Practical experiences from munitions response demonstrations

Kevin Kingdon, Len Pasion, Stephen Billings,
Barry Zelt, Laurens Beran, Nicolas Lhomme

Evolution of processing capabilities driven by live site challenges

2008 Camp Sibert, AL

- Identify single large target among smaller clutter and debris

2009 San Luis Obispo, CA

- Increased TOI target classes
- Significant topographic relief

2010 Camp Butner, NC

- Significant amount of clutter similar in size & shape to 37mm

2011 Camp Beale, CA

- Data requires conservative approach

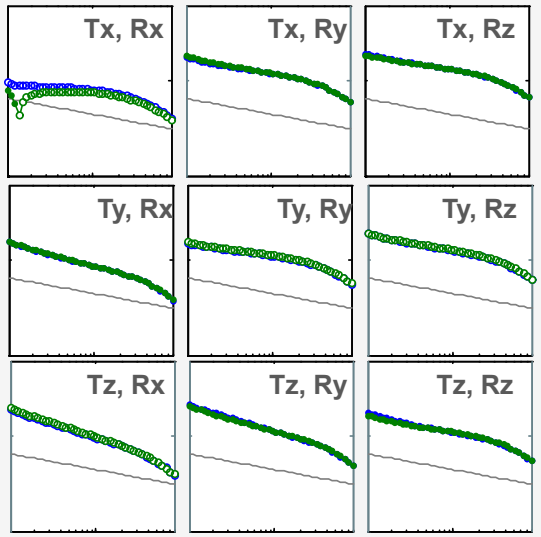
2011 Pole Mountain, WY

- Data support an aggressive strategy

Standard processing flow for UXO detection and classification

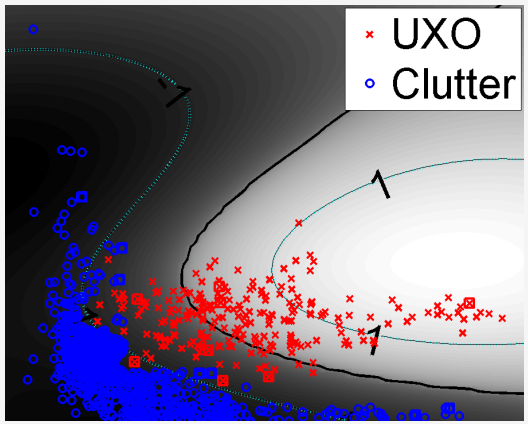
1. Data Acquisition

2. Feature estimation

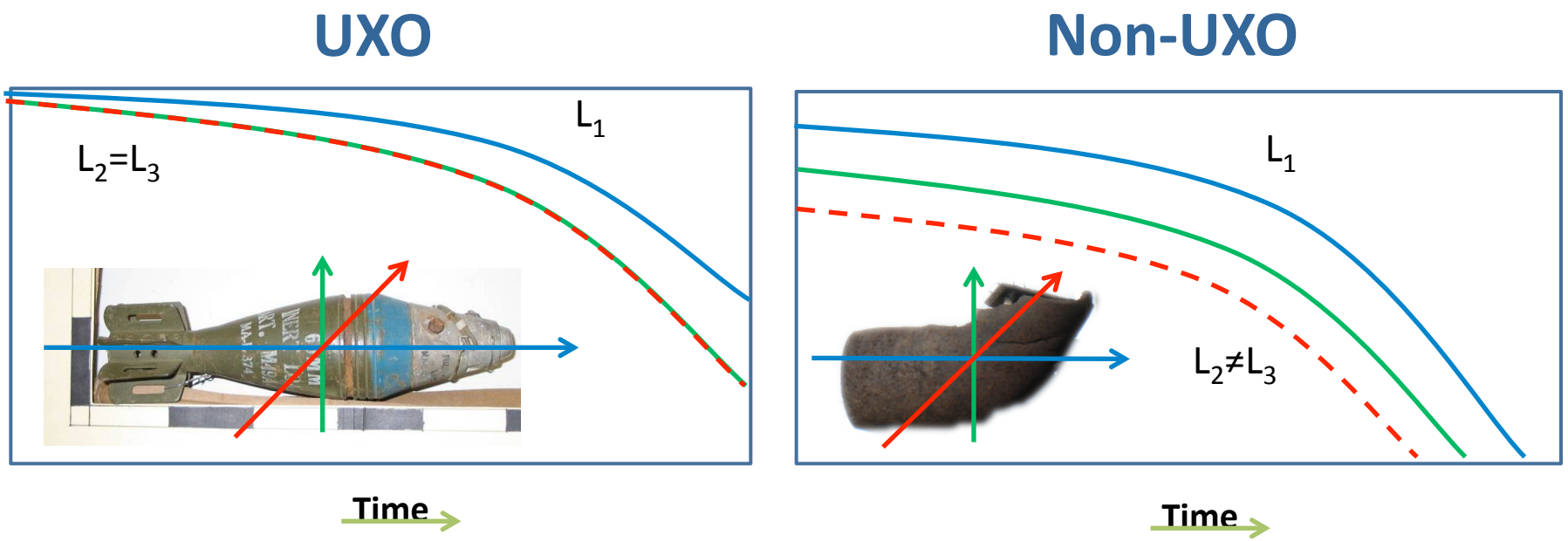


Feature vector

3. Classification



2. Feature Extraction : Target Polarizabilities

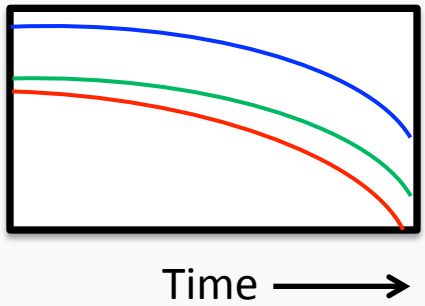


UXO are generally distinguished by:

- large amplitude, slow-decaying primary (L_1) polarizability
- equal secondary polarizabilities ($L_2=L_3$).

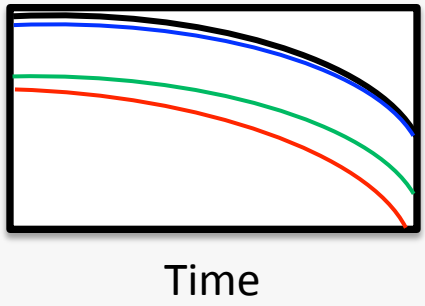
3. Classification: Feature Selection

All polarizabilities



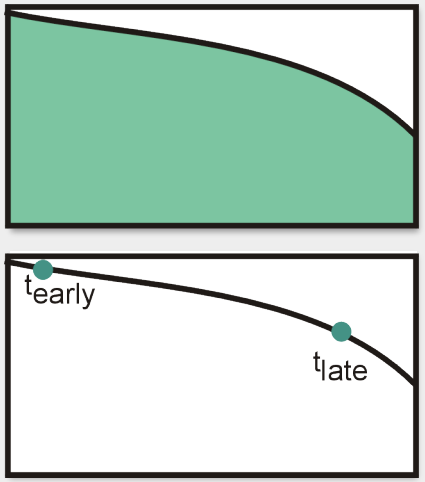
- Size
- Wall-thickness
- Shape

Total polarizability



- Size
- Wall-thickness

Size/decay



- Simplest representation

- ***Choice of features depends on the classification problem and data quality***

UXO Classification at Pole Mountain, WY

- ESTCP Classification Study

- Small ISO
- 37 mm projectiles
- 57 mm projectiles
- 60 mm mortar
- 75 mm projectile
- Horseshoes

MetalMapper data were acquired and processed for distribution in July-August 2011

Feature Extraction

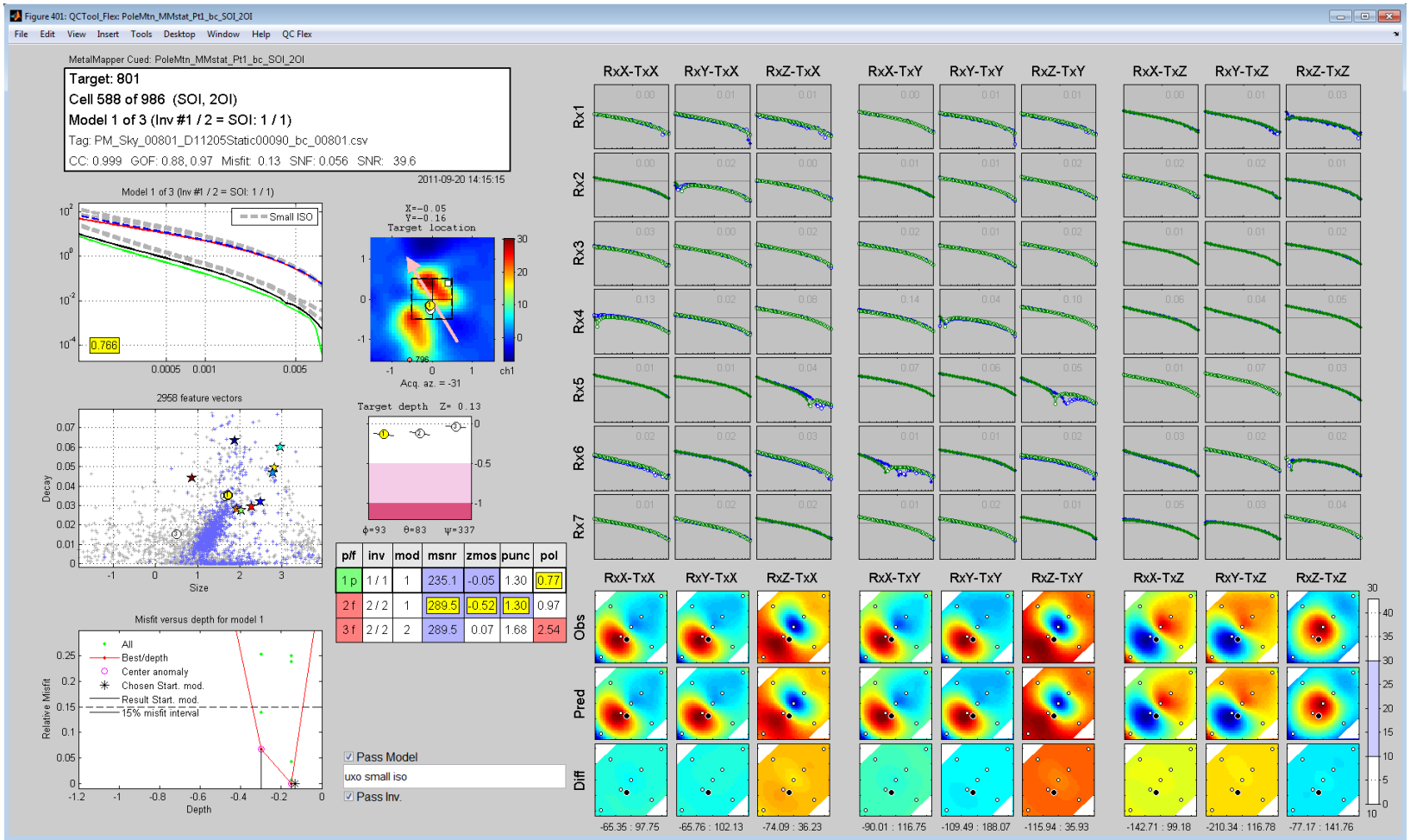
1. **Estimate target parameters**
   - Single source and two source inversions
   - Location, orientation, polarizabilities

2. **Data /Inversion QC**
   - Look for poor fits to the data
   - Determine if any anomalies are “Can’t Analyze”

3. **Model Selection**
   - Determine which of the models should be used in the classifier

Data/Inversion QC and Model Selection

- QC software tools essential for efficient identification of data and inversion issues



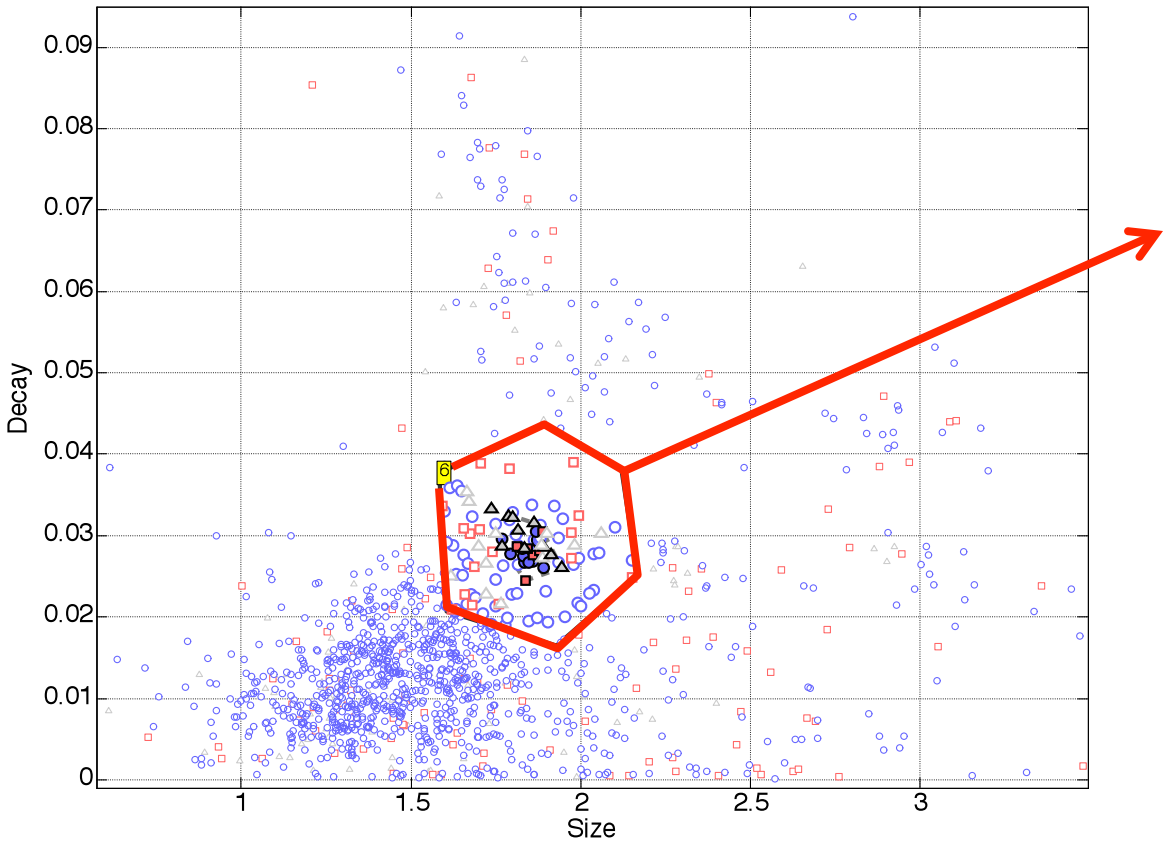
Classification

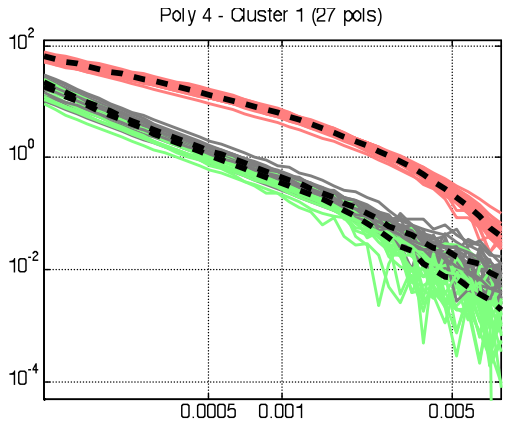
4. **Request training data**
   - Semi-supervised approach
5. **Create Ranked Anomaly List**
   - Library Matching Method
   - Support Vector Machine Classifier
6. **Determine a Stop Digging Point**
   - Manual: Visual inspection of list

Classification

4. Request training data

- Establish clusters of UXO
- Determine extent of UXO clusters and boundaries with clutter classes.



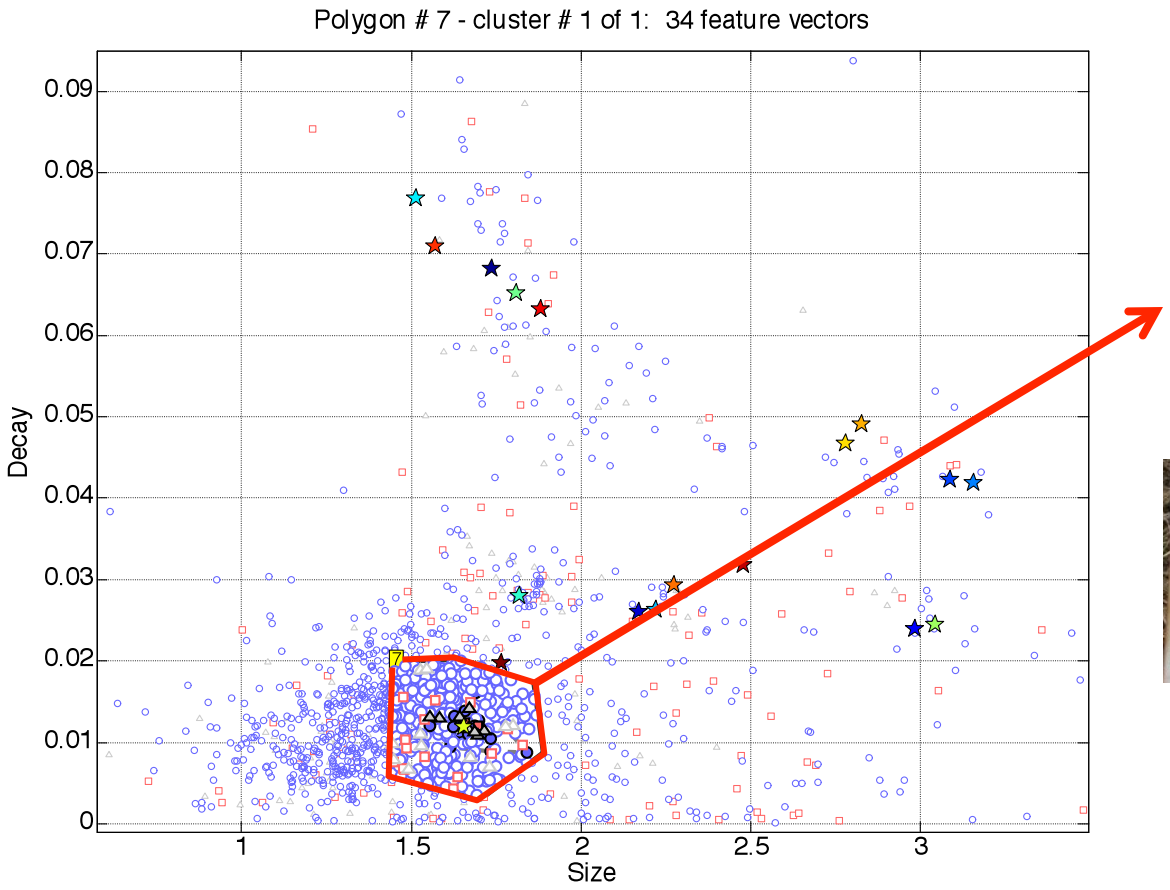


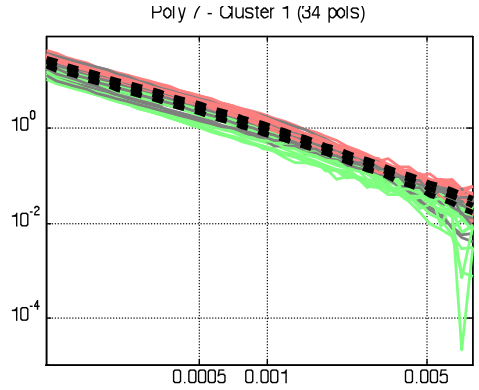
SMALL ISO

Classification

4. Request training data

- Establish clusters of UXO
- Determine extent of UXO clusters and boundaries with clutter classes.



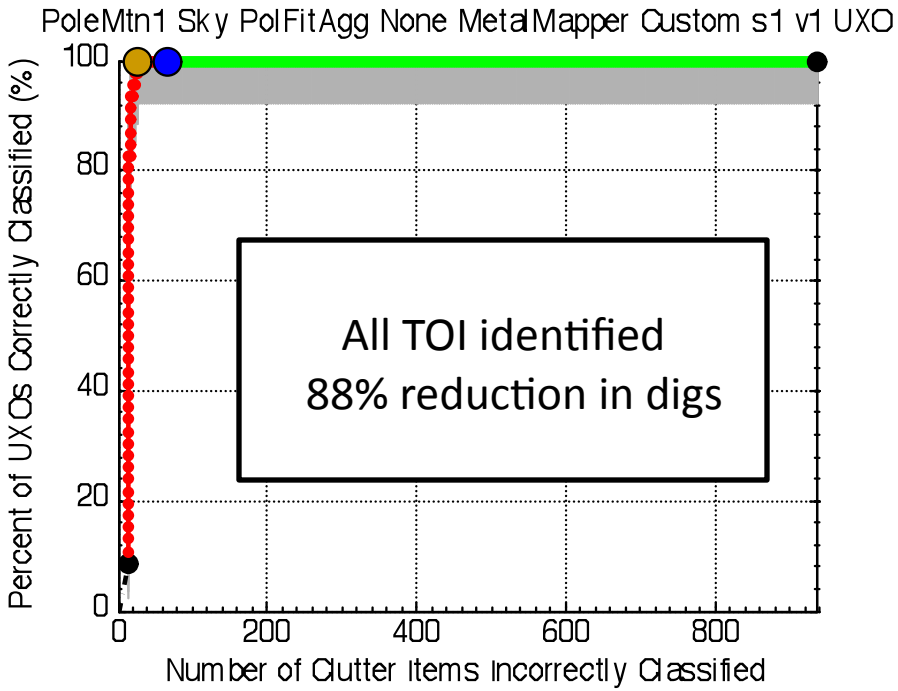


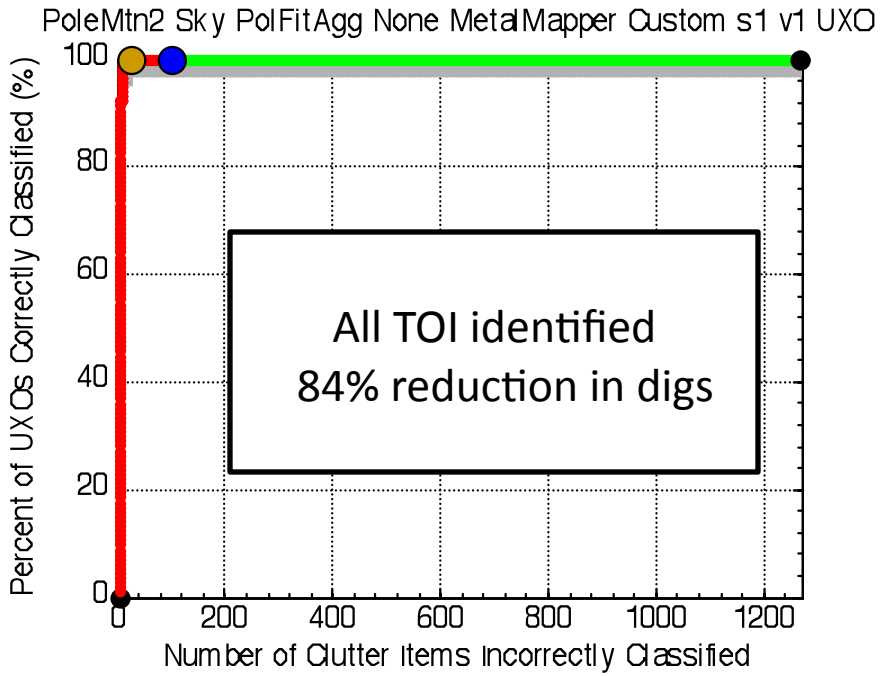
6 cm Fuse

Classification Example:

MetalMapper data processing at Pole Mountain

"Aggressive" dig lists: included polarizability quality and misfits to L1, L2 and L3

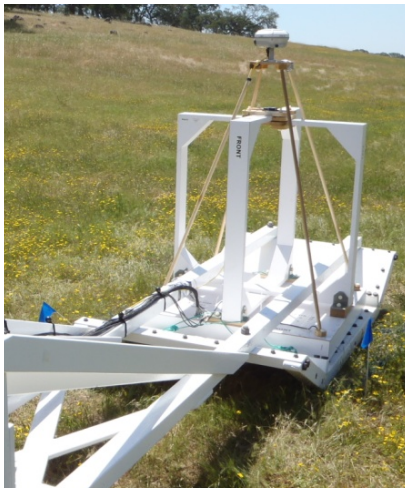




Final ROC curves for Year 1 and Year 2. Both lists found all TOI before the stop dig point.

Beale Open Area: MetalMapper Processing

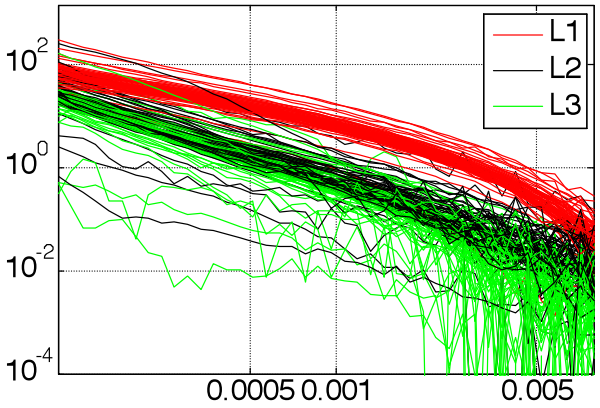
- MetalMapper data collected by Parsons and CH2M HILL
- Two classification methods to each dataset:
  1. Library based
  2. Two-stage conservative approach
- A different analyst for each method and instrument



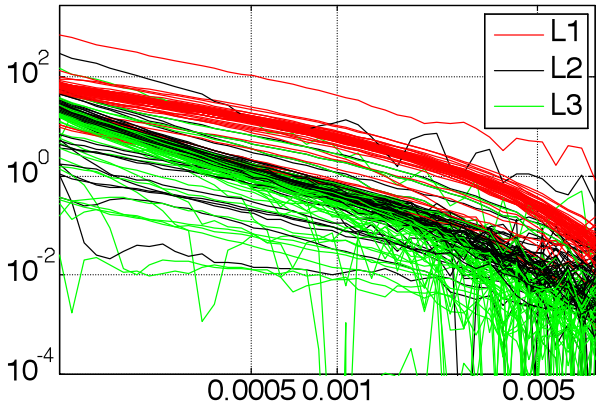
Understanding limitations of the data

- Variation in quality of recovered polarizabilities for ISO

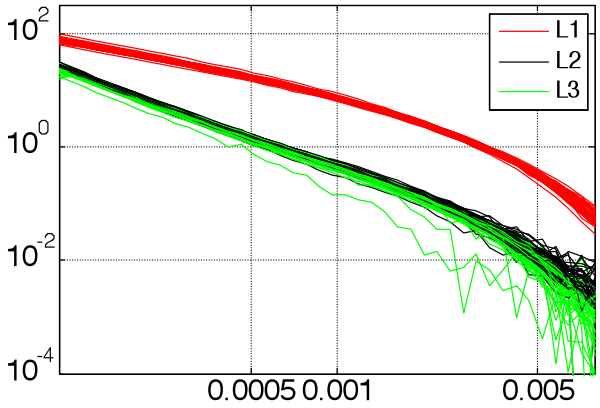
ISO: MetalMapper (P) Camp Beale 2011



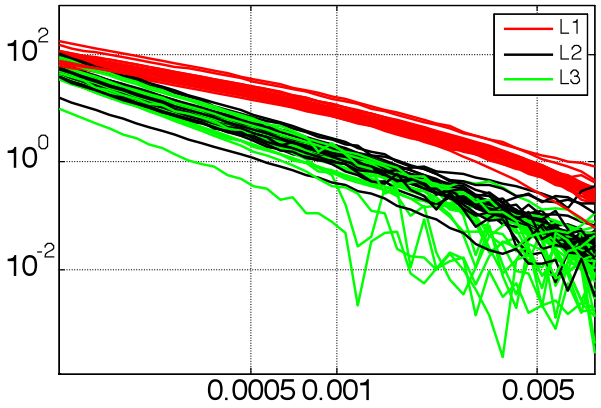
ISO: MetalMapper (C) Camp Beale 2011



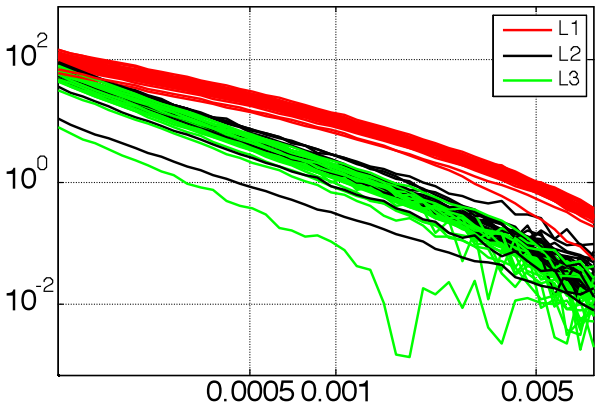
ISO: MetalMapper Pole Mountain 2011



ISO: MetalMapper (URS) Spencer 2012

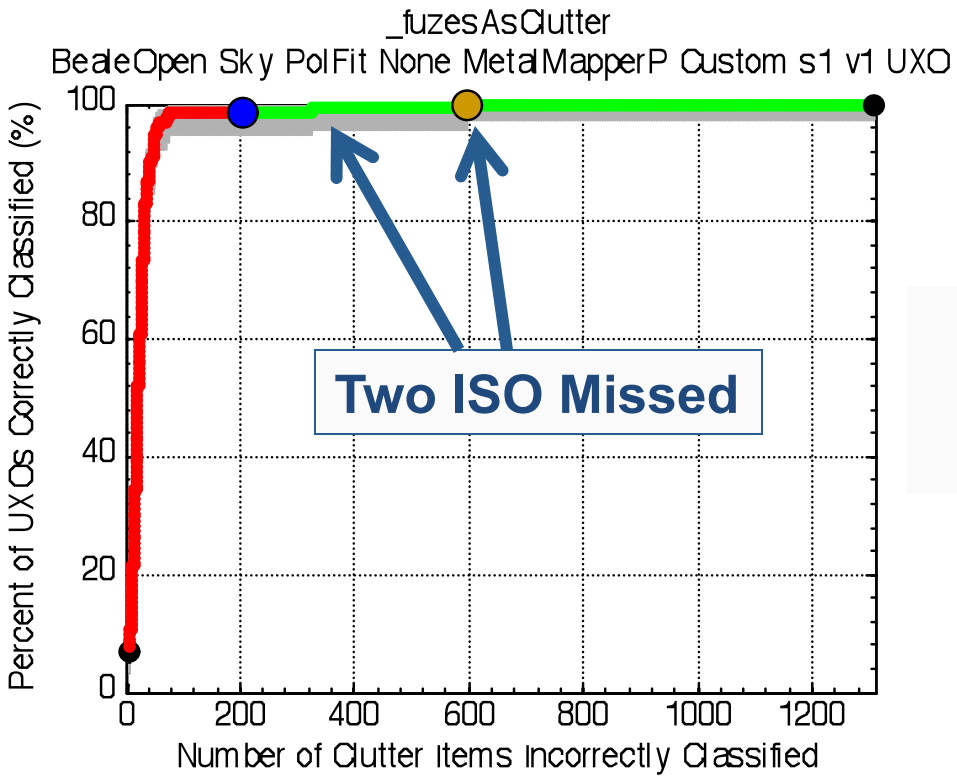


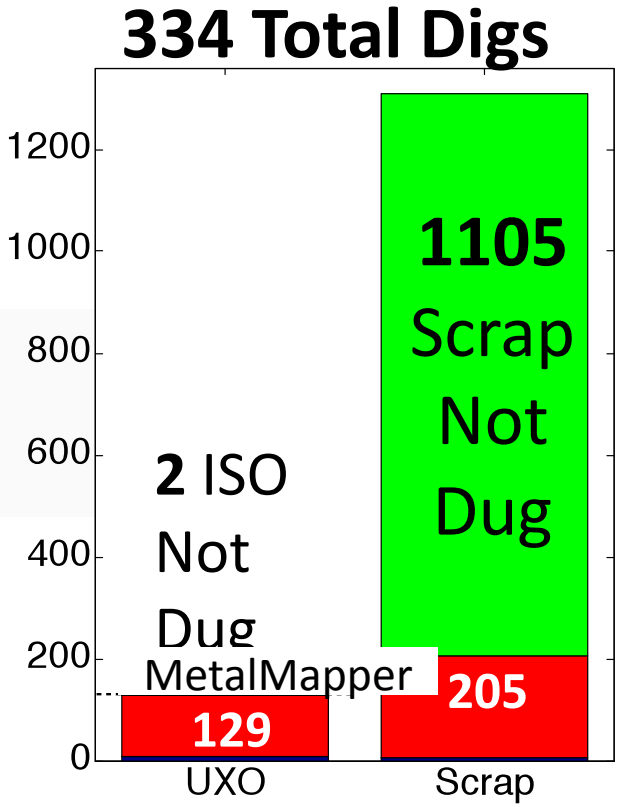
ISO: MetalMapper (NAEVA) Spencer 2012



MetalMapper Processing 1: Library Matching

- Aggressive method
- Two ISO Missed



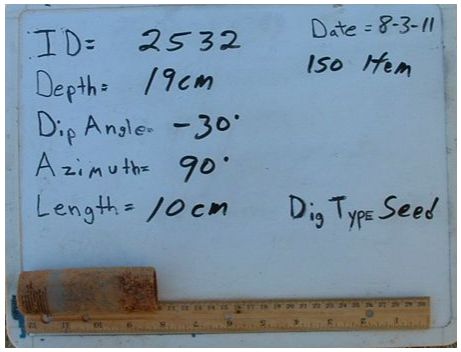


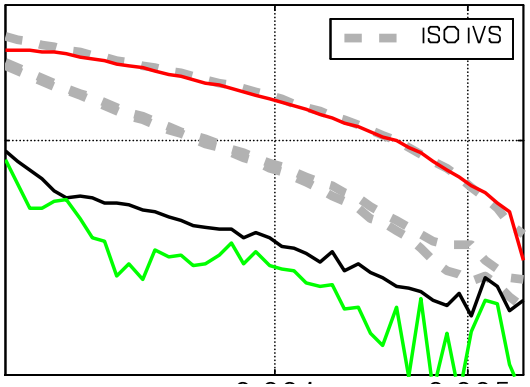
Classification Example:

MetalMapper data processing at Camp Beale

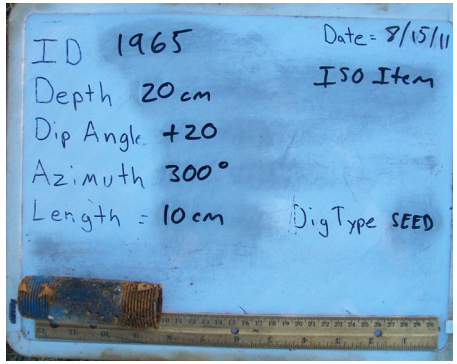
- Two ISO missed

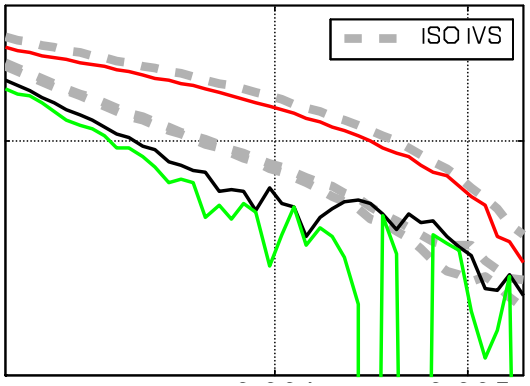
BE-2532 ISO stats seed





BE-1965 ISO stats seed



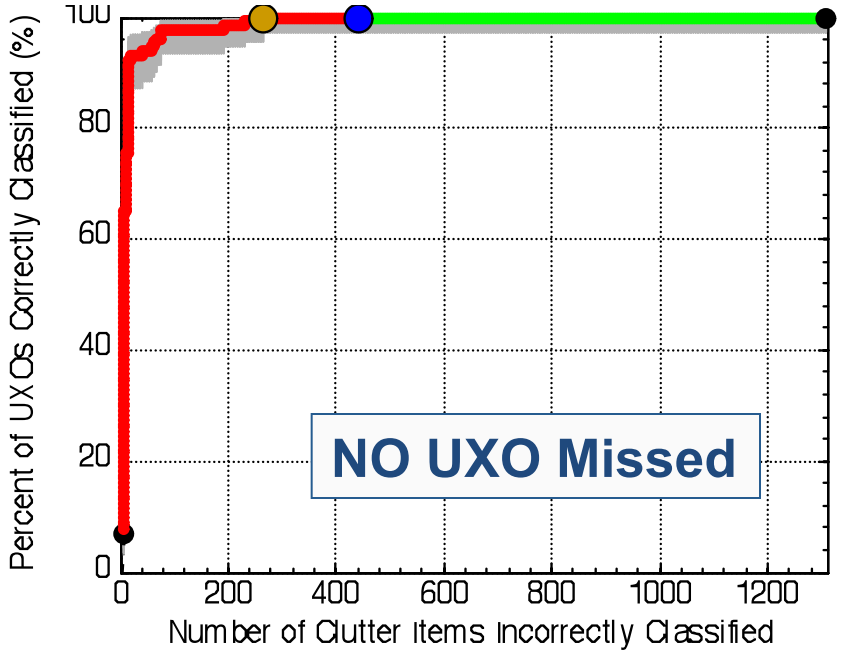


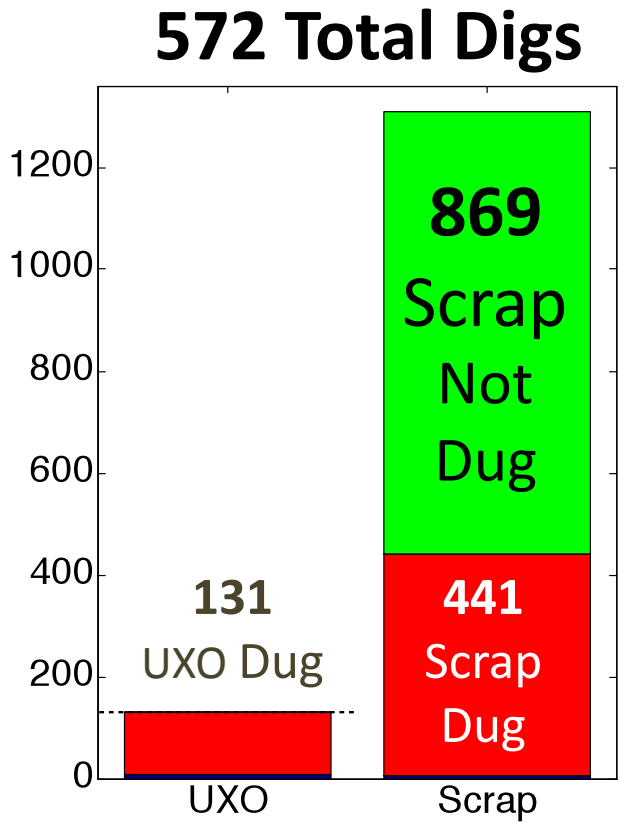
- ***All 3 polarizabilities sometimes not well constrained – should also use primary polarizability***

Classification Example:

MetalMapper data processing at Camp Beale

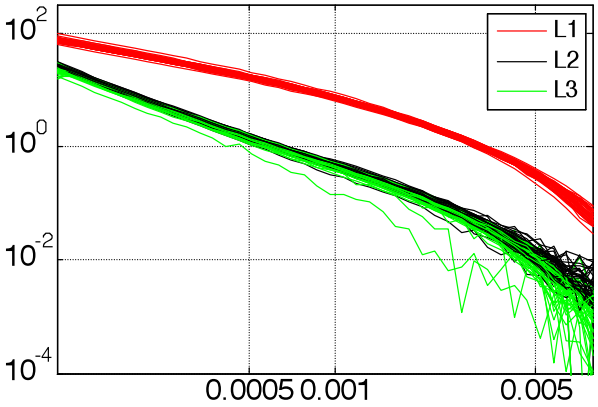
- More conservative approach
- Use all 3 polarizabilities then switch to total polarizability



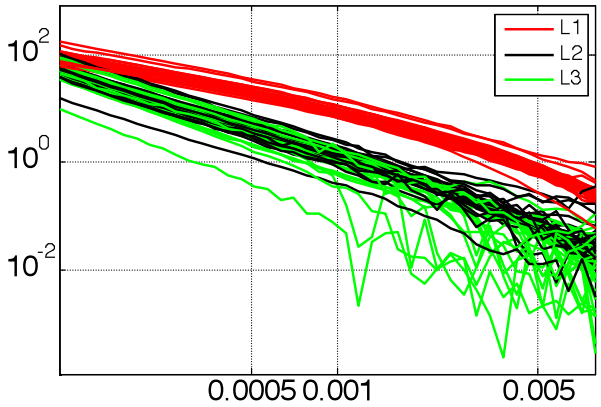


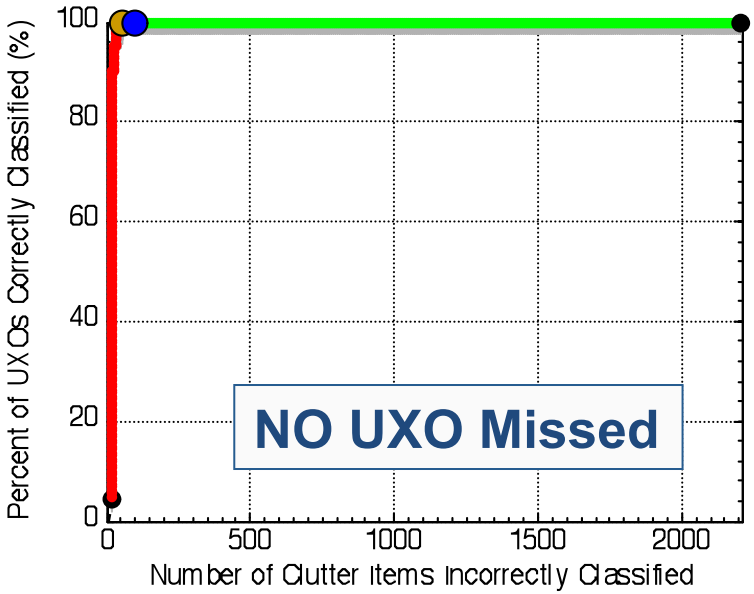
Technology Transfer: Industry Partner Results

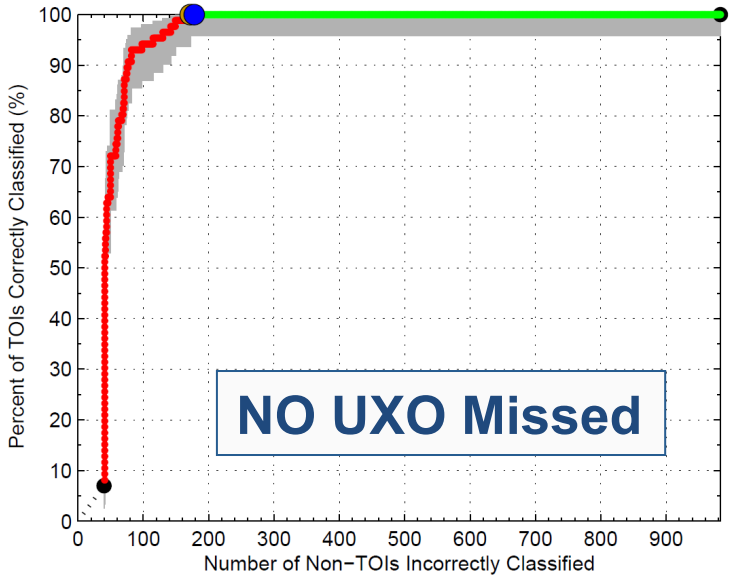
Pole Mountain



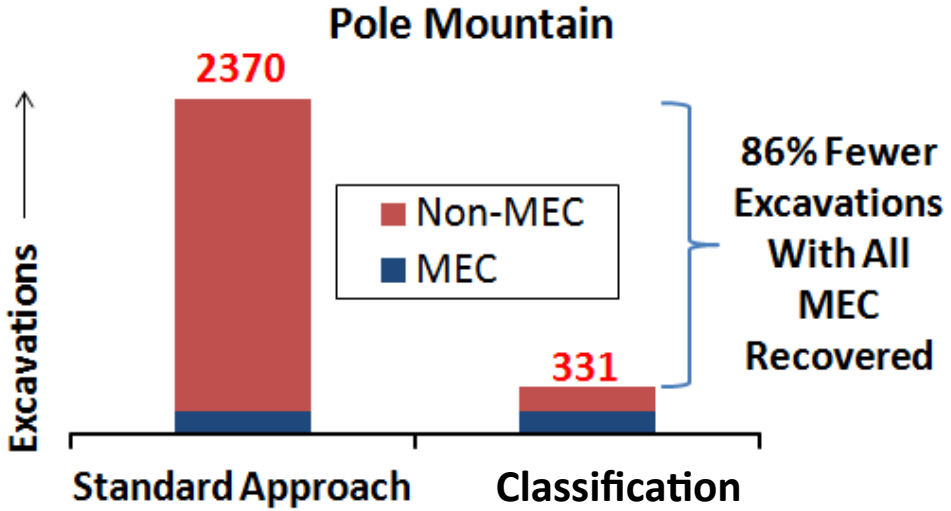
Spencer Range

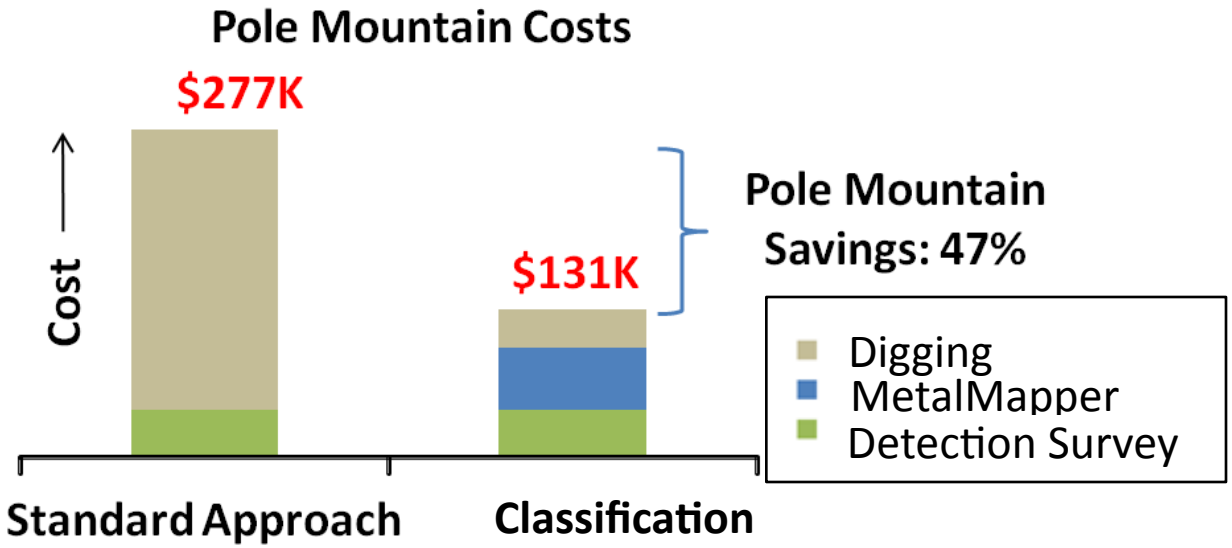






Reduction in Excavations and Cost Reduction





Conclusions

- There are a number key components to successful classification
  1. A reliable data Quality Control (QC) process
  2. Understanding limitations of the data
  3. Selecting an appropriate classification strategy based on the data quality

- Effective classification could be achieved at Pole Mountain and Camp Beale demonstration sites using MetalMapper data

Acknowledgements

The work in this presentation was funded by the Strategic Environmental Research and Development Program (SERDP) and the Environmental Security Technology Certification Program (ESTCP)