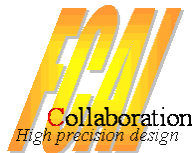


# Development of detectors for future linear colliders

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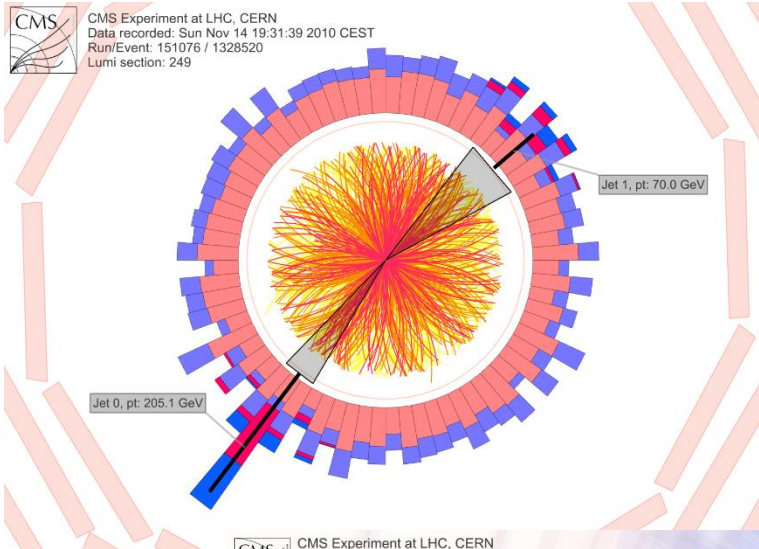
Tomasz Wojtoń

IFJ PAN

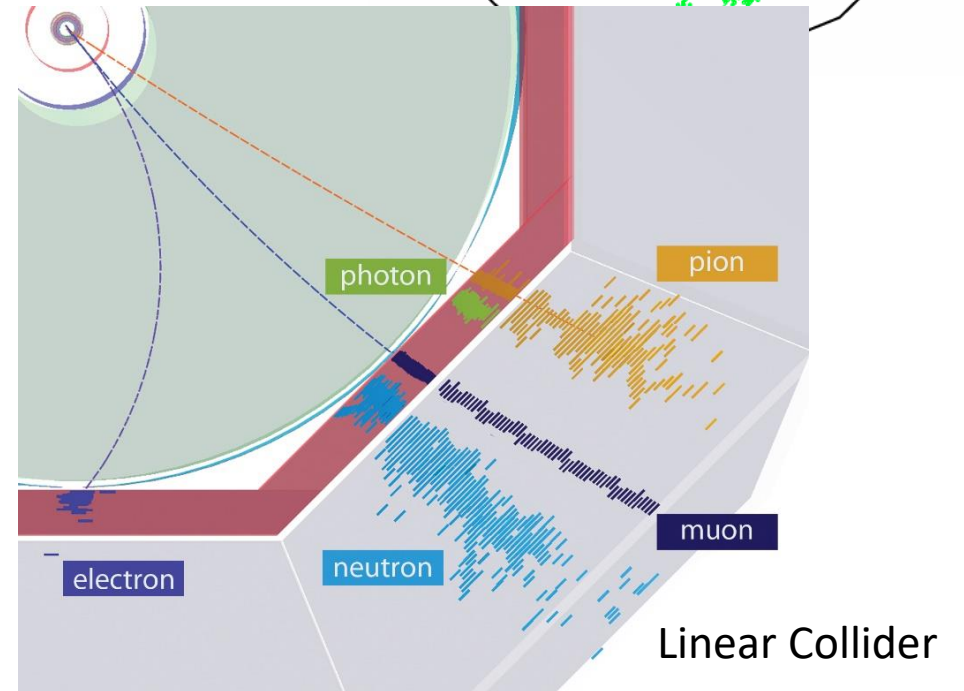
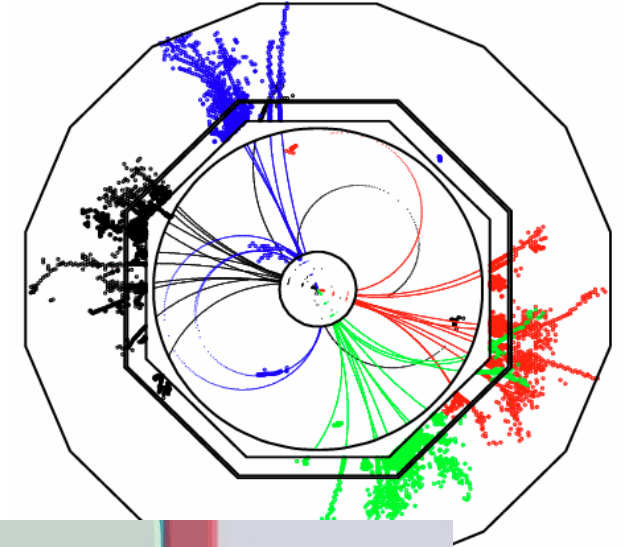
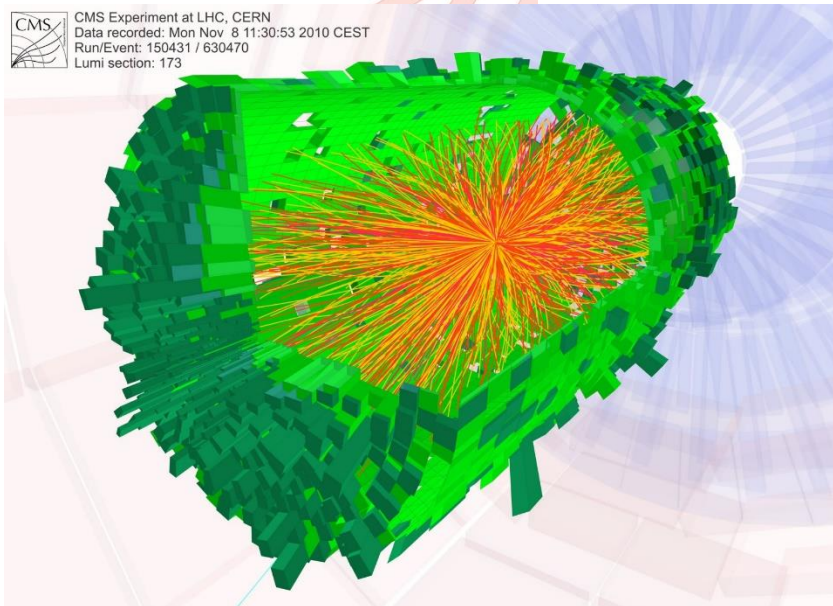




# Why we need new colliders?

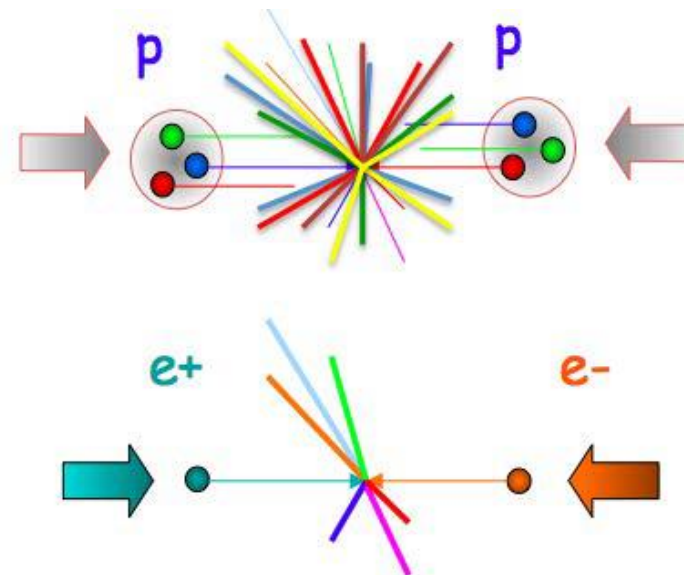
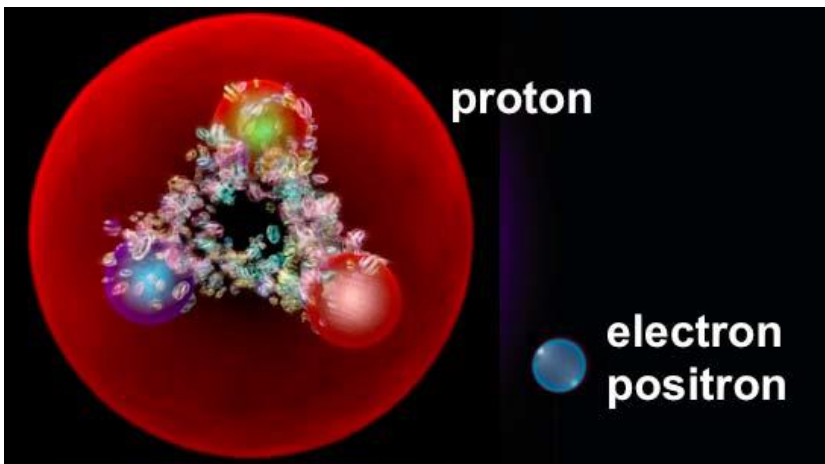


LHC





# $e^+e^-$ collisions – high precision



## p-p collisions

Proton is compound object

- Initial state not known (variety of processes)
- Limits achievable precision

High rates of QCD backgrounds

- Complex triggering schemes
- High levels of radiation

High cross-sections for colored-states

## $e^+e^-$ collisions

$e^+/e^-$  are point-like

- Initial state well defined
- High-precision measurements

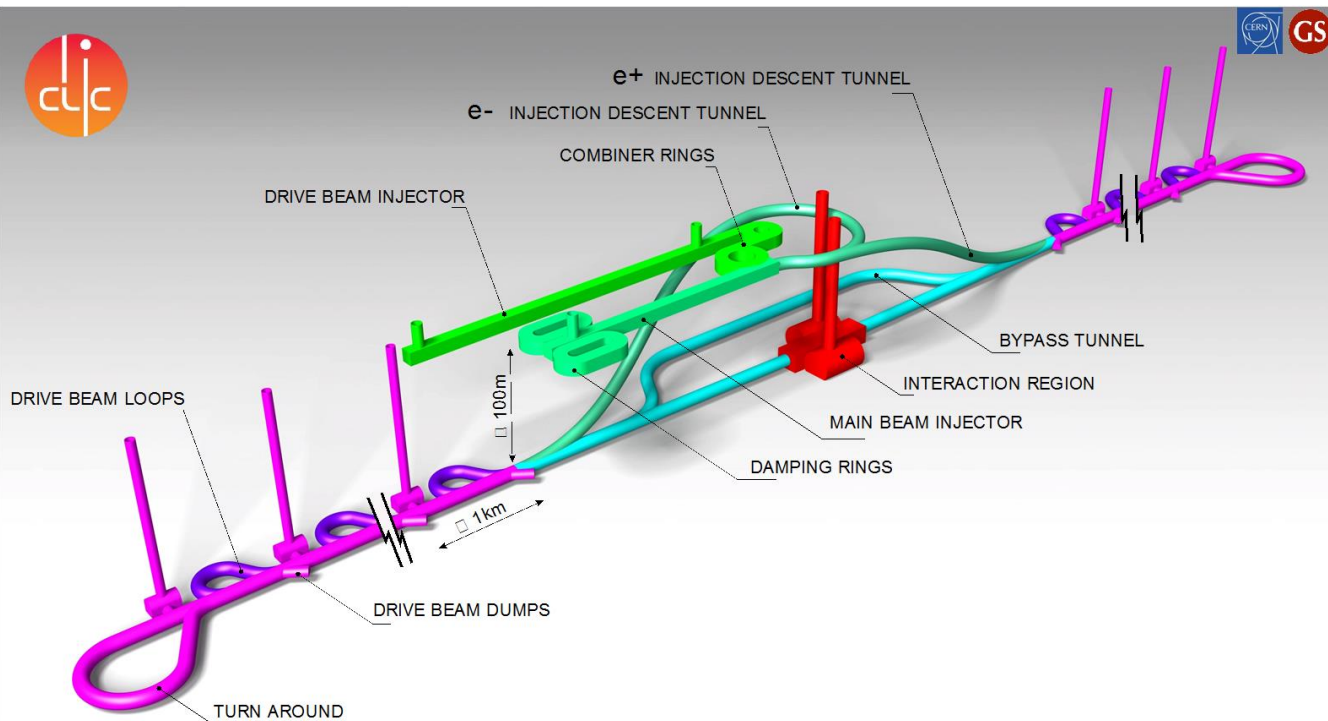
Cleaner experimental environment

- Trigger-less readout
- Low radiation levels

Superior sensitivity for electro-weak states

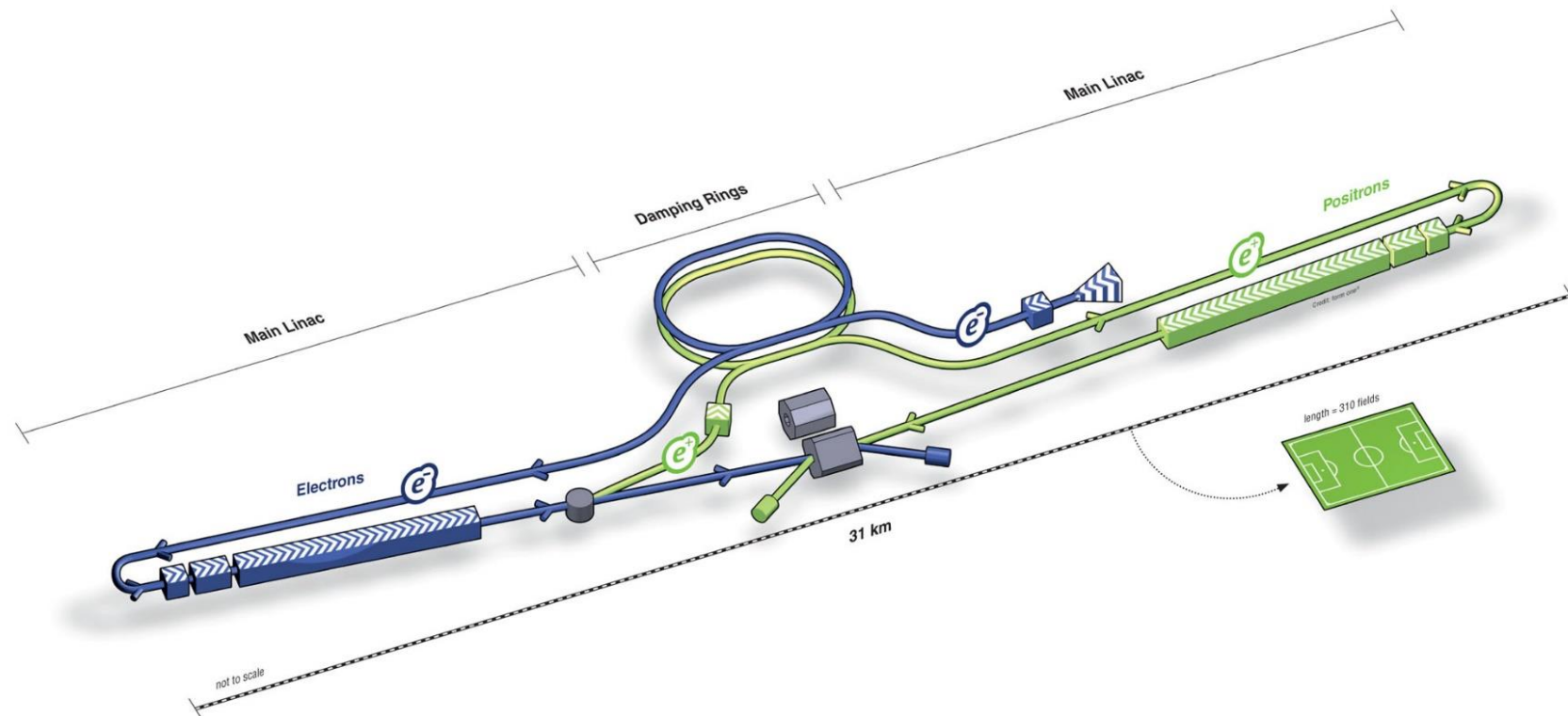


# Projects of future linear colliders



CLIC decisions – 2018/2019

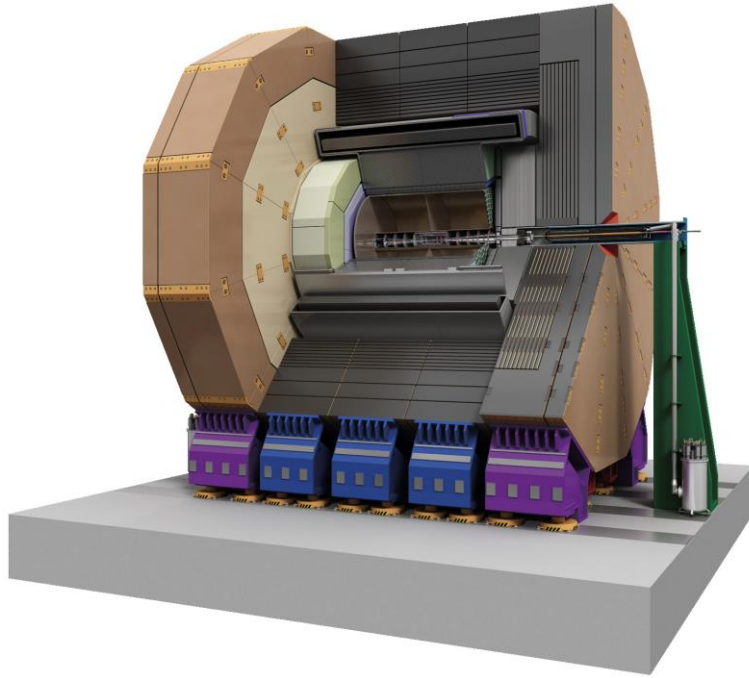
ILC roadmap update – 2018



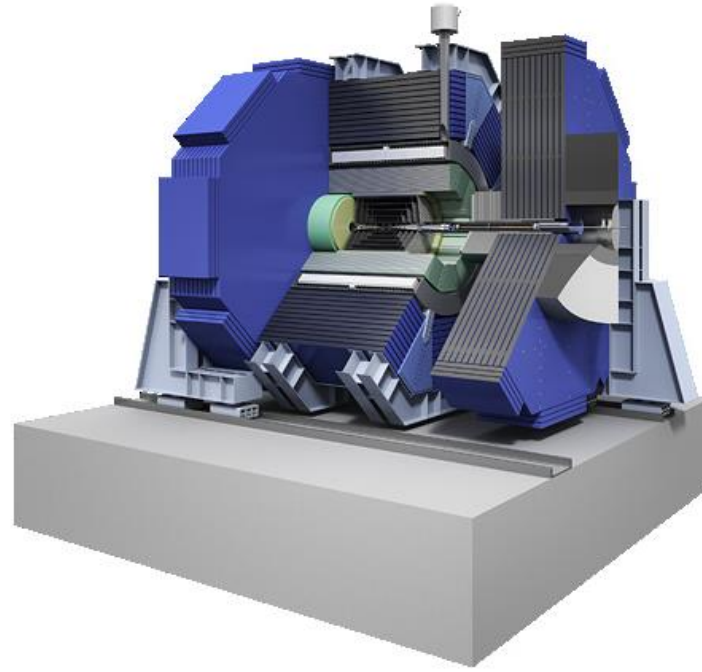




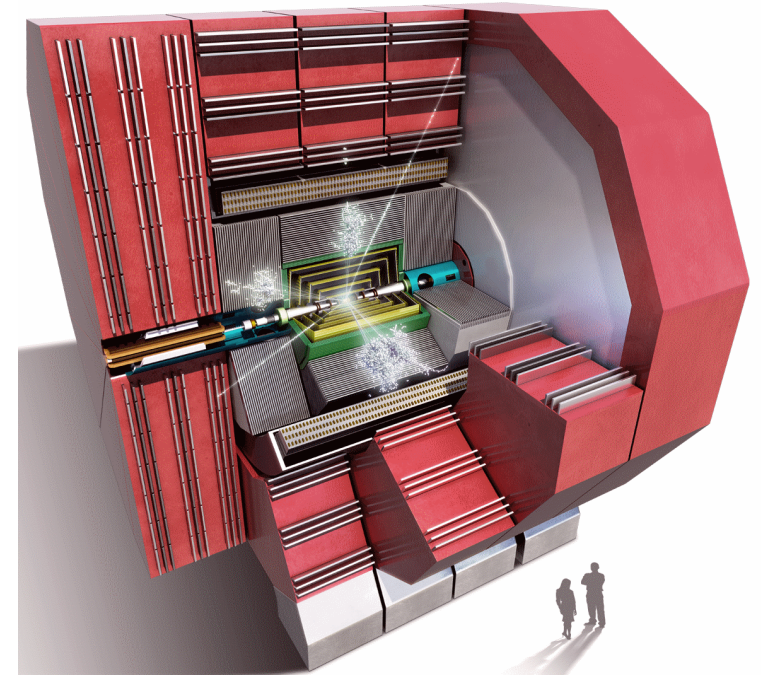
# New projects of detectors



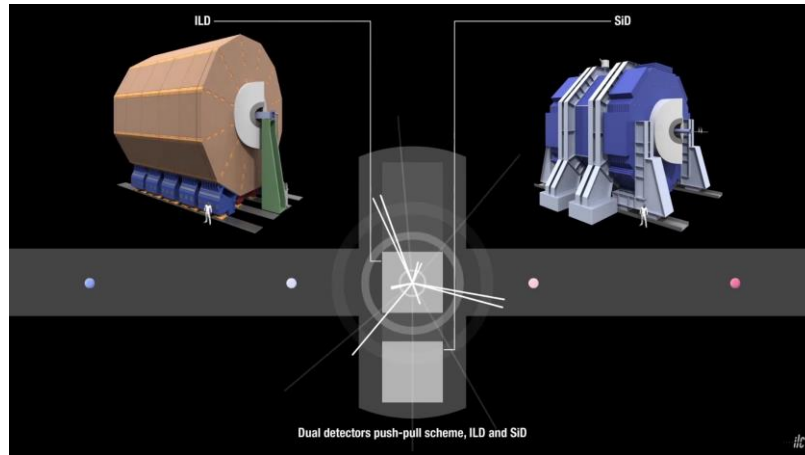
ILD (International Large Detector)



SiD (Silicon Detector)



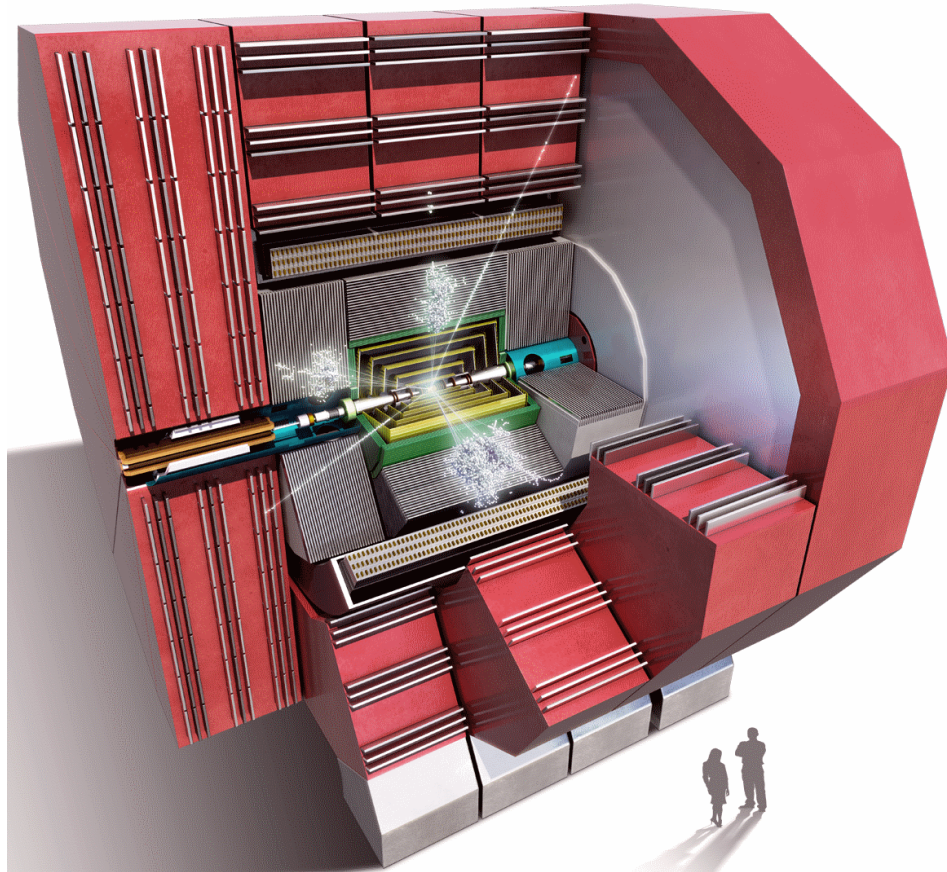
CLIC (Compact Linear Collider) detector



- Height about 15m
- Length more than 11m
- Weight above 10 000 tons



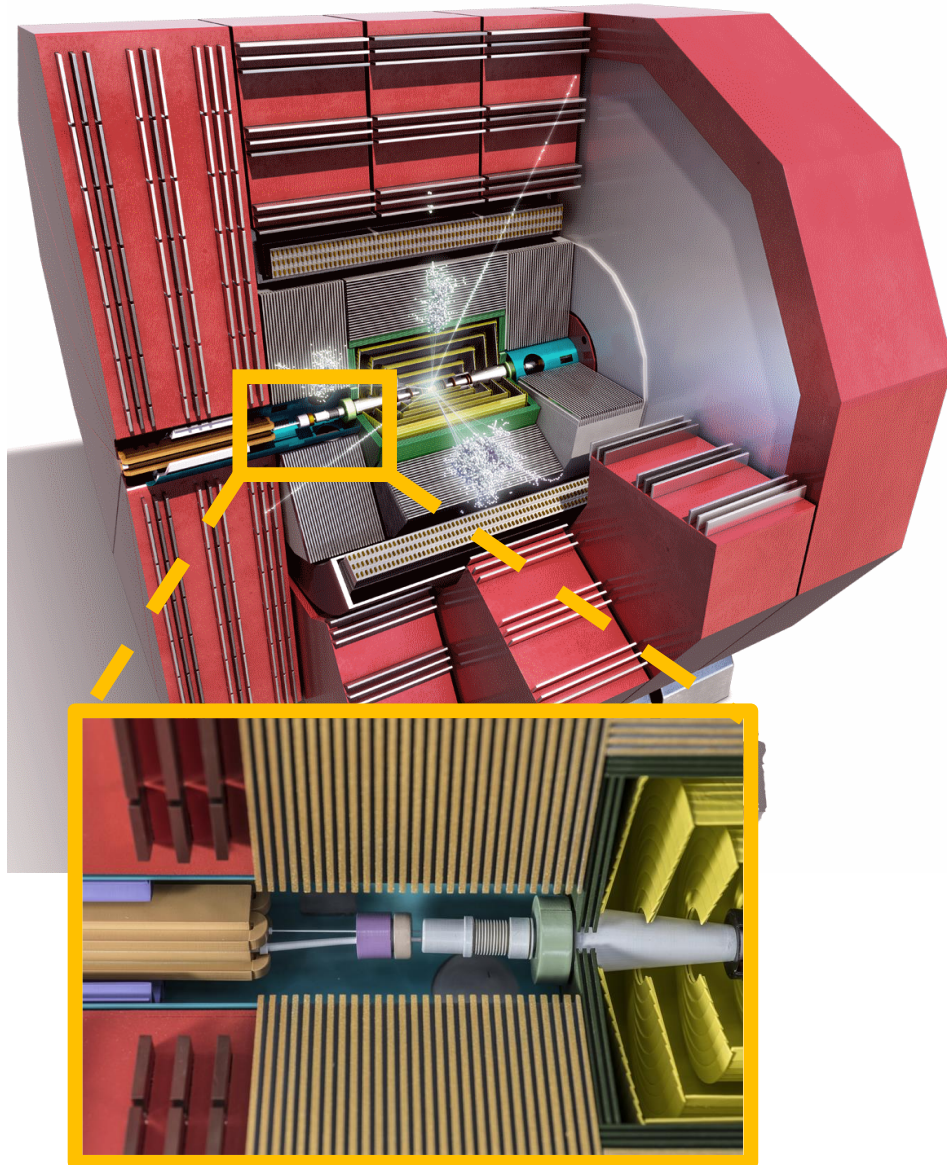
# LumiCal calorimeter







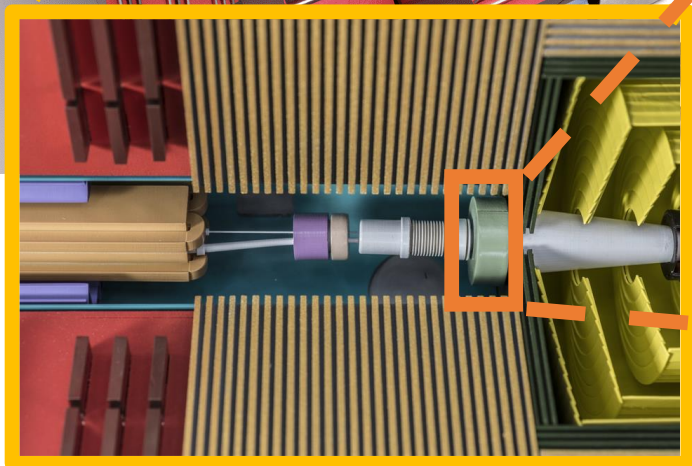
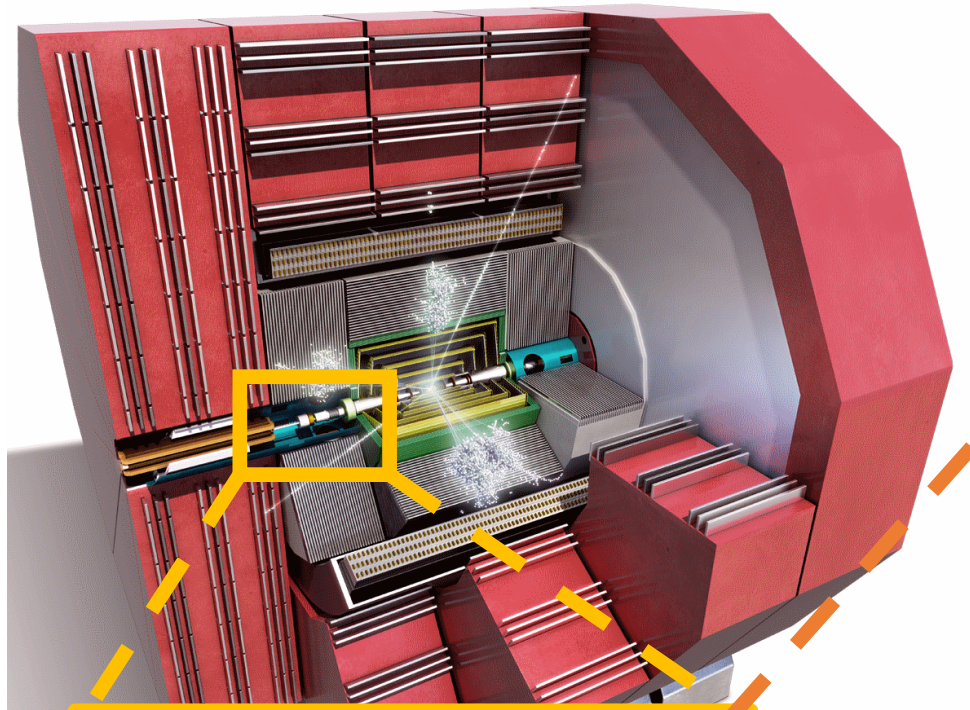
# LumiCal calorimeter



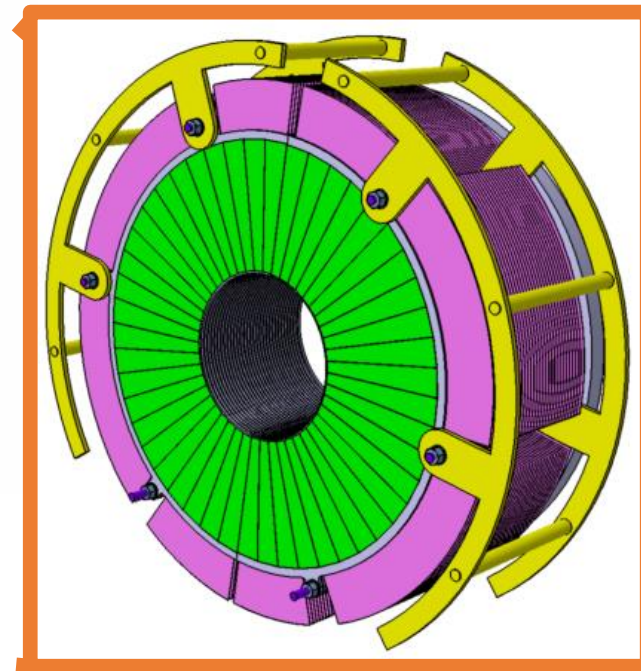
Forward region



# LumiCal calorimeter



Forward region

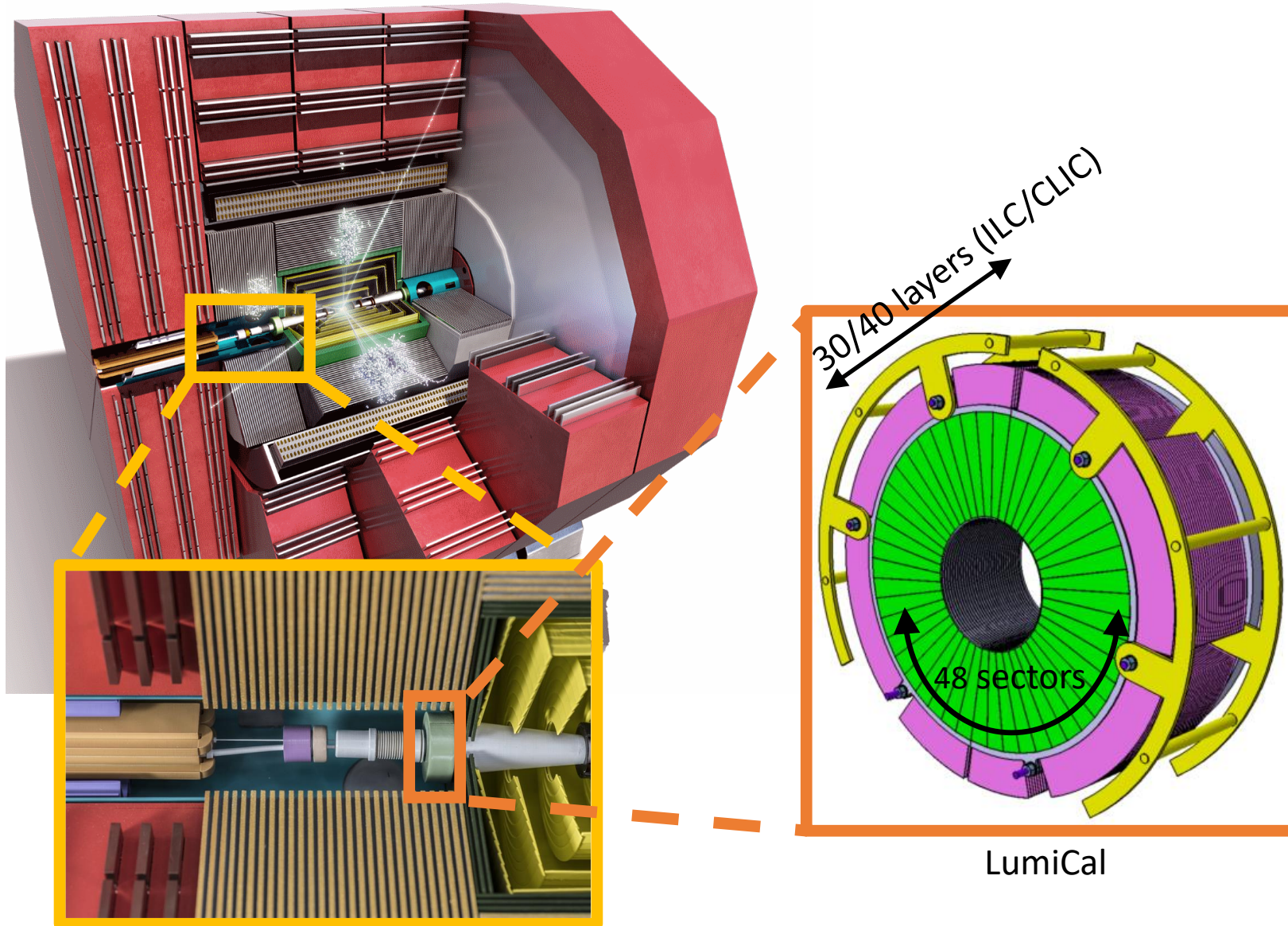


LumiCal





# LumiCal calorimeter



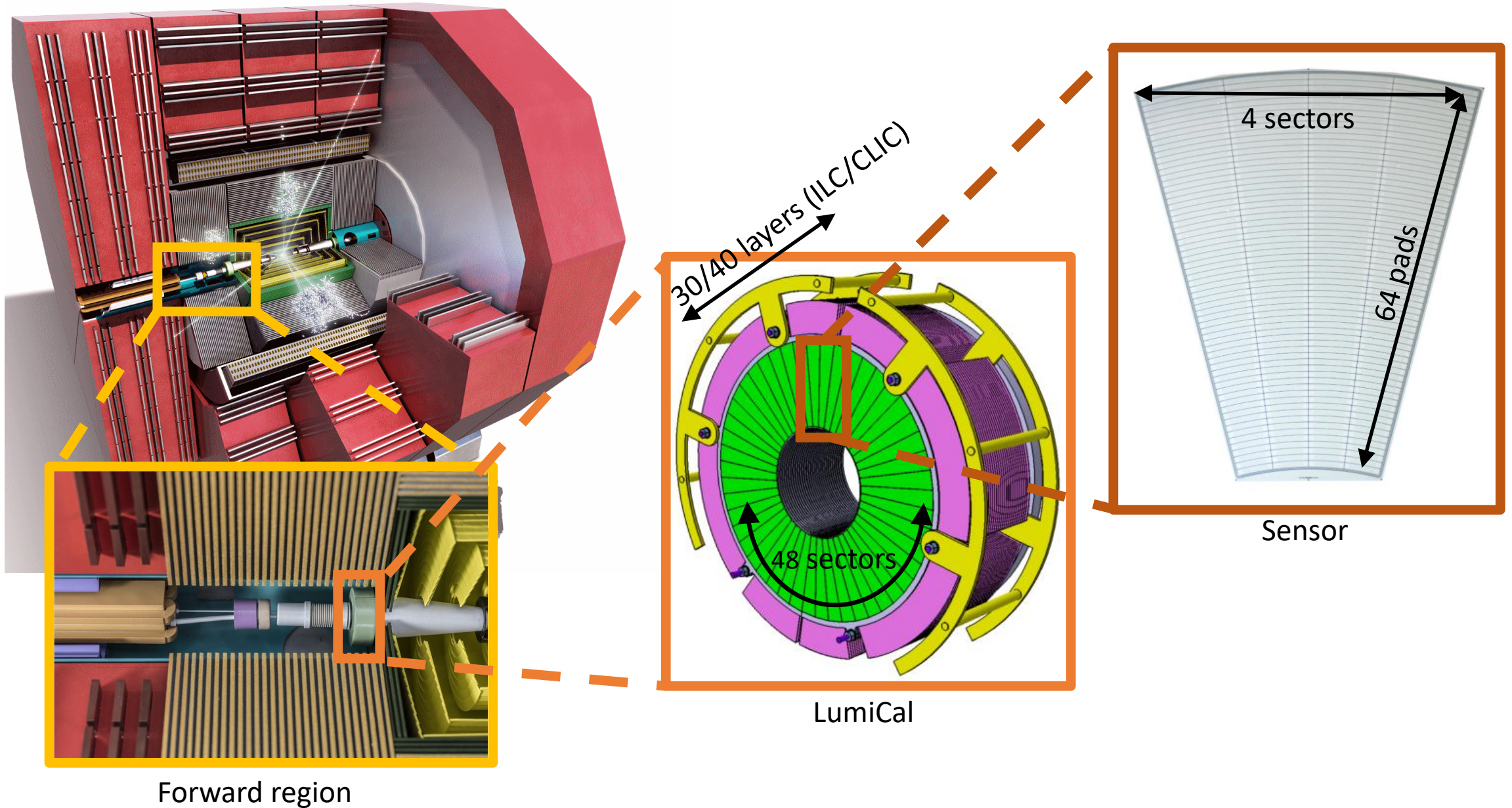
Forward region

LumiCal





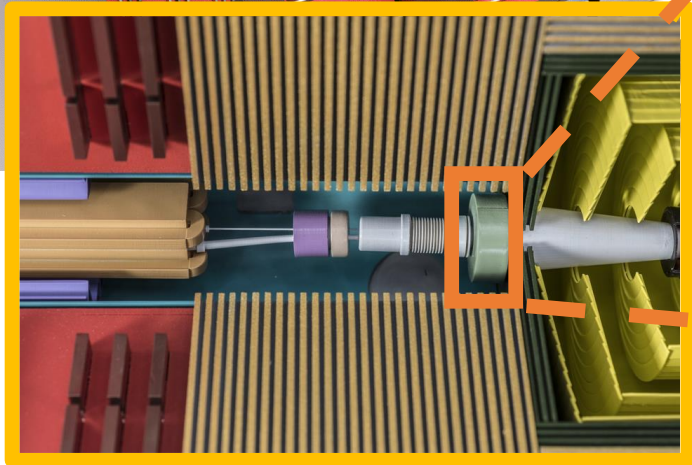
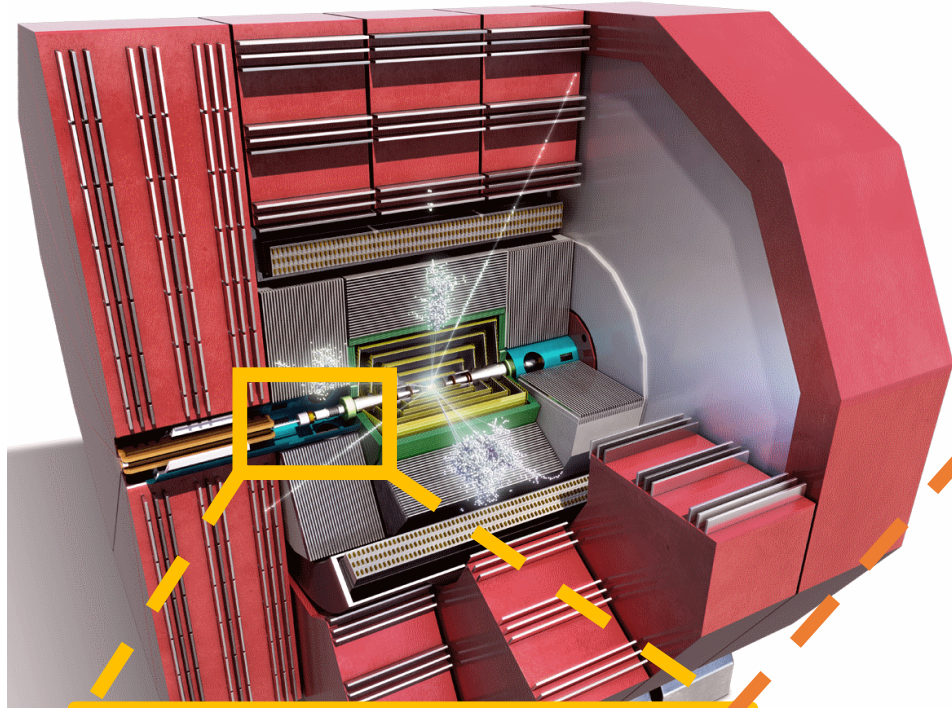
# LumiCal calorimeter



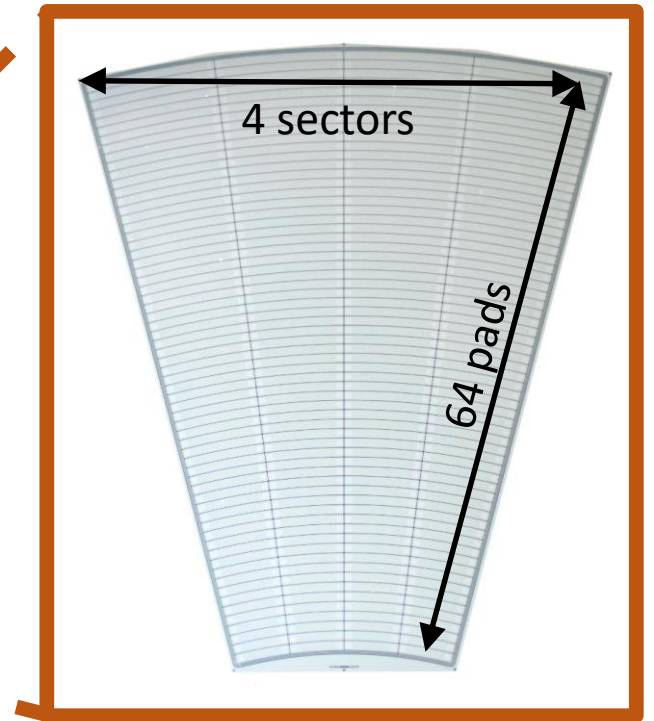
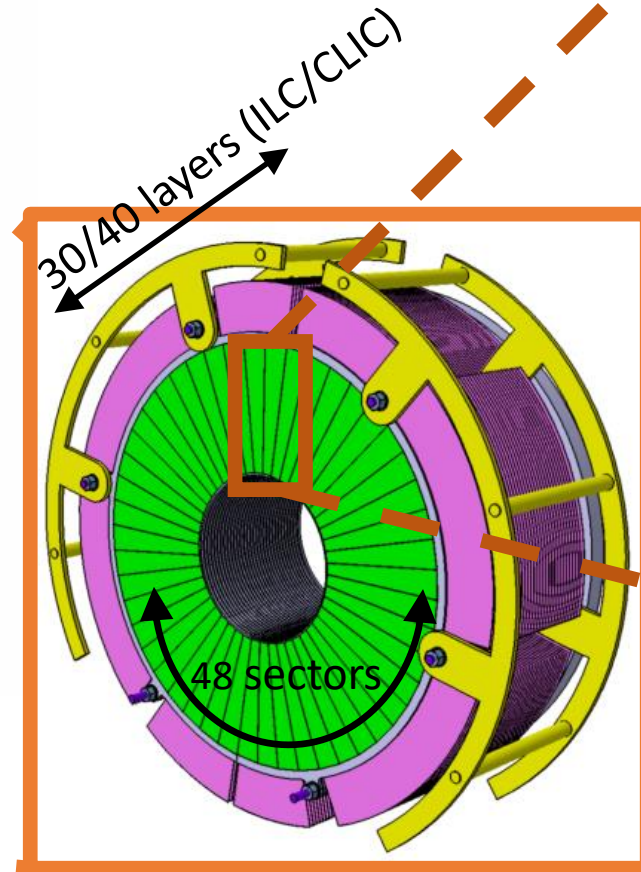




# LumiCal calorimeter



Forward region



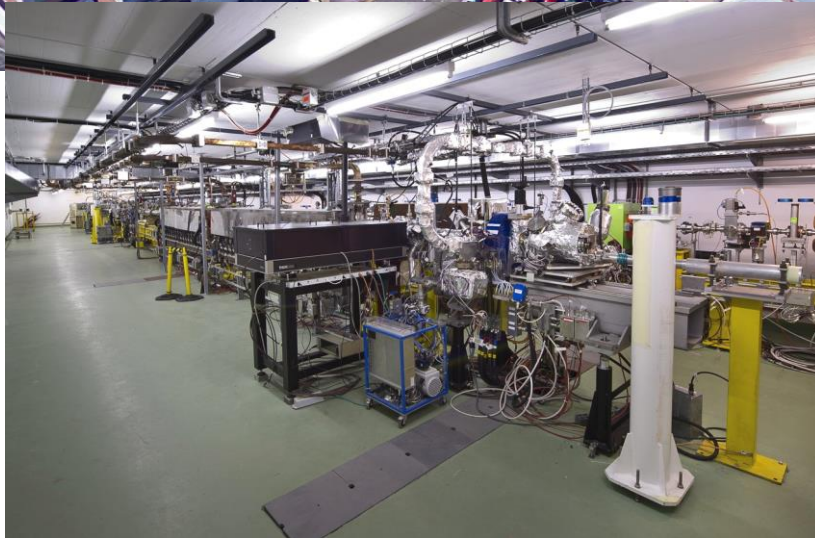
Total:  
 $64 \times 48 = 3\,072$  pads per layer  
**ILC:**  $3\,072 \times 30 = 92\,160$  pads  
**CLIC:**  $3\,072 \times 40 = 122\,880$  pads





# Testing infrastructure

CERN



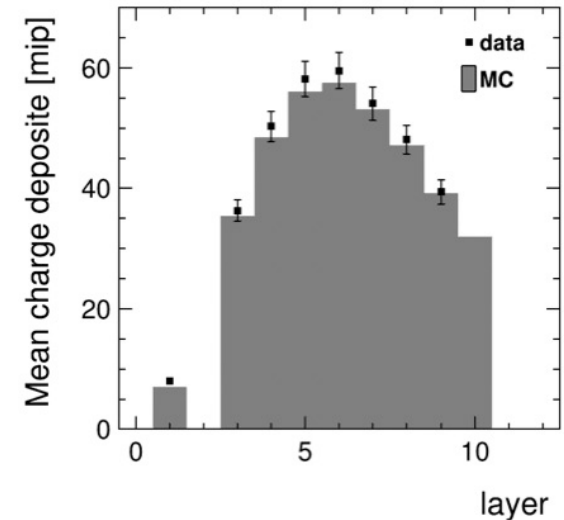
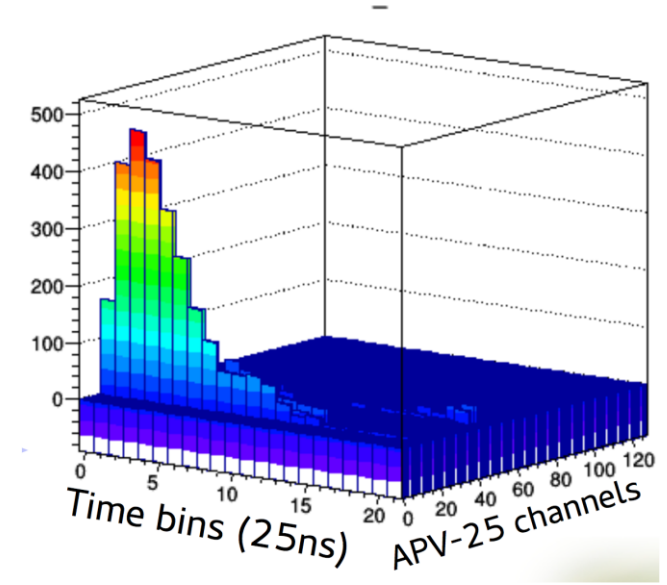
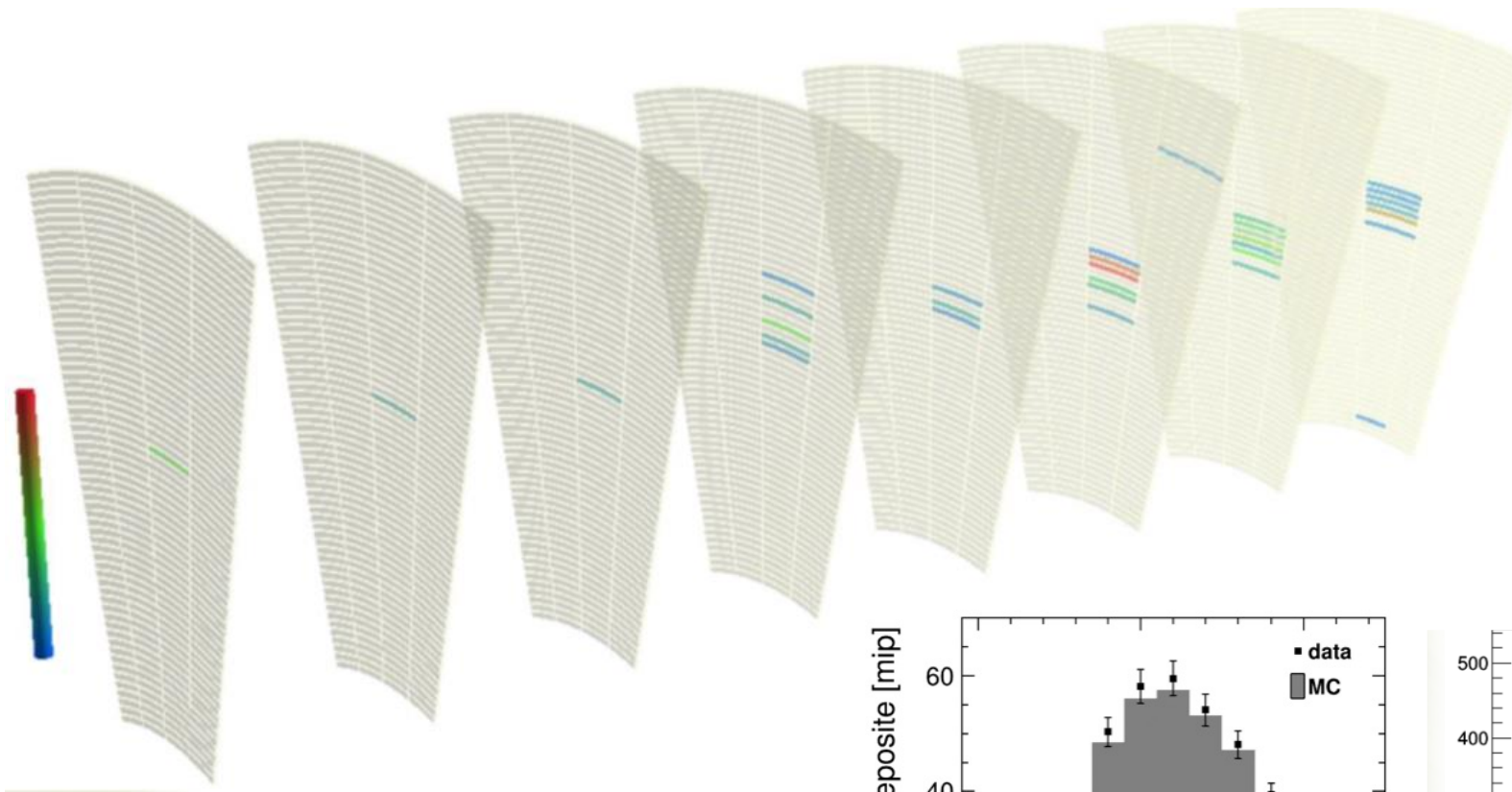
DESY Hamburg



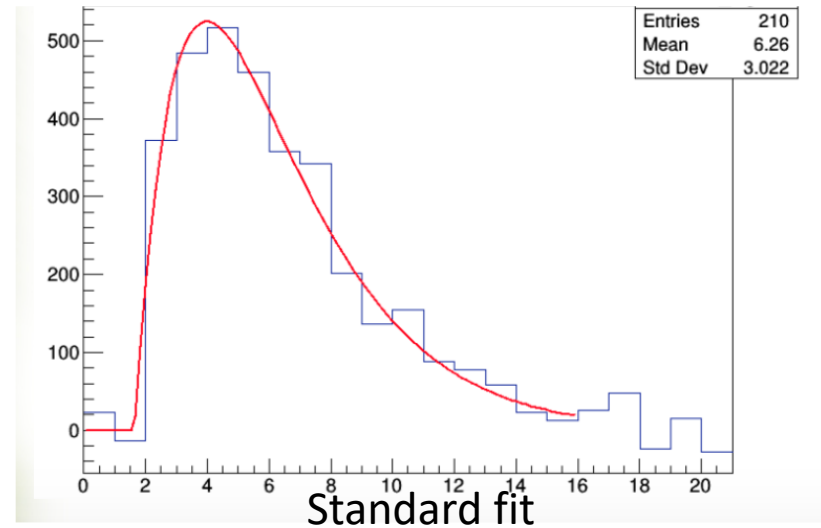
- CLIC Test Facility (CTF3) at CERN end operation in Dec 2016
- The *clear* (CERN Linear Electron Accelerator for Research) is approved for next years



# Event example and signal extraction



Real and MC data comparison

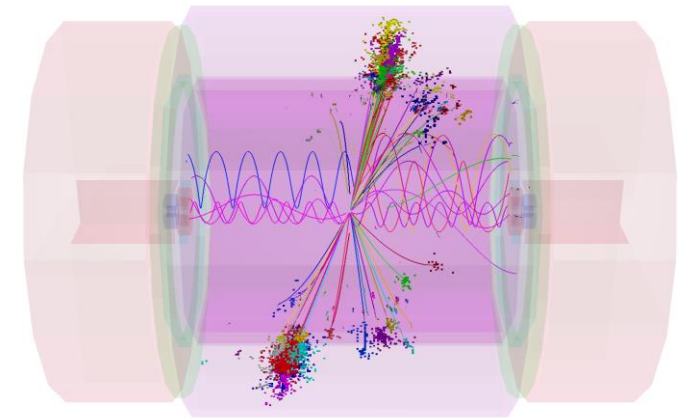
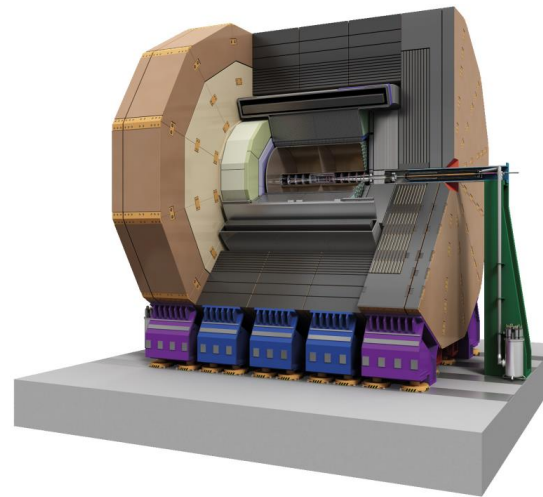
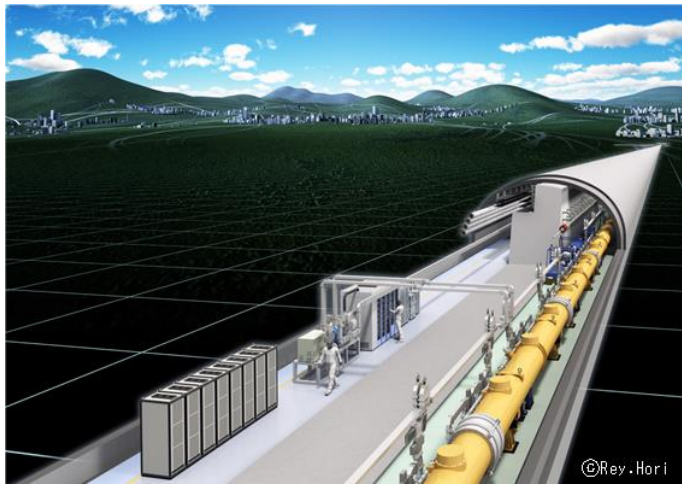


Standard fit

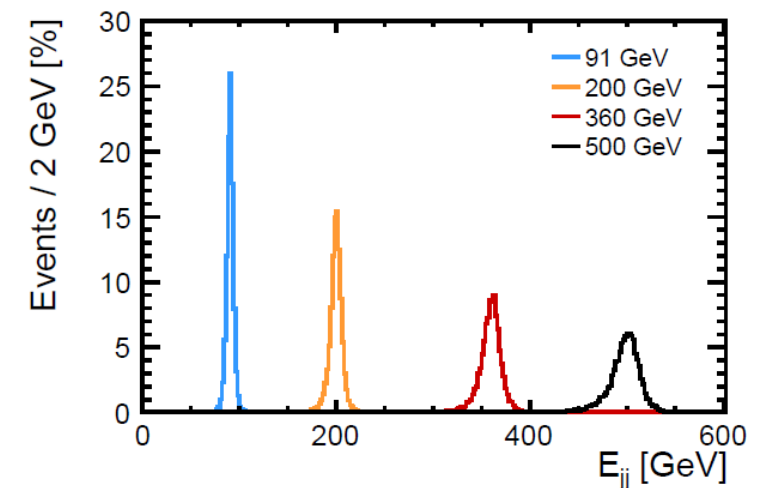




# Accelerator & detector concept, simulation and full reconstruction



- Generic software tools for:
  - Detector designs and simulation descriptions
  - Reconstruction algorithms
  - Run event generation, full simulation and reconstruction







- For data processing DIRAC is used, which provides homogeneous access to heterogeneous resources (from laptops to batch farm or grid sites)
- The iLCDirac extension of DIRAC was created for linear collider detector studies.
- iLCDirac extension contains interfaces for the LC software, files and extension to run large scale computing.
- Easy interfaces for users to create and send jobs



```
from DIRAC.Core.Base import Script
Script.parseCommandLine()
import UserJob
import Marlin
import DiracLC
d = DiracLC()
j = UserJob()
j.setOutputSandbox("recEvents.slcio")
m = Marlin()
m.setVersion("ILCSoft-01-17-09")
m.setSteeringFile("Steering.xml")
m.setInputFile("SimEvents.slcio")
j.append(m)
j.submit(d)
```



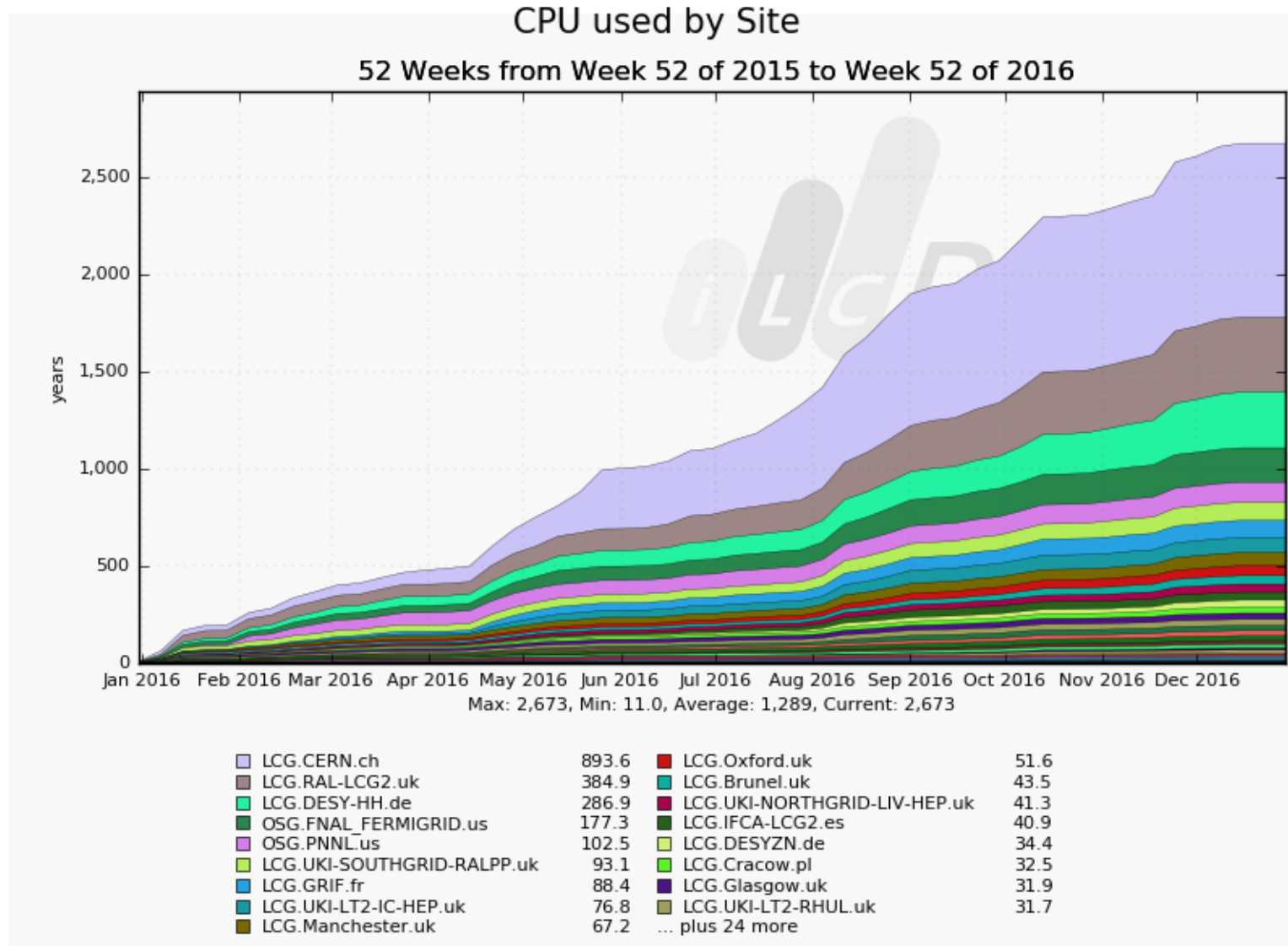
# Simulation performance

- Startup – 130 seconds
- Simulation time for 3 TeV event – 180 sec/event
- Output file size – 14MB/event
- Memory usage – 1.5GB/core

	1 event	1 000 000 events
Simulation time	180 s	50 000 h (5.7 years)
Output filesize	14 MB	13.5 TB



# Dirac statistics – CPU usage



Generated on 2017-02-06 21:04:32 UTC

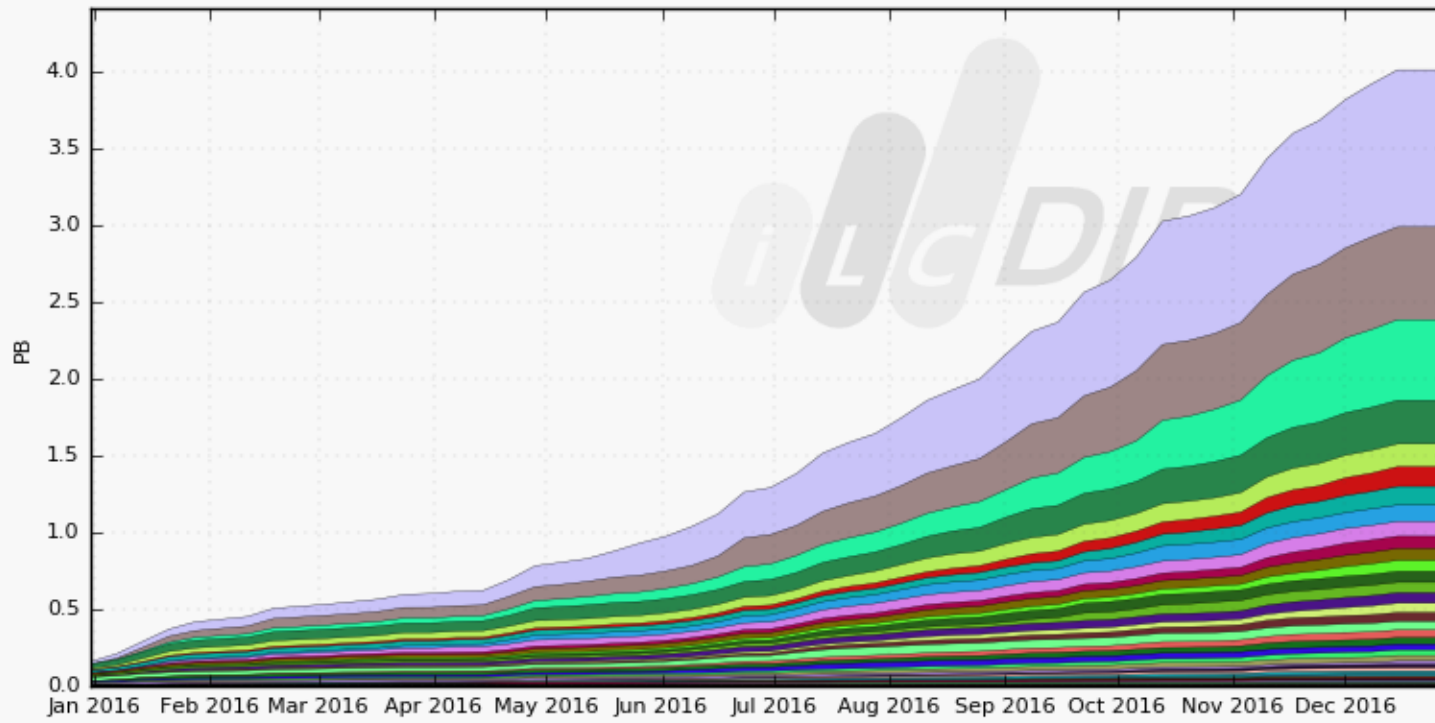




# Dirac statistics – disk space usage

## Cumulative Used disk space by Site

52 Weeks from Week 52 of 2015 to Week 52 of 2016



Max: 4.01, Min: 0.16, Average: 1.69, Current: 4.01

LCG.CERN.ch	1.0	LCG.UKI-NORTHGRID-LIV-HEP.uk	0.1	LCG.LAPP.fr	0.0
LCG.RAL-LCG2.uk	0.6	LCG.Manchester.uk	0.1	LCG.Bristol.uk	0.0
LCG.DESY-HH.de	0.5	LCG.Cracow.pl	0.1	OSG.BNL.us	0.0
OSG.FNAL_FERMIGRID.us	0.3	LCG.IFCA-LCG2.es	0.1	LCG.Birmingham.uk	0.0
LCG.UKI-SOUTHGRID-RALPP.uk	0.1	OSG.MIT.us	0.1	LCG.UKI-LT2-RHUL.uk	0.0
LCG.Oxford.uk	0.1	LCG.Glasgow.uk	0.1	LCG.QMUL.uk	0.0
LCG.Brunel.uk	0.1	LCG.DESYZN.de	0.1	LCG.SCOTGRIDDURHAM.uk	0.0
LCG.GRIF.fr	0.1	LCG.UKI-SOUTHGRID-CAM-HEP.uk	0.1	LCG.Freiburg.de	0.0
OSG.PNNL.us	0.1	OSG.CIT.us	0.1	... plus 15 more	0.0

Generated on 2017-02-06 21:07:15 UTC



# Summary

- Full chain of LC software is ready
- Models of ILD, SiD and CLIC detectors are fully described and implemented for simulation and reconstruction
- CLEAR (CERN Linear Electron Accelerator for Research) approved for next years for electron beam test facility
- Still waiting for construction decision

