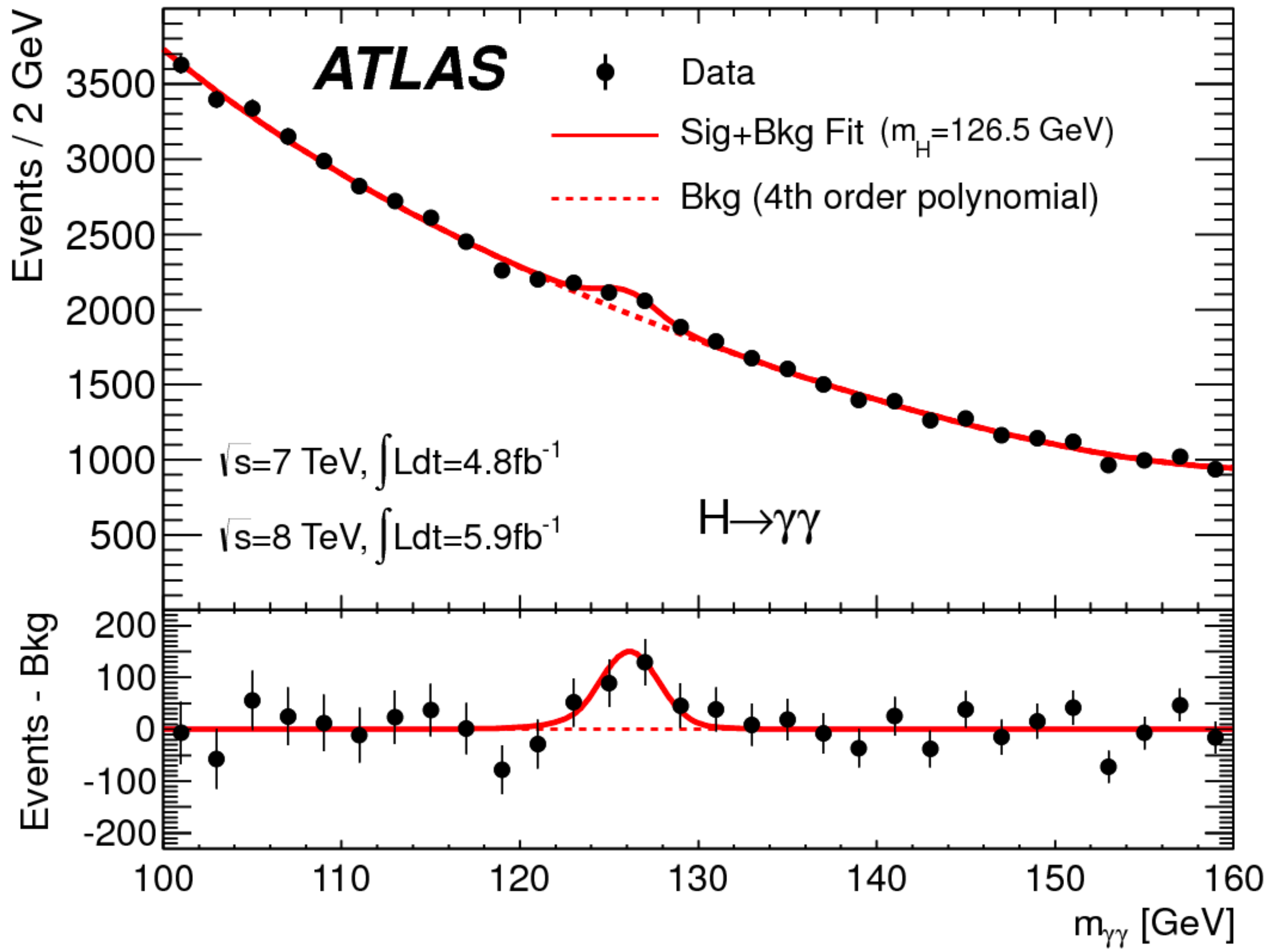


Lecture 10

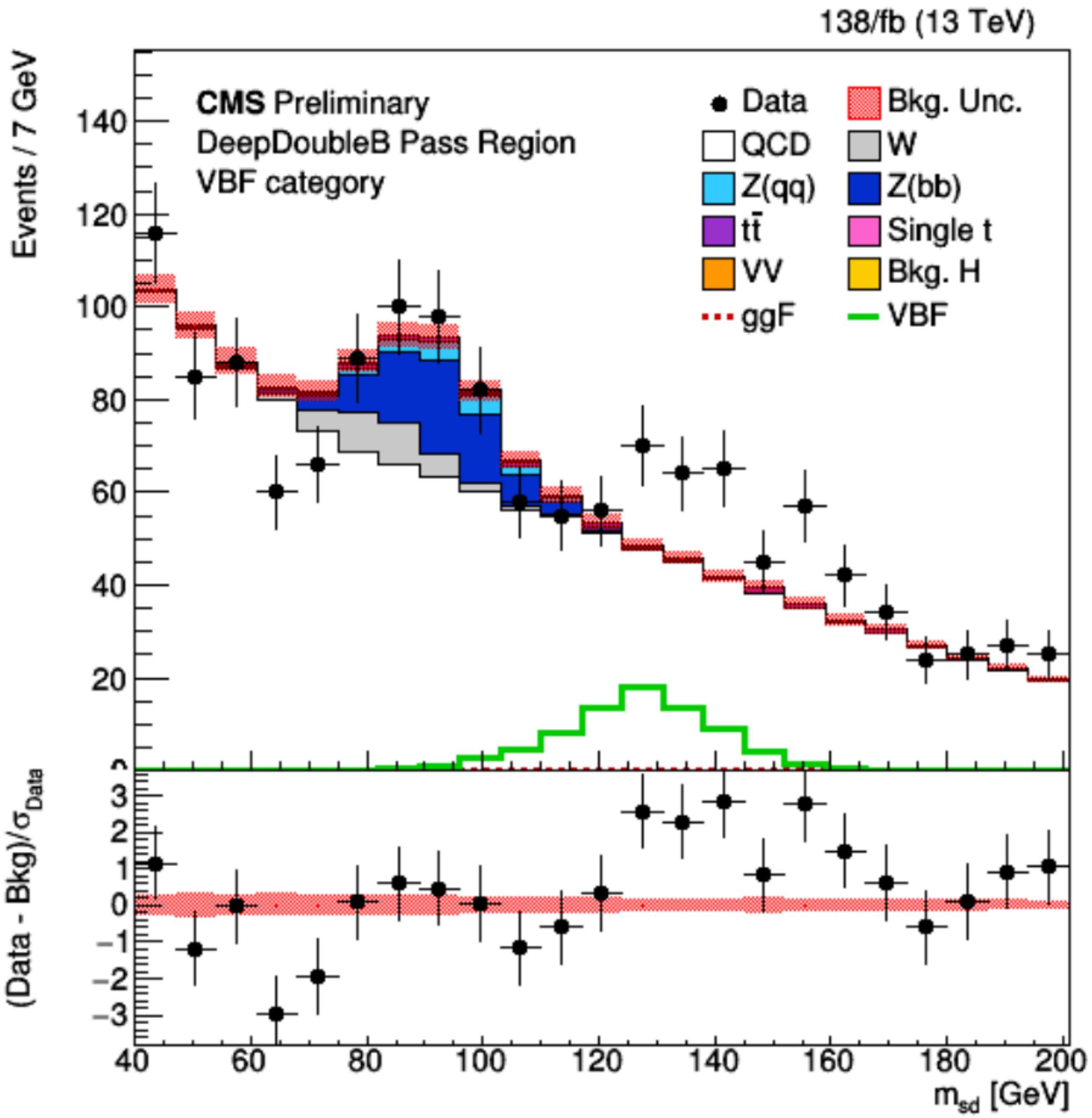
Higgs Boson Discovery
Towards Deep Learning

Blind Analysis

By Judgingunbiased
the analysis
Without knowledge of
the result
you remain unbaised

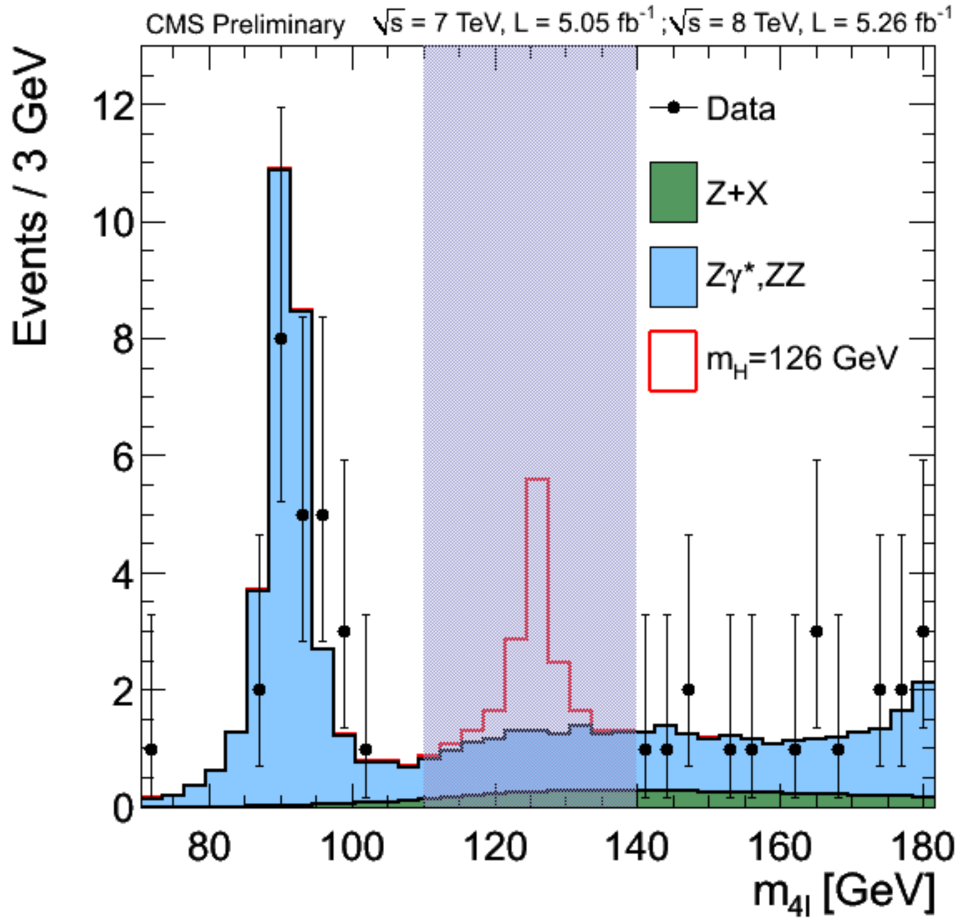
- Strategy :
  - Don't look at the signal region with the full selection
    - In this case don't make the Mass Plot
    - You can make plots of other non-sensitive variables
  - Make a simulated sample to tune everything

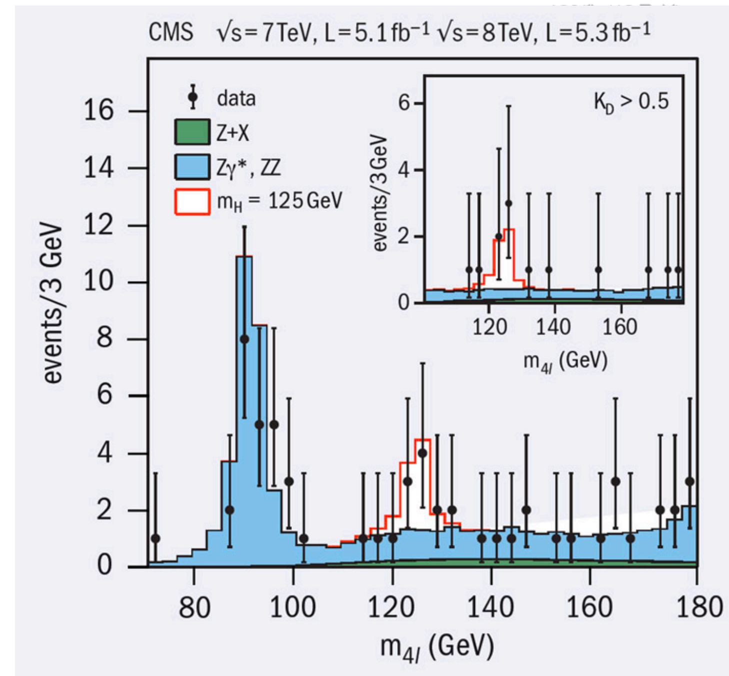
Unblinding



- Once you … box (unblind)
    - Don…
        - C… the sample
        - L… (excluding signal)
        - L…
    - Once you have finally looked at everything you get significance
- https://www.youtube.com/watch?v=KezvwARhBIc

Unblinding



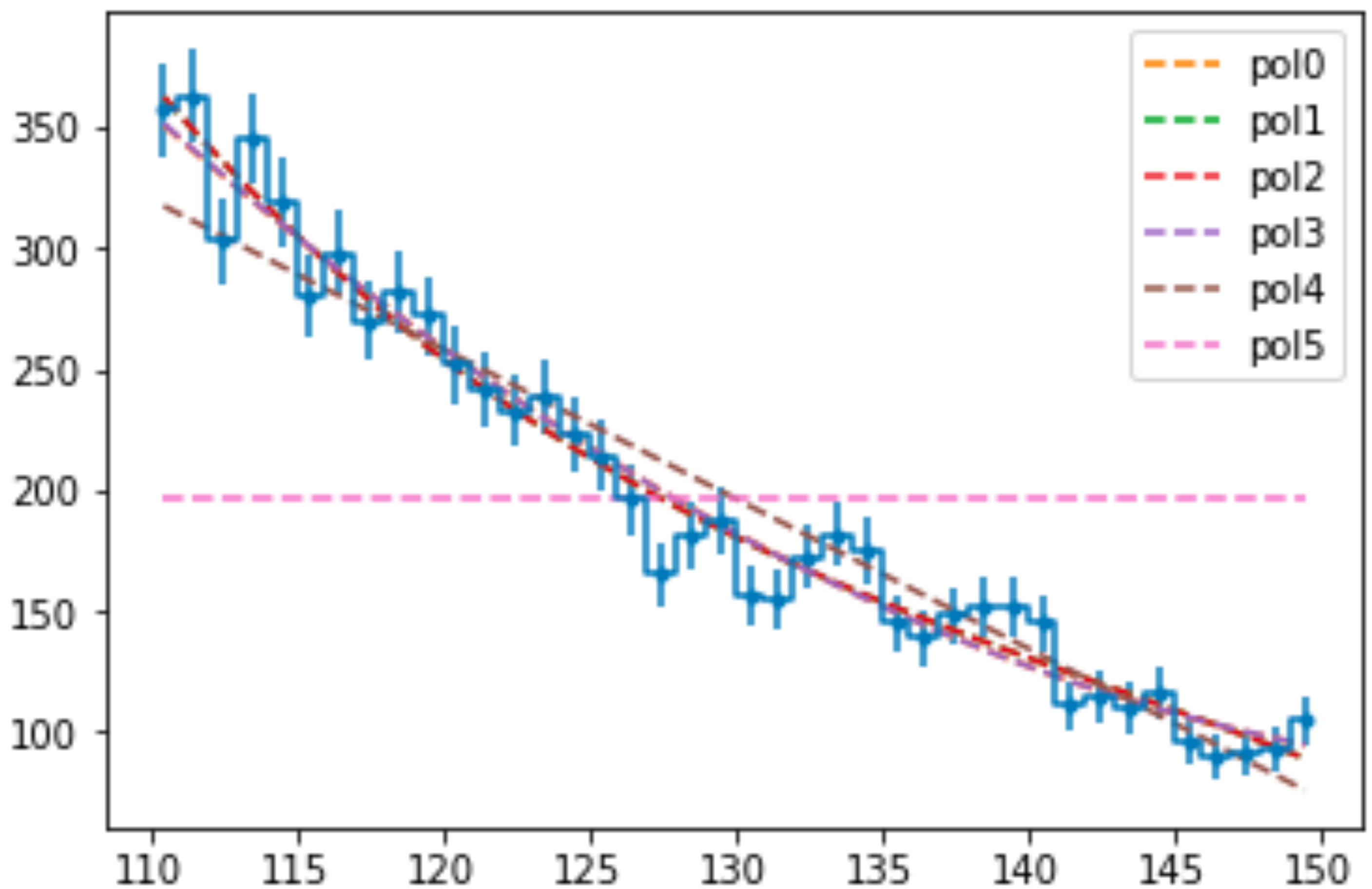


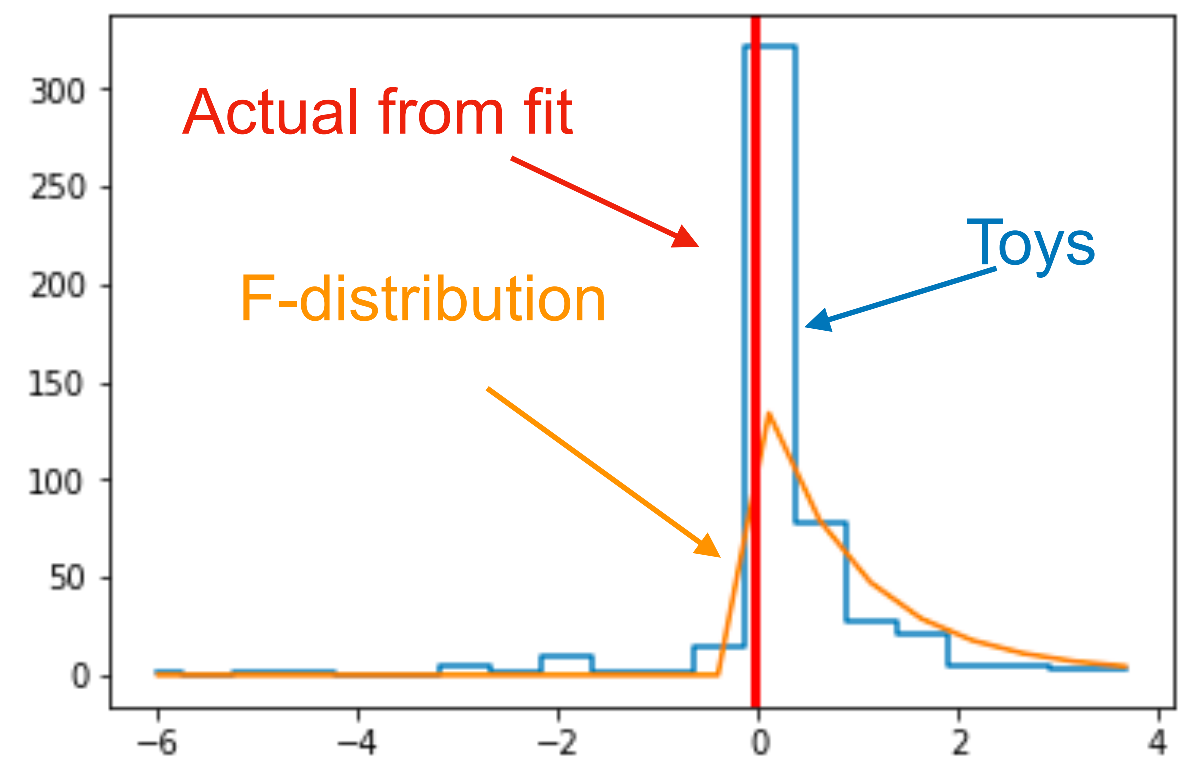
- Once you are ready to search you look in the box (unblind)
  - Done in multiple steps usually
    - Compute the chi2/Goodness of fit of the sample
    - Look at best fit parameters on the fit (excluding signal)
    - Look at the actual Mass plot
  - Once you have finally looked at everything you get significance
- https://www.youtube.com/watch?v=KezvwARhBIc

F-test Example

- Here is an example from previous fit
- Our Actual Δ (x-axis) is consist with a high p-value

Toys: Randomly sample 3rd order dist and fit with 4th order

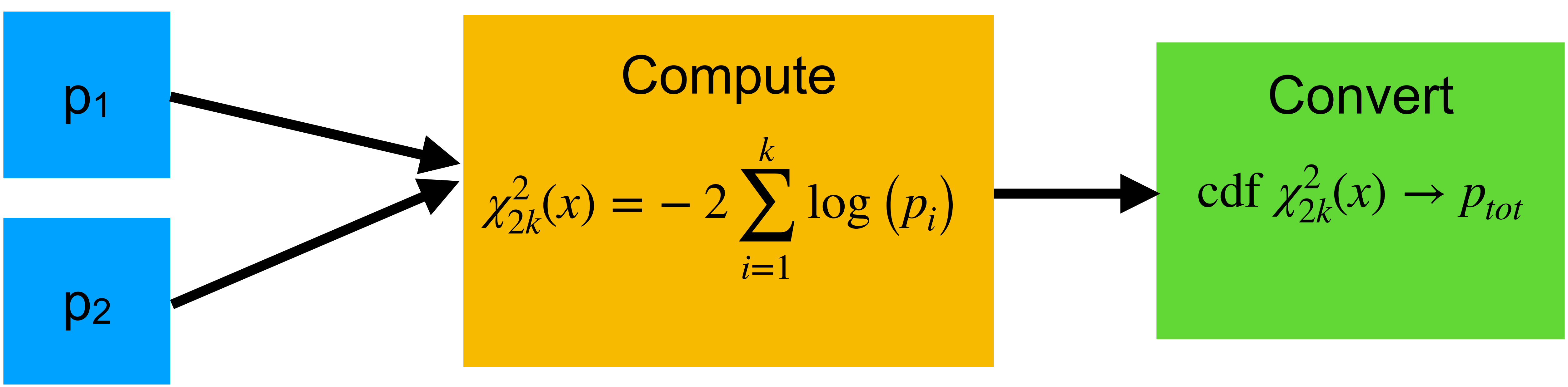




$$\frac{\frac{\mathscr{L}_1 - \mathscr{L}_2}{p_2 - p_1}}{\frac{\mathscr{L}_2}{n - p_2}}$$ For a 4th order to a 3rd order

Combining Categories

- Lets say we have *k* measurements with probability p_i
  - Each measurement is independent of each other
- We can combine categories using the following formula
  - $$\chi^2_{2k}(x) = -2\sum_{i=1}^{k} \log\left(p_i\right)$$
  - Where left is a chi2 distribution with 2k degrees of freedom



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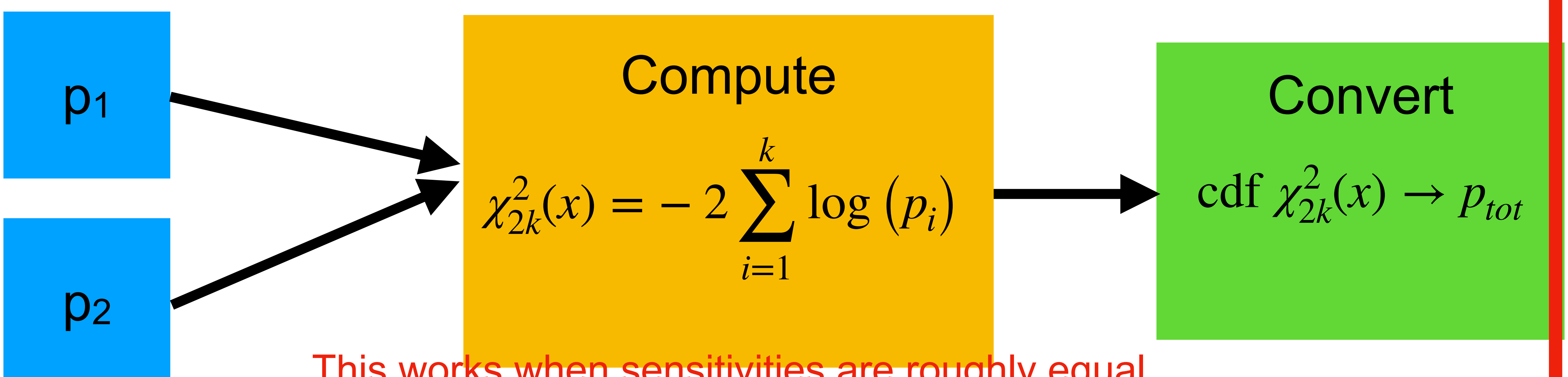
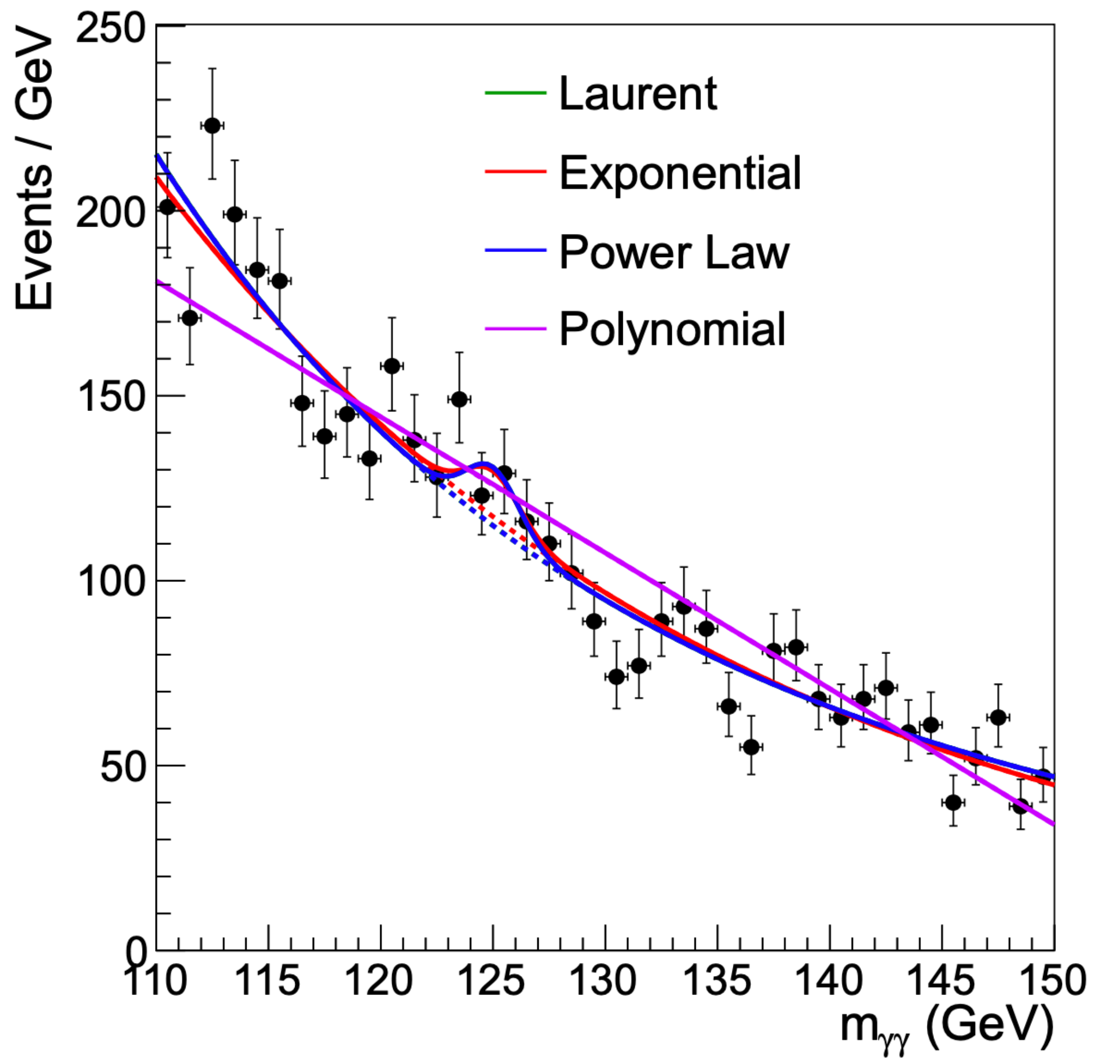
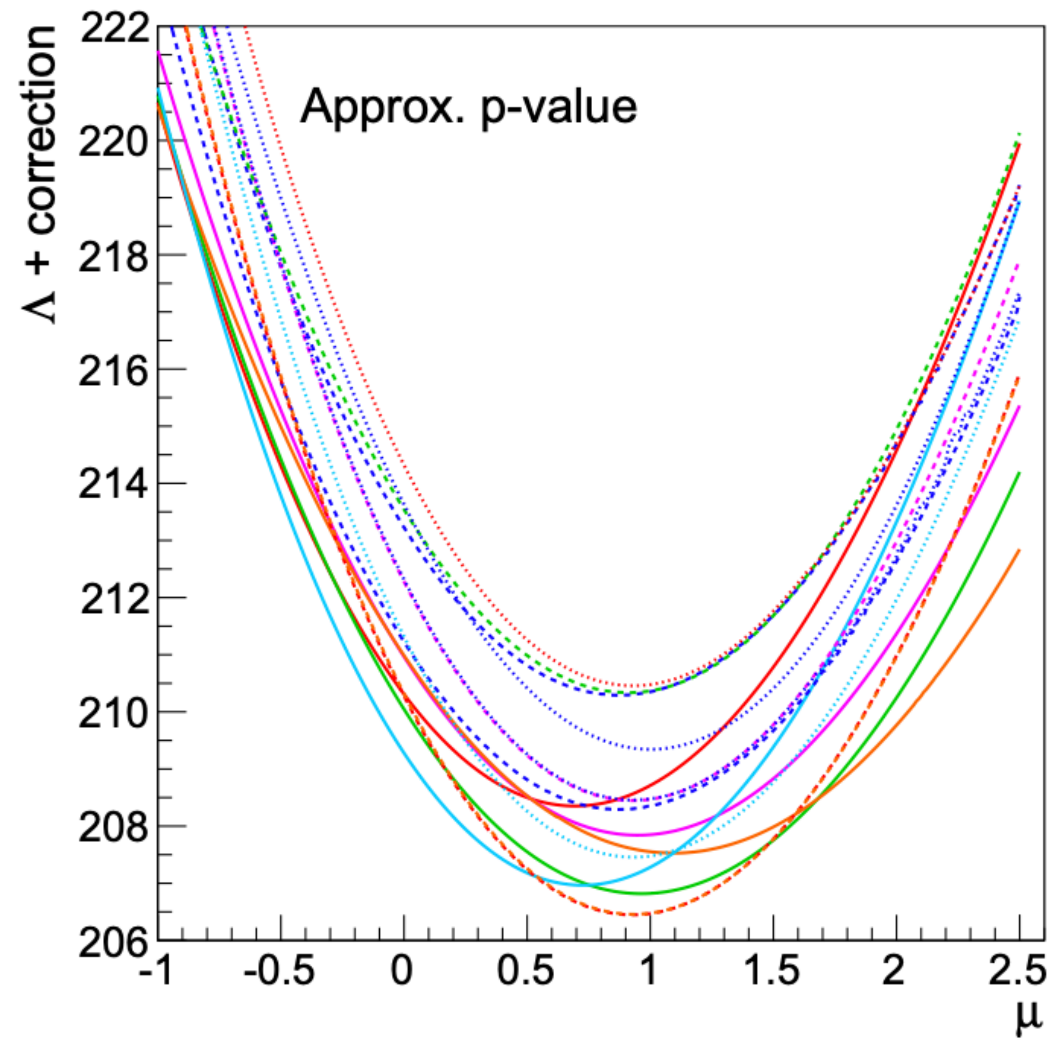


This works when sensitivities are roughly equal
More robust way is to fit all categories simulatneously

Building a Model

- Throwing a barrage of functions at the problem

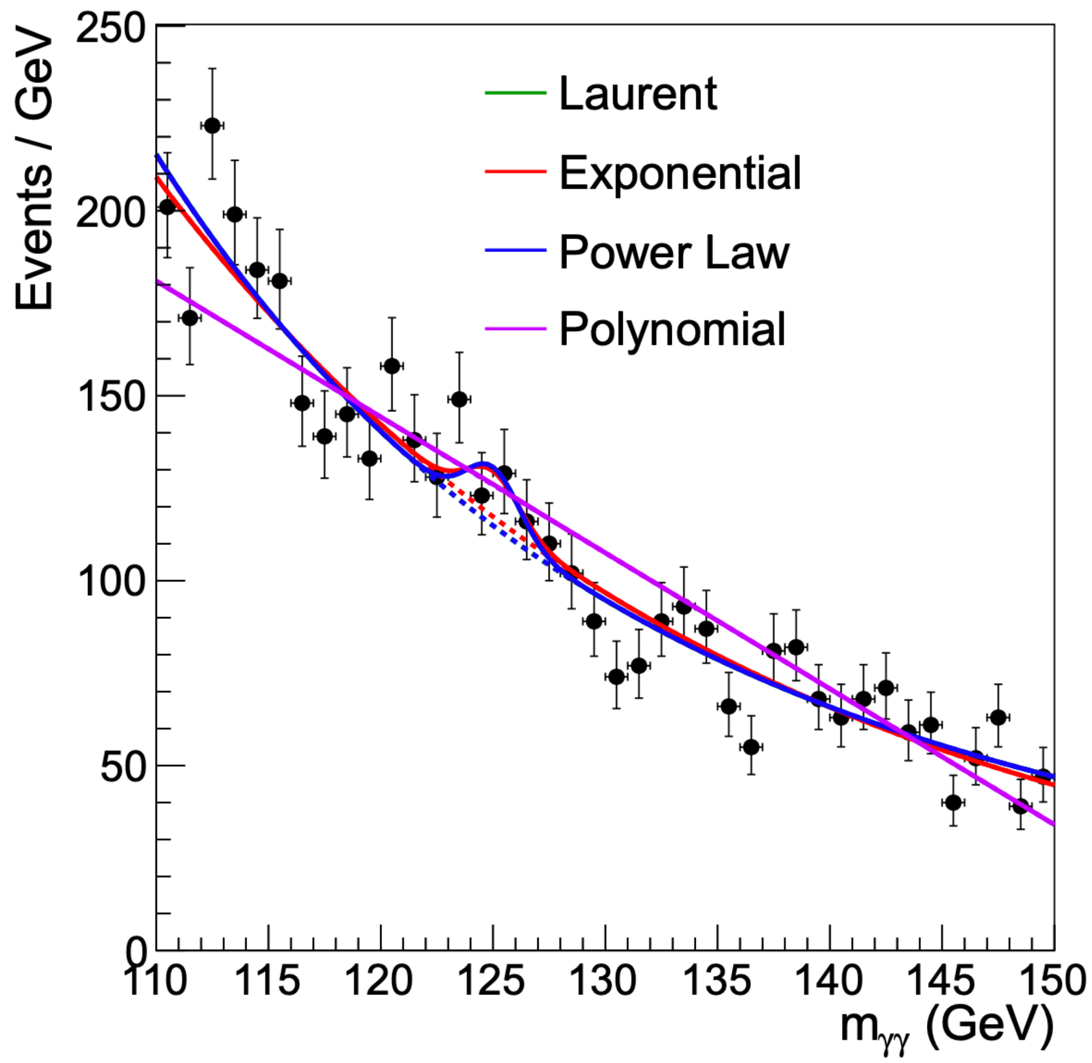


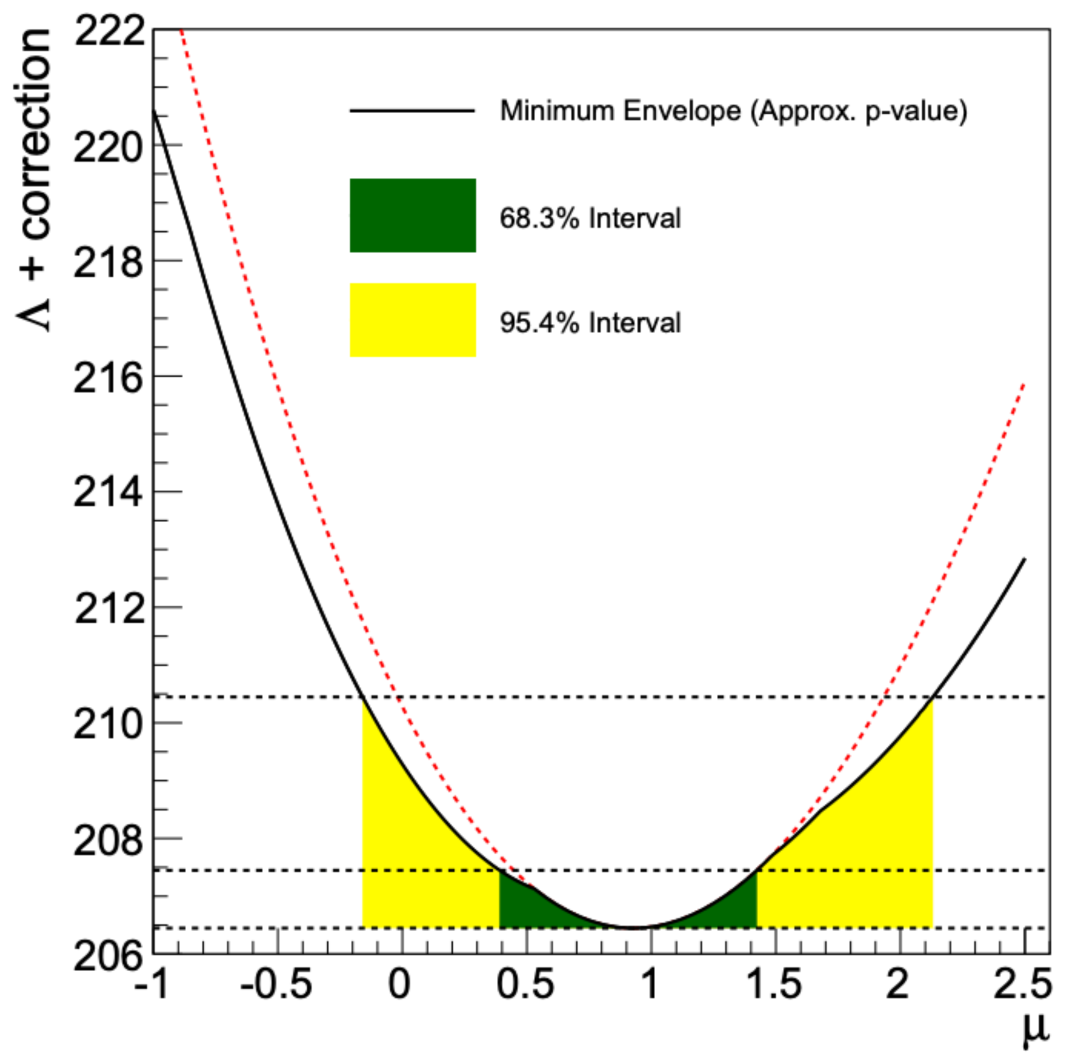


We can try a whole library of functions
The likelihood we get translates to our fit

Building a Model

- Throwing a barrage of functions at the problem

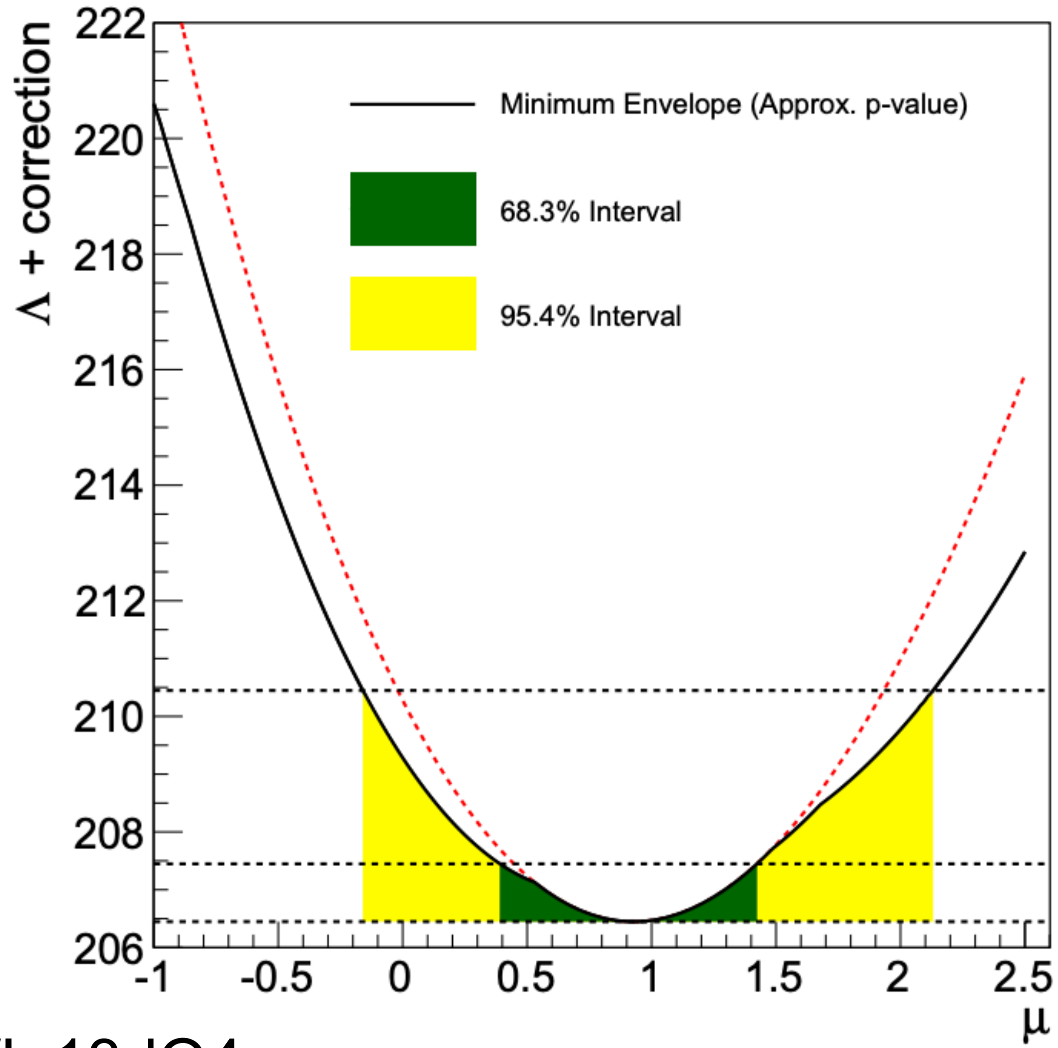




We can try a whole library of functions
The likelihood we get translates to our fit

Combined Likelihood

- Throwing a barrage of functions at the problem

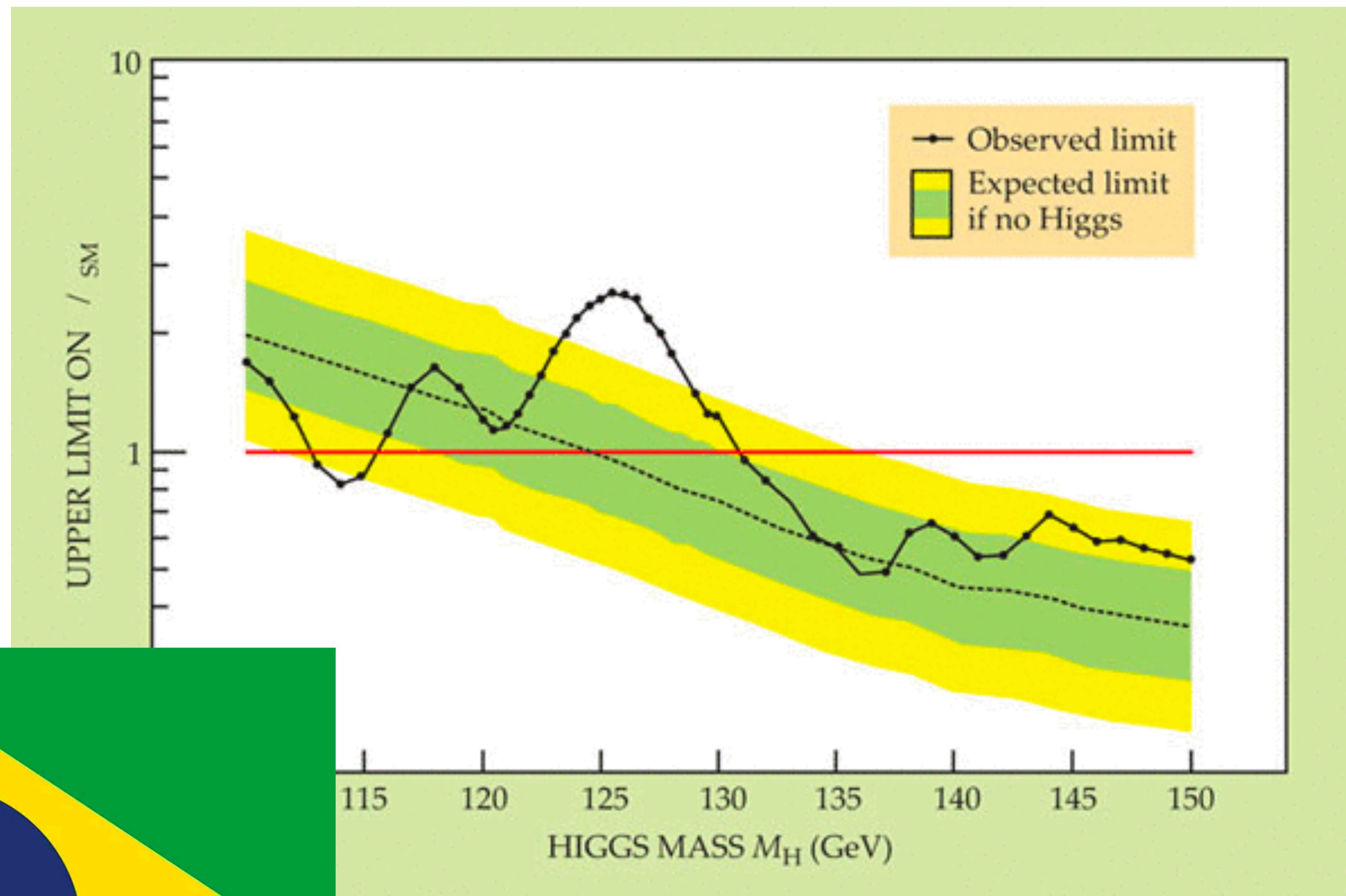


https://www.youtube.com/watch?v=3cHWIp13dQ4

We can try a whole library of functions
The likelihood we get translates to our fit

Brazil Plot

- What is this plot?

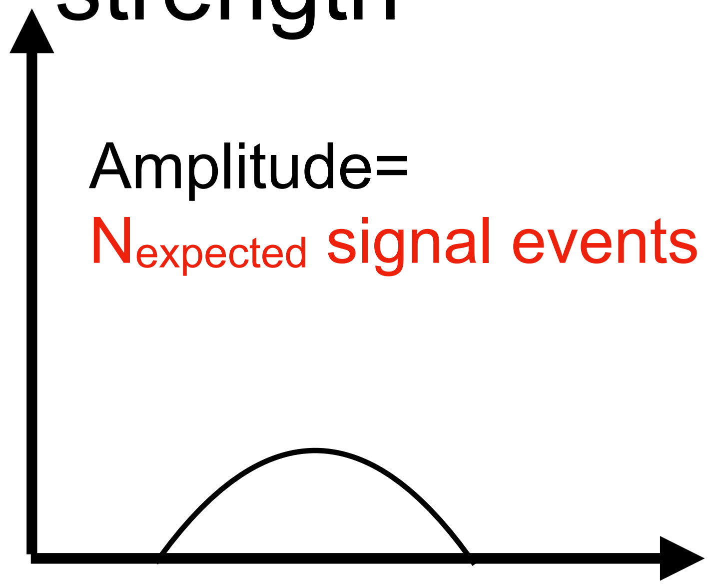


The test of the limits

$$\mu = \frac{N_{\text{observed}}}{N_{\text{expected}}}$$

Null Hypothesis

Higgs signal at a fixed mass and strength



Alt Hypothesis

No signal

What is the 95% confidence level of our signal

Not being there in units of Expected signal strength

The test of the limits

Test Statistic

$$q_\mu = \log(\lambda) = 2\log\left(\frac{\mathcal{L}(\mu = N_{\text{expected}})}{\mathcal{L}(\mu = 0)}\right)$$

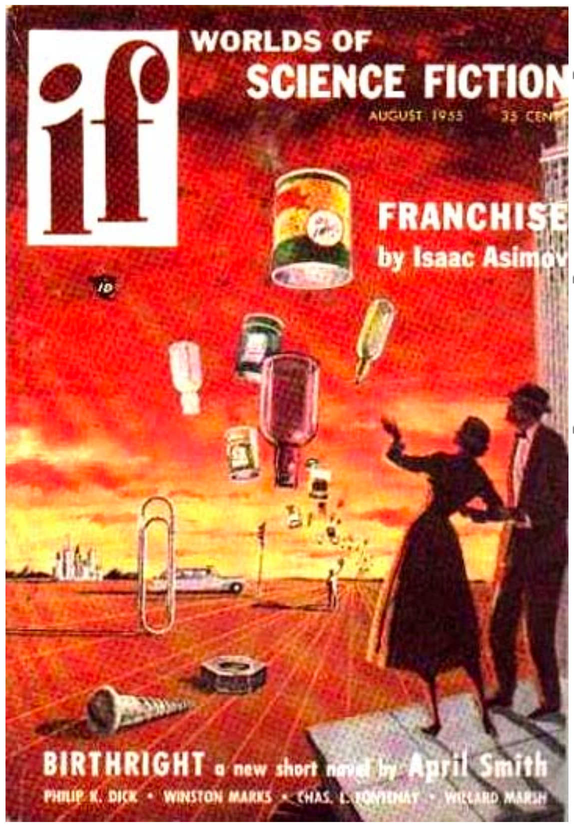
Exclusion : $p\left(q_\mu\right) > 0.95$ following Wilks' theorem

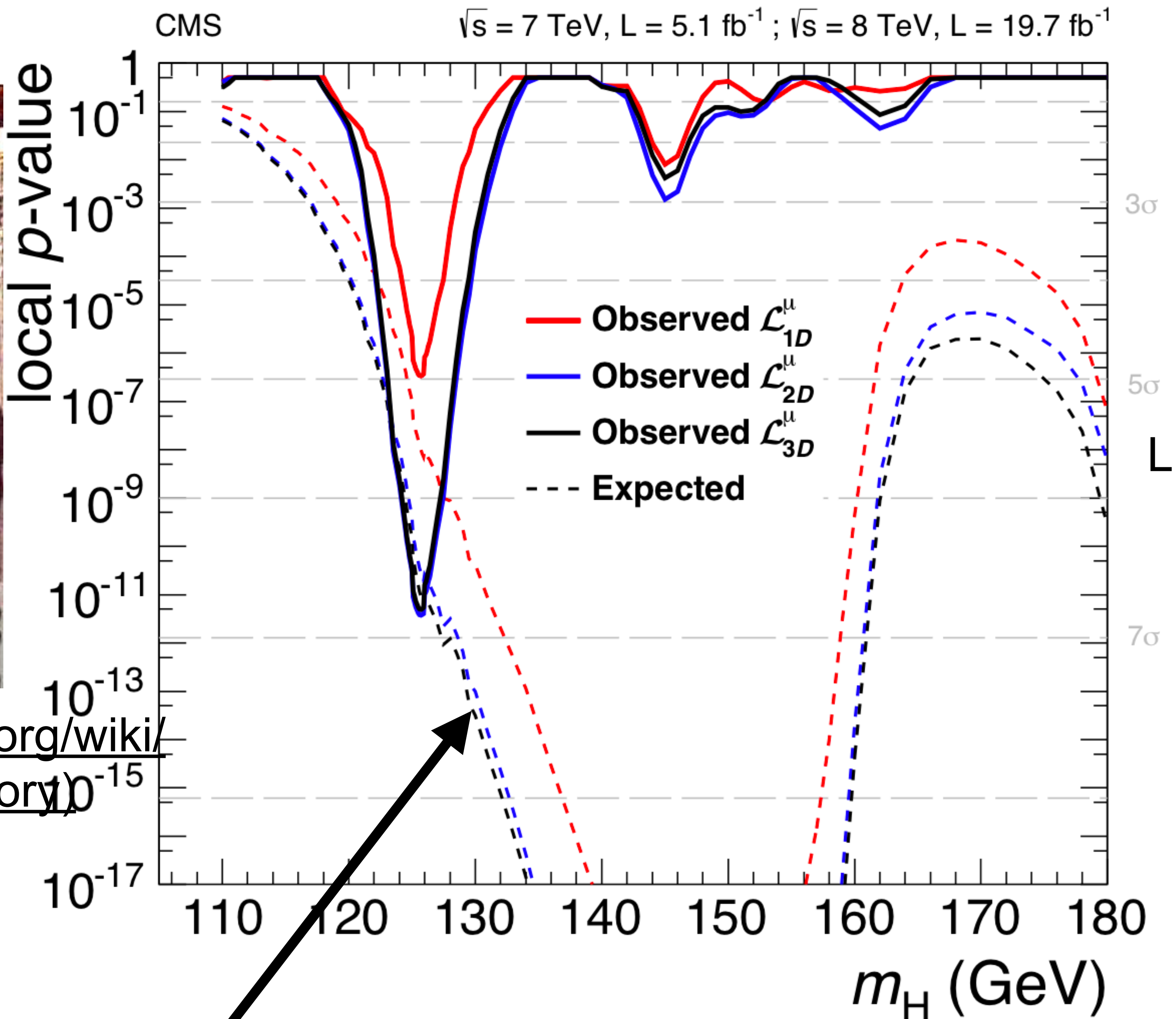
$$q_\mu > \chi^2(p_{95}) = 1.64 \rightarrow \frac{\mu}{\sigma_\mu} > 1.64$$

What is the 95% confidence level of our signal

Not being there in units of Expected signal strength

A p-value view of this





https://en.wikipedia.org/wiki/Franchise_(short_story)

Line is based on the Asimov dataet

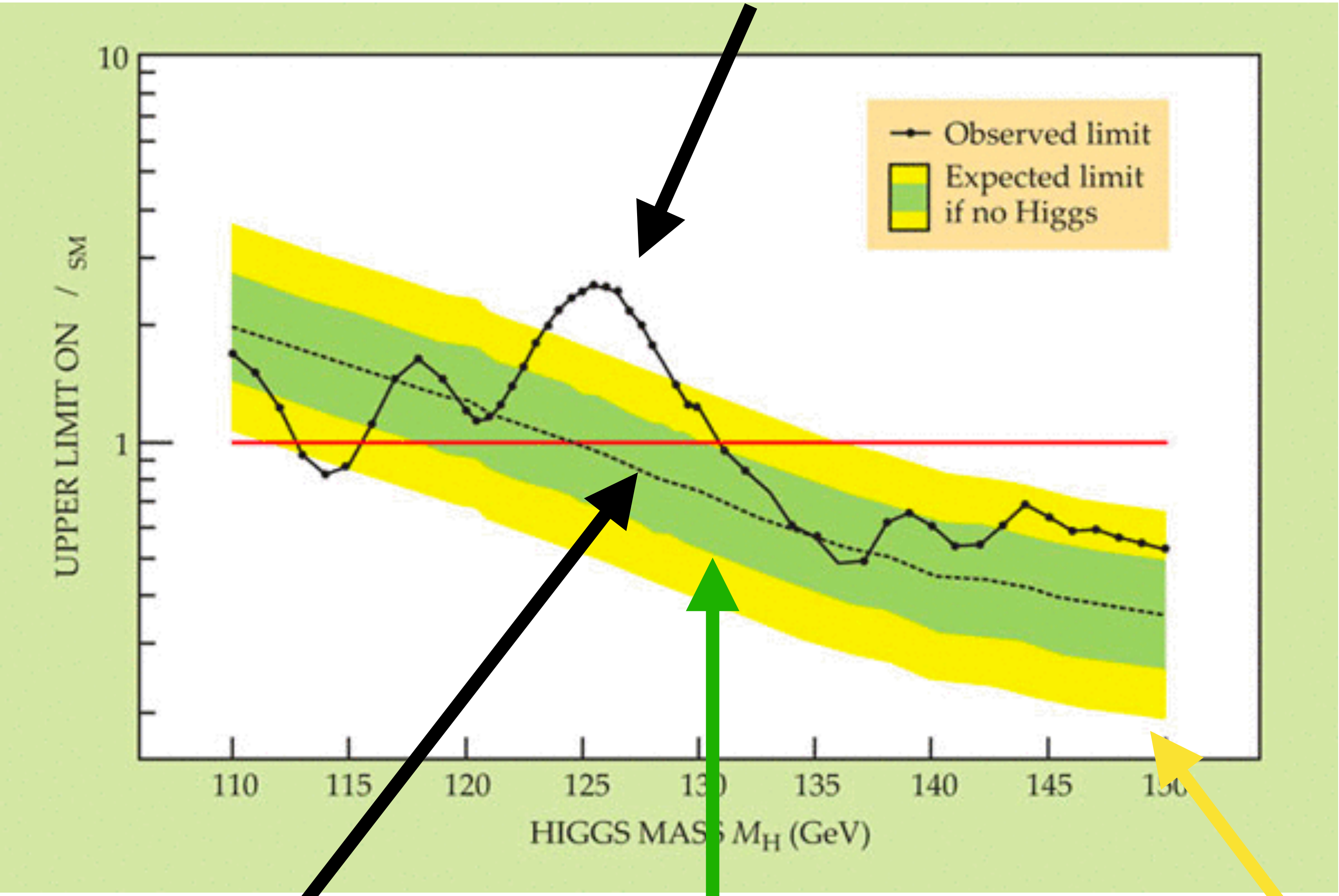
Line we get by running a limit on toy(fake) data with signal ininjected

The expected signal with magnitude by prediction is called the Asimov

Brazil Plot

- What is this plot?

Observed Delta Log Likelihood



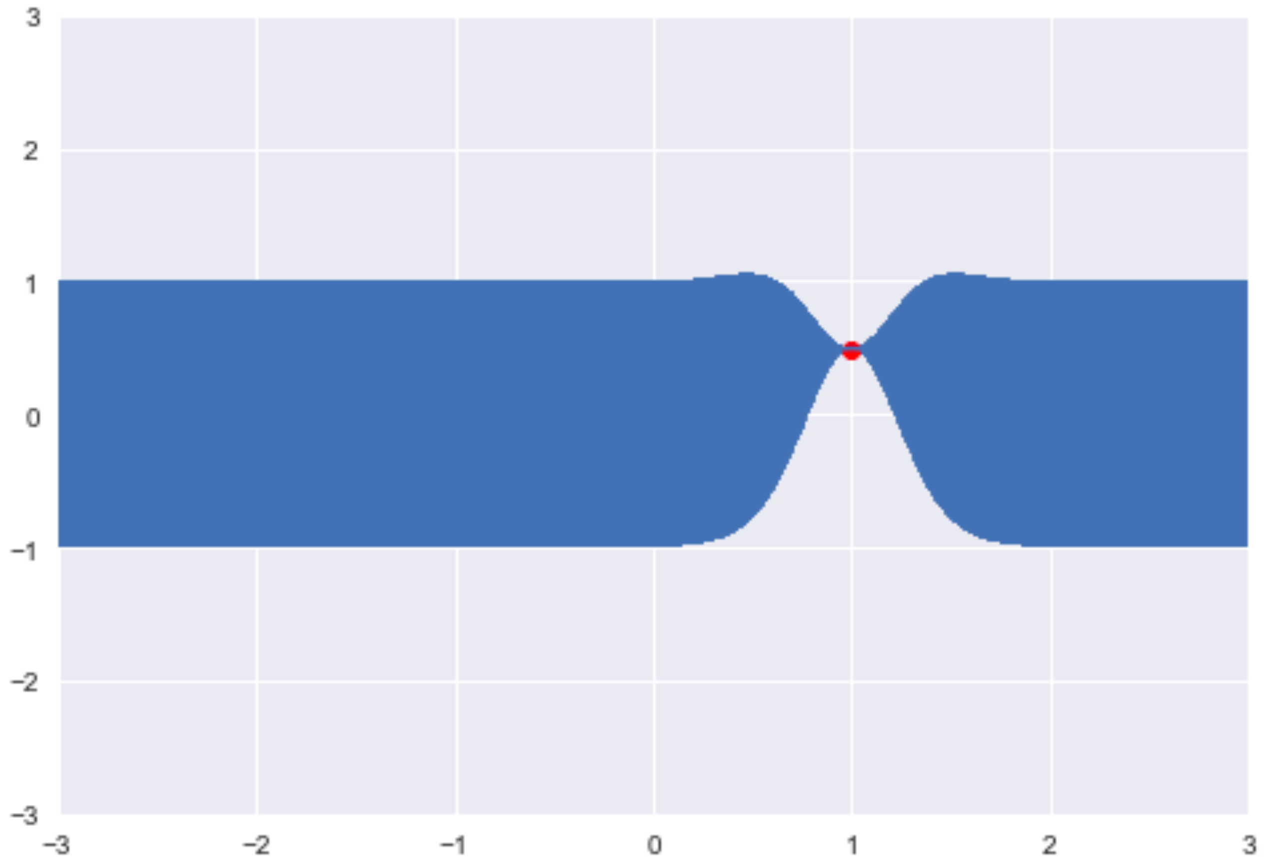
Signal Strength in units Of expected (Defined by prediction)

Expect signal Strength for 95% Exclusion

1 Standard Deviation up and down band

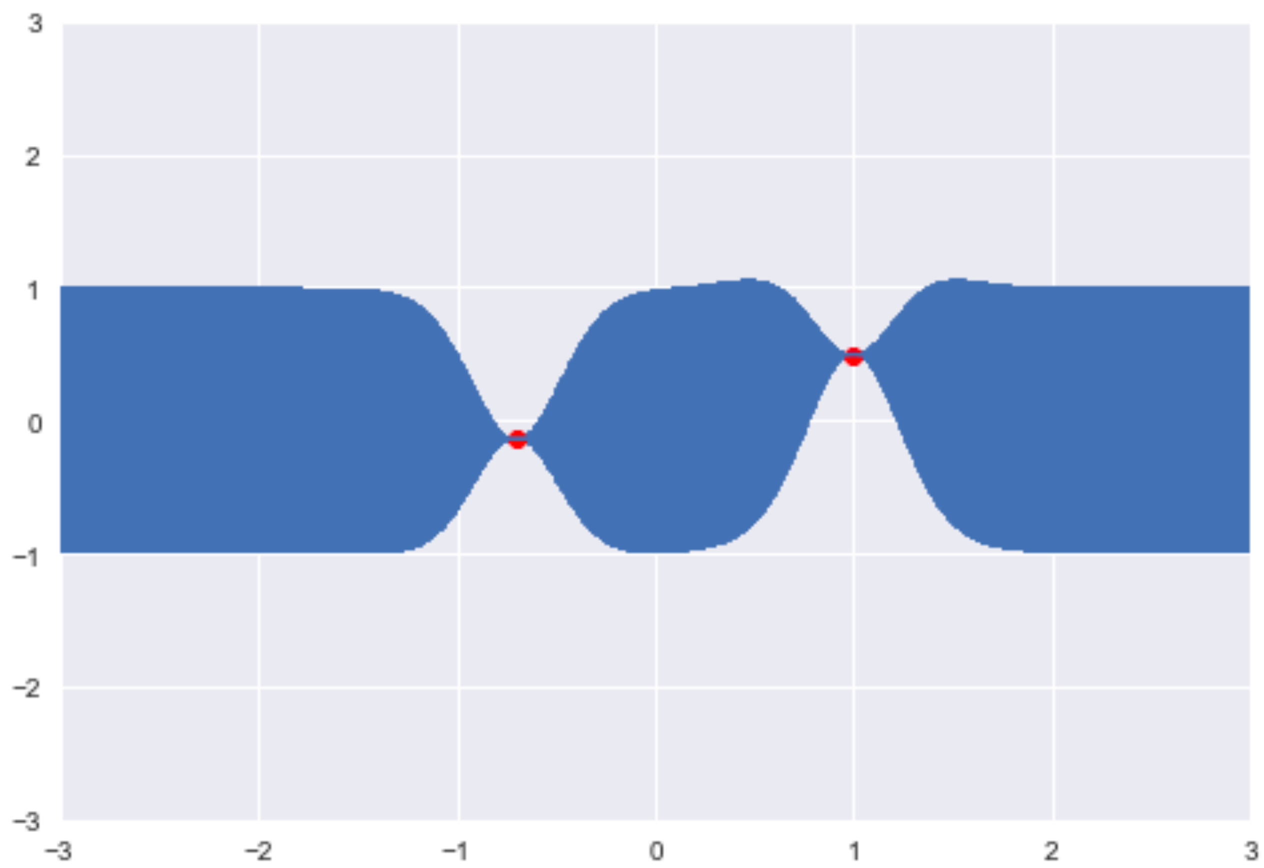
2 Standard Deviation up and down band

Splines+GaussianProcesses



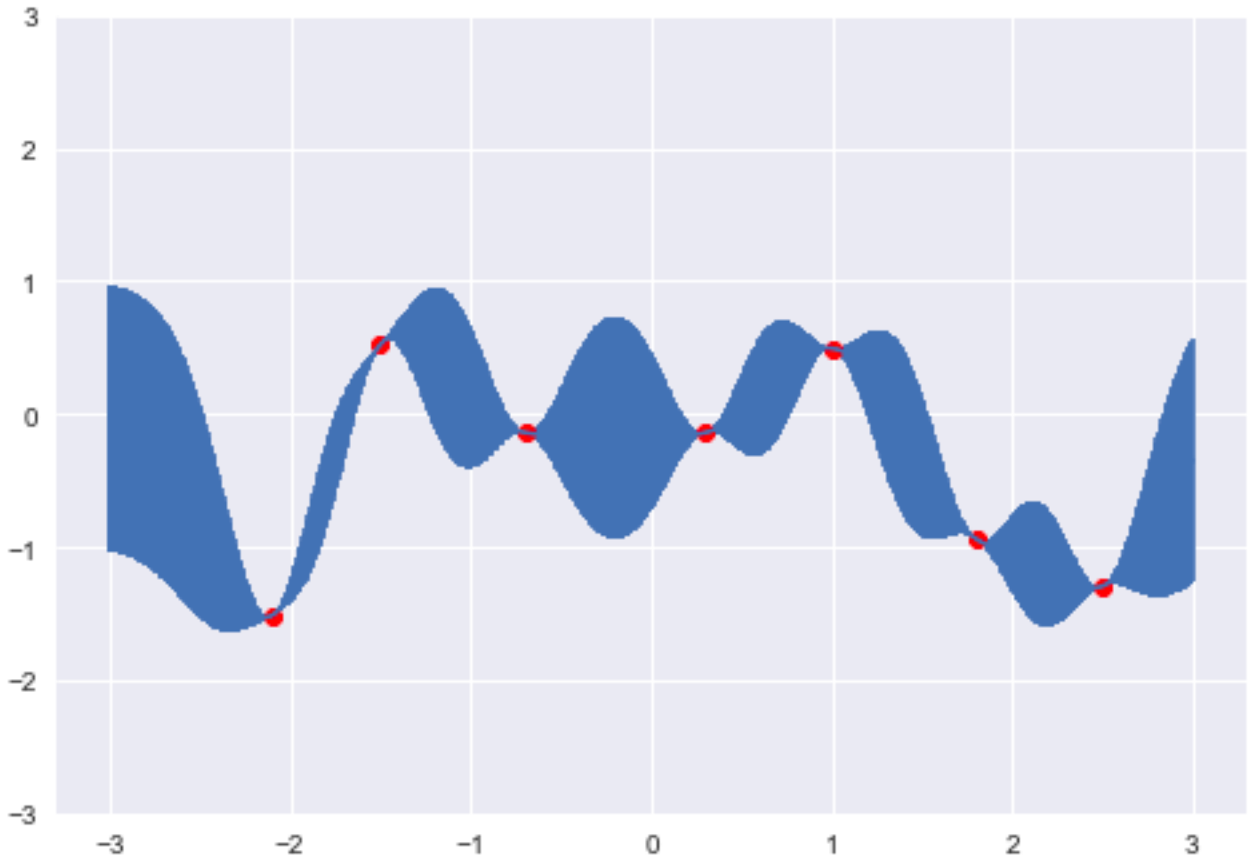
- Gaussian processes allow us to build function choice from the data

Splines+GaussianProcesses



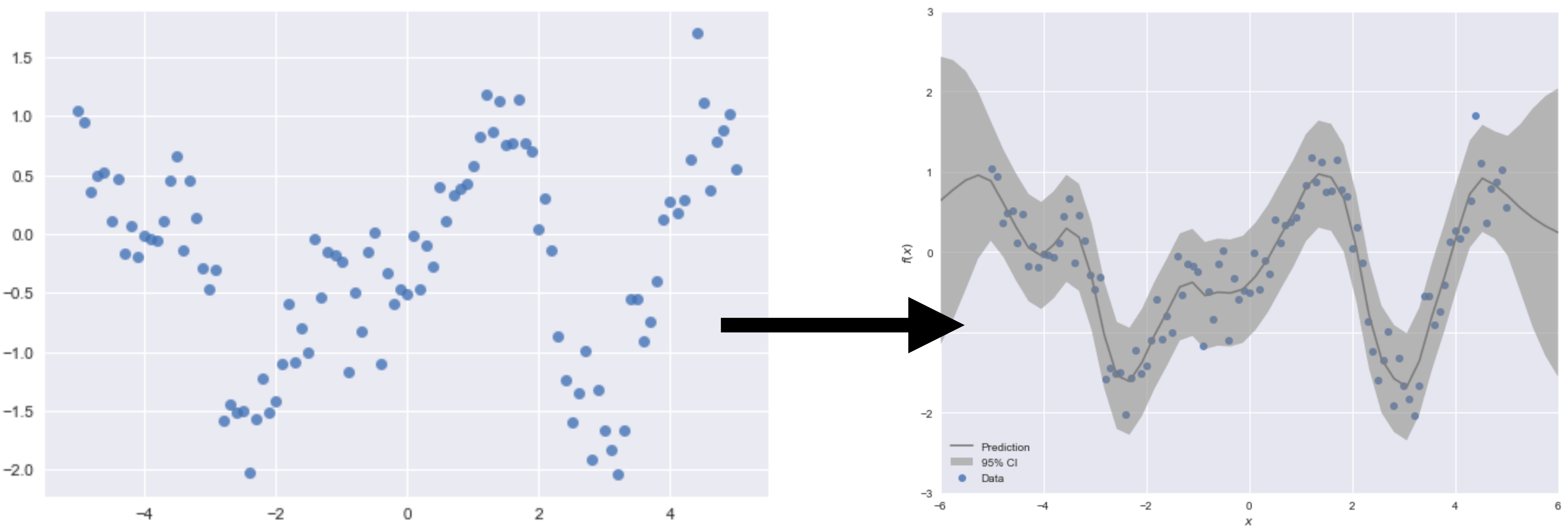
- Gaussian processes allow us to build function choice from the data

Splines+GaussianProcesses



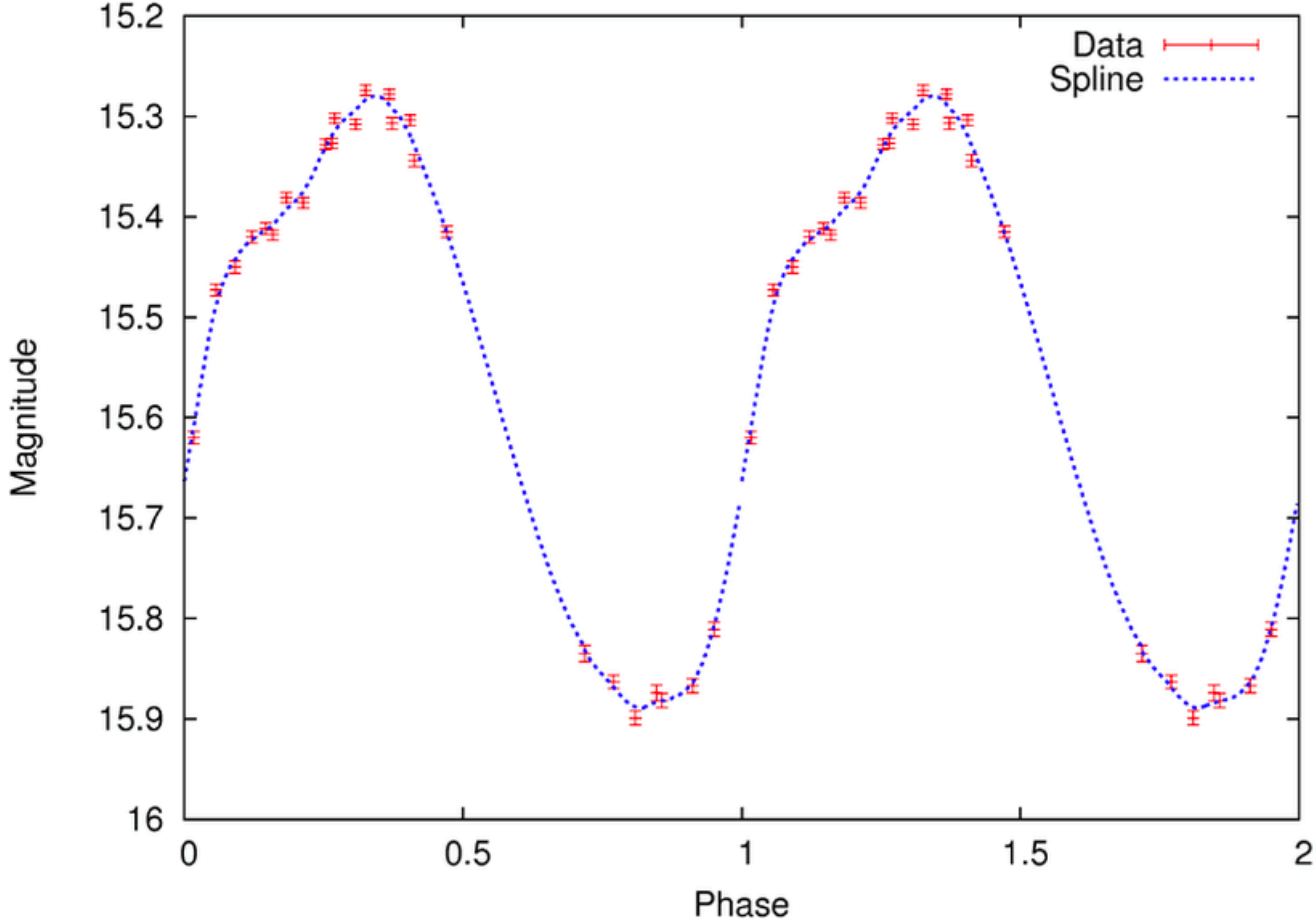
- Gaussian processes allow us to build function choice from the data

Splines+GaussianProcesses



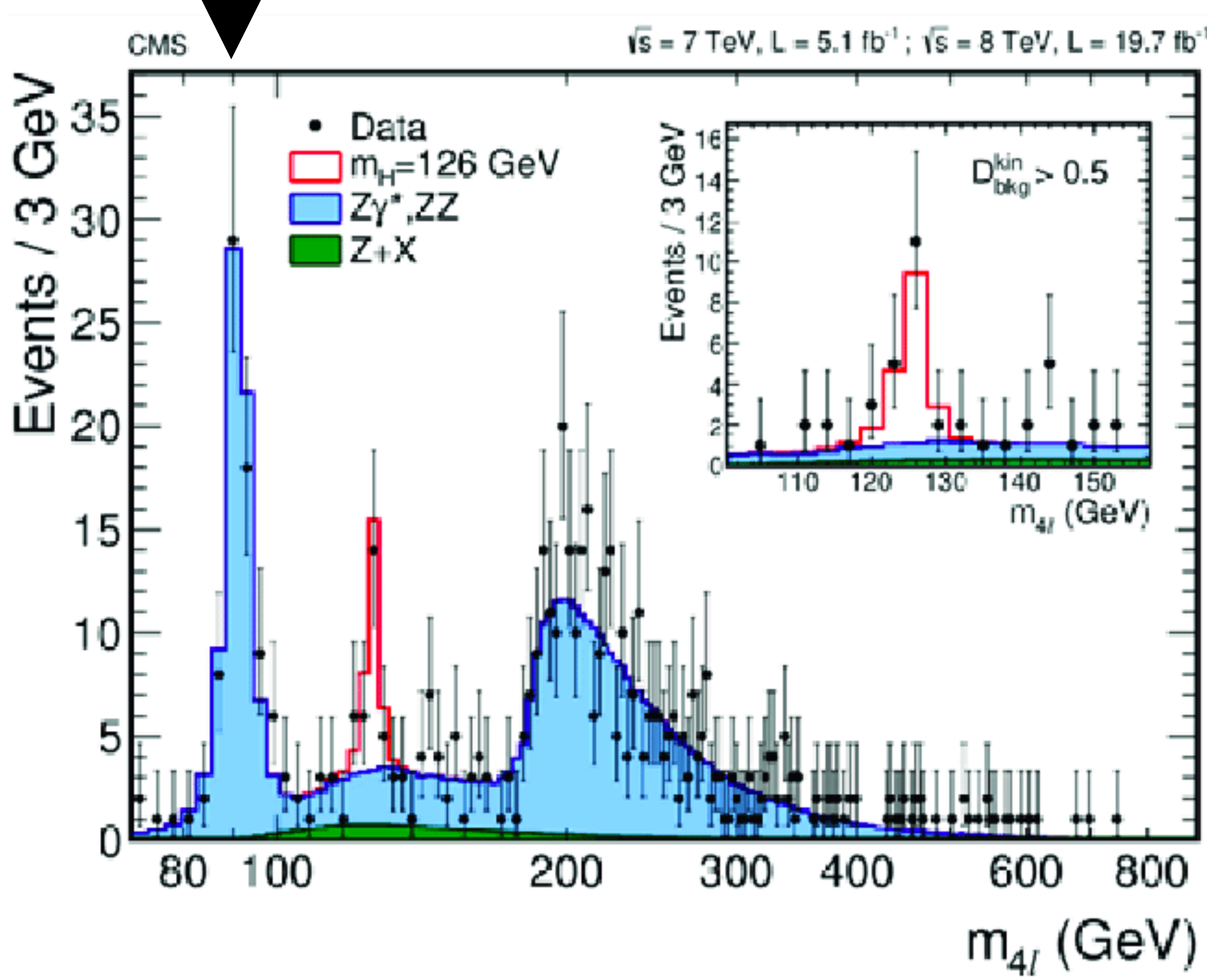
- To go from points to spline automatically

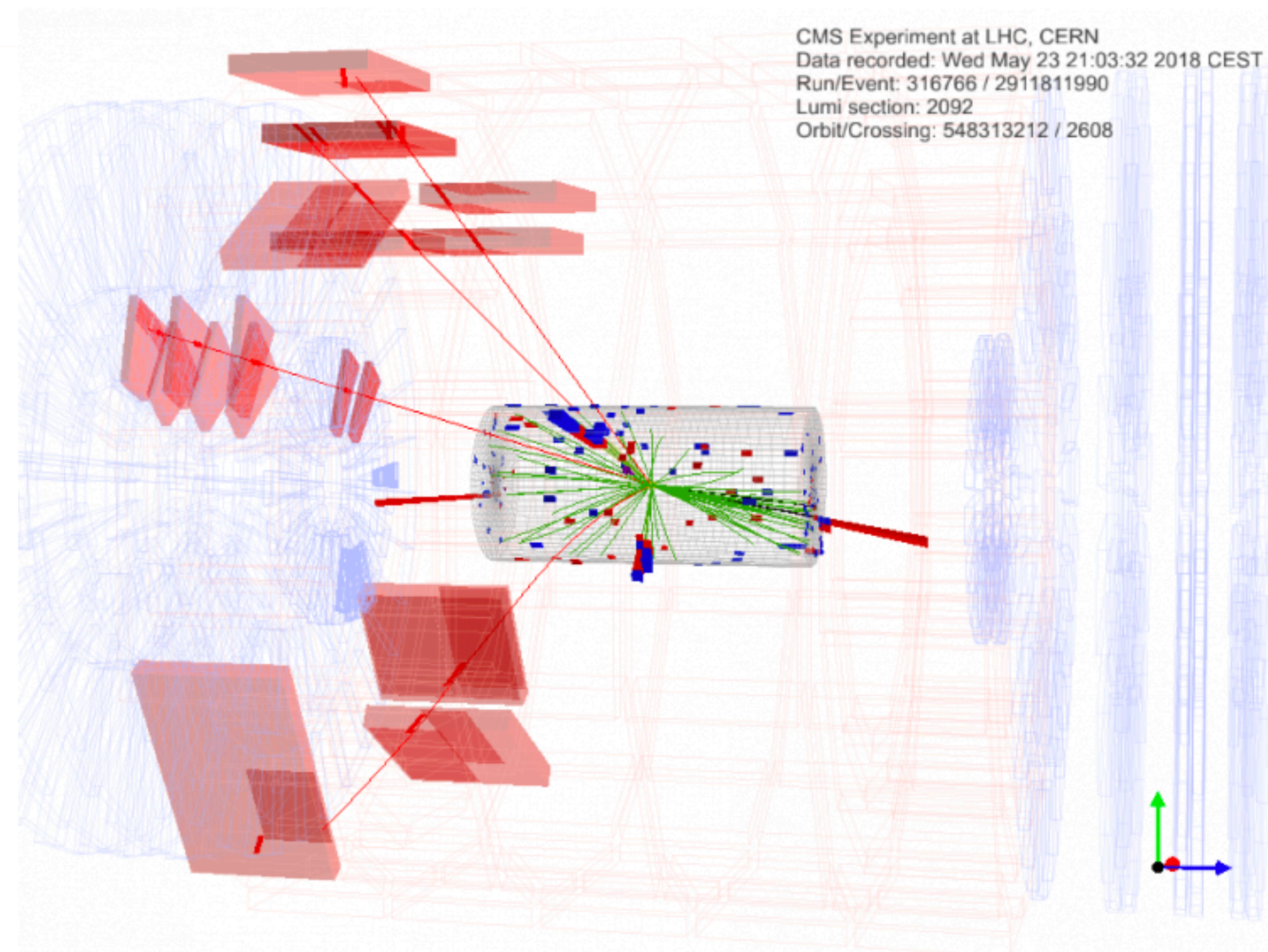
Splines+GaussianProcesses



Higgs to 4 Leptons

Z-boson Peak





- Higgs to 4 leptons aims at taking the mass of 4 leptons
    - A way to test the 4-leptons is the Z boson peak

Backup

Remind me at some point

Explain the Chow Test

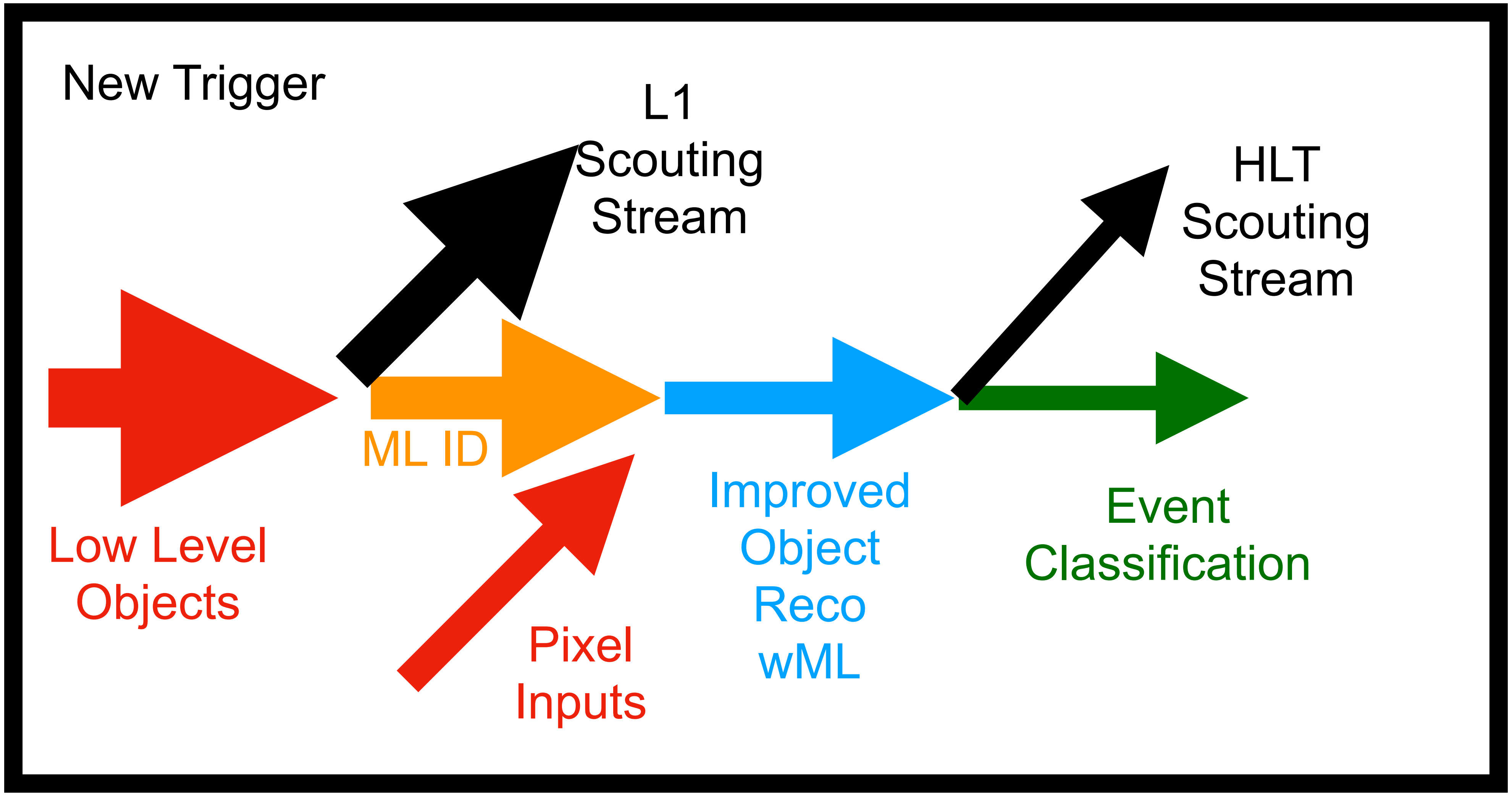
Higher Order Polynomial

Test of higher polynomial order with F-test form is called the chow test

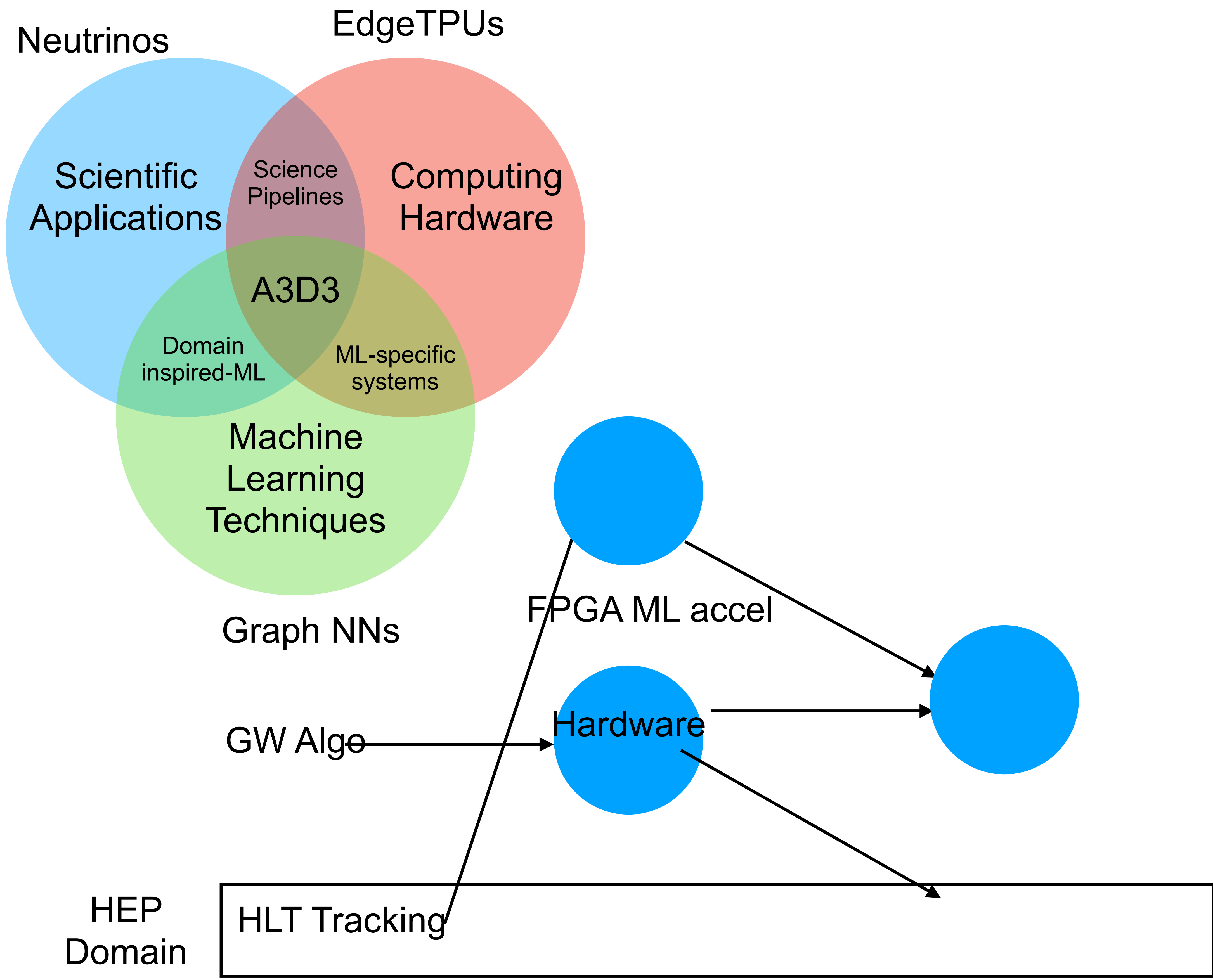
- We can evaluate this through an F-test
  - Recall $\frac{MS_B}{MS_R} \approx 1 = F_{n-1\ m(n-1)}$
- Here we have $\frac{MS_B}{MS_R} \approx 1 = F_{p_2-p_1\ n-p_2}$

$$F = \frac{\left(\frac{\mathrm{RSS}_1 - \mathrm{RSS}_2}{p_2 - p_1}\right)}{\left(\frac{\mathrm{RSS}_2}{n - p_2}\right)},$$

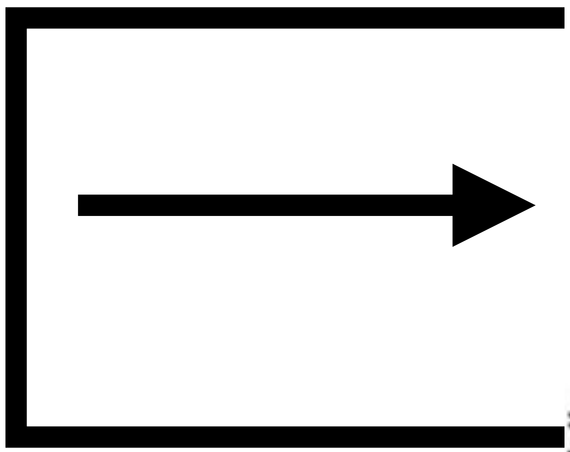
Title Text

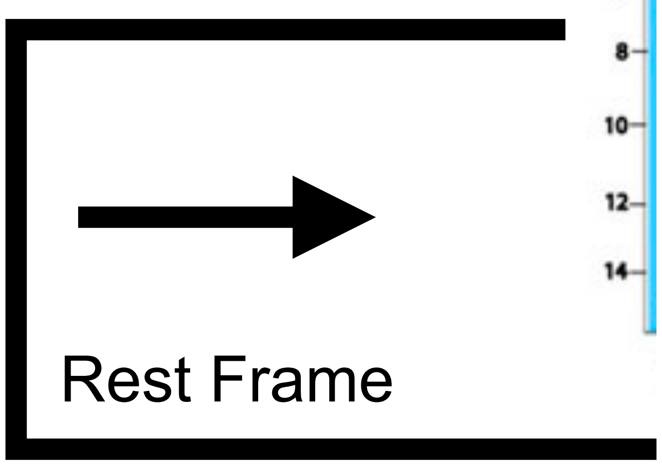


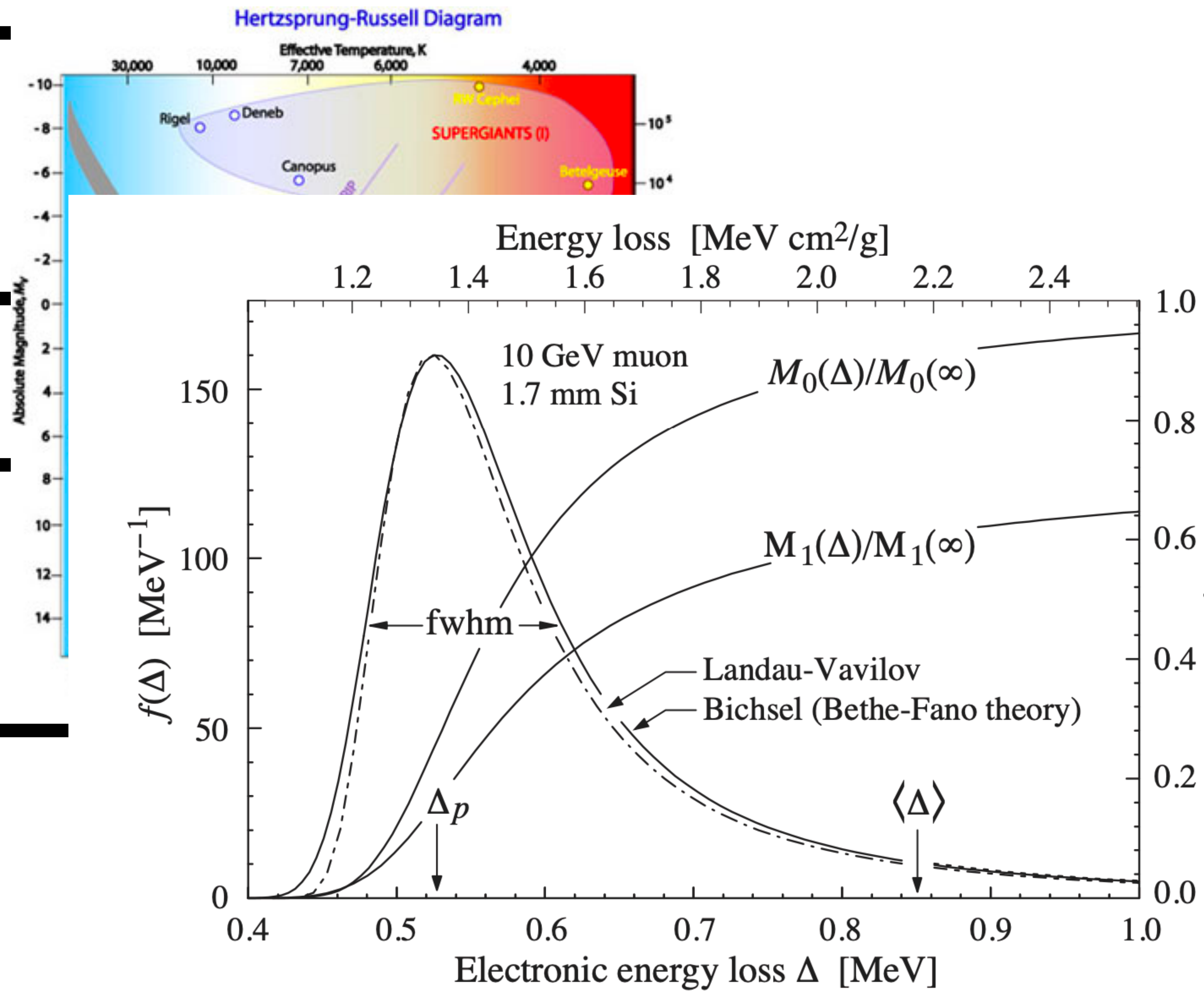
New Trigger
L1
Scouting
Stream
HLT
Scouting
Stream
ML ID
Low Level
Objects
Pixel
Inputs
Improved
Object
Reco
wML
Event
Classification

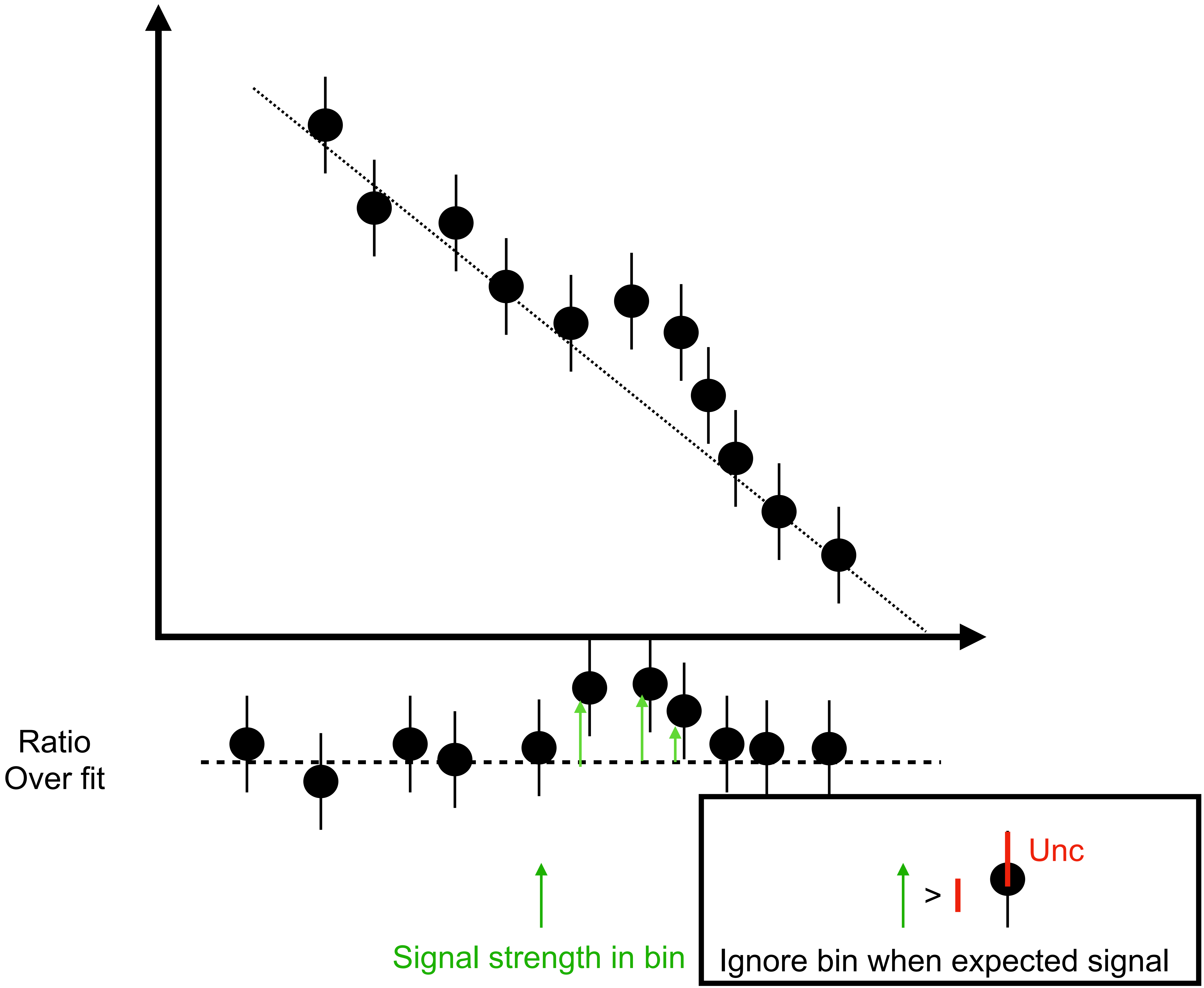

Neutrinos
EdgeTPUs
Scientific Applications
Science Pipelines
Computing Hardware
A3D3
Domain inspired-ML
ML-specific systems
Machine Learning Techniques
Graph NNs
FPGA ML accel
GW Algo
Hardware
HEP Domain
HLT Tracking

Elastic Scatter








Ratio
Over fit
Signal strength in bin
Unc
>
Ignore bin when expected signal