n_TOF Report

Daniela Macina
n_TOF Run Coordinator
CERN
• n_TOF Facility (brief reminder)
• Last experiments in 2016
• Shutdown Activities
• Operation in 2017
• Draft planning 2017-2018
• n_TOF publications in 2016
• Conclusions
The neutron Time Of Flight Facility timeline

1996

- Concept by C. Rubbia
- May 1998
- Proposal submitted

1997

- TARC experiment
- Feasibility: CERN/LHC/98-02+Add

1999

- Construction started

2000

- Commissioning

2001-2004

- Phase I
  - Isotopes Capture: 25
  - Fission: 11

2004-2007

- Problem Investigation

2008

- New Target construction

2009 - 2012

- Phase II
  - Isotopes Capture: 14
  - Fission: 3
  - (n,cp): 2

2010

- Upgrades: Borated-H2O
  - Class-A
  - Second Line

2014

- July

2015

- Phase-3

2015

- EAR2
  - Design and Construction

D. Macina, 55th INTC Meeting, CERN, 8-9 Feb 2017
The neutron Time Of Flight Facility

Spallation Target

EAR1

20 m

185 m
The neutron Time Of Flight Facility: EAR1
The neutron Time Of Flight Facility: EAR2
n_TOF Flux

Wide neutron energy range

Very high instantaneous neutron flux
Measurements last part 2016

**EAR1**

- **75,157 Gd**
  - 2.4x10^18 pot

- **TAC Com**
  - 1.0x10^18 pot

- **233U**
  - 1.5x10^18 pot

- **Recoil test**
  - 0.5x10^18 pot

- **233U TAC**
  - 4.3x10^18 pot

**EAR2**

- **16O test**
  - 0.5x10^18 pot

- **26Al**
  - 5.0x10^18 pot

- **μGAS FLUX**
  - 0.5x10^18 pot

- **PPAC FLUX**
  - 0.5x10^18 pot

- **237Np (μGAS)**
  - 2.0x10^18 pot

**Dates**

- **Wk 27**
- **Wk 28**
- **Wk 29**
- **Wk 30**
- **Wk 31**
- **Wk 32**
- **Wk 33**
- **Wk 34**
- **Wk 35**
- **Wk 36**
- **Wk 37**
- **Wk 38**
- **Wk 39**
- **Wk 40**
- **Wk 41**
- **Wk 42**
- **Wk 43**
- **Wk 44**
- **Wk 45**

**Weekdays**

- **Mo**
- **Tu**
- **We**
- **Th**
- **Fr**
- **Sa**
- **Su**

**No full time beam due to activities in the other area**

D. Macina, 55th INTC Meeting, CERN, 8-9 Feb 2017
$^{233}\text{U} (n,\gamma) \& (n,f)$ in EAR1 (fission tagging)

Essential role in Th-U fuel cycle / Gen-IV systems
Challenge: XS ratio $(n,f)/(n,g) \sim 10$

Detector setup
$(n,g)$ with Total Absorption Calorimeter TAC
$(n,f)$ with novel compact fission chamber

Recorded 950 TB of data
Analysis is ongoing

Courtesy M. Bacak
Very limited statistics
Fission chamber response

(n,f)
#protons: 1.5e16

Courtesy M. Bacak
Very limited statistics
Response of 1 BaF2 crystal

Crystal # 29

DRAFT

10^1
10^2
10^3
10^4
10^5
10^6

neutron energy [eV]

counts / 1e12 protons

Beam On U3 Total
Beam On background dummy & absorber
Beam Off U3 + absorber + ambient background
red + green - ambient background

γ from (n,g) + (n,f)

Courtesy M. Bacak
237\text{Np} (n,f) at EAR2 with $\mu$MGAS

237\text{Np} potential target of incineration in fast neutron reactors
Discrepancies of $\sim 6\%$ in the fission $\sigma \rightarrow$
- Measure 237\text{Np} (n,f) in EAR1 with PPAC
- Measure 237\text{Np} (n,f) in EAR2 with $\mu$MGAS

Detector SetUp

- 235\text{U} & 238\text{U} to use for reference
- One 237\text{Np} sample prepared at IPN-Orsay from the same batch as in the PPAC measurement, in order to cross out discrepancies coming from the sample

Courtesy A. Stamatopoulos
$^{237}\text{Np (n,f)}$ are already quite visible (20% statistics and one $^{237}\text{Np}$ sample)

α background from $^{237}\text{Np}$ decay

Courtesy A. Stamatopoulos
Activities during the EYETS 2016-2017

- Bought additional SP Device digitisers to permanently equip both areas for the most demanding experiments (64 channels per area). New digitisers already at CERN and presently under test
- Refurbishing the rack area in EAR1
- Installation of the new cooling system in EAR2 to keep a constant temperature in the bunker (and rack area) at 20 °C
- Preparation of the SIR course to enter the n_TOF Experimental Areas
n_TOF Operation in 2017

<table>
<thead>
<tr>
<th>Week</th>
<th>April</th>
<th>May</th>
<th>June</th>
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<tr>
<td>Mo</td>
<td>14</td>
<td>15</td>
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<tr>
<td>Su</td>
<td>26</td>
<td>28</td>
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</table>

29 weeks operation $\rightarrow \sim 1.84 \times 10^{19}$ P.O.T.
<table>
<thead>
<tr>
<th>Area</th>
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<th>INTC</th>
<th>Comment</th>
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<tbody>
<tr>
<td>EAR1</td>
<td>$^{69,71}$Ga (n,γ)</td>
<td>P-466</td>
<td>Astrophysics</td>
<td>✓</td>
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<tr>
<td>EAR1</td>
<td>$^{88}$Sr (n,γ) and $^{89}$Y (n,γ)</td>
<td>P-453</td>
<td>Astrophysics &amp; nuclear technologies</td>
<td>✓</td>
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<tr>
<td>EAR1</td>
<td>$^{154}$natGd (n,γ)</td>
<td>P-437</td>
<td>Astrophysics</td>
<td>✓</td>
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<tr>
<td>EAR1</td>
<td>$^{16}$O (n,α)</td>
<td>P-430</td>
<td>Basic nuclear physics &amp; nuclear technologies</td>
<td>✓</td>
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<tr>
<td>EAR1</td>
<td>Recoil test (2nd part)</td>
<td>I-165</td>
<td>Detector development for nuclear physics measurements</td>
<td>✓</td>
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<tr>
<td>EAR2</td>
<td>$^{244,246}$Cm</td>
<td>P-469</td>
<td>Nuclear technologies</td>
<td>✓</td>
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<tr>
<td>EAR1</td>
<td>$^{12}$C (n,p)</td>
<td>P-488</td>
<td>Basic nuclear physics</td>
<td>Submitted for recommendation</td>
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<tr>
<td>EAR2</td>
<td>$^{241}$Am (n,γ)</td>
<td>P-491</td>
<td>Nuclear technologies</td>
<td>Submitted for recommendation</td>
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<tr>
<td>EAR2</td>
<td>$^{241}$Am (n,f)</td>
<td>P-492</td>
<td>Nuclear technologies</td>
<td>Submitted for recommendation</td>
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<tr>
<td>EAR2</td>
<td>Imaging</td>
<td>P-497</td>
<td>Nuclear applications</td>
<td>Submitted for recommendation</td>
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<tr>
<td>EAR1 &amp;</td>
<td>$^{230}$Th(n,f)</td>
<td>P-493</td>
<td>Basic nuclear physics &amp; nuclear technologies</td>
<td>Submitted for recommendation</td>
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<tr>
<td>EAR2</td>
<td>$^{235}$U(n,f)</td>
<td>I-174</td>
<td>Nuclear technologies</td>
<td>Submitted for recommendation</td>
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</table>
Peer Reviewed Publications 2016

[130] M. Barbagallo, A. Musumarra, L. Cosentino, and the n_TOF Collaboration, 
“The $^7$Be$(n, \alpha)^4$He reaction and the Cosmological Lithium Problem: measurement of”

[129] F. Gunsing and E. Chiaveri on behalf of the n_TOF Collaboration, 
“Neutrons in full flight at CERN’s n_TOF facility,”
CERN Courier, article 64364 (2016).

[128] F. Gunsing, O. Aberle, and the n_TOF Collaboration, 
“Nuclear data activities at the n_TOF facility at CERN,”

[127] L. Cosentino, A. Musamarra, M. Barbagallo, and the n_TOF Collaboration, 
“Experimental setup and procedure for the measurement of the $^7$Be$(n, \alpha)$ reaction at n_TOF,”

[126] J. Lerendegui-Maro, S. Lo Meo, C. Guerrero, and The n_TOF Collaboration, 
“Geant4 simulation of the n_TOF-EAR2 neutron beam: characteristics and prospects,”

[125] D.L. Pérez Magán, L. Caballero-Ontanaya, C. Domingo-Pardo, and The n_TOF Collaboration, 
“First tests of the applicability of g-ray imaging for background discrimination in time-of-flight neutron capture measurements,”

[124] P. Žugec, D. Bosnar, N. Colonna, F. Gunsing, and The n_TOF Collaboration, 
“A novel method for estimating the neutron background in measurements of neutron capture reactions,”
n_TOF Publications in 2016

Peer Reviewed Publications 2016


10 publications in 2016
130 since 2002
n_TOF Conference contributions in 2016

6th International Conference on Fission and Properties of Neutron-Rich Nuclei, November 6 - 12, 2016, Sanibel Island, Florida/USA

Fission activities at the CERN n_TOF facility.

Int. Symposium Nuclei in the Cosmos XIV, June 19-24, 2016, Niigata/Japan

Neutron capture cross sections of the s-process branching points $^{147}$Pm, $^{171}$Tm, and $^{204}$Tl;
- A. Musumarra and M. Barbagallo for The n_TOF Collaboration,

The cosmological lithium problem and the measurement of the $^7$Be$(n, \alpha)$ reaction at n_TOF-CERN;
- G. Tagliente and The n_TOF Collaboration,

Recent results in Nuclear Astrophysics at n_TOF/CERN.

Int. Conference on Nuclear Data for Science and Technology, Sept 11-16, 2016, Brugge/Belgium
- J. Balibrea, E. Mendoza, D. Cano Ott, E. Berthoumieux, C. Guerrero, and The n_TOF Collaboration,

Measurement of the neutron capture cross section of the fissile isotope $^{235}$U with the CERN n_TOF total absorption calorimeter and fission tagging based on micromegas detectors;
- D. Cano-Ott, E. Berthoumieux, C. Guerrero, E. Mendoza, and The n_TOF Collaboration,

Measurement of the neutron capture cross section of the fissile isotope $^{235}$U with the CERN n_TOF Total Absorption Calorimeter and a fission tagging based on micromegas detectors;
- E. Chiaveri on behalf of The n_TOF Collaboration

The n_TOF facility: neutron beams for challenging future measurements at CERN;

Monte Carlo simulations of the n_TOF lead spallation target with the GEANT4 toolkit: A benchmark study;
- L. Cosentino and The n_TOF Collaboration,

Study of a proton recoil telescope for the measurement of the $^{235}$U$(n, f)$ fission cross section relative to n-p scattering at n_TOF;
n_TOF Conference contributions in 2016

- E. Dupont, N. Otsuka, O. Cabellos, and The n_TOF Collaboration,
  *Dissemination of data measured at the CERN n_TOF facility*;
- C. Guerrero, C. Domingo-Pardo, M.-A. Cortes-Giraldo, S. Heinitz, U. Koester, J. Lerendegui, M. Paul, J.-M. Quesada, D. Schumann, and The n_TOF Collaboration,
  *Time-of-flight and activation experiments on $^{147}$Pm and $^{171}$Tm for astrophysics*;
- F. Gunsing for The n_TOF Collaboration,
  *The measurement programme at the neutron time-of-flight facility n_TOF at CERN*;
  *High accuracy $^{234}$U(n, f) cross section in the resonance energy region*;
  *New measurement of the $^{242}$Pu(n, $\gamma$) cross section at n_TOF-EAR1 for MOX fuels*;

20 contributions to 3 conferences in 2016

180 since 2001

- C. Massimi, S. Kopecky, and The n_TOF Collaboration,
  *Combined $^{25}$Mg(n, $\alpha$) and $^{25}$Mg(n, tot) measurements: a step forward in the characterization of the $^{22}$Ne($a$, n)$^{25}$Mg neutron source in Red Giant Stars*;
- M. Mastromarco, M. Barbagallo, M. J. Vermeulen, on behalf of The n_TOF Collaboration, CERN,
  *The $^{236}$U(n, $\gamma$) cross section measured at the CERN n_TOF facility*;
- E. Mendoza, D. Cano-Ott, C. Guerrero, and The n_TOF collaboration,
  *Measurement of the $^{241}$Am neutron capture cross section at the n_TOF facility at CERN*;
- F. Mingrone on behalf of The n_TOF Collaboration,
  *High precision measurement of the radiative capture cross section of $^{238}$U at the n_TOF CERN facility*;
- M. Sabaté-Gilarte, J. Praena, I. Porras, J.-M. Quesada, and The n_TOF Collaboration,
  *The $^{33}$S(n, $\alpha$)$^{30}$Si cross section measured at n_TOF EAR2 (CERN): from thermal to the resonance energy region*;
- A. Stamatopoulos, A. Tsinganis, N. Colonna, R. Vlastou, P. Schillebeeckx, A. Plompen, J. Heyse, M. Kokkoris, M. Barbagallo, M. Calviani, E. Berthoumieux, E. Chiaveri, and The n TOF Collaboration,
  *Measurement of the $^{240}$Pu(n,f) cross-section at the CERN n_TOF facility: first results from Experimental Area II (EAR-2).*
Summary and conclusions

- Data analysis going on full steam on the experiments performed in 2016
- Shutdown activities: well on track to be ready for the 2017 start-up
- A lot of very interesting experiments to be planned and performed before the LS2