Accelerator-Based Neutron Source GENEPI2 at LPSC

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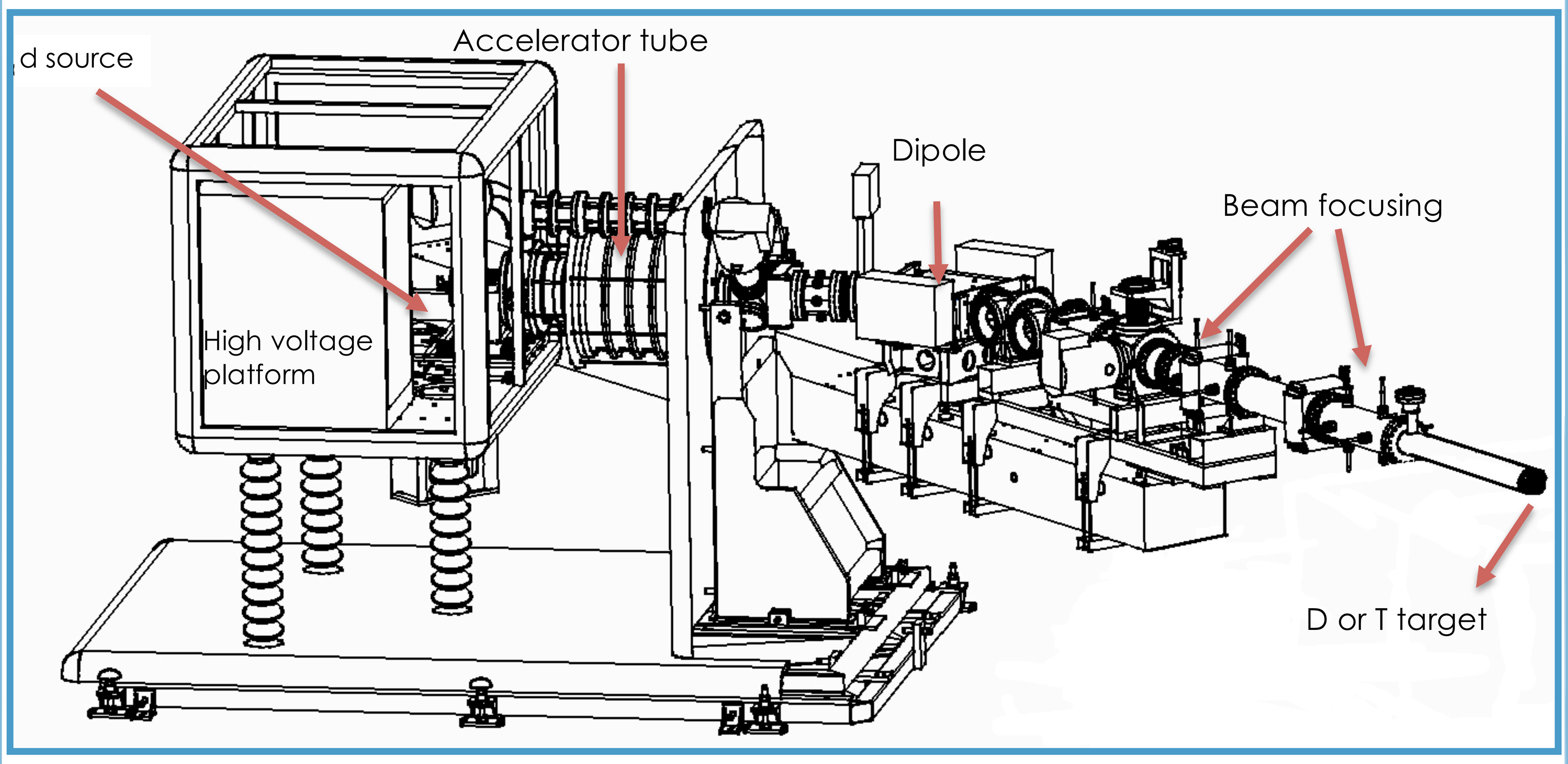
EXPERIMENTAL FACILITY

GENEPI2 (Intense Neutron Generator) is a deuteron (d) accelerator dedicated to fast neutron production. The deuteron beam is produced by a duoplasmatron source. After acceleration at 250 keV and magnetic selection, the beam impacts either a tritium (T) or a deuterium (D) target to produce neutrons by one of the fusion reactions:

- dT reaction : $d + T \rightarrow n + \alpha$
- dD reaction : $d + D \rightarrow n + {}^{3}He$



Blueprint of GENEPI2 ion source, accelerator tube and beam line.

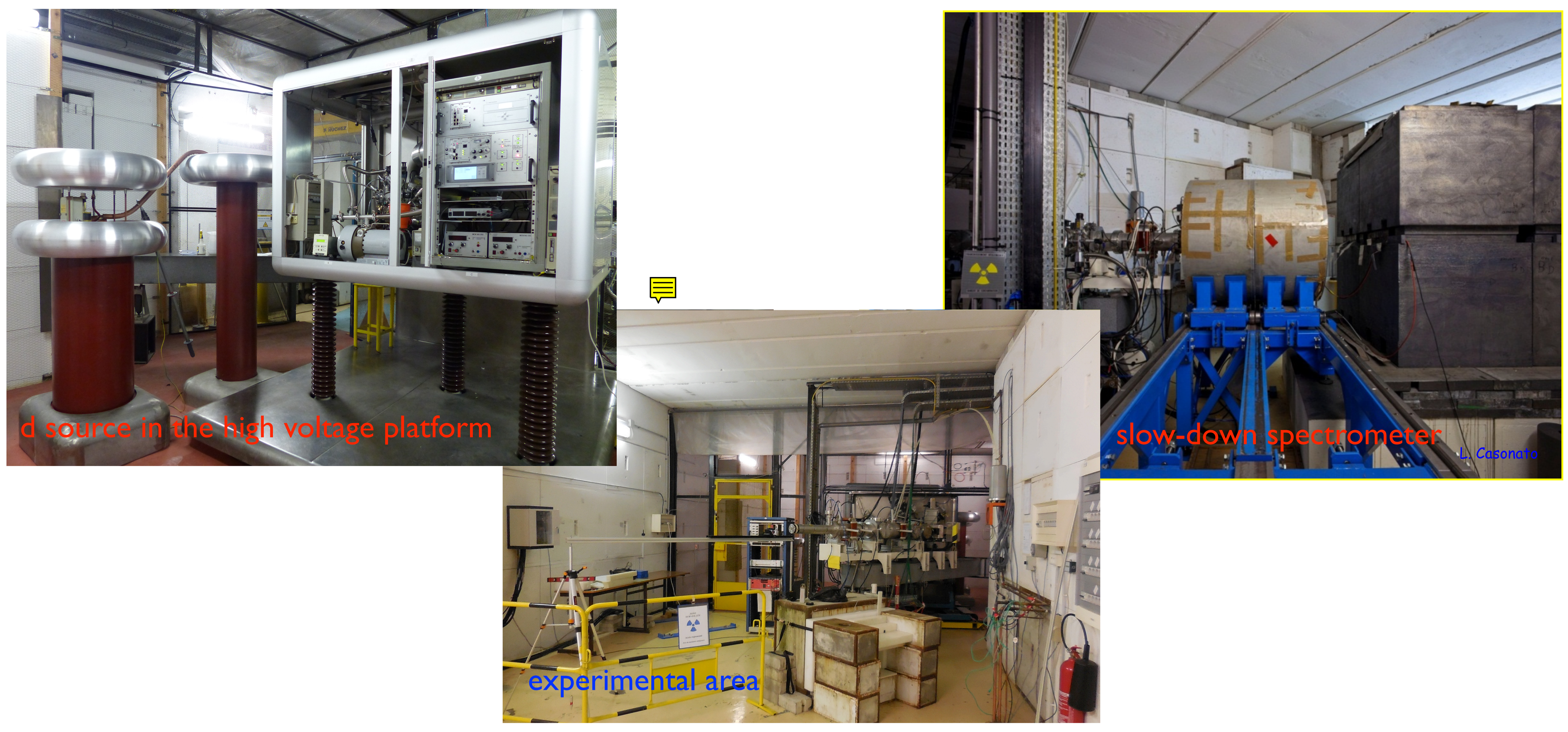
GENEPI2 is a part of the platform for nuclear energy research called PEREN at LPSC (Grenoble). Its main goal is to measure nuclear cross-sections supporting future nuclear reactor concepts. For this reason, the neutrons are produced in short and intense bunches (FWHM ~ 0.7 µs, peak current ~ 45 mA) that can be tagged with a time reference. Ion bunches, and thus neutron bunches, are produced with a repetition rate varying between 100 Hz and 4000 Hz.

NEUTRON PRODUCTION

The table summarizes the specifications of the neutron production.

Target	Average energy (MeV)	Max. Flux (n/s)
DEUTERIUM	2.5	~ 3 E+08
TRITIUM	14.2	7 E+09

Neutrons are emitted from the target in the whole experimental bunker. At a minimal distance of ~3.5 cm, the maximum flux produced at 14.2 MeV is 4.5×10^{7} $n \cdot cm^{-2} \cdot s^{-1}$, corresponding to a fluency of ~ 1.5×10^{11} n/cm^2 for one hour of irradiation.
Next fall, the facility will be upgraded to improve its reliability and the neutron production. A new deuteron source to generate an intense continuous beam will be installed (flux to reach 2×10^{10} n/s level at 14.2 MeV).

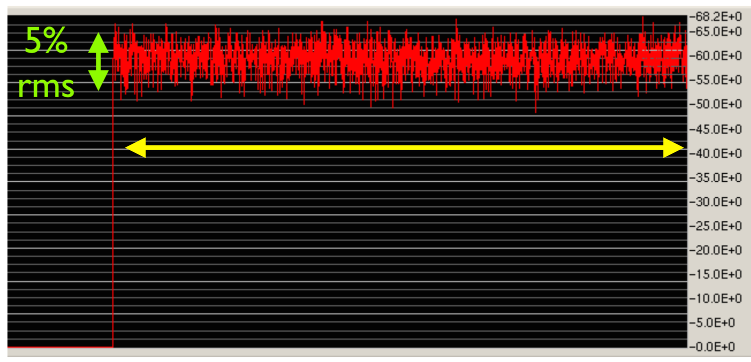


NEUTRON DOSIMETRY

Different complementary methods are used to estimate the neutron flux. The combination of these measurements allows to obtain a dosimetry better than ±15 %.

REAL TIME ESTIMATION

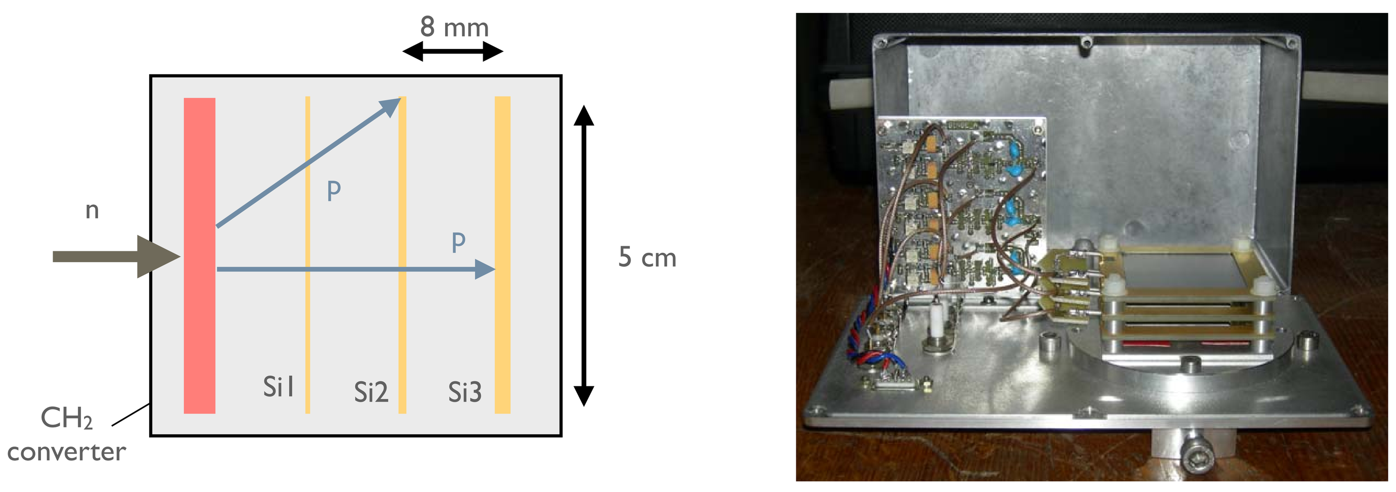
Monitoring of the d^+ current on target
➡ preliminary and rough estimation



Example of peak current monitoring over 30 minutes.

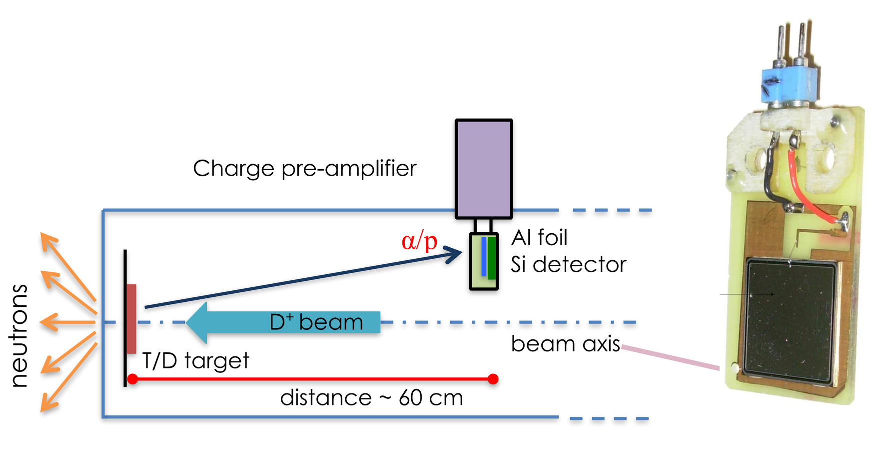
OFF-LINE DATA TREATMENT

• RELATIVE FLUX MEASUREMENT
Direct monitoring of neutrons from dT reaction only using a proton telescope:

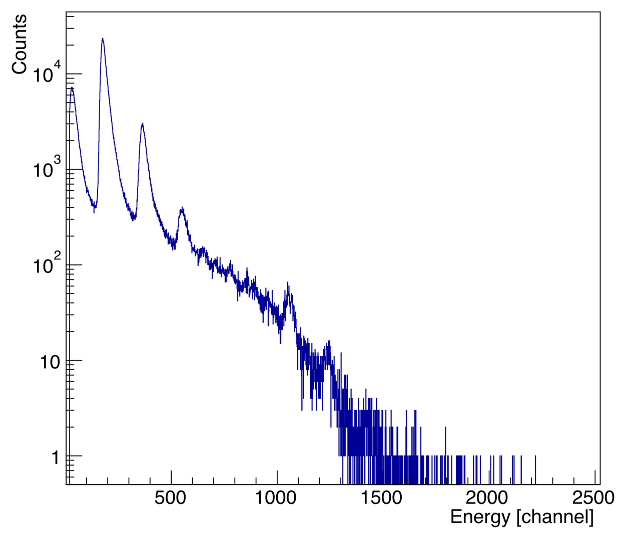


Schematics and picture of the proton telescope: a thin layer of CH2 allows the conversion of neutrons into protons (1 p for 10^3 incident n), then the energetic protons (en. > 9 MeV) are detected by a triple coincidence of the signals from 3 Si detectors (300, 500 and 1000µm).

• ABSOLUTE FLUX MEASUREMENT
➡Detection of particles associated to the neutron production by API (Alpha+Proton Monitor) Si detector
for dT reaction: backscattered α particles
for dD reaction: protons from the nearly equiprobable reaction $d+D \rightarrow p+T$

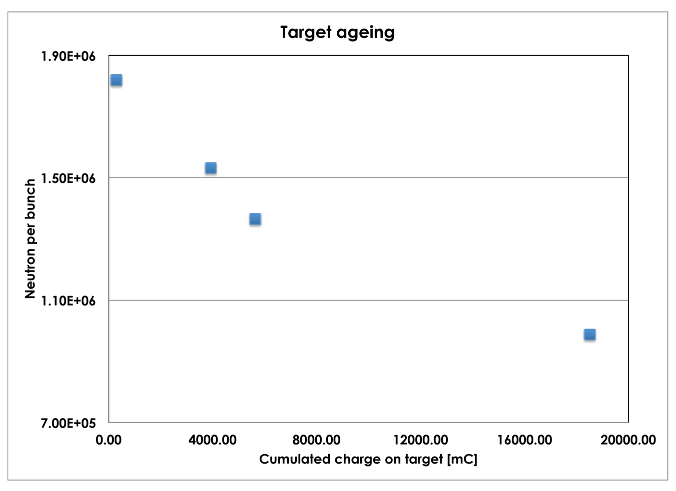


The API detector placed in the beam pipe under vacuum.



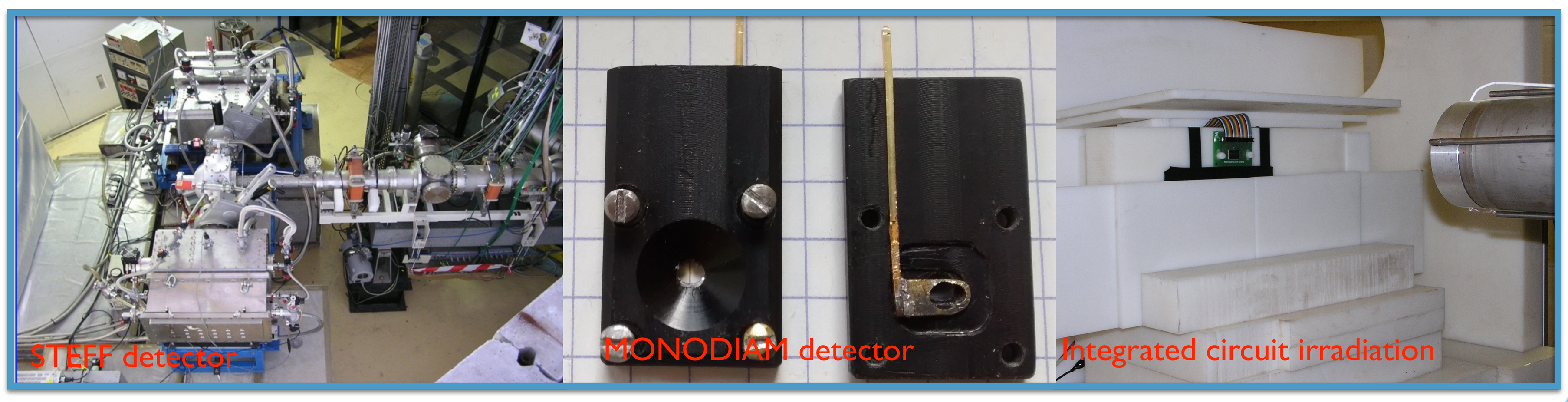
Example of energy spectrum of α particles measured by API.

➡Activation measurements performed at LBA laboratory (LPSC) with Ge detectors
Periodic irradiations of Al foils
∗ cross check of API flux estimation
∗ reference for proton telescope measurement
∗ monitoring of target aging



APPLICATIONS

- Precise nuclear cross-section measurements for research on innovative reactor systems
- Calibration and tests of detectors :
  - ➡ neutron monitors for the GUINEVERE experiment (mock-up of Accelerator Driven System)
  - ➡ nuclear physics :
    STEFF detector (University of Manchester)
    detectors for the NFS (Neutrons For Science) line of SPIRAL2 : fission chamber, liquid scintillator, detector dedicated to the ${}^{16}O(n,\alpha){}^{13}C$ cross-section measurement
  - ➡ medical physics
    MONODIAM : diamond detector for hadrontherapy beam monitoring
- Integrated circuit radiation tests : collaboration with TIMA CNRS laboratory + industrial partners

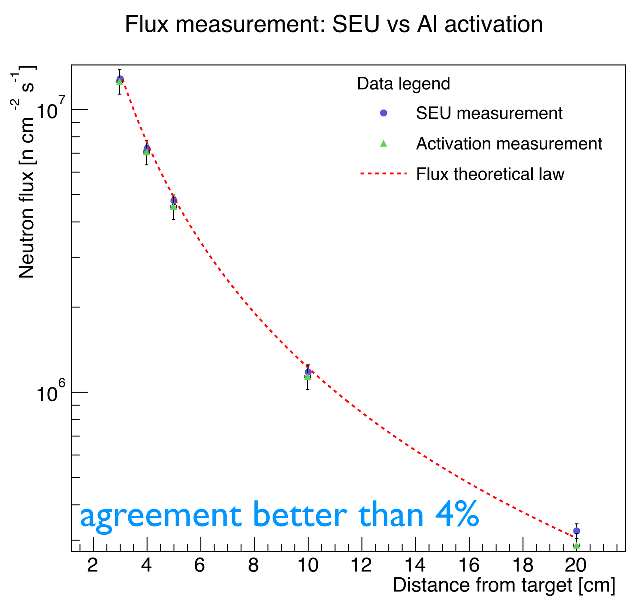


FACILITY CHARACTERIZATION WITH INTEGRATED CIRCUITS

• Neutron dosimetry cross-check

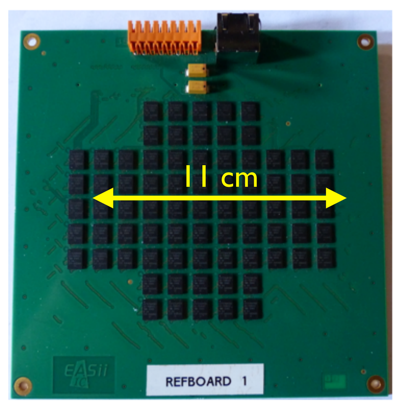
Flux measurement based on single event upsets (SEUs) produced in a SRAM sensitive to fast neutron radiation. The agreement between the estimation from SRAM SEUs and the measurement of Al foil activation is better than 4%.

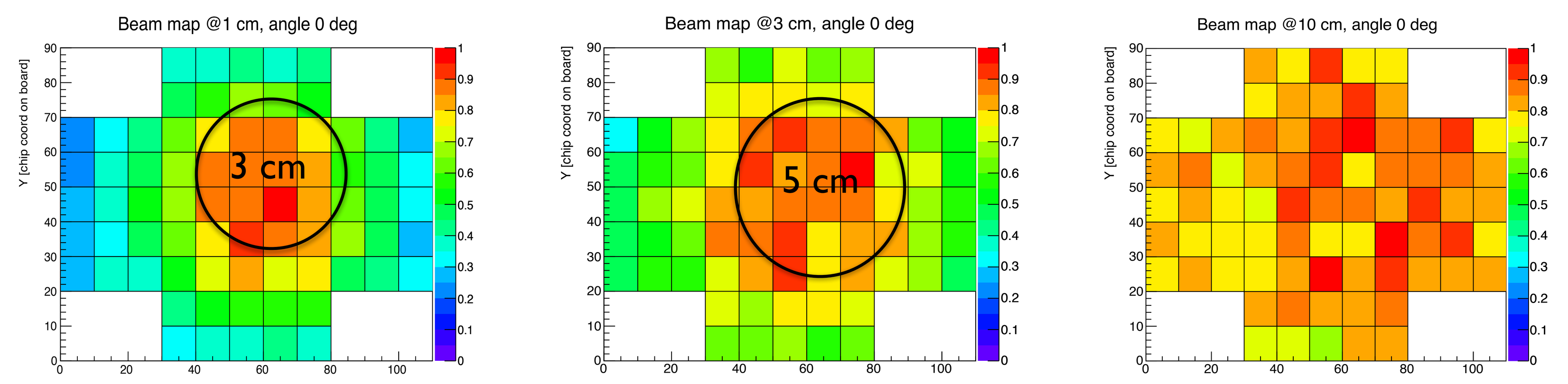
Old SRAM technology already tested at other 14MeV-neutron generators comparable to GENEPI2 (CEA Valduc, Sodern, Frascati)



• Neutron spatial distribution measurement

The spatial distribution of the neutron flux has been measured at several distances from the source point using a matrix of 75 identical chips sensitive to SEU. Each chip is irradiated under a different solid angle. The difference in SEU counts in each chip normalized to the reference chip represents the spatial homogeneity. The goal is to identify the region where homogeneity is better than ±10%.





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