

# ePIC@EIC e la EPPS

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Slides concordate con la comunità ePIC Italia

# EPPS 2020

CERN/SPC/1239/Rev.2

Update of the European Strategy for Particle Physics:  
Remit of the European Strategy Group

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The ESG should take into consideration:

- the input of the particle physics community;
  - the status of implementation of the 2020 Strategy update;
  - the accomplishments over recent years, including the results from the LHC and other experiments and facilities worldwide, the progress in the construction of the High-Luminosity LHC, the outcome of the Future Circular Collider Feasibility Study, and recent technological developments in accelerator, detector and computing;
  - the international landscape of the field.
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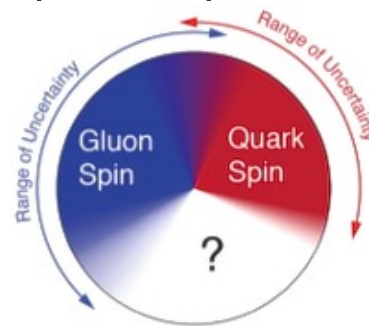
# Principali temi scientifici in ePIC@EIC

## massa del protone

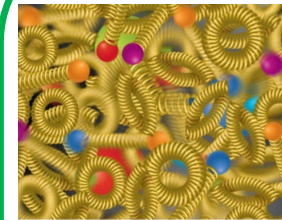


Quarks have very little mass and gluons have none. If you could weigh the mass of all the quarks and gluons outside of a proton, they'd account for only 1% of the total mass of the proton

## spin del protone



$$\frac{1}{2} = \overset{\sim 50\%}{\boxed{\frac{1}{2}\Delta\Sigma(\mu)}} + \overset{\sim 30\%}{\boxed{\Delta G(\mu)}} + \overset{?}{\boxed{L_{Q+G}(\mu)}}$$



## Precision 3D imaging of protons and nuclei

### Nuclear PDFs (Parton Distribution Functions) and Transverse Momentum Distributions (TMDs)

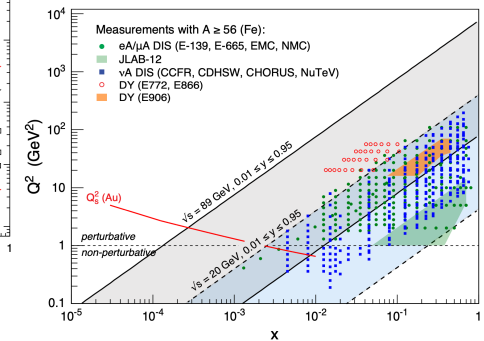
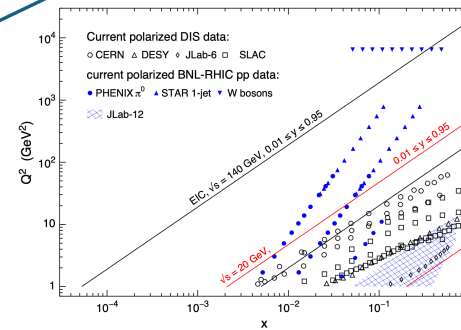
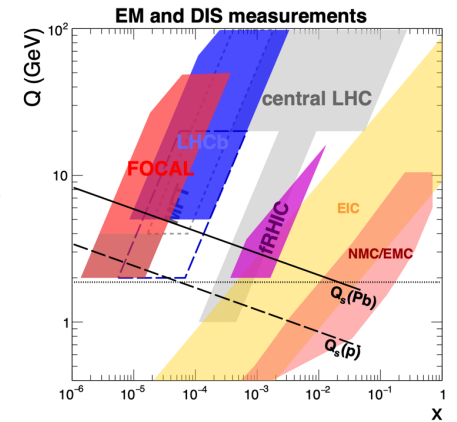
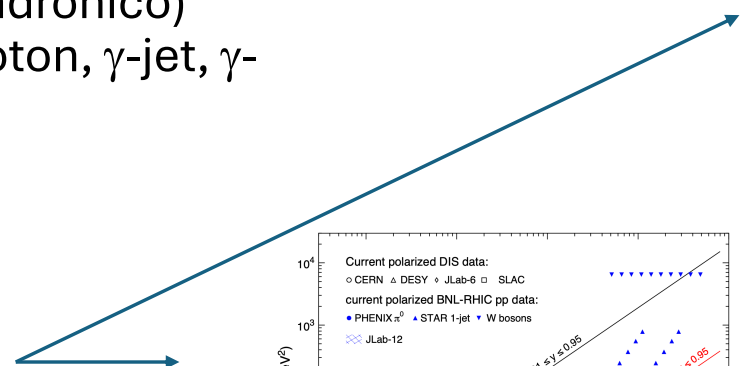
It will help refine our understanding of how quarks and gluons are distributed within protons and neutrons

3D imaging of the nucleon → EIC come "macchina" da PDF...

...e molto altro...

# Sinergie ePIC-LHC sui temi scientifici

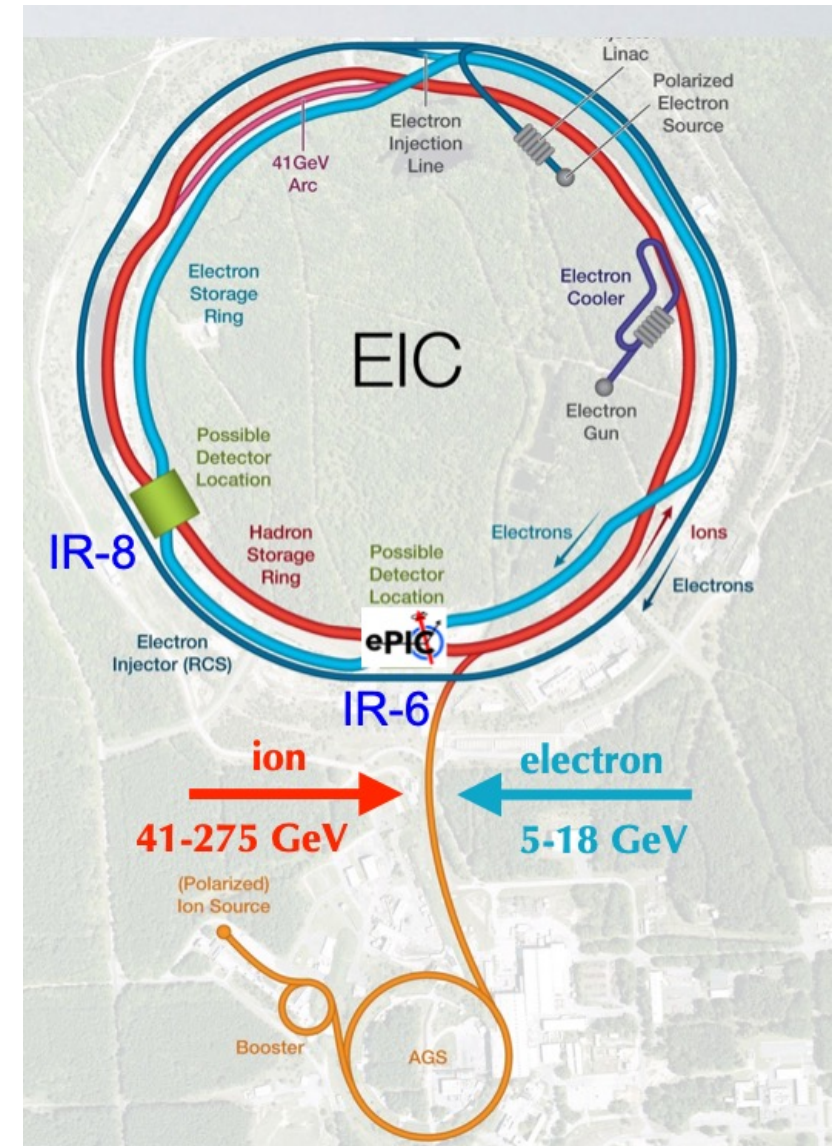
- COMPASS/AMBER
  - vasto panorama di misure, dallo spin del nucleone alle misure di DVCS, chiralità da PDF pione/kaone, TMD da SIDIS (Semi-Inclusive Deep Inelastic Scattering), etc.
- FOCAL
  - ALICE Forward Calorimeter (e.m.+ adronico)
  - Saturazione, gluon pdf via prompt foton,  $\gamma$ -jet,  $\gamma$ -hadron, vector mesons
- LHCspin (@LHCb):
  - polarized target
  - gluon/quark TMD's via HF mesons
- Impatto elevatissimo sulle PDF
  - v. workshop JENAA "Synergies between the EIC and the LHC" <https://indico.desy.de/event/41404/>



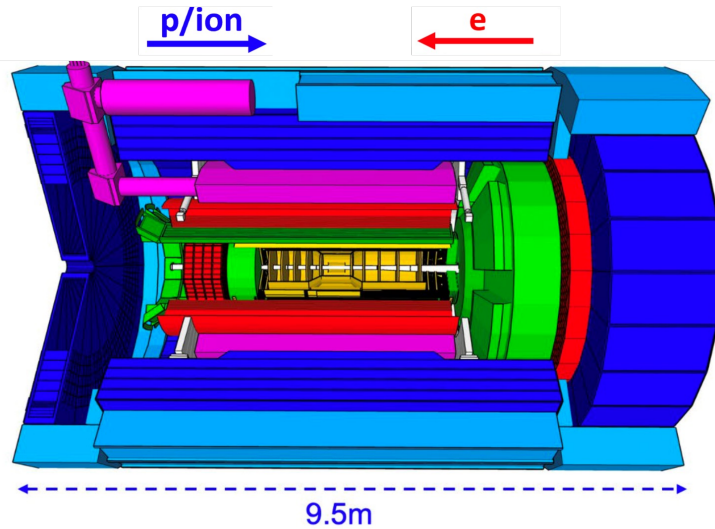
# EIC

## Electron Ion Collider @ BNL (Upton, NY, USA)

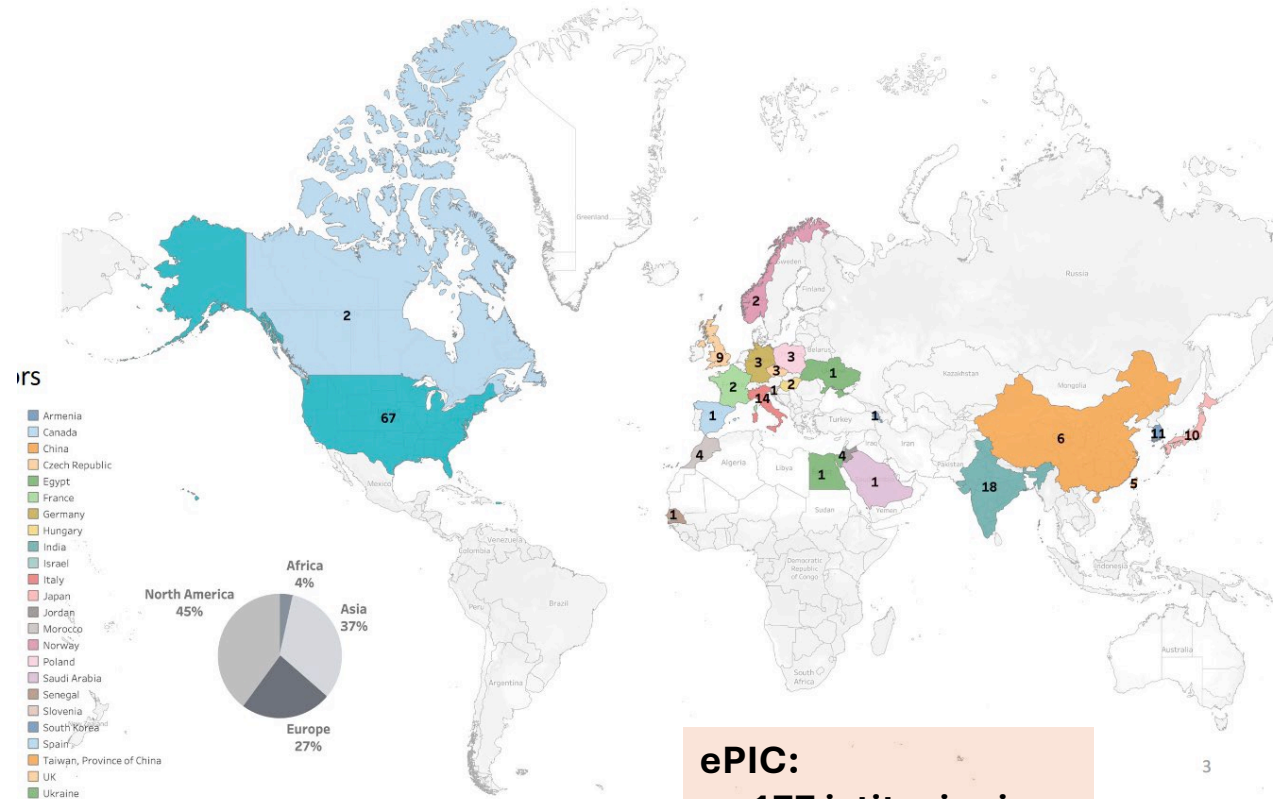
- $\mathcal{L}_{ep} \sim 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$  ( $>100 \times$  HERA)
  - *crab crossing*, CEC, piccolo  $\beta^*$ , crossing rate 100 MHz
- $E_e \times E_h = 5-18 \times 41-275$  (A) GeV  $\rightarrow \sqrt{s} = 20-141$  GeV
- Polarizzazione e/(p-<sup>3</sup>He)  $\sim 70\%$  (per la prima volta!)
- Fasci adronici: da H a U, a più valori di  $\sqrt{s}$
- Unico nuovo acceleratore di grandi dimensioni che partirà entro i prossimi  $\sim 10$  anni
- Costruzione: inizio fine anno prossimo/inizio 2026!
  - DOE: approvato e finanziato
- Anche con contributo INFN:
  - Material Surface Science Laboratory of LNF: stainless-steel beam screen with co-laminated copper and a thin amorphous carbon (aC) coating, with low resistive-wall impedance to limit the heat load on the beam pipes (da un seminario di INFN-Acceleratori presentato da M. Angelucci:  
<https://agenda.infn.it/event/43760/>)



# ePIC: **e**lectron-**p**roton/**i**on **c**ollider collaboration

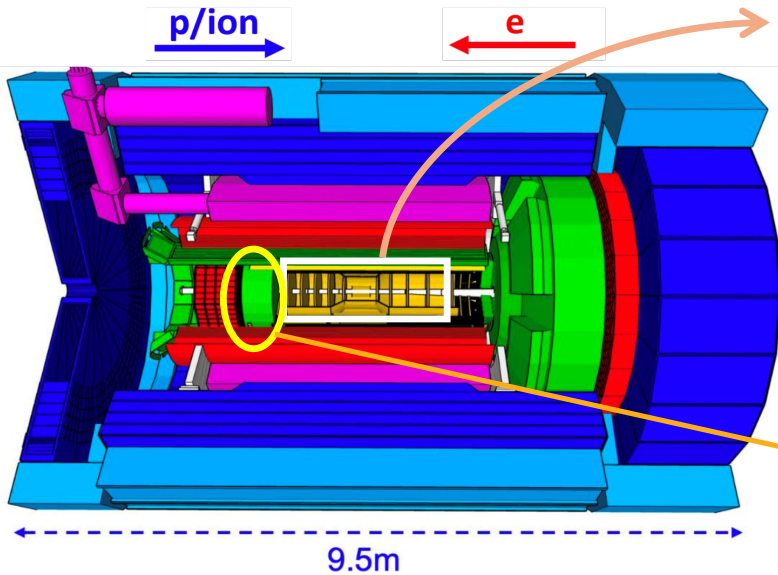


- calorimetri adronici
- solenoidi 1.7 Tesla
- calorimetri e.m.
- TOF, DIRC, RICH
- tracciatori MPGD
- tracciatore MAPS

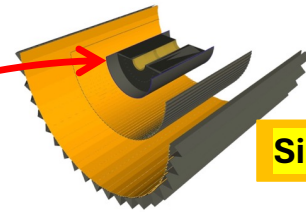
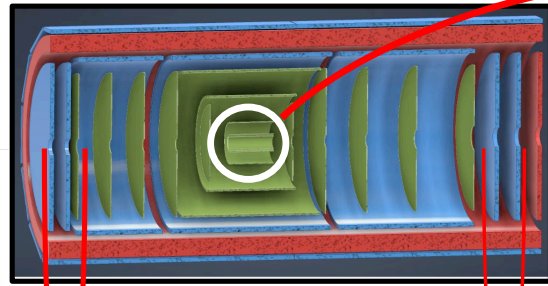


- ePIC:**
- 177 istituzioni
  - 26 paesi
  - ~700 partecipanti

# INFN in ePIC



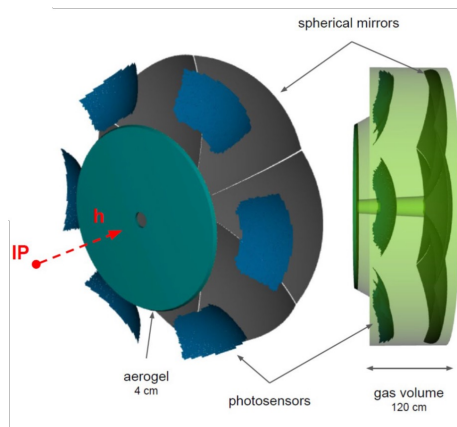
ePIC presente in 14 strutture  
con 122 Ric./Tec., 34 FTE  
(preventivi INFN 2025)



**Silicon Vertex Tracker Barrel**

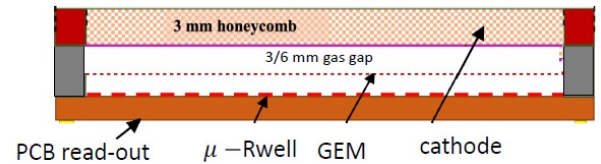
**SVT-IB:**  
Silicon Vertex Tracker – Inner Barrel  
Tre strati, i primi due (L0, L1) responsabilità INFN  
Sensori MAPS sviluppo di **ALICE/ITS3**  
ePIC-SVT in sinergia con ALICE, NA60+

**dRICH  
aerogel+gas**



**$\mu$ RWell Endcaps Tracker**

GEM -  $\mu$ Rwell Technology



## ePIC@INFN Sezione di Catania

- Polo del sud CT-SA-CS  
    QA of sensors (Sipm per dRICH)
- $\mu$ RWell Endcaps Tracker
- SRO
- Infrastruttura calcolo

# EIC-ePIC ranking - 1



## THE PATH TO THE EIC PROJECT

### Fresh news

S. Dalla Torre – CERN Detector Seminar  
24 maggio 2024

#### *Major Nuclear Physics Facilities for the Next Decade*

*Report of the NSAC Facilities Subcommittee accepted on April 26, 2024, by NSAC*

“The EIC will be a new world-leading DOE facility at the forefront of scientific discovery. The Subcommittee ranks the EIC as **(a) absolutely central** in its potential to contribute to world-leading science in the next decade.”

“Concerning readiness of the facility for construction, we rank the EIC in category **(a) ready to initiate construction.**”

**DOE/NSF Nuclear Science Advisory Committee**

[Nuclear Science Advisory Committee \(NSAC\)](#)



# Words by NUPECC ( Nuclear Physics European Collaboration Committee)

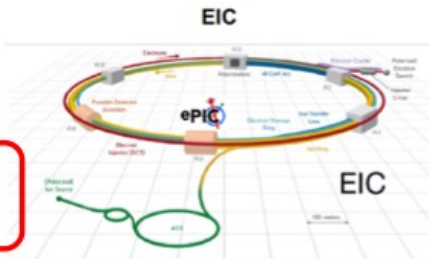
## NuPECC Long Range Plan (to be issued in 2024)



### Recommendations for Nuclear Physics Infrastructures



- Collaboration with non-European infrastructures should be fostered in all areas of nuclear research to seize unique scientific opportunities and synergies that complement scientific programmes based in Europe. In particular, European participation in the construction of ePIC at the future international flagship facility EIC is recommended.



P. Antonioli – CSN3 18-19 giugno 2024

*“First time to my knowledge a non-European infrastructure is recommended at this level in the NuPECC Long Range Plan”*

D. Bettoni at EIC RRB, May 2024

INFN CSI

### Recommendations for Hadron Physics



#### • Future flagship facilities and experiments

We recommend the expedited realisation of the antiproton experiment PANDA, and the support of European groups to contribute to the electron-ion experiment ePIC. By virtue of their different beam species and energy regimes, PANDA and ePIC will explore complementary physics aspects. In a ten-year perspective, these two next-generation experiments must be made ready to launch.

- PANDA: The physics program, including the prospect of unravelling exotic matter, remains unique and compelling. PANDA will strengthen the European position on the global scene and act as a unifying force for the community. Therefore, we recommend support for its construction and for the development of instrumentation, software and analysis tools.
- ePIC: Here, European researchers will be able to explore unknown features of quarks and gluons inside nucleons and nuclei. We recommend supporting the participation of European groups in ePIC and reinforcing scientific and technological activities which synergize with European projects.

# La raccomandazione della “strategy”

- CE RN-ESU-013, June 2020 “Update of the European Strategy for Particle Physics”
- CE RN-ESU-014 , June 2020 “Deliberation Document on the 2020 update of the European Strategy for Particle Physics”

## 5. Synergies with neighbouring fields

[ESPP 2020](#)

a) A variety of research lines at the boundary between particle and nuclear physics require dedicated experiments and facilities. Europe has a vibrant nuclear physics programme at CERN, including the heavy-ion programme, and at other European facilities. **In the global context, a new electron-ion collider, EIC, is foreseen in the United States to study the partonic structure of the proton and nuclei, in which there is interest among European researchers. *Europe should maintain its capability to perform innovative experiments at the boundary between particle and nuclear physics, and CERN should continue to coordinate with NuPECC on topics of mutual interest.***

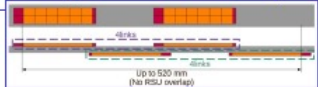
- EIC già citato nella passata edizione
- **Presenza concreta nella prossima edizione: raccomandazione...eseguita!**

# R&D per EIC

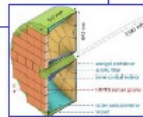


## TECHNOLOGIES: WORLD FIRST AT ePIC

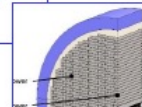
EIC Large Area Sensor (LAS), modification of ITS3 sensor with 5 or 6 RSU forming staves as the basic building elements for the Outer Barrel and the Tracking Disks



HRPPDs for Cherenkov imaging and Time-of-Flight for *pfRICH*

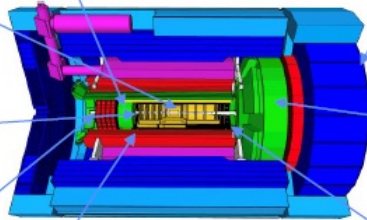
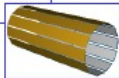


first-time full-size CALICE-like calorimeter in collider experiment in the forward HCal

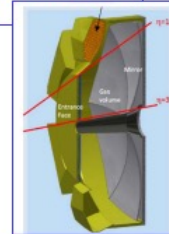


Molti sviluppi citati nel report ECFA di interesse per TUTTA la comunità!

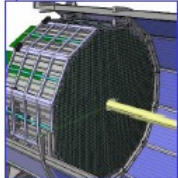
planar double amplification (GEM &  $\mu$ RWELL) modules & 2D-strip readout for the MPGD outer trackers and disks



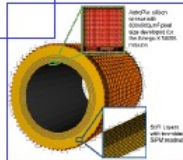
First use of SiPMs as Photosensors in a RICH for the dRICH



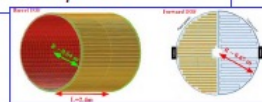
SiPM as Photosensors in crystal calorimetry for backward endcap ECal



Use of ASTROPIX in Calorimetry for the imaging barrel ECal



First time use of AC-LGAD in a collider detector for barrel and forward endcap ToF



THE 2021 ECFA DETECTOR RESEARCH AND DEVELOPMENT ROADMAP

The European Committee for Future Accelerators Detector R&D Roadmap Process Group

European Strategy Update

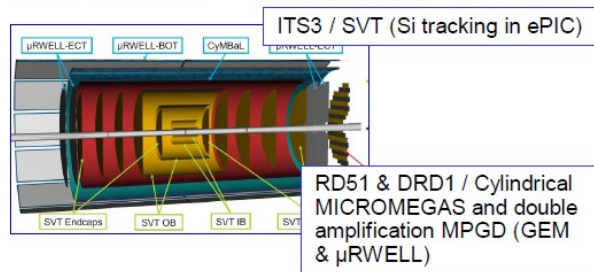
ECFA  
European Committee for Future Accelerators

# Sinergie con esperimenti CERN



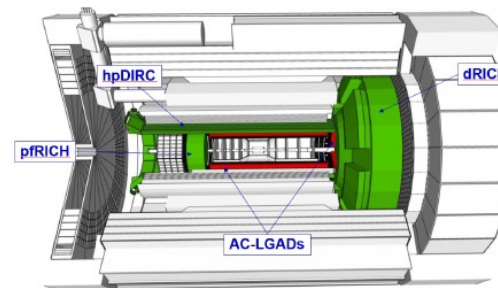
## TECHNOLOGIES: Main synergies with CERN

### TRACKING



### Cherenkov PID

LHCb, COMPASS/AMBER, DRD4 / ePIC :  
Aerogel, gas radiators, photosensors



### Streaming read-out

LHCb, ALICE, ... / ePIC:

- DAQ / analysis architecture
- GTU



### ToF PID

HL-LHC, DRD3 / ePIC :  
AC-LGADs

And more ...

# Timeline

Extended Year  
End  
Stop (EYETS).



**EIC** →

- le tecnologie sviluppate possono essere concatenate agli upgrade per LHC che ci saranno in LS4 (LHCb e ALICE3) e poi per FCC
- si tratta di "programmi compatibili "
- EIC sarà anche ben posizionato nella lunga pausa tra fine LHC e inizio FCC



# Takeaway messages

- LHC ed EIC: programmi complementari, con grande impatto reciproco
- Agende: ciclo di vita di EIC ~20 anni, inserito tra HL-LHC e FCC
- Tecnologie dei rivelatori: molte opportunità di sinergia
- Interesse per EIC consolidato nella comunità (italiana ed europea)
- Elemento di arricchimento delle attività e di aggregazione per le parti interessate agli sviluppi tecnologici