Neutron-Induced Reaction Measurements at n_TOF for Astrophysics

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Why neutron interactions matter

Neutron-induced reactions govern the **production, transformation and destruction** of nuclei across **multiple scientific and technological fields.**

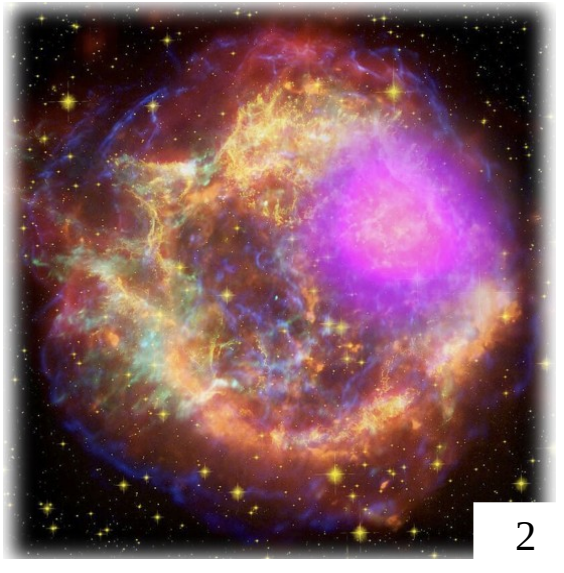


Nuclear Astrophysics

Nucleosynthesis and stellar reaction rates

Nuclear Technology

Reactor calculations, fuel cycles, transmutation.



Nuclear Medicine & Industry

Isotope production, dosimetry and BNCT

Fundamental Nuclear Physics

Nuclear structure, resonance properties and reaction mechanisms

Neutron-induced reactions

Features

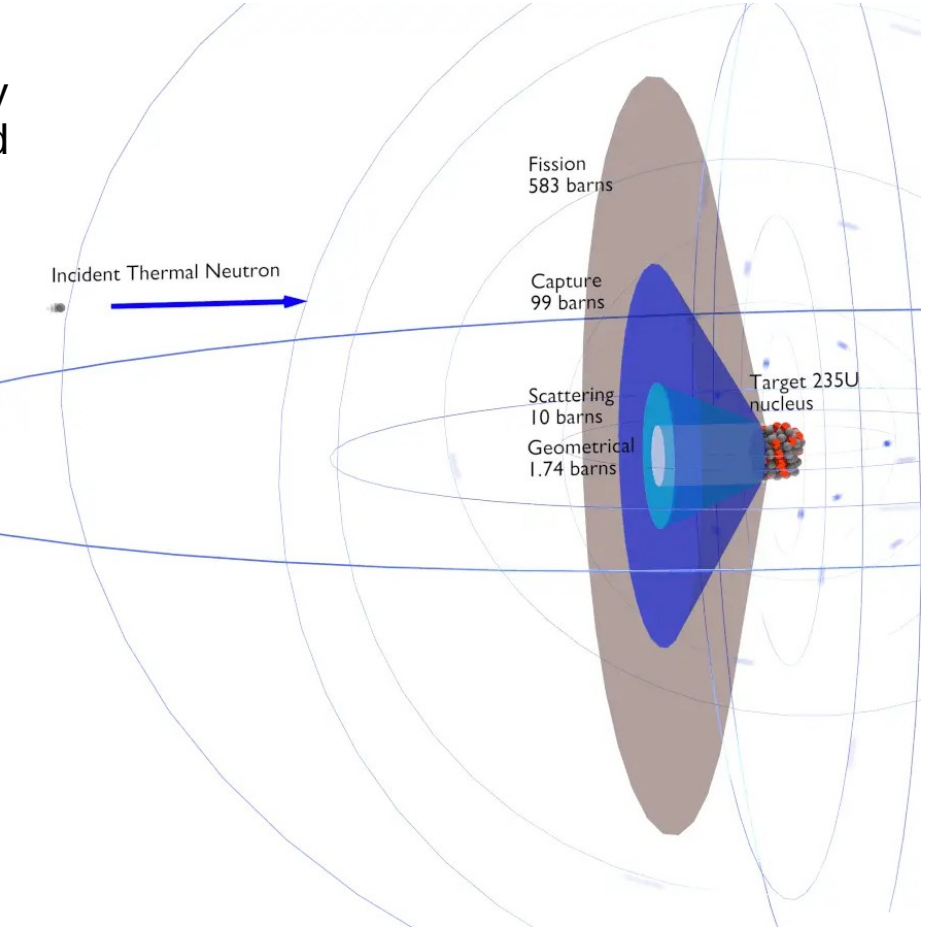
- No Coulomb barrier.
- Reaction probabilities strongly depend on neutron energy and nuclear structure.

Challenges

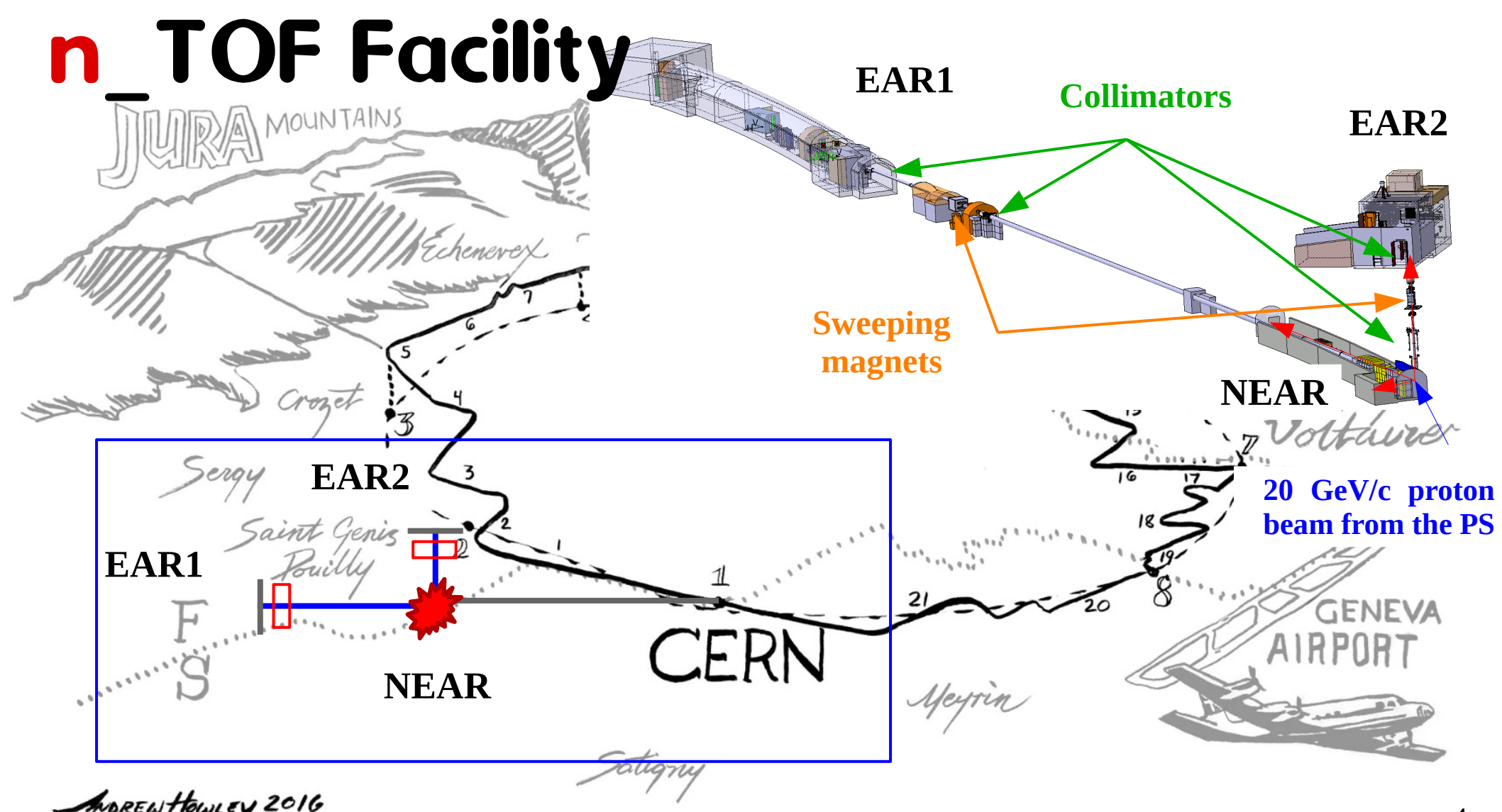
- Neutrons must be produced indirectly and cannot be accelerated or focused electromagnetically.
- Scattered neutrons and beam-related radiation generate background.

Requirements

- Intense, well-characterised neutron field.
- Appropriate energy spectrum and time structure.
- Detection system selective to the reaction products.

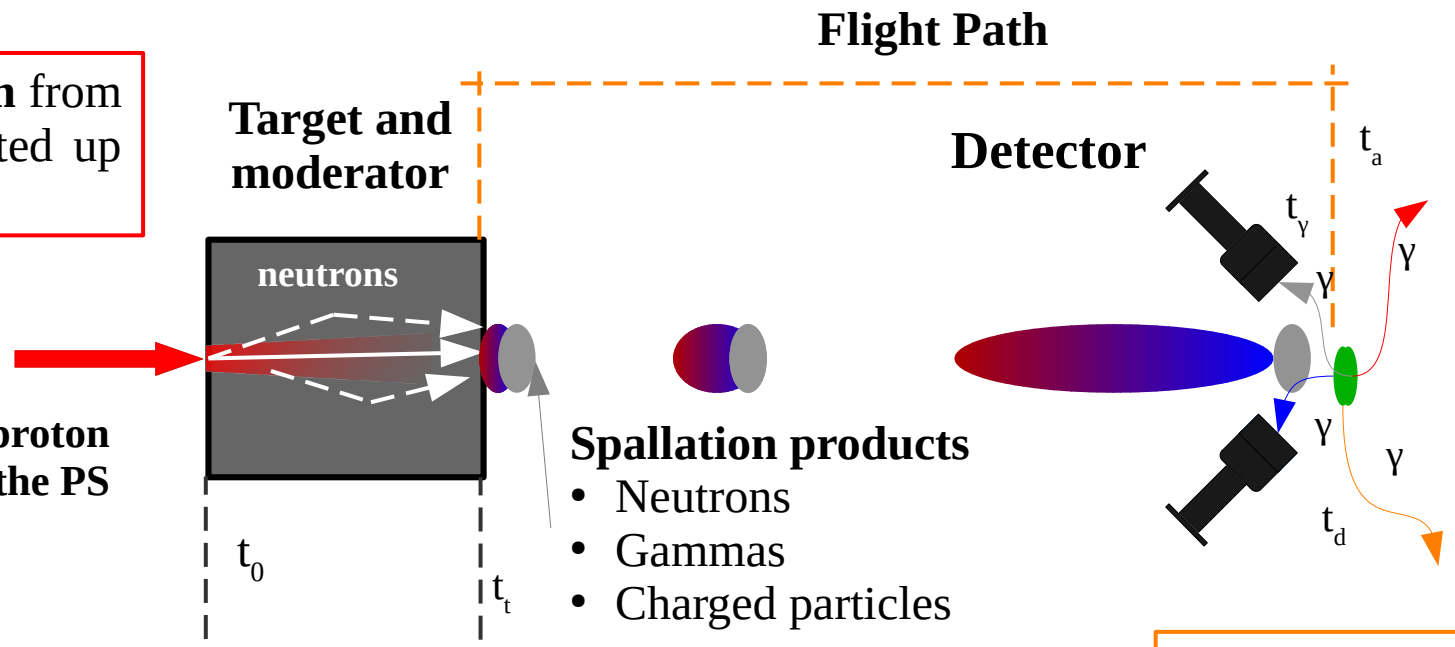


n_TOF Facility



TOF – Time of Flight

Proton beam from PS. accelerated up to **20 GeV/c**.



The **proton pulse defines** the reference time, $\mathbf{t_0}$, for **neutron production**.

The **moderation time**, $\mathbf{t_t}$, is the time that neutrons spend **travelling** through the **target and moderator.**

The **arrival time**, $\mathbf{t_a}$, is the time when **neutrons are captured** in the sample.

n_TOF Facility

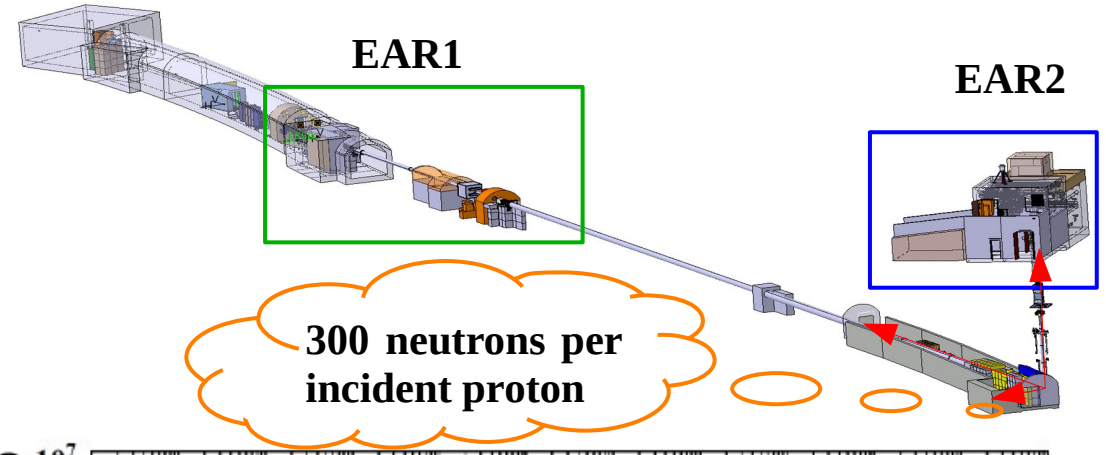
***n**eutron **T**ime **O**f **F**light*

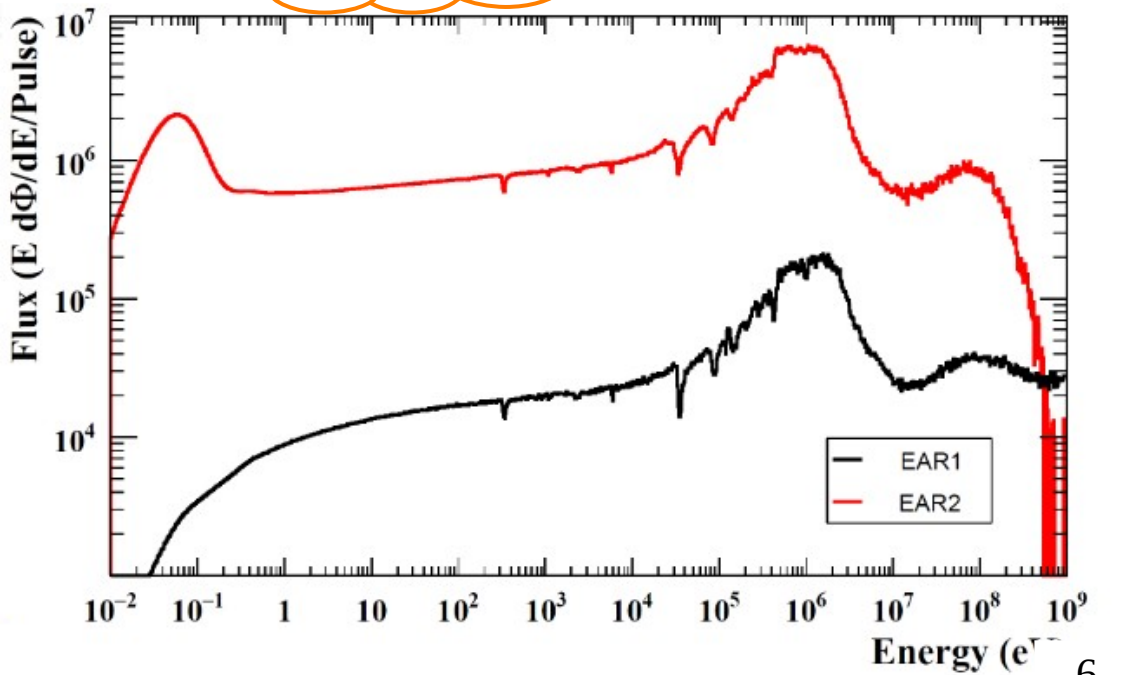
EAR1

- High neutron flux.
- 185 m flight path.
- Low background.
- Very high resolution.

EAR2

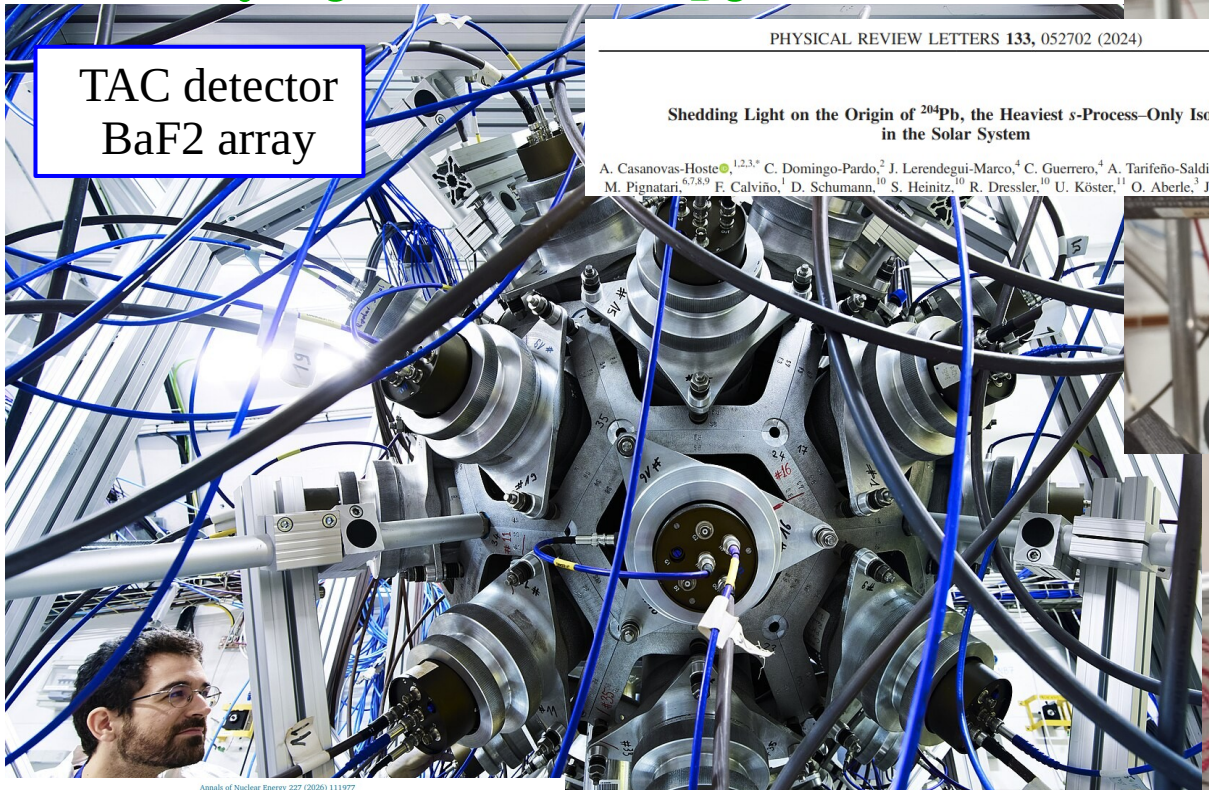
EAR2 (2014)
- Very high flux.
- 20 m flight path.
- Higher background.
- Lower neutron energy resolution.

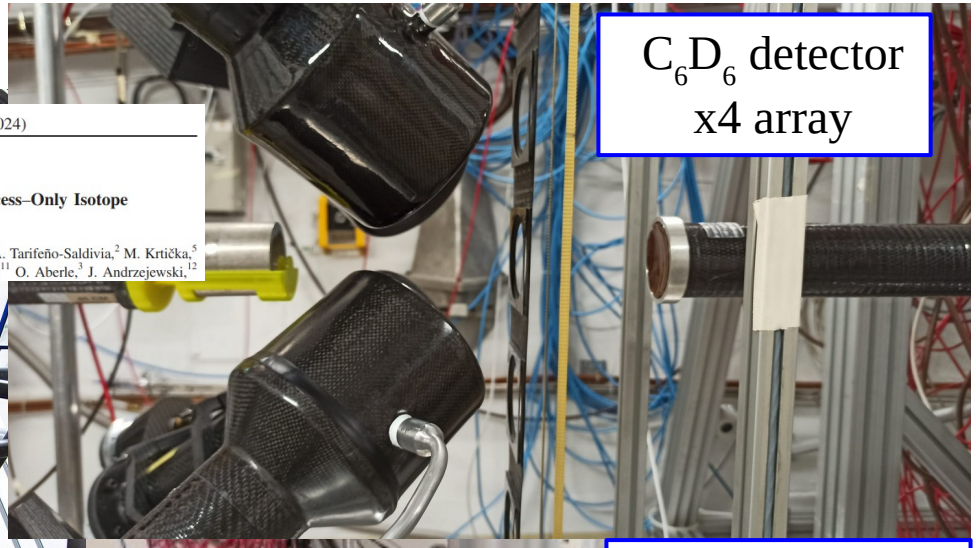


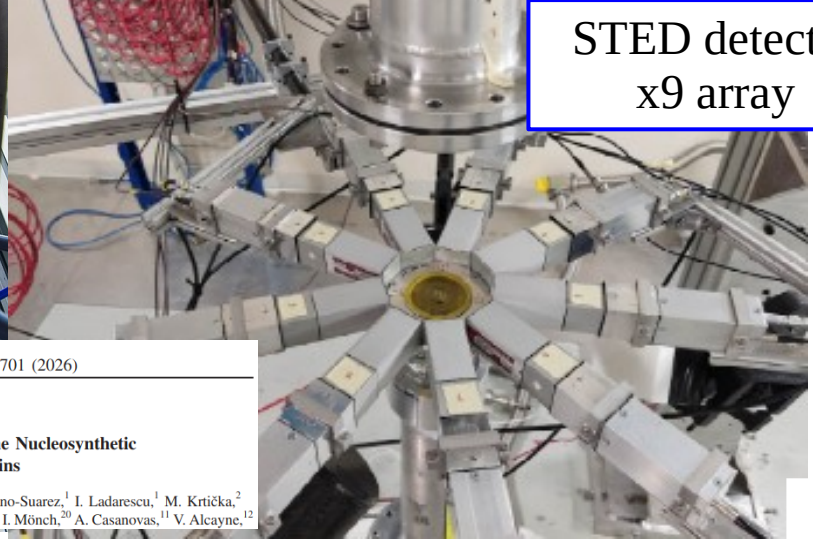


Setups for (n,γ) reactions

Astrophysics, Energy, Medicine







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]

Annals of Nuclear Energy 227 (2026) 111977

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Measurement of the ^{244}Cm neutron capture cross section at the n_TOF facility at CERN

V. Alcayne [1], *, A. Kimura [2], E. Mendoza [1], D. Cano-Ott [1], O. Aberle [3], F. Álvarez-Velarde [1], S. Amaducci [4,5], J. Andrzejewski [6], L. Audouin [7], V. Babiano-Suarez [8], M. Bacak [3,9,10],

PHYSICAL REVIEW LETTERS **137,** 082701 (2026)

First ^{94}Nb(n,γ) Measurement: Constraining the Nucleosynthetic Origin of ^{94}Mo in Presolar Grains

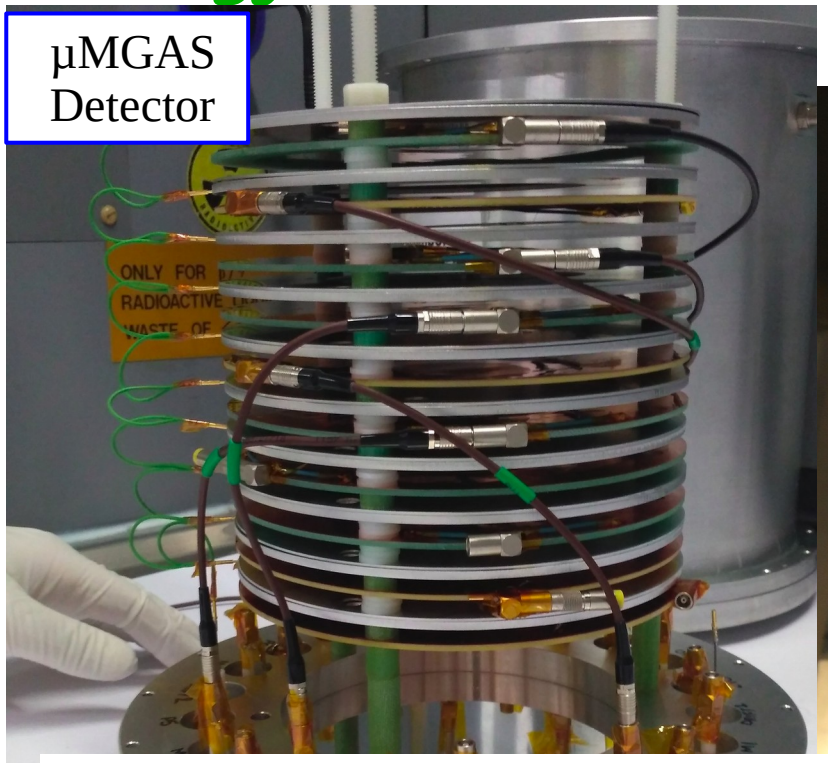
J. Balibrea-Correa,[1,†] J. Lerendegui-Marco,[1] C. Domingo-Pardo,[1] V. Babiano-Suarez,[1] I. Ladarescu,[1] M. Krtička,[2] G. Cescutti,[3,4] S. Cristallo,[5,6] D. Vescovi,[7,6] N. Liu,[8] E. A. Maugeri,[9] U. Köster,[10] I. Mönch,[20] A. Casanovas,[11] V. Alcayne,[12]

Setups for (n,cp) reactions

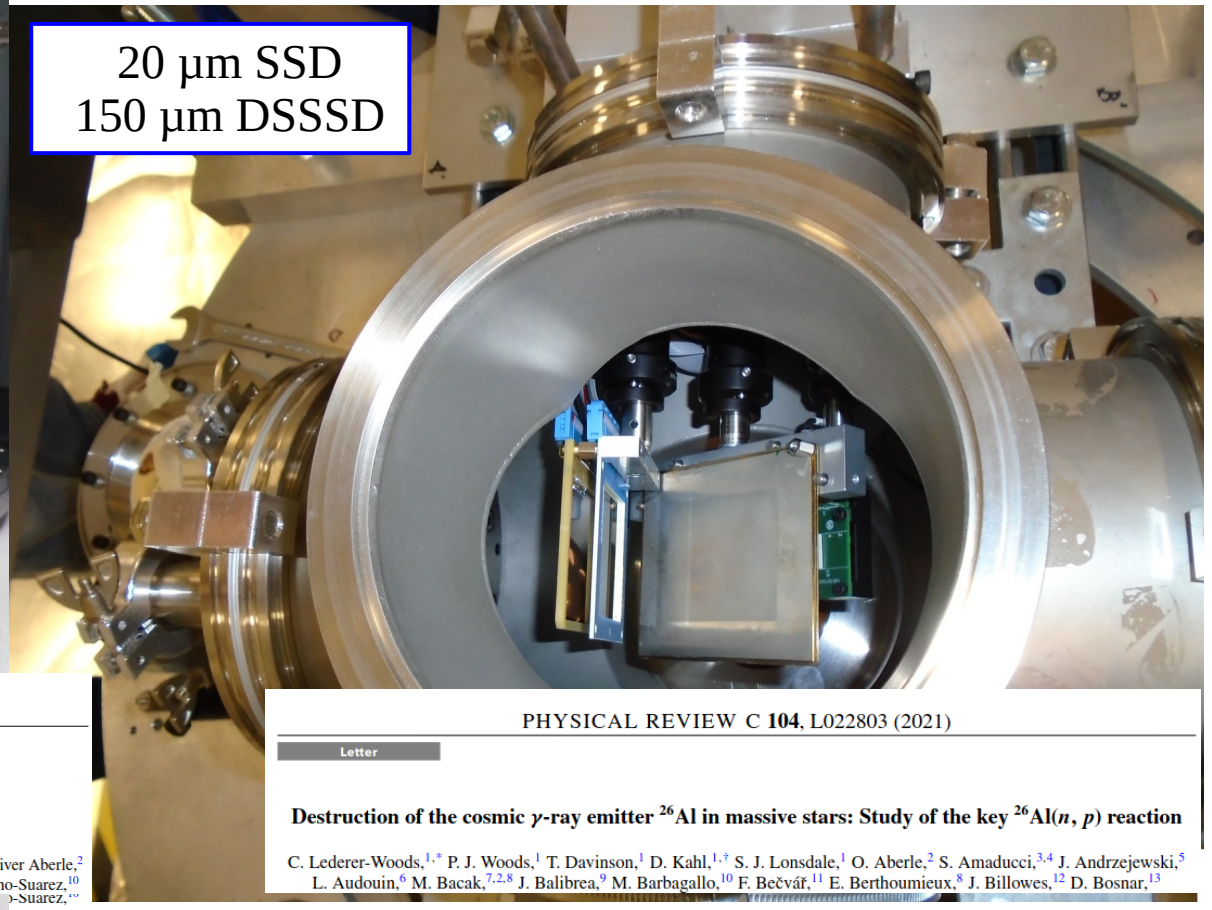
Energy, Medicine, Astrophysics

Silicon detector setups for charged-particle discrimanation

µMGAS Detector



20 µm SSD
150 µm DSSSD



PHYSICAL REVIEW C **107**, 064617 (2023)

Measurement of the ^{14}N(n, p)^{14}C cross section at the CERN n_TOF facility from subthermal energy to 800 keV

Pablo Torres-Sánchez,[1,*] Javier Praena,[1] Ignacio Porras,[1] Marta Sabaté-Gilarte,[2,3] Claudia Lederer-Woods,[4] Oliver Aberle,[2] Victor Alcayne,[5] Simone Amaducci,[6,7] Józef Andrzejewski,[8] Laurent Audouin,[9] Vicente Bécares,[5] Victor Babiano-Suarez,[10]

PHYSICAL REVIEW C **104**, L022803 (2021)

Letter

Destruction of the cosmic γ-ray emitter ^{26}Al in massive stars: Study of the key ^{26}Al(n, p) reaction

C. Lederer-Woods,[1,*] P. J. Woods,[1] T. Davinson,[1] D. Kahl,[1,†] S. J. Lonsdale,[1] O. Aberle,[2] S. Amaducci,[3,4] J. Andrzejewski,[5] L. Audouin,[6] M. Bacak,[7,2,8] J. Balibrea,[9] M. Barbagallo,[10] F. Bečvář,[11] E. Berthoumieux,[8] J. Billowes,[12] D. Bosnar,[13]

Conclusions

Neutron-induced reactions are important in a wide range of fields.

Therefore, they **need to be measured** over a **broad energy range.**



… **Neutrons alone are not enough.**

At **n_TOF**, neutron flux **from thermal energies up to GeV**, **three experimental areas**, and new **detector developments** enable a wide range of neutron-induced reaction measurements.

However, several **experimental limitations** must still be considered, experimental background, samples quality, detector performance...

There is no universal measurement technique: the optimum approach is isotope-, reaction- and energy-dependent.

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Thank you for your attention!!!