RD50

CCE/CV measurements with irradiated p-type MCz diodes

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RD50 Workshop
Praha, 27. 06. 2006

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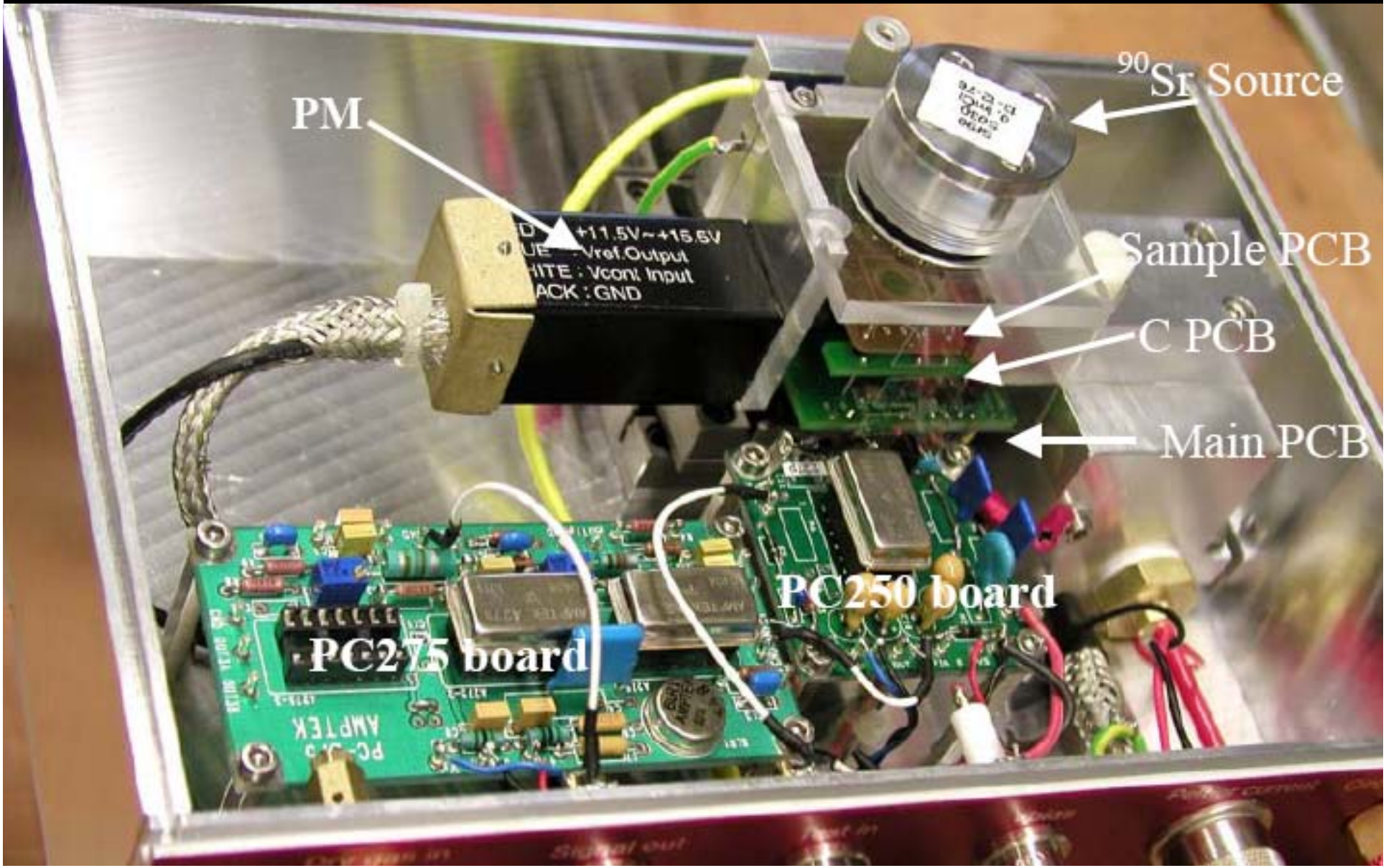
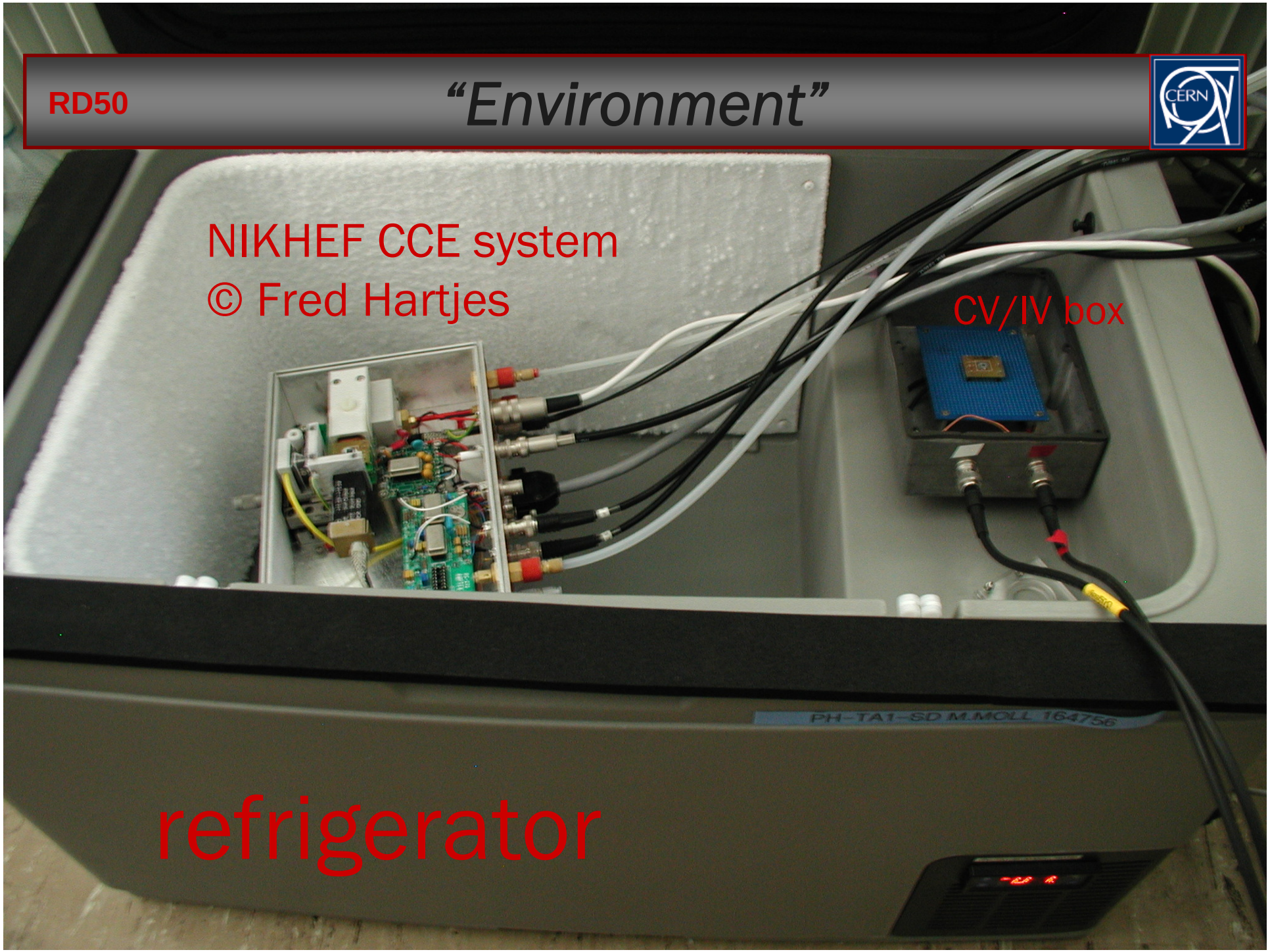
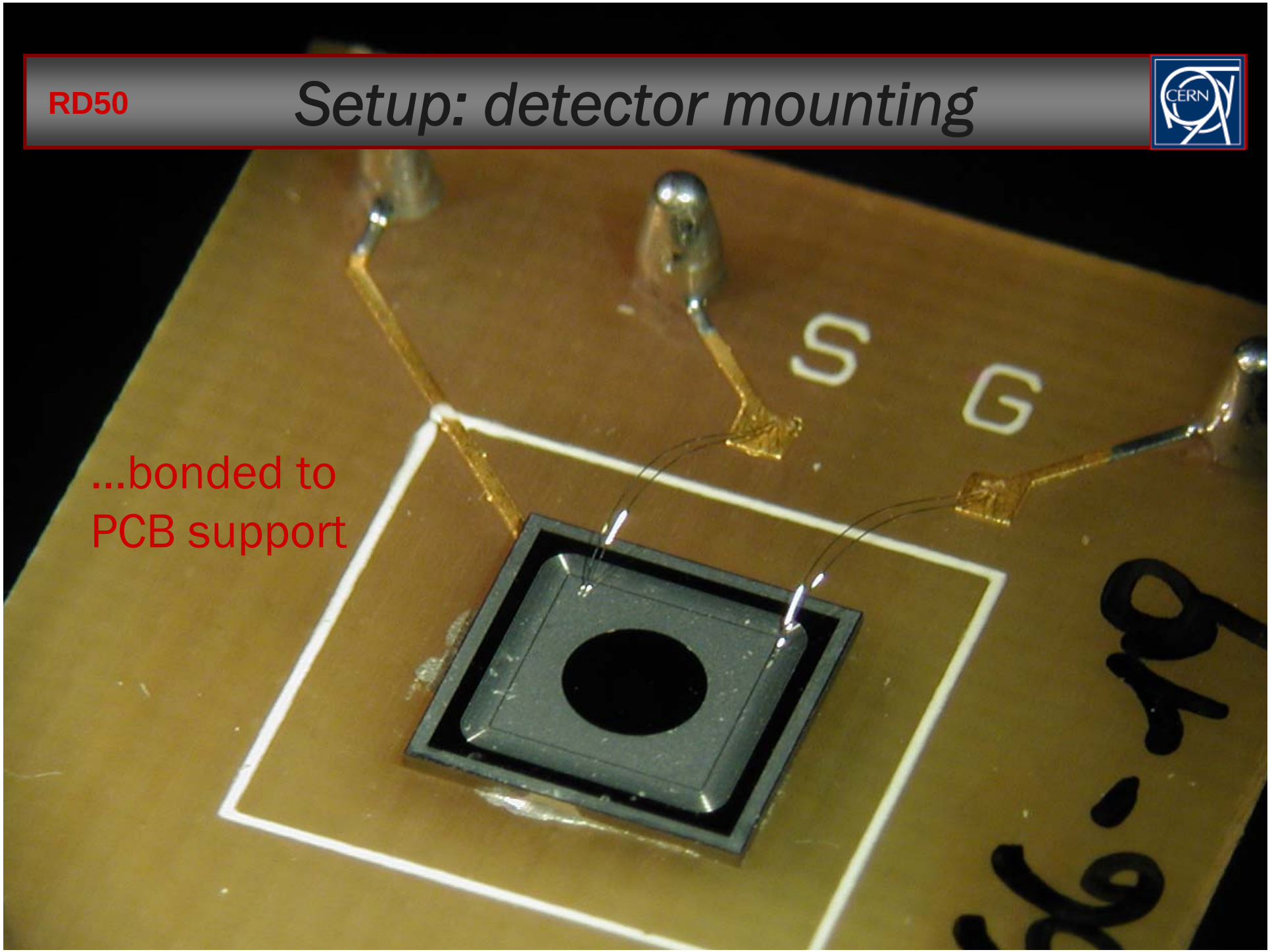
Setup: *NIKHEF CCE system © Fred Hartjes*



"Environment"

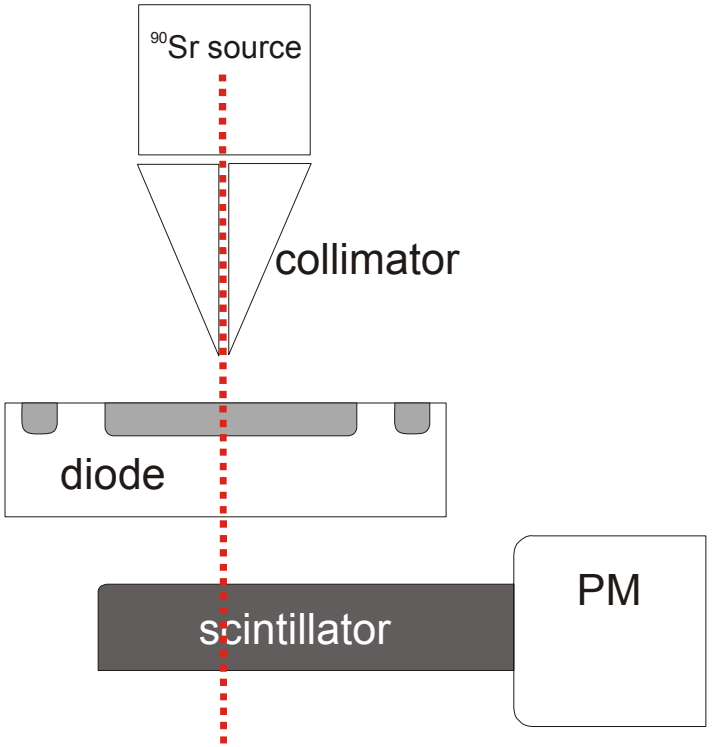


Setup: detector mounting



...bonded to
PCB support

CCE: measurement parameters



signal shaping time: 2.5 µs

Gain calibration factor: 245 e^-/mV

temperature:
down to -30 °C with fridge + peltier

bias: up to 1000 V

noise: 567e^- + 4.26 e^- /pF

trigger rate with ^{90}Sr source: ≈ 50-60 Hz

guard ring: connected to ground

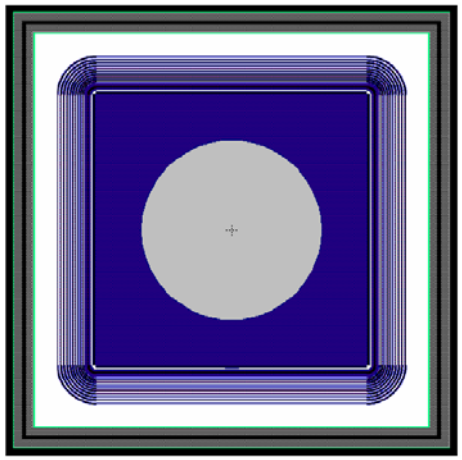
Investigated material

ITC-IRST square MG diodes n^+/p (batch SMART2)
300 µm MCz

W066 – series: p-spray dose = 3 x 10^{12} cm^{-2}
W182 – series: p-spray dose = 5 x 10^{12} cm^{-2}

Irradiation: 24 GeV/c protons @ CERN/PS up to $\Phi = 10^{16}$ cm^{-2}

Die dimension: $(5920\ \mu m)^2$
Diode area (p+ implant): 13.688 mm^2
Metal hole area: 4.524 mm^2 (Φ 2.4 mm)
1 Large guard (~90 µm) + 10 float rings

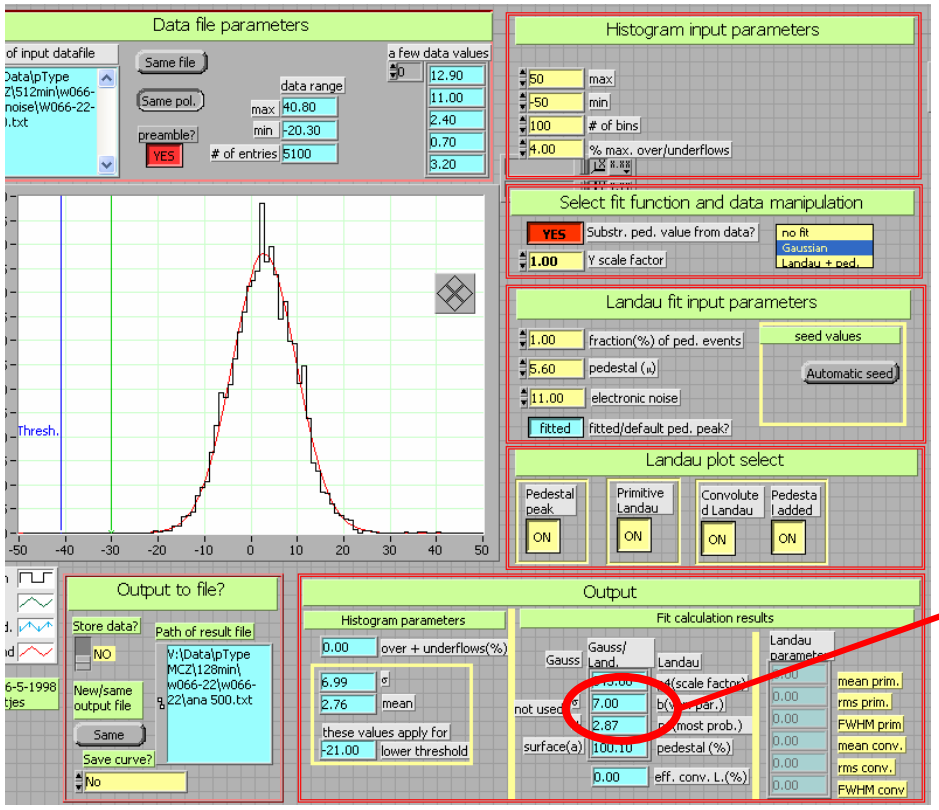


CCE: measurement & analysis

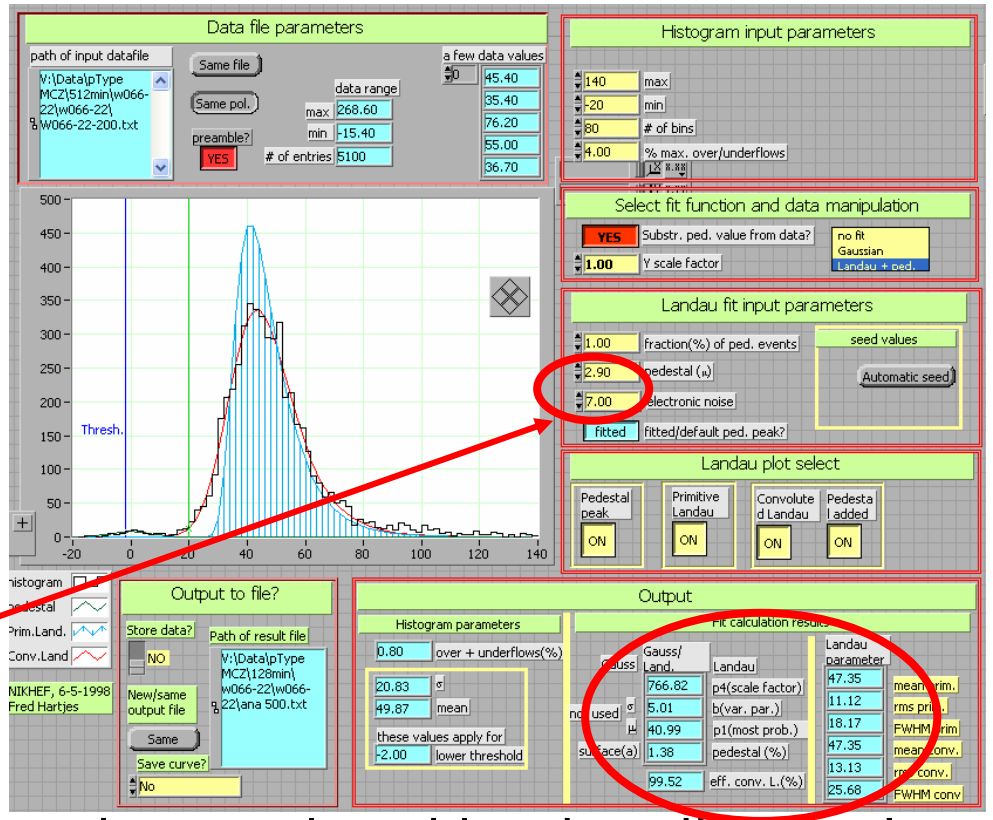
Example: p-type MCz IRST-W066-22

irradiation: $\Phi = 3.5 \times 10^{14}$ p/cm^2 temperature: -10 °C

annealing: 512 min @ 80 °C bias: 200 V

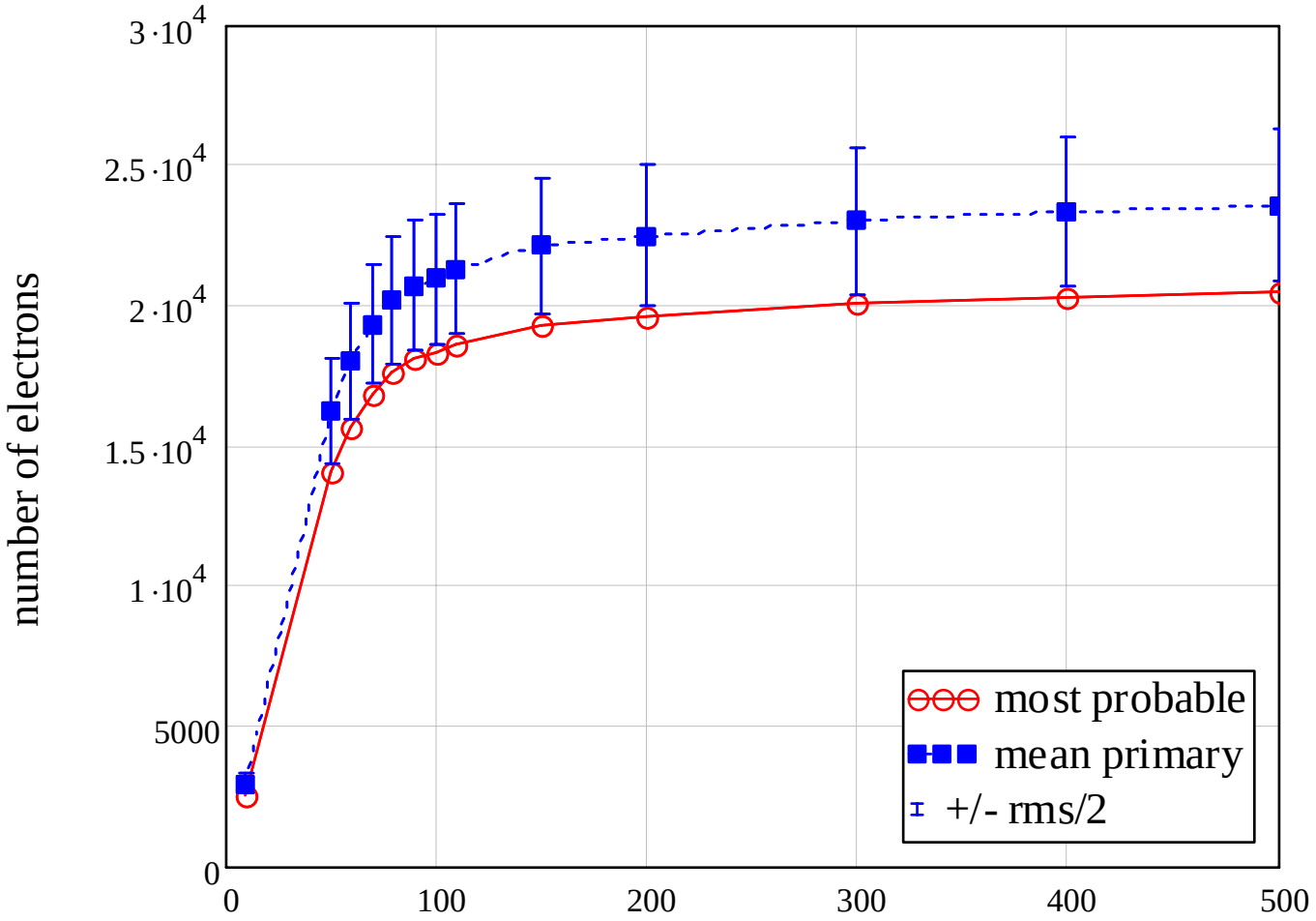


pedestal measurement



deconvoluted landau distribution

CCE: measurement & analysis



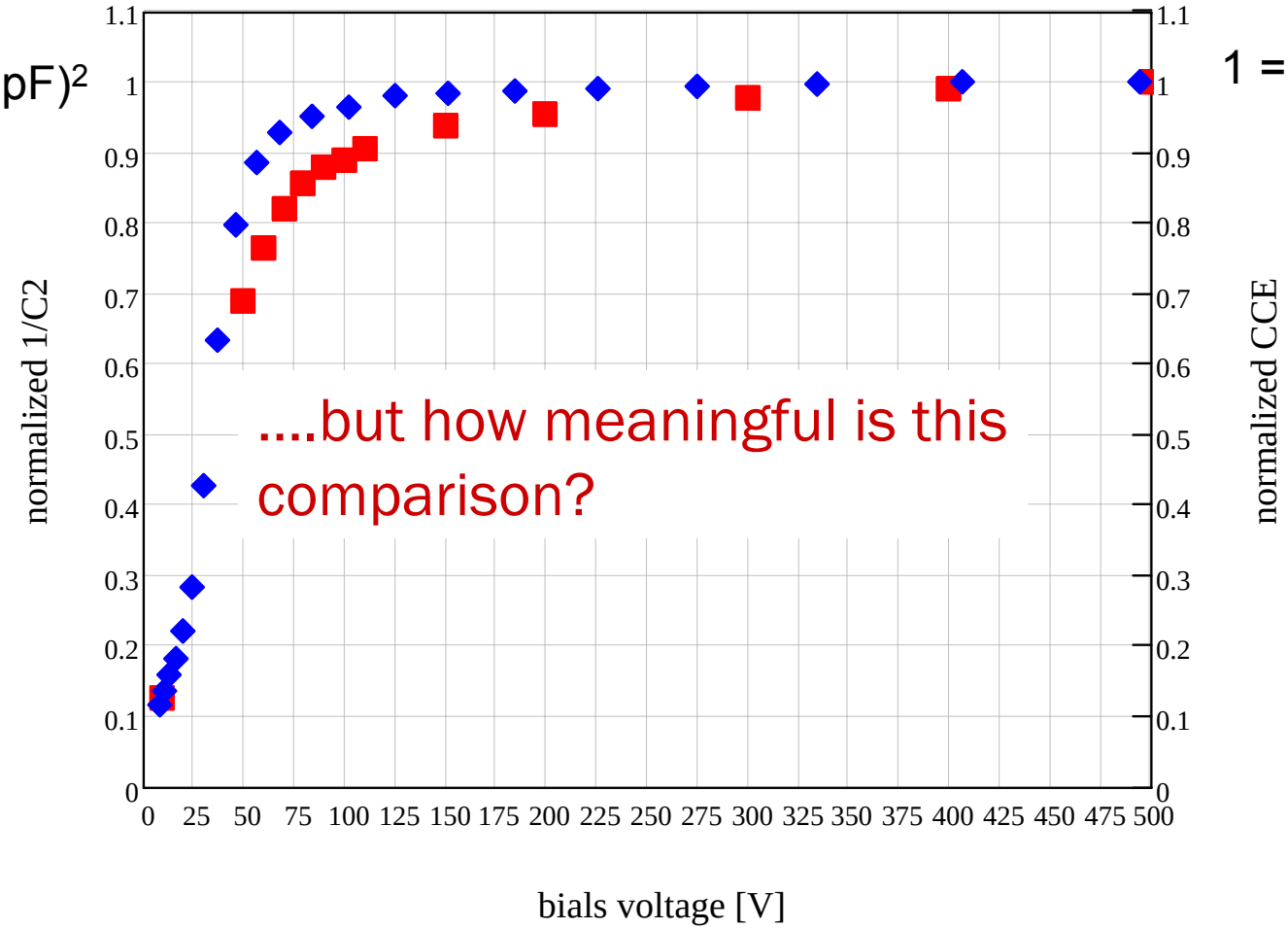
w182-21 (-20 deg C)

Φ=1E14 p/cm² /4min@80°C

CCE: comparison to CV

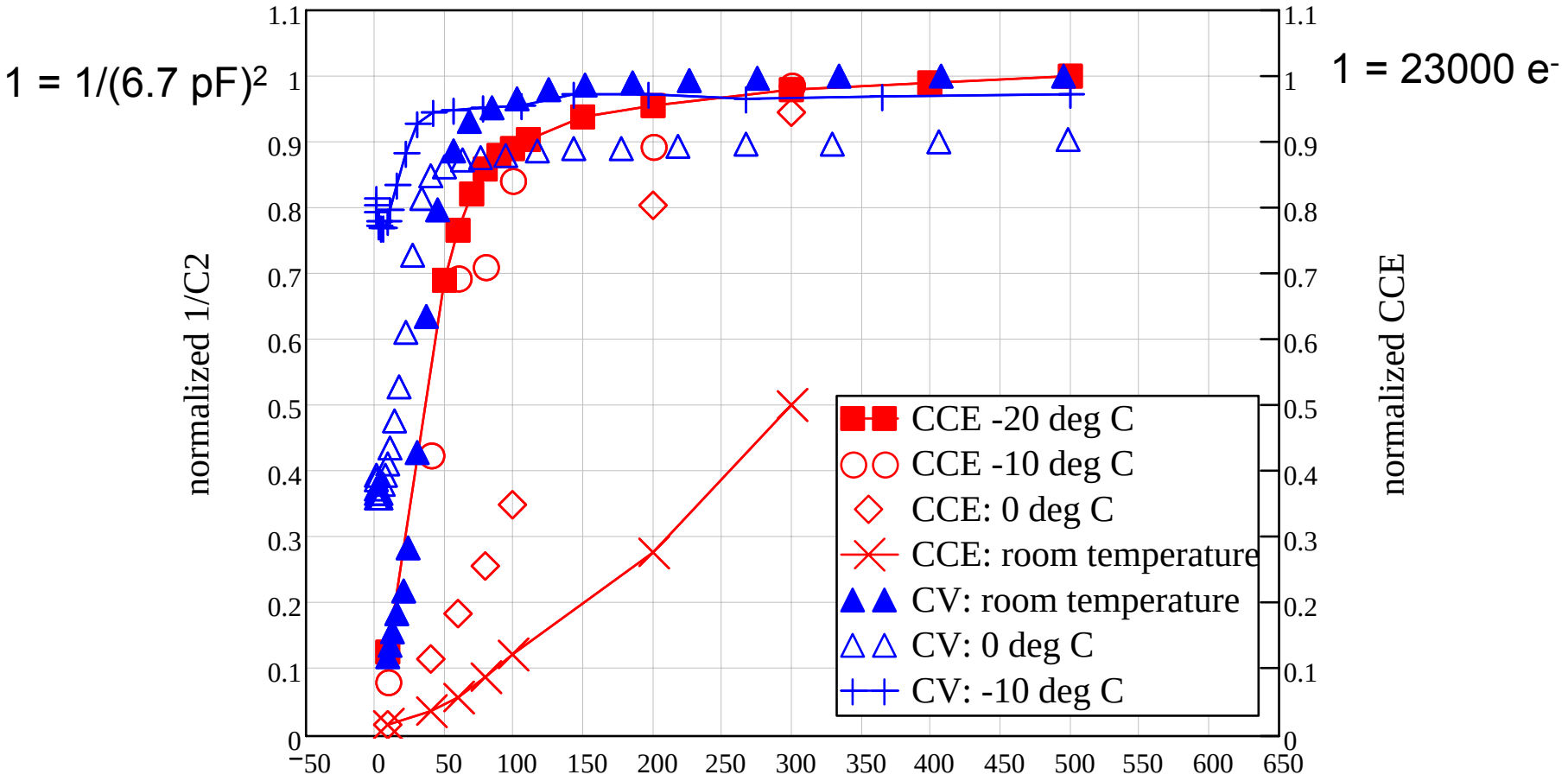
1 = 1/(6.7 pF)^2

1 = 23000 e$^-$



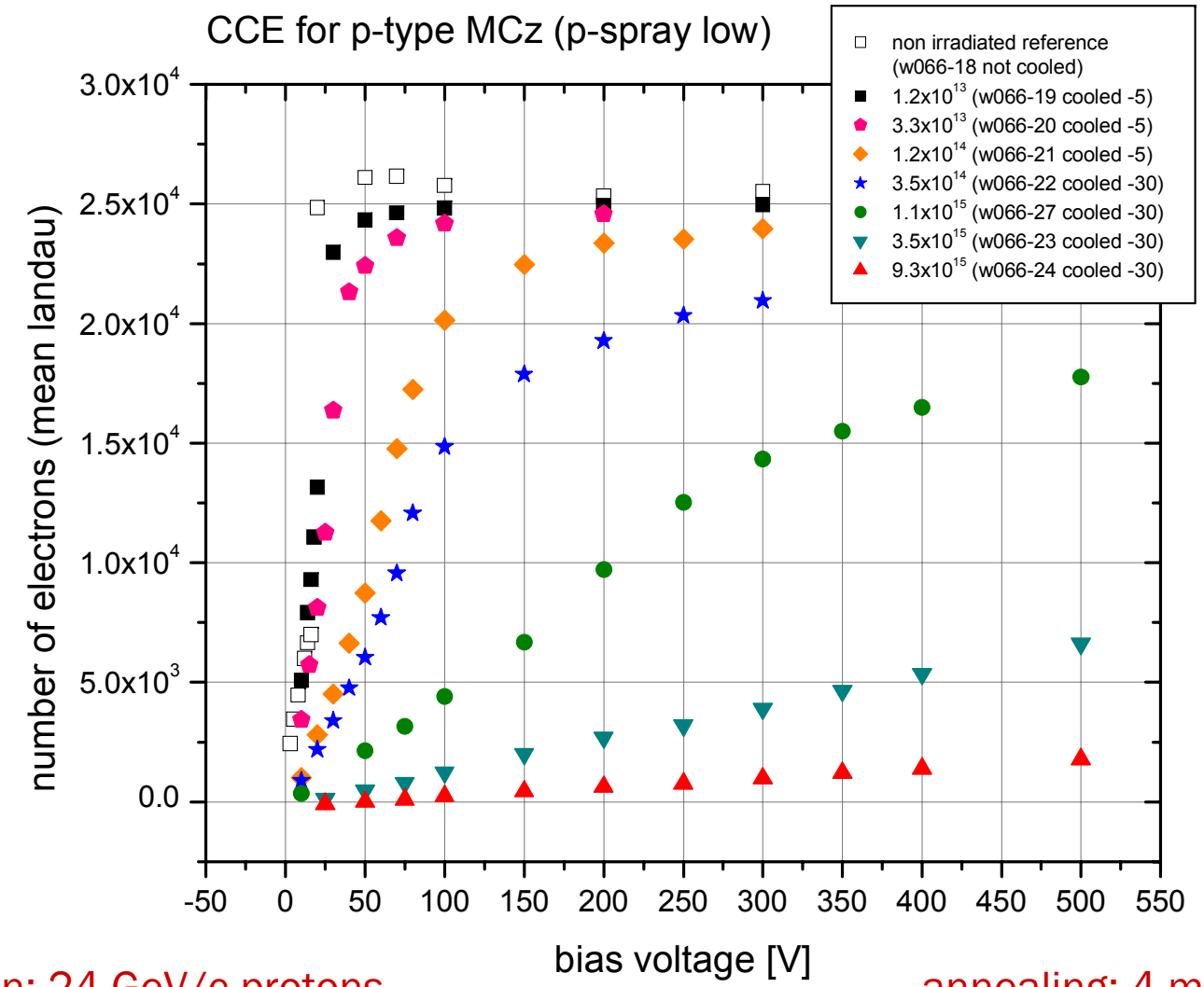
W182-21 / Φ=1E14 p/cm^2 /4min@80^{o}C

CCE: comparison to CV???



....considering the T-dependencies in the measurements of irradiated detectors!

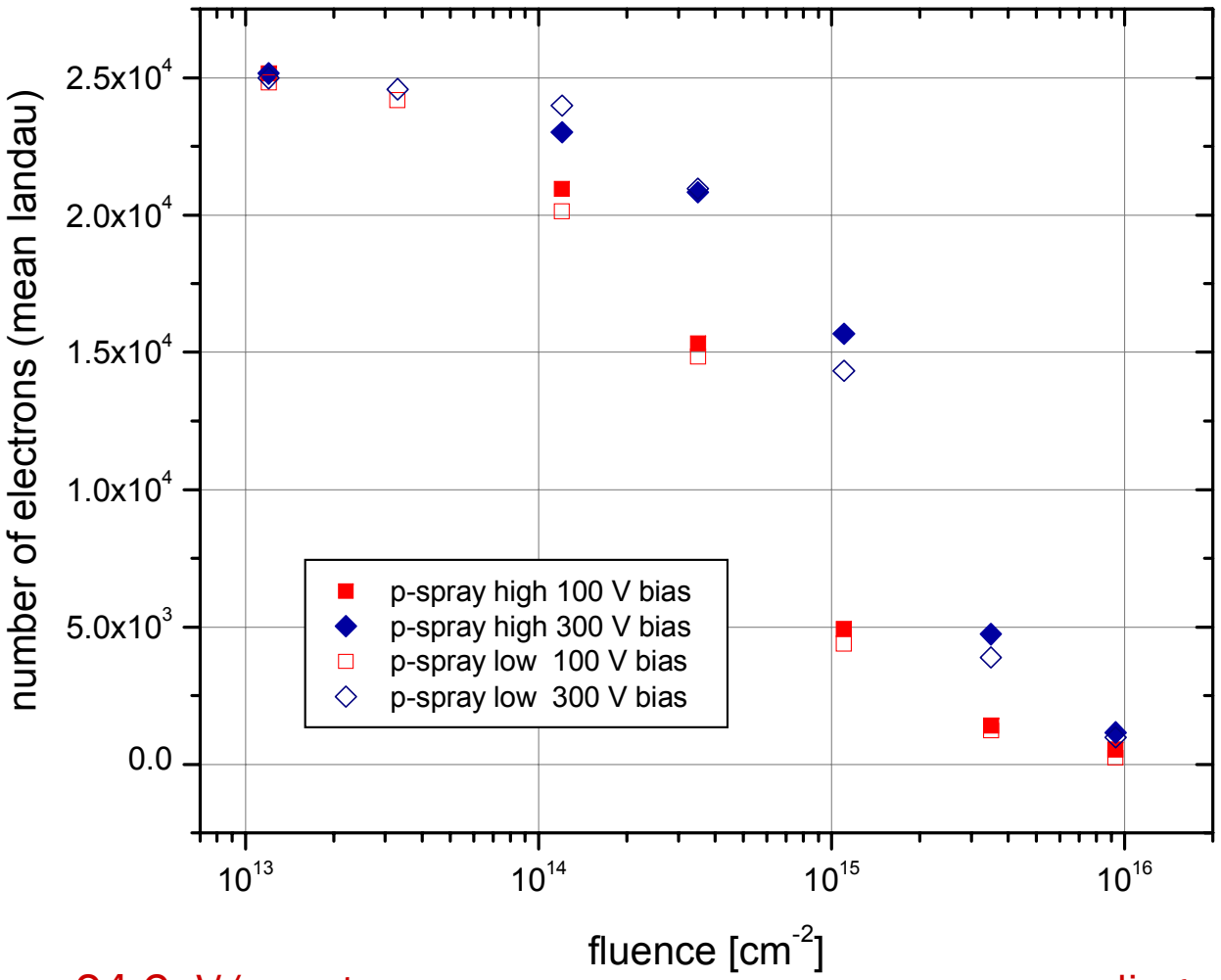
CCE for irradiated detectors



irradiation: 24 GeV/c protons

annealing: 4 min @ 80 °C

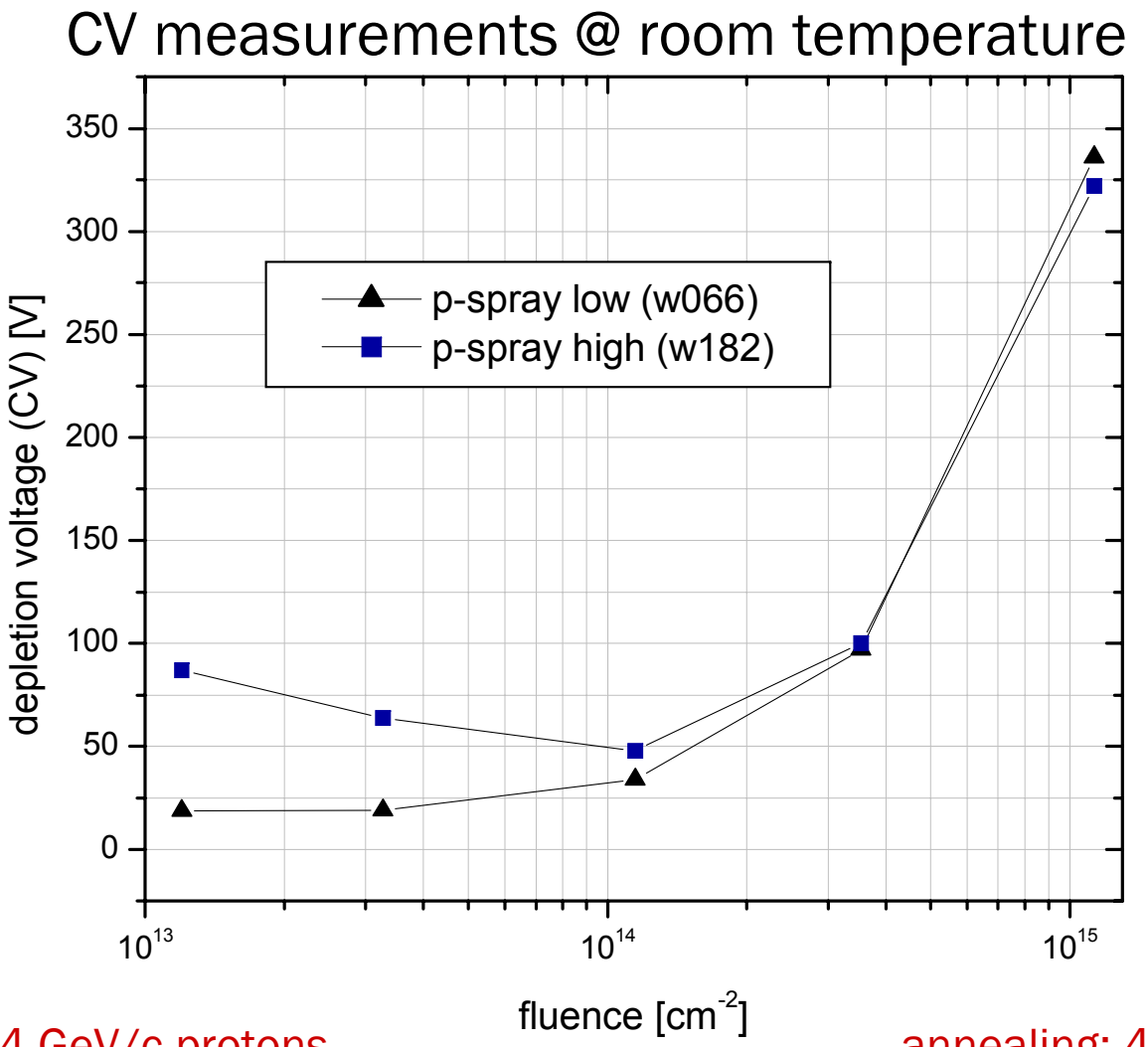
CCE as a function of fluence



irradiation: 24 GeV/c protons

annealing: 4 min @ 80 °C

V_{DEP} as a function of fluence

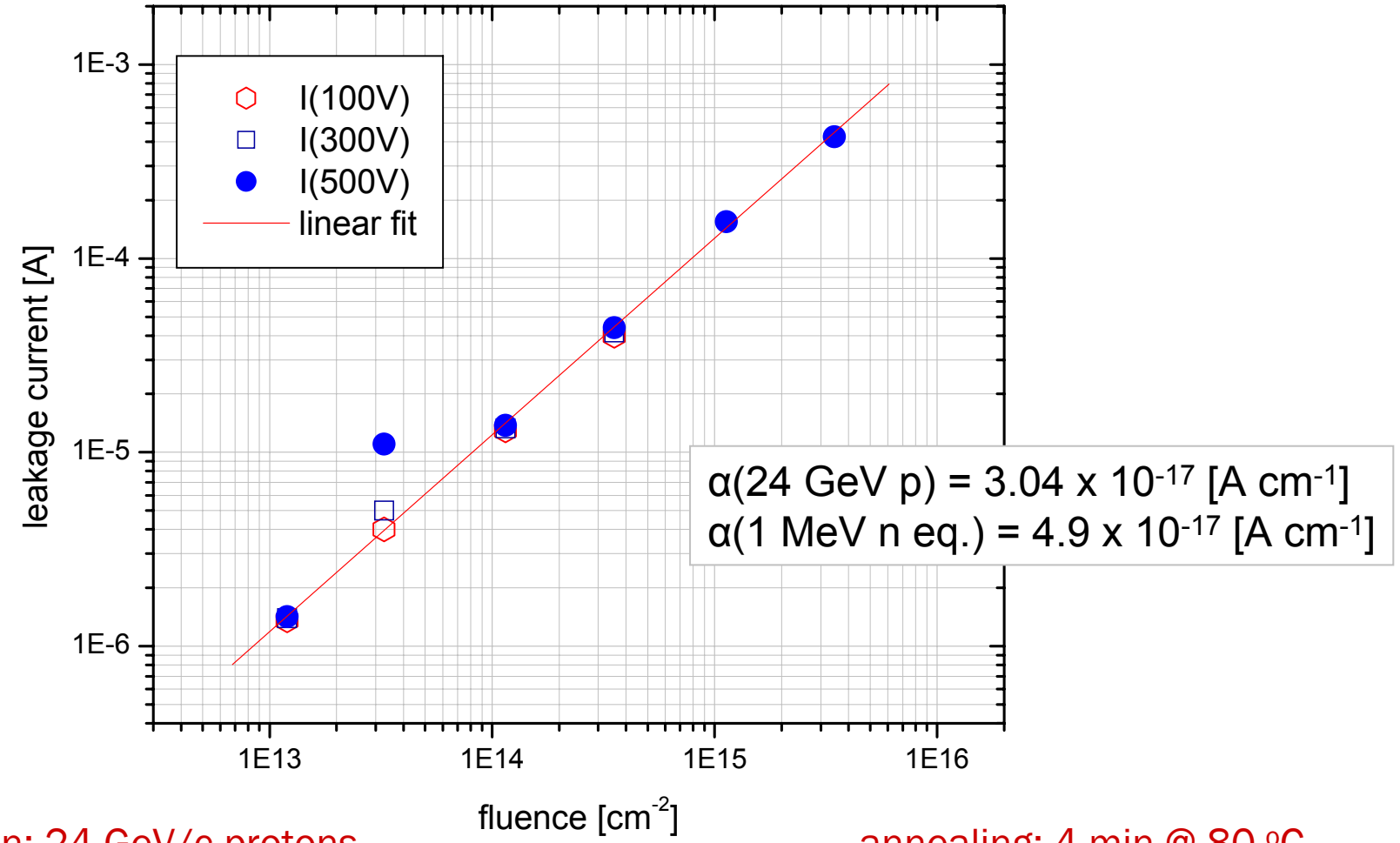


irradiation: 24 GeV/c protons

annealing: 4 min @ 80 °C

Leakage current

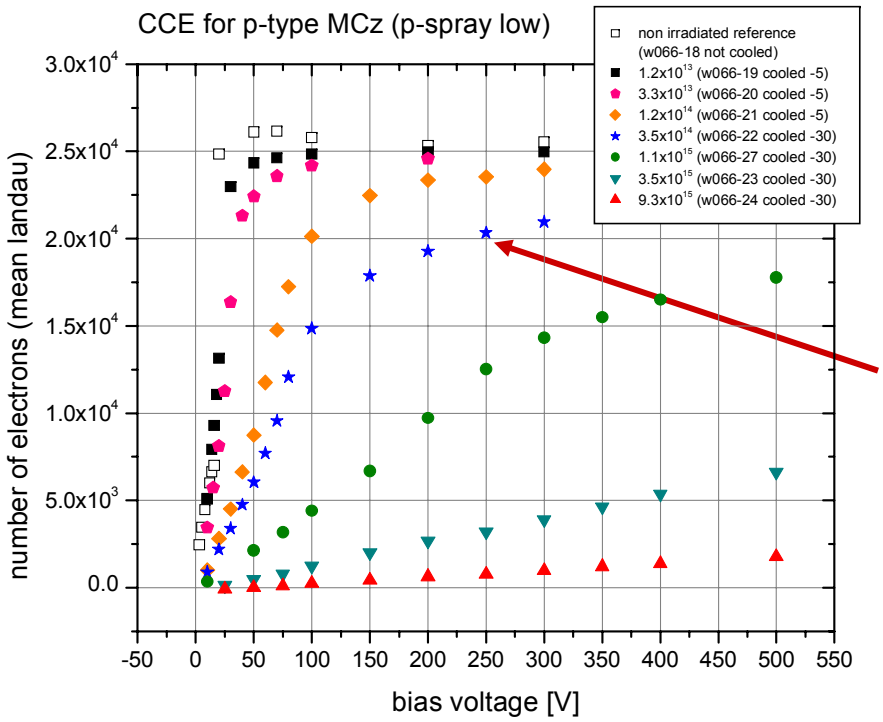
IV measurements @ room temperature



irradiation: 24 GeV/c protons

annealing: 4 min @ 80 °C

Annealing study



Annealing study with one of the irradiated detectors:

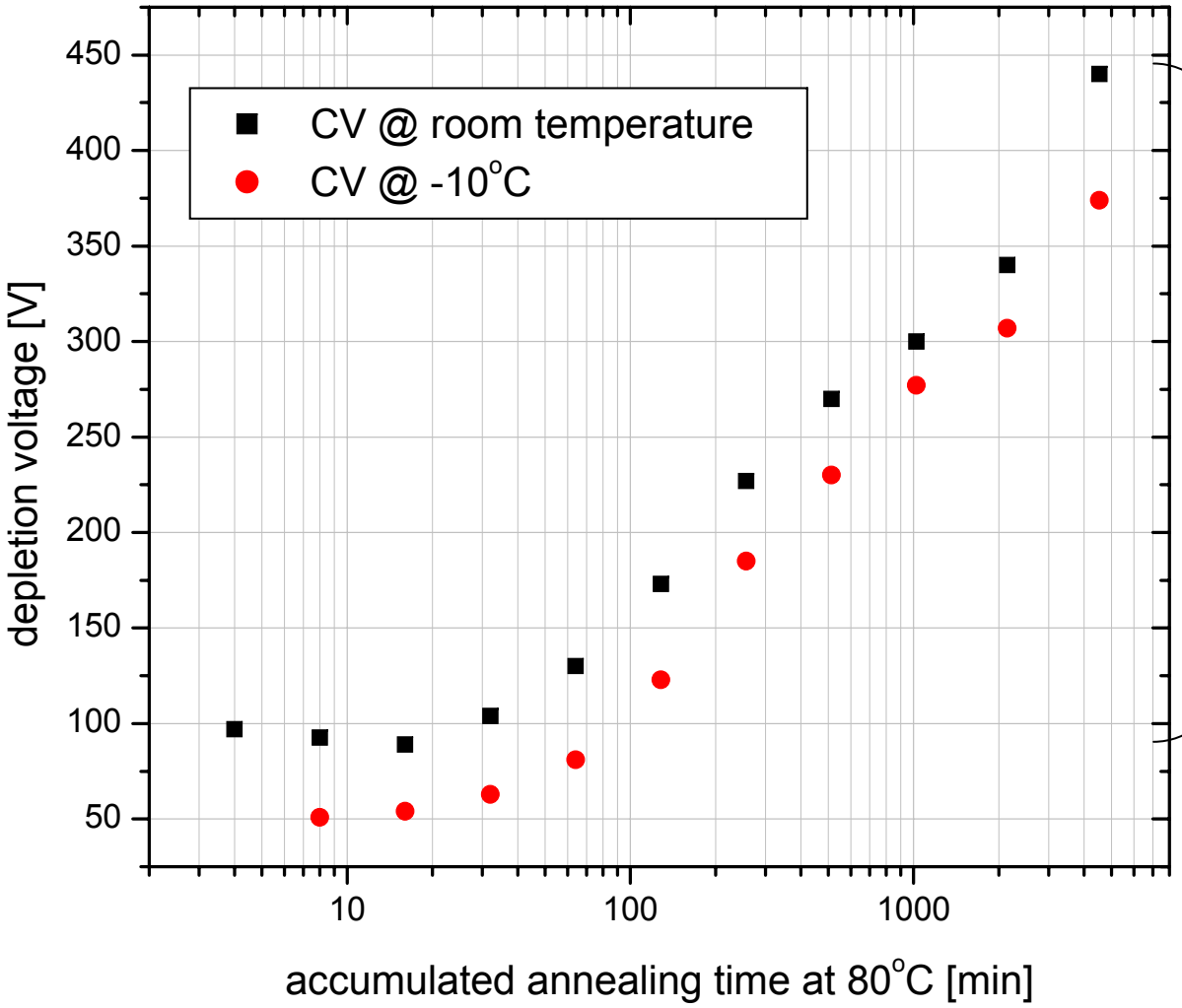
annealing @ 80 °C

IRST-W066-22
- irradiation: $\Phi = 3.5 \times 10^{14}$ p/cm^2
- CCE: 82% @ 300 V

measurements:
- -CCE @ -10 °C
- -CV/IV @ -10 °C
- -CV/IV @ RT

Annealing: V_{DEP}

IRST-W066-22 irradiation: $\Phi = 3.5 \times 10^{14}$ p/cm^2



preliminary evaluation:

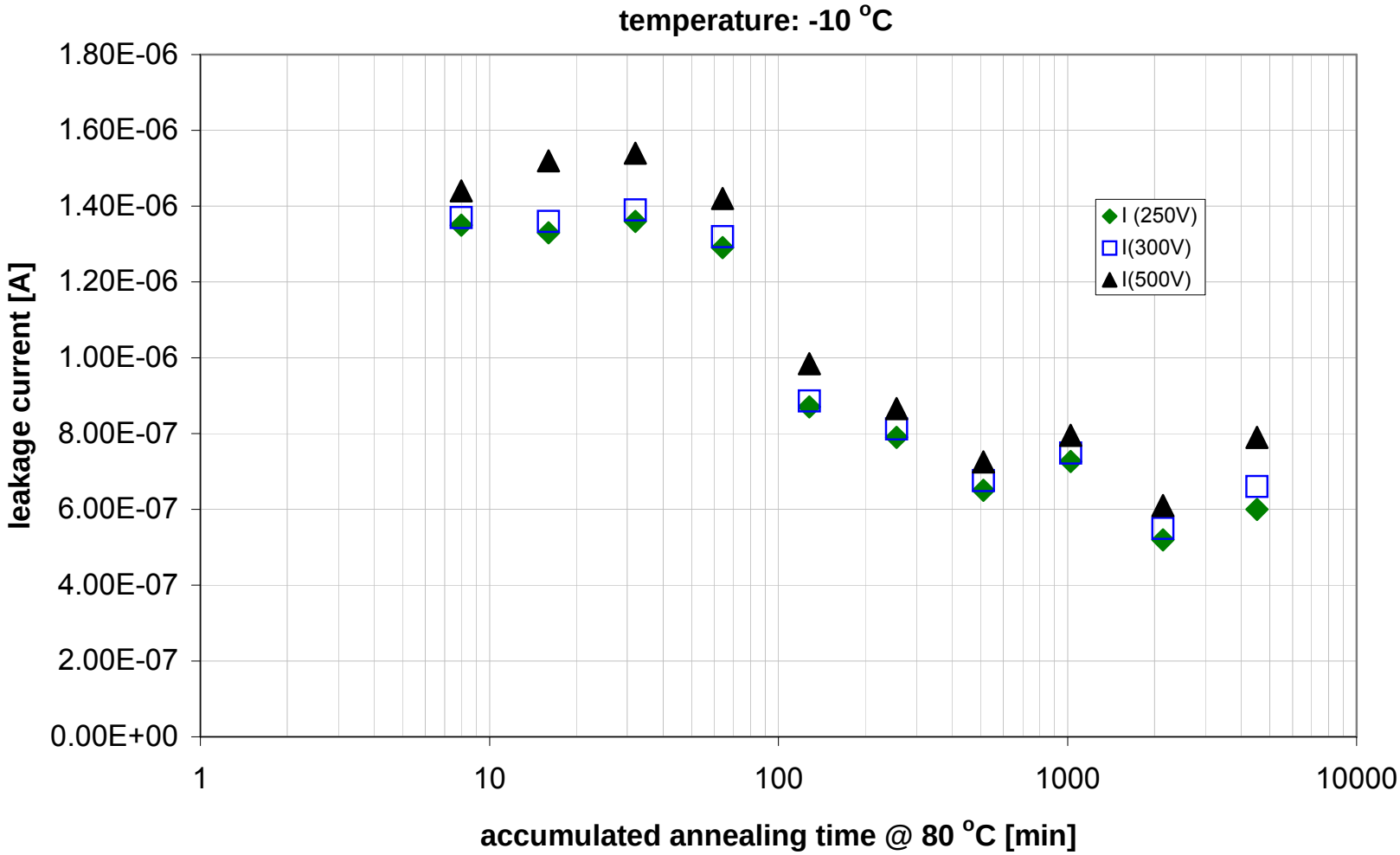
$\Delta N_{eff} \approx 5E12$ cm^{-3}

$\Delta N_{eff}/\Phi_{(24\ GeV/c\ p)} \approx 0.014$

$\Delta N_{eff}/\Phi_{(1\ MeV/c\ n)} \approx 0.023$

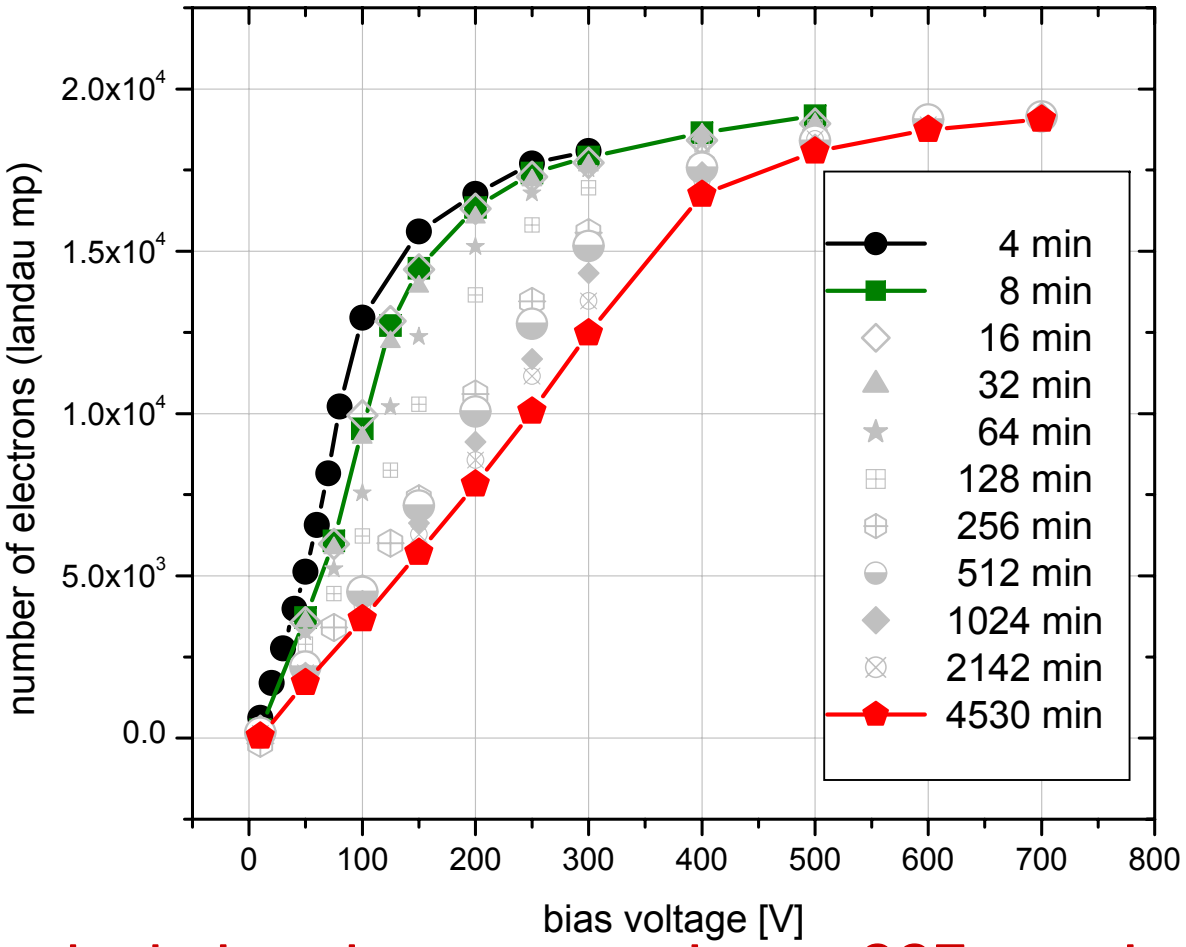
Annealing: leakage current

IRST-W066-22 irradiation: $\Phi = 3.5 \times 10^{14}$ p/cm^2



Annealing: CCE

IRST-W066-22 irradiation: $\Phi = 3.5 \times 10^{14}$ p/cm^2 CCE@-10^{o}C



only depletion changes, maximum CCE remains at 82%

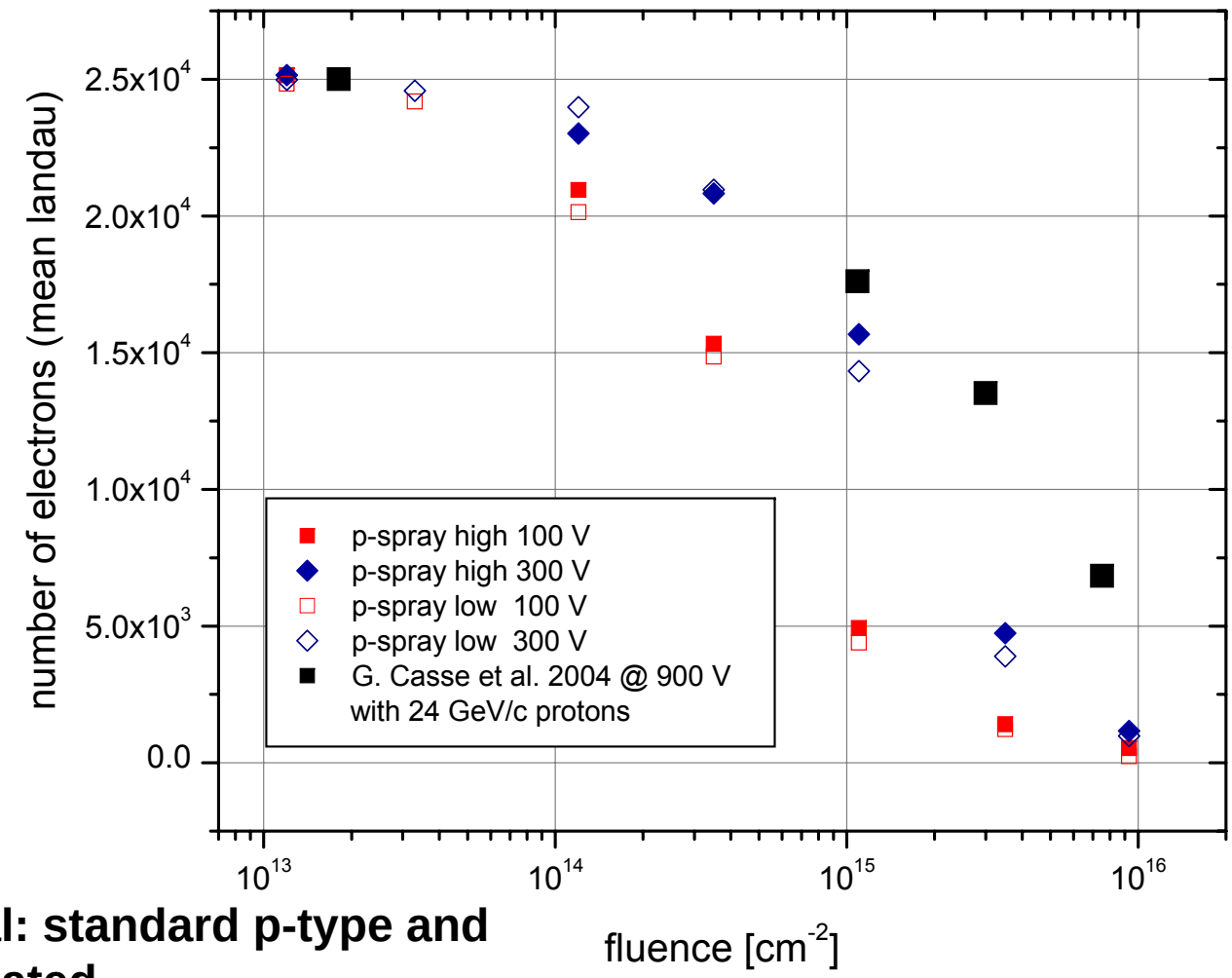
Summary

- CCE/CV/IV measured for p-type MCz diodes irradiated up to fluences of 10^{16} 24 GeV/c p/cm^{-2}

  CCE(300V): 93% @ 1.2E14 p/cm^2 (7.4E13 1MeV/c n/cm^2)
  55% @ 1.1E15 p/cm^2 (6.8E14 1MeV/c n/cm^2)

- Annealing of an irradiated diode changes depletion voltage and leakage current but not CCE

- CCE setup ready to investigate further detectors



Material: standard p-type and oxygenated (DOFZ) p-type