Electron Event Selection in Doubly Charged Higgs Simulations

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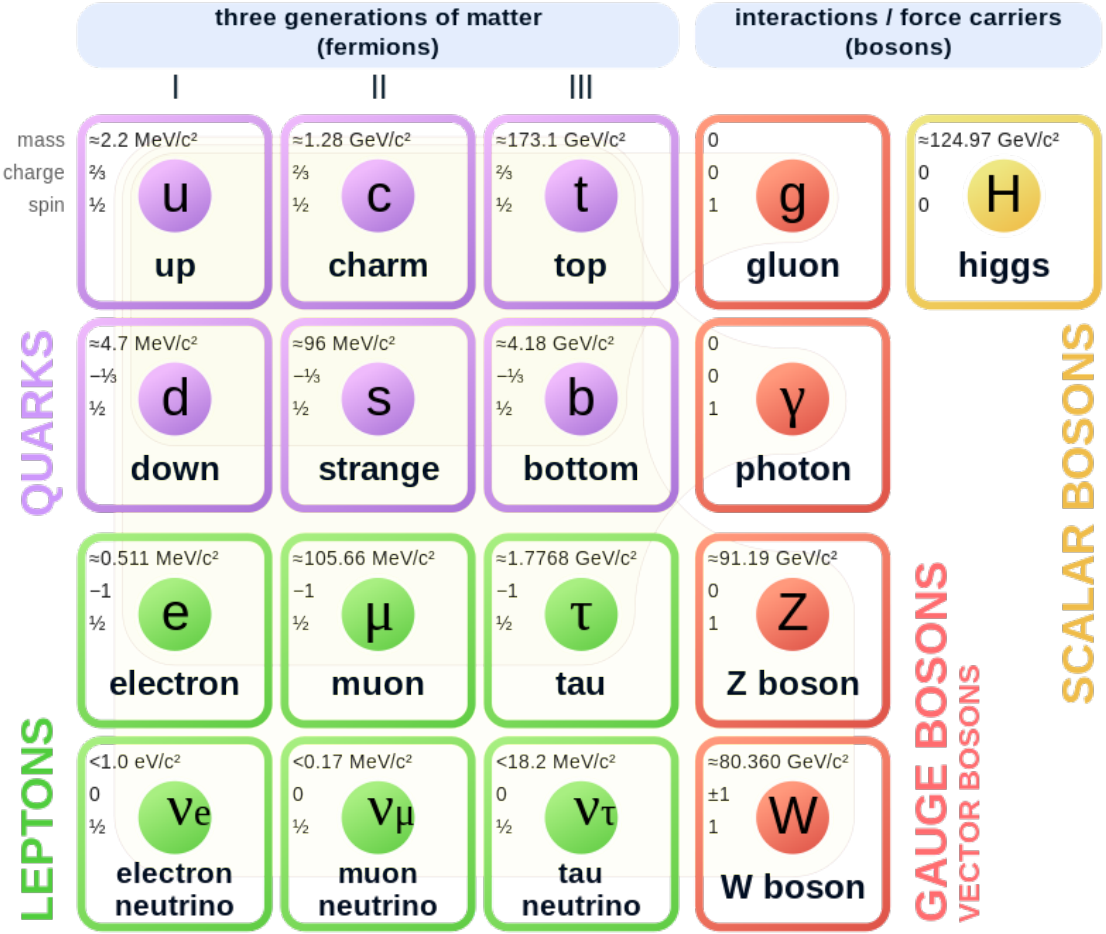
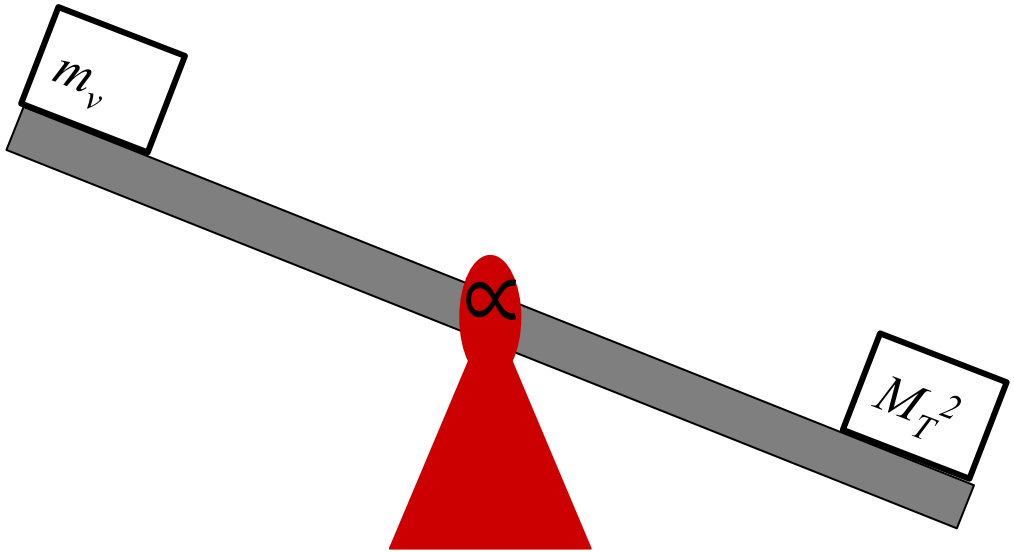
KSU REU 2023

Standard Model of Elementary Particles



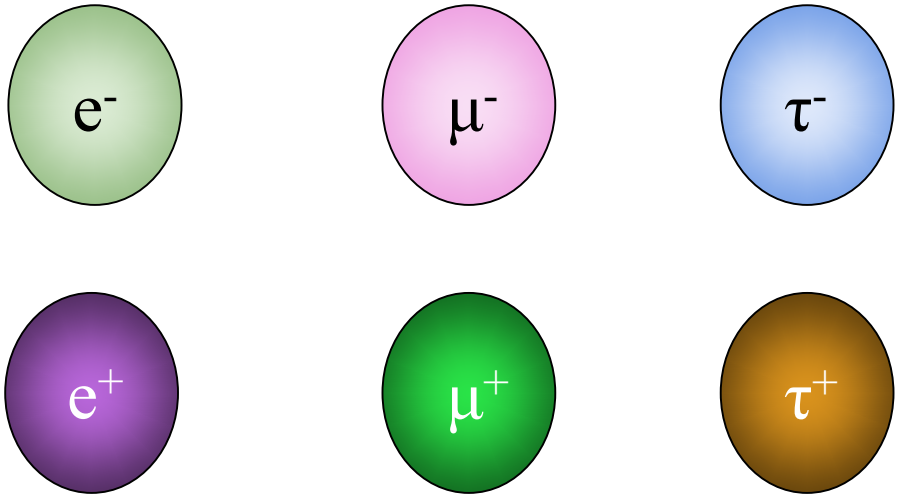
Type II Seesaw Model



[1] Stefan Antusch, et al., **arXiv:1811.03476 [hep-ph] (2018)**, "Low scale type II seesaw: Present constraints and prospects for displaced vertex searches."

Modes of Decay

$$H^{\pm\pm} \rightarrow \ell^{\pm}\ell^{\pm}$$



[2] The CMS Collaboration, **CMS Physics Analysis Summary**., "Asearch for doubly-charged Higgs boson production in three and four lepton final states at $\sqrt{s} = 13$ TeV"

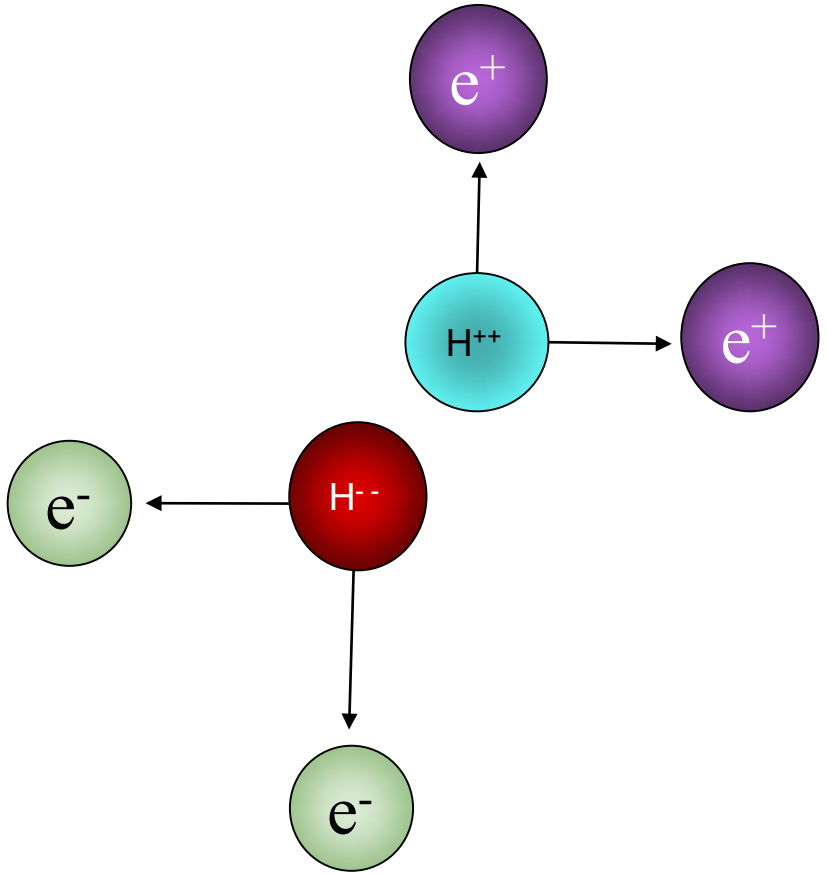
The Process

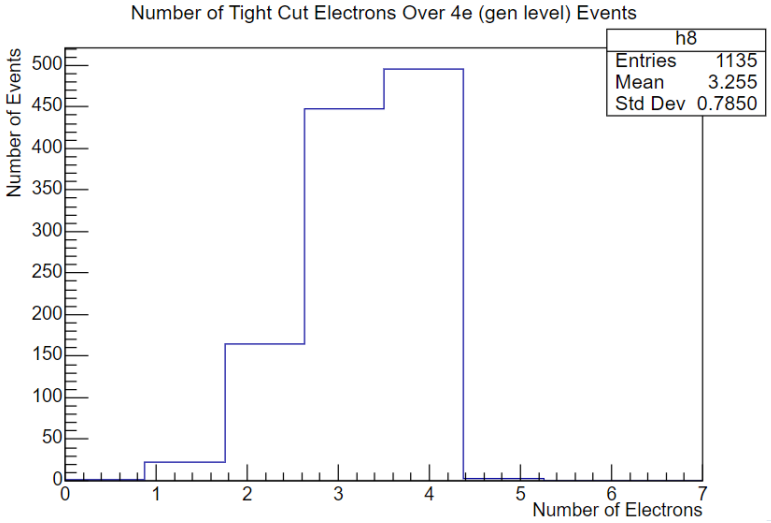
- Choose Leptons
    - Focus on electrons —4e events in particular
- Examine Triggers
- Examine Cuts
    - On Signal and Background

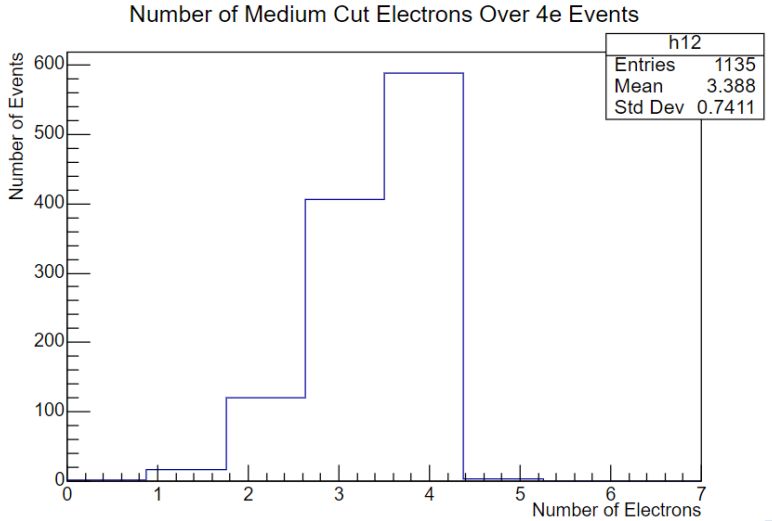
The Triggers

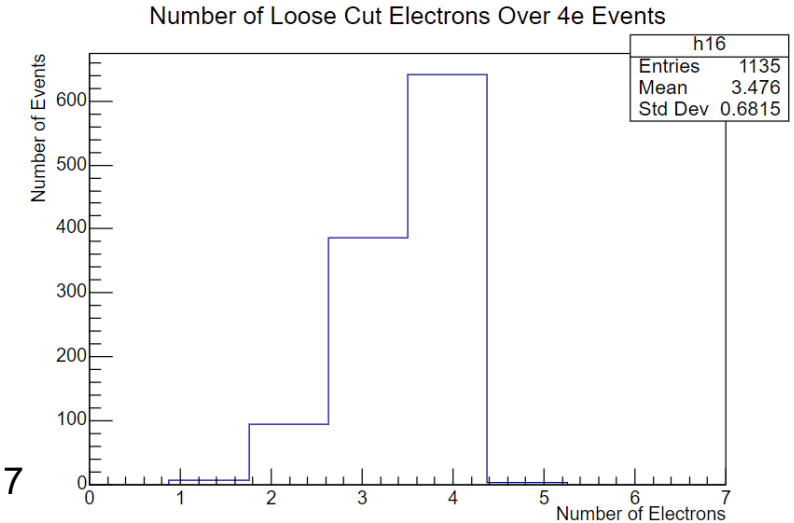
The Cuts—Signal

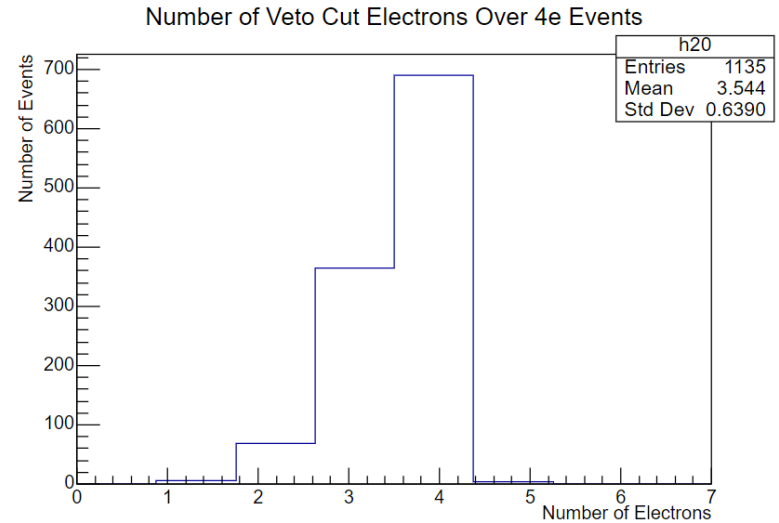
- 5 Levels of Cut:
  - Veto
  - Loose
  - Medium
  - HEEP
  - Tight
- What do these look like?
  - What passes for reconstruction?




Number of Tight Cut Electrons Over 4e (gen level) Events
h8
Entries 1135
Mean 3.255
Std Dev 0.7850
Number of Events
Number of Electrons

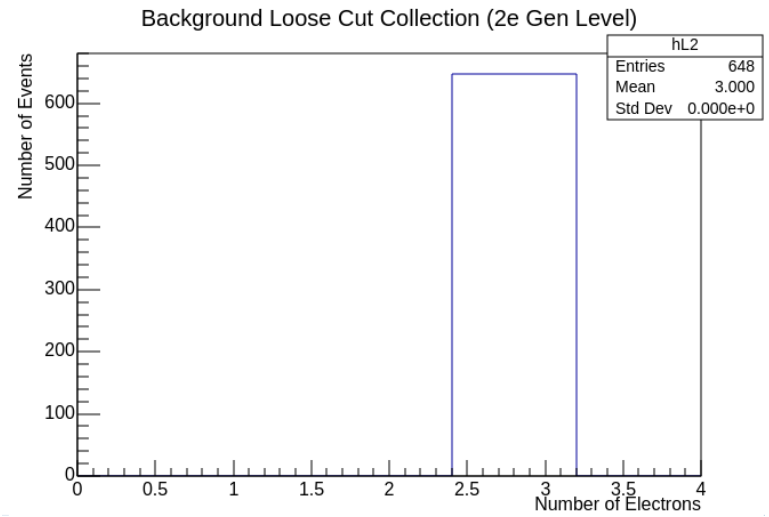

Number of Medium Cut Electrons Over 4e Events
h12
Entries 1135
Mean 3.388
Std Dev 0.7411
Number of Events
Number of Electrons


Number of Loose Cut Electrons Over 4e Events
h16
Entries 1135
Mean 3.476
Std Dev 0.6815
Number of Events
Number of Electrons


Number of Veto Cut Electrons Over 4e Events
h20
Entries 1135
Mean 3.544
Std Dev 0.6390
Number of Events
Number of Electrons

The Cuts —Background

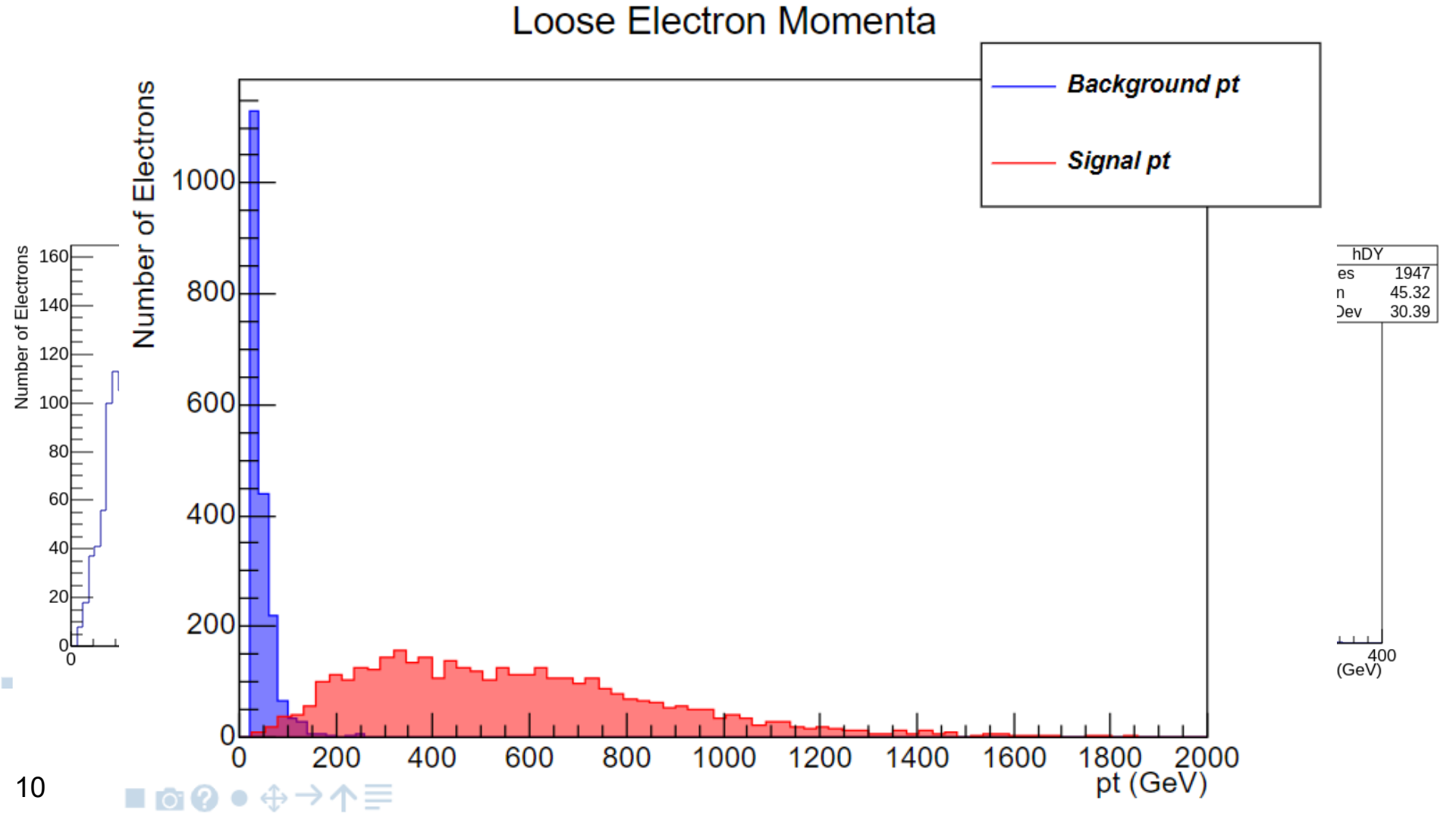
- Many backgrounds to analyze
  - Focus on one
- False electron sources
  - Z boson
  - Bottom quark
- How many events pass 3+ loose electrons?



Quantifying Signal and Background

- Background Contribution =
  - $\text{Luminosity} \times \text{CS} \times \text{BR} \times (\text{3e Acceptance}) \approx 5409$ events
- Signal Contribution 3e =
  - $\text{Luminosity} \times \text{CS} \times (\text{BR})^2 \times (\text{3e Acceptance}) \approx 1.6313$ events
- Signal Contribution 4e =
  - $\text{Luminosity} \times \text{CS} \times (\text{BR})^2 \times (\text{4e Acceptance}) \approx 2.7062$ events

- Acceptance $= N_{passing}/N_{total}$


Loose Electron Momenta
Background pt
Signal pt
Number of Electrons
pt (GeV)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
hDY
es 1947
n 45.32
Dev 30.39
(GeV)

Conclusions & Future Work

- Where do we cut our data?
  - $p_T > 200$ GeV
- Set Expectations for future data
  - Only 1 to 3 $H^{\pm\pm}$ related electron events
  - Significantly More Background events

- Analyze the other backgrounds
  - ZZ, WW, etc.
- Analyze taus similarly
- Analyze selected events

Acknowledgements

Kansas State University

Kim Coy

J.T. Laverty

Loren Greenman

Andrew Ivanov

CERN

National Science Foundation

This material is based upon work supported by the National Science Foundation under Grant No. #2244539. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Questions?