Reconstruction of mass Using SVfit

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Overview

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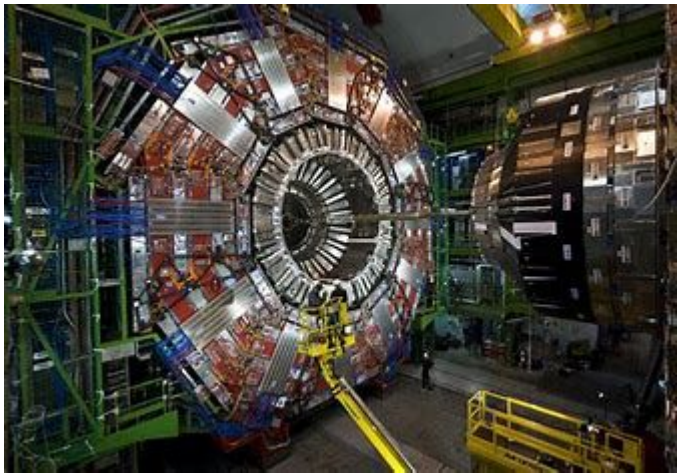
- Increasing Statistics
- Different Channels
- Searching Different Ranges of Energy
- Summary

LHC at CERN

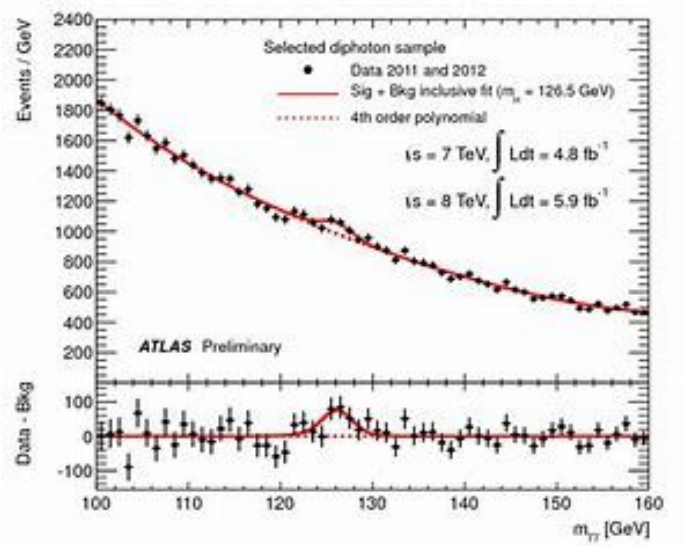
- Worlds largest and most powerful particle collider.
- Established 1954 and is located on France-Switzerland border of the suburb Geneva.
- Consists of four main detectors: CMS, ATLAS, ALICE, and LHCb.
- Highest recorded beam energy is 13.6 TeV.

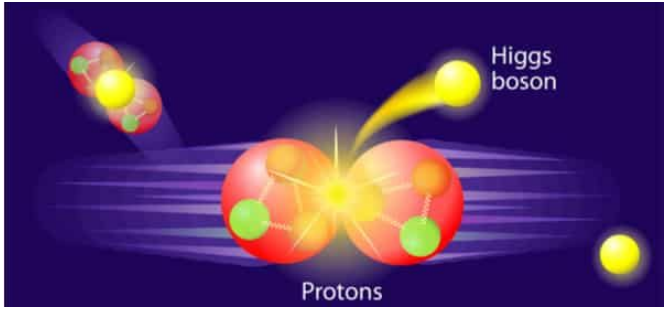


Higgs

In 2012, the Higgs was discovered by the CMS and ATLAS collaborations. They used reconstruction algorithms to identify its decay products.

- Higgs has different ways it can decay, one being a decay into two tau leptons.
- Tau lepton is the heaviest lepton, so it interacts with the higgs field the most making it the ideal candidate.
- Short lifetime, most tau decay before reaching outer layer of tracker.
- Only detectable via parts of the decay products.



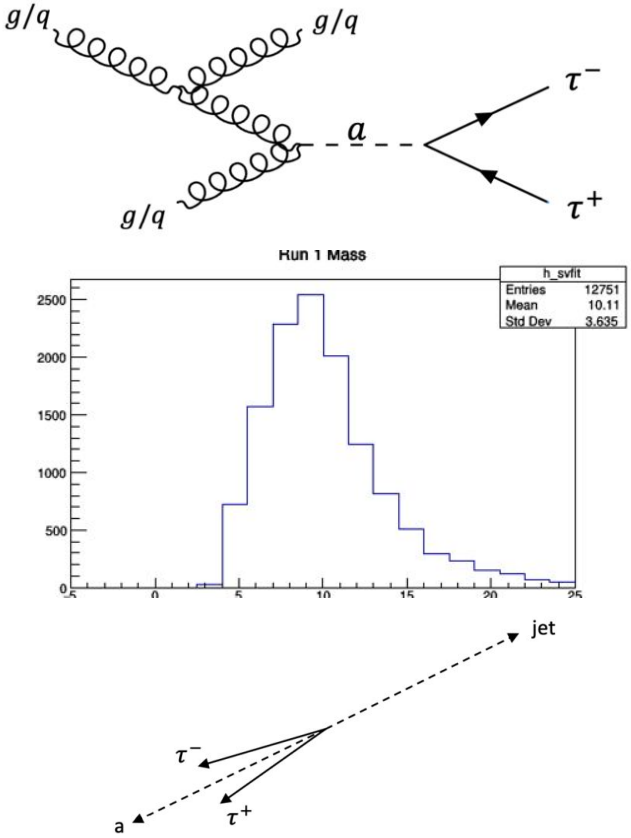


Timid Pseudo Bosons

There are many questions the standard model doesn't answer, such as "Is the higgs a composite particle?", etc. To address the shortcomings of the standard model, physicist proposed new physics models. Some of the models speculate new pseudo-scalar bosons (e.g. timid pseudo-scalars) in the mass range below 100 GeV.

SVfit

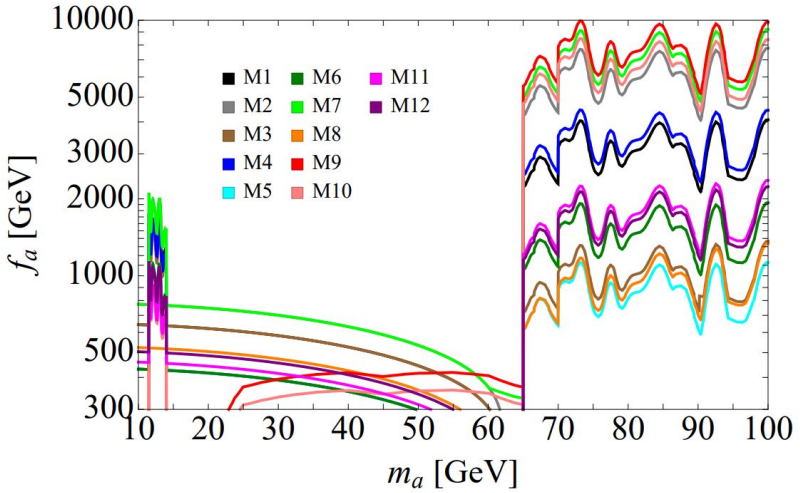
- Software used to reconstruct the higgs boson mass from di-tau decays.
- Uses a likelihood algorithm function P($M_{\tau\tau}$) for each event to measure how compatible the Higgs mass hypothesis from the decaying tau momenta and missing transverse energy in the event.
- SVfit uses a likelihood approach due to the inability to reconstruct the higgs mass analytically.
- SVfit was used in CMS Higgs Analysis and improved the sensitivity of identifying the HIggs by 30%.



Project

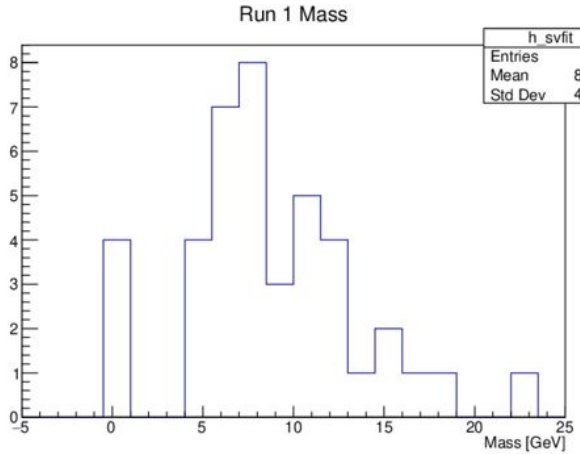
Course of Action:

- Implement the code to loop over all events and multiple files.
- Investigate tau_mu tau_had channel, to study how beneficial that algorithm is.
- Make it applicable for different masses in the 10-65 GeV range.
- Study the performance improvement due to the algorithm.

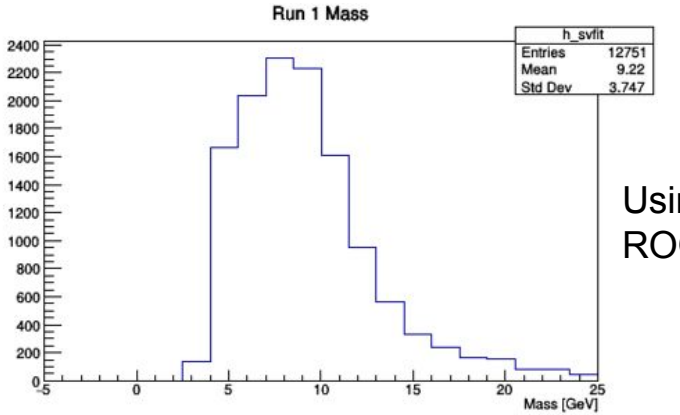


Including More Statistics

- Software initially only did one file at a time where it only computed one event at a time. (You also have to input data manually)
- First, altered code to do multiple events at once.
- Then, made it applicable to run multiple ROOT files. (Currently can run up tp 300 ROOT files at once.)



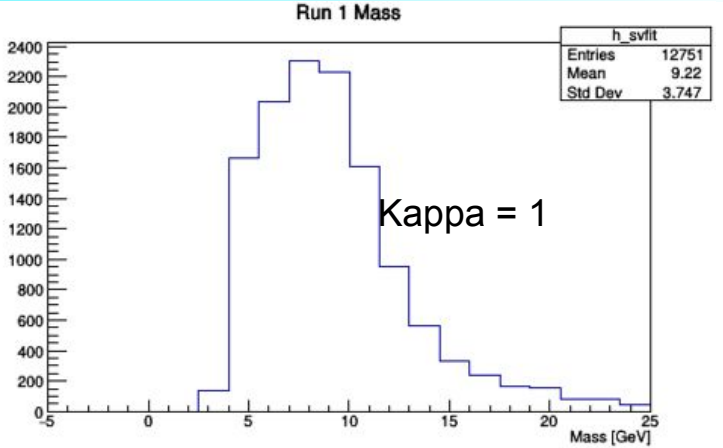
Including all of the events in the ROOT file.

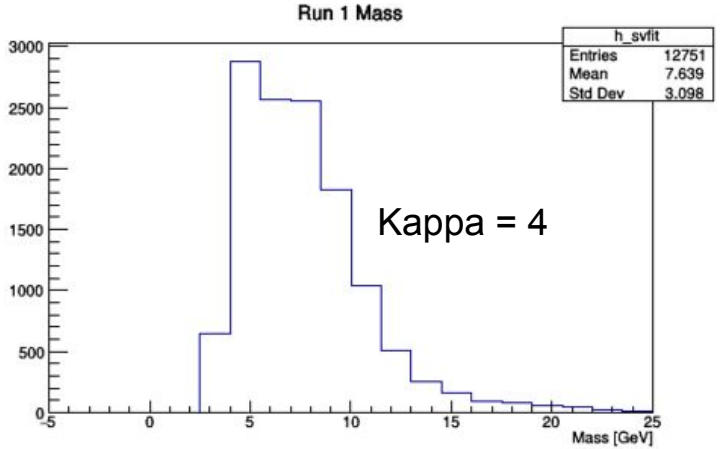


Using multiple ROOT files.

Using different Channels

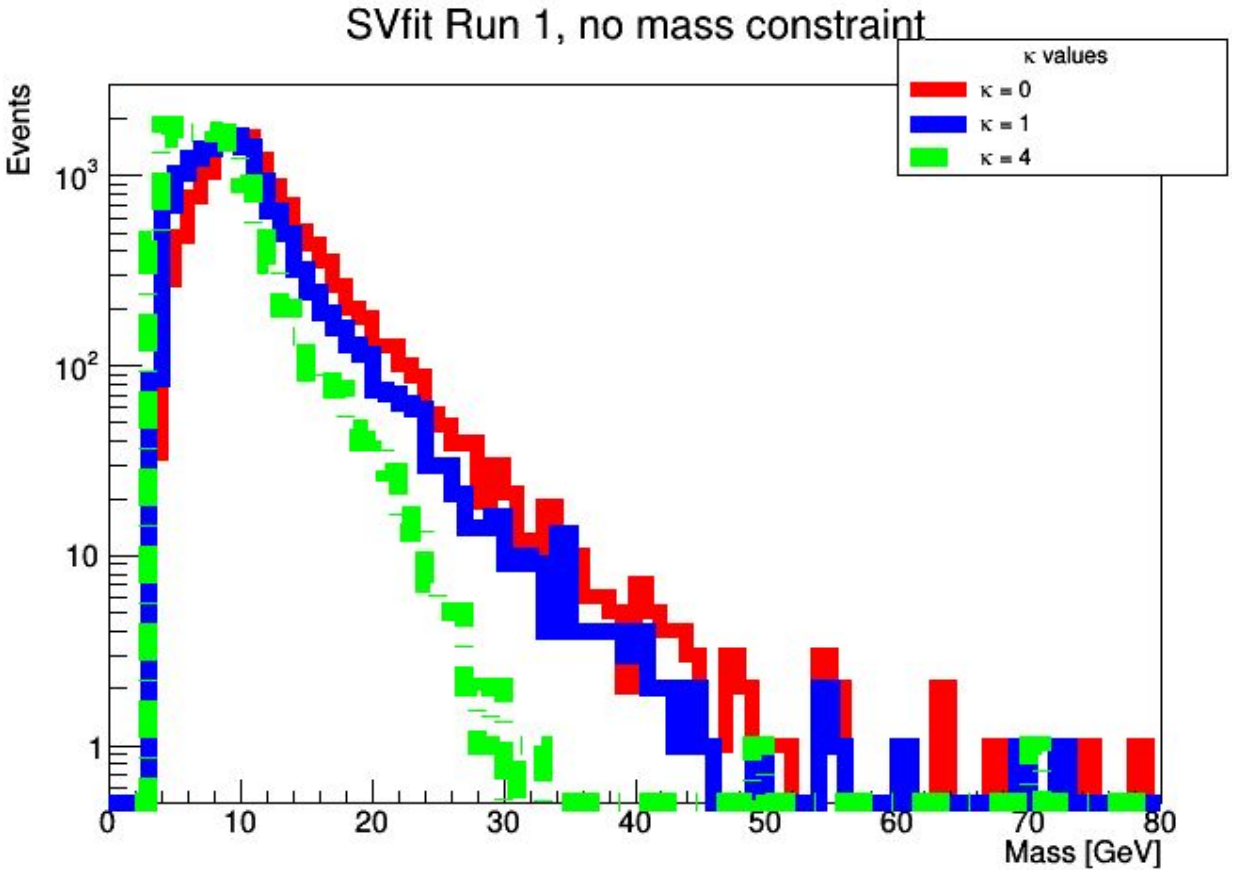
- Code currently has the ability to use different channels, but we will be focusing on tau_mu tau_had.
- Regularization term that reduces tails of distributions is represented by a number 0-6, kappa.
- The higher the value of kappa, the smaller the amount of tails the algorithm is able to cut off.



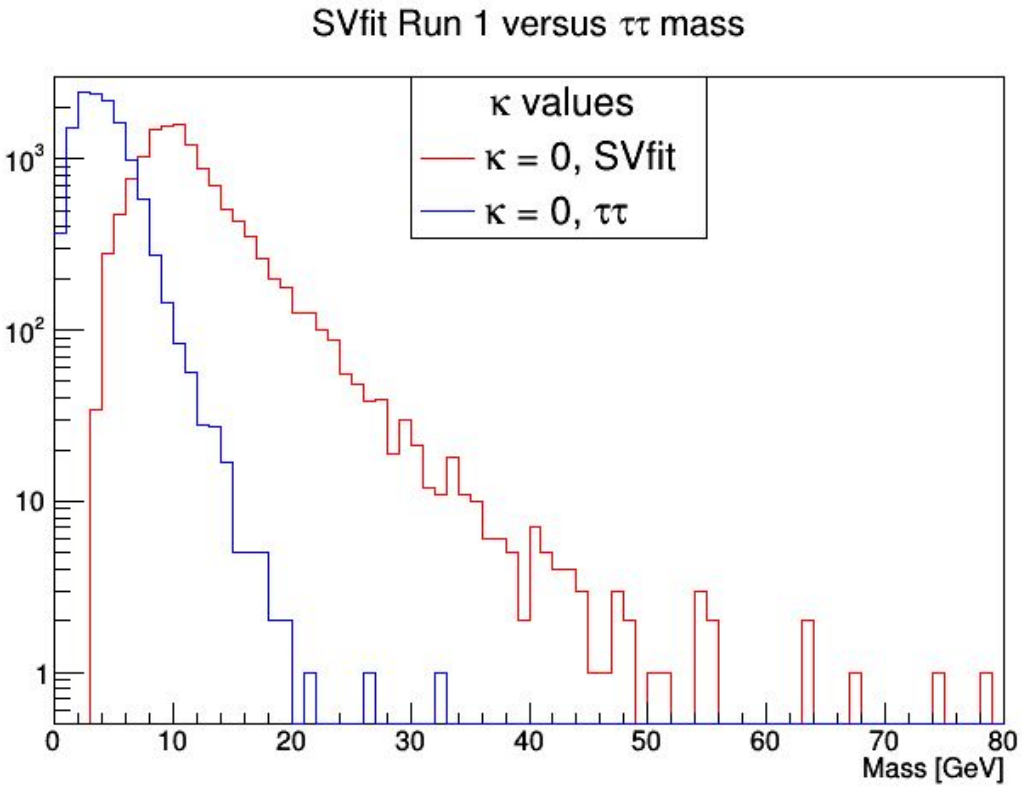


Testing out different energy ranges, 10 GeV High Boosted

- Kappa = 4 reduces our tails on the right side.
- Kappa 1 & 0 are more on target where the peak sits.
- 10 GeV has worse asymmetry for kappa = 1 & 4.
- More tail for kappa = 1 & 0.

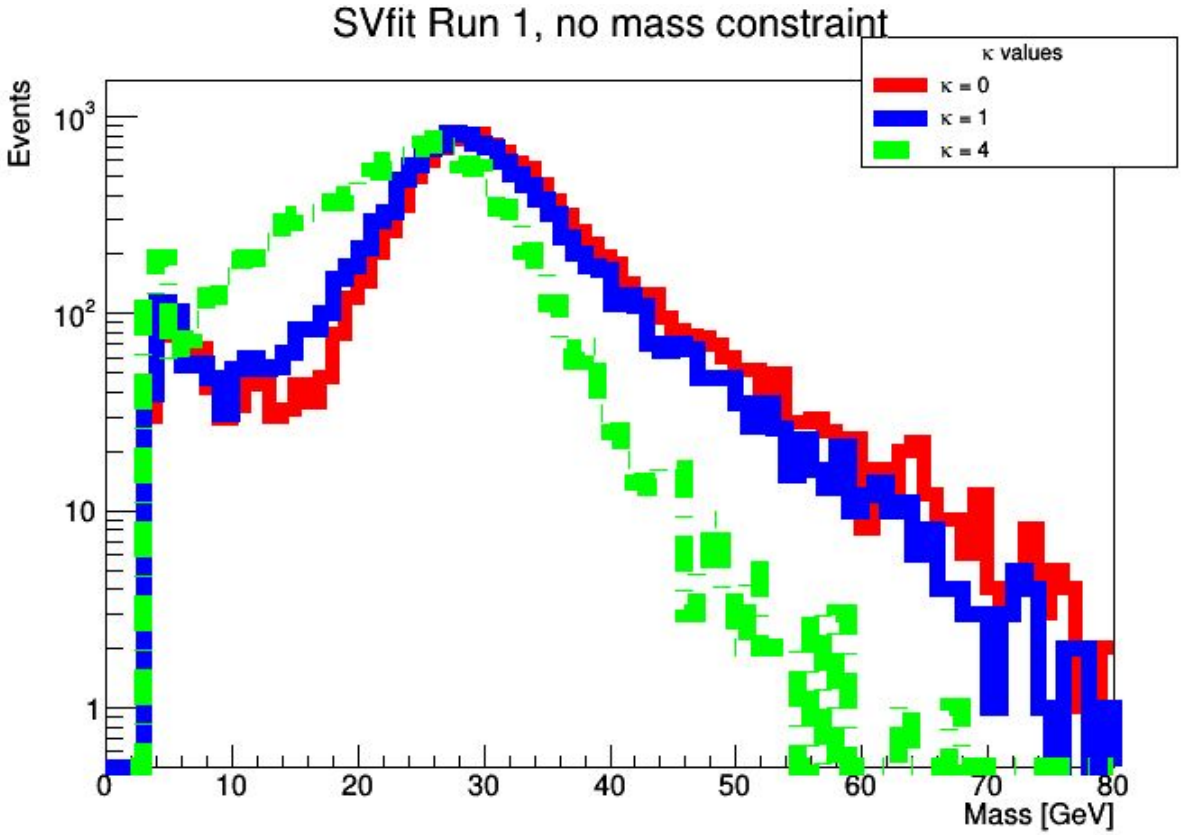


10 GeV High Boosted continued

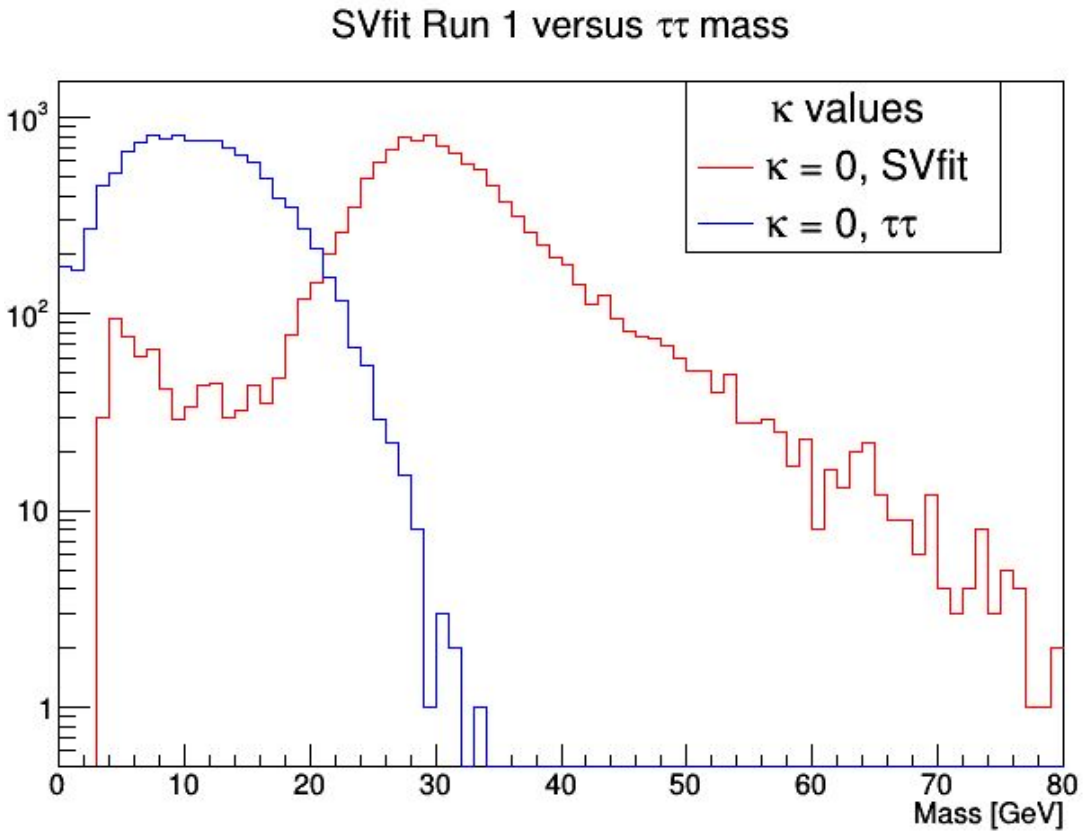


Testing out different energy ranges, 30 GeV High Boosted

- Kappa = 4 reduces our tails on the right side.
- Kappa 1 & 0 are more on target where the peak sits.
- 30 GeV has worse asymmetry for kappa = 4.
- Uncalled for peak near 0 GeV.
- More tail for kappa = 1 & 0.

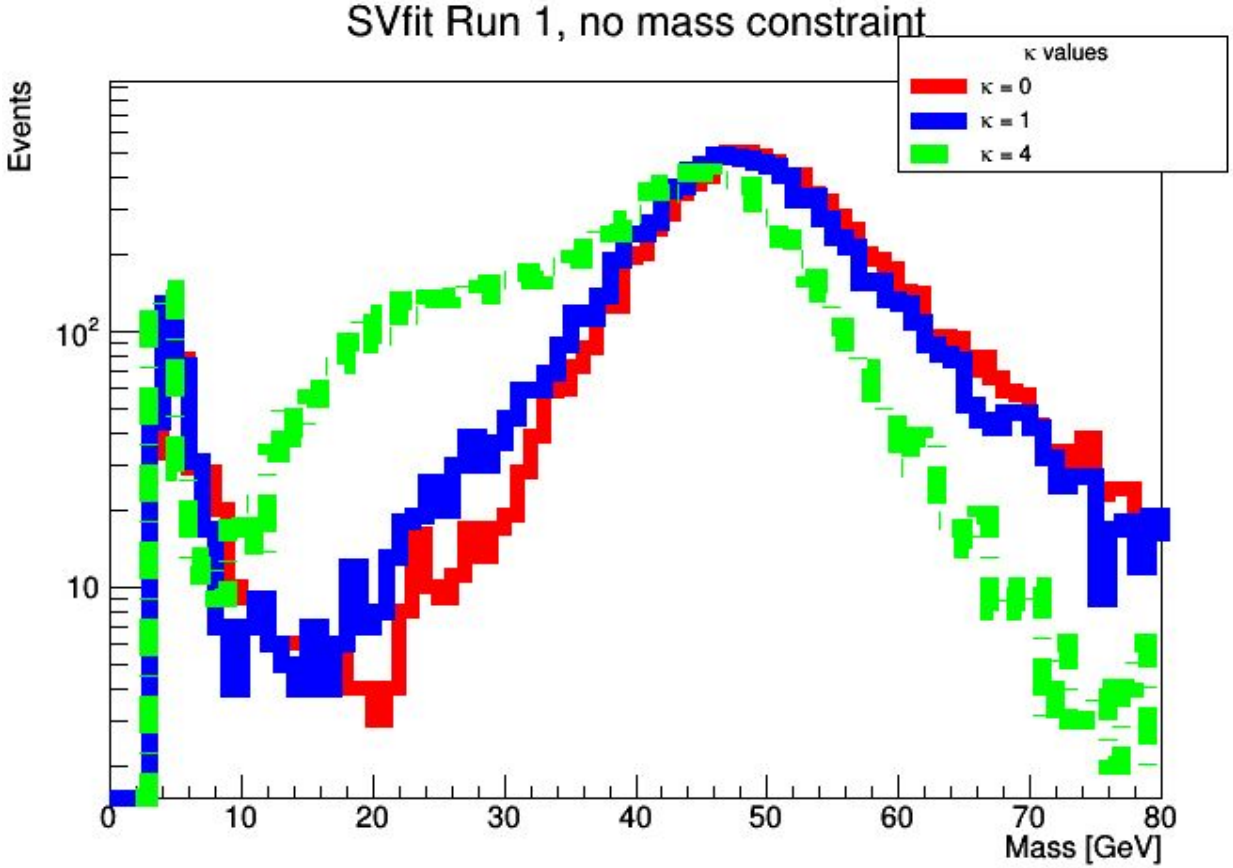


30 GeV High Boosted continued

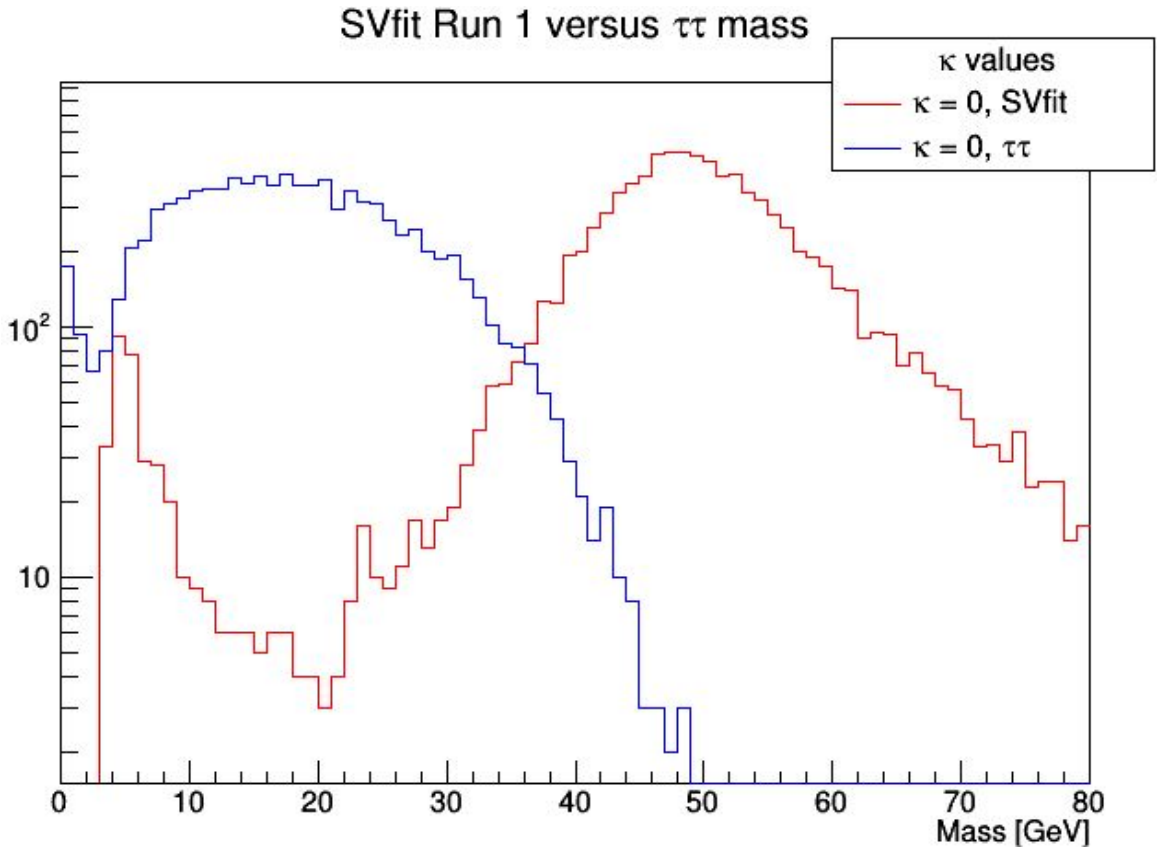


Testing out different energy ranges, 50 GeV High Boosted

- Kappa = 4 reduces our tails on the right side.
- Kappa 1 & 0 are more on target where the peak sits.
- 50 GeV has worse asymmetry for kappa = 4.
- Uncalled for peak near 0 GeV.
- More tail for kappa = 1 & 0.

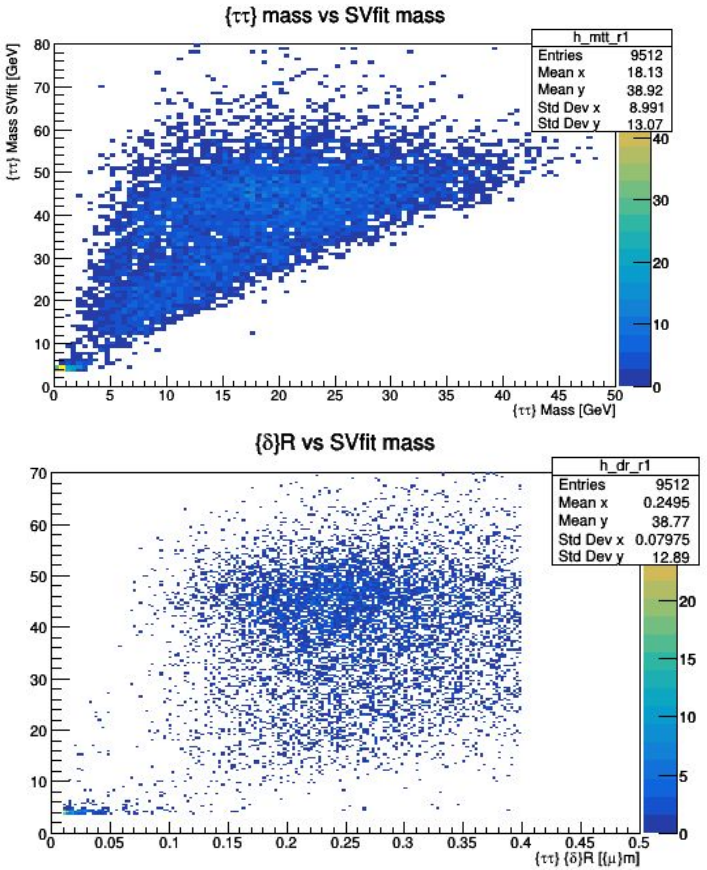


50 GeV High Boosted continued



Small Peak

A muon is identified as both a muon and a tau. Since this happens they are identified as travelling in the same trajectory. This explains why we have a small peak at 0.



Summary

- Code was only able to run one event at a time, now it is able to run multiple events at a time. Along with multiple files.
- Higher number channels reduce the amount of tails but ultimately shifts the plots.
- Increasing the energy also seems to shift the plots more.
- Higher number of kappa causes desymmetrization.
- Got the ball rolling for further investigations and improvements.
- There might need to be some adjustments to how the penal function is applied, or a different function might be beneficial instead.

References

1. Cacciapaglia, G., Ferretti, G., Flacke, T. *et al.* Revealing timid pseudo-scalars with taus at the LHC. *Eur. Phys. J. C* 78, 724 (2018). https://doi.org/10.1140/epjc/s10052-018-6183-4.
2. Bianchini, L., Calpas, B., Conway, J., Fowlie, A., Marzola, L., Perrini, L., & Veelken, C. (2017). Reconstruction of the Higgs mass in events with Higgs bosons decaying into a pair ofτleptons using matrix element techniques. *ELSEVIER*, *862*, 54–84. https://doi.org/10.1016/j.nima.2017.05.001.