INFN-LNS User Commettee 6/12/2013

Welcome & LNS status

Giacomo Cuttone
LNS Director

INFN - Laboratori Nazionali del Sud are located in the Catania University campus area

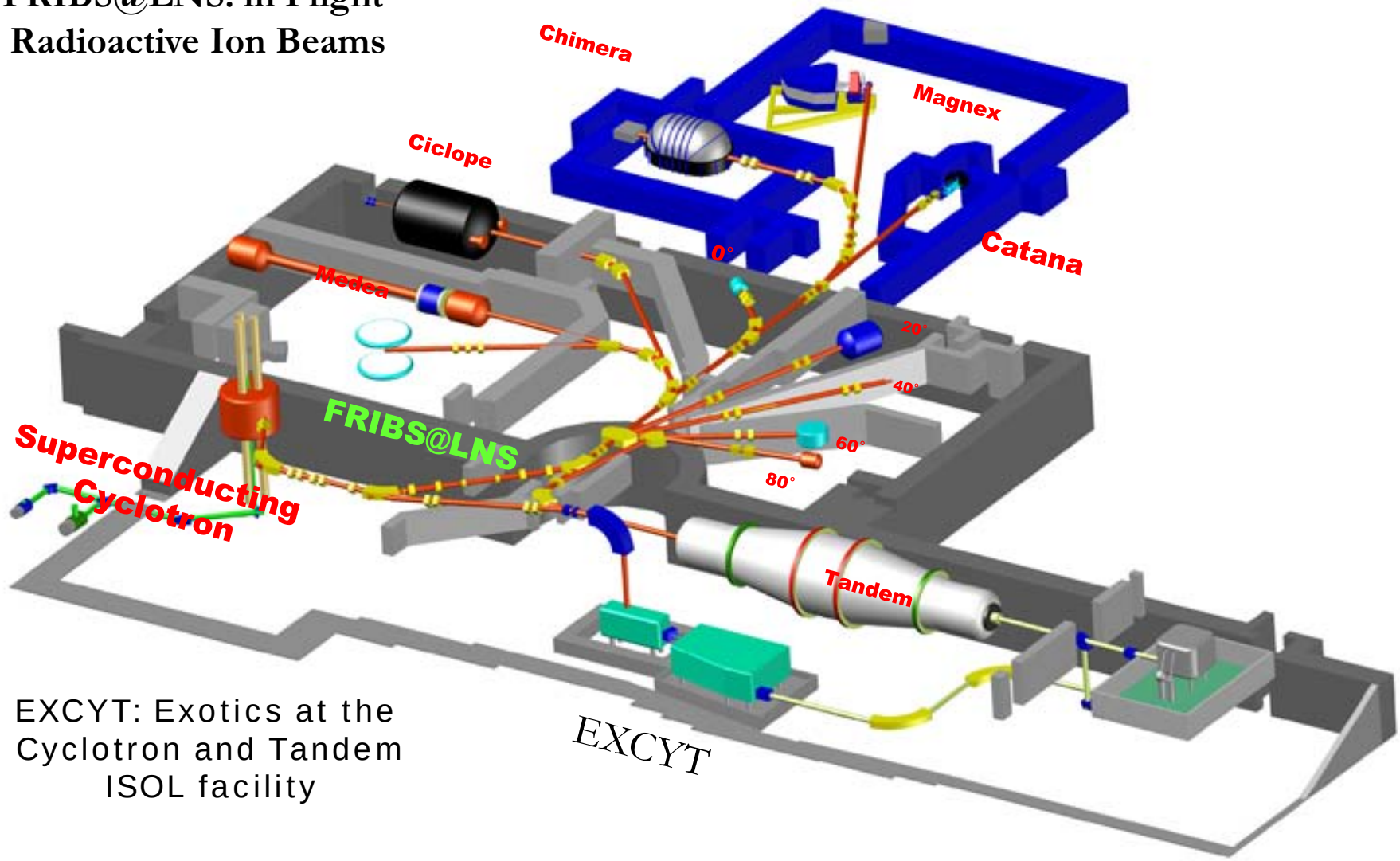
LNS in numbers

- *Total area: 35000 m^2*
- *Total volume: 97000 m^3*

- Staff members: 120 (35 phys. + eng.)
- Associated researchers: 39
- Users (in the last 3 years): 545
- Foreign users: 180
- Annual scientific production: about 150 (papers and proceedings)
- Budget: ~ 11 M€/year (excl. Salaries)

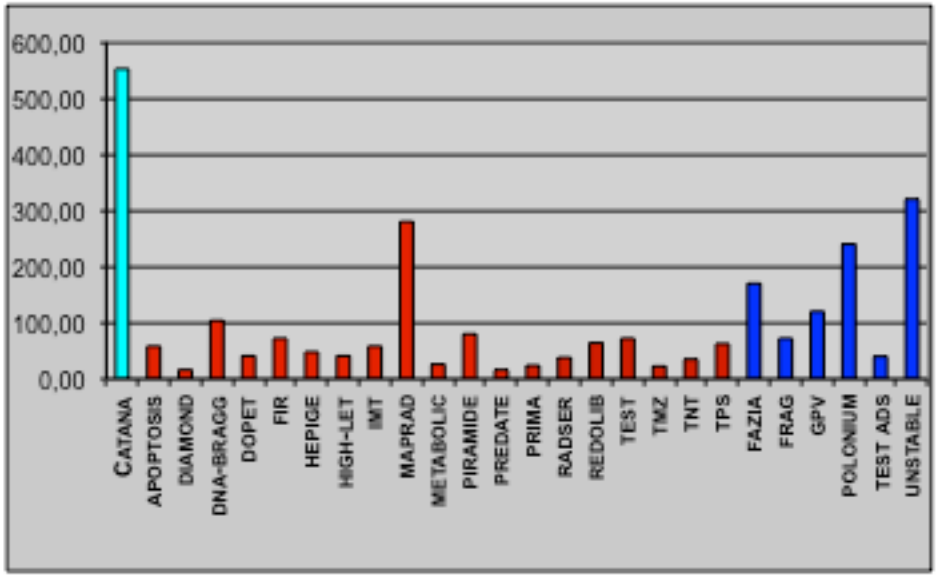
LNS lay-out: accelerators and experimental halls

FRIBS@LNS: in Flight Radioactive Ion Beams



EXCYT: Exotics at the Cyclotron and Tandem ISOL facility

Use of the Superconducting Cyclotron and Tandem beams in 2011

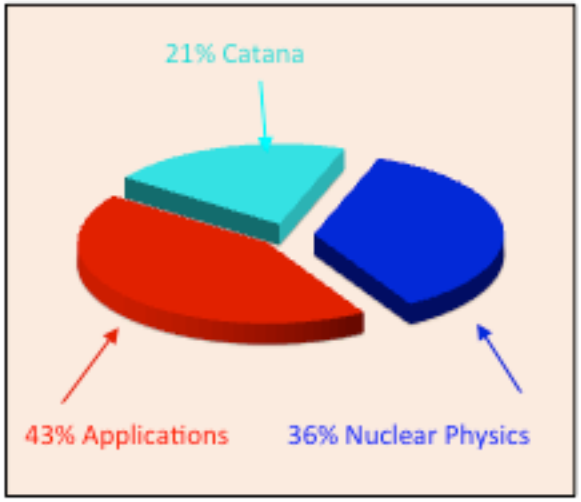


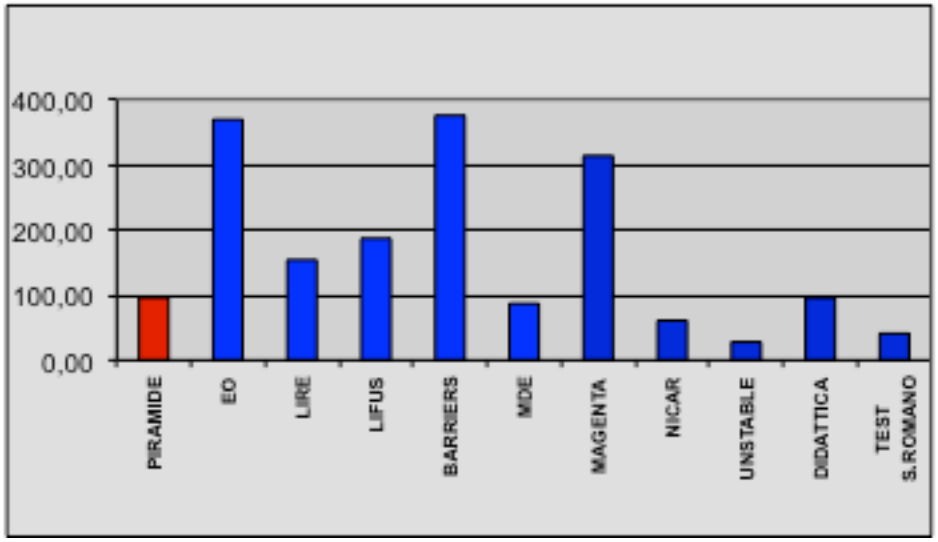
Cyclotron
2672 hours

36%
Nuclear Physics

21%
Catana

43%
Applications

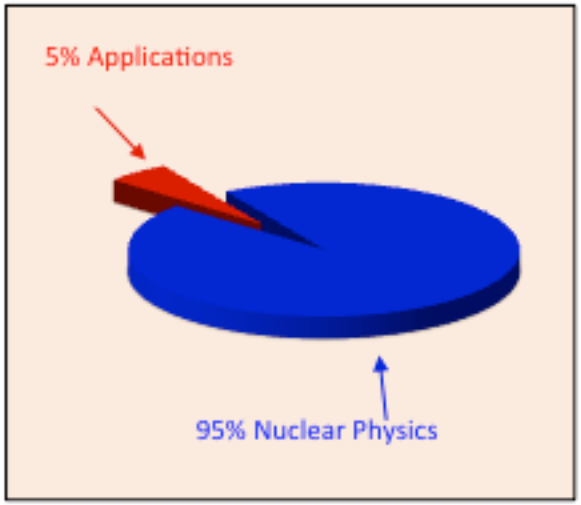




Tandem
1810 hours

95%
Nuclear Physics

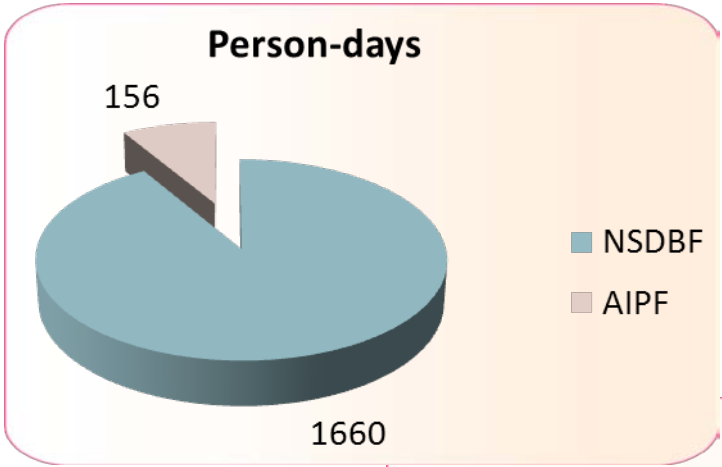
5%
Applications



TNA03 – Deliverables

Nuclear Structure and Dynamics Based Facilities (NSDBF)

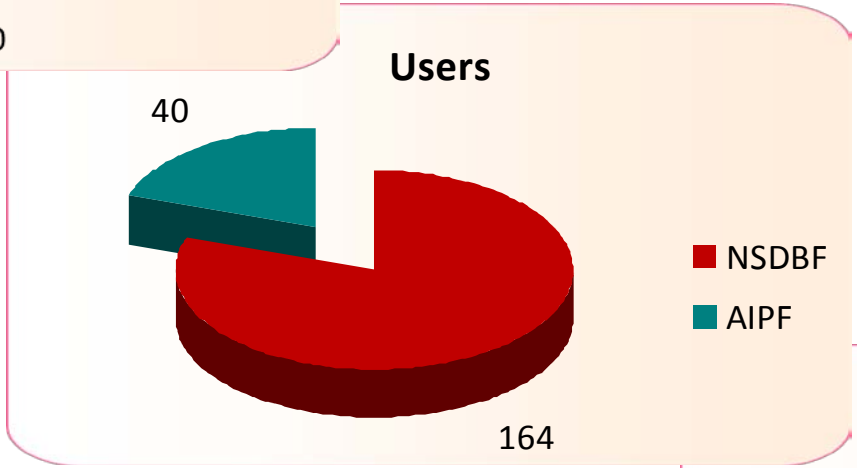
Applied and Interdisciplinary Physics Facilities (AIPF)



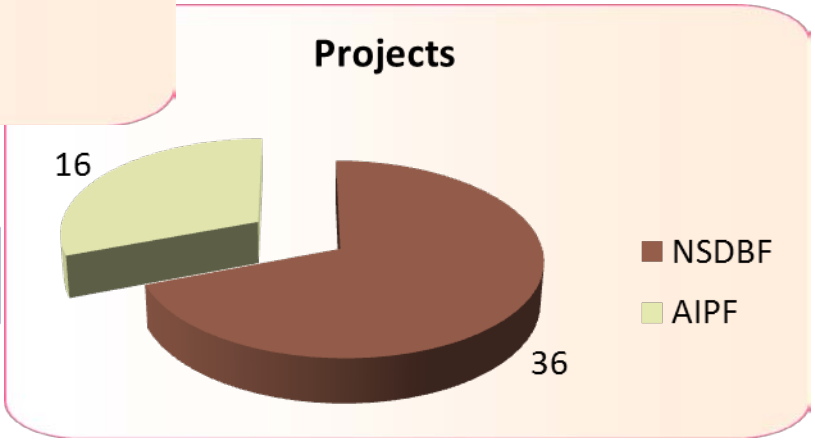
Min. quantity of access to be provided

4424 h / 4y

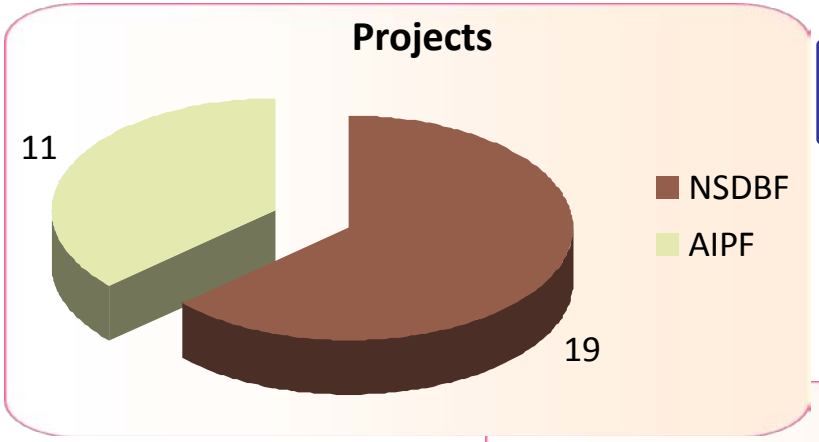
204 users / 4y



52 projects / 4y

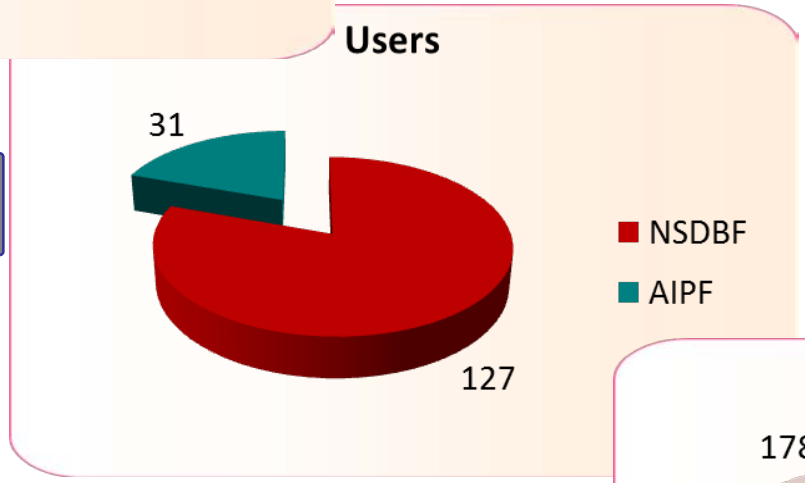


TNA03 – Activity at LNL-LNS until July 2013



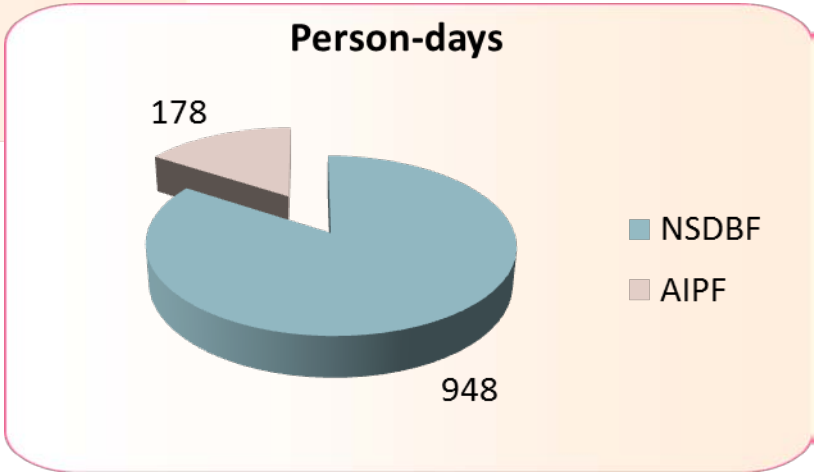
52 projects / 4y (36 @ **NSDBF**, 16 @ **AIPF**)

30 projects (19 **NSDBF**,11 **AIPF**) → **58%**



204 users / 4y

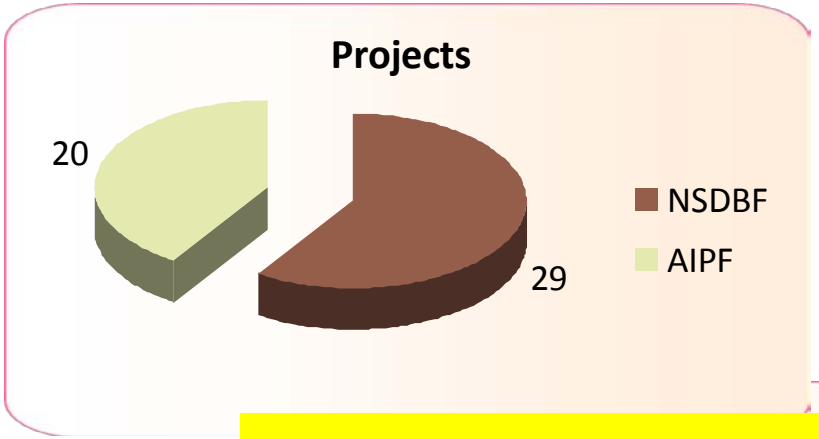
158 users → **77%**



1816 person-days / 4y

1126 person-days → **62%**

TNA03 – Activity at LNL-LNS by March-July 2014

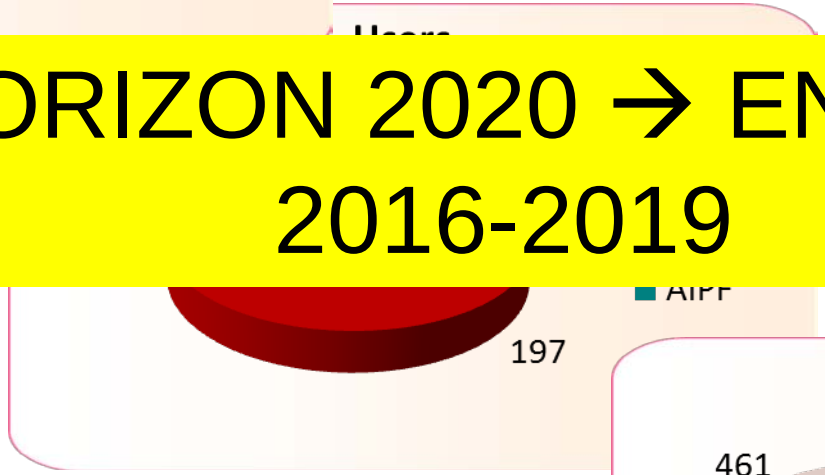


52 projects / 4y (36 @ **NSDBF**, 16 @ **AIPF**)

49 projects (29 **NSDBF**,20 **AIPF**) → **94%**

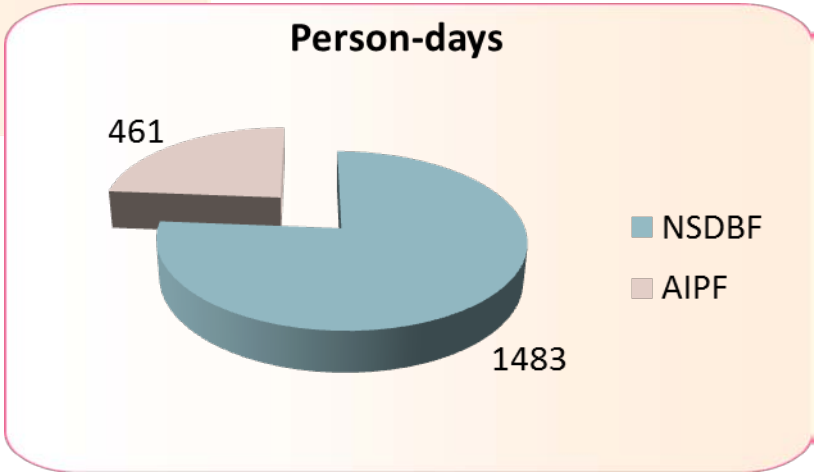
204 u

266 users



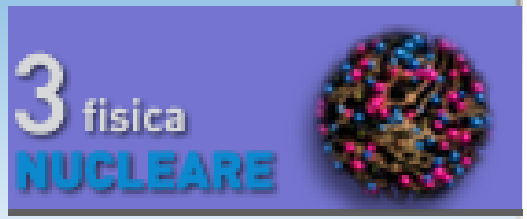
1816 person-days / 4y

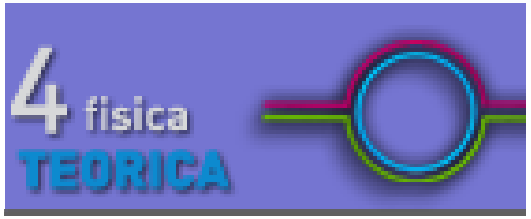
1944 person-days



HORIZON 2020 → ENSAR2
2016-2019

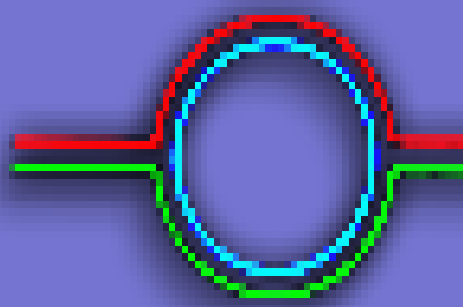
Scientific activity

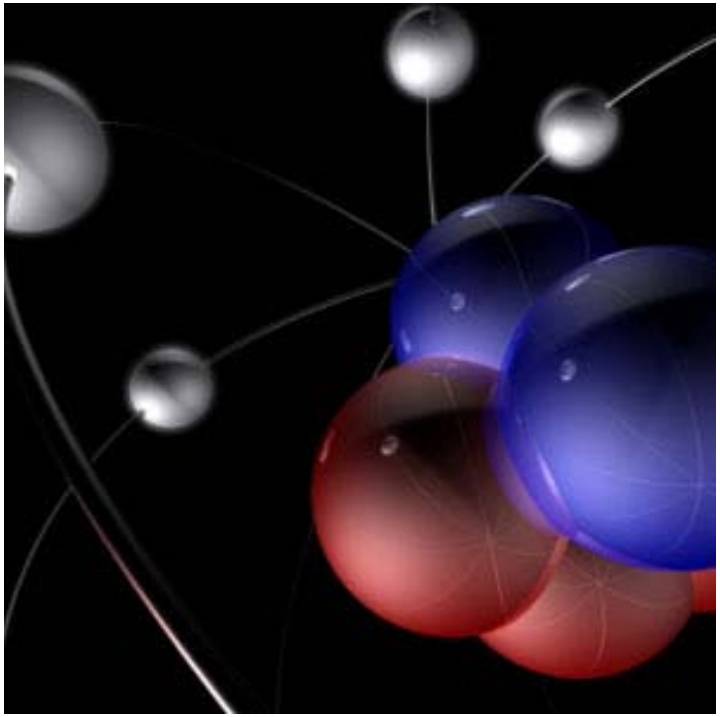


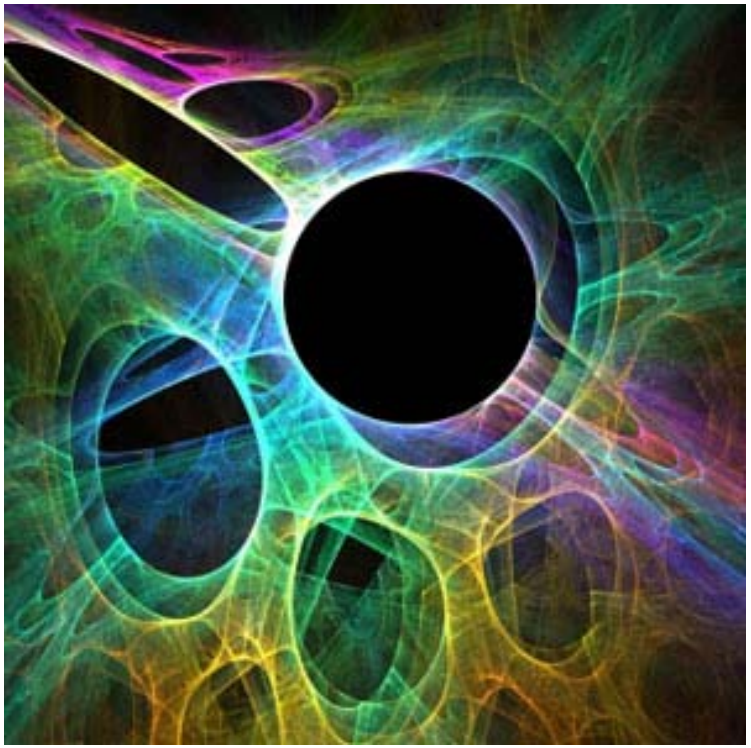


3 fisica NUCLEARE

4 fisica TEORICA







CHIMERA (CHarged Ion Mass and Energy Resolving Array)

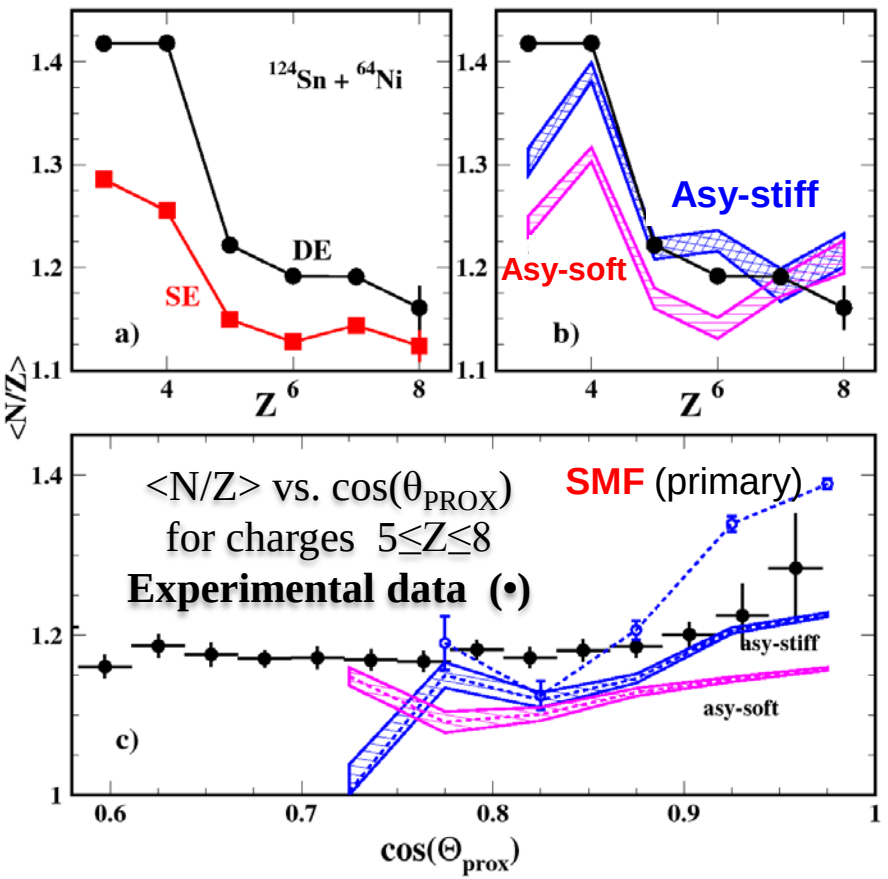
is a 4pi detector for charged particles devoted to the study of nuclear reaction at intermediate energies and operating at *Laboratori Nazionali del Sud* in Catania

CHIMERA

- GDR
- Caloric curve & phase transition
- Multifragmentation
- Isospin dependence of EoS
- Di-proton decay

Symmetry energy constraint as “seen” by the CHIMERA 4π detector

^{124}Sn+^{64}Ni 35 A.MeV E. De Filippo talk

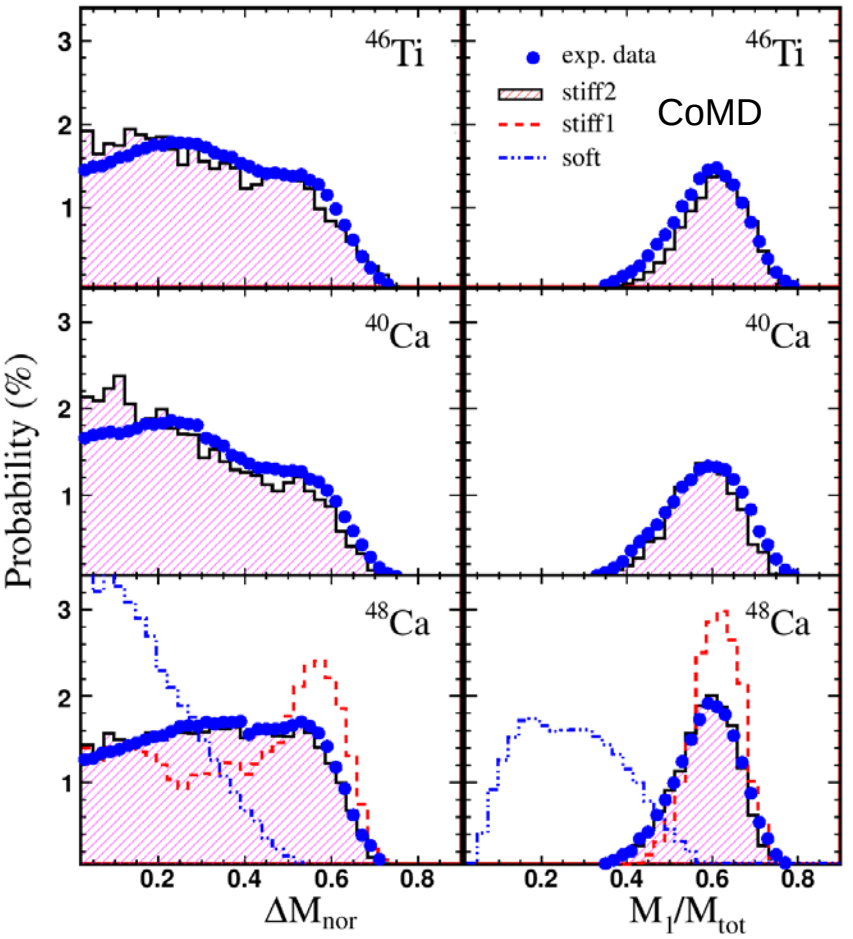


*E. De Filippo et al, Phys. Rev. C **86** 014610 (2012)*

1) **Neck** fragmentation mechanism
2) **Iso-diffusion** : ZY Sun et al., PRC 82 051503 (2010)

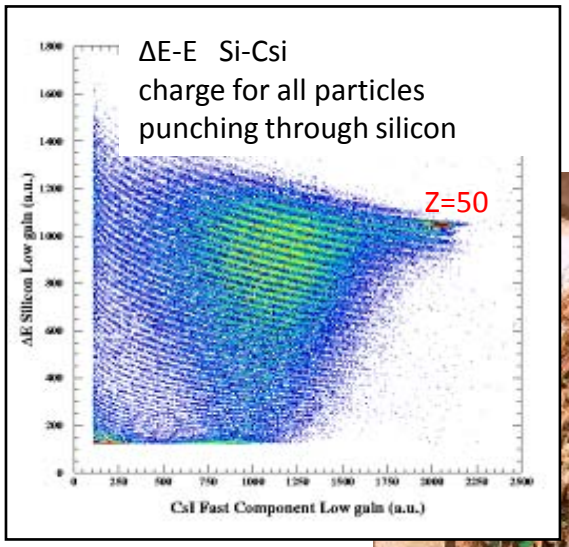
Quasi-fusion reactions
F. Amorini et al. PRL 102 112701 (2009)
G. Cardella et al., PRC 85 064609 (2012)

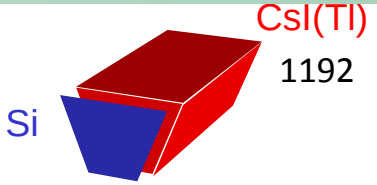
M.Papa,G.Giuliani and A.Bonasera, J.Comput Phys 208 403-415(2005)

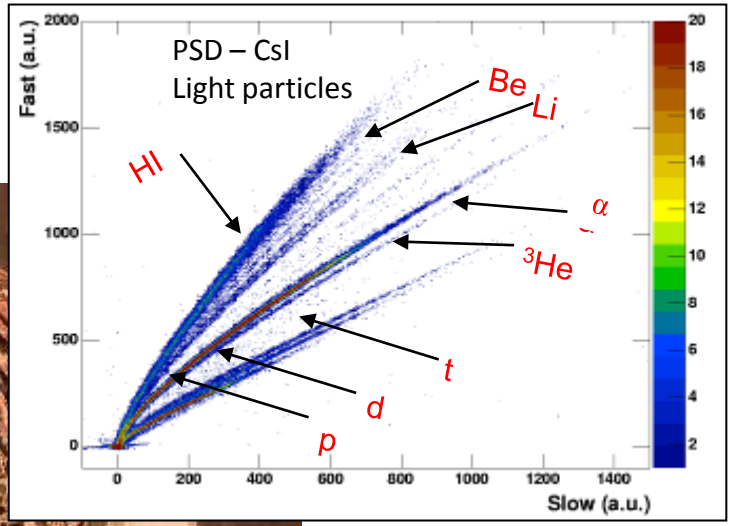


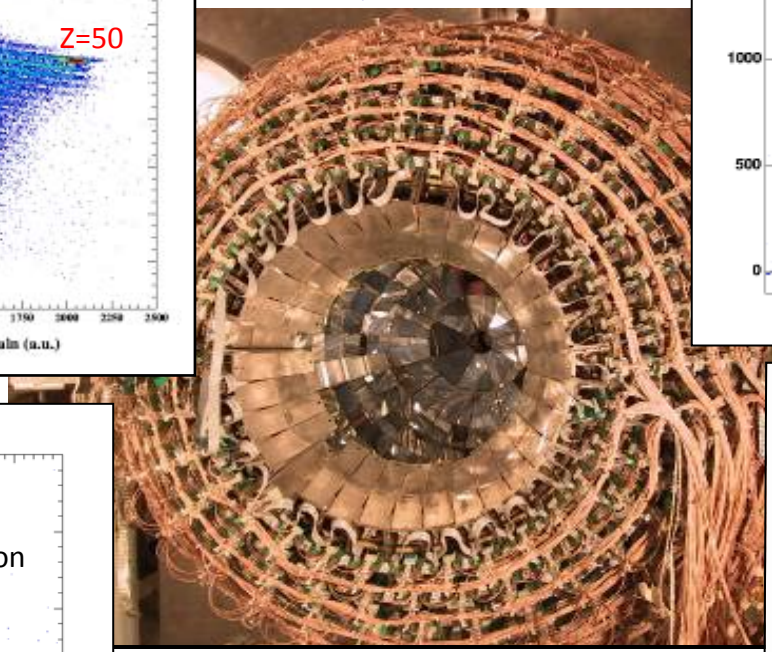
^{40}Ca (25 MeVA) + … (M. Papa talk)

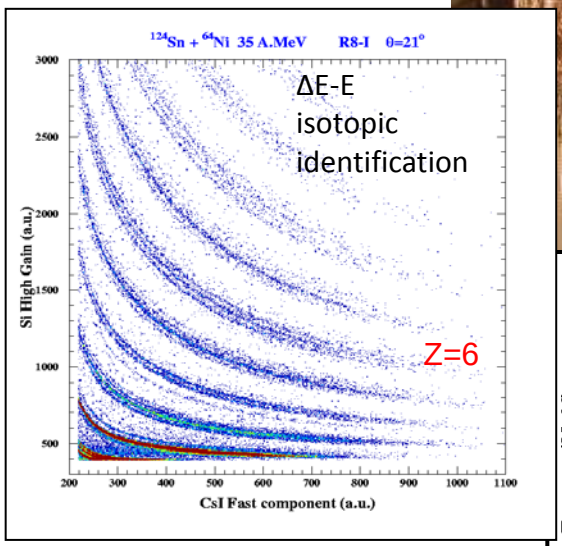
CHIMERA Detector: Identification methods

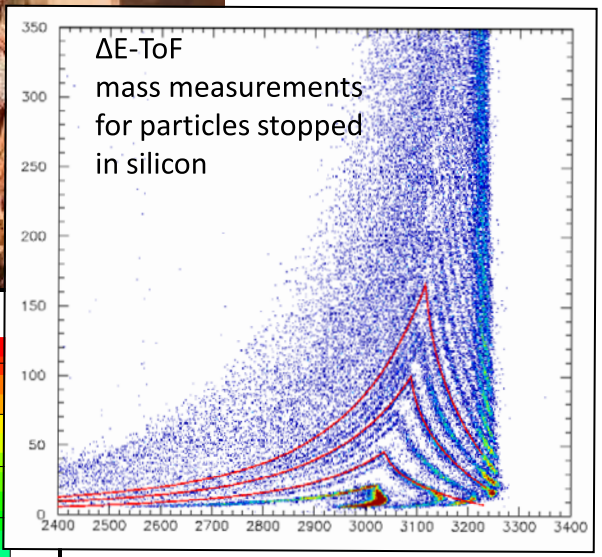


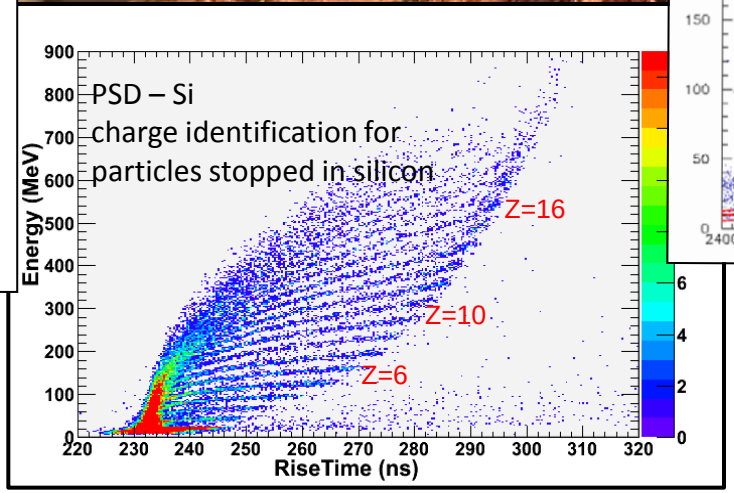




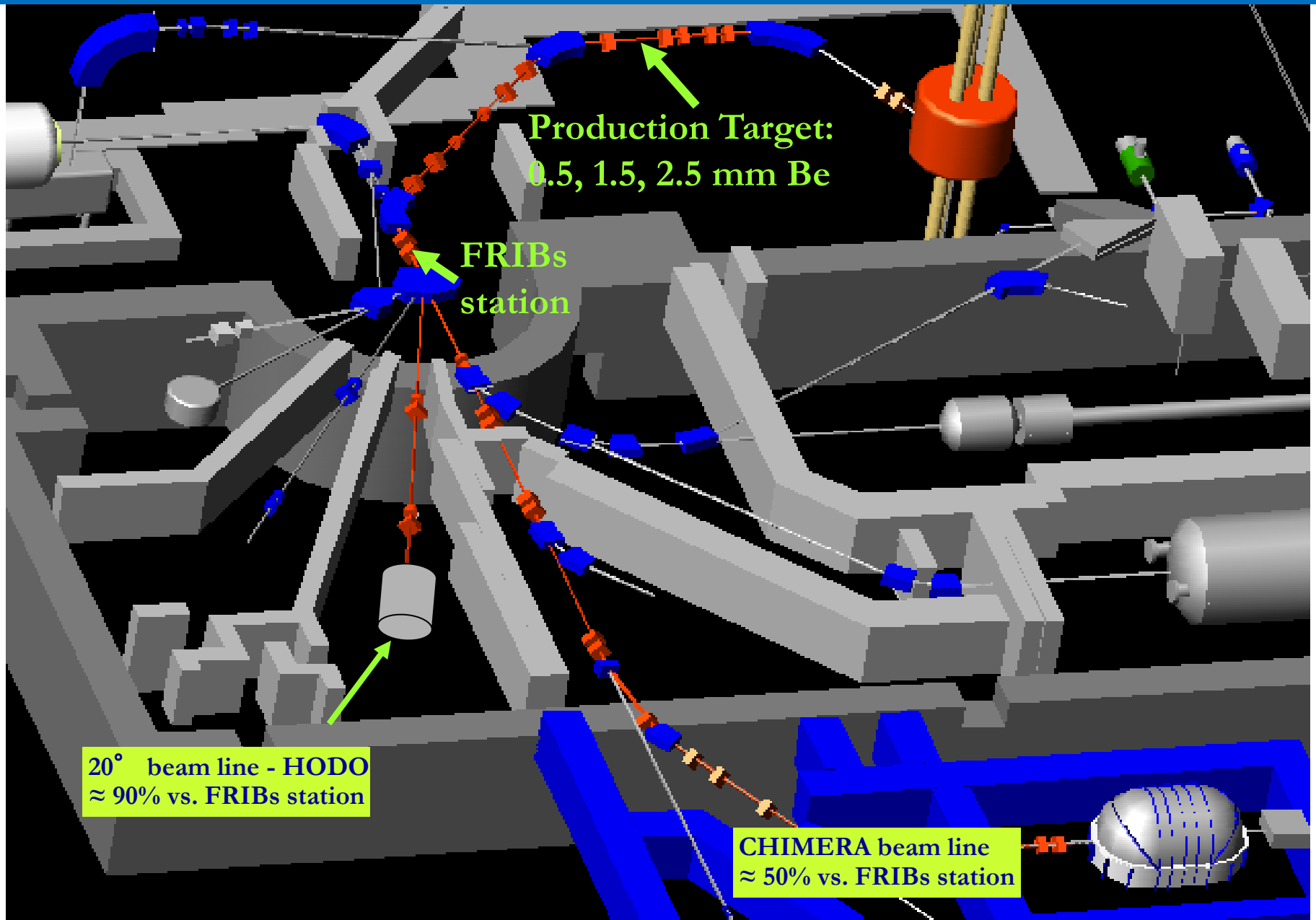






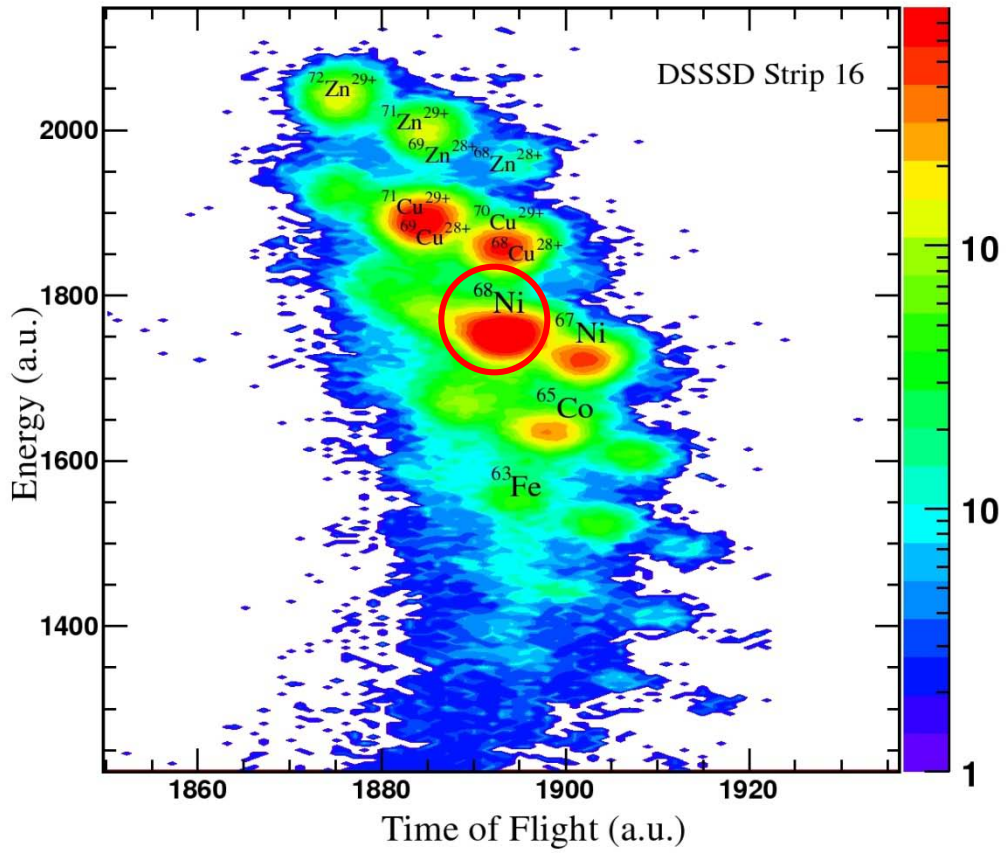


FRIBS@LNS: in Flight Radioactive Ion Beams



NEW – MARCH 2012 : ^{68}Ni production with ^{70}Zn primary beam

CHIMERA + FRIBS



Production of a ≈30 A.MeV ^{68}Ni beam at LNS (TimeScaleZn test)

We used a $^{70}Zn^{19+}$ (40 A.MeV) primary beam impinging on a 250 μm ^{9}Be target. The maximum intensity obtained for the primary beam was ≈300 enA (0.03 kW)

Beams identification was obtained using the CHIMERA-IFEB tagging system constituted by a large surface MicroChannel plate followed by a Double Side 32x32 Silicon Strip Detector (DSSSD)

The production rate was 7 KHz / 30 Watt; reaching 100 Watt of primary beam current, we could obtain $2x10^4$ pps rate (Lise++ prediction is $5x10^4$ pps / 0.1 kW)

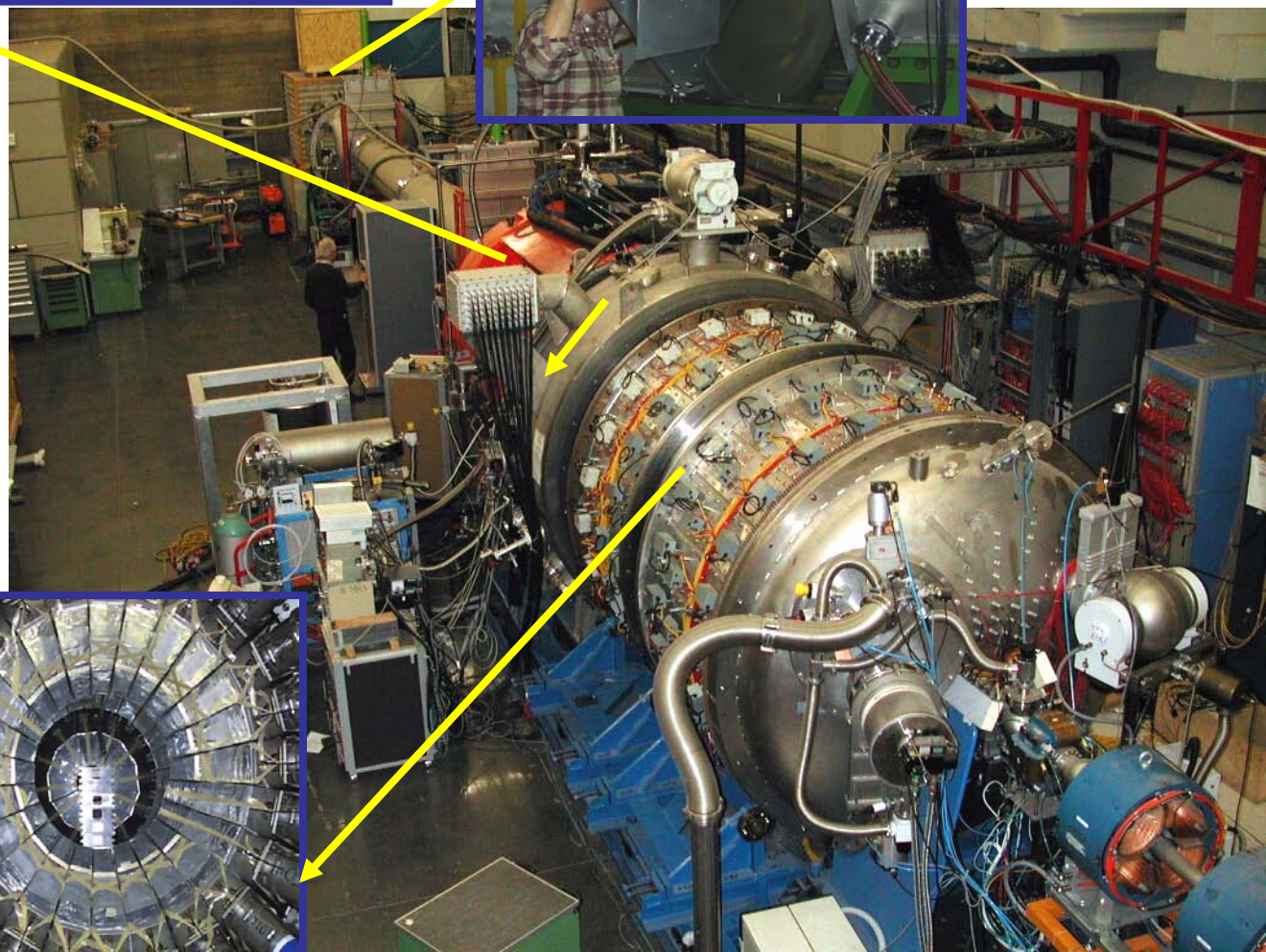
We verified that contamination due to not fully stripped ions can be neglected due to the low probability of charge state 27+ (<10%) and to the stripping effect of the MCP foil

MEDEA - SOLE - MACISTE

MACISTE

8 gas -plastic position sensitive detectors

$\theta \leq 6^0$



SOLE

Superconducting Solenoid

$0^0 \leq \theta \leq 6^0$

MEDEA

180 BaF_2 detectors

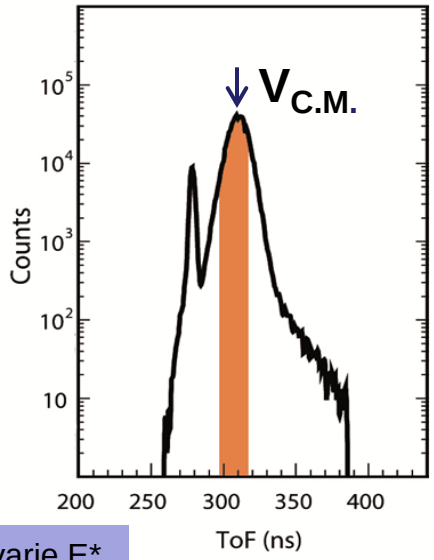
$30^0 \leq \theta \leq 180^0$

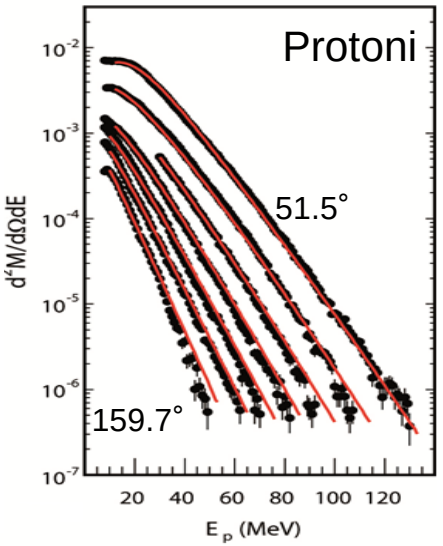
Studio del quenching della GDR in nuclei caldi con A ~ 120-136

^{116}Sn + ^{12}C	@ 17 A MeV
^{116}Sn + ^{12}C	@ 23 A MeV
^{116}Sn + ^{24}Mg	@ 17 A MeV
^{116}Sn + ^{24}Mg	@ 23 A MeV

- Selezione in ToF dei residui
- Misura del pre-equilibrio da spettri di LCP

Caratterizzazione del sistema: E*, A



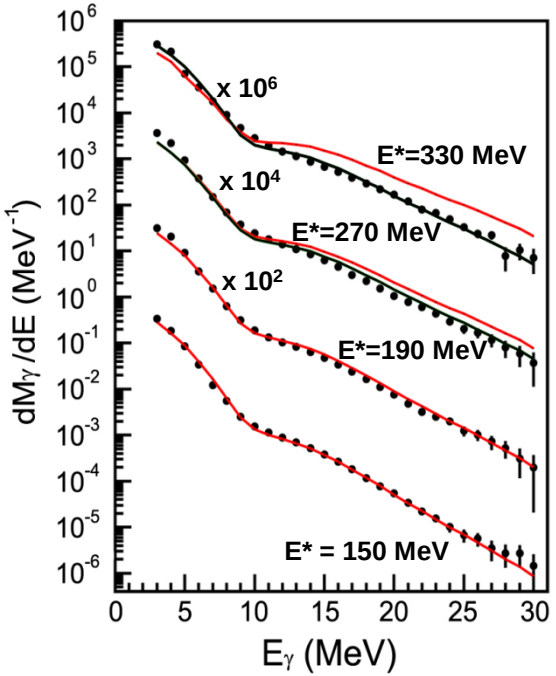


Fit degli spettri di protoni e alfa effettuato assumendo l'emissione da due sorgenti in movimento:

- Nucleo composto
- Sorgente di pre-equilibrio

150< E* < 330 MeV

Spettri γ e calcoli CASCADE per le varie E*



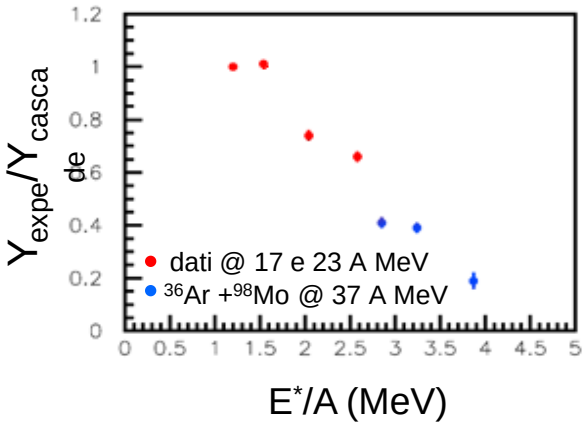
CASCADE inputs:

- 100% EWSR
- E_{GDR} = 14. – 14.5
- Γ_{GDR} = aumenta con E* (da 11 a 15 MeV)
- a = a(T)

– Standard Cascade calc.

– Cascade con cut-off a E* = 240 MeV

M_γ integrata (12 – 20 MeV)



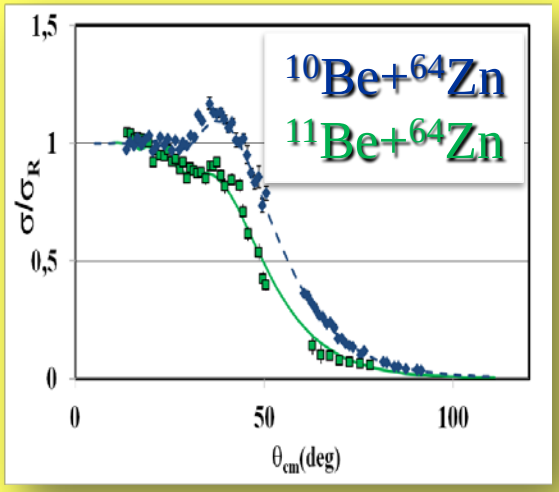
Il quenching della GDR compare a E*/A ≈ 2.0-2.2 MeV/A

Effetti di struttura sui meccanismi di reazione intorno alla barriera Coulombiana.

Collisioni indotte da nuclei con alone e/o debolmente legati, →
Raggio maggiore della sistematica e bassa soglia di breakup →
Attesi effetti sui meccanismi di reazione

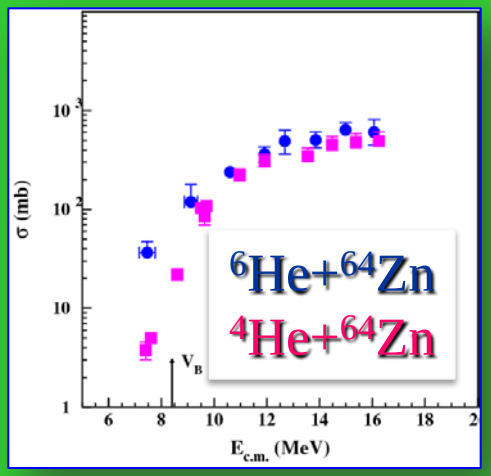
Distribuioni angolari elastiche per ^{10}Be+^{64}Zn e ^{11}Be+^{64}Zn stessa Ecm mostrano per ^{11}Be: Soppressione di σel Enhancement di σr.

σ_R ^{10}Be ≈1.2b σ_R ^{11}Be ≈2.7b



A. Di Pietro et al.:
Phys. Rev. Lett. 105,022701(2010)
: Phys. Rev. C 85, 054607 (2012)

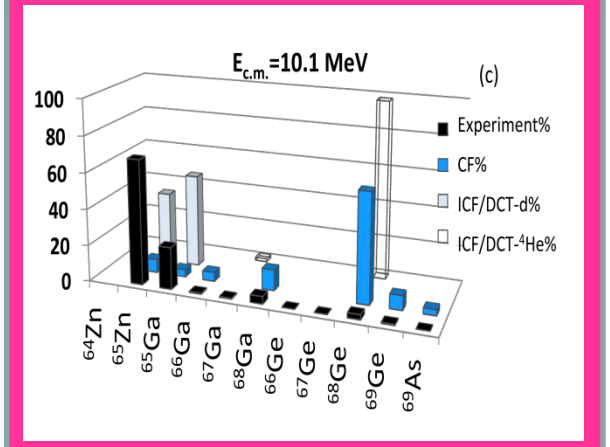
Funzioni di eccitazione di Fusione per ^{6}He+^{64}Zn e ^{4}He+^{64}Zn mostrano un enhancement della fusione per il nucleo halo ^{6}He



V. Scuderi et al.:
Phys. Rev. C 84, 064604,(2011)

In collisioni indotte da nuclei debolmente legati come ^{6}Li, ^{7}li, i meccanismi dominanti sotto barriera sono fusione incompleta e transfer.

Rese relative per ^{6}Li+^{64}Zn

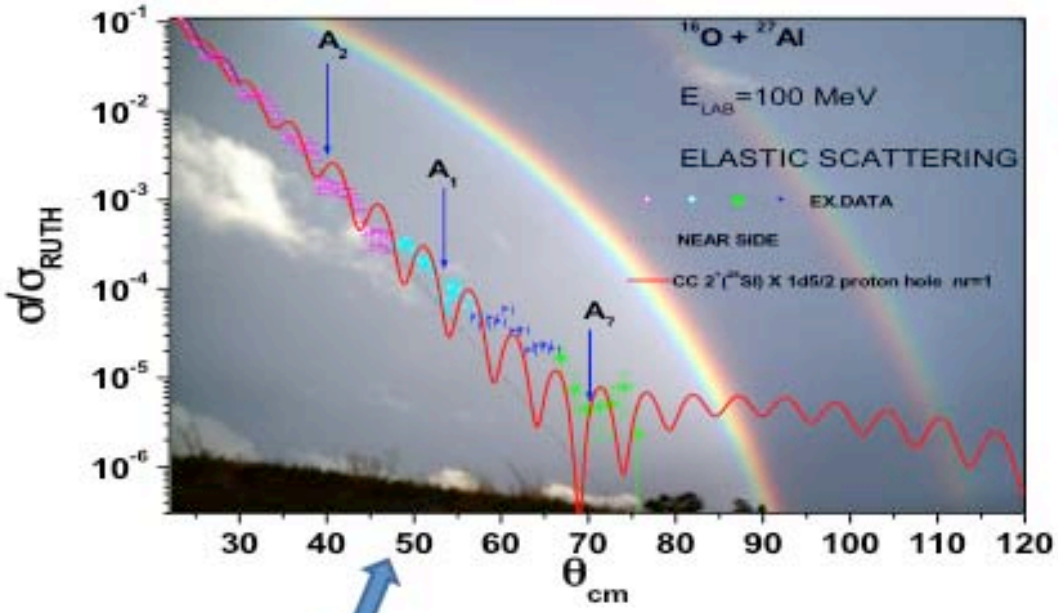


A. Di Pietro et al et al.:
Phys. Rev. C 87, 064614,(2013)

MAGNEX*EDEN

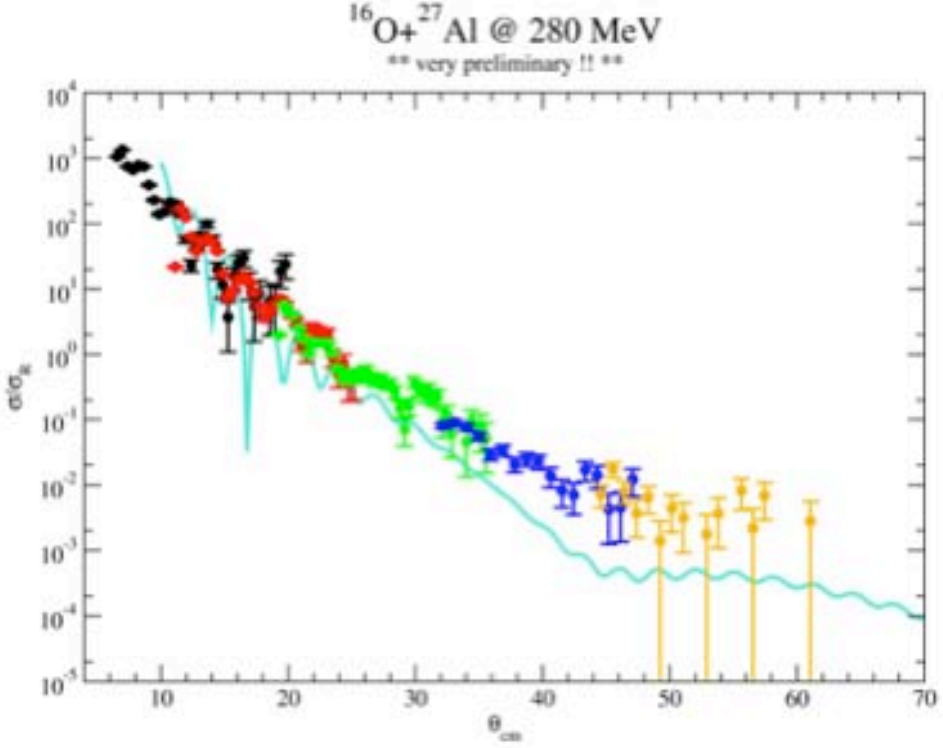
- Light nuclei structure
- Nuclear astrophysics
- Spectroscopy
- Structure effects on reaction mechanism

Nuclear Rainbow in $^{16}O + ^{27}Al$ elastic scattering



Tandem beam

Cyclotron beam



MAGNEX

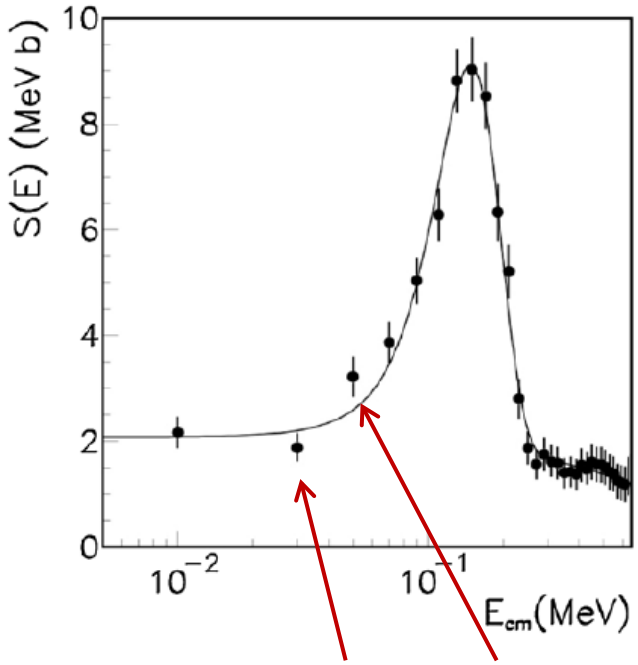
THM activities

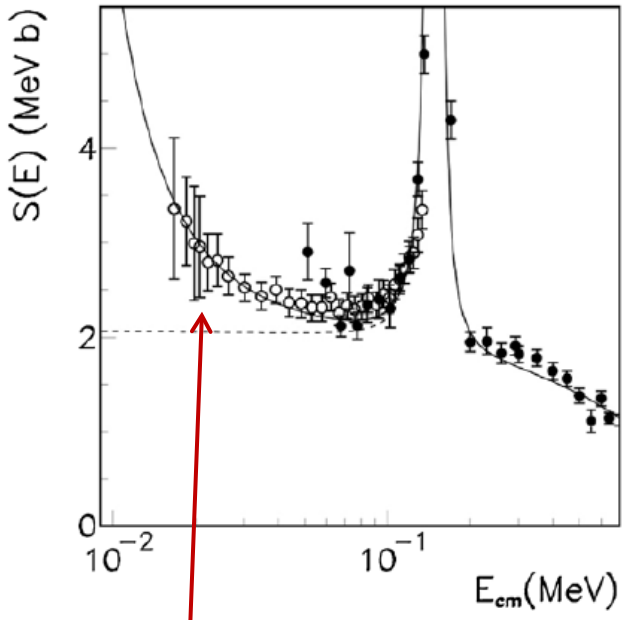
Progetto Premiale Astrofisica Nucleare

- Today, the THM is believed to be the unique technique which allows one to investigate nuclear effects in nuclear and astrophysical scenarios.

ASFIN

New measurement of the $^{11}B(p,\alpha_0)^8Be$ bare-nucleus S(E) factor via the Trojan horse method L. Lamia et al., JPG 39(2012)015106



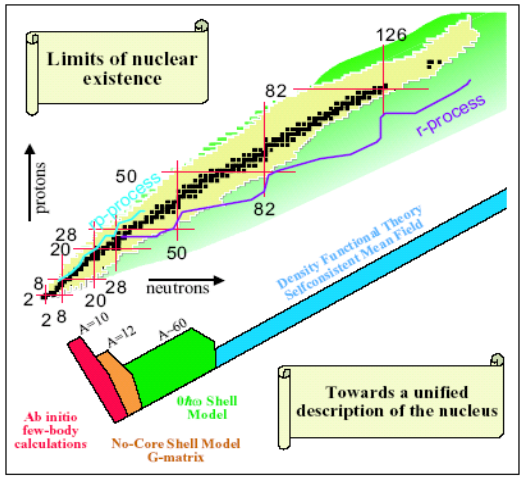


THM data + fit

From the comparison betwee direct data (affected by the electron screening) and the THM data (without screening effects) it is possible to extract the electron screening potential.

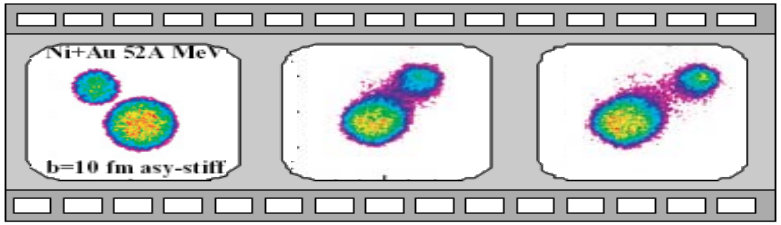
$$U_e^{\mathrm{THM}} = 472 \pm 160 \text{ eV}$$

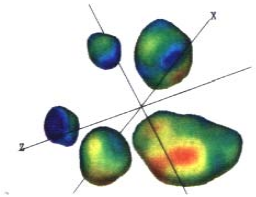
Nuclear Matter EoS : from Heavy-Ion Collisions to neutron stars

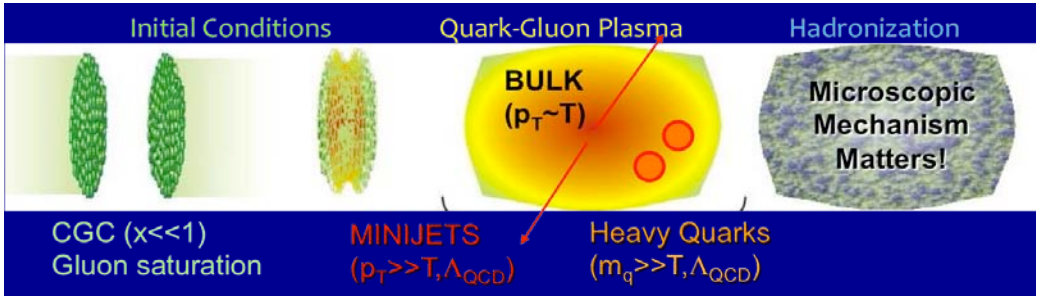


- ❖ Collective modes of medium-heavy nuclei
- ❖ Dynamics of nuclear many-body system
- ❖ Transport theory of nuclear and quark matter
- ❖ Phase Transitions in strongly interacting systems
- ❖ Structure and life of neutron stars

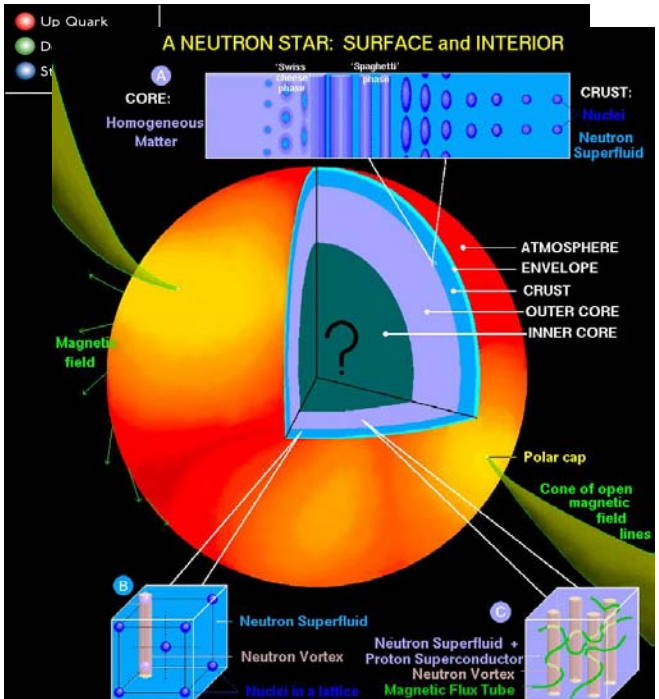
from 10 AMeV …



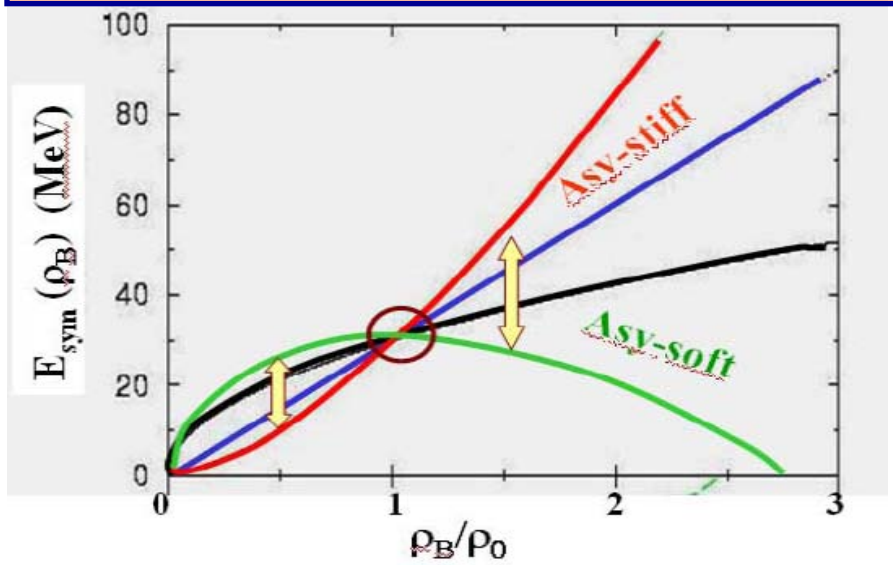


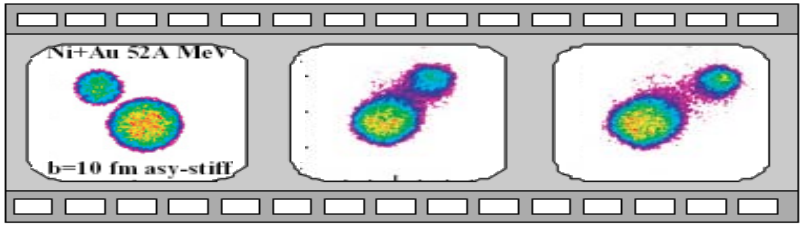


… to 10 ATeV



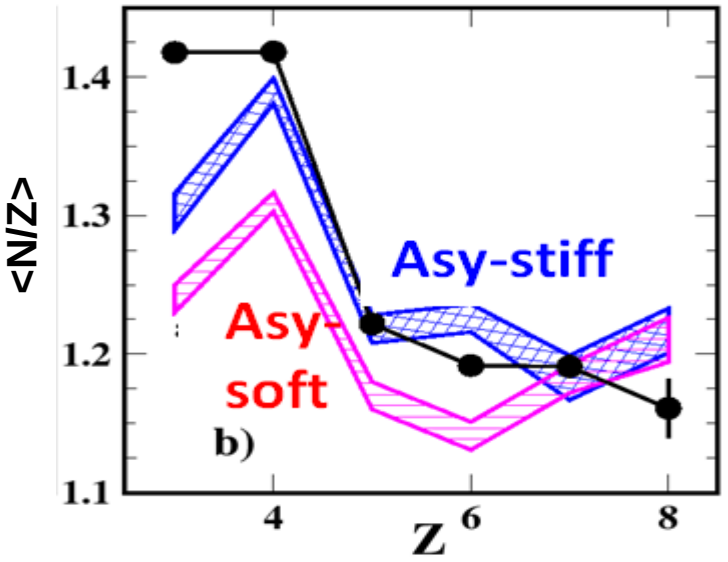
Unveiling the symmetry Energy at low density





Proprietà isotopiche dei frammenti in collisioni ad Energie di Fermi

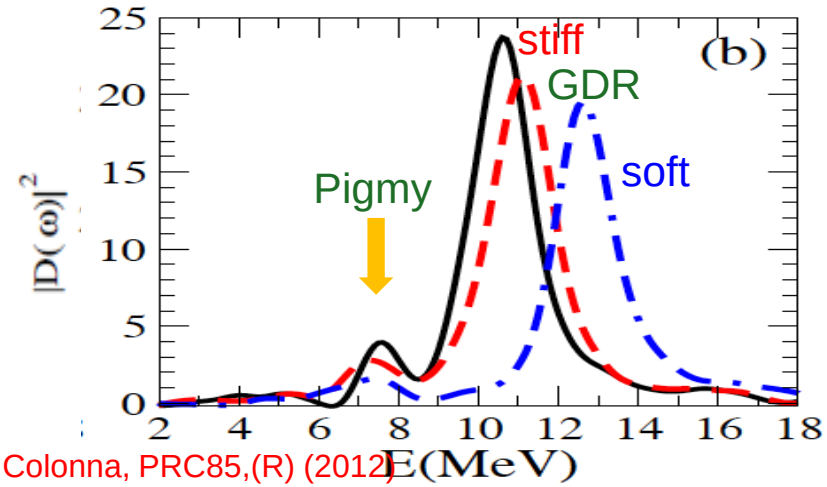
$^{124}Sn+^{64}Ni$ 35 A.MeV



E.De Filippo et al. (Chimera coll), PRC86(2012)

Miglior accordo per N/Z frammenti (neck) con Asy-stiff

GDR and Pygmy resonance in ^{140}Sn

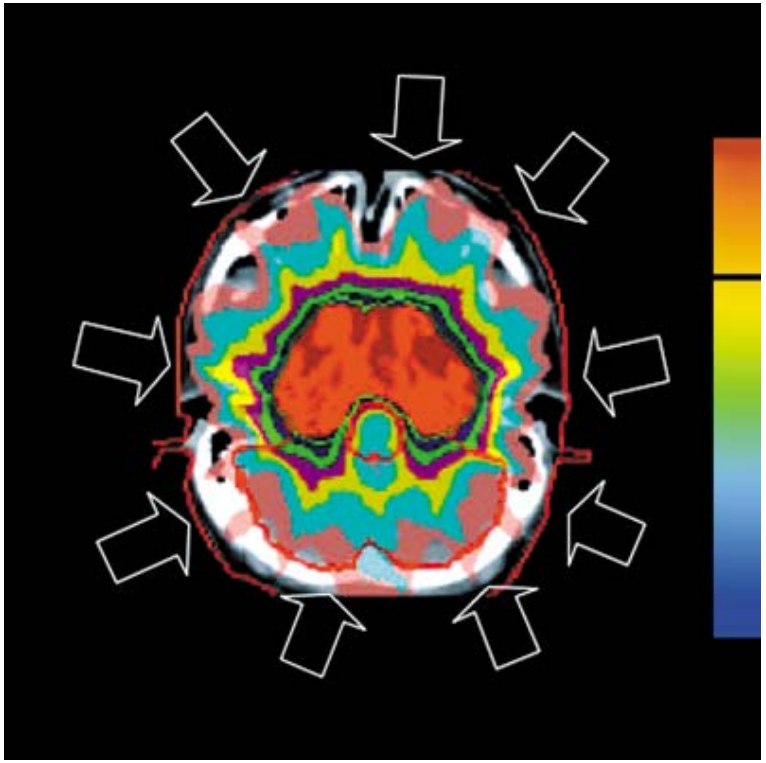


M.Colonna, PRC85,(R) (2012)

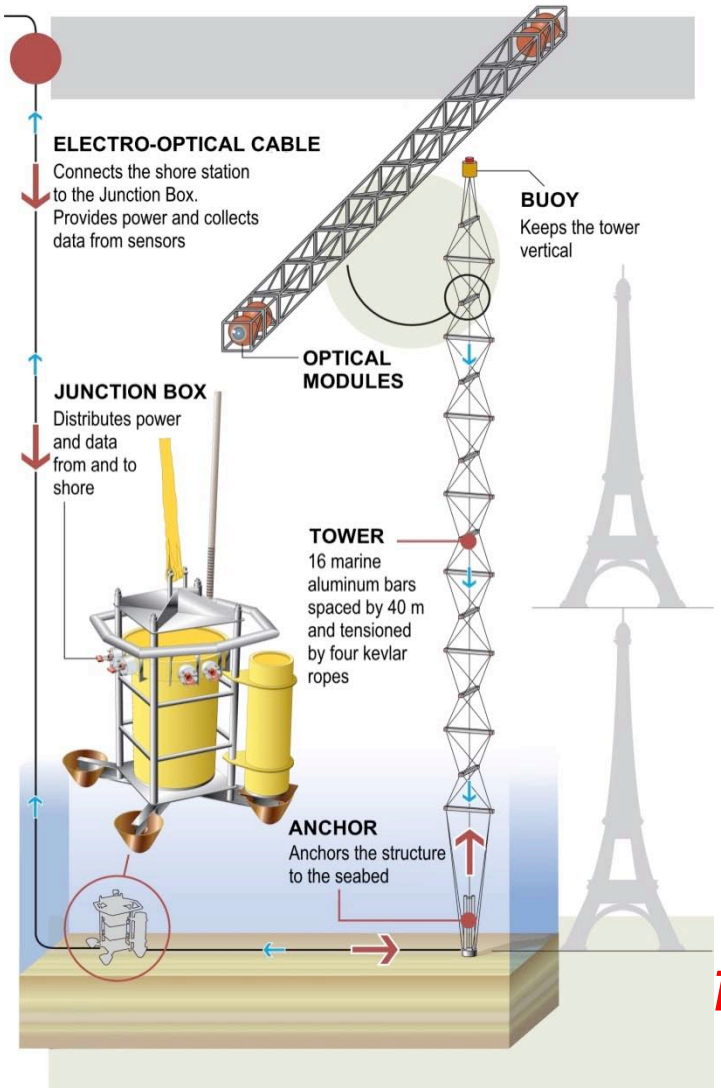
Pygmy: modo isoscalare che appare per sistemi ricchi di neutroni

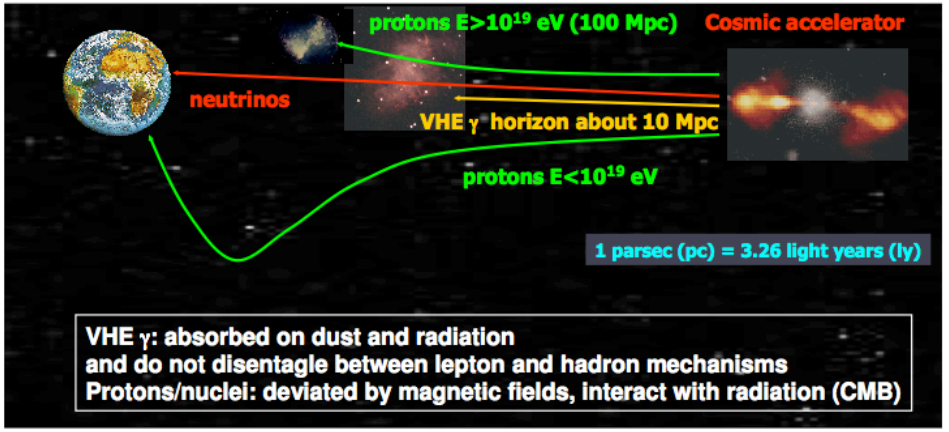
2 fisica delle
ASTROPARTICELLE

5 ricerca
TECNOLOGICA



NEMO and KM3NeT: High energy neutrino astronomy at LNS





Neutrinos will provide unique pieces of information on the High Energy Universe. Detection possible by tracking the secondary muons in a km-cube size array of photosensors in deep sea waters

20.8 M€(PON Funds) are at LNS for the realization of 8 towers and 24 strings at LNS-Porto Palo Lab

The Catania Test Site: a multidisciplinary deep sea-lab

LIDO demo mission of ESONET-EMSO: Refurbishment of SN1 and OnDE observatories
Goals: Bioacoustics, ocean monitoring,Tsunami warning.

100 Mbps Internet Radio Link

LNS Test Site Laboratory at the port of Catania

20 km

5 km

5 km

North Branch (SN1)

4 LBW hydrophones
2 LF hydrophones
CTD, ADCP,
Seismometers
magnetometers
pressure gauges
GPS time stamping

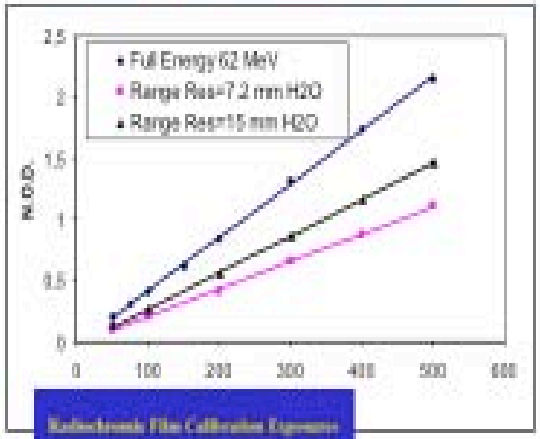
South Branch (Onde2)

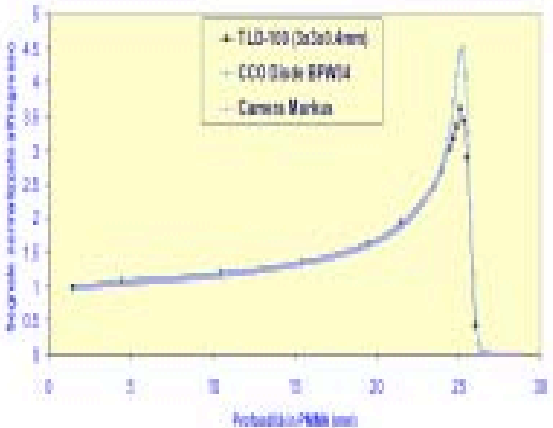
4 LBW hydrophones
Underwater GPS time stamping

Infrastructure requested by UCL and CSIC for installation of deep-sea stations in 2013

- CATANA: first Italian protontherapy facility
  - p @ 62 MeV by CS for treatment of ocular tumours[1]
  - More than 330 patients treated
  - Tumour local control of 95%[2]

- Expertise in the development and test of detector for relative and absolute dosimetry





[1] G. A. P. Cirrone *et al.*, IEEE Transaction on Nuclear Science, Vol. 51, N. 3, (2004).
[2] G. Cuttone *et al.*, THE EUROPEAN PHYSICAL JOURNAL PLUS, vol. 126, 65 (2011)

PATIENTS FOLLOW-UP

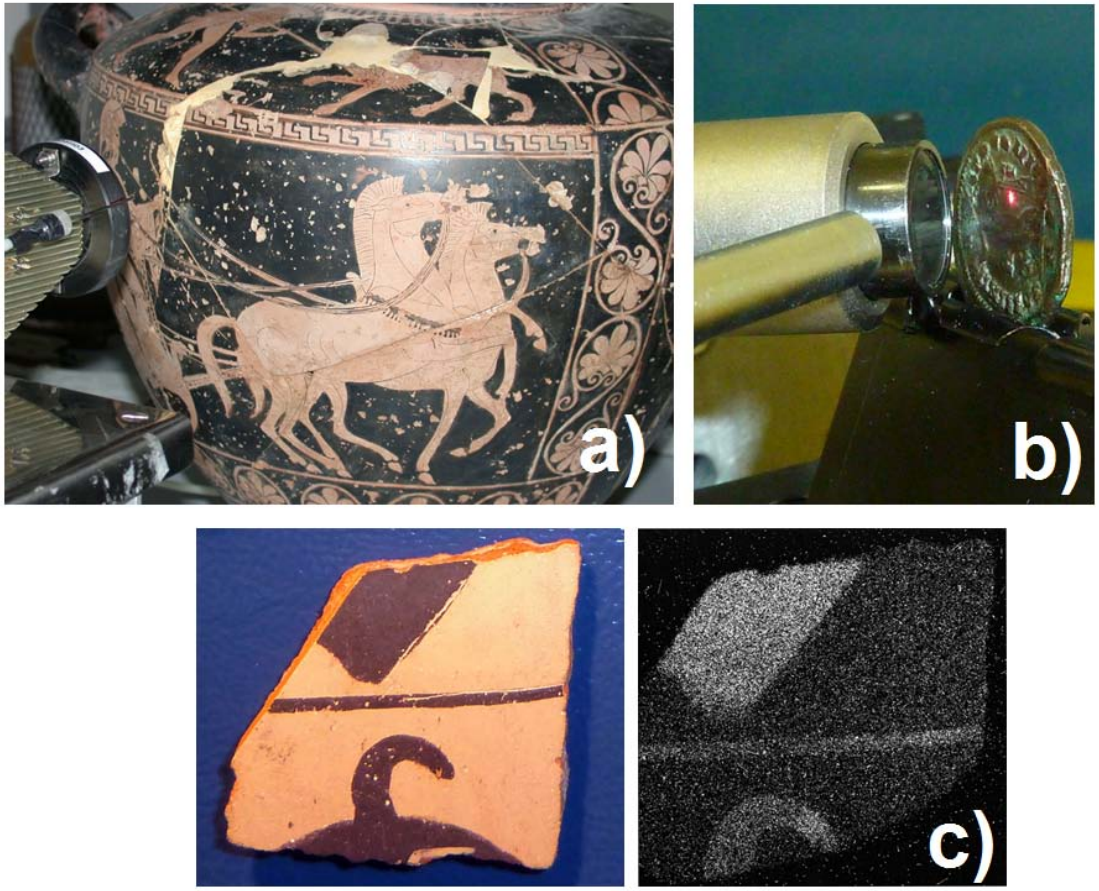
350 patients treated (Feb. 2002-Jul 2012)

- **336 uveal melanomas**
- **8 conjunctival melanoma**
- **6 other malignancies (orbital RMS, non-Hodgkin Lymphoma, various metastases)**

Follow-up on 220 patients: 95% of success

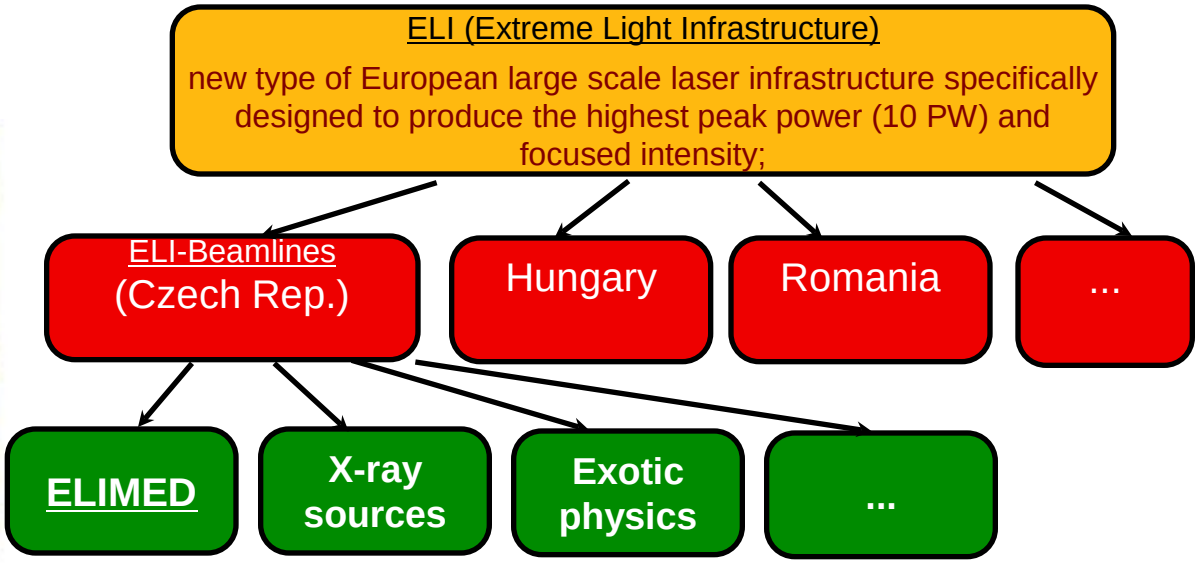
Follow-up: PT Center at Cannizzaro Hosp. in Catania. Tender in progress (120 M€). INFN is part of the game having on this item a dedicatd MoU with Regione Sicilia

LANDIS: Applications of nuclear physics in the field of cultural heritage

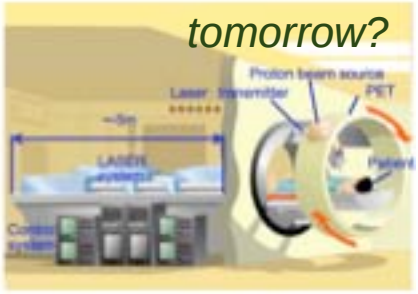


LANDIS collaboration: *innovative IBA (Ion Beam Analysis) and XRS (X-ray Spectrometry) non-destructive methods for in-situ applications in the Cultural Heritage field. The figure shows some complementary techniques – the PIXE-alfa, the LE-micro-XRF (low energy micro-XRF) and the X-ray imaging and space resolved spectroscopy – recently commissioned at the LANDIS laboratory for the analysis of surfaces in Arts and Archaeology.*

ELI-Beams and the ELIMED idea



- Why ELIMED?
  - Realization of a facility at ELI-Beamlines, to *demonstrate the clinical applicability of the laser-driven protons*
  - **Compactness, cost-reduction**, new pioneering treatment modalities



- Why ELIMED at INFN?

-The project we are proposing is related to the preparatory phase of ELIMED (2013-2015): optimisation of the proton beams, transport, diagnostic dosimetric and radiobiologic studies.

European Spallation Source – Lund (Sweden)

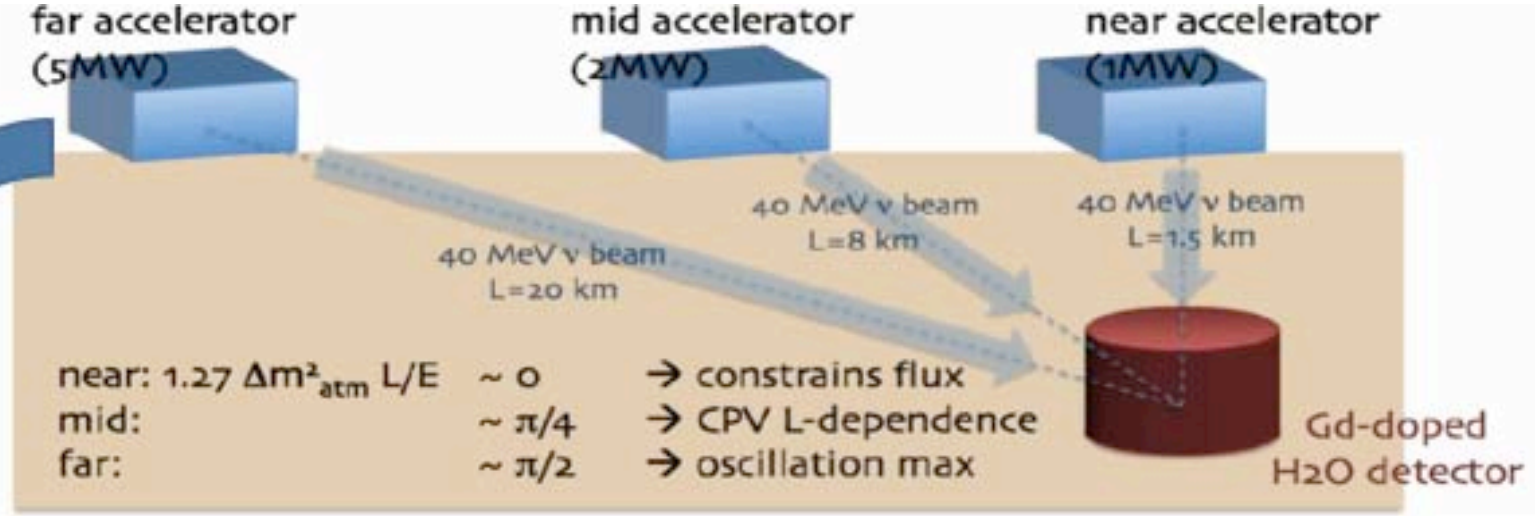
ACCELERATORS

- High power, highly **reliable Front Ends**
- High intensity light ions **Linacs** : systems design, beam dynamics, performance and current projects, reliability issues,
- **Synergies** with ongoing and planned projects on accelerator driven systems, transmutation, neutrino factories, HEP injectors, materials science

	Nominal	Upgrade
Average beam power	5.0 MW	7.5 MW
Macropulse length	2.86 ms	2.86 ms
Repetition rate	14 Hz	14 Hz
Proton energy	2.5 GeV	2.5 GeV
Beam current	50 mA	75 mA
Duty factor	4%	4%
Beam loss rate	< 1 W/m	< 1 W/m

- **Beam loss handling** and **diagnostics systems** for high brightness hadron accelerators (≪1 W/m with localized exceptions)
- Current state of **theory** and **simulation tools**, confronting predictions with experiment,
- **Low-energy superconducting structures,** to be checked: how competitive they are for energies below 100 MeV…

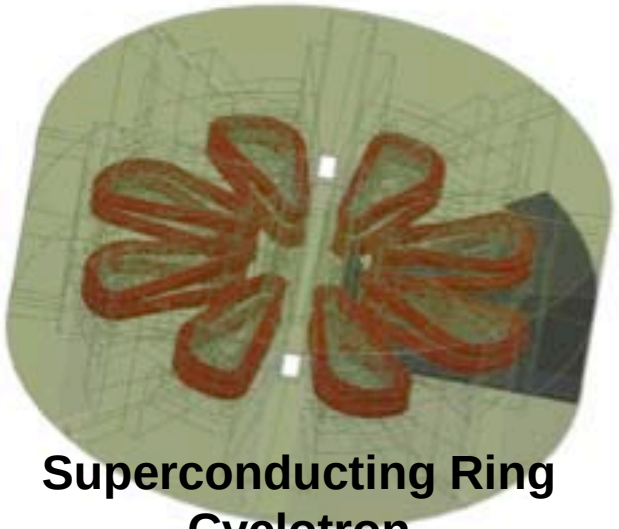
DAEδALUS: experiment overview



Accelerator Complex designed by LNS

VIS source

Normal conducting Cyclotron



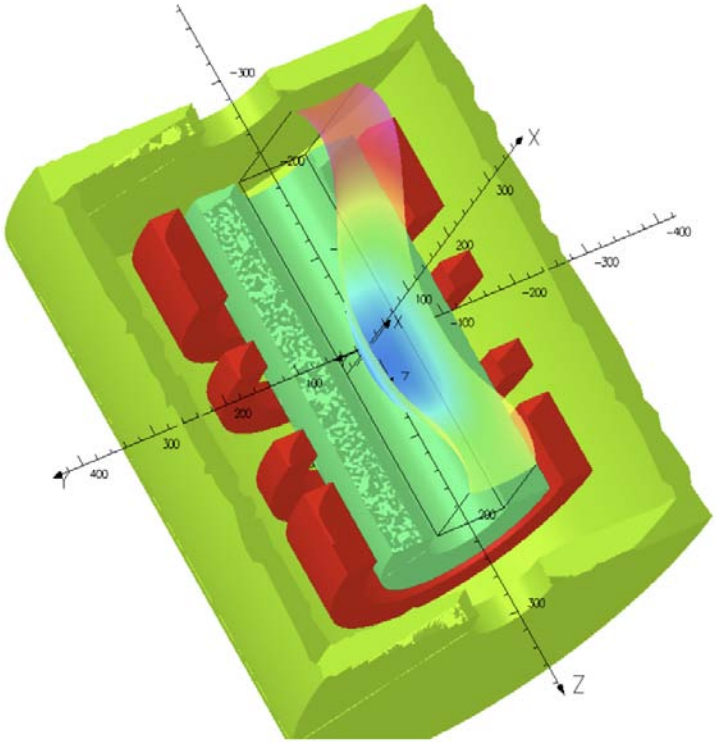
Superconducting Ring Cyclotron

INFN Istituto Nazionale di Fisica Nucleare

LABORATORI NAZIONALI DEL SUD

AISHa

Advanced Ion Source for Hadrontherapy



AISHA is a hybrid ECRIS: the radial confining field is obtained by means of a permanent magnet hexapole, while the axial field is obtained with a **Helium-free superconducting system.**

The **operating frequency of 18 GHz will permit** to maximize the plasma density by employing commercial microwave tubes meeting the **needs of the installation in a hospital** environments.

Radial field	1.3 T
Axial field	2.6 T - 0.4 T - 1.5 T
Operating frequencies	18 GHz (TFH)
Operating power	2 kW
LHe	Free
Iron yoke diameter/length	42 cm / 60 cm
Source weight estimation	480 kg

UNIONE EUROPEA

Regione Siciliana

PO FESR Sicilia 2007/2013

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CONCLUSIONS

- The LNS are characterized by a scientific activity varying from basic nuclear physics, to nuclear and particle astrophysics, to advanced nuclear applications;

- This broad spectrum of activity and excellent results obtained make the LNS a point of reference at European and international level;

- The LNS is also an important center for university and post graduation training, thanks to the world-class skills acquired over time;

- Thanks to the accelerators, the equipment and the skills acquired, the future sees the LNS involved in:
  - activities of increasing interest in nuclear physics;
  - nuclear and particle astrophysics projects with unique aspects in the world;
  - important contributions to European and International projects;
  - nuclear and interdisciplinary applications.

- The LNS are candidates to become a centre for astrophysics from keV to TeV.