MAX-PLANCK-GESELLSCHAFT

GERDA

Operation of **Bare Ge detectors** in liquid argon for the GERDA experiment

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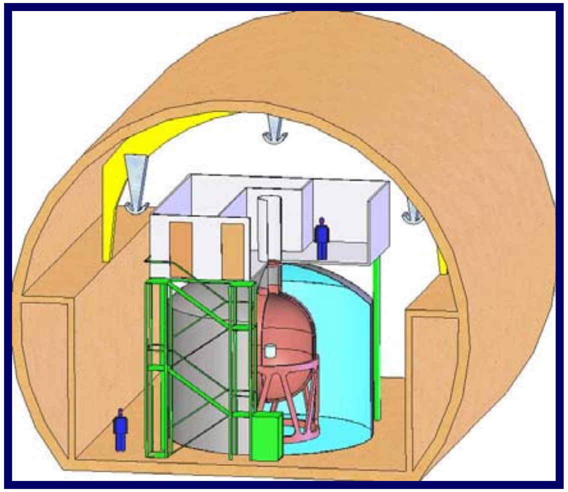
Outline

- GERDA Phase I detector assembly
- Test bench of GERDA Detector Laboratory
- Operation of bare HPGe detectors in LN_2/LAr
  - Study of leakage current (LC) under varying γ irradiation conditions
  - Long term stability measurement
- Status of the Phase I detectors

GERmanium Detector Array for the search of neutrinoless ββ decays of ^{76}Ge

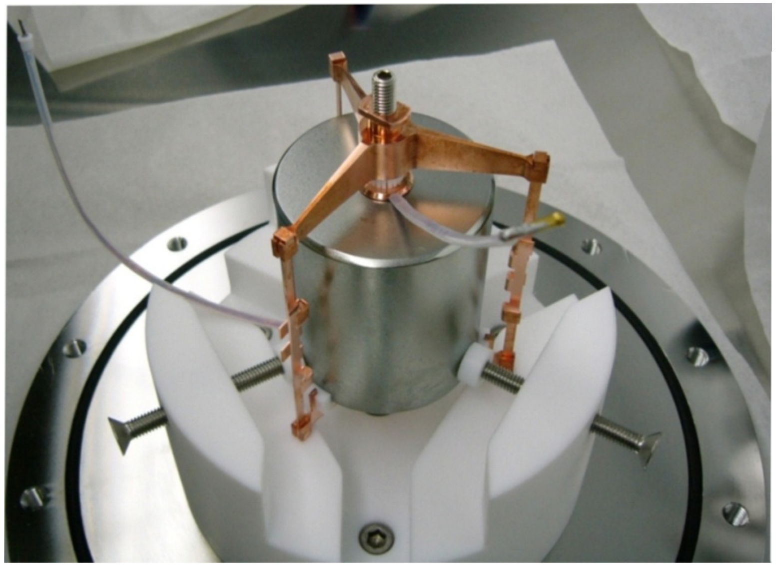


- Operation of bare enriched HPGe detectors in LAr
  - ➡ Extremely low background
  - ➡ Excellent energy resolution
- **Phase I**
  - Enriched ^{76}Ge (86 %)
    - Reprocessed HDM (5) and IGEX (3) detectors: 17.9 kg
  - Non enriched Ge
    - Reprocessed Genius-TF detectors (6): 15 kg

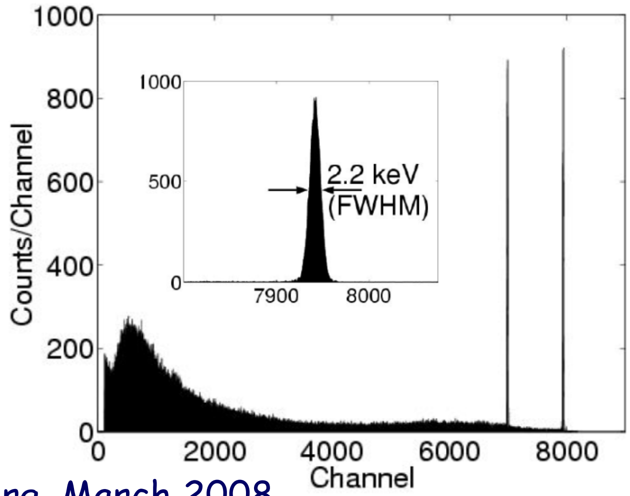
Phase I detectors operated in LAr

Non-enriched HPGe dectector Prototype 1

- Same technology as Phase I detectors
- To test
  - Phase I detector assembly
  - Detector handling (> 45 cooling/warming cycles)
  - Spectroscopy performance
  - Detector stability in LAr/LN_2

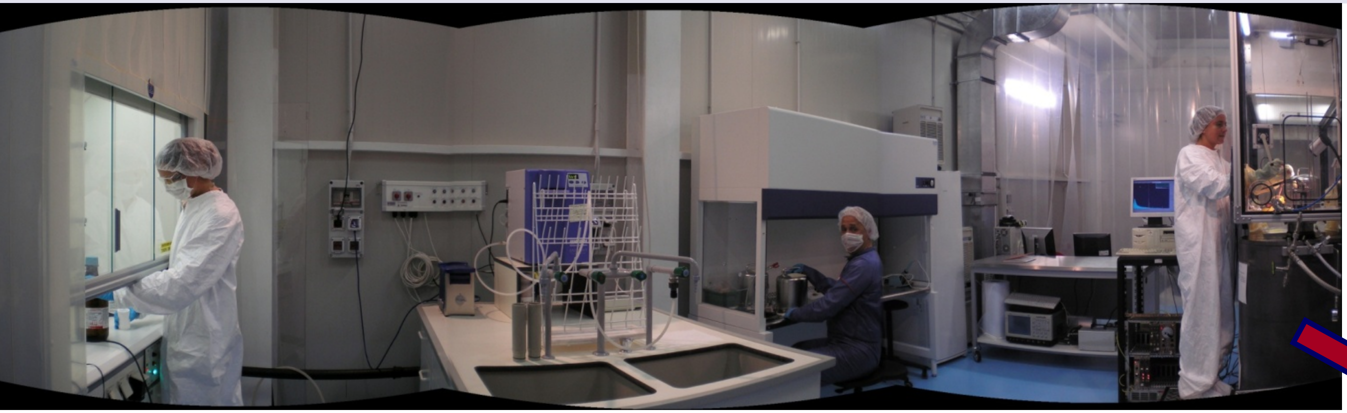


Phase I low mass holder: Cu, PTFE, silicon

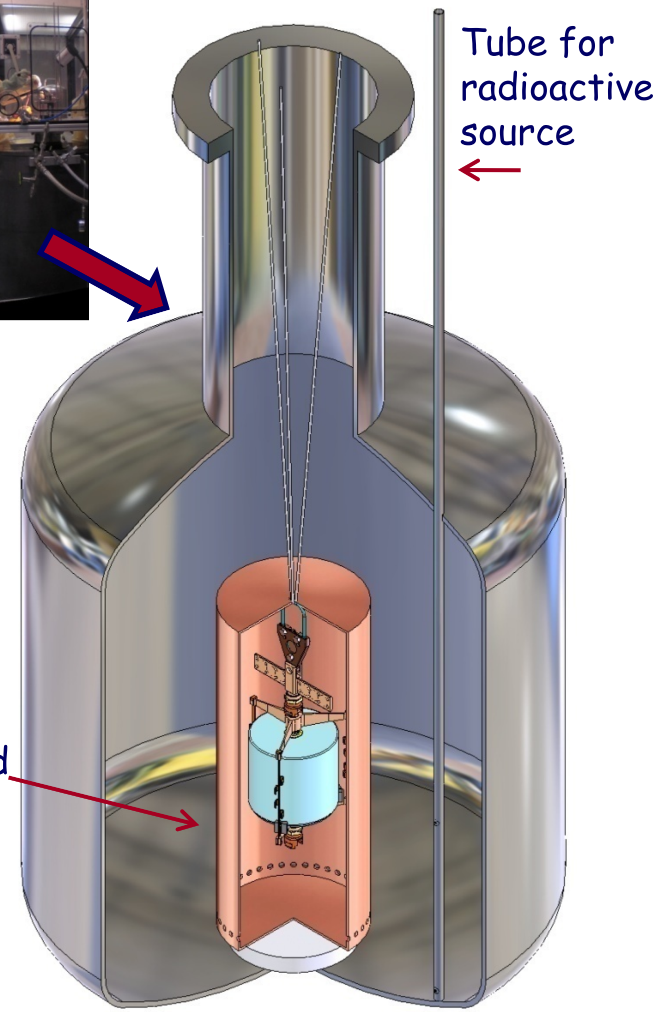


Same resolution as obtained in a test cryostat!

GERDA Detector underground Laboratory, LNGS

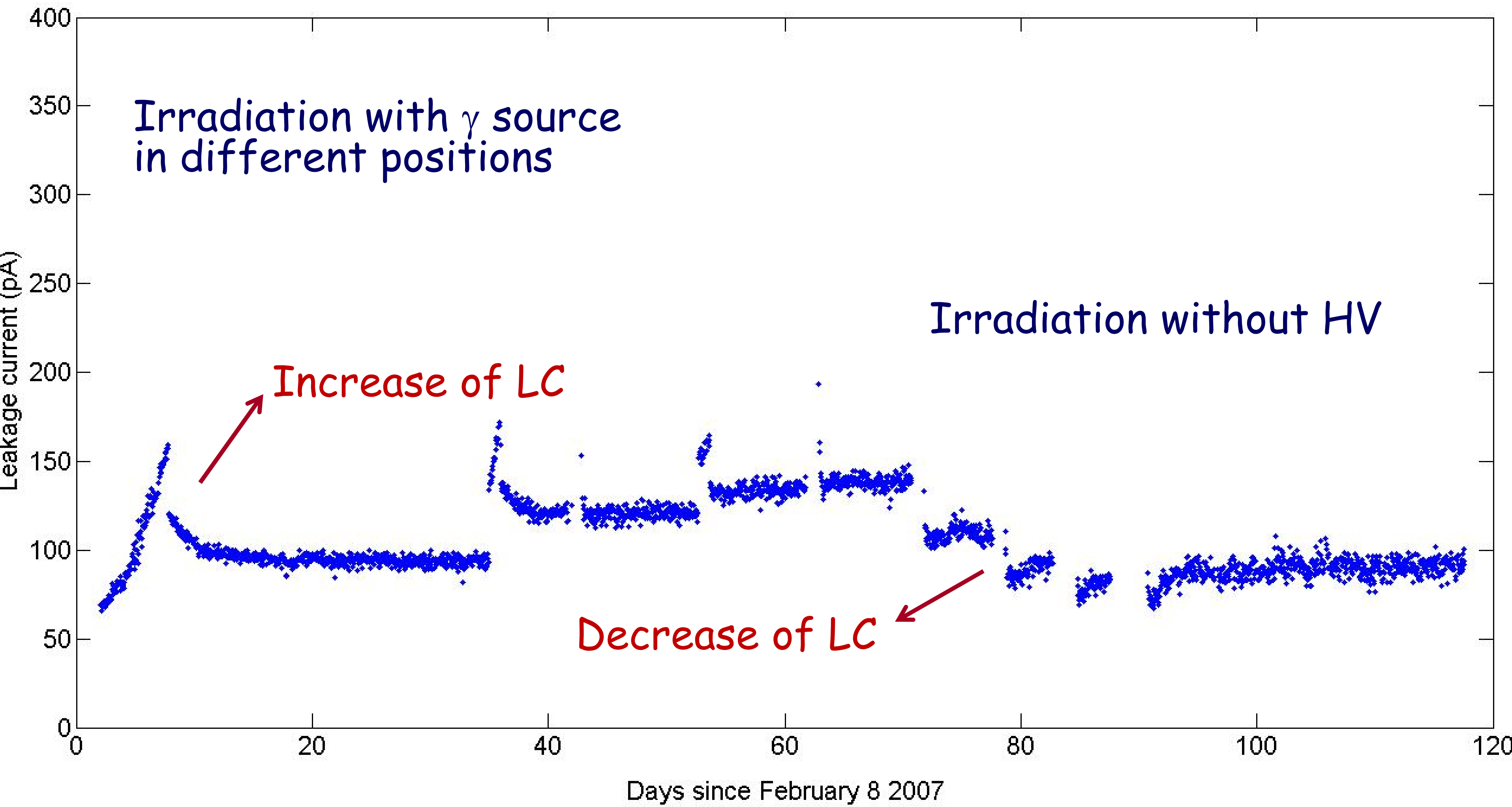


Detector test bench



- To test Phase I detectors
  - Clean room level 10 000
  - Clean benches level 10
- 2 x detector test benches
  - 70 l Dewar
  - LAr and/or LN_2
  - Resolution ~3 keV FWHM
- 4 x different detectors tested

Leakage current (LC) in response to long-term γ irradiation



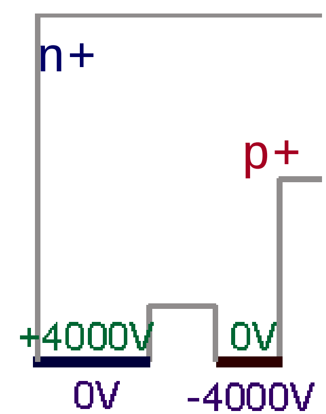
γ radiation-induced increase of LC in LAr

1) γ irradiation in liquid argon results in an increase of LC (~ 10 pA/day)

2) γ radiation-induced LC is partly reversible by irradiation without HV

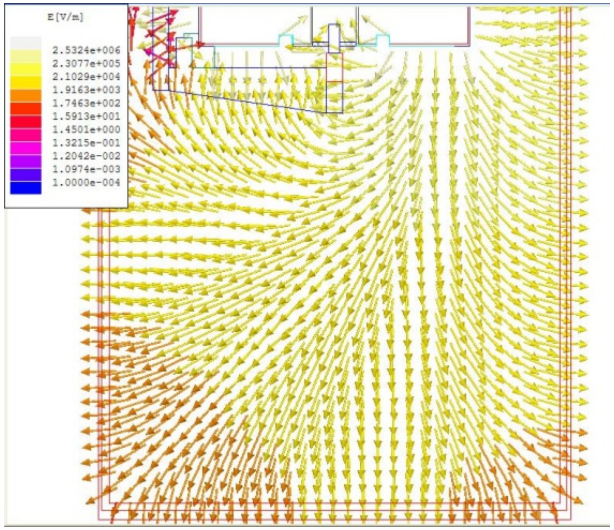
3) LC increase is stronger when the γ source irradiates the groove side of the detector assembly

4) γ radiation-induced increasing rate of the LC is stronger with -HV

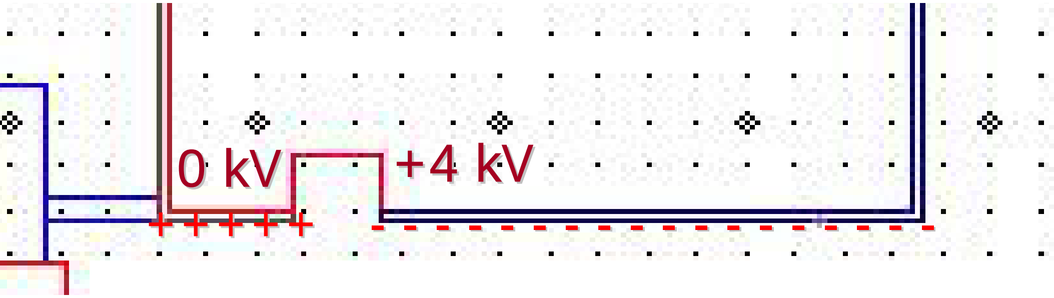


Most likely explanation: Charge collected on passivation layer

- Collection of +/- charges changes conductivity of passivation layer



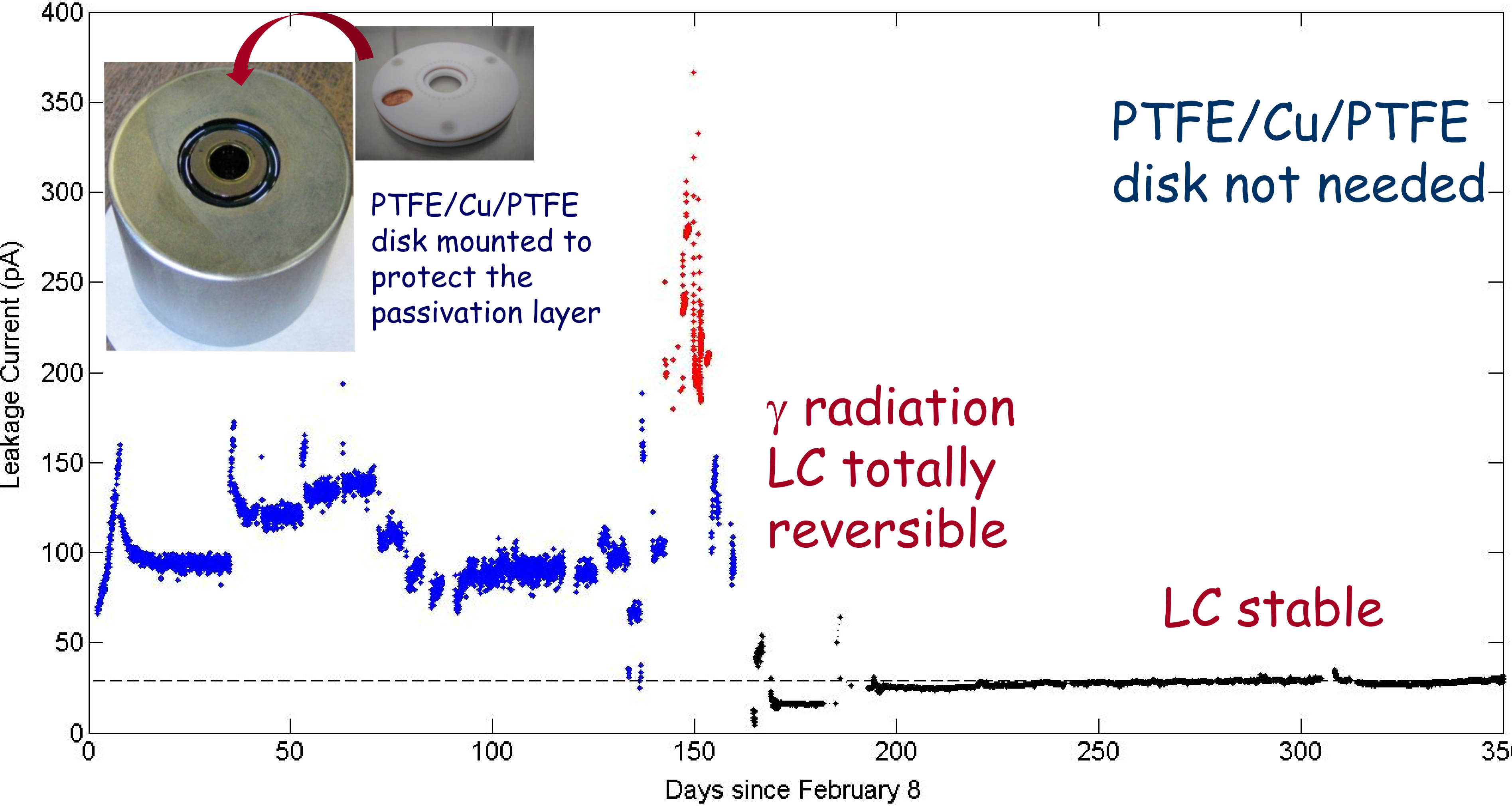
E field numerical computation



- + (-) charges collected on the inner (outer) part of the passivation layer

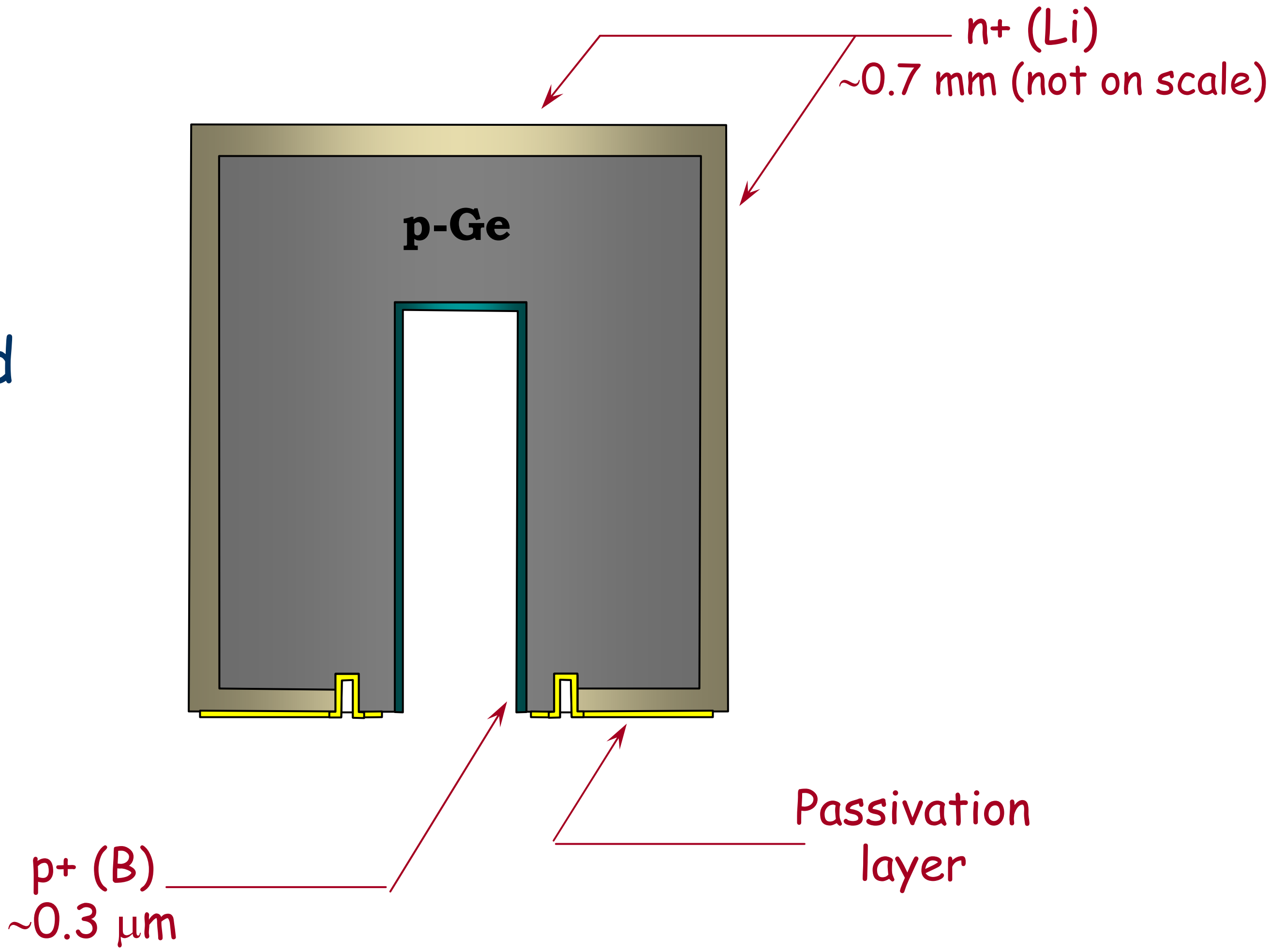
- γ radiation-induced decrease of LC: UV light from LAr scintillation

Long-term stability (7 months)

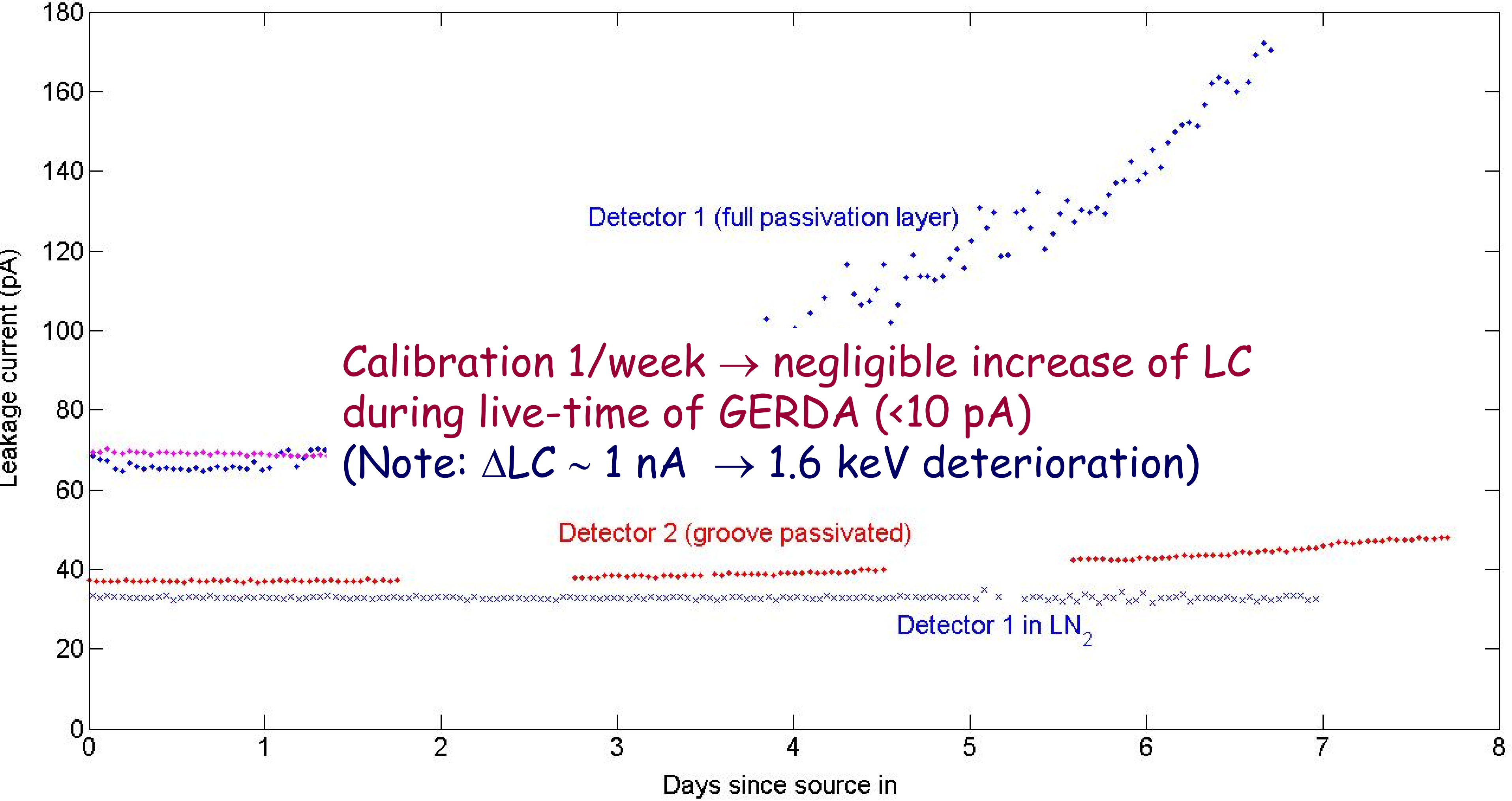


Irradiations using others diodes with different passivation layers

3) Not passivated



γ radiation-induced increase of LC



Calibration 1/week → negligible increase of LC during live-time of GERDA (<10 pA)

(Note: ΔLC ~ 1 nA → 1.6 keV deterioration)

Summary 1

- 2 years of operation with bare HPGe detector in LN_2/LAr
  - Phase I detector assembly tested successfully (2.2 keV / 3 keV FWHM)
  - Detector handling protocol defined (> 45 warming and cooling cycles)
  - Detector parameter stable over long-term measurement
- After 1 year of continuous operation in LAr
  - Detector parameters **not** deteriorated (10pA$\rightarrow$10pA)

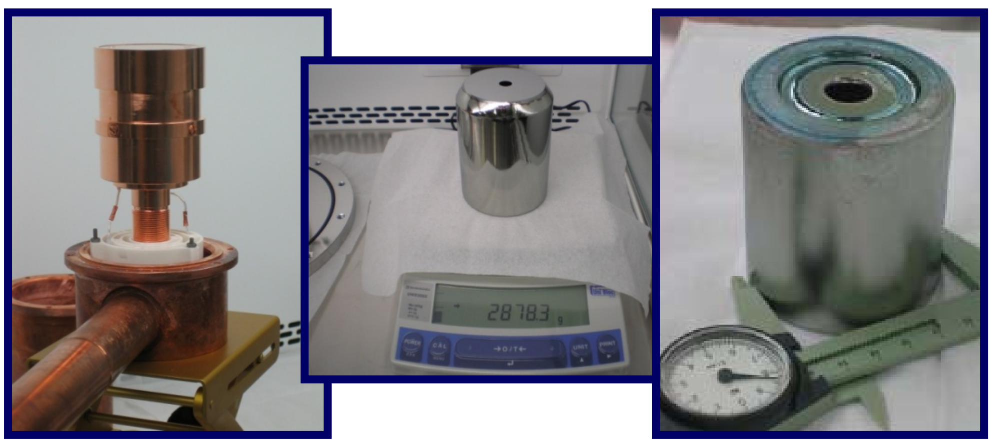
Summary 2

- 1 year study with prototype continuously operated in LAr under varying γ irradiation conditions
  - γ irradiation results in an increase of the LC
  - γ radiation-induced LC is reversible
  - Reduce size of passivation layer strongly suppresses LC increase
  - **Not** a problem for GERDA
- Genius-TF result "limited long-term stability of naked HPGe detectors" not confirmed

(Krivosheina and Klapdor-Kleingrothaus, Phys. Scr. T127 (2006) 52-53)

Outlook - GERDA Phase I enriched diodes

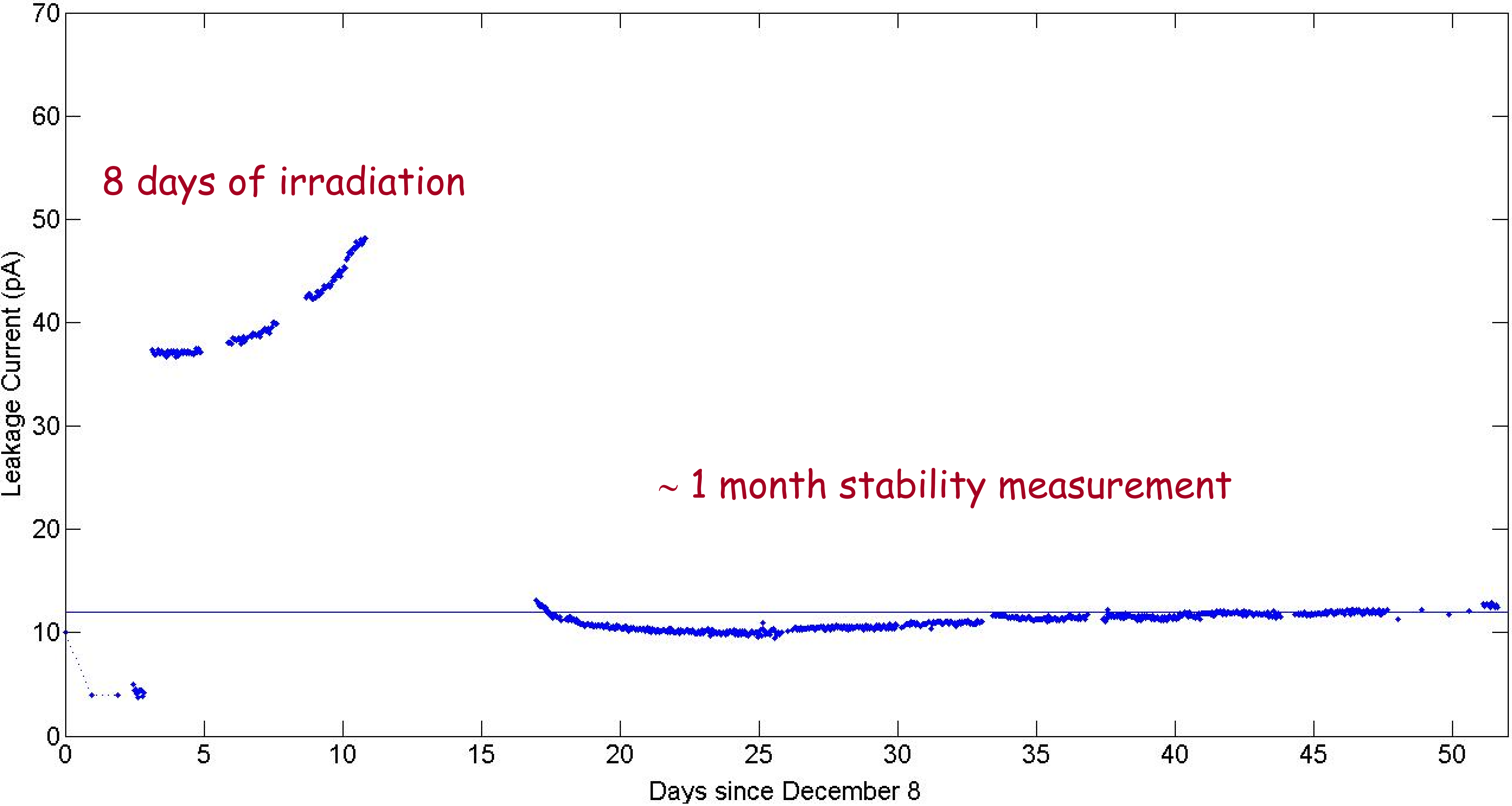
- All enriched detectors in GERDA Detector Laboratory, LNGS, in 2005
- Testing in their cryostats → all detectors in working condition



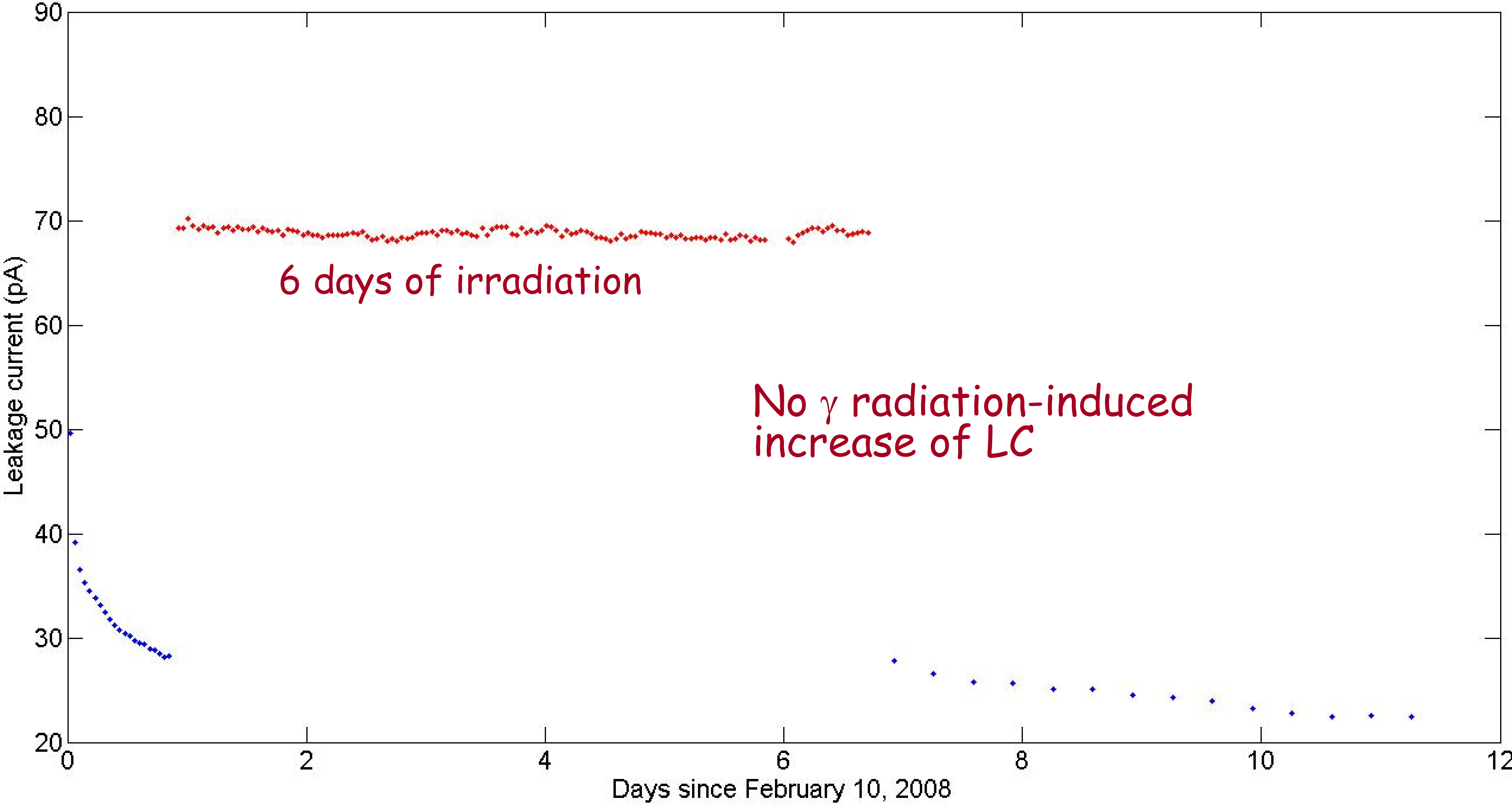
- Opening and dimensions measurement

- Refurbishment procedure of the Phase I enriched diodes is ongoing at Canberra Semiconductor, Olen (detectors stored underground)

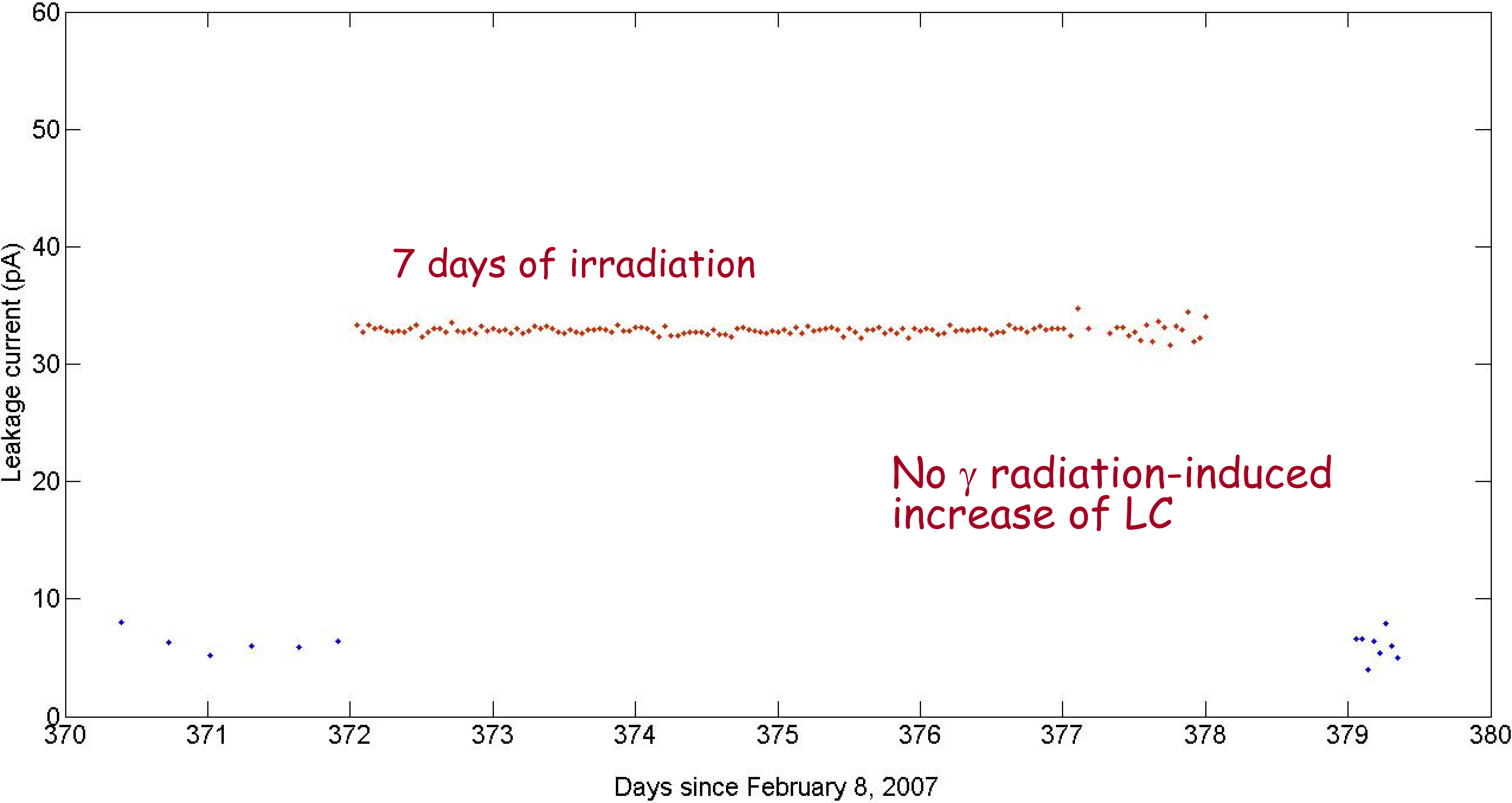
Prototype detector 2
(with passivation layer only on the groove)



Prototype detector 3 (without passivation layer)



Prototype detector 1 in LN_2 (with full passivation layer)



LESSONS from 3 years of GENIUS - Test-Facility in GRAN SASSO

GENIUS-TF
2003-2006 y

- Unexpected high background from 222Rn (not reduced, even with second Cu box) !!!

- Even more serious:

- *Long-term* operation of naked Ge detectors in liquid nitrogen *critical !!*

- After 3 years from 6 detectors – 3 destroyed (high leakage current), still only 1 detector running with nominal high voltage !!!!!!!!!!

$0\nu\beta\beta$,

Dark Matter

- Question:

Can full GENIUS – like experiment be performed at all ???

GOOD LUCK BOYS !!!!

At present worldwide, except for GENIUS-TF,

NOT ONE

detector in liquid nitrogen, underground or on Earth´s surface, is running long-time

H.V.K.-K. et al. CERN COURIER 2003, NIM A511 (2004) 341

Table 1
The high voltages applied to the detectors after installation in GENIUS-TF I, II and III as function of time, and the nominal voltages

Detectors	D1	D2	D3	D4	D5	D6
GENIUS-TF-I, from 10.12.2003, till 25.09.2004						
10.12.03	2404	2603	2879	2301	n. inst.	n. inst.
06.04.04	2600	2220	2879	2301	–	–
04.05.04	2600	2220	3200	2500		
GENIUS-TF-II, from 18.11.2004, till 28.02.2005						
08.10.04	250	1296	261	954	1253	502
18.11.04	364	2200	347	2298	3501	1015
20.01.05	364	2200	347	2298	3501	1000
GENIUS-TF-III, from 15.03.2005						
15.03.05	80	1802	20	2153	3501	980
03.05.05	0	1700	0	1500	3501	980
09.03.06	–	1700	–	–	3500	911
19.05.06	–	1600	–	–	2100	850
Nom.	3000	2600	3200	2500	3500	2000