UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II

INFN Istituto Nazionale di Fisica Nucleare

Workshop on basic research and interdisciplinary applications with small accelerators

Storia e possibili applicazioni dell'acceleratore Tandem dell'Universita' Federico II di Napoli

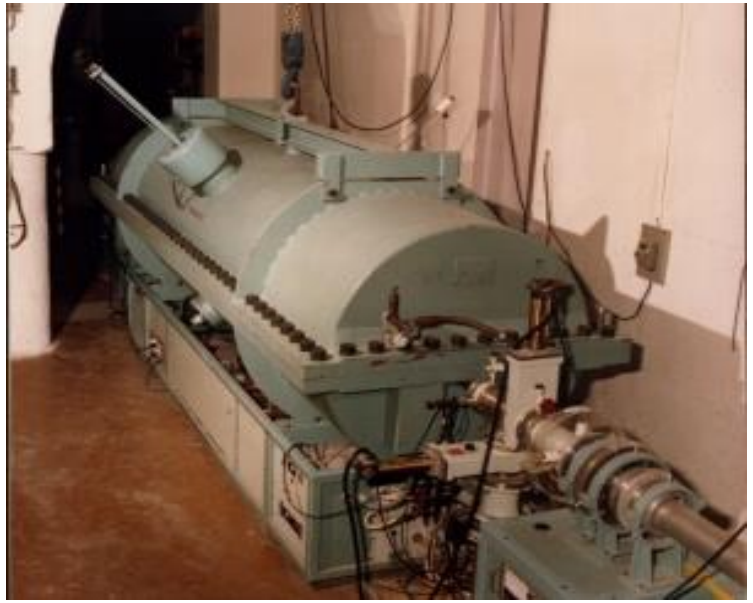
Luigi Campajola

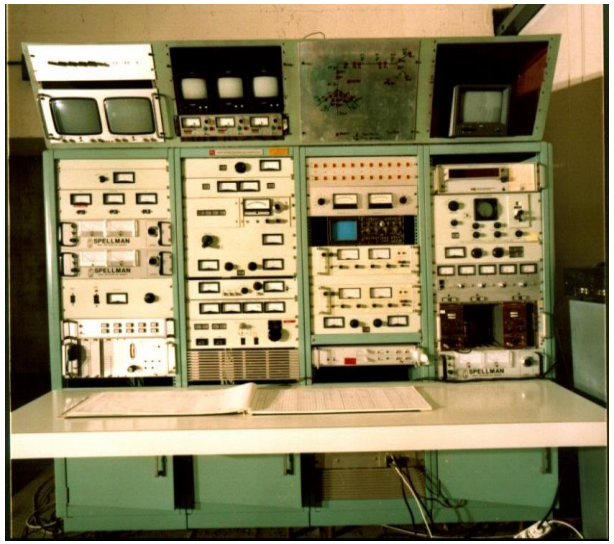
17-18 January 2018

Univ. Federico II, Compl. Monte S. Angelo

LABORATORIO ACCELERATORE

The accelerator is an HVEC TTT3 Tandem with a nominal maximum voltage of 3 MV.

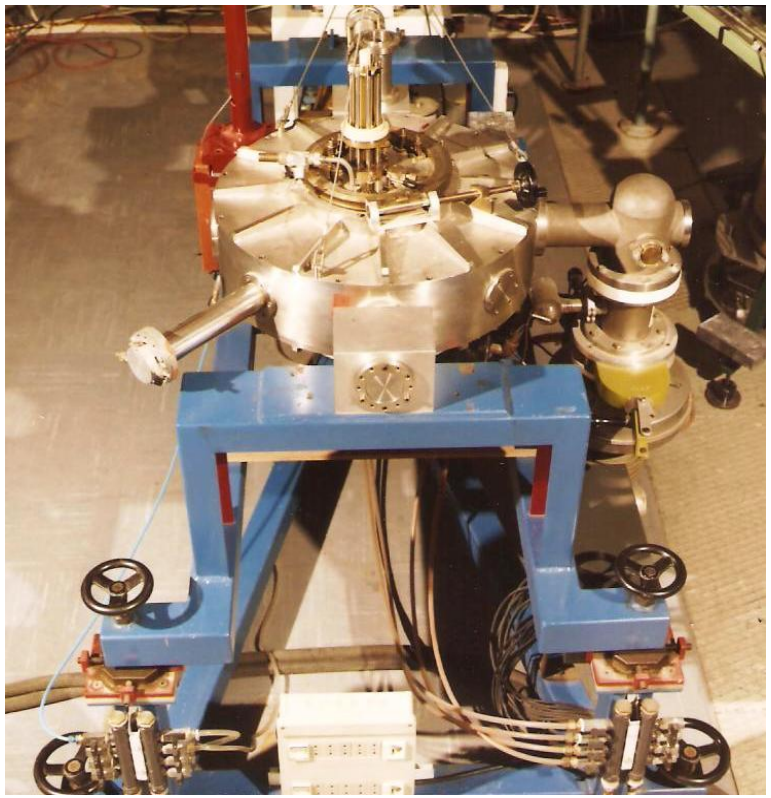


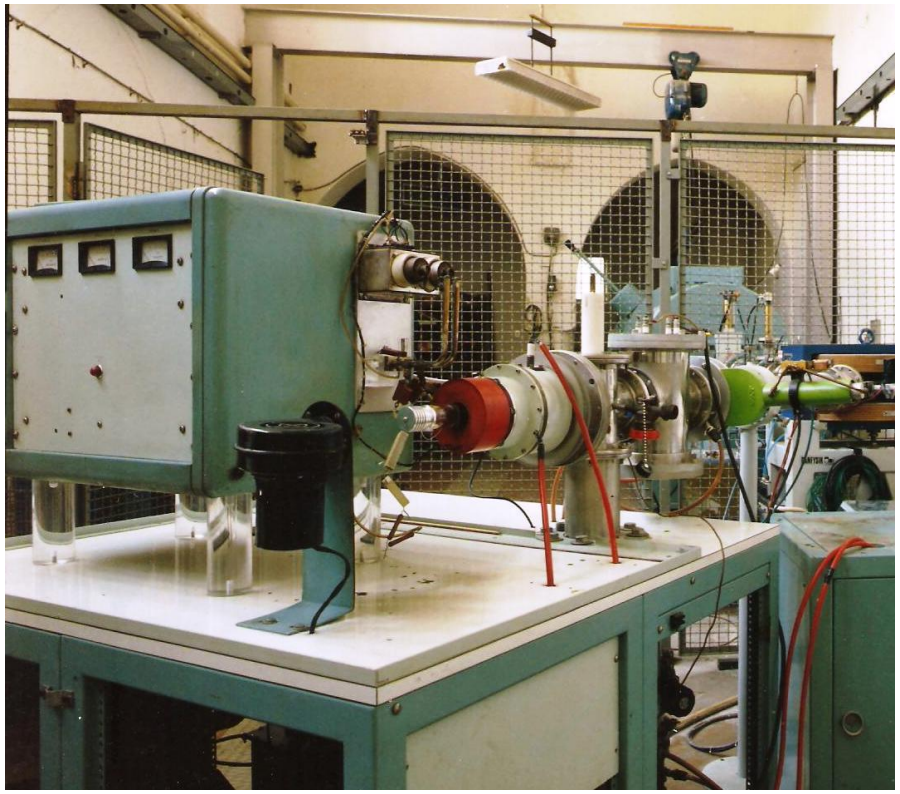


Operations in the “Padiglione Rodi” started in 1977

LABORATORIO ACCELERATORE

It was equipped with a RF source, a 90° analysing magnet and a general-purpose scattering chamber.

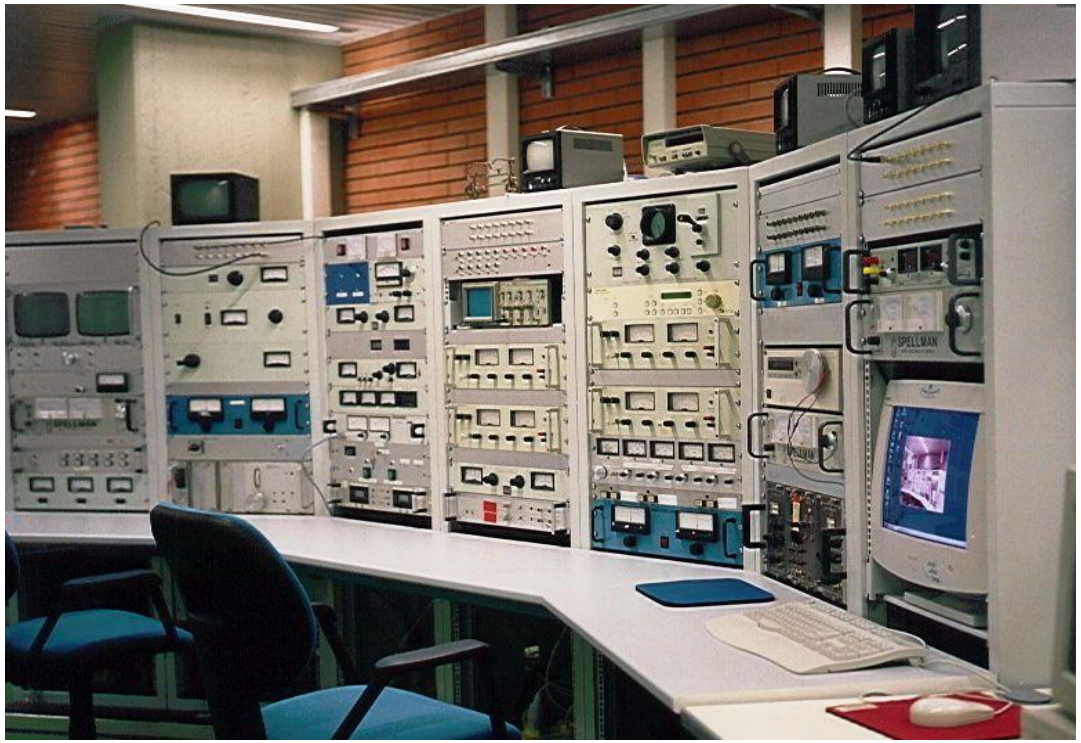




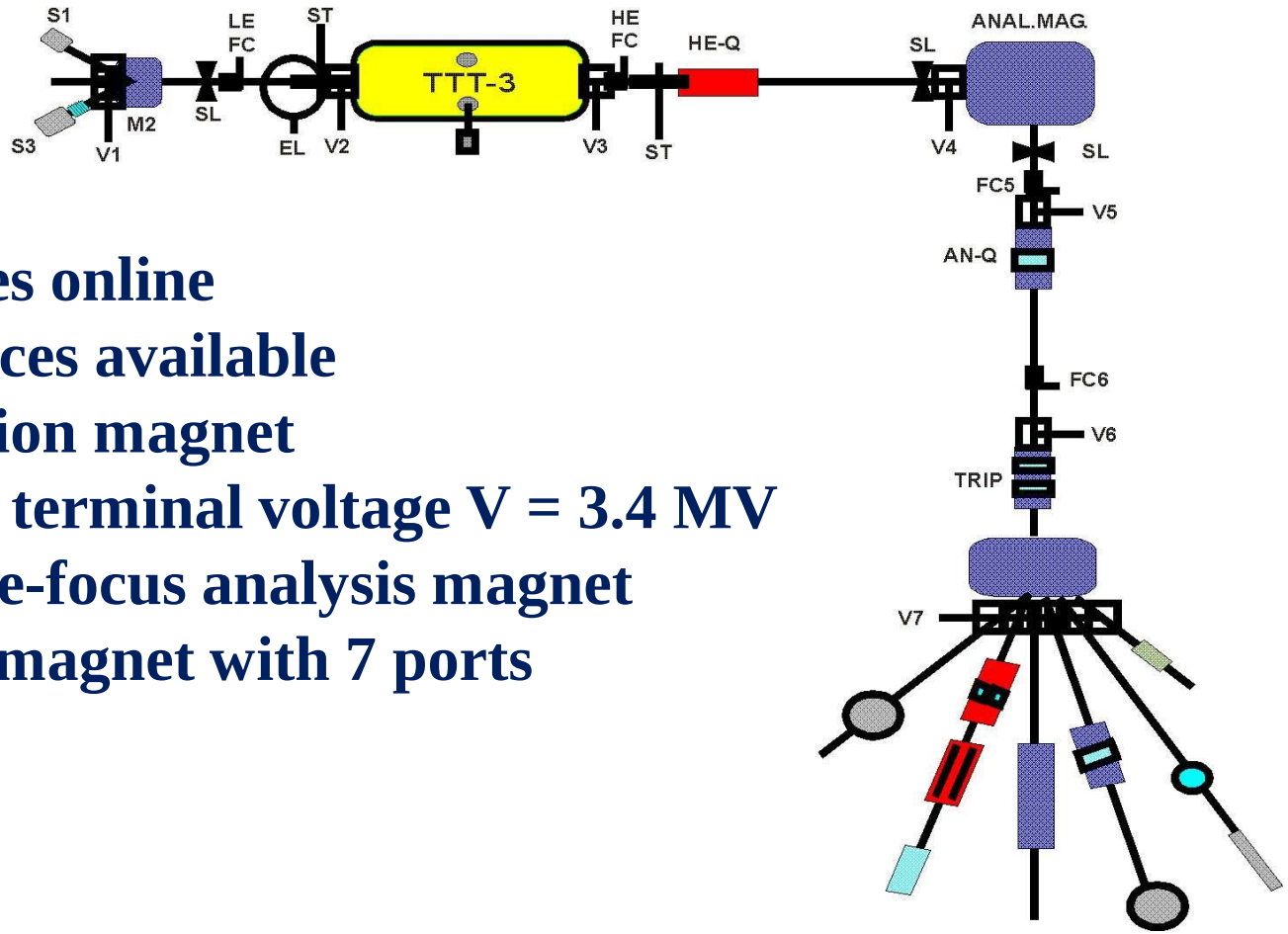
<u>H and He beams were available</u>

The new LABORATORIO ACCELERATORE

In 1997 the accelerator moved to the new campus.



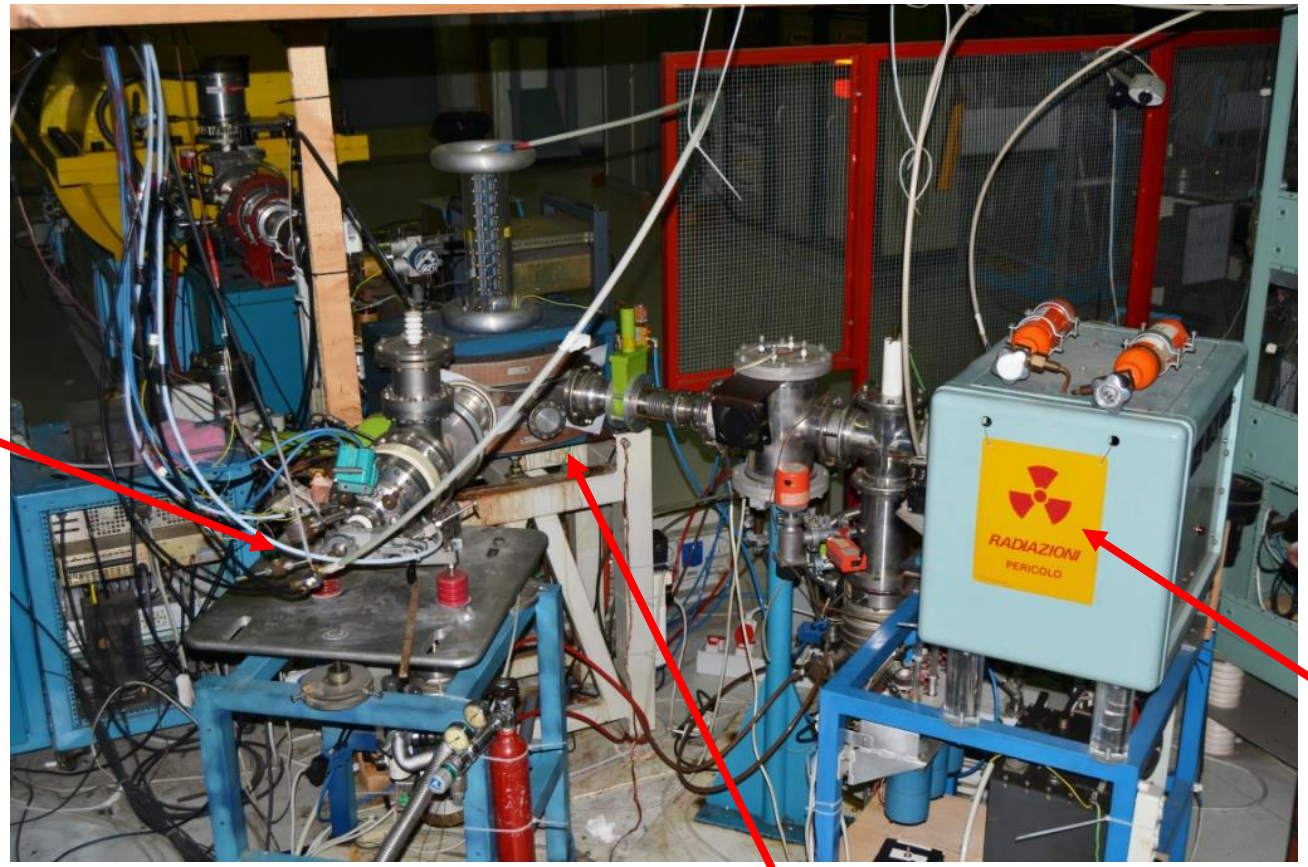
The lay-out of the accelerator

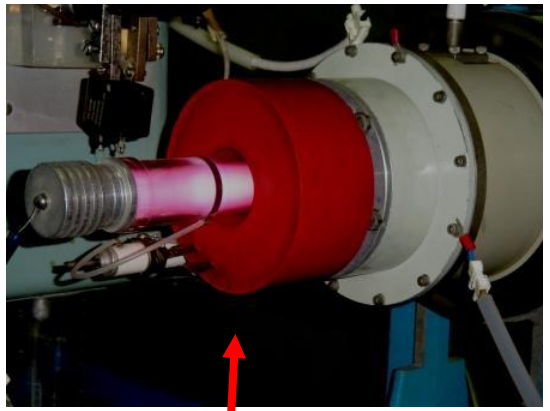


- two sources online
- other sources available
- 35 ° injection magnet
- maximum terminal voltage V = 3.4 MV
- 90 ° double-focus analysis magnet
- switching magnet with 7 ports

The Injector

Sputtering source

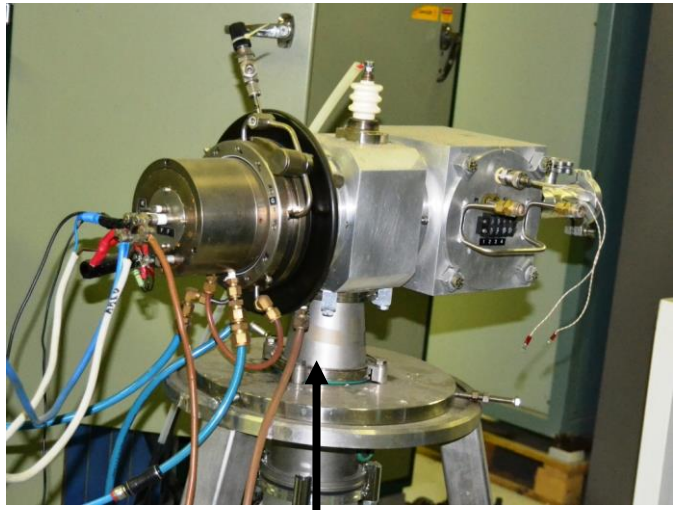




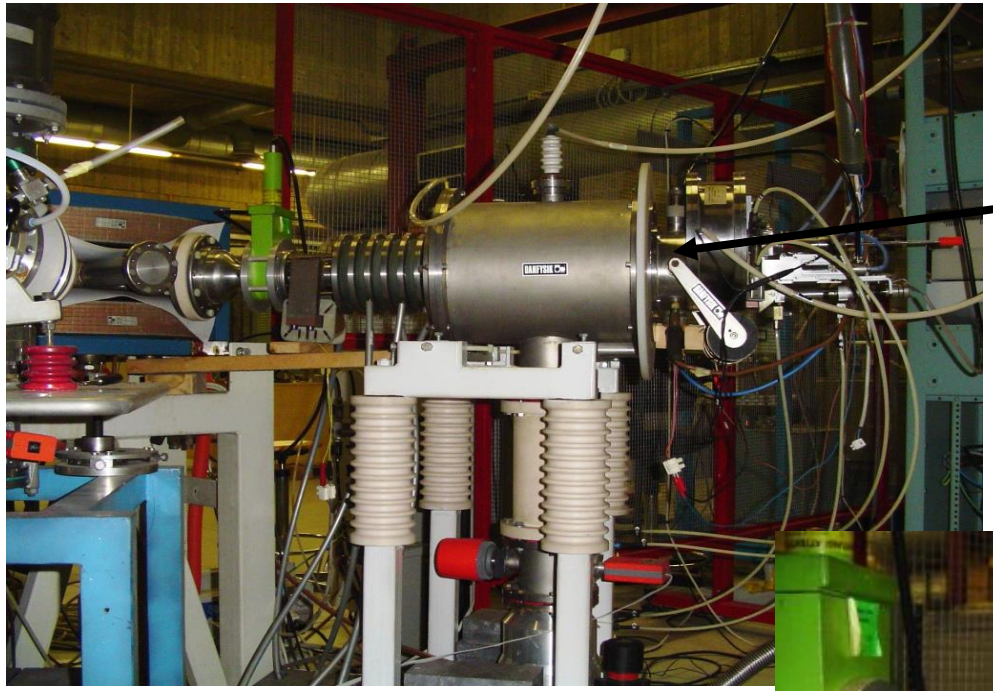
RF source

35° Injection Magnet

Off-line sources

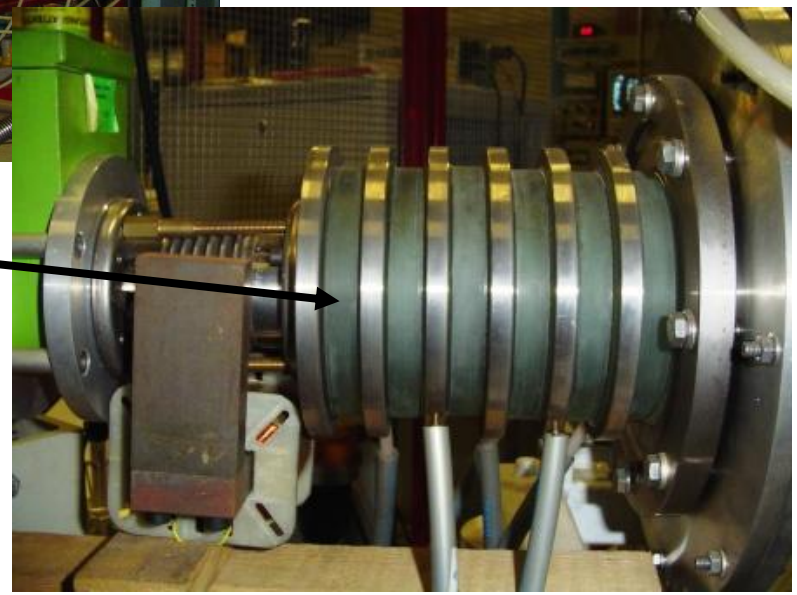


Duoplasmatron source



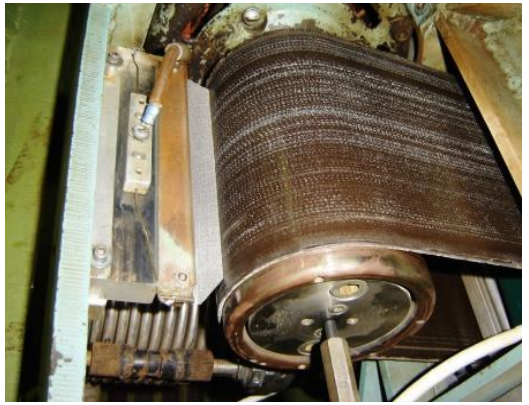
Multisample sputtering source with a home made 90 kV preacceleration

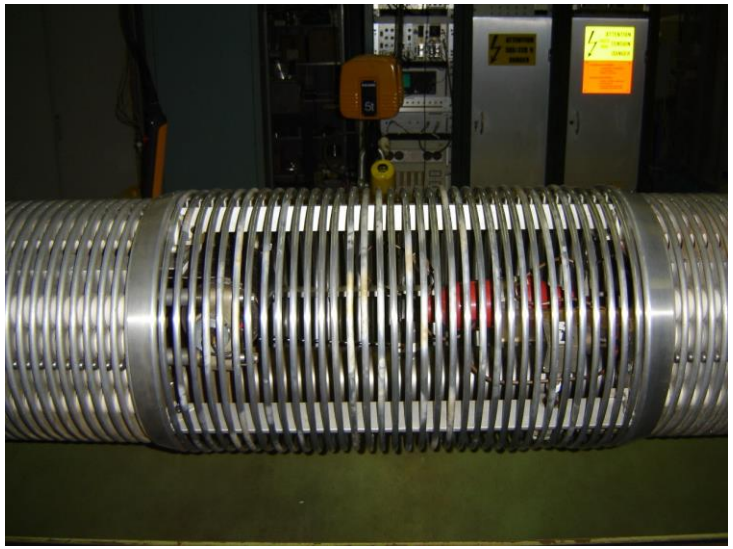
90 kV preacceleration:
gain in transmission efficiency
up to 75% for heavy ions

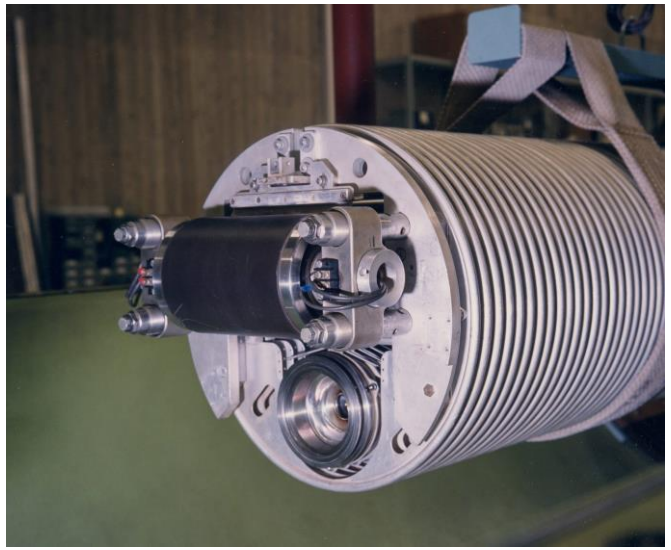


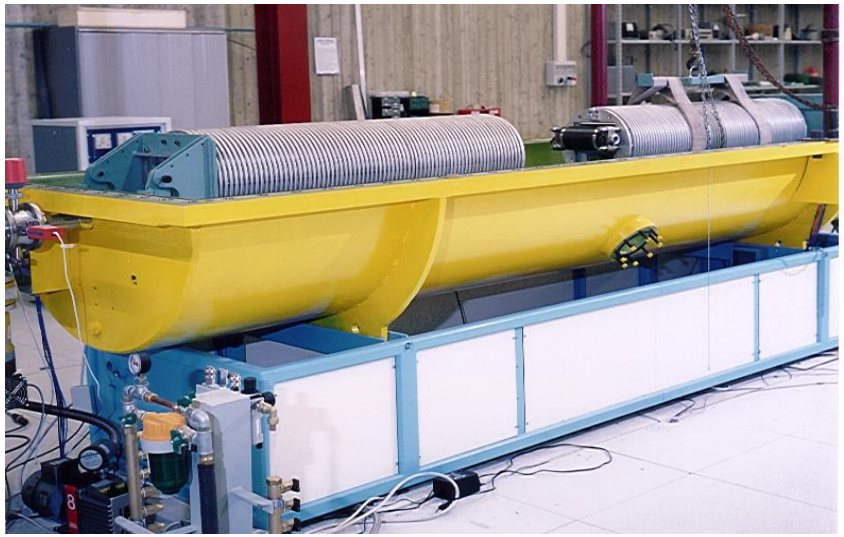
Main technical features of the TTT3 accelerator

- Electrostatic accelerator, Van de Graaff type
- Double stage, belt charging system
- Two stripper systems: foil and gas
- Maximum terminal voltage: 3,4 MV (nominal 3 MV)

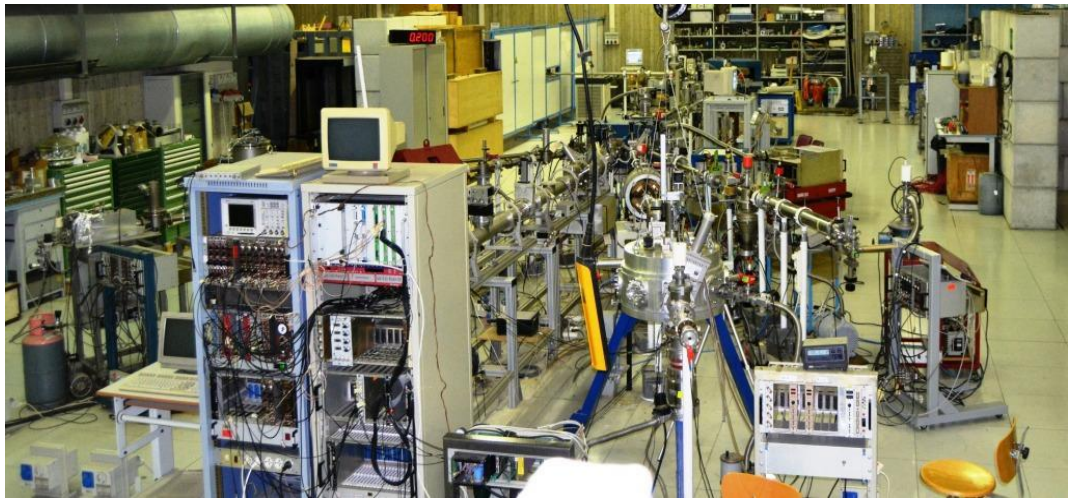


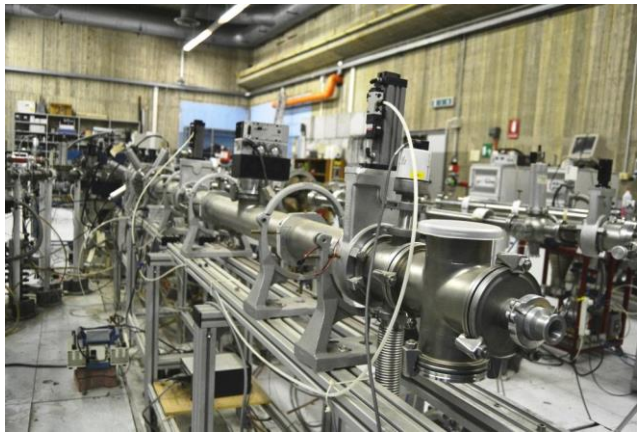


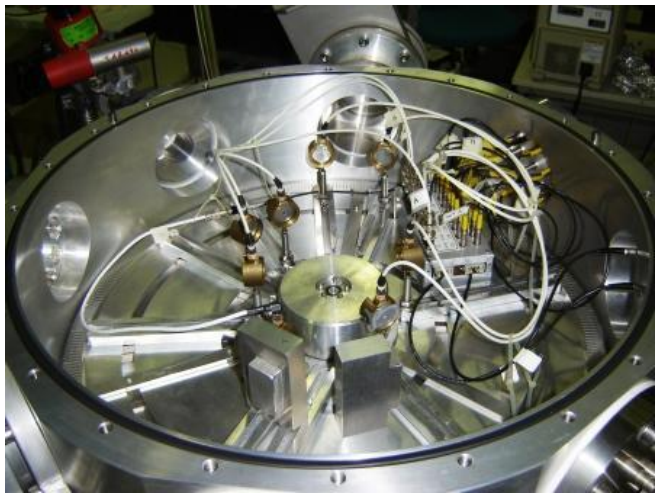




Beam lines







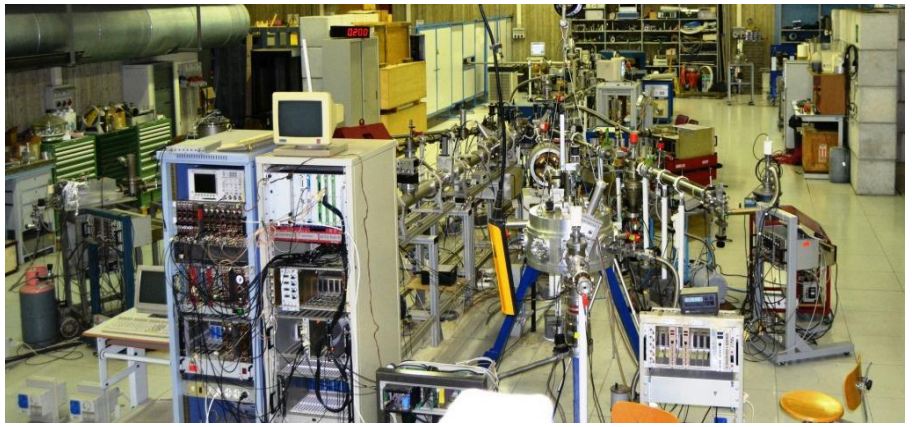
Up to 7 beam lines available

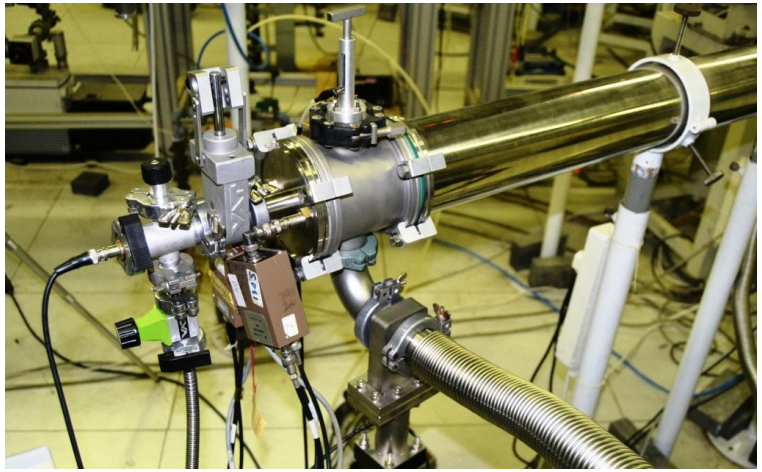
- Scattering chamber (IBA & Nuclear Reactions)
- Ion implantationion with extracted beam
- Radiation Biophysics
- Neutron production

Available:

- AMS beam line equipped with Wien Filter and E-DE Ionization Chamber
- X-Y scanner for ion implantation under vacuum

Gallery

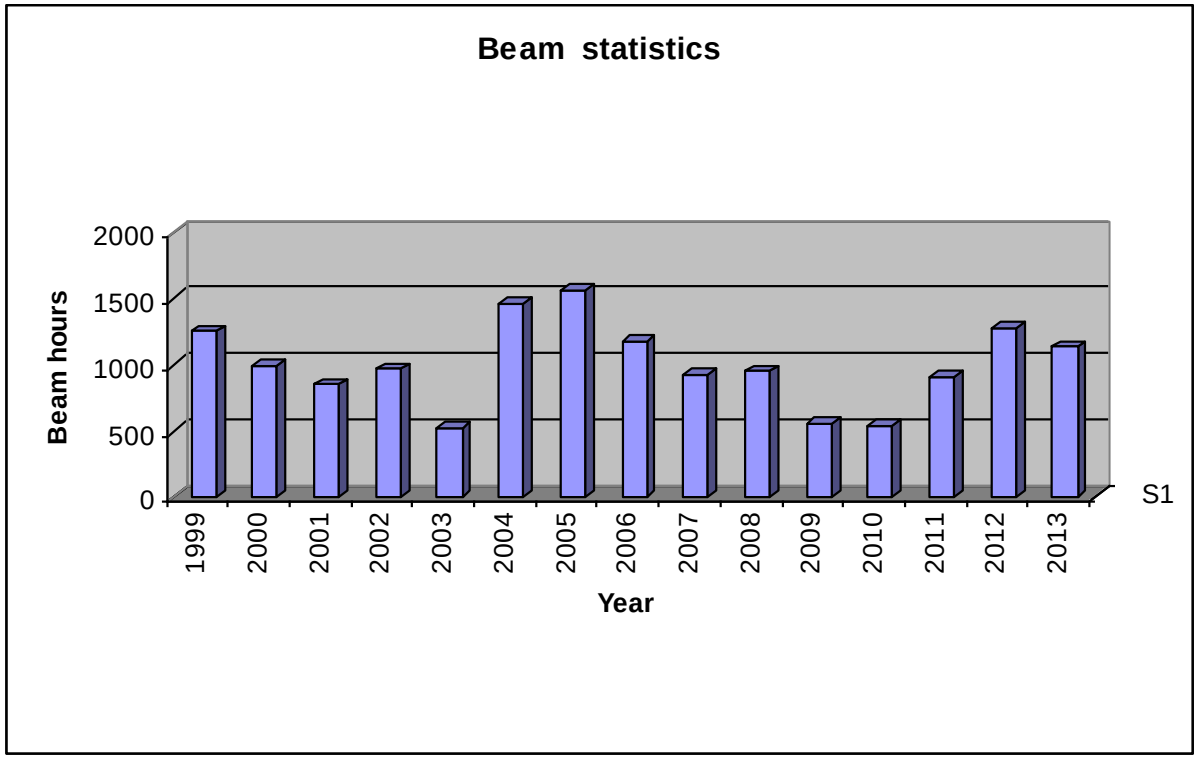


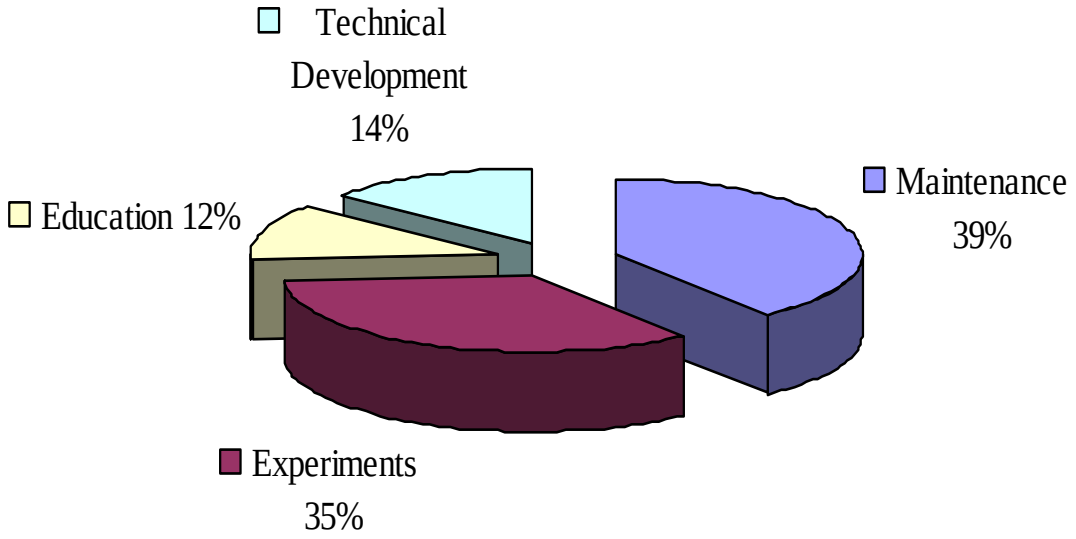


Ions

Ion	E MeV	$I_{analysed}$ nA	E_{max} MeV
^{1}H	6,5	100	6,5
^{2}H	6,5	10	
^{3}He	10	20	10
^{4}He	10	20	10
^{6}Li	13		13
^{7}Li	13	20	13
^{9}Be	13		16
^{10}B	13		20
^{11}B	13		20
^{12}C	16	100	20
^{13}C	16		20
^{14}N	13		16
^{16}O	16	100	23
^{19}F	19	50	23

Statistiche





Finanziamenti

anno	Università k€	Dip. k€	INFN k€	Tot k€
1999	12,5 (25 ML)		6,5 (13 ML)	19
2000				
2001	12,9		6,7	19,6
2002	12,9		6,7	19,6
2003	12,6		6,7	19,3
2004	12,3		6,7	19
2005		-0,4	6,7	6,3
2006		3,3	6,7	10
2007		0,3	6,7	7
2008		0,3	6,7	7
2009		6	8	14
2010			8	8
2011			8	8
2012			8	8
2013			8	8
2014				

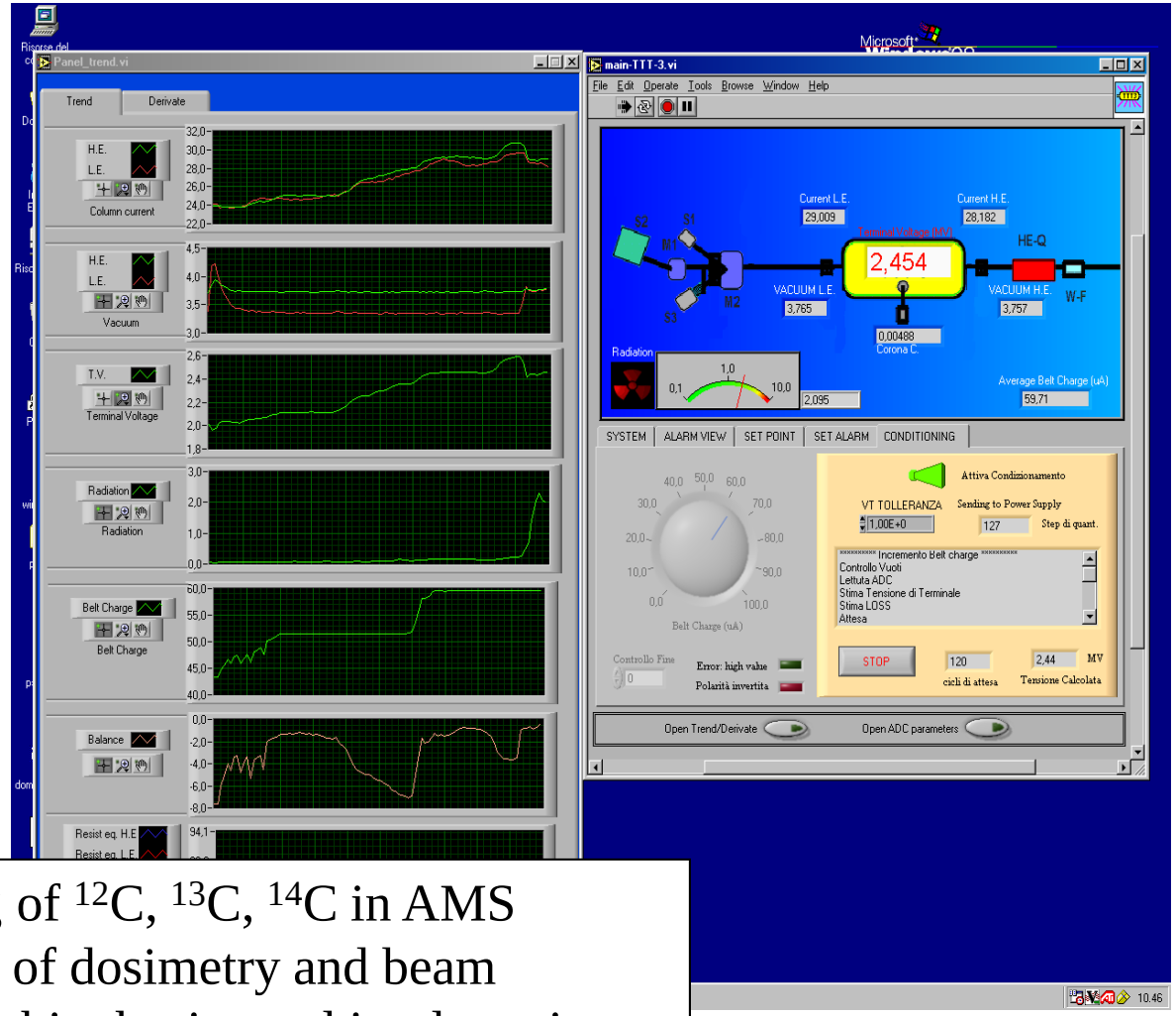
Computer monitoring and automatic operations

Monitoring:
LE and HE column current, Corona Current, Terminal Voltage, Radiations, …

Automatic management:
Pumping systems (pumps, gauges, valves …), Van de Graaff
Automatic shutdown
…

Automatic conditioning and setting of Term.Volt.

Automatic measurements



- Fast cycling of ^{12}C, ^{13}C, ^{14}C in AMS
- Automation of dosimetry and beam uniformity in biophysics and implantation

Main improvements

- Very accurate alignment of the tubes within the columns.
- Modification of the spark gaps and of electrical configuration of the first electrodes.
- Improved handling of SF_6

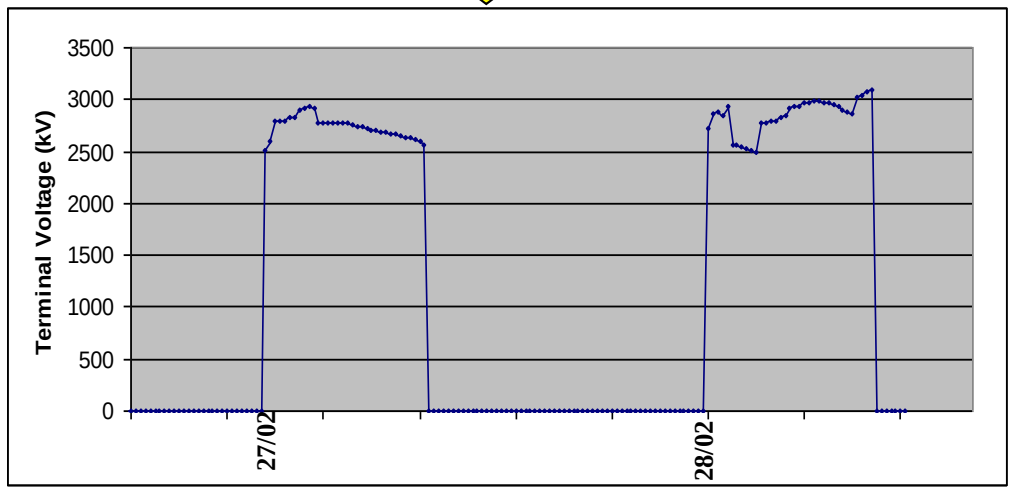
↓

- Life time of the belt charge: > 11 y
- Long duration of the strippers
- Reduced ripple (< 300 V P-P)

→ Improvement of the maximum terminal voltage
Reduced conditioning time

→ TV_{max} = 3,4 MV

Two days working after half a day of conditioning →

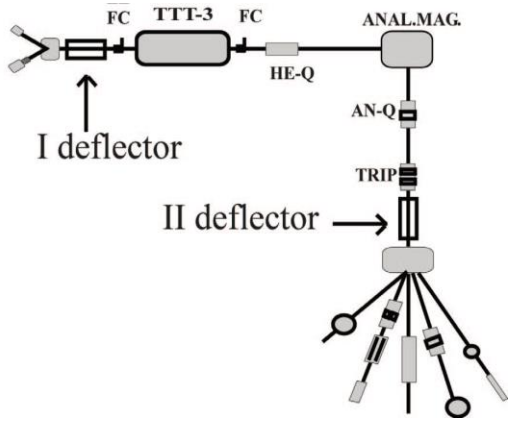


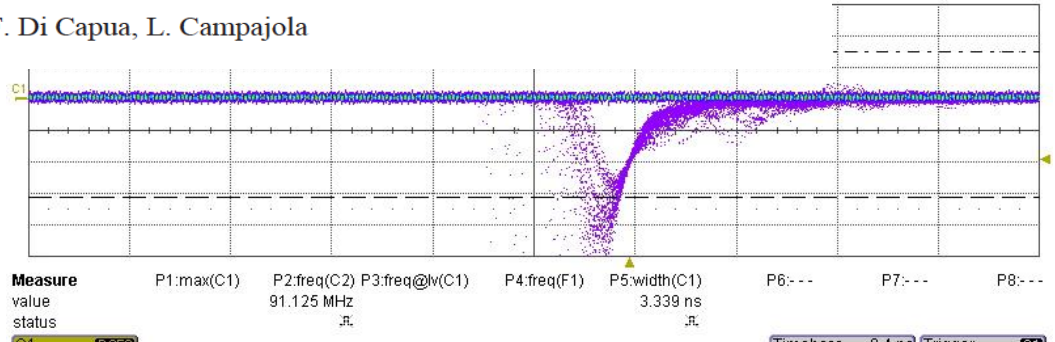
Beam Pulser

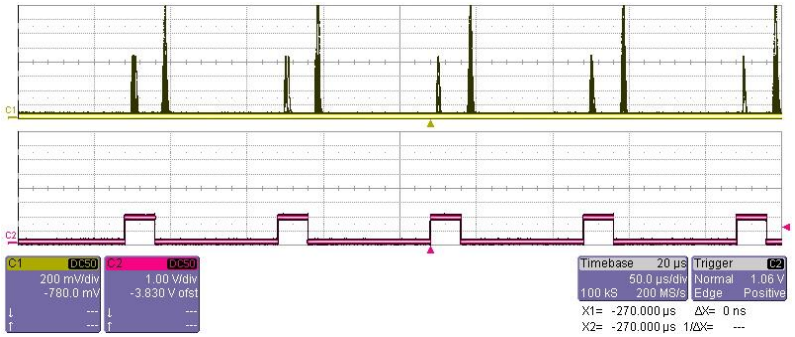
978-1-5090-1642-6/16/$31.00 ©2016 IEEE

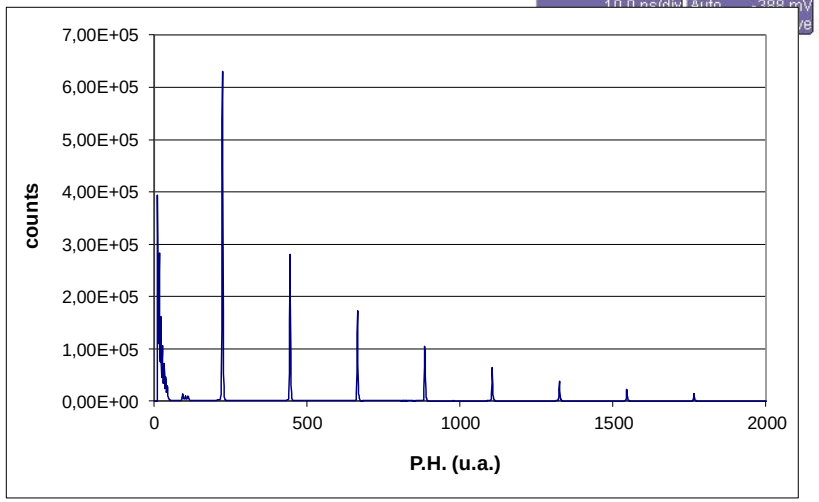
A Beam Pulser at the TTT-3 Tandem Accelerator of the University of Naples

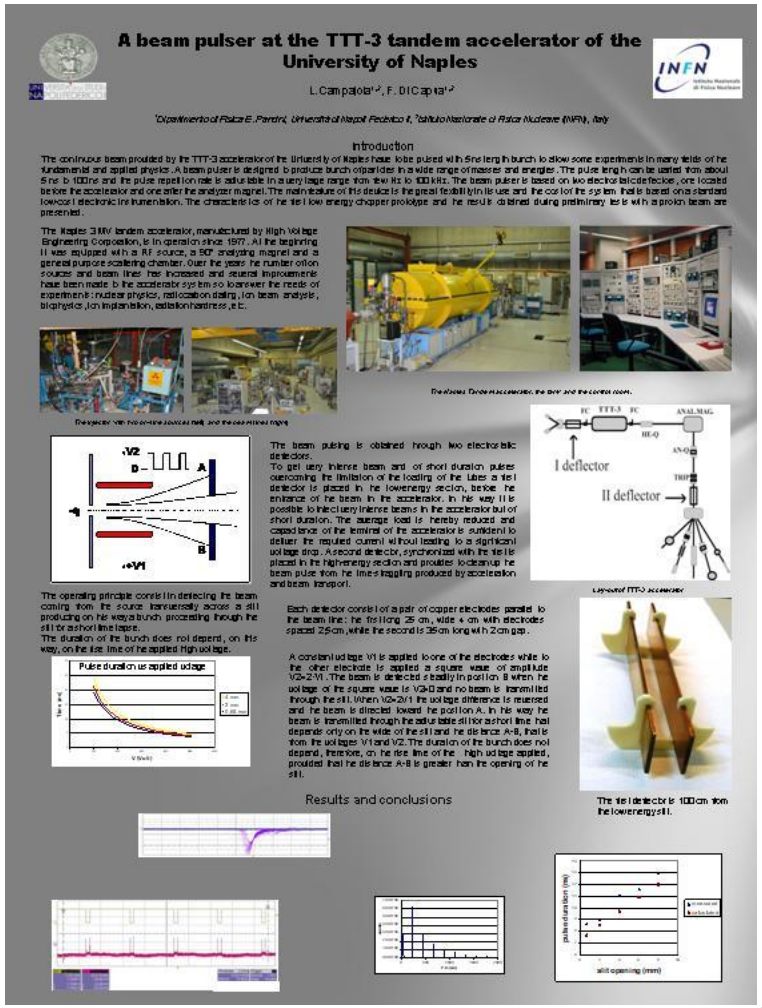
F. Di Capua, L. Campajola











Main activities

Fisica nucleare	**Studio di reazioni nucleari a bassa energia**
Biofisica	**Irraggiamento di matrici biologiche con ioni** **Studio del danno cellulare**
Analisi di materiali con fasci ionici	**Caratterizzazione di superfici** **Misura di elementi in traccia** **Studio di nuovi rivelatori**
AMS	**Datazioni archeologiche**
Impiantazione ionica	**Elettronica e nuovi materiali**
Radiation hardness	**Elettronica e nuovi materiali**
Produzione e rivelazione di neutroni	**Fisica nucleare di base ed applicata**
Didattica	**Diffusione Rutherford** **Reazioni nucleari** **Misure di stopping power**

Nuclear physics

Z. Phys. A 356, 107–109 (1996)

ZEITSCHRIFT
FÜR PHYSIK A

Short note

Production of an 8.0 MeV ^{7}Be ion beam at the Naples TTT-3 accelerator

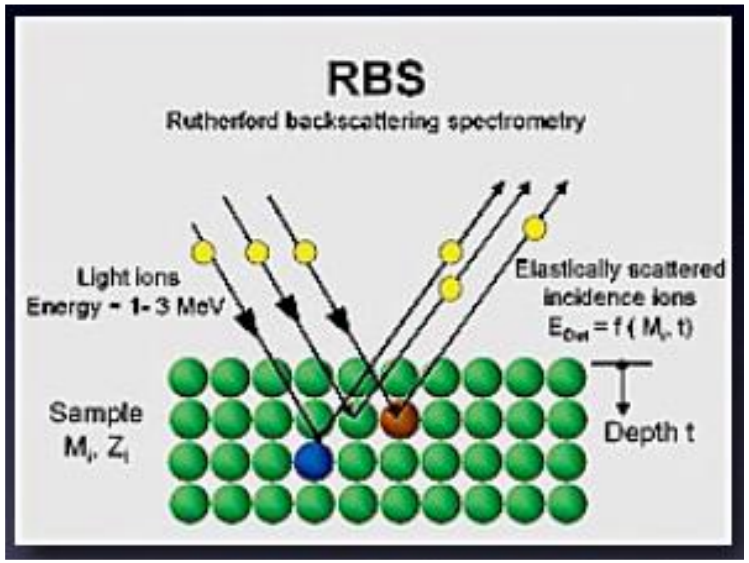
L. Campajola[1], L. Gialanella[1,2], K. Brand[3], A. D'Onofrio[4], U. Greife[2], E. Huttel[5], R. Kubat[5], G. Oliviero[1], H. Rebel[6], V. Roca[1], C. Rolfs[2], M. Romano[1], M. Romoli[1], S. Schmidt[2], W.H. Schulte[2], F. Strieder[2], F. Terrasi[7], H.-P. Trautvetter[2], D. Zahnow[2]

PHYSICAL REVIEW C **78**, 064001 (2008)

Off-energy-shell *p*-*p* scattering at sub-Coulomb energies via the Trojan horse method

A. Tumino,[1,2,3,*] C. Spitaleri,[1,2] A. Mukhamedzhanov,[4] G. G. Rapisarda,[1,2] L. Campajola,[5] S. Cherubini,[1,2] V. Crucillá,[1,2] Z. Elekes,[7] Z. Fülöp,[7] L. Gialanella,[6] M. Gulino,[1,2] G. Gyürky,[7] G. Kiss,[7] M. La Cognata,[1,2] L. Lamia,[1,2] A. Ordine,[6] R. G. Pizzone,[1,2] S. Romano,[1,2] M. L. Sergi,[1,2] and E. Somorjai[7]

Elemental Analysis: RBS

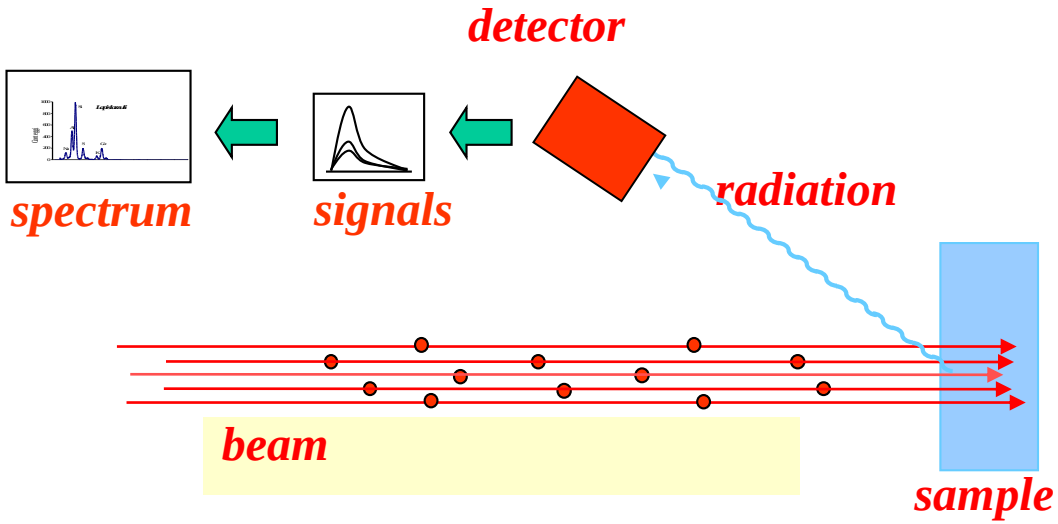


In an elastic collision of a particle with a nucleus of the target, the particle is deflected.

In collisions with nuclei of a given mass M, as the impact parameter decrease:

- ➡ the scattering angle grows
- ➡ the residual energy of the particle decreases

Elemental Analysis: RBS



By the detection of the energy of the particle elastically scattered backward from the nuclei of the target can be determined:

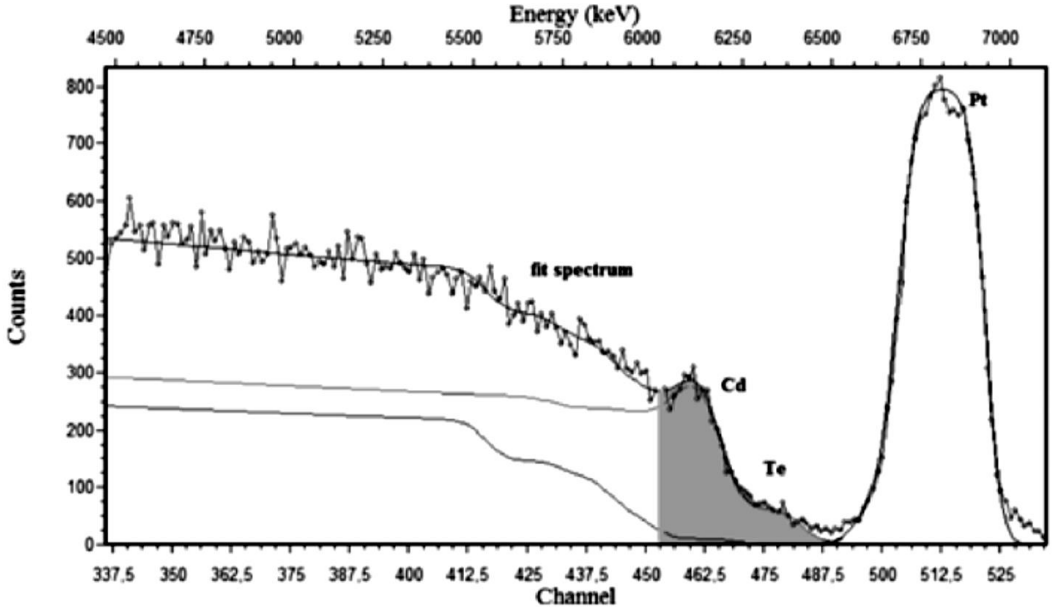
- the elemental composition of the sample
- the concentration profile of the elements as a function of depth in the sample

Elemental Analysis: RBS

IEEE TRANSACTIONS ON NUCLEAR SCIENCE, VOL. 59, NO. 4, AUGUST 2012 1491

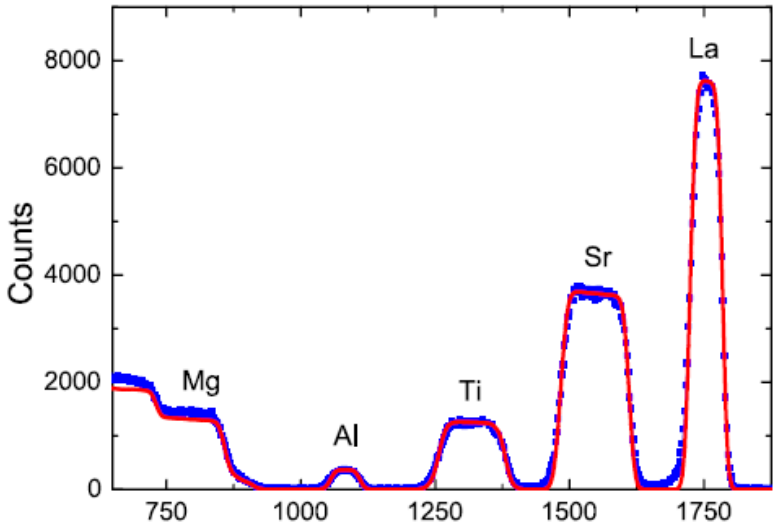
Pt-CdTe Detectors Spectroscopic Performances and RBS and XRF Interface Composition Analysis

A. Raulo, M. Sowinska, G. Hennard, L. Campajola, D. Marano, G. Paternoster, and E. Perillo



La caratterizzazione è stata effettuata mediante la tecnica RBS utilizzando fasci di Li^{3+}

Elemental Analysis: RBS



JOURNAL OF APPLIED PHYSICS **120**, 225306 (2016)

Plasma dynamics and cations off-stoichiometry in $LaAlO_3$ films grown in high pressures regimes

A. Sambri,[1,2,a] Amit Khare,[3] S. Mirabella,[4] E. Di Gennaro,[5] Akif Safeen,[6] F. Di Capua,[5] L. Campajola,[5] U. Scotti di Uccio,[5] S. Amoruso,[5] and F. Miletto Granozio[2]

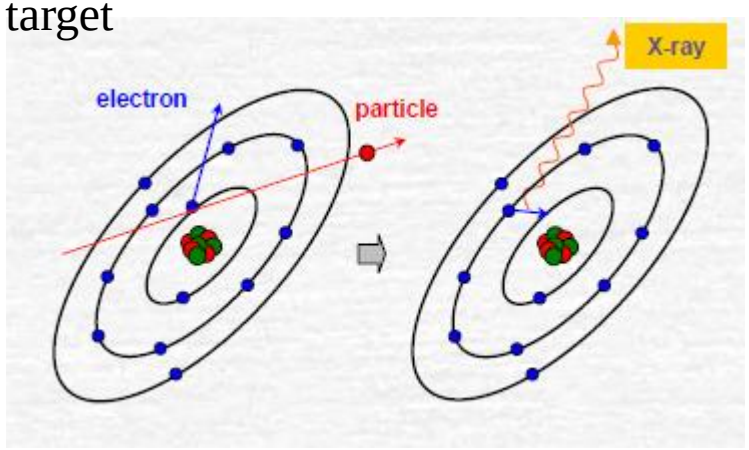
[1]*NEST, Istituto Nanoscienze-CNR, Piazza San Silvestro 12, 56127 Pisa, Italy*
[2]*CNR-SPIN, Complesso Universitario di Monte Sant'Angelo, Via Cintia, I-80125 Napoli, Italy*
[3]*Department of Physics, Indian Institute of Science Education and Research (IISER), Bhopal 462 066, India*
[4]*MATIS IMM-CNR and Dipartimento di Fisica e Astronomia, Università di Catania, Via Santa Sofia 64, 95123 Catania, Italy*
[5]*Dipartimento di Fisica, Università di Napoli Federico II, Via Cintia, I-80125 Napoli, Italy*
[6]*Departments of Physics, Abdul Wali Khan University, Mardan, Pakistan*

La caratterizzazione dei rapporti La/Al è stata effettuata mediante la tecnica RBS utilizzando fasci di C^{3+}

Particle Induced X-ray Emission PIXE

The PIXE technique is used for analysis of low concentrations (trace elements)

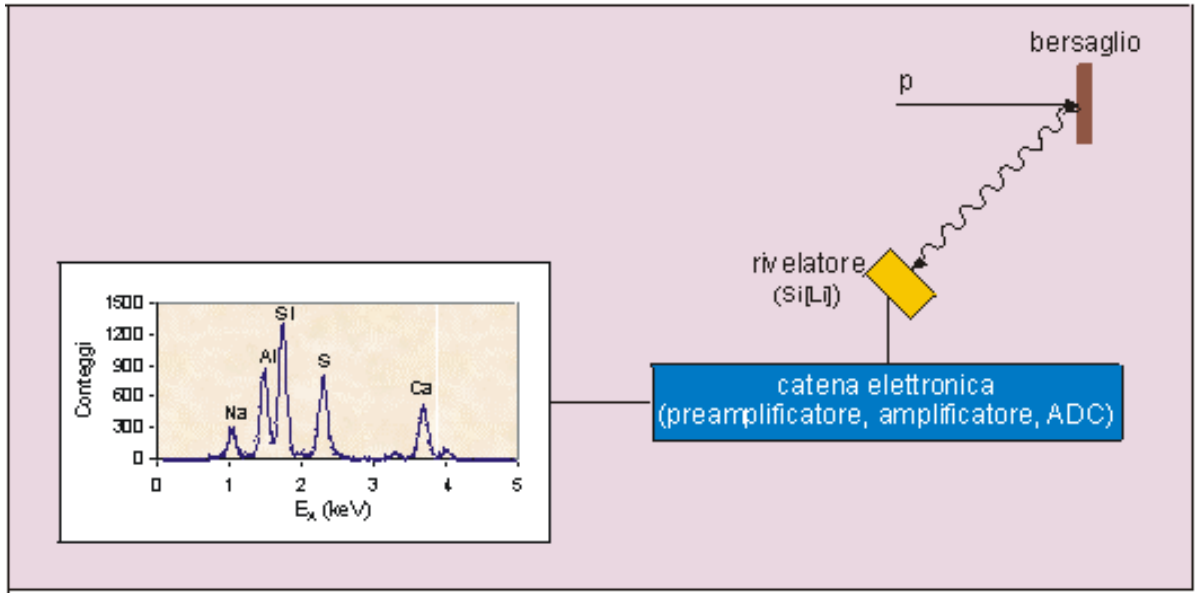
It is based on the process of X-ray emission that occurs when a beam of charged particles causes the ionization of one of the inner shell (K or L) of the atom target



With characteristic times of the order of 10^{-15} s the atom returns to its stable state by filling the gap with an electron from an outer shell

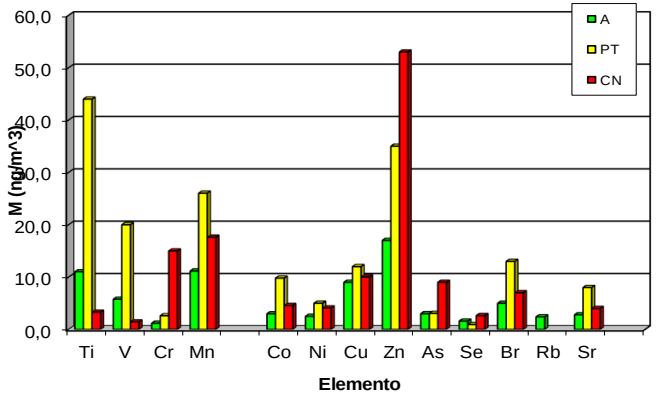
The energies of electrons in different atomic levels are characteristic of each atomic species.

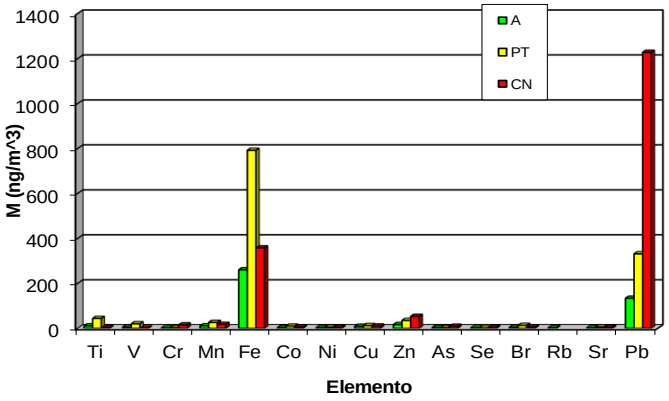
The energies of electrons in different atomic levels are characteristic of each atomic species.



IBA: PIXE

Confronto tra il contenuto degli elementi in traccia nel particolato atmosferico campionato in tre siti

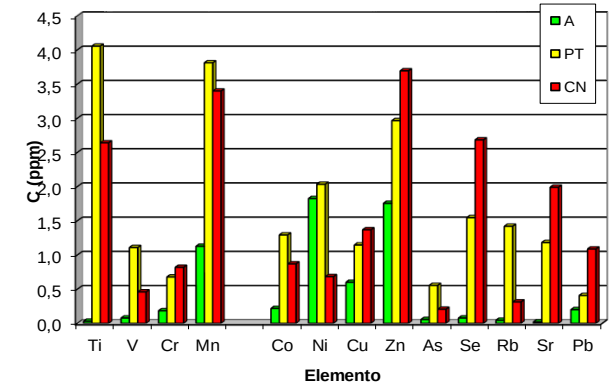


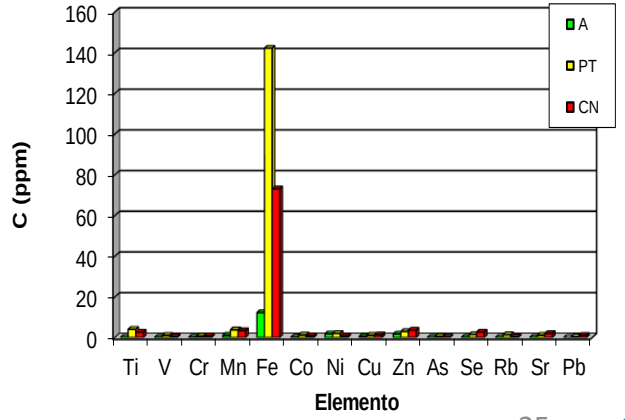


Astroni
Piazzale Tecchio
Corso Novara

La correlazione esistente tra i contenuti nel particolato atmosferico e nelle foglie di Leccio (alberi cittadini) permette di definire procedure di misura semplici senza la necessità di attrezzature complesse.

Confronto tra i contenuti degli elementi in traccia in foglie di Leccio di tre siti



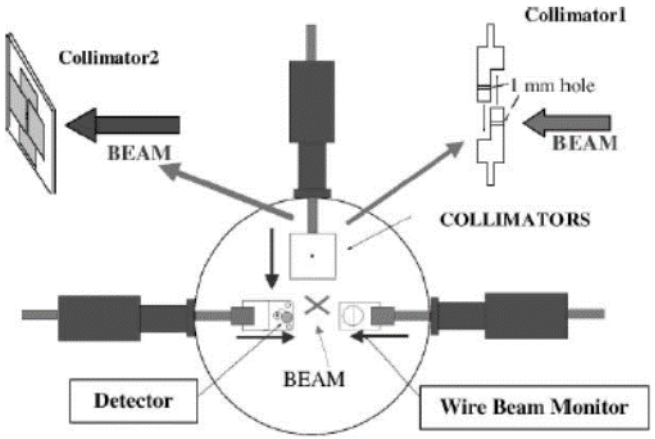


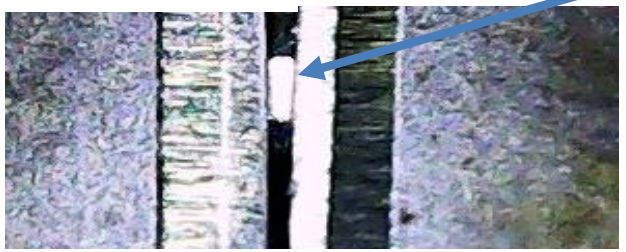
Characterization of detectors: Micro-Beam

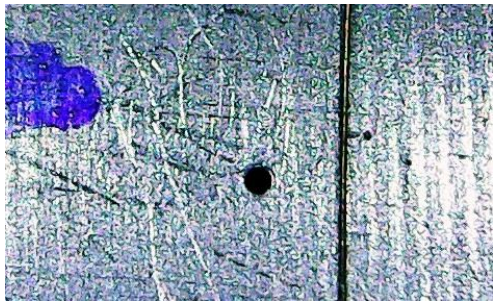
Response of semi-insulating GaAs detectors to low energy protons

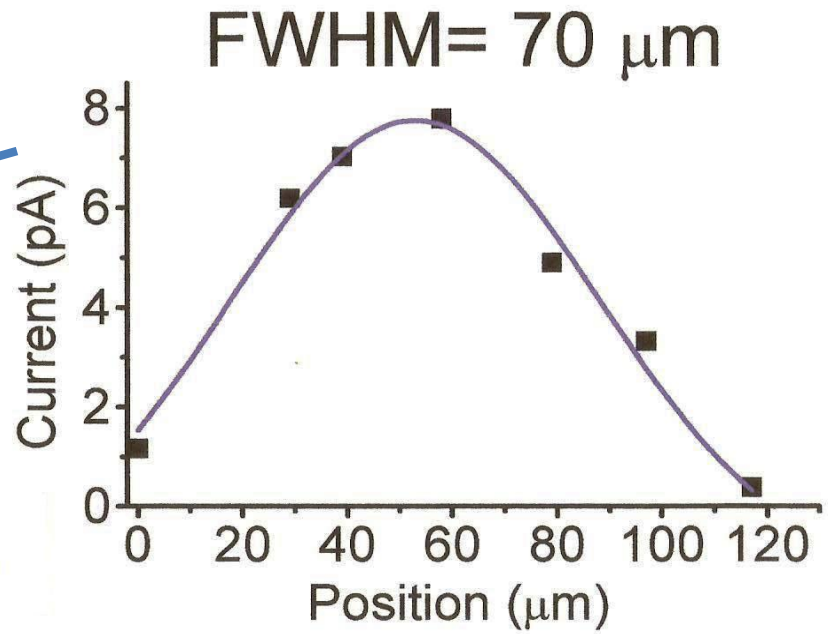
P. Russo[a,b,*], L. Campajola[a,b], C. Carpentieri[a], E. Bertolucci[a,b]

[a] *Dipartimento di Scienze Fisiche, Università Federico II, Napoli, Italy*
[b] *I.N.F.N., Napoli, Italy*









AMS: ^{14}C

Notizie Storiche

In un antico codice del 9° secolo che narra del martirio di S.Emiliano (o Miliano), primo vescovo di Trevi, si legge che “lo legarono ad una giovane pianta d’olivo” per decapitarlo.
Correva l’anno 304 d.C; di origine armena, Emiliano fu inviato a reggere la chiesa locale, ma in seguito all’editto di Diocleziano, fu preso e dopo numerosi supplizi, fu legato ad un olivo novello e poi messo a morte.

AMS: ^{14}C

Magia rossa

Da domani la mostra di preziosi a Palazzo Vallelonga di Torre del Greco

STELLA CERVASIO

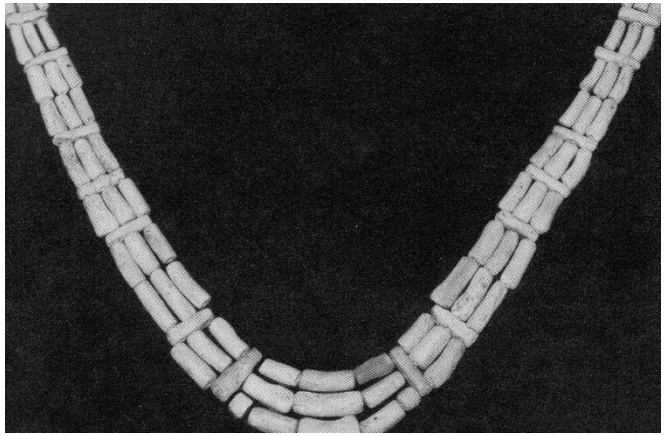
IN OCCIDENTE approdavano spezie. In cambio verso l'Oriente, percorrendo le stesse strade carovaniere, viaggiava una gemma color del sangue, capace di guarire tremende malattie, di salvare i lattanti dai mali oscuri, e di ornare le donne facendole belle come nessuna: il corallo. Torna la biennale di Natale nella capitale dell'Oro rosso, Torre del Greco. La rinnova, come un appuntamento fisso, la passione dei dirigenti della Banca di Credito Popolare (in capo il presidente Antonino De Simone), che si sono rivolti a un'antropologa, Cristina Del Mare, anch'essa presa dalla magia del corallo, per realizzare ad anni alterni una mostra e un libro. Il 2002 è la volta della mostra, che accende le luci sul corallo etnico del nuovo paese «visitato» per ricostruire la storia degli scambi tra Oriente e Occidente: lo Yemen, regno della regina di Saba, che forse proprio con un collier di sanguigne gemme addosso sedusse Salomone. Oggi alle 18 nel settecente-

PEZZI D'ARTE

IN ARGENTO
Una collana di manifattura yemenita

IN ORO
Un'Agd dell'800 in corallo mediterraneo

"Le vie del corallo" la gemma che lega l'Asia all'Occidente



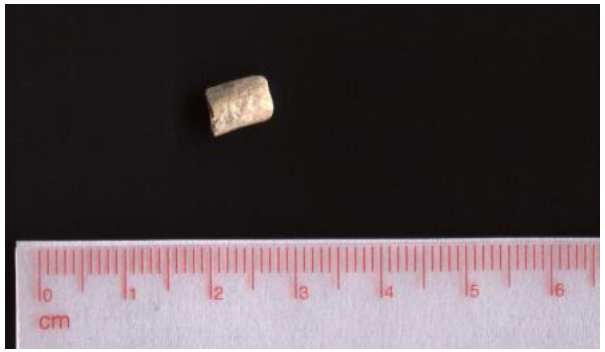
Ornamento in elementi di corallo ritrovato in un sito archeologico della regione dello Yemen centrale

Ornament with coral elements from an archaeological site in central Yemen

Aperta fino al 19 gennaio a Palazzo Vallelonga a Torre del Greco

Una mostra unica al mondo con un corallo di 4500 anni fa

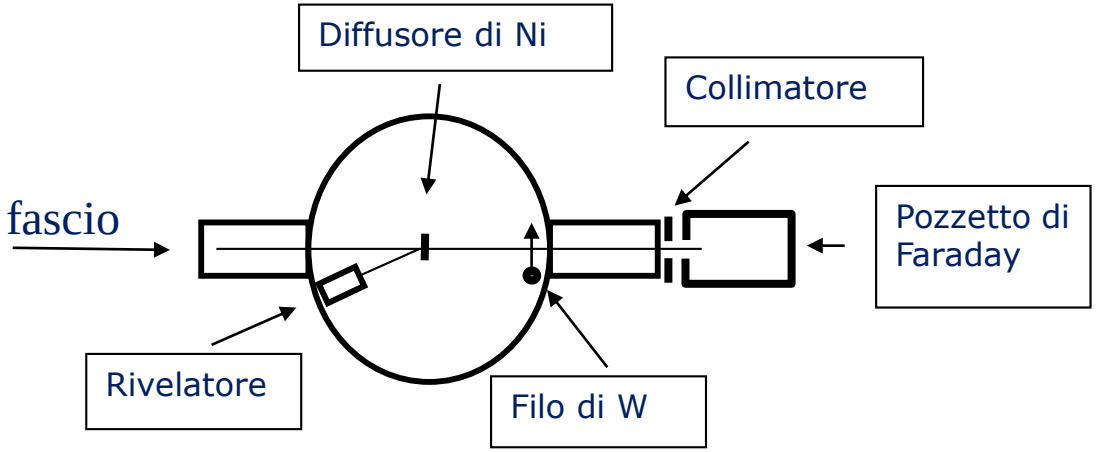
Campione di corallo dal quale è stato prelevato il frammento utilizzato per la datazione:
circa 200 mg
2880 BC – 2440 BC

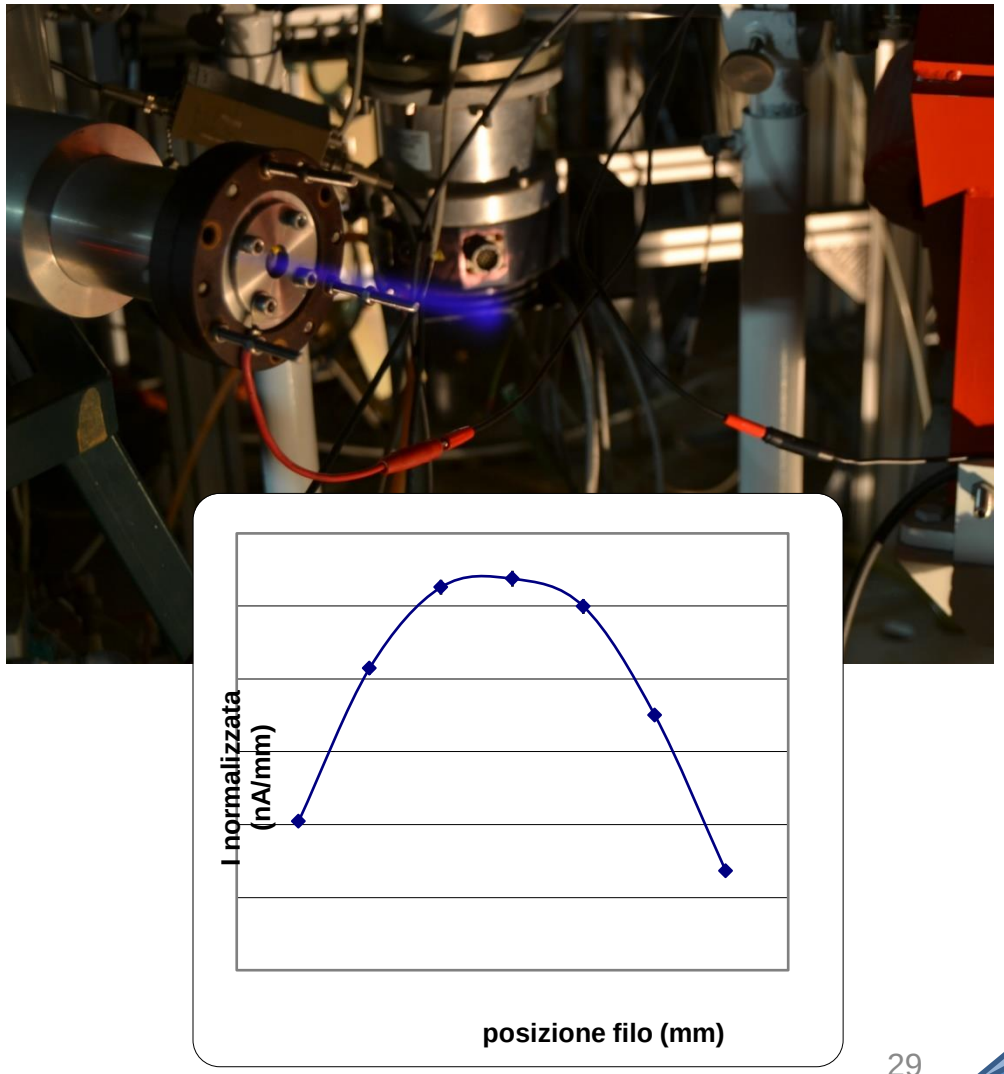


Ion implantation

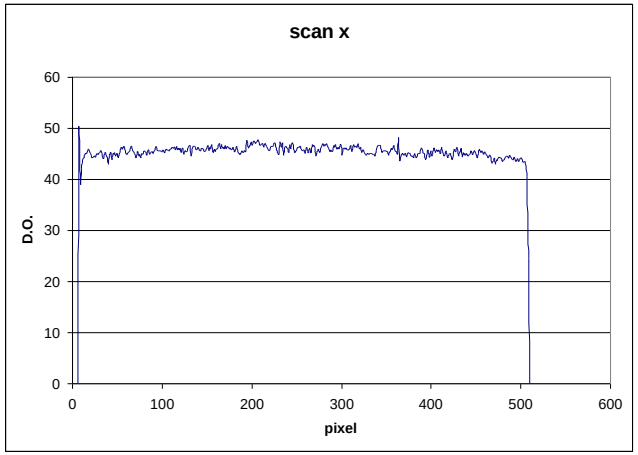
Controllo di uniformità del fascio, flusso e fluenza:

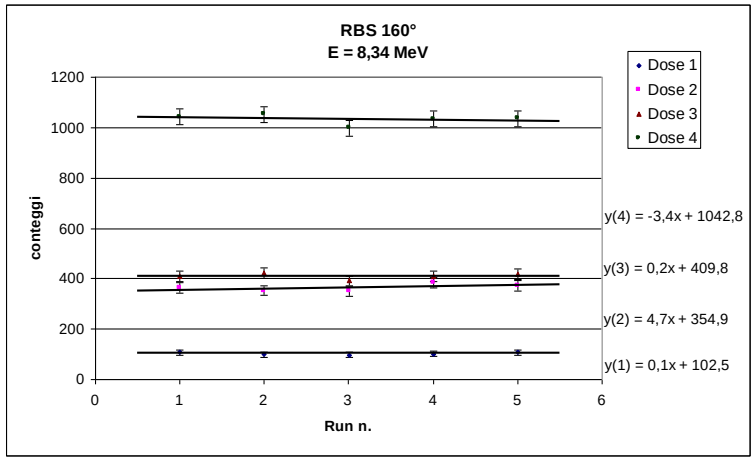
- RBS su foglio sottile di Ni impiegato anche come diffusore
- Scanning con filo di tungsteno
- Faraday Cup con lettura periodica
- Pellicole radiocromiche (GAF) per uniformità e dose

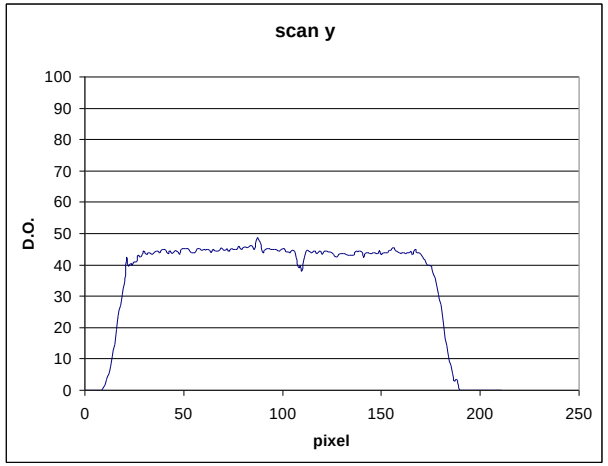


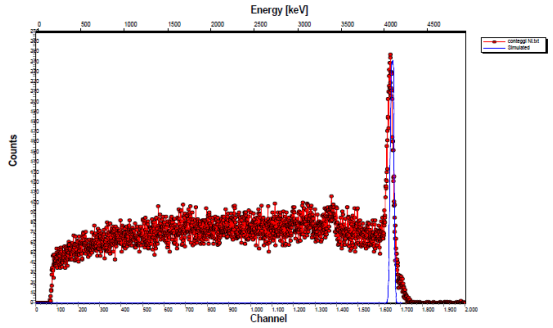


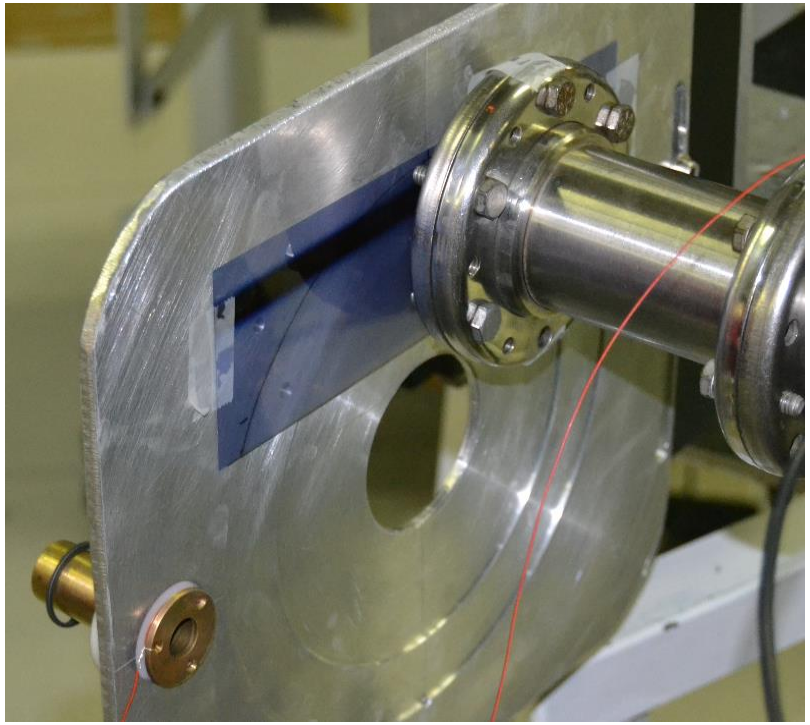
Ion implantation











Absolute dosimetry

JINST

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Absolute dose calibration of EBT3 Gafchromic films

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Napoli, Italy

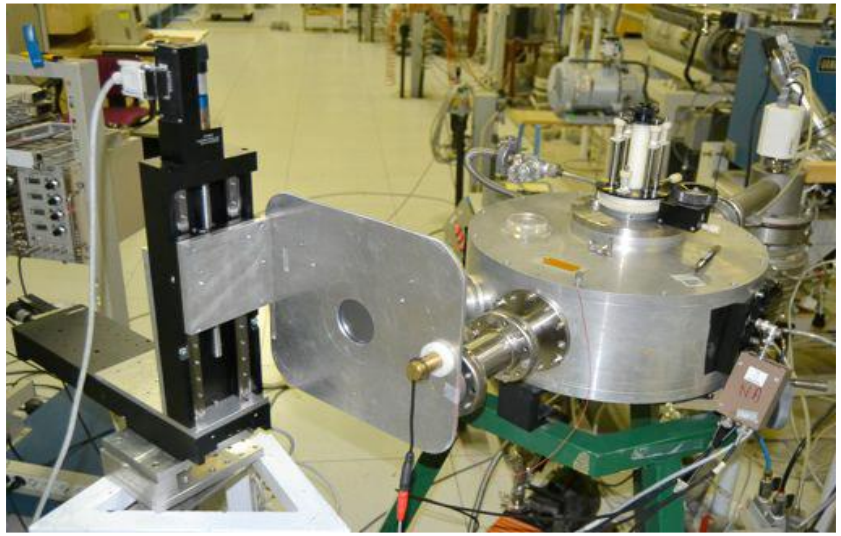
Ion implantation

Struttura dei MOSFET e IGBT.

Fronte

Al 4,5 mm	SiO_2 1 mm	Si 0,5 mm	Si 274 mm

Retro

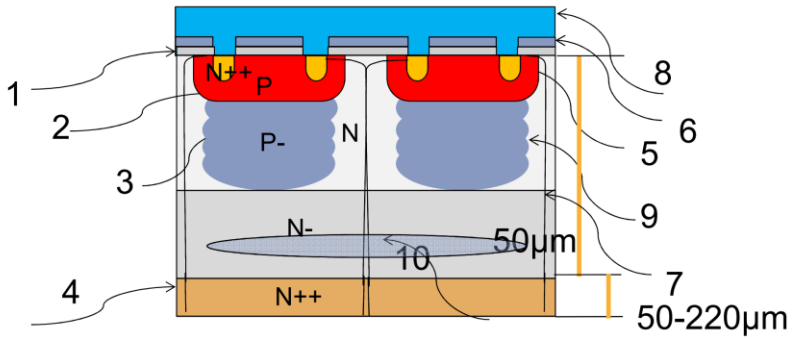


Fronte

Si 100 mm	Si 30 mm	Al 100 0 A	Ni-V00 0 A	Ag 150 0 A

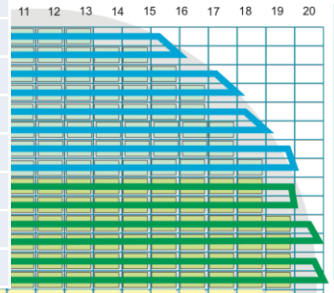
Retro

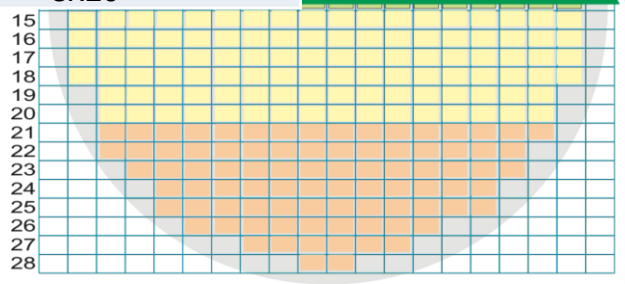
SECTION VIEW OF A SJ POWER MOSFET

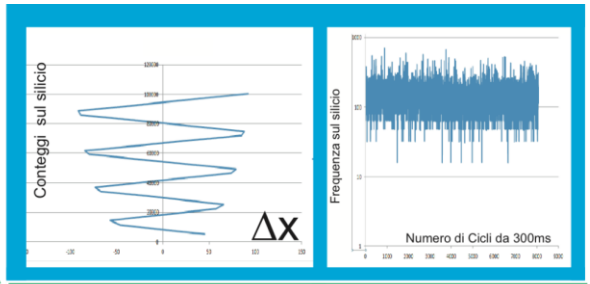


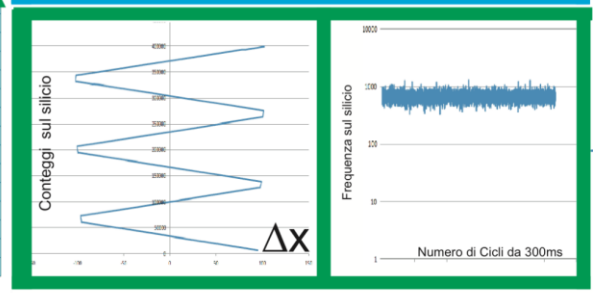
Ion implantation

Waf. ID	E (MeV)	Irradiat. side	Depth (mm)	Reg.	Beam Int. (nA)	Dose (protons/cm^2)
5240335-14H0	5.74	Back	240	1	2.5	10^{11}
				2	13	$5x10^{11}$
				3	25	10^{12}
				4	34	$5x10^{12}$
5240335-15G3	5.60	Back	230	1	2.5	10^{11}
				2	13	$5x10^{11}$
				3	25	10^{12}
				4	50	$5x10^{12}$
5240335-13A2	2.17	Front	40	1	2.5	10^{11}
				2	13	$5x10^{11}$
				3	25	10^{12}
				4	38	$5x10^{12}$
5240335-16F6	2.41	Front	50	1	2.5	10^{11}
				2	13	$5x10^{11}$
				3	25	10^{12}
				4	36	$5x10^{12}$

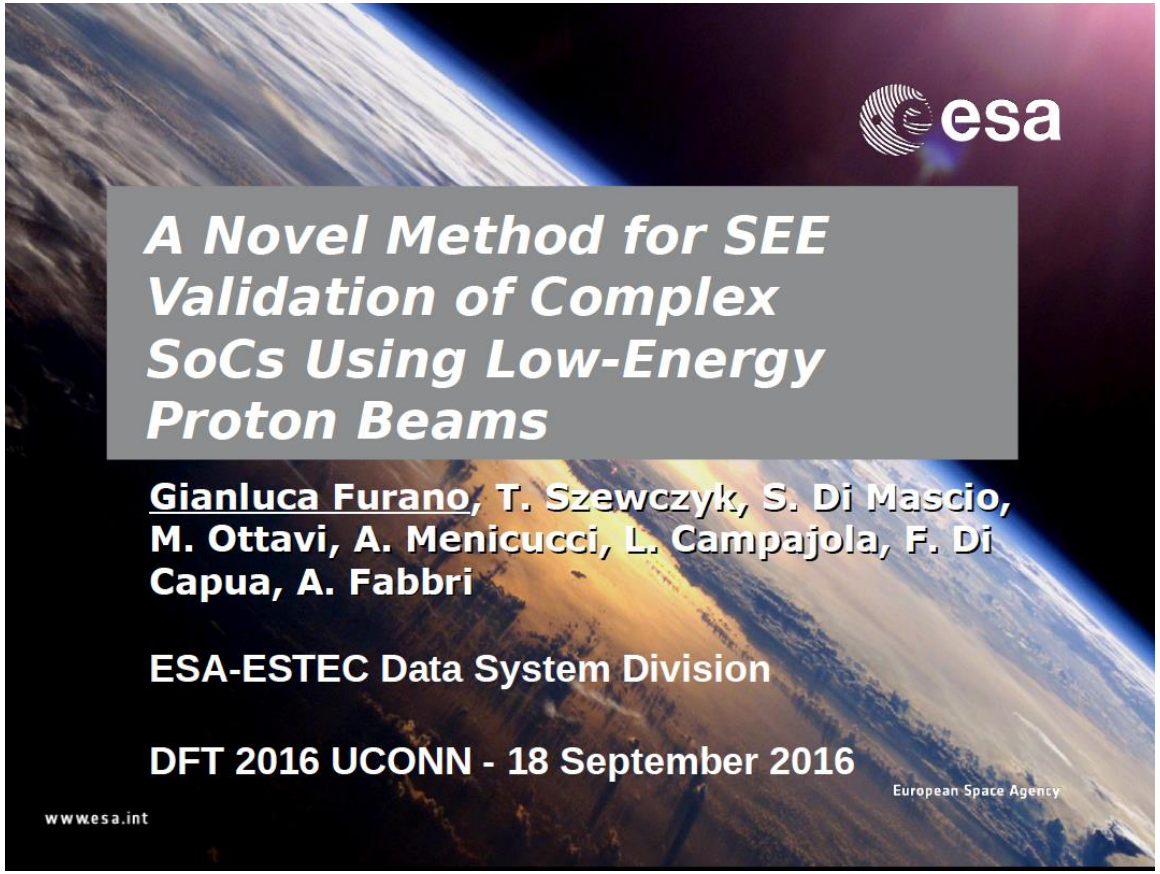








Radiation hardness application with low-energy protons



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A Novel Method for SEE Validation of Complex SoCs Using Low-Energy Proton Beams

Gianluca Furano, Stefano Di Mascio, Tomasz Szewczyk, Alessandra Menicucci, Luigi Campajola, Francesco Di Capua, Andrea Fabbri, Marco Ottavi

2016 11th International Conference on Design & Technology of Integrated Systems in Nanoscale Era (DTIS)

Qualitative Techniques for System-on-Chip Test with Low-Energy Protons

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Radiation hardness

Neutrons

Produzione di neutroni attraverso le reazioni:

$d(d,n)^3He$

$^7Li(p,n)^7Be$

- Produzione del fascio di deutoni mediante sorgente RF e/o sorgente sputtering modificata
- Realizzazione del canale dedicato con camera di scattering per la rivelazione della particella associata ^3He

Neutrons

Educational Activity

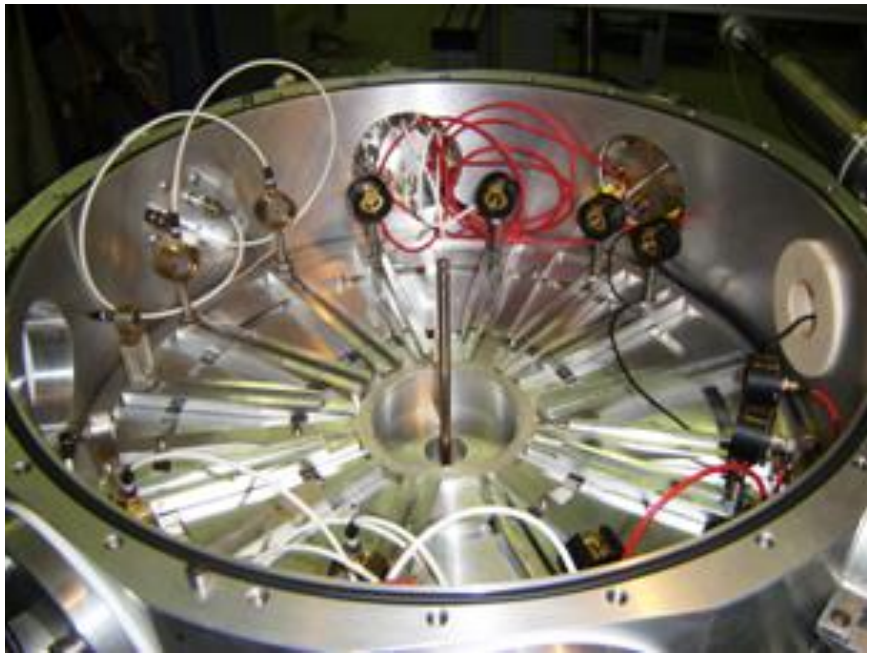
- Tesi di laurea magistrale
- Attività sperimentali connesse al corso di «Particle Accelerators» del dottorato in Fisica
- Laboratorio del I anno del corso di Laurea Magistrale in Fisica

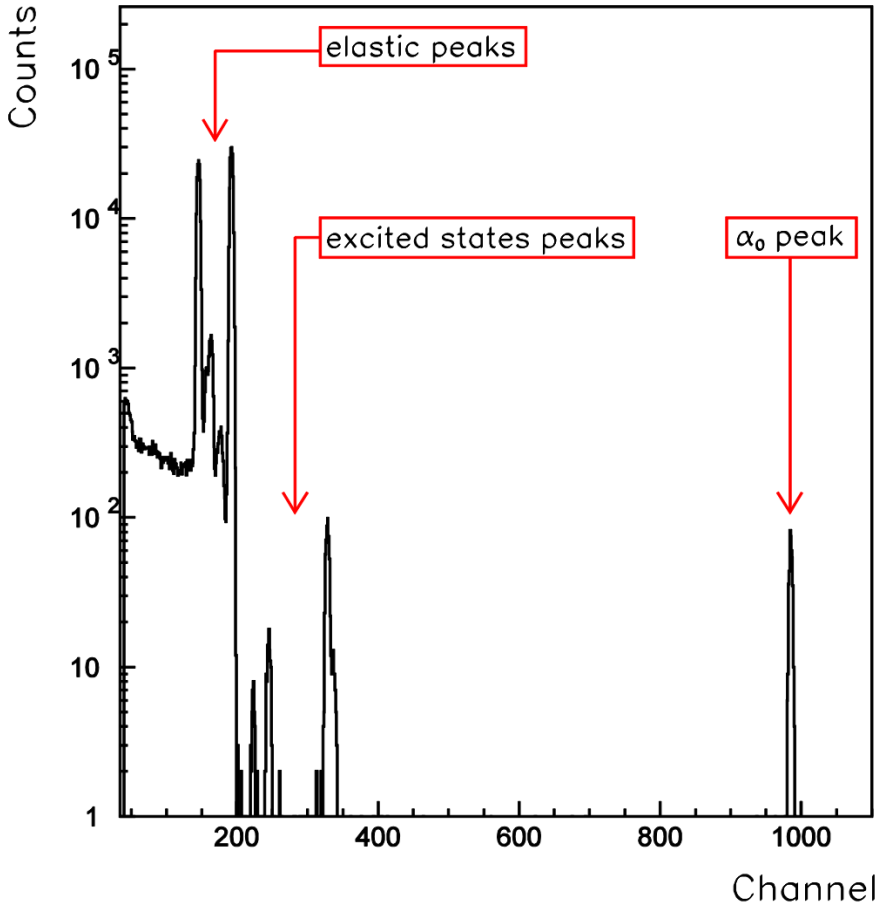
3 gruppi/anno (3 studenti/gruppo)

- Diffusione Rutherford
- Reazioni Nucleari
- Misure di perdite di energia
- Spettroscopia nucleare
- AMS

Educational Activity

Studio della reazione $^{19}F(p,\alpha)^{16}O$





- Diffusione elastica del protone su $^{12}C, ^{16}O, ^{19}F, ^{137}Ba$
- Stati eccitati dell' ^{16}O $(\alpha_3, \alpha_2, \alpha_1, \alpha_\pi)$
- Picco $\alpha_0 \rightarrow E_{\alpha_0} = 6.96MeV$?

Cosa si può fare con una reazione nucleare ?

- Analisi elementale: RBS
- Spettroscopia nucleare
- Modelli atomici
- Meccanica quantistica
- …

Educational Activity

Studio della reazione $^{19}F(p,\alpha)^{16}O$

- Verifica sperimentale del principio di equivalenza massa-energia
- Verifica delle leggi di conservazione (energia, impulso, momento angolare)
- Verifica del modello di Rutherford
- Analisi composizionale
- Spettroscopia nucleare (^{16}O)
- Meccanica quantistica
- Confronto tra formule classiche e formule relativistiche

Educational activities with a tandem accelerator

Pierluigi Casolaro, Luigi Campajola, Emilio Balzano, Eliana D'Ambrosio, Rodolfo Figari, Emanuele Vardaci and G La Rana

Fine