

Situazione esperimenti presso la Sezione di Milano

Chiudono 5 esperimenti

Continuano con responsabilità locale:

SICILIA (call)	RL Dario Giove
CLYC	RL Stefano Riboldi (Agnese Giaz)
Retina	RL Nicola Neri
Techn_Osp	RL Flavia Groppi
MC_INFN	RL Paola Sala
RedSox2	RL Giuseppe Bertuccio
eLIBANS	RL Andrea Pola
NADIR	RL Stefano Agosteo
RadioLab	RL Flavia Groppi

Continuano con responsabilità nazionale

Ardesia	RN e RL Carlo Fiorini
HVR_CCPD	RN e RL Attilio Andreazza
SL_EXIN	RN e RL Luca Serafini
L3IA	RN e RL Dario Giove

Nuovi con responsabilità nazionale

XPLORE (call)	RN e RL Dario Giove
Hadrocombi	RN e RL Alessandro Lascialfari
Design*	RN e RL Andrea Castoldi

Nuovi con responsabilità locale

MoVelt (call)	RL Giuseppe Battistoni
Plasma4Beams	RL Massimiliano Rome
Traccia	RL Roberta Vecchi
NEPED	RL Andrea Pola (INFN ENERGIA)

13 esperimenti continuano
7 esperimenti nuovi



Development of **Silicon Carbide** Detectors for Intense **Luminosity** Investigations and other **Applications**

Scientific responsible (PI) of the project: **Salvatore Tudisco (LNS)**

External institutions, involved in the project with letter of endorsement

CNR-IMM – Catania

External companies, involved in the project Fondazione Bruno Kessler (FBK) –

FBK - Trento ; ST Microelectronics – Catania

INFN-LNS

INFN-CT

INFN-MI

INFN-Mib

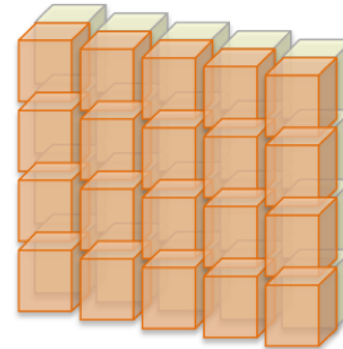
INFN-TIFPA

Aim of the Project

A study for the construction of a charge identification Telescopes wall with an innovative material, Silicon Carbide, whose characteristics make it very appealing for NUMEN and ELI experiments.

NUMEN Requirements

- ✓ 1x1 cm² ΔE - E telescope
- ✓ thickness of ΔE stage 100 μm
- ✓ thickness of E stage 500-1000 μm
- ✓ hard to the radiation damage
- ✓ good energy resolution (1-2 %)
- ✓ High stability (electric and thermal)

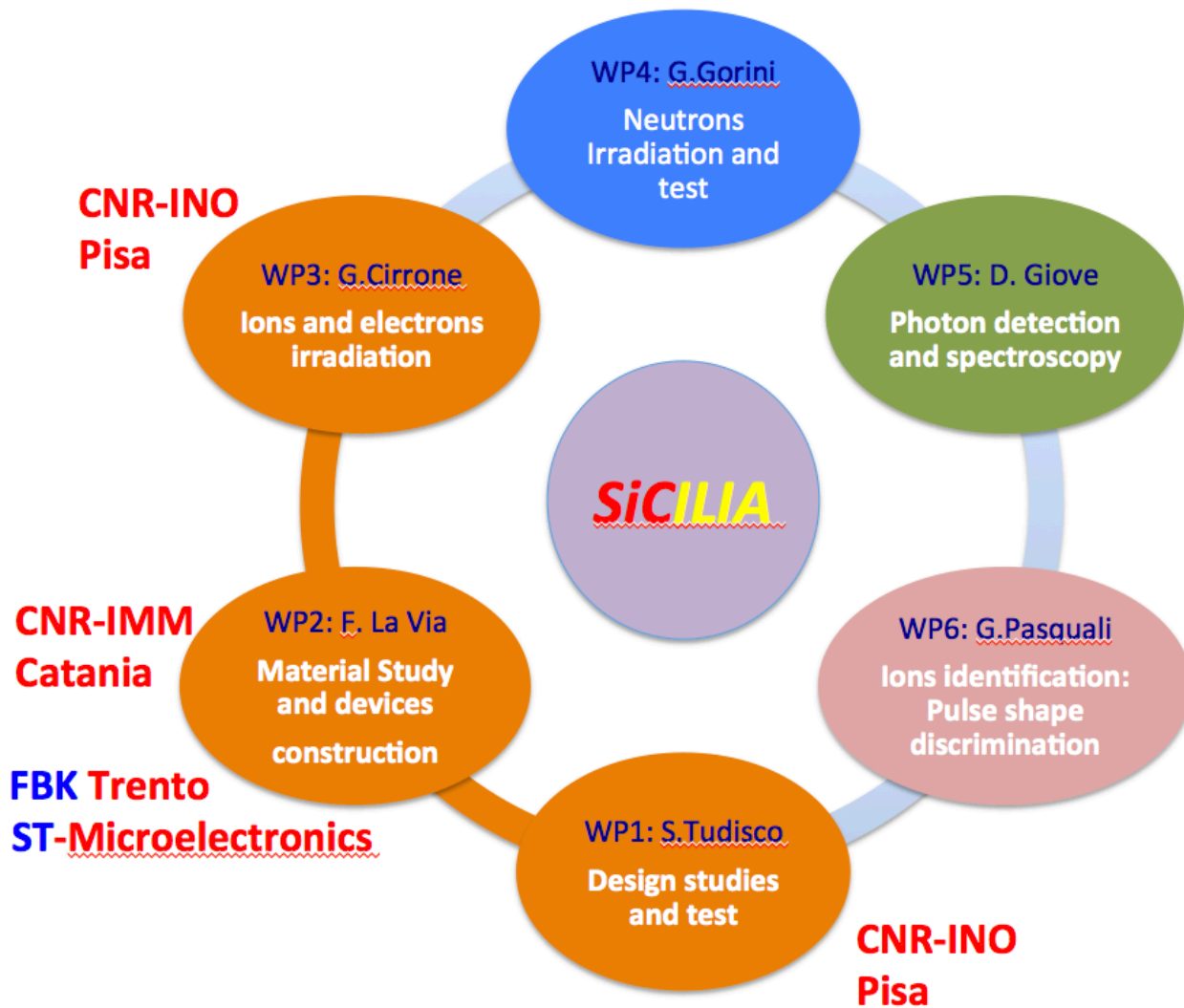


RD50 - CERN

Property	Diamond	GaN	4H SiC	Si
E_g [eV]	5.5	3.39	3.26	1.12
$E_{\text{breakdown}}$ [V/cm]	10^7	$4 \cdot 10^6$	$2.2 \cdot 10^6$	$3 \cdot 10^5$
μ_e [cm ² /Vs]	1800	1000	800	1450
μ_h [cm ² /Vs]	1200	30	115	450
v_{sat} [cm/s]	$2.2 \cdot 10^7$	-	$2 \cdot 10^7$	$0.8 \cdot 10^7$
Z	6	31/7	14/6	14
ϵ_r	5.7	9.6	9.7	11.9
e-h energy [eV]	13	8.9	7.6-8.4	3.6
Density [g/cm ³]	3.515	6.15	3.22	2.33
Displacem. [eV]	43	≥ 15	25	13-20

- Wide bandgap (3.3eV)
⇒ lower leakage current than silicon
- Signal (for MIP !):
Diamond 36 e/ μm
SiC 51 e/ μm
Si 89 e/ μm
⇒ more charge than diamond Si/SiC $\approx$ 2
- Higher displacement threshold than silicon
⇒ radiation harder than silicon

NUMEN



Strutture di bordo

- P/N Junction
- Schottky diode

P/N Junction: letteratura assente per quanto concerne l'argomento specifico

Schottky diode: grande letteratura presente nell'ultimo decennio perlomeno

Schottky diode: possibilità di disegnare una struttura ai bordi partendo dai riferimenti in letteratura da complementare con una discussione relativa ai dettagli di processo

Simulation Tools

TCAD (Europractice)

ATHENA (Silvaco)

Materiale Bulk

Rapid development of SiC technology (proper compensation of dopants) allowed to produce high resistivity SiC (semi-insulating), now commercially available – even in form of 6-inches in diameter and 300-500 μm thick wafers.

Lifetime of excess carriers in SiC is reported to be between 100ns – 10 μs , depending on material quality.

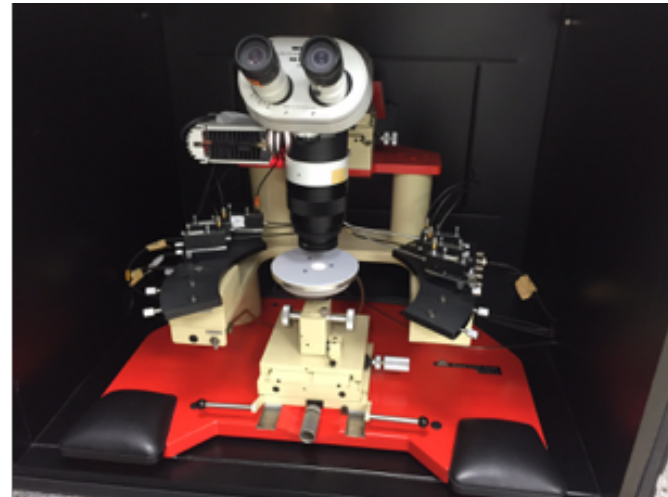
2000 US\$ for a 76.2 mm diameter high purity SiC 1E5 Ohm cm

Keithley based station

Messo in funzione lo strumento (molto complesso da utilizzare e attualmente in grado di misurare bassissime correnti solo provenienti da una probe triassiale.

Possibilità di affiancarlo con strumentazione da INFN-Mi e POLIMI.

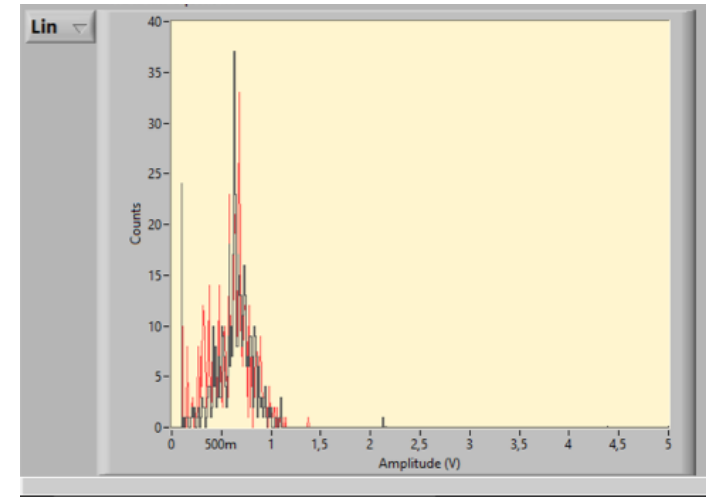
Chuck da 6" disponibile



Stazione di irraggiamento SiC @ POLIMI

Effettuati primi test con sorgenti da taratura su campioni SiC per la messa a punto della catena.

Commercial SiC UV detector
Alfa source 241Am



Attività 2016

Acquisto materiale bulk di elevato spessore (500 micron) da due produttori e caratterizzazione
Definizione del processo produttivo di un primo lotto e sua realizzazione

Attività 2017

Definizione del design produttivo definitivo e sua realizzazione
Test spettroscopici su componenti disponibili

Richiesta finanziaria 2017

Complessivi 35 Keuro

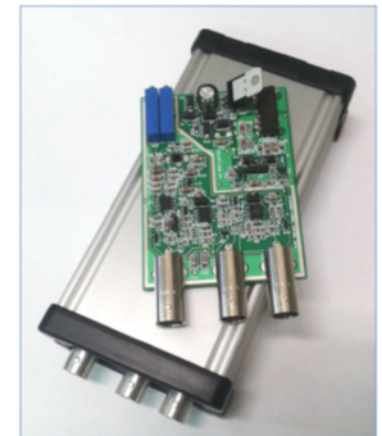
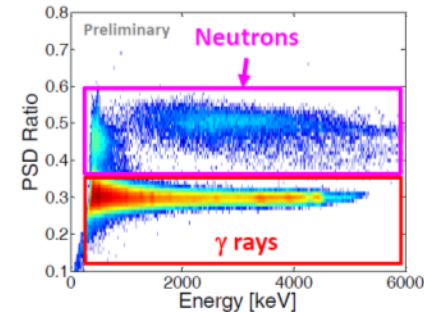
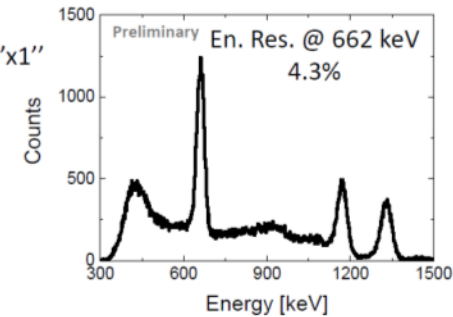
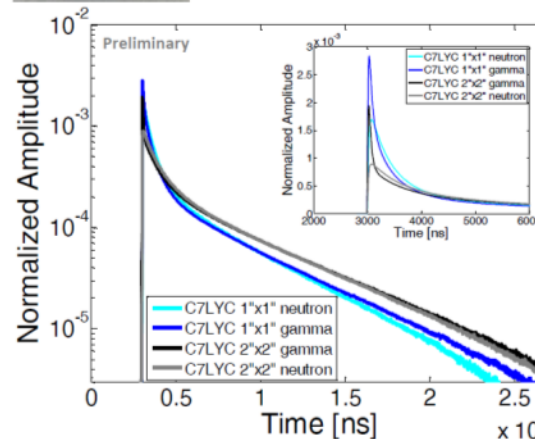
Attività 2016

- ✓ Caratterizzazione di uno scintillatore CLYC ${}^7\text{Li}$ 2" x 2"
- ✓ Studio delle risposte in termini di prestazioni spettroscopiche di energia, discriminazione γ/n , risoluzione temporale, efficienza e radioattività interna in rapporto a cristalli di dimensioni minori (CLYC ${}^7\text{Li}$ 1" x 1")
- ✓ Completamento dell'analisi dati dei test con fascio a Legnaro e sorgente di neutroni al LASA effettuati nel 2015
- ✓ Studio e realizzazione di un modulo di elettronica analogica (formatore multi banda) che consente di mantenere le prestazioni intrinseche del rivelatore CLYC anche in caso di acquisizione e processamento digitale dei segnali
- ✓ 2 Articoli su rivista internazionale
- ✓ 5 Presentazioni orali a conferenze internazionali
- ✓ 2 Tesi di Laura Triennale

Characterization of 2" x 2" CLYC scintillator



Properties:
Signals are slightly different from 1"x1"
The neutron gamma discrimination capability is maintained
Energy Resolution 4.3% and time resolution ~ 2 ns



Attività previste per il 2017

- ✓ Caratterizzazione del cristallo CLYC ${}^7\text{Li}$ 3" x 3" acquistato nel 2016 in termini di prestazioni spettroscopiche di energia, discriminazione γ/n , risoluzione temporale, efficienza, radioattività interna in rapporto a cristalli di dimensioni minori (CLYC ${}^7\text{Li}$ 2" x 2")
 - ✓ Caratterizzazione danno da radiazione per cristalli CLYC dopo esposizione a fasci di
protoni e neutroni in termini di peggioramento della capacità di discriminazione
gamma/neutroni e di risoluzione spettroscopica
 - ✓ Studio e sviluppo di algoritmi digitali per il processamento dei segnali dei rivelatori
CLYC per misure di energia, tempo e P.S.D.
 - ✓ Test con fascio di neutroni (Legnaro)
 - ✓ Test con fascio di neutroni (Orsay)
 - ✓ Test di misura del fondo di neutroni in applicazioni di terapia medica con fascio di protoni (Cracovia)
-

Anagrafica e Richieste 2017

Anagrafica Milano Celoria

Agnese Giaz - 50%

Benedicte Million - 30%

Nives Blasi - 30%

Stefano Riboldi - 30%

✓ Missioni : 10 keuro

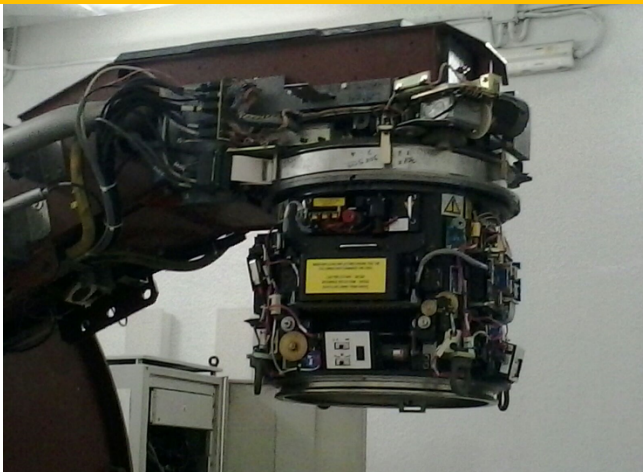
✓ Consumo: 3 keuro

e_LiBANS

e_Linac Based **Actively-monitored** Neutron Sources

2016-2018

Acceleratore Elekta SL 24 MV



In collaborazione con
DF-UNITO e ELEKTA spa

ANNO 2017

Torino (≈ 4 FTE)

Resp. Naz. M. Costa

LNF (≈ 2 FTE)

Resp. Loc. R. Bedogni

Trieste (≈ 1 FTE)

Resp. Loc. G. Giannini

INFN MI-PoliMi (1.8 FTE)

Andrea Pola (0.4), PA, Resp. Loc.

Alessandro Porta (0.7), Ric. Univ.

Luisella Garlati (0.5), Tecnico Dottorato

Alessandro Bassanetti (0.3), Tesista

Proposta

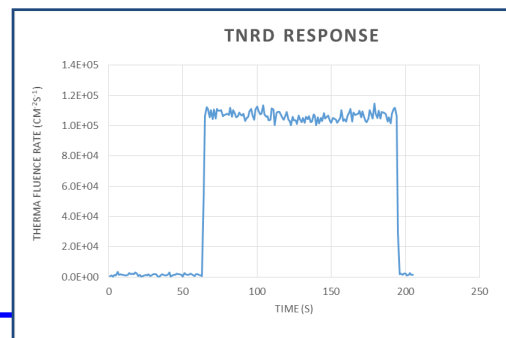
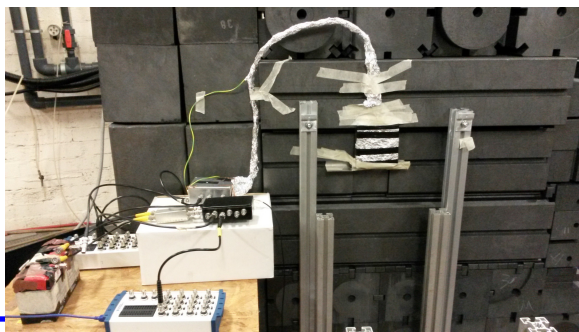
Premesse: il Dipartimento di Fisica Univ. di Torino mette a disposizione un bunker + sala controllo per ospitare un Elekta SL 24 MV (e-linac ospedaliero *usato e ricondizionato*)

Obiettivi

- Progettare, realizzare DUE convertitori (γ, n) - moderatori che, accoppiati alla testata del e-Linac, permettano di ottenere campi intensi ($> 10^7 \text{ cm}^{-2} \text{ s}^{-1}$) di neutroni termici (convertitore termico) ed epitermici (convertitore EPI-termico).
- Sviluppare e caratterizzare diagnostiche attive di neutroni termici ed epitermici (radiation hard, gamma insensitive, space resolved), per equipaggiare i convertitori.
- Eseguire la caratterizzazione metrologica dei campi prodotti, in spettro e quantità radiometriche / dosimetriche, al fine di poter offrire condizioni di test-beam molto ben conosciute.
- Sfruttare facilities di calibrazione esistenti presso la collaborazione (HOTNES @ LNF/ENEA, ESTHER @ PoliMi,)

Attività e_LiBANS 2016 – In corso

- Progetto e realizzazione della testata termica in fase conclusiva.
- e-LINAC montato a Torino. Accensione in Luglio (ditta Elekta).
- **Prototipi di rivelatore termico (solid-state & vented ion chambers) e relativa elettronica in fase di test**



Test Diagnostiche Termiche Attive (TNRD) presso LNL-INFN (MUNES)

Attività 2017 Previste

- Realizzazione del sistema di diagnostiche neutroniche termiche “permanenti”
- Accoppiamento alla testata del LINAC
- Caratterizzazione metrologica completa
- Progetto dell’irraggiatore epi-termico
- Disegno e prototipo della diagnostica epitermica
- Acquisto del materiale per l’irraggiatore epi-termico

Richieste di Milano per l’ anno 2017

- **Consumo**

Realizzazione irraggiatore epitermico per test diagnostiche 12 k€

Materiale 2 k€

- **Missioni**

Test beam a Torino	1 k€	Calibrazione
diagnostiche epitermiche metrologia primaria	2 k€	
Presentazione risultati a NEUDOS13		1 k€

Tot: 18 k€

Esperimento RETINA

“REal time TRacking INnovative Approach”



Nicola Neri
INFN, Sezione di Milano

Milano, 11 Luglio 2016

RETINA experiment

- ▶ **Real time tracking at 40 MHz rate.** Improve track trigger performance for the LHC upgrade. See LHCb-PUB-2014-026.
- ▶ Retina algorithm inspired by neurobiology. Based on massive parallelisation and interconnectivity
- ▶ **Implementation in commercial FPGA** with fully pipelined architecture
- ▶ INFN Milano and Pisa

People	Position	FTE 2017
J. Fu	Assegnista UniMi	0,3
N. Neri	Ricercatore INFN	0,3
B. Dey	PostDoc stranieri INFN	0,3
M. Lazzaroni	PA	0,1
FTE		1

Assegnazioni 2016

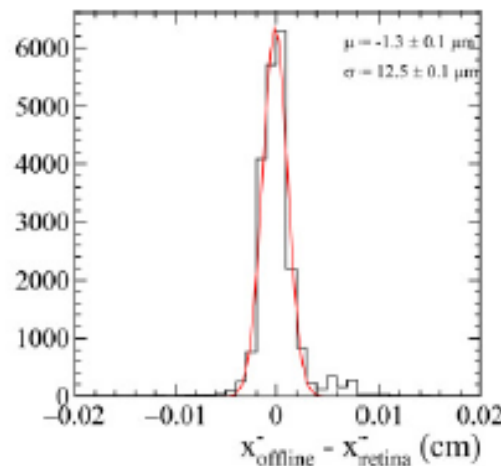
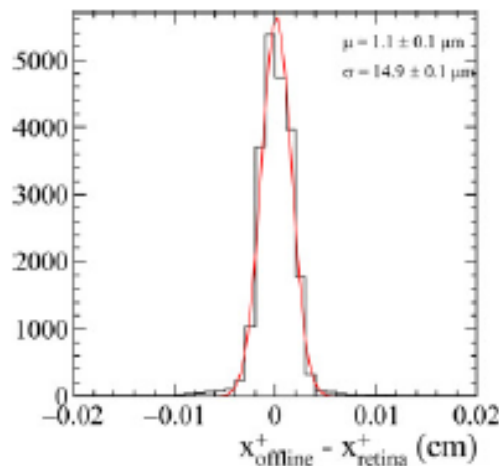
Capitolo	kEuro
Consumo	1
Costruzione Apparati	18
Totale	19

Activity and results 2016

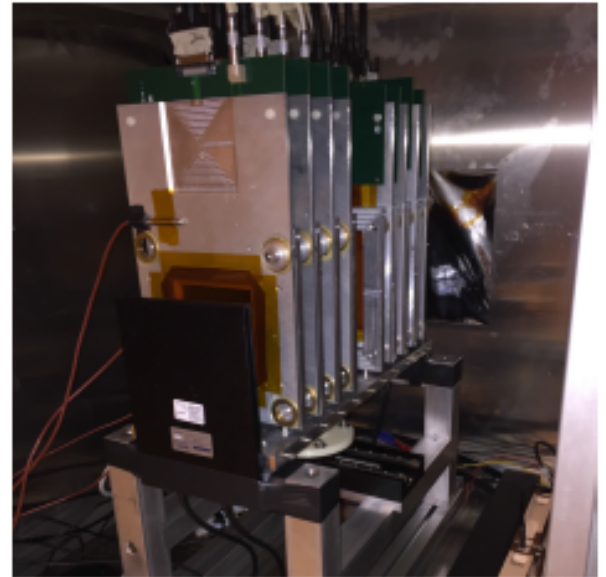
► Milestone 2016 completata al 100%

- Test su fascio del telescopio a silicio e ricostruzione in tempo reale delle tracce
- Risultati presentati a VCI 2016 e pubblicati su NIM A, doi:10.1016/j.nima.2016.05.129

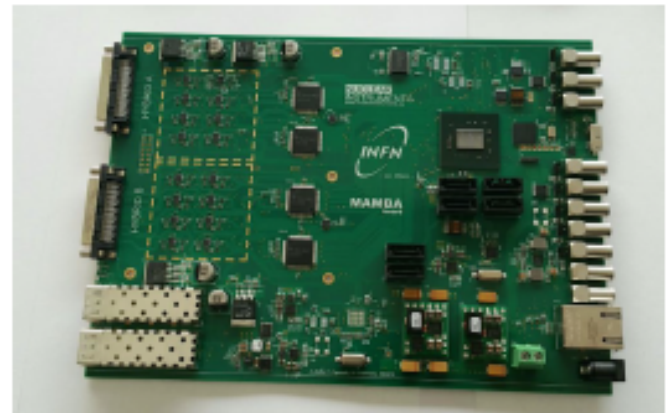
Track parameters determined in real time agree with offline results. Testbeam data



telescope on beam at CERN



Retina board with Kintex7 FPGA



Activity and plans

- ▶ Contributions at conferences:
 - NSS-MIC15, 2 oral contributions: Neri, Petruzzo
 - VCI16, 1 oral contribution: Neri
 - Vertex16, 1 poster: Petruzzo
 - Twepp16, 1 poster: Petruzzo
 - ▶ Work in progress in Milano:
 - Retina algorithm on large FPGA and setup for test at 40 MHz
 - ▶ In 2017:
 - simulation of a sector of a detector for real-time track reconstruction at 40 MHz. Additional board with FPGA (Stratix V) is required
-
- ▶ Richieste 2017:
 - Consumo laboratorio: 2 kEuro
 - Board con FPGA (Stratix V) 15 kEuro
 - FPGA per generazione dati in ingresso a 40 MHz 5 kEuro

Sezioni partecipanti: TS, TIFPA, BO (IASF-BO), MI, PV, ROMA2 (IAPS-ROMA), CNR Pisa

Responsabile nazionale: Andrea Vacchi

Responsabile locale: Giuseppe Bertuccio

Durata: 2016-2018

Gruppo INFN-MI: G. Bertuccio (80%), A. Castoldi (10%), L. Chang (70%), [M. Ahangarian (100%); M. Gandola (30%) associazione in corso]

FTE: Ricercatori: 0.9; Tecnologi: 0.7 [2]

Collaborazioni: FBK (Trento), Sincrotrone Trieste, LABEC, EuroFEL

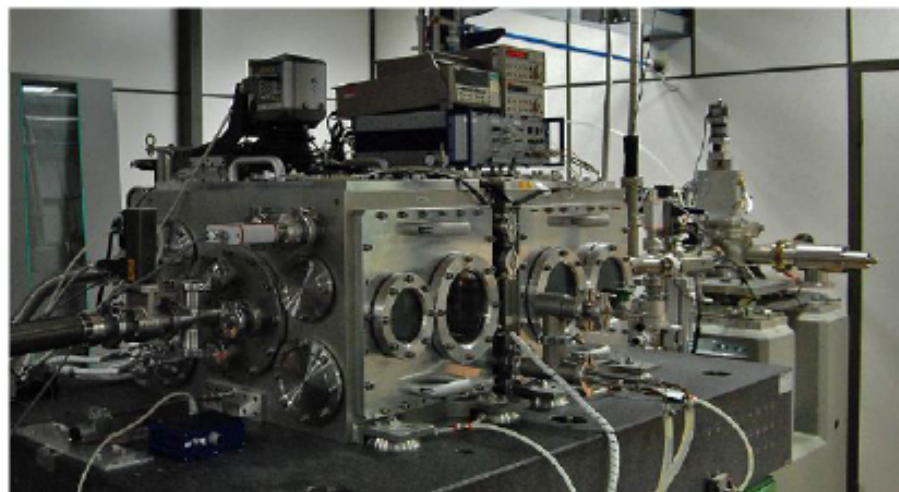
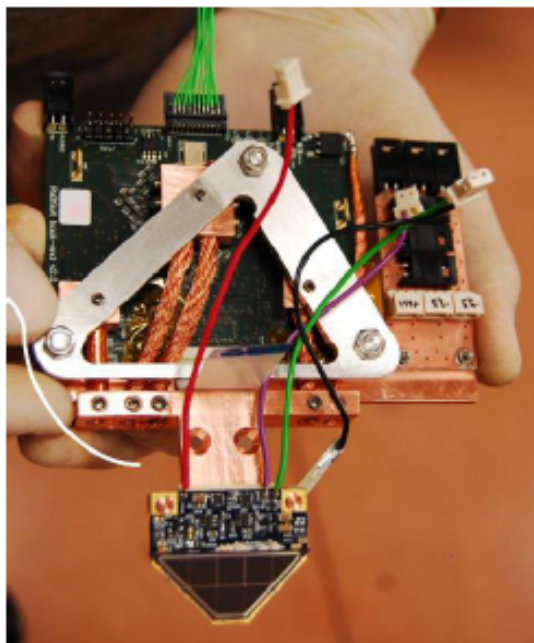
Linea di ricerca: Spettroscopia ed Imaging di X-ray.

- Sviluppo di *Rivelatori a Deriva in Silicio di grande superficie*
- Sviluppo di *CMOS Front-End ASIC a minimo rumore*

Applicazioni: Advanced Light Sources (Sincrotrone e FEL); Astrofisica X e γ ; Beni Culturali

Richieste 2016: Missioni (5k), Inventario (6k); Consumo (19k)

Stato dei lavori – Risultati raggiunti



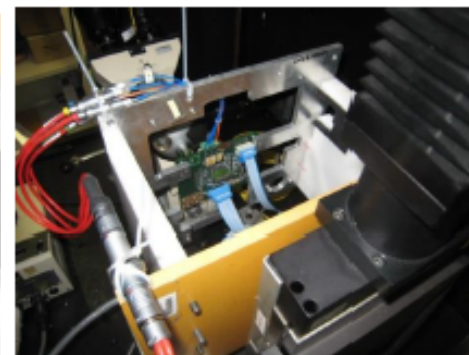
Detection Module for ELETTRA TwinMic: 8 channels detection module equipped with SDDs and SIRIO ultra low noise (1 electron r.m.s.) CMOS Charge Preamplifiers

Programma Attività 2017

- Progettazione, realizzazione e caratterizzazione sperimentale elettronica di Front-End per nuovi rivelatori Pixel Drift Detectors (PixDD)
- Caratterizzazione e ottimizzazione board per sistema ELETTRA - TwinMiC

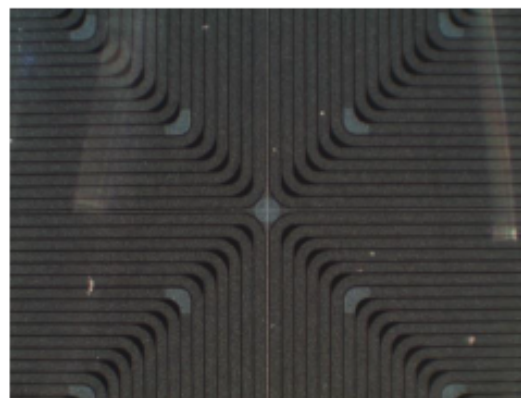
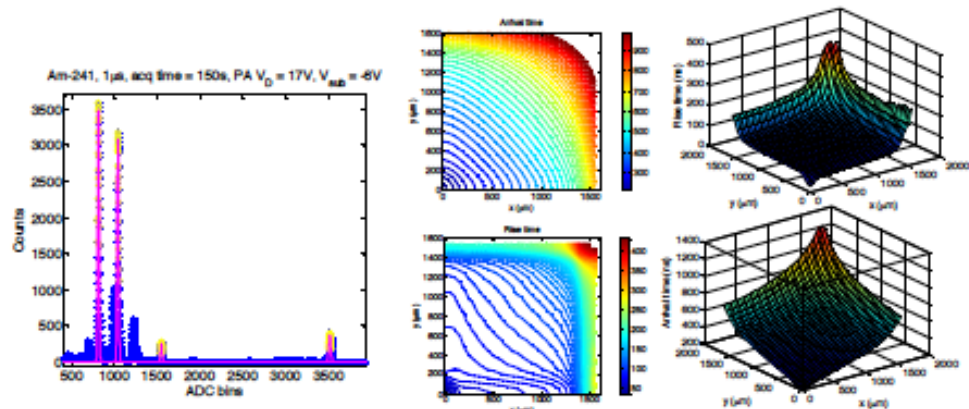
Stato delle attività svolte

- Studio sperimentale prestazioni di matrici trapezoidali di celle SDD 10mm^2 (in aria e in vuoto)
- sviluppo nuovo setup in vuoto per misure ad alta risoluzione



Attività prevista 2017

- Test 2 nuove strutture SDD (array lineare e array trapezio con celle 50mm^2) aventi finestra di ingresso sul back side ottimizzata per basse energie ($<1\text{keV}$). In particolare verranno eseguite scansioni 1D con linee a bassa energia (con sorgenti e/o fascio X).
- Test readout ASIC+SDD a T criogeniche nel nuovo setup in vuoto
- Qualificazione sistema finale in vuoto in condizioni operative compatibili con beamline TwinMic di Elettra.



MC-INFN (7° anno)

Sigla che raggruppa le attività di sviluppo e mantenimento dei codici MC con forte partecipazione INFN (FLUKA e GEANT4) e inquadra la loro partecipazione alle collaborazioni internazionali e ai progetti europei.

Milano → FLUKA

+ co-convener nazionale (P. Sala)

2015 : 16 pubblicazioni MC-INFN, 7 Milano
13 talks MC-INFN, 2 Milano

Finanziamento 2016: 10kE missioni, centralizzato a Mi per la
componente FLUKA (5.2 fte in 2015)
2kE inventariabile per nuovo server

Apporto finanziario all' INFN: 2015 24kE, 2016 4kE (licenze fluka)

Anagrafica 2017: ~15 fte MC-INFN, 4.5 fte FLUKA

1.5 fte Milano : G. Battistoni (30%), F. Broggi (30%),

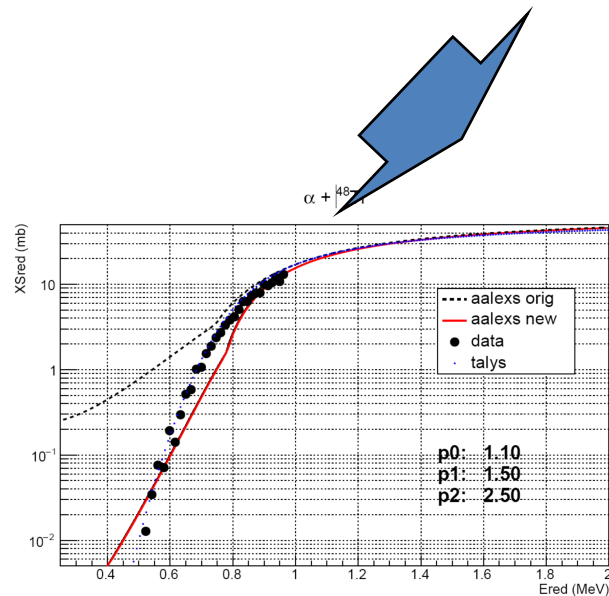
M. Campanella(20%), P.Sala (50%), S.Valle(20%)

Richieste 2017:

15kE missioni (include Roma2, Pv)

Attività' "continue"

- Maintenance del **sito web** (9000 utenti registrati)
- Partecipazione al **supporto utenti** via mailing list (1500 sottoscrizioni)
- Presidenza del **Fluka Coordination Committee**
- Preparazione **corsi per utenti** e possibile partecipazione
- Gestione **licenze commerciali** con TT INFN e CERN
- Partecipazione alla maintenance del codice
- **Sviluppi mirati e supporto esperimenti: ICARUS, adroterapia, LHC**



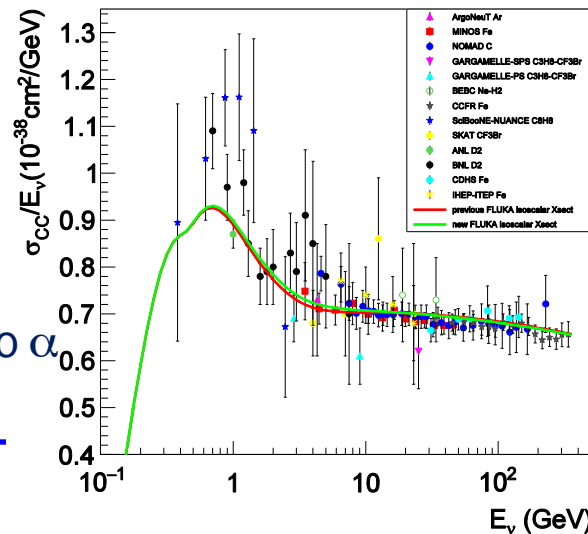
Nuova descrizione sezione d'urto α bassa E

(frammenti fasci adroterapia)

Luglio 2016

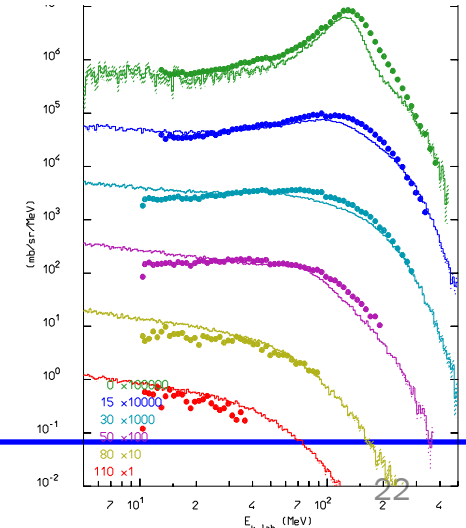
Esempi 2015-16

Perfezionamento sezioni d'urto neutrino (ICARUS)



Miglioramento interazioni ione-ione bassa E (INSIDE)

C+C -> xn+X, 135 MeV/A



Novita' 2017

- Adroterapia: personale CNAO associato in MC-INFN, continua una lunga collaborazione
 - Validazione mediante Fluka di metodi analitici per il calcolo di dose
 - Applicazioni cliniche
 - Valutazione di nuovi “proiettili” (i.e. He)
 - Simulazione nuova linea di fascio
- Effetti biologici radiazioni: studio di fattibilita' per interfacciare il modello biofisico BIANCA
- Neutrini : sviluppo di un interfaccia al package di ricostruzione (LArSoft) in uso per i nuovi exp. DUNE e SBN (con partecipazione degli esperimenti)
- Frammentazione: simulazione complete dell'esperimento FOOT
- Frammentazione: validazione dei modelli su dati esistenti, in attesa dei dati di FOOT

TECHN-Osp (2015-2017) – ROLE of MI

R&D activities aimed at an industrially-based technology for future homeland accelerator- ^{99m}Tc production based on a selected cyclotrons' network in Italy

FTE -MI

	2015	2016	2017
Flavia Groppi (RL)	– 80 %	– 80%	– 70%
Mauro Bonardi	– 100 %	– 20%	
Simone Manenti	– 100 %	– 100%	– 100%
Luigi Gini	– 50 %	– 100%	
Anna Bazzocchi	– 80 %	– 80%	– 80%



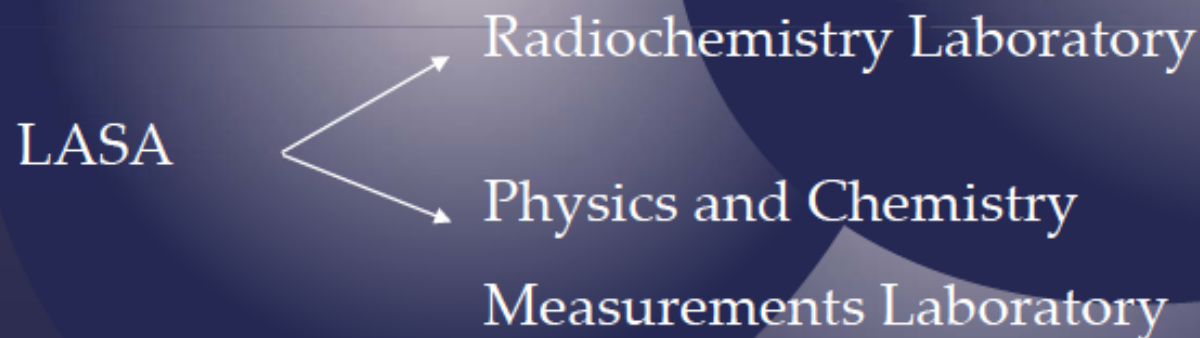
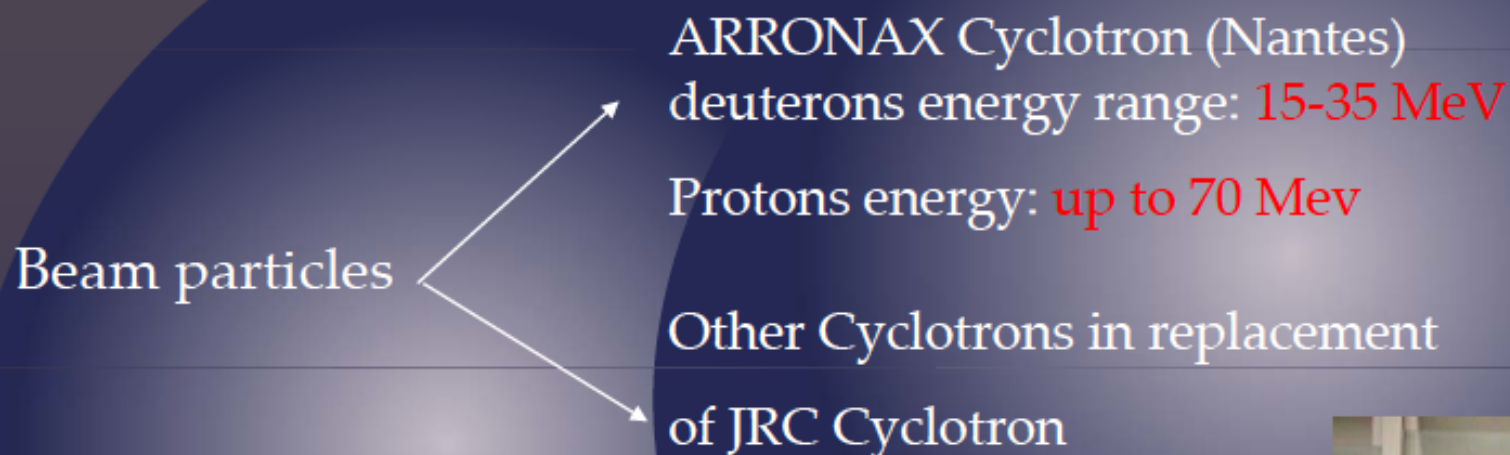
- Ferrara Branch
- Pavia Branch
- Padua Branch
- Milan Branch
- Bologna Branch

BUDGET QUOTATION in k€ (asked)

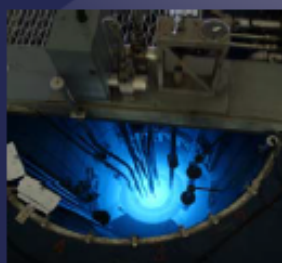
	2015	2016	2017
Consumables (targets, chemical reagents, glassware, standards, exchange resin, columns, etc.):	4 (6)	6 (8)	8
National Missions (Milano, Pavia, Legnaro):	6 (3+8)	4.5 (9)	8
Foreign Missions (at least 3 Nantes, Irradiations):			
Radioactive transport service Nantes-MI; Pavia-MI:	4 (6)	4 (5)	6
Maintenance (nitrogen; filters hoods. Radiochem. Lab.):	2 (4)	2 (4)	4
Durable (transportation system as Type A package)			1

The role of Milano unit

The research activity of the Milano Group is carried out at the following laboratories:



LENA - Pavia

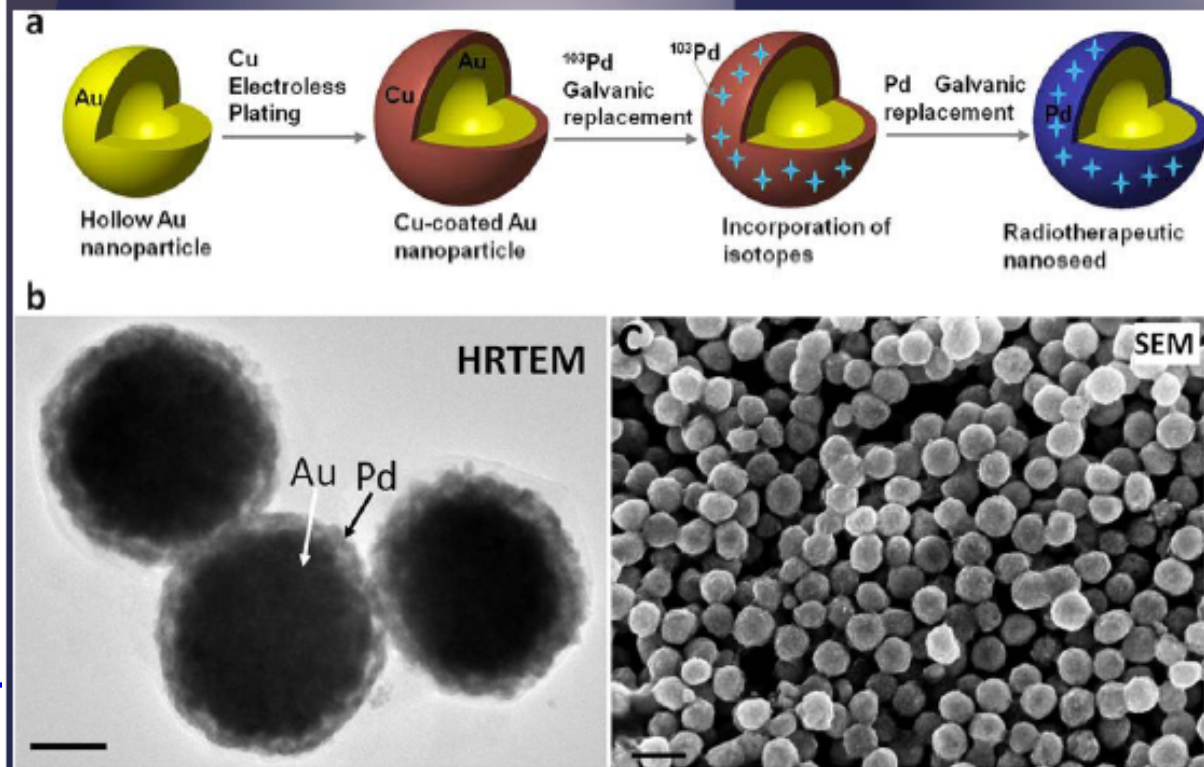


Nuclear Reactor TRIGA MARK II

The role of Milano unit

- In progress -

June 2016 – Dec. 2016	1. Irradiation at ARRONAX to add experimental values to the cross section of $^{89}\text{Y}(\text{d},2\text{n})^{89}\text{Zr}$ nuclear reaction; 2. Thick Target Yield determination for ^{103}Pd production
2017	1. Complete the ^{89}Zr cross sections determination; 2. Start to study the possibility to produce nanoparticles with ^{103}Pd incorporated for radionuclide therapy



Gently by: Moeendarbari, S. *et al.*

[Theranostic Nanoseeds for Efficacious Internal Radiation Therapy of Unresectable Solid Tumors,](#)

Sci. Rep. 6, 20614;
doi:10.1038/srep20614 (2016)



ARDESIA

ARRAY of DETECTORS for SYNCHROTRON RADIATION APPLICATIONS

Goal: Development of a versatile X-ray detector based on arrays of Silicon Drift Detectors and low-noise electronics for synchrotron applications

The ARDESIA collaboration

- Politecnico and INFN-Milano, Italy
- INFN-LNF, Frascati, Italy
- TIFPA, Trento, Italy

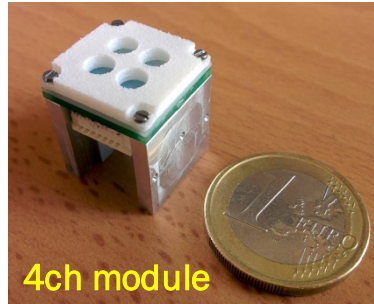
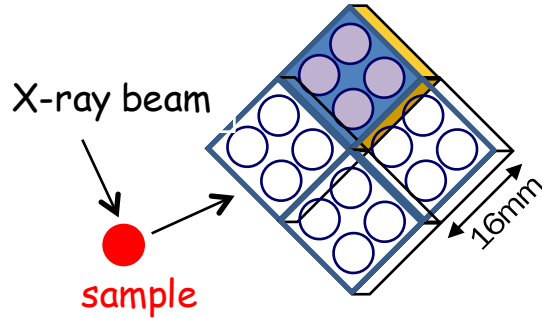
2016

- experimentation of the first detection module (4 channels) with electronics (ASIC and DPP) in laboratory tests
- design and construction of the first complete X-ray spectrometer
- first tests at synchrotron
- start of the design of a second version of the readout ASIC optimized for high-rate spectroscopy measurements

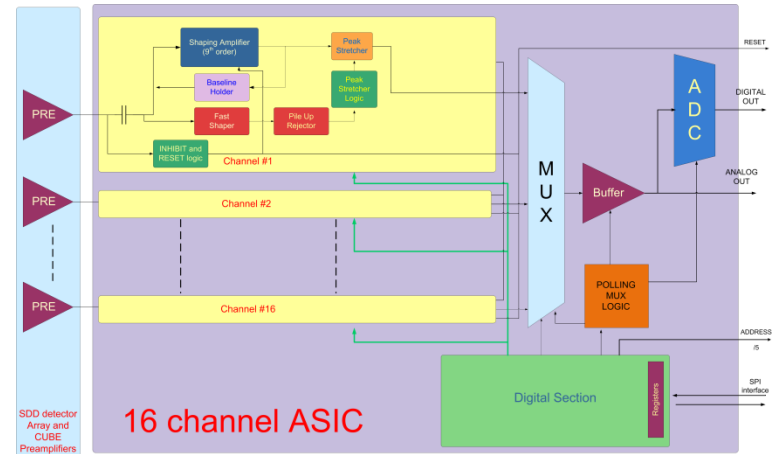
2017

- new production of SDDs (with thicker silicon, 800um)
- production of the second version of the readout ASIC
- continuation of the tests in laboratory and with synchrotron light

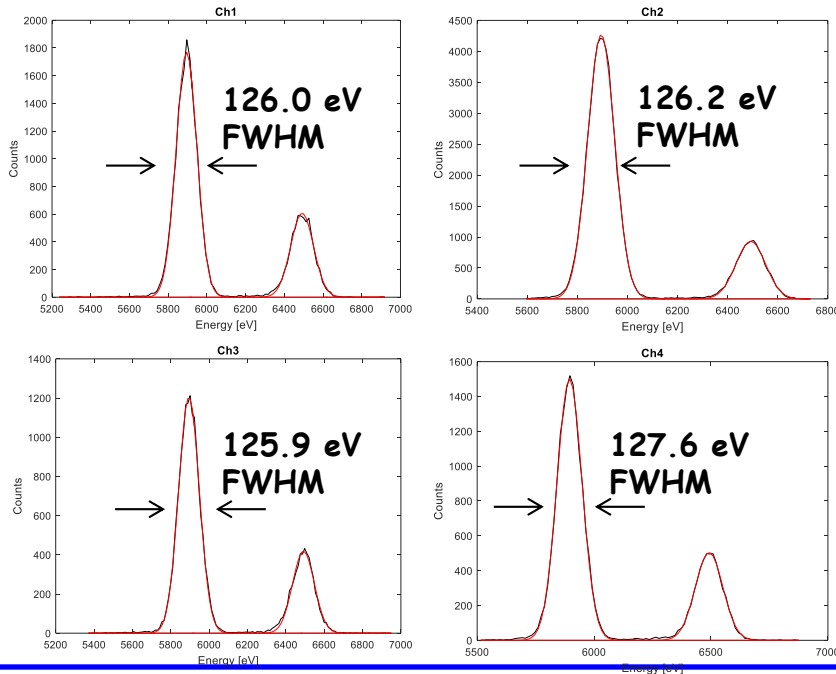
First ARDESIA detection module (4 channels)



*assembled and tested
also with the ASIC*

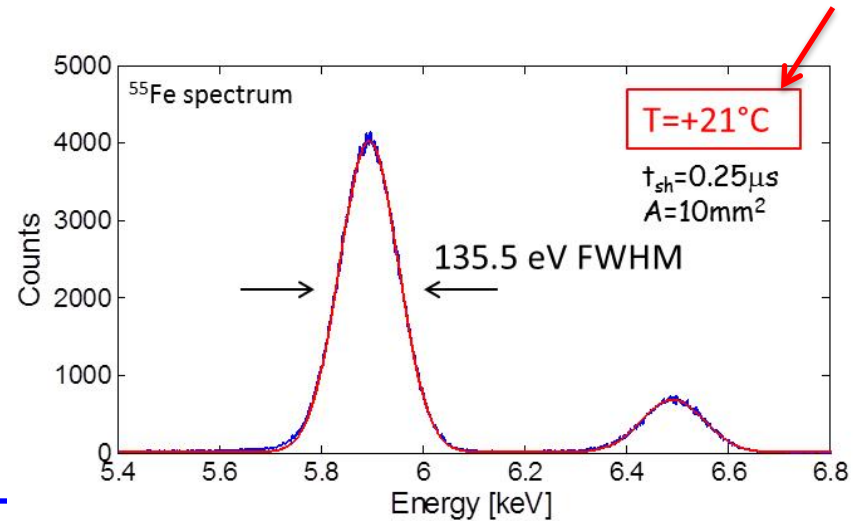


first ^{55}Fe spectra



4×25mm² area, 1.6 μs peaking time, T=-29°C

*also excellent resolution measured
with a test SDD (10mm²) at room T*



- **INFN-Milano (Carlo Fiorini, Resp.Naz.)**

Ruoli e compiti: modulo di rivelazione, elettronica integrata, cooperazione allo sviluppo del DAQ, supporto alla sperimentazione nelle applicazioni, misure di spettroscopia e supervisione del disegno e della produzione di matrici di rivelatori Silicon Drift Detectors.

- **INFN-LNF (Antonella Balerna, Resp. Locale).**

Questa unità comprende : DAFNE-Luce

Ruoli e compiti: contributo alla realizzazione del rivelatore parte vuoto e maschere, sperimentazione rivelatori per spettroscopia X (bassa temperatura, stabilità linearità, bassa radioattività, ecc.), installazione di moduli di rivelazione presso le linee di luce di sincrotrone DXR1 (LNF) e GILDA (ESRF) e conduzione di esperimenti di caratterizzazione.

- **INFN-TIPFA (Nicola Zorzi, Resp. Locale)**

Ruoli e compiti: produzione delle matrici di rivelatori Silicon Drift Detectors presso FBK a Trento.

Partecipazione Milano nel 2017

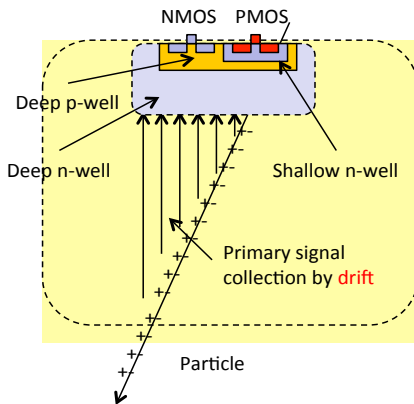
C.Fiorini (PO)	60%
D.Giove (INFN)	20%
M.Carminati (RTD)	40%
A.Grande (Dott.)	100%
G.Bellotti (Dott.)	100%
A.Amirkhani (Dott.)	100%
TOT.	4.2FTE

Richiesta INFN-MI 2017

Consumo	50k
Inventario	5k
Missioni	8k
TOT	63k

Servizio elettronica: assemblaggio bonding 5 moduli ARDESIA (mesi uomo:TBD)
Officina INFN: costruzione strumento (1mese/uomo)

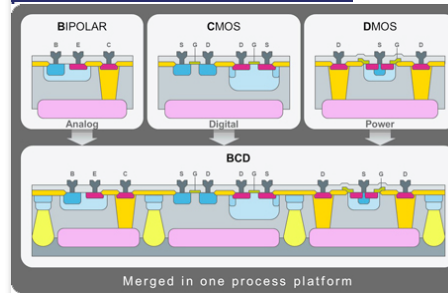
HVR_CCPD: attività finora svolta



CMOS sensor with depletion layer: an attractive solution for tracking in the HL-LHC upgrade

- High-Voltage for depletion
- High-Resistivity substrate
- Charge collection by drift instead of diffusion:
 - faster response
 - radiation hardness

BCD8 technology

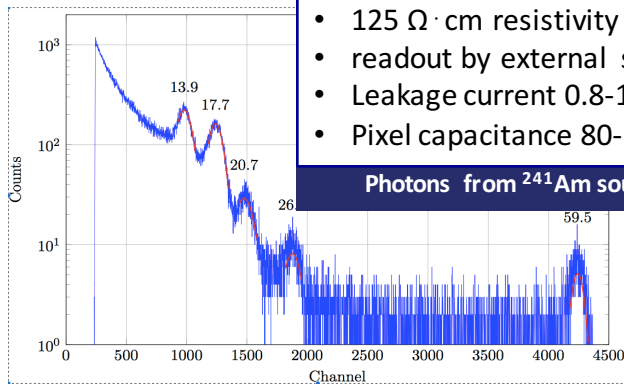


- availability of different devices integrated in the same process
- **epitaxial process:** can grow on different substrates.
- possible to reach thick depletion layers ($\sim 30 \mu\text{m}$)
- **long-term availability:** one of the major ST production lines

Sensor characterization

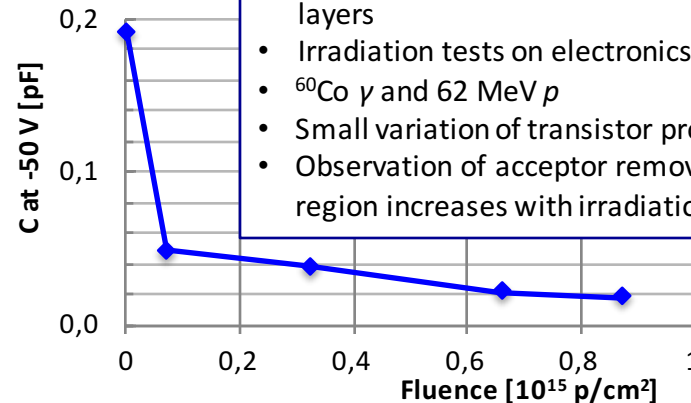
- Performance of $50 \times 250 \mu\text{m}^2$ pixel
- $125 \Omega \cdot \text{cm}$ resistivity substrate
- readout by external spectroscopy chain
- Leakage current $0.8\text{-}1.4 \text{ pA/pixel}$
- Pixel capacitance $80\text{-}90 \text{ fF}$ at 50 V

Photons from ^{241}Am source (energies in keV)



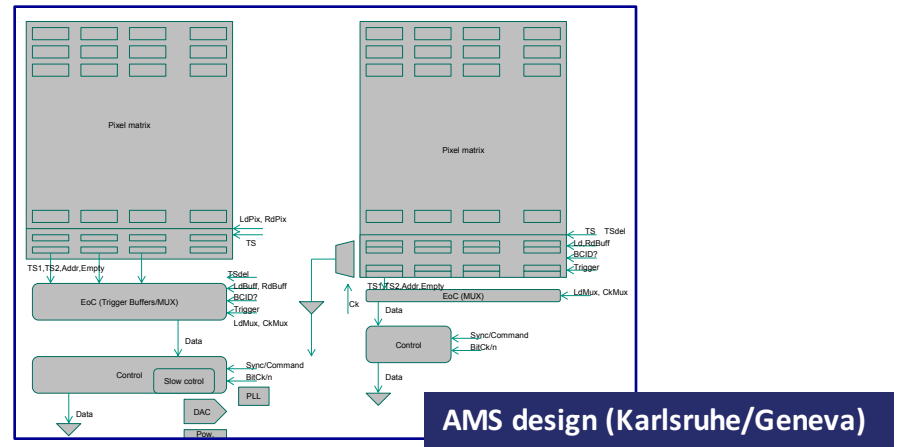
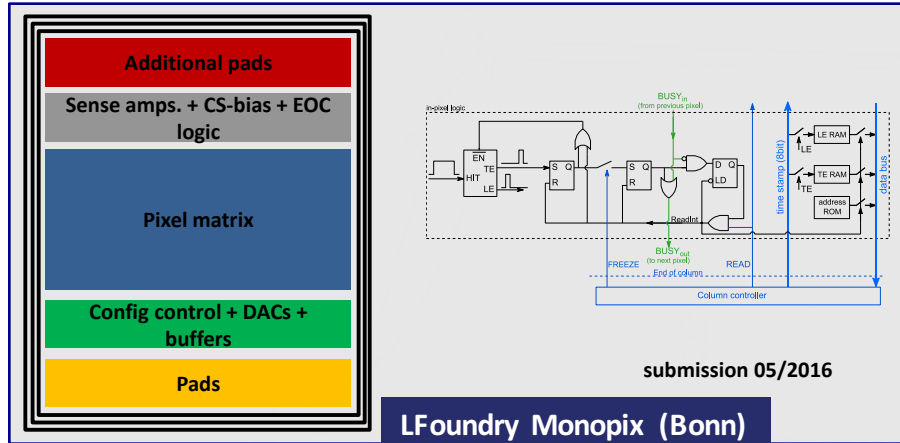
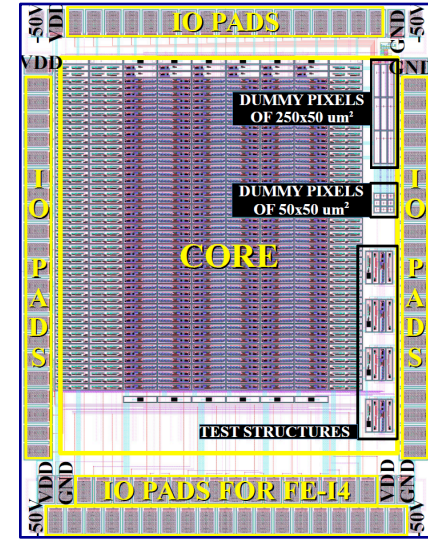
Radiation hardness

- Requirements for HL-LHC applications are 0.1 Grad dose, $10^{15} \text{ n}_{\text{eq}}/\text{cm}^2$ NIEL for outer pixel layers
- Irradiation tests on electronics and sensors
- ^{60}Co γ and $62 \text{ MeV } p$
- Small variation of transistor properties
- Observation of acceptor removal: depleted region increases with irradiation.



HVR_CCPD: piani per il 2017

- Caratterizzazione di matrice con amplificatori integrati:
 - sottomessa giugno 2016
- Partecipazione allo sviluppo di rivelatori completamente monolitici
 - Coinvolti altri gruppi (di origine ATLAS)
 - Probabilmente con LFoundry o AMS



HVR_CCPD: anagrafica e richieste

- **Manpower:** invariato rispetto al 2016:

Attilio Andreazza	Prof. Associato	30%
Valentino Liberali	Prof. Associato	20%
Chiara Meroni	Dirigente di ricerca	30%
Francesco Ragusa	Prof. Ordinario	30%
Mauro Citterio	Dirigente tecnologo	10%

- **Richieste** schede di test
- **Richieste finanziarie** non ancora inserite nel DB
 - in linea con il piano presentato all'inizio del progetto
 - 70 kEur di consumi (contributo ai run di fonderia)
 - 10 kEur di consumi (sistemi e schede di test)
 - 1 kEur di missioni (contatti con i gruppi di Genova e bologna)

SL-Exin: anagrafica

	SL-Exin
C. Curatolo	20
V. Petrillo	10
M. Rossetti	40
A. R. Rossi	30
L. Serafini	10 (RN)
FTE	1.1

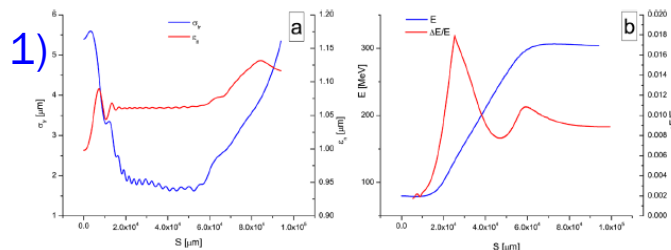
SL-Exin: stato

Parte teorica:

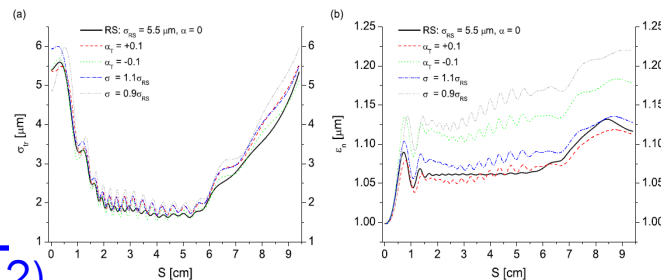
- Individuato un punto di lavoro promettente con beam loading assisted matching¹.
- E' stata studiata la stabilità del punto di lavoro rispetto a variazioni nelle proprietà del fascio².
- Ulteriori ottimizzazioni sono possibili per ridurre ulteriormente l'energy spread e preservare ulteriormente l'emittanza.
- Si sono condotti studi sulla radiazione di betatrone, prodotta durante l'accelerazione, come mezzo di diagnostica del fascio³.
- E' stato simulato un nuovo fascio con parametri più calzanti per l'iniezione.

Plasma Phys. Control. Fusion 58 (2016) 034001

P Tomassini and A R Rossi



A.R. Rossi et al. / Nuclear Instruments and Methods in Physics Research A 829 (2016) 67–72



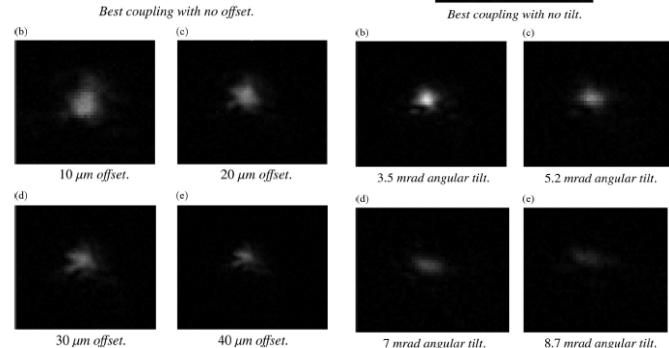
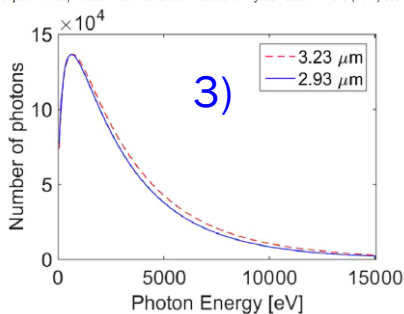
Parte sperimentale:

- E' stato deciso di utilizzare la stessa camera di interazione e la stessa linea di fascio per Exin e per l'esperimento di Thomson backscattering. Questo permette di velocizzare i tempi di commissioning per entrambi gli esperimenti.
- La camera di interazione è terminata nella parte di focalizzazione del laser. La condivisione con SL-Thomson ha richiesto la modifica della parte contenente il capillare e sta per andare in produzione
- Il laser FLAME è stato ottimizzato sia nella generazione dell'impulso laser che nel trasporto verso il bunker di SPARC.
- Sono stati condotti studi preliminari sul guiding del laser nel capillare⁴.

EG. Bisesto et al. / Nuclear Instruments and Methods in Physics Research A 829 (2016) 309–313



V. Shpakov et al. / Nuclear Instruments and Methods in Physics Research A 829 (2016) 330–333



SL-Exin: attività 2017

Molto dipende dalla disponibilità di fascio a SPARC. Entro il 2016 la camera di interazione sarà completamente installata, salvo imprevisti e compatibilmente con la schedula di SPARC. Programma tentativo 2017:

- Commissioning linea di trasporto elettroni e camera di interazione.
- Commissioning linea di trasporto fotoni e final focusing.
- Accoppiamento di elettroni e laser con il capillare e cross-check della diagnostica.
- Accelerazione: in regime lineare.
- Accelerazione: in regime quasi-lineare con particolare riguardo alle condizioni di matching (?).

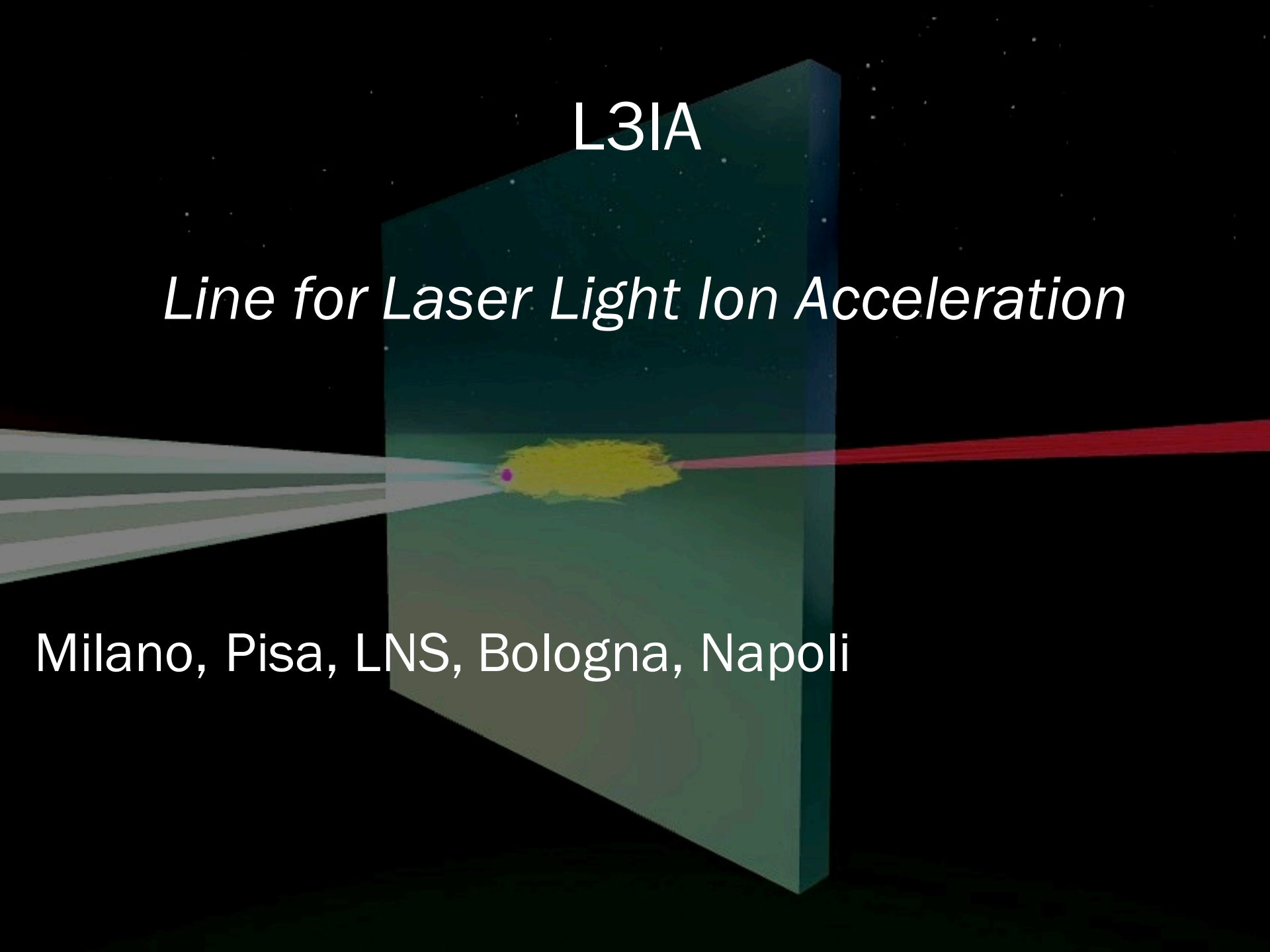
Richieste

Missioni: 3 k€

L3IA

Line for Laser Light Ion Acceleration

Milano, Pisa, LNS, Bologna, Napoli



Objectives of L3IA

Build a laser-accelerated beamline for light ions:

- Develop ion acceleration with ultraintense lasers;
 - Test advanced targets for control of energy spectrum and beam collimation;
 - Establish a proton beam line for detector development;
 - Provide a dedicated test beamline for ELI (e.g. ELImed@LNS)
 - A platform for radiobiology studies towards radiotherapy with laser accelerated ions
-

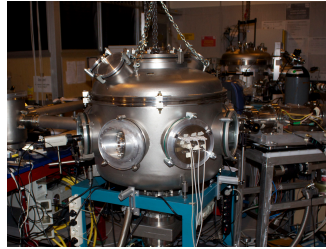
Activity 2016

- Experimental programme with existing laser facility (ILIL) at moderate laser power (10TW)
 - Detector development specific for laser-driven ions (broad spectrum, EMP ...)
 - Laser upgrade to 100 TW (250 TW);
 - Design and construction of final acceleration line@ILIL-PW
-

2016 activity (ILIL, Pisa)

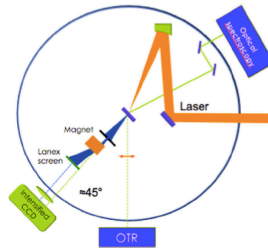
Since October 2014 the experimental chamber "Pavone" @ILIL is operational for laser-solid interaction, dedicated to:

1. TNSA acceleration of light ions;
2. Fast electron transport;
3. Shock generation in nanoengineered target;
4. X-ray generation and applications

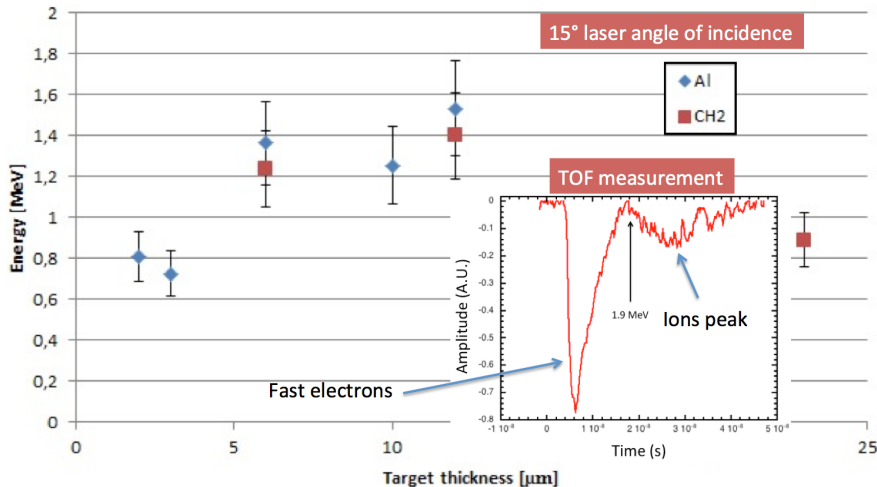


2016 experimental runs dedicated to:

1. Optimization of focusing and target control;
2. Identification of the interaction regime;
3. Thomson-parabola measurements;
4. Solid state detectors;
5. RCF and CR39 measurements

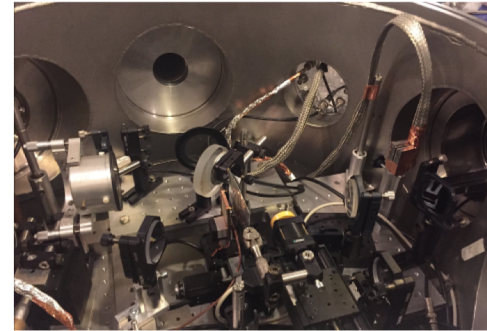


Summary of data 2015-16: max ion energy vs. target thickness



Recent progress

Evidence from numerical simulations (Bologna) for enhanced proton energy at 30° incidence angle

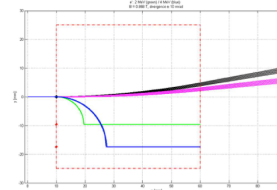


Experimental run 15.6.2016

- Remake ground reference cabling, detector shielding and double shielded signal cables
- Added permanent magnet (0.858 Tesla) 30 mm from the target to remove electrons
- Time of flight measure (distance 330 mm)

Clean TOF measurements

Fast electron signal and EMP noise reduced



30° laser angle of incidence
Evidence of >50% increase in max. ion energy

With magnet

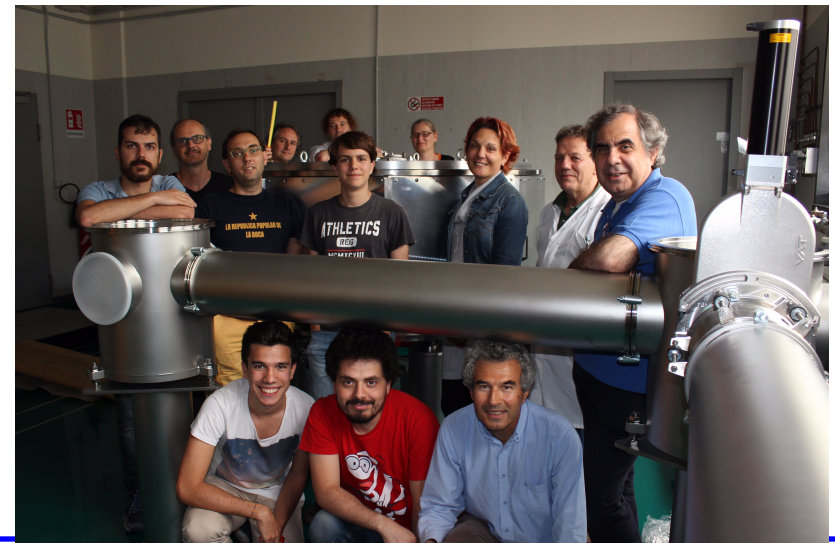
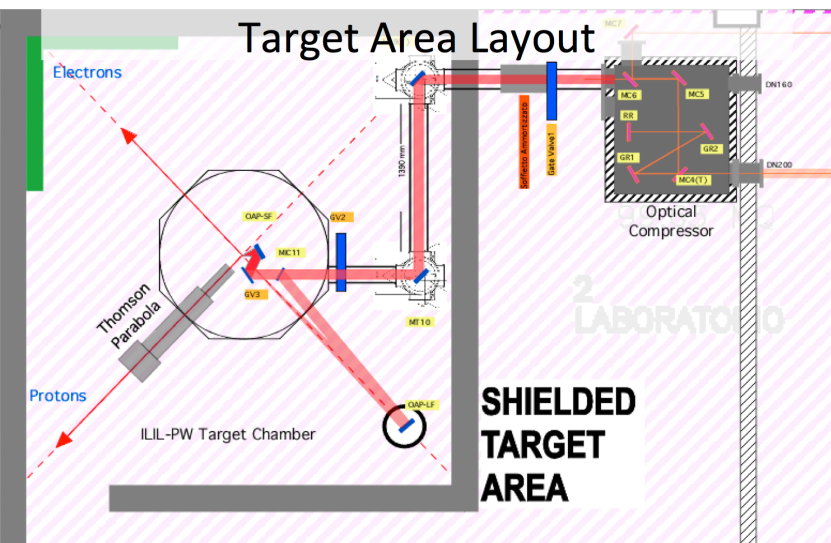


Without magnet



- S/N increased of a factor 10 !
- Completely removed the prompt signal in the TOF collected spectra (diamond detector)
- Proton energies close to 3 MeV





2017 activities

- Complete laser and target area control systems at > 100 TW power
- Laser temporal contrast diagnostic
- Design of the optics for double plasma mirror
- Test experiments to demonstrate control over laser beam compression and focusing
- Establish ion beamline at >7 MeV
- Gradually transfer experimental activities to the new interaction chamber
- Analysis and test of new targets configurations
- Quadrupole based tests on the ion beamline

Richiesta finanziaria complessiva 2017: 396 Keuro
Richiesta Milano 2017: 210 Keuro

Da confermare

Anagrafica Milano:

Dario Giove	40	
Carlo De Martinis	retired	
Alberto Fazzi	30	
Agosteo Stefano	20	
Giancarlo Maero	20	
Massimiliano Romè		20
Giuseppe Gorini	20	
Matteo Passoni	20	

XPLORE – Xray Production with Lasers and Optical Resonators

CALL Proposal

INFN-Mi

INFN-Pisa

CNR-Pisa-Florence

INFN-LNF-Cosenza

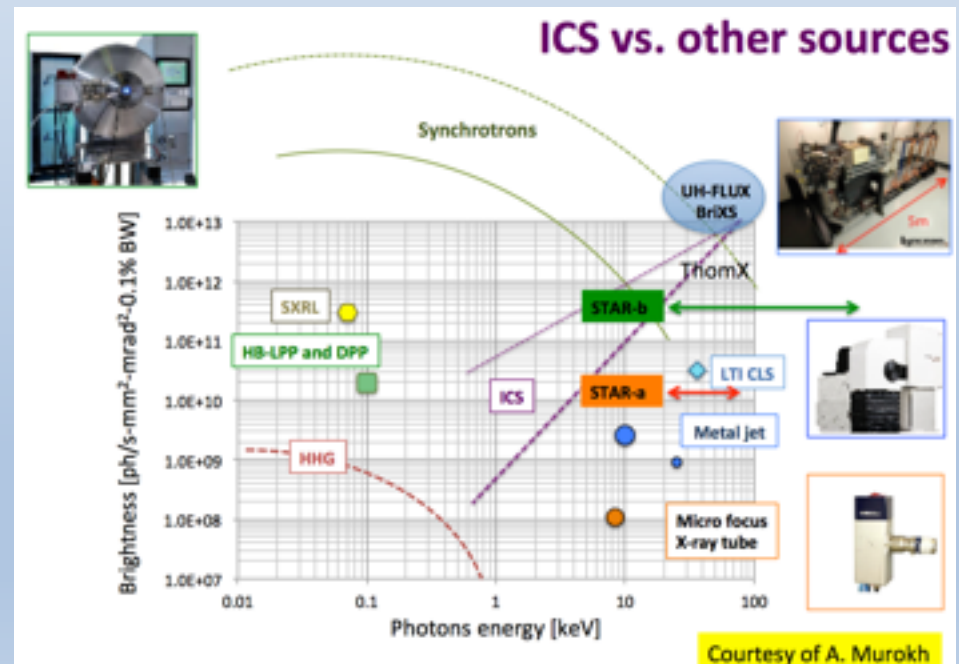
Responsabile nazionale : Dario Giove (INFN-Mi)

The proposal aims to acquire the know how necessary for the realization of the laser source and of the electron-photon interaction stage of an Inverse Compton Source and to build a prototype of the system. Such a know how is mainly related to the following areas of expertise:

- a laser source with suitable parameters (pulse energy, repetition rate, beam quality, stability, noise);
 - a Fabry-Perot cavity for the resonant enhancement of the peak intensity, with a very high finesse (of the order of 1000)
 - a resonance locking system between the FP and the laser system
 - a Compton interaction section between the optical field stored in the cavity and the electron beam.
-

In the last years an interesting scientific discussion has arisen about the development of compact machines to produce beams of **high brilliance mono-chromatic tunable X-rays with energy in the range from 30 to 150 keV** with performances comparable to those of modern synchrotron light sources, although associated to costs and dimensions smaller by at least one order of magnitude (from **100x100 m² down to 10x10 m²**, and from 100s M€ down to 10s M€), so to be compatible with locations inside a University Campus, a large Hospital, a Museum or a mid-size research infrastructure.

The focus on enabled applications by such a machine is on **medical oriented research/investigations**, mainly in the radio-diagnostics and radio-therapy fields, exploiting the unique features of mono-chromatic X-rays, as well as in **micro-biological studies**, and, within this mainstream, **material studies**, **crystallography** and **museology for cultural heritage investigations**. Mono-chromatic bright X-ray beams have been already proven to be a unique tool for advanced imaging at the sub 0.1 mm resolution scale with tremendous reduction in the radiation dose to tissues, joined to an upgraded signal-to-noise and visibility enhancement via phase contrast imaging.

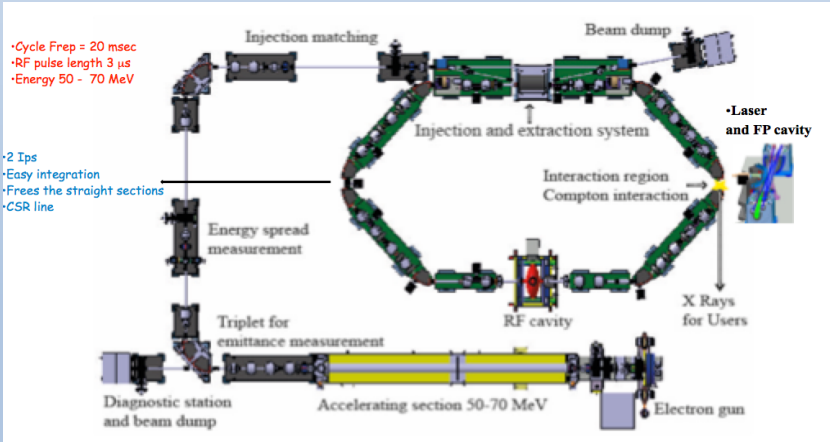


In order to achieve the X-ray photon fluencies required for the applications described in the introduction, the weak Thomson cross section makes it necessary to use very high photon fluxes.

With current technologies, it is possible to produce picoseconds pulses with tens of Joules of pulse energy, but in these high pulse energy systems the repetition rates are limited to few Hz, due to technological limitations in the pumping system. Therefore these systems are clearly incompatible with the repetition rates of electrons.

In order to significantly improve the repetition rate of the laser, while keeping adequate pulse energies, we propose to develop an optical system based on a high finesse Fabry-Perot (FP) cavity injected by a high average power laser system. The pulses coming from the laser are stacked in the Fabry-Perot cavity achieving a passive gain in the cavity ranging from 1000 to 10000. Such an approach is very attractive since it requires a laser system delivering a limited (although relatively high) average power, of the order 100 W, with moderate pulse energy and high repetition rates. The signal is then boosted to the MW level within the passive cavity. This requires a high level of sophistication of all stages of the system.

In addition, the laser system together with the cavity must be coupled to the electron beam pipe, and thus require as much as possible compactness, stability and thermal control.

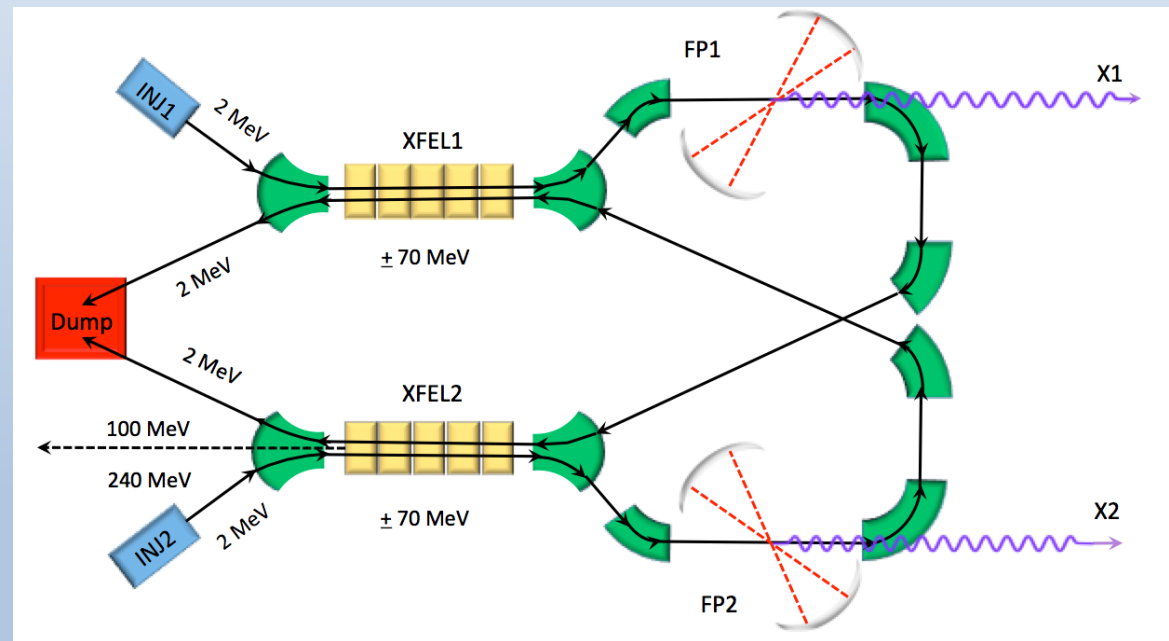


The THOMX layout
(Maximum achievable fluxes about $5 \cdot 10^{12}$. Maximum photon energy 90 keV)

A tentative conceptual lay-out for a compact machine has been recently described in the proposal for a Compact X ray Source named BriXS. BriXS may be as the one shown below. It is based on a Tigner-Variola *push-and-pull* 2-Linac ERL (Energy Recovery Linac) scheme, just wrapped on itself in order to halve the overall length of the machine.

In BriXS first phase there would be only one injector and one electron beam (max average current 1 mA), that would be accelerated into the first XFEL module (5 SC cavities operated at about 10 MV/m accelerating gradient, plus an initial matching section made of SC solenoids and bunching/matching short RF SC cavities). The second XFEL module would de-celerate the beam down to about 2 MeV energy so to lower the demands on the beam dump about the effective beam power (lower than 5 kW). Running at low beam currents (*i.e.* below 100 microA) the second XFEL module would instead accelerate the electron beam up to higher energies (in the range 100-240 MeV), so to drive experiments of radiation generated in crystals, micro-undulators, etc.

In BriXS second phase there would be a second injector delivering a second electron beam with same characteristics of average beam current and beam quality of the first one, so to drive a second Fabry-Perot optical cavity and a second independent X-ray beam-line. The two electron beams would then be re-combined at the exit of the 2 XFEL modules in such a way to counter-propagate inside the modules and compensate for the average beam current seen by cavities, hence the beam power transferred from-to the RF power sources.



Scientific Innovation and Interest for INFN

The development of a high flux Thomson X-ray Source like BriXS is not only strategic to serve high social impact applications in the medical diagnostics and therapy fields, via advanced X-ray beams, but also very synergic to the road pavement towards the high intensity frontier, which is part of the core mission of INFN.

The main lines of R&D which are crucial in this direction, and part of the BriXS machine development are:

- robust high quantum efficiency photocathodes
- photocathode drive laser systems for high average currents (10-100 mA)
- injector design and beam dynamics studies
- RF power for CW S.C. cavities
- optimization of proper RF frequency for stable operation of high intensity beams
- control and characterization of e-g collisions to generate X/g photon beams
- photon machines for Thomson/Compton Sources

Organization

Work Package	Leader	Unit
WP1: System design parameters and integration in a general scheme for an advanced compact X ray based facility	Serafini Luca	Milan-Cosenza
WP2: Numerical simulations	Alberto Bacci Andrea Rossi	Milan
WP3: Optical System	Toci Guido Cialdi Simone	Milan – Florence- Pisa
WP4: Digital Feedback System	Giove Dario Fazzi Alberto	Milan - Cosenza
WP5: International Collaborations	Labate Luca	Pisa
WP6: Project Management	Giove Dario	Milan

The optical package will include:

- laser oscillator optimization and characterization
- laser amplifier design and implementation
- Fabry-Perot cavity with related stabilization system design and implementation

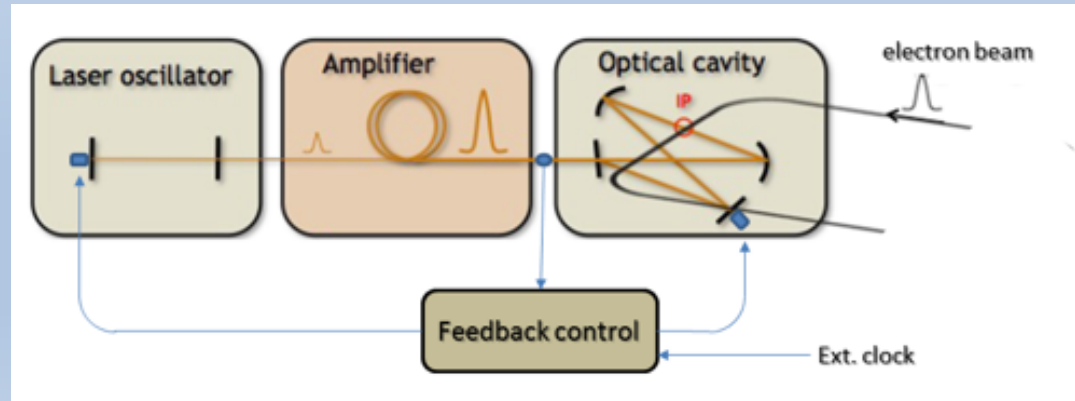
Target parameters for the laser

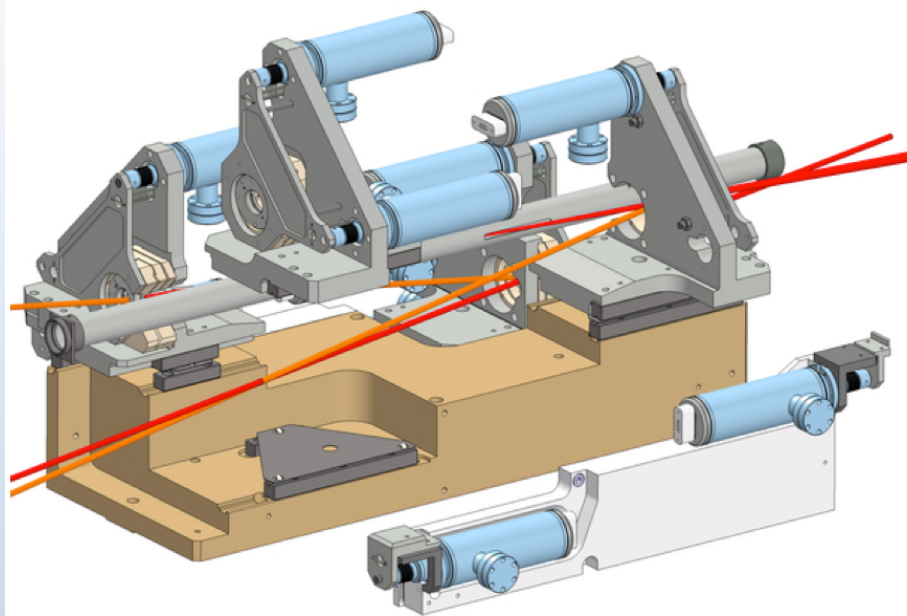
Wavelength: 1 micron

Pulse duration: few ps

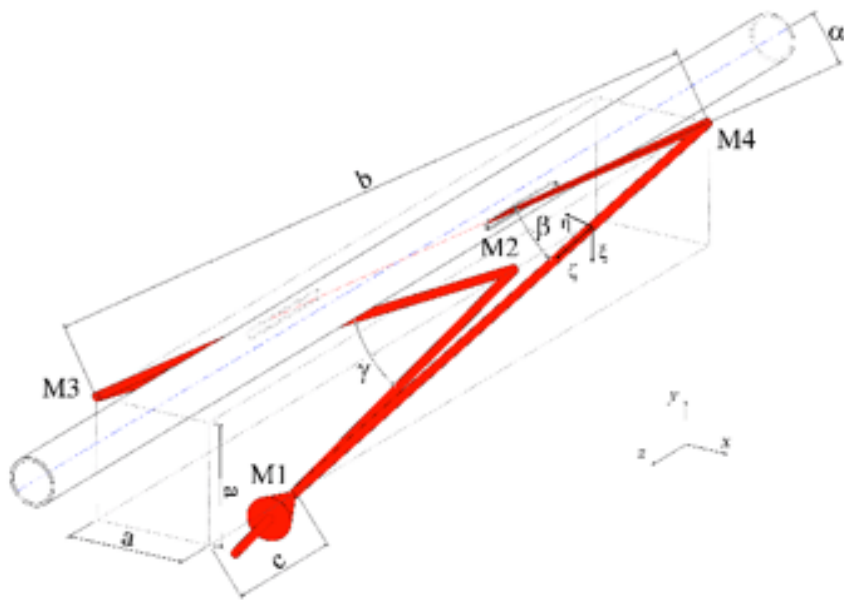
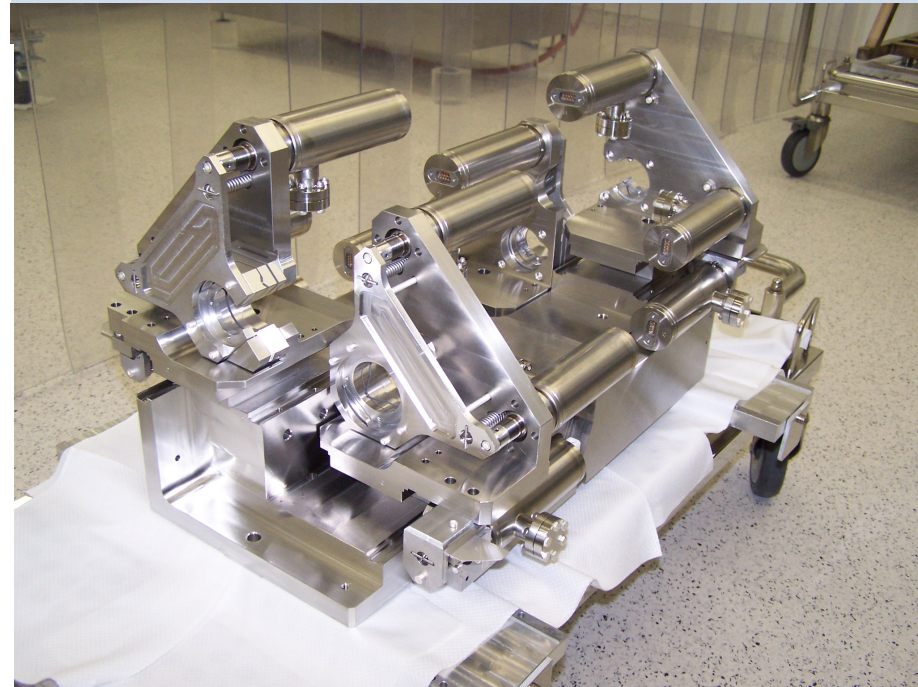
Rep. Rate: 100 MHz

Average power: 100 W

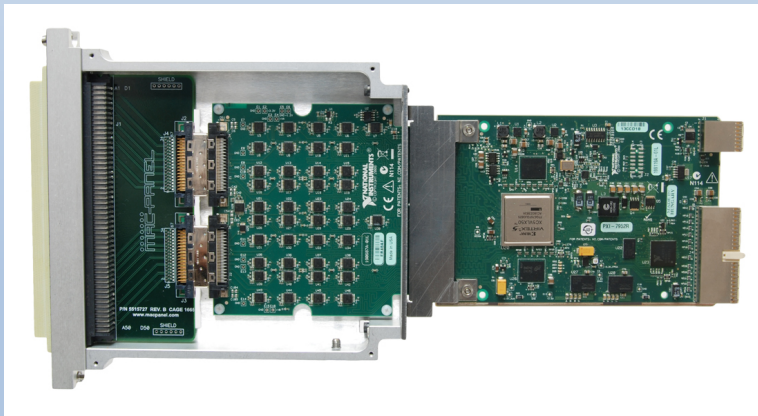
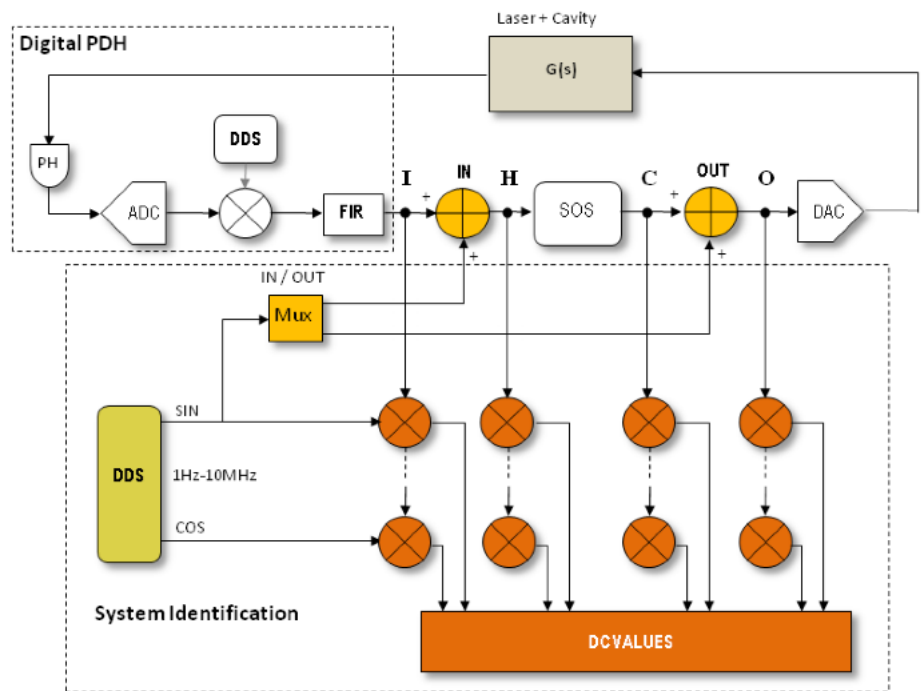
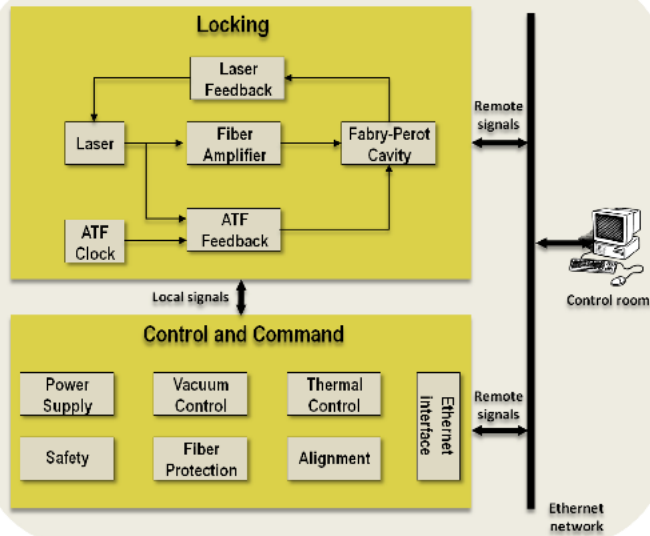




Fabry Perot Cavity (@THOMX)



Digital Feedback System



Giove Dario
Fazzi Alberto
Marco Potenza
Carlo De Martinis
Simone Cialdi
Matteo Paris
Fabrizio Castelli
Nicola Piovella
Stefano Olivares
Luca Serafini
Alberto Bacci
Francesco Broggi
Camilla Curatolo
Y. Drebot
Vittoria Petrillo
Ezio Puppini
M. Rossetti
Andrea Rossi
Verardo Torri

5.7 FTE su 12 FTE totali

Richiesta finanziaria complessiva su tre anni : 1 MEuro

Combining Hadron Therapy with Magnetic Hyperthermia: a New Tool for Pancreatic Cancer Treatment

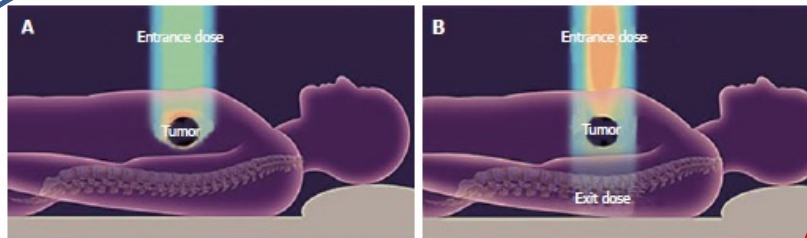
(HADROCOMBI) – 1 year feasibility study

Partecipanti - Unità di Milano-UNIMI e di Roma3 FTE

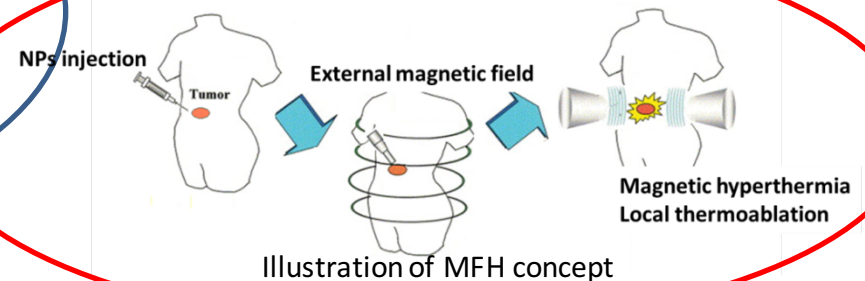
Alessandro Lascialfari – PO - UNIMI – responsabile	0.5
Daniela Bettega – PA – UNIMI	0.75
Flavia Groppi – PA – UNIMI	0.2
Cristina Lenardi – PA – UNIMI	0.2
Ivan Veronese – RI – UNIMI	0.6
Paola Calzolari – Tecnico – UNIMI	0.75
Miriam Lafiandra – PhD – UNIMI	0.75
Francesco Orsini – Tecnico – UNIMI	0.4
Giovanni Savini – PhD – UNIMI	0.2
Marco Cobianchi – PhD – UNIPV	0.2
Antonio Antoccia – PA – Roma 3	0.75
Antonella Sgura – Ric – Roma 3	0.75
Totale	6.05

Combining Hadron Therapy with Magnetic Hyperthermia: a New Tool , for Pancreatic Cancer Treatment

(HADROCOMBI)



(A) targeted proton therapy deposits most energy on target
(B) conventional radiation therapy deposits



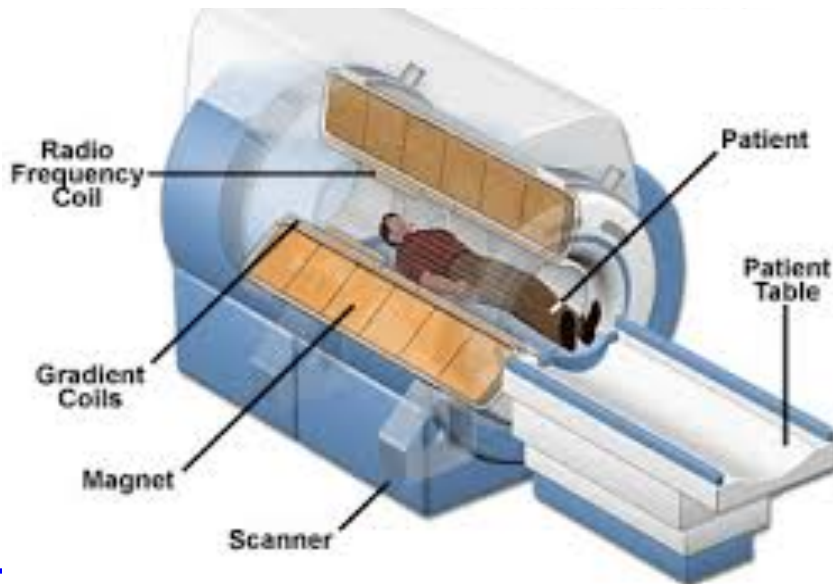
Hadron Therapy and Magnetic Hyperthermia are new and interesting treatments for cancers **where the “classical” therapies fail.**

The **goal of the project** is the investigation of the **possible combined action of the two therapeutic techniques**, for going one step beyond the state of art of pancreatic cancer therapy.

Magnetic Fluid Hyperthermia (MFH)

- * It refers to **local temperature rises**, usually to 40–45°C, rendering the **cells susceptible to various forms of damage** including apoptosis, leading to subsequent cell death.
- * **Other effects**: activation of immunological responses, enhancement of tumor blood flow and oxygenation via greater vascular perfusion and permeability.
- * A number of **therapeutic benefits** in producing **localized heating** (delivering toxic doses of thermal energy to tumors, or increasing the efficacy of anti-cancer drugs).

Magnetic Fluid Hyperthermia allows to strictly controlling the region under treatment by using **Magnetic Nanoparticles (MNPs) as heating elements**.



Used in clinics (Germany, USA)

Web-site : <http://www.magforce.de/en/home.html>

- **Heating** through application of **AC magnetic field** via activation of MNPs directly injected in the tumour mass at high doses (ca. 50 mg/cm³).
- Typically: $f \sim 100$ kHz, amplitude 10 kA/m.
- Minor side-effects

WORKPLAN

Materials:

- * The pancreatic tumor cells lines: PANC-1 and/or BxPC3
- * MNPs for MFH: maghemite ($\gamma\text{-Fe}_2\text{O}_3$) MNP of 16-20 nm, coated with a biocompatible organic moiety.

Three different modalities for each experiment:

- Irradiation alone;
- MNPs + irradiation;
- MNPs + irradiation + MFH.

Protocol for the in-vitro experiments:

- Incubation period of the cells with MNPS
- Irradiation treatment with Carbon Ions or protons at CNAO foundation (Pavia, Italy) and, for comparison, with photons at IRCCS - Istituto Nazionale dei Tumori (Milano), with the following dose-ranges: 0.5 - 4 Gy for Carbon ions; 0.5 - 5 Gy for protons; 0.5 – 7 Gy for photons.
- Following exposure to radiation, cells treatment with MFH (30 mins at 110 kHz, 10 kA/m)
- The treated cells will be followed as concerns viability and imaged. When possible, MNPs distribution and cellular uptake will be determined.
- The application of radiotracer techniques by using ^{59}Fe – radiolabelled FeONPs starting from $^{59}\text{FeCl}$, that will allow biokinetic and mechanistic studies to optimize :
 - a) the uptake, the bioavailability of MNPs in tumor target cells, the fate in the biological system;
 - b) the MNPs surface effects and the influence of the protein corona.

HADROCOMBI - Spese previste

- Materiale di consumo per coltura cellule e determinazione della sopravvivenza (linea cellule tumorali del pancreas da acquistare presso banca (US), terreni di coltura , siero fetale, reagenti , filtri per produzione acqua ultrapura, plastiche monouso per coltura cellulare (flasks , pipette), puntali per determinazione densità cellulare alla semina 10 k €
- Per esperimenti MFH : Materiale criogenico, gas (azoto, elio), materiale elettronico, schede/moduli elettronici, vetreria, materiale elettrico (bobine, condensatori) 6 k €
- Reagenti chimici per cell staining e essiccamento (viability test, functional tests, etc.), materiale per microscopia confocale e SEM, target metallici per SEM (4), analisi ICP-MS (1) 5 k €
- Irraggiamenti presso il LENA (Reattore di PV) per la parte dei radiotraccianti (1), preparazione di nanoparticelle FeO arricchite isotopicamente in ^{57}Fe o ^{58}Fe (0.5), Trasporti radioattivi Pv-LASA (0.5) 2 k €
- Reagenti chimici, liquidi e gas criogenici, per preparazione nanoparticelle magnetiche (in collaborazione con UNIFI e CNR-ICCOM-Firenze) 7 k €
- Unità Roma3 : Materiale di consumo per colture cellulari, terreni, sieri, plasticheria, anticorpi per danno al DNA in immunofluorescenza: gamma-H2AX, 53BP1, reagenti per apoptosi e citotossicità MTT 5 k€
- Missioni Unità MI 6 k €
- Missioni Unità Roma3 3 k €

TOTALE

(36 Unità MI + 6 Unità Roma3) 44 kEuro

INFN Call CSNV 2016



Modeling and **Ve**rification for **I**on beam **T**reatment planning

National Coordinator: Emanuele Scifoni, TIFPA-INFN

Development of innovative **Models** for biologically optimized treatment planning with ion beams and dedicated **Verification devices** for experimental tests in 3 INFN accelerator facilities

Radiobiological implementation in ion TPS of nuclear interactions (**FOOT experiment in CSN3**), intratumor heterogeneity, TCP and NTCP models, will be tested with newly patented tools for in-vitro and in-vivo irradiation, requiring development and update of the 3 complementary INFN accelerator **facilities** for pre-clinical verification

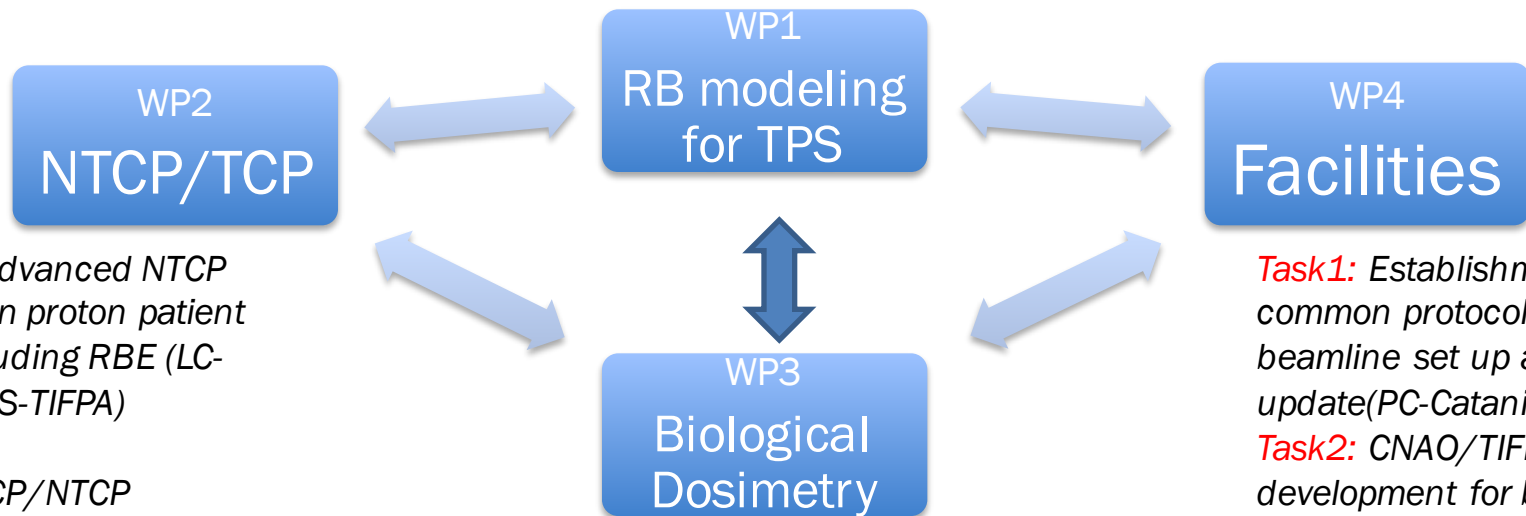
- ✓ Detectors development (including bio-radiation detectors)
- ✓ Accelerators beamline development
- ✓ Advanced Computation
- ✓ Interdisciplinary research for Medical Applications
- ✓ IT output beyond scientific publications: patents, infrastructures, a worldwide unique network of INFN irradiation facilities for TPS verification in hadrontherapy

WP Structure

Task1: RBE modeling for protons(FT – TIFPA)

Task2: OER and ITH modeling (ES- TIFPA)

Task3: Implementantion in RPlanIT (AA – TO)



Task1: Advanced NTCP models on proton patient data including RBE (LC-Napoli/MS-TIFPA)

Task2: TCP/NTCP including hypoxia for different ions (LC-Napoli/ES-TIFPA)

Task1: Development of specific devices for spatially resolved proton RBE measurement (WT-TIFPA/MGP-Napoli)

Task2: Hypoxic, Coculture and Stem cells devices (WT-TIFPA)

Task 3: In vivo and Molecular biomarkers (GR-Catania)

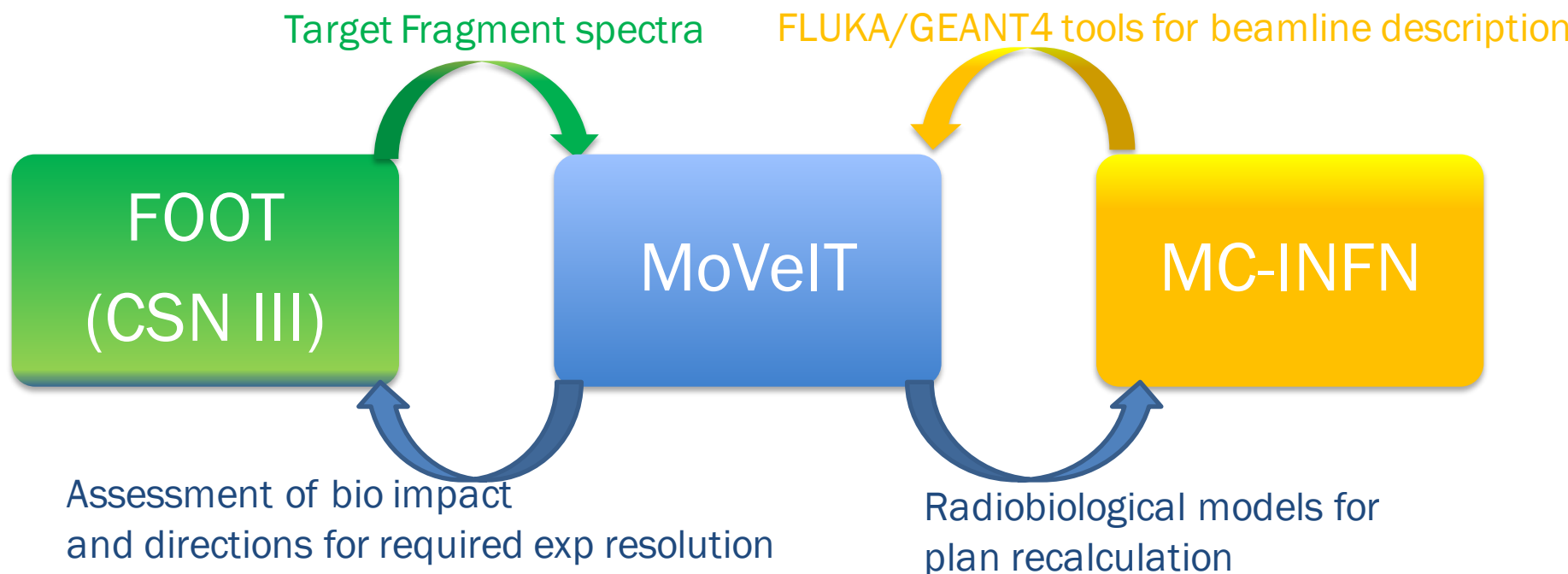
Task1: Establishment of common protocols for beamline set up and update(PC-Catania)

Task2: CNAO/TIFPA/LNS lines development for beam delivering and shaping (PC-Catania)

Task3: Monte Carlo Simulations for beamlines characterization and Target Stations for in vitro – in vivo experiments (PC-Catania/GB-Milano)

Task4: New developments in

Interaction with other INFN projects



Feed from previous related projects: TPS, RDH+IRPT, UFSD

Software and Verification tools:

TRiP98 – Treatment planning for Particles:

Clinical use in pilot project, Research use in GSI, HIT, Aarhus, Lyon etc.

Reference for: Siemens SynGo/PT, RaySearch

Rplanit:

Kernel: pure-DEK (Fork of PlanKIT, INFN developed code, scripting via “R” language)

From TPS and RDH experience

Specific tools for bio plan Experimental verification: Extended Heterogeneous target

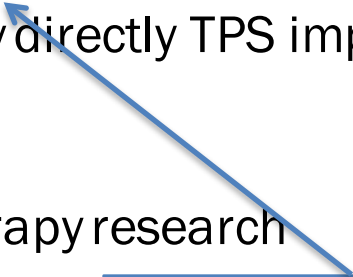
Development of experimental facilities at TIFPA, CNAO and LNS:

All INFN facilities linked to therapy centers, to apply directly TPS improvements

Complementary particles/Energy

Different stage of development at present

Generate a network of INFN facilities for hadrontherapy research



Specific involvement of Milano

INFN Team

- **TIFPA -Trento** (local coordinator: **E. Scifoni**, total ~6 FTE)
M. Durante, F. Tommasino, W. Tinganelli, M. Schwarz, A. Helm, M. Rovituso, S. Hild, C. Manea, P. Spinnato
- Radiobiological modeling for TPS, experimental device design and fabrication, proton beam irradiations
 - **LNS - Catania** (local coordinator: **P. Cirrone**, total ~6 FTE)
G. Cuttone, F. Romano, G. Russo, G. Forte, F. Cammarata, L. Minafra, V. Bravatà
- Low Energy facility, beamline development, MC GEANT4 tools, Radiobiology and Animal Facility
 - **INFN-TO** (local coordinator: **R. Sacchi**, total ~5.5 FTE)
R. Cirio, S. Giordanengo, A. Attili, F. Fausti, S. Giordanengo, L. Manganaro, V. Monaco, A. Staiano, A. Vignati
- Ultrafast Silicon Detectors, RPLANIT code
 - **INFN-NA** (local coordinator: **MG Pugliese**, total ~4 FTE)
L. Cella, P. Simoniello, M. Quarto, V. D'Avino, G. Palma
- NTCP modeling, in vivo irradiations, histology, in situ dosimetry
 - **INFN-MI** (local coordinator: **G. Battistoni** with **I. Mattei, S. Muraro** total ~1.5 FTE
including request of 1 AR)
- Supervision of CNAO Exp facility, FLUKA support
-

National and International Partners

GSI – Darmstadt (Germany)

M. Kraemer, M. Scholz

TRiP98 and LEMIV support

UT Southwestern– Dallas (USA)

H. Choy, M. Story

Use of TPS verification devices

APSS- Trento

M. Amichetti, D. Amelio, M. Schwarz

Clinical support (patient selection and follow up for risk analysis)

UNI –Trento (Biotech, CIBIO)

A. Motta, W. Bonani, A. Bisio

Design and patent of advanced in vitro phantoms

CNAO - Pavia

M. Ciocca, S. Rossi, A. Mairani

Beamline specifics and component simulations

CNR-NA/Uni Parthenope

L. Cella, P. Simoniello

NTCP Modeling, in vivo analysis

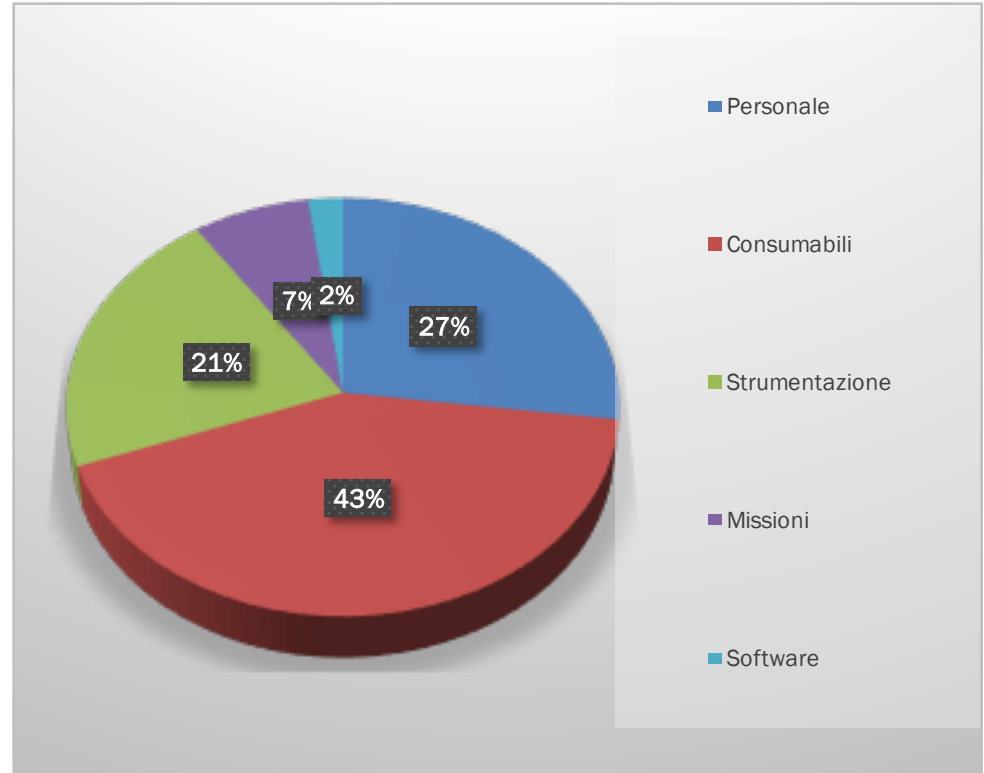
CNR-IBFM (Cefalu')

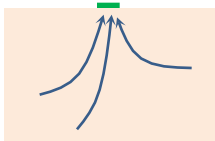
F. Cammarata, G. Russo, G. Forte

Molecular imaging and biomarker analysis

Total Budget

- Preliminary estimations based on initial partners requests:
- Total 945 kEUR in 3 Years:
Milano (3 years):
 - 10 kEuro Missioni
 - 6 kEuro Consumables
- Accounting for 3 total contracts
1 request for Mi
- Probably it will be shifted to increase Instrumentation less Consumables





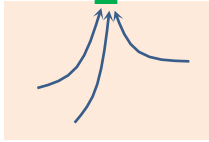
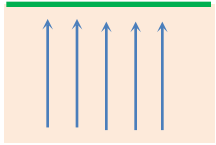
DESIGN (2016*-2018)

Innovative Drift topologiEs in thick Silicon or Germanium detectors for hard X- and gamma-ray spectroscopy

- Durata: 2016 (* in corso d'anno)-2018
- Partecipanti INFN:
 - INFN Milano, resp. locale e nazionale Andrea Castoldi
 - INFN Firenze, resp. locale Massimo Chiari
- Partecipanti esterni: FZ Julich, IEK, Halbleiterlabor (D)

Obiettivo dell'esperimento

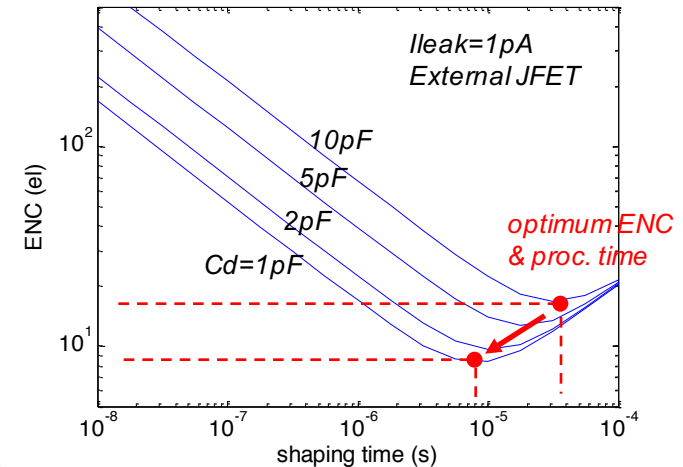
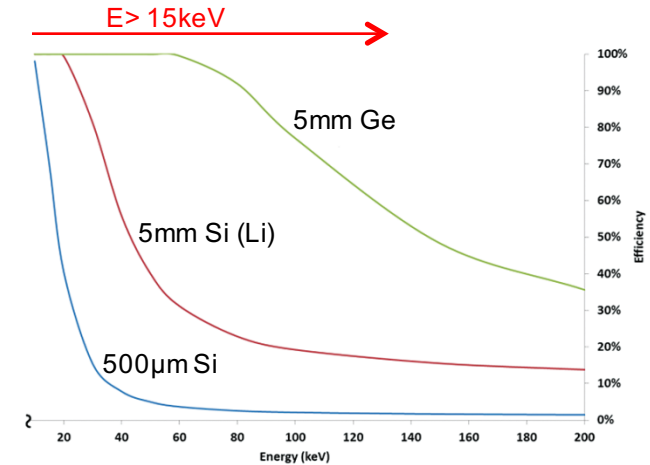
- Sviluppo di nuovi rivelatori in Germanio o Silicio ad alto spessore basati sul principio della deriva per migliorarne le prestazioni in un vasto campo di applicazioni
- Sviluppo di un modulo di rivelazione prototipale e qualificazione delle sue caratteristiche e potenzialita' nella spettroscopia X/gamma



From vertical diodes to drift topologies in thick detectors

Motivations

- In thin silicon technology (<1mm), **Silicon Drift detector is the leading detector** for high resolution/high speed X-ray spectroscopy in a large no. of appl. fields **but efficiency collapses above ~15keV**
 - **Drift topologies** to a point-like anode in **high-Z and/or high-thickness materials** will bring a number of advantages wrt vertical diodes:
 - Smaller cap, smaller noise (Equivalent Noise Charge)
 - Shorter optimum processing time / higher rate
 - Screening effect of the signal charge during the drift
- **Novel drift topologies in Ge and/or thick-Si will open to high energy resolution and fast processing times above the ~15 keV limit, as well as detectors with ultra-low energy threshold and high efficiency**



Scientific relevance/H2020

- ESRF meeting, Paris (2015)



- Round table on common goals/platforms for new detector developments (i.e. H2020) started.
- Ge Drift Detector explicitly mentioned in the summary document in the «wish-list» as one of the 3 main detector development lines to be addressed by the community for H2020

→ timely to start development to keep leadership, design&production should not be delayed

- Pete Siddons, Brookhaven Nat Lab



Prof. Andrea Castoldi,
Dip. Elettronica, Informazione e Bioingegneria
Ed. 24, Via Golgi 40
Politecnico Milano
20133 Milano
Italy

Dear Prof. Castoldi,

I was very interested to learn of your plans to develop a germanium drift detector based on the segmented detector technology at the Forschungszentrum in Jülich. The success of the silicon drift detector in x-ray science has been exceptional, having essentially replaced traditional germanium detectors in the field of x-ray fluorescence spectroscopy. However, such detectors based on silicon have one major disadvantage. The detection efficiency falls off dramatically as the x-ray energy exceeds 12keV. This greatly increases the difficulty of experiments on higher-Z materials such as the higher-Z transition elements, Lanthanides or Actinides. For these elements, one is forced to rely on the outer transitions, the L and M series, which are more complicated and subject to line overlap problems. A high-resolution, high-Z detector would be very attractive. Existing germanium detectors are simple diode structures, and suffer from all of the disadvantages of this structure, in particular the relatively high capacitance. It was to solve this problem that the drift detector concept was first introduced, and indeed it was first proposed as a germanium structure, as you know.

A recent European workshop on x-ray detectors for spectroscopy made mention several times of the benefits a germanium drift detector would provide, although to my knowledge no one has attempted to make such a device since the failed attempt by Rehak and Gatti in the 1980's (see for example the talk by Simonovic: <http://www.esrf.eu/files/live/sites/www/files/events/conferences/2015/ParisSpectroscopy/PDF/Simonovic.pdf>, and the workshop summary by Graafsma: <http://www.esrf.eu/files/live/sites/www/files/events/conferences/2015/ParisSpectroscopy/PDF/Graafsma.pdf>). The latter paper placed such a device near the top of the detector "wish-list" for future development.

I enthusiastically support this project, and am willing to help in any way you think appropriate.

Yours sincerely,

D. Peter Siddons
Detector Development Group Leader
Photon Sciences Division
NSLS-II

- Detector Development Group Leader di NSLS-II/BNL
- past-president della DAC (Detector Advisory Committee) di XFEL a Amburgo
- membro della DAC a SLAC

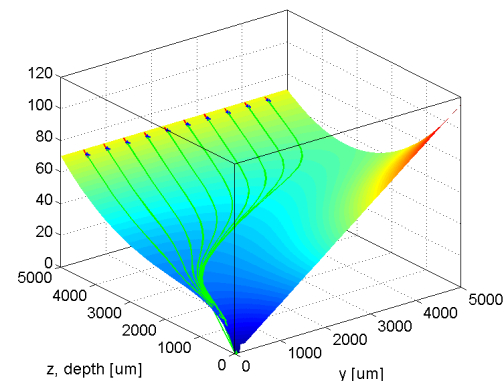
Letter of support that states importance and benefits of a Germanium Drift Detector and offers scientific collaboration

Programma attivita' scientifica

- INFN Milano
- INFN Firenze
- FZJ Julich

1 anno (2016)

- Ottimizzazione simulazioni topologie di rivelatori a drift Ge/Si(Li) -- in corso
- Ottimizzazione/test della tecnologia di produzione -- in corso
- Layout maschere 1° produzione -- iniziata
- 1° produzione rivelatori in Ge (prime strutture a drift, strutture di test)
- Definizione parametri di interesse sensore per applicazioni PIXE/PIGE
- Sviluppo elettronica di lettura basso rumore e polarizzazione



Ge drift detector simulation

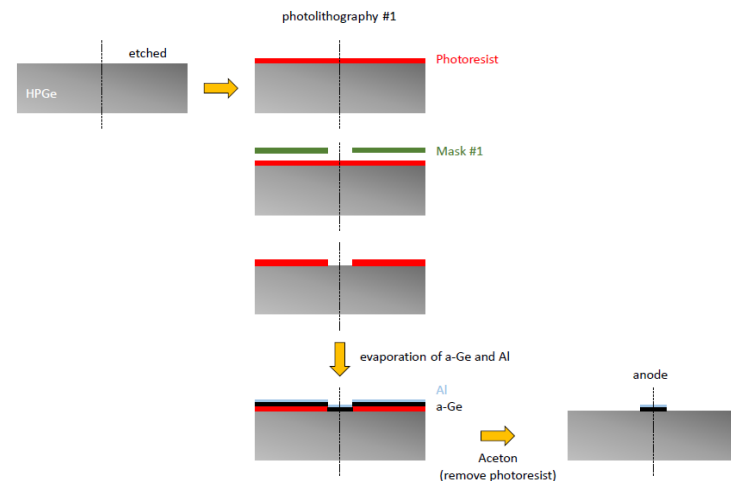
- Ge thickness 5mm @77K
- bulk doping $1e10 /cm^3$
- e+h collection time: 310 ns

2 anno (2017)

- Messa in opera camera a vuoto per test funzionali rivelatori con X/IR a Milano
- Caratterizzazione funzionale primi prototipi (1° produzione) in laboratorio
- Layout maschere e 2° produzione (topologie drift detectors)
- Caratterizzazione funzionale in laboratorio (2° produzione)
- Adattamento camera scattering sulla linea @LABEC e sistema raffreddamento
- Prove su fascio @LABEC per test PIXE/PIGE con primi rivelatori prototipali
- Progetto modulo di rivelazione stand-alone con sensore selezionato per test su fascio @LABEC

3 anno (2018)

- Layout maschere e 3° produzione finale (topologie ottimizzate, large-area)
- Ottimizzazione apparati sulla linea @LABEC per accoppiamento con modulo rivelazione stand alone
- Caratterizzazione funzionale prototipi finali in laboratorio
- Sviluppo/test in lab modulo di rivelazione stand-alone
- Prove su fascio @LABEC per test PIXE/PIGE con rivelatori ottimizzati/modulo stand-alone



Novel Ge technology effort

- Planar process in Ge
- Double-side process, p- and n-implants on same side)

Richieste 2017

INFN Milano (2017) – da finalizzare

▪ Missioni 4.0 kEuro

- Firenze (app. sp. e progetto riv.)
- Julich (ottimizz. tecnologia/layout)

▪ Consumo 24.5 kEuro

- 2a prod. rivelatori Ge (topologie a drift) – 12.5k
- Schede PCB per bias, elettronica – 4.0k
- Front-end (input JFET /CMOS, custom PA) – 4.0k
- Componenti elettronici – 3.0k
- Cavi/connettori/feedthru vuoto – 2.0k
- Accoppiamento dito freddo /finestra X – 4.0k

▪ Inventario 3.3 kEuro

- linear motion feedthru – 3.3 k

• Officina meccanica Sez Milano

3-4 settimane per lavorazioni meccaniche per apparato sperim. vuoto

• Servizio Elettronica Sez Milano

3-4 settimane utilizzo camera pulita per test probe station rivelatori su wafer (senza operatore)

Anagrafica 2017

Andrea Castoldi, PO, 40%
Chiara Guazzoni, PA, 20%
Chang Liu, Dott., 30%
Stefano Maffessanti, AR, 50%

Proposal of a new Experiment

PLASMA4BEAM

Study of the physics and technology of ion sources and of neutron detectors relevant to fusion applications and to the transport of beams into collisional media

Durata esperimento	3 anni (2017-2019)
Sezioni partecipanti	LNL, LNF, MI, MIB, BA
Enti collaboranti	RFX, IGI-CNR, Nanotec/CNR
Responsabile Nazionale	M. Cavenago (LNL)

Workpackages

WP1) negative ion beam sources and intense beams for NBIs (neutral beam injectors) in fusion relevant devices;

WP2) manipulation of beams and plasmas in electromagnetic traps, with applications to beam cooling with buffer gases;

WP3) neutron detectors for fusion applications;

WP4) high intensity positive ion beam sources (resilience and extraction);

WP5) theoretical models and simulations of the beam-plasma or beam-gas interaction, and of the extraction of beams from a plasma.

Introduction

Basic ingredients:

- a) Plasmas: many particle systems; random and or collective motions due to applied and self- consistent fields; collisions important at low temperature.
- b) Beams: many particle systems, ordered motion due to applied and self-consistent fields; collisions usually not very important; manipulation mainly by electromagnetic fields.
- c) Beam optics: collisions typically neglected; self-fields iteratively adjusted; exploitation of invariants of motion from a Hamiltonian mechanics approach.

In practical applications, one is often interested to change the beam properties, e.g. by collisions with a gas or a plasma, under the influence of applied (RF-)electric and (static) magnetic fields. The work of Plasma4Beam is focused on three main applications:

(WP1,3) Production of H^- ions in a reduced-size model of a multi-aperture ion source relevant to fusion applications; ion source accessories and neutron detector relevant to fusion (NIO1, MITICA, ITER).

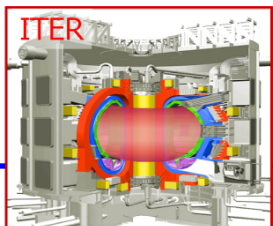
(WP2) Linear trap of particles interacting with a plasma or a gas as in a RFQC (relevant to SPES)

(WP4) Positive ion sources (H^+ , D^+) relevant to IFMIF and MUNES.

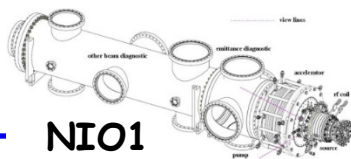
+

(WP5) Development of different tools (e.g. PIC codes) for the simulation of a beam/plasma system; improvements in the relevant theoretical modelling.

The experimental group and equipment is partly based on the previous activities Coolbeam and Beam4fusion [overall, about 50 ISI-indexed publications in the period 2013-2016; MI unit: about 20 pubs, 15 ISI-indexed].



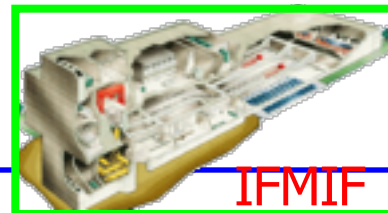
1-3 dpa/lifetime



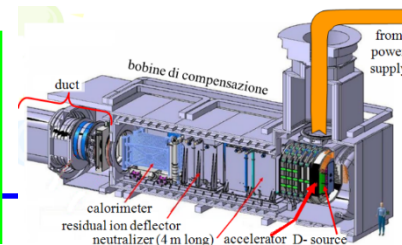
NIO1



RFQ cooler



IFMIF

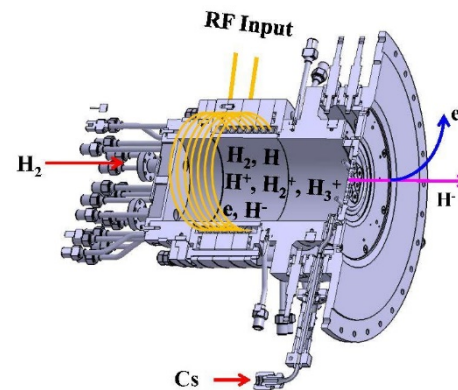
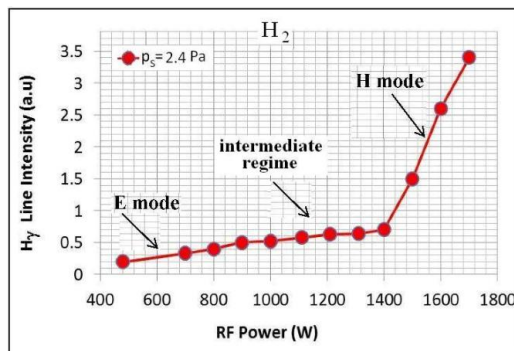


MITICA

WPs description

WP1

- 1) Increase of magnetic filter strength in NIO1, to reduce coextracted electrons (methods: external coils + PM stronger dipoles, 2017);
- 2) Mo cladding of bias plate (2017); upgrade and addition of new bias voltage capabilities (similar to bias disk and Simon effect in ECRIS);
- 3) development of hydrogen plasma online T_e measurement (base method: doping H_2 with Argon, 2017-2019);
- 4) improve rf window power rating (Pyrex 1200 W, alumina 1700W) and perhaps use Shapal to 2500 W (2017-2018);
- 5) clean and condition NIO1 source for minimum sputter; use liquid Cs traditional oven (now fully tested off-line);
- 6) support MetAlice operation at LNL, adding plasma T_e axial scan (2017-2018);
- 7) install the new EG in NIO1 (built by LNL) with new magnet (to be purchased by RFX, requires one month stop in early 2017);
- 8) conceptual development of an energy recovery system (BA, 2017, power electronics RFX); demonstration with an insulator on the existing calorimeter (2019);
- 9) develop improved Cs evaporator (2017-2019) with solid state feeds of interest for Demo (in synergy with Elise and Spider).



NIO1 source (Veltri et al , IPAB2016): luminosity jump for H_2 , cut view of source with ion species (Cs not yet applied)

WP2

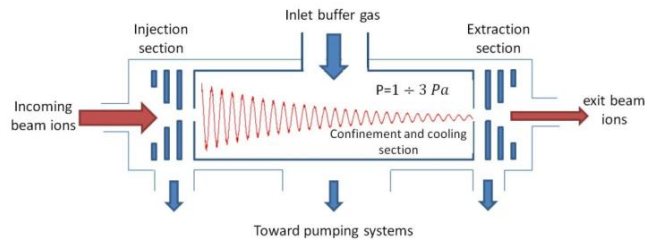
Assembly, installation and test of a RFQC in Eltrap [2017-2018]; beam transmission, capture and cooling in the RFQC [2018-2019] [a letter of interest by SPES has been requested].

Experimental study of the RF-production in an electromagnetic trap of plasmas with a partial degree of neutralization and analysis of their dynamics; applications to charged particle sources: extraction of continuous and pulsed beams (e⁻; ions) [2017-2019].

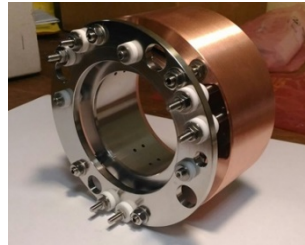
Theory and simulation of confinement, manipulation and control of ensembles of multi-species particle charges [2017-2019].

Design and installation of (DC and RF) quadrupolar electrodes for the beam optics [2017-2018].

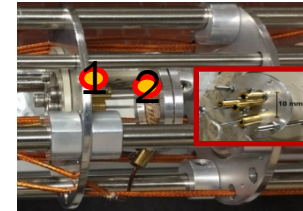
Development of charged particle sources (field emission cathodes, magnetic piston dispenser) [2017-2018].



RFQC scheme



Duel: Support for the thermionic emission sources



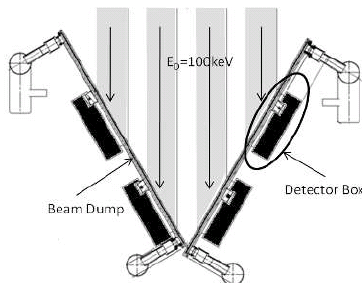
Duel field emission sources

WP3

a) nGEM measurements on SPIDER and MITICA (HD version with chip asic GEMINI, 2017-2018).

b) Measurements on SPIDER with a fast scintillator and n/gamma discrimination (2017-2019).

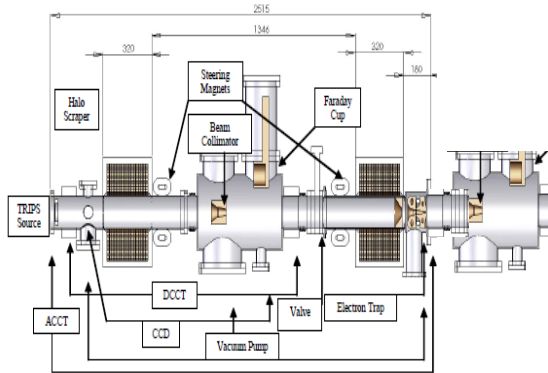
c) Monitoring of the X-rays emitted by a plasma with the use of a standard GEM and a GEMPix.



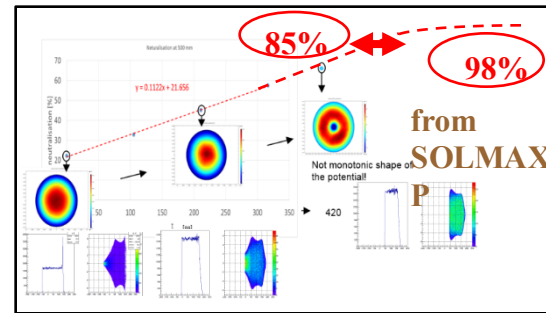
GEM in Spider

WP4

- a) upgrade of TRIPS beam diagnostics including: better Faraday cup (2017), relocation of the existing NIO1 Fast Emittance Scanner (from test-stand FE/SPES to TRIPS , 2017), procurement and installation of the FGA (2017-2018).
- b) Doppler shift spectrometer procurement (2017, in collaboration with IFMIF).
- c) Long run conditioning and operation of TRIPS (2017), effect of solenoid on proton fraction (2017-2018).
- d) Measurement on secondary plasma: commissioning of FGA (2018), systematic gas scan (2018-2019), systematic beam line scan (2019).
- e) Design (2017) procurement and repeated trials of electrode system, to reduce backstreaming, while preserving good beam optics (2018-2019).



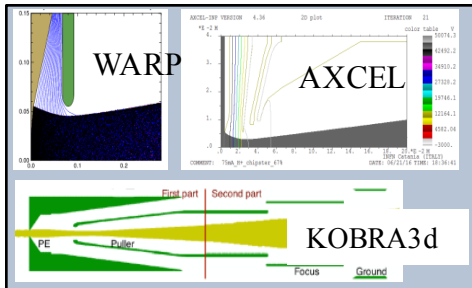
Overview of TRIPS installation



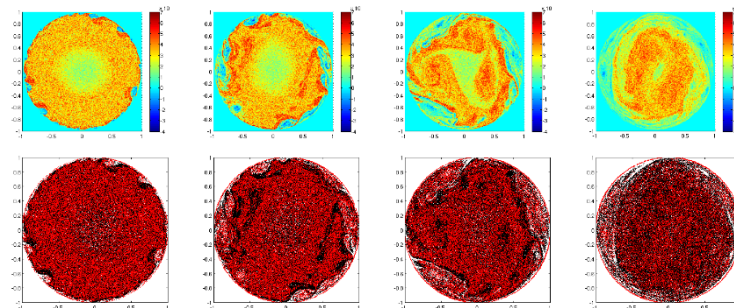
Space charge compensation for a positive beam. Measurement with four grid analyzer and simulations with SOLXMAP

WP5

Development of numerical tools for beam extraction and its interaction with a buffer gas



Simulation of the TRIPS extraction with several commercial codes



Models and Particle in cell studies of unneutralized plasmas

Anagrafica MI - 2017

Ricercatore	Qualifica	%
ROME' Massimiliano	RU Unimi	60
MAERO Giancarlo	RTD-B Unimi	60

WP1: tests on the emittance meter at LNL; participation to experiments on NIO1 [with LNL];

WP2: RFQC tests; RF plasma generation [with LNL];

WP5: Development of numerical tools for the simulation and theoretical modeling of the interaction of an ion beam with a buffer gas and of the beam extraction from plasmas [with LNL, LNF, BA]

Preventivo MI - 2017 (preliminary)

	ITEM	k€
Inventariabile	Pompa turbomolecolare 250 l/s e relativo controller per sistema di pompaggio differenziale RFQC	8.0
Consumo	Passanti HV per generatore RF (2.0); minuteria da vuoto ed elettrica (2.0); materiali semilavorati (2.0);	6.0
Missioni	Misure presso GSI (Darmstadt) per esperimenti di trasmissione, cattura, diagnostica di fasci di particelle cariche e collaborazione su codice PIC (2.5); missioni a LNL (1.5).	4.0
Manutenzione	Sistema raffreddamento magneti ELTRAP e DUEL.	3.0
	TOT MI	21.0

FTE complessivi: 13.8 (LNL: 6, 17p; LNF: 1.6, 4p; MI: 1.2, 2p; MIB: 3.4, 9p; BA: 1.6, 4p).

Richieste generali 2017: ca. 130 k€

TRACCIA

Time Resolved Aerosol Characterization: Challenging Improvements and Ambitions



Sezioni partecipanti:

Firenze (LABEC) - Resp. Naz.

Genova

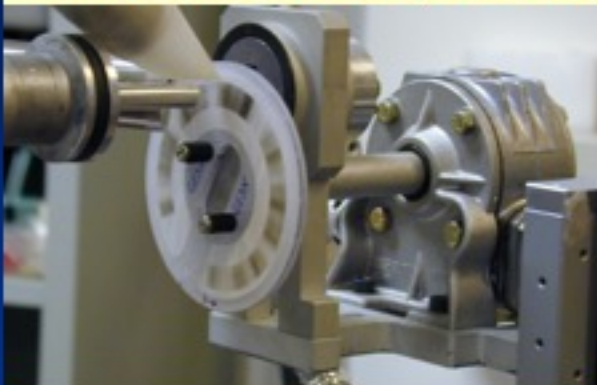
Milano

L'esperimento si inserisce nella linea di ricerca basata sull'uso di tecniche di analisi con fasci di ioni (e non solo !) per lo studio del particolato atmosferico (PM) che, nel corso del tempo, si è concretizzata nelle sigle di CSN5: *SCRIBA, MASAI, NUTELLA, NUMEN, MANIA, DEPOTMASS*.

Il gruppo di ricerca composto dalle 3 sezioni INFN di Firenze, Genova e Milano si è affermato come riferimento mondiale per le analisi composizionali ad alta risoluzione temporale (~ 1 ora) che, soprattutto in aree antropizzate, consentono di distinguere sorgenti intermittenti e processi atmosferici variabili nel tempo che sfuggono agli approcci tradizionali per il controllo della qualità dell'aria (che prescrivono campionamenti su base giornaliera).

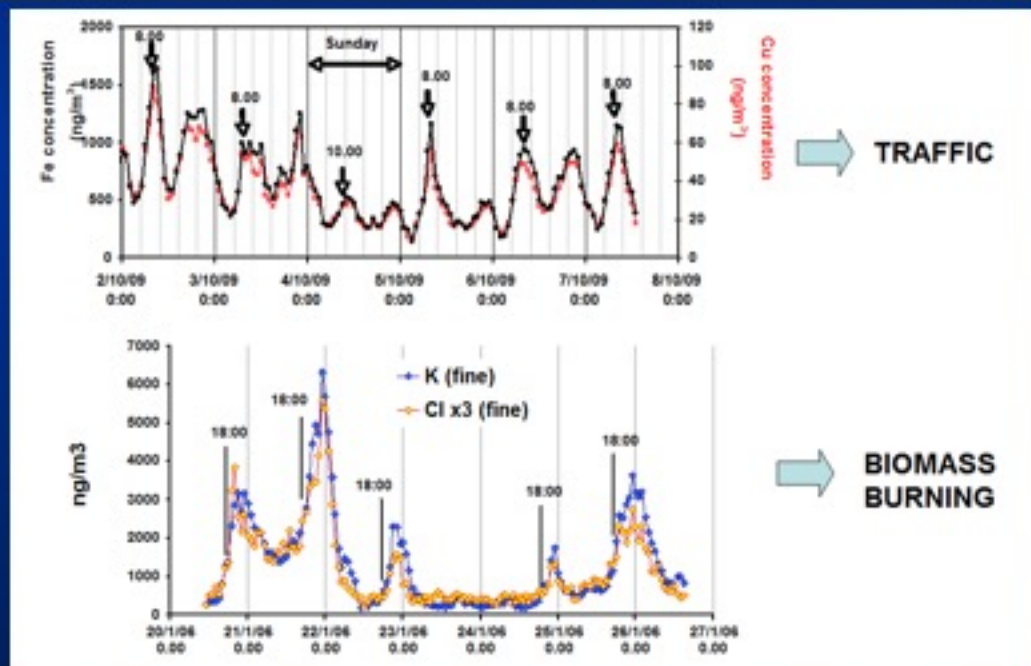
Ad esempio: Analisi della composizione del PM con la tecnica PIXE (Particle Induced X-Ray Emission)

Analisi PIXE di un campione di PM ottenuto con streaker sampler



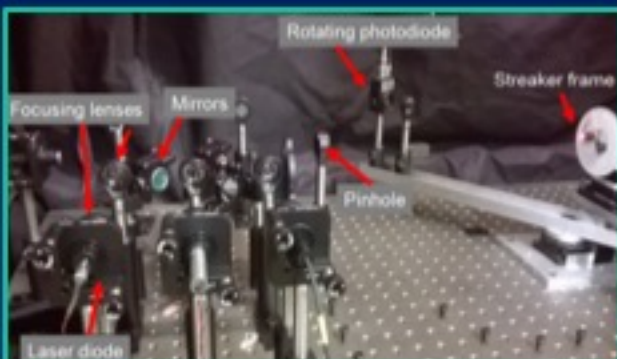
Traccianti elementari con risoluzione oraria ottenuti con PIXE

Per molti anni ci si è basati sull'uso del campionatore *streaker* che ha consentito di ottenere molti e rilevanti risultati: oggi per consolidare la leadership INFN nel settore si intende progettare e costruire un nuovo campionario, che sia quindi di proprietà intellettuale INFN, e che abbia prestazioni nettamente migliori grazie a: (1) un maggiore spessore del materiale depositato (target: aumentare di 1 OdG) e (2) una maggiore affidabilità nelle misure a campo.



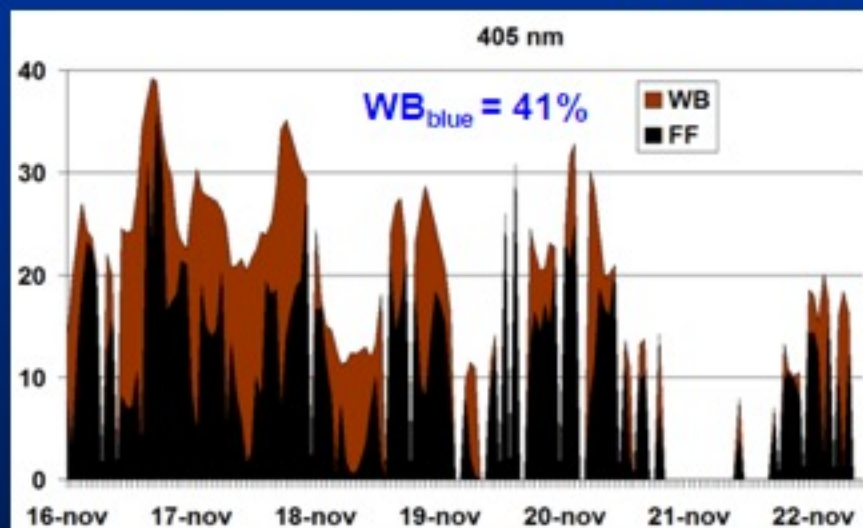
Oltre le tecniche IBA: verso la caratterizzazione completa dell'aerosol atmosferico ad alta risoluzione

Streaker frame



Il nuovo dispositivo sarà adatto non solo alle analisi IBA ma anche alle metodologie ottiche multi- λ sviluppate a Milano e Genova e che consentono di distinguere le sorgenti del particolato carbonioso ovvero la combustione di combustibili fossili (FF) da quella di biomassa (WB)

Milan, wintertime 2015

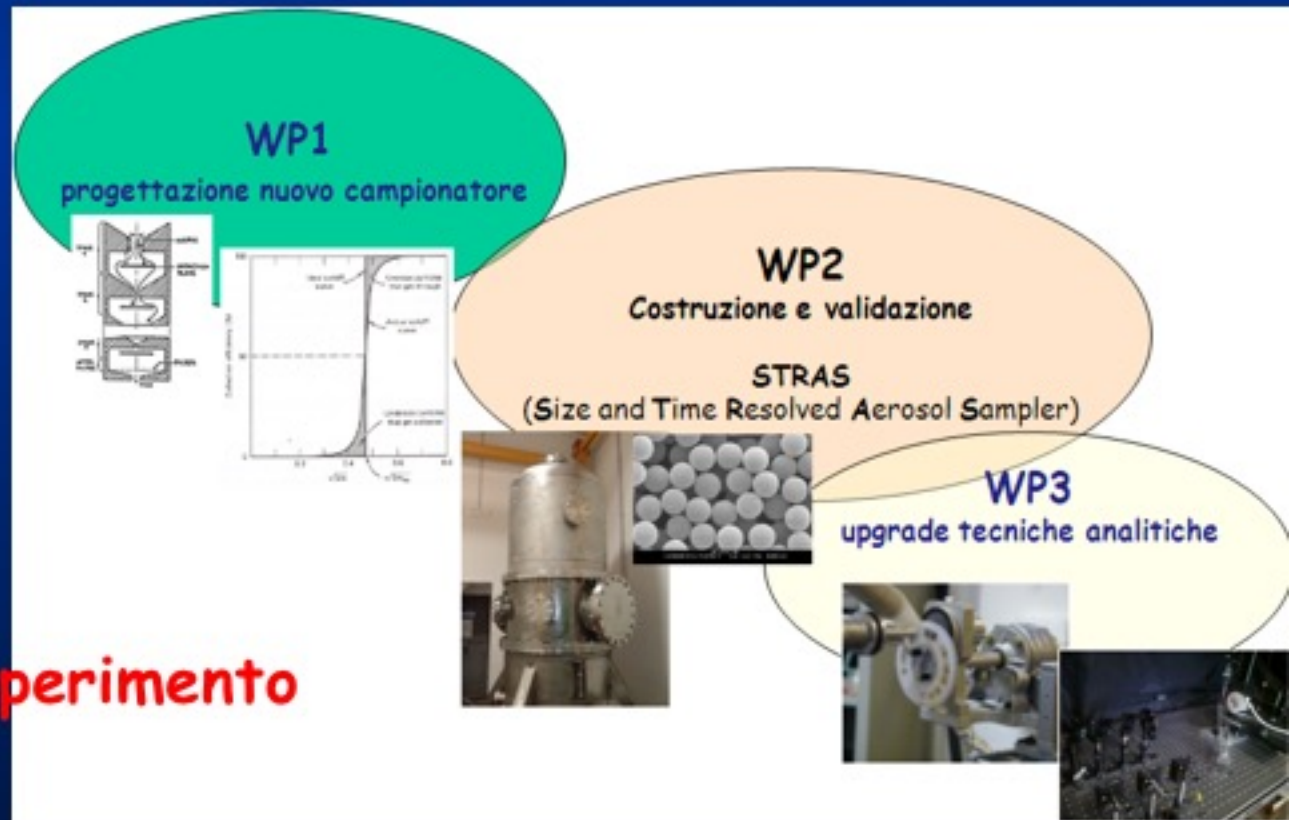


UR-MI: risultati di DEPOTMASS

Proposta tecnico-scientifica

Progetto e costruzione di STRAS (Size and Time Resolved Aerosol Sampler), un campionatore di PM su base temporale oraria, che separi diverse frazioni dimensionali del particolato atmosferico (es. coarse, fine, submicrometrica et al.) con spessori e substrati di raccolta ottimizzati per analisi IBA e ottiche ad alta sensibilità ed affidabilità.

L'esperimento si articolerà in 3 WPs ai quali tutte e tre le sezioni parteciperanno congiuntamente. In particolare, l'UR di Milano nella fase di progettazione WP1 si occuperà dei calcoli relativi alla separazione inerziale in più frazioni dimensionali, in WP2 parteciperà alla fase di validazione del campionatore con aerosol di test e in WP3 effettuerà l'implementazione del set-up ottico multi- λ per misure ad alta risoluzione temporale.



Struttura dell'esperimento

TRACCIA @ Milano: anagrafica e richieste finanziarie



R. Vecchi, PA UNIMI, (70%) Resp. Loc.

G. Valli, Tecnologo UNIMI (70%)

V. Bernardoni, AR UNIMI(70%)

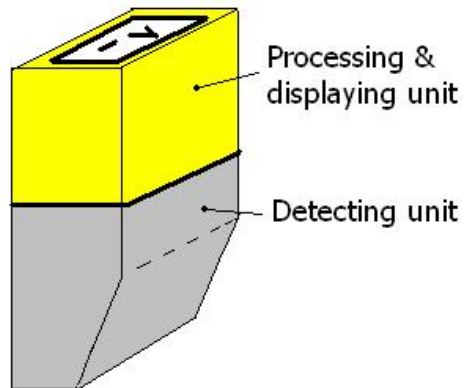
Totale: 2.1 FTE

SEDE/anno	Missioni	Inventariabile	Consumo
Milano 2017	3	7	4
Milano 2018	4	2	4
Milano 2019	3	2	4

NEPED

Neutron Electronic Personal Dosemeter

INFN-E 2017-2018



Unità partecipanti

LNF (2.0 FTE) Resp. Loc. R. Bedogni

Milano (1.5 FTE)

A. Pola (R. Loc.) 0.4 FTE

A. Bassanetti(Ass.) 0.7 FTE

L. Garlati (Ass.) 0.5 FTE

Commissione di pertinenza

INFN-E



Ambito

Sviluppo di un dosimetro personale a lettura diretta per radiazione neutronica dai neutroni termici ($< \text{eV}$) a 20 MeV

La proposta mira a sviluppare e testare un prototipo pre-industriale, sulla base di competenze di progettazione e di rivelazione già presenti all'interno del gruppo e con l'Endorsement di imprese operanti nel settore della dosimetria individuale.

Motivazione

Sul mercato esistono diversi dosimetri a lettura diretta (electronic personal dosemeter EPD) con buone prestazioni per raggi gamma e beta.

Il settore degli EPDn è ancora molto acerbo

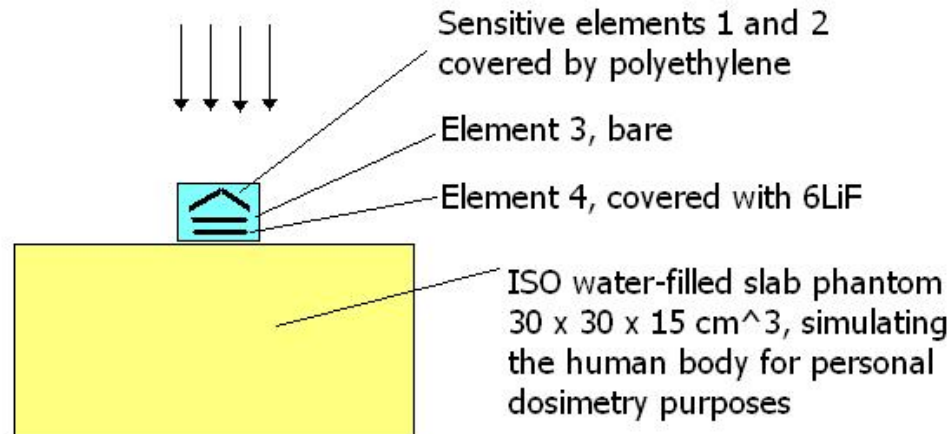
- evidenziato nell'ambito di recenti inter-confronti IAEA o EURADOS
- necessità di migliorare la risposta combinata in Energia ed angolo

Esistono in pratica due modelli con **modeste prestazioni di misura**

~~(Incertezza dovuta a variabilità energetica ed angolare **supera il fattore 20**, utili in pratica SOLO se si conosce bene lo spettro del campo da misurare, il che avviene solo in rari casi operativi).~~

Core idea

- Dispositivi a stato solido funzionalizzati in-house con risposta modificata per migliorare la dipendenza angolare
- Combinazione delle tecniche ad “albedo termico” e a protoni di rinculo per migliorare la risposta in energia
- Applicazione di tecniche consolidate (NESCOFI & NEURAPID) per eliminare la sensibilità parassita ai gamma



Competenze e facilities

Competenze in:

- Rivelatori per neutroni a stato solido, spettrometria dei neutroni, sviluppo dell'elettronica associata (maturata in NESCOFI, NEURAPID)
- Competenze in progettazione Monte Carlo complessa

Disponibilità di facilities di test e calibrazione all'interno del gruppo: fasci monoenergetici (2.5 MeV e 14.2 MeV all'ENEA), sorgenti radio-nuclidiche veloci ed epitermiche (Milano) e campi termici (Milano ed ENEA).



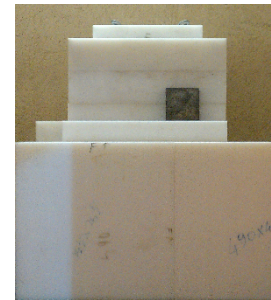
FNG (ENEA Frascati)



PoliMi Panoramic irradiator
Thermal pile



ESTHER and HOTNES



Attività

2017 Monte Carlo design

Identificazione e prova dei sensori e dei filtri

Sviluppo di scheda analog dedicata

Messa a punti degli algoritmi