Karlsruhe Institute of Technology

Institute of Experimental Particle Physics

CMS Germany

BMBF FSP-CMS

arXiv review

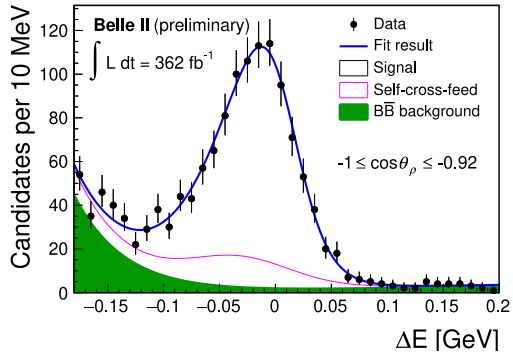
ETP Weekly Meeting

Moritz Molch | April 29, 2024

Belle II measurement of the branching fraction of $B^- \to D^0\rho^+$

- Belle II analyses rely on reconstructing both B mesons in $\Upsilon(4S) \to B\bar{B}$ decays using one as signal and the other as tag meson
- Significant difference in tagging efficiency of $B^- \to D^0\rho(770)^-$ decays between data and simulation
- Reconstruction:
  - Reconstruction of D^0 by combining K^- and π^+ in D^0 mass window
  - Reconstruction of ρ^- by combining π^0 and π^- in ρ^- mass window
  - Combination of D^0 and ρ^- to B^- via a kinematic fit
- Observables:
  - $\Delta E = E^*_B - E^*_{\text{beam}}$ in e^+e^- center-of-mass frame
  - $\cos\theta_\rho$ with θ_ρ being the angle between $\vec{p}(\pi^-)$ and $\vec{p}(B^-)$ in the ρ^- rest frame

arXiv:2404.12660v1 [hep-ex]



Belle II measurement of the branching fraction of $B^- \to D^0\rho^-$

- Backgrounds:
  - $B\bar{B}$: B decays other than the signal decay
  - Self-cross-feed: misreconstruction by taking a final-state particle from other B meson
- Disentanglement of non-resonant $B^- \to D^0\pi^-\pi^0$ and $B^- \to D^0\rho^-(\to \pi^-\pi^0)$: Template fit on background-subtracted $\cos\theta_p$ distribution
- Result:

$$\mathcal{B}(B^- \to D^0\rho^-) = (0.939 \pm 0.021(\text{stat}) \pm 0.050(\text{syst}))\,\%$$

- Current world average:

$$\mathcal{B}(B^- \to D^0\rho^-) = (1.34 \pm 0.18)\,\%$$

- Relative precision of world average improved by factor of 2

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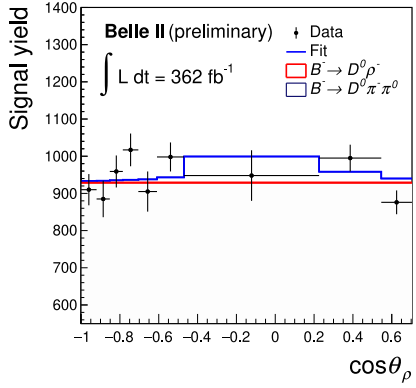

Review of Machine Learning for heavy flavour jet tagging

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arXiv:2404.01071v1 [hep-ex]

- Comprehensible review of history of machine learning approaches to flavour tagging of jets at ATLAS and CMS
- Developments for both, single- and multi-pronged jet tagging, are described:
  - Single-pronged jet tagging: Does a jet originate from a b, c, light flavour quark or a gluon?
  - Multi-pronged jet tagging: Does a (large-radius) jet originate from a resonance, a W/Z/H boson, a top quark, ...?
- Approaches are divided into three generations:
  - Run-1 and early Run-2: boosted decision trees and shallow neural networks
  - During Run-2: deep neural networks, convolutional neural networks, recurrent neural networks
  - After Run-2 and Run-3: deep sets, graph neural networks, transformers
- Outlook: Trend of using lower-level input features is likely to continue
  - Requires even more advanced architectures, poses significant challenges to computing and storage infrastructure
  - Is the neural network learning patterns in the simulation, which are not present in data?

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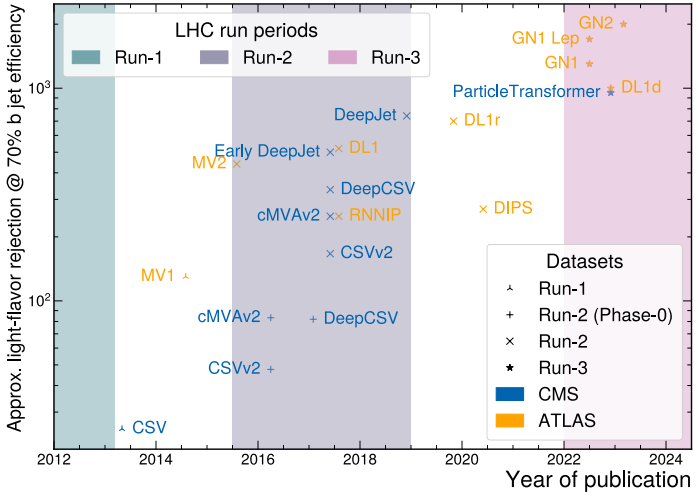

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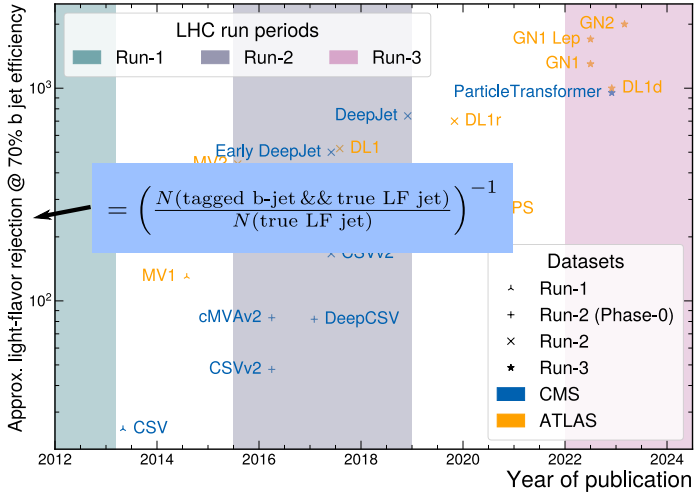

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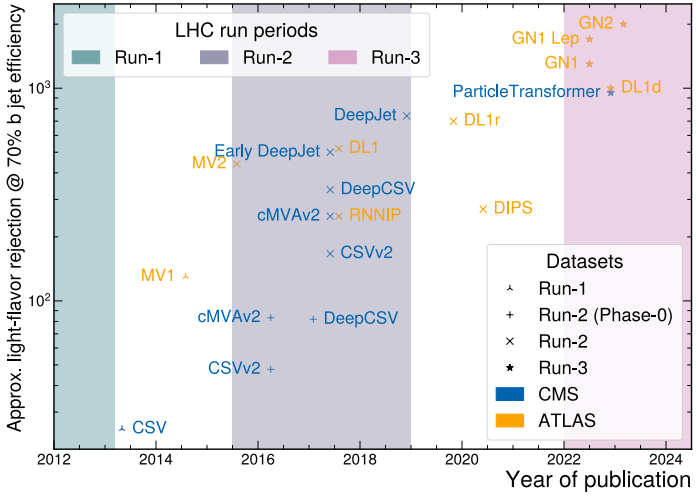

ATLAS search for non-resonant H(bb)H($\tau\tau$) production

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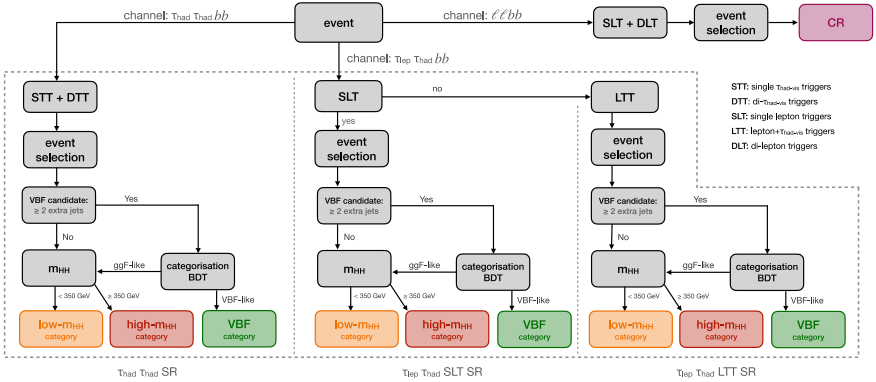
arXiv:2404.12660v1 [hep-ex]

- Update on arXiv:2209.10910v2 [hep-ex]
- Targets gluon-gluon fusion (ggF) as well as vector boson fusion (VBF) production channels



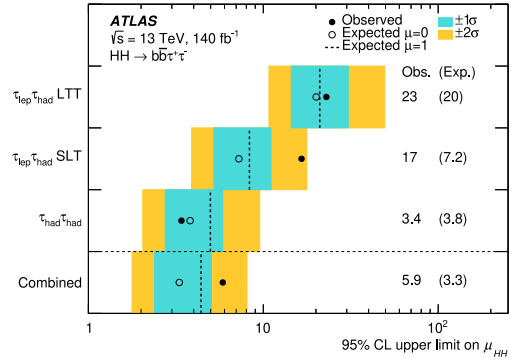
ATLAS search for non-resonant H(bb)H($\tau\tau$) production

- Boosted decision trees used for categorization as well as for signal-background separation
- Observed (expected) limit on the Higgs pair production signal strength modifier:

$$\mu_{HH} = \frac{\sigma_{HH}}{\sigma_{HH}^{SM}} < 5.9(3.3) \quad \text{CMS : } 3.3(5.2)$$

  at 95 % confidence level (CL)
- Excess in SLT region: 2.7σ with respect to background-only 2.3σ with respect to SM hypothesis
- Dominant uncertainty source: size of the recorded dataset

arXiv:2404.12660v1 [hep-ex]



Backup

Feynman diagrams for SM Higgs pair production

arXiv:2404.12660v1 [hep-ex]