n_TOF Physics Report

68th INTC Meeting

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Commissioning approved by the INTC:

PROTON REQUEST n_TOF facility		
	EAR1 ($\cdot 10^{17}$)	EAR2 ($\cdot 10^{17}$)
Target Commissioning	**25**	**25**
Neutron Flux	15	21
Beam Profile	7	13
Resolution Function	14	14
Background	17	17
Total Neutron Beam Characterization	**53**	**65**
Contingency	**5**	**5**
TOTAL	**83**	**95**

Table 3. Summary of the proton request for commissioning the n_TOF facility.

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

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

Commissioning of the third-generation spallation target and the neutron beam characteristics of the n_TOF facility

30th September 2020

Spokesperson: Marco Calviani (marco.calviani@cern.ch)
Spokesperson: Javier Praena (jpraena@ugr.es)
Technical coordinator: Oliver Aberle (oliver.aberle@cern.ch)

Requested protons: $83 \cdot 10^{17}$ (EAR1). $95 \cdot 10^{17}$ (EAR2)

Experimental Area: EAR1 and EAR2

CERN-INTC-2020-072 / INTC-P-587
30/09/2020

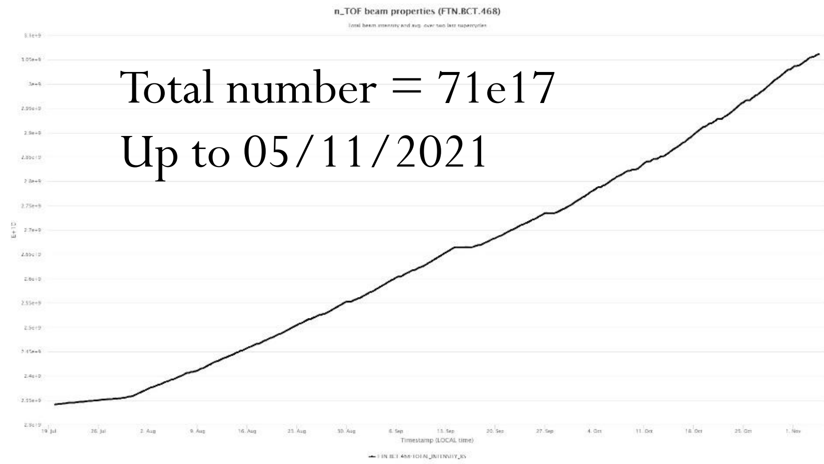
In the committee's view, the commissioning part is unavoidable for reliable and safe operation of the facility. In addition, experience by the collaboration with the planning and interpretation of experiments has shown that the characterisation of flux, spatial profile, resolution function and background are essential for any physics campaign. Therefore, the requested protons should be allocated. Optimization of beam time in 2021 will be called upon by those with approved experiments. It is however, strongly recommended that these optimizations are not allowed to compromise good commissioning and a high quality characterisation of the experimental conditions.

*The **INTC recommends 178e17 protons** for approval by the Research Board.*

2 configurations collimator+moderador in EAR1
3 configurations collimator+moderator in EAR2
The whole commissioning will be carried out in the period 2021-2023.

Protons in 2021: as foreseen, 84e17 protons

We are going to receive the expected number of protons as approved by the INTC.



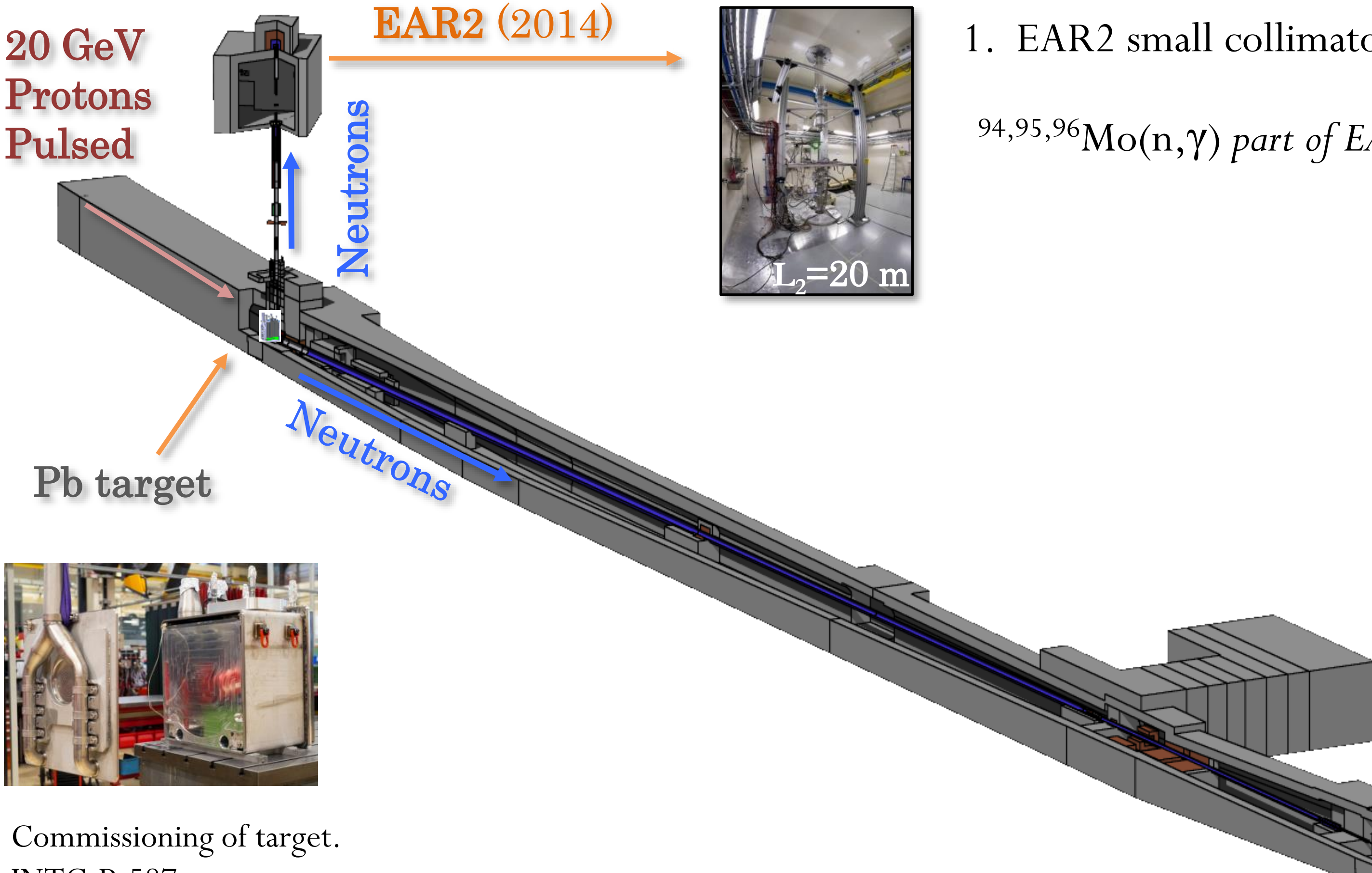
- 25e17 Target + 21e17 EAR2 Commissioning + 38e17 EAR1 Commissioning = 84e17 protons.
- The excellent Target performances allowed to advance the expected date for delivering high intensity pulses on the target.
- The coordination between the EAR1 and EAR2 (NEAR, cooling time) allowed us to advance the Commissioning and in the Physics Program.
- However, we have had to deal with few MDs and studies on the proton beam characteristics, as discussed in the following.

Campaign 2021: commissioning and proposals.

20 GeV Protons Pulsed

EAR2 (2014)

Neutrons



65·10[17] protons

L_2=20 m

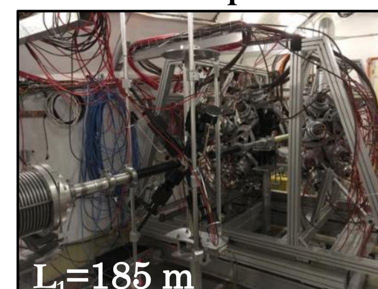
1. EAR2 small collimator + Demineralized Water.

^{94,95,96}Mo(n,γ) *part of EAR2* (2e18). INTC-P-569

Pb target

Neutrons

53·10[17] protons



EAR1 (2001)

Commissioning of target. INTC-P-587
Commissioning of the flux INTC-I -222

NEAR (2021)

^{176}Yb(n,γ)^{177}Yb→^{177}Lu. INTC-P-607

4. EAR1 small collimator + Borated Water.

5. EAR1 big collimator + Borated Water.

Protons organized by dates

Dates (Protons·e17)	Target / PS	EAR1 (small and large collimator)	EAR2 (small collimator)	NEAR
19/07 - 13/08 (10)	Monitoring target / Intensity increased smoothly, post-LS2	Aligment Detector settings	Aligment Detector settings	R2M
13/08 – 13/09 (21.6)	Monitoring the parameters / Optics post-LS2	Commissioning Small collimator Flux & Beam Profile	Commissioning Flux	R2M R2E
13/09-15/09	Technical Stop: activation of the FTN line. Solution: coming back from 15x15 mm^2 beam (post-LS2) to pre-LS2 optics.			
16/09 - 27/09 (7.1)	Monitoring the parameters / Optics *quasi* pre-LS2	Commissioning Large collimator Flux – Beam Profile	Commissioning Time-to-Energy Conversion (RF)	Multiactivation1 (MAM2.1) R2M
28/09 – 03/10 (4.6)	Monitoring the parameters / Optics *quasi* pre-LS2	Commissioning Time-to-Energy Conversion (RF)	Commissioning Time-to-Energy Conversion (RF)	Multiactivation2 (MAM1) R2M
03/10 – 08/10 (4.9)	Monitoring the parameters / Optics *quasi* pre-LS2	Commissioning Time-to-Energy Conversion (RF)	Commissioning Background (iTED-B6D6-sTED)	Multiactivation2 (MAM1) R2M
08/10 - 11/10 (2.5)	Monitoring the parameters / Optics *quasi* pre-LS2	Commissioning Time-to-Energy Conversion (RF)	Tarat Test (INTC-I-233)	Multiactivation2 (MAM1) R2M
11/10 – 15/10 (3)	Monitoring the parameters / Optics *quasi* pre-LS2	Commissioning Time-to-Energy Conversion (RF)	^{94,95,96}Mo(n,γ) INTC-P-569 (EAR2)	Multiactivation2 (MAM1) R2M
15/10 – 21/10 (8.7)	Monitoring the parameters / Optics *quasi* pre-LS2	Commissioning Background (iTED)	^{94,95,96}Mo(n,γ) INTC-P-569 (EAR2)	Multiactivation2 (MAM1) R2M
21/10 – 25/10 (3.8)	Monitoring the parameters / Optics *quasi* pre-LS2	Commissioning Background (TAC)	^{94,95,96}Mo(n,γ) INTC-P-569 (EAR2)	Multiactivation3 (Antilope) R2M
25/10 – 01/11 (7.1)	Monitoring the parameters / Optics *quasi* pre-LS2	^{176}Yb(n,γ) INTC-P-607	^{94,95,96}Mo(n,γ) INTC-P-569 (EAR2)	Multiactivation3 (Antilope) R2M
01/11 – 10/11		^{176}Yb(n,γ) INTC-P-607	Commissioning Flux & Beam Profile	Multiactivation4 (MAM2.2) R2M

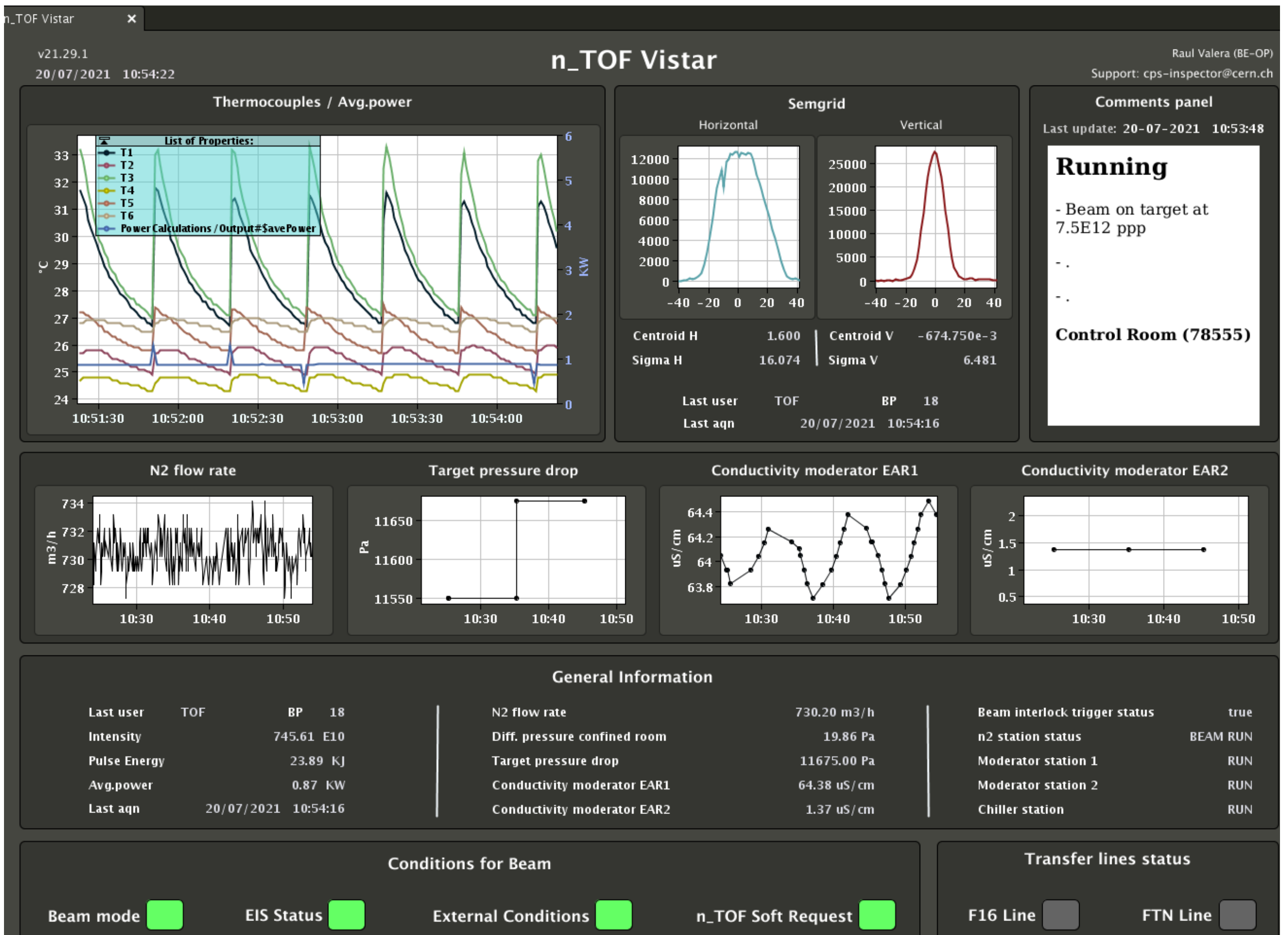
Protons organized by Experimental areas

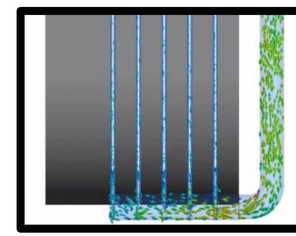
Protons ·e17	EAR1		EAR2		NEAR	
CM=Commissioning	**Protons**	**Detectors**	**Protons**	**Detectors**	**Protons**	**Devices**
CM small collimator Flux and Beam Profile	21.6	Simon1, PPAC1, Timepix, MGAS1, PTB (iTED)	30.6	Simon2, Timepix, MGAS2, PPAC2, PTB		
CM small collimator Time-2-Energy (RF)	13.8	C_6D_6(Legnaro)	11.8	C_6D_6(Bicron)		
CM small collimator Background	10	C_6D_6(Legnaro), iTED, HPGe, TAC	5.3	C_6D_6(Bicron), iTED, sTED, C_6D_6(Legnaro)		
CM large collimator Flux and Beam Profile	7	PPAC1, MGAS1				
Tarat (INTC-I -233)	2.2		2.2			
^{94,95,96}Mo(n,γ) INTC-P-569 (EAR2)			19.6	C_6D_6(Bicron)		
^{176}Yb(n,γ) INTC-P-607	15	C_6D_6(Legnaro)				
CM Flux					7 18 12 ...	MAM2.1 MAM1 Antilope MAM2.2
R2M R2E					84 8	Al Containers SRAM
MD proton beam						

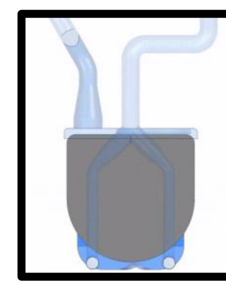
Target Commissioning: proton beam

Monitoring: temperature in different position of the target (K thermocouples), the average intensity on target, the beam dimensions on target, the beam impact point on targe, monitoring N_2 flow rate, pressure.

We started with a Proton Beam as Pre-LS2= 16x7mm2





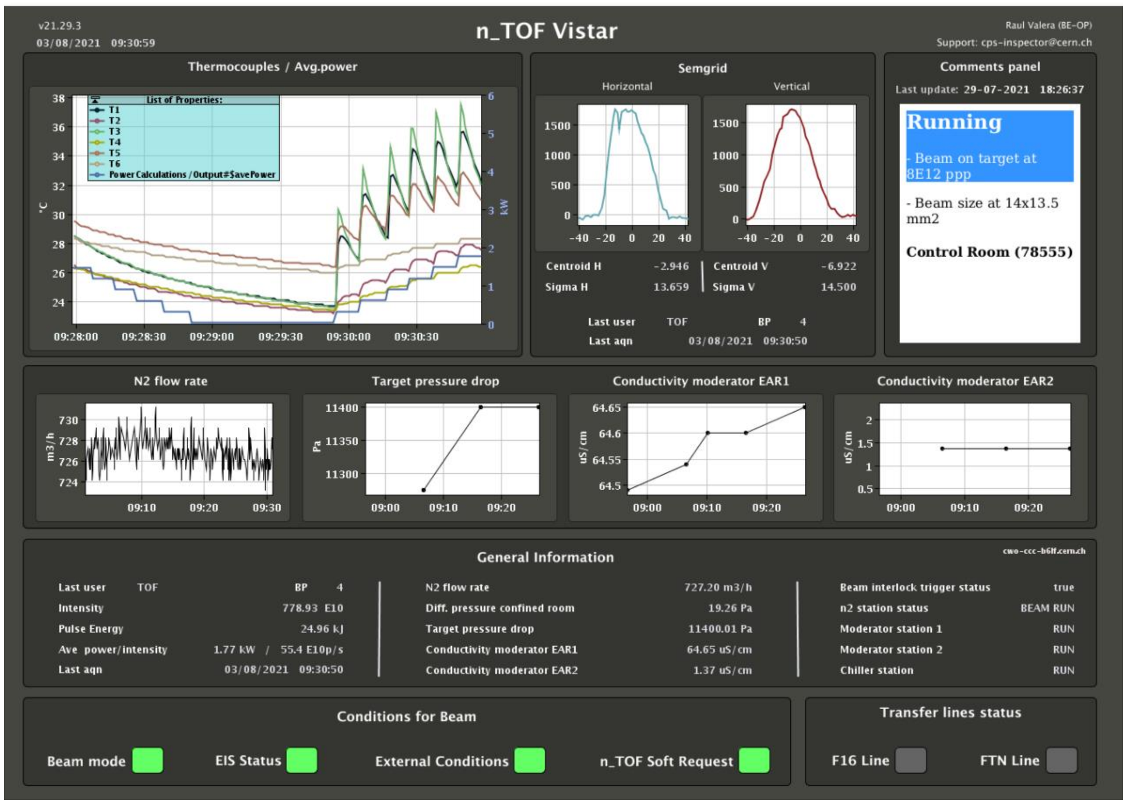


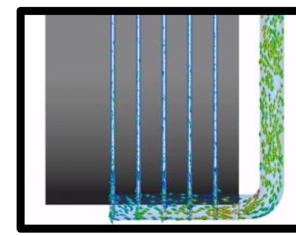
N_2-cooled Pb neutron spallation target
R. Esposito, M. Calviani

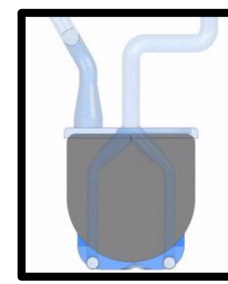
Target Commissioning: proton beam

Monitoring: temperature in different position of the target (K thermocouples), the average intensity on target, the beam dimensions on target, the beam impact point on targe, monitoring N_2 flow rate, pressure.

After one week we changed to the New Proton Beam, post-LS2= 14x14mm2.





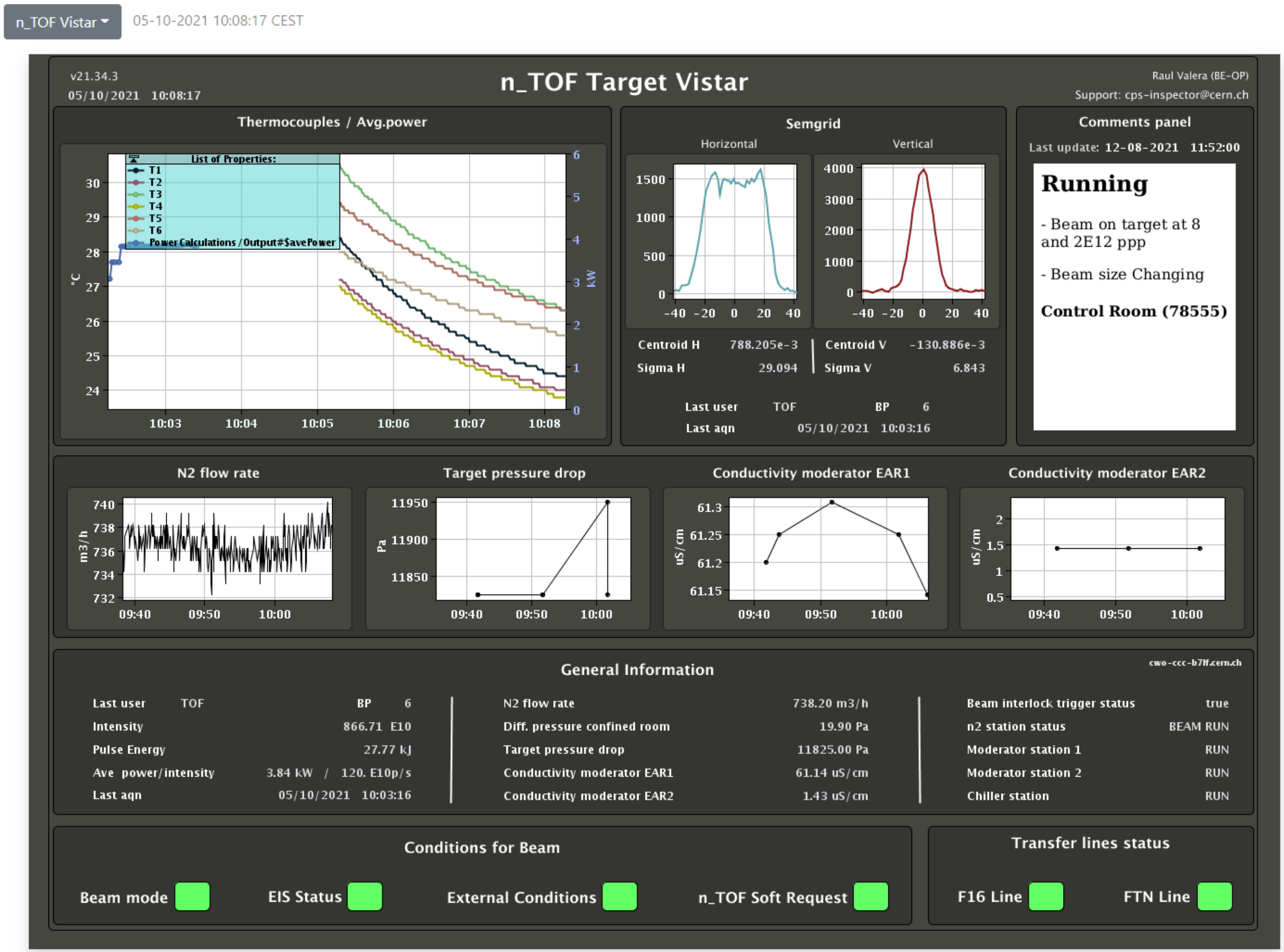


N_2-cooled Pb neutron spallation target
R. Esposito, M. Calviani

We ran in this configuration from the end of July until 13/09.
Technical Stop. Hot spot in FTN line, 18mSv/h at 1 cm after 30 hours of cooling.

Proton beam from 16/09-YETS

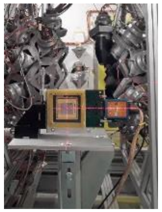
Second configuration post-LS2 = 30x7mm2.

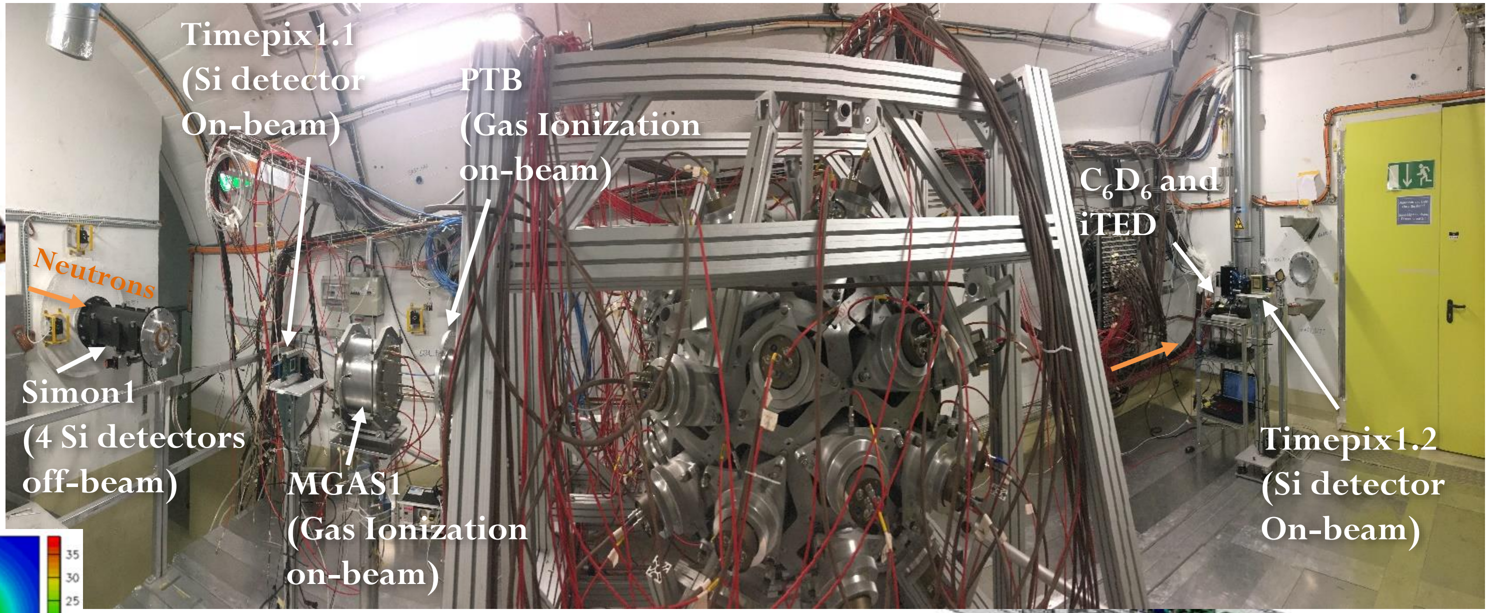


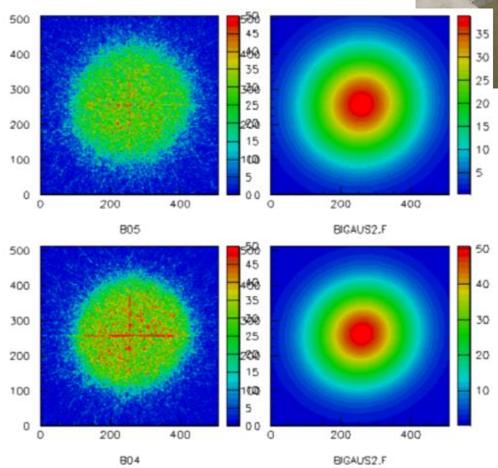
EAR1: setups and preliminary results

EAR1 small collimator alignment. Detector settings.

EAR1
@ 185 m

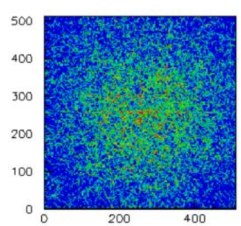




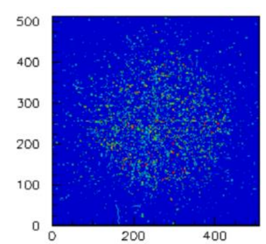


To be completed and extended with PPAC2 with U235(n,f)

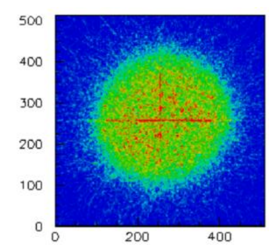
En < 1 eV



1eV < En < 100 k eV

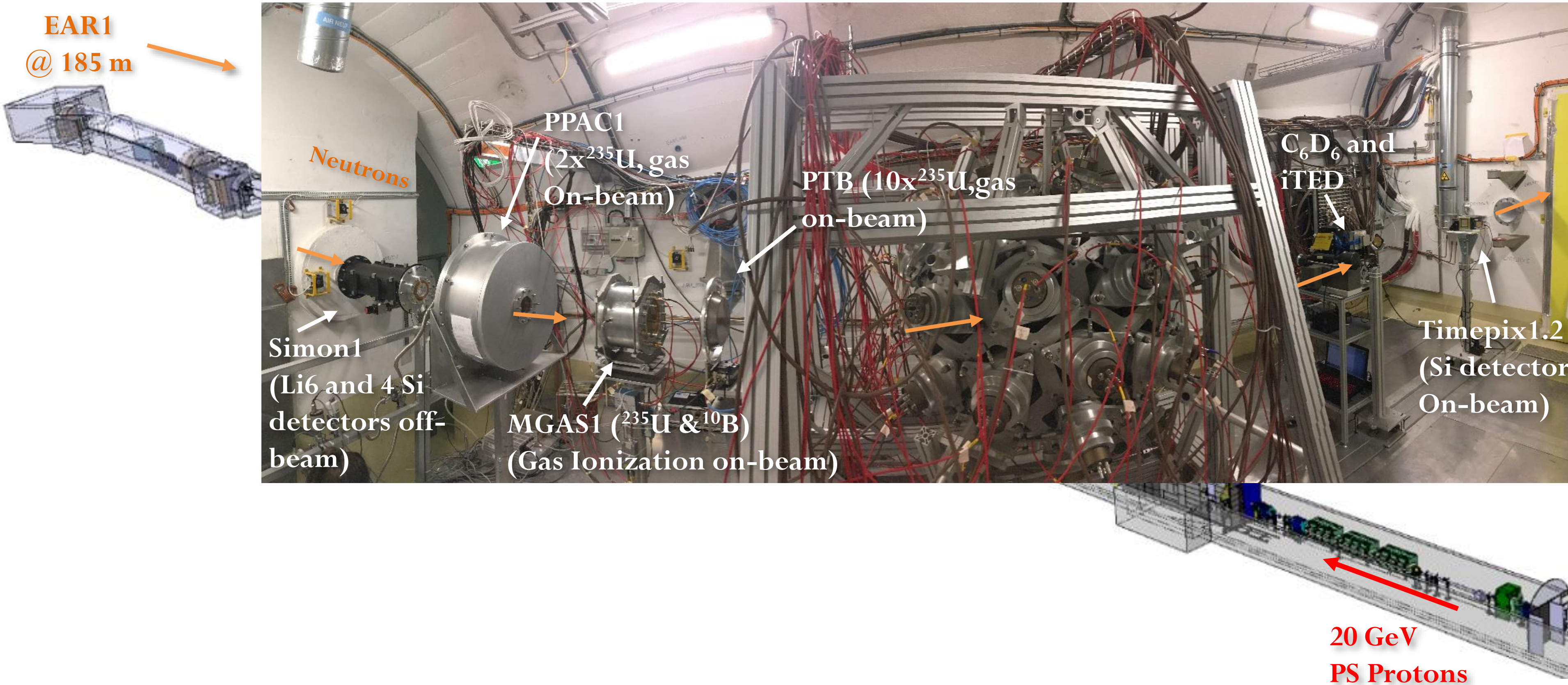


En > 1 MeV

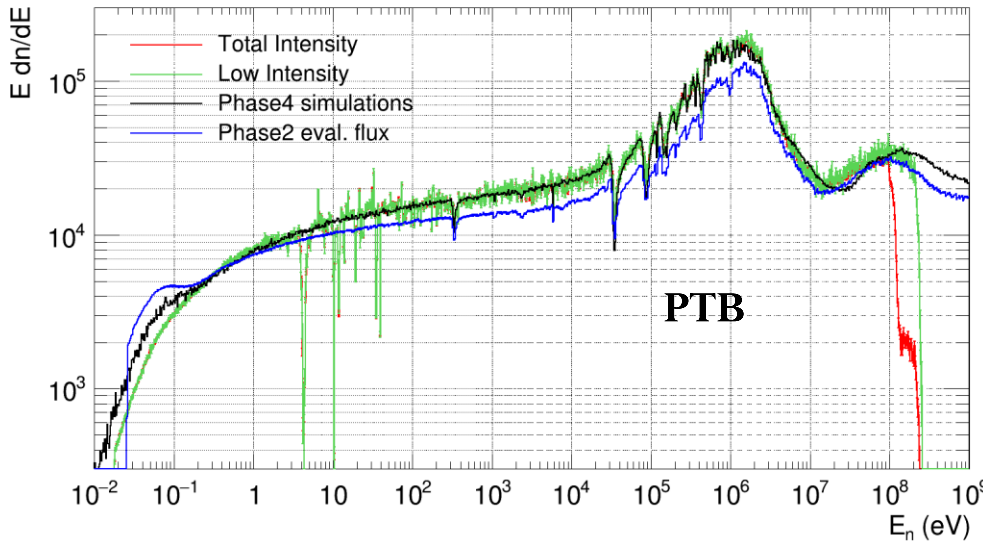


Fabrizio Murtas, Michi Bacak

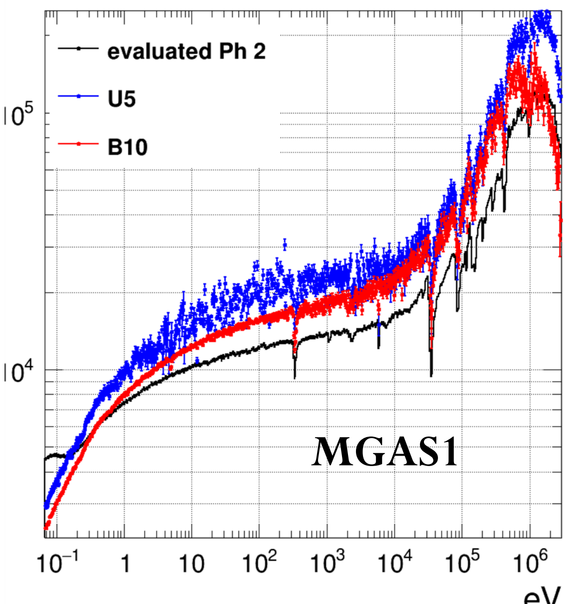
EAR1 CM neutron flux and beam profile



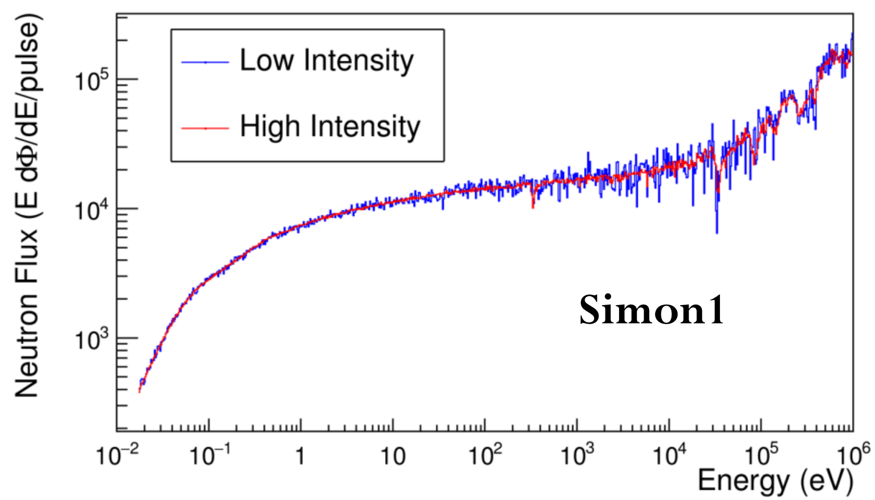
EAR1 small collimator neutron flux: preliminary results



Michi Bacak, Mirko Dietz, Elisa Pirovano, Ralf Nolte



Elisso Stamati and N. Patronis

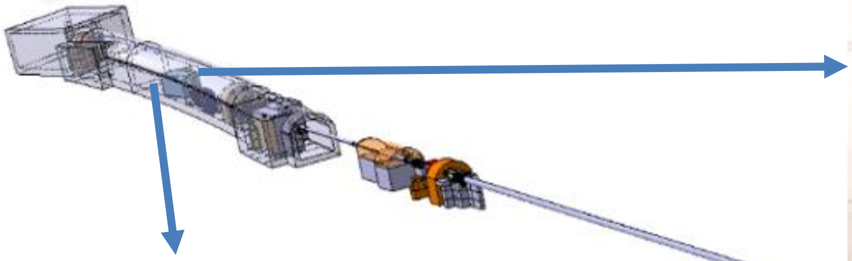


Simone Amaducci

EAR1: change from small (2 cm) to large collimator (8 cm)

New collimator with the same apertures.
Faster Exchange with high precision

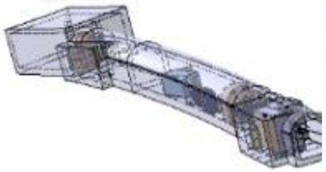
EAR1
@ 185 m

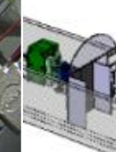


EAR1 small collimator Time-to-Energy, Background and ^{176}Yb(n,γ)

Selected (n,γ) resonances in the reactions with Au, Si, Fe, Ir, S provides the information

EAR1
@ 185 m

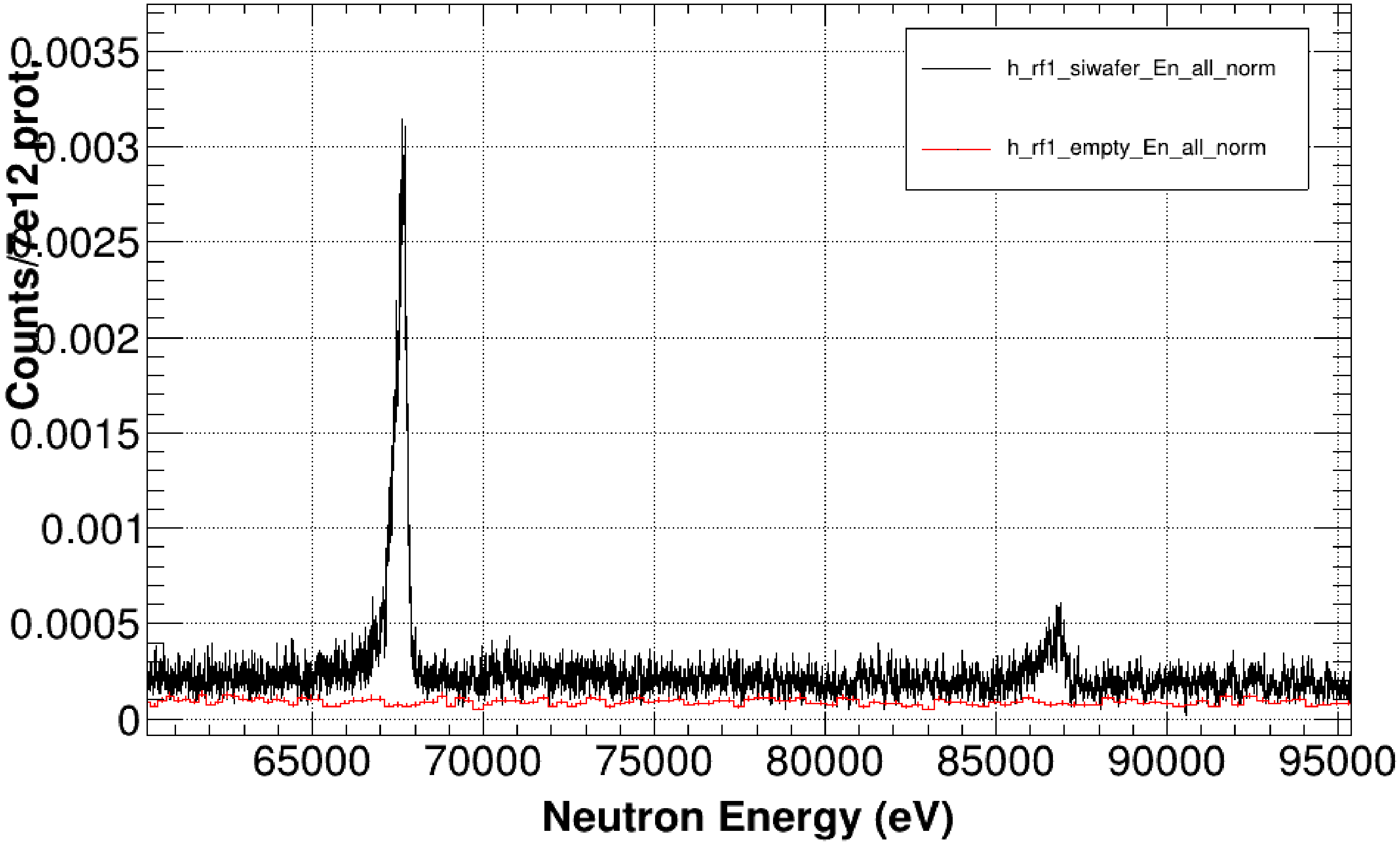




Adrià Casanovas ,Víctor Alcayne, Jorge Lerendegui, Francisco García Infantes

EAR1 small collimator Time-to-Energy: preliminary results

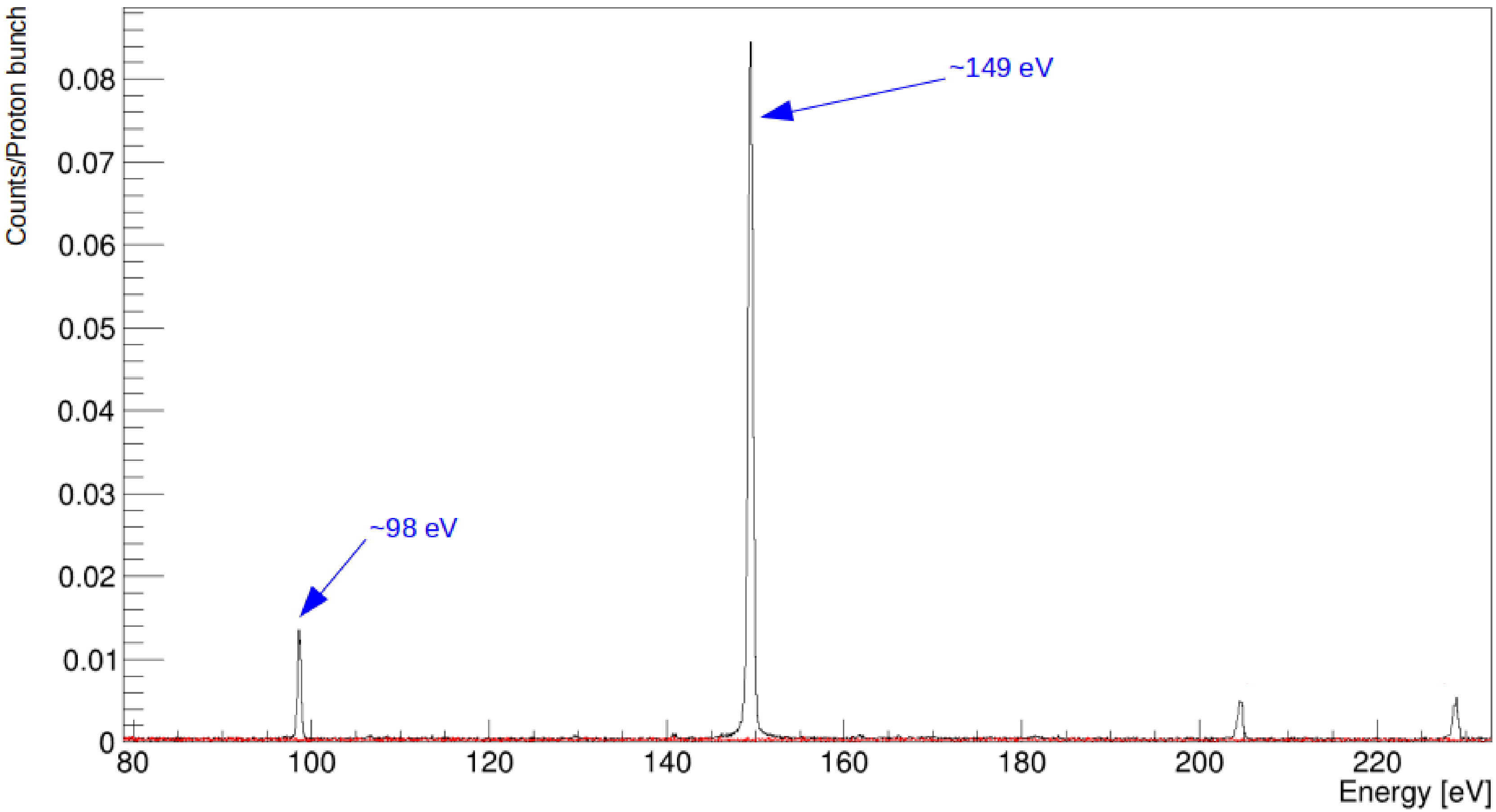
Excellent resolution of resonances even at 70 keV and higher energies (as previous target)



Adrià Casanovas ,Víctor Alcayne, Jorge Lerendegui

^{176}Yb(n,γ) Physics Measurement (INTC-P-607): preliminary results

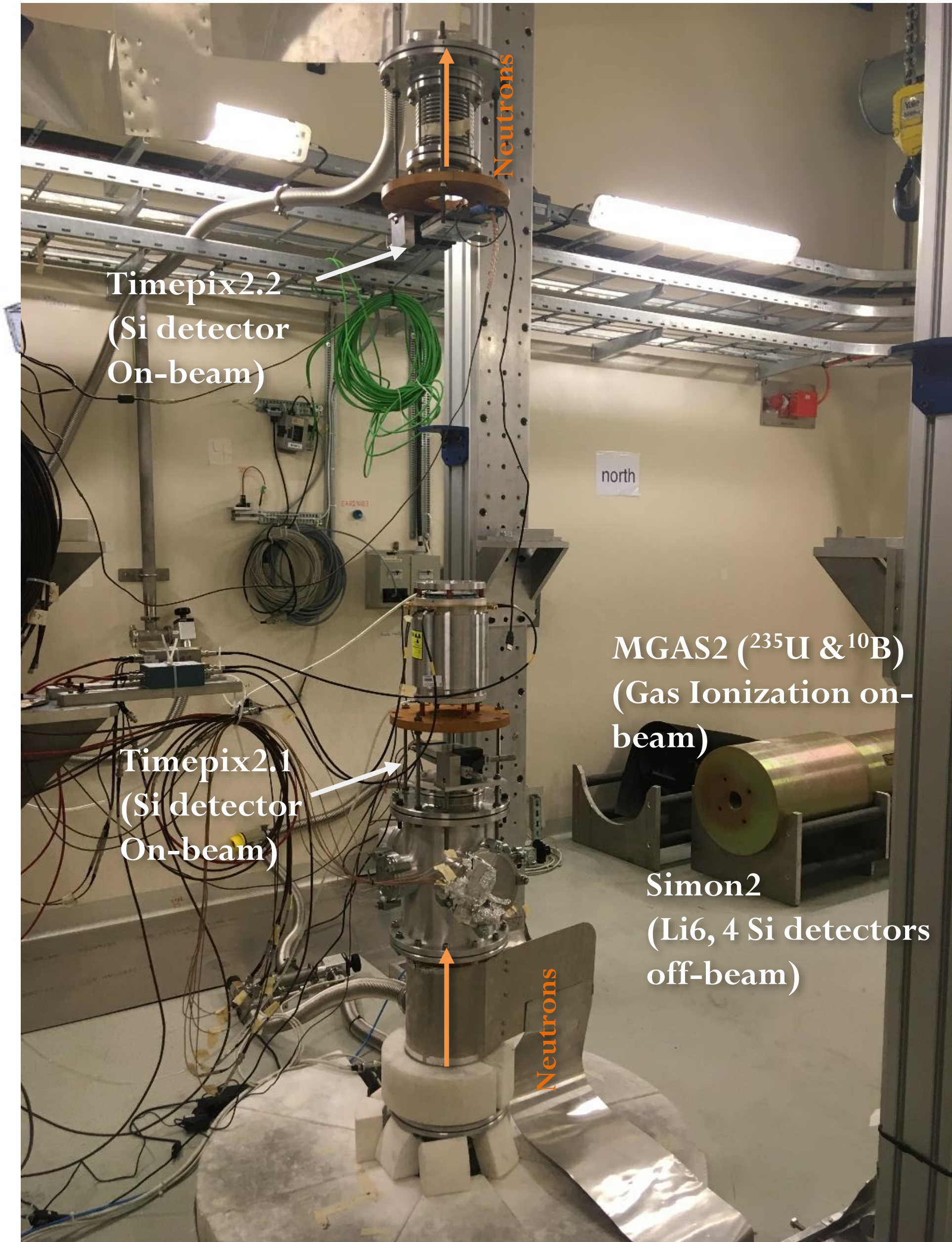
For the first time the resonances of the ^{176}Yb(n,γ) have been resolved

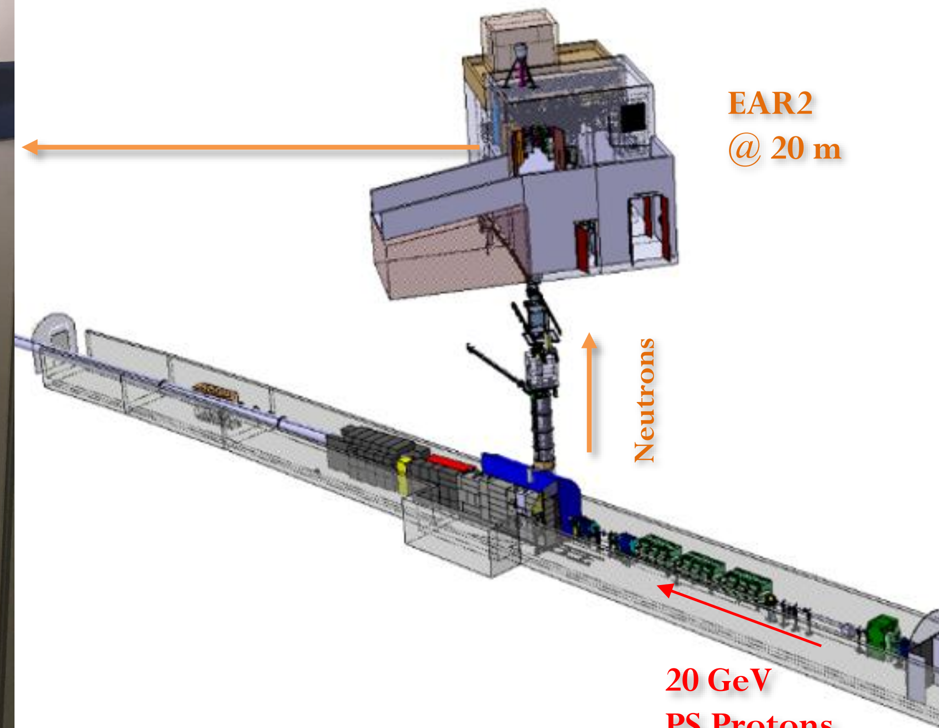


Francisco García Infantes (CERN PhD), Adrià Casanovas

EAR2: setups and preliminary results

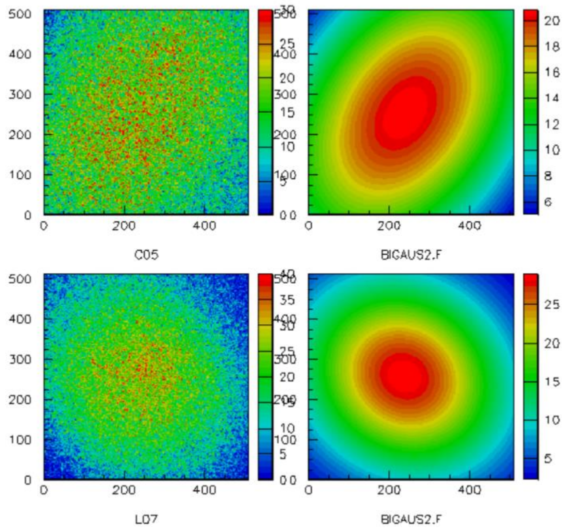
EAR2 small collimator alignment. Detector settings.





EAR2 small collimator CM beam profile: Timepix

All energies



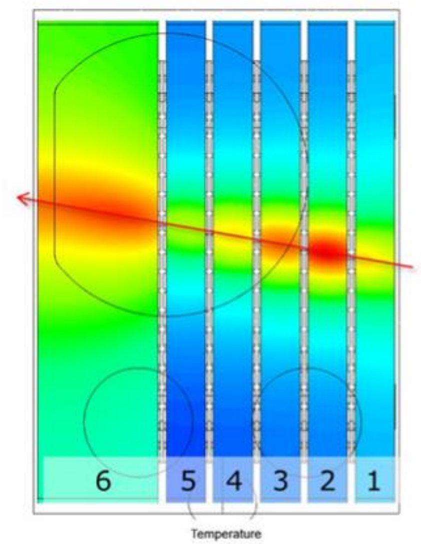
Downstream

Upstream

Fabrizio Murtas, Michi Bacak

To be completed and extended with PPAC2 with U235(n,f)

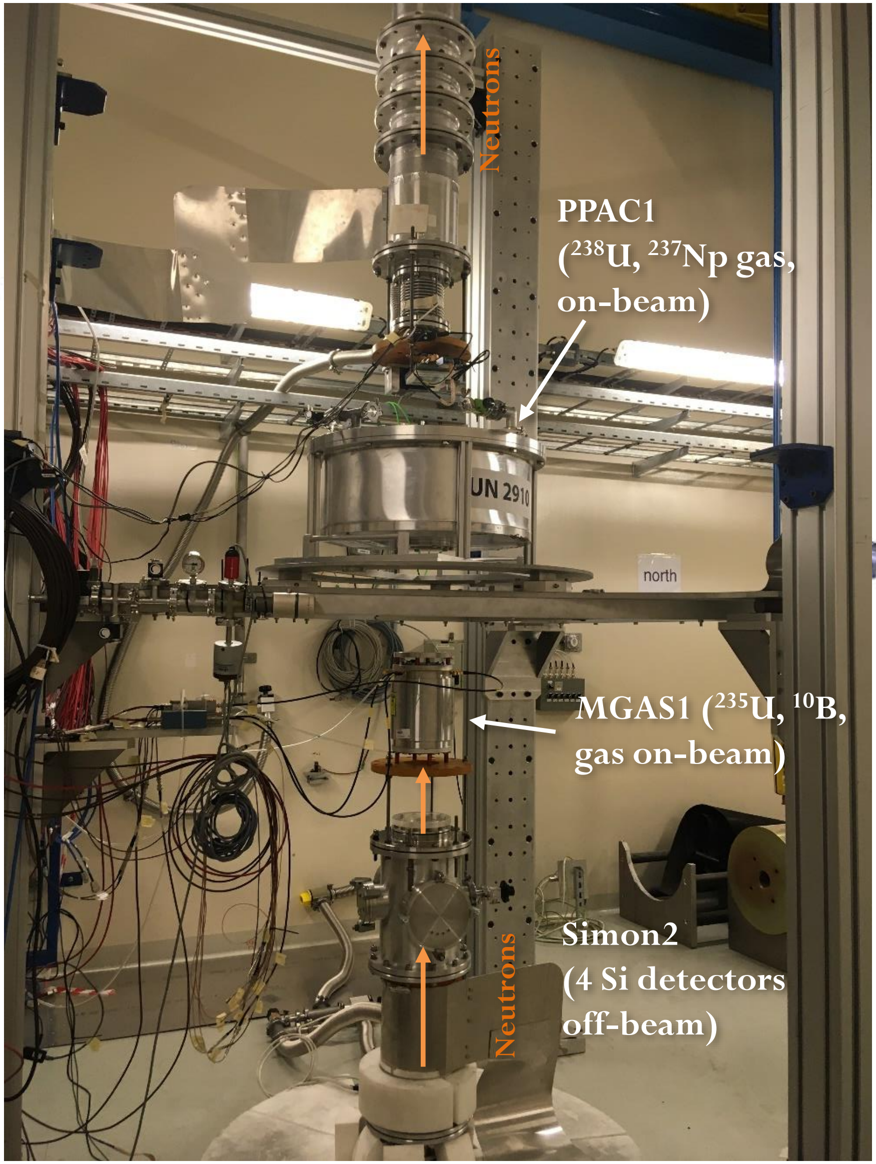
Zenithal/vertical view of the target

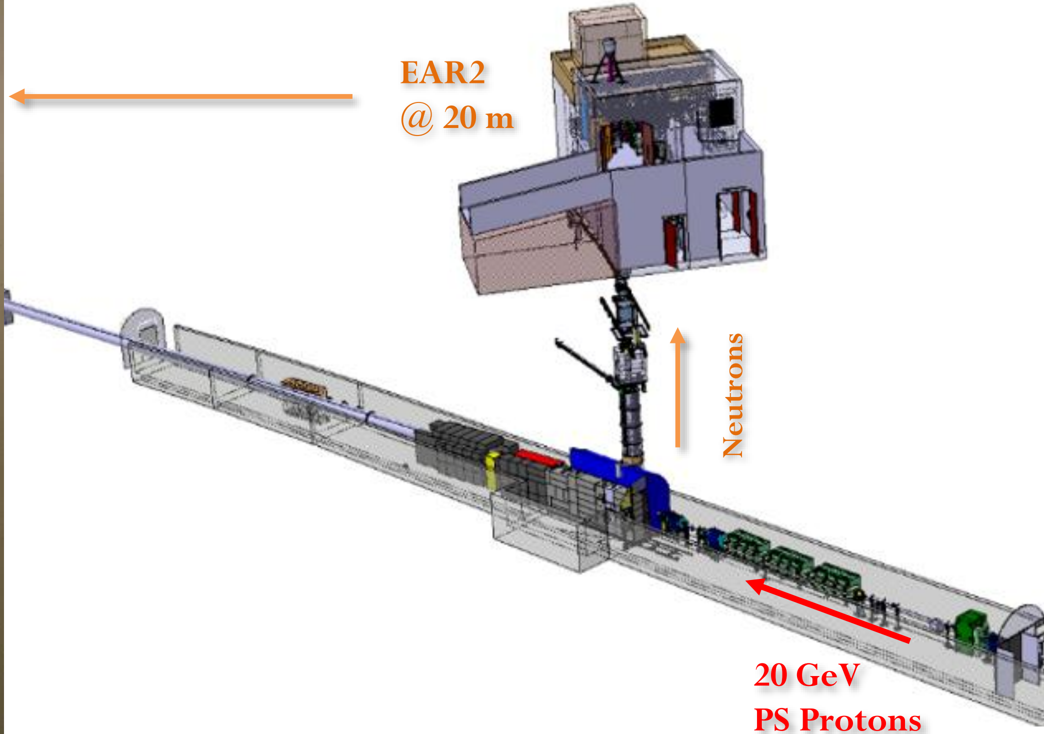


20 GeV
PS Protons

Particular important because EAR2 is closer to the target (20 m) and the beam "seen" from vertical position is not a point.

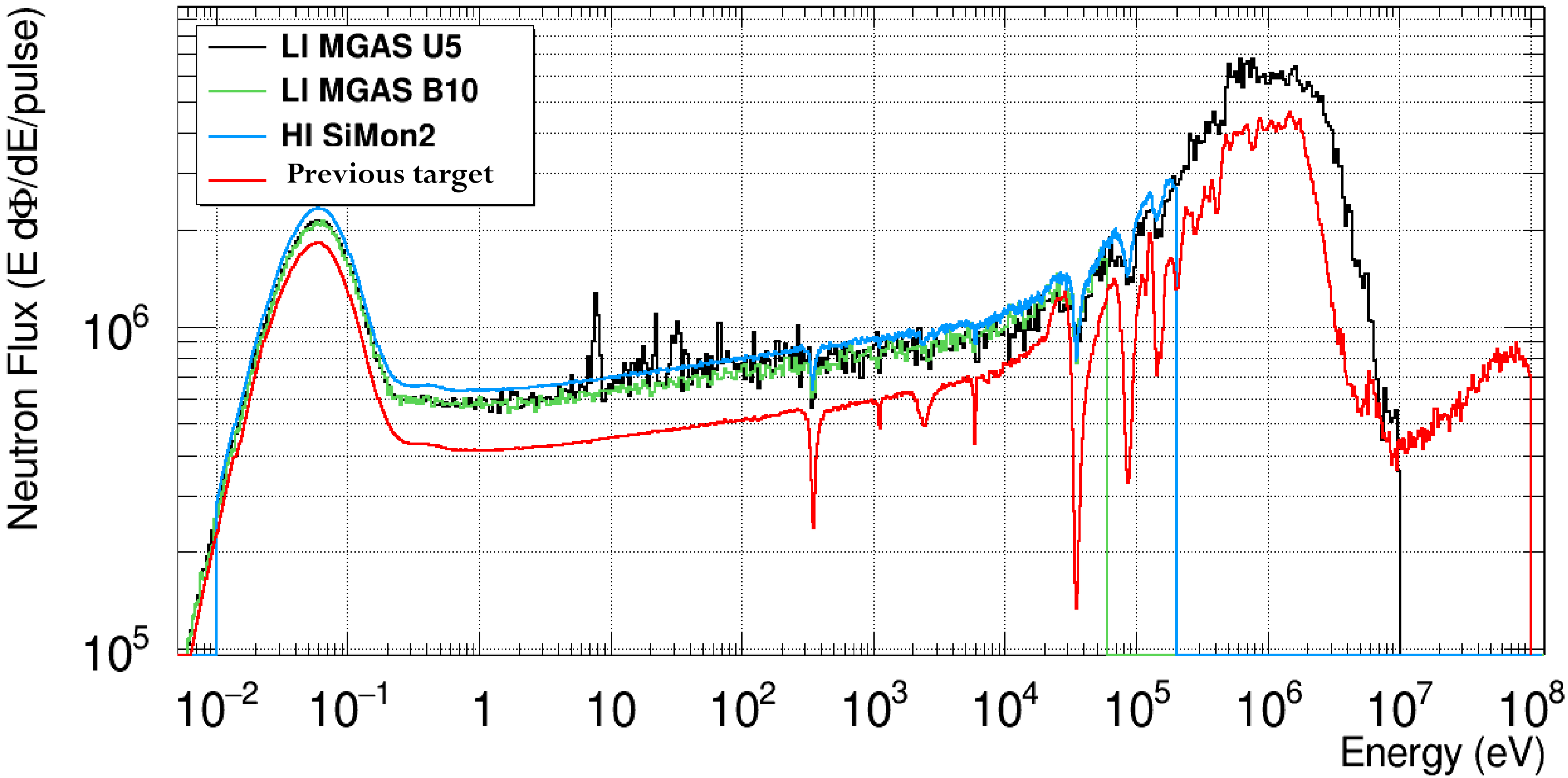
EAR2 small collimator neutron flux setup.





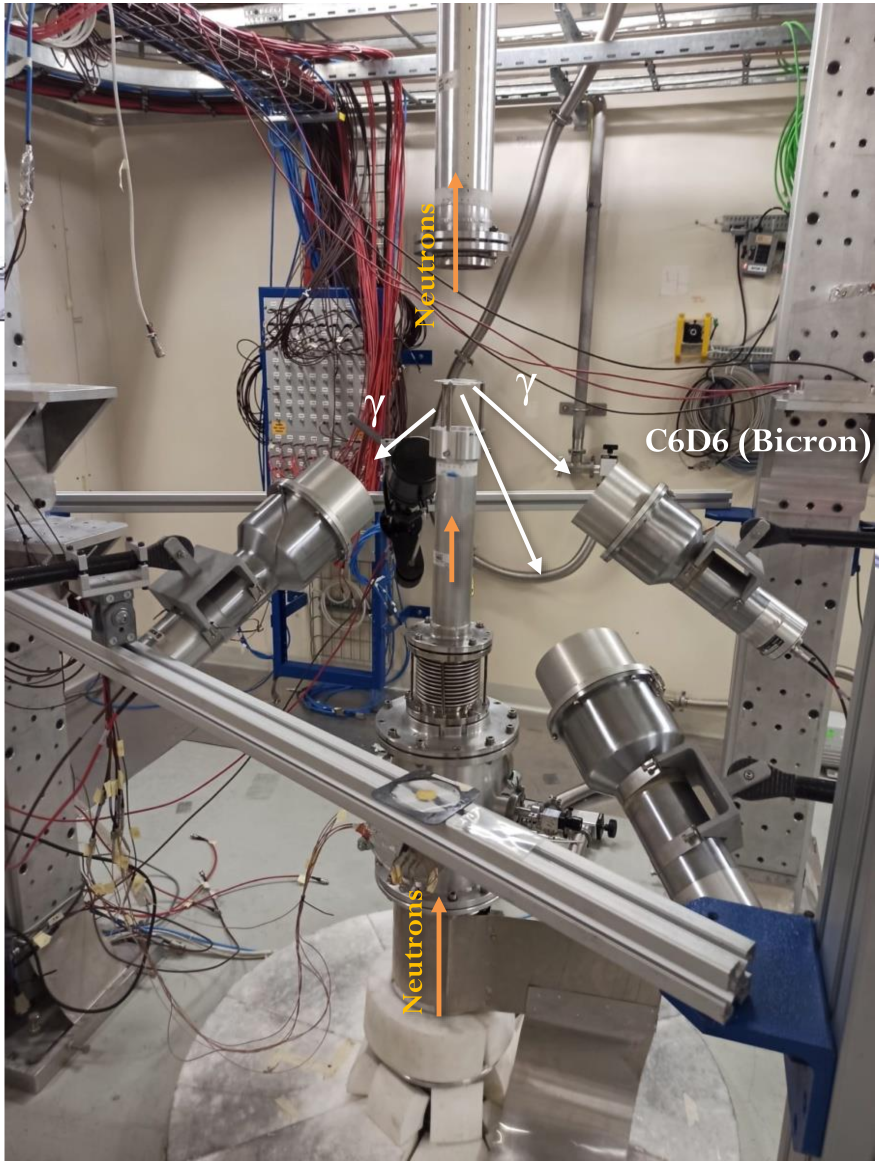
EAR2 small collimator neutron flux: preliminary results

Preliminary good agreement between detectors. Higher flux than previous target

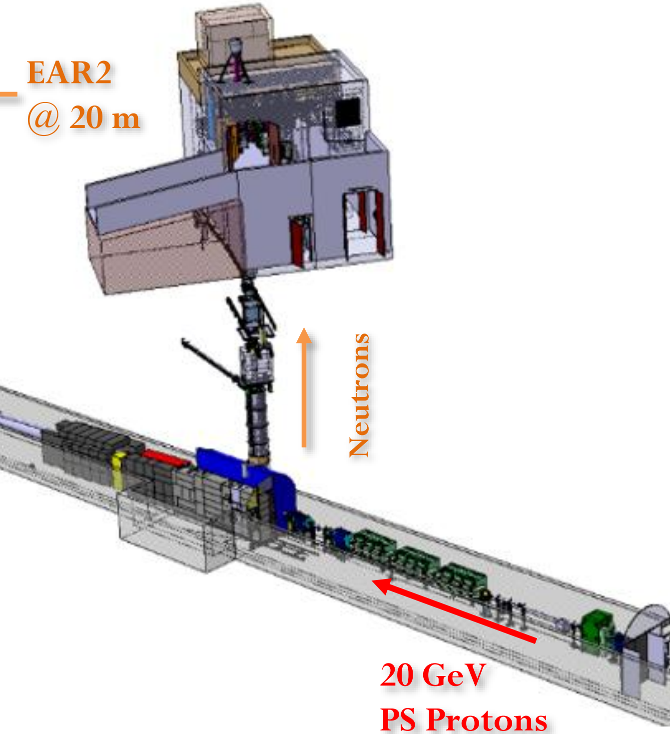


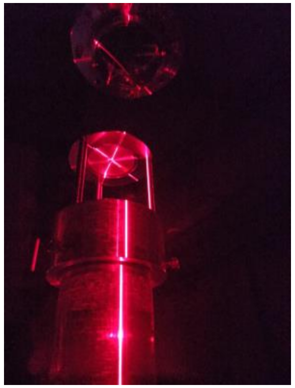
Marta Sabaté, José A. Pavón, Simone Amaducci

EAR2 small collimator Time-to-Energy, Background & $^{94,95,96}Mo(n,\gamma)$



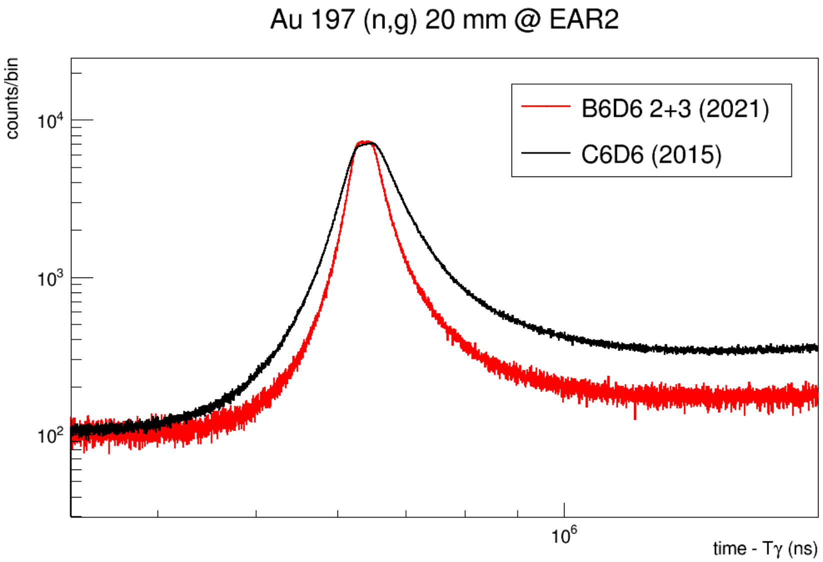
Selected (n,γ) resonances in the reactions with Au, Si, Fe, Ir, S, Se, U provides the information

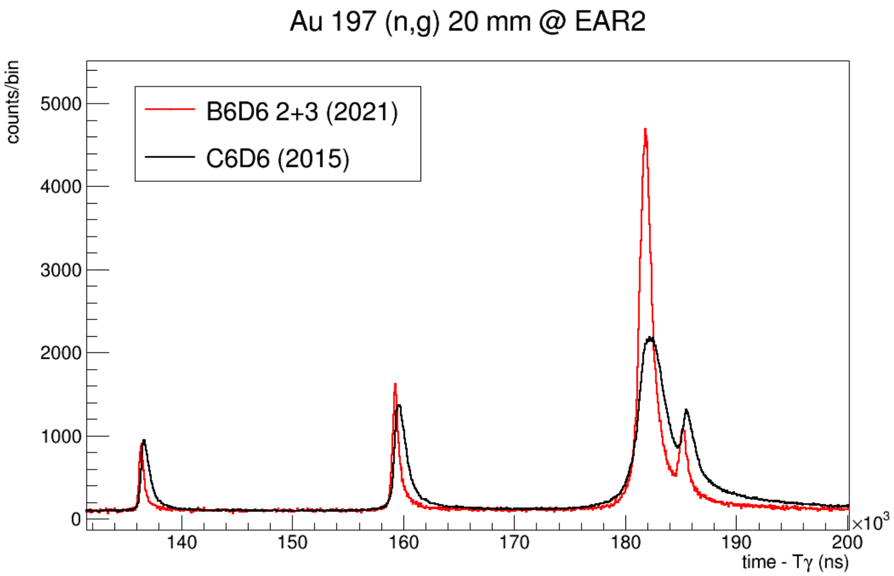




EAR2 small collimator Time-to-Energy: preliminary results

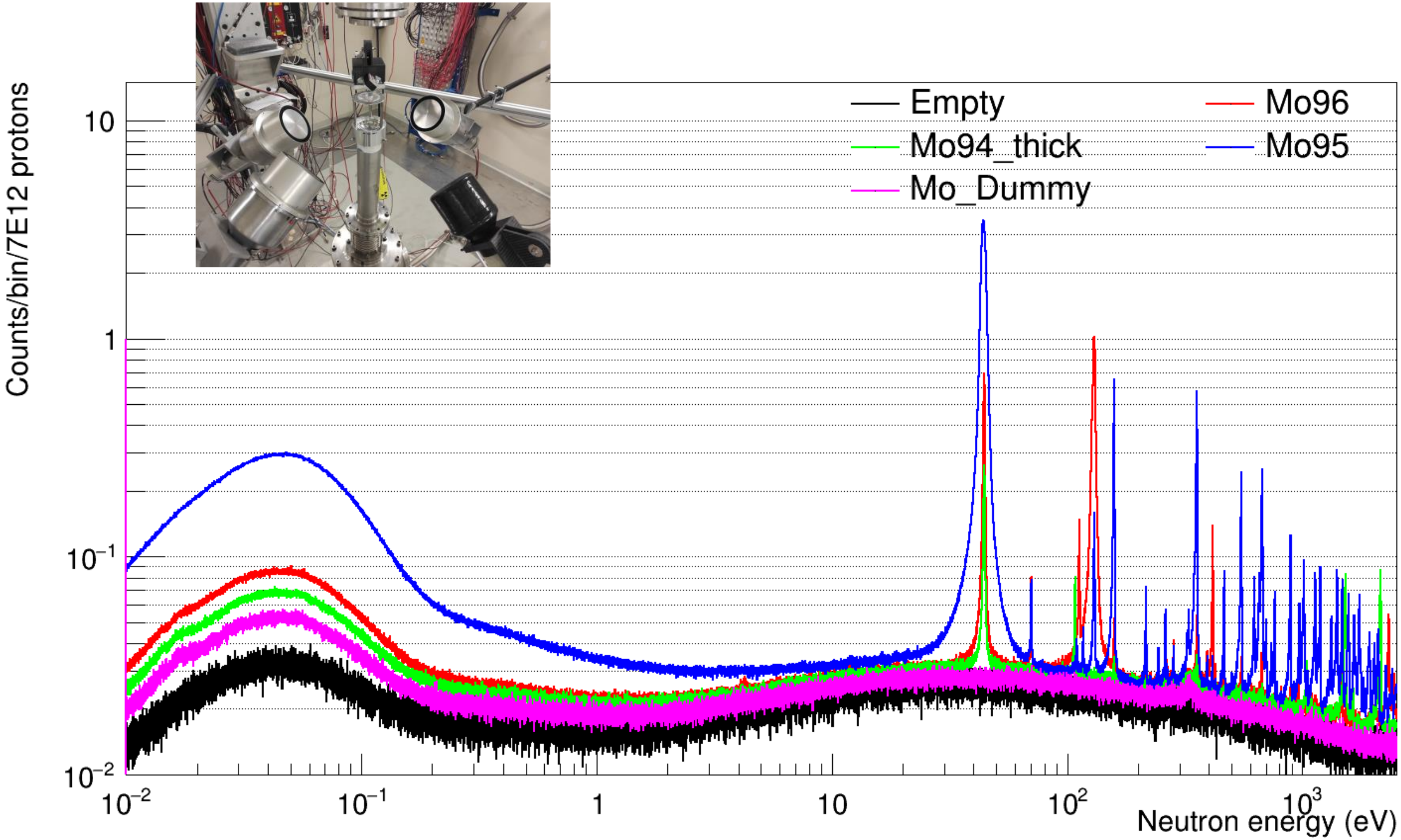
Better resolution of the resonances than with the previous target





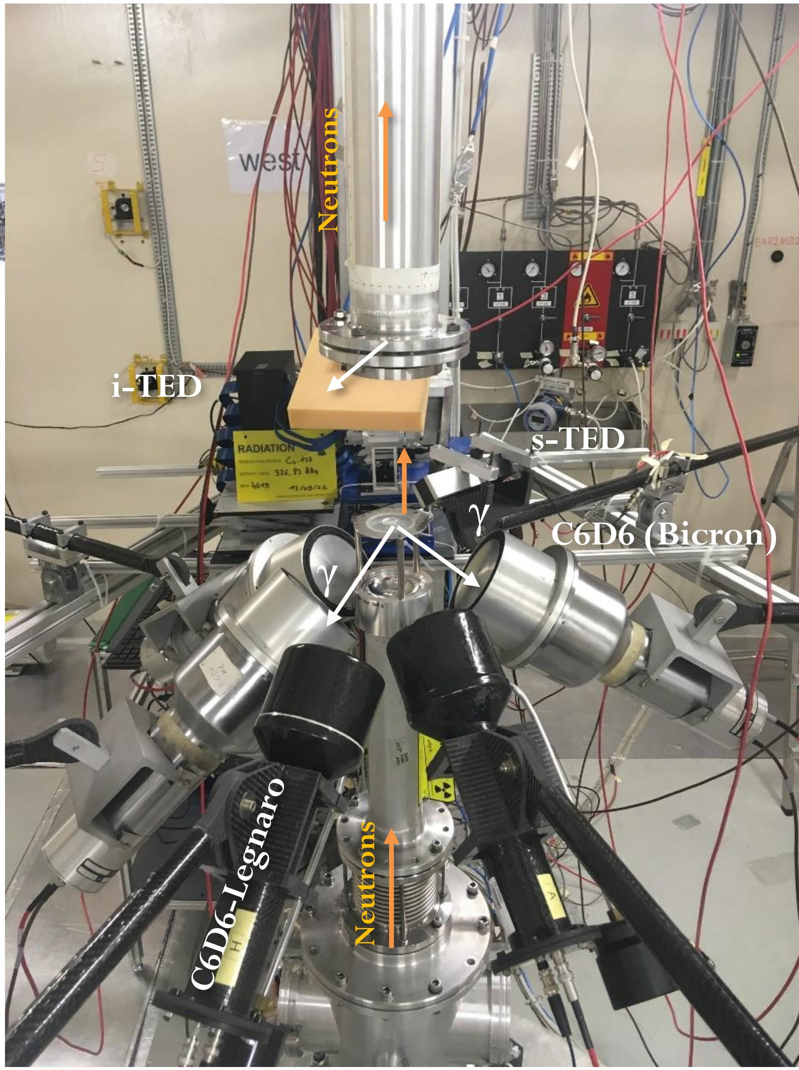
Víctor Alcayne, Jorge Lerendegui, Adrià Casanovas

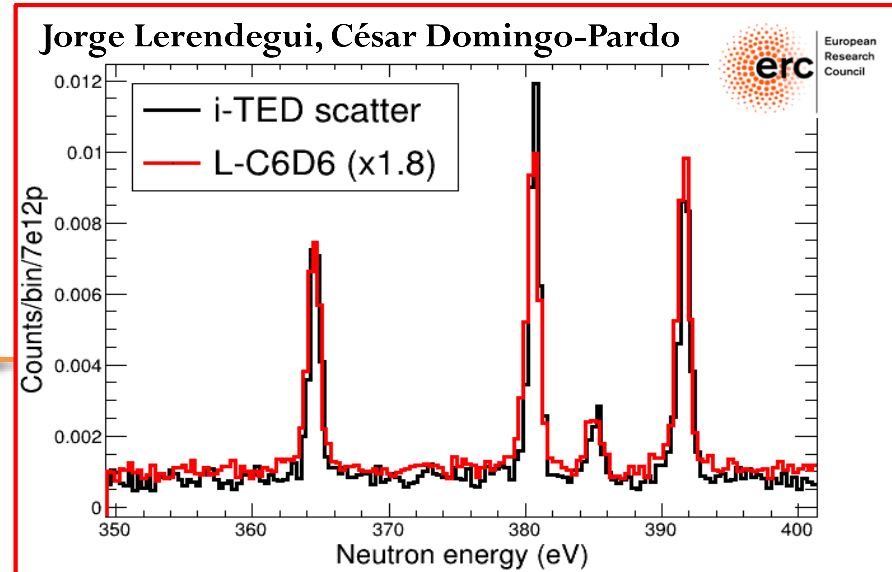
$^{94-96}$Mo(n,γ) Physics Measurement (INTC-P-569): preliminary results

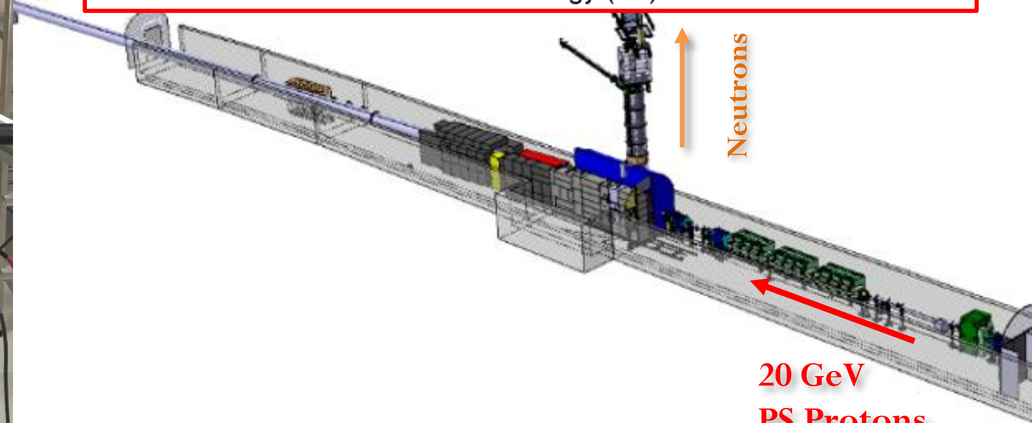


Alice Manna, Cristian Massimi, Riccardo Mucciola

EAR2 small collimator Background: several (n,γ) detectors

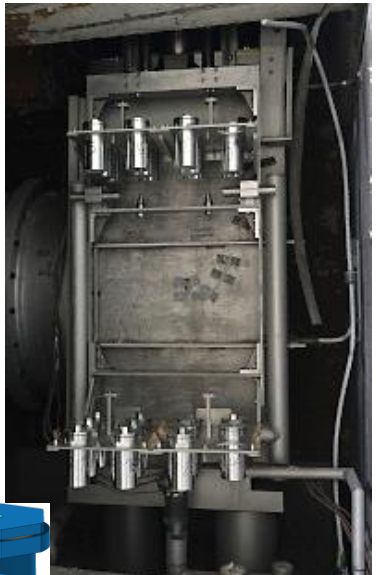


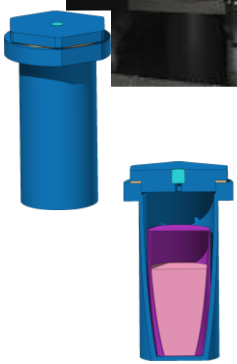




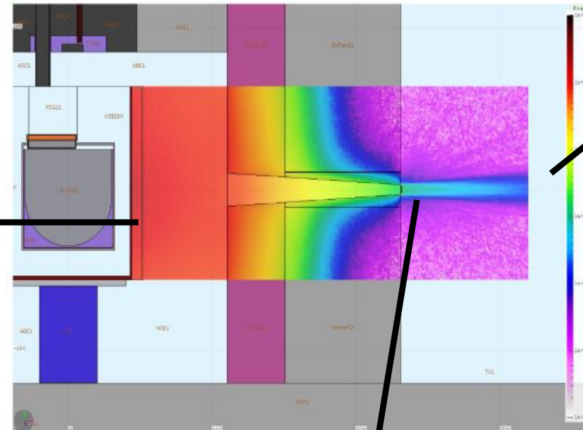
NEAR (new experimental area)

NEAR: new experimental area, three locations on going



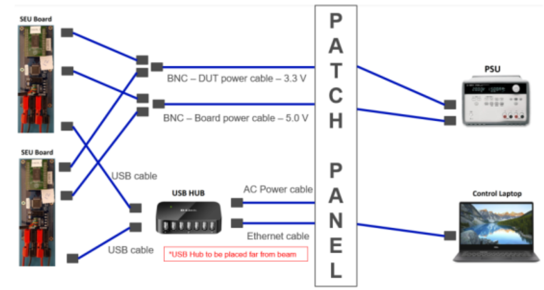


R2M

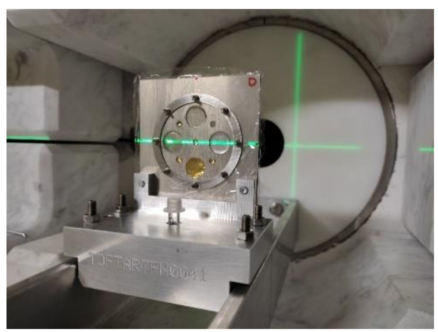


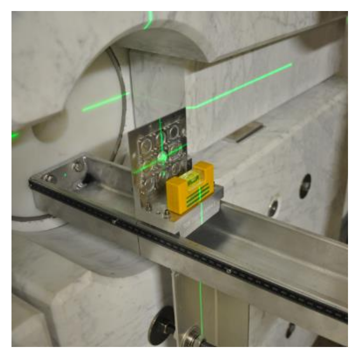
R2E

Single Event Upsets
Single Event Latch-up



Commissioning of neutron fluence for Physics Measurements





Dominika Senojova, Matteo Ferrari, Oscar Fjeld, Oliver Aberle, Ana-Paula Bernardes, Elisso Stamati, Pablo Torres, Pablo Pérez, Mario Sacristán.

Summary

- **Target Commissioning** has been successful, and the performances are excellent. New elements across the lines, new elements for monitoring the target and proton beam.

- **Commissioning of the Neutron Beam at the EAR1** has been finished. Small and large collimators have been used. Both with borated water as moderator. Finished.

- **Commissioning of the Neutron Beam at the EAR2** has been finished with small collimator and demineralized water as moderator. To be continue in 2022.

- **Physics Program has been started.** ^{94,95,96}Mo(n,γ) INTC-P-569 finished in EAR2,to be continued in EAR1,^{176}Yb(n,γ) finished INTC-P-607, INTC-I-233.

- **NEAR neutron fluence commissioning** has been finished. R2M and R2E has already carried out studies in the NEAR station.

Perspectives during the YETS and after

- To finish the analysis regarding the commissioning.
- 28/02/2021 proton beam back, low intensity.
- Physics Program: ^{79}Se(n,γ) (INTC-P-580) EAR1, ^{94}Nb(n,γ) (INTC-P-577) EAR2,…

Proton beam

- Fixed impact point of the proton beam on target.

- **Our Needs for Physics:**
  - Proton pulses with two different intensities: 7.5-8.5e12 and 2-3.5e12.
  - 1.05e17 protons per day made in 30 days, in average, as the campaigns before the LS2.

- **Our Constrains from Target:**
  - Maximum average intensity on target = 160e10 p/s
  - Dimensions for high intensity pulses ≈ 215 mm^2.
  - Dimensions for low intensity pulses ≈ 40 mm^2.

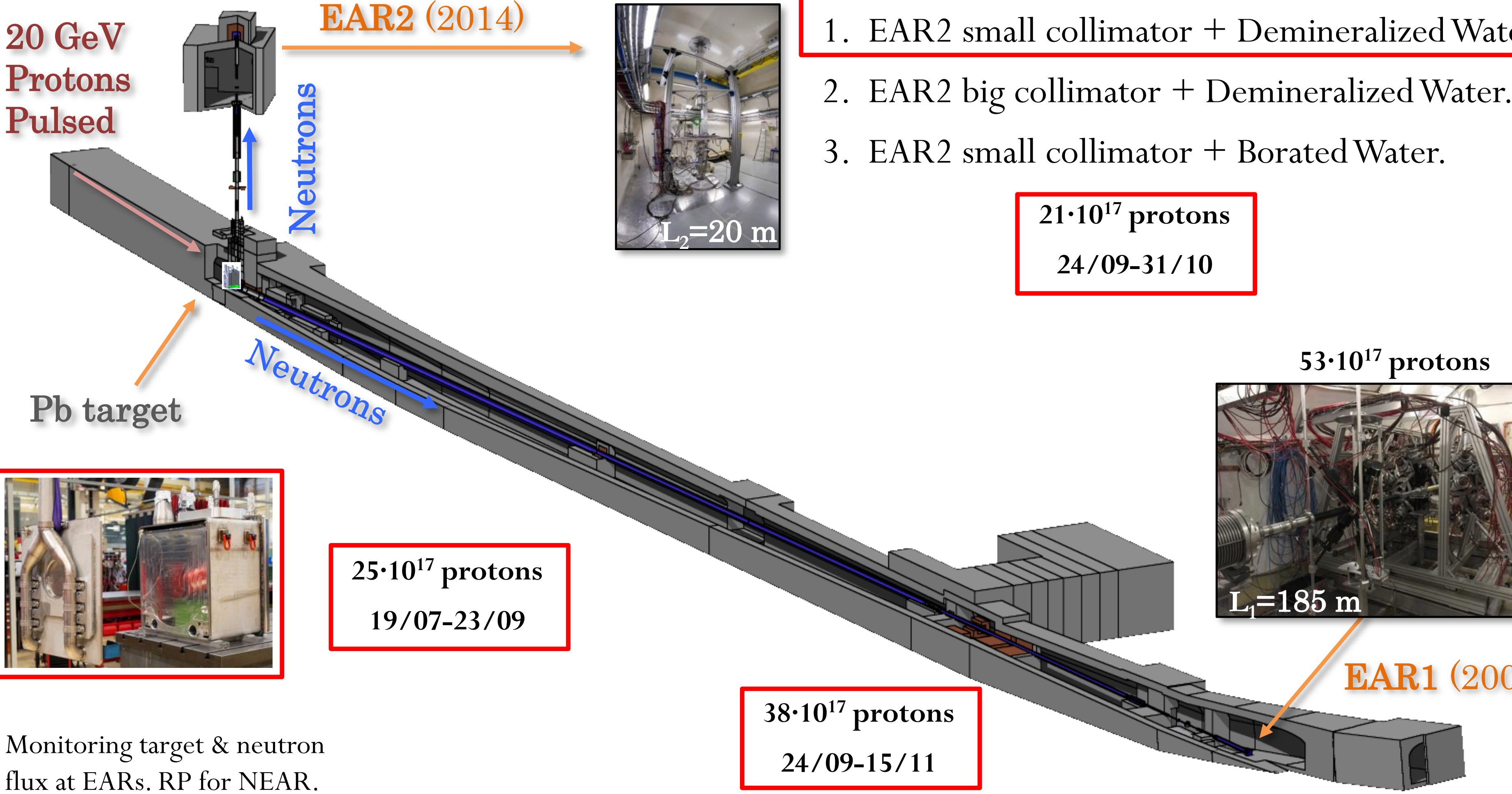
Thanks to the PS team for the constant feedback for improving the quality of the proton beam

Thank you on behalf
n_TOF Collaboration

Javier Praena

Prof. Universidad de Granada (Spain)
CERN Scientific Associate (EP/SME)
n_TOF Physics Coordinator

Commissioning. In red what is planned in 2021 (YETS on 15th Nov)



$65 \cdot 10^{17}$ protons

1. EAR2 small collimator + Demineralized Water.
2. EAR2 big collimator + Demineralized Water.
3. EAR2 small collimator + Borated Water.

$21 \cdot 10^{17}$ protons
24/09-31/10

$53 \cdot 10^{17}$ protons

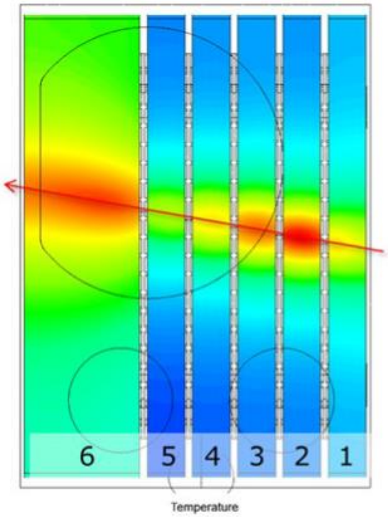
$25 \cdot 10^{17}$ protons
19/07-23/09

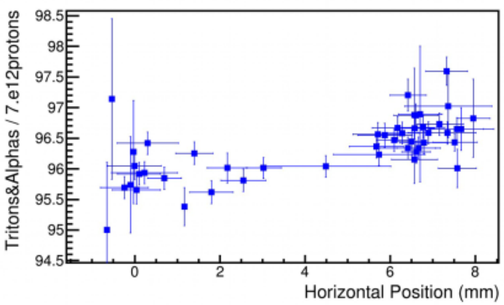
$38 \cdot 10^{17}$ protons
24/09-15/11

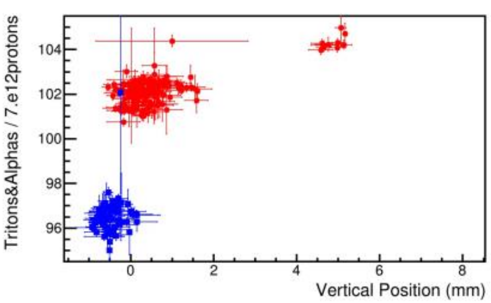
4. EAR1 small collimator + Borated Water.
5. EAR1 big collimator + Borated Water.

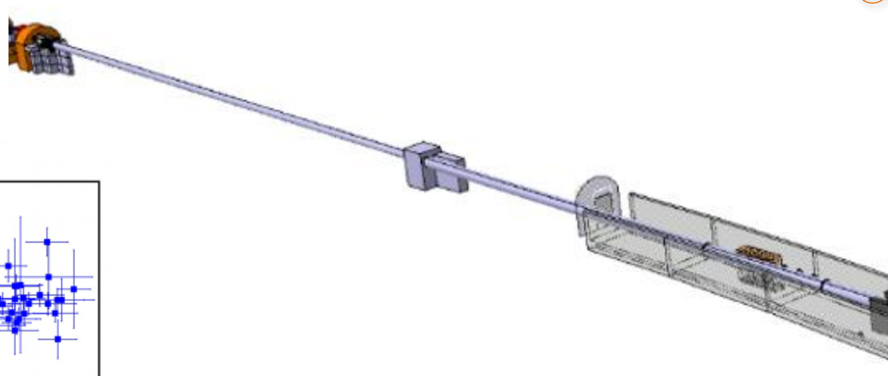
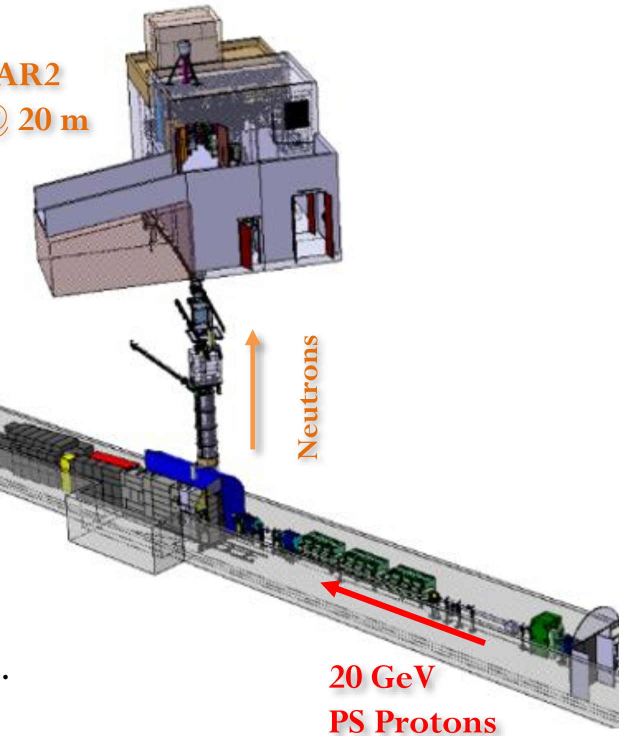
Monitoring target & neutron flux at EARs. RP for NEAR. Commissioning of Flux.

EAR2: flux versus position on the target







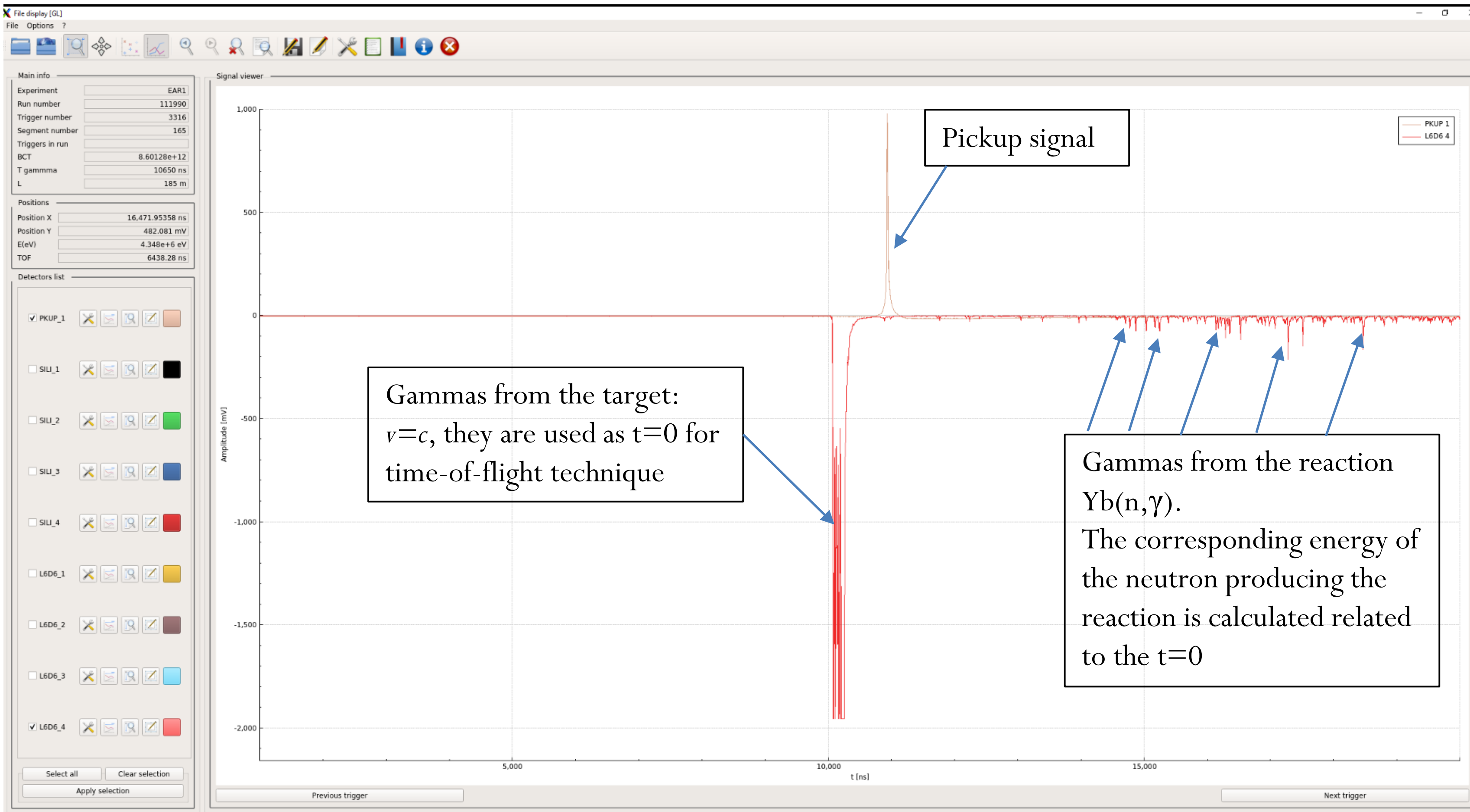



Change in the horizontal position
has not impact.
Change in the vertical position has impact.

The position has been carefully solved by PS team.

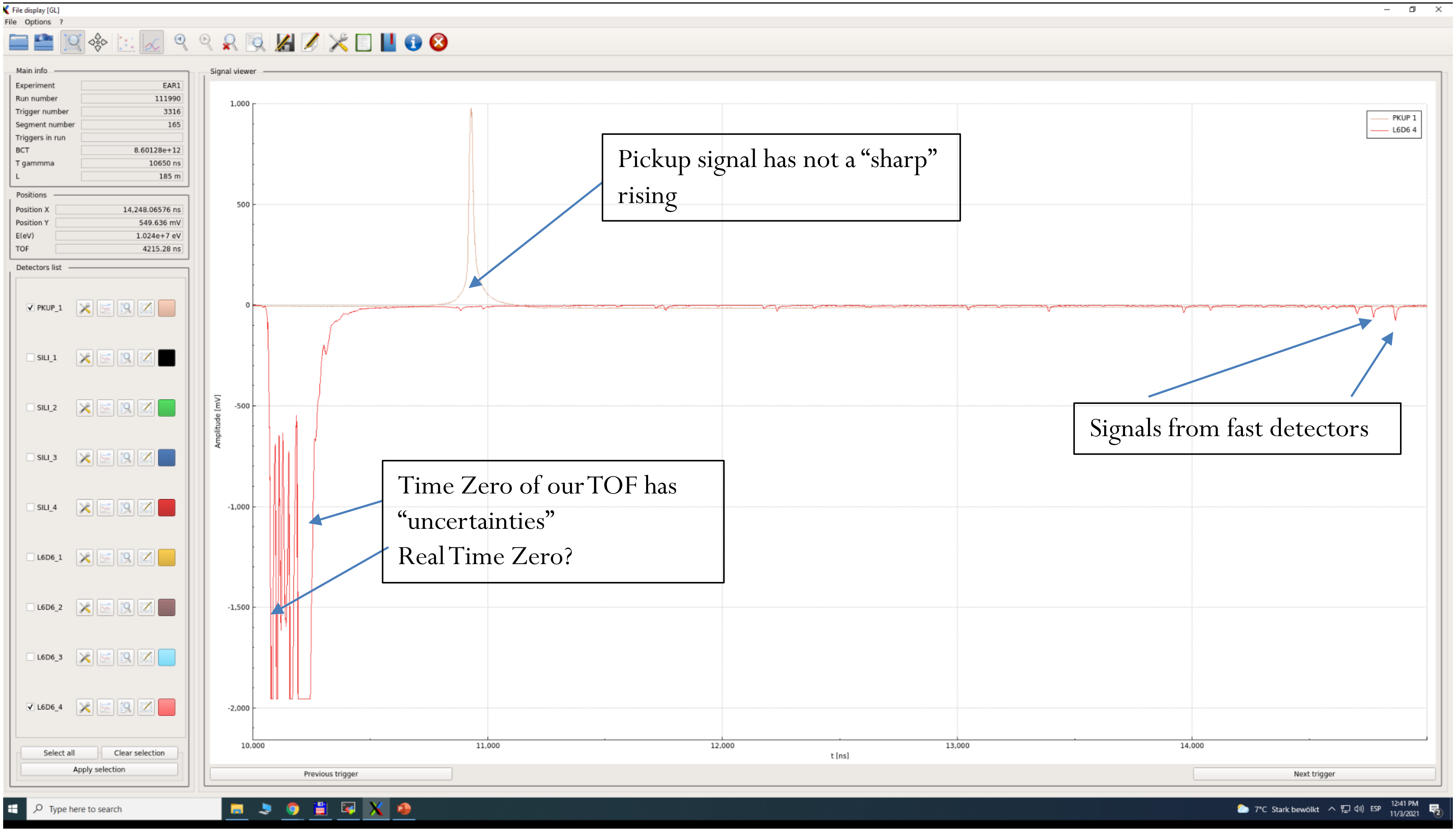
Fast detectors: what we see…

Red are signals from the detectors: all are gammas but coming from the target or from the experiment.
Brown is the pickup signal induced by the corresponding proton pulse.

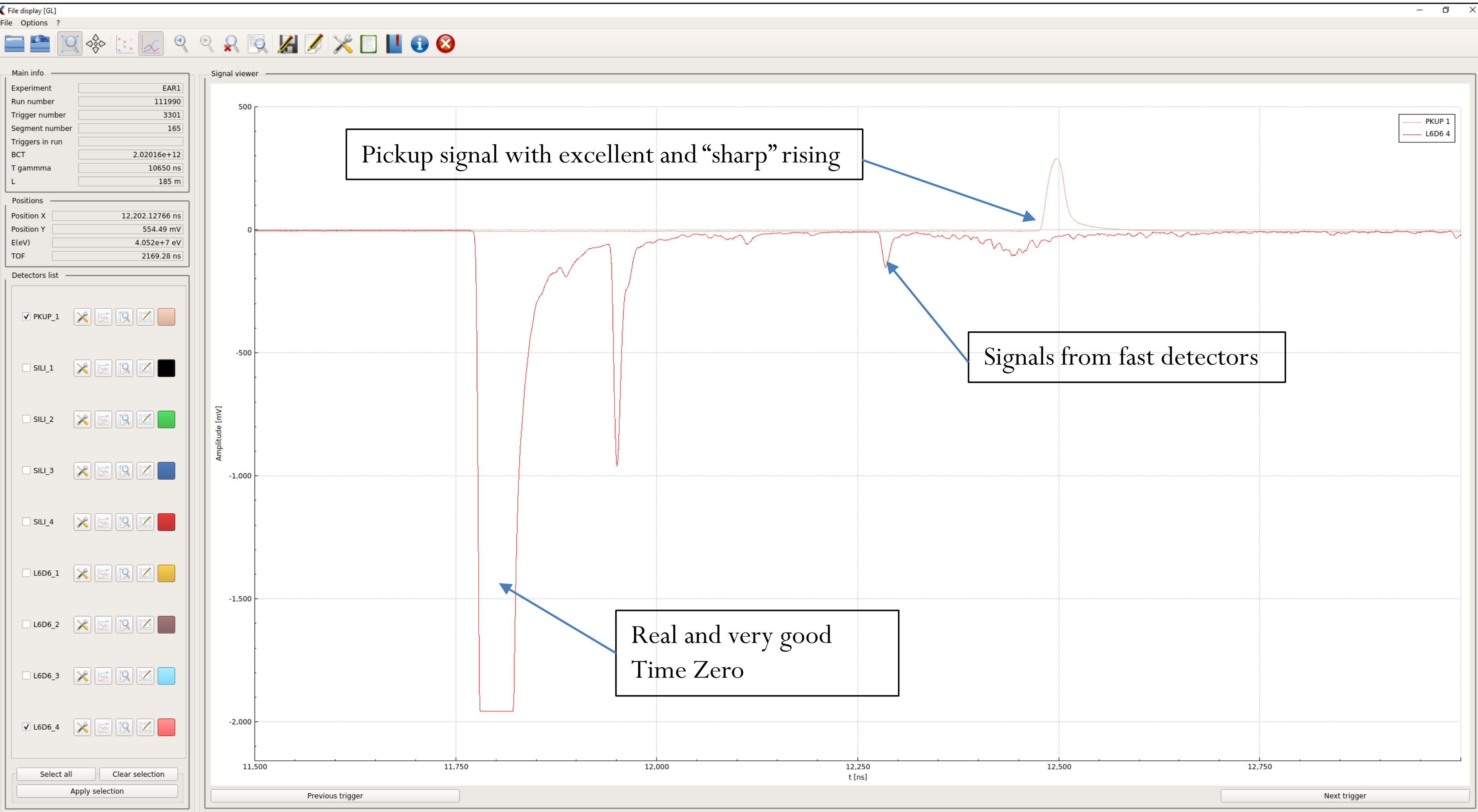


“Bad” time structure (high intensity 8.5e12ppp)

Zoom of the previous slide



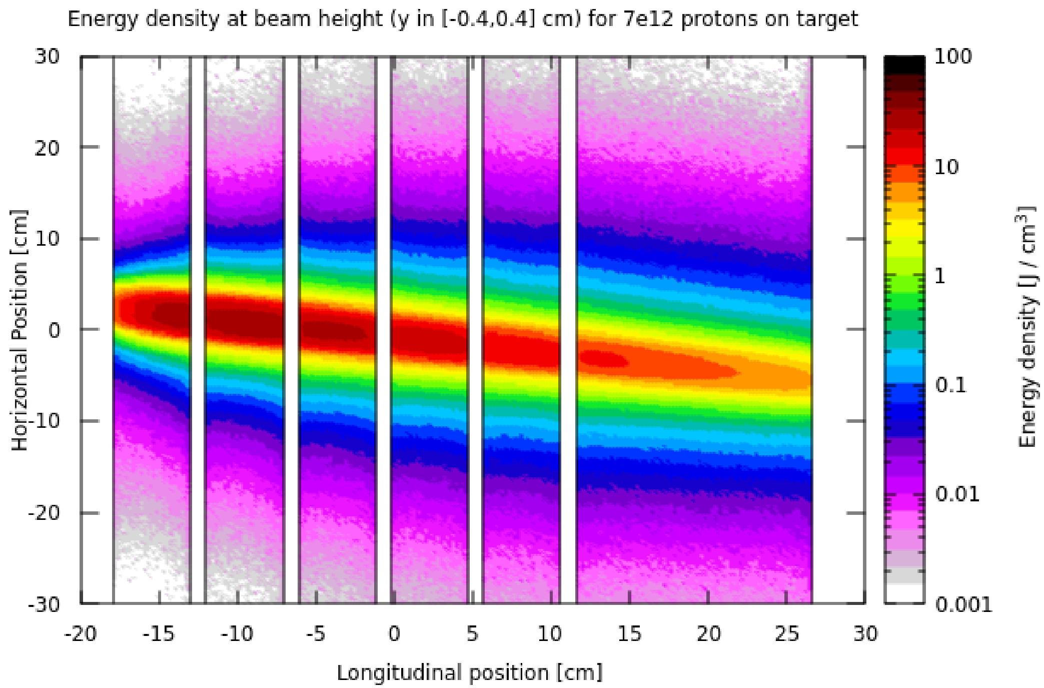
“Good” time structure (low intensity 2e12ppp)



There is a clear correlation between the pickup signal and the time structure detected

Energy deposition in the target

7e12 ppp

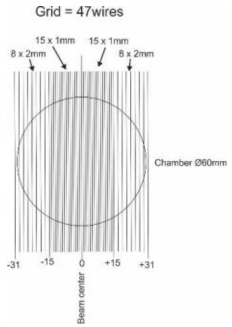


Thanks G. Lerner and V. Vlachoudis

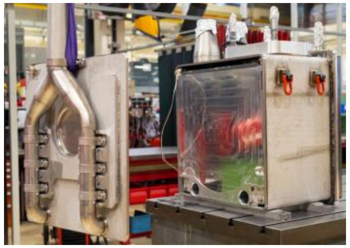
Proton beam size and position & neutron flux

Secondary Electron Monitor (SEM) will act as monitoring for the positioning and size of the proton beam. SEM was installed on the Week 5 2021 in the proton transfer line to the target (FTN).

Correlated to neutron detectors at EARs.



Temperature & proton intensity



K-thermocouples located between the Pb slices for monitoring the temperature versus proton intensity.

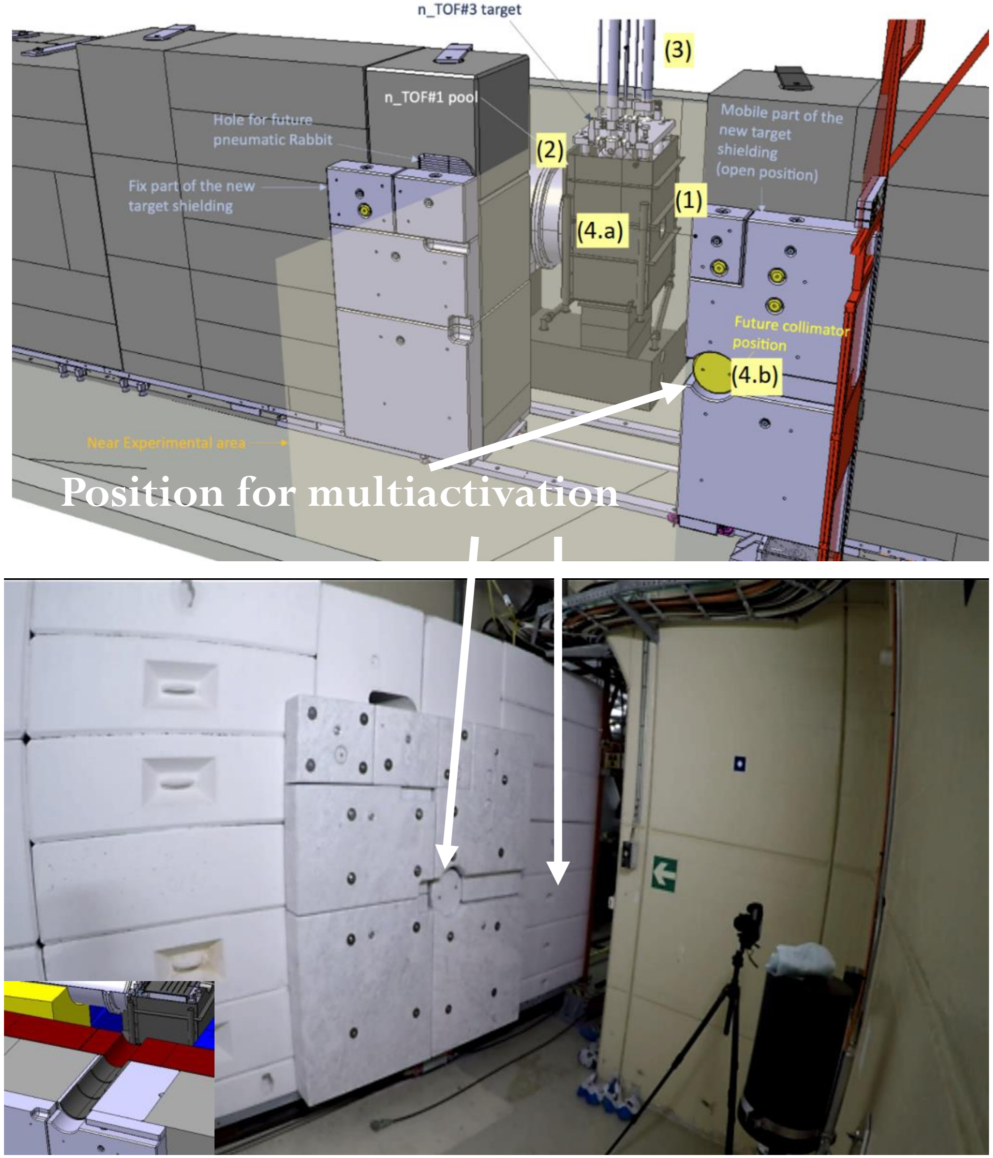
Neutron fluence with SPND

Self Powered Neutron Detectors (SPND) will be used for determining the neutron fluence in a possition close to the target.

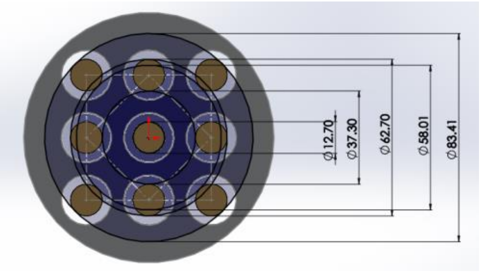
Cross-check with FLUKA and EARs data.

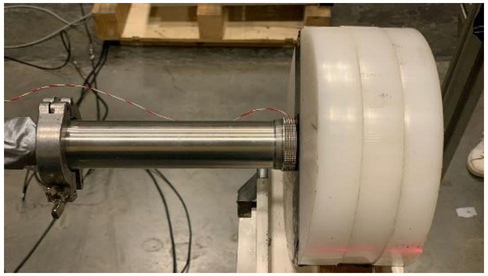
Work ongoing.

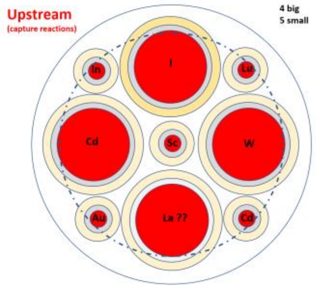
NEAR: multiactivation characterizations of the neutron flux.



Few slots are already planned for accessing NEAR for the characterization of the neutron flux and the RP conditions.







Ana-Paula Bernardes

Outlook of the proton request

- 25e17 Target +55 days * 1.05e17 p/day = 83e17 protons.

PROTON REQUEST n_TOF facility		
	EAR1 ($\cdot 10^{17}$)	**EAR2 ($\cdot 10^{17}$)**
Target Commissioning	**25**	**25**
Neutron Flux	15	21
Beam Profile	7	13
Resolution Function	14	14
Background	17	17
Total Neutron Beam Characterization	**53**	**65**
Contingency	**5**	**5**
TOTAL	**83**	**95**

Table 3. Summary of the proton request for commissioning the n_TOF facility.

Working Groups and Meetings

- Document of the Commissioning presented at the INTC (November 2020):
  - [CERN-INTC-2020-072 ; INTC-P-587.]
  - **https://cds.cern.ch/record/2737307**.
- Facility Operation Meetings (weekly). R. Steerenberg, K. Hanke.
- n_TOF Facility Commissioning Working Group (2-3 weeks). M. Calviani, J. Praena.
- n_TOF NEAR Technical Meetings (2 weeks). A. Bernardes
- n_TOF Target Installation Coordination (weekly). R. Franqueira Ximenes.
- NEAR Working Group (monthly). N. Colonna, A. Mengoni.
- Local Team Meetings (two weeks). A. Mengoni, J. Praena.