Report from the European Committee for Future Accelerators

H. Abramowicz – ECFA chair
Tel Aviv University

Plenary ECFA meetings

- 99th Plenary ECFA - Gran Sasso, 30 June - 01 July 2016,
http://indico.cern.ch/event/537088/

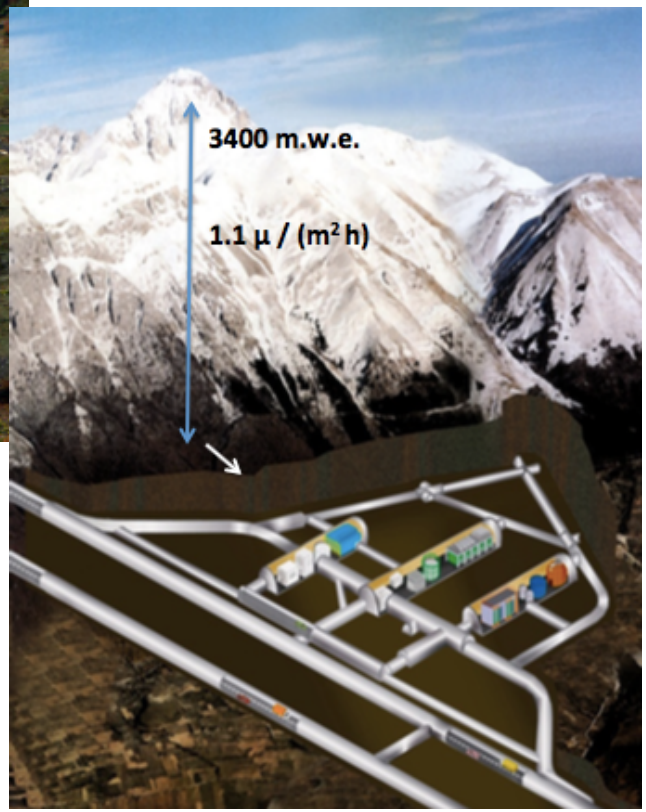
- 100th Plenary ECFA - CERN, 24/25 November 2016,
http://indico.cern.ch/event/570312/

RECFA country visits
Norway - 2 October 2015,
http://indico.cern.ch/event/449732/
Switzerland - 1 April 2016,
http://indico.cern.ch/event/513150/
Sweden - 21 May 2016,
http://indico.cern.ch/event/517355/
•Greece - cancelled

Overview

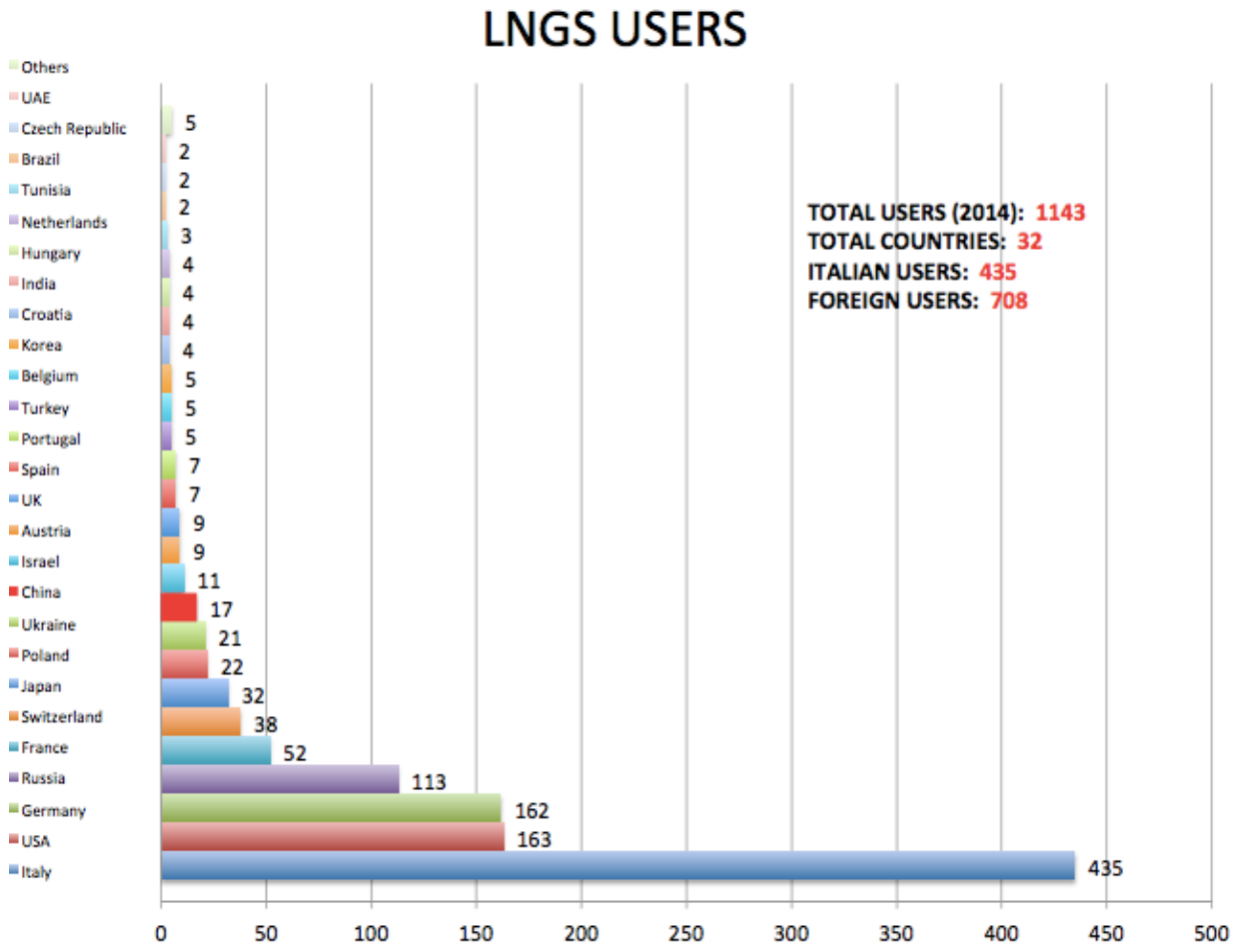
- European Labs
  - Gran Sasso
  - Frascati
  - DESY
- Physics at PECFA – selection
  - Accelerator neutrino-physics
  - High field magnets
- Future facilities
  - HL-LHC
  - Linear Collider
  - Electron-ion collider
- ApPEC contribution
  - Gravitational waves
  - KM3Net
- ECFA activities

Gran Sasso – from Stefano Ragazzi



- 1979: proposal by A. Zichichi to Italian Parliament
- 1982: Approval of LNGS construction
- 1987: construction completed
- 1989: Start data taking of first large experiment (MACRO)

Gran Sasso



LNGS Activities

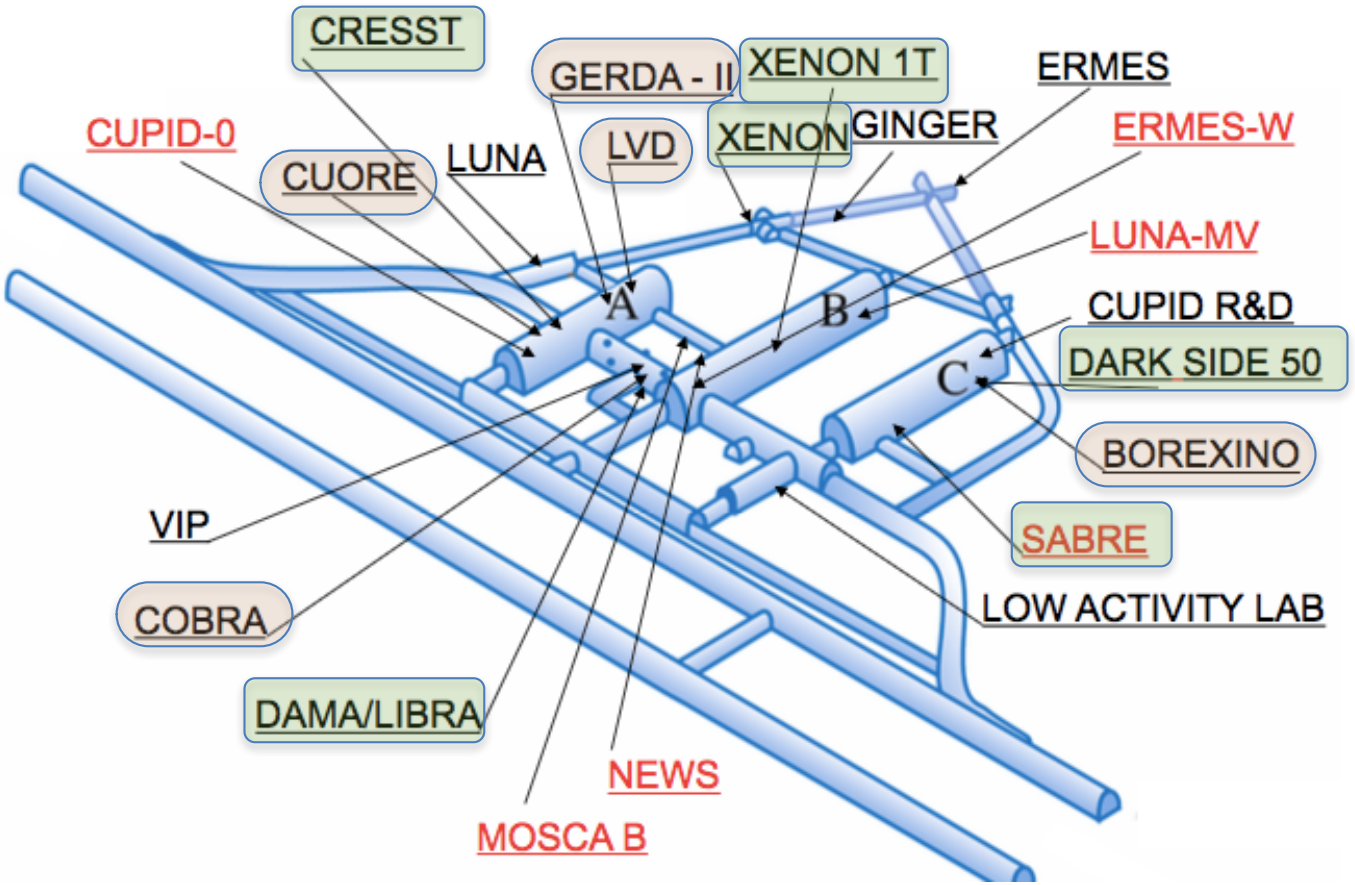
- Neutrino Astrophysics
- Neutrino Physics
- Dark Matter searches
  - ➢ particle physics
  - ➢ astrophysics
  - ➢ cosmology
- Nuclear Astrophysics – reactions relevant for
  - ➢ Big Bang nucleosynthesis
  - ➢ Star nucelosyntesis

- GINGER
  - Ring-laser to probe Lense-Thirring effect
- Cosmic Silence
  - Study effect of very low radiation doses on cells, fleas, …
  - Test Linear No Threshold model
- ERMES-W
  - Primary resources, global geodynamic…
- VIP
  - Test Pauli Exclusion Principle

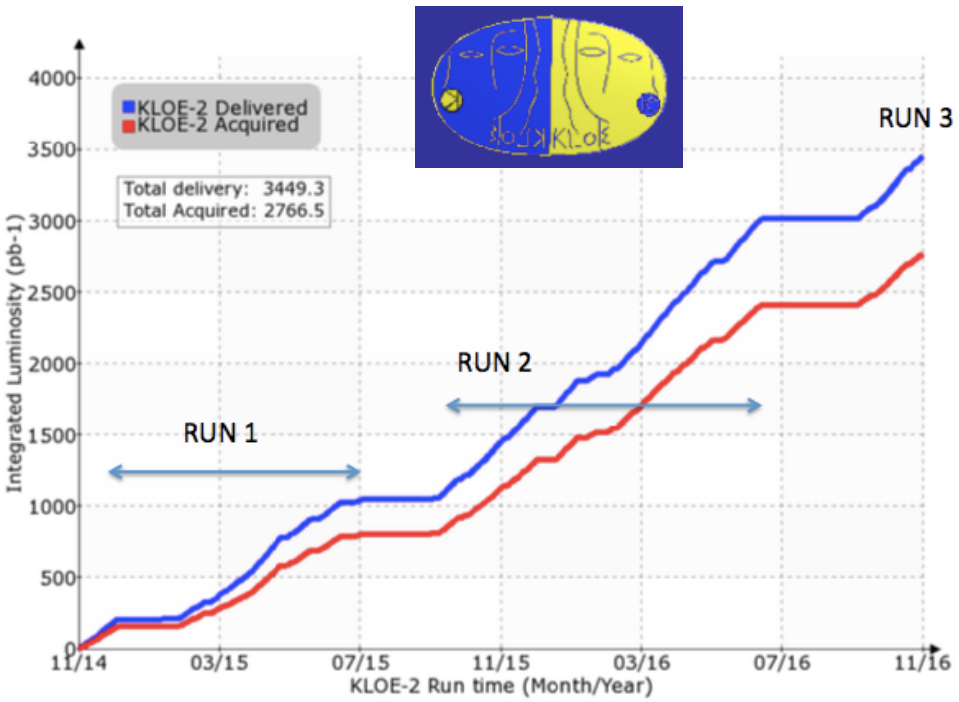
- SN neutrino:
  - LVD 1 kton liquid scint. Waiting for SN since 1992
- Solar Neutrino:
  - Borexino: real-time measurement of pp neutrino, …, Geo-neutrinos
- Double Beta Decay
  - Gerda / Gerda-II: ^{76}Ge
  - **CUORE** – *the coldest m^3 in the world* : ^{130}Te
  - Cobra: ^{116}Cd
  - LUCIFER: R&D phase on crystals
- Sterile Neutrino
  - Borexino-SOX (CeSOX first)

- DAMA/Libra: NaI
  - Reports annual modulation
- NaI
  - INFN/LNGS is going to support independent test of DAMA result: SABRE
- CRESST
  - $CaWO_4$ scint with bolometric r/o
- XENON family
  - Double phase liquid Xe TPC
- DarkSide
  - Liquid Ar TPC double phase

LNGS Activities



Report from Frascati – P. Campana



Run 3 started after summer shutdown. Peak L=2.0 10^{32} $cm^{-2}s^{-1}$ compatible with previous data taking. Goal to reach 5/fb delivered to KLOE2 by July 2017

Beam Test Facility also for students

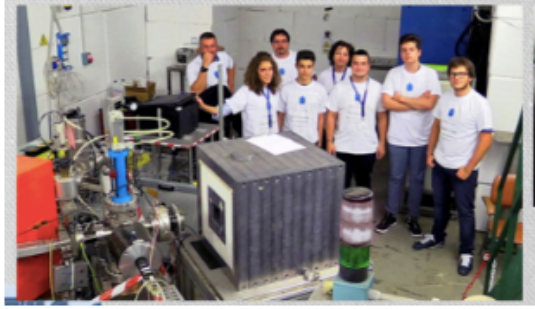
Highlights 2016: Education & Training

Sep. 22nd-24th: "Beamline for Schools", prize to one Italian school not going to CERN: Liceo Scientifico T.C. Onesti, Fermo

- Experiment on Cherenkov in water detection with CMOS sensor

Oct. 5th- 7th: "Incontri di Fisica", Training on modern research for high school physics teachers.

- BTF detectors, diagnostics, DAQ, data analysis, etc.



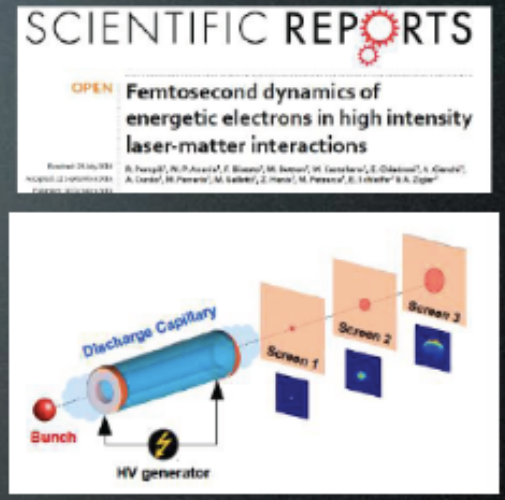
Excellent experiences, to be repeated in 2017, in connection with Beam4Schools at CERN

Report from Frascati

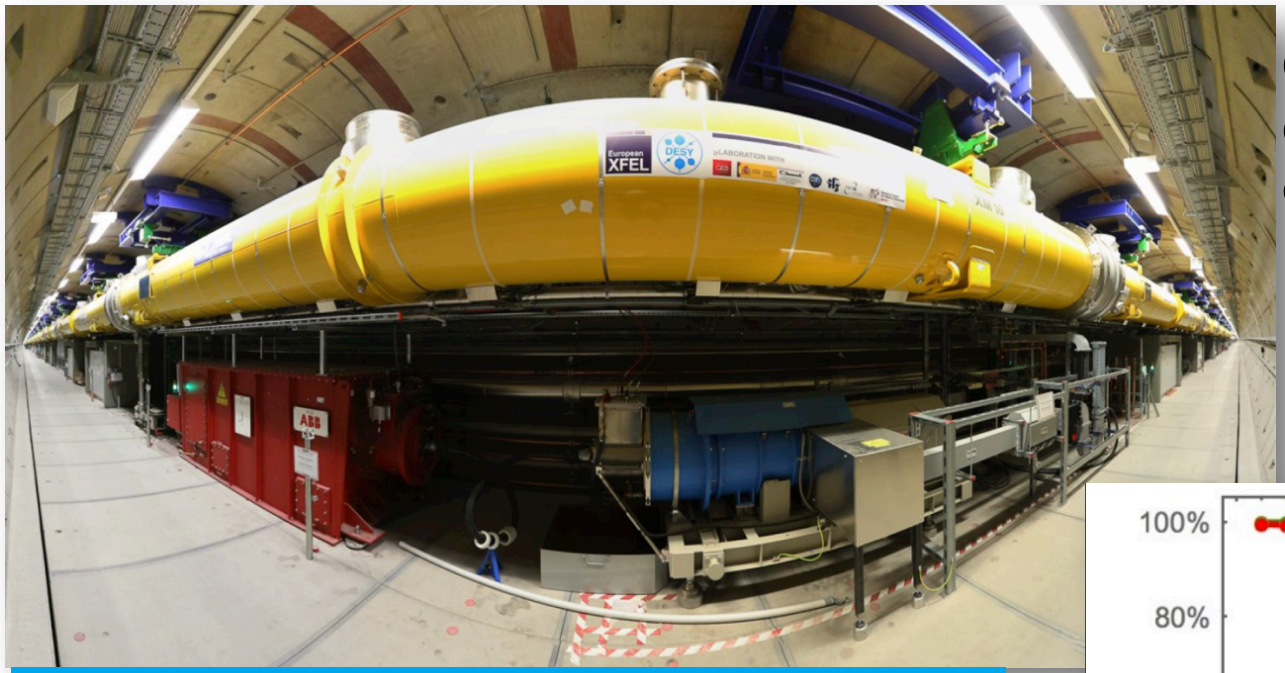
SPARC_Lab – plasma acceleration and photon facility

Highlights

- TNSA: results published by Nature Scientific Reports
- PWFA: active plasma lens results submitted to PRL
- LWFA: self-injected beam accelerated up to > 200 MeV, betatron radiation detected, accelerated charge measured
- EuSPARC design study in progress, layout , linac and FEL studies

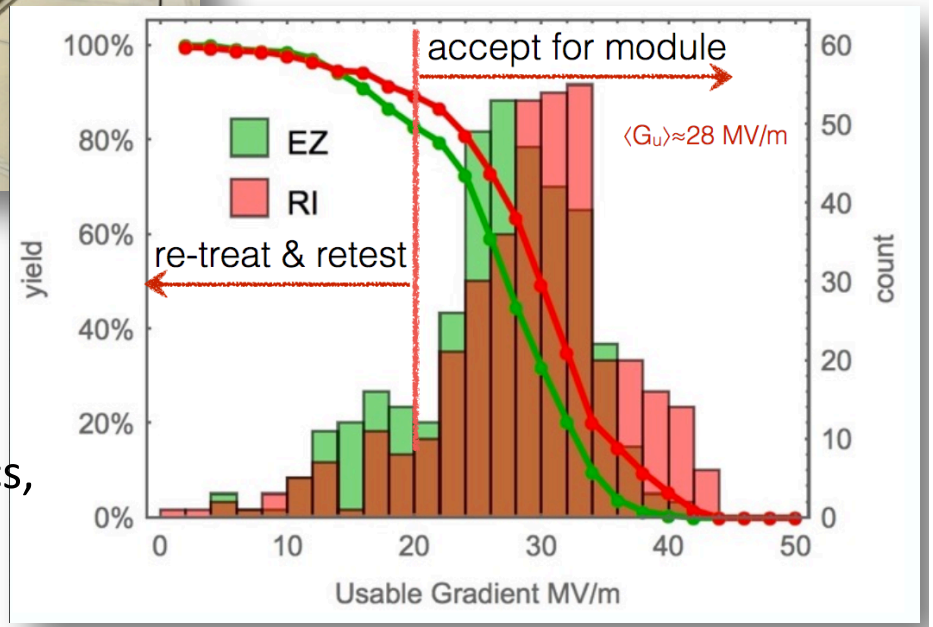


Report from DESY - J. Mnich



Cool down delayed by 6 weeks due to problems with helium exhaust pipe at the end of the line

- 100% of SC linac installed (96 cryomodules)
- Warm beamline section installation completed
- Injector commissioning completed 7/2016

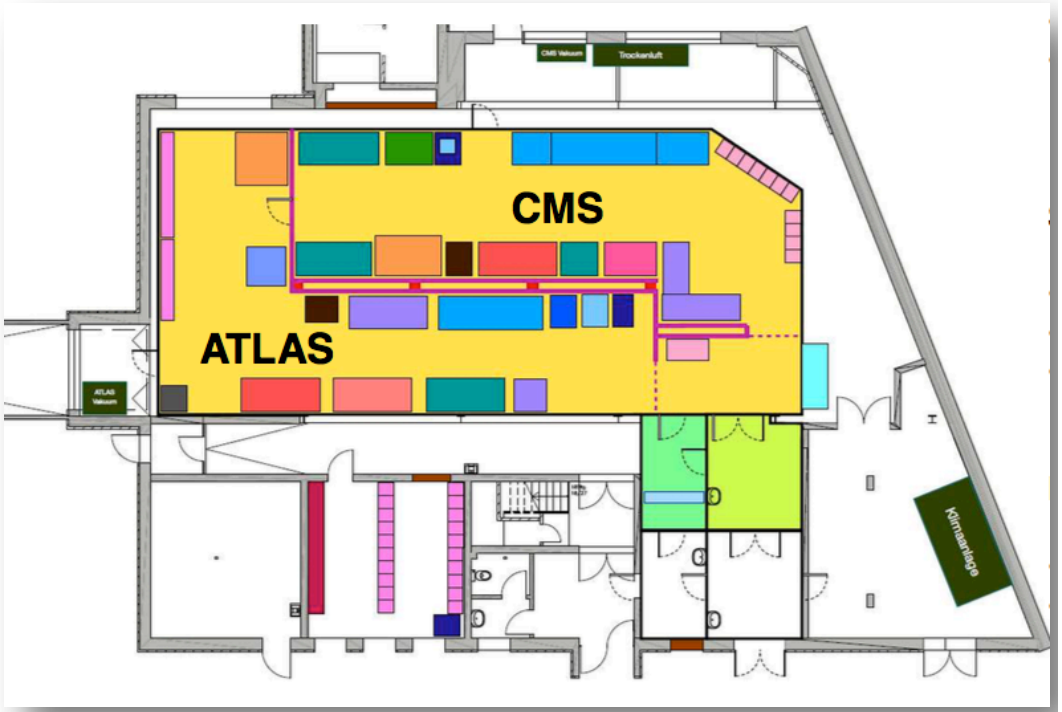


Cavity performance very close to ILC specs, on an industrial scale!

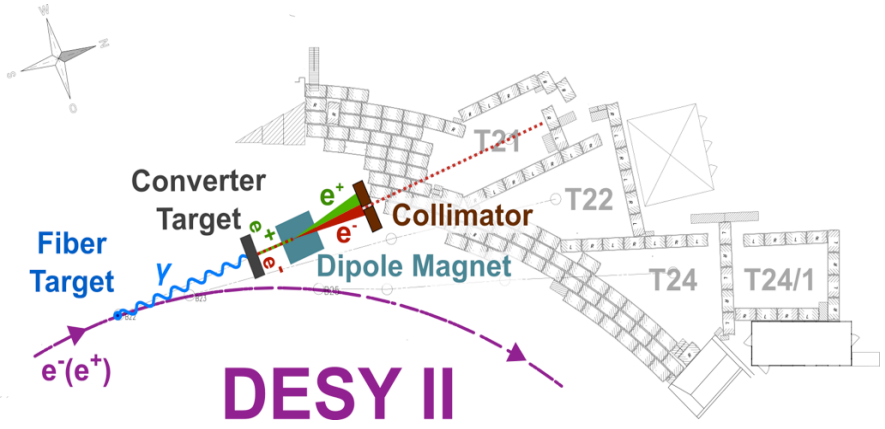
Report from DESY

Moved to Schenefeld in June 2016

Part of Detector Assembly Facility (DAF) - ground floor of building 25c for LHC upgrade, module production and testing → mid 2017



DESY-II TEST BEAM FACILITY



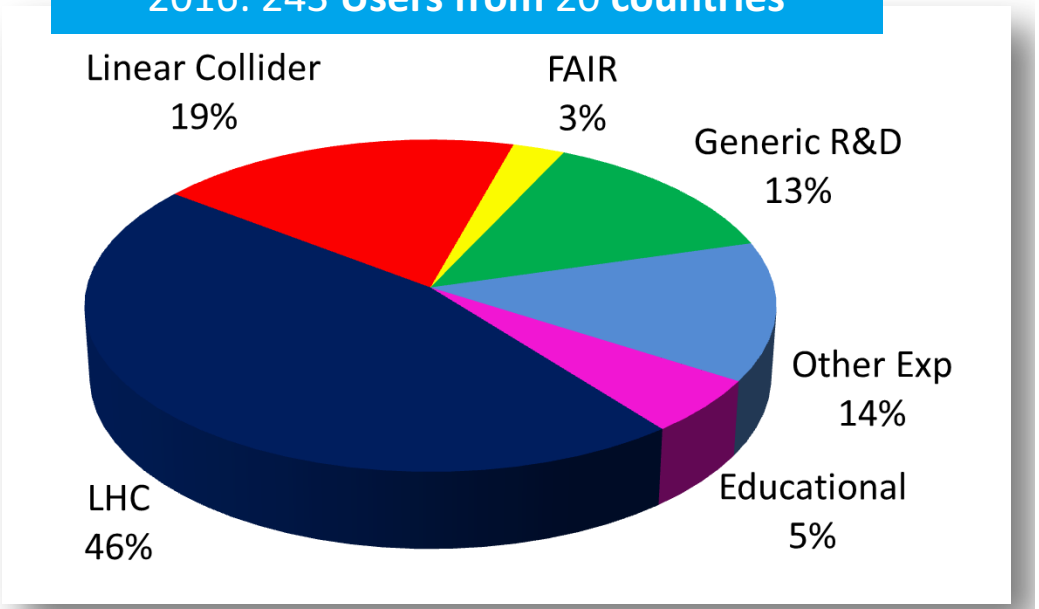
Unique infrastructures at DESY

- Two pixel beam telescopes
  - High demand – requested by >70% of users
- PCMAG
  - 1T superconducting solenoid with 1m diameter
  - unique infrastructure worldwide

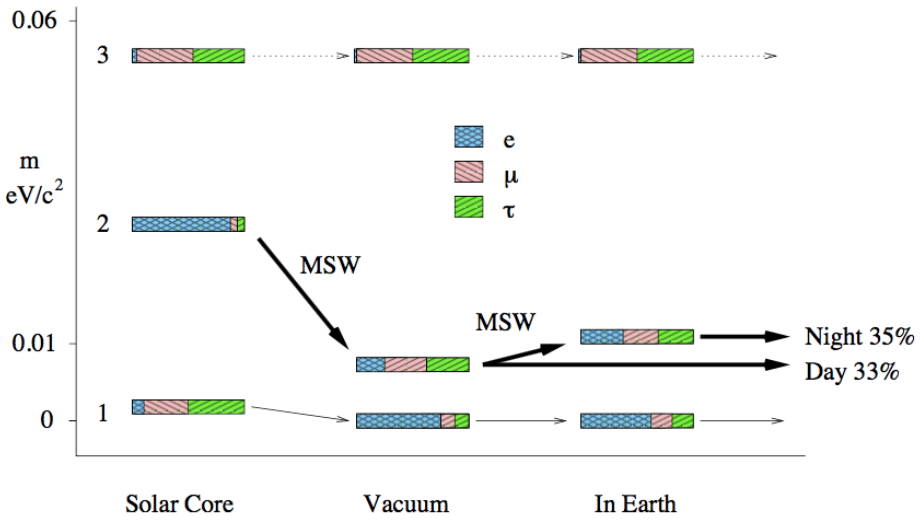
Shutdown 2015-2016

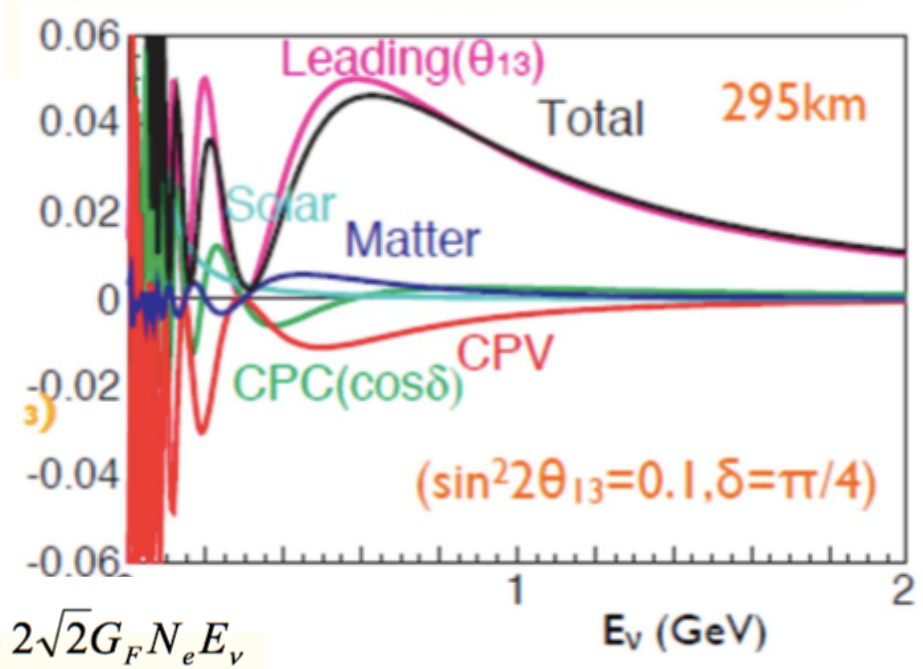
- Complete overhaul of beam diagnostics in DESY-II Tunnel
- New Gas Safety System
- Laser Alignment System in each area
- New cabling & fiber links

2016: 243 **Users from** 20 **countries**



Neutrino Physics – M. Lindner, D. Duchesneau, F. Sanchez, A. Vacheret





Investigate $\nu_\mu \rightarrow \nu_e$ et $\bar{\nu}_\mu \rightarrow \bar{\nu}_e$ oscillations

$$a = 2\sqrt{2} G_F N_e E_\nu$$

$$p(\nu_\mu \rightarrow \nu_e) = 4c_{13}^2 s_{13}^2 s_{23}^2 \sin^2 \frac{\Delta m_{13}^2 L}{4E} \times \left[1 \pm \frac{2a}{\Delta m_{13}^2}(1-2s_{13}^2)\right] \quad \theta_{13} \text{ driven}$$

$$+ 8c_{13}^2 s_{12} s_{13} s_{23} (c_{12} c_{23} \cos\delta - s_{12} s_{13} s_{23}) \cos\frac{\Delta m_{23}^2 L}{4E} \sin\frac{\Delta m_{13}^2 L}{4E} \sin\frac{\Delta m_{12}^2 L}{4E} \quad \text{CPeven}$$

$$\mp 8c_{13}^2 c_{12} c_{23} s_{12} s_{13} s_{23} \sin\delta \sin\frac{\Delta m_{23}^2 L}{4E} \sin\frac{\Delta m_{13}^2 L}{4E} \sin\frac{\Delta m_{12}^2 L}{4E} \quad \text{CPodd}$$

$$+ 4s_{12}^2 c_{13}^2 \{c_{13}^2 c_{23}^2 + s_{12}^2 s_{23}^2 s_{13}^2 - 2c_{12} c_{23} s_{12} s_{23} s_{13} \cos\delta\} \sin\frac{\Delta m_{12}^2 L}{4E} \quad \text{solar driven}$$

$$\mp 8c_{12}^2 s_{13}^2 s_{23}^2 \cos\frac{\Delta m_{23}^2 L}{4E} \sin\frac{\Delta m_{13}^2 L}{4E} \frac{aL}{4E}(1-2s_{13}^2) \quad \text{matter effect (CP odd)}$$

Neutrino Physics

Future Long Baseline Projects in the World:

US : DUNE/LBNF

Liquid Argon TPC 4x10 kton

at SURF (Homestake Mine) ~2400mwe

On axis Beam from Fermilab (1.2-2.4MW)

baseline=1300 km <E> ~3 GeV

Japan : Hyper-K

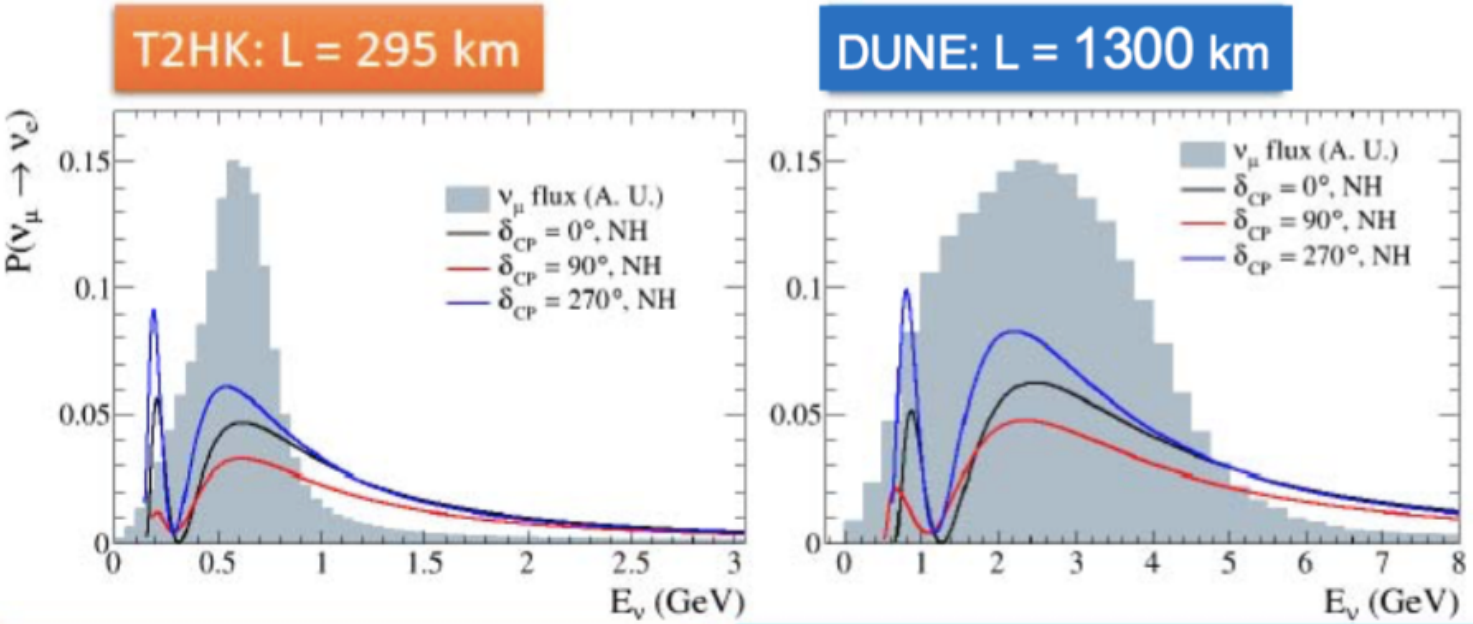
Water Cherenkov 520 kton

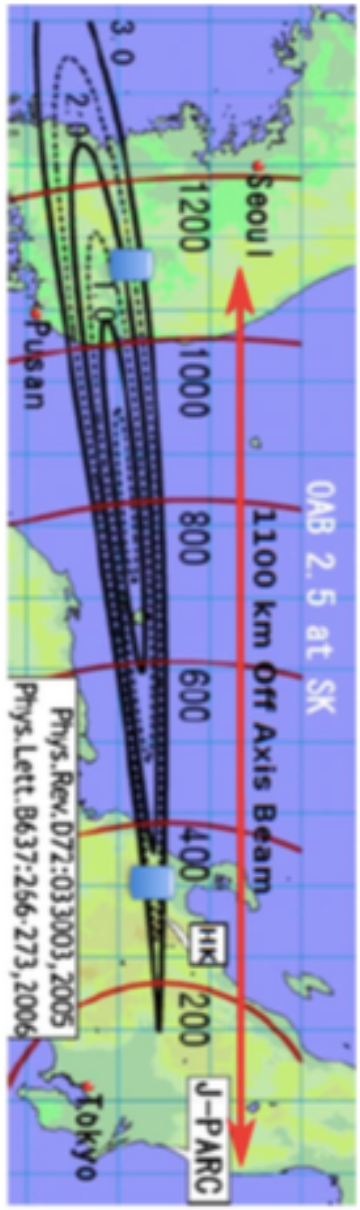
At Tochibora near Kamioka, ~ 1750 mwe

Off axis Beam from JPARC (1.3MW)

baseline=295 km <E> ~0.7 GeV

Hyper-K and DUNE: Two complementary approaches





Neutrino Physics

Summary and outlook

From now on to 2021

- T2K and Nova: continue to run in neutrino and anti-neutrino mode (about 20% of data now)
- Aim to increase the significance of the hint on δ_{CP} at $3\pi/2$ up to 2σ
- Aim to rule out the maximal mixing or not

From 2021 to 2026

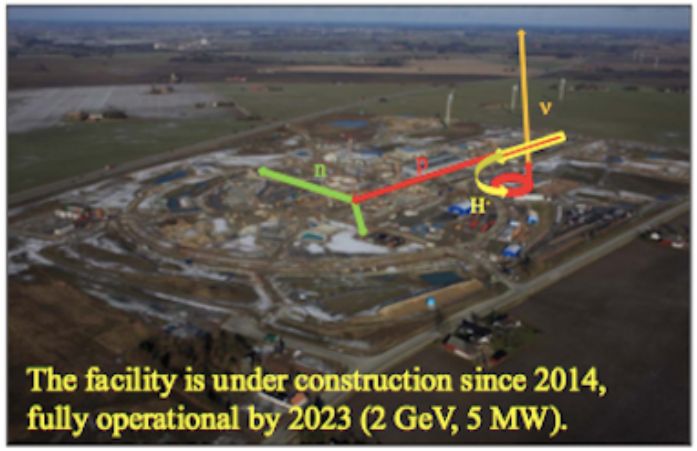
- T2K-Phase II: 3 times T2K statistics => aim at 3σ sensitivity to CP violation evidence for favorable parameters
- Octant determination or measure θ_{23} with 1.7° precision

From 2026 to 2036

- DUNE and Hyper-K:
  - Discover at 5σ and measure δ_{CP} with a precision better than 10°,
  - Determine Mass Hierarchy,
  - Measure with high precision θ_{23} and θ_{13}
  - Proton decay searches
  - Atmospheric, solar and supernovae neutrino observation

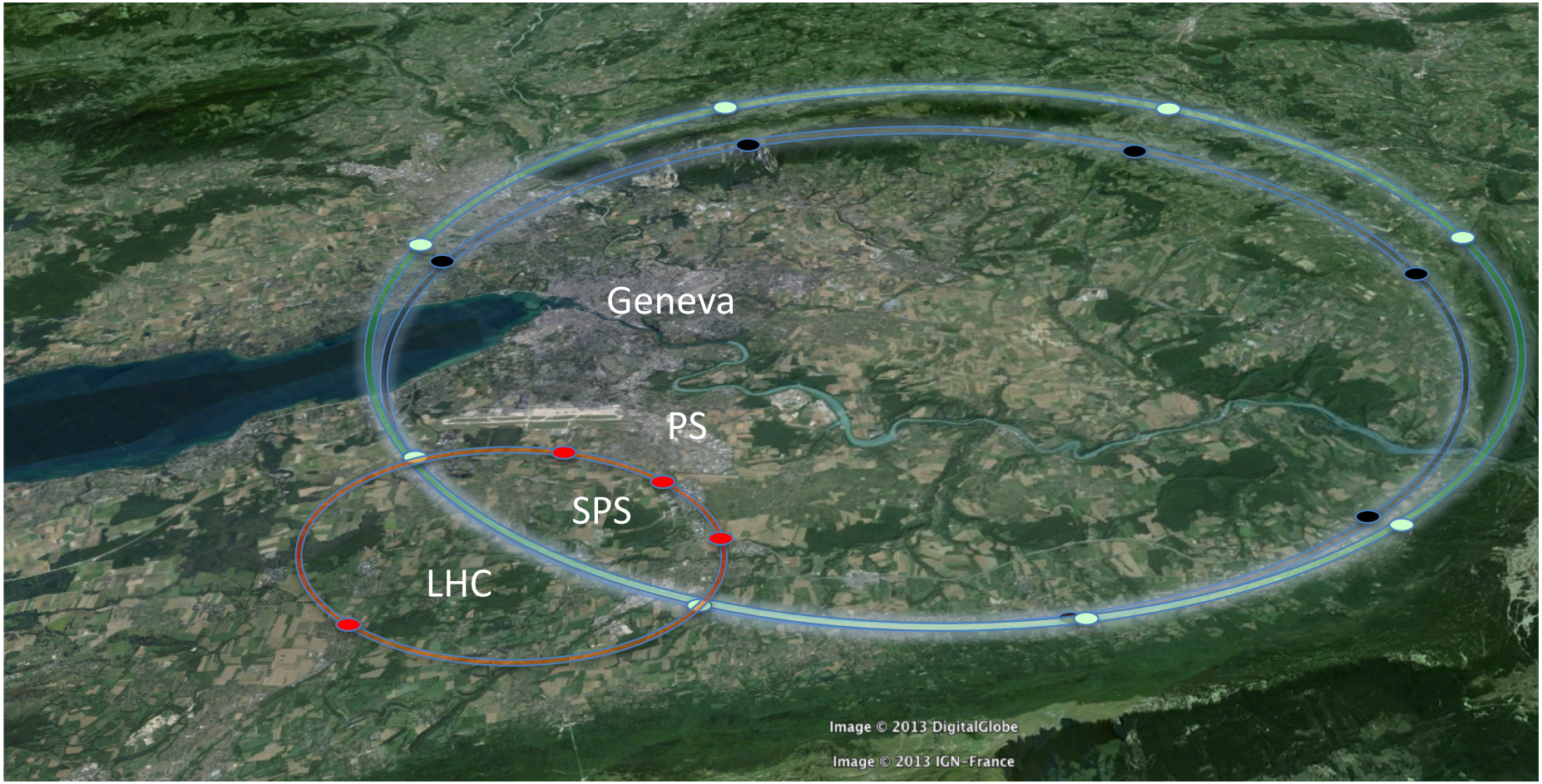
- Beyond DUNE and Hyper-K:

ESSνSB:



The facility is under construction since 2014, fully operational by 2023 (2 GeV, 5 MW).

High field magnets for future hadron colliders – G. de Rijk



LHC
27 km, 8.33 T
14 TeV (c.o.m.)

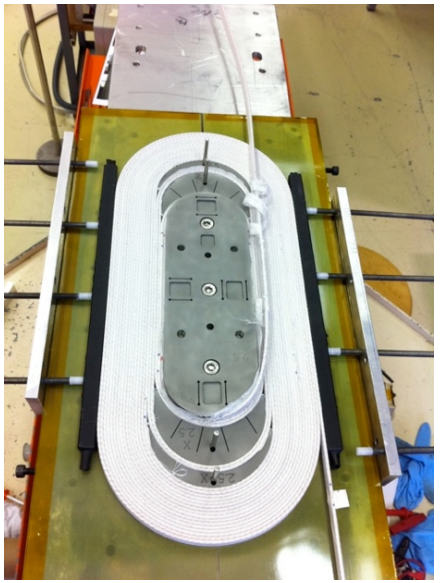
HE-LHC
27 km, **20 T**
33 TeV (c.o.m.)

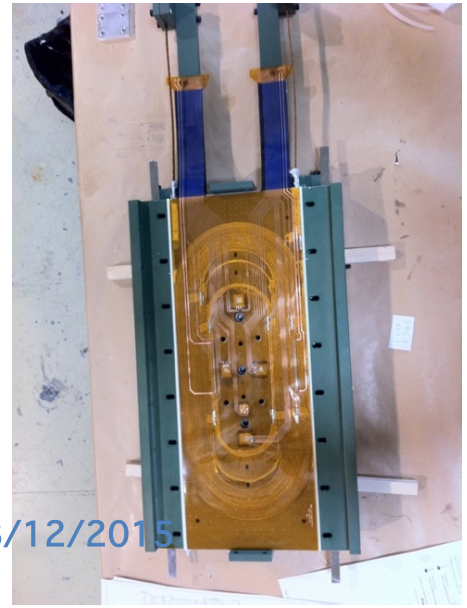
FCC-hh
80 km, **20 T**
100 TeV (c.o.m.)

FCC-hh
100 km, **16 T**
100 TeV (c.o.m.)

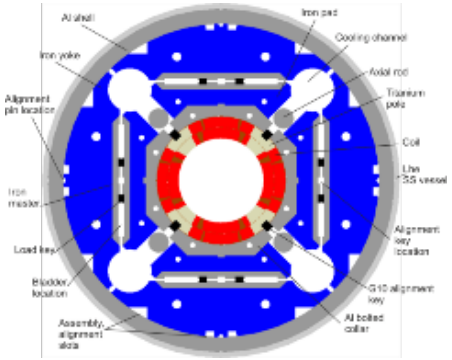
Using Nb_3Sn conductor in magnets

- Nb_3Sn has to be reacted after winding for ~100 hours at 650°C (wind and react)
- Cables have to be insulated with a non-organic woven insulation: glass or ceramic fibres
- After reaction the coils has to be impregnated to prevent any movements and to take care that stresses are distributed, instrumentation connections are moulded in
- Reacted Nb_3Sn is brittle and stress sensitive

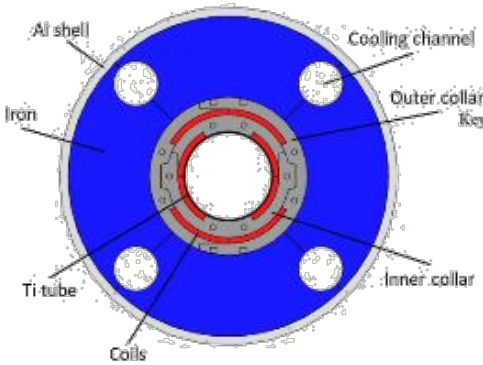




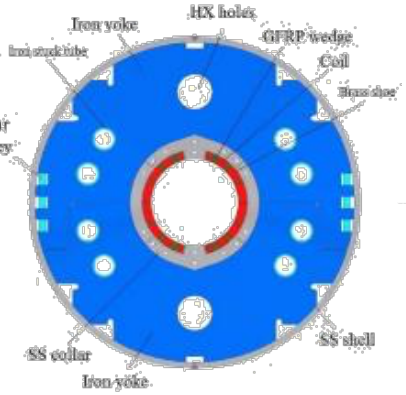
HILUMI IT magnet zoo



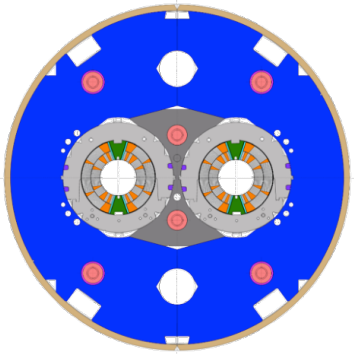
Triplet QXF (LARP and CERN)



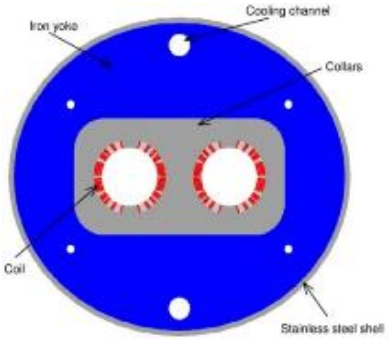
Orbit corrector (CIEMAT)



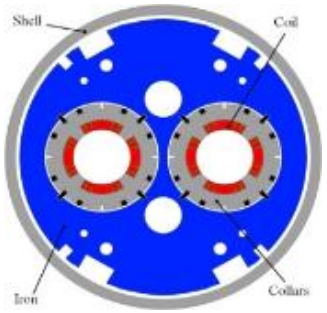
Separation dipole D1 (KEK)



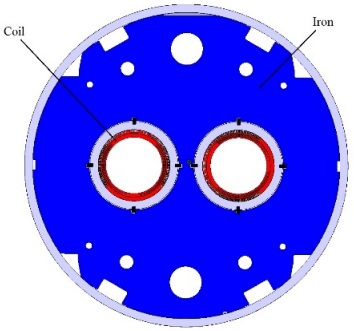
11 T dipole (CERN)



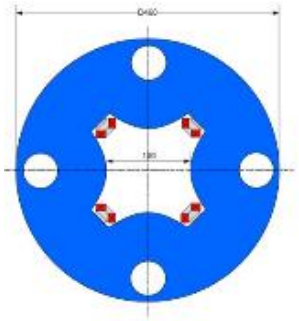
Recombination dipole D2 (INFN)



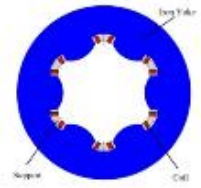
Q4 (CEA)



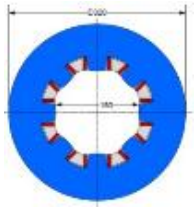
D2/Q4 orbit corrector (CERN)



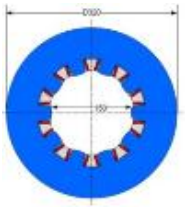
Skew quadrupole (INFN)



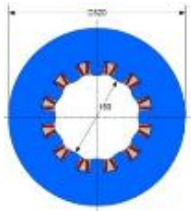
Sextupole (INFN)



Octupole (INFN)



Decapole (INFN)

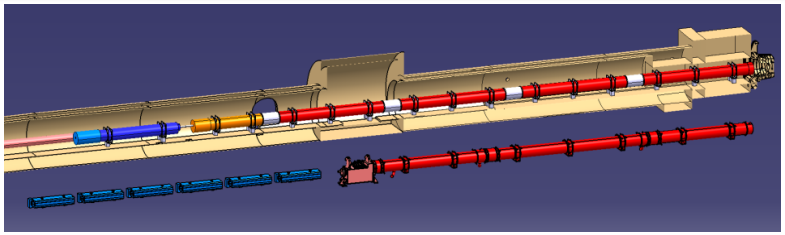


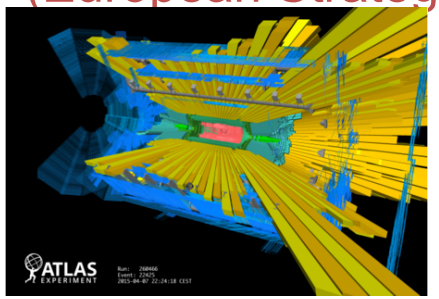
Dodecapole (INFN)

Courtesy E. Todesco

Conclusions

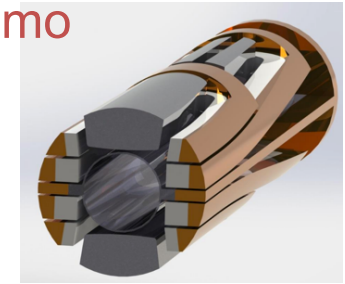
LHC Run-II provides results to define future HEP roadmap (European Strategy 2018)





EuCARD²

Accelerator-grade HTS 5 T demo



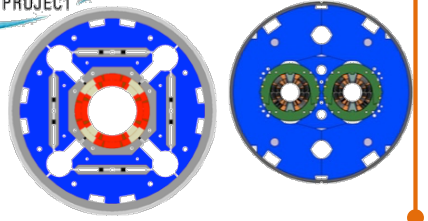
HL-LHC demonstrates large-scale use of Nb_3Sn

High Luminosity LHC

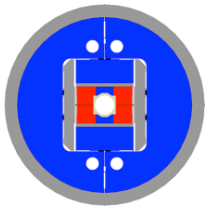
End of LHC useful life

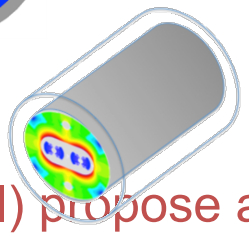
2015 2016 2017 2018 2019 2020 2025 2030 2035 2040

12 T accelerator technology



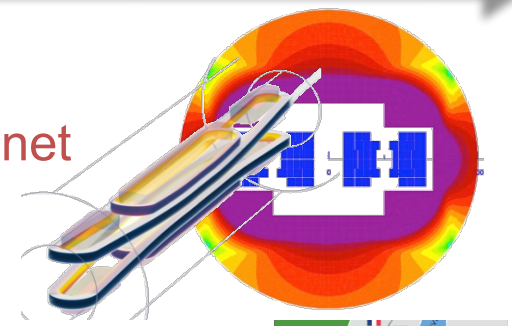
16 T magnet model(s)

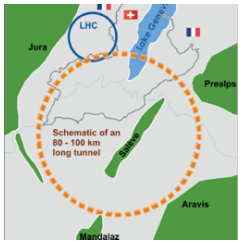




16 T accelerator technology

20 T magnet model(s)



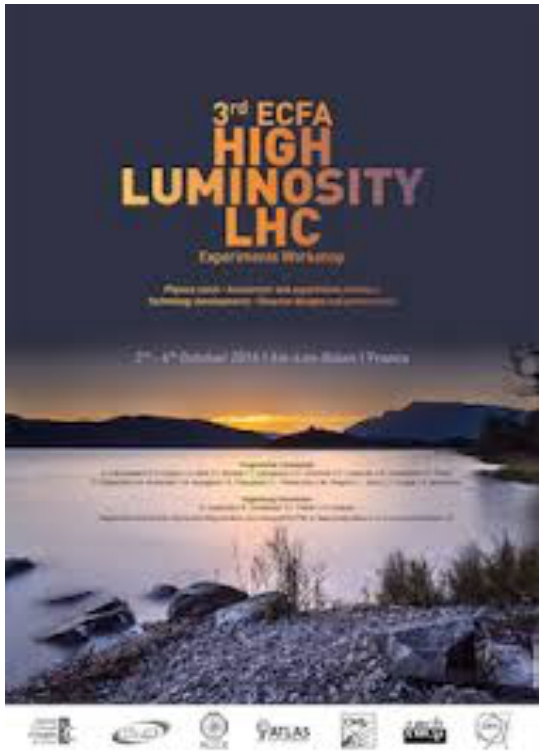


FCC CDR (EuroCirCol) propose a new energy frontier accelerator

FCC construction decision

Summary of ECFA 2016 HL-LHC Workshop

K. Einsweiler, LBL + D. Contardo, Lyon



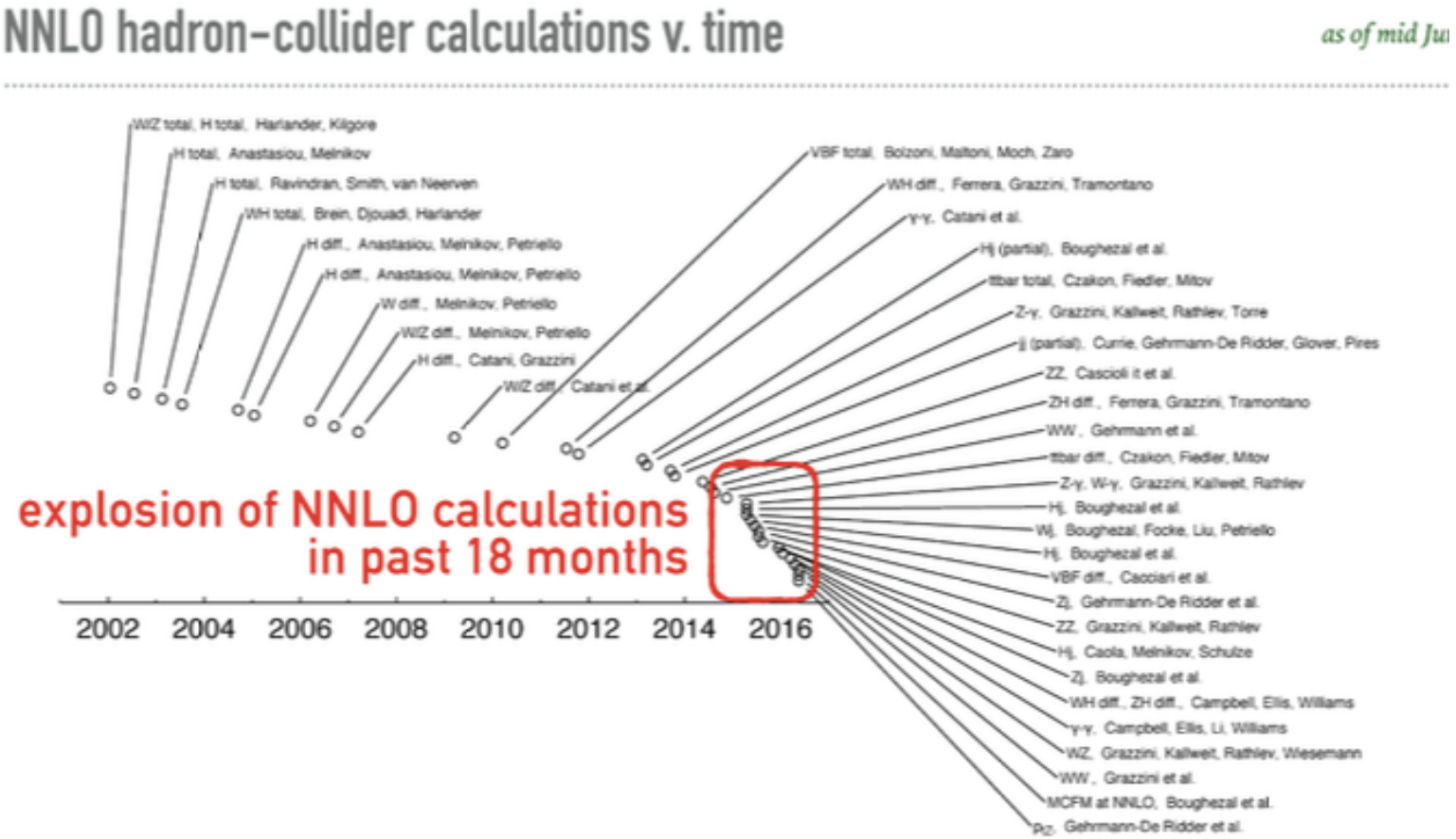
- Attempt to summarize intense 4 days of ECFA 2016 in ~35 mins with selected highlights Very superficial overview to give "flavor"
- This workshop has evolved from the 2013 and 2014 predecessors because the experiments are now entering their TDR phase, with all aspects of their detector designs transitioning from R&D towards construction => large focus on designs and their performance.
- This meeting was roughly ¾ detectors, 1/8 accelerator, and 1/8 physics. Will spend very little time on physics, more time on accelerator and experimental interface, and most of the time on the detector side.
- Indico may be found here:

https://indico.cern.ch/event/524795/timetable/

High luminosity LHC workshop

Physics for HL-LHC Overview

- Gavin Salam plot of availability of NNLO calculations versus time => many technical breakthroughs lead to a revolution (critical for Run 2 physics) !



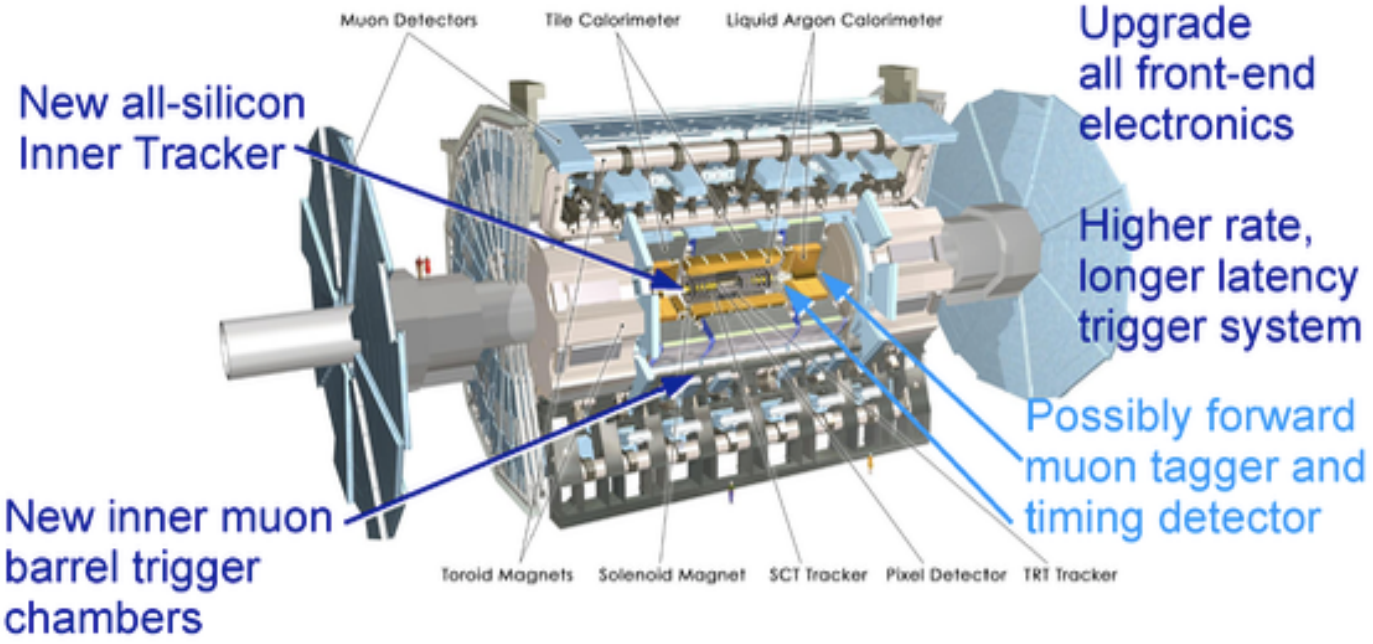
Upgrade Overviews: ATLAS

- Overview of phase-2 upgrades at top level – first TDR submission Dec 16 !
  Expect to have total of 6 TDRs submitted by ~end 2017, MOUs by Fall 2018.

Overview of Phase-II Upgrades

5

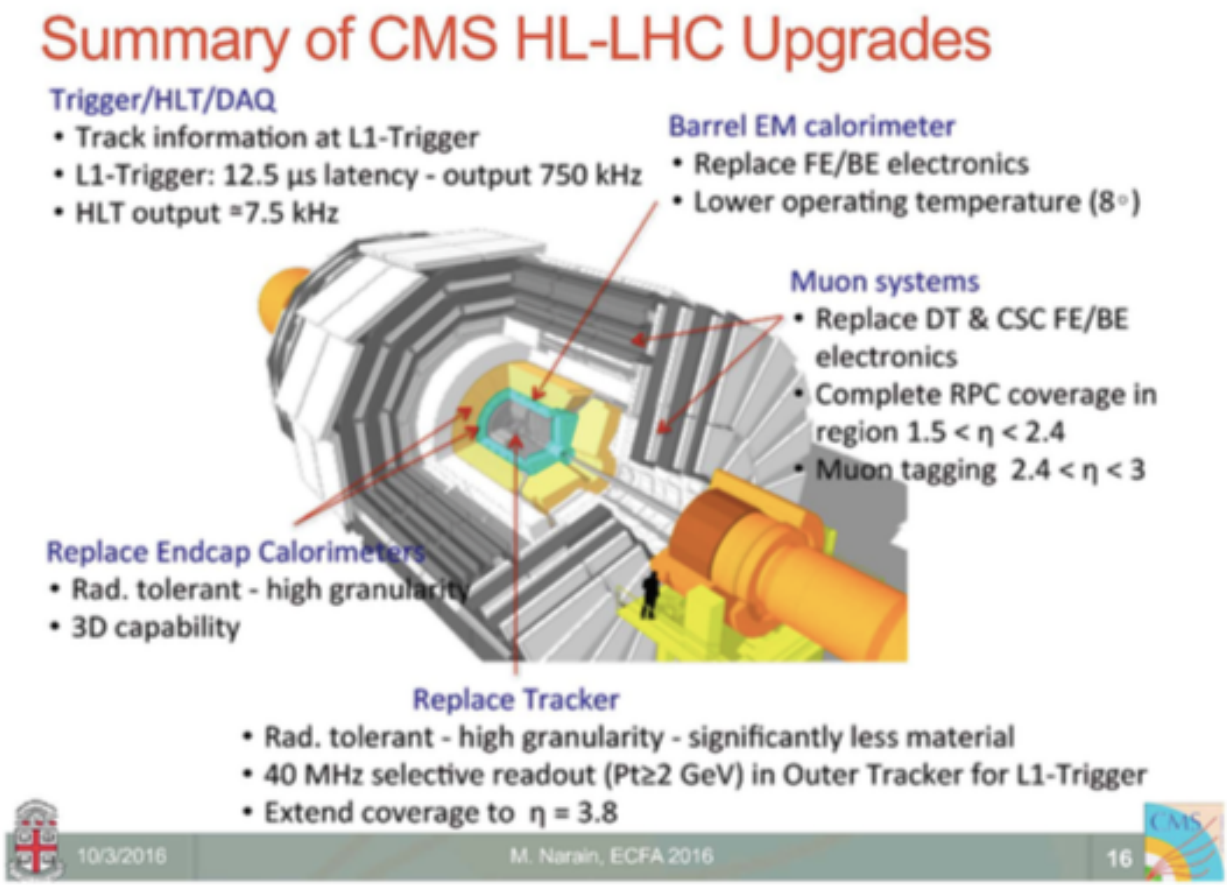
Overall scope of Phase-II upgrades is mostly settled



Now evaluating different design/implementation options
towards submission of TDRs over next 15 months

Upgrade Overviews: CMS

- Overview of phase-2 upgrades at top level – first TDR submission mid-2017. Expect to have total of 4 TDRs submitted by ~end 2017, MOUs by Fall 2018.



Computing for HL-LHC Overview

- Biggest challenge is data management, not CPU (although that is still hard !)

Conclusions

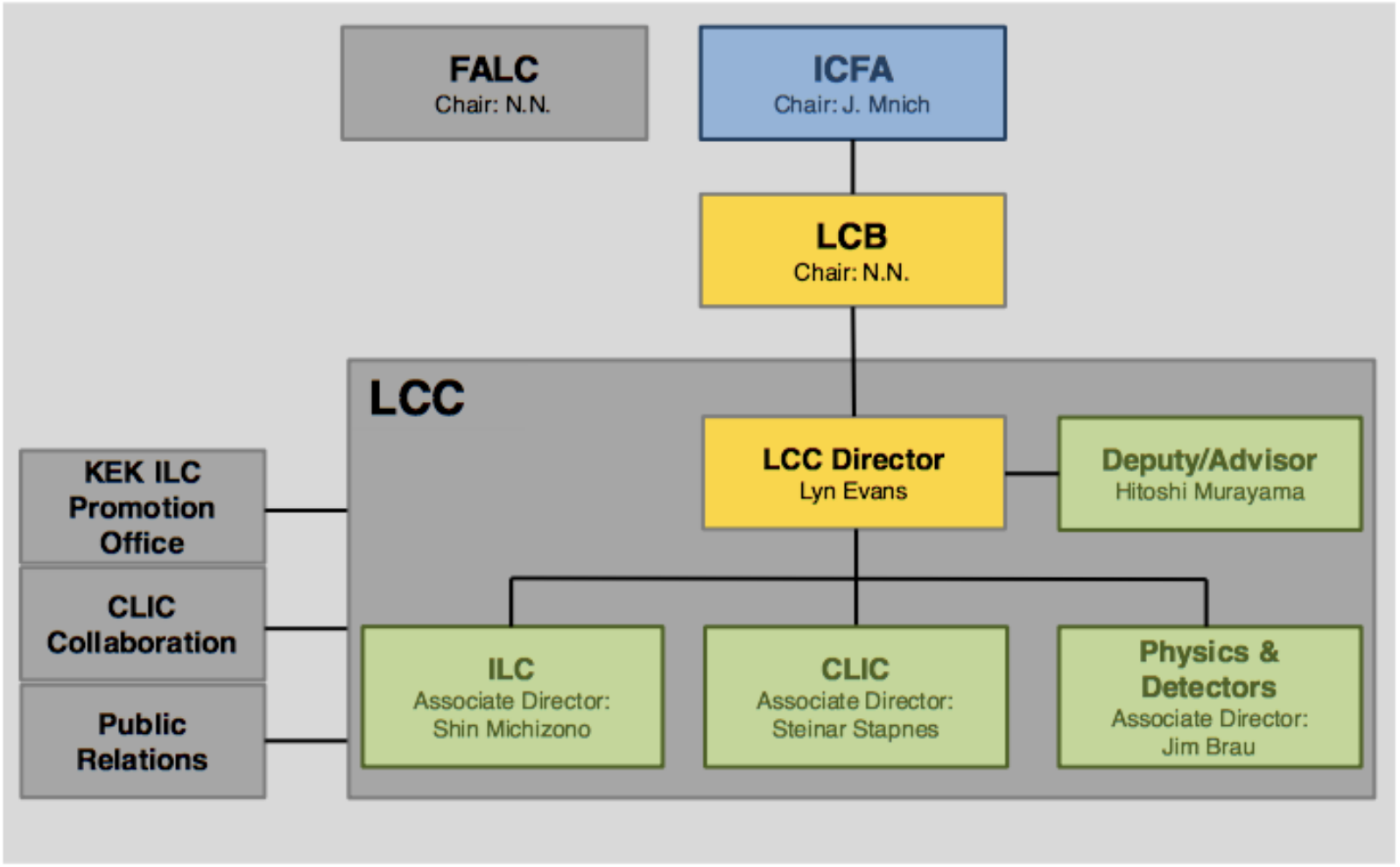
- We identified a concrete set of steps in preparation for computing at HL-LHC
- To keep cost of computing under control in 2026 we need to invest effort from now. Data will be the challenge.
- The effort spans many areas: online, offline software, distributed computing, physics, infrastructure and facilities. The detector layout will play a crucial role
- It is important to consider cost of computing when choices are made
- We are on schedule to define a computing model for HL-LHC in the next three years

Linear Collider organization reviewed

At the February 2016 meeting, ICFA decided to continue the LC organization beyond 2016

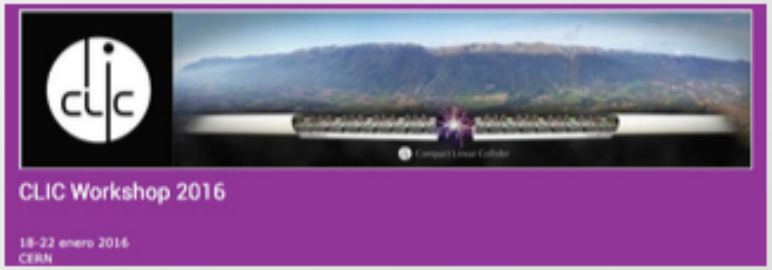
- with updated structure and mandate
  - as little changes as necessary
  - keep names of LCB and LCC
- making it "leaner"
- main purpose over the next years to
  - have oversight of worldwide R&D efforts
  - keep the successful close collaboration and synergy between ILC and CLIC
  - promote LC in political circles and general public

LC new organization (to be reviewed in <3 years)



ECFA Linear Collider Physics and Detector Study
Juan Fuster

- **CLIC workshop 2016, CERN, 18-22 Jan.**
  https://indico.cern.ch/event/449801/

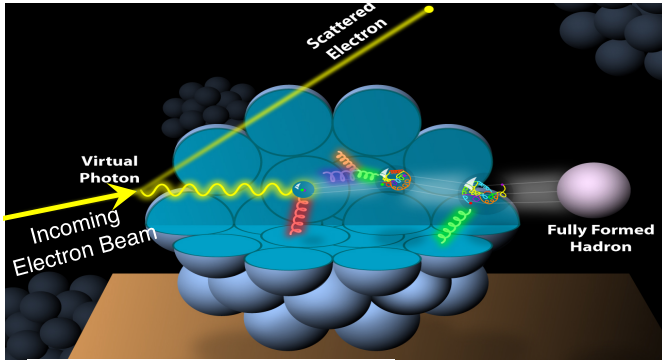


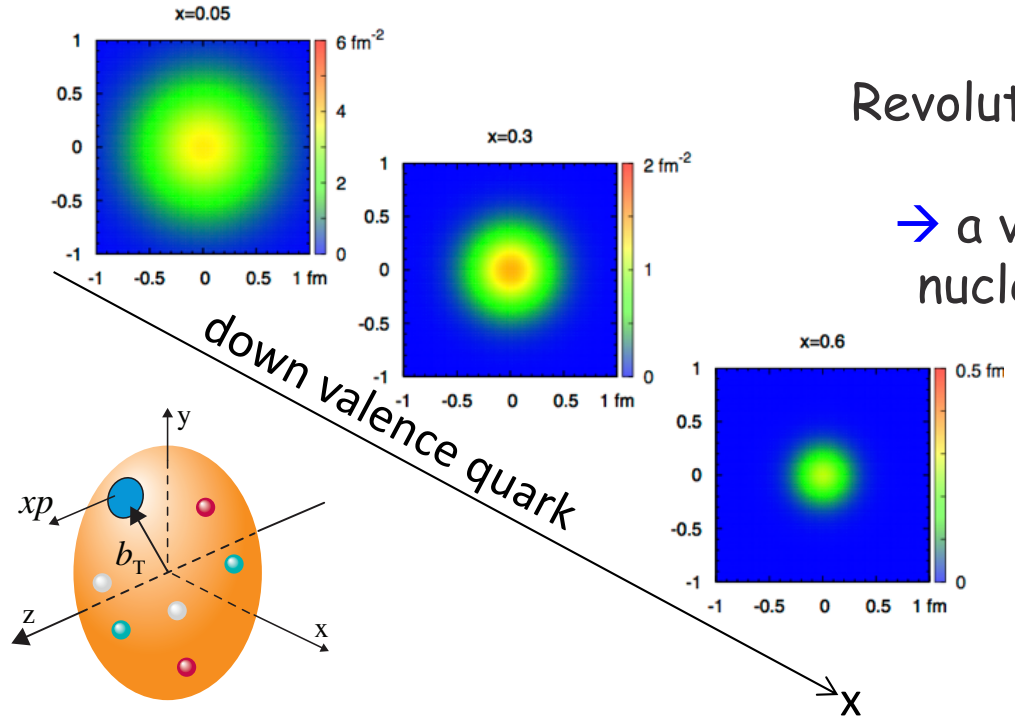
- **ECFA - Linear Collider Workshop 2016, Santander (Spain), 30 May – 5 June.**
  http://www.ifca.unican.es/congreso/ECFALC2016
  Local chair: Alberto Ruiz
  "Omnibus" type workshop: Accelerator, ILD, CLICdp, SiD, R&D Collaborations, Plenaries, etc..

- **LCWS16, Linear Collider Workshop 2016, Morioka (Japan), 5-9 December (313 participants)**
  http://lcws2016.sgk.iwate-u.ac.jp/Welcome.html

LCWS2016 in Morioka – amazing social and media impact

Electron ion collider in the US – E. Aschenauer





What is the EIC:

A high luminosity (10^{33} – 10^{34} cm^{-2}s^{-1}) polarized electron proton / ion collider with $\sqrt{s_{ep}}$ = 20 – 100 GeV upgradable to 140 GeV

Why an EIC:

Revolutionize our view of nucleon structure and the glue!

→ a very diverse physics program impacting nuclear, heavy ion and high energy physics

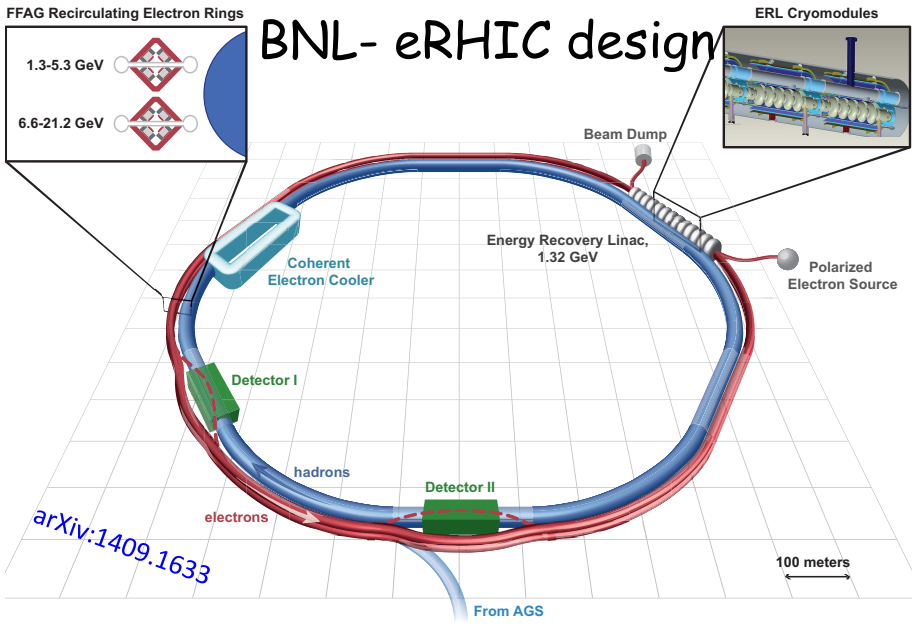
Potentially important input to HL-LHC

Electron ion collider in the US

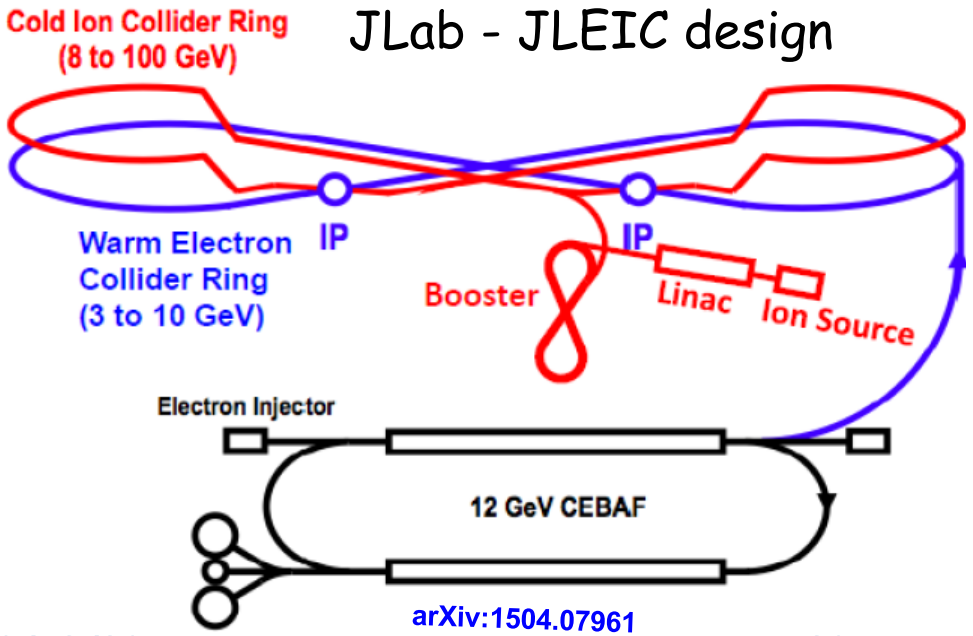
What is new/different:

HERA: factor 100 to 1000 higher luminosity
both electrons and protons / light nuclei polarized
nuclear beams: deuterium to Utanium
COMPASS: factor 10 to 100 higher luminosity
>2 decades increase in kinematic coverage in x and Q^2

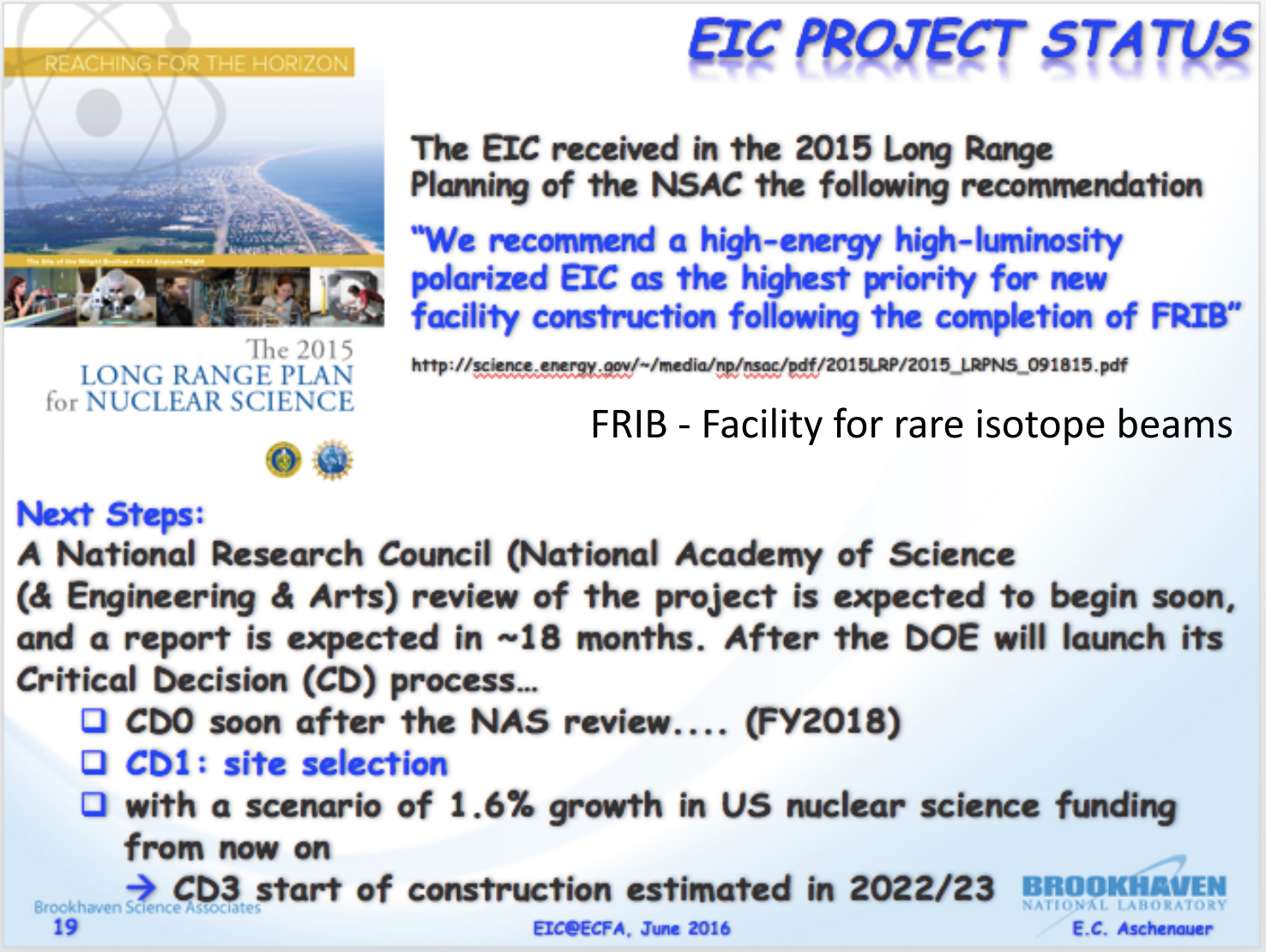
BNL- eRHIC design



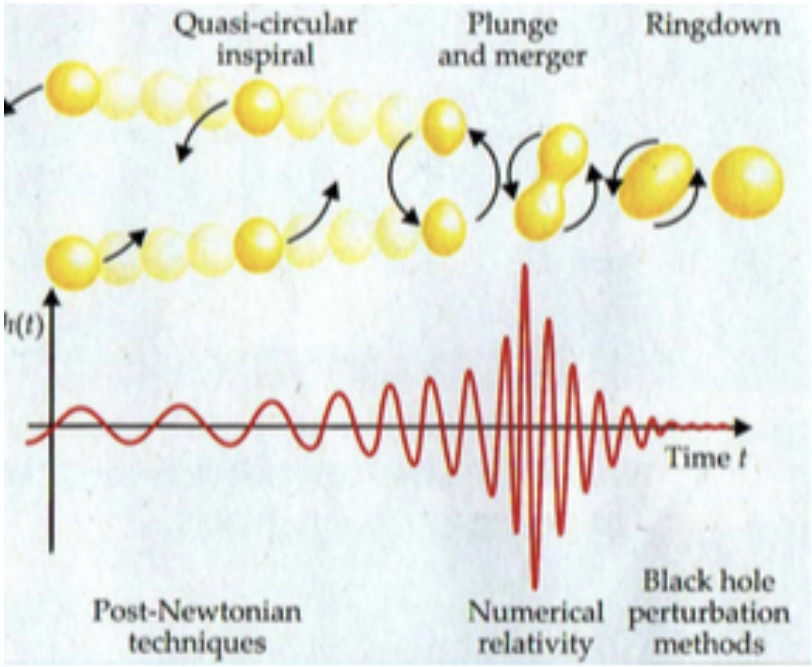
JLab - JLEIC design

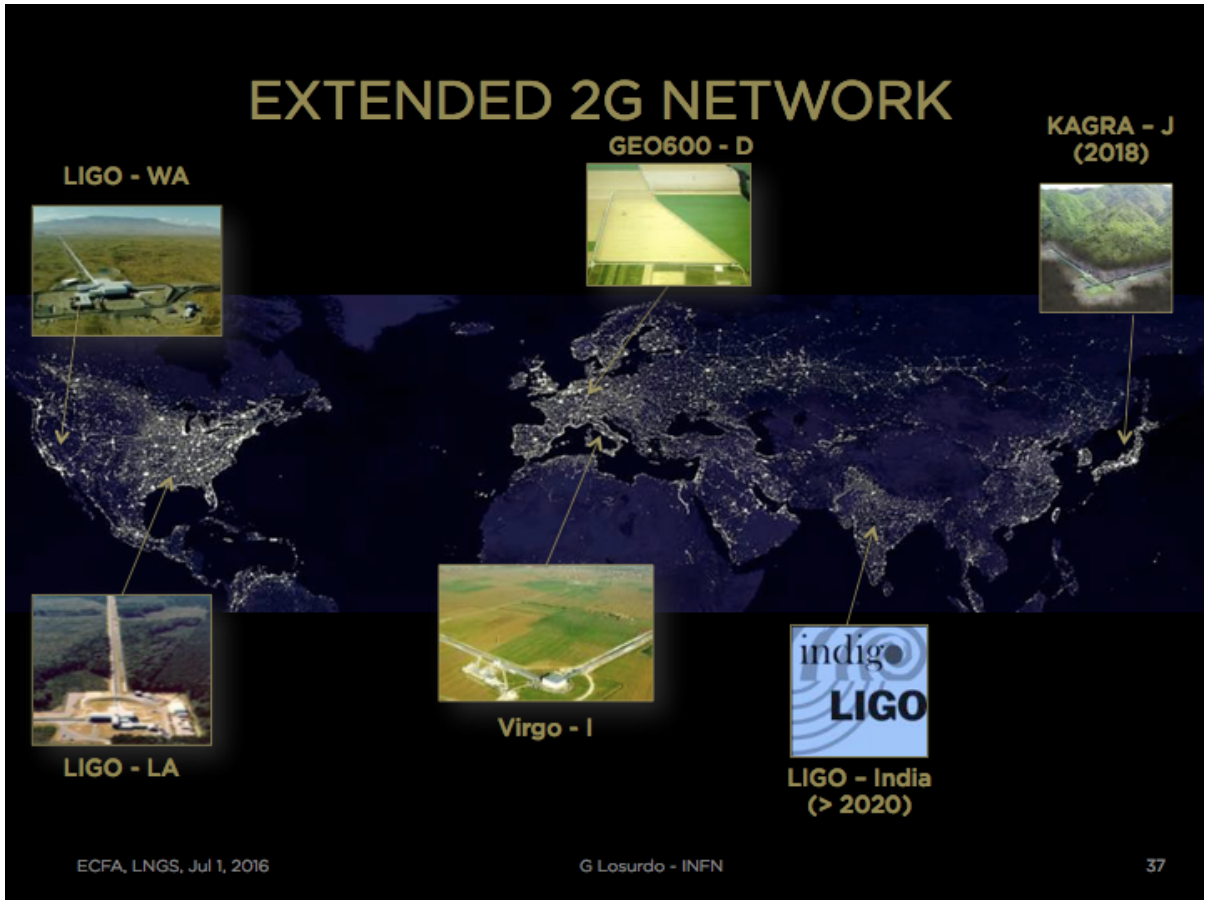


Electron ion collider in the US



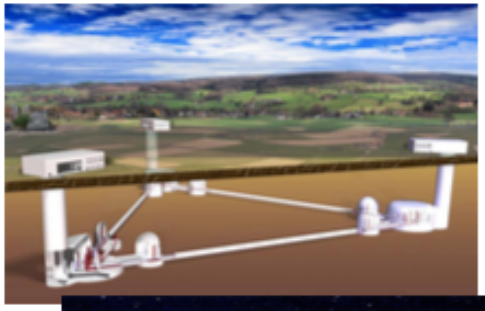
Gravitational waves - G. Losurdo, C. van den Broeck

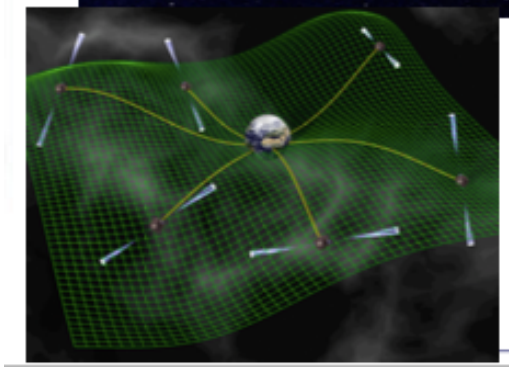




Gravitational waves

The next few decades





- Einstein Telescope (~2030?)
  - 3rd generation observatory
  - 10^5 binary mergers per year
  - Evolution of the Universe (e.g. dark energy)
  - Conceptual design study concluded in 2011
- eLISA (approved for 2034)
  - 3 probes in orbiting the Sun, 10^6 km distance
  - Probe low frequencies: 10^{-5} – 10^{-1} Hz
  - Mergers of supermassive binary black holes throughout the Universe; study their growth
  - "Pathfinder" mission 2015: huge success!
- Pulsar timing arrays (in progress)
  - Correlate variations in pulse arrival times between widely spaced pulsars to see effect of GWs
  - Ultra-low frequencies: 10^{-9} – 10^{-6} Hz
  - Supermassive binaries long before they merge

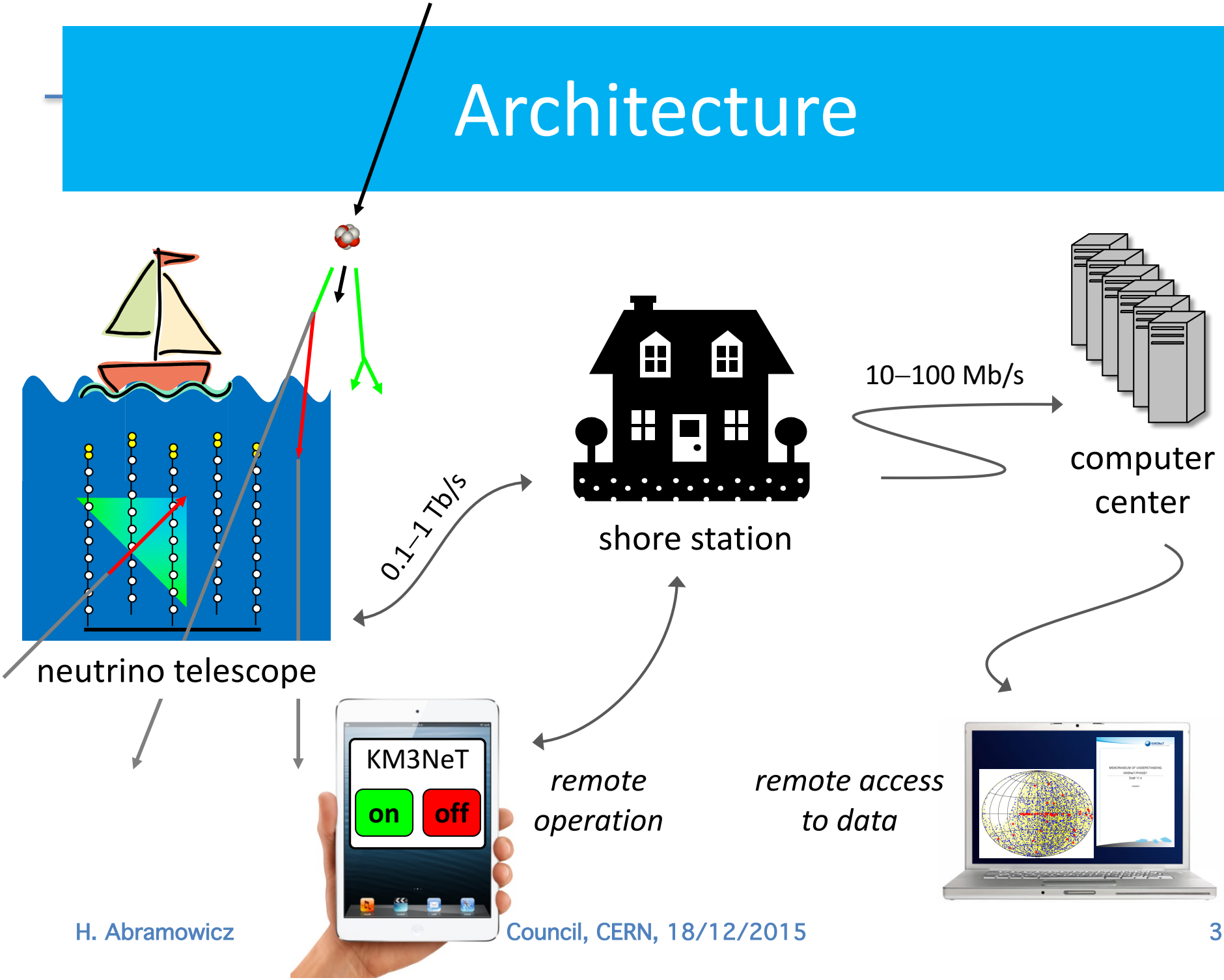
Together provide wide range of frequencies to search for primordial gravitational waves!

KM3Net neutrino telescope – Maarten de Jong

- KM3NeT is a new Research Infrastructure
  - network of cabled observatories
  - located in deep waters of Mediterranean Sea
  - hosting multi-km^3 Neutrino Telescope

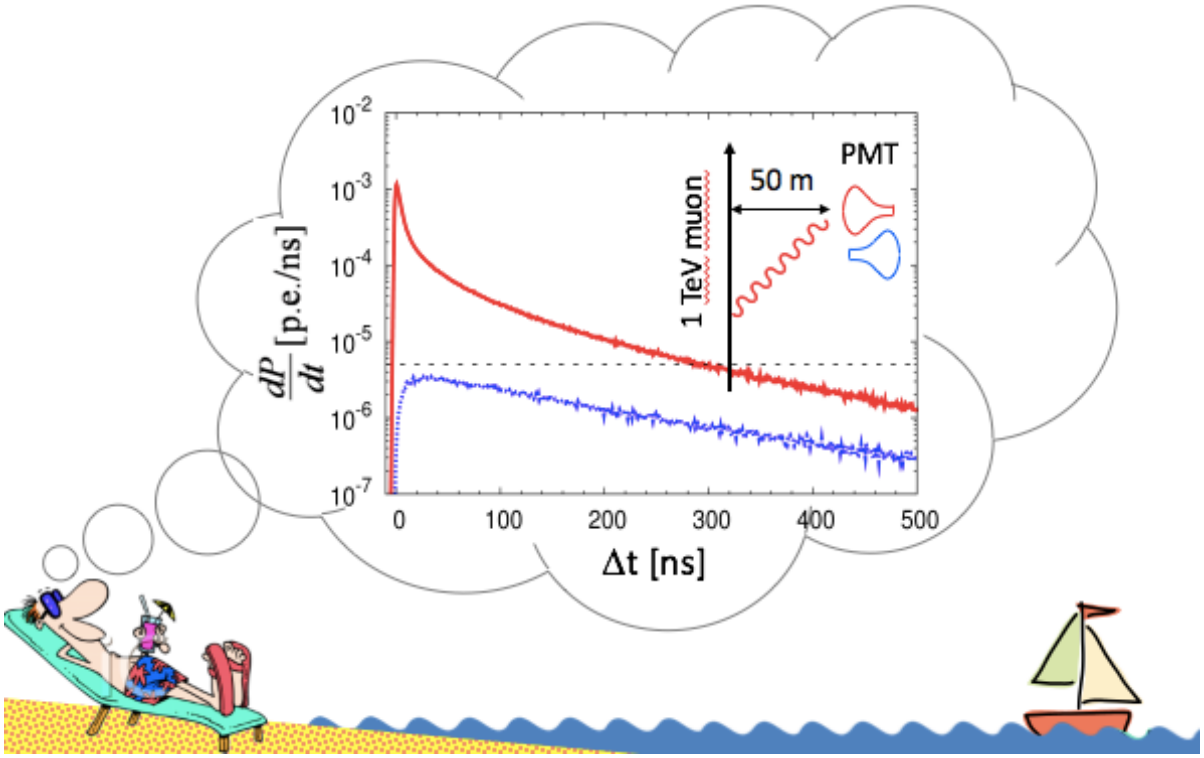
1. Discovery and subsequent observation of high-energy neutrino sources in Universe
2. Measurement of neutrino mass hierarchy
3. Synergy with Earth & Sea sciences

Architecture



KM3Net neutrino telescope

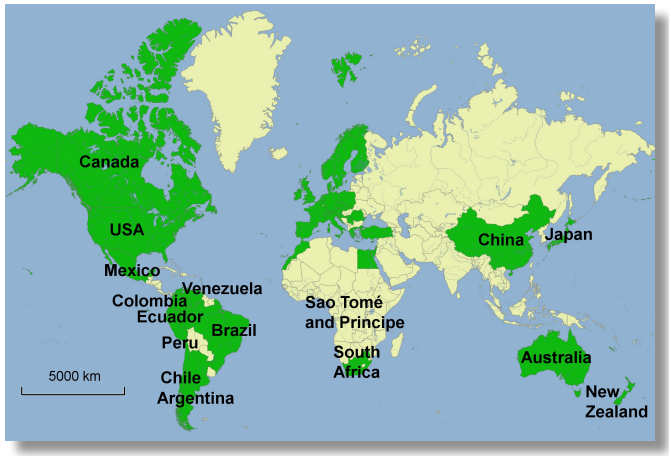
Optical module kit



International Particle Physics Outreach Group

IPPOG report

International Masterclasses, the flagship activity of IPPOG trained over **13'000 students and 1'000 teachers in Spring every year !**
Over 200 institutions in over 46 countries participating.



CERN Courier June 2014

Education

High-school students from all geographical regions master real event-display programmes, software tools and analysis methods. Having been introduced to the problem, they identify electrons, muons, photons and jets by exploiting their characteristic signals in various detector elements, perform event selection and categorization, and achieve the final analysis goals. (Image credits, left to right: Caroline Hamilton/CoEPP/University of Melbourne, Jayne Ion/iON creative, Franziska Viebach/TU Dresden.)

International Masterclasses in the LHC era

Each year in spring, the International Particle Physics Outreach Group organizes the International Masterclasses, which give students the opportunity to analyse data from the LHC.

The International Masterclasses (IMCs) began in 2005 as an ini-

ATLAS "discovery" data are available for students to search for a Higgs boson; CMS approved 13 Higgs candidates in the mass region of interest, which are mixed with a more abundant sample of W and Z events, for "treasure hunt" activities; ALICE data allow students to study the relative production of strange particles, which could be a tell-tale signal of quark–gluon plasma production; LHCb teaches students how to measure the lifetime of the D meson; and particles containing b and c quarks are studied extensively to shed light on the mystery of antimatter in the universe.

Students quickly master real event-display programmes – such

CERN Courier June 2015

Faces & Places

IPPOG

Reaching out with particle physics

IPPOG's participants in Paris. (Image credit: Dominique Longieras/ LAL-Orsay.)

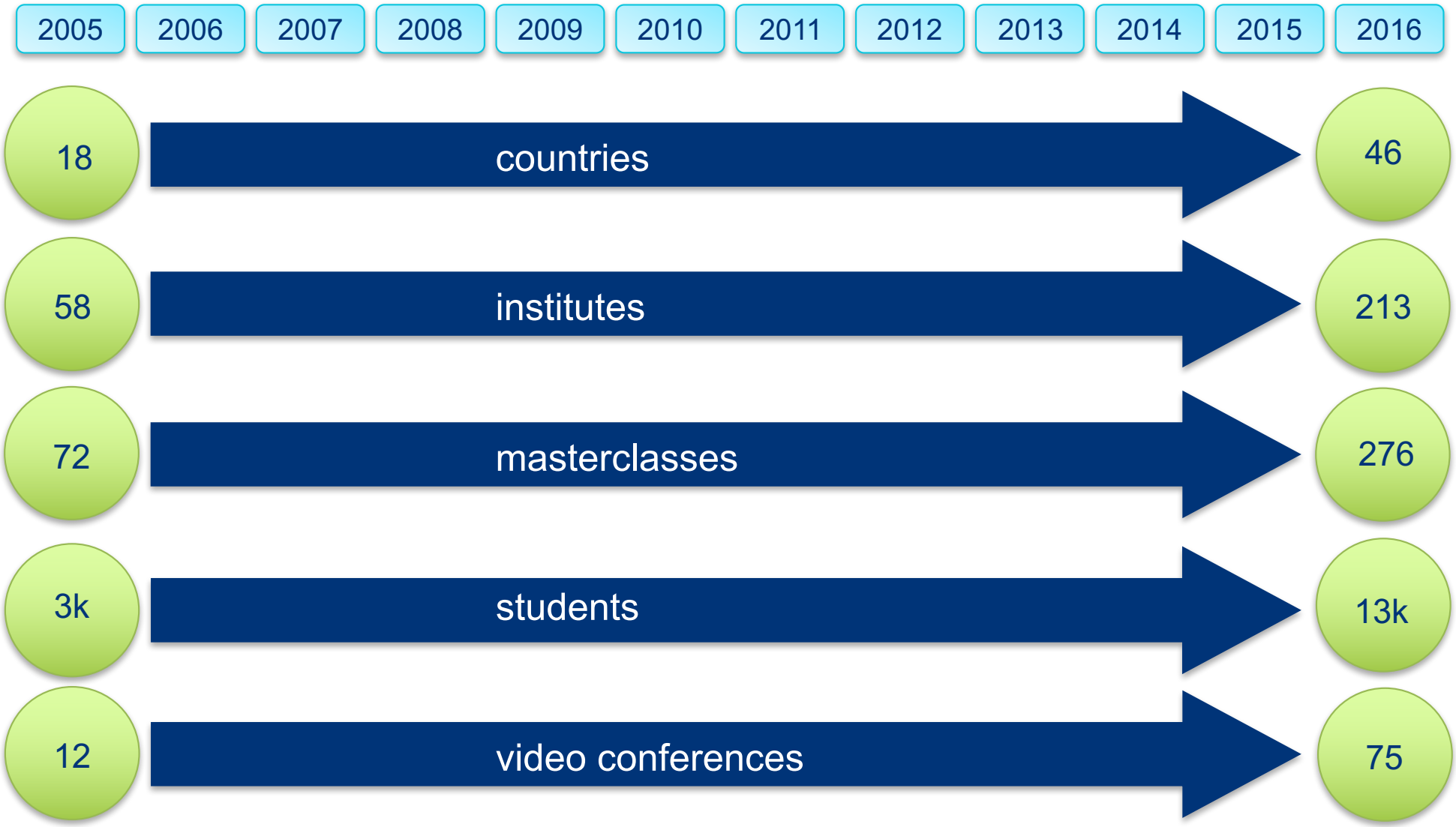
How do we communicate about the LHC as a discovery machine, following the Higgs boson of 2012? How do we take the particle-physics masterclasses to new countries, age groups and settings? What makes a good educational game? How do we join in the existing national cosmic-ray-detector programmes, to take them further? These were some of the questions addressed at the 9th meeting of the International Particle Physics Outreach Group (IPPOG), which took place in Paris on 16–18 April.

common project or for an activity going on in only one country. Between the meetings, work continues and ideas are tested: do they work, for example, with real students and teachers? Other topics on the agenda of the recent meeting included discussions on how to boost the educational use of CERN open-access data, and how to bring science education and outreach to particle-physics conferences in a more effective way. There was also news on web resources, exhibits and programmes for teachers and students in the

the communication between researchers, teachers and participants goes on across a longer timescale, may become particularly important. At the other end of the spectrum are the "masterclasses in a box", which are based on printed images and foreseen for settings where no computers are available.

There were also presentations on activities such as the most recent edition of the International Cosmic Day and the International Muon Week. These are crucial when the goal is to have more modern and

Evolution of Masterclass participation



ECFA Detector R&D Panel

New mandate expanded beyond LC activities

New structure

ECFA/16/298, http://cds.cern.ch/record/2211641

- Panel will have an advisory role with 4 to 5 experts
- Panel will set up review committees on demand
- Panel will constitute a contact point for new activities/groups

Detector R&D Panel

Astroparticle	- Els Koffemann (NL)
Calorimetry	- Laurent Serin (FR)
Gaseous Detectors	- Silvia Dalla Torre (IT)
Silicon	- Phil Allport (UK)
Electronics/DAQ	- Arno Straessner (DE)
General	- Lucie Linssen (CERN)

Ex-officio - Ariella Cattai (ICFA, CERN)

Chair to be selected by the panel

- Endorsed by PECFA and by ApPEC

ECFA Meetings 2017

Plenary ECFA

- Venice, 5-12 July 2017, Special ECFA/EPS HEPP Session
- CERN, 16-17 November 2017, 101th PECFA meeting

Restricted ECFA – country visits

- Bulgaria, Sofia, 24-25 March 2017 (?)
- Belgium, Brussels, 21-22 April 2017
- Finland, Helsinki, 19-20 May 2017
- Cyprus/Turkey – Fall 2017 under discussion

Joint ECFA-EPS Session in Venice

PARTICLE PHYSICS AND SOCIETY
EXTENDING OUR VISION AND REACH

Expression of gratitude to the Council Support Team for all their help

Happy and Peaceful Holidays