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# D-Days: Standard Model and beyond

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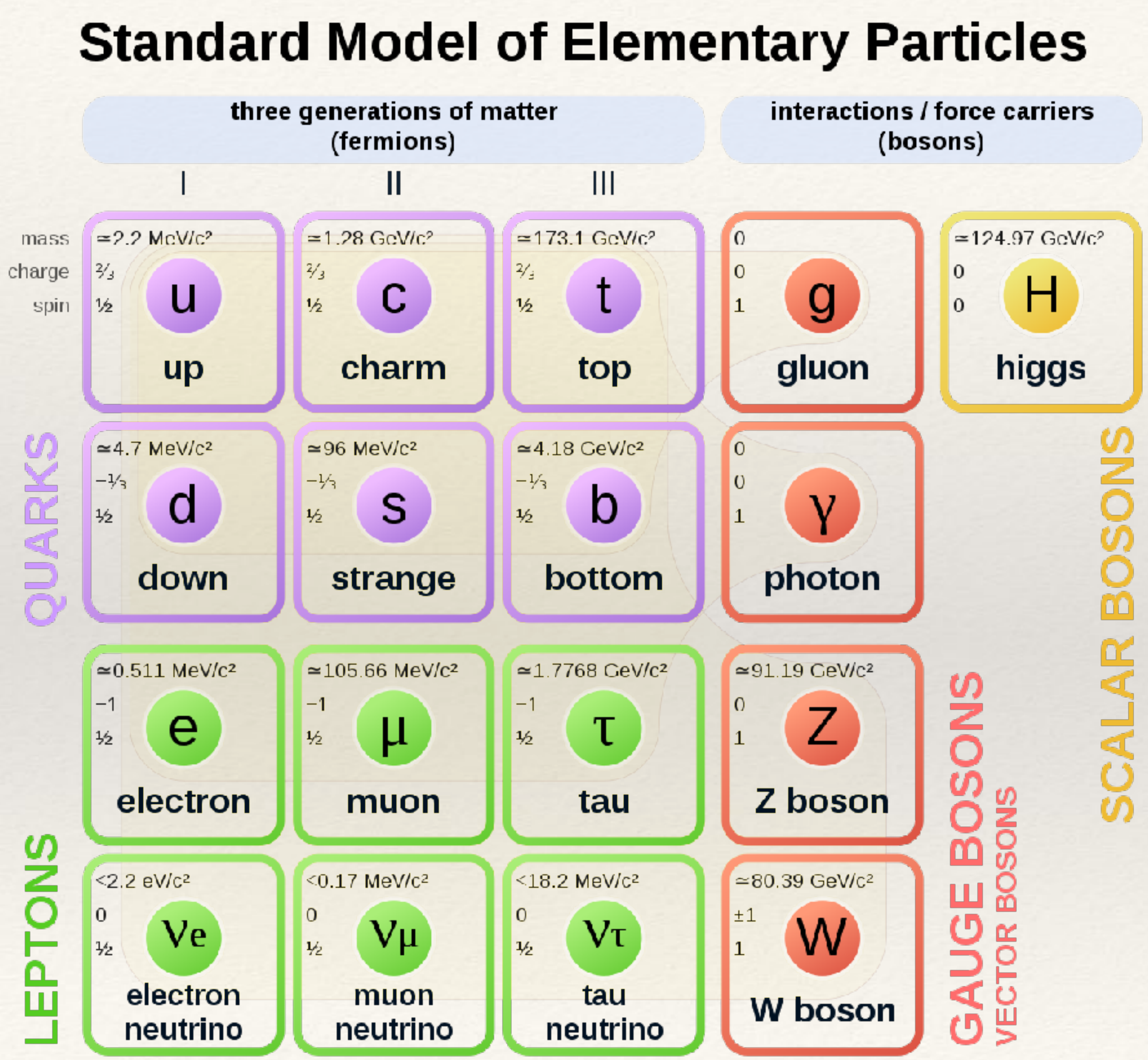
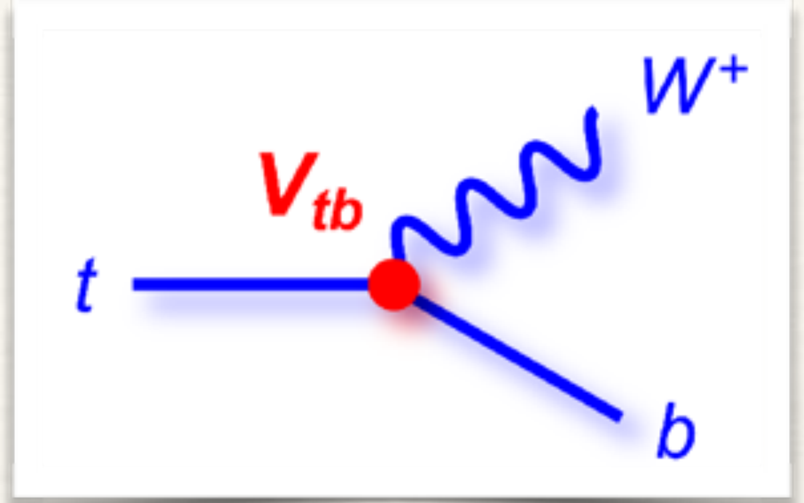
# Introduction: Standard Model



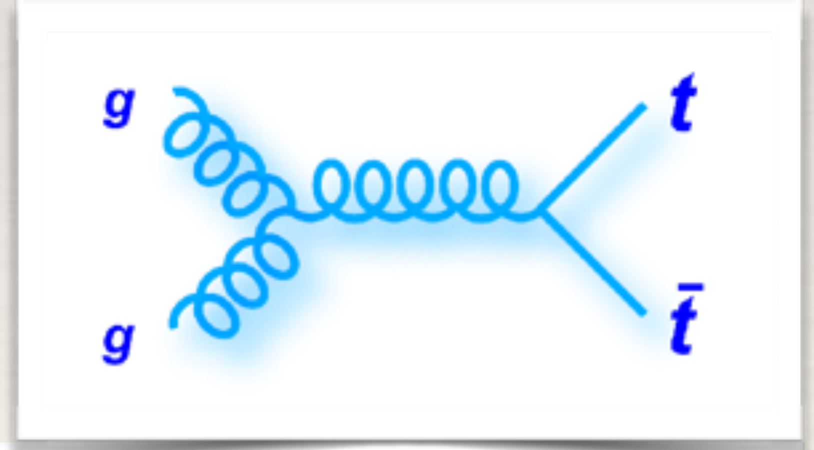

## *b*-quark

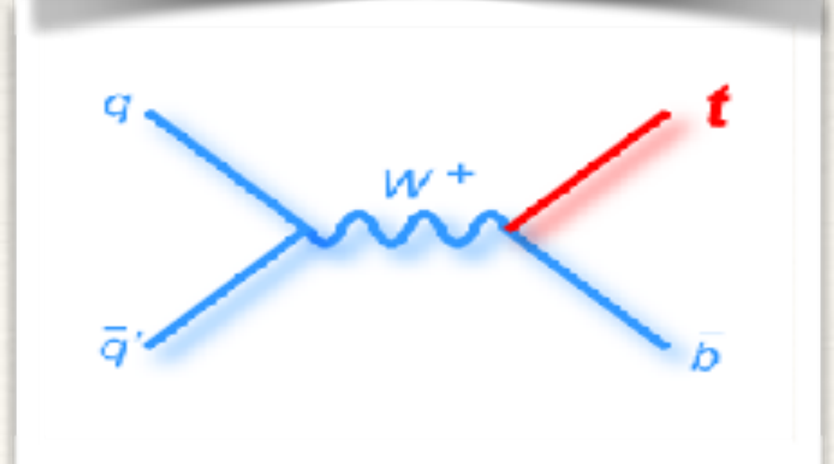



- Produced in *t*-quark decay
- Bound states are exceptionally **long-lived**

## *t*-quark

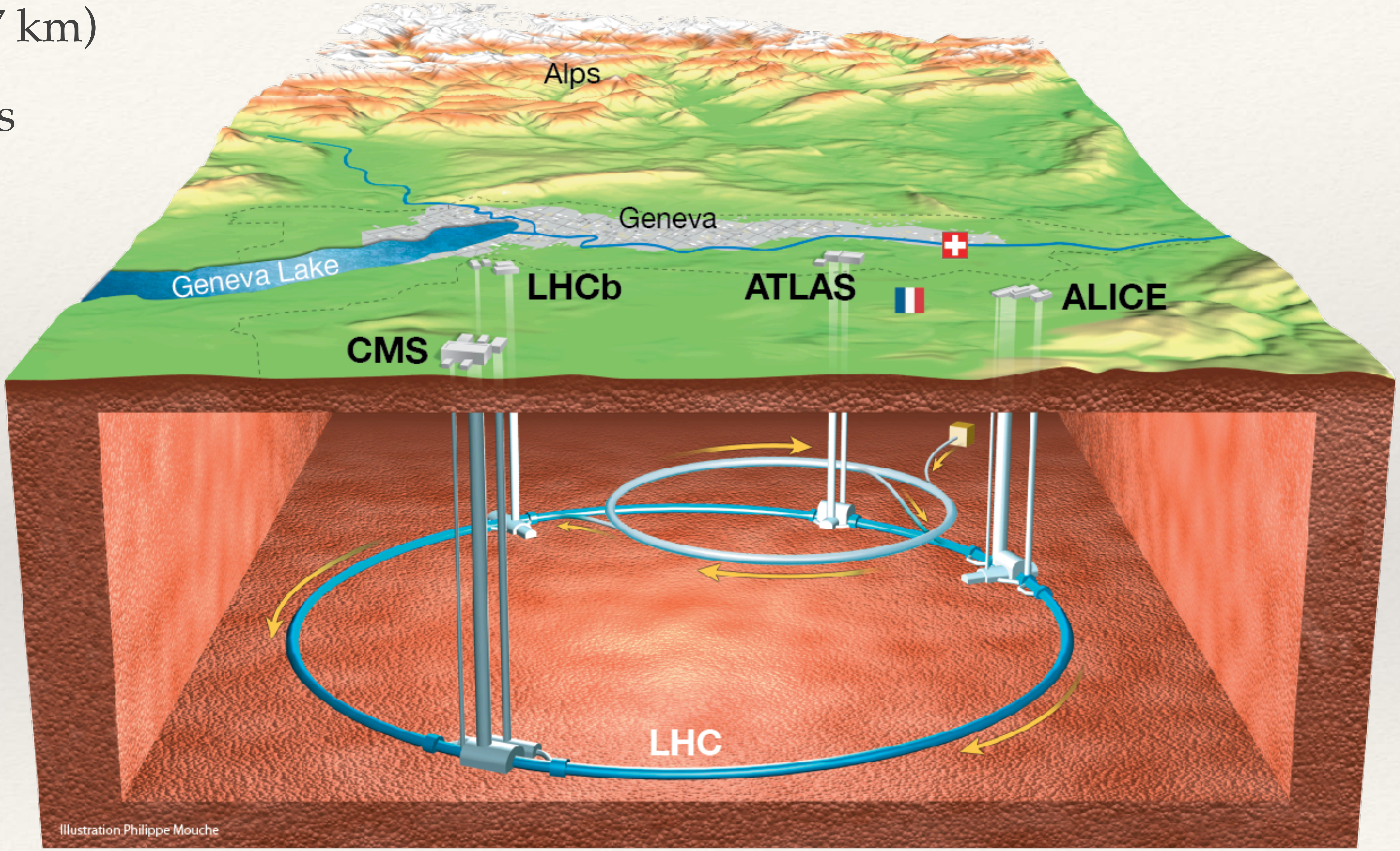
- **Heaviest** elementary particle
- **Doesn't form bound states**
- Produced via
  - gluon fusion / decay ($t\bar{t}$ pairs)
  - Weak interaction (single-top)



# Introduction: Large Hadron Collider

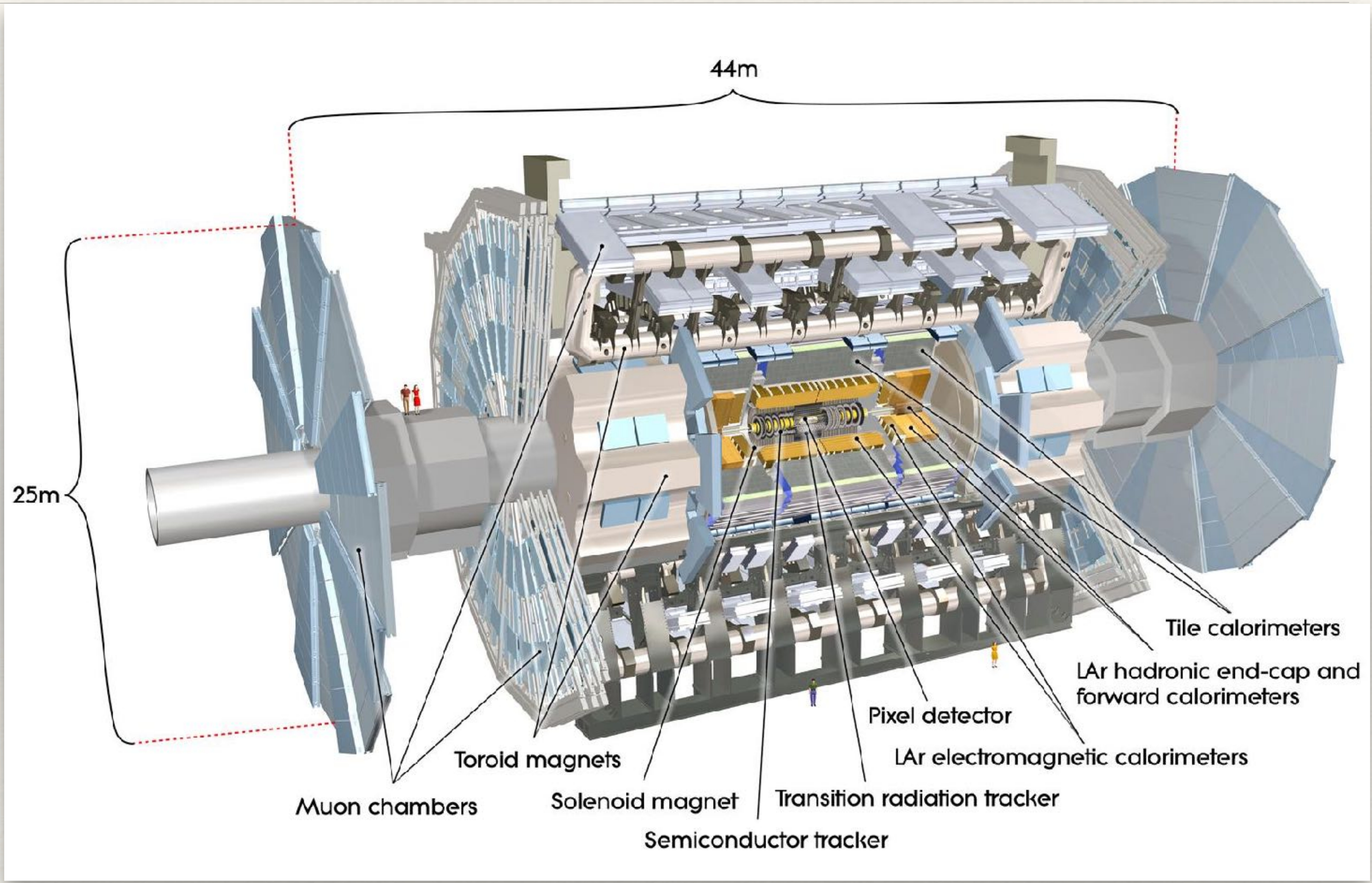
- World's largest accelerator (27 km)
- 8 T supra-conducting magnets
- Protons **and** lead ions
- Up to 13 TeV collision energy
- 4 interaction points



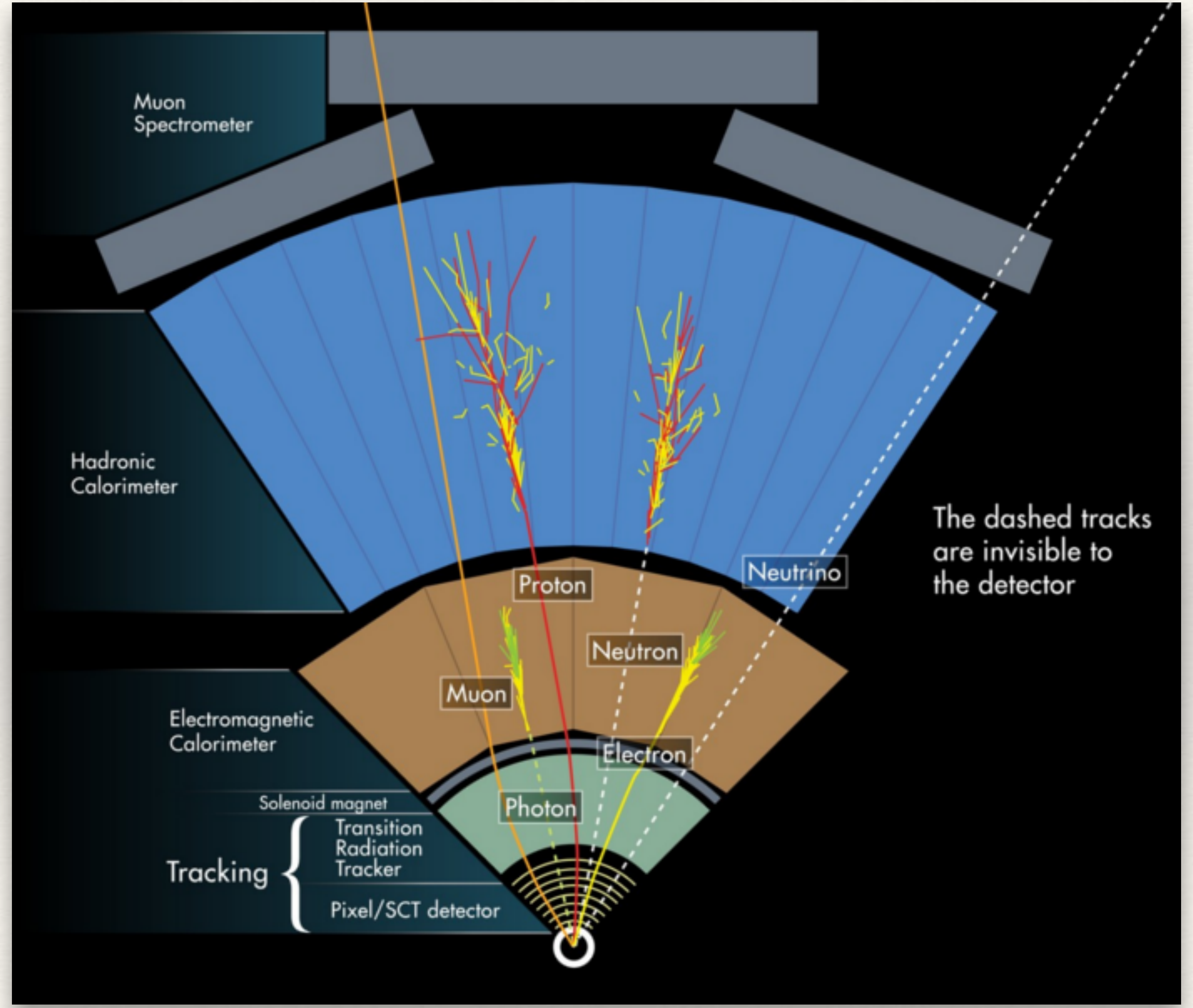
# Introduction: ATLAS

**Main physics topics explored in ATLAS:**

- Tests of the Standard Model (e.g. Higgs physics)
- Precision measurements (e.g. of particle masses)
- Searches for the new resonances, dark matter, exotic phenomena



# Introduction: particle detection

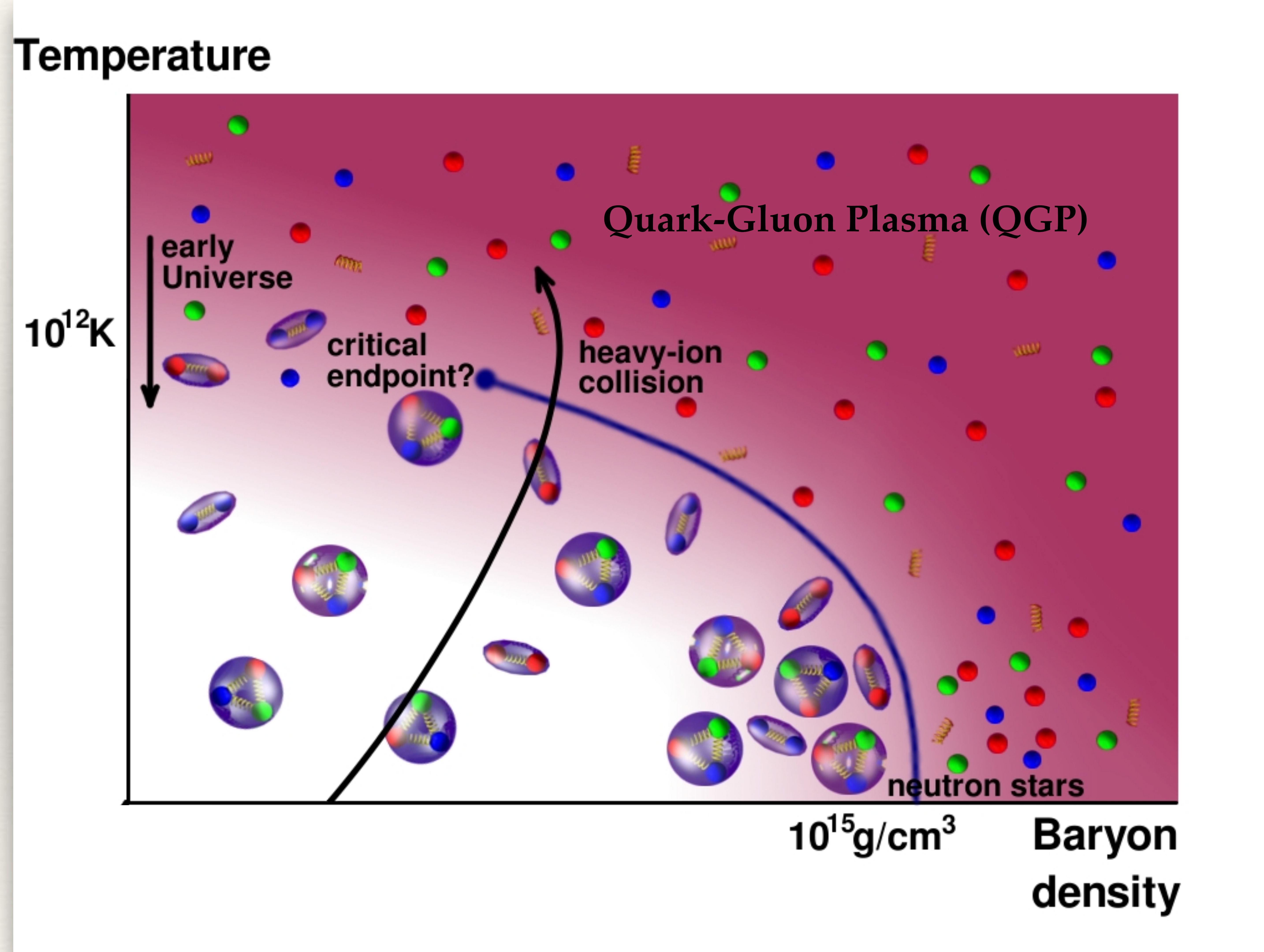


# Introduction: Quark-Gluon Plasma in a (hot) nutshell

- Quarks and gluons are **confined** in hadrons
- **Phase transition** where quarks and gluons are *free* to propagate

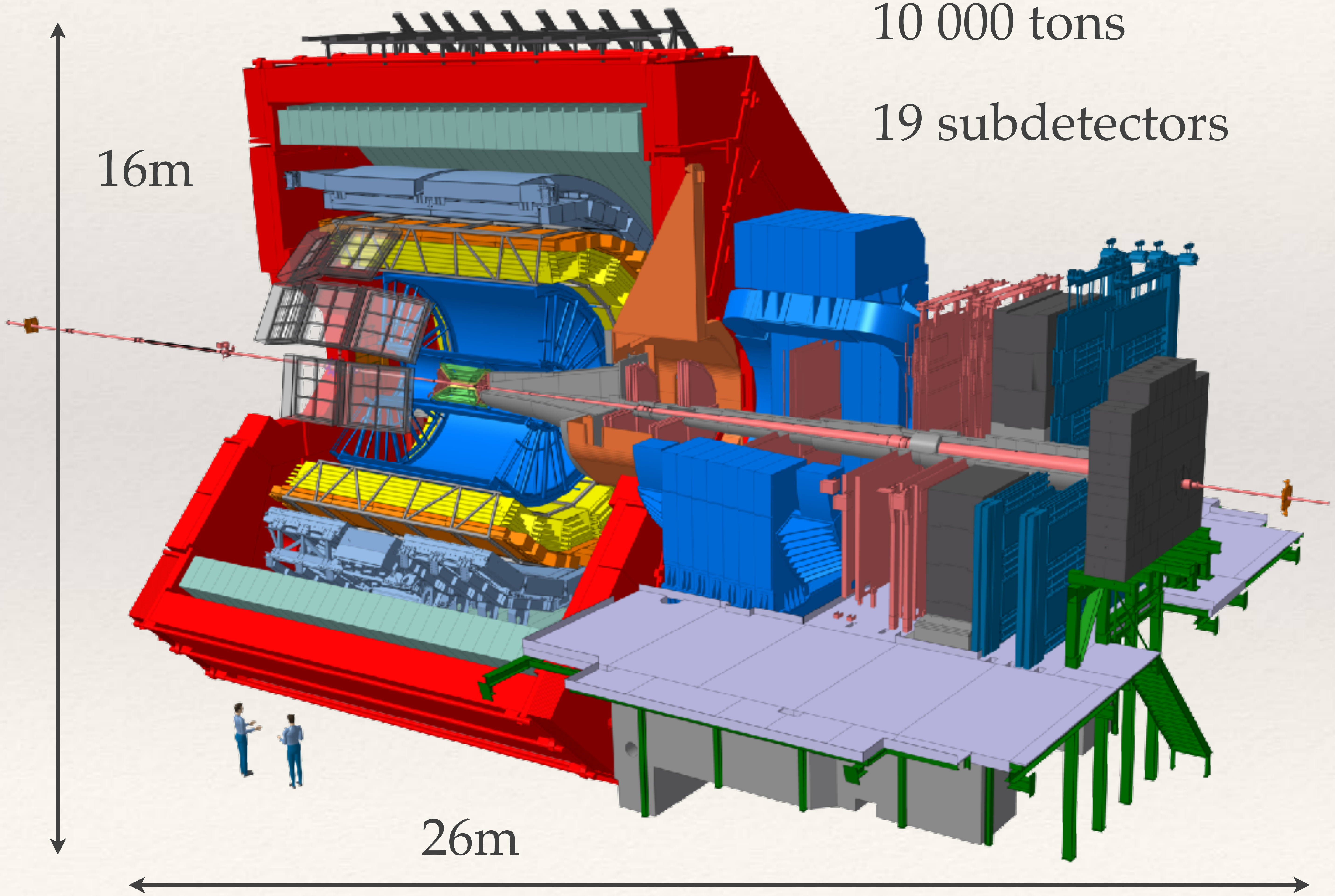
  ☞ **Quark-Gluon Plasma !**

- Primordial state of the Universe (~1 μs after the Big Bang)
- Core of dense neutron stars ?
- Ultra-relativistic **heavy-ion collisions**



# Introduction: A Large Ion Collider Experiment

Studying the **Quark-Gluon Plasma** properties **in the lab**




10 000 tons

19 subdetectors

**Physics impacts**

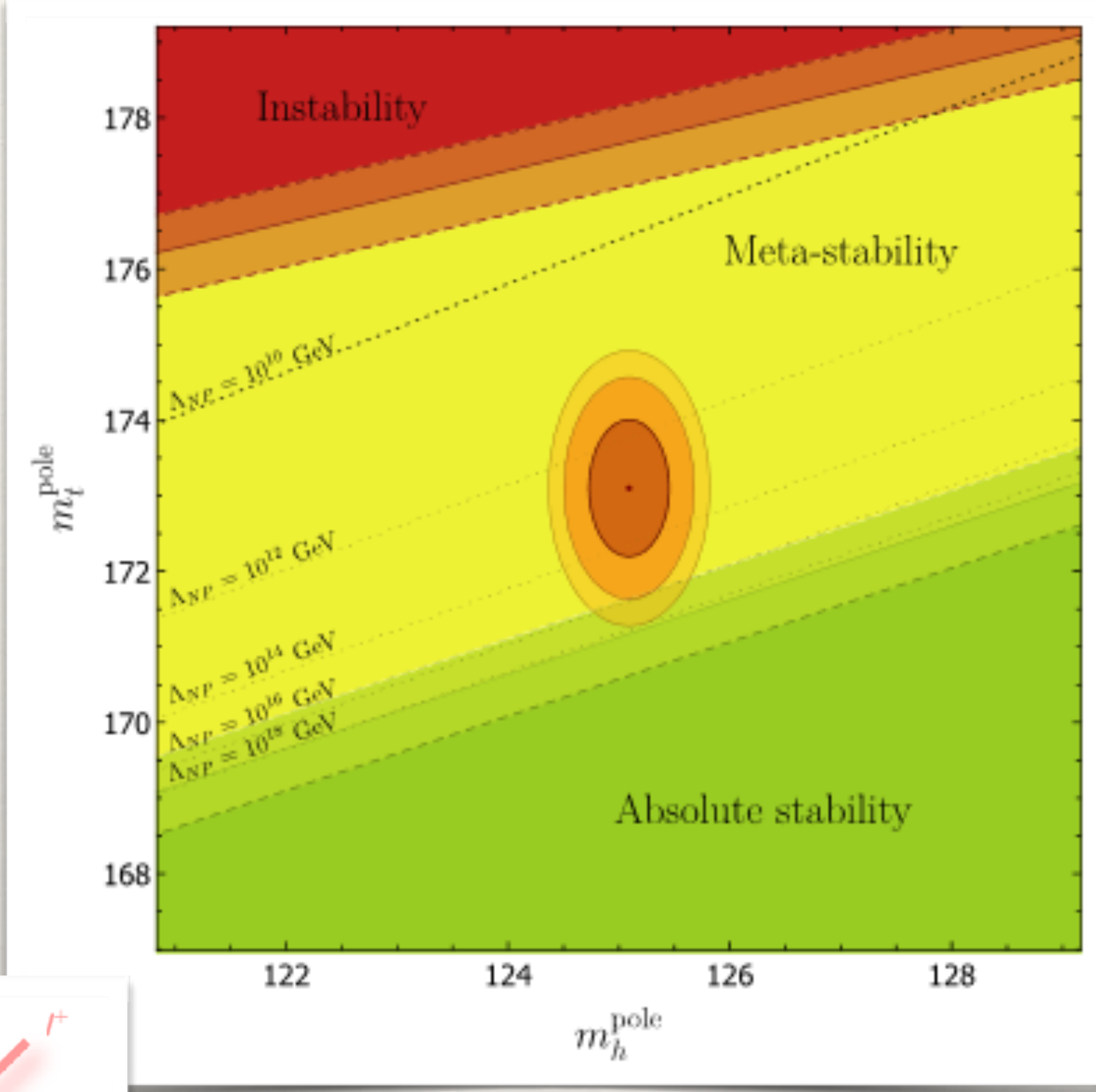
- confinement / deconfinement
- non-perturbative QCD
- EoS of neutron stars
- cosmological models
- limits of hydrodynamics
- …

# Top quark mass measurements

# Top quark mass measurements: motivation

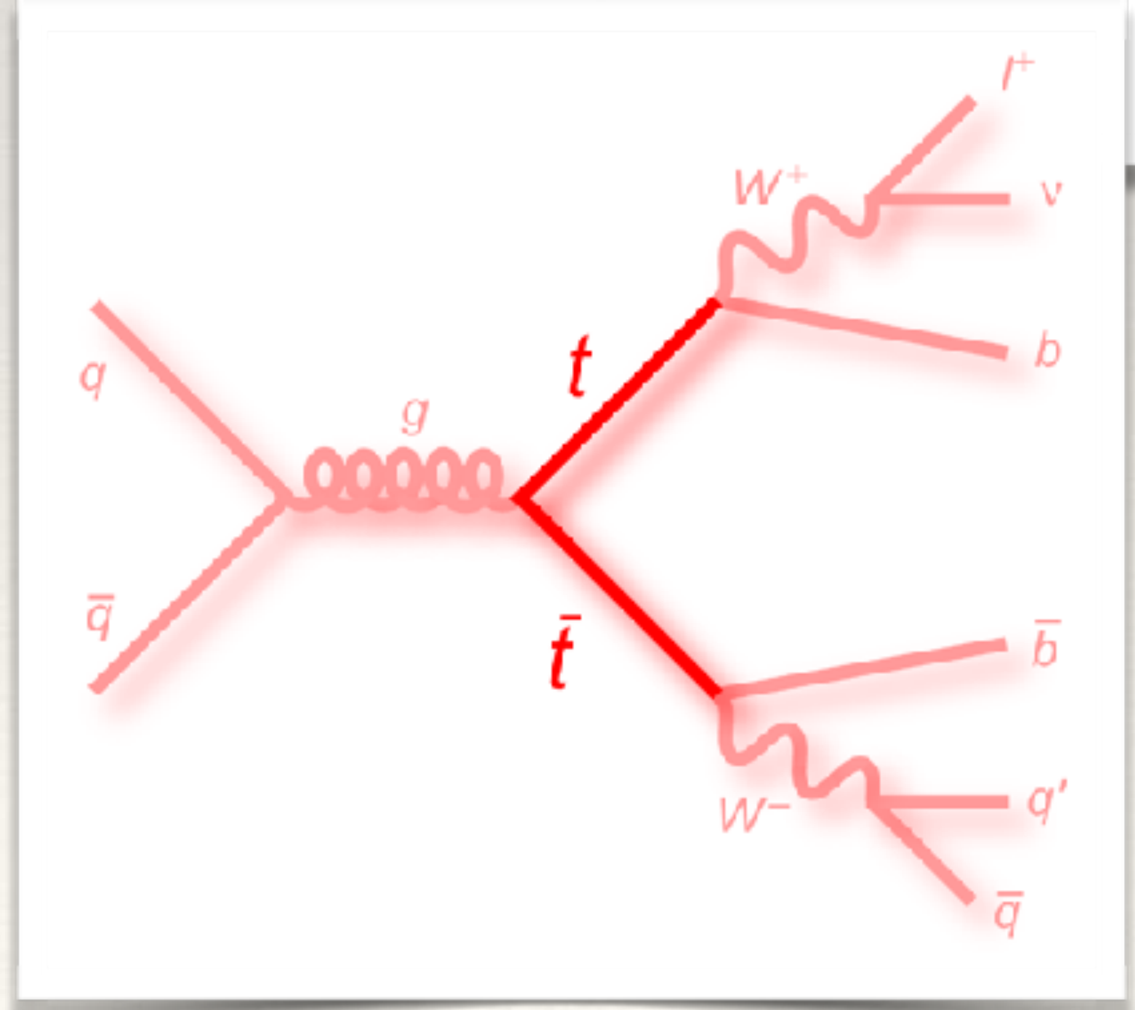
Why measuring the top quark mass?

- Input for **Electroweak precision tests**
- Impacts the **vacuum stability** of the Standard Model
- Cosmological consequences (e.g. **Universe lifetime** **PhysRevD.97.056006** )



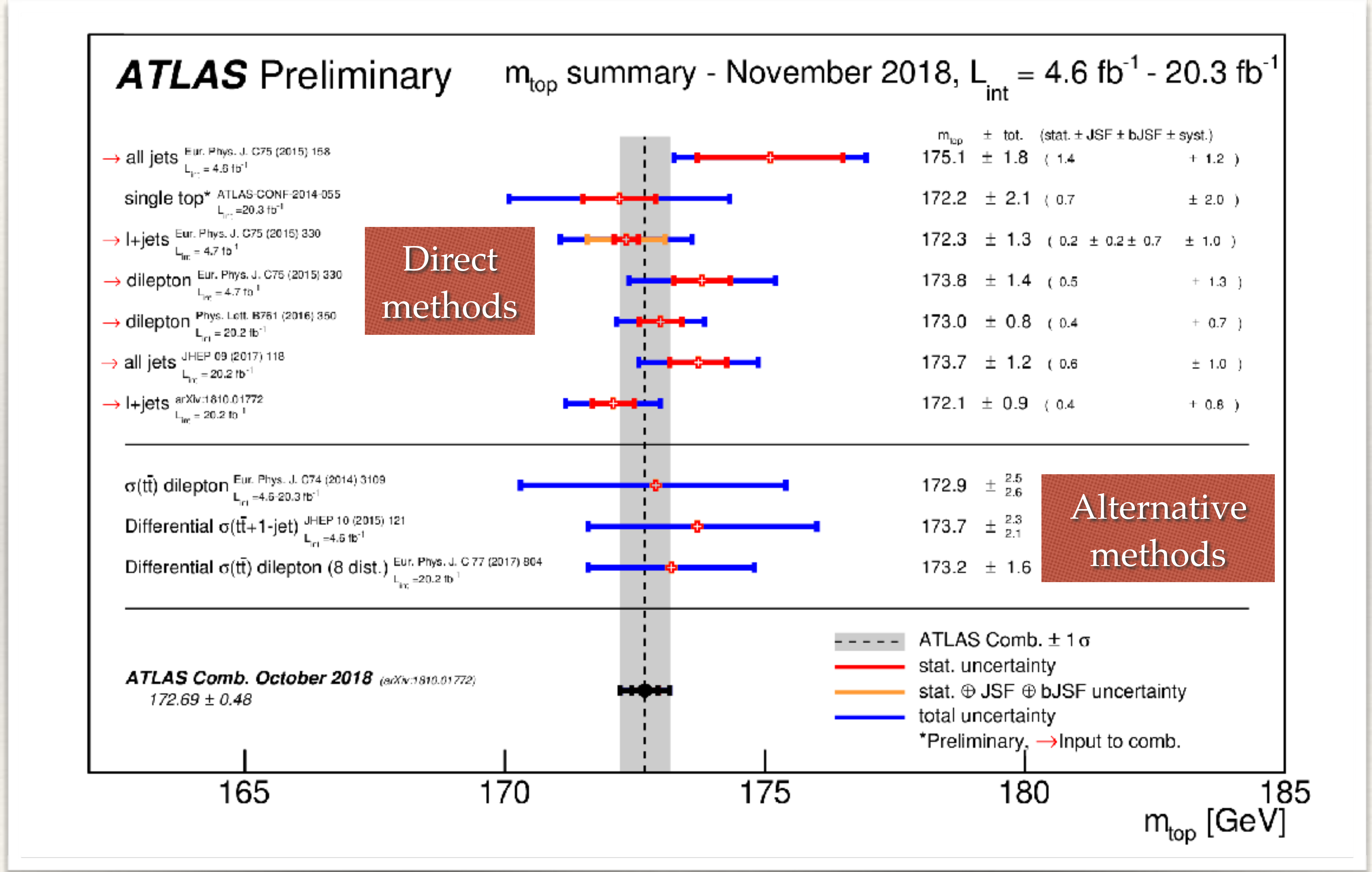

- PhysRevD.97.056006

- Top is the only quark for which **free** mass (the one in the Lagrangian) can be measured directly **JHEP 1709, 099 (2017)**



# Top quark mass measurements: direct vs alternative methods

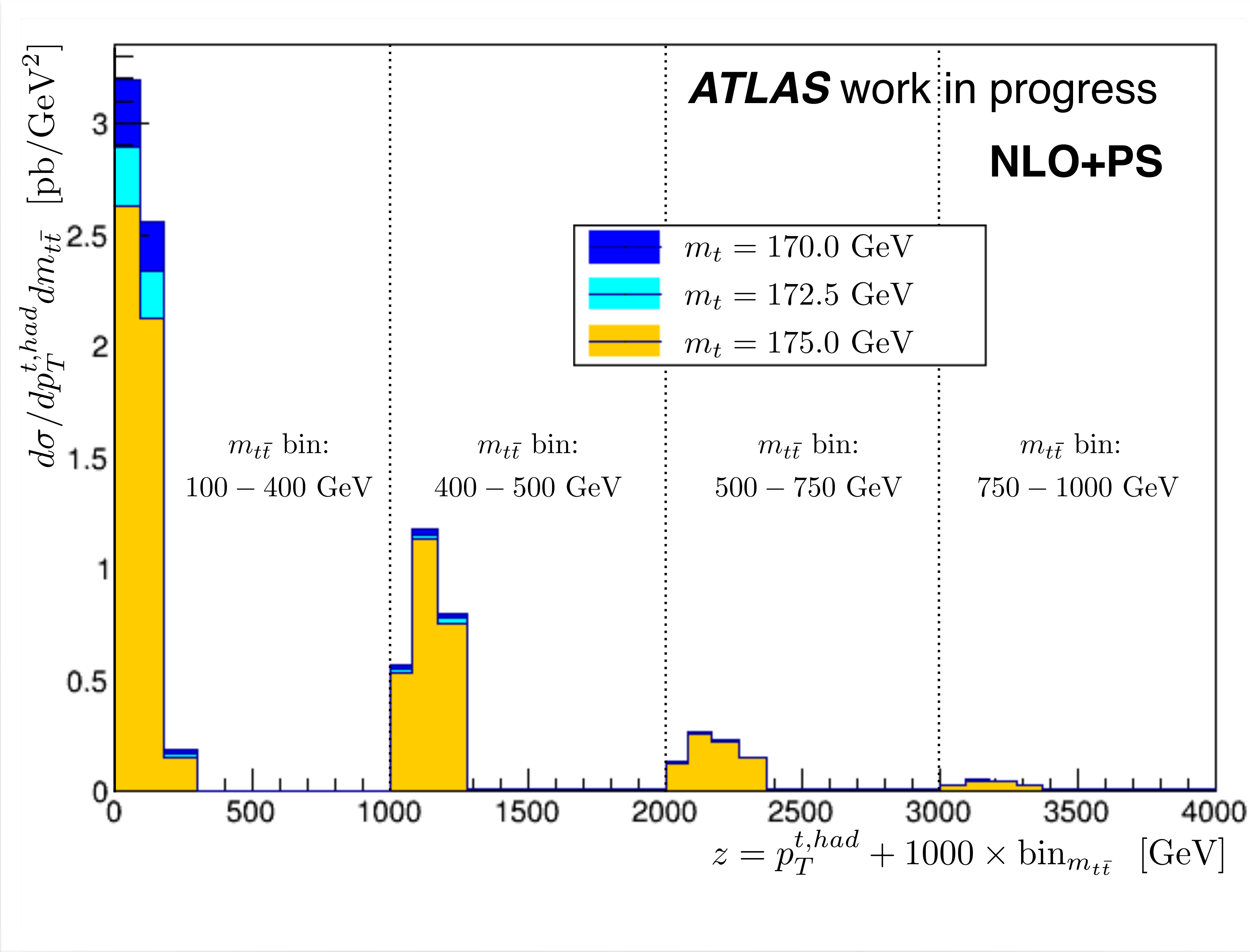
- Direct methods:
  - Use kinematical observables
  - Compare data to **Next-to-Leading-Order-plus-Parton-Shower (NLO+PS)** predictions
- Alternative methods:
  - Use $t\bar{t}$ cross-section
  - Compare data to **Next-to-Next-to-Leading-Order (NNLO)** calculations
  - Smaller theoretical uncertainties

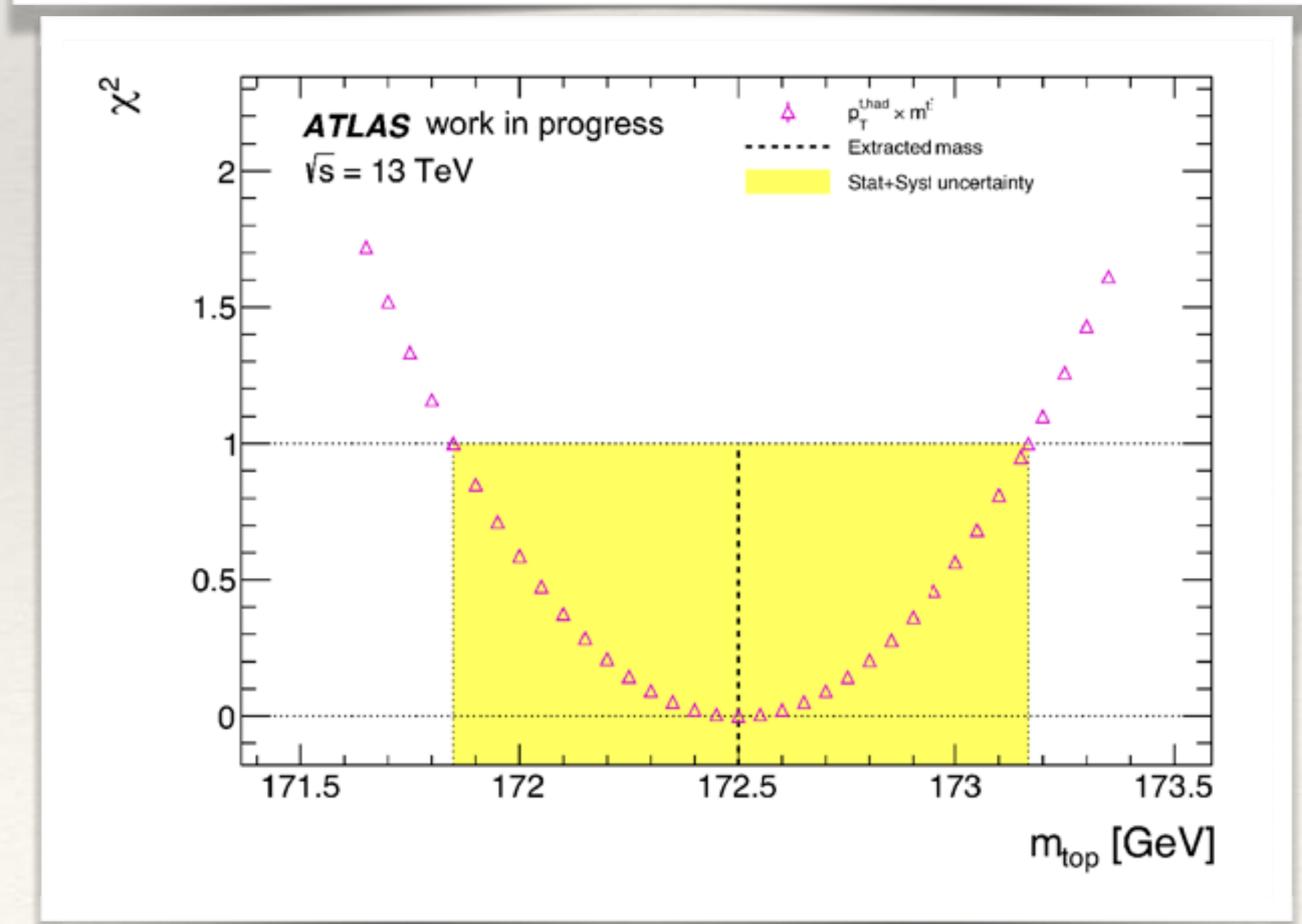


# Top quark pole mass determination from top-quark pair differential cross-sections

- $pp \to t\bar{t}$ process
- **lepton+jets** top decay channel
- data: 36.1 / fb @ 13 TeV

- double differential cross section $d^2\sigma/dm_{t\bar{t}}dp_T^{t,had}$
  - more precise than single differential cross section
- compare to the theoretical NNLO predictions
  - Theoretical scale uncertainty improved w.r.t NLO
- mass extraction using $\chi^2$ minimisation
- **Next step**: mass extraction using the data (currently working with the MC pseudo-data)

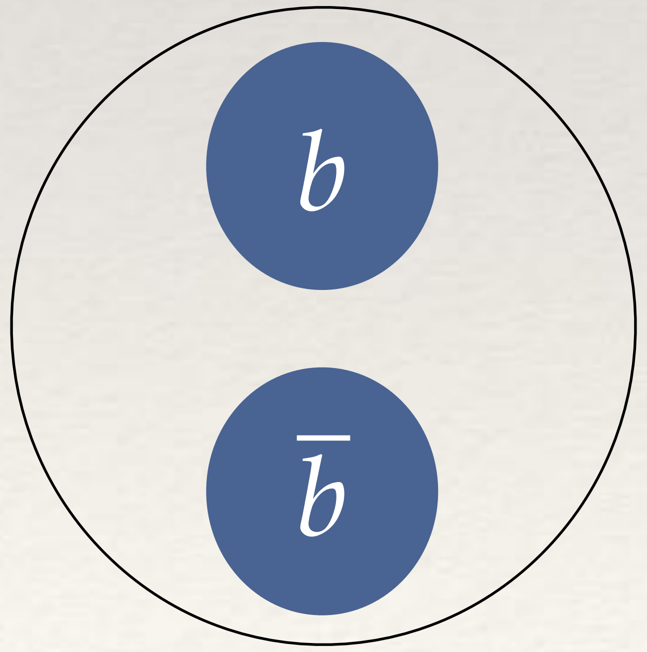


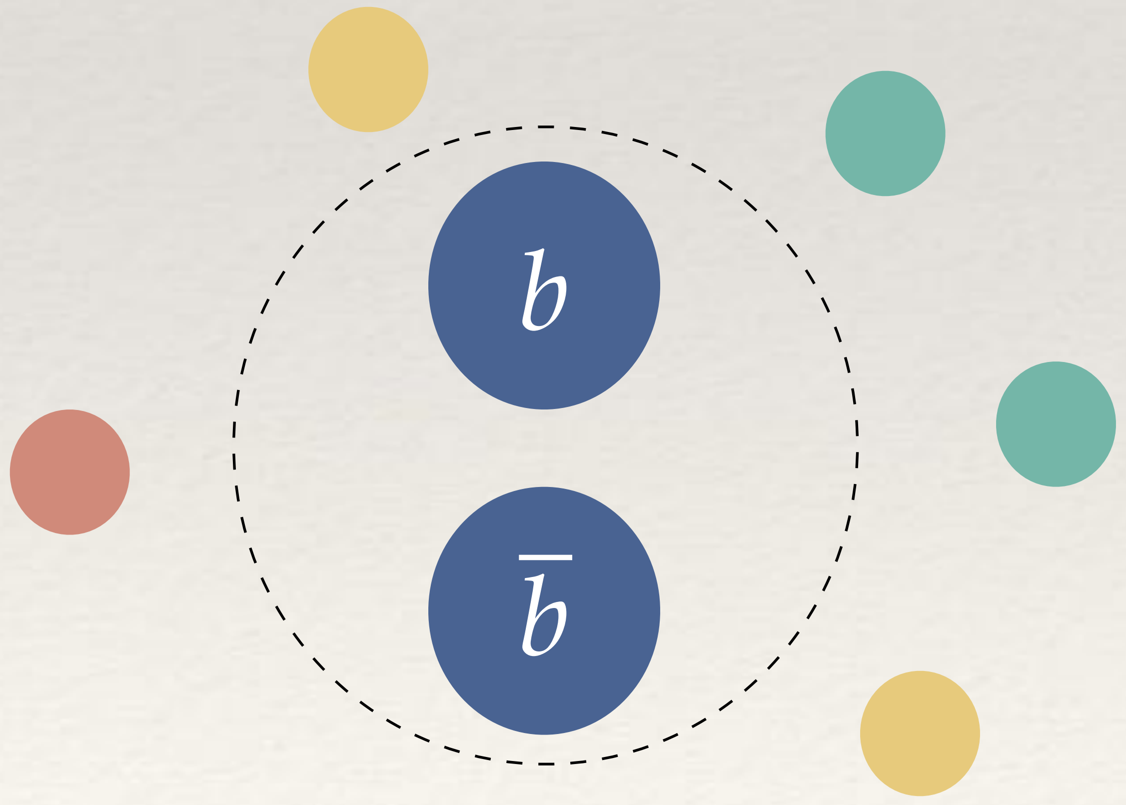
# Upsilon production in heavy-ion collisions

# Physics motivation - A *smoking gun* of the deconfinement

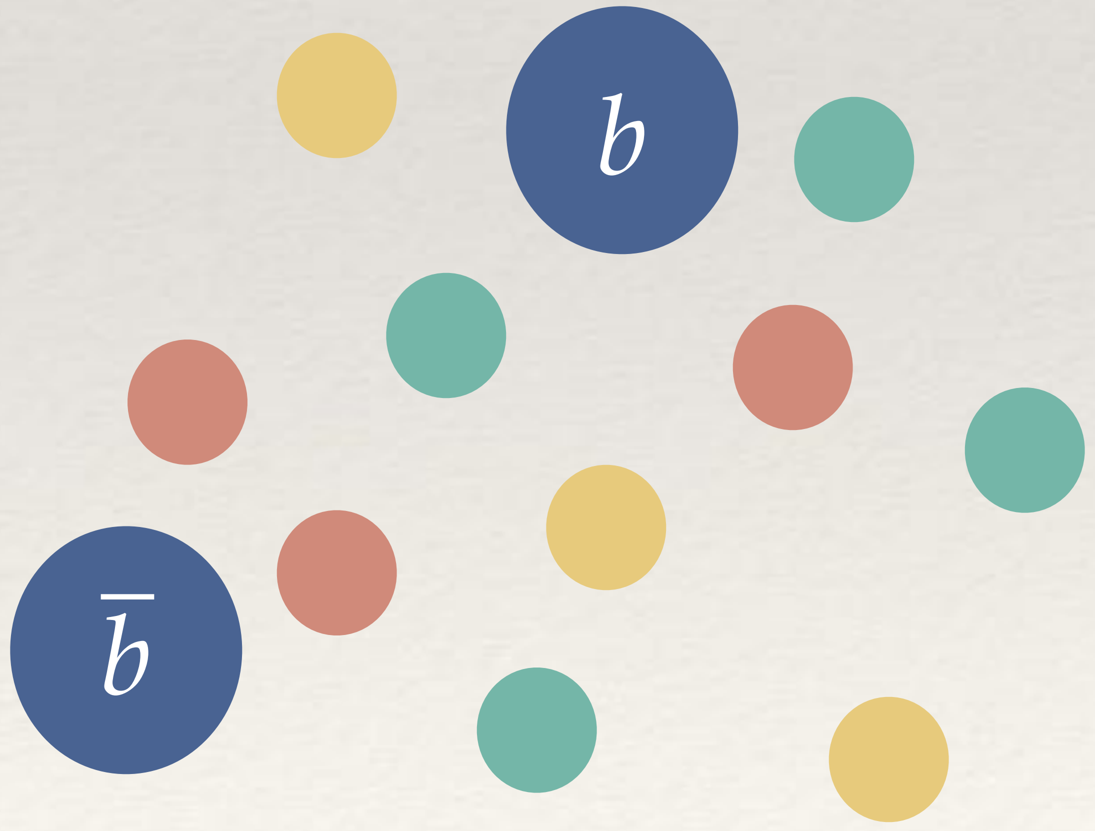
- $\Upsilon = b\bar{b}$ **bound state**
- produced before the QGP formation ☞ **ideal probes** of the hot medium
- if the temperature is high enough, the pair breaks up ☞ **upsilon suppression**
- different binding energies ☞ ***sequential melting*** ☞ **QGP thermometer !**



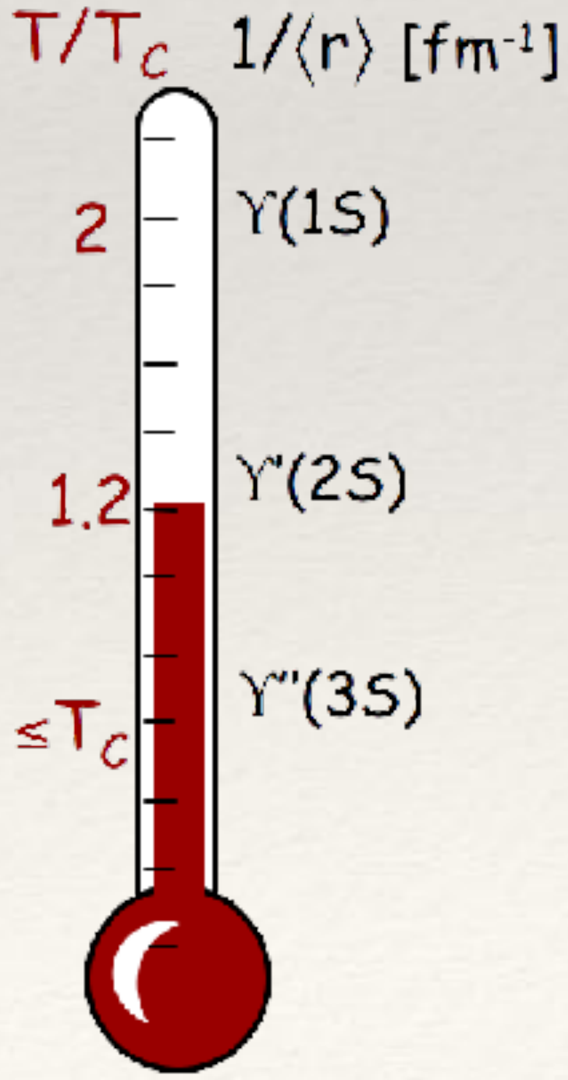

vacuum



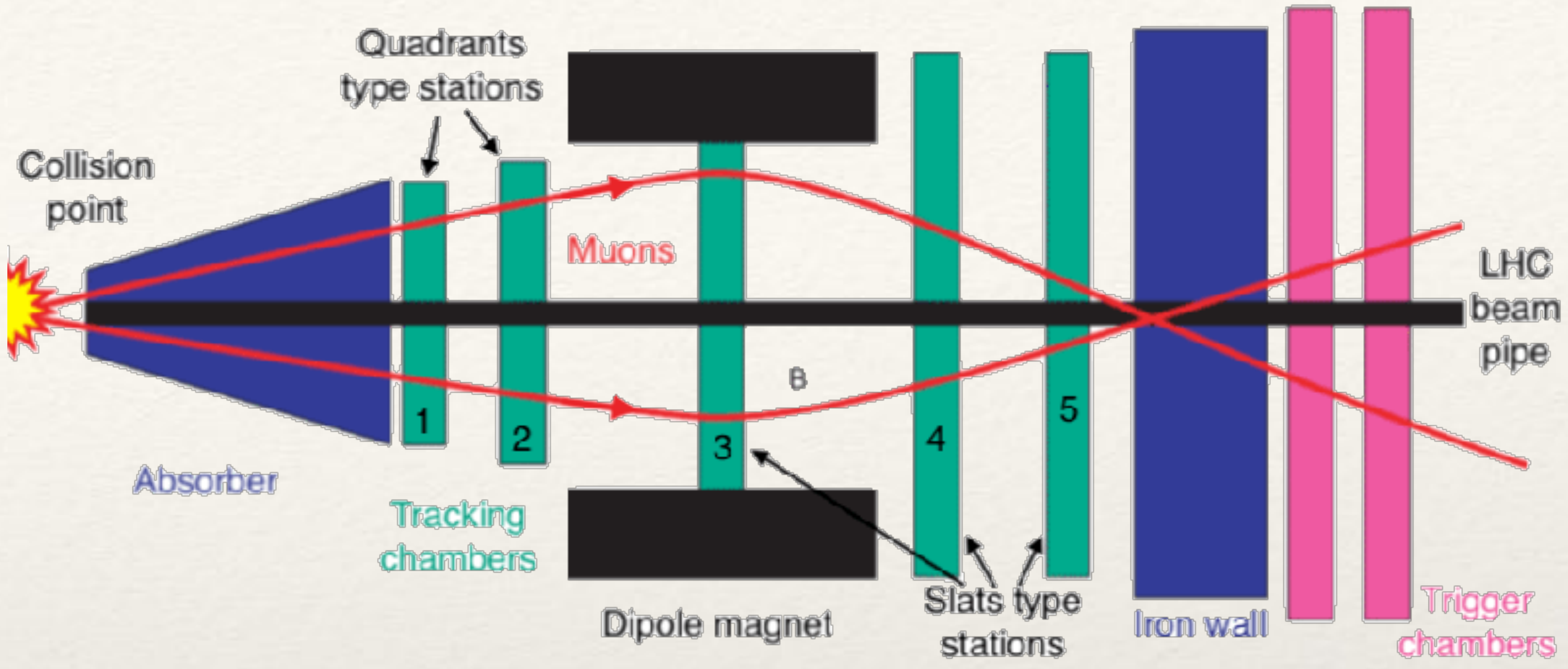

low temperature QGP




high temperature QGP



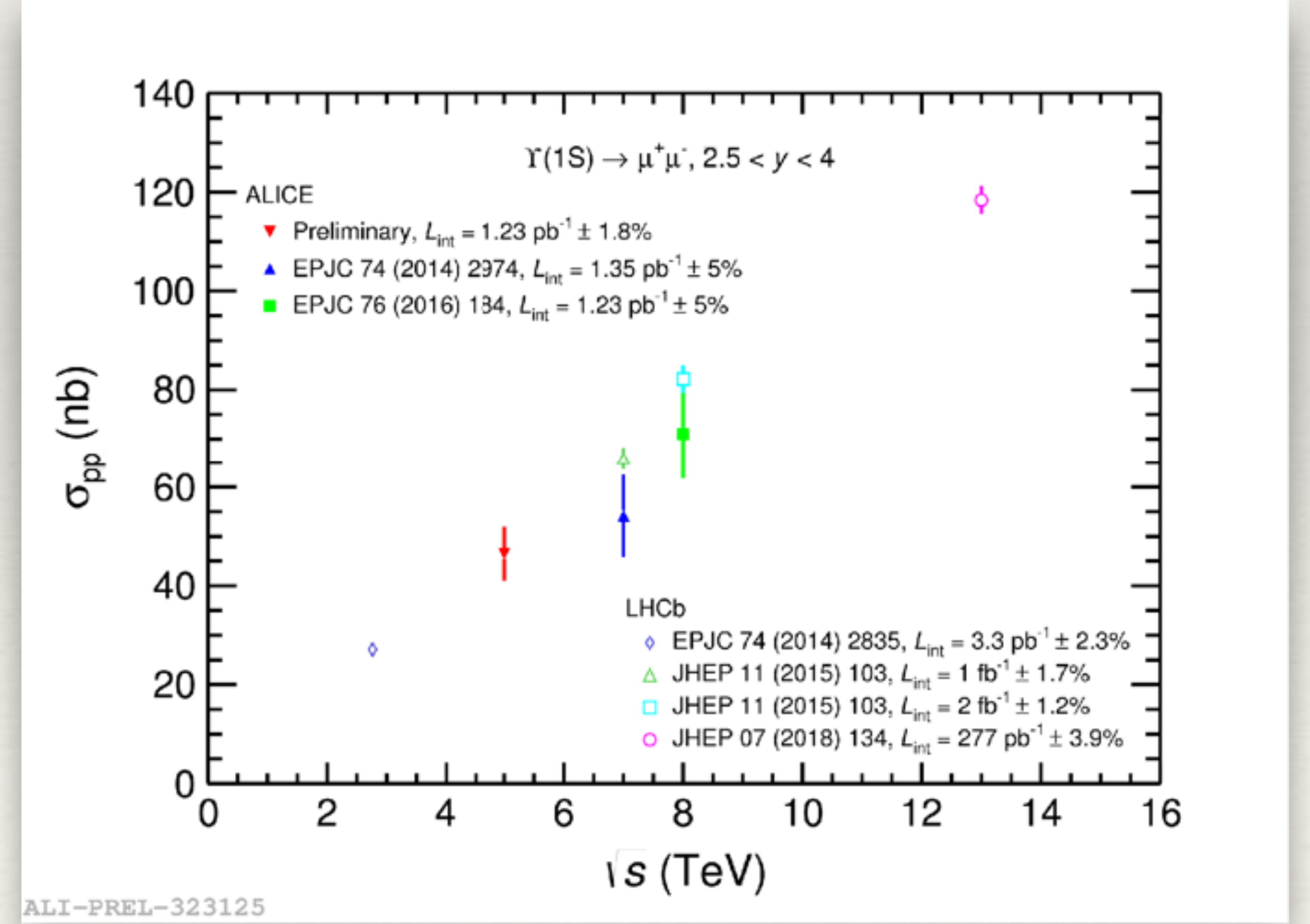
# Upsilon production in proton-proton collisions




- Measurement of upsilon suppression w.r.t **production in pp collisions** (reference)

- 2017: pp @ 5 TeV

- $\Upsilon \rightarrow \mu+ \mu-$ with ALICE muon spectrometer




- Result: production **cross-section**
  ☞ **consistent** with other measurements

  ☞ **precision improvement** for suppression

# Upsilon production in heavy-ion collisions

- 2015: Pb-Pb collisions @ 5 TeV
- $\Upsilon(1S)$ suppression compatible with models

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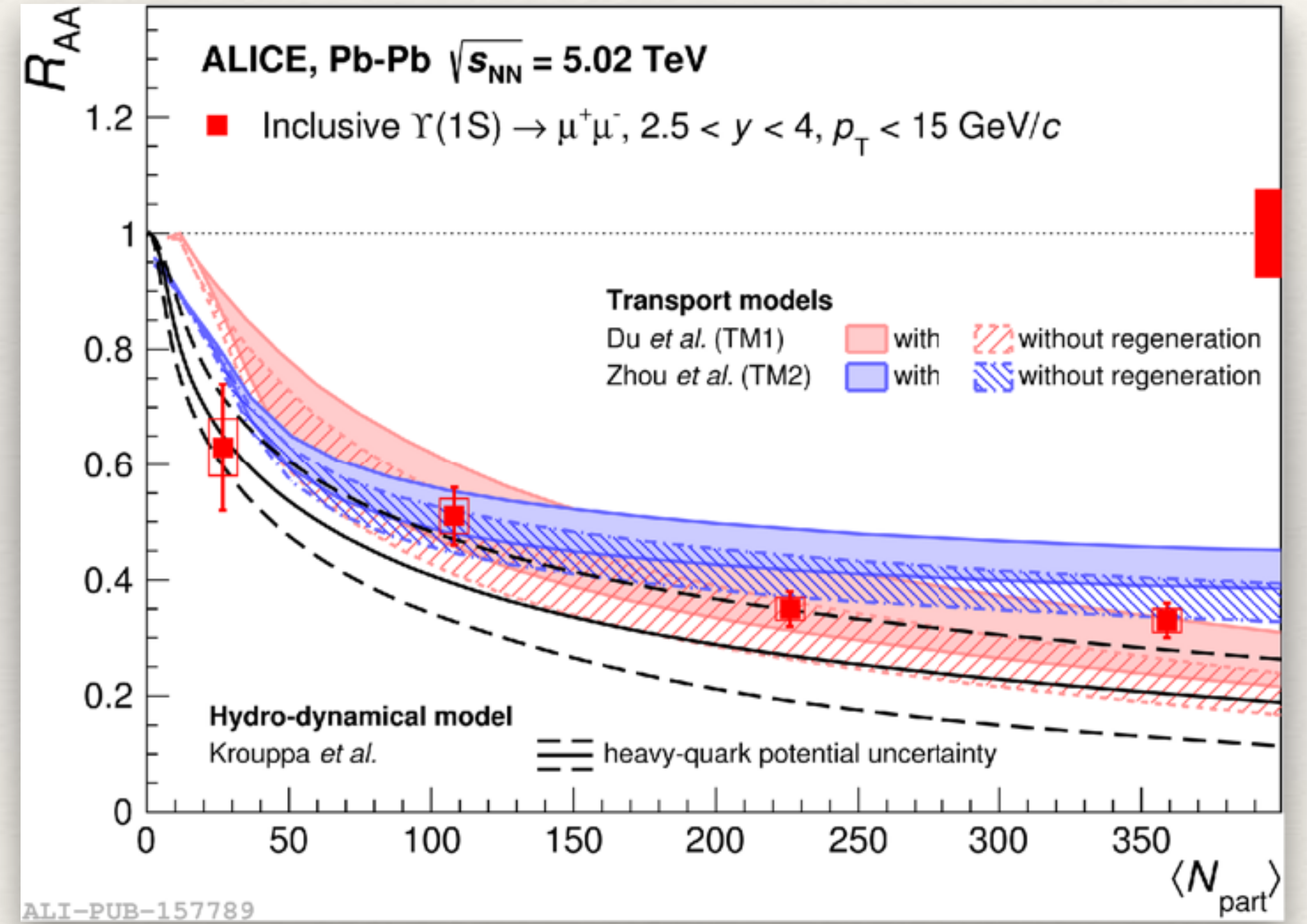
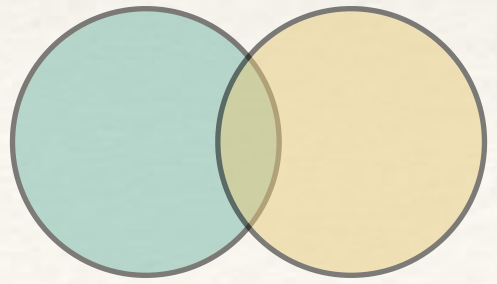
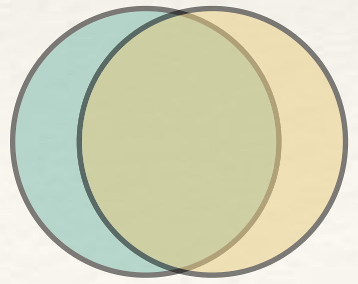
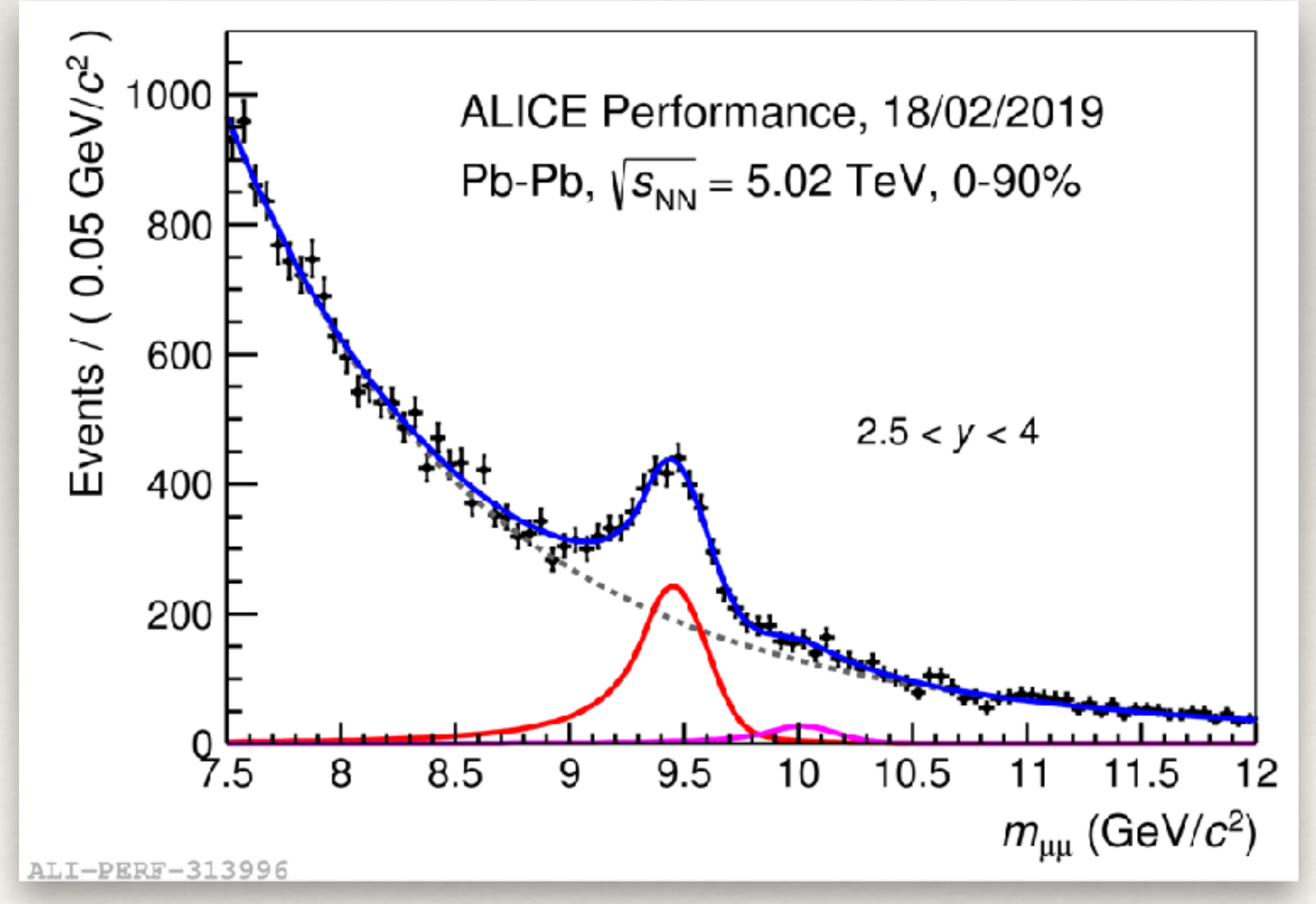


- 2018 > 2 x 2015 data
  - ☞ **reduce uncertainties**
  - ☞ differential study
- analysis on-going



# Thank you for your attention !