The neutron Time-of-Flight facility, n_TOF at CERN: Status and perspectives

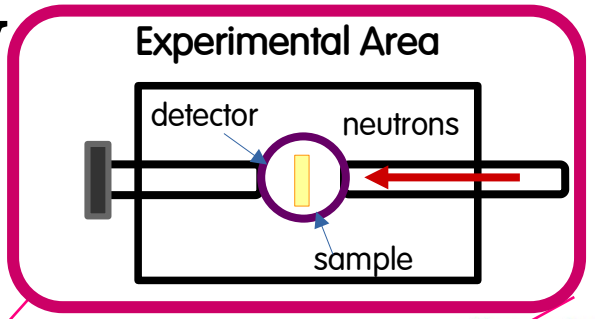
A. Manna on behalf of the n_TOF Collaboration

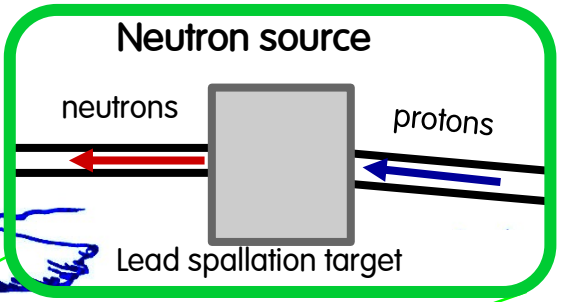
nBHEAM 2025: Neutron Beams at High Energy: Applications and Metrology

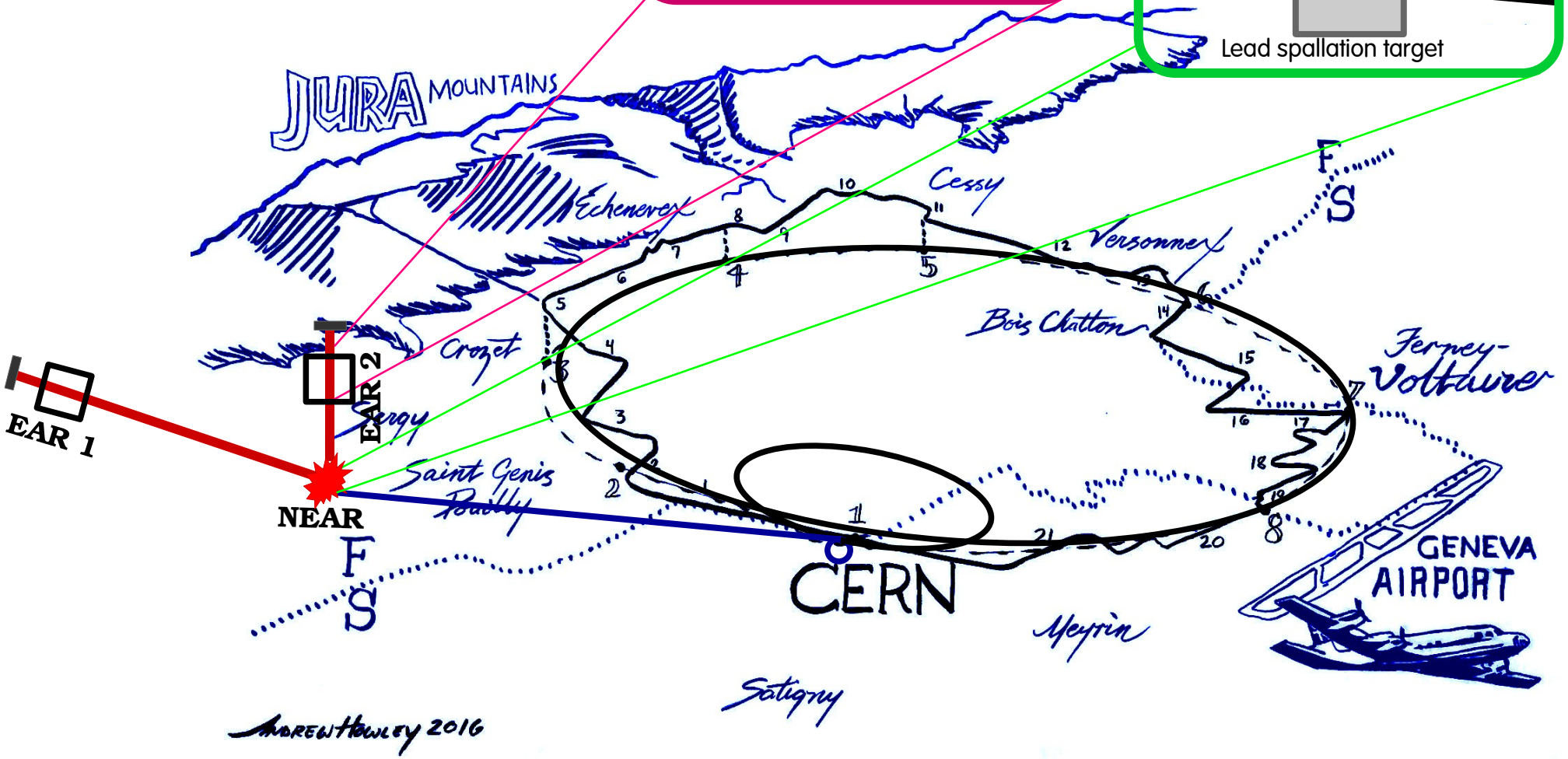
7-8 July 2005

n_TOF facility

neutron Time Of Flight

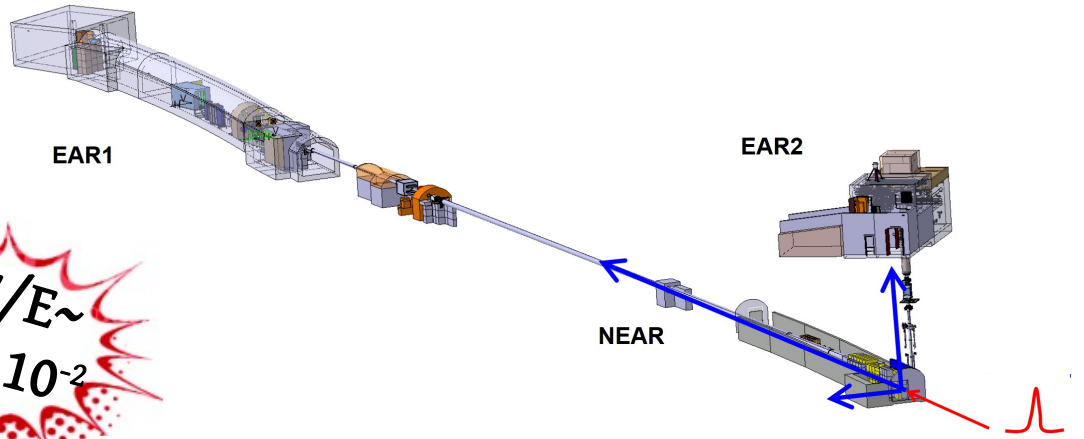






n_TOF facility

neutron Time Of Flight



✧ High energy resolution

$\Delta E/E \sim 10^{-5} - 10^{-2}$

Time of Flight (ToF) technique

long flight path: 185 m @ EAR 1
20 m @ EAR 2

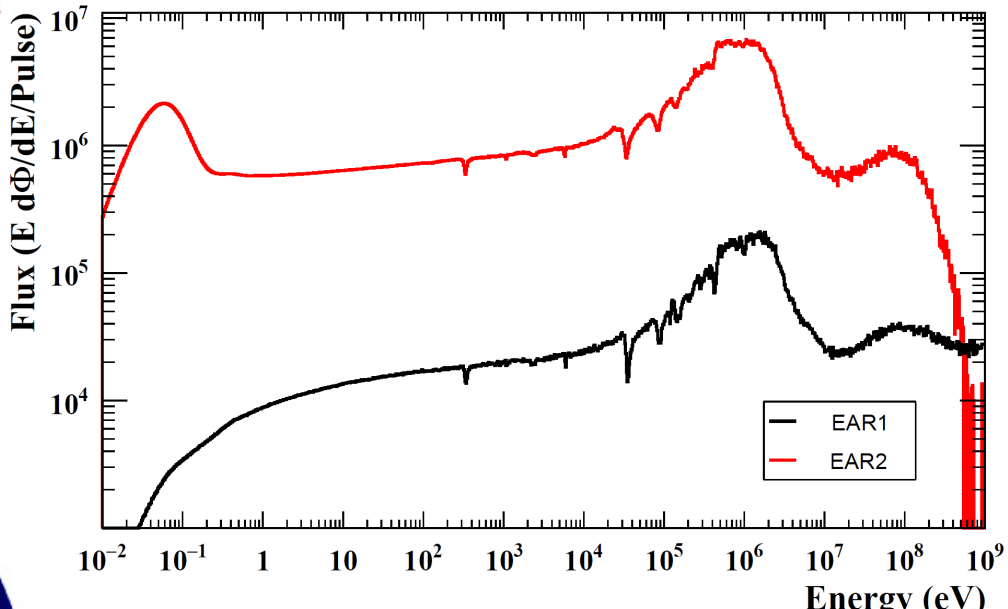
+ proton bunch: 7 ns r.m.s. long

✧ High neutron flux & wide energy range

Spallation reaction

$7 \cdot 10^{12}$ protons, 20 GeV/c
1.3 ton Pb Target

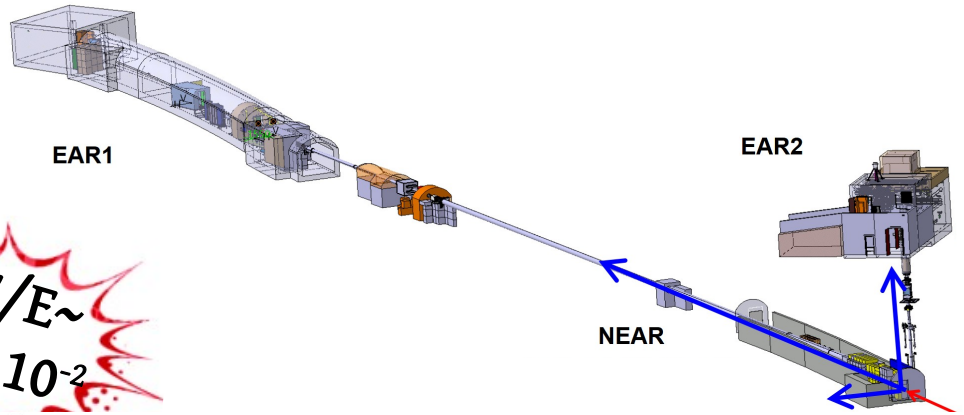
350 neutrons per incident proton



@ target : 2 10^{15} n/pulse
@ EAR 2: 10^{7} n/cm^2/pulse
@ EAR 1: 10^{5} n/cm^2/pulse

n_TOF facility

neutron Time Of Flight



- **High energy resolution**

  Time of Flight (ToF) technique

  long flight path: 185 m @ EAR 1
  20 m @ EAR 2

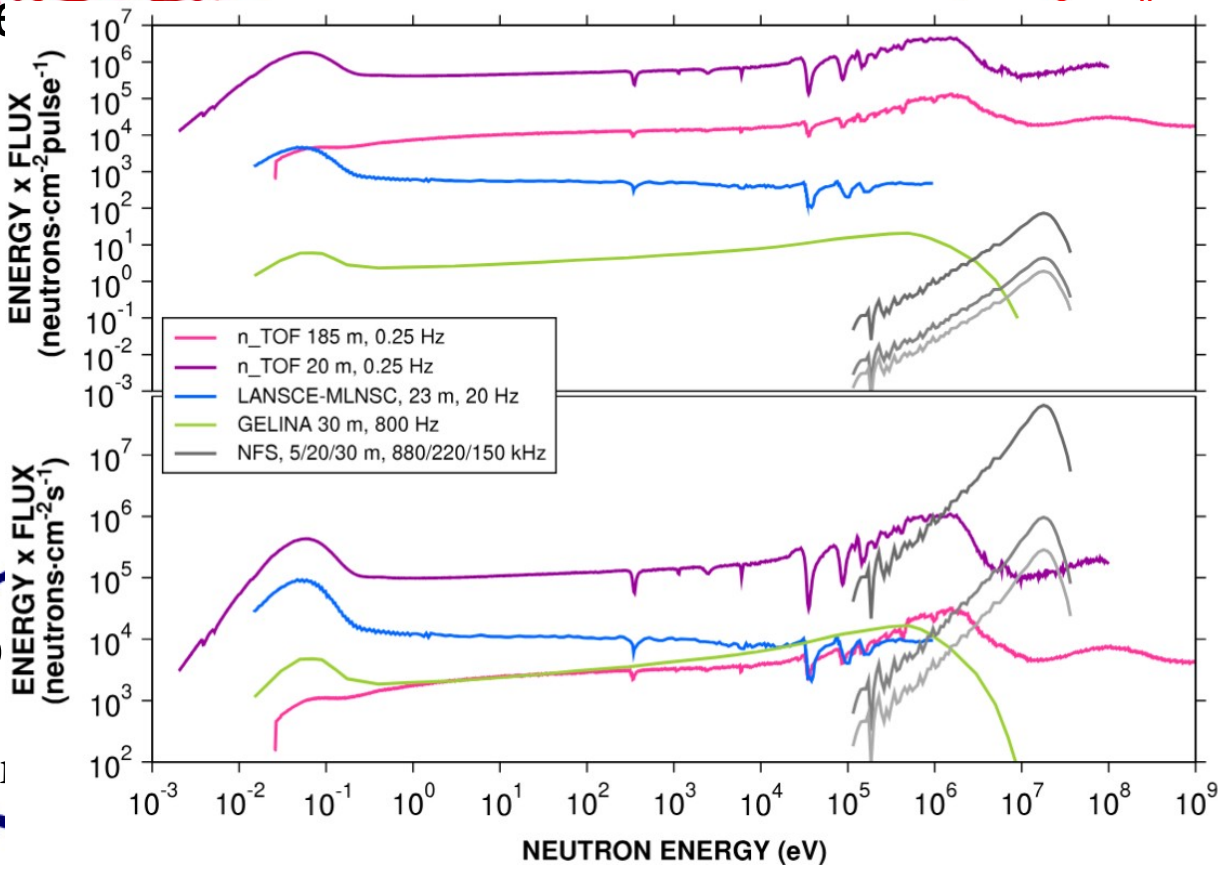
  + proton bunch: 7 ns r.m.s. long

  $\Delta E/E \sim 10^{-5} - 10^{-2}$

- **High neutron flux & wide energy range**

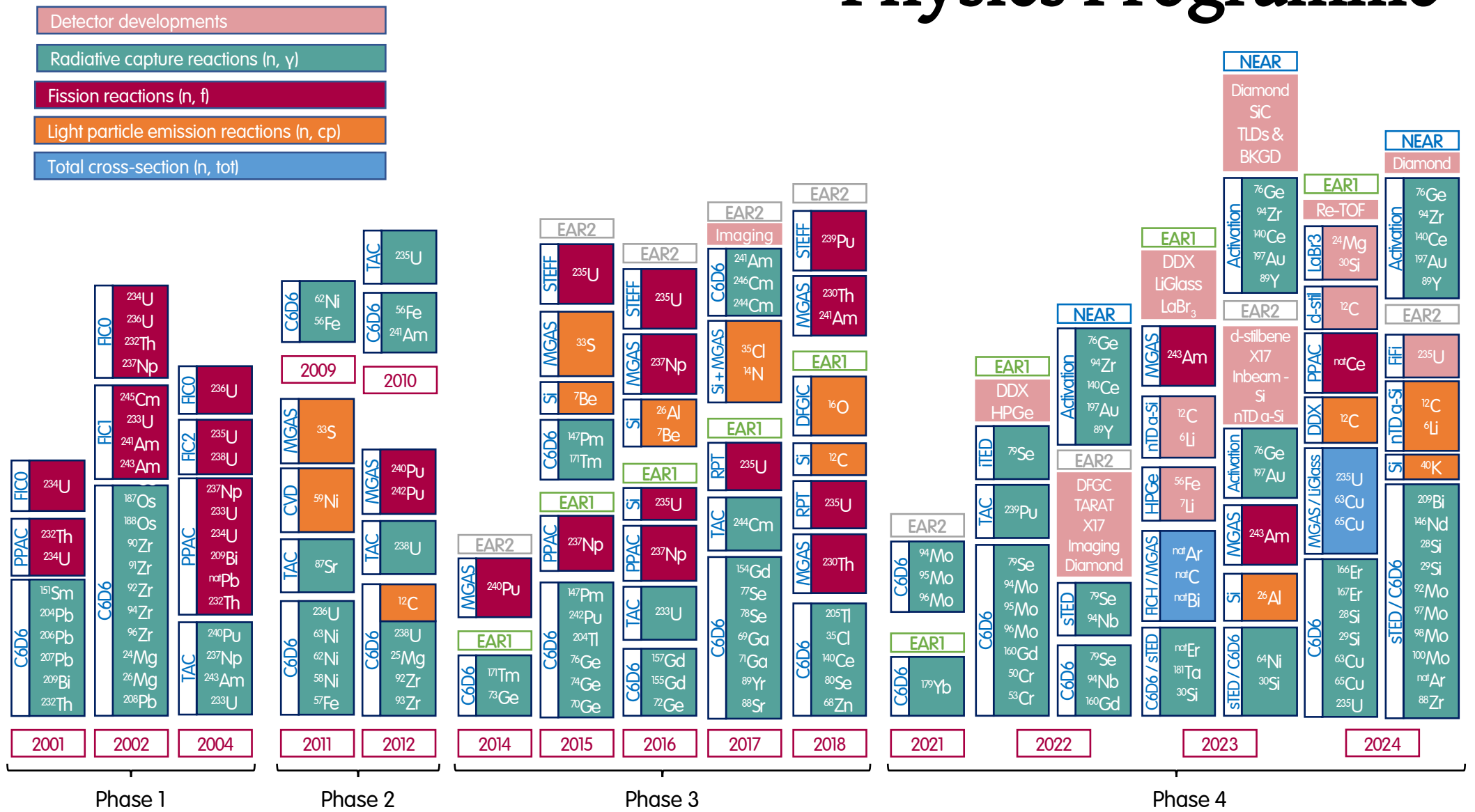
  Spallation reaction

  $7 \cdot 10^{12}$ protons, 20 GeV/c
  1.3 ton Pb Target

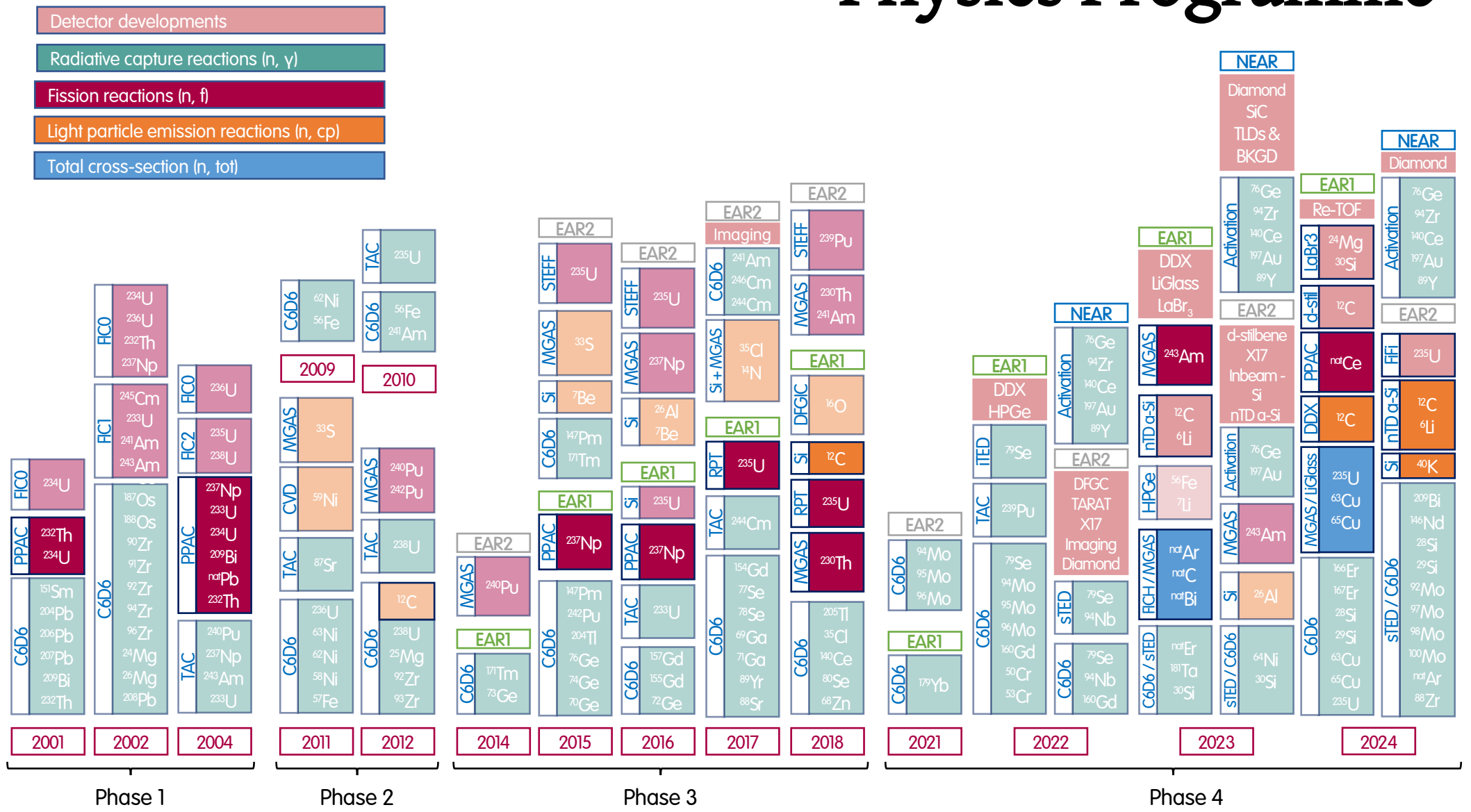


350
per
p

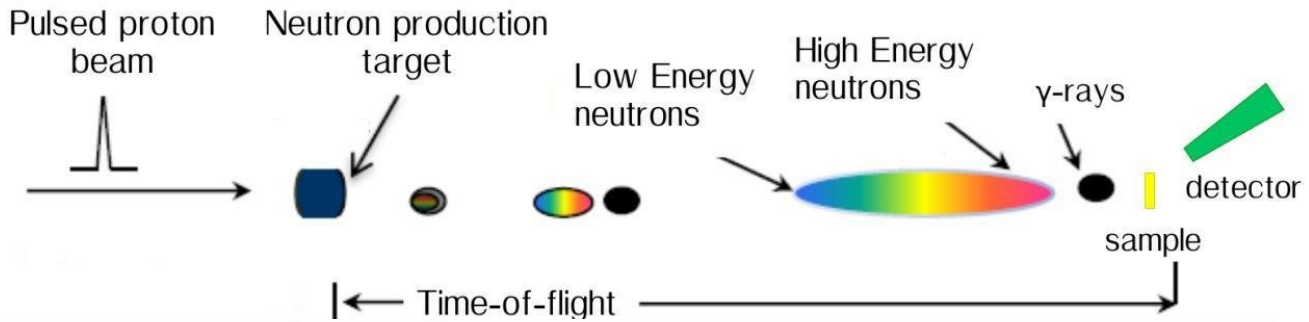
Physics Programme

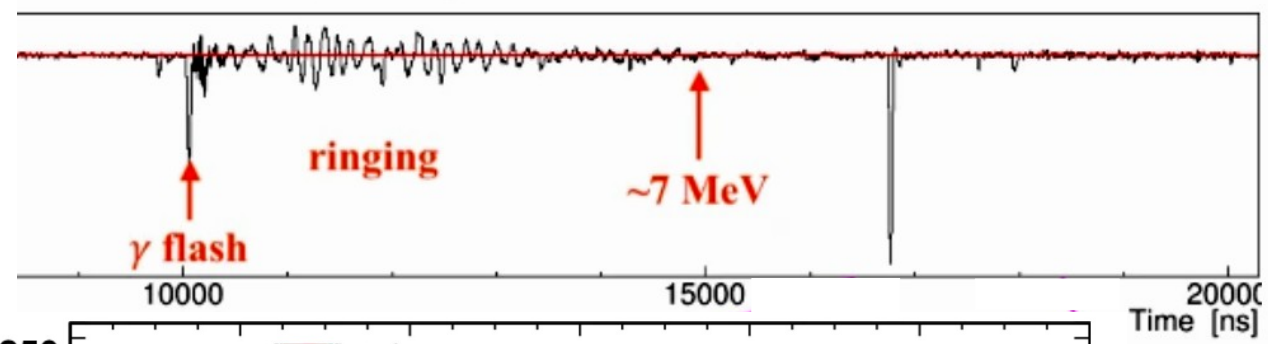


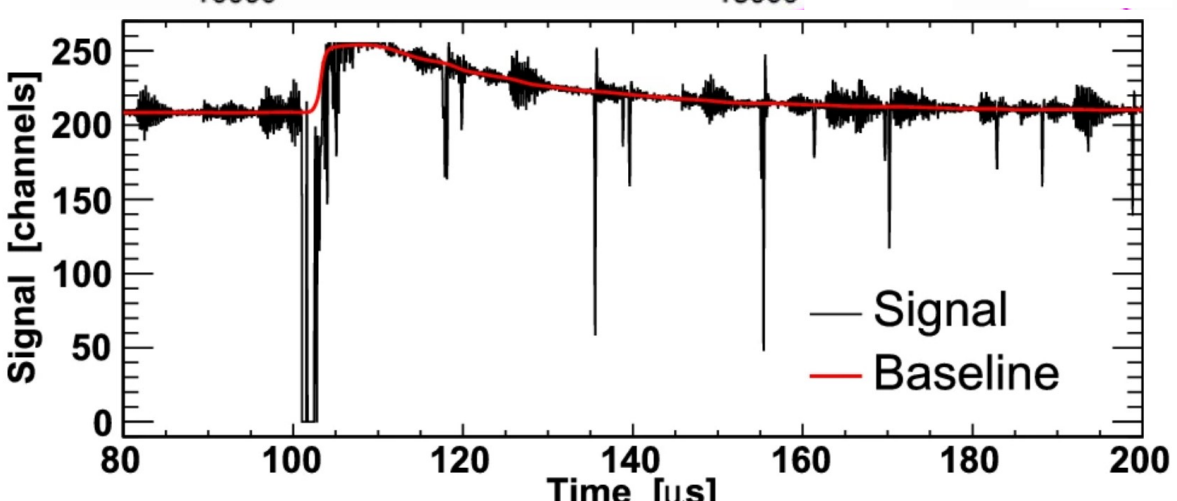
Physics Programme



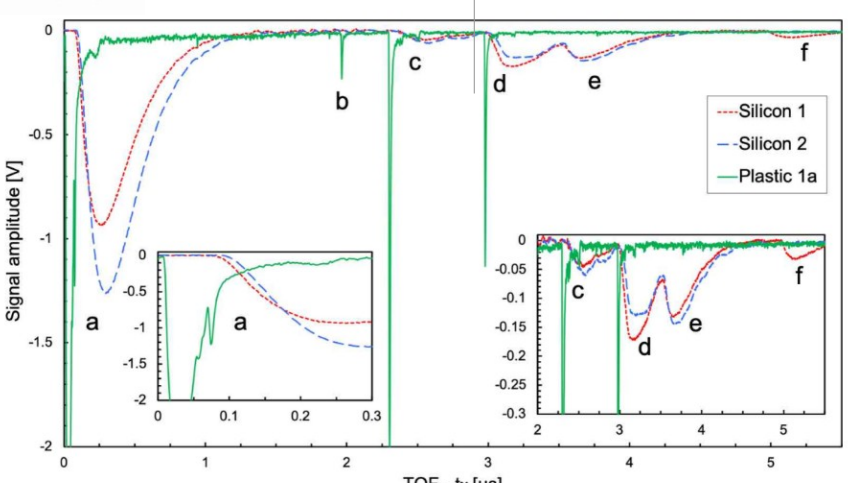
n_TOF facility







Energy (MeV)	TOF(μs) EAR1	TOF(μs) EAR2
1	12.7	1.39
10	3.63	0.40
50	1.34	0.15
100	0.82	0.09
150	0.60	0.07
200	0.47	0.05
250	0.39	0.04
300	0.33	nan not a neutron
500	0.20	nan not a neutron
1000	0.09	nan not a neutron



Some examples

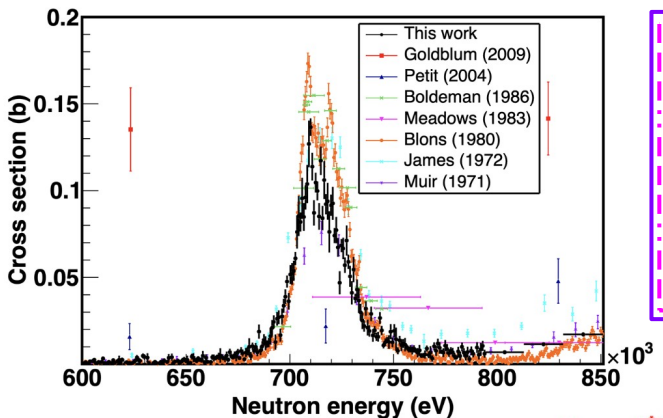
PHYSICAL REVIEW C **108**, 014616 (2023)

Micromegas

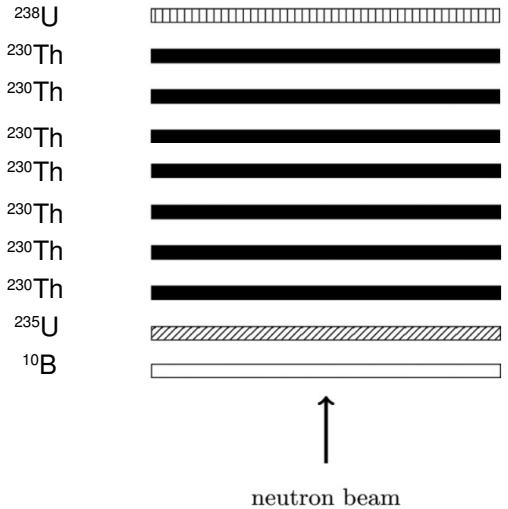
Link to paper>>

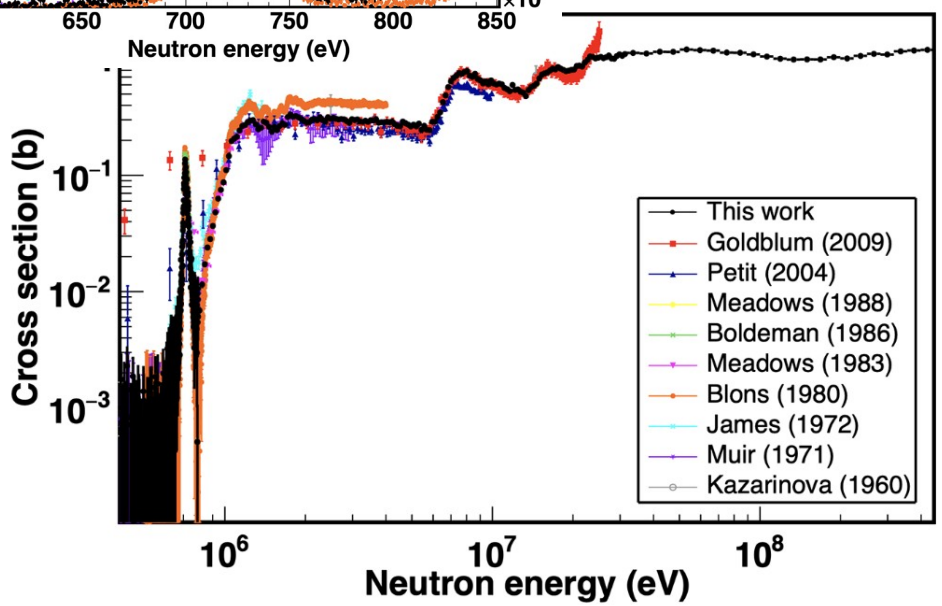
Measurement of the neutron-induced fission cross section of ^{230}Th at the CERN n_TOF facility

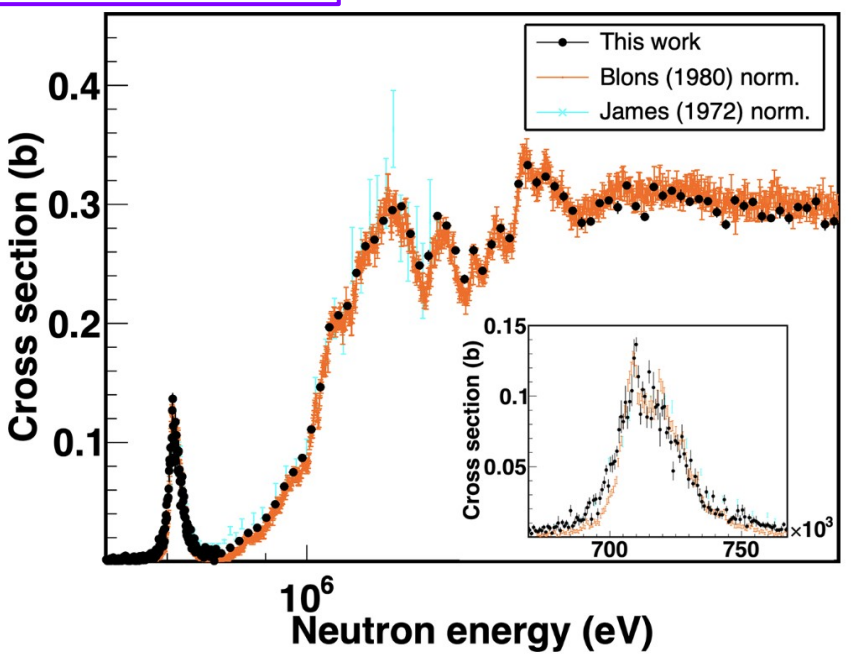
V. Michalopoulou,[1,2,*] A. Stamatopoulos,[1] M. Diakaki,[1] A. Tsinganis,[2,3] R. Vlastou,[1] M. Kokkoris,[1] N. Patronis,[4] Z. Eleme,[4]



- Cross section up to 400 MeV
- First data for neutron energies above 25 MeV
- EAR1 + EAR2 combined measurement







Some examples

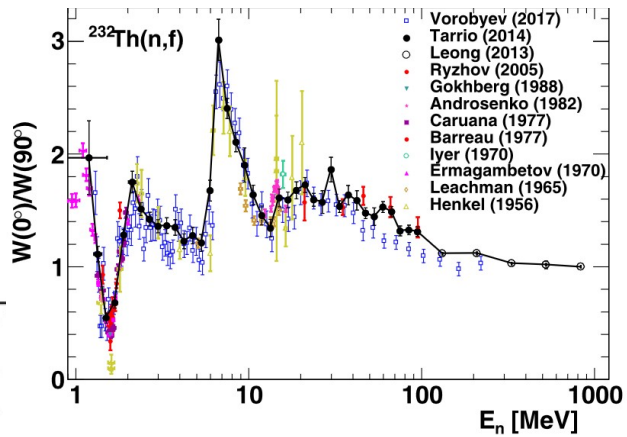
PHYSICAL REVIEW C **107**, 044616 (2023)

PPAC

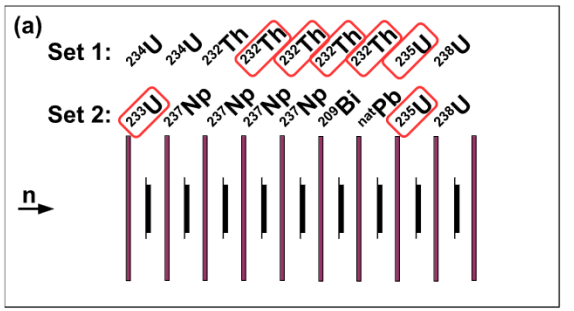
Link to paper>>

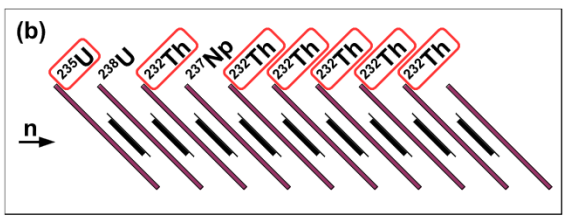
Neutron-induced fission cross sections of ^{232}Th and ^{233}U up to 1 GeV using parallel plate avalanche counters at the CERN n_TOF facility

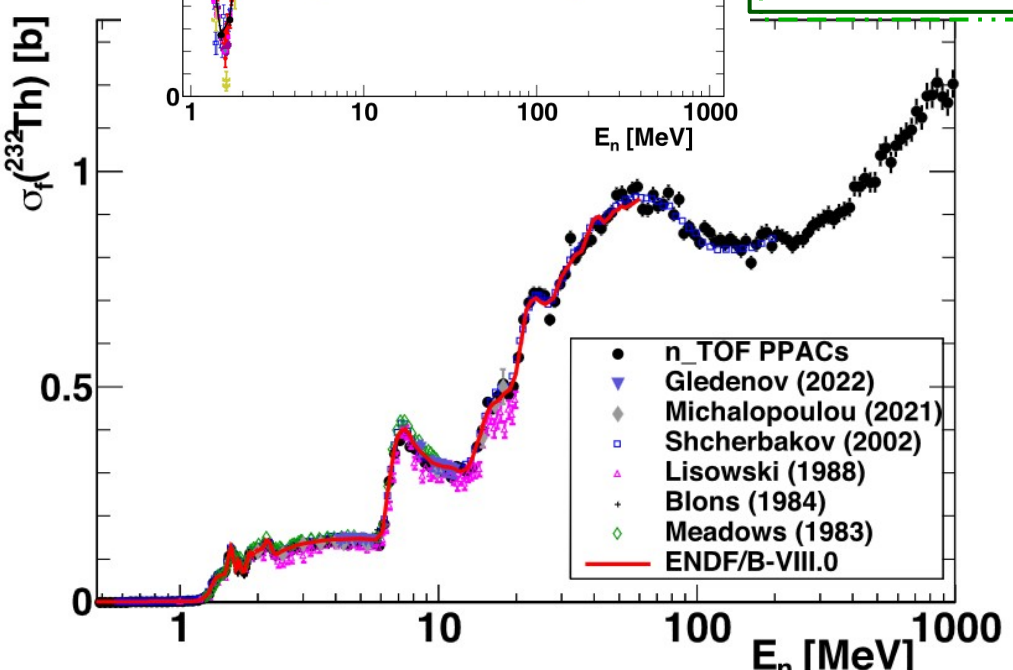
D. Tarrío,[1,2,*] L. Tassan-Got,[3] I. Duran,[2] L. S. Leong,[3] C. Paradela,[2,4] L. Audouin,[3] E. Leal-Cidoncha,[2] C. Le Naour,[3]

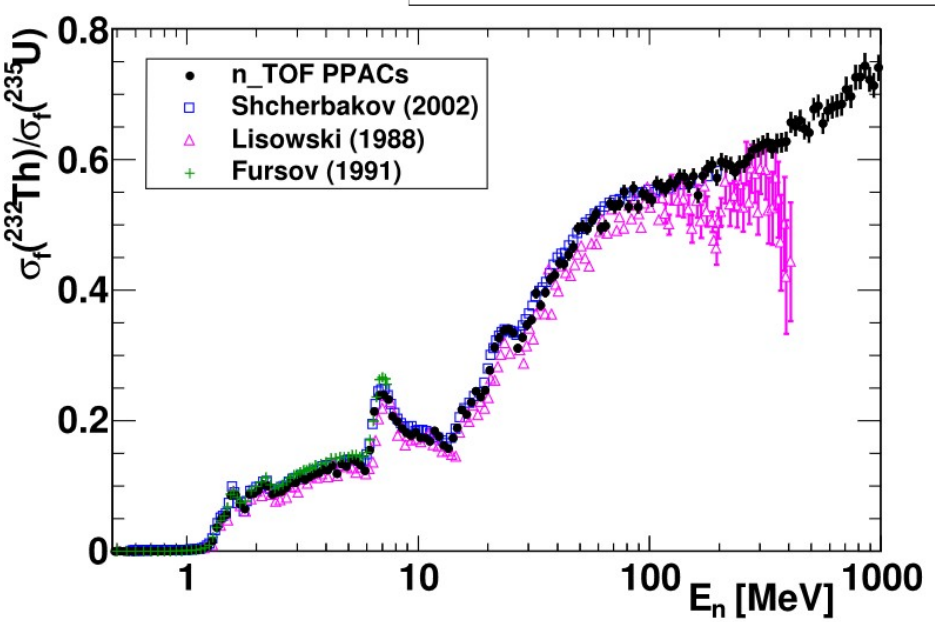


- Fission cross section up to 1 GeV
- FFAD measured
- Ratios are not normalized to previous evaluations









Some examples

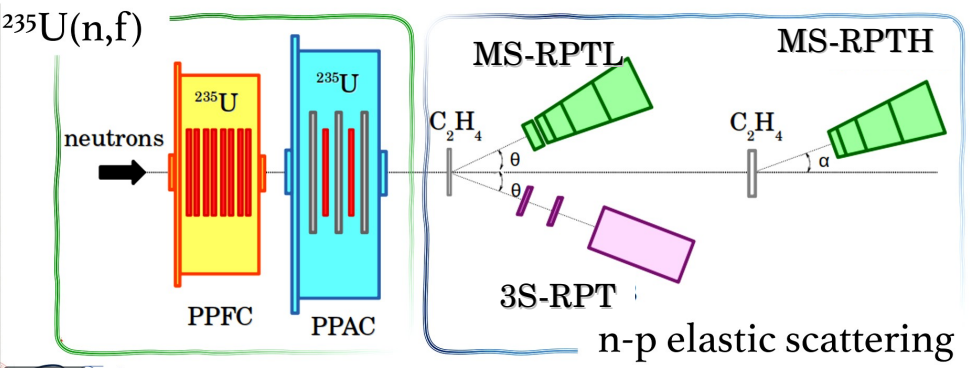
Phys. Lett. B 860 (2025) 139213

Letter

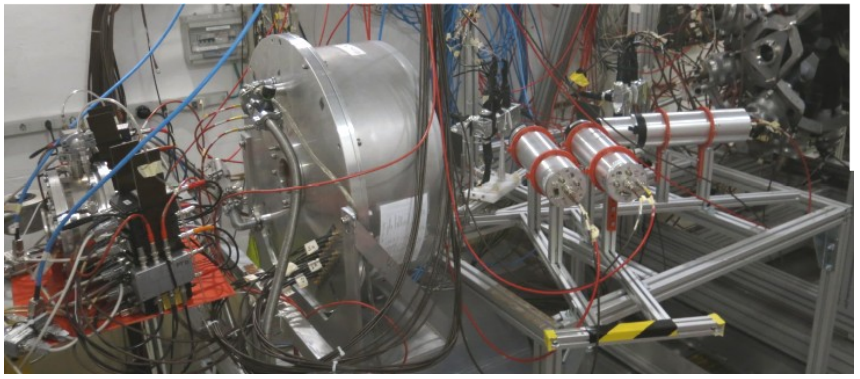
New insights on fission of ^{235}U induced by high energy neutrons from a new measurement at n_TOF

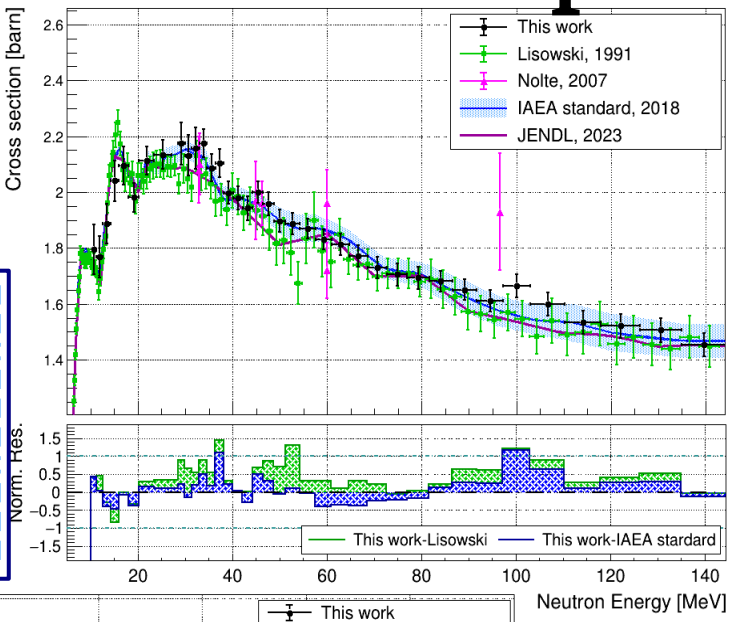
Link to paper>>

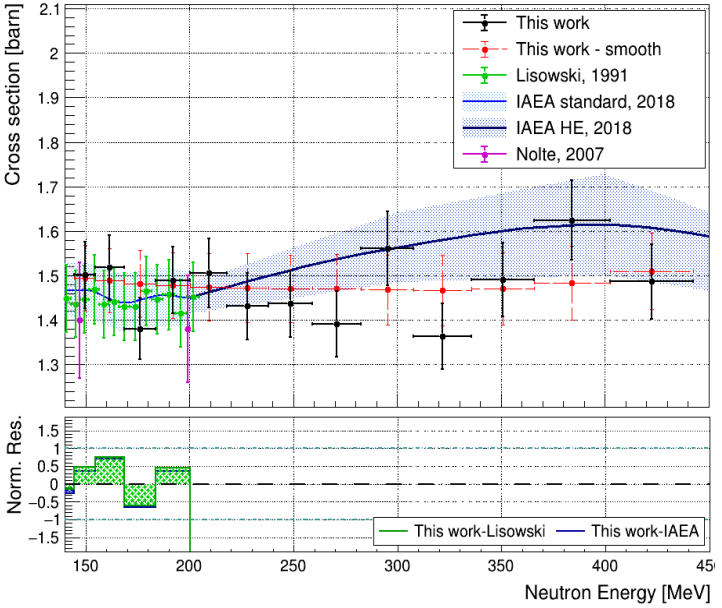
A. Manna [a,b,*], E. Pirovano [c,**], P. Console Camprini [d,a], L. Cosentino [e], M. Dietz [f,c], Q. Ducasse [c], P. Finocchiaro [e], C. Le Naour [g], D. Mancusi [h], C. Massimi [a,b], A. Mengoni [d,a], R. Nolte [c], D. Radeck [c],



^{235}U(n,f) fission cross section measured wrt n-p elastic scattering energy limit extension





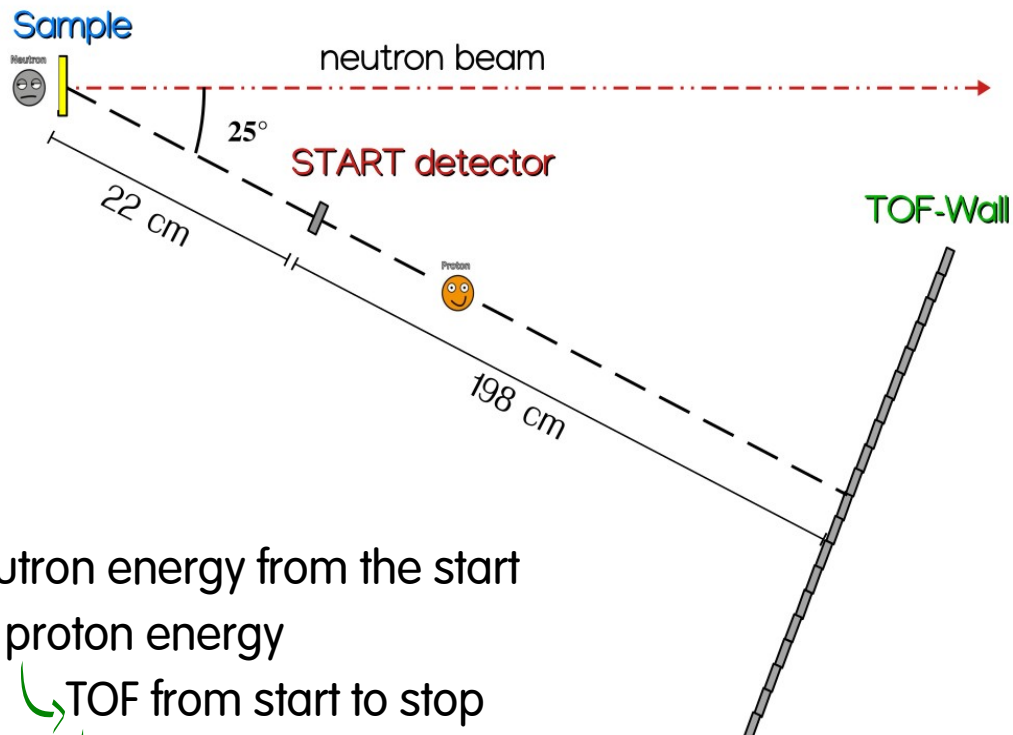


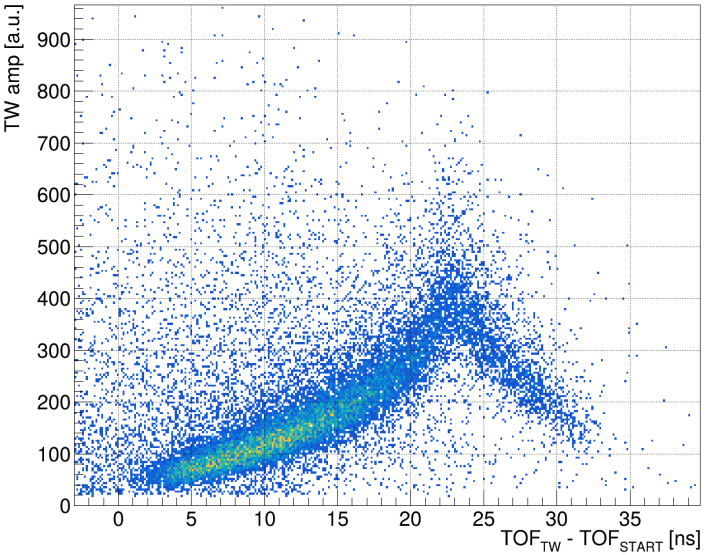
Ongoing....Re-TOF neutron flux detector

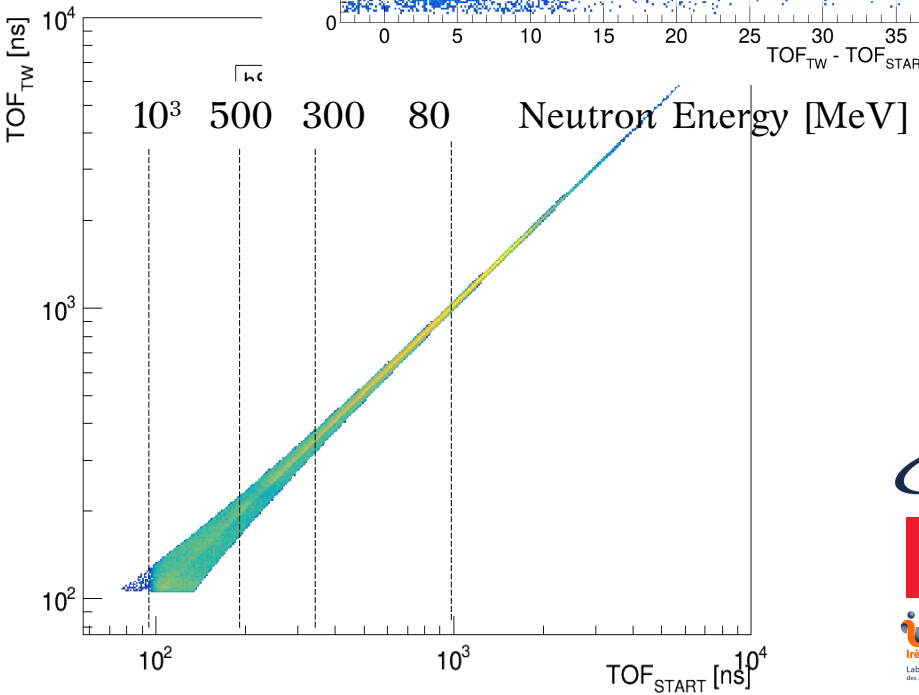
From ~ 290 MeV: opening of the inelastic channel

$$n + p \rightarrow N + N + \pi$$

Fix kinematic from the elastic channel $E_p = E_n \cos^2\vartheta.$

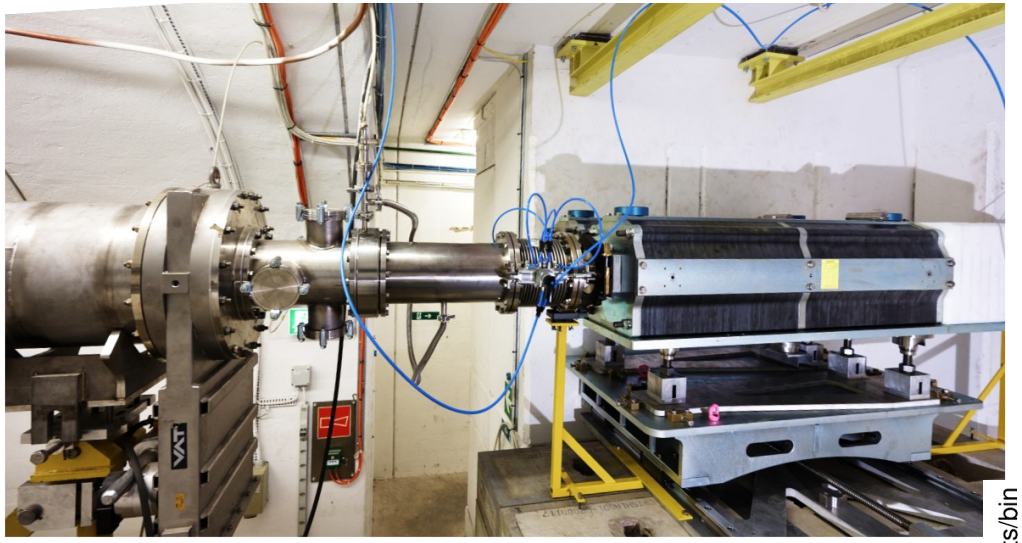


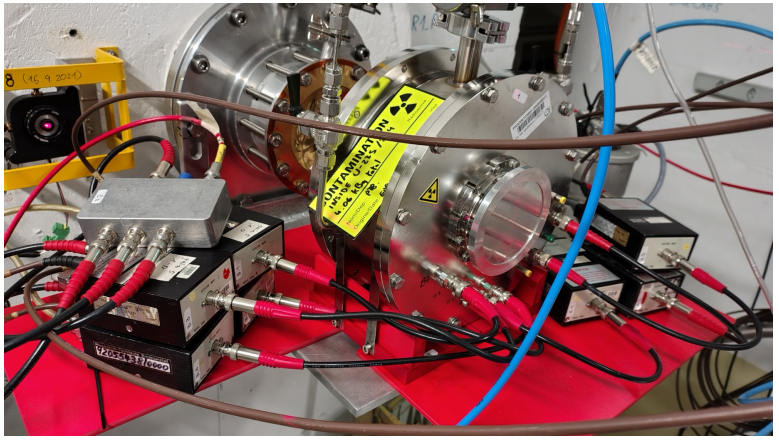


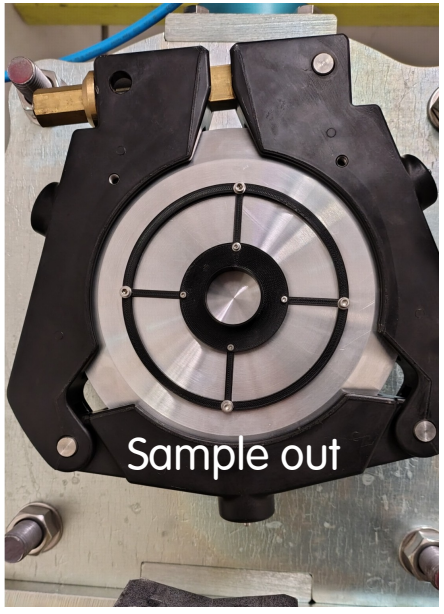


Neutron energy from the start
- proton energy
  - TOF from start to stop
    - Impose the coincidence window between start and stop

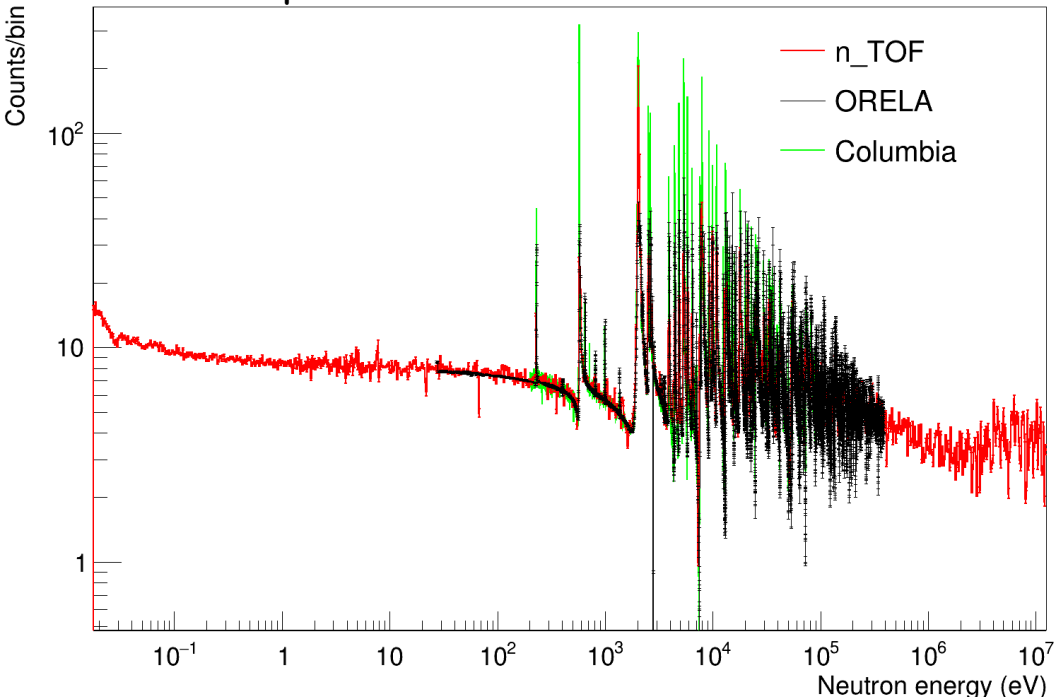
Ongoing....1st transmission measurement





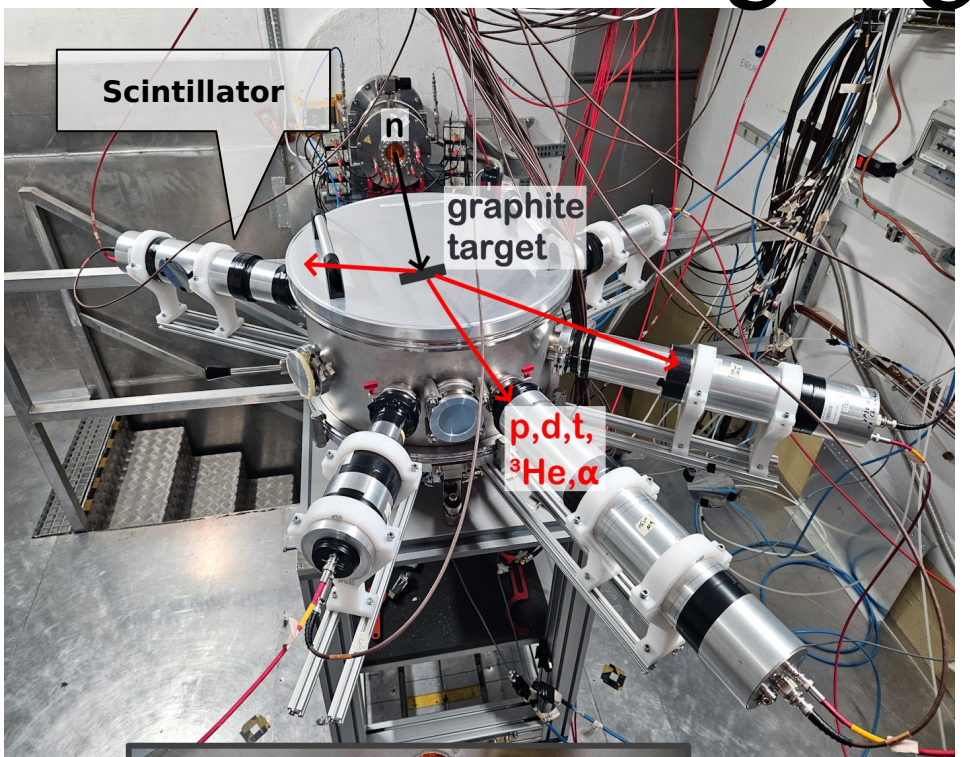


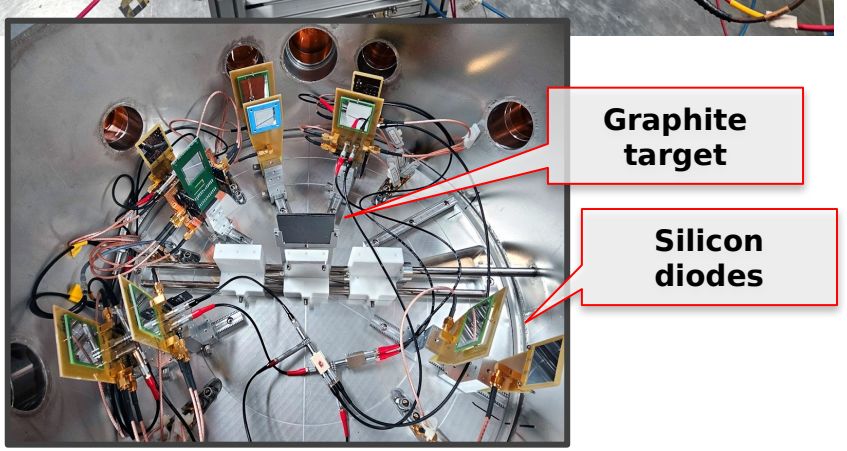
6 x ^{235}U samples



Ongoing....(n,cp) measurement

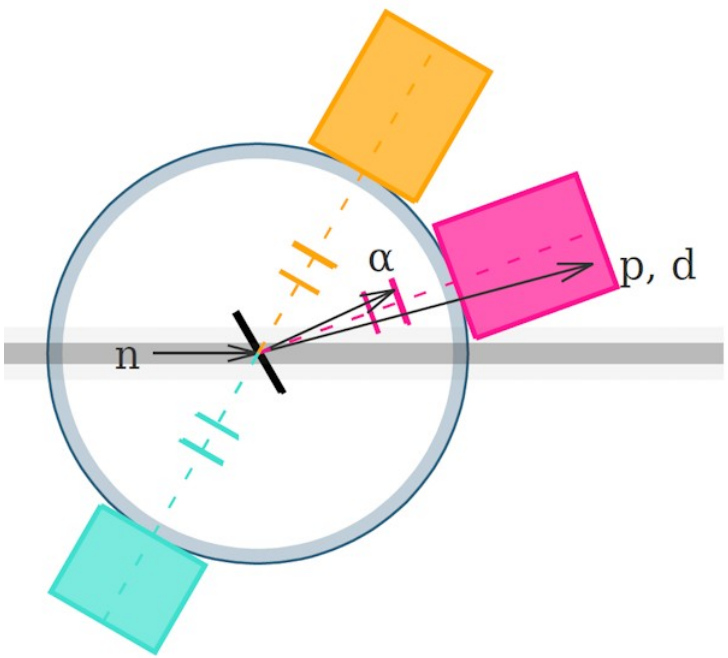
see M. Dietz talk



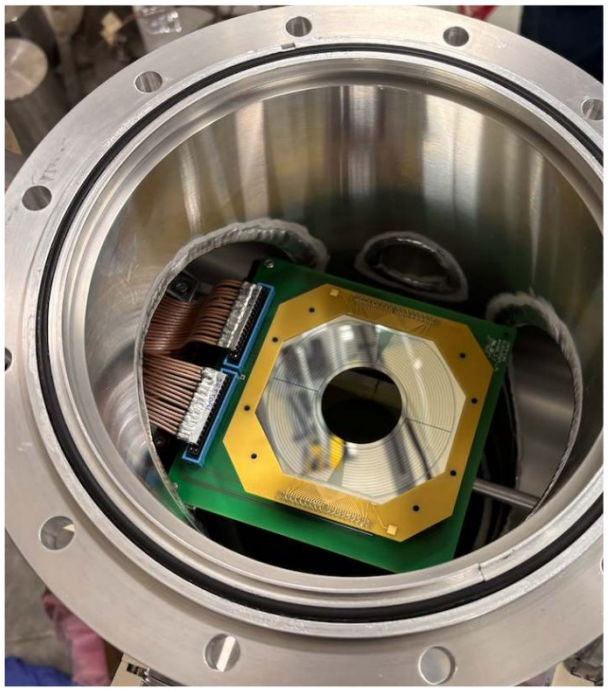


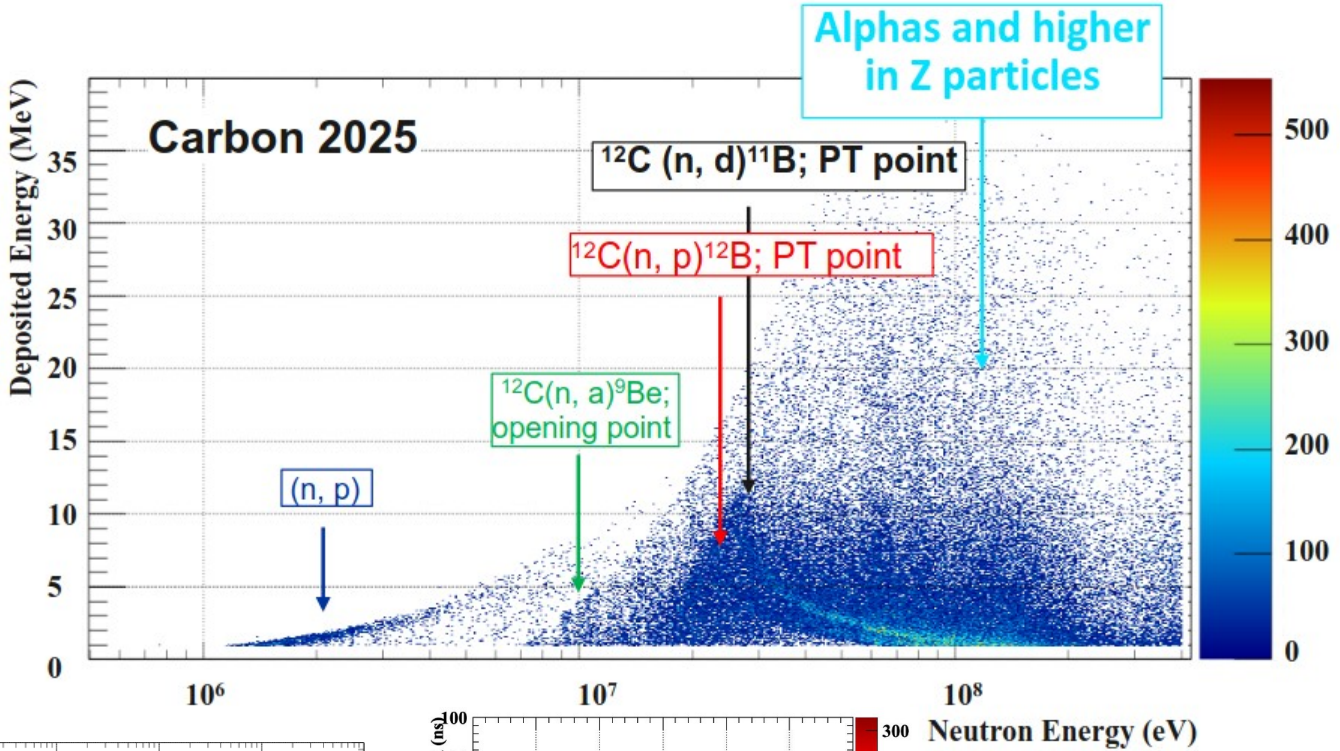
carbon for (n,lcp) reactions

Double-Differential Cross Section of Neutron-Induced Charged-Particle Emission of Carbon from 20 MeV to 250 MeV



Ongoing....(n,cp) detector development

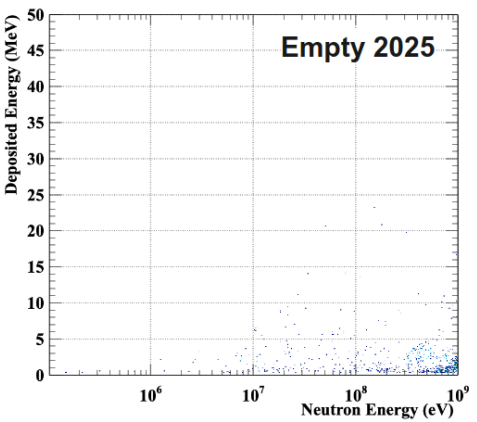


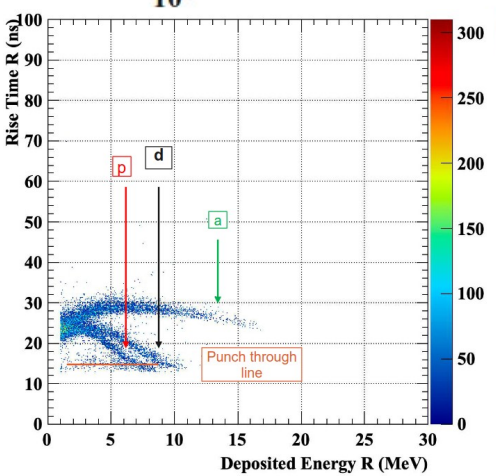


Single-stage detector coupled with PSA software with Identification Methods:

1. Different stopping powers
2. Signal Shape Analysis

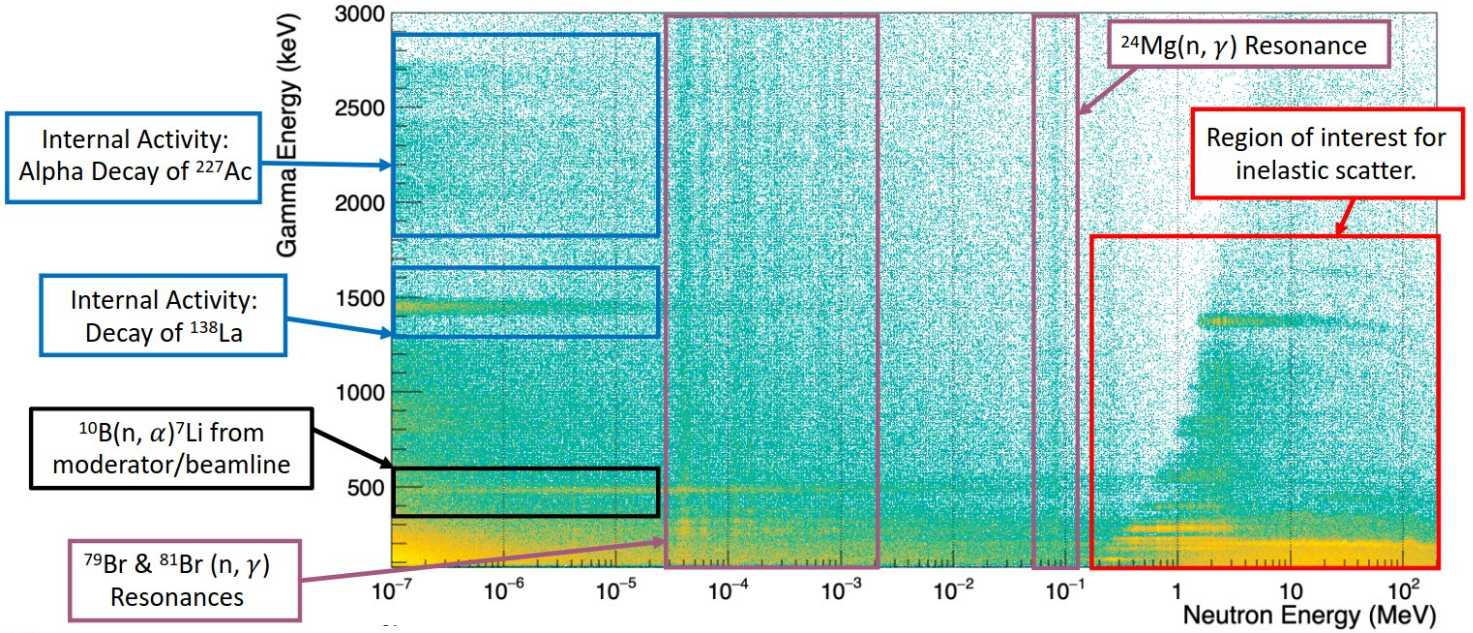
(e.g. Rise Time, ToT)

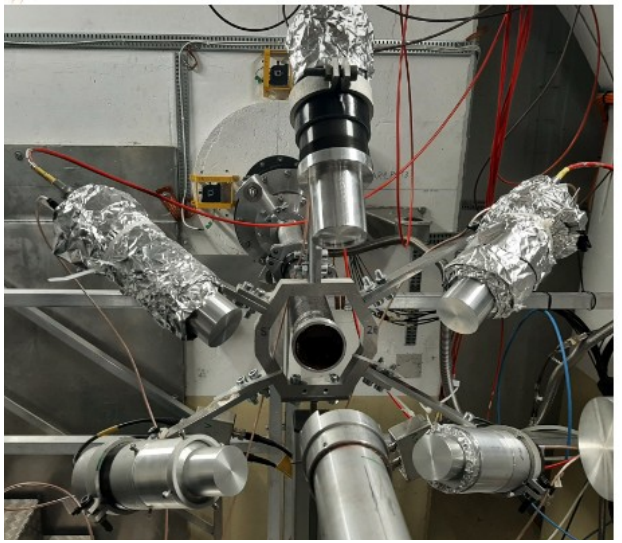


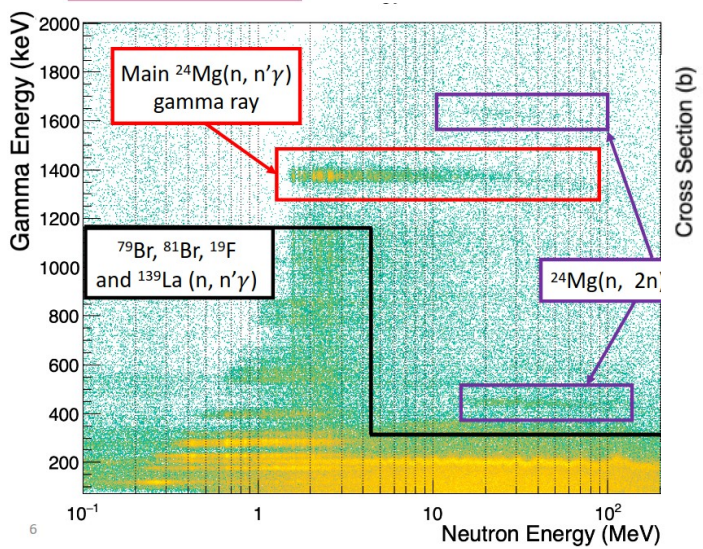


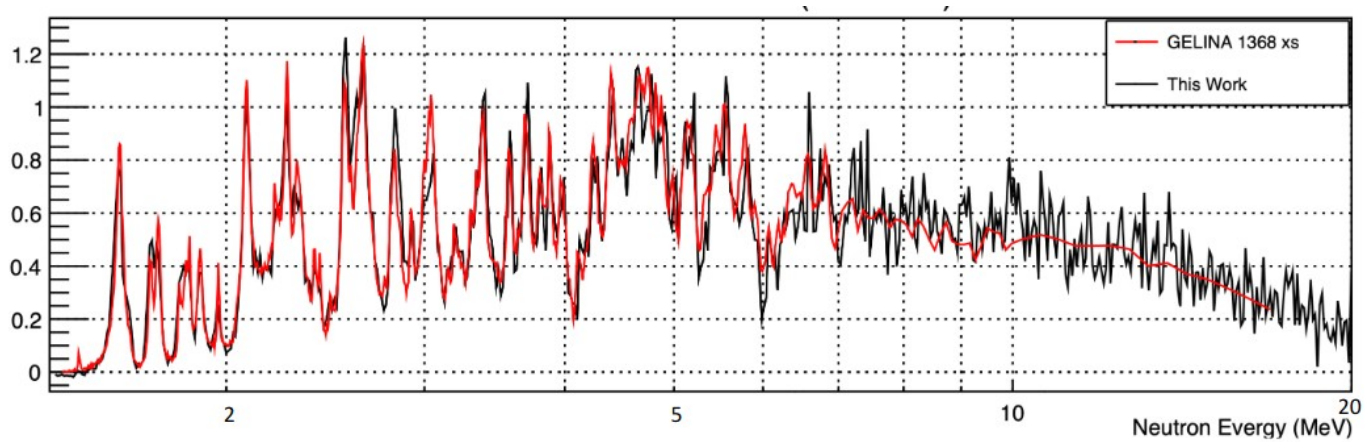
Charge discrimination between Z= 1 and Z= 2 at 2.5 MeV is achieved

Ongoing....(n, n'γ) measurements







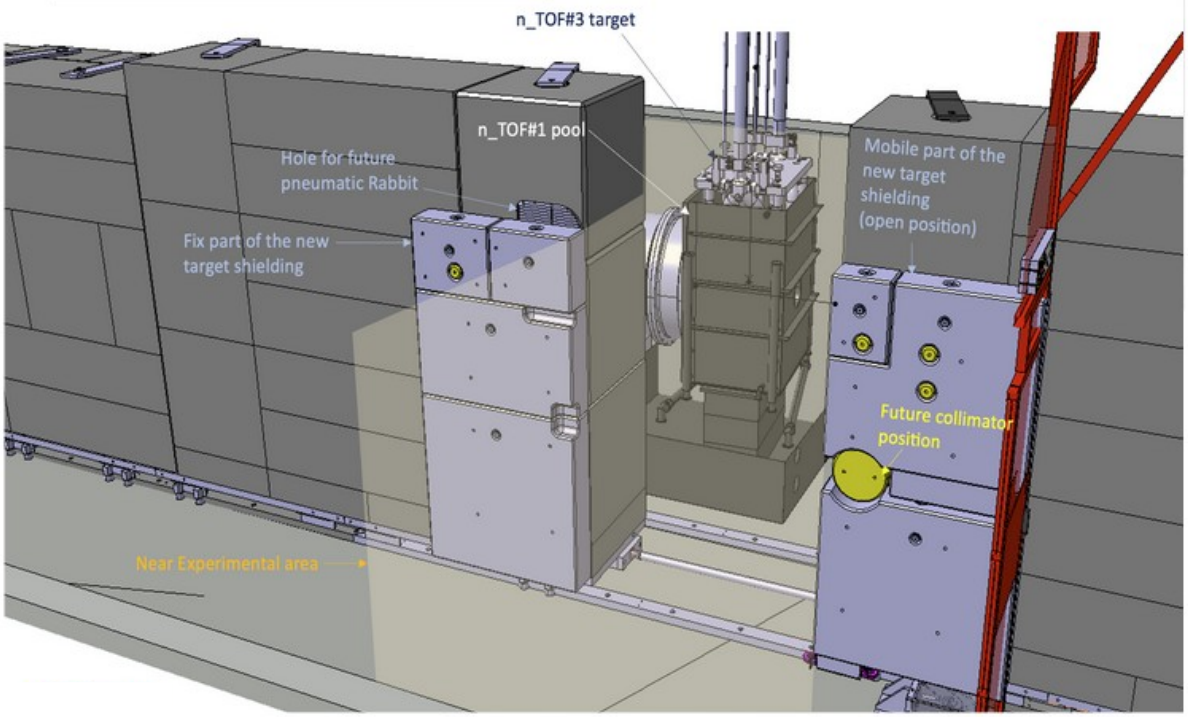


Activation measurements

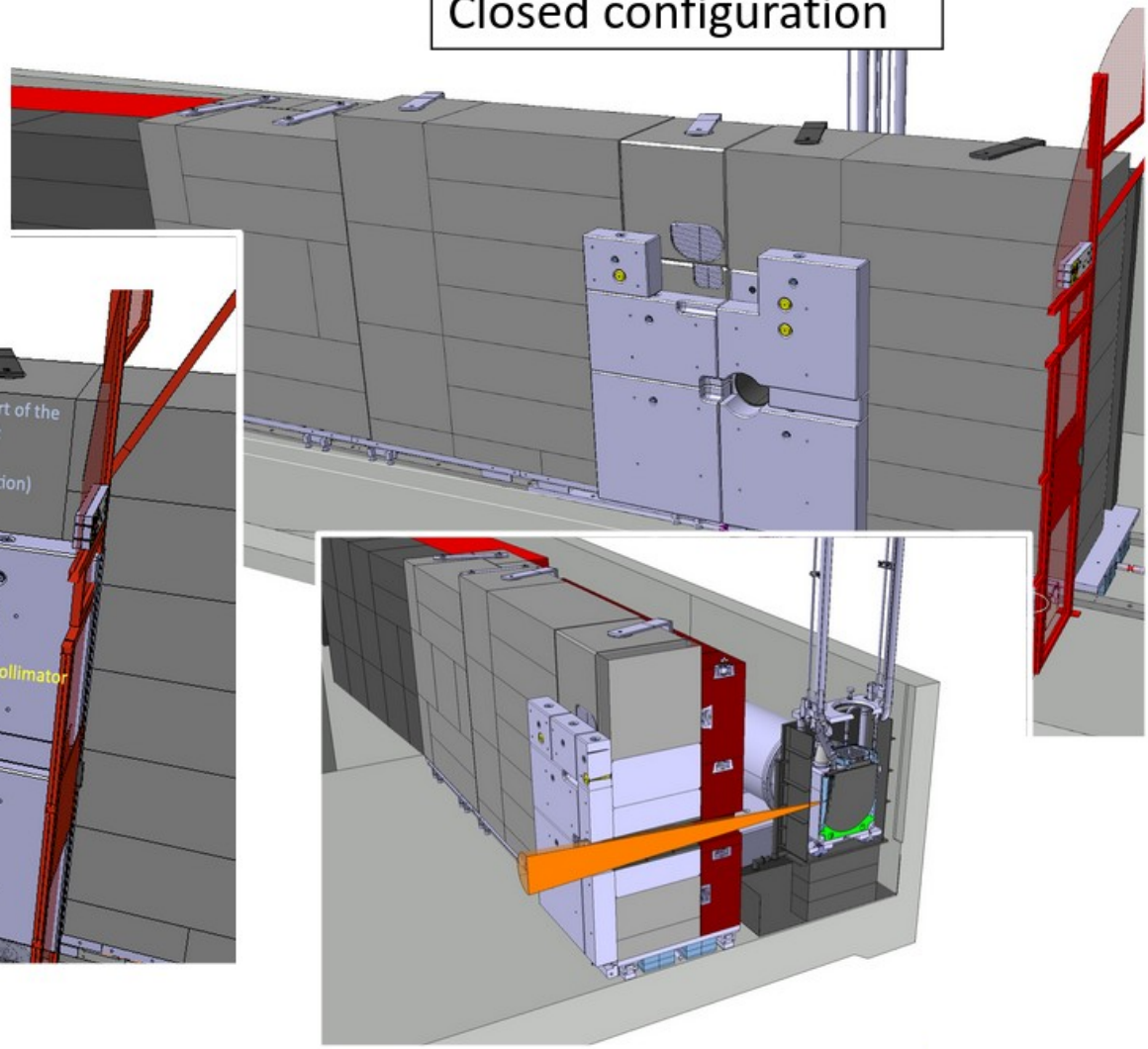
see M. Bacak talk

The NEAR Station

Open configuration

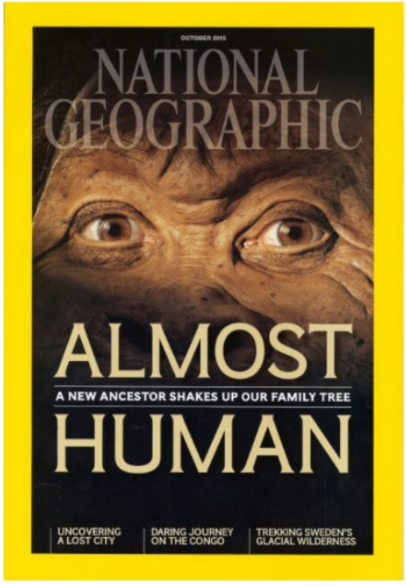


Closed configuration



Activation measurements

In Autumn 2013, Lee Berger recovered more than 1500 hominid fossils (representing 15 or more individuals) at the Rising Star cave complex in the Cradle of Humankind UNESCO World Heritage site (COHWHS)



Unknown hominid species named Homo Naledi (200-300 kY old) , whose characteristics do not fit in the present scheme of the human evolution

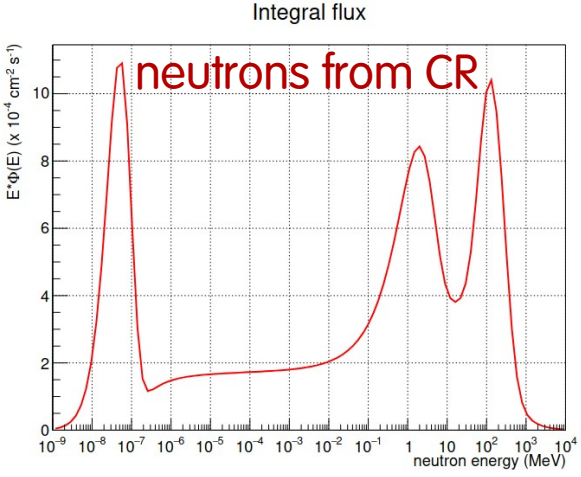
Geo-dating: using 2 radioactive isotopes,
^{10}Be and ^{26}Al produced inside quartz by cosmic rays → **Burial dating**

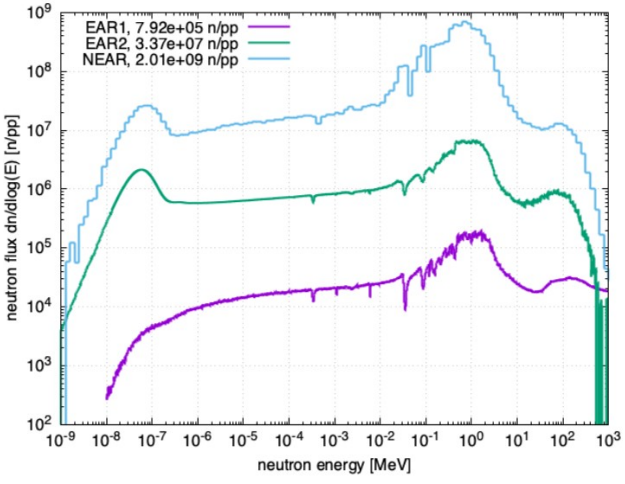
Energy threshold for:

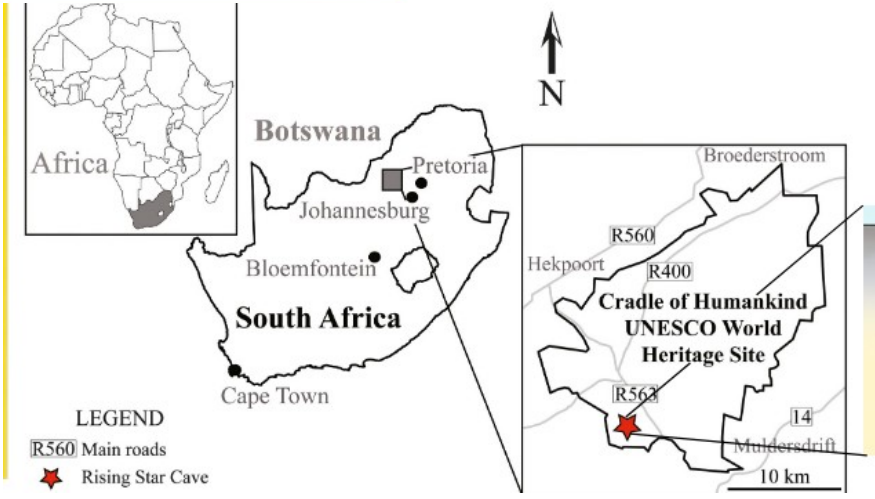
^{28}Si(n,x)^{26}Al ⟶ 17 MeV

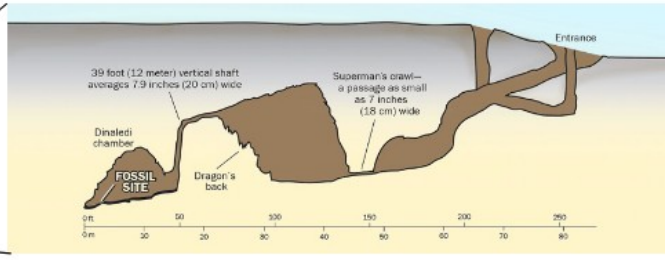
^{28}Si(n,x)^{10}Be ⟶ 58 MeV

^{16}O(n,x)^{10}Be ⟶ 28 MeV









Production Rate

Conclusions

n_TOF: neutron flux from thermal up to GeV

But ...neutrons alone are not enough!!

In the last years strong detector development to extend the type of detectors capable to work in the high energy region:

1. Recovery from the γ-flash: first signal in the experimental area
2. Compress kinematics in Energy (TOF technique)

Now, many possible neutron induced reactions can be studied:

Fission cross section measurement
(n,cp)
(n,n'γ)
activation measurements

Opening to new physics cases for the scientific programme of the next years @ n_TOF

Conclusions

n_TOF: neutron flux from thermal up to GeV

Thank you for your attention

But ...neutrons alone are not enough!!

In the last years strong detector development to extend the type of detectors capable to work in the high energy region:

1. Recovery from the γ-flash: first signal in the experimental area
2. Compress kinematics in Energy (TOF technique)

Now, many possible neutron induced reactions can be studied:

Fission cross section measurement
(n,cp)
(n,n'γ)
activation measurements

Opening to new physics cases for the scientific programme of the next years @ n_TOF