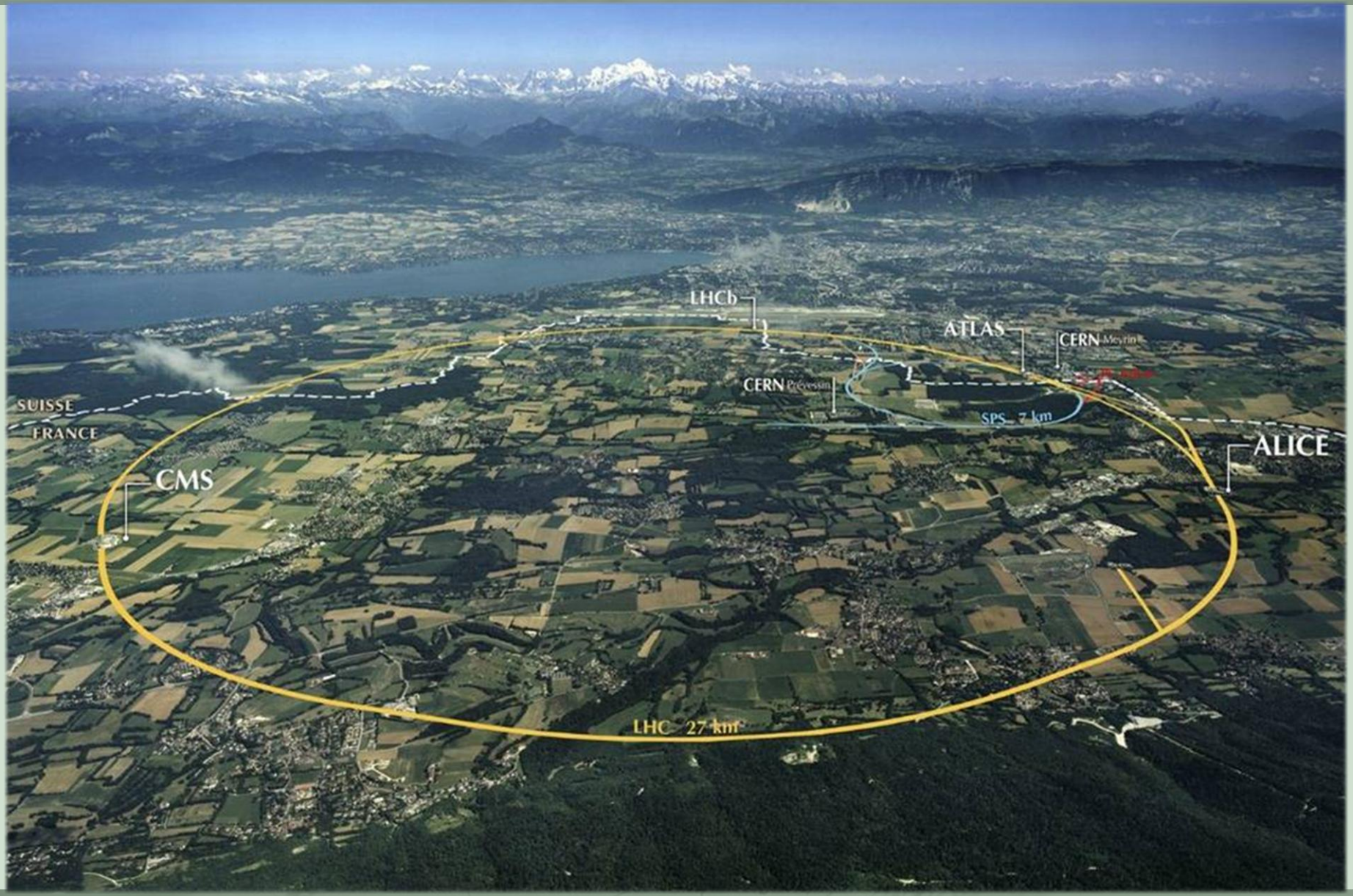
MEASUREMENT OF THE HIGGS BOSON TRANSVERSE MOMENTUM WITH THE ATLAS DETECTOR

Robert Reed – robert.reed@cern.ch

INTRODUCTION



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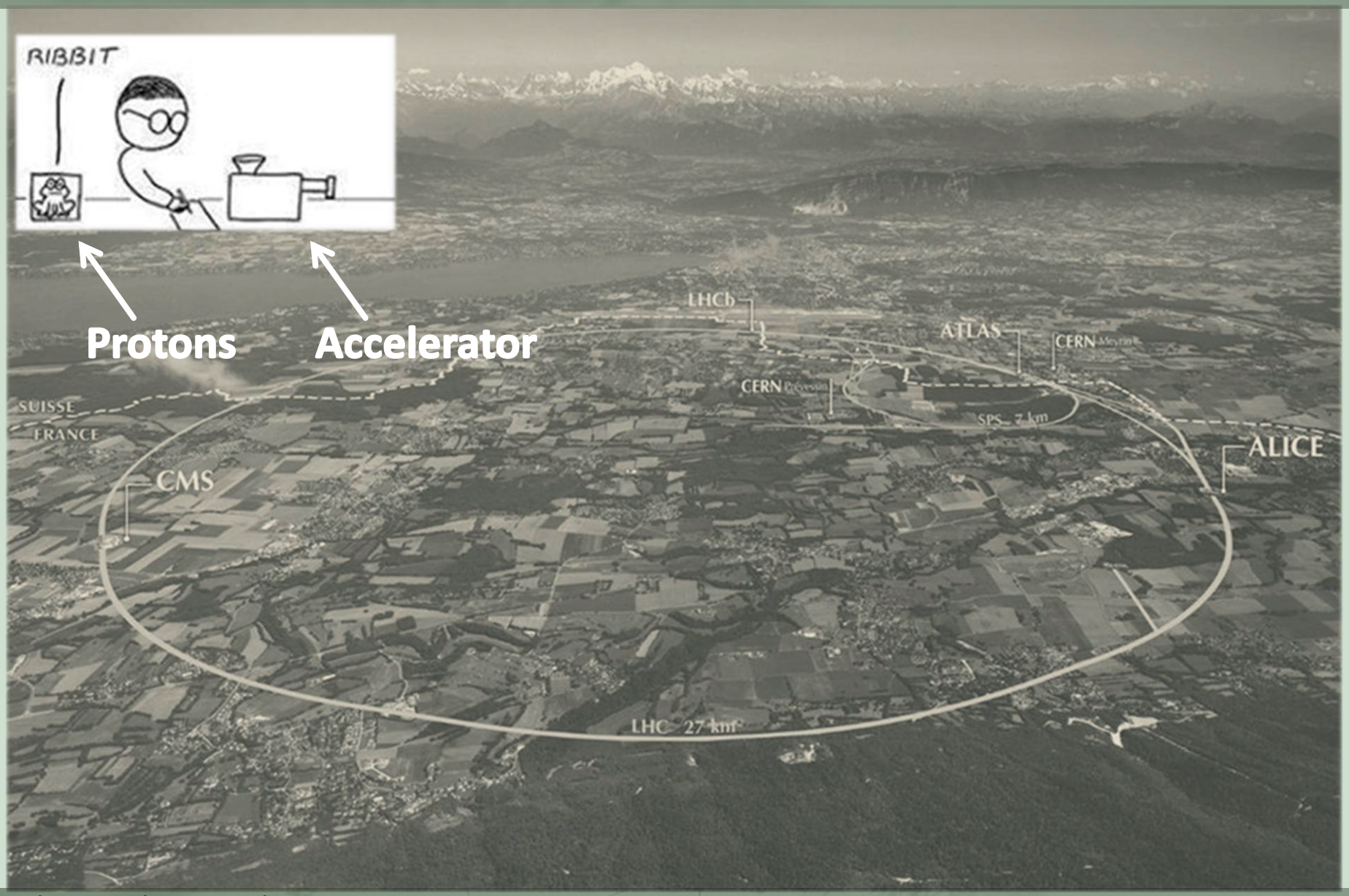

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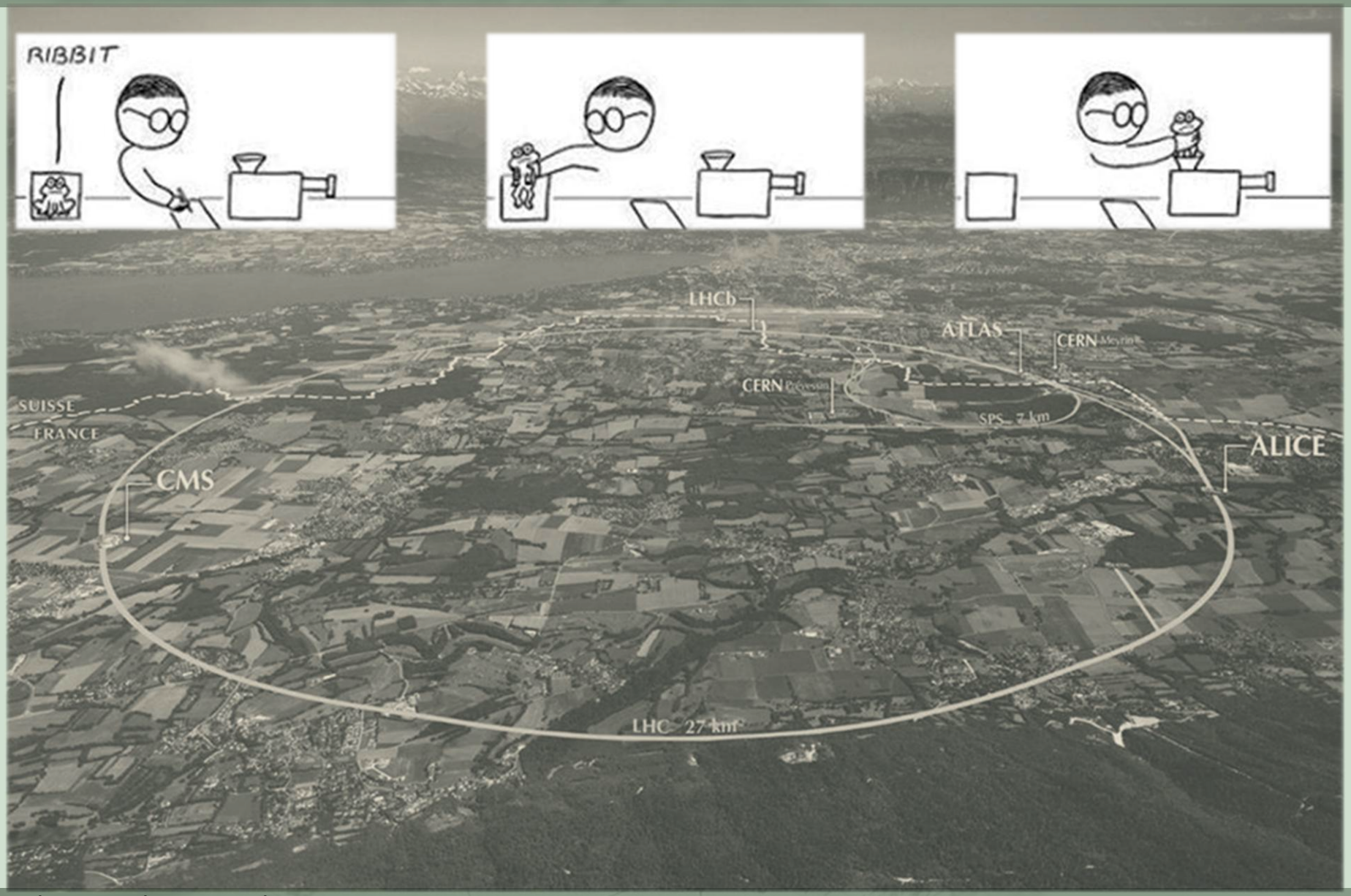

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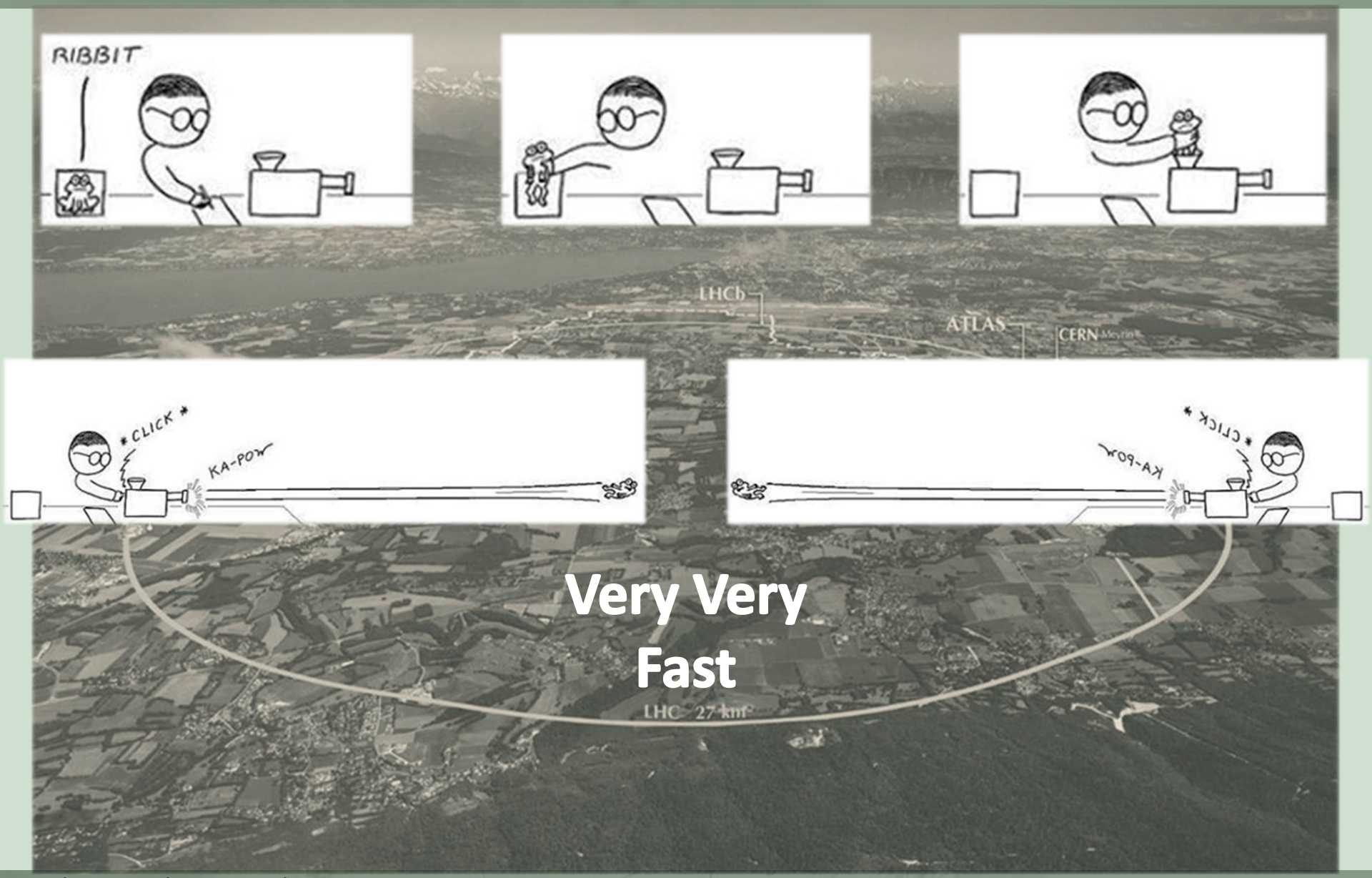

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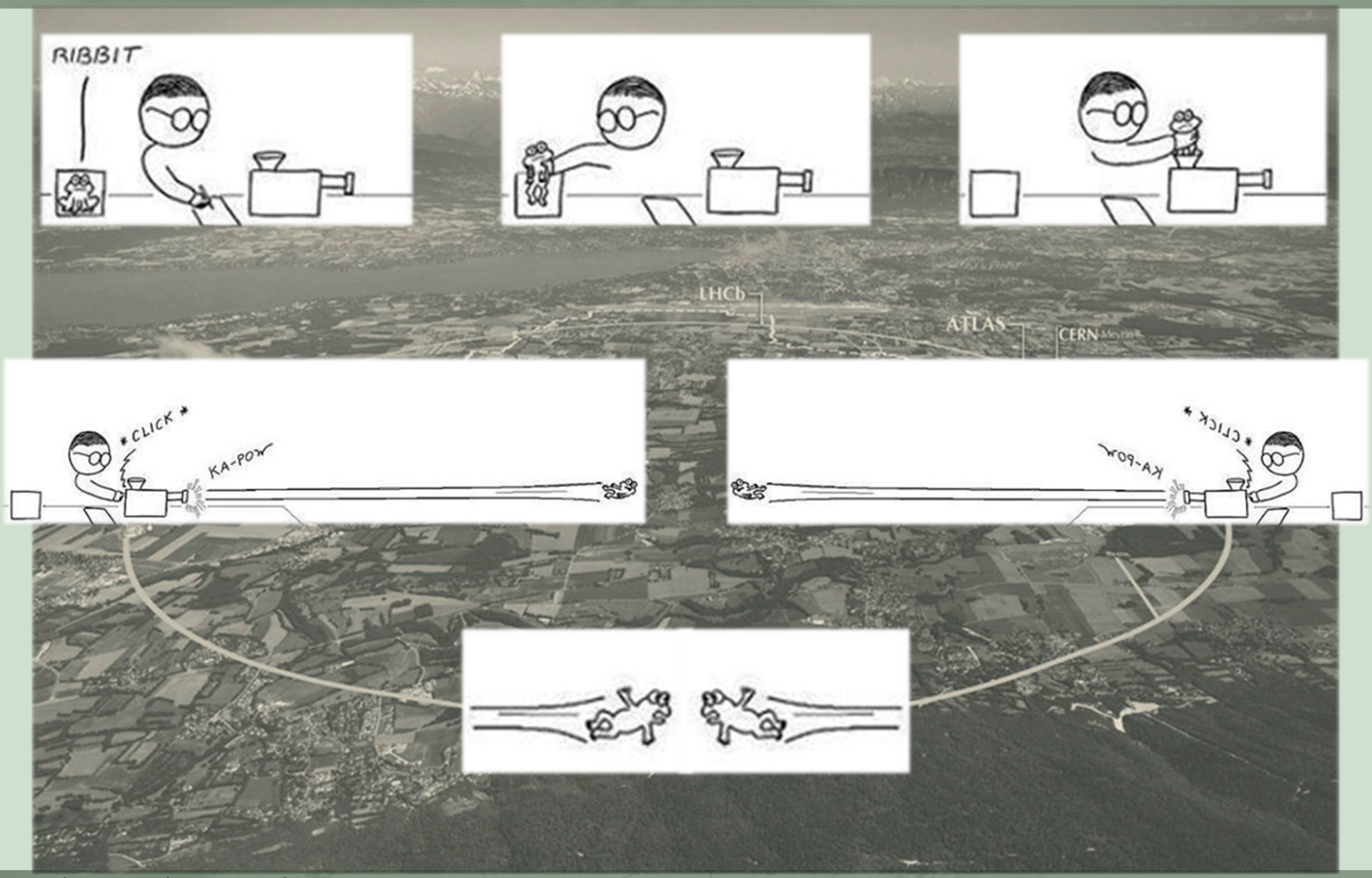
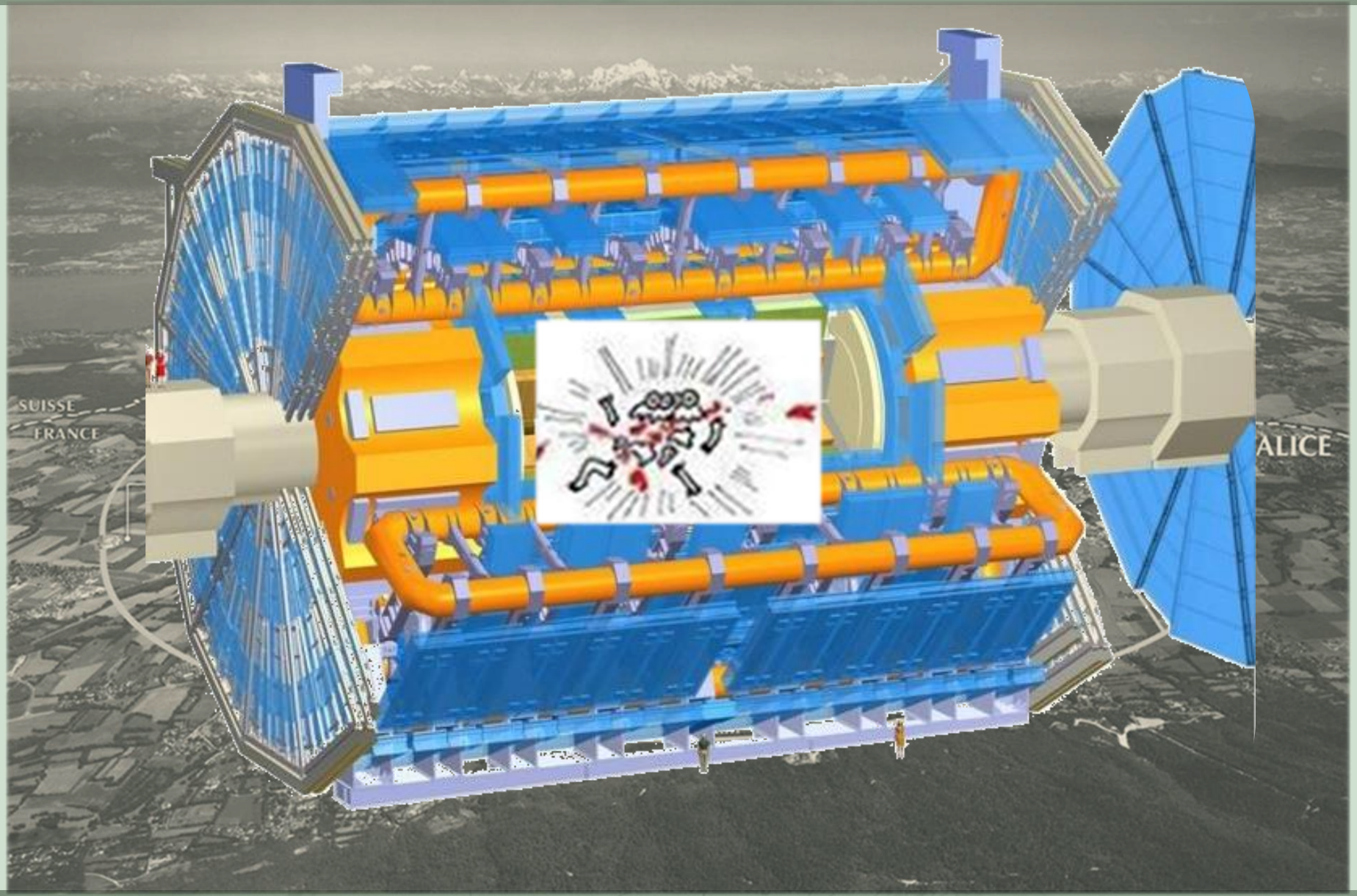


INTRODUCTION

Deep Inelastic Scattering

INTRODUCTION



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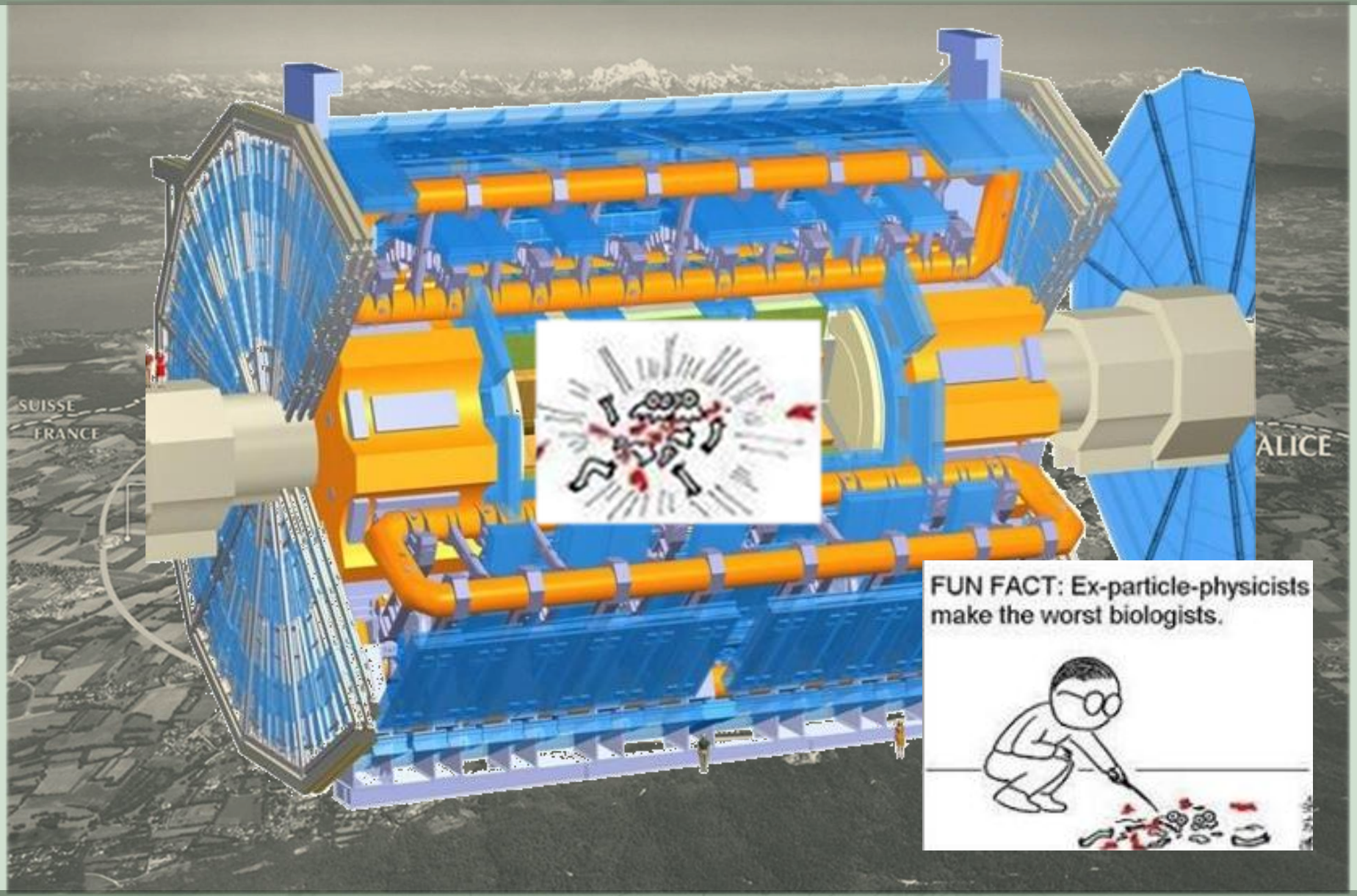

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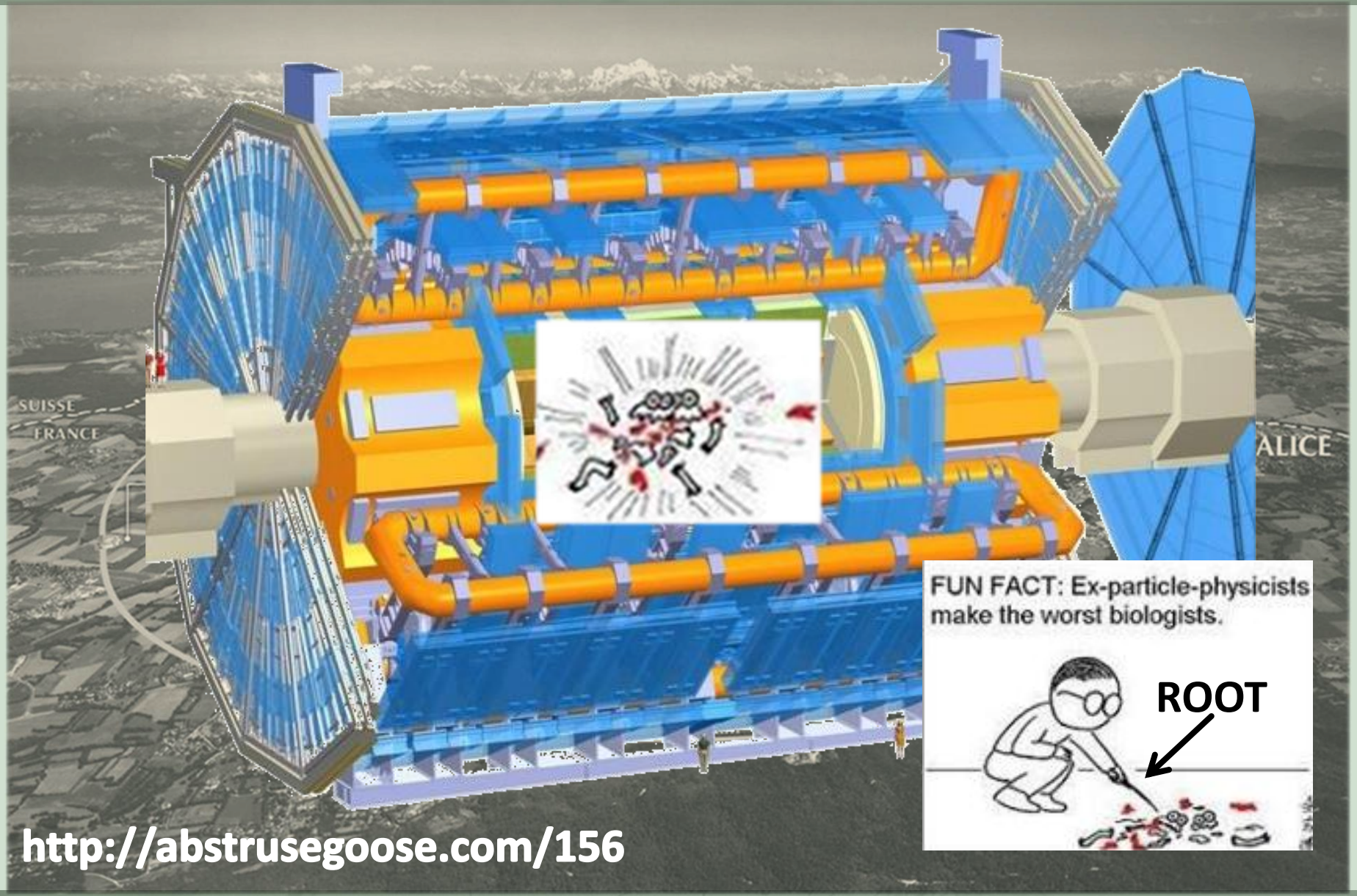
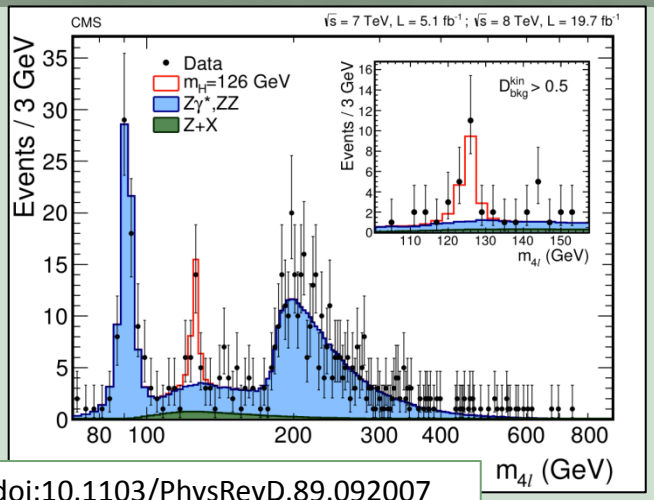
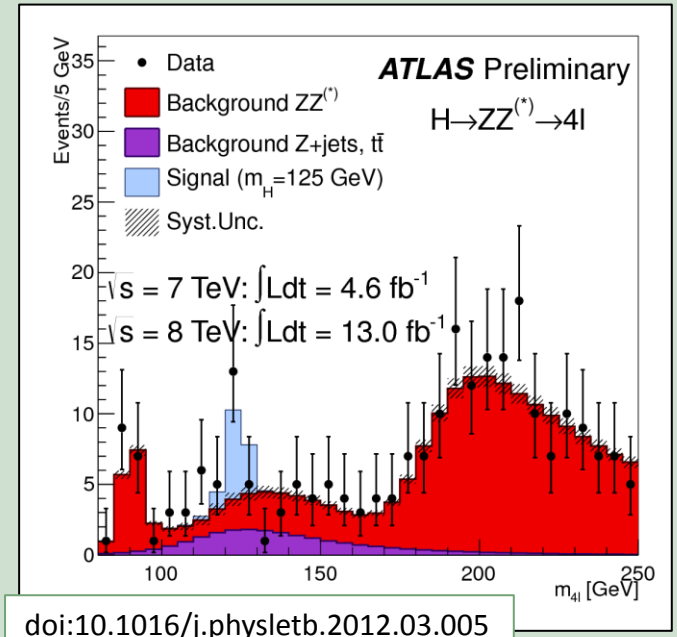


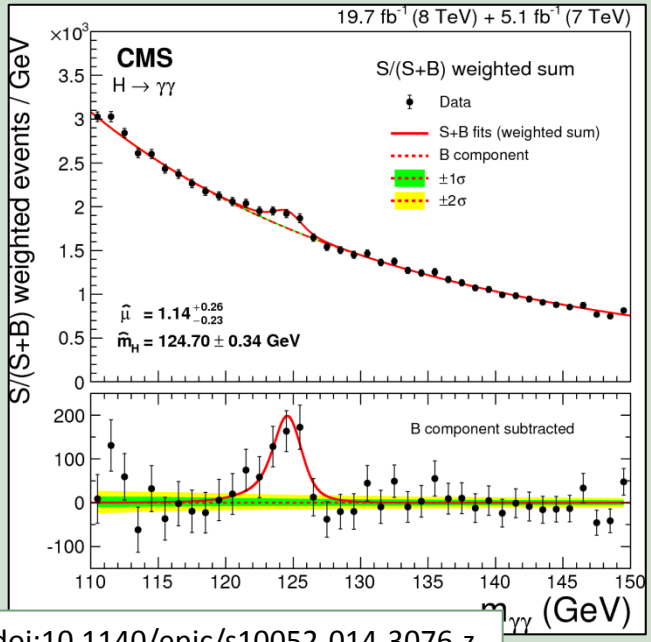
DISCOVERY OF THE HIGGS



doi:10.1103/PhysRevD.89.092007



doi:10.1016/j.physletb.2012.03.005



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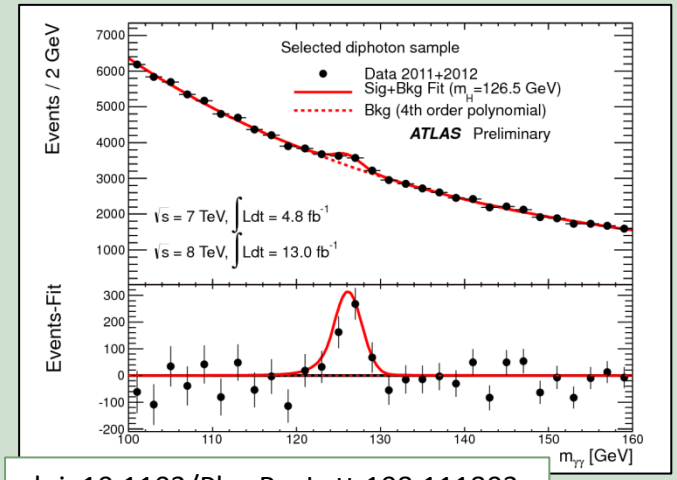

doi: 10.1103/PhysRevLett.108.111803

PRODUCTION MECHANISMS

- What is inside this packet of protons?

PRODUCTION MECHANISMS

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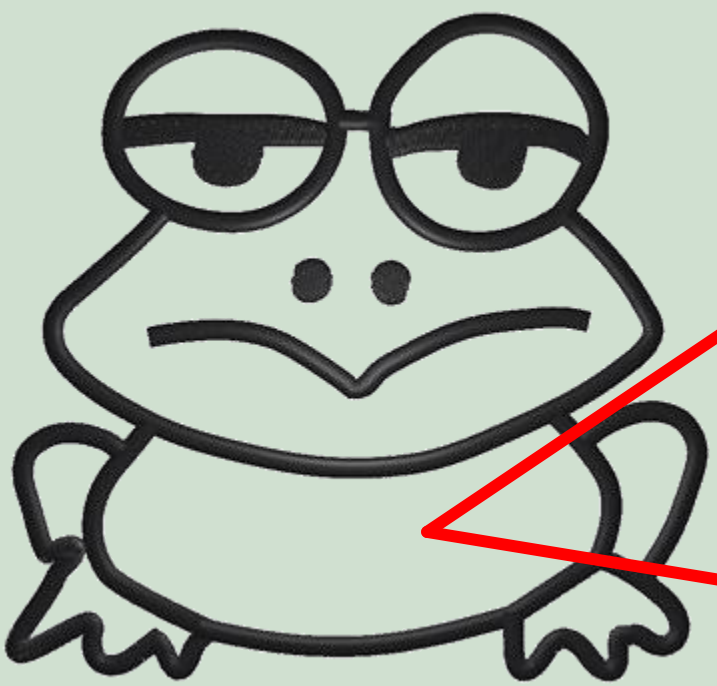
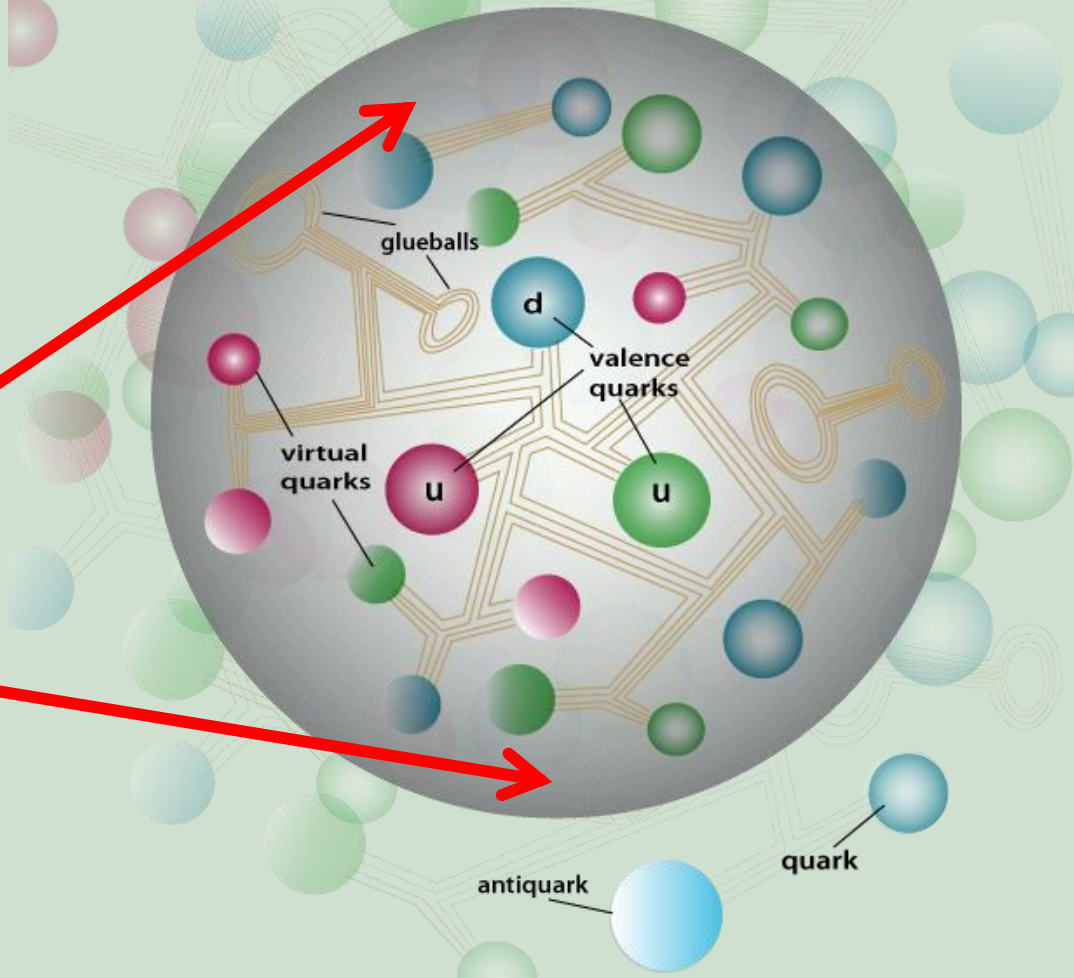
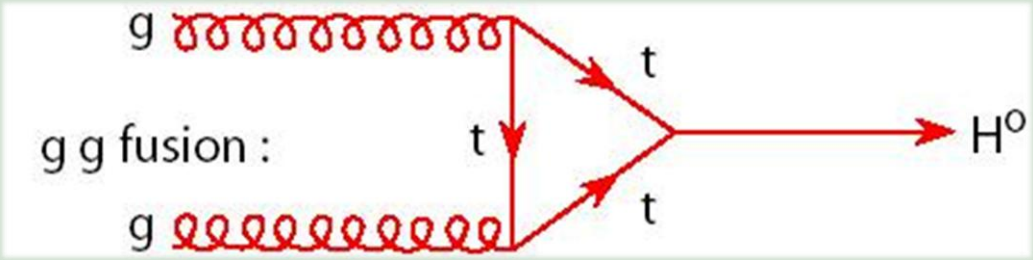
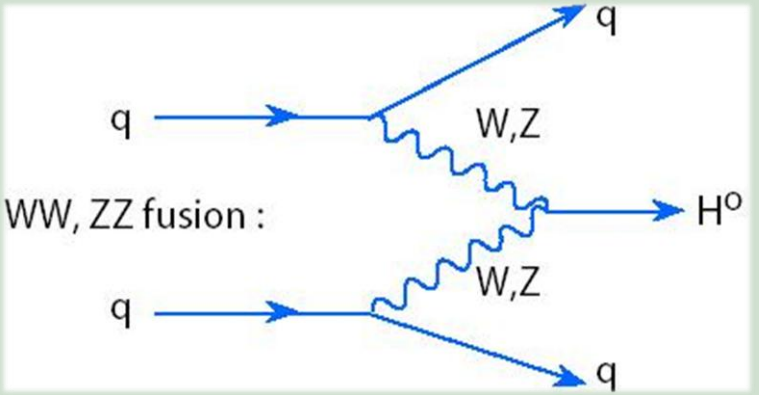
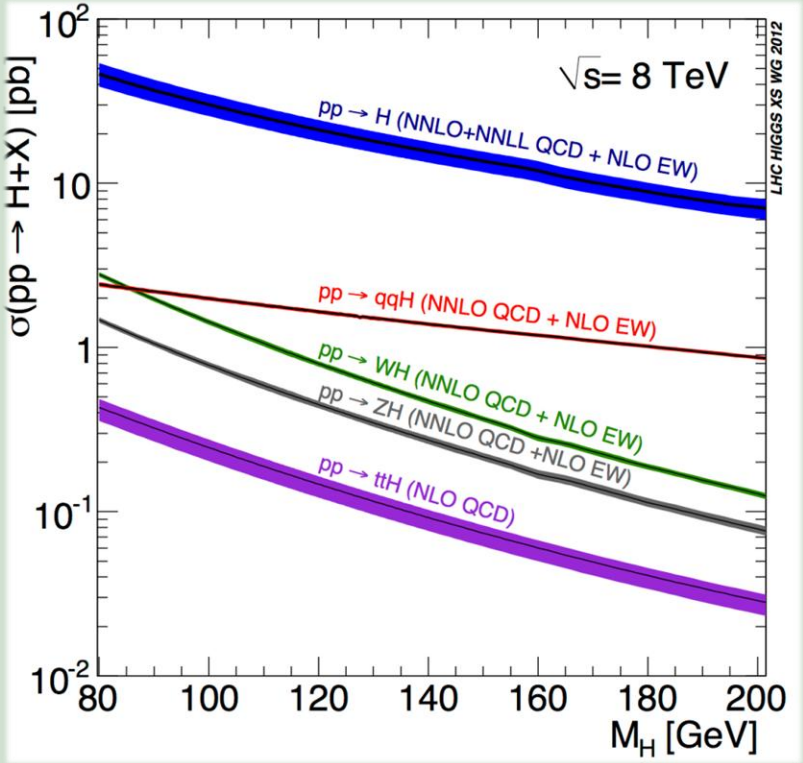


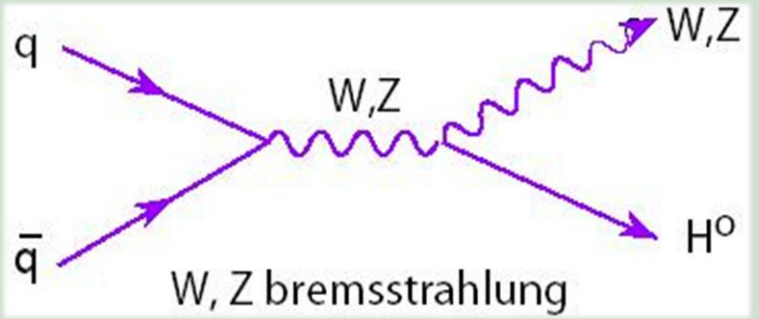


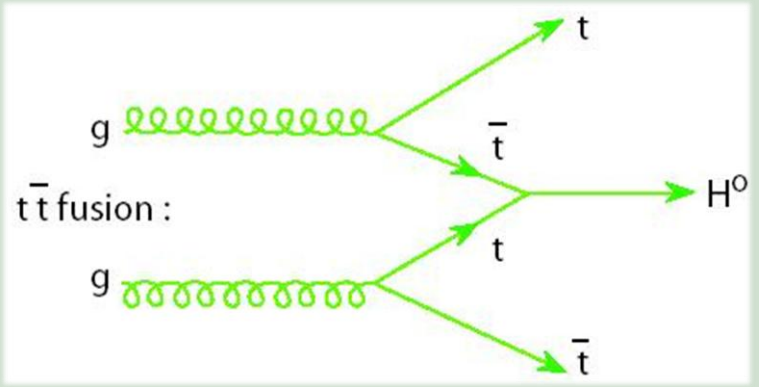
PRODUCTION MECHANISMS



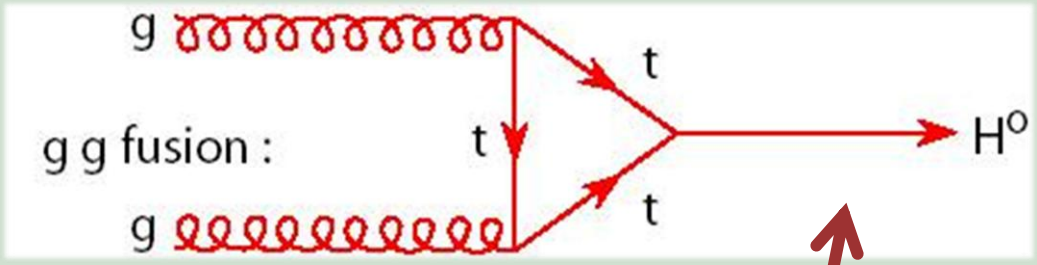


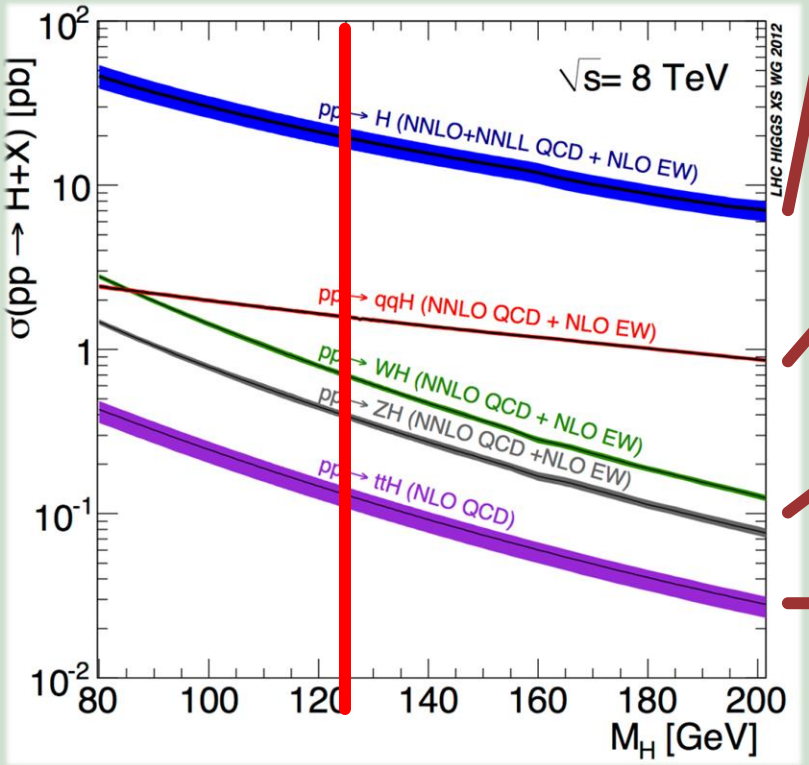


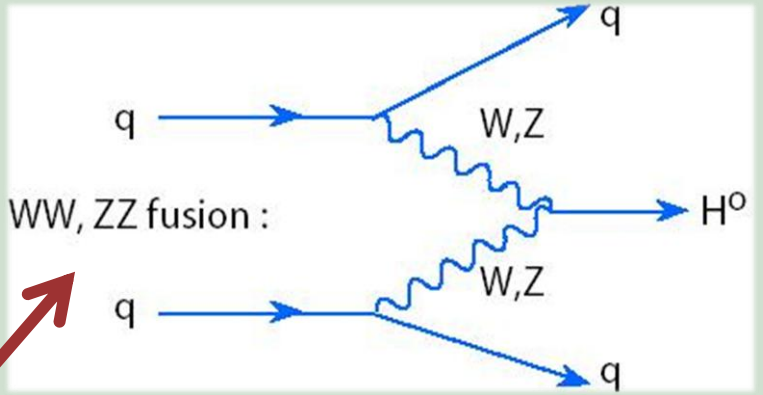


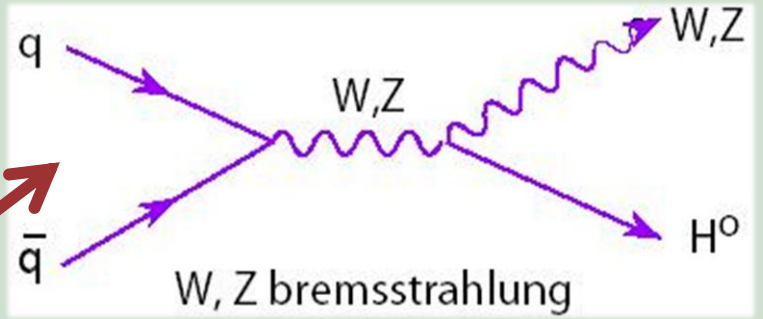


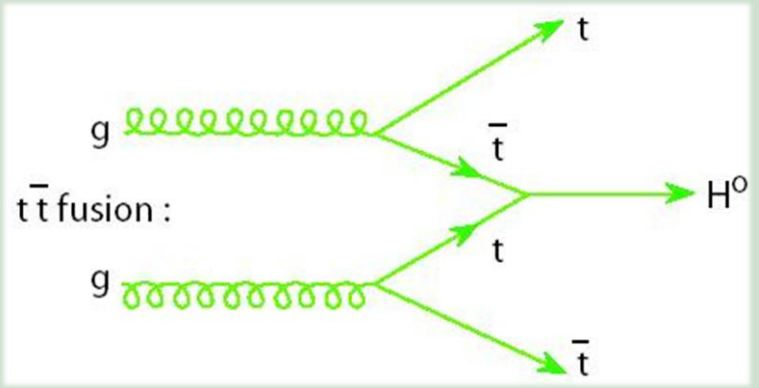
PRODUCTION MECHANISMS



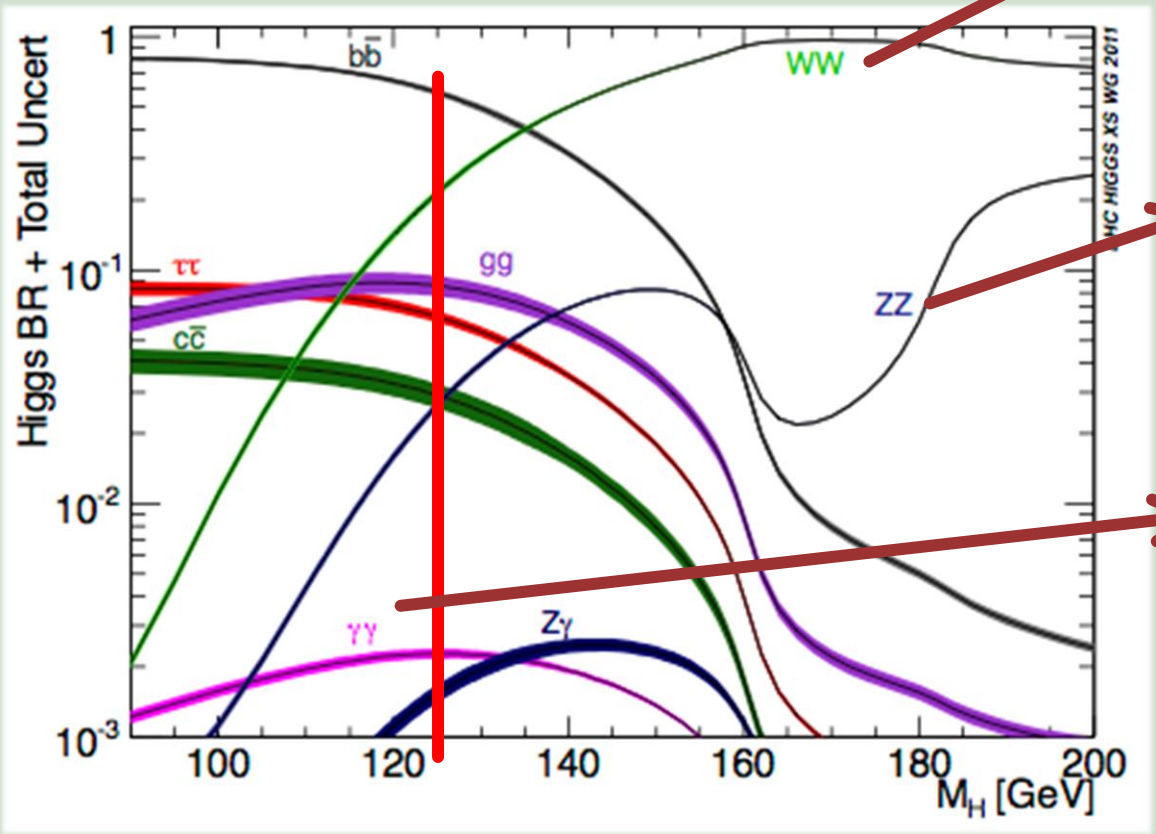








HIGGS DECAY CHANNELS

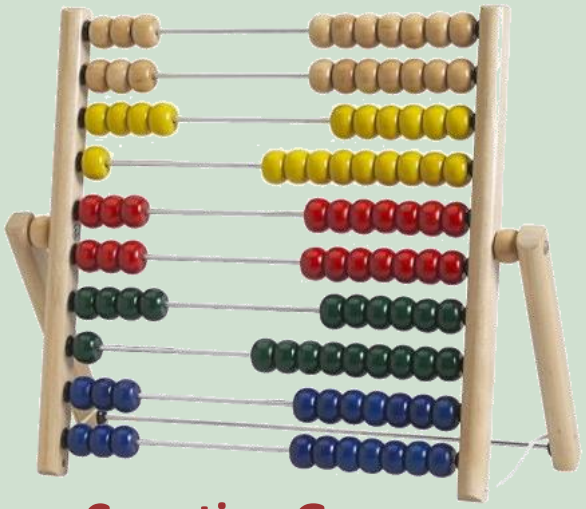


- H -> WW
  - Large Signal
  - Large background
  - Neutrinos
- H -> ZZ
  - Neutrinos
  - 4l = Clean signal
    - Rare
- **H -> γγ**
  - Clean signal
  - Significant background
  - Probes production mechanism well
  - Simpler final state

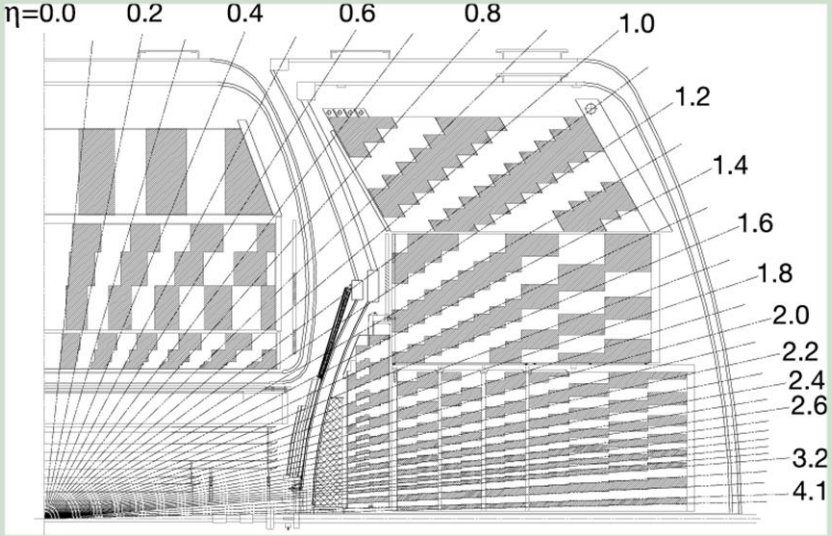
MEASURING THE HIGGS CROSS SECTIONS

- What do we count?
- Event Selection (Higgs -> γγ)
  - Events must have 1 collision vertex with three inner tracks $P_T > 400$ MeV
  - Photon clusters must have $P_T > 25$ GeV and $|\eta| < 2.37$
  - Two highest photons selected
  - $105 \leq m_{\gamma\gamma} < 160$ GeV
  - Leading (subleading) must satisfy $p_T / m_{\gamma\gamma} > 0.35$ (0.25)
- Veto electrons/Muons
- Jets must be seperated from photons by $\Delta R > 0.4$

$$\Delta R = \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2}$$

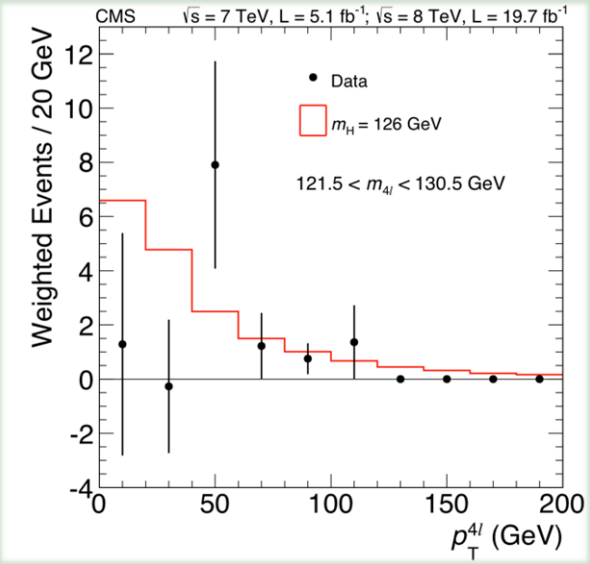


Counting Game

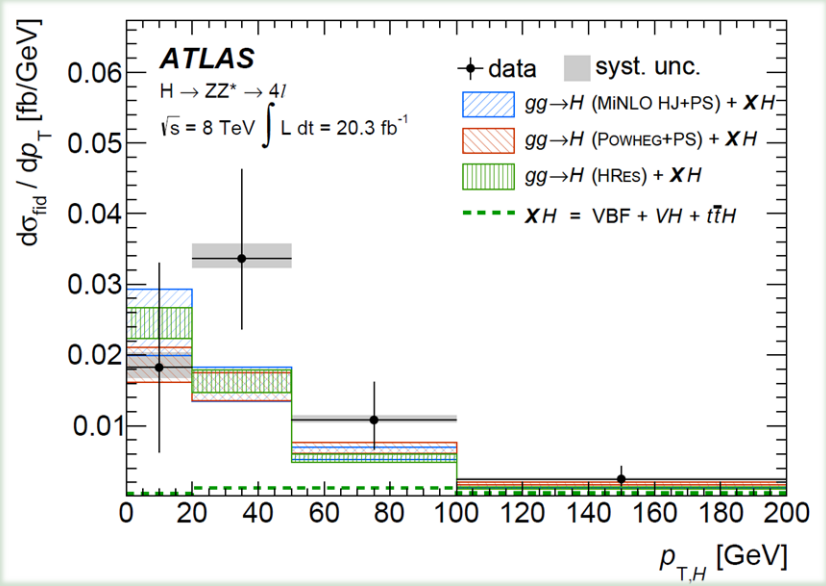


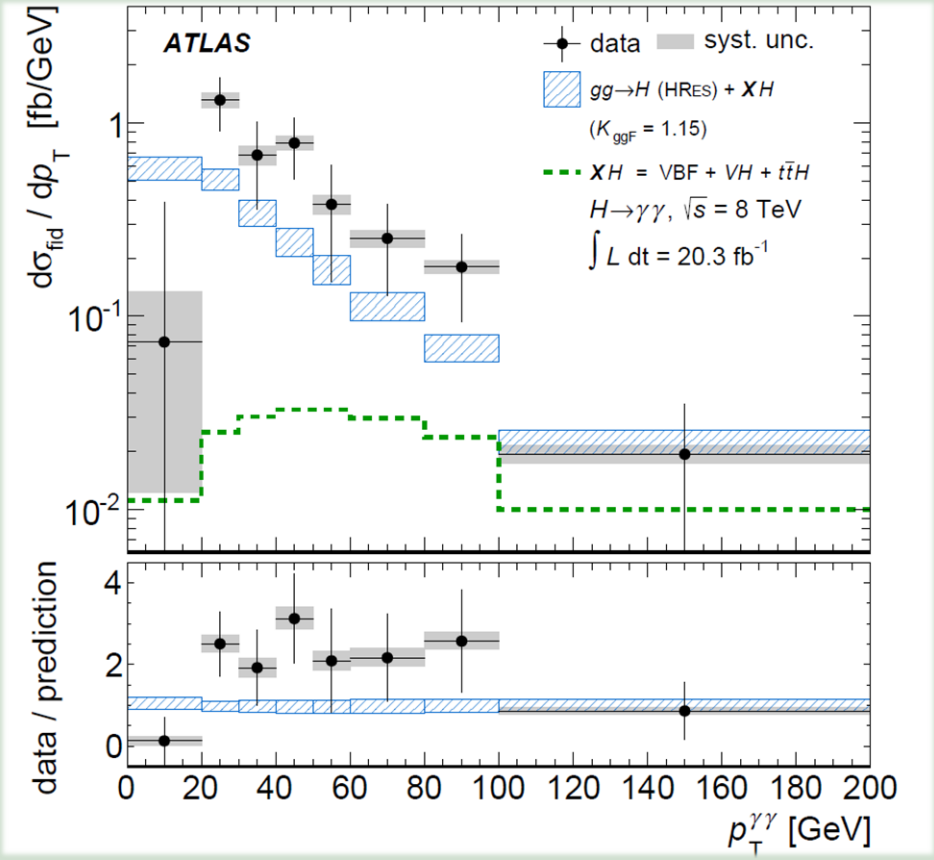
Pseudorapidity Range

P_T DISTRIBUTIONS ($\gamma\gamma$ & 4l)



- Insights into the Higgs boson kinematics.
- Probes perturbative-QCD of gg fusion.

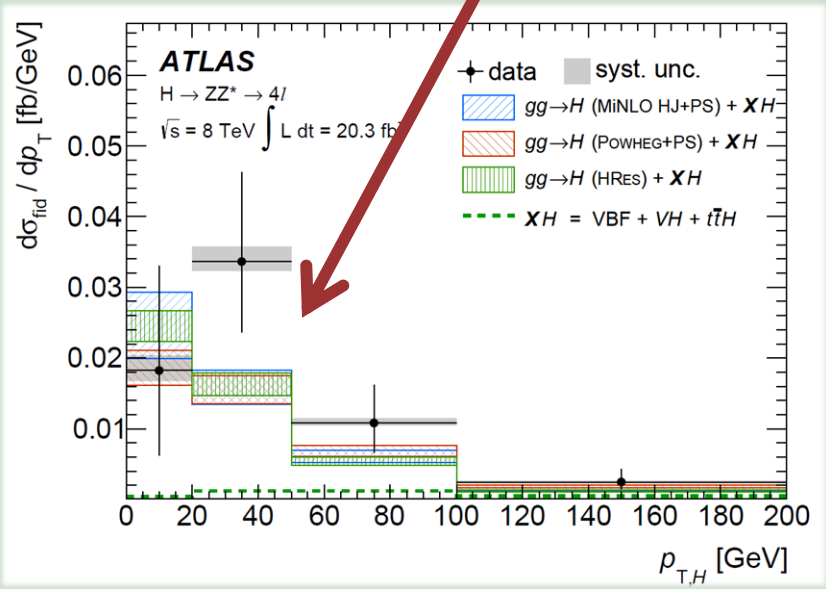


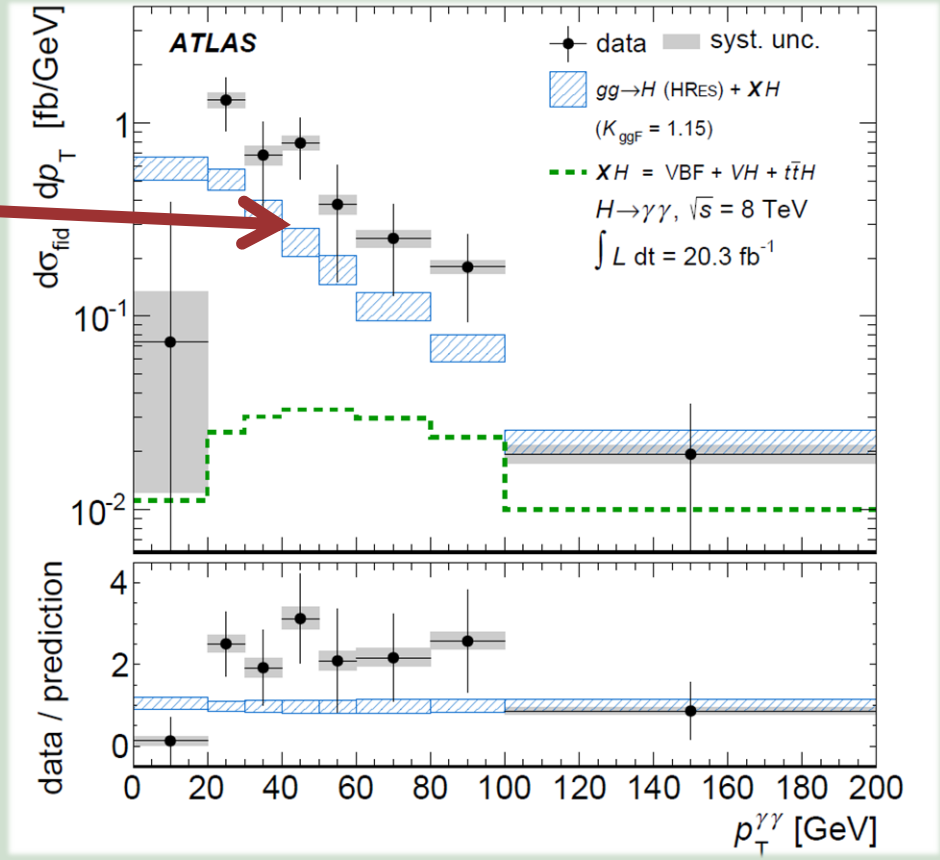


P_T DISTRIBUTIONS

- We observe an excess in the Higgs P_T
- How significant of an excess?
  - Using Kolmogorov Test

Excess?



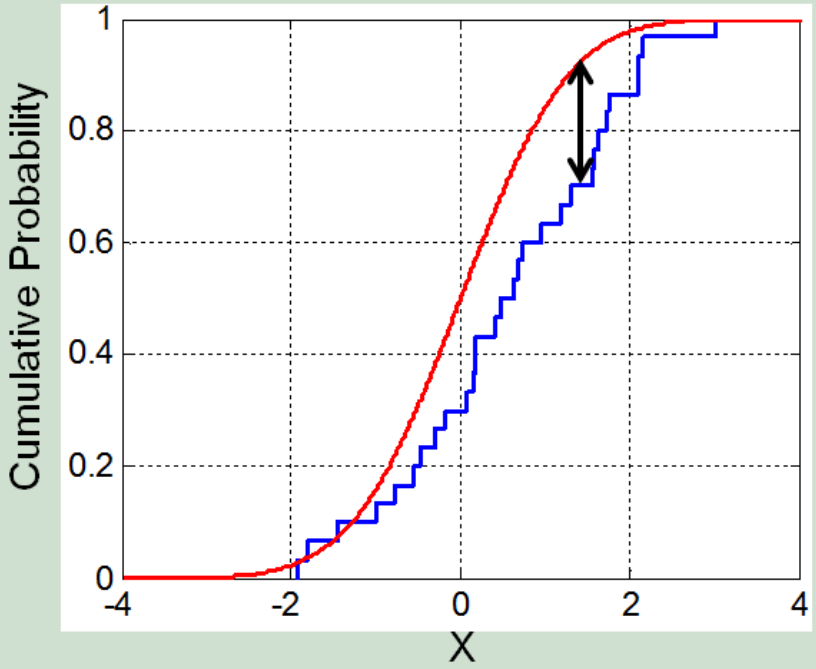


KOLMOGOROV - SMIRNOV TEST

- K-S test statistic (two sample) defined by:

$$D_{n,n'} = sup_x \left| F_{1,n}(x) - F_{2,n'}(x) \right|$$

Supremum (max) of the set



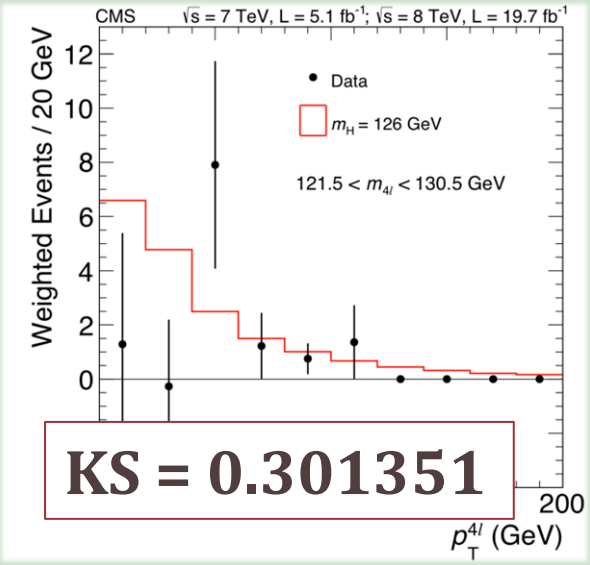
Empirical Distribution Function

$$F_n(x) = \frac{1}{n} \sum_{i=1}^{n} I_{X_i \leq x}$$

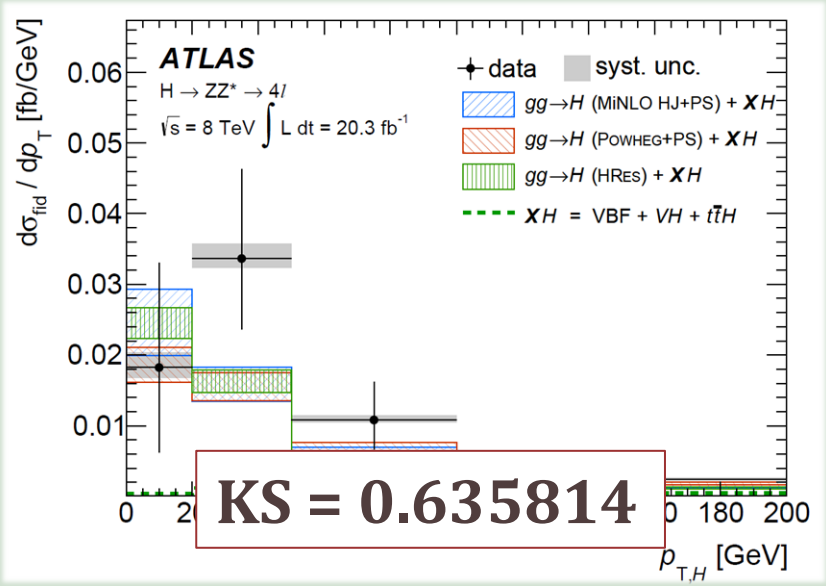
Indicator Function

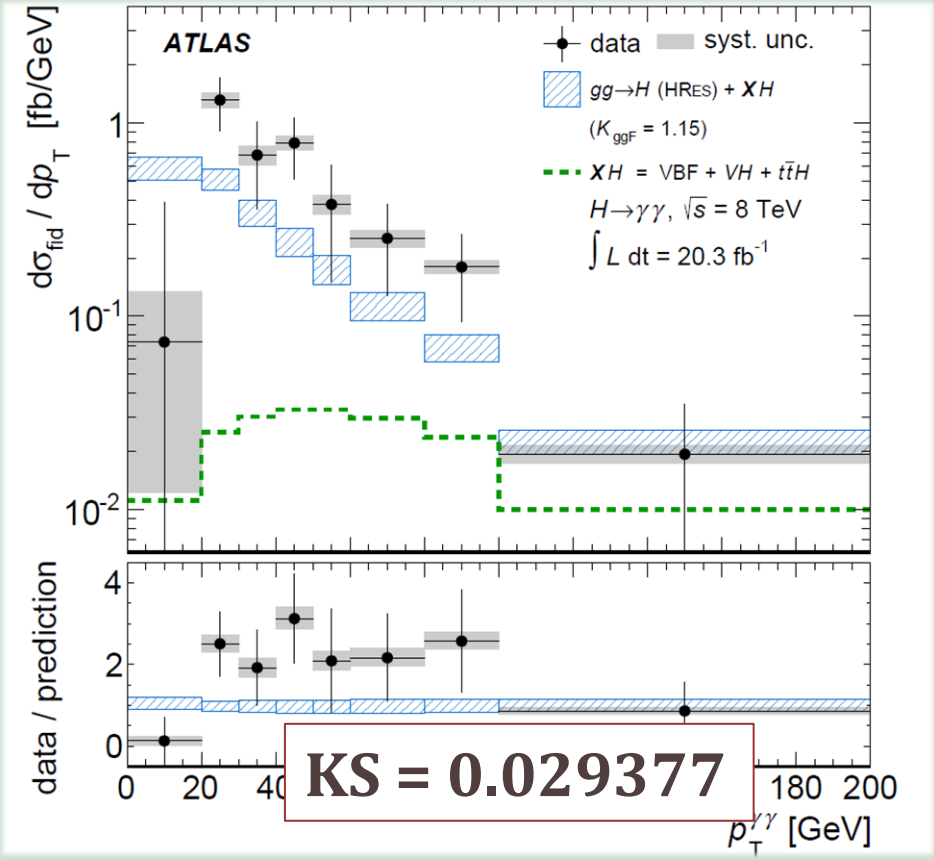
$$I_{X_i \leq x} = \begin{cases} 1 \; if \; X_i \leq x \\ 0 \; if \quad else \end{cases}$$

KOLMOGOROV - SMIRNOV RESULTS



- Total KS value is a product of all probablities
- $KS_{total} = 0.00563 \sim 2.8 - 3\ \sigma$





SUMMARY AND PLANS

- Seeing an **excess** in the Higgs P_T spectrum
  - Statistical fluctuation? (Possibly, 2015 data taking)
  - Some new BSM physics? (Possibly, see talk by Stefan)
- Kolmogorov Test
  - Product showing around 3σ significance
- Issues with the KS Test
  - Weak for small bin number (such as this case)
  - Not ideal for models based on data (Likelihood fits etc)
- Use a likelihood ratio test
  - Need the actual data sets
  - Need to redefine the test to use SM as null hypothesis & use with a different model (Dark Matter etc)

Questions?

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No frogs were harmed in the making of this presentation