Some thoughts on a possible MEM+ML Challenge

Josh Bendavid (Caltech)

Caltech

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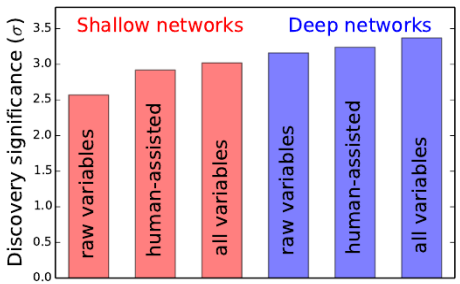
Introduction - High Level and Low Level Features

- HEP analyses typically use a mix of "high level" and "low level" features.
- e.g low level: four-vectors, high-level: transverse mass
- In the ML context these can be complementary eg as classifier inputs
- In the appropriate limit ML technique may be able to learn relevant information only from low-level variables



P. Baldi et al, arXiv:1410.3469

MEM Discriminator as a High Level Feature

- Matrix Element method discriminator built from underlying matrix elements of signal and background, with appropriate/necessary integrals for phase space and detector response
- Is a rather complex high level feature, with lots of physics knowledge built in
- MEM discriminators already commonly combined with ML techniques, eg as input to ML classifier together with low level or detector-related features to augment physics content of the MEM with that from the simulation

Hybrid NN+MEM

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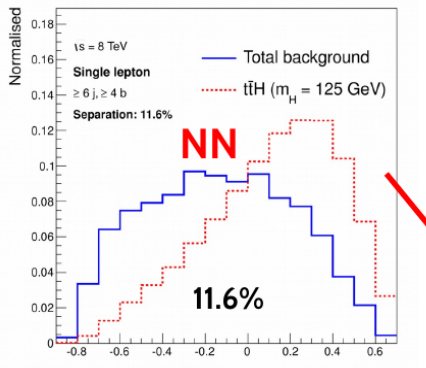

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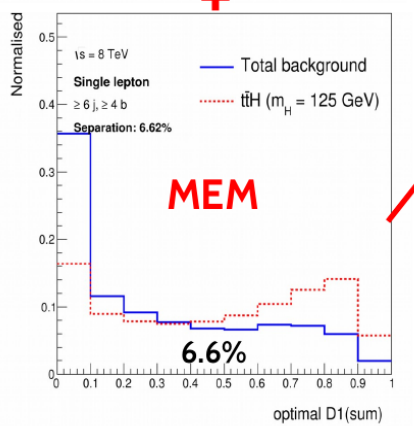
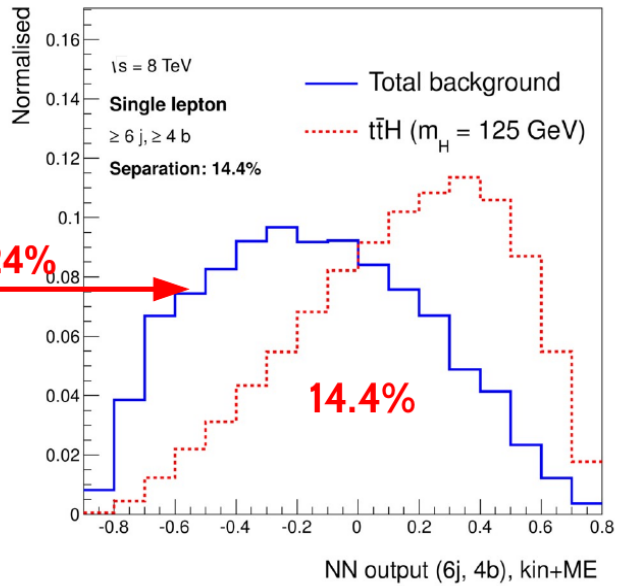


Most sensitive analysis region (6j, 4b)

+24%



Expected limit on signal strength: **3.1 → 2.6 (16%)**

EPJC 75 (2015) 349 (ATLAS $ttH \rightarrow bb$)

MEM Discriminator as a High Level Feature

- The same physics knowledge directly or indirectly underlies the Monte Carlo, so a machine learning technique may in principle be able to learn it $\rightarrow$ quantify with representative example
- Consider a possible ML challenge for signal/background discrimination with two (or three) variations
  1. MEM + low level features from simulation (make sure low level features contain at least all inputs to MEM evaluation)
  2. Low-level features only
  3. Low-level features plus faster-to-evaluate ML-based proxy for MEM (this was discussed during DS workshop at least)
- Challenge could be based on an existing ATLAS/CMS analysis or some variation, but would need to ensure sufficiently large MC samples for meaningful deep-learning tests (fast-simulation could be used for this purpose)
- (If CPU-time for MEM evaluation is the critical path, then larger samples could be provided with low-level features only)