IMPERIAL

Postgraduate study in the

Imperial Particles Community

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11 December 2025

Introduction

Welcome to Imperial's Particles Community!

This presentation is to introduce you to the Particles Community and postgraduate study with us

After the talk there will be a tour of some of our research activities

After the tour, we'll reassemble here in 539 at 15:15 for:

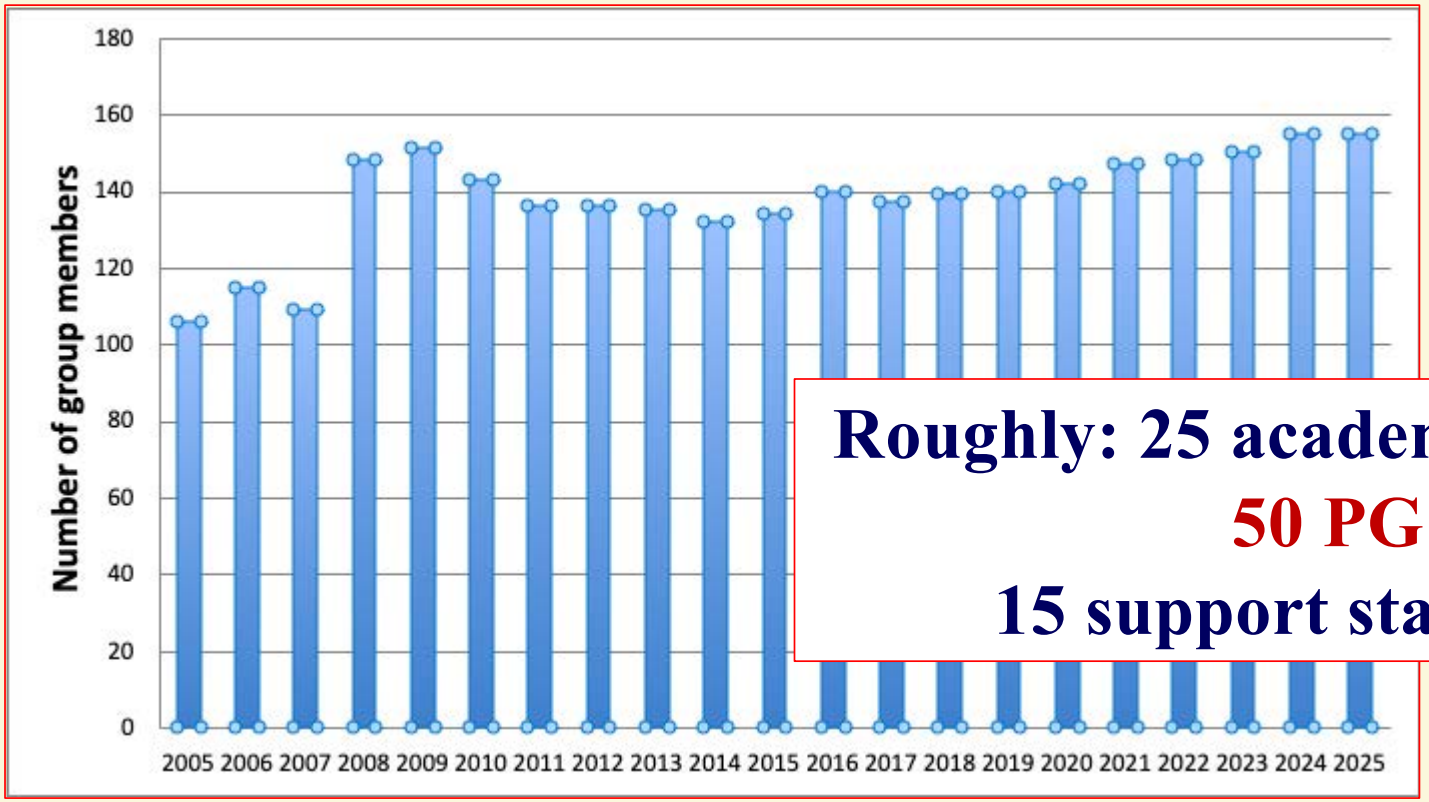
- For informal discussion with staff and students …
  - An opportunity to get answers to your questions

Importantly, an opportunity to talk "off the record" to current graduate students

Particle Physics at Imperial

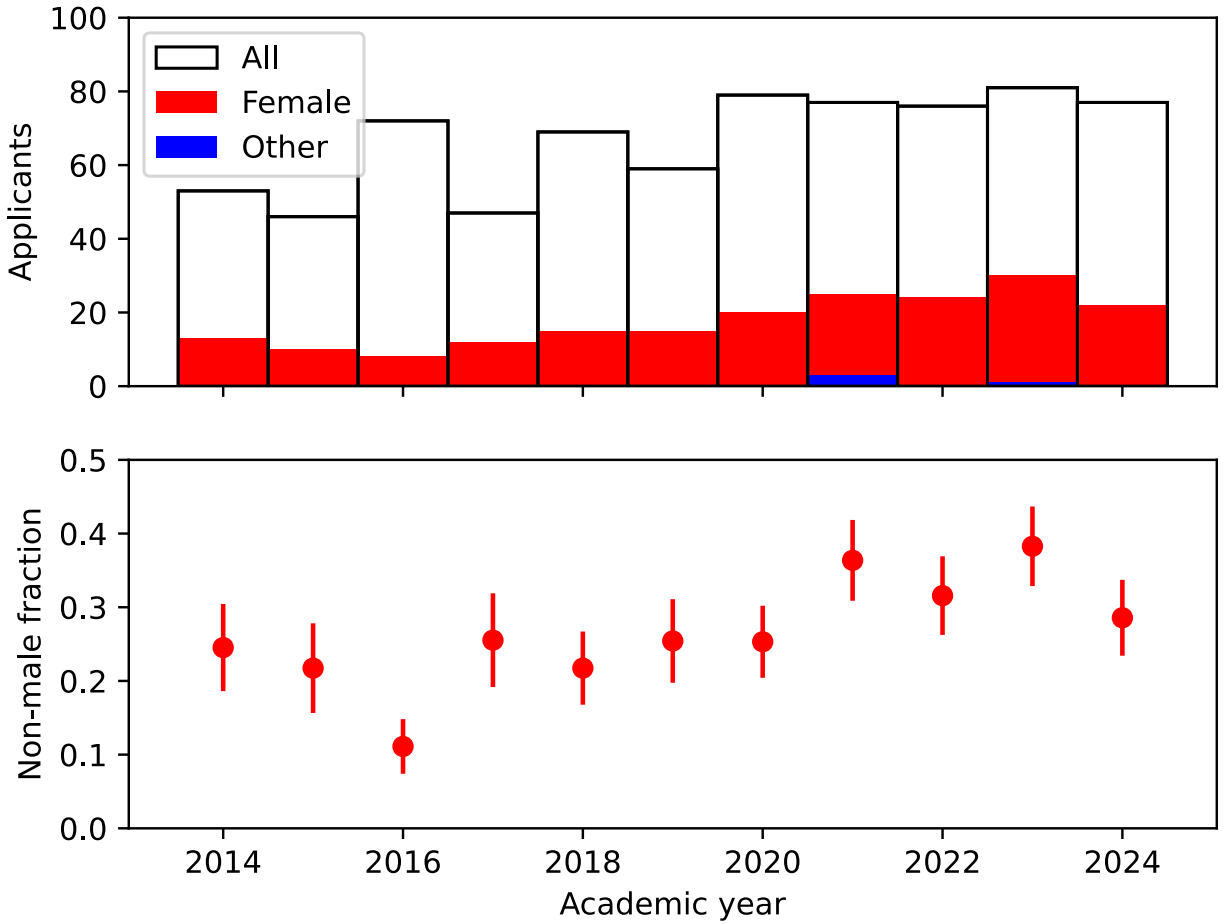
One of the largest particle physics groups in the UK; 155 members at the moment

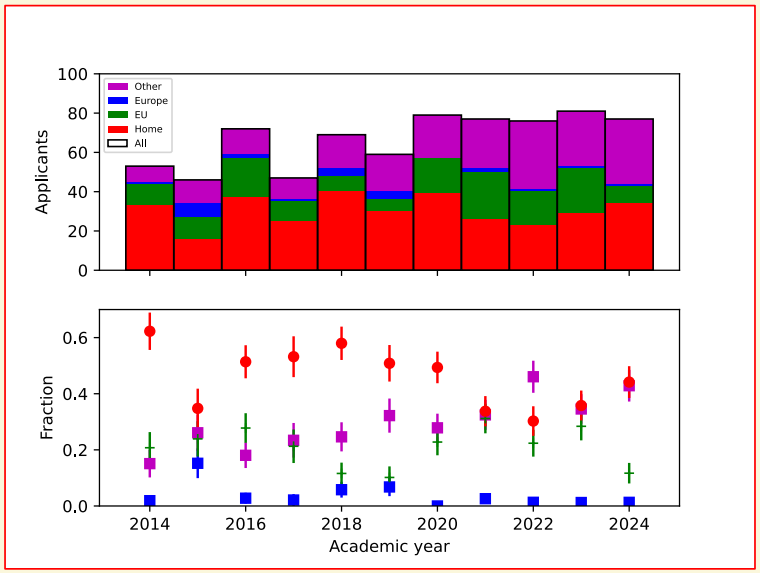
- Involved in the full spectrum of activities across the field
- Among the largest postgraduate cohorts in UK



Roughly: 25 academics, 50 research staff,
50 PG students,
15 support staff and 20 visitors

Some more statistics





Our mission

Is to:

Search for new fundamental particles, forces and phenomena

Exploit this knowledge to understand the Universe

Develop new technologies/techniques to drive our field forward

Exploit technologies/techniques to benefit of science and society

Understanding Nature's building blocks

Search for new fundamental particles, forces and phenomena

At the highest possible energies:

***CMS* at the *LHC* in Switzerland studies the Higgs Boson, searches for new particles, seeks to understand the nature of dark matter**

Through precise measurement of decays at the highest possible rate:

***LHCb* at the LHC studies rare B-meson decays to see whether particles and anti-particles behave the same way and to seek evidence for new particles and forces**

Understanding Nature's building blocks

Search for new fundamental particles, forces and phenomena

By measuring particles evolution as they travel through space and time:

T2K **in Japan and** ***NOvA*** **in the US measures how muon neutrinos change into other types of neutrino to understand why the Universe contains matter, not antimatter**

Using particles provided by Nature:

LZ **in the US searches for dark matter particles in a liquid xenon detector operating deep underground**

By probing rare decays that "should not happen at all":

COMET **in Japan is looking for muons turning into electrons without neutrinos being produced, a process extremely sensitive to new phenomena**

SBN **experiments (MicroBooNE and SBND) examine the properties of neutrinos; how a neutrino evolves as it moves through space-time and matter …**
They also search for sterile neutrinos, dark matter and other new phenomena

Understanding Nature's building blocks

Search for new fundamental particles, forces and phenomena

Developing revolutionary new detector facilities:

DUNE in the US and _Hyper-K_ in Japan are next-generation neutrino experiments with exquisite sensitivity which will allow the neutrino mass hierarchy to be determined, the study of supernovae neutrinos, and much more

Other detector-development activities too, e.g. CMS & LHCb updrades …

Studying gravity using atom interferometry:

AION harnesses new quantum sensors to search for dark matter and new sources of gravitational waves

Creating accelerator technologies to drive the field forward:

as part of the _John Adam's Institute_ the group is developing the techniques for tomorrow's neutrino beams and energy frontier (muon) collider

Technologies for fundamental physics

Ambitious R&D that underpins the discovery programme

Enormous computing power:

The volume of data from our experiments demands a step change in computing: we are leaders in the development of GridPP, a paradigm shift in the way we analyse our data with the potential for wide application

Creating impact; applying our technologies to the problems of today:

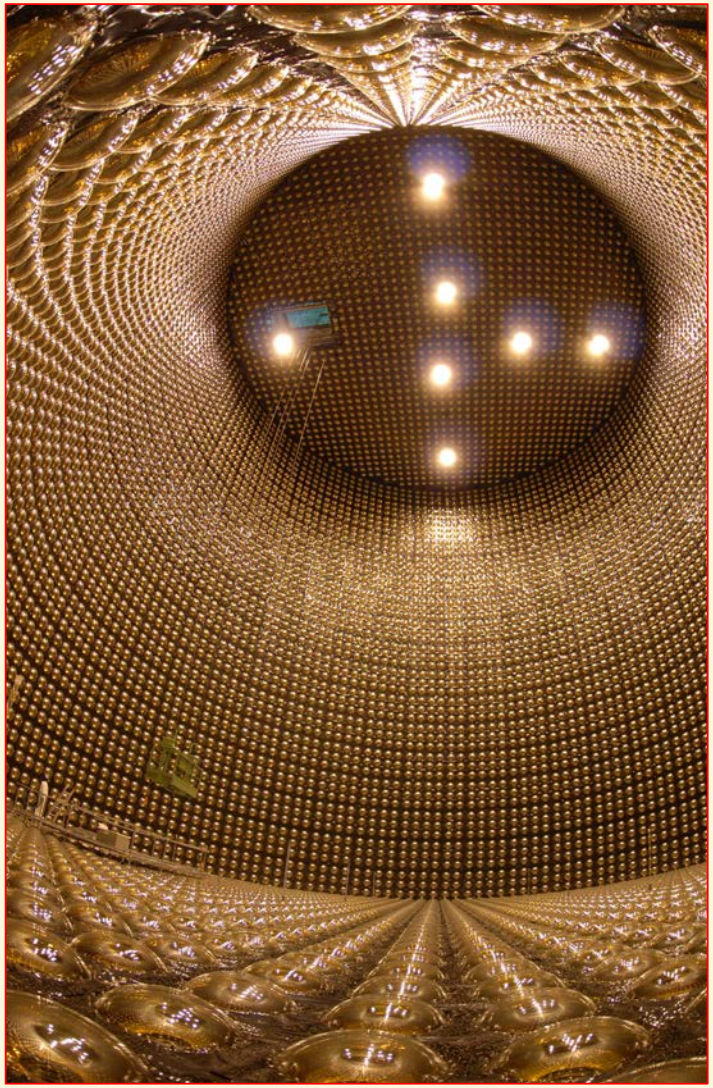
LhARA **and the** ***CCAP*** **seek to harness laser acceleration using novel accelerator techniques, advanced diagnostics and computing to transform cancer treatment using much improved particle beam therapy**

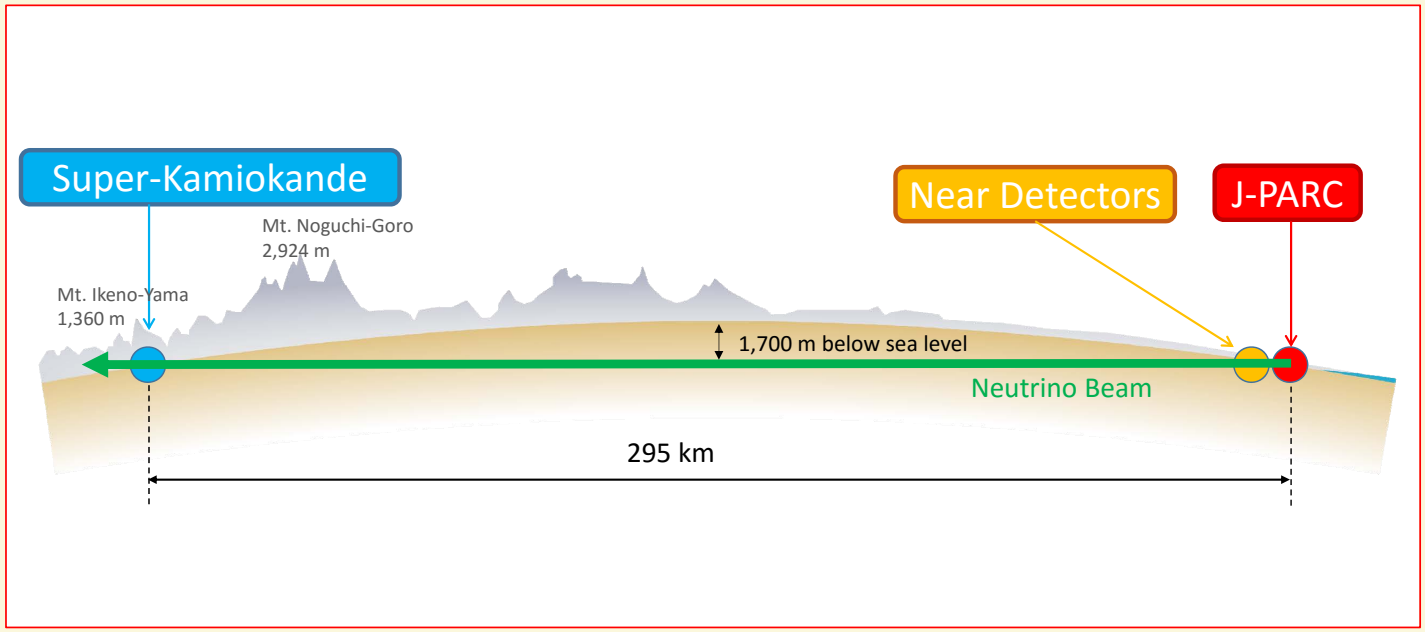
Our laboratories

CERN, Geneva: CMS, LHCb

J-PARC, Japan (T2K, Hyper-K, COMET)

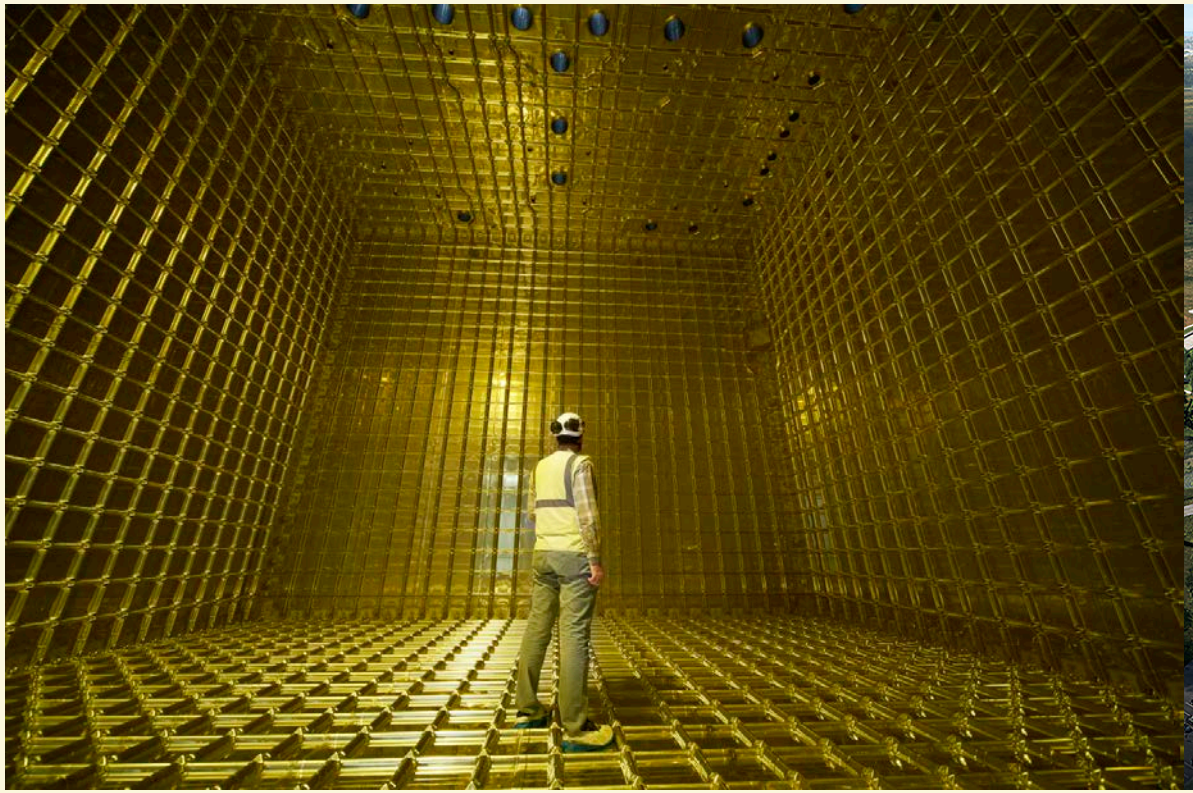
Kamioka, Japan (T2K, Hyper-K, Super-K)



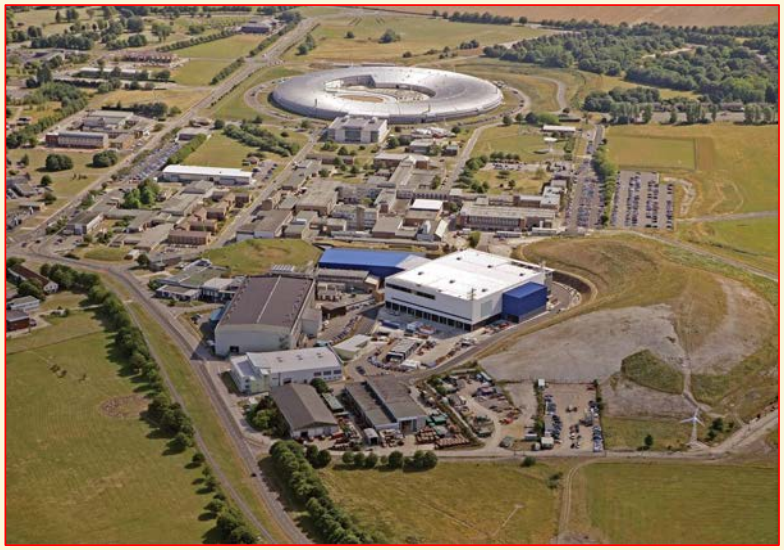


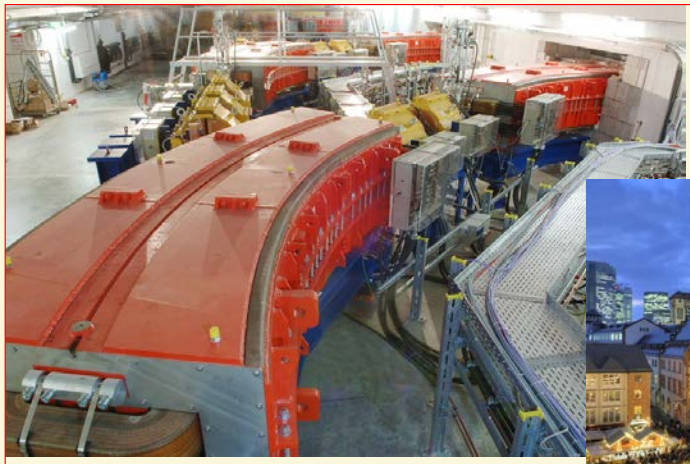
Sanford Lab, South Dakota (LZ, DUNE)

Fermilab/Sanford (DUNE)



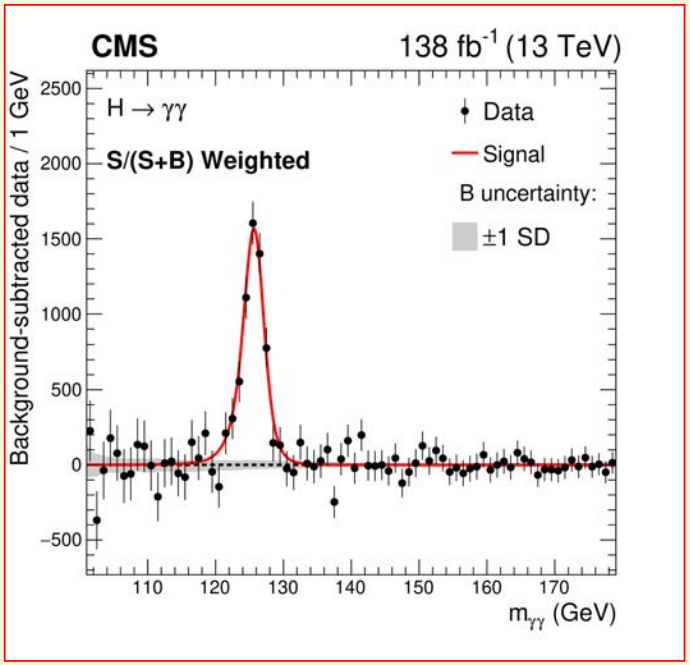
CERN, MedAustron, DL, (GSI), RAL (CCAP)

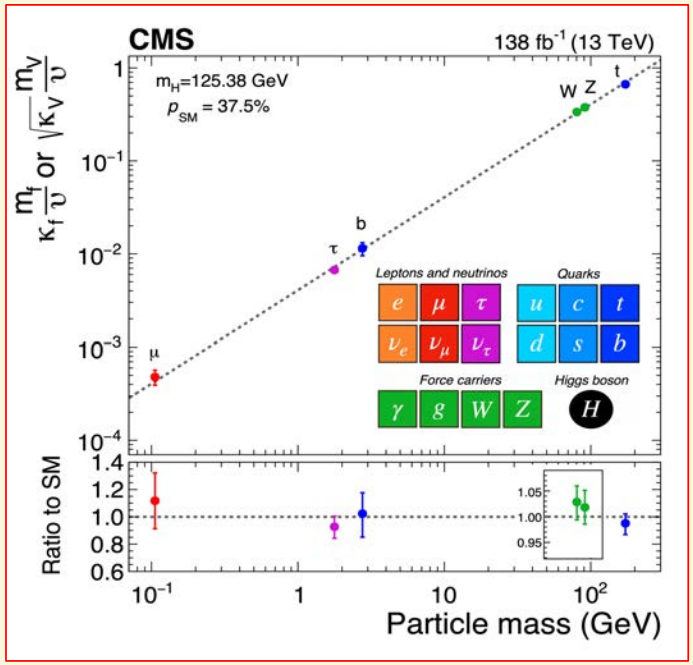




South Kensington

CMS: Higgs





Imperial played central role in Higgs discovery in 2012

Now we:

Study Higgs decays searching for new particles and phenomena
Measure Higgs boson properties precisely seeking evidence for the breakdown of the Standard Model

CMS: search for new particles and forces

We search the data for dark matter particles …

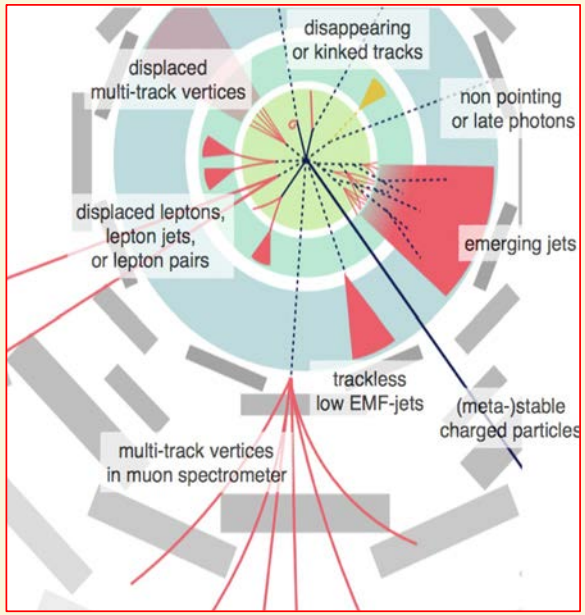
… known to exist but no evidence of a dark-matter particle yet!

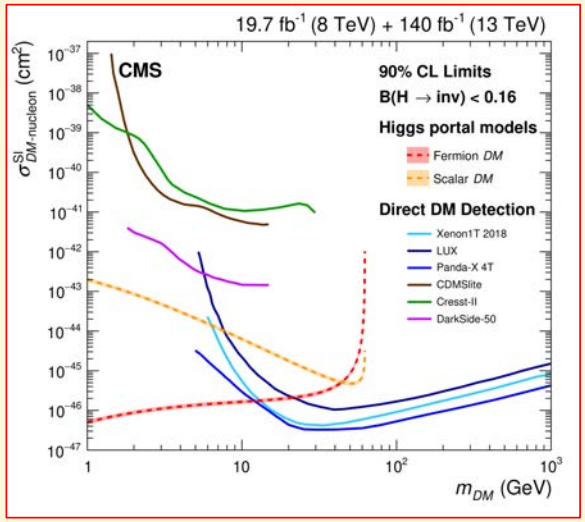
So, we seek evidence for dark matter:

- Directly produced in pp collision
- Produced in Higgs decay

We also search for:

- Exotic long-lived particles with spectacular signatures





CMS: upgrade

R&D for significant improvements to CMS detector

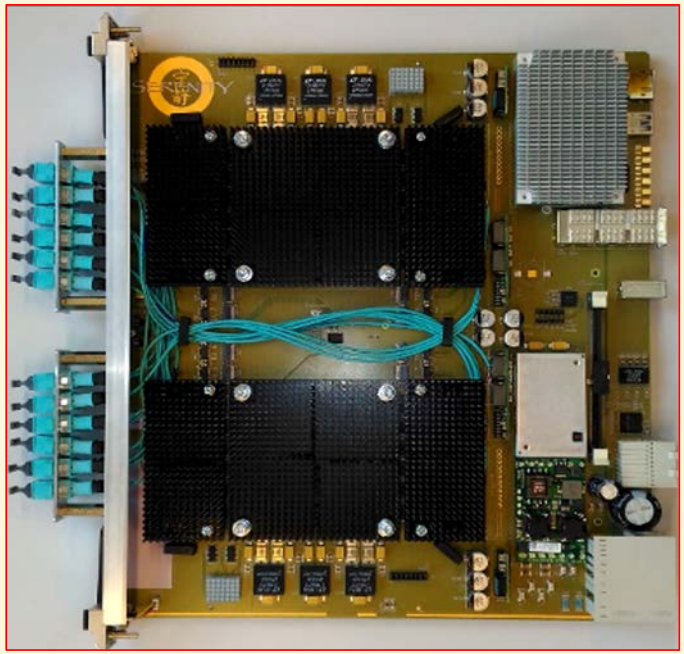
Readout chip designed at Imperial

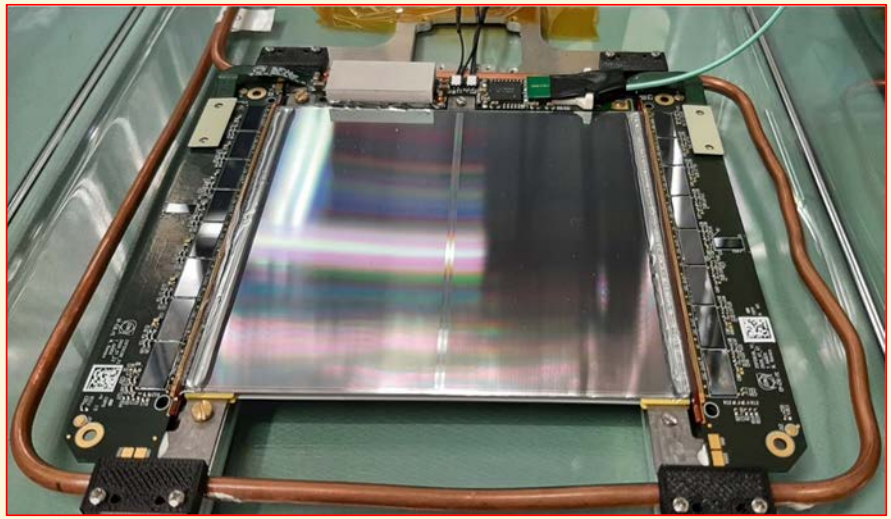
- Gives momentum selection to reduce backgrounds

Serenity board designed at Imperial

- Handle huge data volumes from upgraded detector
- Sophisticated data-processing algorithms

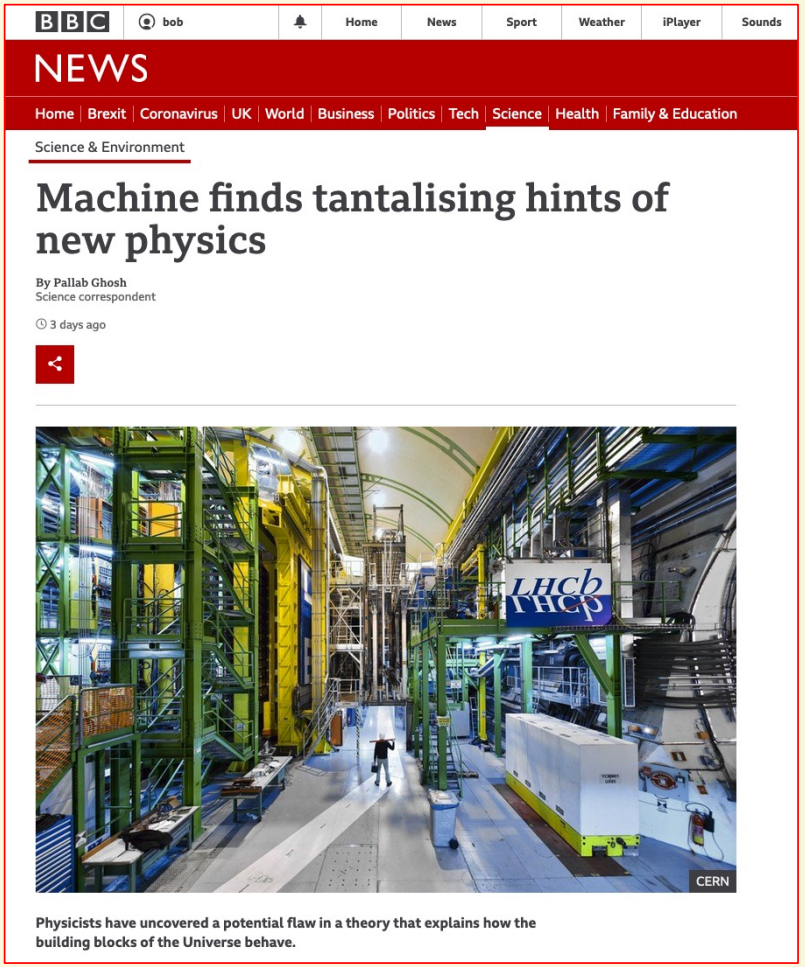
We have leading roles across the CMS upgrade programme!





LHCb

We have made several measurements that show evidence for new physics which have been widely reported



Continuing to explore these effects with new decays and much more data

LHCb upgrade

LHCb has undergone a major upgrade:

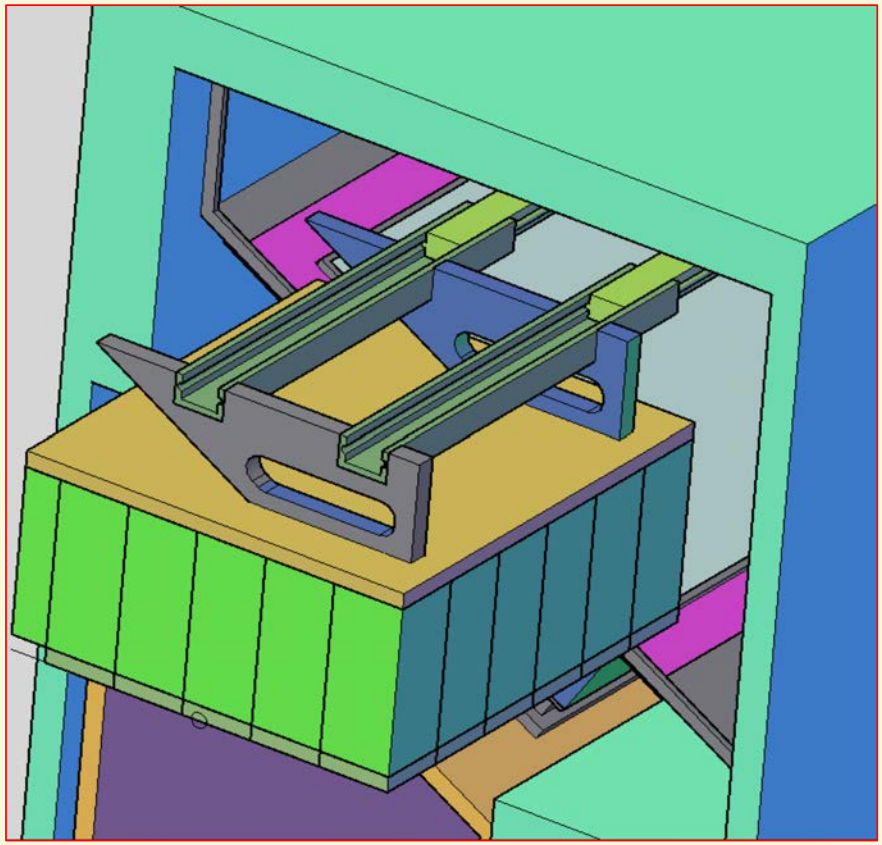
- Much higher data rates to accumulate large samples more quickly

We led design of key parts of the Ring Imaging Cherenkov (RICH) detectors:

- Essential for many of the most exciting final states

Further upgrades to LHCb now being planned:

- Excellent opportunity to get involved!



Dark Matter search: LUX-Zeplin (LZ)

Gravitational effects imply:

- 85% of matter in Universe is dark but no candidate dark-matterparticle in Standard Model

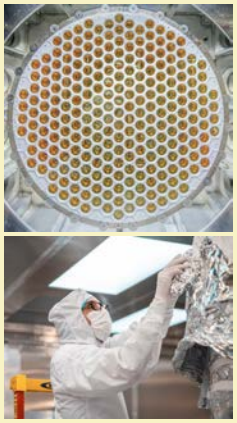
LZ collaboration aims to:

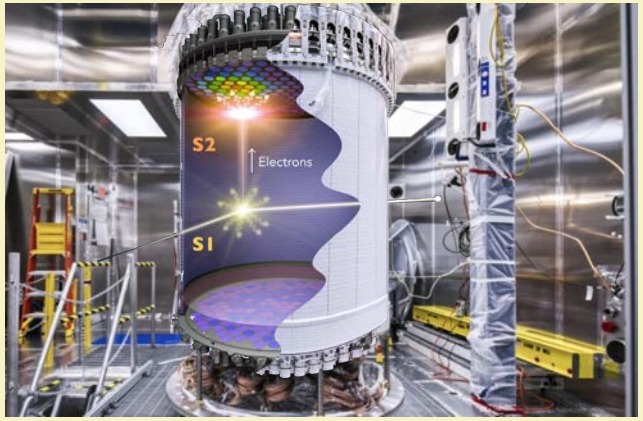
- Directly detect scattering of dark matter off xenon nucleus

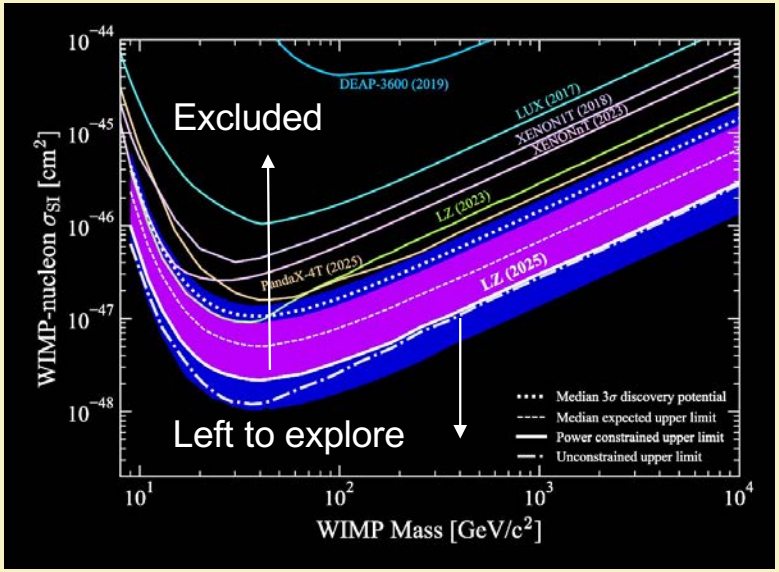
World's most sensitive searches for Weakly Interacting Massive Particles:

- Taking data, already the most sensitive search in the world!

We are leading LZ in the UK!







Future **dark matter and beyond: XLZD**

Ultimate dark matter detector

- Detector with 60 – 80 t xenon target to measure down to the irreducible background from neutrinos

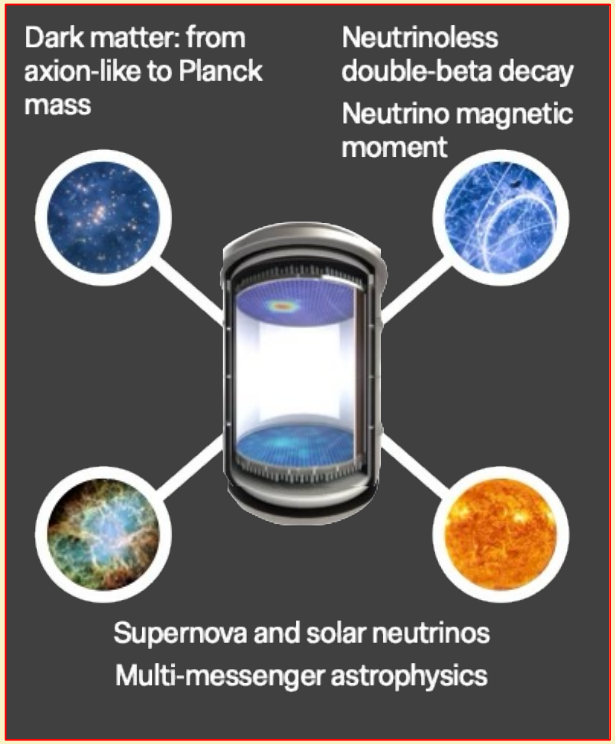
XLZD in the UK:

- Boulby lab as one possible site for XLZD with SURF in the US, LNGS in Italy and Snolab in Canada

Beyond dark matter

- Sensitive to neutrinos and rare processes connected to the nature of neutrinos and the matter-antimatter asymmetry of the Universe

We are leading XLZD in the UK!



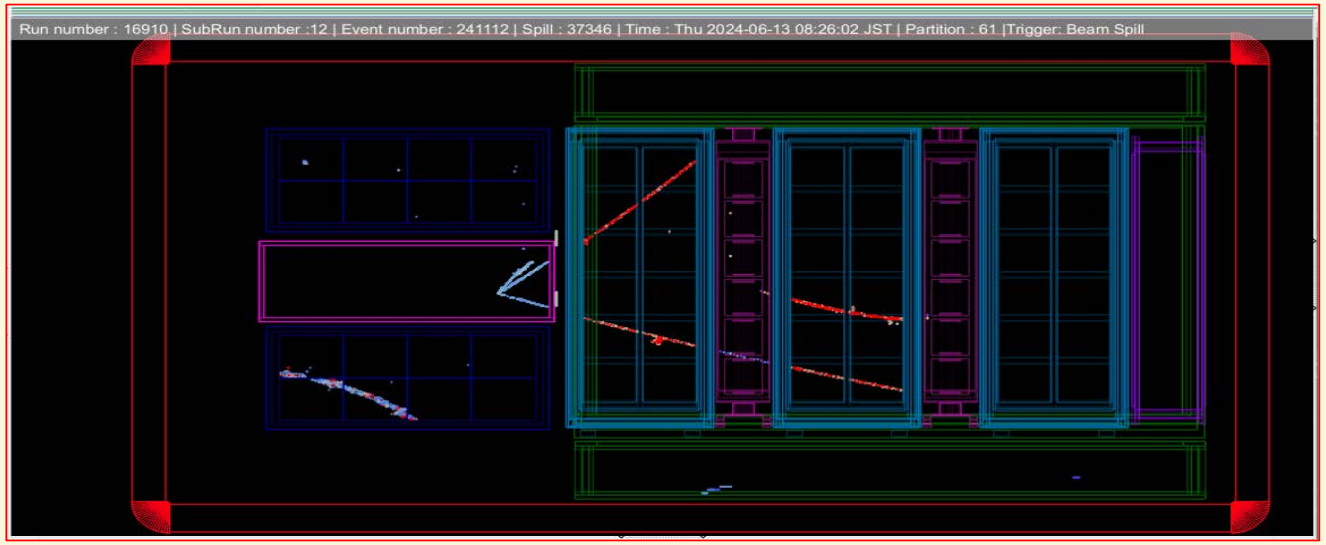
Long baseline neutrinos

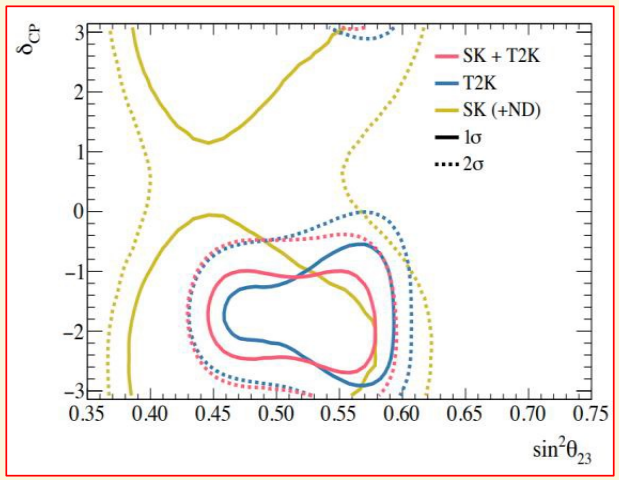
Strong contribution to T2K and NOvA experiments:

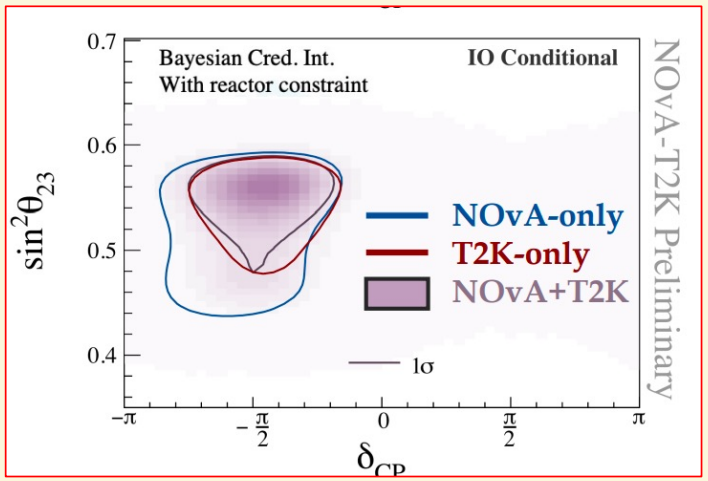
- Leading in both collaborations:
  - Neutrino oscillations in both experiments and in joint analyses
  - Neutrino interactions and unoscillated beam

Main objectives now:

- Determine the ordering of neutrino masses
- Determine whether neutrinos violate matter/antimatter (CP) symmetry







Starting to exclude regions of CP parameter space!

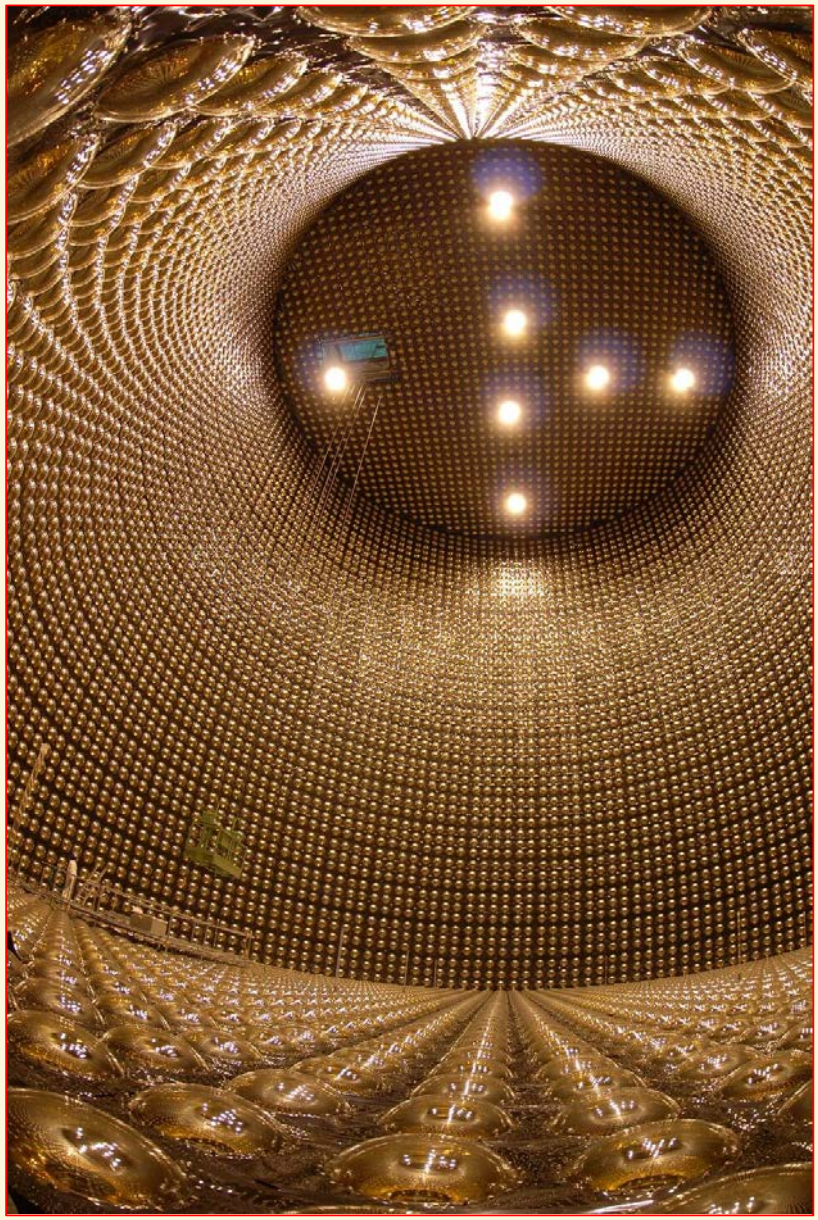
Super-K

Astrophysical neutrinos with Super-K experiment

Gadolinium added to pure water:

- Adds sensitivity to low-E neutrons

Developing novel calibration methods that can also be applied to Hyper-K experiment



Future long-baseline neutrinos
Strong contributions to both DUNE and HK

Future experiments will measure CP violation *precisely*

- We have leading roles in oscillation physics in both DUNE and Hyper-K

DUNE:

- Very high power neutrino beam and high resolution argon detectors
- Building anode planes for the DUNE far detector; and
- Building data acquisition system and high-pressure argon gas near detector

Hyper-K:

- Will have the largest far detector and upgrade of T2K beam for high power
- We are building novel PRISM-technique near detector

MicroBooNE and SBND

Article | Open access | Published: 03 December 2025

Search for light sterile neutrinos with two neutrino beams at MicroBooNE

The MicroBooNE Collaboration

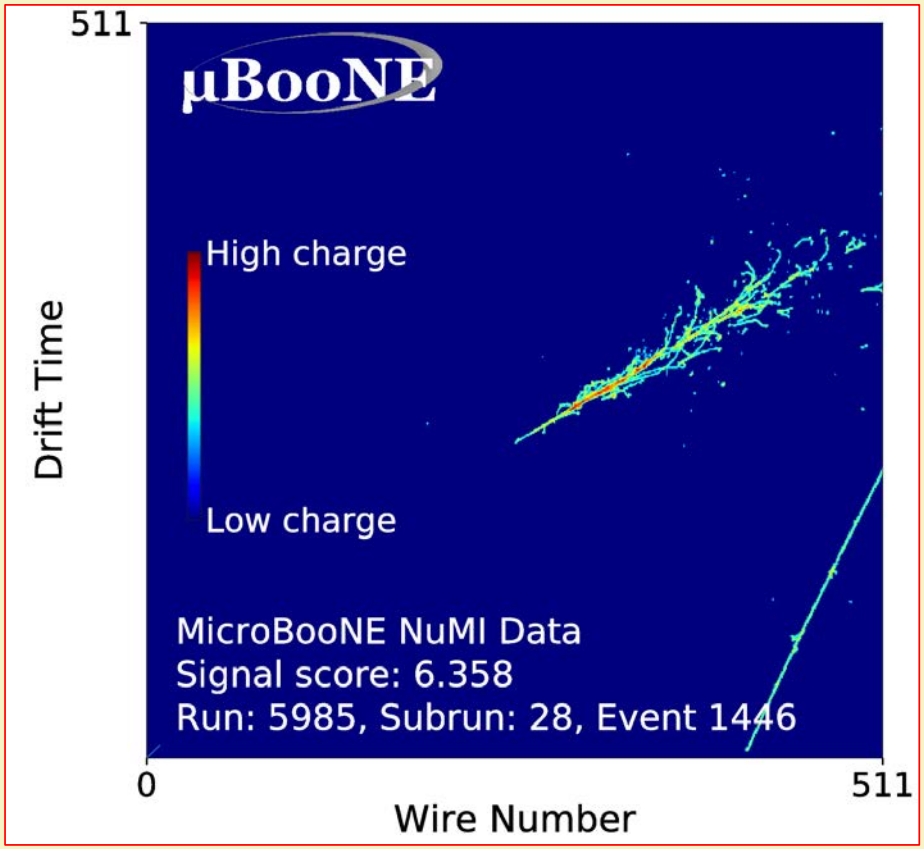
Nature **648**, 64–69 (2025) | Cite this article

Served by high intensity neutrino beam at Fermilab:

- Measure neutrino interactions (cross sections);
- Search for sterile neutrinos; and
- Perform world-leading new-physics searches (dark matter, HNLs, Higgs Portal Scalars)

Develop liquid-argon technology for DUNE:

- The only experiments that have a liquid-argon detector exposed to a real neutrino beam!



COMET: Muon-to-Electron Conversion Search

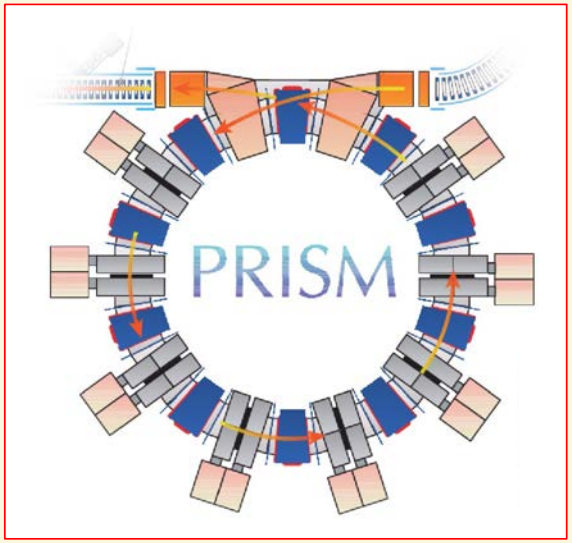
at J-PARC

Broad search for new phenomena in:

- The spontaneous conversion of a muon into an electron inside a nucleus …
  - Physics beyond the Standard Model smoking gun!

Multi-year programme:

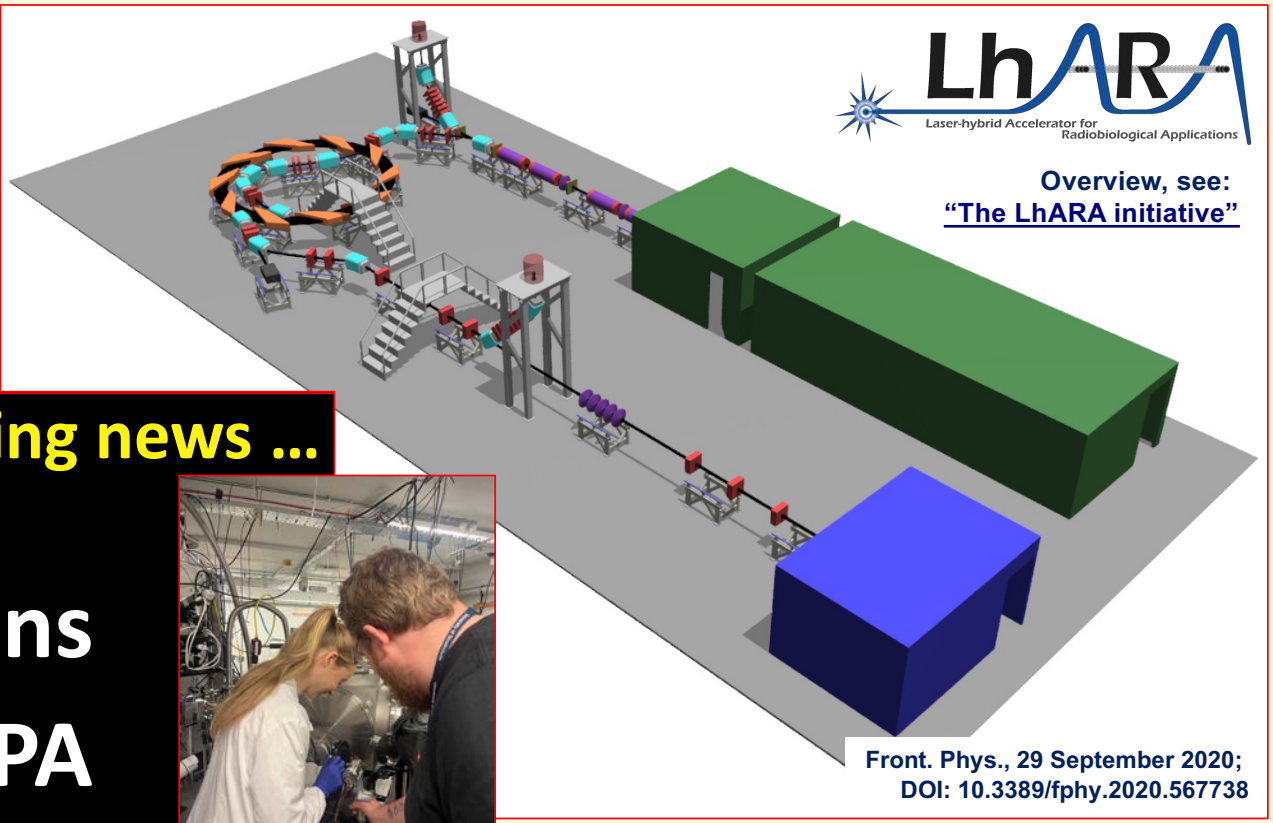
- Preliminary data (Phase-α) from 2023
- Phase-I data-taking starts in 2027
- Phase-II to follow
- PRISM experiment in the long term



LhARA: the Laser-hybrid accelerator for Radiobiological Applications

Ambitious programme!

Opportunities from development of novel techniques, to biomedical research and PP spin-in



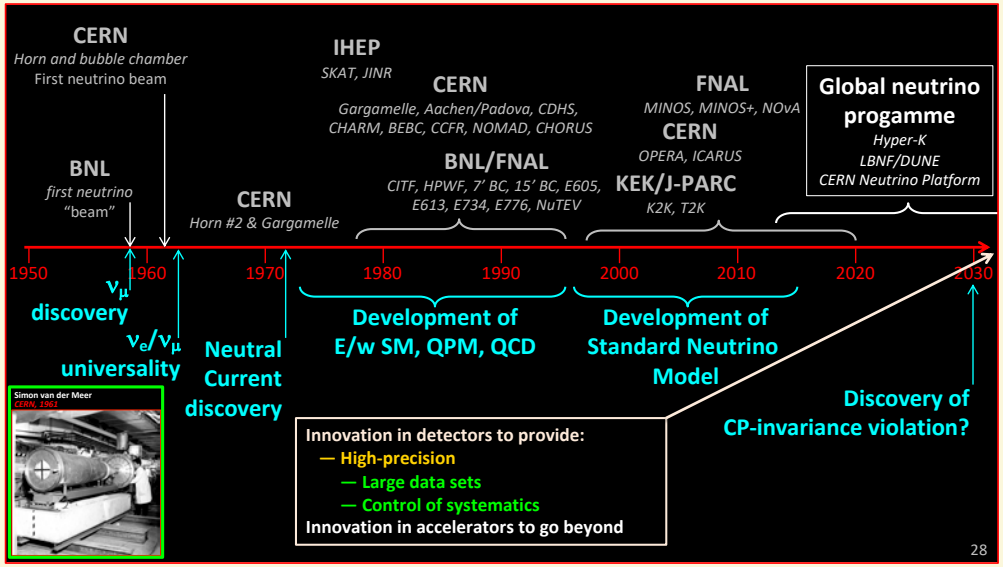
Overview, see:
"The LhARA initiative"

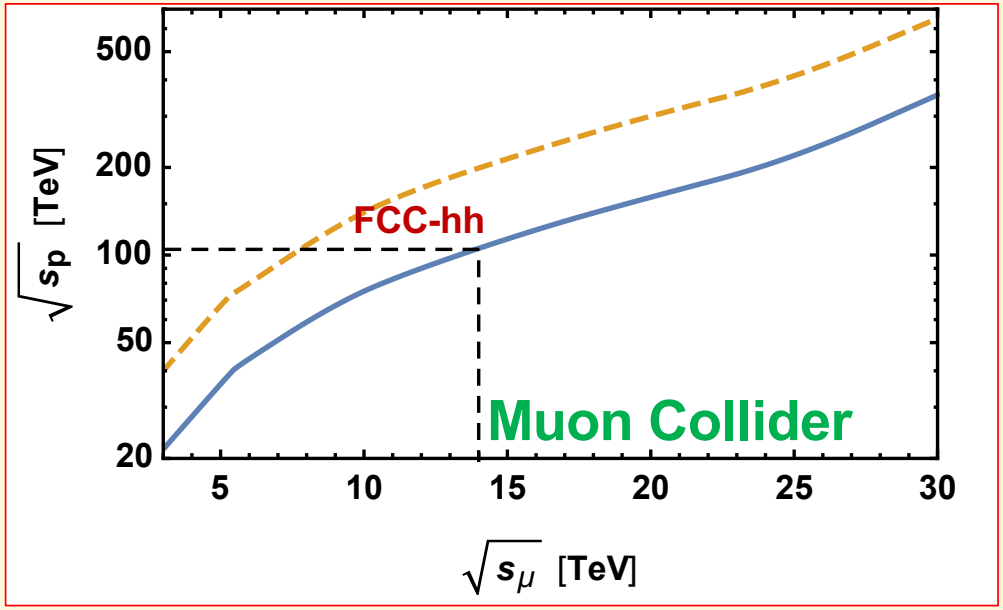
Front. Phys., 29 September 2020;
DOI: 10.3389/fphy.2020.567738

Breaking news …

First cell irradiations on PoPLaR @ SCAPA 19th November 2025!

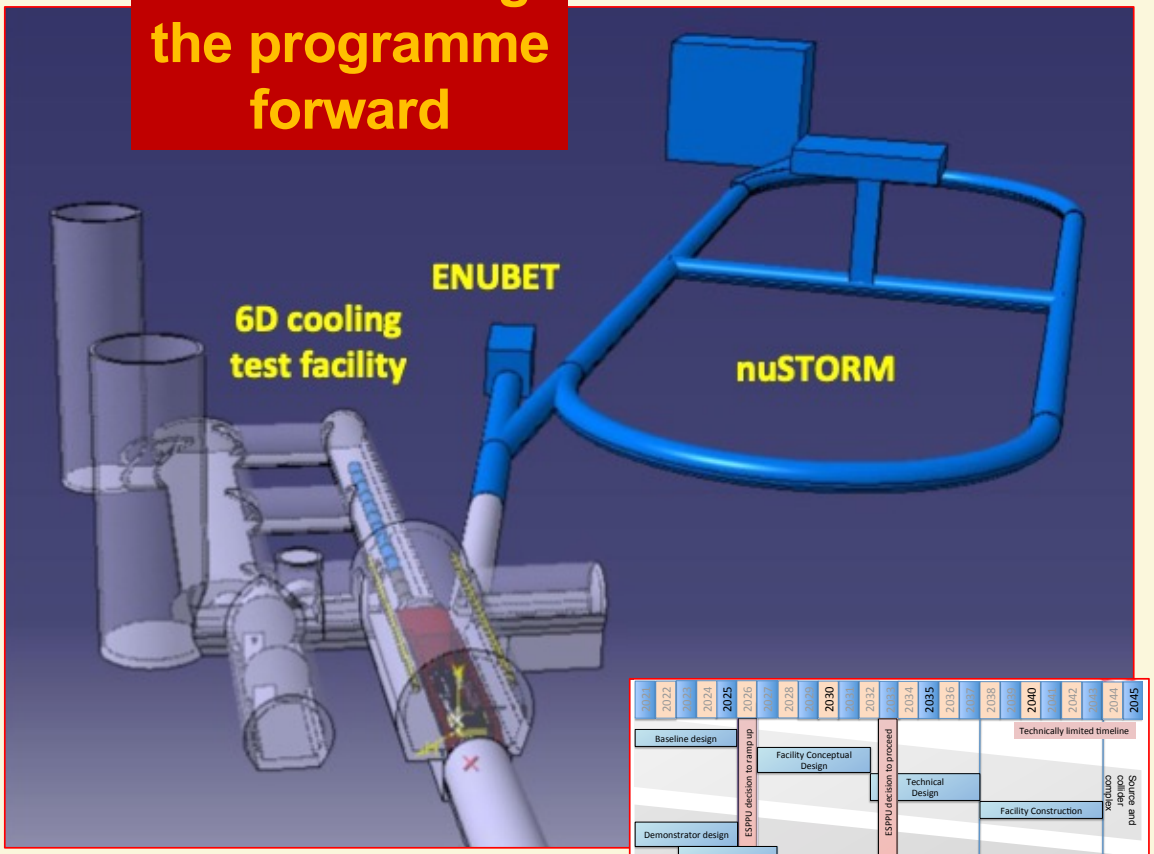
Part of our drive to develop the technologies to drive field forward …

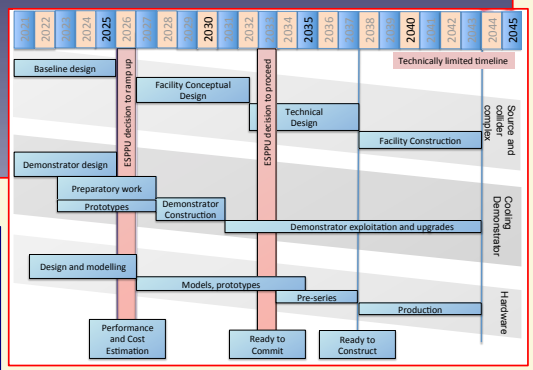




nuSTORM

We are driving the programme forward

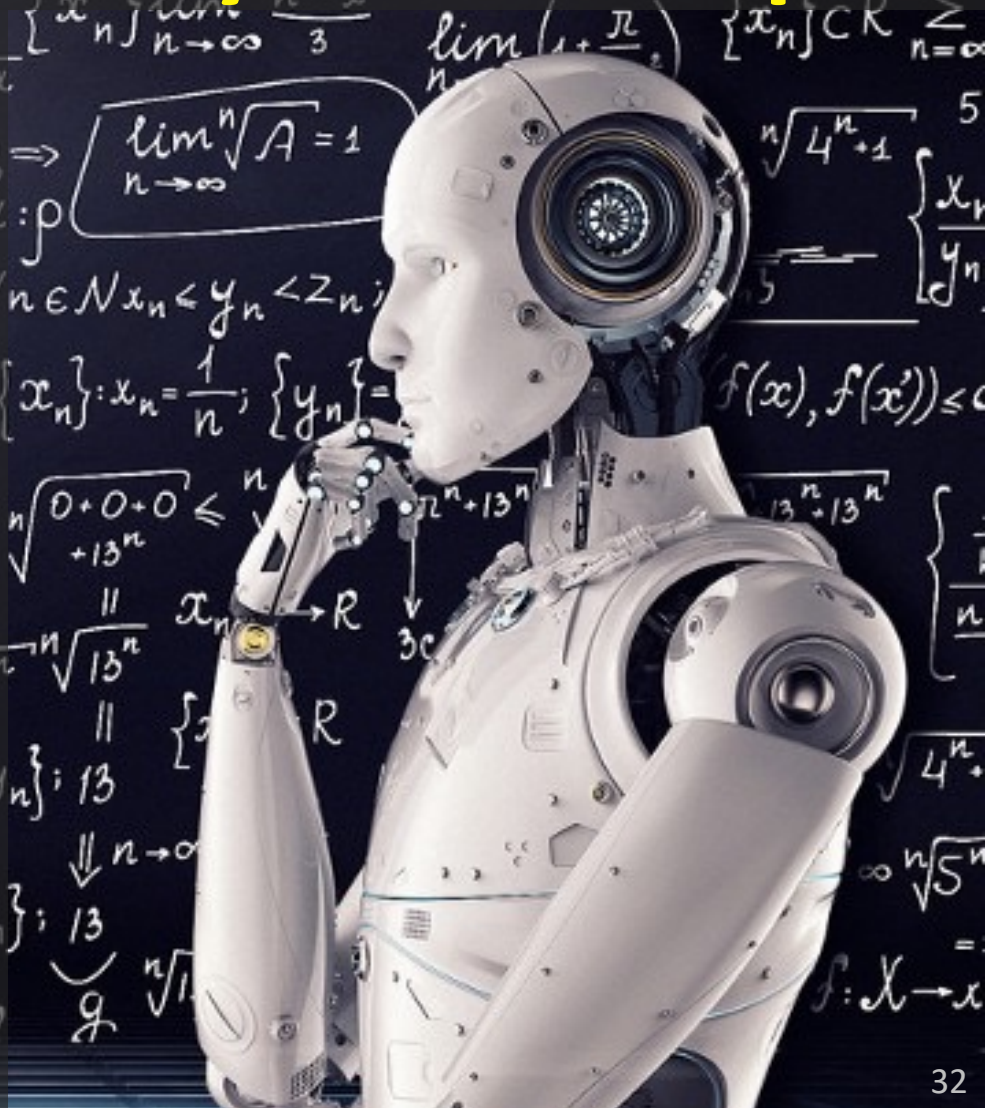




Exploiting techniques developed for e.g. LHARA & ISIS

Development of new analysis techniques

- Extensive big data, machine learning and quantum computing opportunities including:
  - Opportunity to attend graduate school ML course
  - Involvement with industry via ***CDT in data science***
  - Centre of excellence in **High-throughput Digital Electronics and Embedded Machine Learning**



The Imperial Particles Community

One of the largest cohorts of any UK particle physics group

- Impacts on scale and breadth of graduate education we can offer
- Most of our students decide on their project in December:
  - Once you have been with us for a term
- Students form a cohort and work and learn from each other

One of the broadest range of projects in the country

- Different physics, labs/countries, detector technologies, phase of experiment
- Leadership in many experiments: academics, RAs and students

London!

https://www.topuniversities.com/best-student-cities

QS Best Student Cities 2023

In Association With :

1. London
2. Munich
3. Seoul

"Why, Sir, you find no man, at all intellectual, who is willing to leave London. No, Sir, **when a man is tired of London, he is tired of life; for there is in London all that life can afford.**"

— Samuel Johnson

South Kensington

A beautiful part of London dedicated to the Arts and Sciences as a legacy of 1851 Great Exhibition

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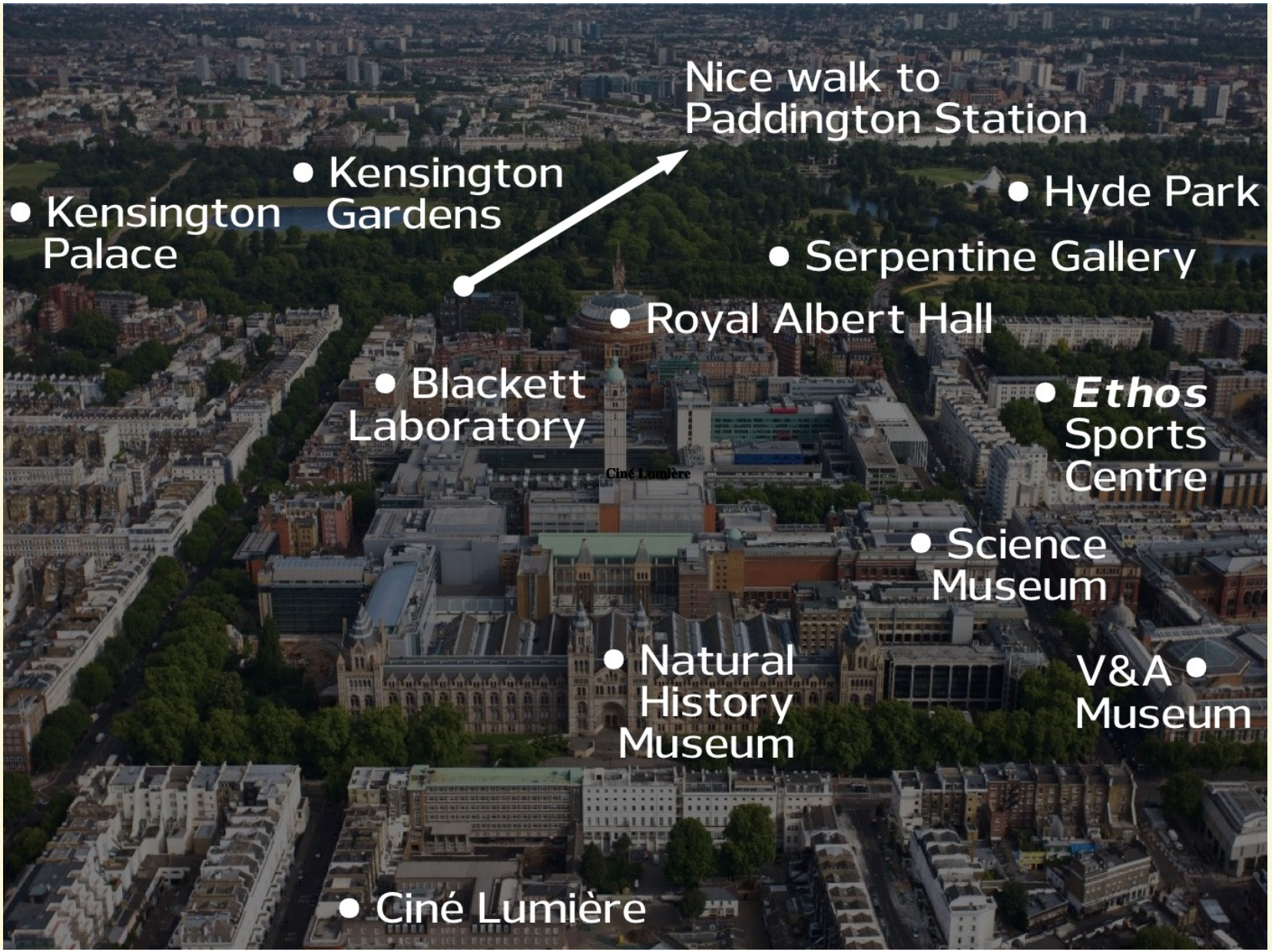
Nice walk to Paddington Station
Kensington Gardens
Kensington Palace
Hyde Park
Serpentine Gallery
Royal Albert Hall
Blackett Laboratory
Ethos Sports Centre
Ciné Lumière
Science Museum
Natural History Museum
V&A Museum
Ciné Lumière

PhD studentships

We have STFC “quota” studentships for UK nationals

- Search for “STFC student eligibility requirements”

Good stipend, excellent travel support London weighting in addition to UK-wide STFC stipend

Can work on any experiment

- No need to select specific experiment/supervisor in application
- Instead, choose project at end of first term, after (extensive) graduate courses and opportunity to discuss with our research groups – will allow you to make an informed choice

PhD studentships …

Project-specific studentships are also available – we shall let you know before interview …

STFC:
- Project studentships often secured during recruitment process

John Adams' Insitute:
- Studentship to work on our accelerator science programme (LhARA, nuSTORM, ISIS-II, …)

Other/department:
- Some opportunities "come up" during recruitment process …

PhD studentships … continued

Non-STFC scholarships …

By nation of origin, particular groupings etc. – search for “Imperial fees and funding” – most require you to specify a potential project and supervisor in the application

Imperial College President’s Scholarships

- Hyper-competitive: need to be a top student from a top university, research experience required
- Particles Community can only support one application per round
- Very broad eligibility (especially nationality)
- Get in touch if you you’d like to apply

Also, graduate programmes at our partner Laboratories, e.g.:

- CERN Graduate Programme
- STFC RAL: PPD &/or ISIS Departments

Application and selection process

See http://www.imperial.ac.uk/high-energy-physics/opportunities/postgraduate-opportunities/

Fill the Central College application form!

Initial application deadline 21st January 2026

Interviews in first two weeks of February

Interviews

Two interviewers; about 30 minutes long

- Be ready to discuss your undergraduate or summer projects …
- And physics in general

Generally at 10am, 11am, 1pm or 2pm

There is a lot of competition for places

- We are interested in how you think (and respond) more than what you already know
- Our discussion is likely to “stretch” you to see how far you can go
- We are looking for the top students to be our future colleagues!

Remainder of the afternoon

A tour of the activities in the Community:

- We'll split you into groups
- Each group will be led by a guide to each stop on the tour

Please ask anyone anything about how your time with the group might go

After the tour you will have a chance to meet more group members informally in Blackett 539
For online participants this ZOOM link will stay live throughout the afternoon

Online Q&A sessions: 09Jan26: 10:00—11:00 and 16:00—17:00