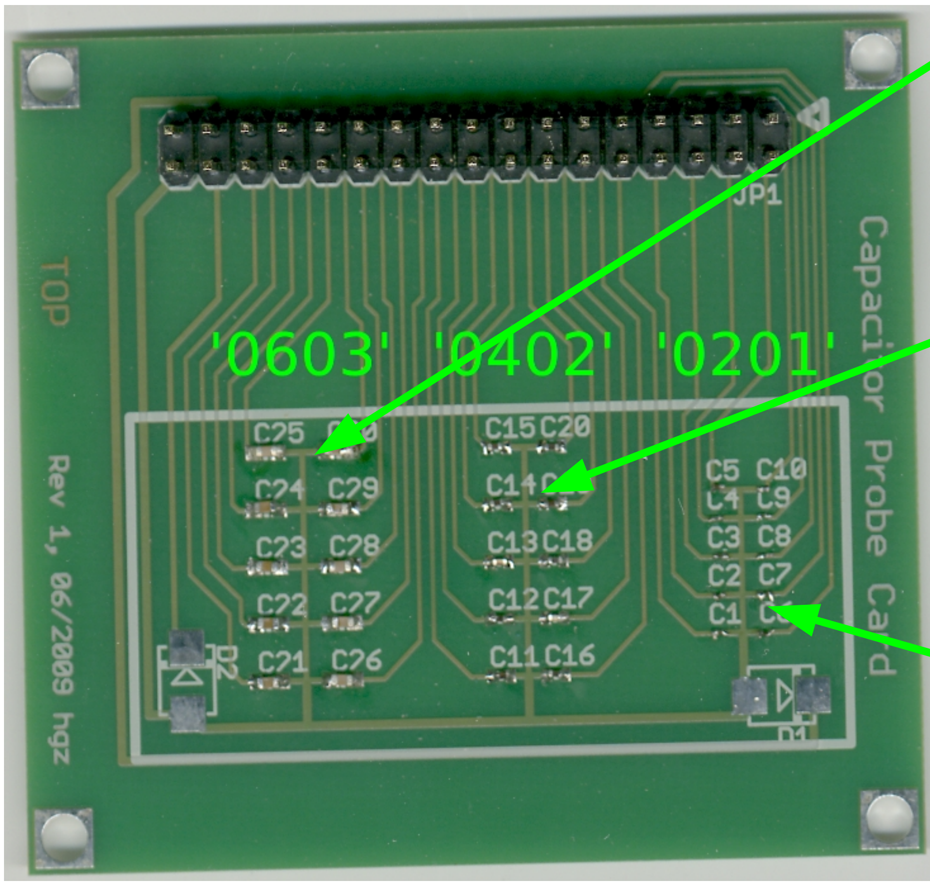
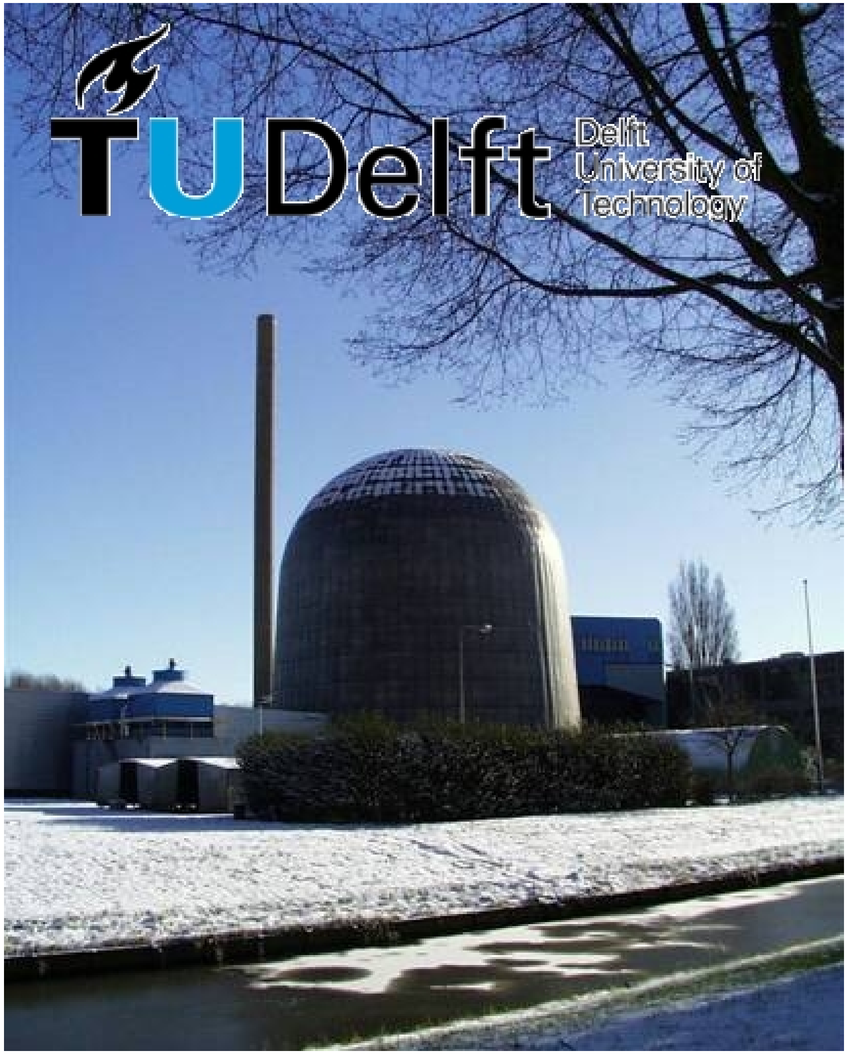
Radiation Hardness of capacitors

The examined capacitors



- Taiyo Yuden,
  100nF,
  6.3V rated voltage,
  0.6mm*0.3mm²(0201)
- Kemet,
  100nF,
  16V rated voltage,
  1mm*1.5mm²(0402)
- Kemet,
  100nF,
  16V rated voltage,
  1.6mm*0.8mm²(0603)

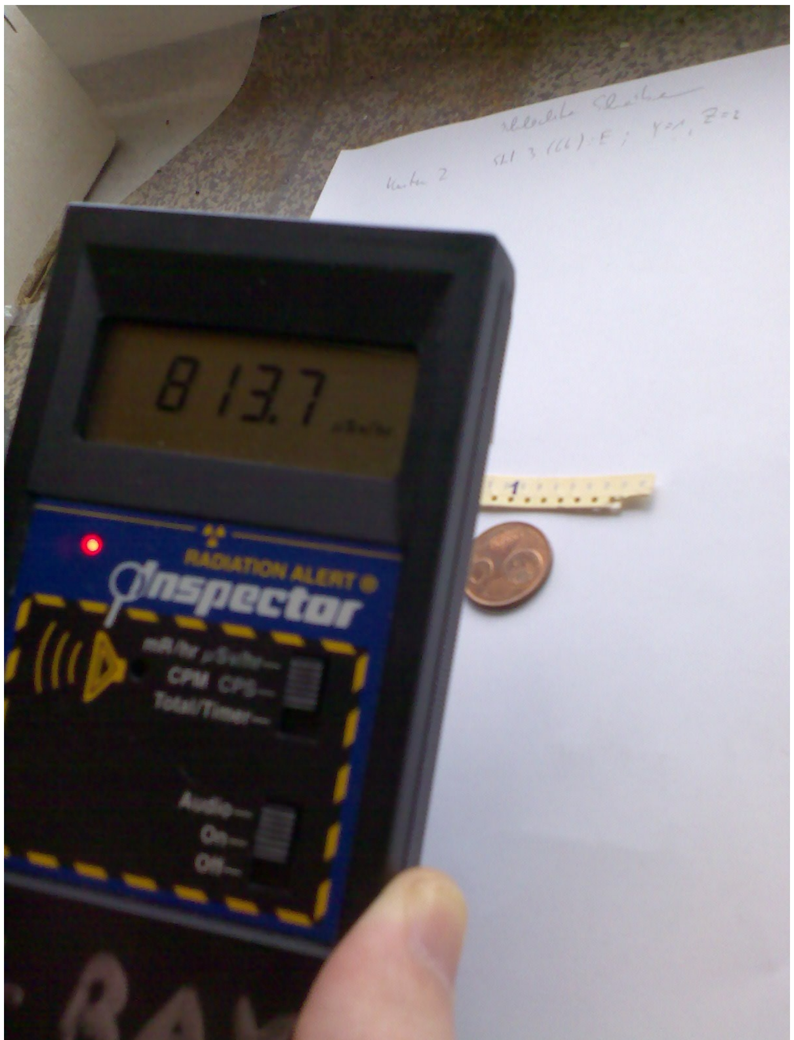
Radiation @TU Delft



A batch of each capacitor-type has been irradiated with neutrons at the reactor of TU Delft.

energy range	**fluence** $\left[\frac{\text{neutrons}}{\text{cm}^2}\right]$
thermal neutrons (< 100 meV)	$1,656 \cdot 10^{17}$
epithermal neutrons (< 1 eV)	$1,602 \cdot 10^{15}$
fast neutrons(< 20 MeV)	$1,1664 \cdot 10^{16}$

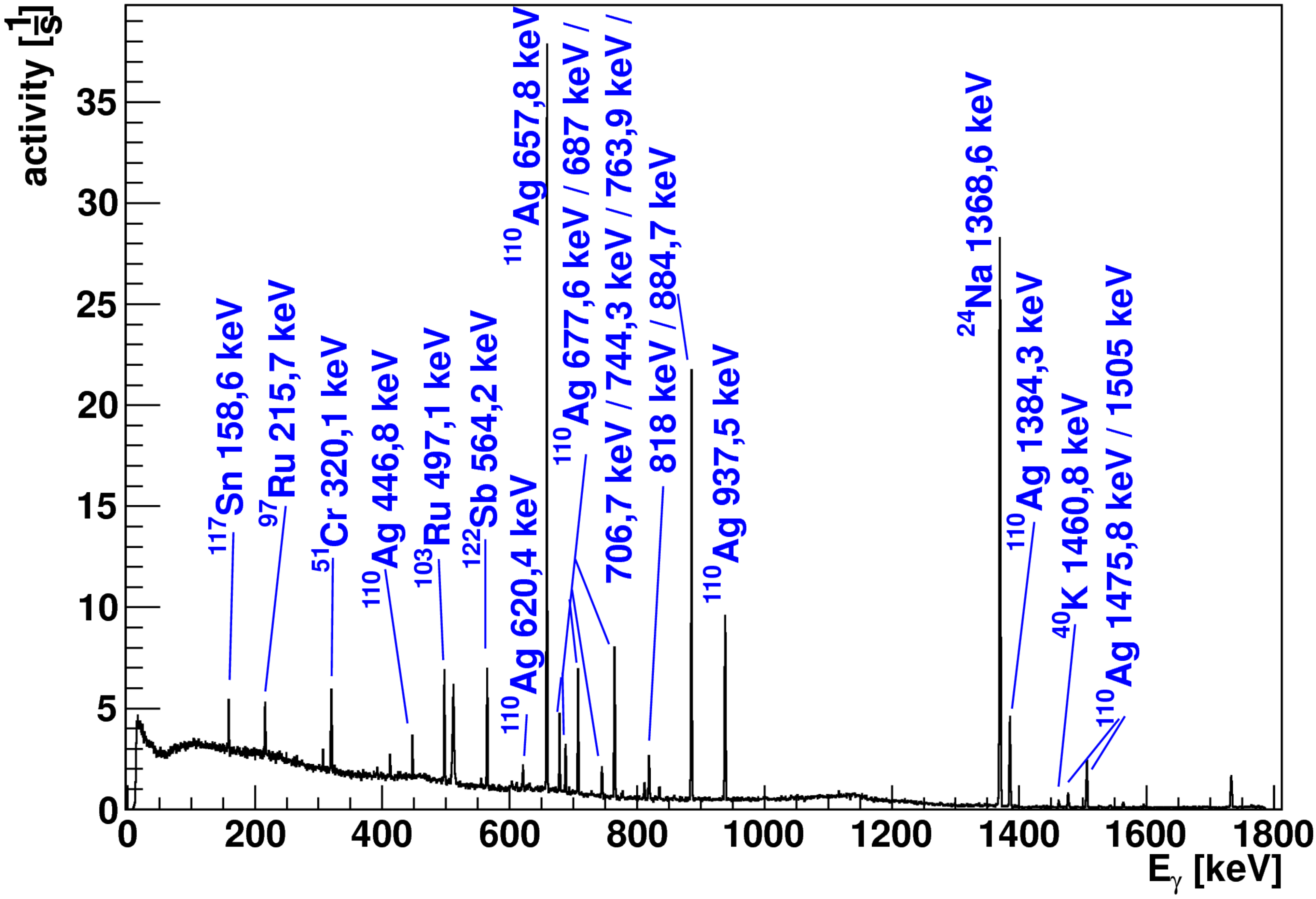
Strong activation after radiation



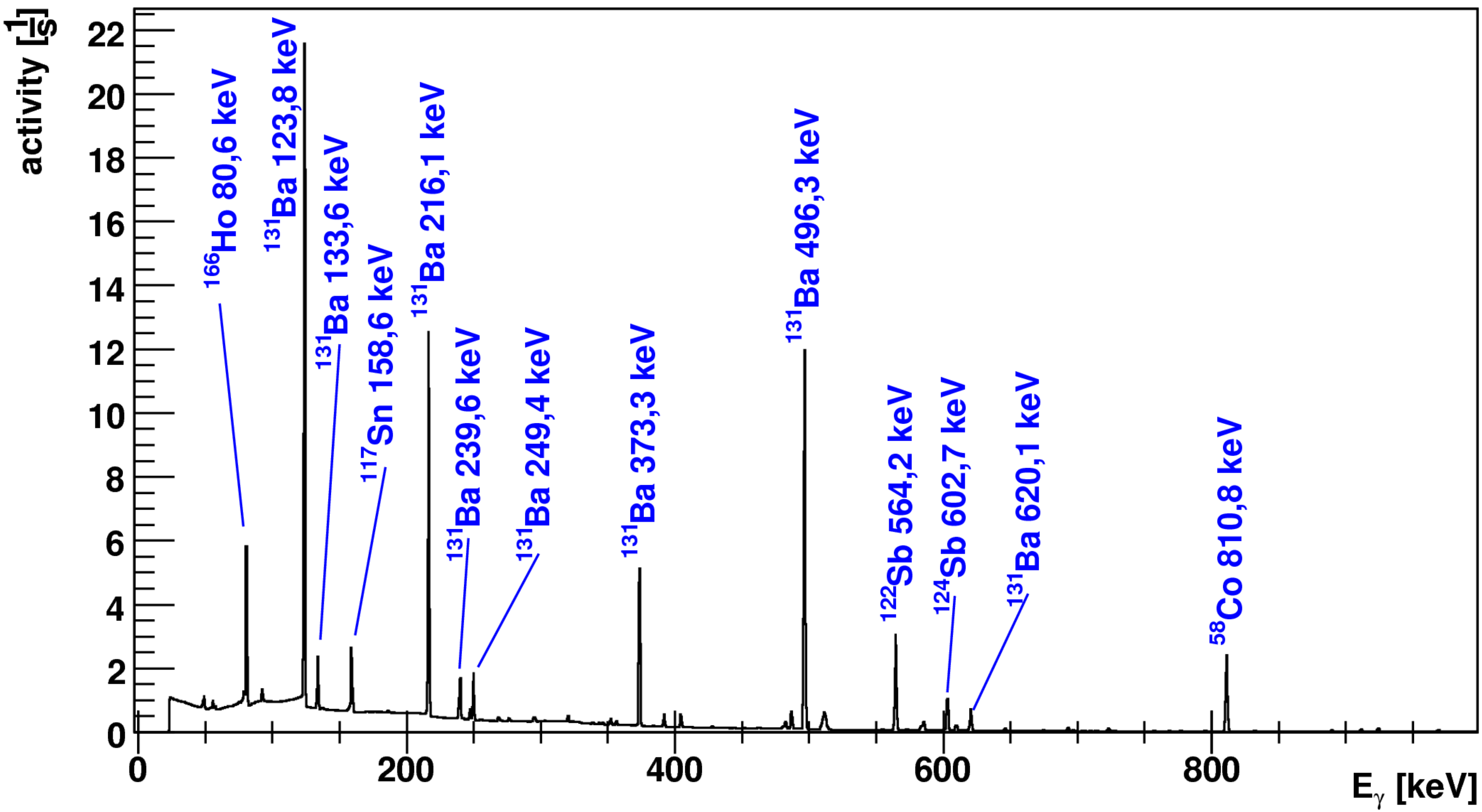
$>800\,\frac{\mu\mathrm{Sv}}{\mathrm{h}}$ at day 4 after irradiation make it impossible to immediatly start the electrical analysis.

Gamma spectra can be taken at that time.

Neutron activation analysis, 0603



Neutron activation analysis, 0201



Neutron activation analysis

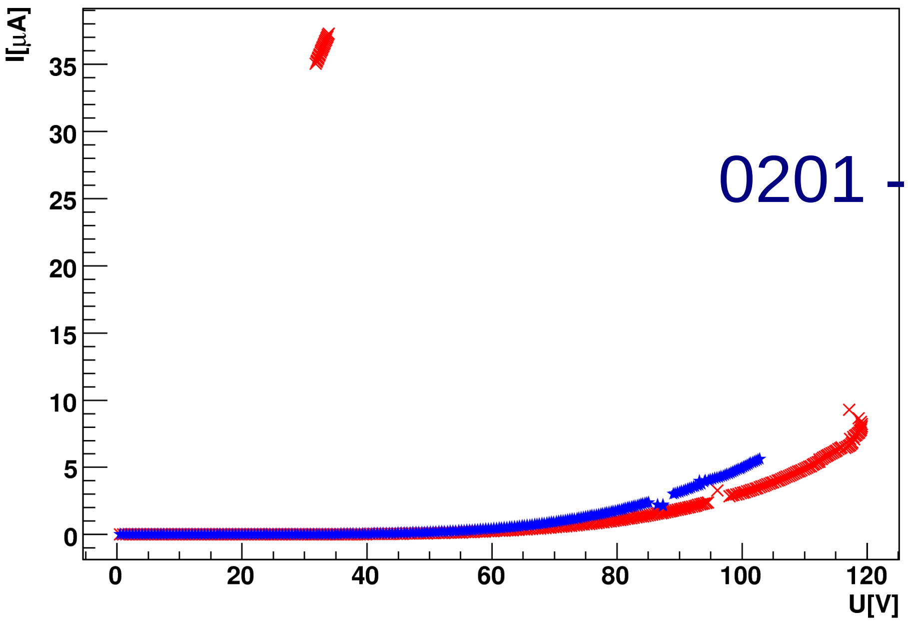
nuclides, 0603	$T_{1/2}$ [d]	$\sigma_{n,th.}$ [b]
$^{116}Sn \rightarrow {}^{117}Sn$	13,6	0,13
$^{96}Ru \rightarrow {}^{97}Ru$	2,9	0,29
$^{50}Cr \rightarrow {}^{51}Cr$	27,7	15,9
$^{109}Ag \rightarrow {}^{110}Ag$	249,8	91,1
$^{102}Ru \rightarrow {}^{103}Ru$	39,3	1,27
$^{121}Sb \rightarrow {}^{122}Sb$	2,7	5,8
^{58}Co	70,9	
$^{23}Na \rightarrow {}^{24}Na$	15h	0,53
$^{39}K \rightarrow {}^{40}K$	$1,25 \cdot 10^9$ a	2,1

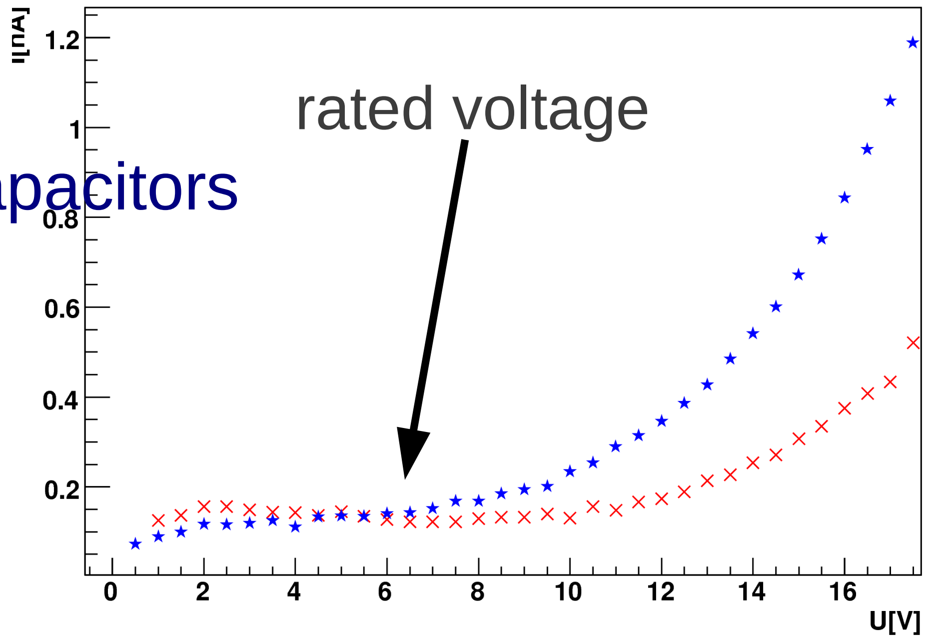
nuclides, 0201	$T_{1/2}$ [d]	$\sigma_{n,th.}$ [b]
$^{165}Ho \rightarrow {}^{166}Ho$	26,82	64,7
$^{130}Ba \rightarrow {}^{131}Ba$	11,5	8,7
$^{116}Sn \rightarrow {}^{117}Sn$	13,6	0,13
$^{121}Sb \rightarrow {}^{122}Sb$	2,7	5,8
$^{123}Sb \rightarrow {}^{124}Sb$	60,2	3,9
^{58}Co	70,9	

The use of low neutron capture cross section materials is preferred for $\overline{P}$ANDA.

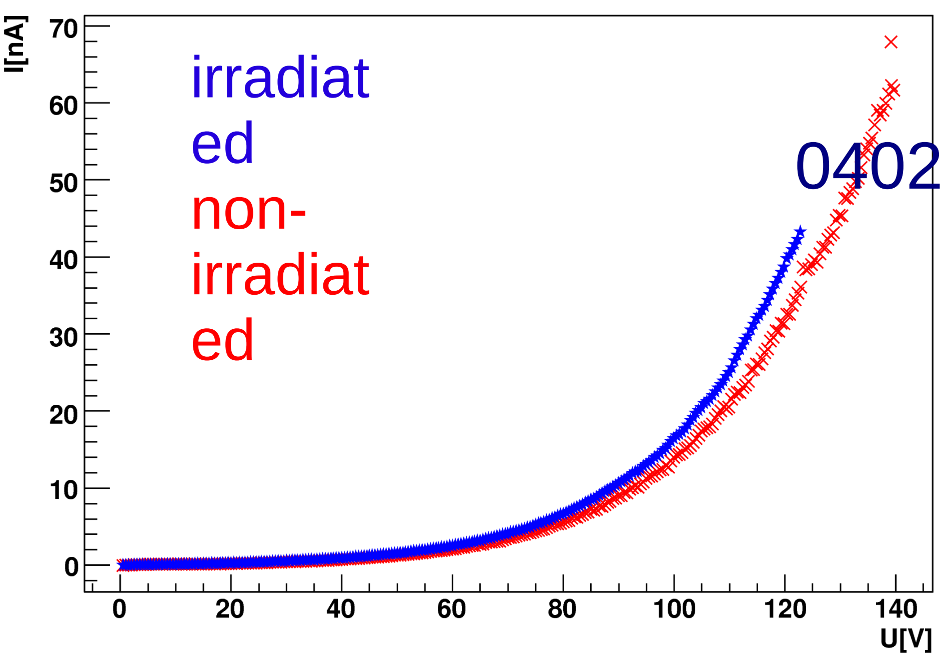
Leakage current

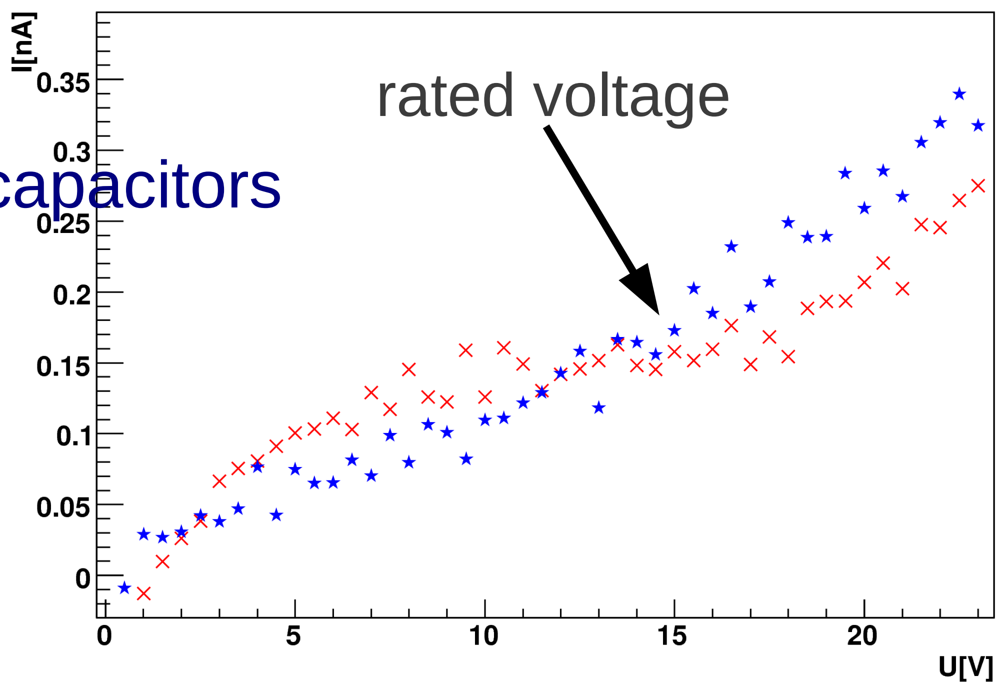
0201 - capacitors



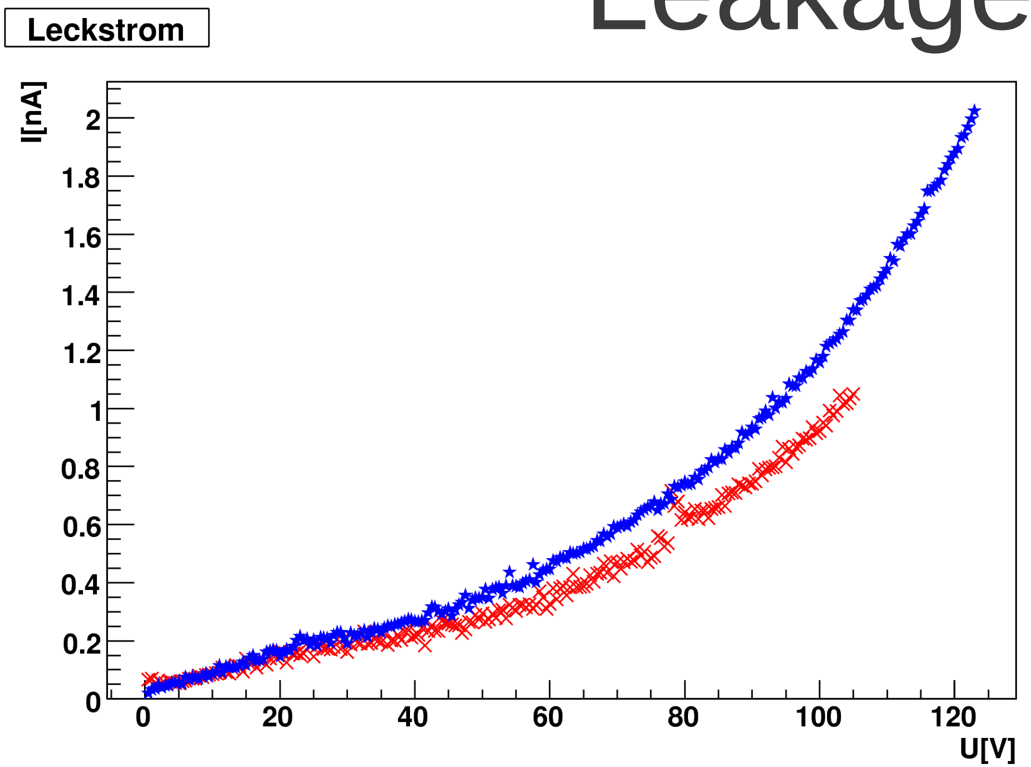


0402 - capacitors





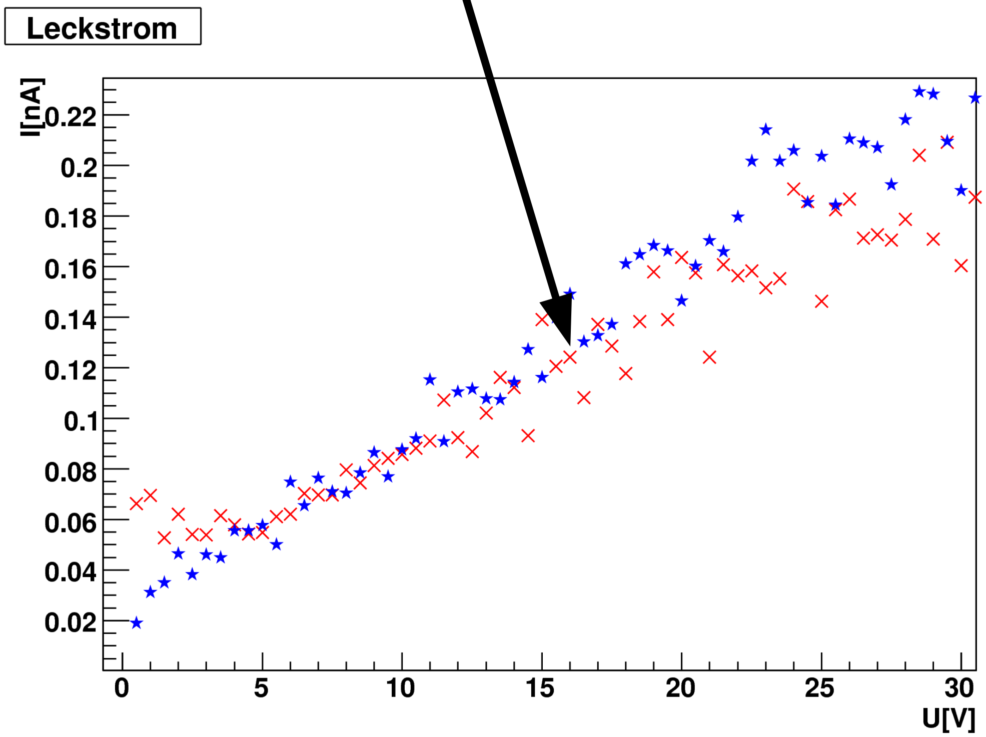
Leakage current



0603 – capacitors

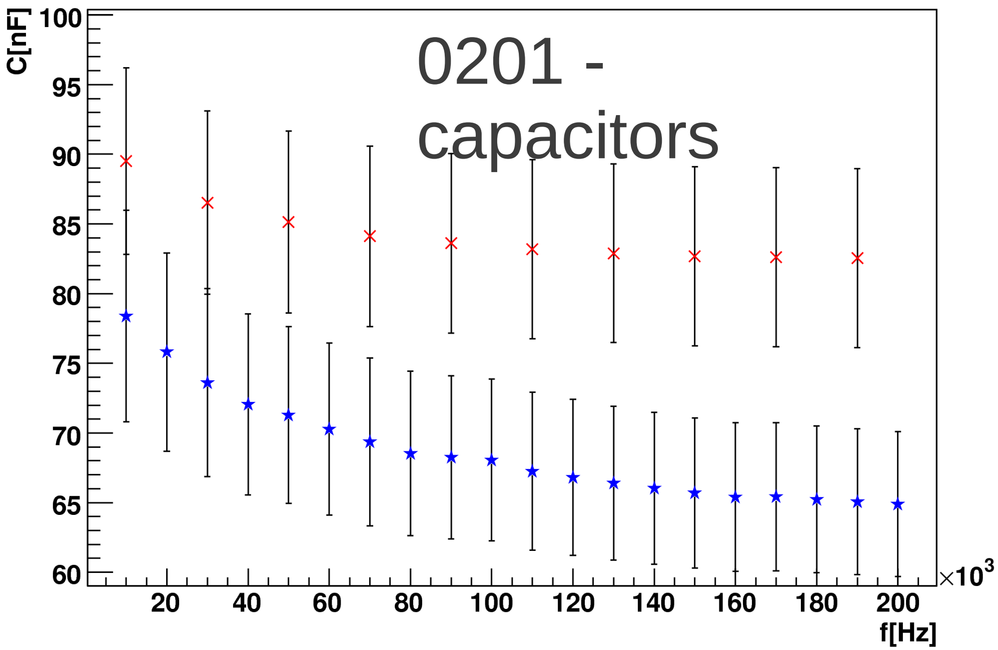
irradiated
non-irradiated

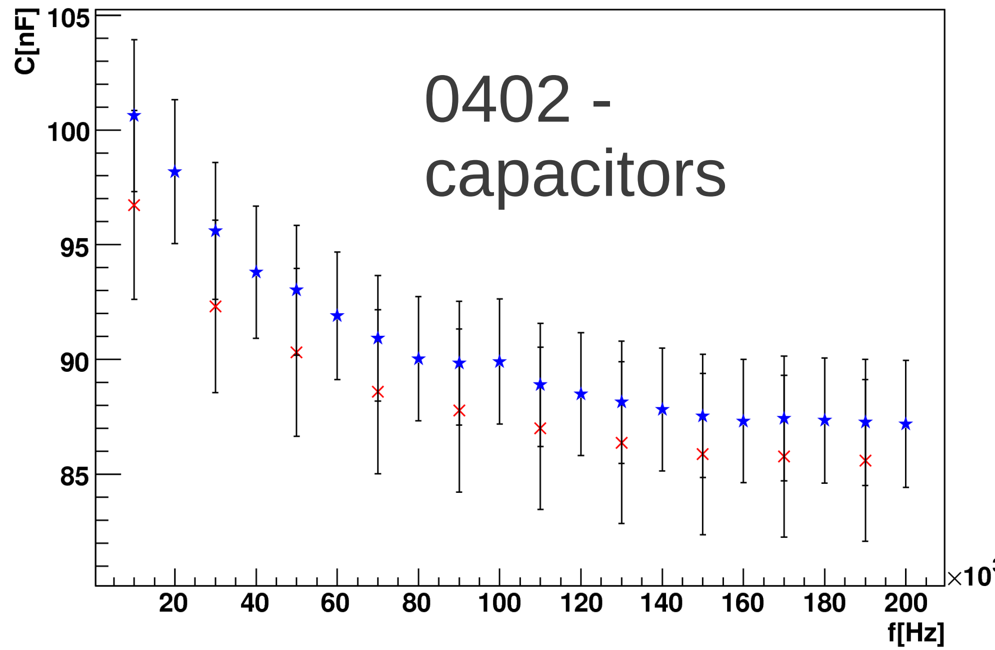
Rated voltage

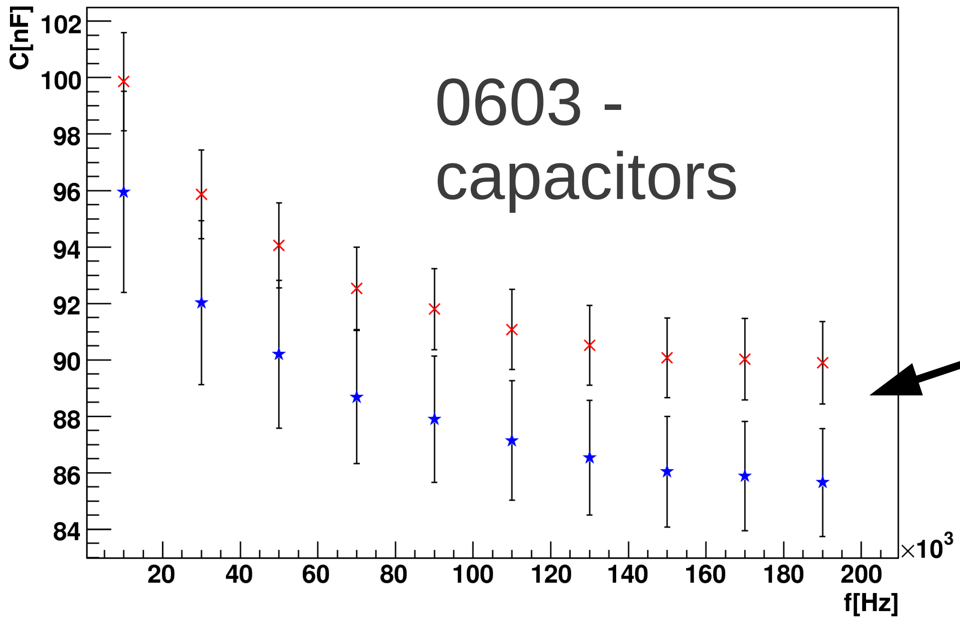


All irradiated capacitors show a higher leakage current than their non-irradiated equals, but only at voltages above their rated voltage.

capacitance







test a larger number to be sure that it's not statistic fluctuation

Conclusion

Even though the 0201-capacitors showed the biggest changes in capacitance and leakage current due to irradiation, they are still the best choice because of their lower activation.

A larger number of 0201-capacitors should be examined to determine if the seen behavior is typical for all 0201-capacitors or for capacitors of this manufacturer (Taiyo yuden).

Thank you for your attention!