Results From Modules and Hybrids Irradiation

(preliminary)

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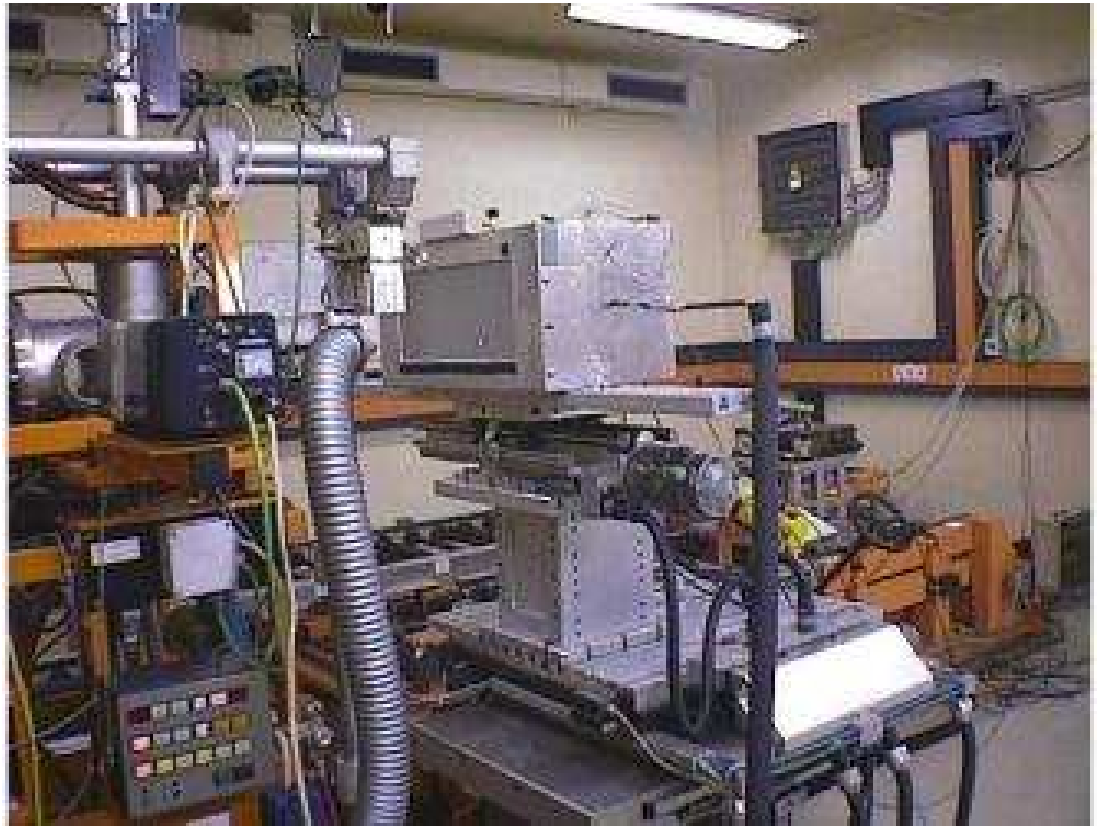
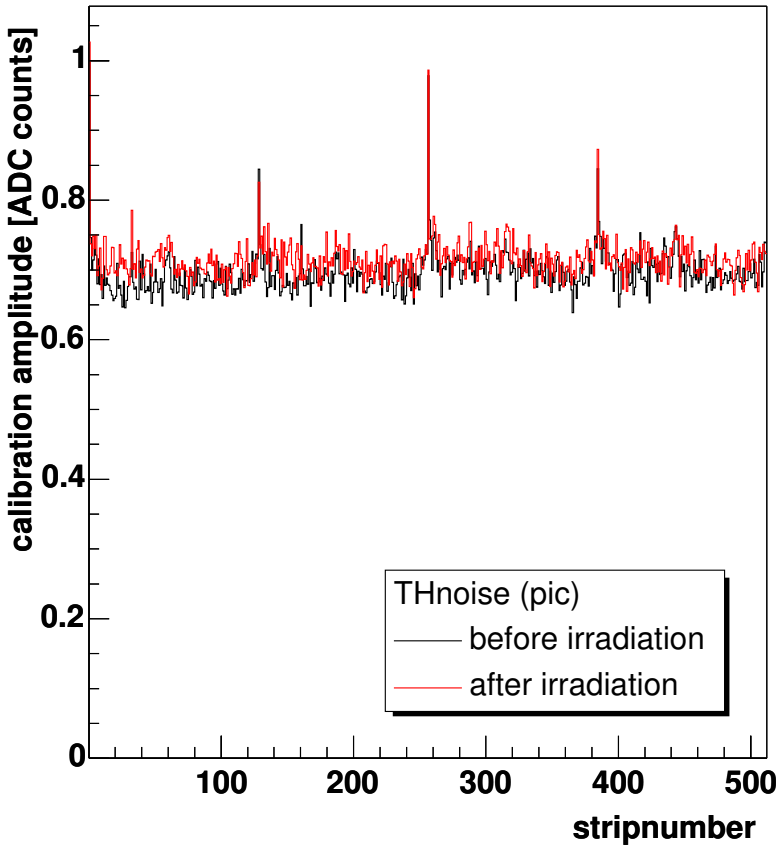
The Radiation Facility

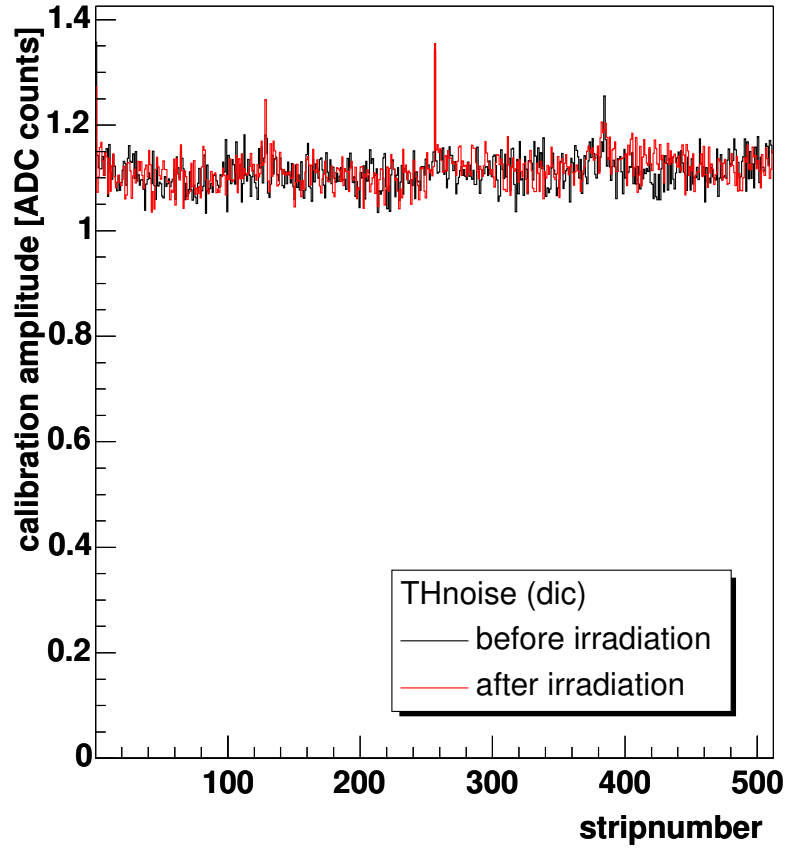


Compact Cyclotron
irradiated with 24 MeV protons
fluence:
hybrids
2.4×10^{-14} 1MeV(n)/cm^2
modules
0.5×10^{-14} 1MeV(n)/cm^2
dose:
$340kGy$ / $70kGy$

Hybrid Irradiation

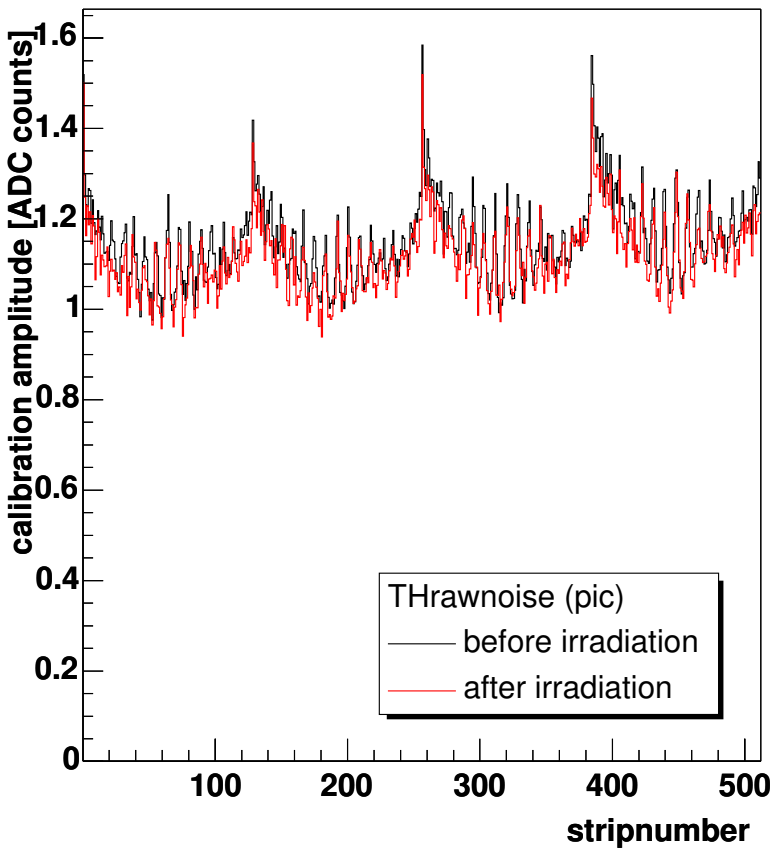
Common Mode Corrected Noise

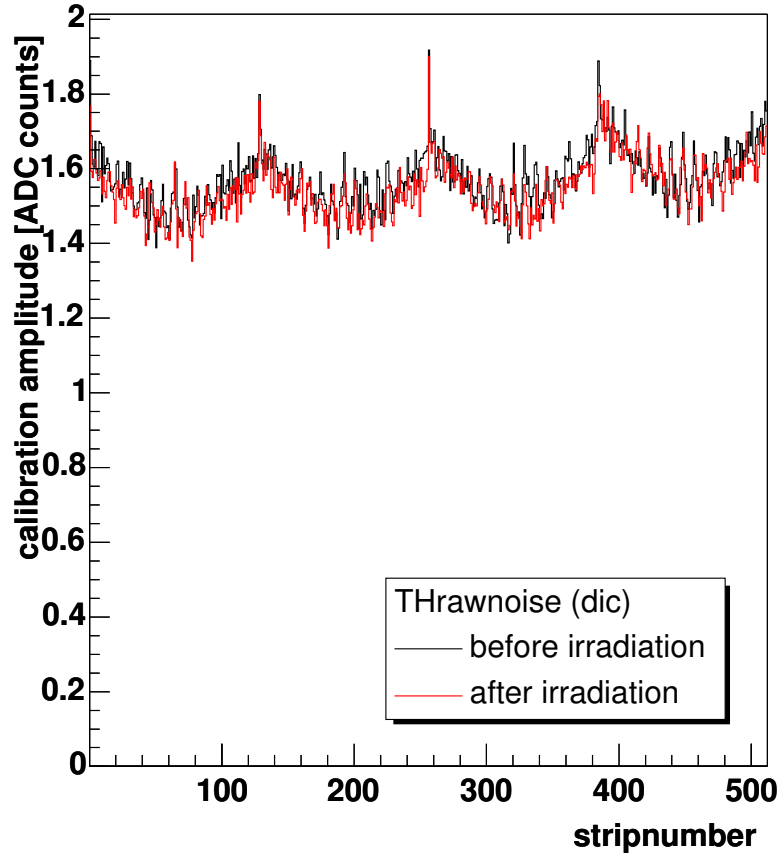




Noise is nearly the same before and after irradiation, for all modes

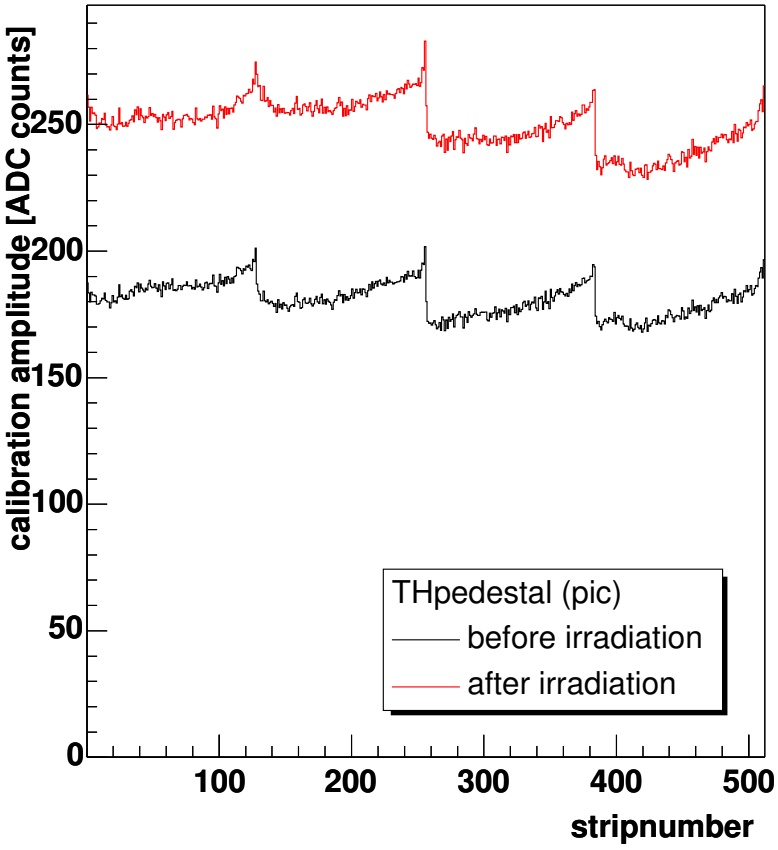
Raw Noise

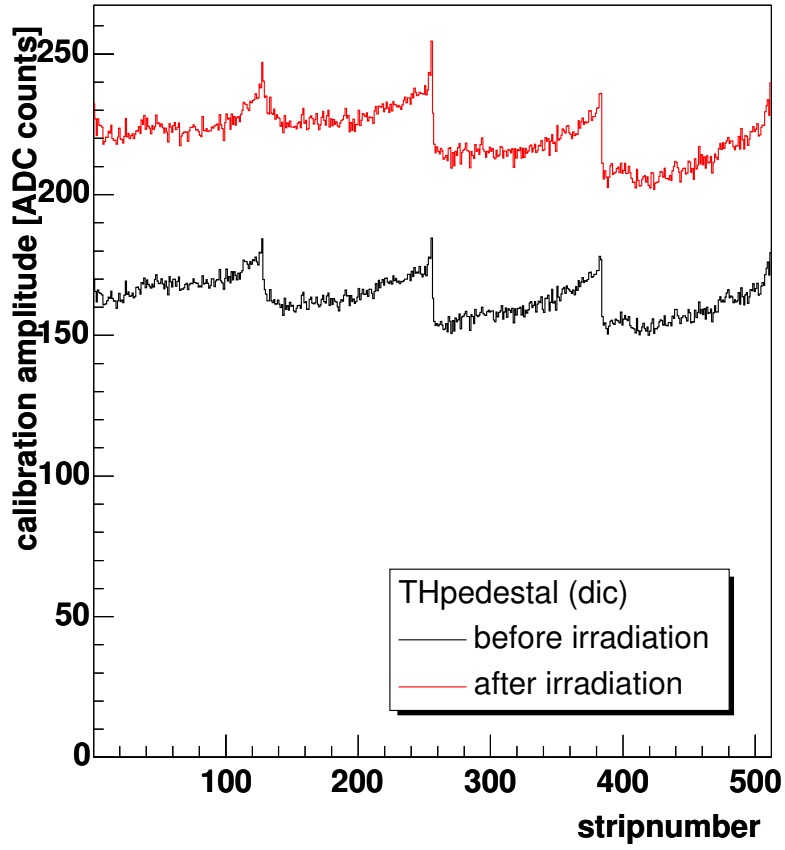




The raw noise shows no change due to irradiation

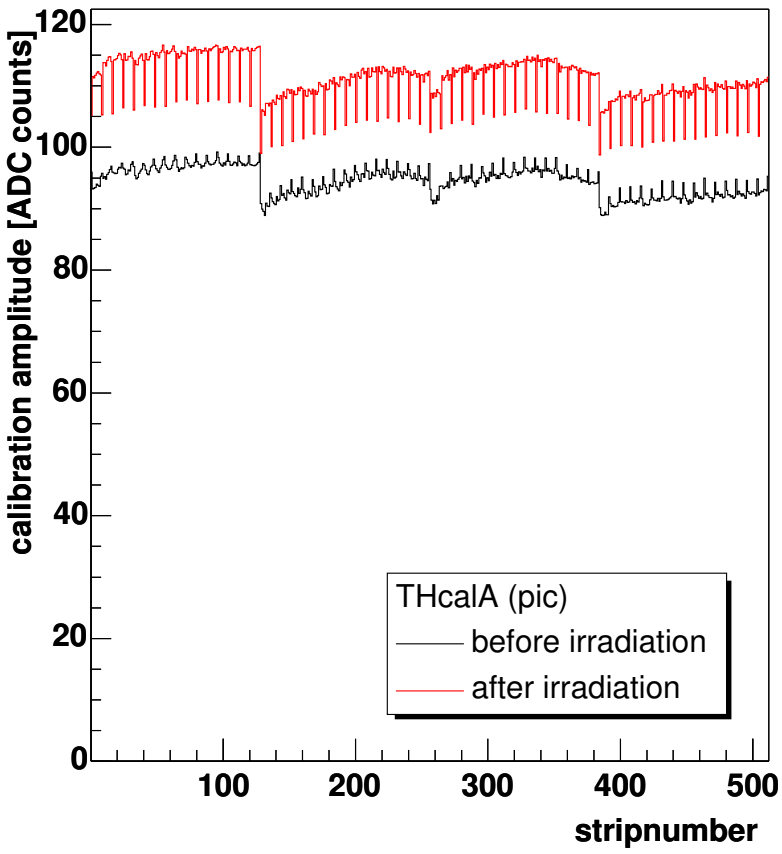
Pedestal

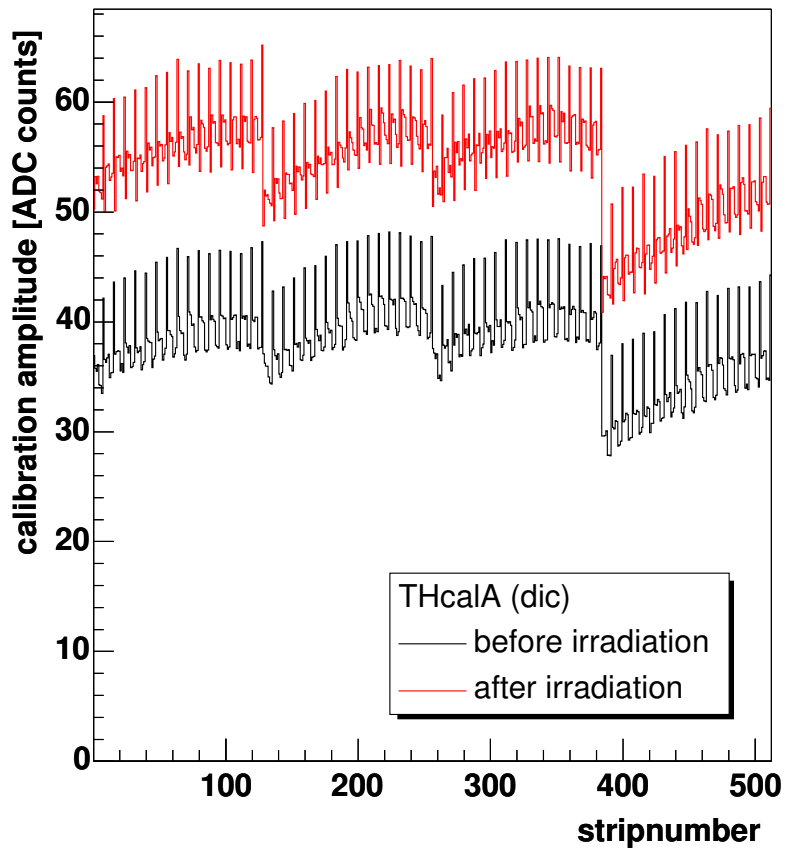




Pedestal increased after irradiation by $60...70$ ADC counts, the same behavior was seen in the irradiation on ceramic hybrids

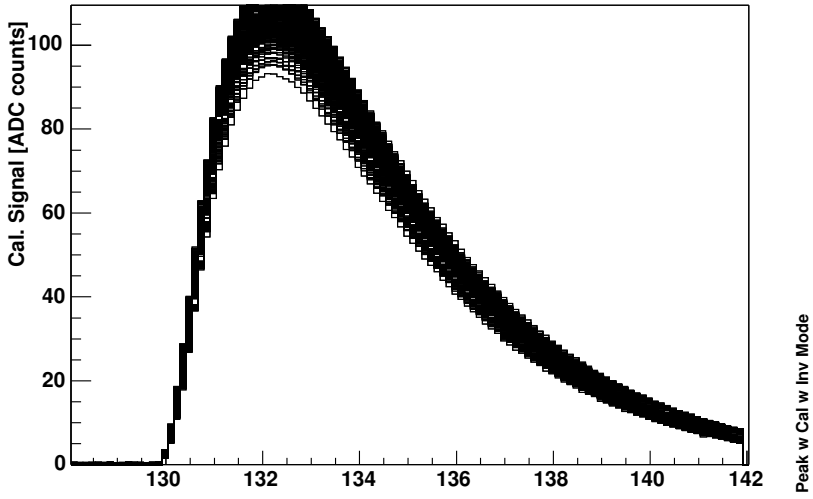
Calibration Amplitude

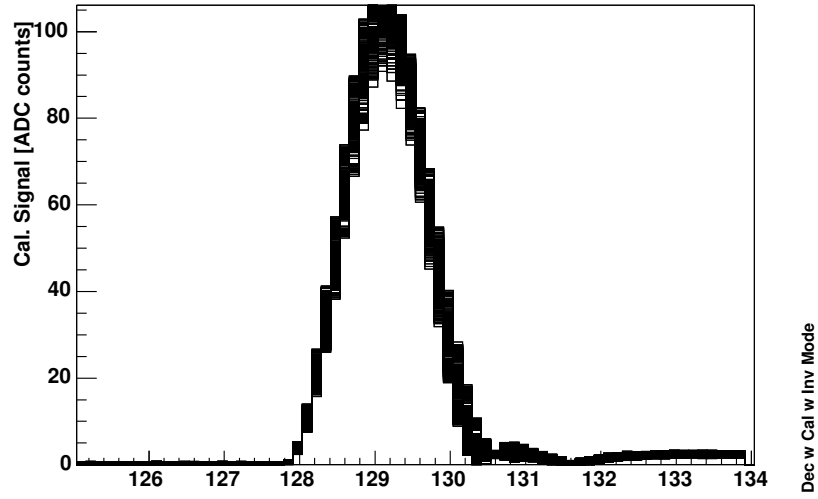


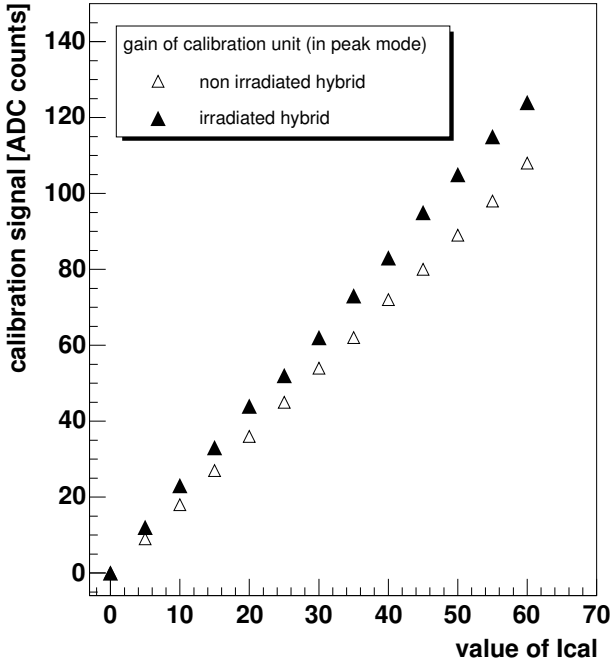


After irradiation the calibration amplitude increased the pattern (one calibration cell has higher/lower signal) seen in the ARC System too (may be timing effect $\Rightarrow$ not seen on modules)

Calibration Pulse Shape

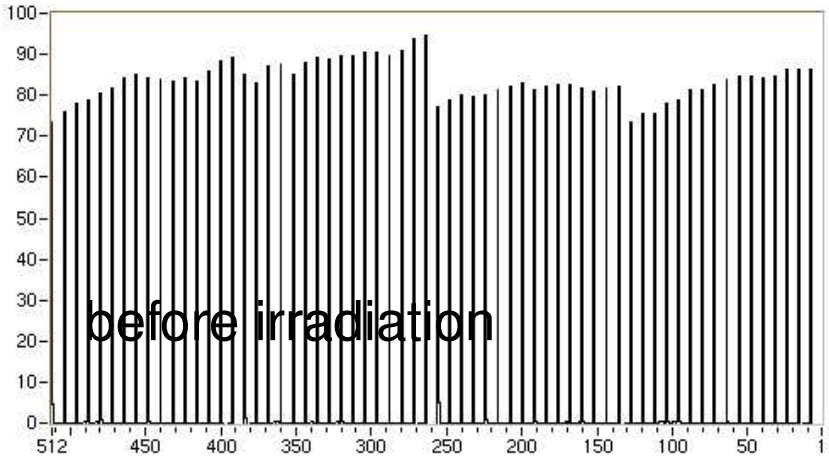


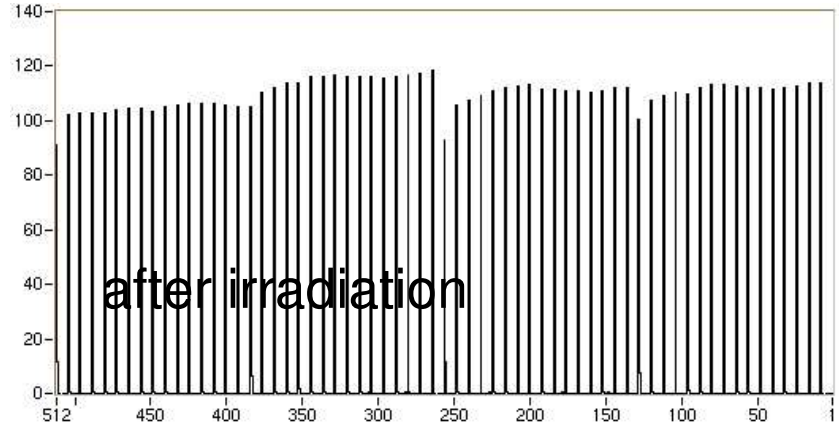




- pulse shapes have the same rise time as before
- slope of calibration unit's gain changed
- change of pedestal height and calibration amplitude due to oxide charge in n-MOS transistors, responsible for adjustment of pedestal and cal. height

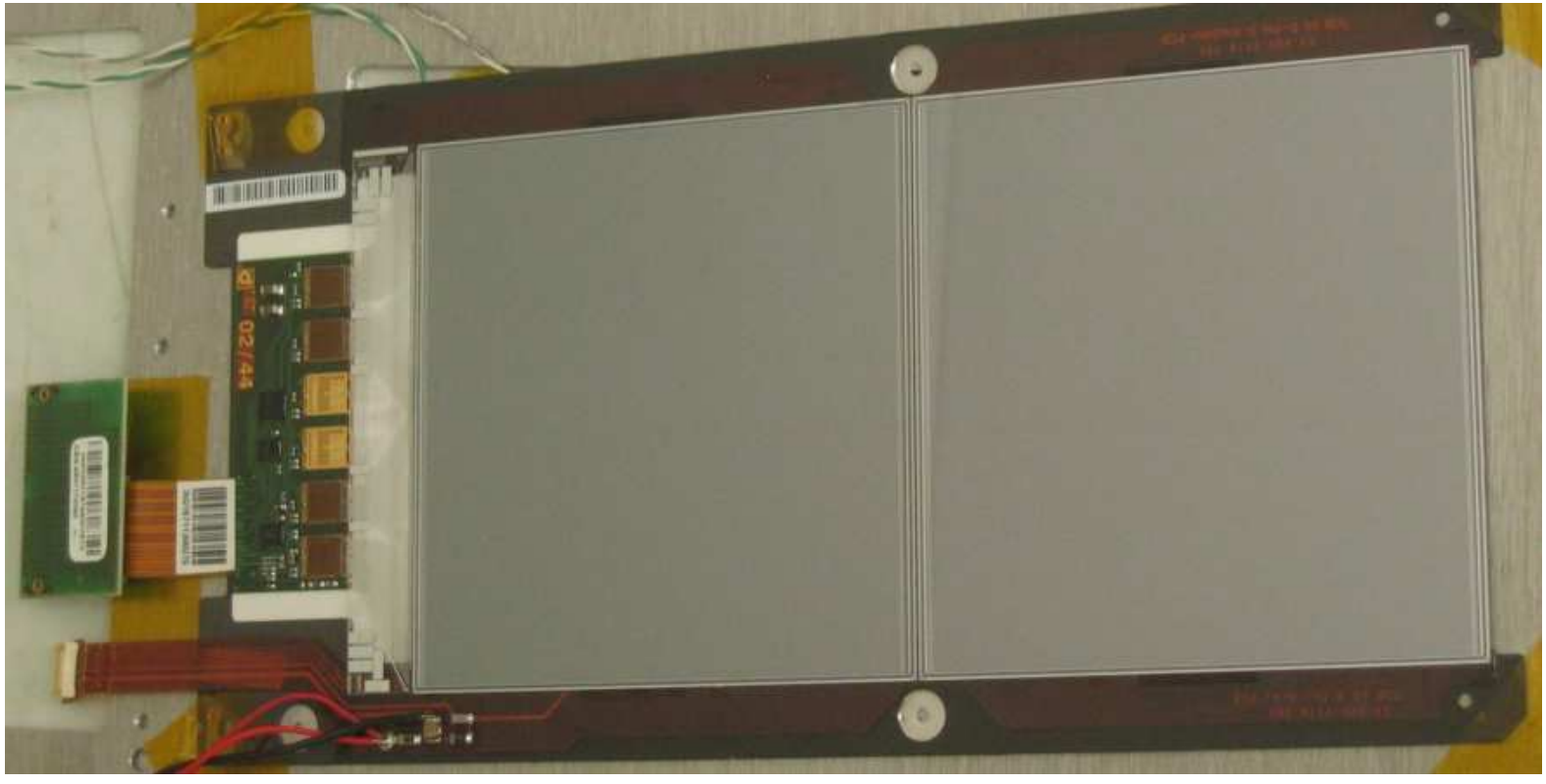
Comparison with Previous Measurements



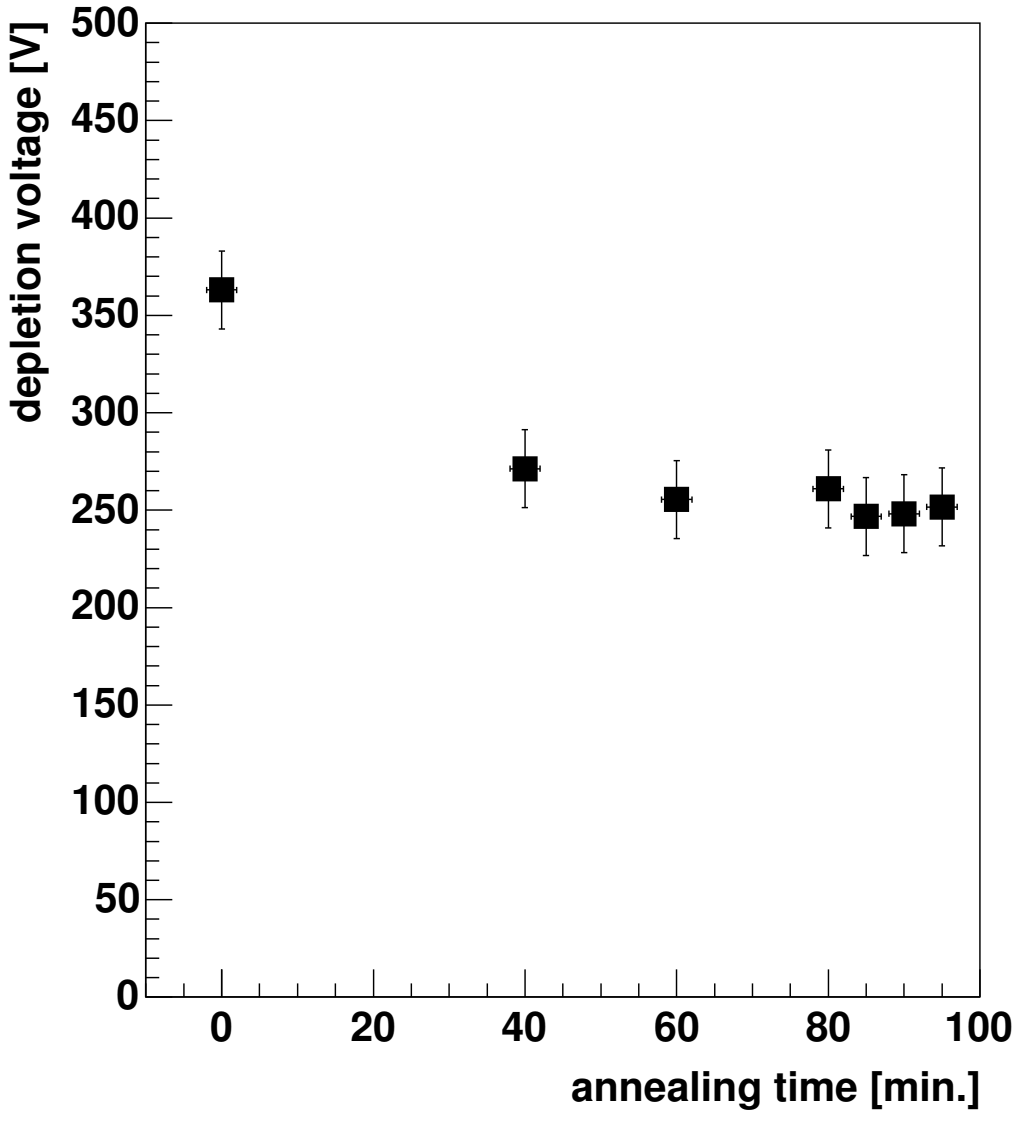


Previous irradiation qualification of ceramic hybrid showed same behavior in calibration signals and pedestals

Module Irradiation



Annealing Curve



- all annealing steps at 60° C
- CV -, IV - measurements in sensor probe station
- module transport frame cooled to $\approx -15^\circ$ C
- cooling done with laminar flow of pre-cooled dry air over complete module

Hamburg Model

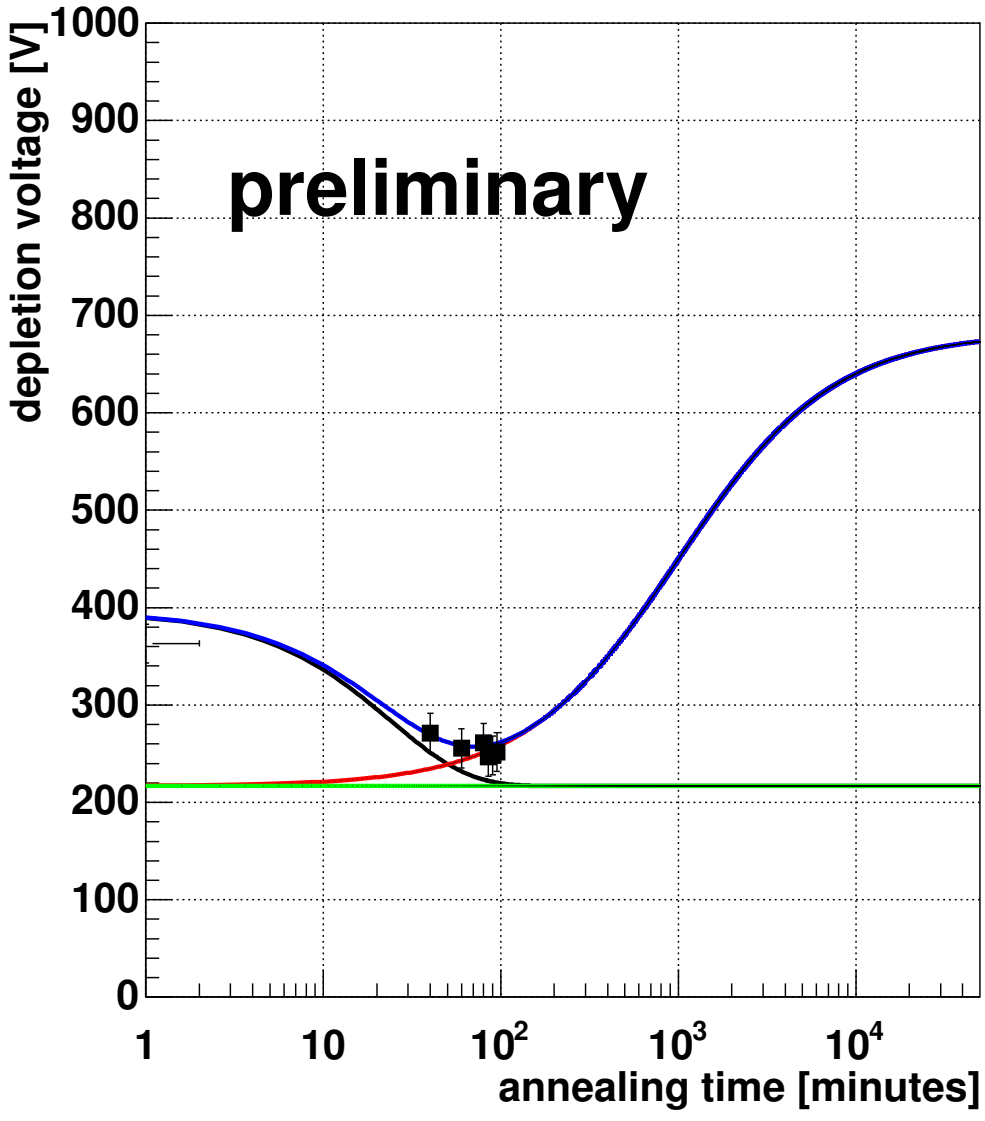
The depletion voltage is proportional to the effective space charge concentration, which is changed during irradiation, this change could parameterized by the “Hamburg Model”

$$\Delta N_{eff}(F_{eq}, t) = N_A(F_{eq}, t) + N_C(F_{eq}) + N_Y(F_{eq}, t)$$

where

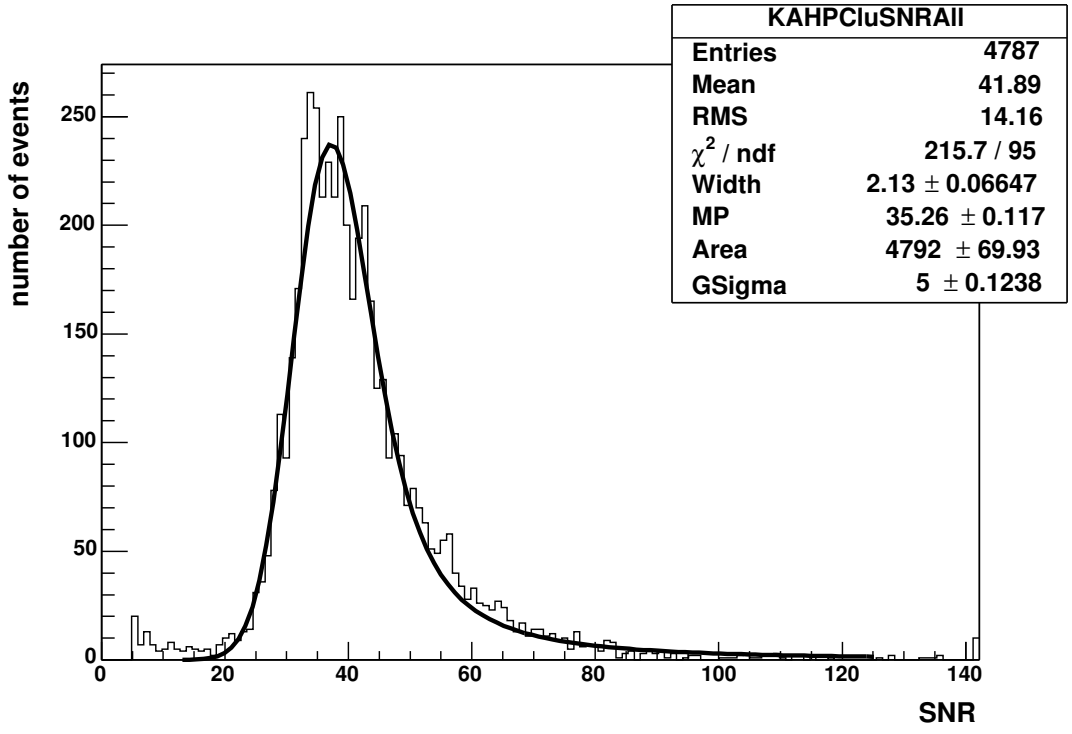
- $N_C(F_{eq}, t) = N_{C,0}(1 - e^{-cF_{eq}}) + g_c F_{eq}$ is the stable damage
- $N_A(F_{eq}) = F_{eq} \sum_i g_{a,i} e^{\frac{t}{\tau_{a,i}}}$ describes the short term annealing
- $N_Y(F_{eq}, t) = N_{Y,\text{inf}} \left(1 - \frac{1}{1+\frac{t}{\tau_Y}}\right)$ describes the long term (reverse) annealing behavior

Hamburg Model and Data



- estimated fluence of 0.5×10^{-14} 1MeV(n)/cm^2, and resistivity between 4 kΩ and 8 kΩ
- parameterization fits well for data points around minima
- data for 200, 500 and 1000 minutes of annealing are planed to see behavior of reverse annealing

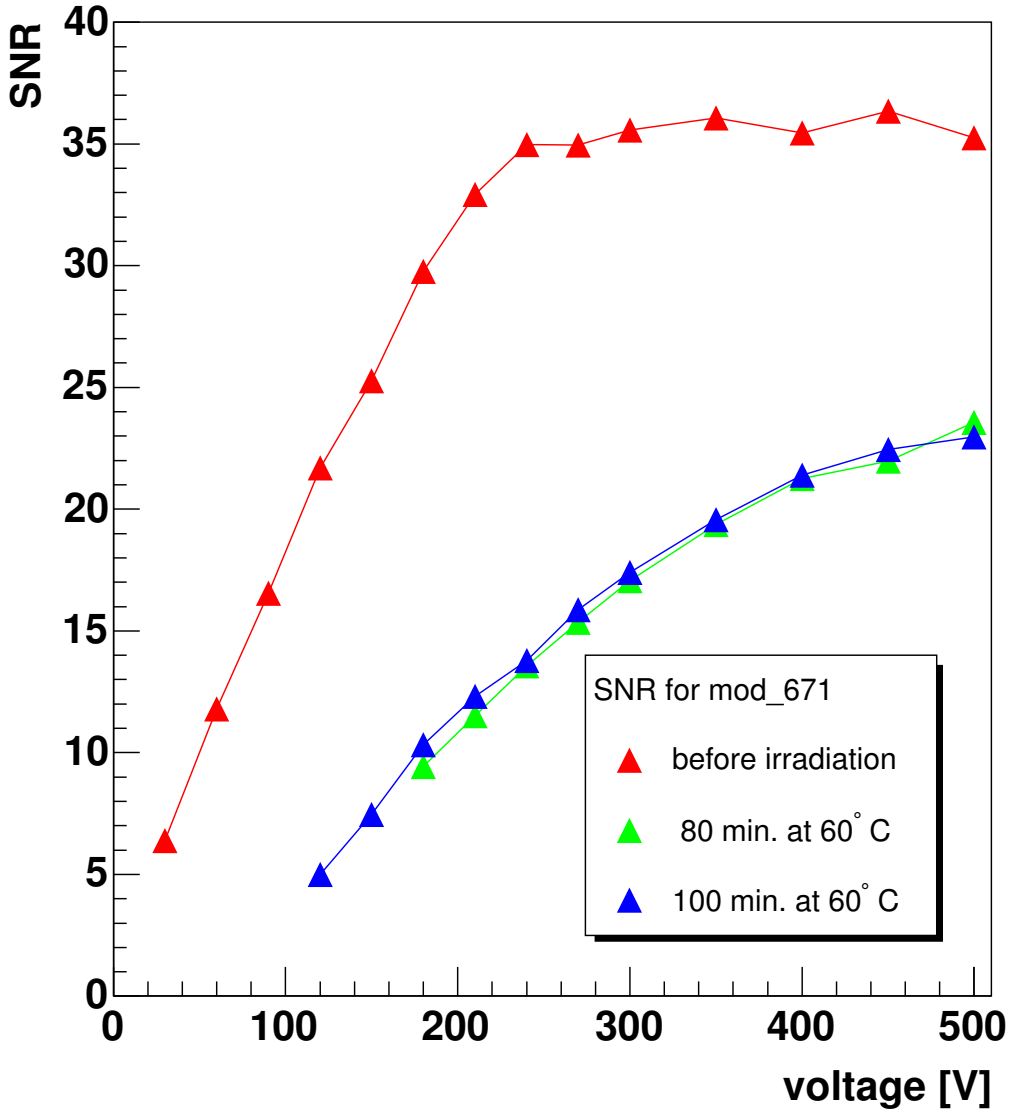
Signal to Noise Ratio



peak mode / 500 **V**

- SNR plot were fitted by a Landau fit convoluted with a Gaussian distribution
- measurements performed with ^{90}Sr source
- module was cooled during measurements to $(-14 \pm 2)^\circ$ C (one voltage scan lasts ≈ 1 hour)
- same APV setting before and after irradiation

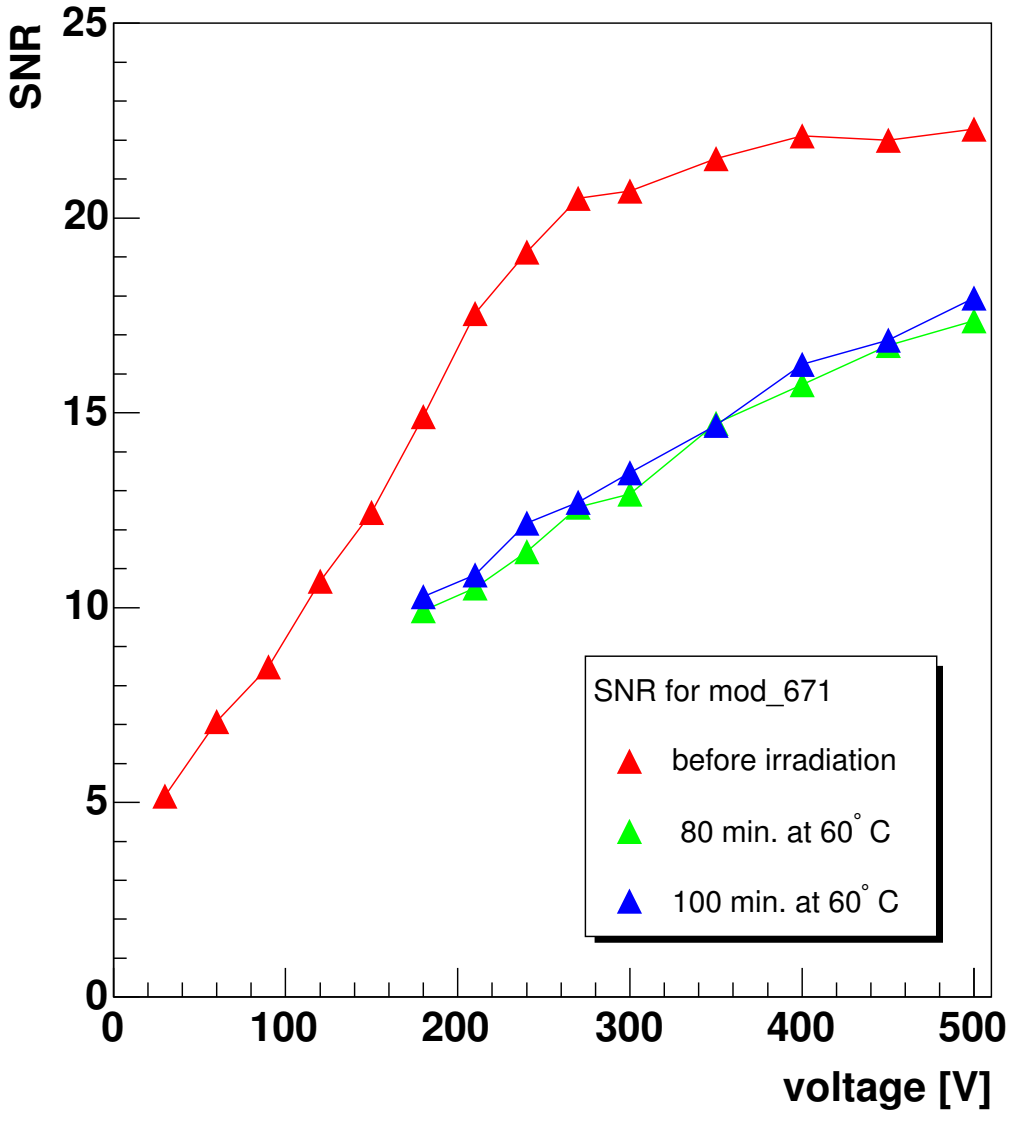
SNR vs. Voltage in Peak Mode



Module 671

- SNR before irradiation ≈ 34 for voltages > 200 V
- SNR after irradiation > 20 for voltages > 400 V
- no saturation in SNR seen up to 500 V for irradiated module

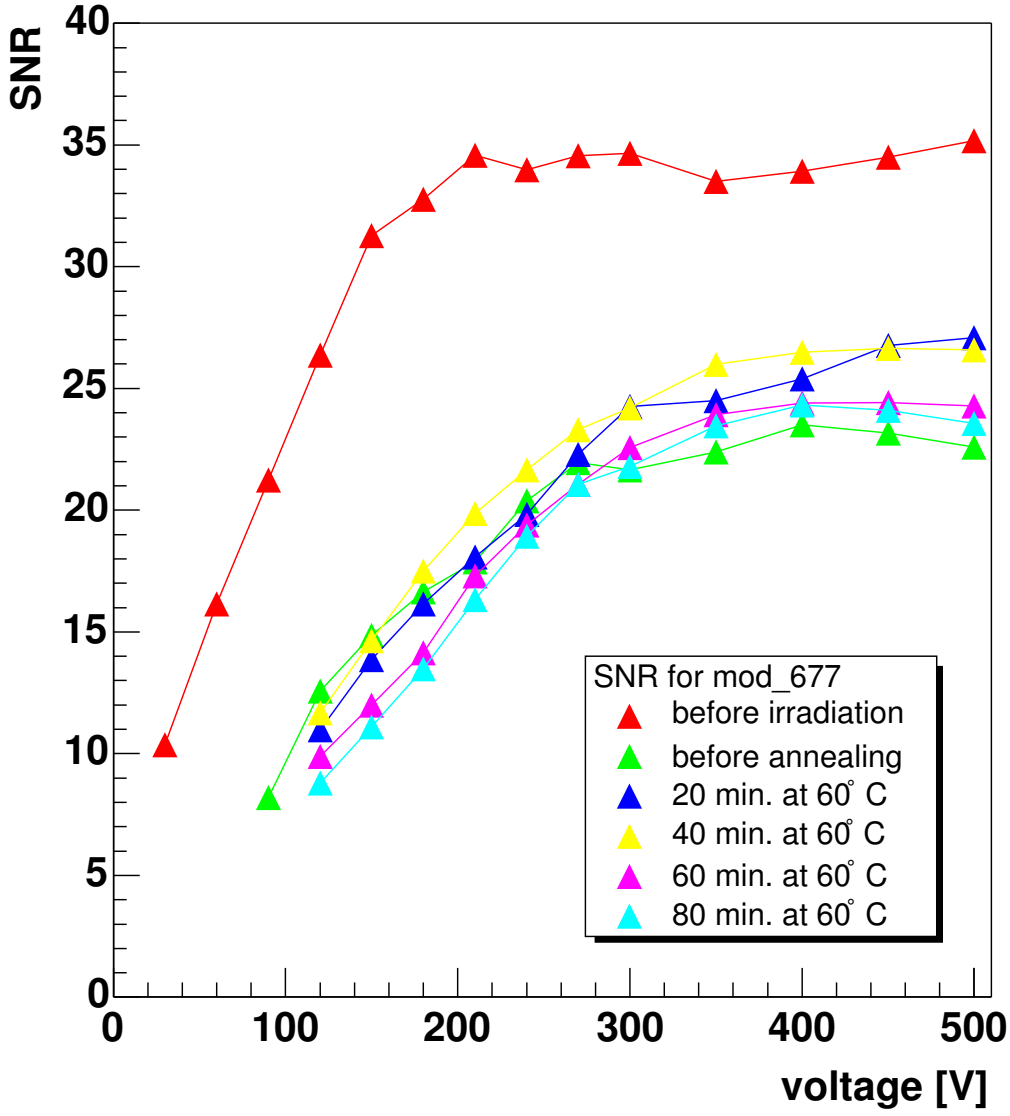
SNR vs. Voltage in Dec. Mode



Module 671

- SNR before irradiation ≈ 22 for voltages > 250 V
- SNR after irradiation > 15 for voltages > 400 V
- no saturation in SNR seen up to 500 V for irradiated module

SNR vs. Voltage in Peak Mode



Module 677

- SNR before irradiation $\approx 33..34$ for voltages > 200 V
- SNR after irradiation > 22 for voltages > 300 V
- saturation in SNR starts at ≈ 300 V for irradiated module and at ≈ 200 V for non-irradiated module

Summary

- 2 outer barrel modules (to outer barrel fluence) and hybrid (to inner barrel fluence) irradiated with protons (in Karlsruhe)
- 1 outer barrel mdule irradiated with neutron (in Louvain-la-neuve)
- hybrid with globtob fixation for bonds will be irradiated this week
- further annealing steps on the modules will be done