

Neutron irradiation program in Prague

Jan Bohm, Jan Brož, Zdeněk Doležal, Peter Kodyš,
Petr Kubík, Marcela Mikeščíková



Charles University in Prague

Academy of Sciences of the
Czech Republic



Motivation

Lack of large size ($\sim 10\text{cm}$) neutron irradiation facilities able to deliver dose of $1\text{E}15 \text{ n/cm}^2/\text{s}$

Contents

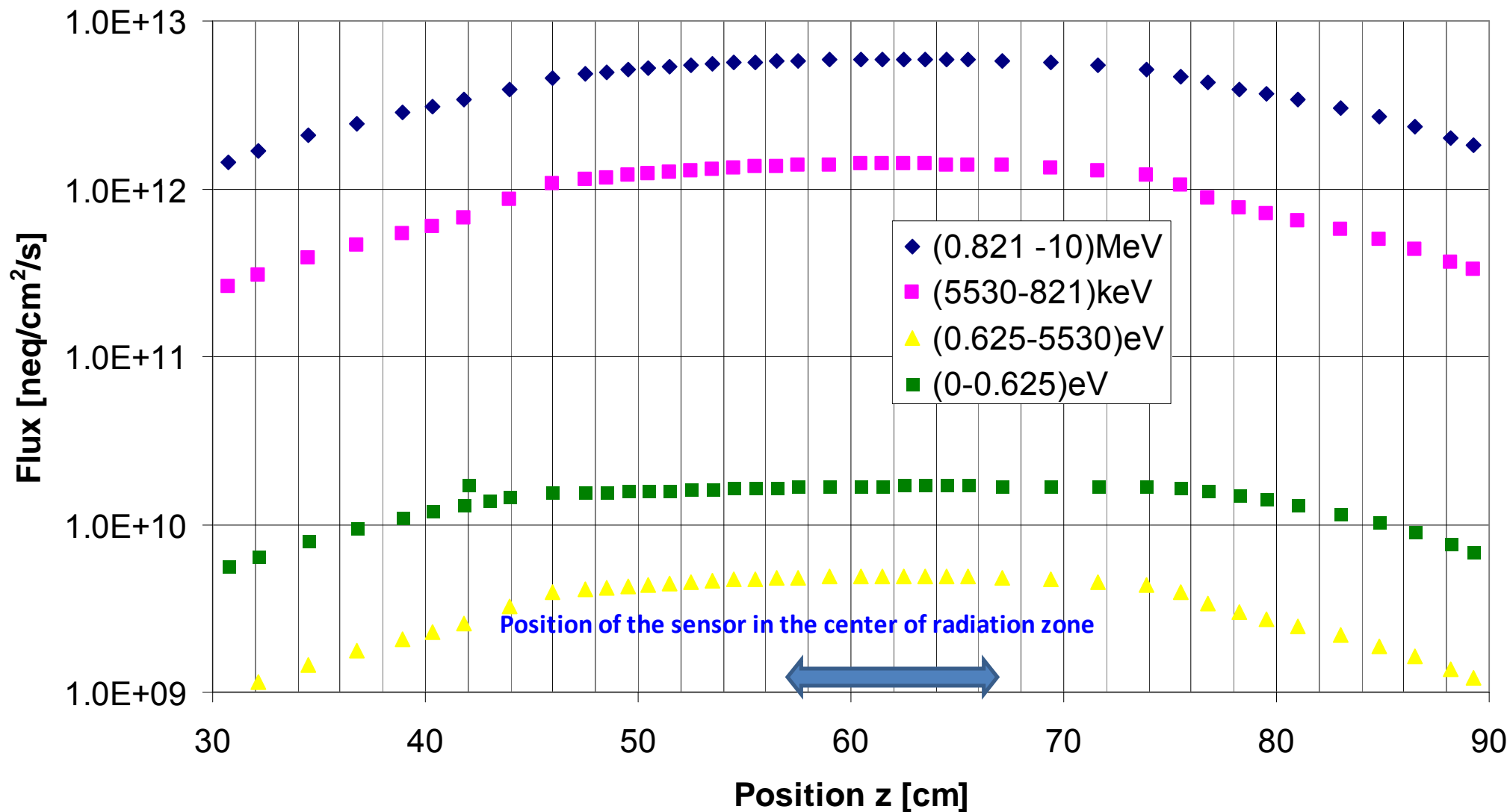
- Neutron Irradiation Facilities in Prague
 - Experimental reactor at NRI Rez near Prague
 - Cyclotron-based fast neutron facility at NPI Rez near Prague
- Detector preparation for irradiation
- Post irradiation steps

Experimental reactor at NRI Rez

- Maximum inner diameter available for a sample: 108 mm
- Sensors irradiated with neutrons of all directions
- Fast neutron channel
- Neutron flux $\sim 5E12$ n/cm²/s

Experimental reactor at NRI Rez

1 MeV neutron flux vs. position z



Experimental reactor at NRI Rez

- Irradiation dose equivalent: any
- Inhomogeneities controllable
- Dose monitoring ???
- Cooling: large problem (encapsulated space)
- Irradiation time ~15 minutes
- Services and online monitoring: problem
- Price ~ 1 k EUR
- Date: any

Discussions with reactor staff continue, but achieving our wishes (temperature, bias) seems difficult -> looking for other options

Cyclotron-based fast neutron facility at NPI Rez

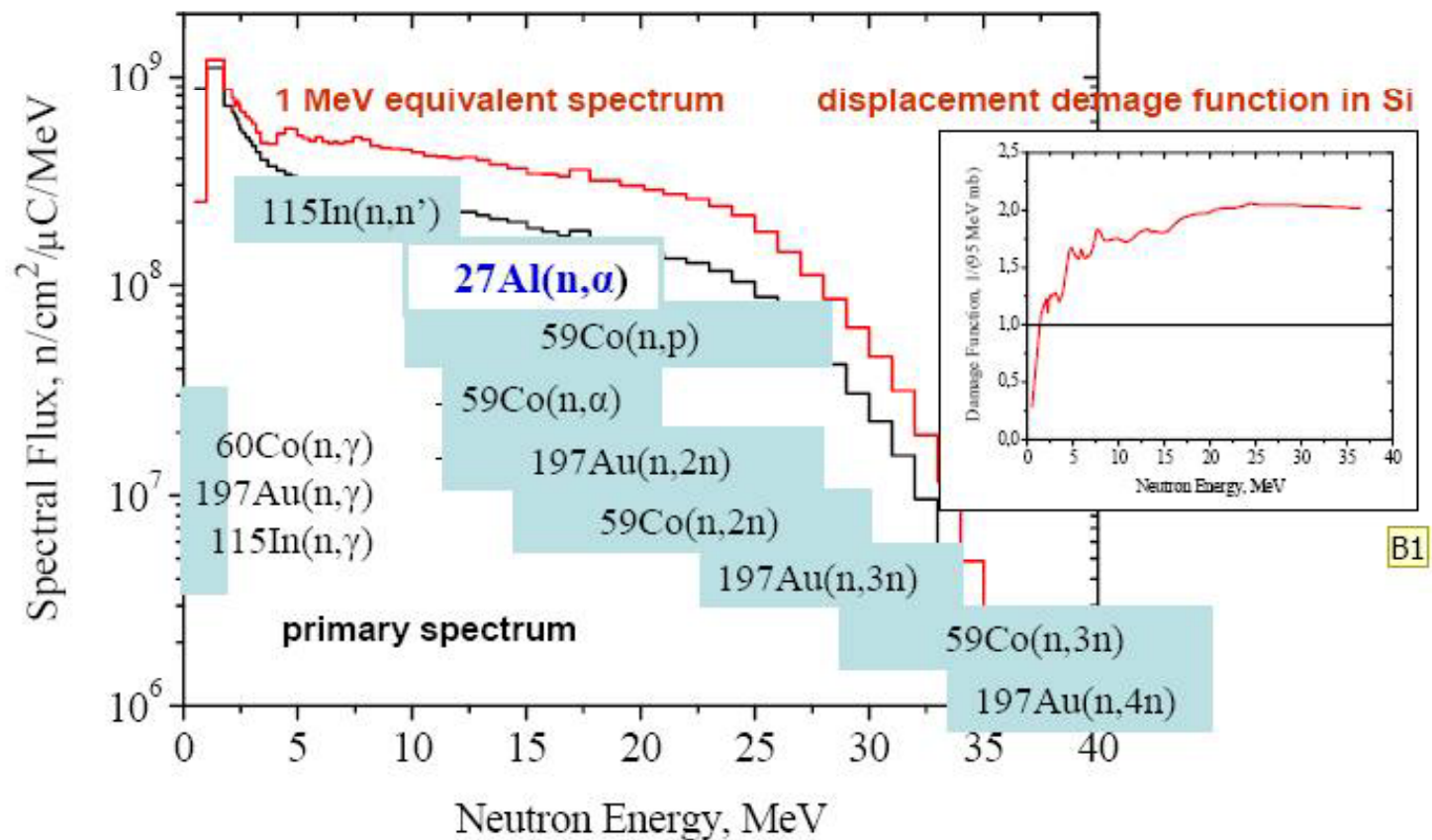
- $D_2O(p,xn)$ reaction
- ($E_p = 37\text{MeV}$, thick flowing heavy water target)
- Forward emitted neutrons:
 - mean energy 13.9 MeV (fluenced averaged)
 - energy range up to 32 MeV
 - angular FWDH < 40 degrees
 - flux $\approx 10^{11}\text{n/cm}^2/\text{s}$ (3 mm distance from the target)



Cyclotron-based fast neutron facility at NPI Rez



- **determination of p-D₂O neutron spectrum in terms of displacement damage characteristics**
 - **RADMON detectors**

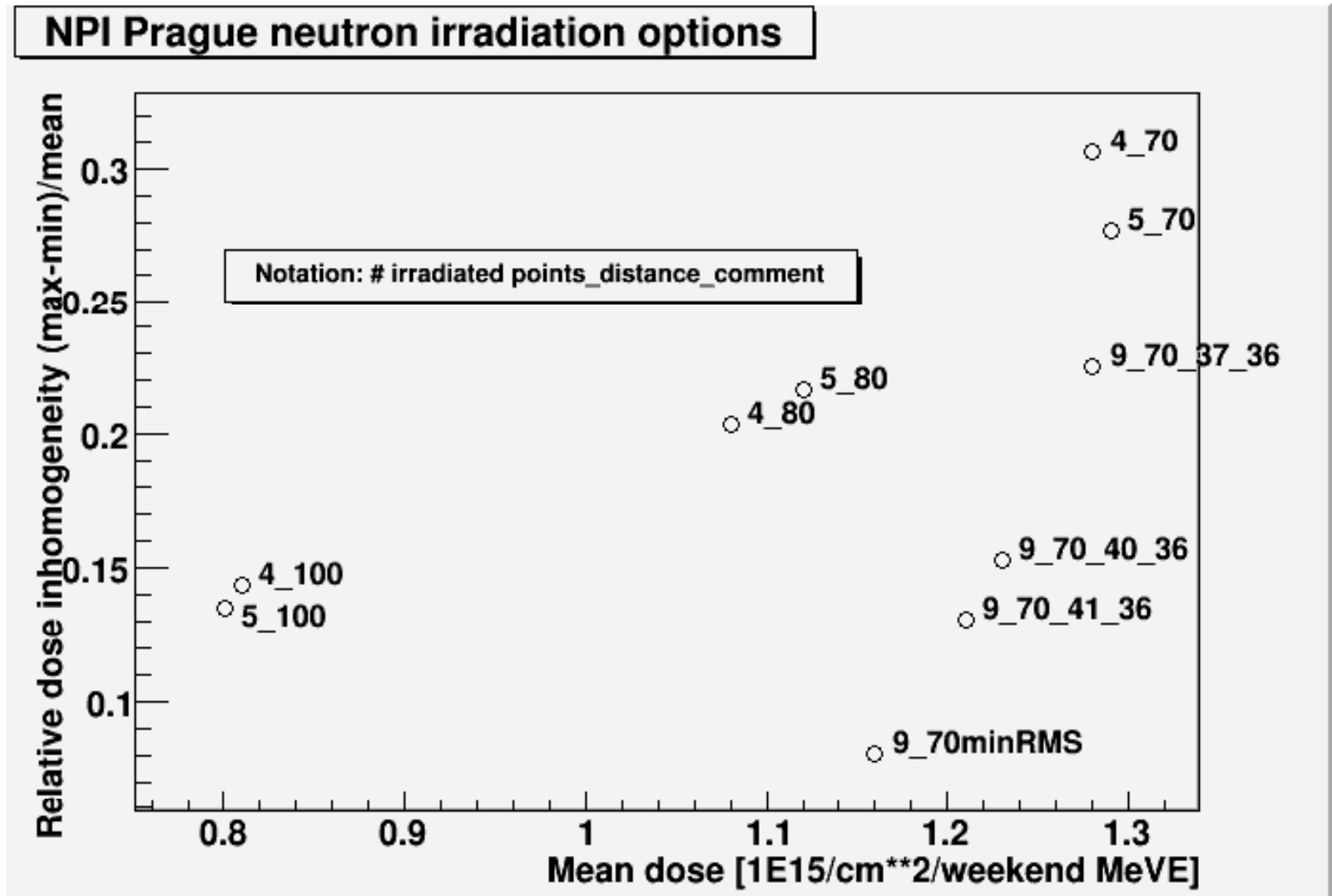


Cyclotron-based fast neutron facility at NPI Rez

- 👍 Dose irradiation equivalent (see next slide) up to $2E15$ n_{eq}/cm^2 in beam axis per one irradiated period (~40 hours)
- 👍 Large space available
- 👍 Inhomogeneities over 10×10 cm² can be kept below 10% (scanning the samples - see next slide)
- 👍 Dose monitoring OK
- 👍 Cooling under preparation, plan $-30^\circ C$
- 👍 In ~40 hours we get $1.3E15$ n_{eq}/cm^2 over 10×10 cm²
- 👍 Leakage current on line monitoring possible ($C_{interstrip}$, R_{bias} , $R_{interstrip}$, C_{coupl} at 3 strips, V_{dep})
- 👍 Used by LAr upgrade irradiation up to $1E16$ n_{eq}/cm^2
- 👎 Price ~ 7 k EUR per 40 hours
- 👎 Availability: June 26-28, 2009, than October 2009

Cyclotron-based fast neutron facility at NPI Rez

Mean dose vs. inhomogeneities: comparing various scenarios (distance, number of scanned points, positions)

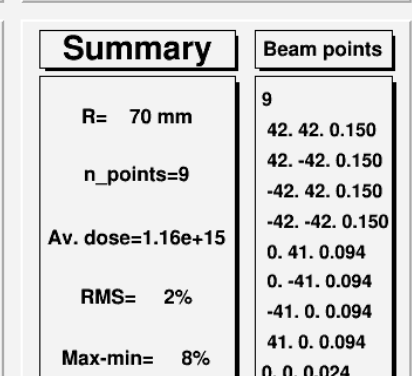
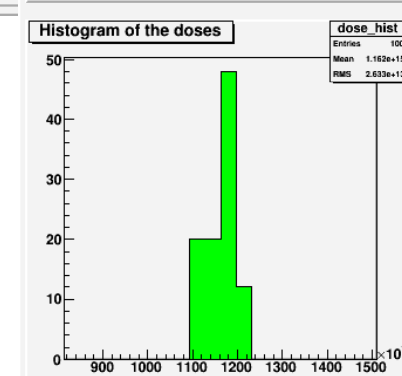
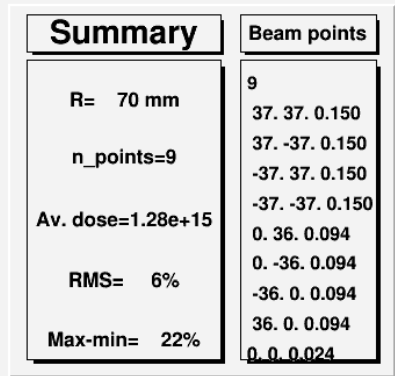
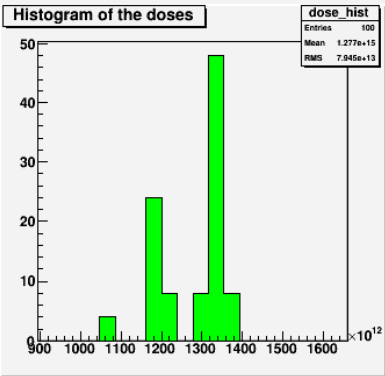
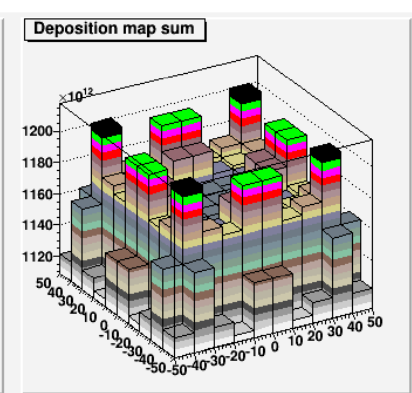
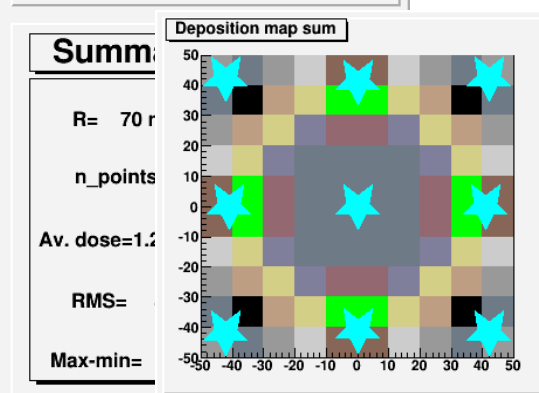
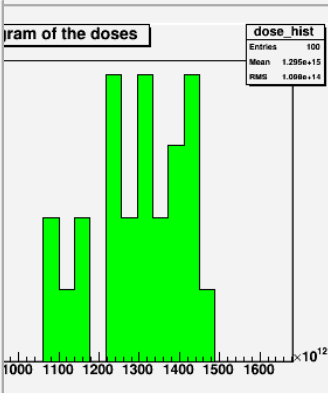
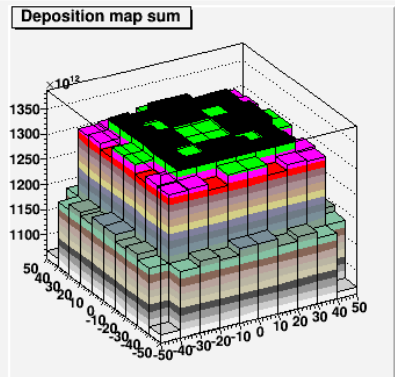
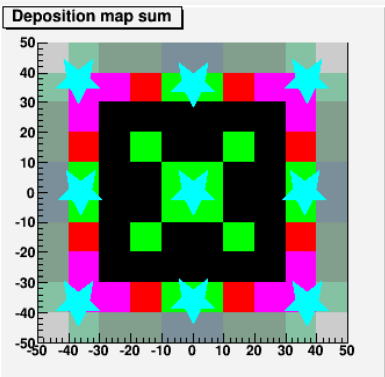
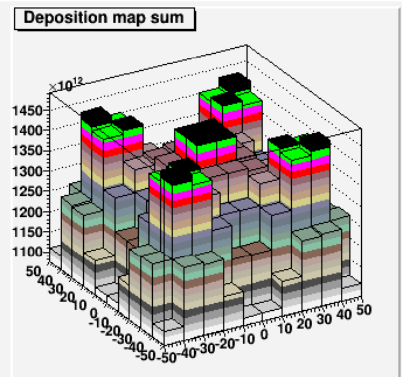
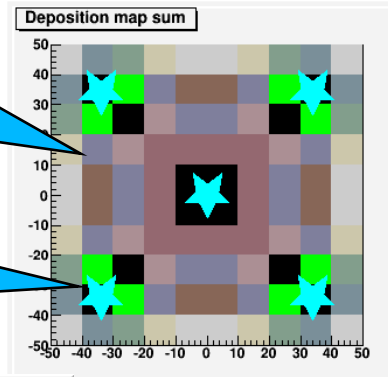


Cyclotron-based fast neutron facility at NPI Rez

Different irradiation scenarios:

Dose map over 10x10 cm² sensor area

Beam impact points

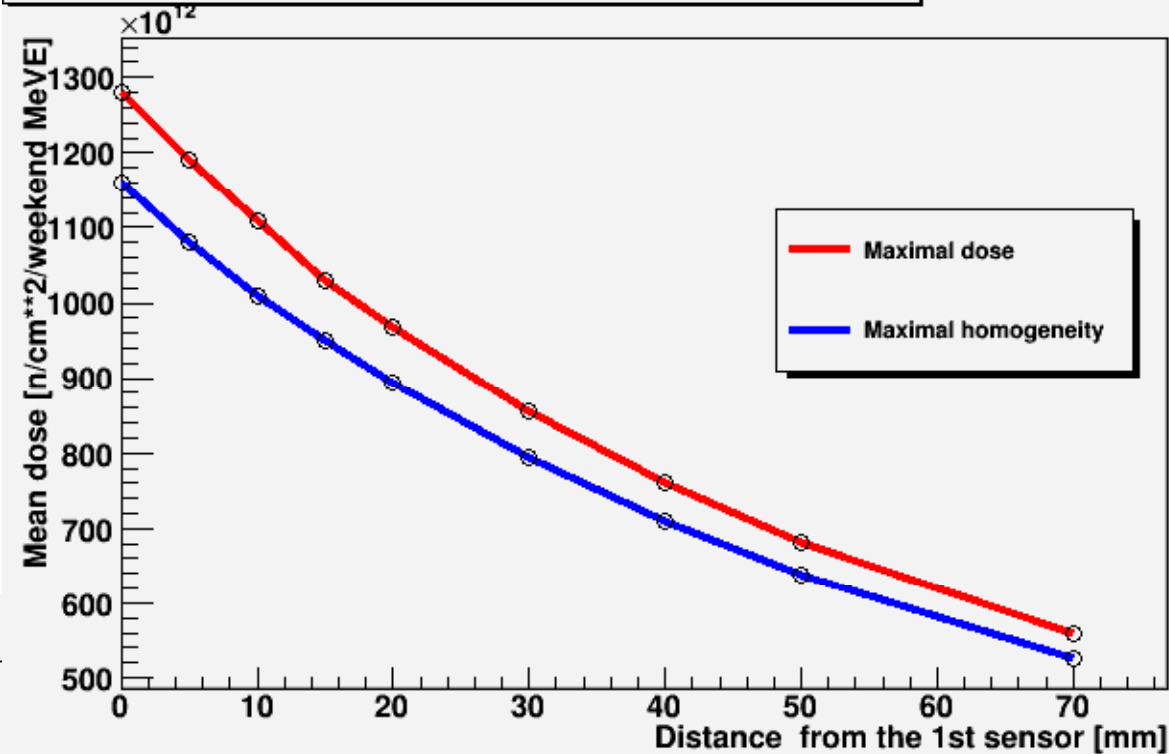


Cyclotron-based fast neutron facility at NPI Rez

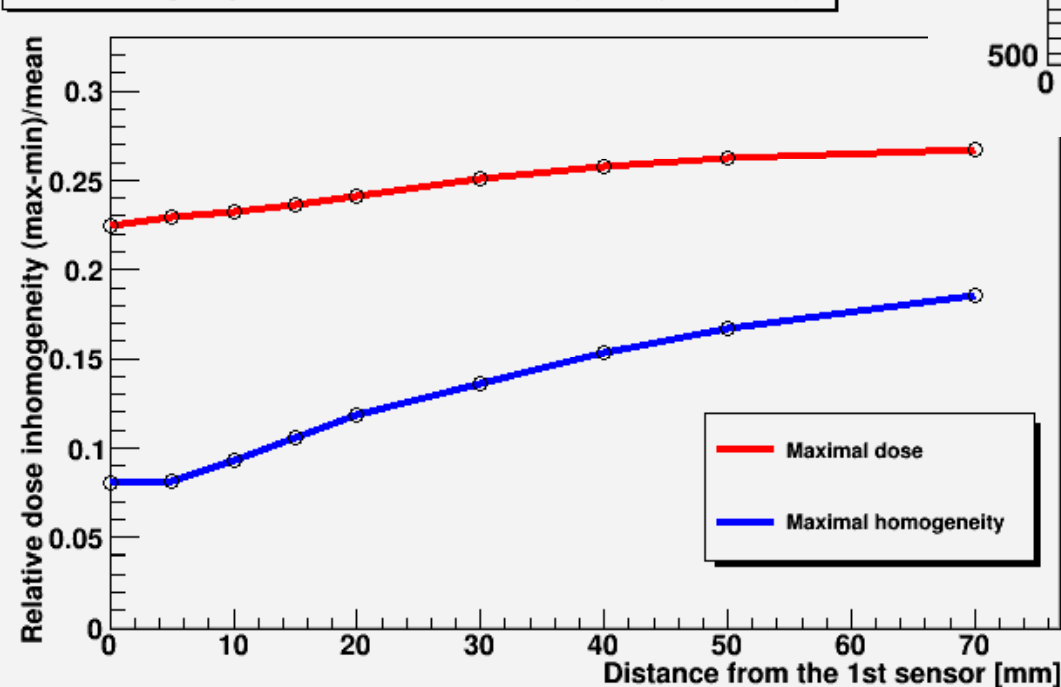
Dose and homogeneity for detectors stacked behind the first one, 2 scenarios

Dose drops to $\frac{1}{2}$ 50 mm behind the first sensor

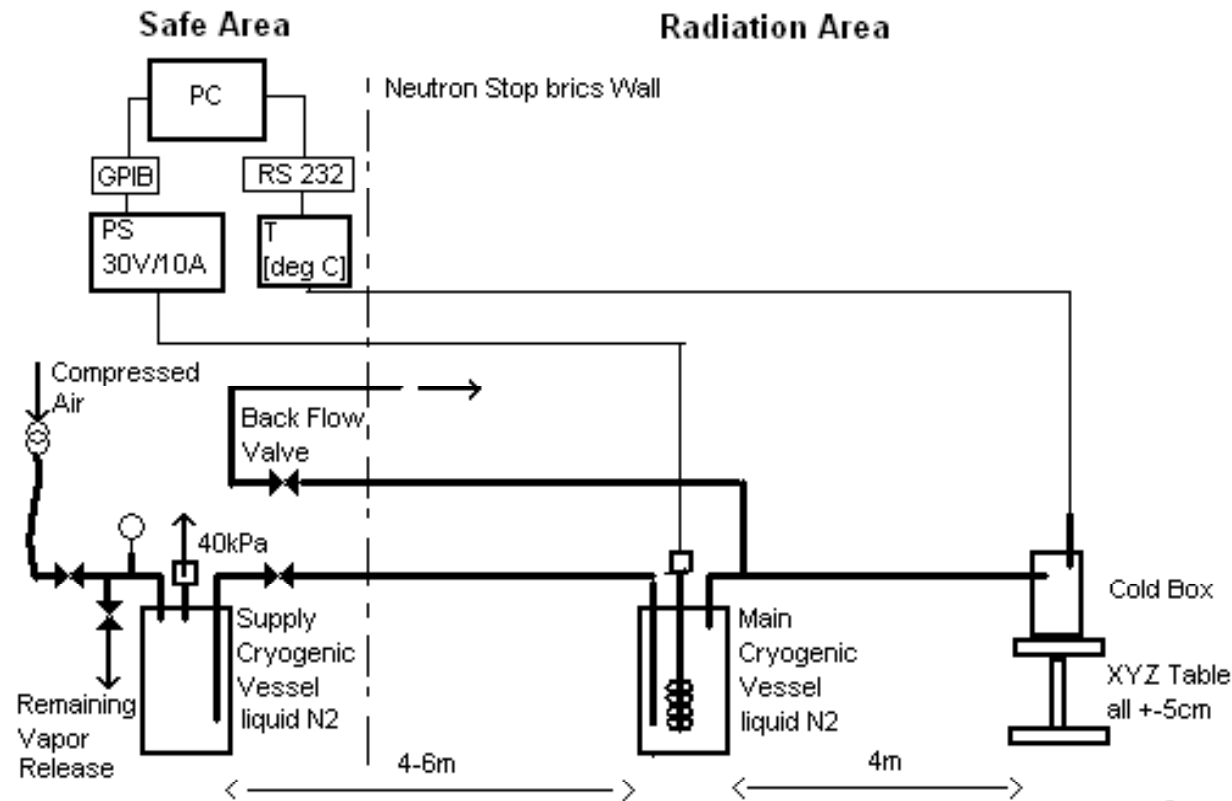
Mean dose vs. distance from the 1st sensor (@70mm), 2 scenarios



Dose inhomogeneity vs. distance from the 1st sensor (@70mm), 2 scenarios



Cyclotron-based fast neutron facility at NPI Rez cooling schematics



Humidity/Temperature
Probe NH232



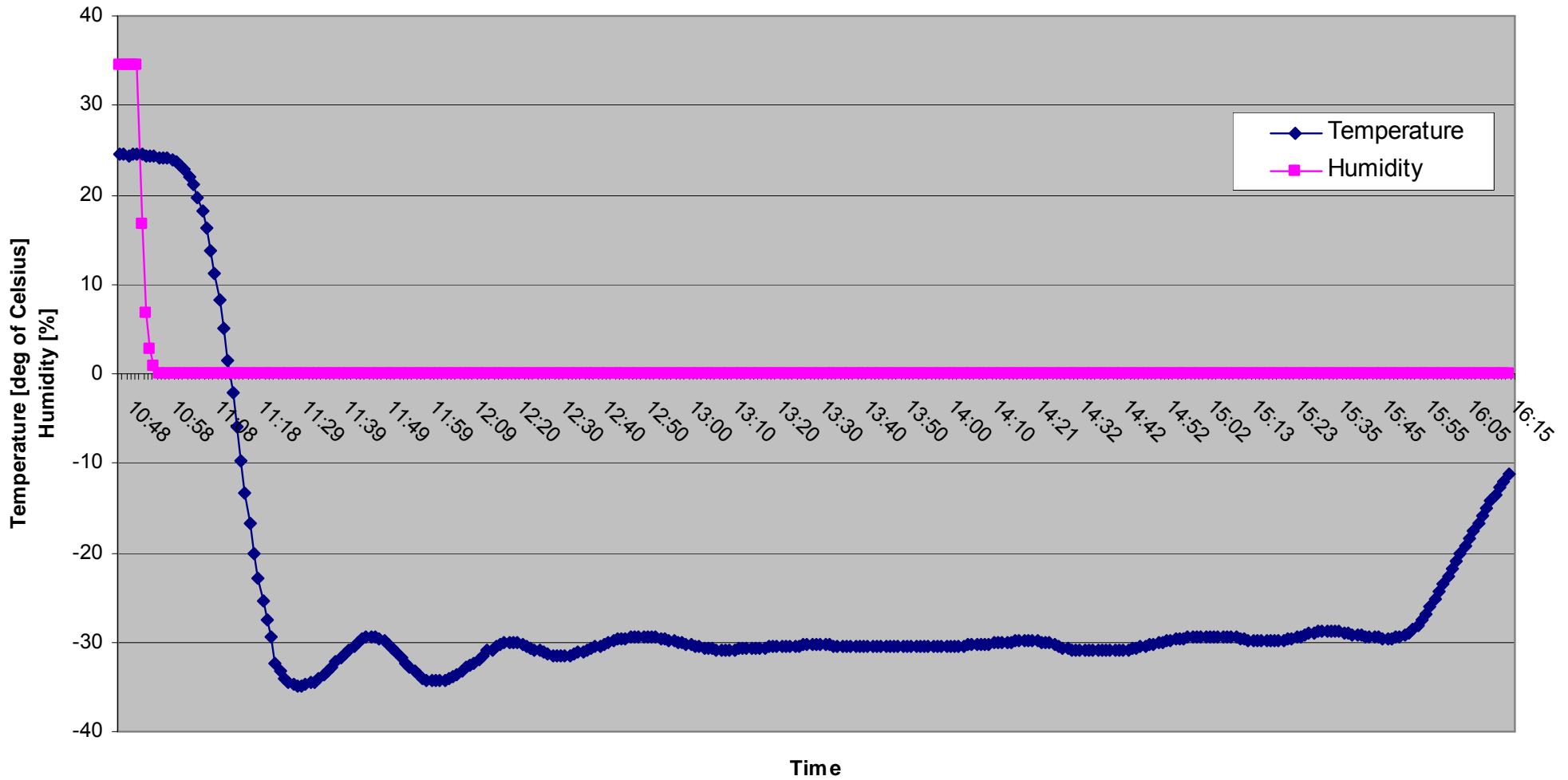
Compressed Air System
For pumping of liquid N2
Made in IPNP



Heating System
For Liquid N2
vaporization
Made in Cryocom
comp.
Modified in IPNP

Cyclotron-based fast neutron facility at NPI Rez test of cooling system

Cooling Diagram
Temperature controlled by Power to heating element only
(Start 10:52 Stop 15:52)



Irradiation plan

- Cyclotron test run in June 26-28, 2009 to qualify the facility
- Irradiation of few HPK ATLAS07, ATLAS07 minis
- Dose monitoring by ELMA diodes to crosscheck with Ljubljana
- Testing all infrastructure and services
- Aiming at $\sim 3E14 n_{eq}/cm^2$
- If qualified go for October 2009 with large samples (incl. electronics, etc.) and full dose

Preparation status

- 6 full size HPK sensors delivered in second week of May
- ATLAS07-P-SSSD-Series I: VXX73414-W32, W33, W35, W36, W37 and W38
- Basic characteristics measurement (more in Marcela Mikestikova's talk):
IV, CV, $C_{\text{interstrip}}$, R_{bias} , $R_{\text{interstrip}}$, C_{coupl} at 3 strips, V_{dep} , strip integrity
- Mechanical mounting to frame on progress
- Transport frames on progress
- Cooling facilities quickly finishing
- Position system ready
- Details are discussed with experts

Conclusions

- New neutron irradiation facility might become available for large area samples
- Any comments and suggestions welcome to avoid trivial mistakes