CLUSTERING FOR BSM SEARCHES
DARK MACHINES – UNSUPERVISED LEARNING

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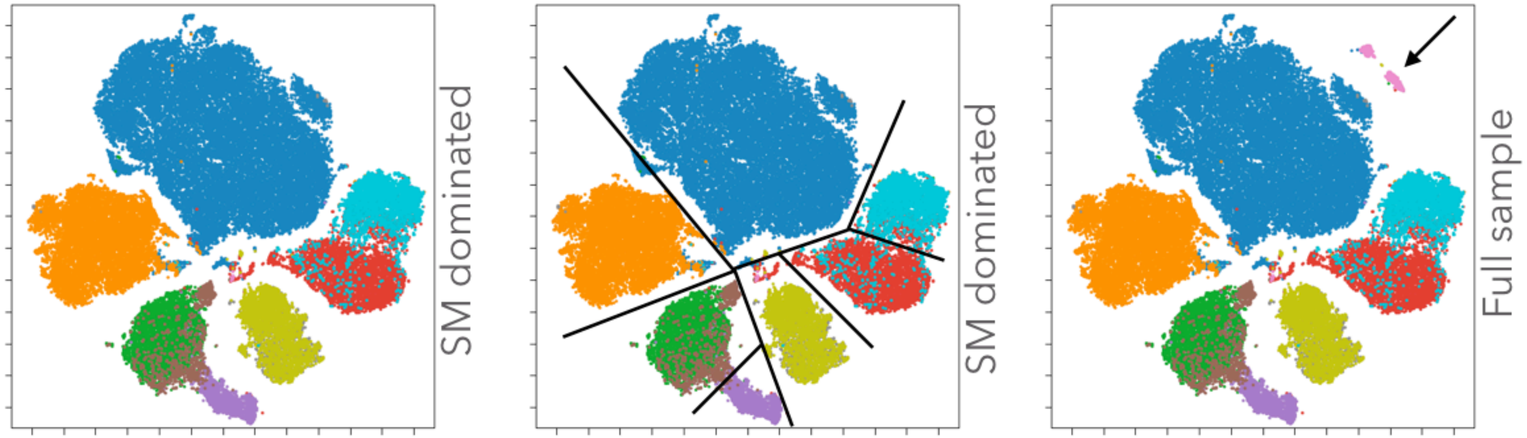
ATLAS EXPERIMENT

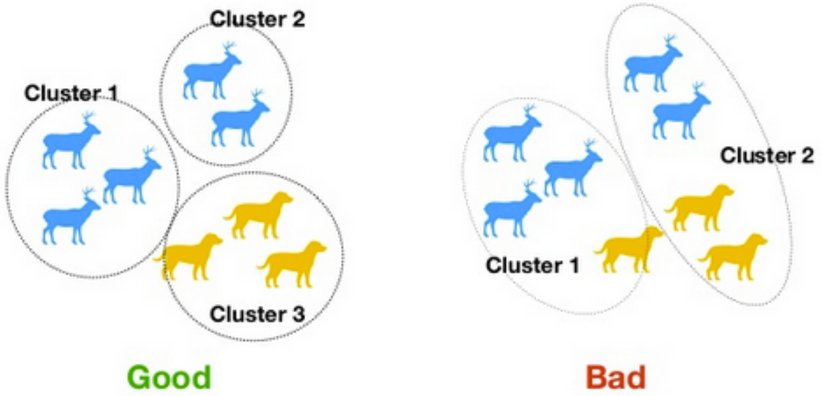
Clustering for BSM searches

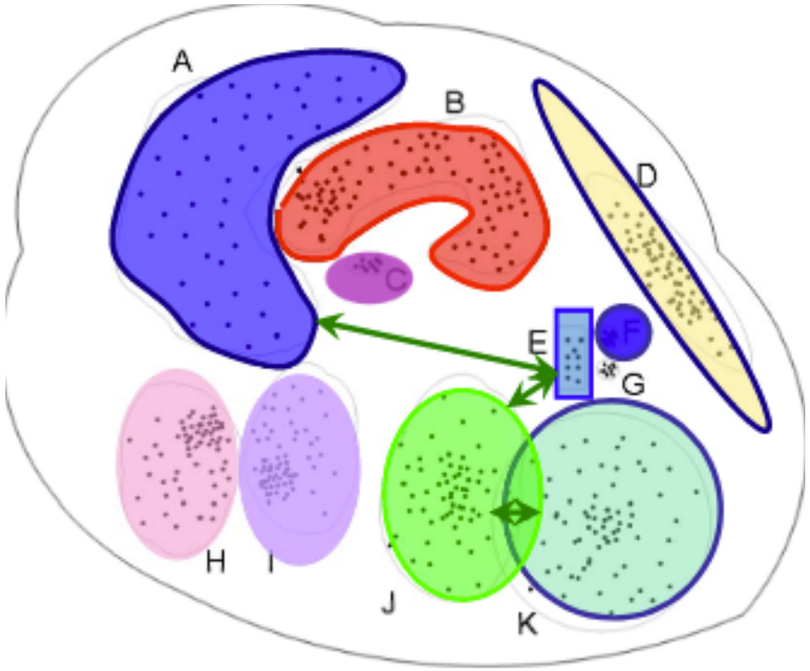
- Idea started at the first DarkMachines WS in Leiden, talk by Erzebet Merenyi
- Unsupervised learning can be used for New Physics searches.
- Use clustering algorithm for new physics searches.
- Proof of concept using MC, application on data.
- Define classes using Standard Model processes, use selections dominated by SM.
- Apply clustering algorithm on data, allow for new cluster to be found.
    - If new cluster appears, investigate the new class, new physics candidates.
    - If no new clusters found, investigate if there is excess in existing clusters.
- Clustering + Anomaly detection.



Clustering for LHC data

- Clustering for high dimensional parameter space:
  - Partition the parameter-space into clusters:
    - Investigate different clustering algorithms.
    - Measure the cluster quality (separation and scatter)
    - Choice of objects for clustering (track, lepton, jet, boosted jet, W, Z, H, top, etc.)
    - Use control regions dominated by one SM background to define clusters. Use validation regions.
- Challenges:
  - High dimensionality, clustering method not very good for increasing number of dimensions, find optimal performance.
  - Large volume
  - Highly structured





Anomaly detection for clusters

- Look for anomalies:
  - Excess/es
  - New cluster
- Try different new physics scenarios:
  - New resonance
  - Excess in the tails of distributions
  - Disappearing track, highly ionising particles
  - Feebly interacting new particles
  - SUSY scenarios
- See if single setup could be made, if not investigate dedicated incarnations.