

INFN-E-MAFLUNE(closed), INFN-E-ADS, UE-CHANDA(closed), OCAPIE

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In Collaboration with:

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Viberti⁶

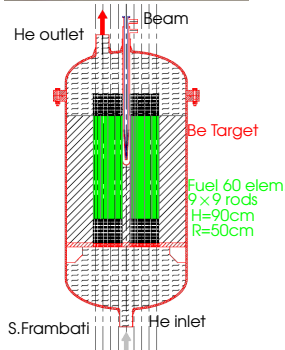
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Consiglio di Sezione, Genova, Italy

UE-CHANDA (closed 6/18) and INFN-E-ADS

- WP12 Task 12.4: “New infrastructure for studies of transmutation and fast system concepts”, (INFN, Ansaldo Nucleare).
- Project was inserted in 3-year research program of Centro Fermi (external funds, rep. M. Ripani),
- deliverable presented on concluding CHANDA meeting and approved,
- summarizing article: F. Panza et al., “An ADS irradiation facility for fast and slow neutrons” submitted in EPJ Plus.

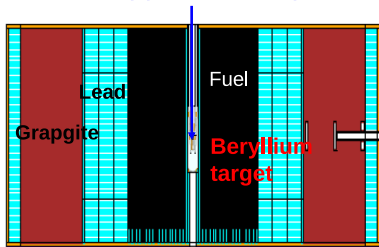
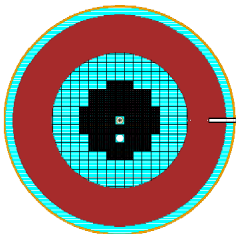
G.Ricco et al., EPJ Plus 129: 64 (2014)



An ADS irradiation facility for fast and slow neutrons



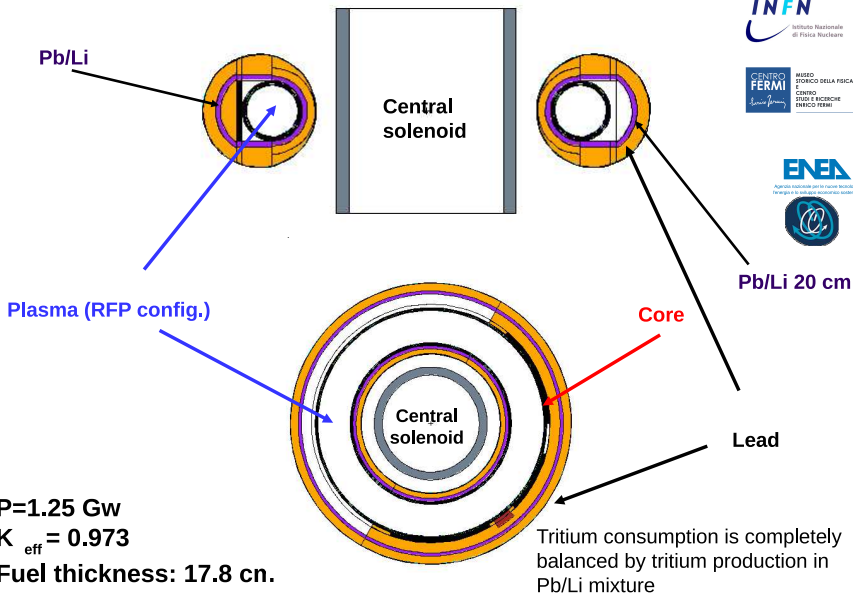
Beam pipe, 70 MeV-1 mA protons



Thermal power $P=565$ kW
 $k_{\text{eff}} = 0.974$

- **Fast core** based on MOX (U-Pu) fuel and solid Lead matrix
- **Reflector** surrounding the core made by **composite lead-graphite-lead** structure
- **Cooling** of core through **water** pipes

Fusion-fission hybrid reactors



P=1.25 Gw

$K_{\text{eff}} = 0.973$

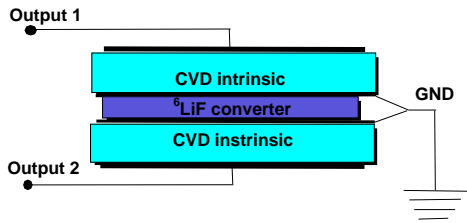
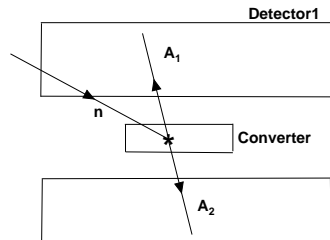
Fuel thickness: 17.8 cm.

Ocapie (P. Saracco)

- completata la fase di test ed installazione della farm HPC. Report al meeting CCR (maggio 2017);
- realizzati diversi test di applicazione reali (Calvelli et al., "A Parallel Simulator of Quench in Superconducting Magnets", Borreani et al., "Preliminary thermal-fluid-dynamic assessment of an ADS irradiation facility for fast and slow neutrons", IJHT 2017, Borreani et al., "Design and Selection of Innovative Primary Circulation Pumps for GEN-IV Lead Fast Reactors", Energies 2017, Saracco et al., "Energy models for the evaluation of the effective neutron lifetime", Physor 2018)
- entrambi gli AdR hanno lasciato tra fine 2017 (Calvelli) e marzo 2018 (Borreani);
- solo 1 sostituito con N. Chentre a partire da aprile (N. Chentre et al., "Completeness of the eigenstates of the neutron diffusion operator in non-homogeneous media", submitted to EPJPlus N. Chentre et al., "On reactivity measurement for subcritical multiplying systems", accepted for Phytra4 - September 2018 P. Saracco et al., "Fissile distribution and the critical problem of a nuclear reactor: a mathematical approach", invited talk at Phytra4 - September 2018).

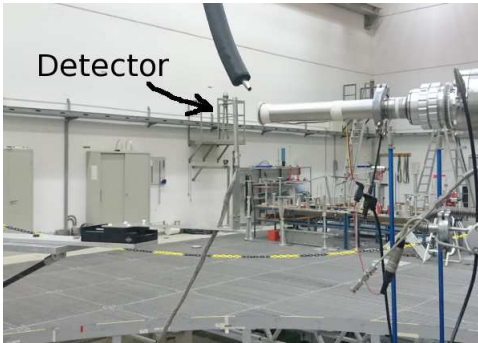
INFN-E/MAFLUNE+EU-CHANDA: n-spectrometer

- proposal "Response of neutron spectrometer based on diamond detectors to quasi-monoenergetic neutrons" submitted to FP7 CHANDA Transnational Access (TNA) workpackage board,
- proposal was approved by CHANDA PAC 6/Exp.5,
- granted 20 h of beam time at PTB facility (Germany) and 2240 EUR for support of two users,
- included per diem of 120 EUR/day and reimbursement of travel expenses,
- experiment run on Feb. 19-22 2018, results presented at final CHANDA meeting 16-17 April in Madrid.



Experiment at PTB (Braunschweig)

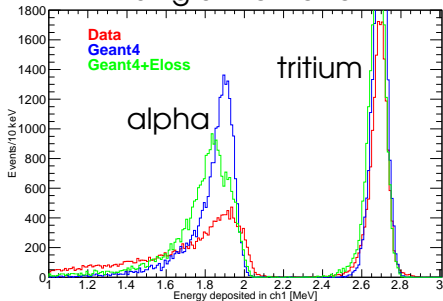
- Spectrometer was installed at 5 ± 0.05 cm from source: thin LiF/TiF target (0° w.r.t. proton beam),
- solid angle covered by detector was 5.85476 mstr,
- neutron flux varied: 0.15 (0.3 MeV), 0.9 (0.6 MeV) 0.4 (0.9 and 1.25 MeV), 0.8 (2 MeV) $\times 10^6$ n/cm²s,
- flux monitors and beam charge were recorded,
- thermalized neutron calibrations.



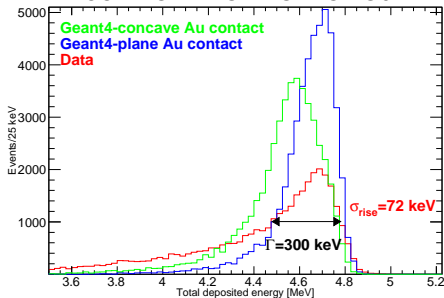
Calibration with Thermal Neutrons

- t-peak resolution was 35 keV (RMS), where 24 keV due to electronics ($NF \simeq 0.8$ dB, $f_H < \frac{1}{2\pi 60ns} \simeq 3$ MHz, $V_{rms} \simeq 0.8$ μ V, $E/Q \simeq 81$ keV/fC, expected 20 keV),
- α -peak exhibits excessive energy loss tail at l.h.s.,
- total energy peak rise resolution (no eloss): 72 keV,
- total energy peak full width: 300 keV,
- efficiency at $E_n = 0$ was 2.3×10^{-5} cps/nv.

Single Diamond

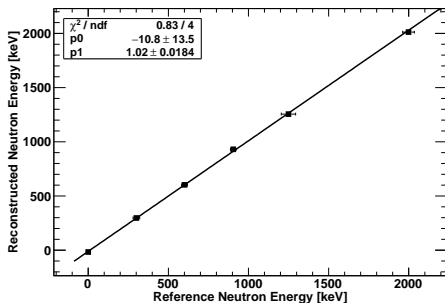
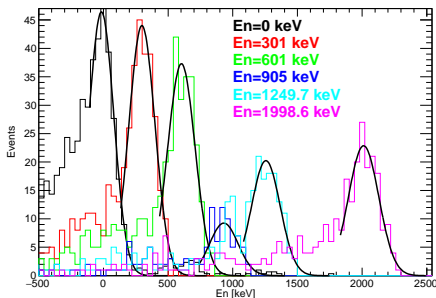


Sum of Two Diamonds



Neutron Energy Reconstruction

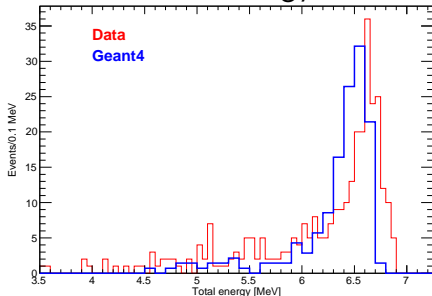
- five beam energies + thermal calibration: 0-2 MeV,
- reference energy reconstruction within 1σ stat.,
- E_n^{rec} stat. uncertainty and deviation <20 keV,
- RMS of Gaussian part of the peak was 100 keV,
- measured peak RMS made of: 50 keV electronics, 30-40 keV energy loss and 20-40 keV beam spread.



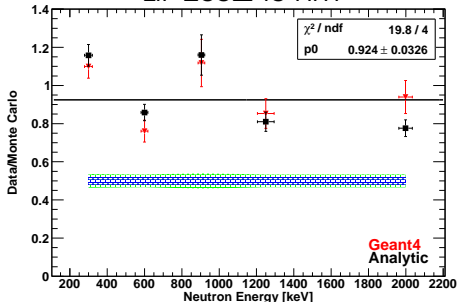
Neutron Spectrum Reconstruction

- PTB absolute neutron flux normalization precision: 1.7% monitor + 1.8% distance,
- reconstructed neutron flux has 5% stat.unc.,
- sensitive to absolute neutron energy $<20\%/10$ keV,
- Geant4 sys. uncertainties: ${}^6\text{Li}$ cross section ENDF 1-4% (world data spread 10%), product angular distribution TBD, energy loss TBD.

uniform energy loss



LiF 200 ± 40 nm



Results/Future Developments

INFN-E/MAFLUNE:

- developed compact neutron spectrometer,
- tested at fast and thermal reactors, DD and DT fusion source, PTB monochromatic neutron source,
- external funds from Centro Fermi,
- interest for reactor characterization: Budapest University, MASURCA (CEA) and DTT,
- meeting with CAENSys demonstrated interest for TT.

INFN-E/ADS:

- 1 submitted H2020-FETOPEN proposal “CYCLADS” (**CERN**, AIMA-DeV, ASG, ENEA, HNE, iThEC, N-21, PSI, INFN),
- 2 study of fusion-fission hybrid systems based on RFX and DTT.

Publications INFN-E/MAFLUNE 2017

- 1 M.Osipenko et.al, "*Upgrade of compact neutron spectrometer for high flux environments*", NIM A883, 14 (2018),
- 2 M.Osipenko et.al, "*Calibration of the compact neutron spectrometer at PTB*", in preparation.

Publications ADS/CHANDA 2017

- 1 F.Panza, M.Osipenko, G.Ricco, M.Ripani, P.Saracco, "*Influence of reflector materials and core coolant on the characteristics of accelerator driven systems*", Annals of Nuclear Energy, 109 (2017) 162,
- 2 F.Panza, G.Firpo, G.Lomonaco, M.Osipenko, G.Ricco, M.Ripani, P.Saracco and C.M.Viberti, "*A low power ADS for transmutation studies in fast systems*", EPJ Nuclear Sci. Technol. 3 (2017), 36,
- 3 W.Borreani, M.Bruzzone, D.Chersola, G.Firpo, G.Lomonaco, M.Palmero, F.Panza, M.Ripani, P.Saracco, C.M.Viberti, "*Preliminary thermal-fluid-dynamic assessment of an ADS irradiation facility for fast and slow neutrons*", INTERNATIONAL JOURNAL OF HEAT AND TECHNOLOGY 35 (2017), S186,
- 4 G.Lomonaco, W.Borreani, M.Bruzzone, D.Chersola, G.Firpo, M.Osipenko, M.Palmero, F.Panza, M.Ripani, P.Saracco, C.M.Viberti, "*Initial thermal-hydraulic assessment by OpenFOAM and FLUENT of a subcritical irradiation facility*", Thermal Science and Engineering Progress 6C (2018), 447.

Proceedings INFN-E/ADS, CHANDA 2017

- 1 F.Panza, G.Firpo, G.Lomonaco, M.Osipenko, G.Ricco, M.Ripani, P.Saracco and C.M.Viberti, "*A new hybrid fast-slow ADS for research and applications*", in Proceedings of the Third International Workshop on Technology and Components of Accelerator-Driven Systems, Mito, Japan, 6-9 September 2016, published by OECD-NEA, Nuclear Science NEA/NSC/R(2017)2 June 2017, p.307,
- 2 F.Panza, G.Firpo, G.Lomonaco, M.Osipenko, G.Ricco, M.Ripani, P.Saracco and C.M.Viberti, "*New infrastructure for studies of transmutation and fast systems concepts*", in Proceedings of the 13th International Conference on Radiation Shielding (ICRS-13) & 19th Topical Meeting of the Radiation Protection & Shielding Division of the American Nuclear Society 2016 (RPSD-2016), Paris, France, 3-6 October 2016, EPJ Web of Conferences (2017) 153, 05003,
- 3 F.Panza, G.Lomonaco, W.Borreani, G.Ricco, M.Ripani, M.Osipenko, P.Saracco, G.Firpo, C.M.Viberti, "*An ADS irradiation facility for fast and slow neutrons*", EUCARD-2 Workshop - Status of Accelerator Driven Systems Research and Technology Development, CERN, 7-9 February 2017, <https://indico.cern.ch/event/564485/>,
- 4 W.Borreani, M.Bruzzo, D.Chersola, G.Firpo, G.Lomonaco, M.Palmero, F.Panza, M.Ripani, C.M.Viberti, "*Preliminary thermal-fluid-dynamic assessment of an ADS irradiation facility for fast and slow neutrons*", 2nd AIGE/IIETA International Conference and 11th AIGE 2017 Conference on "Energy Conversion, Management, Recovery, Saving, Storage and Renewable

INFN-E Genova 2019

Project	Start/End	Person	FTE
INFN-E		M. Ripani (RN)	0.4
		M. Osipenko	0.1
		P. Saracco	0.2
		N. Chentre (AdR)	1.0
		G. Ricco ^A	
		F. Panza (AdR)	1.0
		G. Lomonaco ^A	0.3
		G. Firpo ^A	0.1
		C. Viberti ^A	0.1
Total			3.2

Richieste Servizi 2019

Servizio	Richieste (m.u.)	Obiettivi
Elettronica	1	sviluppo PCB det. montaggio, cavi
Progettazione	1	involucro det.
Officina	1	involucro det.