The development of a neutron converter for the production of radioactive beams at iThemba LABS

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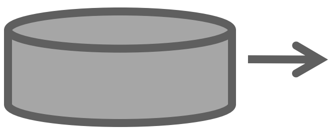
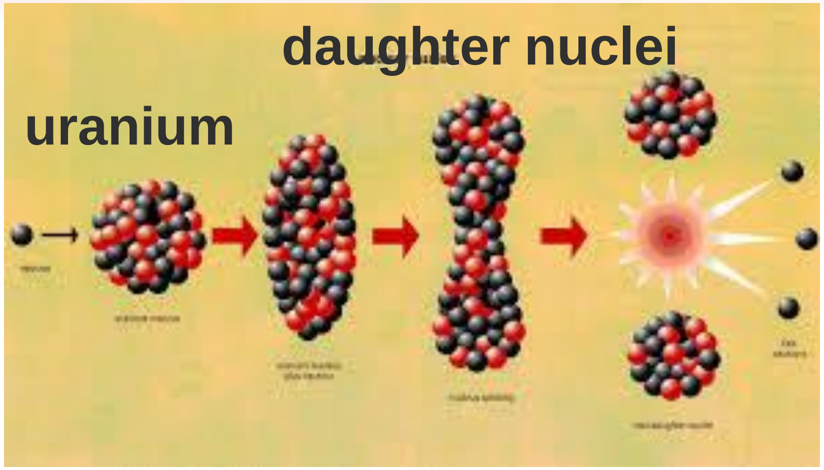
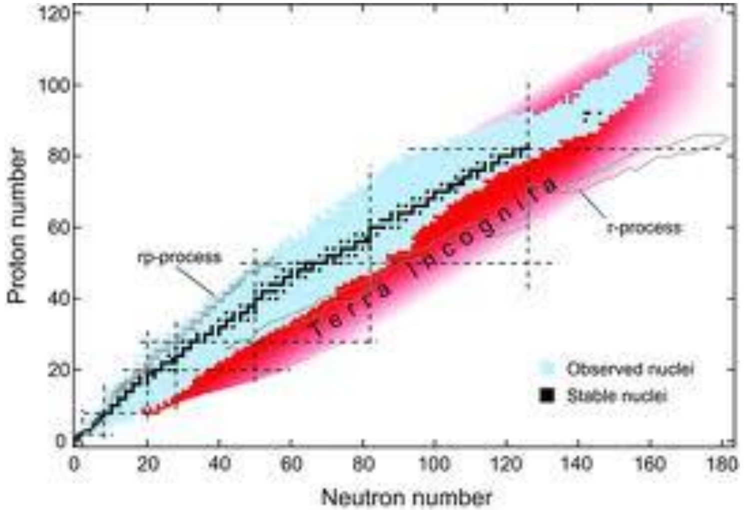
Energy Postgraduate Conference 2013

1. INTRODUCTION & MOTIVATION

accelerator







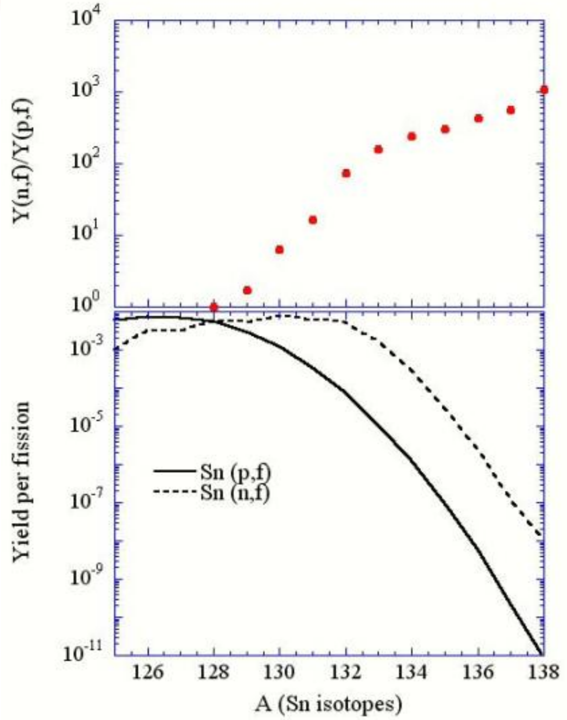


Figure 1: comparison of yields of proton induced fission for 70MeV protons (solid), and neutron induced fission for neutrons (dashed) for Sn isotopes. The upper plots give the yield ratios. Measurements done in the Holifield RIB Facility at Oak Ridge National Laboratory.

1. INTRODUCTION & MOTIVATION

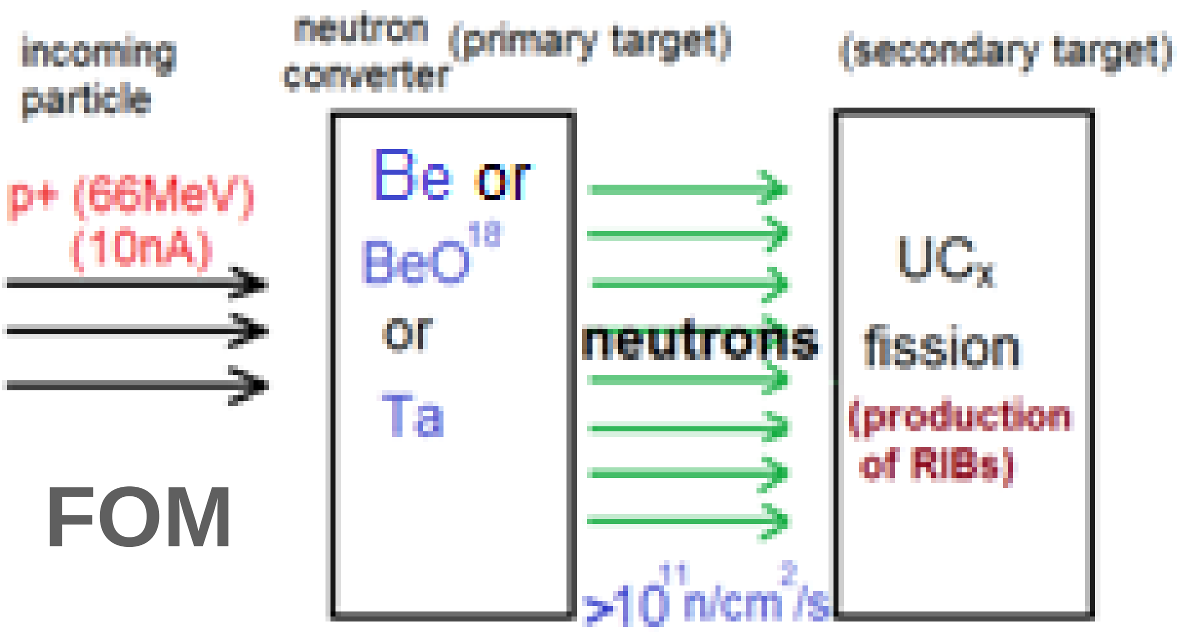


Figure 2: A simple ISOL system showing proton beam bombarding the primary "neutron converter" target. Neutrons produced continue towards the secondary UCx target to induce the fission process.

- So there is a need to convert protons from the cyclotron into neutrons. **What is the best target material to produce neutrons with a proton beam?**
- The figure below shows the proposed Isotope Separation Online (ISOL) target system for the production of RIBs. **What is the best geometry for the UCx target?**

WE PROPOSE TO MEASURE NEUTRON ENERGY AND ANGLE YIELDS OF NEUTRONS ON POSSIBLE "CONVERTER" TARGETS.

1.INTRODUCTION & MOTIVATION

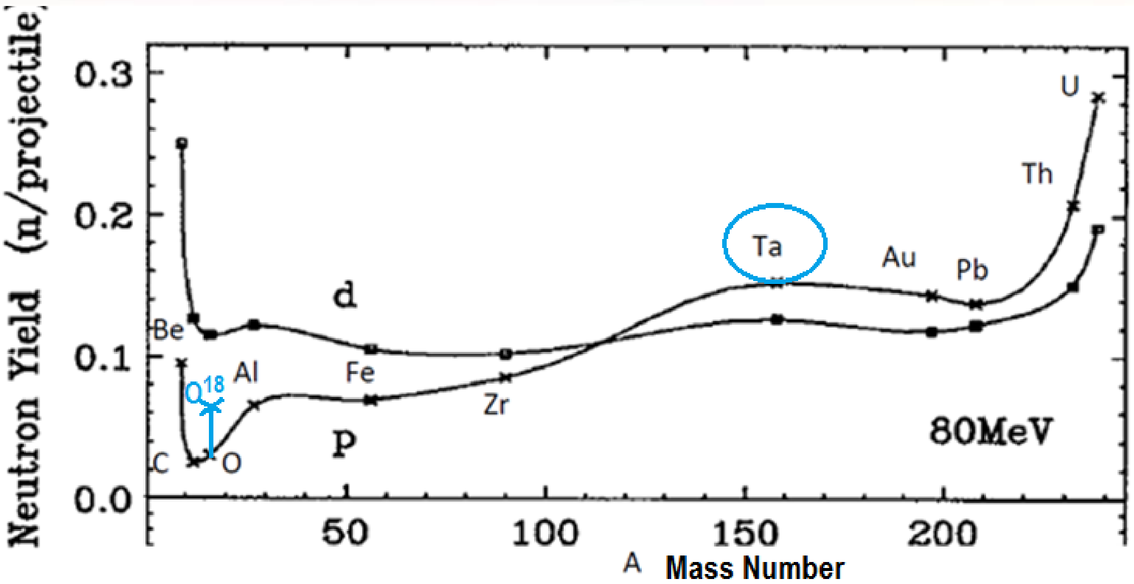
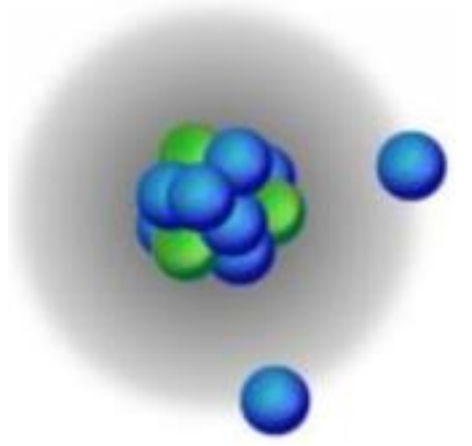
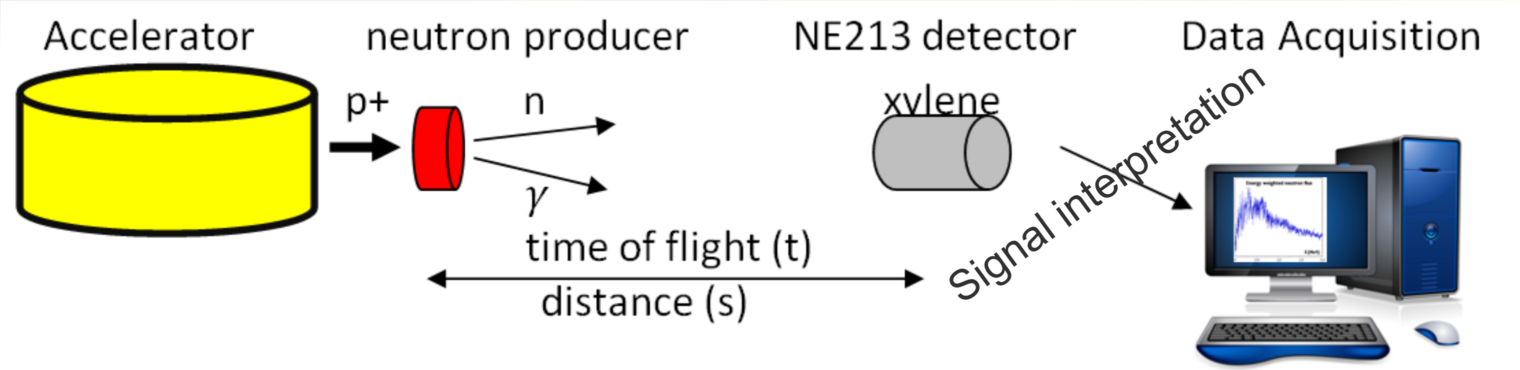


Figure 3: comparison of neutron yields induced 80MeV protons (p) and deutrons (d). Measurements done by Ridikas & Mittig at GANIL - France



For optimised layout of the RIB target system it is necessary to measure neutron energies and their angular distribution of chosen candidates: Be; O^{18} [3] and Tantalum.

2. EXPERIMENTAL TECHNIQUE (TOF)



$v_n = \frac{s}{t}$ thus $E_k = \frac{1}{2}mv^2$ ⟹ neutron energy spectrum

collimation & shielding for optimised neutron measurements

limited space for TOF measurements

Figure 5: This is the iThemba LABS neutron facility showing collimated neutron beam holes at 0° and 16°. It shows the shielding which makes this facility the best for neutron measurements.

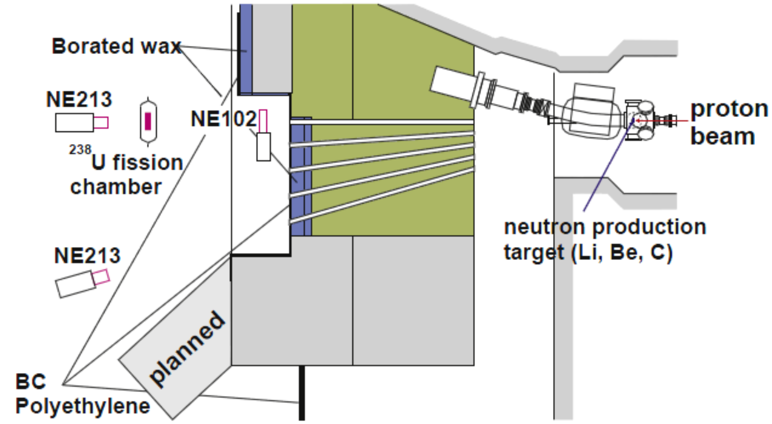


Figure 4: The sketch of the iTL neutron beam facility [4]

2. EXPERIMENTAL TECHNIQUE (TOF)

- To investigate how the presence of neutron scatterers and absorbers affect the measurement.

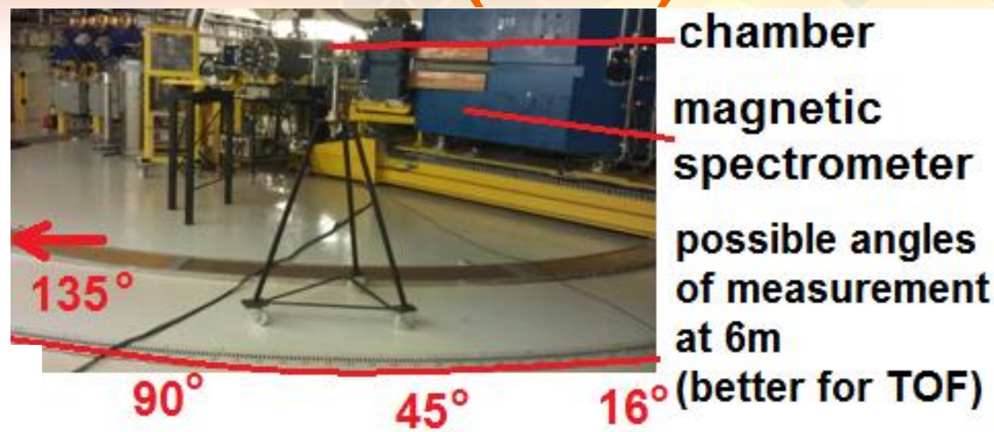


Figure 6: This is the iThemba LABS spectrometer vault showing collimated neutron beam holes at 0º and 16º. It shows the shielding which makes this facility the best for neutron measurements.

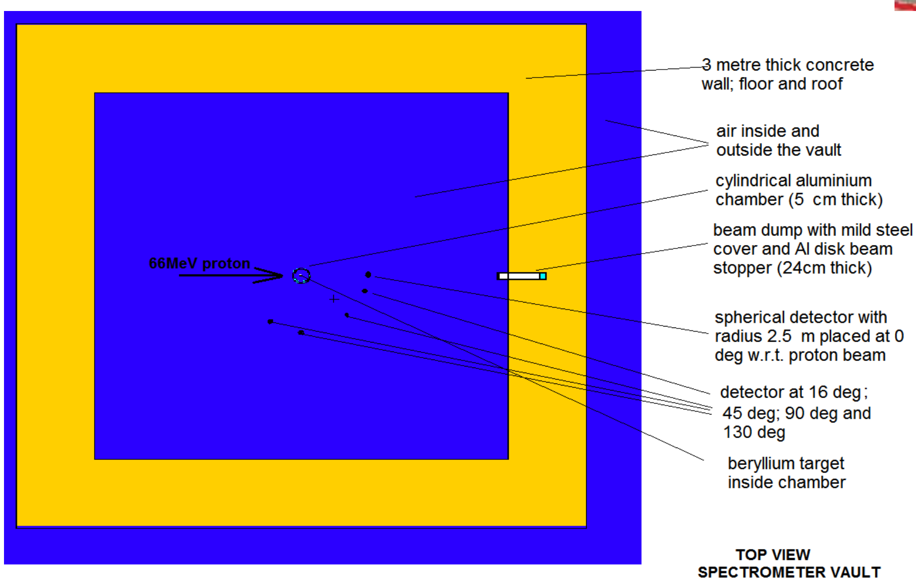


Figure 7: MCNPX geometry of the spectrometer vault with the chamber and beam dump

The geometry of the spectrometer vault generated by MCNPX [5] input file.. This thickness degrades the proton energy by 2 MeV (SRIM 2008) [6], thus allowing quasi-monoenergetic neutrons between 62 - 64 MeV to be produced.

3. RESULTS & DISCUSSIONS

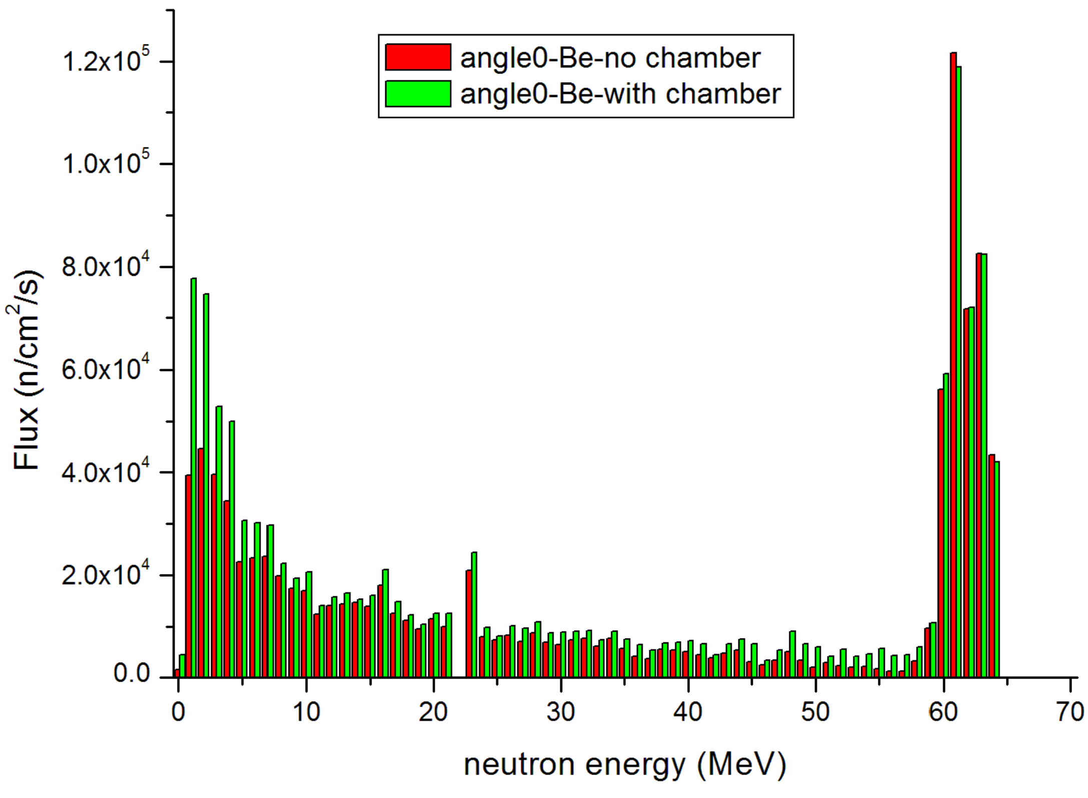


Figure 8: Shows the neutron spectrum at angle 0 with no chamber only Be target compared to neutron spectrum at angle 0 with the spectrometer chamber.

The effect of the spectrometer chamber simulation is shown on the left. The flux-energy distribution of neutrons produced by protons on Be with no chamber are calculated then compared to the Be inside the spectrometer chamber. The presence of the chamber considerably increase the neutron flux at low energies.

3. RESULTS & DISCUSSIONS

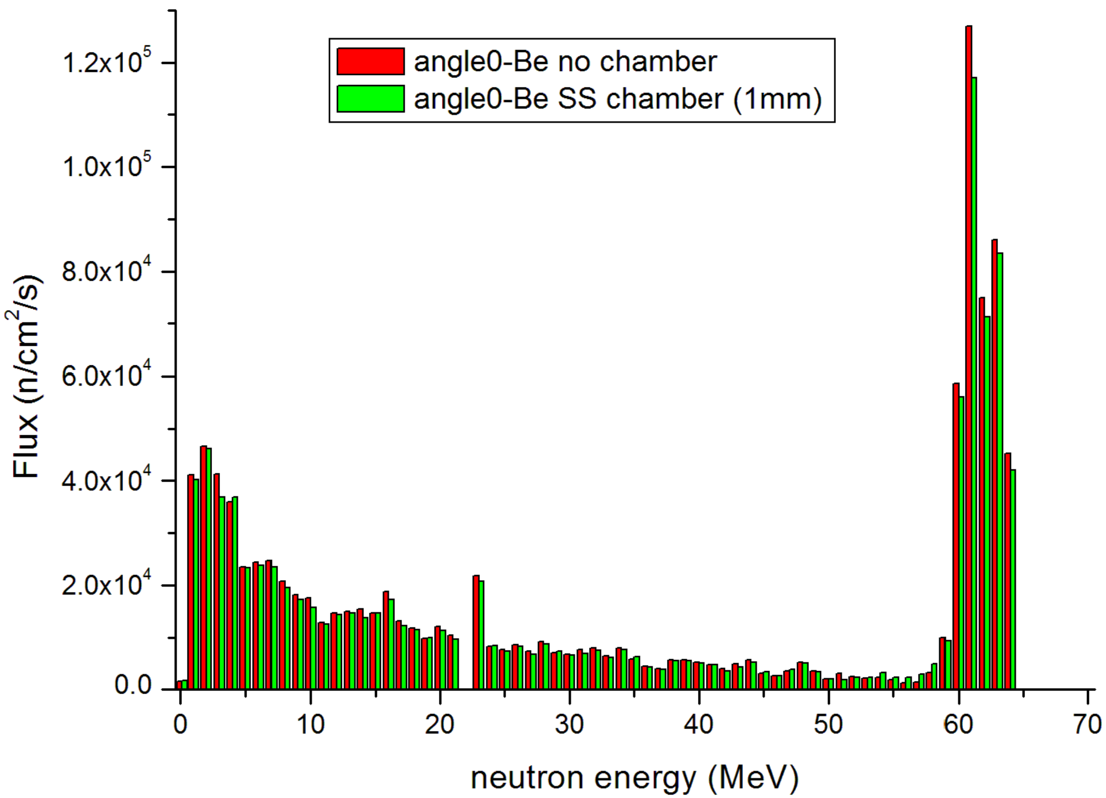
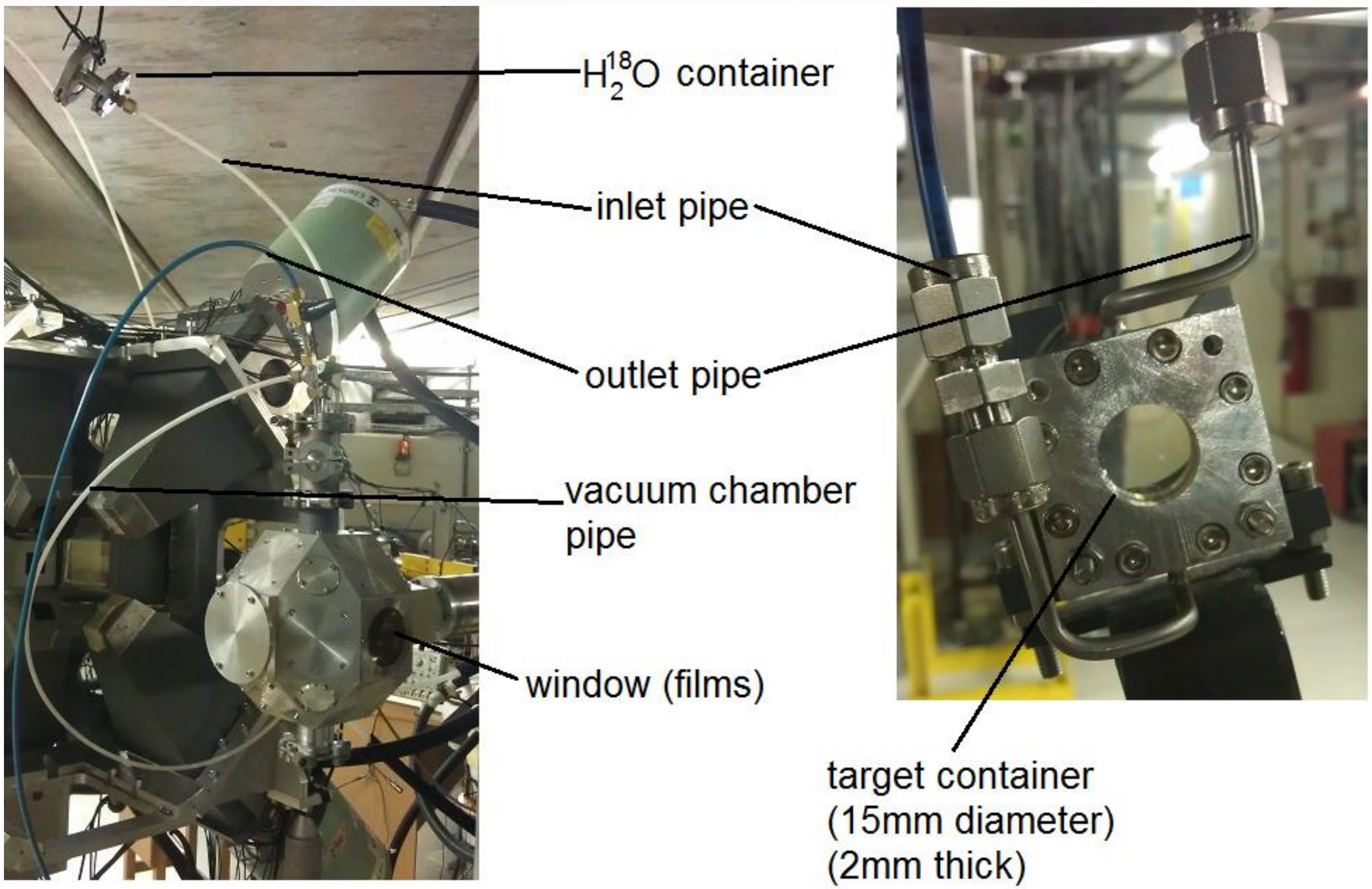


Figure 9: Compares the neutron spectrum from the Be target only at angle 0 to the spectrum when the proposed stainless steel chamber of 1mm thickness is used.

On the left are the results of the proposed chamber made of stainless steel (1mm thick) compared to the spectrum with no chamber. Results show that scattered neutrons from this chamber are negligible.

4. IN PROGRESS



4. IN PROGRESS & CONCLUSIONS

- The aim is to achieve 5% accuracy in measurements. Currently the counting statistics and error prediction are being calculated and analysed.

- The neutron vault will be used to measure the neutron spectrum at 0^o and 16^o whereas a new stainless steel chamber of 1mm thickness needs to be constructed to measure angles 16^o; 45^o; 90^o and 135^o.

- The assembly of the new steel chamber to accommodate all the targets to be measured is underway.

5. PROJECT RELEVANCE TO ENERGY

Particularly in the nuclear energy generation:

- Understanding 'neutronics' as neutrons are important in nuclear reactors.
- Knowledge of neutron sources is relevant for transmutation of long-lived actinides and fission products from nuclear waste [7].
- Simulation codes used in this project (MCNPX; FLUKA etc) are relevant in the design of power plants.
- Knowledge of neutron measurements is relevant in radiation monitoring, a key issue in nuclear facilities

6. REFERENCES

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[7] A. Krasa, *Neutron Sources for ADS lecture notes,* Czech technical University, Czech, May 2010

7. ACKNOWLEDGEMENTS

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