ChTEC-Infra (WP3-Task 3.3)

- Generalities
- Discussion proposed activity by each partner
- Discussion: Where are we? Where we go?

What?

- JRA1 tackles four key challenges faced by the ChETEC-INFRA astronuclear laboratories that limit progress:
  - solid targets (**task 3.1**, PI R. Spartà/INFN, participants: IFIN-HH, ATOMKI, UKE, UoC, CNRS, UNIPD, about 43 person-months)
  - gas targets (**task 3.2**, PI T. Szücs/ATOMKI, participants: HZDR, CNRS, TUD, UMIL, UNIPD, about 17 person-months)
  - **the detection of neutrons (task 3.3, PI J. J. Valiente Dobon/INFN, participants: NCBJ, PTB, ISMA*, UNIPD, about 32 person-months)**
  - the production of nuclear charge separated beams for accelerator mass spectrometry (**task 3.4**, PI Robin Golser/UNIVIE, participants: HZDR, about 12 person-months)

*External collaboration – no person-months

GUF IS INVOLVED IN ALL THE ACTIVITIES CONCERNING THE WEBSITE

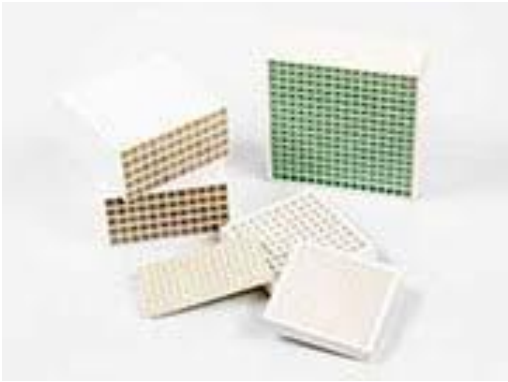
JRA1 - WP3: Astronuclear Laboratory

- Task 3.1
  - **R. Spartà**, T. Szücs, M. Heine, M. Moukaddam, S. Courtin, L. Trache, M. La Cognata, A. Caciolli, D. Mengoni, A. Tumino, G. Lanzalone, A. Zilges, A. Blazhev, S. Prill, S. Wilden, F. Heim, …
- Task 3.2
  - **T. Szücs**, M. Heine, M. Moukaddam, S. Courtin, D. Bemmerer, U. Bilow, K. Zuber, A. Guglielmetti, A. Caciolli, D. Mengoni, R. Depalo, …
- **Task 3.3**
  - **J.J. Valiente Dobon, L. Swiderski, R. Nolte, E. Pirovano, M. Dietz, A. Caciolli, D. Mengoni, R. Depalo, A. Gottardo, …**
- Task 3.4
  - **R. Golser**, P. Steier, M. Martschini, D. Bemmerer, A. Wallner, J. Lachner, …

T3.3 proposed activity

Position sensitive fast neutron detector

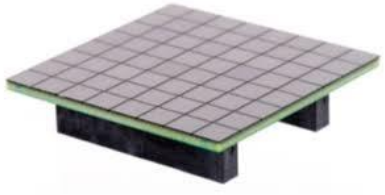
Scintillator material(s):



- stilbene crystals
- plastics
- organic glass (OGS)
- composite scintillators

+

Photodetector(s)



Large area SiPM (MPPC)

Position sensitive PMT (MAPMT)

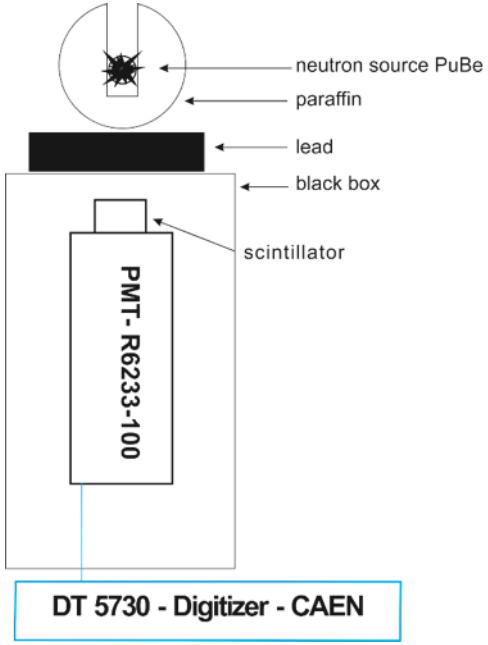
Required detector characteristics/performance:

- positional resolution of (?)
- n/γ discrimination down to (?)
- ToF with resolution of (?)
- new methods for fast-n/γ discrimination (?)
- capability to operate in intense gamma flux (?)
- radiation damage studies (?)
- slow neutron detection (?)

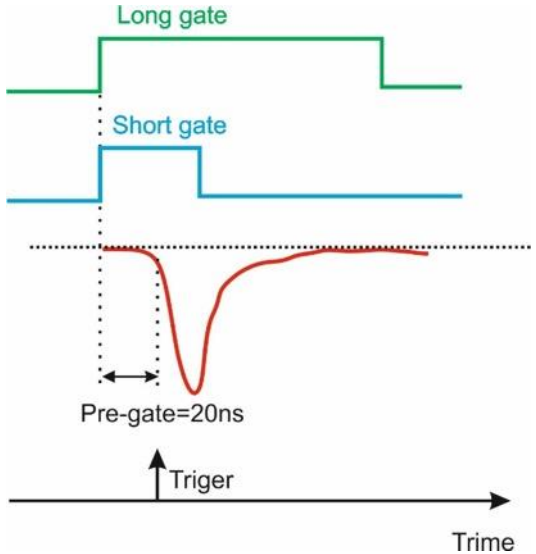
T3.3 proposed activity

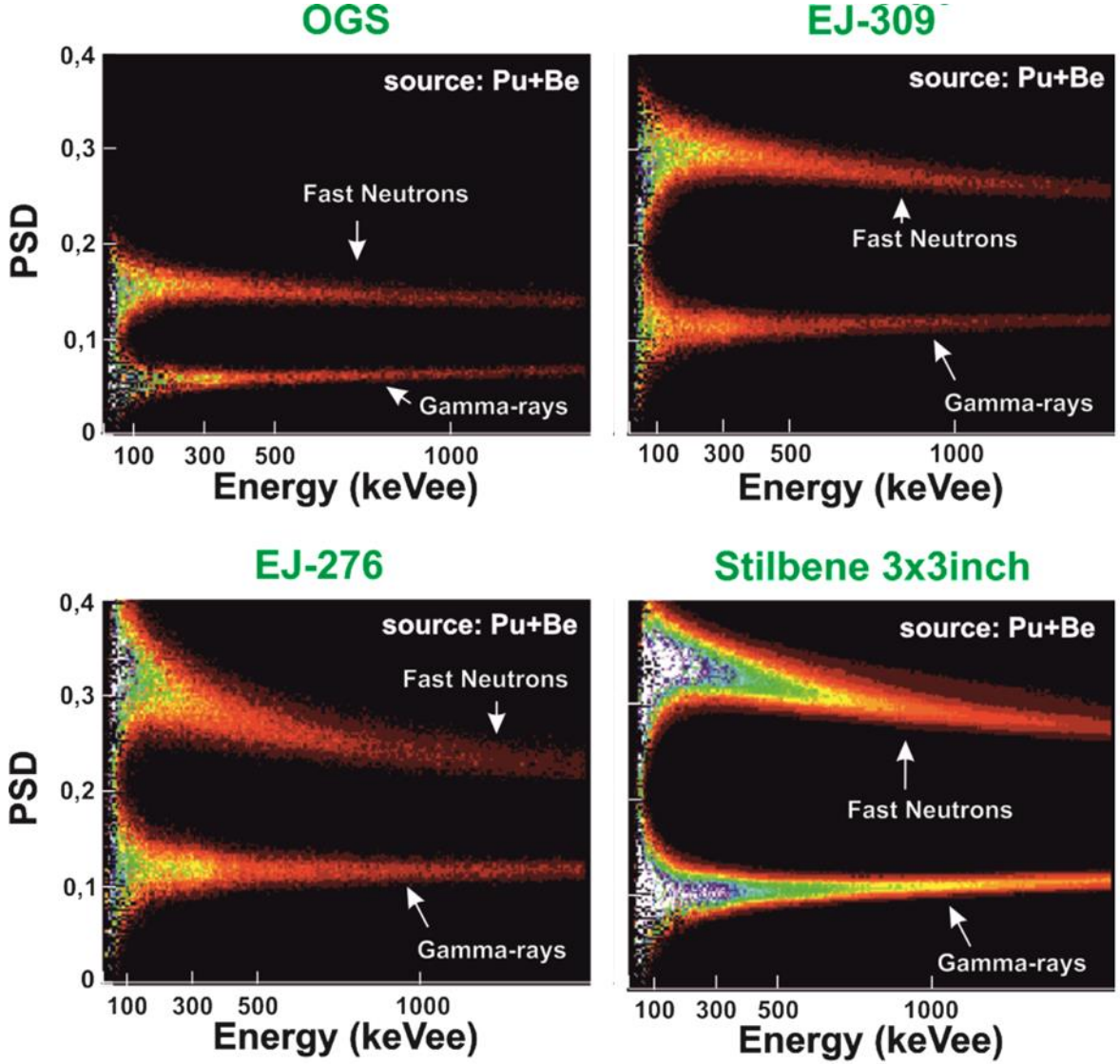
Organic Glass Scintillator – developed at Sandia NL (USA):

- high light output (~20 000 ph/MeV)
- emission spectrum peaked at ~430nm
- fast scintillation Decay (~3 ns)
- very good PSD discrimination (FOM = 1.4 @ 100 keVee)



$$PSD = (Q_{long} - Q_{short})/Q_{long}$$





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White Neutron Beams for Detector Studies

(Quasi-)monoenergetic and 'white' neutron sources:

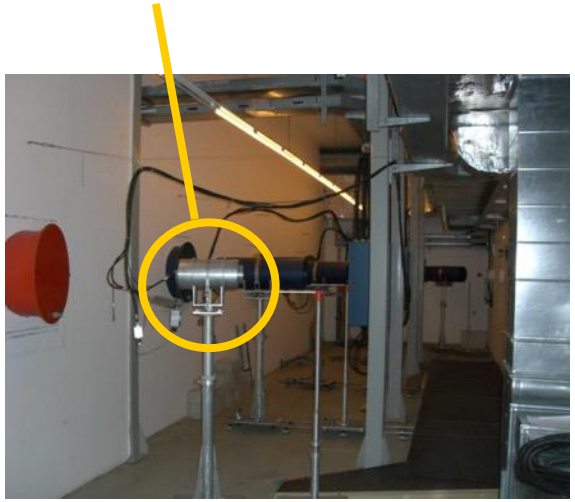
D(d,n), ^{15}N(p,n), ...

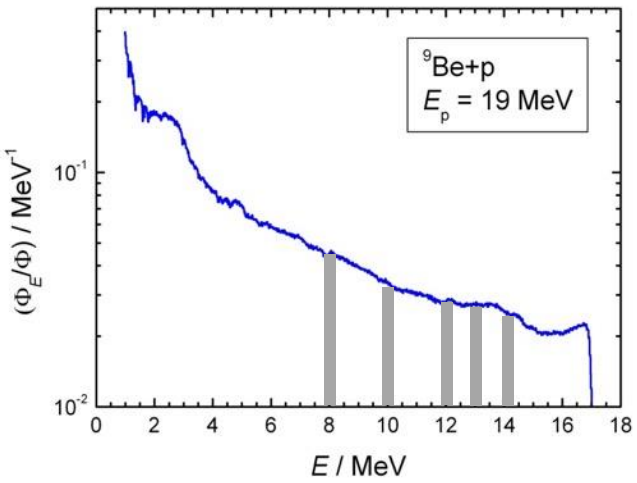
^{9}Be + p(19 MeV), ^{9}Be + d(13 MeV)

Energy selection via TOF

Flight paths: 11 m - 30 m

Ref: D1, RPT1





Detector development:

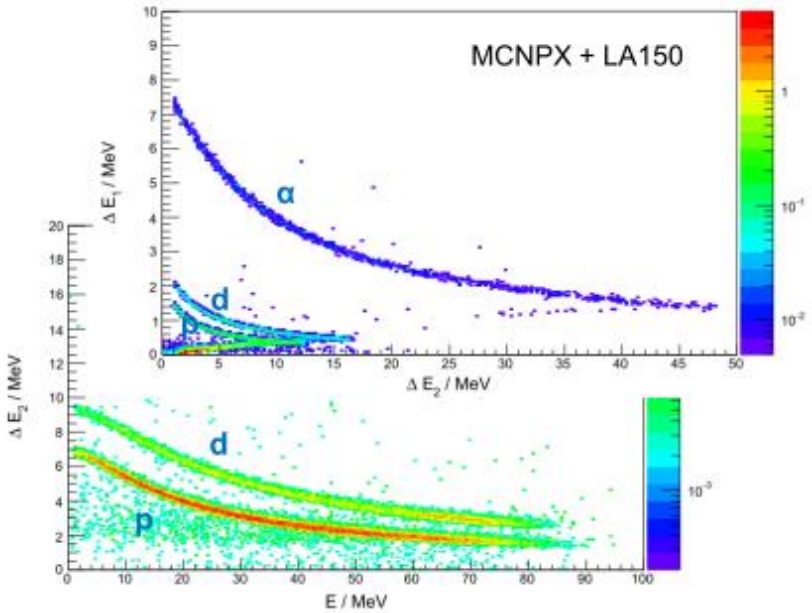
- Light yield (Quenching)
- Efficiency (ref.: D1, RPT1)
- …

High-energy DDX for ^{12}C(n, lcp x) at n_TOF

Experiment:

- n_TOF EAR1
- 3×10^{18} protons on spallation target (about 30 days)
- sample: 225 mg/cm² C
- development of ΔE^2-E telescopes for H and He ions
- neutron energy range of interest: 100-200 MeV

Goal: provide data to support improvement of INC models



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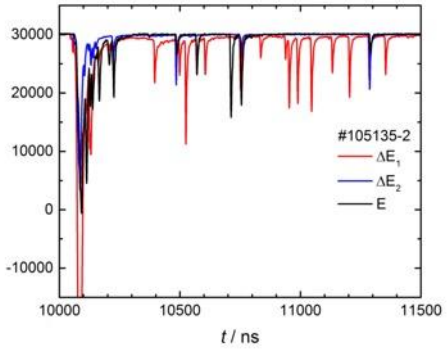
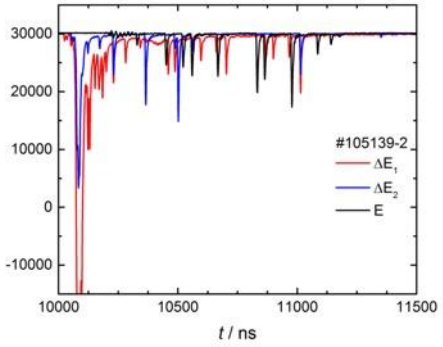
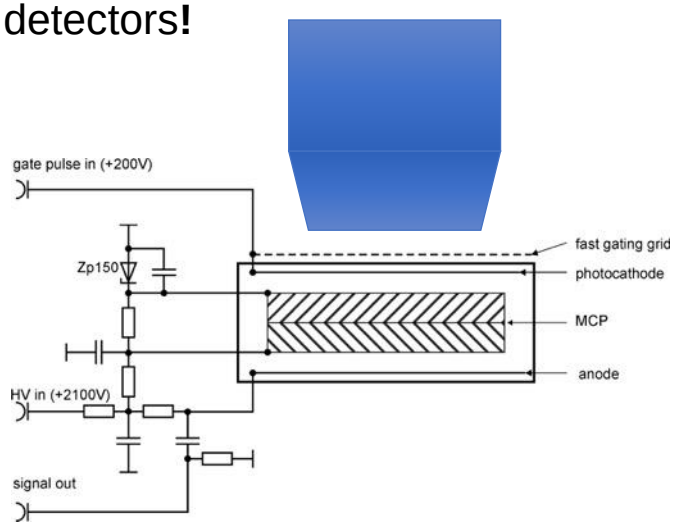
Gated PLANACON MCP PMT

… the γ-flash is a problem for *E* detectors**!**







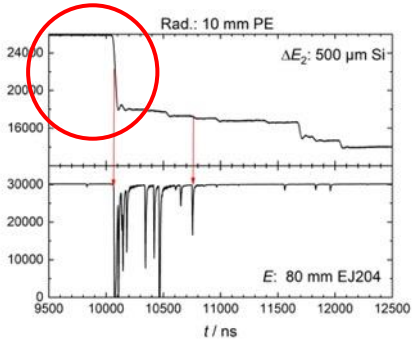
Gated Preamplifiers for Si Diodes

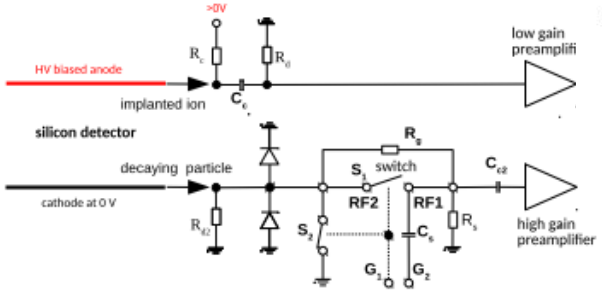
Canberra 2006 preamp:

γ-flash limits dynamic range

Adaption of gated pre-amps (HZDR development) for Si diodes (Δ*E* detectors):

- γ-flash immunity
- improved dynamic range





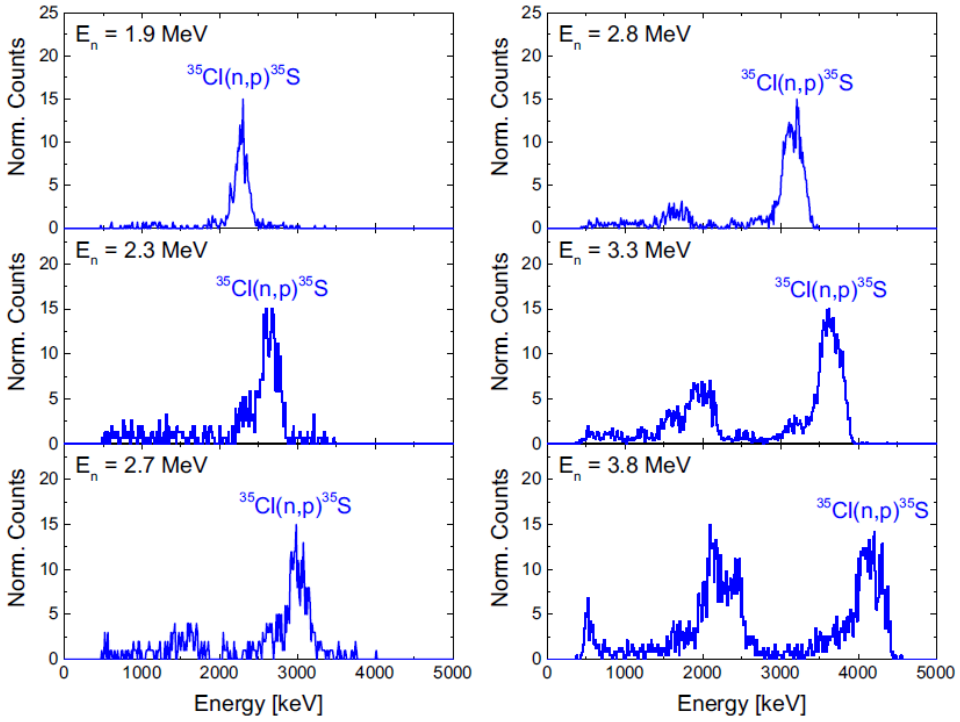
Ref.: Sebastian Urlass (CERN/HZDR), PhD Thesis

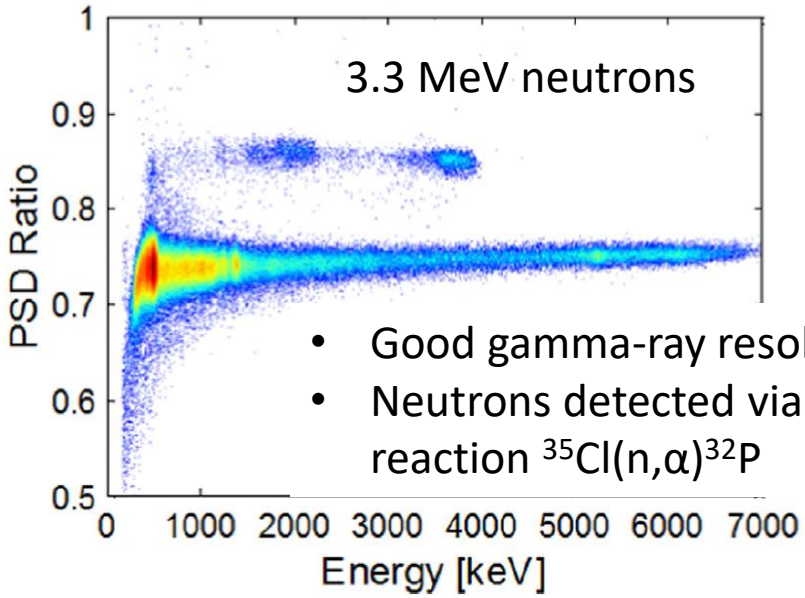
CLYC (TLYC) scintillators for combined neutron/gamma-ray spectroscopy

INFN Istituto Nazionale di Fisica Nucleare

CHETEC INFRA

A. Giaz et al. Nuclear Instruments and Methods in Physics Research A825 (2016) 51–61





- Good gamma-ray resolution (<4% at 1MeV)
- Neutrons detected via the $^{35}Cl(n,p)^{35}S$ reaction $^{35}Cl(n,\alpha)^{32}P$

Excellent n/gamma-ray discrimination

Direct (no TOF)
Neutron energy measurement
Neutron spectroscopy

What we want to do

- Tests with ^{252}Cf, AmBe source: TOF and direct spectrum at the same time
- Test also a TLYC ?
- Proton/α PSA to improve the neutron P/T ratio
- Towards a 4π array for beta-delayed neutron spectroscopy ?

INFN-LNL

Main goal: work on polysiloxane detectors applications in nuclear astrophysics:

Detectors already available and tested in Padua and LNL by project other than ChETEC-INFRA
They offers many interesting characteristics.
They can be used for fast or thermal neutrons. Good gamma ray discrimination

Possible use in nuclear astrophysics experiments
Possible test case: study of the d+d -> n + ^{3}He and d+d -> p + ^{3}H at LNL and other facilities involved in the ChETEC-INFRA network

References:

T. Marchi et al., Sci. Rep., 9 (1) (2019), p. 9154
S. Carturan et al., Nucl. Instrum. Methods A, 925 (2019), p. 109
A. Quaranta et al., Mater. Chem. Phys., 137 (2013), p. 951

Contents lists available at ScienceDirect

Nuclear Inst. and Methods in Physics Research, A

journal homepage: www.elsevier.com/locate/nima

Flexible scintillation sensors for the detection of thermal neutrons based on siloxane ^{6}LiF containing composites: Role of ^{6}LiF crystals size and dispersion

S.M. Carturan [a,b,*], M. Vesco [a,b], I. Bonesso [a], A. Quaranta [c,d], G. Maggioni [a,b], L. Stevanato [a], E. Zanazzi [c,d], T. Marchi [b], D. Fabris [e], M. Cinausero [b], F. Pino [a,b], F. Gramegna [b]

[a] Department of Physics and Astronomy, University of Padova, Via Marzolo 8, Padova, Italy
[b] Laboratori Nazionali di Legnaro - INFN, Viale dell'Università 2, Legnaro, Italy
[c] Department of Industrial Engineering, University of Trento, Via Sommarive 9, Povo, Trento, Italy
[d] TIFPA, Trento Institute for Fundamental Physics and Applications, Via Sommarive 14, Povo, Trento, Italy
[e] INFN — Section of Padova, Via Marzolo 8, Padova, Italy

Task 3.3

- Develop and test new neutron detector materials, such as composite scintillators, new plastics, etc. especially with low afterglow
- neutron-gamma discrimination capabilities
- new methodologies and algorithms for neutron/gamma discrimination
- Develop a read-out system based on SiPM or Photomultipliers that will allow to obtain a spatial resolution and to be used in environments with intense gamma flash

When?

Deliverables

D3.1	Report on the experimental techniques used for solid target production on the project web site
D3.2	Report on the development of a gas-jet target with in-beam target thickness diagnostic, on the project web site and in a scientific journal
D3.3	Provide to the community, upon request, one sample each of three possible scintillator materials for neutron detector in cooperation with industry
D3.4	Report on testing by radioactive sources and beam bombardment of the solid targets produced
D3.5	Report, on ChETEC-INFRA web site, on community-accepted methods to measure two non-routine AMS isotopes of astrophysical relevance
D3.6	Scientific publication on isobar suppression by ion-gas or ion-laser-interaction
D3.7	Publication on ChETEC-INFRA web site and in a scientific journal of target production protocols, characterization procedures, and results
D3.8	Report on the development of a gas cell target to be used for angular distribution measurements, on the project web site and in a scientific journal
D3.9	Report on the ChETEC-INFRA web site on different materials studied for neutron detection and position sensitive neutron detectors

Milestones:

- **M9** Measurement capability for Hf-182 by AMS developed and ready for external users (Task 3.4, month 36)

Key performance indicators:

- 10 scientific publications from this WP.
- 5 accelerator laboratories (both from inside and outside the consortium) where one of the target- or detector production techniques developed here is taken to routine operation.
- 5 PhD students trained in at least two of the tasks developed in JRA1.

GAANT CHART

WP3

INFN
ML

SIMPLE GANTT CHART by Vertex42.com
https://www.vertex42.com/ExcelTemplates/simple-gantt-chart.html

Project Start: sab, 5/1/2021

Display Week: 1

TASK	ASSIGNED TO	PROGRESS	START	END
TASK 3.1	R. Spartà			
D 3.1		0%	5/1/21	10/31/22
D 3.4		0%	11/1/22	4/30/24
D 3.7		0%	5/1/24	4/30/25
TASK 3.2	T. Szucs			
D 3.2		0%	5/1/21	10/31/22
D 3.8		0%	11/1/22	4/30/25
TASK 3.3	J.J. Valiente Dobon			
D 3.3		0%	5/1/21	4/30/23
D 3.9		0%	5/1/23	4/30/25
TASK 3.4	R. Golser			
D 3.5		0%	5/1/21	4/30/24
D 3.6		0%	5/1/24	10/31/24
M 9		0%	5/1/21	4/30/24

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Where are we? Where we go?

- Partners hold a large know-how on the field of neutron detector development
- Materials under consideration: polysiloxane, CLYC, TLYC, OGS, composite scintillators …? Synergies?
  - **Provide to the community with three samples upon request. (Milestone D3.3)**
- Read-out systems and front-end electronics: traditional PM, SiPM, Gated PLANACON MCP PMT, …?
- Position sensitive neutron detectors ?
- Commercial partners for new scintillators: Scionix, Sandia NL (USA), …? Do we contact tchem as a community or individually?
- Associated partners: A. Getkin (ISMA Inst. of Scint. Materials Charkiv, UA)
- Report on the web site: We could place all the references to publications that we will publish regarding these topics until 2024. **(Milestone D3.9)**