

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

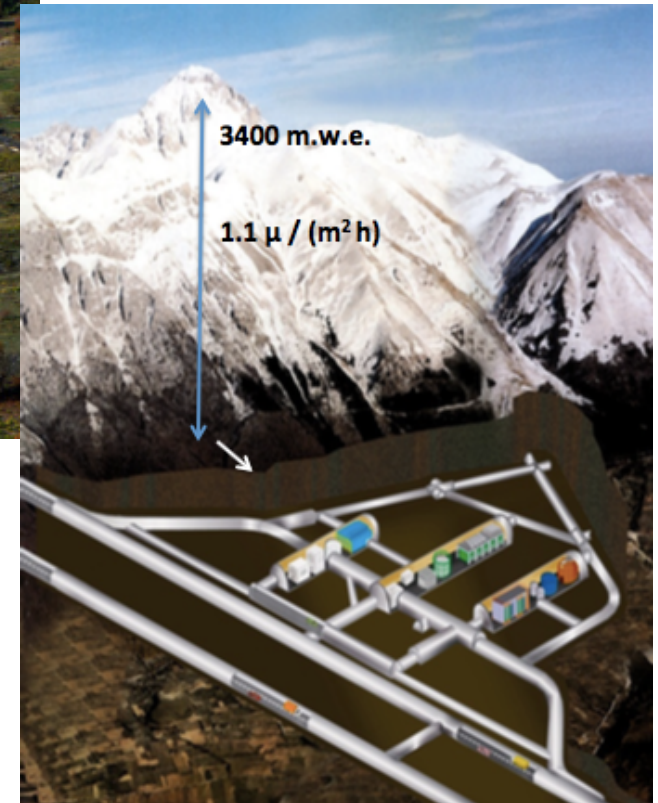


Overview

- 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

ECFA European Committee for Future Accelerators

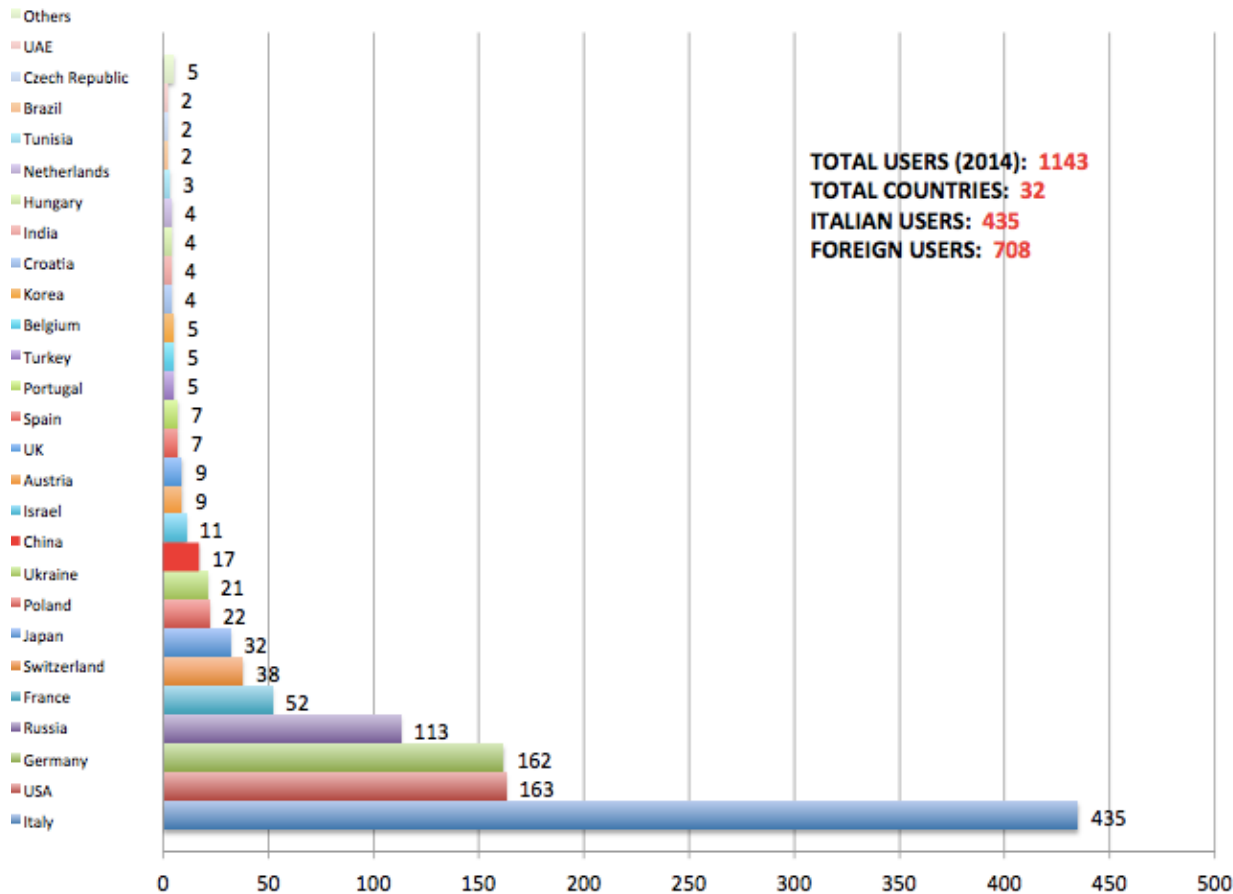
Gran Sasso - from Stefano Ragazzi



- 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 USERS



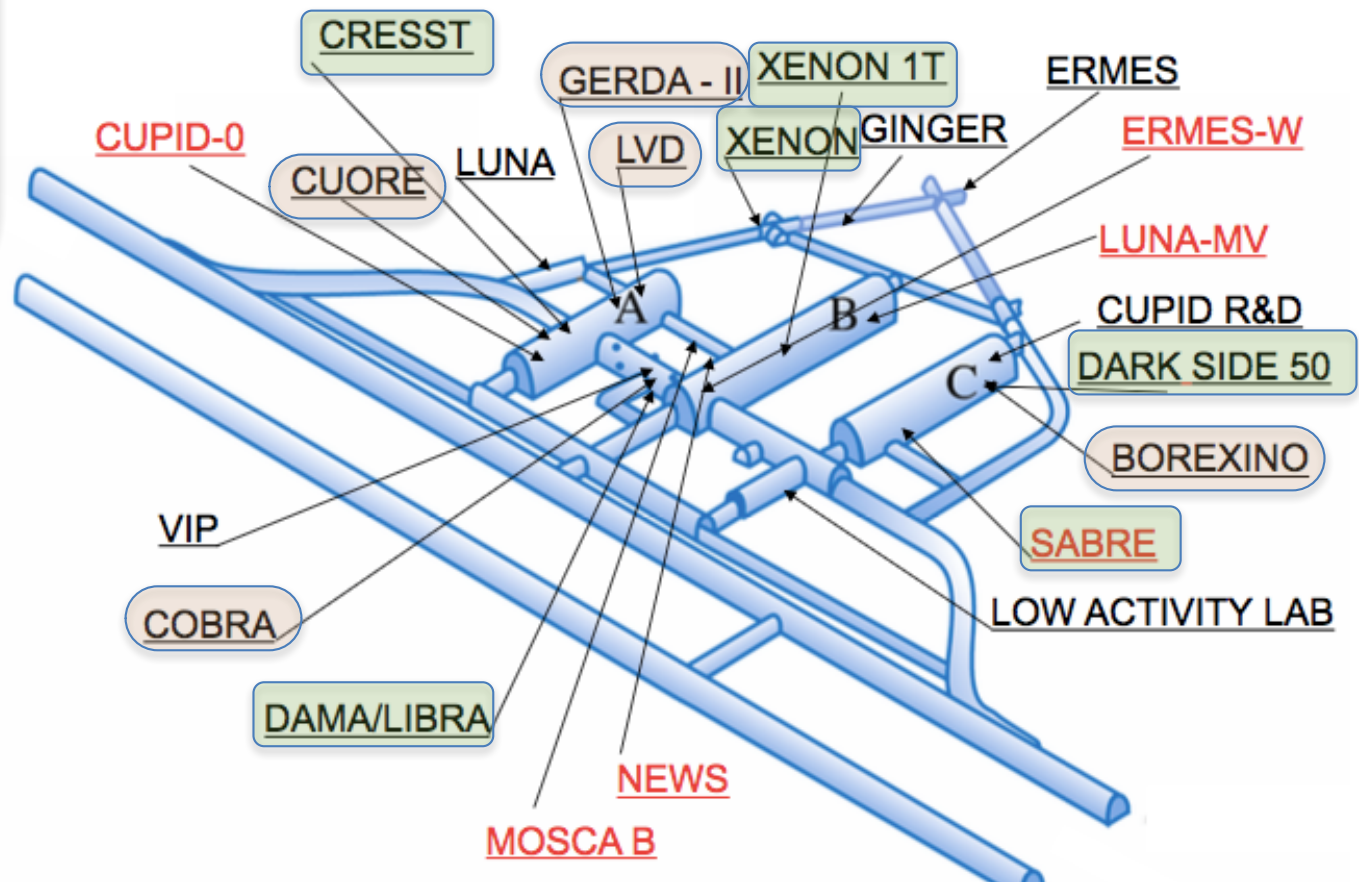
LNGS Activities

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

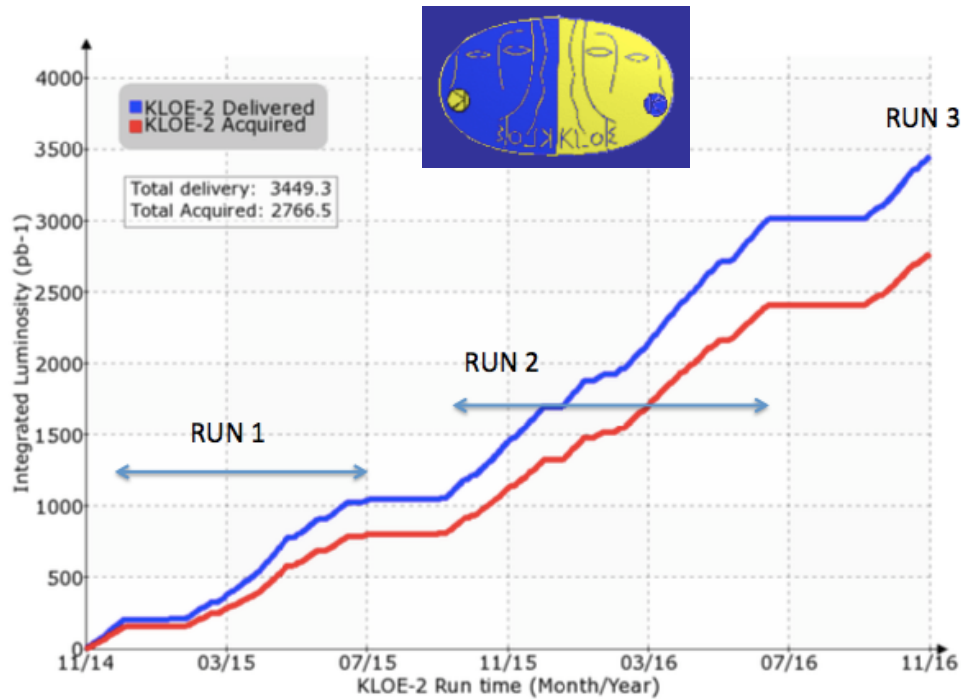
- SN neutrino:
 - LVD 1 kton liquid scint. Waiting for SN since 1992
- Solar Neutrino:
 - Borexino: real-time measurement of pp neutrino, ..., Geo-neutrinos
- Double Beta Decay
 - Gerda / Gerda-II: ^{76}Ge
 - CUORE – *the coldest m³ in the world* : ^{130}Te
 - Cobra: ^{116}Cd
 - LUCIFER: R&D phase on 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



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

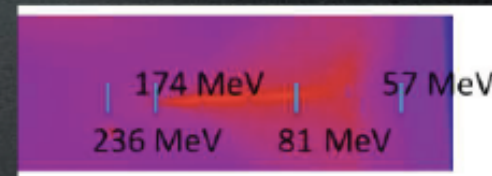
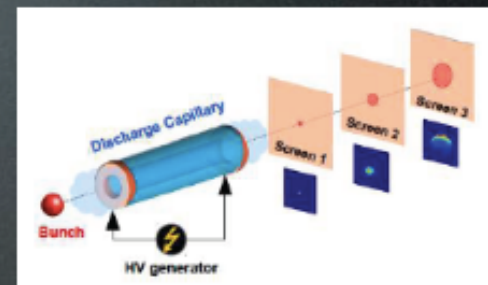
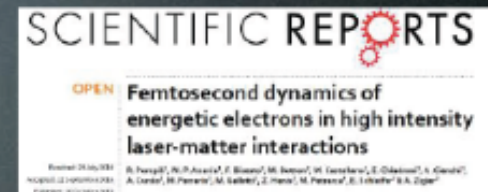
Highlights

- TNSA: results published by Nature Scientific Reports

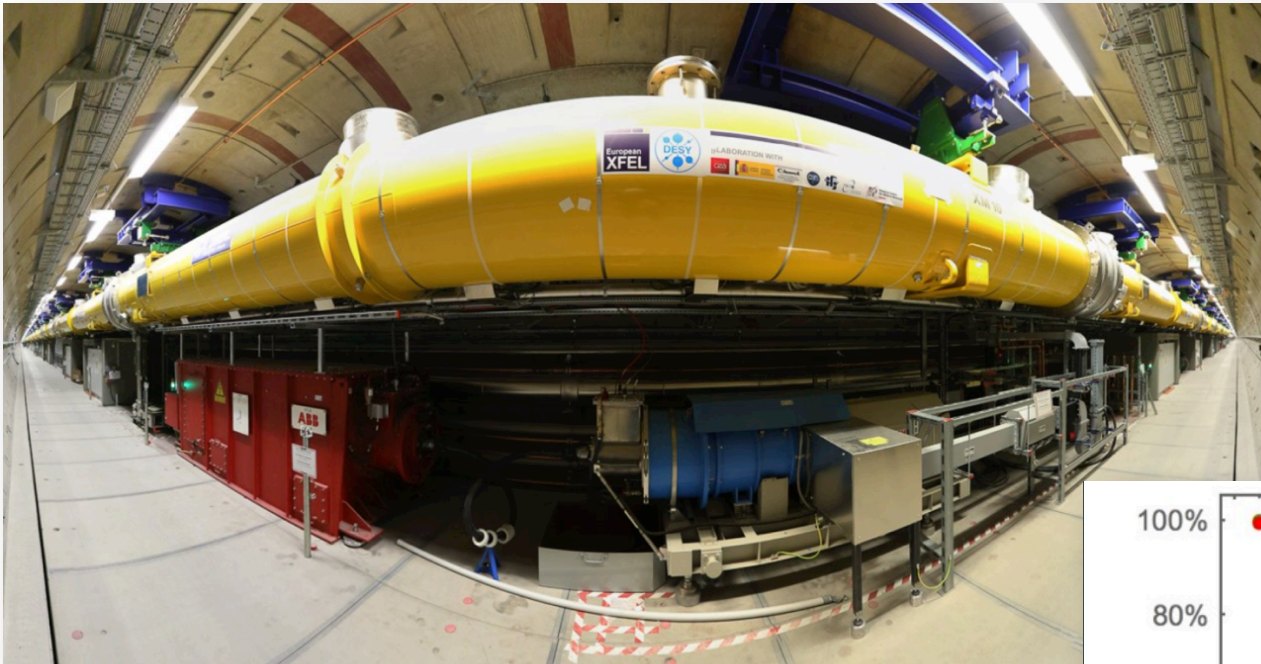
- PWFA: active plasma lens results submitted to PRL

- 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



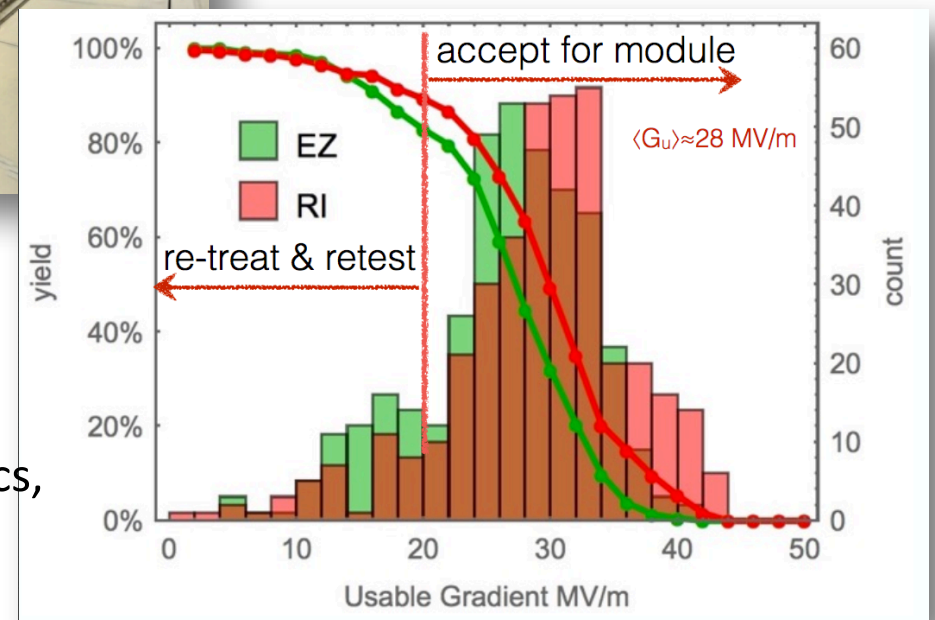
Report from DESY - J. Mnich



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!



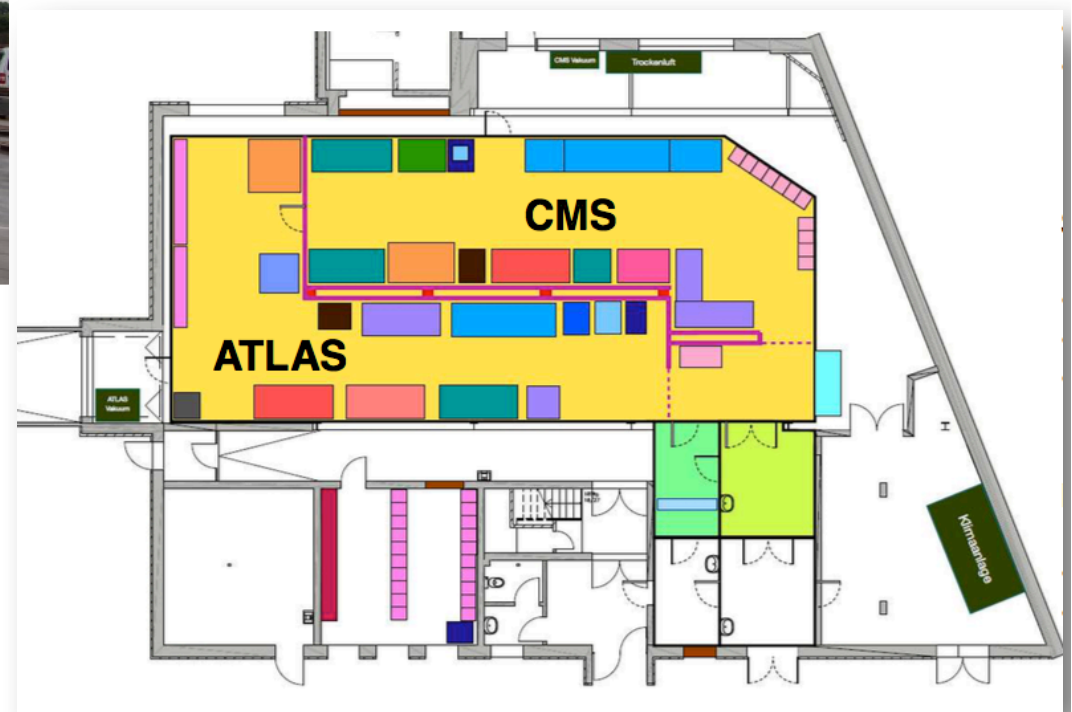
Report from DESY



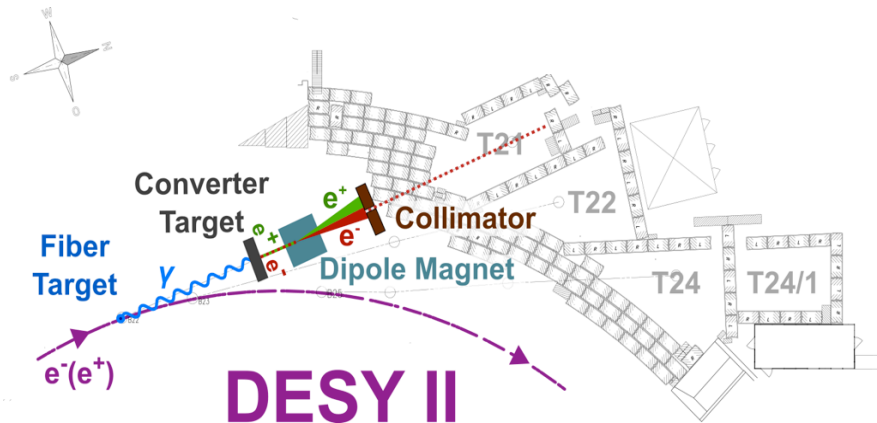
Headquarter - XHQ

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



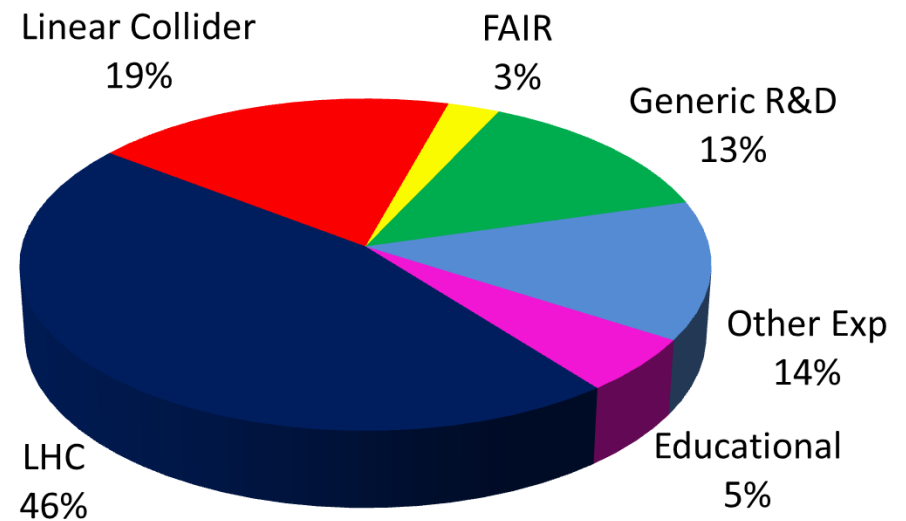
Unique infrastructures at DESY

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

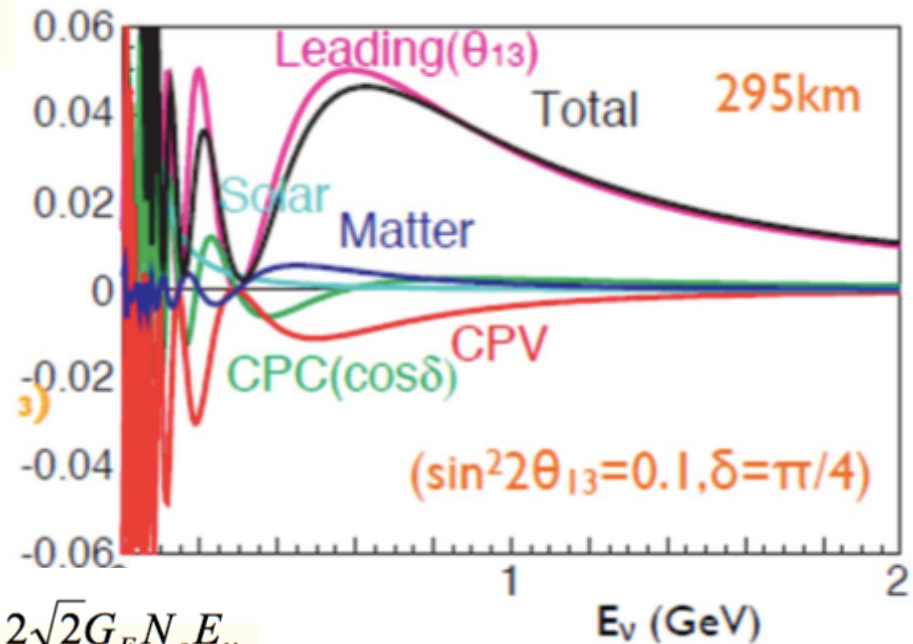
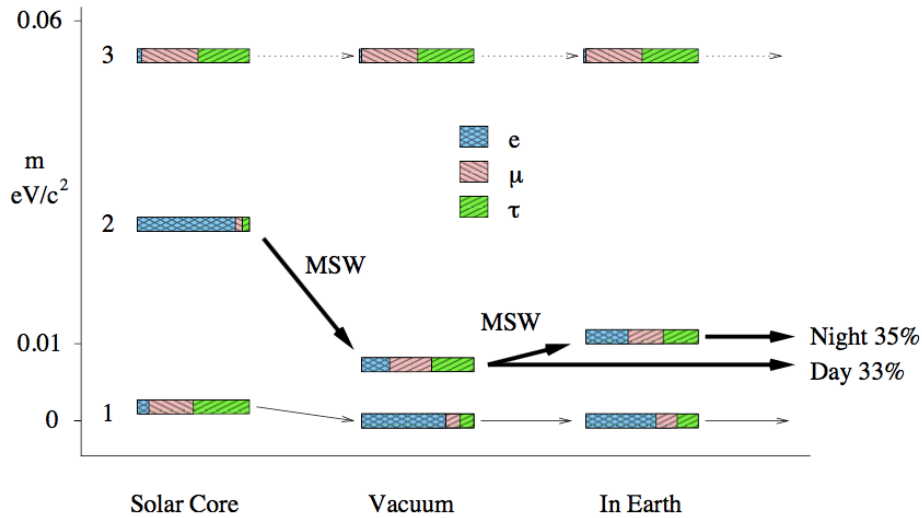
2016: 243 Users from 20 countries

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



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

$$\begin{aligned}
 p(\nu_\mu \rightarrow \nu_e) &= 4c_{13}^2 s_{13}^2 s_{23}^2 \sin^2 \frac{\Delta m_{13}^2 L}{4E} \times \left[1 \pm \frac{2a}{\Delta m_{13}^2} (1 - 2s_{13}^2) \right] && \theta_{13} \text{ driven} \\
 &+ 8c_{13}^2 s_{12} s_{13} s_{23} (c_{12} c_{23} \cos\delta - s_{12} s_{13} s_{23}) \cos \frac{\Delta m_{23}^2 L}{4E} \sin \frac{\Delta m_{13}^2 L}{4E} \sin \frac{\Delta m_{12}^2 L}{4E} && \text{CP even} \\
 &\mp 8c_{13}^2 c_{12} c_{23} s_{12} s_{13} s_{23} \sin\delta \sin \frac{\Delta m_{23}^2 L}{4E} \sin \frac{\Delta m_{13}^2 L}{4E} \sin \frac{\Delta m_{12}^2 L}{4E} && \text{CP odd} \\
 &+ 4s_{12}^2 c_{13}^2 \{c_{13}^2 c_{23}^2 + s_{12}^2 s_{23}^2 s_{13}^2 - 2c_{12} c_{23} s_{12} s_{23} s_{13} \cos\delta\} \sin \frac{\Delta m_{12}^2 L}{4E} && \text{solar driven} \\
 &\mp 8c_{12}^2 s_{13}^2 s_{23}^2 \cos \frac{\Delta m_{23}^2 L}{4E} \sin \frac{\Delta m_{13}^2 L}{4E} \frac{aL}{4E} (1 - 2s_{13}^2) && \text{matter effect (CP odd)}
 \end{aligned}$$

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

Neutrino Physics

Future Long Baseline Projects in the World:

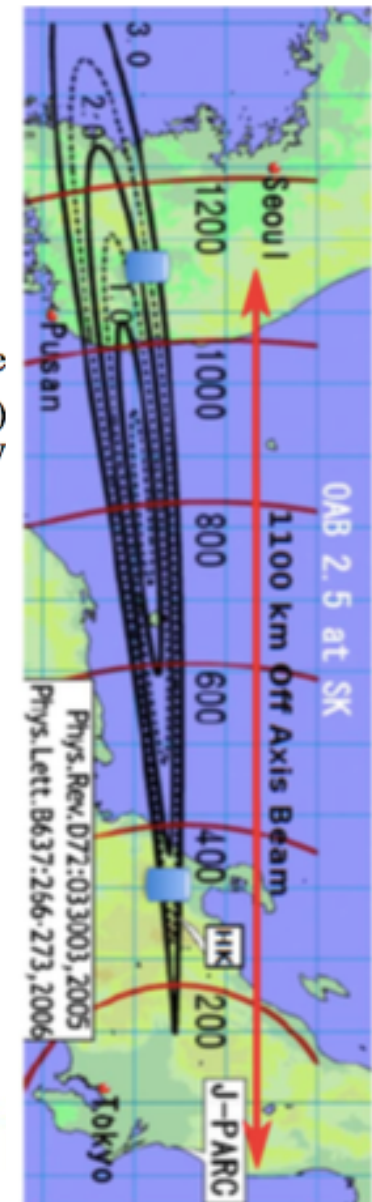
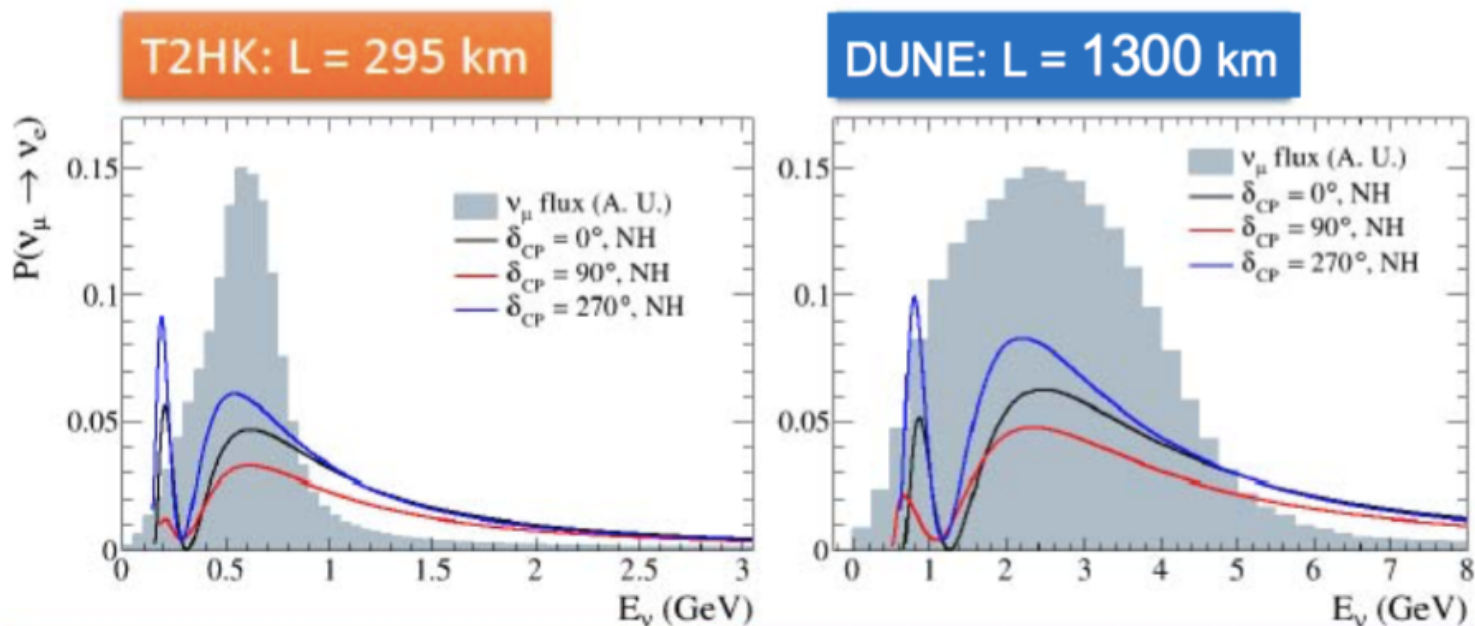
US : DUNE/LBNF

Liquid Argon TPC 4x10 kton
 at SURF (Homestake Mine) ~2400mwe
 On axis Beam from Fermilab (1.2-2.4MW)
 baseline=1300 km $\langle E \rangle \sim 3$ GeV

Japan : Hyper-K

Water Cherenkov 520 kton
 At Tochibora near Kamioka, ~ 1750 mwe
 Off axis Beam from JPARC (1.3MW)
 baseline=295 km $\langle E \rangle \sim 0.7$ 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

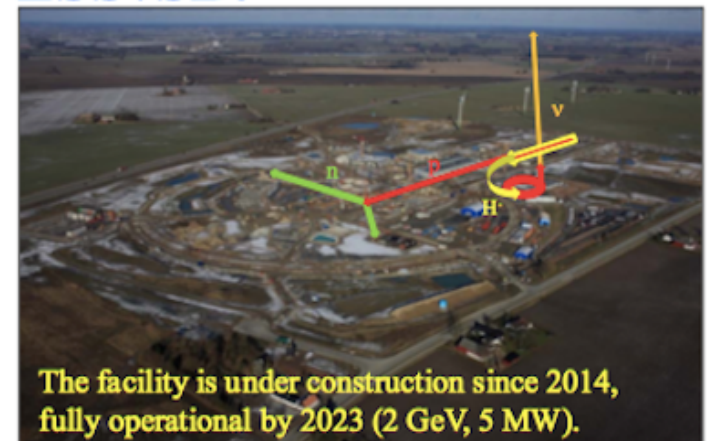
From 2021 to 2026

- 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

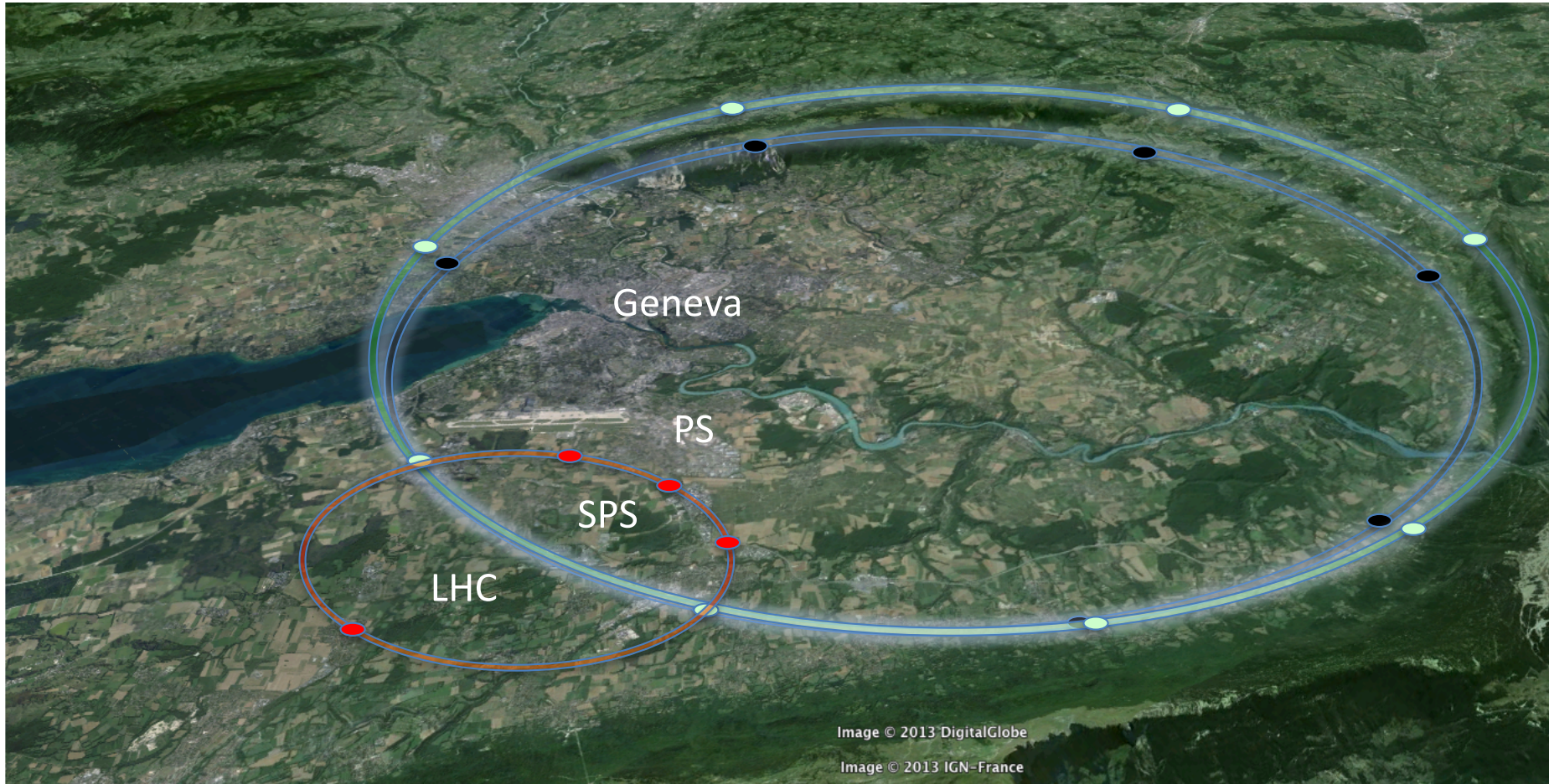
- DUNE and Hyper-K:
 - Discover at 5σ and measure δ_{CP} with a precision better than 10° ,
 - Determine Mass Hierarchy,
 - Measure with high precision θ_{23} and θ_{13}
 - Proton decay searches
 - Atmospheric, solar and supernovae neutrino observation
- Beyond DUNE and Hyper-K:

ESSvSB:



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



LHC

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

#5Abramowicz

HE-LHC

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

Council, CERN, 18/12/2015

FCC-hh

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

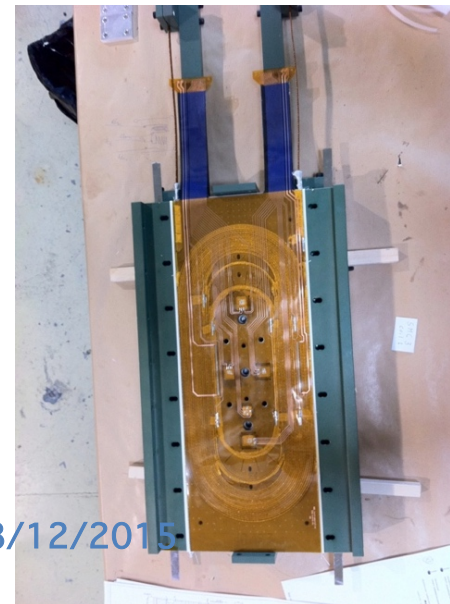
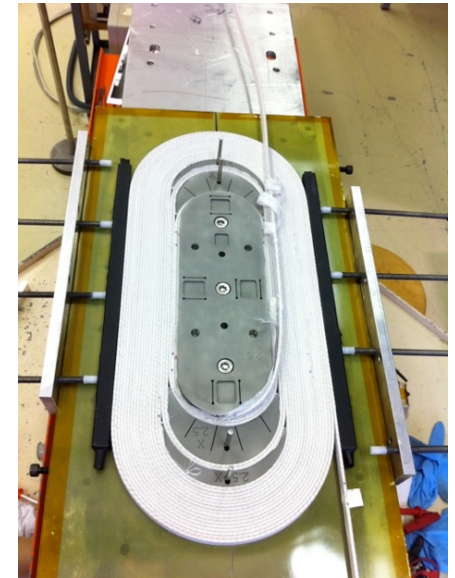
FCC-hh

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

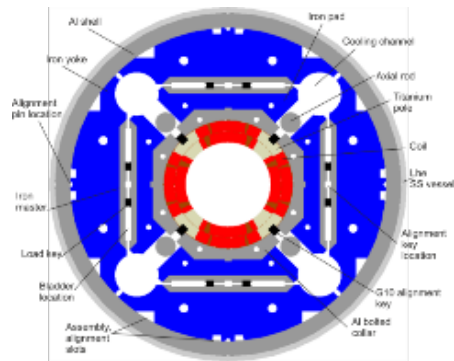
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Using Nb₃Sn conductor in magnets

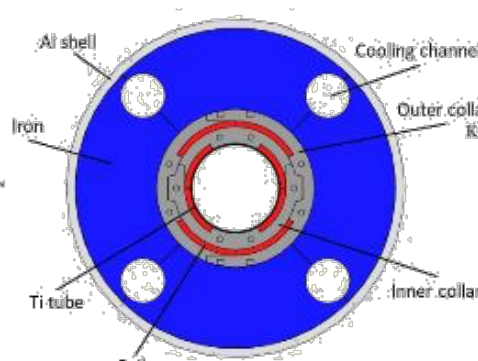
- Nb₃Sn has to be reacted after winding for ~100 hours at 650°C (wind and react)
- Cables have to be insulated with a non-organic woven insulation: glass or ceramic fibres
- After reaction the coils has to be impregnated to prevent any movements and to take care that stresses are distributed, instrumentation connections are moulded in
- Reacted Nb₃Sn is brittle and stress sensitive



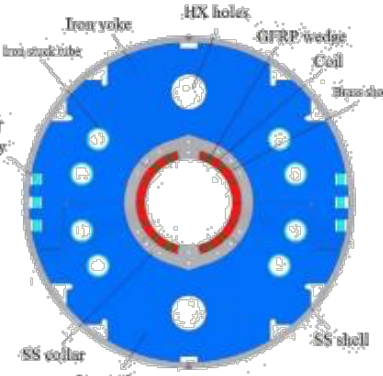
HILUMI IT magnet zoo



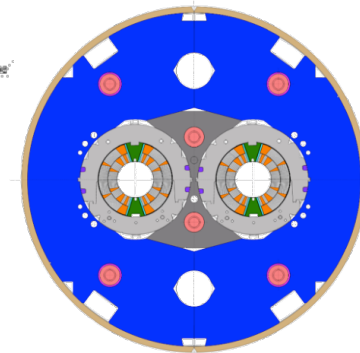
Triplet QXF (LARP and CERN)



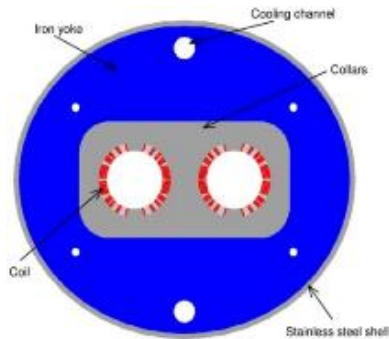
Orbit corrector (CIEMAT)



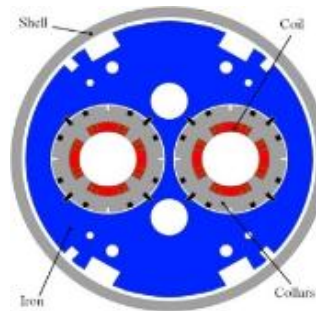
Separation dipole D1 (KEK)



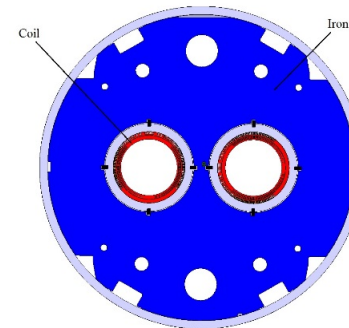
11 T dipole (CERN)



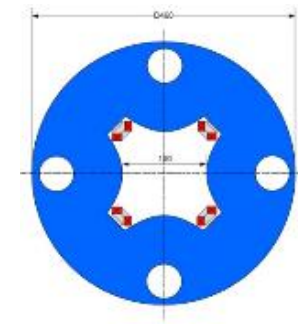
Recombination dipole D2 (INFN)



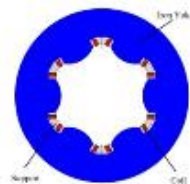
Q4 (CEA)



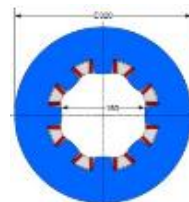
D2/Q4 orbit corrector (CERN)



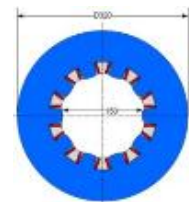
Skew quadrupole (INFN)



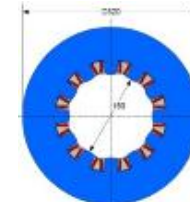
Sextupole (INFN)



Octupole (INFN)



Decapole (INFN)



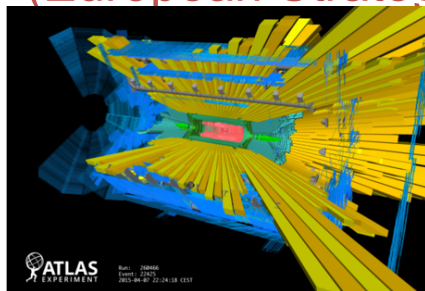
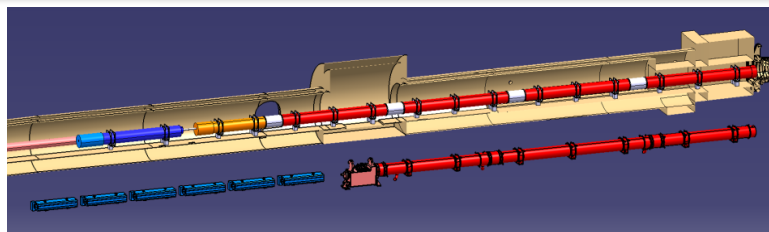
Dodecapole (INFN)

Council, CERN, 18/12/2015

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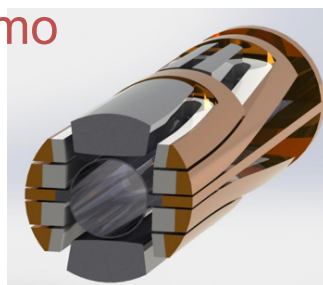
Conclusions

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



Accelerator-grade HTS 5 T demo

HL-LHC demonstrates large-scale use of Nb₃Sn



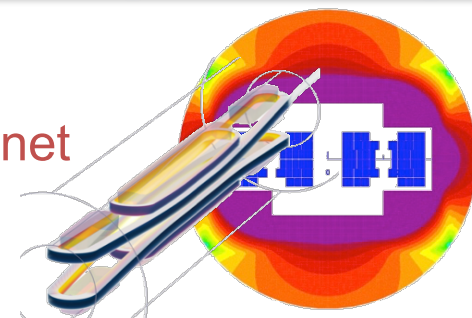
End of LHC useful life



12 T accelerator technology

16 T magnet model(s)

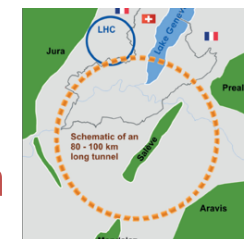
20 T magnet model(s)



16 T accelerator technology

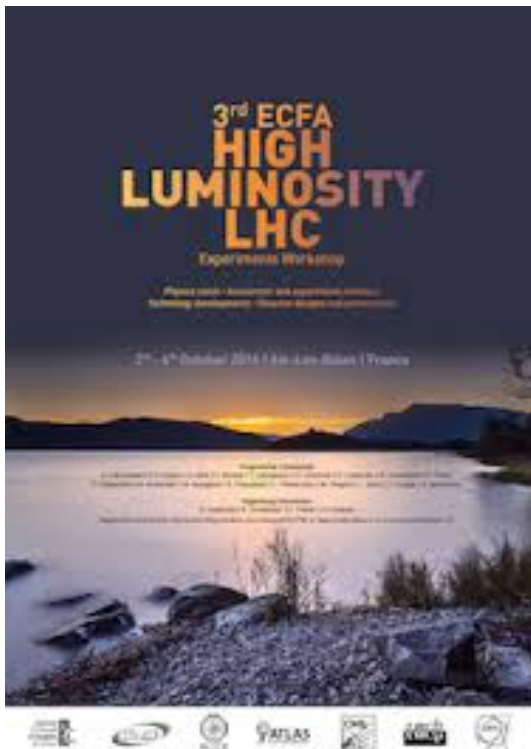
FCC CDR (EuroCirCol) propose a new energy frontier accelerator

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 $\frac{3}{4}$ detectors, $\frac{1}{8}$ accelerator, and $\frac{1}{8}$ 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/>

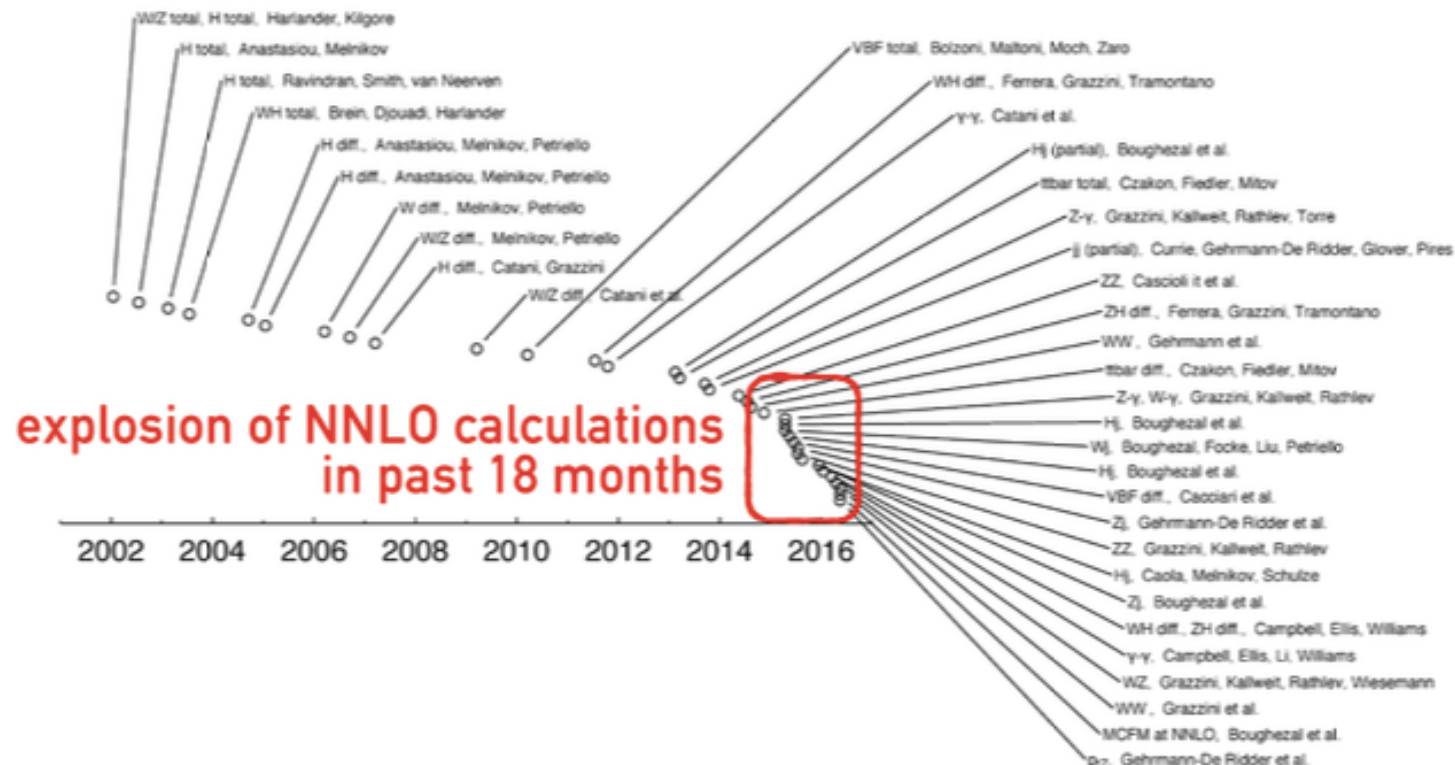
High luminosity LHC workshop

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) !

NNLO hadron-collider calculations v. time

as of mid Jun

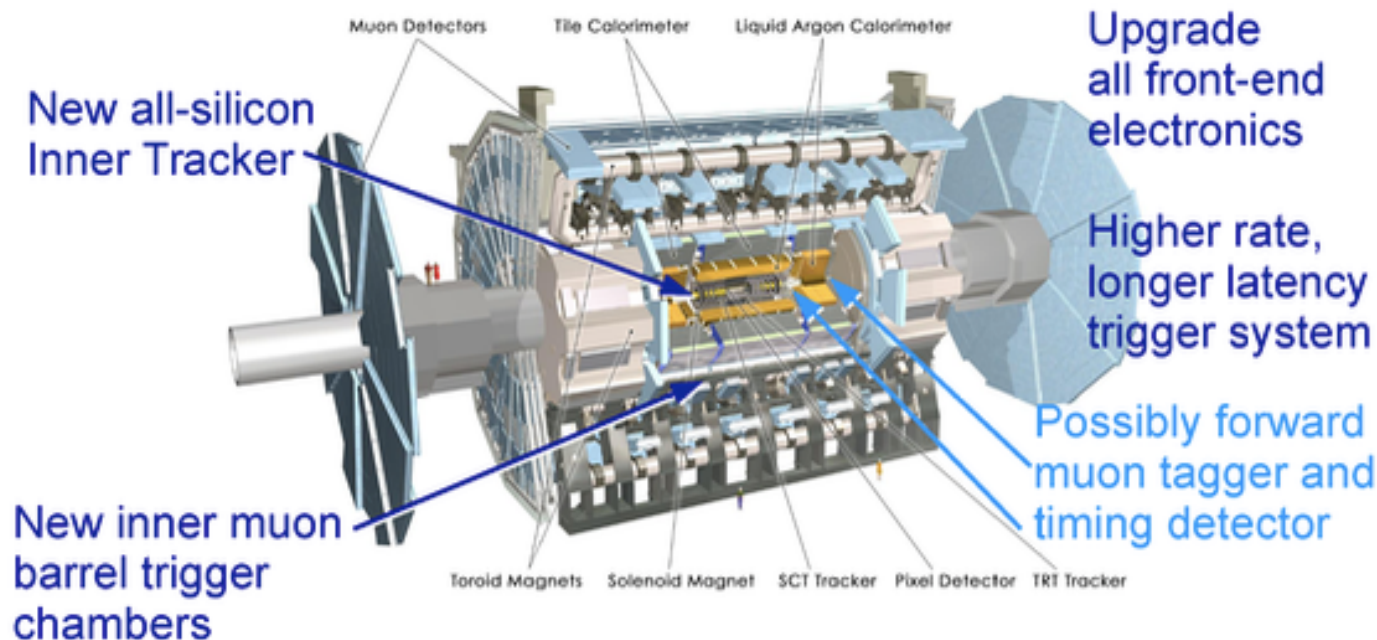


Upgrade Overviews: ATLAS

- 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

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.

Summary of CMS HL-LHC Upgrades

Trigger/HLT/DAQ

- Track information at L1-Trigger
- L1-Trigger: 12.5 μ s latency - output 750 kHz
- HLT output \approx 7.5 kHz

Barrel EM calorimeter

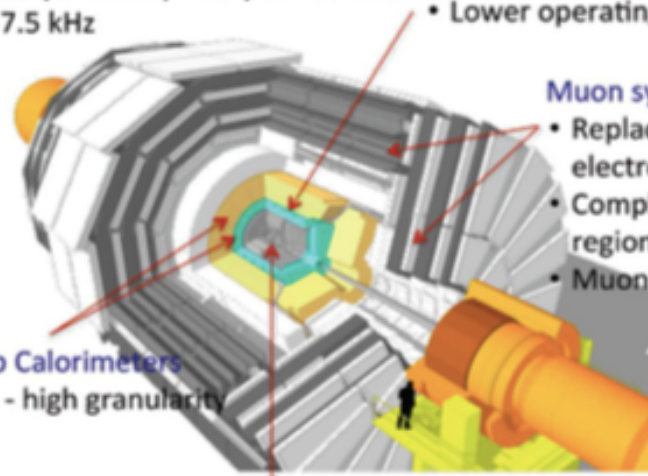
- Replace FE/BE electronics
- Lower operating temperature (8 $^{\circ}$)

Muon systems

- Replace DT & CSC FE/BE electronics
- Complete RPC coverage in region $1.5 < \eta < 2.4$
- Muon tagging $2.4 < \eta < 3$

Replace Endcap Calorimeters

- Rad. tolerant - high granularity
- 3D capability



Replace Tracker

- Rad. tolerant - high granularity - significantly less material
- 40 MHz selective readout ($P_t \geq 2$ GeV) in Outer Tracker for L1-Trigger
- Extend coverage to $\eta = 3.8$



10/3/2016

M. Narain, ECFA 2016

16



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

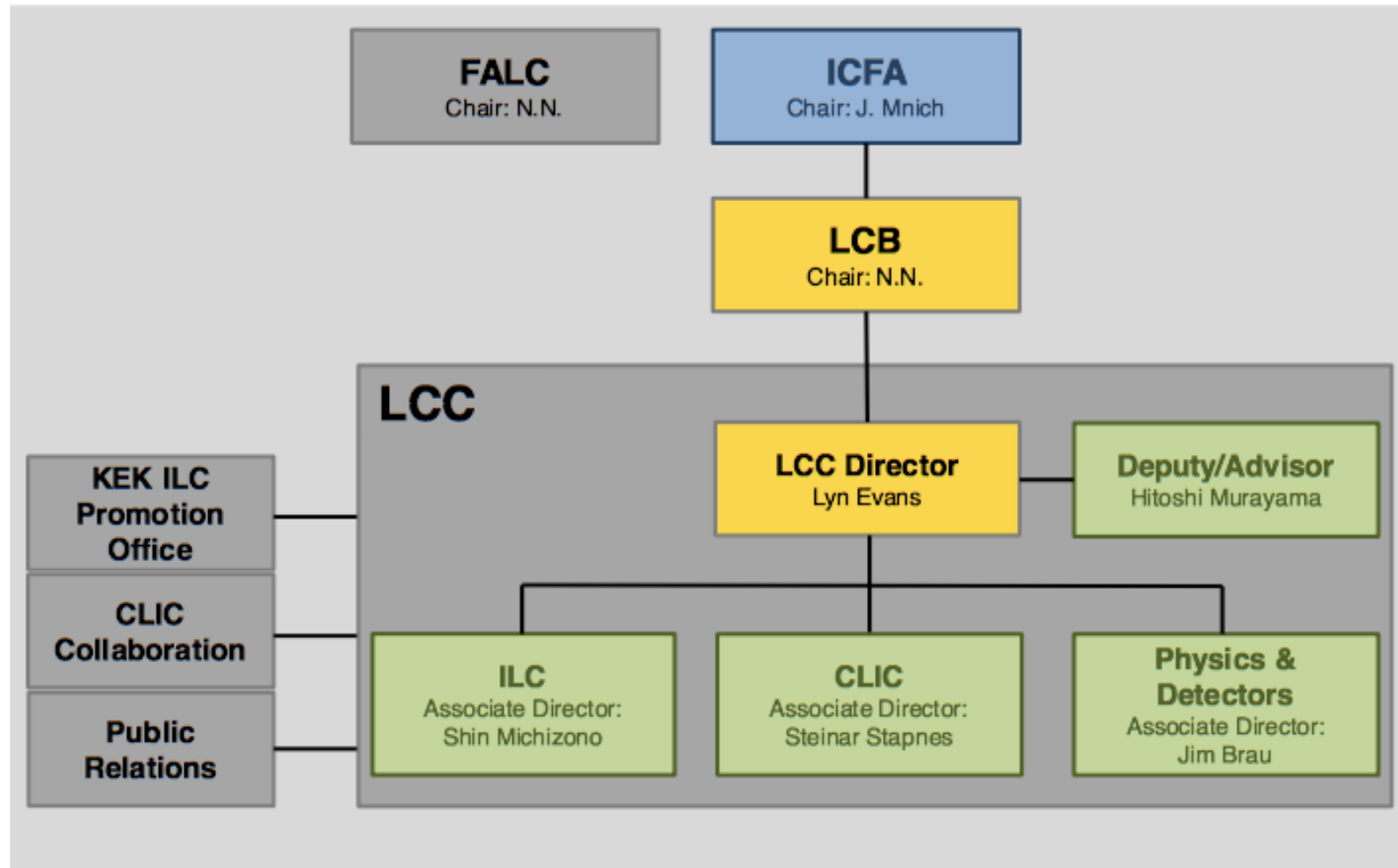
Linear Collider organization reviewed

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

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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>

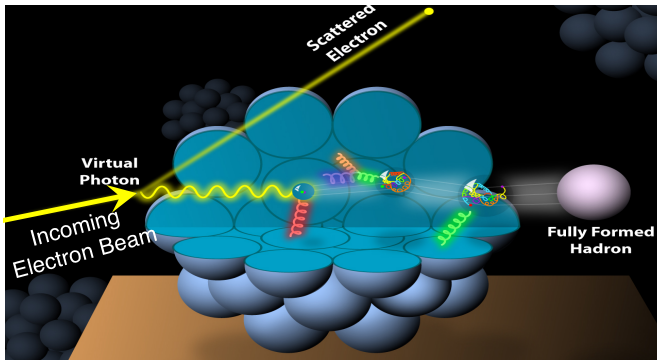


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LCWS2016 in Morioka - amazing social and media impact



Electron ion collider in the US - E. Aschenauer



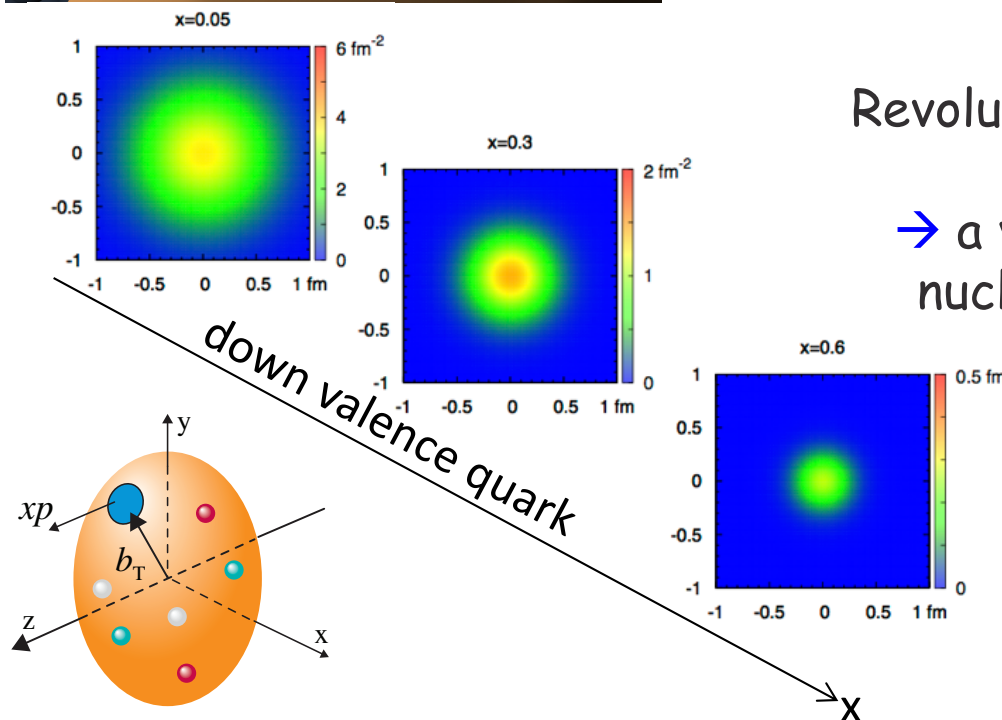
What is the EIC:

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



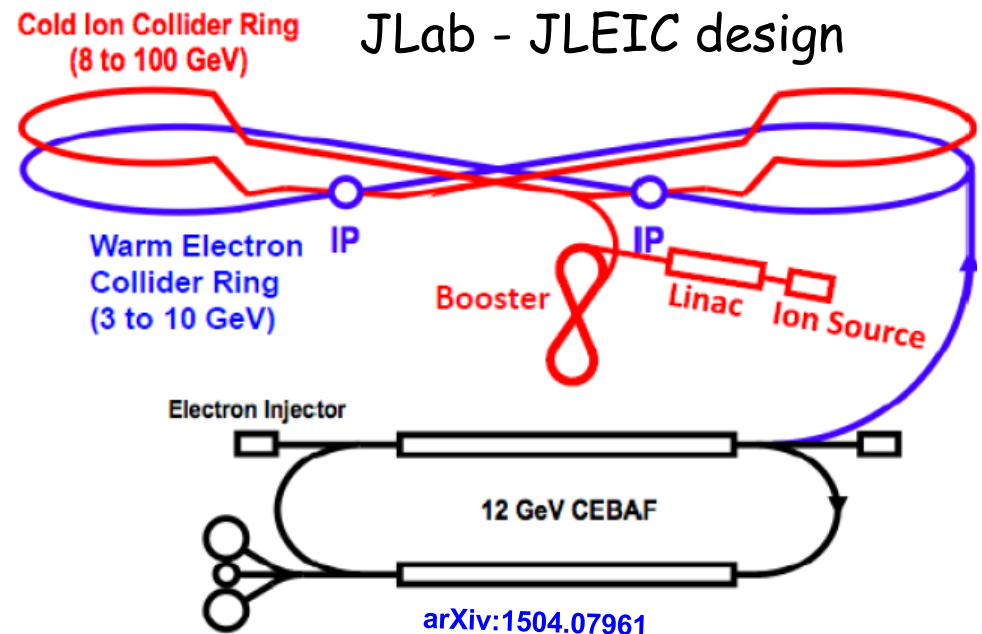
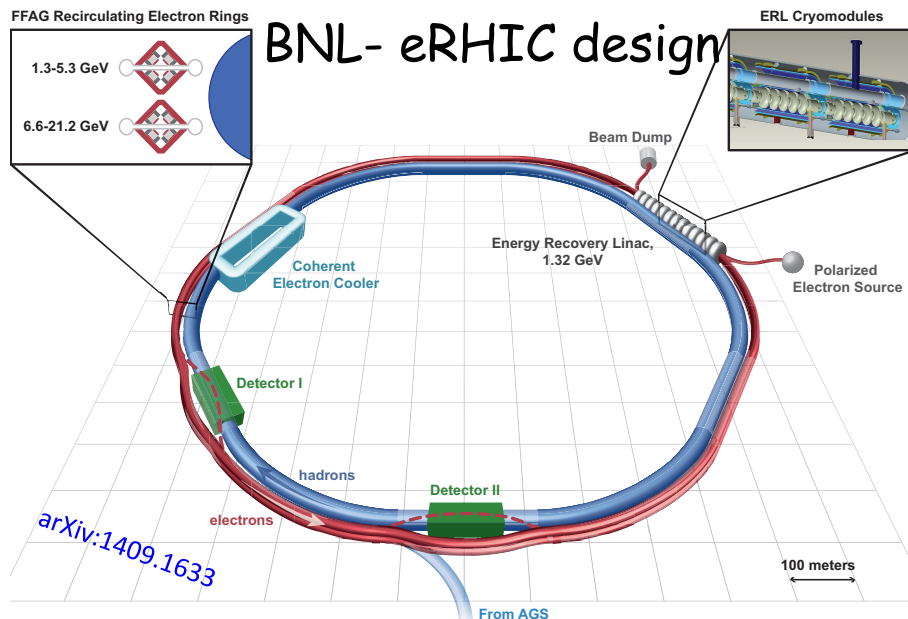
Potentially important input to HL-LHC

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 Uranium

COMPASS: factor 10 to 100 higher luminosity
 >2 decades increase in kinematic coverage in x and Q^2




Electron ion collider in the US



REACHING FOR THE HORIZON

The 2015
LONG RANGE PLAN
for NUCLEAR SCIENCE



EIC PROJECT STATUS

The EIC received in the 2015 Long Range Planning of the NSAC the following recommendation

"We recommend a high-energy high-luminosity polarized EIC as the highest priority for new facility construction following the completion of FRIB"

http://science.energy.gov/~media/np/nsac/pdf/2015LRP/2015_LRPNS_091815.pdf


FRIB - Facility for rare isotope beams

Next Steps:
A National Research Council (National Academy of Science (& Engineering & Arts) review of the project is expected to begin soon, and a report is expected in ~18 months. After the DOE will launch its Critical Decision (CD) process...

- ❑ CD0 soon after the NAS review.... (FY2018)
- ❑ **CD1: site selection**
- ❑ with a scenario of 1.6% growth in US nuclear science funding from now on
- ➔ **CD3 start of construction estimated in 2022/23**

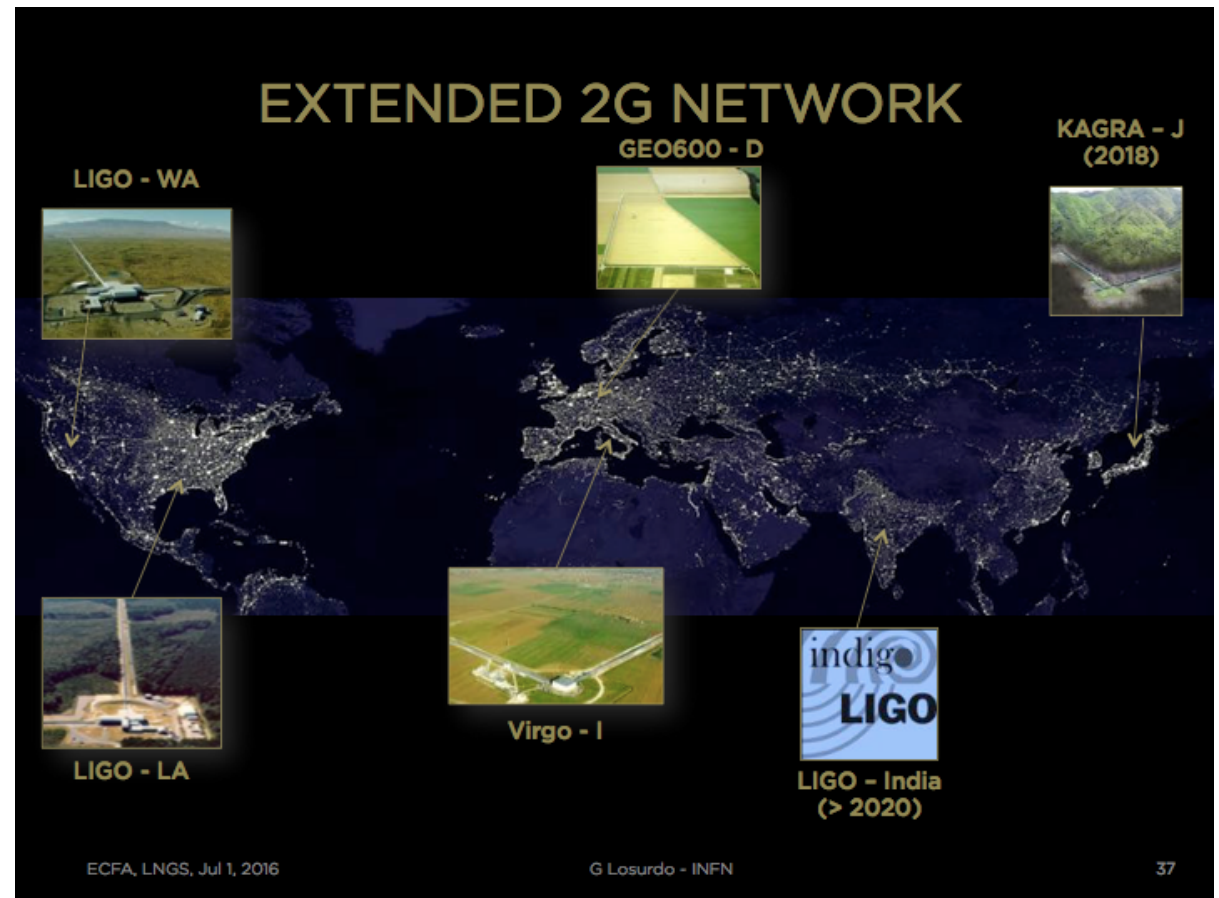
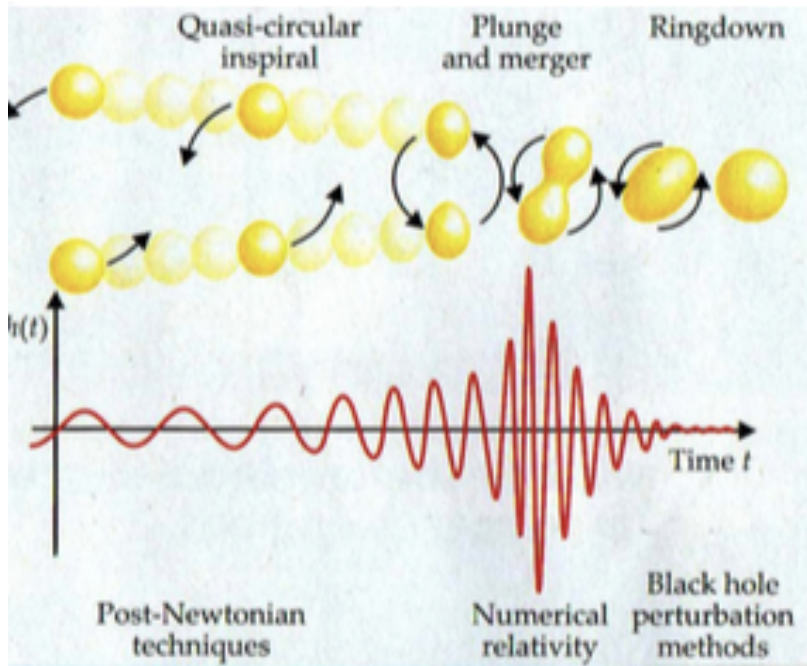
Brookhaven Science Associates
19

EIC@ECFA, June 2016



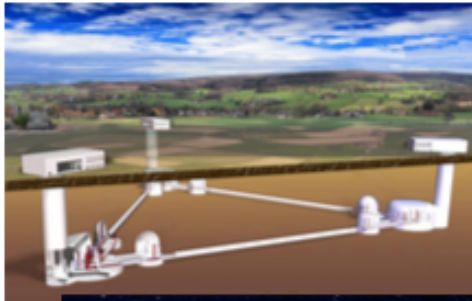
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E.C. Aschenauer

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



Gravitational waves

The next few decades



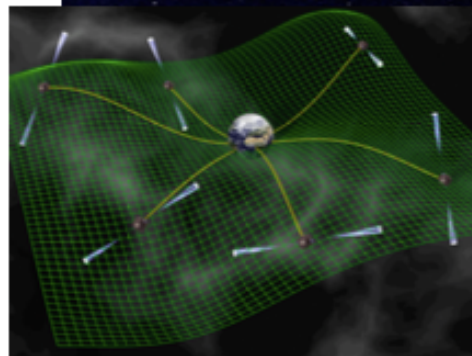
□ Einstein Telescope (~2030?)

- 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)

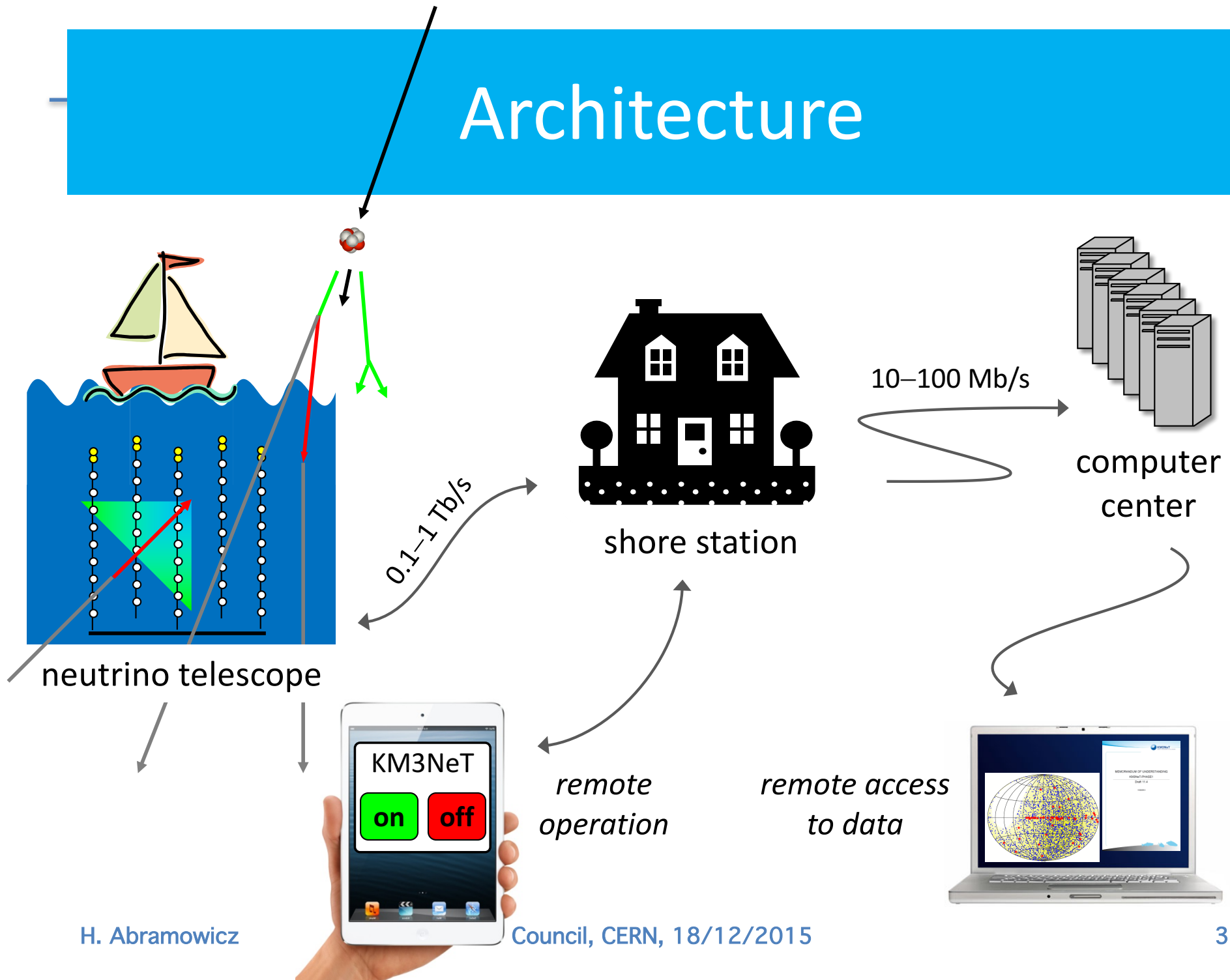
- Correlate variations in pulse arrival times between widely spaced pulsars to see effect of GWs
- Ultra-low frequencies: 10^{-9} – 10^{-6} Hz
- Supermassive binaries long before they merge

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

KM3Net neutrino telescope - Maarten de Jong

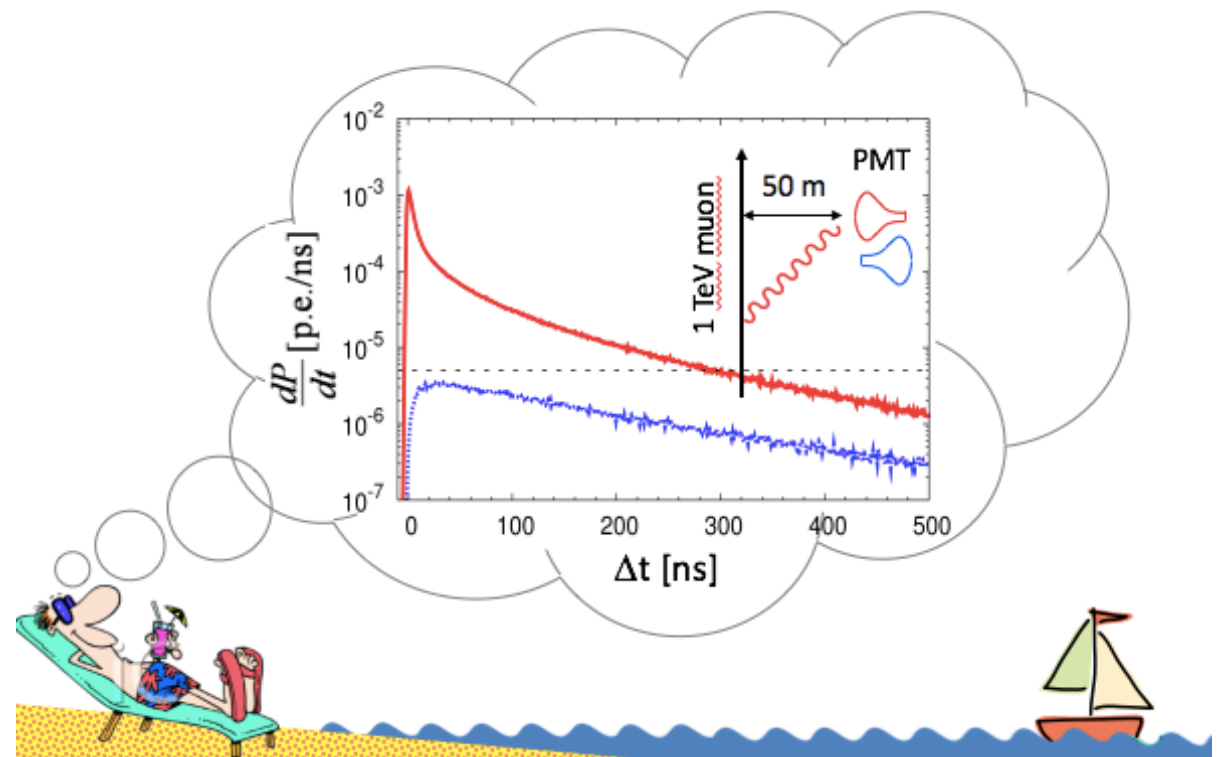
- [KM3NeT](#) is a new Research Infrastructure
 - network of cabled observatories
 - located in deep waters of Mediterranean Sea
 - hosting multi-km³ Neutrino Telescope
1. Discovery and subsequent observation of high-energy neutrino sources in Universe
 2. Measurement of neutrino mass hierarchy
 3. Synergy with Earth & Sea sciences

Architecture



KM3Net neutrino telescope

Optical module kit

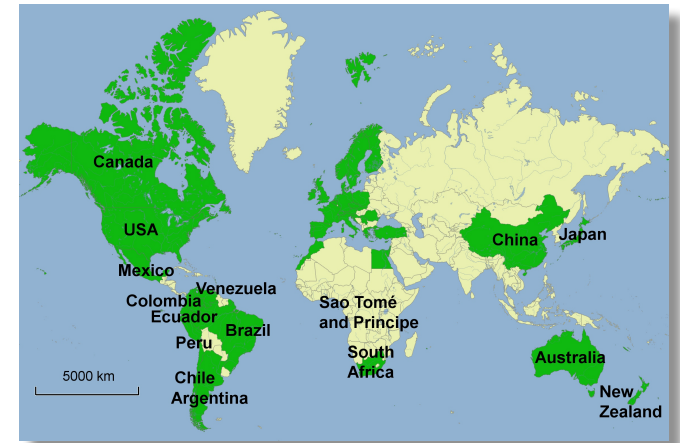




International Particle Physics Outreach Group

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, Franciska 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.

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.

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

Students quickly master real event-display programmes – such

CERN Courier June 2015

Faces & Places

IPPOG

Reaching out with particle physics

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.



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

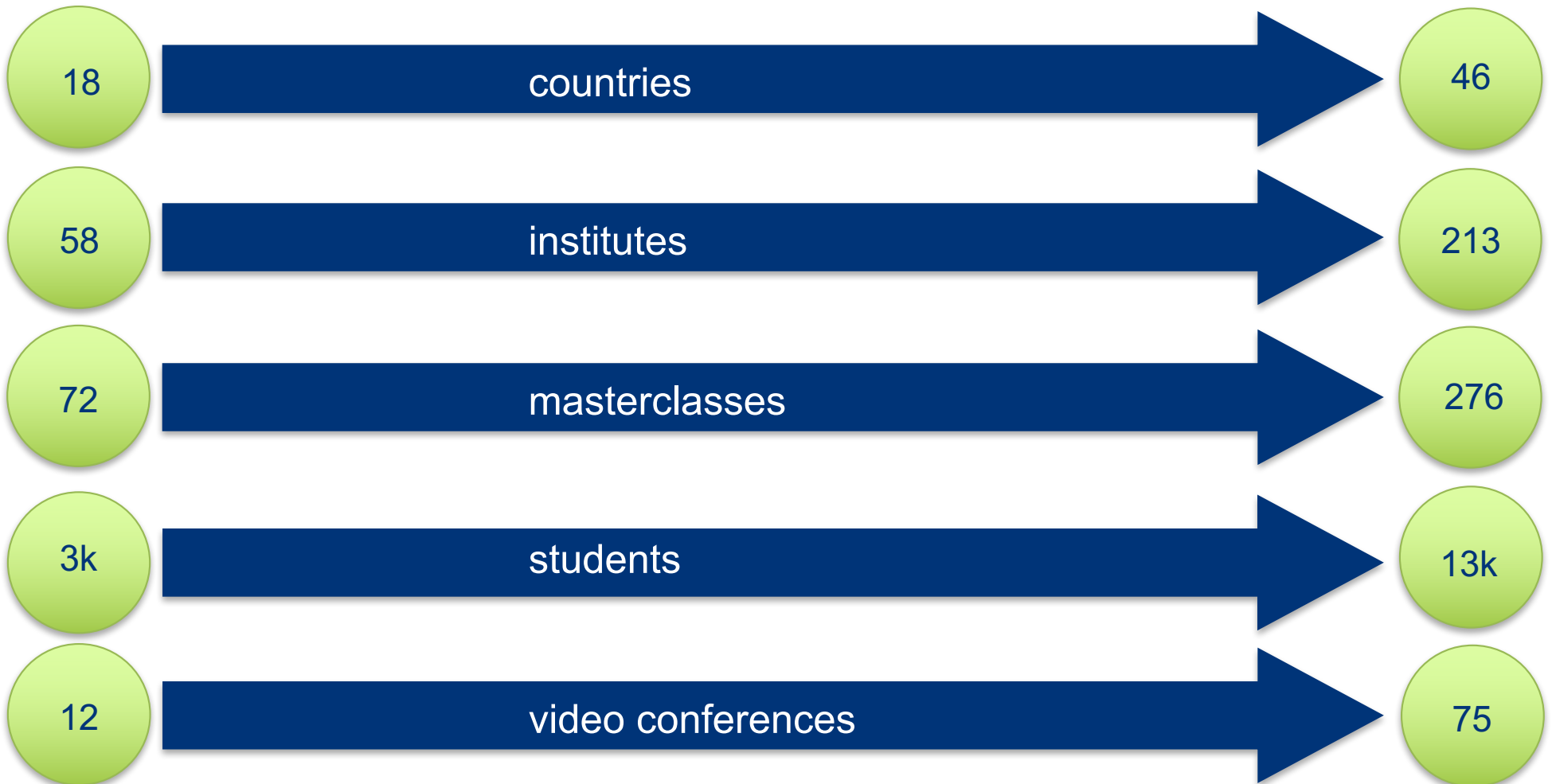
common project or for an activity going on in only one country. Between the meetings, work continues and ideas are tested: do they work, for example, with real students and teachers? Other topics on the agenda of the recent meeting included discussions on how to boost the educational use of CERN open-access 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

2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016



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-EPoS Session in Venice

PARTICLE PHYSICS AND SOCIETY EXTENDING OUR VISION AND REACH

**EUROPEAN PHYSICAL SOCIETY
CONFERENCE ON HIGH ENERGY PHYSICS**
5-12 July 2017 – Lido di Venezia, Italy

- Astroparticle Physics and Cosmology
- Neutrinos and Dark Matter
- Flavour and CP Violation
- Standard Model and Beyond
- Electroweak Symmetry Breaking
- Quantum Field and String Theory
- QCD and Heavy Ions
- Accelerators and Detectors
- Outreach, Education, and Diversity

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**PARTICLE PHYSICS AND SOCIETY
EXTENDING OUR VISION AND REACH**
**SPECIAL JOINT ECFA/EPoS HEPP SESSION
8 JULY 2017**
**ABSTRACT SUBMISSION DEADLINE
10 MAY 2017**

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Dipartimento di Fisica e Astronomia Galileo Galilei

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Scan to discover!
<http://eps-hep2017.eu>

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

Happy and Peaceful Holidays