Former Activities and Current Physics-Related Projects

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Overview

- PhD at ATLAS in late 2021
- Now in DUNE Database Group

Former activities:

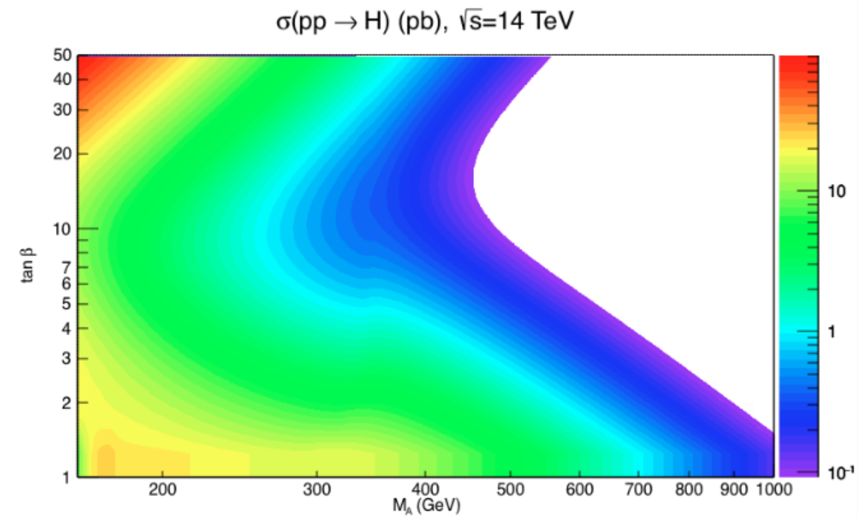
- Research at ATLAS
  - Search for BSM A/H to tautau
- Other activities
  - Machine Learning applications for LiDAR sensors

Current Physics-related work at DUNE

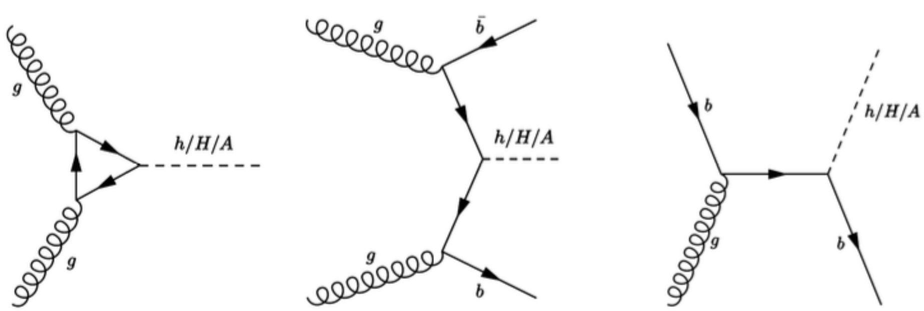
- Slow Controls data analysis

BSM A/H to tautau - Motivation

- Often assume two Higgs doublets
- Electroweak symmetry breaking
  $\rightarrow$ five mass eigenstates: $h, H, A, H^{\pm}$
- Several Assumptions $\rightarrow$ two parameters to describe Higgs sector at tree level:
  - m_A
  - $\tan\beta = \frac{<H_u^0>}{<H_d^0>}$



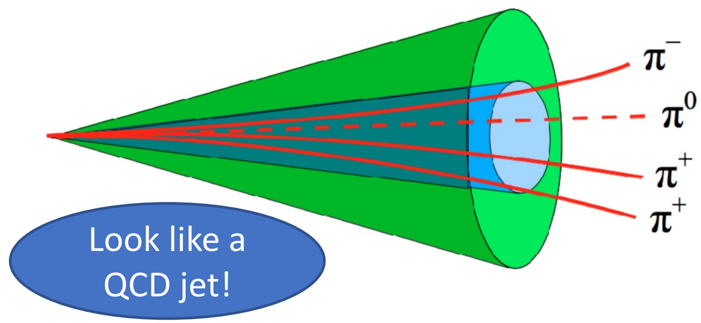
JHEP 06, 168 (2015), 1502.05653



- A/H coupling depends on particle's mass
- $\tan\beta$ can further increase coupling to down-type fermions
- Di-τ decay channel very promising!

Hadronic Tau-Lepton Decays

- Only lepton that can decay hadronically
  - Mainly into pions

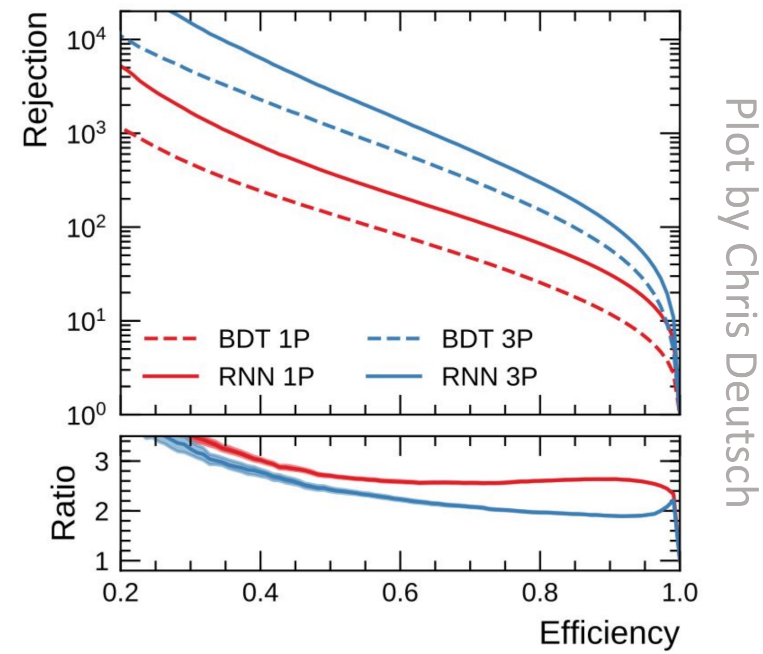


- Reconstruction:
  - Start from 'jet' in calorimeter (Clustering)
  - Geometrically match & classify tracks

- After Reco: candidates mostly jets from quarks/gluons (QCD)

- Identification ('ID') algorithm to discriminate against 'fakes'

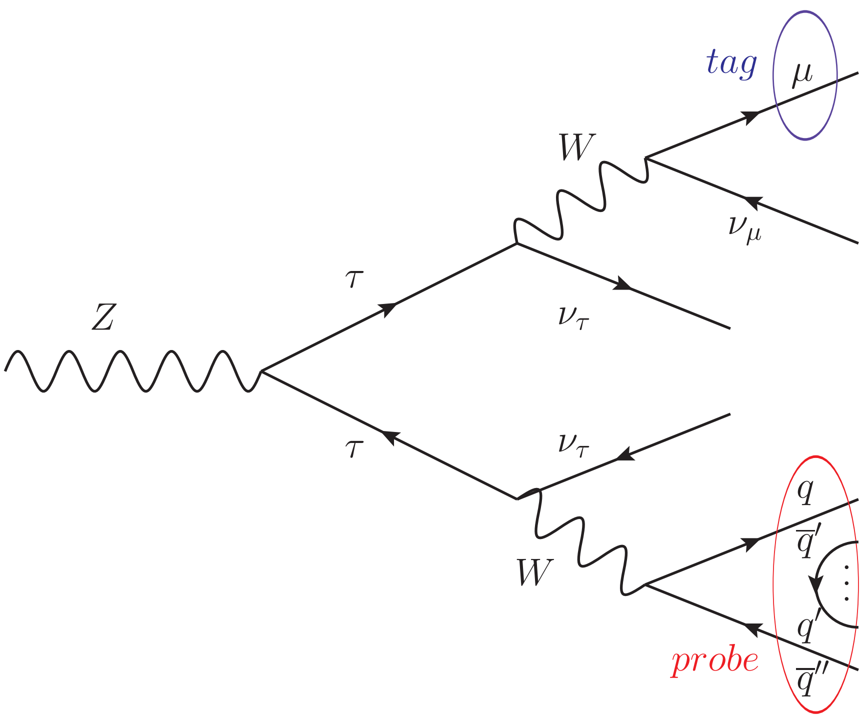
  - Quali task:
    Evaluate ID performance on real data



Tau-ID Performance Evaluation

- Analyses rely on simulated tau-lepton decays
  - Correct for different classification efficiencies on data vs MC

$$SF = \frac{\epsilon_{data}}{\epsilon_{MC}} \qquad \epsilon = \frac{\#(\tau_{pass})}{\#(\tau_{all})}$$



How to know efficiency on real data?

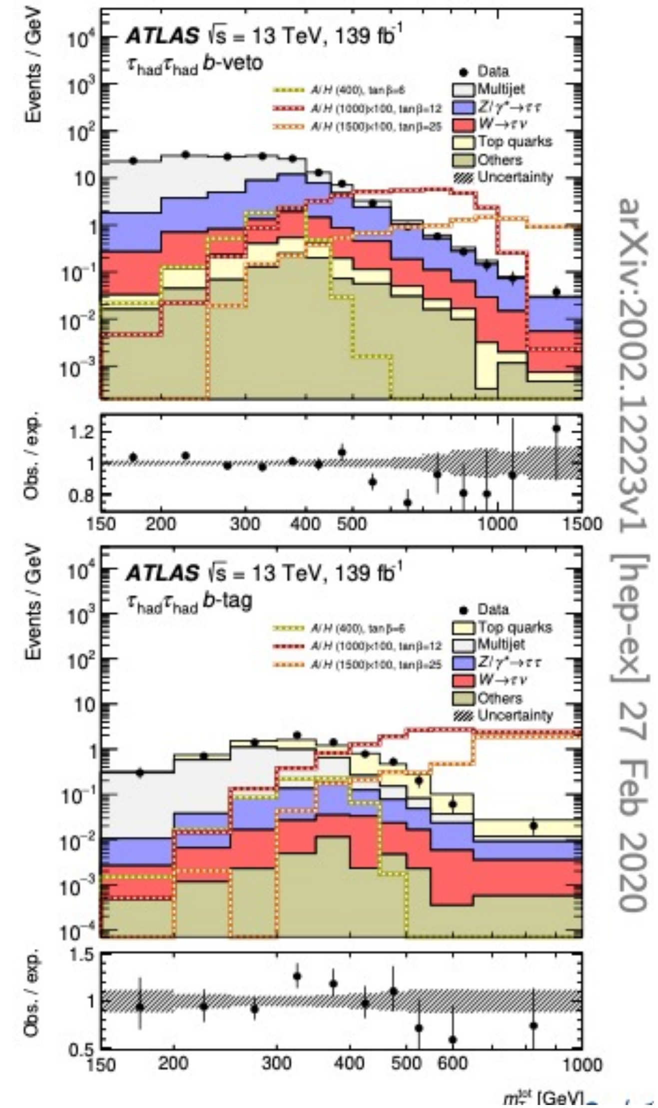
- Dataset enriched with true tau's
- Solid background estimate
- Estimate true tau contribution via fit

Resulting scale factors have been deployed by ATLAS

BSM A/H to tautau – Analysis Strategy

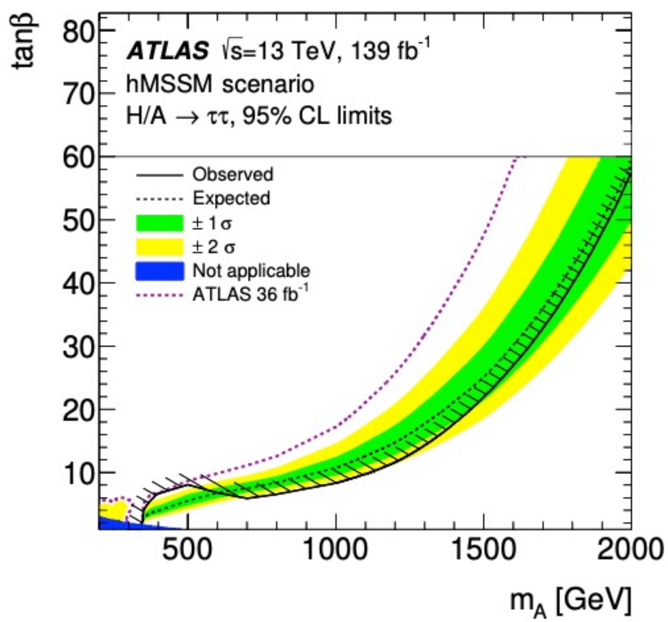
- Full dataset at $\sqrt{s} = 13$ TeV
- Split into τ decay modes: hadhad & lephad
- b-veto/b-tag signal regions exploit different production mechanisms
- Special challenges:
  - Much background from fakes
  - At least 2 ν in each event
    - Difficult mass reconstruction

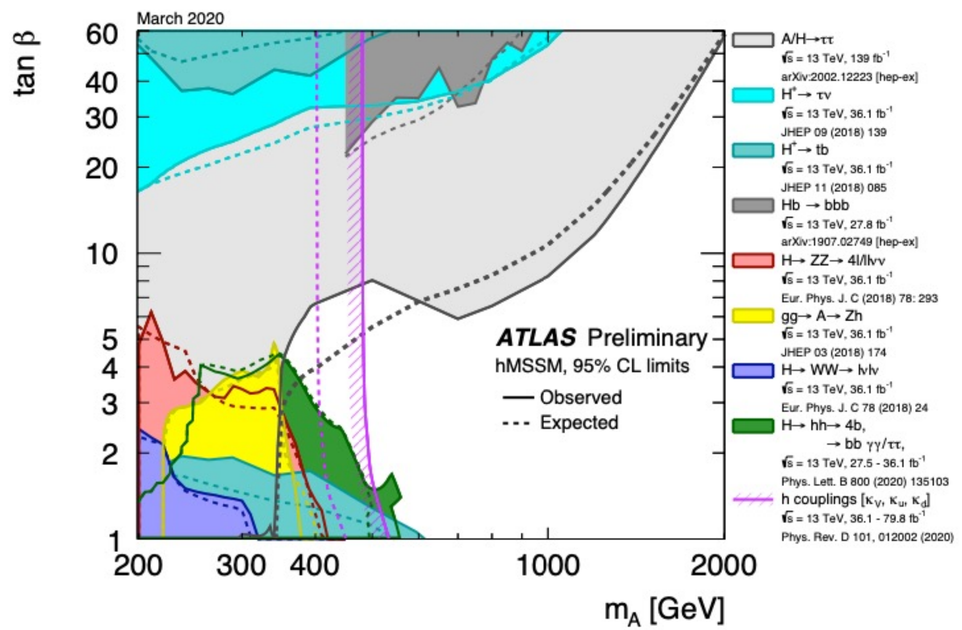
$$m_{\mathrm{T}}^{\mathrm{tot}} = \sqrt{m_{\mathrm{T}}^2(E_{\mathrm{T}}^{\mathrm{miss}}, \tau_1) + m_{\mathrm{T}}^2(E_{\mathrm{T}}^{\mathrm{miss}}, \tau_2) + m_{\mathrm{T}}^2(\tau_1, \tau_2)}$$



BSM A/H to tautau - Results

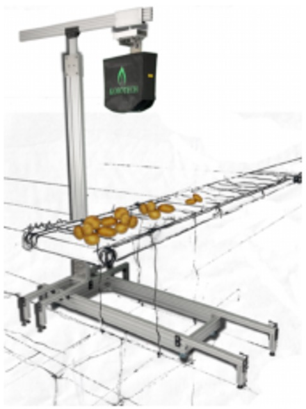
- Limits set in different scenario
- Large additional phase space excluded





arXiv:2002.12223v1 [hep-ex] 27 Feb 2020

Machine Learning for LiDARs - I

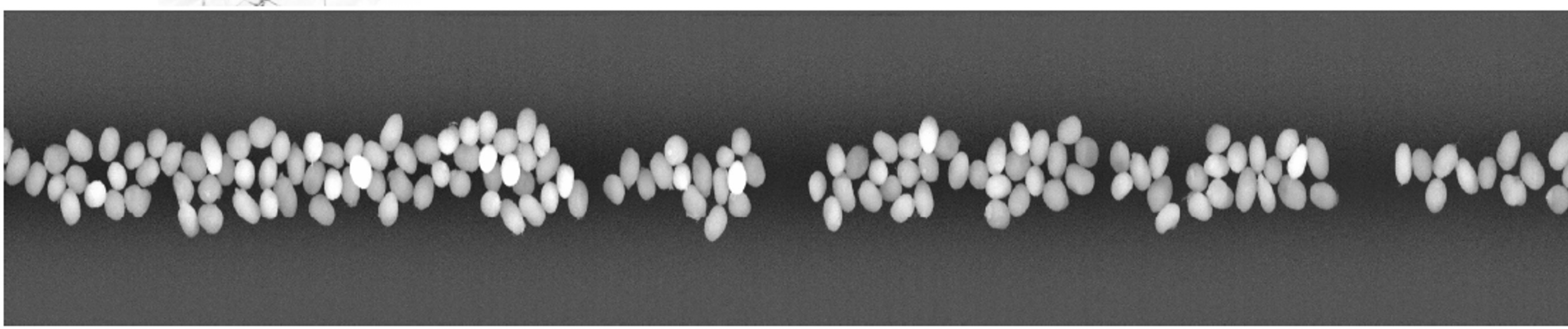


~ 500 kHz

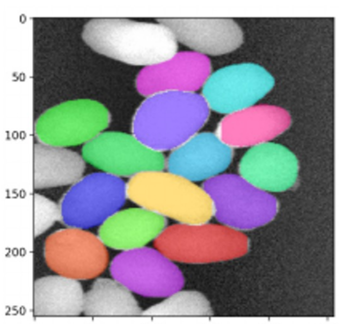
Real Time Output

RAW DATA

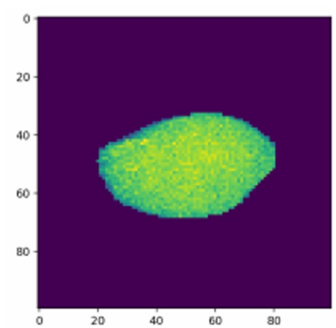
3D Reco



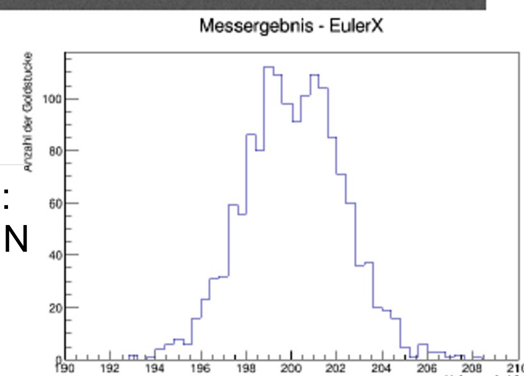
Segment.: Deep Learning



Isolation



Regression: simple FFNN



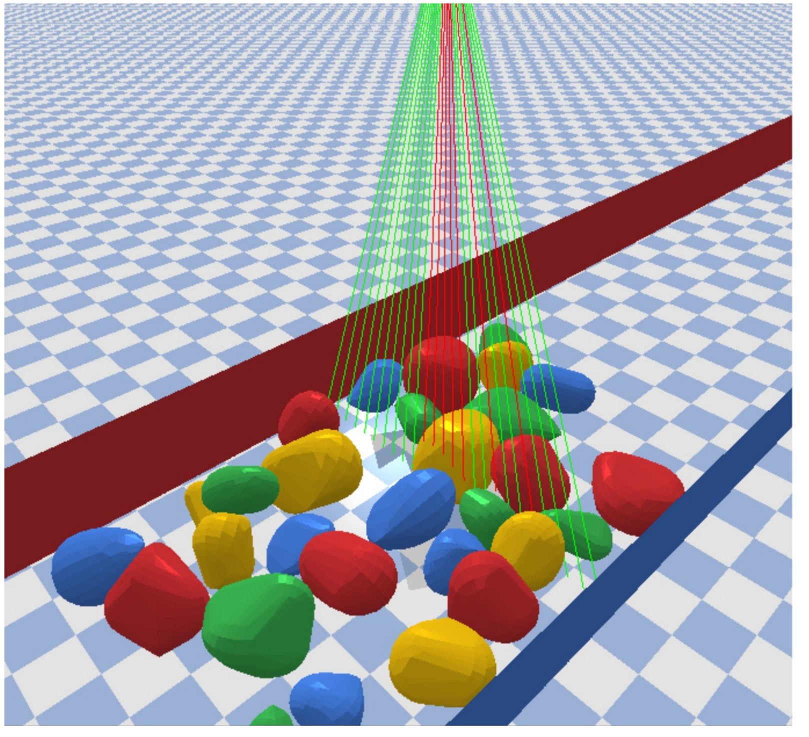
Machine Learning for LiDARs - II

Supervised learning approach

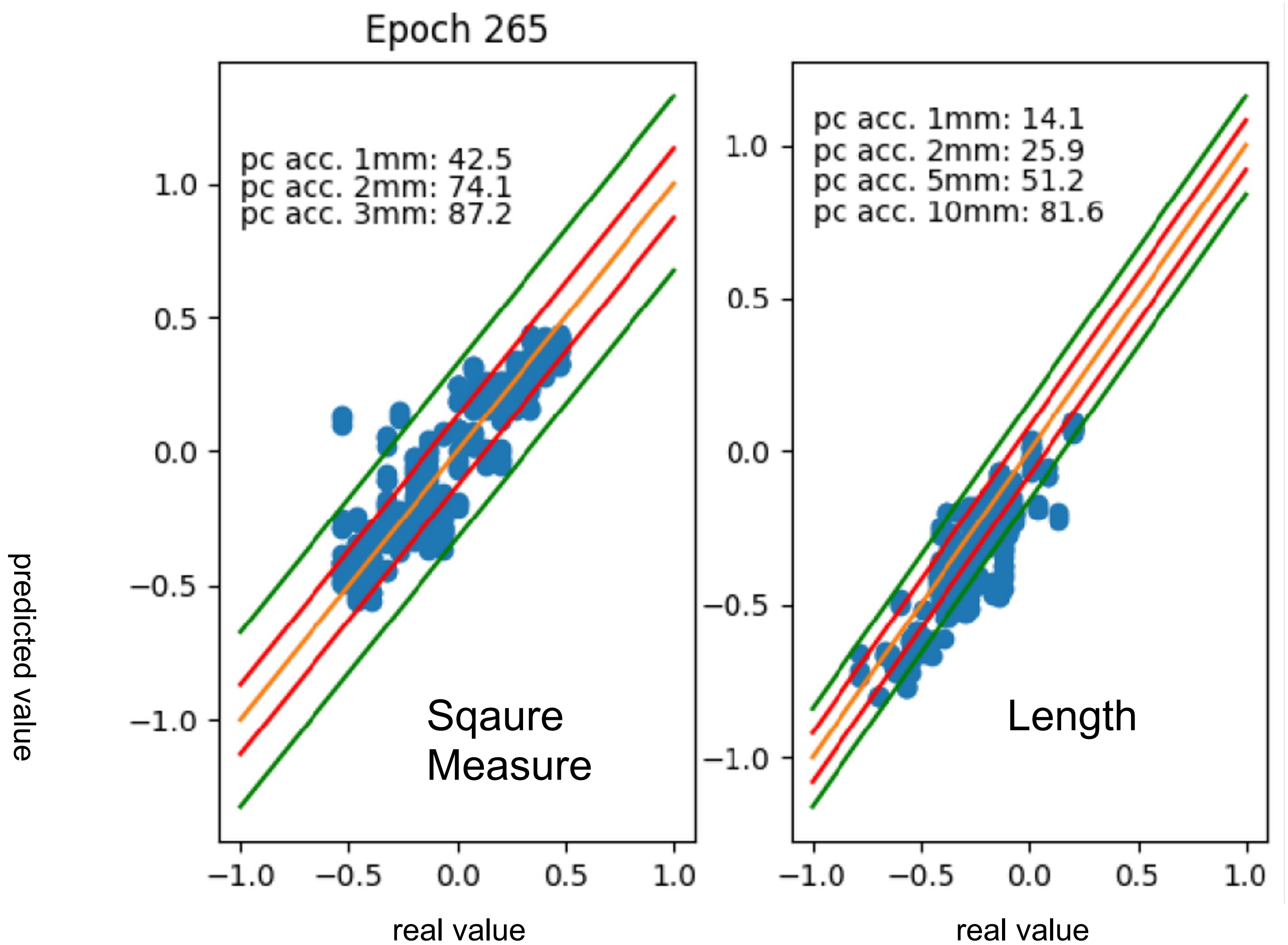
- Need large labelled data set

Developed Simulation

- MC potatoe generator
- Physics engine
- Detector simulation



Machine Learning for LiDARs - III



Validated precision close to detector resolution

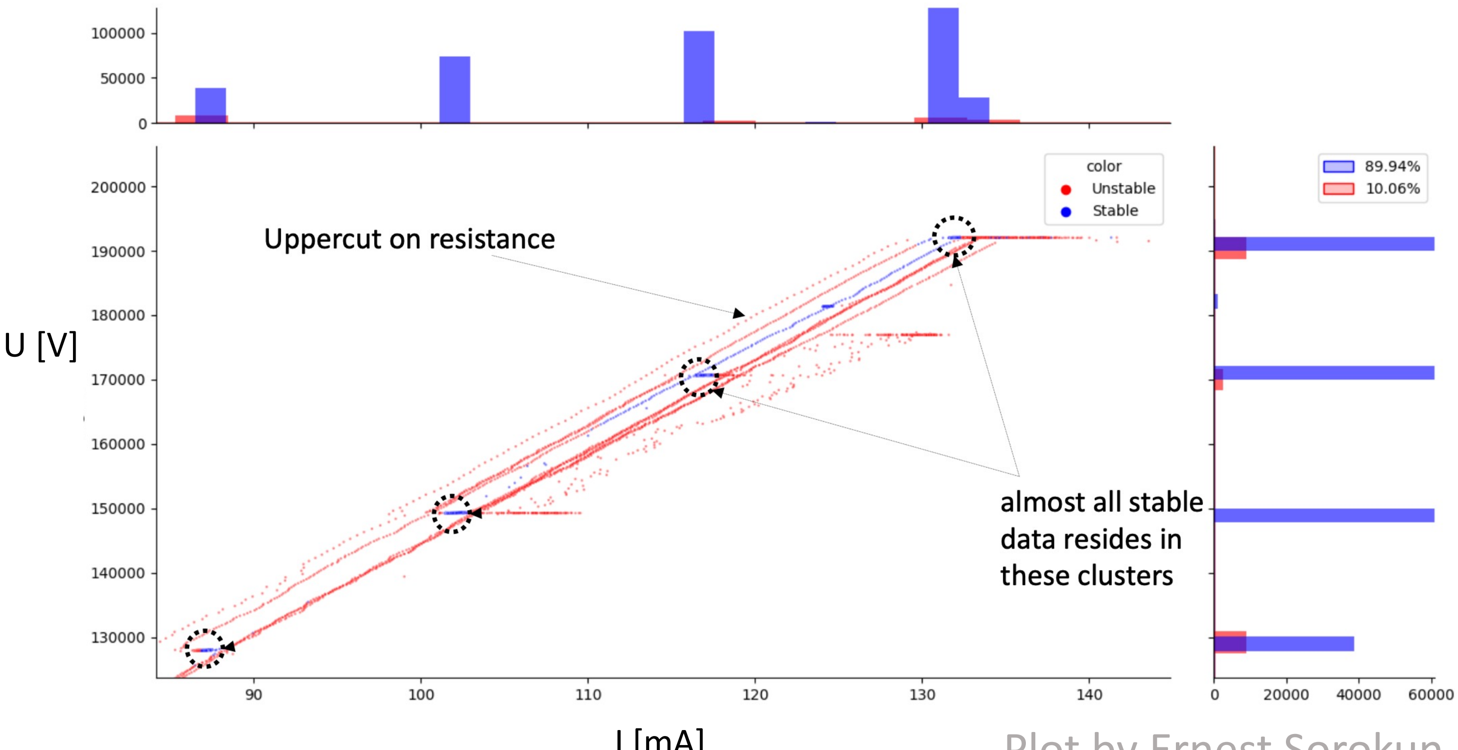
Physics at DUNE – Slow Controls

- Database group develops conditions Data base for (proto)DUNE
  - Understand requirements: gather use cases
  - Investigated output of offline Slow Controls data analysis (May)
    - Identification of unstable HV periods

- Since August: supervise IRIS-HEP Fellowship project:
  - ‘Data Reduction for the ProtoDUNE Detector Control System’
  - Focus on unstable HV analysis for now

Physics at protoDUNE – Unstable HV Analysis

- Procedure of original analysis (only Run1):
  - Consider time-indexed voltage and current
  - Define hand-picked cuts on resistance (change over time)
- Goals of project:
  - Look for pattern in data that naturally divides into stable / unstable
  - Derive results for more recent data



classification according to original cut-based analysis

Plot by Ernest Sorokun

Conclusion and Outlook

- Have a physics / data analysis background
  - Search for BSM and tau calibration / identification at ATLAS
- Now part of database group
  - Developing conditions database
- Still enjoy doing physics analysis
  - Currently supervising data analysis project @ protoDUNE
- Open to new projects after the Fellowship

Thank you for your attention

BDT vs RNN TauID

<u>BDT TauID</u>

- 12 'high-level' input variables

<u>RNN TauID</u>

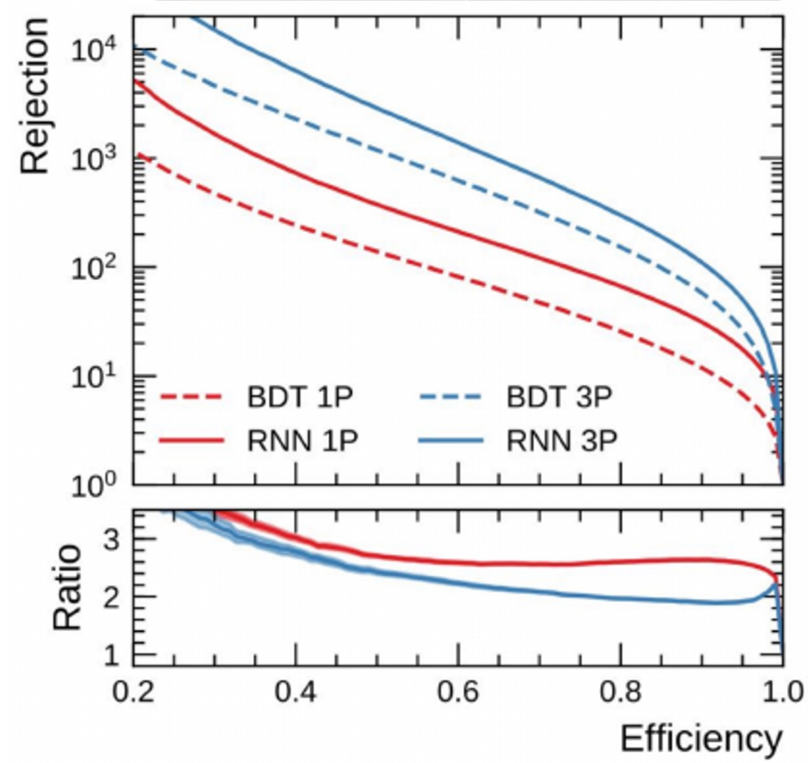
- BDT input variables
- Track-level variables
- Cluster-level variables

<u>RNN clearly outclasses BDT ID</u>

- Expect $\approx$ 30% higher di-Tau yield

But: New Scale Factors were needed for RNN ID by tauWG

(Also BDT ID SF for full Run-2 dataset)



Plot by Chris Deutsch