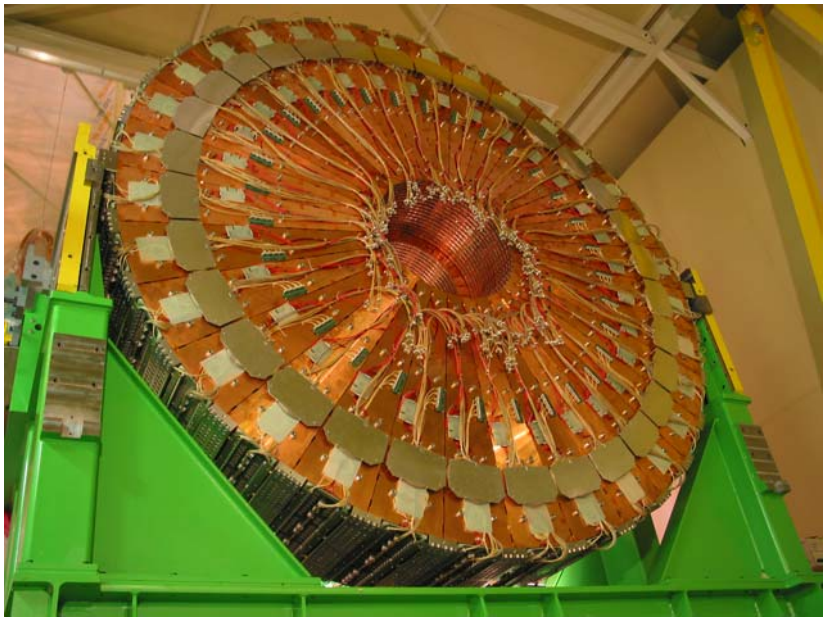
# Radiation Hardness Of HEC Electronics



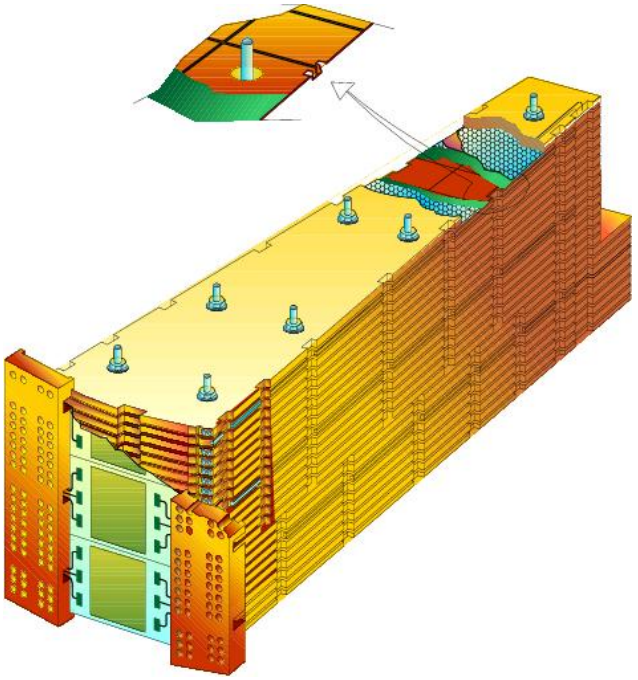
Emanuel Rauter ATLAS HEC

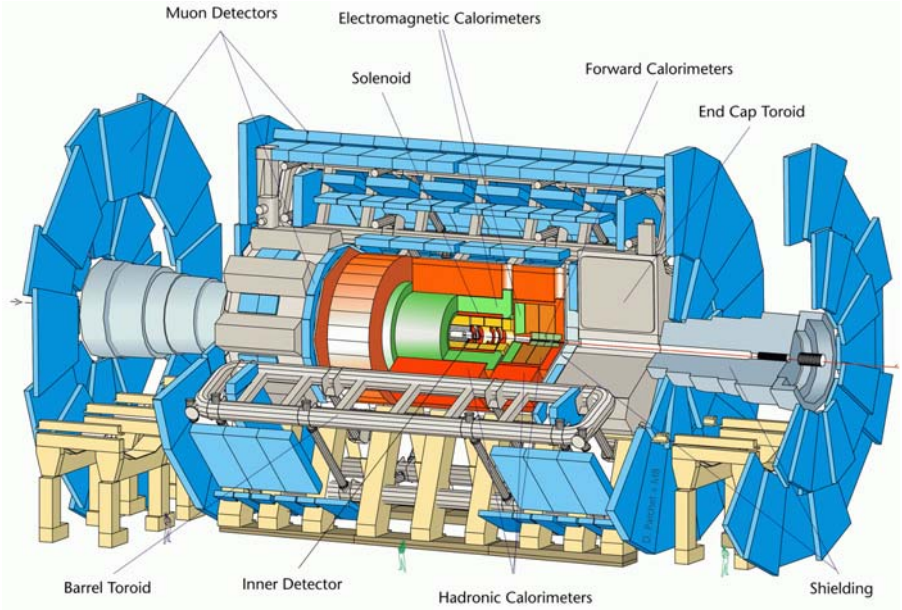
# Contents

- Calorimeter
- Electronics
- Radiation effects on electronic components
- Test of radiation hardness

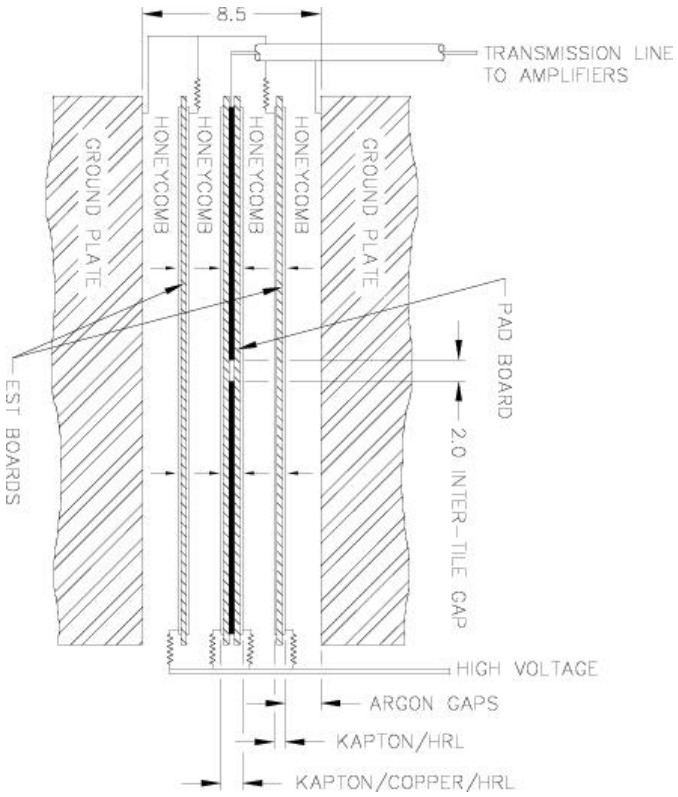
# The Calorimeter

Hadronic End Cap Calorimeter of ATLAS is a LAr Calorimeter, i.e. Argon as aktive material, cupper plates as absorber material.





# Recalling The Principle




- Incoming particles cause shower of secondary particle

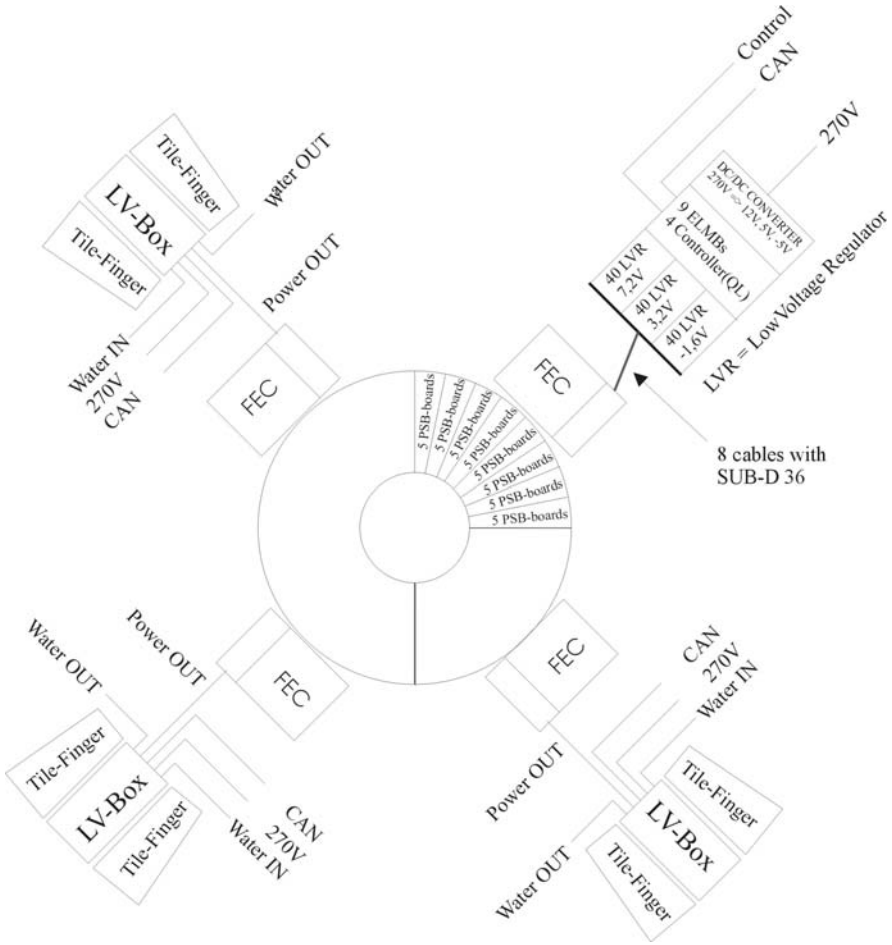
=> ionisation of Ar

- In electrical field (HV) electrons drift towards electrodes and induce charge.
- Due to the electron drift velocity the signal response is slow (400ns), but rise time of the signal (~1ns) is very short.

# Cold Electronics

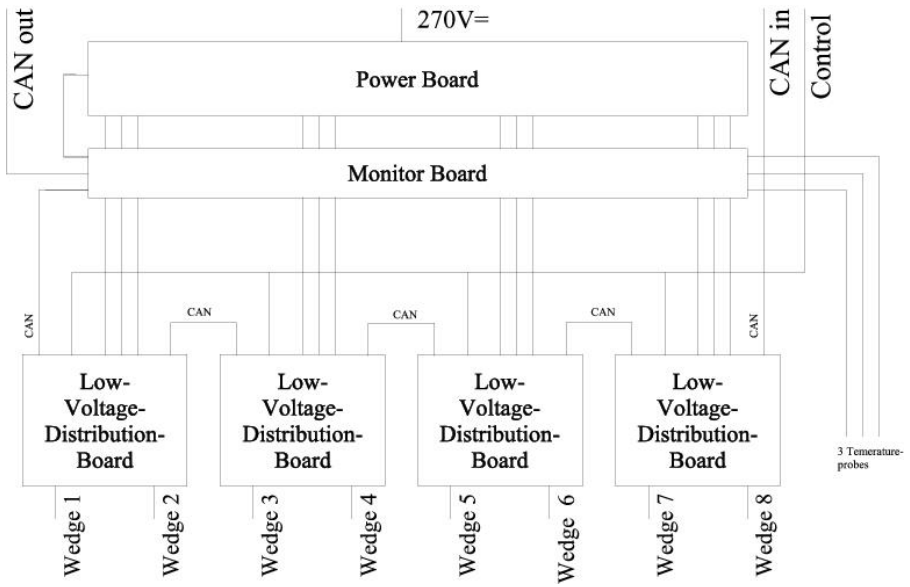
- In conventional LargCalo the signal rise time is limited by capacitance and inductance of signal cables which are used to sum passive. For ATLAS requirements this would be too slow.
- In HEC summing is done active in direct proximity of the gaps together with the pre amplifying.
- Boards with high integrated GaAs chips positioned on circumference of the HEC wheels.
- Those PSB need to be supplied by a low voltage system.

# LV System




- LV System controlled by PVSS
- The boxes are positioned along the outside wall of the cryostat and supplied by 270 V coming from USA15
- Each LV box supplies a quarter of a HEC wheel, meaning 40 PSB.

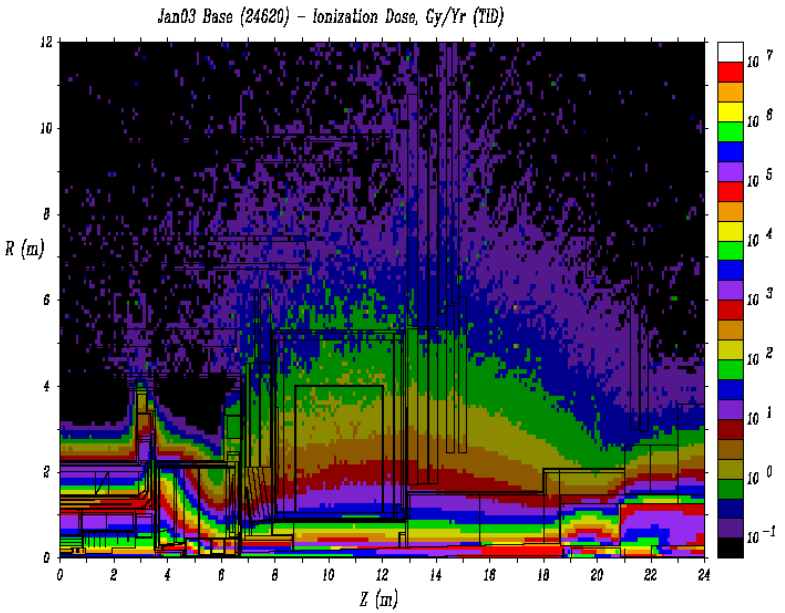
# LV Box

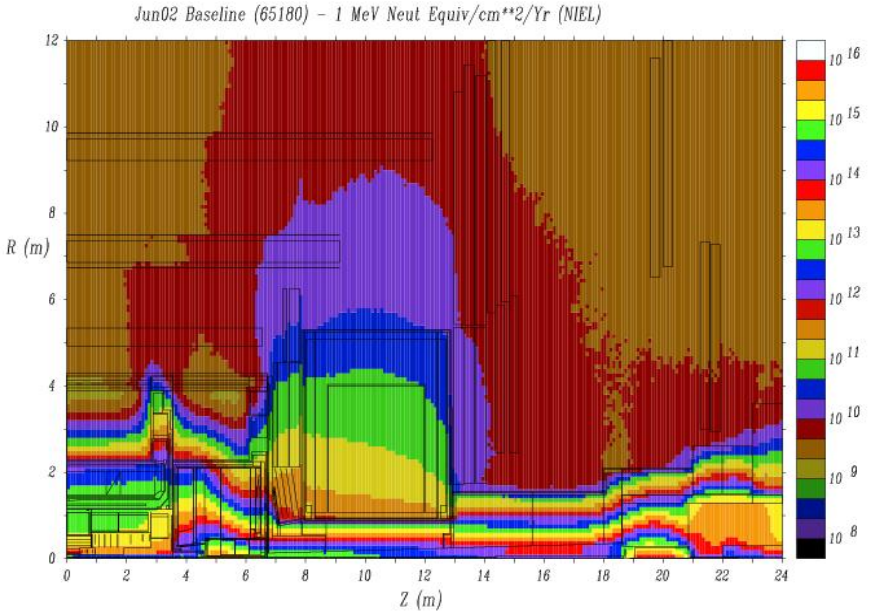



- Power board converting the 270 V supply voltage to the middle voltages of 10 / 6 / - 4 V.
- Distribution boards converting the middle voltages to the output voltages of 7,2 / 3,2 / -1,6 V and distributing them to the single PSB.
- One board monitoring the whole box i.e. currents, voltages and temperatures.

# Radiation in ATLAS

- At high Luminosity running the components will be exposed to a high radiation field of mainly n and $\gamma$.
- RHAWG is supplying Simulations and supervising
- For us: 75 Gy and $1,5 \cdot 10^{12} \frac{n}{cm^2}$



# Radiation Effects

- Displacement: heavy, neutral particles act on bulk
- Chemical bond rupture photon or charged particle

=> Dangling bonds, recombination centers

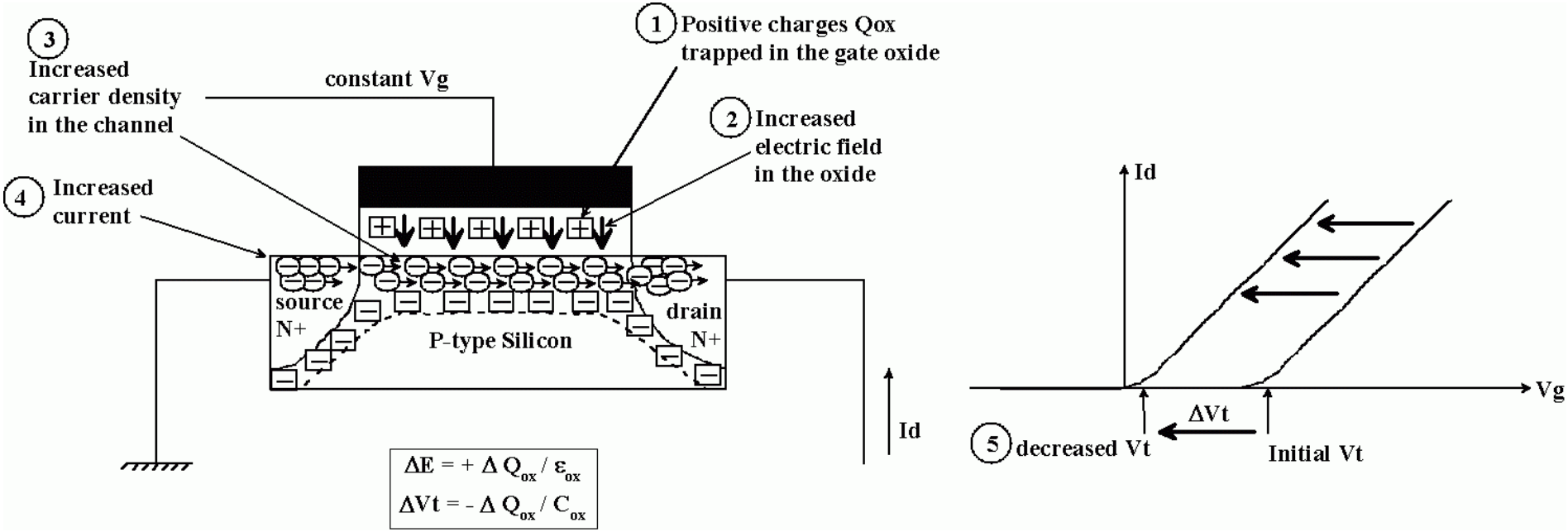
- Ionization i.e. electron-hole pair creation: charged particles act on surface
    - instantaneous SEE

      => high e+e- density => transistant current across oxide
    - accumulated TID

    partial recombination, e+ trapped, e- leaves oxide

    => long term net positive trapped charges

# Threshold Voltage Decrease

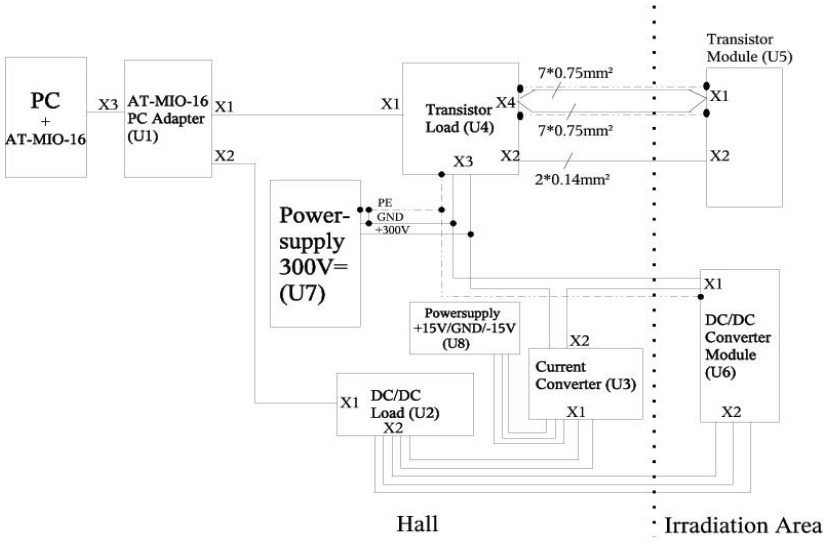


# Setup at JINR In Dubna

- Irradiation carried out at pulsed neutron source ИБР-2.
- ИБР-2:
  - Frequency 5 Hz
  - half width of pulse 220 μs
  - peak power 1500 MW
  - flux 10 Gy/s of $\gamma$ , $10^{12}\frac{n}{cm^2 s}$
- Since flux is too high in direct beam, the equipment was set up in peripheries.

# Measurement

- DC/DC converter module
  - output voltages and input current working under load
- Separate module of power transistors which are used in DC/DC converter
  - switching and measuring drain voltage and current



# Dosimetry

• The methods of threshold detector activation were used to determine the neutron fluence.

•Nickel probes placed in irradiation area were activated by the reaction

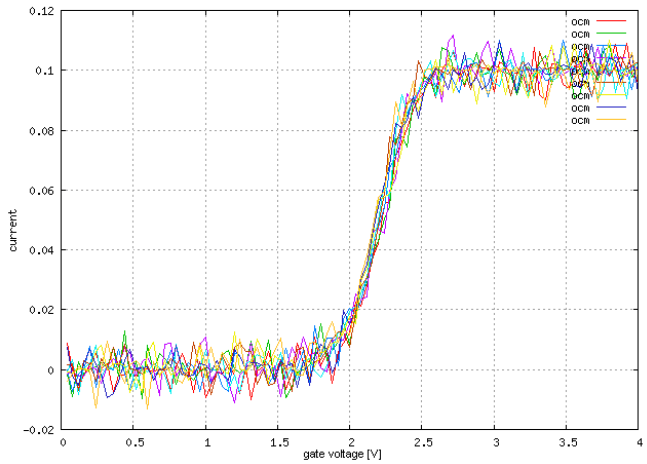
$$^{58}Ni(n, p)^{58}Co$$

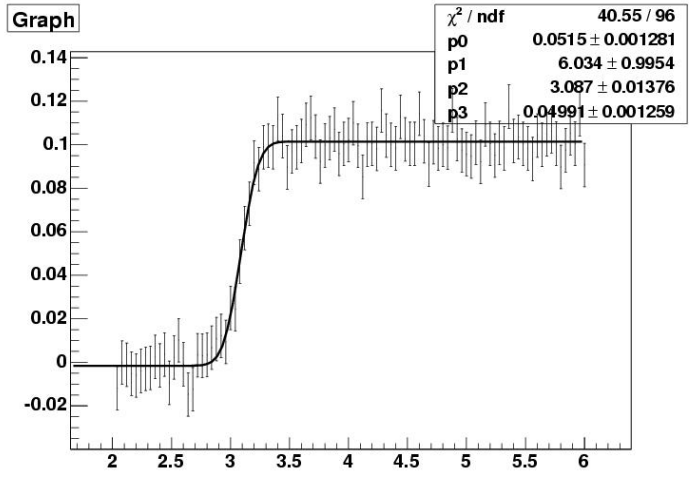
• Induced γ- activity of this reaction was measured with a GeLi detector

Latest values: $6.9 \cdot 10^{7} \frac{n}{cm^{2}s}$ at the position of the DC/DC converter

• The γ-dose rate was measured (by some kind of γ-dosimeters) to be 4.9 Gy per hour

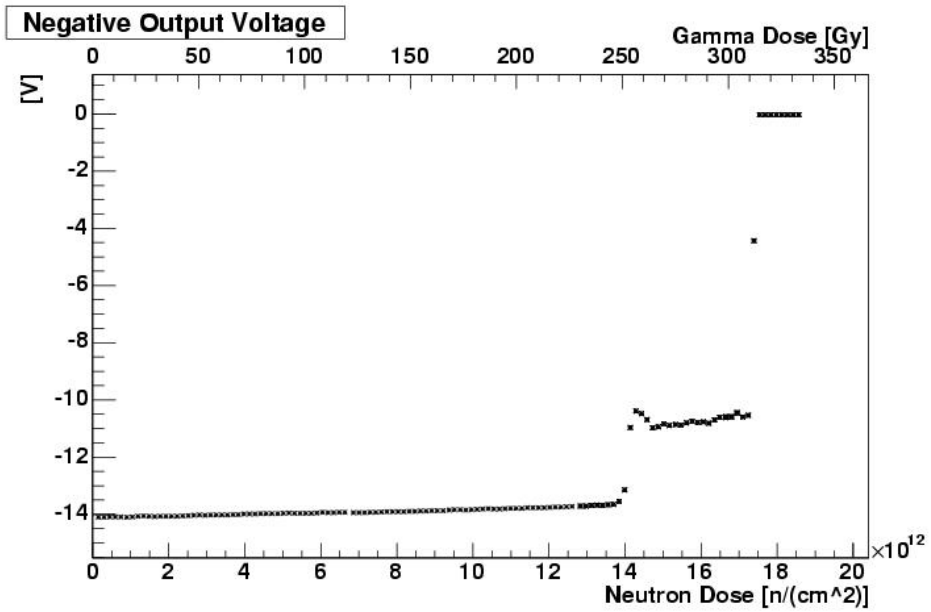
# Results, Noise

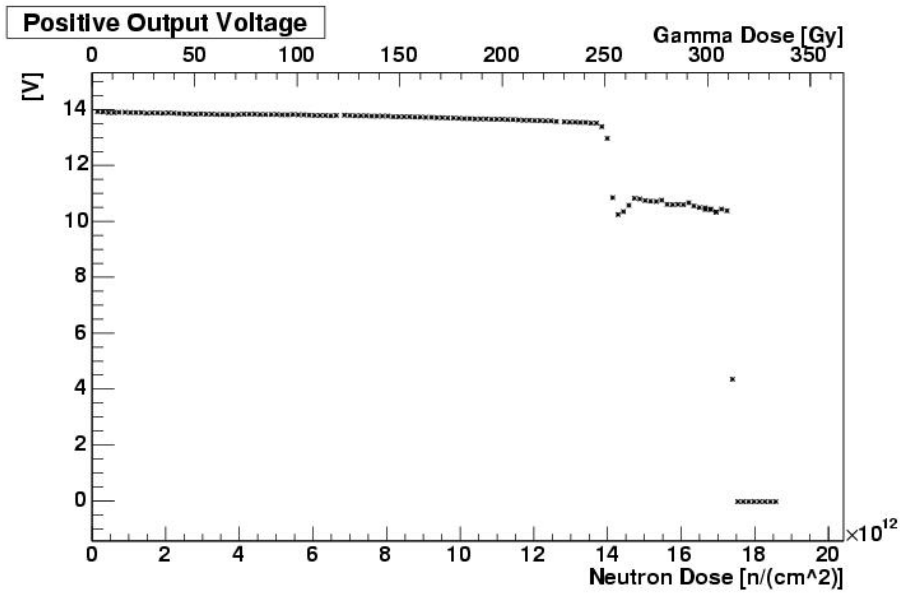


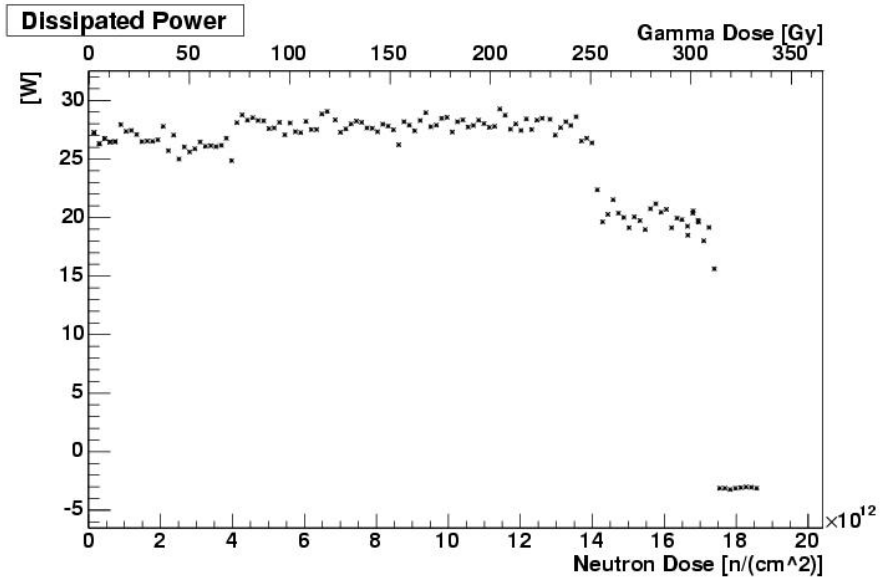

- Unexpected huge, high frequency noise, not well understood, because of 1s sampling
- Data analysis with fit on error function for transistors, averaging for DC/DC converter

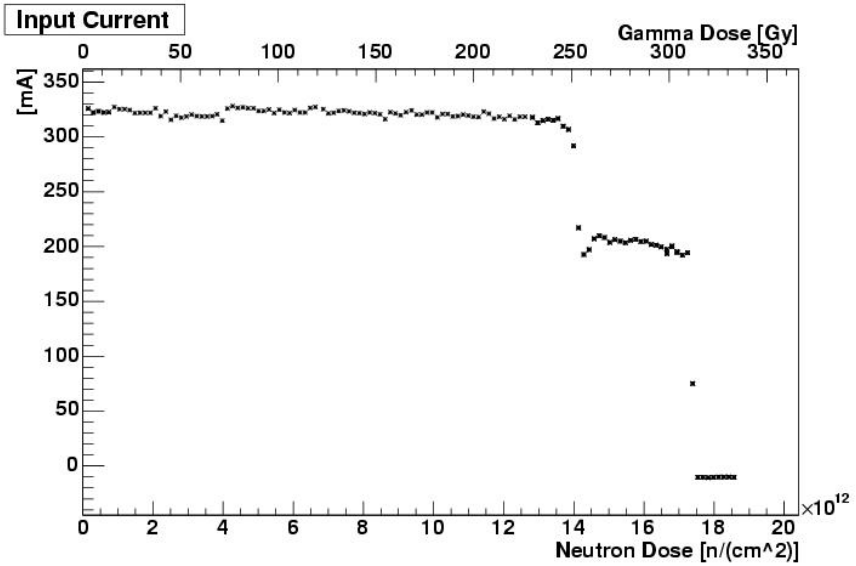
# DC/DC Converter



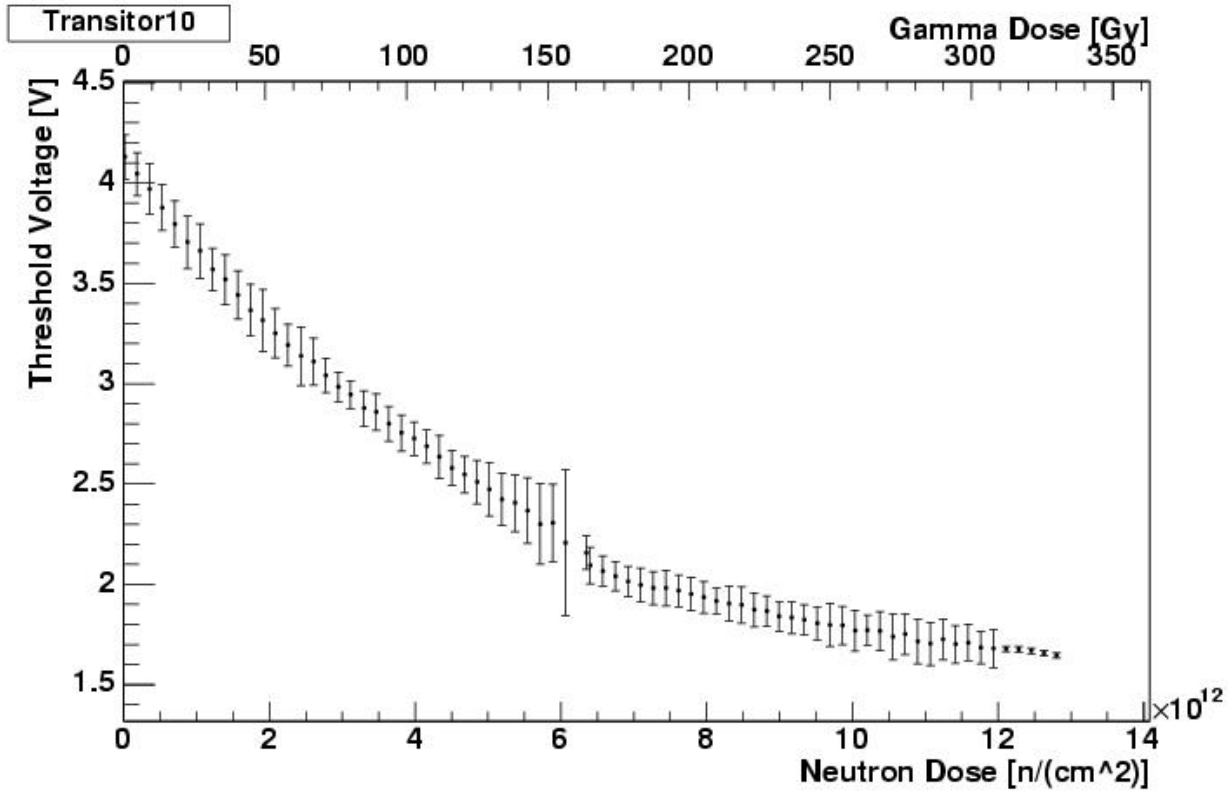



# DC/DC Converter



# Transistors



# Conclusion / Outlook

- Requirements are fulfilled for single modules
- Load transistors not responsible for breakdown of DC/DC converter, probably caused by failure of control transistors
- Next test in Dubna of whole system
- Better understanding of dosimetry is needed
- Other radiation effects SEE to be tested in proton beam

# Literature


• Oberlack, Schacht, ATLAS – Ein Schluesselexexperiment zum Verstaendnis von Kraeften und Materie, MPI-PhE/2000-27

•Dentan, Radiation Effects on Electronic Components, http://atlas.web.cern.ch

• Giustino Radiation Effects on Semiconductor Devices, POLITECNICO DI TORINO I Facoltà di Ingegneria, Marzo 2001

• Cwienk, Habring, Rudert, LV Powersupply, HEC Note 137