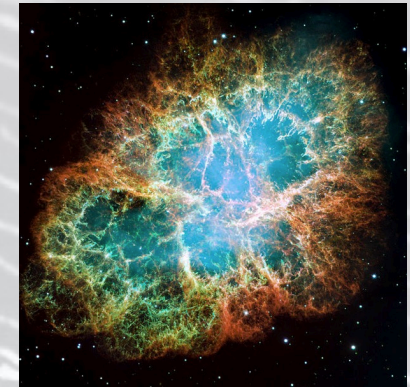
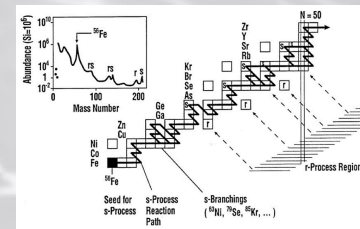
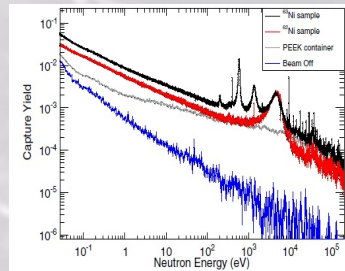
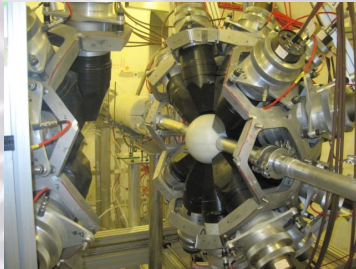
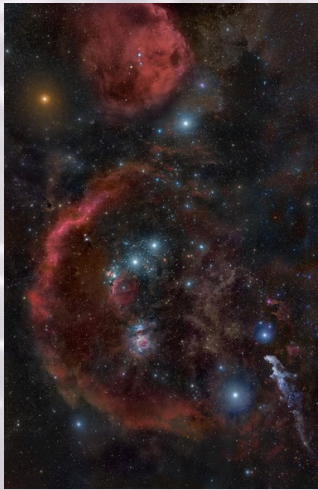


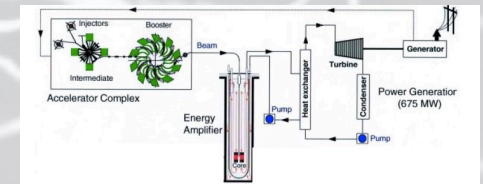
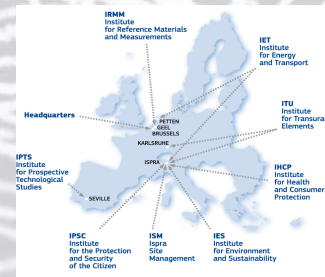
# n\_TOF

## Neutron cross sections for science and technology

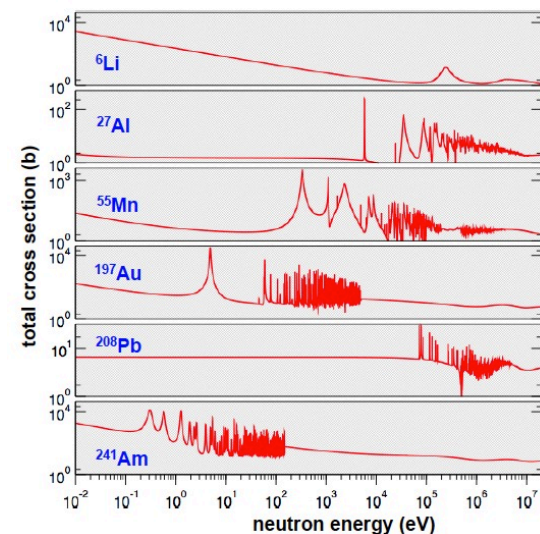
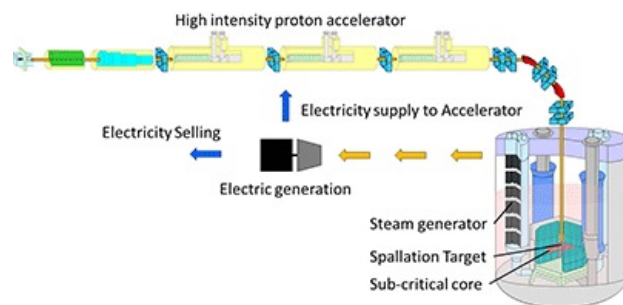
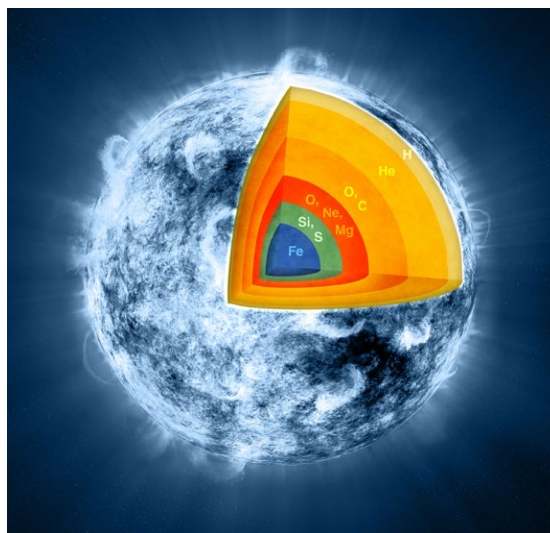


**n\_TOF**  
neutron Time Of Flight  
@ CERN

**GELINA**  
@ EC-JRC-GEEL



# Research fields



## Nuclear Astrophysics

- ✓ **N**ucleosynthesis of heavy elements
- ✓ **S**tellar evolution
- ✓ **B**ig bang nucleosynthesis

## Nuclear technology and medical application:

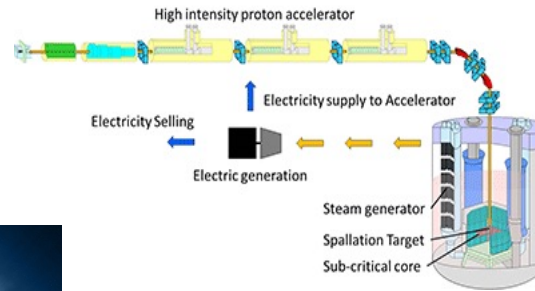
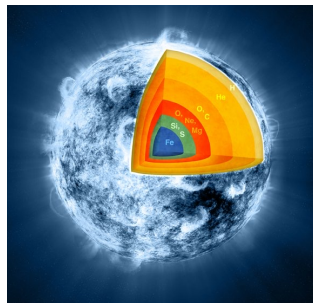
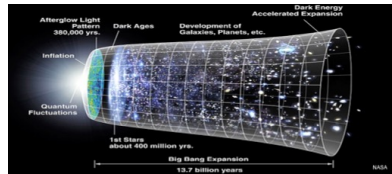
- ✓ **F**ission reactors (Gen-IV, ADS)
- ✓ **F**usion
- ✓ **T**ransmutation of nuclear waste
- ✓ **N**eutron capture therapy (adrontherapy)

## Basic Nuclear Physics

- ✓ **N**uclear structure effects on fission
- ✓ **E**xcited states (spin parity of resonances)
- ✓ **S**ymmetries and fundamental interactions

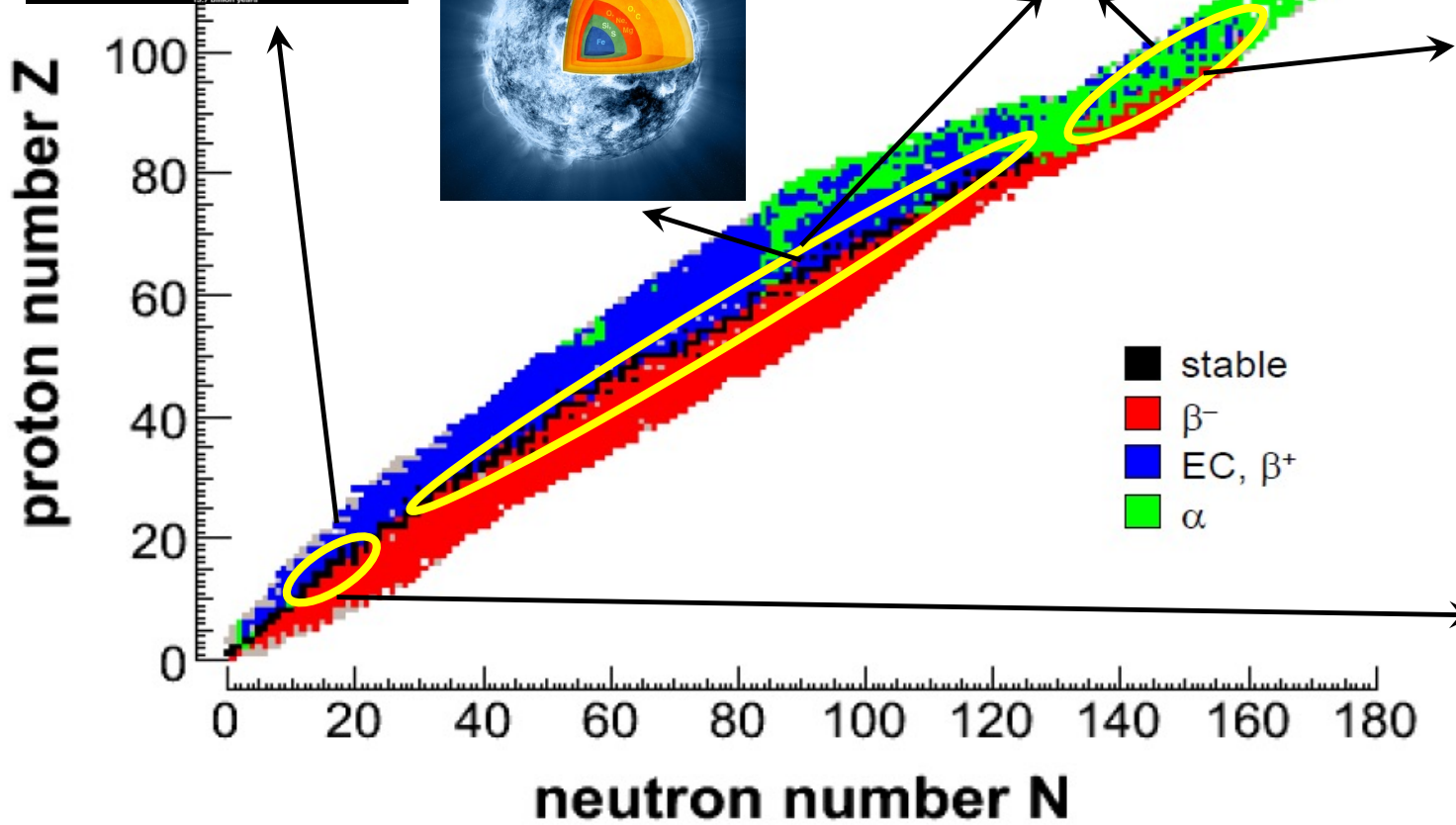
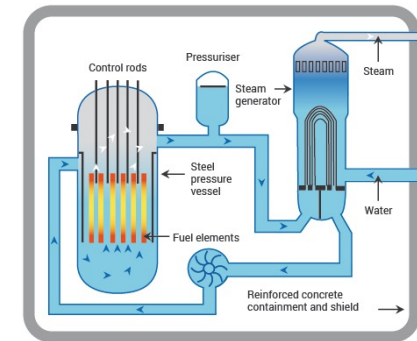
# Research fields

## Nuclear Astrophysics Big Bang and Stellar nucleosynthesis

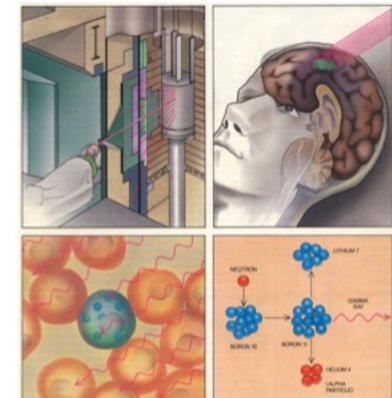


## Nuclear reactors: energy production & waste management

A Pressurized Water Reactor (PWR)



## Nuclear medicine neutron capture therapy





# n\_TOF Collaboration

11 INFN  
Sections

n\_TOF - ITALY

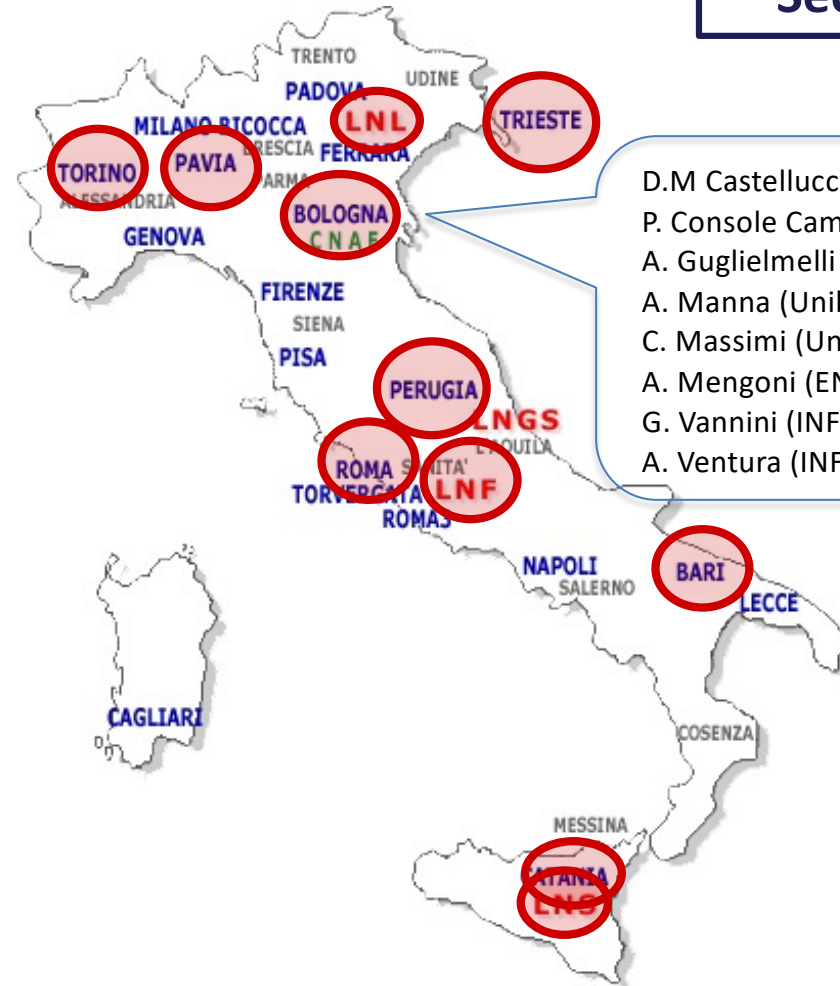
33 researchers  
(INFN + University)  
17.0 FTE

Close collaboration with  
**ENEA** (Bologna, Frascati)  
**INAF** (Teramo), **CNR** (Bari)



47 researchers  
23.6 FTE

*Responsabile Nazionale:*  
**C. Massimi** (Unibo, INFN-Bo)

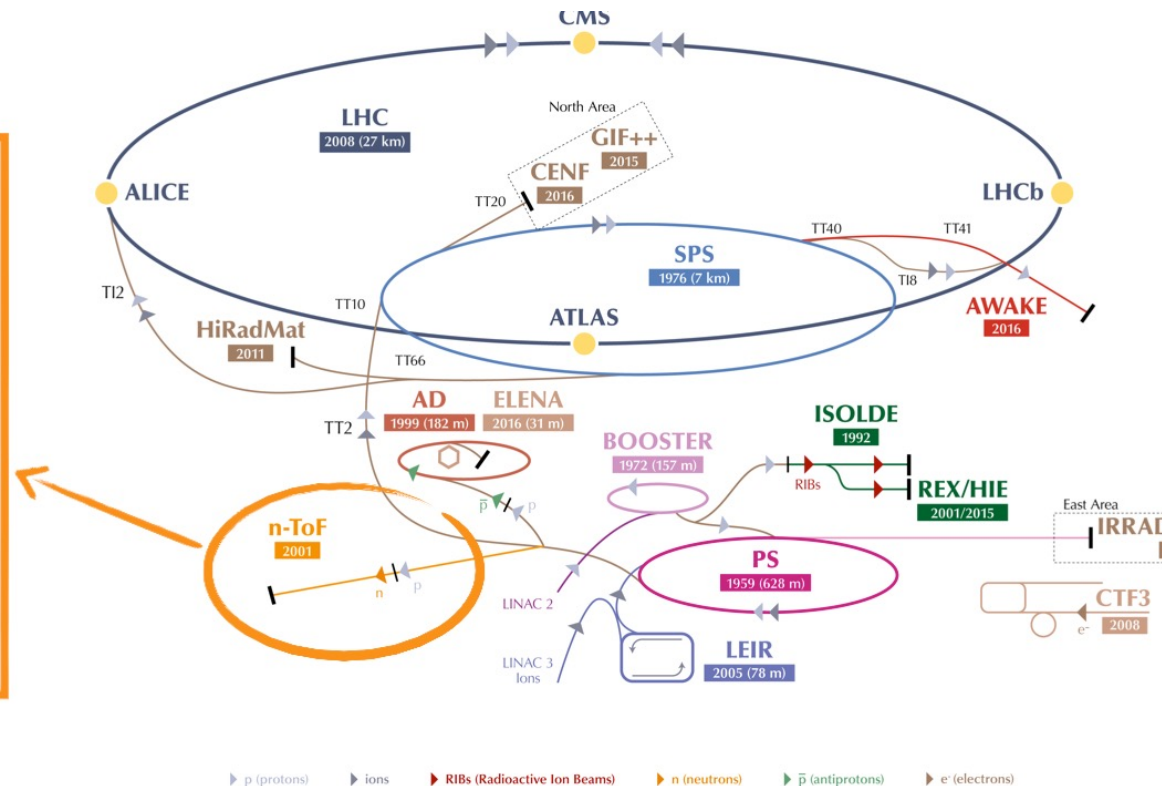
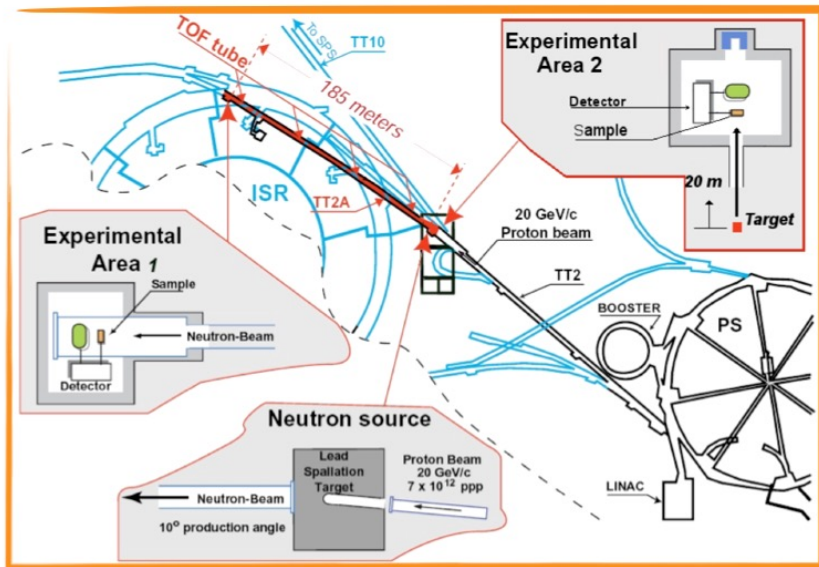


D.M. Castelluccio (ENEA)  
P. Console Camprini (ENEA)  
A. Guglielmelli (ENEA)  
A. Manna (Unibo)  
C. Massimi (Unibo)  
A. Mengoni (ENEA)  
G. Vannini (INFN)  
A. Ventura (INFN)



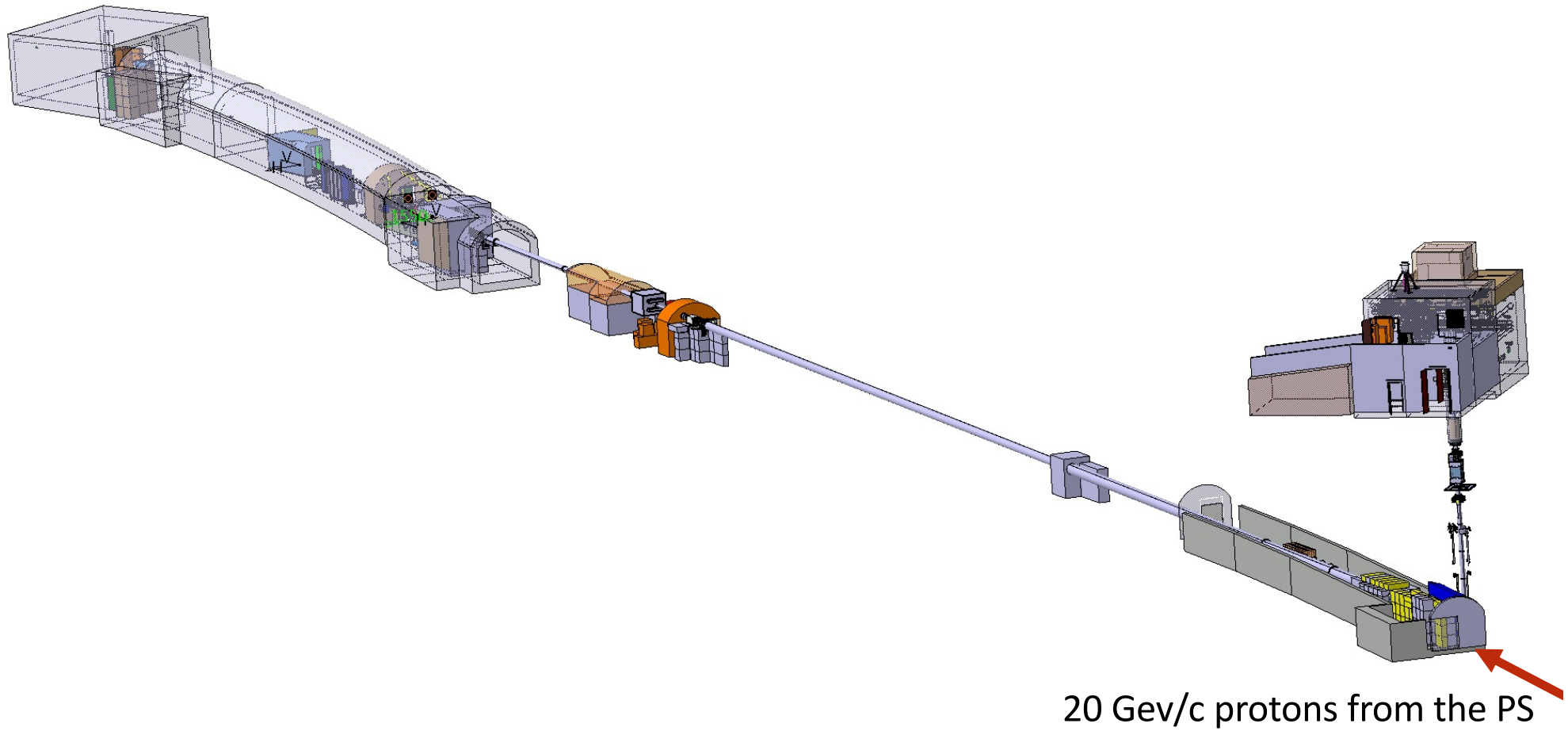
# n\_TOF facility

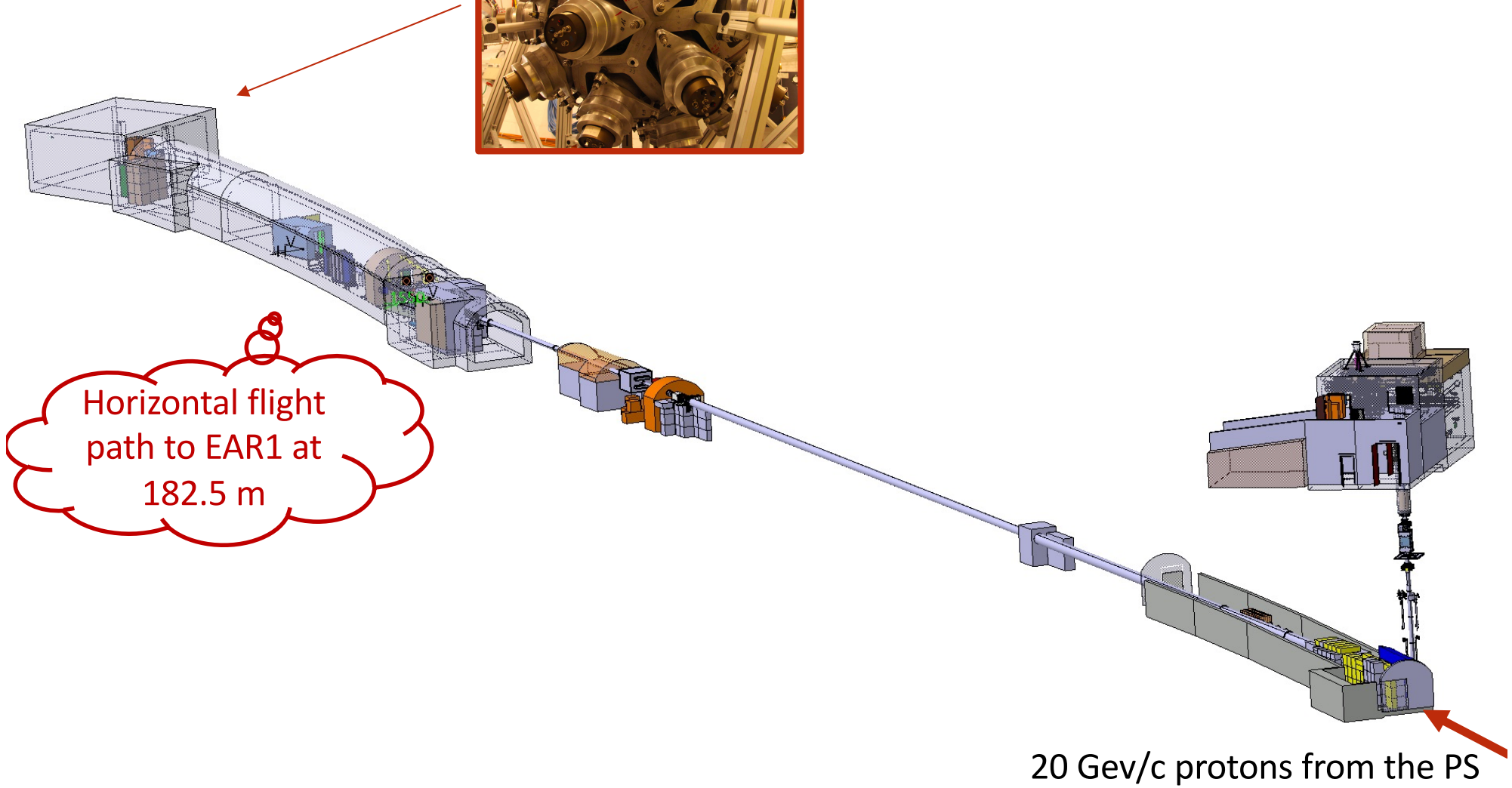
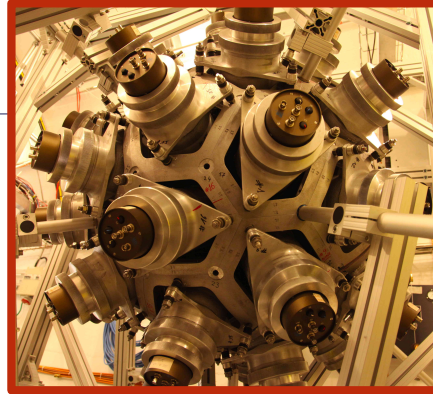
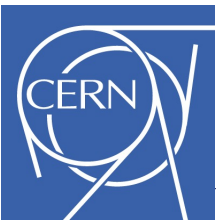
The features of the n\_TOF facility are related to the PS proton beam:  
**high energy, high current, low duty cycle.**



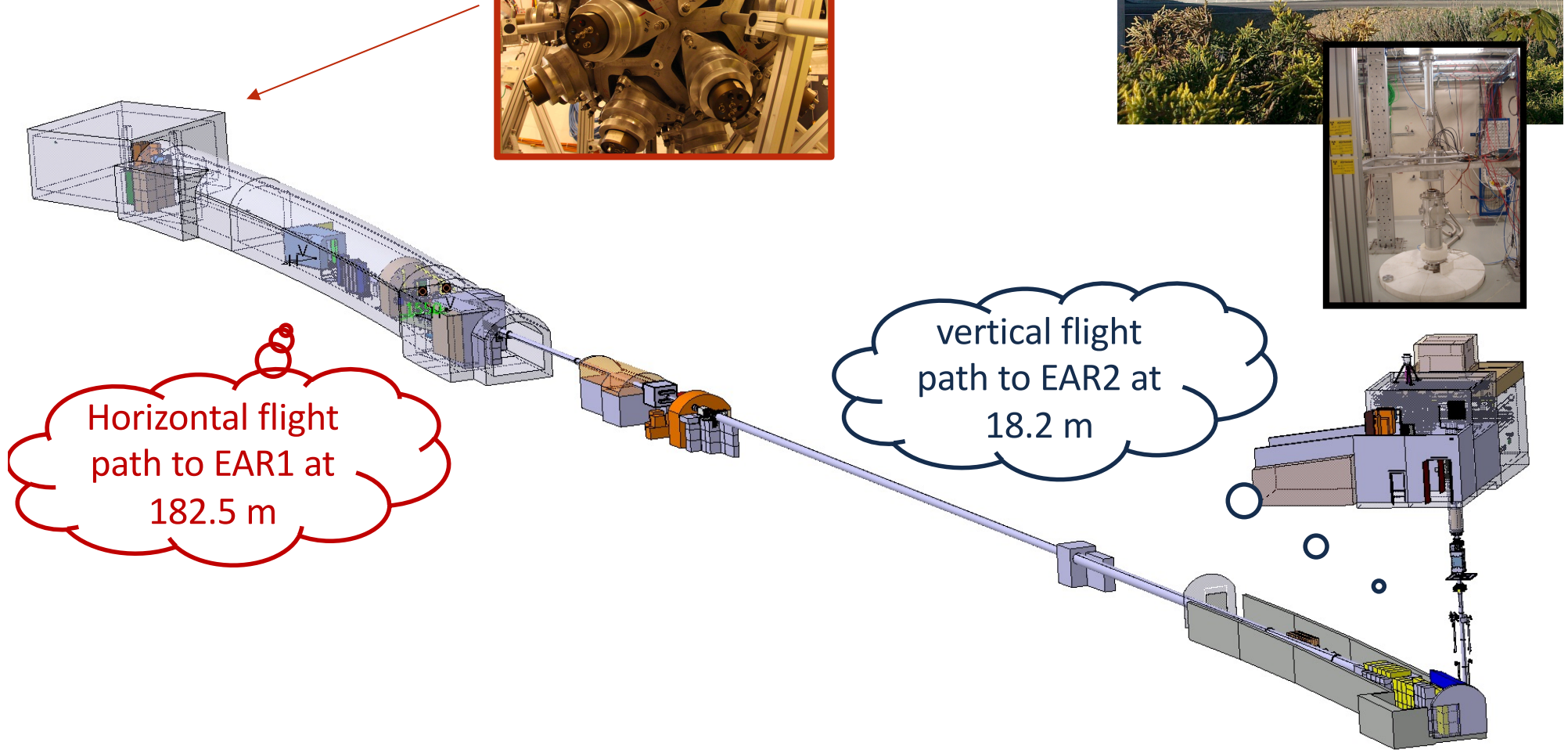
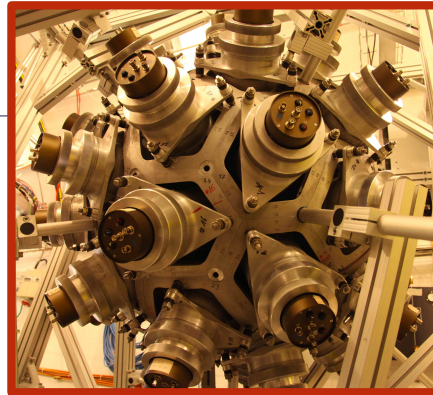


# n\_TOF facility





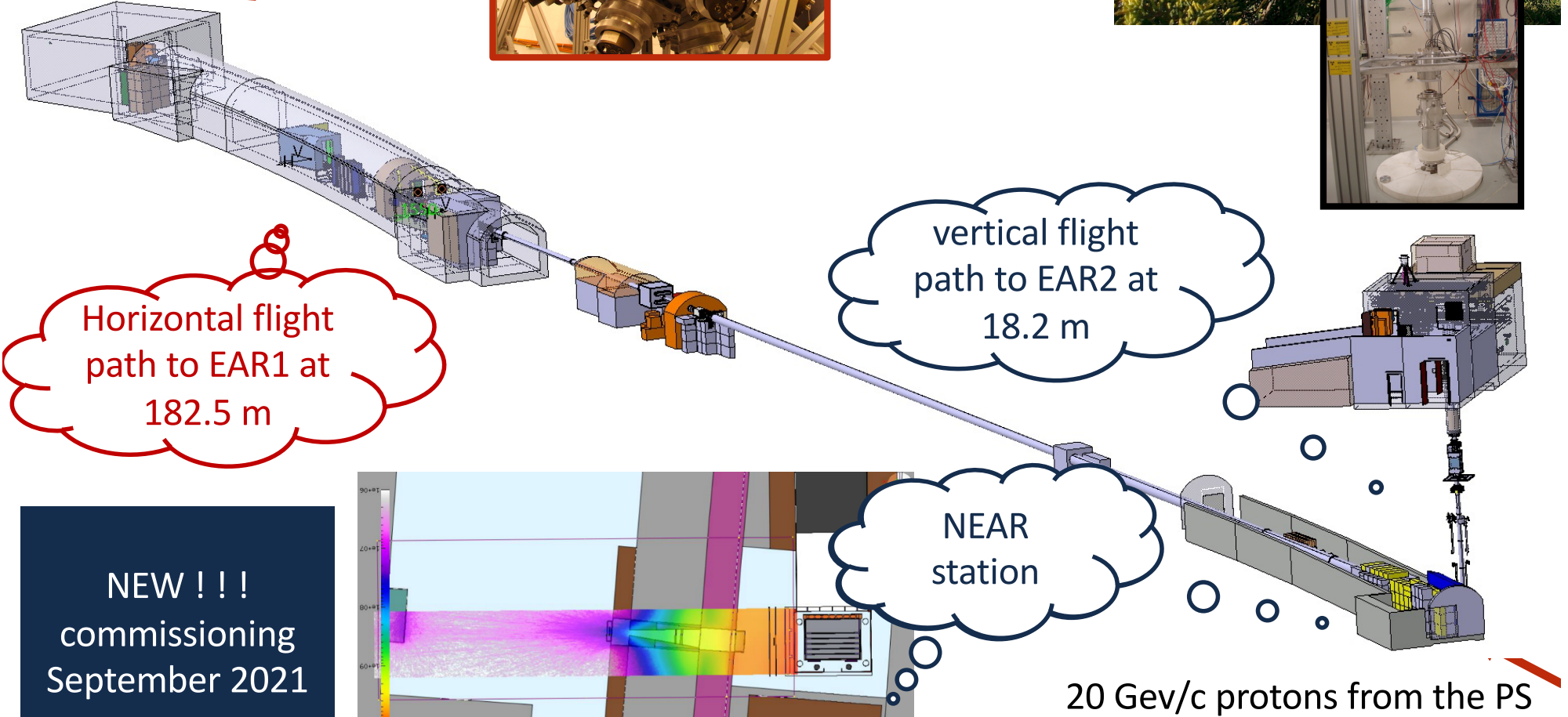
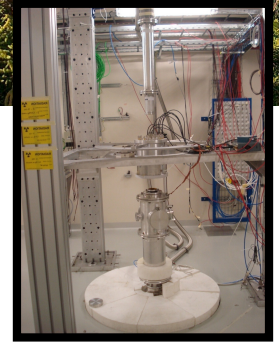
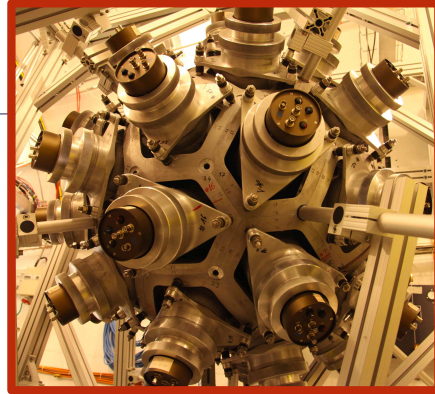




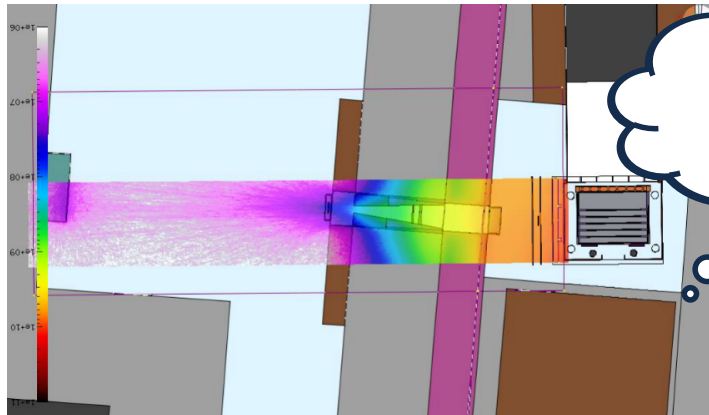
Horizontal flight path to EAR1 at 182.5 m

vertical flight path to EAR2 at 18.2 m

20 GeV/c protons from the PS



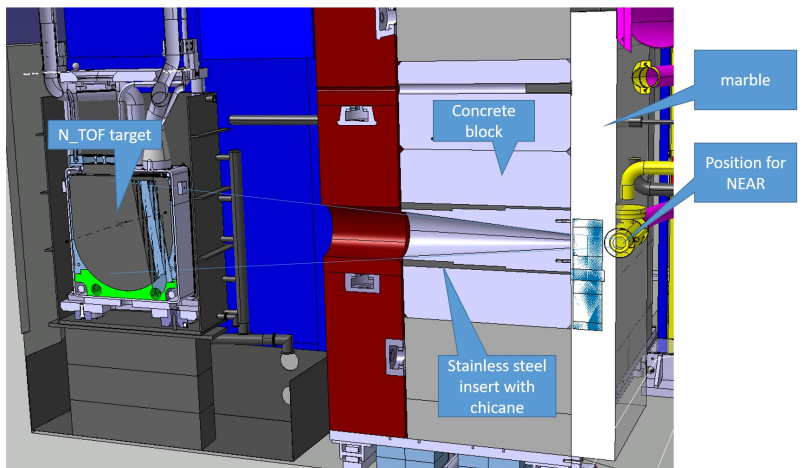
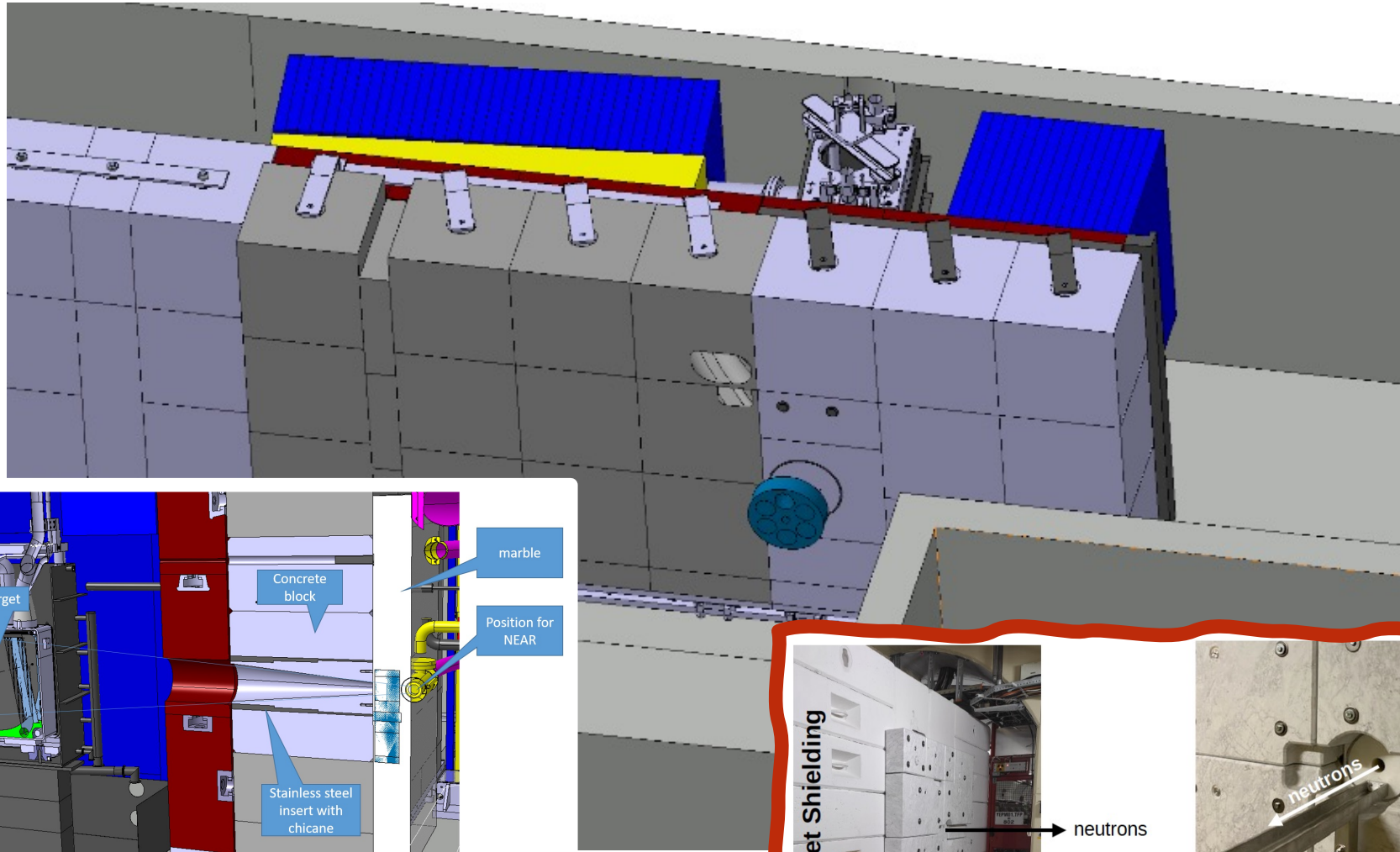
**NEW !!!**  
 commissioning  
 September 2021





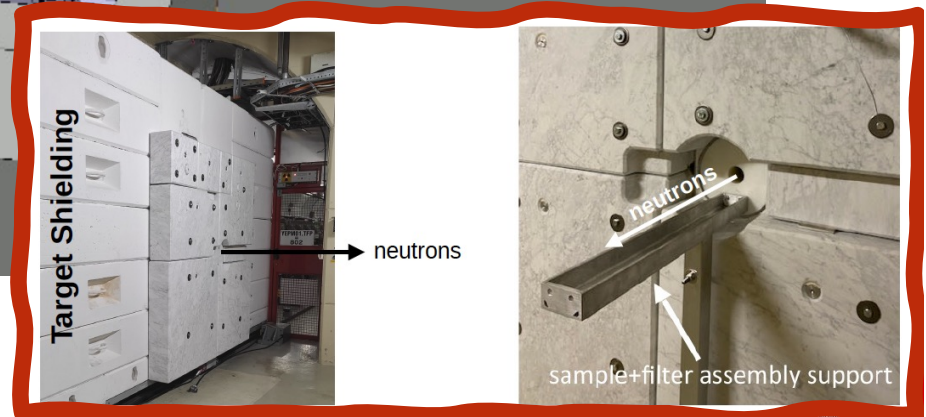
# NEAR

**NEAR station: activation measurements on rare isotopes with short half-life** (produced at CERN@ISOLDE or PSI). Also suitable as **irradiation station**



S. Girod EN-EA

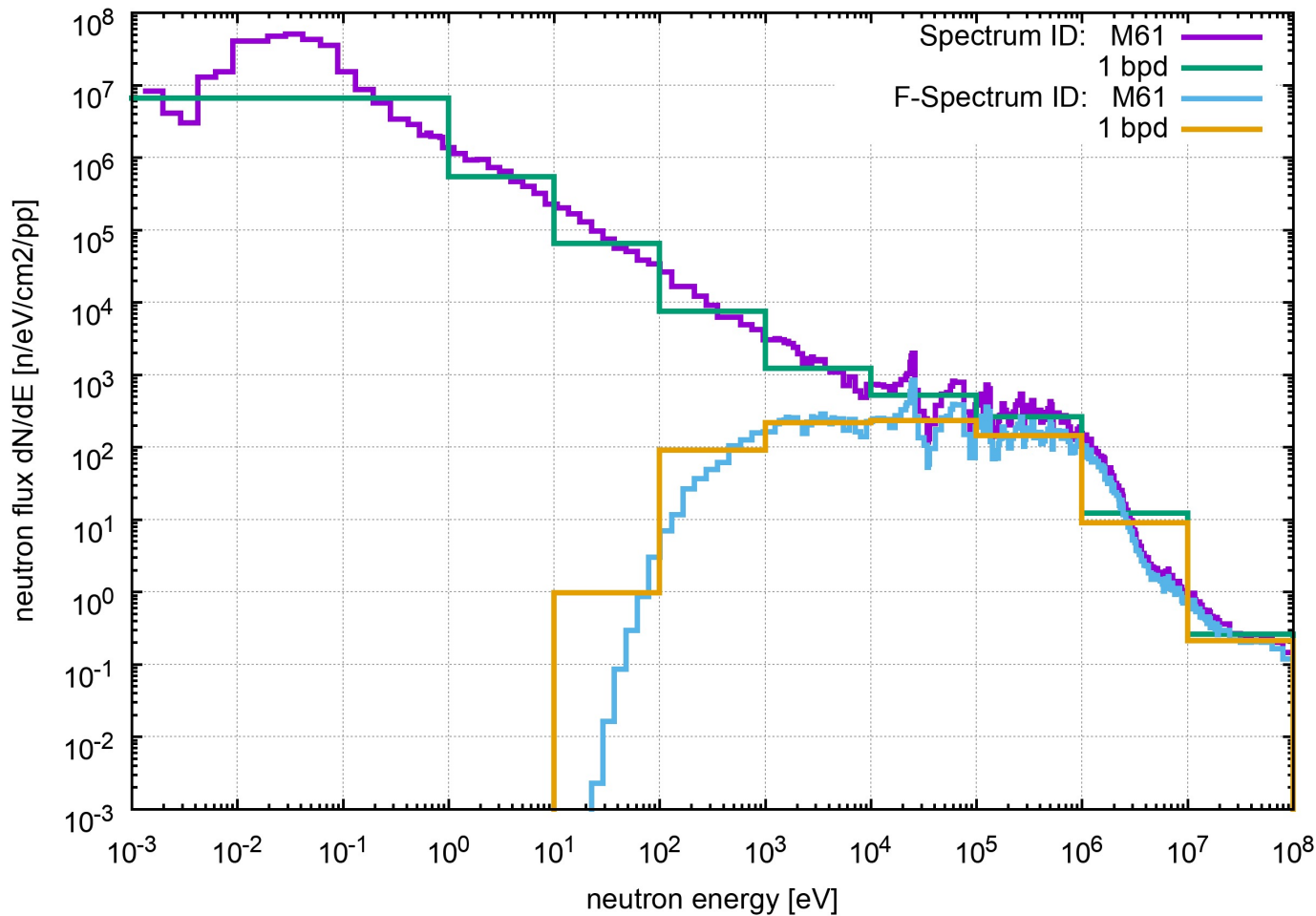
3





# NEAR

**NEAR station: activation measurements on rare isotopes with short half-life** (produced at CERN@ISOLDE or PSI). Also suitable as **irradiation station**



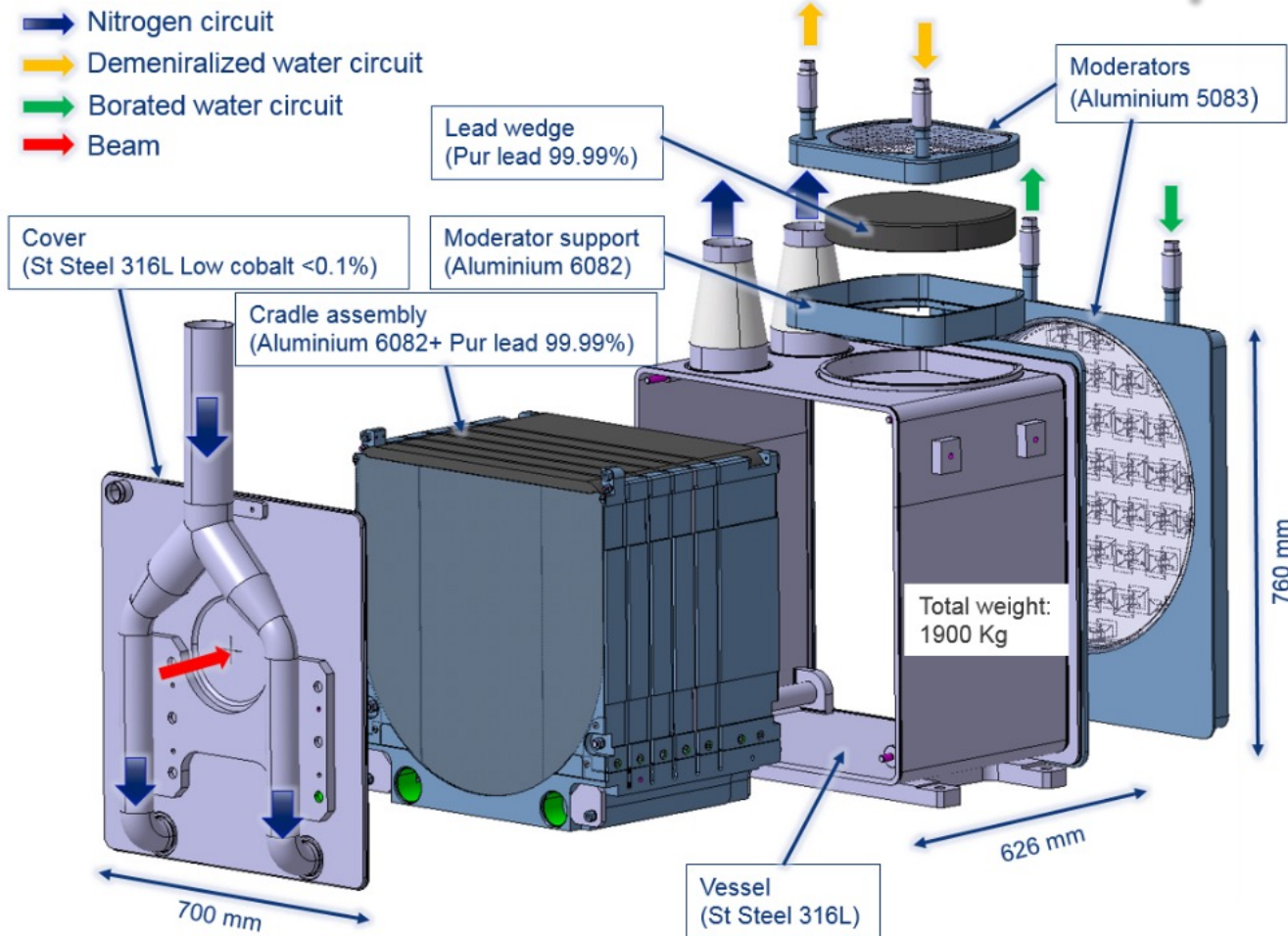
Neutron **FLUX**  
@ **NEAR** station

Neutron energy range	n/cm <sup>2</sup> /pp
All energies	4.6x10 <sup>8</sup>
$E_n < 1$ keV	0.2x10 <sup>8</sup>
$1$ keV $< E_n < 1$ MeV	2.9x10 <sup>8</sup>
$E_n > 1$ MeV	1.5x10 <sup>8</sup>



# Spallation target #3

First beam  
19.07.21



1550 Kg

1x15cm + 5x5.0 cm Pb  
64 x 62 x 46 cm

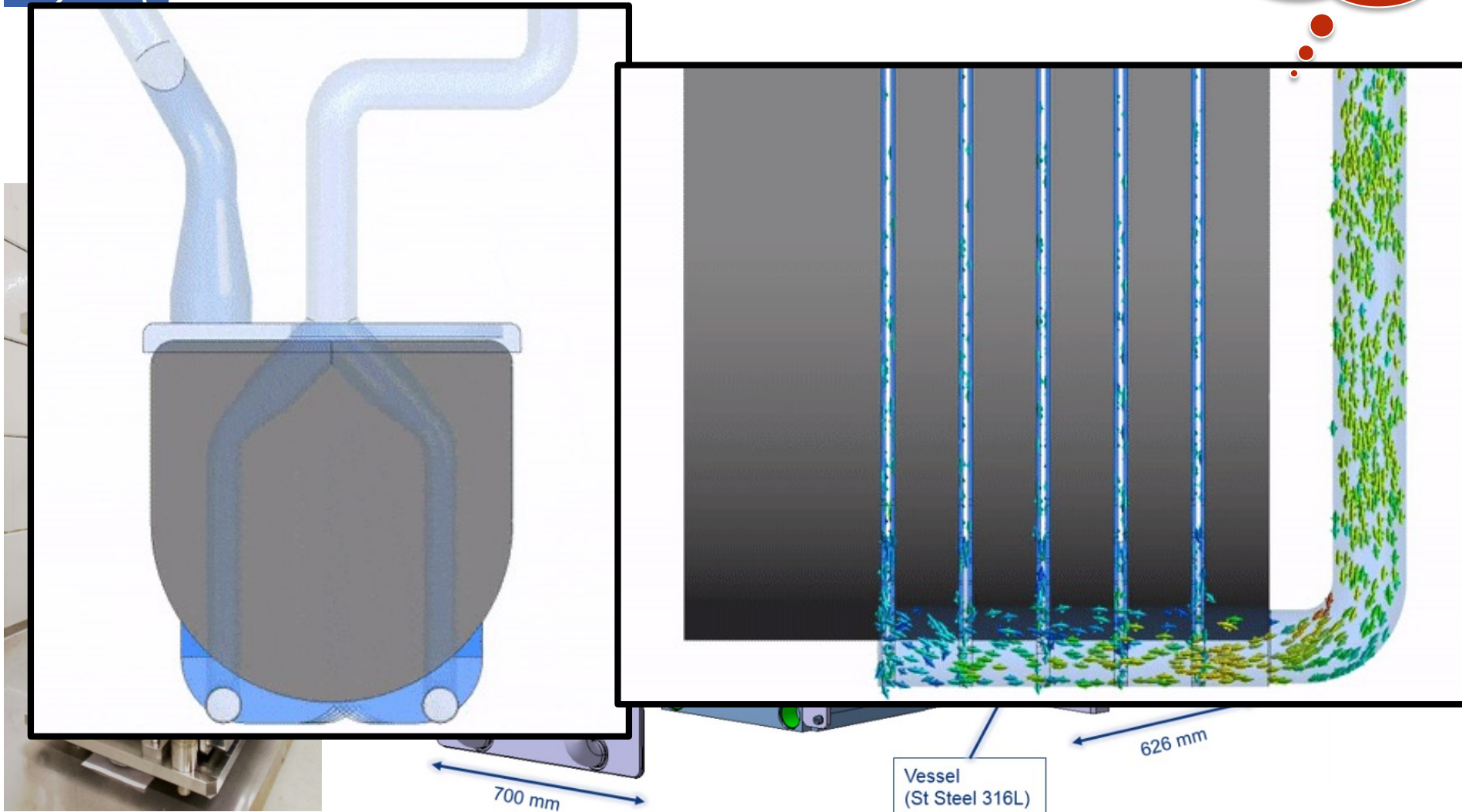
Moderator  
H<sub>2</sub>O + B

Cooling  
N<sub>2</sub> pure (99.995%)



# Spallation target #3

First beam  
19.07.21



1550 Kg

1x15cm + 5x5.0 cm Pb  
64 x 62 x 46 cm

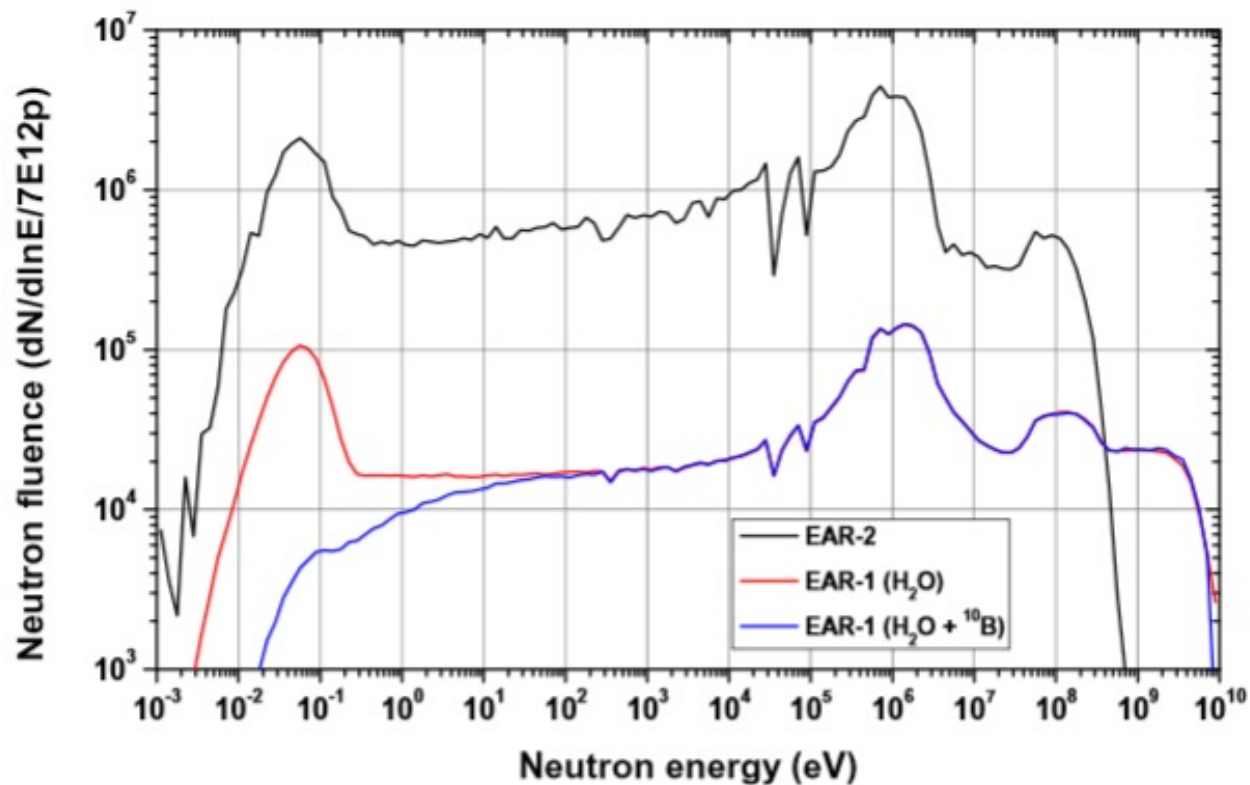
Moderator  
H<sub>2</sub>O + B

Cooling  
N<sub>2</sub> pure (99.995%)



# n\_TOF facility

The features of the n\_TOF facility are related to the PS proton beam:  
**high energy, high current, low duty cycle.**



Neutron energy  
 $10 \text{ meV} < E_n < 1 \text{ GeV}$

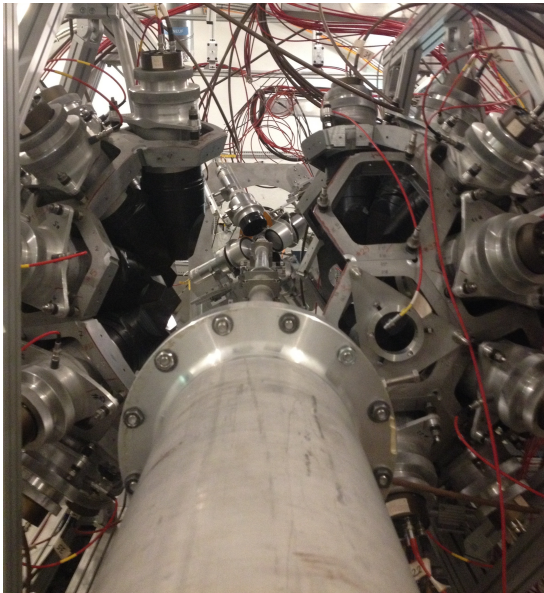
Neutron flux  
EAR2  $10^6 \text{ n/cm}^2/\text{pulse}$   
EAR1  $10^5 \text{ n/cm}^2/\text{pulse}$

Energy resolution  
 $\Delta E/E \sim 10^{-4} @ \text{EAR1}$

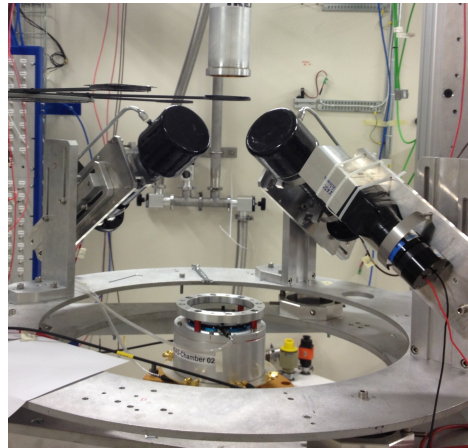
# Detectors

## $(n,\gamma)$ reactions

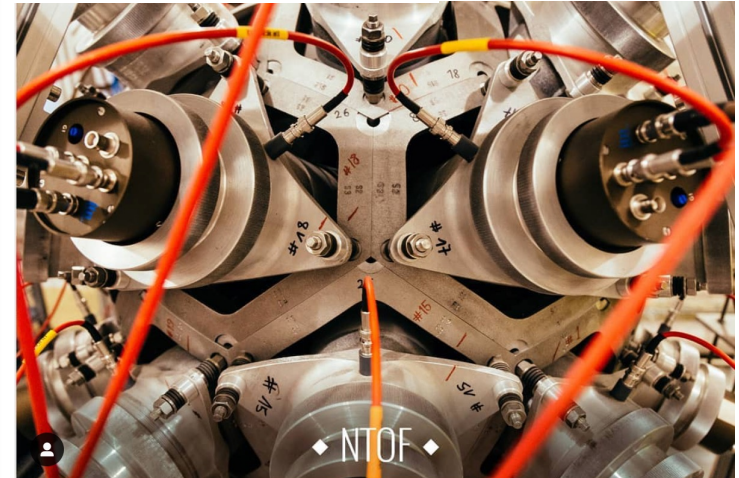
Total Absorption Calorimeter  
(TAC)  $\text{BaF}_2$



$\text{C}_6\text{D}_6$  liquid scintillators



inf\_n Insights •



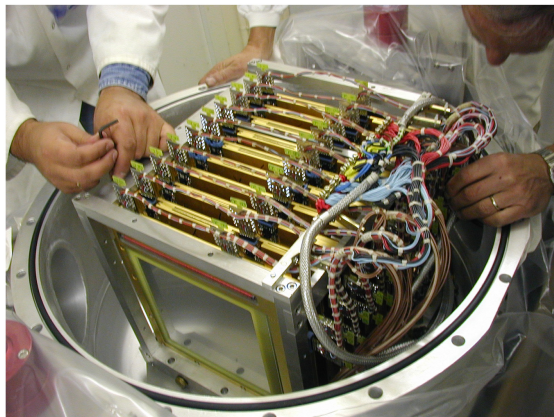
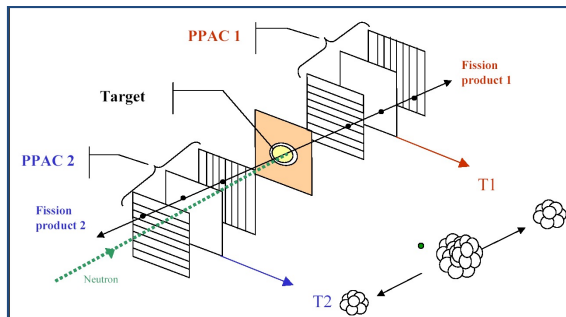
Relevant INFN contribution:  
test, maintenance and  
optimization of the capture  
detectors



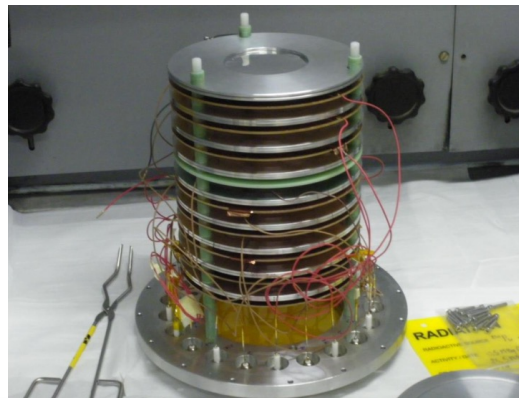
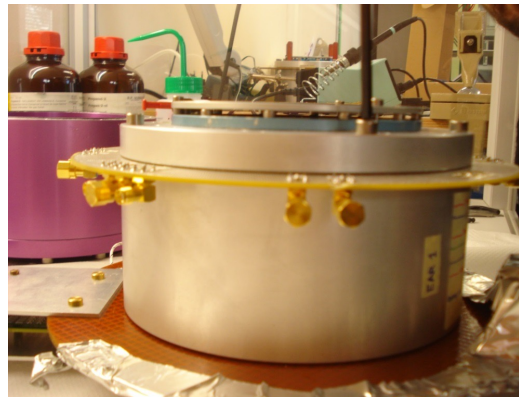
# Detectors

## Fission reactions

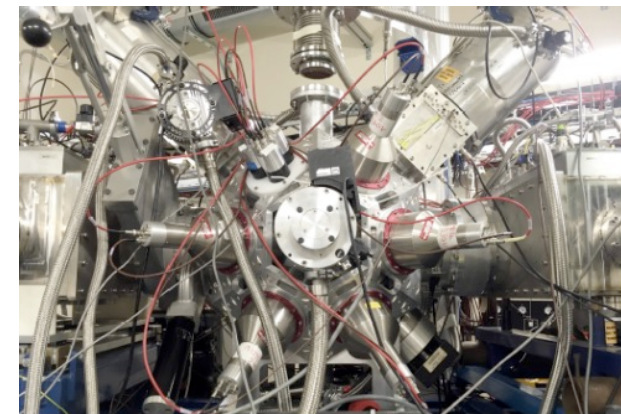
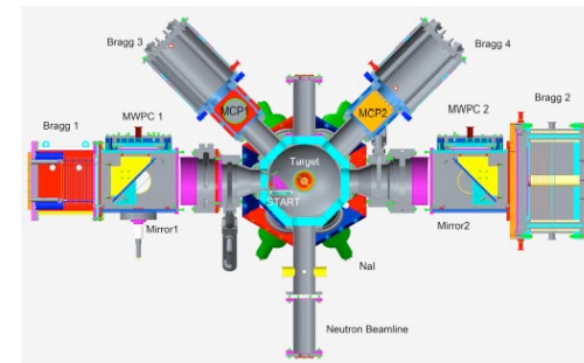
Parallel Plate Avalanche Chamber (PPAC)



MicroMegs

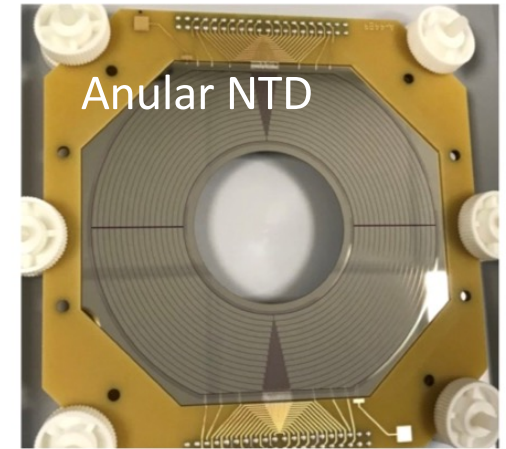


STEFF



Setup based on Si detectors for high accuracy measurements (EPJ A front page) developed by LNS

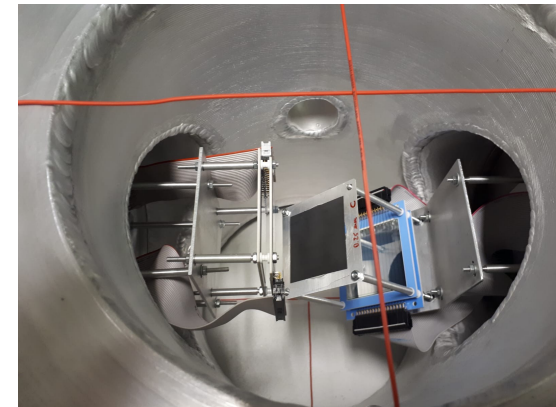
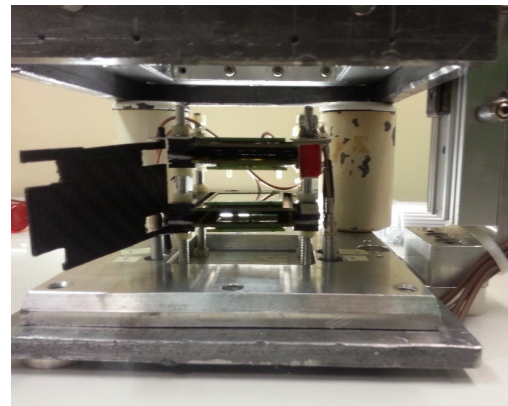
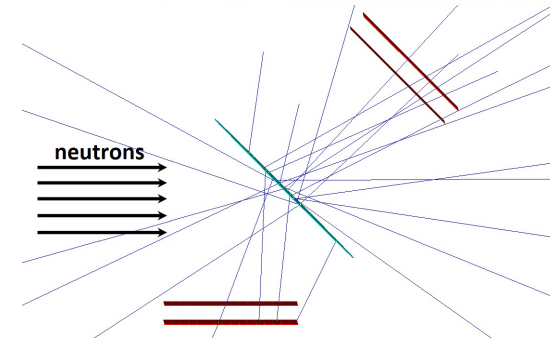
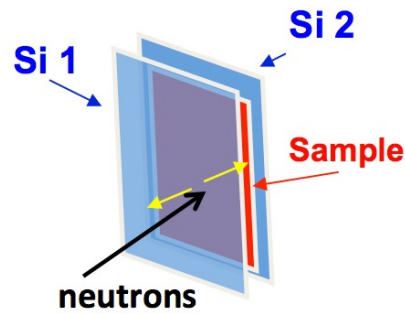
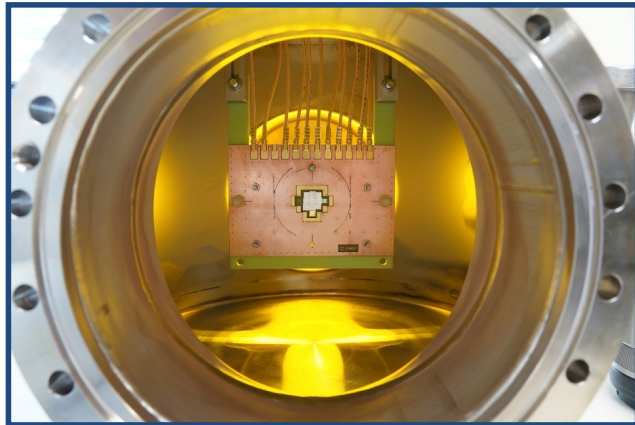
# Detectors



## (n,cp) reactions

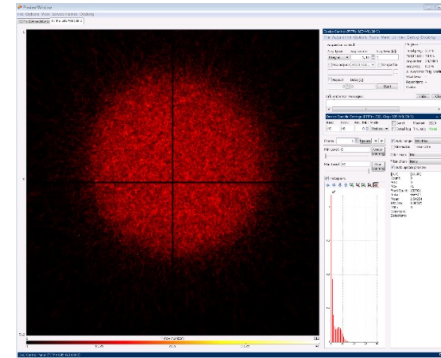
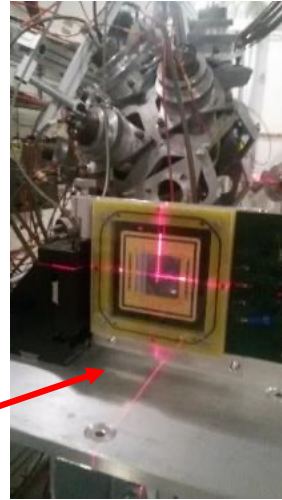
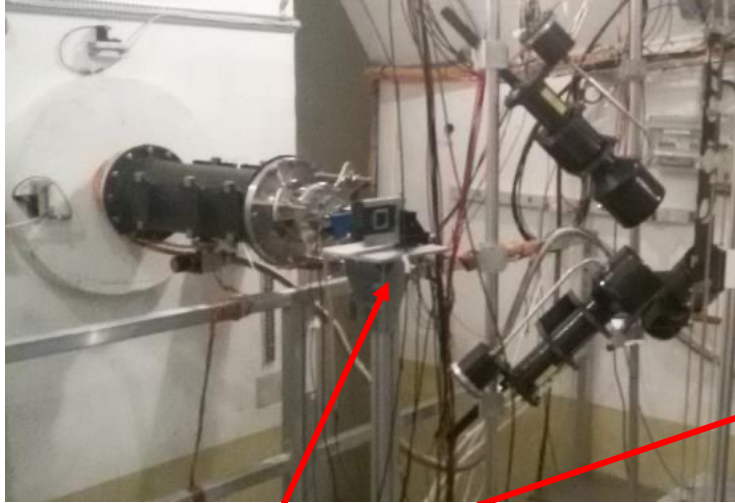
Silici

Diamond detectors

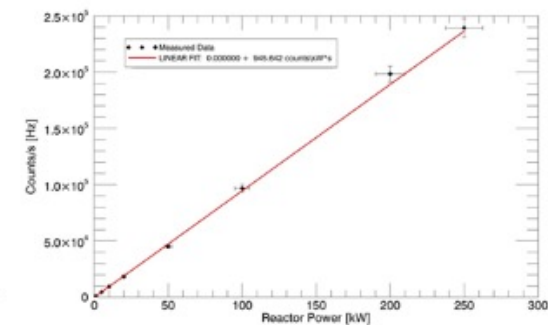
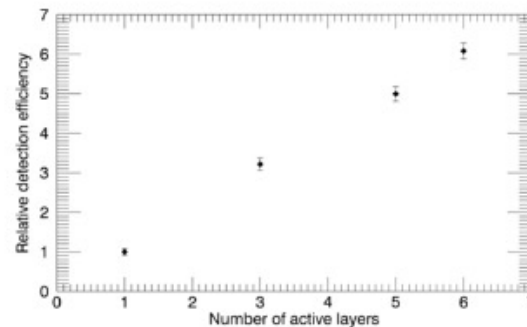
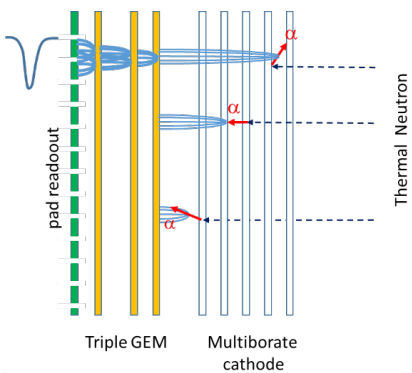
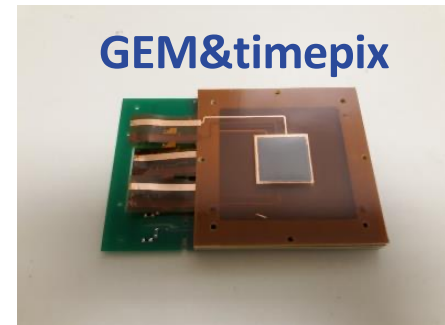


Setup for  ${}^7\text{Be}(n,p)$ ,  ${}^7\text{Be}(n,\alpha)$  e la  ${}^{12}\text{C}(n,p)$  developed by INFN

# Detectors

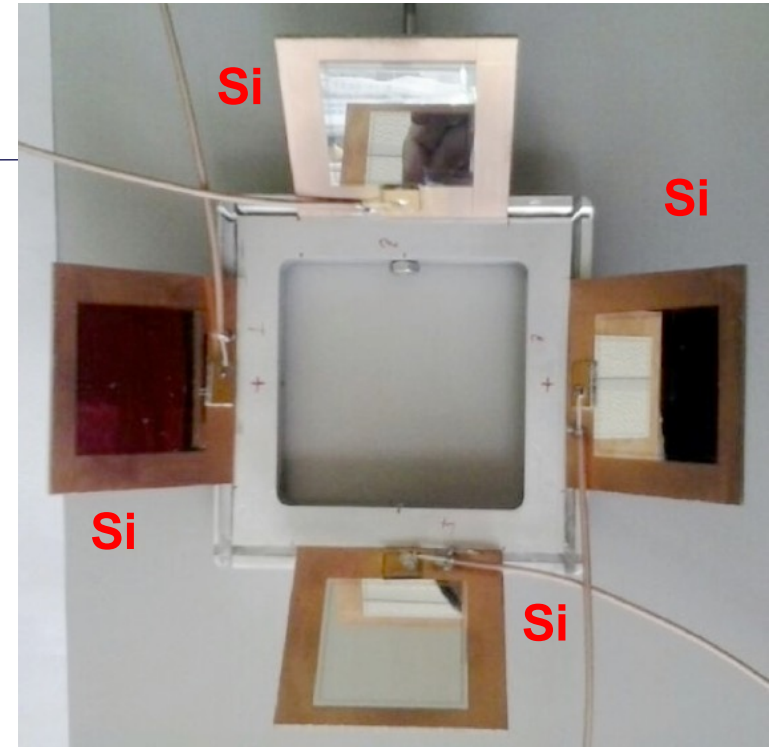
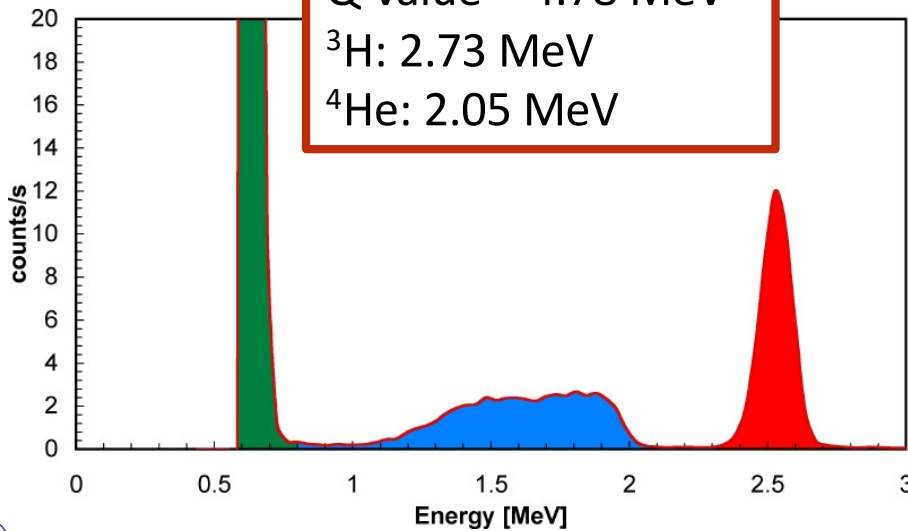
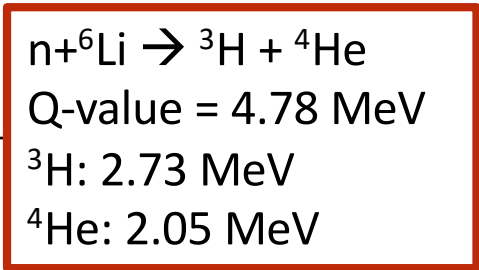
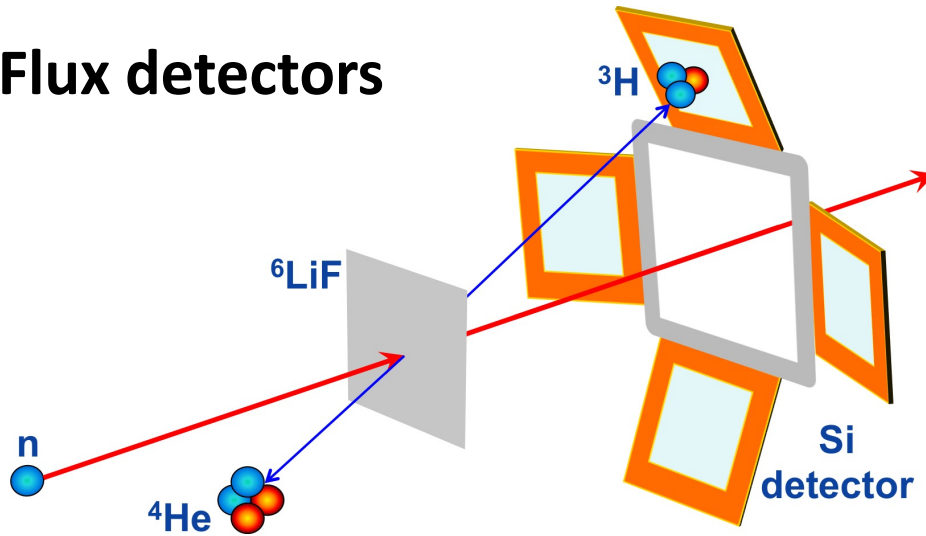


**Quad-Timepixes** used to find neutron beam line.  
**Borated GEM** (High efficiency th. neutron detector) in cooperation CERN - ESS - INFN

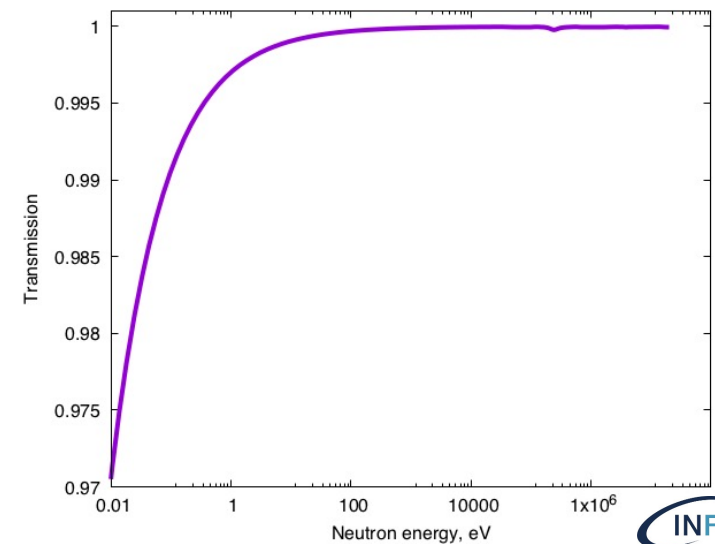


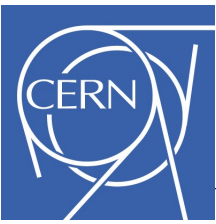
# Detectors

## Flux detectors



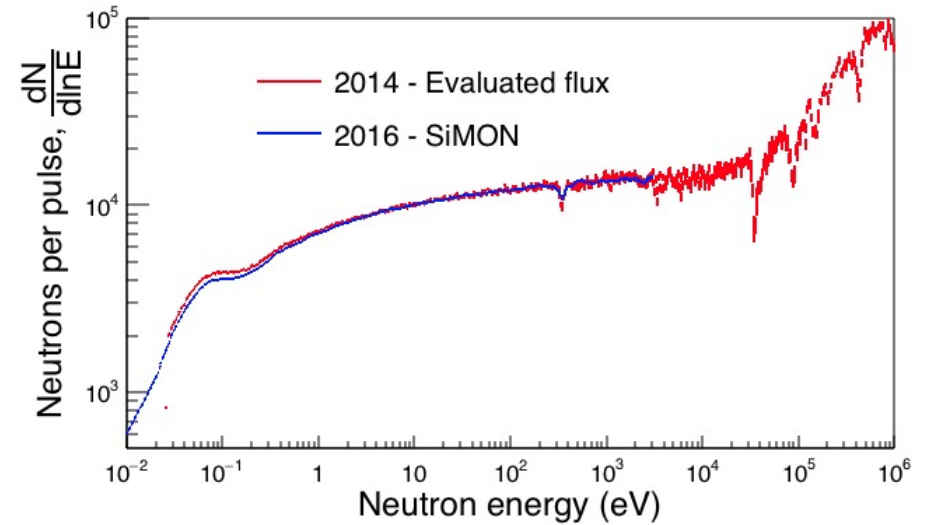
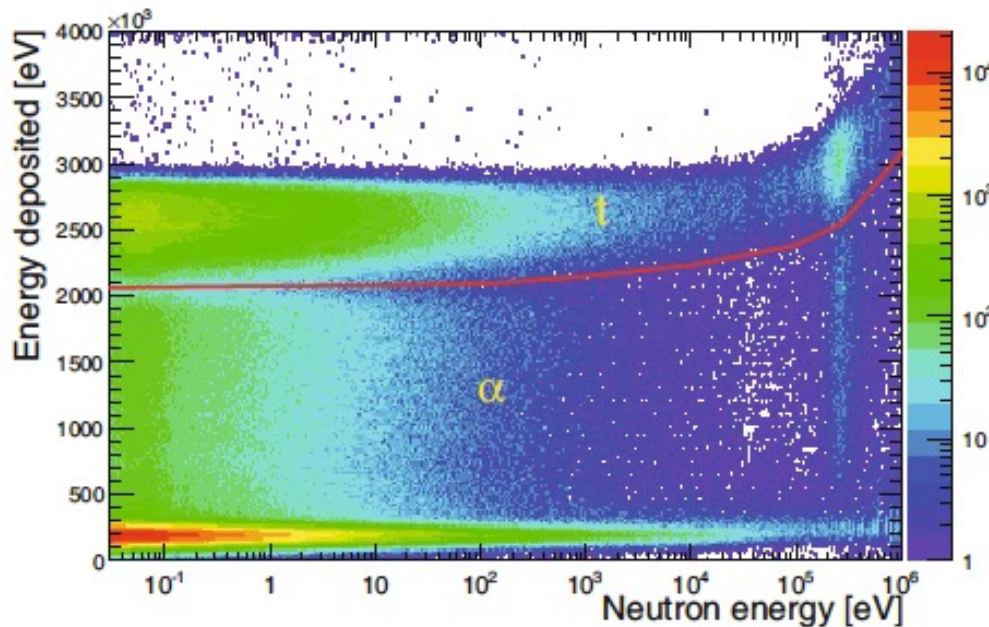
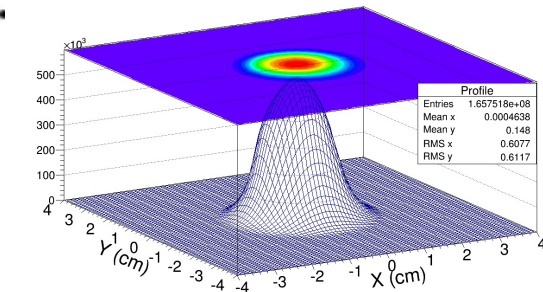
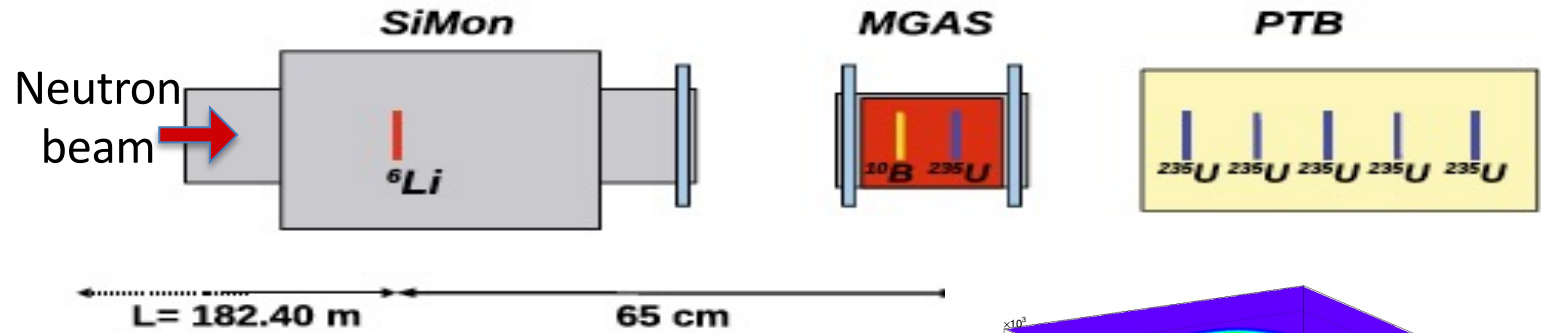
MSX09-3007 3 cm × 3 cm,  
**300 μm** thick > particle range



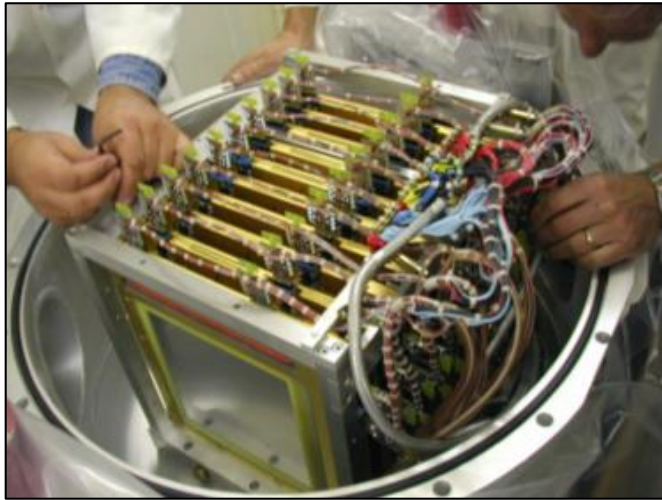


# Beam characterizations

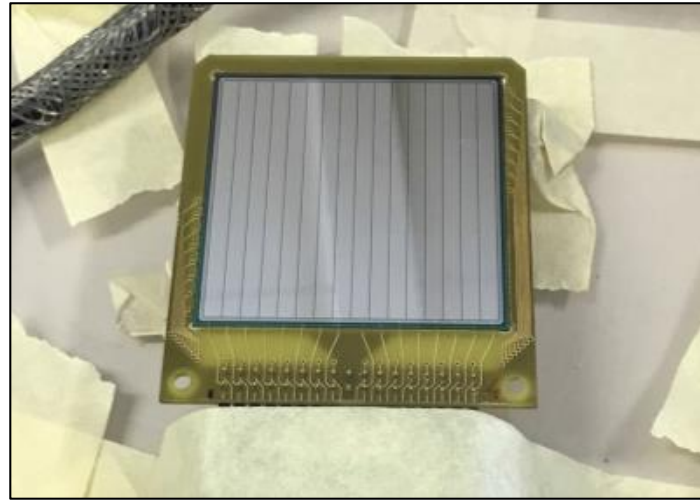
3 different detectors based on 3 neutron standards



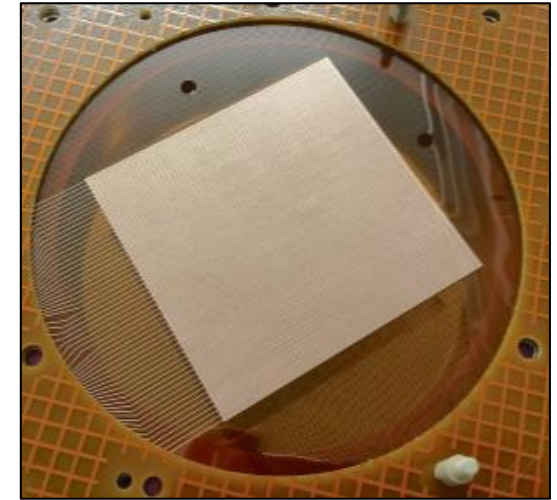
# Beam characterizations



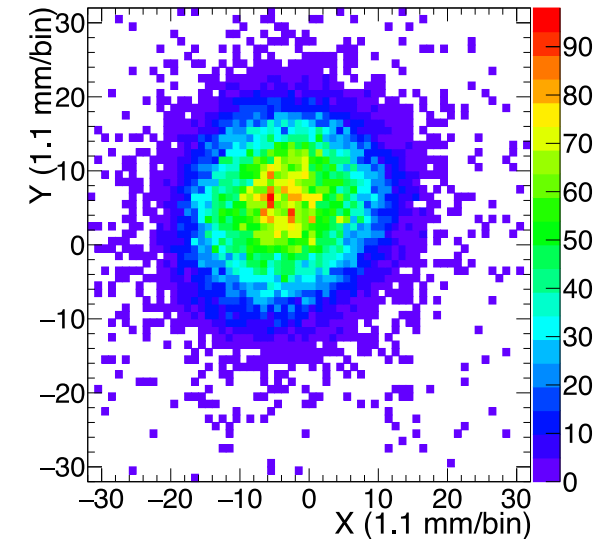
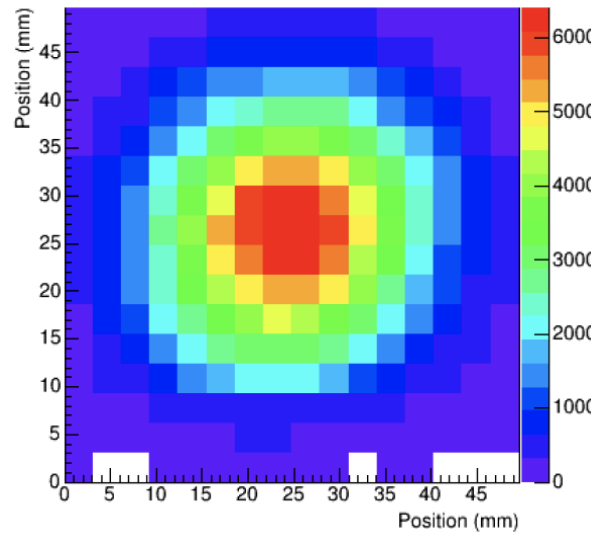
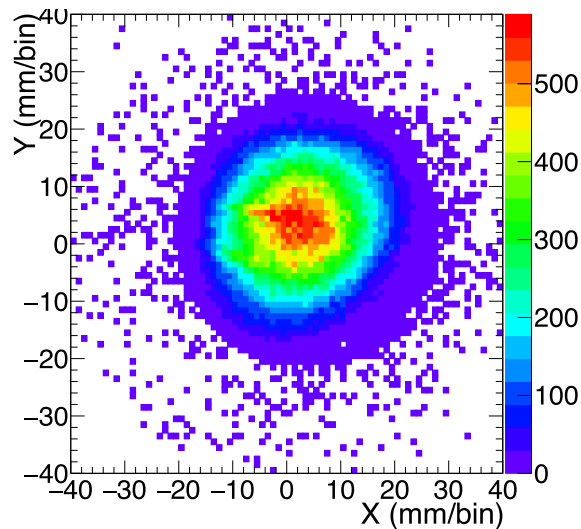
PPAC



SiMon2D



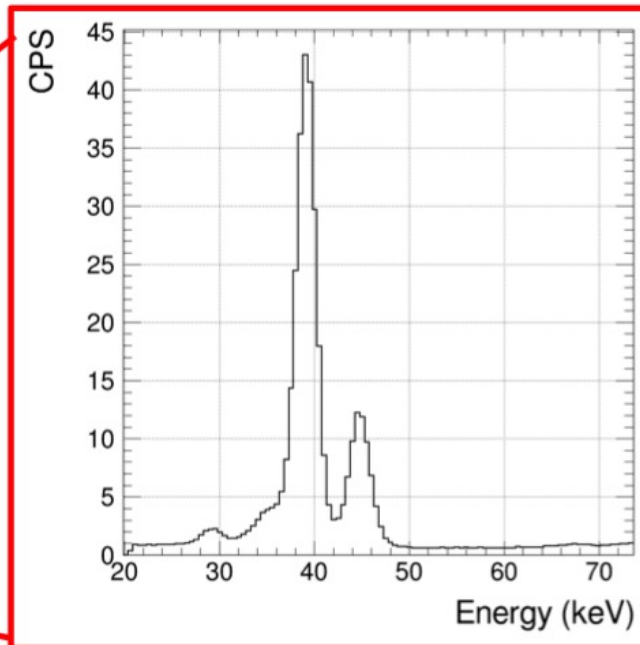
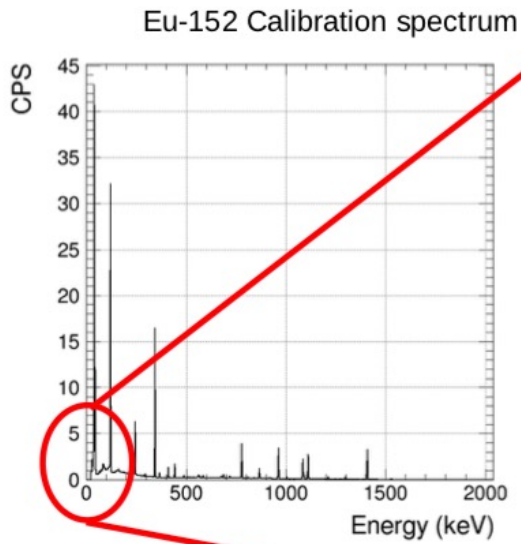
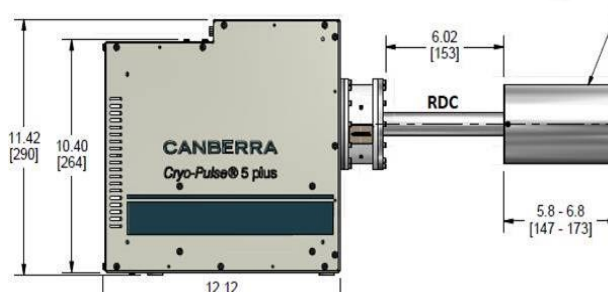
XY MicroMegas





# HPGe for NEAR

Measurement station equipped with HPGe

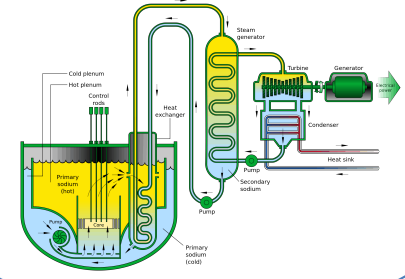


# ACTIVITIES

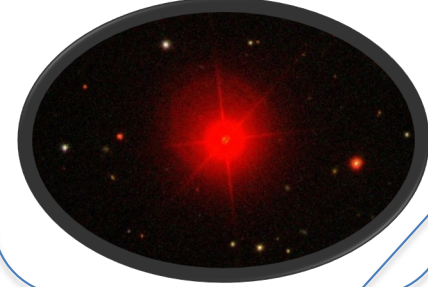
## Big Bang nucleosynthesis



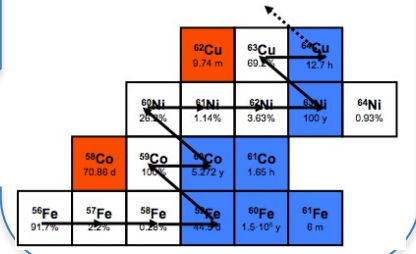
## Capture cross section technologies



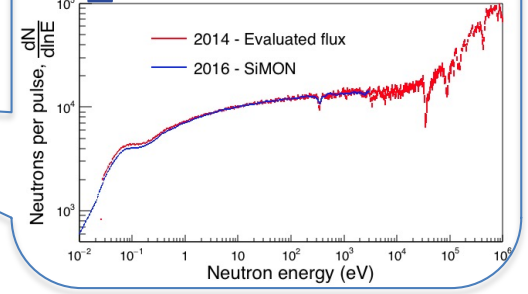
## Neutron source in Red Giants stars



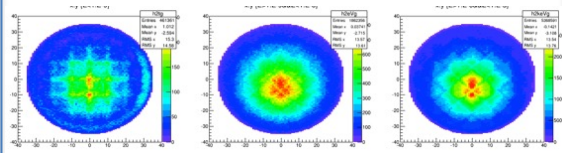
## s process: Nucleosynthesis of heavy elements



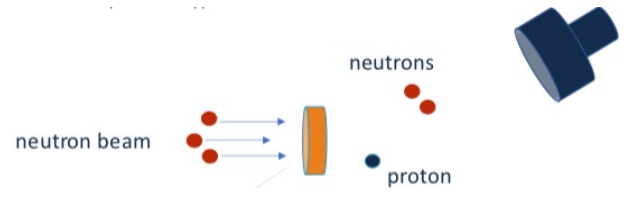
## Characterization of the n\_TOF neutron flux



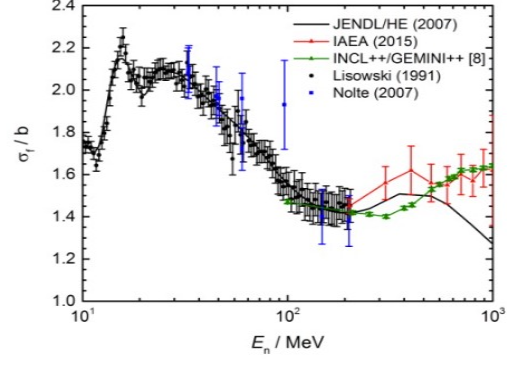
## MC Study of the n\_TOF spallation source



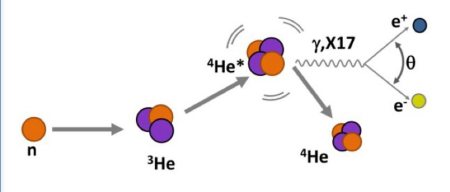
## neutron – neutron scattering length



## Fission at intermediate energy



## New Physics: Hunting the X17 boson



COLLABORATION with FOOT



# Interest

Thesis 2021:

- PhD 1
- Master 1
- Bachelor 2

Thesis

2017	3
2018	
2019	2
2020	1
2021	3

Contact for thesis:

- ENEA (→ NewCleo)
- Laboratorio per l'Energia Nucleare Applicata (LENA)
- Transmutex

# n\_TOF @ BO

- ✓ Richieste ai servizi limitate (... e mai programmate)
  - ✧ → **risposta sempre pronta e soddisfacente**
- ✓ Prezioso il supporto del **CNAF** per il calcolo
- ✓ **Per il futuro prevediamo richieste maggiori per lo sviluppo del rivelatore di neutroni in collaborazione con FOOT**



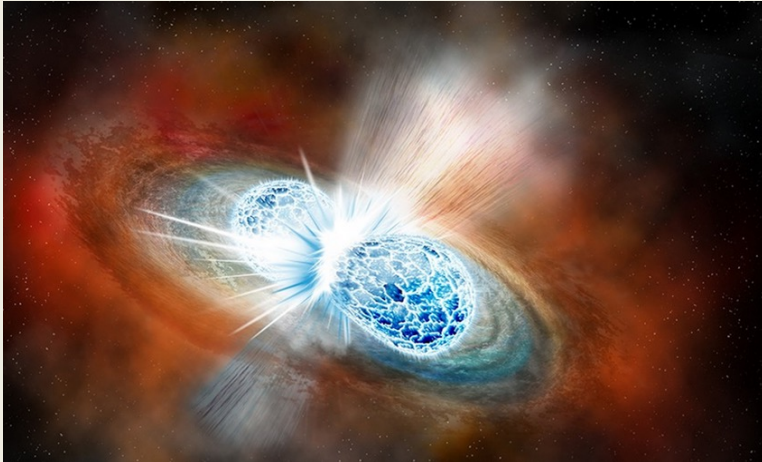
**GRAZIE !**

# Backup slides

---

# Conclusion / future

## Neutron Star Merger – r process



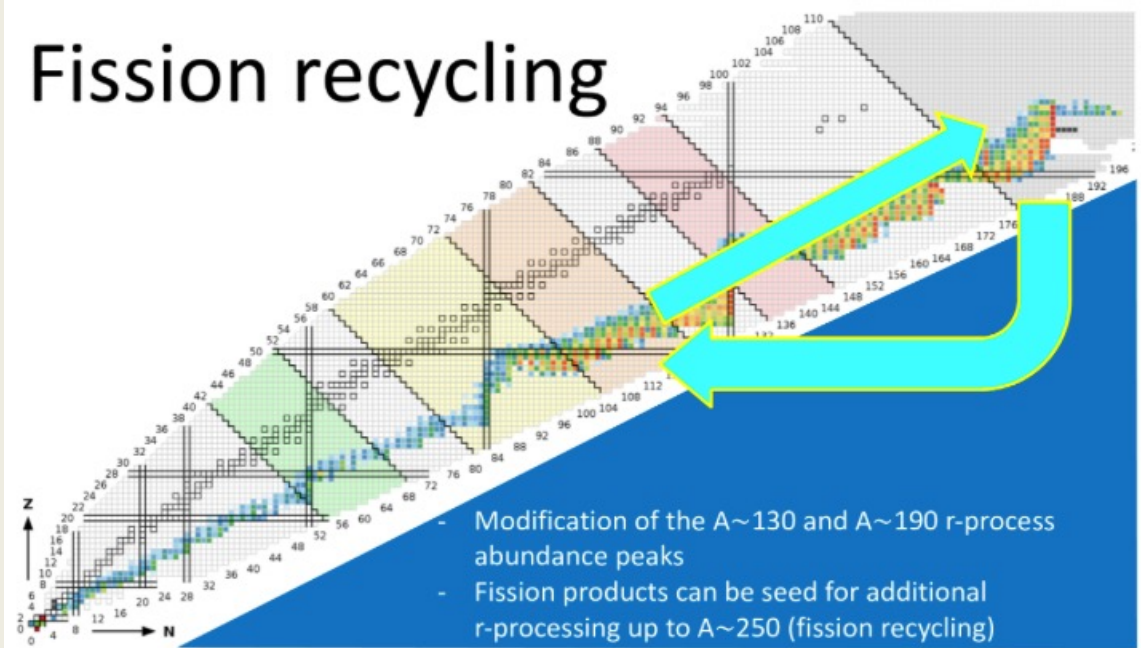
**r-process contribution to observed elemental abundances?**

**r process = Solar yields – s process**



**Improve the physics of both the s-process (neutron capture) and the r-process (fission)**

## Fission recycling



# Backup slides

HIGHLIGHTS FISICA

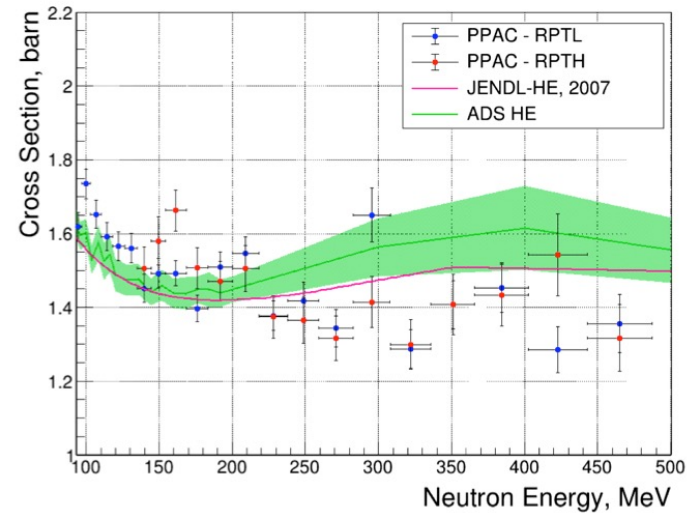
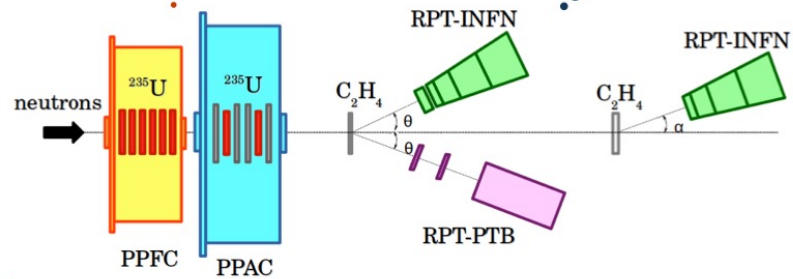
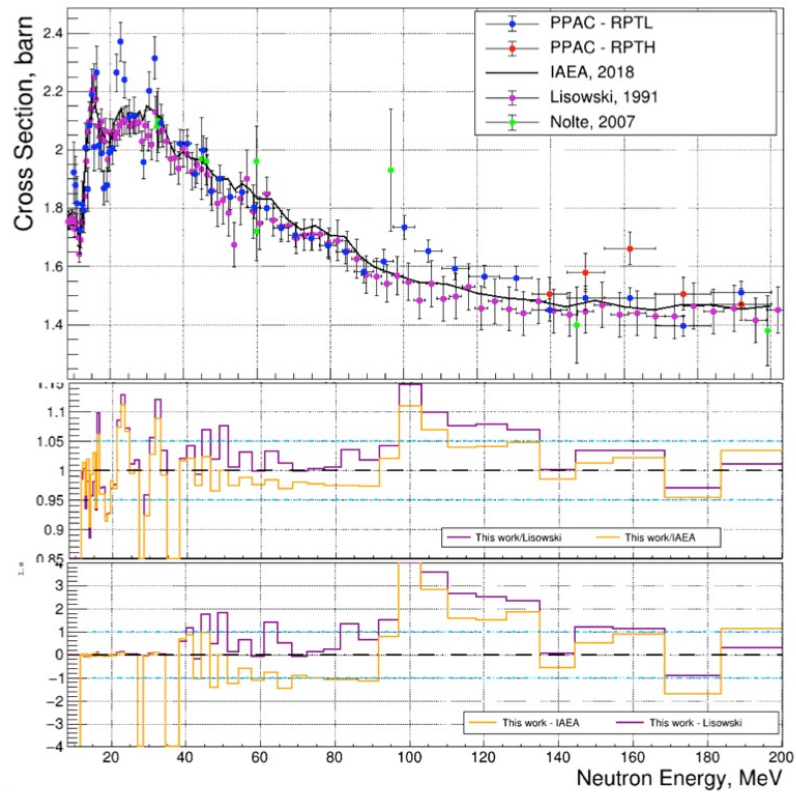
n\_TOF



$^{235}\text{U}(n,f)$

Fission detectors

Flux detectors  
n-p scattering



← → ✎ 📄 ↩ PhD Alice Manna



# Backup slides

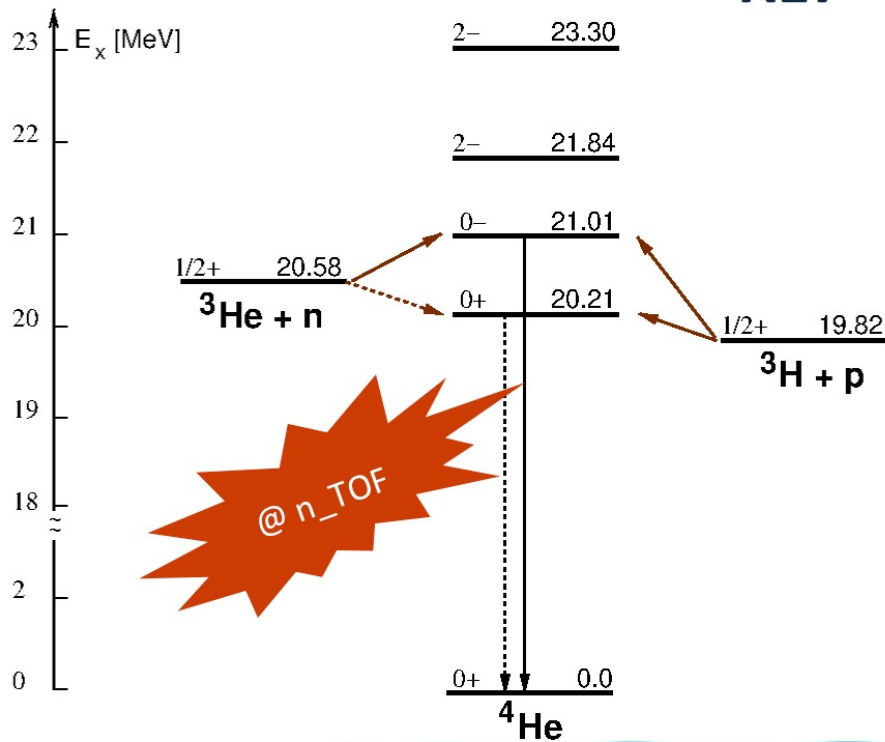


n\_TOF

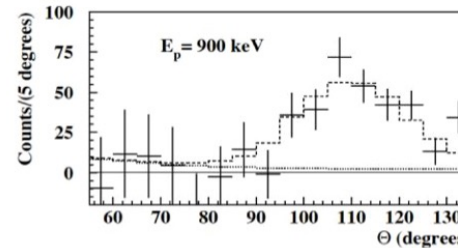
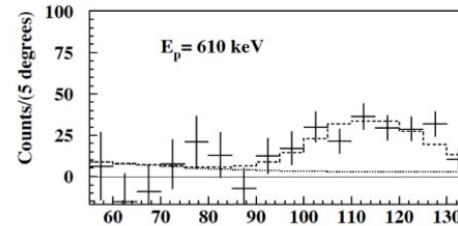
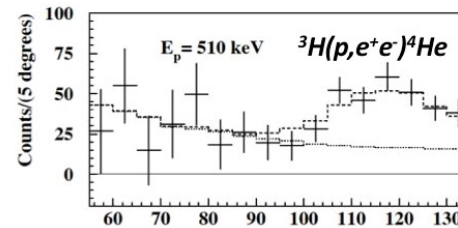
New proposal



X17



$e^+e^-$  pairs created by the forbidden M0 transitions from the two  $0^-$  states to the ground-state



Krasznahorkay, A.J.; et al.: "Observation of Anomalous Internal Pair Creation in  ${}^8\text{Be}$ : A Possible Indication of a Light, Neutral Boson". *Physical Review Letters*. **116** (42501): 042501 (2016).  
 Krasznahorkay, A.J.; et al.: "New evidence supporting the existence of the hypothetical X17 particle". [arXiv:1910.10459v1](https://arxiv.org/abs/1910.10459v1) [[nucl-ex](https://arxiv.org/abs/1910.10459v1)] (23 October 2019), [arXiv:2104.10075](https://arxiv.org/abs/2104.10075) (20 April 2021)



# Backup slides



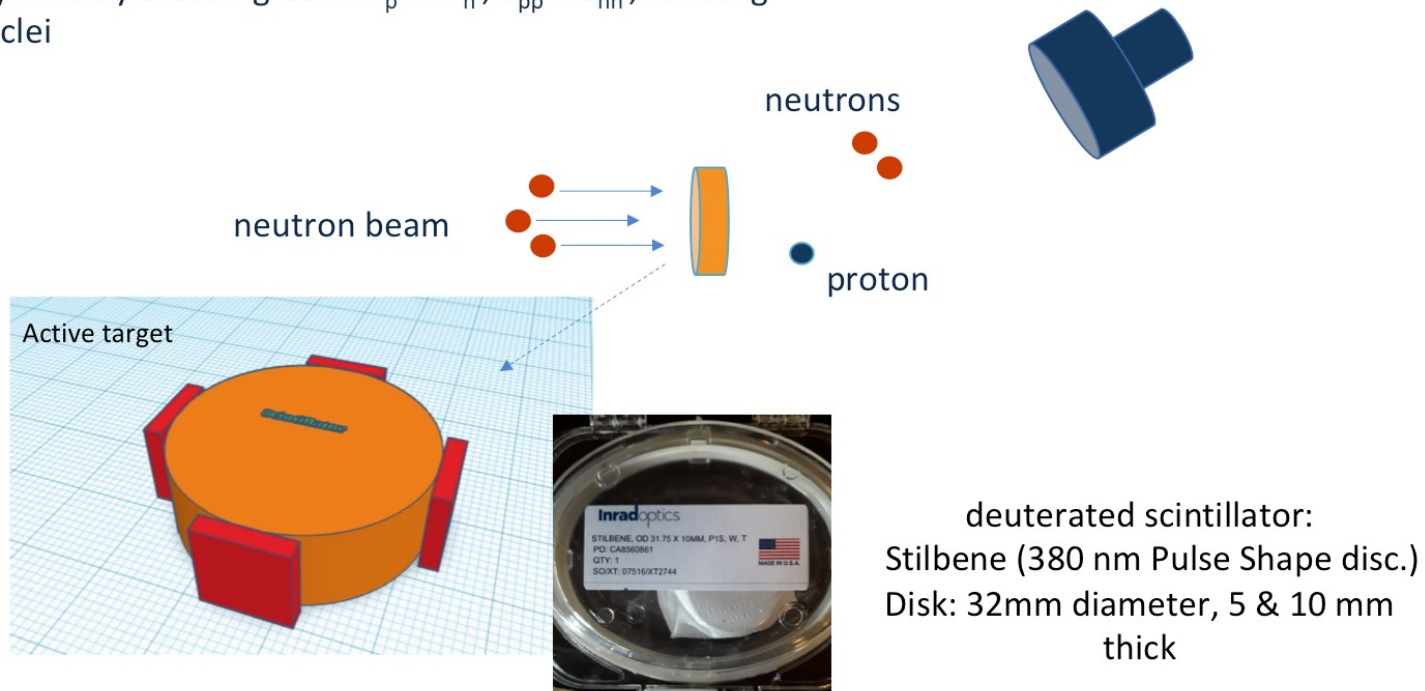
n\_TOF ...

New proposal



## Neutron neutron scattering length

Neutrons and protons behave in the same way under nuclear interaction?  
Charge symmetry is a special case of the **isospin invariance**, its violation is known as charge symmetry breaking CSB:  $m_p \neq m_n$ ;  $a_{pp} \neq a_{nn}$ ; binding energy  $\neq$  mirror nuclei

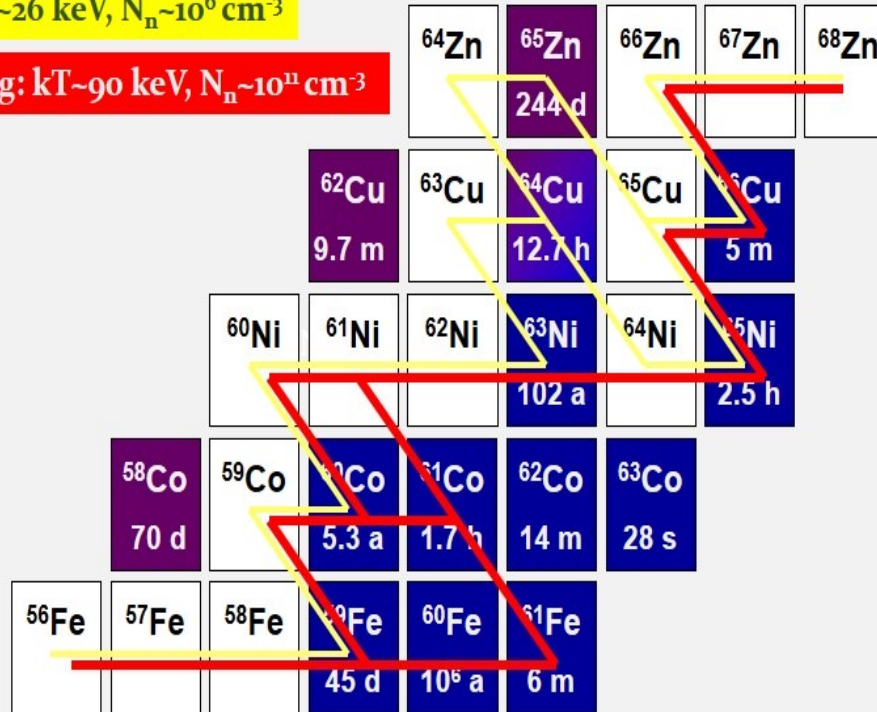


# s-process branching



He core burning:  $kT \sim 26 \text{ keV}$ ,  $N_n \sim 10^6 \text{ cm}^{-3}$

Carbon shell burning:  $kT \sim 90 \text{ keV}$ ,  $N_n \sim 10^{11} \text{ cm}^{-3}$



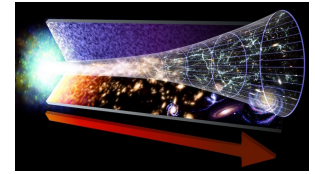
$^{63}\text{Ni}(n, \gamma)$

$^{63}\text{Ni}$  ( $t_{1/2} = 100 \text{ y}$ ) first branching point determines abundance of  $^{63,65}\text{Cu}$

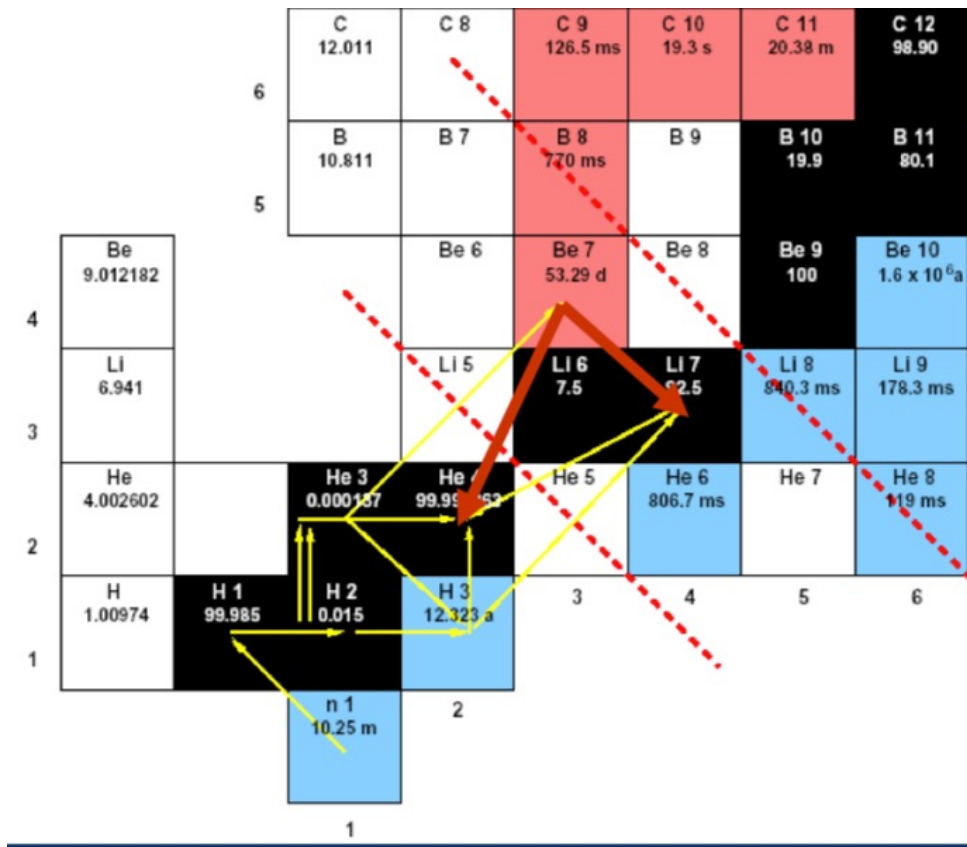
The branching depends on the **stellar condition**, on the isotope half-life and on the **neutron capture cross section**



# BBN: need for ${}^7\text{Be}$ destruction

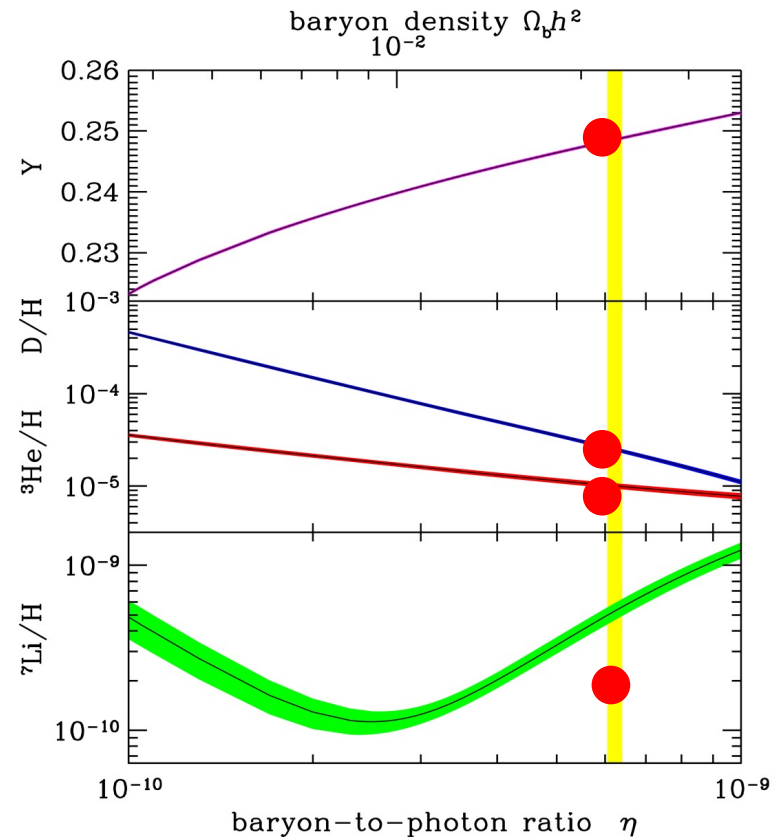


BBN successfully predicts the abundances of primordial elements such as  ${}^4\text{He}$ , D and  ${}^3\text{He}$ . Large discrepancy for  ${}^7\text{Li}$ , which is produced from electron capture decay of  ${}^7\text{Be}$

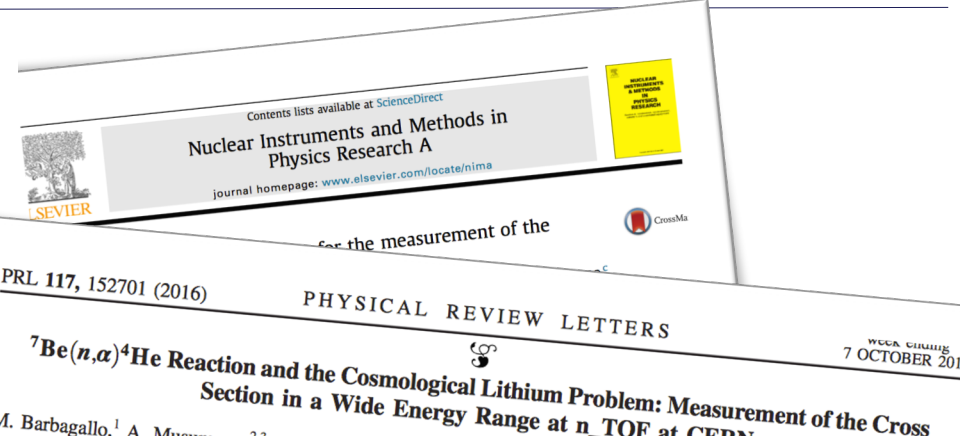
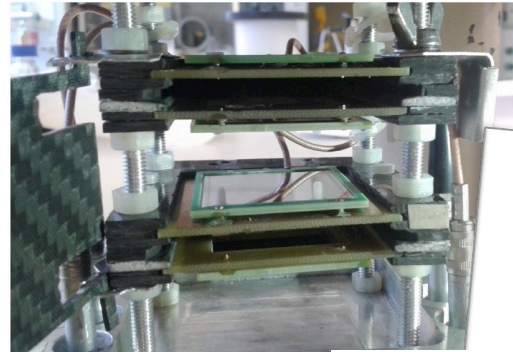
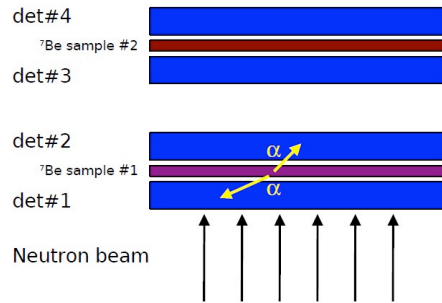
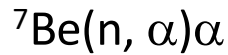
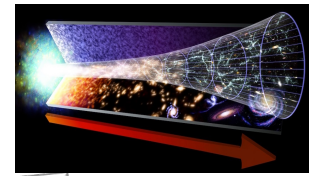


Destruction via neutron interaction?

~ 95% of  ${}^7\text{Li}$  is produced by the decay of  ${}^7\text{Be}$  ( $T_{1/2}=53.2$  d)




# BBN: need for ${}^7\text{Be}$ destruction



PHYSICAL REVIEW LETTERS  
moving physics forward

Dear Sir or Madam,

We are pleased to inform you that the Letter




${}^7\text{Be}(n, \alpha){}^4\text{He}$  reaction and the cosmological lithium problem: Measurement of the cross section in a wide energy range at n\_TOF at CERN

M. Barbagallo et al. (n\_TOF Collaboration)  
Phys. Rev. Lett. 117, 152701 (2016)


Published 3 October 2016

has been highlighted by the editors as an Editors' Suggestion. Publication of a Letter in *Physical Review Letters* represents a considerable achievement, as the journal receives fewer than 1000 Letters per year, and is ranked first among physics journals in the Scholar five-year h-index. A highlighted Letter is one of six Letters in each issue that are highlighted as Editor's Suggestion. These Letters are given broad and special attention in the journal, and their coverage in the press substantially more than that of other Letters. The impact of these Letters can be found on our webpage [www.prl.org](http://www.prl.org).

Yours sincerely,

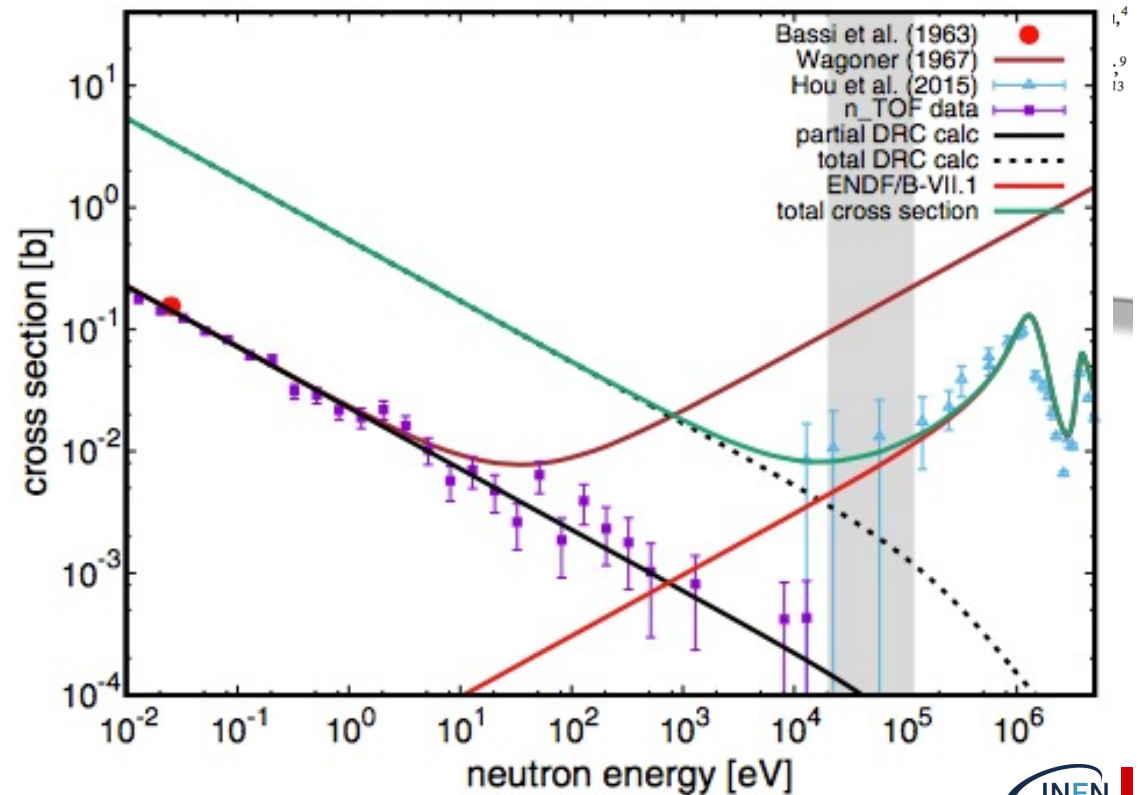


Hugues Chaté  
Editor  
Physical Review Letters



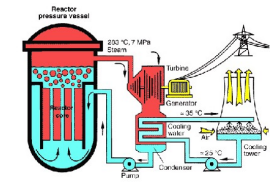
Professor Pierre Maystre  
Editor in Chief  
Physical Review

PRL Editor's Suggestion!



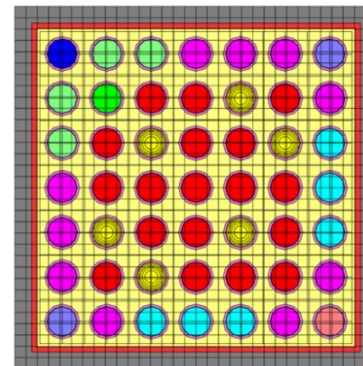
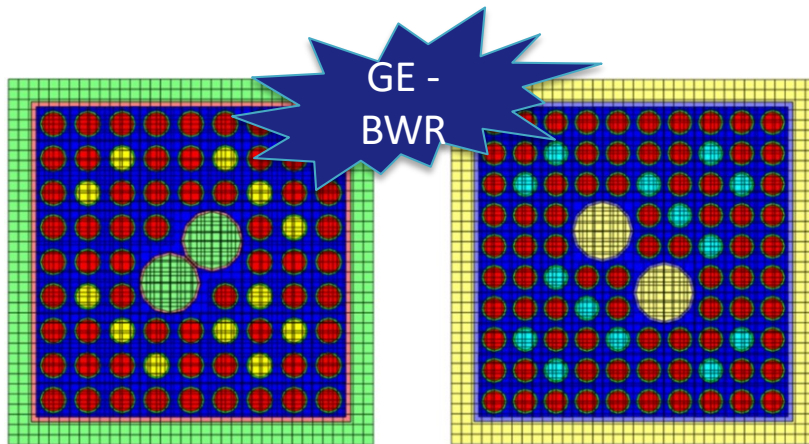
1 bachelor thesis 15/07/2016

# Neutron poison



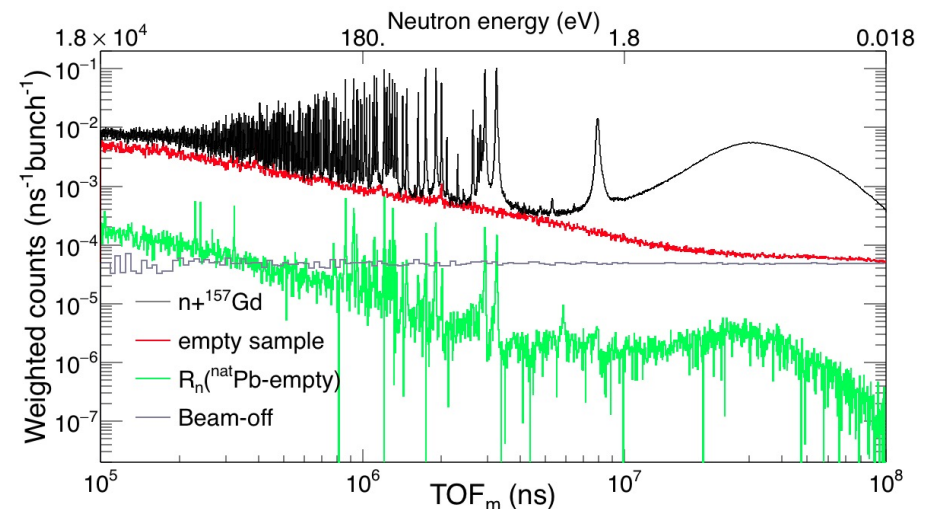
$^{155,157}\text{Gd}(n, \gamma)$   
 “burnable neutron poison”

Proposal (INFN) in close collaboration with ENEA

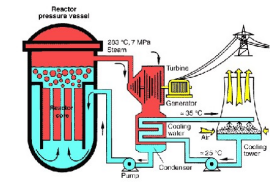


The uncertainty on Gd cross sections gives the largest contribution to the uncertainty on  $k_{\text{eff}}$  after  $^{235,238}\text{U}$ .

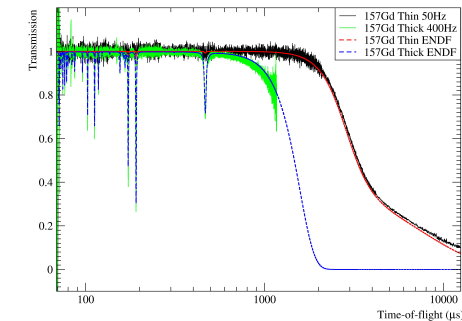
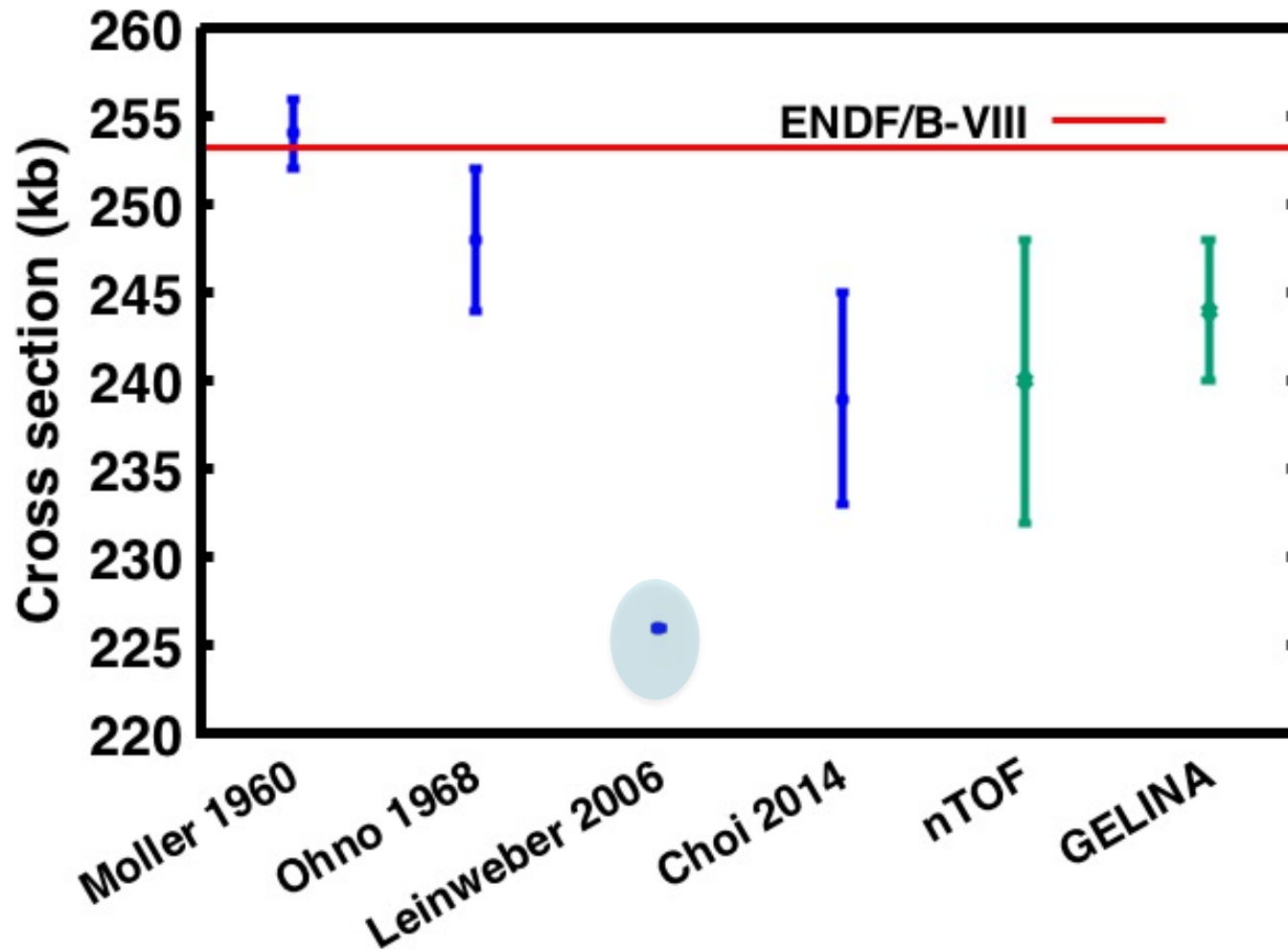
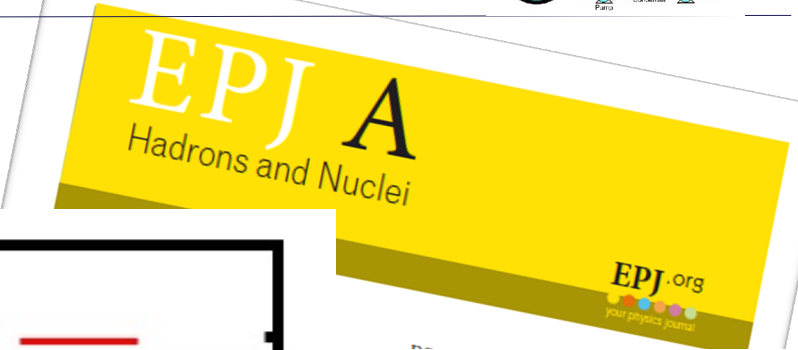
To increase the efficiency of reactor fuel, it is necessary to increase the initial enrichment of  $^{235}\text{U}$  in the fuel.  
 High enrichments pose severe safety problems due to the high initial excess reactivity. This can be inherently compensated by loading the fuel with “burnable neutron poisons”, i.e. isotopes with very high capture cross section



# Neutron poison



**$^{155,157}\text{Gd}(n, \gamma)$**   
**“burnable neutron poison”**



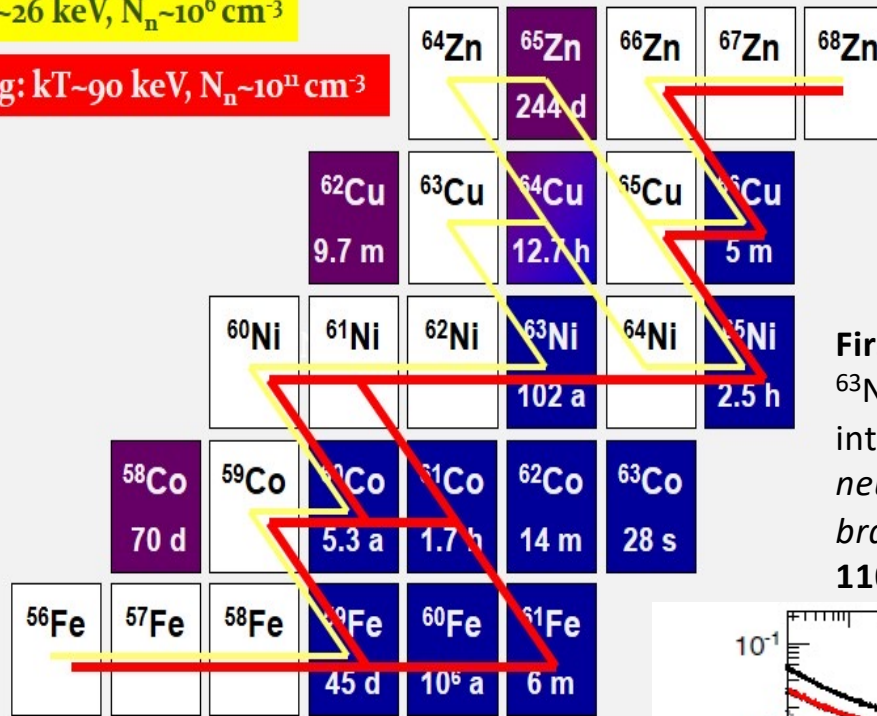
240±8 kb  
 244±4 kb  
 Ratio = 1.6%

# s-process branching



He core burning:  $kT \sim 26 \text{ keV}$ ,  $N_n \sim 10^6 \text{ cm}^{-3}$

Carbon shell burning:  $kT \sim 90 \text{ keV}$ ,  $N_n \sim 10^{11} \text{ cm}^{-3}$



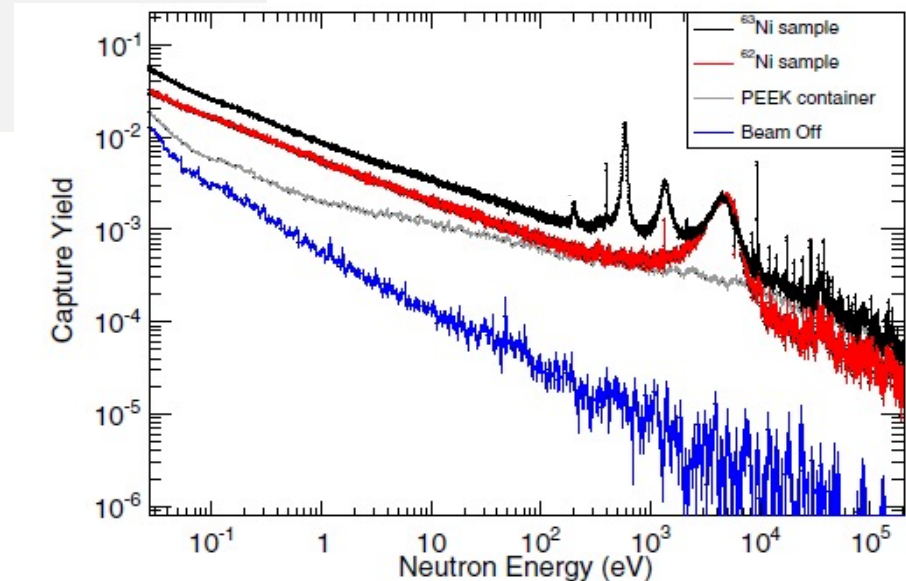
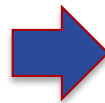
The branching depends on the **stellar condition**, on the isotope half-life and on the **neutron capture cross section**

First high-resolution measurement of the  $^{63}\text{Ni}(n, \gamma)$  reaction in the energy range of interest to s-process nucleosynthesis: «The neutron capture cross-section of the s process branch point isotope  $^{63}\text{Ni}$ » *Phys. Rev. Letters* **110** (2013) 022501

$^{63}\text{Ni}(n, \gamma)$

$^{63}\text{Ni}$  ( $t_{1/2}=100 \text{ y}$ ) first branching point determines abundance of  $^{63,65}\text{Cu}$

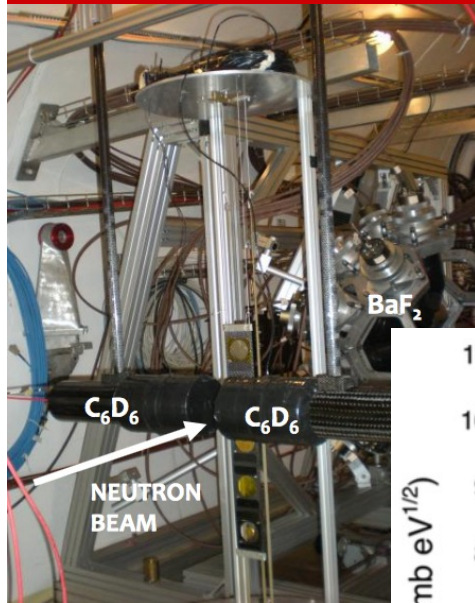
The measurement was performed in 2011 at n\_TOF using an array of  $\text{C}_6\text{D}_6$  detectors



# Measurement of $^{238}\text{U}(n, \gamma)$

ANDES (FP7) project:  $^{238}\text{U}(n, \gamma)$

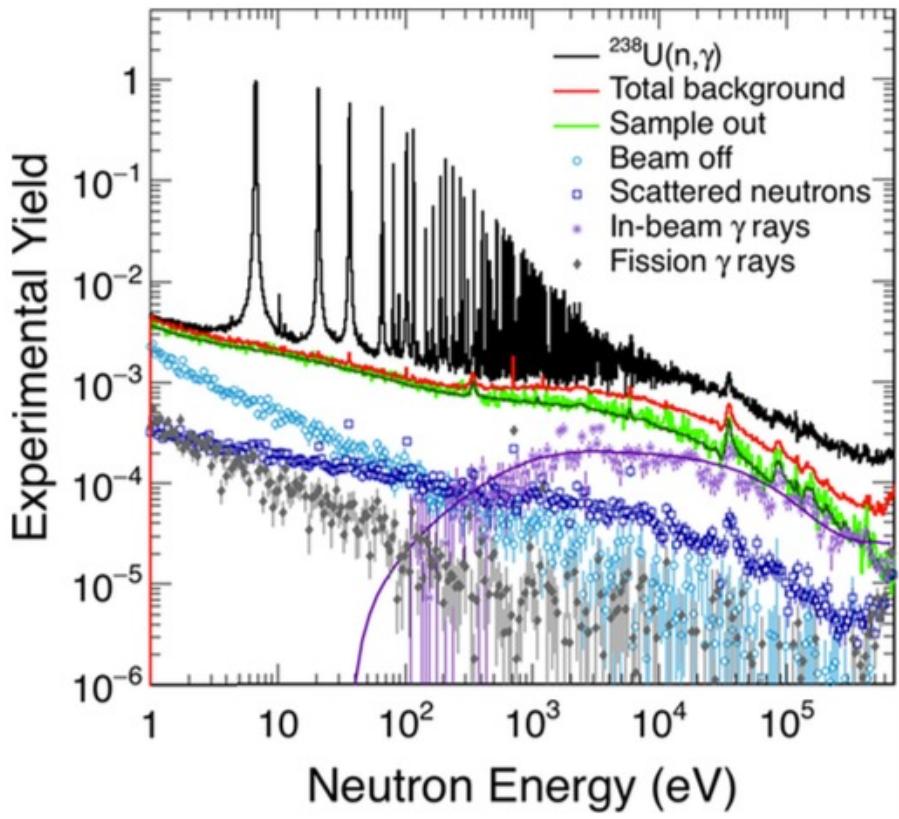
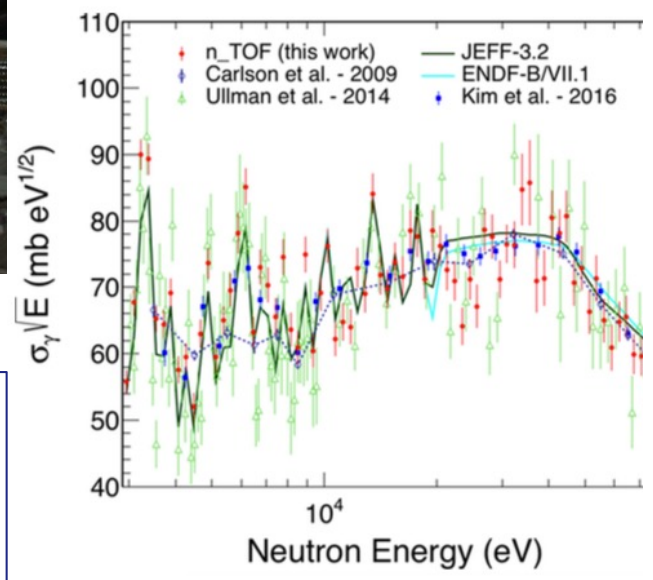
- n\_TOF  $\text{C}_6\text{D}_6$  + TAC
- GELINA  $\text{C}_6\text{D}_6$



PHYSICAL REVIEW C 95, 034604 (2017)

Neutron capture cross section measurement of  $^{238}\text{U}$  at the CERN n\_TOF facility in the energy region from 1 eV to 700 keV

F. Mingrone,<sup>1,2,3,\*</sup> C. Massimi,<sup>2,3</sup> G. Vannini,<sup>2,3</sup> N. Colonna,<sup>4</sup> F. Gusing,<sup>5</sup> P. Žugec,<sup>6</sup> S. Altstadt,<sup>7</sup> J. Andrzejewski,<sup>8</sup> L. Audouin,<sup>9</sup> M. Barbagallo,<sup>4</sup> V. M. Brugger,<sup>1</sup> M. Calviani,<sup>1</sup> F. Calvi, M. A. Cortés-Giraldo,<sup>15</sup> M. Diak K. Fraval,<sup>5</sup> S. Ganesan,<sup>21</sup> A. R. C. ...<sup>10</sup> F. Bečvář,<sup>11</sup> F. Belloni,<sup>5</sup> E. Berthoumieux,<sup>5,1</sup> J. Billowes,<sup>12</sup> D. Bosnar,<sup>6</sup> ...<sup>14</sup> E. Cerutti,<sup>1</sup> E. Chiaveri,<sup>1,12</sup> M. Chin,<sup>1</sup> G. Cortés,<sup>13</sup> ...<sup>16</sup> E. G. Ferrel, ...<sup>17</sup> M. G. ...<sup>18</sup> A. ...<sup>19</sup> A. Ferrari,<sup>1</sup> ...<sup>20</sup>

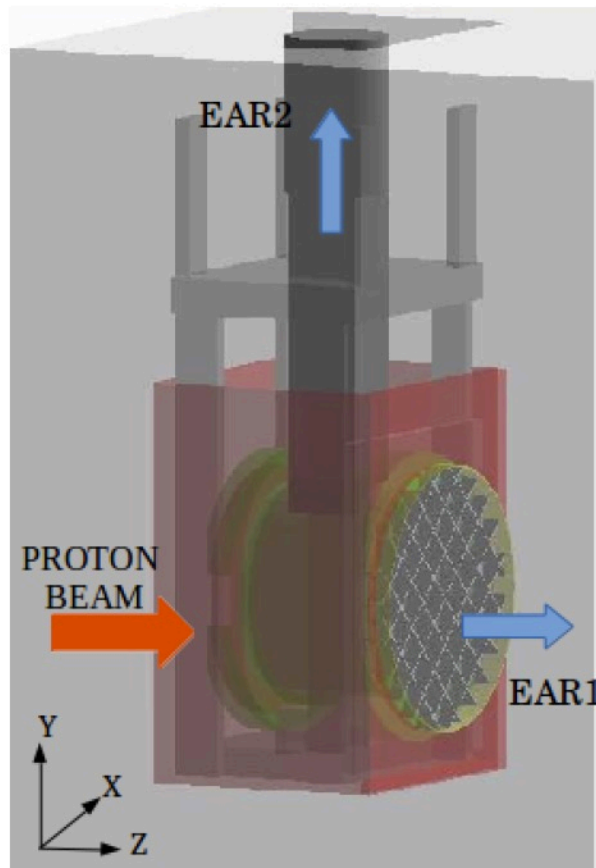
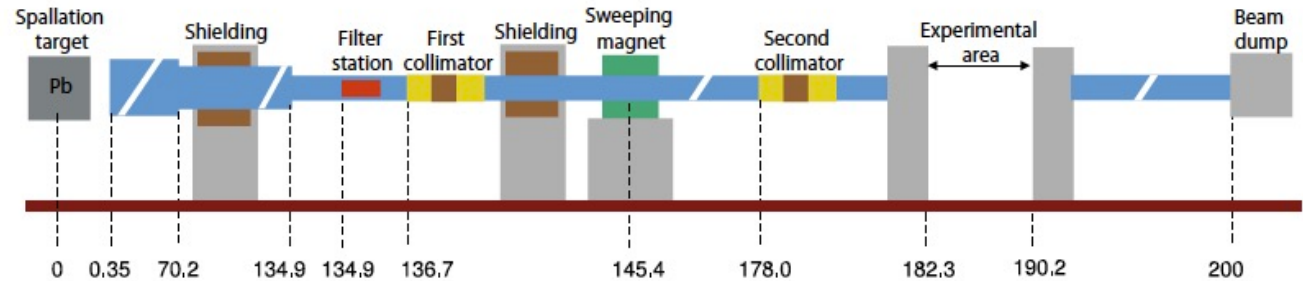


First measurement together Los Alamos, for  $E_n > 100$  keV

# MC simulation of n\_TOF source

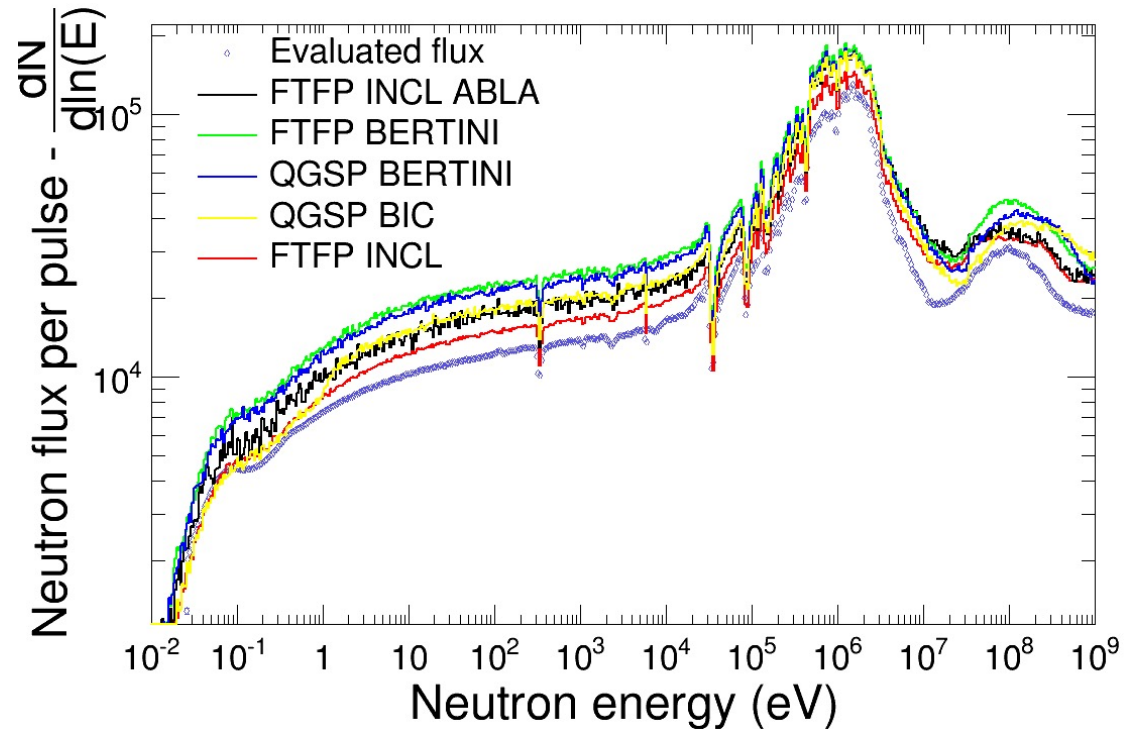
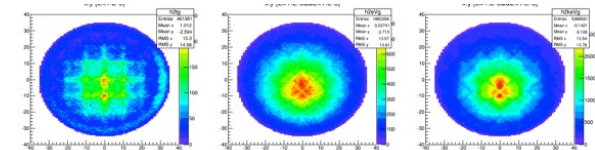
Geant4 simulation of the n\_TOF neutron source and transport to EAR1

20 GeV/c protons on lead



S. Lo Meo, M. A. Cortés-Giraldo, C. Massimi, *et al.*, Eur. Phys. J. A 51 (2015) 160

1 bachelor thesis 23/09/2016



# $^{140}\text{Ce}$ : Galactic chemical evolution

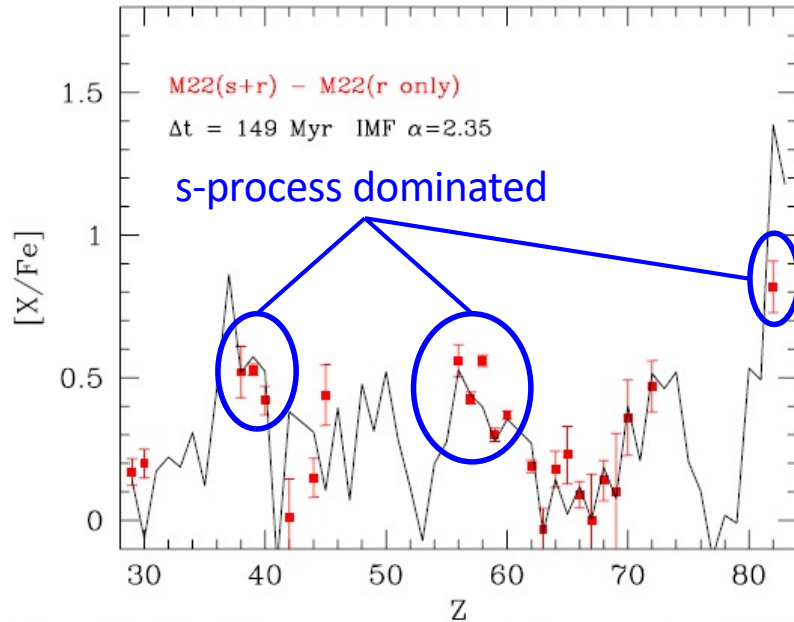


Figure 11. Best fit of the average s-process chemical pattern of stars in M22.

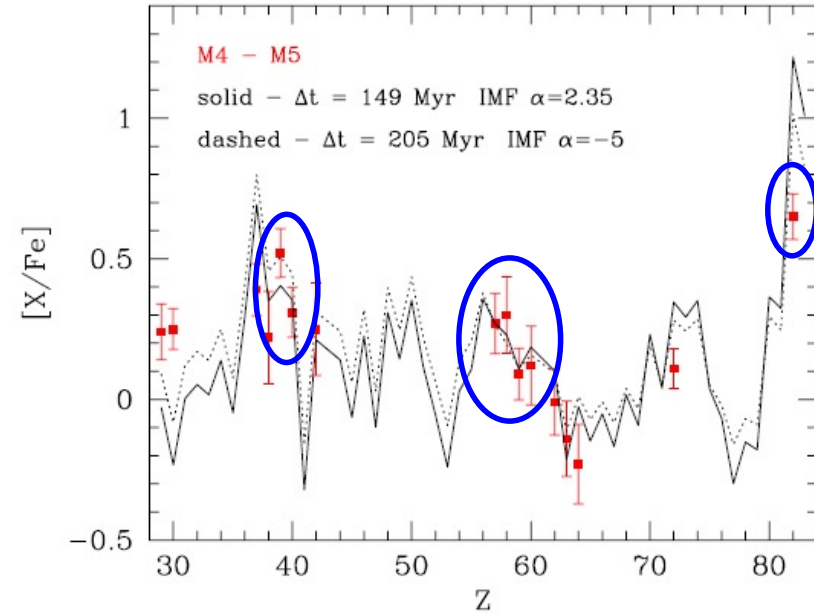


Figure 13. Best fit of the average s-process chemical pattern of stars in M4.

The pollution of AGB stars with a mass ranging between 3 to 6  $M_{\text{SUN}}$  may account for most of the features of the s-process enrichment of M4 and M22.

M22



M4



M5





# $^{140}\text{Ce}$ : Galactic chemical evolution

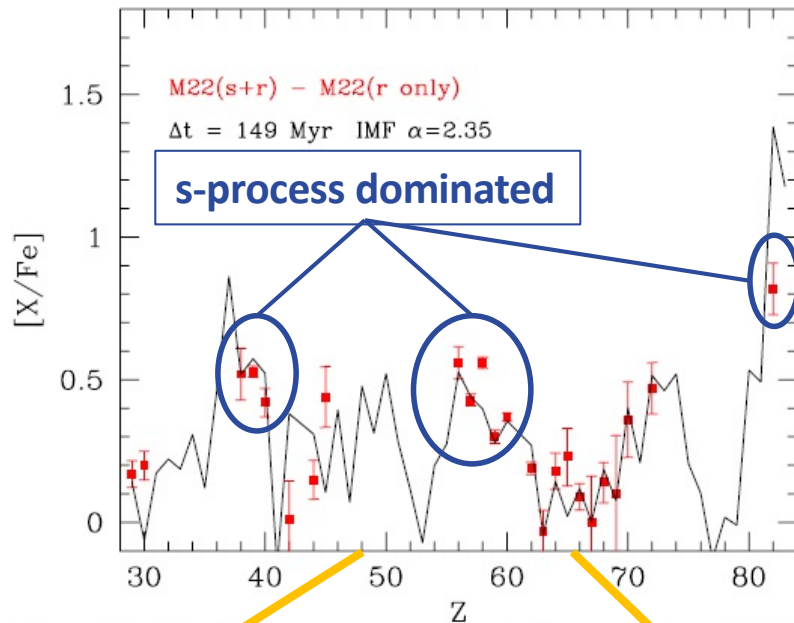


Figure 11. Best fit of the abundances of elements in M22.

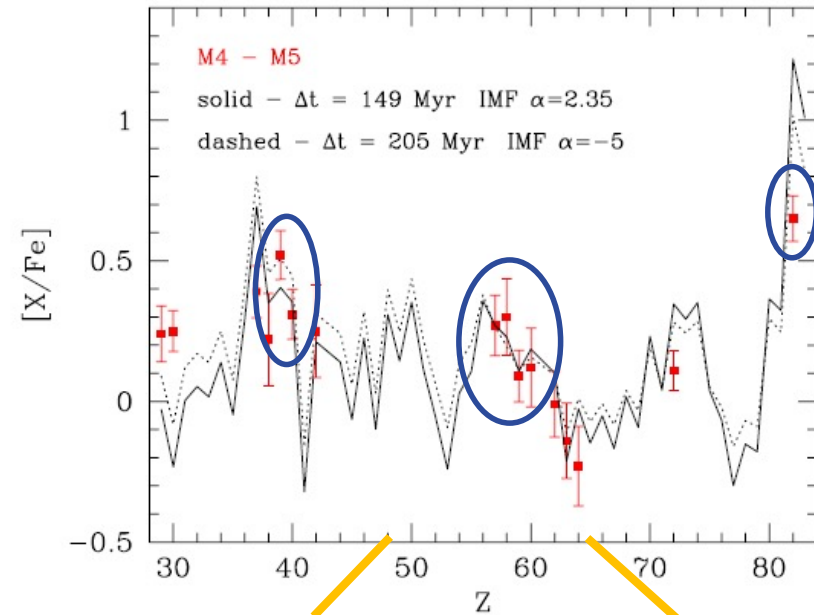
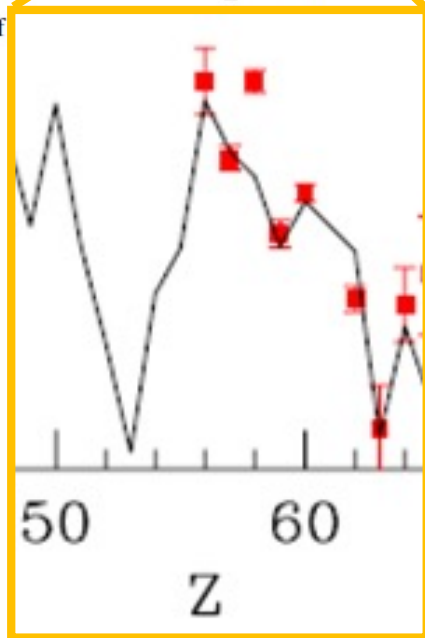
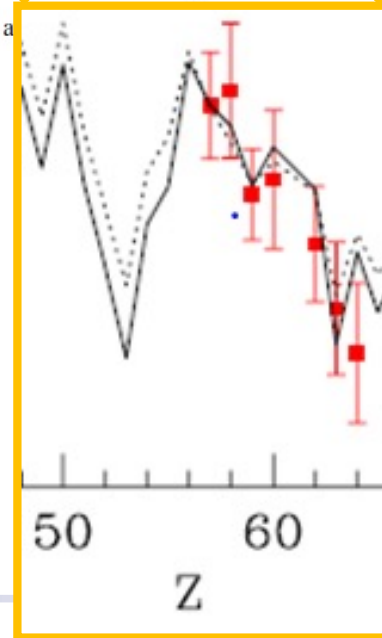


Figure 13. Best fit of the abundances of elements in M4.



Abundances of elements in the s-process peak are well reproduced apart from Cerium

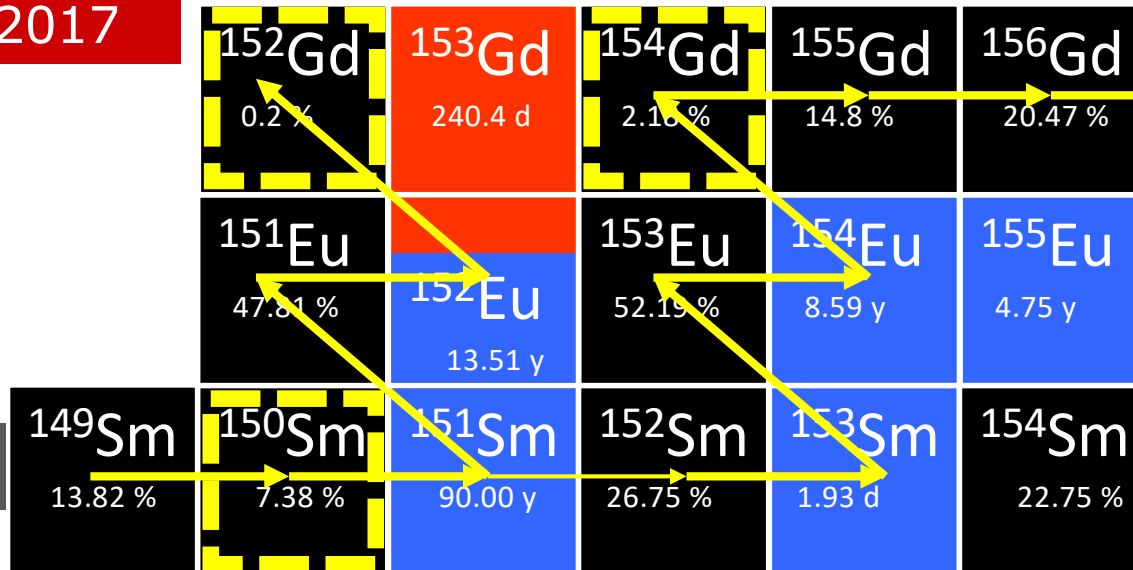


# s-only isotope

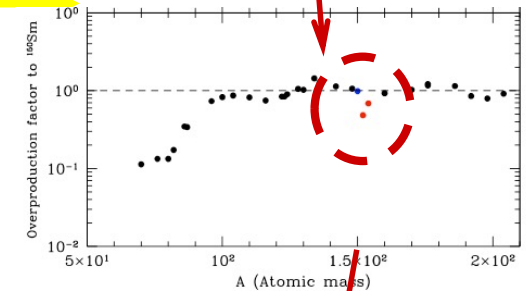
**$^{154}\text{Gd}(n, \gamma)$**   
August 2017

- $\beta^+$
- stable
- $\beta^-$

**s process**



Disagreement between observations and models



Discrepancies in nuclear data need to be resolved

$^{152}\text{Gd}$  e  $^{154}\text{Gd}$  are **s-only** isotopes: they can be produced only via s process because they are shielded against the  $\beta$ -decay chains from the r-process region by the isobars samarium.

**r process**

**Proposal (INFN) in close collaboration with INAF**

# Dissemination



**GIANTS 2017**  
5-6 October 2017 Palazzo Poggi - Bologna  
Europe/Rome timezone

**Overview**  
Advisory Committee  
Organizing Committee  
Registration  
Registration Form  
List of participants  
Venue  
How to get here  
Map  
Accommodation (link)  
Internet connection  
Poster

**ALMA MATER STUDIORUM UNIVERSITÀ DI BOLOGNA**  
**INFN** Istituto Nazionale di Fisica Nucleare  
**INAF-Osservatorio Astronomico di Bologna**

**IX Incontro dei Gruppi Italiani di Astrofisica Nucleare Teorica e Sperimentale**  
Sezione INFN di Bologna - Dipartimento di Fisica e Astronomia - INAF

Il nono incontro del Gruppo Italiano di Astrofisici Nucleari Teorici e Sperimentali vuole continuare una tradizione iniziata nel 1996 a Catania e poi proseguita con gli incontri di Napoli (1998), Genova (2001), Ferrara (2003), Teramo (2005), Perugia (2006), Catania (2010) e Padova (2015). In questa edizione verranno discussi i temi legati alla nucleosintesi cosmologica e stellare, alle sorgenti di neutroni e alle reazioni di cattura neutronica, alla luce dei più recenti risultati sperimentali ottenuti da ASFIN, ERNA, LUNA e n\_TOF.

Support

26 presentations by PhD students and postdocs

<http://agenda.infn.it/event/GIANTS-IX>

9<sup>th</sup> edition, Bologna

5-6 October 2017

Organizing committee composed by young researchers from n\_TOF, ASFIN, ERNA and LUNA

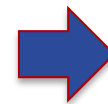


Idea of a **Newsletter** of the italian group of Nuclear Astrophysics.

Scientific board composed by 7 researchers from different experiments.

- 1<sup>st</sup> number February 2018
- We are on facebook:

<https://www.facebook.com/infgiants/>



# Dissemination



facebook

The screenshot shows the Facebook profile page for 'Giants - Gruppi Italiani di Astrofisica Nucleare Teorica e Sperimentale'. The page features a cover photo of a starry night sky and a profile picture with the same theme. The name 'GIANTS' is prominently displayed in red. Below the name, the full name of the group is written. The page includes navigation options like 'Like', 'Following', and 'Share', along with a 'Write a post...' section and a list of recent posts.

The cover of the first issue of the GIANTS newsletter, dated February 2018. The title 'GIANTS' is in large red letters, followed by 'GRUPPI ITALIANI DI ASTROFISICA NUCLEARE TEORICA E SPERIMENTALE'. The subtitle is 'NOTIZIARIO DI ASTROFISICA NUCLEARE'. The issue number and date are 'NUMERO 1 - FEBBRAIO 2018, SOMMARIO'. The table of contents lists:
 

- PAG.1 FOCUS SU ONDE GRAVITAZIONALI E NUCLEOSINTESI
- PAG.4 ASFIN APPROCCIO INDIRETTO ALL'ASTROFISICA NUCLEARE
- PAG.5 ERNA ASTROFISICA NUCLEARE CON ERNA
- PAG.6 LUNA L'ESPERIMENTO LUNA AI LNGS
- PAG.7 IL TOF NUCLEOSINTESI DEL PROCESSO S AD N\_TOF
- PAG.8 ARTICOLI IN USCITA, CONFERENZE, BANDI E ALTRE NOTIZIE

 At the bottom, it says 'Puoi commentare le notizie sulla nostra pagina facebook' and provides the contact email 'giants@lists.infn.it'.

The cover of the second issue of the GIANTS newsletter, labeled 'NUM. 2'. The title 'GIANTS' is in large red letters, followed by 'GRUPPI ITALIANI DI ASTROFISICA NUCLEARE TEORICA E SPERIMENTALE'. The subtitle is 'NOTIZIARIO DI ASTROFISICA NUCLEARE'. The issue number is 'NUM. 2'. The table of contents lists:
 

- Sommario di questo trimestre
- Focus I neutrini e il Sole
- ASFIN Un intenso periodo sperimentale
- ERNA Misura diretta in inversa, la  ${}^7\text{Be}(p,\gamma){}^8\text{B}$
- LUNA Misura diretta di  ${}^{13}\text{C}(\alpha,n){}^{16}\text{O}$  @ LNGS
- IL TOF 2018 al CERN
- Notizie dal mondo Nuclear Astrophysics at FRIB
- Articoli, conferenze, bandi e altre notizie

 There is a small image of a solar flare and a caption 'IL SOLE VISTO TRAMITE NEUTRINI DA SUPER-KAMIOKANDE'.

The cover of the third issue of the GIANTS newsletter, dated September 2018. The title 'GIANTS' is in large red letters, followed by 'GRUPPI ITALIANI DI ASTROFISICA NUCLEARE TEORICA E SPERIMENTALE'. The subtitle is 'NOTIZIARIO DI ASTROFISICA NUCLEARE'. The issue number and date are 'NUM. 3 - SETTEMBRE 2018'. The table of contents lists:
 

- Sommario di questo trimestre
- pag. 1 Focus Nucleosintesi e grandi survey
- pag. 4 ASFIN L'astrofisica nucleare su Nature
- pag. 5 ERNA La pallasite di Mineo: un pezzo unico!
- pag. 6 LUNA Misura di  ${}^{22}\text{Ne}(\alpha,\gamma){}^{26}\text{Mg}$  a LUNA400
- pag. 7 IL TOF Fisioni stellari
- pag. 8 Notizie dal mondo Low energy RI beam facility for Astrophysics
- pag. 10 Articoli, conferenze, bandi e altre notizie

 At the bottom, it says 'IL FOCUS DI QUESTO NUMERO: NUCLEOSINTESI E GRANDI SURVEY Risultati da GAIA e dalla GAIA-ESO survey'.

Trimestrale di Astrofisica Nucleare

	Type	Targeting	Reach	Engagement
La maggior parte degli elementi chimici di cui è composto	Image	Public	320	31 16
Anche la Pallasite di Mineo (il pezzo unico protagonista di un	Image	Public	182	9 7
Venerdì 28 settembre 2018 si terrà in 116 città italiane la	Image	Public	109	2 0
Tra il 24 e il 29 Giugno si è tenuta presso i Laboratori	Image	Public	721	109 34
CERIO UNA VOLTA.... Tutti gli elementi che conosciamo in	Image	Public	809	109 39
L'astrofisica nucleare su Nature!	Image	Public	51	4 7
100 miliardi di miliardi di miliardi di miliardi di neutrini al secondo!	Image	Public	854	86 25
Giants - Gruppi Italiani di Astrofisica Nucleare Teorica e	Image	Public	54	20 9
Ecco a voi il secondo numero della newsletter dei GIANTS in	Image	Public	228	29 19
L'astrofisica nucleare ha, tra i suoi obiettivi, la misura della	Image	Public	2.4K	233 97

# Proton recoil telescope

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Proposal to the ISOLDE and Neutron Time-of-Flight Committee

Measurement of the  $^{235}\text{U}(n, f)$  cross section relative to n-p scattering up to 1 GeV

May 06, 2017

L. Audouin<sup>1</sup>, M. Barbagallo<sup>2</sup>, N. Colonna<sup>2</sup>, L. Cosentino<sup>2</sup>, M. Diakaki<sup>3,4</sup>, I. Duran<sup>5</sup>, P. Finelli<sup>6,7</sup>, P. Finocchiaro<sup>2</sup>, J. Heyse<sup>7</sup>, S. Lo Meo<sup>8,2</sup>, C. Massimi<sup>2,6</sup>, P.F. Mastinu<sup>2</sup>, P.M. Milazzo<sup>2</sup>, F. Mingrone<sup>9</sup>, A. Musumarra<sup>2,9</sup>, R. Nolte<sup>10</sup>, C. Paradela<sup>7</sup>, D. Radeck<sup>10</sup>, P. Schillebeeckx<sup>7</sup>, L. Tassan-Got<sup>7</sup>, G. Vannini<sup>2,4</sup>, A. Ventura<sup>2</sup>

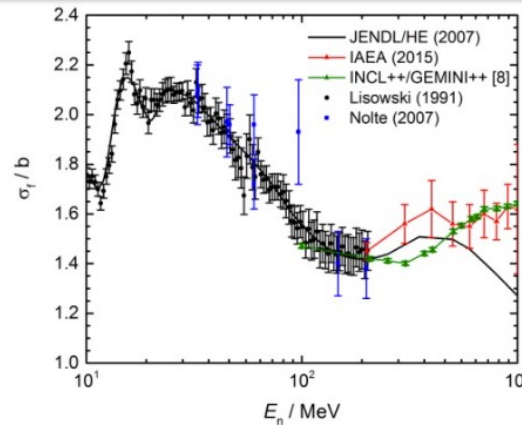
<sup>1</sup> CNRS-IN2P3, Univ. Paris-Sud, Univ. Paris-Saclay, Orsay, France  
<sup>2</sup> INFN - sezioni di Bari, Bologna, LNL, LNS and Trieste, Italy  
<sup>3</sup> CERN, Switzerland  
<sup>4</sup> National Technical University of Athens, Greece  
<sup>5</sup> Universidad de Santiago de Compostela, Spain  
<sup>6</sup> Dipartimento di Fisica e Astronomia, University of Bologna, Italy  
<sup>7</sup> European Commission, Joint Research Centre - Geel, Belgium  
<sup>8</sup> ENEA - Bologna, Italy  
<sup>9</sup> Dipartimento di Fisica e Astronomia, University of Catania, Italy  
<sup>10</sup> Physikalisches-Technische Bundesanstalt, Braunschweig, Germany

Spokespersons: C. Massimi (massimi@bo.infn.it), R. Nolte (ralf.nolte@ptb.de) and L. Cosentino (cosentino@lns.infn.it)  
 Technical coordinator: O. Aberle (oliver.aberle@cern.ch)

Measurement ongoing at CERN:  $^{235}\text{U}(n, f)$

First measurement for  $E_n > 200$  MeV (extension of the standard)

First experimental determination of the neutron flux  $E_n > 200$  MeV

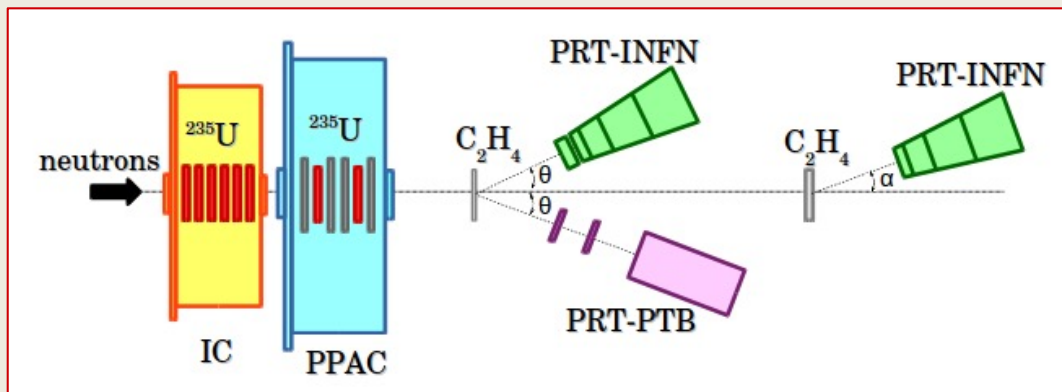


n\_TOF facility is a unique tool for the cross section measurement of the  $^{235}\text{U}(n, f)$  reaction, relative to the  $\text{H}(n, n)\text{H}$  reaction, up to 1 GeV.

For this measurement a **Proton Recoil Telescope** has been developed and realized with fast scintillators and solid state detectors. It has been successfully tested in 2016 and 2017 at the n\_TOF facility.

Proposal approved by the INTC committee, meeting 28.06.2017

S  
E  
T  
U  
P



1 PhD  
on this project

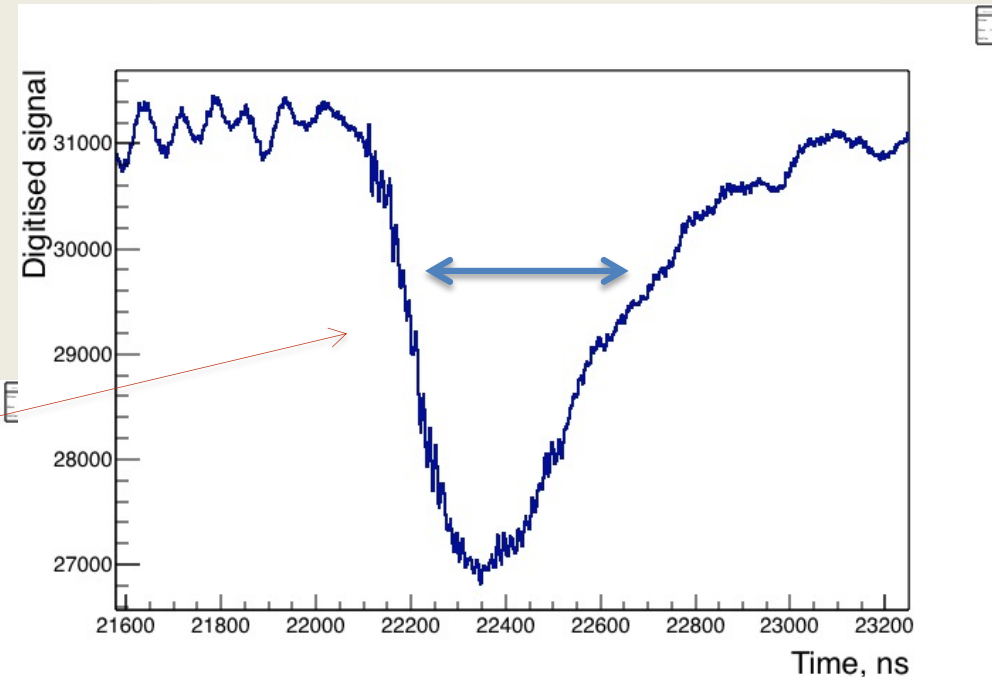
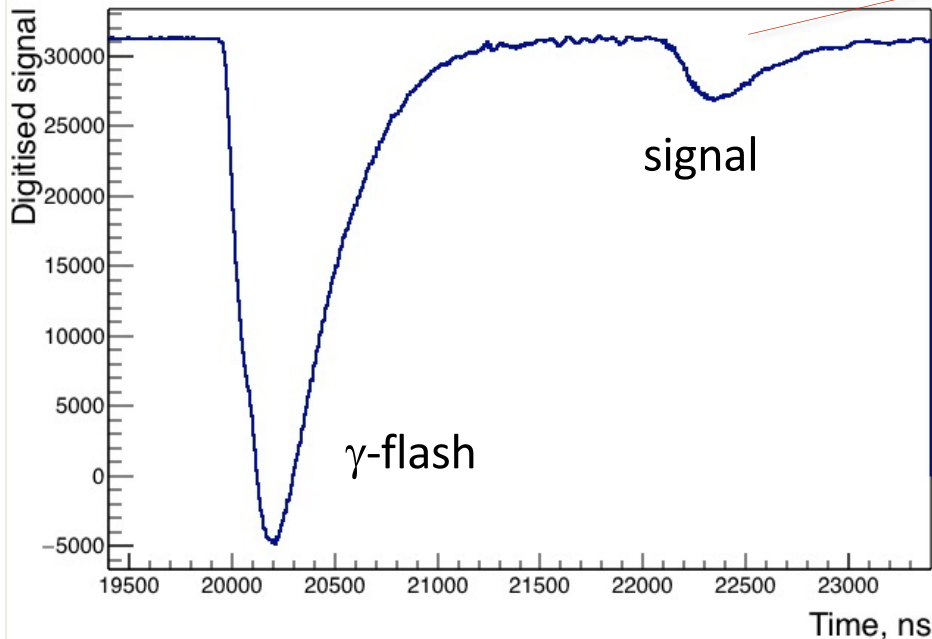
# Silicon Monitor (SiMon)

to measure flux as a function of  $E_n$

**SiMon** is **not** a **fast** detector  
risetime  $\sim 25$  ns  
Signal width  $\sim 500$  ns

Performances under  
neutron beam

After shaping the signal (amplifier)



Each silicon detector connected to a fADC:

- Sampling rate 100-1000 MS
- Resolution 14 bit

# n\_TOF collaboration

(BARC – Mumbai, India)  
CEA – Saclay, Francia  
CERN – Geneva, Svizzera  
CIEMAT – Madrid, Spagna  
ENEA – Bologna, Italia  
IFIC – Valencia, Spagna  
IFIN – Bucharest, Romania  
INFN, Italia  
IPNO – Orsay, Francia  
IST – Lisbon, Portogallo  
JAEA – Tokyo, Giappone  
JINR – Dubna, Russia  
JRC – Geel, Belgio  
KIT - Karlsruhe, Germania  
NTUA – Athens, Grecia  
PSI – Villingen, Svizzera  
PTB - Braunschweig, Germania

UBAS – Basel, Svizzera  
UEDB – Edinburgh, Regno Unito  
UGF – Frankfurt, Germania  
UGRAN – Granada, Spagna  
UIG – Ioannina, Grecia  
ULP – Lodz, Polonia  
UMAN – Manchester, Regno Unito  
UPC – Barcelona, Spagna  
UPRG - Prague, Repubblica ceca  
USC – Santiago, Spagna  
USE – Sevilla, Spagna  
UVIE – Vienna, Austria  
UYRK – York, Regno Unito  
UZAG – Zagreb, Croazia

# Misura del rate di distruzione del $^7\text{Be}$

## Problema cosmologico del litio

Osservazioni:  $(\text{Li}/\text{H}) = (1.7 \pm 0.5) \times 10^{-10}$

Teoria (BBN):  $(\text{Li}/\text{H}) = (5.1 \pm 0.7) \times 10^{-10}$

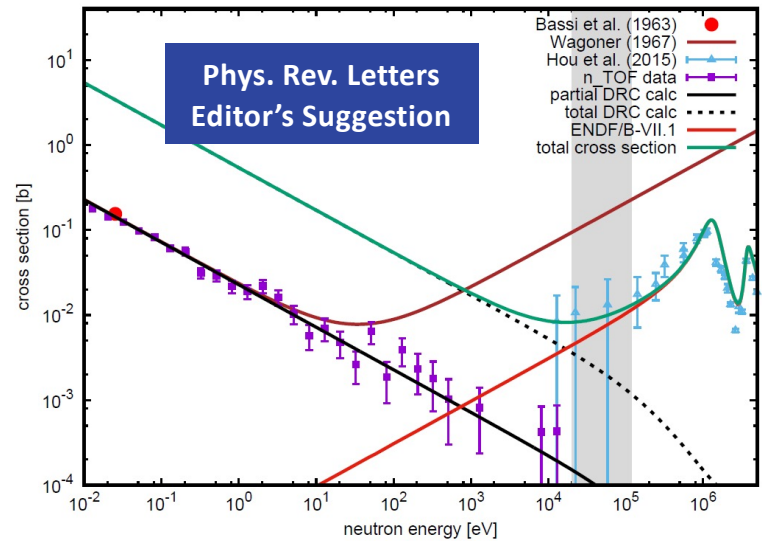
Difficoltà: (i) Attività specifica del  $^7\text{Be}$  **13 GBq per  $\mu\text{g}$** ;  
 (ii) vita media breve **53.3 d**



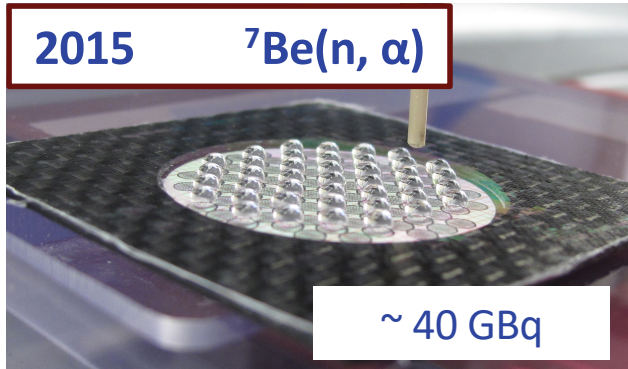
## Soluzione Nucleare

$\sim 95\%$  del  $^7\text{Li}$  deriva dalla cattura elettrocinica del  $^7\text{Be}$

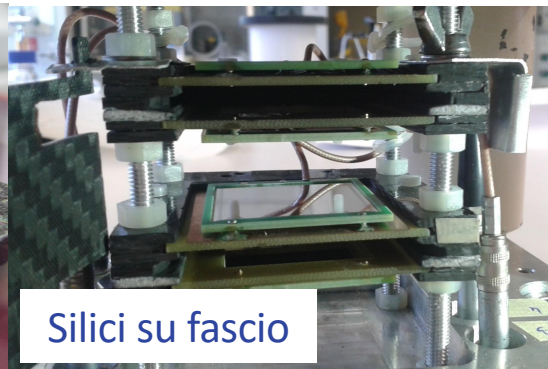
n\_TOF  
EAR 2



2015  $^7\text{Be}(n, \alpha)$

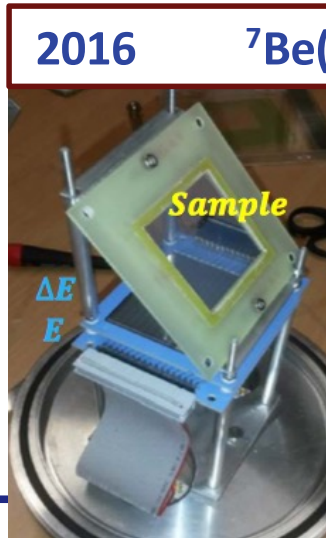


$\sim 40 \text{ GBq}$



Silici su fascio

2016  $^7\text{Be}(n, p)$



Bersaglio:  
PSI (Berillio)  
+  
ISOLDE  
(arricchimento  $^7\text{Be}$ )  
 $\sim 1.1 \text{ GBq}$

