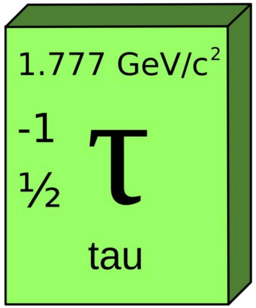
Three-Prong Tau Reconstruction in the ATLAS Detector

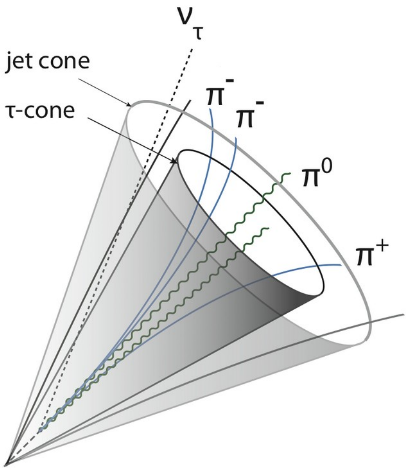
By Advait Dhingra

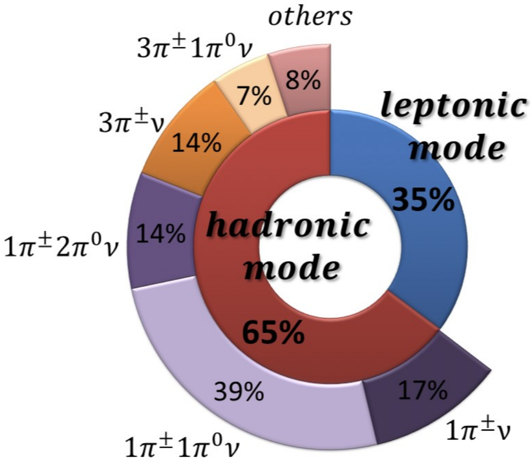
(this is not an official ATLAS or University of Bonn analysis)

τ lepton?



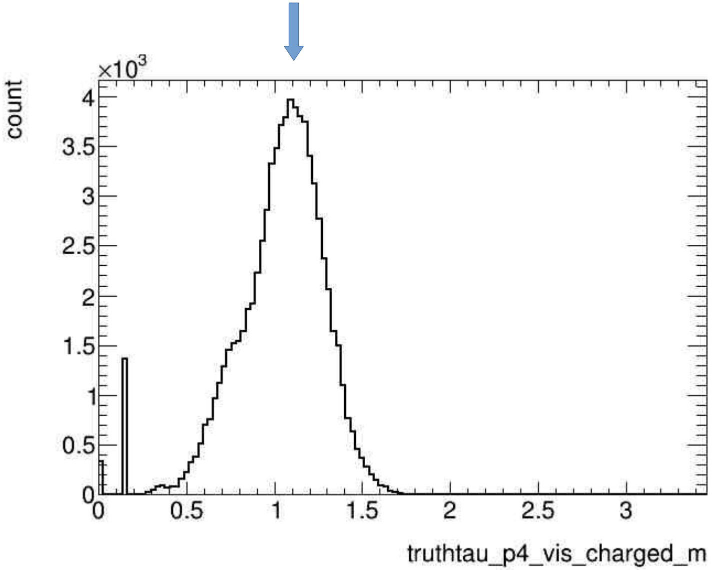
- Lepton group, 3rd generation
- M = 1776.86 MeV (1.78 GeV)
- Lifetime: 2.9 * 10^-13s
- Decay: Leptonic and hadronic modes



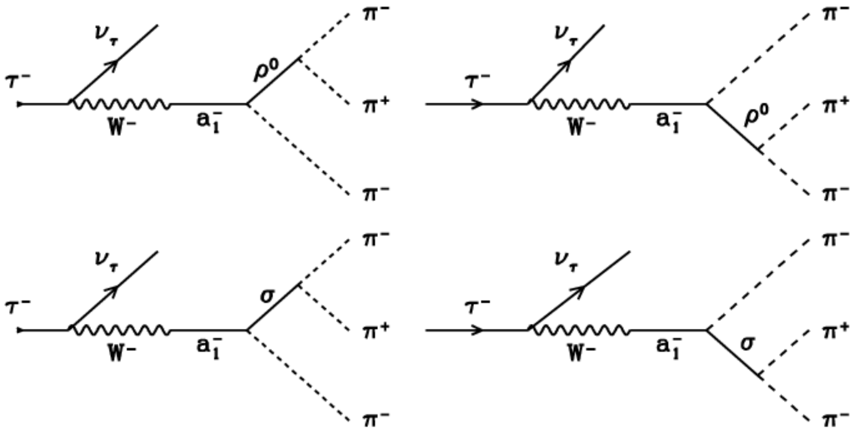


Three Prong τ Decay

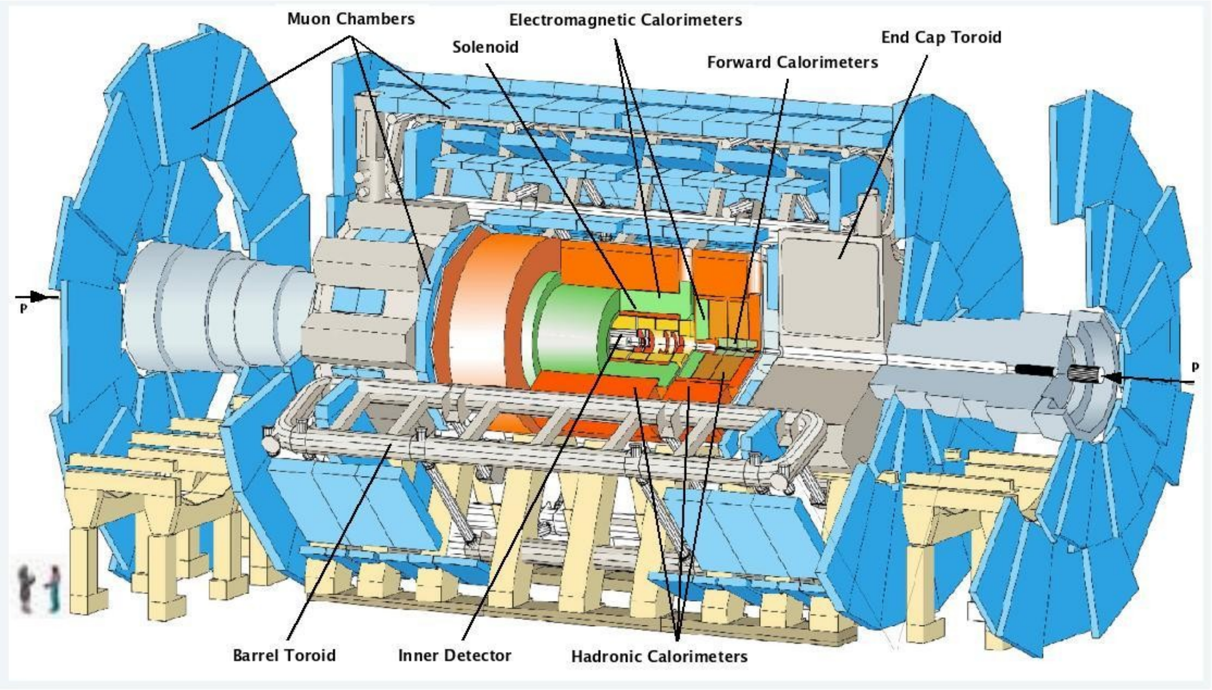
- τ → a1 → π^-+ρ^0 → π^-π^-π^+
- Resonance at a1 meson mass (~1.2GeV)

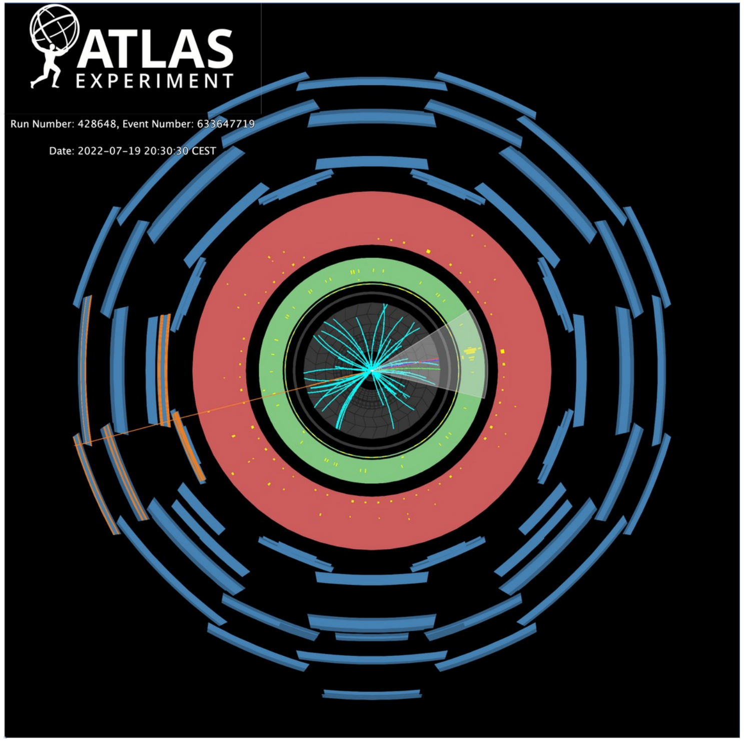


(Monte Carlo data)



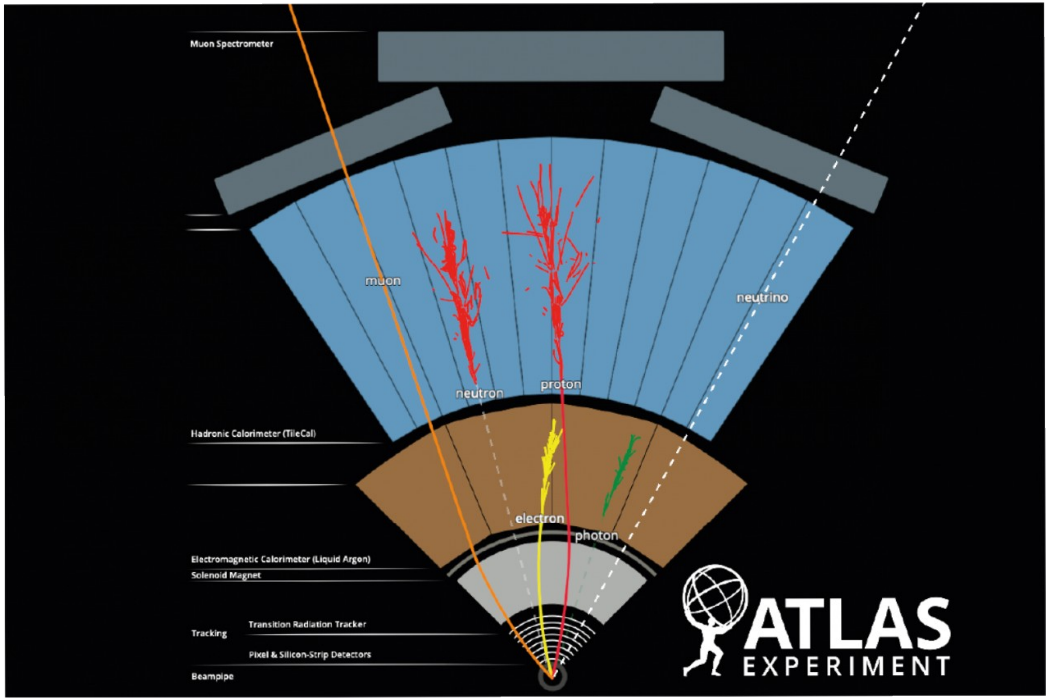
The ATLAS Detector





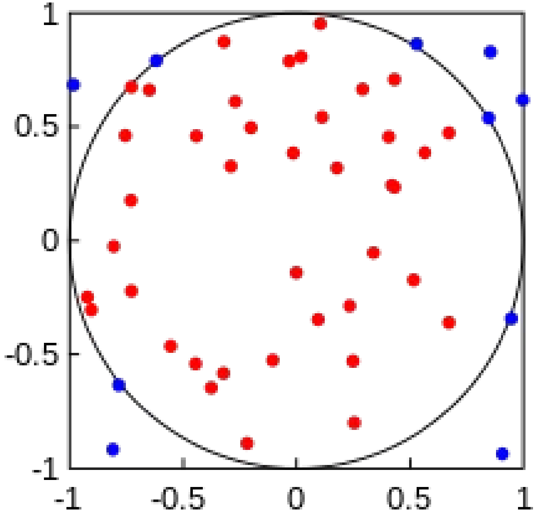
τ Signal in ATLAS

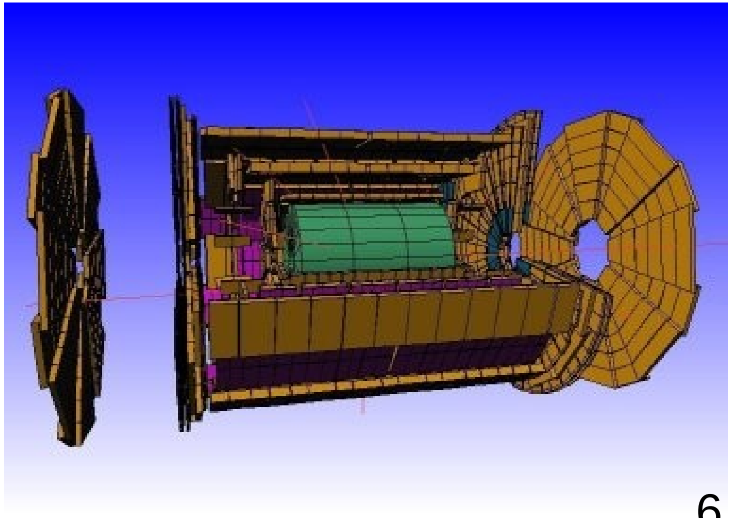
- Leptonic decay: ecal or muon chamber energy deposition
- Hadronic: Jets (hcal)



Monte Carlo Data

- Simulation using random generation
- Data produced by MC Simulation
- Can be used to simulate scattering and decay processes

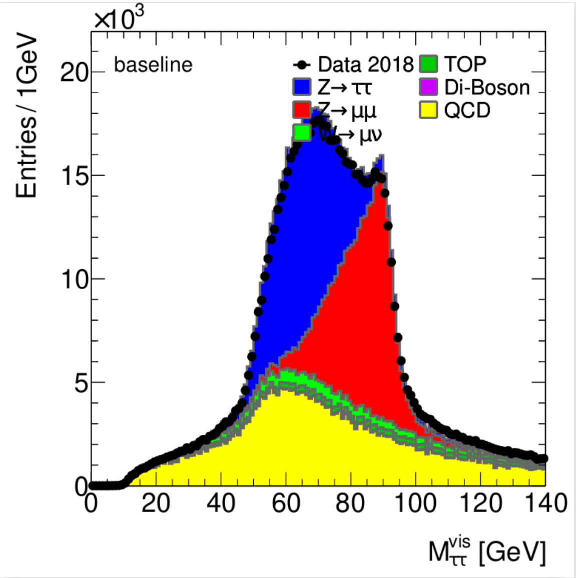


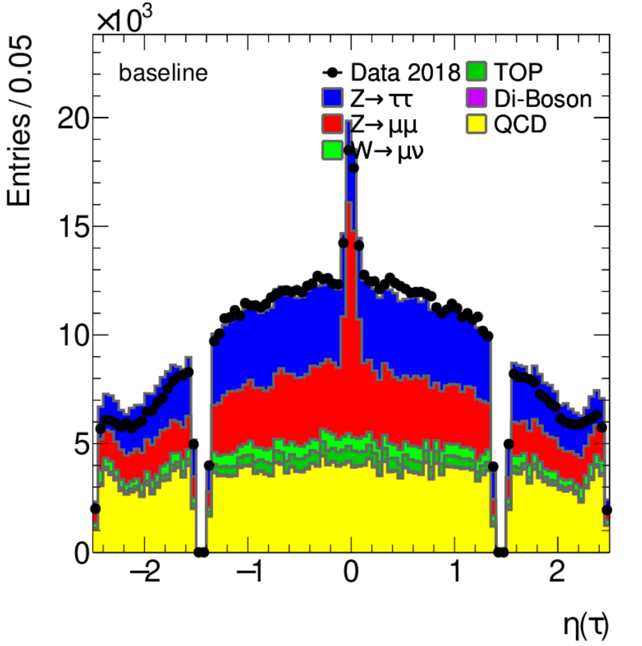


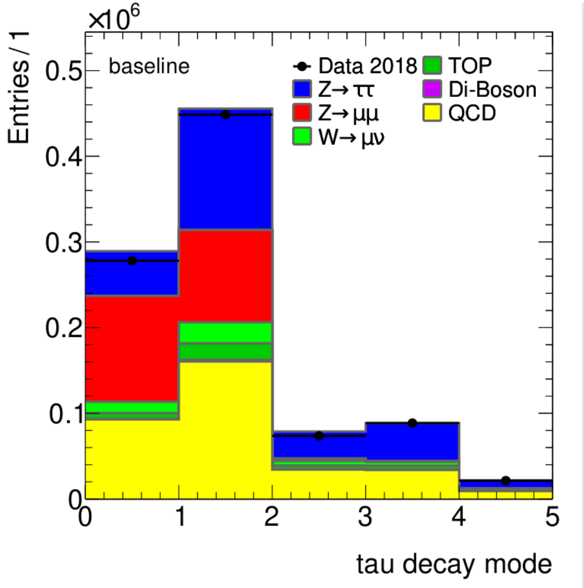
Signature

- Z → τ(lep)+τ(had) ➡ hadrons + ν
-
- ↳ μ
- μ + τ candidate
- Isolated + tight μ + opposite charge
- Relevant backgrounds:
  - Z → μμ: one μ reconstructed as τ
  - W → μν: μ + additional jet
  - QCD → Non-τ jets

Selection Decay Modes

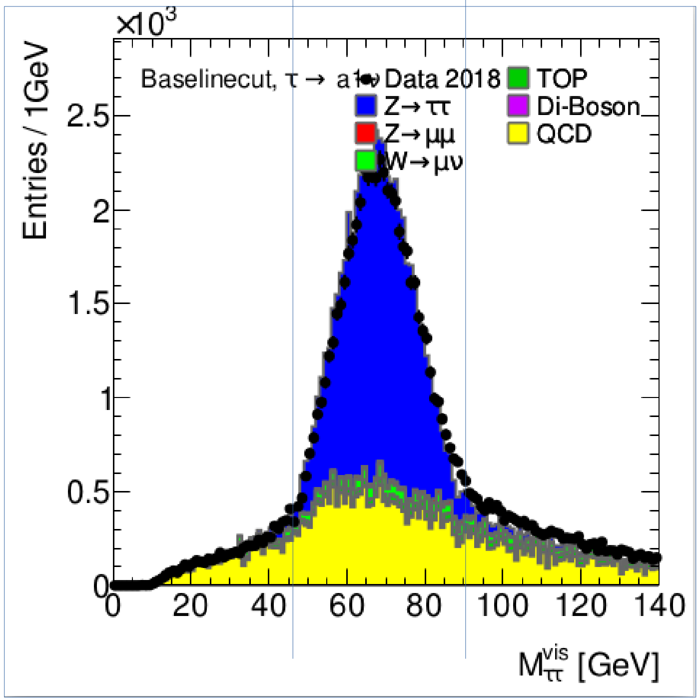




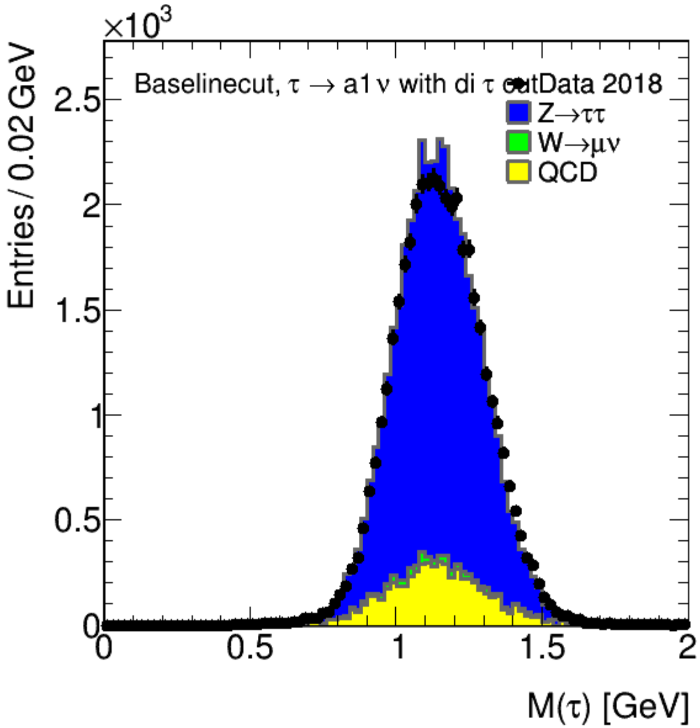


0: 1p0n
1: 1p1n
2: 1pXn
3: 3p0n
4: 3pXn

Select τ→ a1 decays



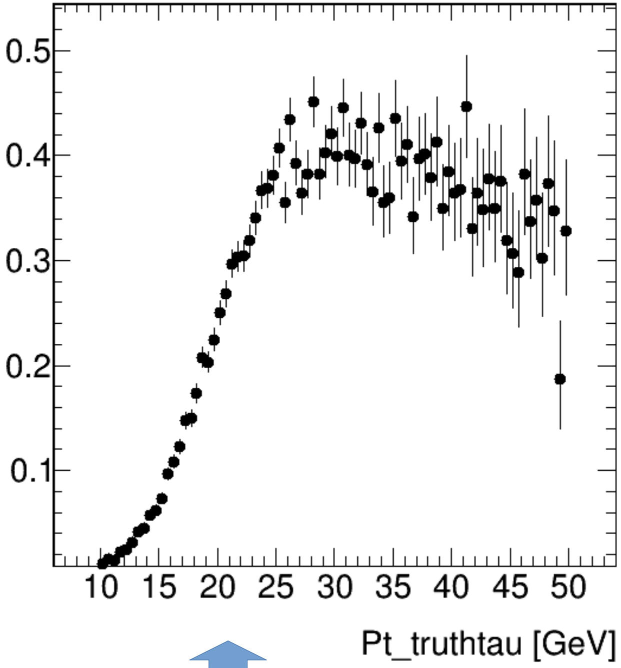
m(τ)



Low Energy Tau Reconstruction

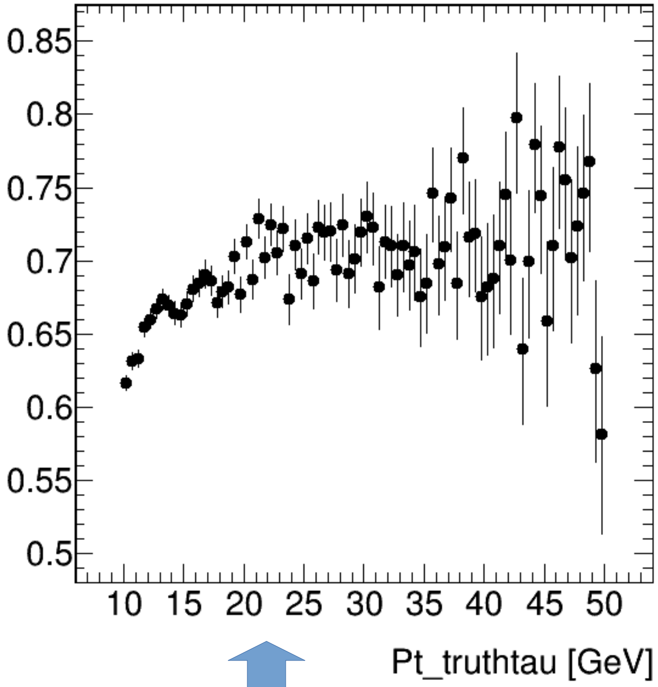
6-10 GeV

Tau Jet Reconstruction Efficiency



E =(n_inc + n_ex)/(n_inc)

Truth Pions Reconstruction Efficiency



Less efficient

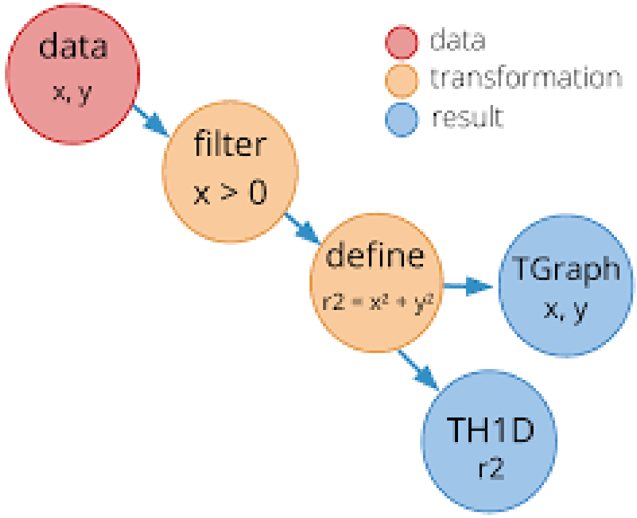
More efficient

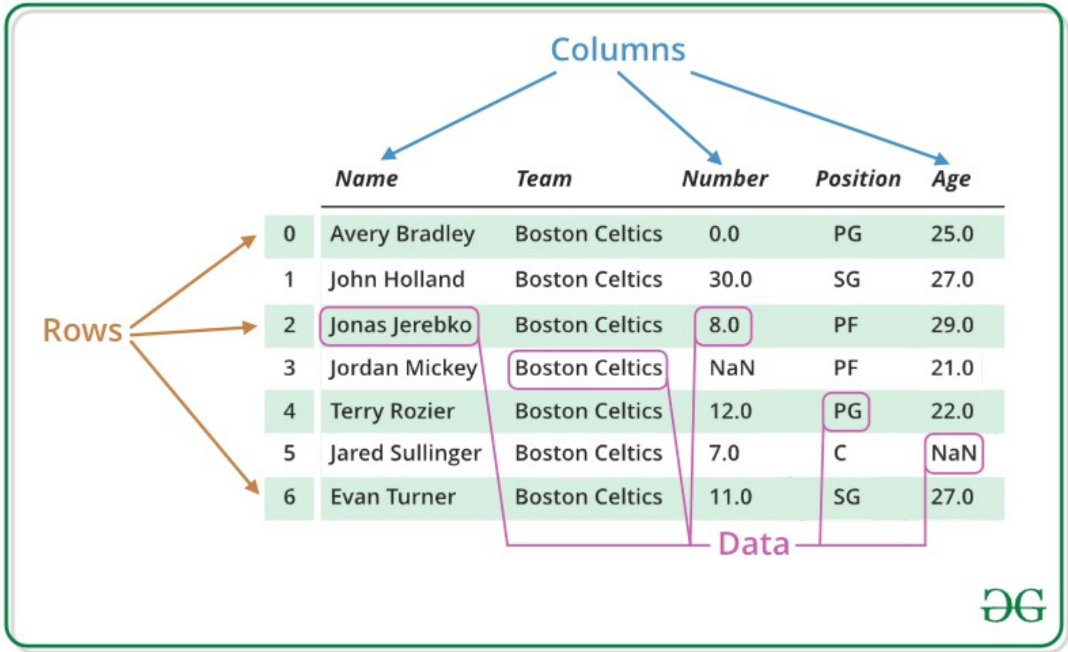
ROOT Data Analysis Framework

RDataFrame

- A “swiss-army knife” for data analysis and manipulation
- Tabular structure

Internal computation graph

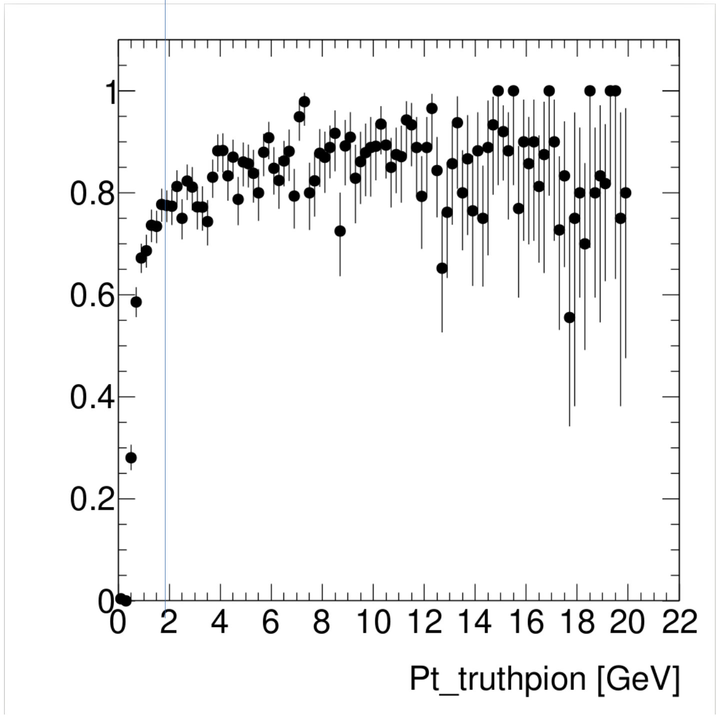




	Name	Team	Number	Position	Age
0	Avery Bradley	Boston Celtics	0.0	PG	25.0
1	John Holland	Boston Celtics	30.0	SG	27.0
2	Jonas Jerebko	Boston Celtics	8.0	PF	29.0
3	Jordan Mickey	Boston Celtics	NaN	PF	21.0
4	Terry Rozier	Boston Celtics	12.0	PG	22.0
5	Jared Sullinger	Boston Celtics	7.0	C	NaN
6	Evan Turner	Boston Celtics	11.0	SG	27.0

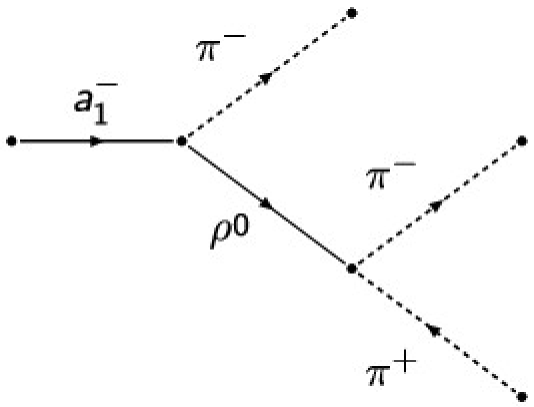
Efficiency Plots

- Eff = (truth π and reconstructed)/(truth π)



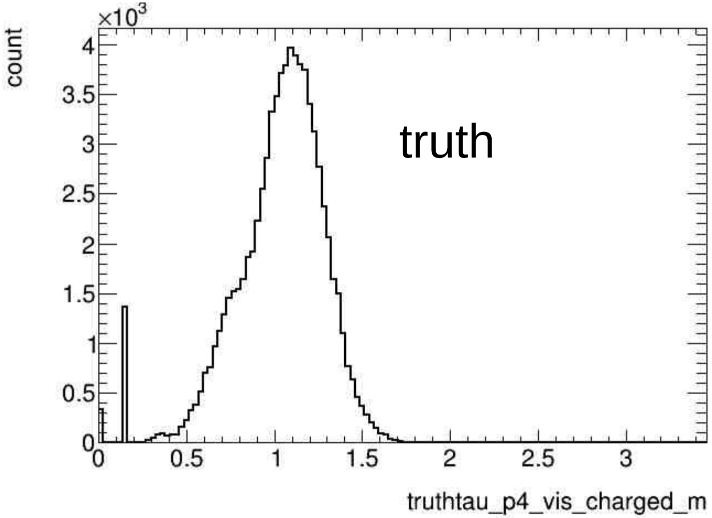
Track Selection

- $-2.5 < \eta < 2.5$
- pT > 2
- d0 < 0.1
- 3π combinatoric
  - Sum of charges: -1
  - m(2π+-) ~m(ρ)

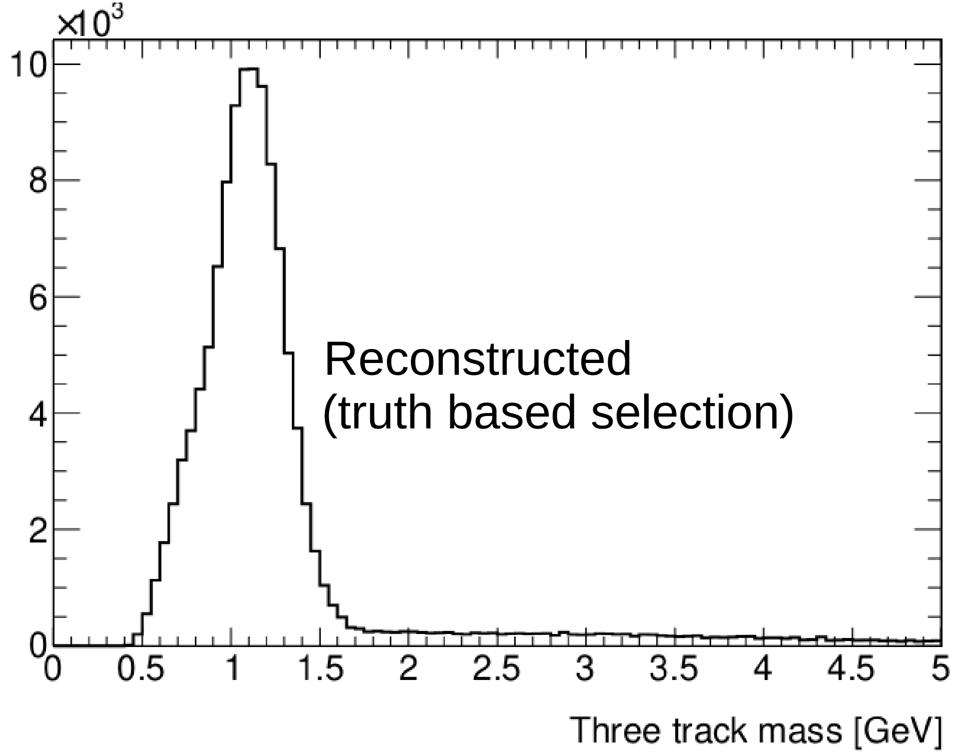


Mass Plot with Perfect Track Selection

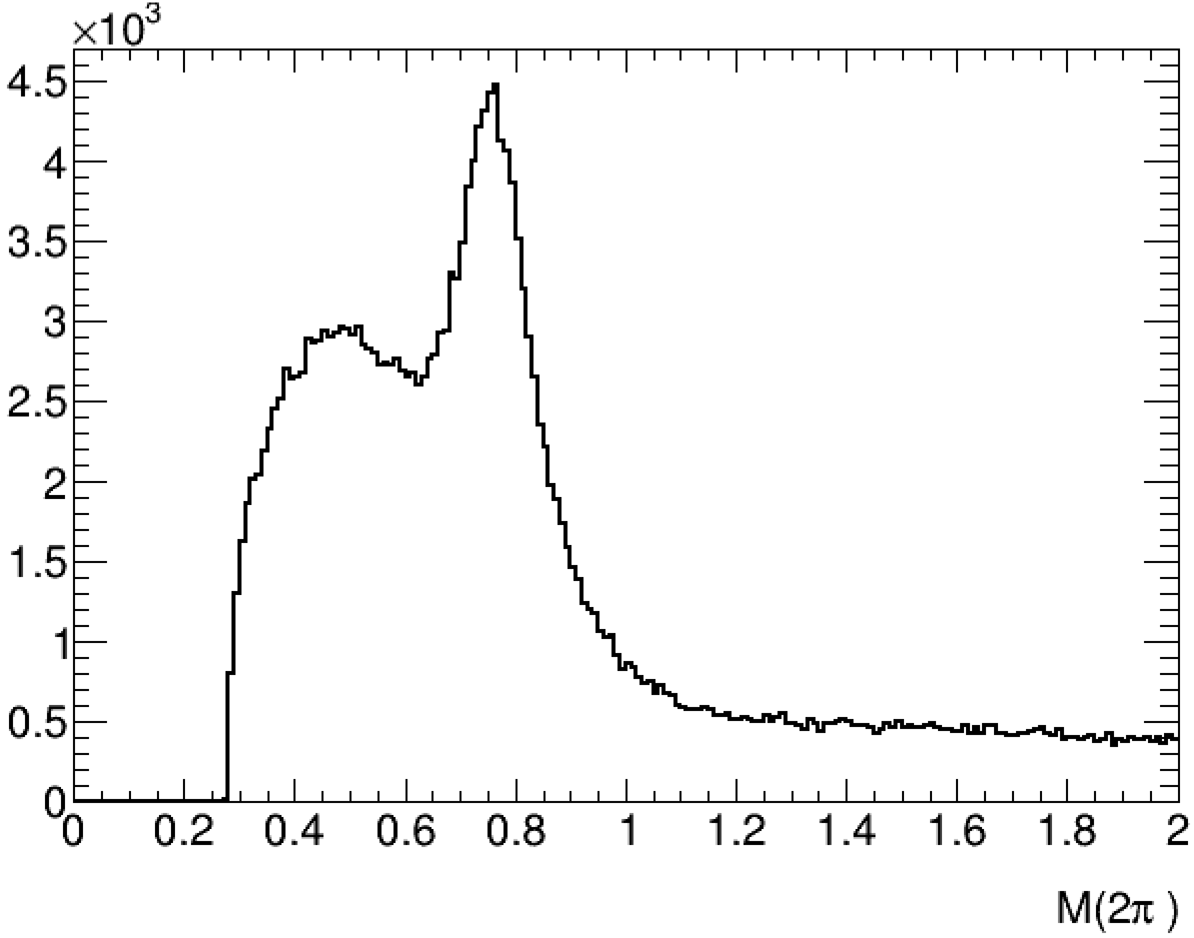
- Use Track-Truth Link to identify correct Pion tracks



Resonance at a1 mass (~1.2GeV)



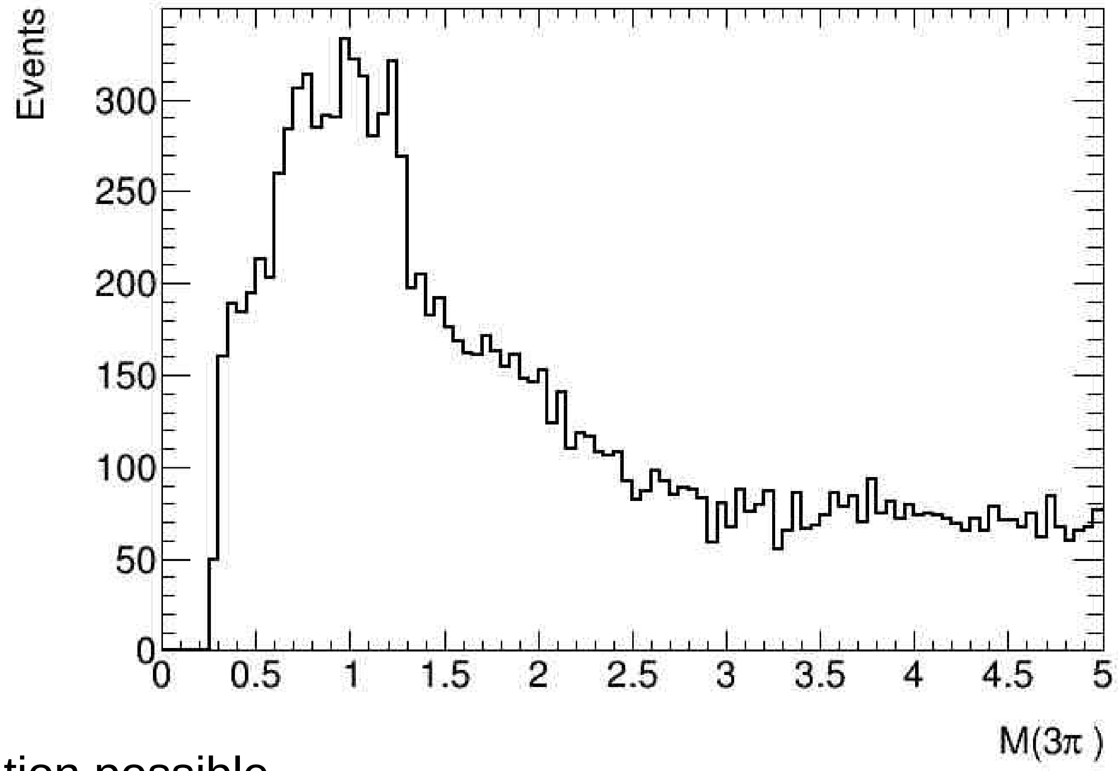
Reconstructed 2π Mass



2π = less filters = more events

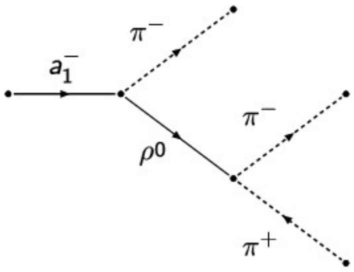
Resonance at ρ mass (~775MeV)

Reconstructed Mass Plot



Better optimization possible

Conclusion



- $Z \rightarrow \tau\tau$: clean a1 resonance selected from data
- ATLAS τ reconstruction is jet-seed based
- Could use pure track info to identify τ decays at low pt (→ higher efficiency)
- Make use of physics (ρ resonance and a1 resonance)
- Next steps: refine the track selection and the three track combinatoric selection to improve the a1 resonance

Lessons Learned

- Optimal selection filters
- Efficient code
- Testing with less data to save time and cpu power

End of presentation

- Thank you to Dr. Christian Grefe for his immense support and guidance