School of Neutron Scattering

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NEPIR: the fast neutron source at LNL

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LNL (Legnaro Nuclear Labs)

The Legnaro Nuclear Laboratories, located in the town of Legnaro (Italy), at 10 km from Padova.

The new SPES laboratory

Aereal view of the Legnaro Laboratories

Fast neutrons at LNL: the **NEPIR** project

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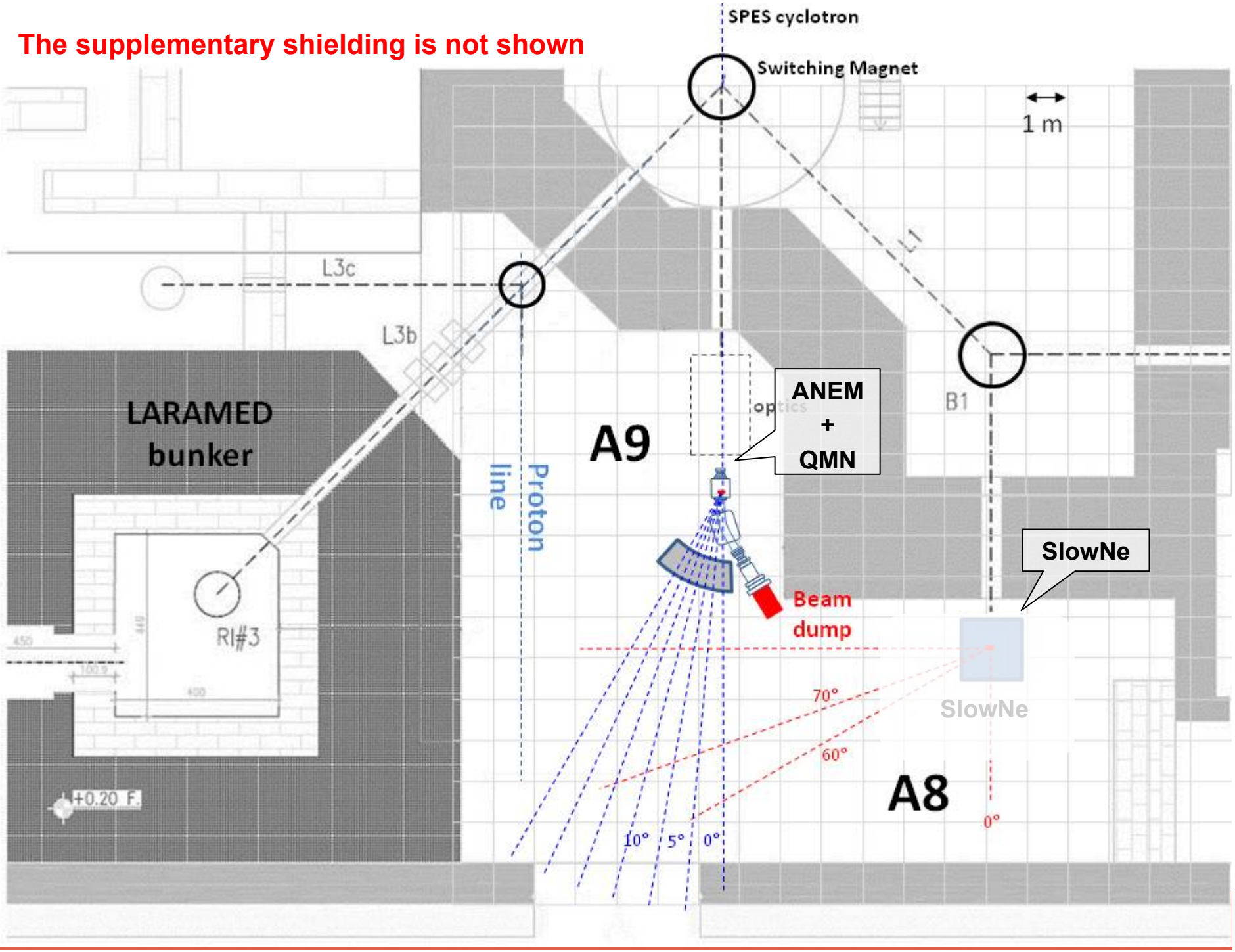
The **QMN**, **ANEM** and **PROTON** subsystems will be used for the study of **radiation damage effects in electronic devices and systems** induced by **flight-altitude and sea-level atmospheric neutrons** and **solar protons**.

Neutrons for electronics

QMN discrete	Energy range 20-70 MeV 😐	Essential to study energy dependencies (cross-section vs energy curves) ☺	Neutron flux at test point is **user controlled**, up to 10^6 n cm^{-2} s^{-1} ☺	Angle correction ☺!
ANEM continuous	Energy cut-off 70 MeV ☹	Useful to make flexible studies/checks for unexpected sensitivity to lower energy neutrons before full energy tests at very high-energy facilities (i.e. Chip-IR at ISIS), 😐 → ☺	Neutron flux at test point is **user controlled**, flux at test point ϕ (E_n > 1 MeV) ~ 10^7 n cm^{-2} s^{-1} ☺	

•**PROTON:** a general purpose low intensity beam (max few hundred nA) of direct protons with variable energy (20-70 MeV).

The supplementary shielding is not shown

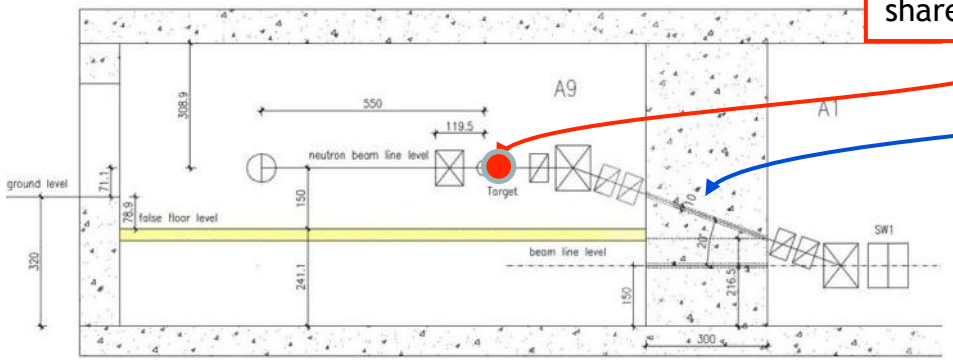


NEPIR experimental hall

SPES hall A9, side view of the Fast Neutron Line (QMN+ANEM)

The ANEM target system will exchange position with the QMN multi-target system and will share the 0º line.

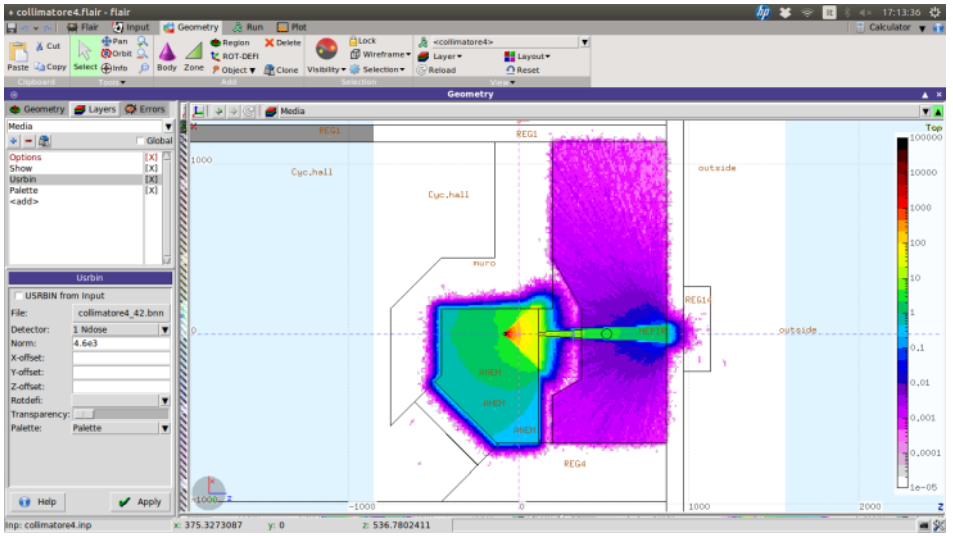
Chicane to:
- avoid neutrons towards cyclotron
- have test point at same distance from floor and ceiling (minimize albedo)
- use degradator for lower energy neutrons



Vertical section of NEPIR experimental hall as it is now

At the test point, the neutron beam is 1.50 m from the false floor (3.91 m from the bottom cement floor). The optics: two dipole magnets, two quadrupole doublets, a single quadrupole, and a bending magnet for the spent proton beam. The supplementary shielding is not shown.

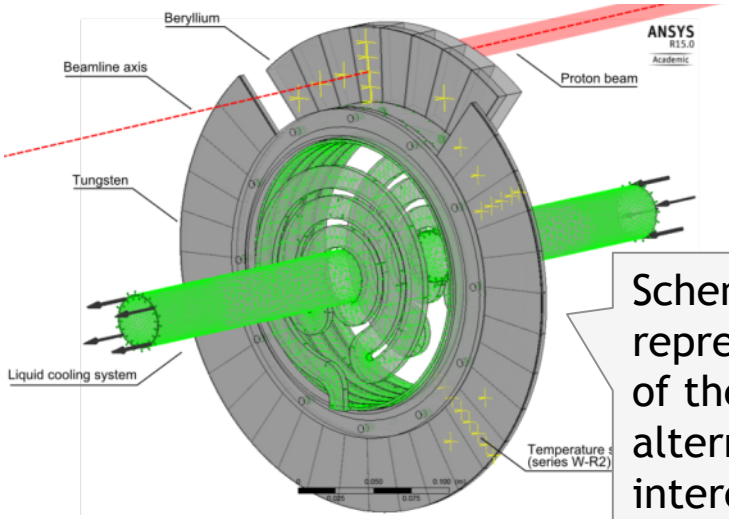
The NEPIR experimental hall as it is now



Shielding calculations using Fluka and MCNP is work in progress (curtesy of Stefano Trevisan)

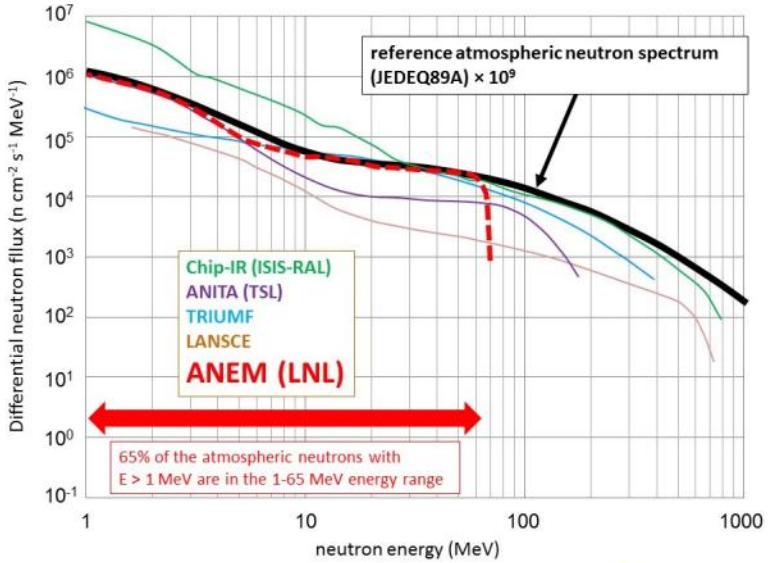
ANEM working principle

ANEM the Atmospheric NEutron Emulator is an experiment financed by INFN to design and manufacture a target for the production of neutrons with simil-atmospheric energy distribution

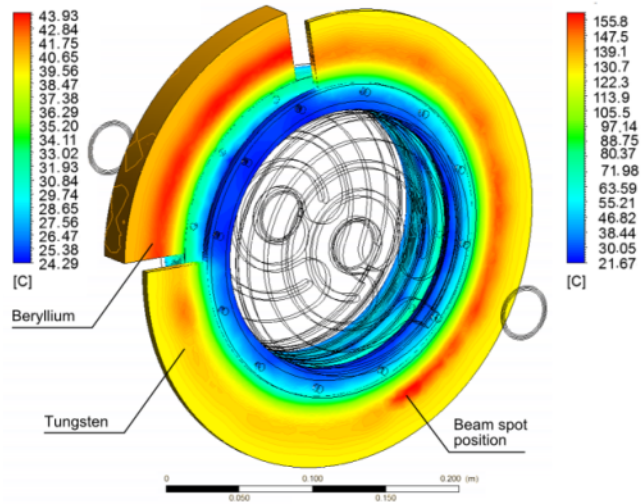


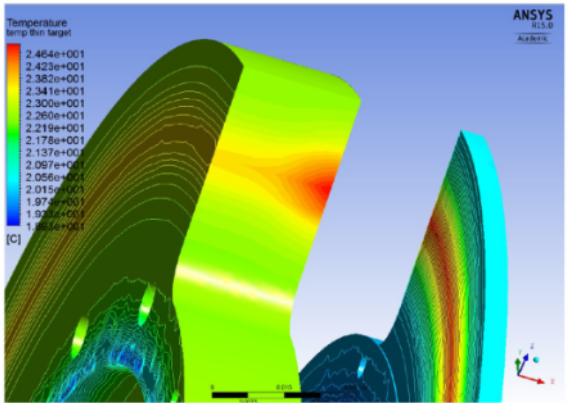
Schematic representation of the two sectors alternatively intercepting the proton beam

Composite neutron spectrum generated by ANEM, compared with the atmospheric spectrum (x $3x10^9$)

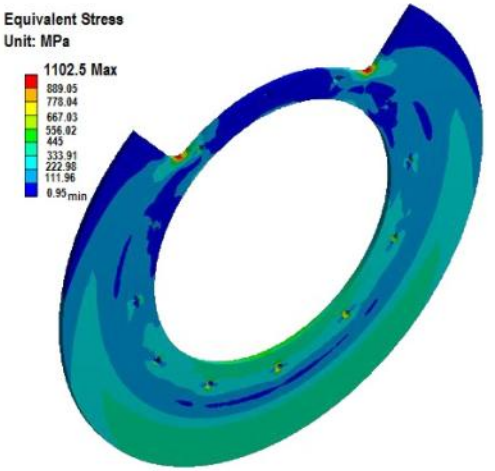


Thermal performance modeling





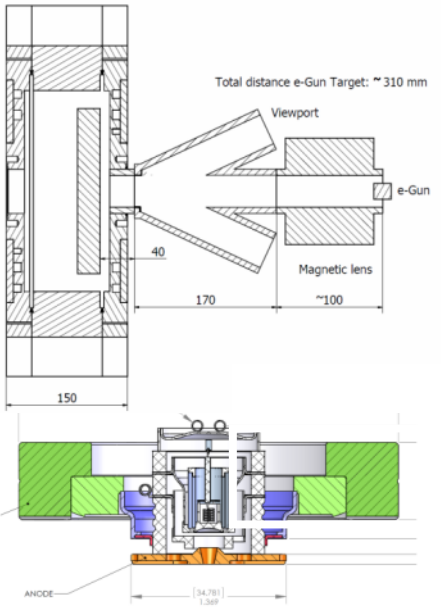
Power deposition in the Be sector, the bragg peak is visible



A dynamic model of the stress induced by the thermal expansion is being developed.

ANEM prototype

The ANEM prototype will undergo thermal tests in the next months



The thermal tests will use a 10 kV electron beam,
- Maximum current 1 A
- Beam current controlled by varying cathode voltage;
- Electron emitter shaped to give and initial rough focusing
- Flange mounted (CF 3 3/8) gun assembly;
- Independent magnetic focusing coil (by Danfysik): minimum beam spot 1 cm^2 (gaussian);

Altair electron gun

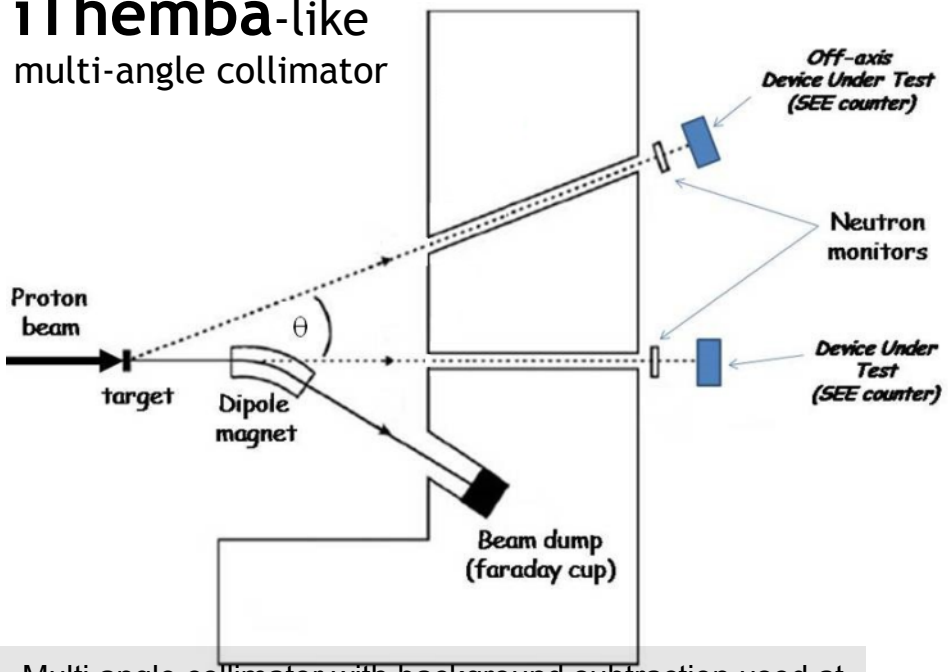
The prototype is being assembled in Padova

QMN

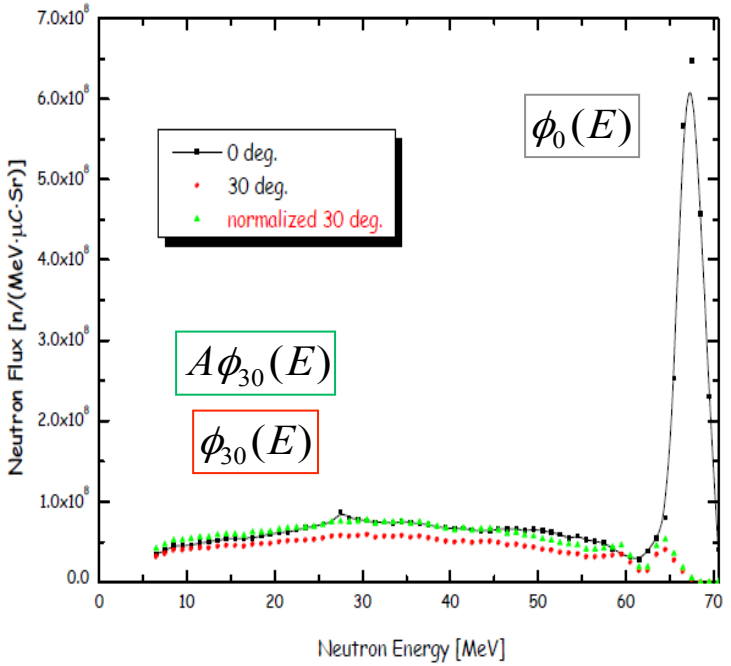
Multi-purpose Quasi Mono-energetic Neutrons (QMN) in the 20-70 MeV energy range, produced in few mm thick Li or Be targets.

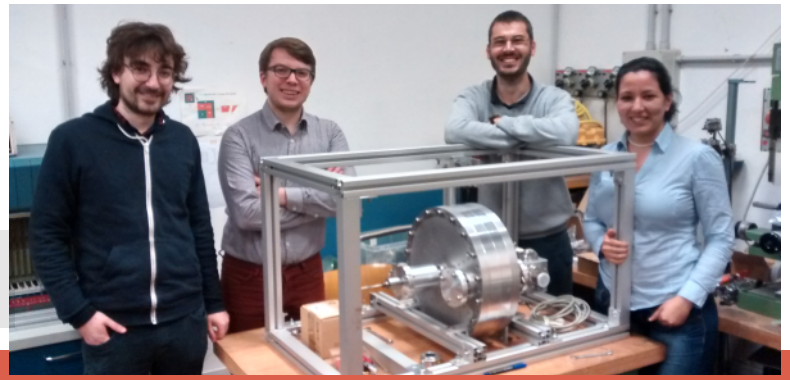
The neutron fluence of forward going mono-energetic neutrons can be corrected by subtracting the neutrons measured at angles typically in the 15º-30º range (*"wrong-energy tail correction technique"*);

iThemba-like
multi-angle collimator



Multi angle collimator with background subtraction used at iThemba Labs (South Africa)





The NEPIR people S. Trevisan, E. Mazza, L. Silvestrin and G. Acosta