A. De Caro (University of Salerno and INFN)

The Masterclasses program for various experiments

Outline

- Masterclass
  - Historical overview: why, when, what
  - IPPOG
- Italy & INFN in IPPOG

- Activities involving schools in ePIC
  - Vi presento ePIC!
  - Preparation of masterclass exercise(s)

Origin of the Masterclasses

https://cerncourier.com/a/how-the-particle-physics-masterclasses-began/

- Idea proposed in 1996
- Physicists: Roger Barlow and Ken Long
- Goal: give students a real research experience in particle physics

The start can be dated precisely: it was in a discussion between Ken Long and myself that took place during a coffee break at the committee meeting of the UK Institute of Physics (IOP) High-Energy Particle Physics (HEPP) group on 17 October 1996. We were frustrated at difficulties with outreach – or the public understanding of science, as it was then called – to schools. Particle physics had a great story to tell, with fine pictures and enthusiastic speakers, but schools were slow to respond to our offers to visit and give talks. Our words and pictures could not compete with the colour and noise of chemists and the experiments they included in their lectures. Surely it was impossible to show real particle physics in the classroom? As Ken and I talked, bits of the answer came together and more followed over e-mail discussions in the succeeding weeks:

What are Particle Physics Masterclasses?

Outreach activities for high-school students

- Activities organised by Universities and Research Institutes
- Students experience a day as particle physicists
- They analyse real experimental data from high-energy physics experiments
- They discuss their results in a national/european/international meeting

First Masterclass in particle physics

https://cerncourier.com/a/how-the-particle-physics-masterclasses-began/

- First event organised on April 11th 1997
- Took place in some United Kingdom Universities:
  - Imperial College, Manchester, Oxford, Durham, Liverpool, Swansea and Lancaster Universities
- Students spent a day at Universities

• Rather than go to schools and talk to a dozen pupils, we would invite them to come to us, in university lecture theatres that could accommodate hundreds of people.

• A full-day event would make the trip worth their while and allow time for a range of topics and activities.

• We would run the event from local universities but consider it a national event and organize publicity centrally using the IOP.

• Most important, we would use the new computer clusters that were being installed for undergraduates but not used much outside of university term time.

What Do Students Do During a Masterclass?

- Study particle signals recorded by detectors
- Identify particles
- Measure quantities such as invariant mass
- Reconstruct particles

- …after a brief introduction with talk(s)

First Masterclass in particle physics

https://cerncourier.com/a/how-the-particle-physics-masterclasses-began/

- Analysed real particle-physics data
  - Identifying Interesting Events at LEP

Terry's package was revolutionary in that it gave school students real particle-physics data and real tools, and asked them to make decisions. Presented with simple Z decays from the OPAL experiment at CERN's Large Electron–Positron (LEP) collider, the students had to classify them as electron, muon, tau or quark decays, according to the patterns in the detector. The only difference from actual analysis was that such a classification would not be done by a physicist, but by a program using criteria devised by a physicist. Terry and I had spent a lot of time puzzling over the OPAL event display to understand the detector for the first muon-pair results, so I can certify that this exercise was close to real research.

What Did Students Do During first Masterclass?

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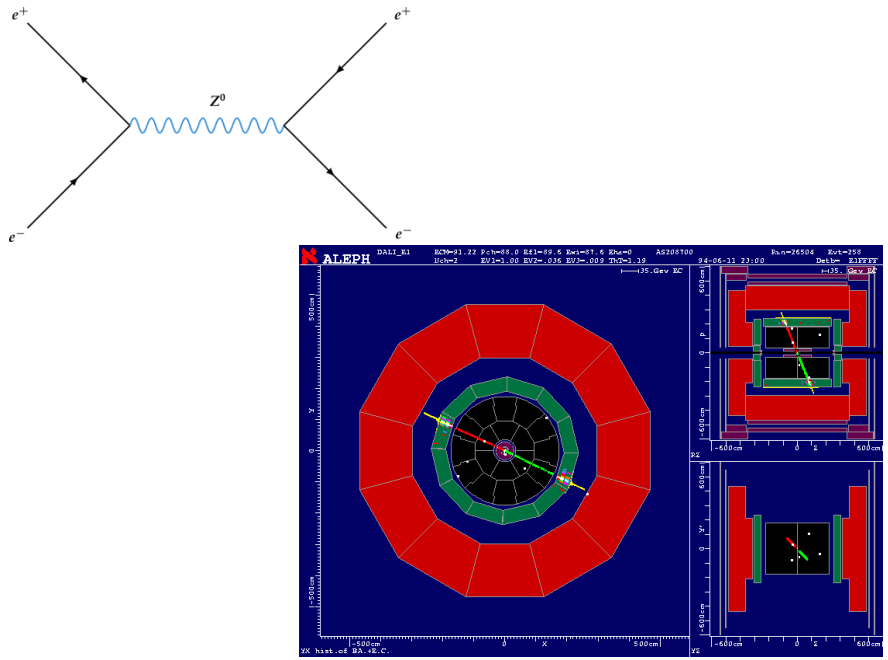

Note only two particles (no jets), tracks, nothing beyond the ECAL.

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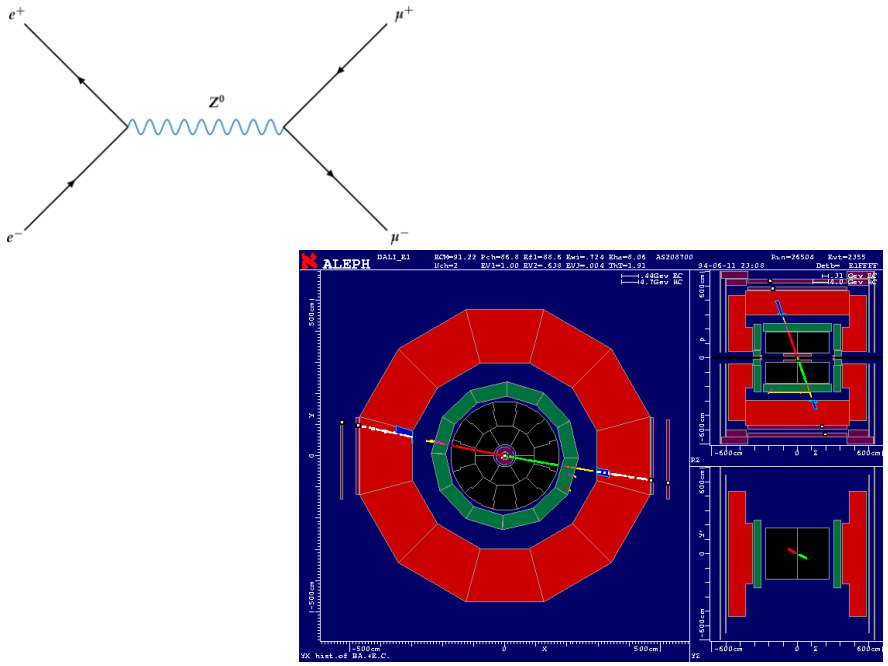

Just two tracks: minimal interactions in the calorimeters, and activation of the outer muon system.

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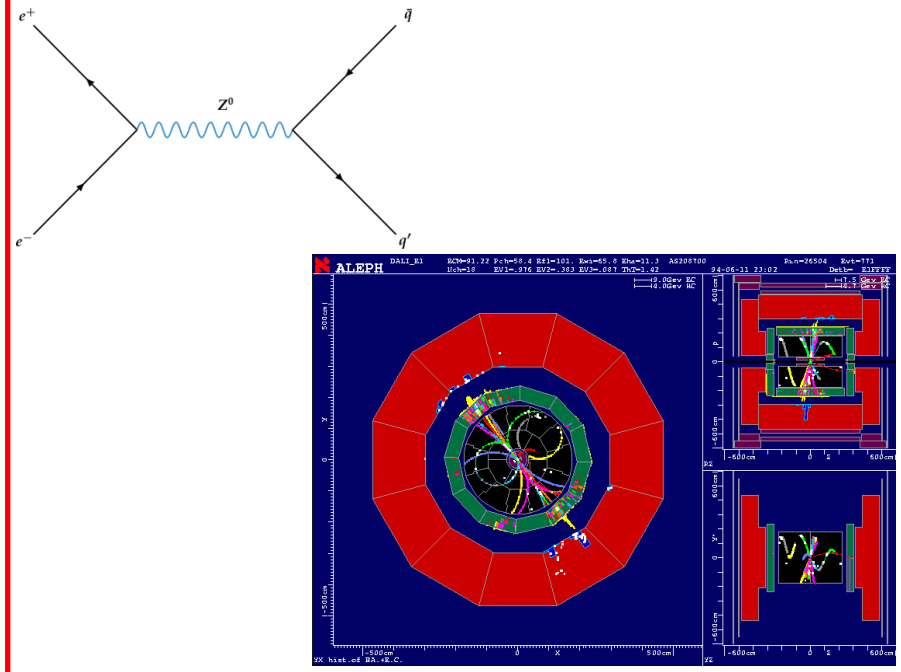

The hadronic decays of the Z^0 are really decays into quark-antiquark pairs of one of the five following types of quark: u,d,s,c or b. The top quark is not involved because it is more massive than the Z^0.

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The basis for the masterclasses was:

"Think globally, act locally"

Scheme written up in the HEPP group newsletter (January 1998):

- not just talks
- Using PC clusters, participants involved in an activity that is not far from real research.
- A national scheme spreads the publicity.
- It runs every year.

From (UK) National to European Particle Physics Masterclass

In 1997 the European Particle Physics Outreach Group (EPPOG) was formed

- with the support of:
  - the European Committee for Future Accelerators (ECFA)
  - the High-Energy and Particle Physics Board of the European Physical Society (EPS)
- with the purpose of
  - fostering outreach expertise, pooling resources, and carrying out communication activities for particle physics to schools and the public

From European to International Particle Physics Masterclass

EPPOG expanded to International Particle Physics Masterclass program

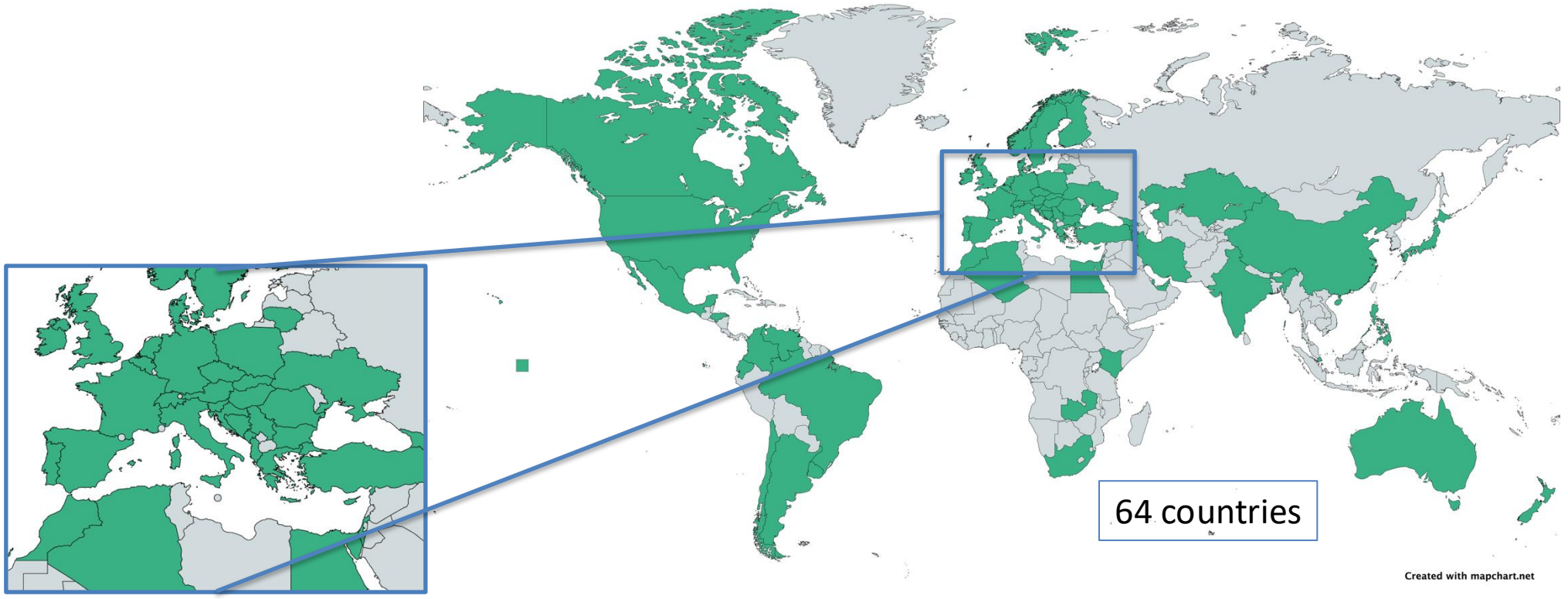
- allowing students worldwide to analyze real experimental data and thus familiarize themselves with activities that mostly pertained to the research environment until then.

EPPOG was officially renamed IPPOG

- to reflect its growing international spread.

International Particle Physics Outreach Group

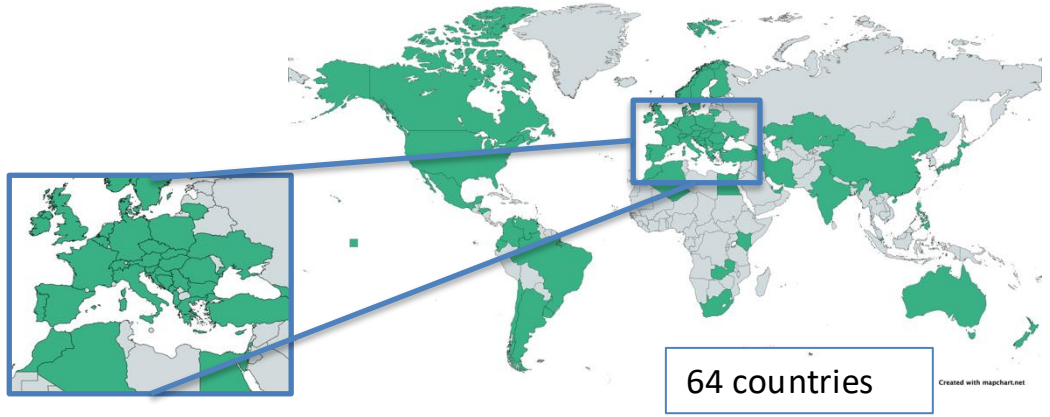
- In 2016 it became a formal collaboration



International Particle Physics Outreach Group

- In 2016 it became a formal collaboration

34 country representatives
9 experiments
1 international lab. (CERN)
2 national labs. associated (DESY, GSI)



Partnerships have been developed with other outreach groups: QuarkNet (USA)

International Particle Physics Masterclass

become *scientists for a day*

- 1997: started with measurements from LEP experiments:
  - OPAL, DELPHI, ALEPH, L3
- 2012: followed by the four large LHC experiments:
  - ATLAS (Z and W boson-related measurements),
  - CMS (Z and W boson-related measurements),
  - ALICE (quark–gluon plasma-related observables),
  - LHCb (heavy-flavor measurements).

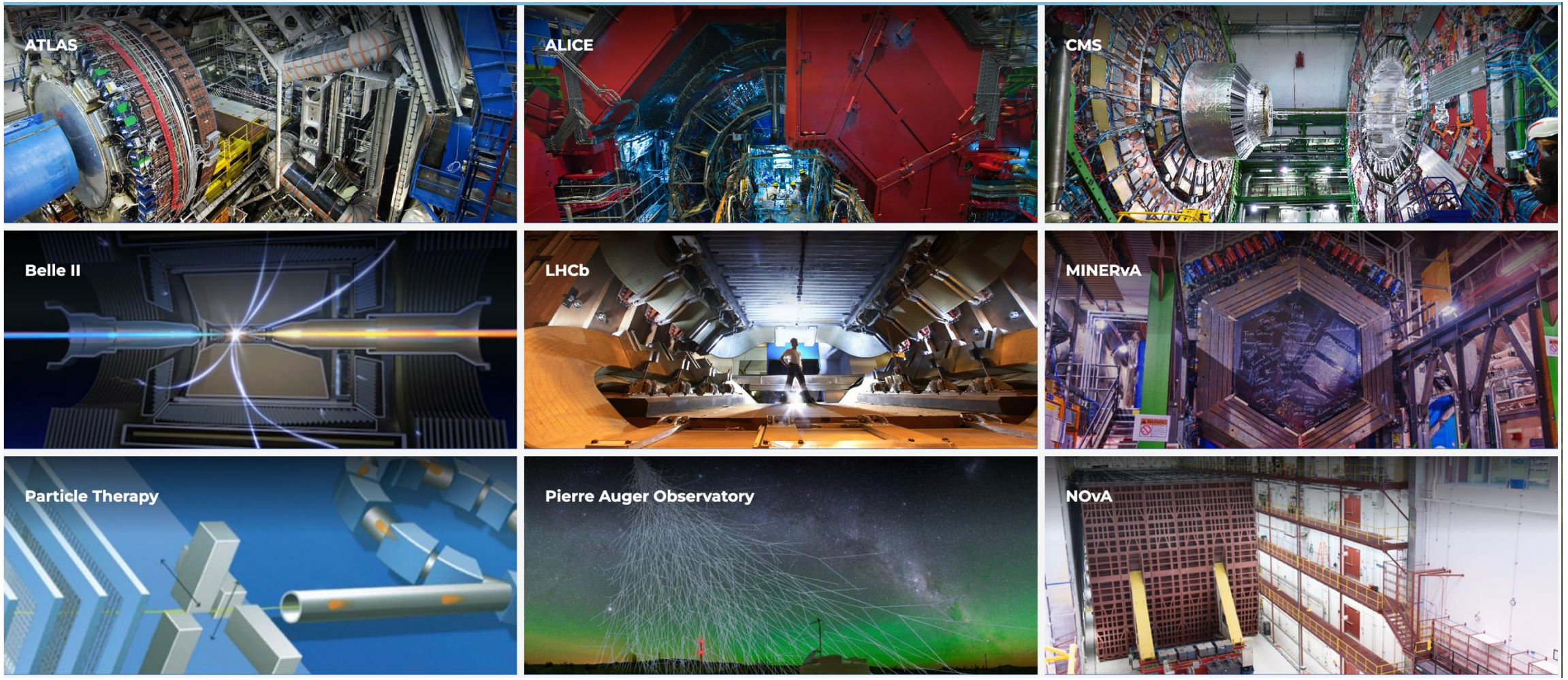
International Particle Physics Masterclass

become *scientists for a day*

- HEP masterclass program beyond the original CERN-related theme:
  - 2020: Belle II at KEK (flavor physics measurements),
  - 2021: a medical physics particle therapy masterclass connects fundamental research with its application.
  - 2022: the Pierre Auger Observatory enriched the landscape with cosmic ray sessions
  - 2024: neutrino physics at Fermilab with MINERvA and NOvA.
  - 2026: cosmic neutrino exercise just arrived with KM3NeT.
  - Gravitational wave exercise is under development

International Particle Physics Masterclass

become *scientists for a day*



Internation Particle Physics Masterclass

become *scientists for a day*

16.03. - 21.03.2026

	Mon, Mar 16	Tue, Mar 17	Wed, Mar 18	Thu, Mar 19	Fri, Mar 20	Sat, Mar 21
topic	VC 1: ATLAS Z	VC 1: ATLAS Z	VC 1: ATLAS W	VC 1: ATLAS Z	VC 1: ATLAS Z	VC 1: ATLAS Z
time	16:00 CET	16:00 CET	16:00 CET	16:00 CET	16:00 CET	16:00 CET
moderator	Lauren	Eleni T.	Elena	Chilufya	Eleni X.	Eleni X.
moderator	Tadej	Matt	Orçun	Tadej	Lauren	André
	Milan	Banska Bystrica	Tbilisi, BTU	Athens, UoA	Orsay	Magurele
	Kragujecav	Athens, NTUA	Yerevan	Grenoble	Zaragoza	Coimbra
		Ljubljana	Parma	Bergen	Oslo	Lisbon
			Krakow	Skierniewice		Covilhã
			Telavi			Alba Iulia
						Novi Sad
topic	VC 2: LHCb	VC 2: CMS	VC 2: ALICE	VC 2: CMS	VC 2: ALICE	
time	16:00 CET	16:00 CET	16:00 CET	16:00 CET	16:00 CET	
moderator	Giorgia + Mick	Mariana	Julia	Fabio	Despina	
moderator	Nuria	Luna	Marika	Michael	Julia	
	Rio de Janeiro, UFRJ	Padua	Padua	Yerevan	Campinas	
	Maynooth	Varna	Lyon	Tipaza	Prague, CTU	
	Constantine	São Paulo, SPRACE	Constantine	Palaiseau	Constantine	
	Annecy	Székesfehérvár	Algiers	Hvar	Sofia, University	
		A Coruña		Naama	Heidelberg	

International Particle Physics Masterclasses in Italy

INFN responsibility

9 IPPOG masterclasses

- LHC (ALICE, ATLAS, CMS, LHCb)
- Belle II
- Particle Therapy
- MINERvA
- Pierre Auger
- KM3NeT

FERMI

DarkSide

E.Torassa (PD): Italy and INFN representative member in IPPOG

"Ricercatori per un giorno" – è questo lo spirito che anima l'iniziativa **Masterclass di Fisica** dell'Istituto Nazionale di Fisica Nucleare (INFN). Ogni anno studentesse e studenti delle scuole superiori di tutta Italia sono invitati ad andare nelle università e strutture di ricerca per utilizzare dati reali raccolti da esperimenti di fisica con gli acceleratori, di astrofisica, di fisica medica e di ricerca di materia oscura. L'esperienza di laboratorio viene preceduta da una o più lezioni di formazione.

IPPOG Masterclass

Fermi Masterclass

Dark Masterclass

~2600 selected italian pupils involved this year (partial)

…and ePIC?

Pupils don’t know the future ePIC experiment

Vi presento ePIC! [2025, 2026]

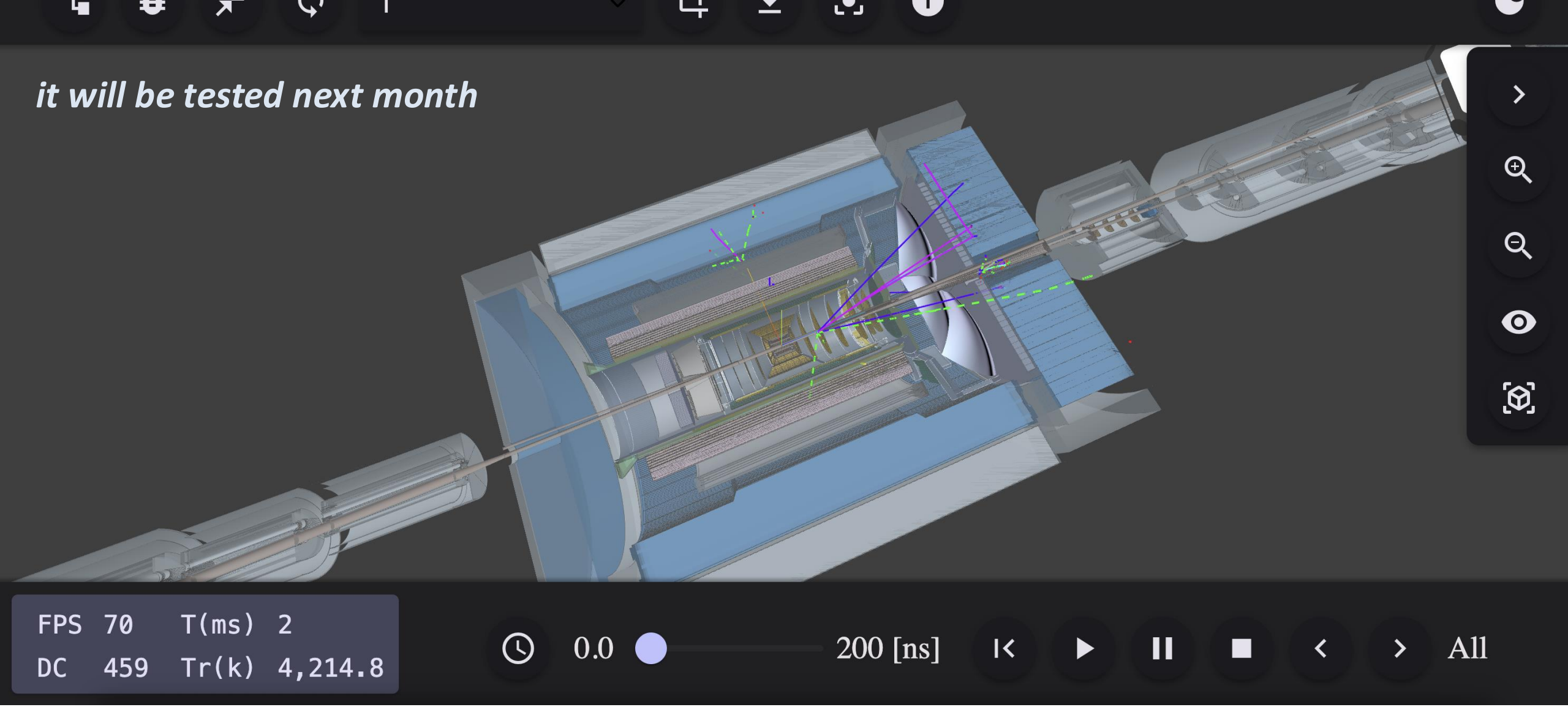
https://agenda.infn.it/category/2222/

M.Capua idea and proposal

…and Casal Monferrato (TO) and Bari

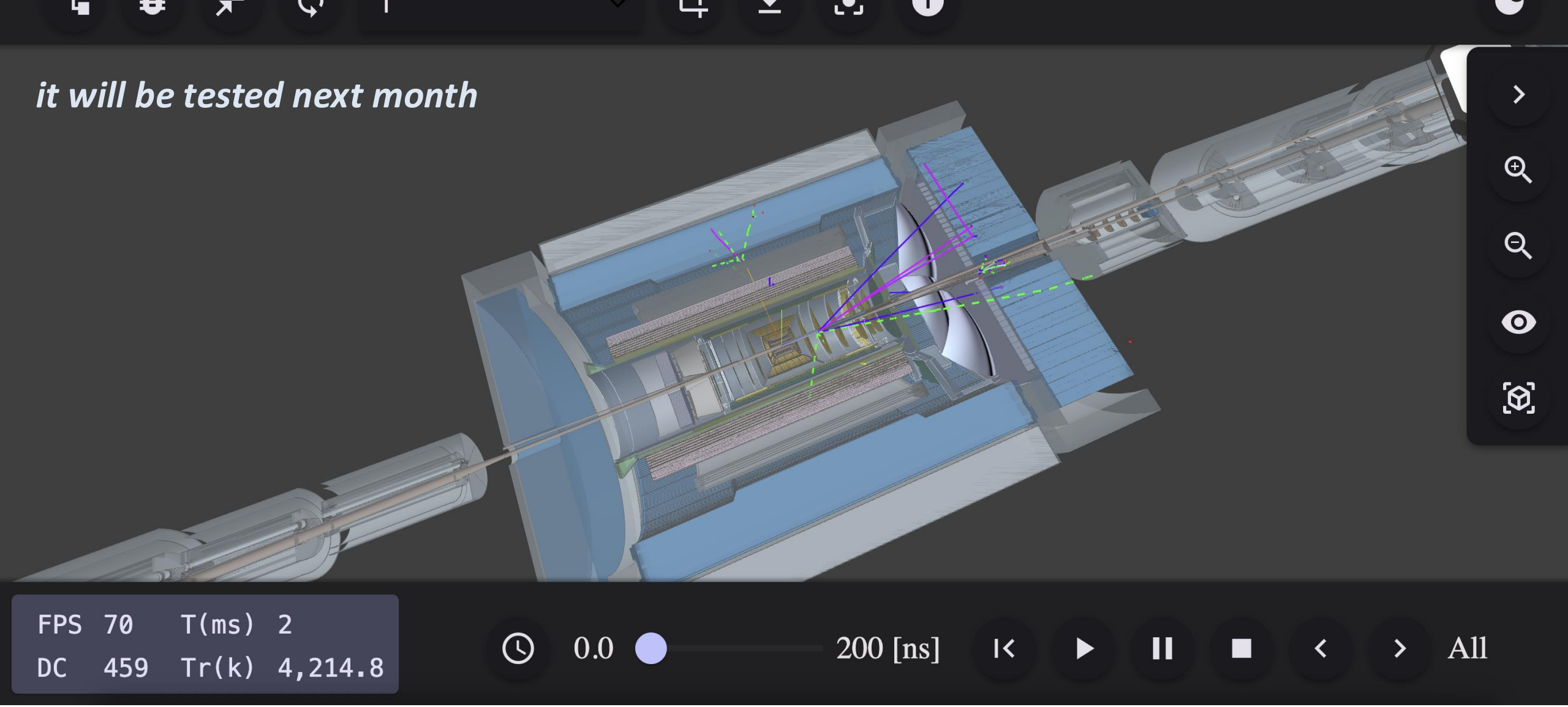
We are moving slowly.

Now we are presenting the project to pupils and teachers (our hooks 😉)



Ideas for trial exercise on ePIC

Use official ePIC event display tool
to classify ePIC interesting events



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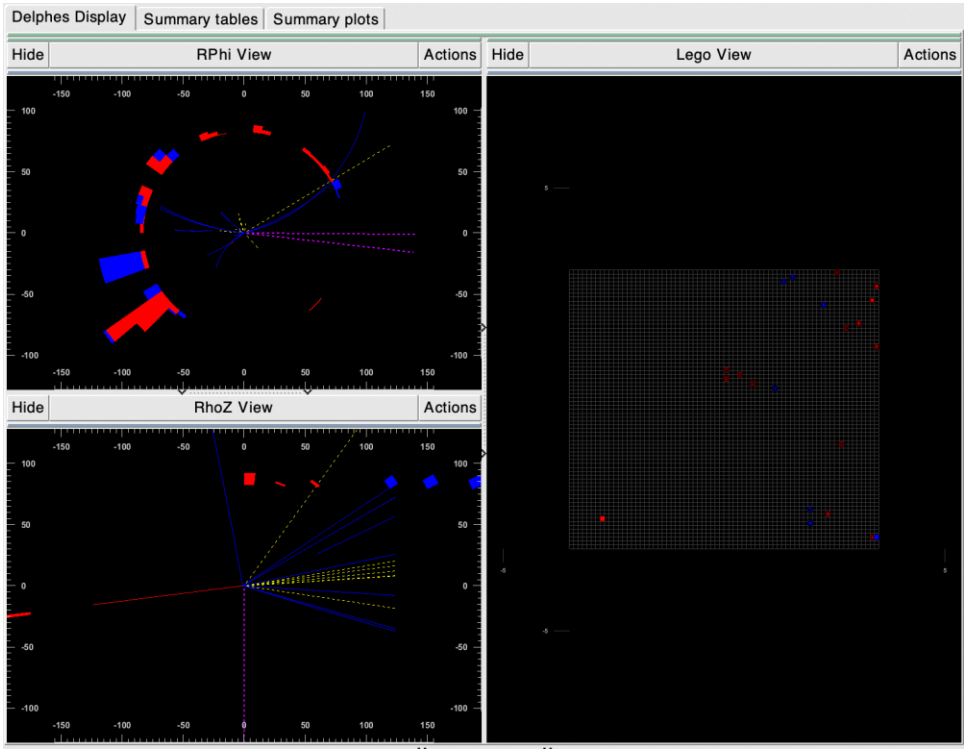
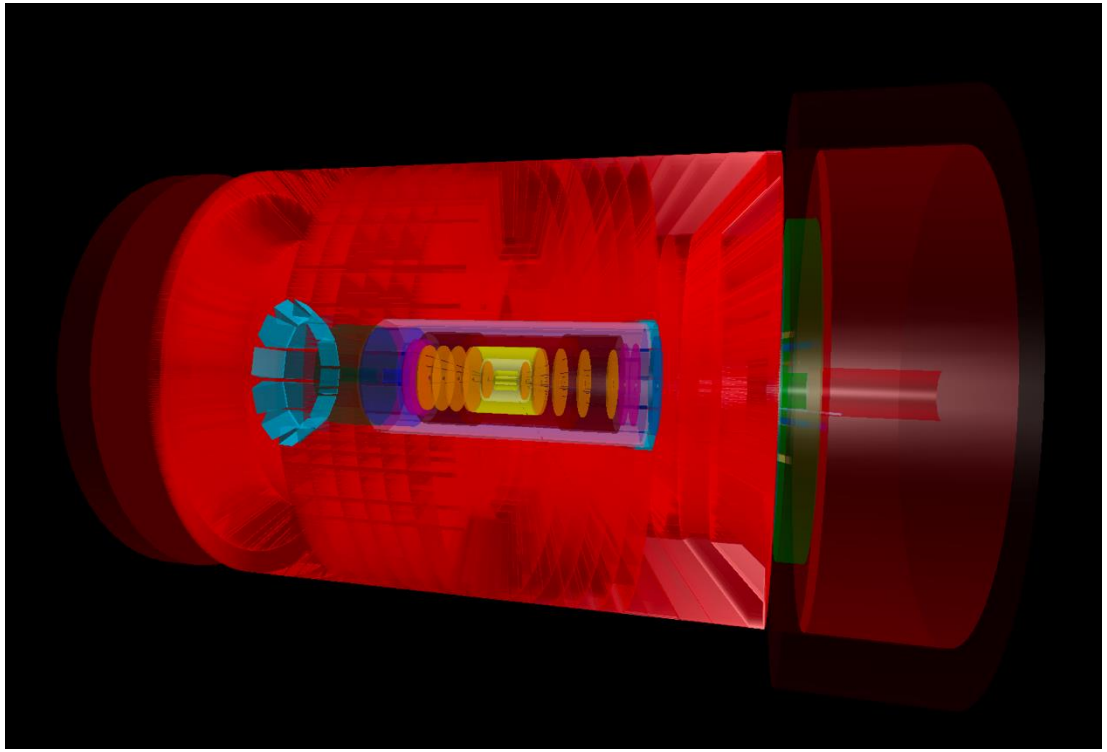
Other idea for trial exercise on ePIC

S.Costanza bachelor student implemented ePIC geometry in a *delphes card*





Play with detector parameters to test physics performance

Why Masterclasses Are Important

Introduce students to modern physics research

Develop data analysis and scientific reasoning

Connect schools with research institutes

Inspire future scientists