Esperimento NUCL-EX

A. NUCLEX-SPERIM - Dinamica e Termodinamica Nucleare

- Fusione–Fissione
- Pre-equilibrio
- Clustering
- Densità dei Livelli
- Energia di Simmetria

Con fasci stabili e
fasci radioattivi (SPES)

B. NUCLEX-FAZIA

- Sviluppo di un rivelatore 4π con alta risoluzione in carica e massa per studiare la fisica dell'isospin

Indice:

Introduzione

Sede	Ricercatori	Tecnologi	FTE
Legnaro	6		3.6
Padova	1		0.5
Bologna	4	1	3.45
Firenze	10		9.6
Napoli	7	1	5

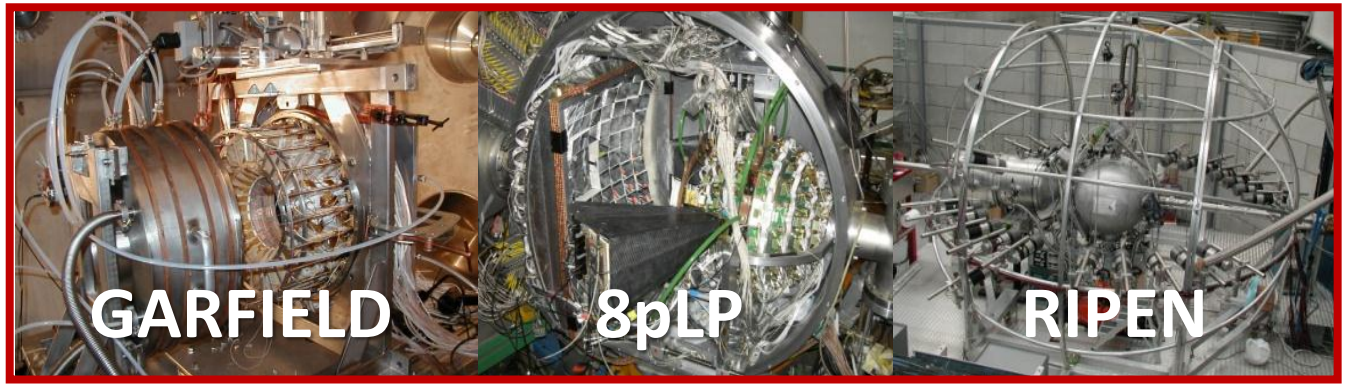
Rappresentanti Nazionali:
F. Gramegna (LNL)
G. Casini (FI)

30 Ricercatori (22 FTE)

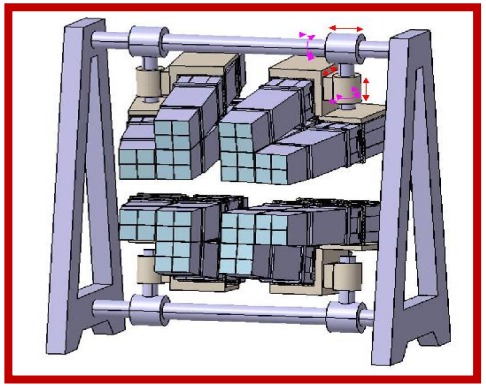
Collaborazioni internazionali:
Francia: GANIL; LPC; IPNO.
Turchia: Nevsehir University.
Russia: Moskow State University; Jyvaskyla, Dubna.
India: BARC, Mumbai.

Collaborazioni italiane:
-Esp HYDE (INFN gr 5).
-Gruppo di C. Broggini (PD).
-G. Collazuol (PD).

Responsabilità apparati @ LNL



Dimostratore di FAZIA



Attività 2012 -2013: misure completate

Setup	Periodo	Esperimento	Reazioni misurate	Stato dell'analisi
GARFIELD	Giu–Lug 2012	*csym* PAC: 06/2011	$^{32}S+^{40}Ca$ (17.7 AMeV) $^{32}S+^{48}Ca$ (17.7 AMeV) $^{32}S+^{48}Ti$ (17.7 AMeV) + ^{197}Au per calib e ^{12}C per fondo	In corso Calibrazioni completate
GARFIELD	Ott-Nov 2012	*delight* PAC: 06/2012	$^{14}N + ^{10}B$ (80, 60 MeV) $^{14}N + ^{12}C$ (80 MeV) + ^{197}Au per calib	In corso Risultati preliminari disponibili Poster INPC + contributo L. Morelli (in preparazione)
GARFIELD	Dic 2012 Gen 2013	*delight2* LNL - free beamtime	$^{12}C + ^{12}C$ (95 MeV) $^{12}C + ^{11}B$ (95 MeV) $^{12}C + ^{13}C$ (95 MeV)	In corso
GARFIELD	Feb-Mar 2013	*aclust* PAC: 06/2012	$^{16}O + ^{65}Cu$ (16AMeV) $^{19}F + ^{62}Ni$ (16AMeV) $^{19}F + ^{65}Cu$ (16AMeV) + ^{197}Au per calib	In corso Calibrazioni in corso
RIPEN	Lug+Sett-Ott 2013	*25Mg* USP:06/2012	$^{25}Mg(\alpha,n)^{28}Si$ @CN (3, 4, 5 MeV)	In corso*** Analisi in fase avanzata Poster INPC + contributo R. Depalo (in preparazione)
RIPEN	Mag-Giu 2013	*SHE* PAC: 01/2013	$^{50}Ti+ ^{208}Pb$ (294 MeV)	Esp appena terminato*** Calib con sorgenti in corso.
FAZIA	Nov-Dic 2012 Mag 2013	*commissioning* PAC 06/2012	$^{40}Ar +$ Sn Ni (35AMeV) $^{84}Kr +$ Sn Ni (35AMeV)	Completato solo in parte per problemi al CS. Da recuperare

Attività 2012 -2013: produzione scientifica

Setup	Esperimento	Articoli	Conferenze
GARFIELD	delight 2011	Baiocco G. et al., Phys. Rev. C 87, 054614 (2013)	G. Baiocco Varenna 2013 G. Baiocco Eurisol Lisbona 2012
GARFIELD	delight2		L. Morelli INPC 2013
GARFIELD	NUCLEX csym/isospin – General Talk		F. Gramegna EURORIB 2012 (INVITED)
RIPEN	Betabeams	Edgecock, T. R. et al., Phys. Rev. STAB 16, 021002 (2013) E. Wildner et al, Phys. Rev. STAB, to be published	E. Wildner Florida 2012 T. Marchi Varenna 2012 M. Cinausero EURORIB 2012 M. Cinausero INPC 2013
RIPEN	25Mg		R. Depalo INPC 2013
8PLP	ISOSPIN Level density	Moro, R. et al., Eur. Phys. Journal A 48, 159 (2012)	
FAZIA	TECH	-Barlini, S. et al., NIM A 707, 89 (2013) -Le Neindre, N. et al., NIM A 701 , 145 (2013) -Pasquali, G. et al., Eur. Phys. Journal A 48 , 158 (2012)	G. Casini INPC 2013 (INVITED)
FAZIA	ISOSPIN diffusion	Barlini, S. et al., Phys. Rev. C 87, 054607 (2013)	S. Piantelli, Antalya 2013 (INVITED)

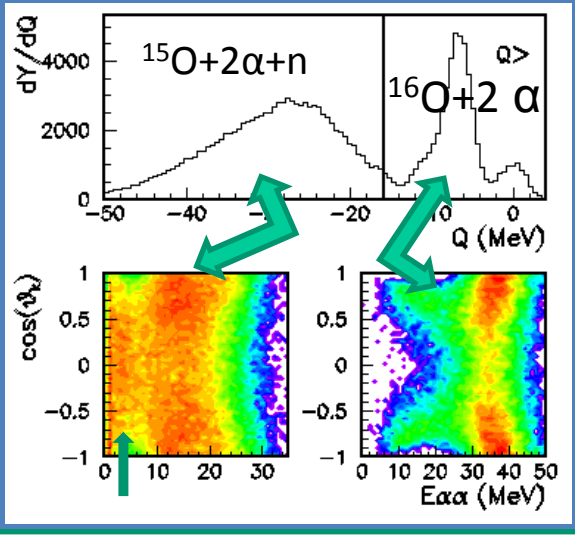
Esp: *delight – delight2*

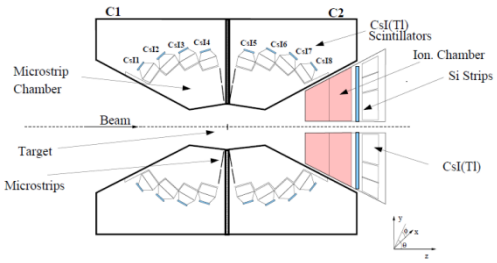
clustering in sistemi leggeri

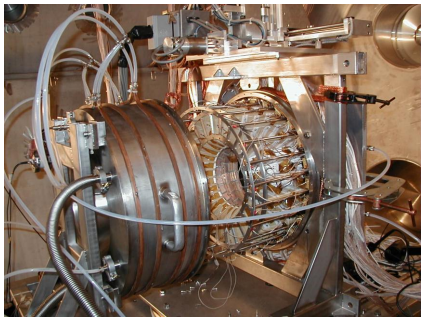
NUCL-EX

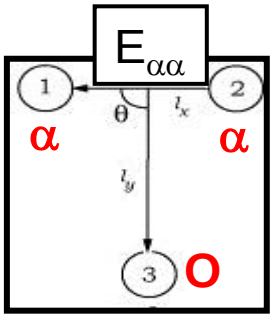
G.A.R.F.I.E.L.D. General ARray for Fragment Identification and Emitted Light particles in Dissipative collisions

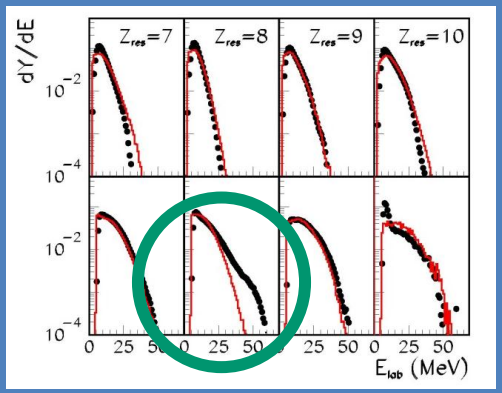
α–α correlations in complete kinematics
α-cluster dominance at all dissipation











deviation from statistical behavior for 2a-$^{16-x}$O-xn channel

Complete detection of dissipative ^{12}C+ ^{12}C reactions at 95 MeV with GARFIELD + RCo

PHYSICAL REVIEW C 87, 054614 (2013)

α-clustering effects in dissipative ^{12}C + ^{12}C reactions at 95 MeV

G. Baiocco,[1,2,*] L. Morelli,[1] F. Gulminelli,[2] M. D'Agostino,[1] M. Bruno,[1] U. Abbondanno,[3] S. Barlini,[4,5] M. Bini,[4,5] S. Carboni,[4,5] G. Casini,[5] M. Cinausero,[6] M. Degerlier,[7] F. Gramegna,[6] V. L. Kravchuk,[6,8] T. Marchi,[6,9] A. Olmi,[5] G. Pasquali,[4,5] S. Piantelli,[5] and Ad. R. Raduta[10]

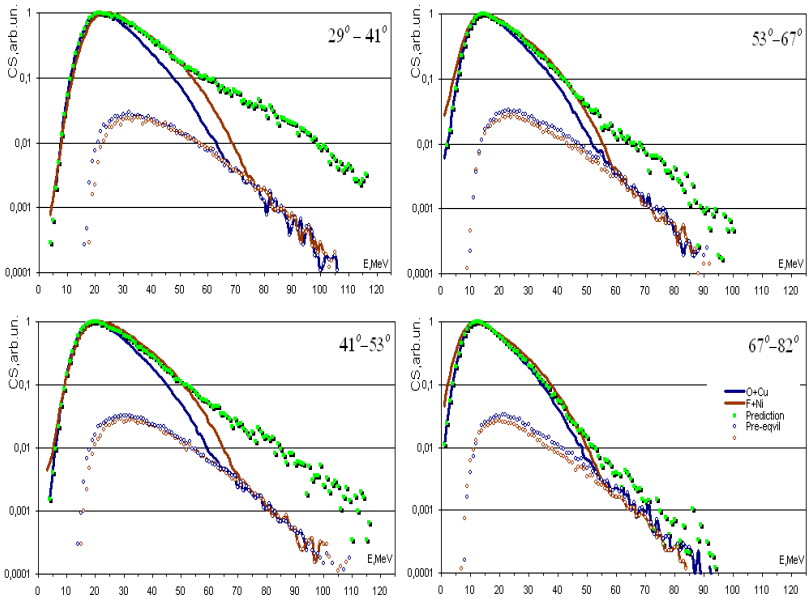
^{14}N + ^{10}B -> ^{24}Mg E_b = 80 MeV

^{12}C + ^{12}C, ^{13}C E_b = 95 MeV

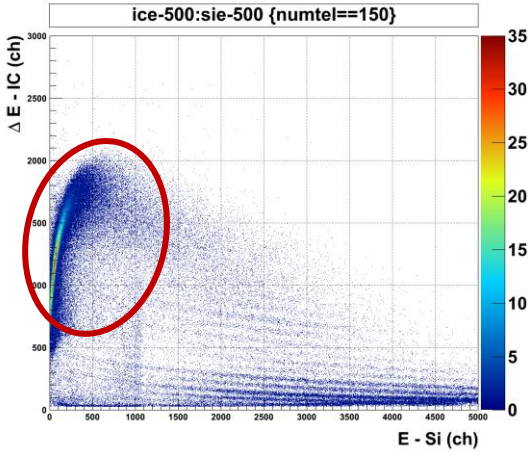
Esp: aclust

Pre-equilibrium a-particle emission as a probe to study a-clustering in nuclei

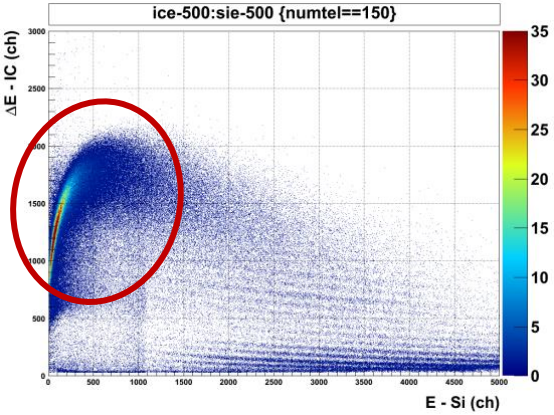
- Hybrid model calculation $^{19}F+^{62}Ni$
- Hybrid model calculation $^{16}O+^{65}Cu$
- Hybrid model + clustering $^{16}O+^{65}Cu$



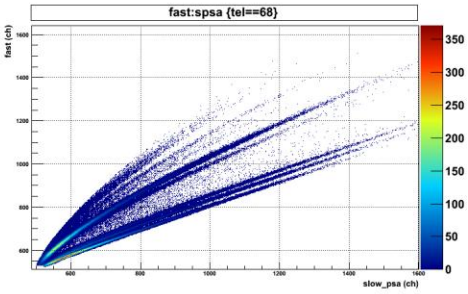
O. Fotina et al. Int.Journ. Mod. Phys. E19(2010)1134
D. O. Eremenko et al. Phys. Atom. Nucl. 65 (2002)18

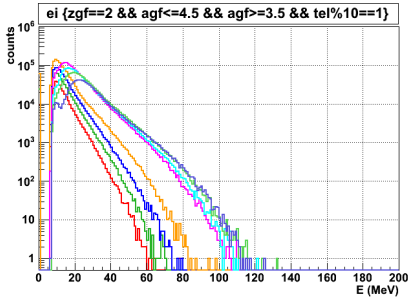


$^{19}F + ^{62}Ni$
$E_b = 256$ MeV



$^{16}O + ^{65}Cu$
$E_b = 256$ MeV





G.A.R.F.I.E.L.D.
General ARray for Fragment Identification and Emitted Light particles in Dissipative collisions

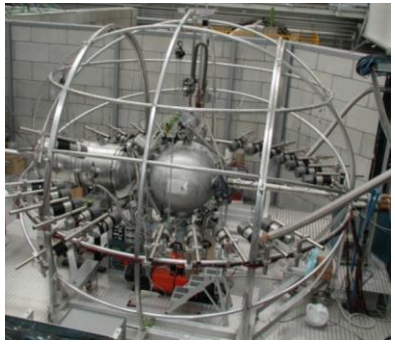
RIPEN – upgrade elettronica

Detectors

24 -30 x
BC501 Anode signal

1x
time reference signal (RF)

Ancillary detectors signals



Front End electronics

CAEN V2718 | CAEN V1720 | CAEN V1720 | CAEN V1724 | CAEN V1751 | CAEN V1495

clk sync line

VME BUS: 80 MB/s

Optical Fiber
Conet1 CAEN protocol
(Up to) 70 MB/s

DAQ

CAEN A2818
(256k BUFFER)

PCI Bus: 133MB/s

RAM: 1 file per board buffer (500 MB)

Storage *(RAW SHAPES)*

NFS

ACQUISTION PC
(*Desktop PC performance: 4 cores, 4 GB RAM*)

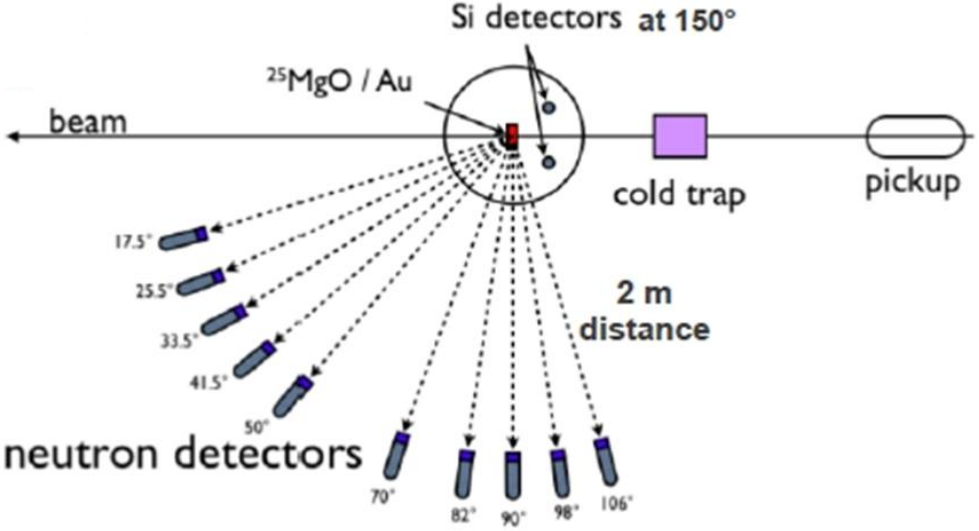
On-line monitors

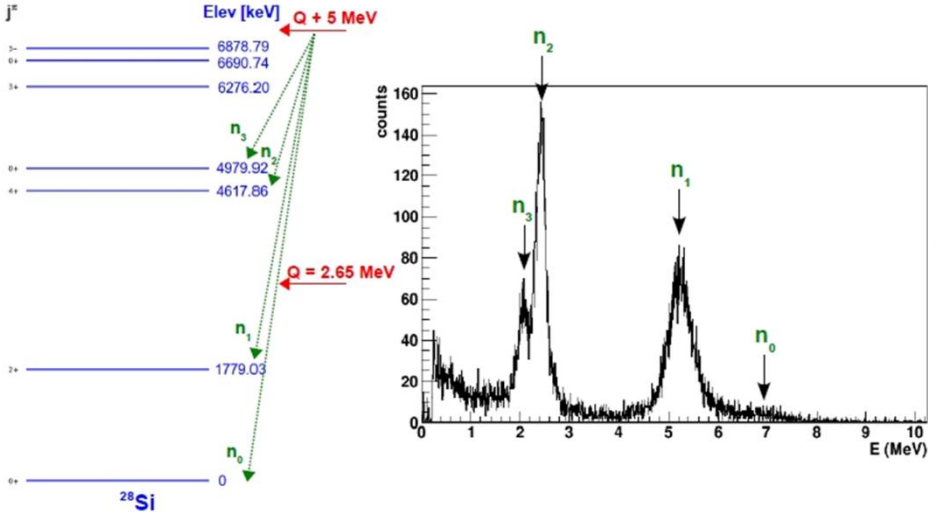
RIPEN @ CN Van de Graaf accelerator

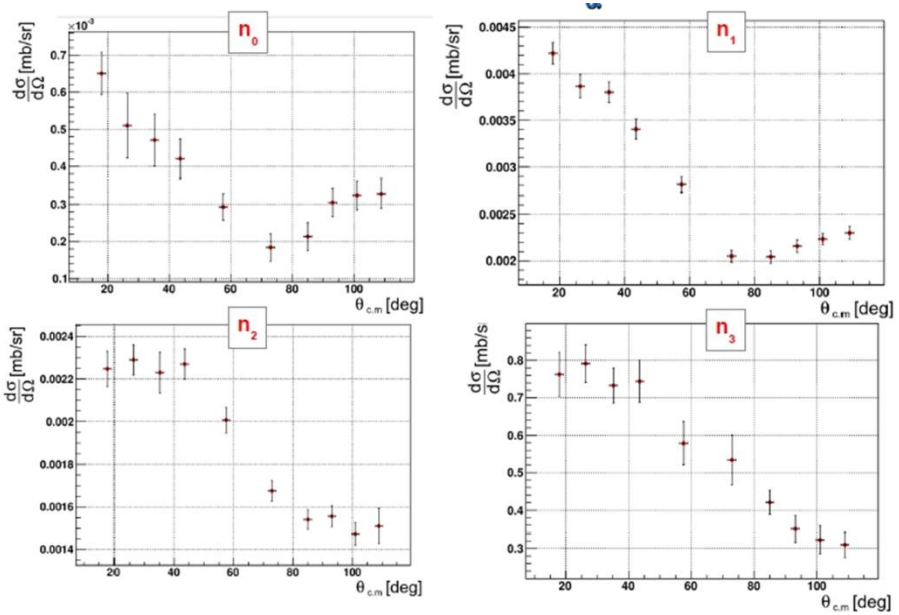
^{26}Al mainly produced by
^{25}Mg(p,γ)^{26}Al

^{25}Mg(α,n)^{28}Si (Q=2.654MeV)
"destroys" ^{25}Mg seeds

Biggest impact on ^{26}Al abundance in the explosive C/Ne burning



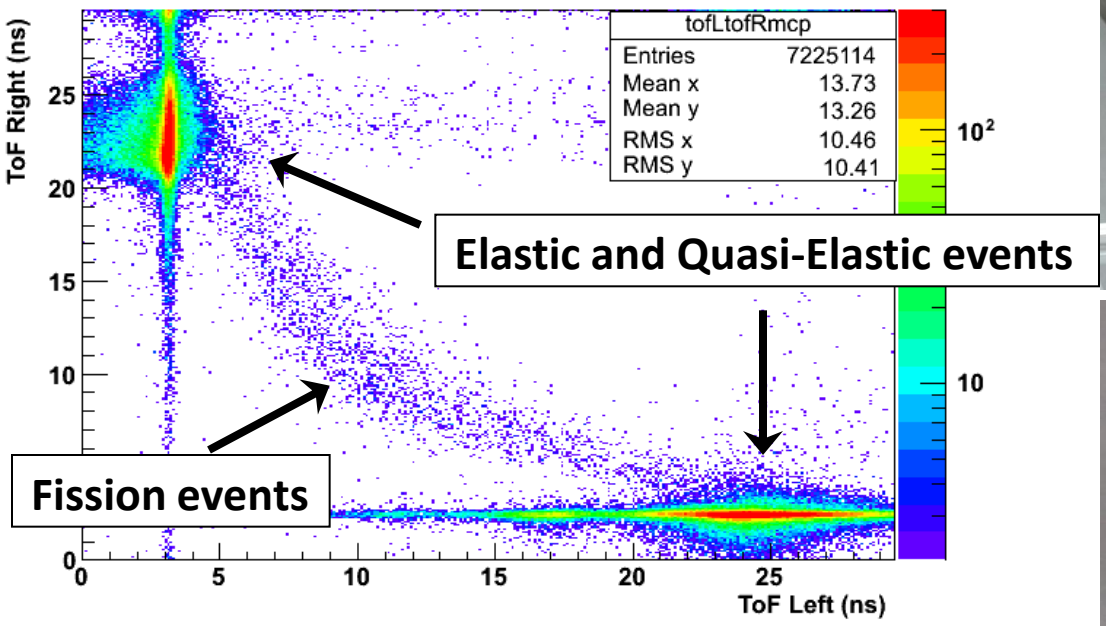


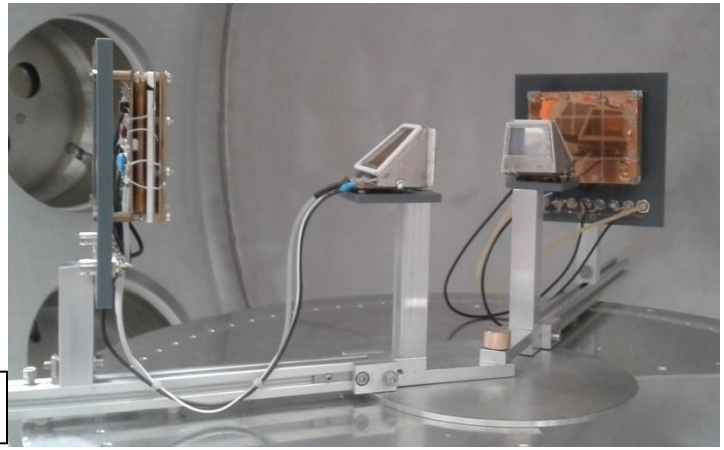


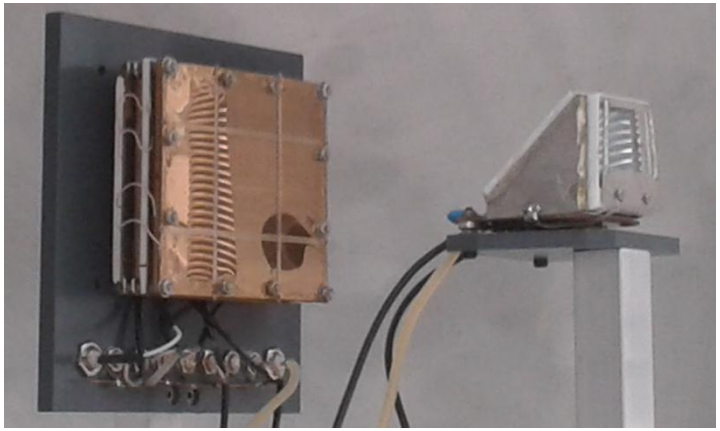
Study of binary fragmentation and compound nucleus fission in the fusion reactions ^{50}Ti+ ^{208}Pb at 294 MeV bombarding energy

- RIPEN detectors coupled with the CORSET spectrometer for heavy fragments
- New complete digital electronics front-end

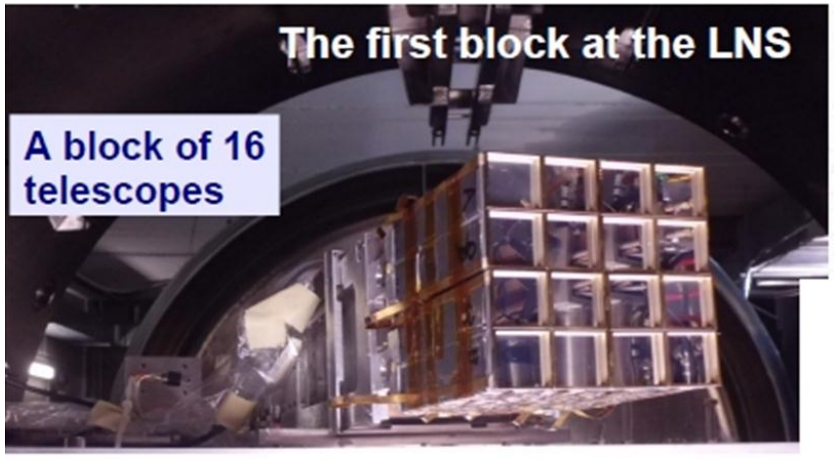
ToF correlation matrix Left –Right CORSET



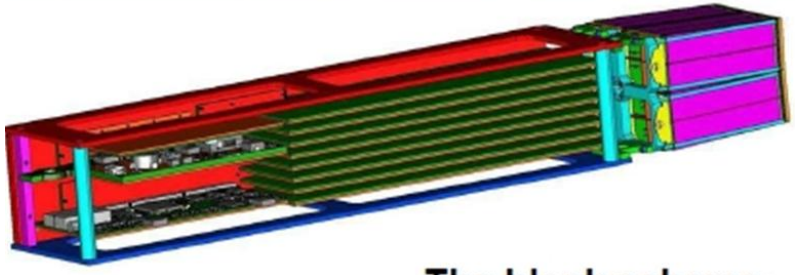




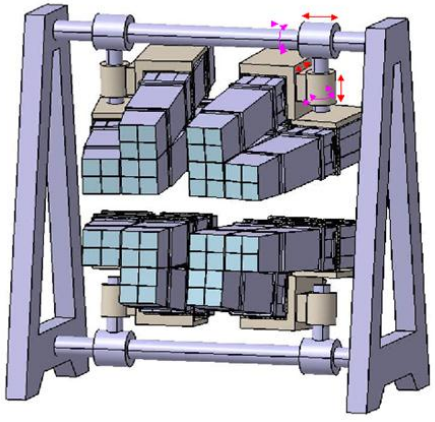
Il dimostratore di FAZIA

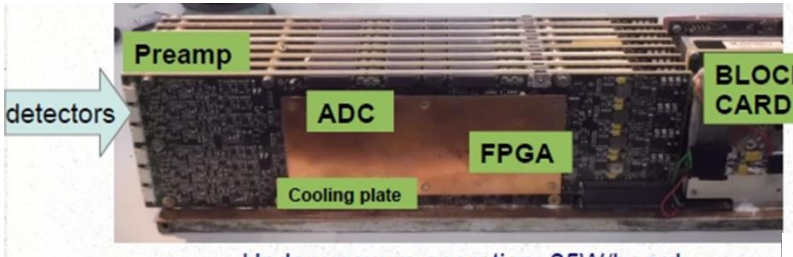


- Stage 1 (silicon 300 µm)
  - Charge 250 MeV full scale 250 Ms/s 14 bit
  - Charge 4 GeV full scale 100 Ms/s 14 bit
  - Current 250 Ms/s 14 bit
- Stage 2 (silicon 500 µm)
  - Charge 4 GeV full scale 100 Ms/s 14 bit
  - Current 250 Ms/s 14 bit
- Stage 3 (CsI + photodiode)
  - Charge 4 GeV full scale 100 Ms/s 14 bit



The block scheme





Under vacuum operation: 25W/board

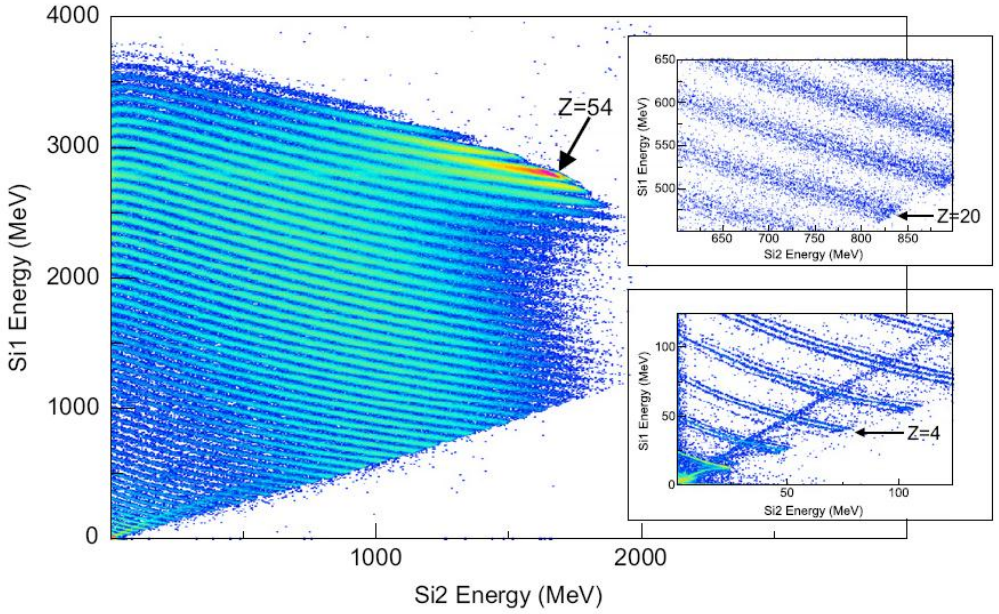
Embedded Logics

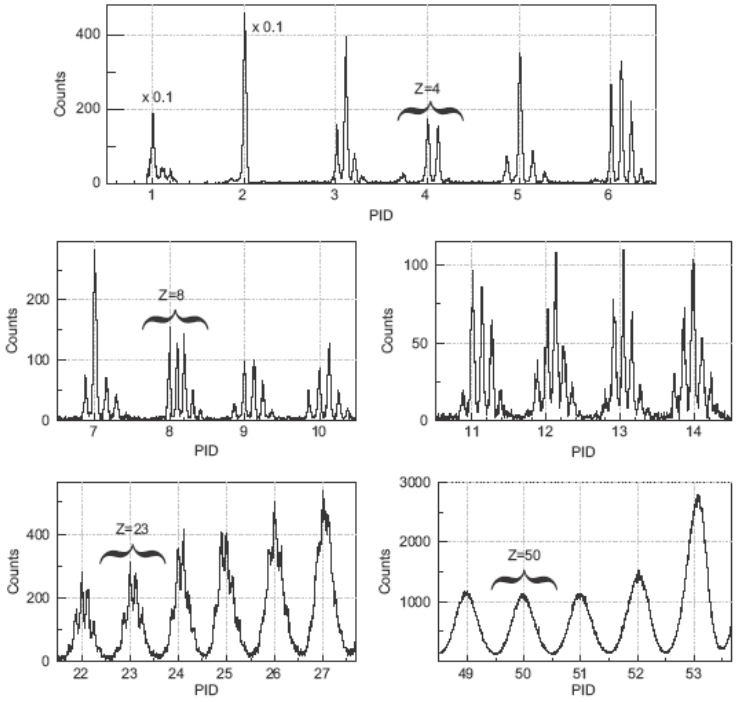
- Trigger
- Memories & buffers
- Communication

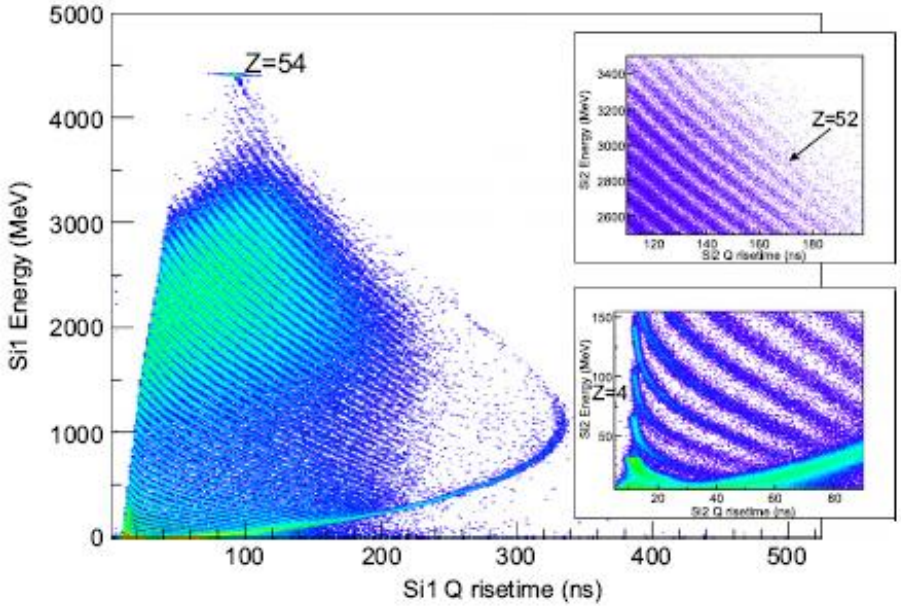
Embedded functions

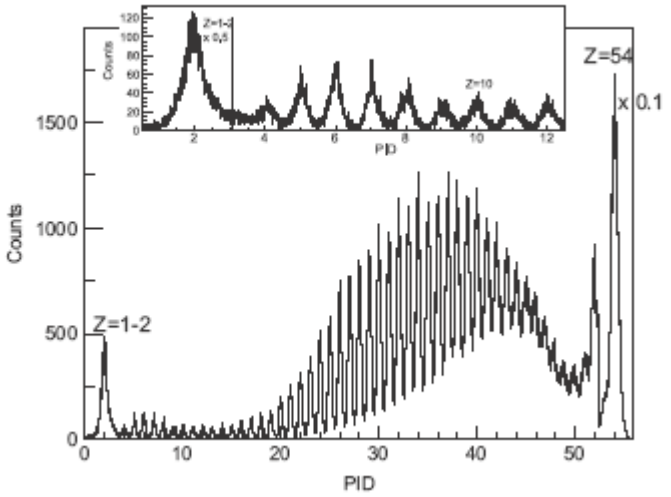
- Pulser to all chan
- Generation and regulation of bias V

Il dimostratore di FAZIA









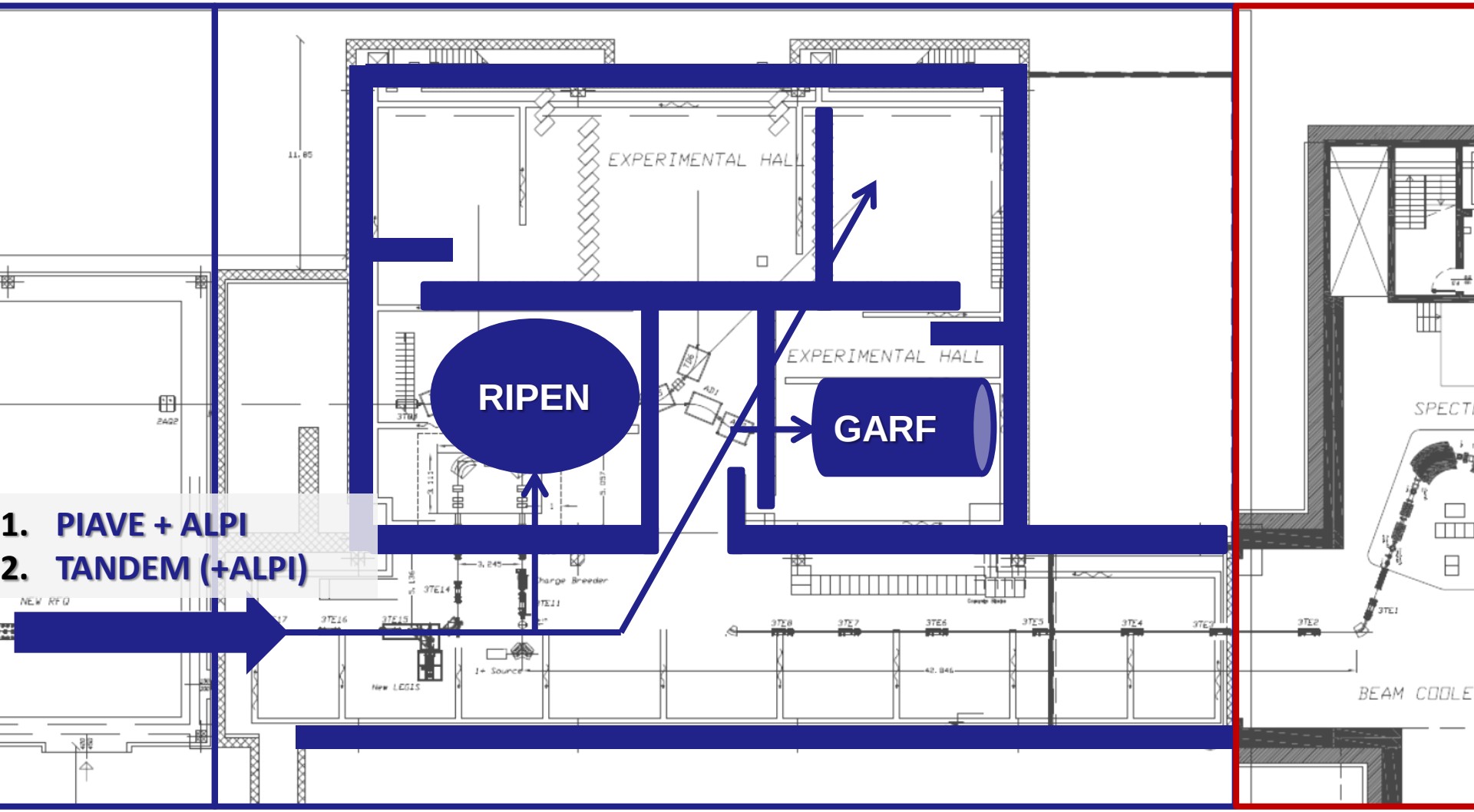
Prospettive 2013 - 2014

Programma 2014 a Legnaro

ACCEL. LNL (ZONA ALPI)

SALA SPERIMENTALE 3

SPES

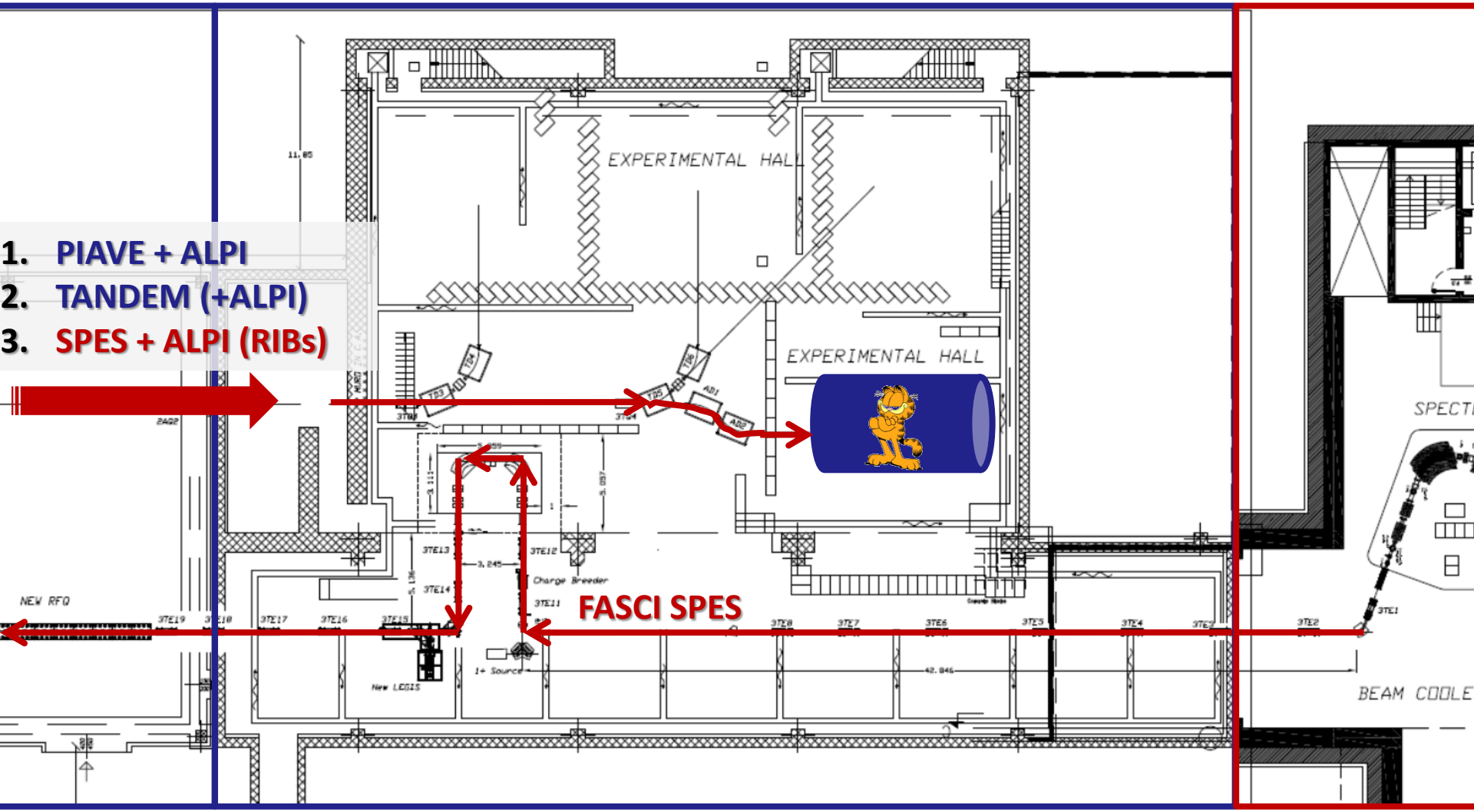


Programma 2014 a Legnaro

ACCEL. LNL (ZONA ALPI)

SALA SPERIMENTALE 3

SPES



Programma 2014 a Legnaro

ACCEL. LNL

SALA SPERIMENTALE 3

SPES

Dalla seconda metà 2013 fino autunno 2014 la III sala LNL inagibile per installazioni linee di trasporto di SPES

- **GARFIELD sarà inattivo**

Si userà tale periodo per una manutenzione straordinaria dei rivelatori e dell'elettronica

- **RIPEN dovrà essere rimosso per alloggiamento Charge Breeder SPES.**

I rivelatori verranno utilizzati in altre aree sperimentali.

Proposte di esperimento sottoposte al PAC e all'USP dei LNL :

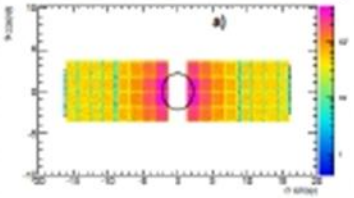
- 8pLP – Clustering Effects in ^{48}**Cr** Composite Nucleus Produced via ^{24}Mg + ^{24}Mg Reactions – (TANDEM – ALPI)
- RIPEN – Study of Prompt Neutron Emission Spectra in Fast Neutron Induced Fission of ^{238}U and ^{232} and 30 keV Neutron Induced Fission on ^{235}U (CN)

Il dimostratore di FAZIA: programma sperimentale

ACCETTATI DAL PAC LNS

2014 - 15 4 FAZIA blocks in a stand-alone configuration. Partial covering of forward angles from 2 to 16 degrees
MAIN PHYSICS: QP features, QP fragmentation cross section

64telescopes



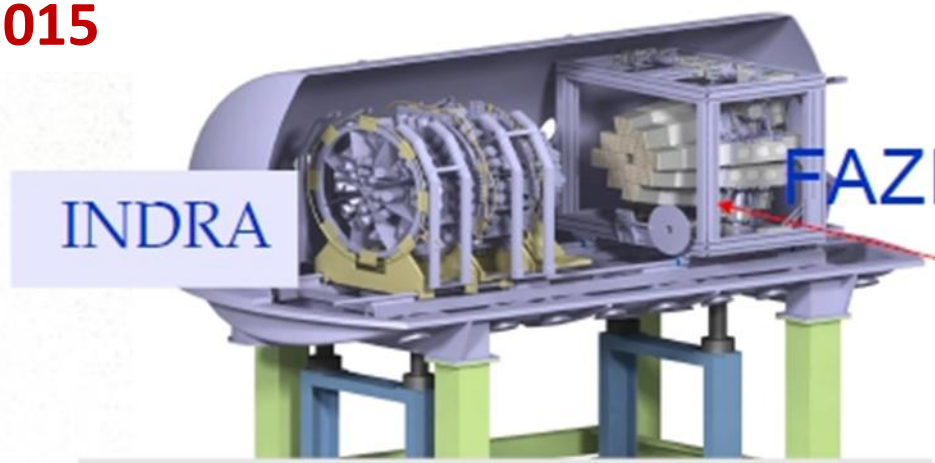
Geometry of 4 blocks

Two proposals for next LNS-PAC at the Fermi energy domain

- **40,48Ca+40,48Ca** at 35AMeV to refine VAMOS-INDRA data and to accurately determine fragment cross sections
- **78Kr+46,50Ti** at 35AMeV in reverse kinematics, to investigate the role of isospin diffusion on QP sequential fission

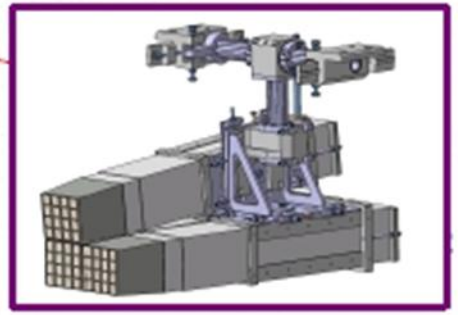
> 2015

192 telescopes

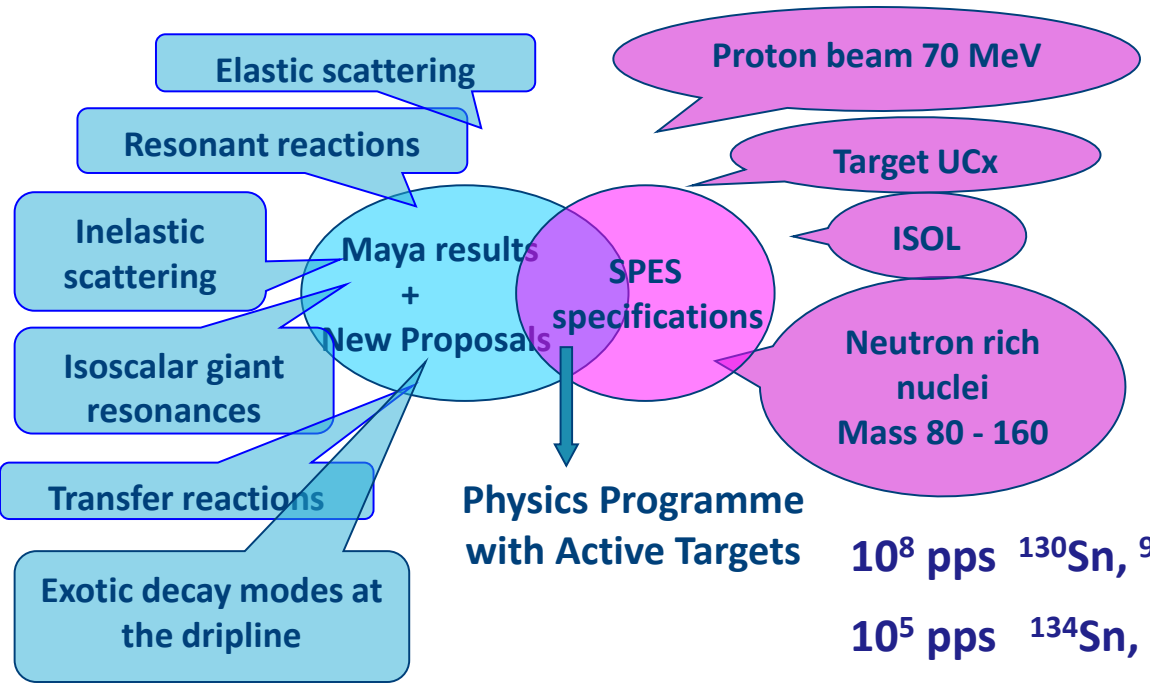


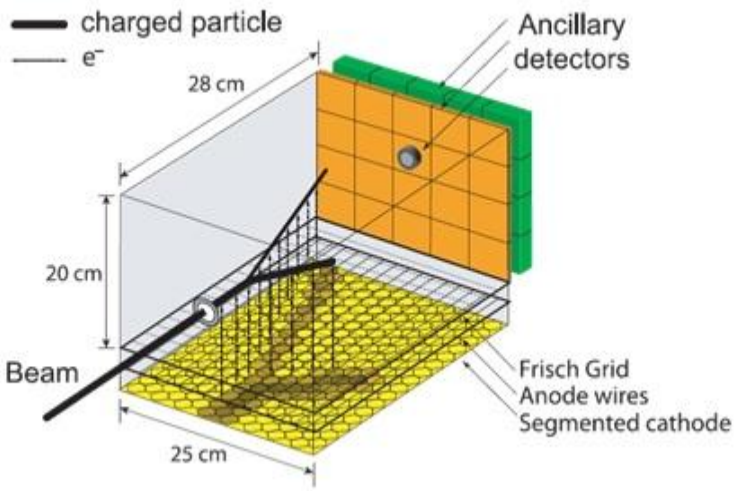
Campaign with the multidetector INDRA at GANIL

3-block supporting arm



Studio di fattibilità: Active Target

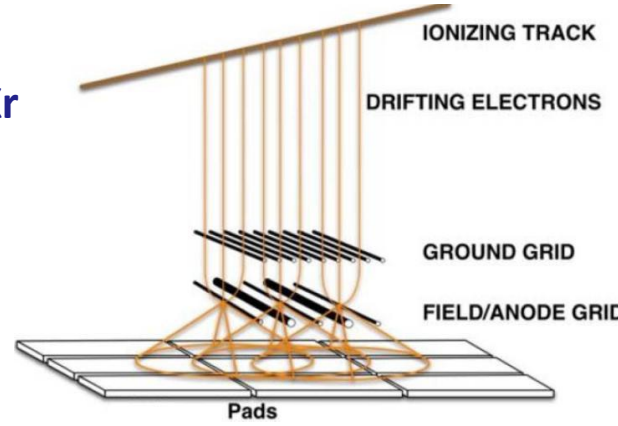




10^8 pps ^{130}Sn, ^{90}Kr

10^5 pps ^{134}Sn, ^{95}Kr, ^{94}Kr

E ~ 10 AMeV



Time-Projection Chamber (TPC) …

- Electrons, produced by ionization, drift to an amplification zone
- Signals collected on a segmented "pad" plane⇒2D-image of the track
- 3rd dimension from the drift time of the electrons

… + the detection gas is the target

- Large target thickness and still good resolution
- Low detection threshold

Contatti con: Exotic + LNS stream

The **ACTAR TPC** collaboration is actually composed by:

Centre d'Etudes Nucleaires de Bordeaux Gradignan (CENBG), France
Grand Accelerateur National d'Ions Lourds (GANIL), France
Institut de Physique Nucleaire d'Orsay (IPNO), France
Institut de Recherche sur les lois Fondamentales de l'Univers (IRFU), France
University of Leuven (KUL), Belgium
Universidade de Santiago de Compostela (USC), Santiago, Spain

Richieste finanziarie per il 2014

- **Missioni**

1.0 KE	Turni a LNL
1.5 KE	Turni Fazia a LNS
0.5 KE	Riunioni collaborazione nazionali
0.5 KE	Manutenzione apparati
0.5 KE	Riunioni collaborazione FAZIA
1.0 KE	Contatti Scientifici coll. ACTAR
1.0 KE	Turni (ISOLDE,RIKEN)

- **Consumo**

1.5 KE	Consumo vario

TOTALE PD: 7.5 KE

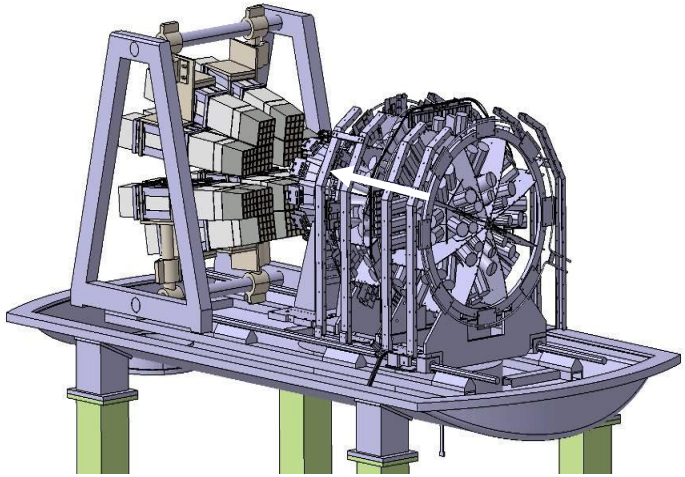
Voce	BO		Fi		NA		LNL		PD	
	sperim	fazia	sperim	fazia	sperim	fazia	sperim	fazia	sperim	fazia
Missioni	15.5	8.5	10.5	28	7.0	15	15.0	11.0	4.0	2.0
Inventario							15.0			
Consumo	5.5	2.5	2.5	1.5	2.5	2.0	19.5	4.5	1.5	
Manutenzioni	4.0									
Apparati	41.5	24.0		74.0		30.0	17.0			

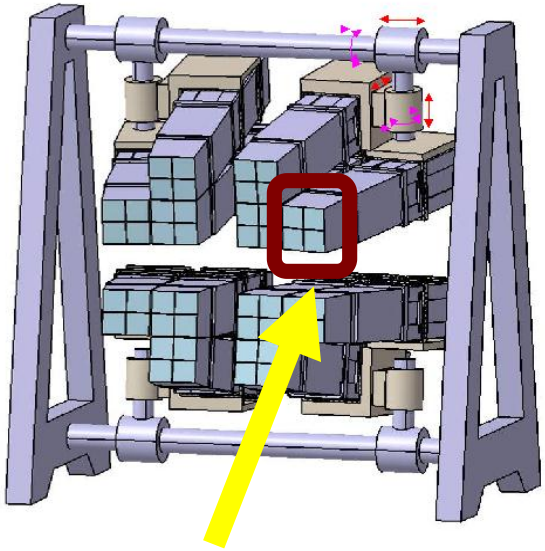
BACKUP

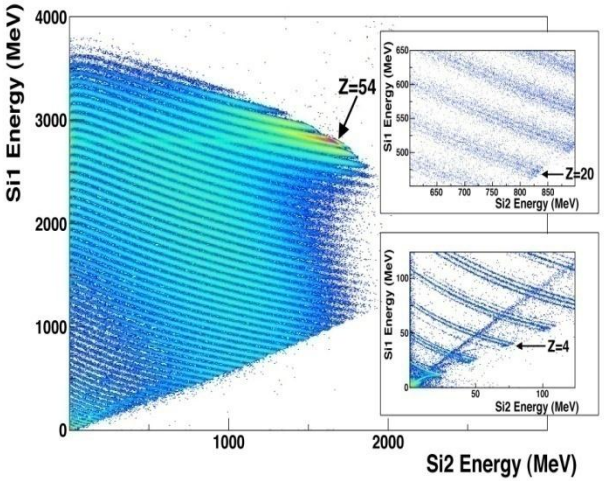
FAZIA: Phase II

Medium-range plan 2012-2015

The 192 telescopes of FAZIA demonstrator will be ready at the end of 2013.
Initially they will be coupled with : INDRA
Then with: GARFIELD@LNL, RIPEN@LNL and CHIMERA@LNS







Coupling FAZIA + INDRA

WITH STABLE BEAMS &
1st DAY EXP with SPIRAL2

Basic BLOCK: 4x4 telescopes

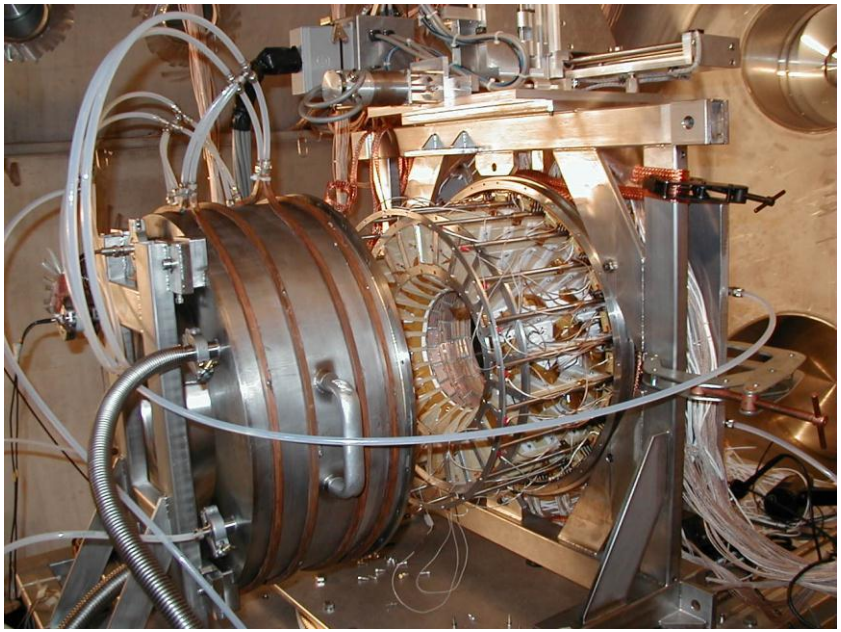
Transport properties of isospin asymmetric nuclear matter: neck emission and isospin drift

$^{40,48}Ca+^{40,48}Ca$ at 15, 25, 35AMeV, $^{58}Ni+^{58}Ni$ at 30-45AMeV
Related to deep-inelastic processes, isospin equilibration and drift; isoscaling for massive ejectiles

$^{78,86}Kr+^{40,48}Ca$ ---> 20-60AMeV
Related to the surface or volume expansion in central collisions

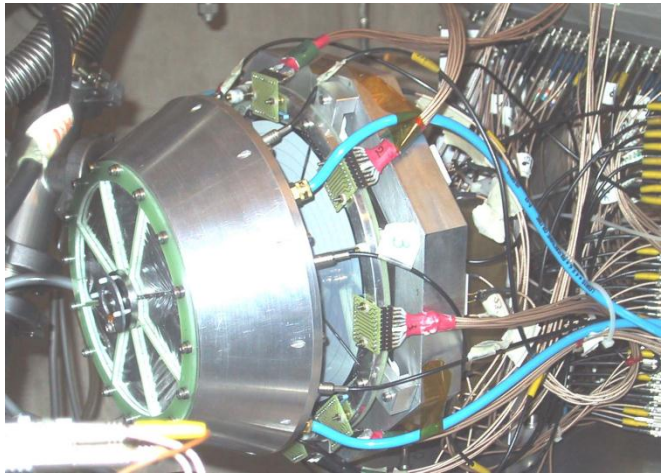
GARFIELD

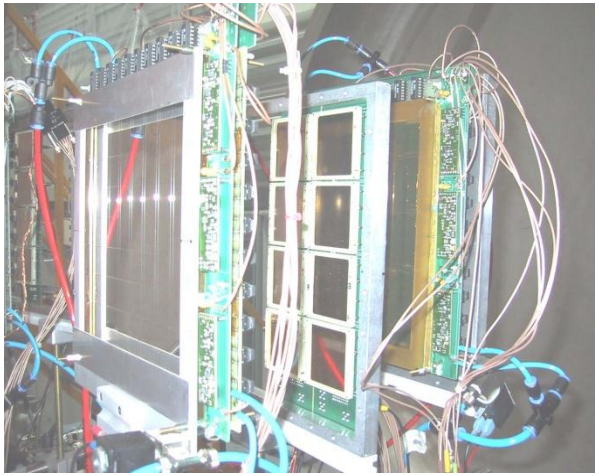
Fragments and Light Particles identification

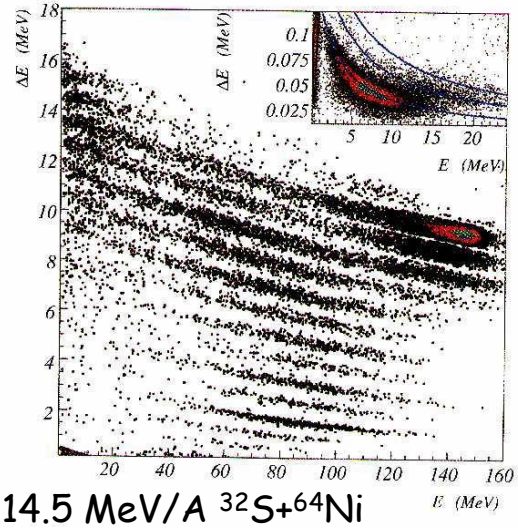


- 2 **Drift chambers** : 180 micro-strip detectors + 180 CsI(Tl) ($\theta = 30^0 - 150^0$)
- **Ring Counter**: annular telescope, Ionization Chamber + Si + CsI(Tl) ($\theta = 6^0 - 18^0$)
- **Time of Flight system**: 4 Position Sensitive Parallel Plate Avalanche Counters

Drift Chamber



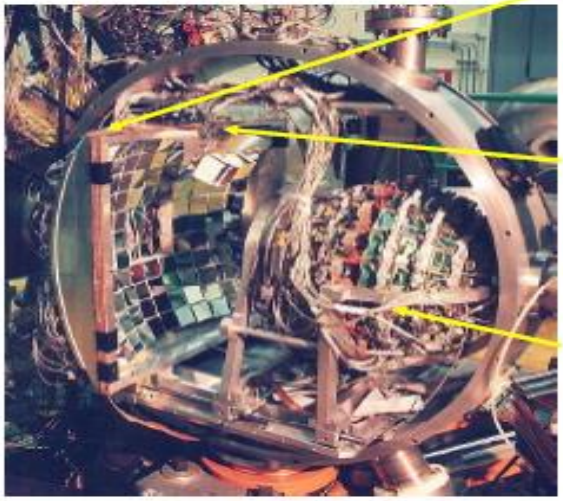




14.5 MeV/A $^{32}S+^{64}Ni$

THE 8πLP SPECTROMETER

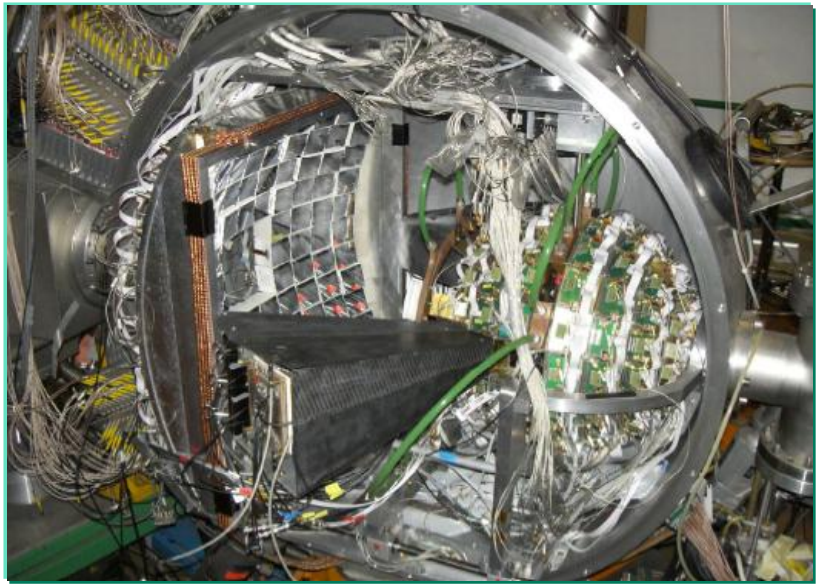
At the LNL a 4π charged light particle detector is fully operational (8πLP). It is based on ΔE-E, Time Of Flight (TOF) and Pulse Shape Discrimination (PSD) techniques and consists of 259 ΔE-E telescopes organized as follows:



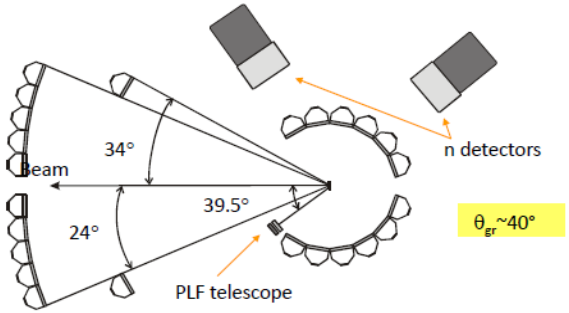
WALL : 116 telescopes (11x11 modules)
300 μm Si + 15 mm CsI(Tl)
target distance: 60 cm
angular coverage: 2° - 24° (Δθ ~ 4°)

RING : 20 telescopes
300 μm Si + 15 mm CsI(Tl)
target distance: 40 cm
angular coverage: 24° - 34° (Δθ ~ 7°)

BALL : 126 telescopes (∅ = 30 cm)
300 μm Si + 5 mm CsI(Tl)
target distance: 15 cm
angular coverage: 34° - 177° (Δθ ~ 18°)



Coupling 8πLP with external neutron detectors



BC501 scintillators
∅ 12.8 cm, 5 cm thick
d =115.5 cm
θ = 60°, 136° (ϕ = 0°, 20°).