Quantum Mechanics I introductory remarks

Babis (Charalampos) ANASTASIOU
ETH Zurich

Fall Semester 2022

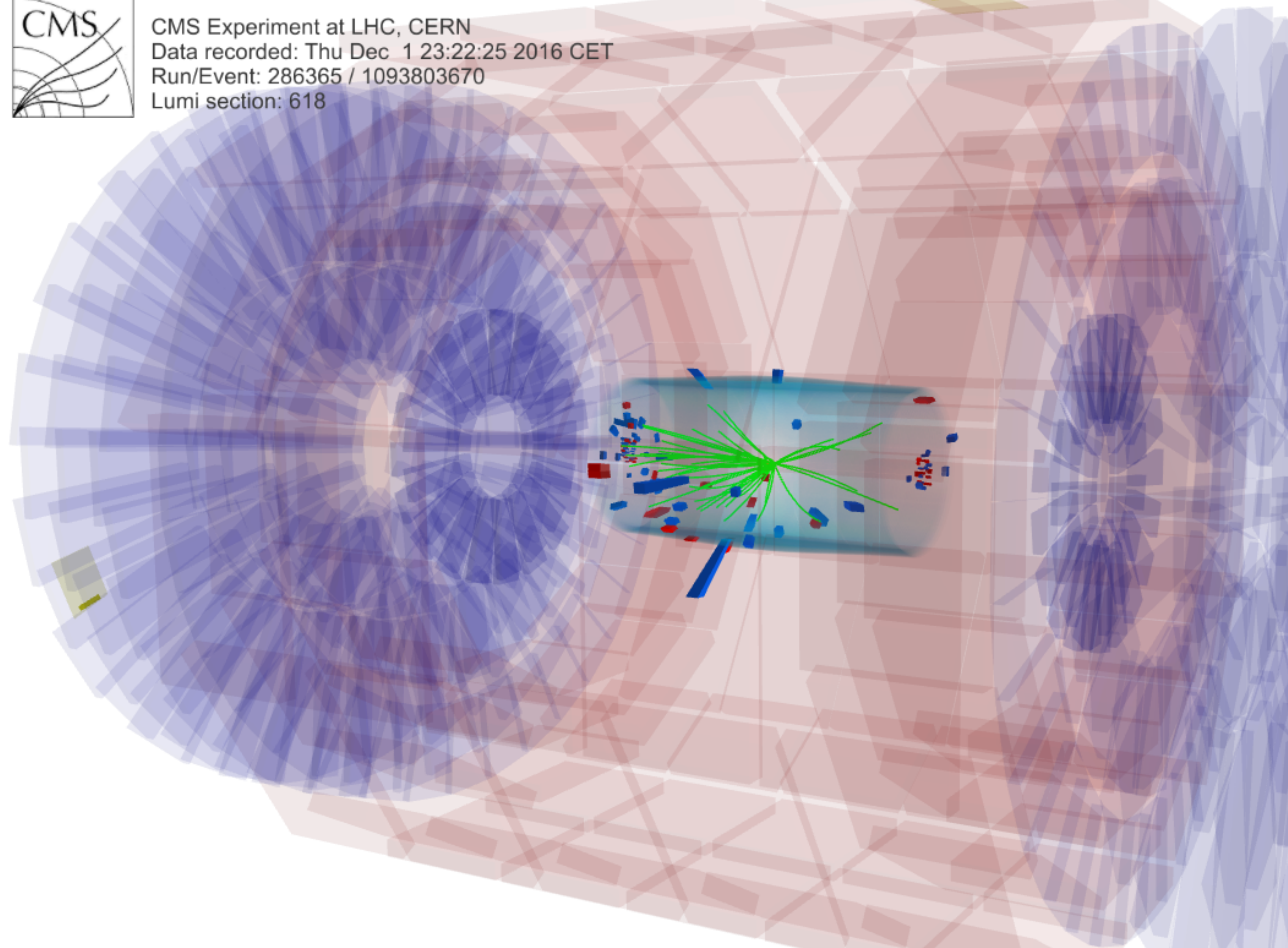
Tue 09:45-11:30	HPV G 4 »
Thu 11:45-12:30	HPV G 4 »

No. 30 – Golden State Warriors	
Position	Point guard
League	NBA
Personal information	
Born	March 14, 1988 (age 34) Akron, Ohio, U.S.
Listed height	6 ft 2 in (1.88 m)
Listed weight	185 lb (84 kg)
Career information	
High school	Charlotte Christian (Charlotte, North Carolina)
College	Davidson (2006–2009)
NBA draft	2009 / Round: 1 / Pick: 7th overall
Selected by the Golden State Warriors	
Playing career	2009–present
Career history	
2009–present	Golden State Warriors

Lyn Evans

Evans in 2012

Born	Lyndon Rees Evans 1945 (age 76–77) Aberdare, Wales
Nationality	Welsh
Alma mater	Swansea University
Awards	Fundamental Physics Prize (2012)
	Scientific career
Fields	Physics
Institutions	CERN, Large Hadron Collider; Linear Collider Collaboration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CMS Experiment at LHC, CERN
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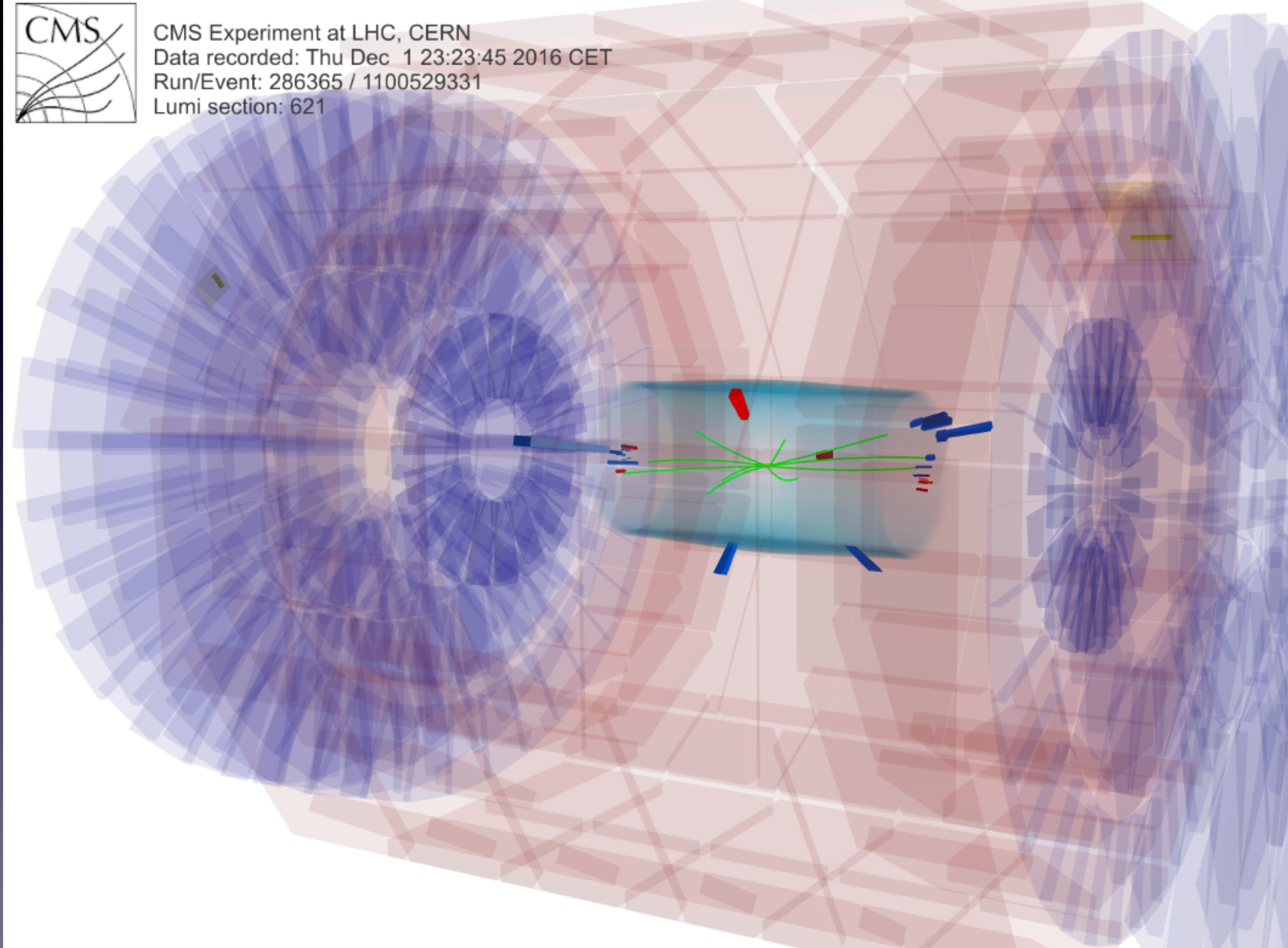
Run/Event: 286365 / 1093803670
Lumi section: 618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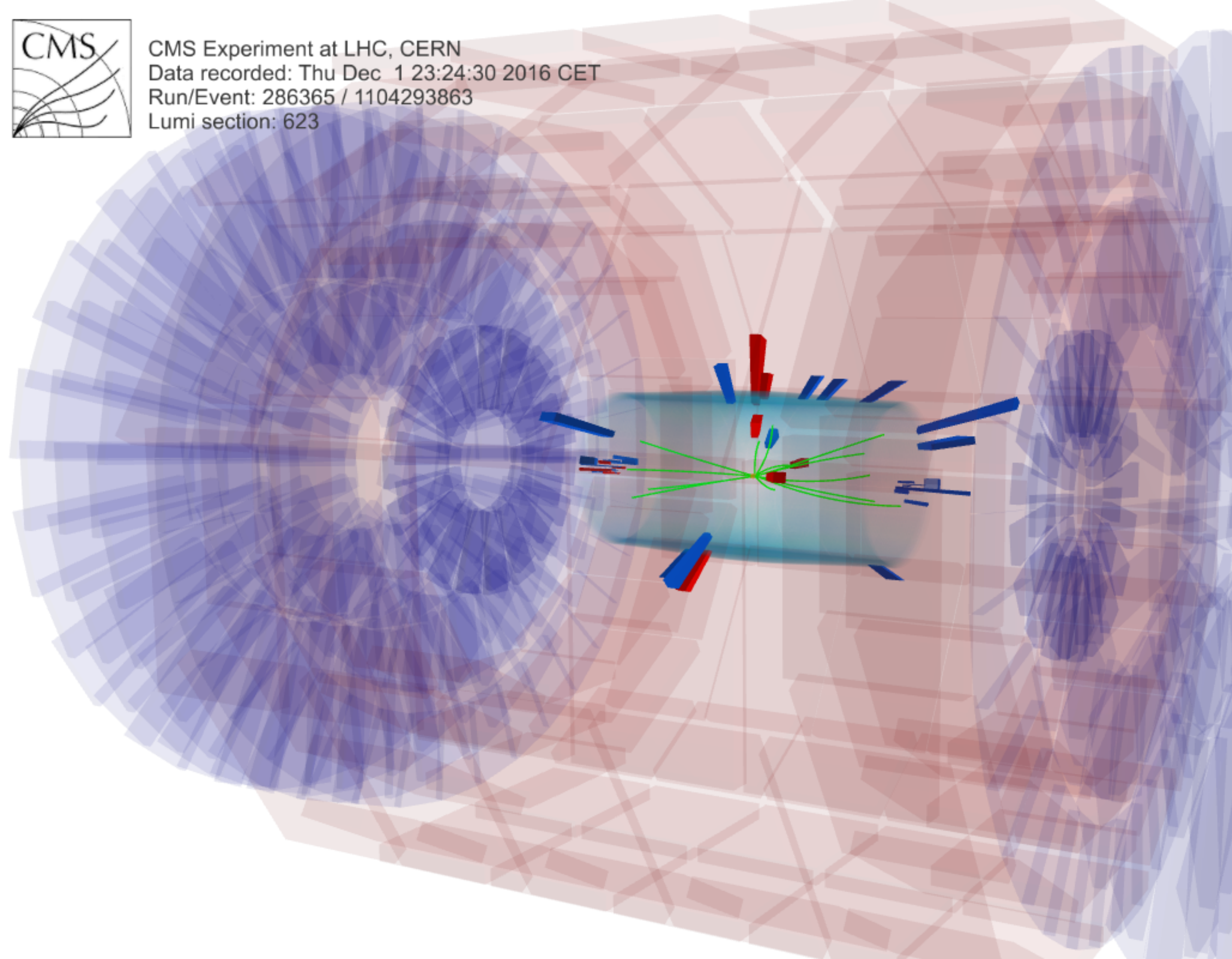
Lumi section: 621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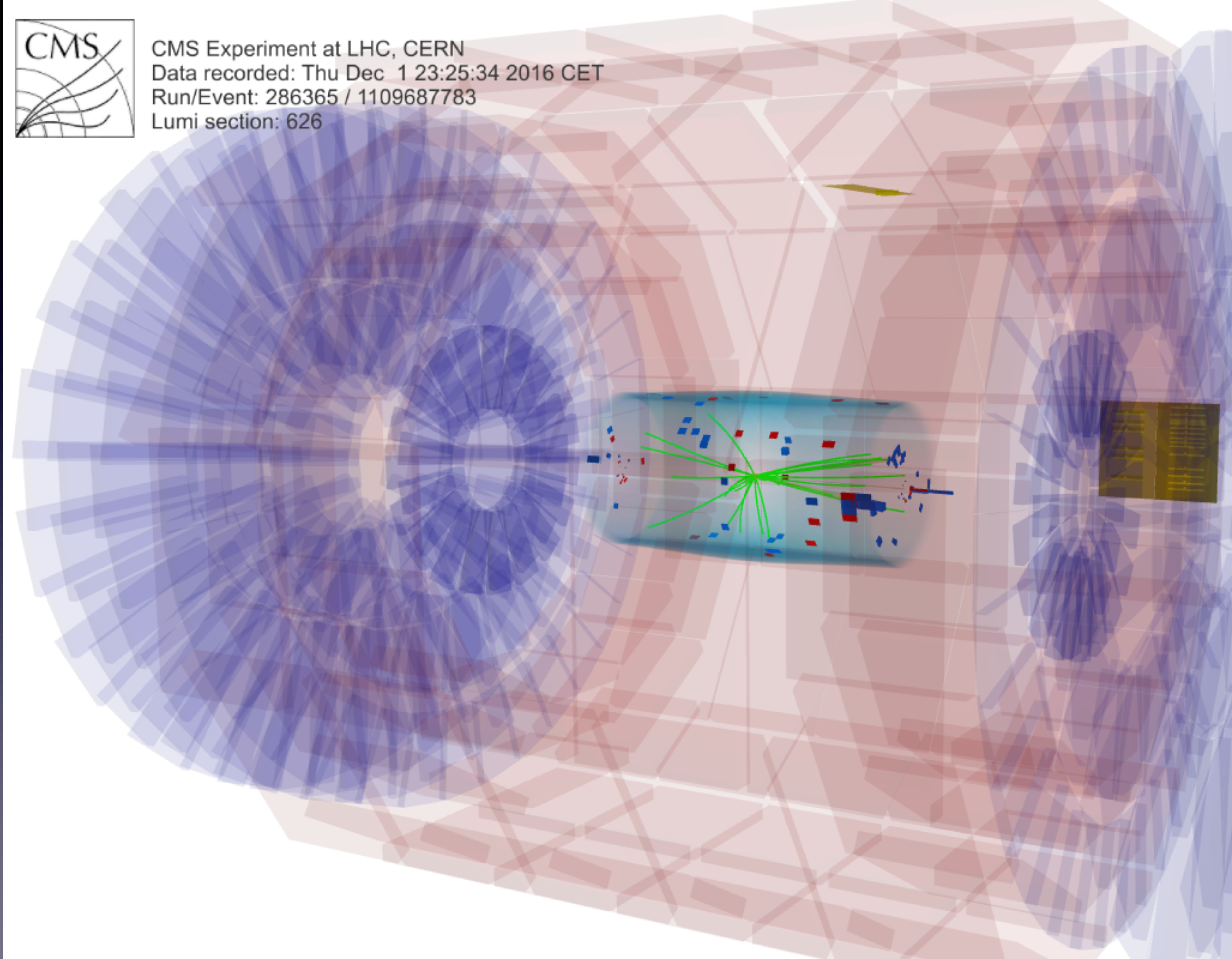
Lumi section: 623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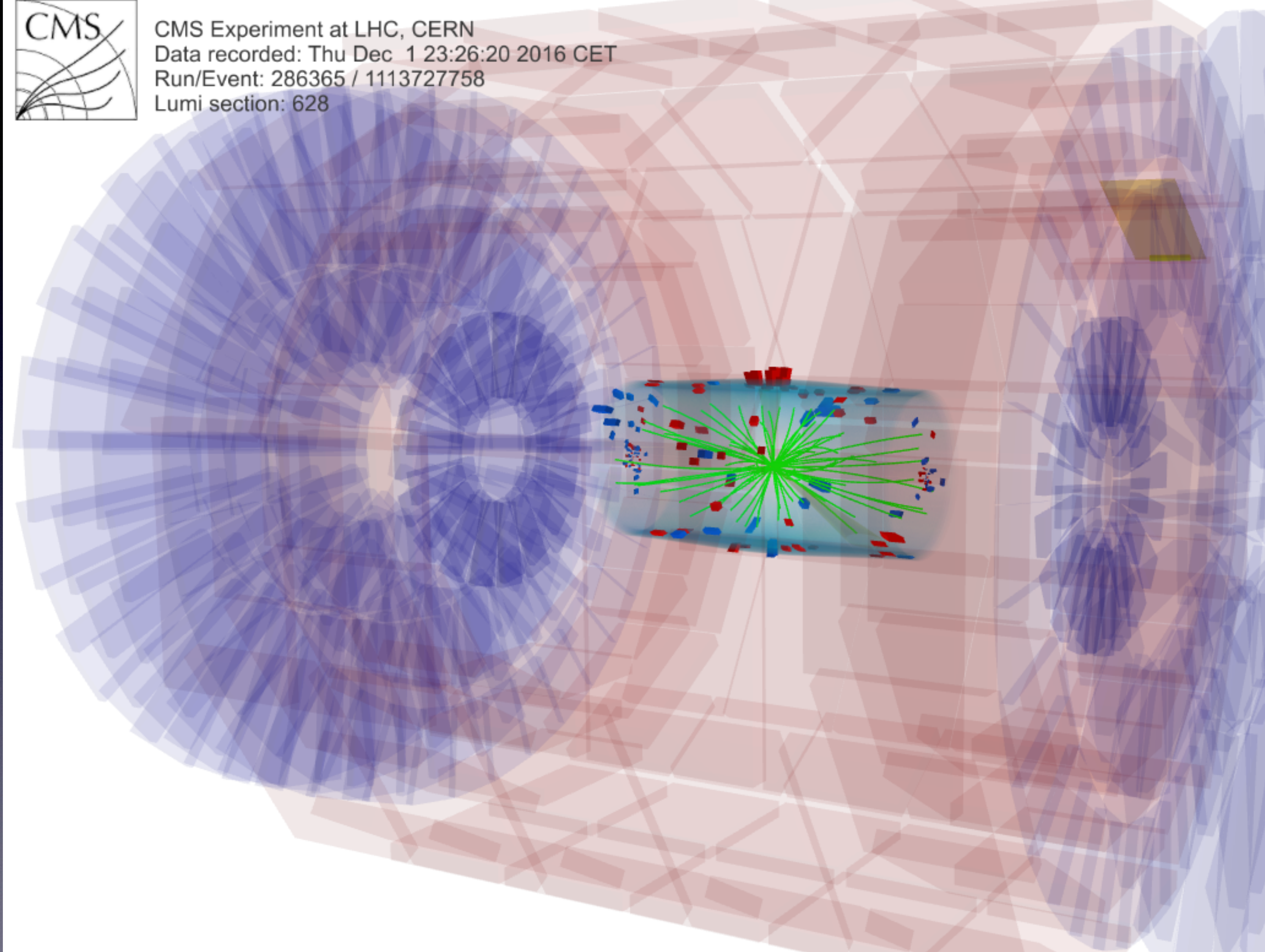
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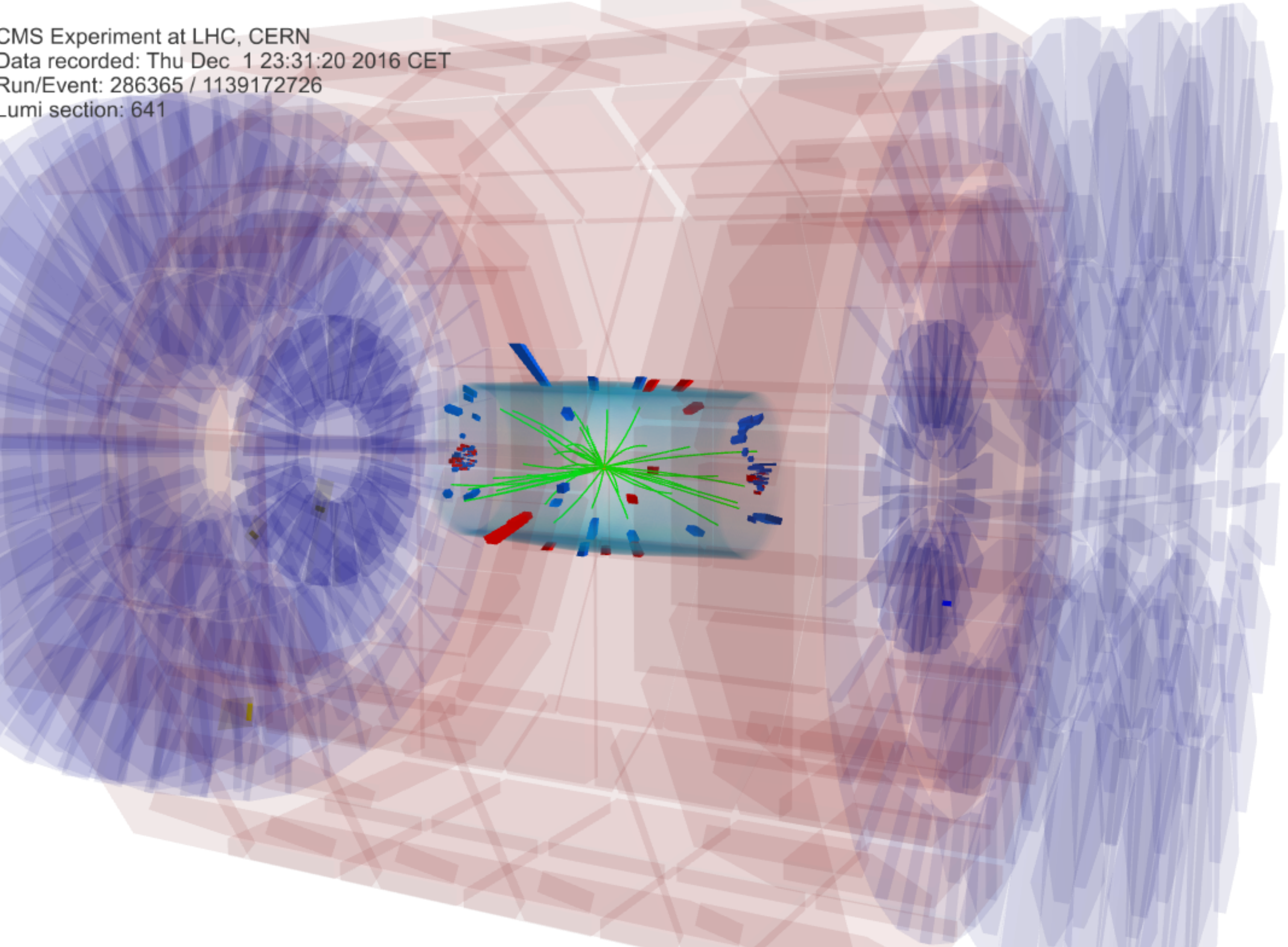
Lumi section: 628

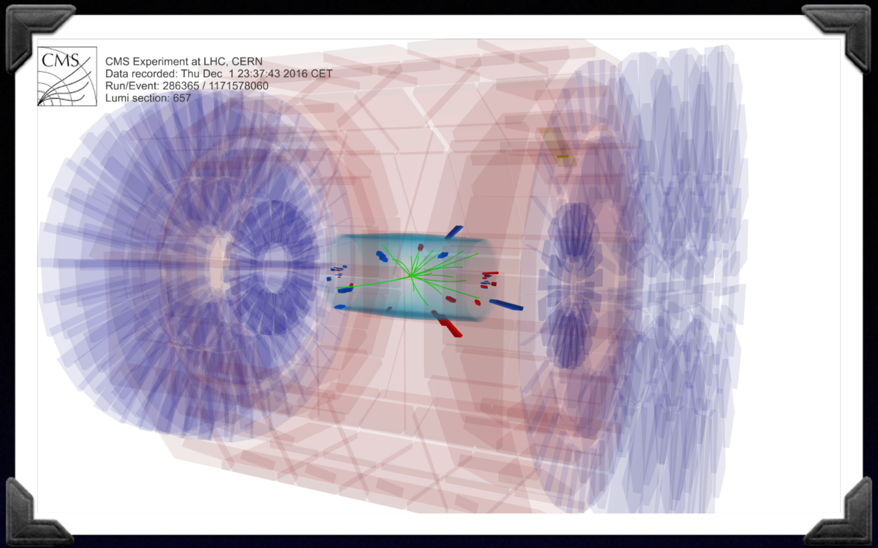


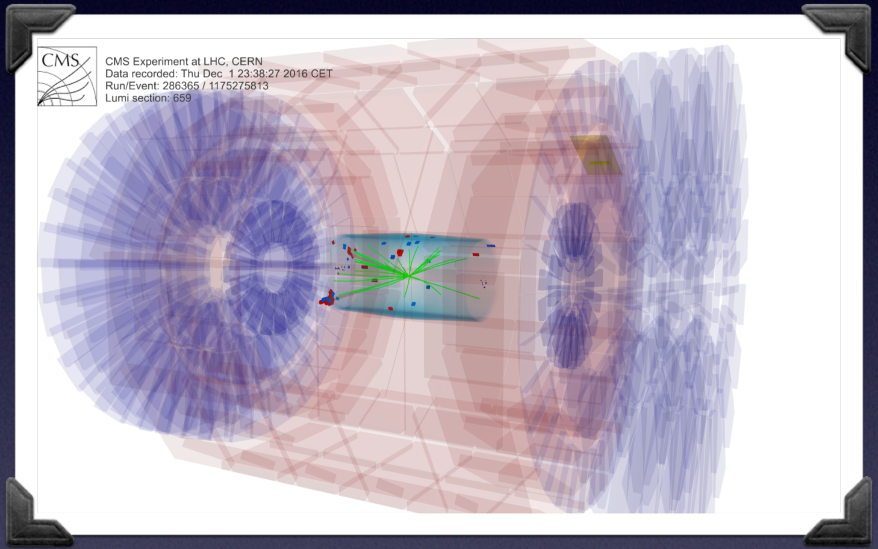
CMS Experiment at LHC, CERN
Data recorded: Thu Dec 1 23:31:20 2016 CET
Run/Event: 286365 / 1139172726
Lumi section: 641

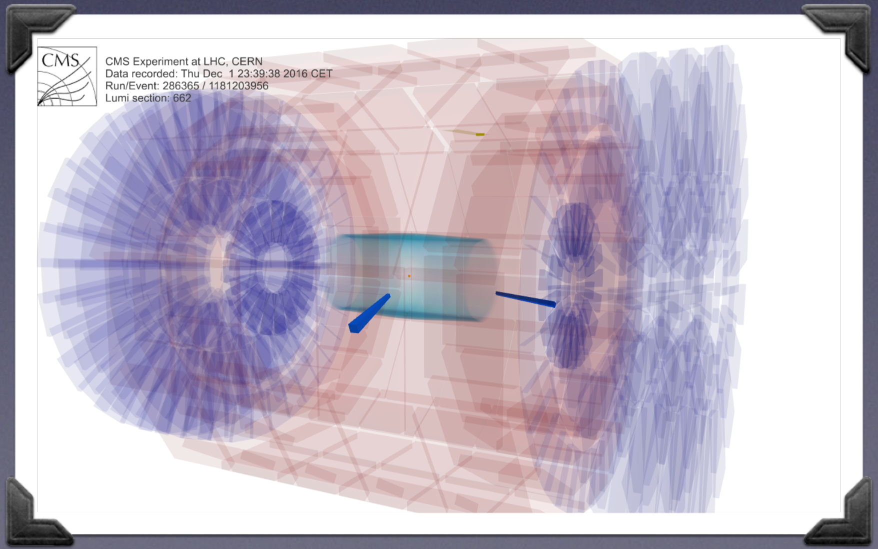
- Various outcomes (events) of proton-proton collisions at the Large Hadron Collider

- What event occurs at a given time is a matter of luck

- with a probability given by the fundamental laws of particle physics.

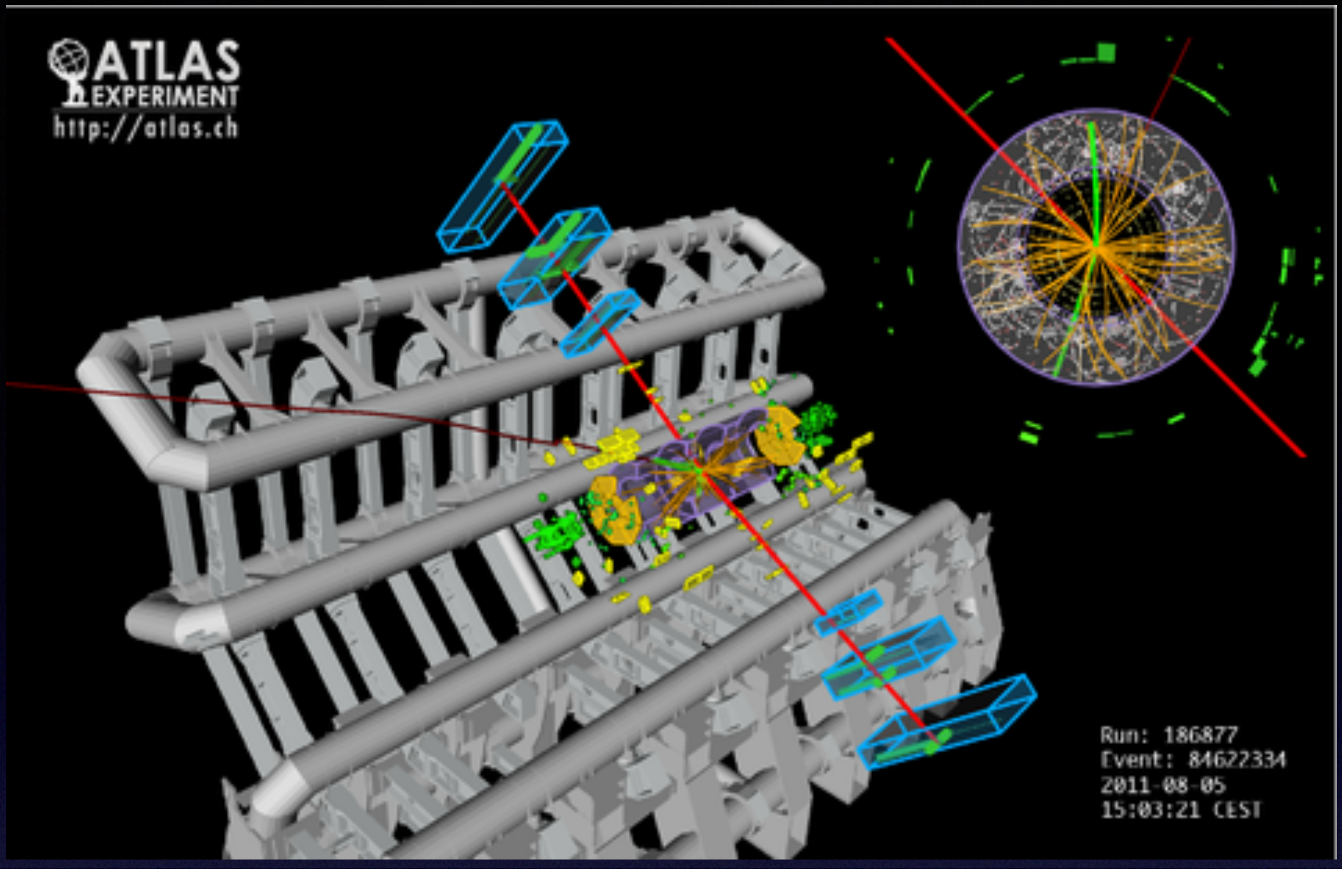


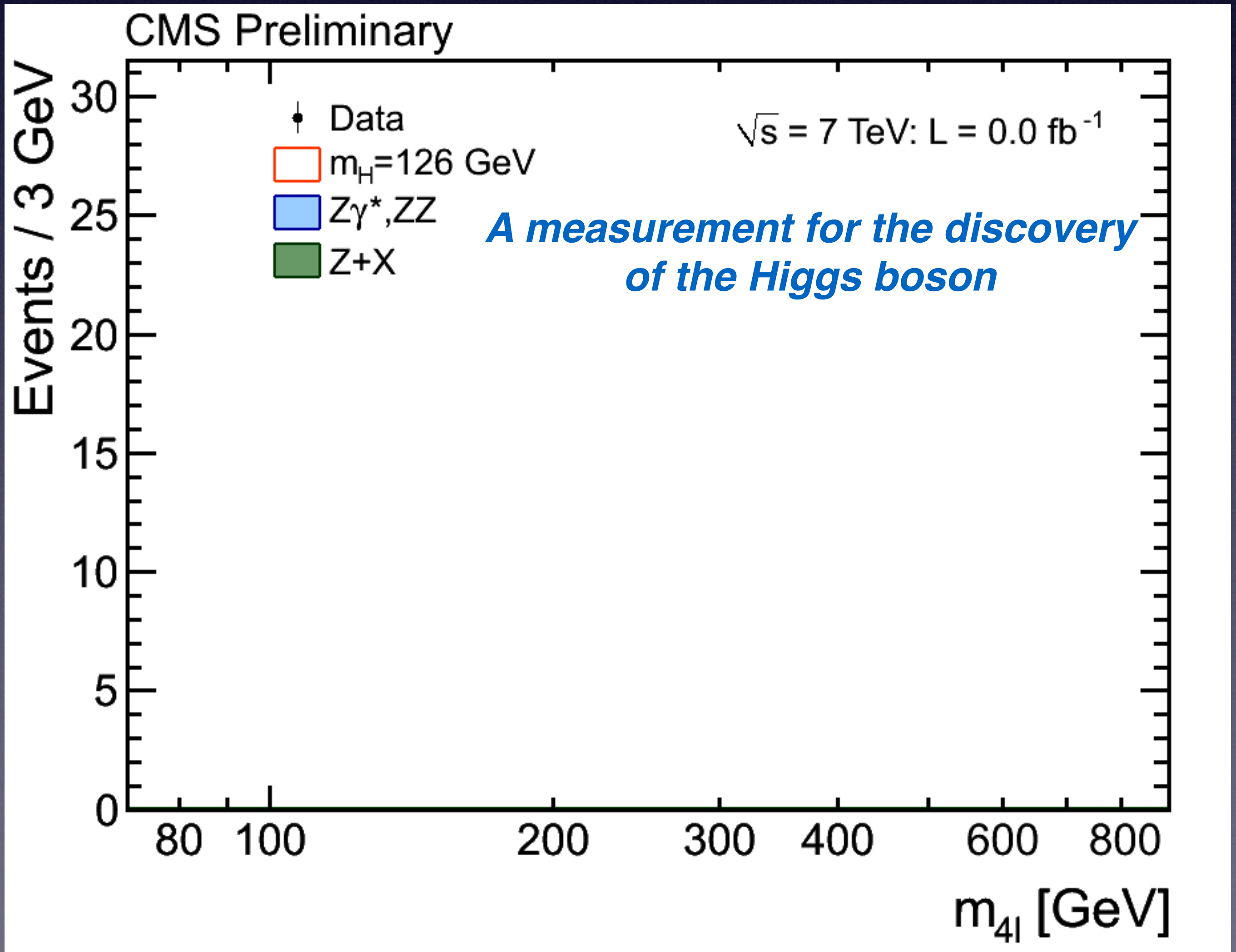




Physical measurements

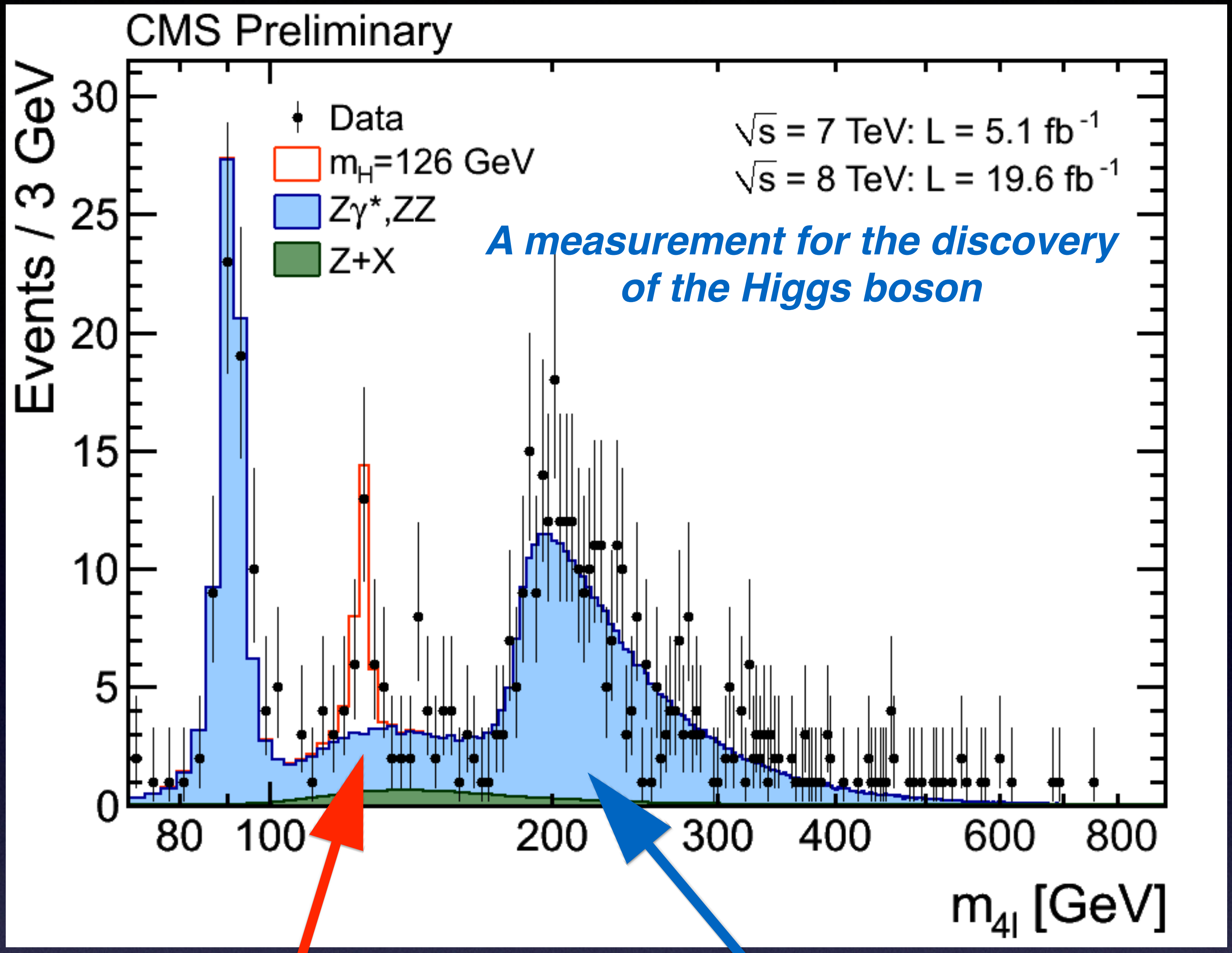
- Counting experiments
- Grouping together events…
- …according to the number, type, energy and direction of produced particles.

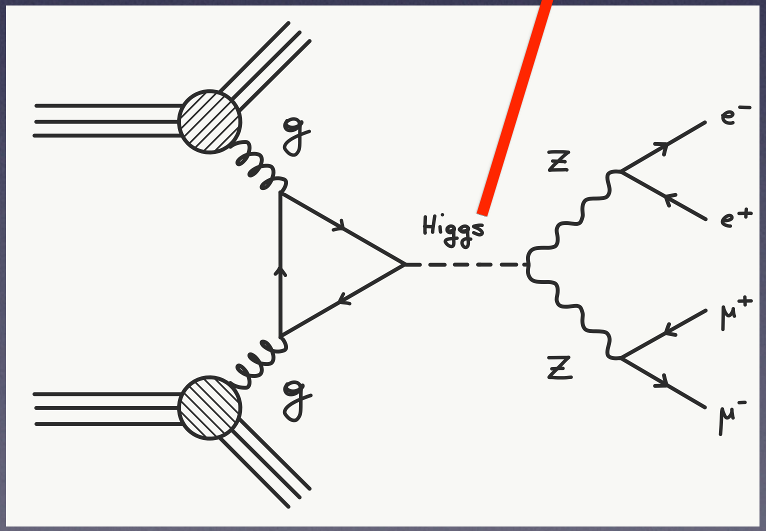


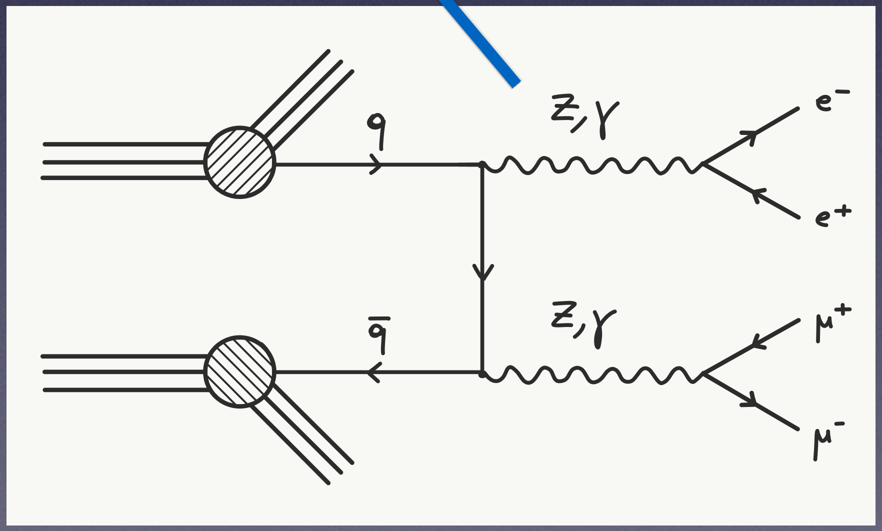


Physical measurements

- Experiments measure probabilities.
- Measurements are revealing of the underlying fundamental physics.
- Can probe tiny distances…e.g. Higgs boson lifetime is $\mathcal{O}\left(10^{-22}\right)$ seconds

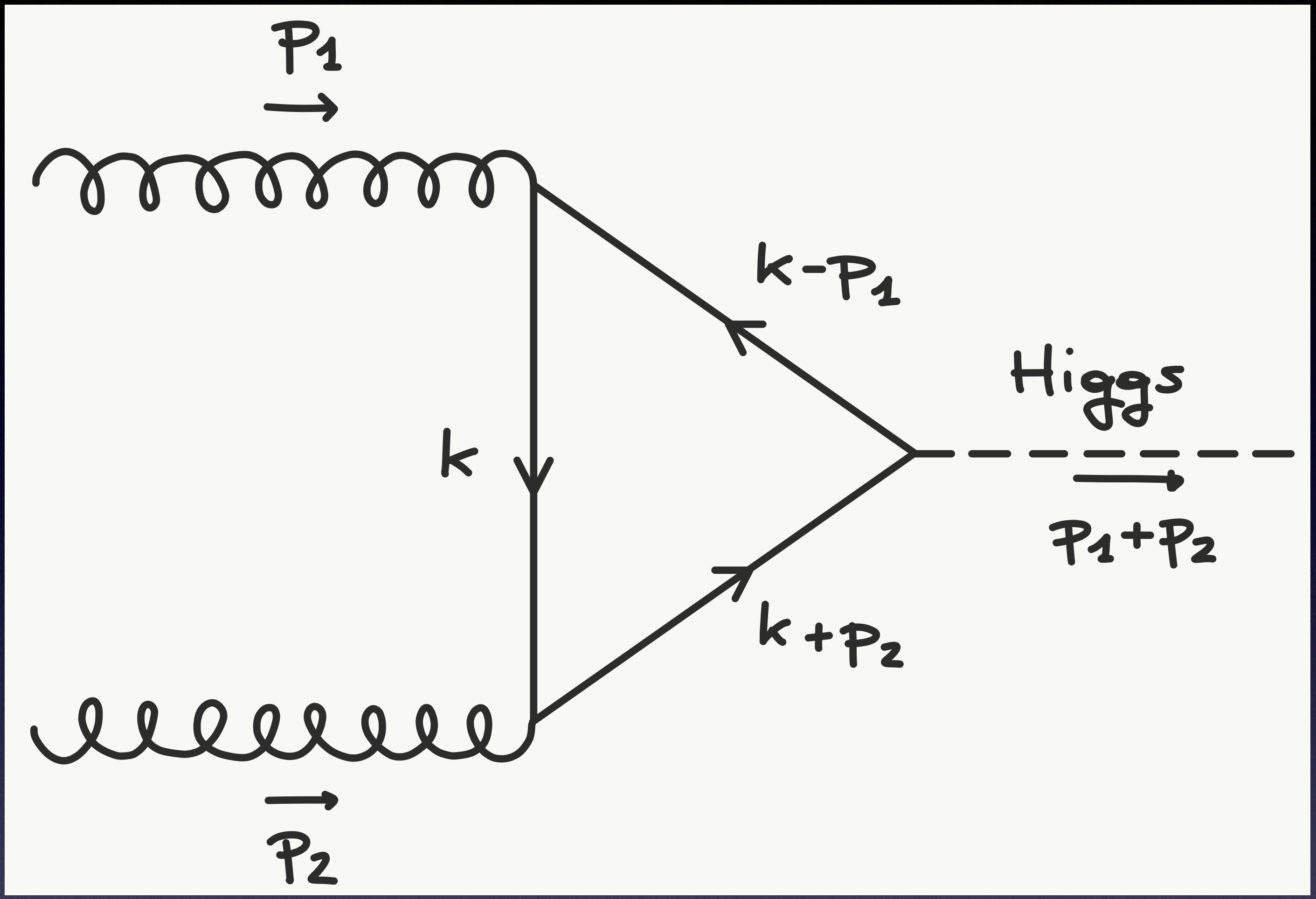






Feynman diagrams

- Pictorial representation of what happens in a physical process
- Pictorial representation of a mathematical expression for the probability amplitude
- Feynman rules for the propagation of particles (graph lines) and their interaction (graph vertices) are the fundamental physics laws in the Standard Model



$$(-1) \quad \epsilon^{\mu}(p_1) \quad \epsilon^{\nu}(p_2) \quad 1$$

$$\int \frac{d^4k}{(2\pi)^4} \sum_{s,i}$$

$$\left(\frac{i}{\not{k} - m_t \mathbf{1}}\right)_{s_1 s_2} \delta_{i_1 i_2} \quad \left(\frac{i}{\not{p}_1 - \not{k} - m_t \mathbf{1}}\right)_{s_3 s_4} \delta_{i_3 i_4} \quad \left(\frac{i}{\not{p}_2 + \not{k} - m_t \mathbf{1}}\right)_{s_5 s_6} \delta_{i_5 i_6}$$

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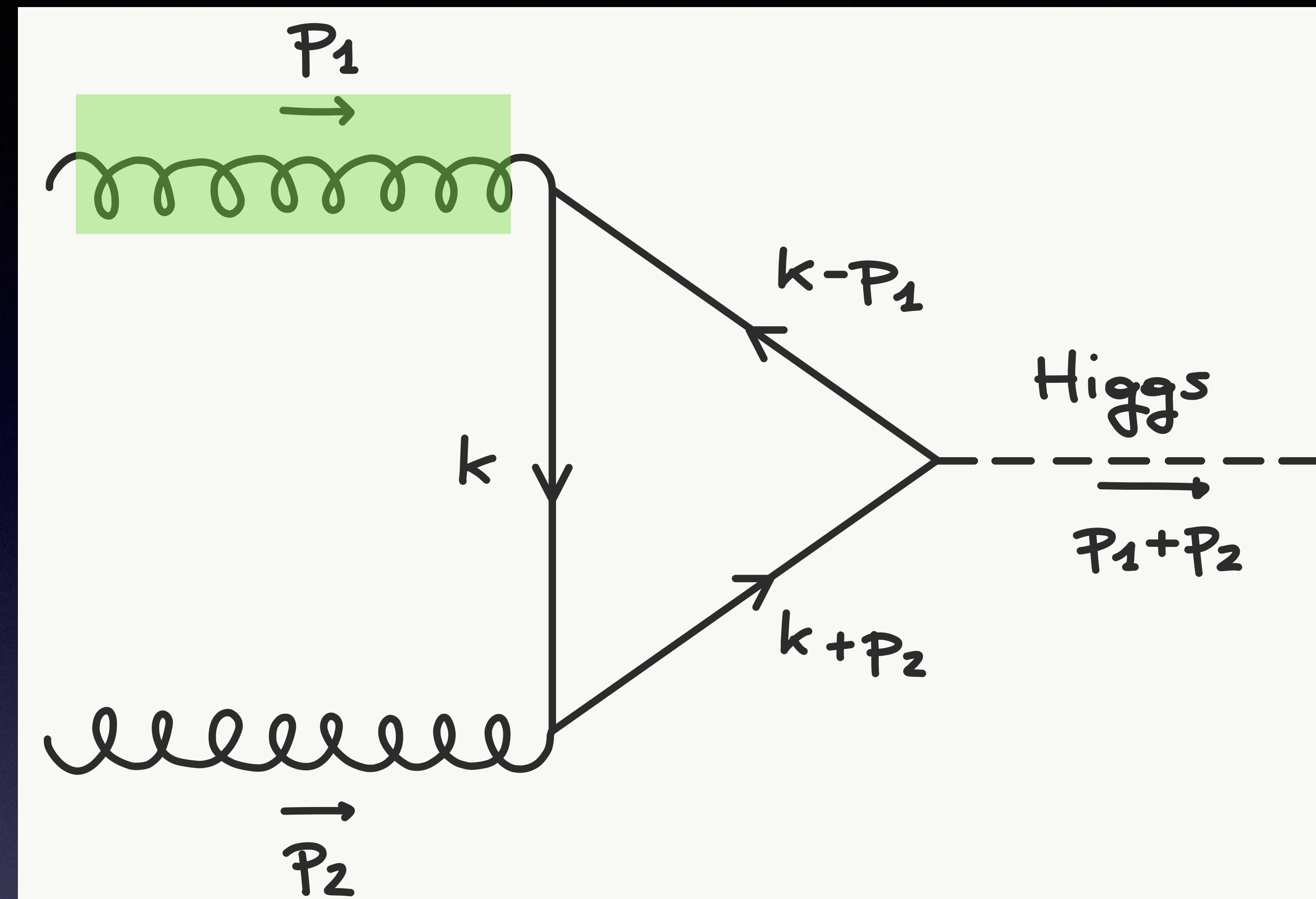

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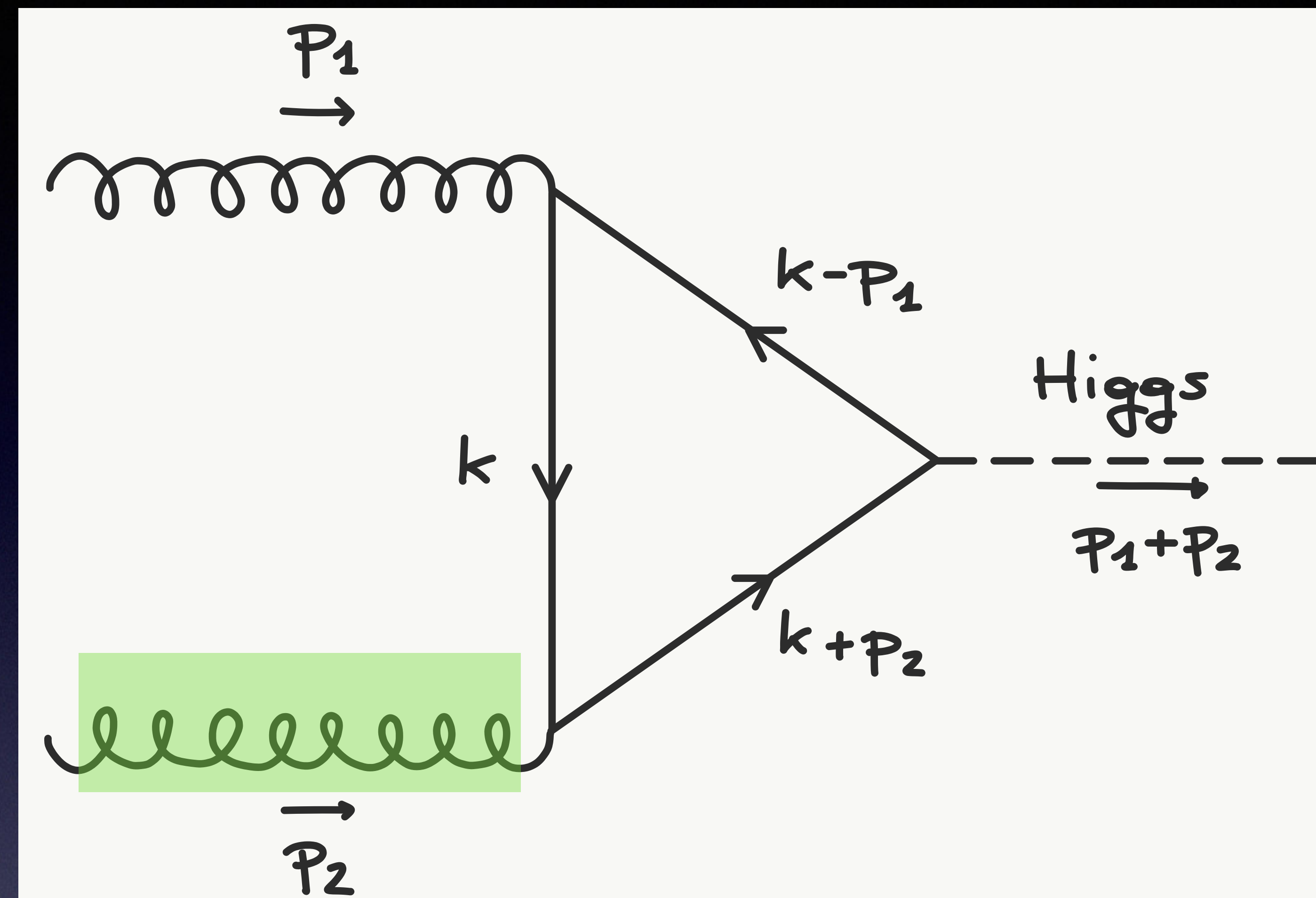

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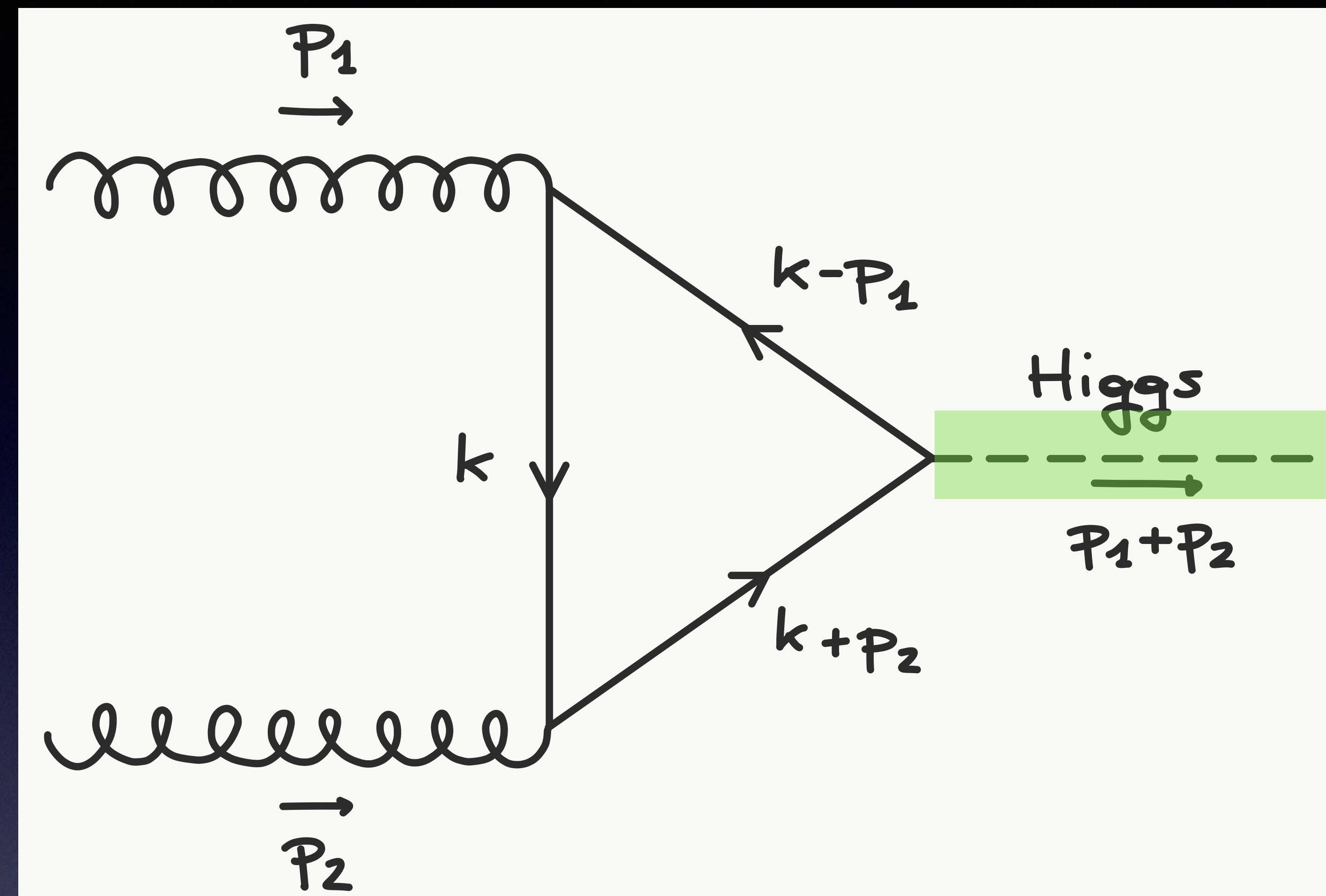

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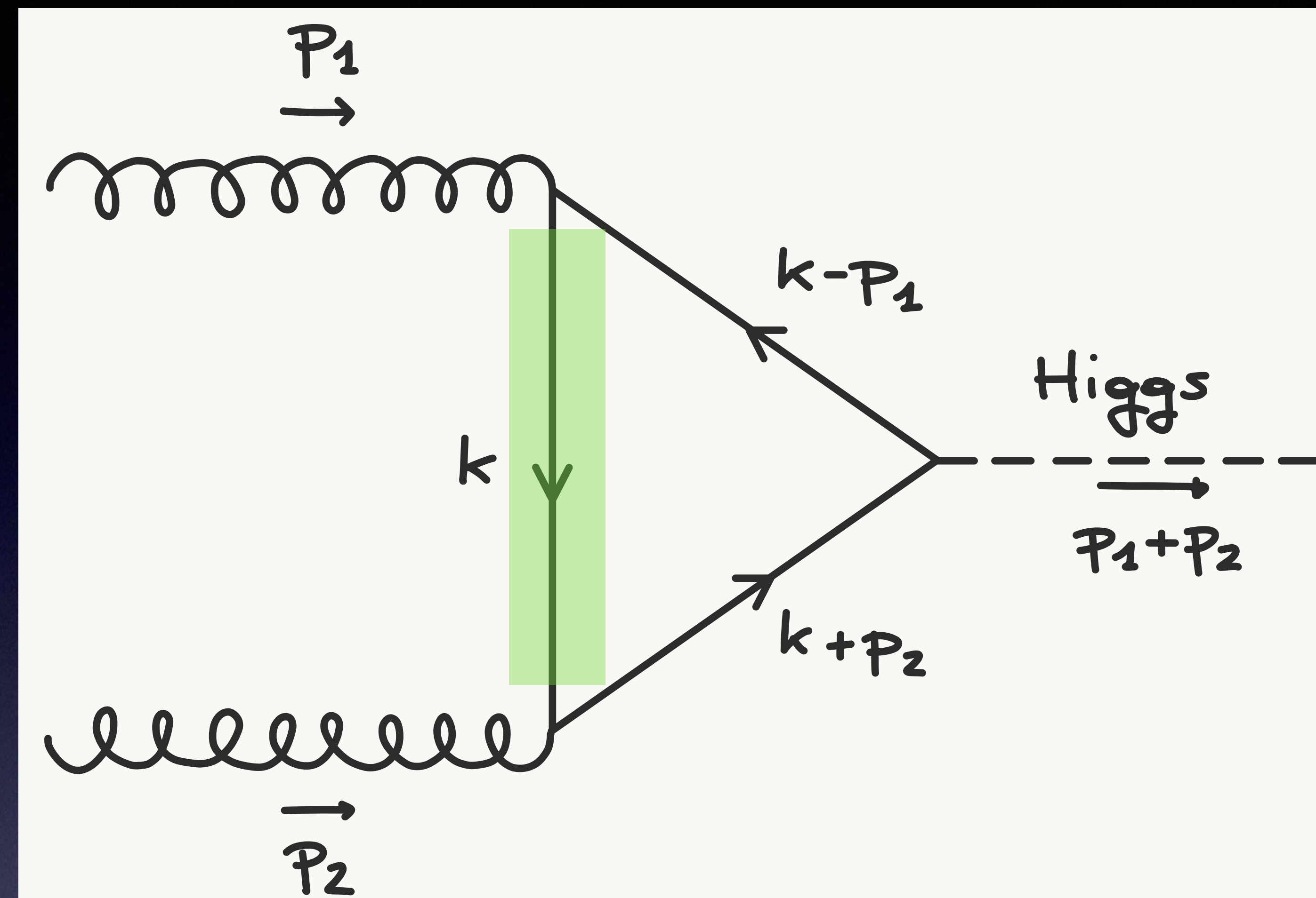

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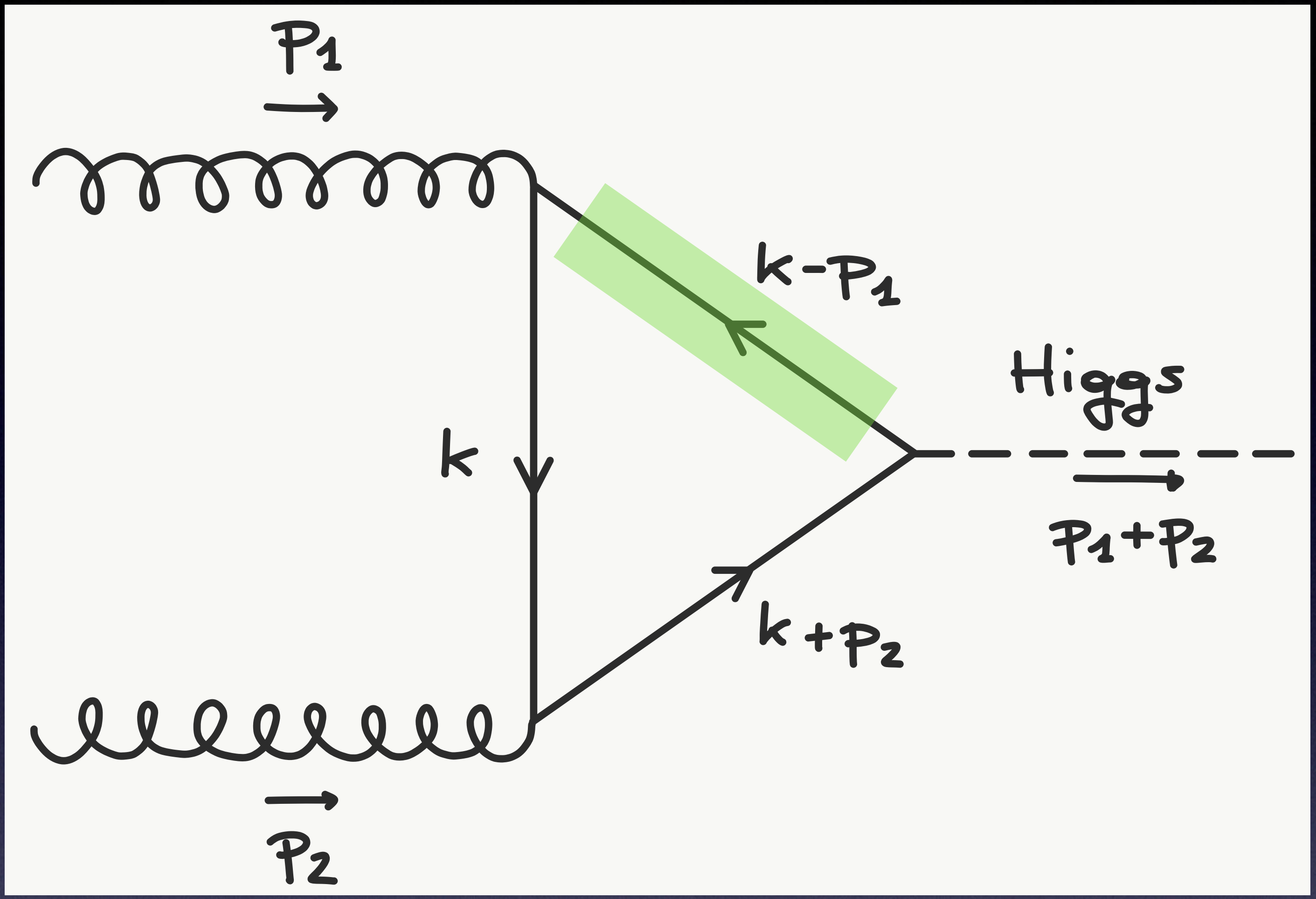

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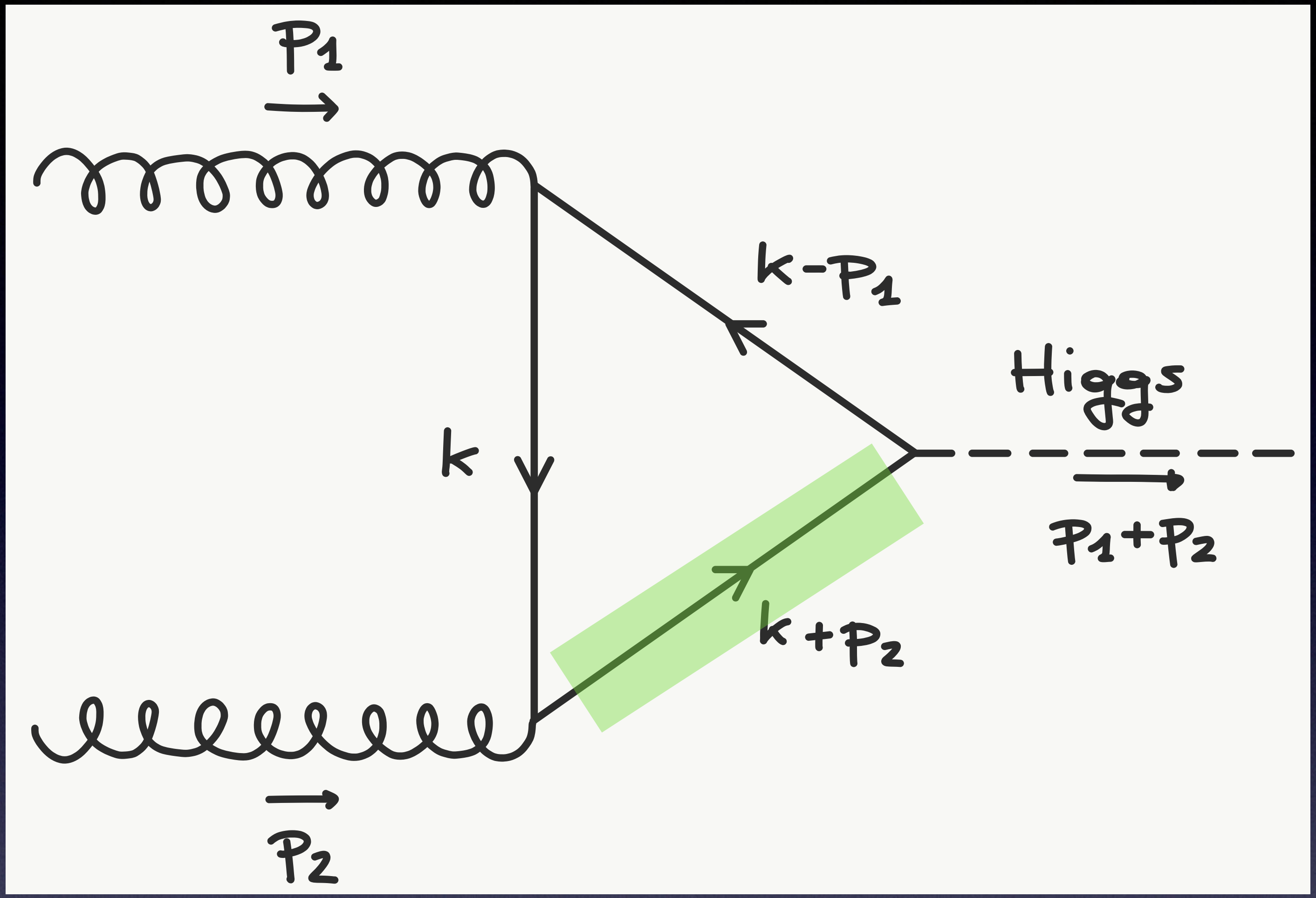

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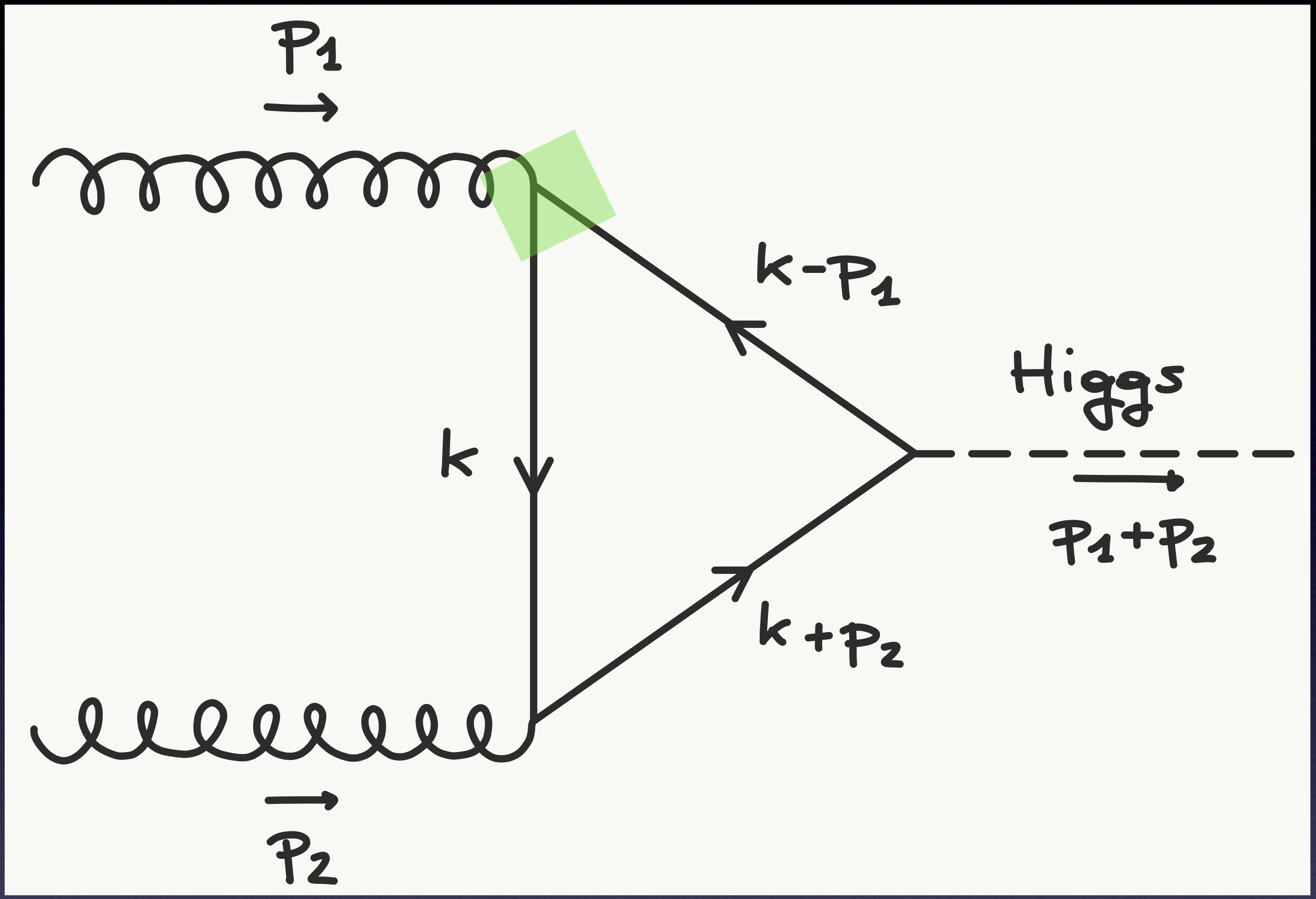

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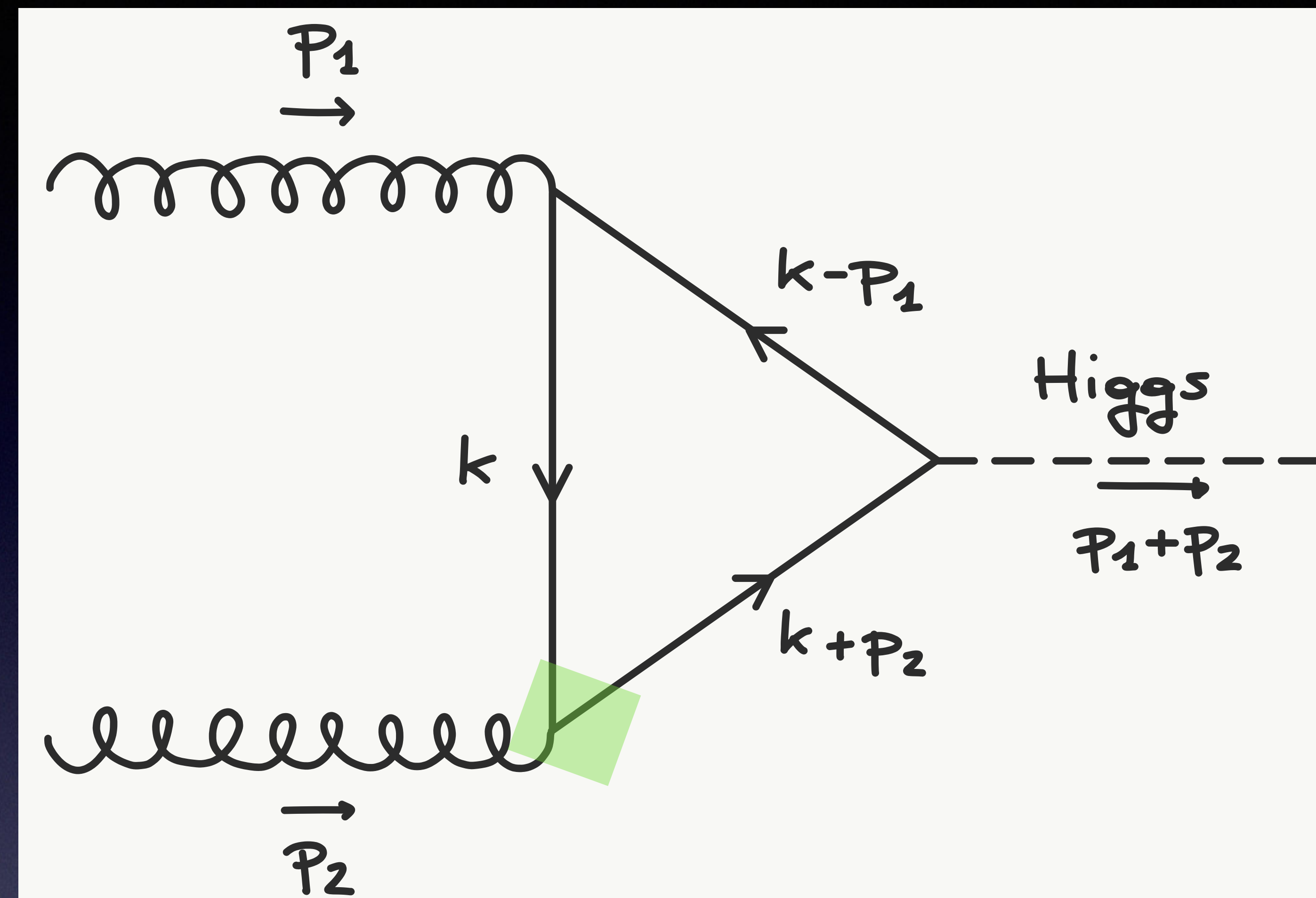

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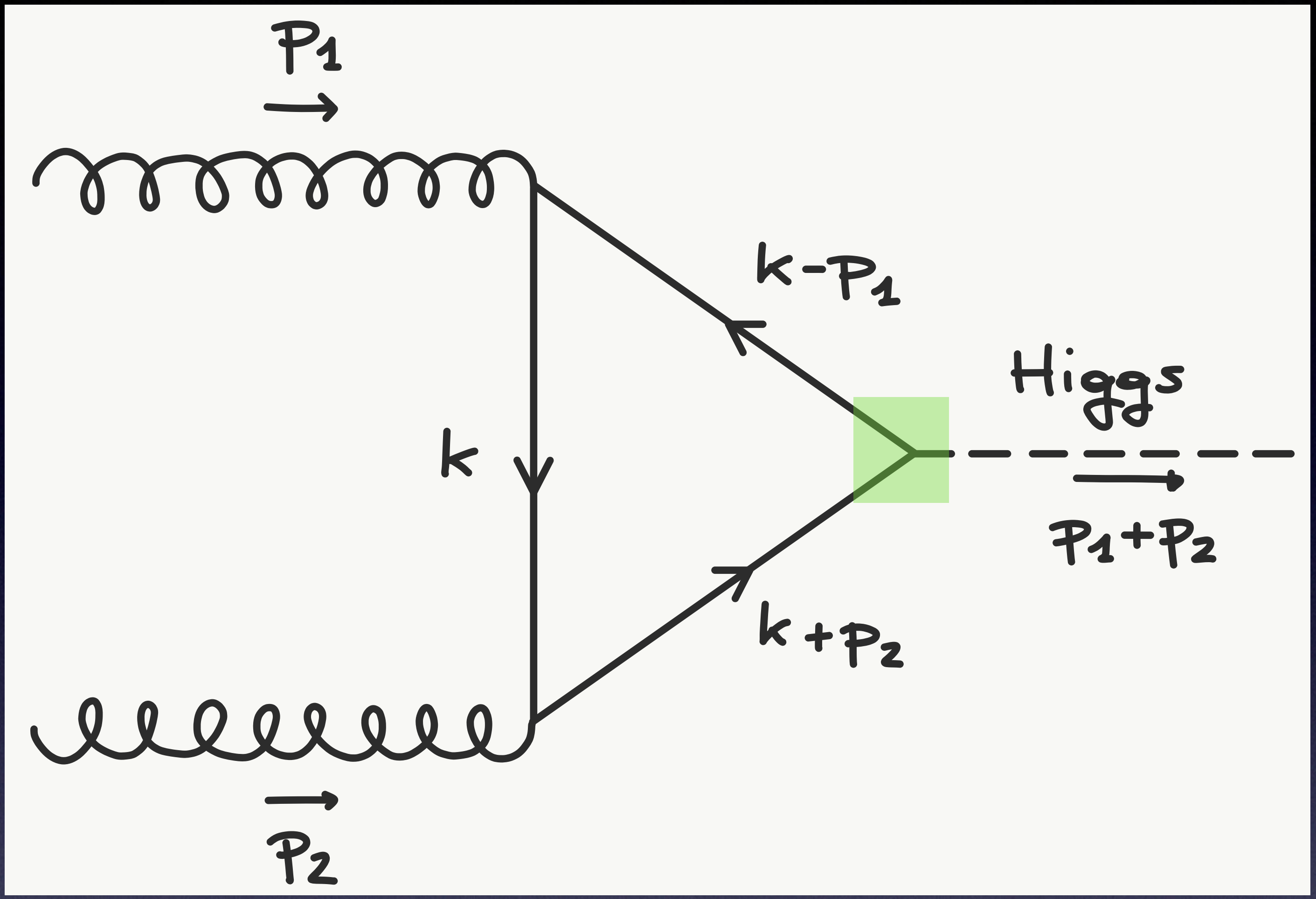

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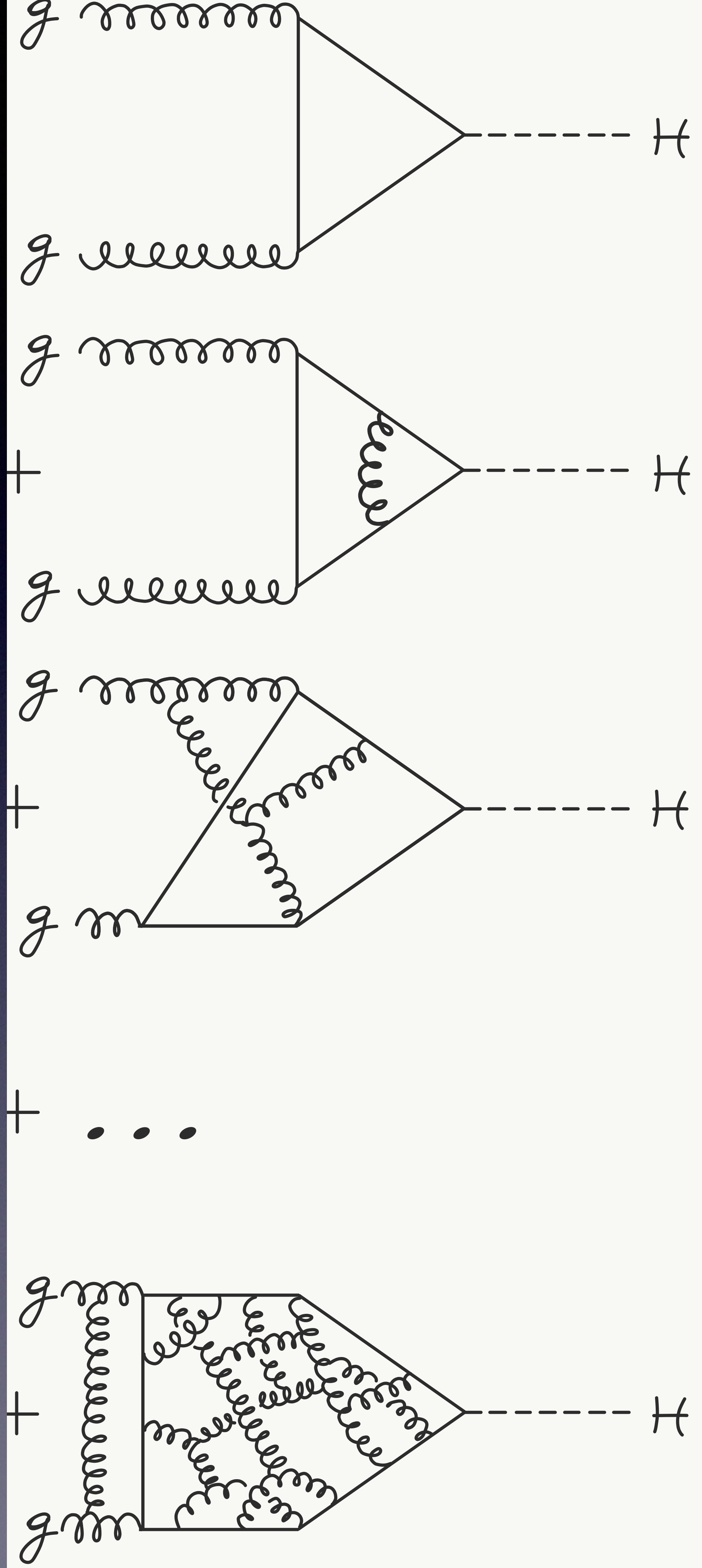
Infinite number of Feynman diagrams

- Infinite number of graphs which contribute to the probability of producing a Higgs from gluons…
- … or any other physical process



In this lecture series

- Understand quantum mechanics as a general framework.
- What are the fundamental principles and laws? Formalism(s).
- The role of symmetries in Quantum Mechanics
- Time evolution (in various pictures)
- What are (some of) the consequences of quantum laws?
- Strangeness of quantum laws, a deeper understanding/interpretation?
- Exact and approximate (mostly in QM II) solutions.
- Very basics of quantum computing (permitting time)

Tutorials

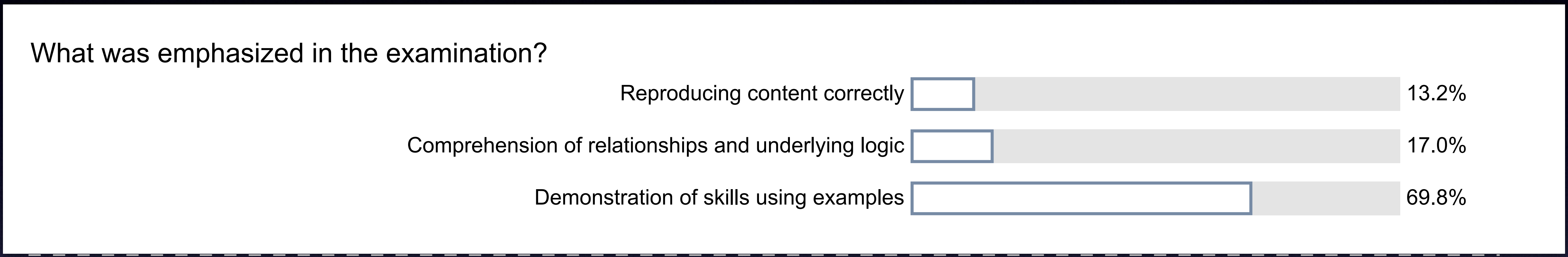
- Zeno Capatti
- Andrea Favorito
- Julia Karlen
- Tony Metger
- Paola Tavella
- Alessandro Tarantola

From second week of semester

Thu 09:45-11:30	15:45-17:30

Enrollment into exercise classes via Moodle
(you will receive a notification)

Evaluations and Exams



- 3 hours written exam.
  Consists of:
  - $\mathcal{O}(10)$ short questions (5 mins each) testing understanding of logic.
  - Two larger problems (1 hour each), testing skills and ability to apply theory in practice. Similar in spirit and difficulty to the ones in exercise classes, but combining material from the full semester.

- Continuous performance assessment.
  - 1/4 grade bonus on the grade of the exam
  - At least, 8 exercise sheets, worked out at >80%