EIC interest from INFN perspective

TALY

COMMUNITY AND SITES

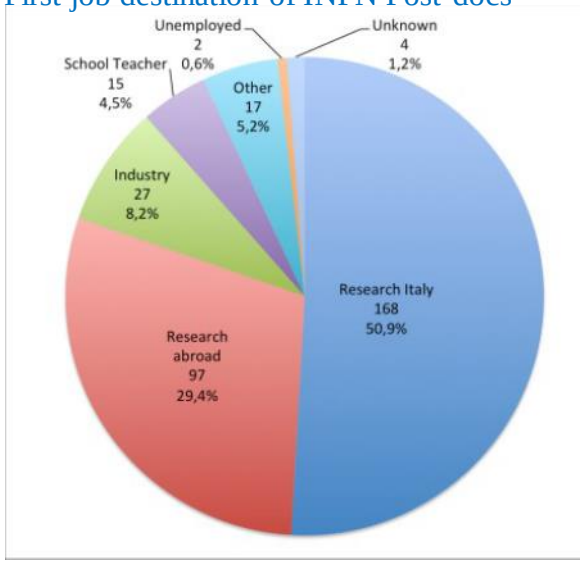
- c. 2100 staff
Number has been growing with recent new appointments
- over 3800 affiliated academic staff

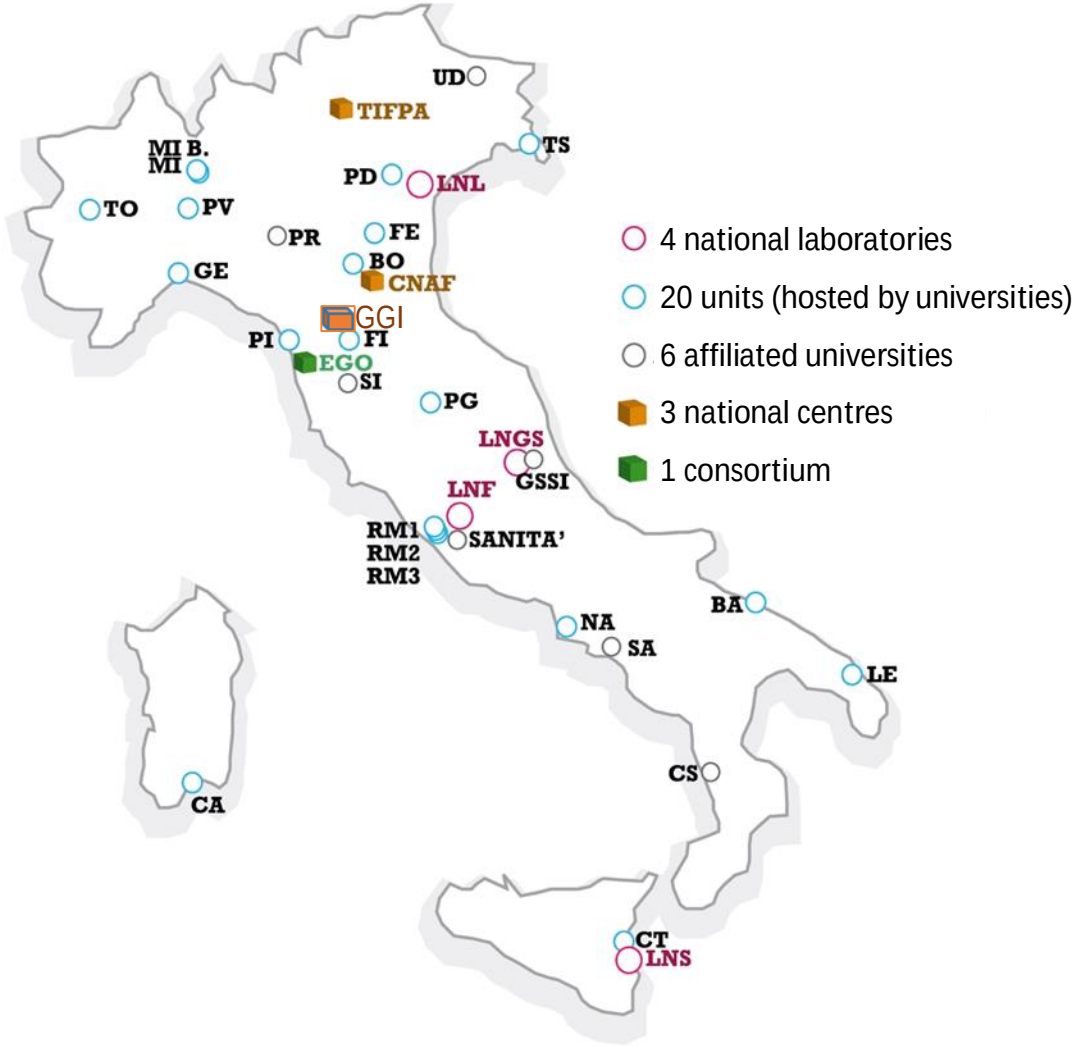
INFN operates in close collaboration with 26 Italian Universities as part of a wide cooperation scheme.

Every year INFN covers 20 percent of all grants available at Italian Universities for Ph.D. research projects in physics

(~150 grants/year)

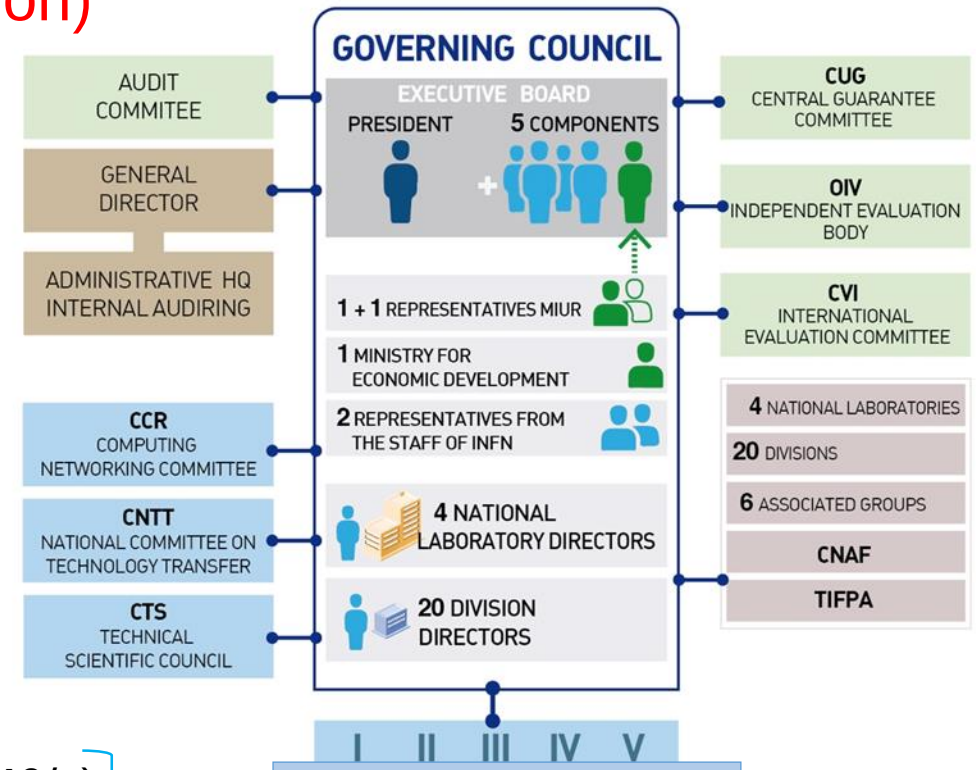
First job destination of INFN Post-docs





BUDGET & GOVERNANCE

c. 330 MEuro/year (c. 300 MEuro from Ministry of Research)
Past years -> ~constant funding (no increase for inflation)



Scientific committee members: representatives for the units and the national labs.

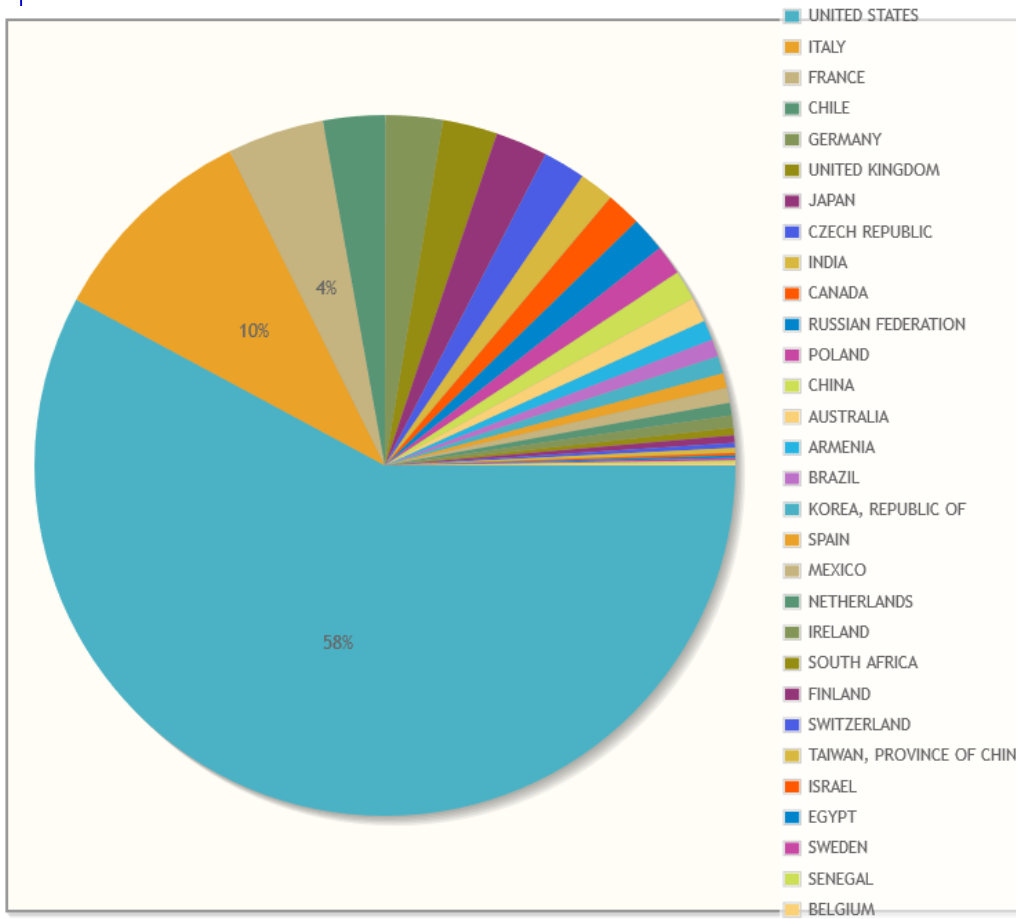
Each committee is overseen by a member of the Executive Board (bottom-up and top-down simultaneous approach)

I particle physics at accelerators (budget:20 M€/y)
II astroparticle physics (budget: 12 M€/y)
III nuclear physics (budget: 9 M€/y)
IV theoretical physics (budget: 3 M€/y)
V technology R&Ds (budget: 5 M€/y)

→ 5 Scientific Committees

INFN @ EICUG

- Several enthusiastic INFN researchers are strongly involved in the EIC project:
  - 85 (/ 873) from 15 INFN units (updated on July 11, 2019)
    - 25 theorists
    - 60 experimentalists
  - for comparison, in 2018: 63 (/788)
    - A growing community
    - Actively involved since years
- INFN-EICUG members serving on EICUG:
  - the 15 members of the IB
  - IB deputy-chair: Andrea Bressan
  - member of the SC: Marco Radici



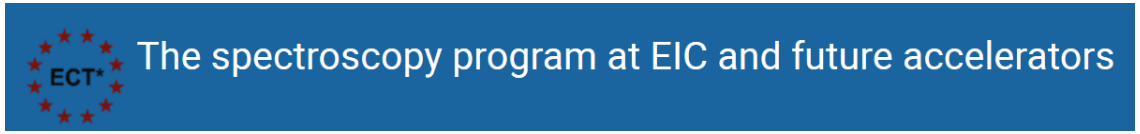
INFN Contributions to EICUG WS

- EICUG2017 – Trieste, 18-22/7/2017
  - organized by INFN-Trieste and Trieste University
- EICUG2018 – Washington, 30/7-2/8 2018
  - INFN contributions:
    - International Advisory Committee, 2 members from INFN
    - 3 plenary talks by INFN speakers
    - 1 convener of the parallel sessions from INFN
    - 1 talk in parallel session by an INFN speaker
    - 1 talk in the detector workshop by an INFN speaker
- EICUG2019 – Paris, 22-26/7/2019
  - INFN contributions:
    - International Advisory Committee, 2 members from INFN
    - 3 plenary talks by INFN speakers
    - 1 convener of the parallel sessions from INFN
    - 4 talks in parallel session by INFN speakers

EIC Events Hosted by INFN

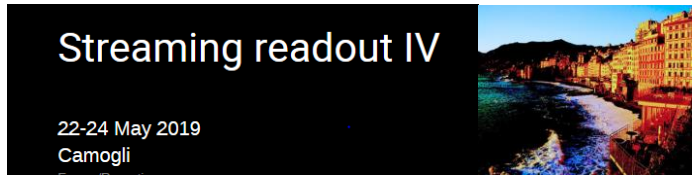
- EICUG2017 (https://eicug2017.ts.infn.it)
  - Trieste, 19-22 July 2017

- The spectroscopy program at EIC and future accelerators (https://indico.ectstar.eu/event/29/)
  - Trento, 19-21 December 2018



- EIC software meeting
  - Trieste, 21-22 May 2019

- Meeting of the EIC Streaming Readout consortium (https://agenda.infn.it/event/18179/overview)
  - Camogli, 22-24 May 2019



INFN & EIC, a bit of history

- INFN participation in EIC scientific program is discussed in the yearly bilateral meetings between INFN and DOE in Washington D.C. :
  - October 2016 October 2017 December 2018

- 11 May 2017 – a BNL delegation (D. Gibbs and R. Tribble) visits INFN headquarters: EIC is the key point of the agenda
  - Representatives of the INFN community interested to EIC invited

- 19-22/7/2017 – EICUG meeting in Trieste
  - E. Nappi: "INFN consider EIC an important opportunity for the hadronic physics community and encourage partnerships and collaborations with the other Institutions involved in the project''

- May2018 – INFN management visits Jlab, INFN contribution to the EIC project discussed in this context

- May 2018 – a collaboration of INFN experimentalists interested in EIC is formed

- 10 June 2018 – the EIC_NET project is appro

INFN Management

INFN Management

INFN Community

INFN Community

INFN Management

INFN Management

INFN Community

INFN Management

INFN & EIC, a bit of history

- INFN participation in EIC scientific program is discussed in the periodic… between INFN and DOE:
  - October 2016 October 2017 December 2018
- 11 May 2017 – a BNL delegation visits INFN he… the agenda
  - Representatives of the EIC interested c…
- 19-22/7/2017 – EICUG
  - E. Nappi: "INF… hadronic physics community and encourage … institutions involved in the project''
- M… …NFN contribution to the EIC project discussed in this …
- Ma… …tion of INFN experimentalists interested in EIC is formed
- 10 Ju… 018 – project EIC_NET approved

INFN Management

INFN Management

INFN Community

INFN Management

INFN Management

INFN Community

INFN Management

EFFECTIVE SYNERGIES OF TOP-DOWN & BOTTOM-UP ACTIONS

EIC_NET

- A bottom-up initiative
  - Dedicated to prepare INFN participation in EIC proposed and approved in 2018 with financial support starting from 1/1/2019
- SCIENTIFIC REFERENCE
  - EIC_NET is reviewed by the INFN CSN3 (Scientific Committee for Nuclear Physics)
- PARTICIPANTS (present picture)
  - 46 experimentalists from 11 INFN units
    - Bari, Bologna, Catania, Ferrara, Frascati, Genova, Padova, Roma1, Roma2, Torino, Trieste
  - Mainly physicists active in ALICE, COMPASS, JLAB experiments

INFN activities in EIC_NET

- PHYSICS
  - Event generators for the electron-nucleon and electron-nucleus scattering (Trieste)
  - Building-up the physics case for hadron spectroscopy at EIC (Genova, Roma2, Bologna)
  - Simulation studies to extract diffractive structure functions (Torino)

- MONTE CARLO STUDIES
  - Simulation studies for physics and detectors (Bari, Bologna)
  - Particle identification at EIC by a Time-of-Flight detector (Bologna)

- DETECTOR R&D

A host of cutting-edge technologies are being developed:

  - Electromagnetic calorimetry (Genova, Roma2)
  - Streaming RO (Genova, Roma2)
  - R&D for Cherenkov imaging techniques (Catania, Ferrara, Frascati, Roma1)
  - R&D for gasous single photon detectors for Cherenkov applications (Bari, Trieste)

Additional Financial Support

- PROGETTI GRANDE RILEVANZA (Projects of Large Relevance) 2018

  (Ministry of Foreign Affairs)

“A triggerless DAQ for the Electron Ion Collider (EIC)”

  - INFN Participants: Genova, Roma1, Roma2
  - Participants from abroad : MIT


Grande Rilevanza

Stati Uniti d'America
Physics and Astrophysics

Identificativo PGR06034

Elementi generali

Area di ricerca	Physics and Astrophysics
Titolo (in italiano)	Un sistema di acquisizione triggerless per l'Electron Ion Collider (EIC)
Titolo (in altra lingua)	A triggerless DAQ for the Electron Ion Collider (EIC)
Parola chiave #1	streaming readout
Parola chiave #2	electromagnetic calorimeter
Parola chiave #3	hadron physics

Financial Support From Abroad

In collaboration with Colleagues from USA within the program:

"Generic R&D for EIC"

- eRD1 "Calorimeter Consortium"
  - Genova, Roma 2
- eRD6 "Tracking & PID detector R&D towards an EIC detector"
  - Trieste
- eRD14 "ID Consortium for an integrated program for Particle Identification (PID) at a future Electron-Ion Collider"
  - Ferrara, Roma 1
- eRD20 "Developing Simulation and Analysis Tools for the EIC"
  - Trieste
- eRD23 "Streaming Readout for EIC Detectors"
  - Contact persons: M. Battaglieri (from INFN) and J.C. Bernauer
  - Genova, Roma 2

European Grant

- project STRONG-2020 financed by the EU community, 2 WPs:
  - JRA4 "3D structure of the nucleon in momentum space" (Cagliari, Pavia, Torino, Trieste) [Theorists & Experimentalists]
  - JRA14 "Micropattern Gaseous Detectors for Hadron Physics " (Trieste)

INFN Theorists & EIC

Theoretical Hadronic Physics in Italy organized in INFN project NINPHA:

NINPHA National INitiative in Physics of HAdrons

located in: TOrino, PaVia, GEnova, PeruGia, RoMa1, CAgliari

National Coordinator: E. Boglione (TO)

Population (end 2018):

TO	3 staff	1 post-doc	1 PhD
PV	4 staff	3 post-doc	4 PhD
GE	3 staff	1 post-doc	1 PhD
PG	3 staff		1 PhD
RM1	1 staff	1 post-doc	1 PhD
CA	3 staff	2 post-doc	1 PhD
Tot	17 staff	8 post-doc	9 PhD

INFN theoretical activity for EIC within a more general project related to hadron physics at large

INFN funds: 42 k€ from CSN4 for 2019 + 2 (non Italian) post-doc's (RM1, CA)
Other funds: ERC Consolidator 3DSpin (Univ. PV + INFN, P.I. Bacchetta - PV)
Related project 3DGlue (Univ. PV, post-doc Celiberto - PV)
Marie-Curie GLUECORE (INFN, post-doc Echevarria - PV)
participation in Horizon2020 project STRONG2020 (just approved)

Contribution of INFN Theorists to EIC

- Main goals:
  - full 3D mapping (in momentum and position space) of confined parton dynamics inside the nucleon
  - understand how partons make up hadrons through QCD
- Research items:
  - properties of 3D partonic distributions (TMDs, GPDs, GTMDs, Wigner): factorization th.'s, evolution eq.'s, universality, matching with fixed-order pQCD, calculations, relation to partonic (orbital) angular momentum, etc..
  - phenomenological extraction of PDFs / TMDs from global fits of exp. data
  - modeling of TMDs, GPDs, GTMDs; support to experimental activities (JLab12)
  - models of double parton distributions; studies of double parton scattering and search for new physics at LHC
  - study of proton polarizabilities in Compton scattering; support to experiments (Mainz)
  - quark models of baryon and meson wave functions; study of spectrum of meson hybrids and X, Y, Z resonances; support to spectroscopy activities at JLab
- Other activities:
  - co-organization of various workshops, particularly at ECT*(Trento) and INT (Seattle)
  - members of IAC / conveners in many workshops and conferences (Light-Cone, MENU, DIS, QCD Evolution, EuNPC, Transversity, EICUG meetings..)
  - Pasquini (PV) member of IAC at CFNS (Center for Frontiers in Nuclear Science)

EIC from INFN Perspective

- A large community of INFN experimentalists (> 150 researchers), nowadays involved in ALICE, COMPASS and JLAB Hall A&B experiments, and ~ 30 theorists are potential contributors to EIC

- INFN management has recognized EIC as a relevant project for the nuclear physics program

- The aggregation process will follow the standard INFN bottom-up approach EIC_NET -> EIC
  - Formation of a homogeneous and organic INFN community
  - Hierarchic management structure
  - Dedicated budget
  - Key roles in EIC

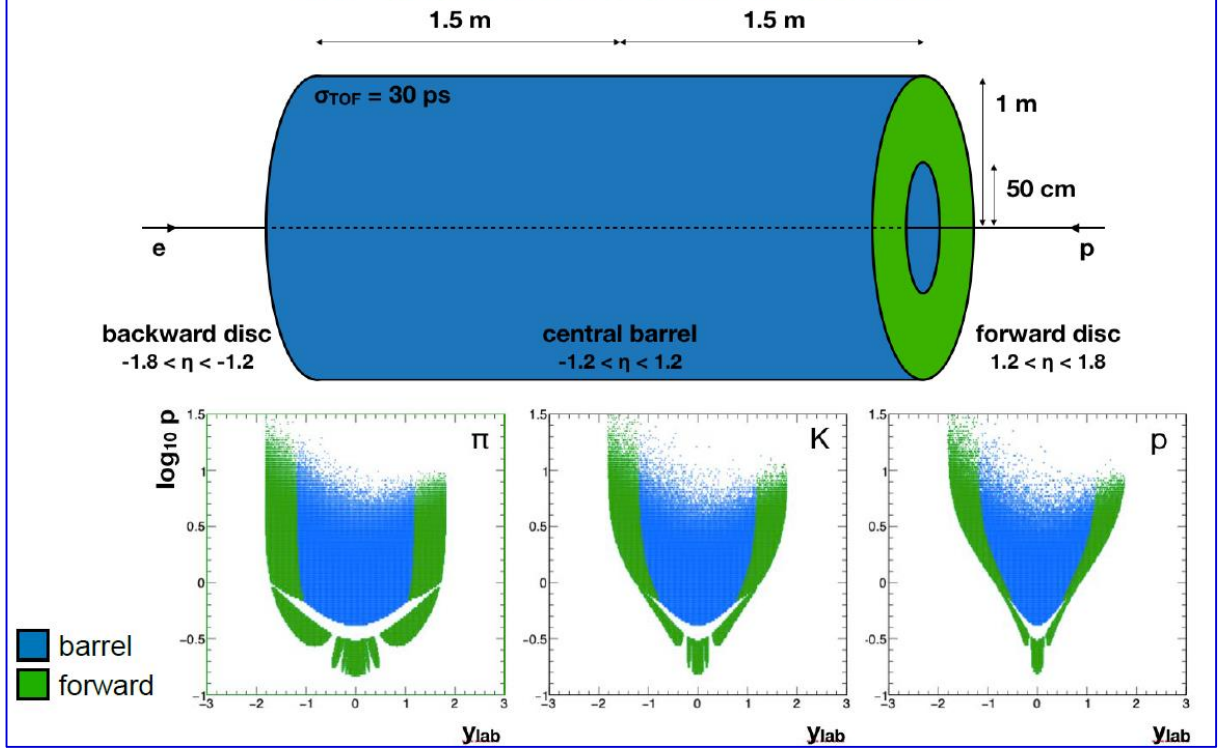
Conclusions

- The EIC project is the natural evolution of COMPASS, JLAB & ALICE experiments
- The program “Generic R&D for the EIC”, has greatly triggered the INFN involvement in EIC
- Preparatory activities for EIC have been officially recognized and supported by INFN
  - both on the experimental and theoretical sides
- Effective synergy between INFN management and the INFN community wishing to contribute to EIC
  - the winning approach
- INFN looks forward to strengthening the contacts with US teams and providing a major contribution to the development of EIC

Monte Carlo Studies

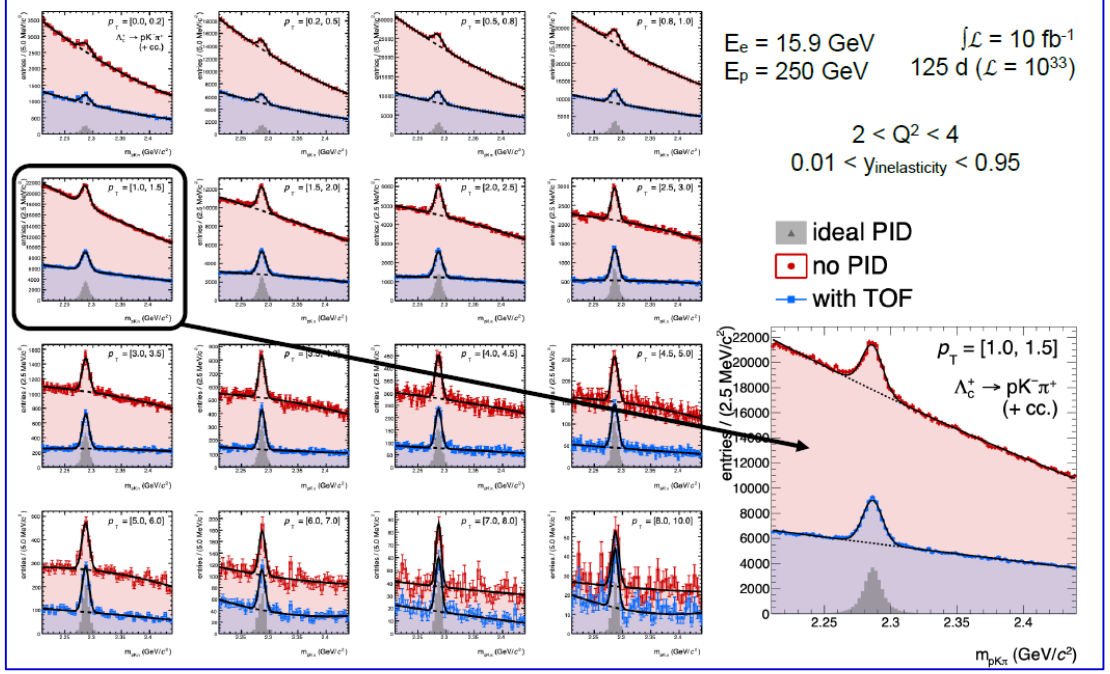
→ simulation studies of the physics impact of a high-resolution TOF detector for EIC
→ preliminary results on acceptance and PID capabilities of a TOF detector concept for EIC

TOF detector concept and acceptance



→ simulation studies of the physics impact of a high-resolution TOF detector for EIC
→ preliminary results on acceptance and PID capabilities of a TOF detector concept for EIC

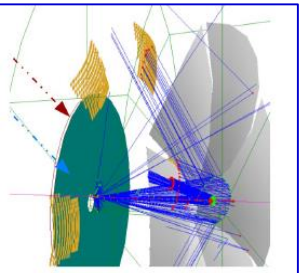
Impact of TOF PID on Λ_c reconstruction



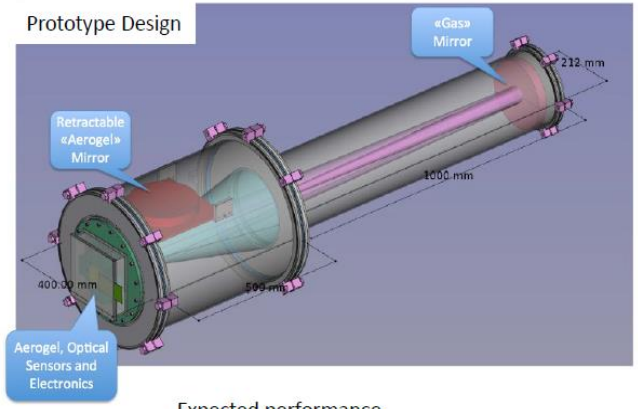
Detector R&D

Dual RICH (dRICH)

dRICH hadron-ID with dual radiator aerogel (n~1.02) + freon gas (n~1.0008) for h-endcap extended momentum range (up to ~ 50 GeV/c

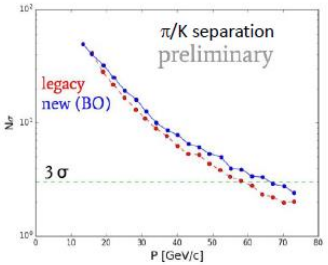


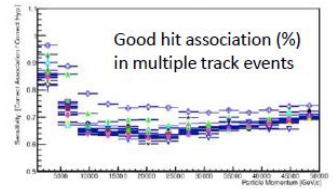
Prototype Design



MonteCarlo studies

Geometry and reconstruction algorithm optimization



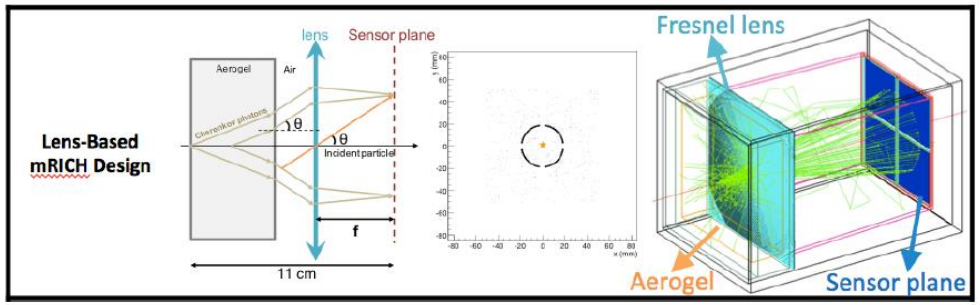


Expected performance

1 p.e. Error (mrad)	Aerogel	C_2F_6 Gas
Chromatic error	3.2	0.51
Emission	0.5	0.5
Pixel	2.5	0.42

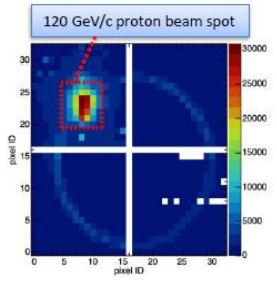
Modular RICH (mRICH) & Readout Electronics

mRICH hadron-ID compact solution for e-endcap limited momentum range (up to ~ 10 GeV/c)

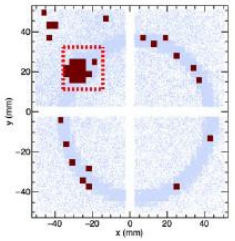


Fresnel lens focalizes and centers the ring

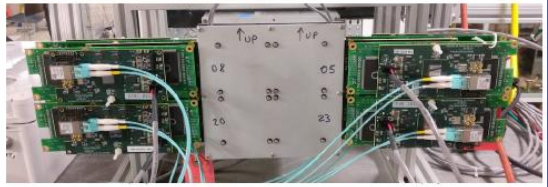
Cumulative image



Single data event over simulation shaded image



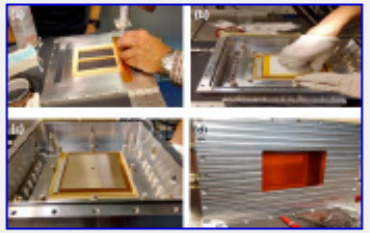
Sensors and readout of prototype derived from CLAS12 RICH

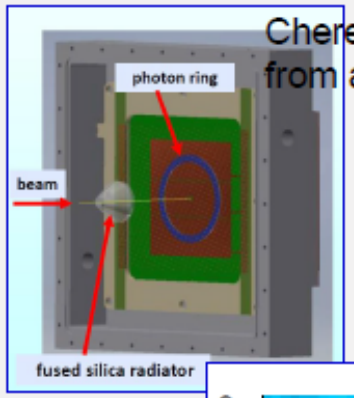


Detector R&D

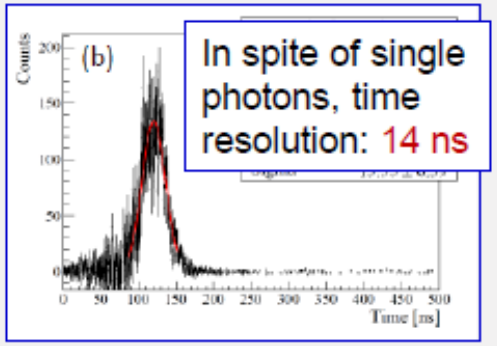
R&D – gaseous photondetectors

- Prototype: construction & test beam
- Data analyzed
- Design of prototype version 2 ongoing

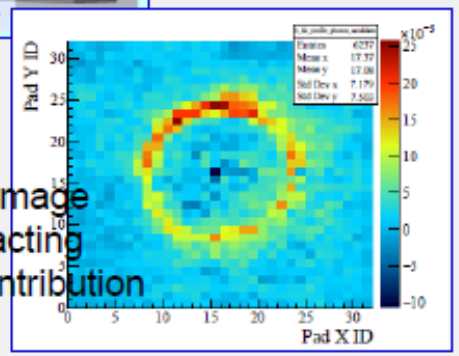




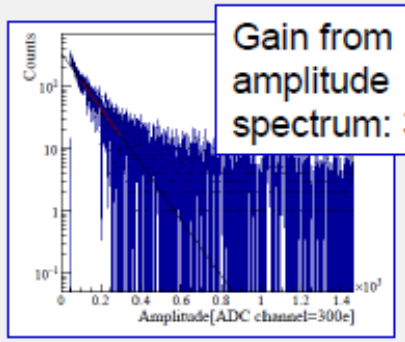
Cherenkov photons from a quartz radiator



In spite of single photons, time resolution: 14 ns



Clear ring image after subtracting the MIP contribution

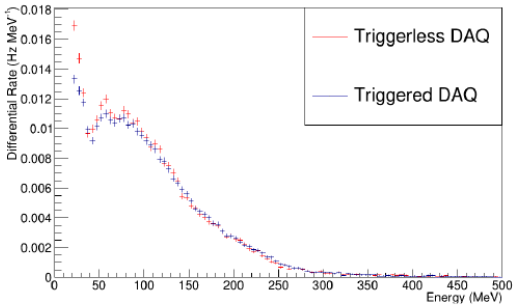


Gain from amplitude spectrum: 30 k

Streaming readout

- The EIC detector will be one of the few major collider detectors to be built from scratch in the 21st century: it requires an integrated, up-to-date readout scheme.
- A fully "Streaming Readout" (SR) approach is currently being considered as part of the ongoing EIC R&D activity, with a very active consortium (eRD23) formed after the 2018 proposal approval.
  - **Italian leadership:** PI M. Battaglieri (INFN-Genova)
- A significant part of the ongoing activity is devoted to the **validation** of the new technology, with one-to-one comparison with a traditional triggered solution.
  - **The EM calorimeter** was the first study case – this detector will play a crucial role in the trigger for any reaction of interest.
  - **First tests (2019):** $PbWO_4$ prototype exposed to cosmic rays. Excellent agreement between results obtained with SR and with triggered approach.
  - **Next step (2020-):** measurements at a test-beam facility

Energy deposited in a single crystal



EM clusters multiplicities