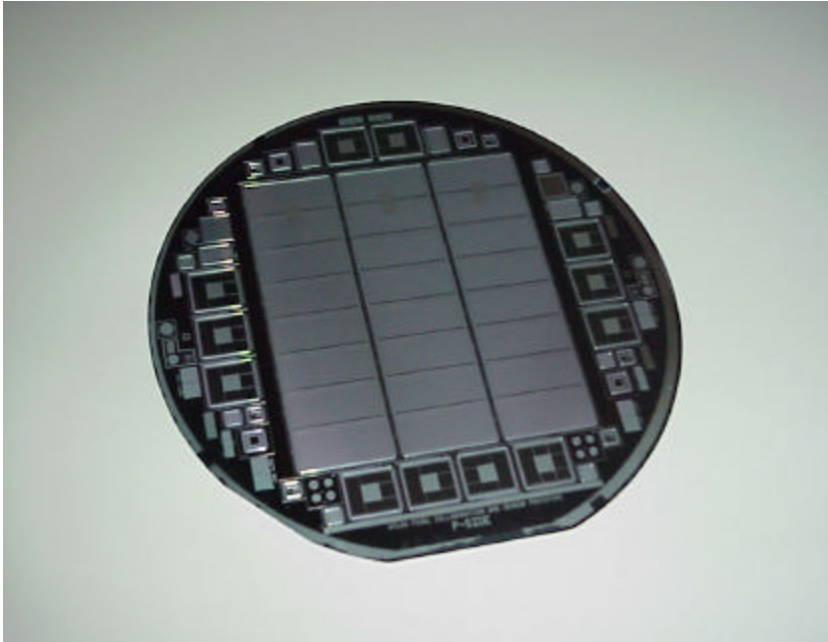
ALICE microstrip detectors

- The fabrication of 400 microstrip detectors for ALICE - ITS is in progress.
- Average leakage current of single strips of about 200pA
- The percentage of broken capacitors lower than 1%.



*Development of ALICE microstrip detectors at Irst,
NIMA 461, pp. 188-191, 2001*

ATLAS Pixel Detector prototypes



pixel "n-on-n"

oxygen enriched substrate

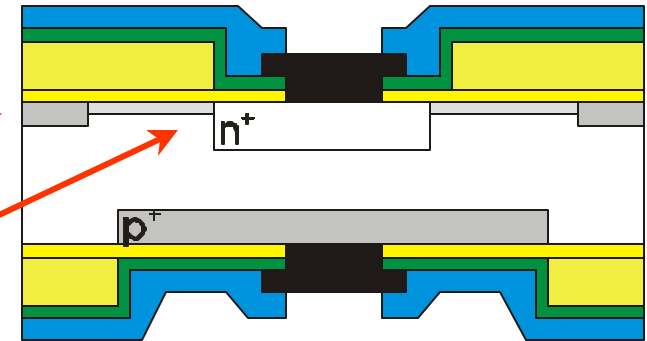
"moderated p-spray isolation"

A specially tailored technology has been developed for the fabrication of ATLAS pixel detector prototype on thin silicon wafers (250 μm).

moderated p-spray

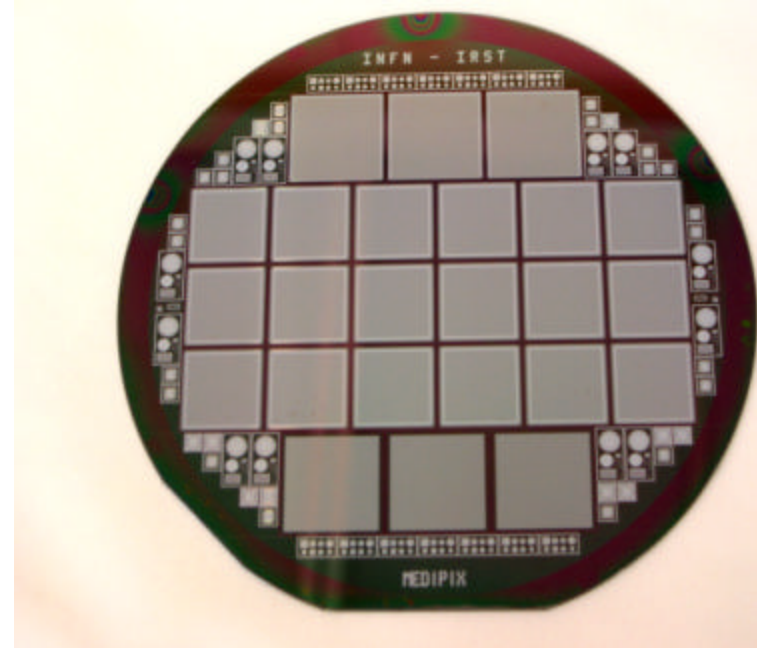


p-spray



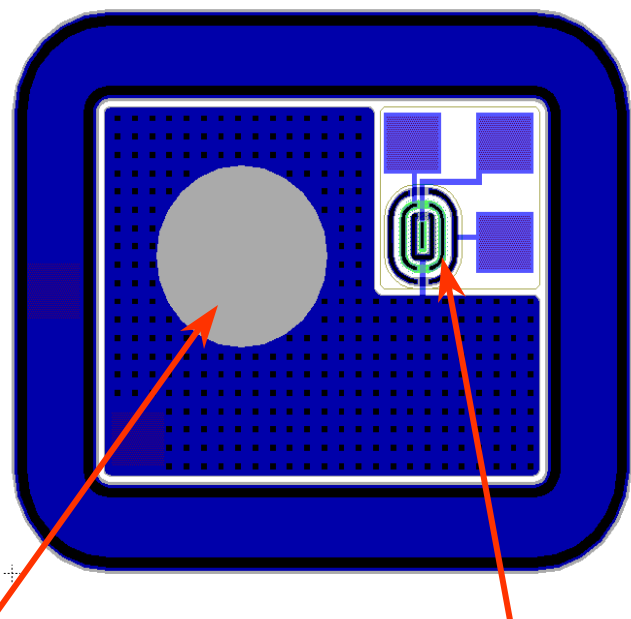
Fabrication of ATLAS pixel detector prototype at Irst, NIMA 465, pp. 83-87, 2001

- Silicon pixel detectors for medical applications, and, in particular, in the field of digital radiography.
- Collaboration with INFN groups
- Pixel detectors made on thick silicon wafers (525-800 mm) and possibly embedding the front-end transistor (JFET) in the detecting element.



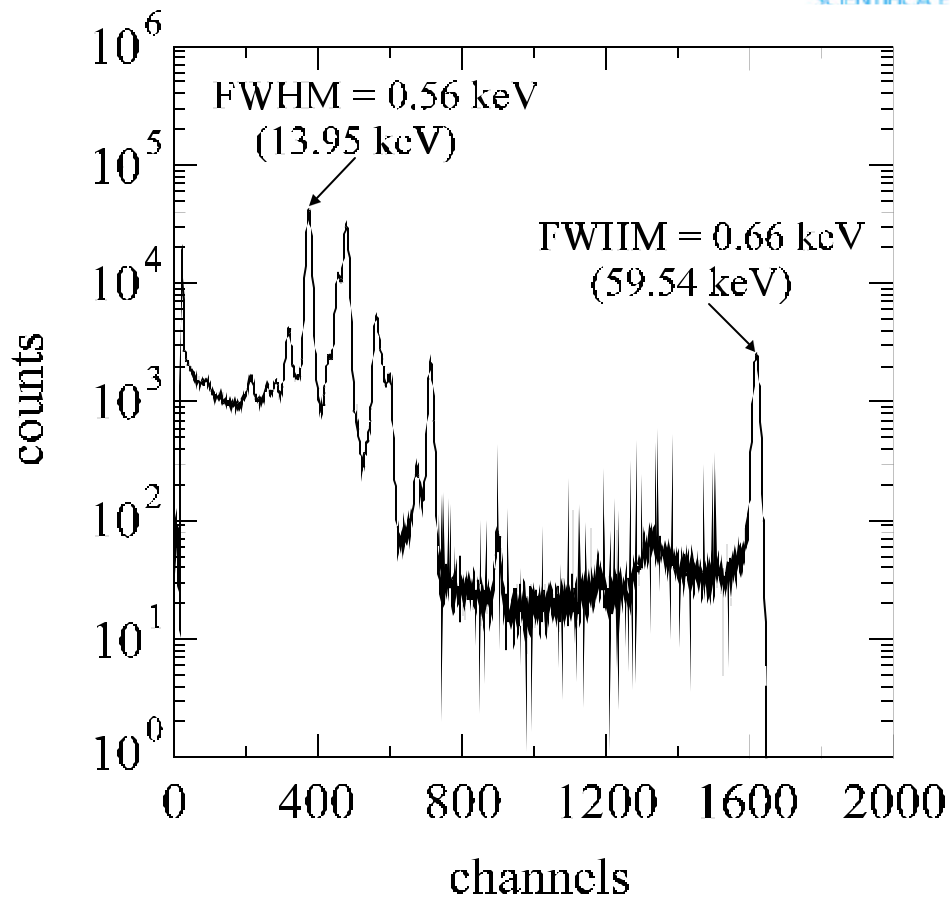
Design of semiconductor detector for digital mammography, presented @ IWORLD 2002 Amsterdam

PI N+JFET test structures



PIN diode
(0.32 mm²)

N-JFET
(W/L=200/12 μm)



Am²⁴¹ spectrum acquired at RT
(ENC = 60 electrons rms @ $\tau_s=10 \mu\text{s}$)

Monolithic integration of Si-PIN diode and n-channel double-gate JFET's for room temperature X-ray spectroscopy, NI MA 458, pp. 275-280, 2001

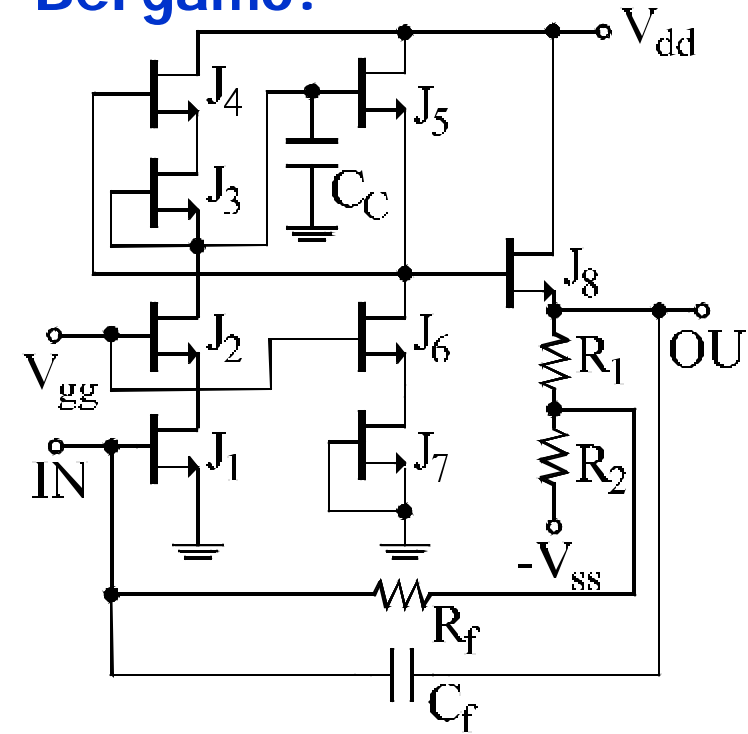
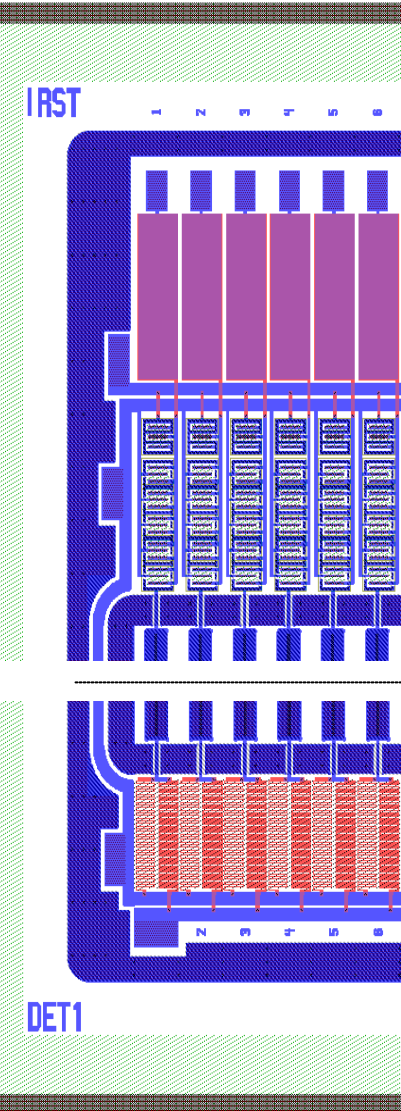
Project with Universities of Pisa, Pavia, Trieste, Bergamo.

Strip detector
with integrated
source-follower

Source-follower

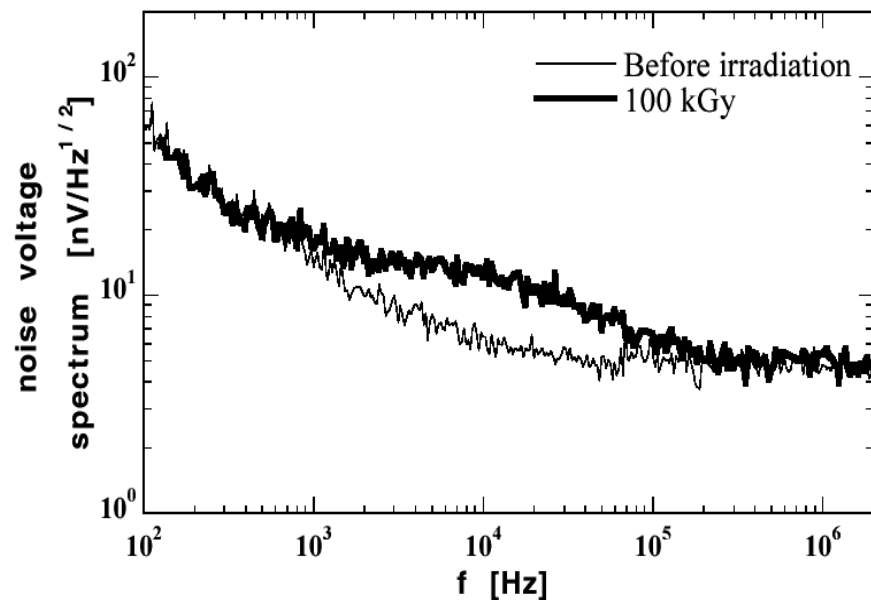
Strip detector

Poly-Si bias resistors

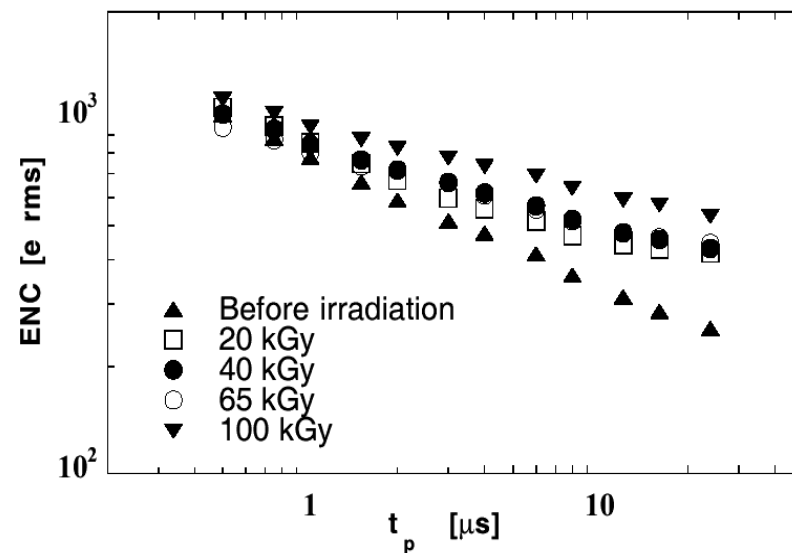


Monolithic charge
sensitive amplifier

*Feasibility studies of microelectrode silicon detectors with
integrated electronics, NI MA 478, pp. 372-376, 2002*



Gate referred noise voltage spectrum for a JFET with $W/L=1000/4$. Before and after exposure to a 100 kGy γ -ray integrated dose.

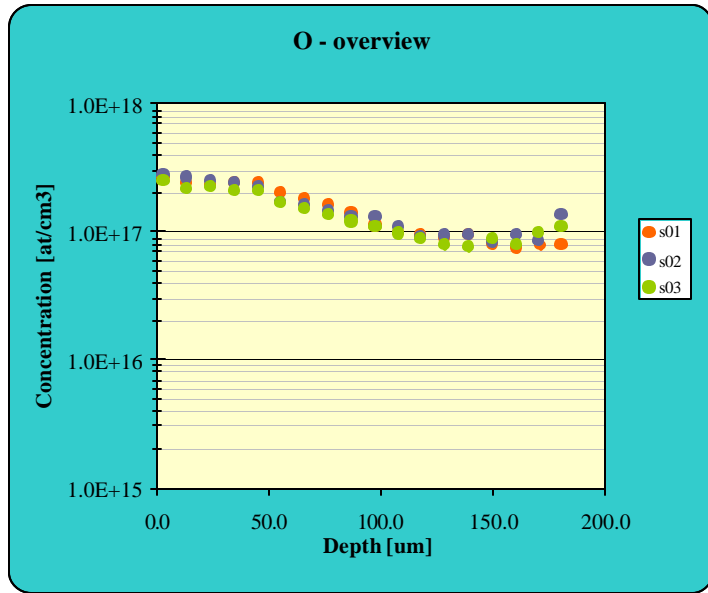


Equivalent Noise Charge as a function of peaking time for the preamplifier, before and after exposure to γ -ray.

Ionizing radiation effects on JFET devices and circuits fabricated in a detector-compatible process, paper presented @ RADECS2002 - Padova

Oxygenation Process

IRST_OXY @ 1150°C
12h dryO₂ + 36h N₂

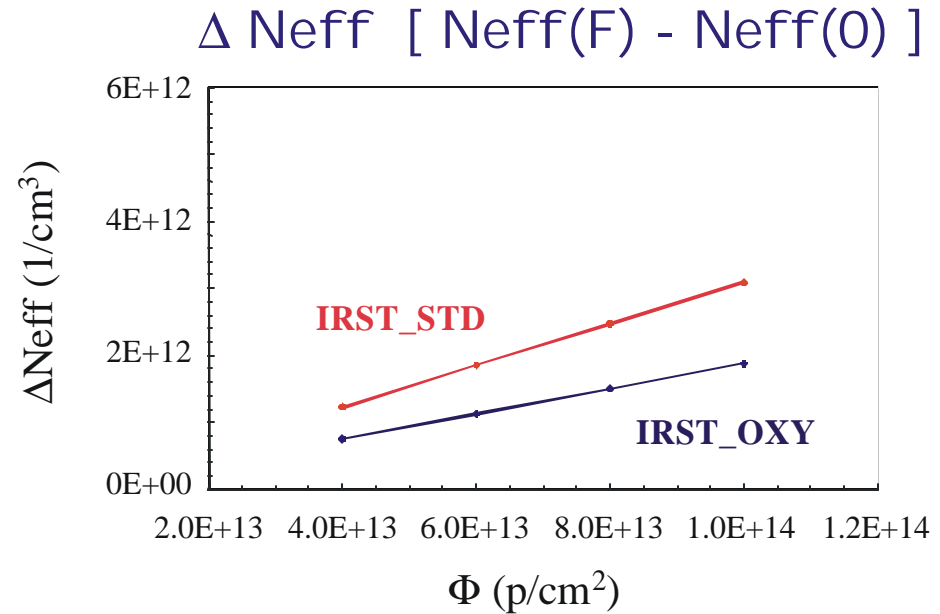


Oxygen concentration profiles
measured by SIMS (ITME,
Poland) on IRST samples

Irradiation tests

in progress with :

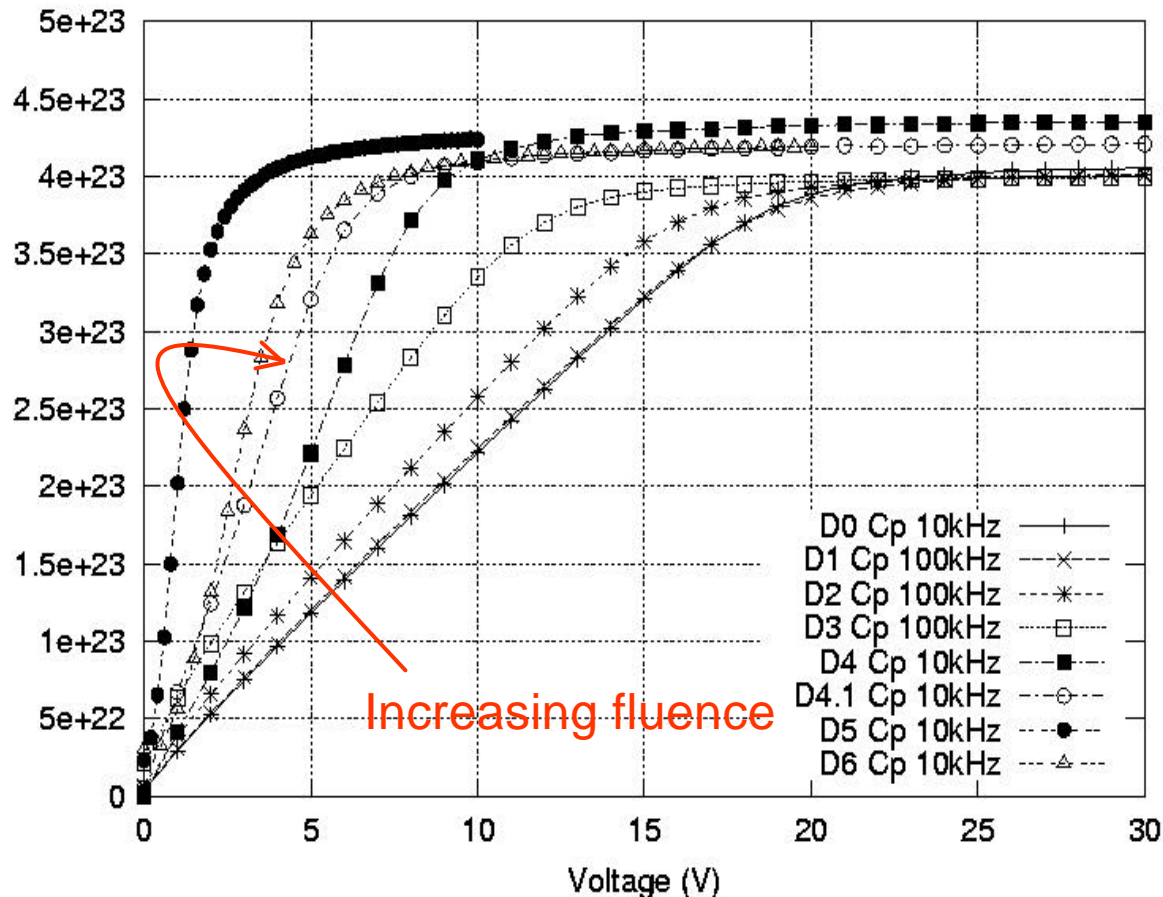
- Protons @ Legnaro (INFN Padova)
- High energy electrons @ INFN Trieste



Data provided by INFN - Padova

*Radiation hardness of silicon diodes for high energy physics applications,
to be presented @ NSS 2002 Norfolk*

Studies of radiation damage from high energy electrons (Elettra, Trieste)

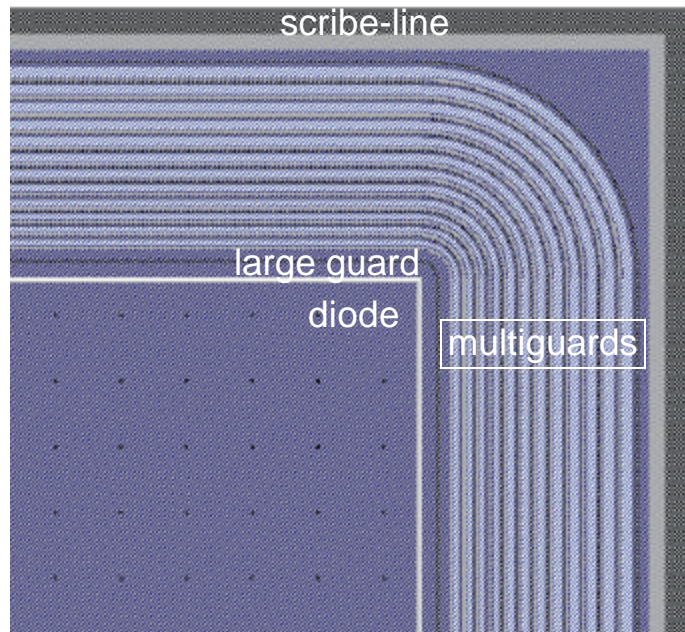


- Motivated by results from BaBar microstrip detectors
- Test structures irradiated with 900 MeV electrons
- Both surface and bulk radiation damage observed
- **Substrate type-inversion**

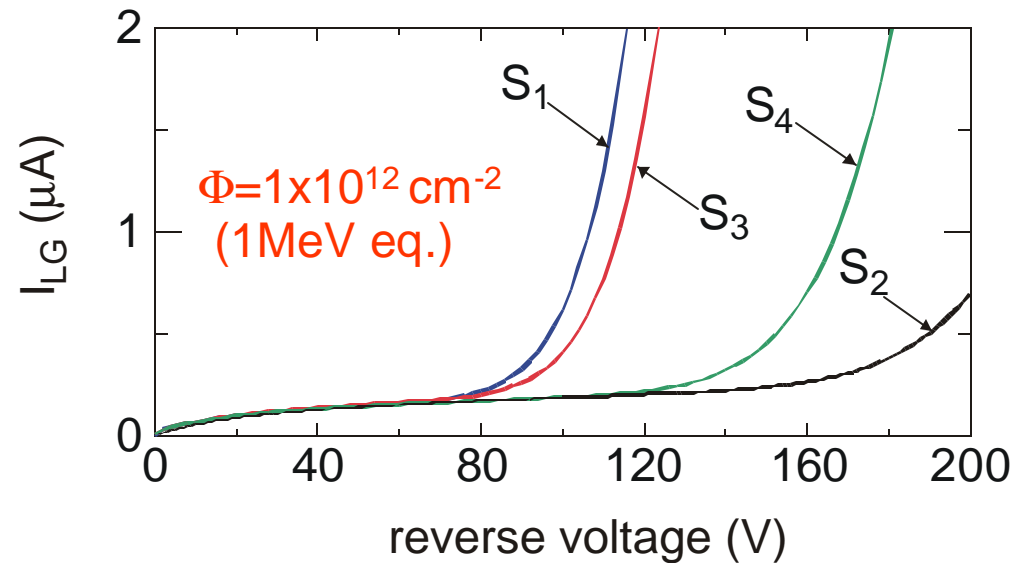
Studies of radiation damage by 900 MeV electrons on standard and oxygen enriched silicon devices presented by S.Dittongo

All-P-type multiguard termination

multiple p⁺ floating guard rings with different multiguard layout (S₁ ... S₄)
field-plates extending inward and overlapping the preceding ring implant
no n⁺ implant, with process simplification



Top right corner of the S2 layout.



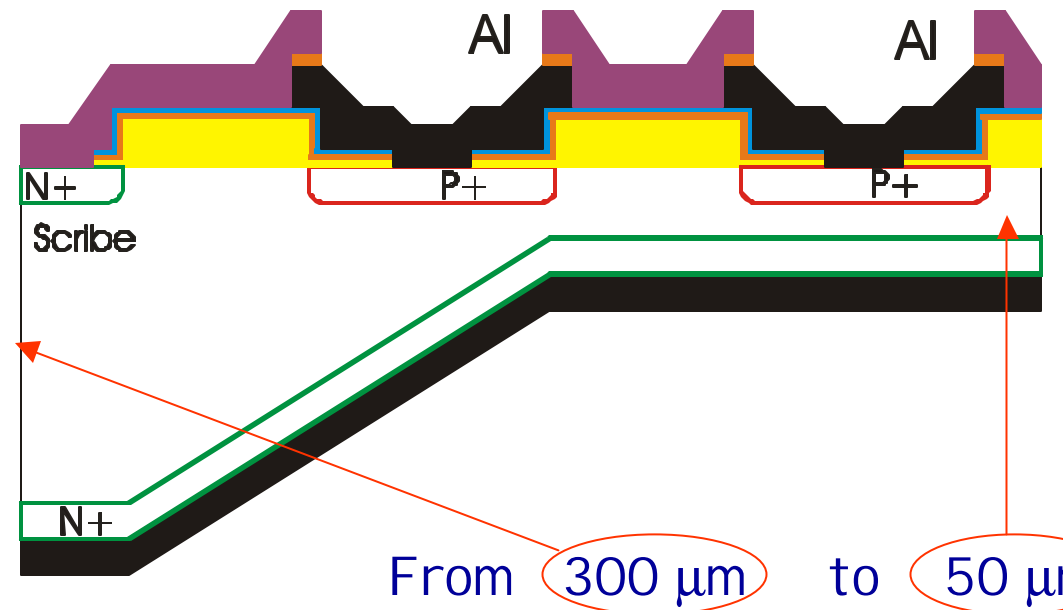
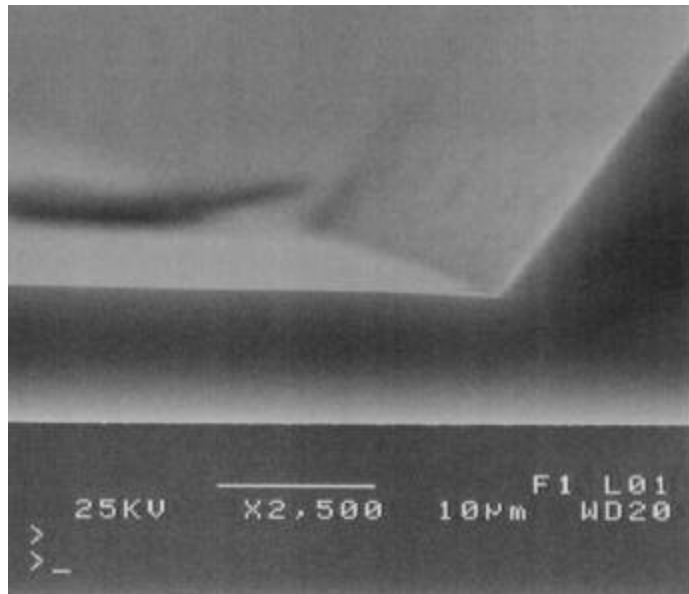
Large-guard current vs reverse-bias voltage
after neutron irradiations.

A novel silicon microstrip termination structure with all-p-type multiguards and scribe-line implants, to appear in IEEE TNS Aug.2002

Detectors on thinned silicon

Silicon wet etching
(TMAH solutions on Si <100>)

- Standard process (single side)
- test the idea on simple diode



Conclusions

- Silicon radiation detectors represent one of the main research activities at ITC-IRST
 - Near future developments include:
 - ALICE microstrip detectors
 - Microstrip detectors with integrated electronics
 - All-p-type termination structures
 - Oxygenated silicon wafers
 - New detector structures (thin and 3D)
- } RD50