Attività di Gruppo III e preventivi 2022

Luciano L. Pappalardo
Consiglio di Sezione INFN
Ferrara, 06/07/2021

Il Gruppo III a Ferrara

Esperimenti:

- **JEDI (R.N. & R.L.: Paolo Lenisa)**
- **JLab12 (R.N. & R.L.: Marco Contalbrigo)**
- **EIC-Net (R.L.: Marco Contalbrigo)**

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Fisica:

- Misure di simmetrie fondamentali (P, T, CP) mediante ricerca di EDM in Storage Rings
- Studio della struttura interna degli adroni mediante misure di DIS
- Studio sperimentale dell'interazione forte nel regime non perturbativo
- Ricerca di DM: Assioni con Storage Ring e Dark Photon in Beam-dump experiments

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Tecnologie

- Tecnologie di polarizzazione (ABS, polarimetria, celle di accumulazion, etc)
- Sviluppo di rivelatori (tracciatori, RICH, SiPM, etc)
- Magneti superconduttori

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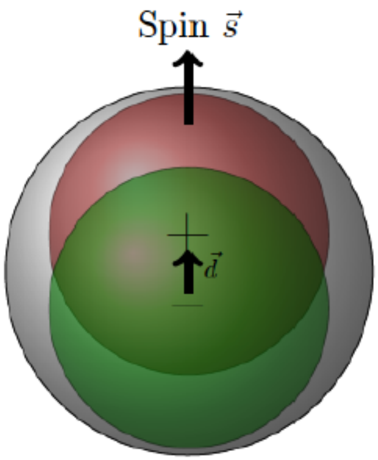
Principali Laboratori di riferimento
- FZ, Juelich, GE
- Jlab, USA
- BNL, USA

JEDI (R.N. & R.L.: Paolo Lenisa)

- EDM
- Test of fundamental symmetries (P, T, CP)

EDM of fundamental particles



- Permanent separation of + and − electric charge in a fundamental particle (including hadrons)
- It's a fundamental property of particles (like magnetic moment, mass, charge)

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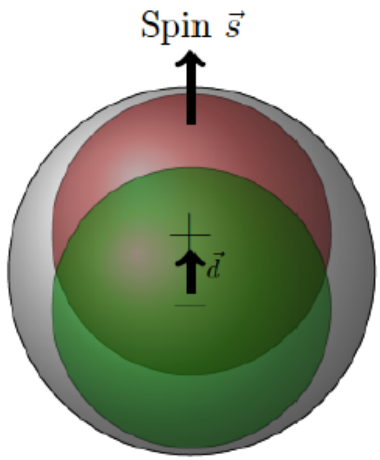

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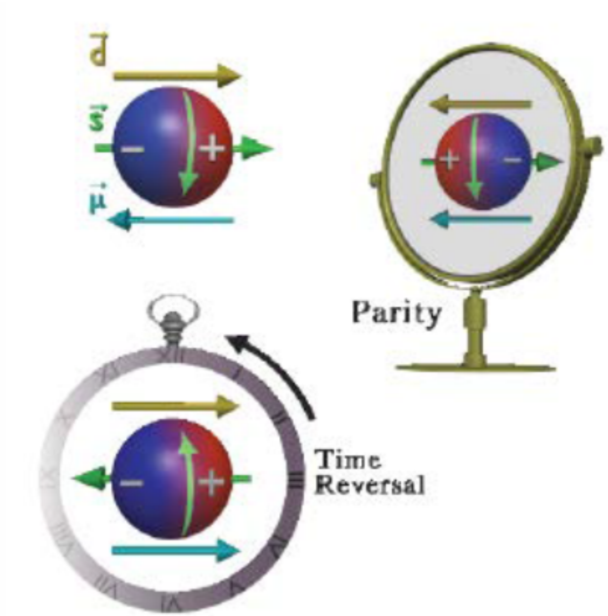


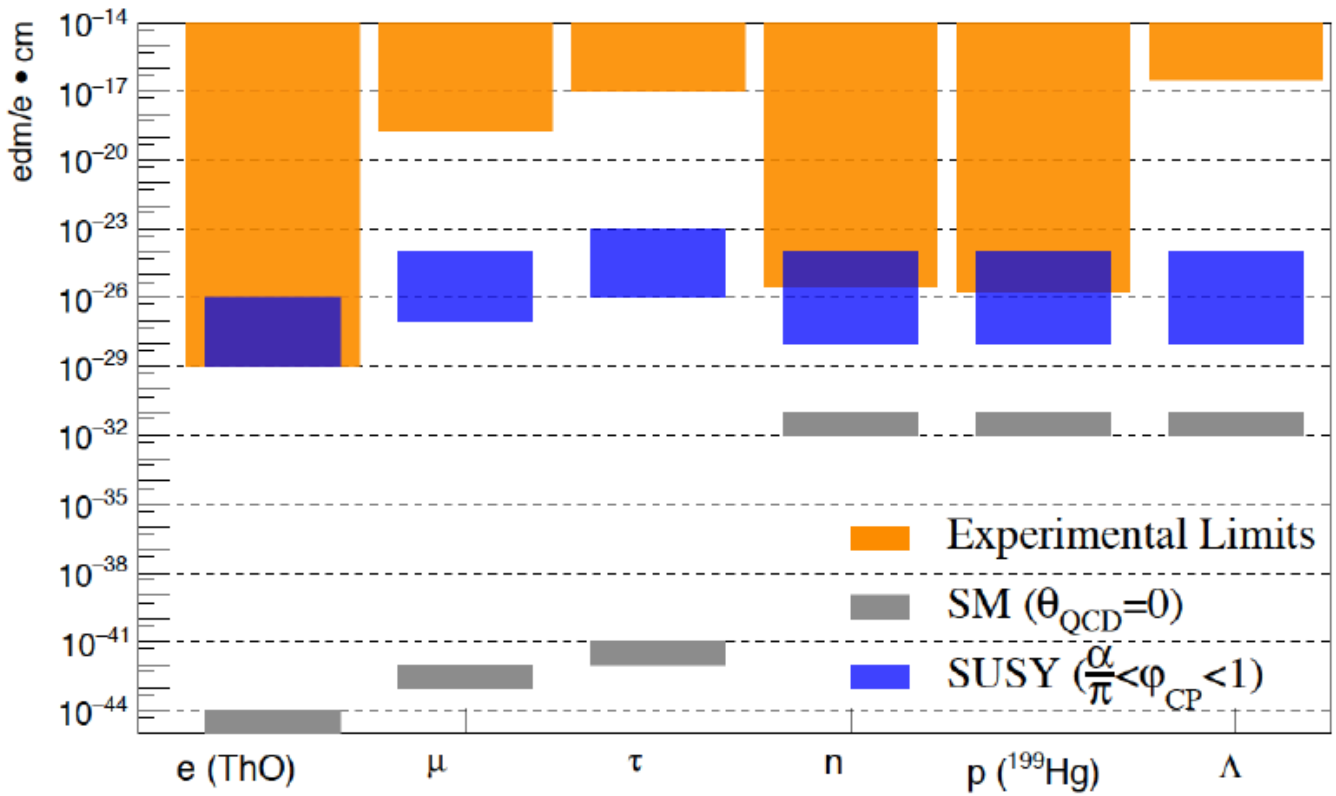
s: spin
μ: magnetic dipole moment
d: electric dipole moment

$H = -\mu \frac{\vec{s}}{s} \cdot \vec{B} - d \frac{\vec{s}}{s} \cdot \vec{E}$

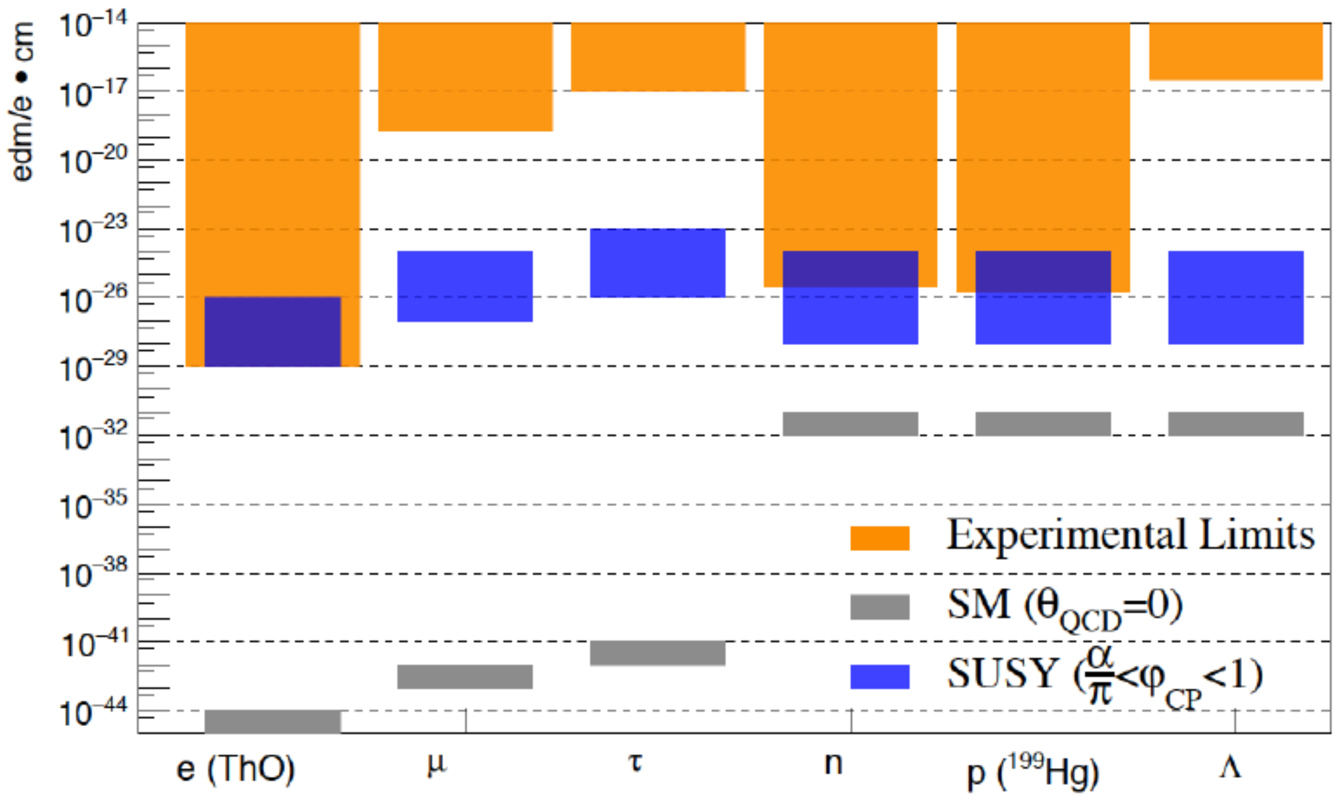
- T: $H = -\mu \frac{\vec{s}}{s} \cdot \vec{B} + d \frac{\vec{s}}{s} \cdot \vec{E}$
- P: $H = -\mu \frac{\vec{s}}{s} \cdot \vec{B} + d \frac{\vec{s}}{s} \cdot \vec{E}$

- Permanent EDMs violate P and T symmetries. Assuming CPT also CP must be violated
- A non-zero EDM could provide new sources of CP violations (beyond SM)
- Relevant for matter-antimatter asymmetry in the Universe

EDM upper limits



EDM upper limits

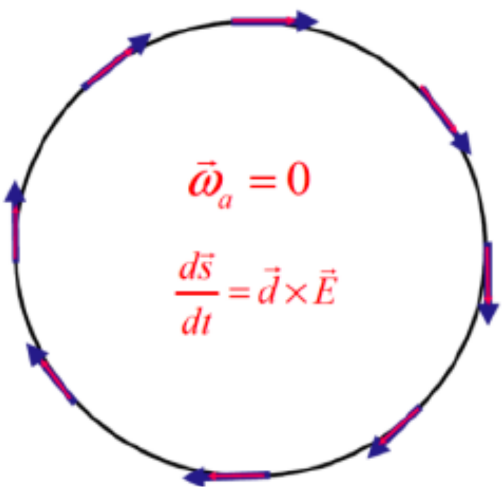


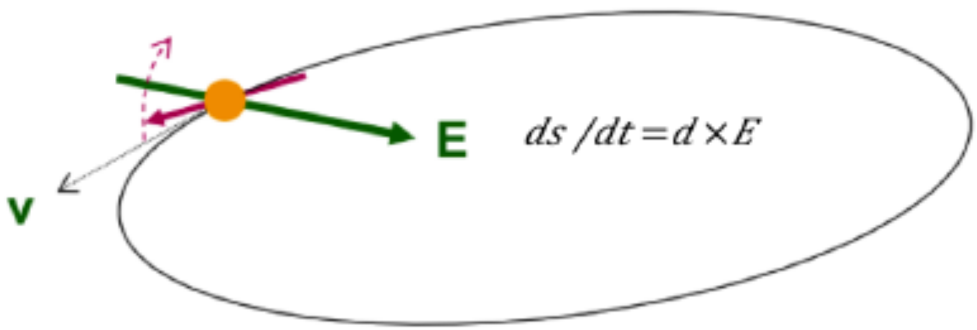
- Objective: EDMs of charged hadrons: p, d, $^3\mathrm{He}$
  - Note: current limit on p-EDM: $2.0 \times 10^{-25} e \cdot cm$ (ind. from $d_p^{\downarrow 199Hg}$)
- Final goal: to bring the limit on p to 10^{-29} e · cm

EDM search at Storage Rings

Procedure

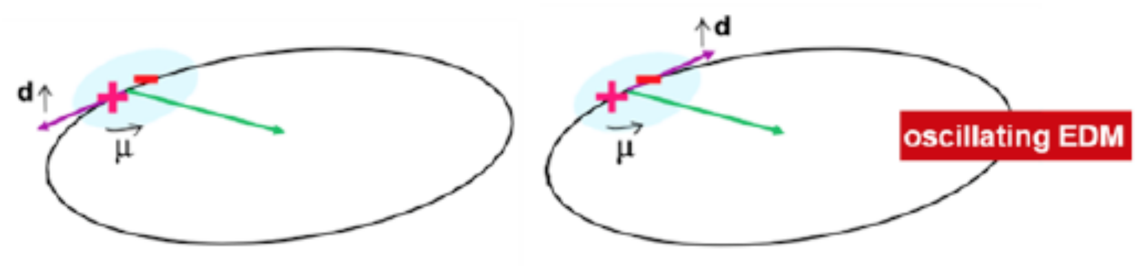
1. Inject particles in storage ring
2. Align spin along momentum ($\rightarrow$ freeze horiz. spin-precession)
3. Search for time development of vertical polarization





EDM search at Storage Rings

Interaction of Axions with ordinary matter (axion-gluon coupling $\frac{a}{f_0} G_{\mu\nu}\widetilde{G}^{\mu\nu}$) can produce a measurable oscillating EDM!



$$\vec{d} = \eta \frac{q\hbar}{2mc} \vec{S}$$

$$\eta = \eta_0 + \eta_1 \sin(\omega_{\text{axion}} t + \varphi_a)$$

$$\omega_{\text{axion}} = \frac{m_a c^2}{\hbar}$$

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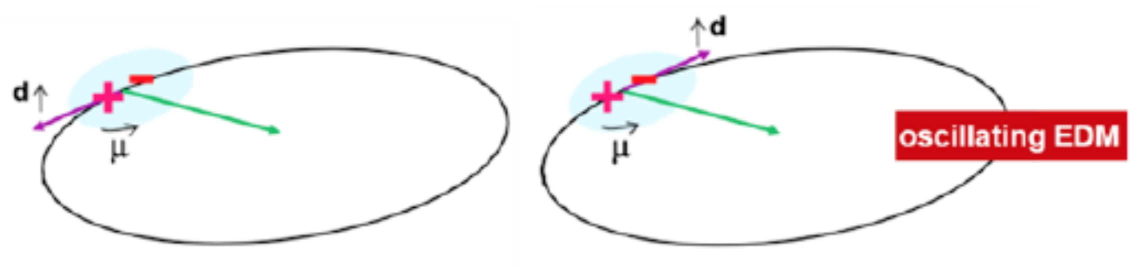

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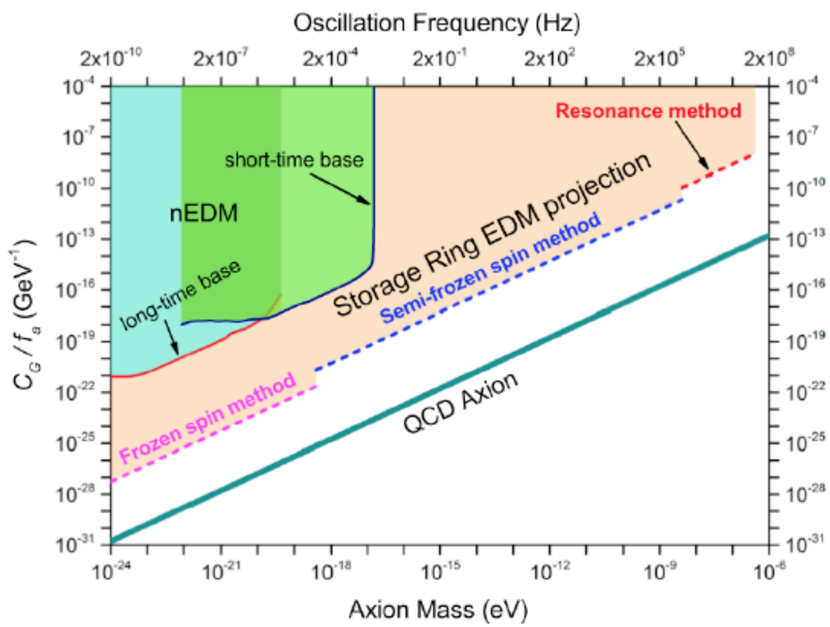

[S. P. Chang et al. Phys. Rev. D 99, 083002]

EDM search at Storage Rings

High precision, primarily electric storage ring

- Crucial role of alignment, stability, field homogeneity and shielding from *unwanted* magnetic fields.
- High beam intensity: $N=4 \cdot 10^{10}$ per fill
- Polarized hadron beams: $P=0.8$
- Long spin coherence time: $\tau = 1000$ s
- Large electric fields: $E \sim 10$ MV/m
- Efficient polarimetry with:
  - large analyzing power: $A = 0.6$
  - high efficiency detection: eff. $= 0.005$

EDM search at COSY

The JEDI Collab. aims at the measurement of EDM of charged particles (p,d, ^3He) at the **COSY Storage Ring** (FZ Juelich)

- No direct measurement for charged hadron EDMs
- Potentially higher sensitivity (compared to neutrons):
  - longer lifetime;
  - more stored protons/deuterons
  - can apply larger electric fields in storage rings
- complementary to neutron EDM:

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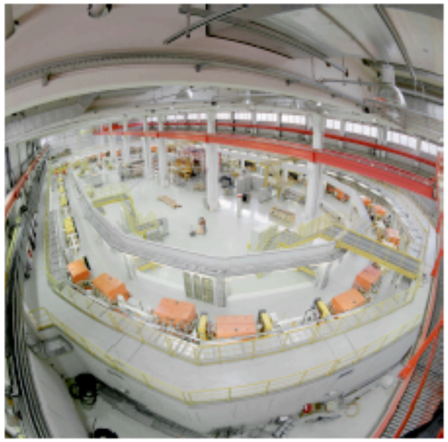
Expected statistical sensitivity in 1 year of DT:

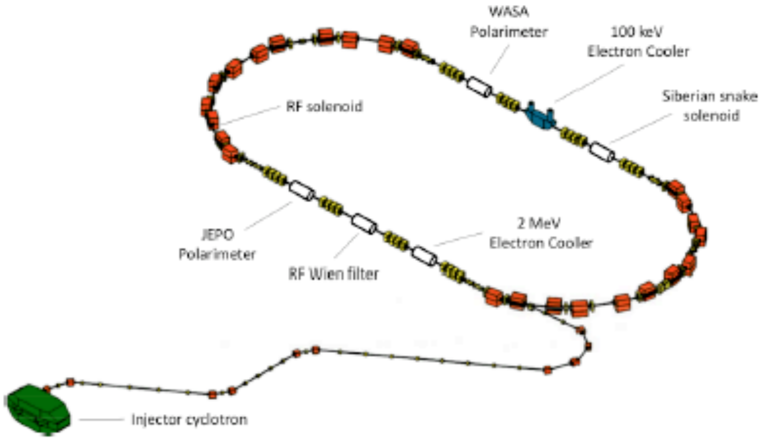
- $\sigma_{stat} = \frac{\hbar}{\sqrt{Nf\tau PAE}} \Rightarrow \sigma_{stat} = 10^{-29} e \cdot cm$
- Experimentalist's goal: provide σ_{syst} to the same level.

EDM search at COSY

COoler SYnchrotron COSY

- Cooler and storage ring for (pol.) protons and deuterons.
- Momenta p= 0.3-3.7 GeV/c
- Phase-space cooled internal and extracted beams



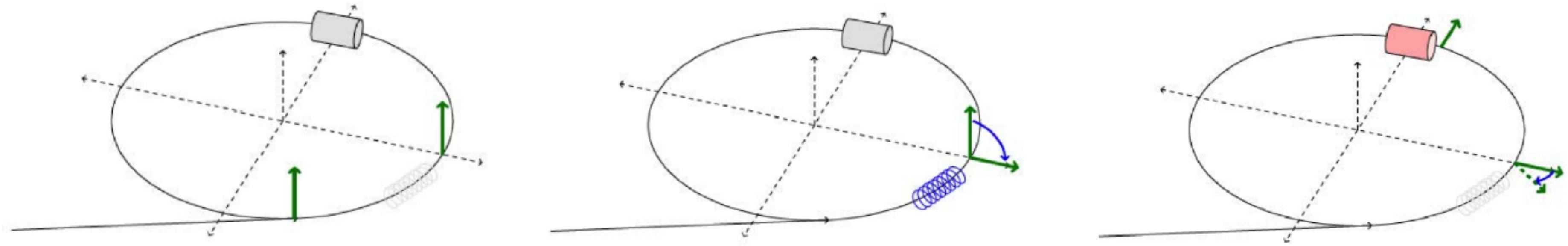


Previously used as spin-physics machine for hadron physics:

- Ideal starting point for srEDM related R&D
- Dedicated and unique experimental effort worldwide

EDM search at COSY: Procedure

1. Inject and accelerate vertically pol. deuterons up to $p \approx 1\ GeV$
2. Flip spin into horizontal plane using solenoidal magnetic fields
3. Exploit **spin-asymmetry** measurements in elastic deuteron-carbon scattering to determine the spin precession (polarimeter)



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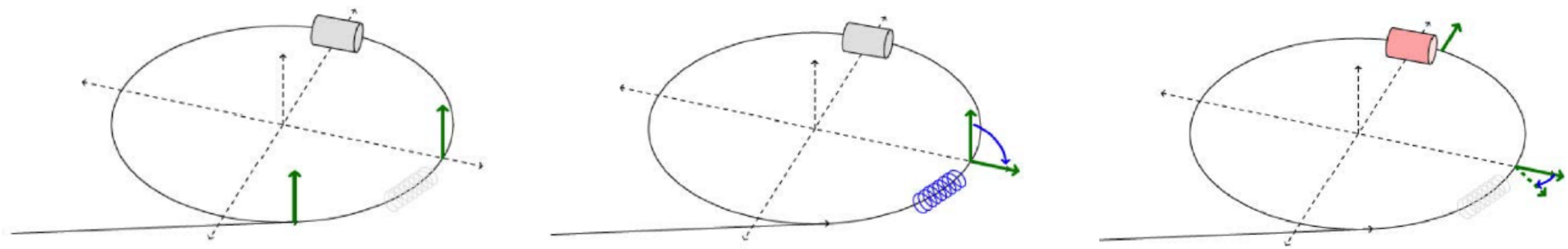


$$\varepsilon_H = \frac{U-D}{U+D} \propto p_H A_x$$

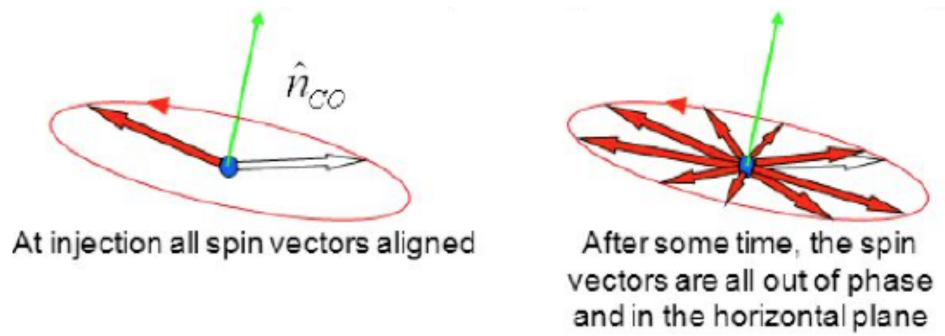
HORIZONTAL polarization — Analyzing power

$$\varepsilon_V = \frac{L-R}{L+R} \propto p_V A_y$$

VERTICAL polarization — Analyzing power

sensitive to EDM

EDM search at COSY: Spin-Coherence Time



- **Critical requirement: long Spin-Coherence Time (τ_{SCT}):** spin of all particles preceding with the same frequency
- Large value of SCT of crucial importance since: $\sigma_{Stat} \propto \frac{1}{\tau_{SCT}}$

EDM search at COSY: Spin-Coherence Time

At injection all spin vectors aligned

After some time, the spin vectors are all out of phase and in the horizontal plane

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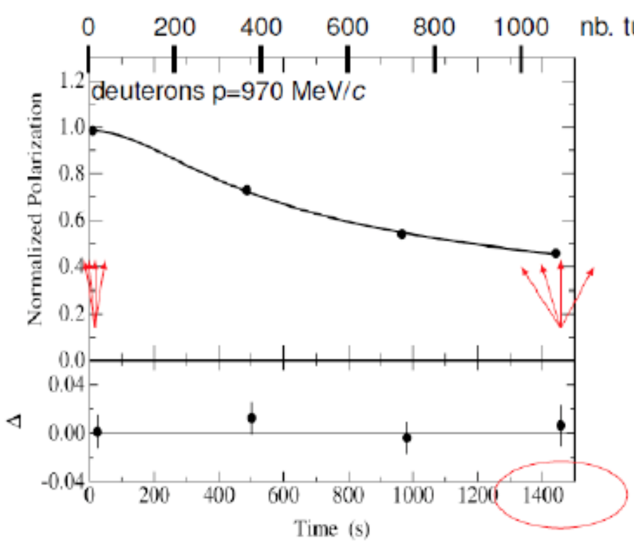
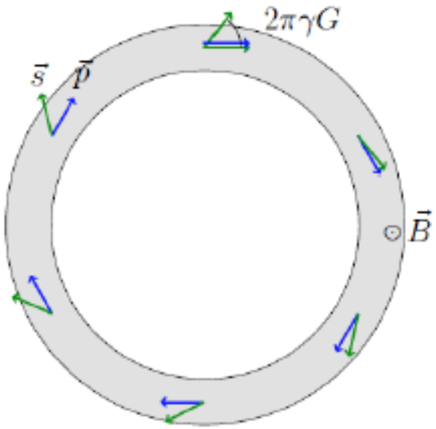
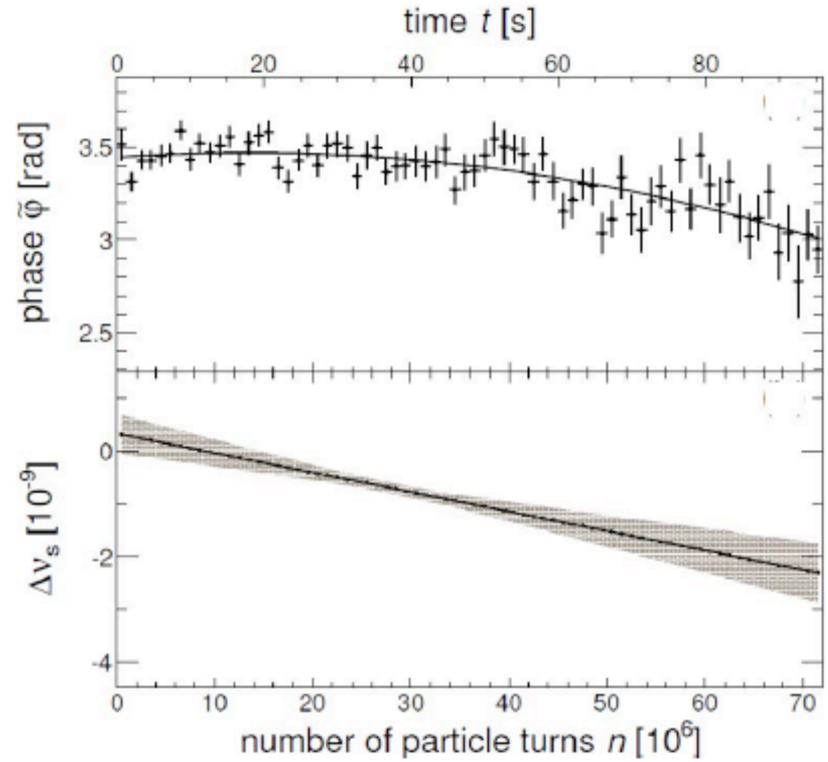


Major achievement

- $\tau_{SCT} = (782 \pm 117)$s
- Previously: τ_{SCT}(VEPP) ≈ 0.5 s ($\approx 10^7$ spin revolutions)

EDM search at COSY: spin tune





Spin-tune ν_s

$$\nu_s = \gamma G = \frac{nb.spin-rotations}{nb.particle-revolutions}$$

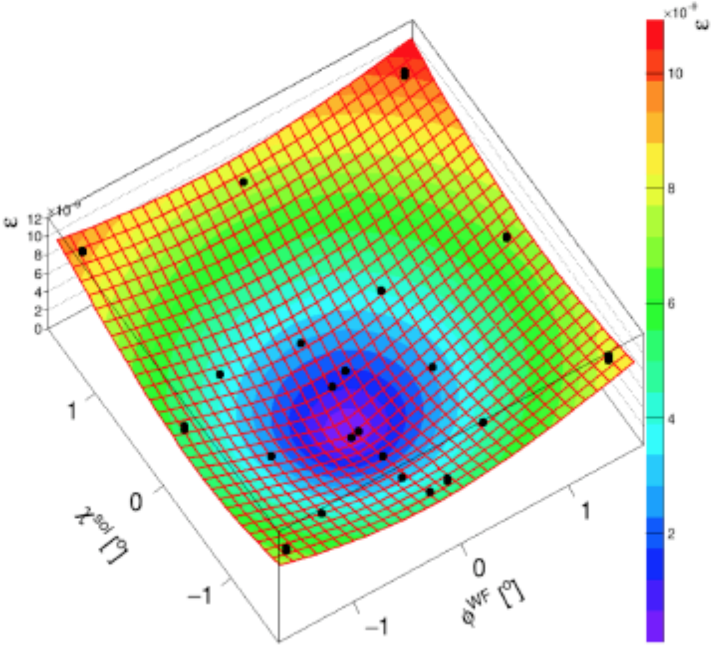
II major achievement *[Phys. Rev. Lett. 115 (2015) 094801]*

- Interpolated spin tune in 100 s:
- $|\nu_s| = (16097540628.3 \pm 9.7) \times 10^{-11}$ $(\Delta\nu_s/\nu_s \approx 10^{-10})$
- Angle precision: $2\pi \times 10^{-10} = 0.6$ nrad
- Previous best: 3×10^{-8} per year (g-2 experiment)
- $\rightarrow$ new tool to study systematic effects in storage rings

EDM search at COSY: first results

First precursor run (Nov. 18)

- 31 points measured
- 2 weeks of measurement
- Parametric resonance strength based on initial slope
- Precession axis RF WF determined from the minimum of the surface:
  $\phi_0^{wf} = -3.80 \pm 0.05$ mrad
  χ_0^{sol} = - 5.51 $\pm$ 0.05 mrad
- Spin tracking to provide orientation of precession axis without EDM



Compatible with $d_D < 10^{-19}$ e·cm

EDM search at COSY: second run

Improvements

- Alignment campaigns of COSY magnet system
- Beam-based alignment
- New tool for fast tune and chromaticity measurement
- Slow control system
- COSY signals and distribution improved
- Rogowski coils at the Wien filter place
- New JEDI polarimeter
- 8 high-speed RF switchers to gate the WF power for one of the bunches

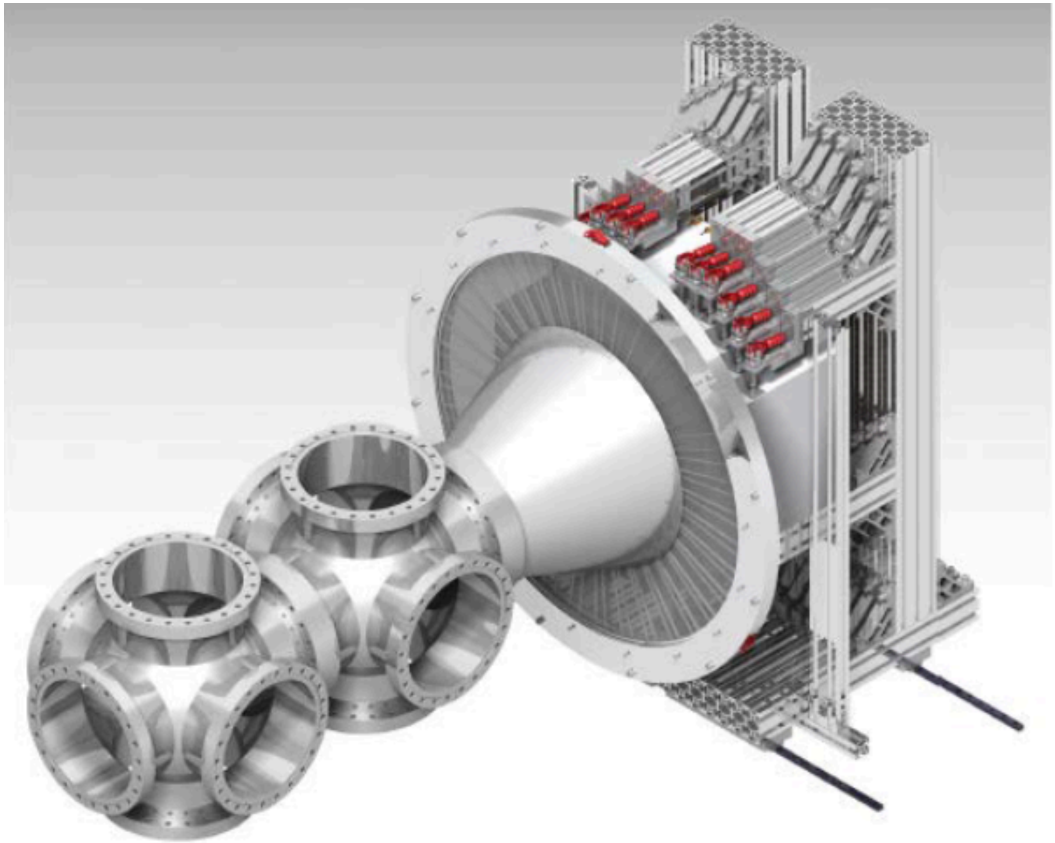
Second precursor (Mar.-Apr. 2021)

- 3.5 weeks of data taking
- 9 Maps
- Two methods successfully used:
  - Initial polarization build up
  - Pilot bunch

Final results by end of 2021

Ferrara contributions:

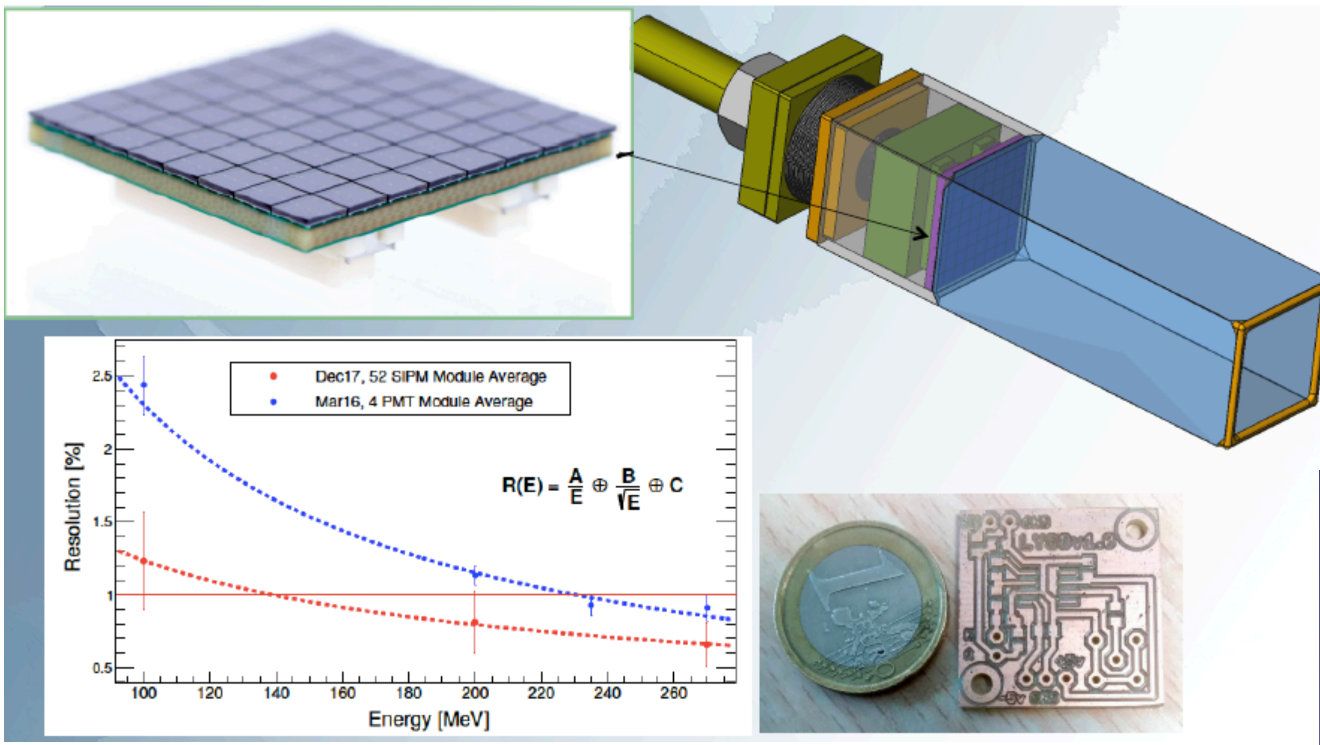
1. Development of a new high-efficiency beam polarimeter

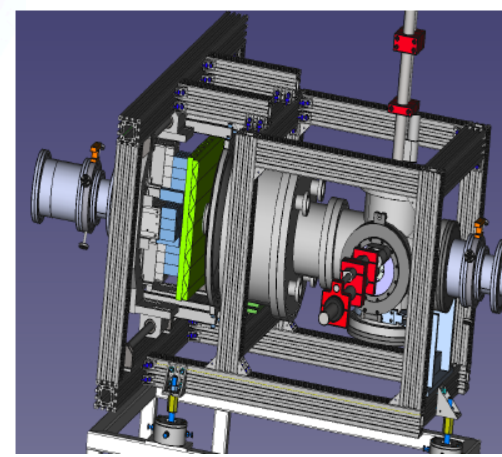


Ferrara contributions:

2. LYSO scint. + SiPM readout system for the polarimeter (installed)

(S. Basile, L. Barion, N. Canale, R. Malaguti, P. Lenisa)





Plans for the future

Stage 1

precursor experiment

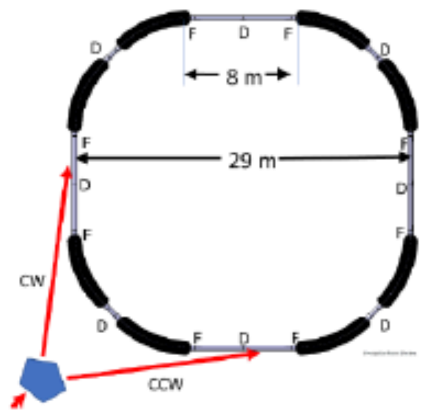
at COSY (FZ Jülich)

- magnetic storage ring

now

Stage 2

prototype ring

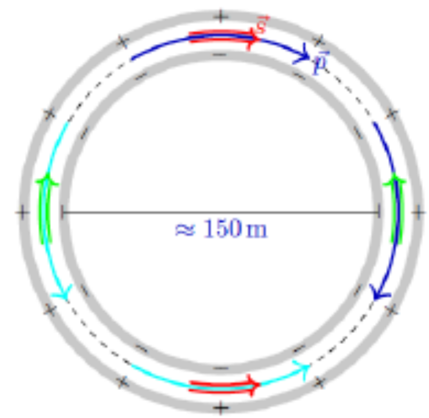


- electrostatic storage ring
- simultaneous ↻ and ↺ beams

5 years

Stage 3

dedicated storage ring



- magic momentum

(701 MeV/c)

10 years

$\sigma_{EDM}/(e \cdot \mathrm{cm})$

10^{-17} 10^{-18} 10^{-19} 10^{-20} 10^{-21} 10^{-22} 10^{-23} 10^{-24} 10^{-25} 10^{-26} 10^{-27} 10^{-28} 10^{-29}

Perspectives

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- Collaboration activity oriented in perspective of next steps of the research
  - Prototype EDM ring for the search of the proton-EDM (→ next slides)
- Beam-time (COSY operation guaranteed till 2024:
  - Study of the proton-spin coherence time
  - Axion search
- Developments
  - Prototype ring design and beam & spin-tracking simulations
  - Low-energy (35 MeV) sampling polarimeter
  - Electrostatic deflectors

Perspectives and Responsibilities

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INFN responsibilities in JEDI Collaboration

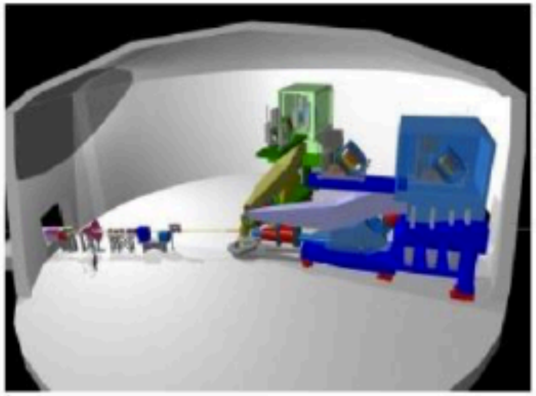
- Co-Spokesperson: P.L.
- Data analysis: S. Dymov, A. Saleev, V. Shmakova
- Polarimeter: N. Canale, L. Barion, V. Carassiti, A. Pesce, R. Shankar, P.L.
- Spin-tracking simulations: R. Shankar

JLab12 (R.N. & R.L.: Marco Contalbrigo)

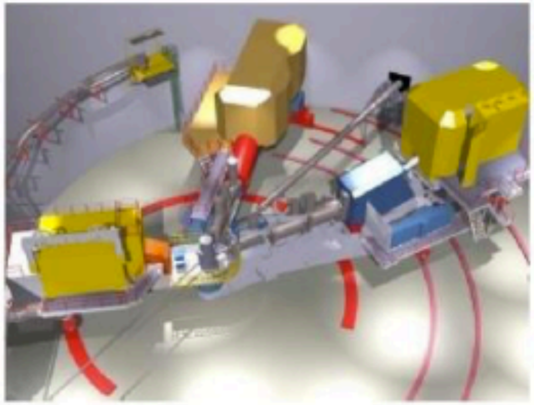
- Nucleon structure and spin physics
- Transverse momentum phenomena (TMDs) & 3D imaging
- GPDs & EM Form Factors of the nucleon

Jlab12 Italia (R.N. & R.L. M. Contalbrigo)

Hall A – Spettrometri ad alta risoluzione e un nuovo rivelatore multipurpose a grande accettanza



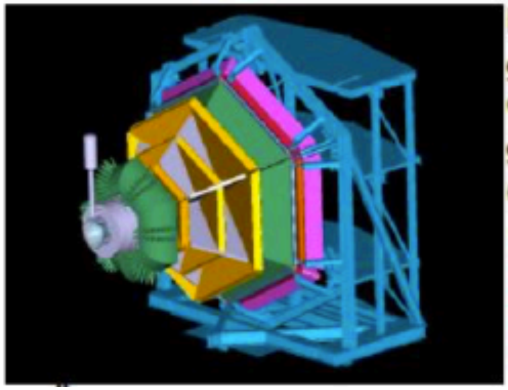
short range correlations, fattori di forma e nuovi esperimenti : SOLID, MOELLER, SBS



Hall C – Super High Momentum Spectrometer (SHMS)

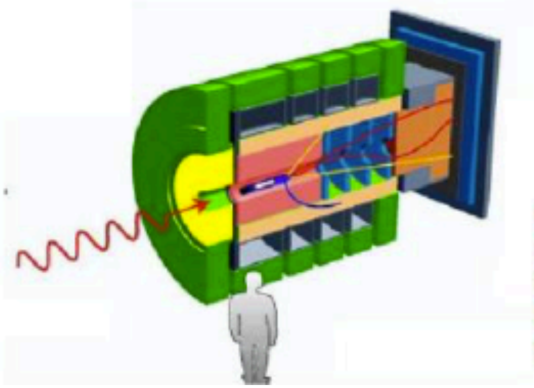
Determinazione precisa delle proprietà dei q di valenza nei nucleoni e nei nuclei

Hall D – Rivelatore GLUEx per esperimenti di fotoproduzione



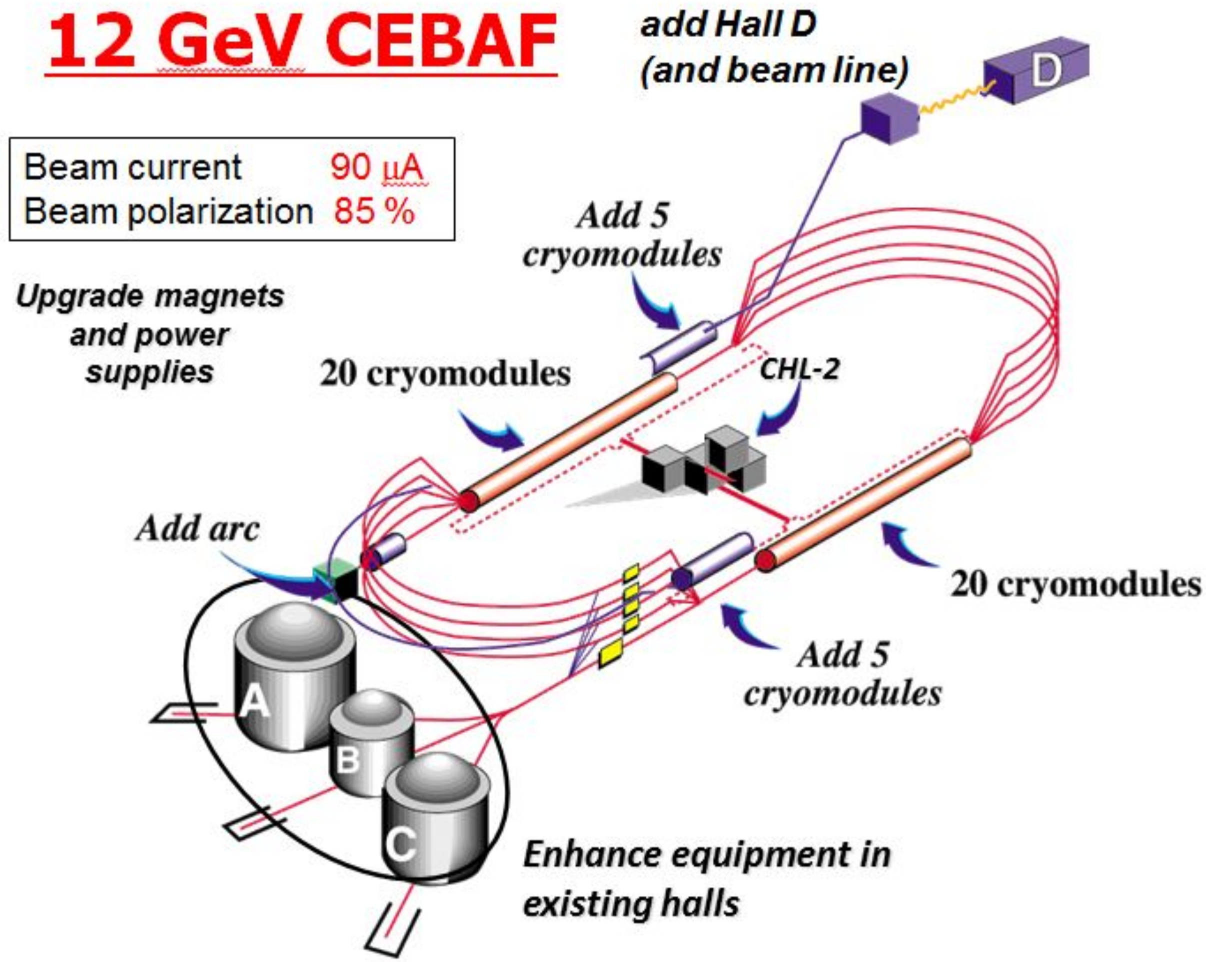
Hall B – Rivelatore a grande accettanza CLAS12 for misure a grande luminosità ($10^{35} cm^{-2} s^{-1}$)

Comprensione della struttura del nucleone via GPDs and TMDs e spettroscopia adronica



Le origini del confinamento attraverso lo studio dei mesoni ibridi

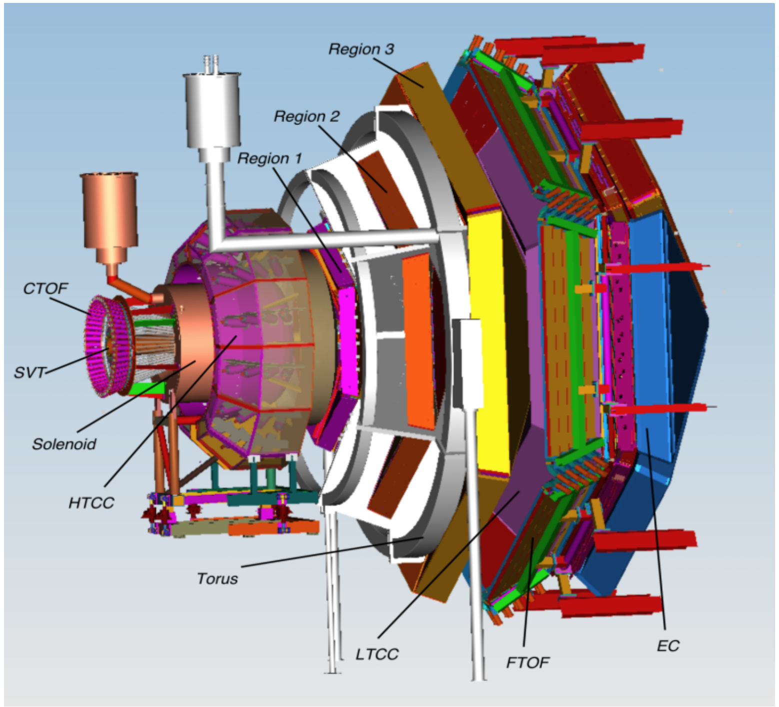
CLAS12 Experiment in Hall-B

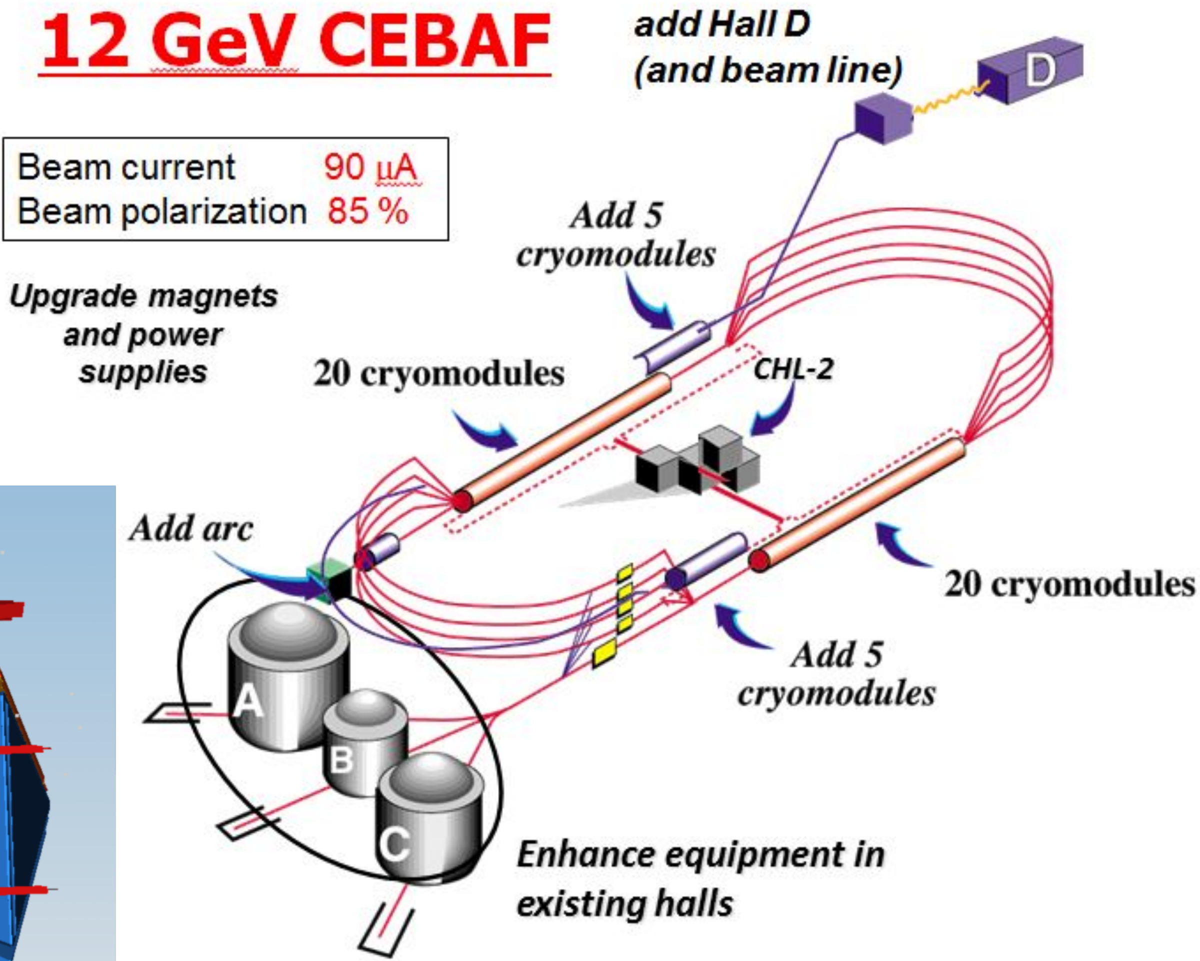


CLAS12 Experiment in Hall-B

CLAS12 detector

- **Lumi up to $10^{35}\ cm^{-2}s^{-1}$**
- High polarized electron beams
- **H and D polarized target**
- **Broad kinematic range**
- **Very good PID**





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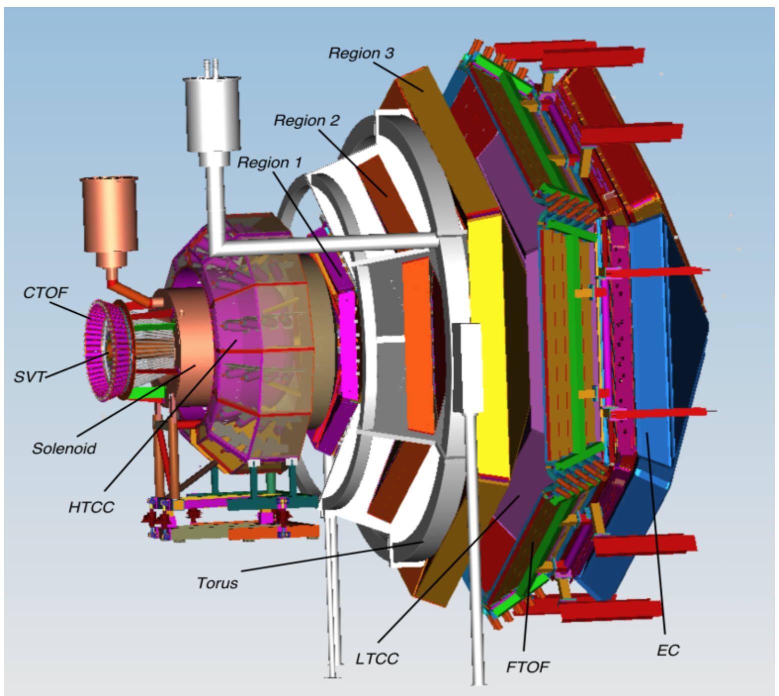
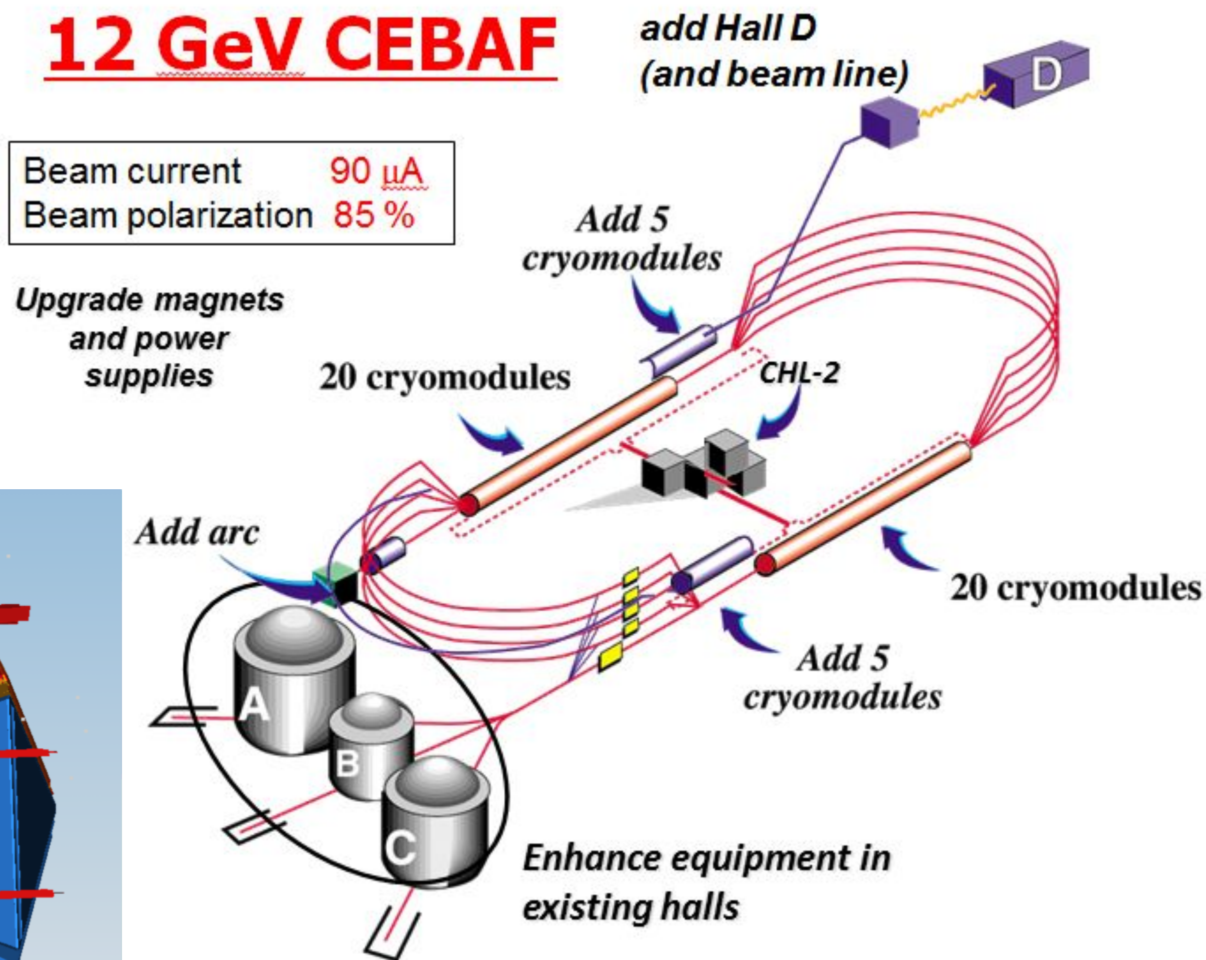
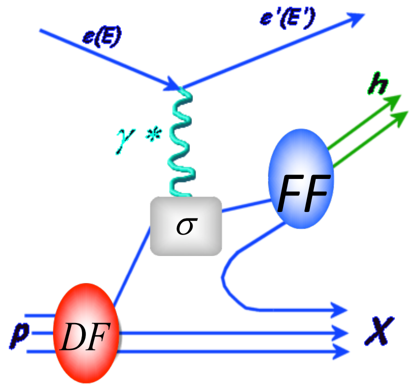
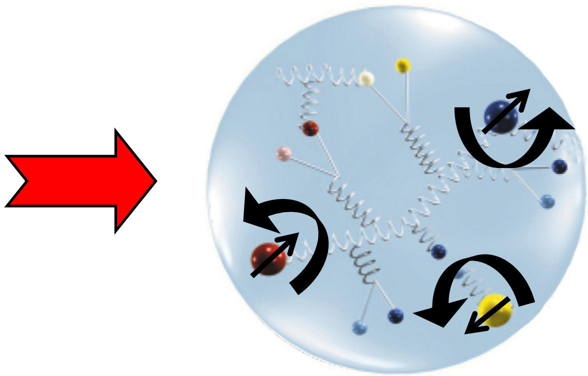


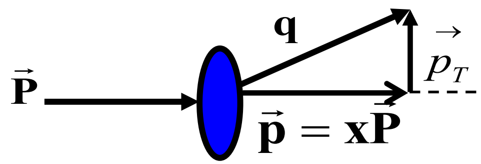


Physics program:
- Hadron spectroscopy
- Nuclear effects in hadronization
- **Nucleon structure** (TMDs, GPDs)

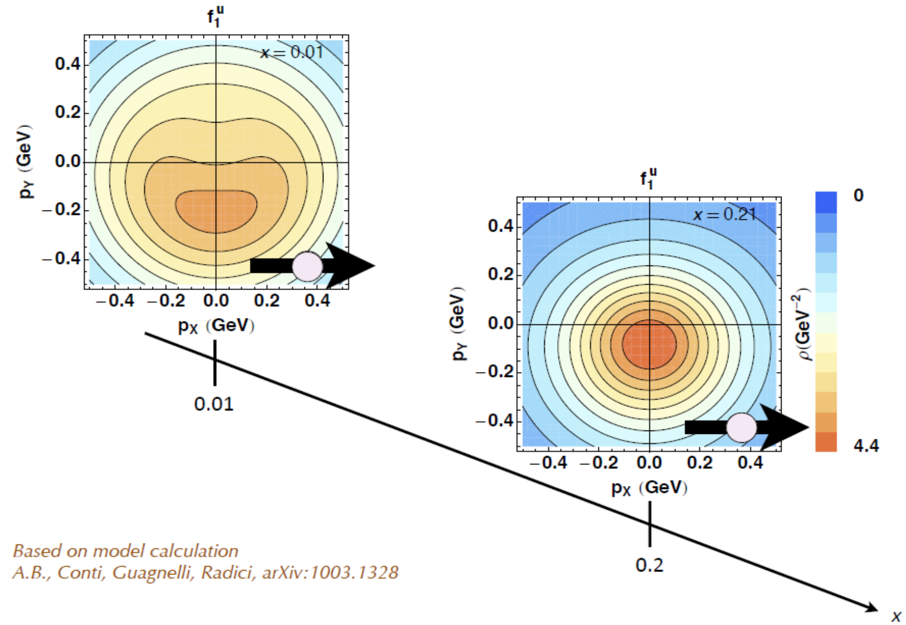
CLAS12 Experiment in Hall-B

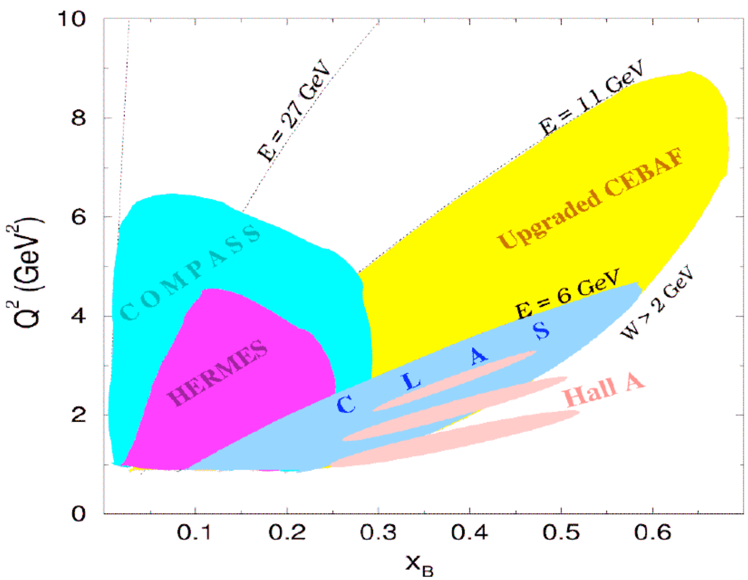






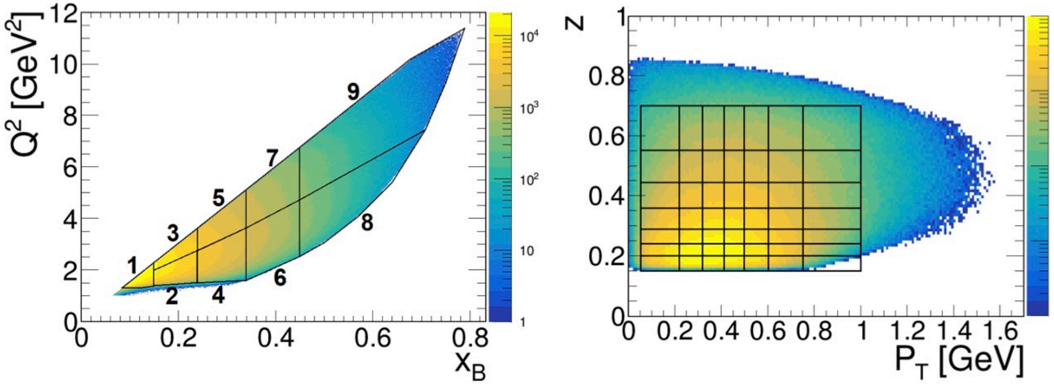
- TMDs depend on x and p_T
- Describe correlations between p_T and quark or nucleon spin (**spin-orbit correlations**)
- Provide **a 3-dim picture** of the nucleon in momentum space (**nucleon tomography**)

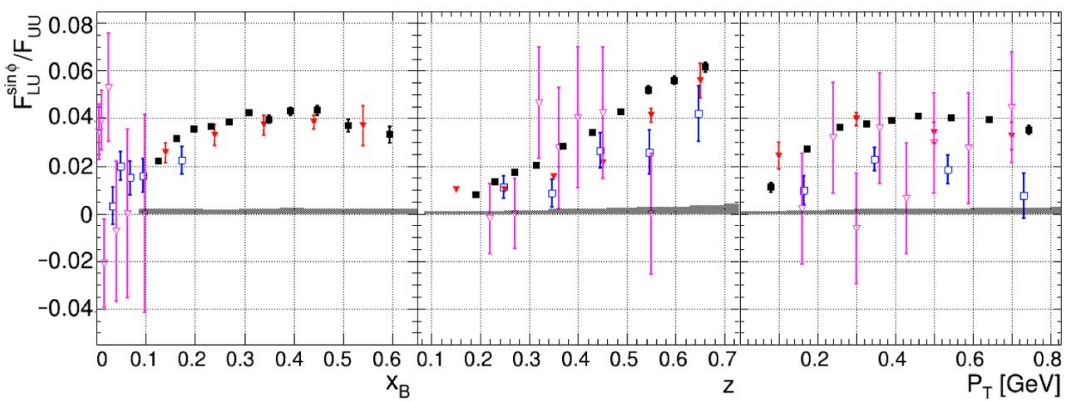




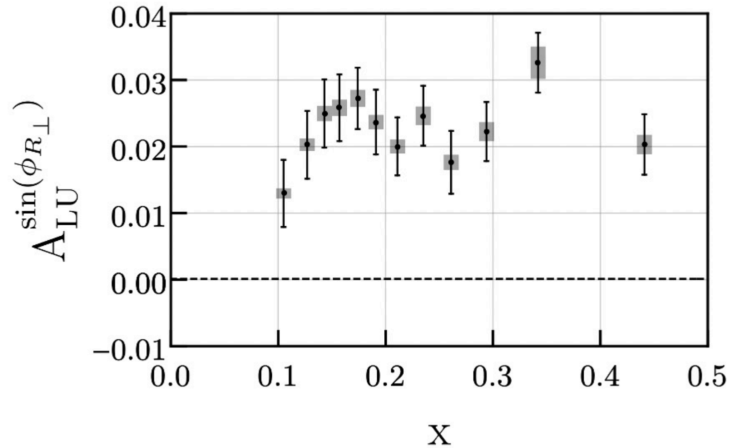
Entering the 12 GeV Era:

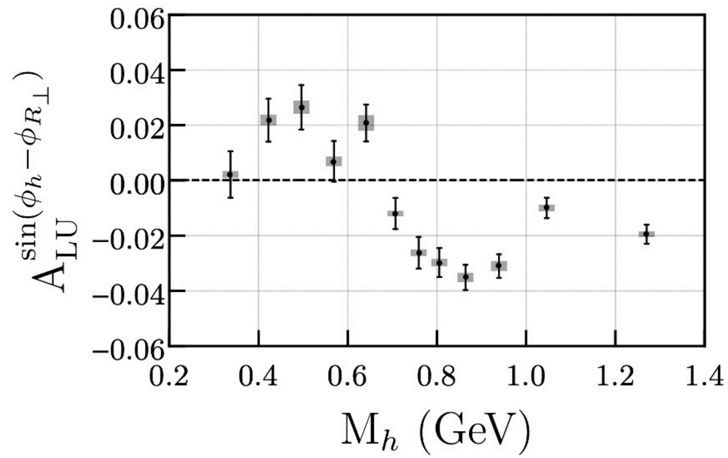
e-Print: 2101.03544 (submitted to PRL)





PRL 126 (2021) 152501





Unprecedented precision in the valence region

New observables in fragmentation

The RICH detector project

Physics Program	Particle Identification Requirement
Internal nucleon dynamics	Flavour tagging
Quark hadronisation in nuclear medium	Constraining models
Spectroscopy	Rare processes

RICH goal:

π/K/p separation of ~4 σ up to 8 GeV/c

for a pion rejection factor ~ **1:500**

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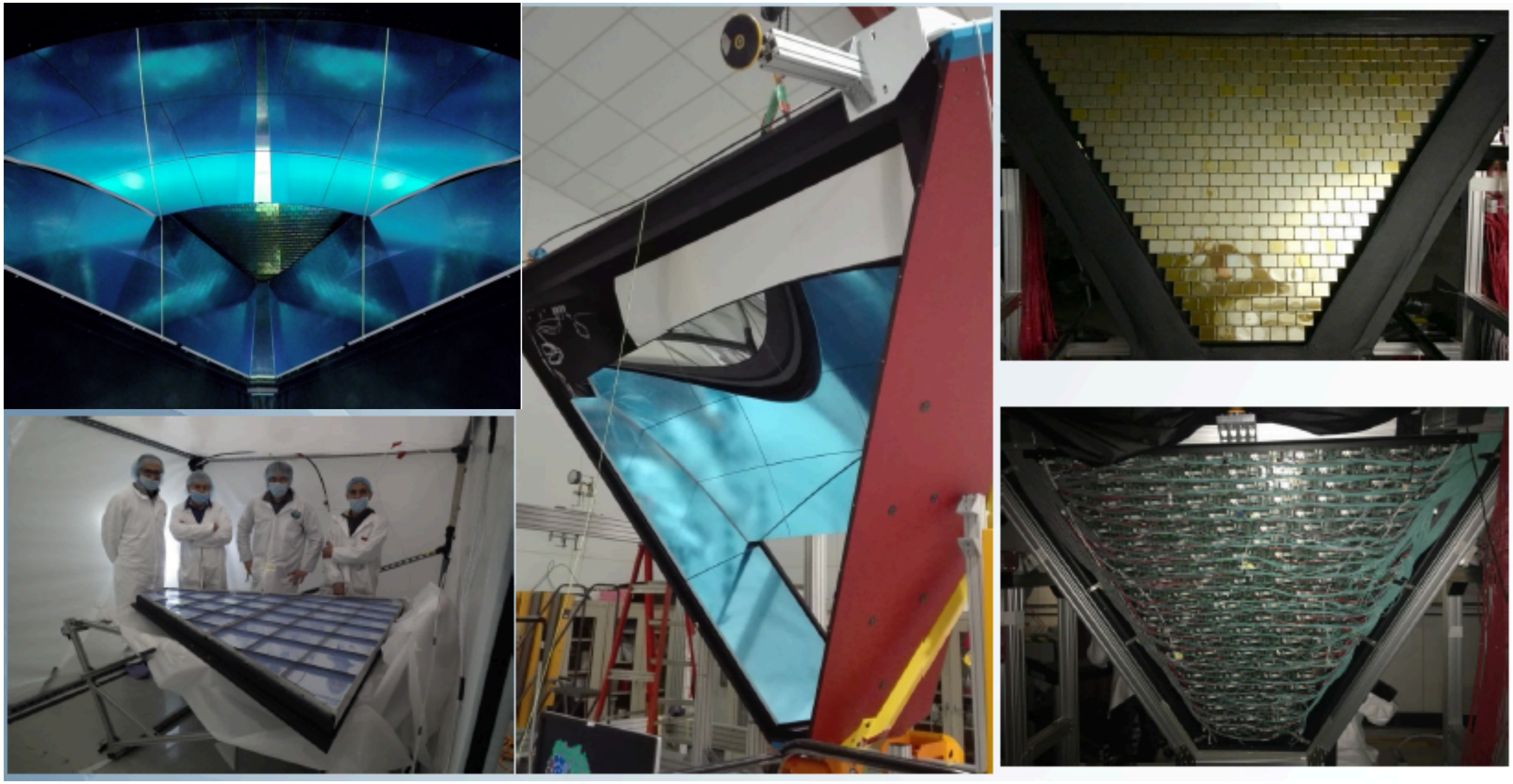
π/K/p separation of ~4 σ up to 8 GeV/c

for a pion rejection factor ~ **1:500**

INSTITUTIONS
INFN (Italy) Bari, Ferrara, Genova, L.Frascati, Roma/ISS
Jefferson Lab (Newport News, USA)
Argonne National Lab (Argonne, USA)
Duquesne University (Pittsburgh, USA)
George Washington University (USA)
Glasgow University (Glasgow, UK)
J. Gutenberg Universitat Mainz (Mainz, Germany)
Kyungpook National University, (Daegu, Korea)
University of Connecticut (Storrs, USA)
UTFSM (Valparaiso, Chile)

The RICH detector construction

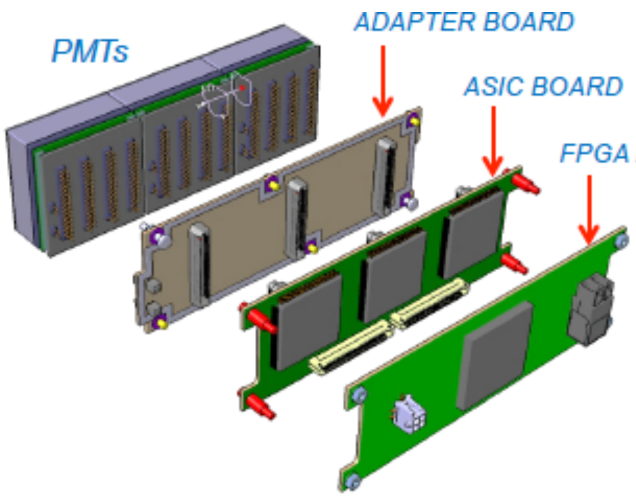


- **First module assembled in January 2018 and in operation**
- **Second module in preparation for beginning 2022**

The second RICH: Front-End electronics

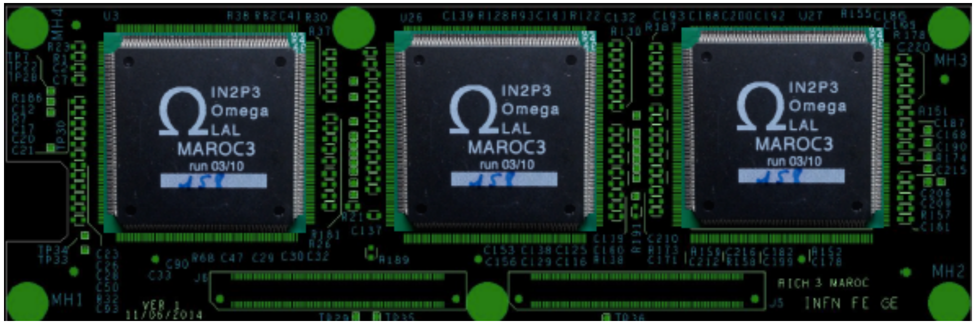
Compact and modular electronics to readout single-photon sensors: multi-anode PMTs, SiPM

Adopted by GlueX DIRC and EIC eRD14, under test for SOLID, possible applications under study



FPGA Board (JLab)

ASIC Board (Ferrara)



Developed (Roberto M.) for RICH1 & RICH2

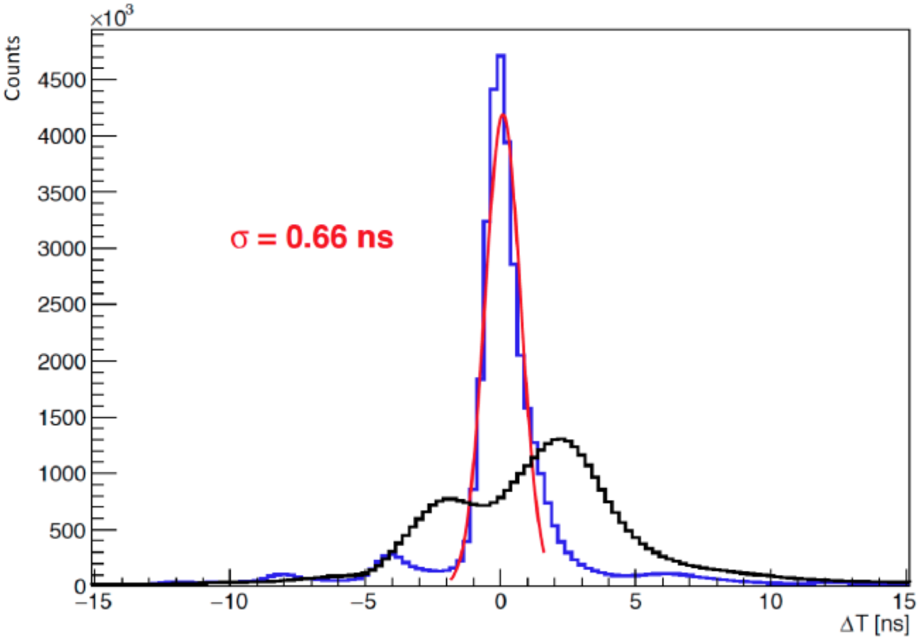
Adapter board evolutions (R. Malaguti, L. Barion)

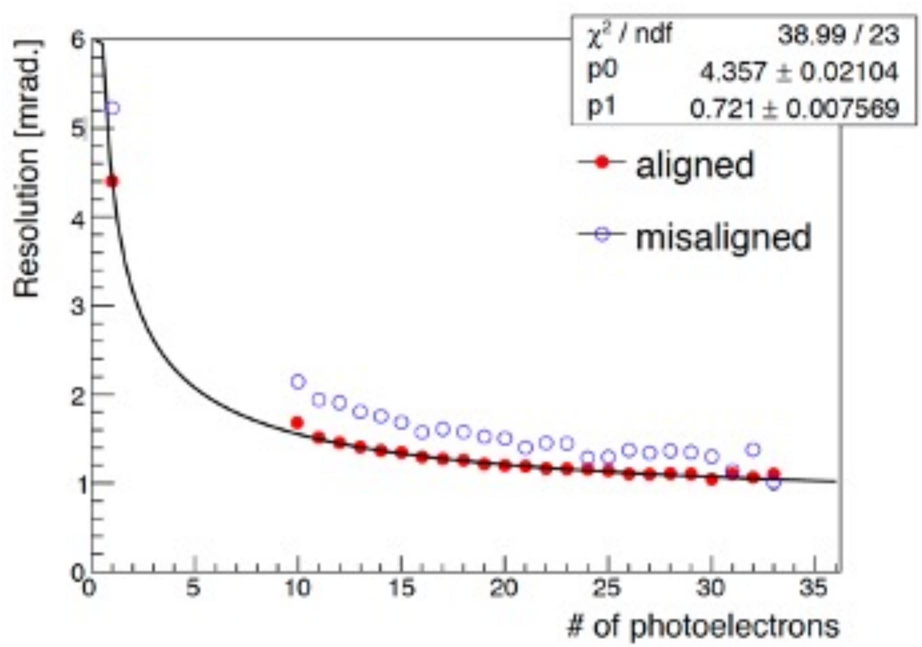
Also adopted by other experiments (Gluex, SOLID, EIC R&D...)

The RICH detector performance

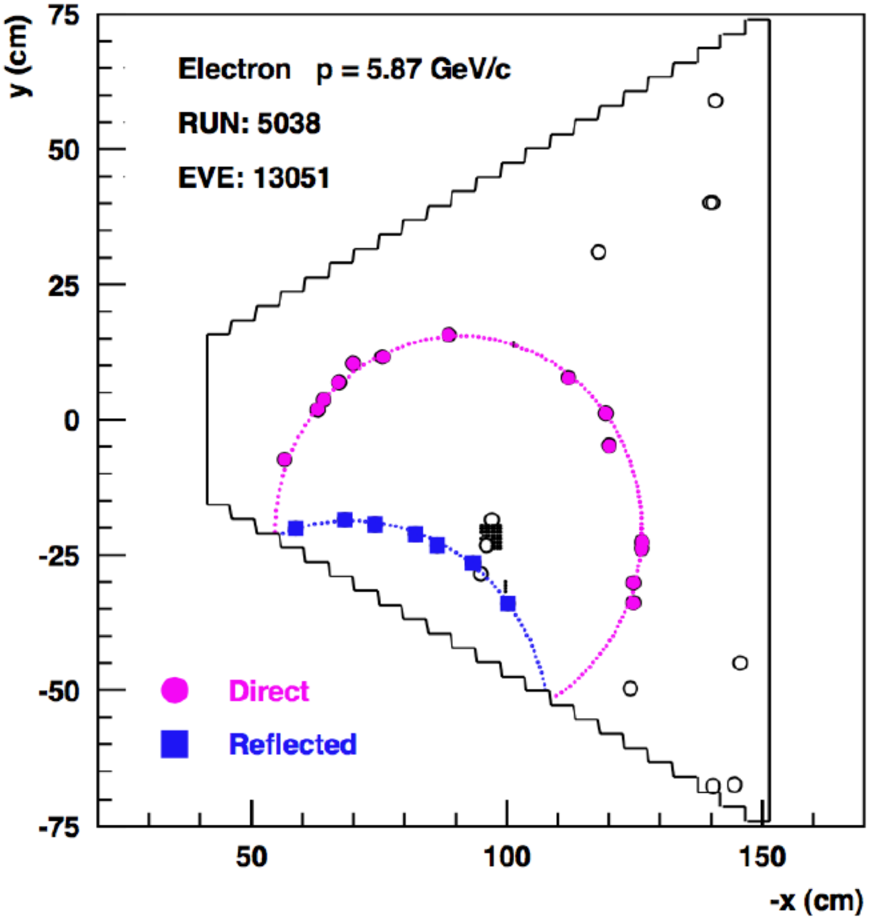
- RICH readout based on single-photon time tagging (design resolution < 1 ns)
- ΔT = diff. in time between time estimated by CLAS and measured by the RICH (~ 0 for all channels after calibration)

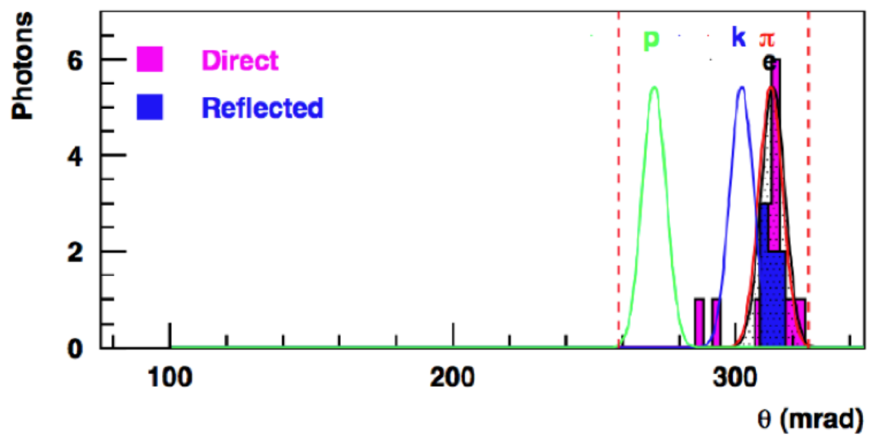
- RICH reconstruction based on ray-tracing to measure the Cherenkov angle of each photon (1.5 mrad resolution on the mean)
- Resolution depends on the precise calibration of optical parameters and alignment of components



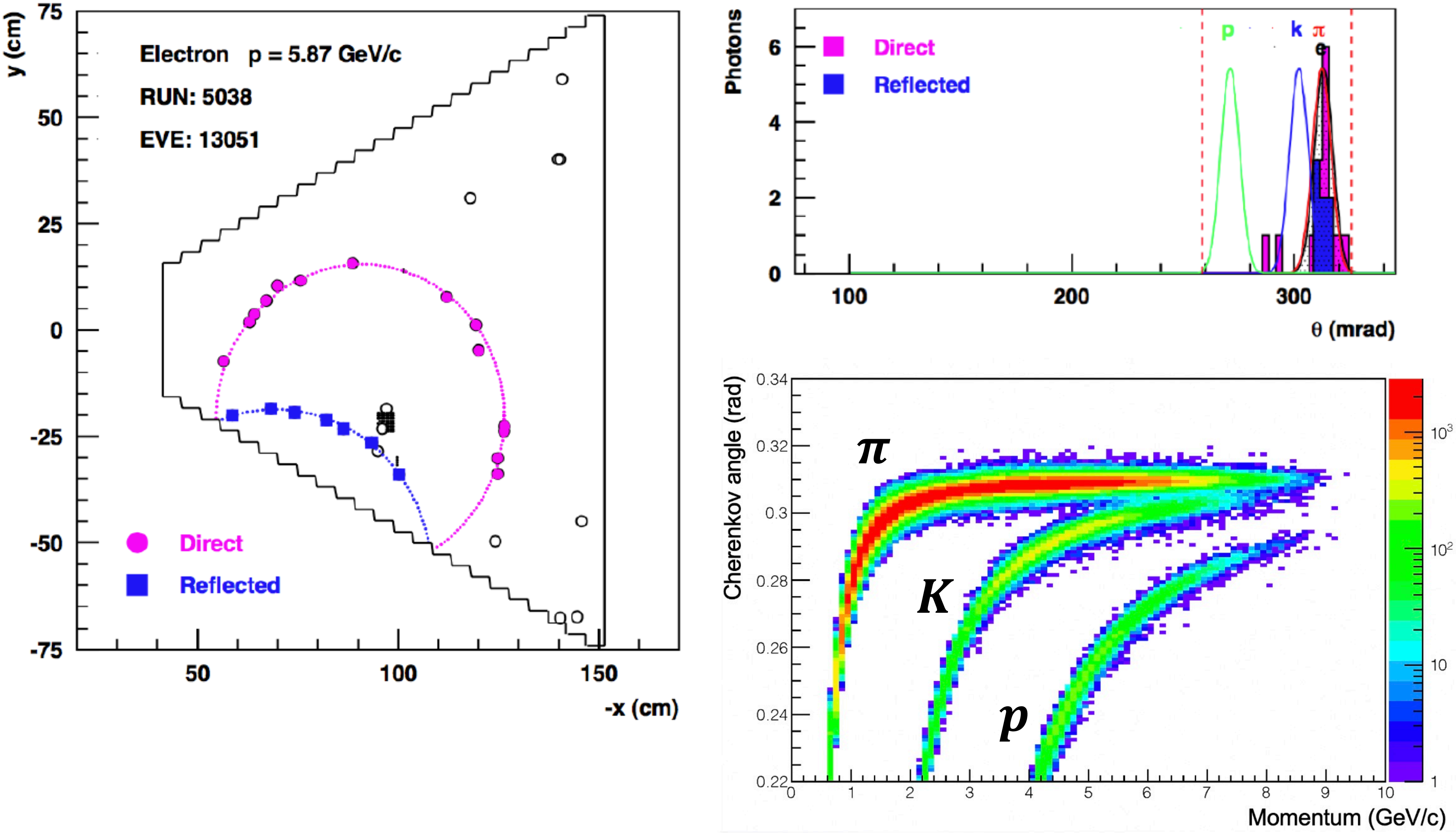


The RICH detector event reconstruction





The RICH detector event reconstruction



The RICH detector

ELSEVIER

Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment

Volume 964, 1 June 2020, 163791

The CLAS12 Ring Imaging Cherenkov detector

M. Contalbrigo [a], V. Kubarovsky [f], M. Mirazita [b], P. Rossi [f, b], G. Angelini [b, j], H. Avakian [f], K. Bailey [g], I. Balossino [a], L. Barion [a], F. Benmokhtar [h], P. Bonneau [f], W. Briscoe [j], W. Brooks [k], E. Cisbani [c], C. Cuevas [f], P. Degtiarenko [f], C. Dickover [f], K. Hafidi [g], K. Joo [i], A. Kim [i], T. Lemon [f], V. Lucherini [b], R. Malaguti [a], R. Montgomery [b], A. Movsisyan [a], P. Musico [d], T. O'Connor [g], D. Orecchini [b], L.L. Pappalardo [a], C. Pecar [h], R. Perrino [e], B. Raydo [f], S. Tomassini [b], M. Turisini [a, b], A. Yegneswaran [f]

The second RICH

Goal:
Installation beginning of 2022, in time for experiments with polarized targets (may 2022)

Ferrara:

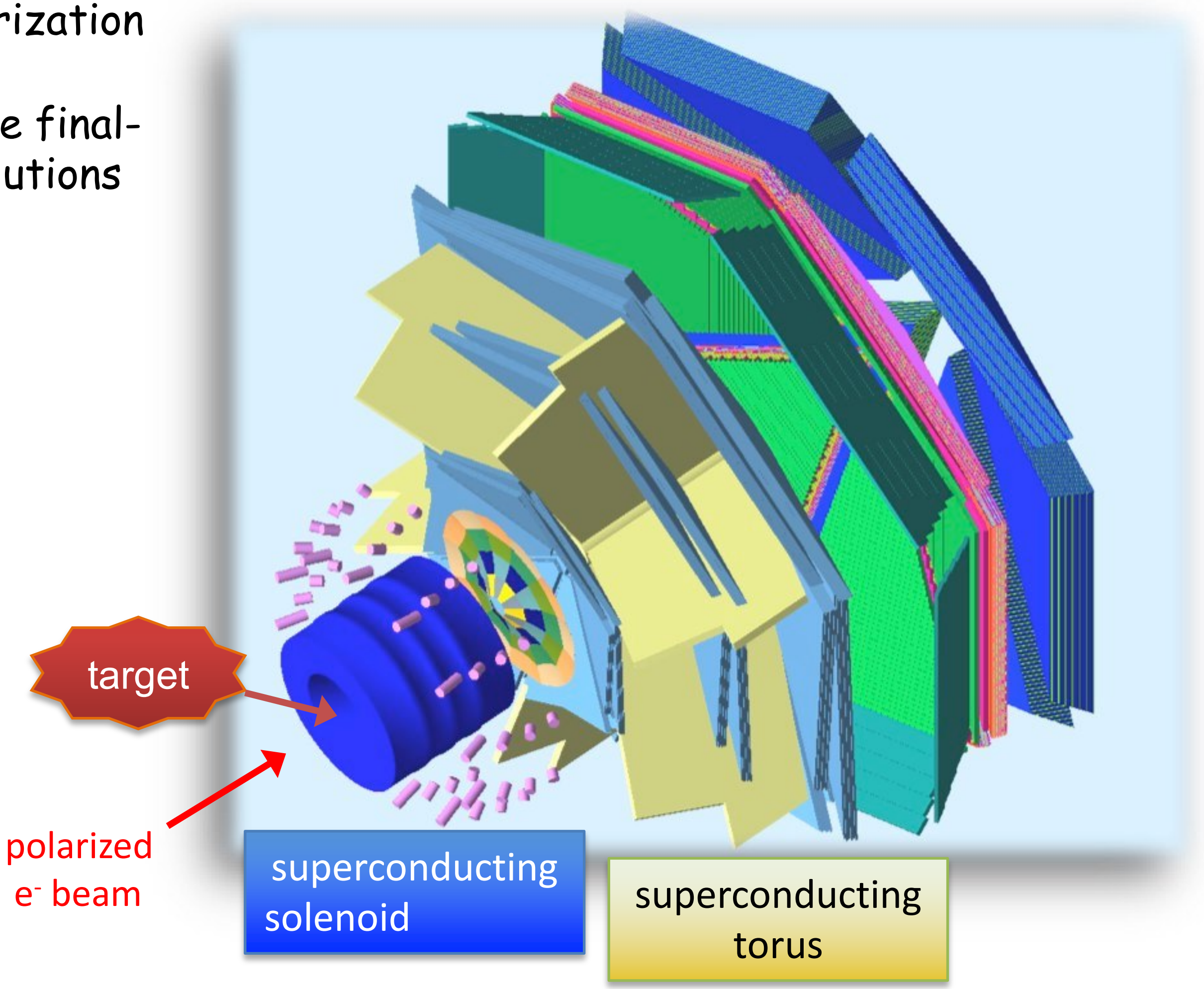
- Coordination
- F/E electronics
- Test-stands for optical components (aerogel/mirrors)

Second Module Plan (FY)	19-2	19-3	19-4	20-1	20-2	20-3	20-4	21-1	21-2	21-3	21-4	22-1
Mechanics												
Aerogel												
Mirrors												
Electronics												
MAPMTS												
Assembling												
Services in Hall + Installation												

The Transverse target

Internal Target

To maintain transverse spin polarization within the CLAS12 solenoid and preserve wide acceptance for the final-state particles, new magnetic solutions are required.



The Transverse target

Internal Target

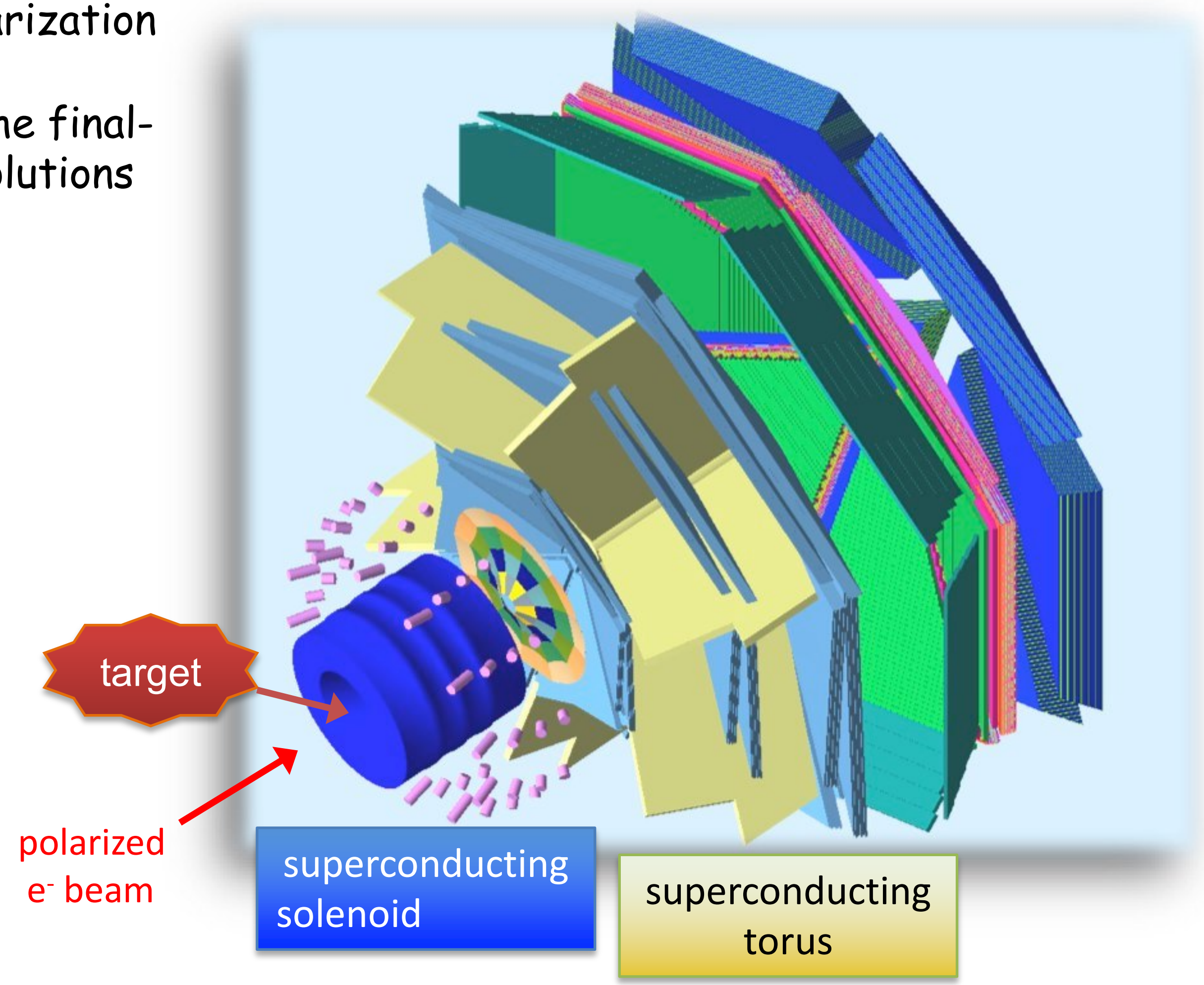
To maintain transverse spin polarization within the CLAS12 solenoid and preserve wide acceptance for the final-state particles, new magnetic solutions are required.

Tracking solenoid

- design up to 5 T longitudinal
- 4K L-He cryostat
- length 1500 mm

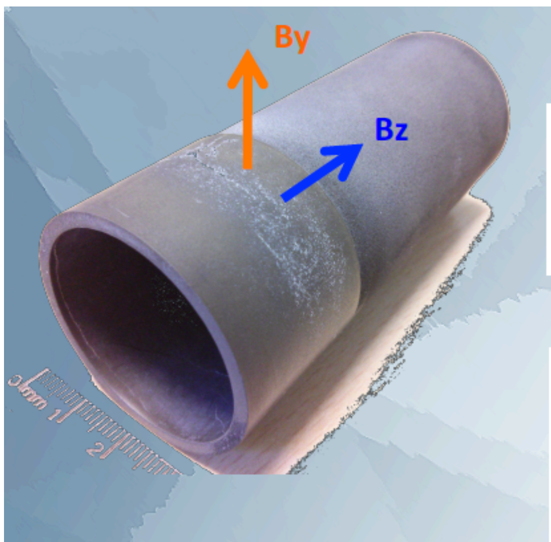
Transverse Target:

- high polarization
- d 25 mm – Length 25 mm
- transverse field up to 2T
- Ammonia (+ He)



Transverse target: bulk transverse magnet

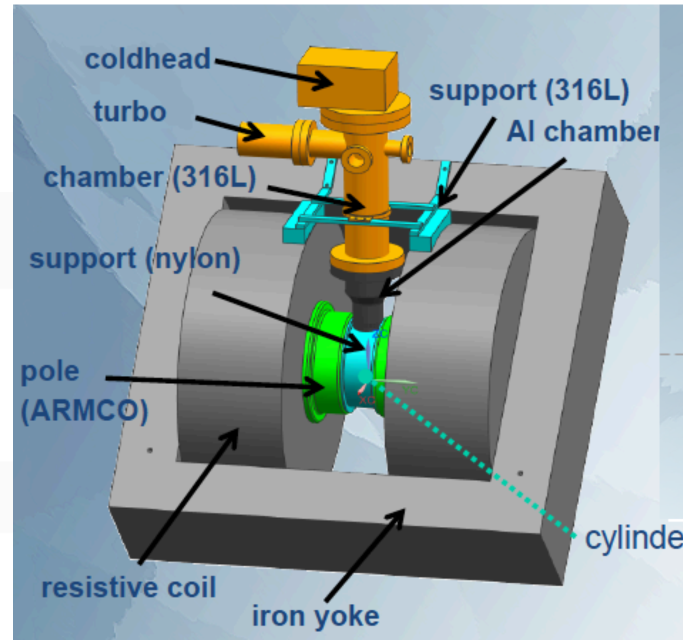
A hollow bulk superconductor is able to provide a transverse holding field inside, while adjusting its internal currents to shield any outside field, without the need of a current supply!



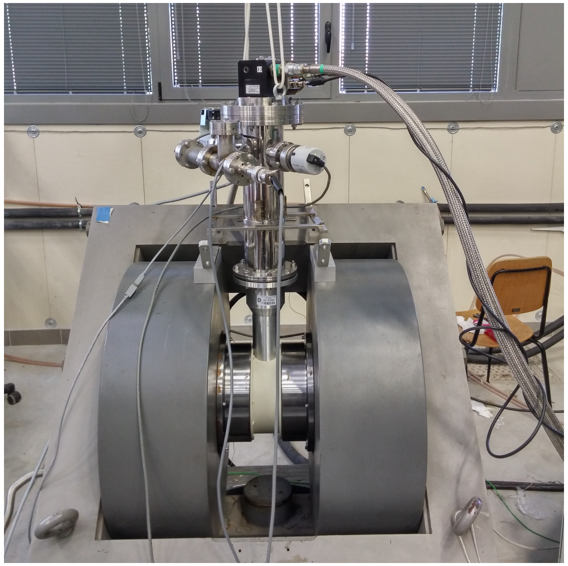
existing sample (courtesy of G. Giunchi)
diameter 39 mm
length 90 mm
thickness ~1 mm

Bulk cylinder (MgB_2)
- longitudinal shield
- transverse magnetization

Features
- no current leads
- Cu free
- self tuning
- few mm thickness
- external magnet for magnetization

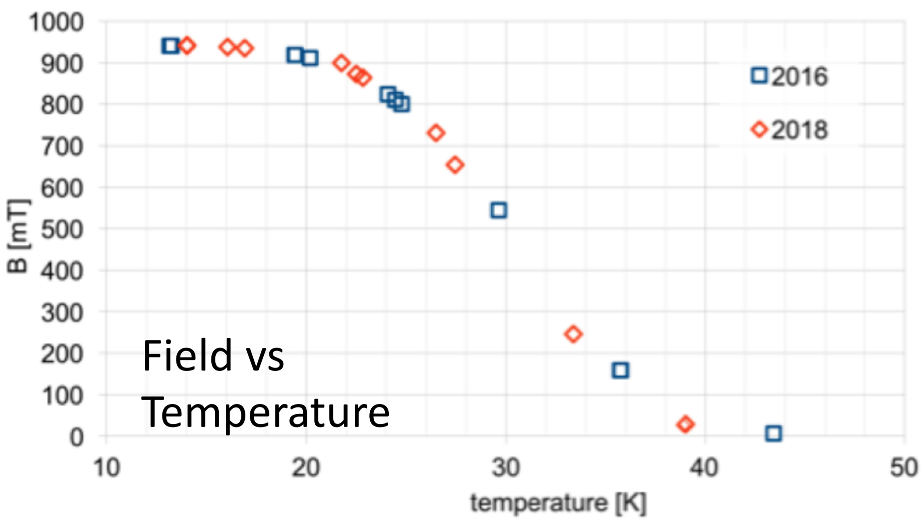


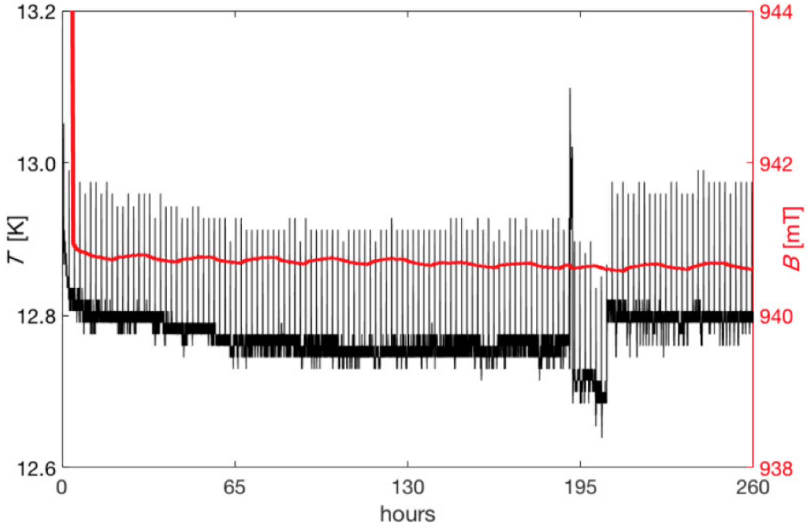
Transverse target: the Ferrara setup



Dipole field frozen for days inside a MgB_2 cylinder:

- After cooling down the MgB2 cylinder inside a dipole field of about 1T, the external field is zeroed and the dipole field at the center of the cylinder measured.
- With the decrease of the temperature below the transition point, an increasing fraction of the original field is trapped.
- At the minimum temperature of 12.8 K reachable by the setup, a field of about 940 mT is preserved for days, without any significant degradation





Transverse target: the new cryostat

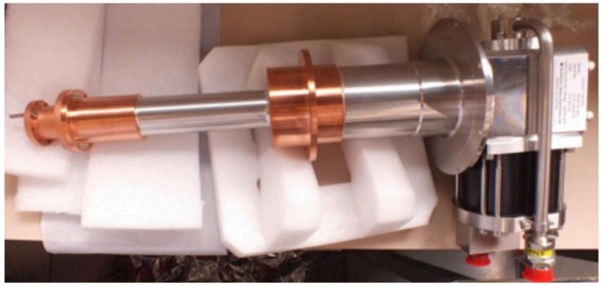
New support **(M. Cavallina)**

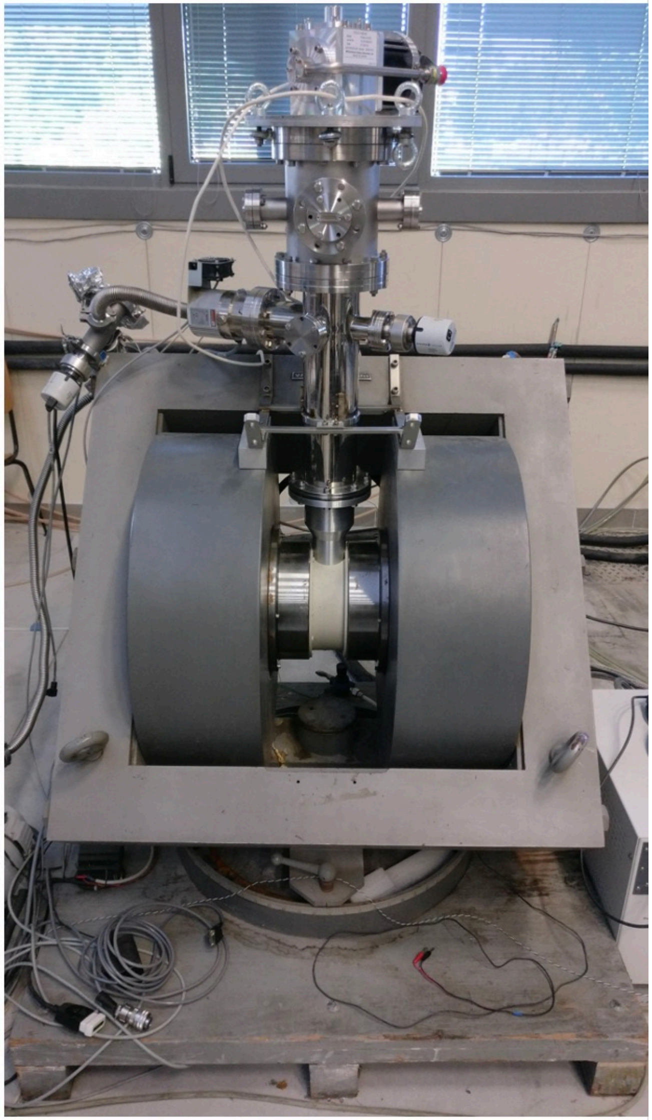
New sensor holder:

3 points x 2 orientation
- center
- off axis
- downstream

New fast access

for MgB_2 sample exchange



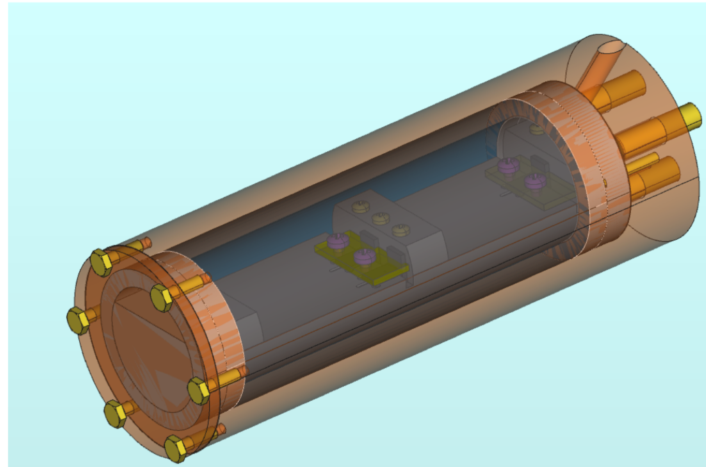


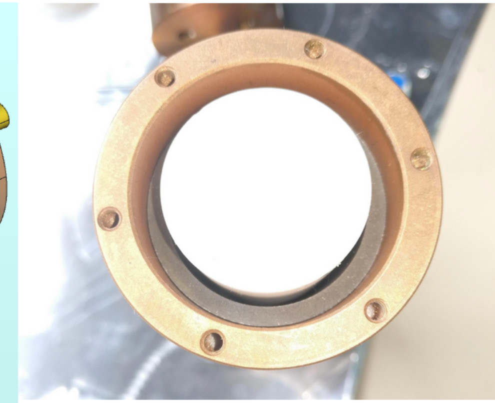
Transverse target: the new sensor holder

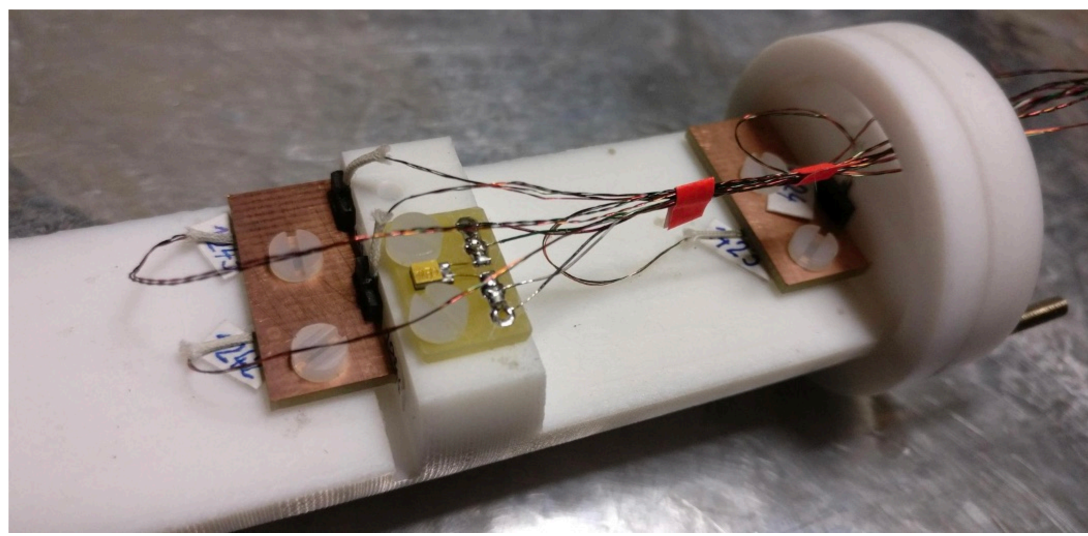
New support

New sensor holder: (**M. Melchiorri**)
- 3 points x 2 orientation
  - center
  - off axis
  - downstream

New fast access
- for MgB_2 sample exchange

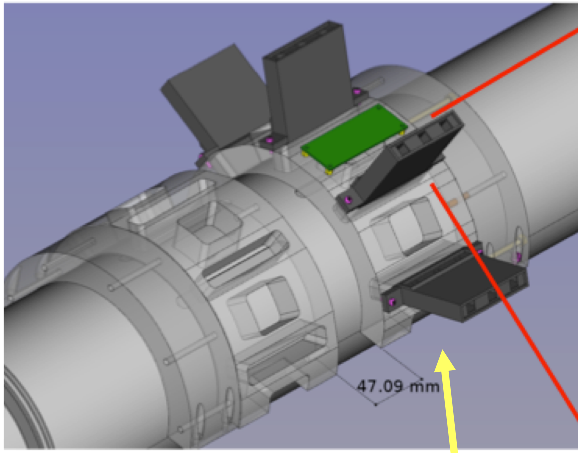




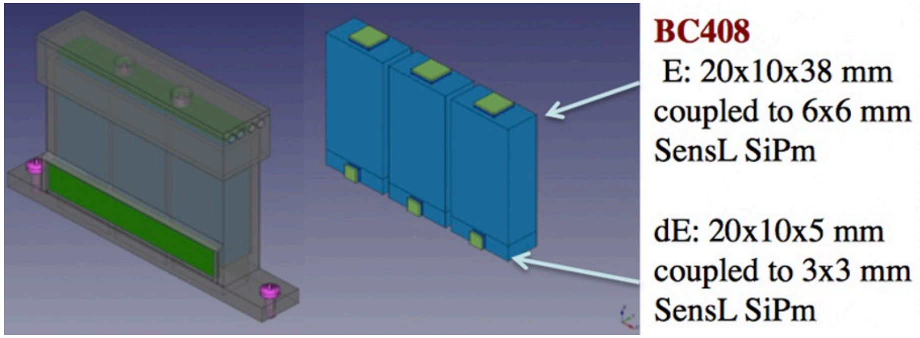


Transverse target: Beam Monitor for test at UITF

UITF beam halo monitor



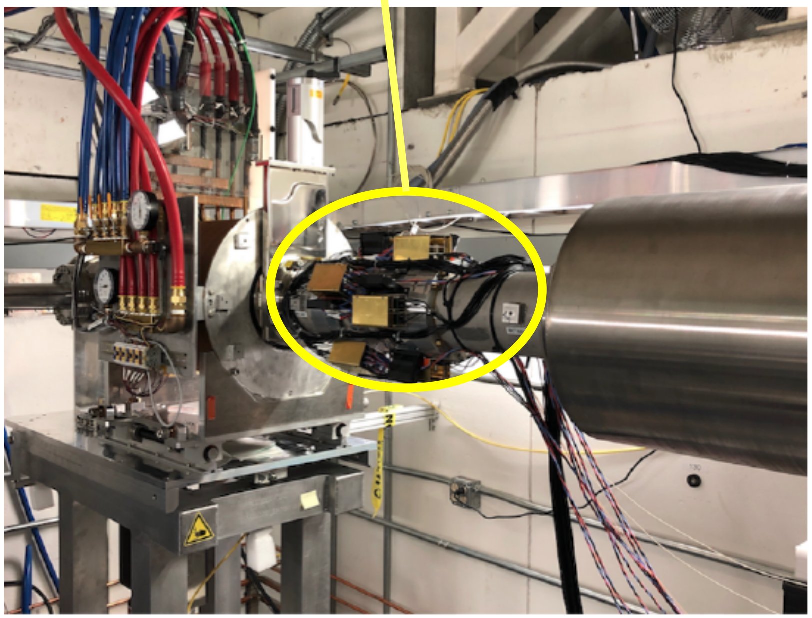
Scintillator + SiPM units

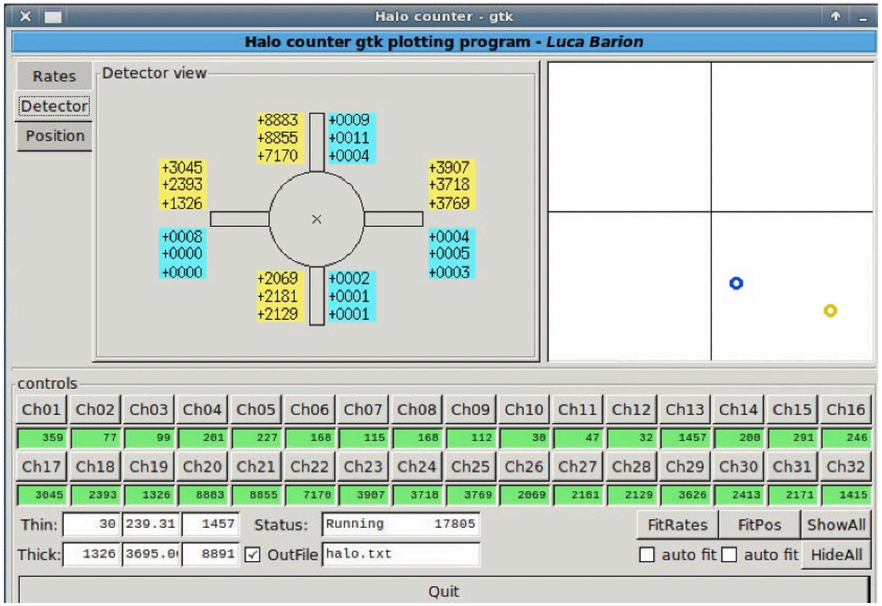


R. Malaguti
(sensori)

I. Neri
(readout)

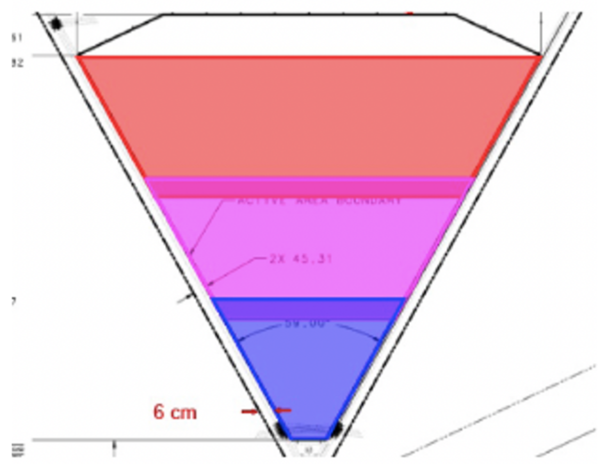
S. Squerzanti
(supp. mecc.)



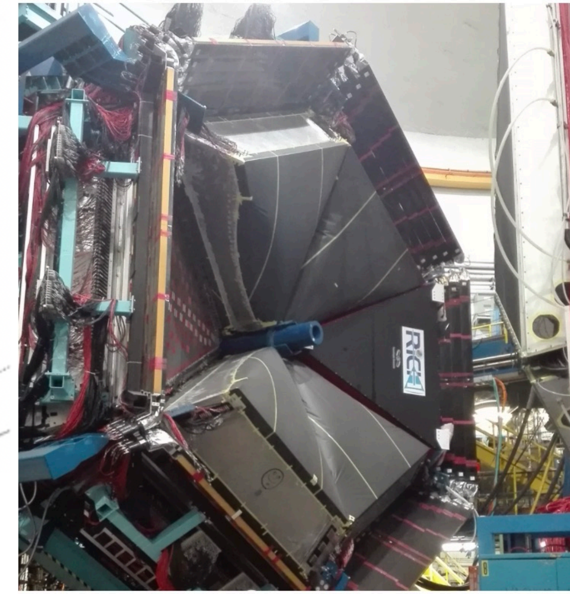


JLab12:
CLAS12 High-Lumi

Substitute the first tracking layer: from wire-chamber to micro-pattern gas detector

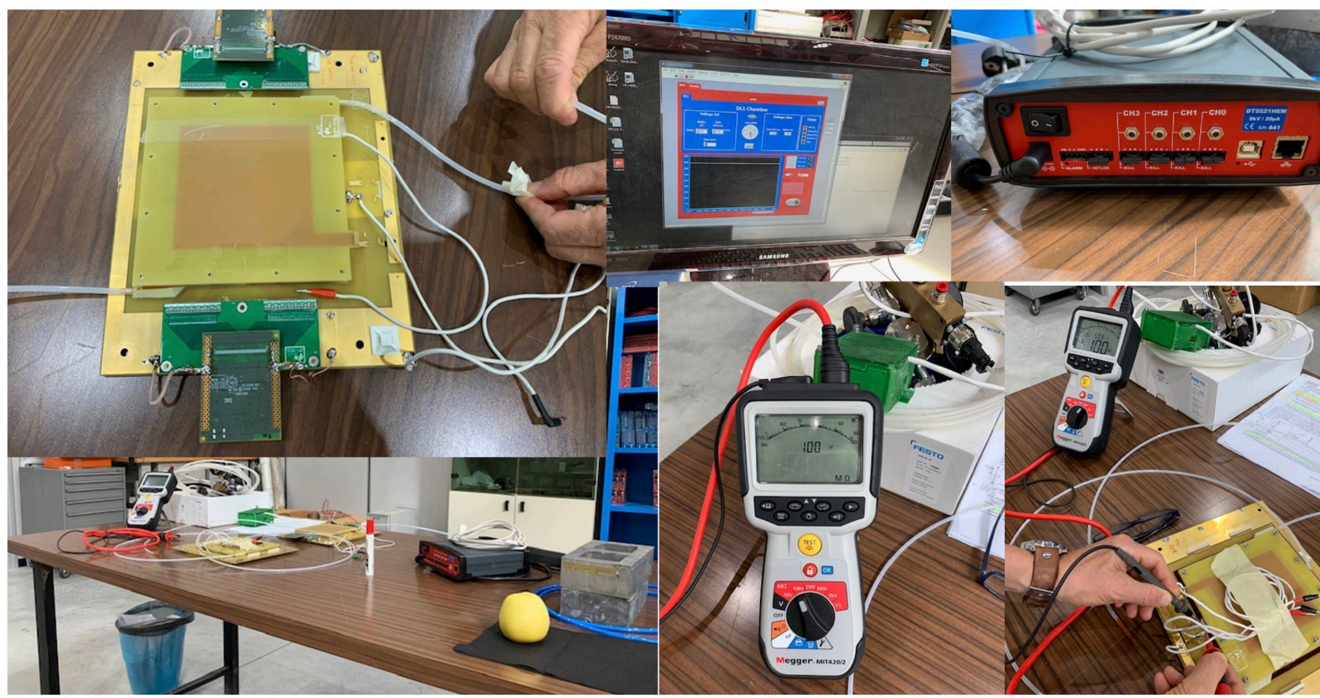


From MWPC to μ-RWELL



Ferrara: Support to readout development (R. Malaguti., L. Barion)

Test-station in 2022



Il gruppo di Ferrara @ JLab

Responsabilita':

- M. C.: responsabile locale e nazionale di JLab12
- M.C.: membro CLAS Coordination Committee
- M. C. responsabile progetto RICH
- M. C. & L.P. Co-spokesperson di diverse proposte di esperimento (PAC34,37,38,39)

Contributi principali

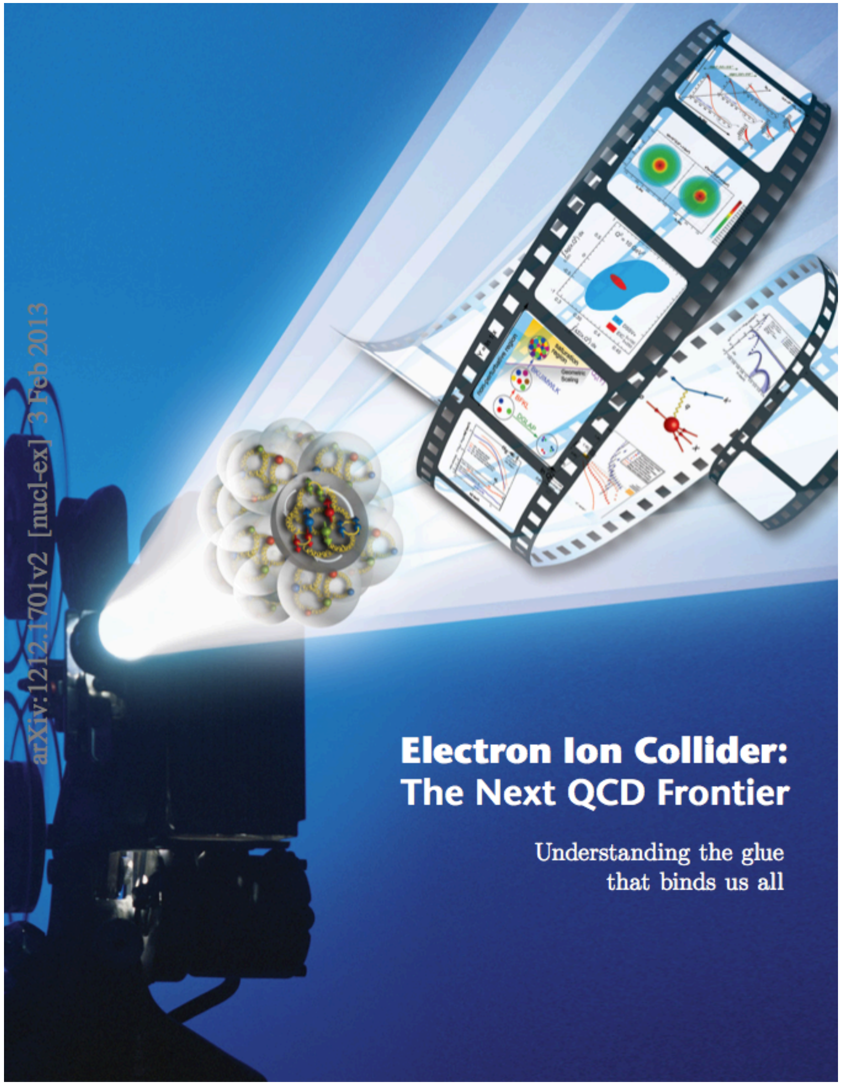
- Data analysis
  - Coordination of deep-process group
  - Data processing
- RICH detector
  - Reconstruction algorithms
  - Second RICH module construction
- Magneti superconduttori
  - Configurazione magnetica per transverse target
  - Frozen field con magneti a bulk di superconduttore

EIC²
EIC Center at Jefferson Lab

EIC-NET (R.L.: Marco Contalbrigo)

- INFN Network for preliminary studies on the EIC project

EIC_NET



Electron Ion Collider:

CD0 Announced in January 2020

“Yellow Report” published (2103.05419)

“Expression of Interest” survey done

“Call for Detectors” ongoing

Strong interest in Italian nuclear physics community (theory and experiment)

Increasing R&D effort

INFN Ferrara working on the PID (Italian Collab. + R&D Consortium eRD14).

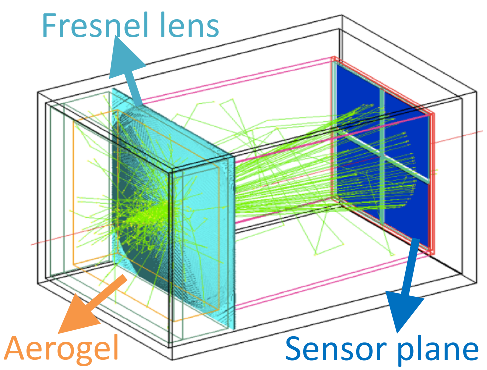
EIC_NET: PID studies

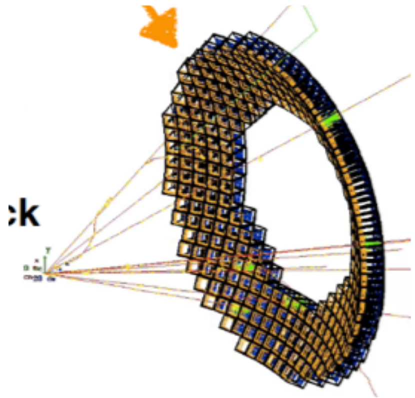
Compact solution for few-GeV range

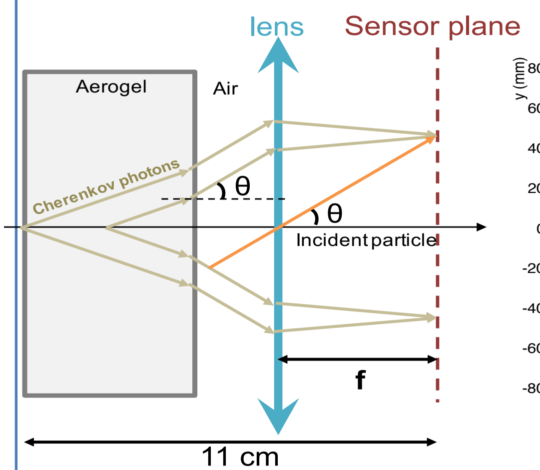
mRICH: An aerogel RICH with Fresnel lens focalization for compact and projective imaging

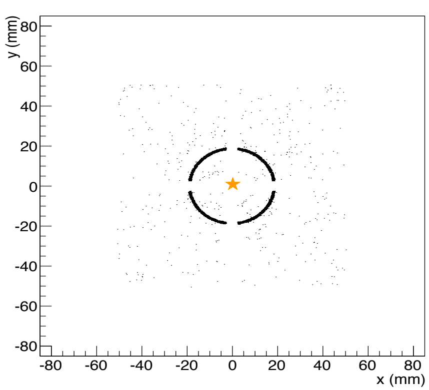
π/K sepration up to ~ 10 GeV/c

superPhenix







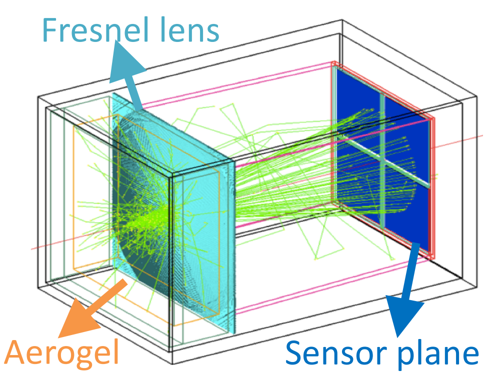


EIC_NET: PID studies

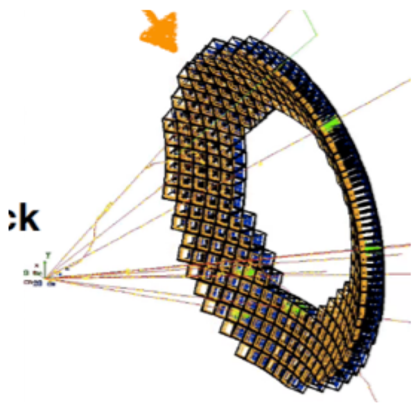
Compact solution for few-GeV range

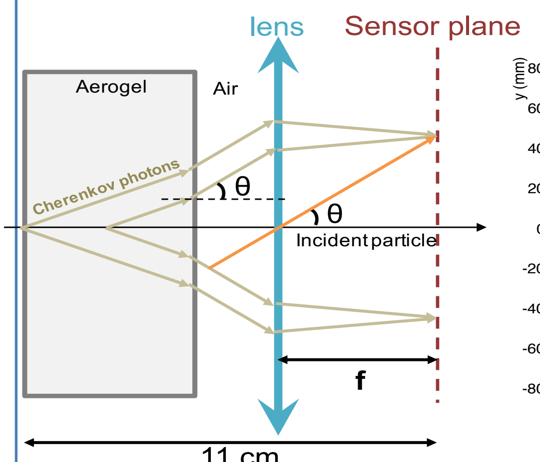
mRICH: An aerogel RICH with Fresnel lens focalization for compact and projective imaging

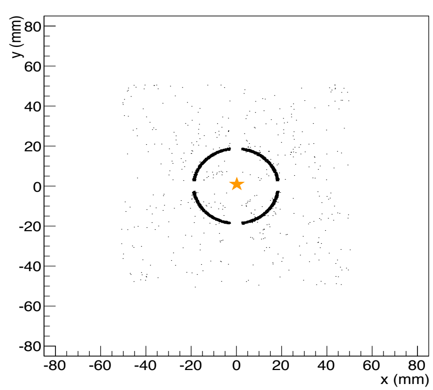
π/K sepration up to ~ 10 GeV/c



superPhenix





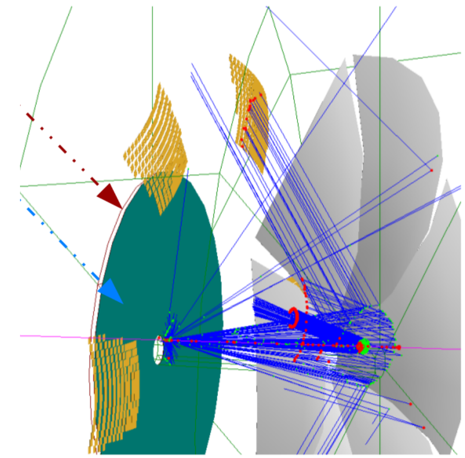


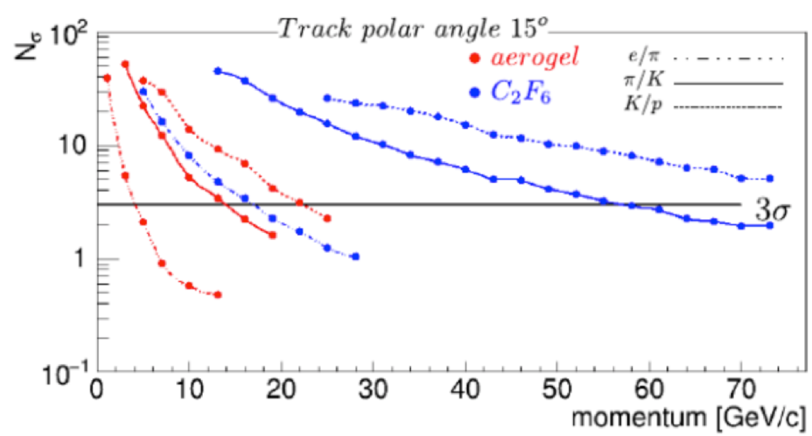
Dual-radiator for extended momentum range

dRICH: A RICH with two radiators (gas + aerogel) for wide momentum coverage

Separation

π/K up to ~ 50 GeV/c
e/π up to ~ 15 GeV/c



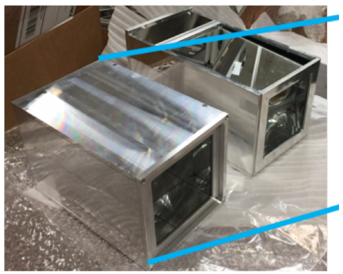


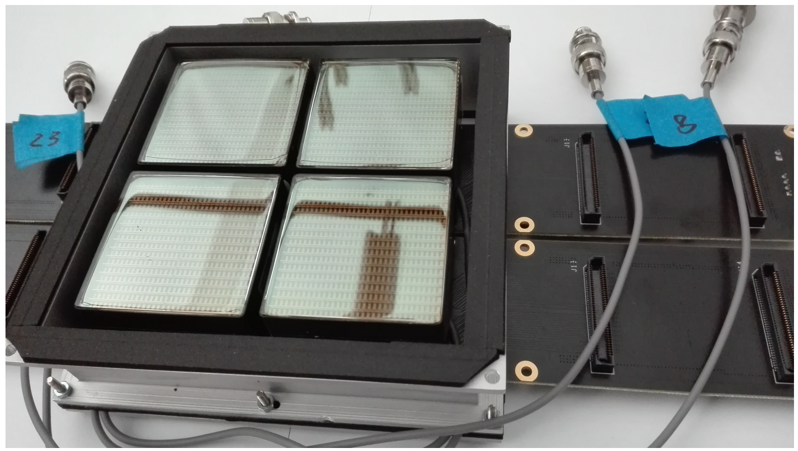
EIC_NET: The modular RICH

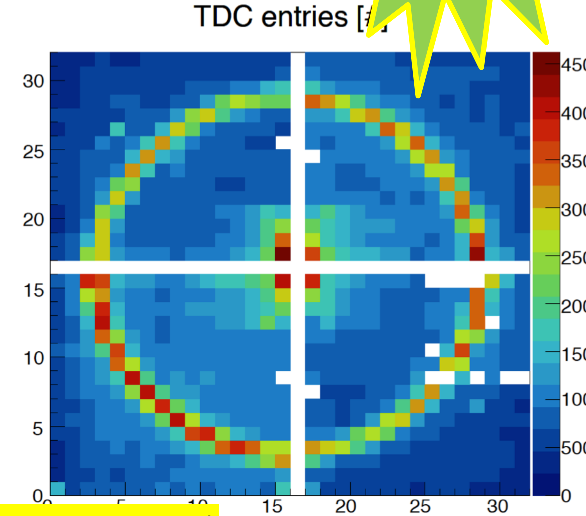
Compact and modular RICH independent elements (Box sensori: **M. Gradara**)

$\geq 3\sigma$ π/k separation
$\sim 2 \div 10$ GeV/c

Two completed mRICH prototypes







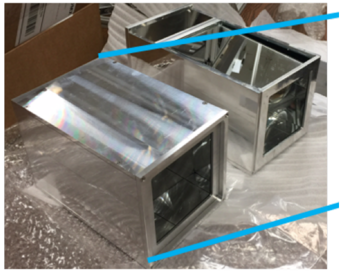
Ferrara: fron-end electronics based on MAROC3 (R. Malaguti, L. Barion)

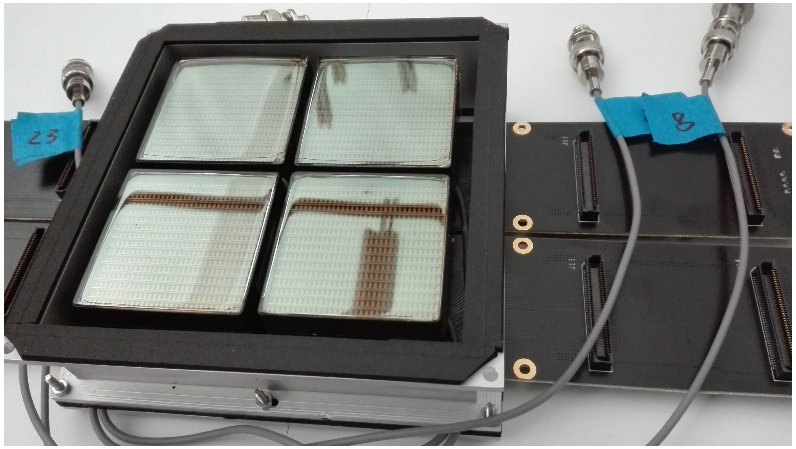
EIC_NET: The modular RICH

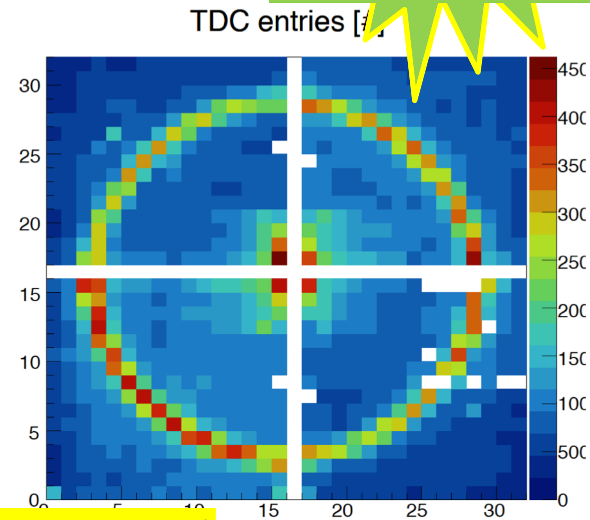
$\geq 3\sigma$ π/k separation ~ 2 ÷ 10 GeV/c

Compact and modular RICH independent elements (Box sensori: **M. Gradara**)

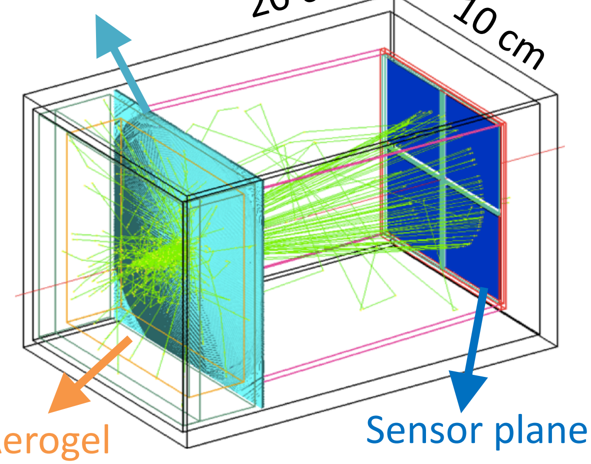
Two completed mRICH prototypes







Ferrara: fron-end electronics based on MAROC3 (R. Malaguti, L. Barion)

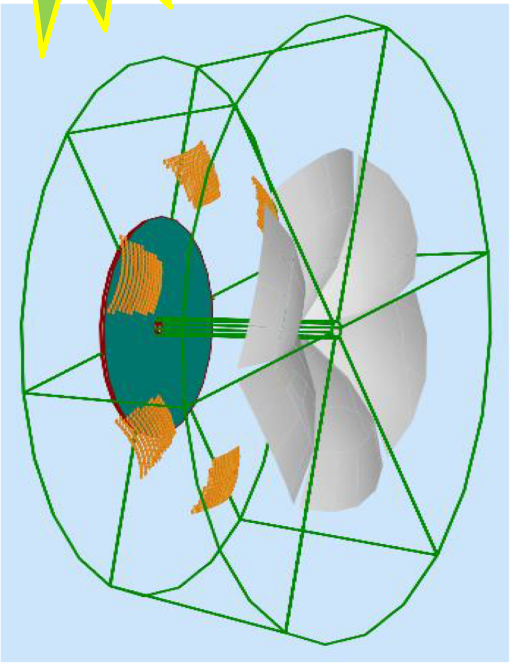


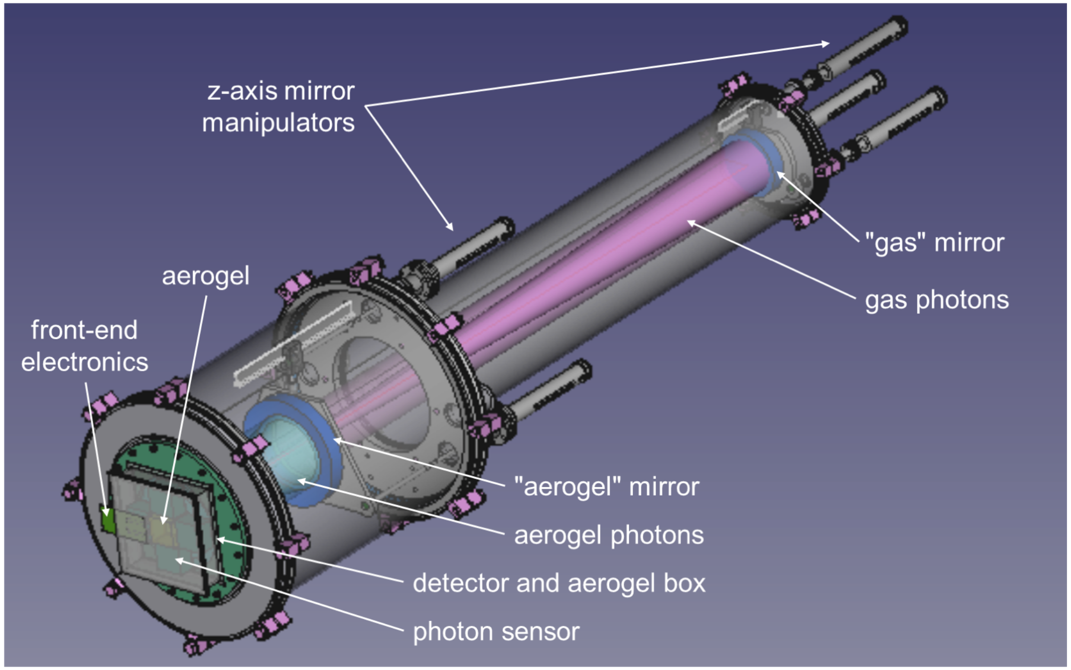
Test beam with external tracking expected at JLab in 2021 and 2022

Ferrara: support for readout & monitoring

EIC_NET: The dual RICH

$\geq 3\sigma$ π/k separation
$\sim 2 \div 50$ GeV/c





Extended 3-60 GeV momentum range

Prototype under construction:

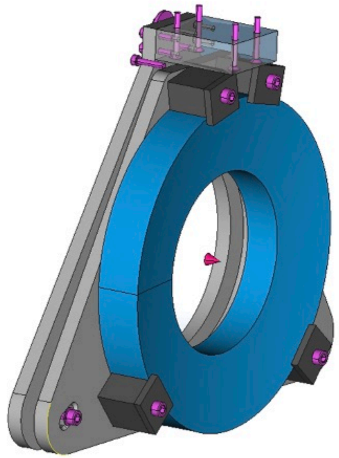
INFN **FE**, BO, CT, LNF, RM1, TO, TS

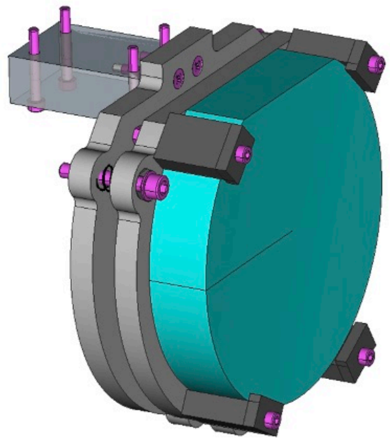
Two test-beam apporved at CERN in 2021:

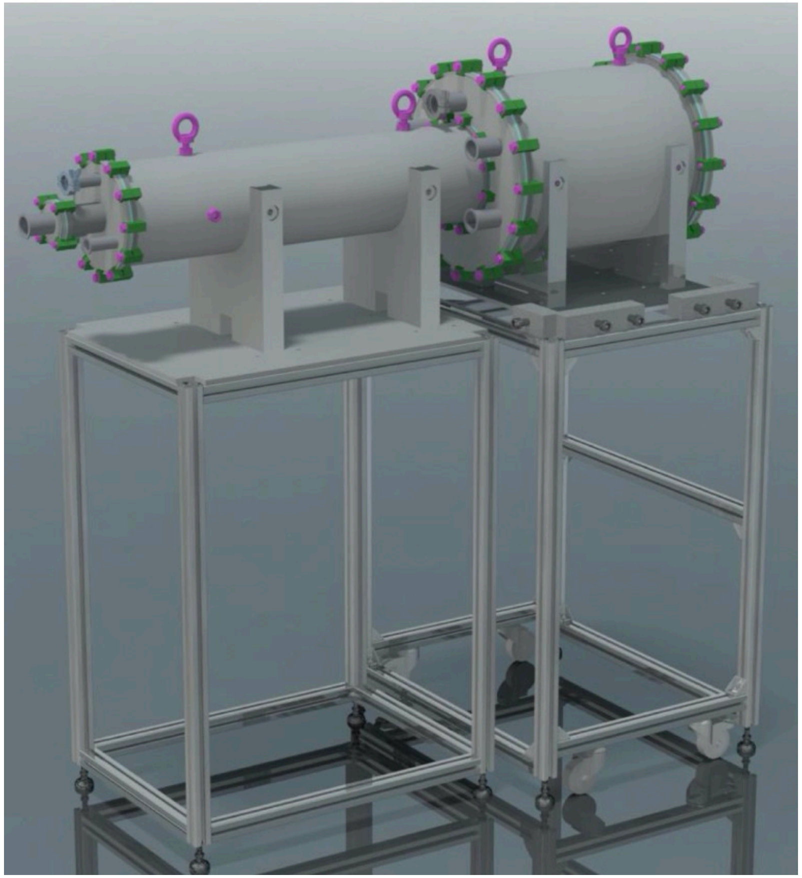
Sep. SPS T4-H6: high-momentum > 20 GeV/c

Oct. PS T10: low-momentum < 15 GeV/c
in conjunction with ALICE PID

EIC_NET:
The dual RICH Prototype

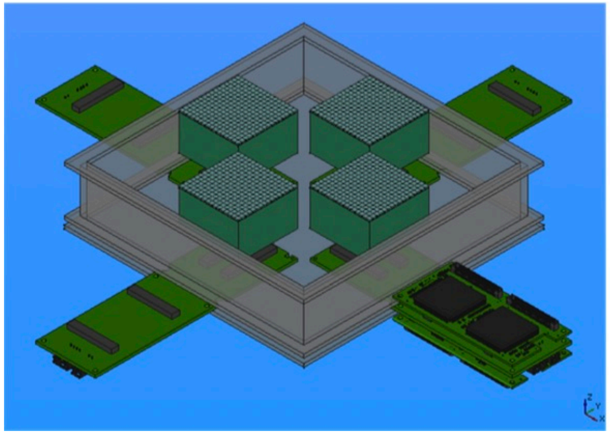


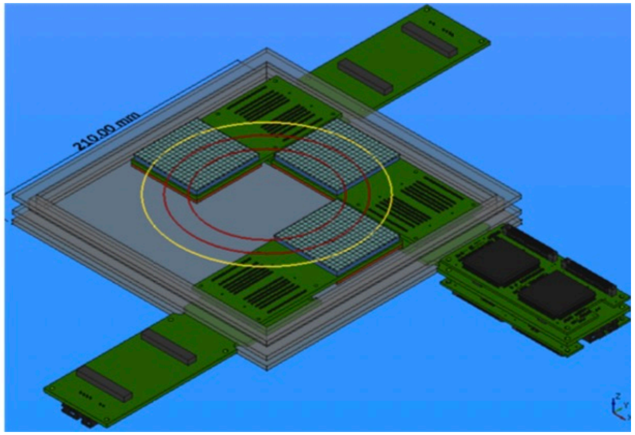




Mirror support and alignment system

Detector box

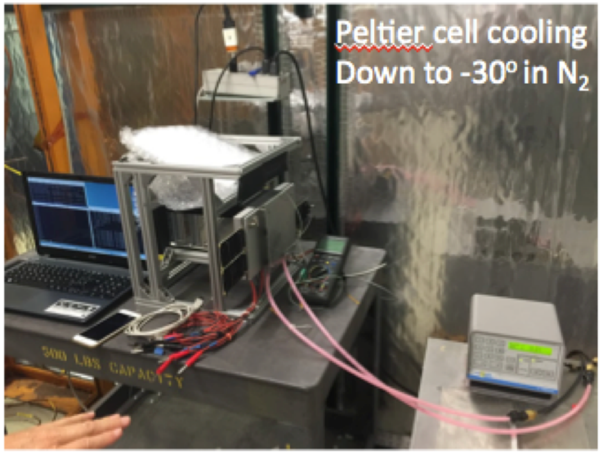


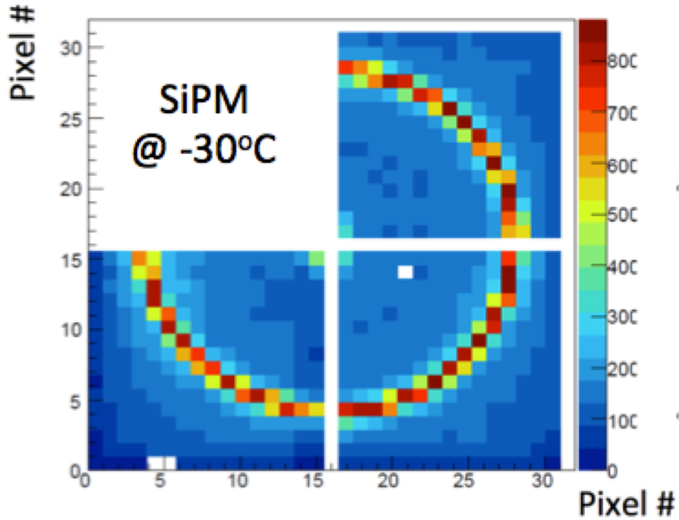


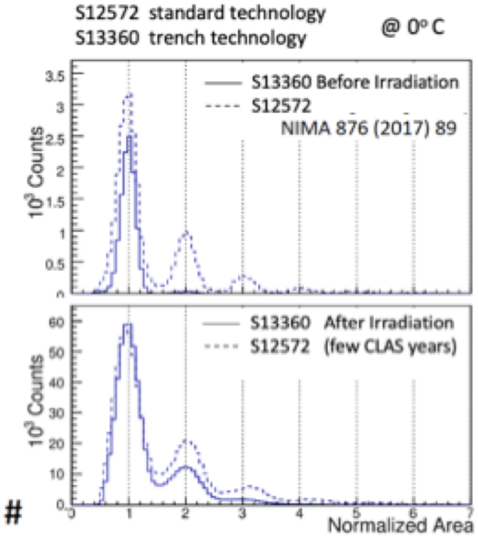
M. Cavallina
(off. Meccancia)

EIC_NET: The SiPM program

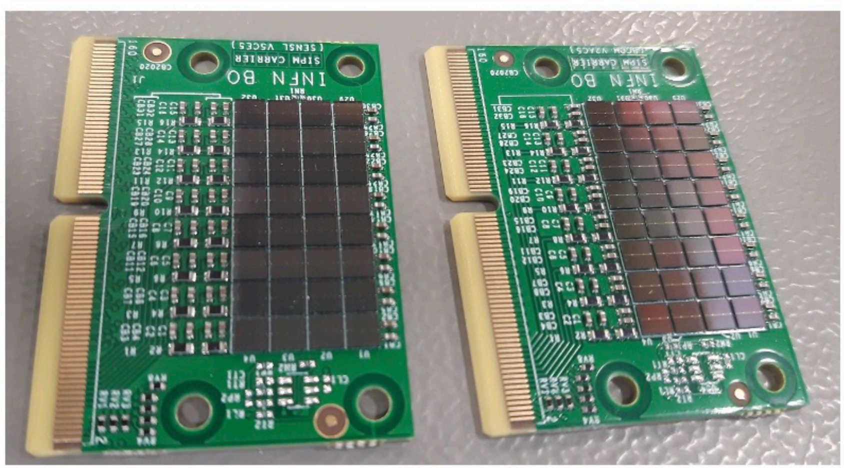
Cherenkov imaging with commercial MPPC and MAROC readout

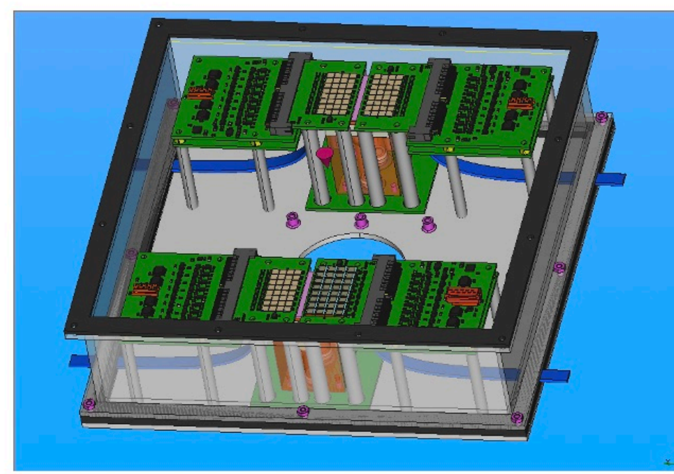






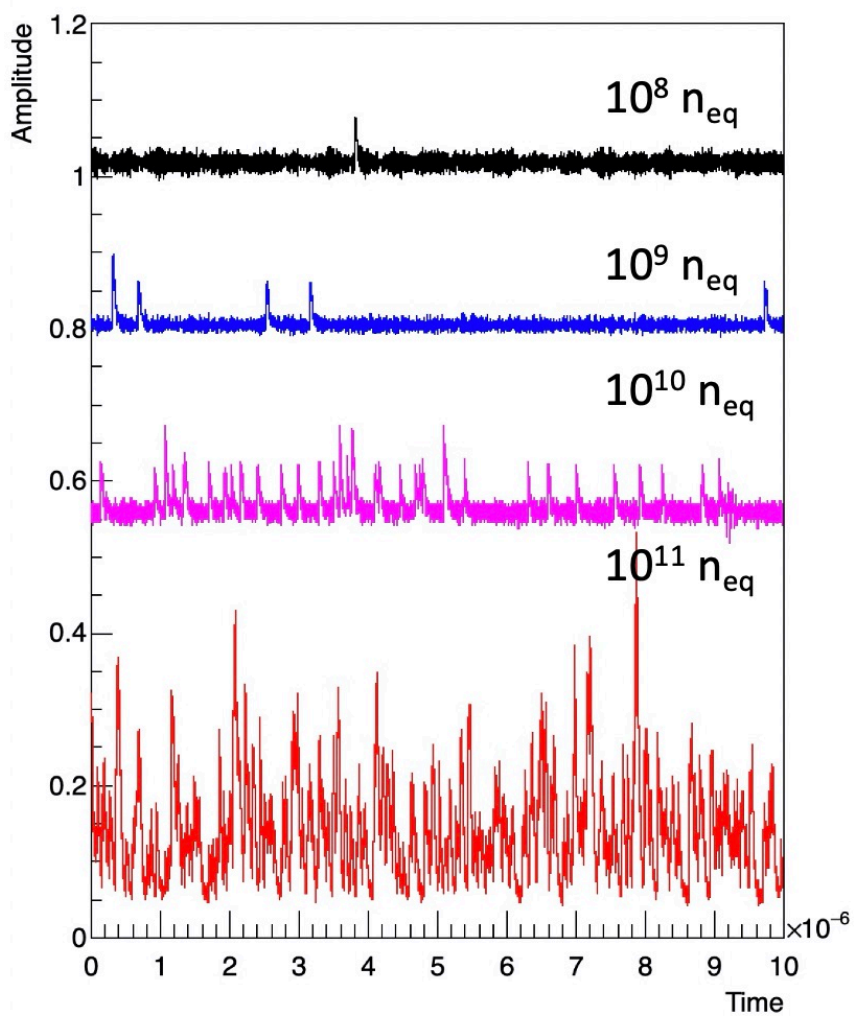
Next: Cherenkov imaging with irradiated SiPM and ALCOR (DarkSide) chip

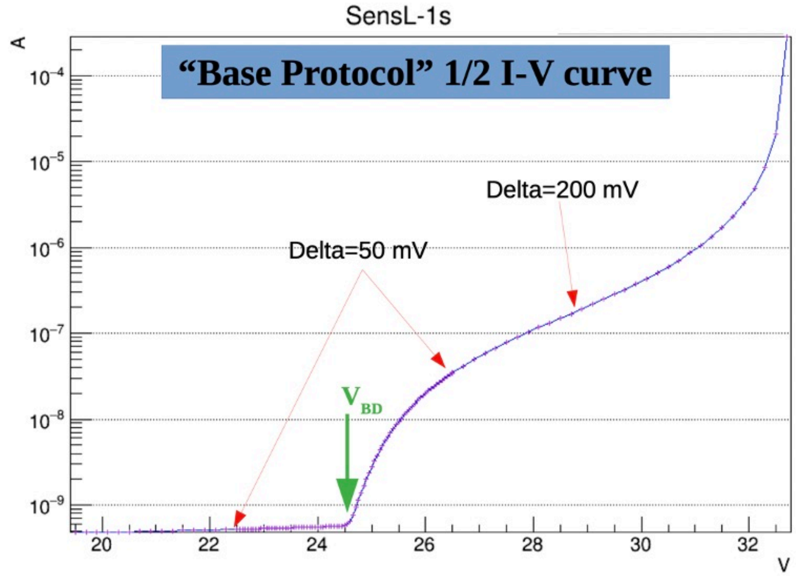


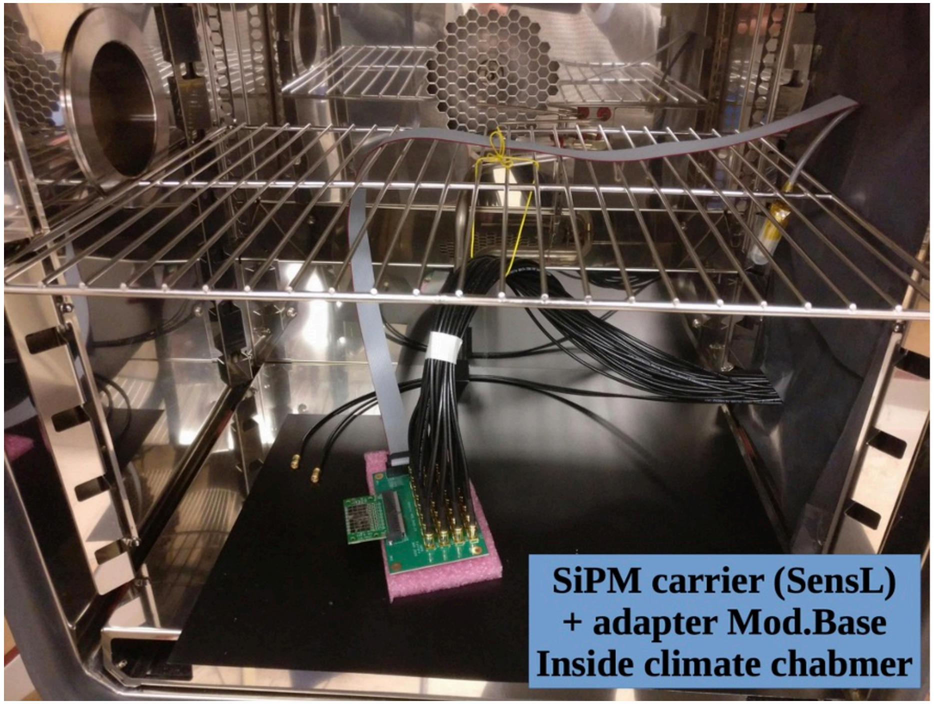


EIC_NET: The SiPM program

Dark counts @ -30º (before annealing)







EIC_NET: responsabilità

Responsabilita':

- M. C.: responsabile locale EIC_NET
- M.C.: activity leader eRD14
- M. C.: IAC POETIC (Physics Opportunities at EIC) Conference

Contributi principali:

- mRICH detector
  - Prototyping and data analysis

- dRICH detector
  - Prototyping and SiPM program

- Electronics
  - MAROC (reference) + ALCOR (INFN development)
  - VME and Ethernet DAQ in collaboration with Jlab

Richieste ai Servizi per 2022

Servizio Meccanico
JLAB12
TTarget: traliccio di supporto per test con doppio campo magnetico disegno e realizzazione esterna
RICH: assemblaggio ed installazione al JLab (inizio 2022) (in supporto a Frascati)
High-L: supporto per stazione di test con μ-rwell
EIC_NET
dRICH: meccanica del prototipo, in supporto a CT
SiPM: meccanica per il raffreddamento dei sensori
EIC: contributo a disegno struttura meccanica rivelatore
JEDI
Step 2: progettazione elementi anello di accumulazione elettrostatico
(LHCb)
LHCspin: progettazione bersaglio polarizzato

Richieste ai Servizi per 2022

Servizio Elettronico
JLAB12
RICH2: assemblaggio e commissioning (supporto in trasferta al Jlab e test a FE).
Ttarget: piccoli contributi alle misure con magneti superconduttori
High-L: supporto per stazione di test con μ-rwell
EIC_NET
dRICH: supporto in preparazione ai test-beam e misure di laboratorio
SiPM: schede di collegamento sensori – readout per irraggiamento SiPM

Anagrafica per 2022

Anagrafica e afferenze (Ric. + Tecnol.)

Name	JEDI	JLab12	EIC_NET
N. Canale (dottorando)	100		
G. Ciullo (staff)	70	20	
M. Contalbrigo (staff)		75	20
S. Dymov (post-doc)	100		
L. Del Bianco (staff)		100	
A. Kononov (dottorando)	100		
P. Lenisa (staff)	75	20	
A. Maragno (dottoranda)	100		
L. Pappalardo (RTD-B)		30	
A. Pesce (post-doc)	100		
A. Seleev (assegnista)	100		
R. Shankar (dottorando)	100		
F. Spizzo (staff)		80	20
S. Vallarino (dottorando)		100	
V. Carassiti	10		
TOTALE/100 (2022)	**8.55**	**4.25**	**0.40**
TOTALE/100 (2021)	6.85	5.00	0.50

Servizio meccanico ed elettronico

Name	JEDI	JLab12	EIC_NET
L. Barion		50	50
M. Cavallina	10	10	
M. Gambetti	10		
A. Magnani		10	
R. Malaguti		15	20
M. Melchiorri		10	
S. Squerzanti			10
TOTALE/100	**0.20**	**0.95**	**0.80**

→ **Totale FTE (Ric. + Tecnol) 2022: 13.20**

→ Totale FTE (Ric. + Tecnol) 2021: 12.35

Richieste finanziarie per 2022

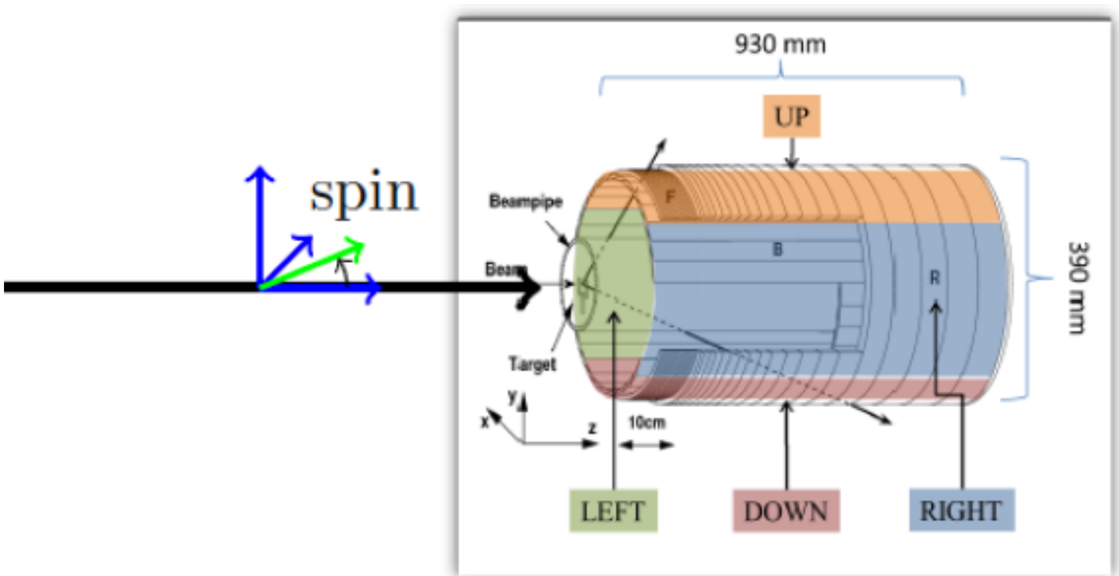
Richieste finanziarie (k€)

Name	JEDI	JLab12	EIC_NET	Dot.3
Missioni	60	45	6	8
Trasp.		5		
Inv.				15
Consumi	50	15	17	6
Apparati				
Altro				3
TOTALE	110	65	23	32

Back-up - JEDI

EDM search at COSY: polarimeter

- Elastic deuteron-carbon scattering
- Up/Down asymmetry $\propto$ *horizontal polarization*
- Left/Right asymmetry $\propto$ *vertical polarization* $\rightarrow$ d



EDDA beam polarimeter

ASYMMETRIES

$$\varepsilon_H = \frac{U-D}{U+D} \propto p_H A_x$$

HORIZONTAL polarization — Analyzing power

$$\varepsilon_V = \frac{L-R}{L+R} \propto p_V A_y$$

VERTICAL polarization — Analyzing power

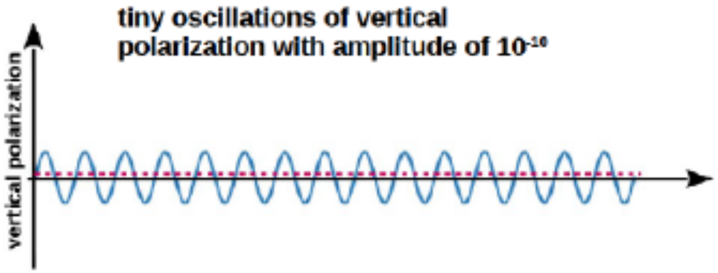
EDM search at COSY: proof of principle experiment

Goal: demonstrate that a Storage Ring can be used for a first EDM measurement

- First measurement ever of the deuteron EDM
- Exploit the motional E^*-field induced in the particle rest frame by the dipoles B-fields of the SR ($E^* = \vec{v}\times\vec{B}$)

Problem: spin precession caused by magnetic moment

- 50% of time spin || to momentum
- 50% of time spin anti-|| to momentum

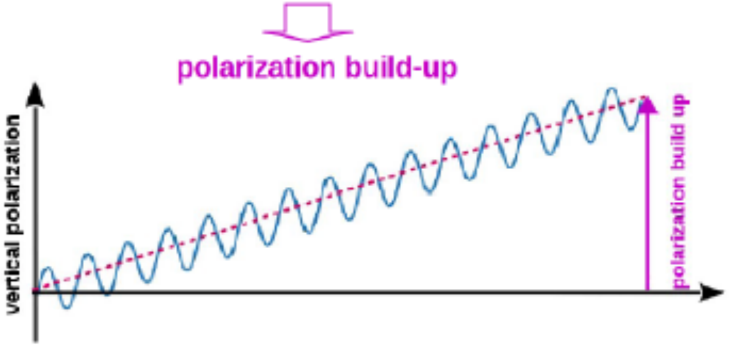


In case of EDM, E^* tilts up (down) the spin when spin and momentum are || (anti-||)
→ no net polarization build-up
→ no net (static) EDM effect is observable!
(not a problem for oscillating EDM → build-up of out-of-plane spin precession!)

Solution: use a resonant Wien filter in the ring

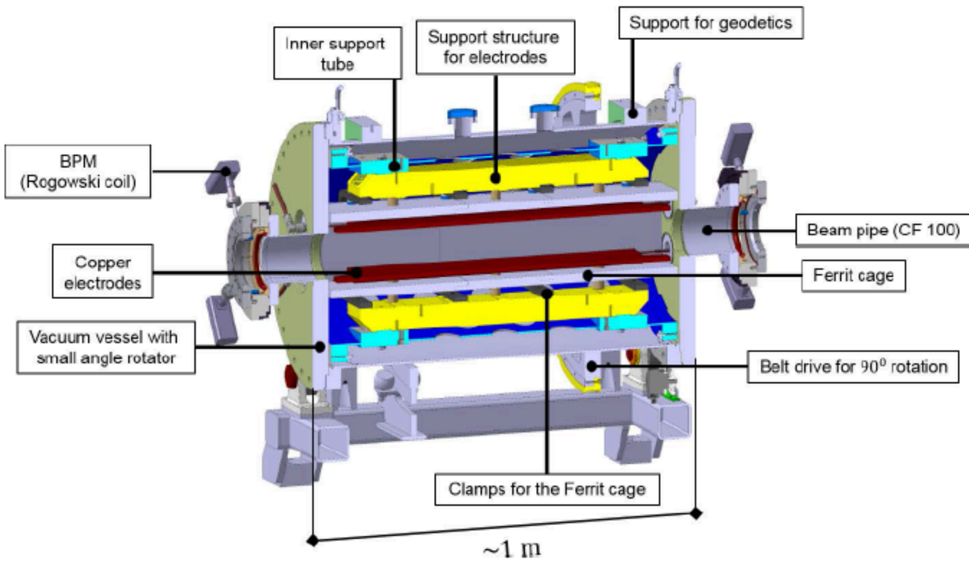
- $\vec{F}_L = q\left(\vec{E} + \vec{v}\times\vec{B}\right) = 0$
- $\vec{E} = (E_x, 0, 0)$
- $\vec{B} = (0, B_y, 0)$

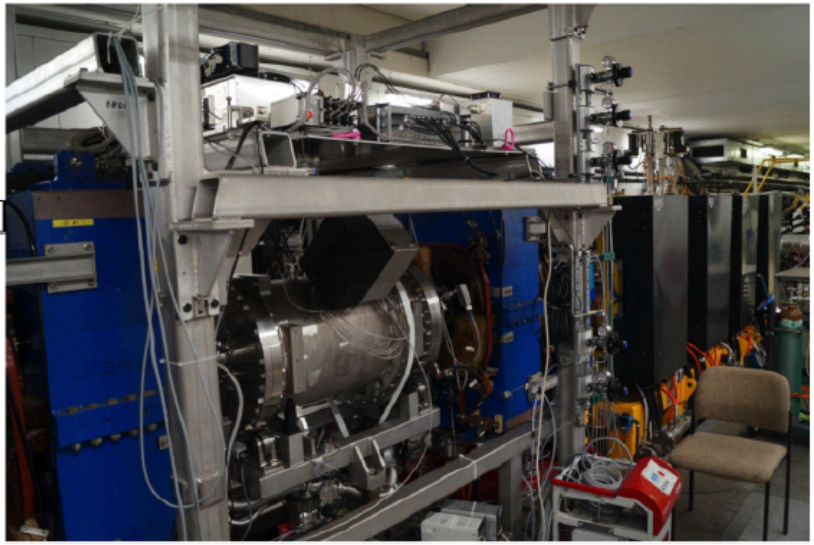
→ net EDM effect can be observed!



EDM search at COSY: proof of principle experiment

- Developed at FZJ in collaboration with RWTH-Aachen
- Installed in the PAX low-β section at COSY



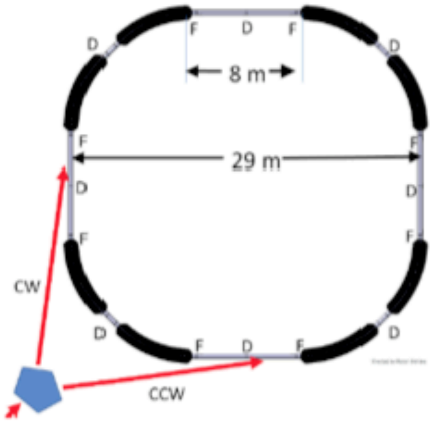


Stage 2: prototye EDM storage ring

- Build demonstrator for charged particle EDM
  - Key-performance enabler for the final ring
- Project prepared by CPEDM working group (CERN+JEDI)
  - P.B.C. process (CERN) & European Strategy for Particle Physics Update
- Possible host sites: COSY or CERN
- S.R. to Search for EDMs of Charg. Part. - Feas. Study (arXiv:1912.07881)

100 m circumference

- p at 30 MeV all-electric CW-CCW beams operation
- Frozen spin including additional vertical magnetic fields



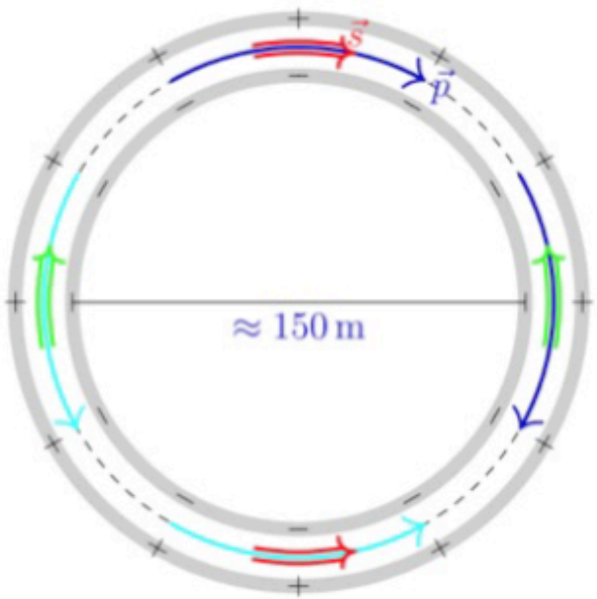
Challenges

- All electric & E-B combined deflection
- Storage and spin-coher. time in elec. machine
- CW-CCW operation
- Orbit control
- Polarimetry
- Magnetic moment effects
- Stochastic cooling

Stage 3: EDM ring

500 m circumference (with E = 8 MV/m)

- All-electric deflection
- Magic momentum for protons (p = 701 MeV/c)



Challenges

- All-electric deflection
- Simultaneous CW/CCW beams
- Phase-space cooled beams
- Long spin coherence time (> 1000 s)
- Non-destructive precision polarimetry
- Optimum orbit control
- Optimum shielding of external fields
- Control of residual (intentional) B_r field

"Holy Grail" of storage rings (largest electrostatic ever conceived)