Characterization of the new neutron beam at n_TOF-Ph2

C. Guerrero[1], M. Calviani[2], E. Berthoumieux[3], S. Andriamonje[2] and
The n_TOF Collaboration[4]

[1] *Nuclear Innovation Unit - CIEMAT, Madrid (Spain)*
[2] *CERN (Switzerland)*
[3] *DAPHNIA – CEA (France)*
[4] *www.cern.ch/nTOF*

Layout

1. Brief out look to n_TOF-Ph1: commissioning and measurements 2001/2004

2. Characterization of the new neutron beam at n_TOF-Ph2

- The neutron beam profile
- The neutron fluence: shape and intensity
- The Resolution Function

3. The 2009 experimental campaign: “The role of Fe and Ni in astrophysics”

4. The 2010 experimental campaign and beyond

n_TOF-Ph1: 2002-2004 physics measurements

n_TOF-Ph1: 2002-2004 physics measurements

Capture

^{151}Sm
^{204,206,207,208}Pb, ^{209}Bi
^{232}Th
^{24,25,26}Mg
^{90,91,92,94,96}Zr, ^{93}Zr
^{139}La
^{186,187,188}Os
^{233,234}U
^{237}Np,^{240}Pu,^{243}Am

Fission

^{233,234,235,236,238}U
^{232}Th
^{209}Bi
^{237}Np
^{241,243}Am, ^{245}Cm

- Measurements of neutron cross sections relevant for Nuclear Waste Transmutation and related Nuclear Technologies
  - Th/U fuel cycle (capture & fission)
  - Transmutation of MA (capture & fission)
  - Transmutation of FP (capture)

- Cross sections relevant for Nuclear Astrophysics
  - s-process: branchings
  - s-process: presolar grains

- Neutrons as probes for fundamental Nuclear Physics
  - Nuclear level density & PSF

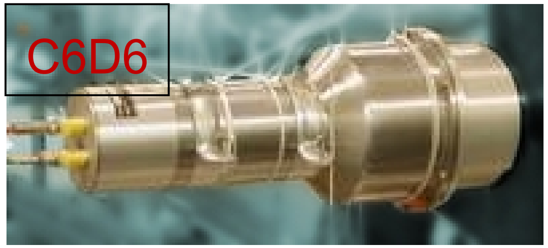
More than **30+10 Journal Papers**
50 large conferences
20 PhD

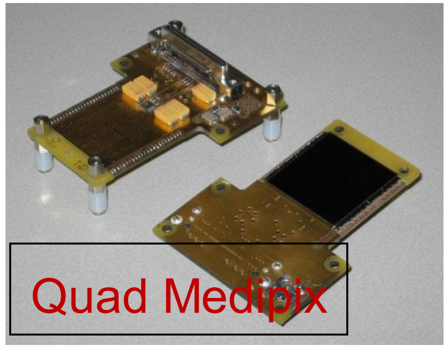
n_TOF-Ph2 commissioning (July-August 2009)

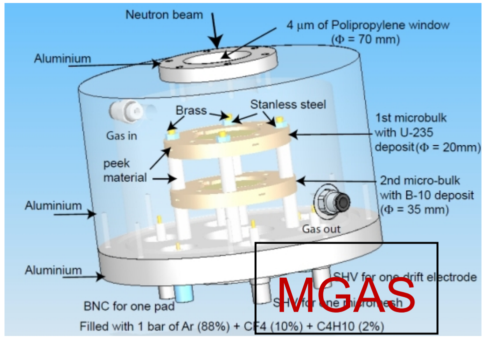
Beam characteristics:

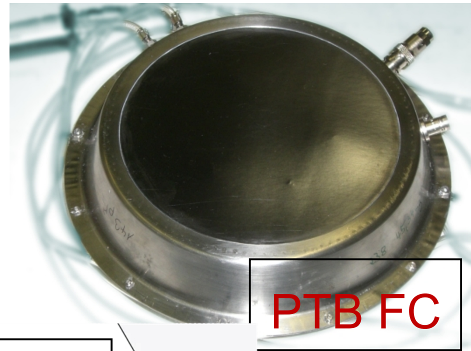
- **Spatial distribution:**
  XY-MGAS detector
  Medipix with LiF & polyethylene
- **Neutron fluence:**
  PTB Fission Chamber ^{235}U
  Micromegas: ^{235}U & ^{10}B
  Silicon Monitor
  Gold foils: activation +TAC
- **Resolution function:**
  C6D6 with $^{54,56}Fe$ (+Simulations)
- **Background:**
  CR-39, TLD, BaF_2 and C6D6

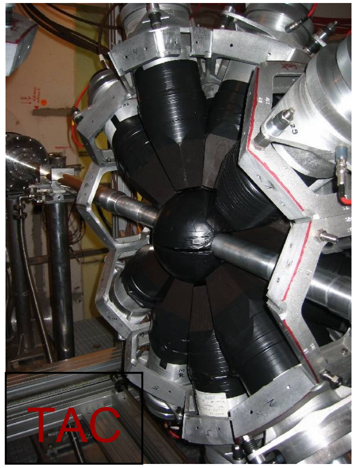
RESULTS ARE PRELIMINARY!!

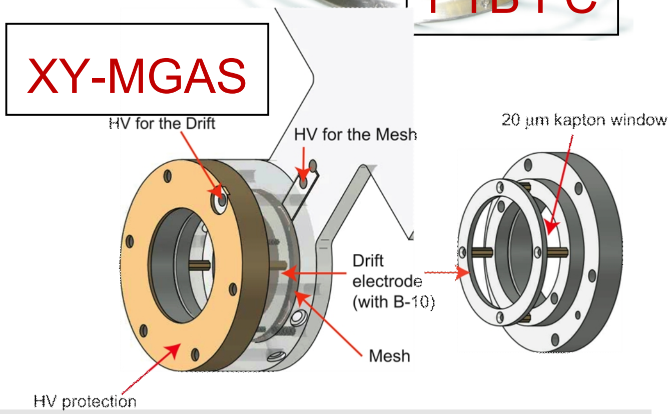












n_TOF-Ph2: neutron fluence shape and intensity

The shape and intensity of the neutron fluence at n_TOF has been characterized by means of five different measurements:

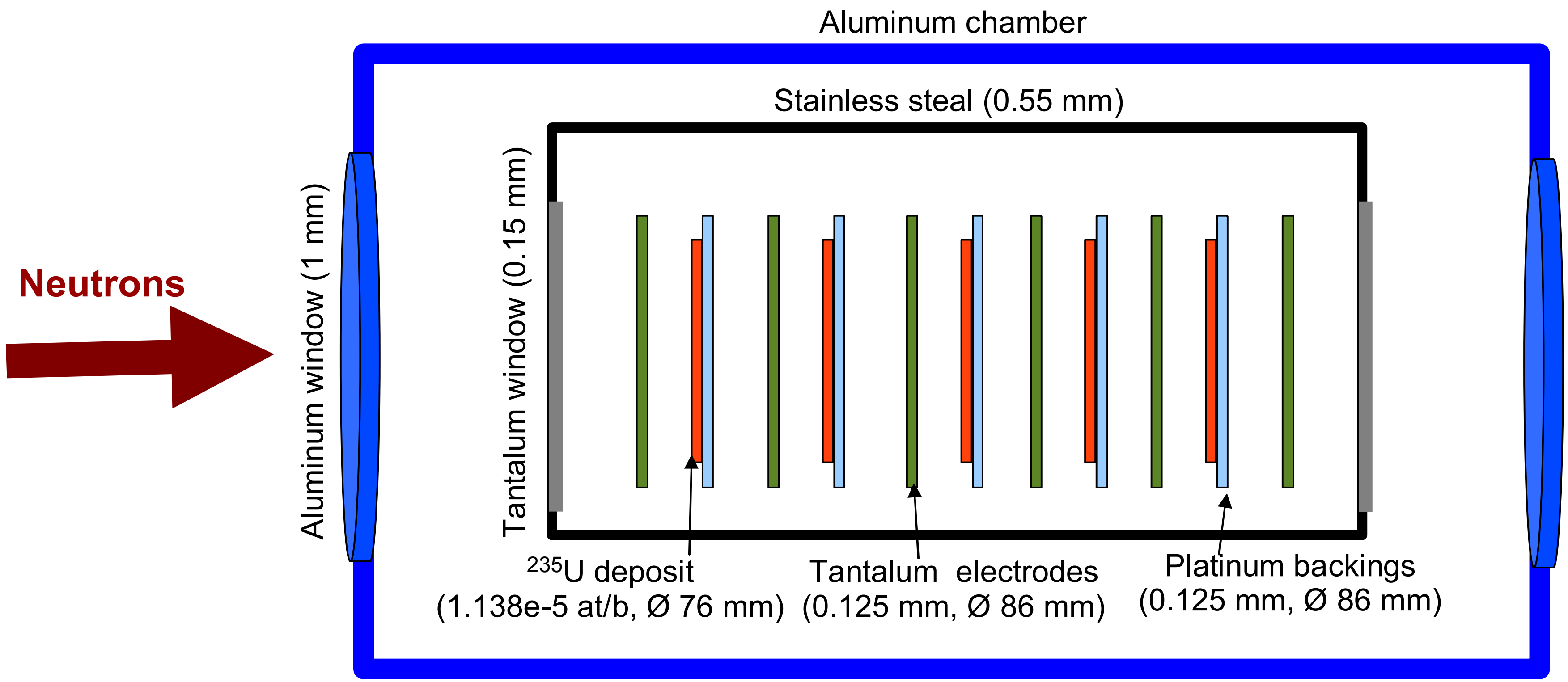
	Reaction	Shape	Intensity
PTB	**^{235}U(n,f)**	Yes	Yes
MGAS	**^{235}U(n,f) & ^{10}B(n,α)**	Yes	~
SiMon	**^{6}Li(n,t)**	Yes (E_n<keV)	~
TAC	**^{197}Au(n,γ)**	No	Yes (@4.9 eV)
Activation	**^{197}Au(n,γ)^{198}Au(β)**	No	Yes (@4.9 eV)

The shape of the neutron fluence is crucial for all capture measurements, which are usually normalized to a saturated resonance at a given energy.

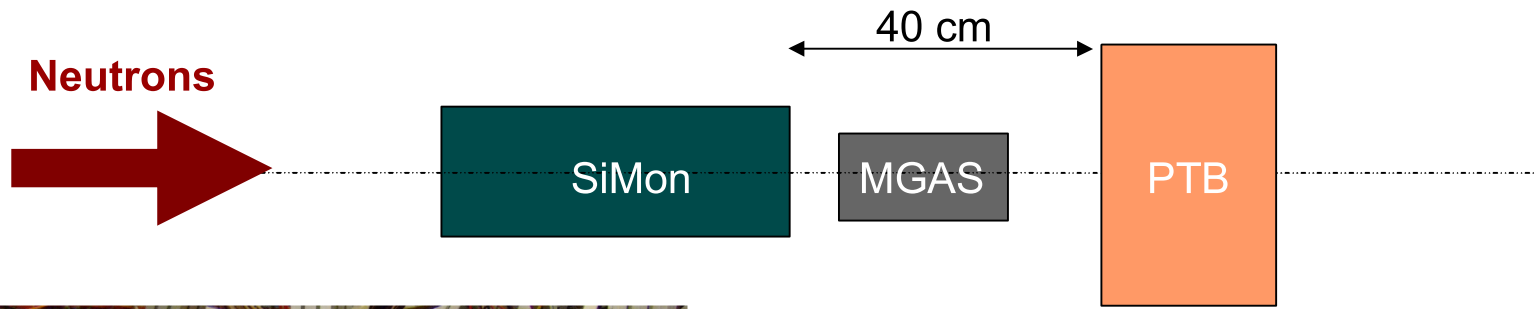
Neutron fluence from the PTB fission chamber

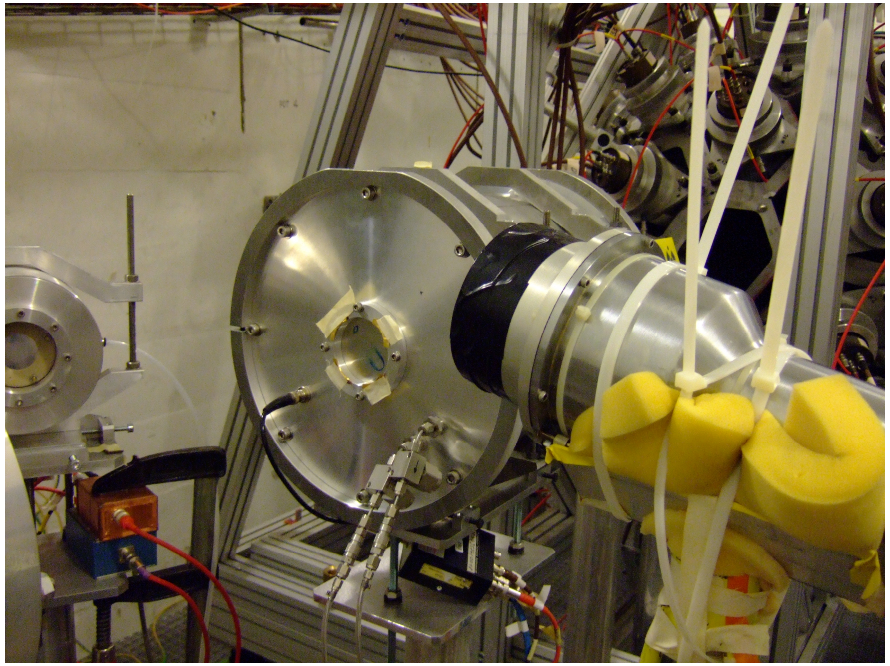
A total of 201.4(5) mg ^{235}U divided in 5 deposits on Platinum backings.

The chamber (mass of uranium and detection efficiency) is well calibrated and has been operating as well as the detection efficiency are well known from previous "international intercomparisons".



Neutron fluence from the PTB fission chamber

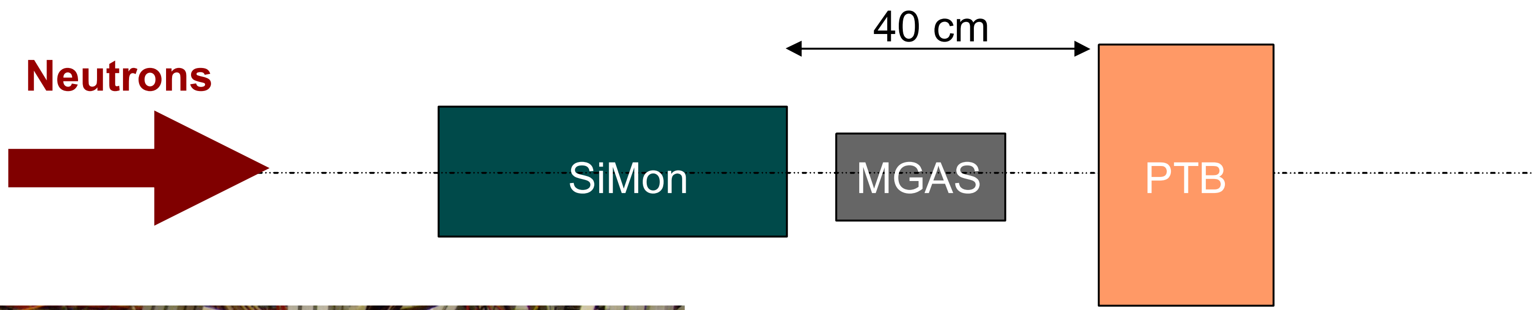


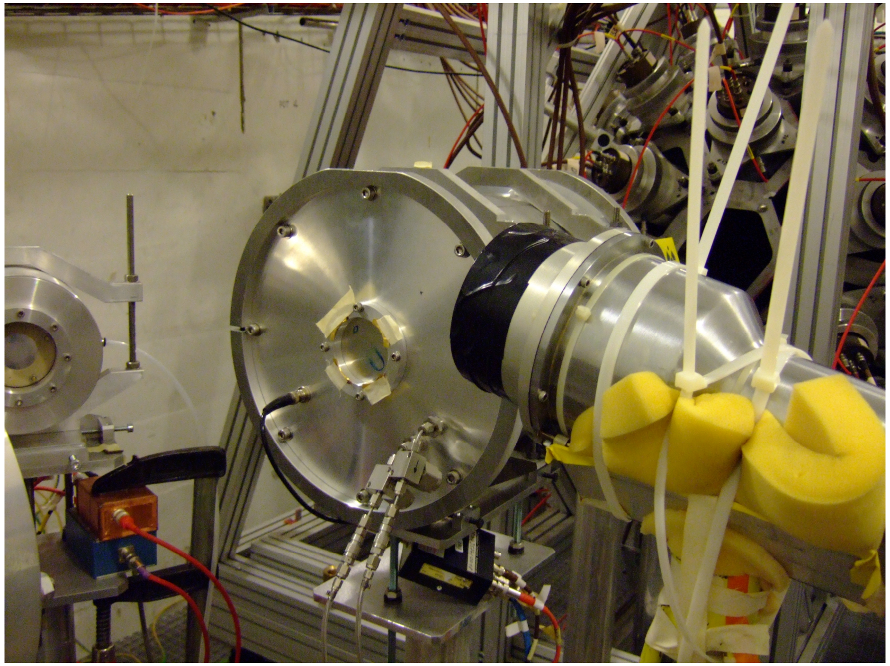


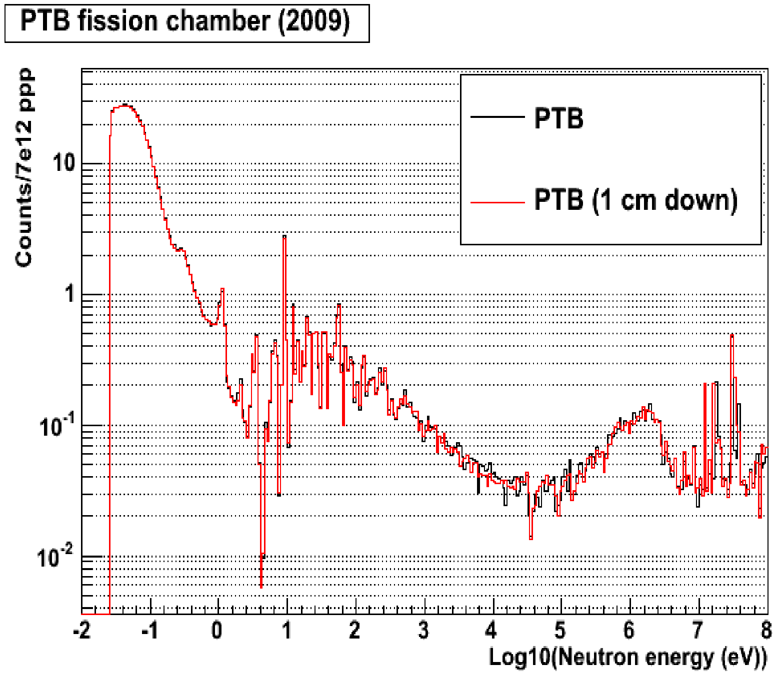
3 flashADC channels:

1) Small range for good α/FF separation
2) Wide range to minimize saturation of FF.
3) Similar to 2), but adding an 8 ms delay for the study of thermal energies.

Neutron fluence from the PTB fission chamber

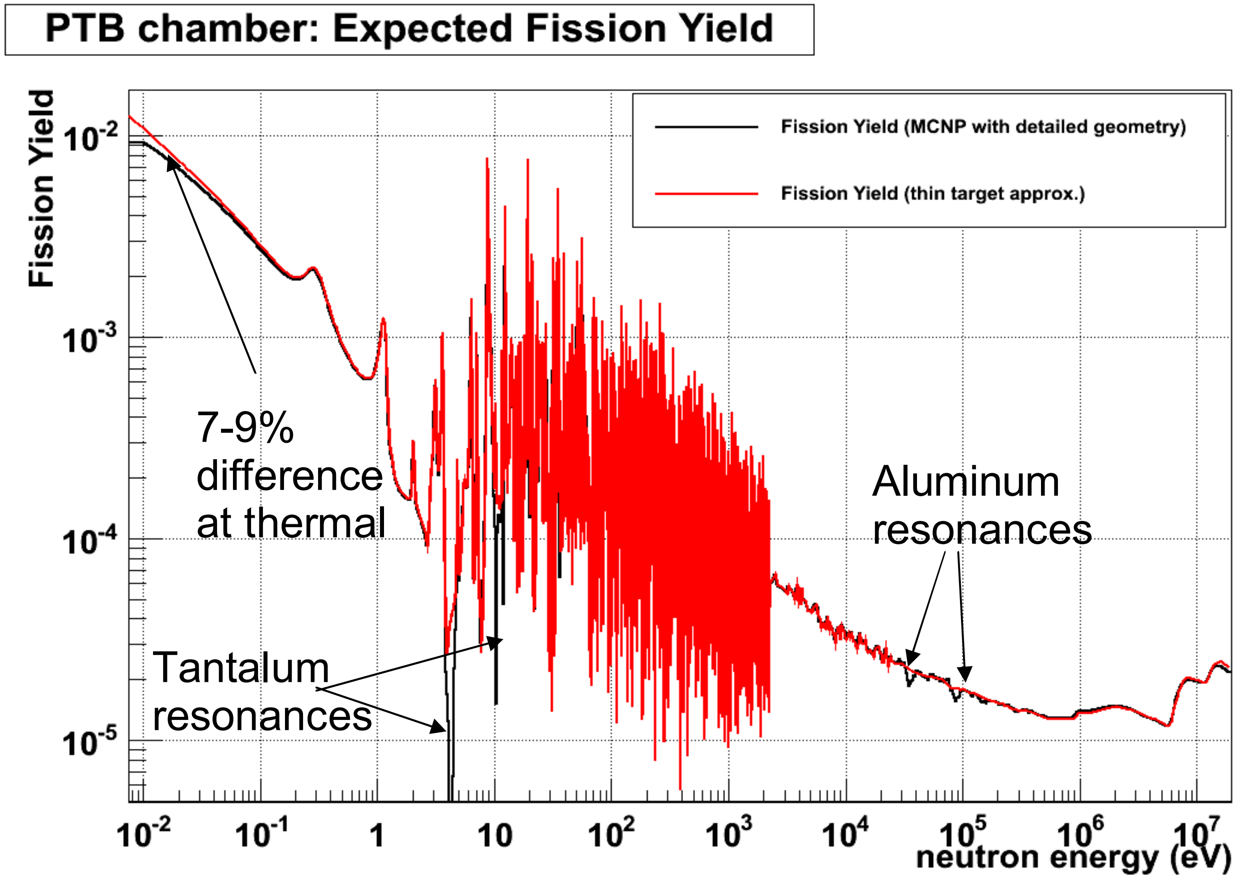




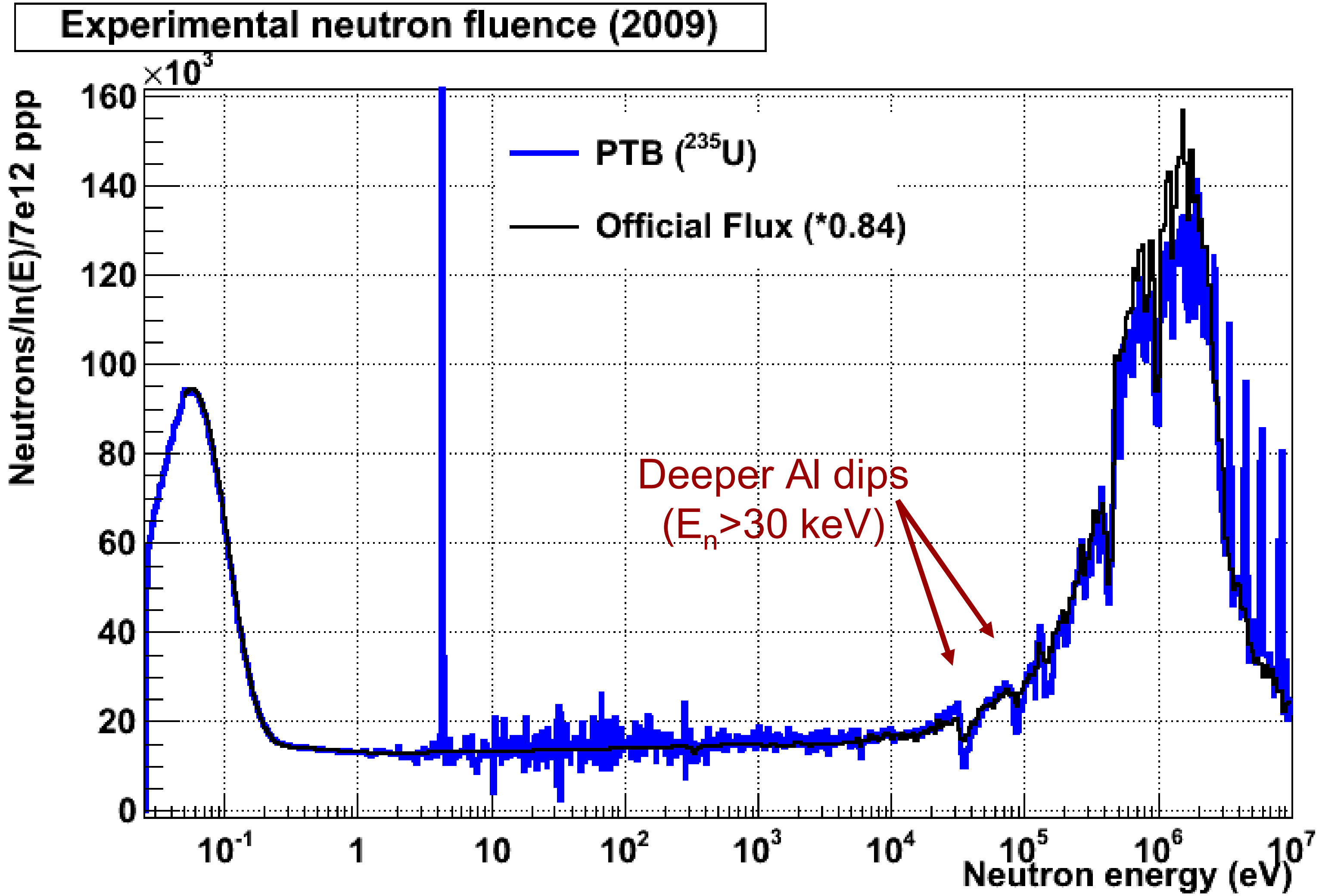


Neutron fluence from the PTB fission chamber

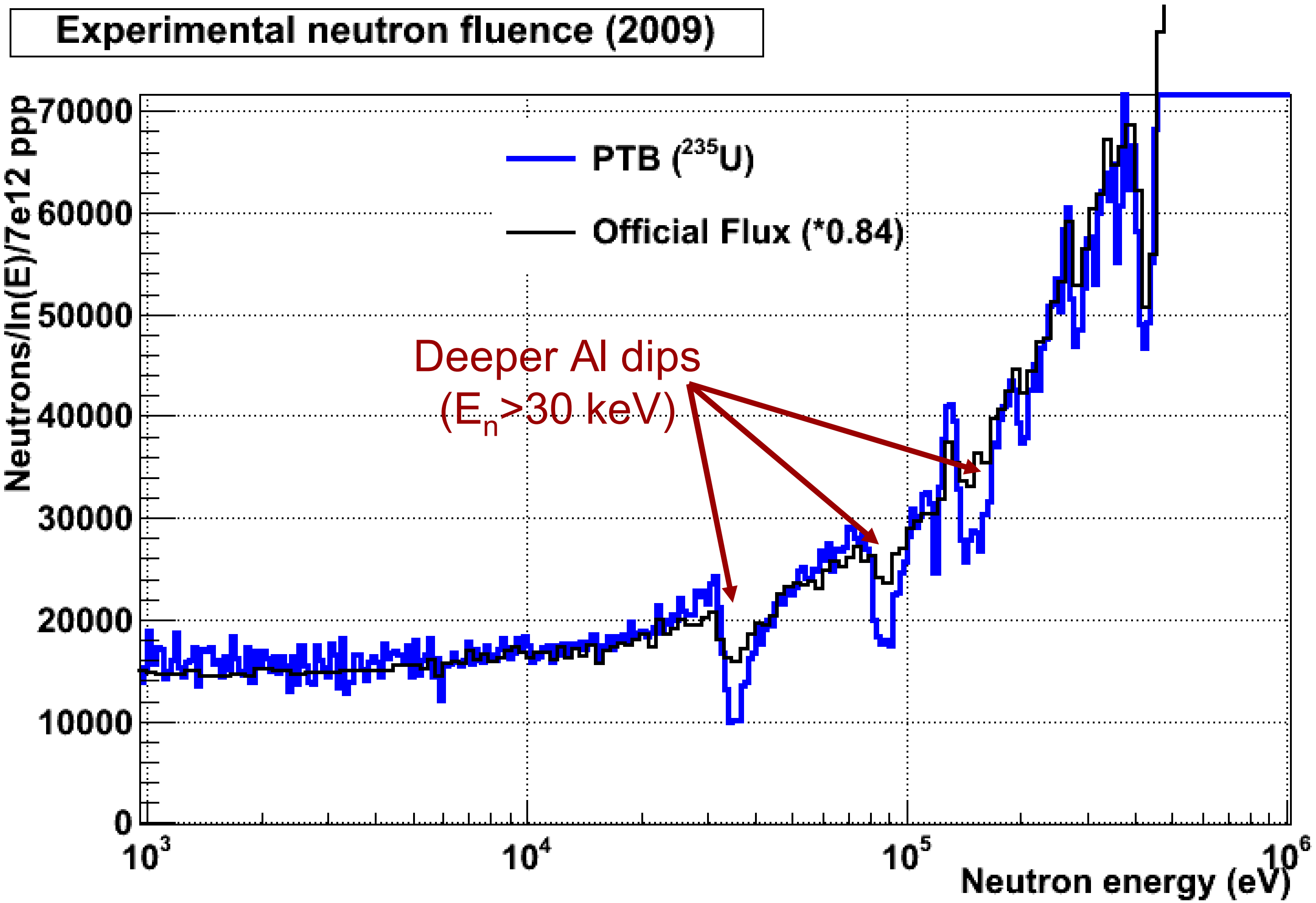
In addition to the simple thin target approximation, a detailed **MCNP simulation** was performed for calculating the fission yield including the effects of the **aluminum** chamber, the **platinum** backings and the **tantalum** electrodes.



Neutron fluence from the PTB fission chamber



Neutron fluence from the PTB fission chamber

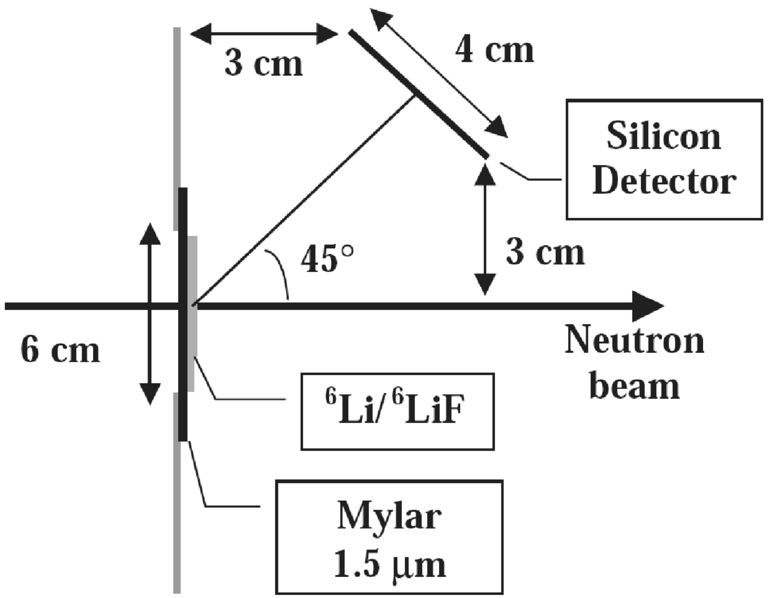


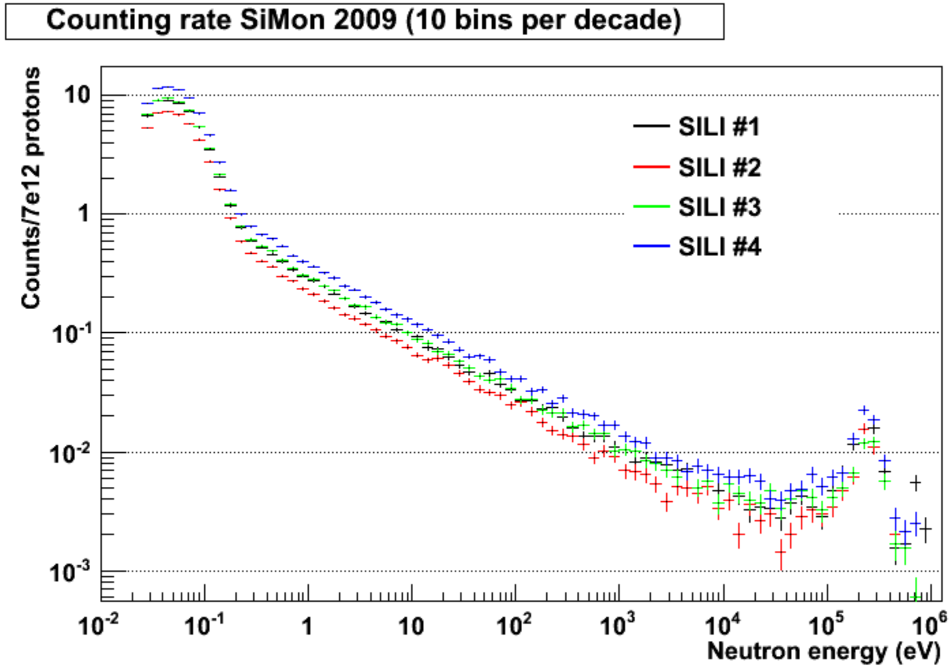
The neutron fluence from the PTB chamber is 16% lower than the Official Flux.

Neutron fluence from the Silicon Monitor (SiMon)

The Silicon Monitor has been used during all the measurement of nTOF-Ph1.

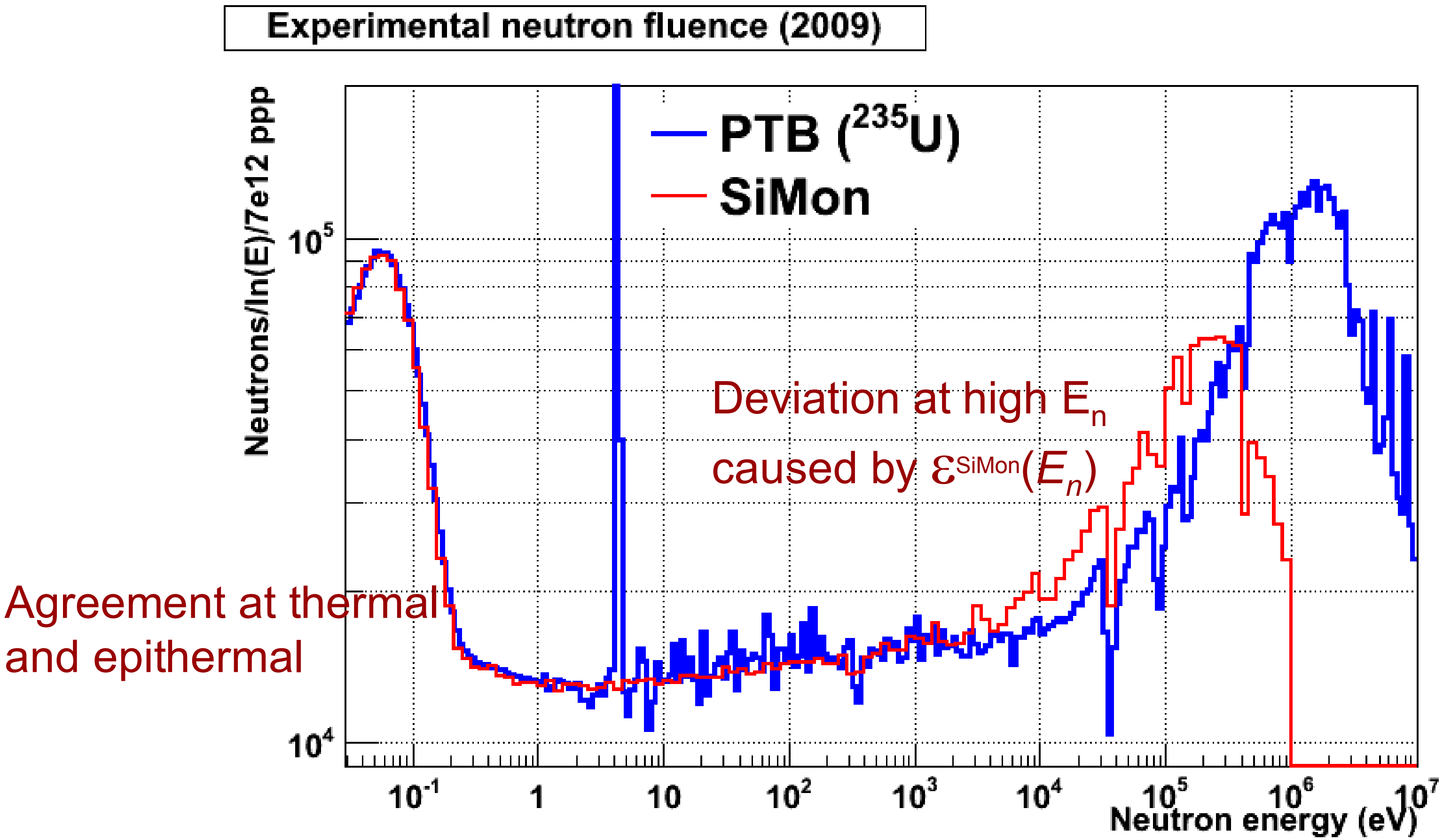
It consists of 4 Silicon detectors looking at a ^{6}Li foil of 200 μg/cm^2.





Neutron fluence from the Silicon Monitor (SiMon)

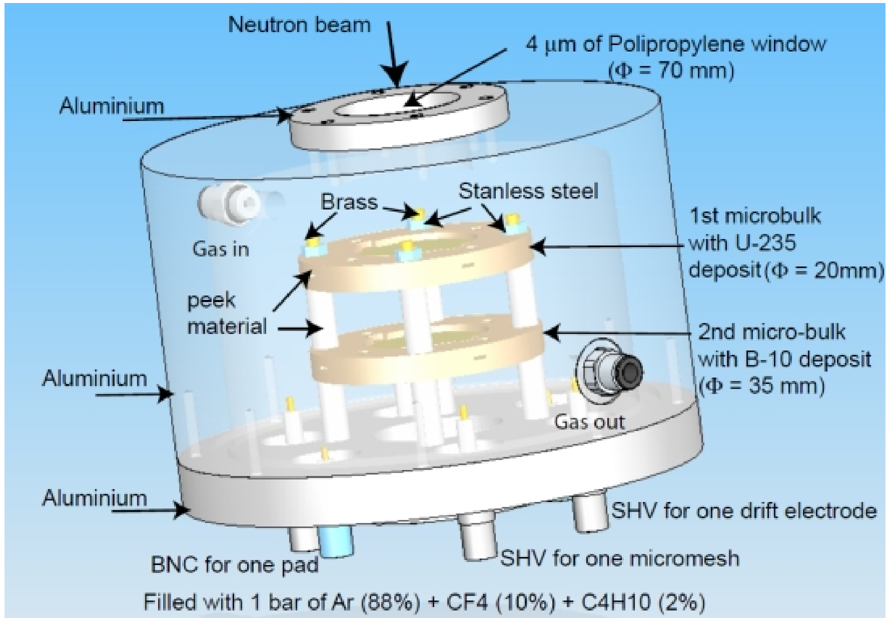
The neutron fluence extracted from the SiMon **is in agreement** (2% lower) **with that resulting from the PTB measurement.**

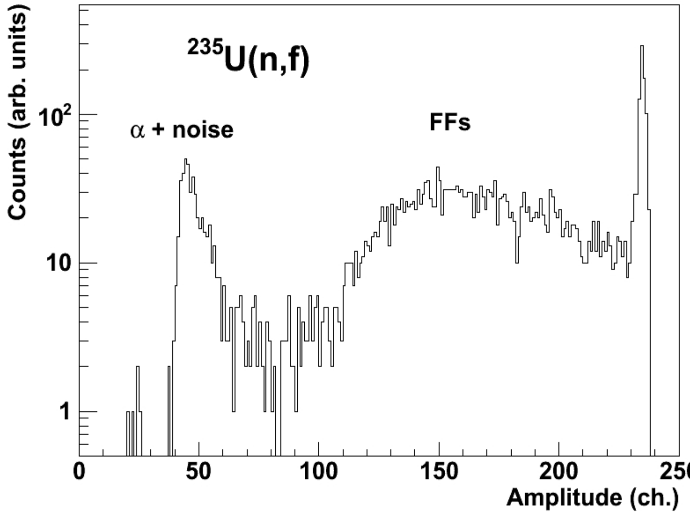


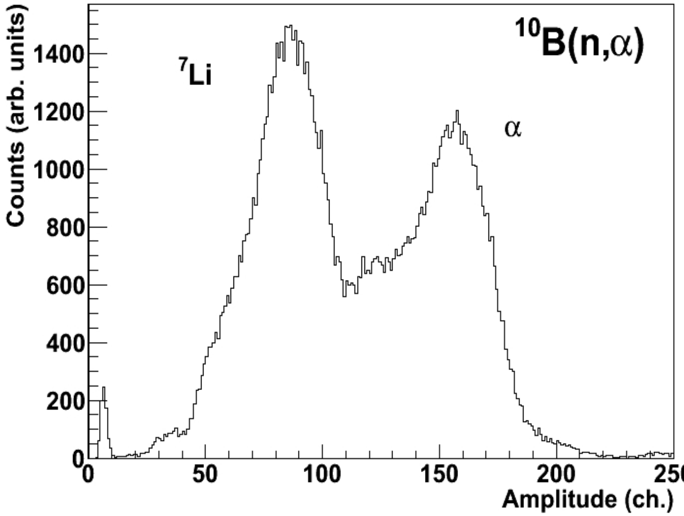
Neutron fluence from the MicroMegas (MGAS)

The MicroMegas detector has been developed at CEA Saclay and it is used at CERN by the CAST and n_TOF Collaborations.

The chamber, intended for monitoring purposes, has very thin polypropylene windows and contains two deposits: ^{235}U and ^{10}B.

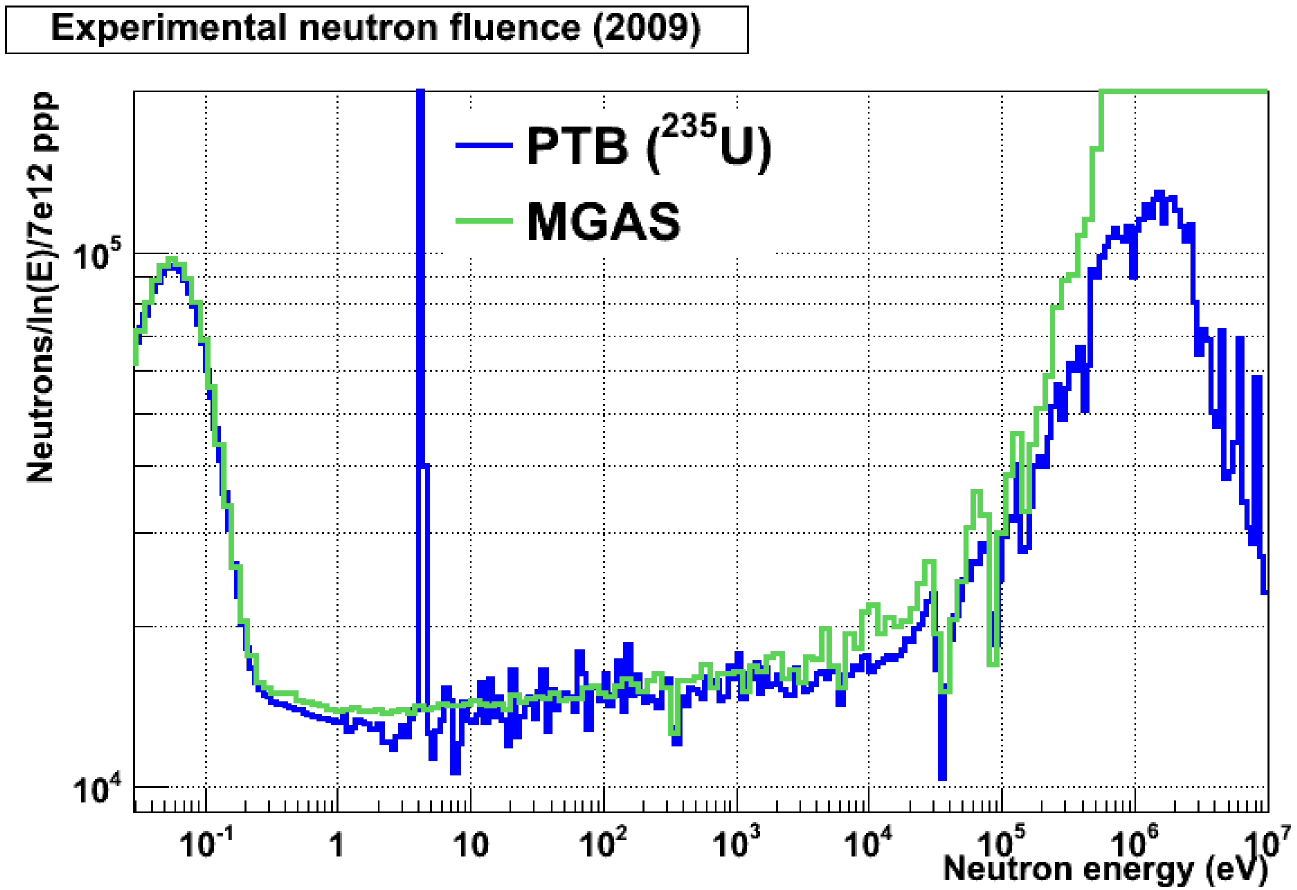




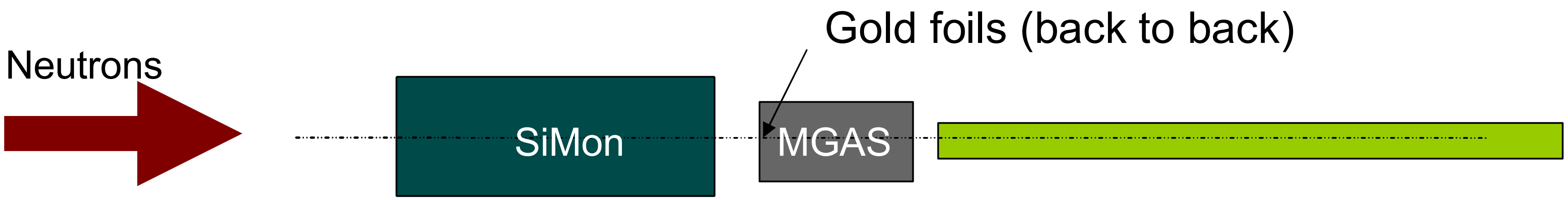


Neutron fluence from the MicroMegas (MGAS)

The neutron fluence extracted from the MGAS is in agreement (5% higher) with that resulting from the PTB measurement. This difference is within the uncertainty of the masses of the sample, but a calibration is already foreseen at a thermal neutron source.



Neutron fluence from the Activation of Gold foils

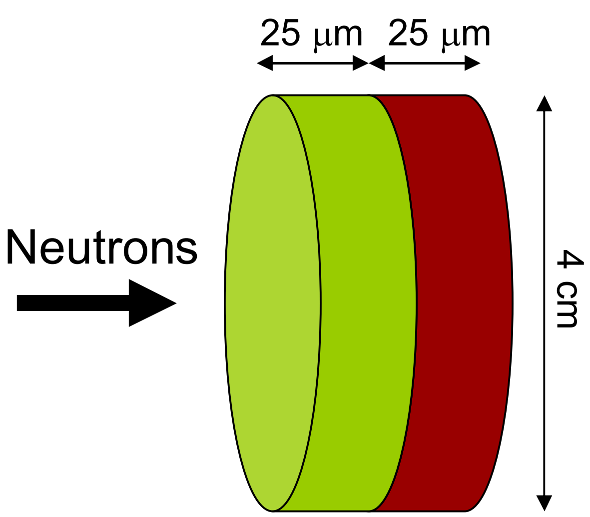


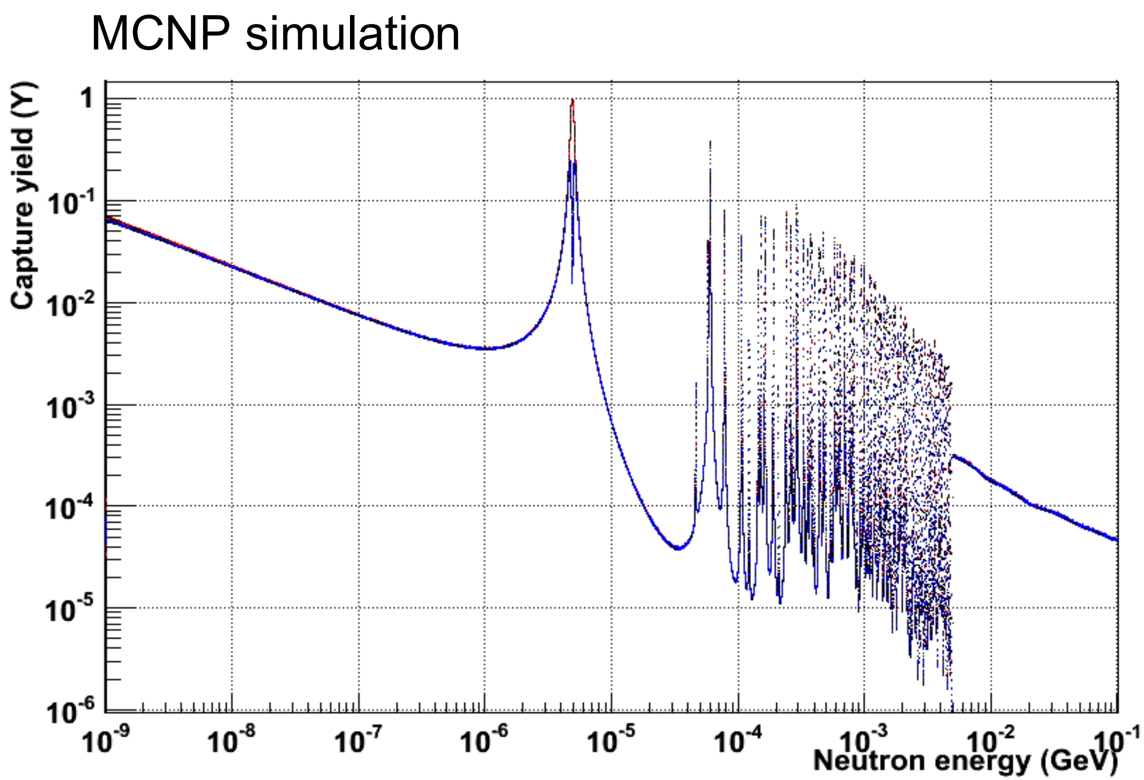
SET #1 (25 μm, 0.602 g & 0.599 g)		SET #2 (100 μm, 3.354 g & 3.257 g)	
# Protons	**Time interval**	**# Protons**	**Time interval**
8.31e15	22/6/09 (1:10-5:58)	2.64e15	15-16/6/09 (21:52-1:03)
1.35e15	22/6/09 (6:22-15:21)	8.95e15	16-17/6/09 (21:24-7:28)
2.9e15	22/6/09 (17:07-18:54)		

		Activity (412 keV line)	Date
SET #1 (25 um)	**Foil C (front)**	38 Bq/g	24/6/09 (1 pm)
	Foil D (back)	29 Bq/g	24/6/09 (1 pm)
SET #2 (100 um)	**Foil 13 (front)**	10 Bq/g	18/6/09 (8 pm)
	Foil 16 (back)	9.5 Bq/g	18/6/09 (8 pm)

Neutron fluence from the Activation of Gold foils

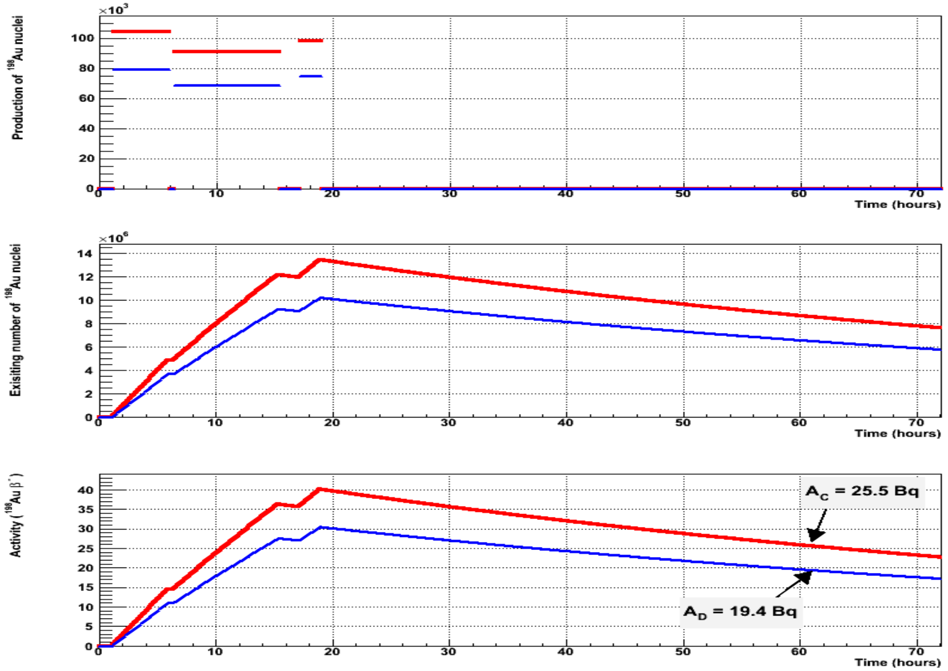
In an activation measurements of two samples (back to back), the neutrons scattered in one sample have a significant effect on the other an hence the usual simplified formulas for calculating the capture yield are not accurate.





Neutron fluence from the Activation of Gold foils

	Captures/ pulse	10^{-3}-10^{-2}	10^{-2}-10^{-1}	10^{-1}-1	1-10	10-10^{2}	10^{2}-10^{3}	10^{3}-10^{6}
Foil C	**3800**	5.1%	42.3%	7.7 %	**40.3 %**	2.0 %	1.8 %	0.8 %
Foil D	**2887**	6.6 %	54.9 %	10.1 %	**23.3 %**	2.0 %	2.2 %	0.9 %
Diff.	**913**	0.7 %	2.4 %	0.2 %	**94 %**	2 %	0.4 %	0.3 %



The neutron fluence at **4.9 eV from activation measurements** (25 mm foils) **is 5% higher than that given by the PTB fission chamber.**

The **accuracy of this measurement (7%)** is dominated by the modeling of the activity measurement (40% HpGe), which **is still ongoing.**

Neutron fluence from the TAC using $^{197}Au(n,\gamma)$

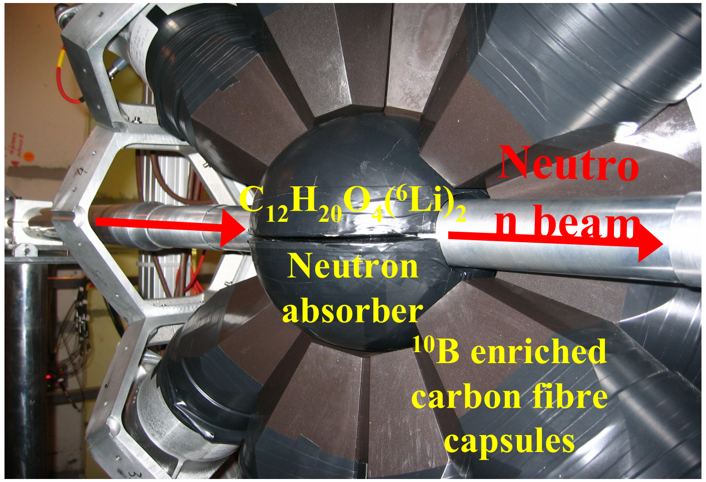
We performed three measurements

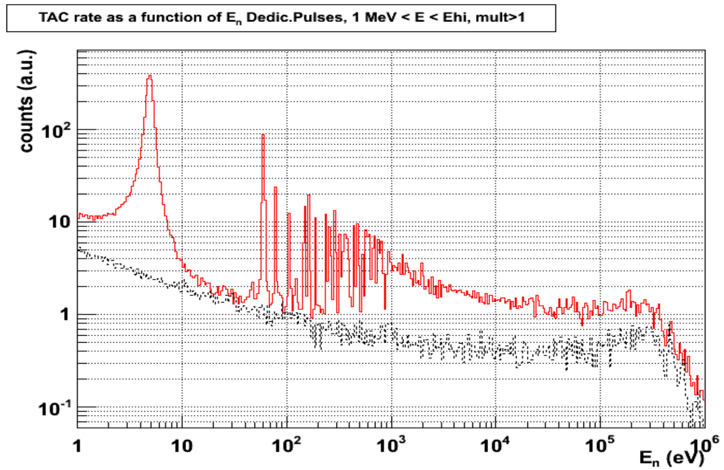
1) Measurement with a **gold ring**, to test the alignment.

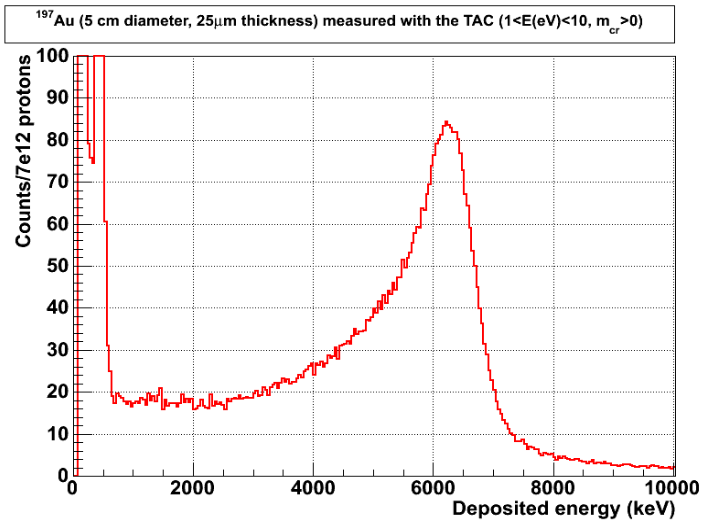
2) Measurement with a **4 cm diameter** gold sample (25 μm).

3) **Background** measurement without sample.

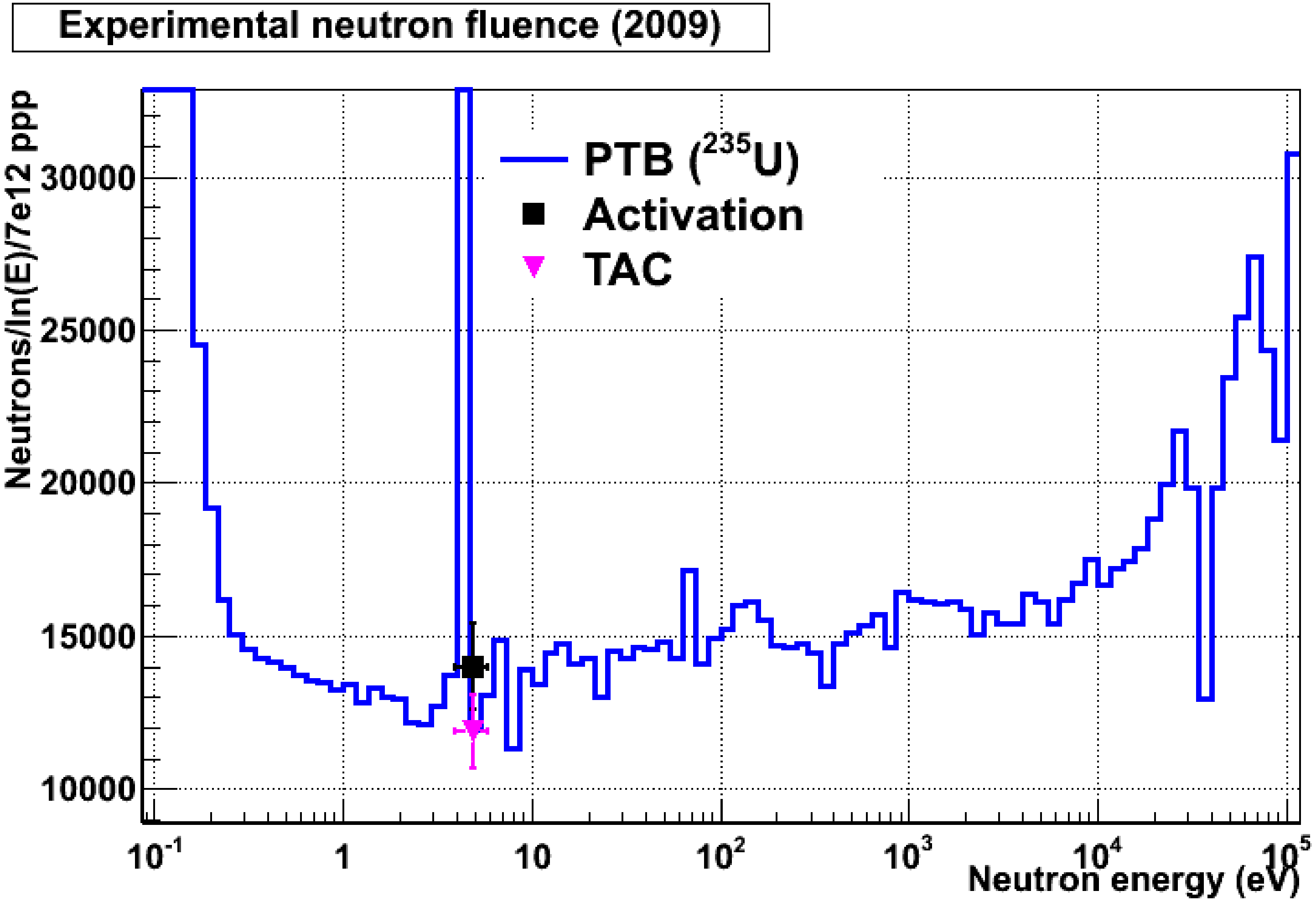
4) Neutron intensity reduced (1·1012 ppp) for minimizing pile-up events.





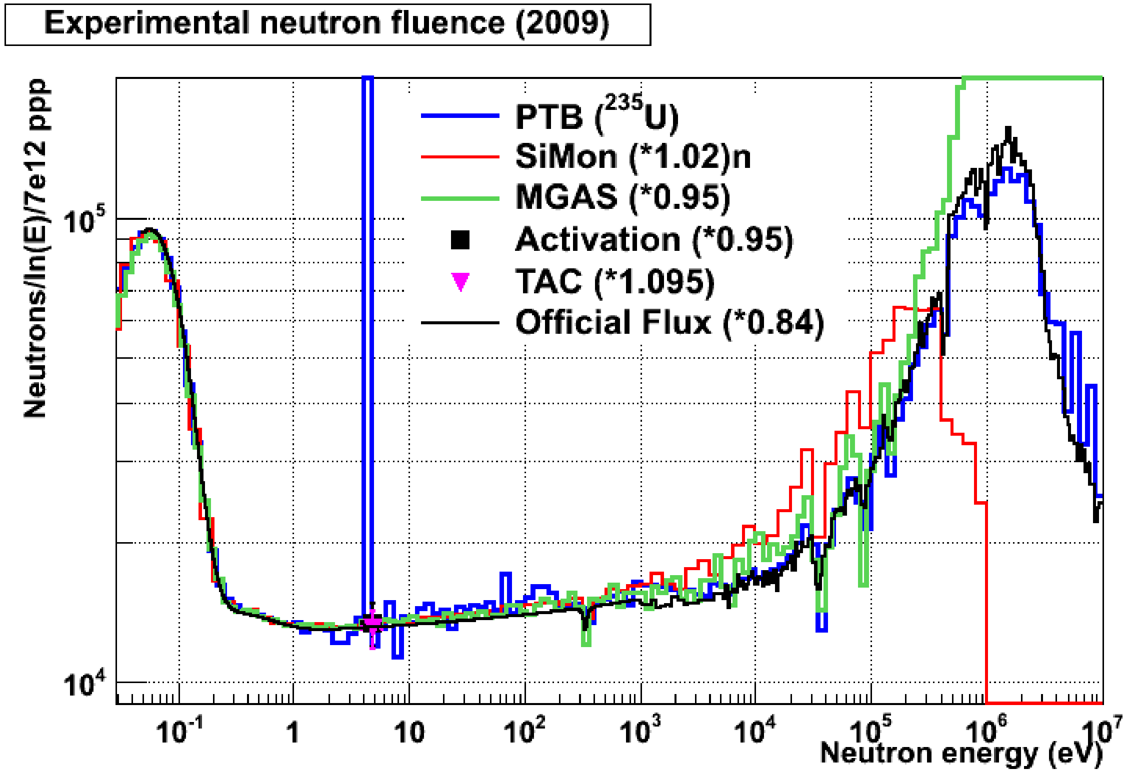


Neutron fluence from $^{197}Au(n,\gamma)$ at 4.9 eV

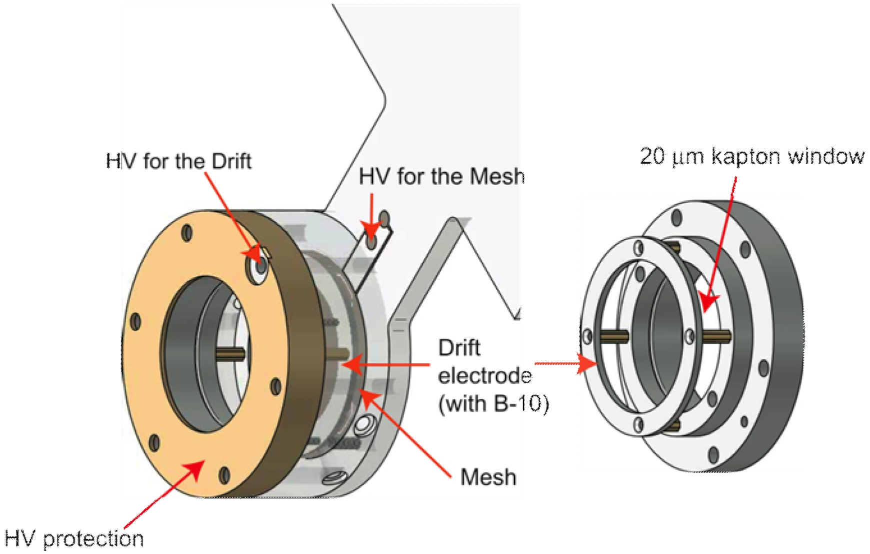


Neutron fluence: intensity and shape

	PTB	SiMon	MGAS	Activation	TAC
Accuracy	~3%	~10% (<kev)	10%	10%	8%
Ratio over PTB	1	0.98	1.05	1.05	0.91



Neutron beam profile from XY-MGAS

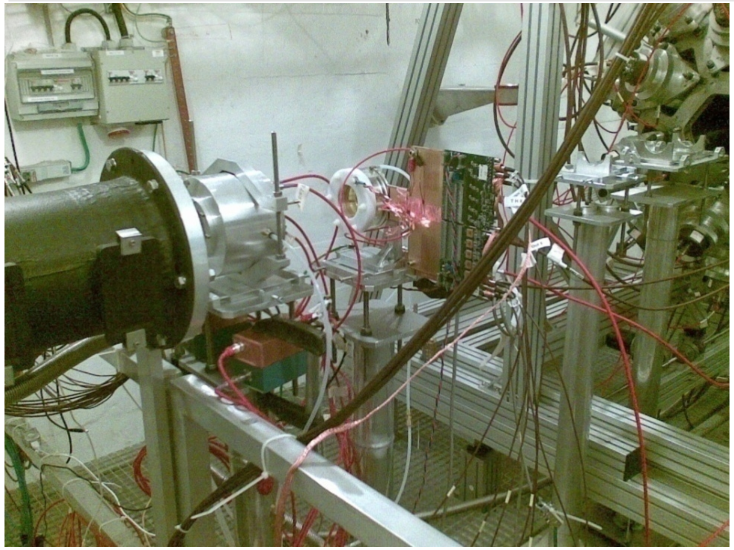


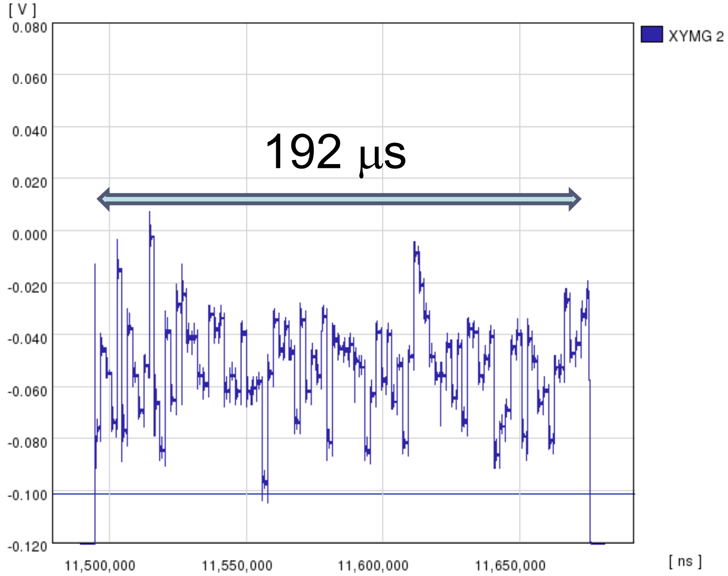
- Detector based on the "micro-bulk" technique.
- Active region is separated in two active regions:
  - conversion (drift) → 480 V
  - amplification (mesh) gap → 330 V

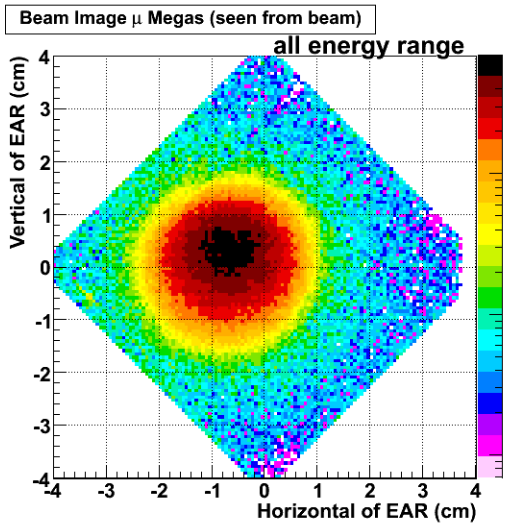
XY-MGAS: anode segmented into 106 strips for each X and Y pad (tilted 90 deg.)
• 212 channels → multiplexed through Gassiplex → 2 (+1 mesh) flashADC channels

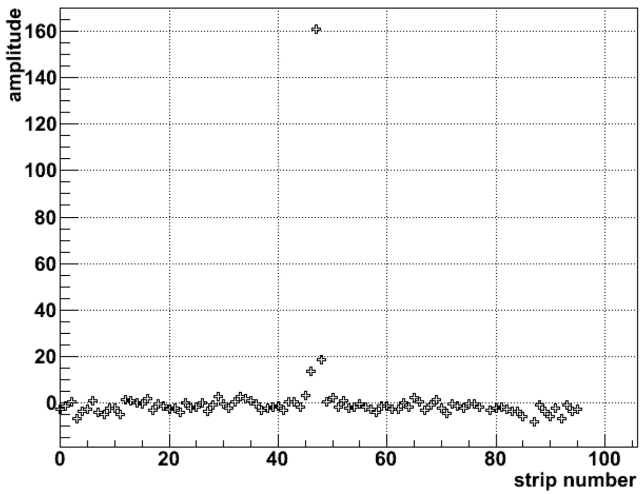
Capable of measuring the Neutron beam profile as a function of energy
from thermal up to ~1 MeV

Neutron beam profile from XY-MGAS





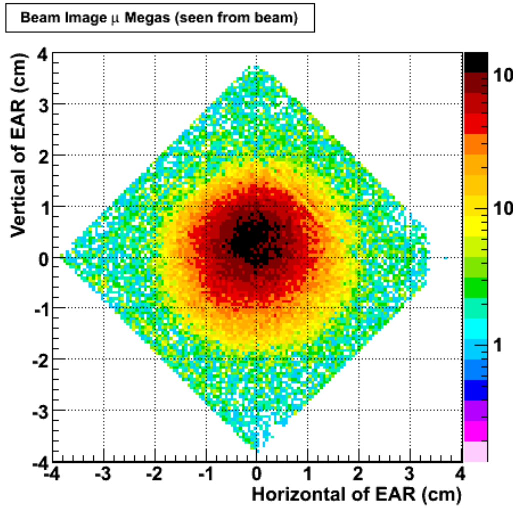


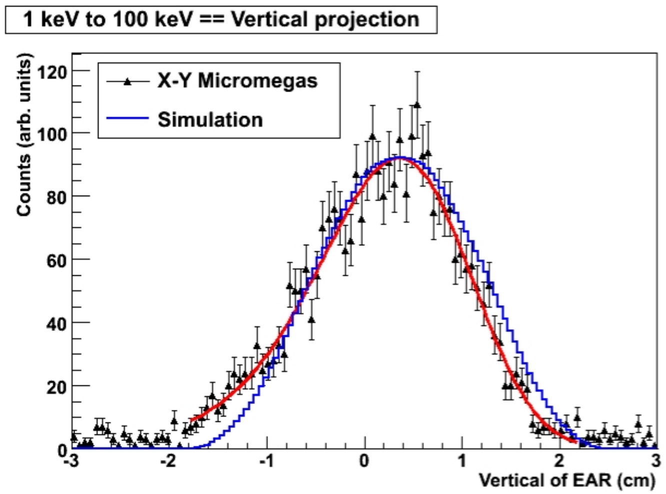


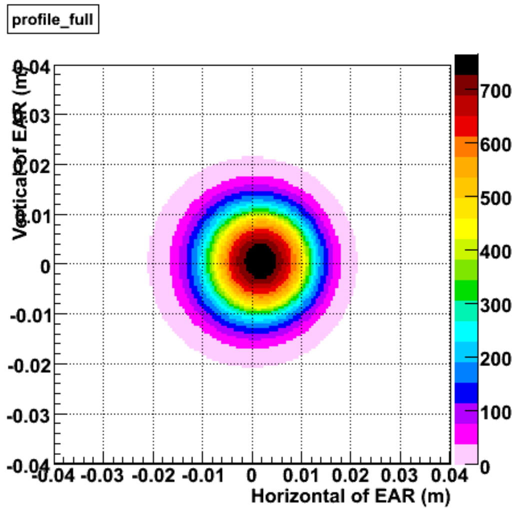
Neutron beam profile from XY-MGAS

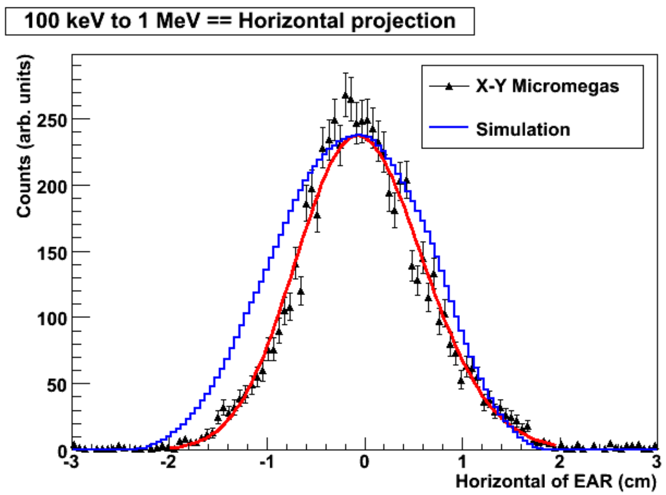
The combination of the XY-MGAS data and MC simulations (ongoing) will result in a beam profile as a function of energy and position.

Crucial for capture measurements with samples smaller than the beam.



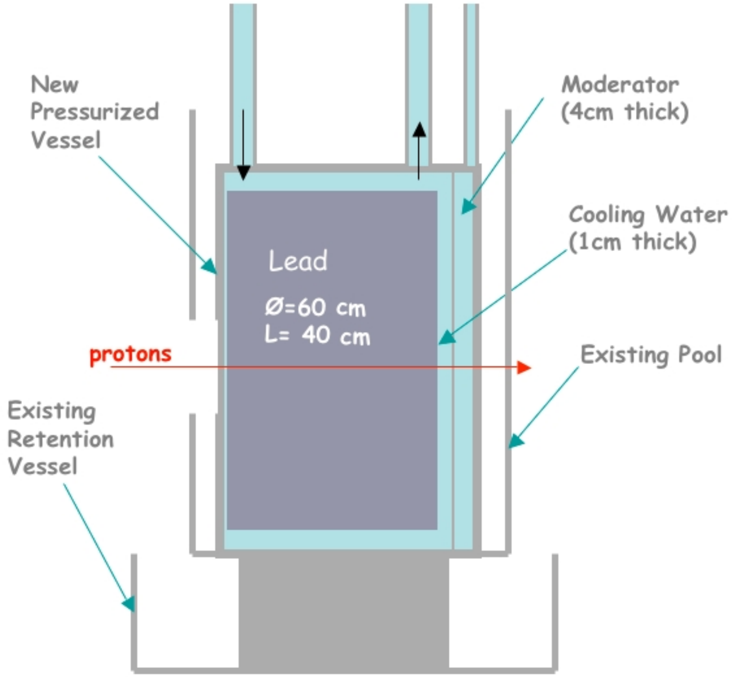


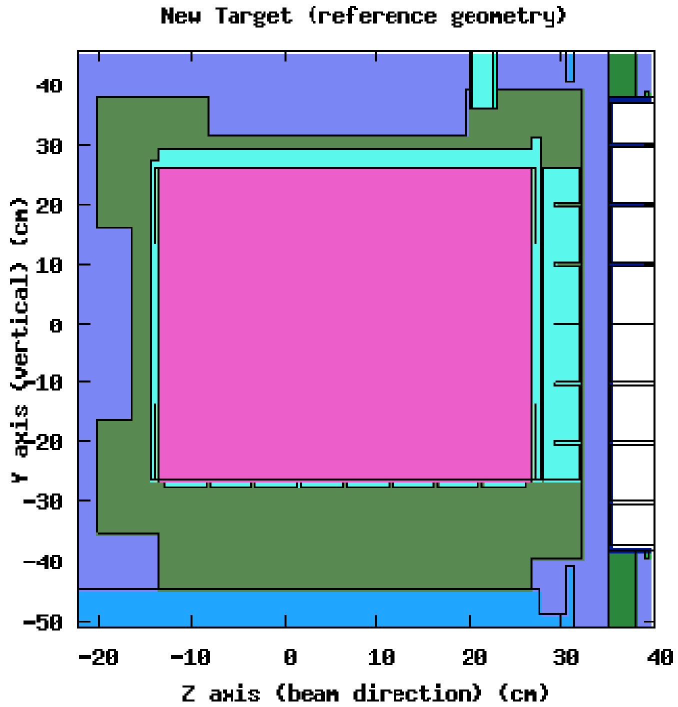




Resolution Function

The Resolution Function is related with the structure of the proton beam, the neutron production and the thermalization of neutrons in the moderator.





NEW Pb TARGET

- -Smaller than the previous Pb target
- - 5 cm of moderator
- -2.8 cm of air after moderator

The Resolution Function is characterized from the combination of simulations and the study of 56Fe and 54Fe narrow resonances.

ONGOING

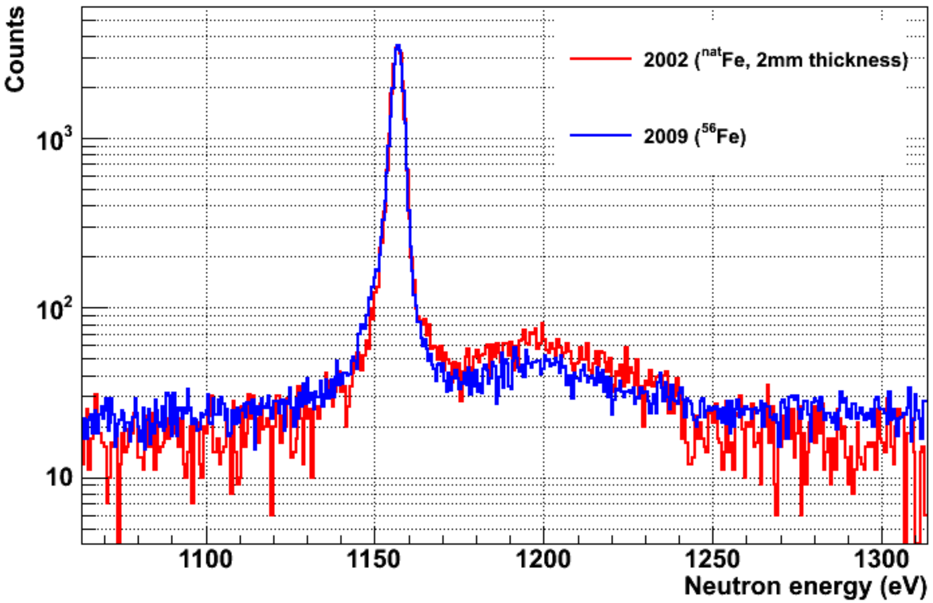
Fe/Ni experimental set-up

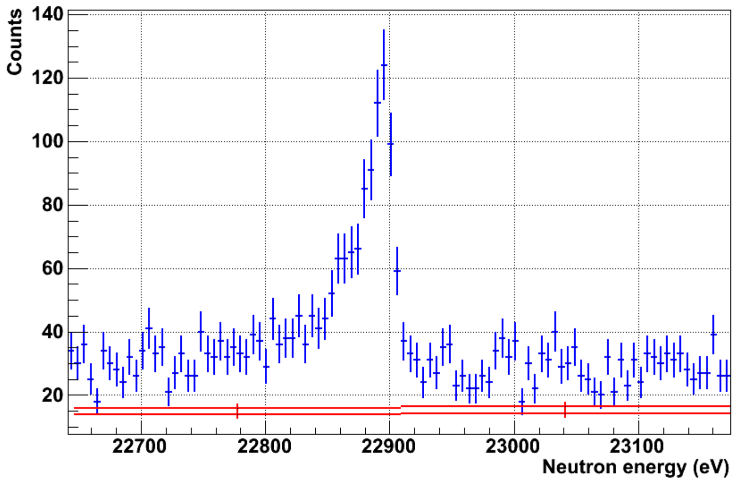
Fe/Ni experimental set-up

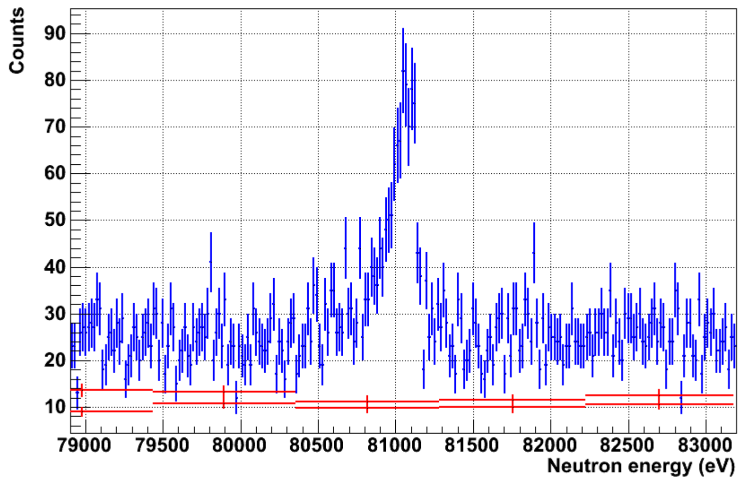
The measurement of ^{56}**Fe(n,γ) is ongoing**.

The set-up includes the **"low neutron sensitivity" C6D6 made of carbon fiber** that provided so many high quality data during n_TOF-Ph1.

The next scheduled measurement will be ^{62}Ni.







What is next?

The **n_TOF Collaboration has been looking forward to the restart of the physics program** during the last 4 years, trough which we had time to **plan new interesting measurements with new detectors and improved set-ups**.

1. The **Fe/Ni measurements will profit from the use of a new moderator** with enriched with ^{10}B: large reduction of in-beam g-ray background (main source by large).
2. The measurement of actinides with the **TAC (start with ^{241}Am, ^{243}Am and ^{238}U)** will profit from the **new Class-A type certification of the EAR-1**:
   - Unsealed sample and a wide variety of new isotopes
   - A new set-u will reduce the background allowing to **reach higher energies (~30 keV)**
   - A new pulse type with lower intensity will reduce the prompt flash, **increase even higher the energy limit (~100 keV)**
   - **Fission tagging** will allow to improve measurements on fissile isotopes.
3. The fission measurements with a **new PPAC set-up** will provide ot only cross sections but also **angular distribution of fission fragments** (starting with ^{232}Th, ^{235}U and ^{238}U).

Summary and conclusions

The **n_TOF facility is back to operation**, with a recovered enthusiasm and ambitious physics program.

The **preliminary results of the commissioning** (July and August 2009) have been presented:

- A total of **5 different and completely independent measurements** have been carried out for determining the **shape and intensity** of the neutron fluence. The results from different detector agree within uncertainties but the analysis is ongoing with the aim of reaching 3% accuracy in the determination of the neutron fluence.

- The **2D neutron beam profile** has been determined using an innovative XY-MGAS detector and a Medipix detector. The comparison with simulations is ongoing but the results are promising up to an energy of 1 MeV.

- The measurement, simulations and analysis of the Res. Function are ongoing.

The **first physics measurement**, a systematic on all Fe and Ni isotopes **has started**.

The upgrades of the facility for next year (borated moderator and Class-A certification) offer the possibility of performing improved measurements and the investigation of a wide range of isotopes.