Jets physics with ATLAS: INTRODUCTION

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Science Coffee Seminar
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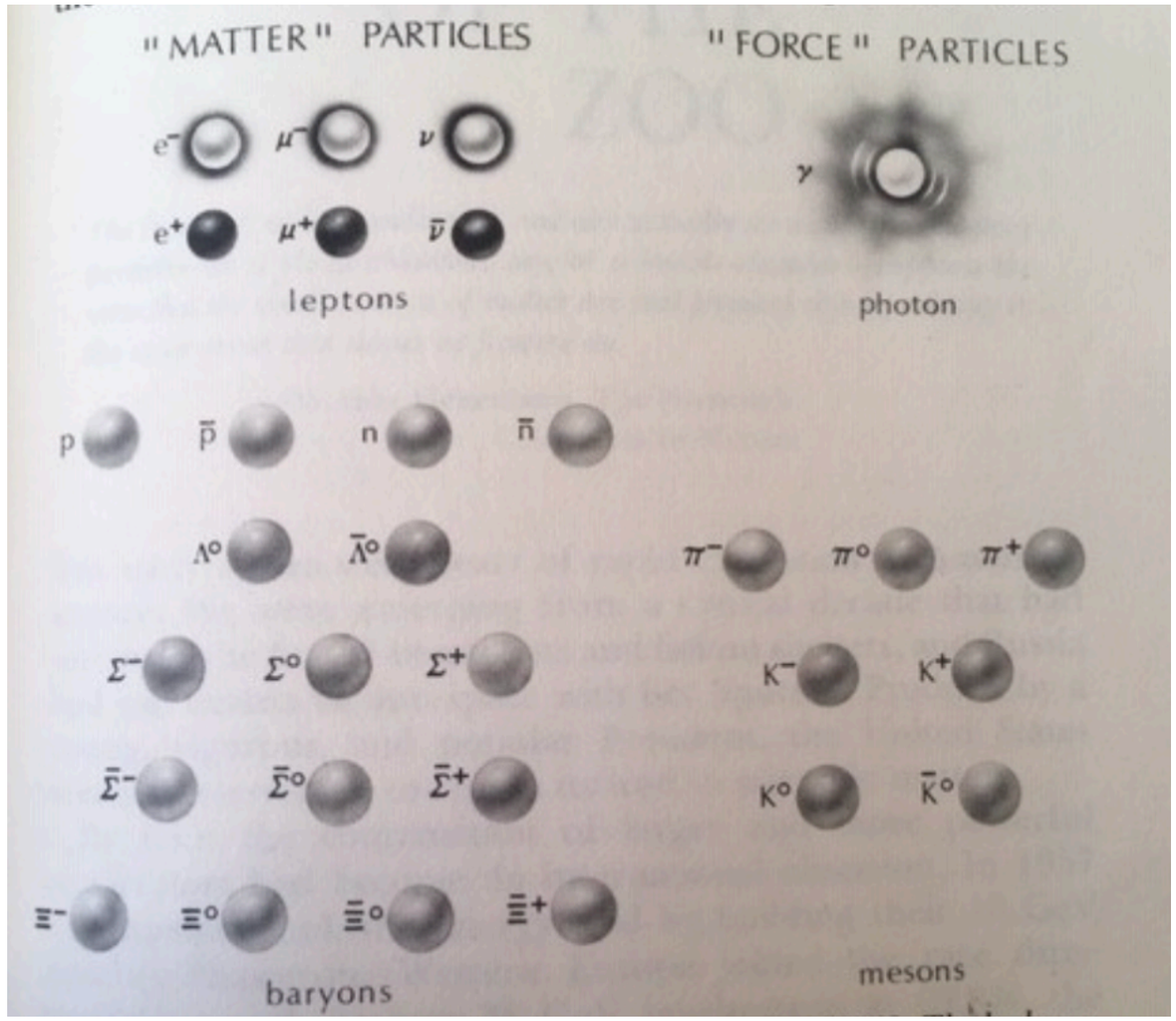
QCD - a very brief introduction

- In 1960 particle physics was a chaotic zoo of observation
  - Electrons, muons and neutrinos - called ***leptons***
  - Protons, neutrons and a plethora of other ***hadrons***



QCD - a very brief introduction

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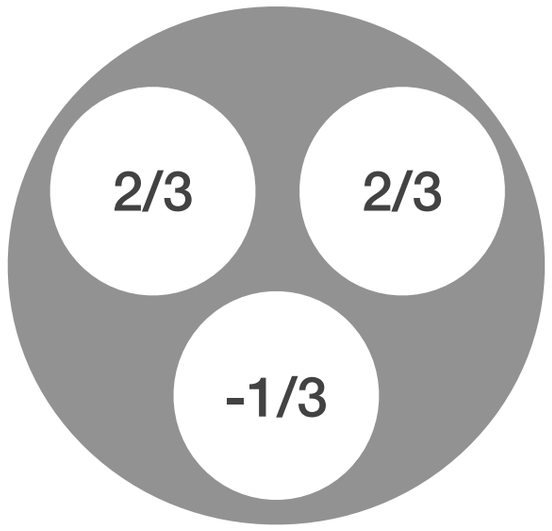
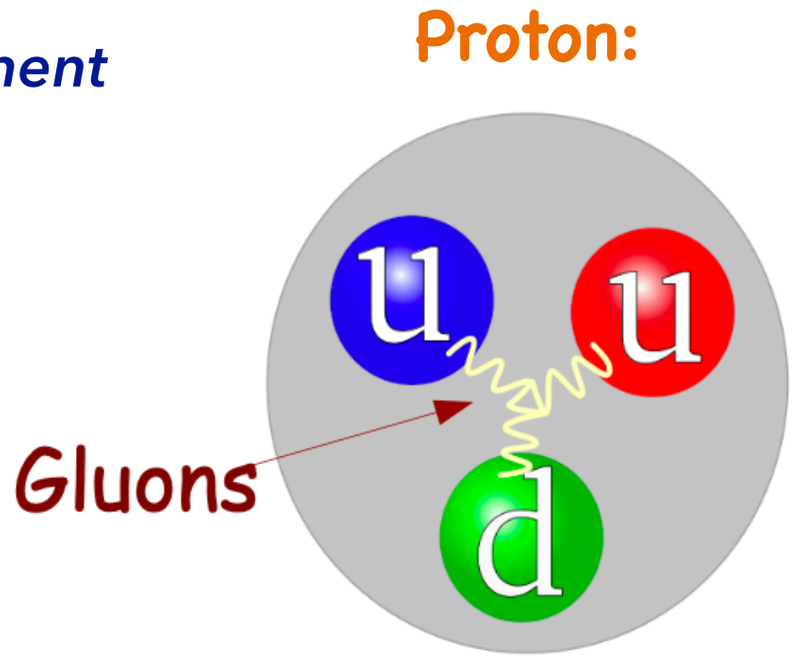
  - Electrons, muons and neutrinos - called ***leptons***
  - Protons, neutrons and a plethora of other ***hadrons***
- Proposed remedy: hadrons consist of tiny, fractionally charged components
  - Murray Gell-Mann named the quirky little things ***quarks***

Proton:



QCD - a very brief introduction

- The quark model had big implications:
  - Pauli exclusion principle demanded a new quantum number
    - ***Color charge***
  - A new strong force holding the quarks together
    - The ***strong force*** carried by ***gluons***
      - Weaker at small distances - ***asymptotic freedom***
      - Stronger at larger distances - ***confinement***



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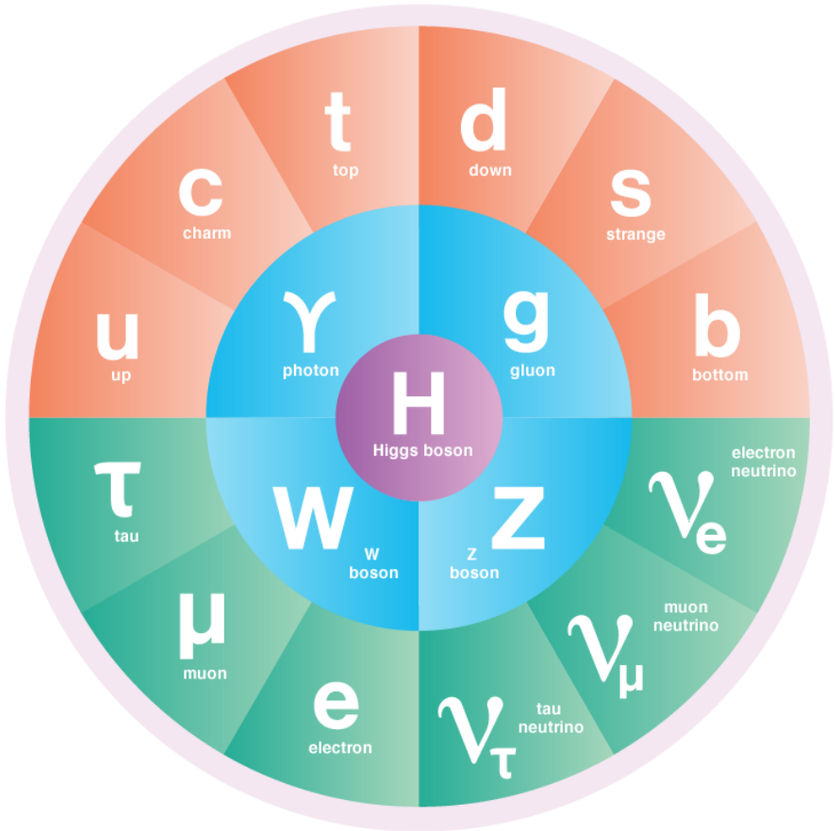
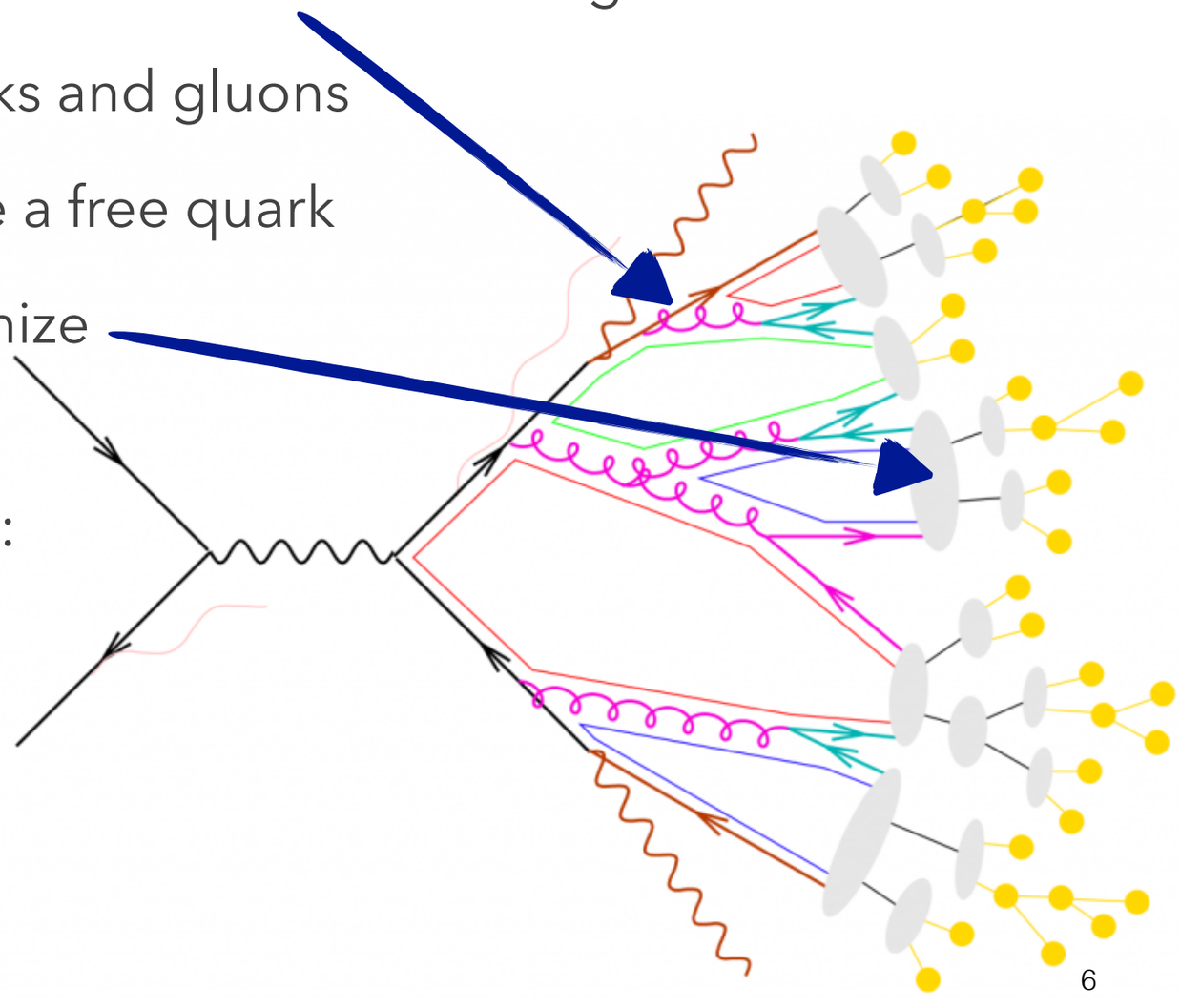
- The Standard Model began to take form



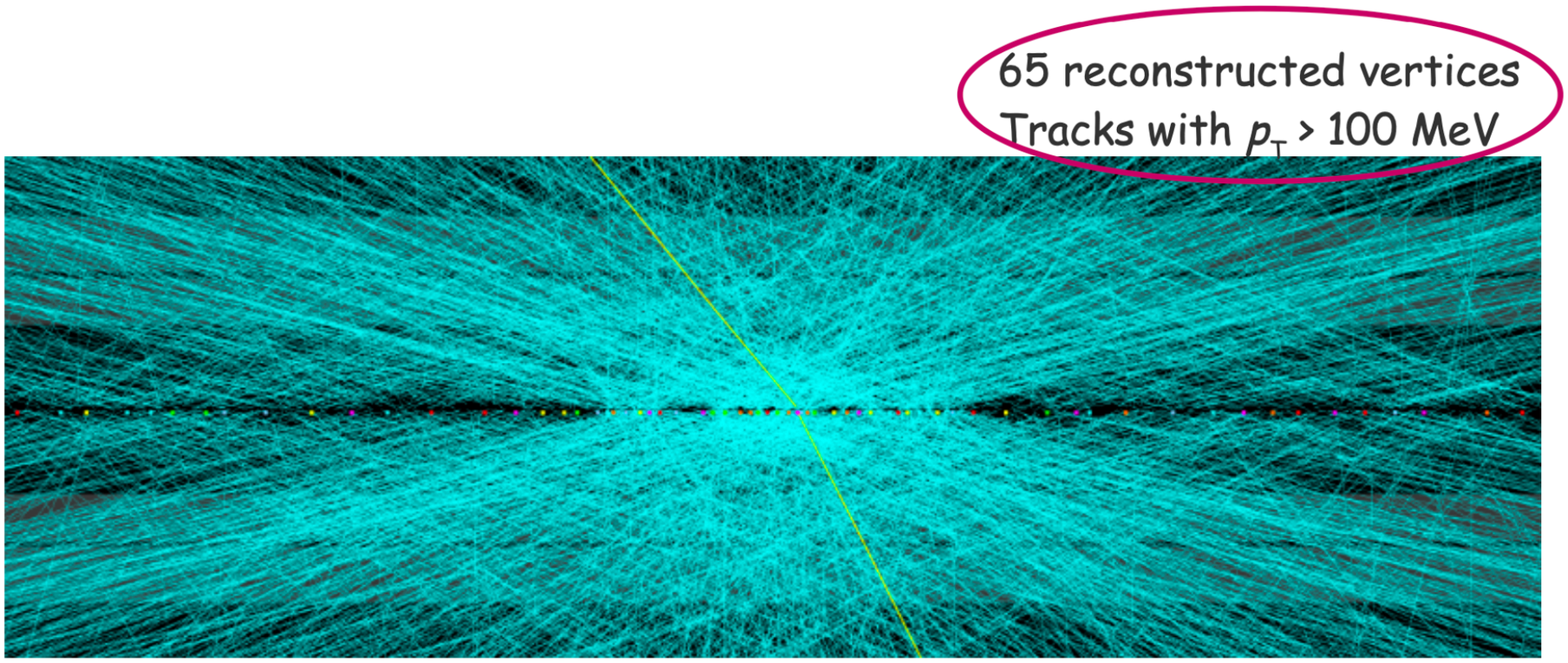
Jets - showering and hadronization

- QCD predicted one detectable signature: ***Jets!***
- Asymptotic freedom: Quarks are ~free at small distances
  - Interact as individual particles at high energies
  - Emit “Bremstrahlung” when accelerated in a hard scattering
    - Forming a narrow shower of quarks and gluons
- Confinement: One can never observe a free quark
  - At distances of ~1 fm quarks hadronize
- First evidence of jets obtained in 1975 with the SPEAR collider at SLAC:
  - Final state hadrons were not isotropically distributed!



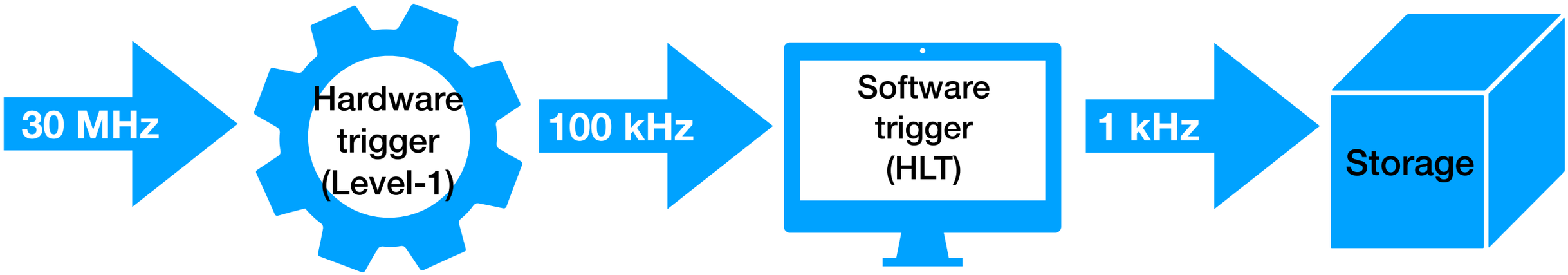
Conditions at the LHC

- High energies: Centre-of-mass energy of up to13 TeV
  - Direct correspondence between jet and the hard interaction
- High luminosity: Proton bunches collide every 25 ns:
  - Many collisions per bunch crossing: (in time) **pile-up**
  - Energy deposits from previous/future bunch crossings: (out-of-time) **pile-up**
- **Pile-up complicates event reconstruction and analyses**



Triggering

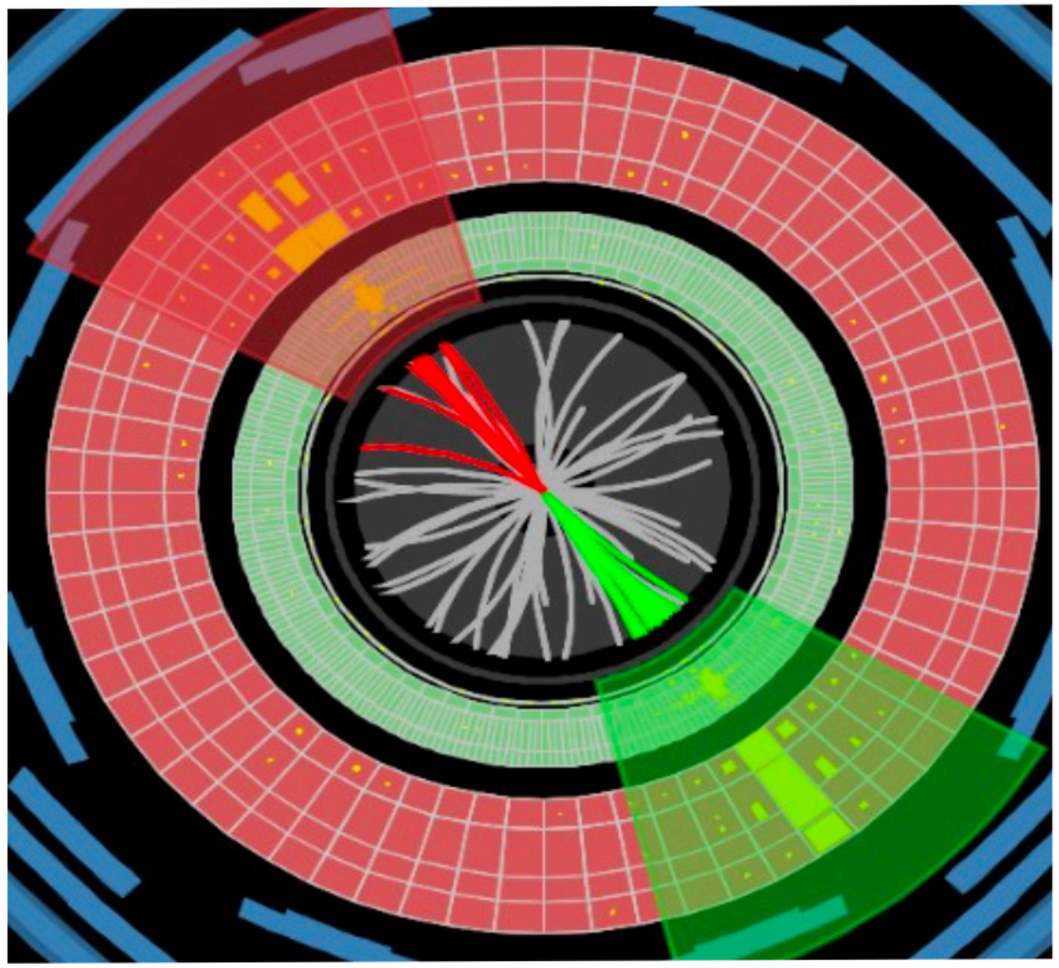
- LHC generates way more data than the experiments can process and store
  - The trigger selects the events that are most likely to be interesting



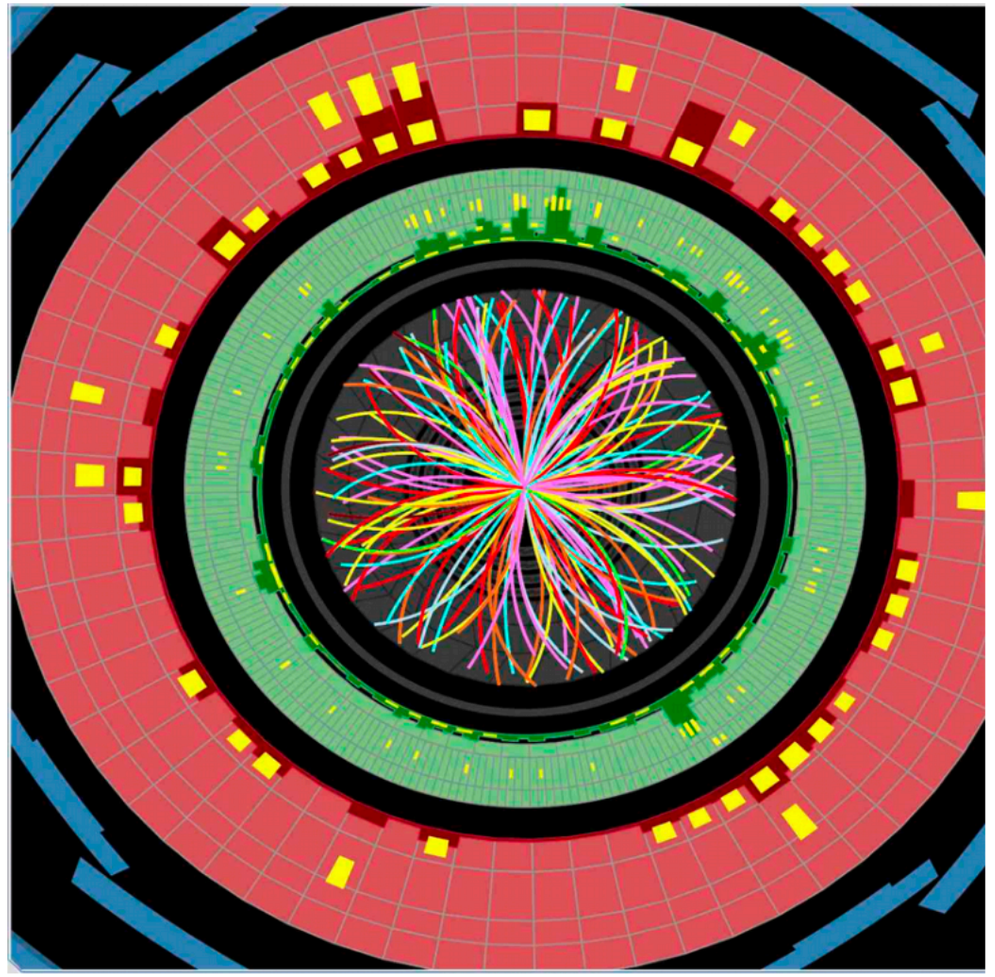
- High probability of producing jets ✖ high luminosity means ***a lot of jets***
  - Probability highest for at lower transverse momentum p_T
- Limited bandwidth: not all events with low-p_T jets can be recorded
  - Only a fraction of these events are stored - ***prescaling***

Defining jets

Clearly two jets

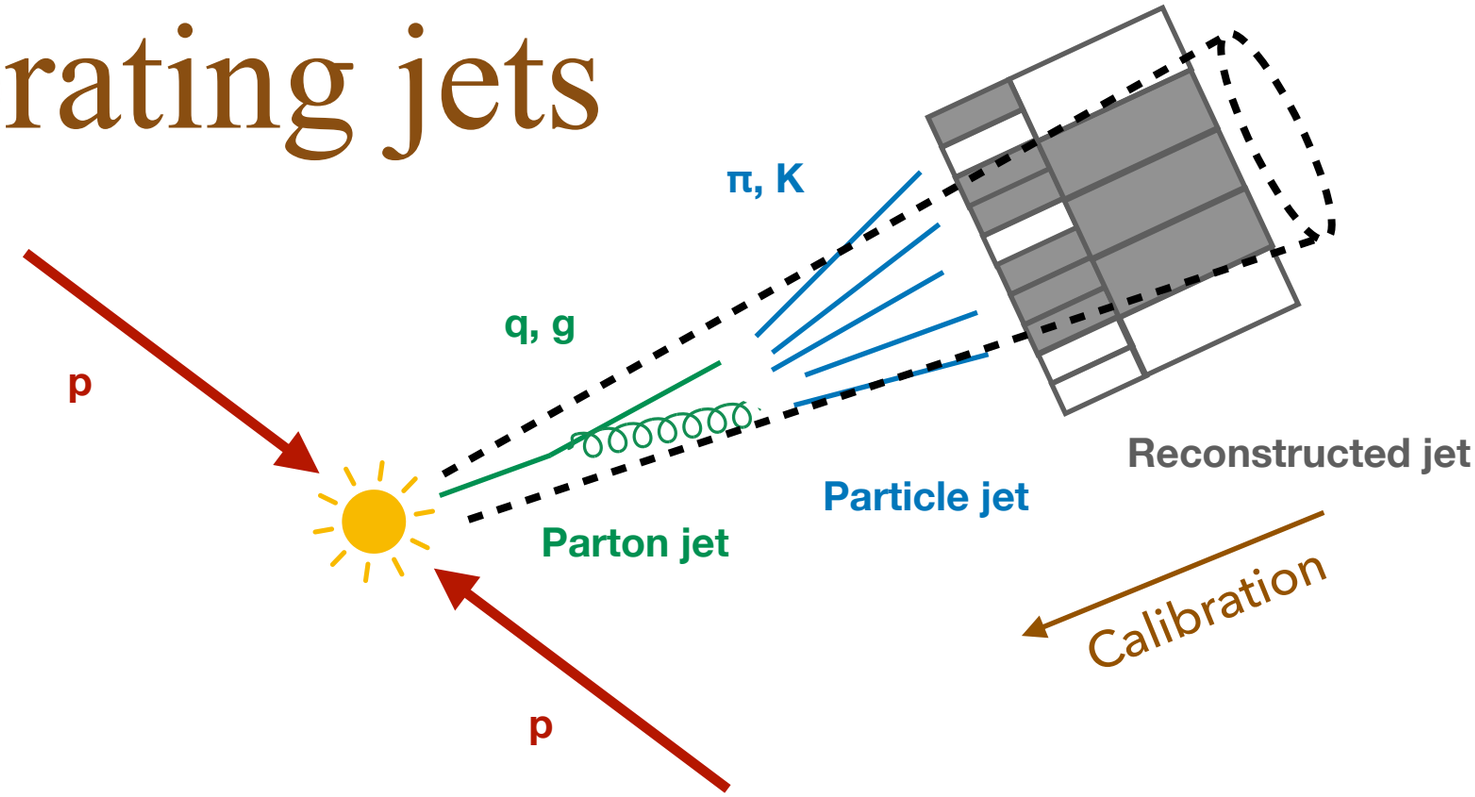


How many do we see here?



Criterion-based definitions are required for the reconstruction

Calibrating jets



Corrects the translation from calorimeter signal to particle jet for detector effects

- **Dead material**
  - Energy deposits in non-sensitive regions
- **Calorimeter non-compensation**
  - Lower response to hadrons
- **Punch-through**
  - Showers extending beyond the calorimeters
- **Pile-up**
  - Additional deposits from other particles
- **Out-of-cone radiation**
  - Particle shower not fully included in the jet cone
- **Energy deposits below threshold**

Teaser

Stay tuned to hear more about why jets are interesting:

- How jets are measured and calibrated
- Two innovative analyses which use jets to search for new physics phenomena