Cold Silicon detectors as Technological Alternative

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on behalf of the
CERN-RD39 Collaboration
http://www.cern.ch/RD39

The CERN-RD39 Collaboration

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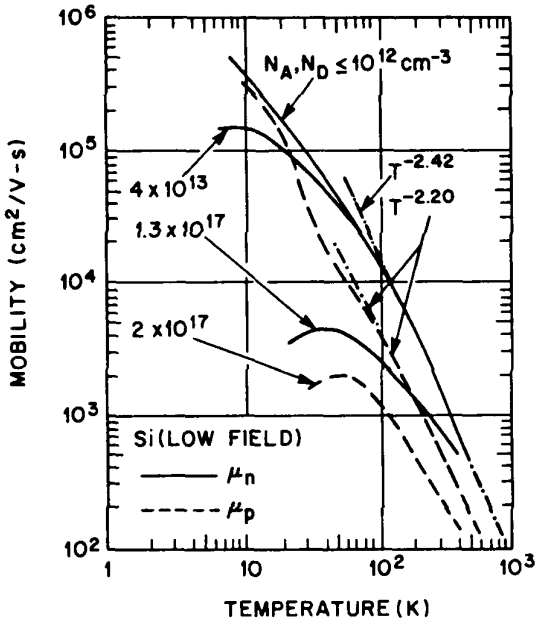
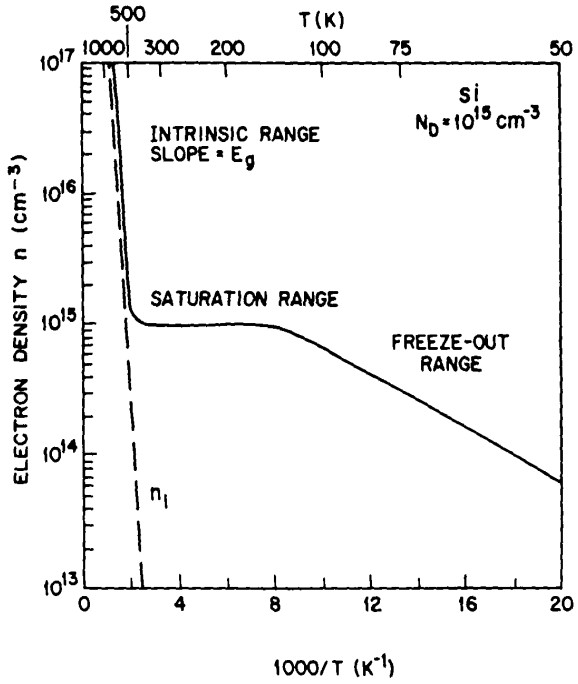
Outline

- Properties of Si at cryogenic temperatures
- CCE of heavily irradiated Si detectors at cryogenic temperatures (up to $2 \cdot 10^{15}$ n/cm$^{2)}$
- Neutralization of induced defects: the Lazarus effect
- Tracking efficiency and position resolution of an irradiated DELPHI module ($4*10^{14}$ n/cm^2)
- Beam monitoring and diagnostic
- Cold silicon for luminosity measurements

Properties of Silicon at Cryogenic Temperatures





Why is the present technology not sufficient ?

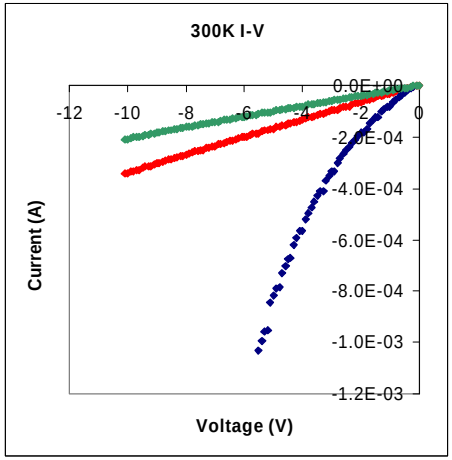
… and how can we improve it ?

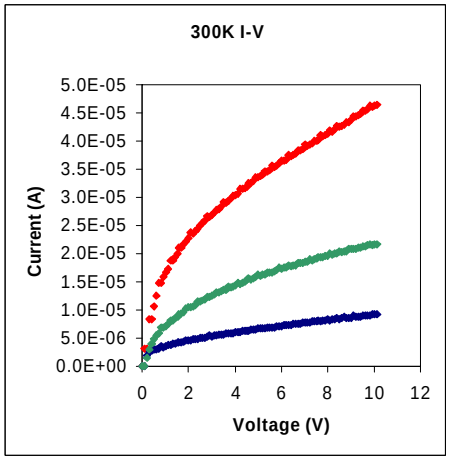
Irradiated Si Detectors

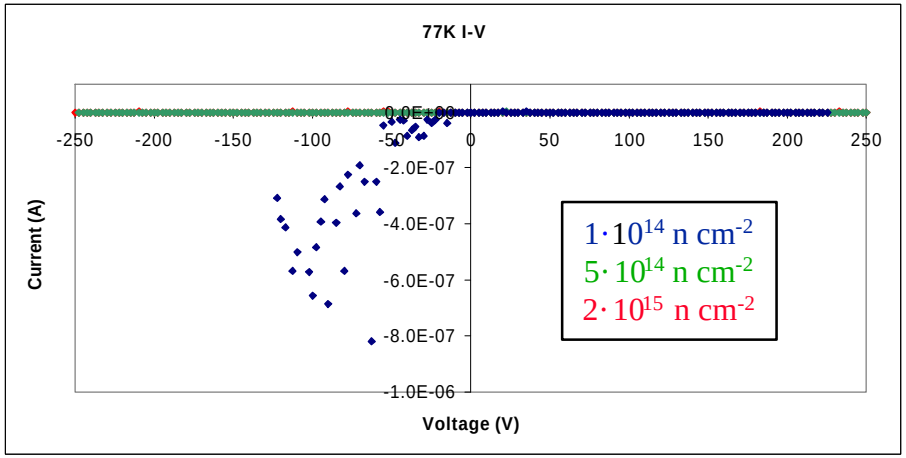
- **Irradiated at room temperature at TRIGA neutron reactor, JSI Slovenia**
- **Stored at room temperature and subjected to thermal cycles, therefore strongly reverse annealed (RA)**
- **Different materials and processes:**
  - **Al/n+/n/p+/Al 1.8 kΩ cm**
  - **Al/n+/n/p+/Al 2.7 kΩ cm**
  - **Al/n+/n/p+/Al 4 kΩ cm**

Current-Voltage Characteristics

Preliminary

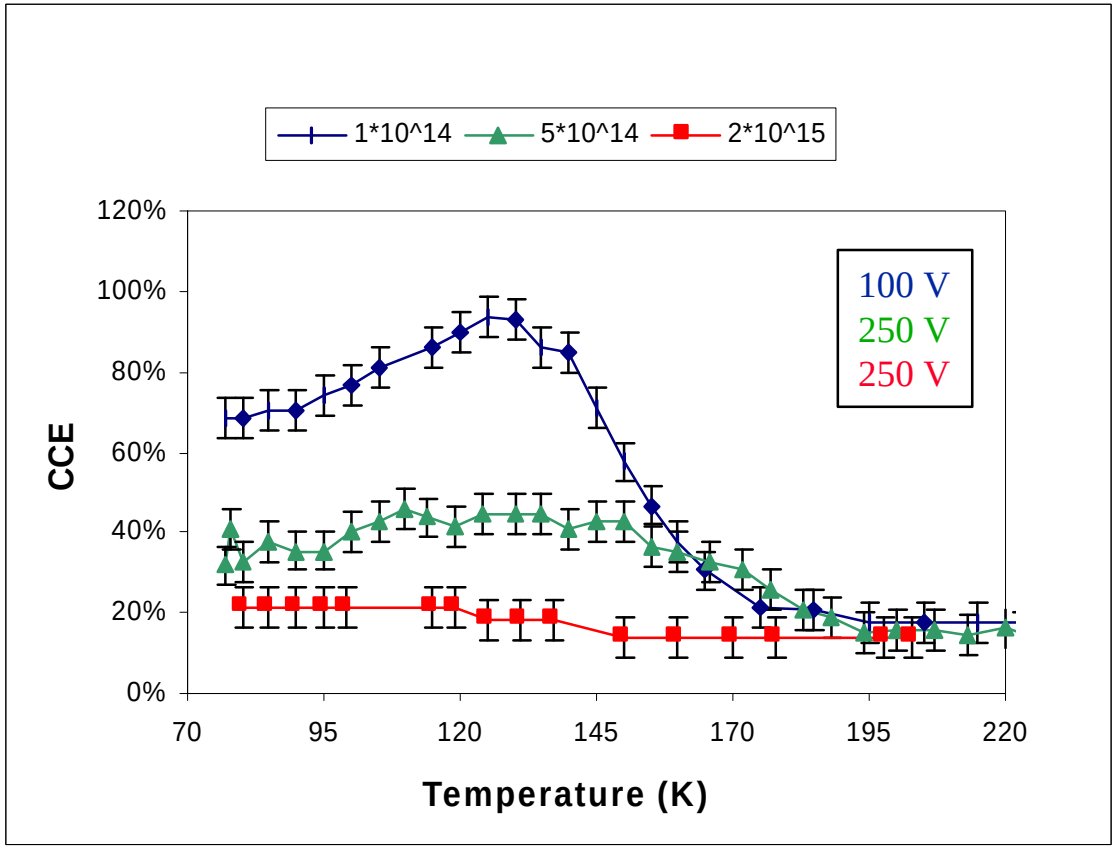






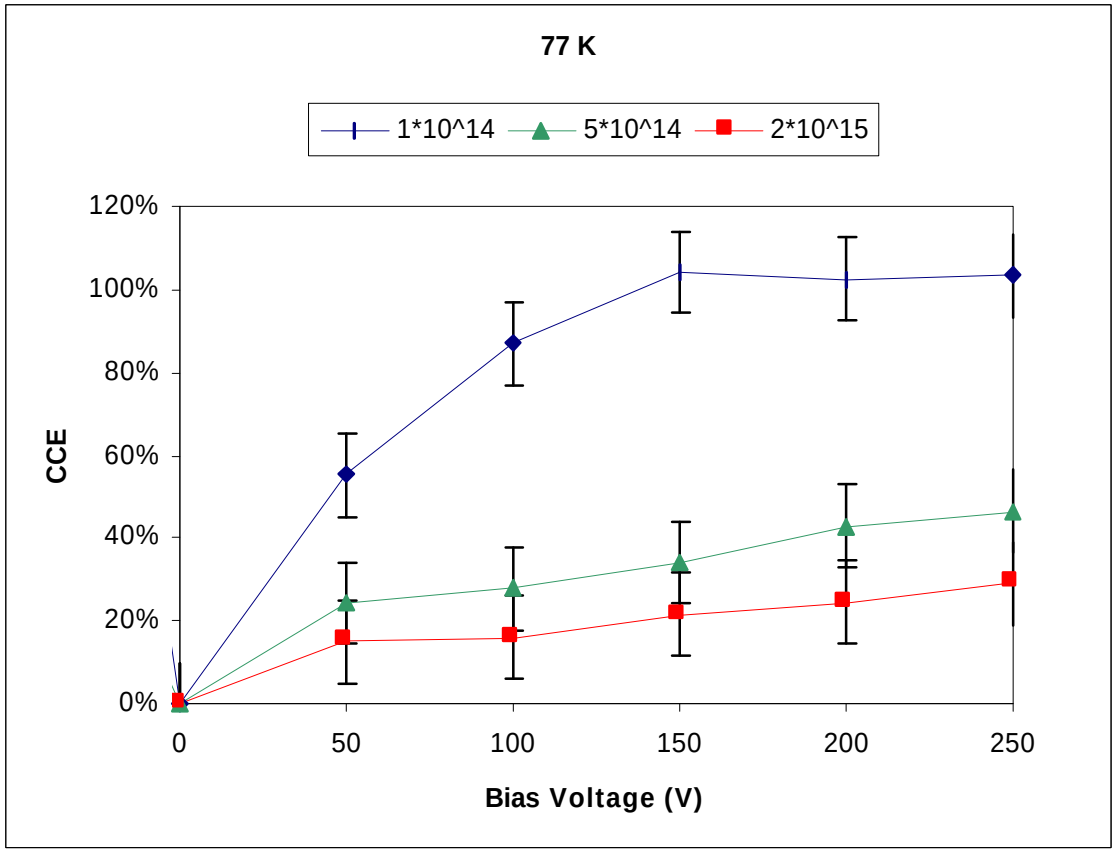
Temperature Dependence of CCE

Preliminary



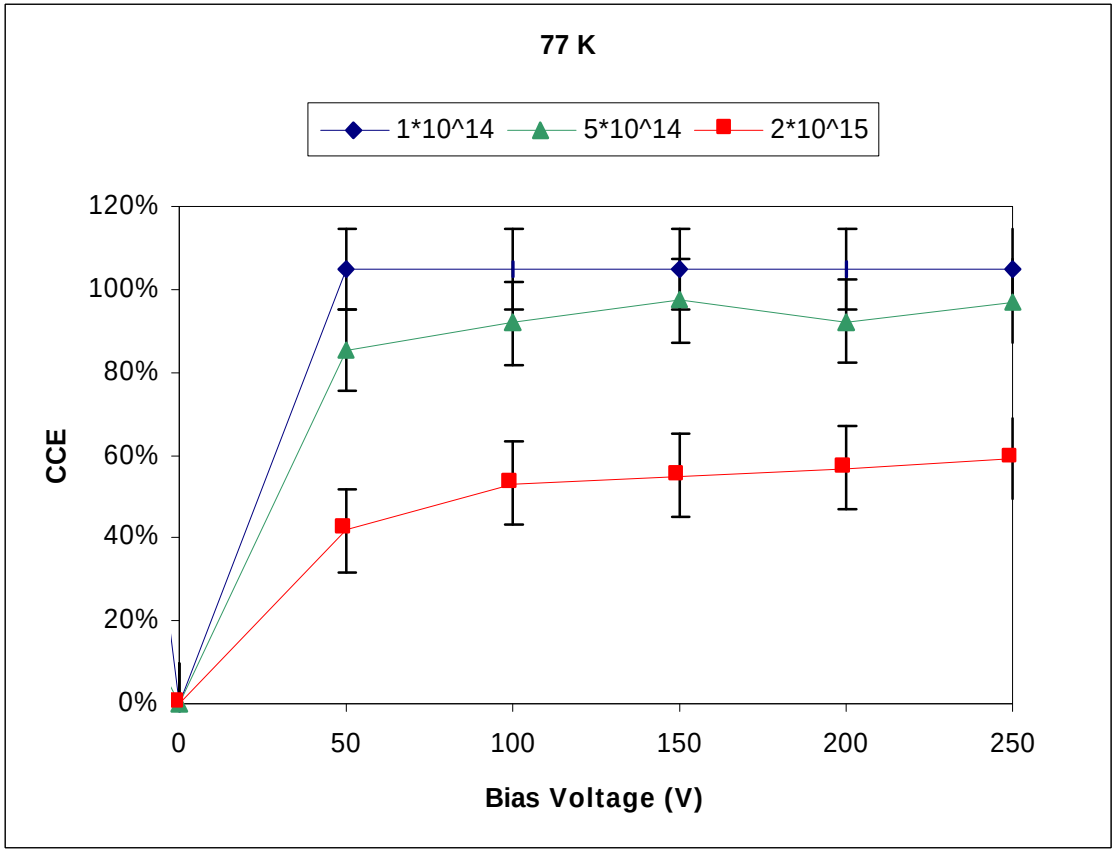
Voltage Dependence of CCE

Preliminary



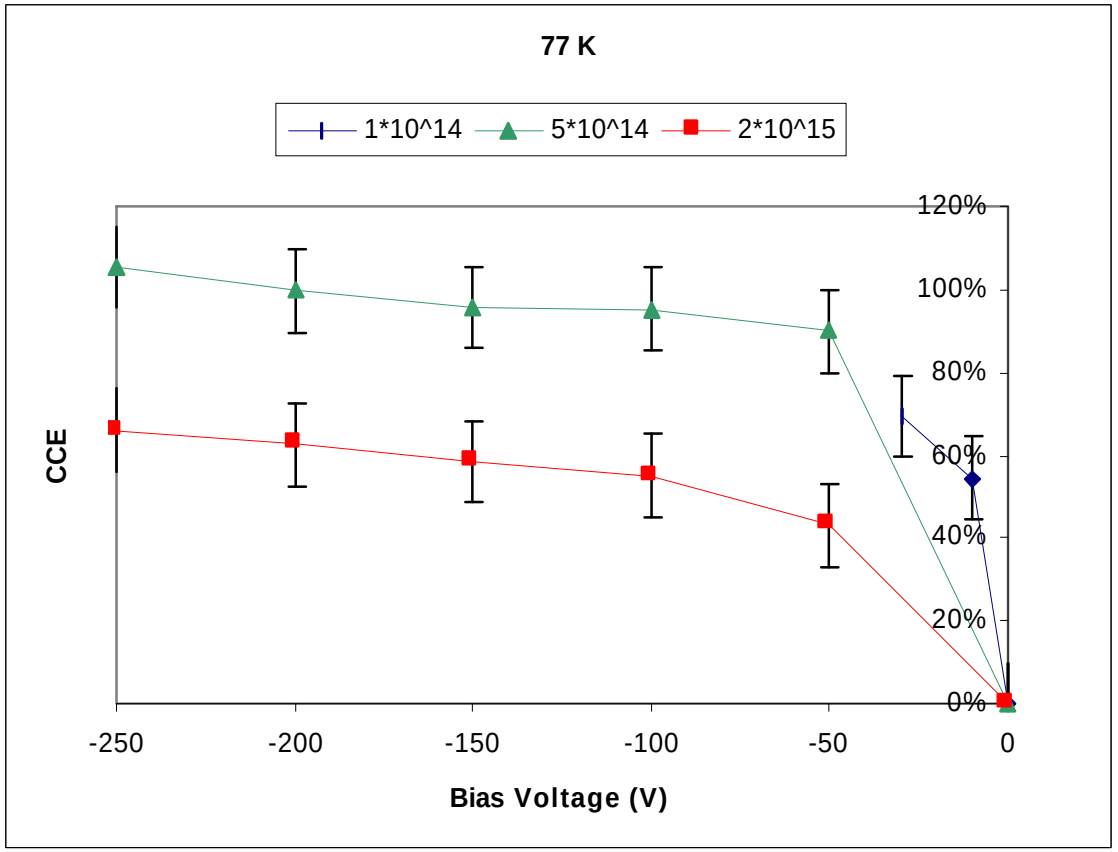
Voltage Dependence of CCE "pumped"

Preliminary



Voltage Dependence of CCE "forward bias"

Preliminary



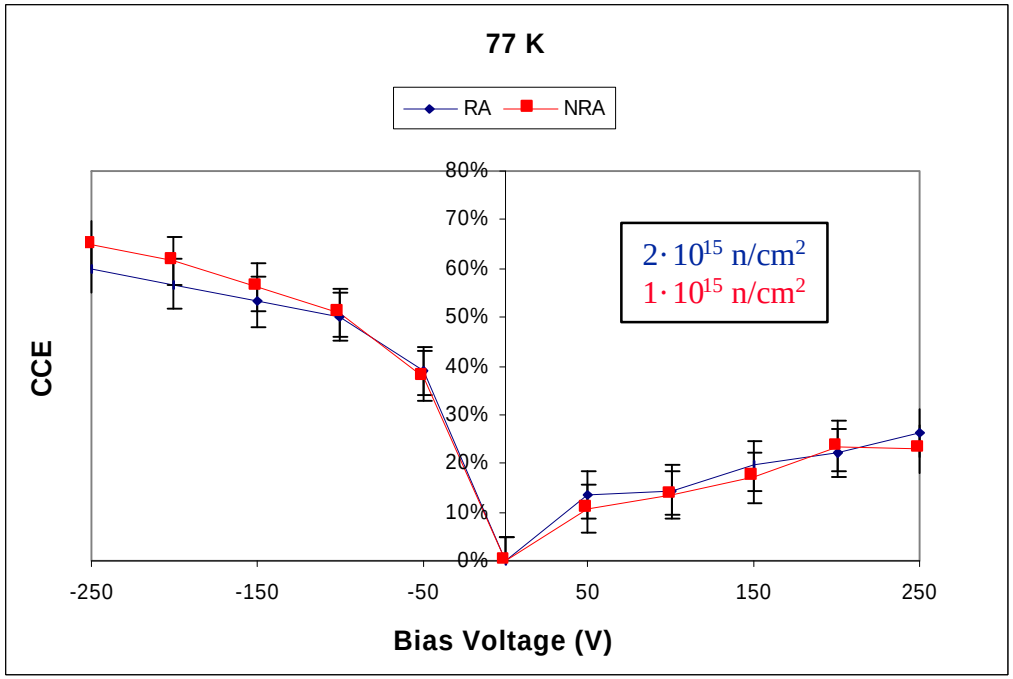
How do we explain all this ?

The Lazarus Effect

What is the role of long term annealing?

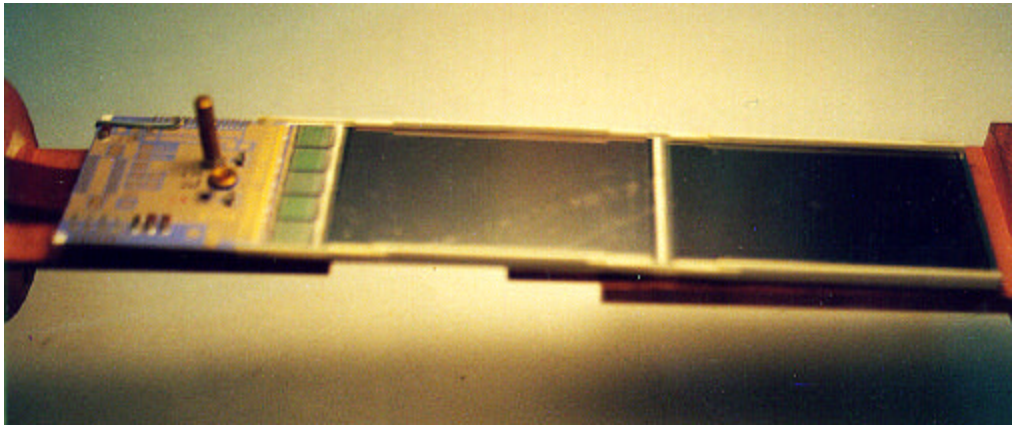
Annealing Effects ...

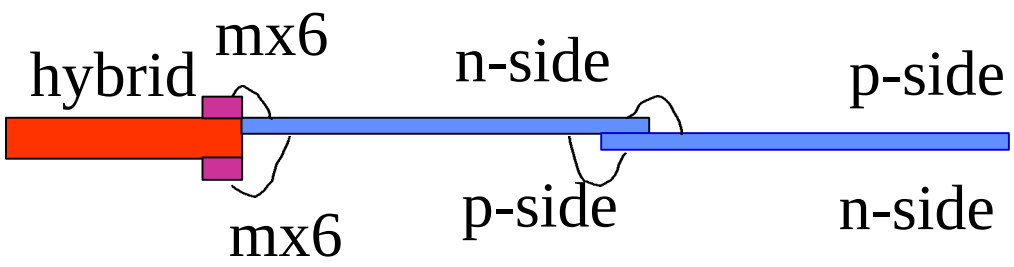
Preliminary



The charge is back, but what about position resolution ?

The DELPHI Module





Detectors:

2x Hamamatzu
320 μm 5.75 x 3.2 cm^2 3-6 Kohm cm
p-side 640 strips
strip pitch 25 μm
r-o pitch 50 μm
n-side 640 strips (p-stops)
strip pitch 42 μm
r-o pitch 42 μm

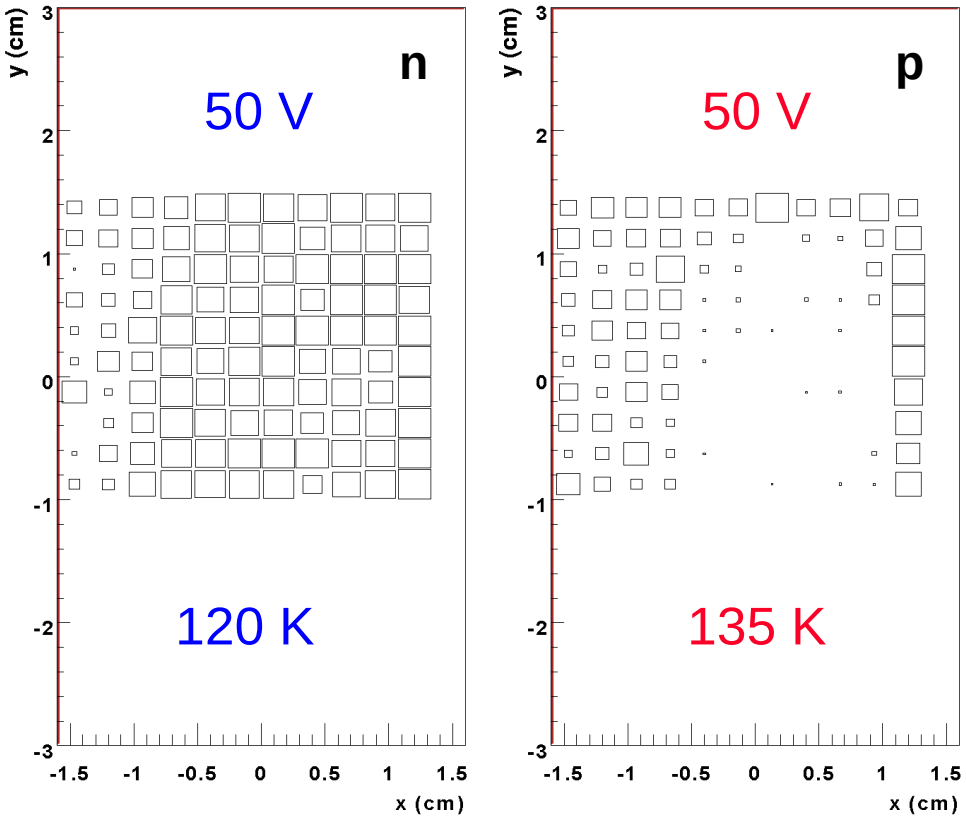
Electronics:

10x Mx6
128 input channels
CMOS technology
2.5 MHz speed
1.5 μs peaking time
"radiation soft"

V. Chabaud et al., CERN-PPE/95-86, 1995

Back from the Dead ...

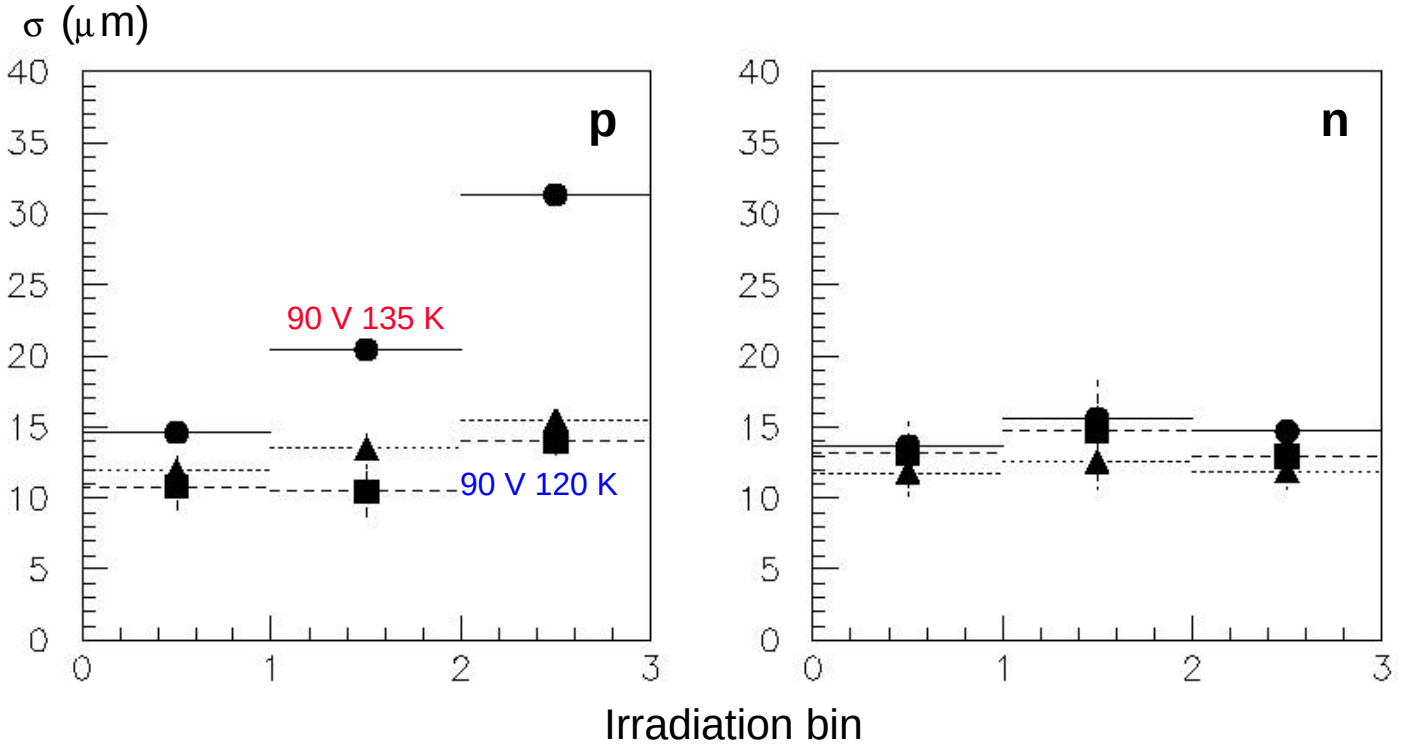
Preliminary



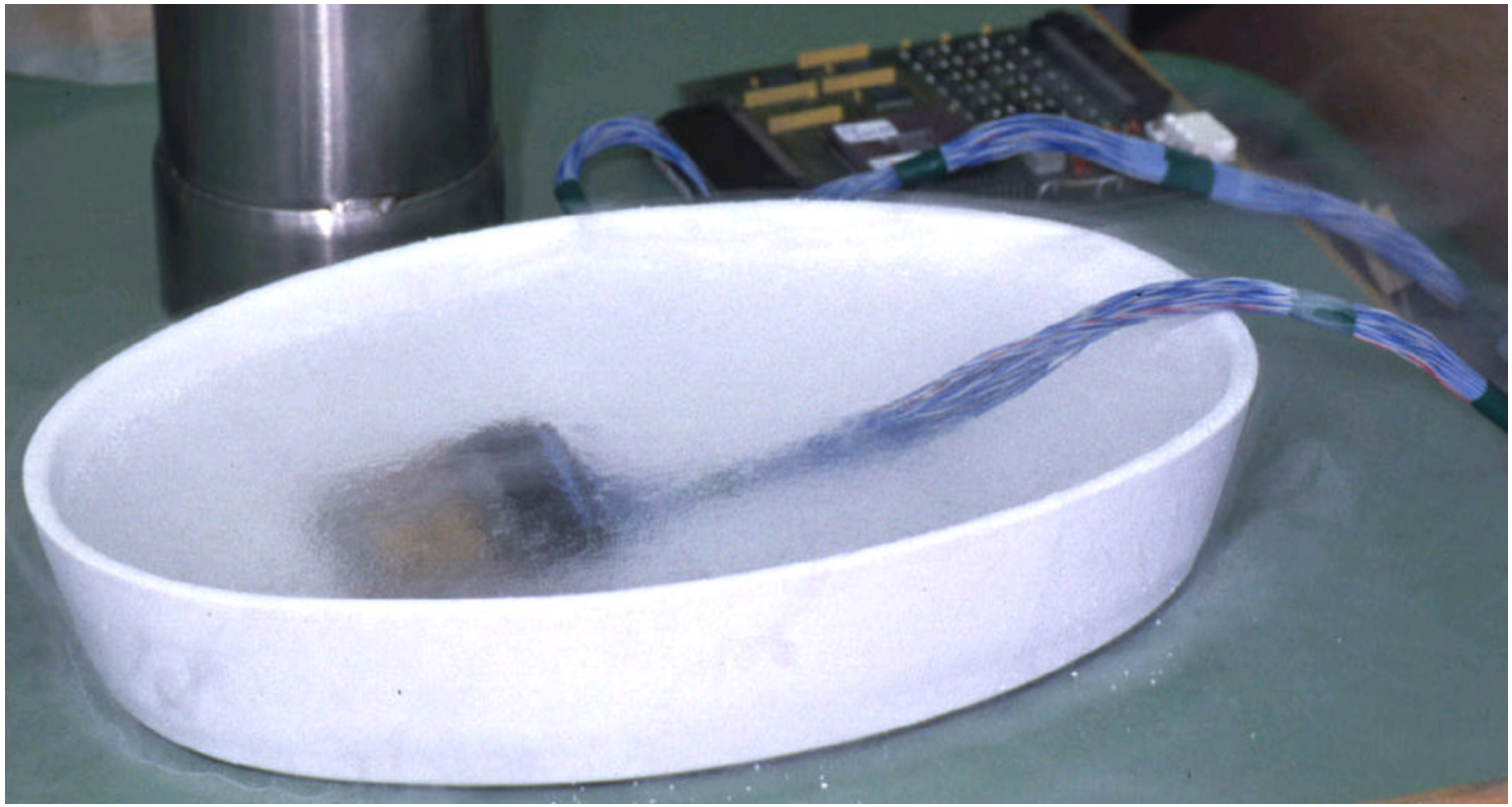
L. Casagrande et al., CERN-EP/98-207, 1995

Position Resolution

Preliminary



Cold Pixel Lasagna ...



The Ω-LHC1 pixel chip (courtesy of CERN-RD19)