Charge collection in MCz Si microstrip and single pad SMART detectors irradiated with 26MeV protons

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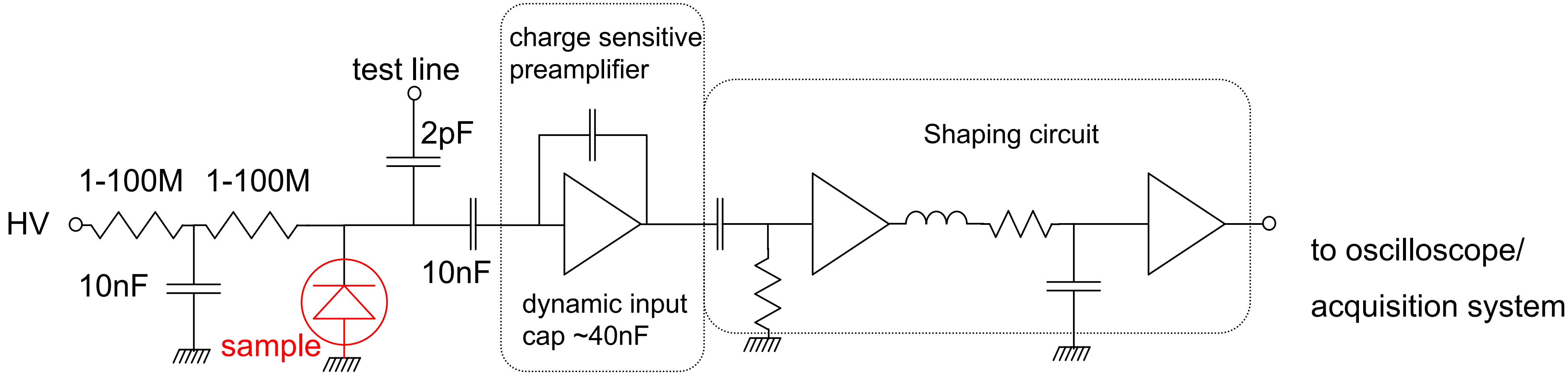
Outline

- Description of Experimental Setups
- CCE results
- Temperature/frequency dependence on CV measurements
- Comparison CCE/CV
- Conclusions

Experimental Setup (1): single pad detectors (INFN Florence)

Electronics:

Charge sensitive preamplifier + shaping circuit using Amptek components



AC coupled

Shaping time: variable from 100ns up to the order of μsec

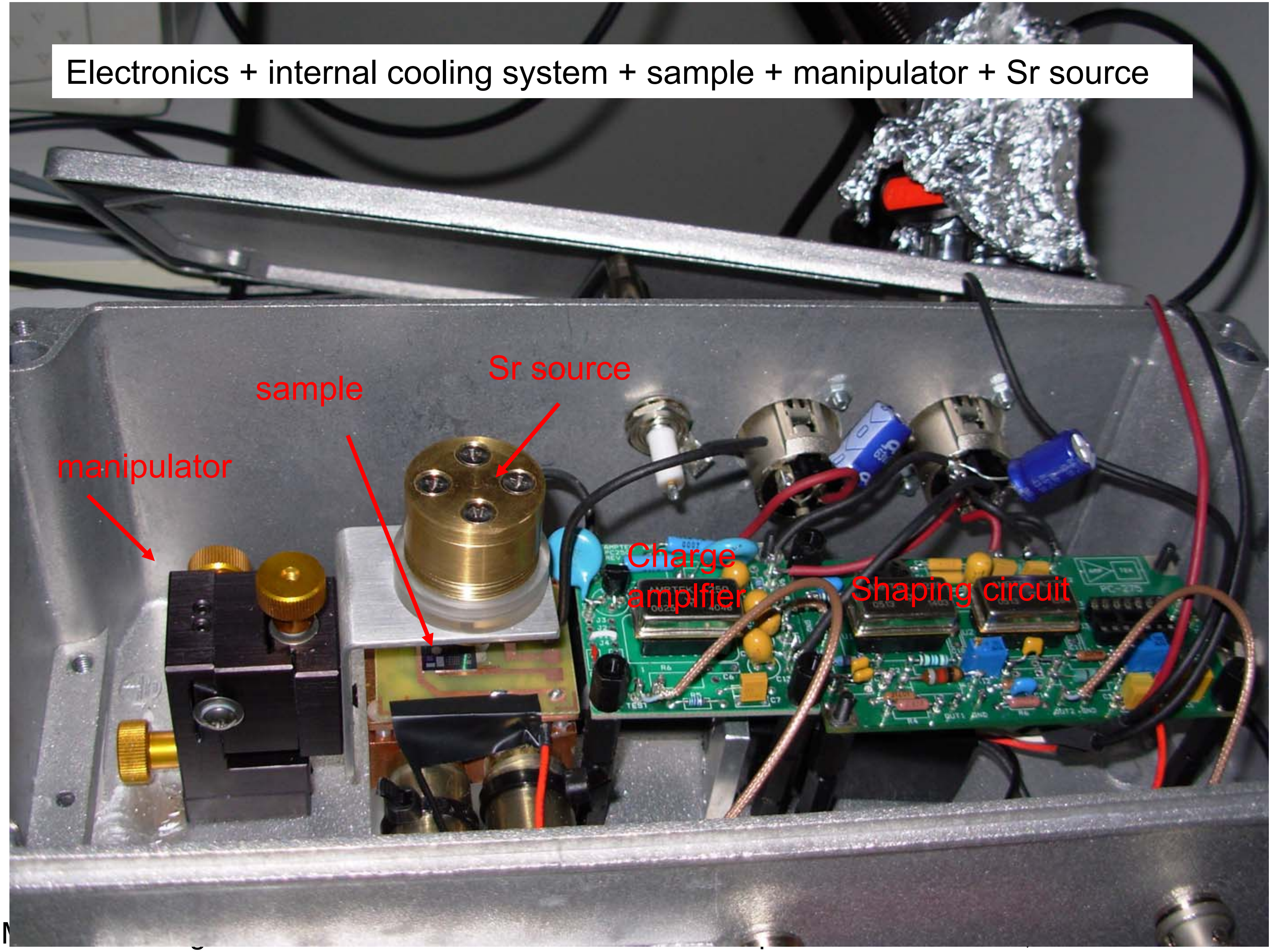
Minimum noise: 500e$^-$ FWHM

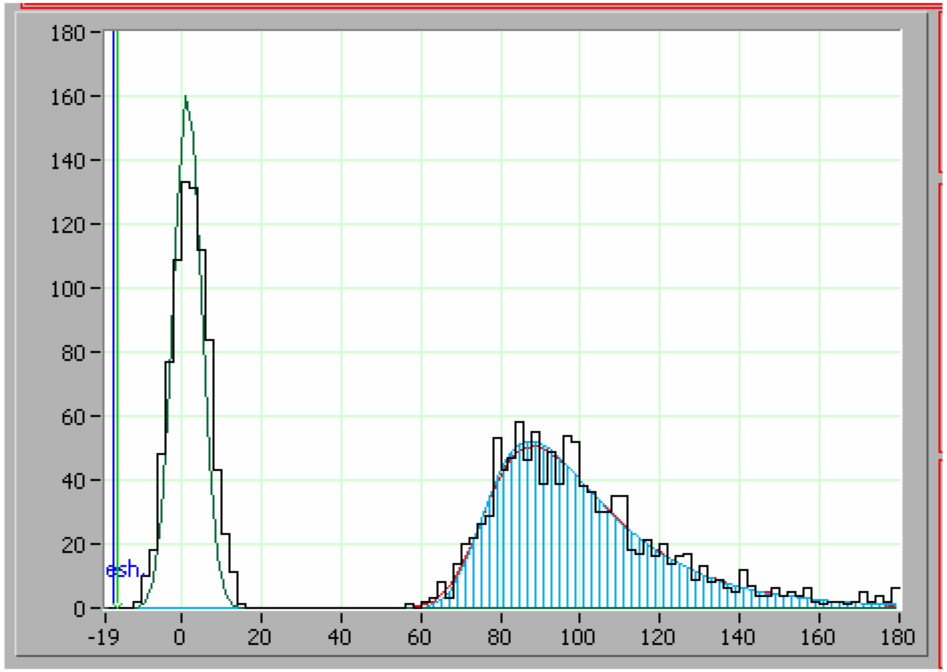
Sample temperature: down to -30/-35°C

Source of charge signal: Sr^{90} 0.1mCi

Trigger line: scintillator+light guide+PMT (from NIKHEF)

Electronics + internal cooling system + sample + manipulator + Sr source





p-type Si diode

Non-irradiated

Measurement on irradiated diodes in progress

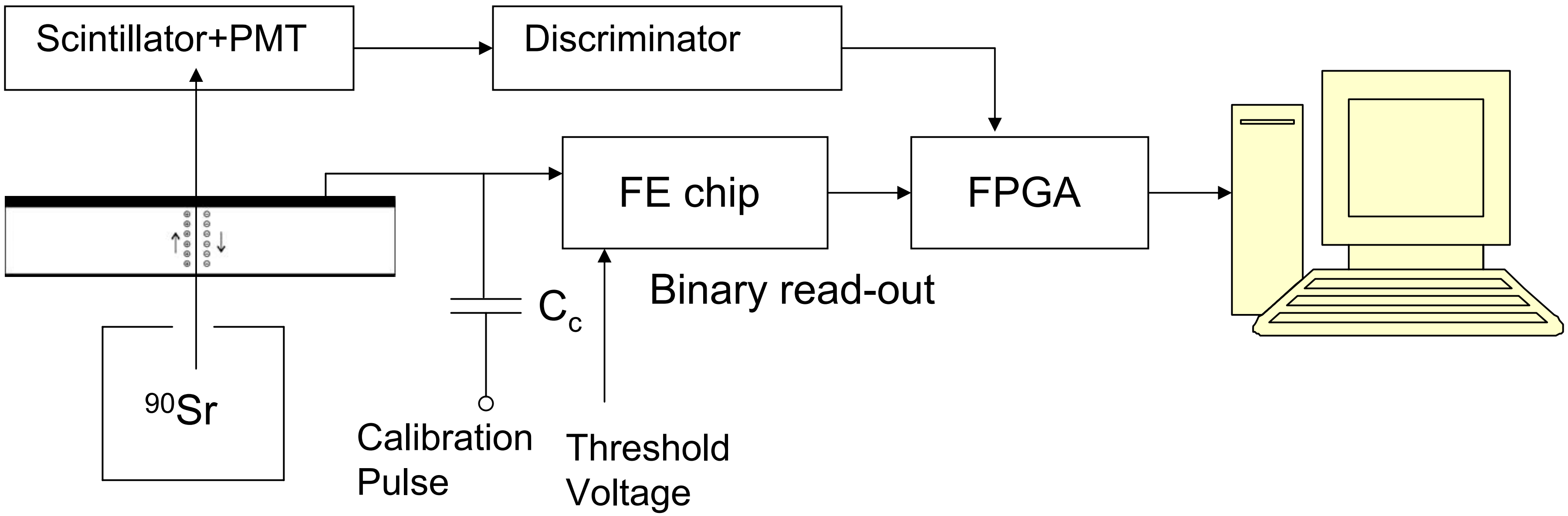
Applied Voltage: 125V (fully depleted)

Most probable deconvoluted Landau peak at 85±2mV

Calibration gives 1mV = 260±5e- so 85±2mV ~ 22000e^-

Noise 750e^-

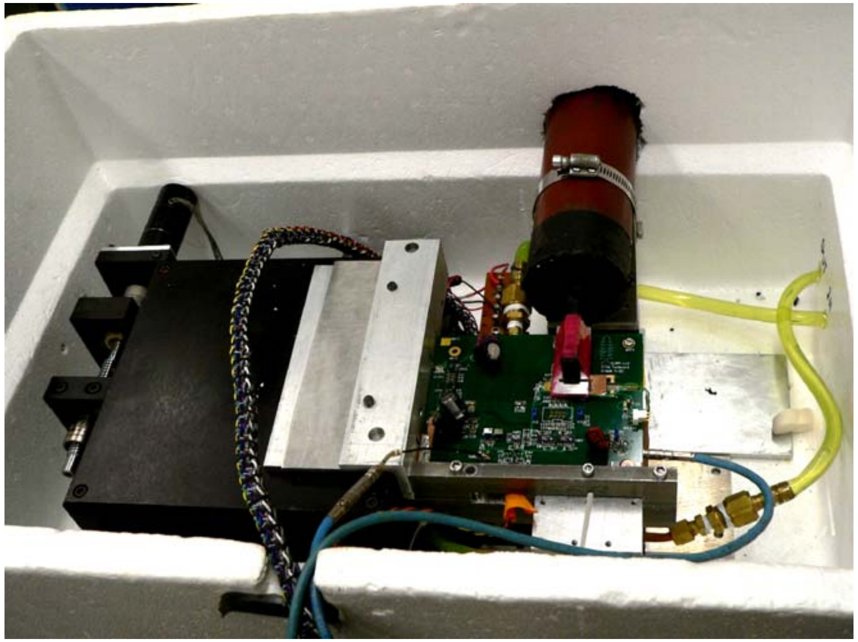
Experimental Setup (2): microstrip detectors (SCIPP)

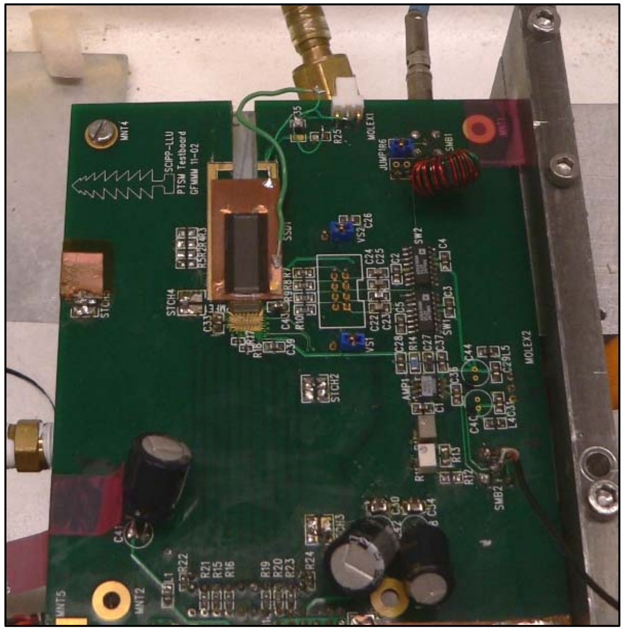


•Hits from scintillator and silicon detector are read out

For fixed threshold and bias voltage:
efficiency=coincidences/scintillator hits

Experimental Setup (2): microstrip detectors



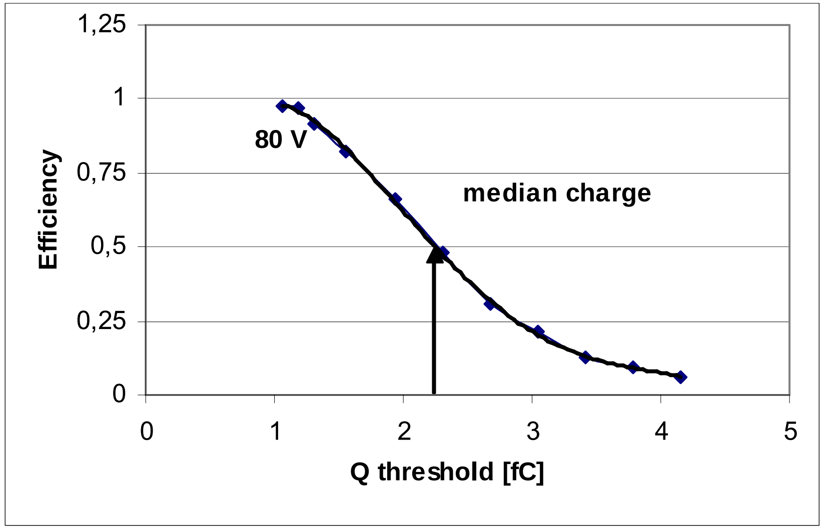


•Shaping time: 100 ns

•Cooling: down to -10÷ -30 °C (liquid nitrogen)

•Scintillator rate 20÷30 Hz

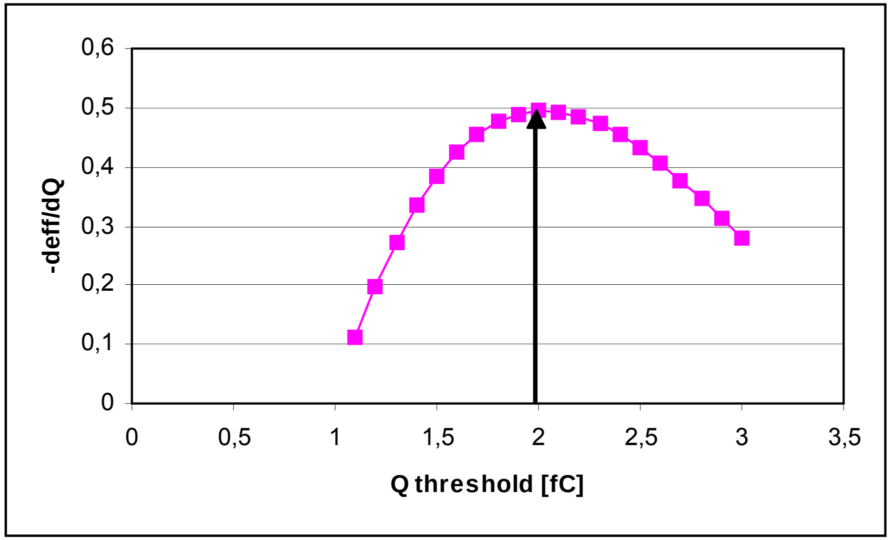
Reconstruction of pulse spectrum



50% Point = Median charge

Fit and differentiate

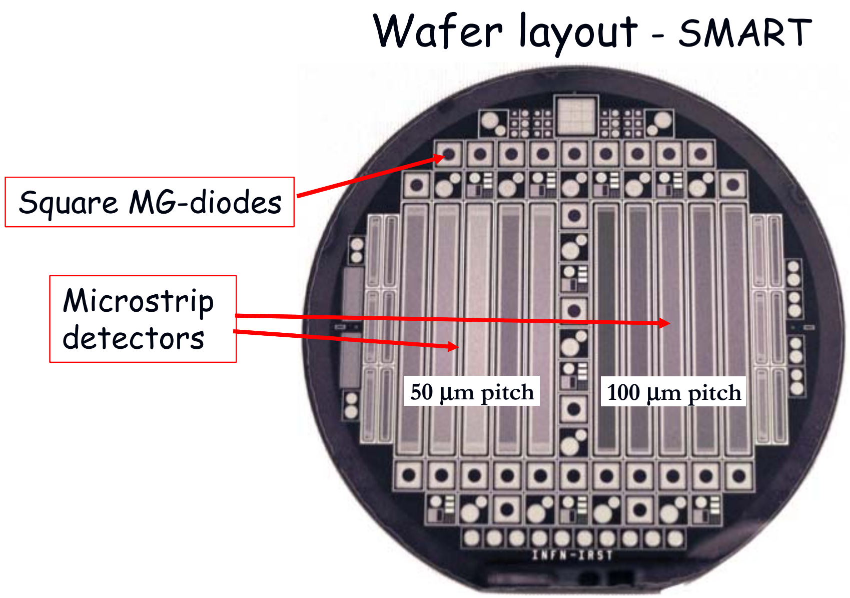
→ Pulse Spectrum



Maximum = Most probable charge

n-type MCz Si microstrip
26 MeV p irradiated, Φ= 3.3x10^{14}cm^{-2}
Vrev=80 V
T -10°C

Samples



Processed at ITC-IRST
Magnetic Cz Si from Okmetic, Finland

Mask: 10 mini-strip + single pad diodes + test structures

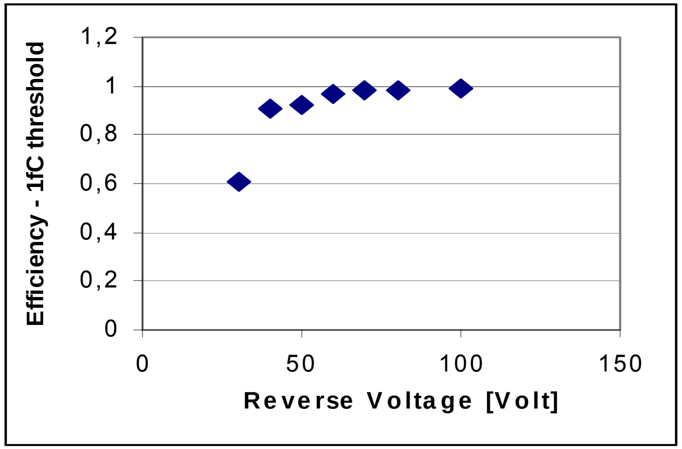
Strips: $0.6x4.7cm^2$, 50/100µm pitch, AC coupled

Tested Devices: p-type diodes, n-,p- type microstrips
Irradiation: Karlsruhe 26MeV protons
Detector thickness: 300µm
Fluences studied in this work:
$4x10^{13}$ -$7x10^{14}cm^{-2}$ 1MeV neutron equivalent

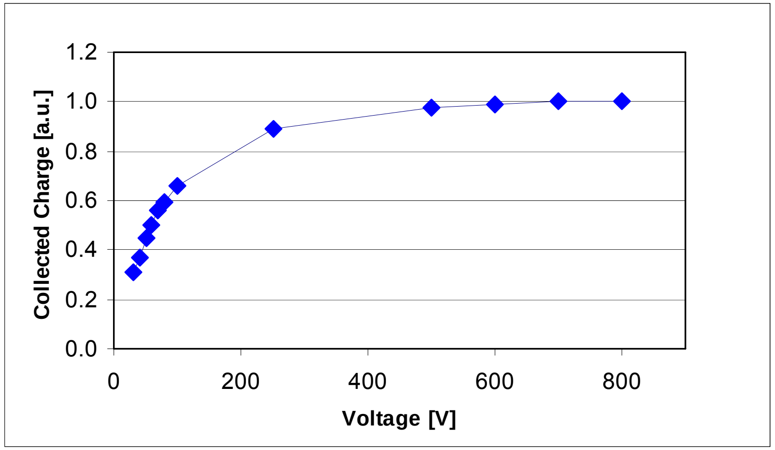
CCE vs reverse voltage: microstrips

MCz n-type, $\Phi=3.3\times10^{14}$ n/cm^2

Efficiency at 1 fC threshold



Median charge vs. applied voltage normalized to saturation value



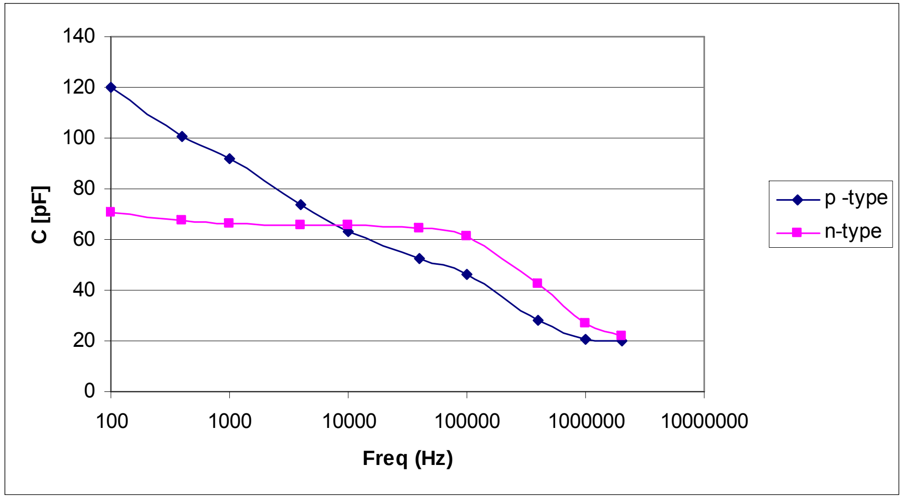
Saturation to 100% efficiency is reached at V_{rev}=60 V

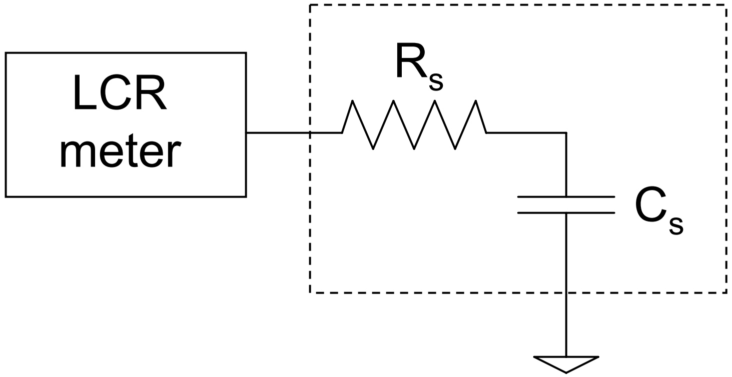
Calibration procedure is under test to estimate the absolute value of the collected charge

CV measurements: frequency dependence

Unirradiated microstrip detectors

C vs F at full depletion

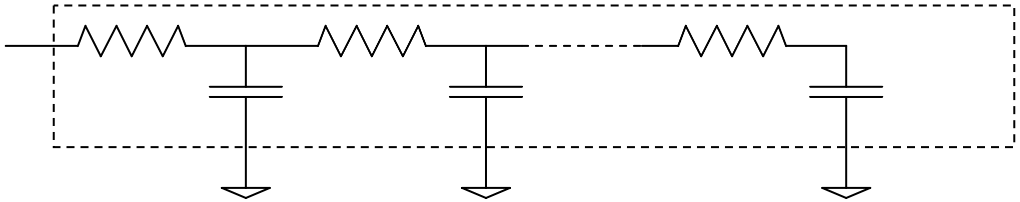




- N-type: C is flat up to f~100 kHz
- P-type: C is f dependent in the whole investigated range

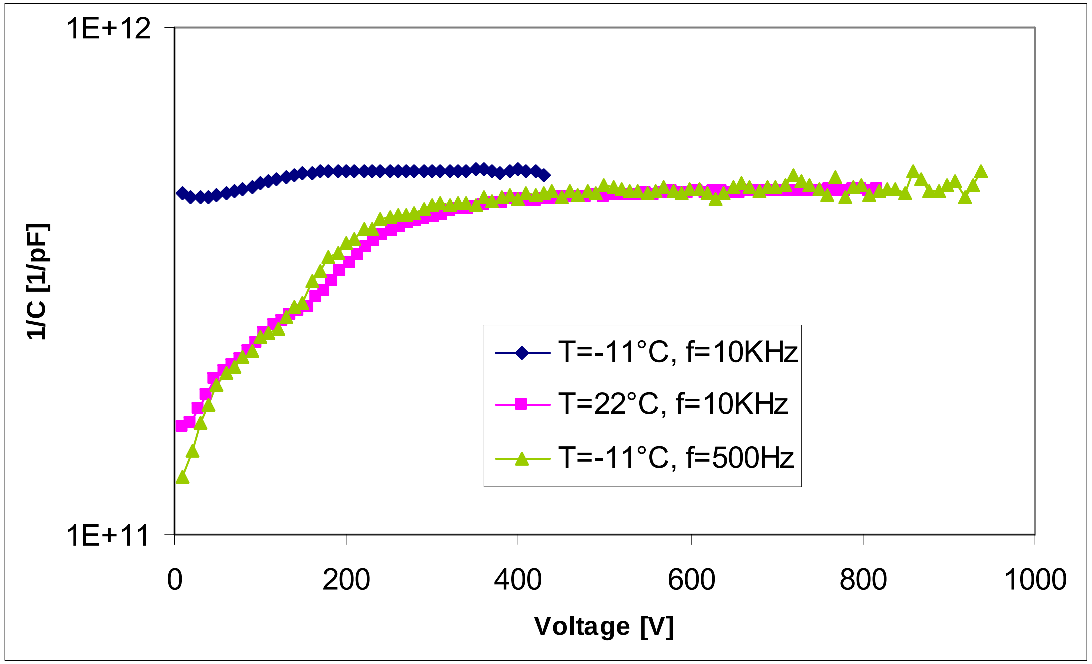
Simulations under way to extract the correct C value in p-type unirradiated microstrips

Strip equivalent circuit:



CV measurements: frequency-temperature correlation

Single Pad detector, MCz n-type, $\Phi=7\times10^{14}$ n/cm^2



Frequency dependence is due to charge/discharge of deep traps

$$\tau \approx \frac{1}{e_n}$$

Emission coefficient

$$e_n \;\alpha\; T^2 \exp(-\frac{E_t}{KT})$$

Cut frequency $f_c \sim e_n$

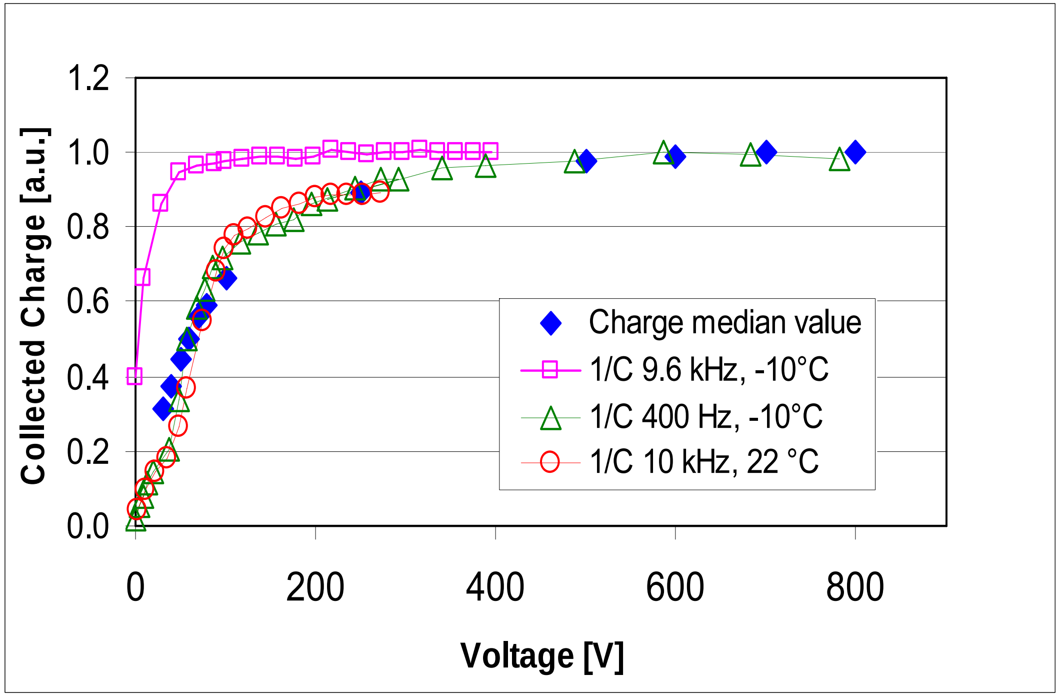
Leakage current due to midgap levels

$$I(T) \propto T^2 \exp(-\frac{E_g}{2KT})$$

$$f(T) = \frac{e_n(T)}{e_n(RT)} f(RT) \approx \frac{I(T)}{I(RT)} f(RT)$$

CCE – CV Comparison

MCz n-type microstrip, $\Phi=3.3\times10^{14}$ n/cm^2



- Low T 10kHz C-V does not fit the charge collection profile
- best fit is obtained at -11°C with a frequency of 400Hz, calculated by the above mentioned formula

Conclusions

- A new low noise experimental setup for CCE measurements on single pad detectors has been constructed, measurements on irradiated structures are under way
- Setup for microstrip detectors has been upgraded for low temperature operation (cooling system down to -10 ÷ -30°C)
- CCE and CV measurements have been performed on MCz microstrip and single pad silicon detectors processed by ITC – IRST, Trento before and after 26 MeV proton irradiation up to a fluence of 7×10^{14} cm^{-2} 1 MeV neutron equivalent
  - We have developed a procedure to scale the test frequency in CV measurements with temperature in n-type irradiated microstrip detectors.
  - Simulations under way for p-type microstrips to extract the value of the capacitance in unirradiated and irradiated microstrips.