PHD PRESENTATION

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Background

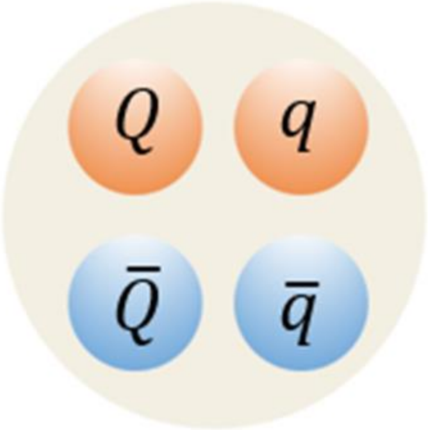
- Studied at “Sapienza” University of Rome
- Master degree in Particle Physics
- Thesis project with CMS group:
  “Search for exotic hadrons at Large Hadron Collider”

  → data analysis for the search of tetraquarks made of beauty quarks

Tetraquarks

Exotic hadrons made of four quarks (TQ)

- existence allowed by QCD
- not well understood internal structure



Two families of **theoretical models** try to explain the structure:

- Pairs of distinct mesons bound together temporarily as a "molecule"

- single cohesive unit of four quarks

$TQ(q\bar{q}Q\bar{Q}) \rightarrow M_1 M_2$

Binding energy between di-mesons : $B = m_{TQ} - M_1 - M_2$

m_{TQ} far from di-mesons threshold → Higher binding energy → More compact state

State of art and studied process

First observation: $X(3872) \to \pi^+\pi^- J/\psi$ (Belle, 2003) arXiv:hep-ex/0309032

Tetraquarks at LHCb: $\mathrm{X}(6900) \to J/\psi\ J/\psi\ \to \mu^+\mu^-\ \mu^+\mu^-$ (2020) ➡ first state with 4 charm quarks arXiv:2006.16957

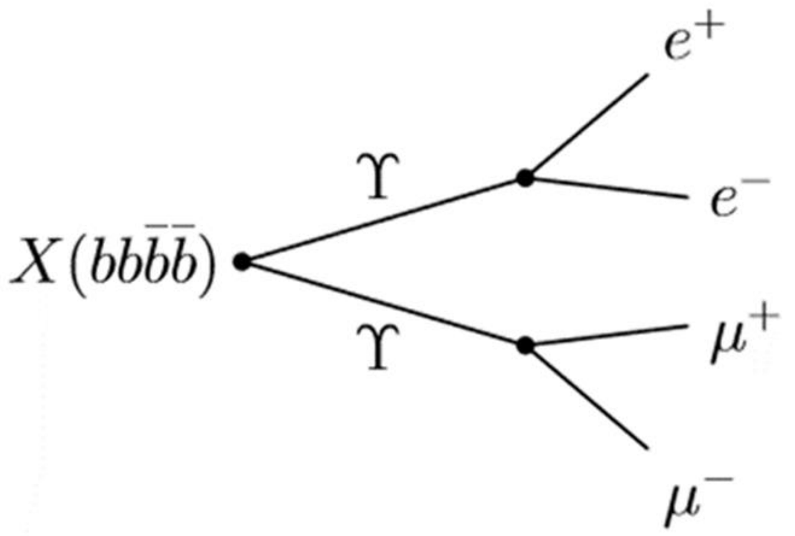
Not yet observed tetraquarks with more than 2 beauty quarks

Tetraquarks at CMS:

- $X\left(bb\overline{b}\overline{b}\right) \to \Upsilon\Upsilon \to 4\mu$ with 2016 data ➡ no evidence arXiv:2002.06393
- $X(cc\bar{c}\bar{c}) \to J/\psi\, J/\psi \to 4\mu$ ➡ ongoing study

In my thesis: search for tetraquarks made of 4 beauty quarks in $2\mu 2e$ final state (2018 data)

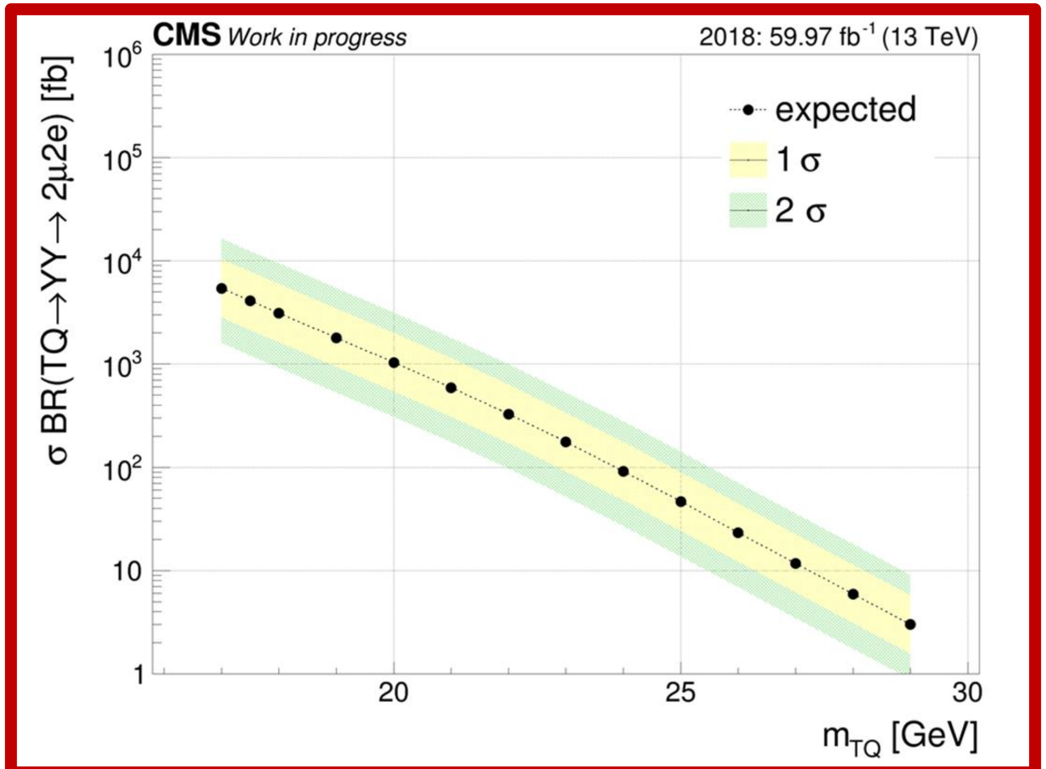
$$\boldsymbol{X\left(bb\overline{b}\overline{b}\right) \to \Upsilon(1S)\Upsilon(1S) \to 2\mu 2e}$$



Outlook and results

- Analysis for the search of a peak in $2\mu 2e$ invariant mass spectrum
- Signal events selection, signal and background models → data fit
- Expected upper limit on $\sigma\, BR$ vs m_{TQ}
  → analysis sensitivity

more sensitive to higher TQ masses



Future possible observation: experimental proof of a possible TQ and more information for theoretical models

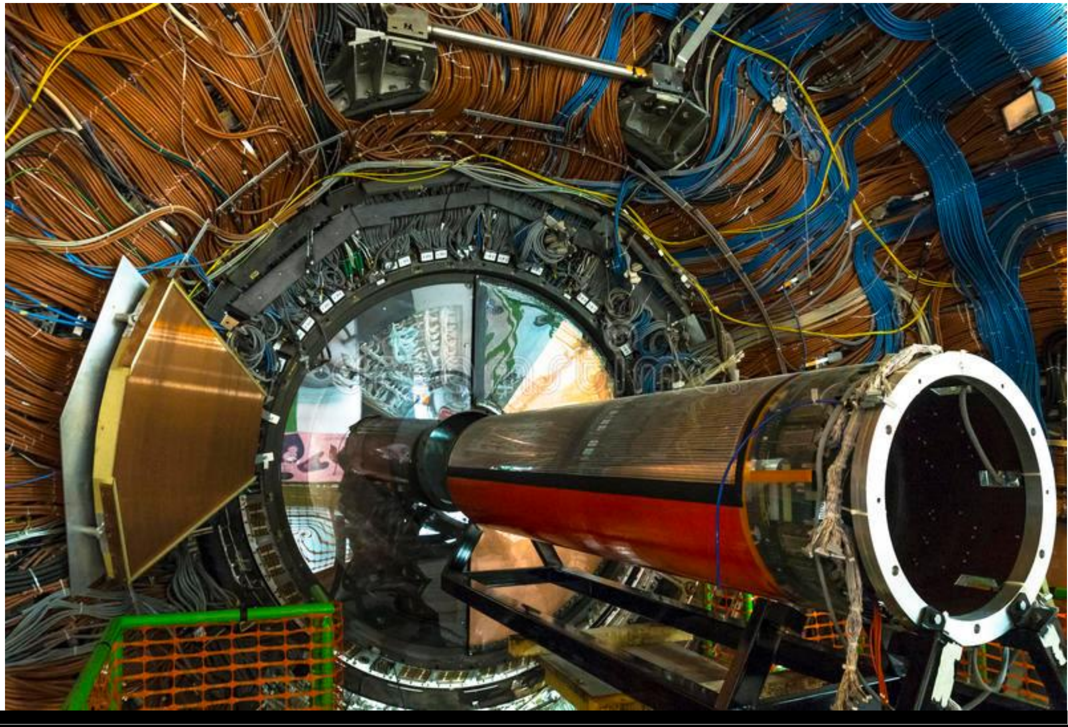
PhD project: the experiment

Large Hadron Collider:

- the most powerfull accelerator in the world
- proton-proton collisions

Large Hadron Collider beauty (LHCb):

- study of beauty and charm quarks, precise measurements of CP violation and rare decays
- using a series of subdetectors to detect mainly forward particles



PhD project: the analysis

Rare B mesons decays

- sensitive to physics processes beyond Standard Model

- measuring these rare branching fractions sets limits on new particles

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