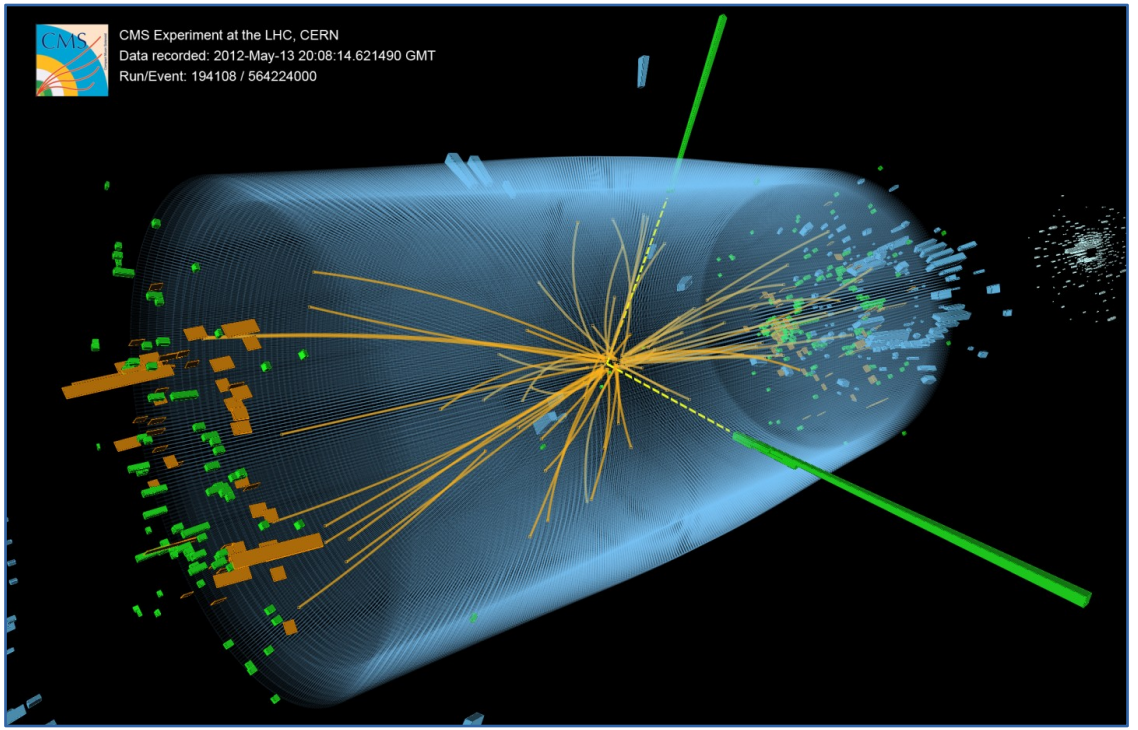
Simulating and Fitting HEP Phenomena

By Piyush Kolhe

What is HEP?

- HEP stands for High Energy Physics, where small particles and their properties are probed.
- We collide particles (for example, two protons) at high energies (TeV scale) to study the fundamental particles and their interactions with each other.
- What's inside a proton?



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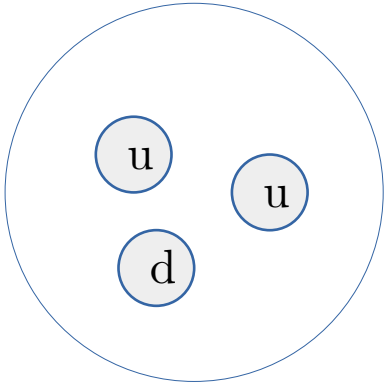
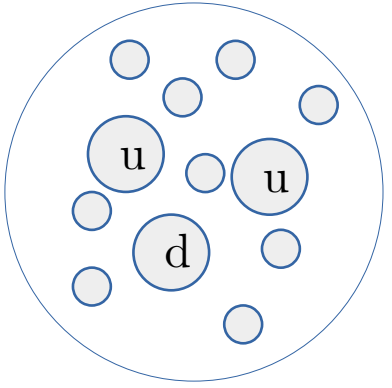
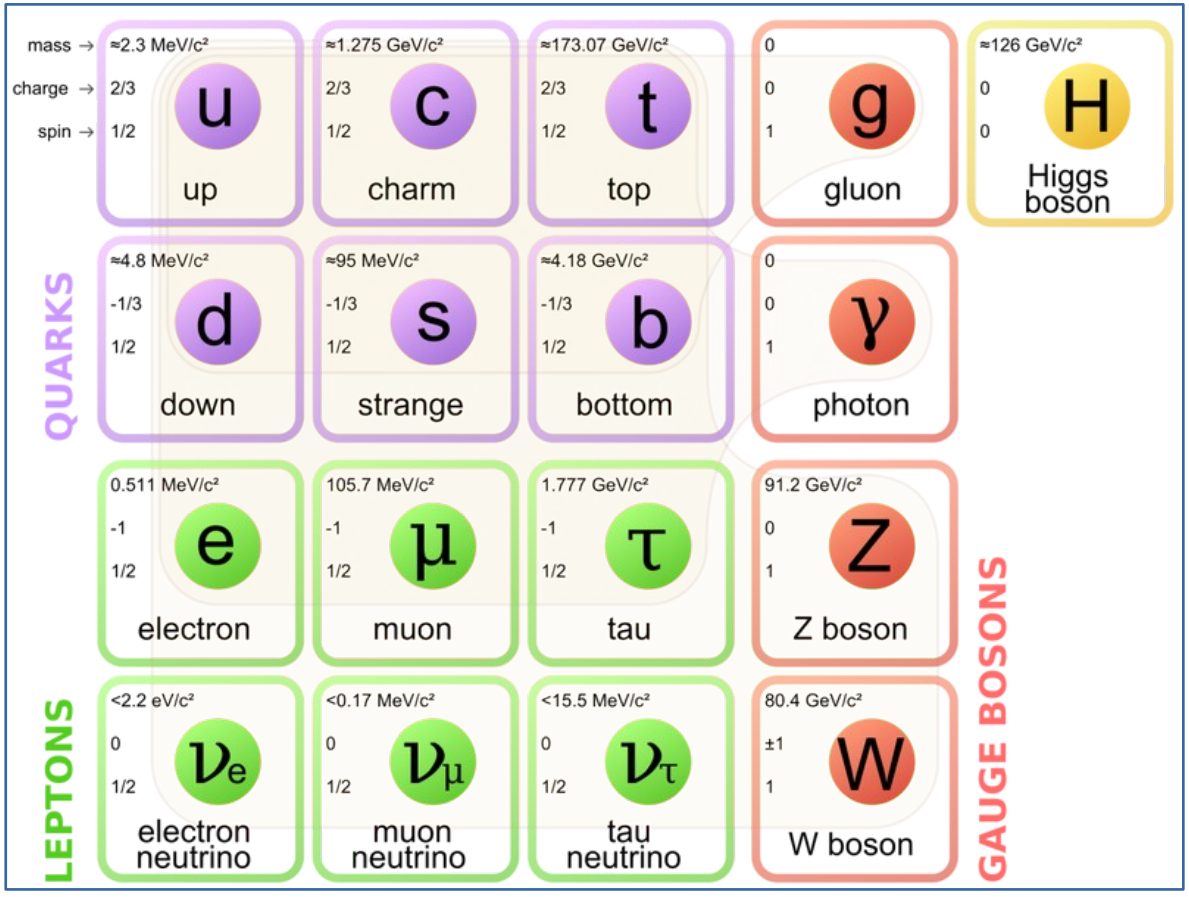
What is a Parton?

- At high energies, a proton is not simply a combination of two up quarks and one down quarks.
- It is more of a sea of partons, the three quarks (u,u,d) are known as the valence partons.





The Standard Model



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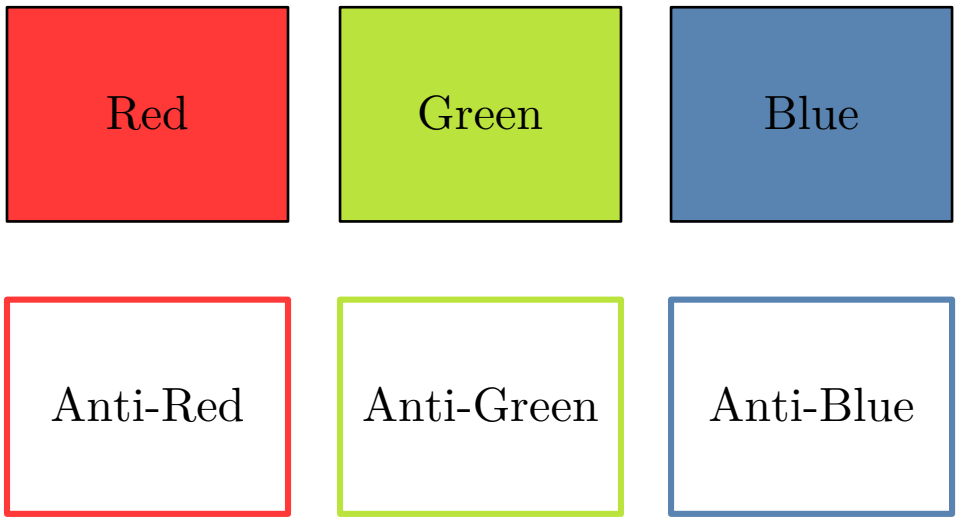
Colour

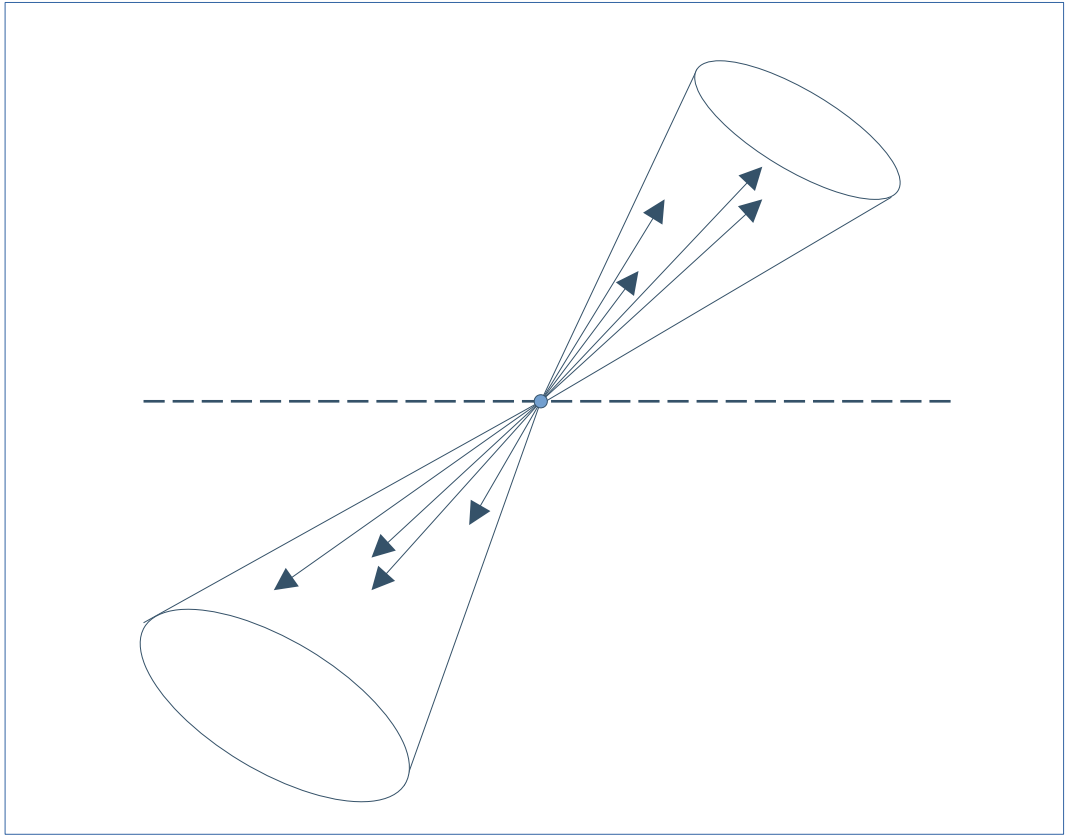
- Quarks and gluons have colour
- Quarks have one colour
- Gluons have one colour and one anti-colour
- Quarks and gluons are also referred to as “coloured particles”
- Colour confinement



Colour Confinement and Hadronization

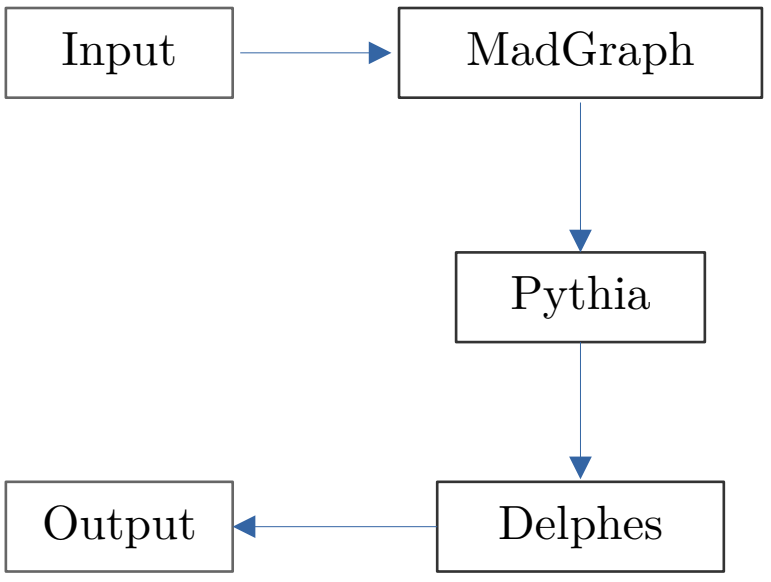
- Implications of colour confinement: a coloured particle cannot be isolated, i.e., only colour-neutral particles can be isolated (and therefore detected)

- Some of the energy and momentum of the particle goes into making other coloured particles which form hadrons, making a jet

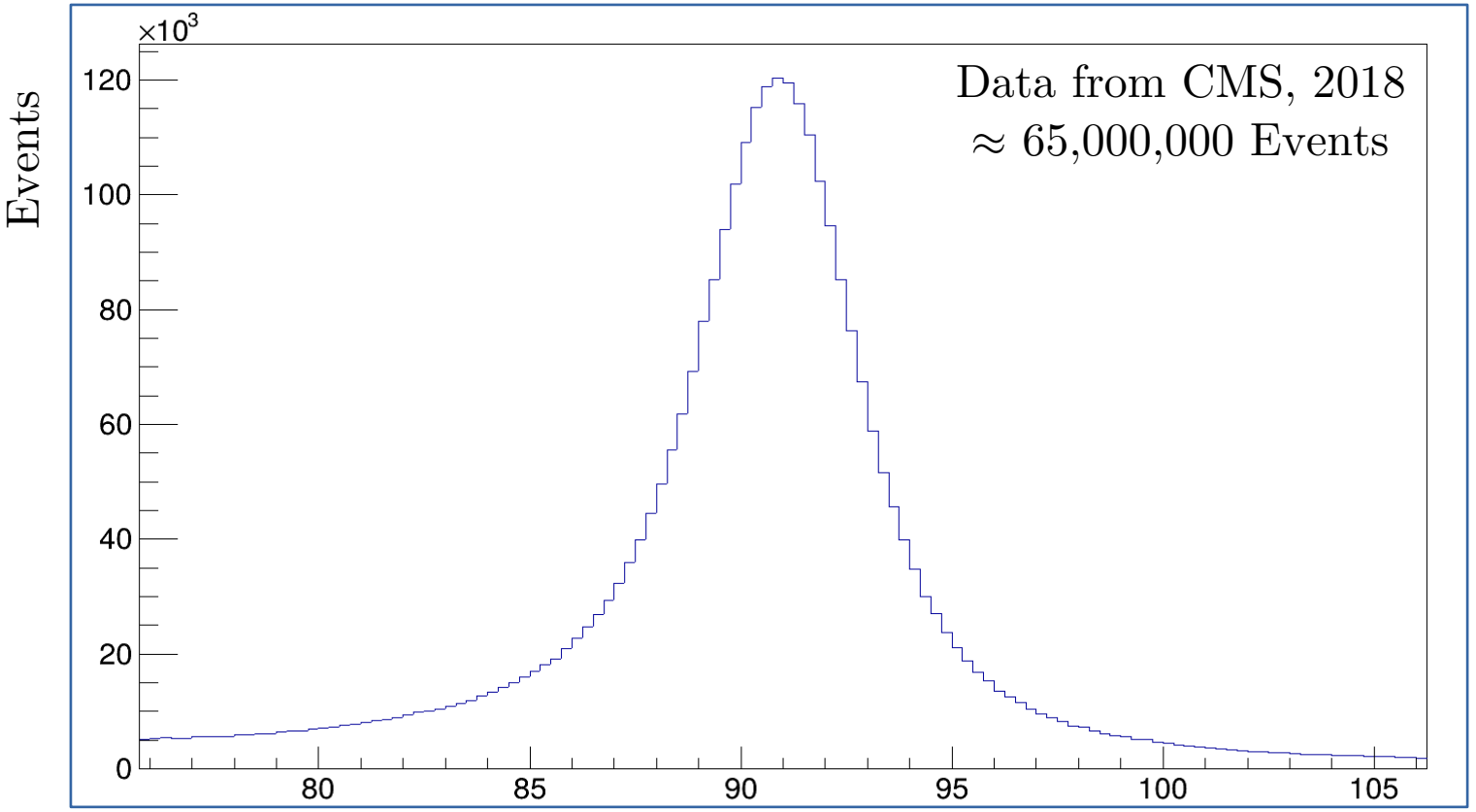


Parts of a HEP MC Simulation

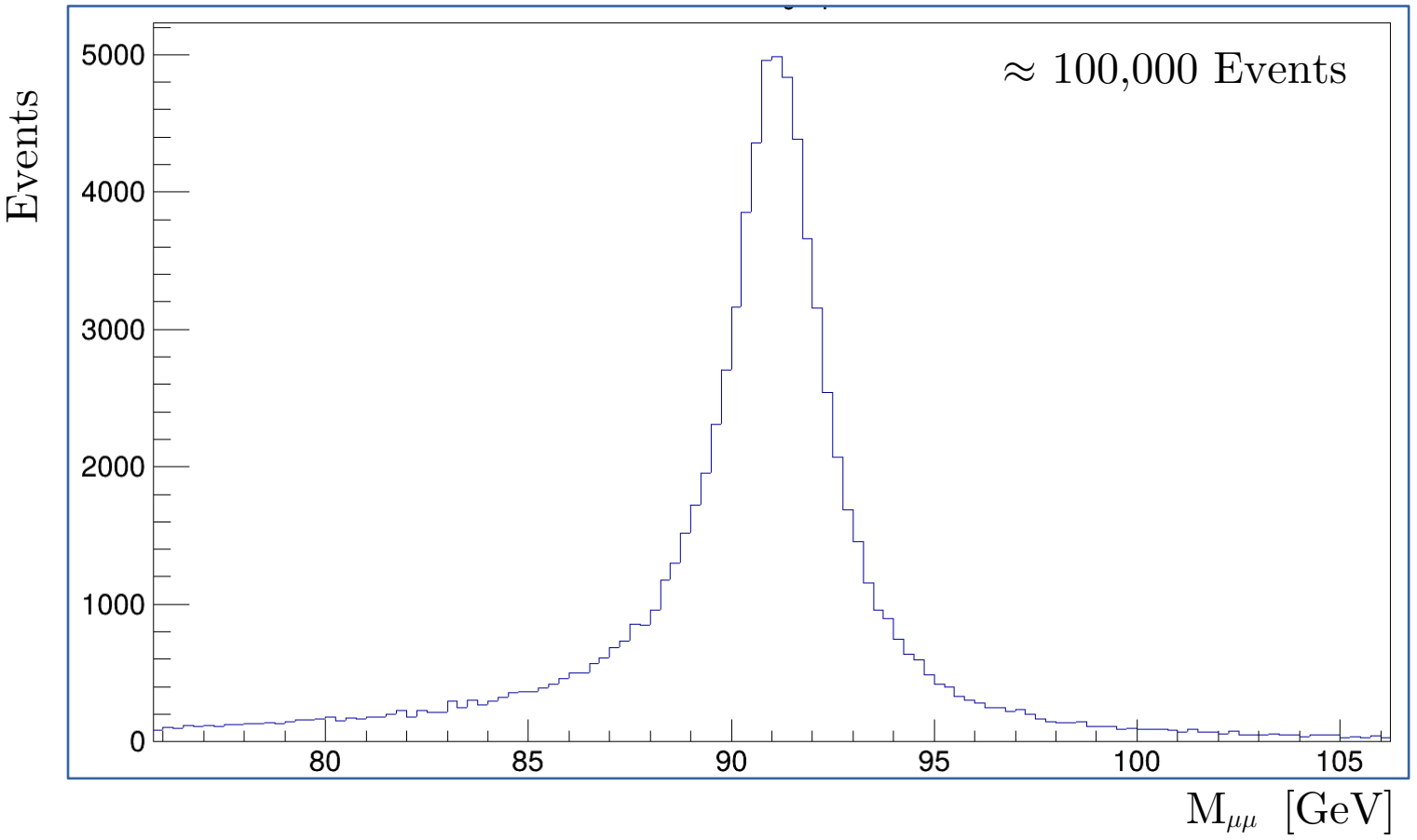
- Event Generation
- Simulation
- Digitization
- Reconstruction



Example (Data)



Example (MC Simulation)



Estimating Background

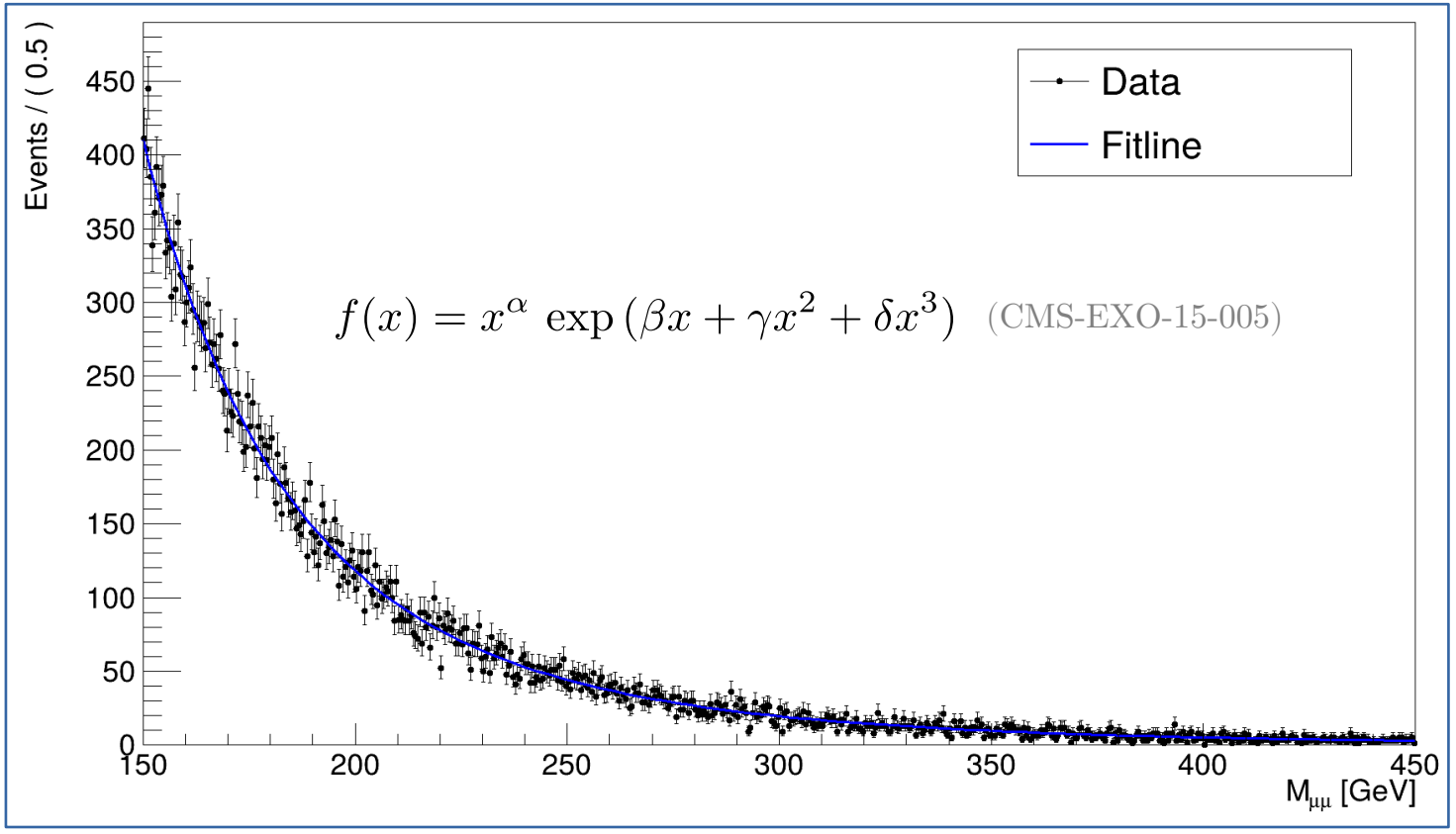
What is background?

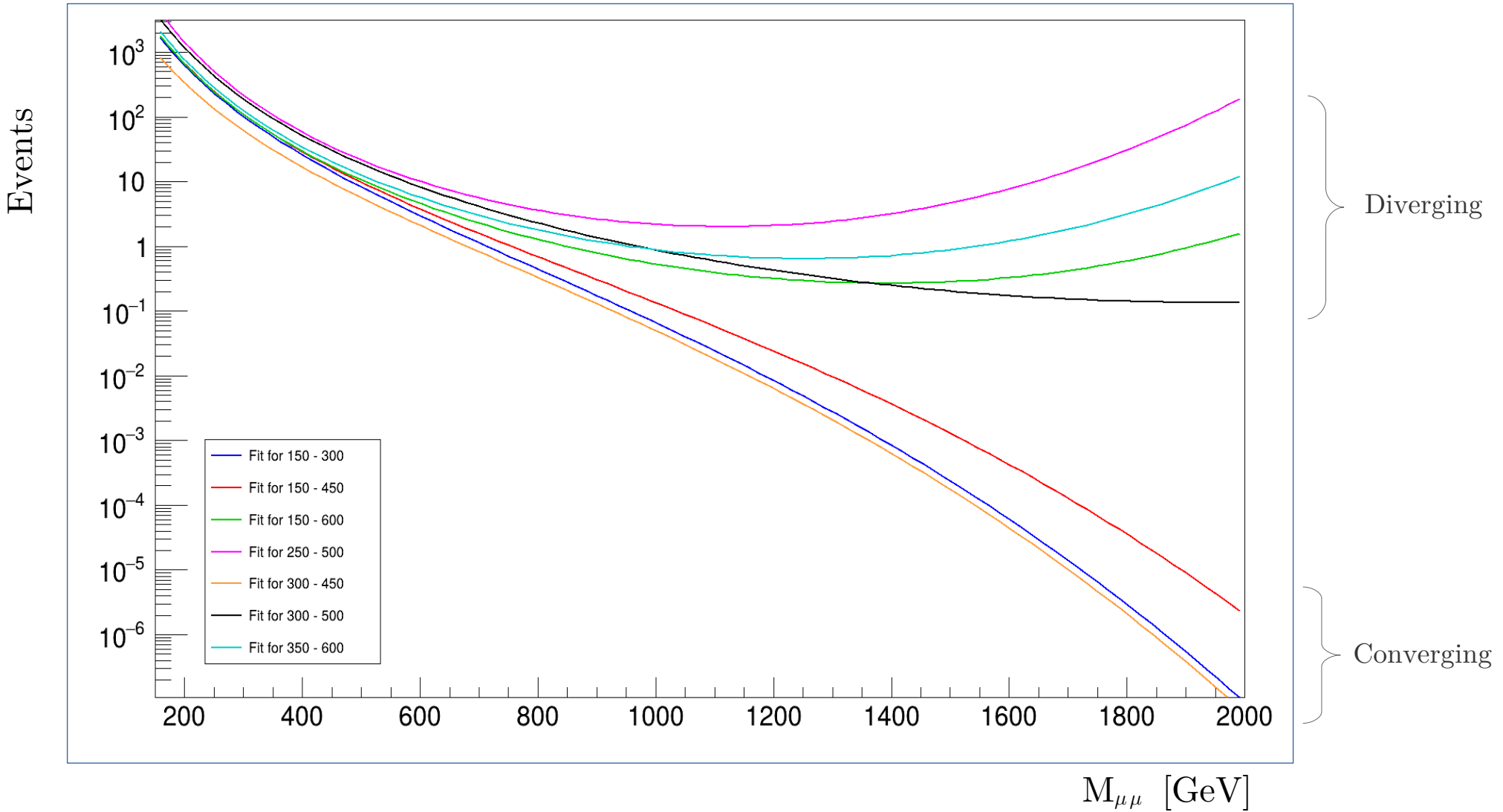
$X \rightarrow \mu^+ \mu^-$ ⟶ Signal

$\gamma^* \rightarrow \mu^+ \mu^-$
$Z \rightarrow \mu^+ \mu^-$
$J/\psi \rightarrow \mu^+ \mu^-$
} Background

How will we tell signal and the background apart?

An example of a fit




Events
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
Fit for 150 - 300
Fit for 150 - 450
Fit for 150 - 600
Fit for 250 - 500
Fit for 300 - 450
Fit for 300 - 500
Fit for 350 - 600
200
400
600
800
1000
1200
1400
1600
1800
2000
$M_{\mu\mu}$ [GeV]
Diverging
Converging

Acknowledgements

First, I'd like to thank prof. Sourabh Dube and his research group for their teachings and guidance throughout the duration of my project.

Second, I'd like to thank L2L for giving me an opportunity to talk about my work.

Thank You

Links To The Images

1) https://cds.cern.ch/images/CMS-PHO-EVENTS-2012-005-1/file?size=large

2) https://www.forbes.com/sites/startswithabang/2019/09/21/ask-ethan-why-are-there-only-three-generations-of-particles/