Fiducialization in DEAP-3600 using Machine Learning algorithms with robust validation

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Queen's University
May 30 2017

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Big Thanks To Everyone At DEAP-3600!

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That's Me!

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Introduction to DEAP-3600 and Machine Learning

Using Machine Learning to improve the Dark Matter discovery potential

Validating the event classification

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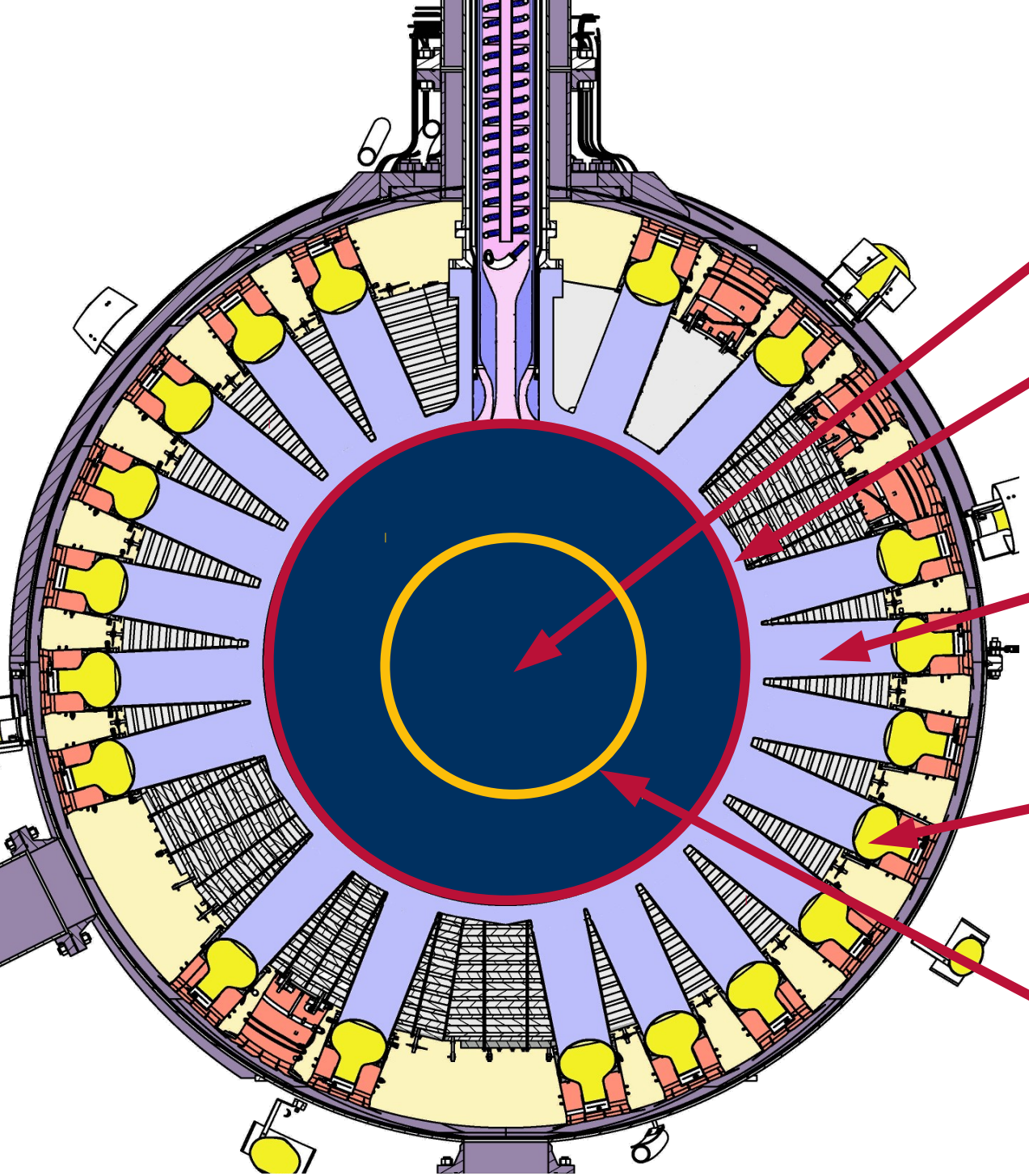

Argon Volume

Wavelength Shifter (TPB)

Acrylic Vessel, Light Guides

Photo-Multiplier Tube (PMT)

Fiducial Volume

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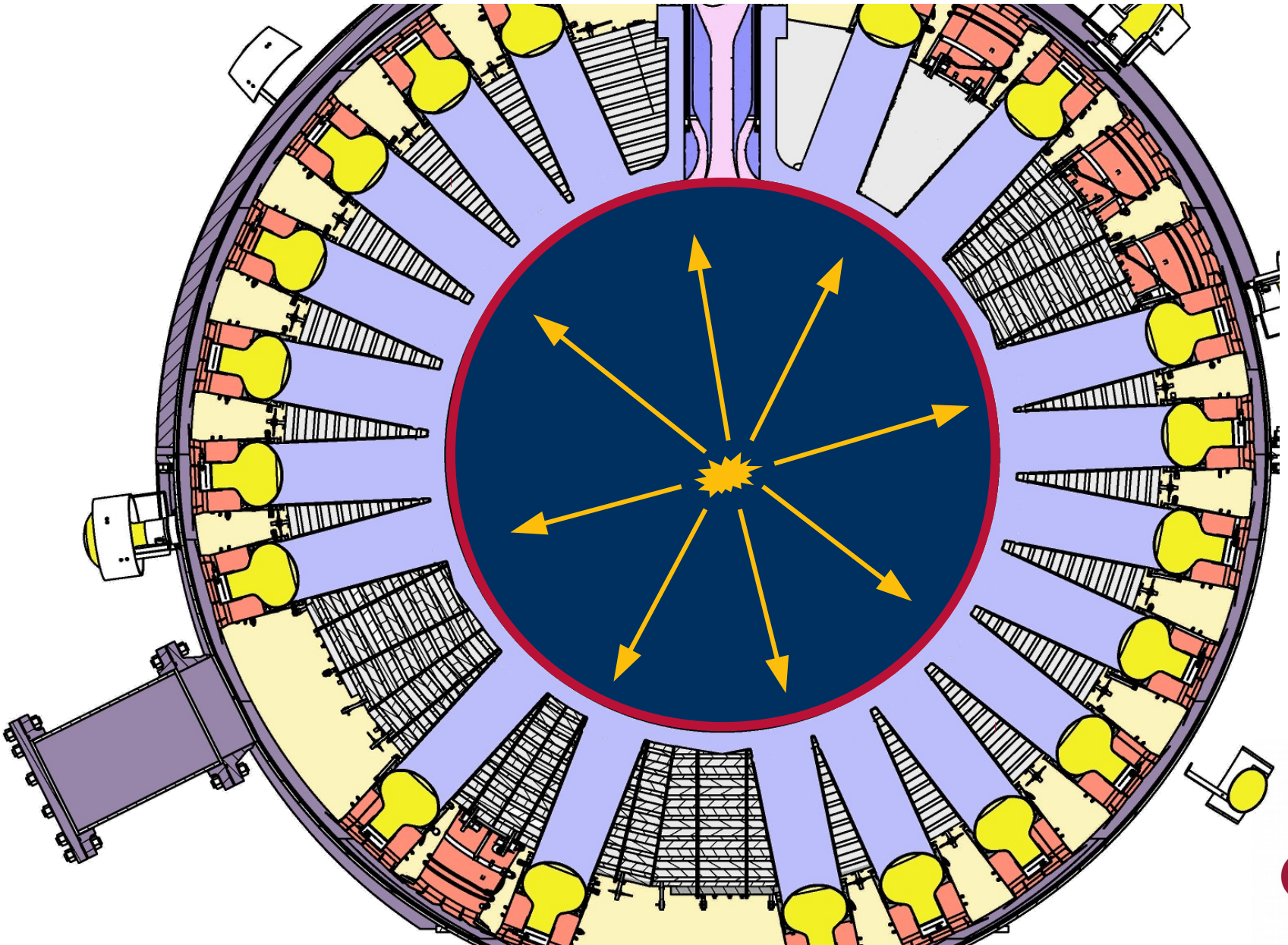
Position reconstruction can be achieved using relative PMT charges



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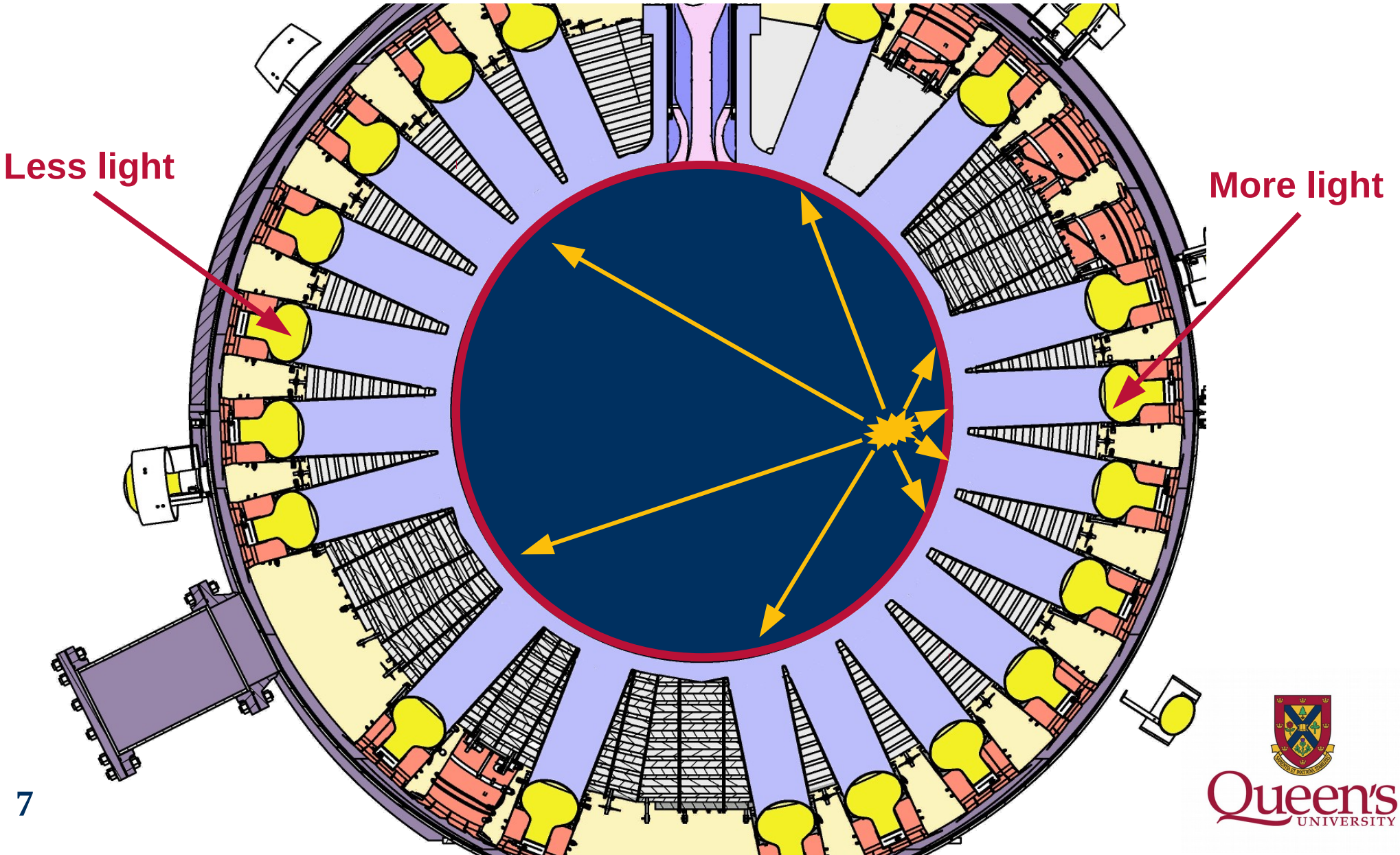
Position reconstruction can be achieved using relative PMT charges



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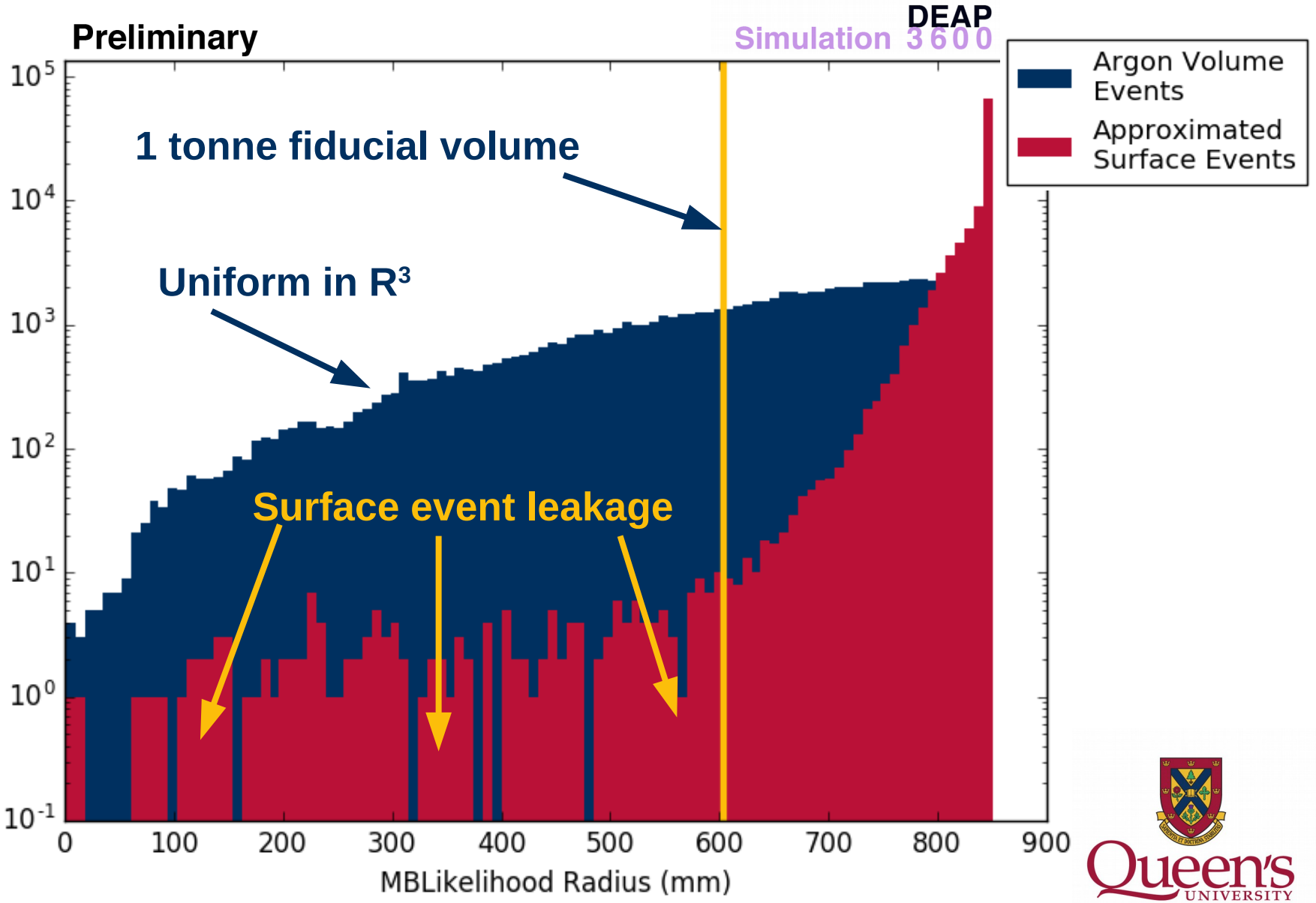
The MBLikelihood algorithm does a good job of creating a fiducial volume



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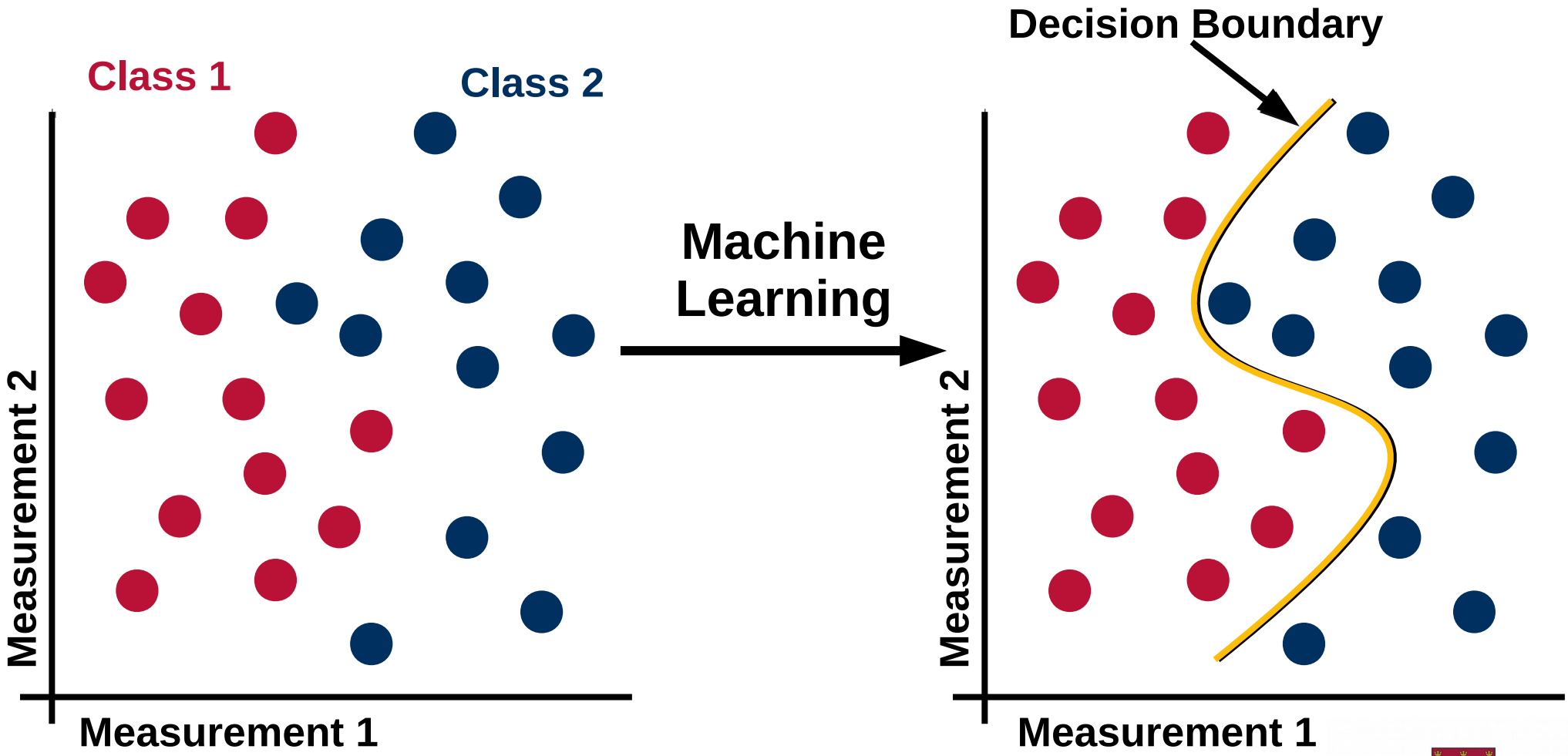
Machine Learning is well poised to assist in creating a fiducial volume



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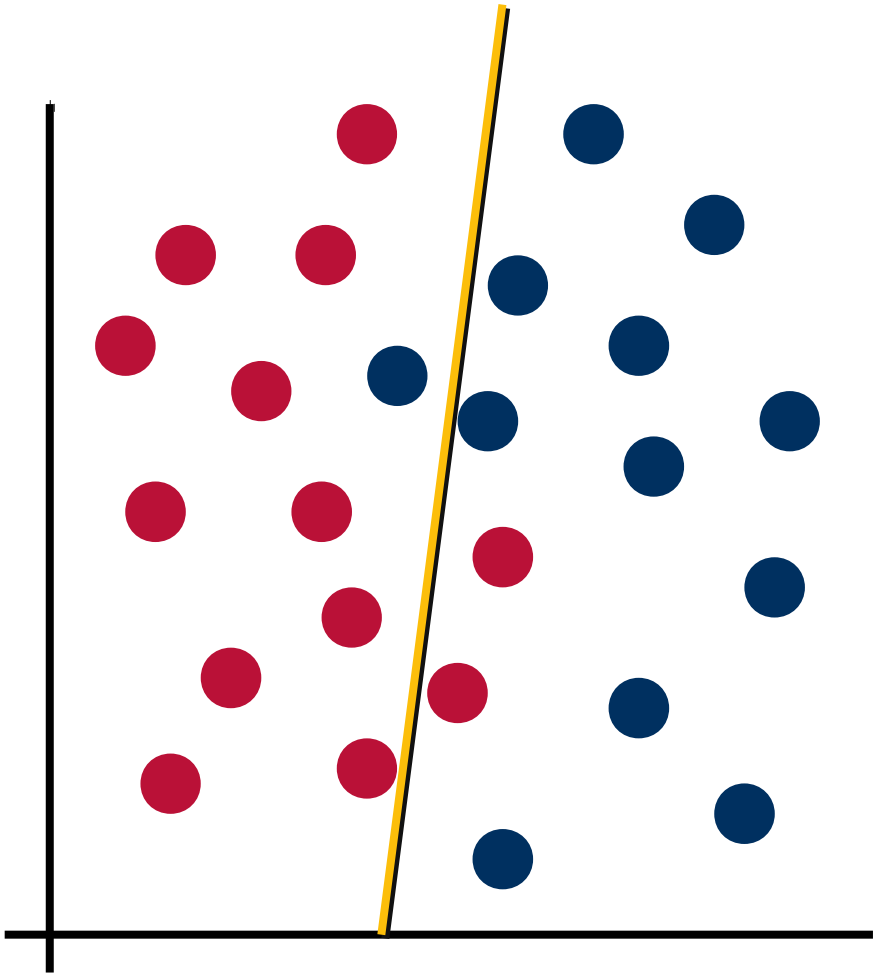
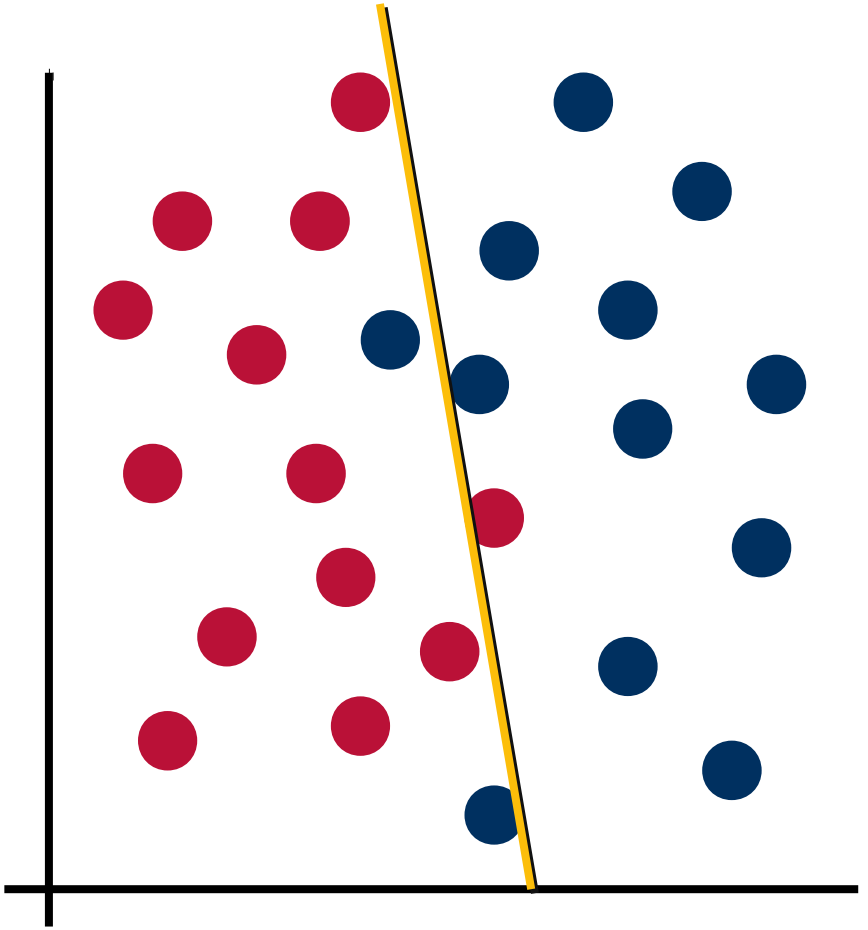
Logistic Regression (LR)



Linear Support Vector Machine (LSVM)



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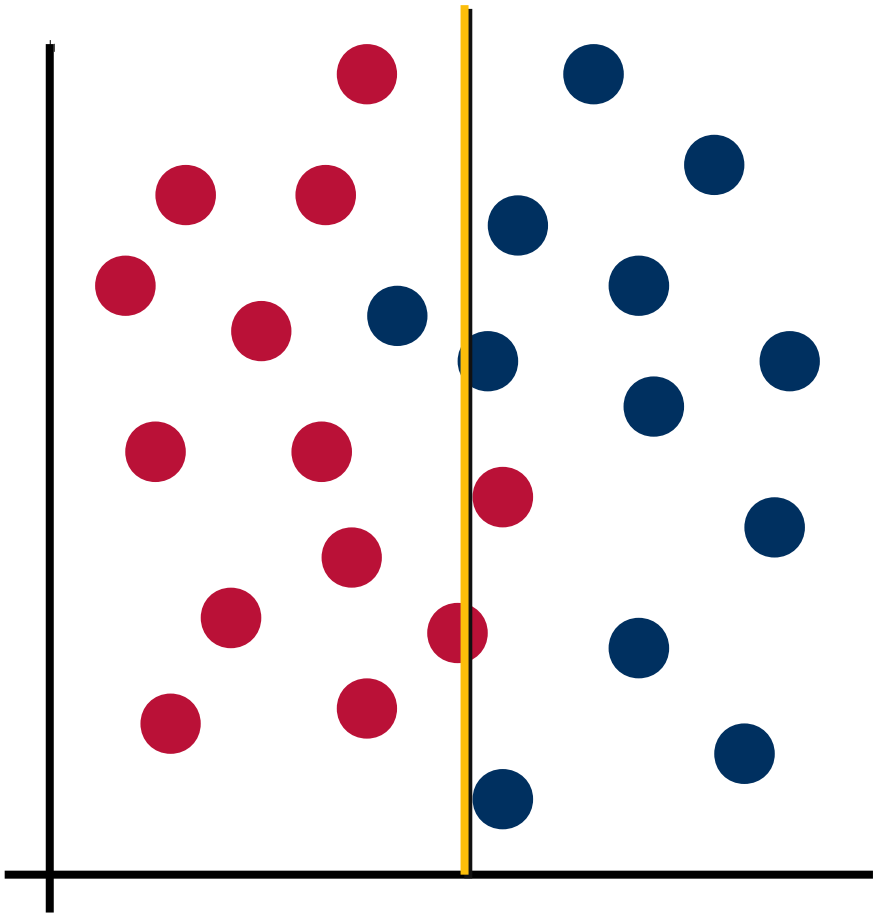
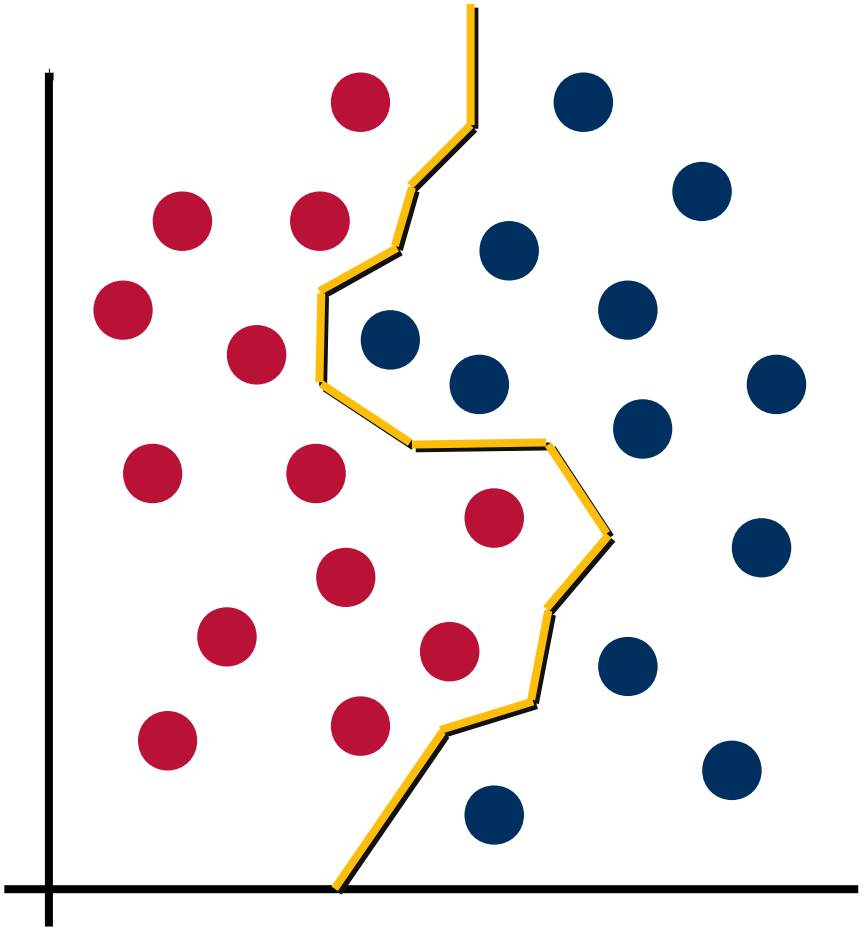
Naive Bayes (NB)



K-Nearest Neighbors (KNN)



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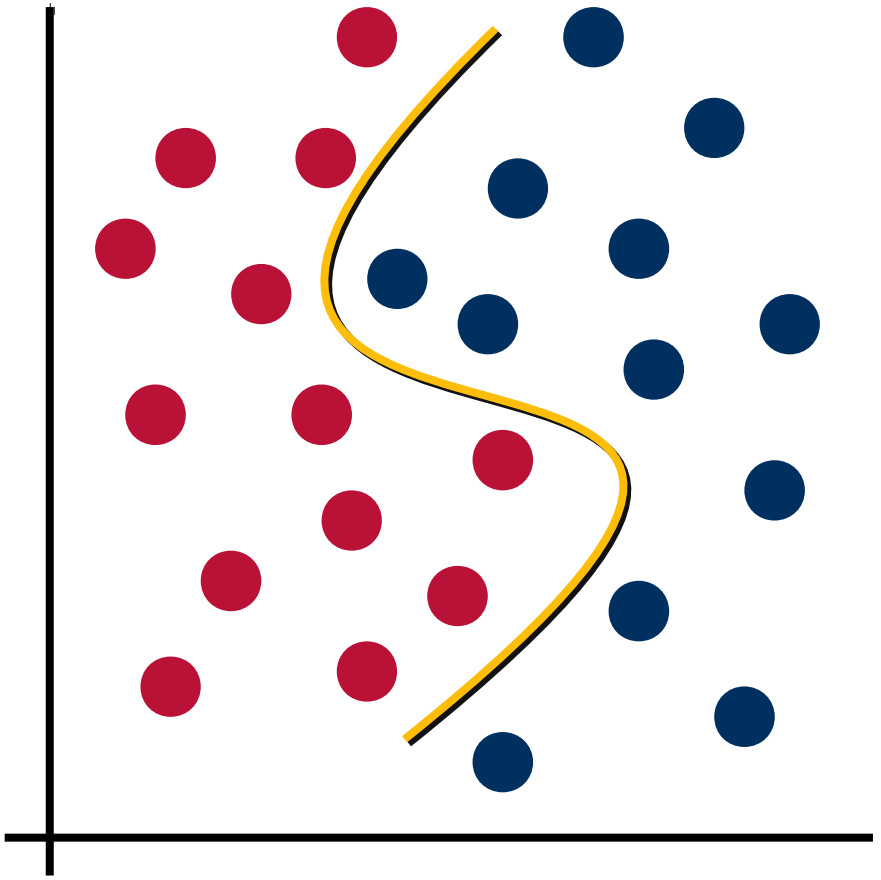
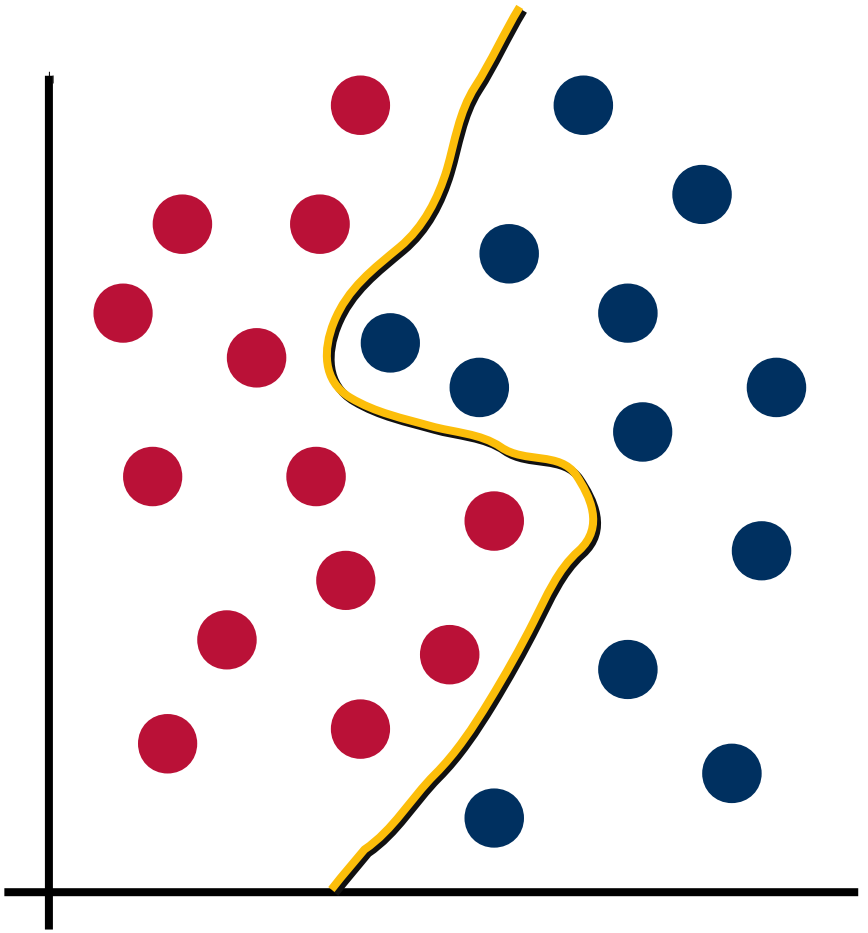
Support Vector Machine (SVM)



Neural Network (NN)



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Using Machine Learning to improve the Dark Matter discovery potential

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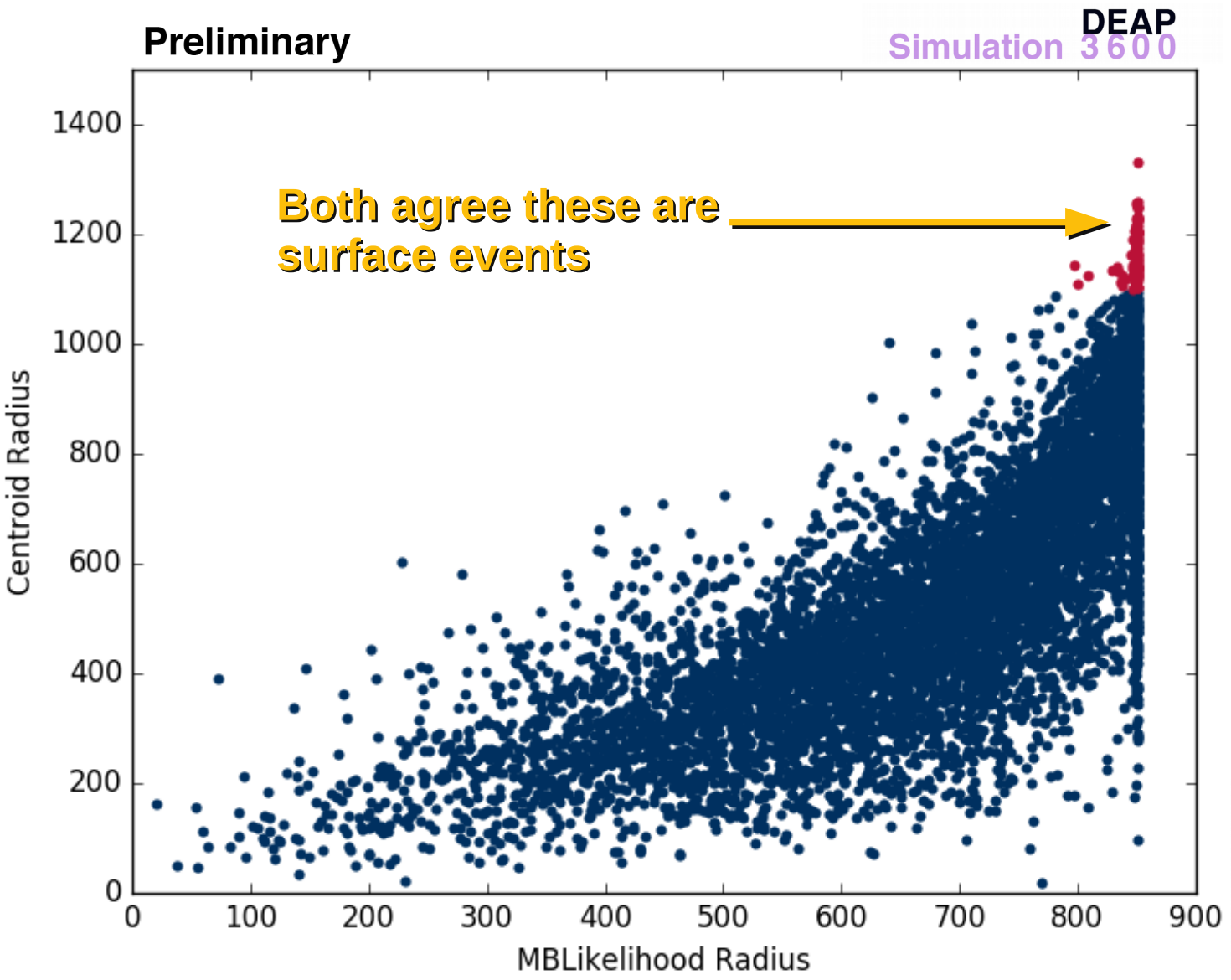
Training data can be taken from the real detector for Machine Learning, but not for MBLikelihood



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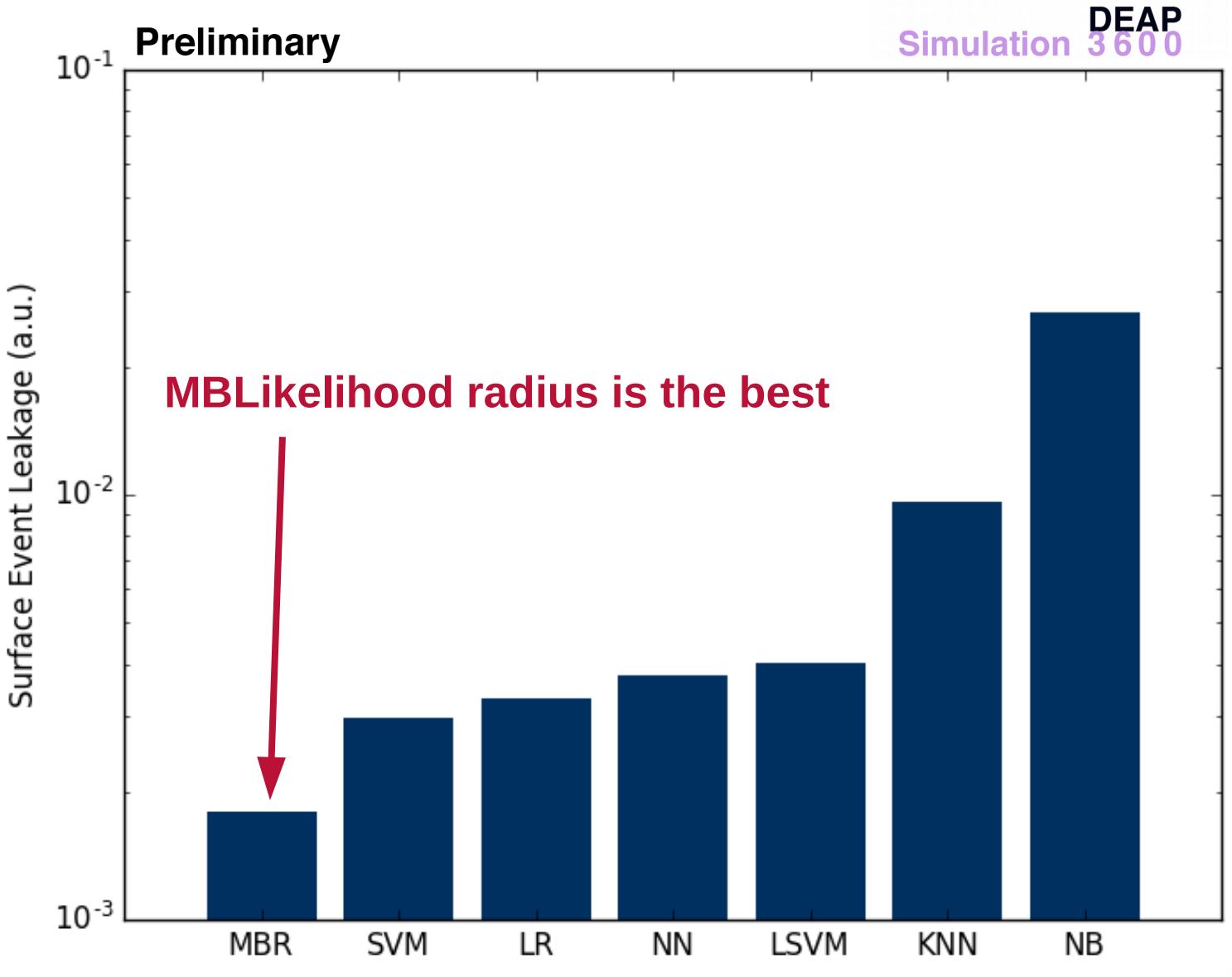
Some Machine Learning algorithms perform well, but don't beat MBLikelihood



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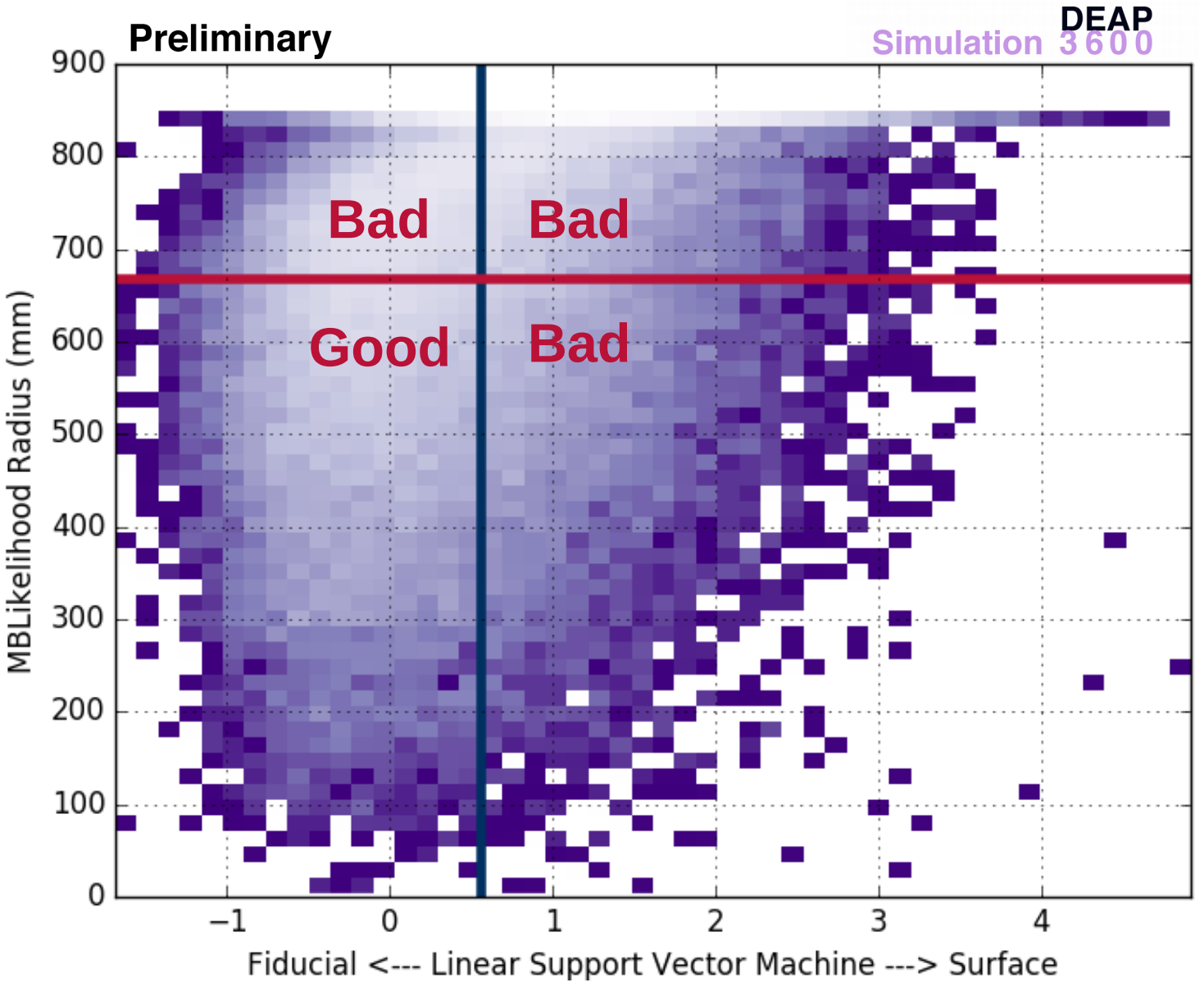
MBLikelihood and Machine Learning algorithms can be combined (Boosted)



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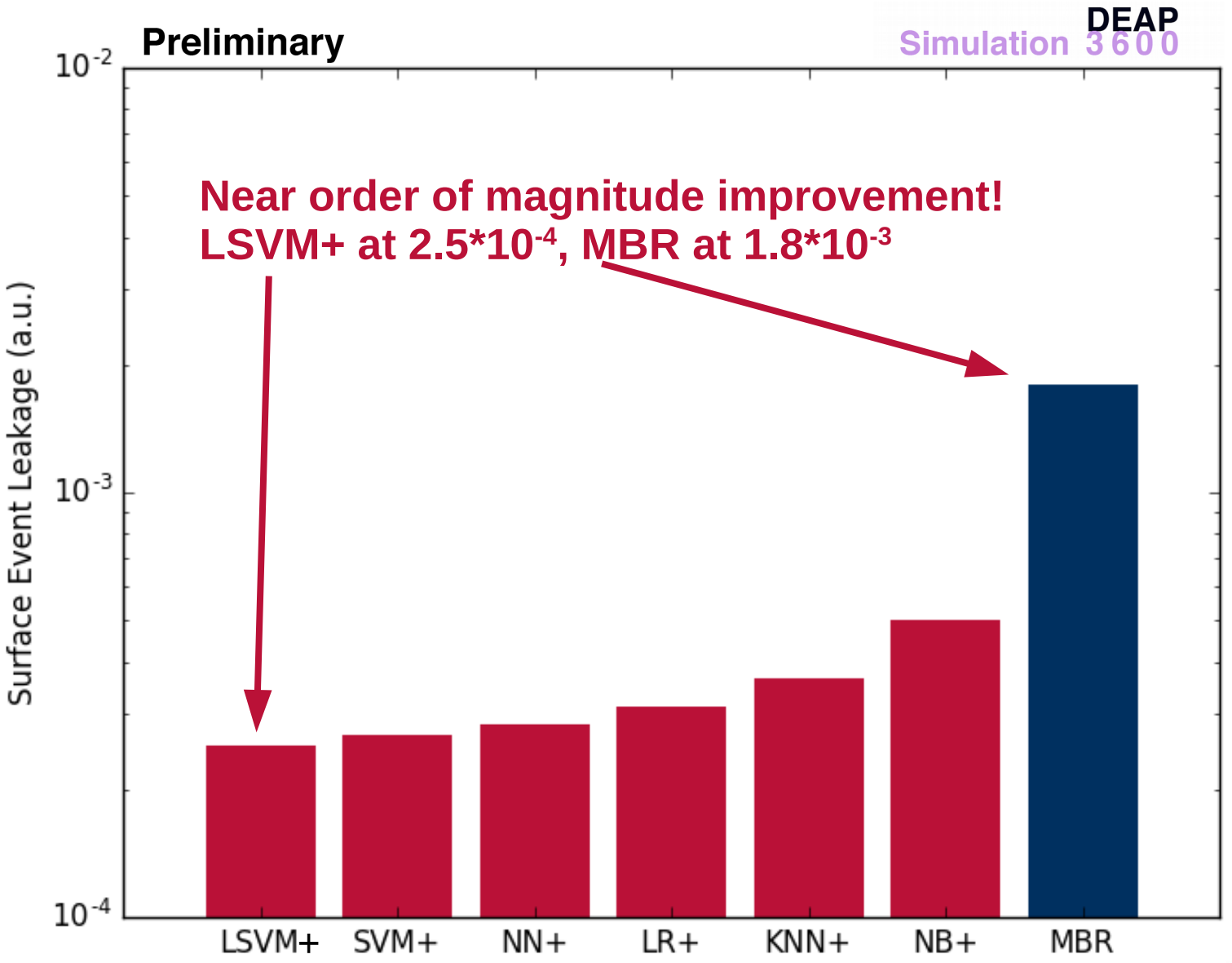
The boosted analysis has reduced surface event leakage



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Validating the event classification

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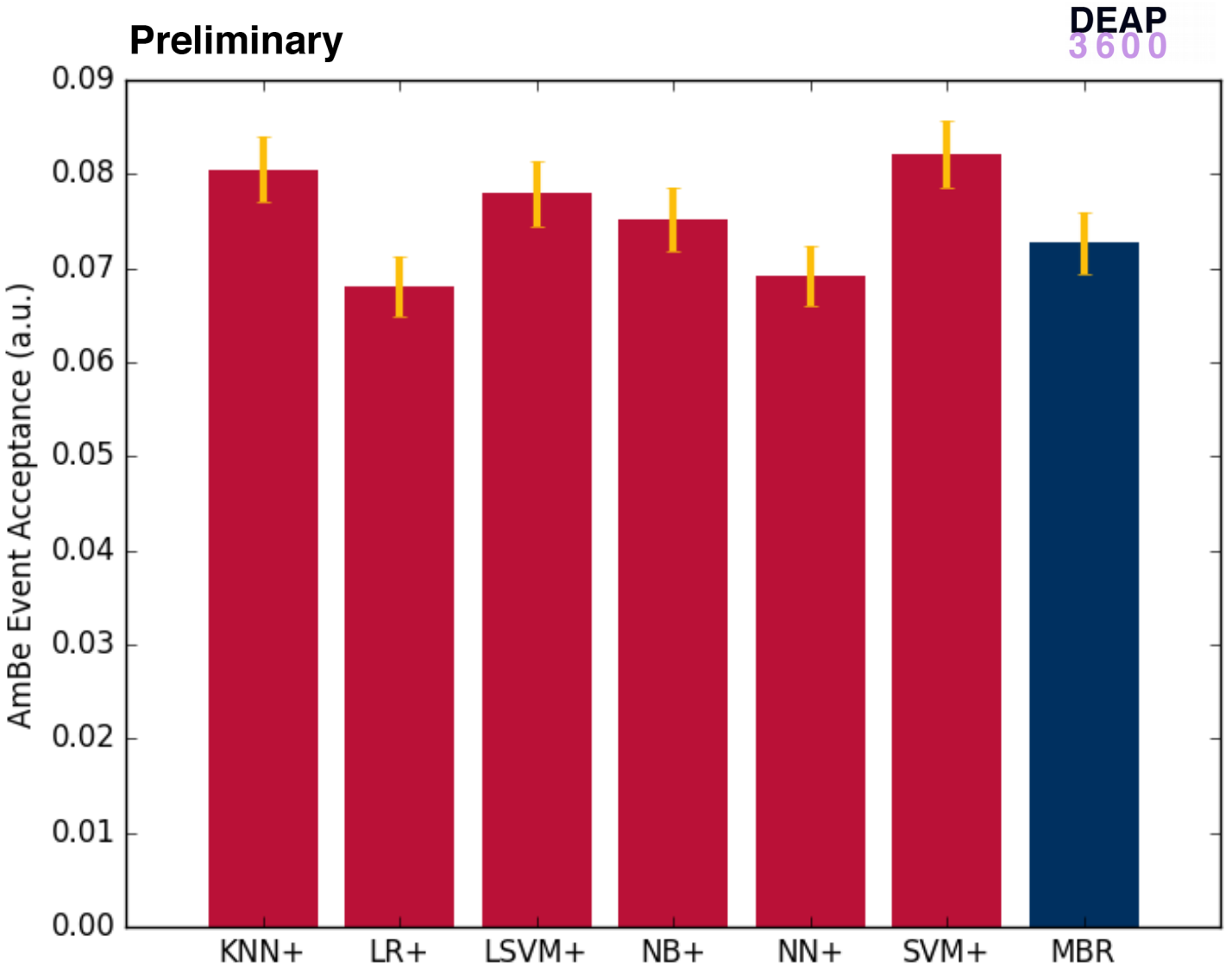
The boosted analysis behaves well on real neutron data



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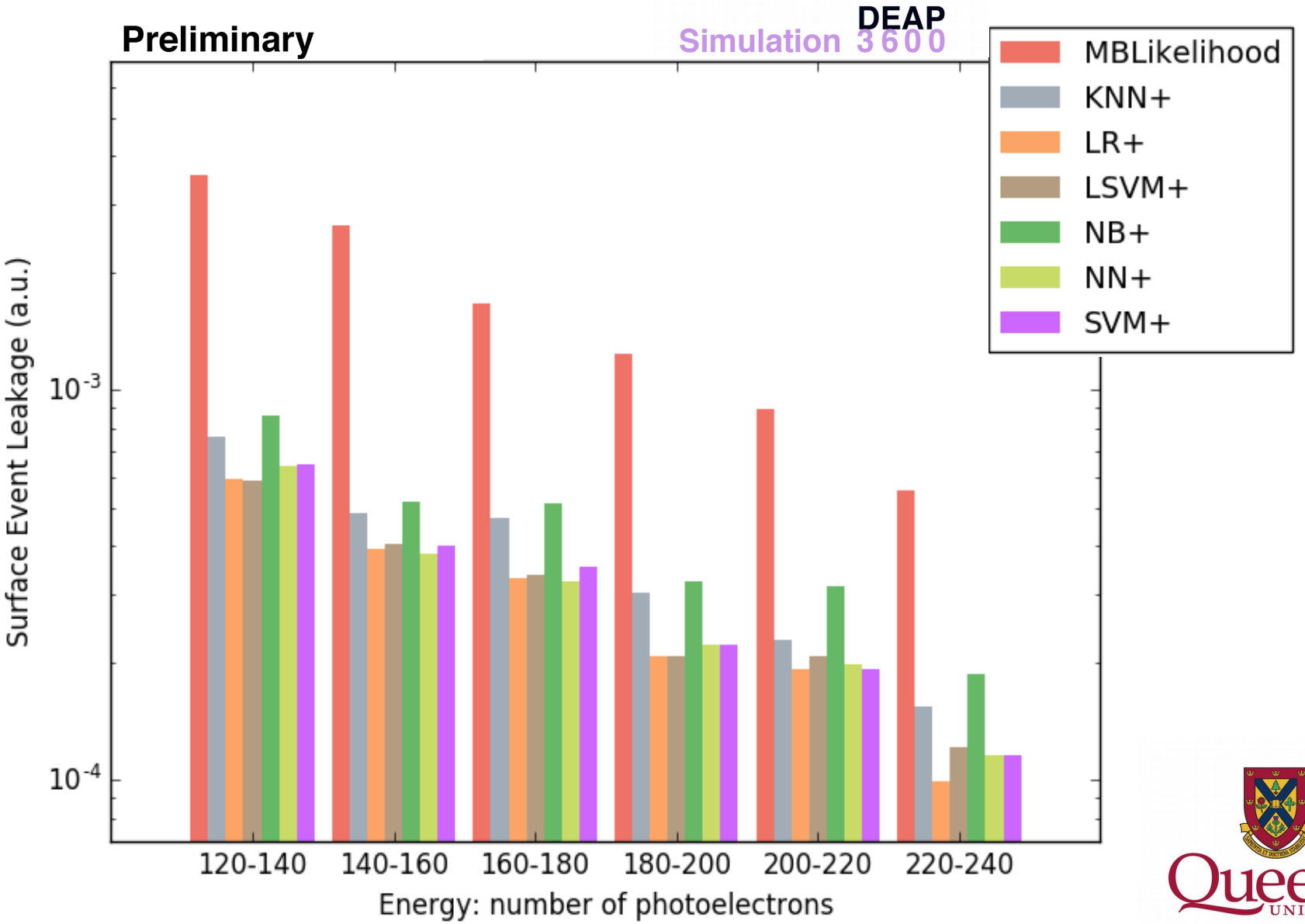
The boosted analysis has an expected energy dependence



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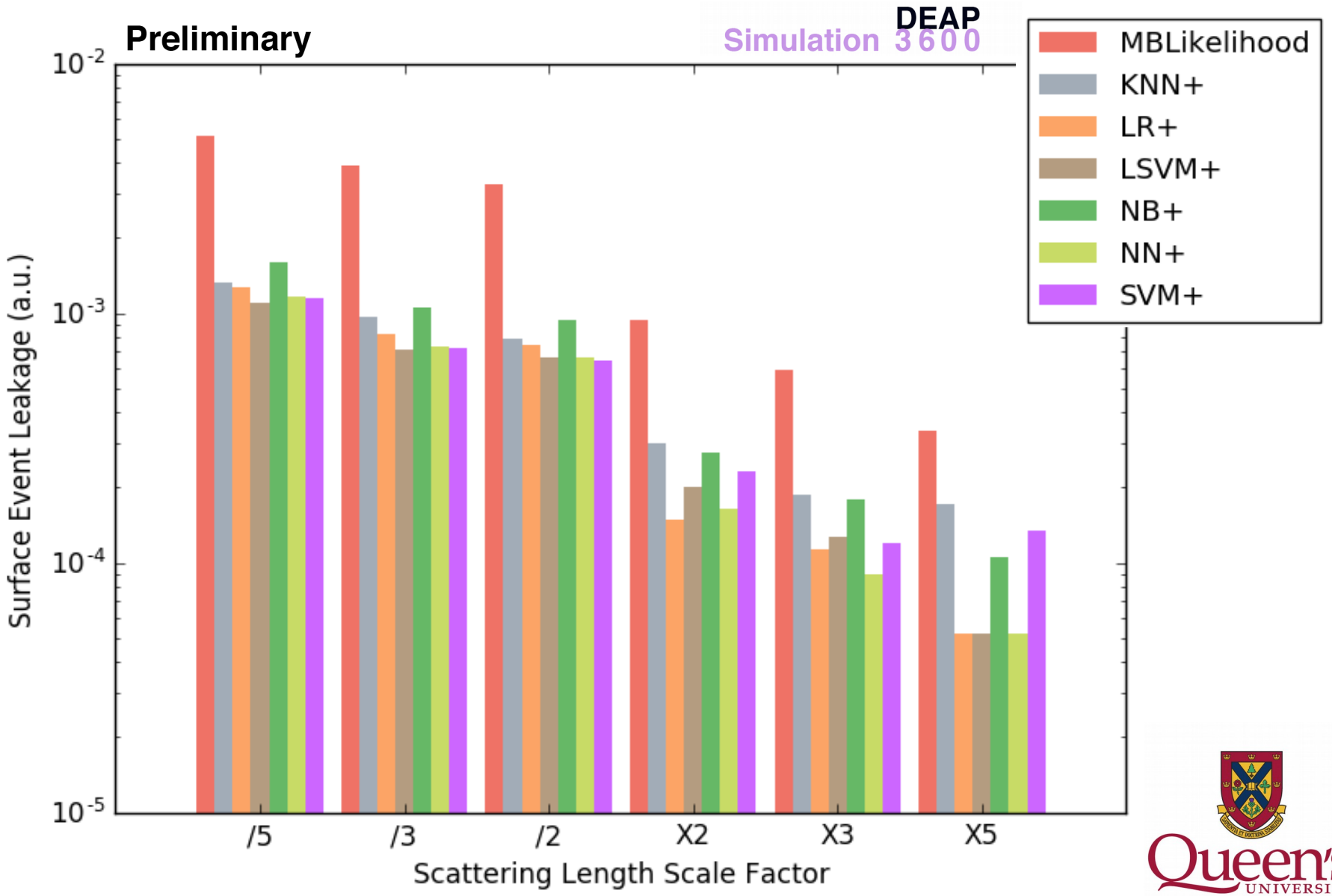
The boosted analysis is robust against changes in the optical model



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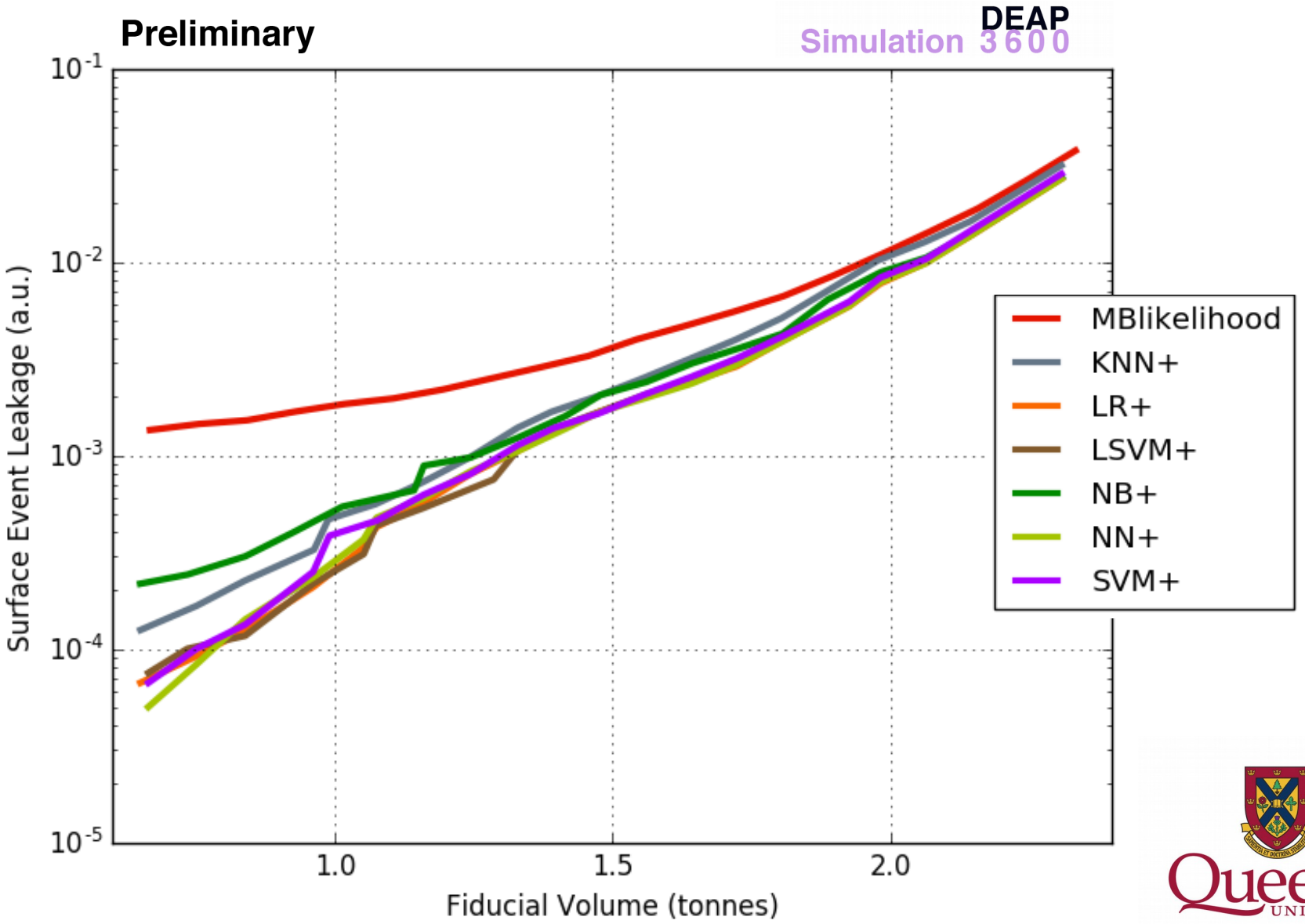
Conclusion: The boosted analysis can increase the fiducial volume by 50%!



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Extra

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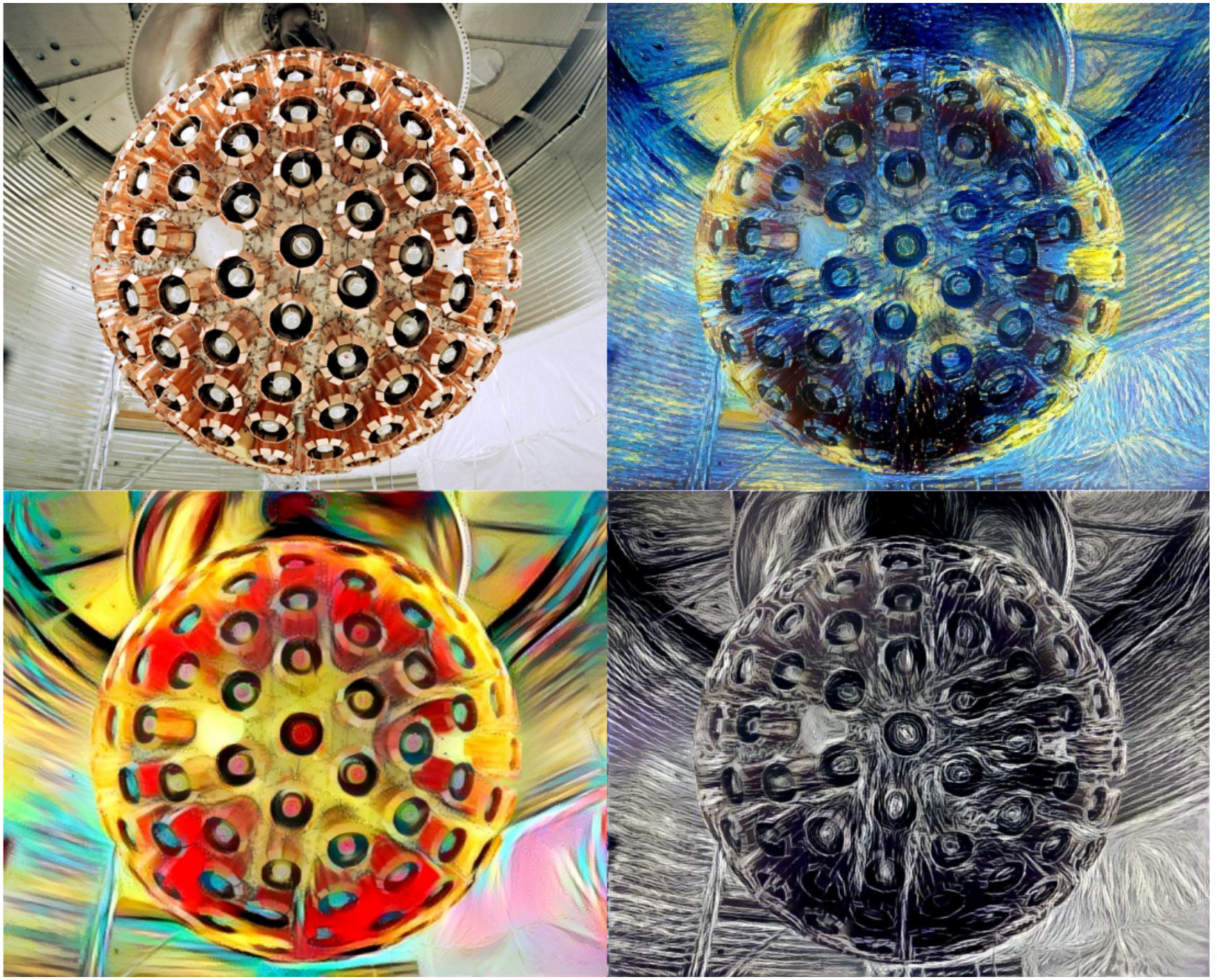

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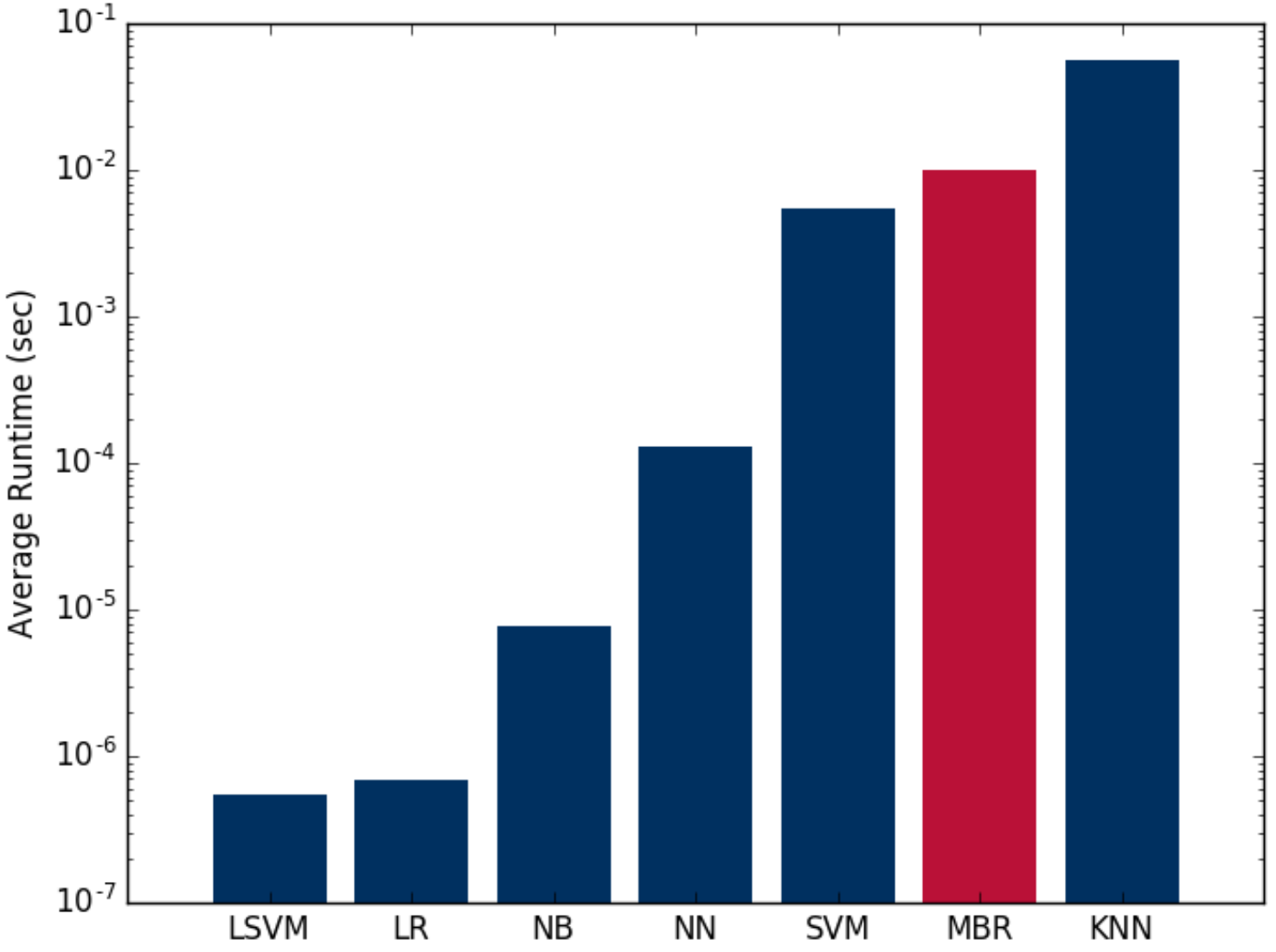
Runtime is very different for each algorithm



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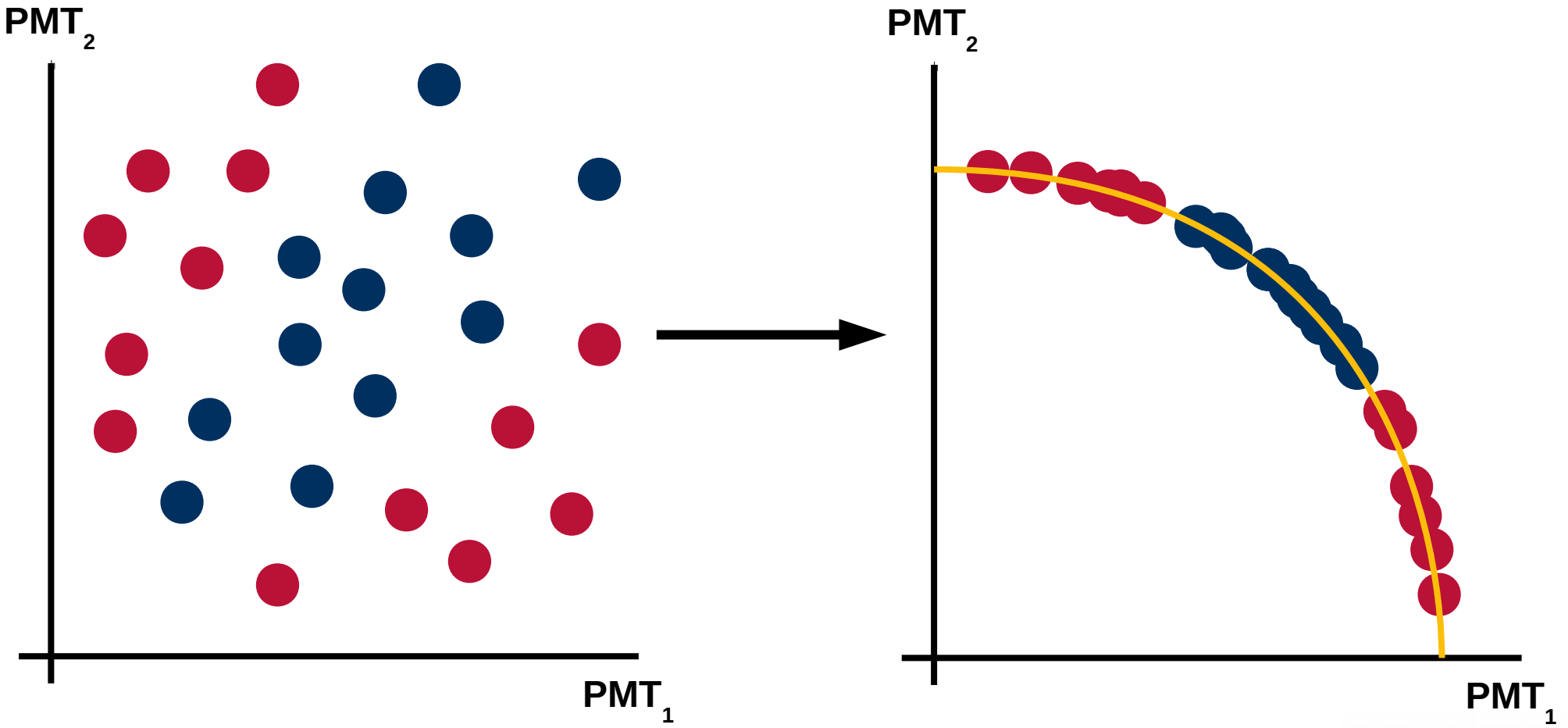
Preprocessing the data allows for easier surface event classification



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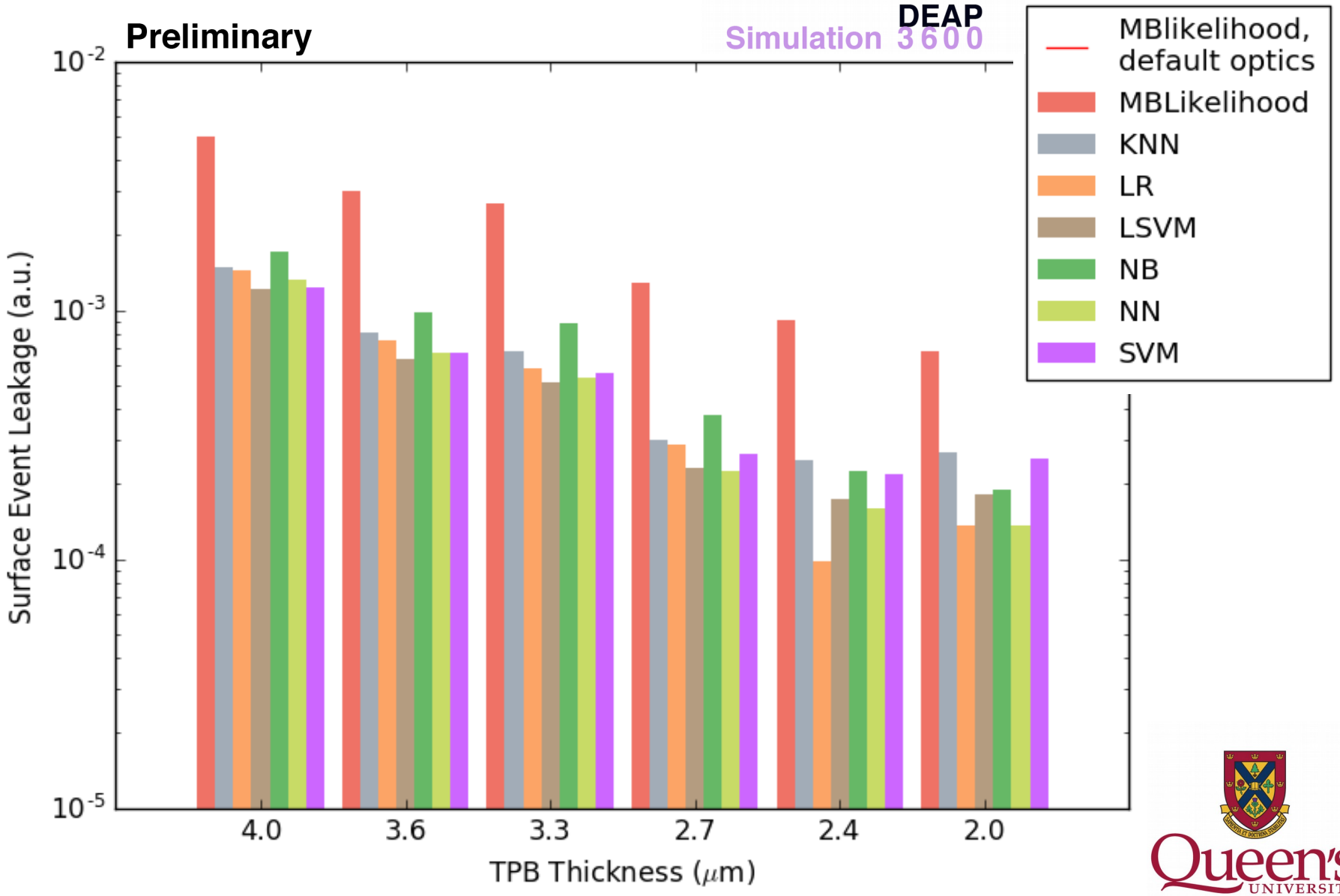
Machine Learning is robust against changes in the optical model



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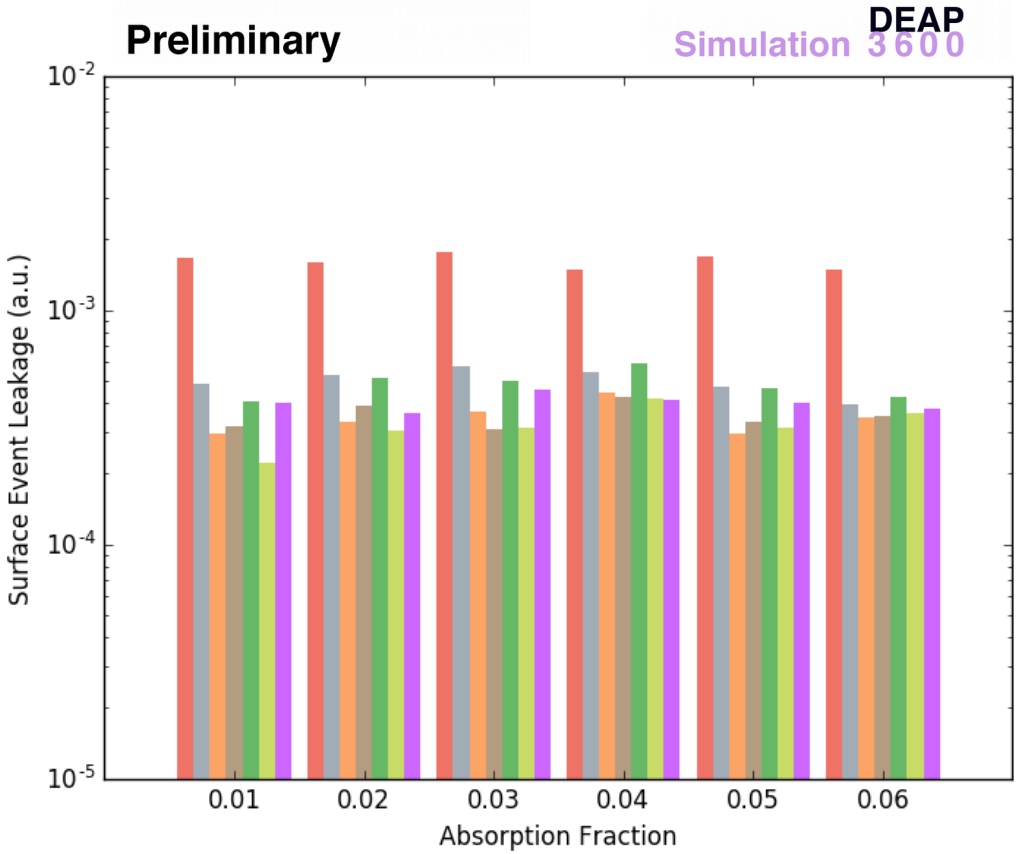
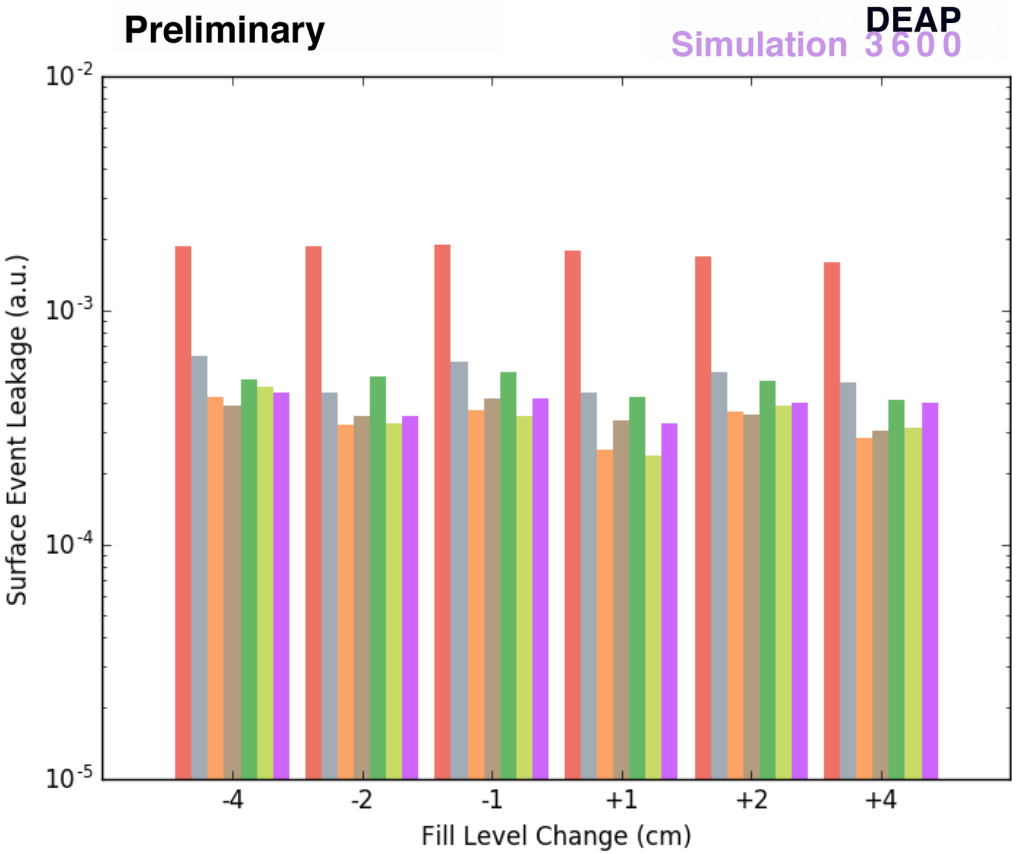
Some optical properties don't affect MBLikelihood or the boosted analysis





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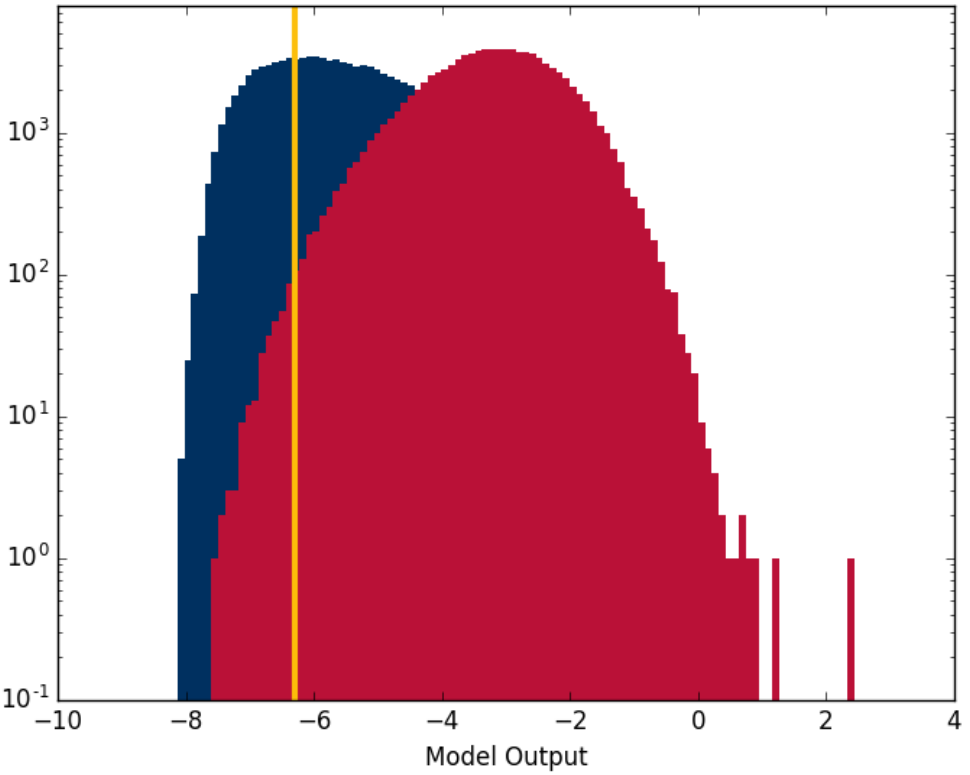
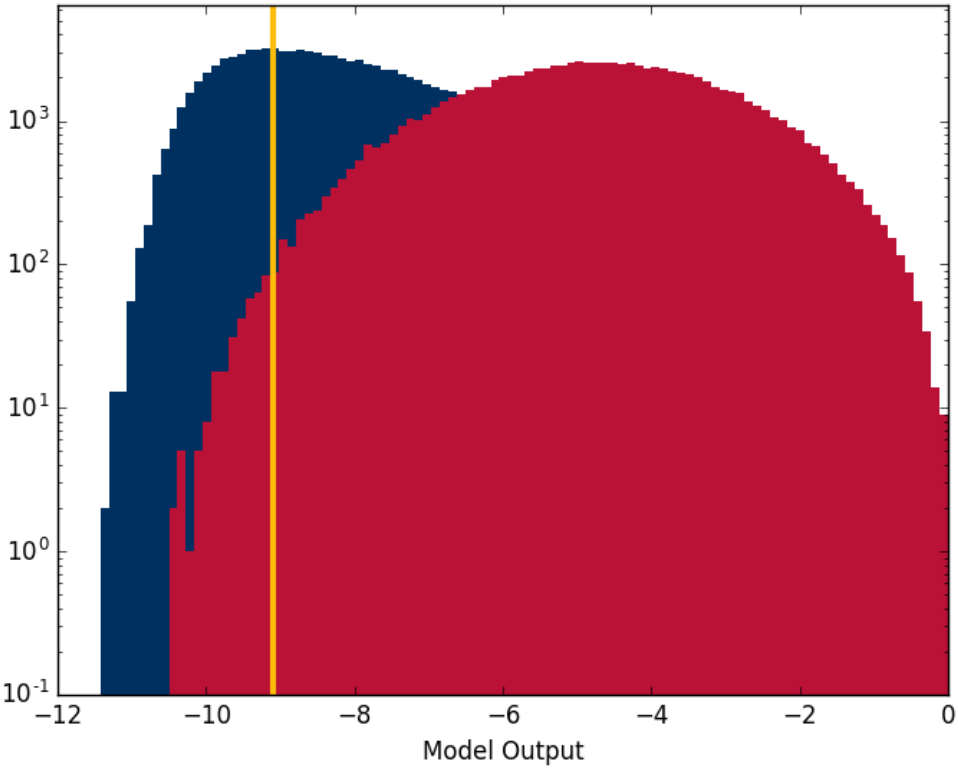
Support Vector Machine



Logistic Regression



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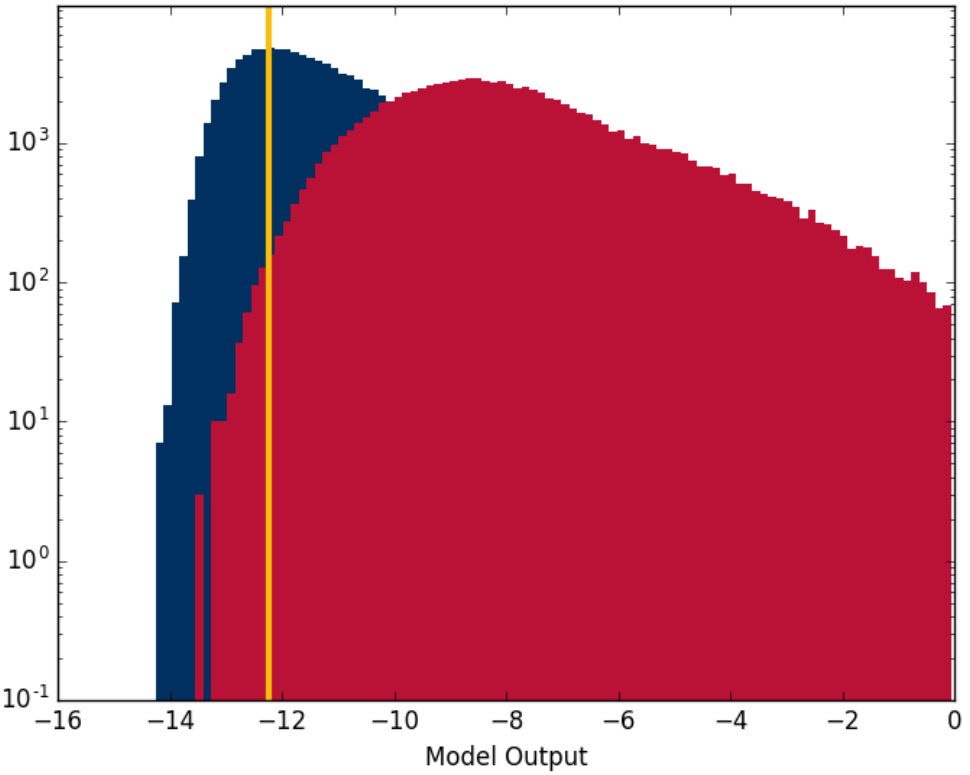
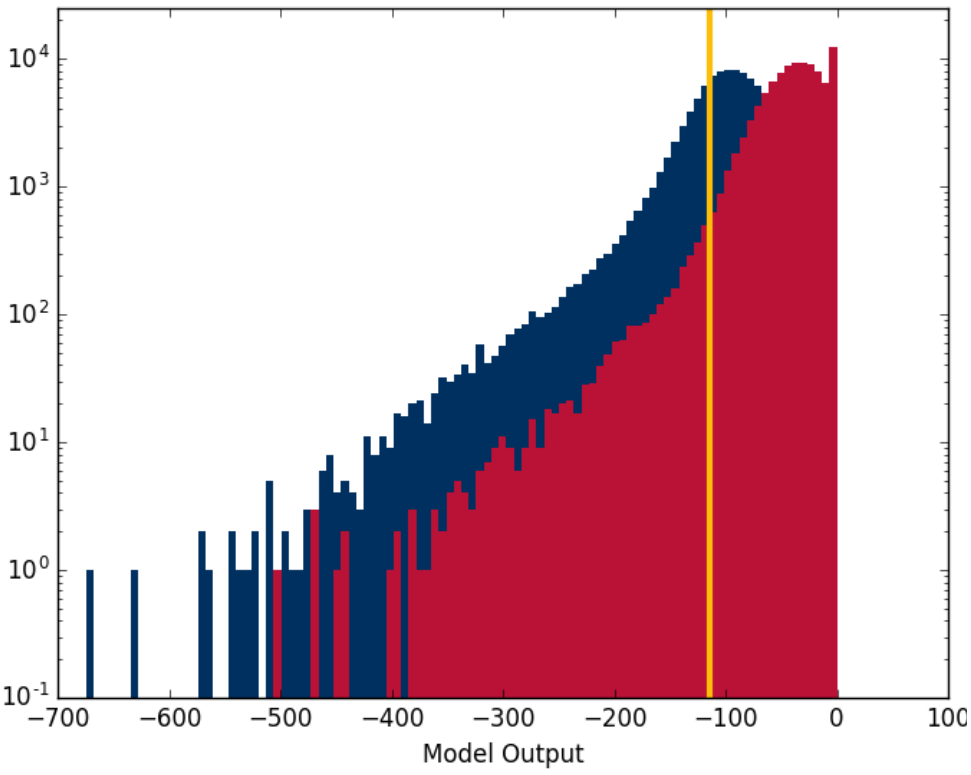
Neural Network



Naive Bayes



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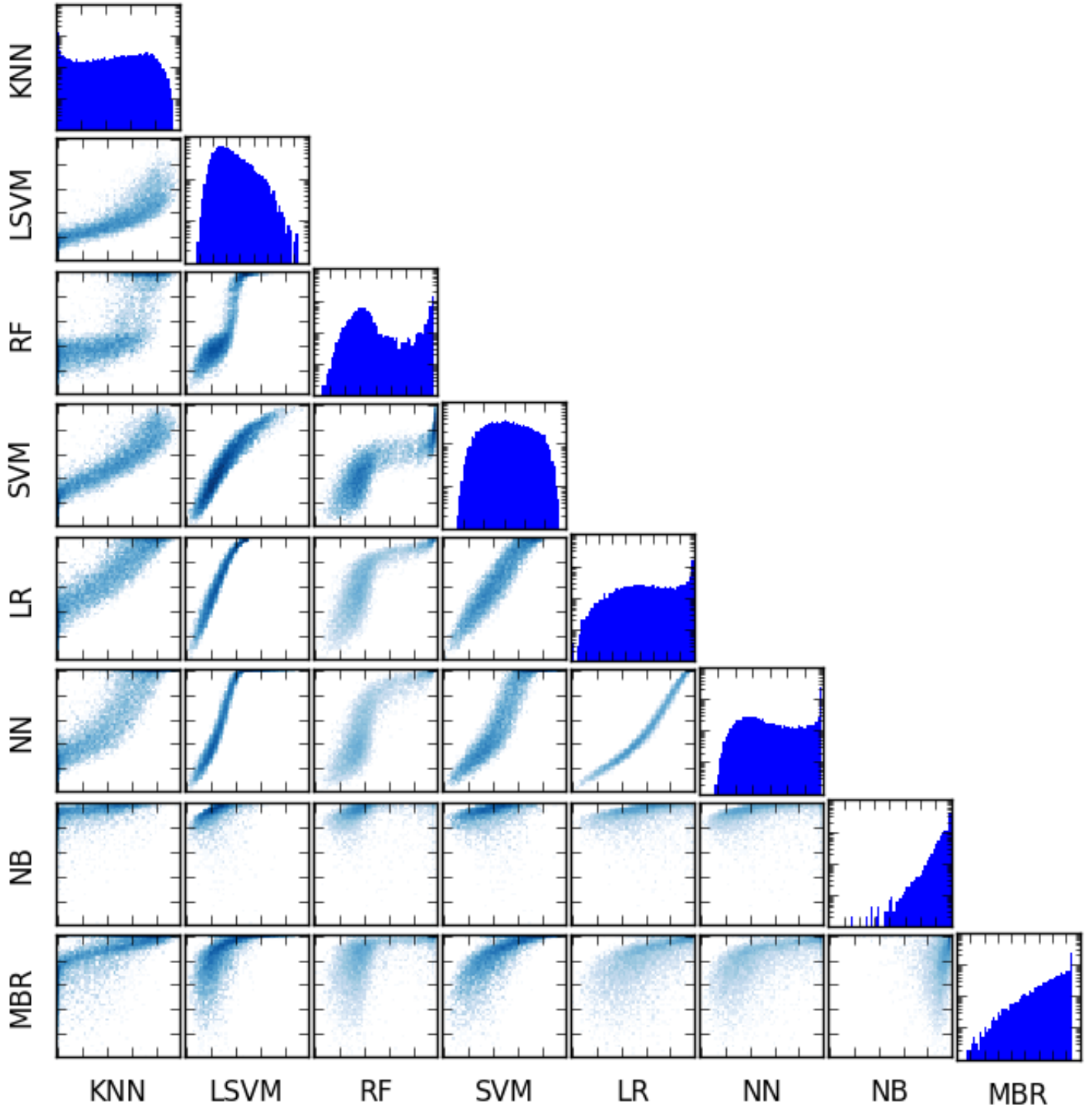

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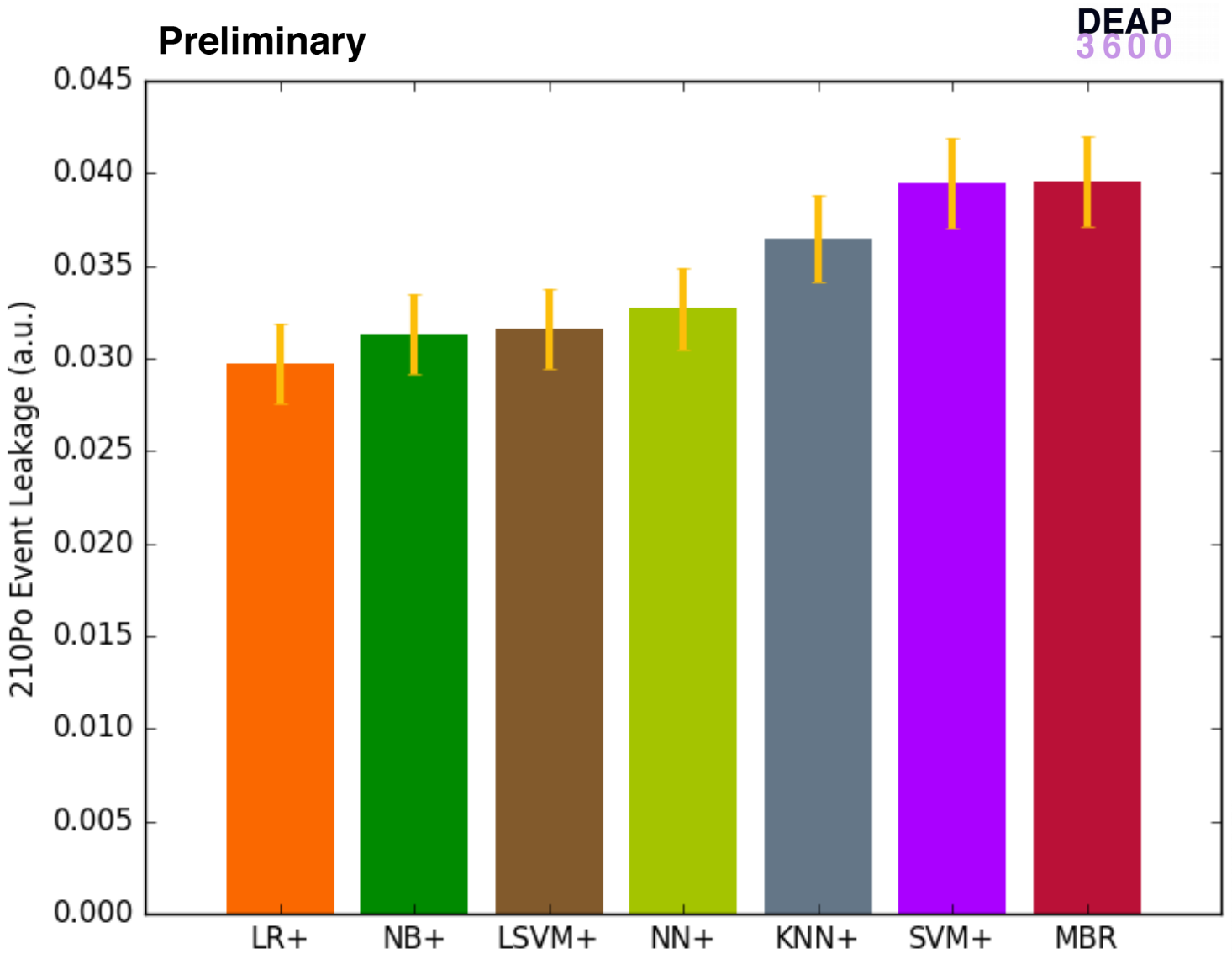
^{210}Po event leakage is reduced with the boosted analysis



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