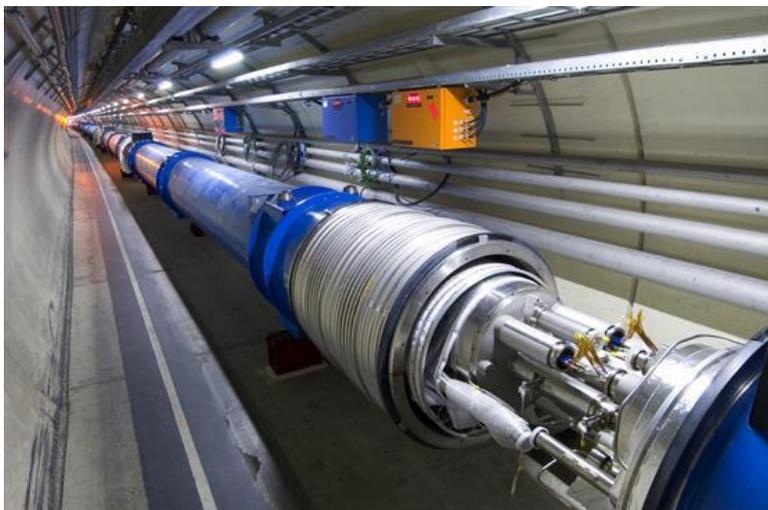


# Summer at CERN?

*Meeri Harkki  
Helsinki Institute of Physics (HIP)*



- The **Helsinki Institute of Physics** (HIP, [www.hip.fi](http://www.hip.fi)) is a physics research institute that is operated jointly by
  - the University of Helsinki
  - Aalto University
  - the University of Jyväskylä
  - the Lappeenranta-Lahti University of Technology
  - the Tampere University
  - with the Finnish Radiation and Nuclear Safety Authority (STUK)
- The research activity at the institute covers an extensive range of subjects in theoretical physics and experimental subatomic physics.



- HIP is also the link between international collaborations and Finland
  - Opportunities in multiple fields of physics: summer student programme (for all students in Finland!), thesis', work as a graduate etc.
  - **LHC** (Large Hadron Collider) is the world's largest particle collider situated at **CERN** (the European Organization for Nuclear Research) on the border of Switzerland and France

- Multiple experiments at CERN that HIP works with (each measuring collisions produced at the LHC):
  - CMS
  - TOTEM
  - ALICE
  - Isolde
- ESRF at Grenoble, France

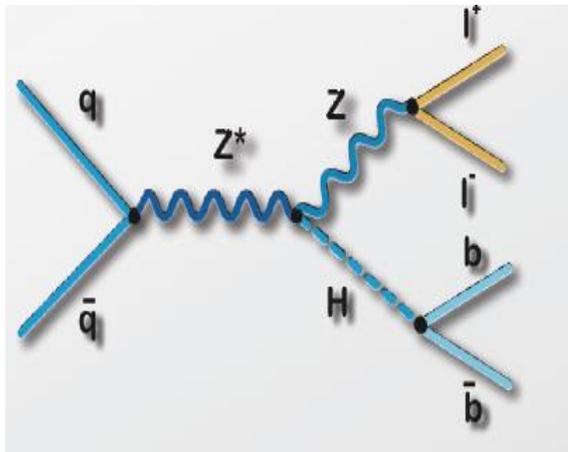


CERN and ESRF locations

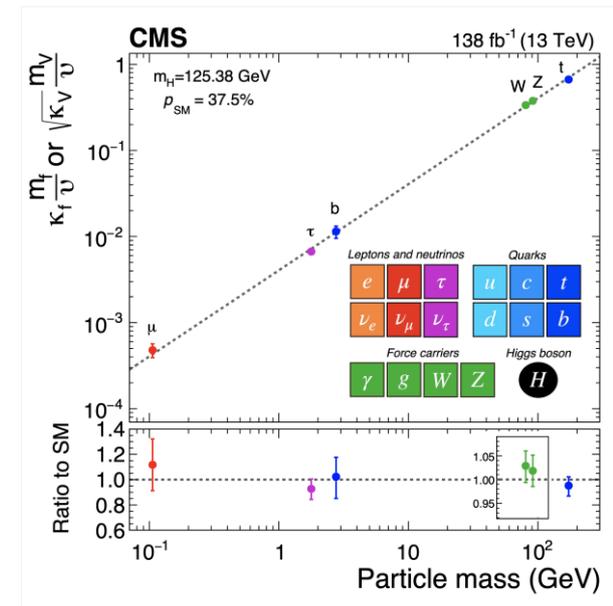
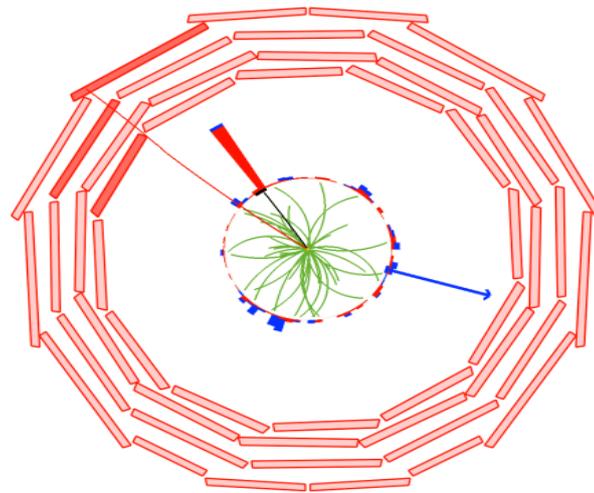


Aerial view of ESRF

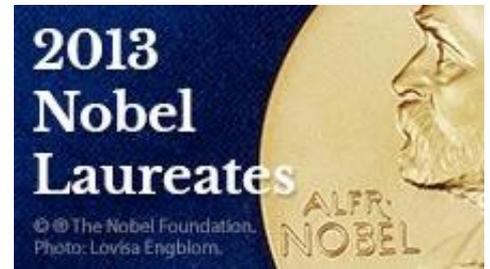
- **New particles and phenomena – rare decays – precision measurements**
- **Higgs particles – electroweak symmetry breaking**
- **Supersymmetry – solution to dark matter?**
- **Exotic particles – new theories?**
- **CP violation, rare decays – are they in the standard model?**
- **Precision measurements – indirect method for studying physics at different energy scales**



P. Eerola



*"for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was confirmed through the discovery of the predicted fundamental particle, by the ATLAS and CMS experiments at CERN's Large Hadron Collider"*



**François Englert and Peter W. Higgs**



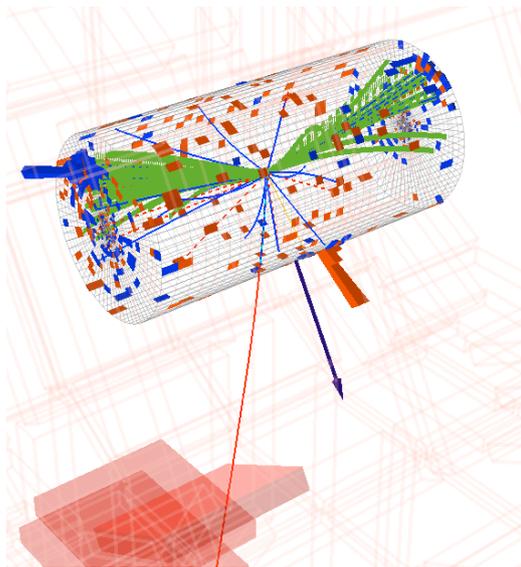
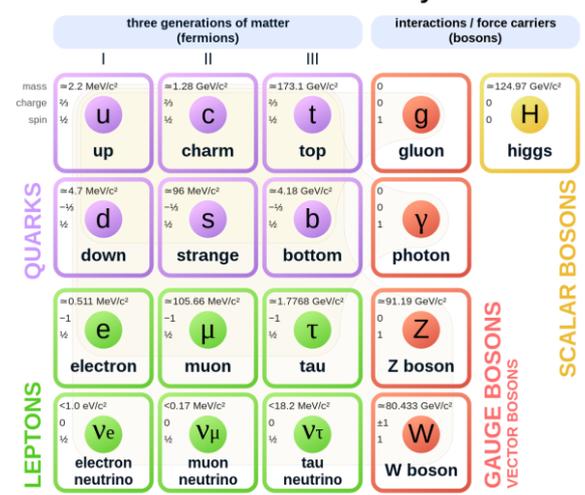
10 years  
**HIGGS boson**  
discovery

- *Collaborations* are the ones building, taking care of and using the experiments – combinations of hundreds of universities and institutes
- **CMS** (Compact Muon Solenoid): Around 200 members from 46 different countries, over 3500 physicists, engineers, other staff and even students
- Various responsibilities and fields of expertise
  - Detectors
  - Physics analysis
  - Communication and open data



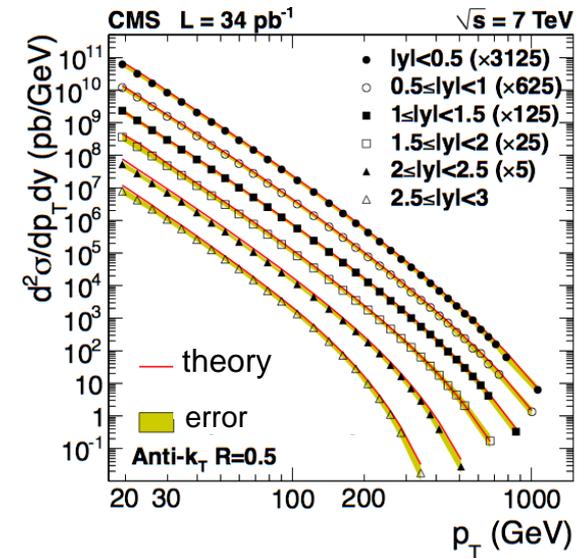
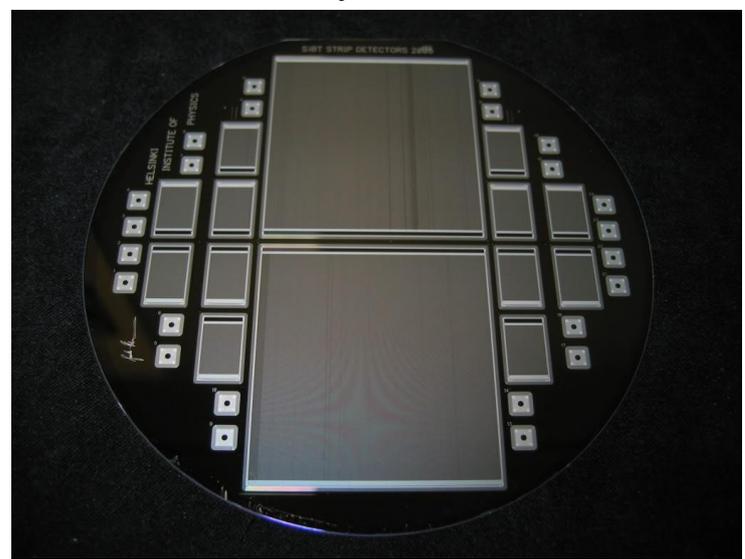
- **...charged Higgs and beyond standard model**
  - Develop techniques for discovery i.e. what collisions to include, where to search, how to search (cuts, AI/ML?)
- **...particle sprays, jets**
  - Jets are born in almost every collision, used in analysis but measurements also need to be accurate
- **...instrumentation and computation**
  - New components for future measurements
  - Help CMS with their computational clusters

### Standard Model of Elementary Particles

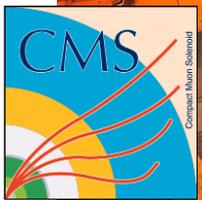
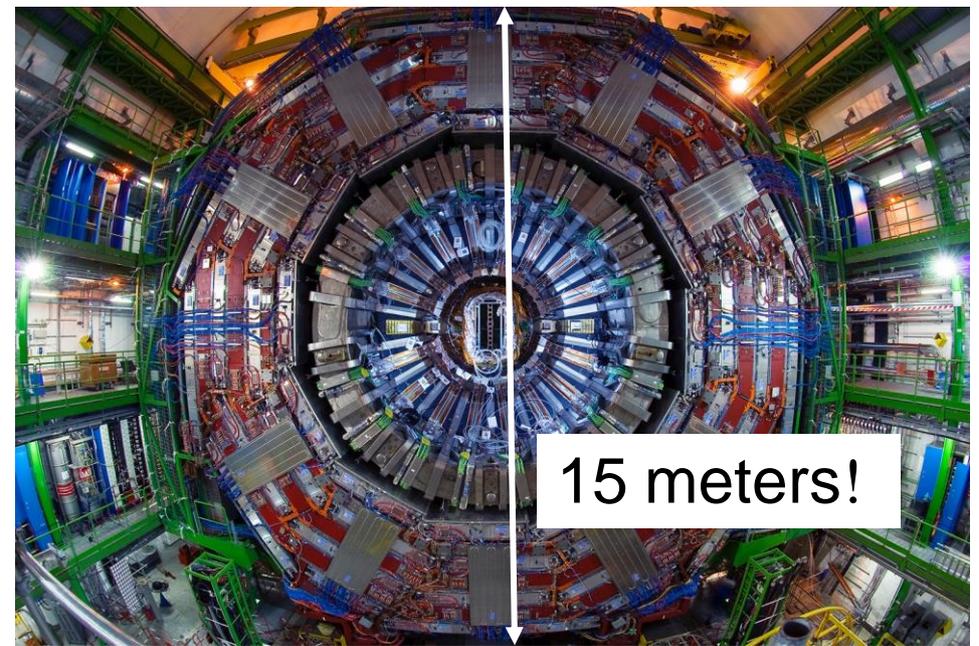
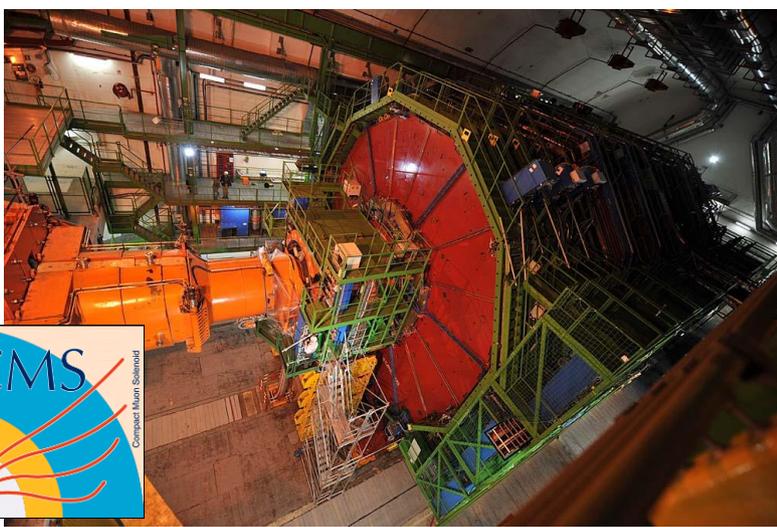
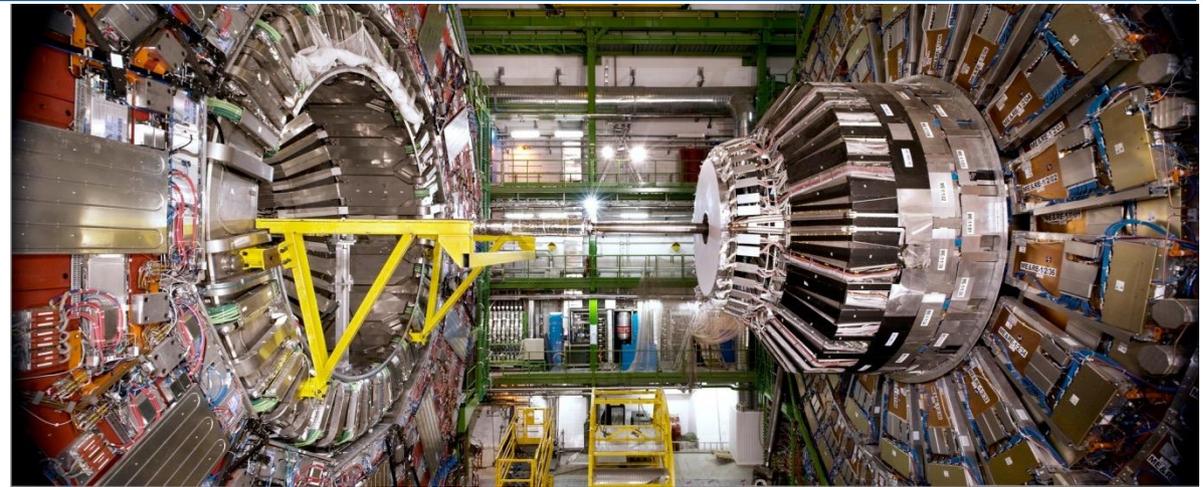


A collision happens...

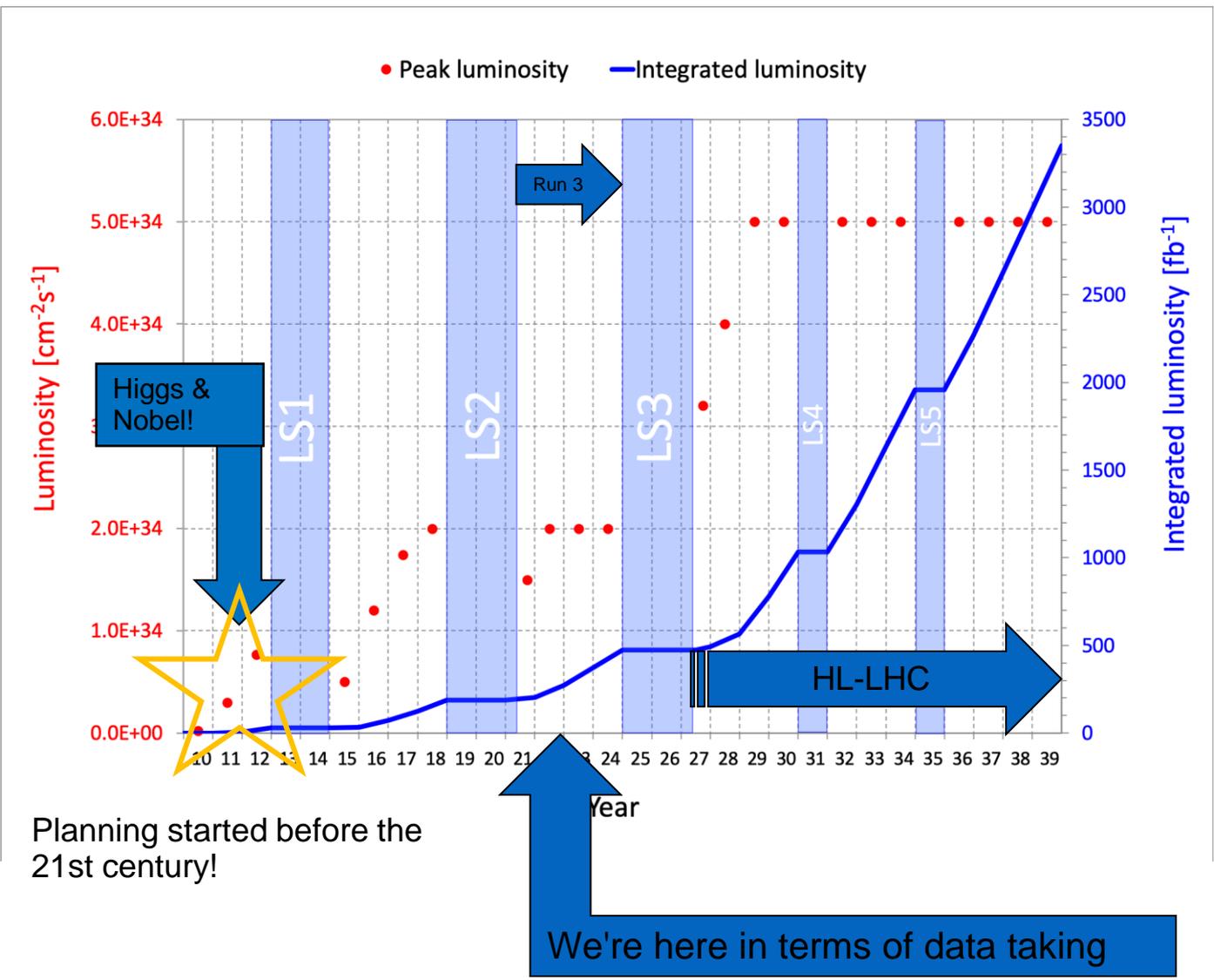
...is measured by the detector...



...and then analyzed



**Run 3 started in 2022 and will keep running and producing new data!**



Great opportunities for students still coming!

[www.hip.fi](http://www.hip.fi) → Graduate Education

[www.hip.fi/summies](http://www.hip.fi/summies)

- Particle physics:
  - Higgs physics at the LHC
  - Jet physics at the LHC
  - Higgs physics with boosted jets at the LHC
  - Vector boson scattering and machine learning at the LHC
  - Operation and Calibration of CMS Experiment at LHC
  - Discovery physics with CMS-TOTEM at the LHC
  - Experimental particle physics in ALICE
  - Open data in use
- Instrumentation – detectors and accelerators
  - R & D of gaseous detectors
- Nuclear physics:
  - Research and development for instrumentation in nuclear physics at ISOLDE
- Mechanical engineering:
  - Mechanical engineering (Design, Materials, Production)
- European Synchrotron Radiation Facility ESRF (Grenoble, France):
  - Research at the synchrotron light source ESRF ([www.esrf.eu](http://www.esrf.eu))

**SUMMER JOBS @ CERN**  
organized by Helsinki Institute of Physics

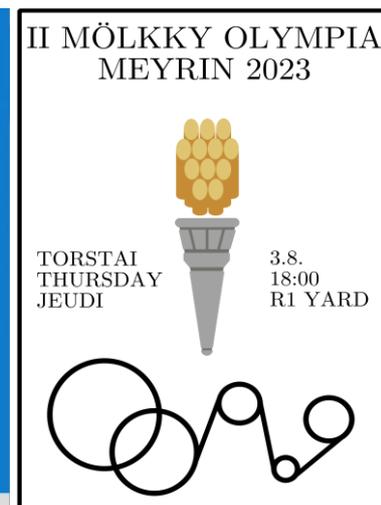
#Higgs  
#Quarks  
#Jets  
#DarkMatter  
#SuperSymmetry  
#ParticlePhysics

#Technology  
#MachineLearning  
#OpenData  
#Engineering  
#Algorithms  
#Instrumentation  
#TechnologyTransfer

**APPLY BEFORE 31.1.2024 @**  
[www.hip.fi/summies](http://www.hip.fi/summies)

The poster features a map of Europe with a red location pin at CERN. A red arrow points from the top right towards CERN. Below the map is a large group photo of people standing in front of a large, dome-shaped structure.

- CERN Summer student programme:
  - Lectures from high profile physicists
  - Visits to experiments
- Hundreds of students from around the world
  - Local events between students
  - Travel company (great location to go see Europe!)
- Great way to be introduced to the community and the field of particle physics and to establish connections for future (*career and friends*)



HIP summies of 2022 organized the first Meyrin mölkky tournament!

- Travel is paid
- Salary ~1400 € per month  
+ travel allowance ~1000 € per month
- Accommodation isn't provided, but HIP office will help with this
  - CERN has two hostels near and at the site and students can also look to share houses/apartments
- Training period June 1st to August 31st (negotiable)
- Detailed information in the HIP Summer Student Guide, <https://www.hip.fi/jobs-vacancies/summer-jobs/summer-jobs-at-cern/>

**SUMMER JOBS @ CERN**  
organized by Helsinki Institute of Physics

#Higgs  
#Quarks  
#Jets  
#DarkMatter  
#SuperSymmetry  
#ParticlePhysics

#Technology  
#MachineLearning  
#OpenData  
#Engineering  
#Algorithms  
#Instrumentation  
#TechnologyTransfer

**APPLY BEFORE 31.1.2024 @**  
[www.hip.fi/summies](http://www.hip.fi/summies)

Applications:

[www.hip.fi/summies](http://www.hip.fi/summies)

- Physics positions:
  - ~3 years of studies by the summer
  - Knowledge of particle physics an advantage, not a requirement
  - Programming skills (C/C++, Python, UNIX) an advantage
- Contact persons will help you with information, feel free to contact them
- Application deadline **31.1.2024**
- Application includes a **motivation letter**, a **study record** and a **resume**
  
- Chosen people will be informed in February-March and they can start preparing for the summer

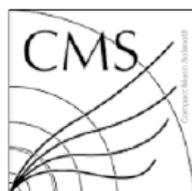


- Intensive one-week course (10 cr.) at CERN in June (3.–7.6.) with a two-day kick-off in Finland in March (14.–15.3.)
- Group of students use methods of **service design** to solve global challenges related to UN SDGs (Sustainable Development Goals). No special skills or pre-requisites required!
- More information at <https://www.hip.fi/cern-bootcamp/>
- Application deadline **31.1.2024**



- 2–3 month internship in CERN's own international program (not associated with HIP)
- Application at: [www.cern.ch/summies](http://www.cern.ch/summies)
- Aimed for physics, engineering and mathematics students. Many projects in different experiments encompassing the whole CERN ecosystem
- Deadline **31.1.2024**
- Requires a **letter of recommendation**
- Application process extends to April with multiple phases in it

# THANK YOU FOR FOLLOWING!



CMS Experiment at LHC, CERN  
 Run/Event : 171178/11119024  
 Lumi section : 12

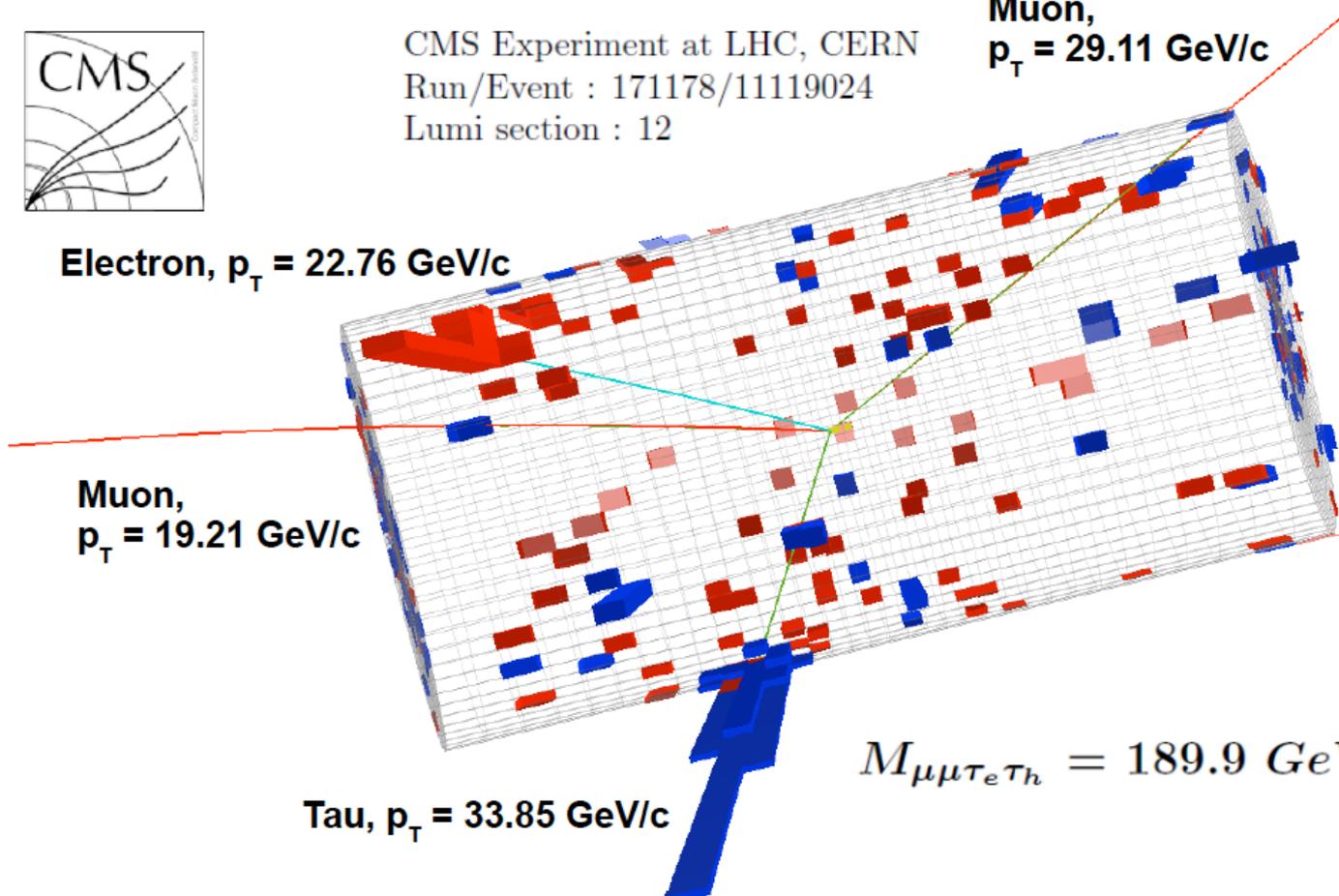
Muon,  
 $p_T = 29.11 \text{ GeV}/c$

Electron,  $p_T = 22.76 \text{ GeV}/c$

Muon,  
 $p_T = 19.21 \text{ GeV}/c$

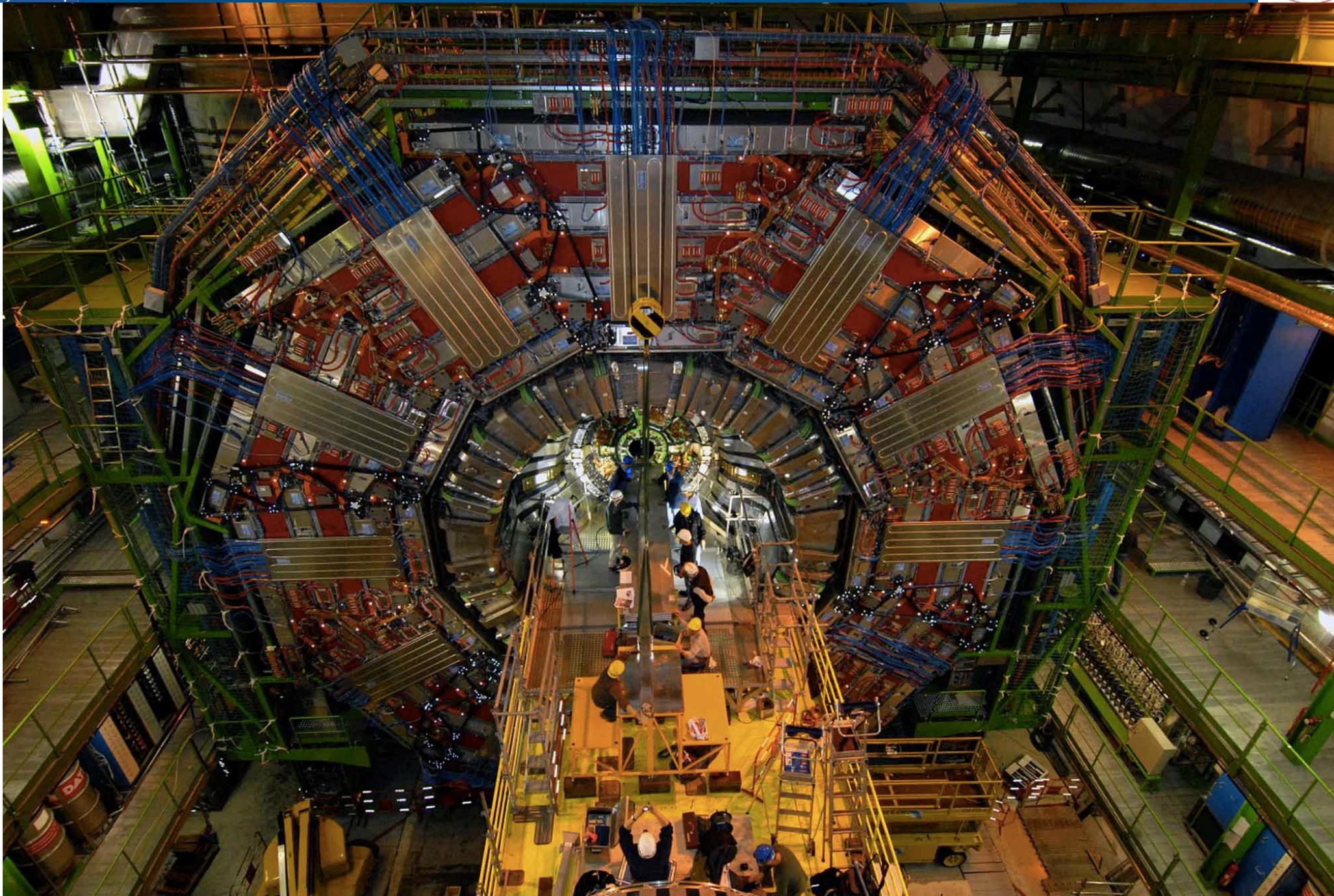
Tau,  $p_T = 33.85 \text{ GeV}/c$

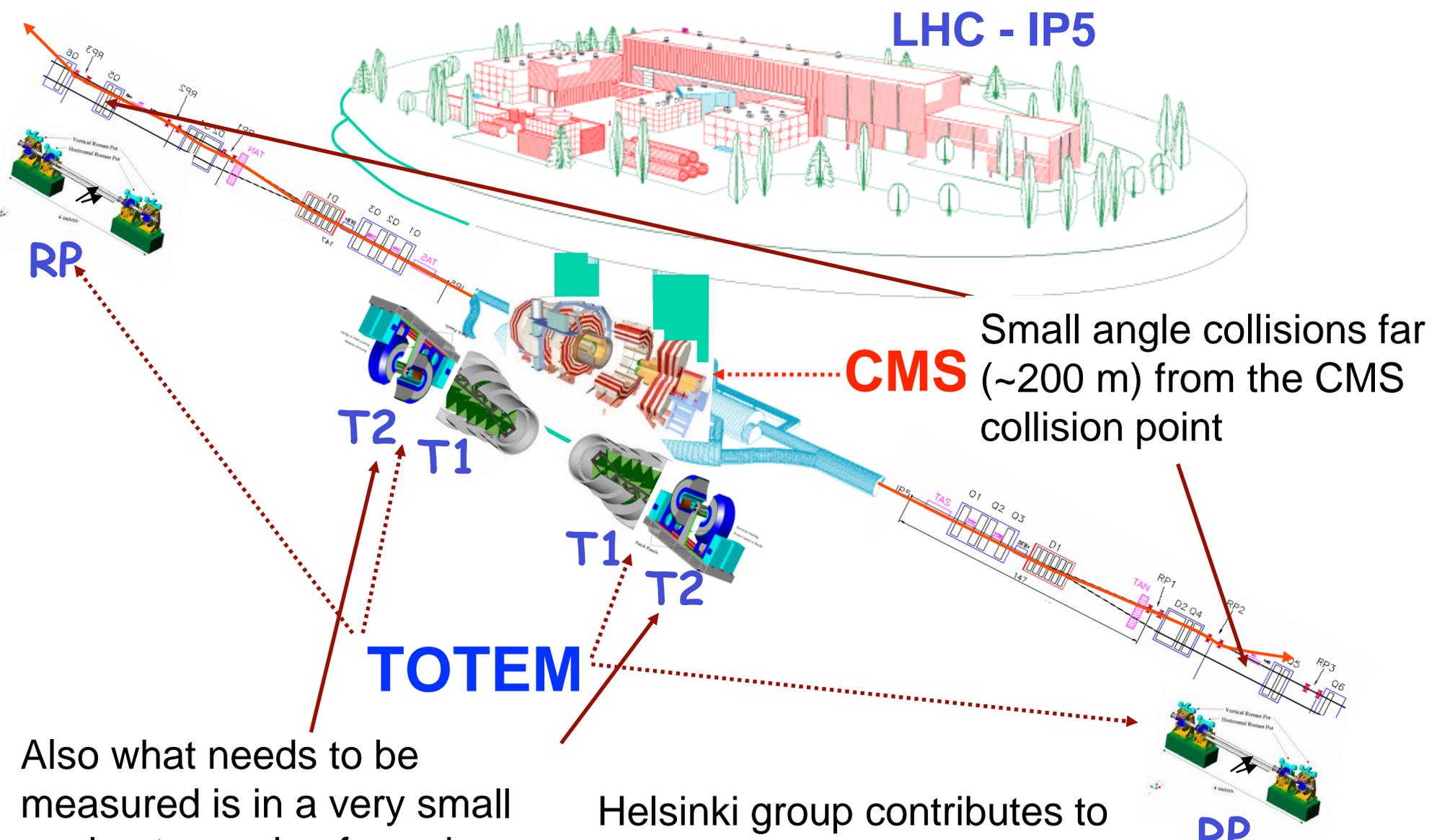
$$M_{\mu\mu\tau_e\tau_h} = 189.9 \text{ GeV}/c^2$$

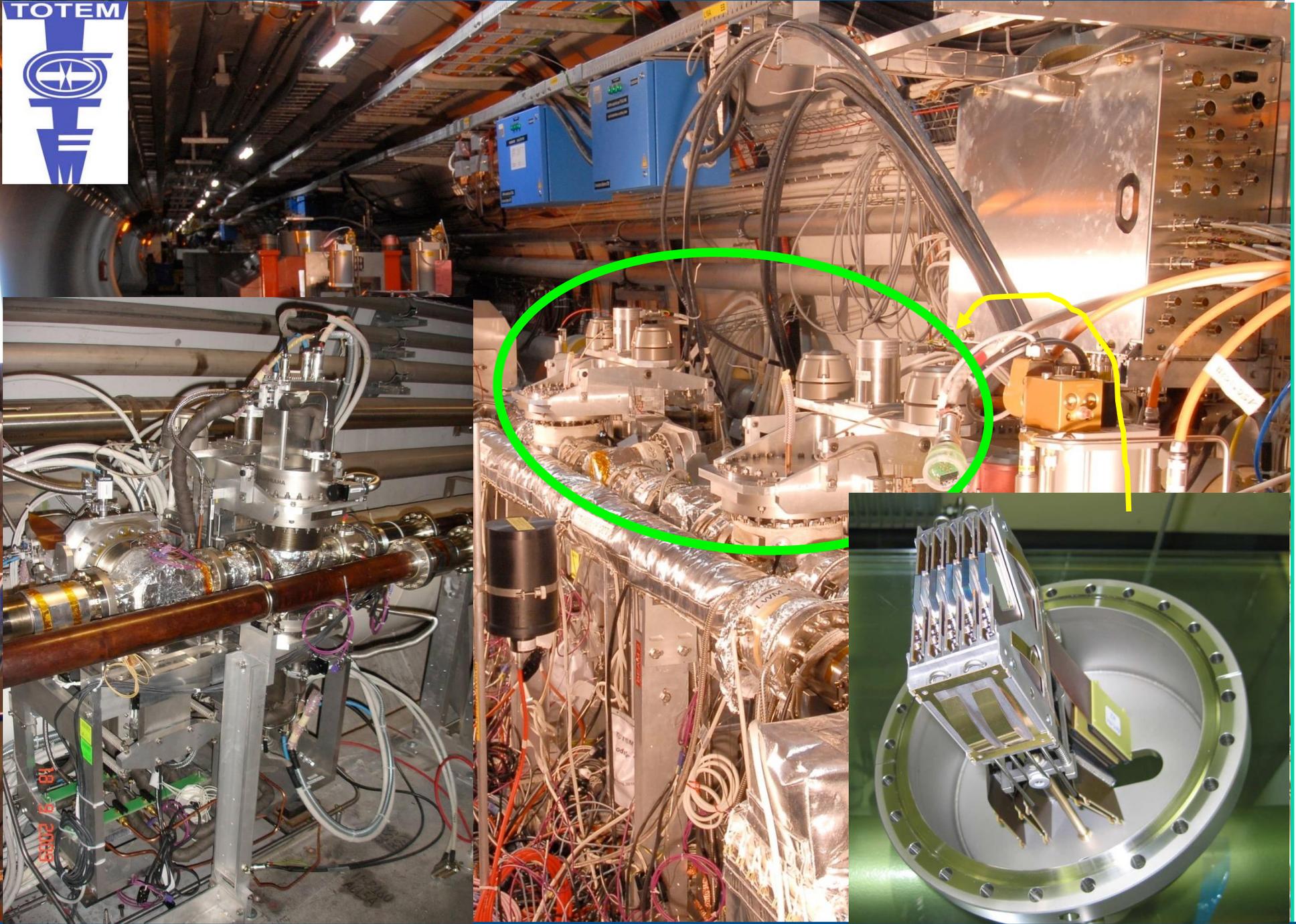


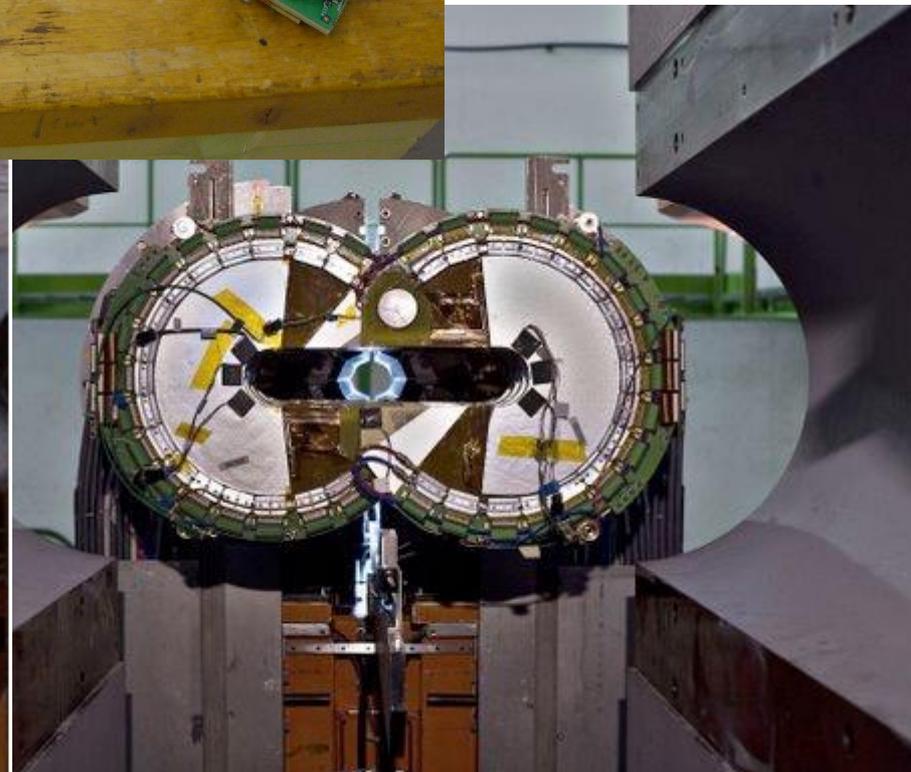
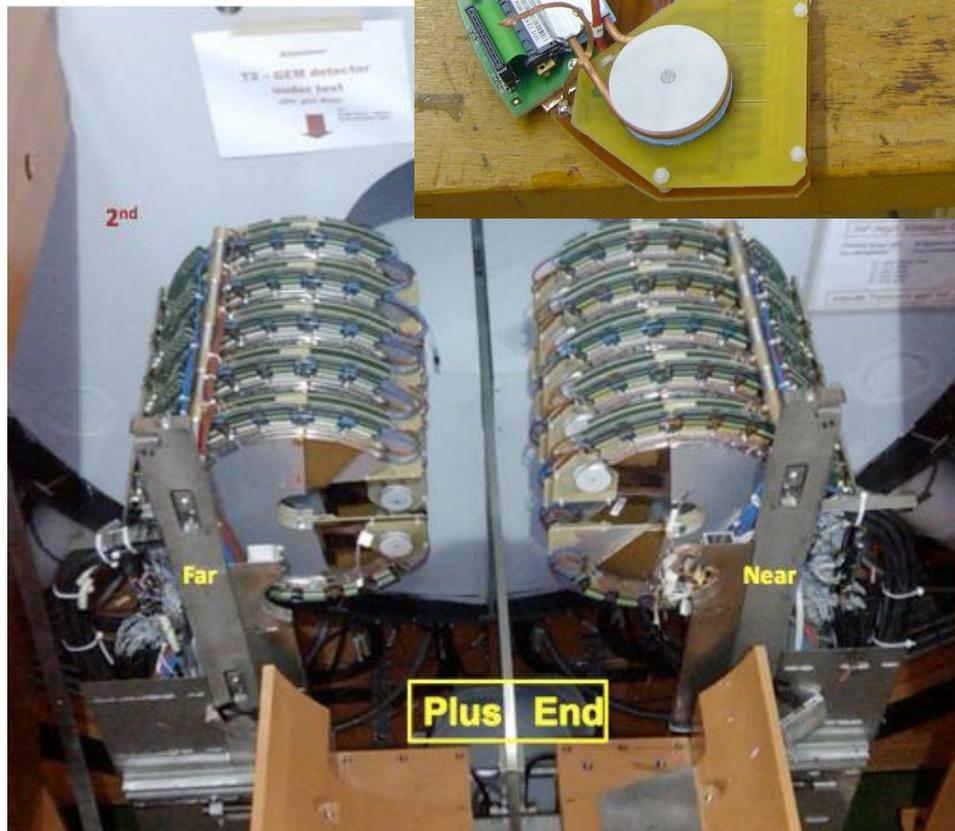
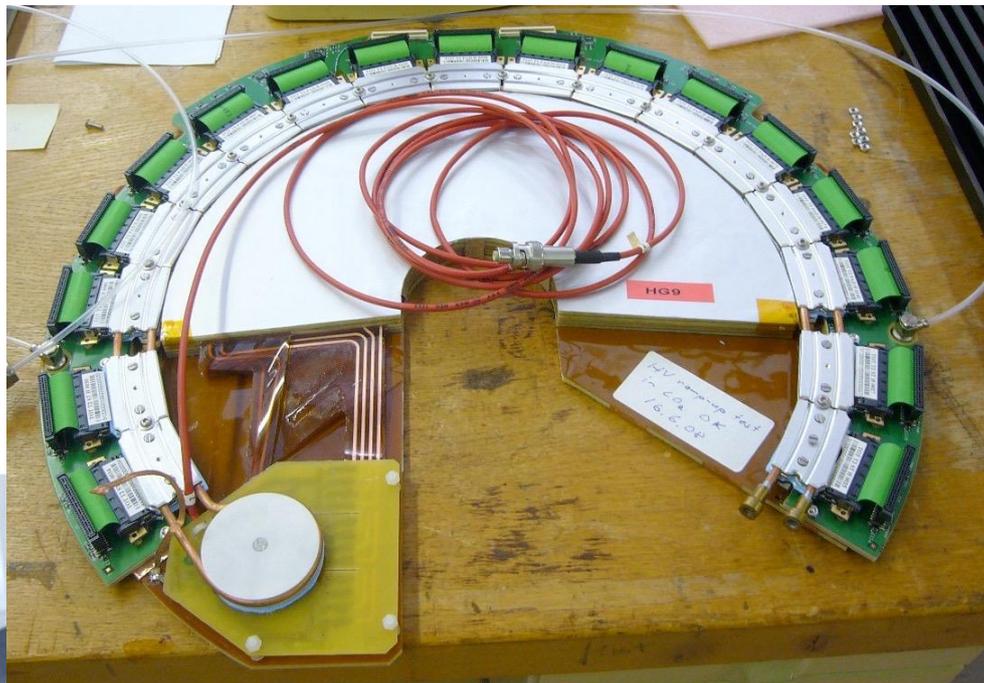
Slides based on previous slides created by:  
 M. Voutilainen, S. Laurila, L. Martikainen, H.  
 Siikonen and N. Toikka

# BACKUP / PREVIOUS YEARS



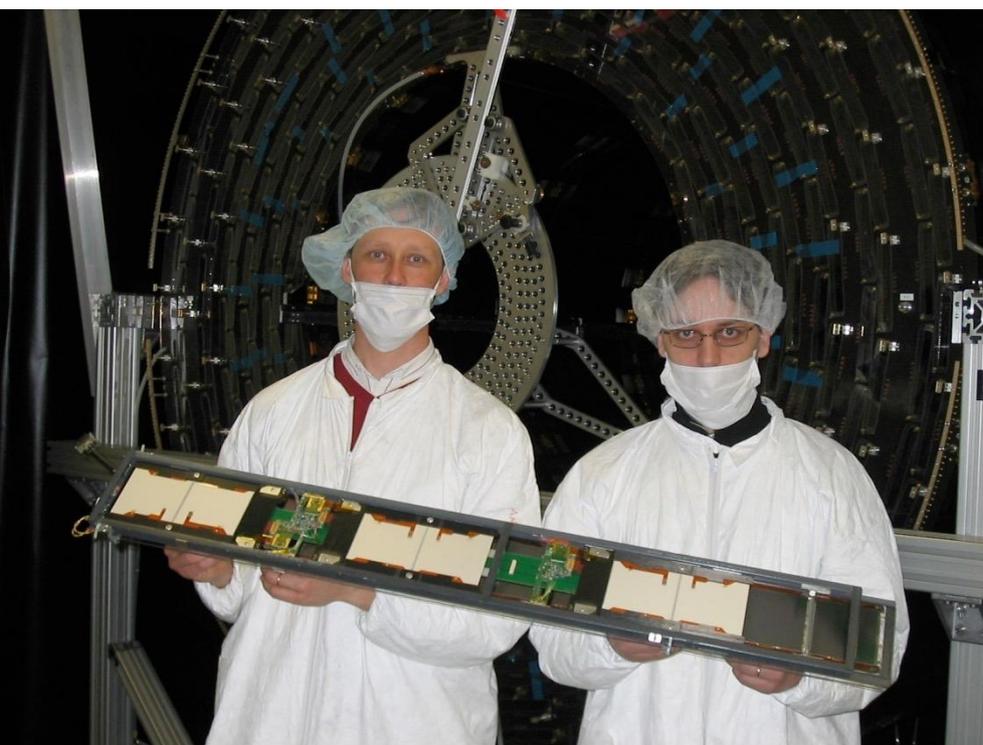






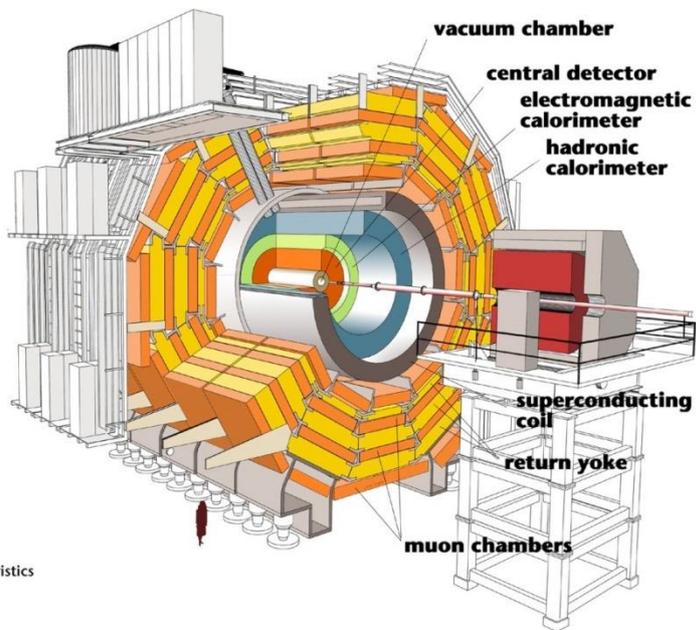
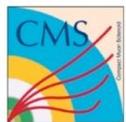


Jälki-ilmaisimien koostuu pii-ilmaisimista, joista muodostuu 10 miljoonaa tiedonlukuyksikköä.



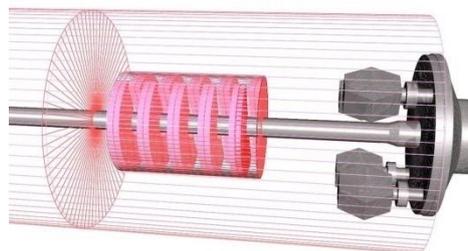
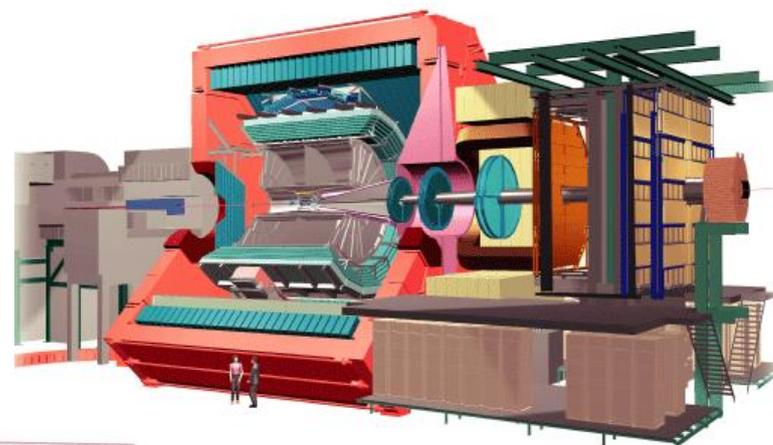
P. Eerola

- Suomalaiset ovat mukana kolmessa kokeessa:
  - CMS – Compact Muon Solenoid – ns. yleiskoe,
  - ALICE – tutkii raskaiden atomiytimien törmäyksiä,
  - TOTEM – tutkii protonien törmäyksiä, joissa törmäysten lopputuotteet siroavat vain vähän suihkun suuntaan verrattuna



Detector characteristics

Width: 22m  
Diameter: 15m  
Weight: 14'500t



- Higgsin ja topin massat vihjaavat vakuumin olevan epästabiili
  - antrooppinen periaate vai uutta fysiikkaa?
- Pimeän aineen etsinnät vetäneet vesiperän, toistaiseksi
  - onko löytö ihan kulman takana LHC:lle ja suorille etsinnöille?

