# CERN
# Status & Outlook

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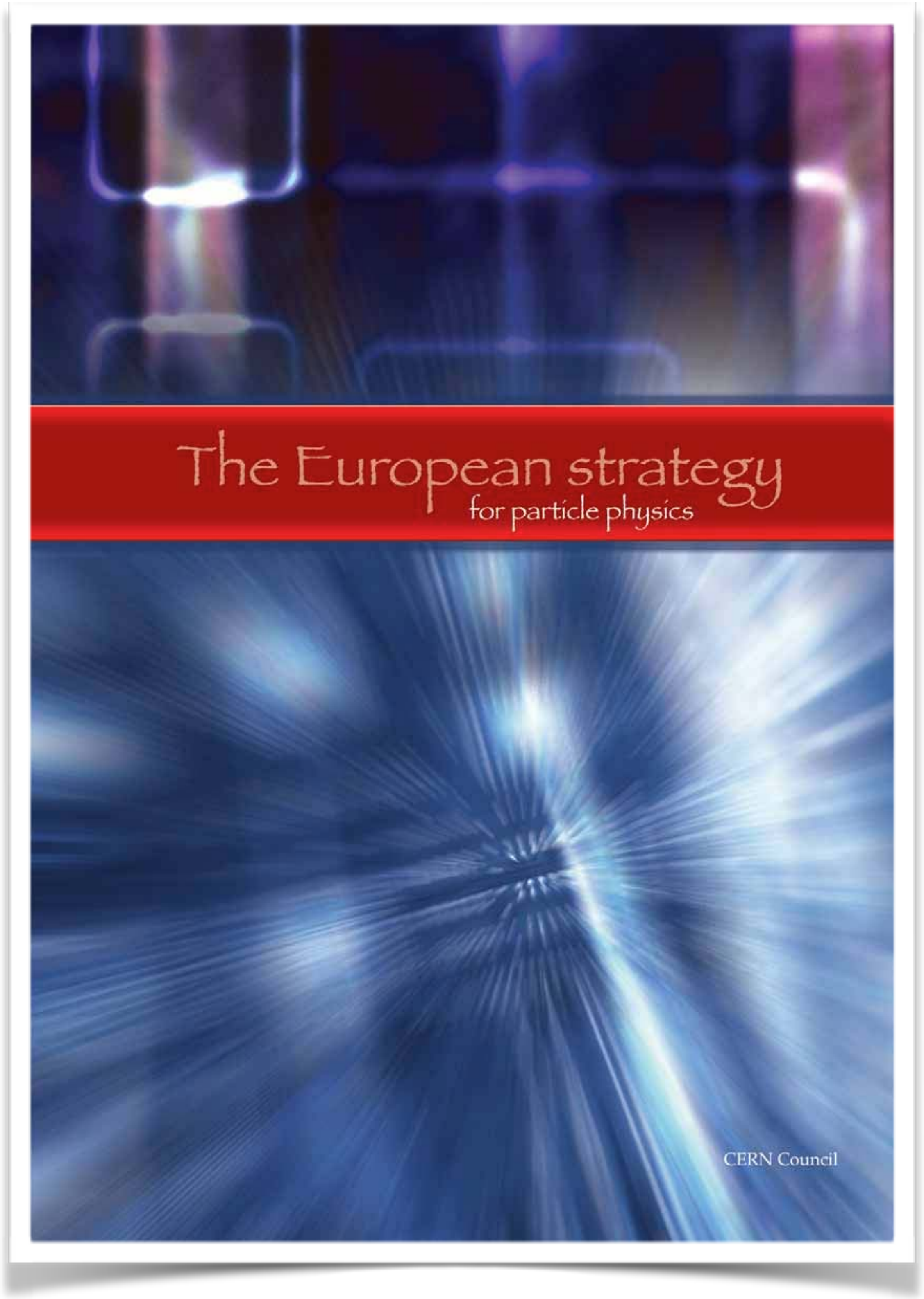
E.Elsen

International Summer School on Symmetries, Fundamental Interactions and Cosmology, Frauenwörth Abbey, Frauenchiemsee, Sep 18-23, 2016

# CERN Programme

- CERN programme is largely driven by the strategy that has been formulated by its users
  - European Strategy of Particle Physics
    - describes the large facilities
    - leaves room for small additional programmes
  - updated every ≥ 5 years
    - implementation monitored by Council

# European Strategy for Particle Physics and updates



The European strategy
for particle physics

CERN Council

2006

Accelerating science and innovation
Societal benefits of European research in particle physics

European Strategy
Update

2013

+
?

European Strategy
Update

~2020

full impact of run 2

# *Energy Frontier*

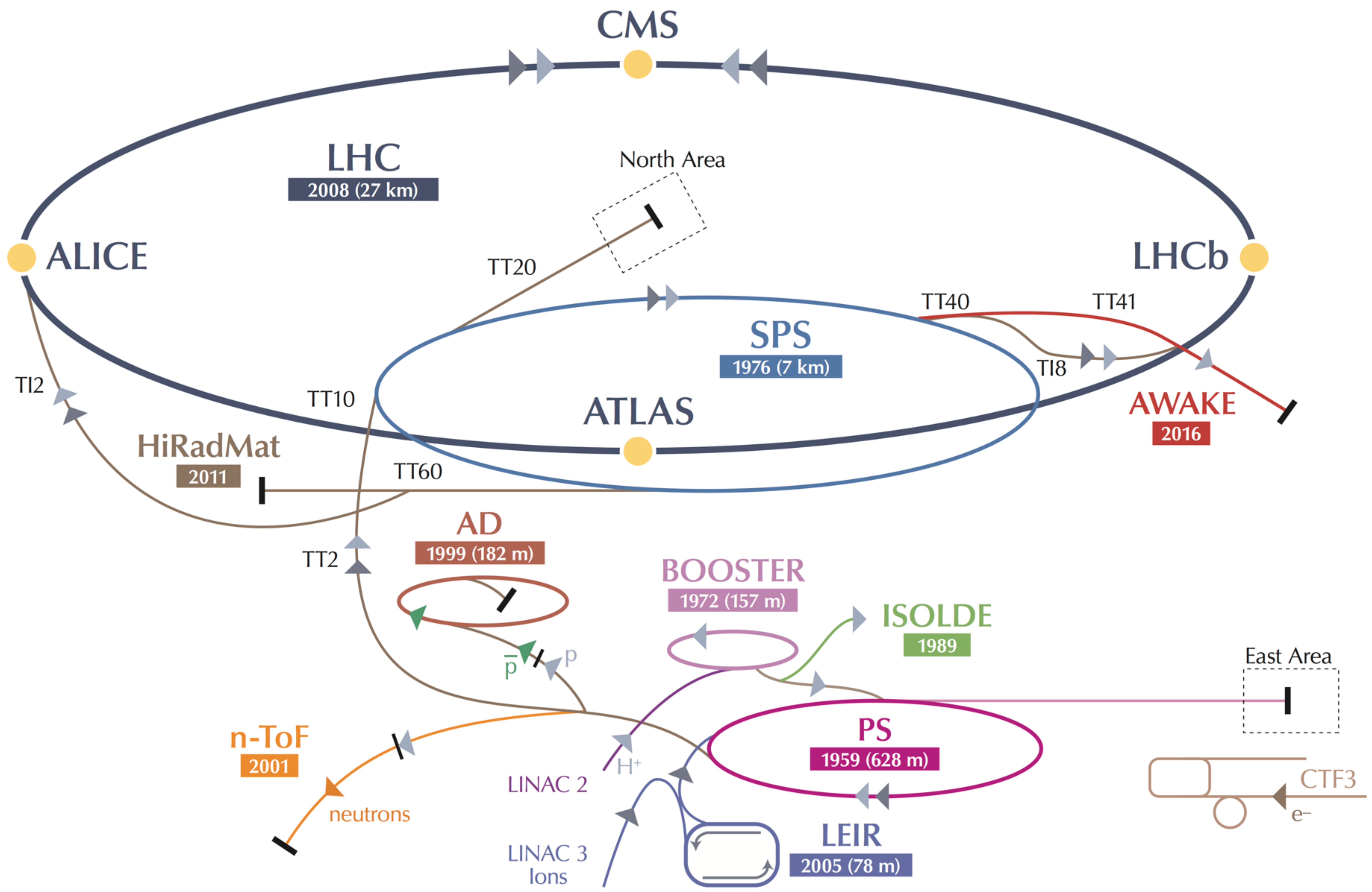
- The discovery of the Higgs boson is the start of a major programme of work to measure this particle’s properties with the highest possible precision for testing the validity of the Standard Model and to search for further new physics at the energy frontier. The LHC is in a unique position to pursue this programme.

  *Europe’s top priority should be the exploitation of the full potential of the LHC, including the high-luminosity upgrade of the machine and detectors with a view to collecting ten times more data than in the initial design, by around 2030. This upgrade programme will also provide further exciting opportunities for the study of flavour physics and the quark-gluon plasma.*


LHCb
ATLAS
CERN Meyrin
PS 628 m
CERN Prévessin
SPS 7 km
SUISSE
FRANCE
CMS
ALICE
LHC 27 km

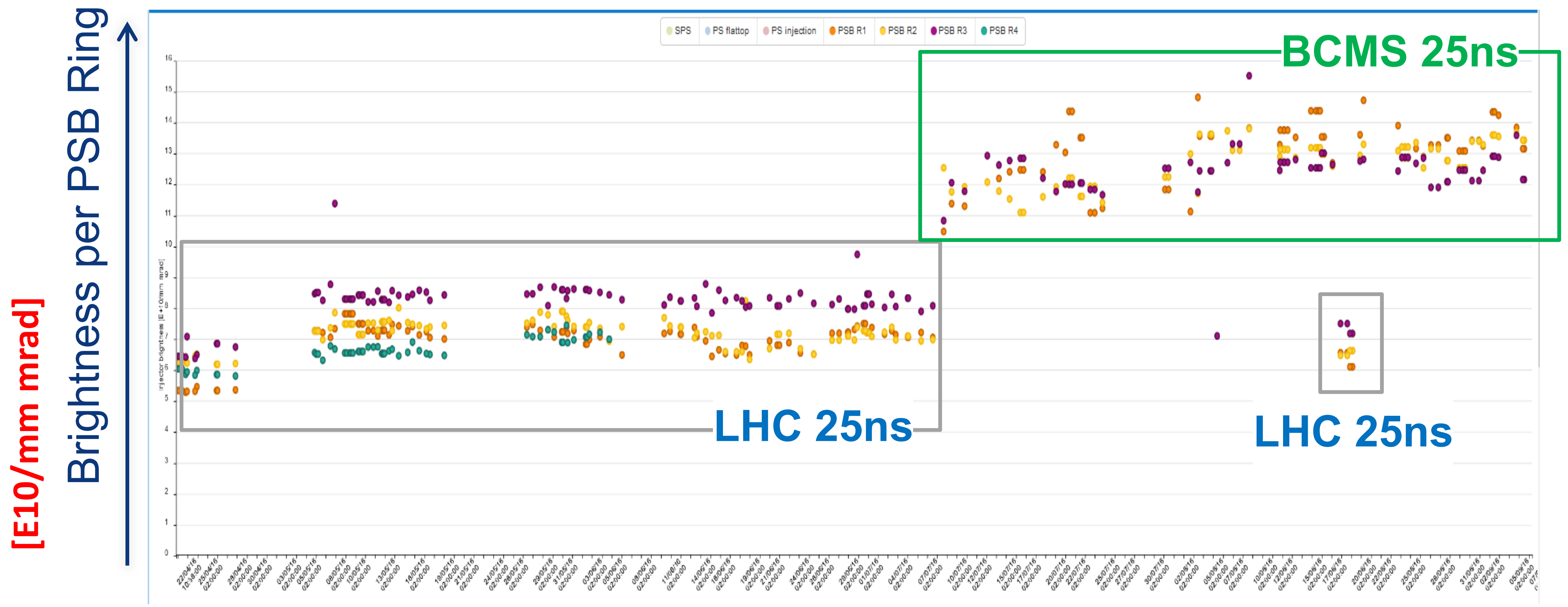
# Experimental Tools of the Research Programme at CERN

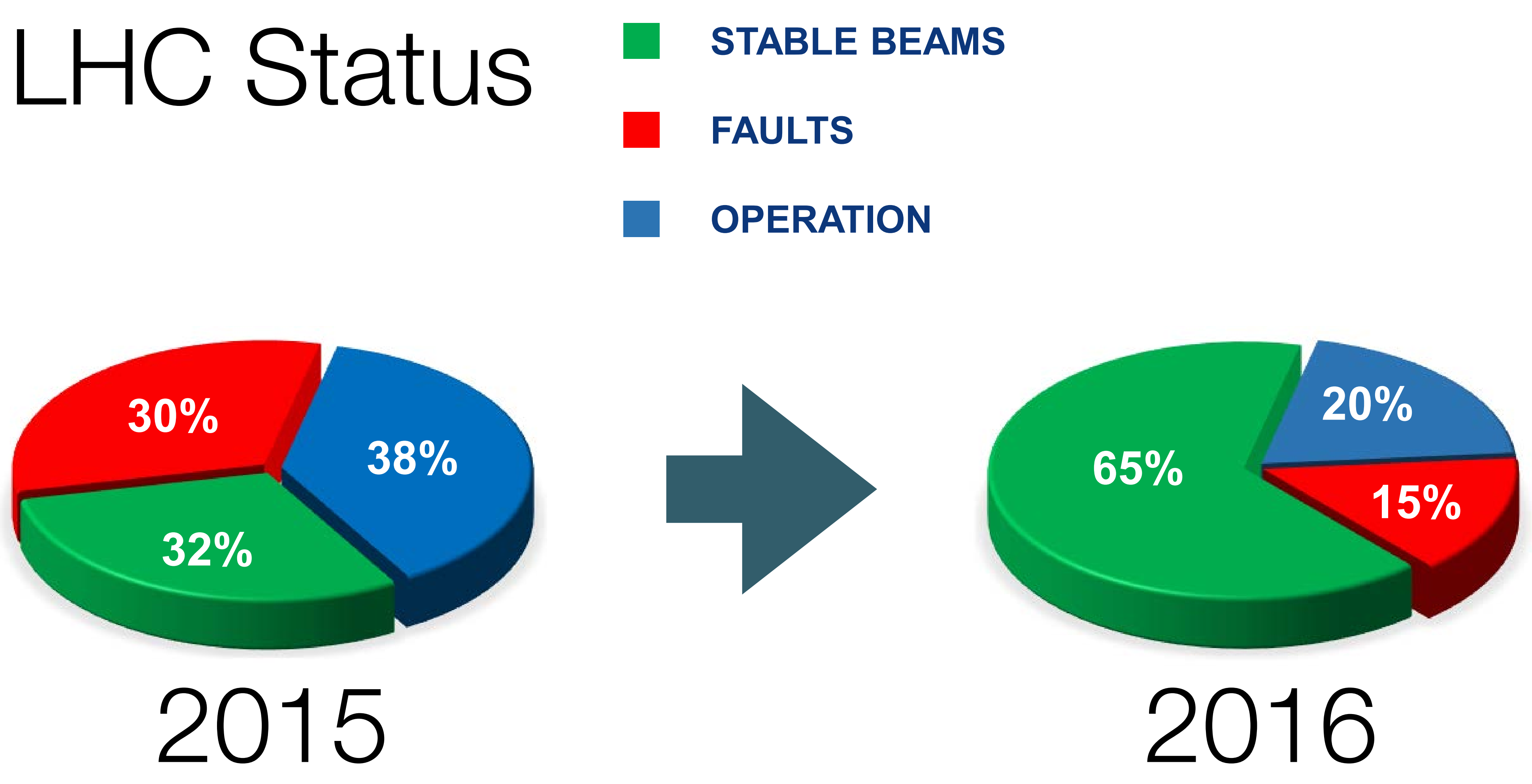
- LHC
  - ongoing run 2 @ 13 TeV
  - HL-LHC (>2025)
- Fixed target programme
- ISOLDE
- AD-programme



# Extraordinary LHC Performance in 2016

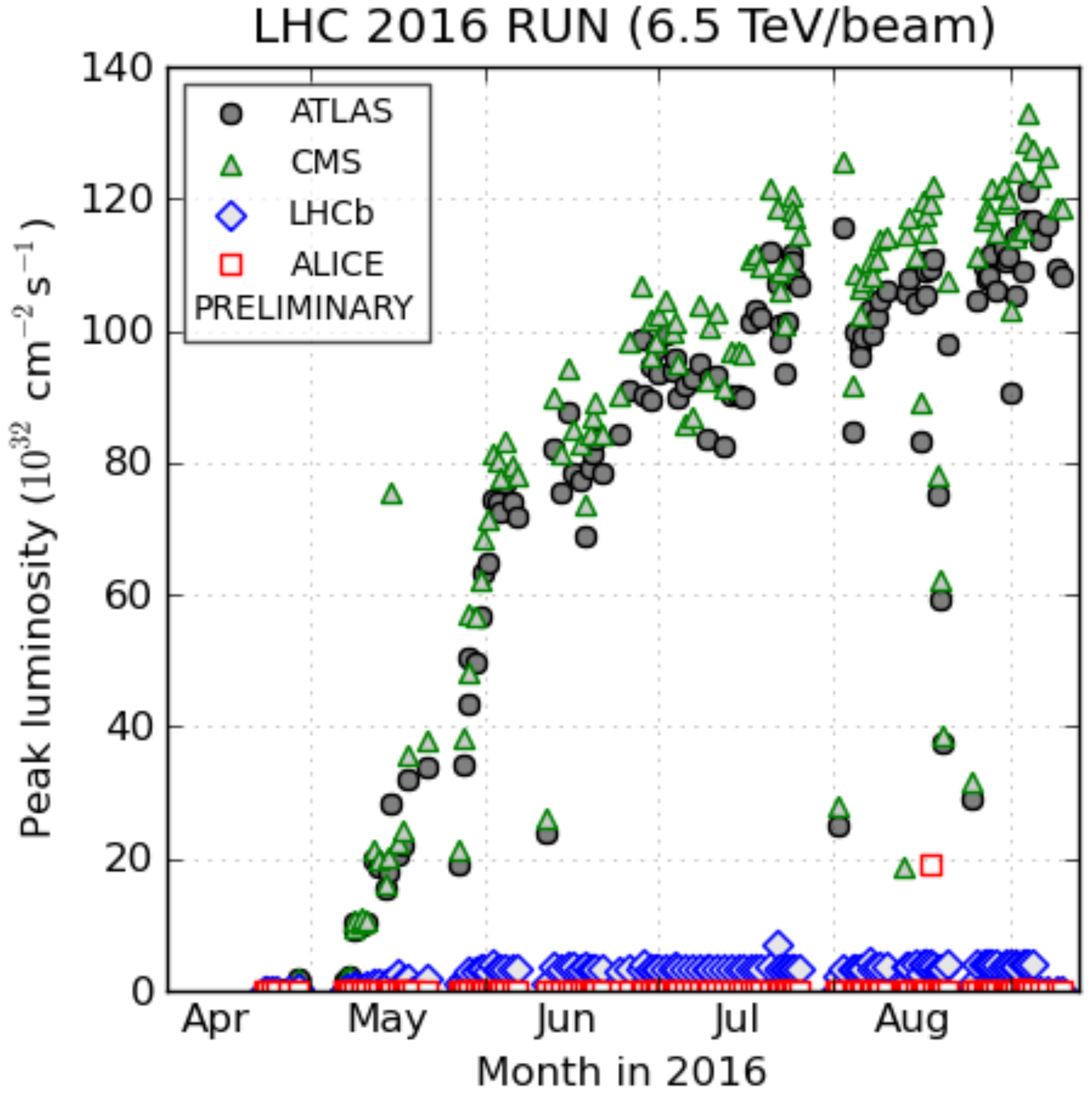
- Batch Compression Merging and Splitting scheme is boosting bunch brightness: bunches collide more effectively → increased pile-up
- Machine availability has essentially doubled (meticulous attention to operation)
- Considerably more physics data to digest



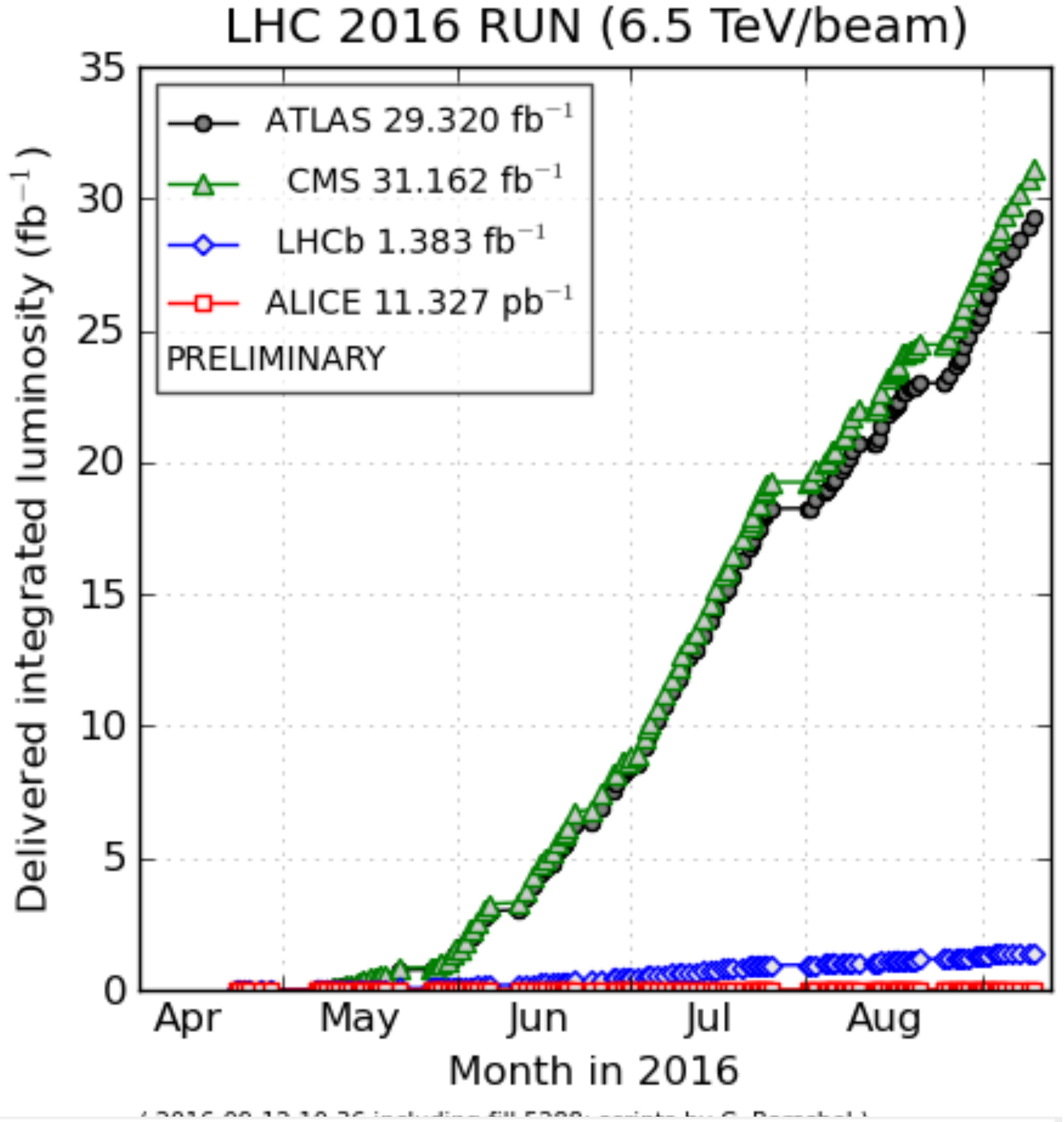


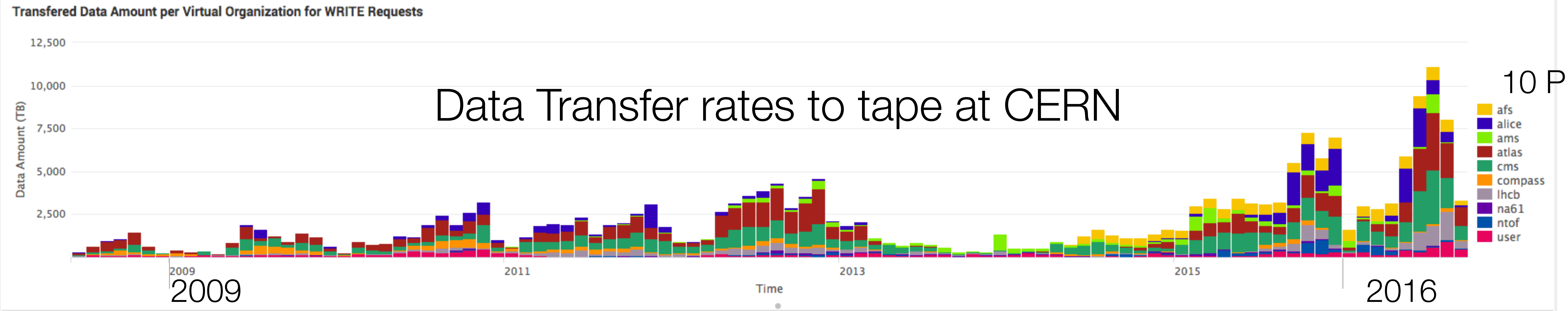
# LHC Luminosity 2016 so far

- Instantaneous (peak) luminosity drives pile-up
- Availability leads to increased computing and data transfer rates
  - >10 PB/d



( 2016-09-12 10:36 including fill 5288; scripts by C. Barschel )



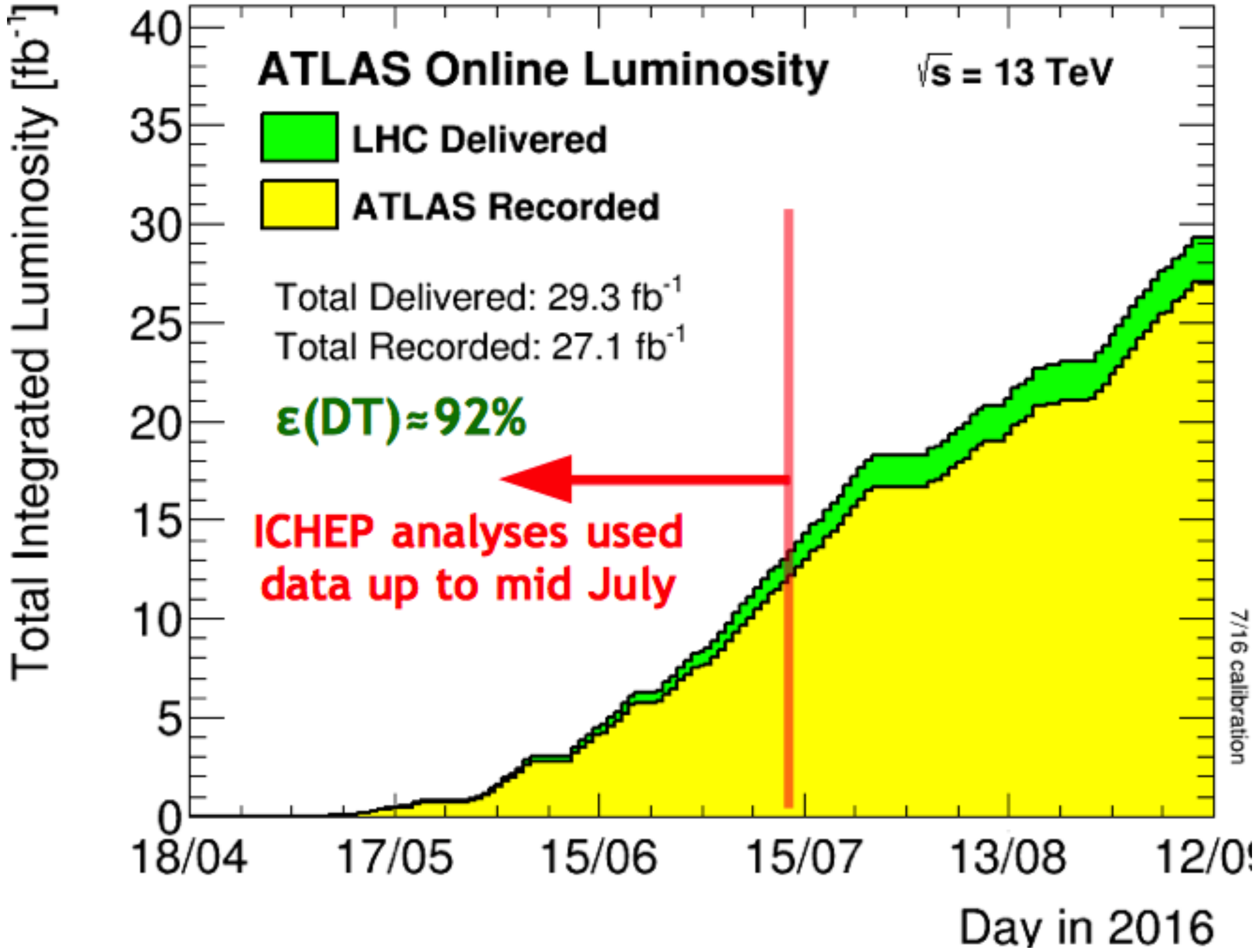


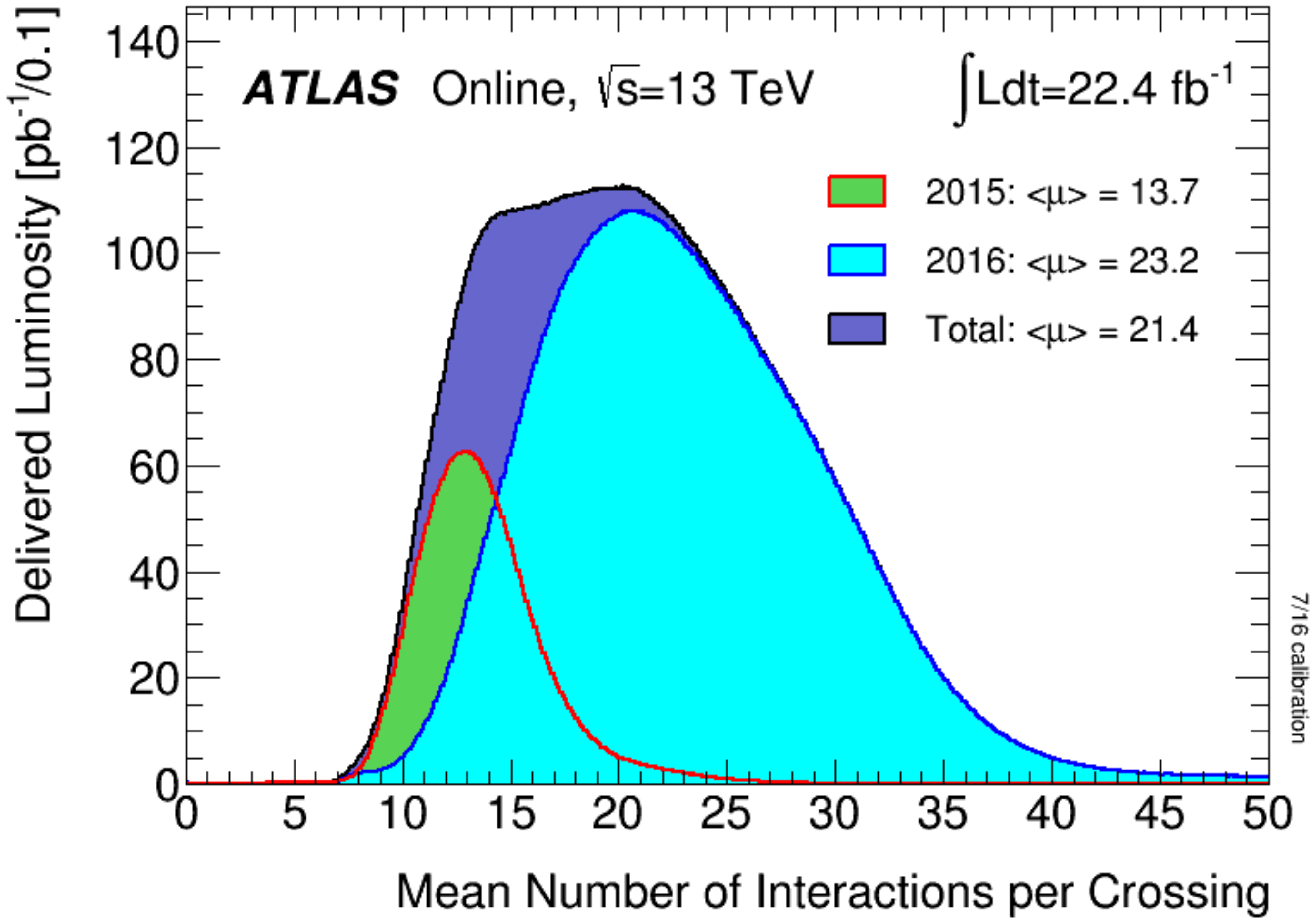
Data Transfer rates to tape at CERN

# ATLAS Data Sample

ATLAS

- 2015: 4.2 $\text{fb}^{-1}$ delivered
- 2016: ≤15 $\text{fb}^{-1}$ used for ICHEP results
  - ε = 91-98% (toroid)





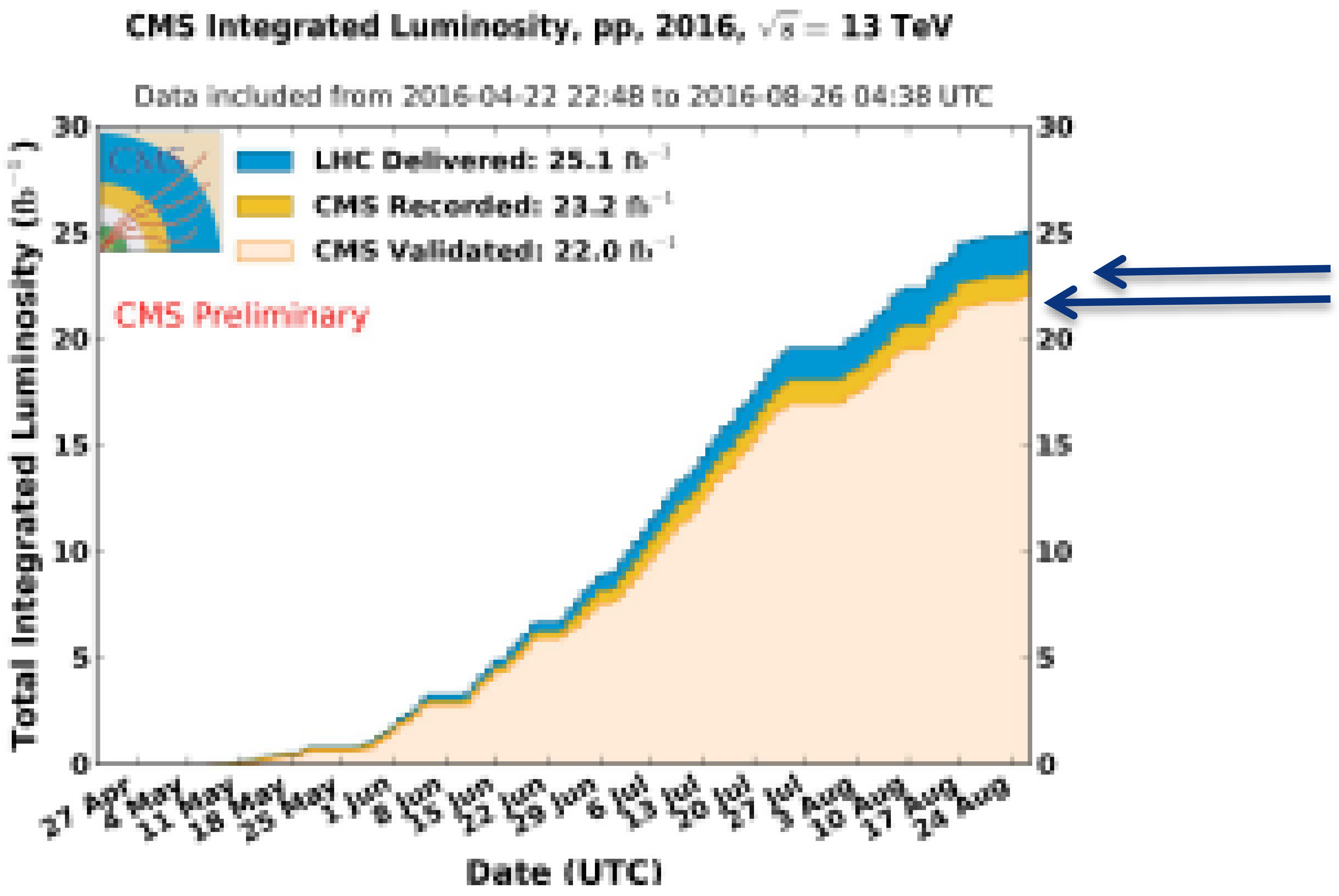
Luminosity uncertainty
±2.1% (2015)
±3.7% (2016, preliminary)
±2.9% (2015+2016, prel)

Design: μ=23

CMS

# CMS Data and Preparation for extended Winter Stop

- Pile-up is a challenge; difficult above 40
- EYETS
  - Install a 4-layer pixel detector (BPIX) and 3 disc FPIX in endcap
    - Readout then copes with $2x10^{34}$ $cm^{-2}$ $s^{-1}$
  - Install SiPMs in HE calorimeter
  - Implement multianode feature of PMTs on HF calorimeter (HF) to reject spurious „missing $E_T$“ signals

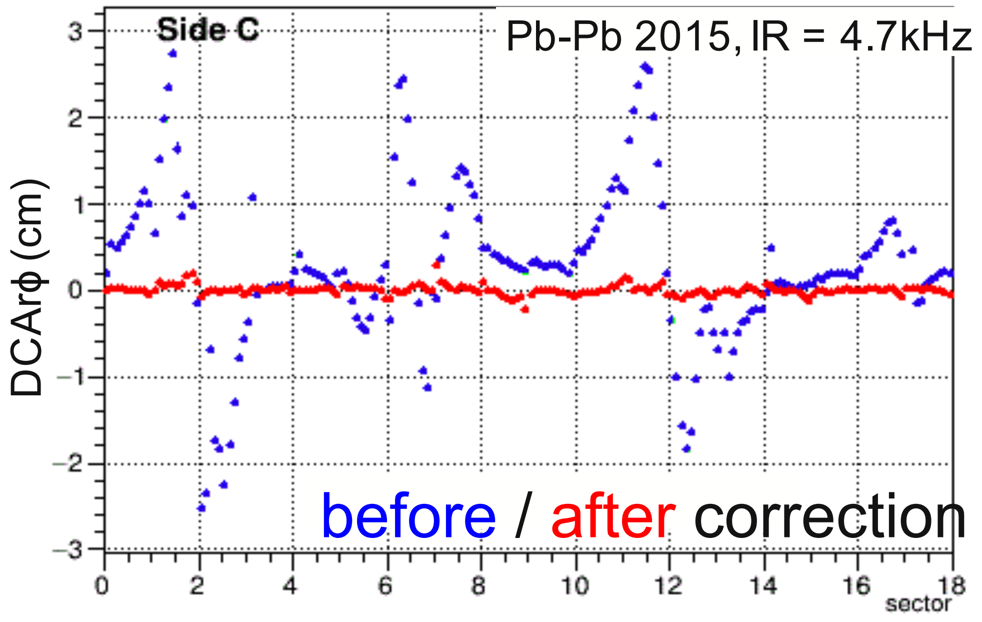


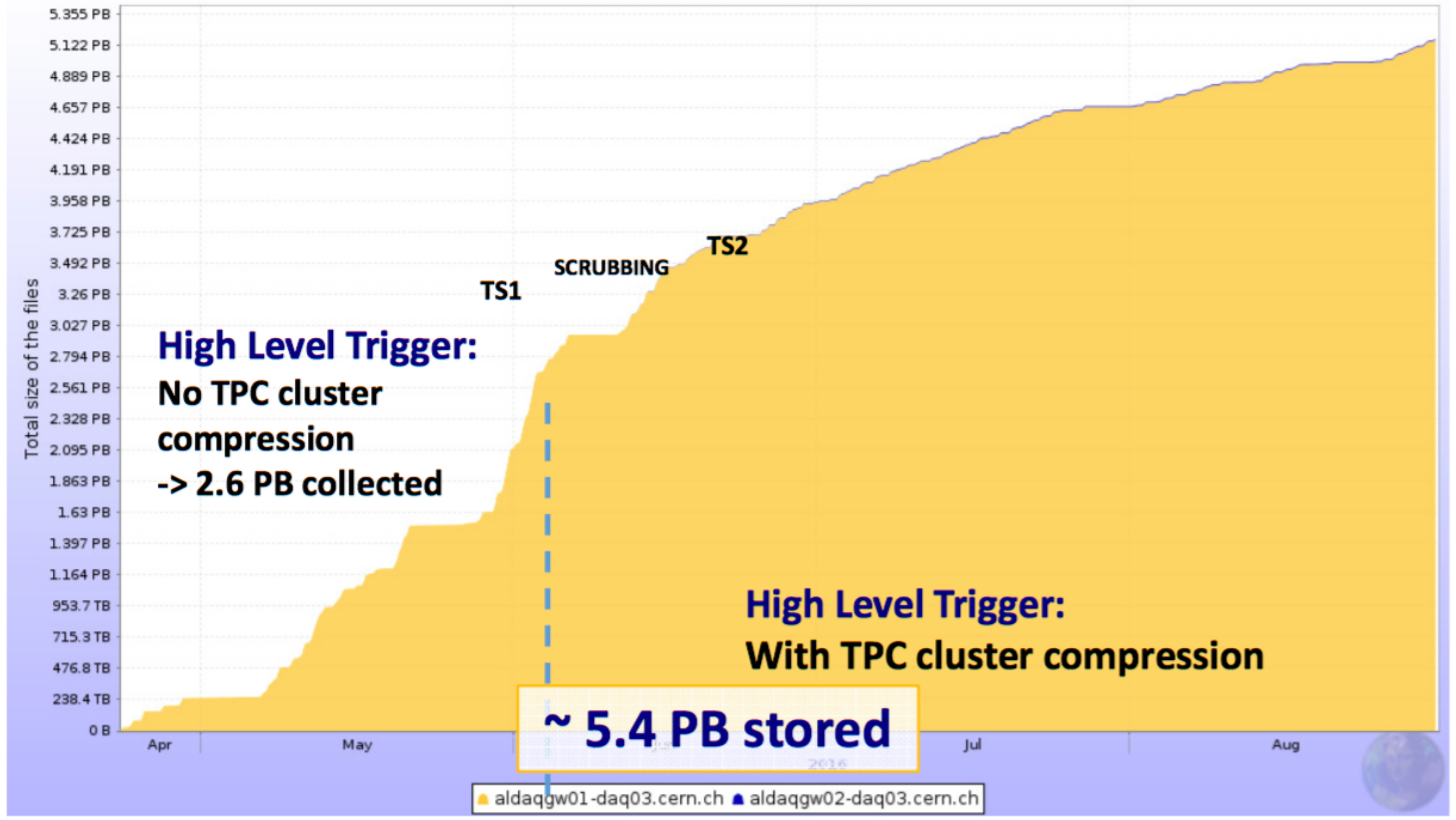
ALICE

# ALICE – Data Taking

- Resume TPC cluster compression
  - RCU2 in place; firmware updates
- TPC field distortions persist
  - proportional to rate
  - related to to edges of IROC chambers
- Can be recovered with methods foreseen for upgraded TPC

effect not yet understood

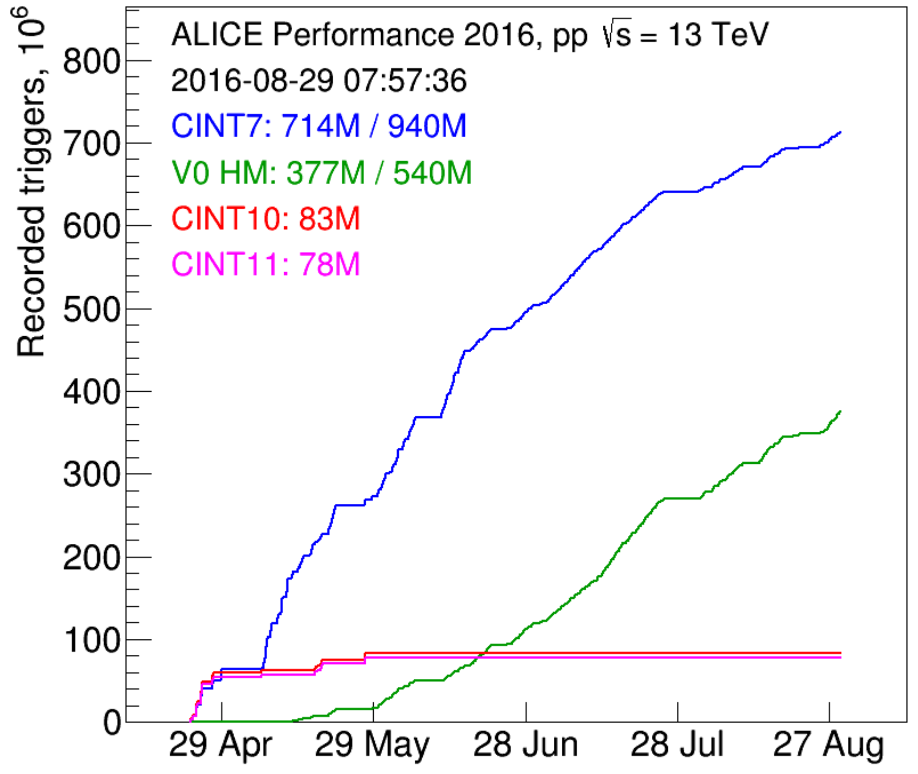


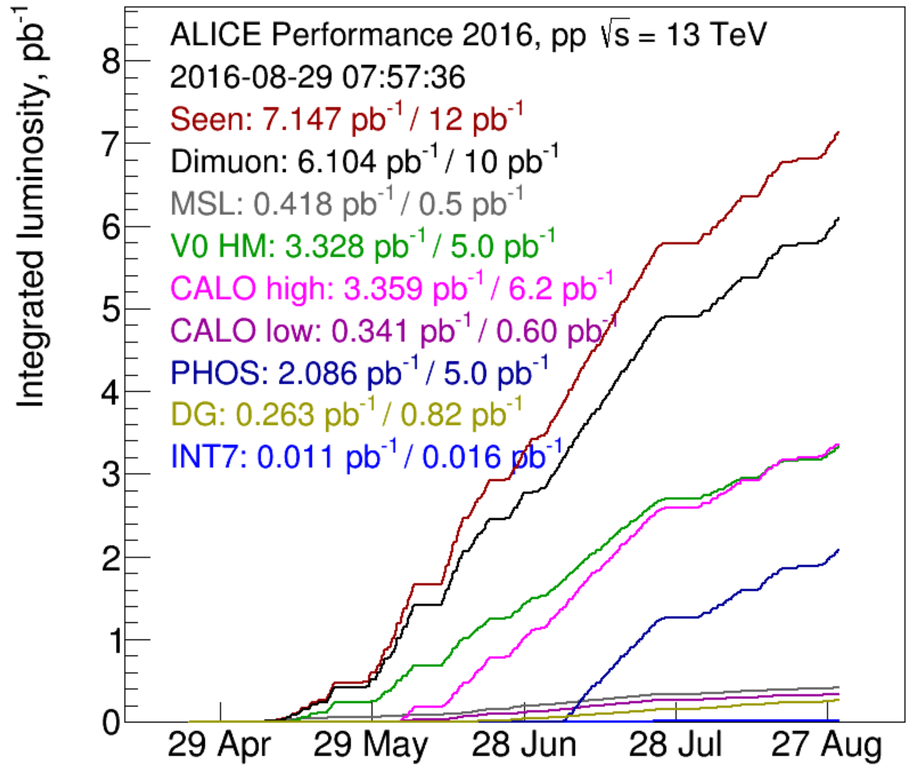


**High Level Trigger:**
**No TPC cluster compression**
**-> 2.6 PB collected**

**High Level Trigger:**
**With TPC cluster compression**

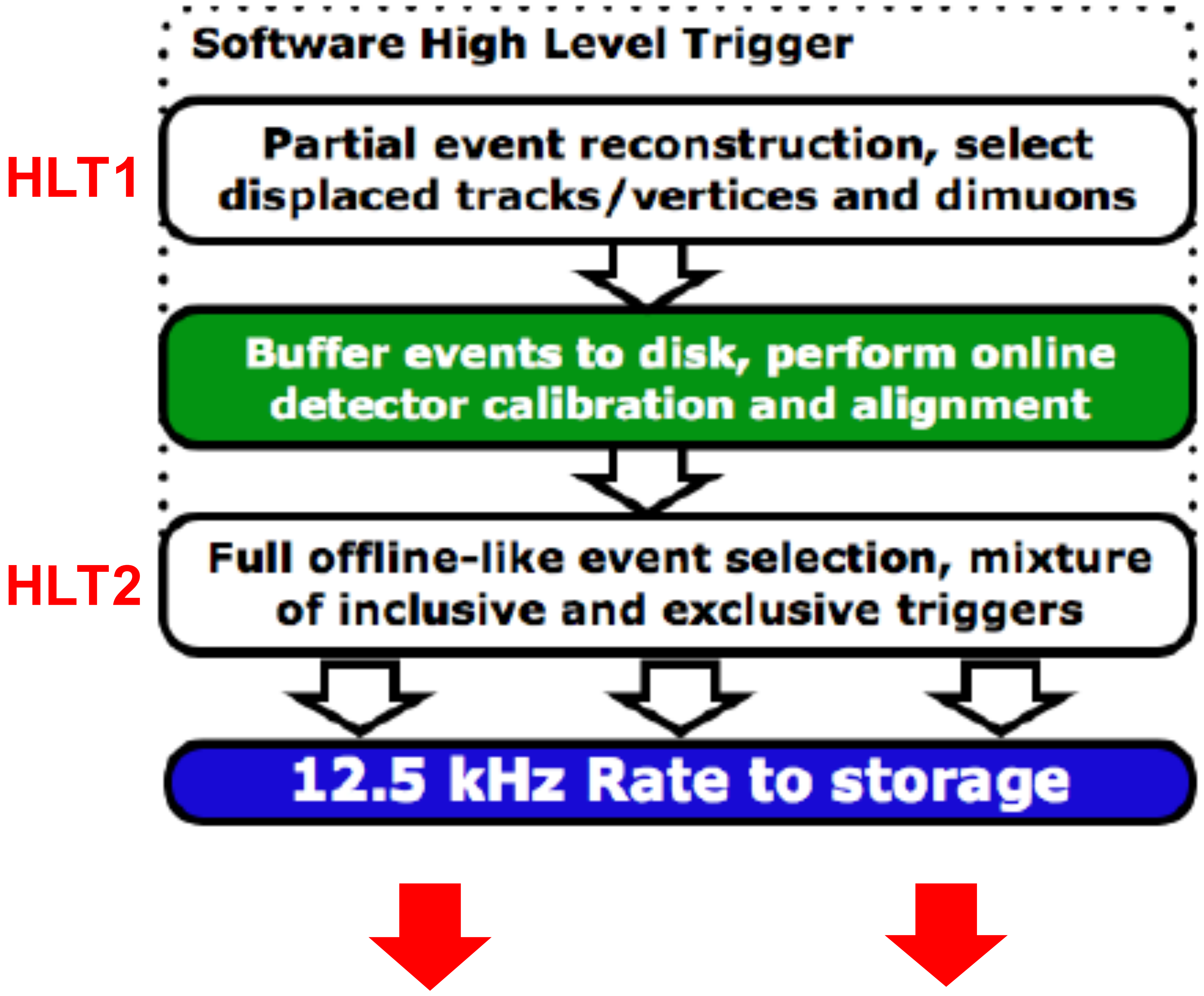
**~ 5.4 PB stored**





LHCb

# LHCb Data Taking



**Software High Level Trigger**

**HLT1**

**Partial event reconstruction, select displaced tracks/vertices and dimuons**

**Buffer events to disk, perform online detector calibration and alignment**

**HLT2**

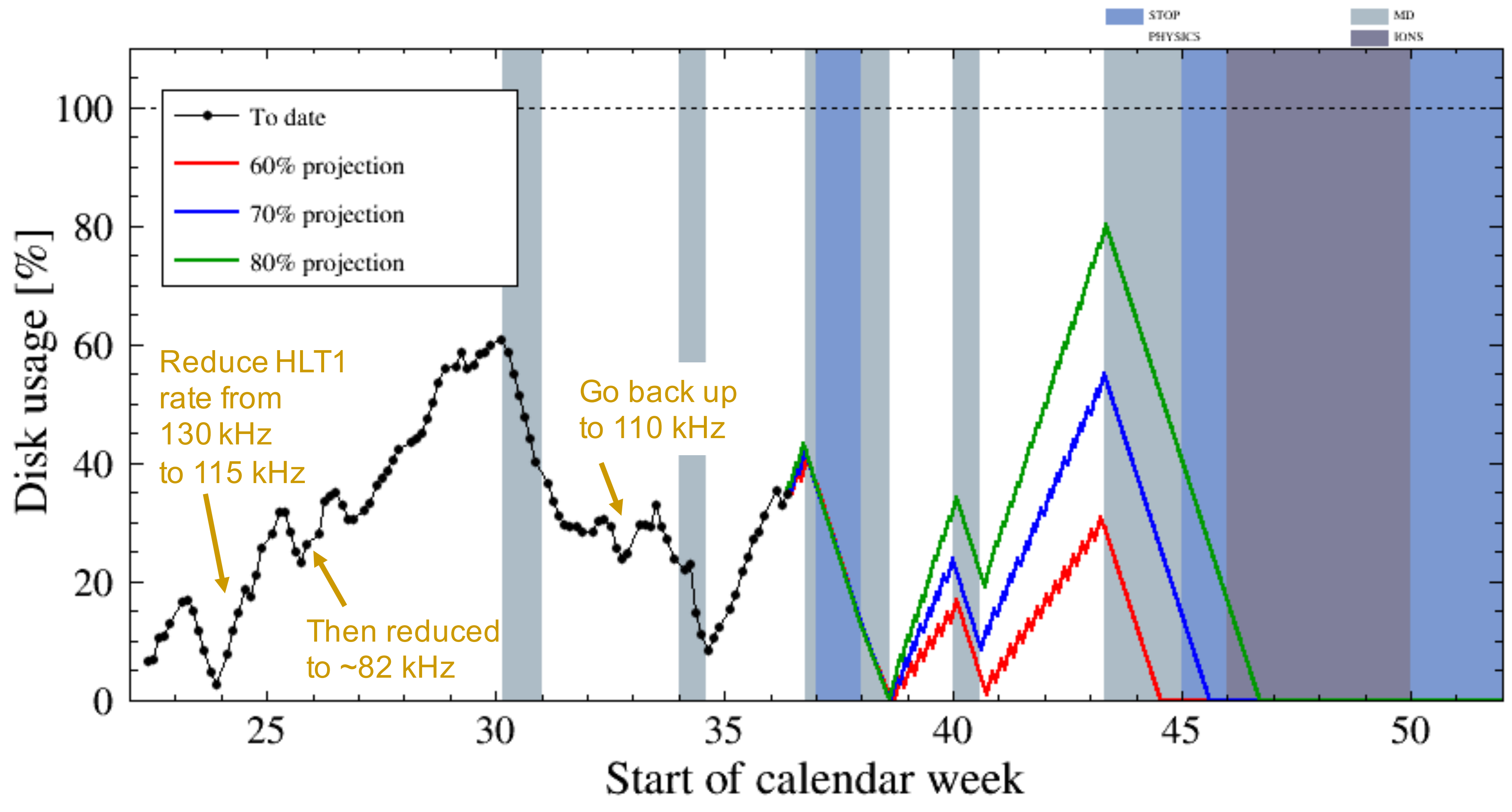
**Full offline-like event selection, mixture of inclusive and exclusive triggers**

**12.5 kHz Rate to storage**

Full stream
(*i.e.* full raw event)

TURBO
(*i.e.* trigger objects)

Dynamic adaptation to LHC machine conditions to maximise physics output



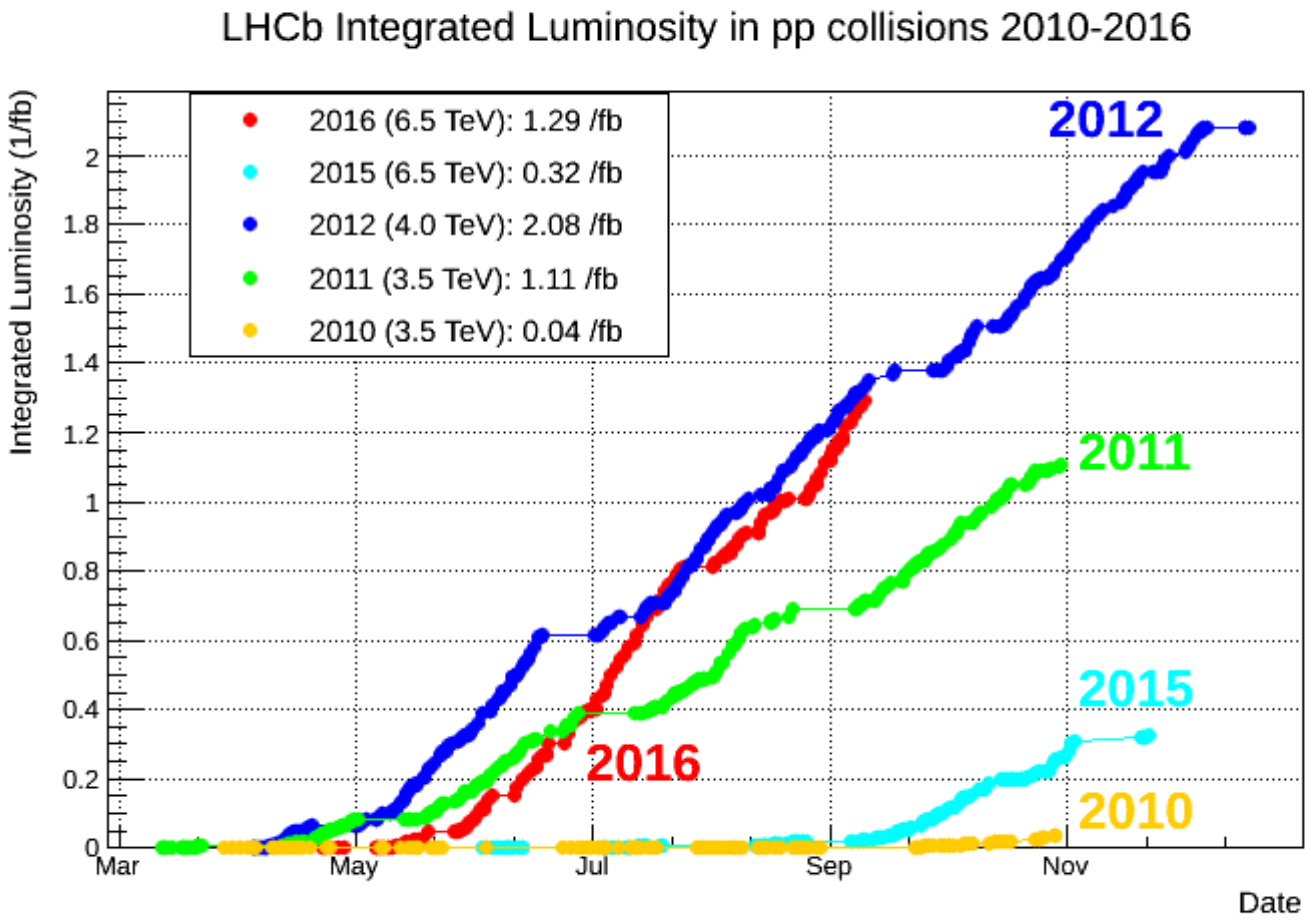
Reduce HLT1 rate from 130 kHz to 115 kHz

Then reduced to ~82 kHz

Go back up to 110 kHz

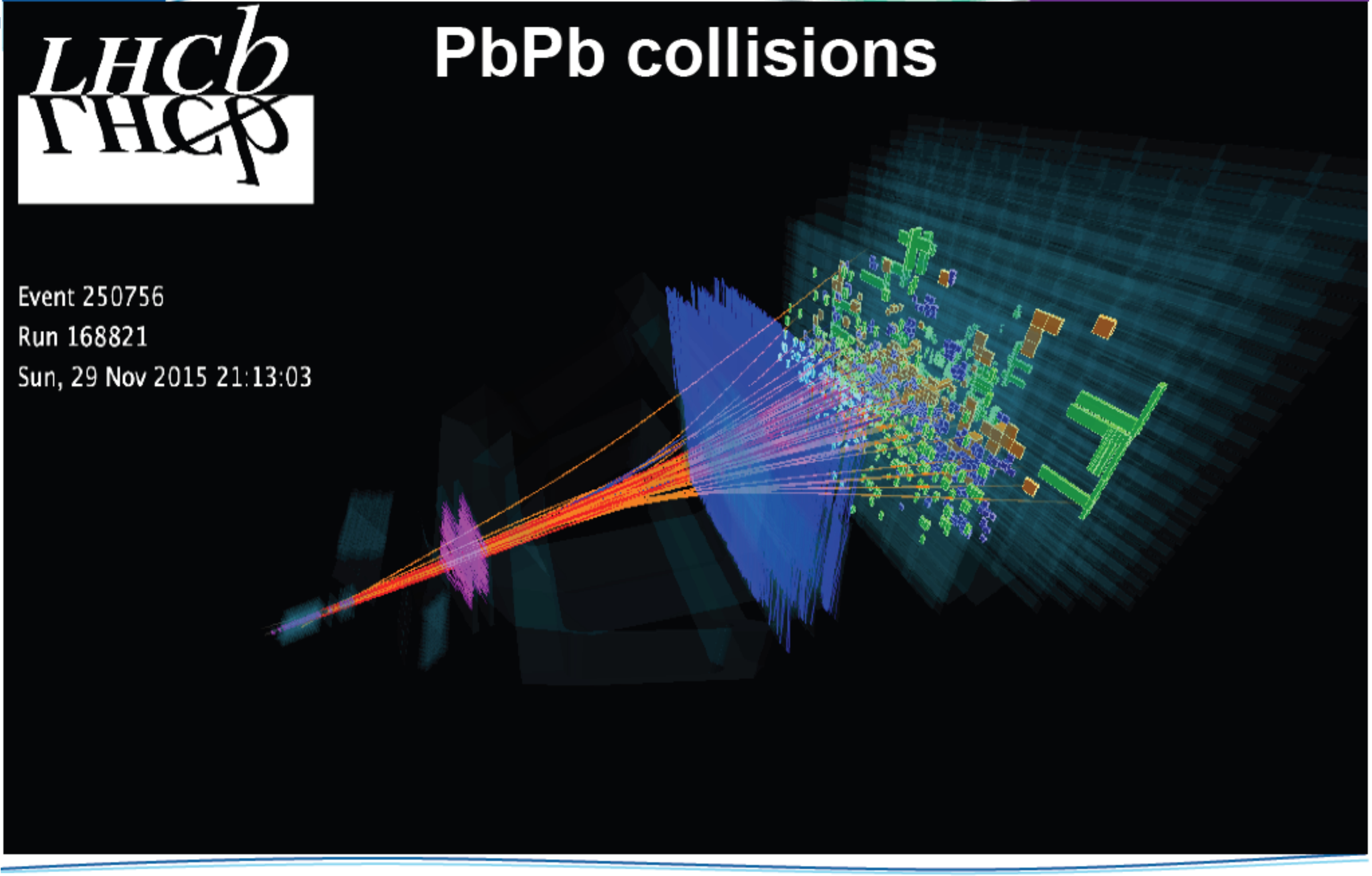
# LHCb Data Sample

- Data taking efficiency ~90% throughout the year
- 1.3 fb$^{-1}$ collected which provides a larger than bb-sample than in 2012 because of the higher cross section at 13 TeV



# some selected physics results

# PbPb collisions

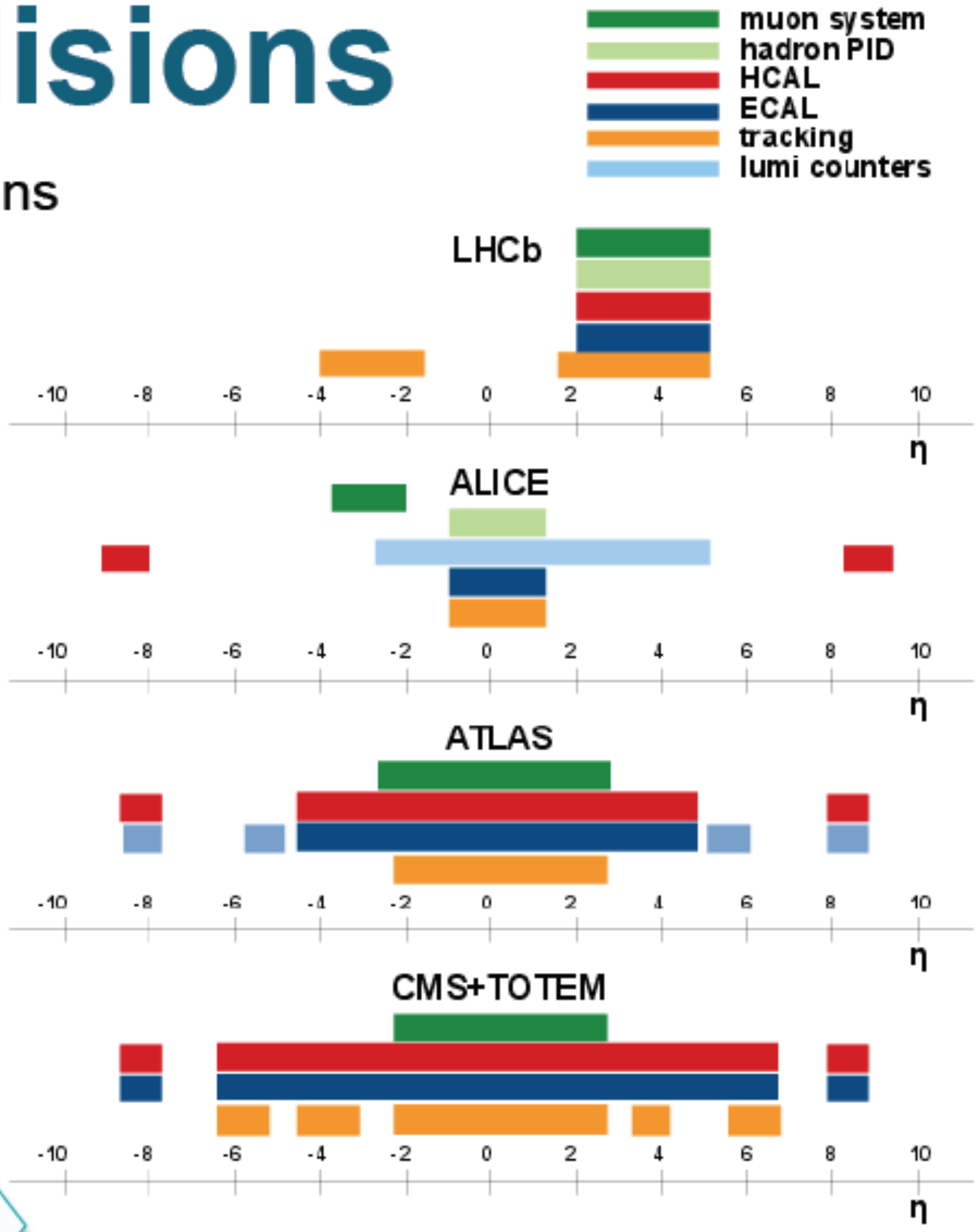


# PbPb collisions

- LHCb is participating in Pb-Pb collision runs
- Unique fully instrumented experiment in the forward region
- Physics motivations:
  - Probe colour screening and quark gluon plasma (QGP) temperature through sequential melting of quarkonium states
  - Structure of nucleons, hadronisation, central exclusive production, …
  - Focus on peripheral collisions in Pb-Pb, with a centrality up to 50%

| | Date | Data sample |
|---|---|---|
| PbPb | 25 Nov.-…. | |
| PbAr | 27 Nov.-… | |

**Data taking ongoing**



ALICE

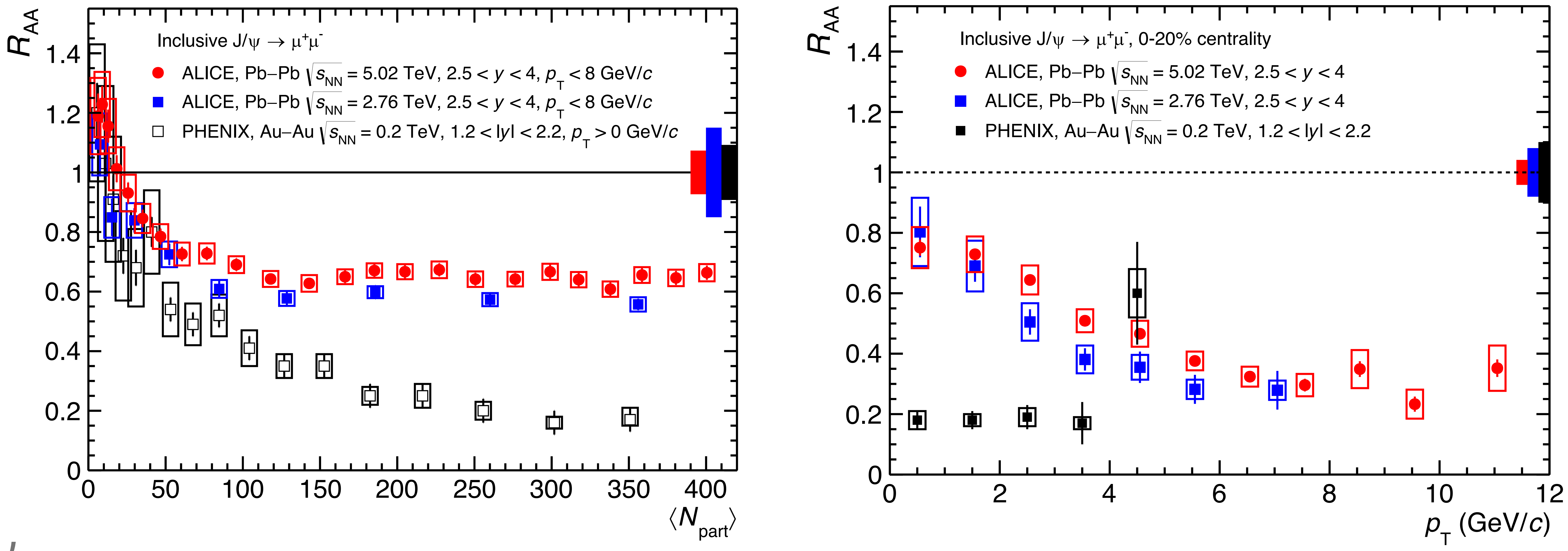
# Pb-Pb: J/ψ suppression at 5 TeV

- nuclear modification factor RAA:

$$R_{AA} = \frac{N(J/\psi)_{AA}}{\langle N_{bin} \rangle N(J/\psi)_{pp}}$$

- very different behaviour between LHC and RHIC (vs both centrality and $p_T$,

- most straightforward explanation: c-cbar recombination at LHC

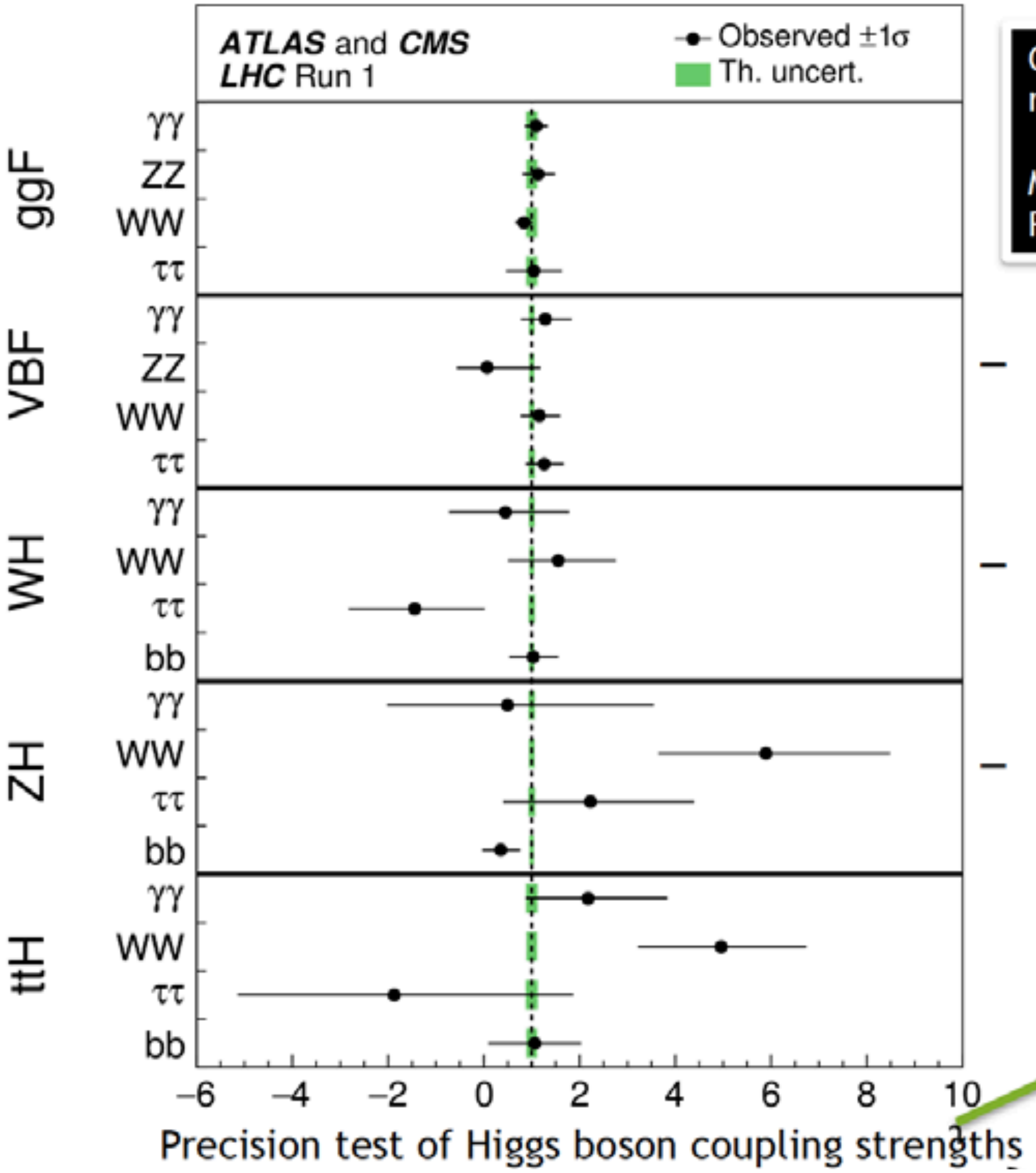


New and precise 5 TeV data support even further increase

# Higgs Boson at 7 and 8 TeV (Run 1)

- ATLAS and CMS have combined their Run 1 data to extract most precise measurement of Higgs coupling

- Higgs (125 GeV) compatible with SM



CMS and ATLAS combined 7 and 8 TeV results Run 1 legacy papers:

Mass: Phys. Rev. Lett. 114, 191803
Rates and couplings: arXiv:1606.02266

- Mass has been measured to 0.2% precision $m_H$=125.09±0.24 GeV
- Angular distributions consistent with spin 0 and even parity
- All couplings are consistent with SM within 2.5σ

Coupling strengths

$$\mu = \frac{\sigma}{\sigma_{SM}}$$

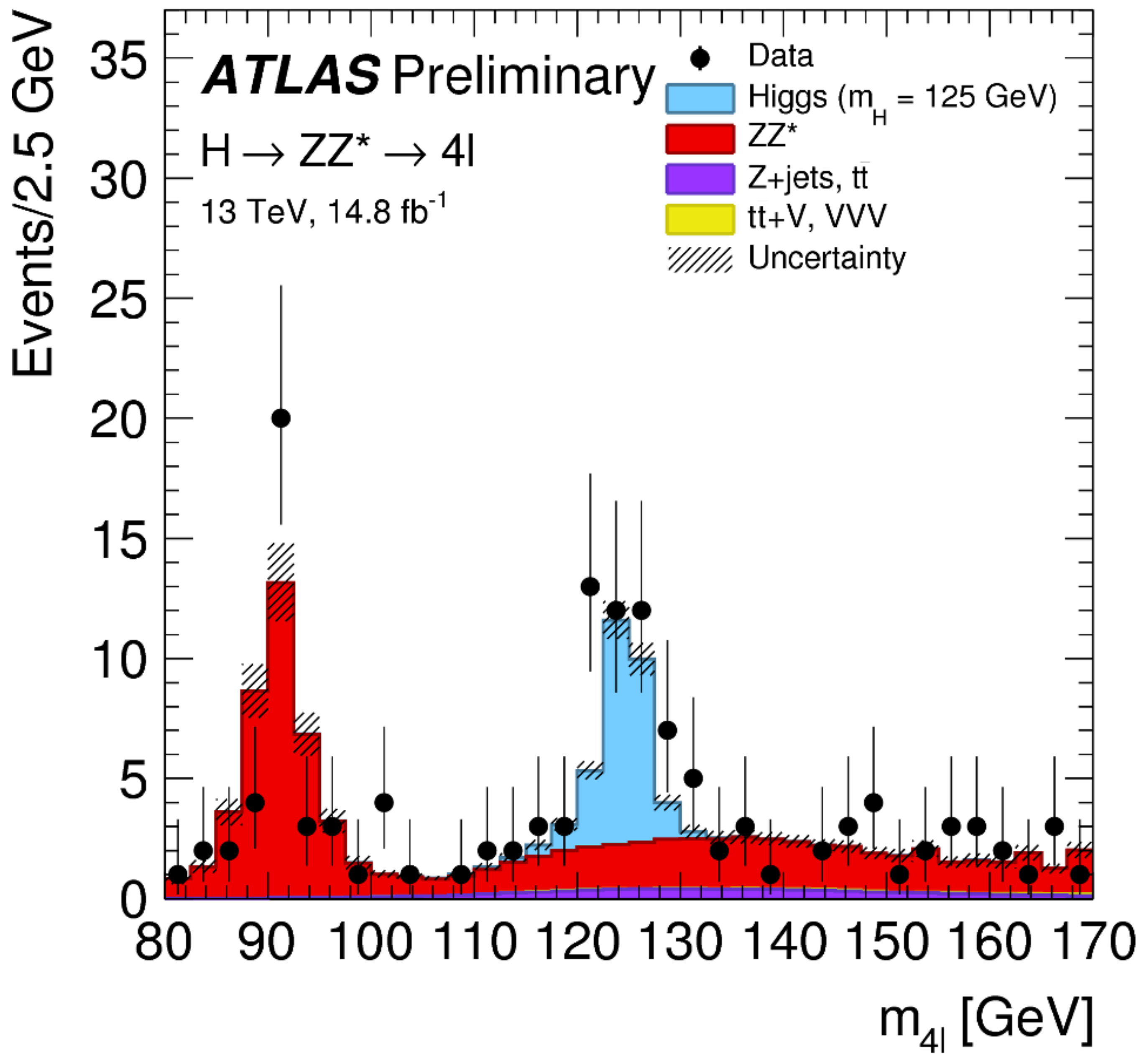
# Higgs Production at 13 TeV (Run 2)

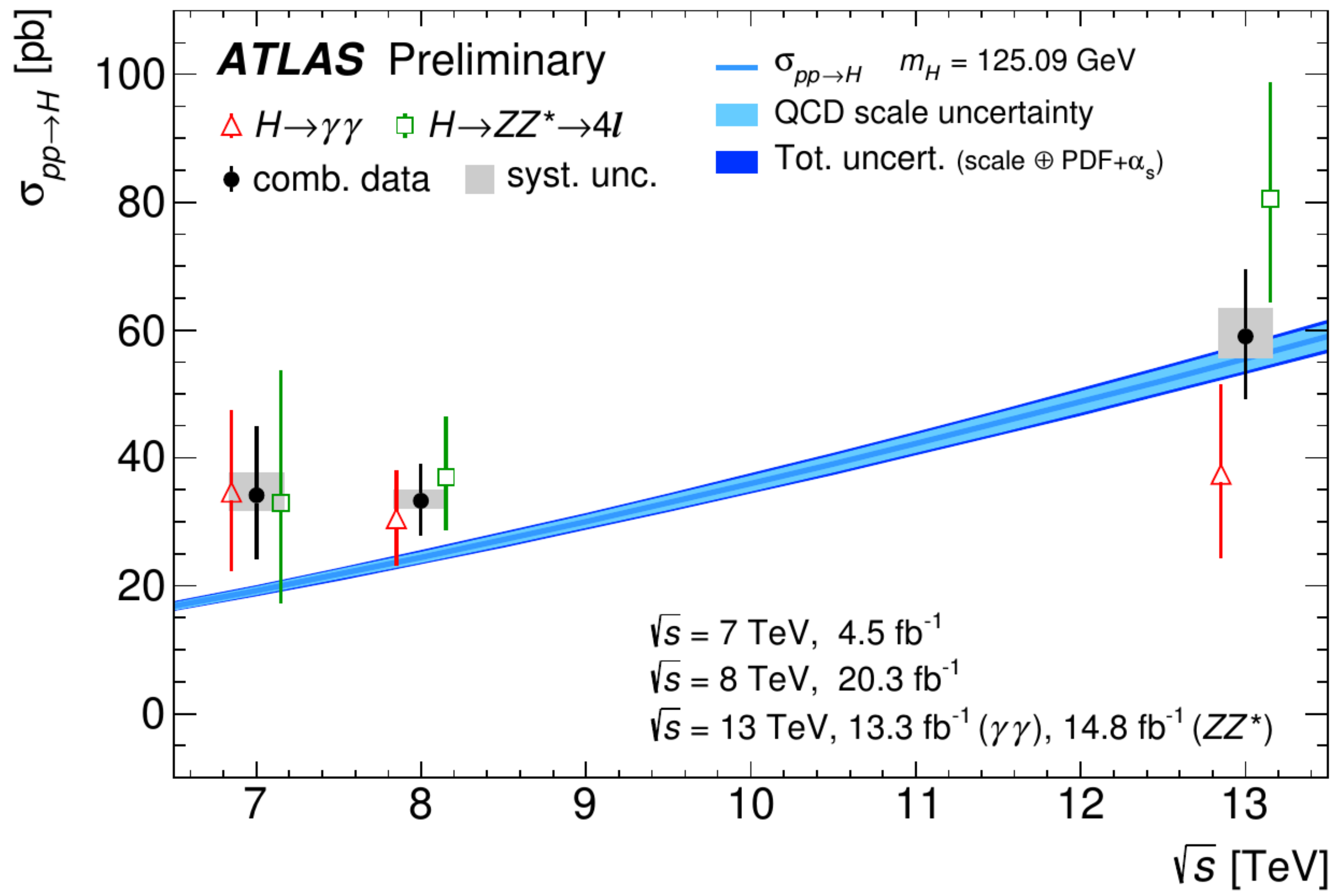
- Overall significance of Higgs production: ~10 σ

- σ(pp→H+X)=

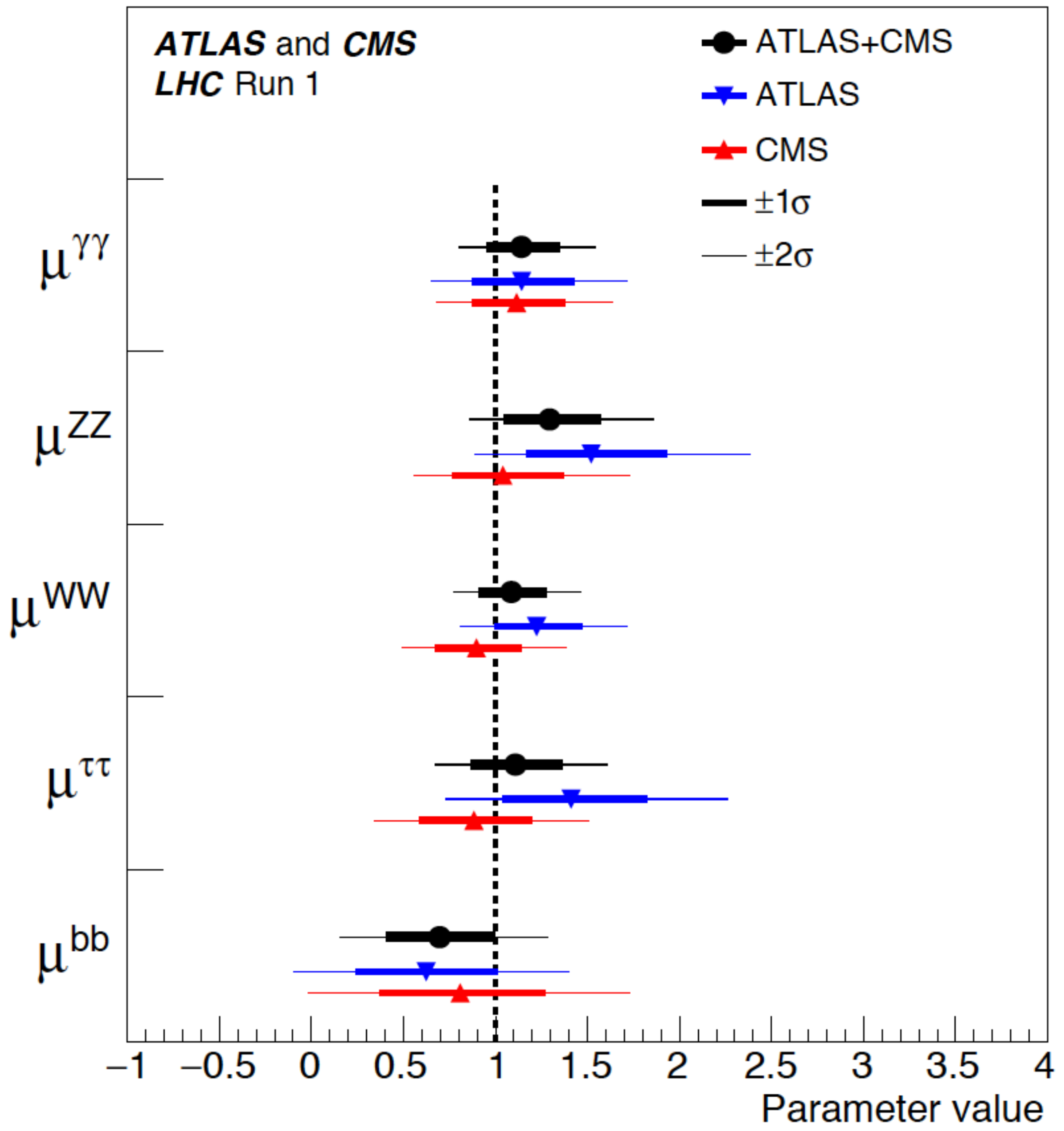
$59.0^{+9.7}_{-9.2}$ (stat.) $^{+4.4}_{-3.5}$ (syst.) pb

$55.5^{+2.4}_{-3.4}$ pb SM



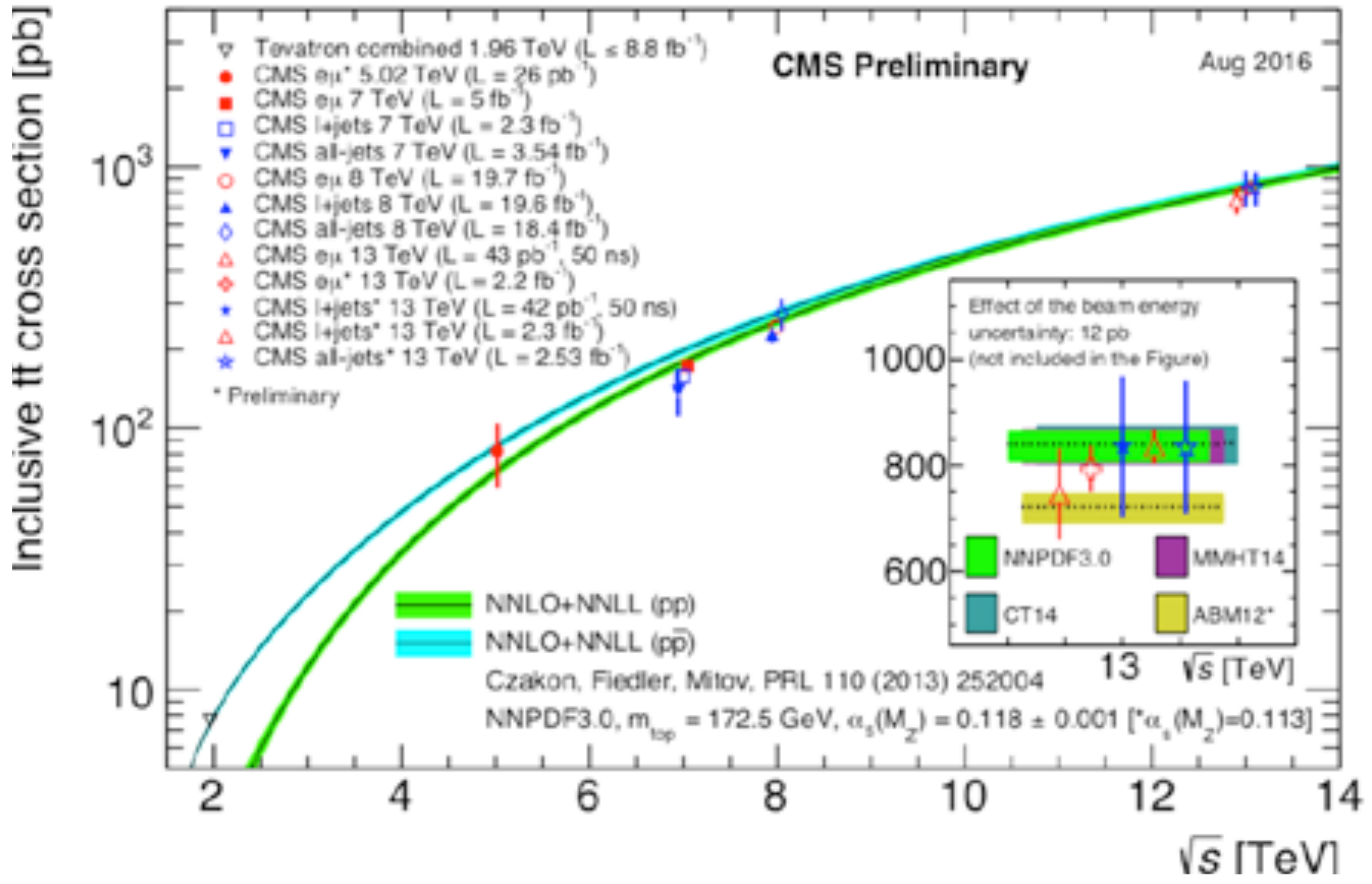


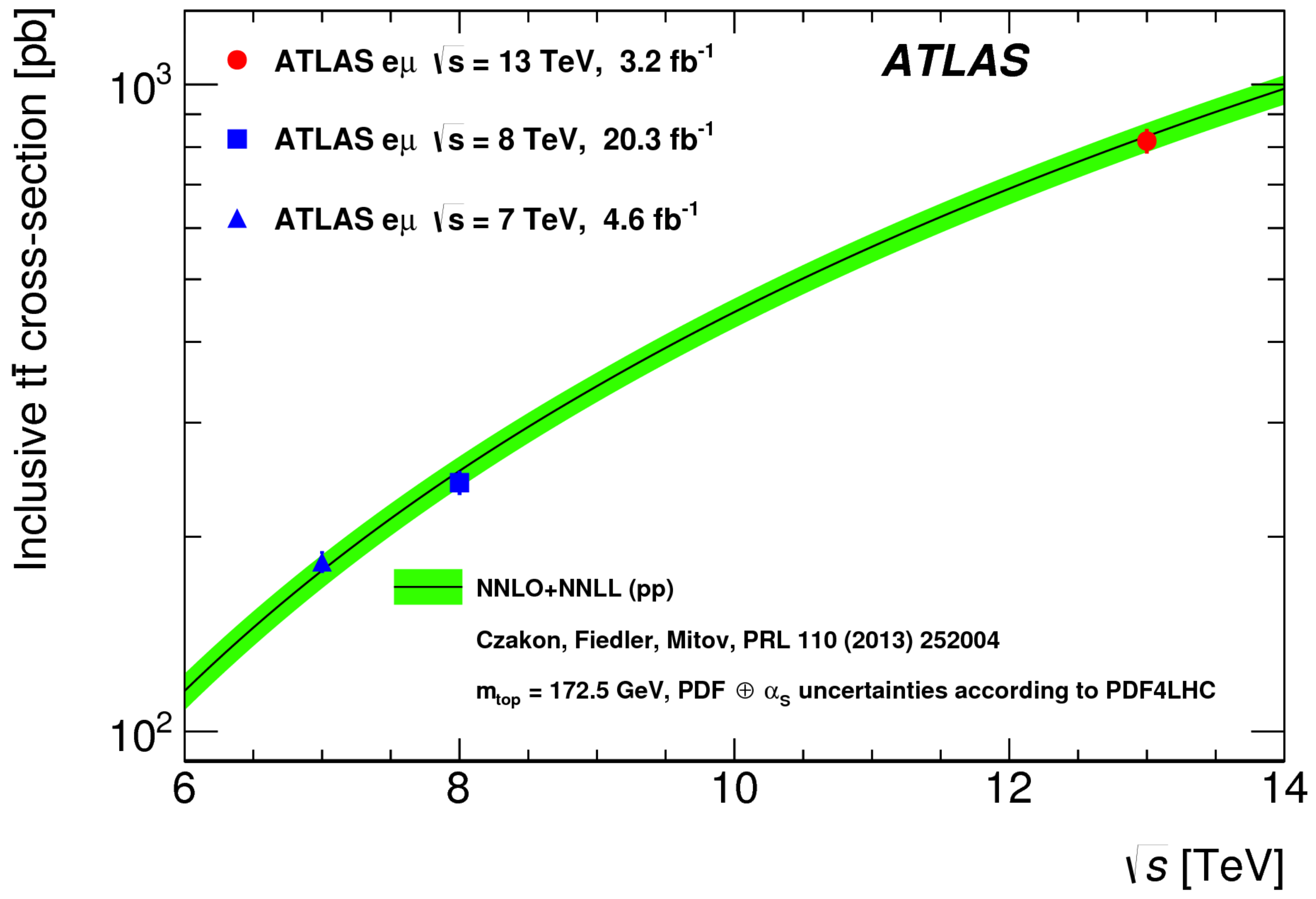
H→bb, i.e. the dominant decay remains an experimental challenge

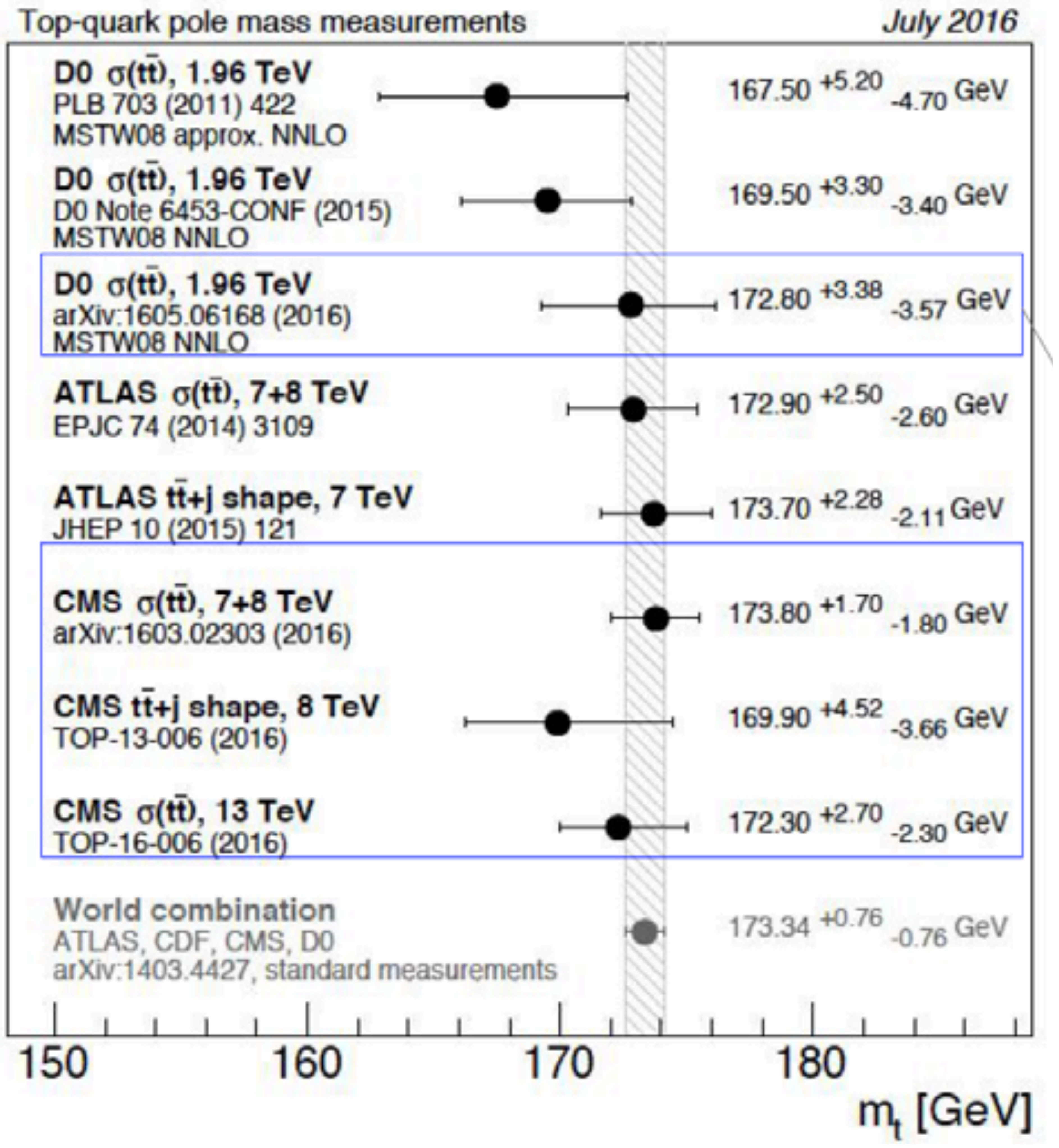


# Top Production

- Top cross and mass measurement are key ingredients in predictions for Physics beyond SM
- NNLO + NNLL calculations give excellent description of σ



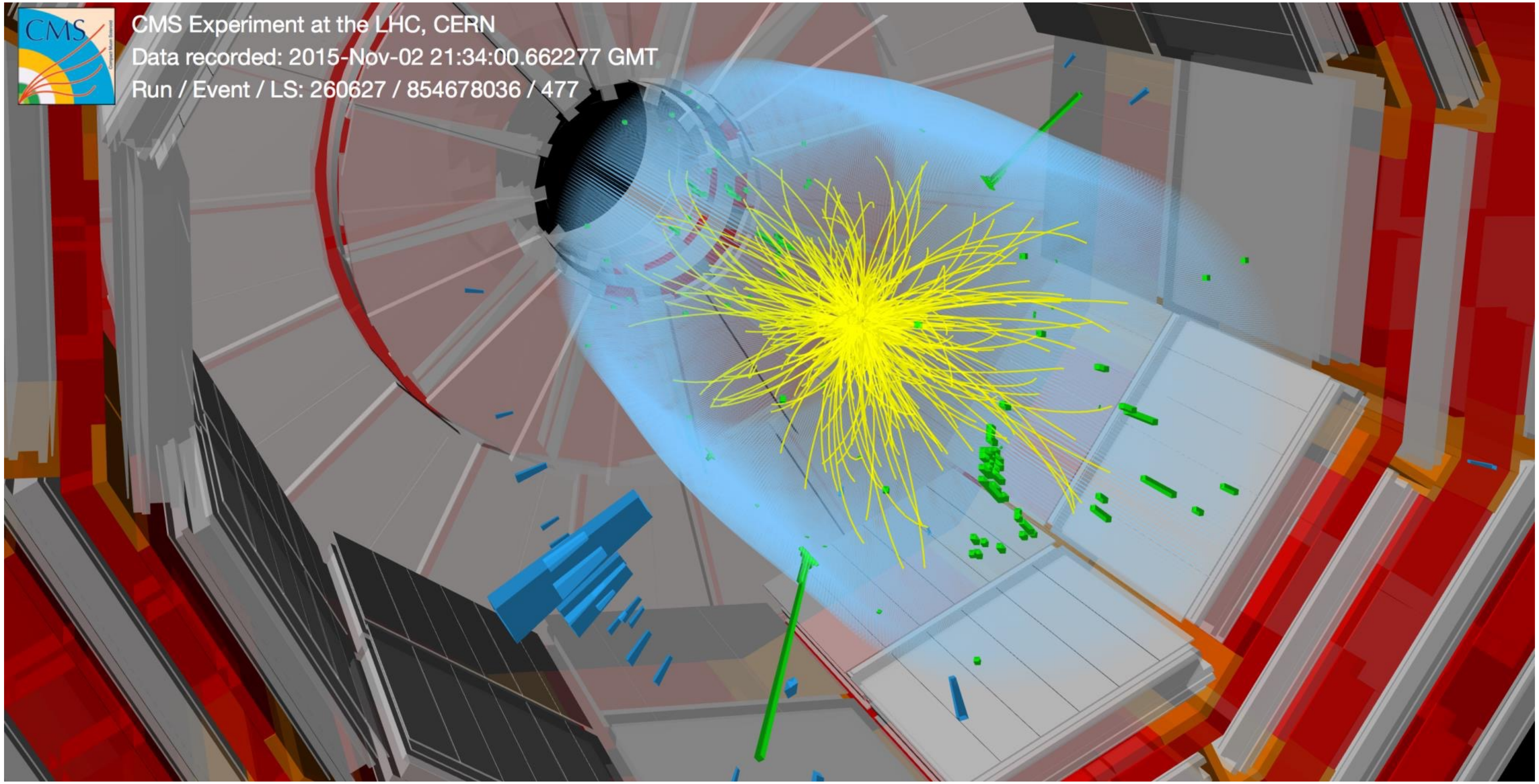




# Search for Diphoton resonances

CMS

$m_{\gamma\gamma}$=745 GeV

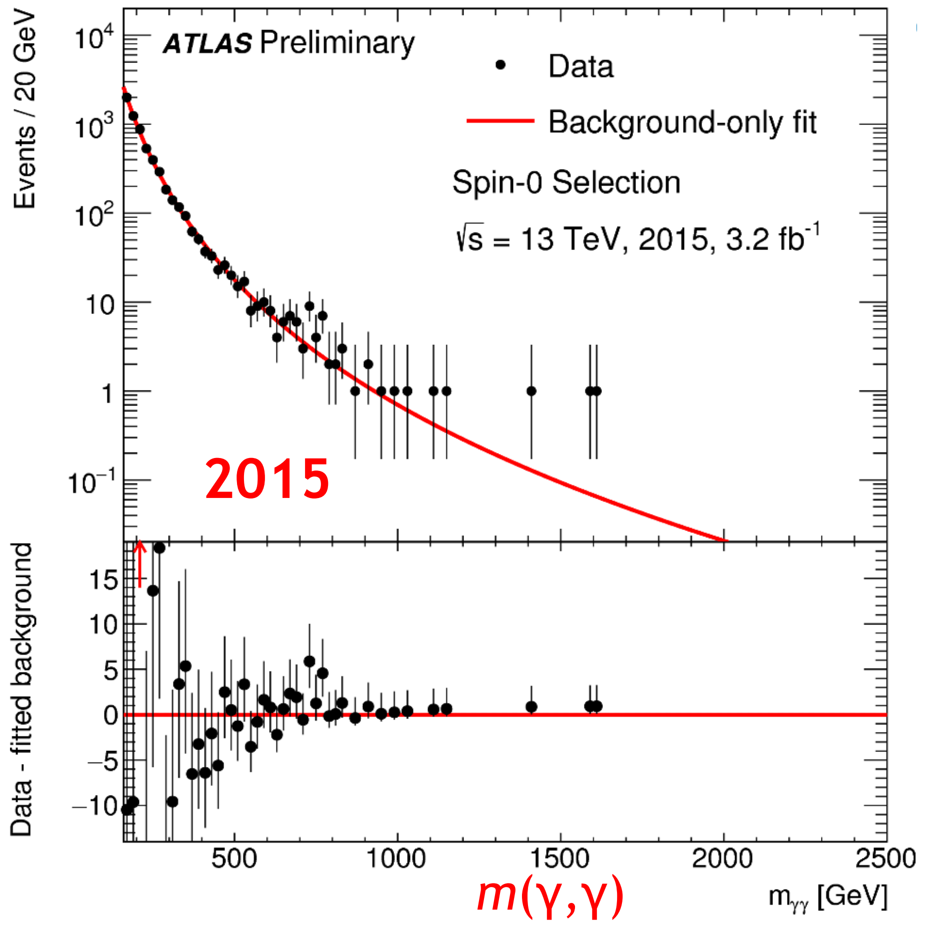


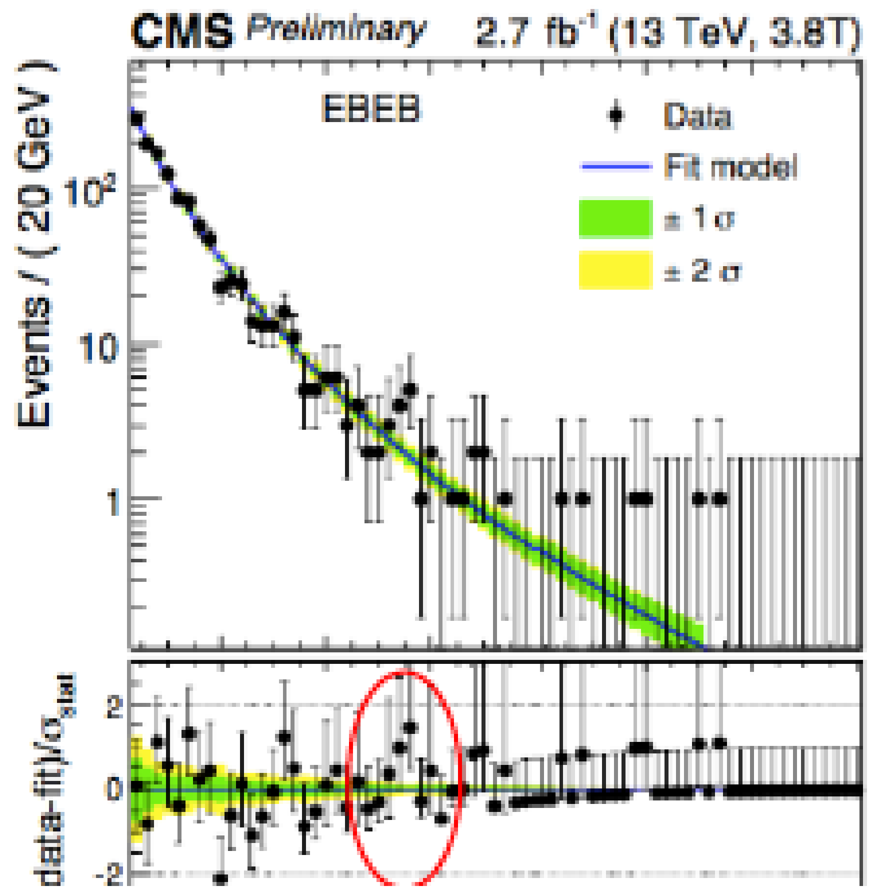
# Di-Photon Search

- Data of 2015 showed indications of excess at 730–750 GeV with a significance of ~2σ (global), ~3.5 σ (local)
- New data with much increased statistics do not show the enhancement
- Discussion spurred many theoretical discussions and exercised the flexibility of interpretation

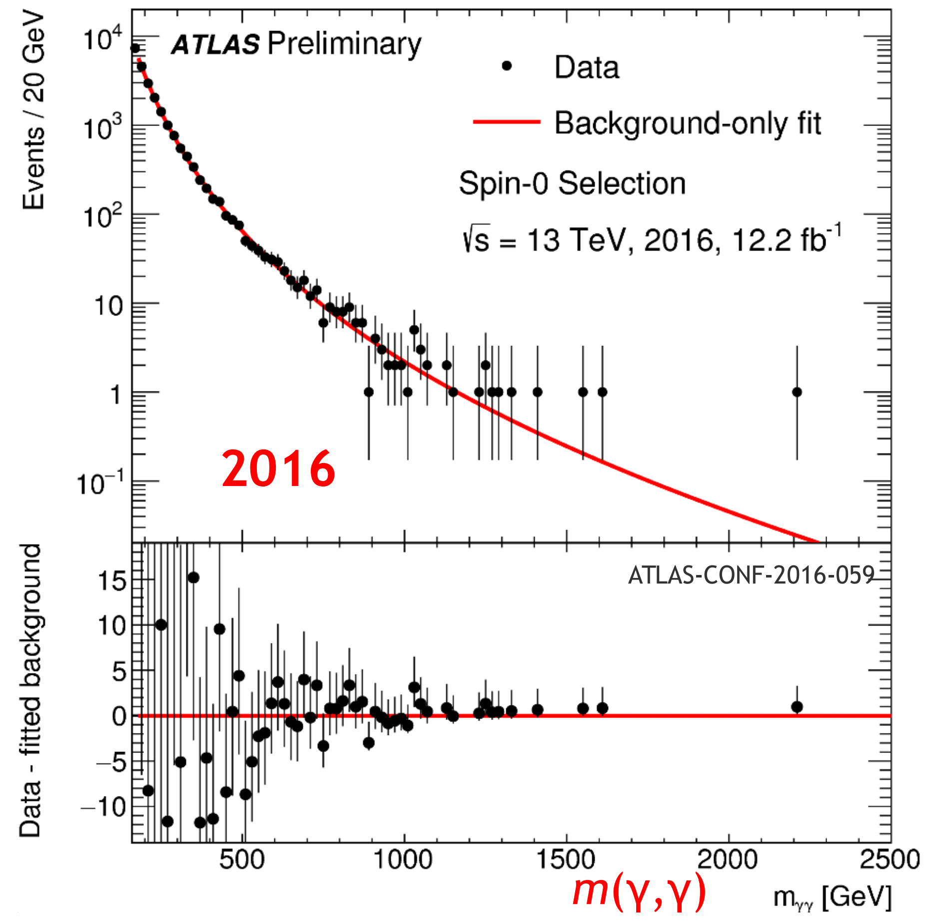
„750 GeV Thing“ was a statistical fluctuation

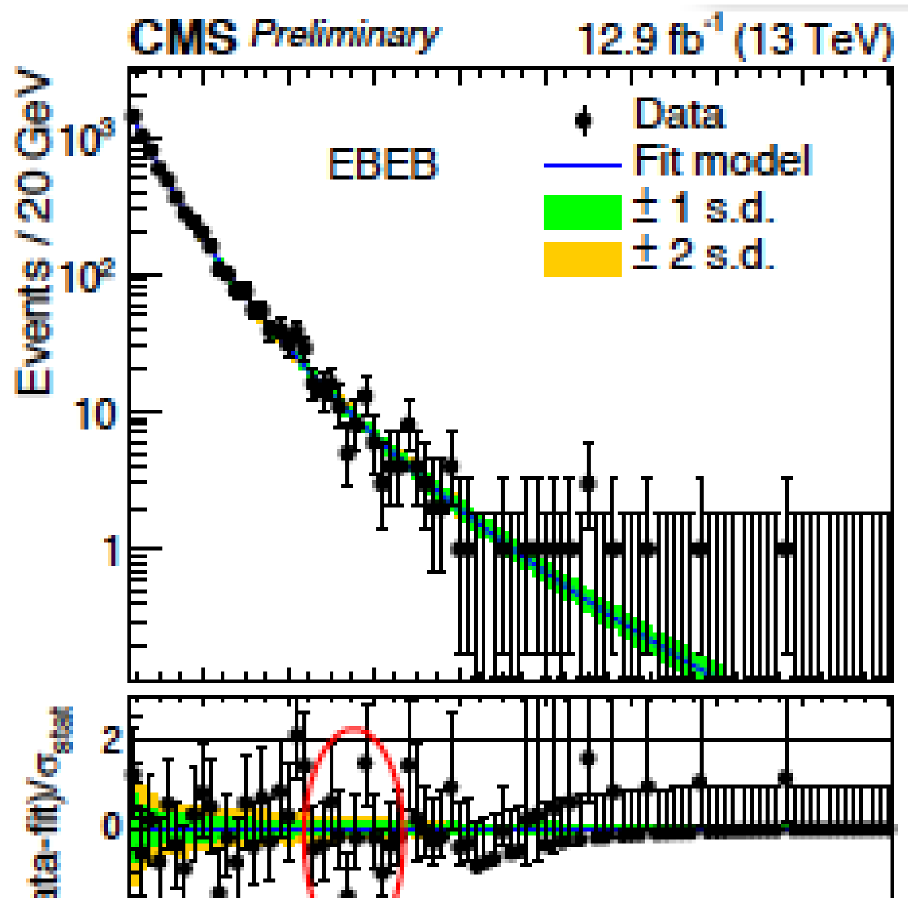
2015



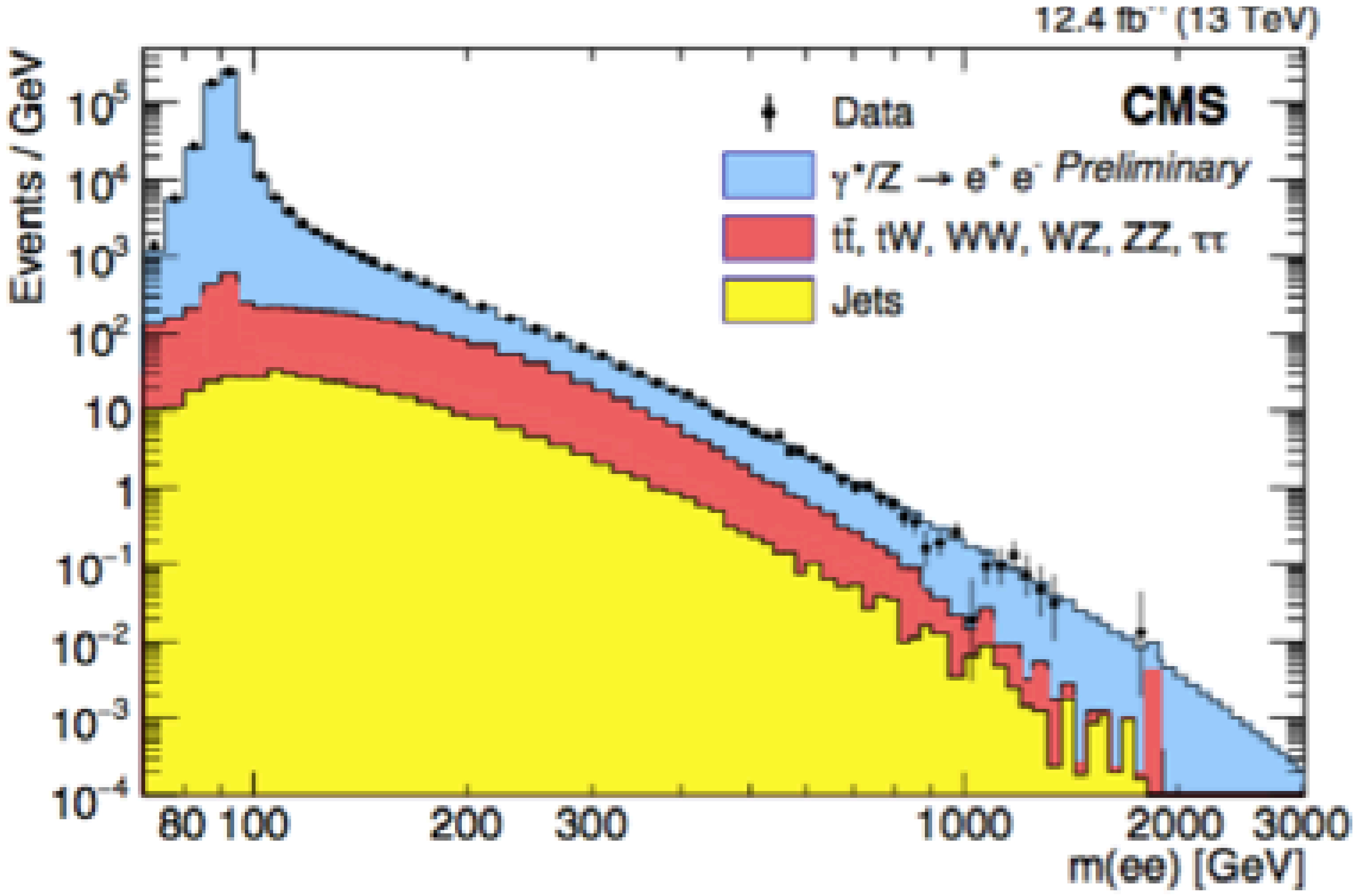


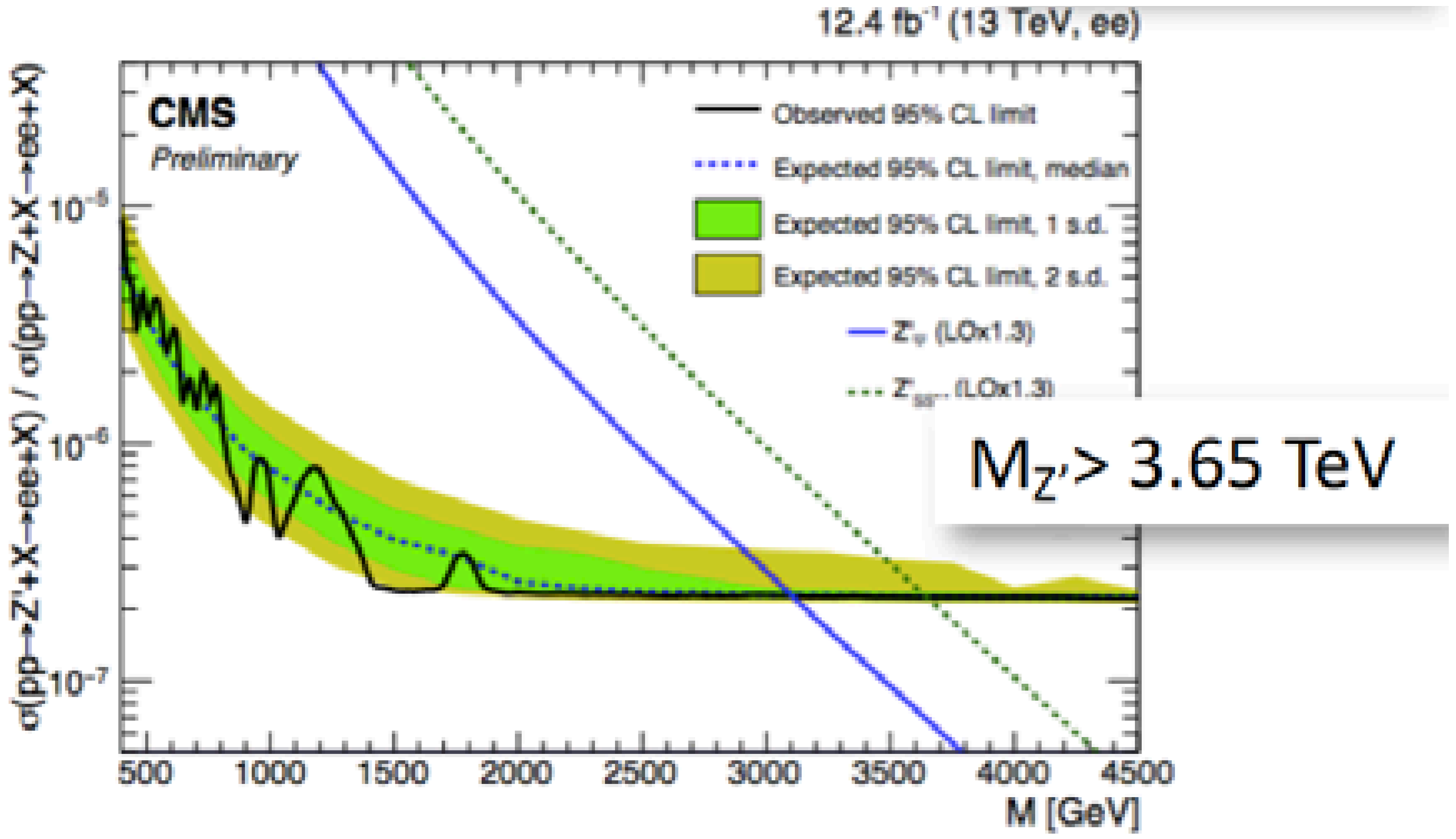
2016





# Search for di-lepton resonances

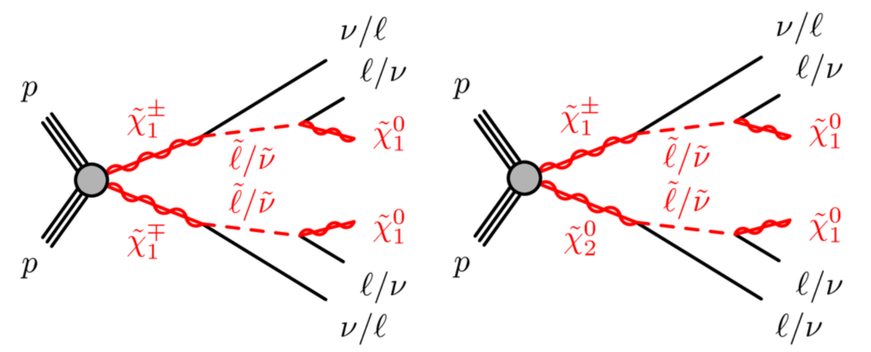


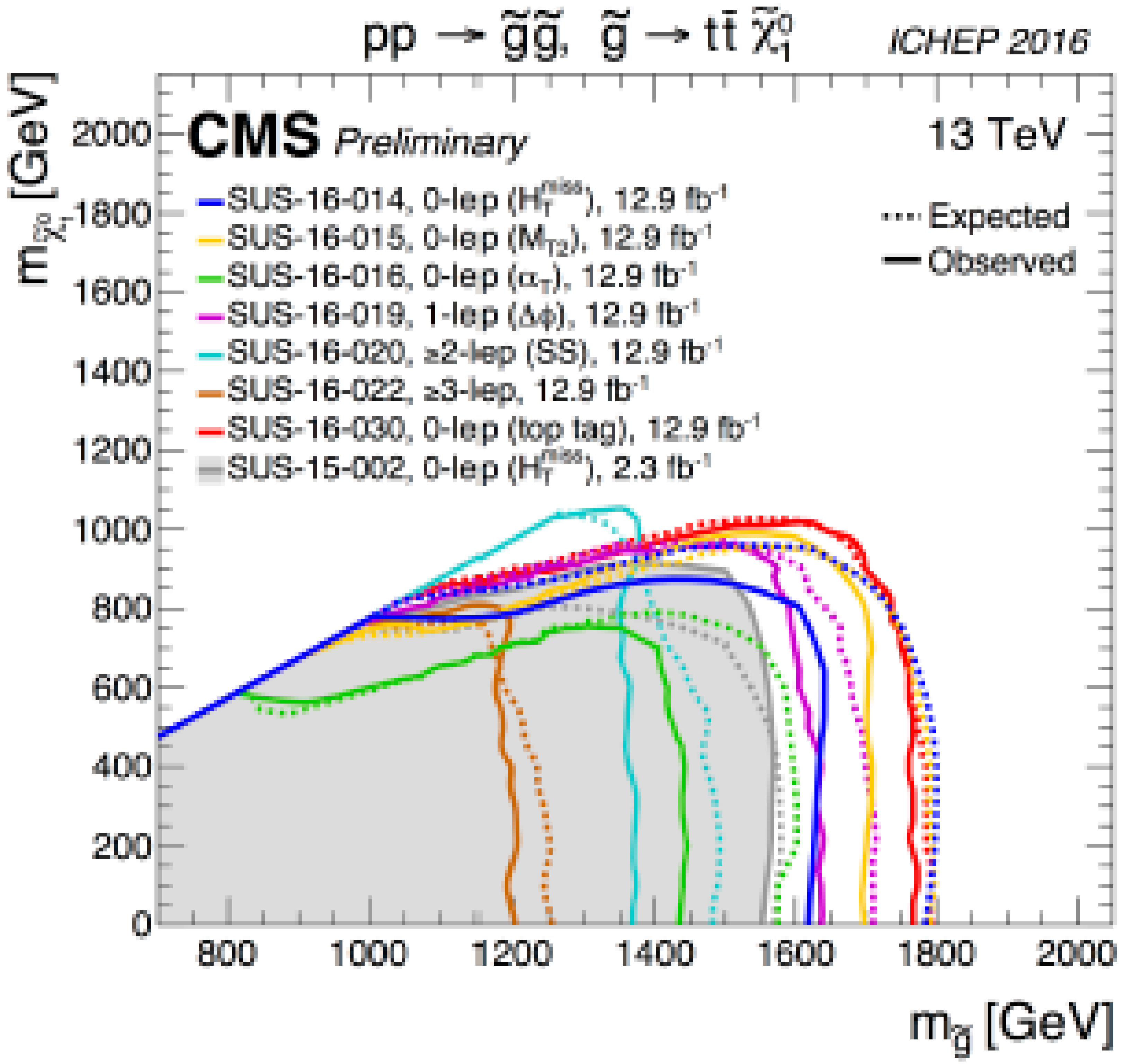


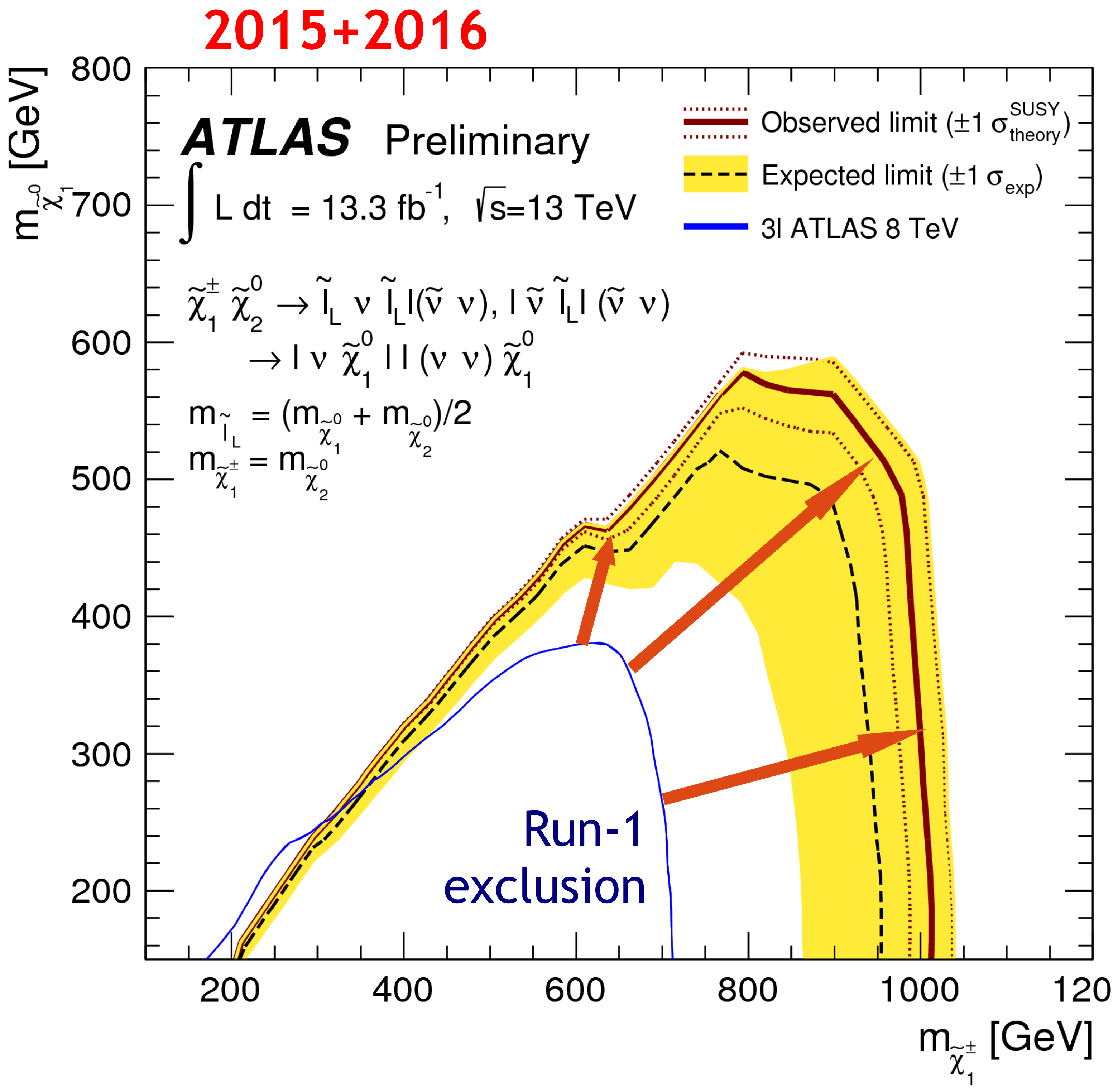
$M_{Z'} > 3.65$ TeV

# Search for Supersymmetry

- Limits extended into the TeV mass range for specific channels
  - huge step from Run 1 analyses

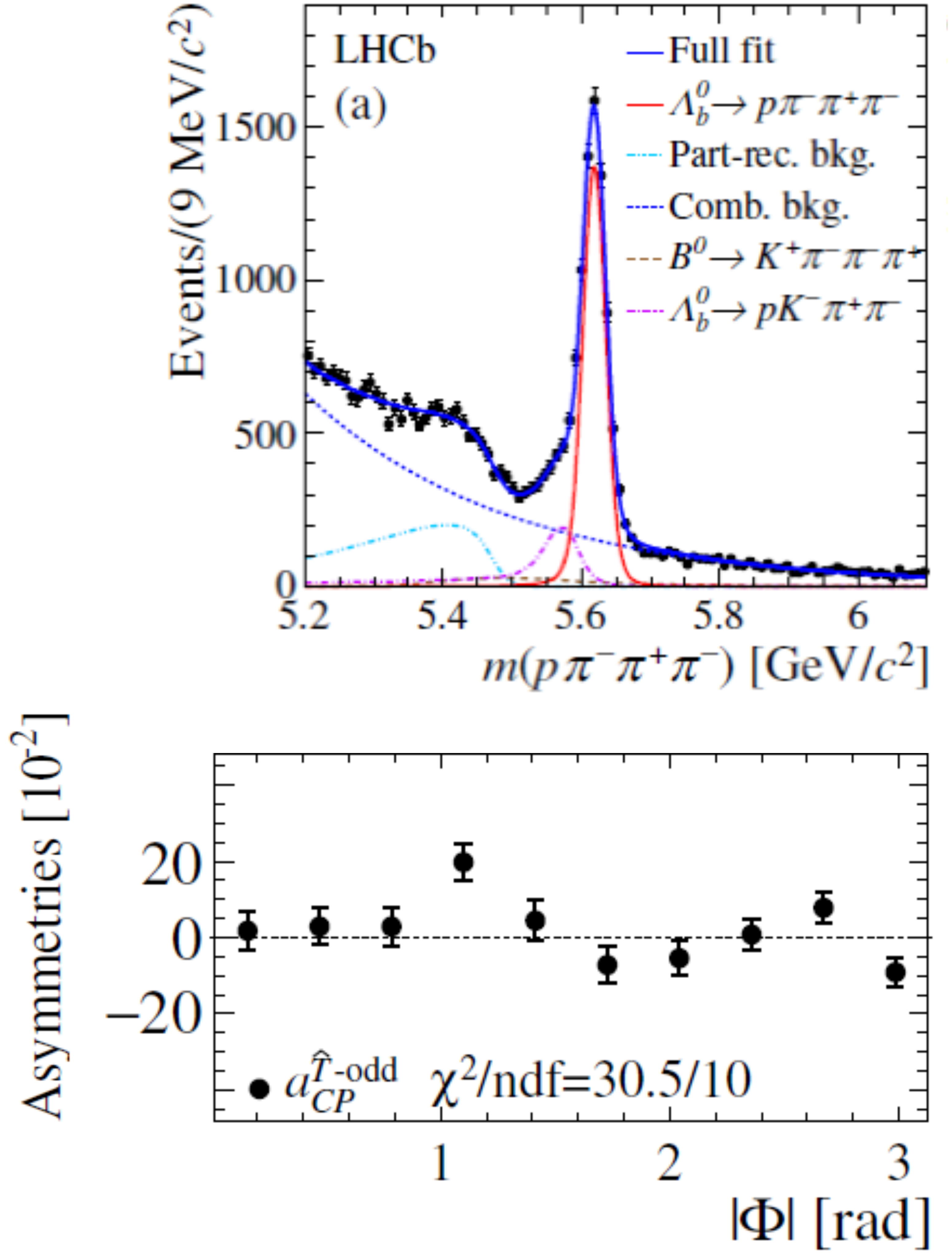






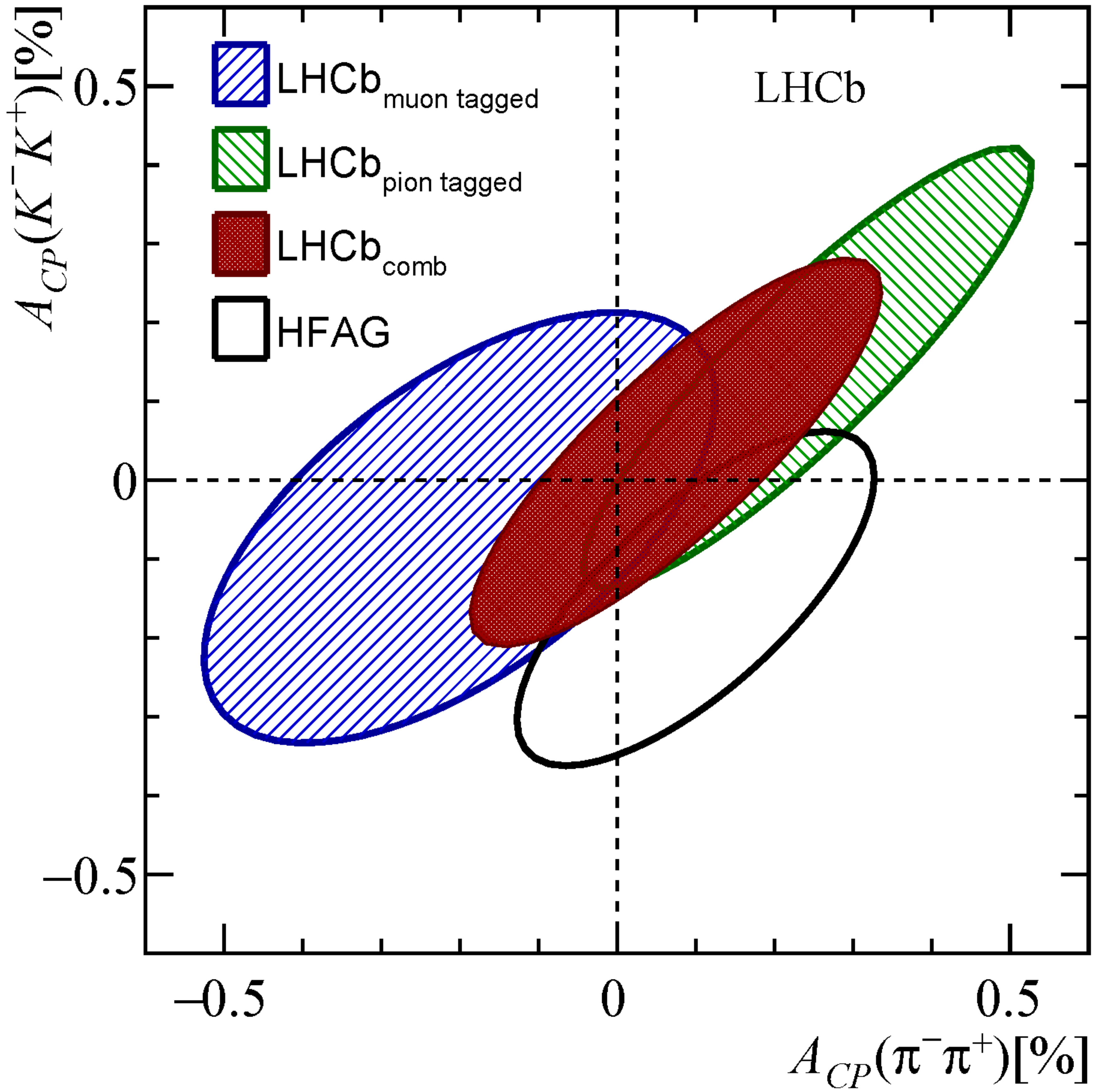
# Precision Physics from LHCb

- CP violation in $\Lambda_b$-decays?
  - Search for CP-violating asymmetries in decay angle distributions of final state
  - Observe CP violation with a significance of 3.3 σ
(First time observation in baryonic systems)



# CP Violation in Charm decays – LHCb

- Test can be done in direct or indirect (time dependent analysis) decays
    - Entering the $10^{-4}$ regime
    - Approaching sensitivity for measurement of expected CP violation in SM



$$\Delta A_{CP} = (-0.10 \pm 0.08\ (\text{stat}) \pm 0.03\ (\text{syst}))\ \%$$

# High-Luminosity LHC (HL-LHC)

- FP7 Design Study completed in 2015
  - first (short) 11 Tesla magnet operational
- HL-LHC now underway as a **project** at CERN
  - and recognised as a landmark on the ESFRI list 2016

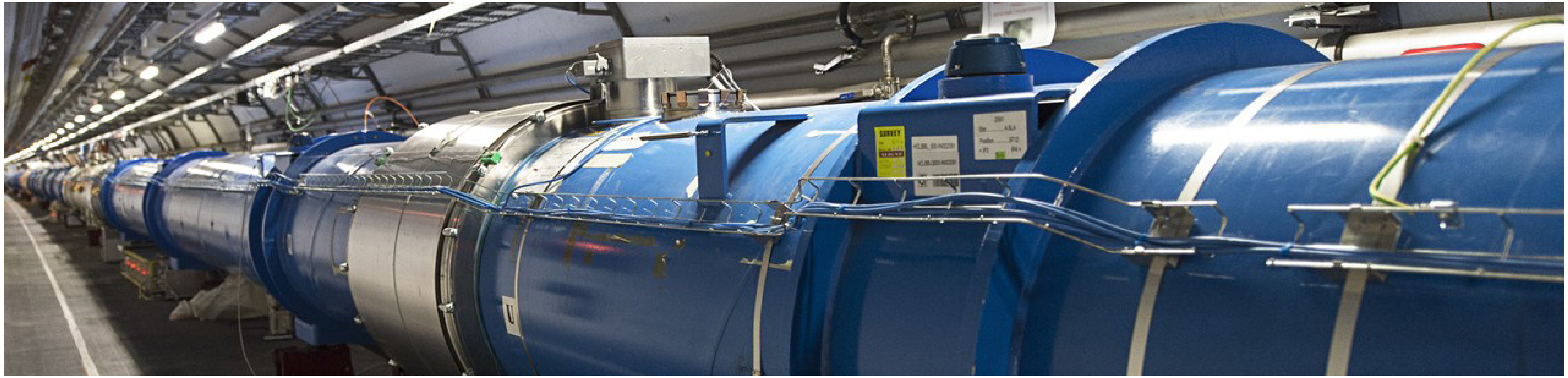
European Strategy Forum on Research Infrastructures ESFRI

STRATEGY REPORT ON RESEARCH INFRASTRUCTURES

P Projects

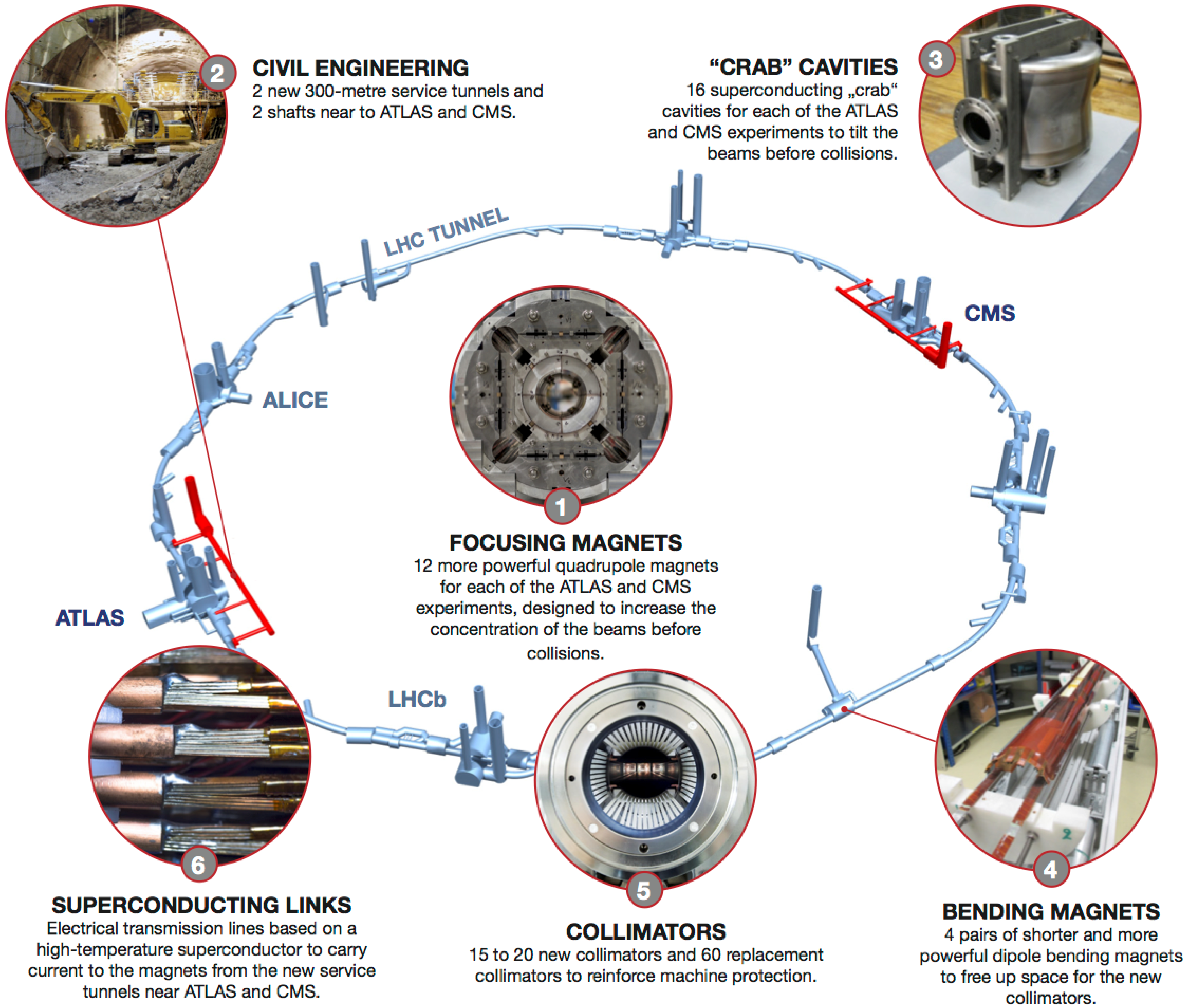
L Landmarks

ROADMAP 2016



# High-Luminosity LHC (HL-LHC)

- $5 \times 10^{34}$ cm$^{-2}$s$^{-1}$ levelled;
  i.e. factor 5 over design
    - to yield 3 ab$^{-1}$ by ~2035
- requires
    - focussing $\beta^{*}$=15 cm
    - crab crossing



**CIVIL ENGINEERING**
2 new 300-metre service tunnels and 2 shafts near to ATLAS and CMS.

**"CRAB" CAVITIES**
16 superconducting „crab" cavities for each of the ATLAS and CMS experiments to tilt the beams before collisions.

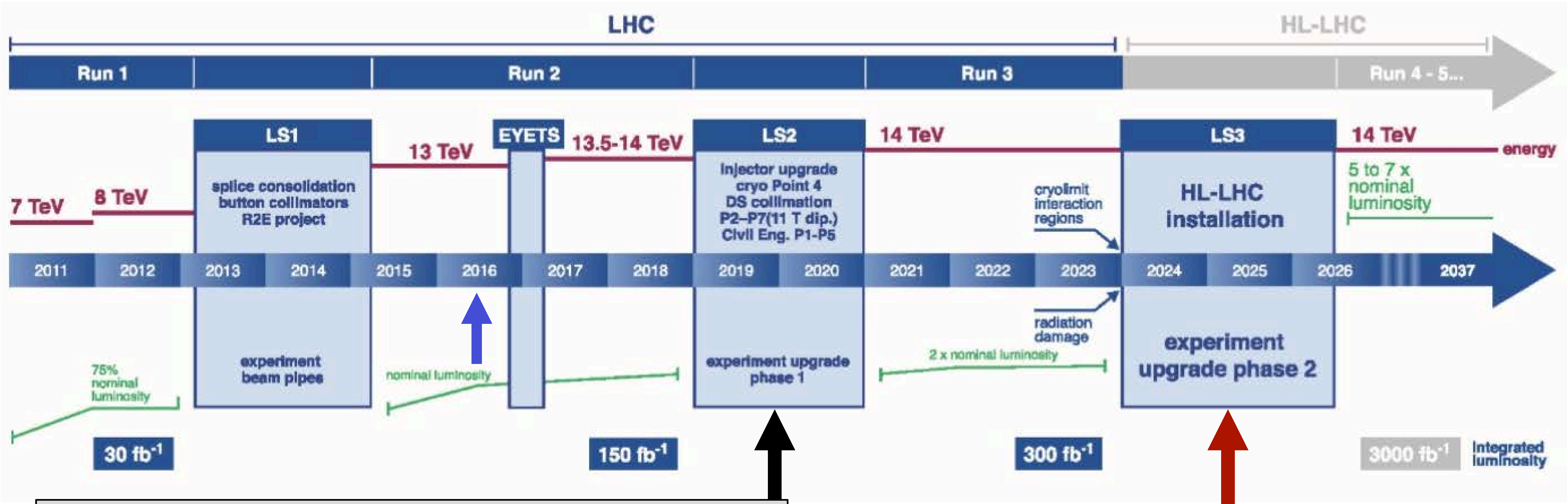
**FOCUSING MAGNETS**
12 more powerful quadrupole magnets for each of the ATLAS and CMS experiments, designed to increase the concentration of the beams before collisions.

**SUPERCONDUCTING LINKS**
Electrical transmission lines based on a high-temperature superconductor to carry current to the magnets from the new service tunnels near ATLAS and CMS.

**COLLIMATORS**
15 to 20 new collimators and 60 replacement collimators to reinforce machine protection.

**BENDING MAGNETS**
4 pairs of shorter and more powerful dipole bending magnets to free up space for the new collimators.

# HL-LHC schedule



LS2 (2019-2020):

- ☐ LHC Injectors Upgrade (LIU)
- ☐ Civil engineering for HL-LHC equipment P1,P5
- ☐ First 11 T dipoles P7; cryogenics in P4
- ☐ Phase-1 upgrade of LHC experiments

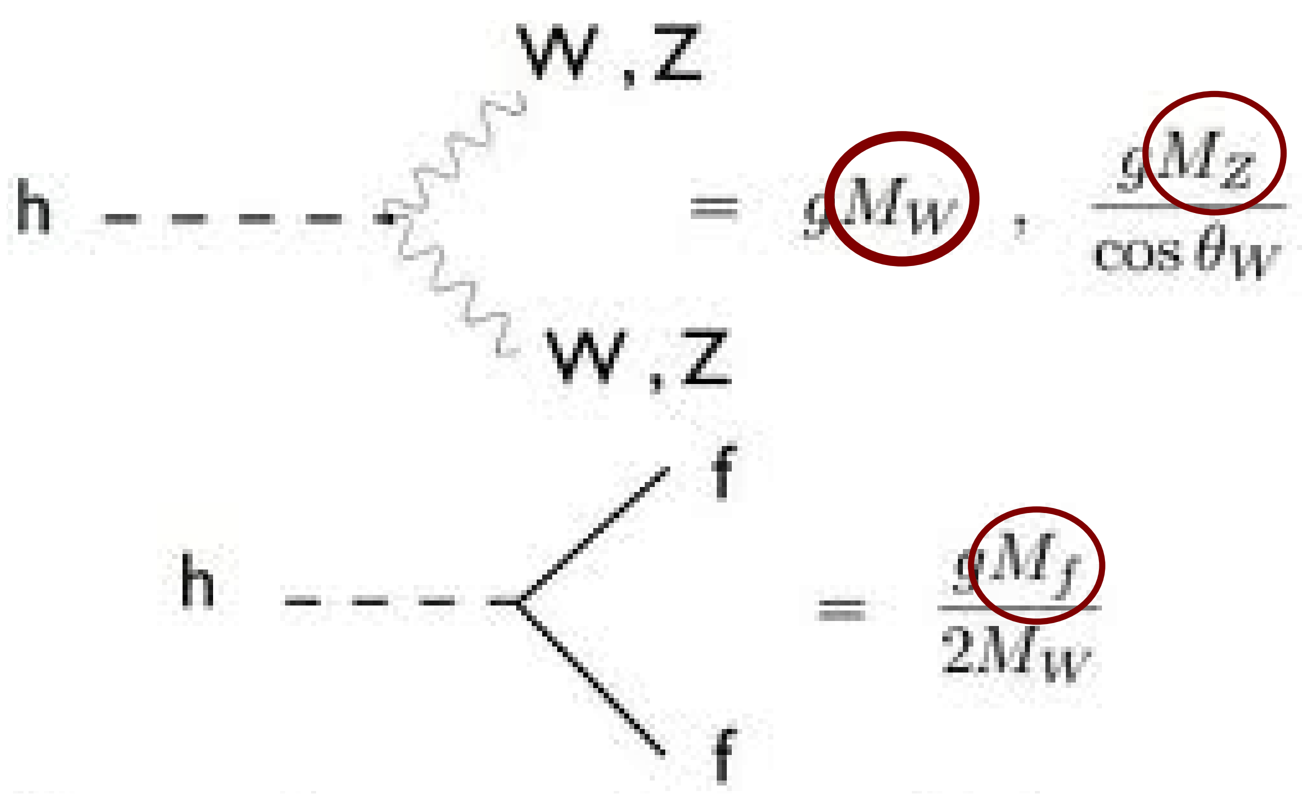
LS3 (2024-2026):

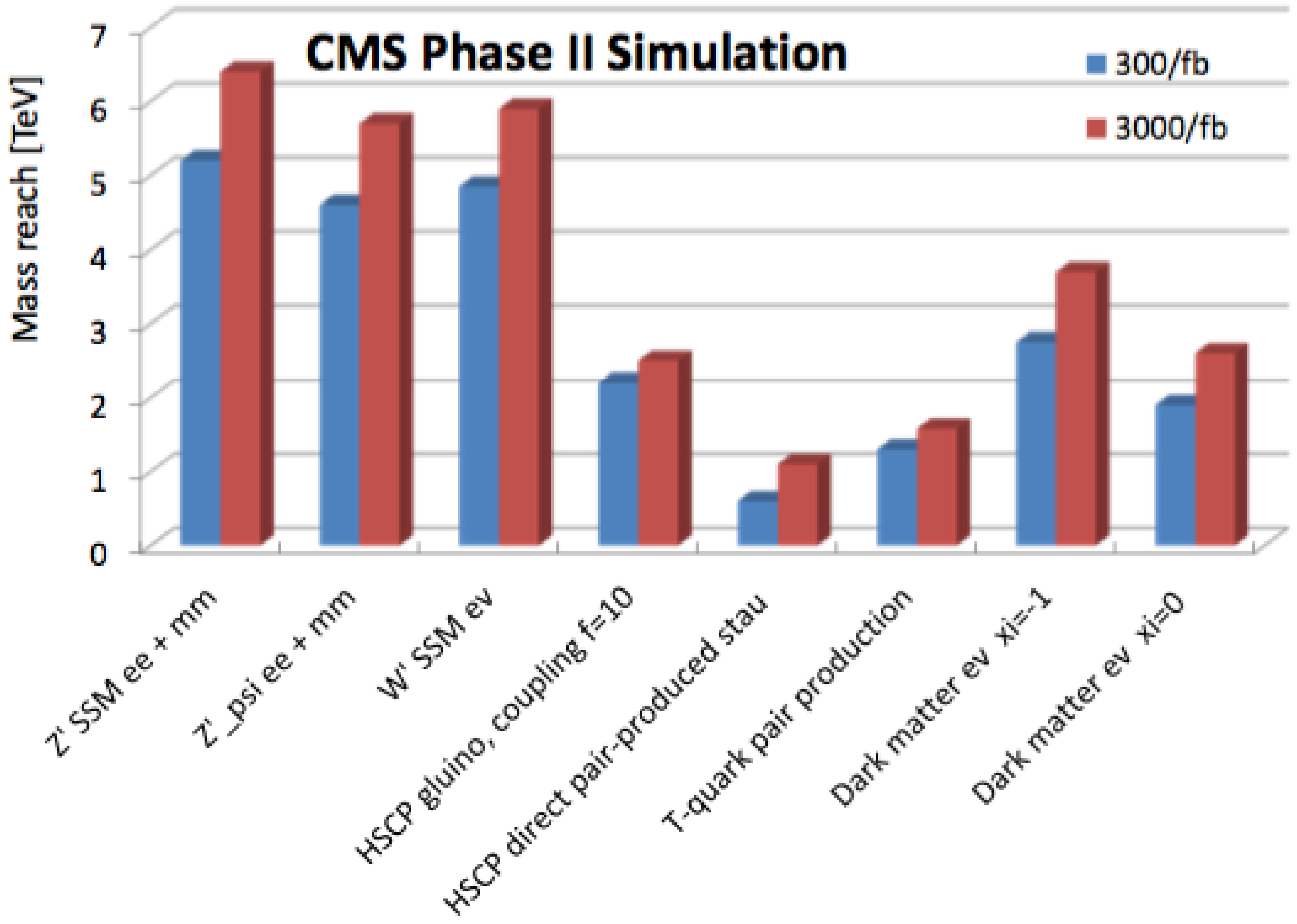
- ☐ **HL-LHC installation**
- ☐ Phase-2 upgrade of ATLAS and CMS

*Schedule driven by radiation damage
to inner triplet (eol: 2023)*

# Brief physics case for HL-LHC

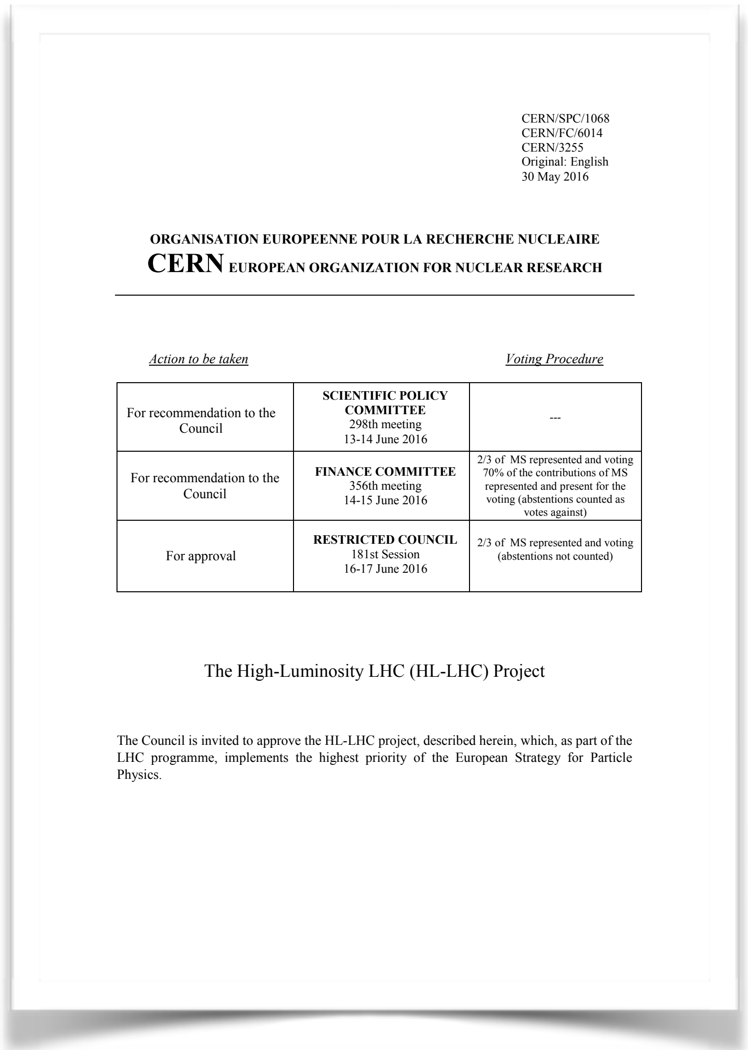
- measurement of Higgs couplings
  - deviations may be at the few %-level
  - access to second generation couplings H→μμ
- 20-30% larger discovery potential (8 TeV)
  - precision measurements





# News from Council

- HL-LHC has been approved in June 2016
  - as a technical project @ the cost of 950 MCHF
- MidTerm Plan 2017-2021 has been approved; cumulative budget deficit limited to 400 MCHF
  - the detailed funding for an EIB credit line has been approved in Sep 2016



CERN/SPC/1068
CERN/FC/6014
CERN/3255
Original: English
30 May 2016

ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE
CERN EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

| *Action to be taken* | | *Voting Procedure* |
|---|---|---|
| For recommendation to the Council | **SCIENTIFIC POLICY COMMITTEE**<br>298th meeting<br>13-14 June 2016 | --- |
| For recommendation to the Council | **FINANCE COMMITTEE**<br>356th meeting<br>14-15 June 2016 | 2/3 of MS represented and voting 70% of the contributions of MS represented and present for the voting (abstentions counted as votes against) |
| For approval | **RESTRICTED COUNCIL**<br>181st Session<br>16-17 June 2016 | 2/3 of MS represented and voting (abstentions not counted) |

The High-Luminosity LHC (HL-LHC) Project

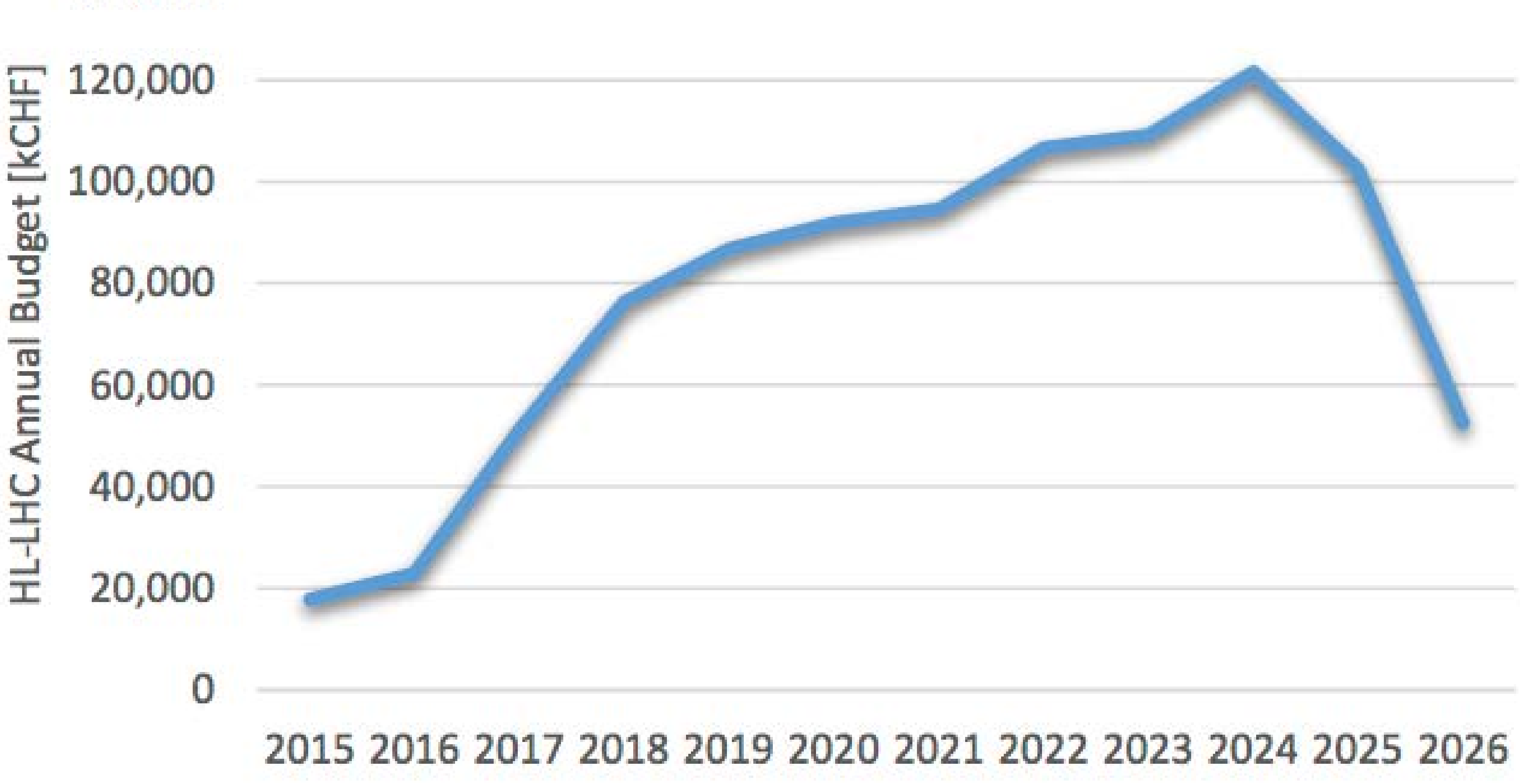
The Council is invited to approve the HL-LHC project, described herein, which, as part of the LHC programme, implements the highest priority of the European Strategy for Particle Physics.

The High-Luminosity LHC Project

Abstract

The scientific case for a luminosity upgrade of the Large Hadron Collider (High-Luminosity LHC, HL-LHC) is presented. It includes measurements of the Higgs boson properties with unprecedented precision and increased potential in the search for new physics. Construction is expected to be completed by the mid-twenties, and by the mid-thirties the HL-LHC should have provided a tenfold increase in the integrated luminosities recorded by the experiments. Main upgrade components include new-technology supercoducting magnets and current leads. The cost of the collider upgrade, which will be realised within a constant CERN Budget, is estimated to be 950 MCHF. The main technical challenges, as well as the ongoing R&D work and the main milestones of the implementation plan, are described.

3 | Page



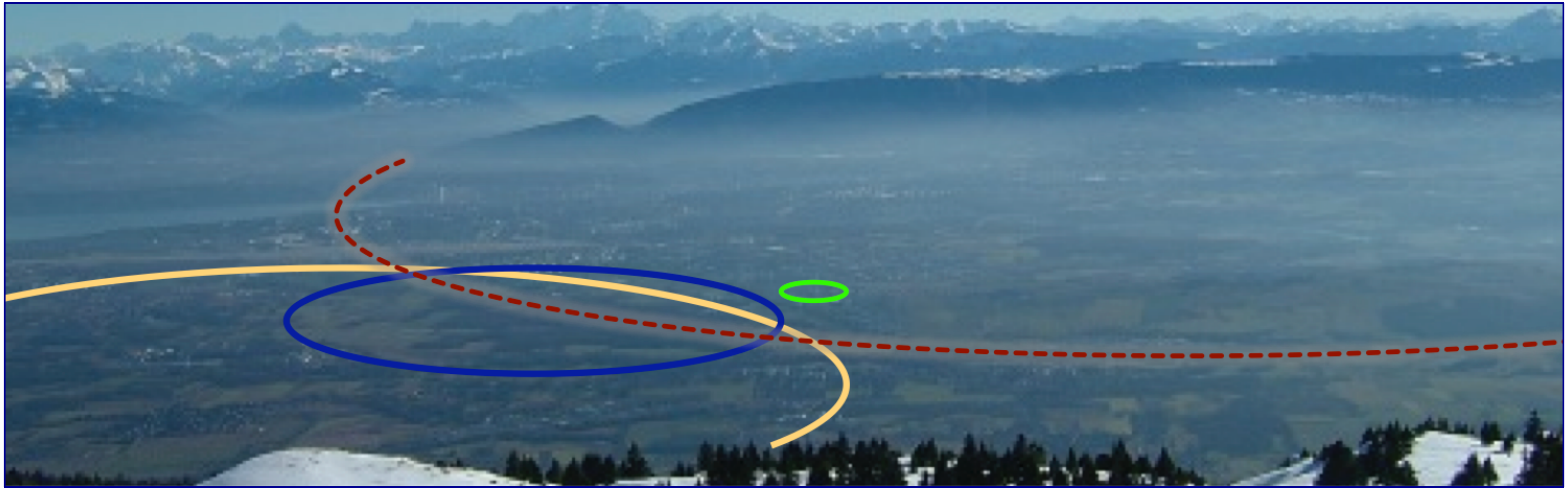
# *Energy Frontier*

- To stay at the forefront of particle physics, Europe needs to be in a position to propose an ambitious post-LHC accelerator project at CERN by the time of the next Strategy update, when physics results from the LHC running at 14 TeV will be available.

  *CERN should undertake design studies for accelerator projects in a global context, with emphasis on proton-proton and electron- positron high-energy frontier machines. These design studies should be coupled to a vigorous accelerator R&D programme, including high-field magnets and high-gradient accelerating structures, in collaboration with national institutes, laboratories and universities worldwide.*

# Highest energy hadron colliders

# Future Circular Collider FCC



- European Design Study
- ~100 TeV pp in a ~100 km ring

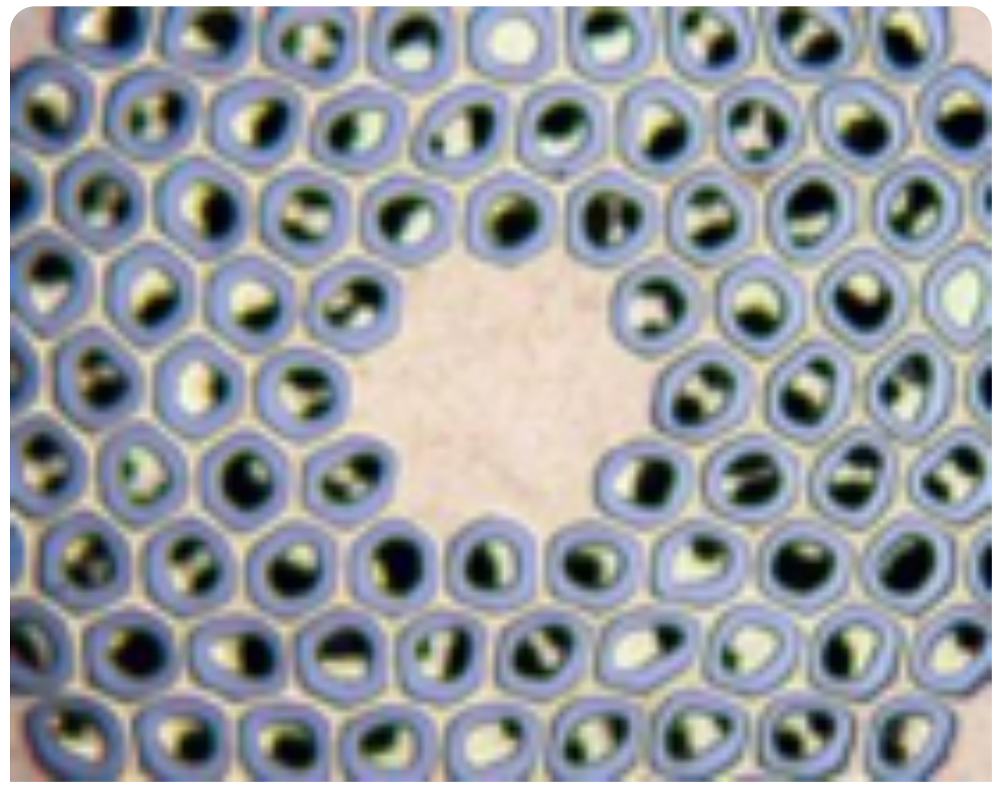
# High-field magnets

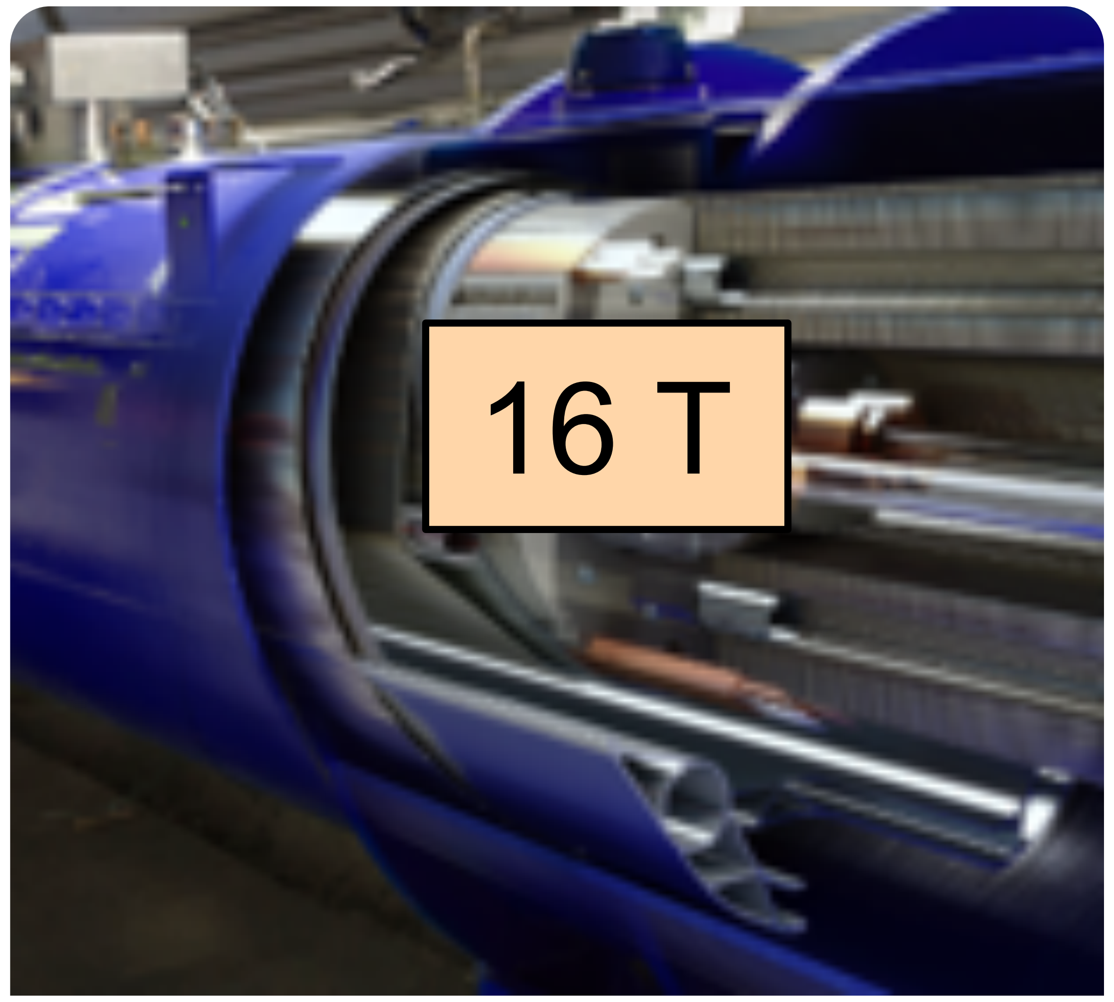
- Key to high energies
  - FCC and
  - HE-LHC = use of high field magnets in existing LHC ring

  - $Nb_3Sn$ may lead to ~16 T magnets
    - HL-LHC magnets provide a ~1.2 km test of the technology
  - an insert of HTS may increase field to 20 T

# Magnet R&D

- LHC: nominal 8.3 T; exercise 9 T (being studied)
- HL-LHC:
  - 11 T dipoles in dispersion suppression collimators
  - 12-13 T low-$\beta$ quadrupoles ATLAS and CMS IR's

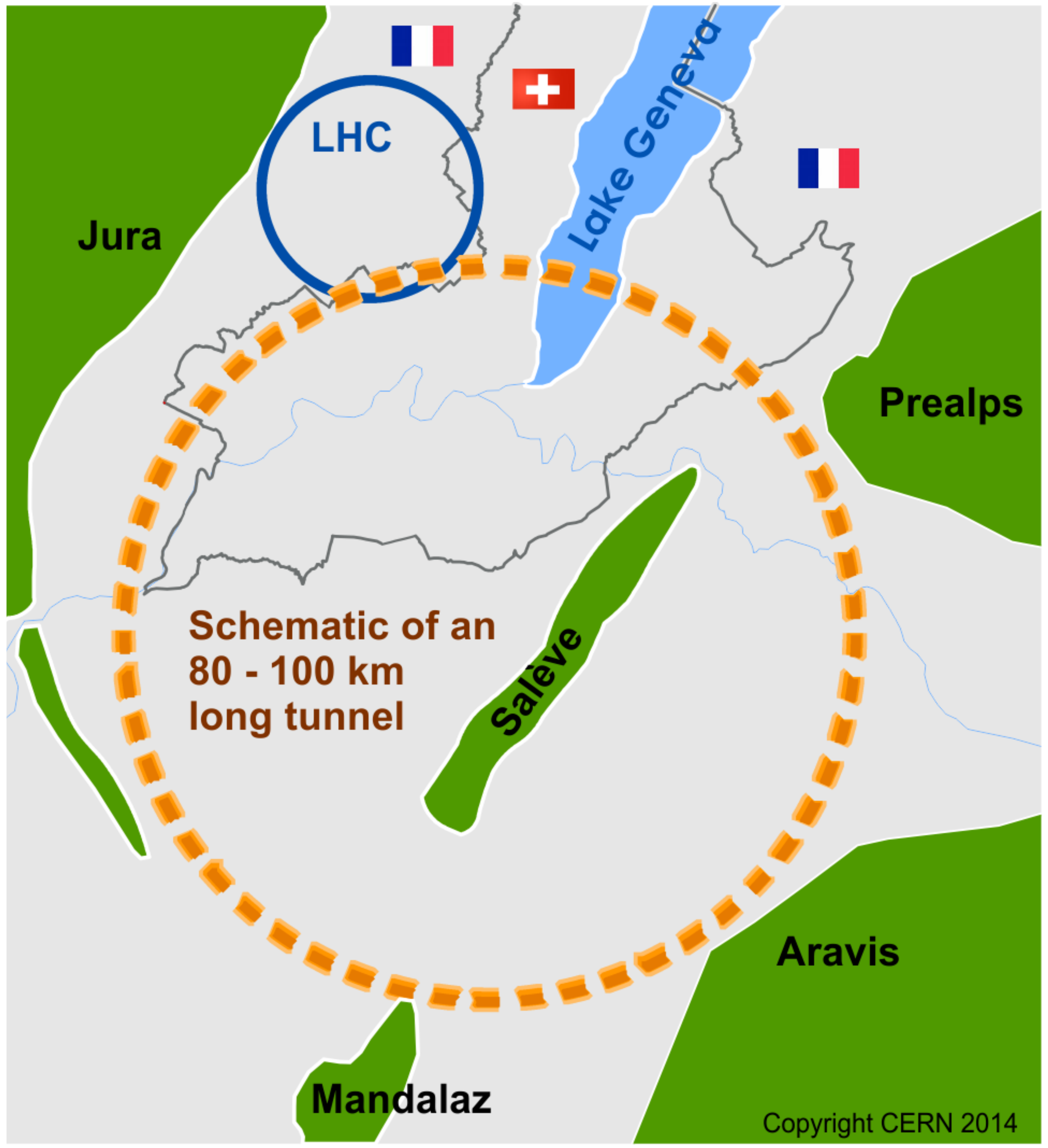




Dec 2015: 2 in 1 dipole of 1.8 m length reaches nominal 11.3 T.

# Conceptual Design Report by end 2018

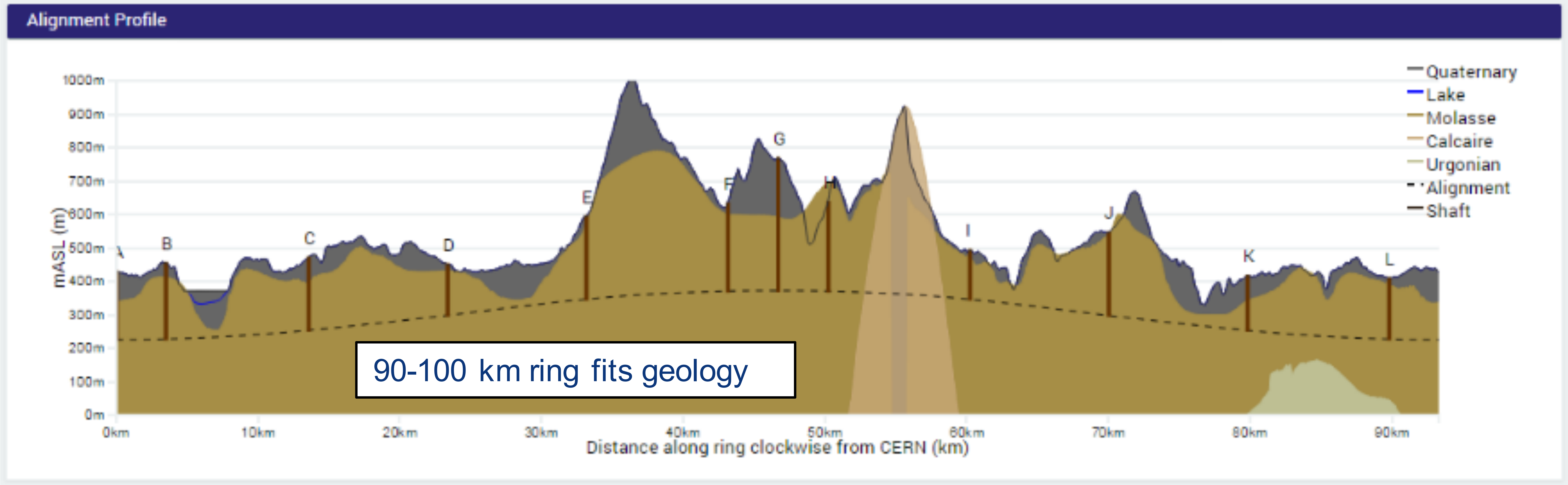
- **pp-Collider (FCC-hh) – sets the boundary conditions**
  - **100 km ring, $\sqrt{s}$=100 TeV, L~2x$10^{35}$**
  - **HE-LHC is included (~28 TeV)**
- $e^+e^-$-Collider as a possible first step
  - $\sqrt{s}$= 90 - 350 GeV,
    L~1.3x$10^{34}$ at high E
- eh-Collider as an option
  - $\sqrt{s}$=3.5 TeV, L~$10^{34}$



Copyright CERN 2014

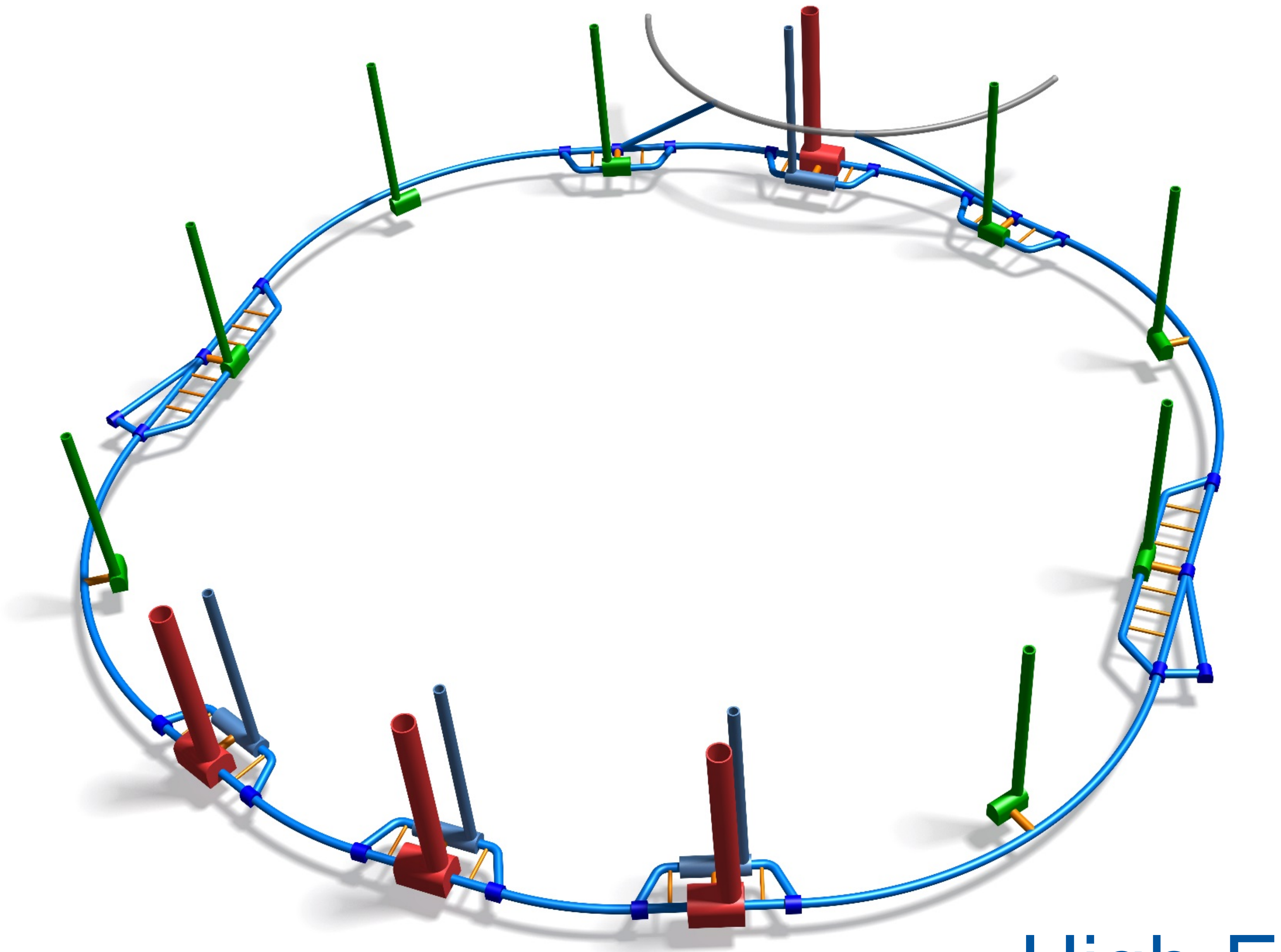
# Site investigations @ CERN

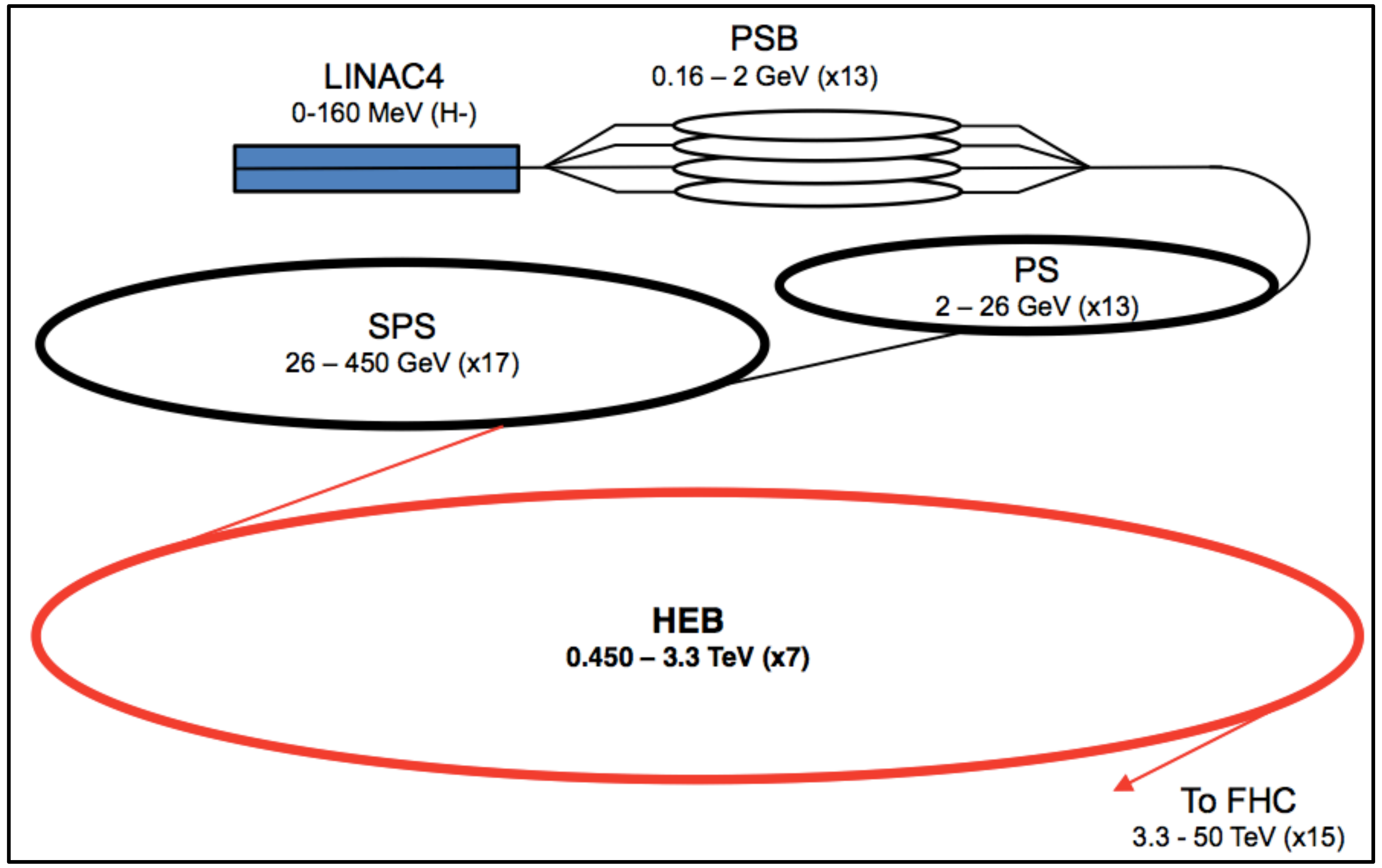
- Studies are site independent. – FCC@CERN benefits from existing infrastructure.



90-100 km ring fits geology

# 3-D Model and Injectors @ CERN





High-Energy Booster (HEB) is "refurbished" LHC

– New power converters to achieve fast ramp (50 A/s)

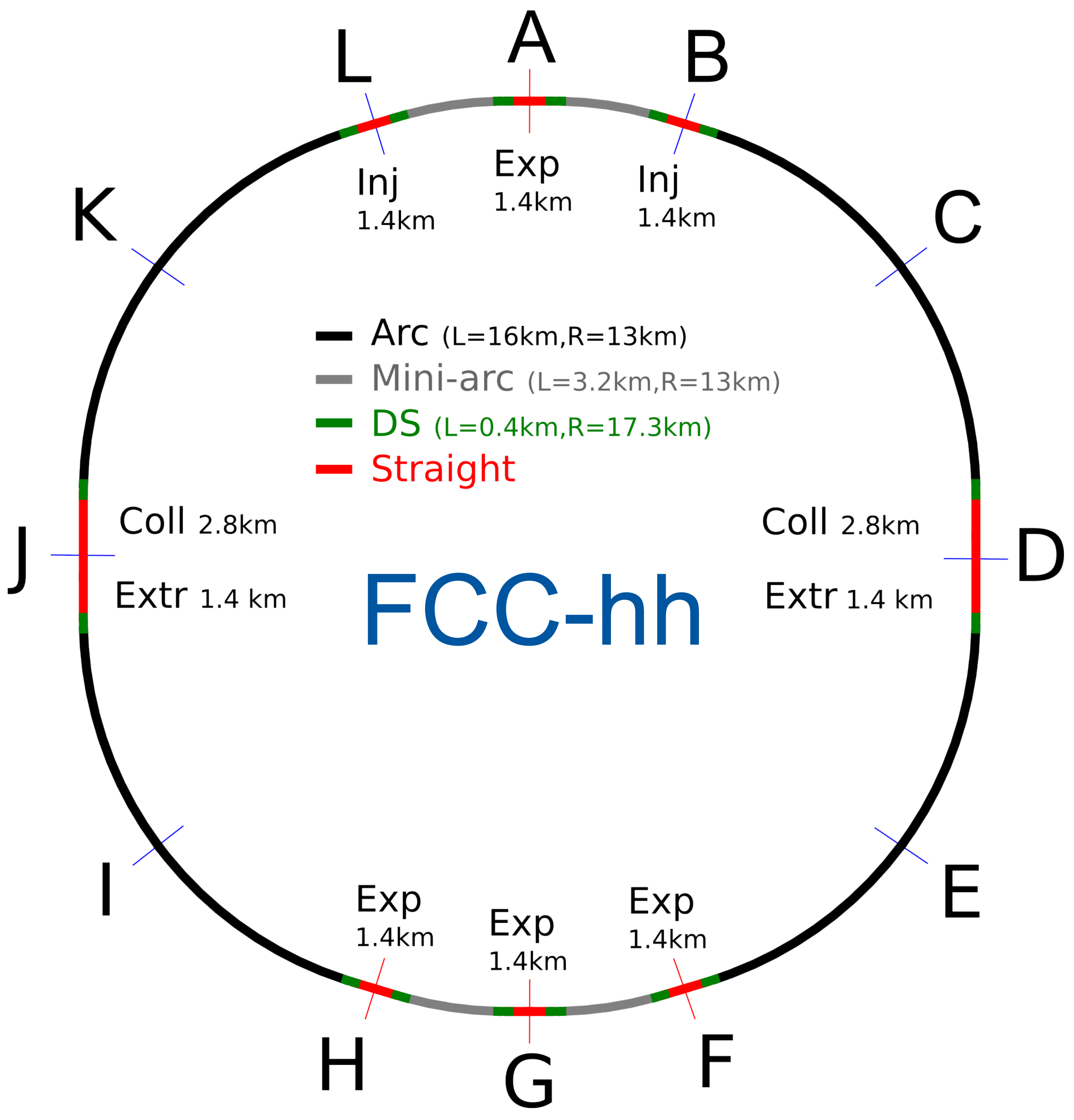
– Resulting filling time 30 mins

# FCC-hh Parameters

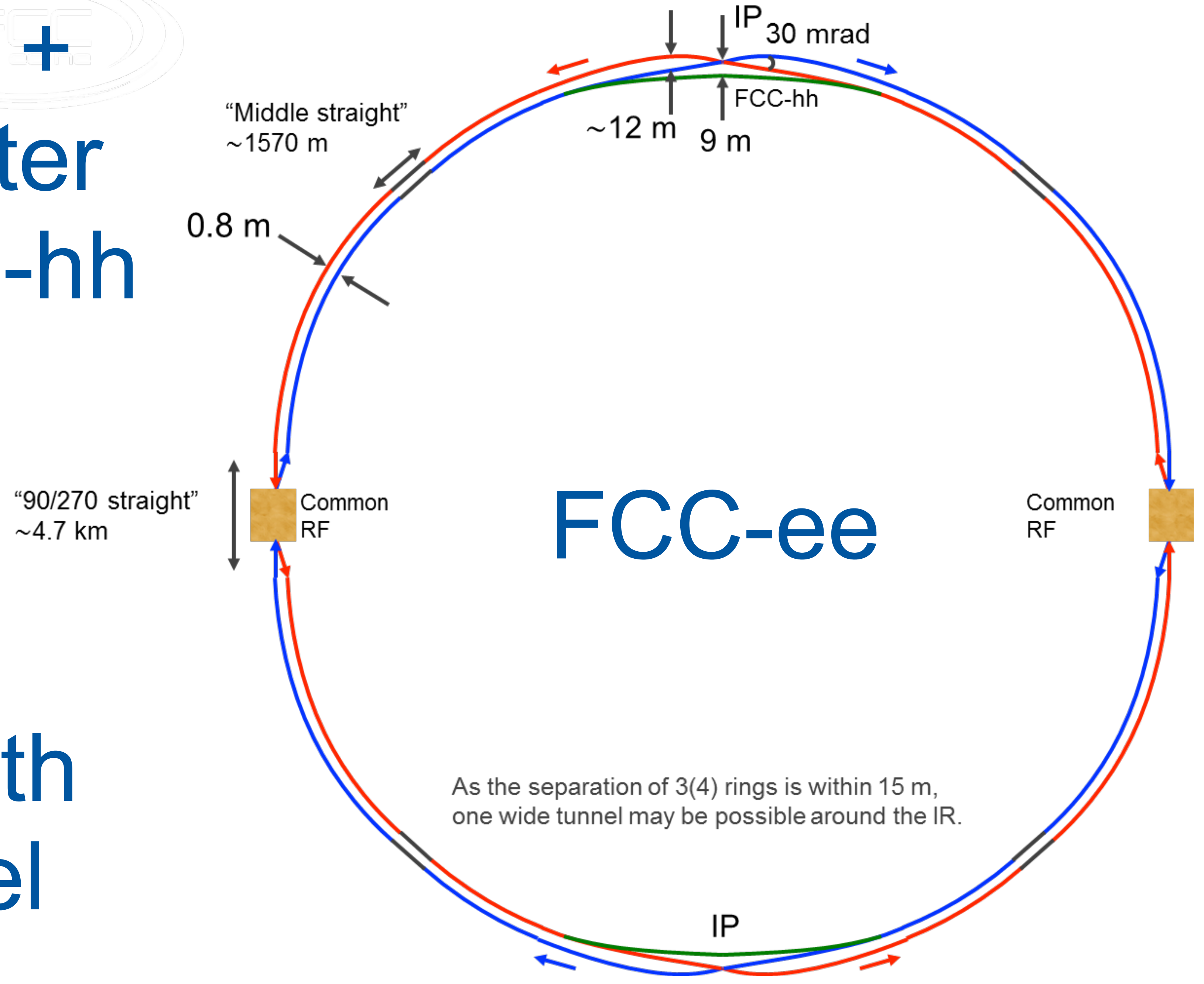
| Parameter | FCC-hh | | SppC | LHC | HL LHC |
|---|---|---|---|---|---|
| collision energy cms [TeV] | 100 | | 71.2 | 14 | |
| dipole field [T] | 16 | | 20 | 8.3 | |
| # IP | 2 main + 2 | | 2 | 2 main + 2 | |
| bunch intensity $[10^{11}]$ | 1 | 1 (0.2) | 2 | 1.1 | 2.2 |
| bunch spacing [ns] | 25 | 25 (5) | 25 | 25 | 25 |
| luminosity/Ip [$10^{34}$ cm$^{-2}$s$^{-1}$] | 5 | ~25 | 12 | 1 | 5 |
| events/bunch crossing | 170 | ~850 (170) | 400 | 27 | 135 |
| stored energy/beam [GJ] | 8.4 | | 6.6 | 0.36 | 0.7 |
| E-loss/turn<br>synchrotron radiation/beam | 5 MeV<br>3 MW | | 2 MeV<br>5.8 MW | 7 keV<br>5.4 kW | 7 keV<br>9.5 kW |

# Layout of FCC-hh and FCC-ee

- Closed orbit solution now available for both machines.



**2 rings + 1 booster in FCC-hh tunnel**



**FCC-ee compatible** with **FCC-pp** tunnel layout

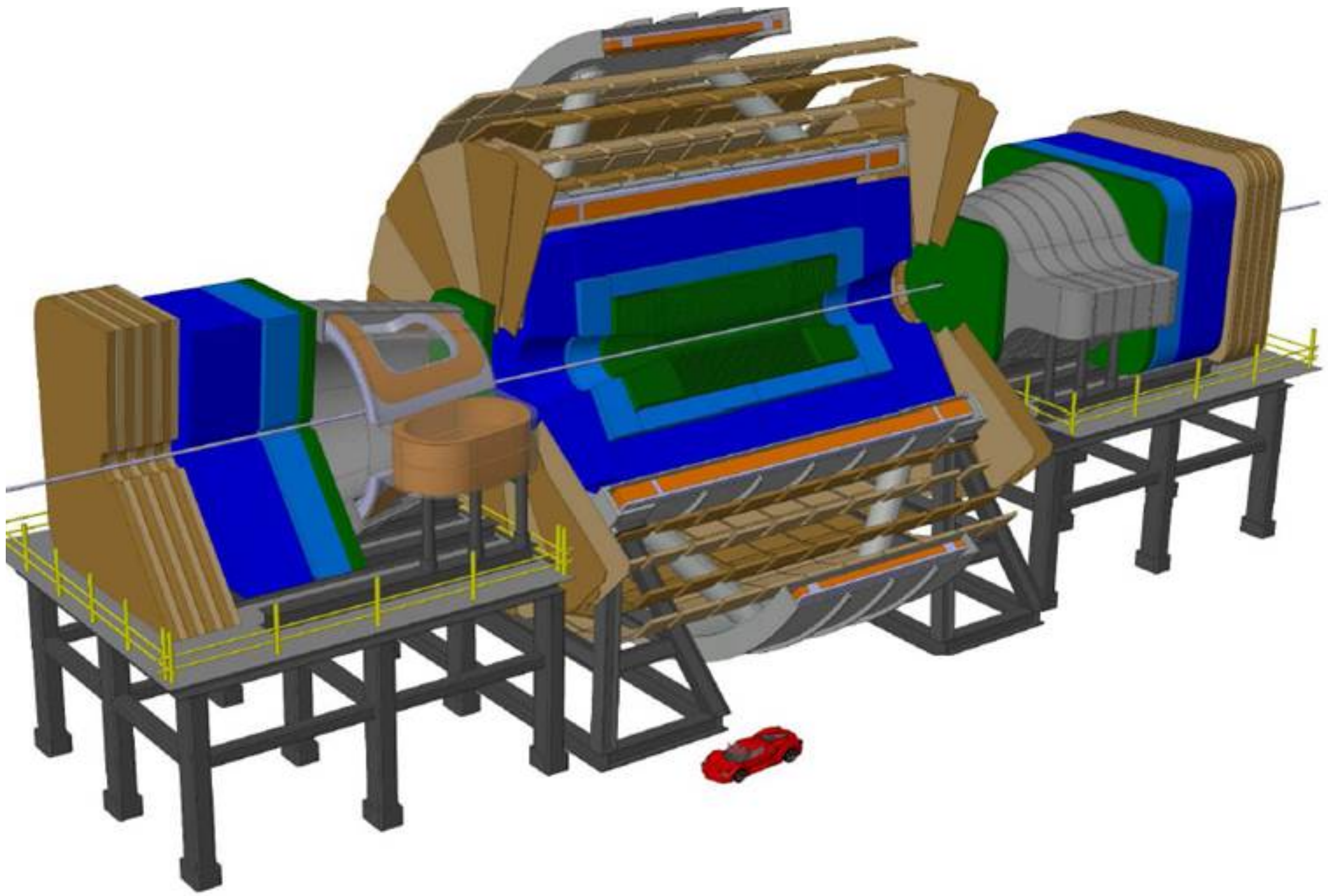
# Circular Lepton Colliders

| parameter | FCC-ee | | | CepC | LEP2 |
|---|---|---|---|---|---|
| **energy/beam [GeV]** | **45** | **120** | **175** | **120** | 105 |
| bunches/beam | 90000 | 770 | 78 | 50 | 4 |
| beam current [mA] | 1450 | 30 | 6.6 | 16.6 | 3 |
| **luminosity/IP x $10^{34}$ cm$^{-2}$s$^{-1}$** | **70** | **5** | **1.3** | **2.0** | 0.0012 |
| energy loss/turn [GeV] | 0.03 | 1.67 | 7.55 | 3.1 | 3.34 |
| **synchrotron power [MW]** | **100** | | | **103** | 22 |
| RF voltage [GV] | 0.08 | 3.0 | 10 | 6.9 | 3.5 |

FCC-ee
- 2 rings
- 2 IP with crab waist

CepC (China)
– 1 ring with possible double ring sections

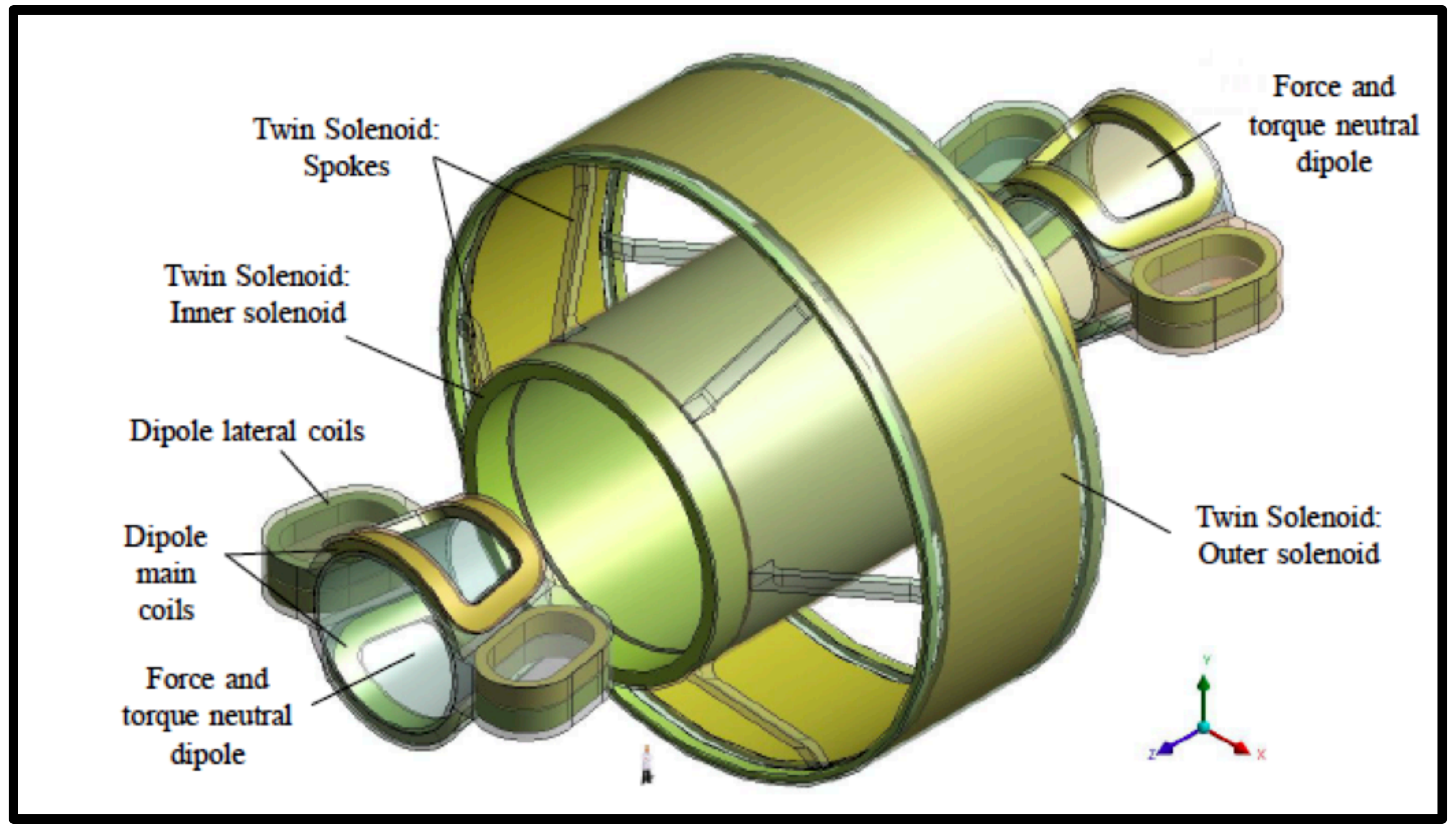
# FCC detector concepts for 100 TeV



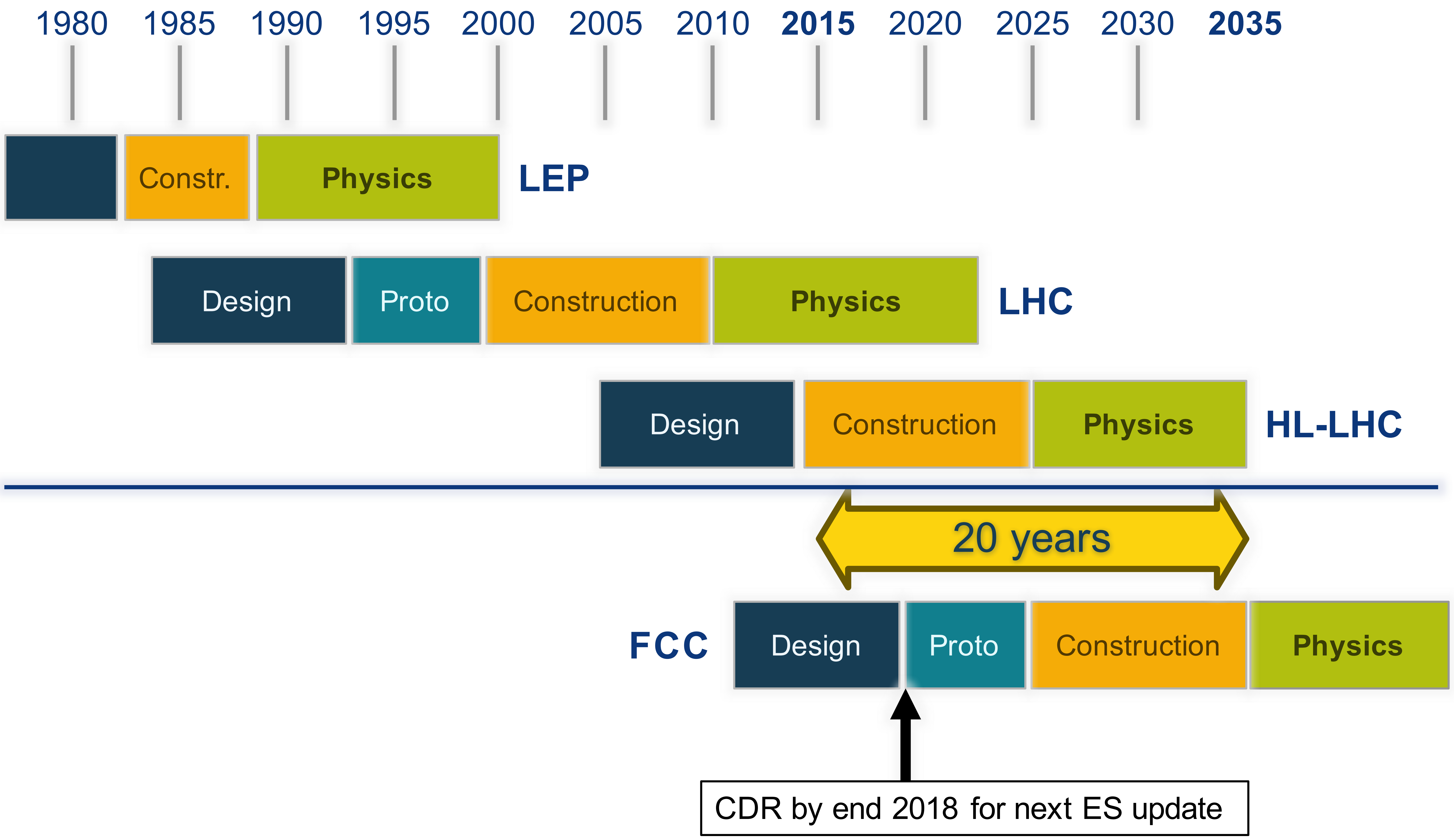
Driving requirements:

$BL^2$ ~10 x ATLAS/CMS for 10% muon momentum resolution at 10-20 TeV. Requires 1μm resolution

- large-bore, high-field solenoid
- return flux captured by twin solenoid
- Coverage with tracking and precise calorimetry up to $|\eta|$~5 for light particles
- forward dipole à la LHCb: B~10 Tm



# Possible Timeline



1980 1985 1990 1995 2000 2005 2010 **2015** 2020 2025 2030 **2035**

Constr. | **Physics** | **LEP**

Design | Proto | Construction | **Physics** | **LHC**

Design | Construction | **Physics** | **HL-LHC**

20 years

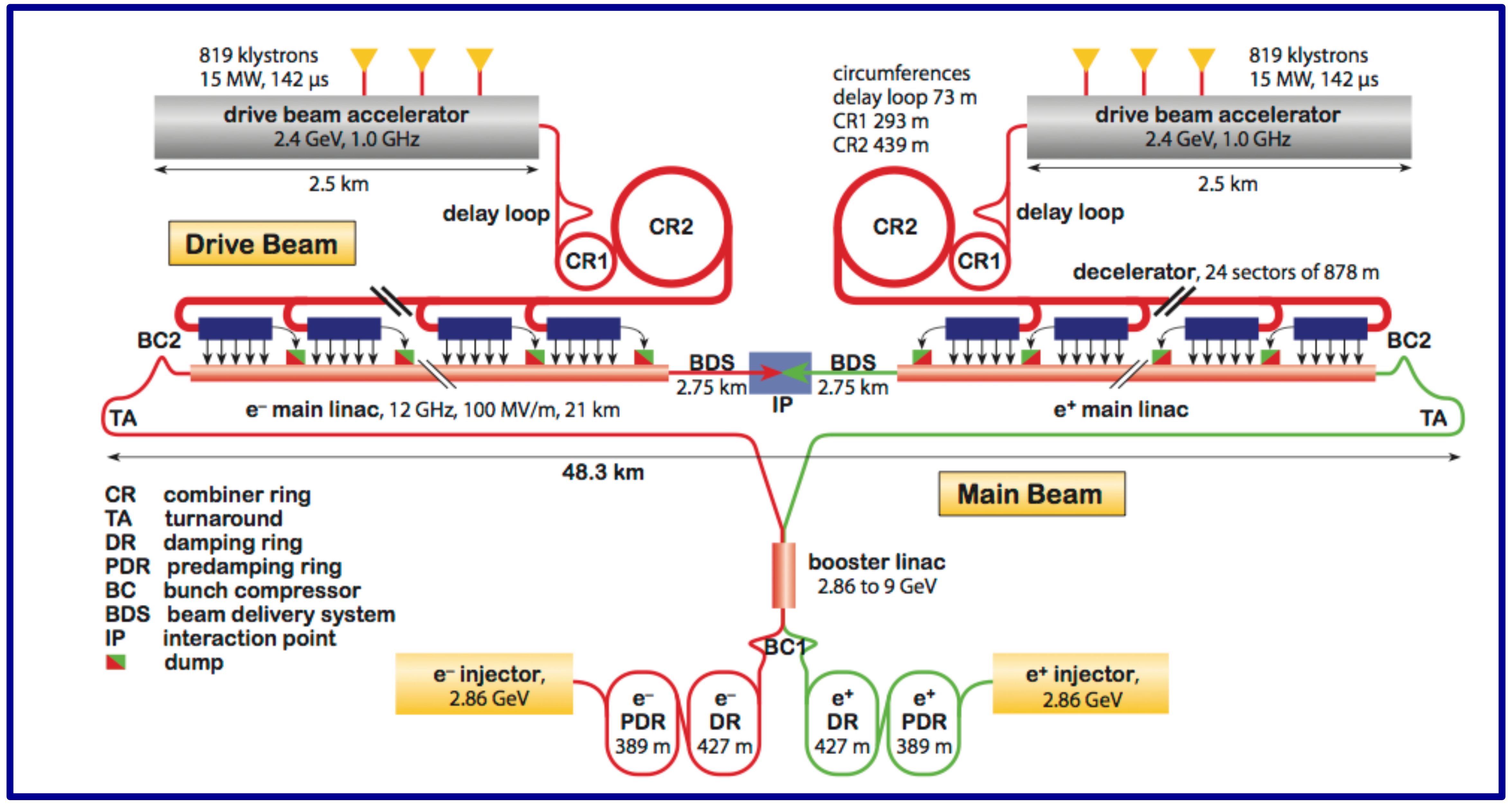
**FCC** | Design | Proto | Construction | **Physics**

CDR by end 2018 for next ES update

# Highest energy in lepton colliders

# Compact Linear Collider CLIC

- $e^+e^-$ collider 1-3 TeV
- currently only option for the TeV region
- exploring 380 GeV operation (klystrons?)
- decisive input to next update of European Strategy for Particle Physics



- CDR 2013
- CTF3 has provided key results
  - experimental programme will end 2016
- ready for a demonstrator

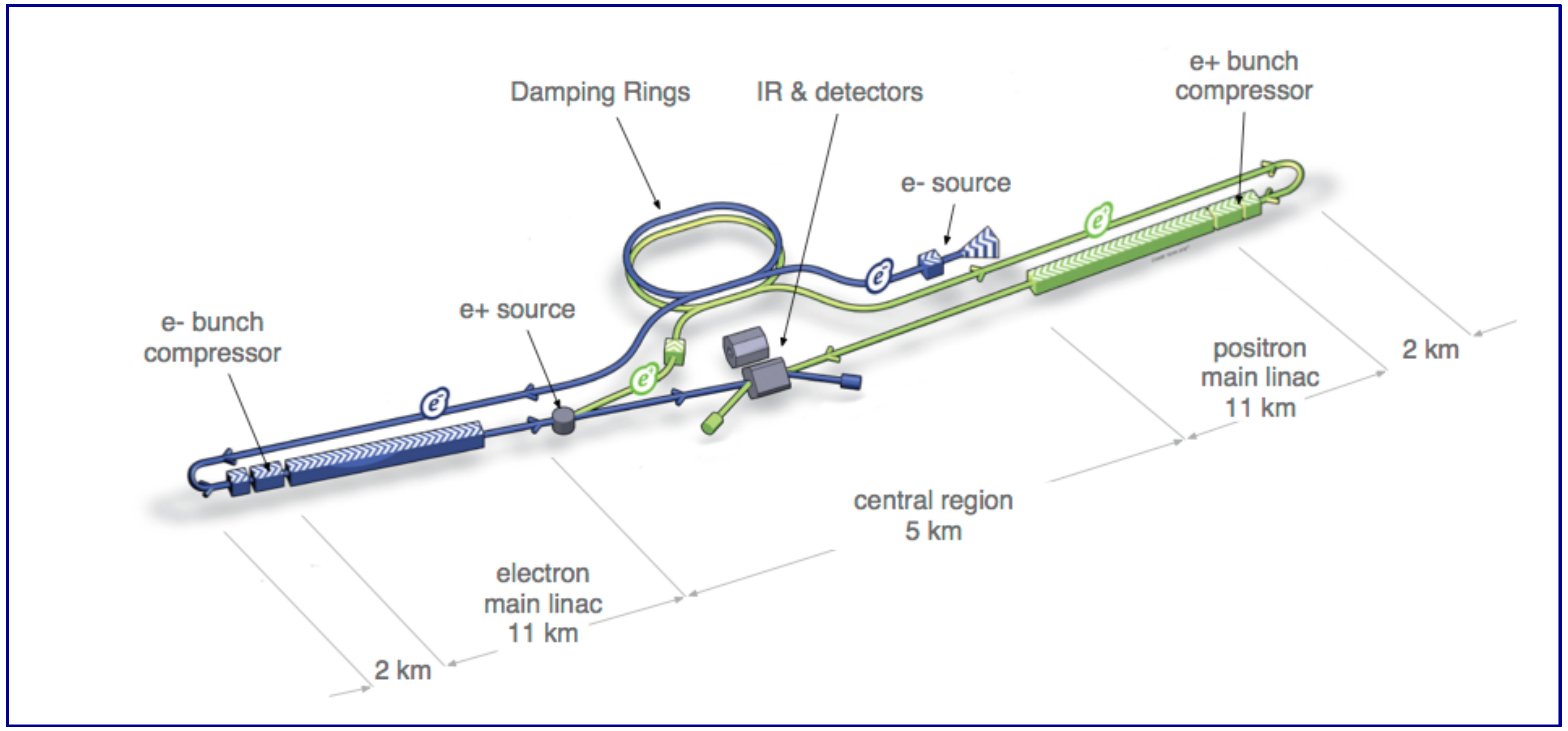
# *$e^+e^-$ collider*

- There is a strong scientific case for an electron-positron collider, complementary to the LHC, that can study the properties of the Higgs boson and other particles with unprecedented precision and whose energy can be upgraded. The Technical Design Report of the International Linear Collider (ILC) has been completed, with large European participation. The initiative from the Japanese particle physics community to host the ILC in Japan is most welcome, and European groups are eager to participate.

  *Europe looks forward to a proposal from Japan to discuss a possible participation.*

# International Linear Collider ILC

- $e^+e^-$ collider $\sqrt{s}$ = 0.5 TeV (upgradeable to 1 TeV)
- precision Higgs and Top programme and beyond



- Project is mature (TDR 2012)
- hosting evaluated by Japanese government
- international project (without host laboratory)

# International Linear Collider

- Ministry MEXT continues to evaluate the implications of hosting ILC in Japan
  - cost, manpower (skills)
- ICFA decided to prolong the mandate of the Linear Collider Board (LCB) for two years
  - slightly streamlined structure

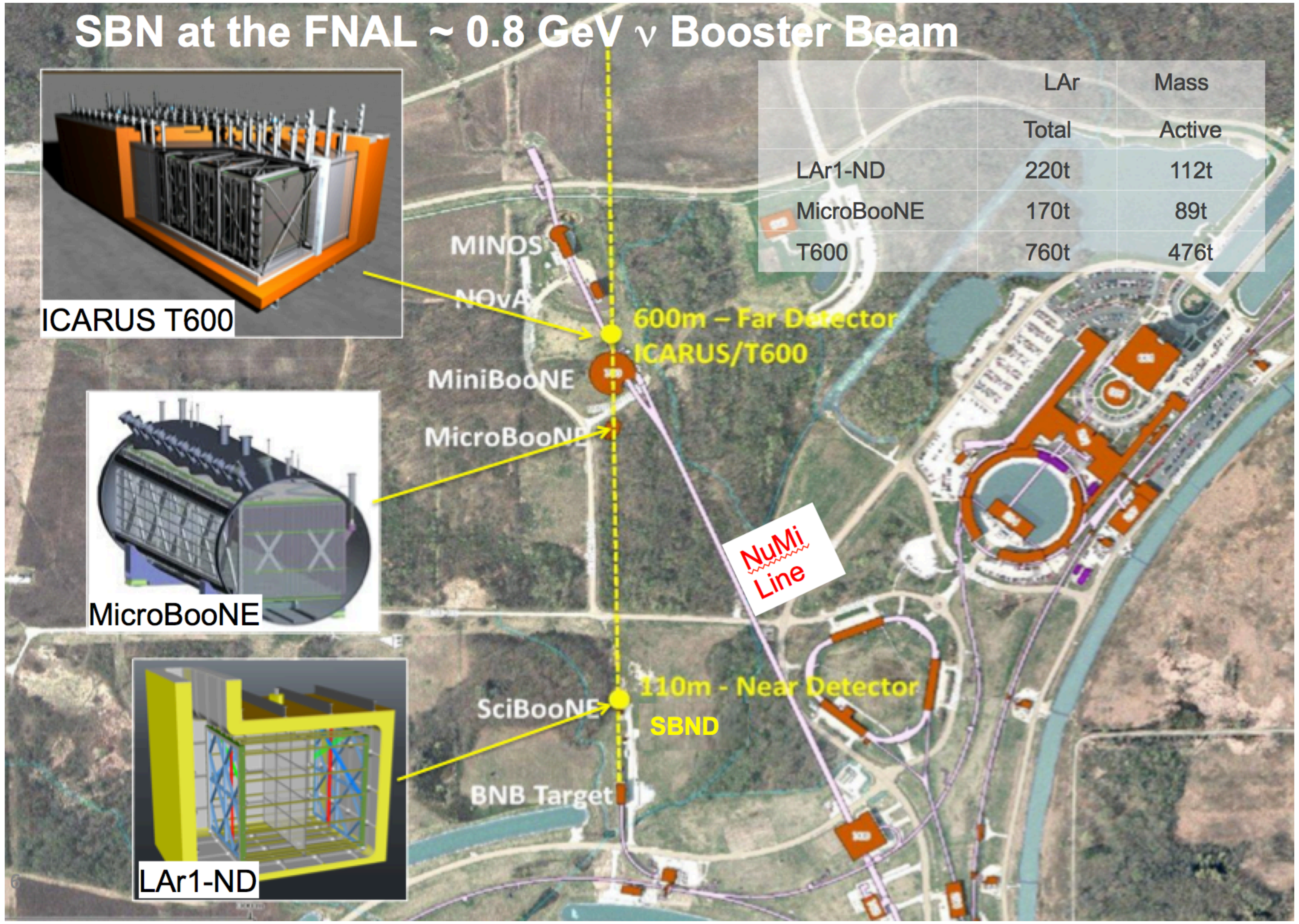
# *ν-physics*

- Rapid progress in neutrino oscillation physics, with significant European involvement, has established a strong scientific case for a long-baseline neutrino programme exploring CP violation and the mass hierarchy in the neutrino sector. CERN should develop a neutrino programme to pave the way for a substantial European role in future long-baseline experiments.

  *Europe should explore the possibility of major participation in leading long-baseline neutrino projects in the US and Japan.*

# Short baseline programme at Fermilab

- To resolve experimental inconsistencies in the measured ν-spectrum
- Using
  - LAr-ND (near detector)
  - MicroBooNE
  - refurbished ICARUS



SBN at the FNAL ~ 0.8 GeV ν Booster Beam

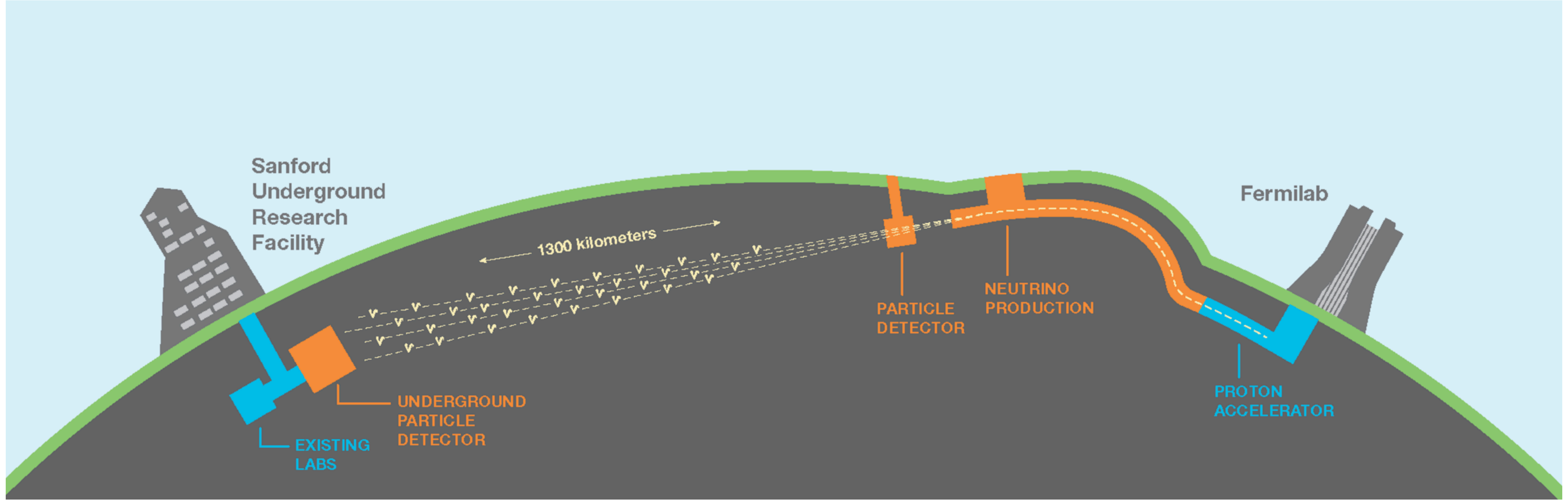
| | LAr | Mass |
|---|---|---|
| | Total | Active |
| LAr1-ND | 220t | 112t |
| MicroBooNE | 170t | 89t |
| T600 | 760t | 476t |

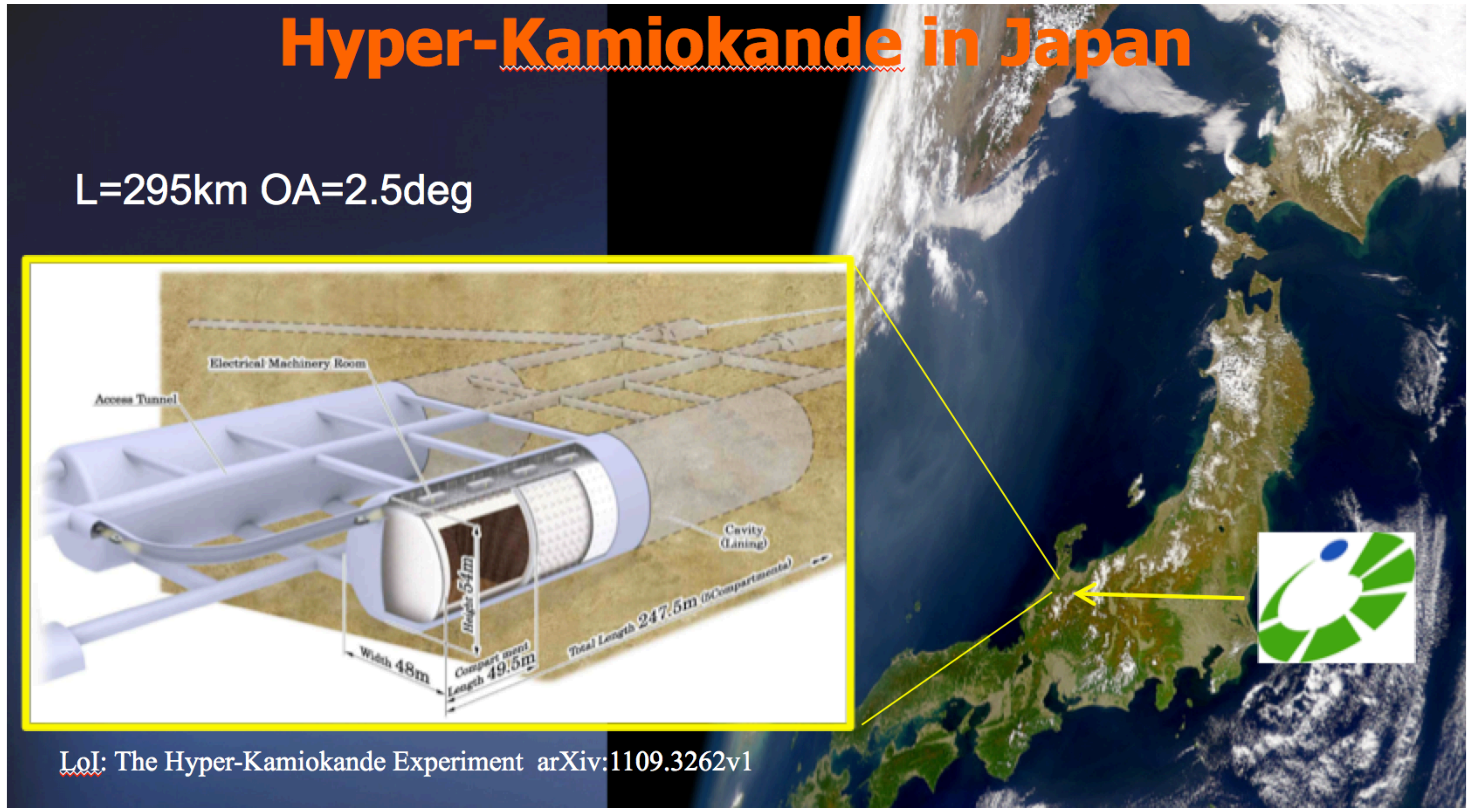
# Long baseline neutrino programmes

- Fermilab is planning a long baseline neutrino facility (LBNF), a wide band neutrino beam to the DUNE experiment (LArTPC) in South Dakota

- KEK is considering Hyper-K (water Cherenkov detector) at Kamioka

- Goals: neutrino-oscillation parameters, mass hierarchy and CP-violation

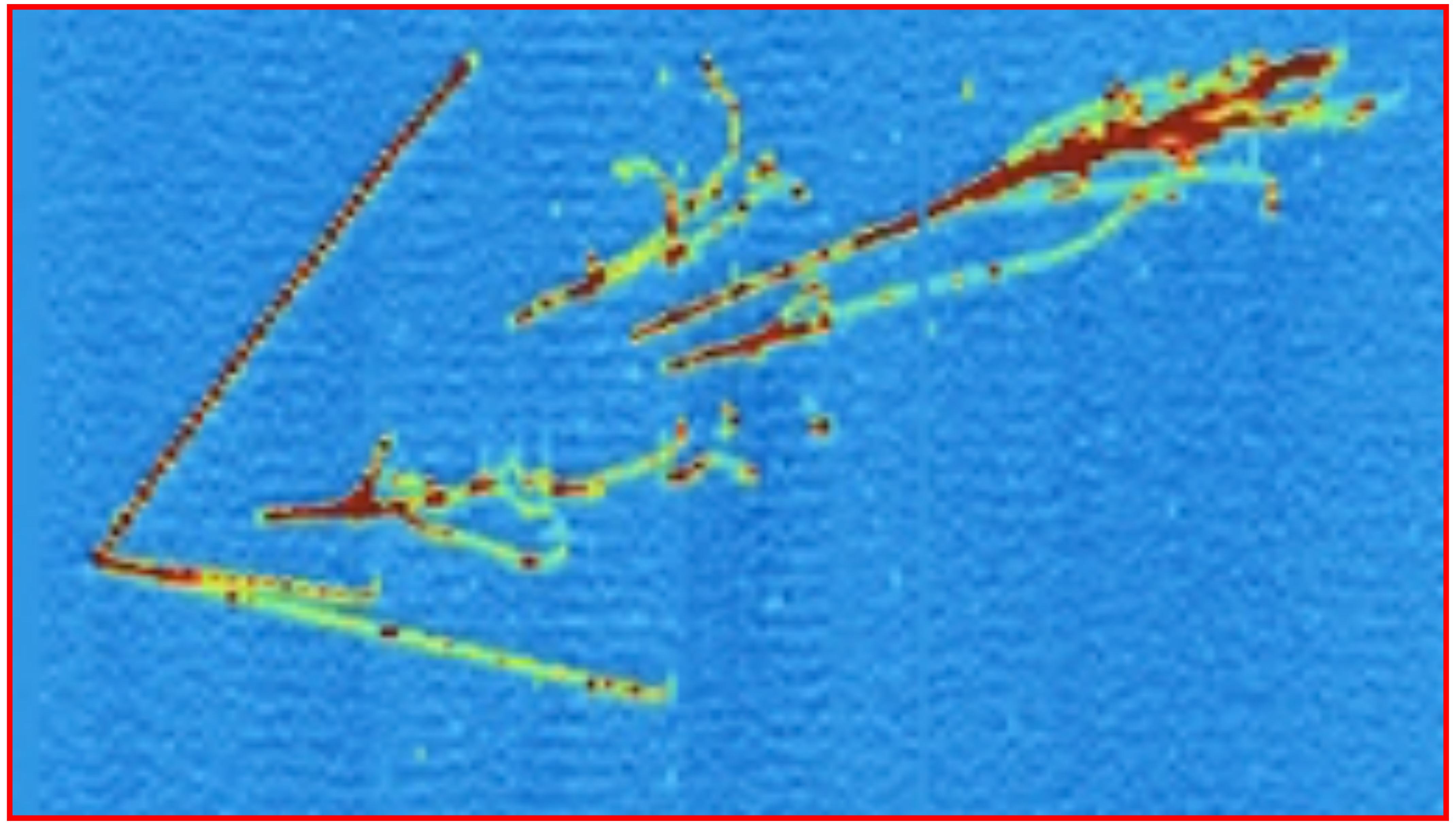


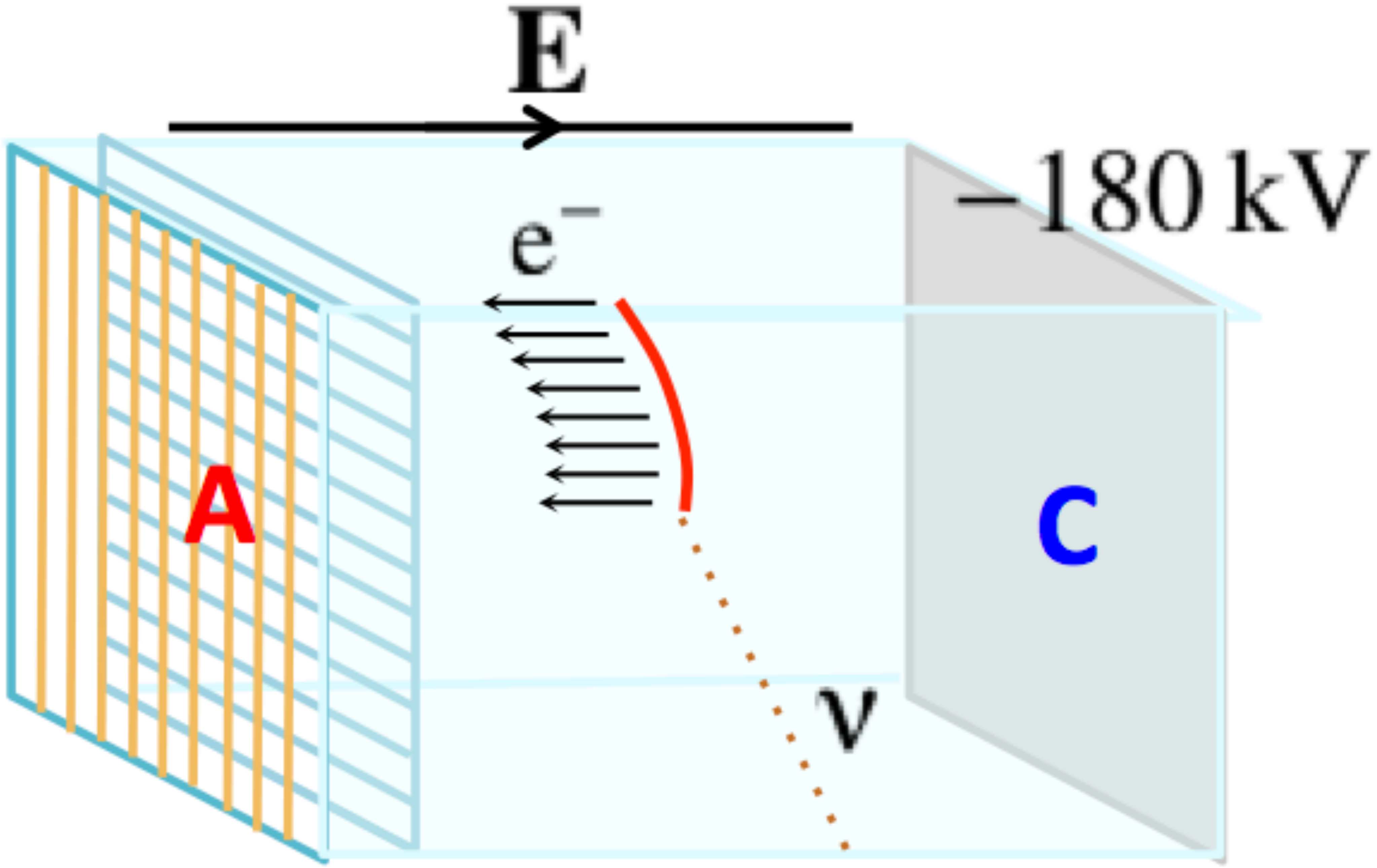


LoI: The Hyper-Kamiokande Experiment arXiv:1109.3262v1

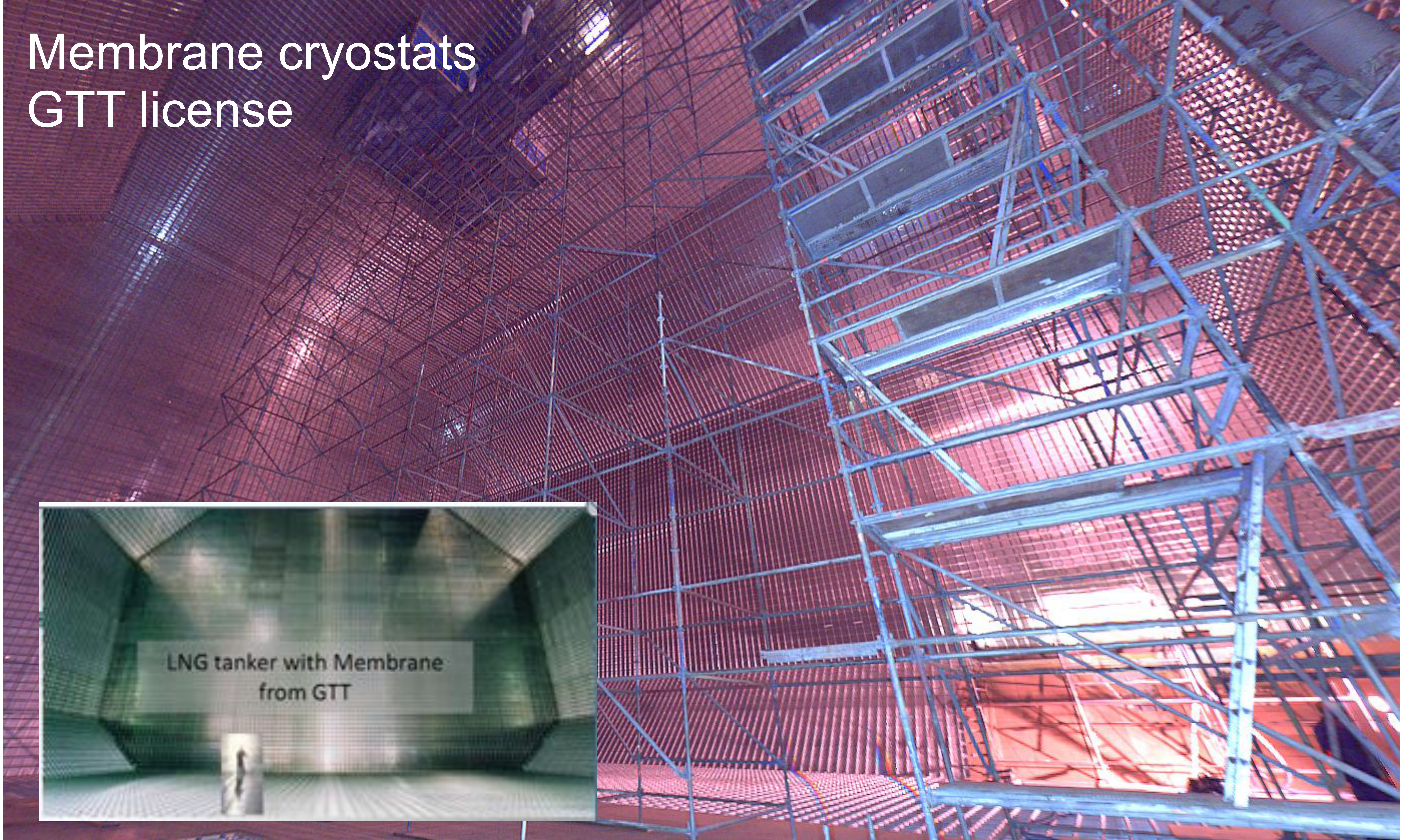
# LAr Technology

- LarTPC large scale active detectors
  - few mm precision
  - good energy resolution





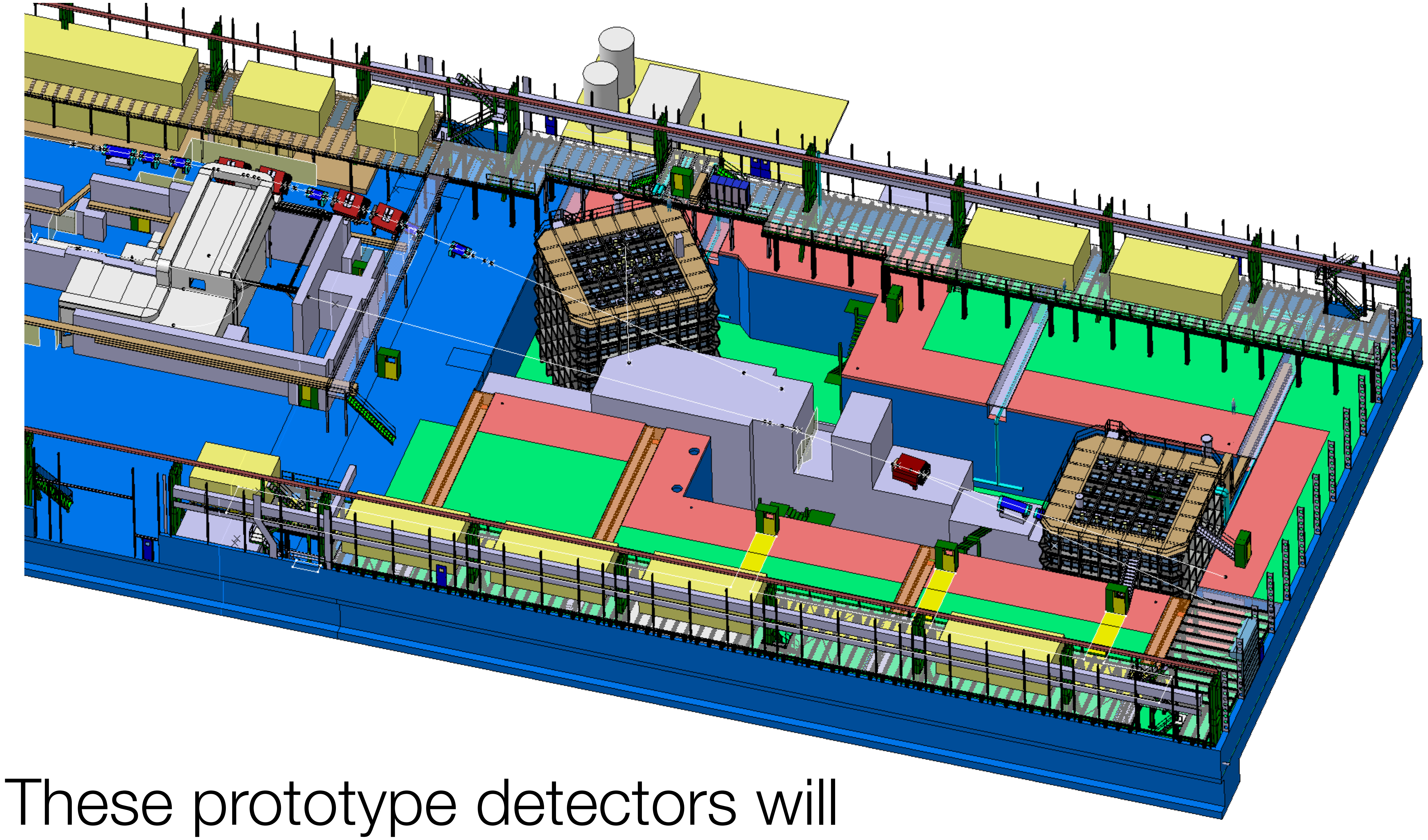
# Membrane cryostats
# GTT license



LNG tanker with Membrane from GTT

# Neutrino Platform at CERN

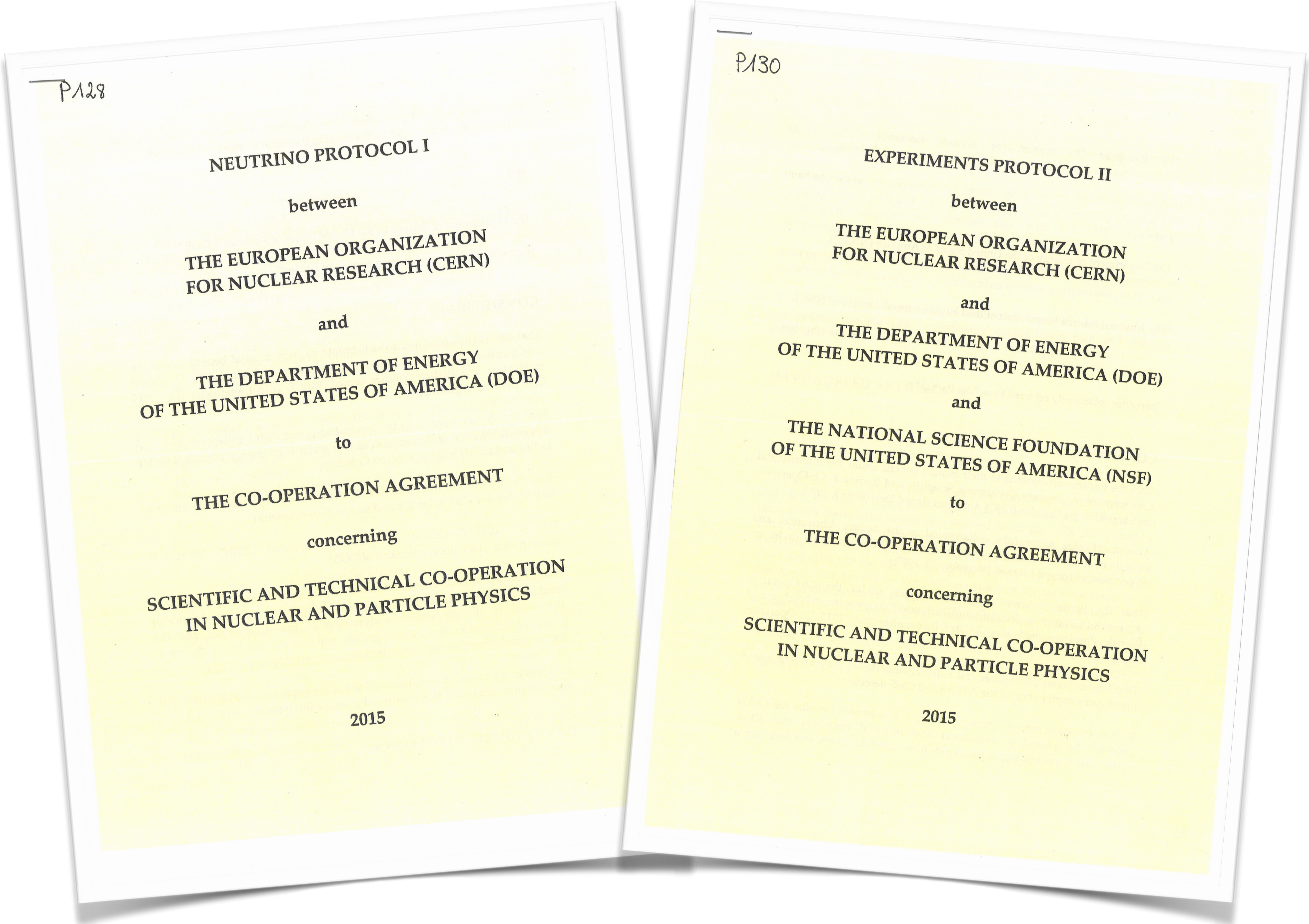
To develop experimental techniques, e.g. protoDUNE
– single phase
– double phase



These prototype detectors will generate a data stream comparable to that of ALICE in Heavy Iron Running

# International Framework of Neutrino Programme

- no ν-beams at CERN
- foster European engagement in short- and long-baseline neutrino programmes
- Memoranda of Understanding have been concluded end of 2015
  - being supplemented by addenda on work programme



P128

NEUTRINO PROTOCOL I

between

THE EUROPEAN ORGANIZATION
FOR NUCLEAR RESEARCH (CERN)

and

THE DEPARTMENT OF ENERGY
OF THE UNITED STATES OF AMERICA (DOE)

to

THE CO-OPERATION AGREEMENT

concerning

SCIENTIFIC AND TECHNICAL CO-OPERATION
IN NUCLEAR AND PARTICLE PHYSICS

2015

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P130

EXPERIMENTS PROTOCOL II

between

THE EUROPEAN ORGANIZATION
FOR NUCLEAR RESEARCH (CERN)

and

THE DEPARTMENT OF ENERGY
OF THE UNITED STATES OF AMERICA (DOE)

and

THE NATIONAL SCIENCE FOUNDATION
OF THE UNITED STATES OF AMERICA (NSF)

to

THE CO-OPERATION AGREEMENT

concerning

SCIENTIFIC AND TECHNICAL CO-OPERATION
IN NUCLEAR AND PARTICLE PHYSICS

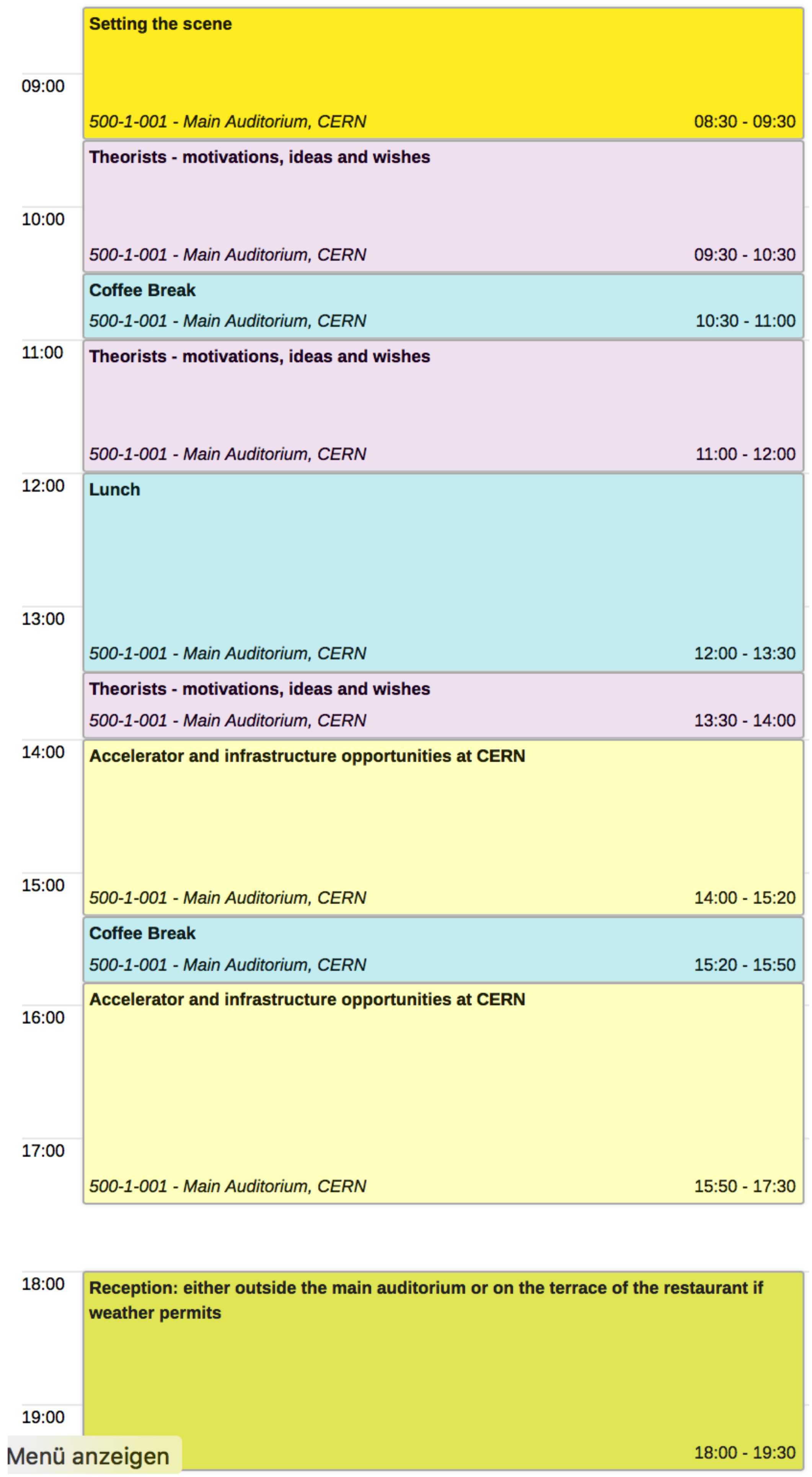
2015

CERN engages in external projects

# Beyond the LHC flagship project – at CERN

# Physics-Beyond-Colliders (PBC)

- Workshop 6-7 Sep 2016
- Convened by
  - C Vallee, J Jäckel, M Lamont
- saw 342 registered participants
- Will contribute to ESPP update



**Setting the scene**
*500-1-001 - Main Auditorium, CERN* 08:30 - 09:30

**Theorists - motivations, ideas and wishes**
*500-1-001 - Main Auditorium, CERN* 09:30 - 10:30

**Coffee Break**
*500-1-001 - Main Auditorium, CERN* 10:30 - 11:00

**Theorists - motivations, ideas and wishes**
*500-1-001 - Main Auditorium, CERN* 11:00 - 12:00

**Lunch**
*500-1-001 - Main Auditorium, CERN* 12:00 - 13:30

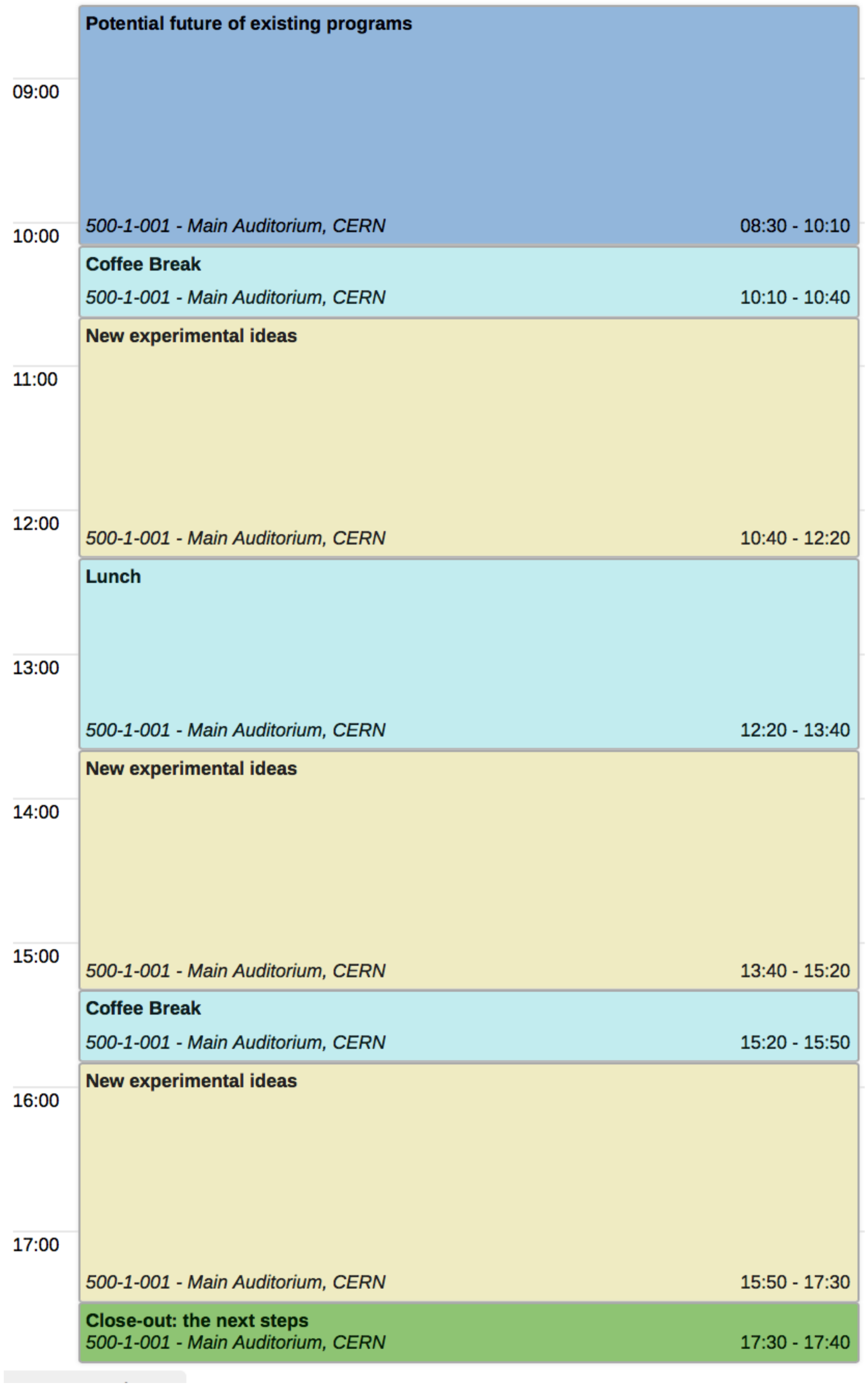
**Theorists - motivations, ideas and wishes**
*500-1-001 - Main Auditorium, CERN* 13:30 - 14:00

**Accelerator and infrastructure opportunities at CERN**
*500-1-001 - Main Auditorium, CERN* 14:00 - 15:20

**Coffee Break**
*500-1-001 - Main Auditorium, CERN* 15:20 - 15:50

**Accelerator and infrastructure opportunities at CERN**
*500-1-001 - Main Auditorium, CERN* 15:50 - 17:30

**Reception: either outside the main auditorium or on the terrace of the restaurant if weather permits**
18:00 - 19:30



**Potential future of existing programs**
*500-1-001 - Main Auditorium, CERN* 08:30 - 10:10

**Coffee Break**
*500-1-001 - Main Auditorium, CERN* 10:10 - 10:40

**New experimental ideas**
*500-1-001 - Main Auditorium, CERN* 10:40 - 12:20

**Lunch**
*500-1-001 - Main Auditorium, CERN* 12:20 - 13:40

**New experimental ideas**
*500-1-001 - Main Auditorium, CERN* 13:40 - 15:20

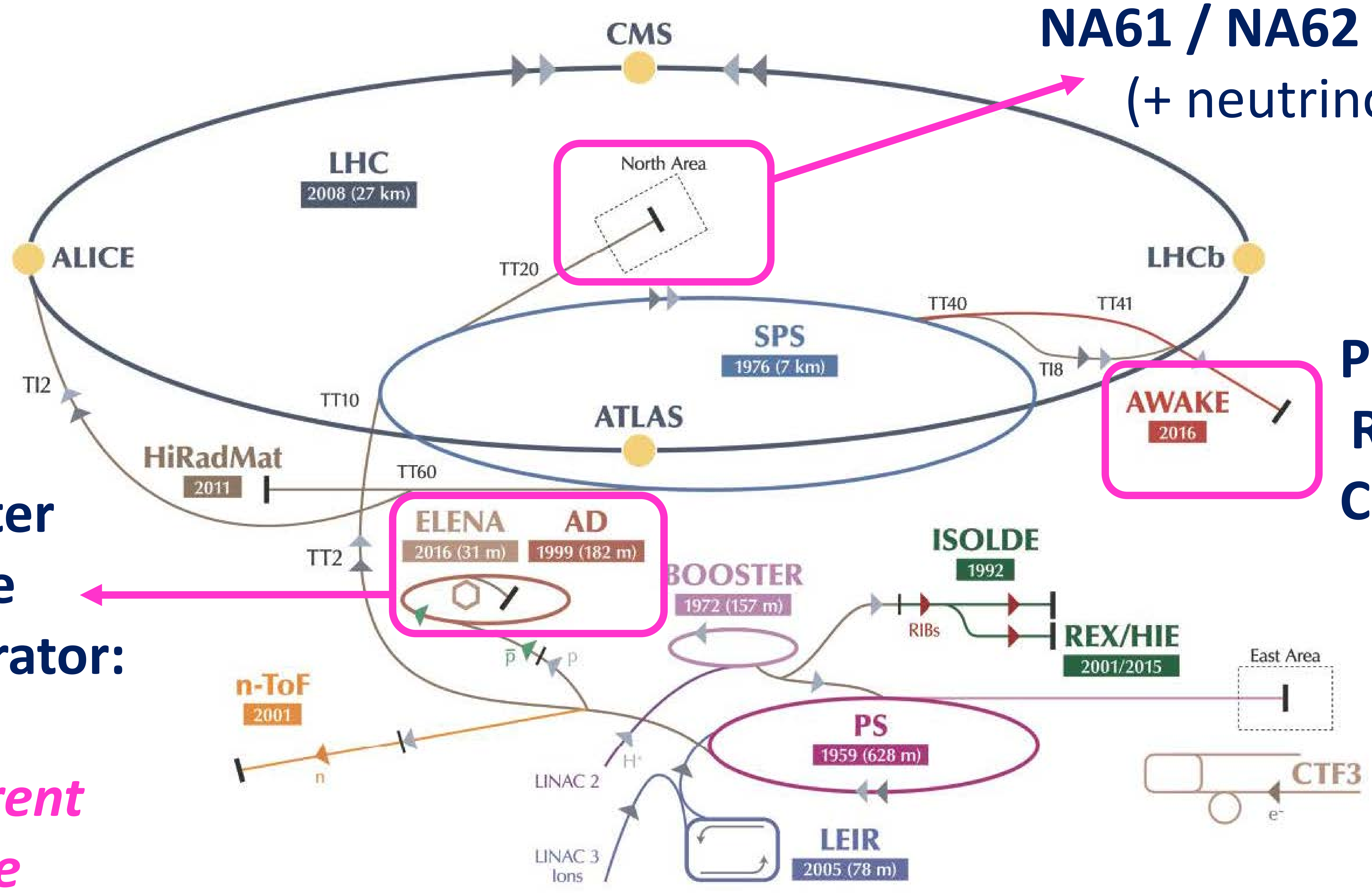
**Coffee Break**
*500-1-001 - Main Auditorium, CERN* 15:20 - 15:50

**New experimental ideas**
*500-1-001 - Main Auditorium, CERN* 15:50 - 17:30

**Close-out: the next steps**
*500-1-001 - Main Auditorium, CERN* 17:30 - 17:40

# Particle Physics Programme on LHC injectors

Some Examples following



**NA61 / NA62 / NA64 / COMPASS**
(+ neutrino platform R&D)

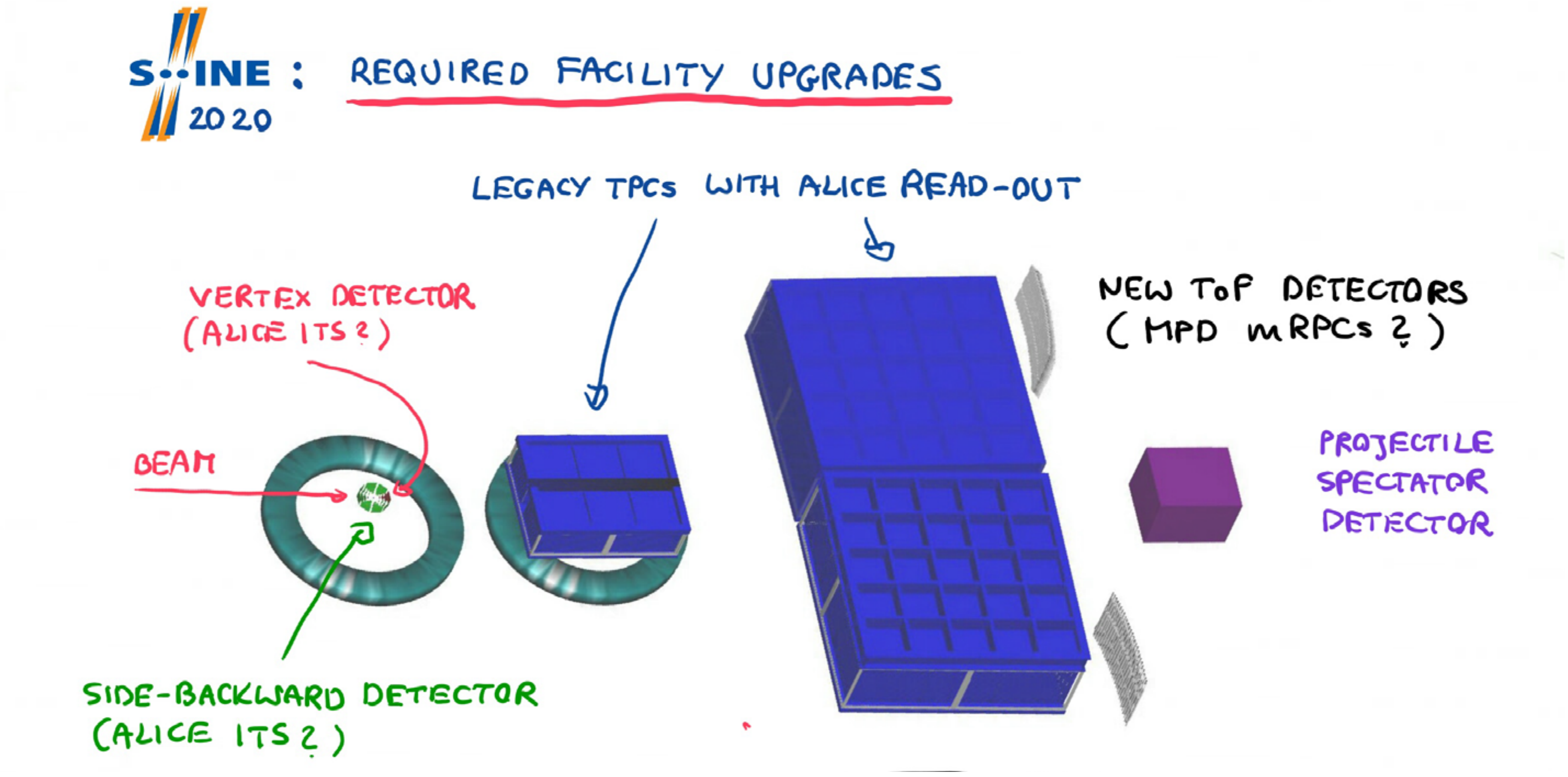
**Plasma acceleration R&D on the former CNGS extraction line**

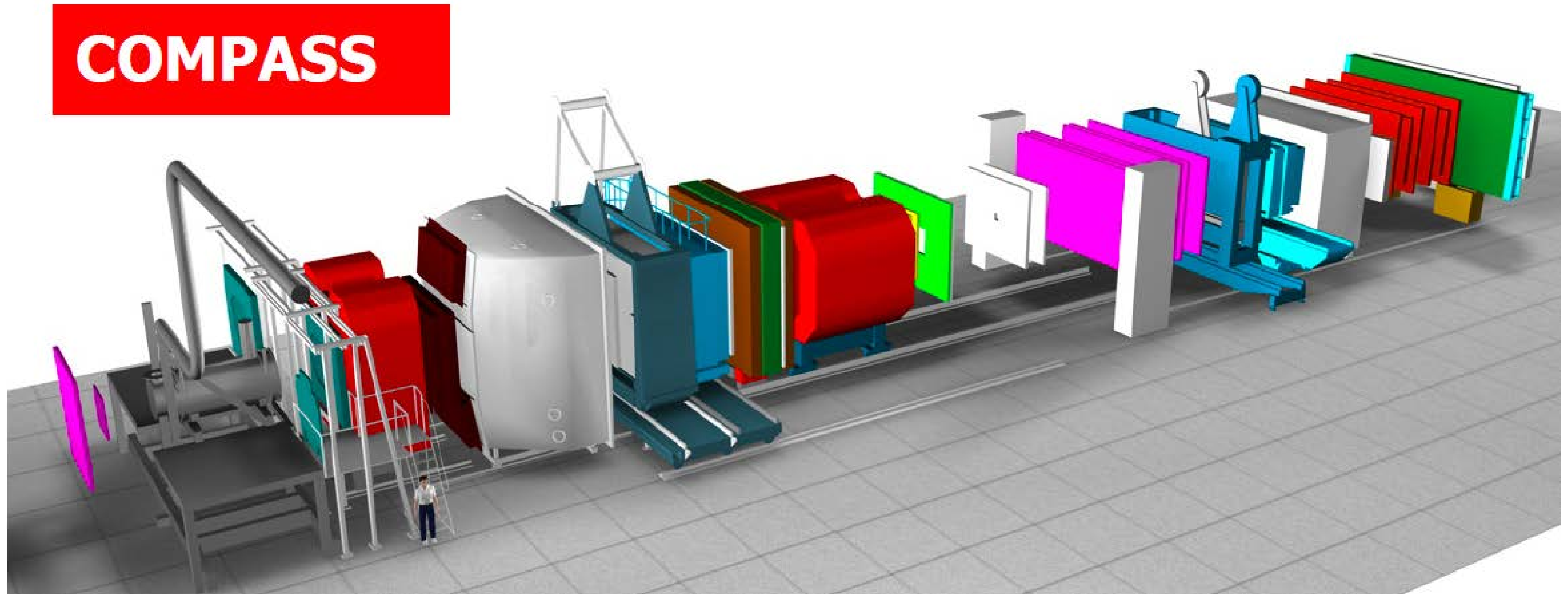
**Vibrant antimatter program on the Antiproton Decelerator:**
***bright future secured with current ELENA upgrade***

***NB: recent stop of major programs (e.g. CNGS) leaves room for new significant initiatives***

# Fixed Target Programme

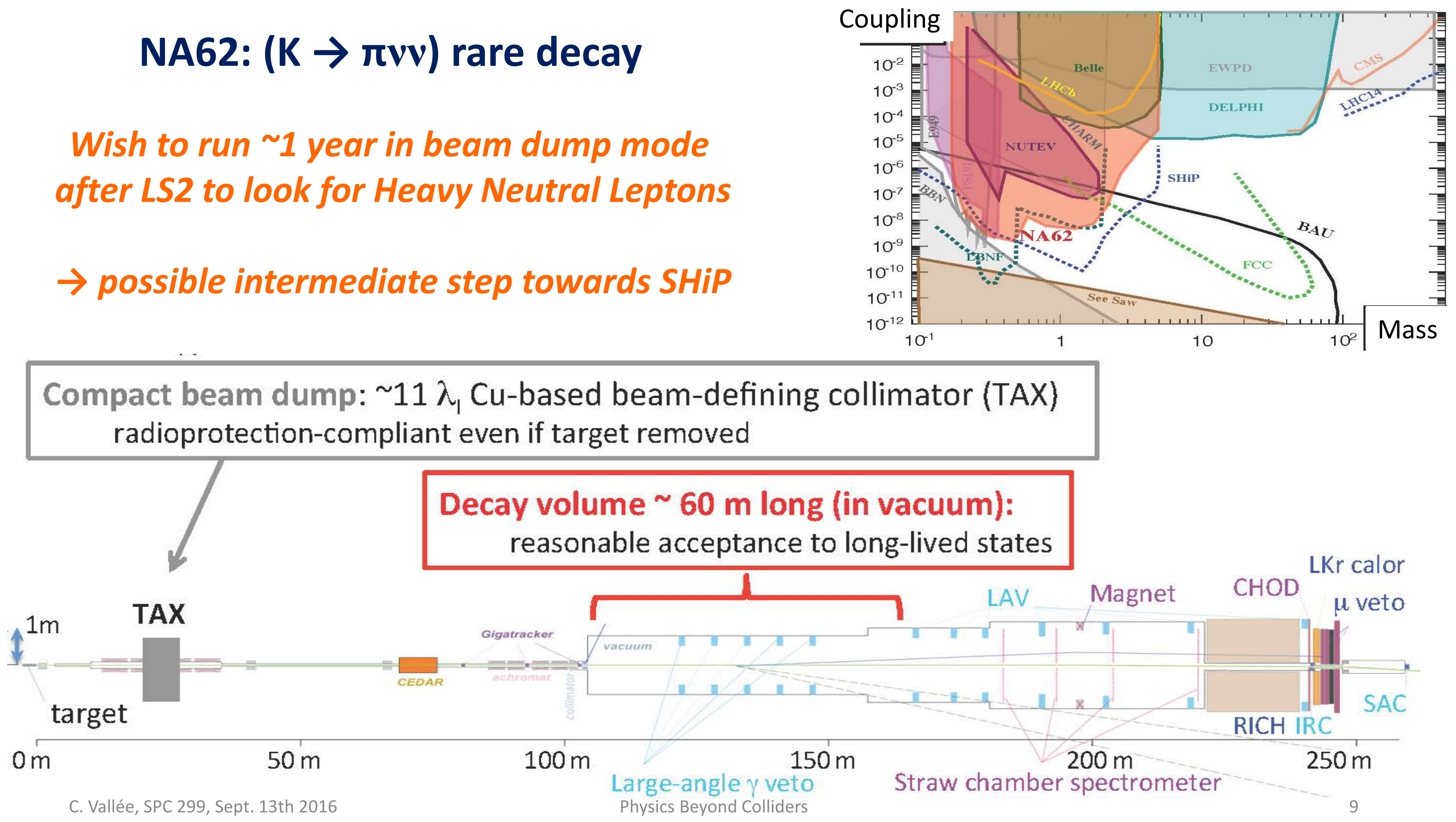
- NA61
  - Charm deconfinement
  - support for ν-programme
- COMPASS
  - Drell-Yan with pbar and K-beams





# Search for Hidden Particles

- NA62
    - rare $K^- \rightarrow \pi^- \nu\nu$ decays
    - then search for HNL



**NA62: (K → πνν) rare decay**

*Wish to run ~1 year in beam dump mode after LS2 to look for Heavy Neutral Leptons*

*→ possible intermediate step towards SHiP*

**Compact beam dump:** ~11 $\lambda_I$ Cu-based beam-defining collimator (TAX) radioprotection-compliant even if target removed

**Decay volume ~ 60 m long (in vacuum):** reasonable acceptance to long-lived states

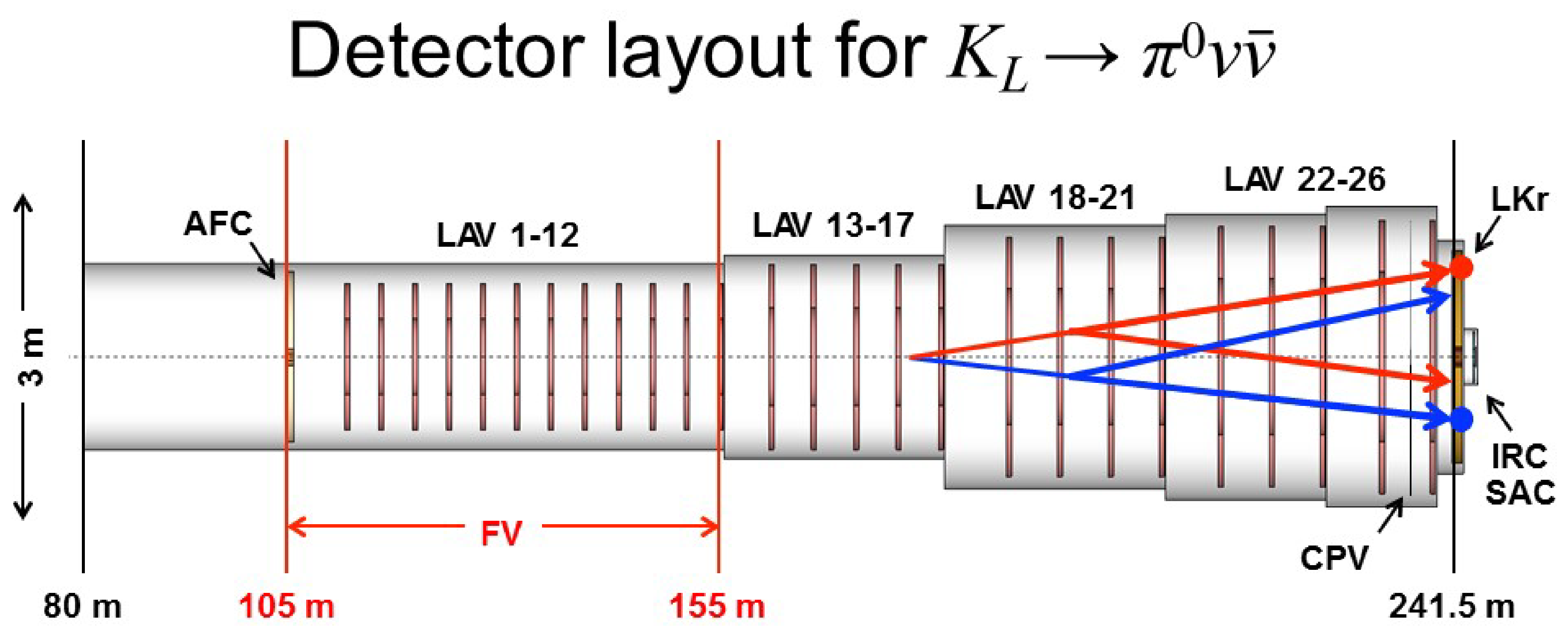
C. Vallée, SPC 299, Sept. 13th 2016

Physics Beyond Colliders

9

- SHiP
    - Preparing for Comprehensive Design Report

**New idea: NA62+ for ($K^o \rightarrow \pi^o\nu\nu$) rare decay**

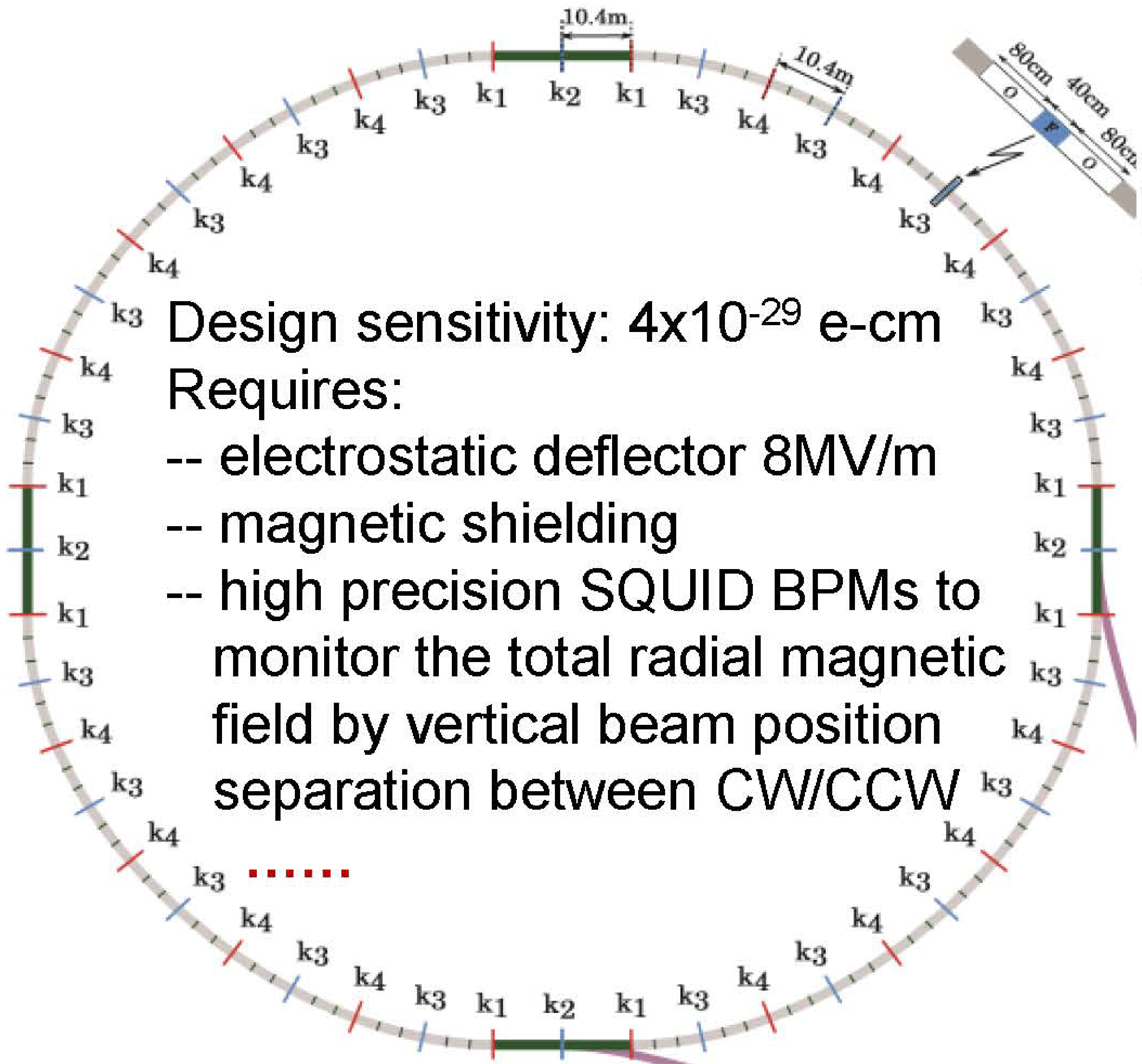


Detector layout for $K_L \rightarrow \pi^0 \nu\bar{\nu}$

# Precision EDM Measurements using electrostatic ring

**$10^{-29}$ e-cm sensitivity would correspond to 100 TeV for new physics energy scale.**

**Pure electrostatic ring applicable to proton only**



Design sensitivity: $4\text{x}10^{-29}$ e-cm

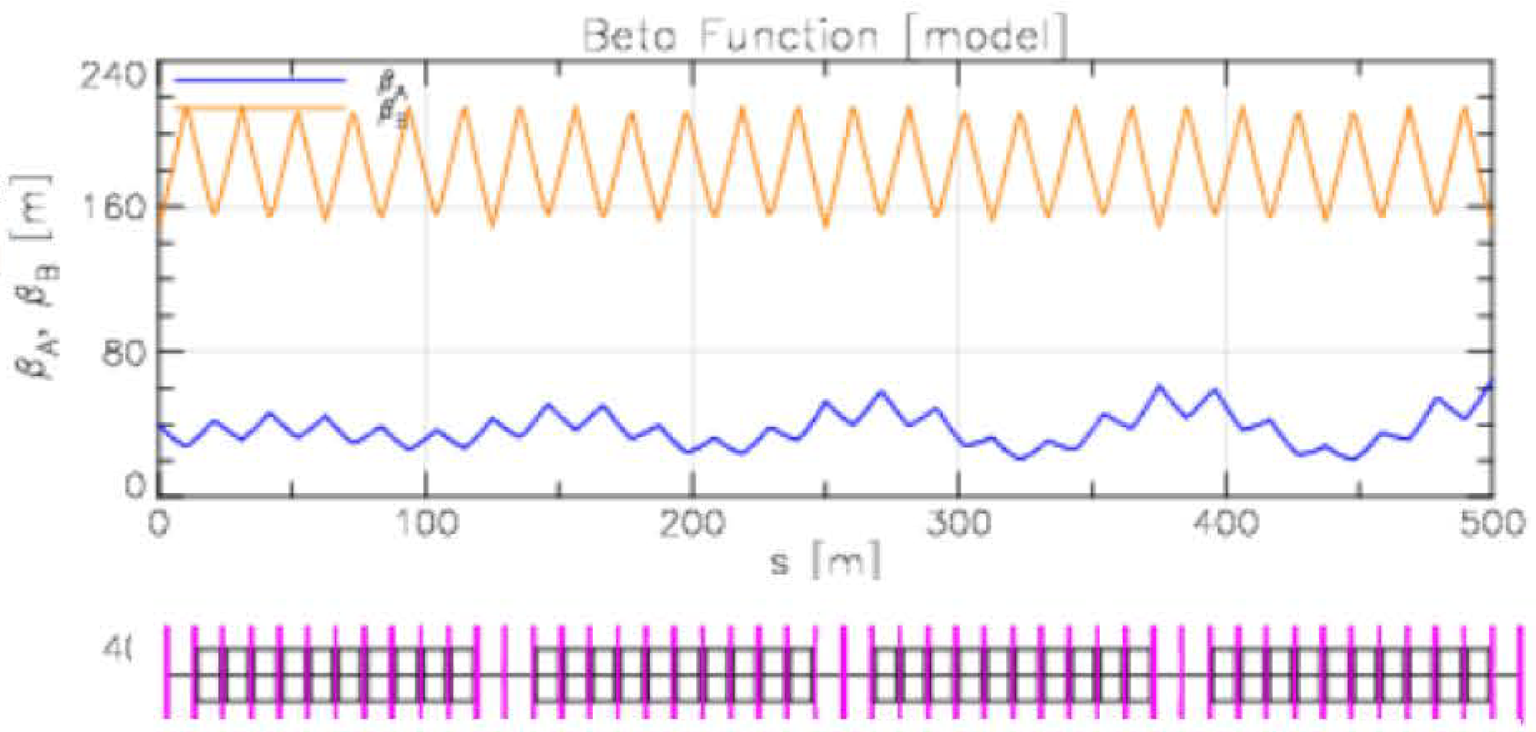
Requires:

-- electrostatic deflector 8MV/m

-- magnetic shielding

-- high precision SQUID BPMs to monitor the total radial magnetic field by vertical beam position separation between CW/CCW

……



| | |
|---|---|
| Bending radius | 52.3 m |
| circumference | 500 m |
| Electrode spacing | 3 cm |
| Deflector shape | cylindrical |
| Harmonic, RF[MHz] | 100, 35.878 |
| $Q_x$, $Q_y$ | 2.42, 0.44 |
| $\varepsilon_x$ , $\varepsilon_y$ [mm-mrad] | 17, 3.2 |
| maximum $\frac{dp}{p}$ | $4.6\text{x}10^{-4}$ |
| Dispersion, max [m] | 30 m |

V. Anastassopulos et al, https://arxiv.org/abs/1502.04317

# Strategy Roadmap

- The CERN Council started first discussion on next Strategy Update
  - await results of LHC Run 2
  - expect conclusion of ILC evaluation in Japanese ministry of Science etc. (MEXT)
- Next ESPP Update currently expected for spring 2020
  - LHC will work the energy frontier
  - and then many more ideas that have to be cast into strategies

# Conclusion

- Internationally balanced strategies have proven to be powerful means of
  - setting priorities among physicists and
  - ascertaining financial support for the large infrastructures of our field
- Given the long lead times it is important that they be carried out in the respective timeframe
- Strategies need to be updated and adjusted every 5-8 years, i.e. whenever an important implementation step has been made or nature has reveal another secret