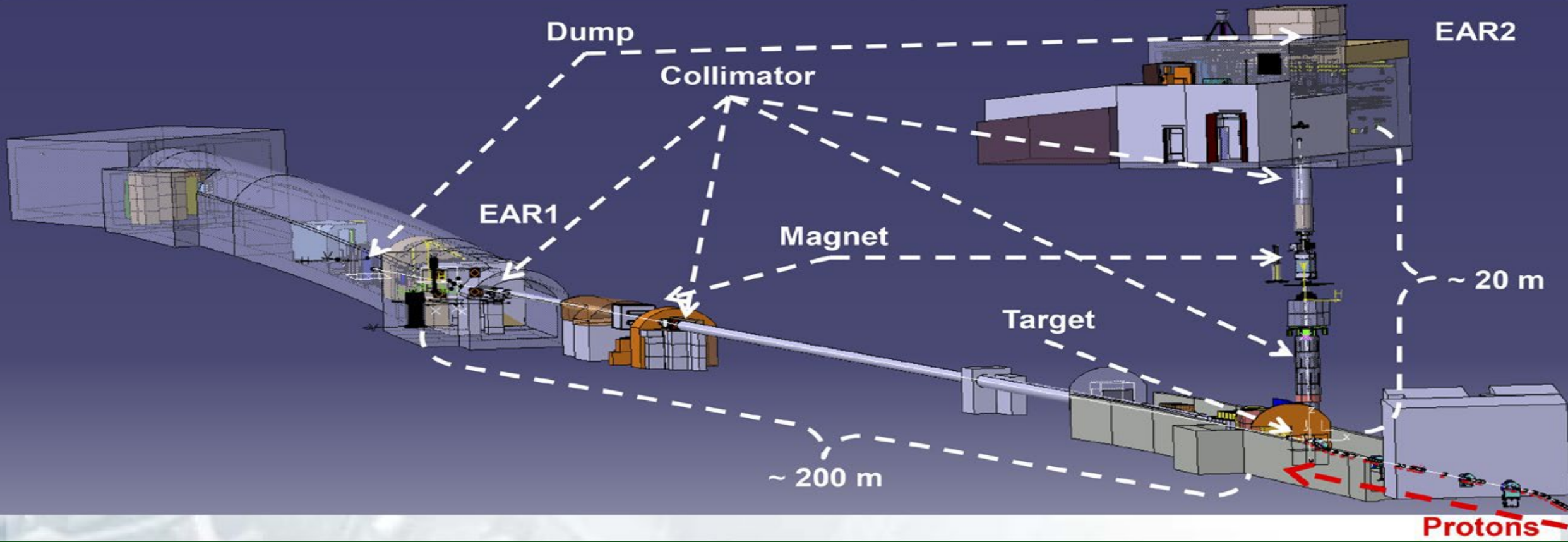


n_TOF Physics Report

77th INTC meeting
November 2024





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Stella GOULA, Alice MANNA, Alberto MENGONI, Riccardo MUCCIOLA, Michele SPELTA



The 2024 campaign

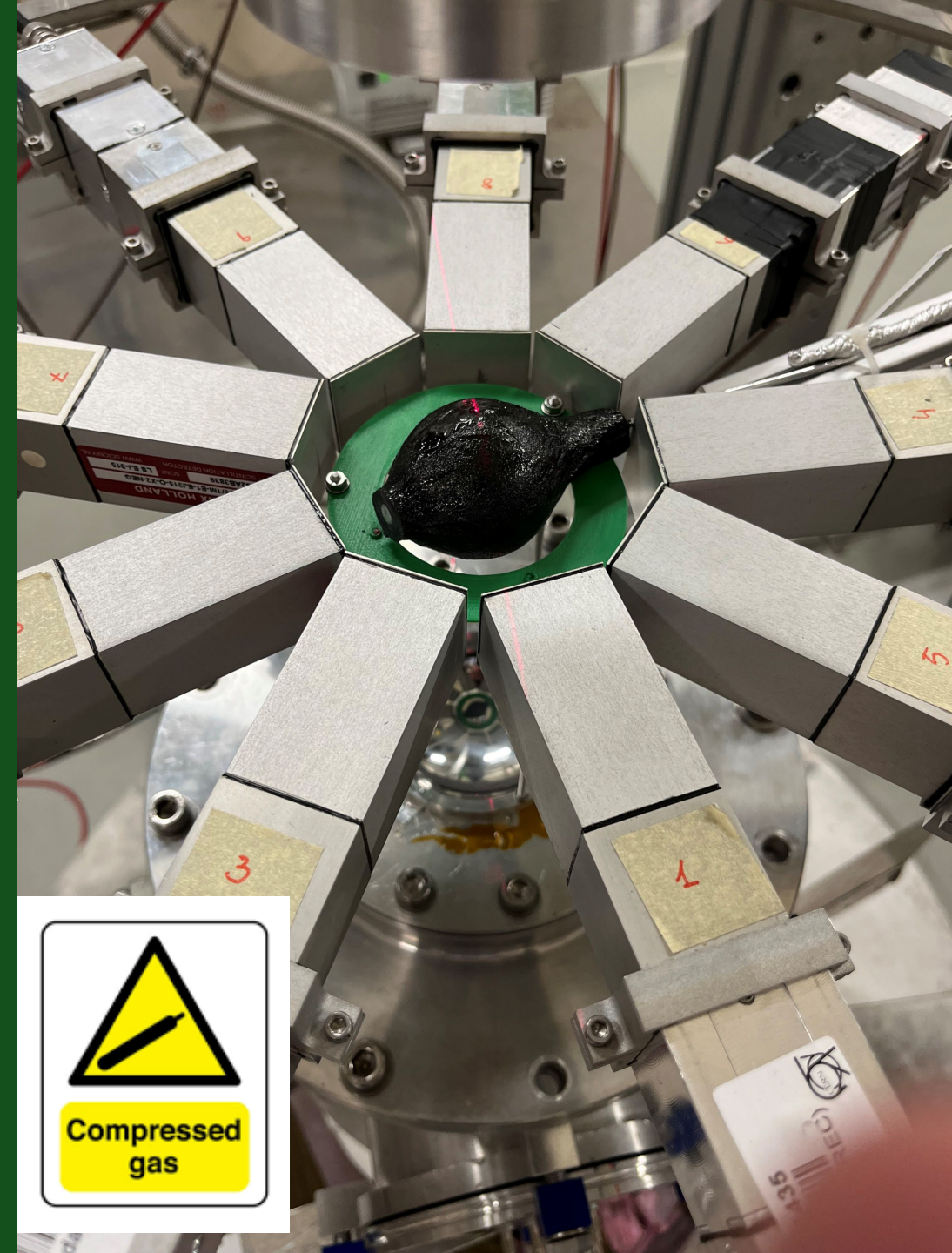
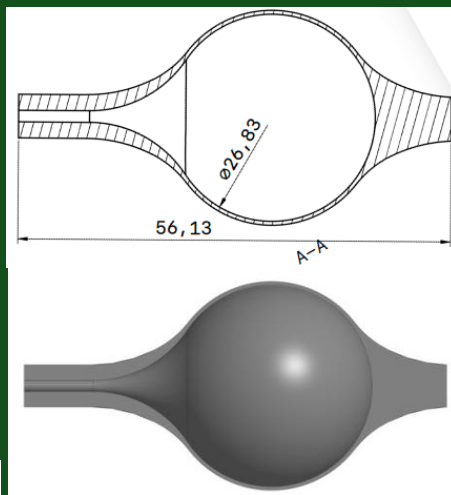
reaction	motivation	Proposal/Lol	EAR
$^{28,29,30}\text{Si}(n,\gamma)$	isotopic abundances in pre-solar grains nucleosynthesis in massive stars	INTC-P-653	1+2
$^{24}\text{Mg}(n,n'\gamma)$	HPGe + LaBr3(Ce) detector test new reaction channel investigations	INTC-I-261	1
$\text{Ce}(n,f)$	search for new fission modes in light systems around Z=60	INTC-P-665	1
$^{166,167}\text{Er}(n,\gamma)$	burnable neutron absorbers for nuclear technologies	INTC-P-656	1
$^{209}\text{Bi}(n,\gamma)$	radiological burden associated to ^{210}Po inventory termination point of the s-process nucleosynthesis	INTC-P-675	2
$^{146}\text{Nd}(n,\gamma)$	s-process nucleosynthesis in AGB stars	INTC-P-671	2
$^{88}\text{Zr}(n,\gamma)$ 	extremely large neutron absorption cross section radioactive sample with $t_{1/2} = 83.4$ d	INTC-P-693	2
$^{92,97,98}\text{Mo}(n,\gamma)$	multiple nucleosynthesis processes for different stable isotopes development of nuclear fuel for advanced nuclear reactors	INTC-P-569-ADD-1	1+2
$^{238}\text{U}(n,\gamma)$ 	key reaction for any nuclear technology applications	INTC-P-672	1
$^{63,65}\text{Cu}(n,\gamma)$	advanced nuclear technologies applications s-process nucleosynthesis about the iron peak	INTC-P-689	1
$^{40}\text{Ar}(n,\gamma)$	understanding neutron propagation in argon first capture measurement on a gas sample at n_TOF	INTC-I-256	2
$^{40}\text{K}(n,p), (n,\alpha)$	s-process nucleosynthesis in massive stars	INTC-P-645	2
$^{12}\text{C}(n,lcp)$	proton radiation therapy	INTC-P-651	1

Ar(n, γ) *With a look towards the future*

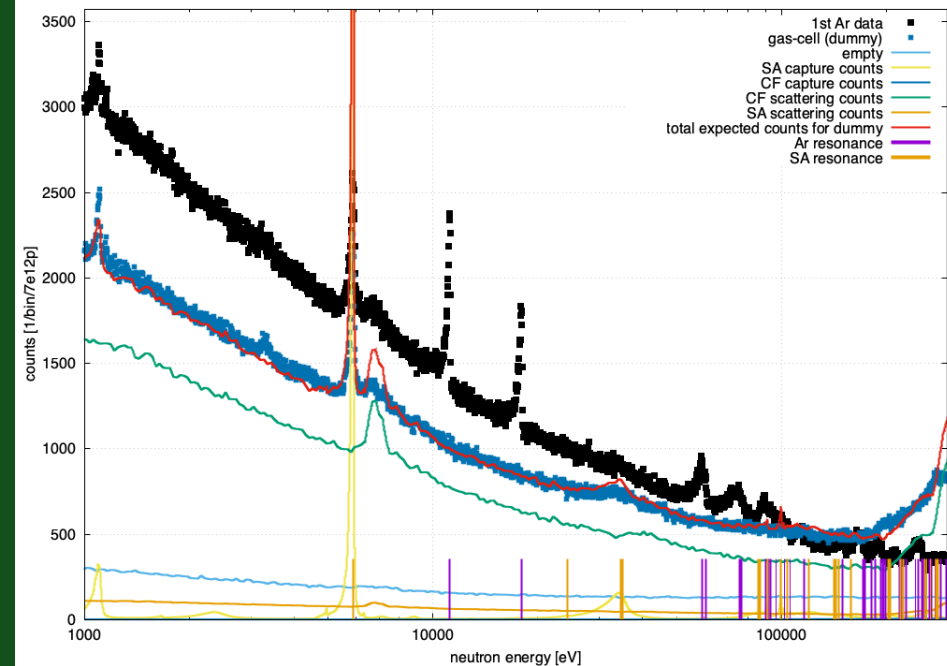
First measurement on a gas target performed at n_TOF

200 bar Argon gas-cell developed by the n_TOF Collaboration

full operation watched over by CERN safety authorities (including RP)



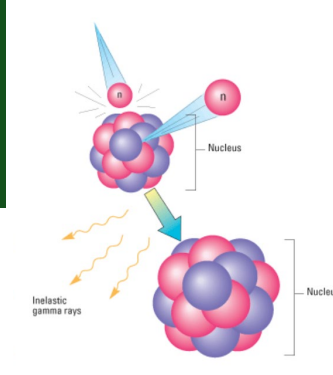
ndays: 0.1, nprotons[7.e12]: 1.4e+04, bpd : 1000, Ar-pressure: 201 bar, R-sphere: 20.0 mm, SA-thick: 0.50 mm, CF-thick: 1.20 mm, bif: 0.18



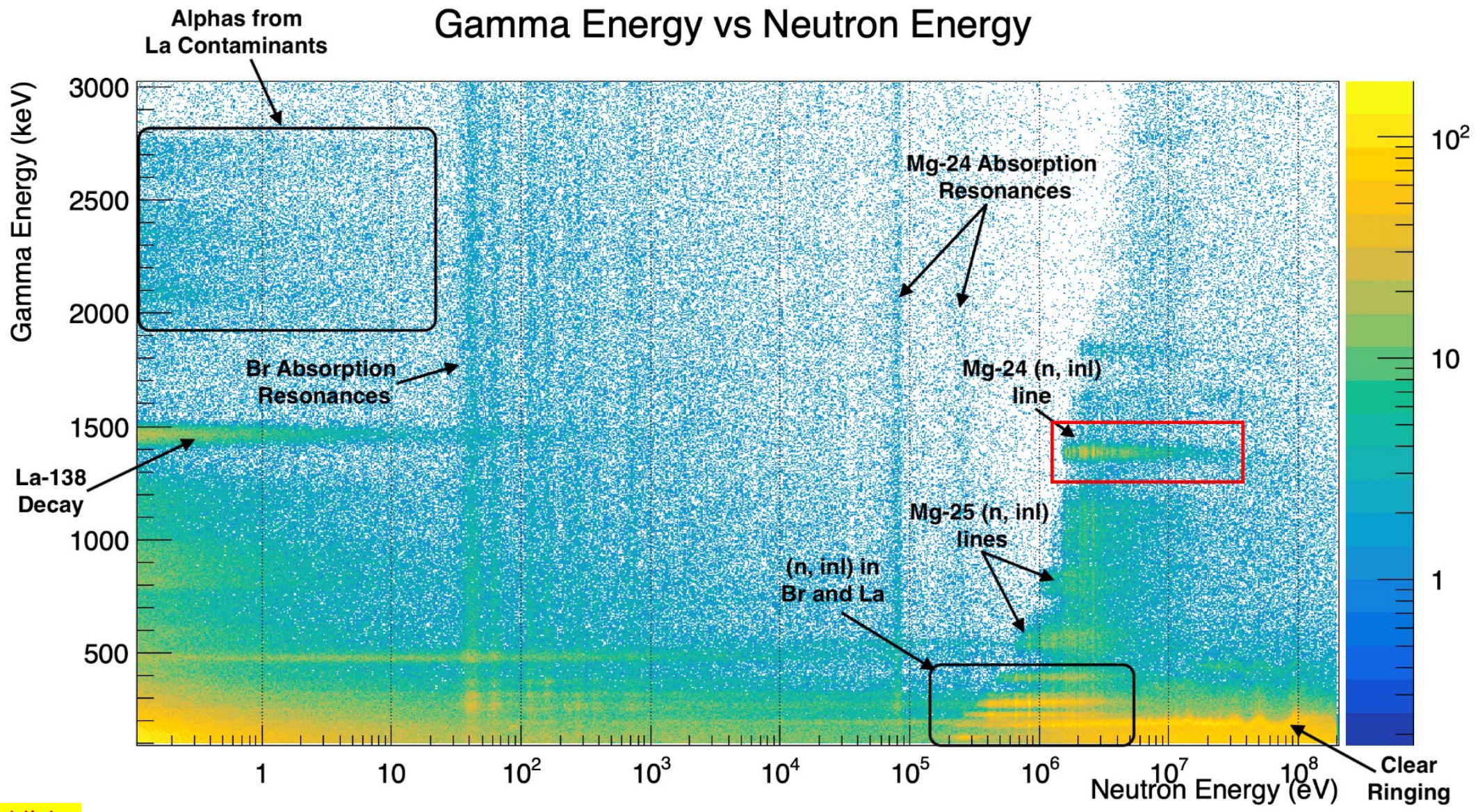
Highlights

$(n, n' \gamma)$

With a look towards the future



Gamma Energy vs Neutron Energy



Highlights

$^{88}\text{Zr}(n, \gamma)$

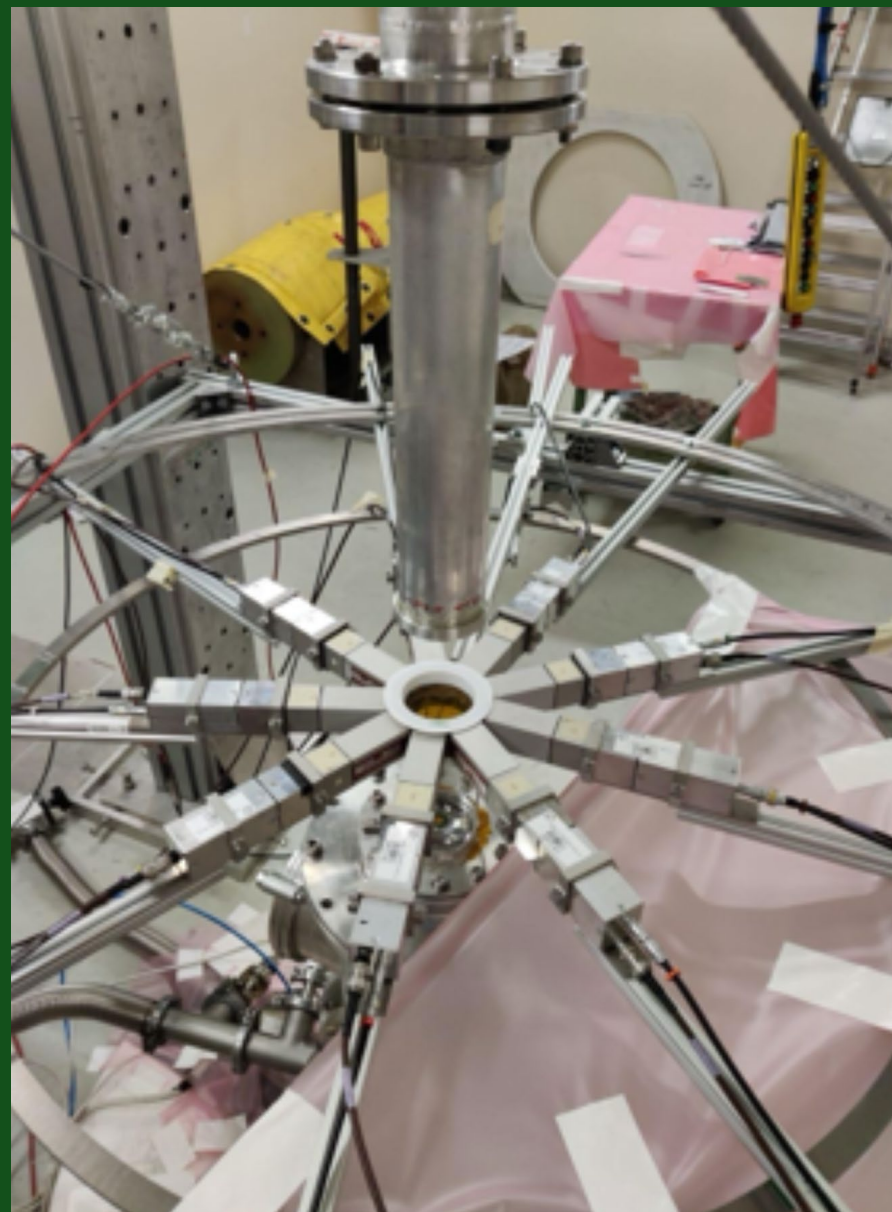
The 'special' run: 16.08 – 11.09

The Physics Case

$^{88}\text{Zr}(n, \gamma)$

- material prepared at Los Alamos
- separated at PSI
- delivered to CERN on 15 August

of atoms : 1.15×10^{16}
mass : $1.68 \mu\text{g}$
activity : 1.1 GBq
: $\sim 30 \text{ mCi}$



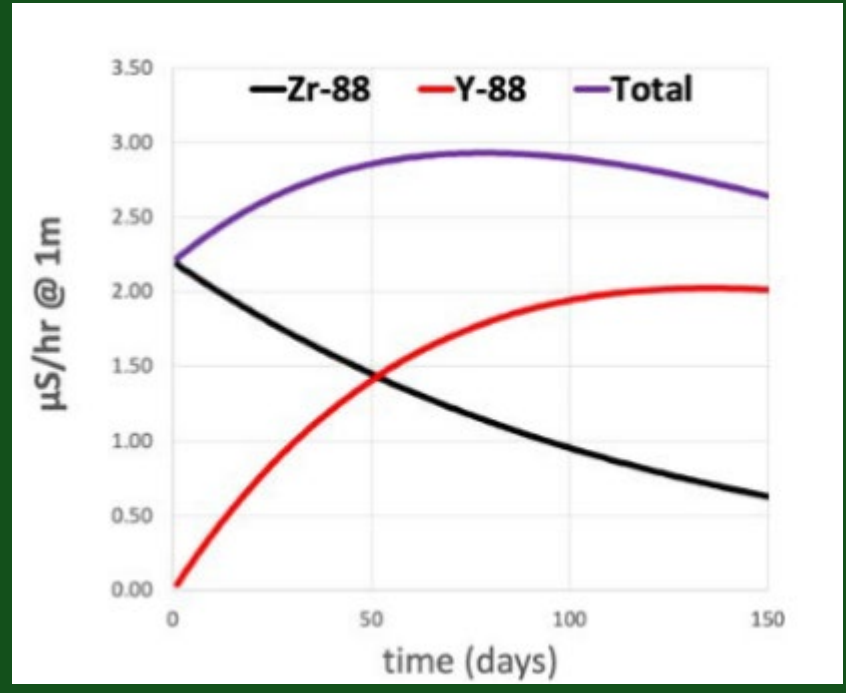
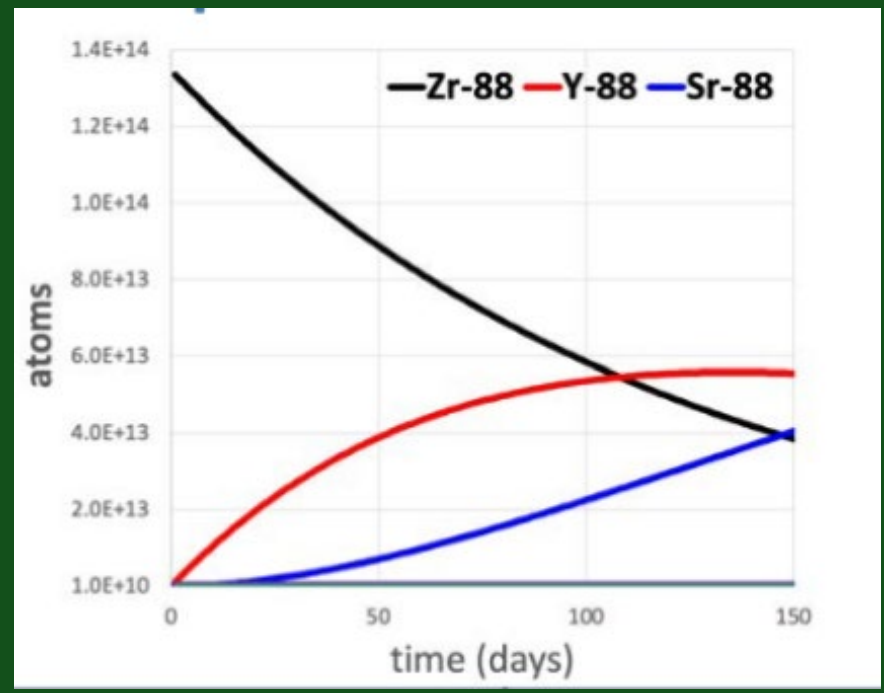
$^{88}\text{Zr}(n, \gamma)$

Highly-radiative sample, half-life of 83 days

Decrease of sample mass Vs t

Increase of activity Vs t

Zr 88 83.4 d ϵ γ 393 (n, γ)	Zr 89 78.4 h ϵ β^+ 0.9; 2.4 γ 1507; g m	Zr 90 51.45 $\alpha \sim 0.014$
Y 87 13 h ly 381 ϵ β^+ ... g	Y 88 106.6 d ϵ β^+ ... γ 1836; 896; ... m	Y 89 16.0 s 100 ly 909 α 0.001 + 1.25
Sr 86 9.86 α 0.81 + 0.23	Sr 87 2.81 h 7.00 ly 388 ϵ α 16	Sr 88 82.58 α 0.0058



Signal to background ratio (SBR) decreases Vs t

Proposal approved by the INTC, $3.0\text{E}18$ protons request
How to use them?

At day 1, signal well above the background

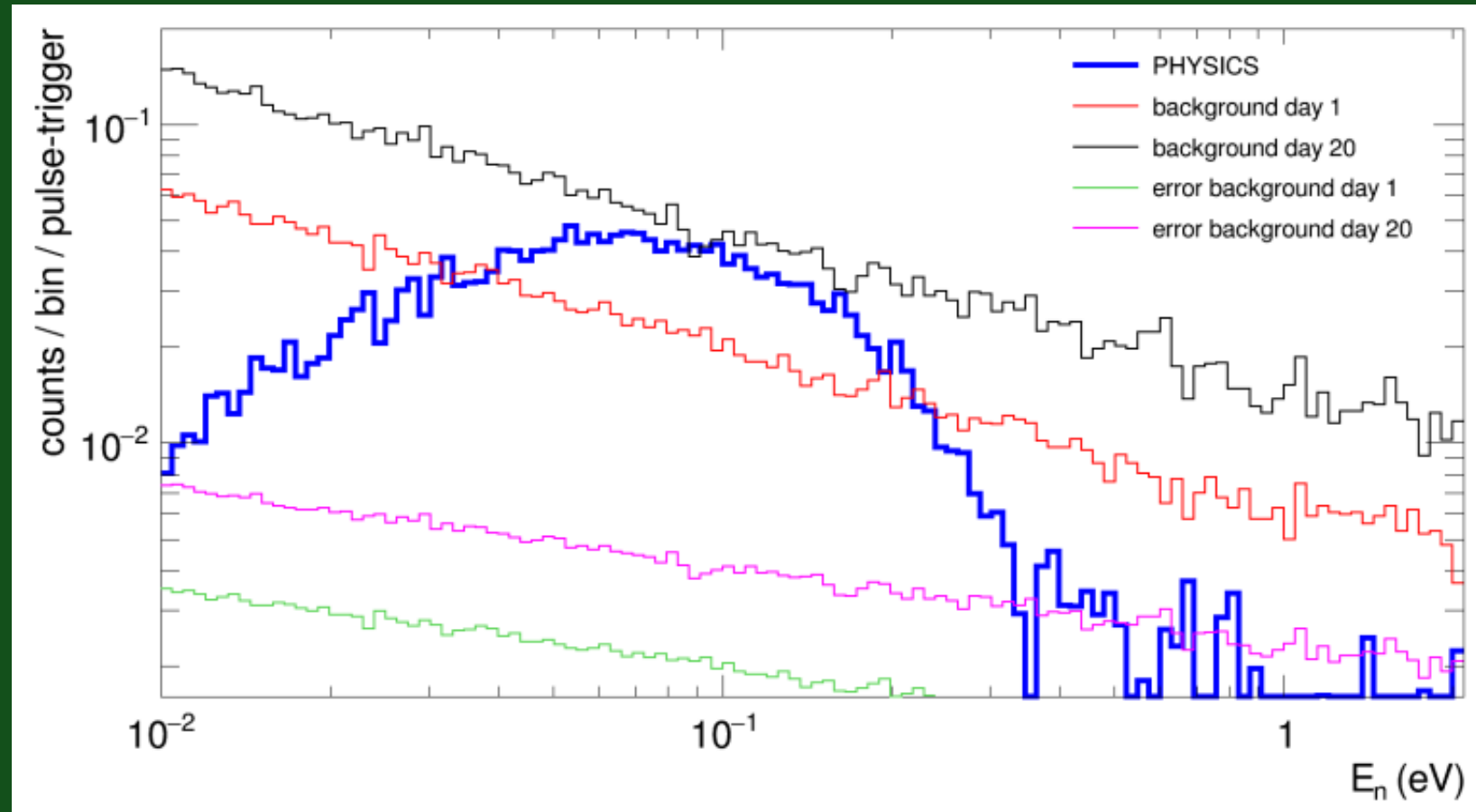
At day 20, with the 'special' PS delivery of $1.5\text{e}17$ p/d,
50% more, wrt to "nominal flux" of $1.08\text{e}17$ p/d

SBR ≈ 1

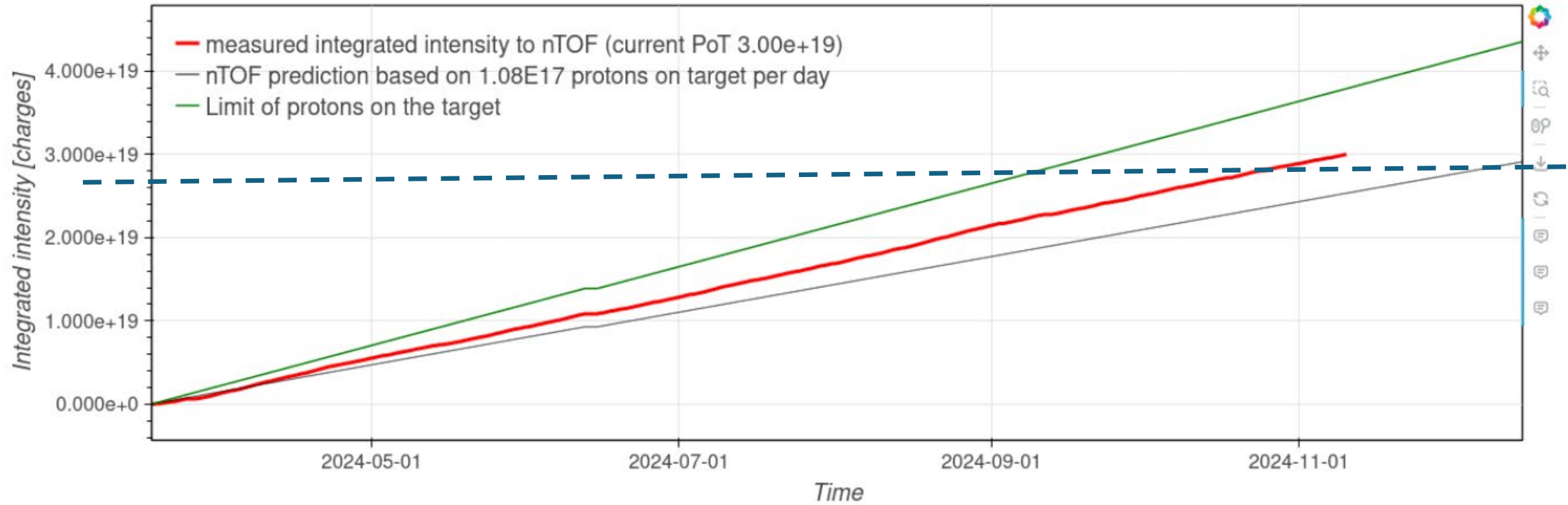
Thanks to

Dedicated bunches
 $850\text{E}10 \rightarrow 1000\text{E}10$

Parasitic bunches
 $350\text{E}10 \rightarrow 800\text{E}10$

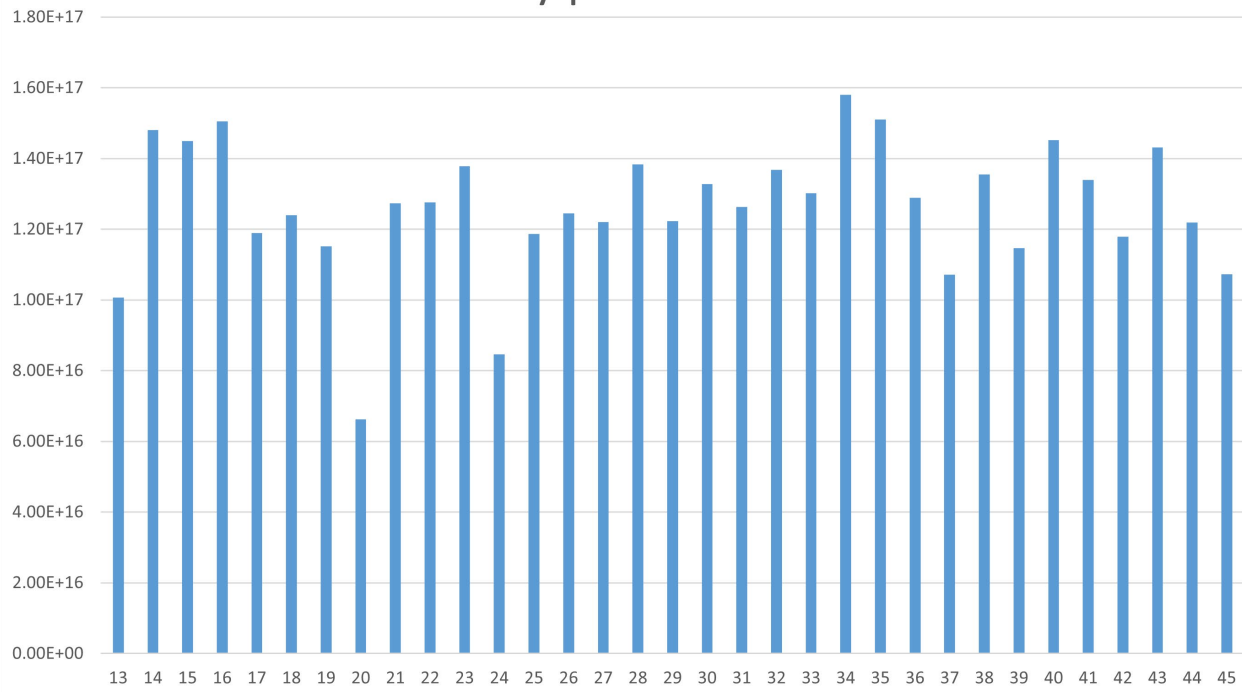


Status on 10.11 ($3.00E19$ Vs $2.65E19$, +20% PoT)



The protons bargain

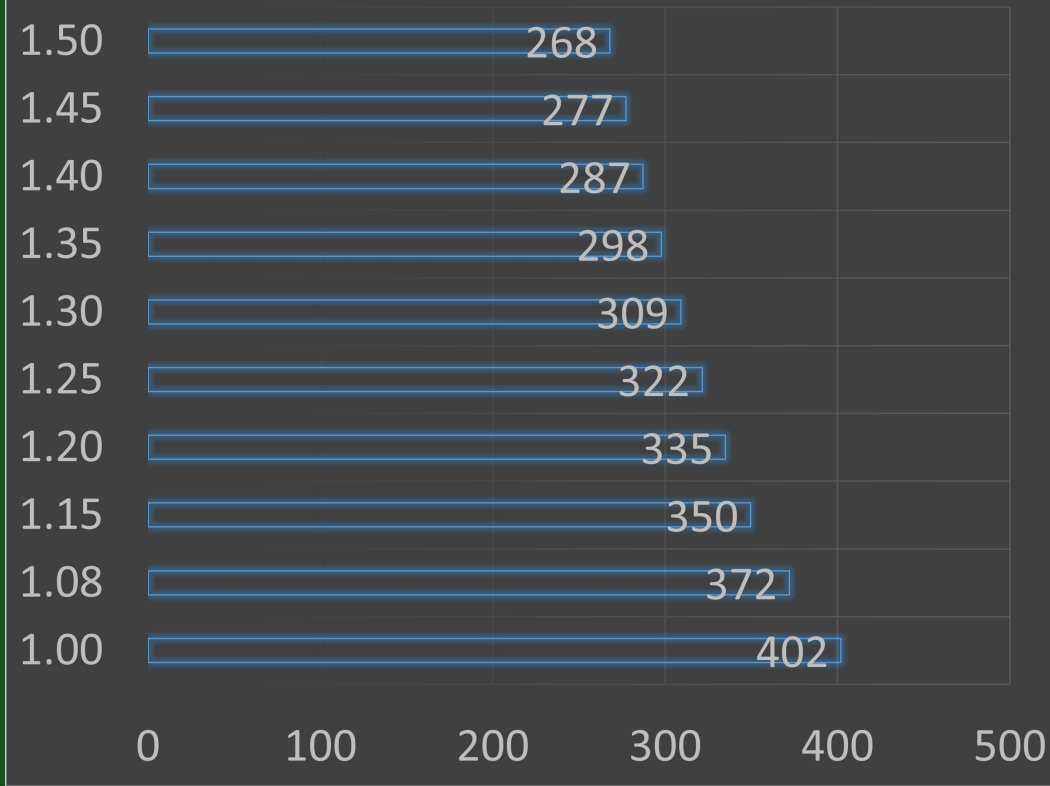
Daily protons 2024



Protons (10E17)	EAR1 (10E17 p)
Residual of already approved by the INTC (End of 2024)	293
Submitted Nov 24 INTC	109
Residual + Submitted	402

Beam Intensity (p/day - 10¹⁷)

Beam Days



RUN 2025
19/03 → 8/12
264 days

RUN 2026
20/02 → 31/08
192 days

New proposals

The neutron capture cross section of ^{124}Sn and its impact on neutrinoless double β decay searches

Speakers: Aman GANDHI, Mariam Alexandru BOROMIZA

(Horia Hulubei National Institute of Physics and Nuclear Engineering (RO))

Fast neutrons inelastic cross section on Si for space applications and fundamental research

Speaker: Cristina PETRONE (Horia Hulubei National Institute of Physics and Nuclear Engineering (RO))

Measurement of the neutron capture cross section of ^{87}Sr

Speakers: Frank GUNSING (Université Paris-Saclay (FR)) and Emilio MAUGERI (Paul Scherrer Institute (CH))

New high-resolution measurement of $^{56}\text{Fe}(n, \gamma)$ at n_TOF-EAR1 for Nuclear Astrophysics and Nuclear Technology

Speaker: Adria CASANOVAS-HOSTE (Universitat Politècnica Catalunya (ES))

Measurement of the inelastic scattering cross section of neutrons on F by γ -ray spectroscopy

Speakers: Giuseppe LORUSSO (Nuclear Physics Laboratory, Teddington (GB))

and Michael BACAK, Tobias WRIGHT (The University of Manchester (GB))

Addendum

Measurement of (n,cp) reactions in EAR1 using an enhanced experimental setup

Speaker: Styliani Goula (University of Ioannina (GR))



facilities and methods

n_TOF at CERN: Status and Perspectives

<https://doi.org/10.1080/10619127.2024.2376484>



Paper in preparation for a special issue on Universe

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Expression of Interest to the SPS and PS Experiments Committee

Neutron Activation Station at the SPS Beam Dump Facility
(BDF)

October 18, 2024

EoI to SPSC

Full list of n_TOF publications: <https://twiki.cern.ch/NTOFPublic/ListOfPublications>

PHYSICAL REVIEW LETTERS 133, 052702 (2024)

Shedding Light on the Origin of ^{204}Pb , the Heaviest *s*-Process-Only Isotope in the Solar System

A. Casanovas-Hoste^{1,2,3,*}, C. Domingo-Pardo,² J. Lerendegui-Marco,⁴ C. Guerrero,⁴ A. Tarifeño-Saldivia,² M. Krtička,⁵ M. Pignatari,^{6,7,8,9} F. Calviño,¹ D. Schumann,¹⁰ S. Heinitz,¹⁰ R. Dressler,¹⁰ U. Köster,¹¹ O. Aberle,³ J. Andrzejewski,¹² L. Audouin,¹³ V. Bécáres,¹⁴ M. Bacak,¹⁵ J. Balibrea-Correa,¹⁴ M. Barbagallo,¹⁶ S. Barros,¹⁷ F. Bečvář,⁵ C. Beinrucker,¹⁸ E. Berthoumieux,¹⁹ J. Billowes,²⁰ D. Bosnar,²¹ M. Brugger,³ M. Caamaño,²² M. Calviani,³ D. Cano-Ott,¹⁴ R. Cardella,³ D. M. Castelluccio,^{23,24} F. Cerutti,³ Y. H. Chen,¹³ E. Chiaveri,³ N. Colonna,¹⁶ G. Cortés,¹ M. A. Cortés-Giraldo,⁴ L. Cosentino,²⁵ L. A. Damone,^{16,26} M. Diakaki,¹⁹ E. Dupont,¹⁹ I. Durán,²² B. Fernández-Domínguez,²² A. Ferrari,³ P. Ferreira,¹⁷ P. Finocchiaro,²⁵ V. Furman,²⁷ K. Göbel,¹⁸ A. R. García,¹⁴ A. Gawlik-Ramięga,¹² T. Glodariu,^{28,†} I. F. Gonçalves,¹⁷ E. González-Romero,¹⁴ A. Goverdovski,²⁹ E. Griesmayer,¹⁵ F. Gunsing,^{19,3} H. Harada,³⁰ T. Heftrich,²⁸ J. Heyse,³¹ D. G. Jenkins,³² E. Jericha,¹⁵ F. Käppeler,^{33,‡} Y. Kadi,³ T. Katabuchi,³⁴ P. Kavargin,¹⁵ V. Ketlerov,²⁹ V. Khryachkov,²⁹ A. Kimura,³⁰ N. Kivel,¹⁰ M. Kokkoris,³⁵ E. Leal-Cidoncha,²² C. Lederer-Woods,³⁶ H. Leeb,¹⁵ S. Lo Meo,^{23,24} S. J. Lonsdale,³⁶ R. Losito,³ D. Macina,³ J. Marganiec,¹² T. Martínez,¹⁴ C. Massimi,^{24,37} P. Mastinu,³⁸ M. Mastroianni,¹⁶ F. Matteucci,^{39,40} E. A. Mauger, ¹⁰ E. Mendoza,¹⁴ A. Mengoni,²³ P. M. Milazzo,³⁹ F. Mingrone,²⁴ M. Mirea,^{28,†} S. Montesano,³ A. Musumarra,^{25,41} R. Nolte,⁴² A. Oprea,²⁸ N. Patronis,⁴³ A. Pavlik,⁴⁴ J. Perkowski,¹² I. Porras,^{3,45} J. Praena,^{4,45} J. M. Quesada,⁴ K. Rajeev,⁴⁶ T. Rauscher,^{47,48} R. Reifarth,¹⁸ A. Riego-Perez,⁴⁹ Y. Romanets,¹⁷ P. C. Rout,⁴⁶ C. Rubbia,³ J. A. Ryan,²⁰ M. Sabaté-Gilarte,^{3,4} A. Saxena,⁴⁶ P. Schillebeeckx,³¹ S. Schmidt,¹⁸ P. Sedyshev,²⁷ A. G. Smith,²⁰ A. Stamatopoulos,³⁵ G. Tagliente,¹⁶ J. L. Tain,² L. Tassan-Got,¹³ A. Tsinganis,³⁵ S. Valenta,⁵ G. Vannini,^{24,37} V. Variale,¹⁶ P. Vaz,¹⁷ A. Ventura,²⁴ V. Vlachoudis,³ R. Vlastou,³⁵ A. Wallner,⁵⁰ S. Warren,²⁰ M. Weigand,¹⁸ C. Weiss,^{3,15} C. Wolf,¹⁸ P. J. Woods,³⁶ T. Wright,²⁰ and P. Žugec^{21,3}

(n_TOF Collaboration)

<https://doi.org/10.1103/PhysRevLett.133.052702>

Conclusions

Excellent year

13 experiments performed [9 (n, γ), 1 (n, f), 2 (n, lcp), 1 (n, n' γ)]

Road to new measurements successfully paved
(gas samples, inelastic scattering, high radioactivity sample...)

Several detector developments

Significant increase of proton beam intensity

+20% of protons received wrt what expected

Daily brainstorming

