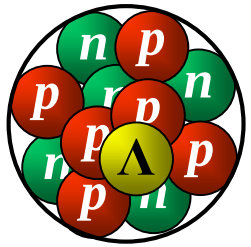
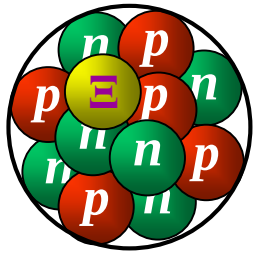
Esperimento ULYSSES (UnraveLing hYpernuclear Spectroscopy and Structure Experiment)

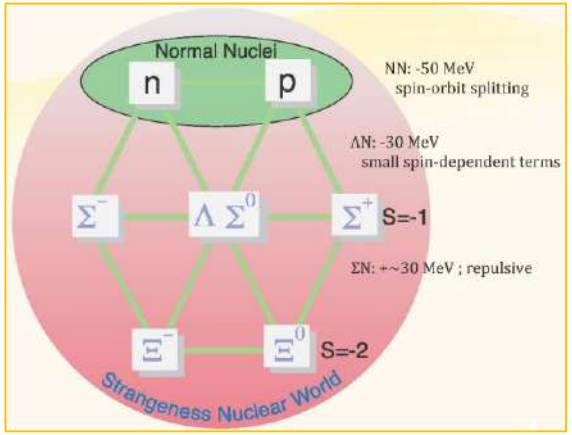
Ipernuclei: nuclei con un iperone (Λ, Ξ) costituente

- studio dell'interazione YN (YY) difficile con esperimenti di scattering come per NN a causa della breve vita media di Y
  - stato legato di Y in nucleo = (femto)laboratorio privilegiato
  - energia di legame (separazione) di Y nell'ipernucleo: B_Λ → informazione sulla hamiltoniana di interazione
  - E70 produzione diretta di ${}^{12}_{\Xi}Be$ J-PARC (Giappone): dicembre 2022





- modi di decadimento e vita media:
  - Mesonic Weak Decay, NonMesonic Weak Decay
  - sistematica *p*-shell hypernuclei (*sd* shell)
  - caso singolare ${}^{3}_{\Lambda}H$ (n, p, Λ): $B_\Lambda \sim 0.13$ MeV → $\tau \approx \tau(\Lambda_{free})$: da verificare
  - misura precisa a J-PARC (Giappone)
  - progetto di apparato dedicato per la misura: simulazione



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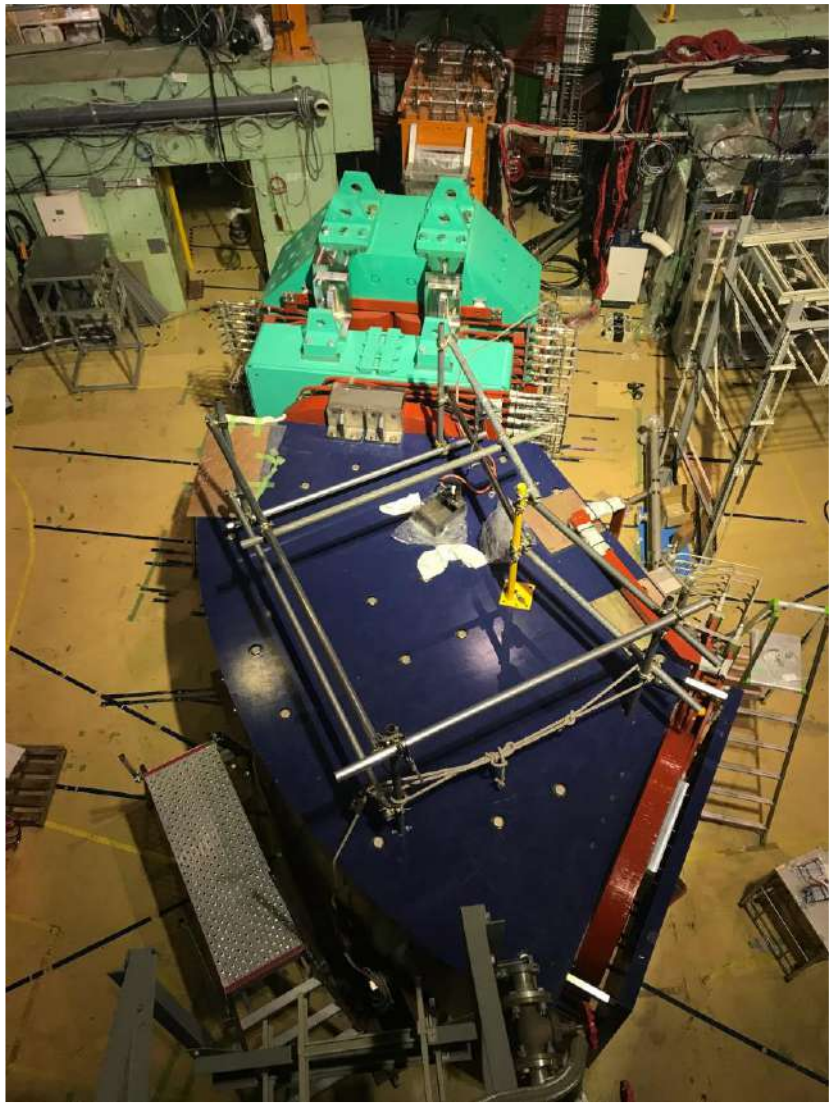
alessandro.feliciello@to.infn.it

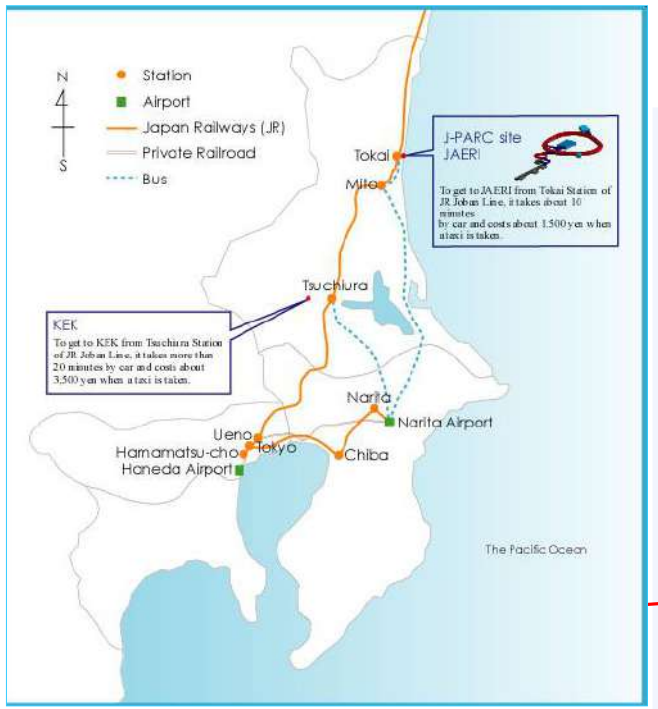
E70 @ K1.8

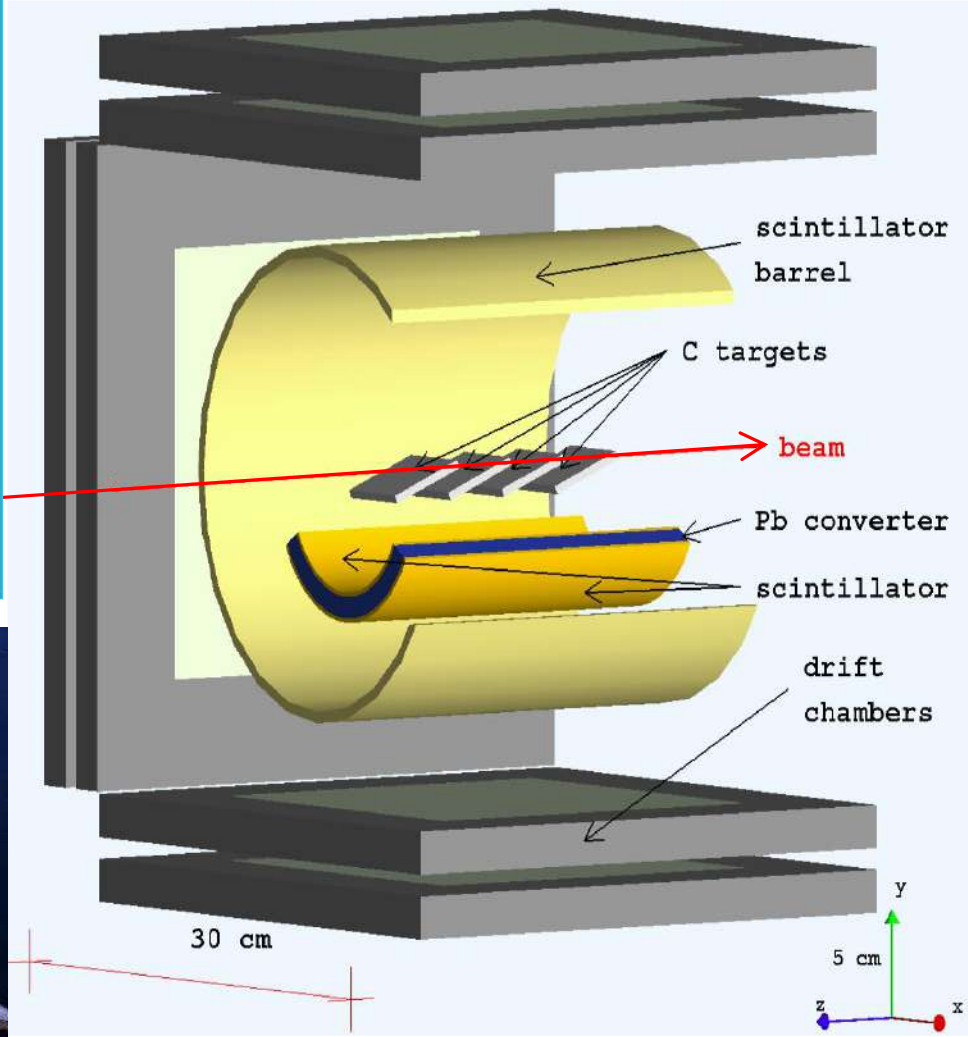
Japan Proton Accelerator Research Complex

$$\pi^- + {}^{12}\mathrm{C} \rightarrow K^0 + {}^{12}_{\Lambda}\mathrm{B}$$

M. Agnello *et al.*, *NPA* 954 (2016) 176.







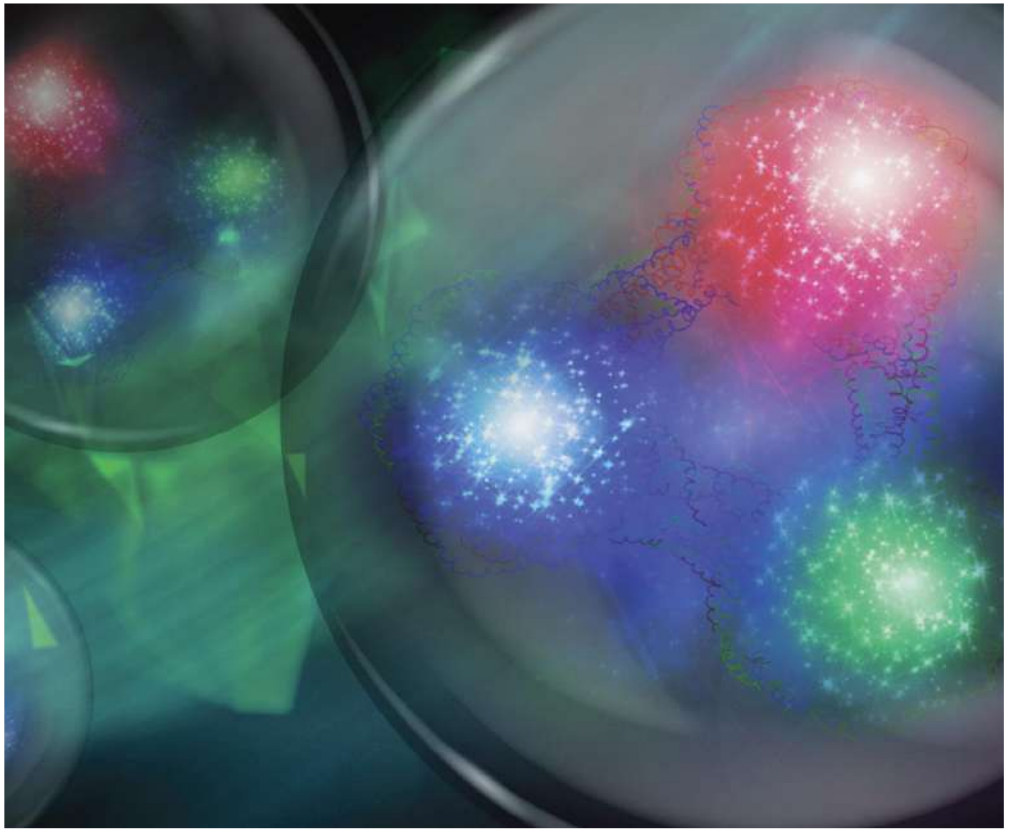
$$K^- + {}^{12}\mathrm{C} \rightarrow K^+ + {}^{12}_{\Xi}\mathrm{Be}$$

G4

Fisica nucleare al JEFFERSON LAB: argomenti disponibili per tesi

Tesi (triennali/magistrali) disponibili per lavori di analisi dati e sviluppo software per gli esperimenti

- CLAS
- CLAS12
- HPS
- BDX, νBDX



Contatto:
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Jefferson Lab

U.S. DEPARTMENT OF ENERGY | Office of Science

JSA

Argomenti di ricerca di fisica subatomica presso CEBAF @JLAB (U.S.A.)

- **Confinamento dei quark**
  - Perché i quark non vengono mai osservati da soli ma solo in aggregati?
- **Fisica dei nuclei**
  - Studio del ruolo dei quark nella struttura dei nuclei atomici e le loro interazione con il mezzo nucleare denso
- **Test del modello standard e delle simmetrie fondamentali**
  - Studio dei limiti del modello Standard delle interazioni fondamentali
- **Struttura elementare dei protoni e dei neutroni**
  - Descrizione dettagliata delle distribuzioni spaziali e di impulso dei quark, che forniscano una rappresentazione finale della struttura interna dei nucleoni

CEBAF AT JEFFERSON LAB

Jefferson Lab's Continuous Electron Beam Accelerator Facility (CEBAF) enables world-class fundamental research of the atom's nucleus. Like a giant microscope, it allows scientists to "see" things a million times smaller than an atom.

1 INJECTOR

The injector produces electron beams for experiments.

2 LINEAR ACCELERATOR

The straight portions of CEBAF, the linacs, each have 25 sections of accelerator called cryomodules. Electrons travel up to 5.5 passes through the linacs to reach 12 GeV.

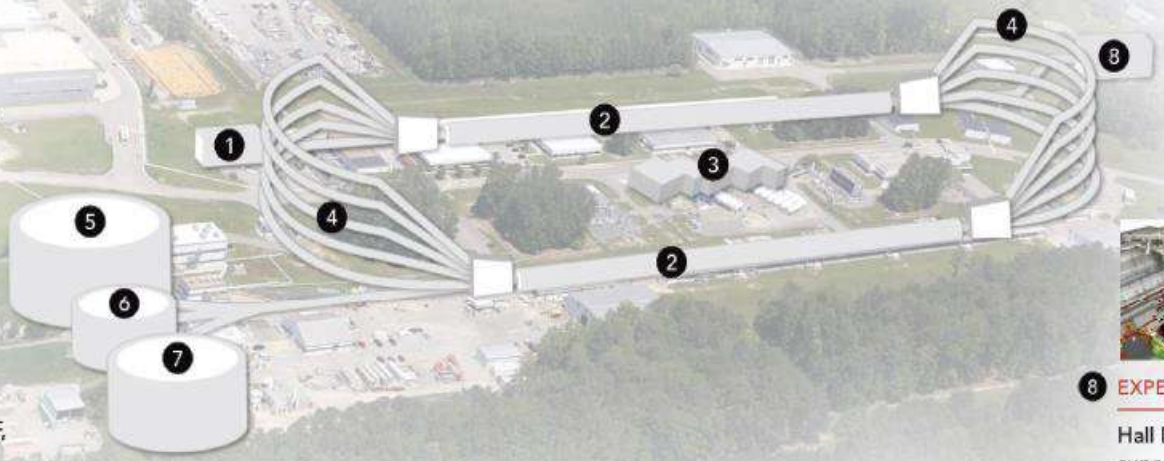


Diagram representational of below ground structure

8 EXPERIMENTAL HALL D

Hall D is configured with a superconducting solenoid magnet and associated detector systems that are used to study the strong force that binds quarks together.

3 CENTRAL HELIUM LIQUEFIER

The Central Helium Liquefier keeps the accelerator cavities at -456 degrees Fahrenheit.

4 RECIRCULATION MAGNETS

Quadrupole and dipole magnets in the tunnel focus and steer the beam as it passes through each arc.

5 EXPERIMENTAL HALL A

Hall A is configured with two High Resolution Spectrometers for precise measurements of the inner structure of nuclei. The hall is also used for one-of-a-kind, large-installation experiments.

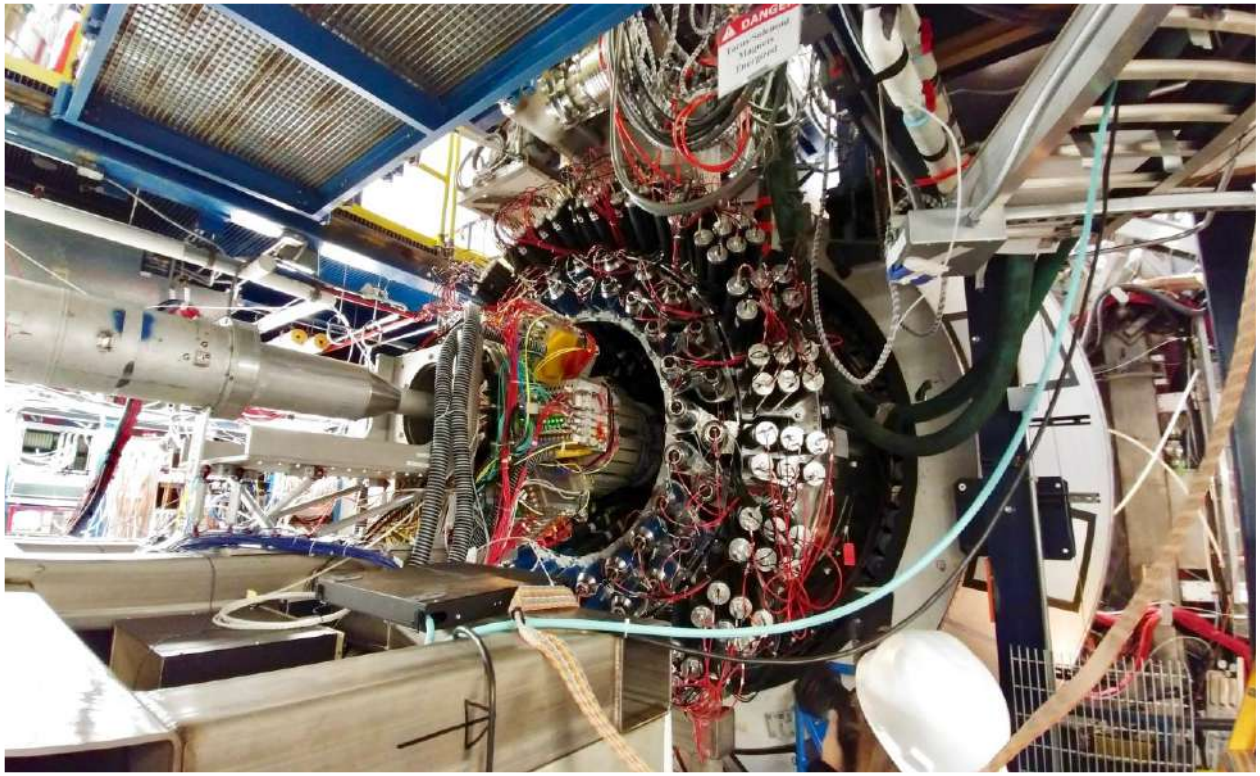
6 EXPERIMENTAL HALL B

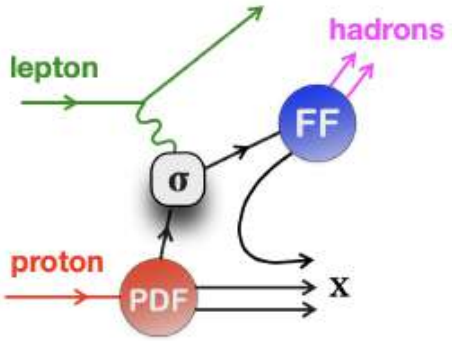
The CEBAF Large Acceptance Spectrometer surrounds the target, permitting researchers to measure simultaneously many different reactions over a broad range of angles.

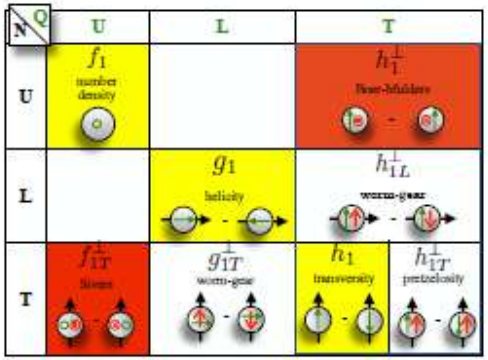
7 EXPERIMENTAL HALL C

The Super High Momentum Spectrometer and the High Momentum Spectrometer make precise measurements of the inner structure of protons and nuclei at high beam energy and current.

Fisica nucleare a JLAB-HallB: CLAS12





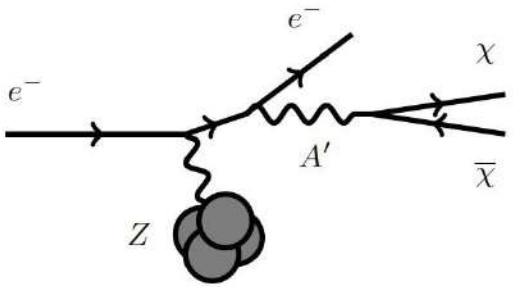


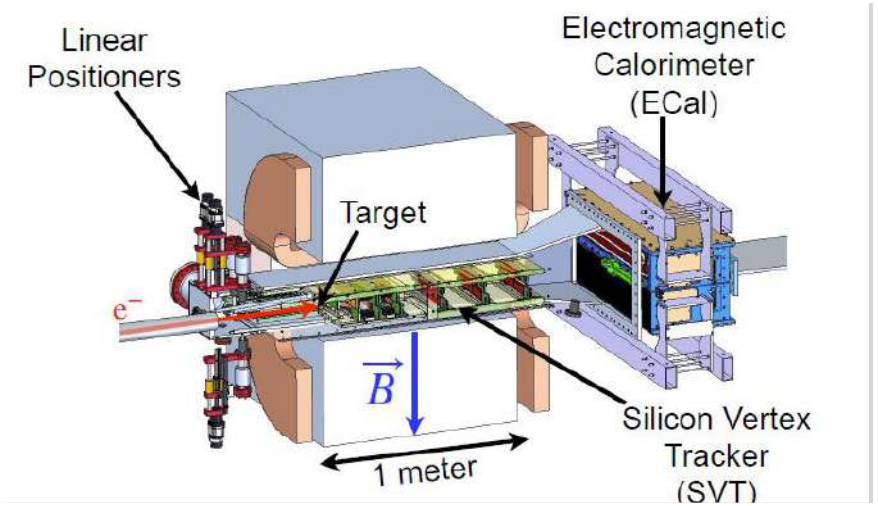
- Collaborazione internazionale, 55 istituzioni da 12 paesi, 50 partecipanti italiani
- Alcune tematiche di ricerca:
  - Imaging delle distribuzioni spaziali e dinamiche (impulso, spin) dei quark all'interno dei nucleoni
  - Lo spettro e la struttura dei barioni e dei loro stati eccitati
  - Ricerche di forme esotiche della materia: nuovi stati mesonici e barionici
  - La struttura gravitazionale dei protone
  - Interazioni quark-guone all'interno dei nuclei

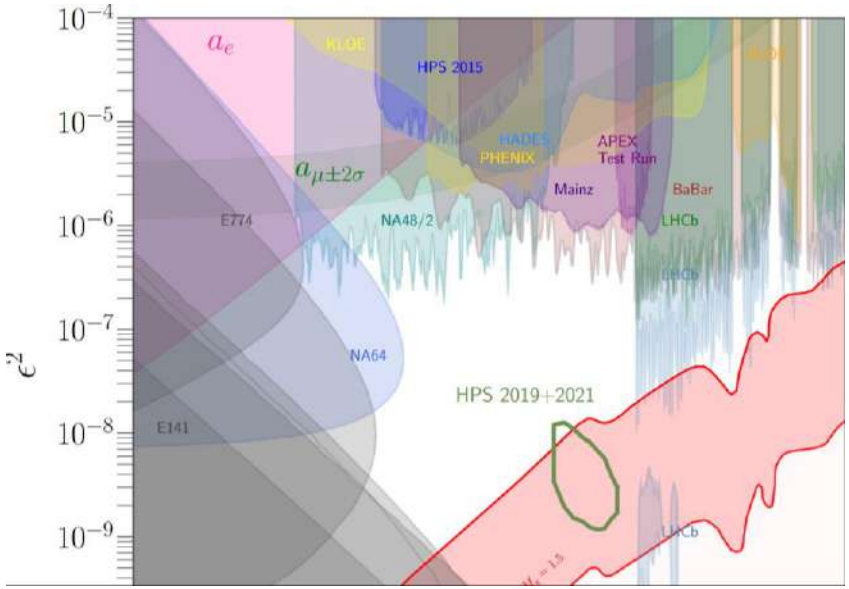
Jefferson Lab

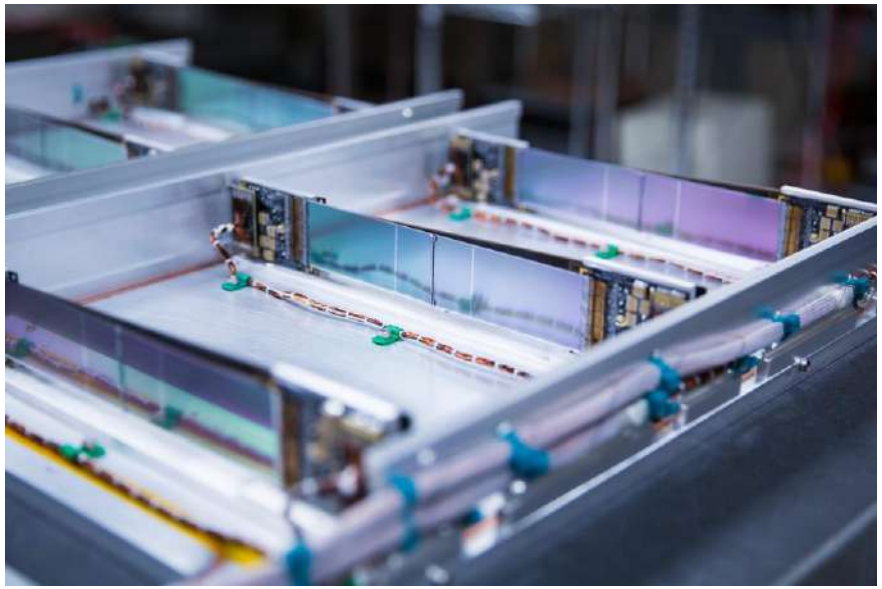
Ricerche di materia oscura agli acceleratori: HPS

- **HPS**
  - Dedicato alla ricerca del dark photon ed altri tipi di materia oscura leggera prodotta agli acceleratori
  - Studio interazione e^- W
  - Ricerca di stati legati nel sistema (e^+e^-) e vertici secondari









Argomenti per tesi disponibili a Torino a.a. 2022, magistrali e triennali

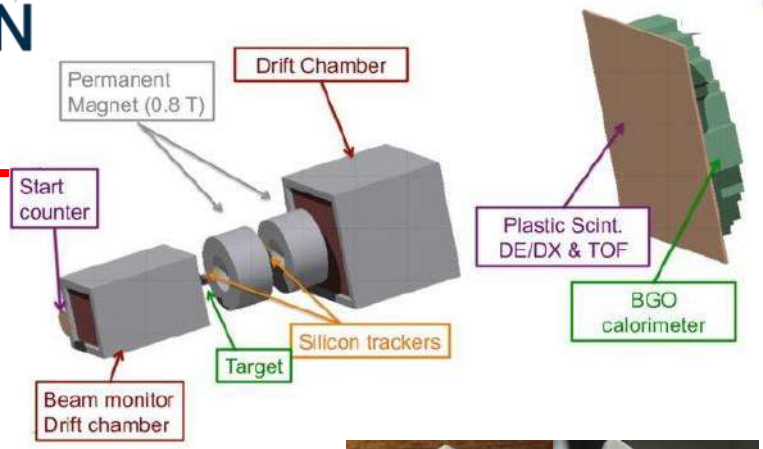
- **CLAS/CLAS12**
  - Studio delle asimmetrie di doppia polarizzazione in interazioni su neutroni di fotoni polarizzati
  - Studio spettroscopico di mesoni contenenti stranezza in reazioni indotte da fotoni reali
  - Studio spettroscopico di resonanze barioniche in reazioni di elettroproduzione
  - Studio dell'interazione elastica elettrone-protone fino a 12 GeV
  - Studio della risposta spaziale del tracciatore a microMegas del Forward Detector di CLAS12
  - Applicazioni di tecniche A.I. per selezione ed analisi dati

- **HPS**
  - Allineamento del rivelatore di vertice per i dati raccolti nel 2019 e 2021
  - Analisi di possibili segnali da materia oscura leggera (ALPs, SIMPs, iDM)

- **νBDX**
  - Studi di fattibilità di un apparato di beam-dump per la misura di sezioni d'urto d'interazione ν-nucleone
  - Studio di modellizzazioni dell'interazione ν-nucleone e realizzazione di generatori per la loro simulazione

Progetto FOOT

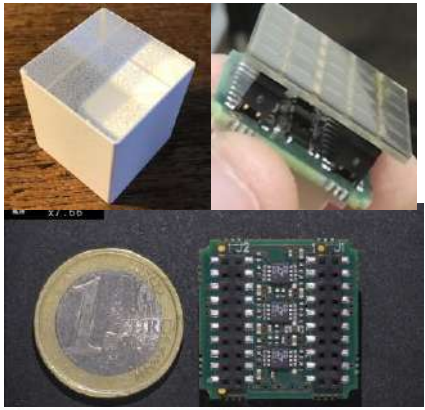
Frammentazione in interazioni nucleari



Collaborazione internazionale (Italia, Francia, Germania, Giappone)

Obiettivo: misurare le sezioni d'urto differenziali di produzione di frammenti secondari.

Ambiti di interesse: adroterapia e spazio

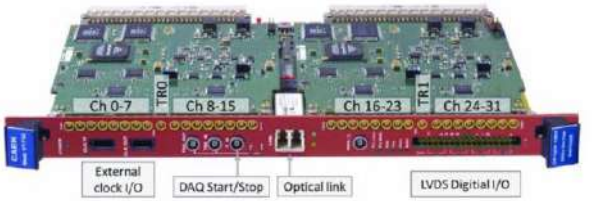


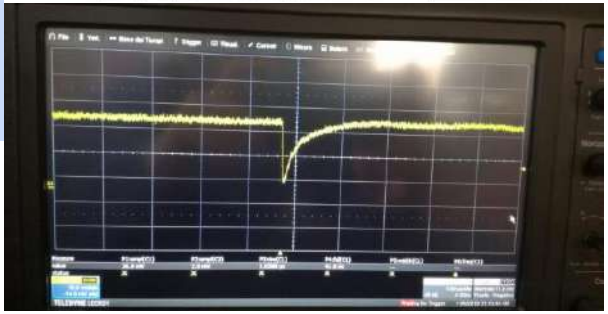
INFN Torino: Costruzione e calibrazione di un calorimetro a BGO

Misure presso HIT (Heidelberg), GSI (Darmstadt) e CNAO (Pavia)

Proposte di tesi triennali e magistrali:

- Costruzione, calibrazione e commissioning del calorimetro per la misura dell'energia cinetica dei frammenti
- Analisi dei dati di frammentazione per interazioni ^{4}He-C e ^{4}He-p





Contatti

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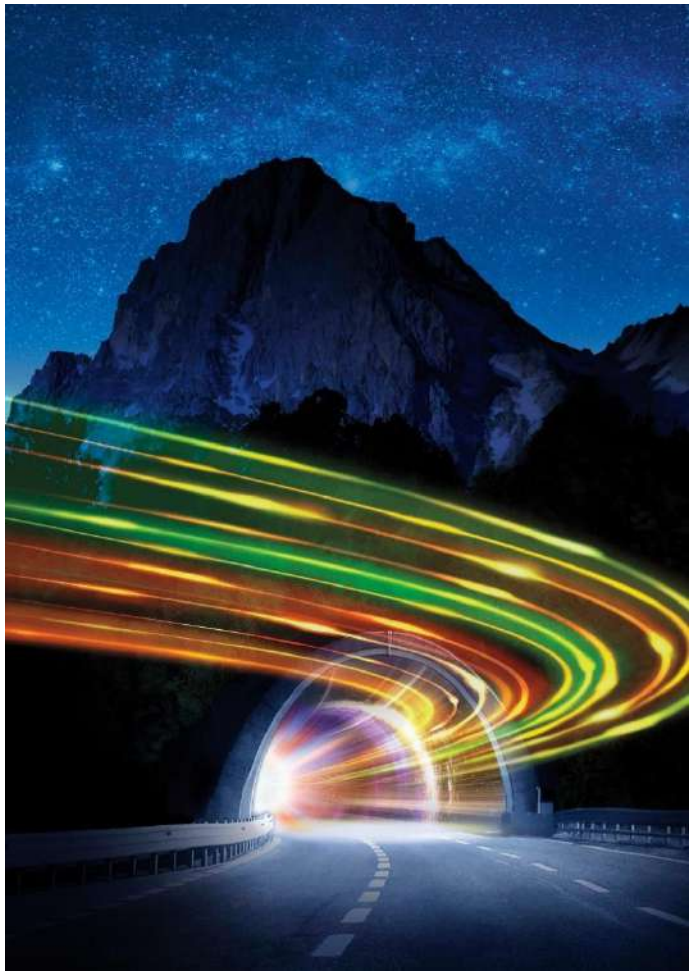
Laboratory for Underground Nuclear Astrophysics

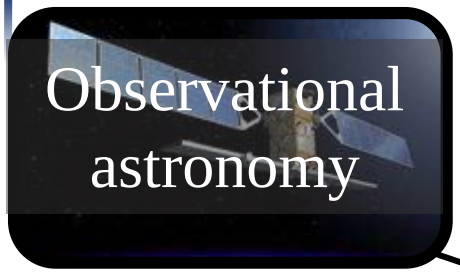


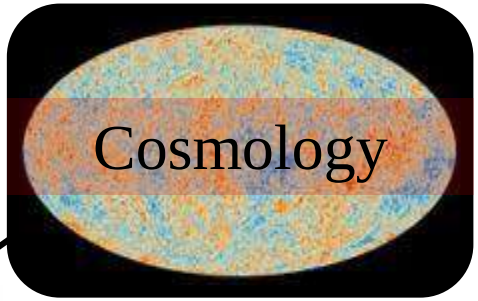
Francesca Cavanna

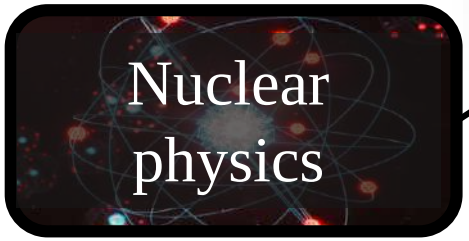
LUNA
Laboratory for Underground Nuclear Astrophysics

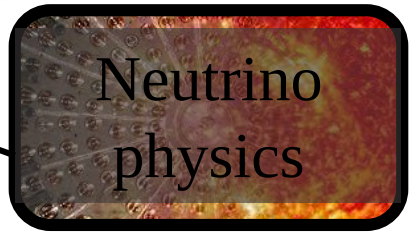
INFN
Istituto Nazionale di Fisica Nucleare

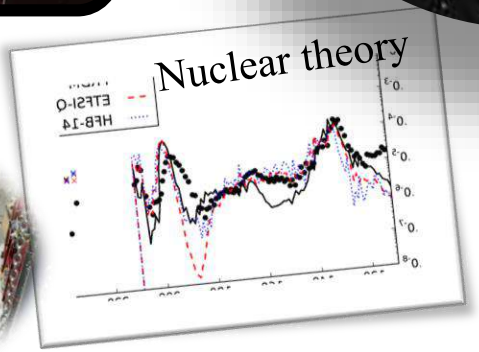
Nuclear astrophysics

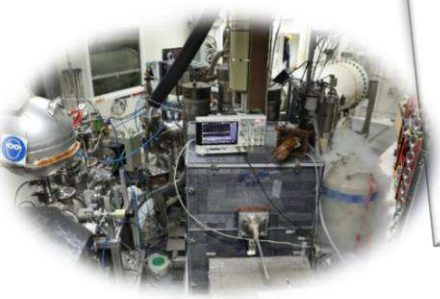




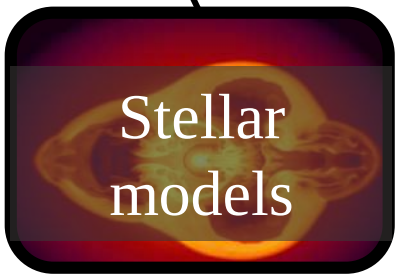


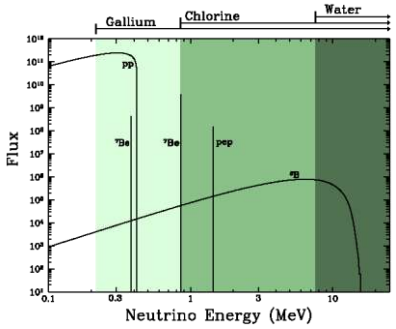






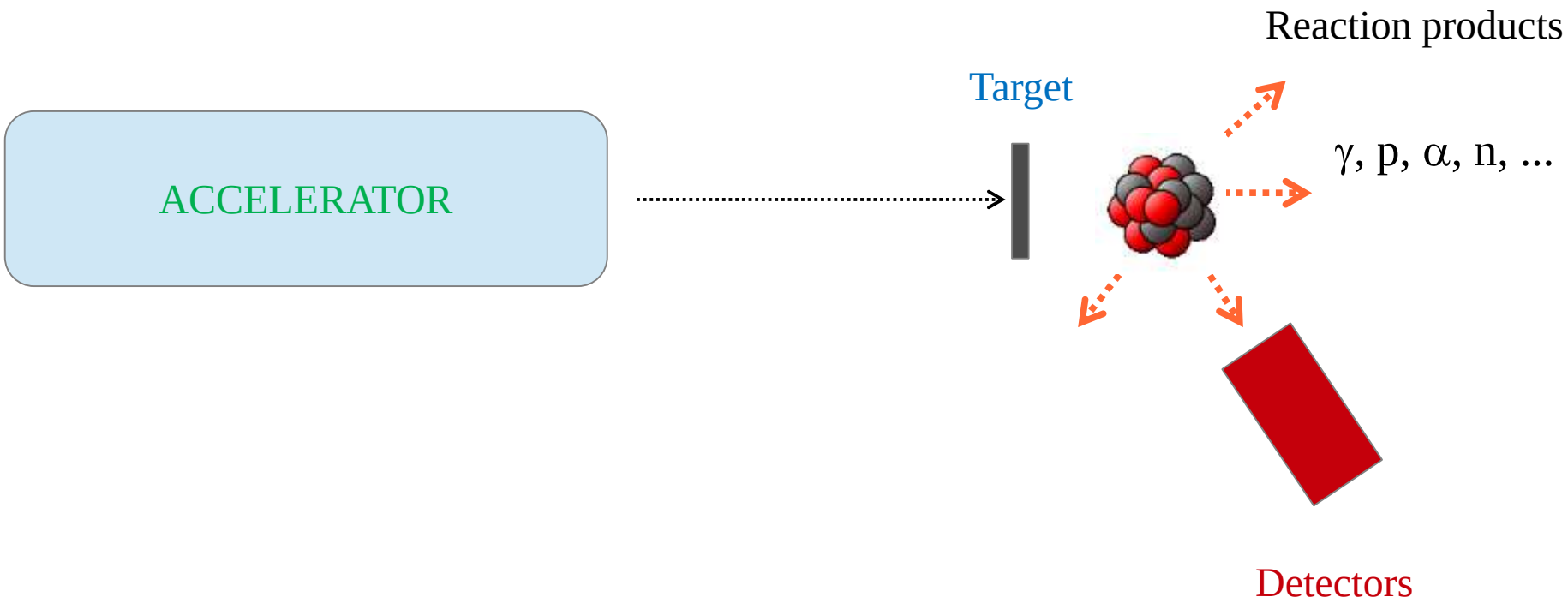
Nuclear experiments





Nuclear reactions at astrophysical energies

Counting Rate = N_p x N_t x cross section x detection efficiency



Experimental Challenges

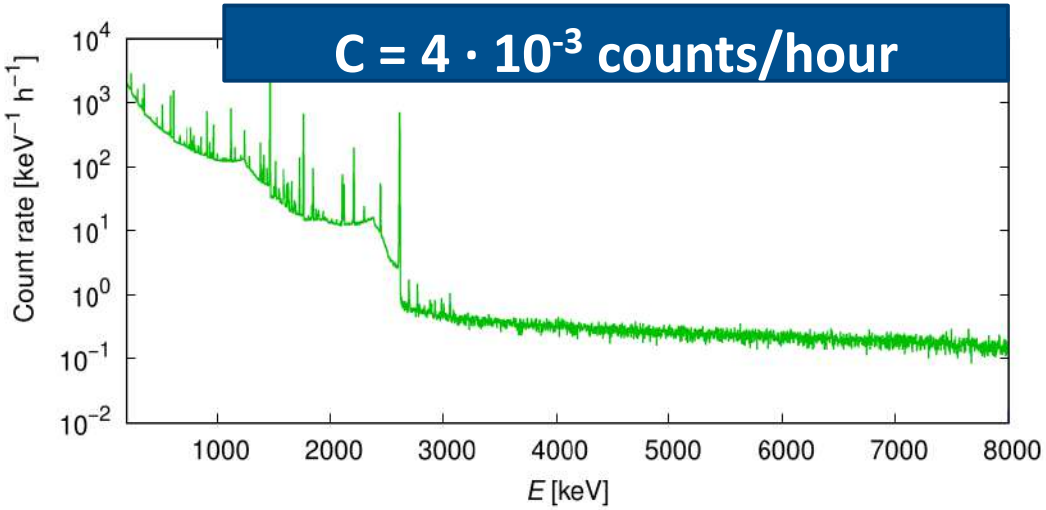
Counting Rate = N_p x N_t x cross section x detection efficiency

10^{14} pps (~100 μA q=1+) typical stable beam intensities

10^{18} atoms/cm^2 typical solid state targets

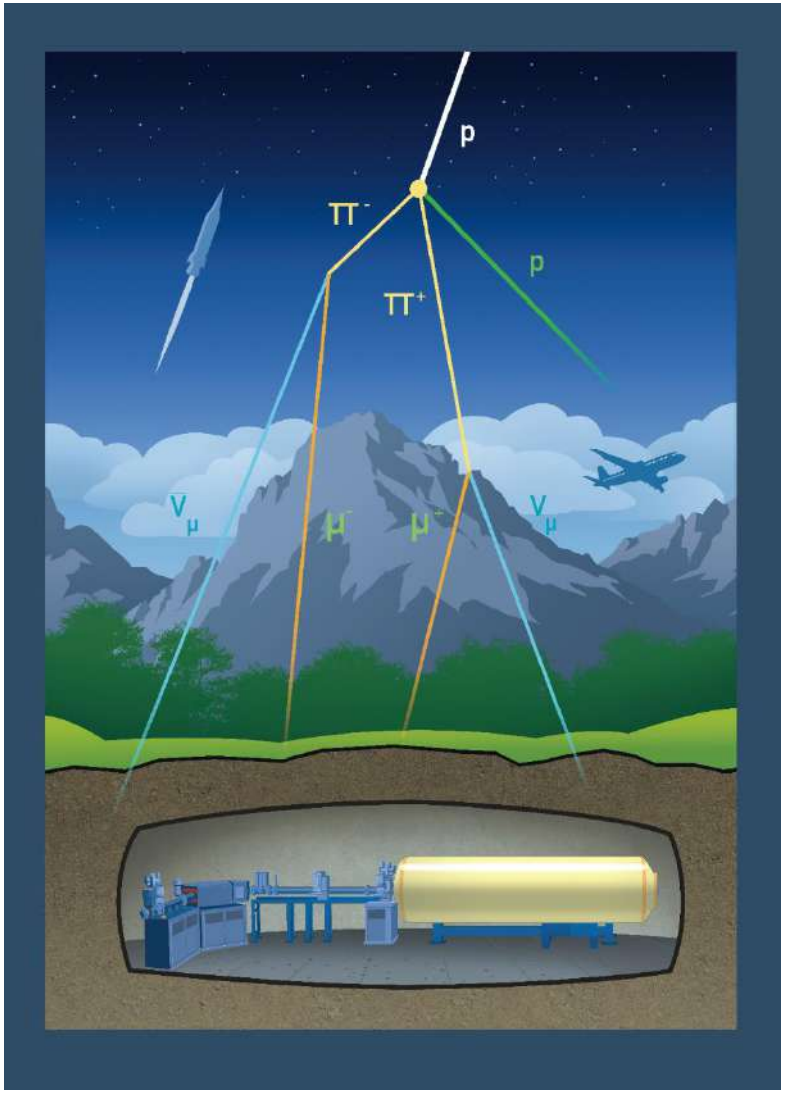
10^{-36} cm^2 (often even smaller)

~1-5% for gamma rays (HPGe detectors)



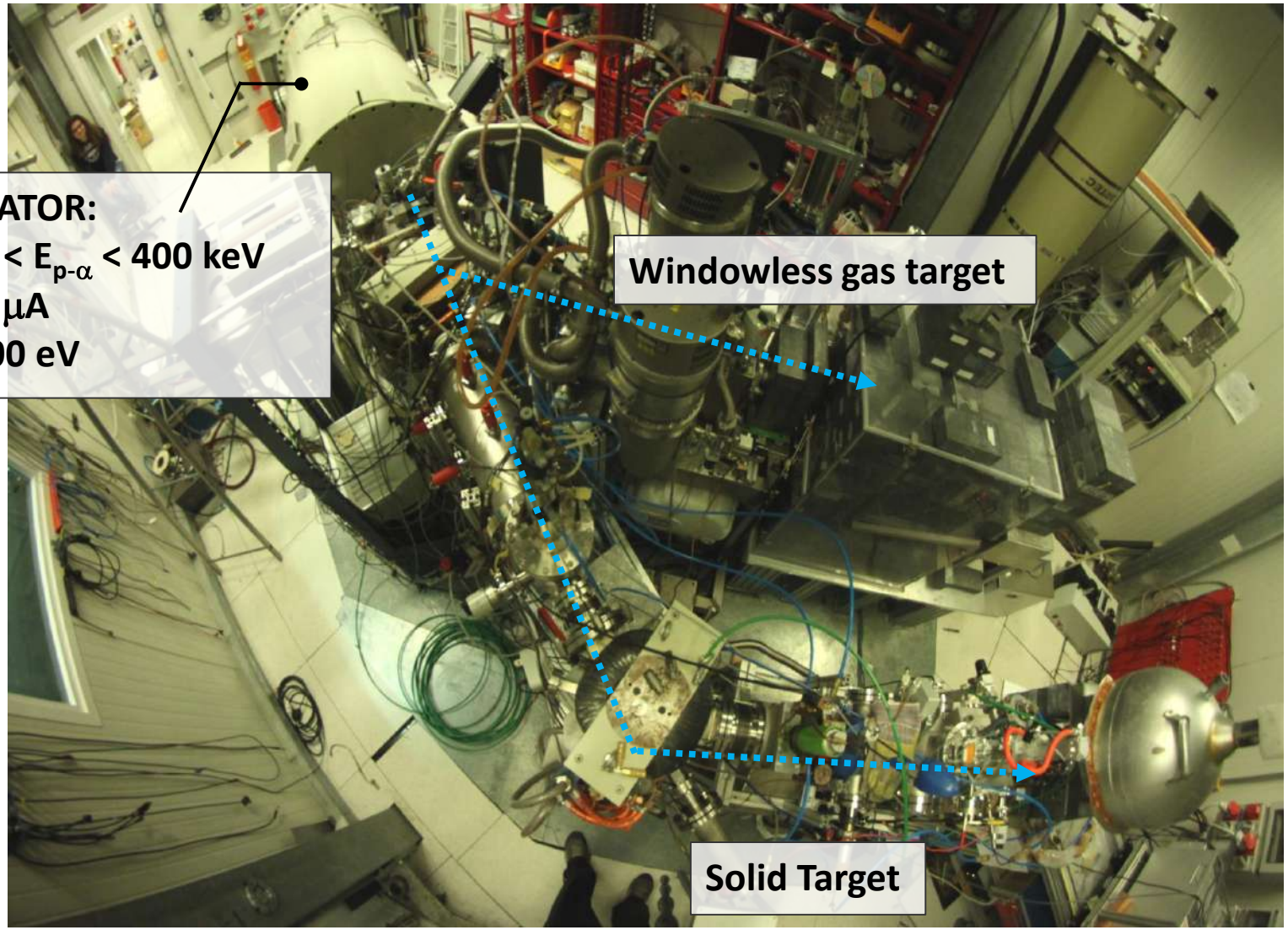
Laboratory for Underground Nuclear Astrophysics

Radiation	LNGS/surface
Muons	10^{-6}
Neutrons	10^{-3}



LNGS (1400 m rock shielding ≡ 4000 m w.e.)

LUNA experimental setup



Bachelor thesis

- ✓ 150h duration
- ✓ Specific task on one of the measurements currently ongoing at LUNA:
  - ❖ Data analysis
  - ❖ Design of a new experimental setup including Geant4 Monte Carlo simulations
  - ❖ Detector characterization: study of the detection efficiency etc.
- ✓ Topics:
  - ❖ Stellar nucleosynthesis: study of the solar composition problem…
  - ❖ Big Bang Nucleosynthesis: study of the element production at the beginning of our Universe, study of the cosmological parameters and physics beyond the Standard Model

Master thesis

- ✓ Run a complete experiment:
  1. Setup preparation and mounting
  2. Data taking
  3. Data analysis and study of the astrophysical impact
- ✓ Possibility to work on hardware and software at the same time
- ✓ Visits to Laboratori Nazionali del Gran Sasso
- ✓ Arrive at a scientific publication at the end of the work

Useful information and contacts

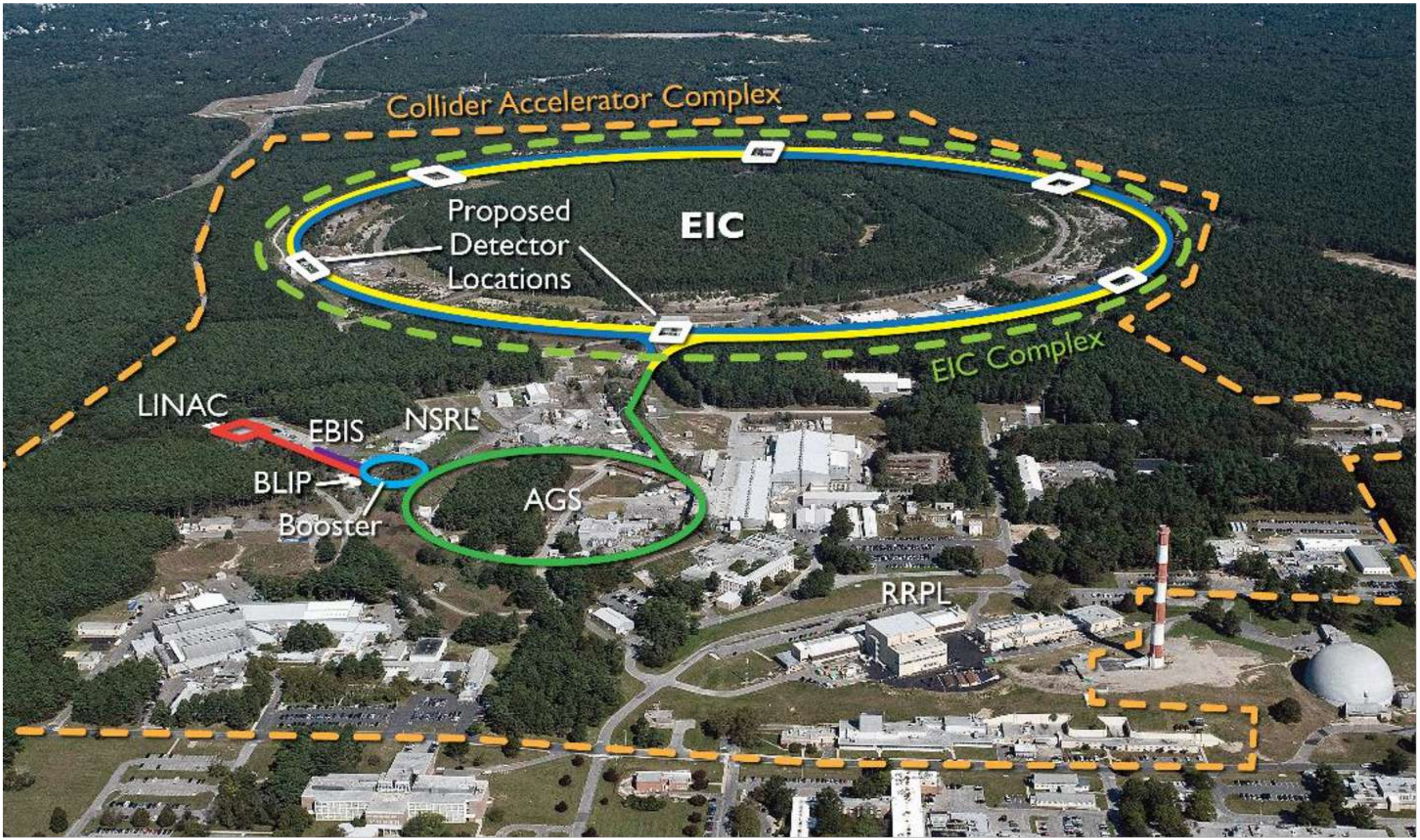
- ✓ INFN provides fellowships for bachelor and master thesis in collaboration with Laboratori Nazionali del Gran Sasso
- ✓ For further information please visit the LUNA website:
  - ❖ https://luna.lngs.infn.it/
- ✓ Contacts:
  - ❖ Francesca Cavanna:
    - Mail: francesca.cavanna@to.infn.it
    - Ufficio: A6 primo piano, edificio vecchio
    - Zoom: https://infn-it.zoom.us/my/fcavanna

Il rivelatore Dual Radiator Rich per il futuro Electron Ion Collider (EIC) al Brookhaven National Laboratory (NY,USA)

https://www.bnl.gov/eic/

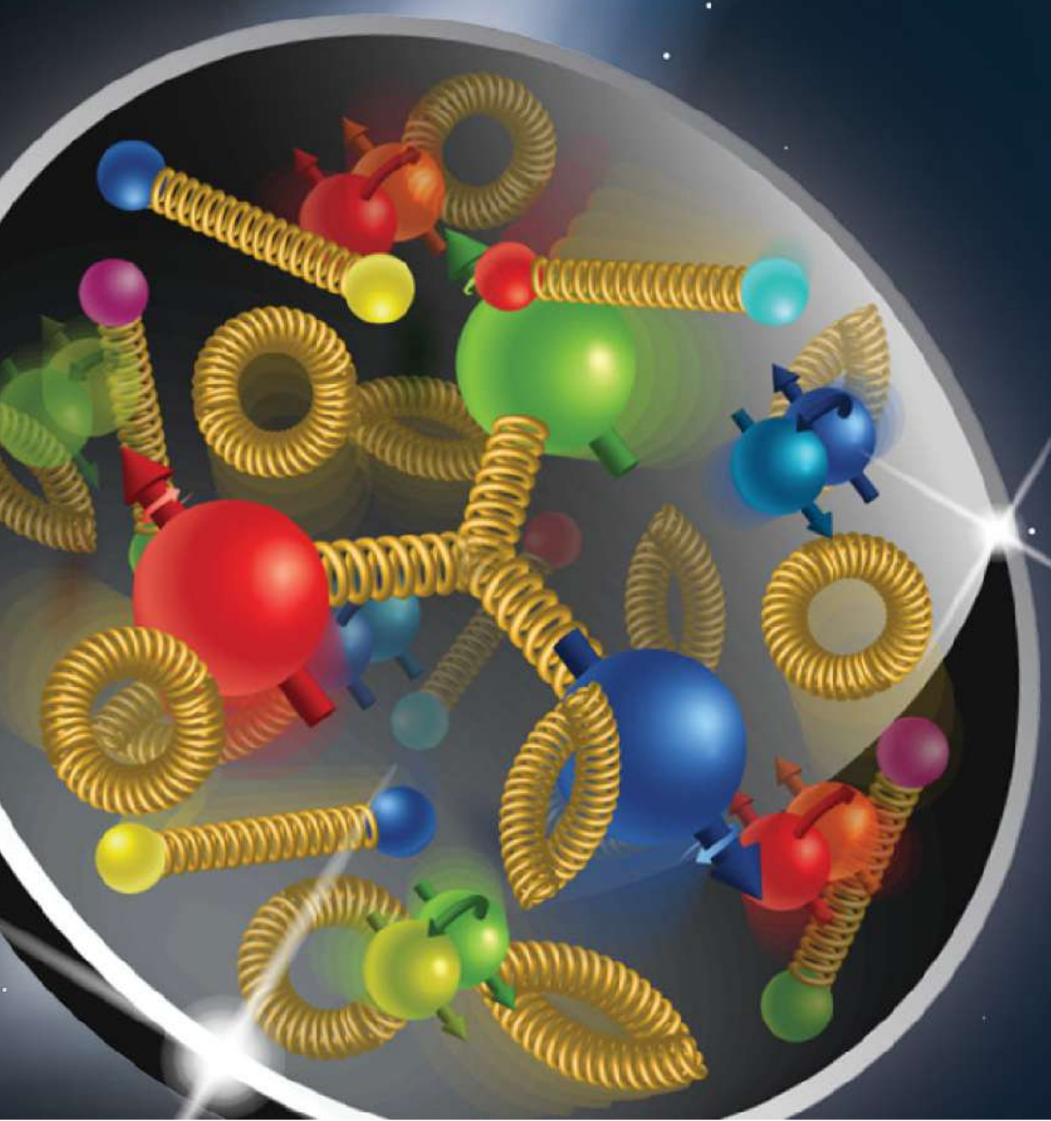
Michela Chiosso
michela.chiosso@unito.it

THE ELECTRON-ION COLLIDER AT BNL



- growing community, 1302 members, 36 countries, 265 institutions

THE ELECTRON–ION COLLIDER'S SCIENTIFIC QUESTIONS

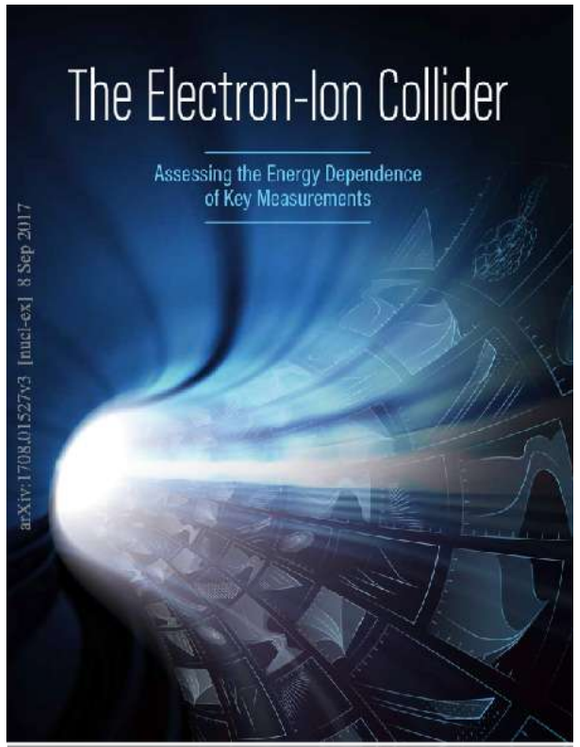


- How do the nucleonic properties such as *mass* and *spin* emerge from partons and their underlying interactions?
- How are the *sea quarks and gluons*, and their spins, distributed in space and momentum inside the nucleon?
- How does the *nuclear* environment affect the distribution of *quarks and gluons* and their interactions in nuclei?

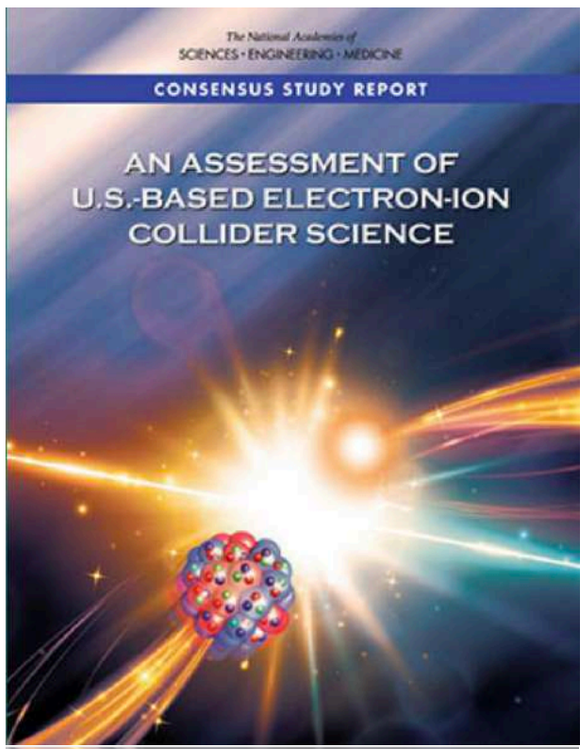
THE ELECTRON–ION COLLIDER: RELEVANT DOCUMENTS

https://www.bnl.gov/eic/science.php

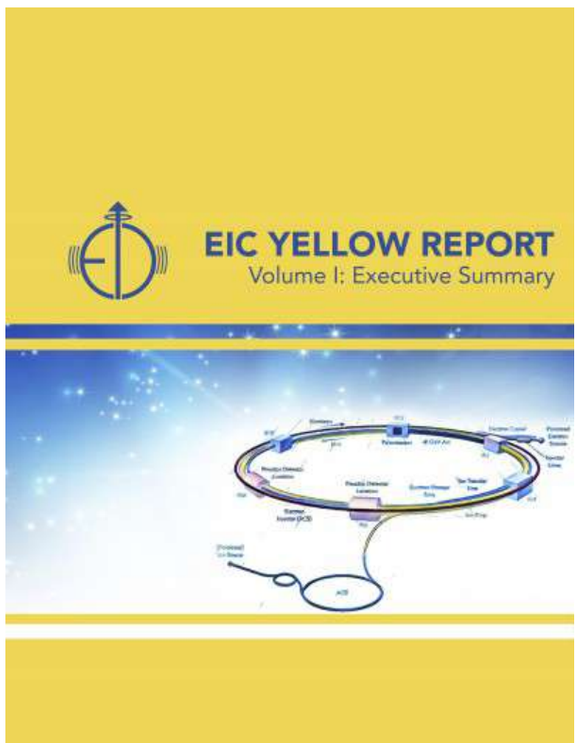
White Paper (2012)
Accardi et al, arXiv: 1212:1701
Accardi et al, Eur. Phys. J. A (2016) 52: 268



BNL Report (2017)
Aschenauer at el, arXiv: 1708.01527



NAS Study (2018)



EIC Yellow Report (2021)
arXiv:2103.05419

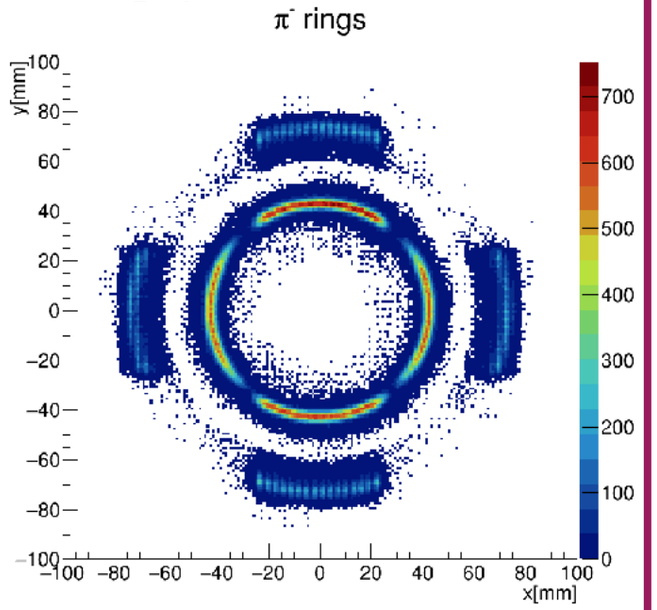
DUAL RADIATOR RICH @ EIC

Two challenges: cover a wide momentum range 3 - 60 GeV/c
work in high (~ 1T) magnetic field

Ring Imaging CHerenkov detector: charge particles identification

$$\cos\theta_c = 1/n\beta$$

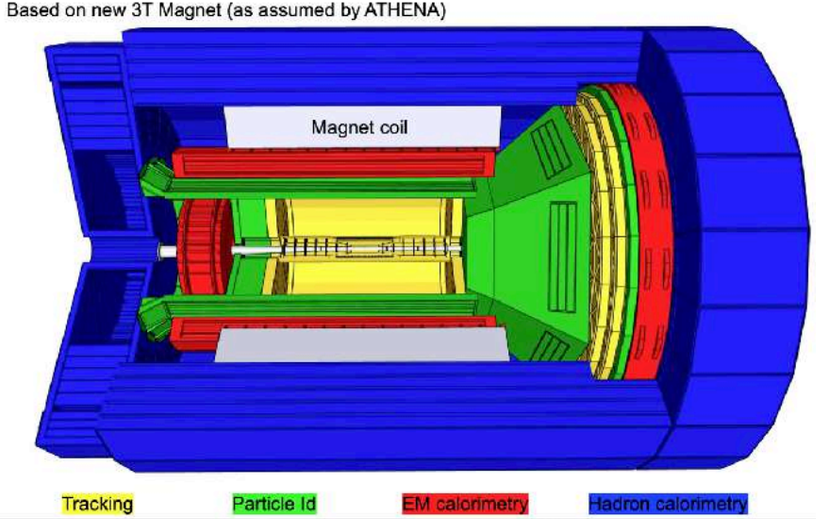
$$p_{th} = \frac{m}{\sqrt{n^2 - 1}}$$

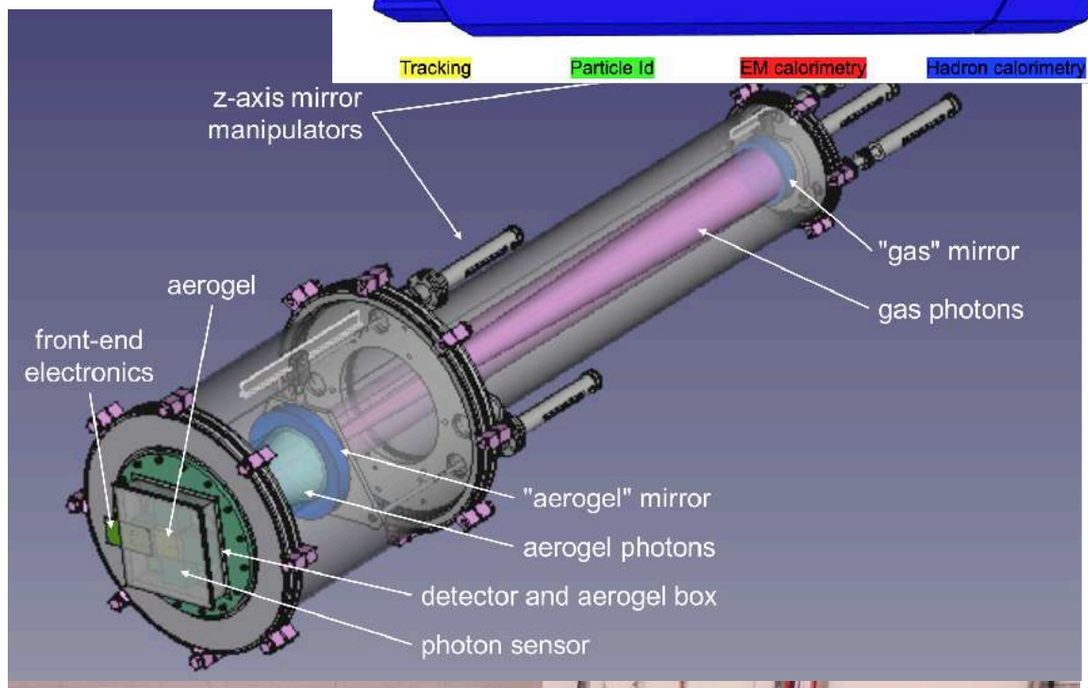


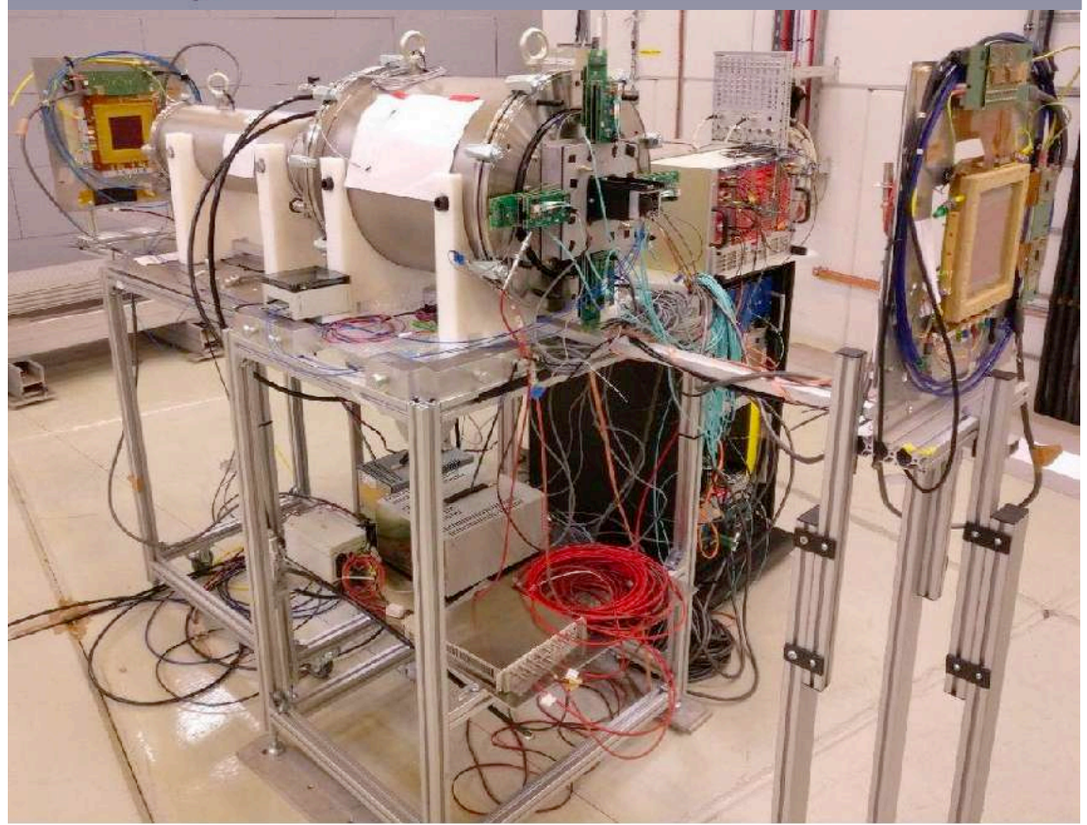
A SiPM R&D program for the dRich @EIC

1. Proof of "feasibility": DCR & operating conditions, single photon detection etc.
2. Radiation tolerance (& annealing)
3. Readout electronics: ASIC (+ streaming readout)

Bologna, Catania, Ferrara, LNF, Roma 1, Torino





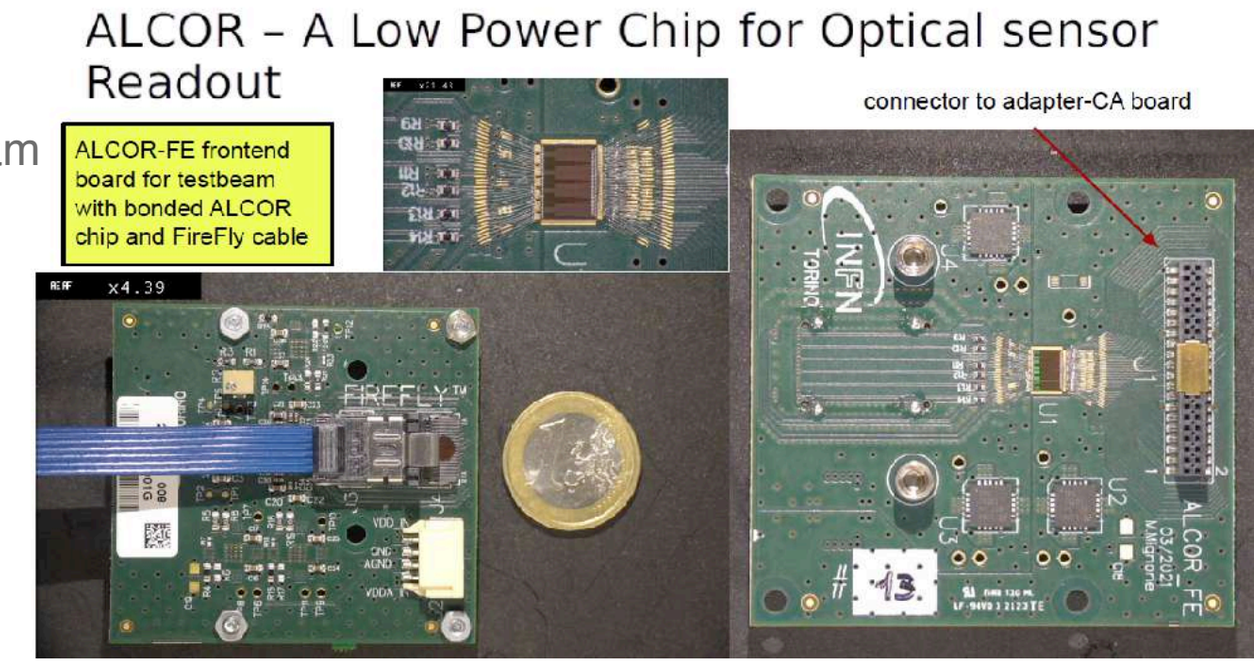


A SIPM R&D PROGRAM FOR THE DRICH @EIC

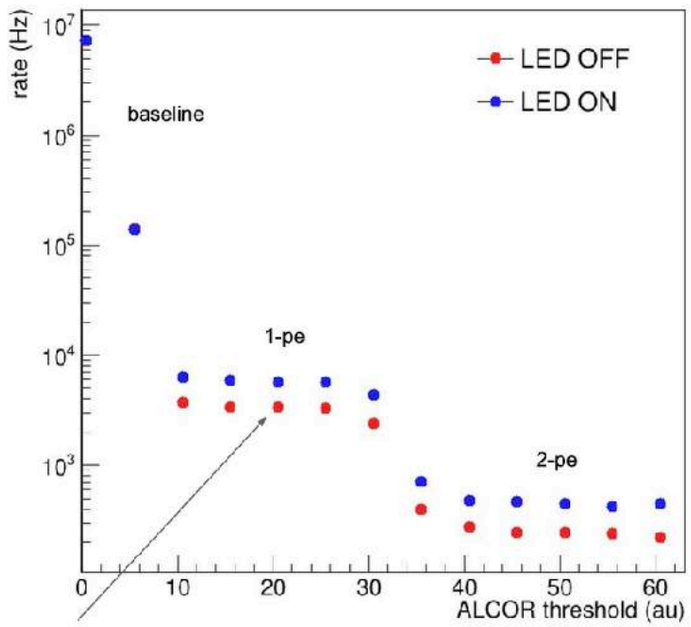
Acquisition of commercial and prototype (FBK) SiPM sensors

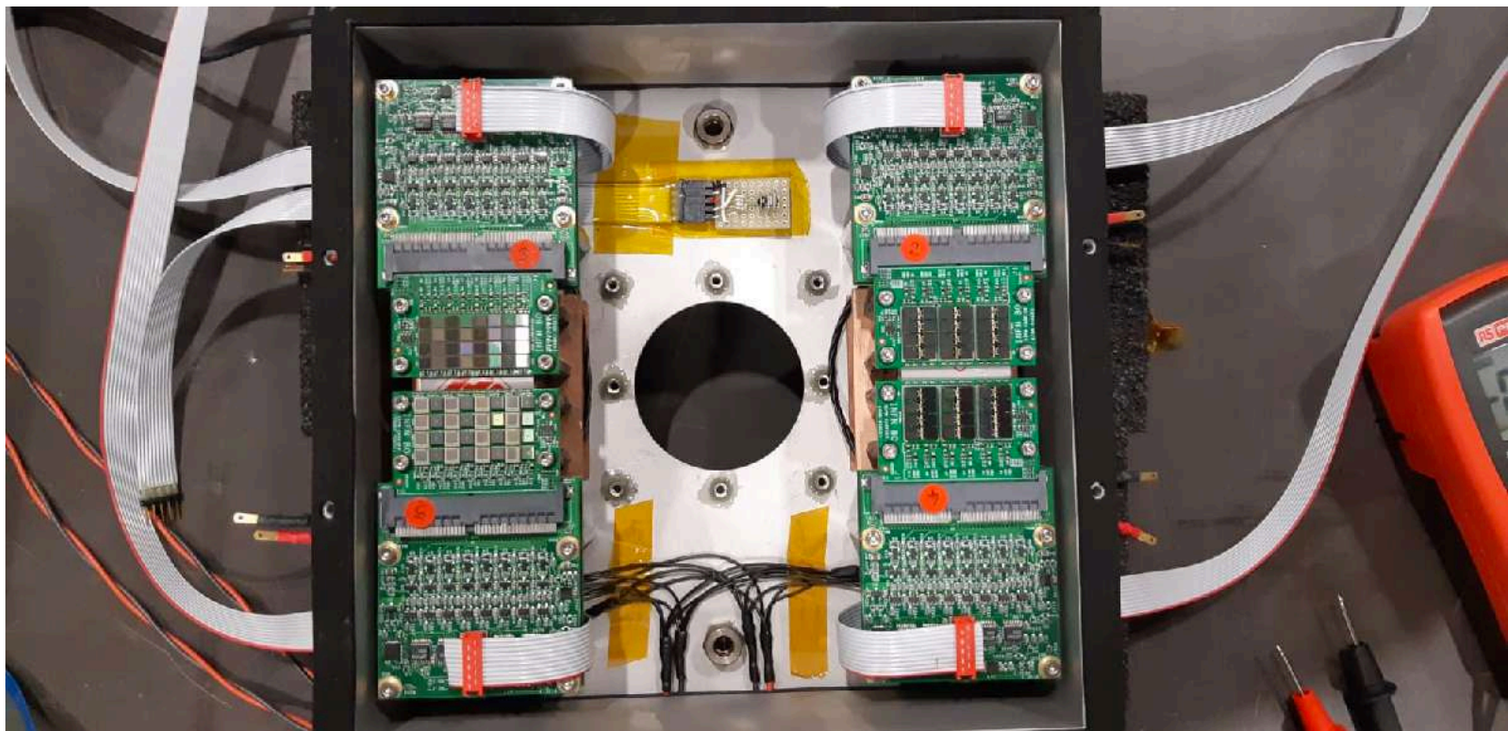
Design and production of dedicated electronics boards

- SiPM carrier boards (BO)
  - host SiPM matrix: designed for irradiation, annealing, testbeam
  - one form factor, different layout for different SiPM family
- SiPM adapter boards (FE)
  - couples the SiPM carrier board with readout system (oscilloscope, ALCOR)
- ALCOR FrontEnd board (TO)
  - hosts ALCOR frontend ASIC
- FireFly breakout board (ARCADIA)
  - links ALCOR I/O to FPGA
  - ALCOR configuration and readout



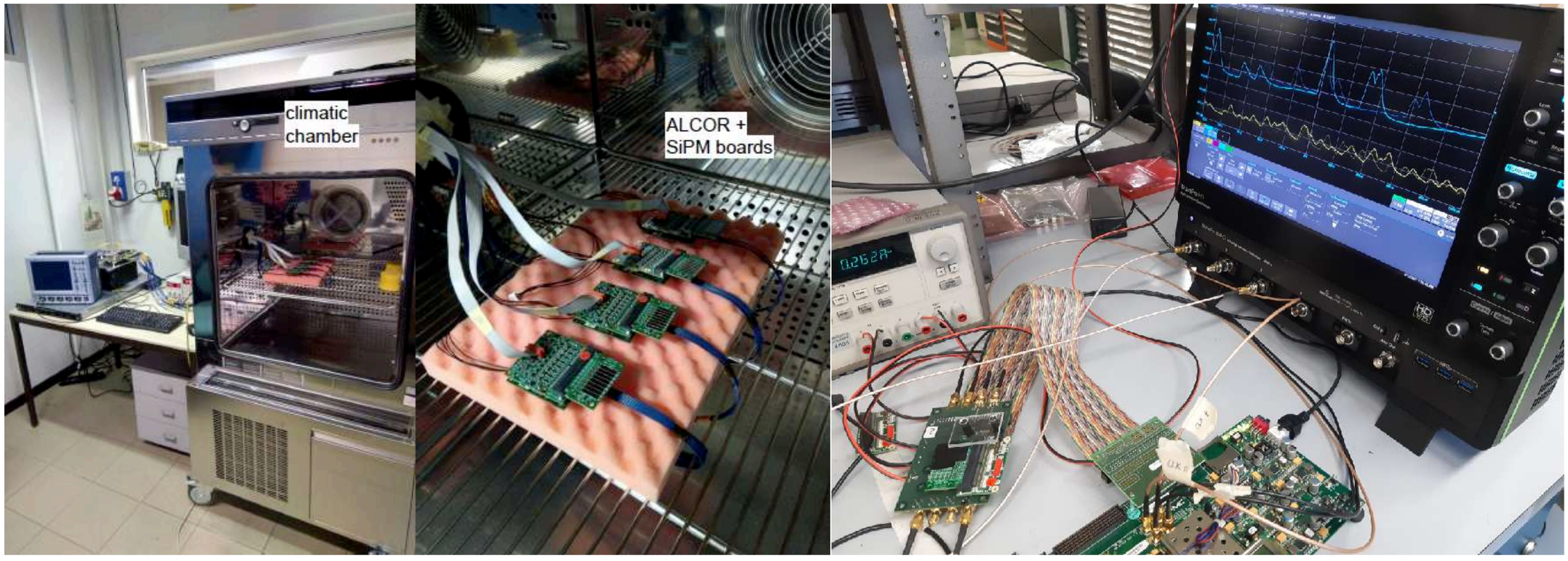
Study the SiPM+ALCOR response to the single photon regime





ALCOR-V2: SCHEDULE AND PLAN

- Submission mid of April 2022
- We should receive the new ASICs (~ 40) by the end of July 2022
- Until November: tests in LAB (electrical and functional tests; tests with irradiated SiPMs)
- Possibly test-beam in October/November at CERN PS: dRich+SIPMs+ALCOR-v2
- Test beam in September at CERN SPS: dRich+SIPMs+ALCOR-v1



DUAL RADIATOR RICH @ EIC: PROPOSTE DI TESI

➤ **A SiPM R&D program for the dRich @EIC**

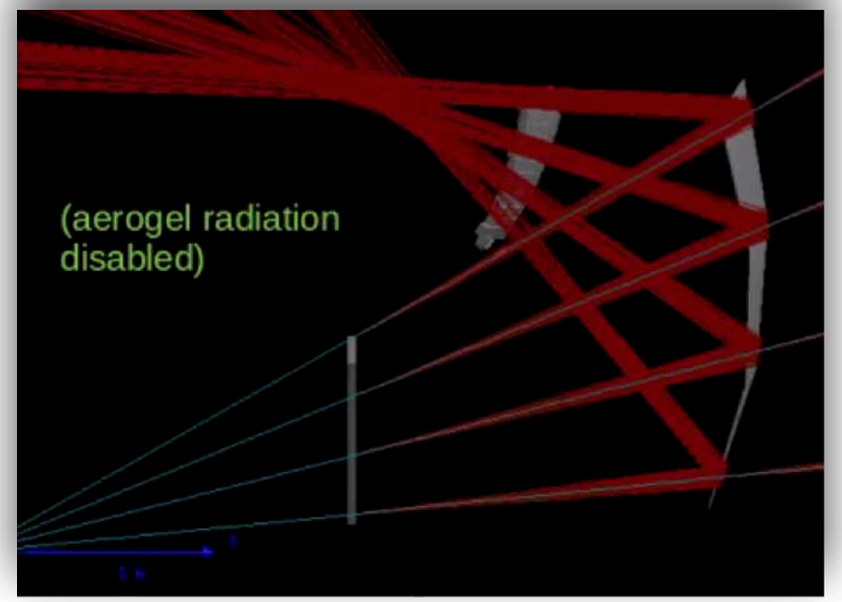
- Disponibile per tesi di laurea triennale e magistrale
- Periodo: da luglio 2022
- Collaborazione con i gruppi di Bologna e Ferrara
- Partecipazione ai test beam al CERN (settembre - novembre) per tesi di laurea magistrale

➤ **Monte Carlo Simulation for the dRich @EIC**

Disponibile per tesi di laurea magistrale

Periodo: da maggio 2022

Collaborazione con i gruppi di Roma 1, Trieste



Per informazioni:
Prof. Michela Chiosso
michela.chiosso@unito.it

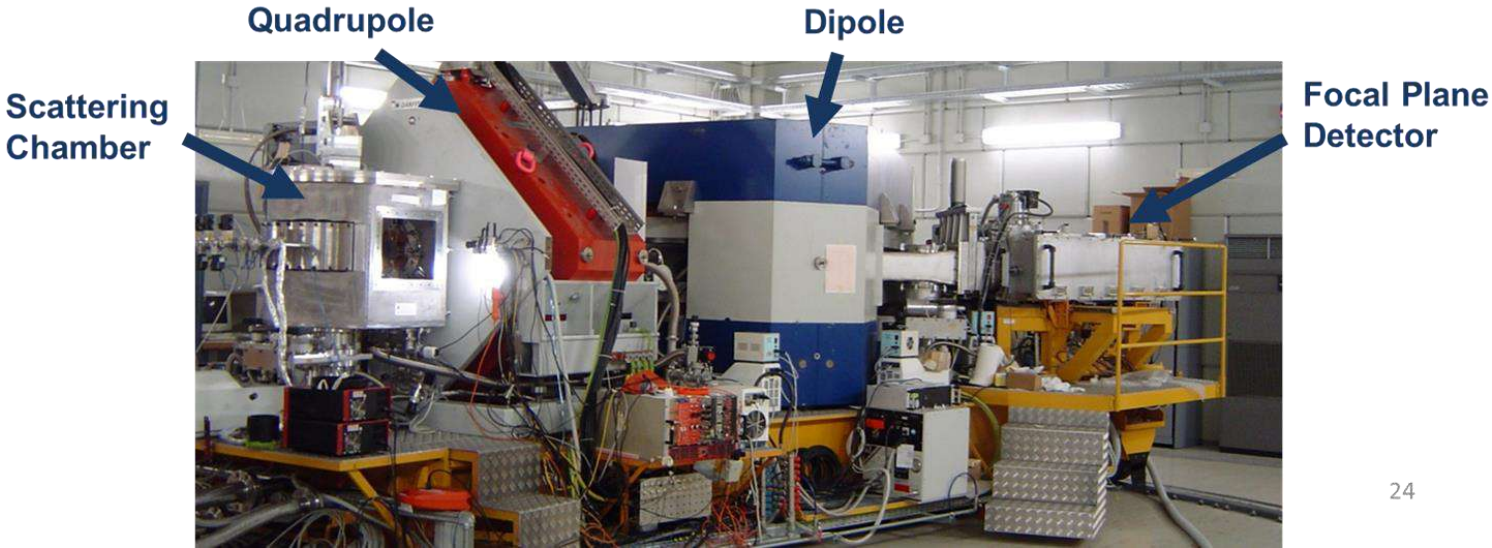
NUMEN (Nuclear Matrix Elements for Neutrinoless double beta decay)

Collaborazione internazionale
(Italia, Brasile, Grecia, Germania, messico, Sud Africa,..)

Il doppio decadimento beta senza neutrini e' il miglior strumento di indagine per determinare se il neutrino e' una particella di Dirac o di Majorana e determinare la massa effettiva del neutrino.

Informazioni sui relativi elementi della matrice nucleare possono essere ottenute ricorrendo a **reazioni di doppio scambio di carica indotte da ioni pesanti** su nuclei di interesse, grazie alla similitudine di questi processi.

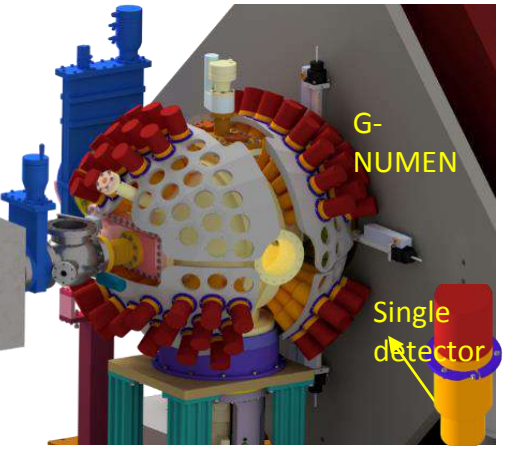
I primi **RUN PILOTA** sono stati eseguiti nei **Laboratori del Sud dell'INFN (Catania)** con il pre-esistente **spettrometro magnetico MAGNEX** e fasci di ioni (10^{10} ioni/s)

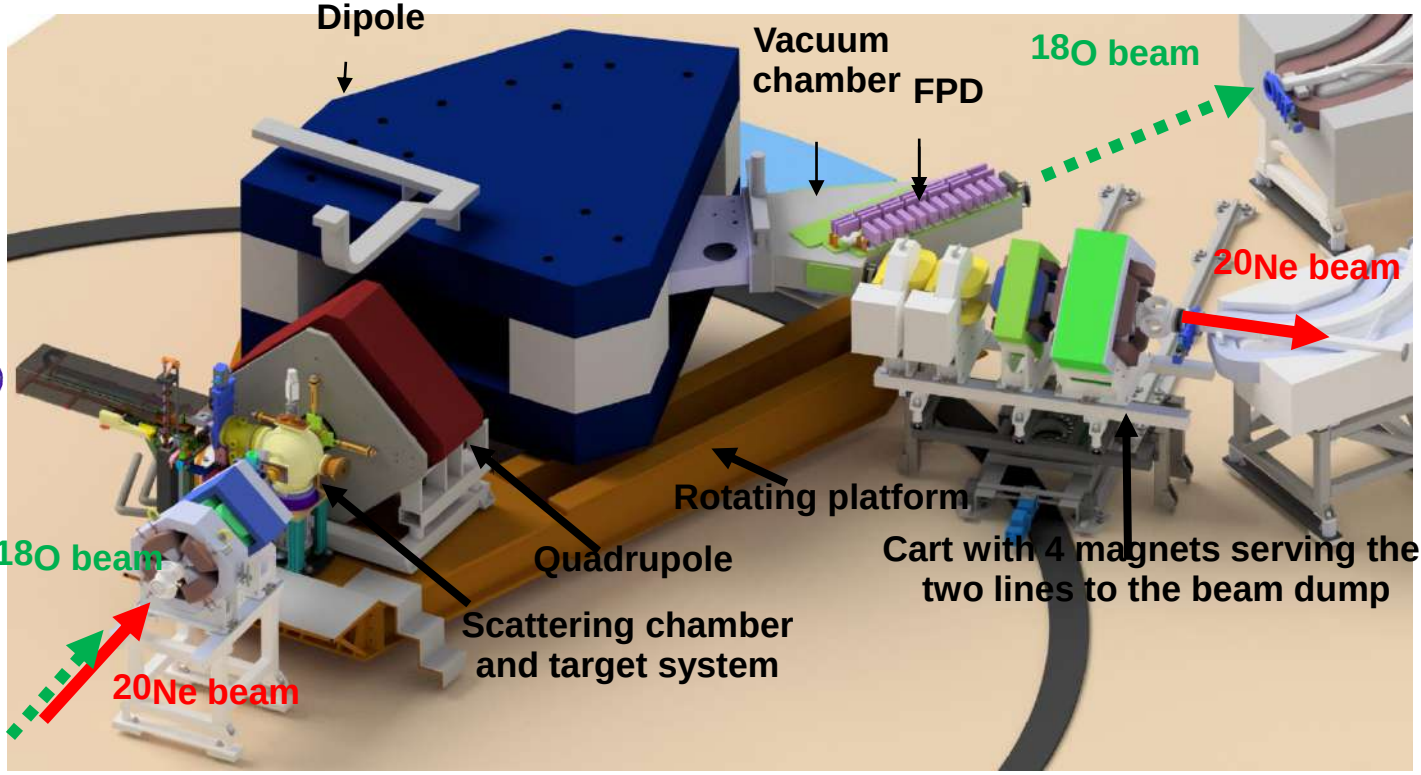


Upgrade di MAGNEX per fasci di ioni fino a 10^{13} ioni/s

Torino collabora a:

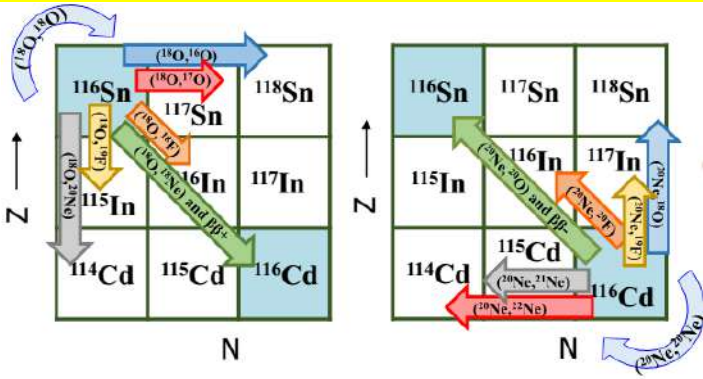
- Sviluppo dei **bersagli** con una tecnica innovativa
- Sviluppo delle colonne del Particle Identification Wall (che insieme al tracciatore costituiscono i rivelatori di piano focale-FPD), che includono sensori di carburo di silicio (**SiC**), prima applicazione, e ioduro di cesio (CsI)
- Sviluppo di G-NUMEN, matrice di sensori di **$LaBr_3$** per la rivelazione di raggi gamma



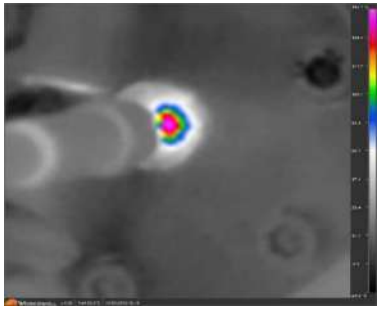


Tesi disponibili

- Analisi di dati per le due classi di reazioni di doppio scambio di carica: (^{18}O,^{18}Ne,) con gli isotopi ^{48}Ti, ^{76}Se, ^{116}Sn , ^{40}Ca, ^{12}C e (^{20}Ne,^{20}O) con ^{116}Cd, ^{130}Te, ^{76}Ge.



- Studio, costruzione e ottimizzazione di un banco di prova per la caratterizzazione dei prototipi di bersaglio.



- Studio e caratterizzazione di sensori SiC.

  Confronto con sensori di Silicio.

- Realizzazione di un sistema per l'acquisizione e la digitalizzazione di segnali da sensori prototipi

Contatto: Daniela Calvo
email: calvo@to.infn.it

Possibilita' di associazione all'INFN per copertura missioni a Catania, e per misure da effettuarsi ai Laboratori di Legnaro dell'INFN.