

HEPHY



# 653.403 / PHM.515UB

# EXPERIMENTAL PARTICLE PHYSICS

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INTRODUCTION TO THE LECTURE

# LINKS

- Moodle @ KFU
  - <https://moodle.uni-graz.at/course/view.php?id=84717>
  - Use 'Fragen zur Vorlesung'
- online.uni-graz.at
  - [https://online.uni-graz.at/kfu\\_online/pl/ui/\\$ctx;design=pl;header=max;lang=de/wbLv.wbShowLVDetail?pStpSpNr=641206&pSpracheNr=1](https://online.uni-graz.at/kfu_online/pl/ui/$ctx;design=pl;header=max;lang=de/wbLv.wbShowLVDetail?pStpSpNr=641206&pSpracheNr=1)
- Slides (Indico) [public]
  - <https://indico.cern.ch/event/975141/>
- Youtube channel with recordings and videos to calculations with intermediate steps [public]
  - <https://www.youtube.com/channel/UC9T3q6DpDJF6iZSMRQeEJTQ>

Fr	<a href="#">20.11.2020</a>	11:45	14:45
Fr	<a href="#">27.11.2020</a>	11:00	13:00
Fr	<a href="#">27.11.2020</a>	13:30	15:00
Fr	<a href="#">04.12.2020</a>	11:00	13:00
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Fr	<a href="#">15.01.2021</a>	11:00	13:00
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Fr	<a href="#">22.01.2021</a>	11:00	13:00
Fr	<a href="#">22.01.2021</a>	13:30	15:00
Fr	<a href="#">29.01.2021</a>	11:00	13:00
Fr	<a href="#">29.01.2021</a>	13:30	15:00

# MODE OF OPERATION

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- Lecture is blocked – two units / day
- Will record & upload to youtube
- Youtube videos will also replace calculations on the board where useful
- Exam: Oral & very likely also remote – three questions from a predefined list

# CONTENT

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## 1. Colliders

- enabling concepts – ideas leading to discoveries
- luminosity & energy – key collider parameters
- facilities of the past and the present

## 2. Collisions

- types of collisions
- interplay of  $e^+/e^-$  and hadron-hadron collisions
- interrelations with the theoretical description

## 3. Interaction of particles with matter

- what happens when a particle hits the detector?
- ionization, bremsstrahlung, pair production, ...

## 4. Detectors

- Gaseous detectors
- Semiconducting detectors
- Scintillators
- Calorimeters
- Particle Identification

## 5. Experiments

- The CERN LHC experiments and beyond

## 6. Data Analysis

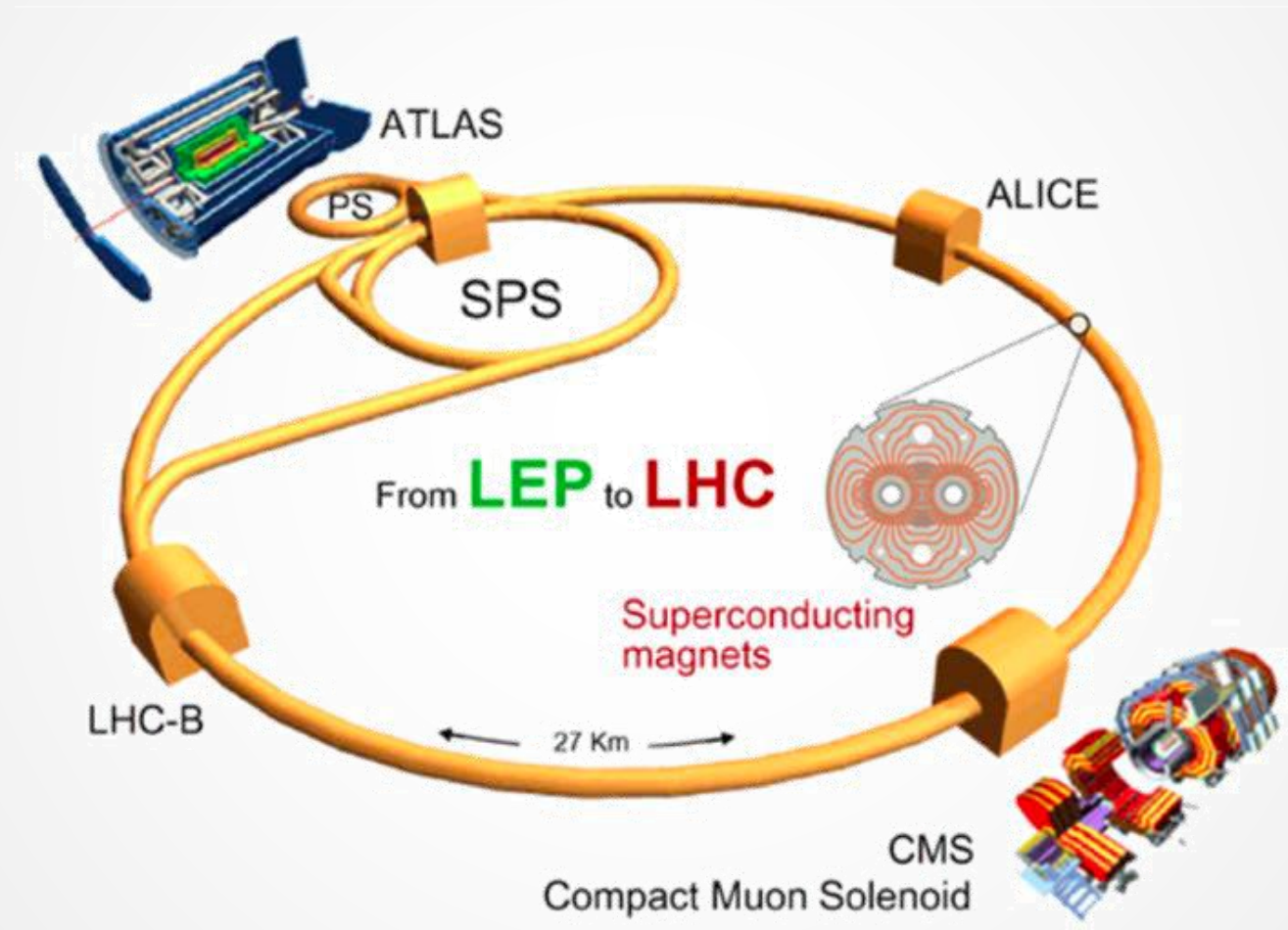
- key techniques for searches and precision measurements
- Interpretation / Statistical tools

# TEASERS

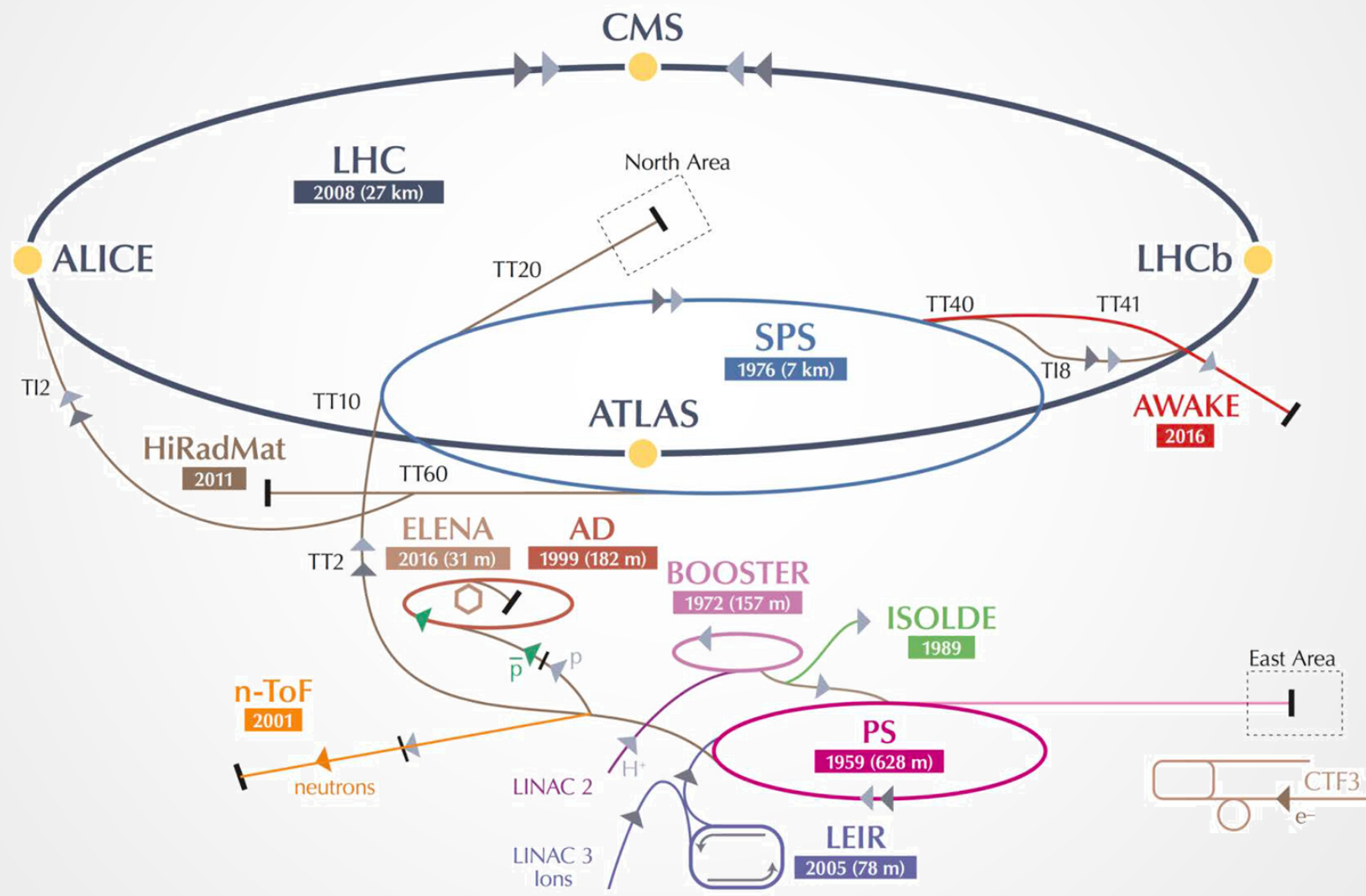
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# COLLIDERS

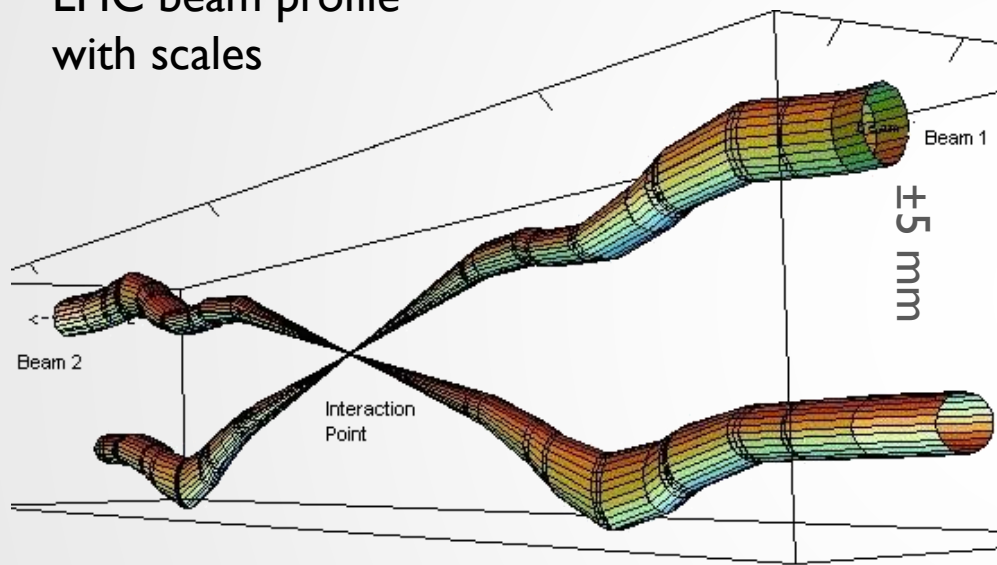
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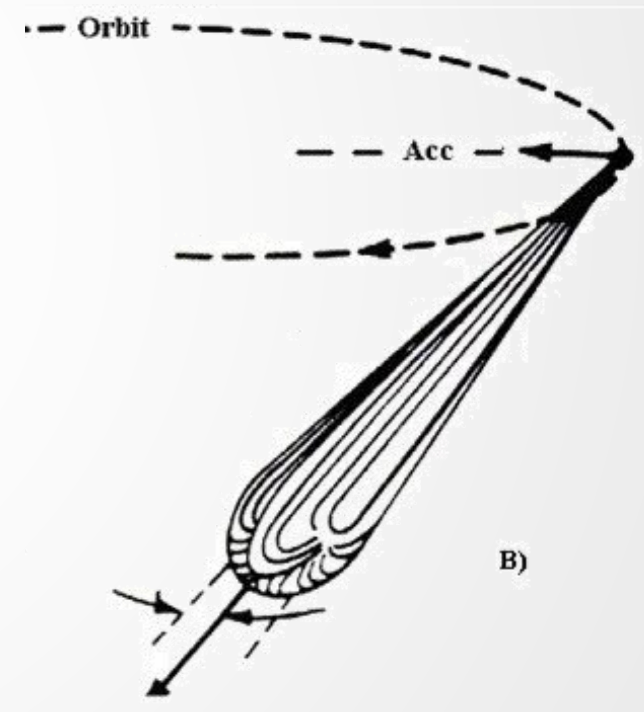
# CERN ACCELERATOR COMPLEX



LHC beam profile  
with scales

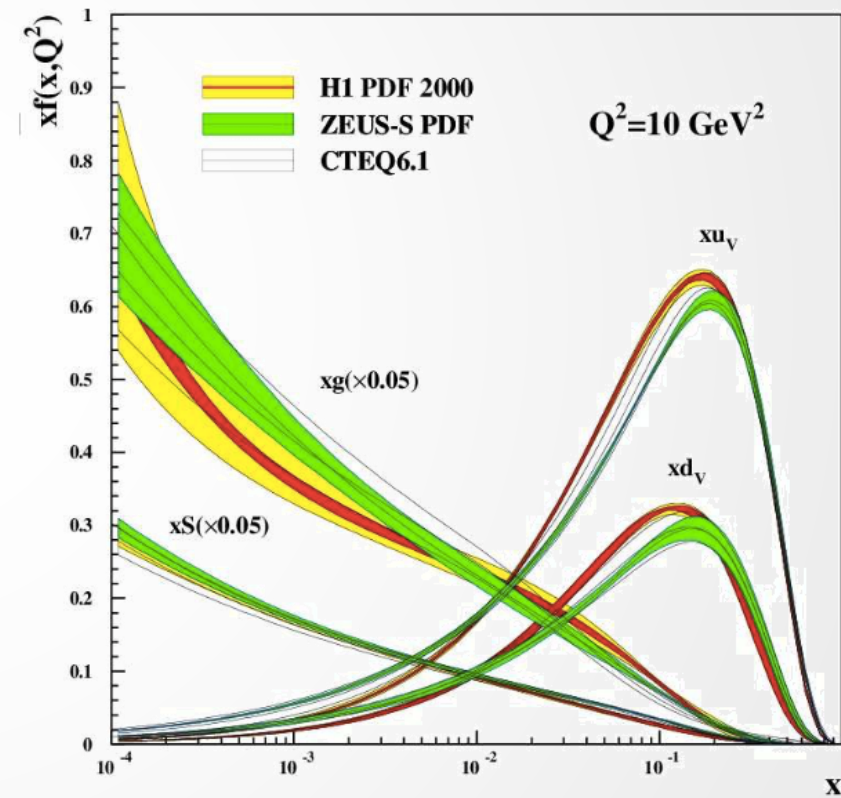
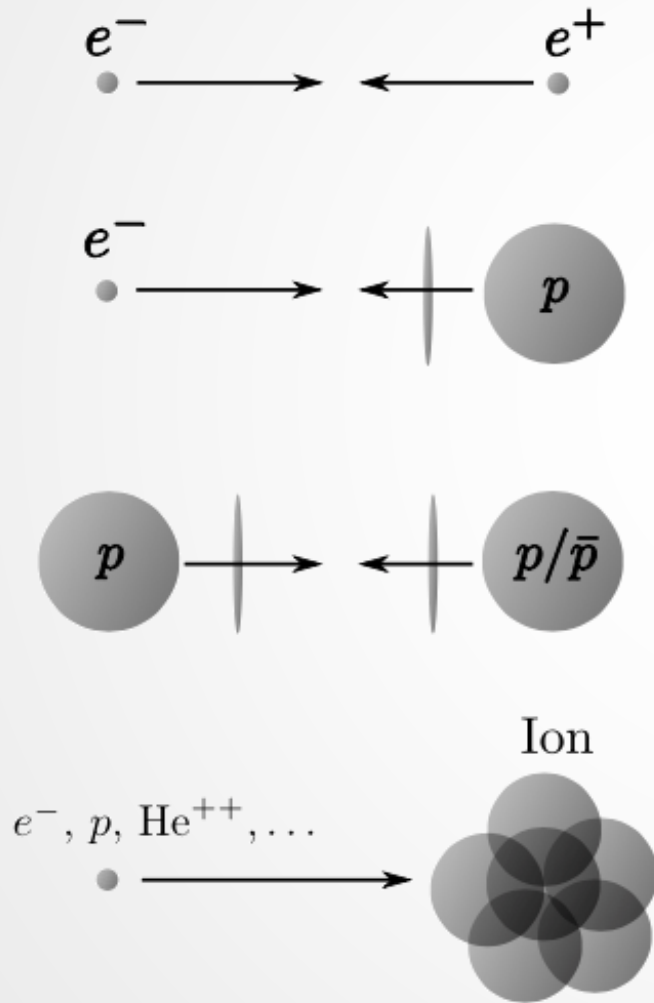


Angular profile of synchrotron radiation

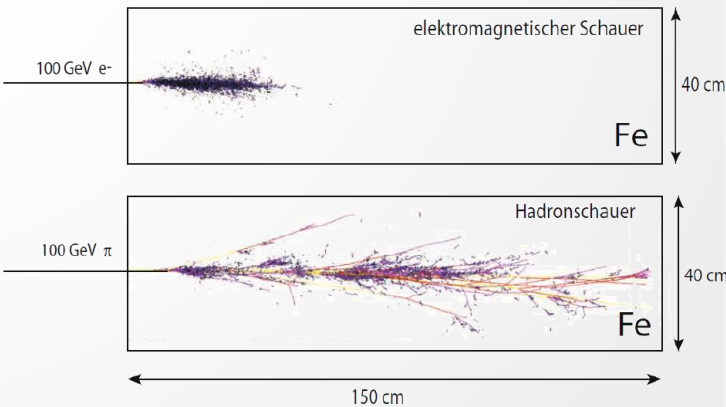
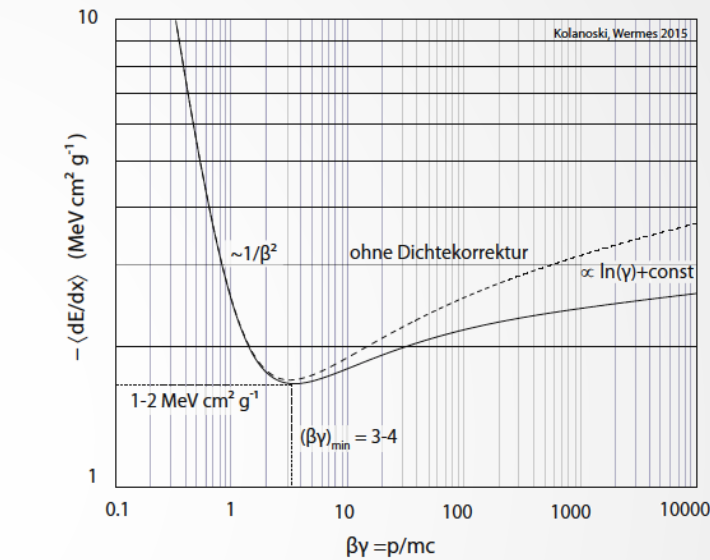
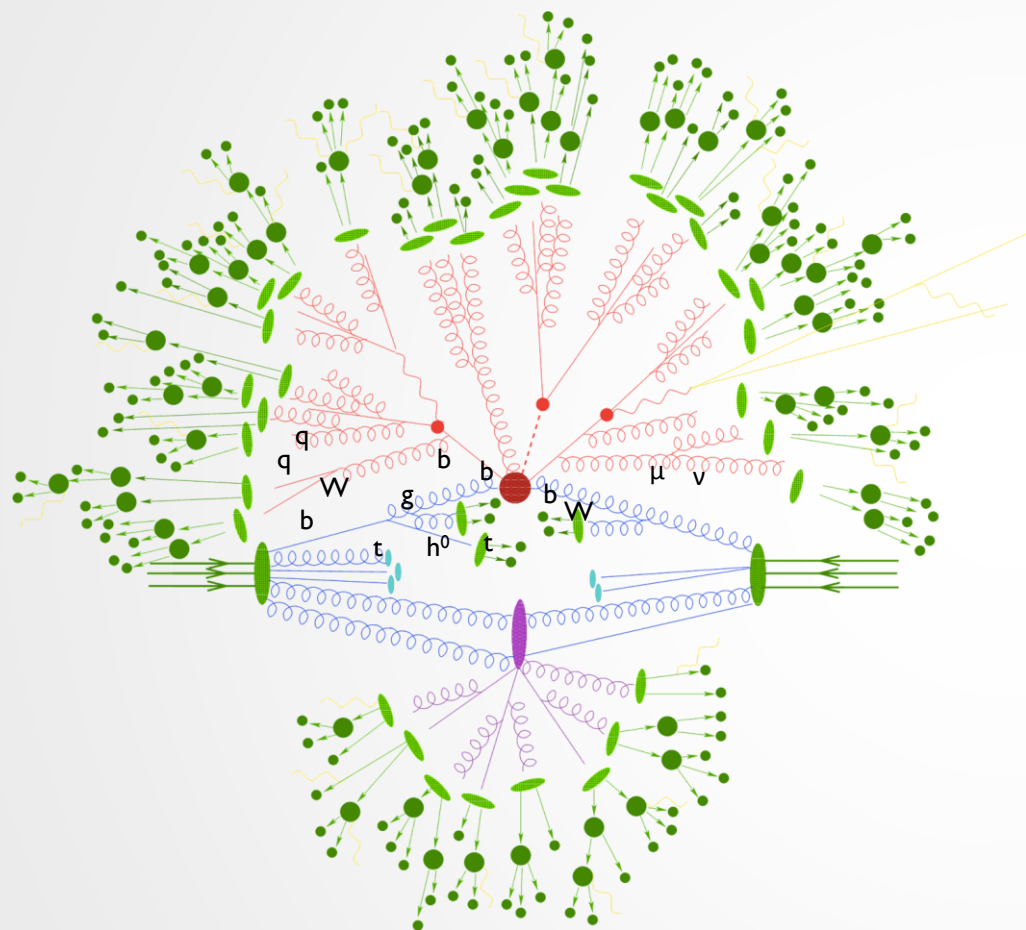




# COLLISIONS

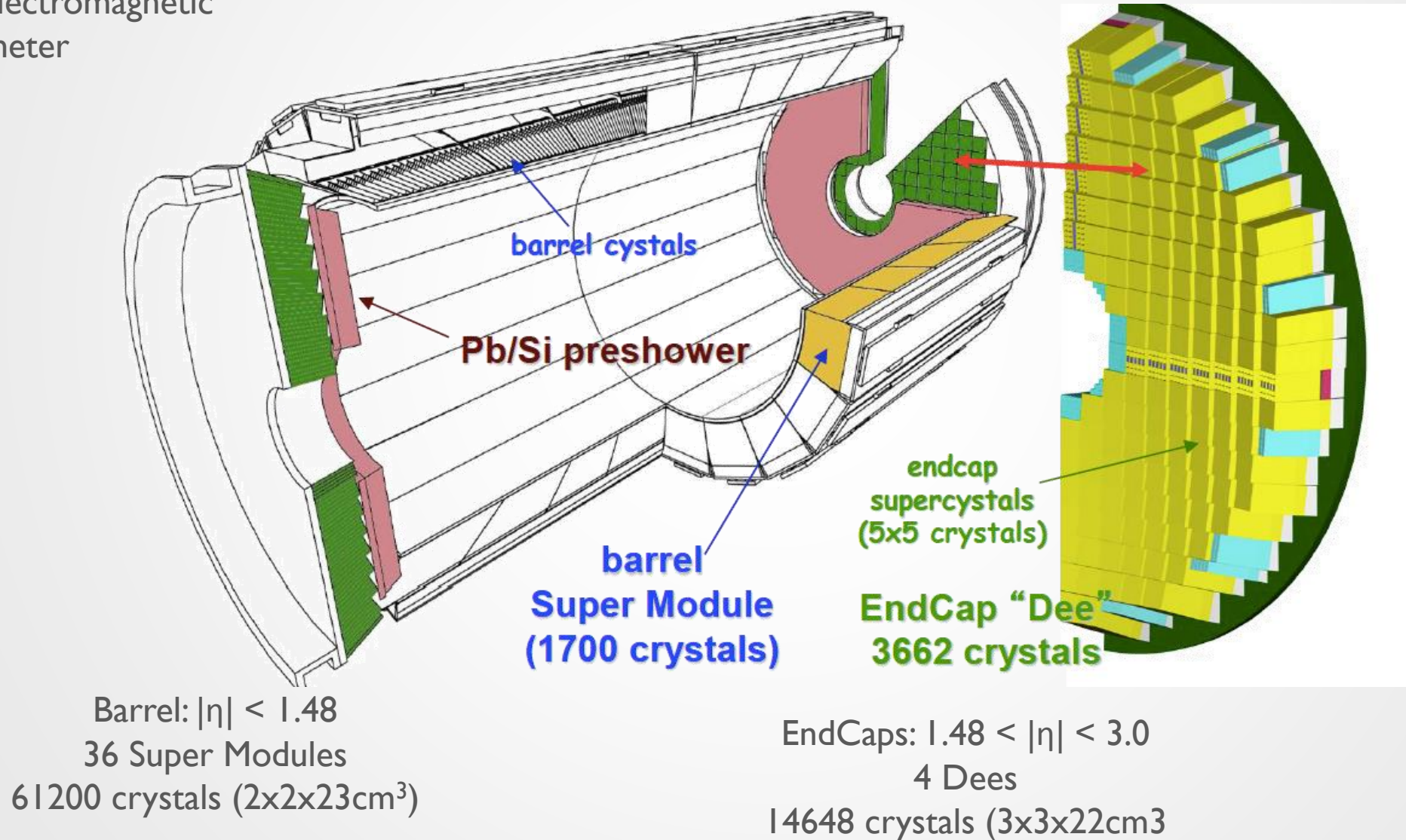


# INTERACTION OF PARTICLES WITH MATTER



# DETECTORS

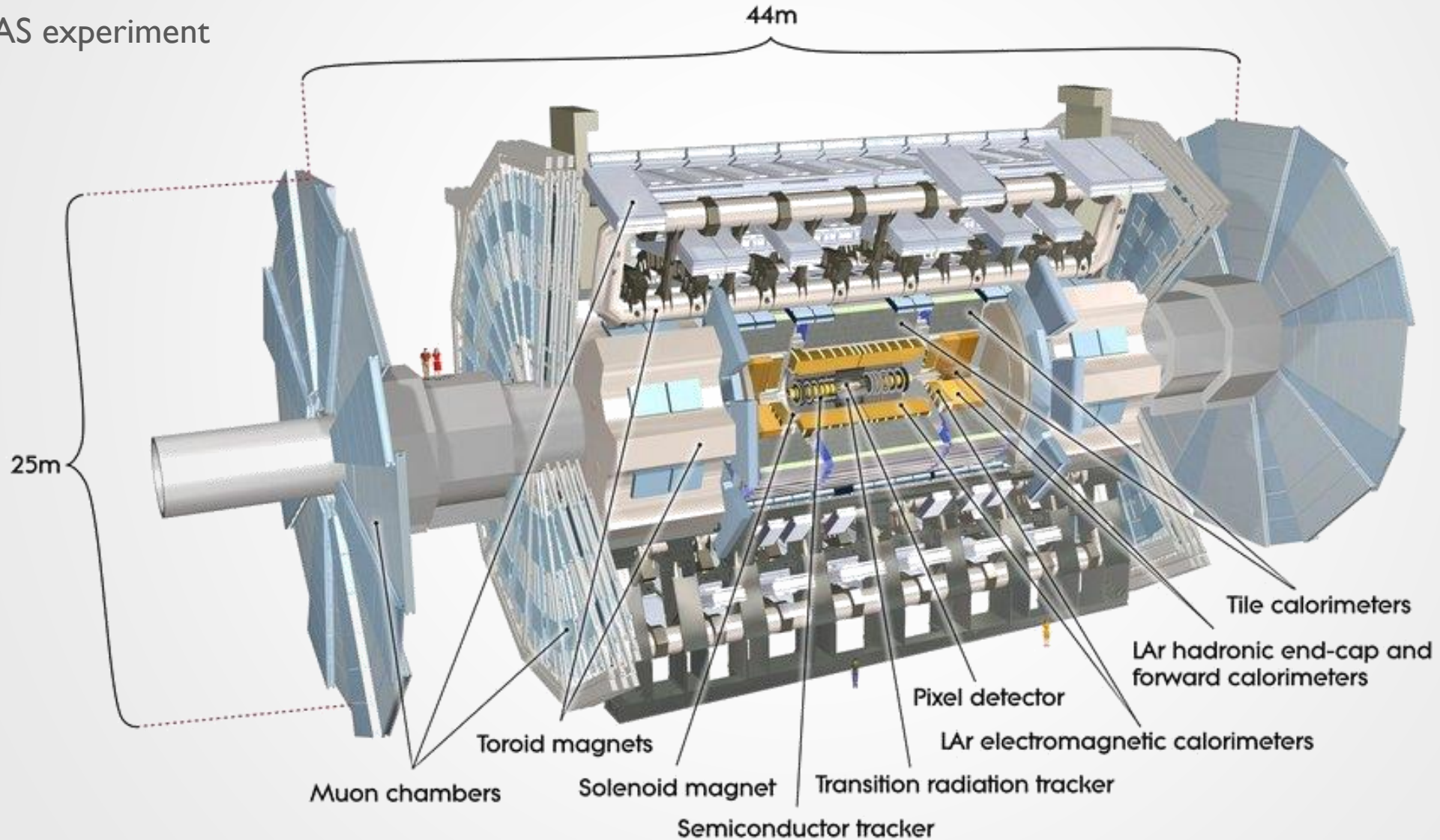
CMS electromagnetic calorimeter



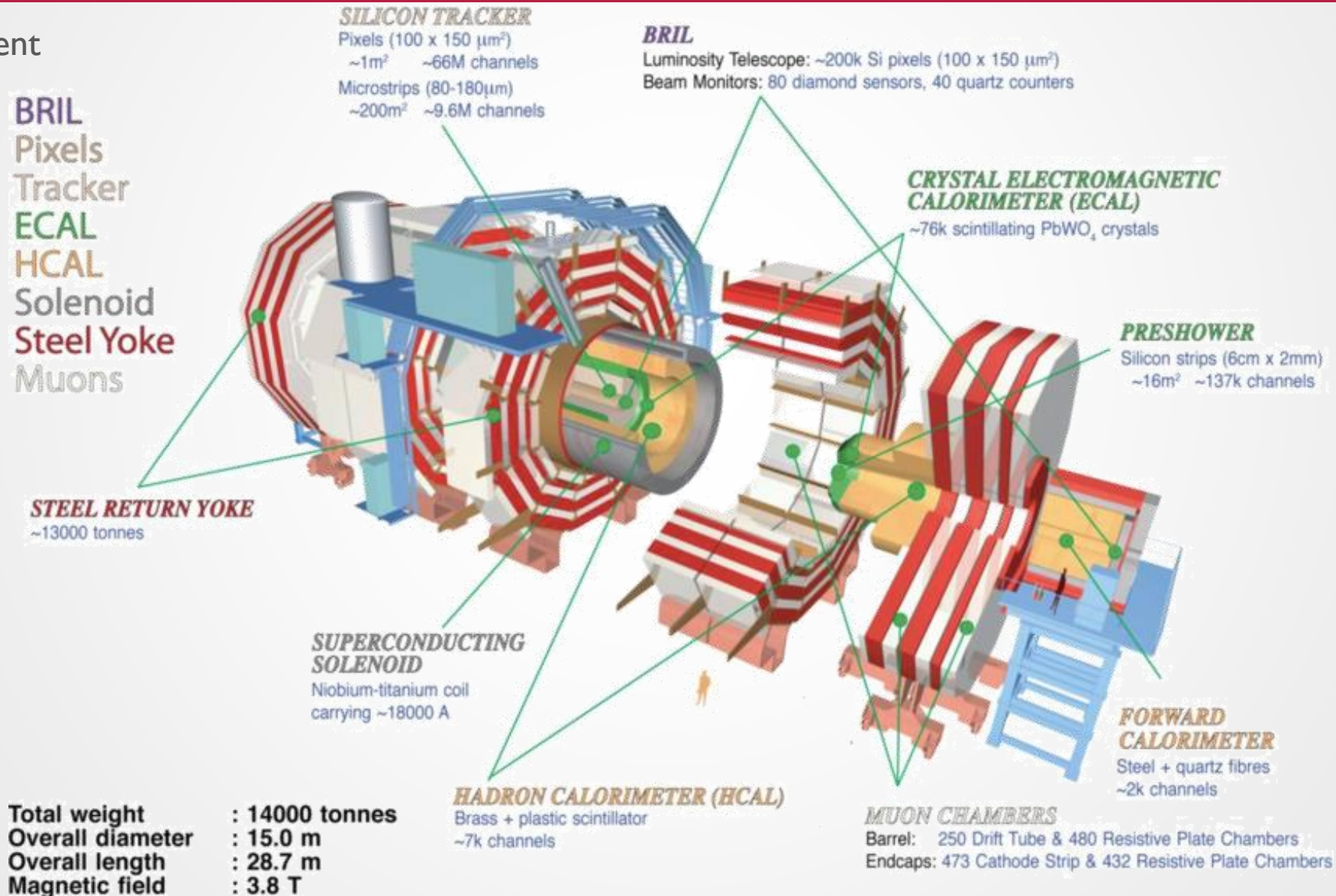


# EXPERIMENTS

## ATLAS experiment



## CMS experiment



Understanding a result:

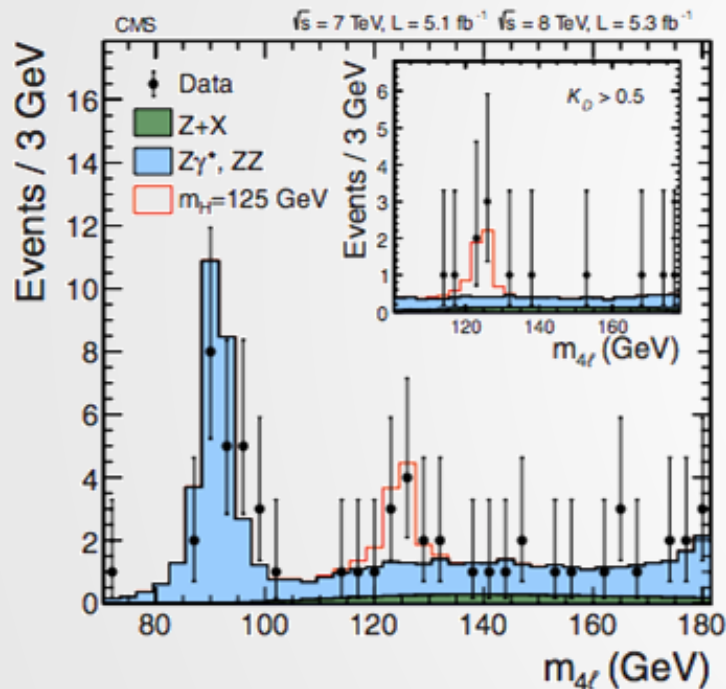


Figure 4: Distribution of the four-lepton invariant mass for the  $ZZ \rightarrow 4\ell$  analysis. The points represent the data, the filled histograms represent the background, and the open histogram shows the signal expectation for a Higgs boson of mass  $m_H = 125$  GeV, added to the background expectation. The inset shows the  $m_{4\ell}$  distribution after selection of events with  $K_D > 0.5$ , as described in the text.

- Which experiment at which facility is the result from?
- Which dataset (energy, luminosity)?
- How are the particles produced, how they decay and how are the decay products measured?
- How do the final, stable particles interact with the detector, what are the detector concepts, timing, resolution, limiting factors?
- How were the detectors assembled to experiments such that the measurement could be done?
- What are the quantities on the axis, why the choice of the binning, what is the meaning of the error bars?
- What does the figure caption mean?