ABCD Irradiation with neutrons

V. Cindro, G. Kramberger, I. Mandić, M. Mikuž, M. Tadel

Ljubljana group

OUTLOOK:

- Irradiation of ABCD2T and ABCD2NT chips

- Irradiation of unbiased ABCD2 chips

SETUP:

- Oslo hybrid with 6 chips: 3 ABCD2T and 3 ABCD2NT
- Melbourne LVDS repeater card
- home made power supplies
- DRAFT, SEQSI, NI-MXI , PC(with NT)
- software from Carlos Lacasta (C++, ROOT)

⇒ long cables are needed to be able to put the hybrid into the reactor core: hybrid is connected to 2.5m of low-mass tapes for power lines and 3 twisted pair lines for signals and after that to another 3.5m of twisted-pair cable and all this to the LVDS repeater card: master chip can drive such a load

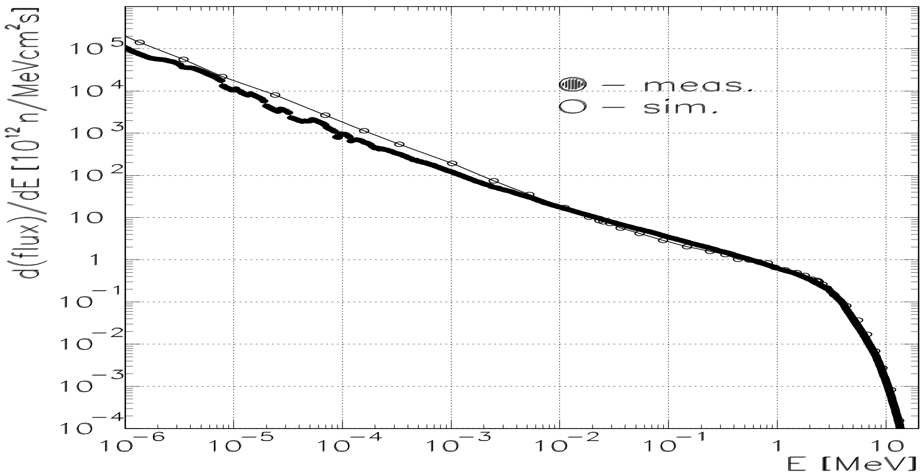
⇒ low mass tapes are used because they do not remain radioactive long after irradiation

- Chips were irradiated in the reactor in Ljubljana
- fluence calculated by the time in the core and power of the reactor i.e.: at 25kW the fluence of 10^{13} n/cm^2 is reached in 24s
- all fluences are quoted in 1MeV NIEL equivalent for silicon and are accurate to ~10%

  i.e. 10^{13} n/cm^2 in our reactor means: ~ 10^{13} n/cm^2 fast neutrons (E>100keV)

  \+ same number of epithermal neutrons (100keV> E > 0.5eV)

  \+ twice as many thermal neutrons (E<0.5eV)
- gamma background not known but not high (less than 100 krad)
- temperature during irradiation ~ 20^o C (but temepratureof the hybrid unknown)



Neutron energy spectrum

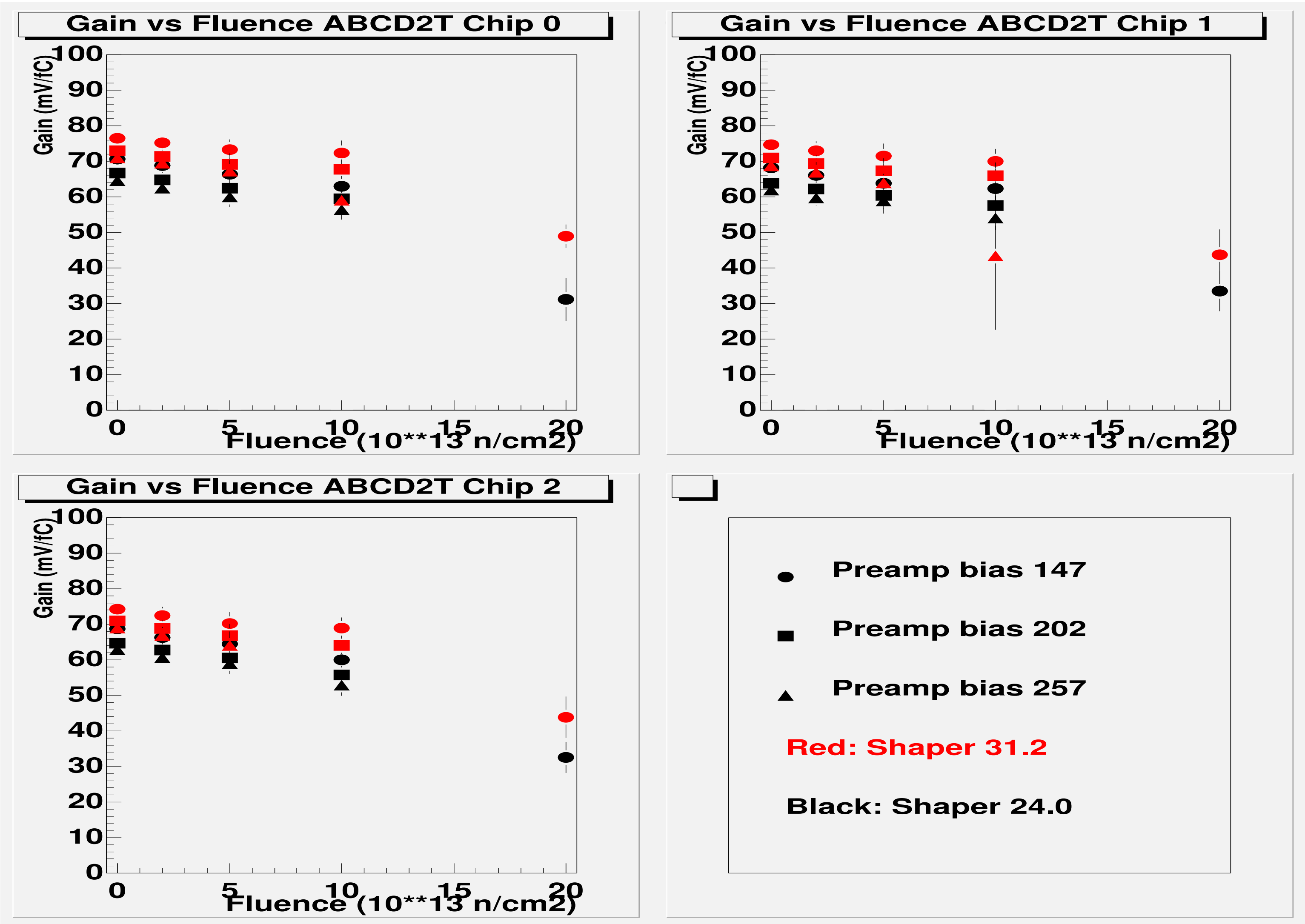
- during irradiation:
  - clock at 40MHz
  - read out the chips

- chip performance was tested after fluences of:
  - $0\ n/cm^2$
  - $2 \times 10^{13}\ n/cm^2$
  - $5 \times 10^{13}\ n/cm^2$
  - $1 \times 10^{14}\ n/cm^2$
  - $2 \times 10^{14}\ n/cm^2$

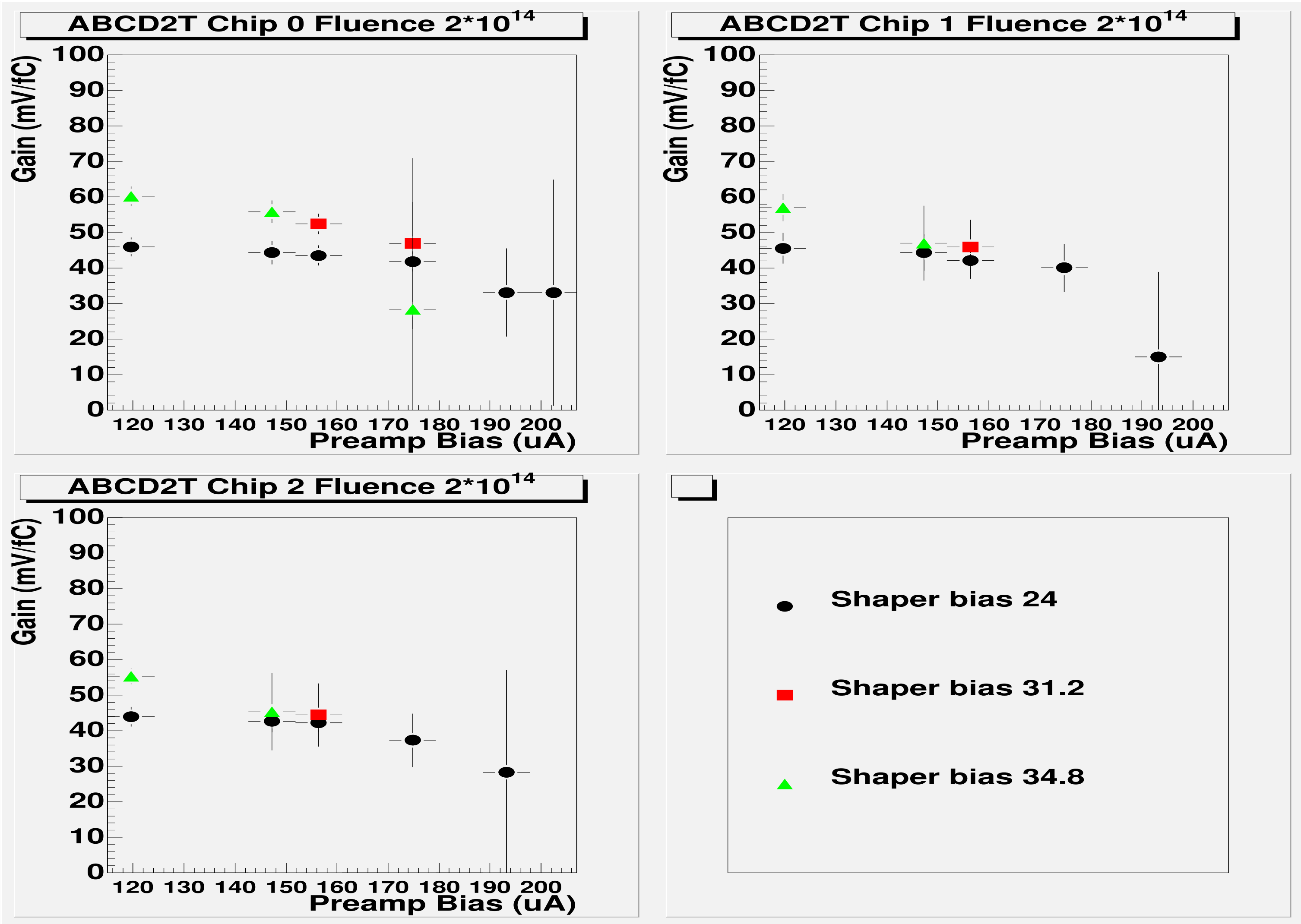
- at each point do threshold scans:
  - edge (01X) data compression
  - pulses 1., 1.75 and 2 fC
  - measure gain, offset and noise at different preamplifier and shaper bias currents settings

- Gain as a function of fluence for ABCD2T chips

→ after $2x10^{14}$ n/cm^2 chips don't work with high preamp biases

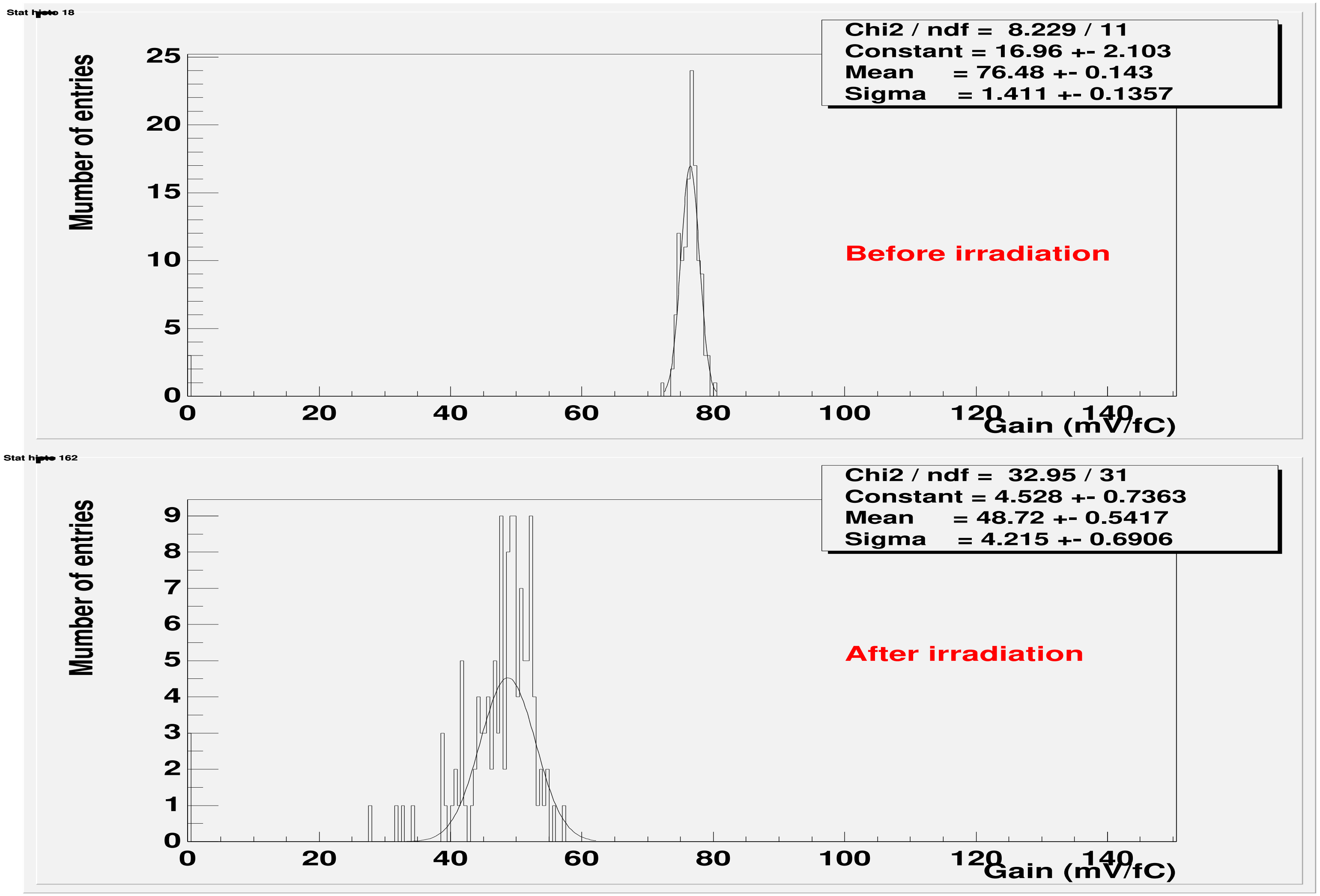


- Gain as a function of preamp bias after irradiation with $2x10^{14}$ n/cm^2 for ABCD2T chips

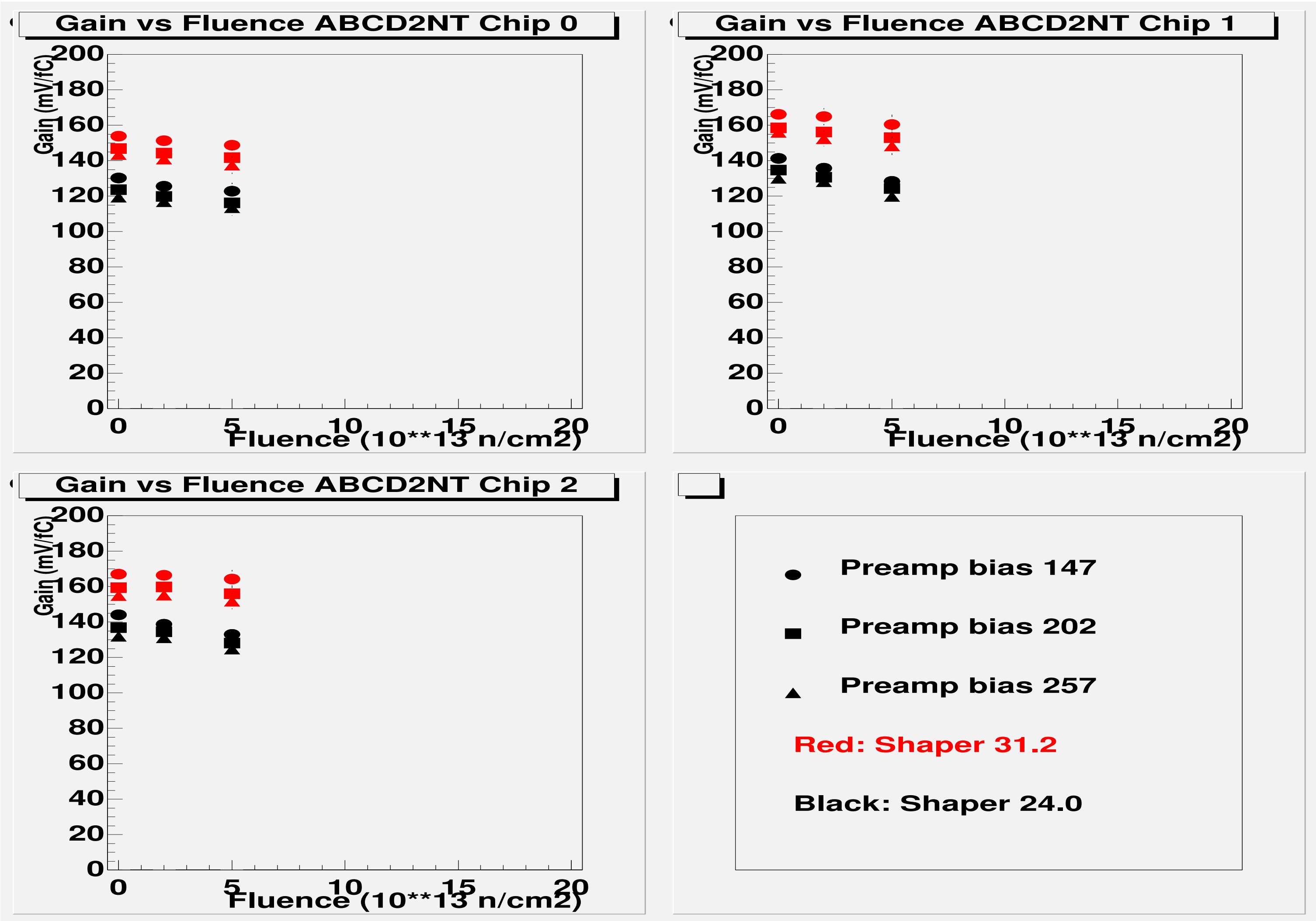


- Gain distribution before and after irradiation with $2x10^{14}$ n/cm^2

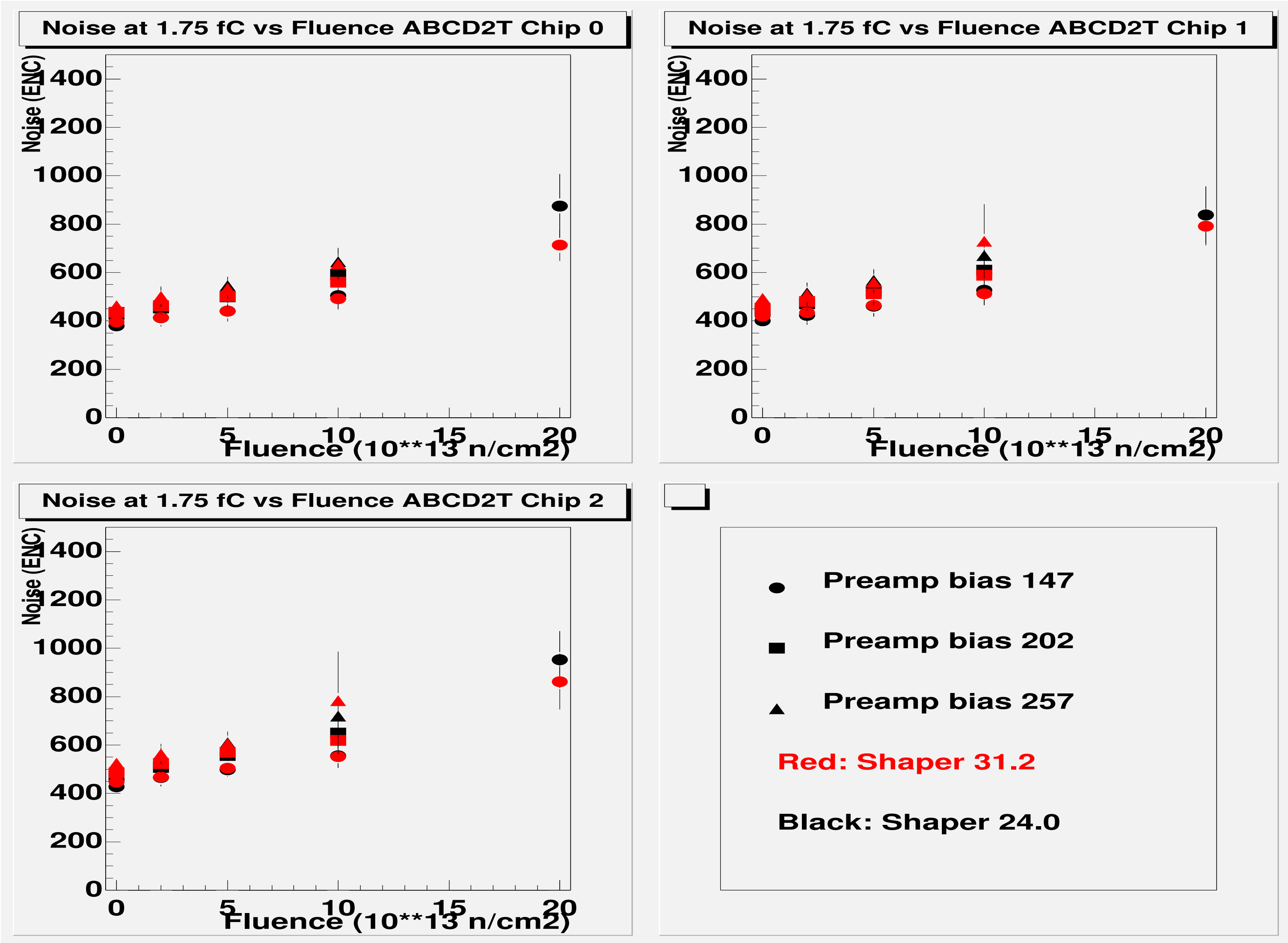
ABCD2T chip 0, Preamp current = 147.2 µA, Shaper current = 31.2 µA



- Gain as a function of fluence for ABCD2NT chips
  - after $5x10^{13}$ n/cm^2 chips return only 0-hit data at any preamp bias
  - hybrid draws ~40% less analogue current than before irradiation

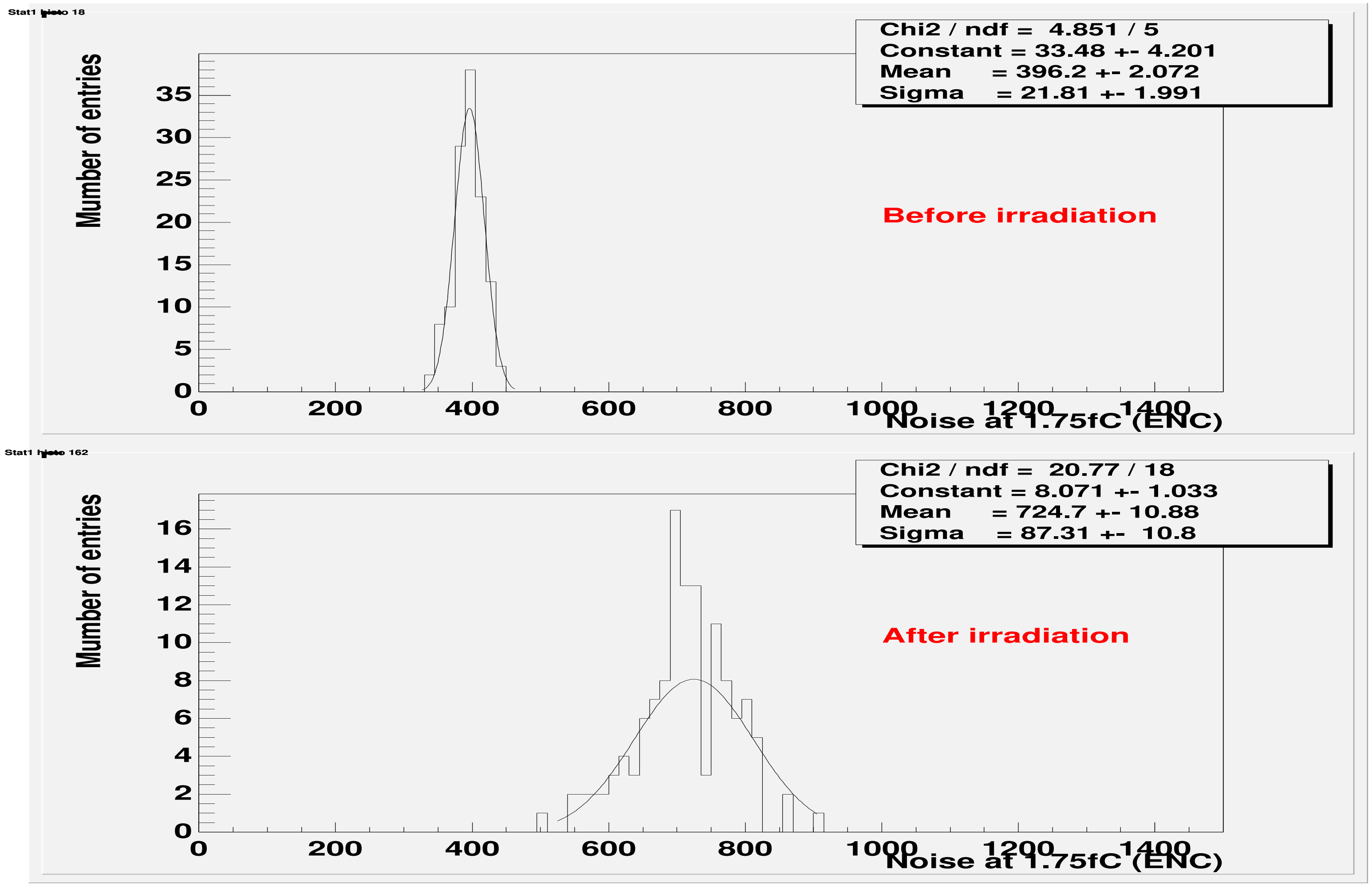


• Noise as a function of fluence for ABCD2T chips

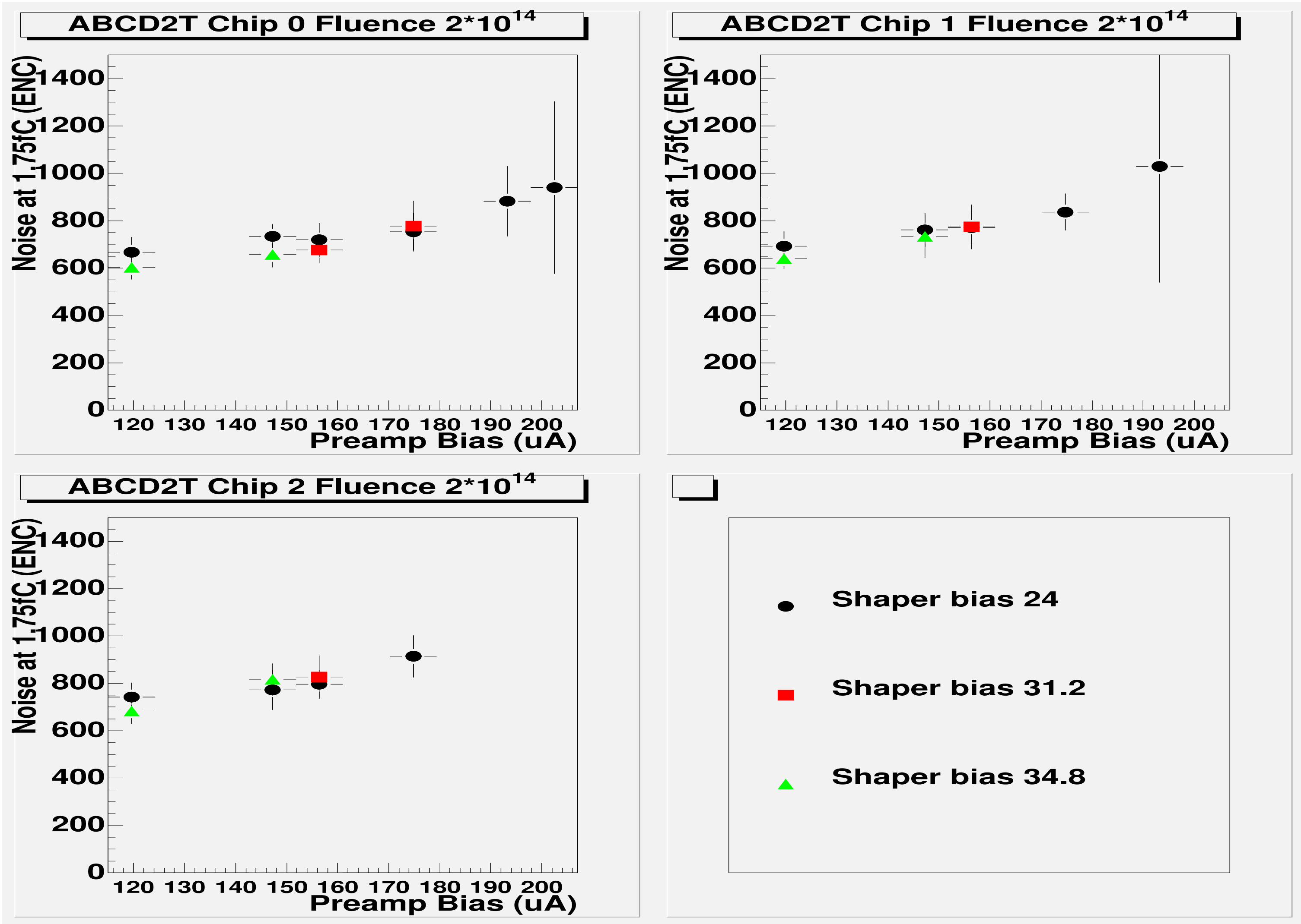


- Noise distribution before and after irradiation with $2x10^{14}$ n/cm^2

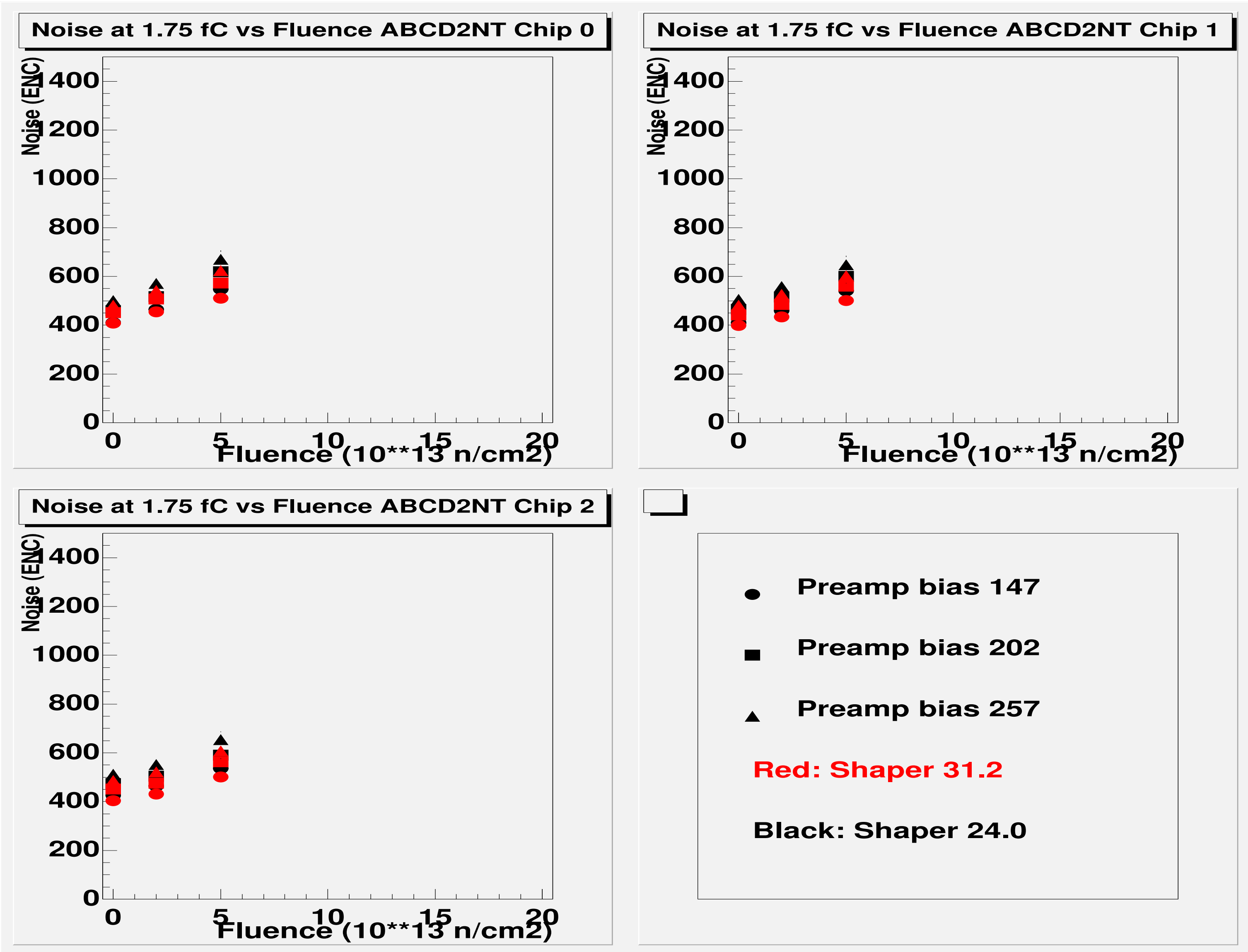
ABCD2T chip 0, Preamp current = 147.2 μA, Shaper current = 31.2 μA



- Noise as a function of preamp bias after irradiation with $2x10^{14}$ n/cm^2 for ABCD2T chips

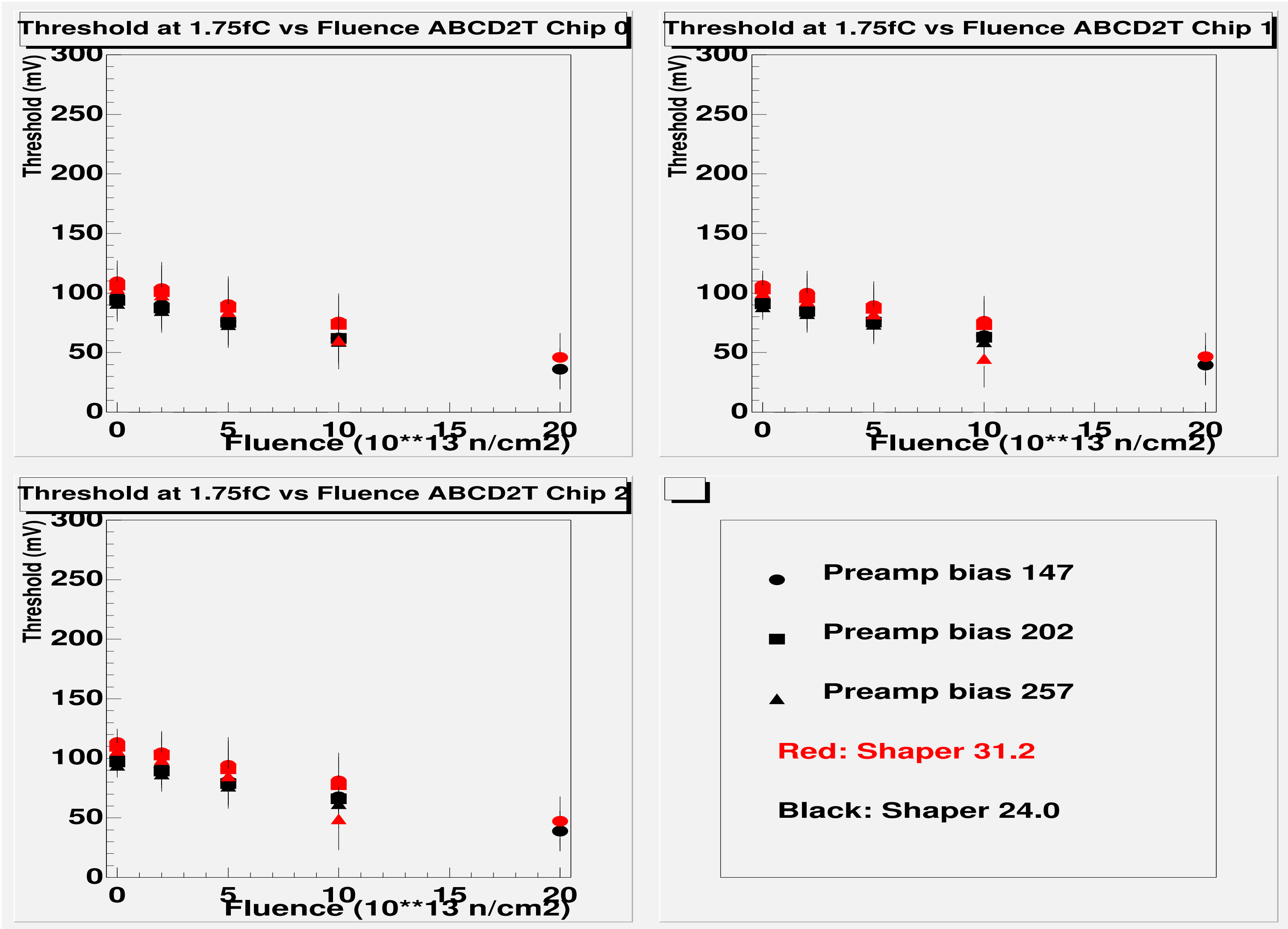


• Noise as a function of fluence for ABCD2NT chips



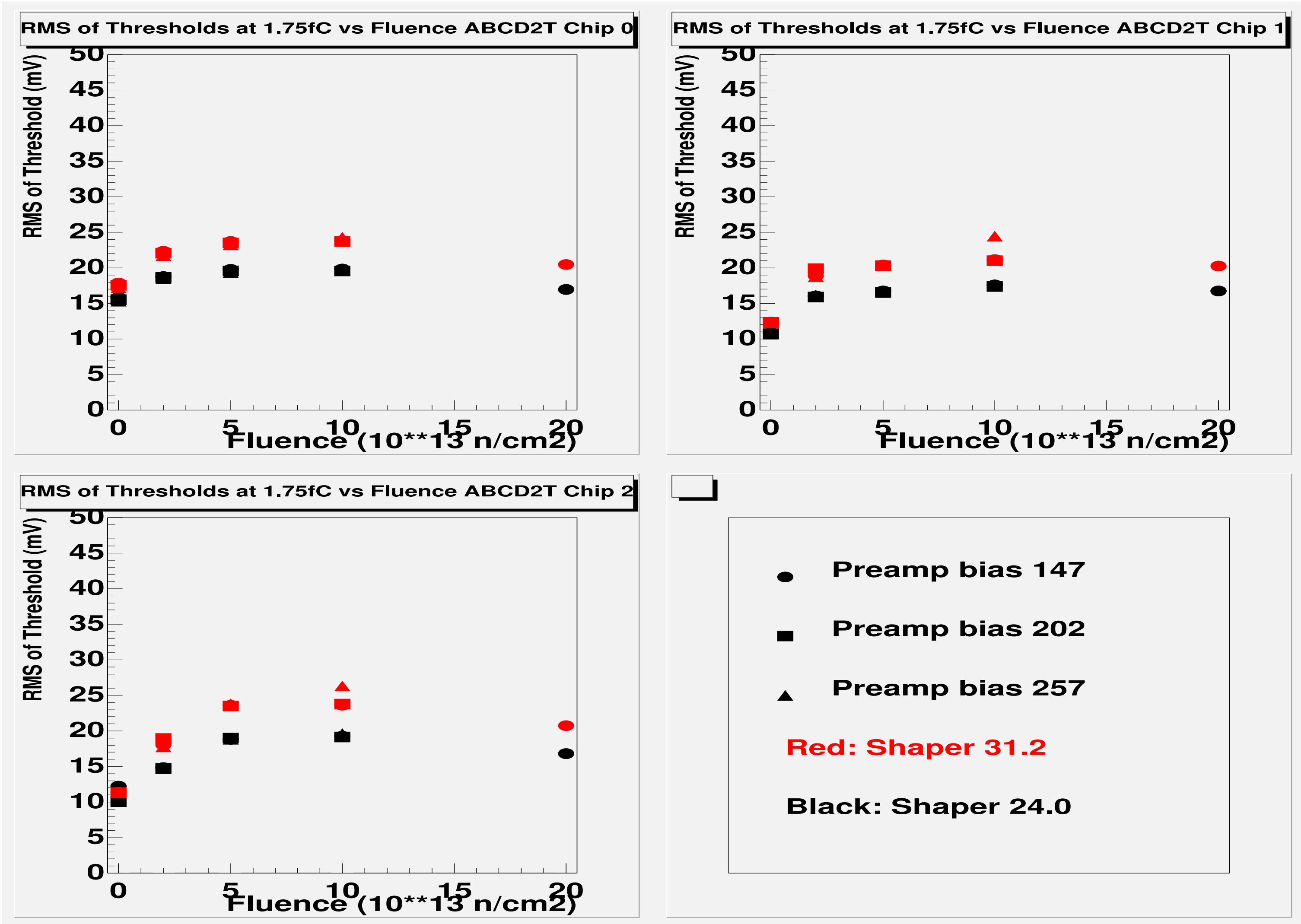
- Threshold (50% point) as a function of fluence for ABCD2T chips

→ not trimmed



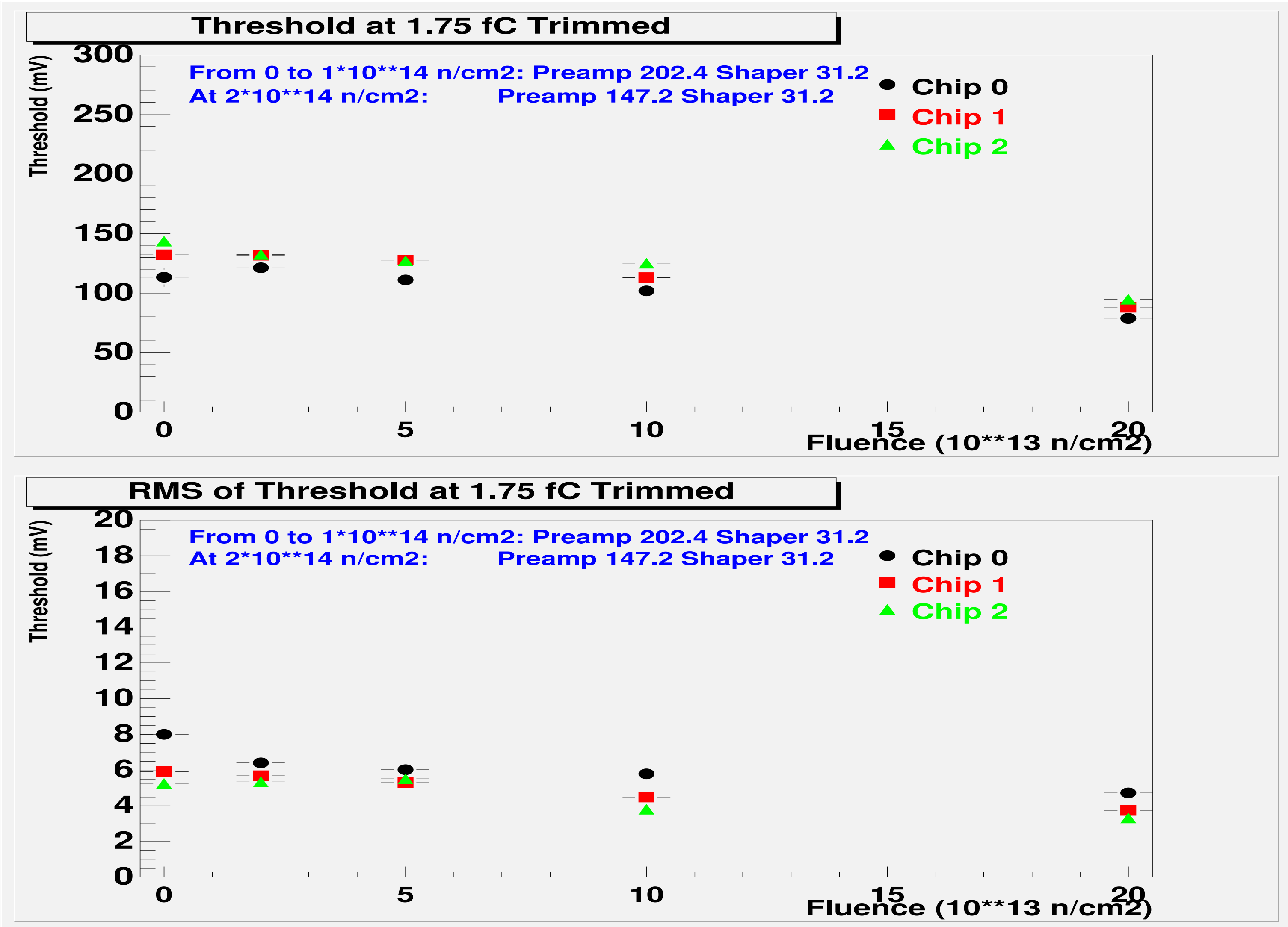
- RMS of threshold (50% point) as a function of fluence for ABCD2T chips

  ➡ not trimmed



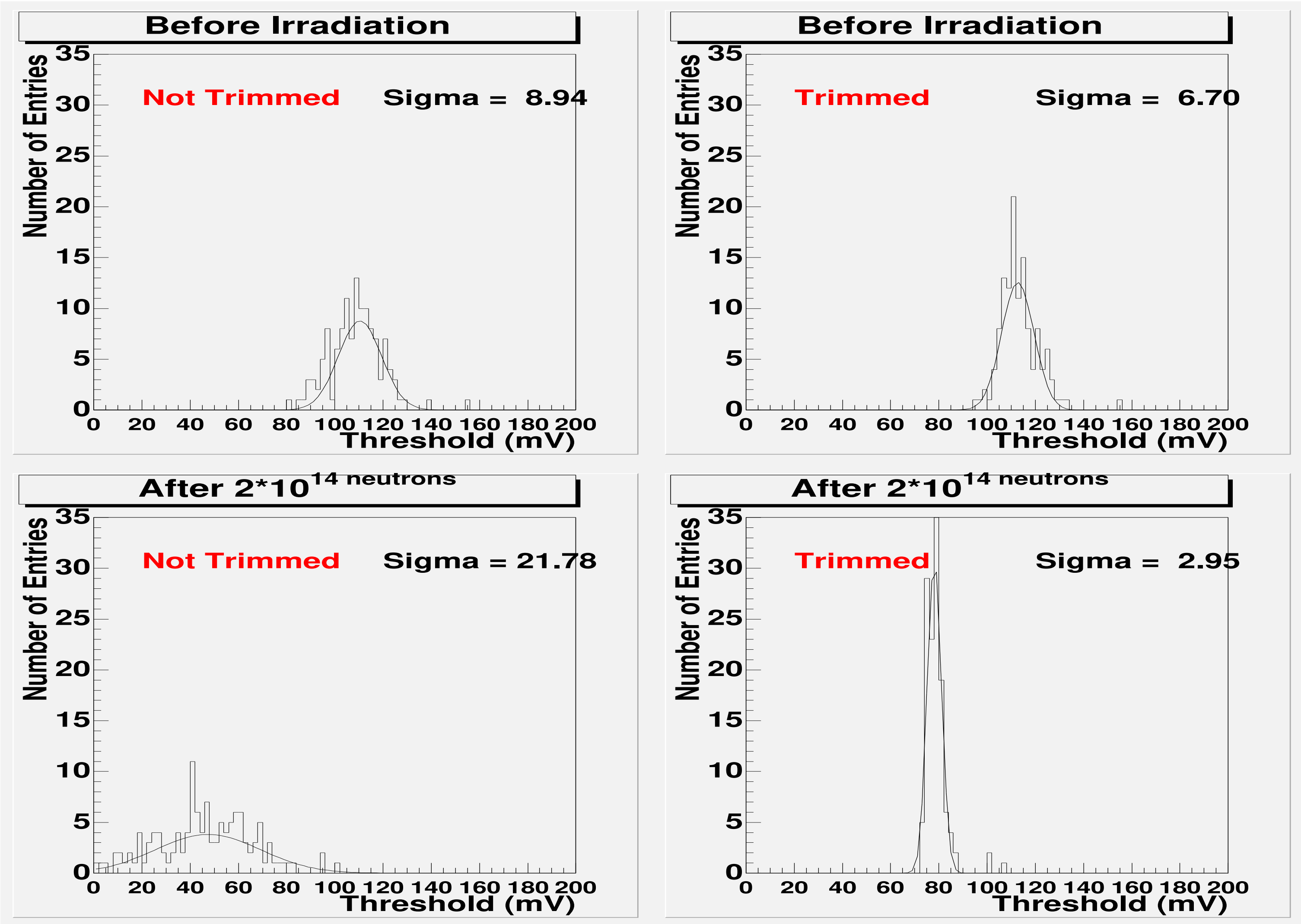
- Thresholds (50% point) as a function of fluence for ABCD2T chips

➡ trimmed

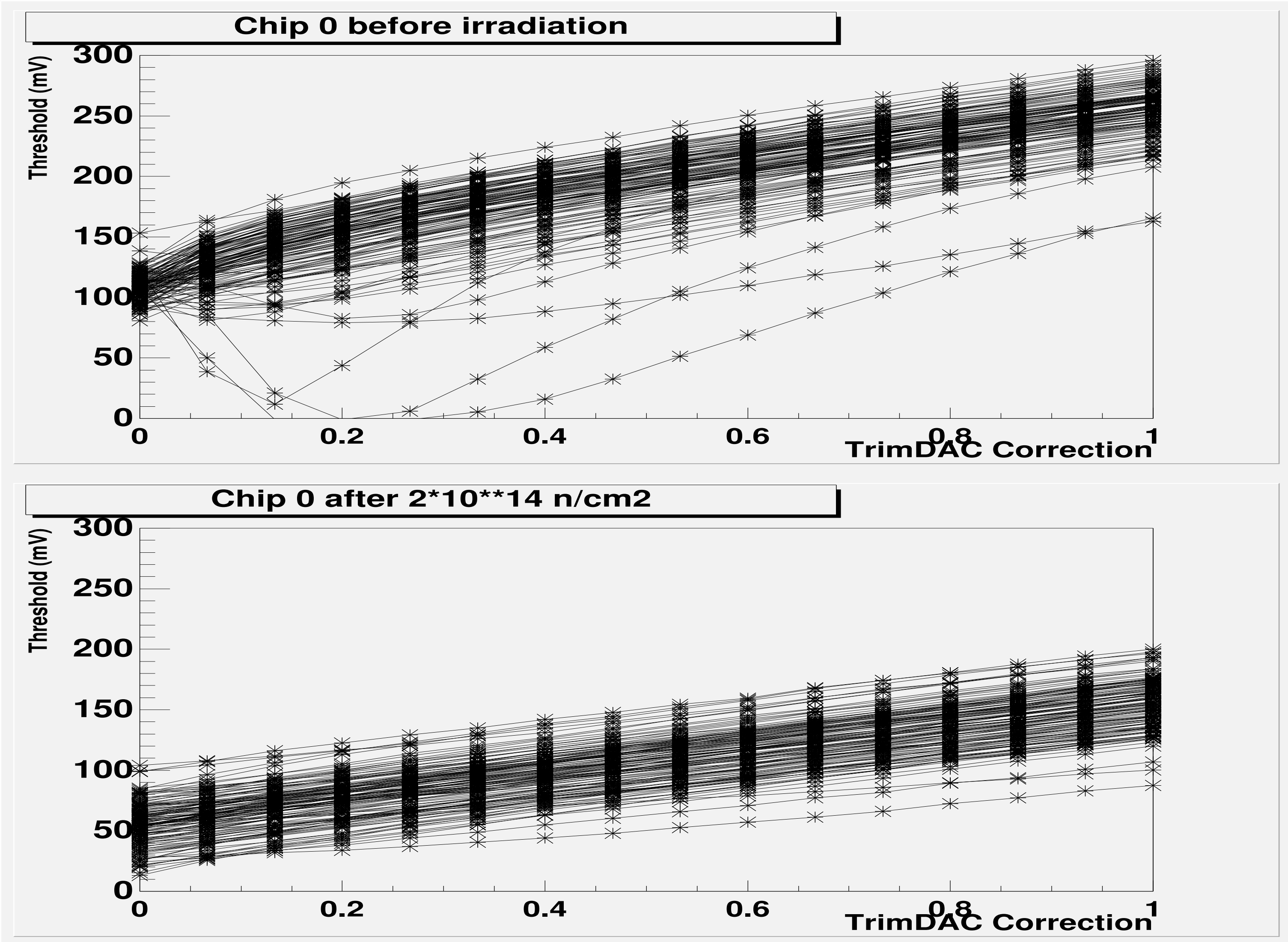


- Threshold distribution before and after irradiation with 2x10^{14} n/cm^2

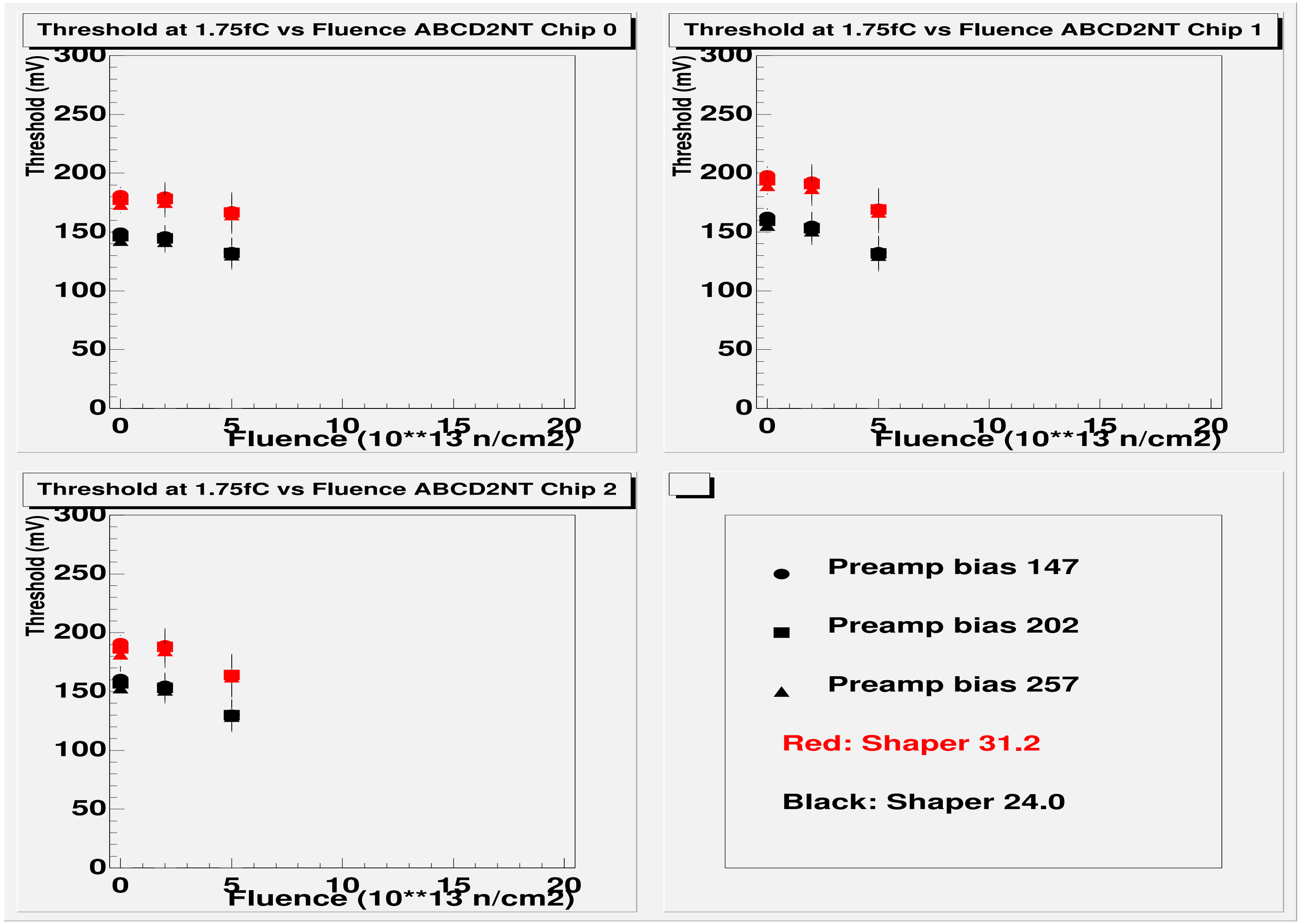
ABCD2T chip 0, Preamp current = 147.2 μA, Shaper current = 31.2 μA



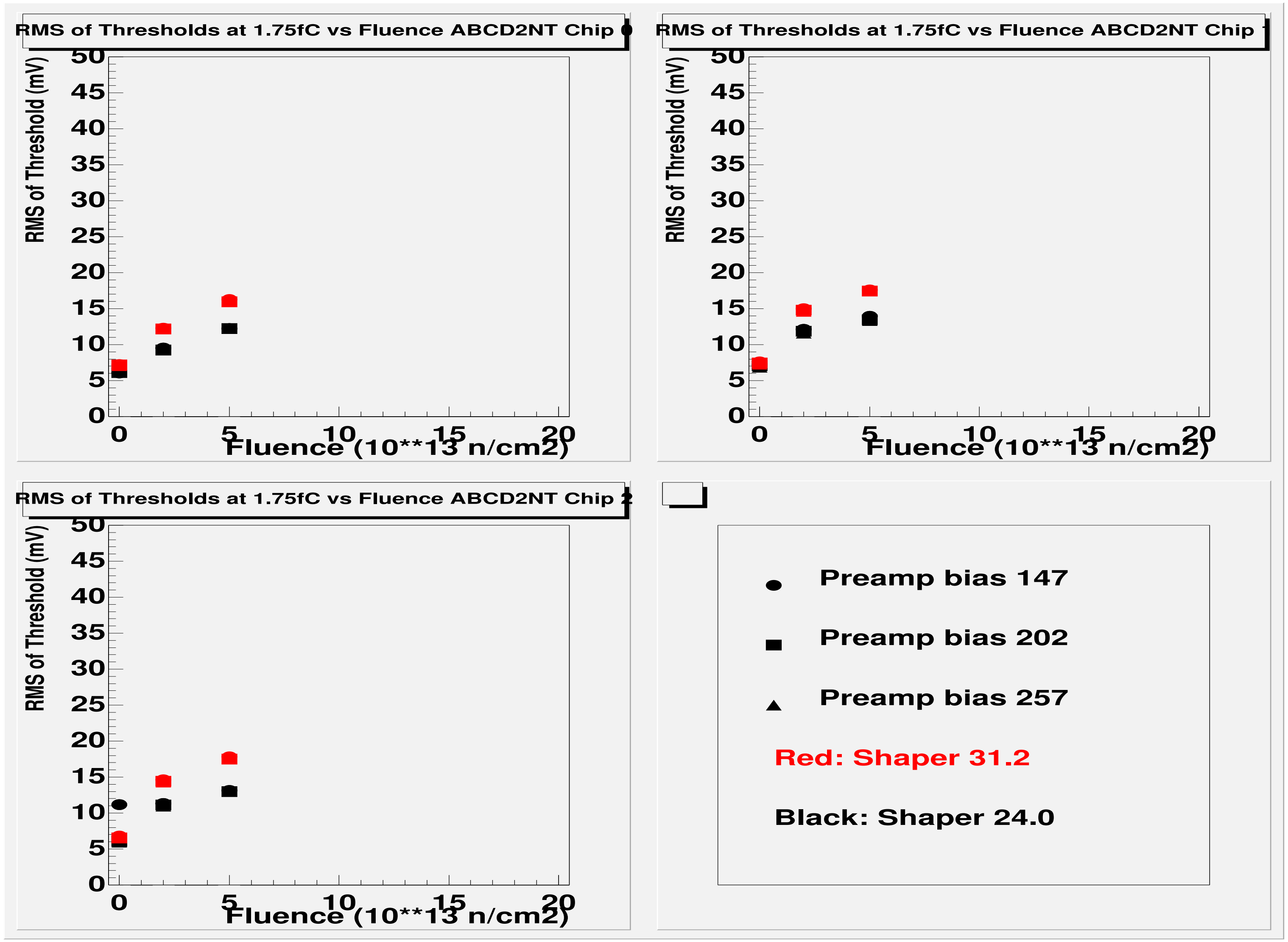
• Trim DAC charachteristics before and after irradiation with 2x10^{14} n/cm^2
ABCD2T chip 0



• Threshold (50% point) as a function of fluence for ABCD2NT chips

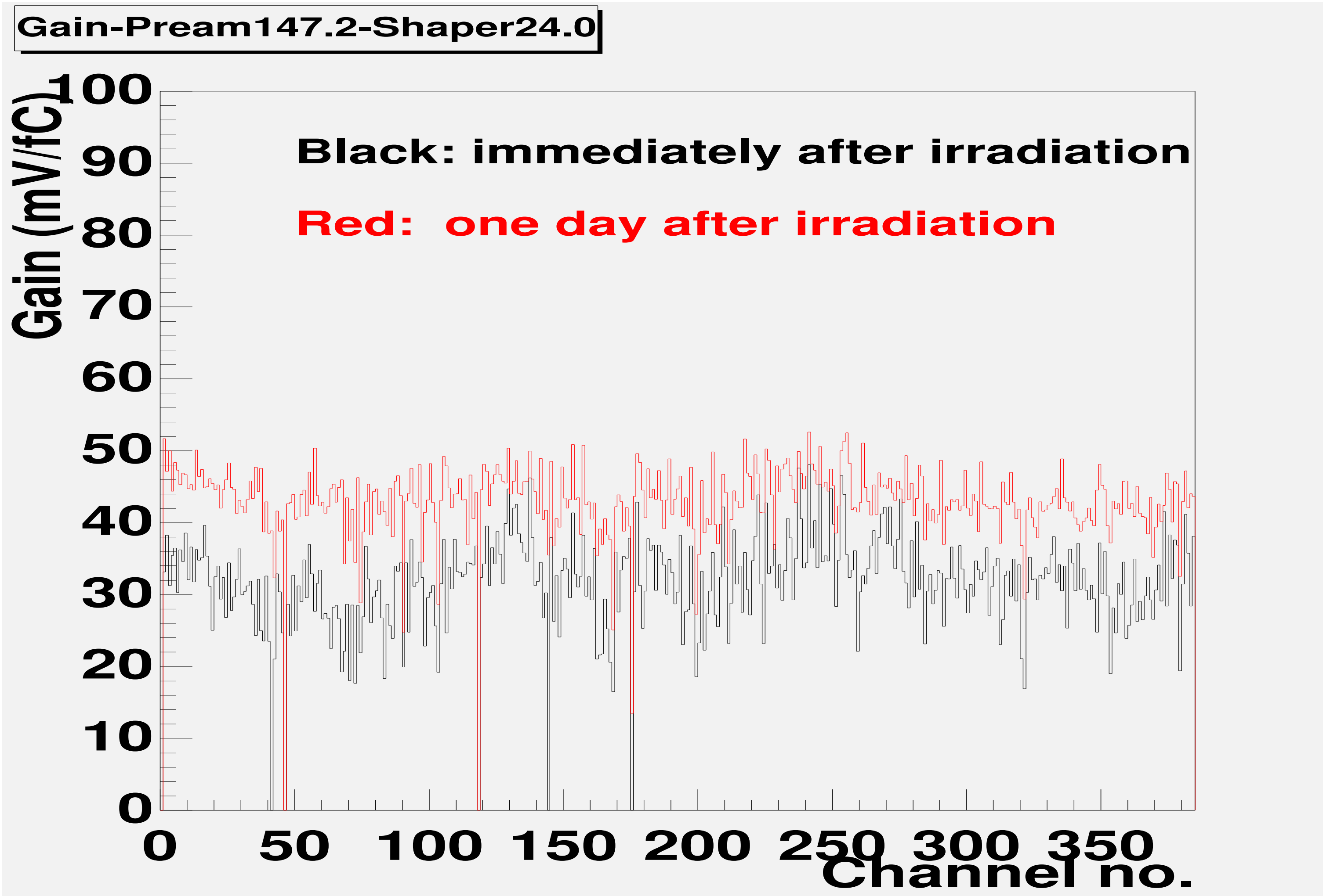


• RMS of threshold (50% point) as a function of fluence for ABCD2NT chips



• there might be some annealing: gain measured one day after irradiation is larger than gain measured immediately after irradiation with 2×10^{14} n/cm^2

ABCD2T chips, Preamp current = 147.2 μA, Shaper current = 24.0 μA



Conclusions from ABCD2T/NT irradiation:

ABCD2T:

- chips work after irradiation with $2x10^{14}$ n/cm^2
- operating range of preamplifier bias current smaller than before irradiation

  before: works at any setting   after: works below ~200 µA
- gain dropped from ~70 mV/fC to ~40 mV/fC
- noise increased from 400 ENC to 800 ENC
- threshold spread increased from ~10mV to ~20mV

  ➡ but can be trimmed down to 3mV
- possible annealing: must check the chips next week

ABCD2NT:

- chips work after $5x10^{13}$ n/cm^2
- after $1x10^{14}$ n/cm^2 return only 0-hit data

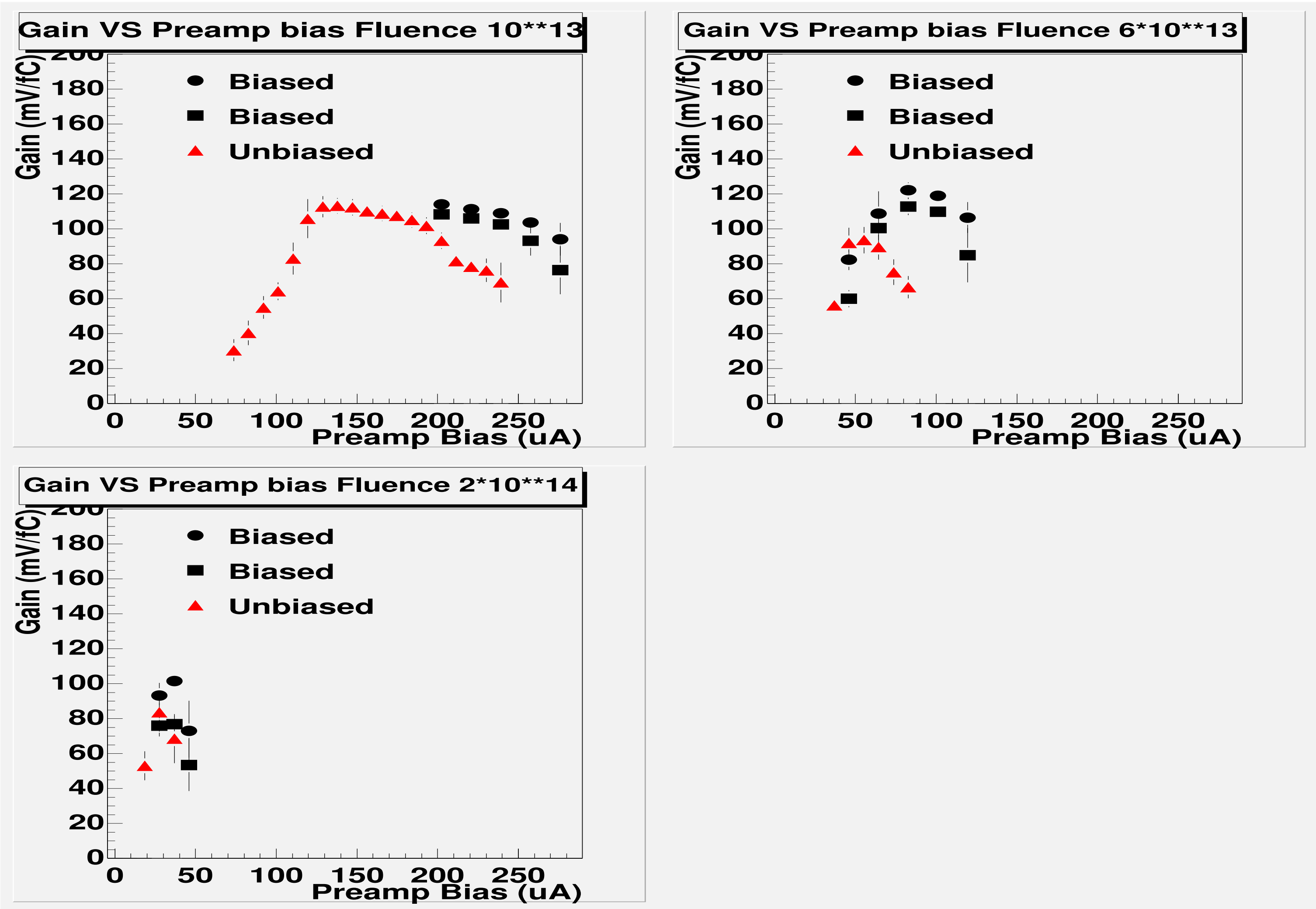
Irradiation of unbiased ABCD2 chips:

- 6 n-type ABCD2 bare chips have been irradiated: 2chips to $1x10^{13}$ n/cm^2
  2 chips to $6x10^{13}$ n/cm^2
  2 chips to $2x10^{14}$ n/cm^2

- after irradiation one chip for each fluence was mounted on the Freiburg kapton hybrid used for irradiation of biased (and clocked ...) ABCD2 chips

- performance of chips irradiated biased was compared to the performance of chips irradiated unbiased

- Gain as a function of preamp current for n-type ABCD2 chips irradiated unbiased and biased



Conclusions from unbiased chip irradiation:

- similar behaviour as a function of fluence for the chips irradiated under bias and for those irradiated without bias

⇨ it is much simpler to irradiate unbiased (bare) chips

⇨ for irradiation of a large number of chips (i.e. one from each wafer for QA) this could be the method