Searching for Ultra Rare Processes With the Large Hadron Collider

$t \to q\gamma$

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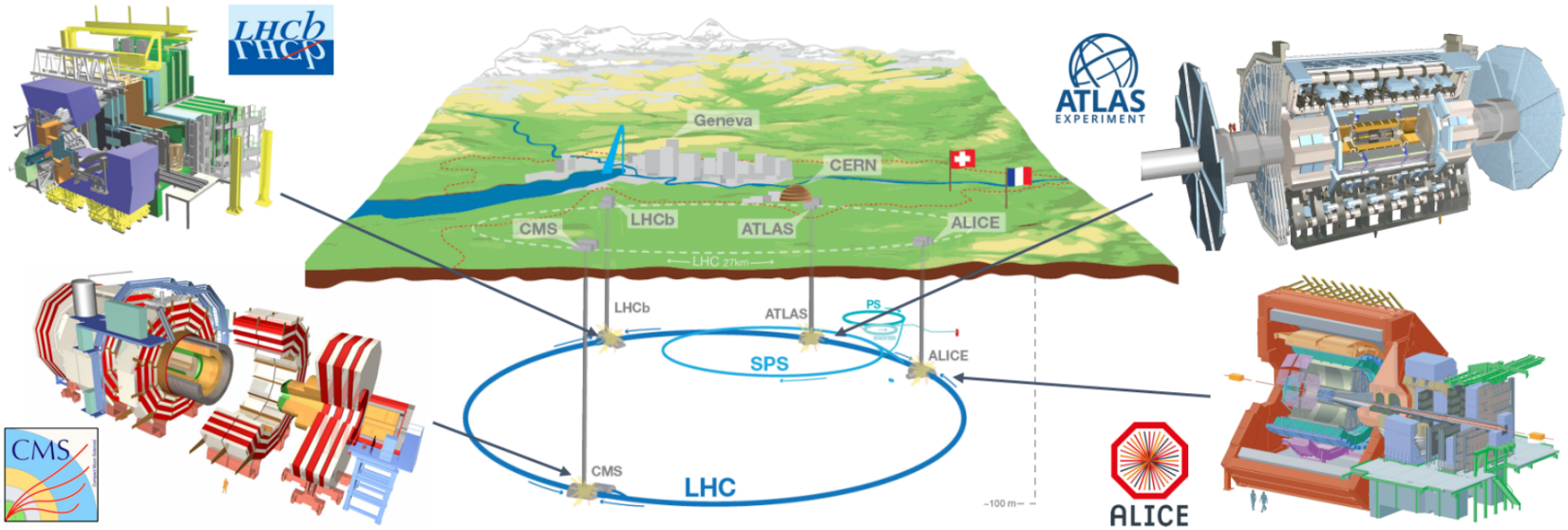
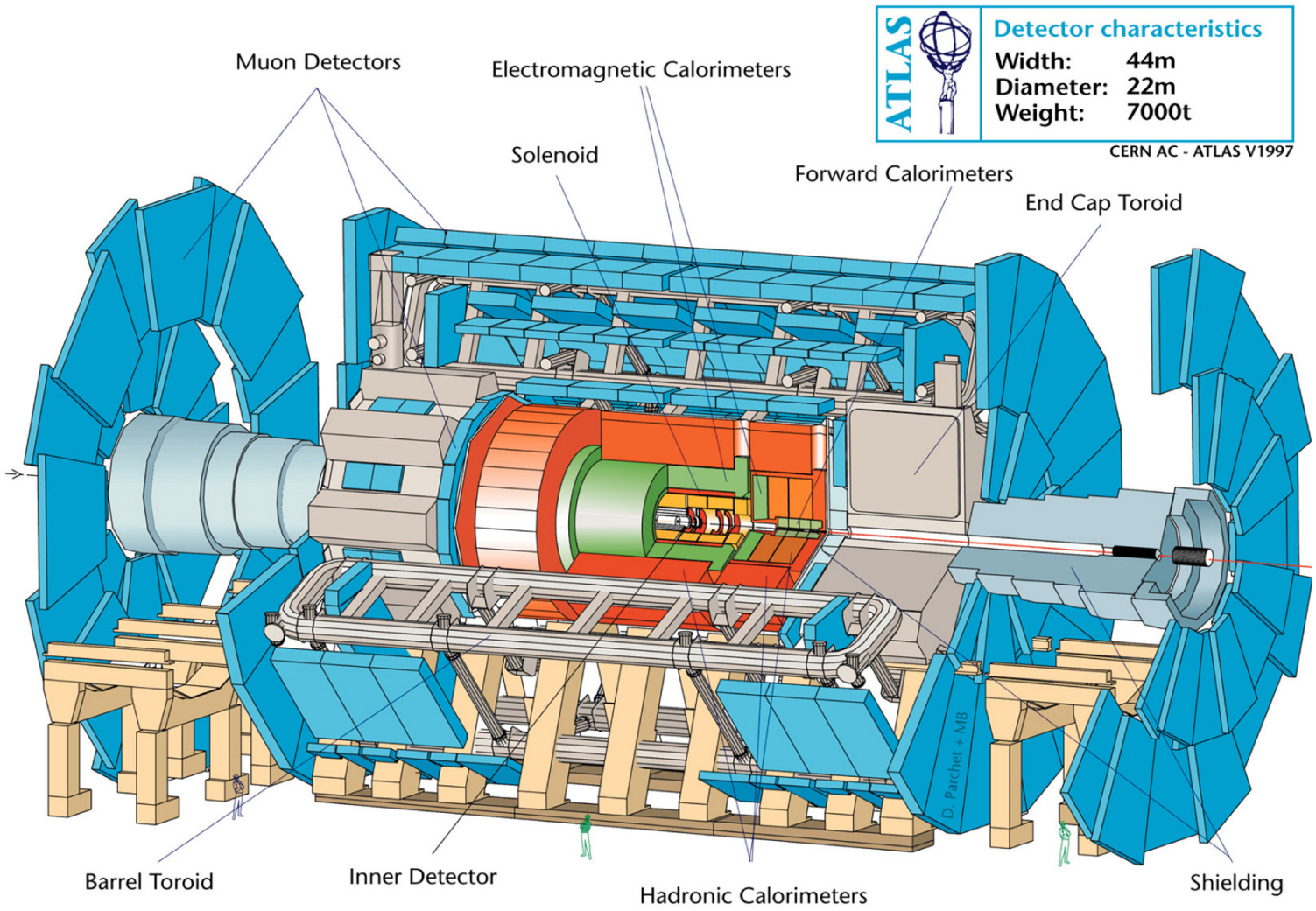
Overview

The Large Hadron Collider

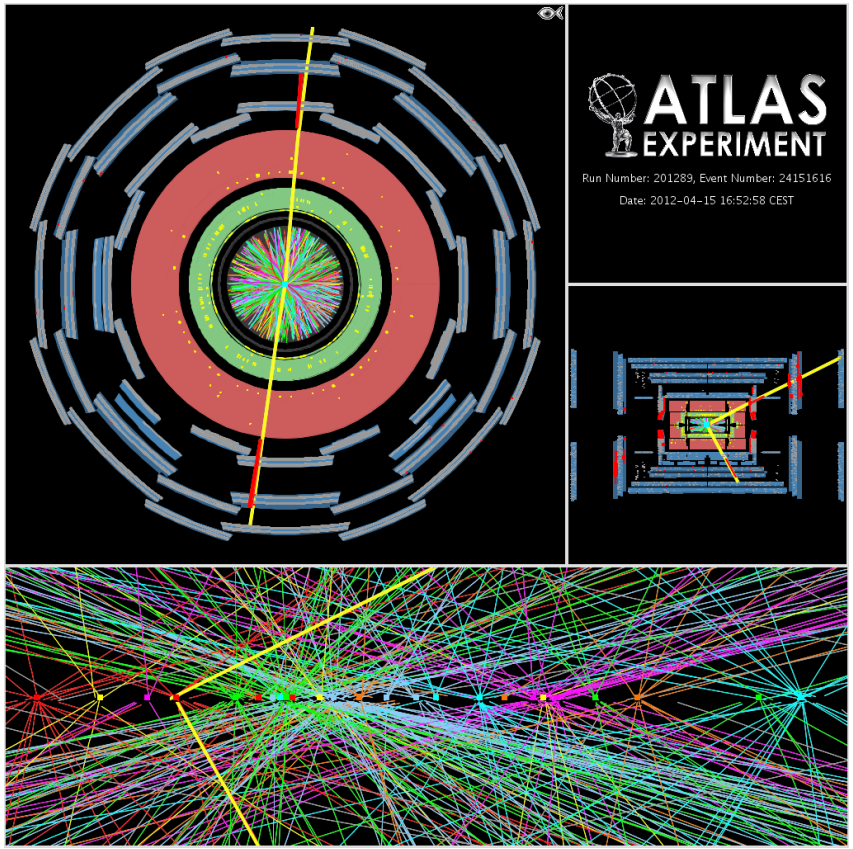


- 27km ring beneath Franco-Swiss Border
- 4 Major Experiments
- Collides protons at center of mass energy 13TeV
- Over 11 Quadrillion (10^{15}) events produced within the ATLAS detector so far

The ATLAS Detector

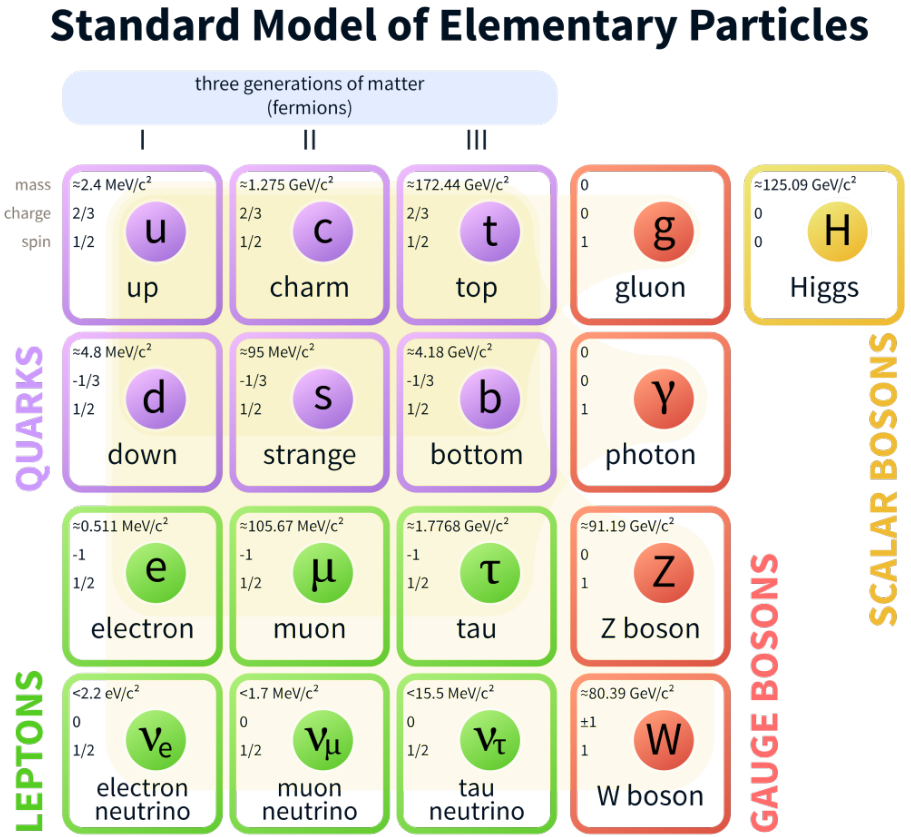


Events in ATLAS



- LHC Provides around 600 million interactions/second
- Save compelling events
- Extremely large, messy data sets
- Detector well modeled for Monte Carlo event generation

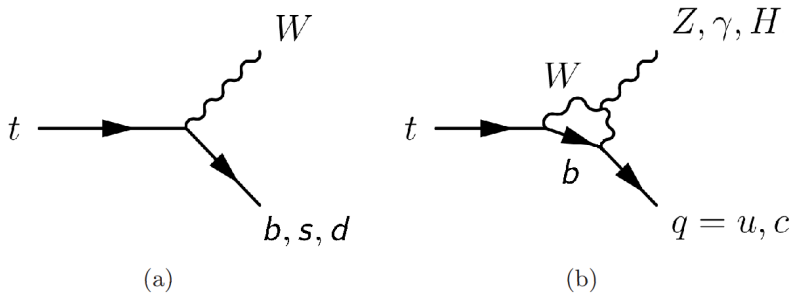
The Standard Model of Particle Physics

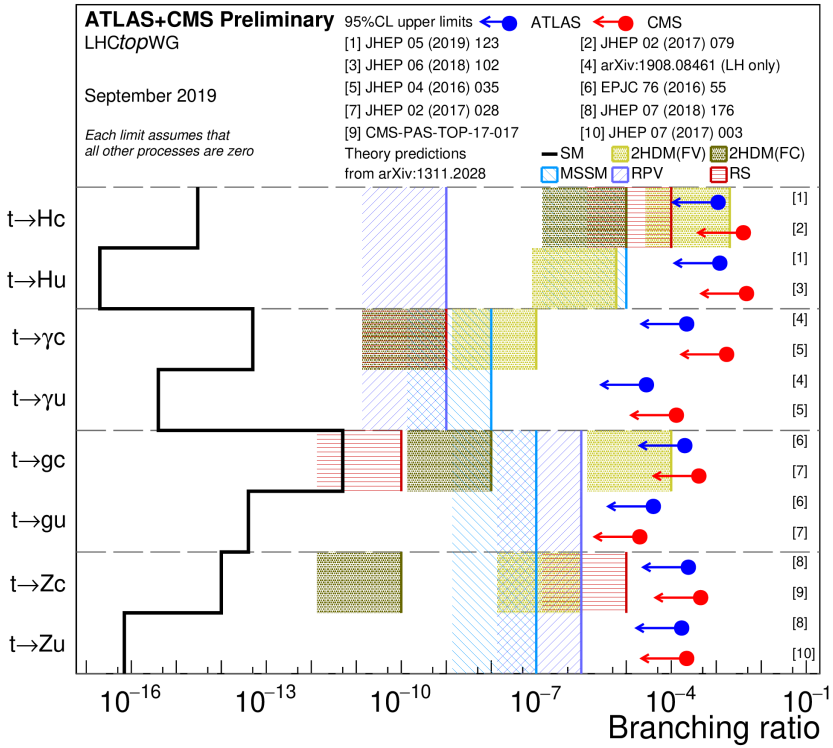


- Our current theory that attempts to explain everything
  - Experimentally precise and well behaved
  - Very few exceptions (i.e. Neutrino Mass, Dark Matter Abundance)

The Top Quark and Flavor Changing Neutral Current Decays

- Heaviest fundamental particle, $172.5\text{GeV}/c^2$
- Lifetime 5×10^{-25}s
  - Allows study of single quark decay





Test

Neural Networks

- Advanced pattern recognition used to classify events
- A dense neural network is used with various low and high level variable inputs
- Supervised learning used to approximate any multidimensional function

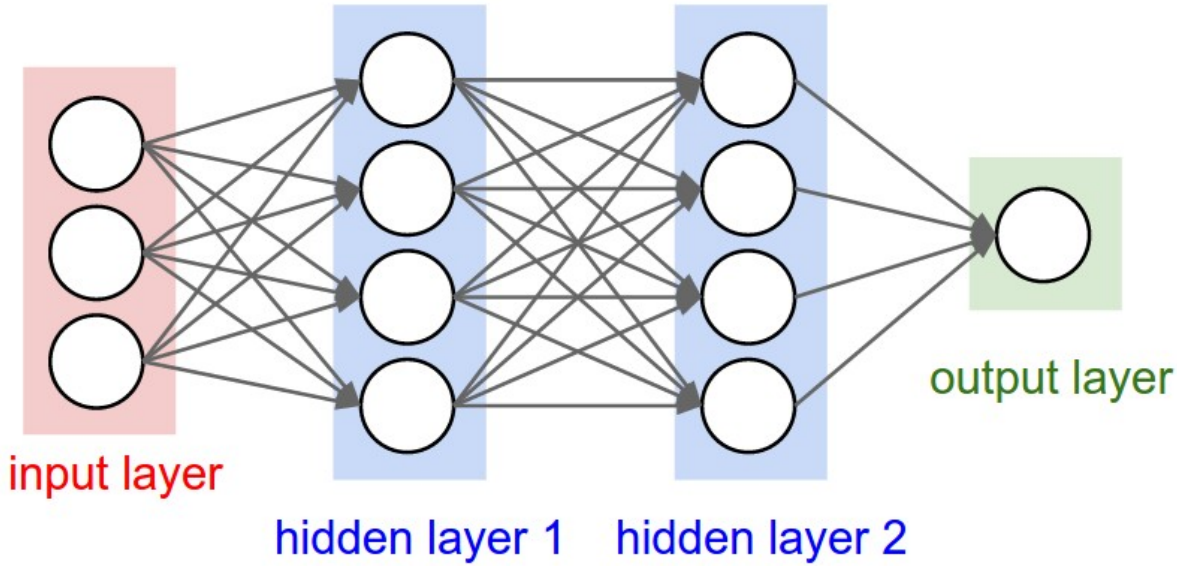
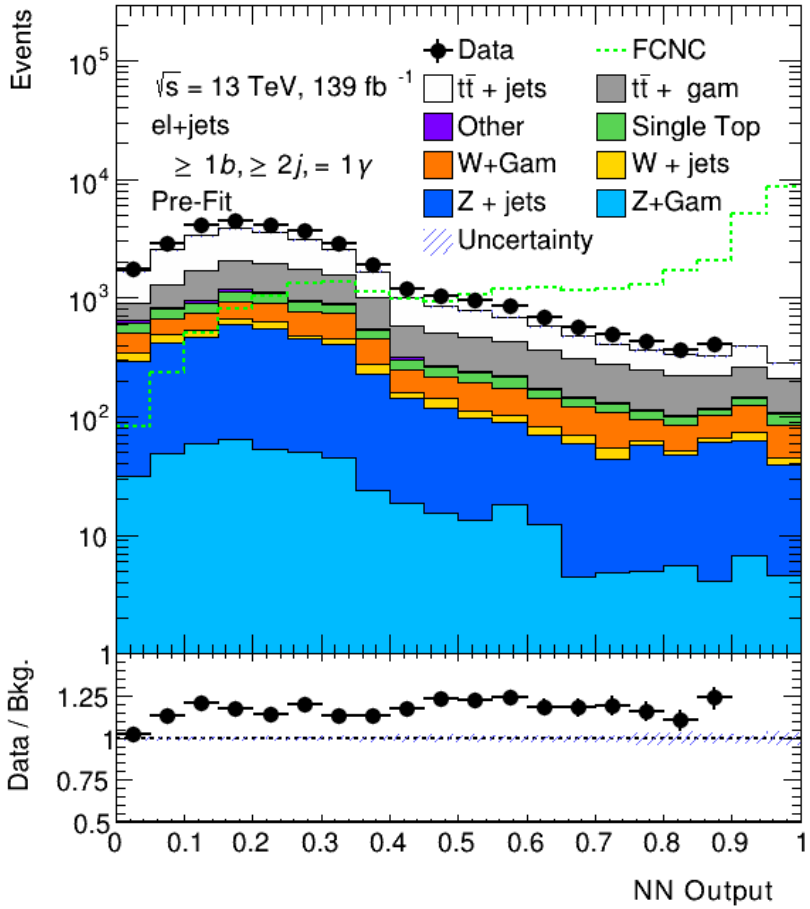
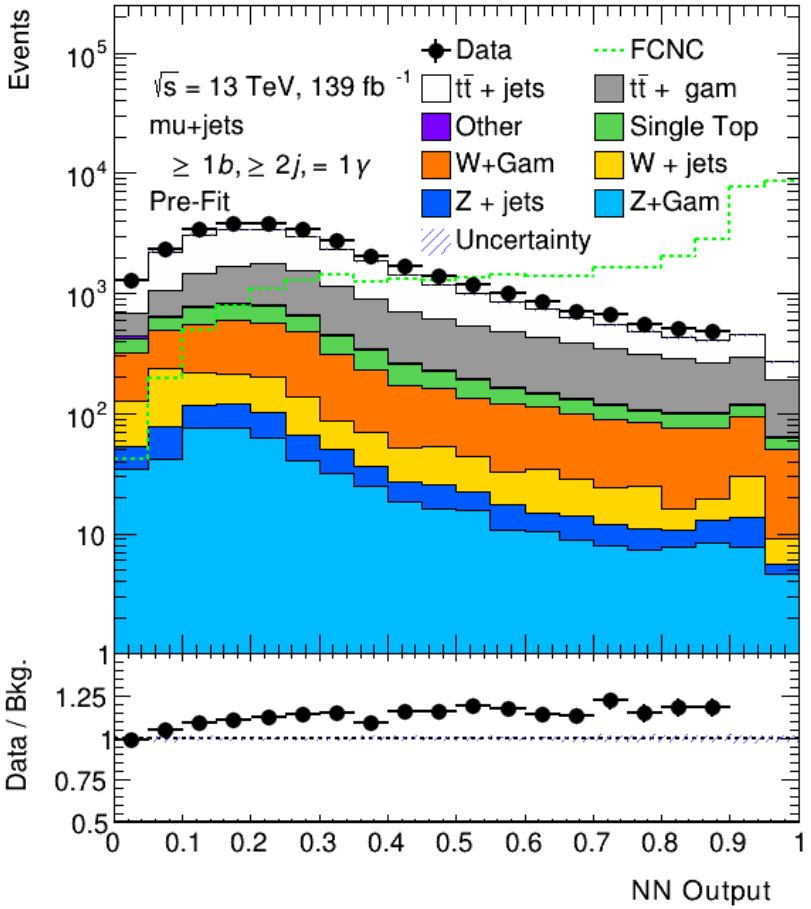


Figure: [Ref: Neural Network]

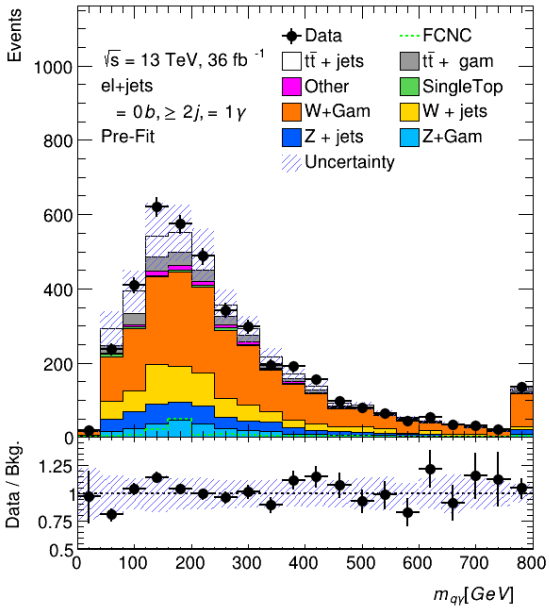
Analysis Neural Network Outputs



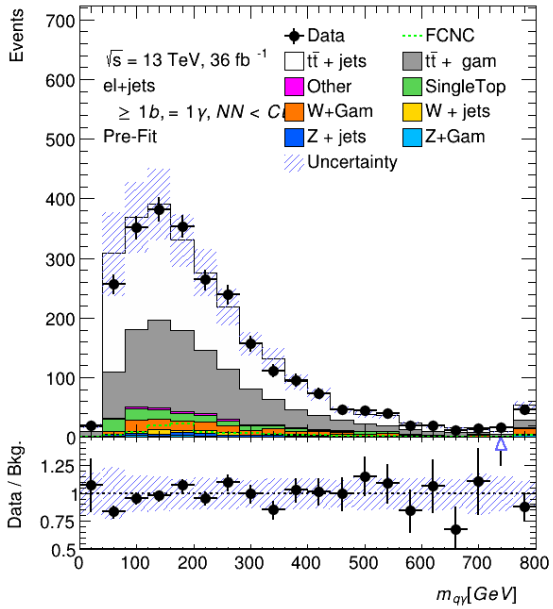


Work In Progress - Results

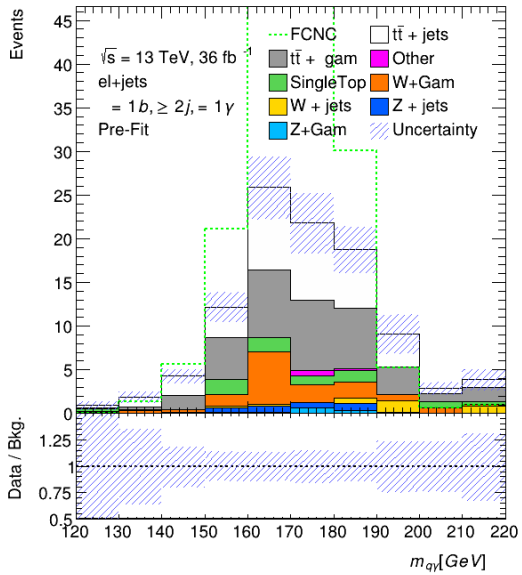
- Background Enriched Region 1



- Background Enriched Region 2



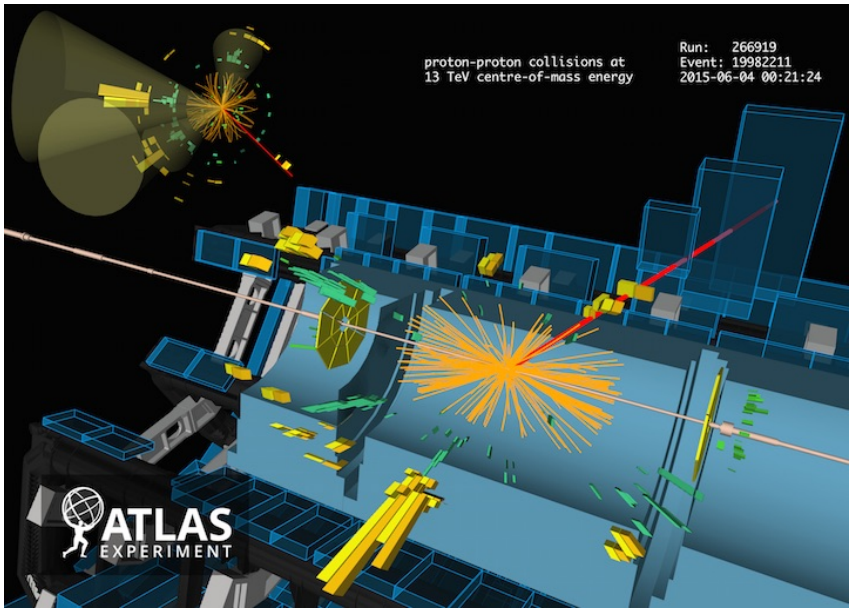
- Signal Enriched Region



Statistics only limit BR($t \to q\gamma$) $\approx 4 \times 10^{-5}$

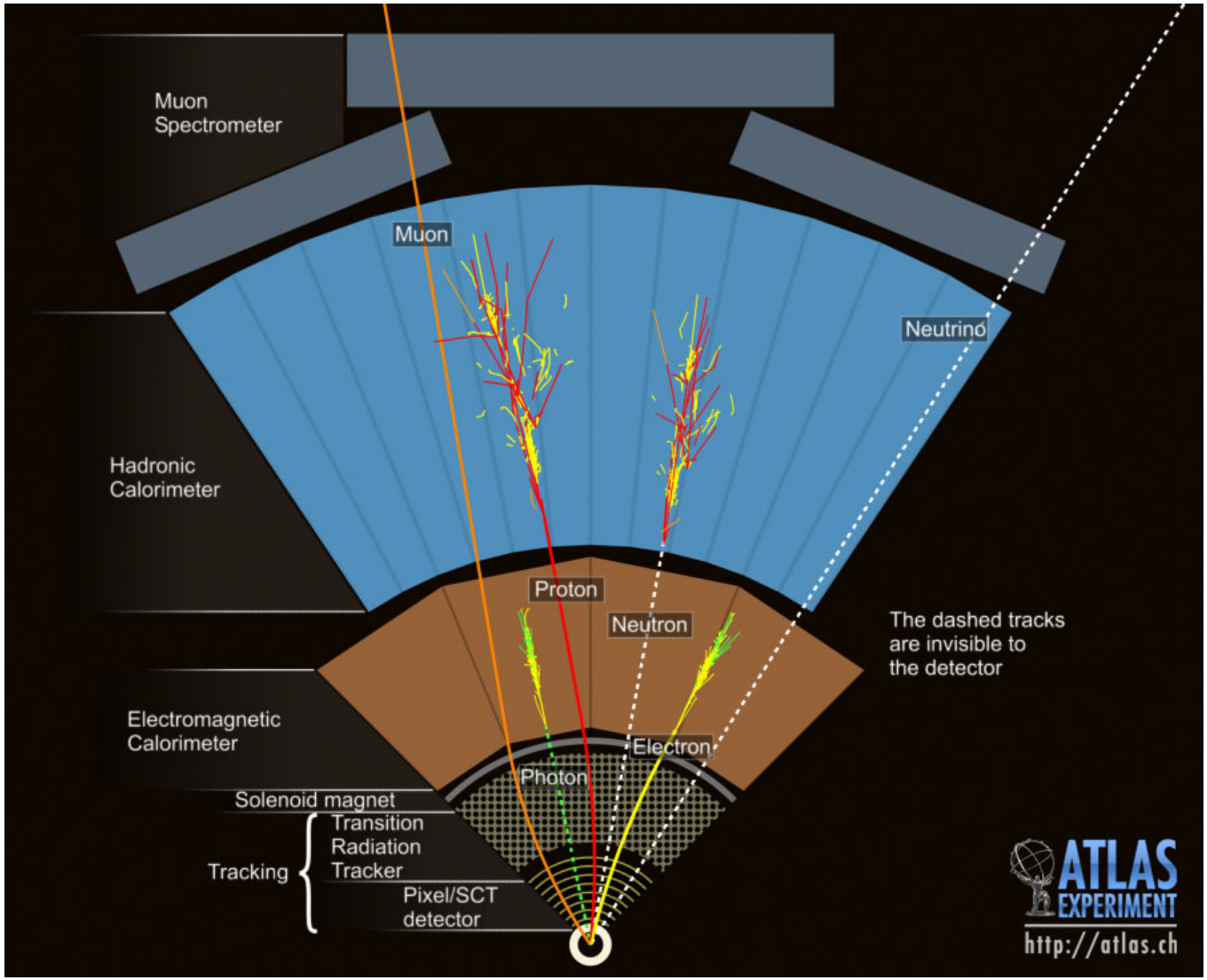
Outlook

- The LHC is being used to search for signs of new physics down many avenues
- Stringent limits being set on processes help to rule out a variety of theoretical models
- Top quarks offer a unique handle for many searches for physics beyond the standard model
- This search expects to set competive limits for this ultra rare process

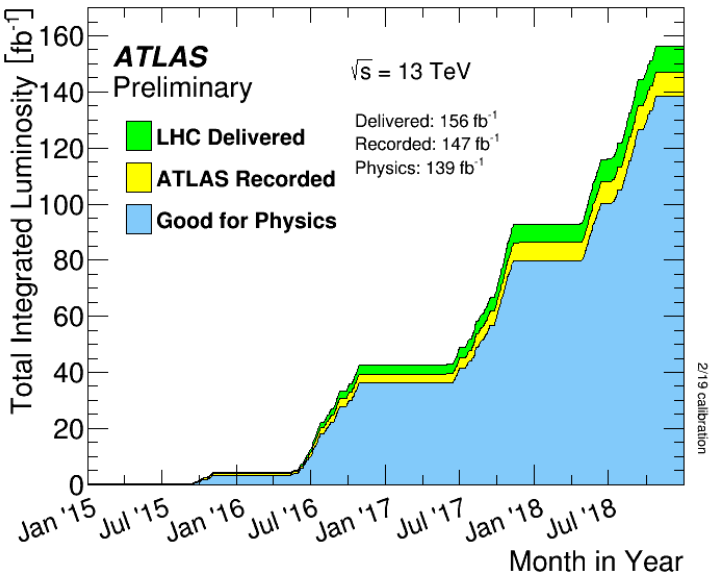


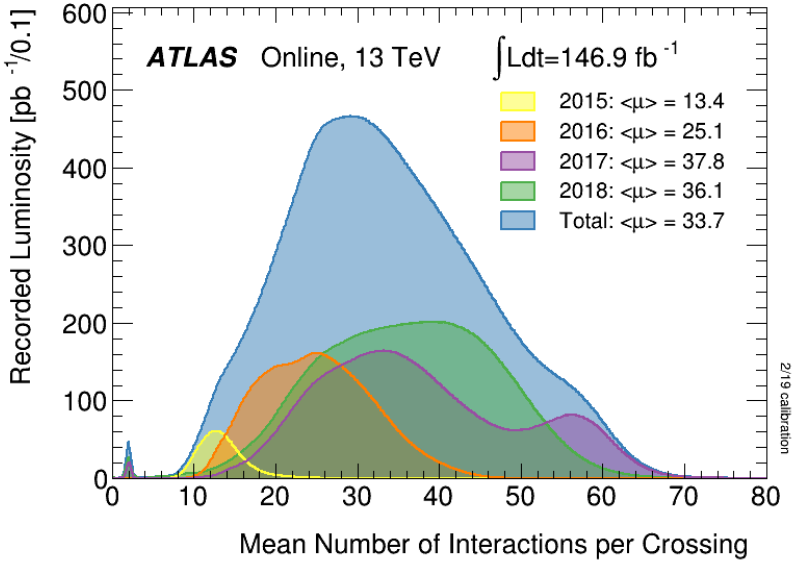
Backup

Particles in ATLAS



Luminosity and Pile-up





FCNC Diagrams