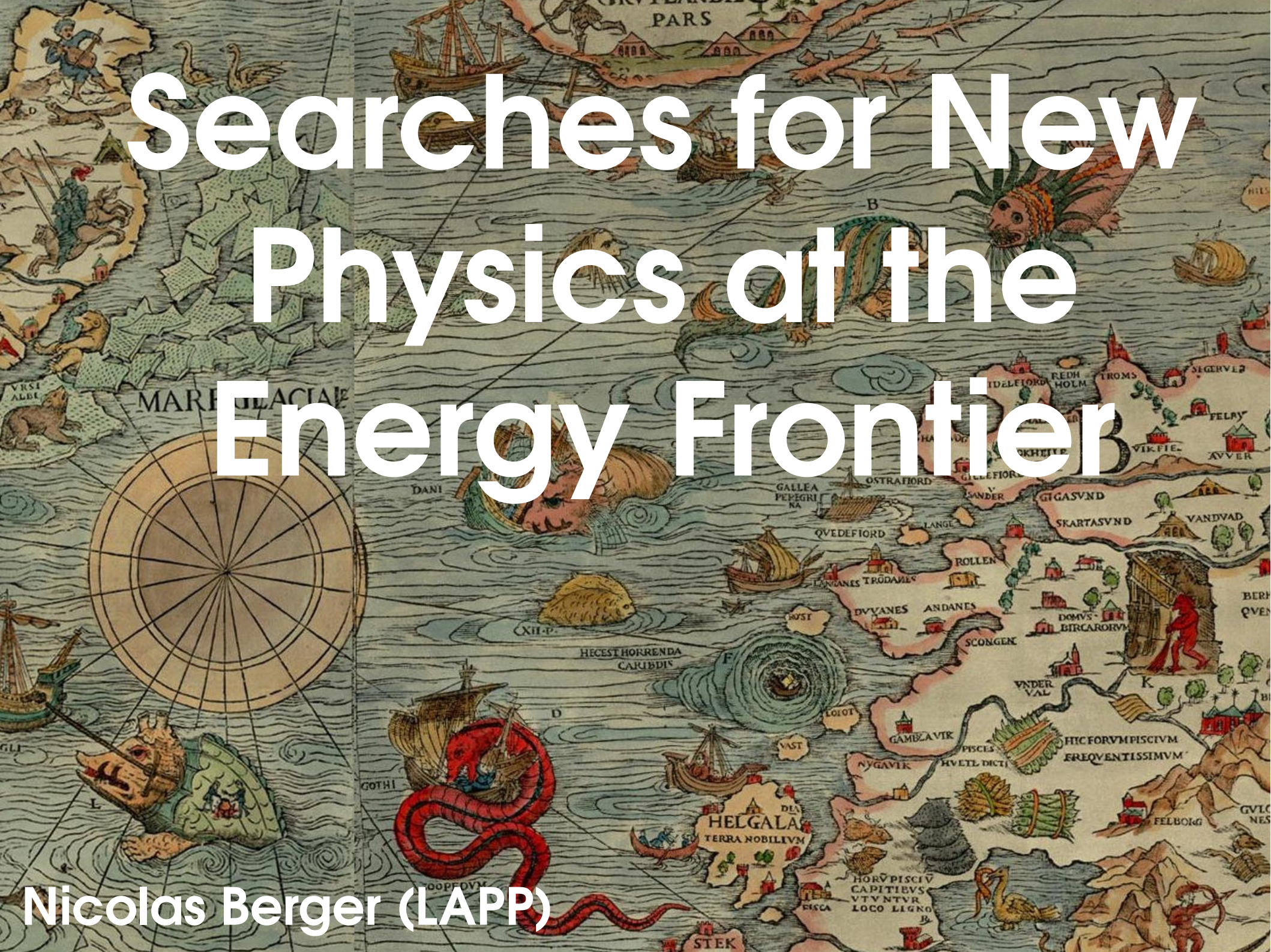
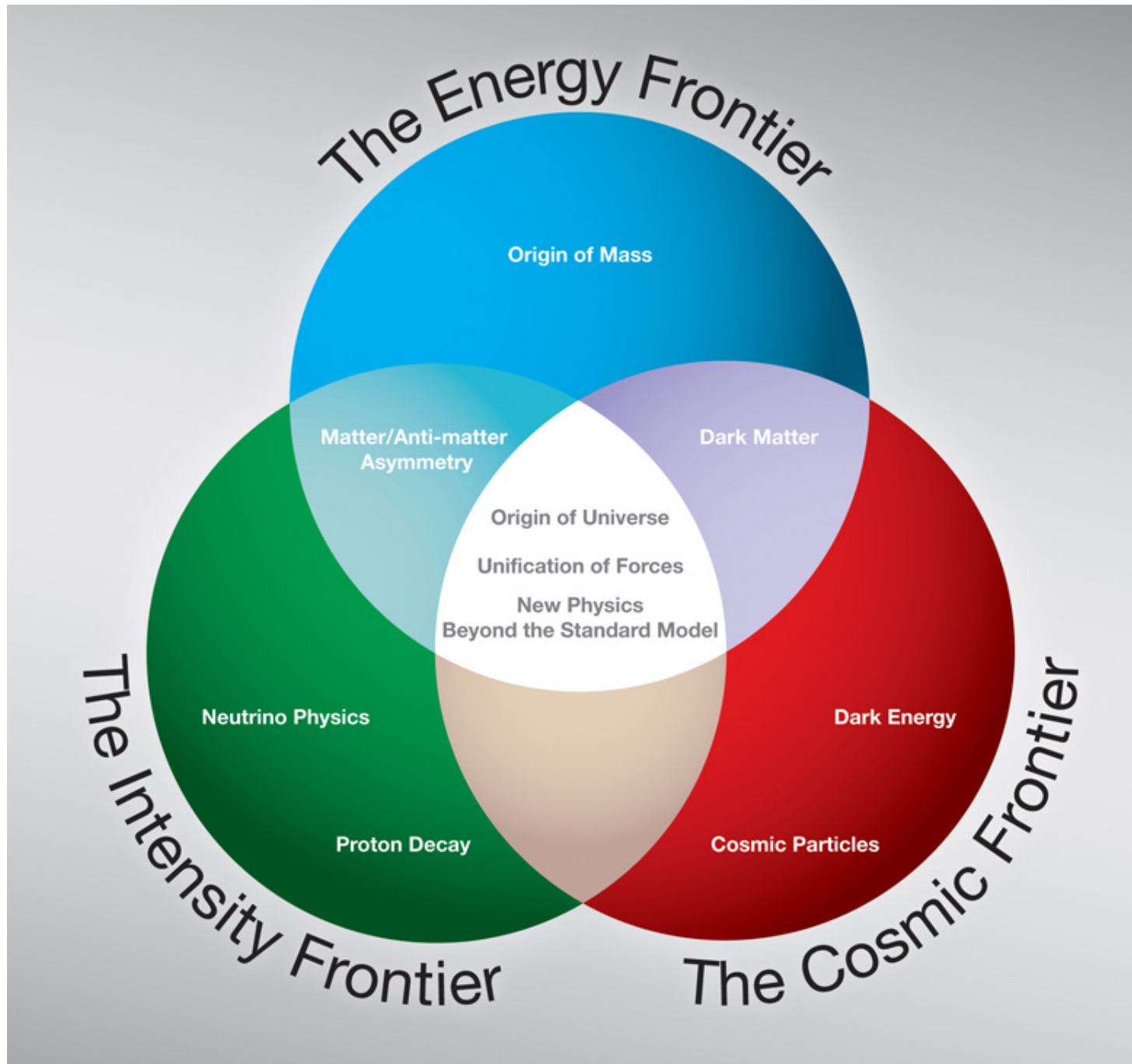


Searches for New Physics at the Energy Frontier

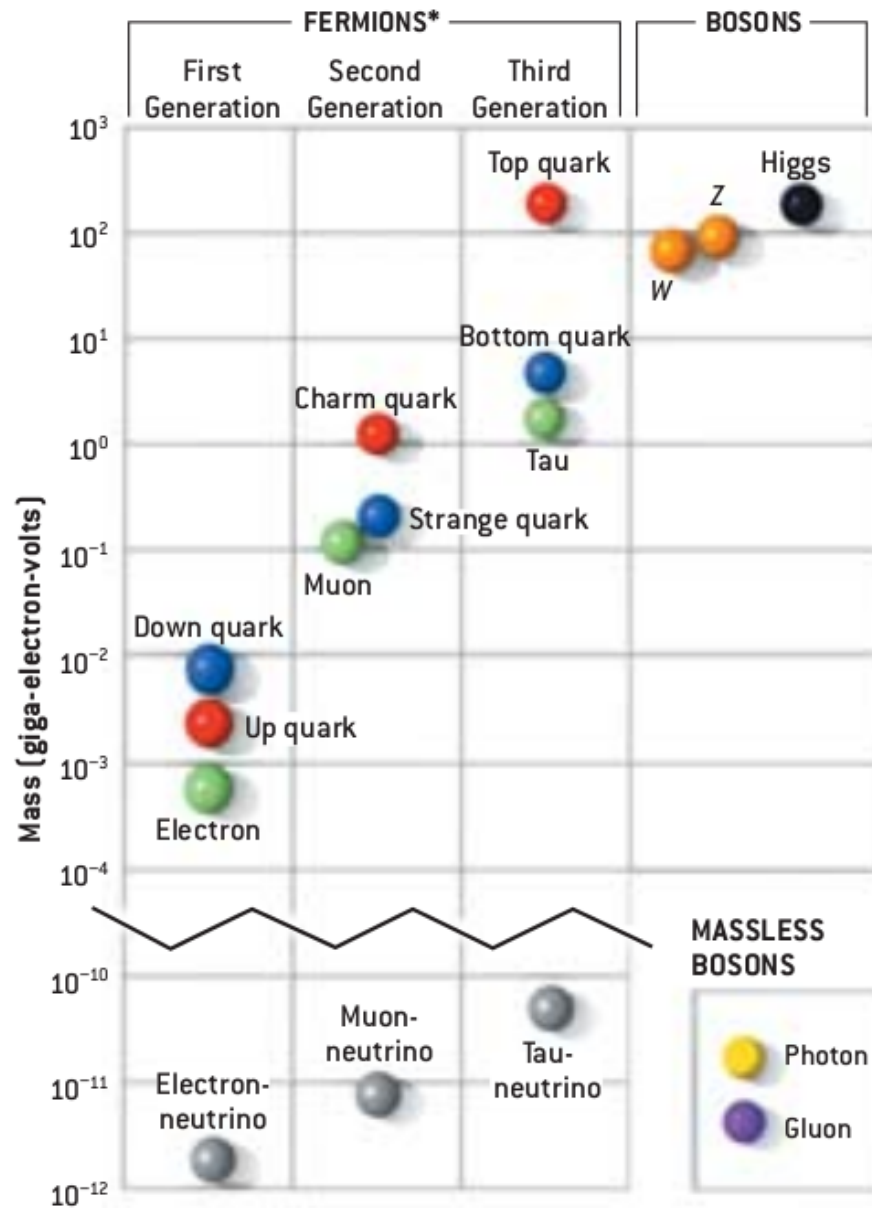
Nicolas Berger (LAPP)



Ubi Sunt Dracones ?



The Energy Frontier



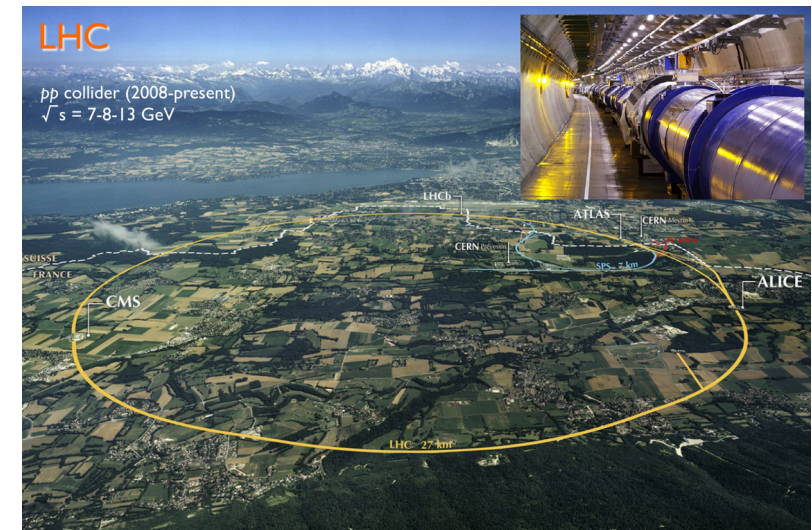
LEP
200 GeV

TeVatron

2 TeV

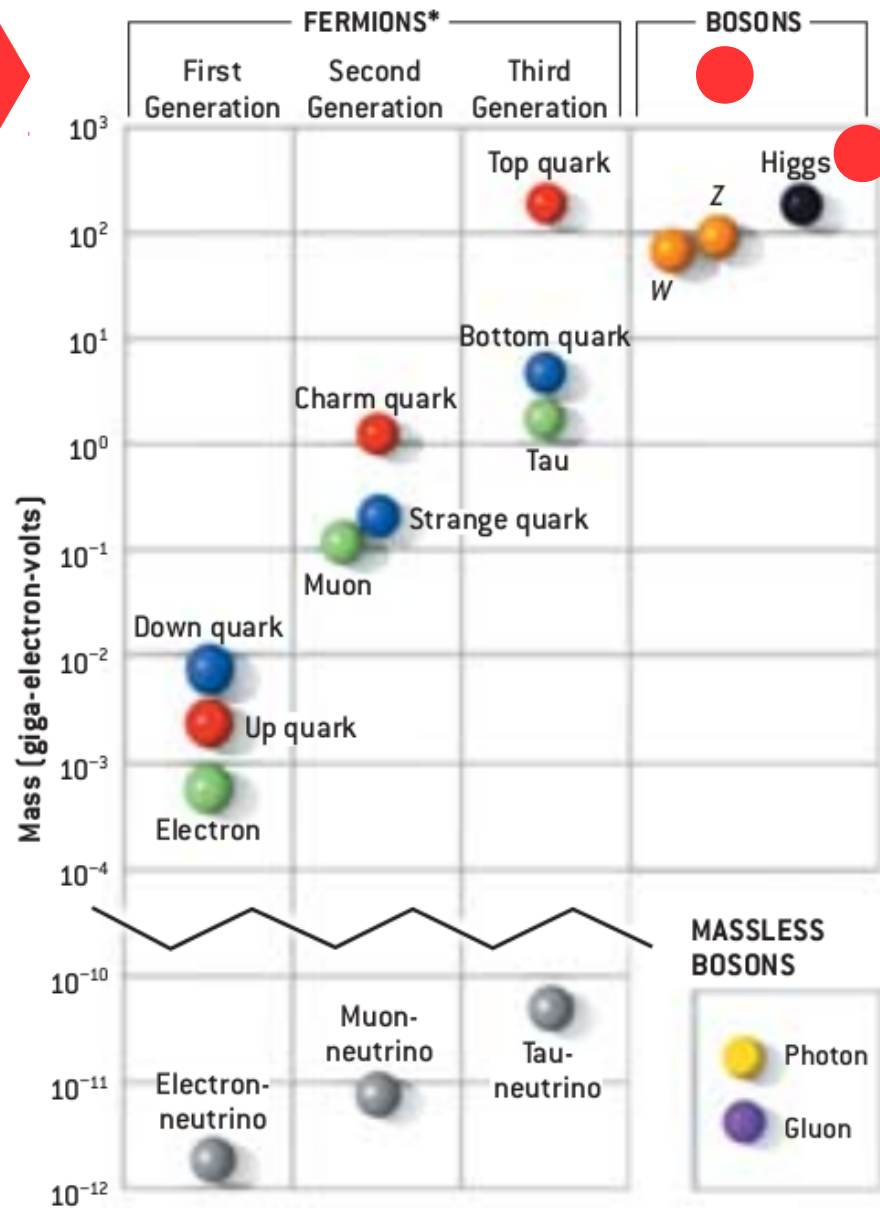
LHC
14 TeV

Need a high-energy collider to produce heavy particles



Expect new physics *at the TeV Scale*

The Energy Frontier



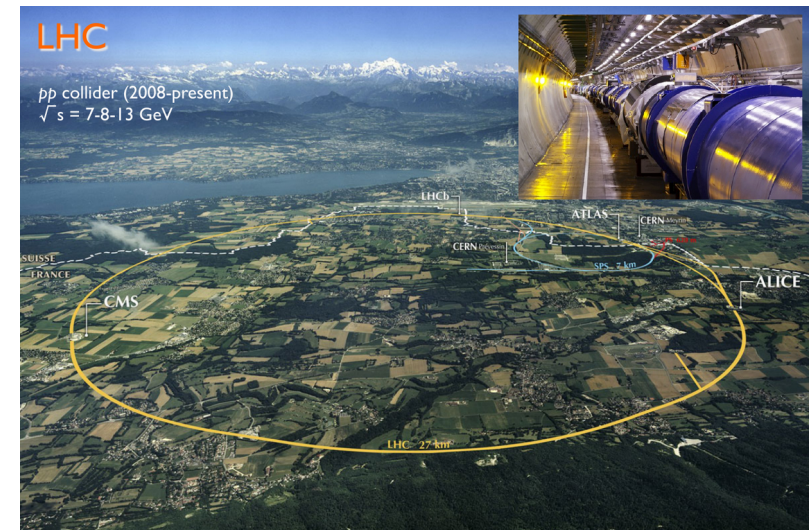
LEP
200 GeV

TeVatron

2 TeV

LHC
14 TeV

Need a high-energy collider to produce heavy particles



Expect new physics *at the TeV Scale*

New Particles

1968: SLAC u up quark	1974: Brookhaven & SLAC c charm quark	1995: Fermilab t top quark	1979: DESY g gluon
1968: SLAC d down quark	1947: Manchester University s strange quark	1977: Fermilab b bottom quark	1923: Washington University* γ photon
1956: Savannah River Plant ν_e electron neutrino	1962: Brookhaven ν_μ muon neutrino	2000: Fermilab ν_τ tau neutrino	1983: CERN W W boson
1897: Cavendish Laboratory e electron	1937: Caltech and Harvard μ muon	1976: SLAC τ tau	1983: CERN Z Z boson

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			2018: CERN Z' Z' boson	

New Interactions

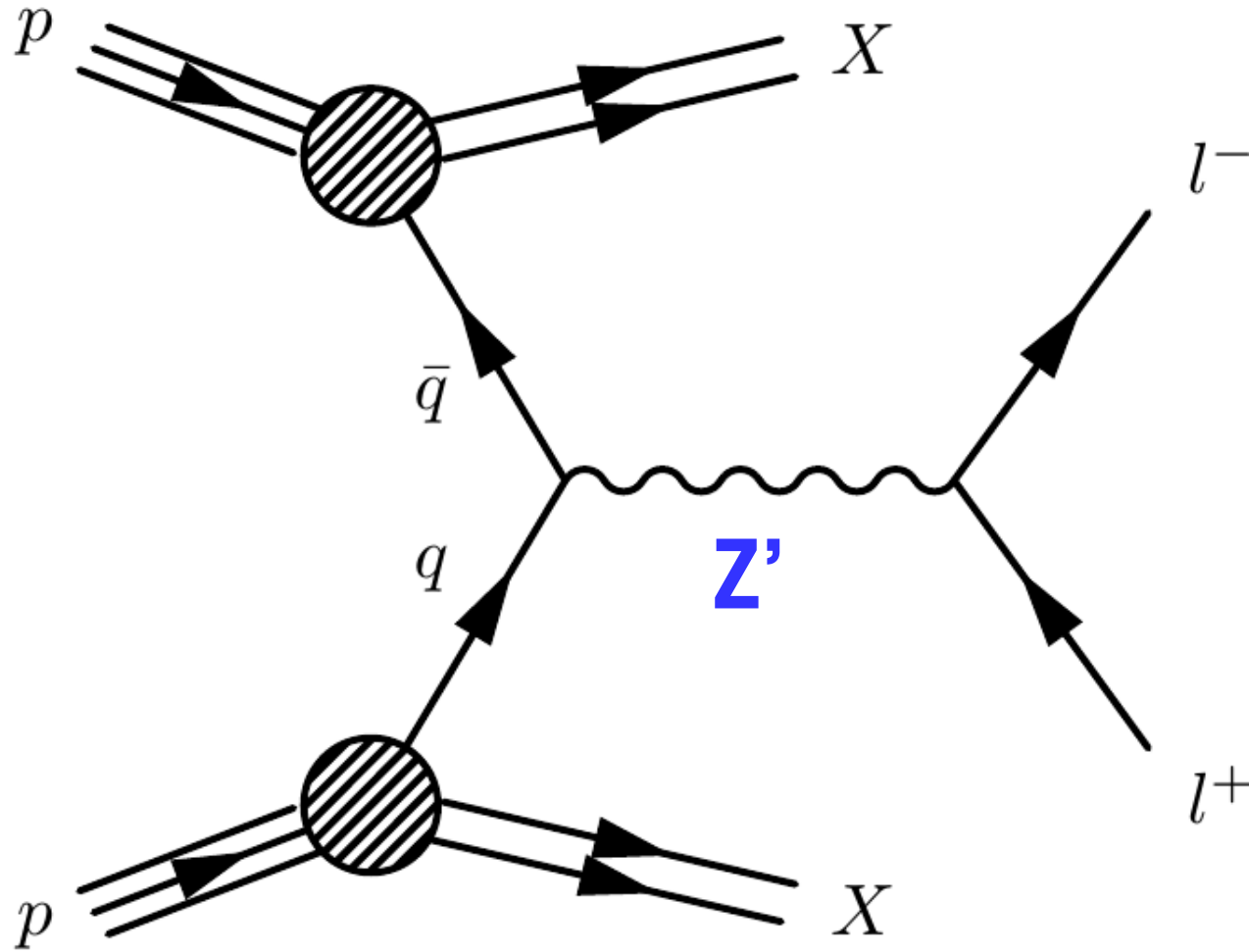
New Particles

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			2018: CERN Z' Z' boson	2018: CERN H' New Higgs Boson

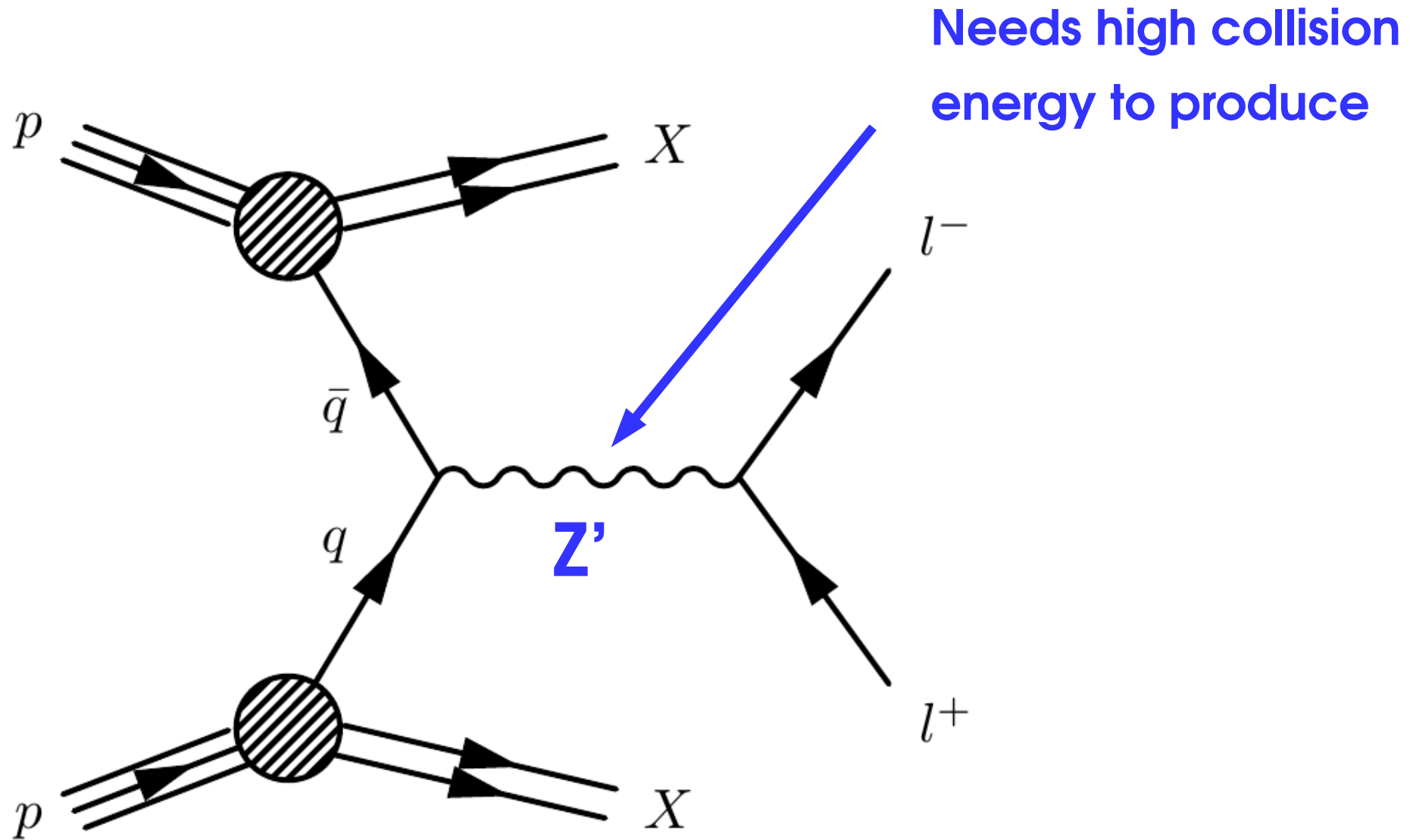
New Interactions

Extended Higgs Sector

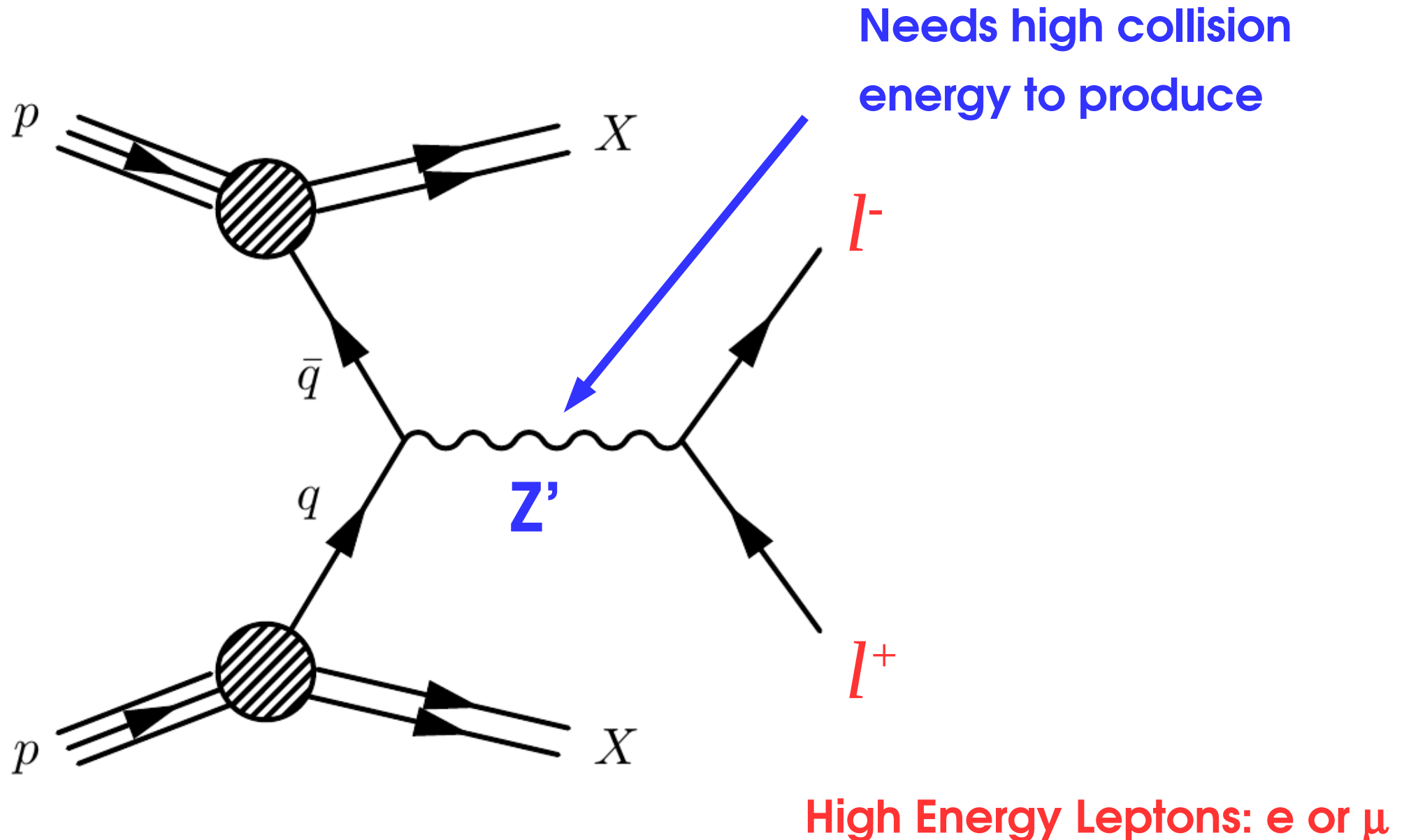
New Vector Boson : Z'



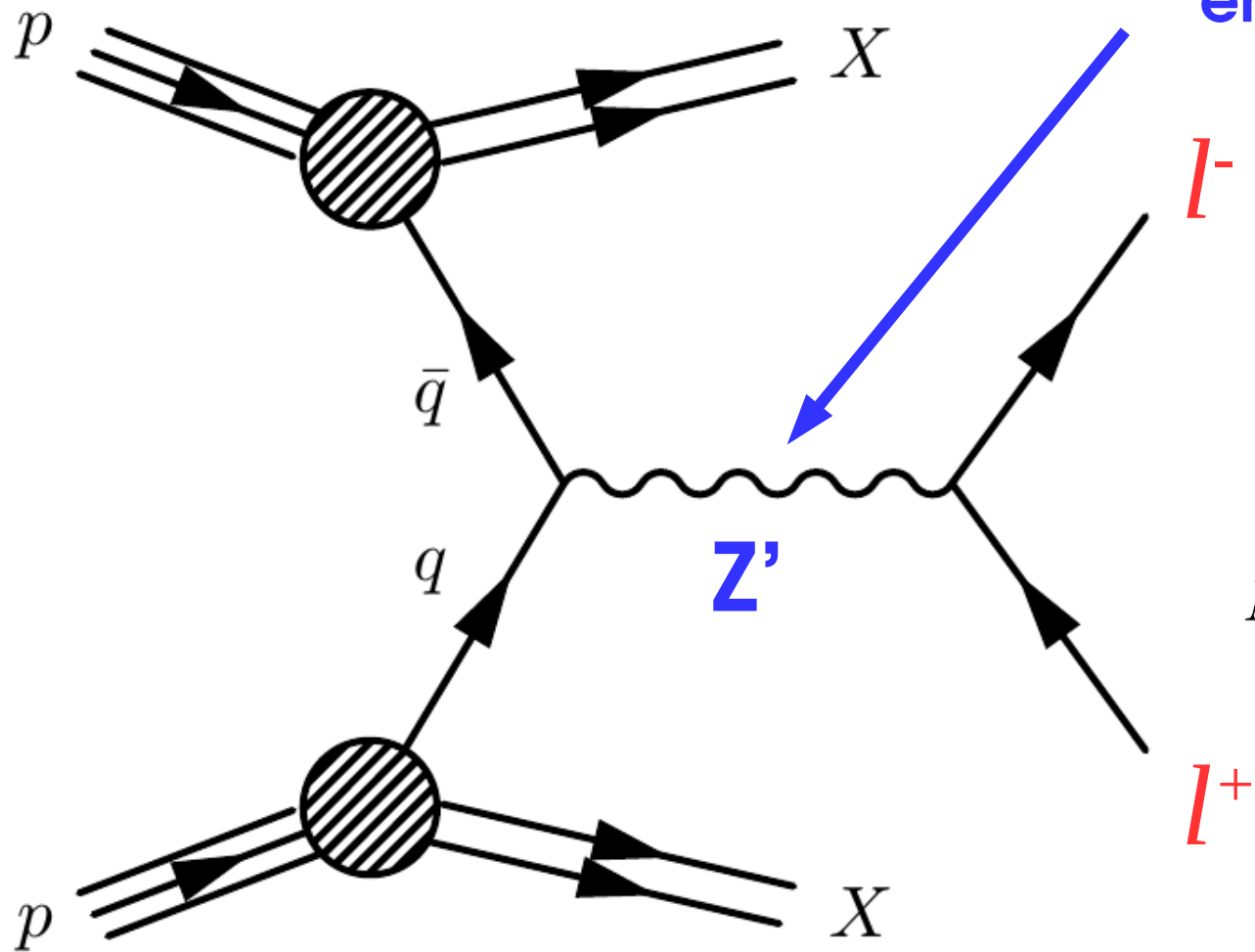
New Vector Boson : Z'



New Vector Boson : Z'



New Vector Boson : Z'



Needs high collision energy to produce

Reconstruct $M_{Z'}$ from Dilepton Invariant mass

$$M = \sqrt{\left(\sum E_i\right)^2 - \left(\sum \vec{p}_i\right)^2}$$

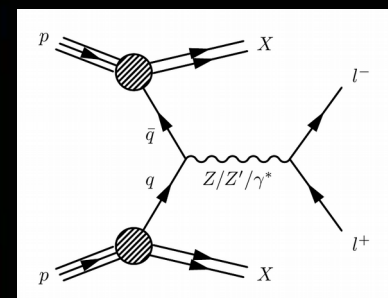
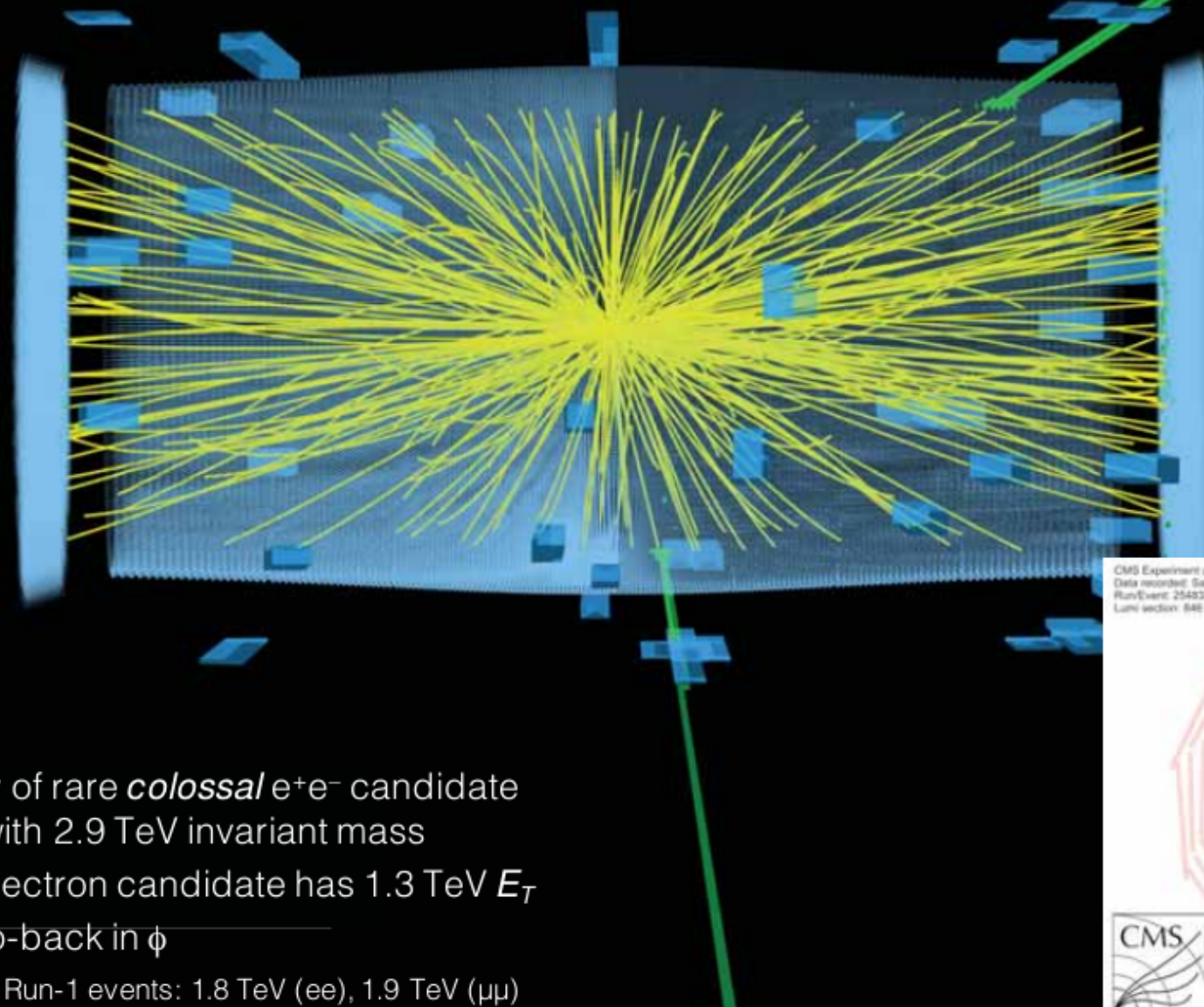
High Energy Leptons: e or μ



CMS Experiment at the LHC, CERN

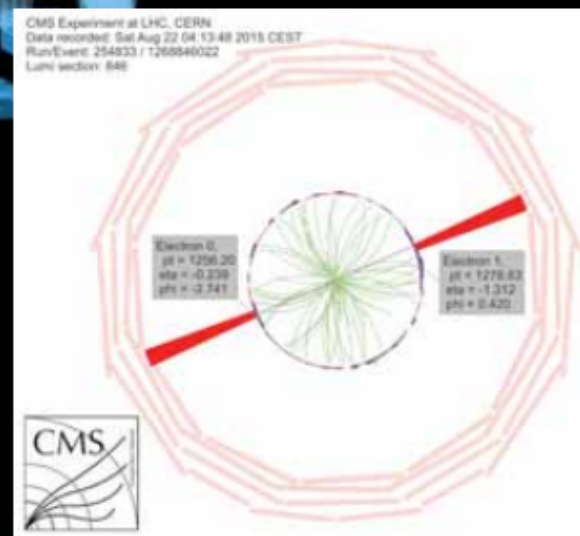
Data recorded: 2015-Aug-22 02:13:48.861952 GMT

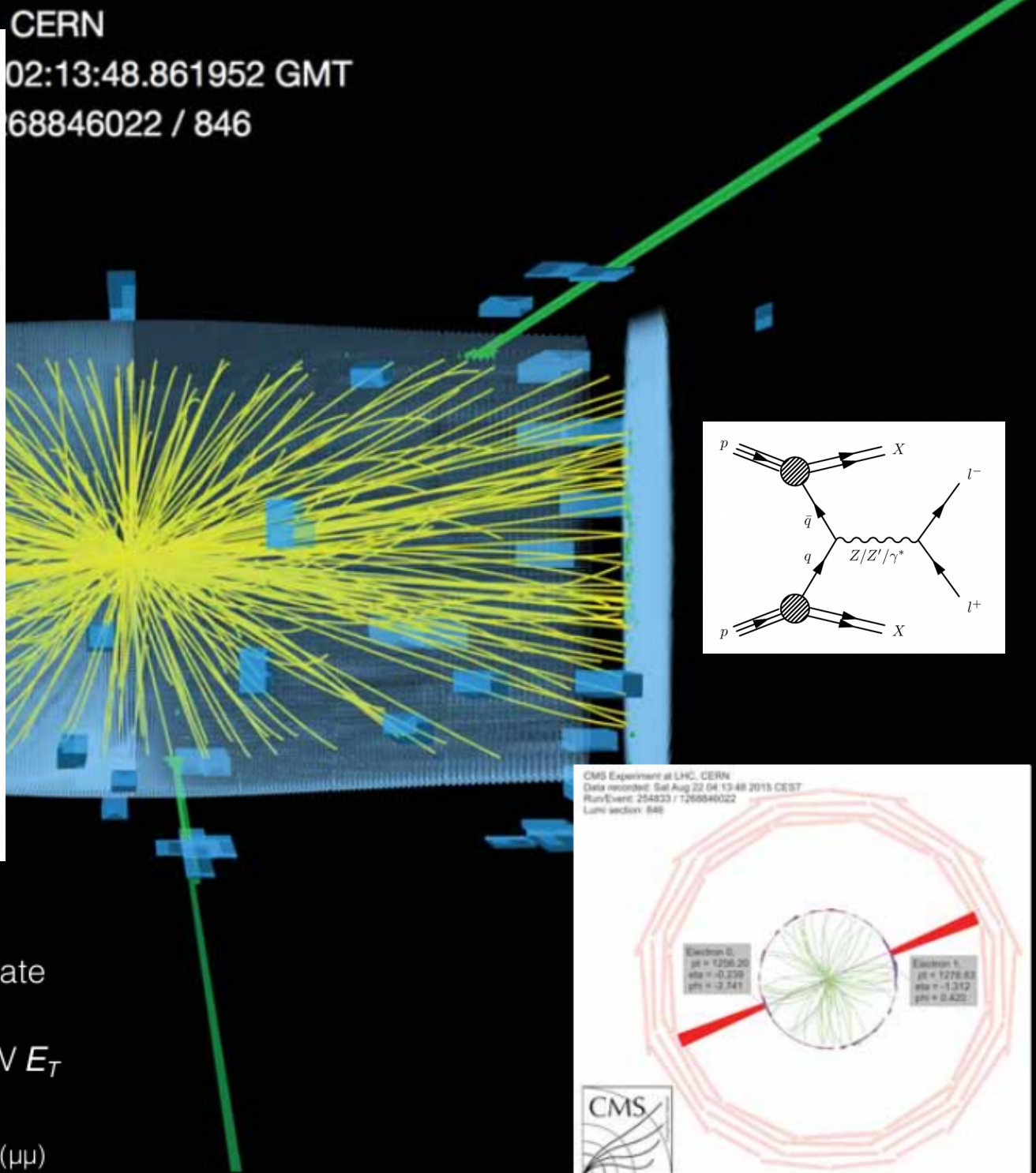
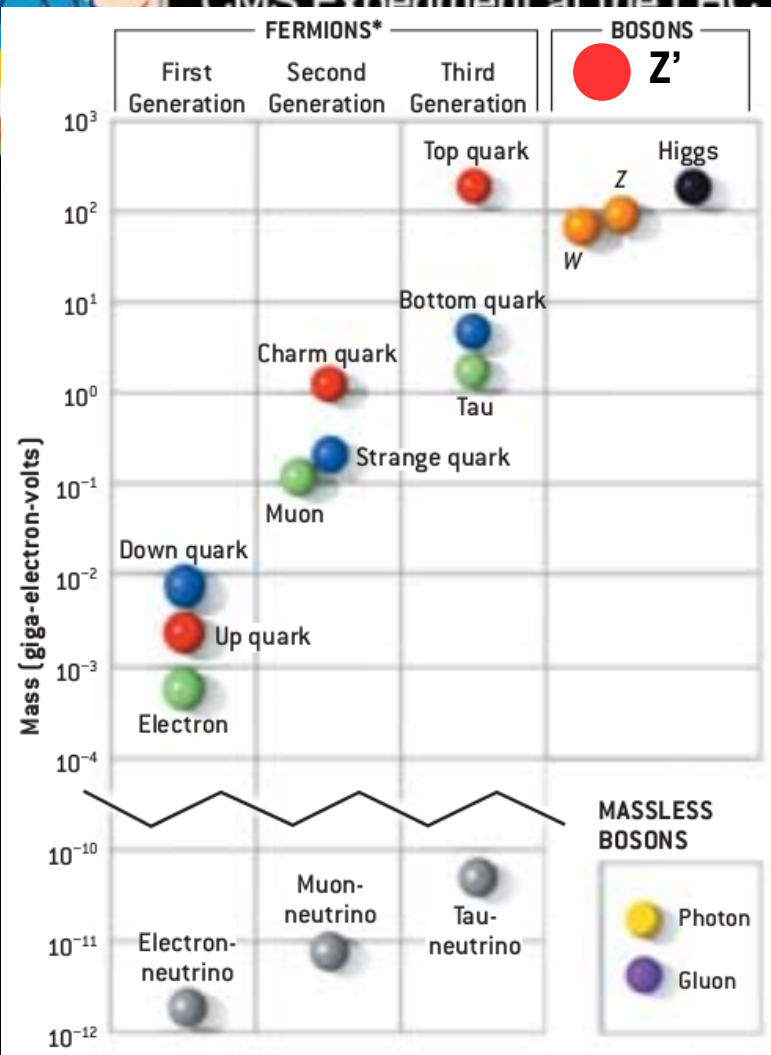
Run / Event / LS: 254833 / 1268846022 / 846



- Display of rare *colossal* e^+e^- candidate event with 2.9 TeV invariant mass
- Each electron candidate has 1.3 TeV E_T
- Back-to-back in ϕ

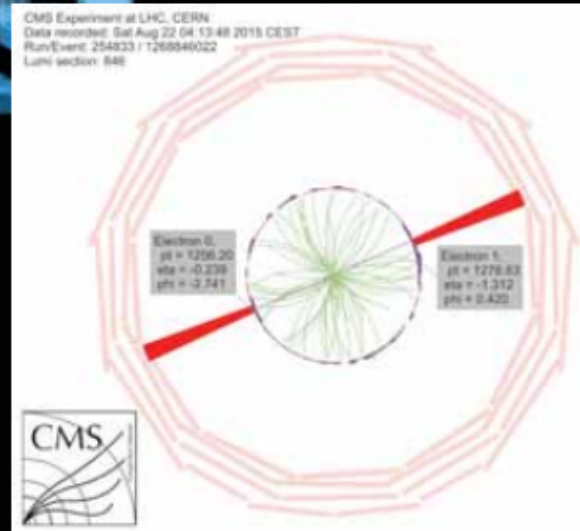
Highest-mass Run-1 events: 1.8 TeV (ee), 1.9 TeV ($\mu\mu$)



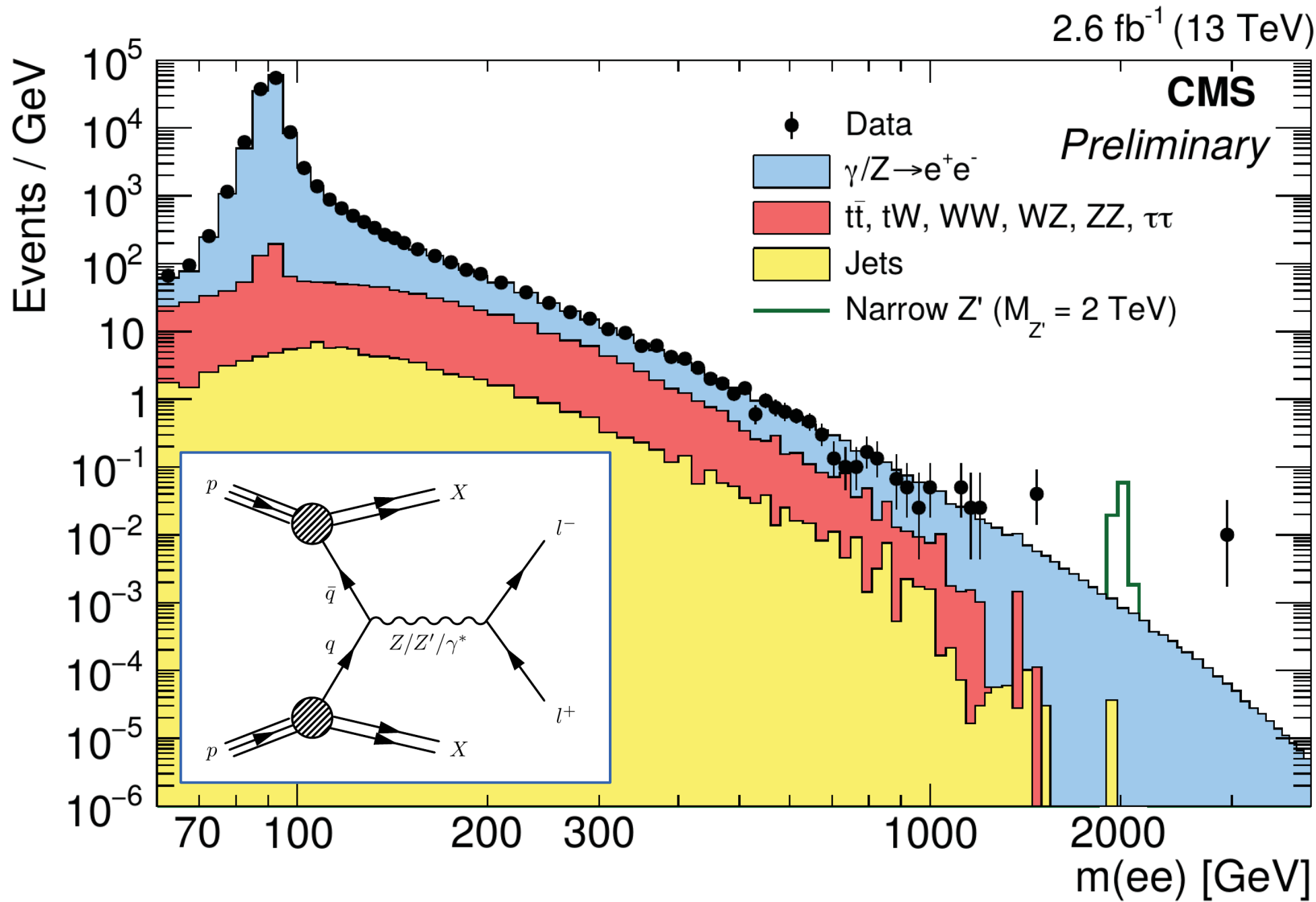
02:13:48.861952 GMT
68846022 / 846

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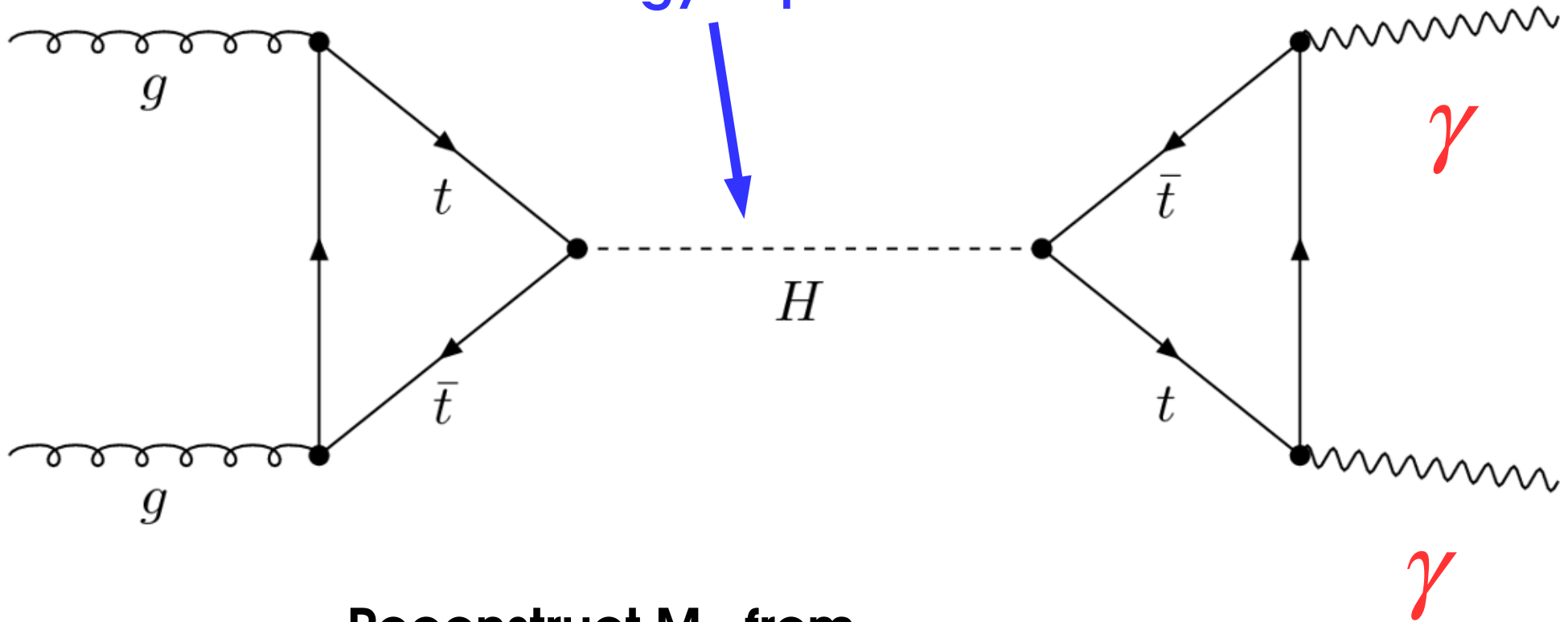


Invariant Mass Distribution



Heavy Higgs

Needs high collision
energy to produce



Reconstruct M_H from
Diphoton Invariant mass

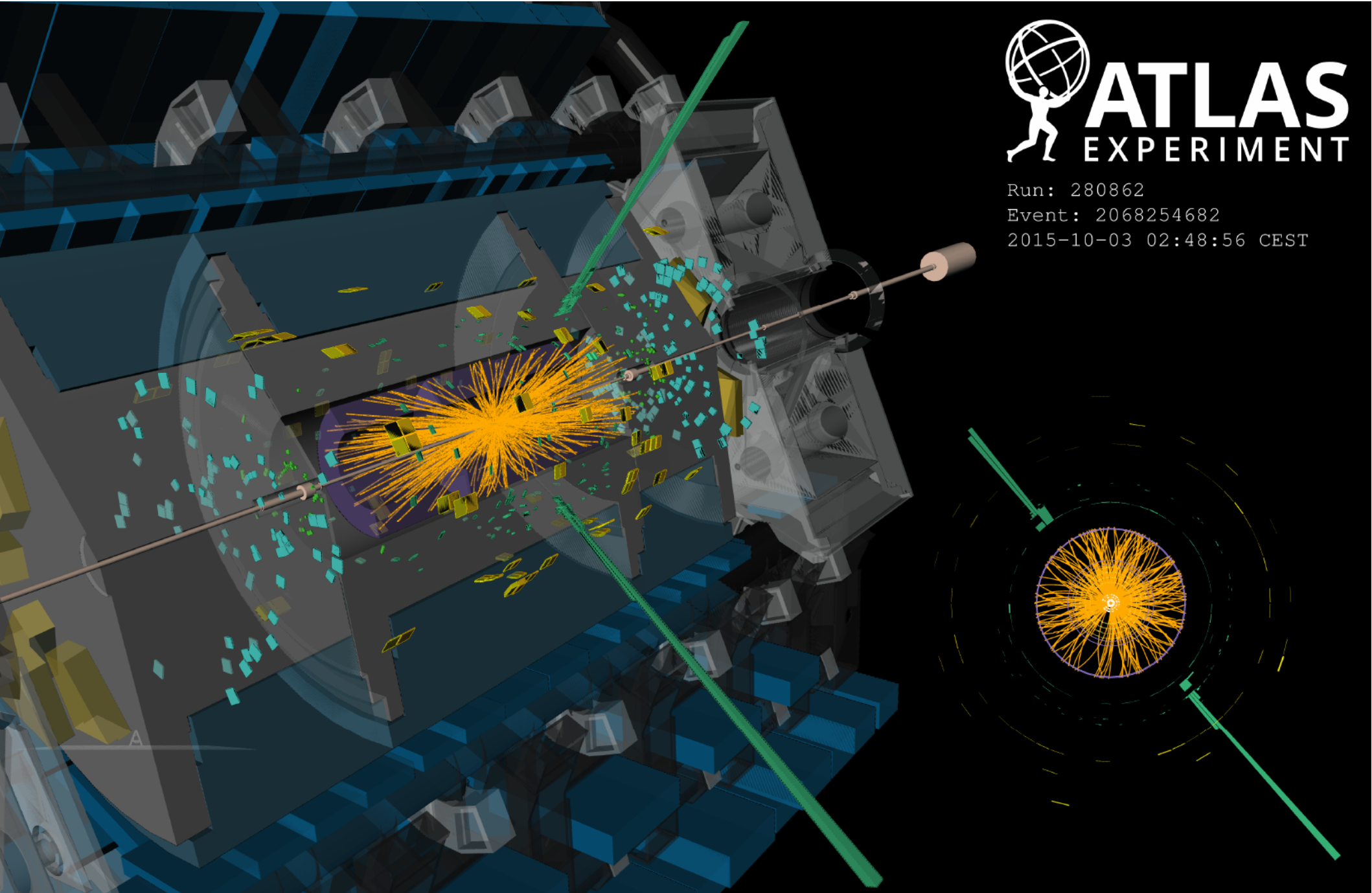
$$M = \sqrt{\left(\sum E_i\right)^2 - \left(\sum \vec{p}_i\right)^2}$$

High Energy
Photons

Run: 280862

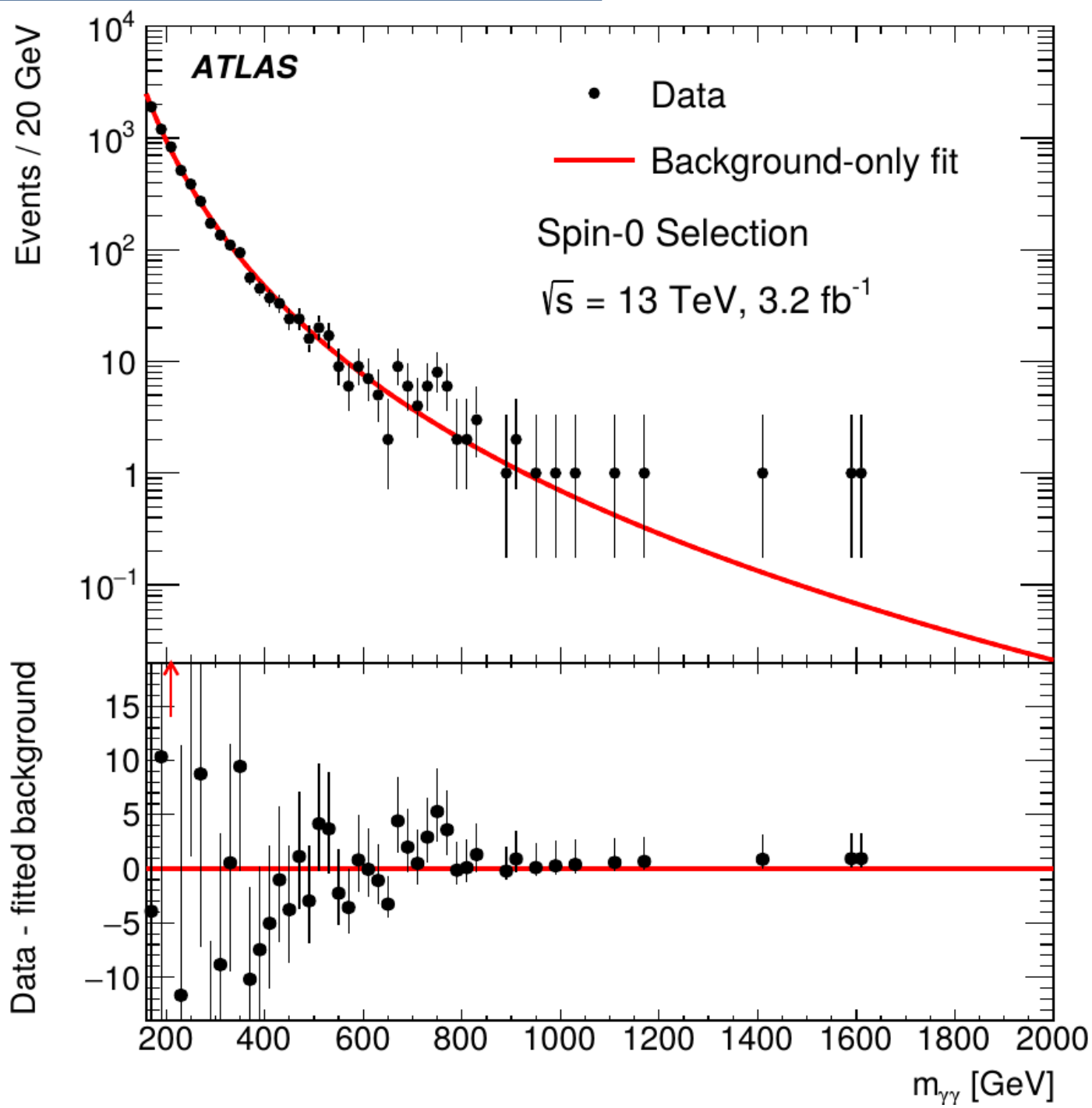
Event: 2068254682

2015-10-03 02:48:56 CEST

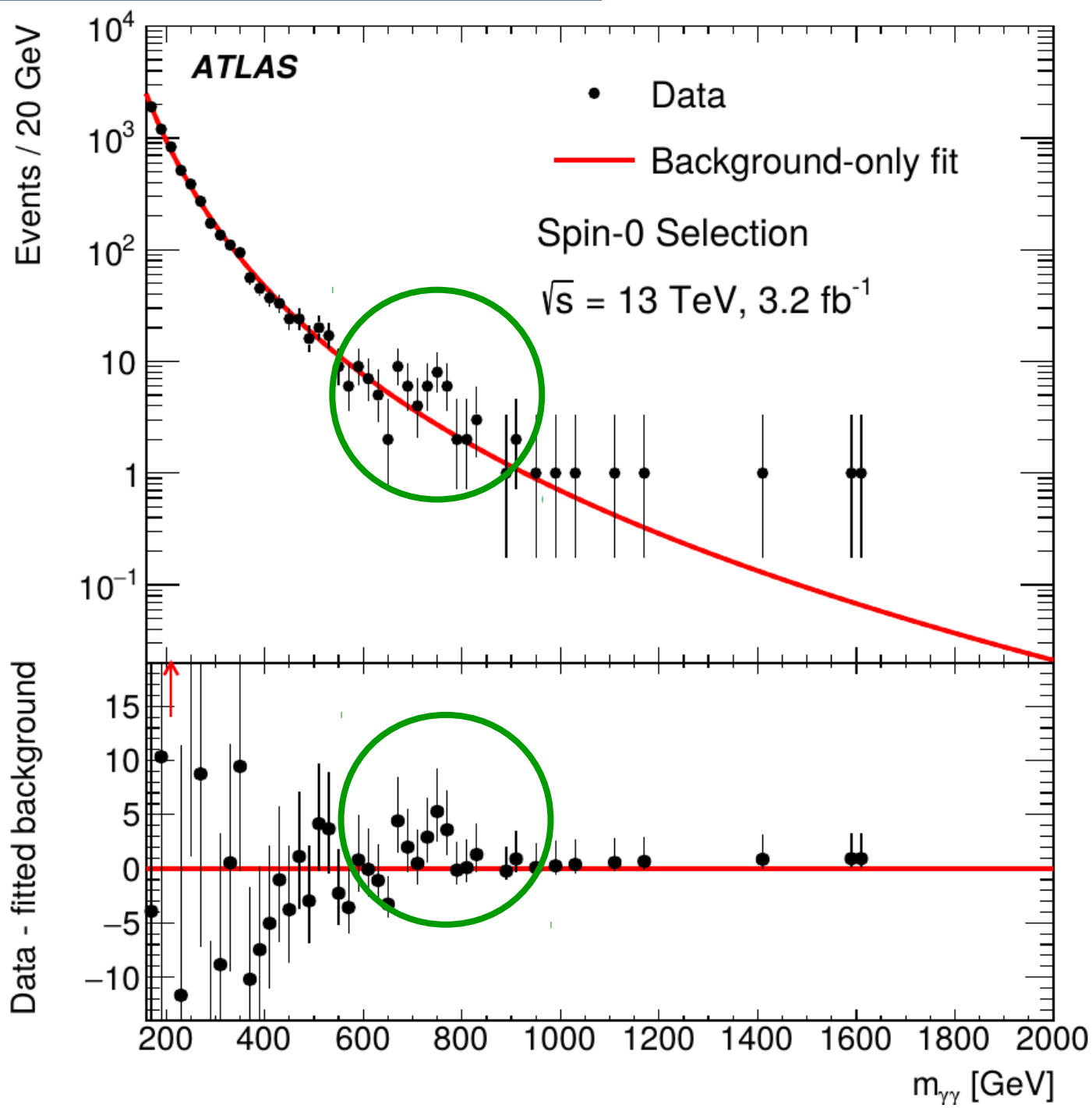


Invariant Mass $M_{\gamma\gamma} \sim 730 \text{ GeV}$

Invariant Mass Distribution



Invariant Mass Distribution



Significance

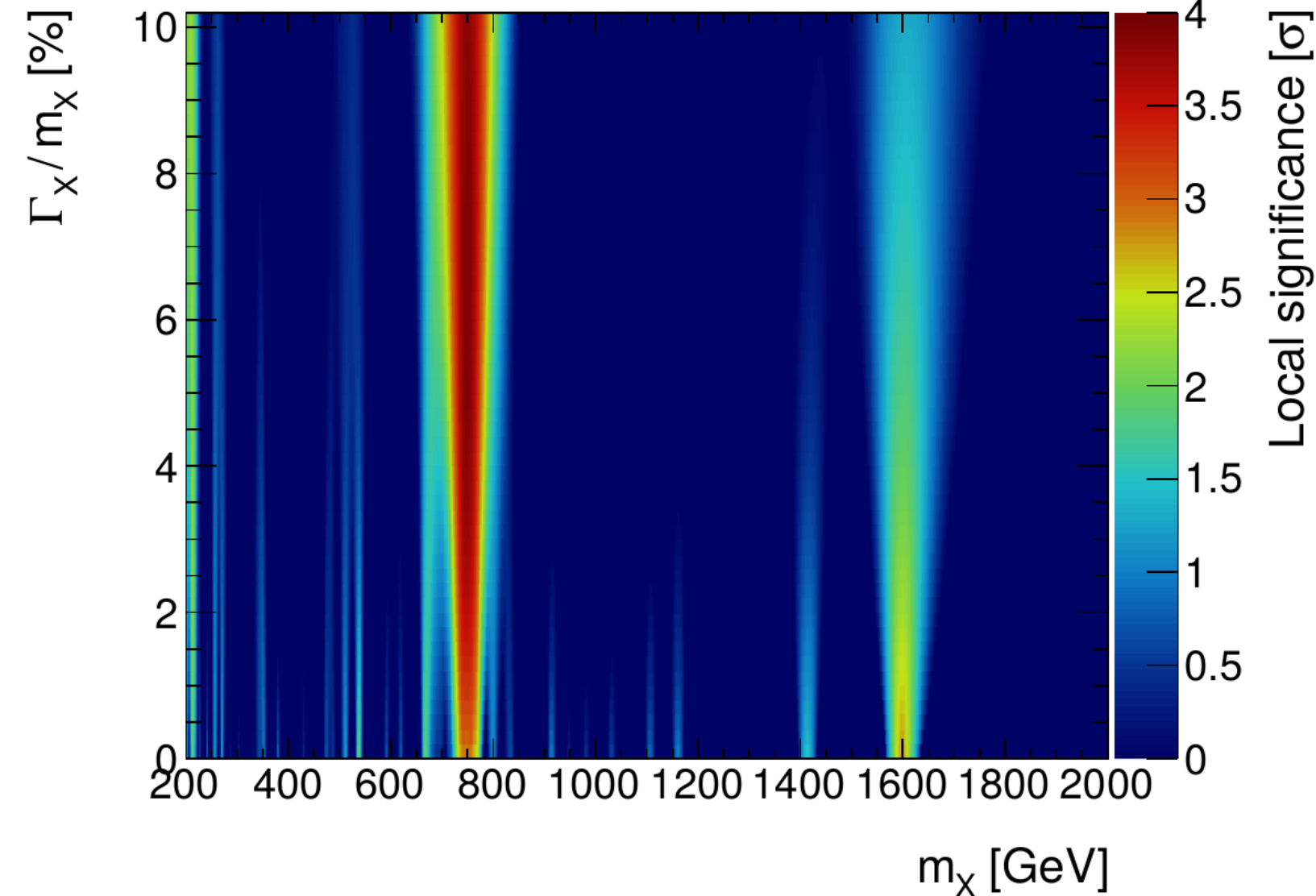
Probability for background to
fluctuate up to here



ATLAS

$\sqrt{s} = 13 \text{ TeV}, 3.2 \text{ fb}^{-1}$

Spin-0 Selection



0.003%

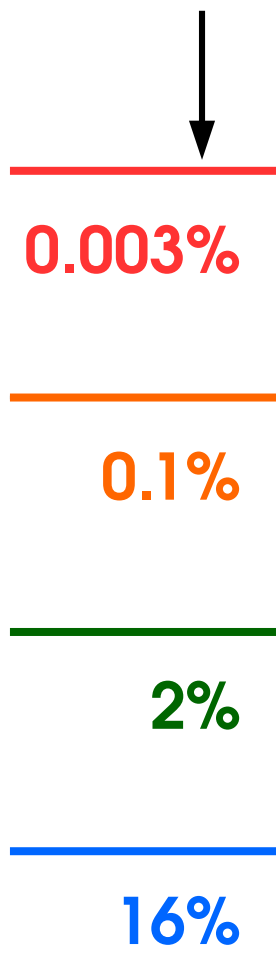
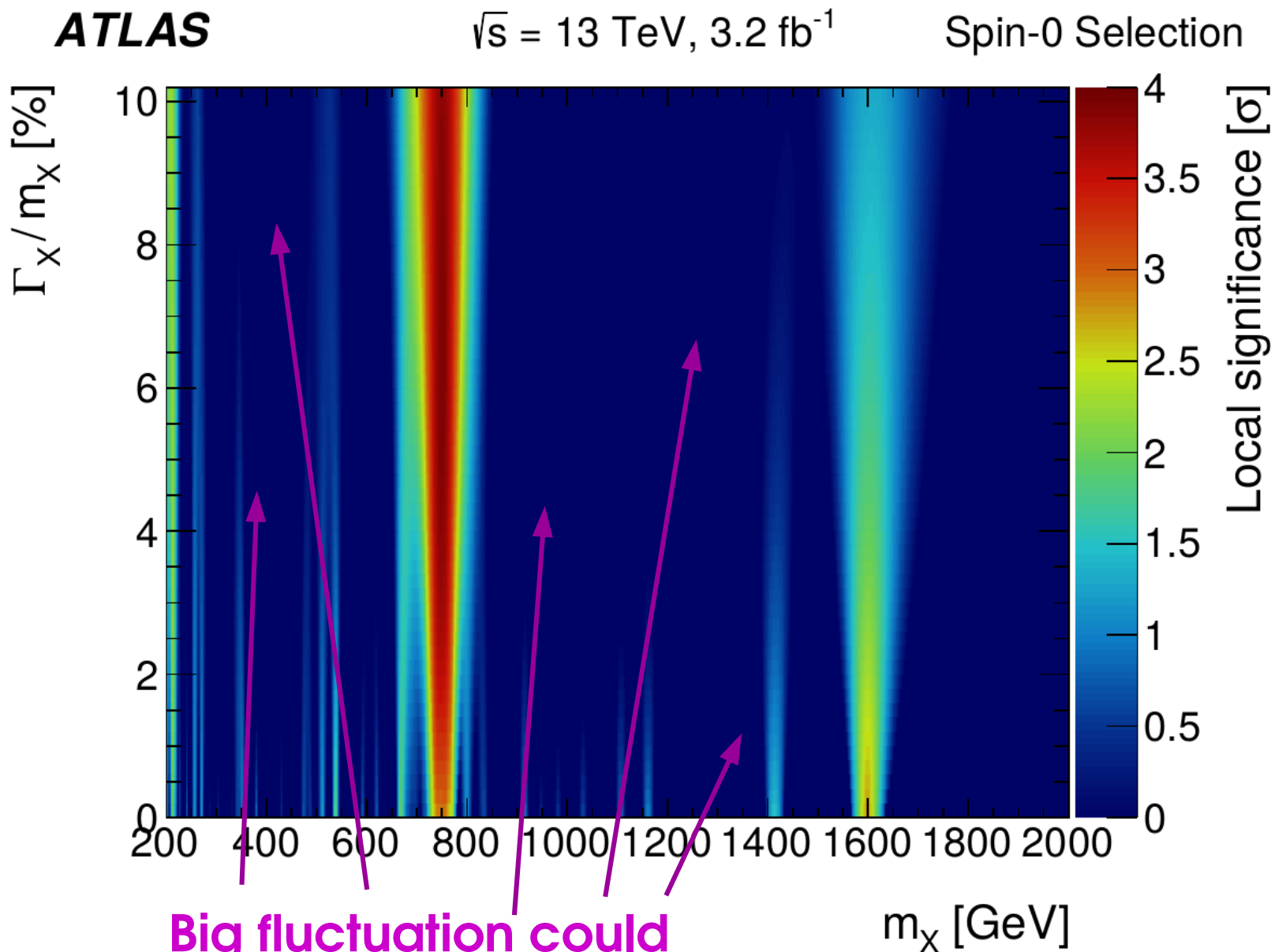
0.1%

2%

16%

Significance

Probability for background to fluctuate up to here

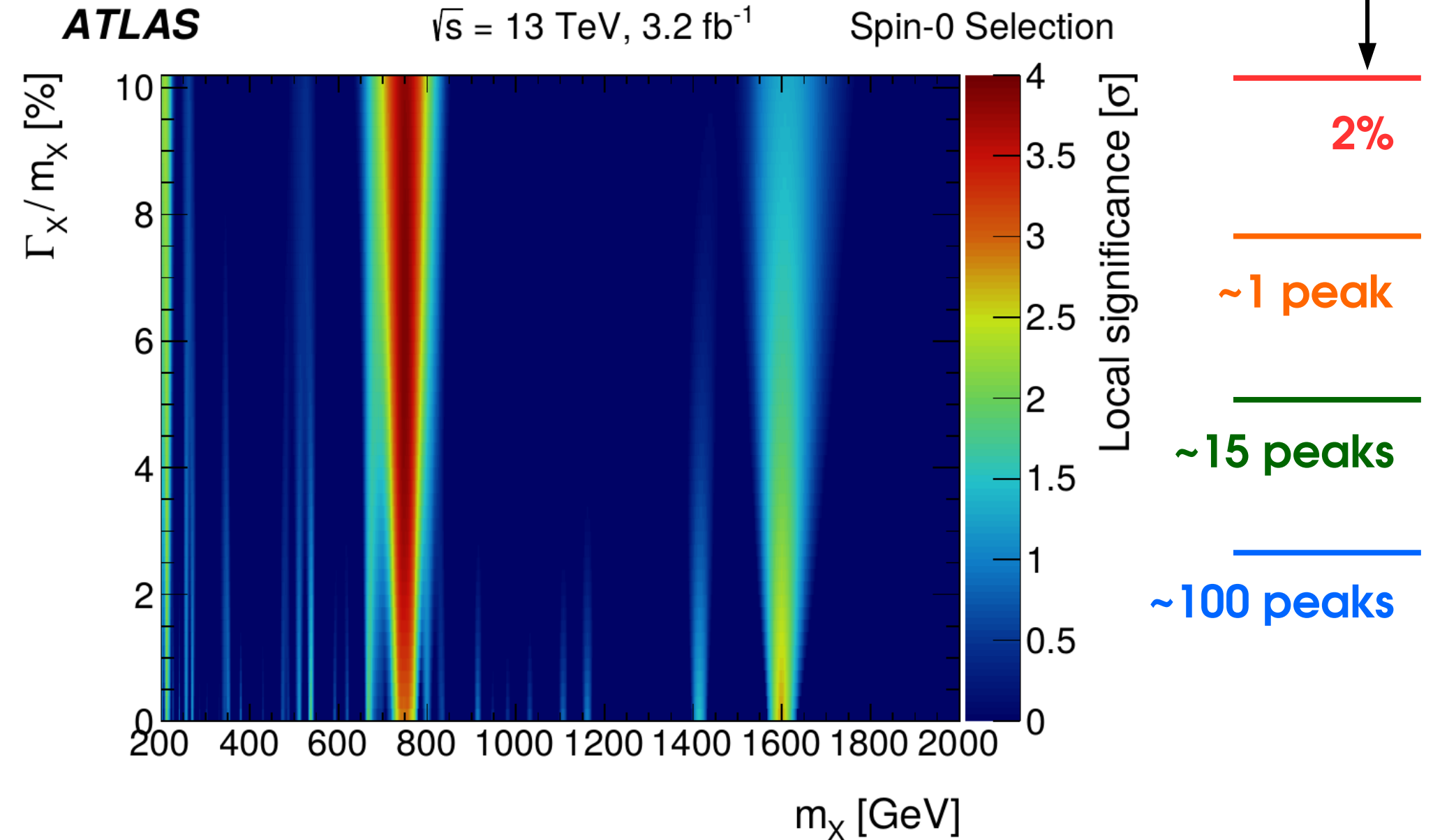


Big fluctuation could have happened here

“Look Elsewhere” Effect

Significance

Probability for background to fluctuate up to here **SOMEWHERE**



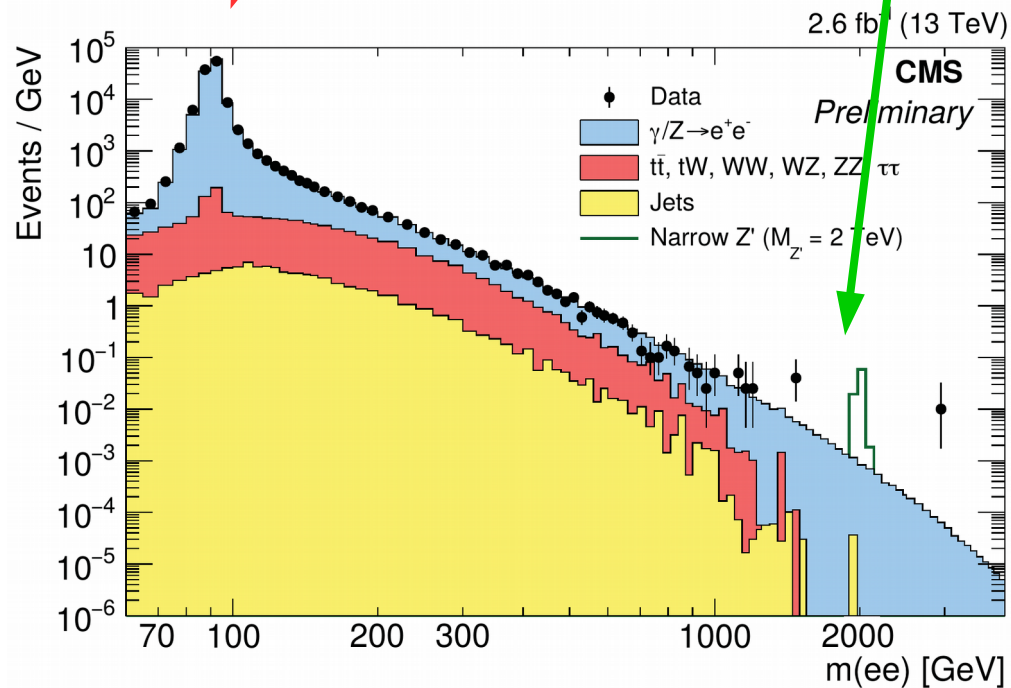
Future

Energy is important ...

.... But lots of data is also **very** important

Lots of
events here

We want some
here too



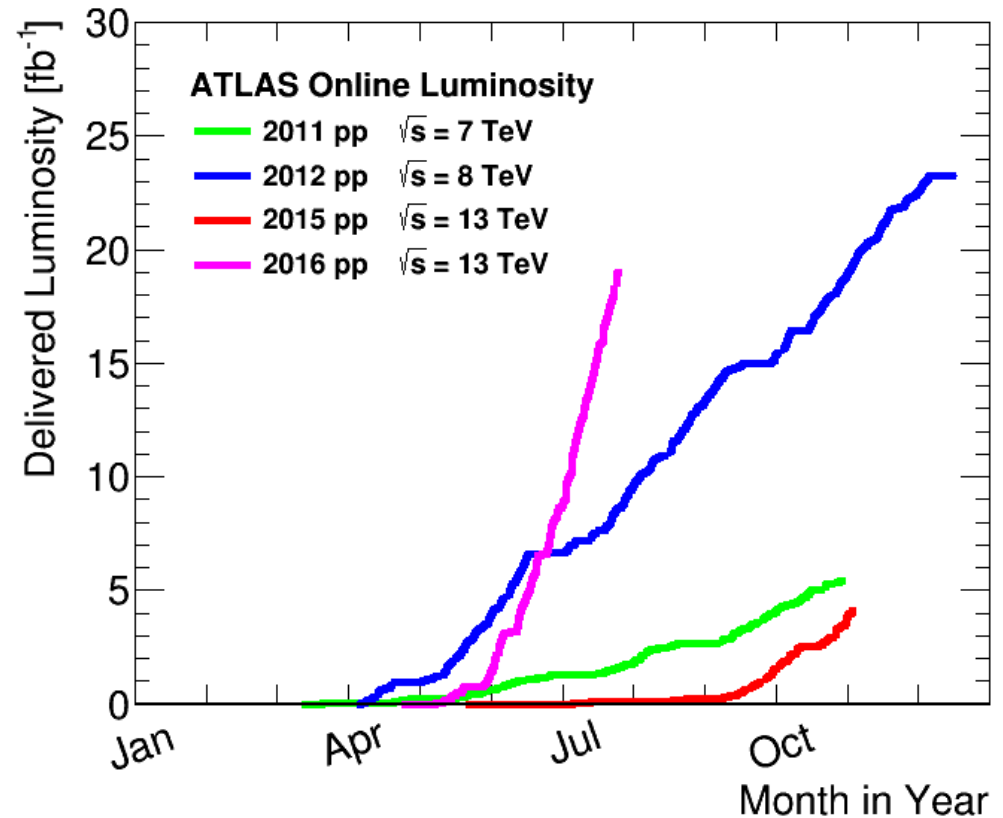
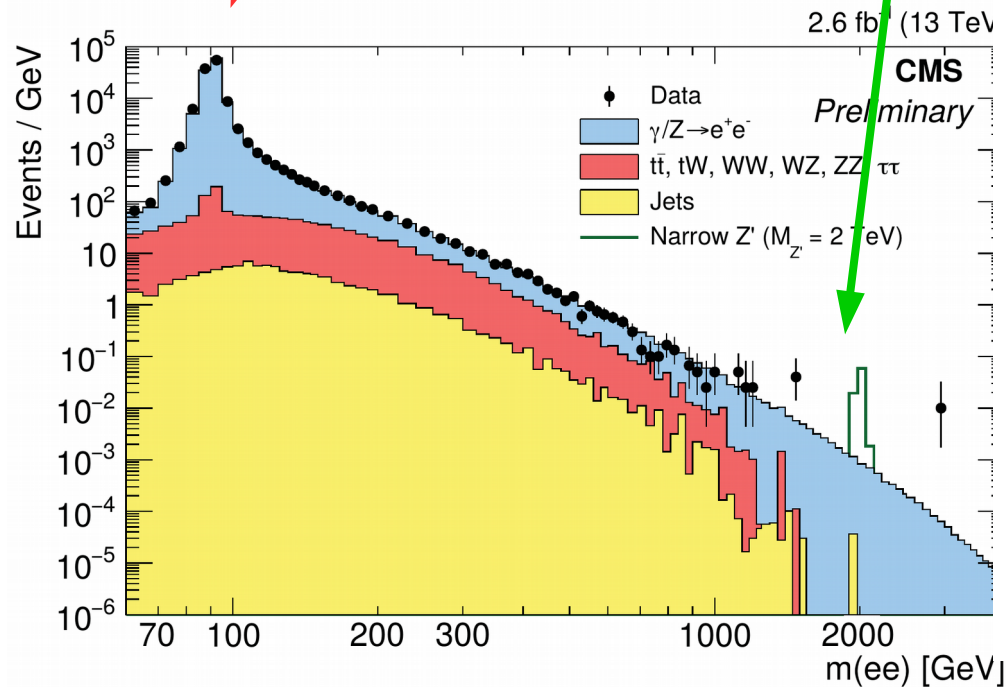
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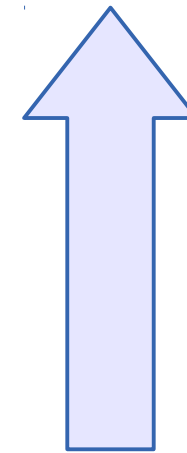
We want some
here too



Future

Energy is important ...

.... But lots of data is also **very** important



LHC
Ultimate
Goal:

3000 fb⁻¹

Lots of
events here

We want some
here too

