Measurement of charge collection in p-type microstrip sensors with SCT128 chip

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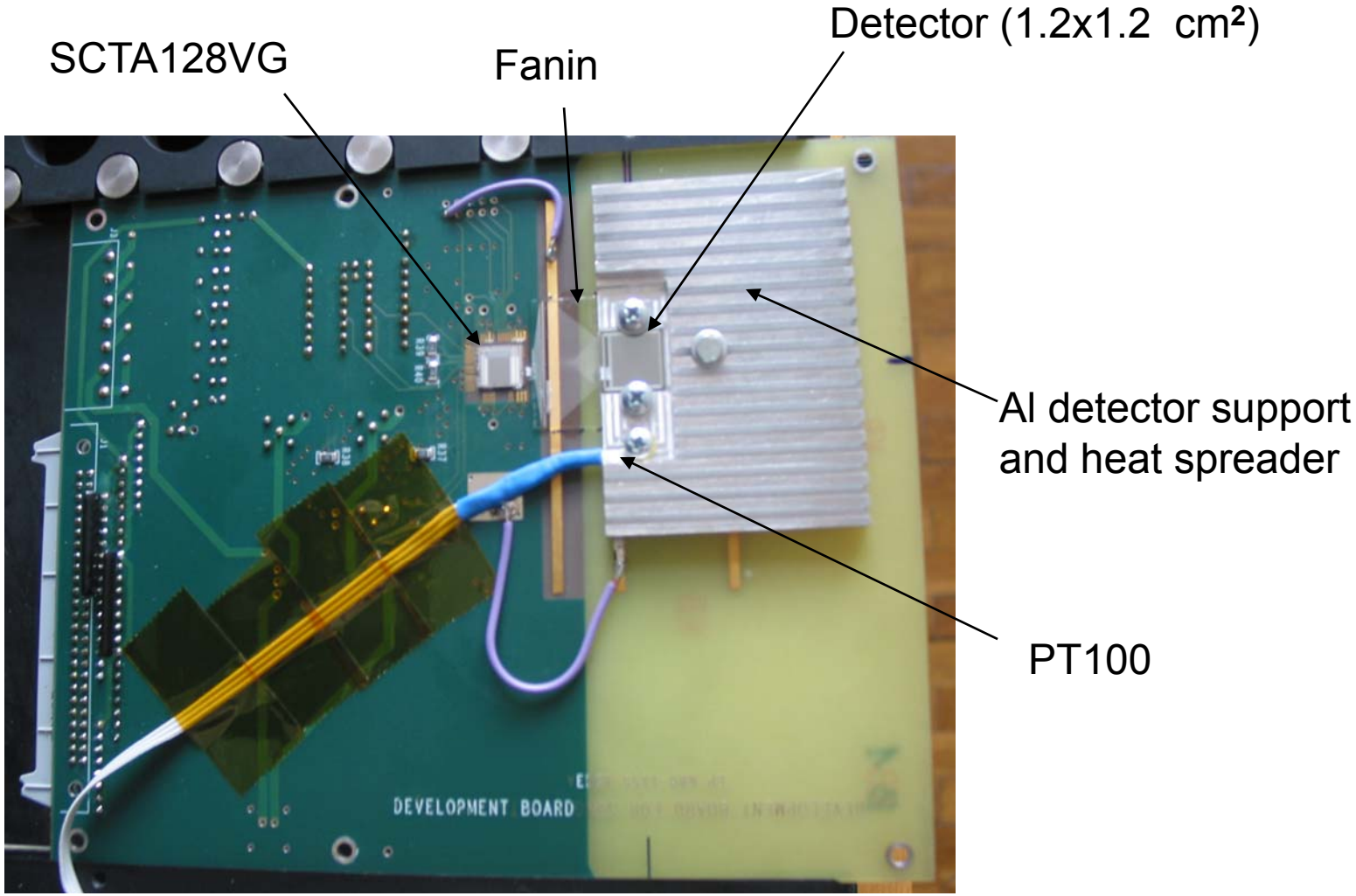
Setup for measurements with SCT128 chip was built in Ljubljana:

- SCTA128VG chip
- drawings of test pcb from CERN (thanks to Jan Kaplon)
- VME module SEQSI (for clock, commands...)
- Tektronix digital scope for data acquisition
- Cambridge LabView software for chip control (thanks to Dave Robinson)
- data acquisition software (thanks to G. Kramberger)
- pitch adapters from Freiburg (thanks to Uli Parzefal)
- coincidence circuit made by Erik Margan
- ^{90}Sr source, photomultiplier, scintillator, power supplies....

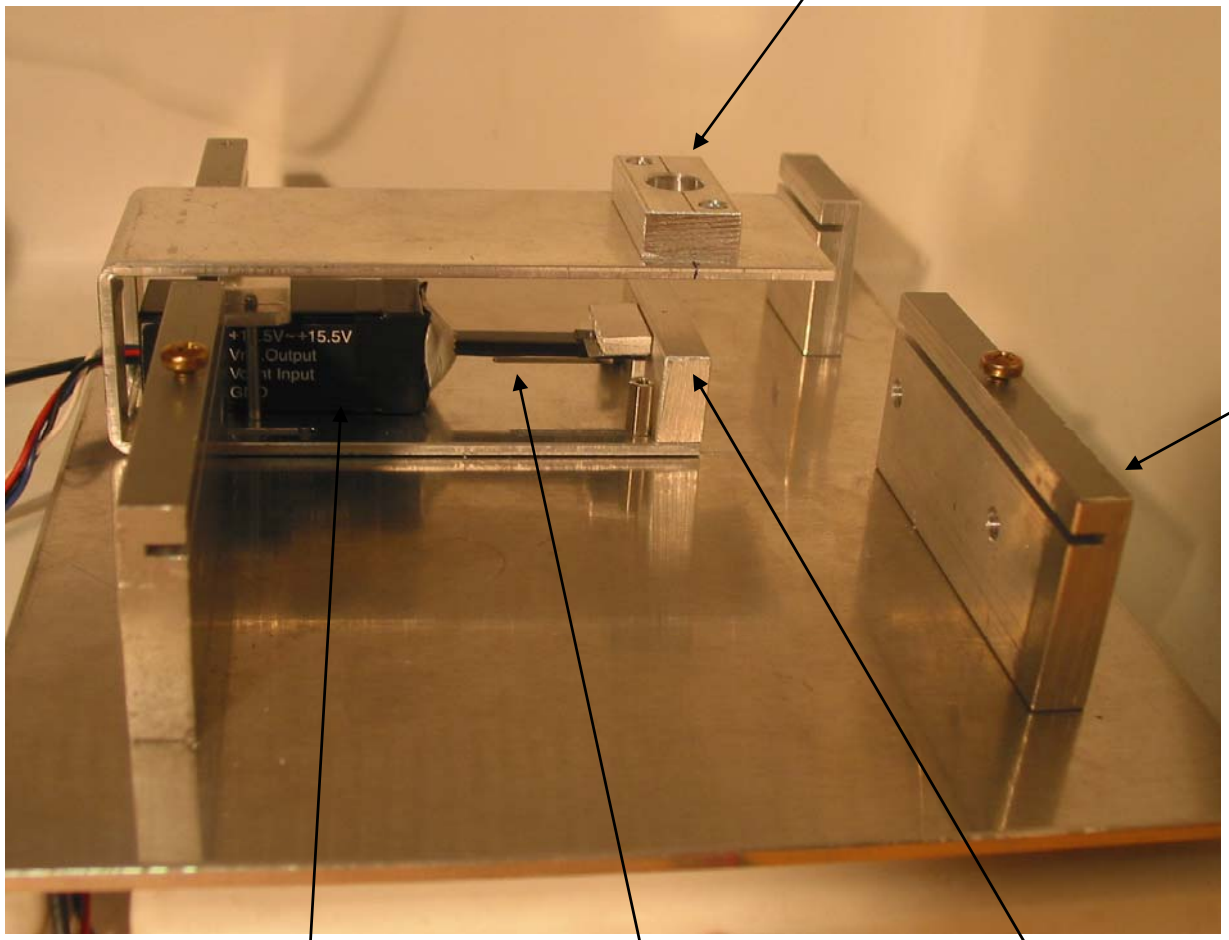
Test PCB


SCTA128VG
Fanin
Detector (1.2x1.2 cm²)
Al detector support and heat spreader
PT100
DEVELOPMENT BOARD

Aluminium support structure

- dimensions: ~ 25 cm x 20 cm x 6 cm

^{90}Sr source is inserted into the upper collimator



Test board holder

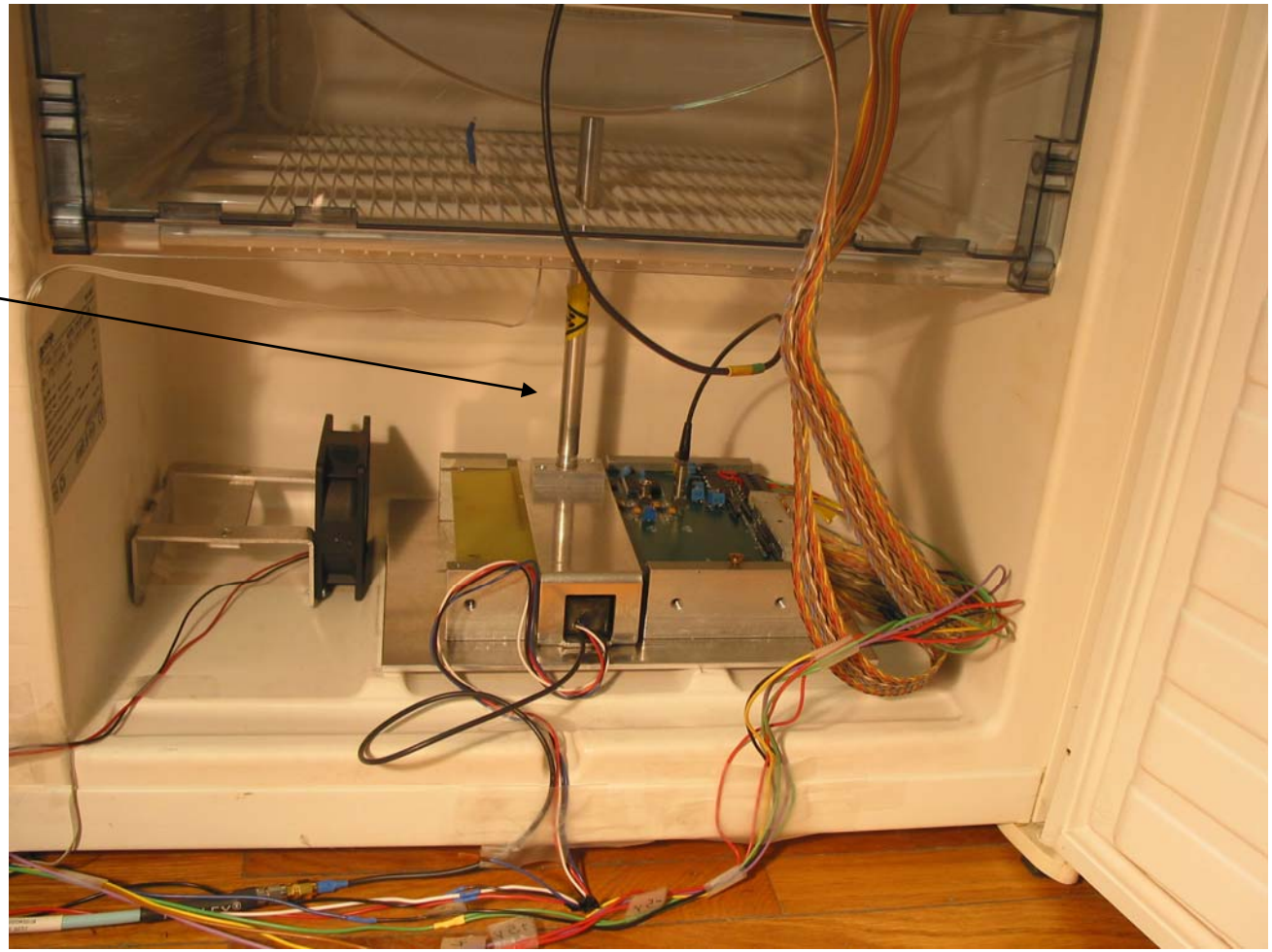
Photo Multiplier

Light guide

Scintillator is under the lower collimator

Setup in the fridge, temperature about - 20˚ C

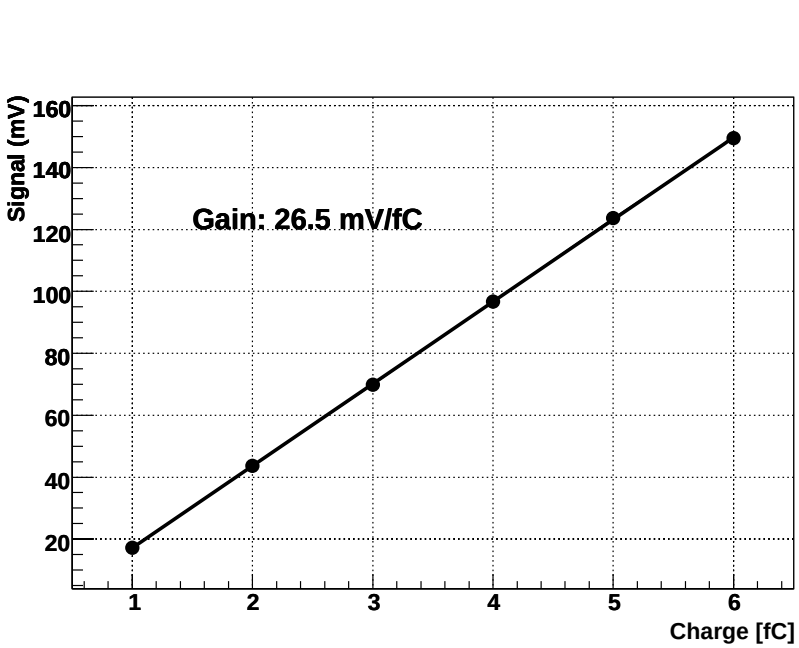
^{90}Sr source holder

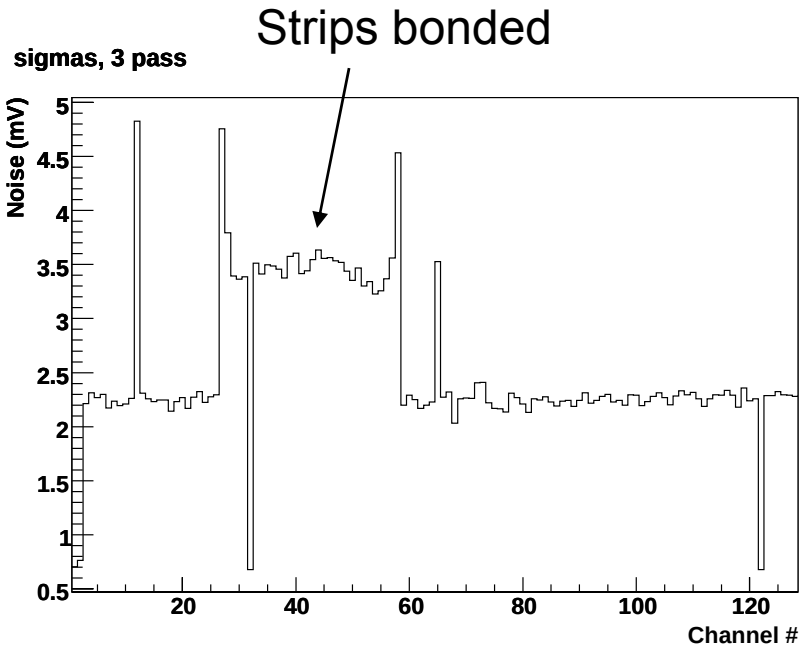


SCTA128VG chip

- 128 channels
- charge sensitive front-end amplifier with about 20 ns peaking time
- sampled every 25 ns (40 MHz sampling clock)

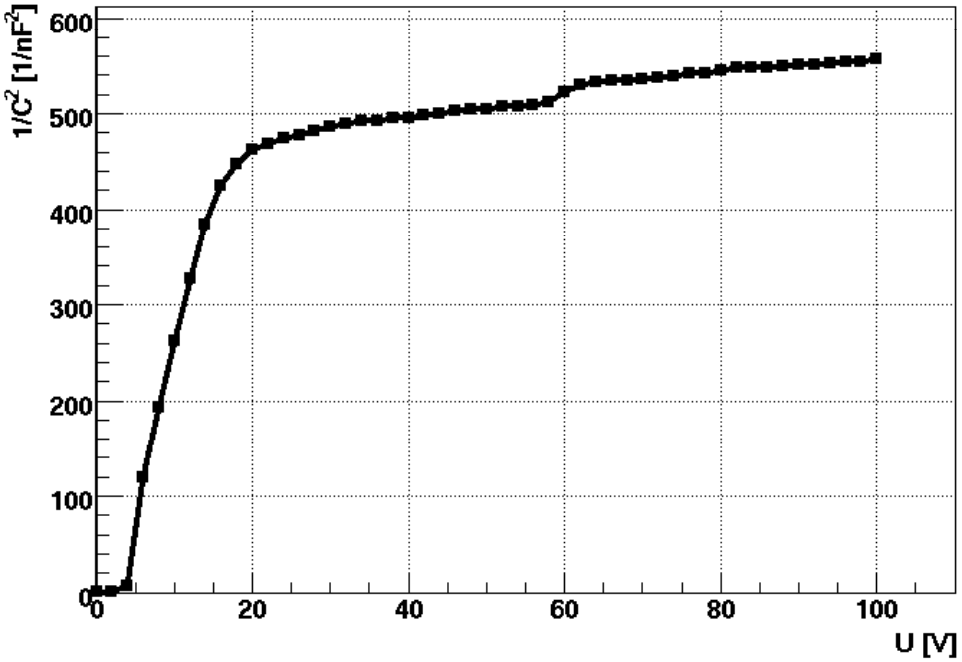
- Gain = 26.5 mV/fC = 4.2 μV/el measured with calibration signals from on-chip capacitors (~10 % accuracy)
- noise with detector connected ~ 800 el





Detectors

- p-type, FZ material, 300 μm thick strip detectors
- strip pitch 80 μm
- n-in-p capacitively coupled
- polysilicon biased, p-sprayed
- designed by Liverpool, produced by Micron Semiconductor, sent to us by Gianluigi Casse



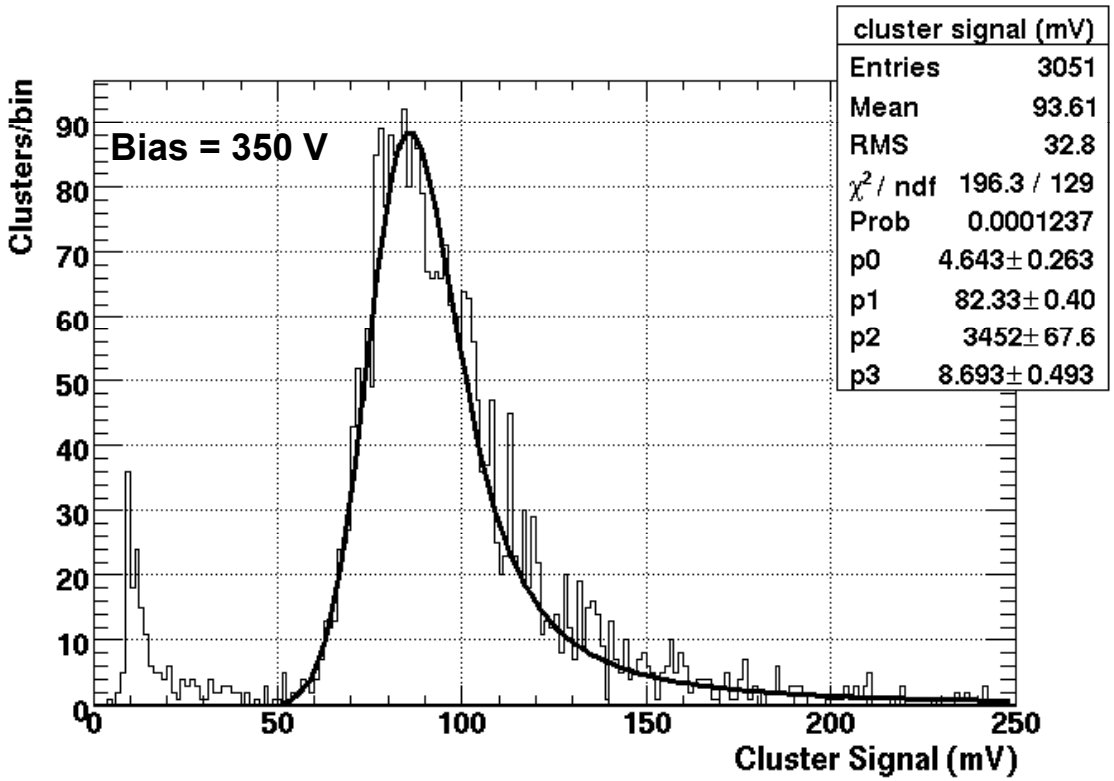
Irradiations

- detectors were irradiated with neutrons in the TRIGA reactor in Ljubljana
- 1 MeV equivalent fluences (same fluence steps as for Liverpool):
  - $5 \cdot 10^{14}$ n/cm^2
  - $1.6 \cdot 10^{15}$ n/cm^2
  - $3 \cdot 10^{15}$ n/cm^2
- after irradiation detectors were annealed for 80 minutes at 60° C

Measurements

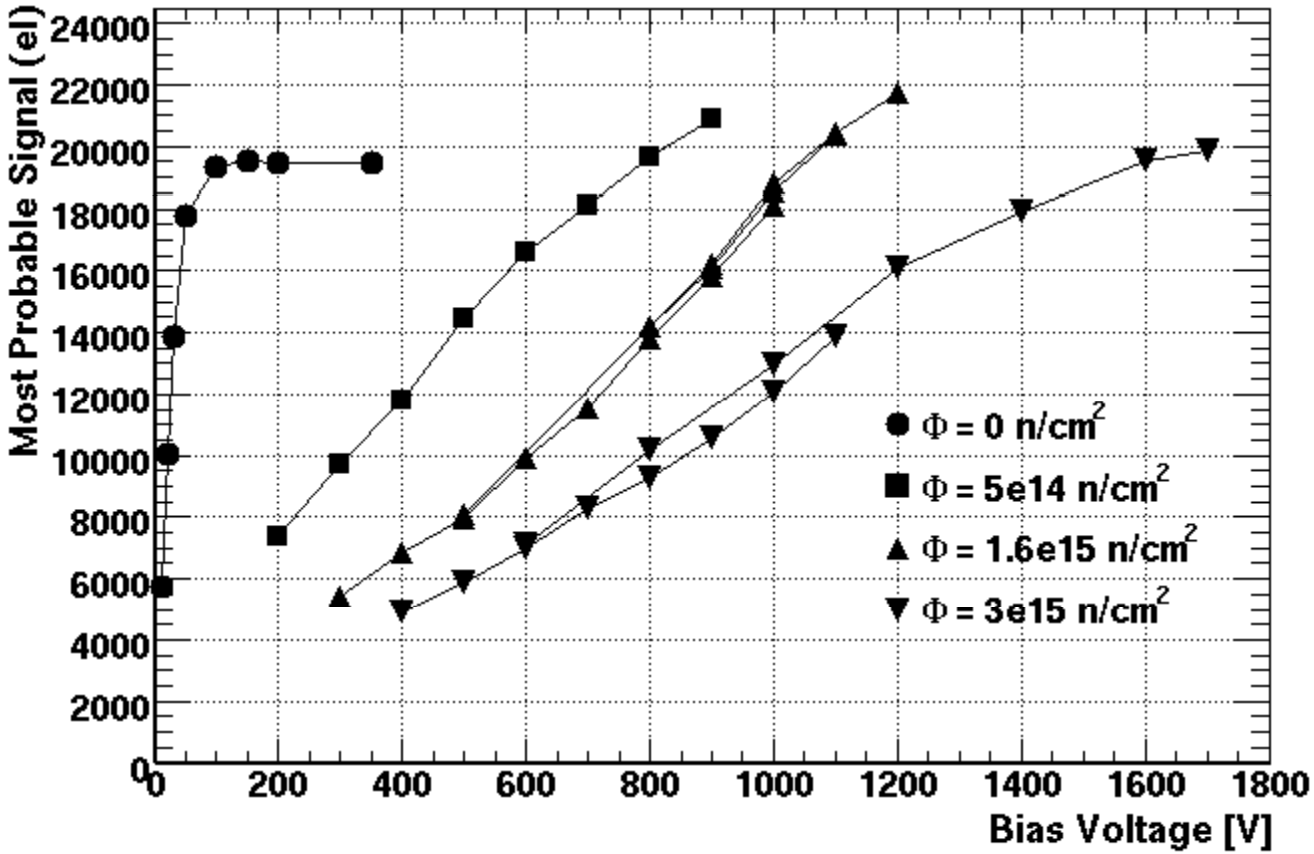
- trigger: signals caused by electrons from ^{90}Sr source in scintillator in coincidence with 40 MHz clock edge
- spectrum of signals from strips (pedestals and common mode variations subtracted) fitted with convolution of Landau and Gauss functions

  ➔ "Most Probable Value" of the Landau function (parameter p1 in the plot below) returned by the fit is the measure of collected charge



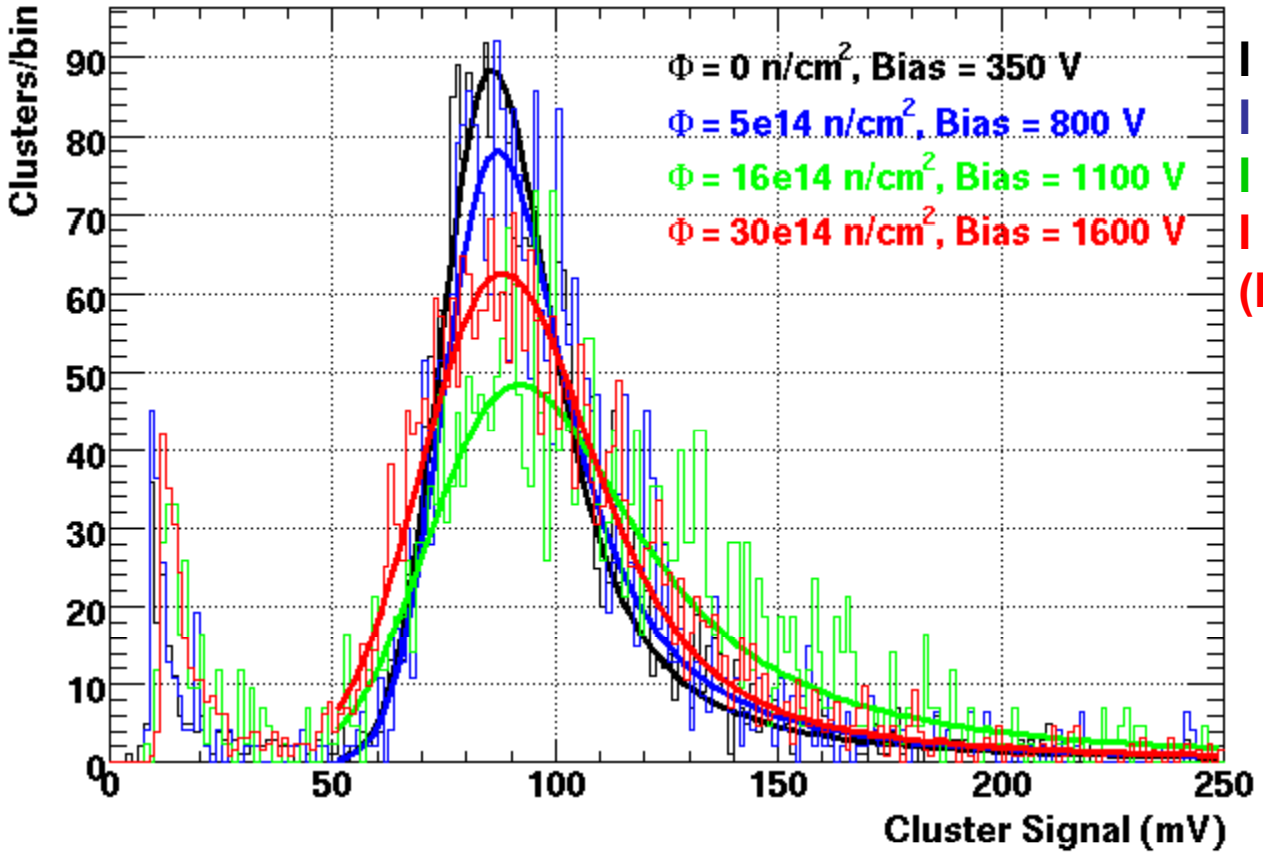
Signal vs. Bias Voltage

- measurements taken at -20° C
- statistical error of points ~ 5%
- highest voltage limited by breakdown
- repeats of measurements are shown at two highest fluences (reproducibility test)



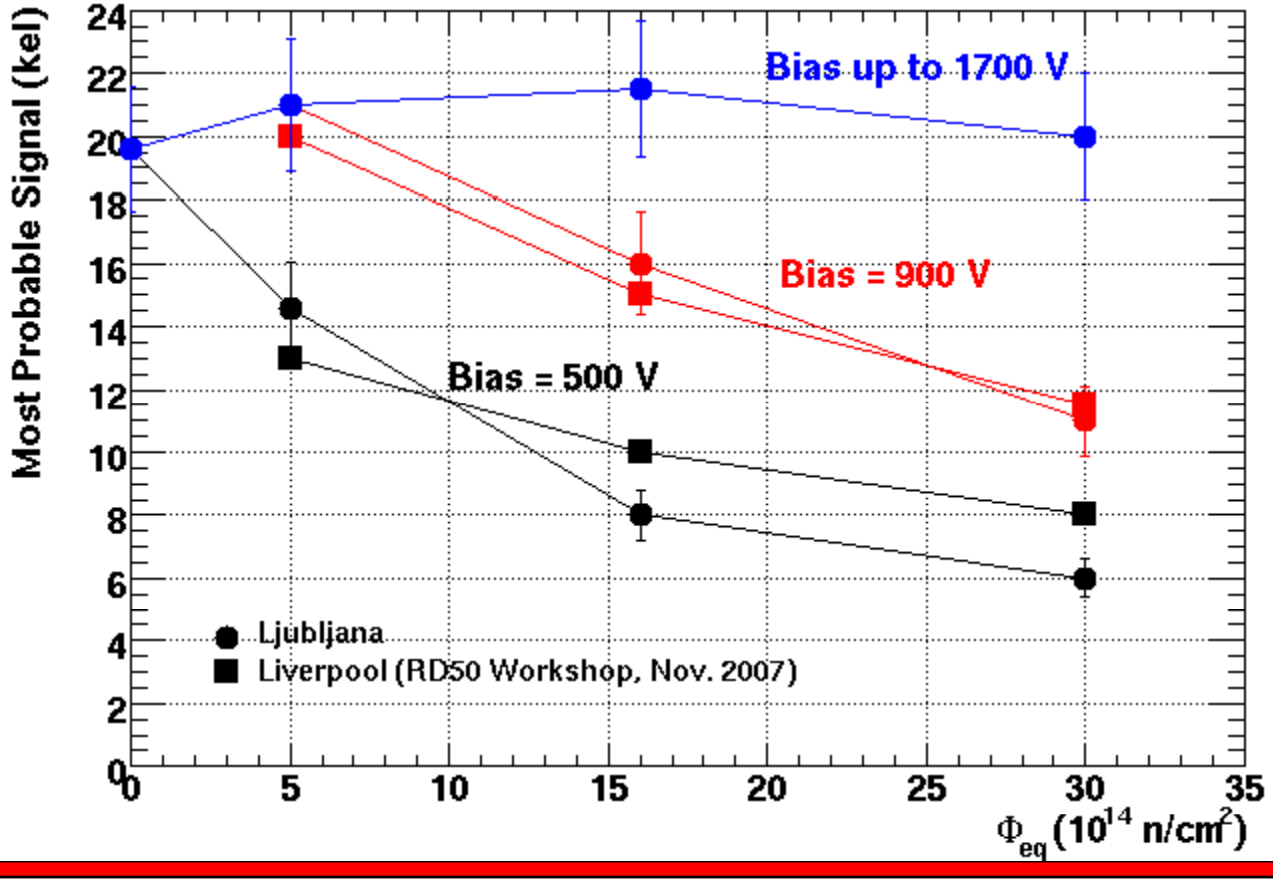
Comparison of spectra in which MP ~ 20 kel measured after different fluences
(normalized to the equal number of clusters in histogram)

- signals at high voltage after irradiation as high as before irradiation



Signal vs. Fluence

- good agreement with Liverpool results
- with present cabling in ATLAS the highest voltage is 500 V
- it seems that higher bias voltage would help

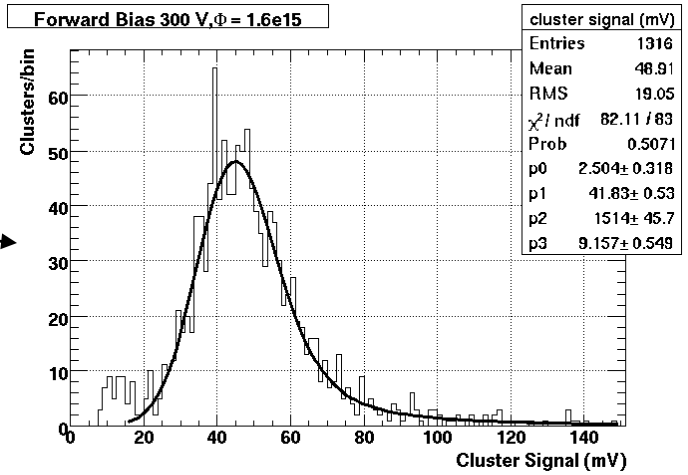


Forward Bias

- after very high fluence detectos can be operated under forward bias

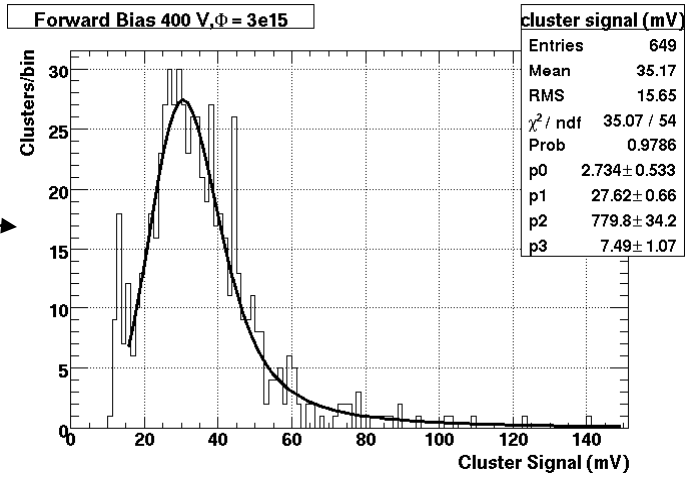
$\Phi = 1.6 \cdot 10^{15}$ n/cm^2, T ~ -40° C
(a cup of liquid N_2 put into the fridge)
Bias = +300 V, I = 200 μA,
MPV = 10 kel

Reverse bias ~ -600 V needed for same MPV, but much lower current (less than 10 μA at this T)



$\Phi = 3 \cdot 10^{15}$ n/cm^2, T ~ -24° C,
Bias = +400 V, I = 600 μA,
MPV = 6.5 kel

Reverse bias ~ -600 V needed for same MPV, but much lower current (35 μA at this T)

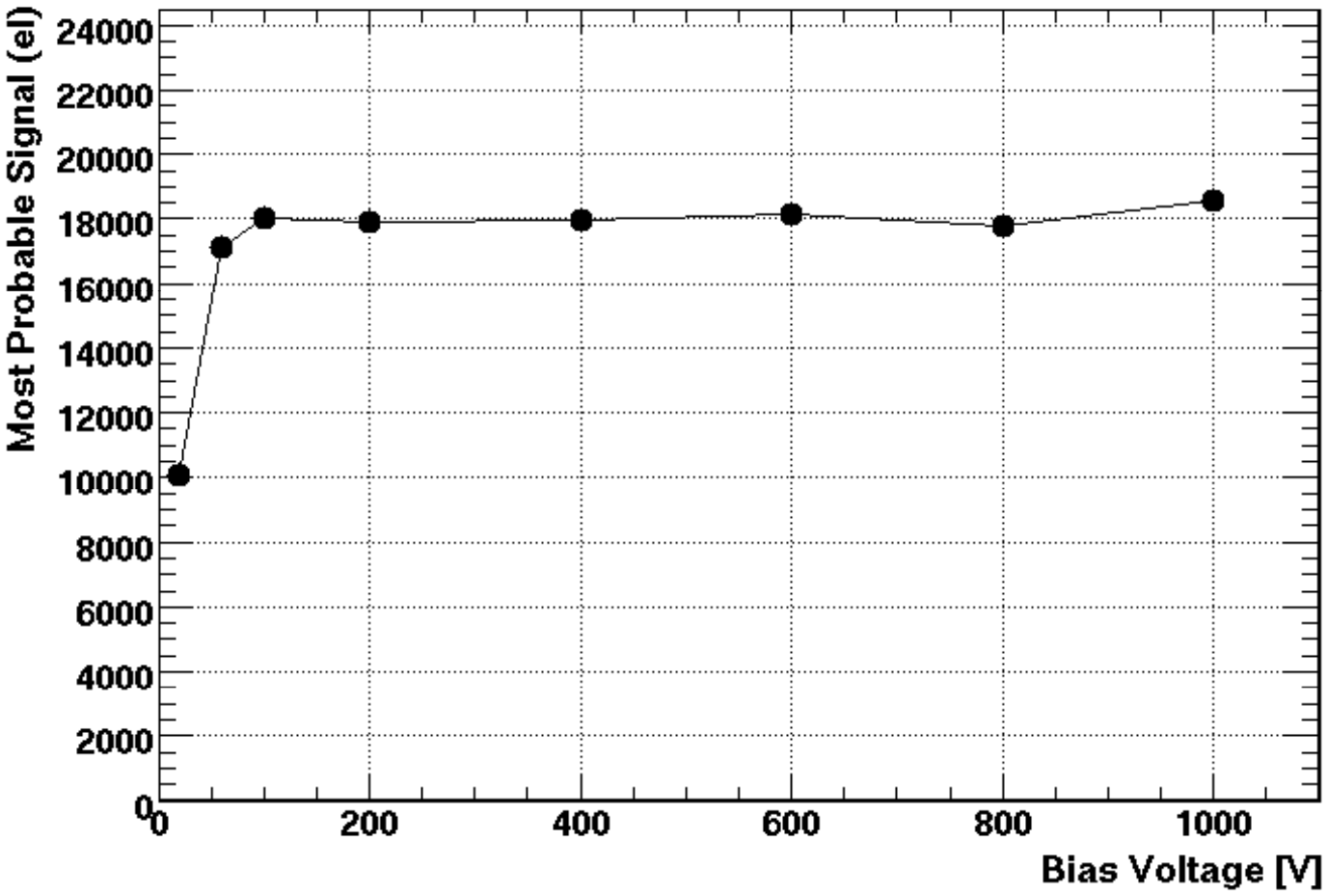


Conclusions

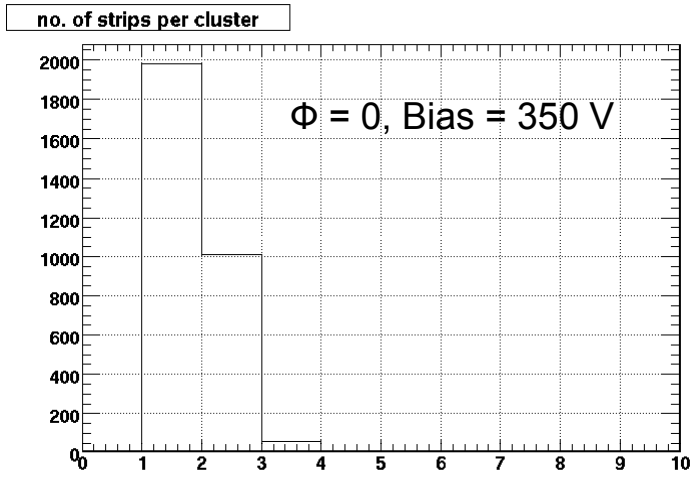
- signals caused by fast electrons from ^{90}Sr source in p-type microstrip detectors were measured with SCT128 chip
- measurements were made up to very high bias voltages (max.1700 V)
- CCE as high as before irradiation measured at sufficiently high voltage in detectors irradiated up to $\Phi = 3 \cdot 10^{15}$ n/cm^2
- good agreement with measurements from Liverpool

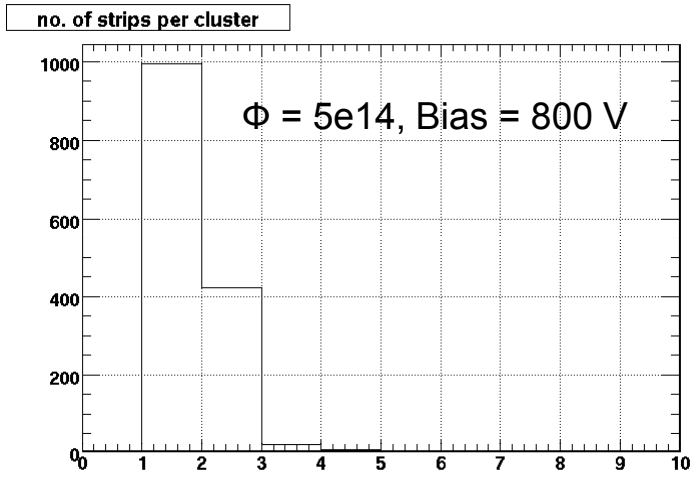
Backup plots

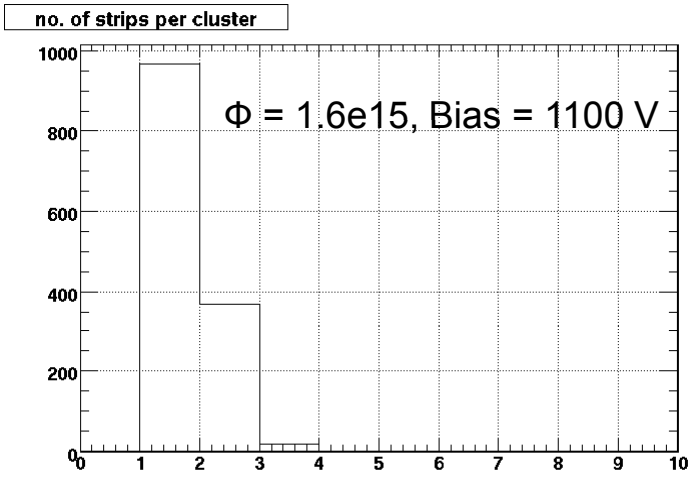
Modul 0, Φ_{eq} = 0 n/cm^2, exposed to few Mrads of gammas

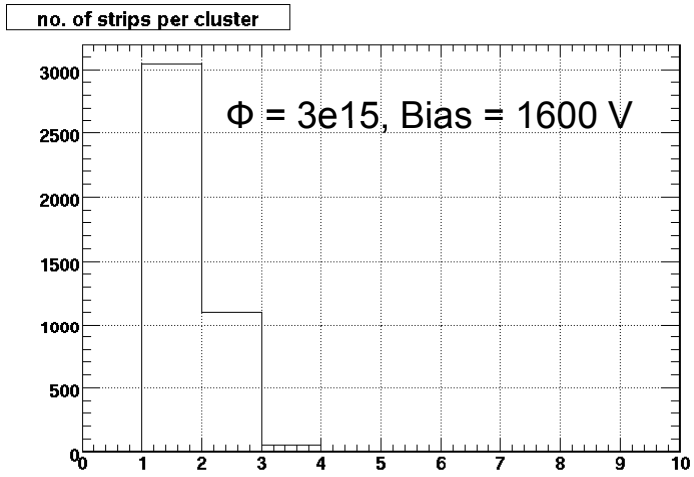


Number of strips per cluster



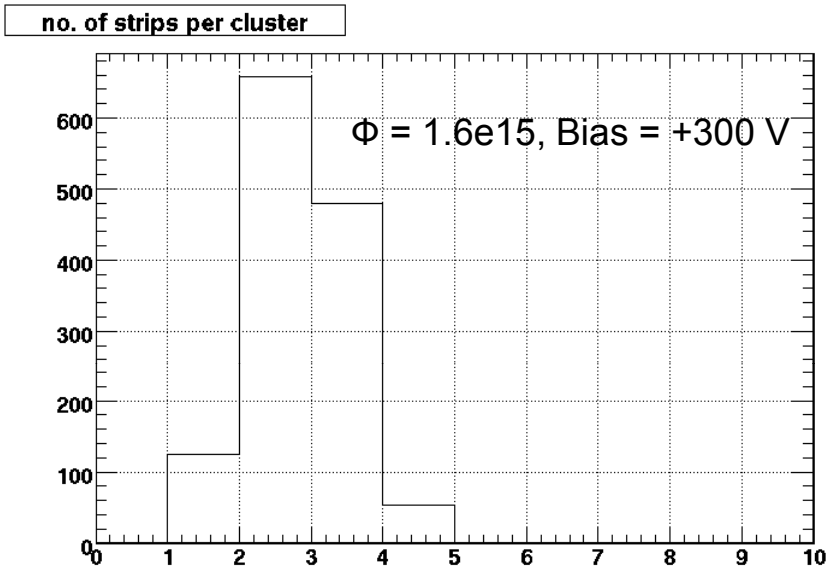


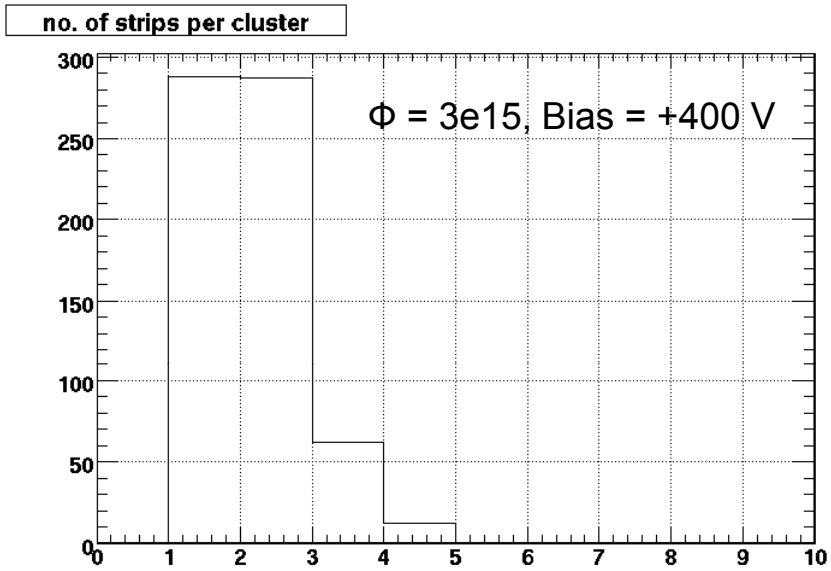




Number of strips per cluster

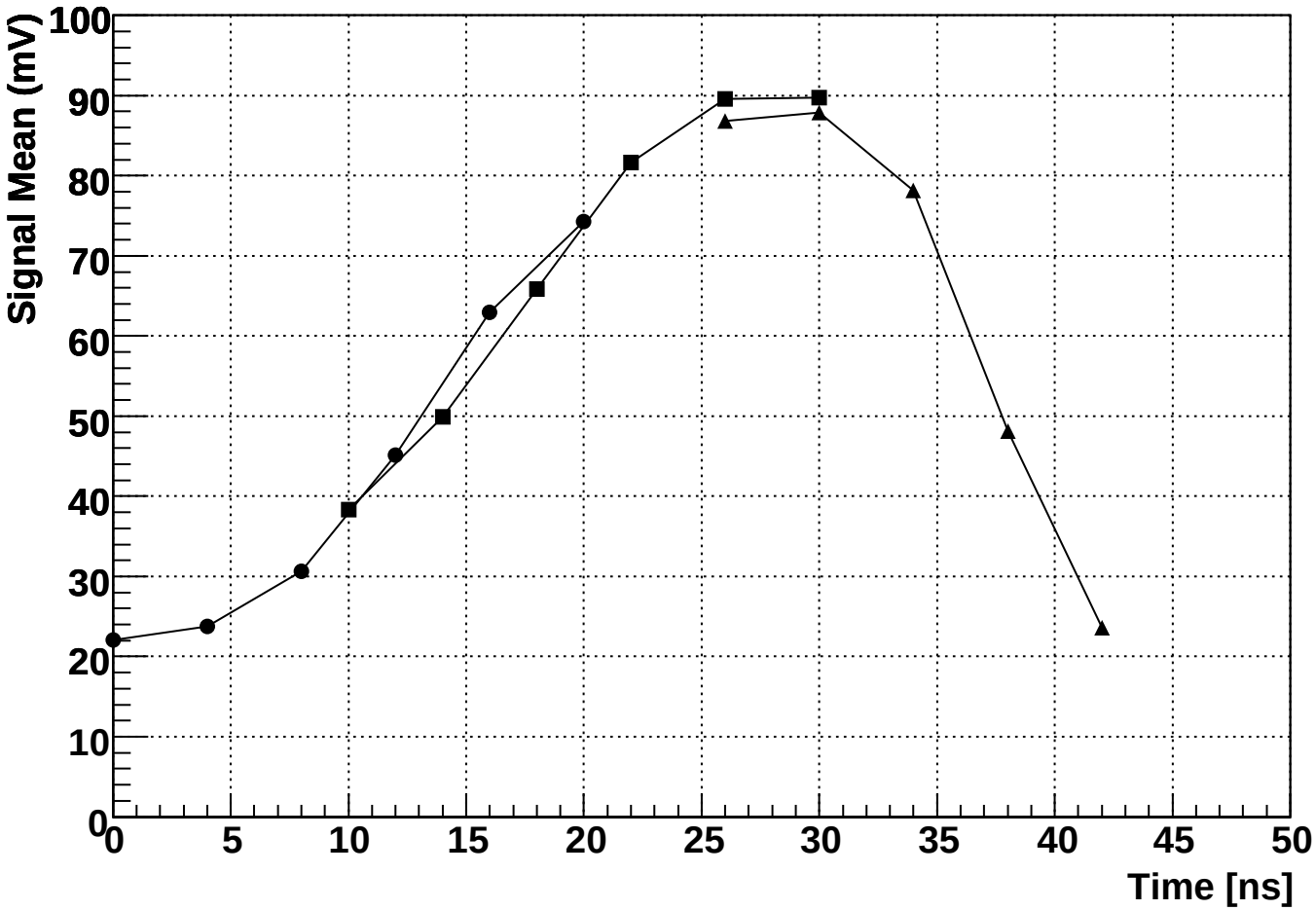
- forward bias





Pulse shape

- signal mean vs. trigger delay, before irradiation
- Bias = 200 V



Signal to noise

- measurements for which MPV ~ 20000 el