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The Interplay of Machine Learning-based Resonant Anomaly Detection Methods

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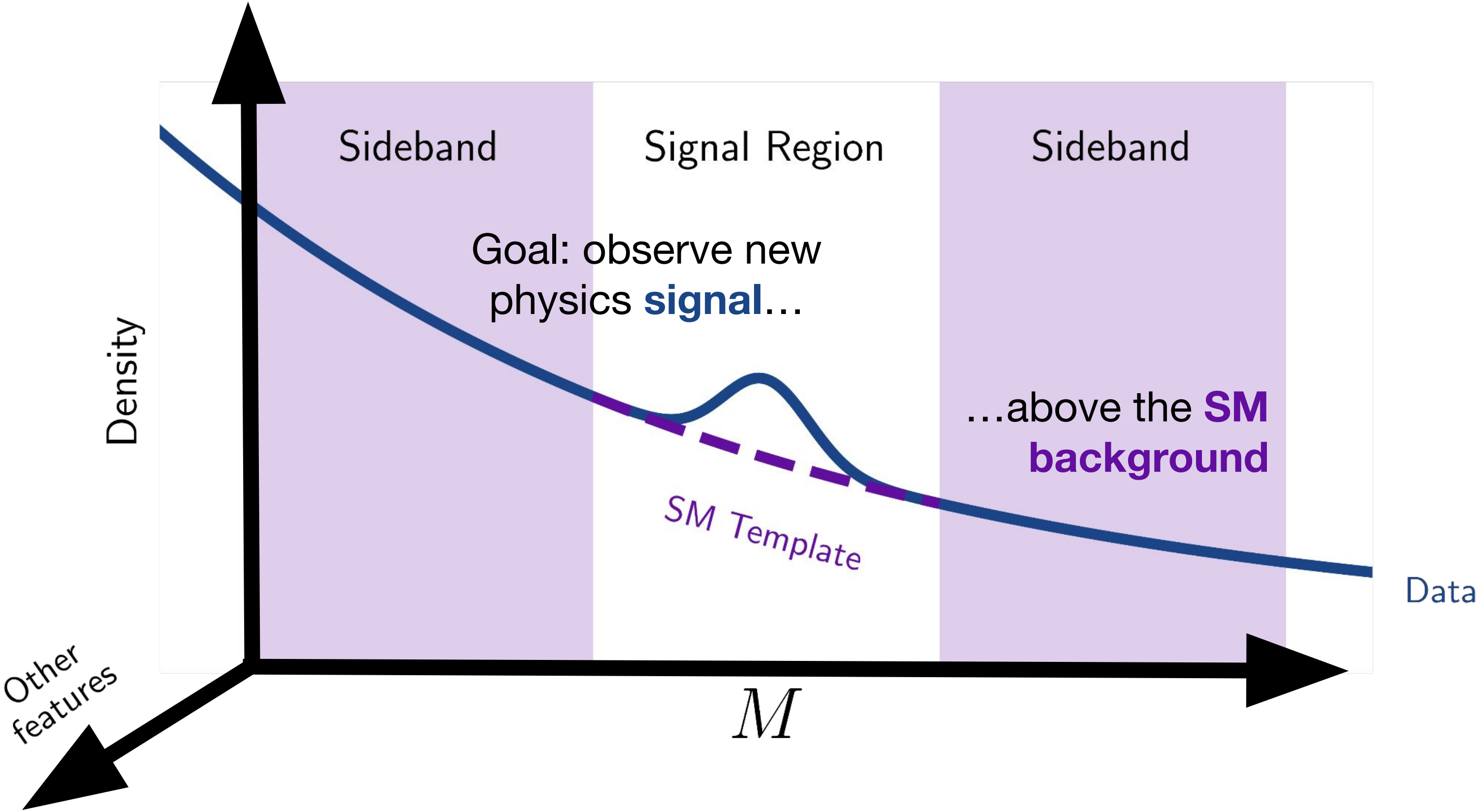
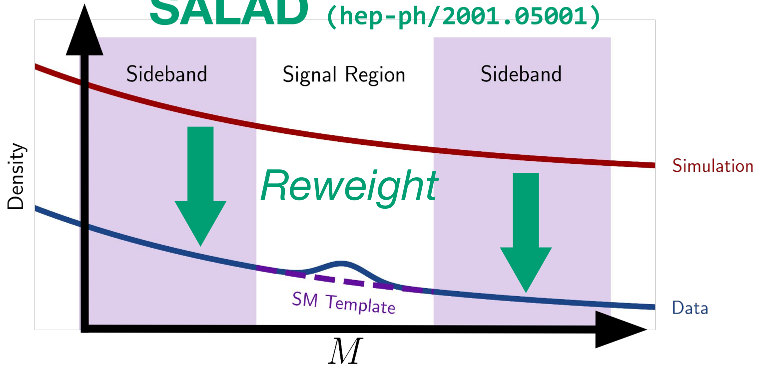
Resonant anomaly detection as a search strategy

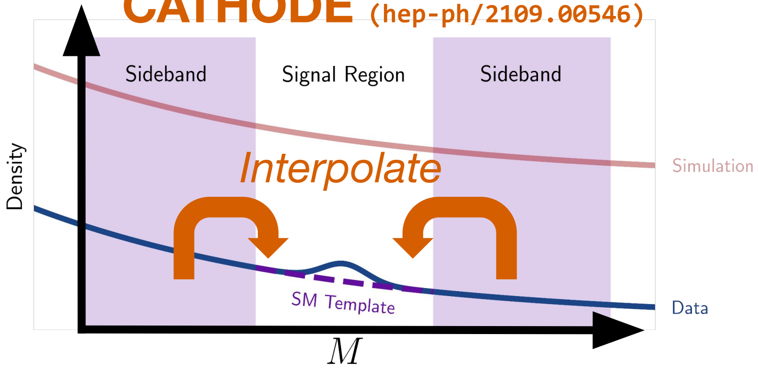


Many* ML techniques can construct the SM Template

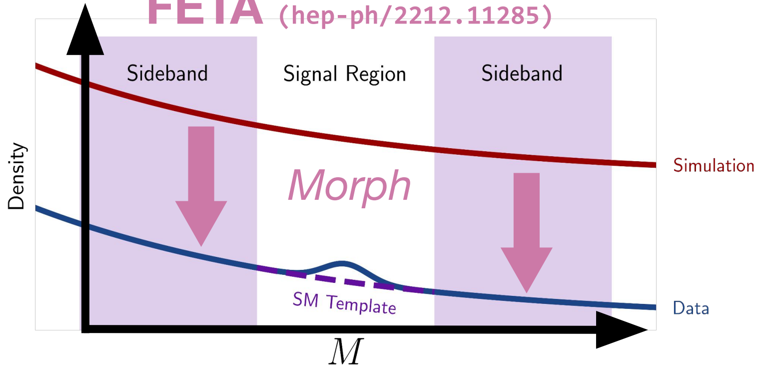
SALAD (hep-ph/2001.05001)



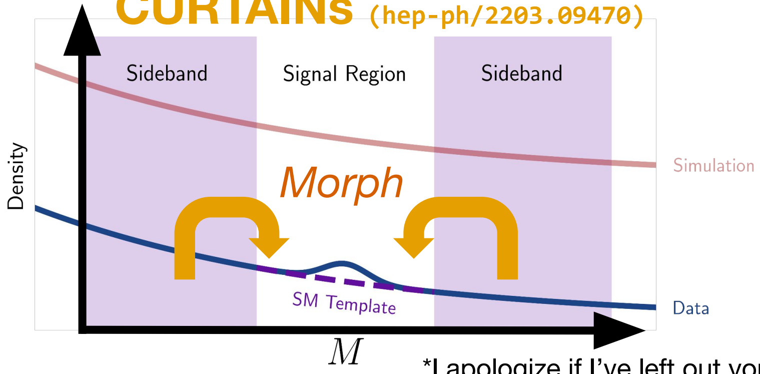
CATHODE (hep-ph/2109.00546)



FETA (hep-ph/2212.11285)

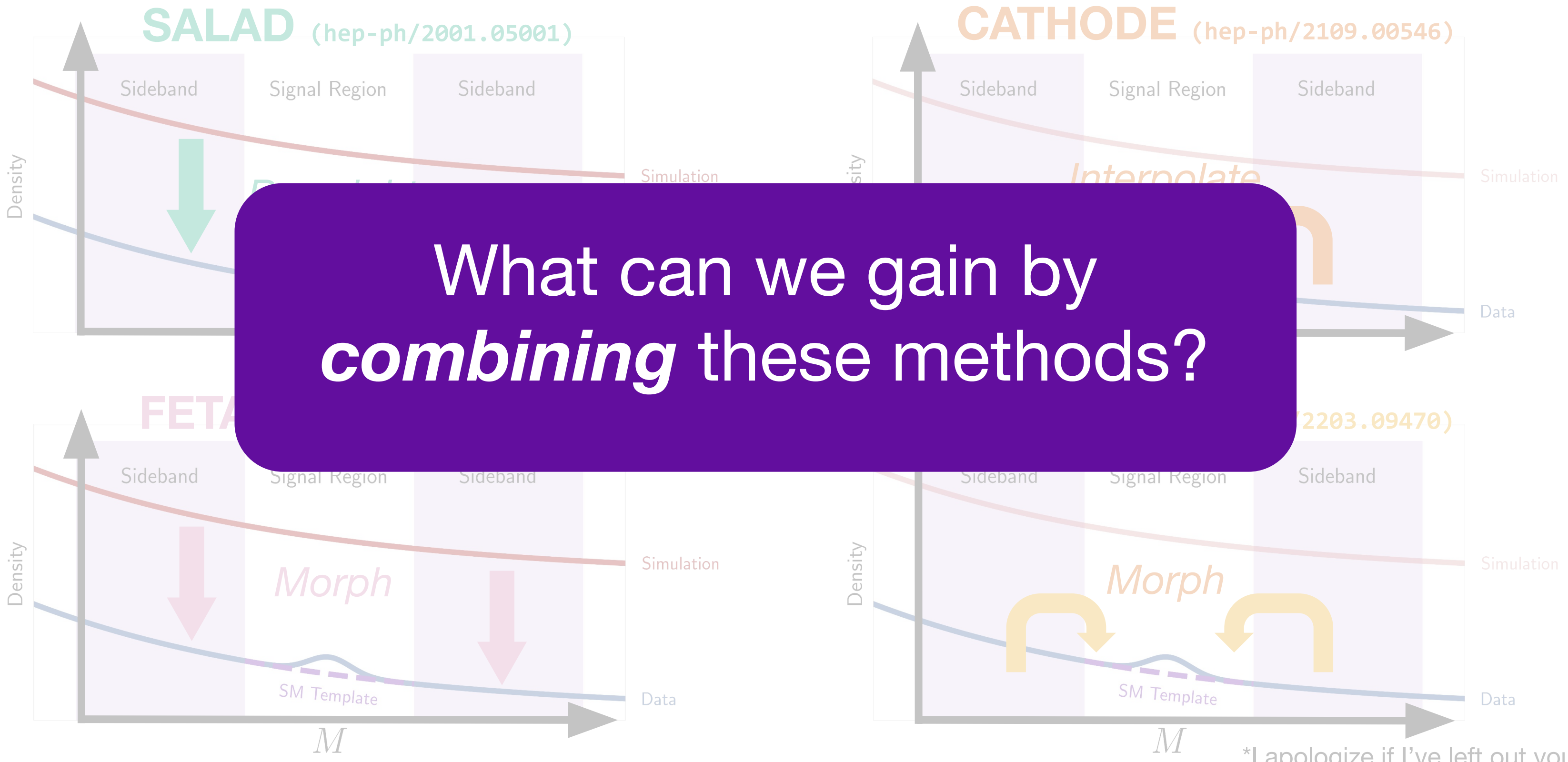


CURTAINs (hep-ph/2203.09470)



*I apologize if I've left out your favorite!

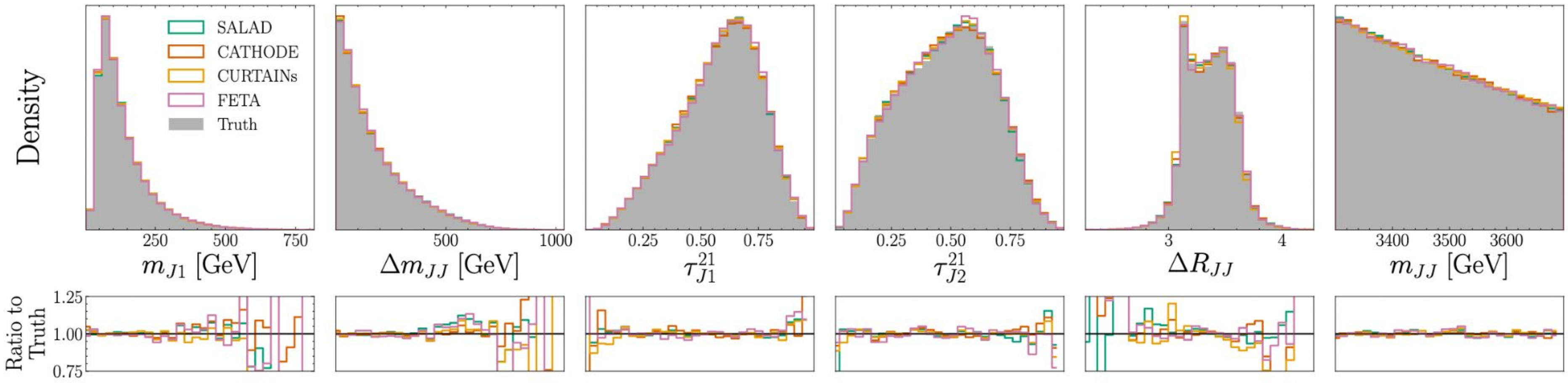
Many* ML techniques can construct the SM Template



What can we gain by ***combining*** these methods?

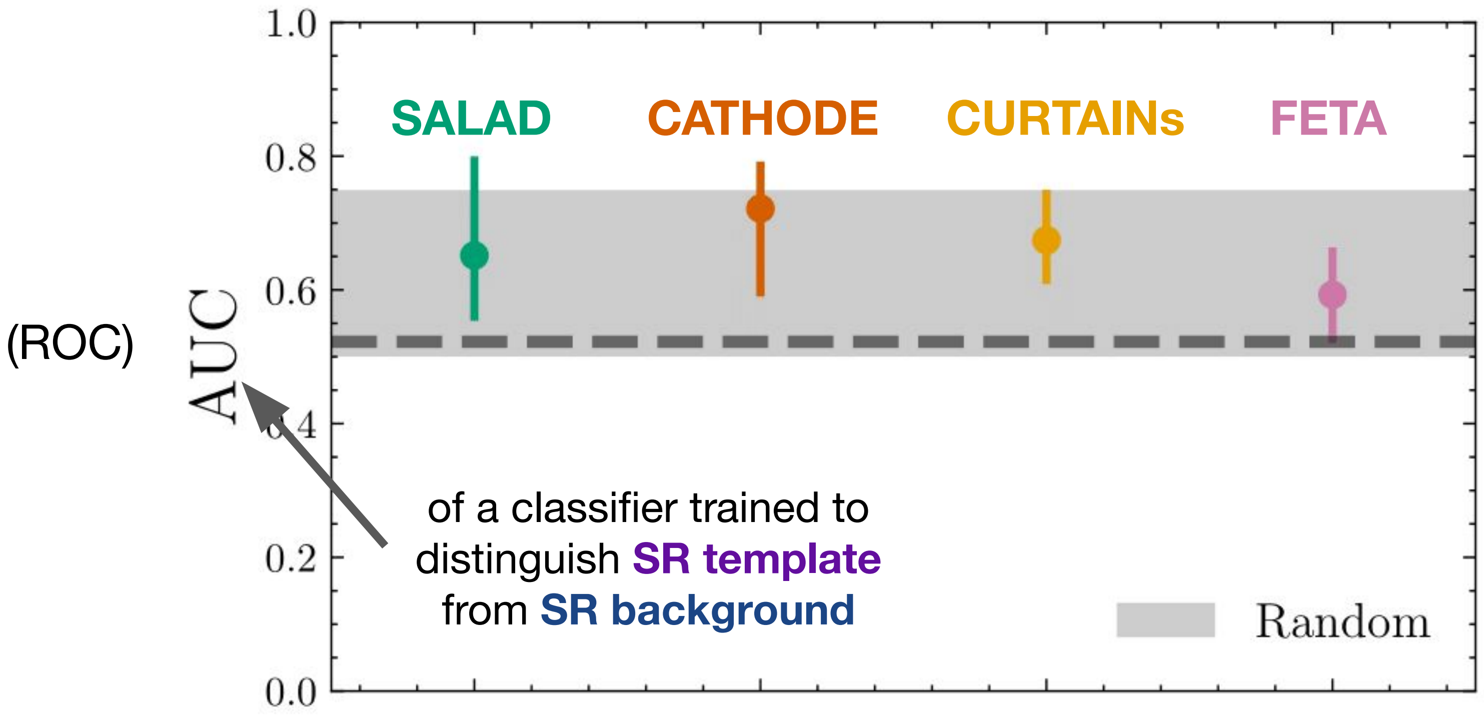
*I apologize if I've left out your favorite!

Study 0: do the methods reproduce the expected marginals?

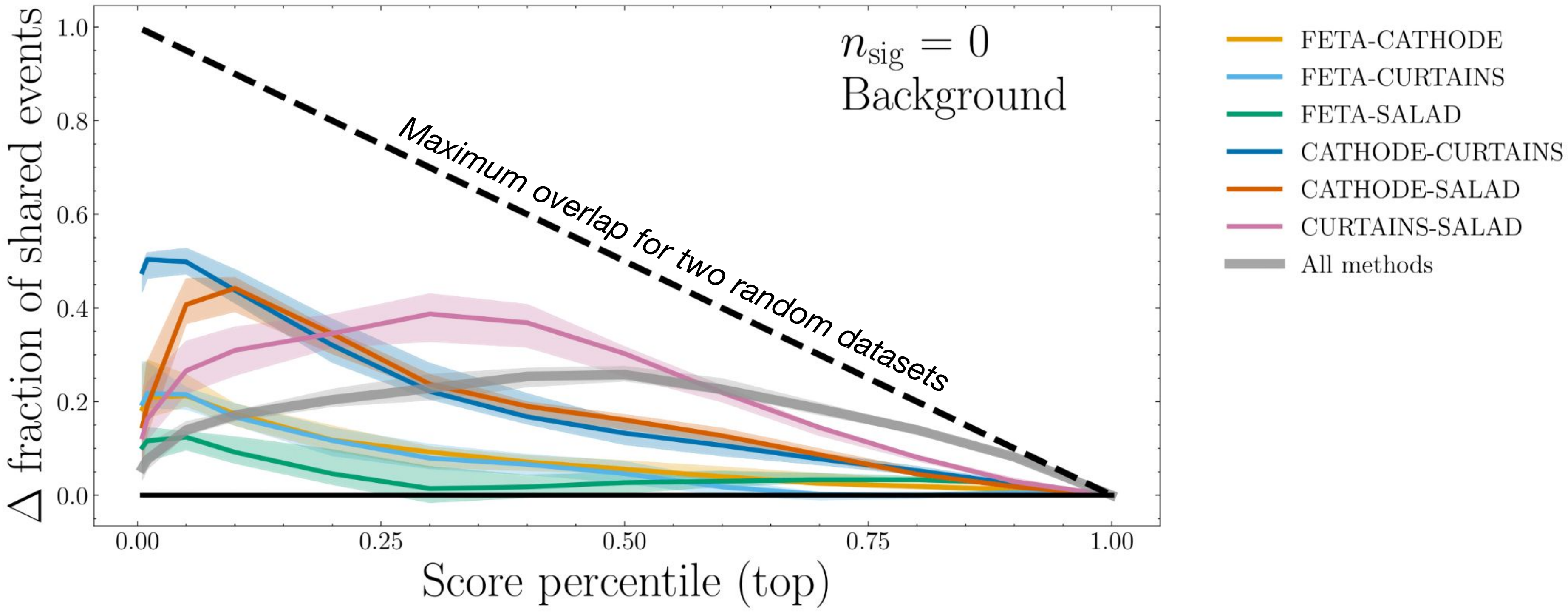


Dataset from the LHC Olympics

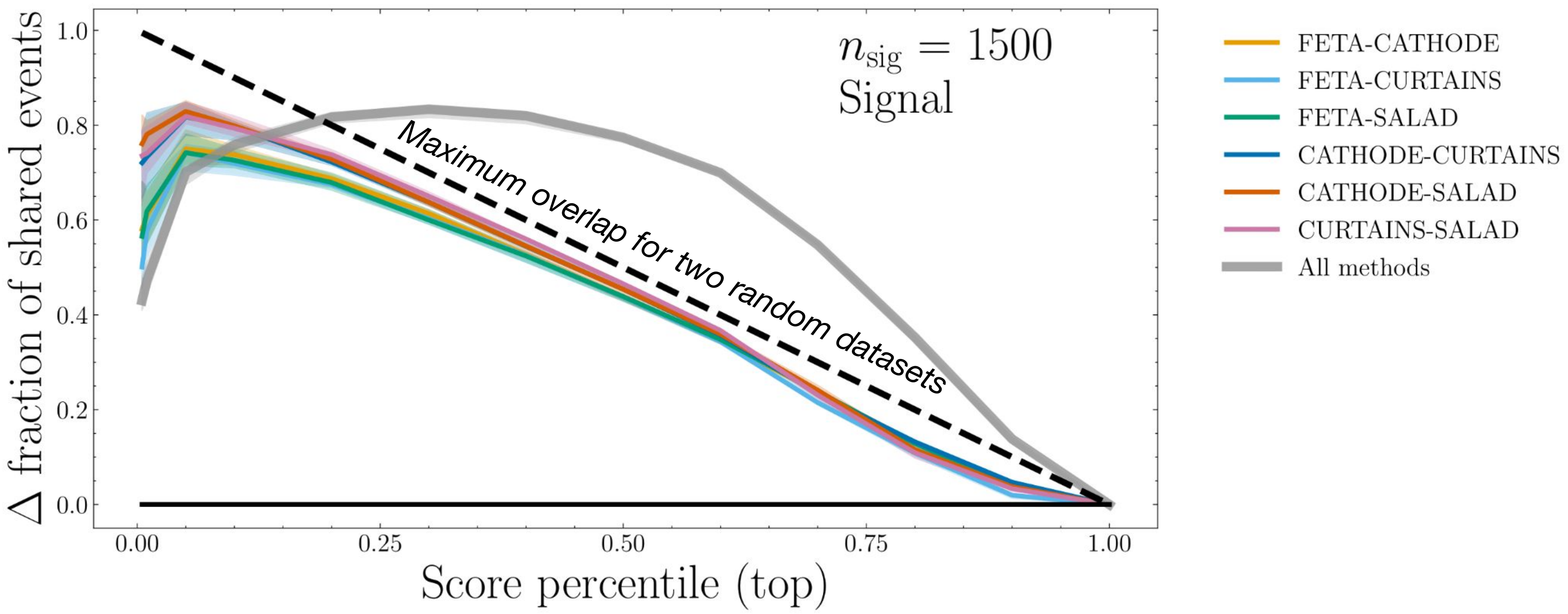
Study 1: are the samples good proxies for SM background?



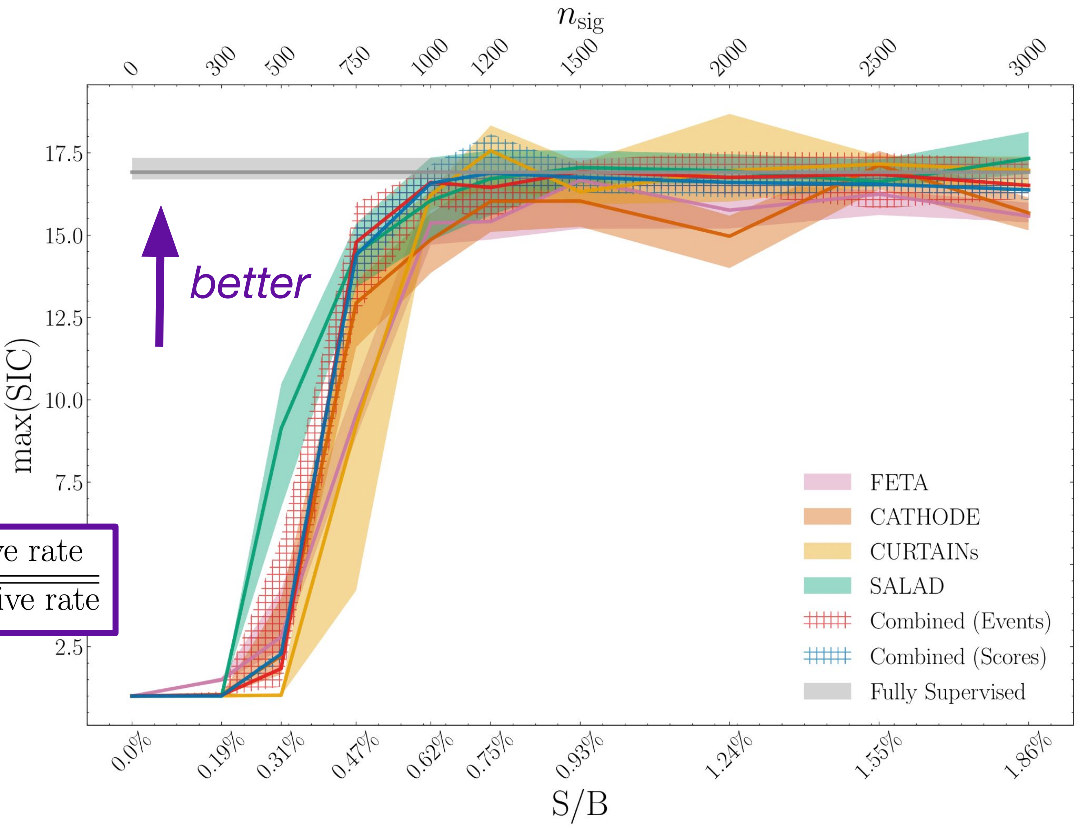
Study 2: do the samples agree on “anomalous” background?



Study 3: do the samples agree on signal?

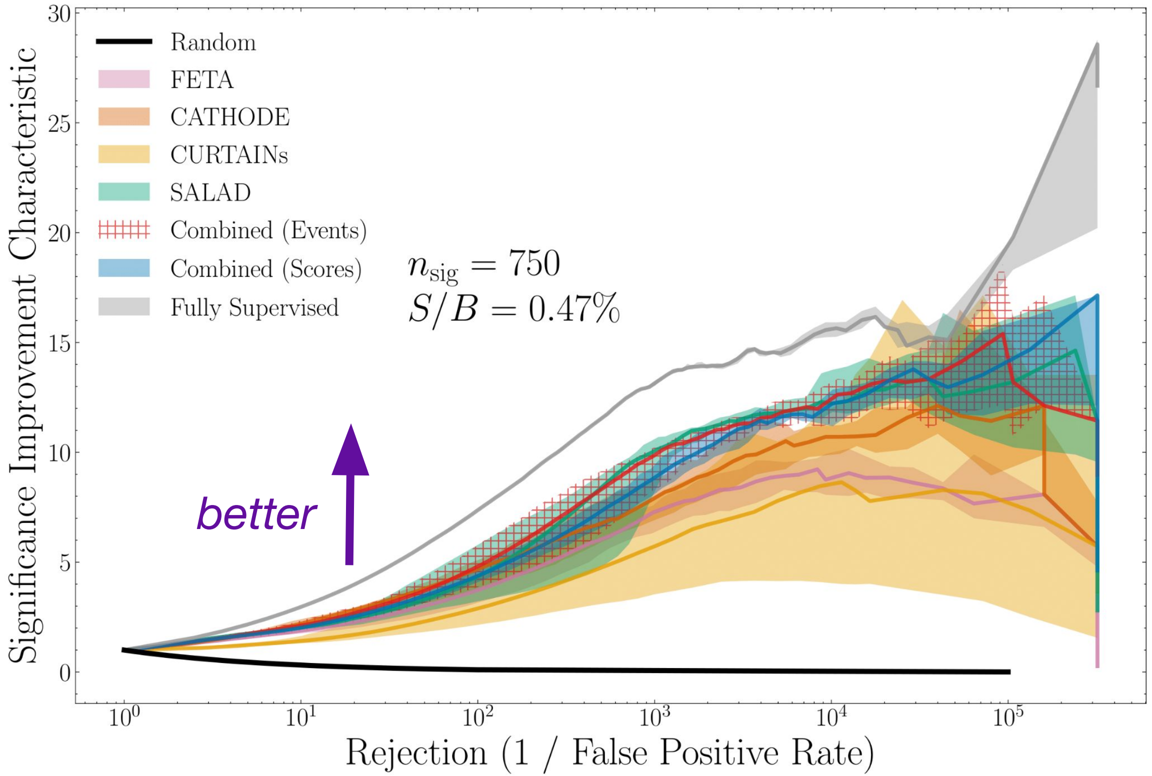


Combination appears to stabilize and improve performance…



$$\text{SIC} = \frac{\text{true positive rate}}{\sqrt{\text{false positive rate}}}$$

…across a range of signal efficiencies



Closing thoughts

- The LHC Olympics dataset has been almost exclusively used for resonant AD. **We should be testing on a variety of signal models!**
- SALAD appears* to beat the combined methods, but reweighting needs regions of overlapping support.
  - What signals **could break individual methods?**
  - Would the combination of samples still perform well on these models?
  - Note that sample combination can be **weighted** (though not explored here).

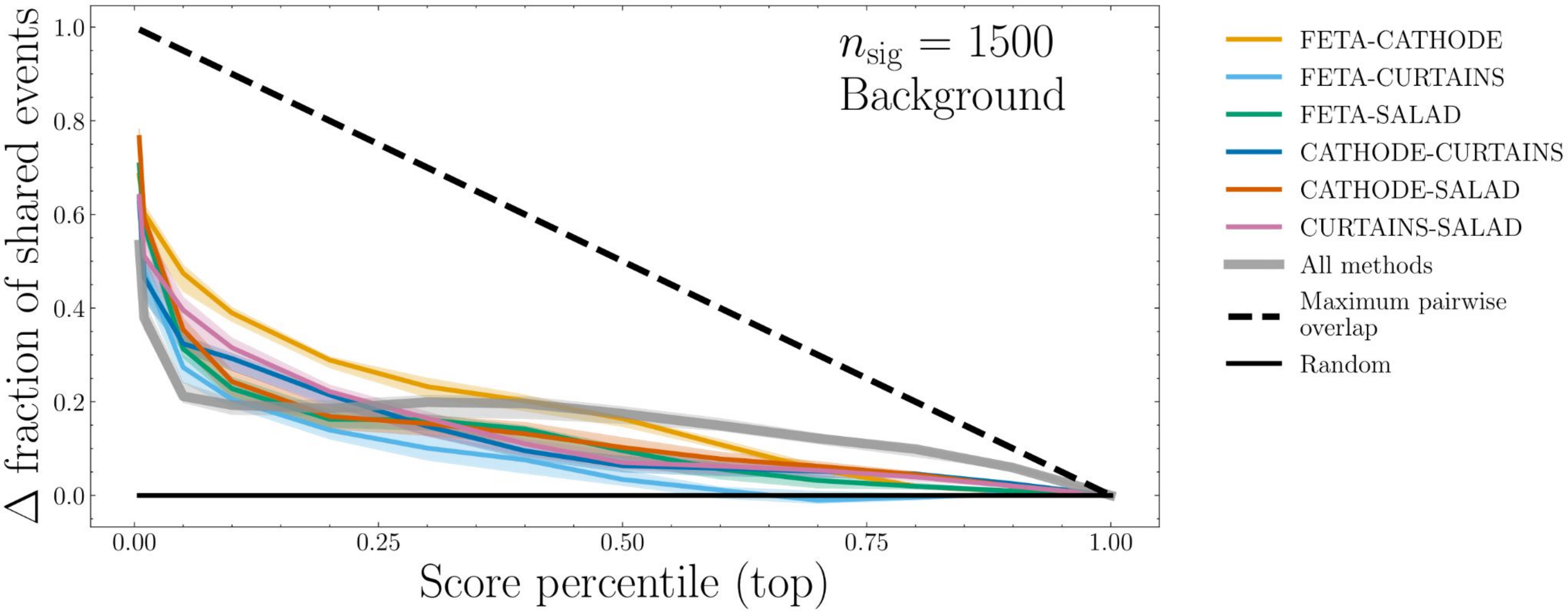
*This SALAD victory is likely a fluctuation – see backups!

Backup slides

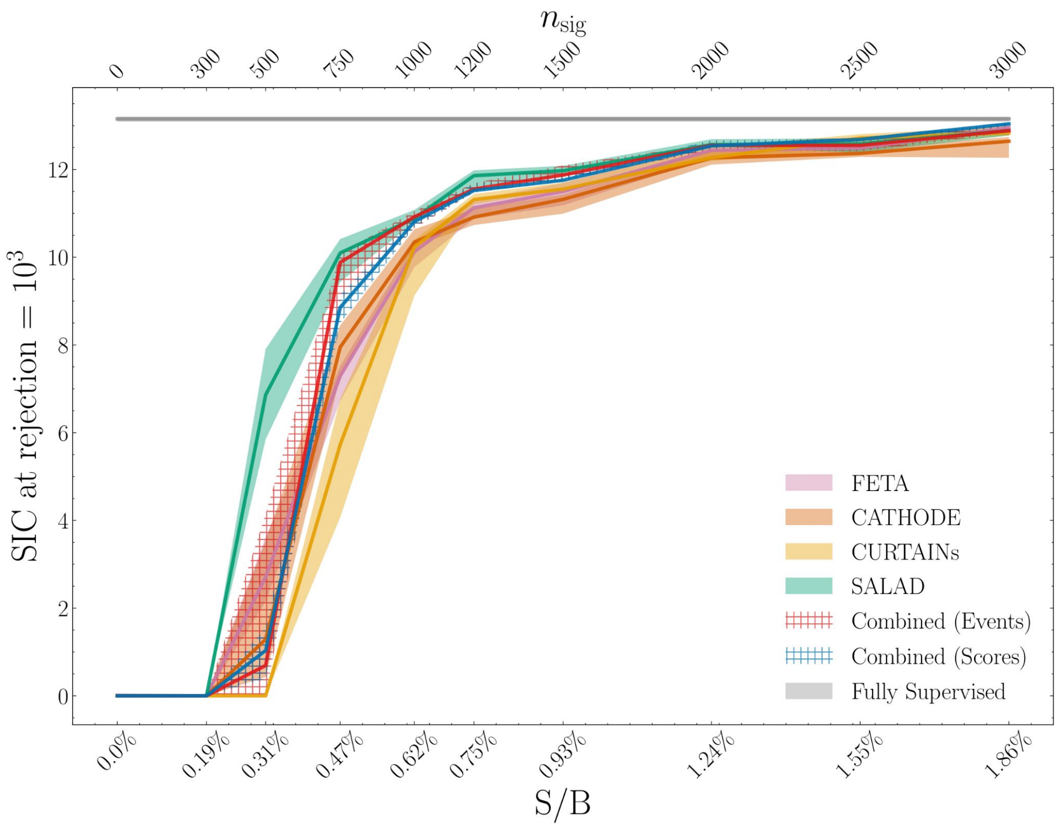
Number of generated samples

Method	Training data	Validation data	# samples	Oversampling
SALAD	793k SIM, 696k DAT	198K SIM, 174K DAT	1,045k	N/A
CATHODE	696k DAT	174K DAT	400k	3
CURTAINs	373k DAT	93k DAT	1,887k	4
FETA	793k SIM, 696k DAT	198K SIM, 174K DAT	732k	6

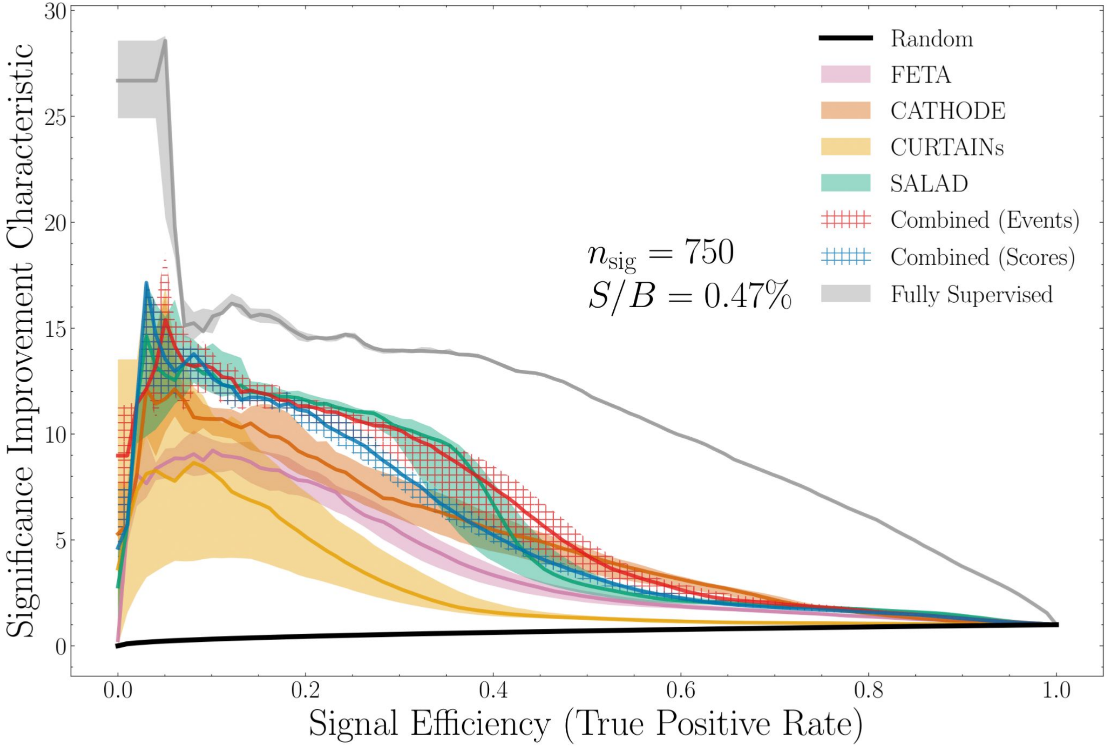
Background overlaps do not agree when there is signal



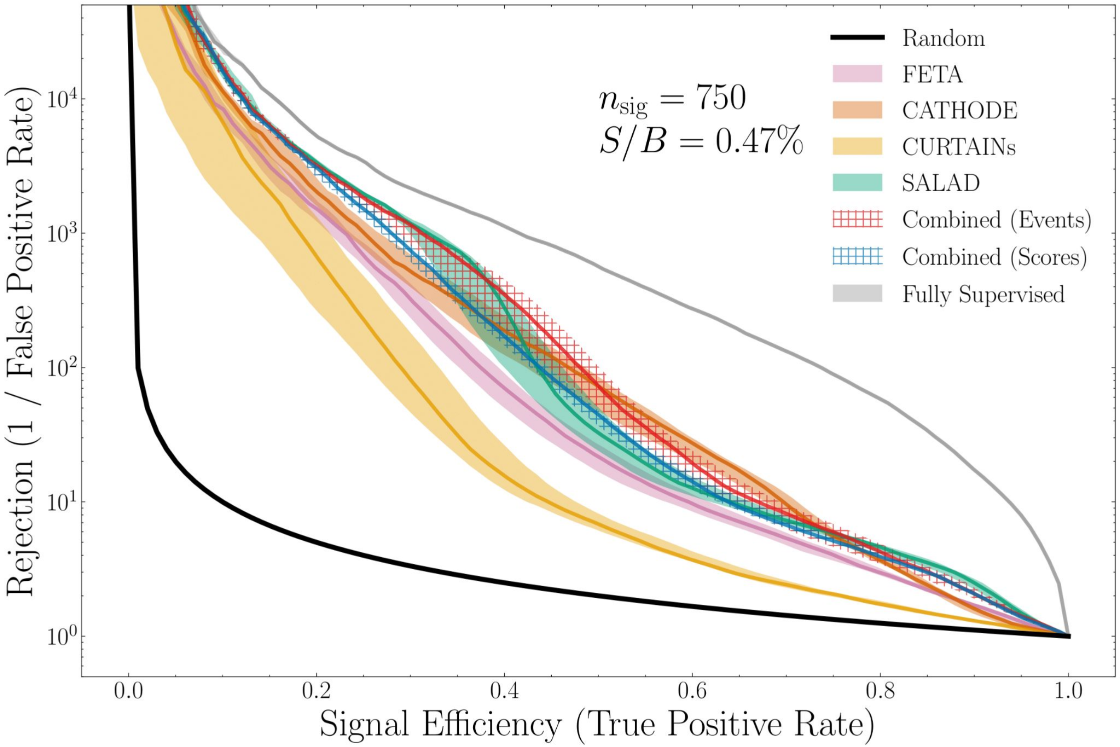
SIC at rejection = 1000



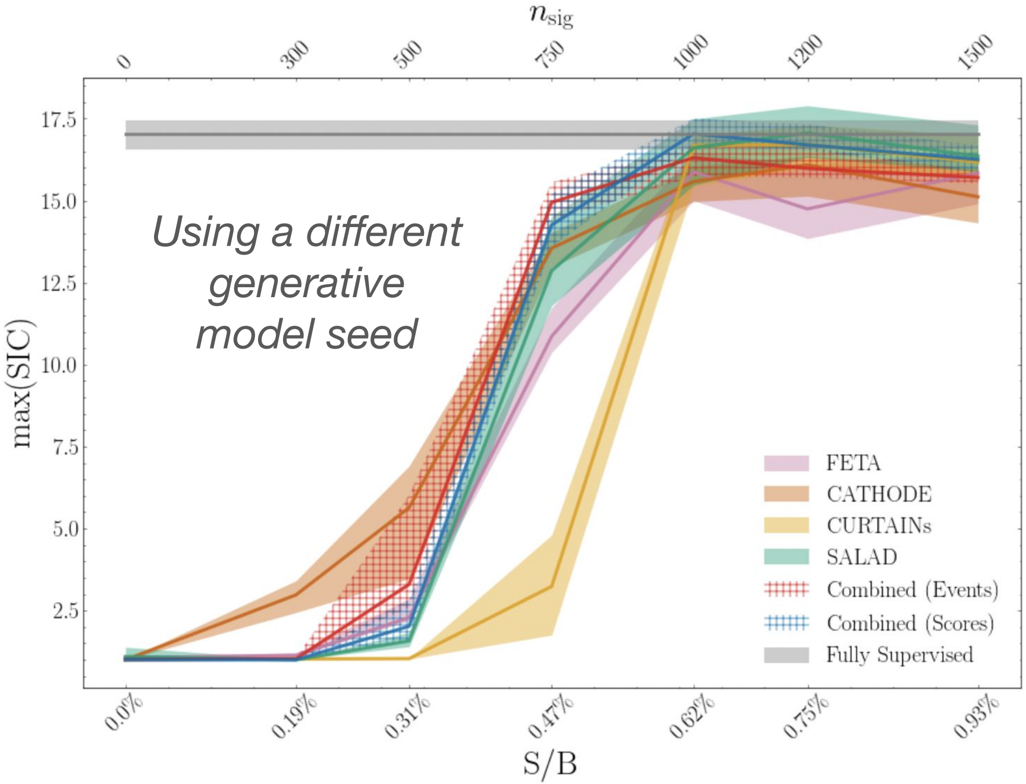
Classifier SIC for n_{sig} = 750

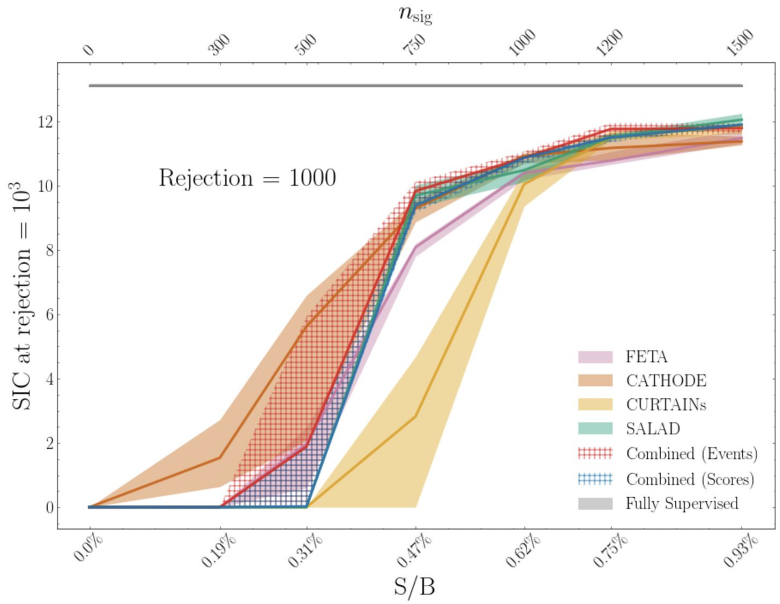


Classifier rejection for n_{sig} = 750

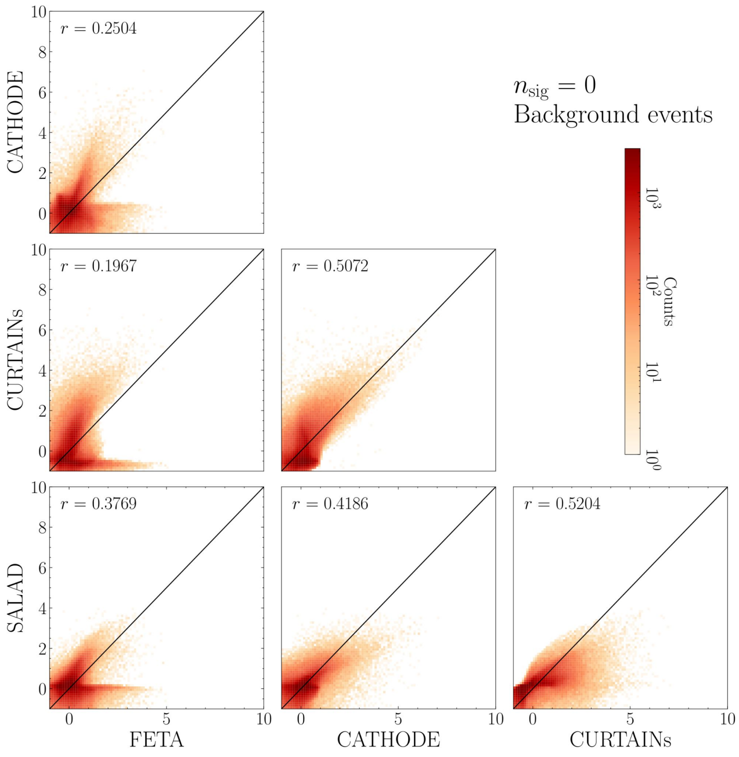


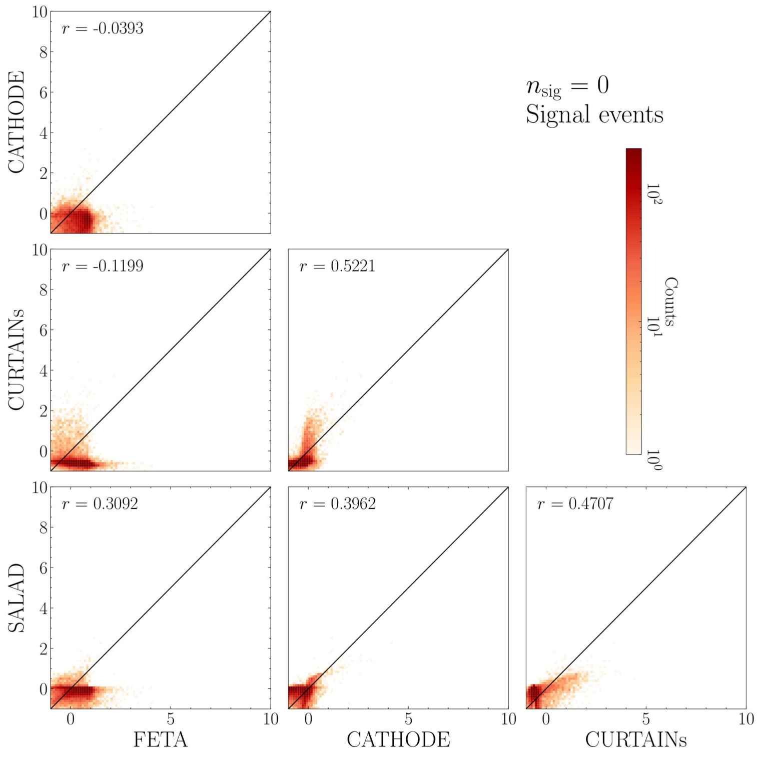
Around n_{sig} = 500, the AD task breaks down





Correlations of scores: background only





Correlations of scores: n_{sig} = 1500