

SAIC Analysis of Data Acquired at Camp Butner, NC

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14. ABSTRACT The Large Scale Classification Project at Camp Butner provides an excellent opportunity to compare and contrast classification performances for static and reconnaissance EMI data and for a variety of analysis approaches. SAIC analyzed EM61 data acquired in reconnaissance mode as well as Metal Mapper and TEMTADS data acquired while stationary. Our analysis included single- and multi-source solvers. Our classification utilizes a decision tree targeting the intrinsic polarizabilities. The decision tree incorporates uncertainty in unanticipated targets-ofinterest and has hasn?t changed dramatically since being developed using data acquired at Aberdeen Proving Ground, Camp Sibert, and Camp San Luis Obispo. We also experimented in the number of training labels (starting with no on-site labels) used to fine tune the classifier. Finally, we utilized two different analysis environments; Oasis montaj and IDL. Two commercial firms, NAEVA and Parsons, also utilized the UX-Analyze module in Oasis montaj to classify Metal Mapper stationary data. During our presentation, we will discuss performances of the various combinations and present lessons learned.					
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SAIC DATA ANALYSIS OF DATA ACQUIRED AT CAMP BUTNER

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The Large Scale Classification Project at Camp Butner provides an excellent opportunity to compare and contrast classification performances for static and reconnaissance EMI data and for a variety of analysis approaches. SAIC analyzed EM61 data acquired in reconnaissance mode as well as Metal Mapper and TEMTADS data acquired while stationary. Our analysis included single- and multi-source solvers. Our classification utilizes a decision tree targeting the intrinsic polarizabilities. The decision tree incorporates uncertainty in unanticipated targets-of-interest and has hasn't changed dramatically since being developed using data acquired at Aberdeen Proving Ground, Camp Sibert, and Camp San Luis Obispo. We also experimented in the number of training labels (starting with no on-site labels) used to fine tune the classifier. Finally, we utilized two different analysis environments; Oasis montaj and IDL. Two commercial firms, NAEVA and Parsons, also utilized the UX-Analyze module in Oasis montaj to classify Metal Mapper stationary data. During our presentation, we will discuss performances of the various combinations and present lessons learned.

Outline

Background

Datasets analyzed

Analysis environment

Inversion schemes

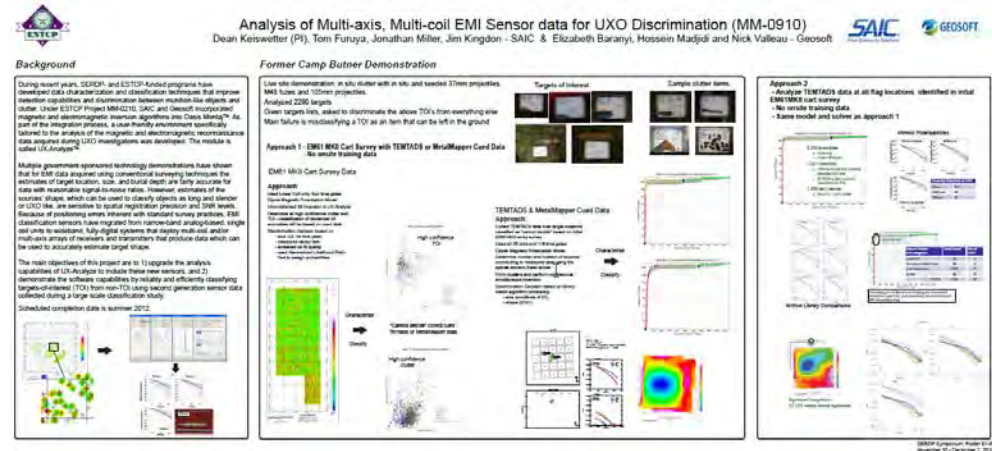
Classification approach

EM61 data as pre-screen

Classification performance

Failure Analysis

Stop by Poster #61 for more details



Project Team & Sponsor

Science Applications International Corporation (SAIC)

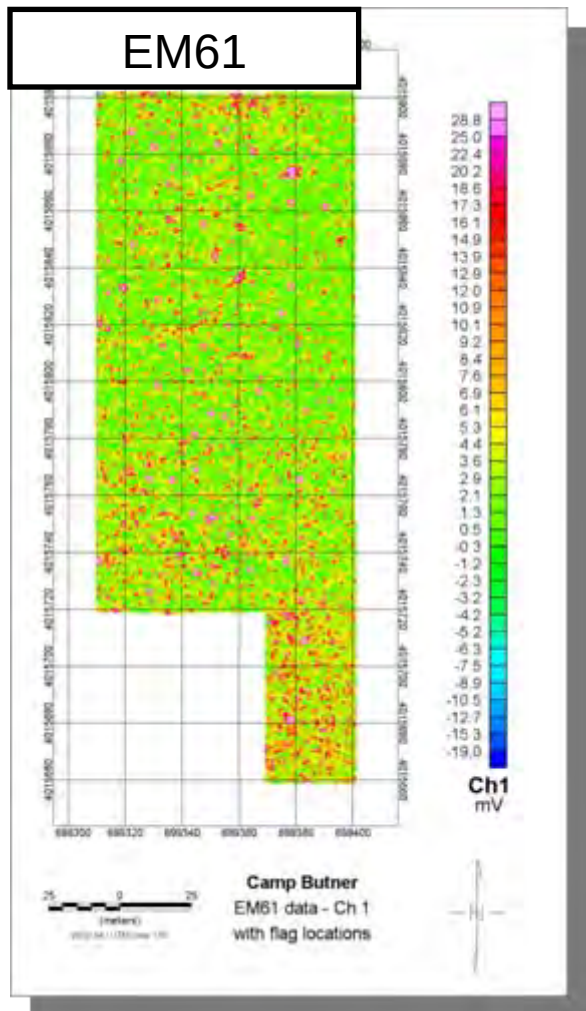
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Tom Furuya	data analyst
Jim Kingdon	data analyst & analysis algorithms
Nagi Khadr	data analyst
Jonathan Miller	analysis algorithms
Bruce Barrow	failure analysis
Tom Bell	technical advisor

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Sensor Data

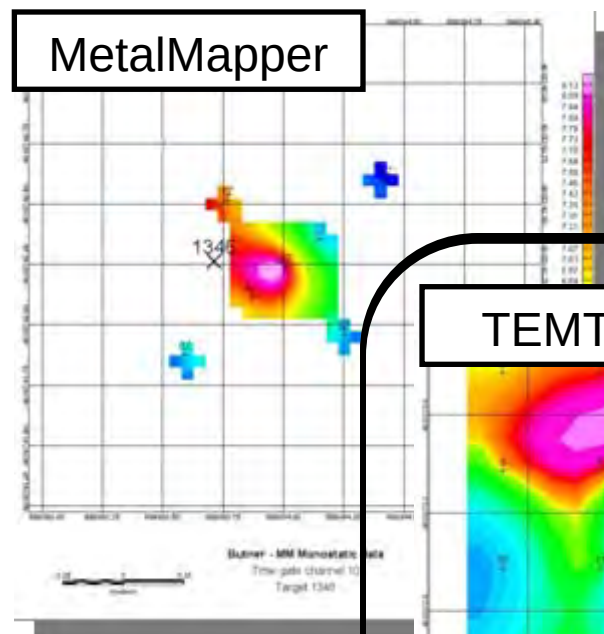
Dynamic

EM61

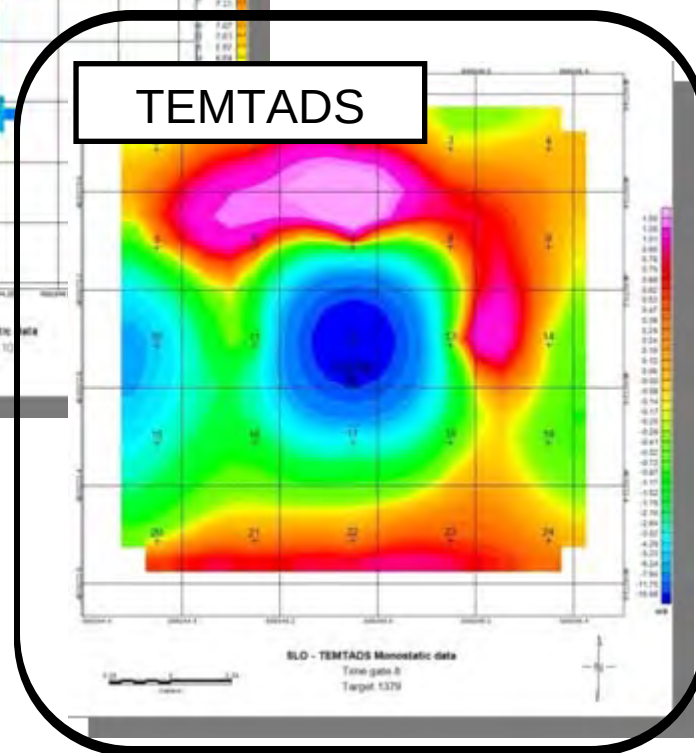


Cued

MetalMapper



TEMTADS



Analysis Environment

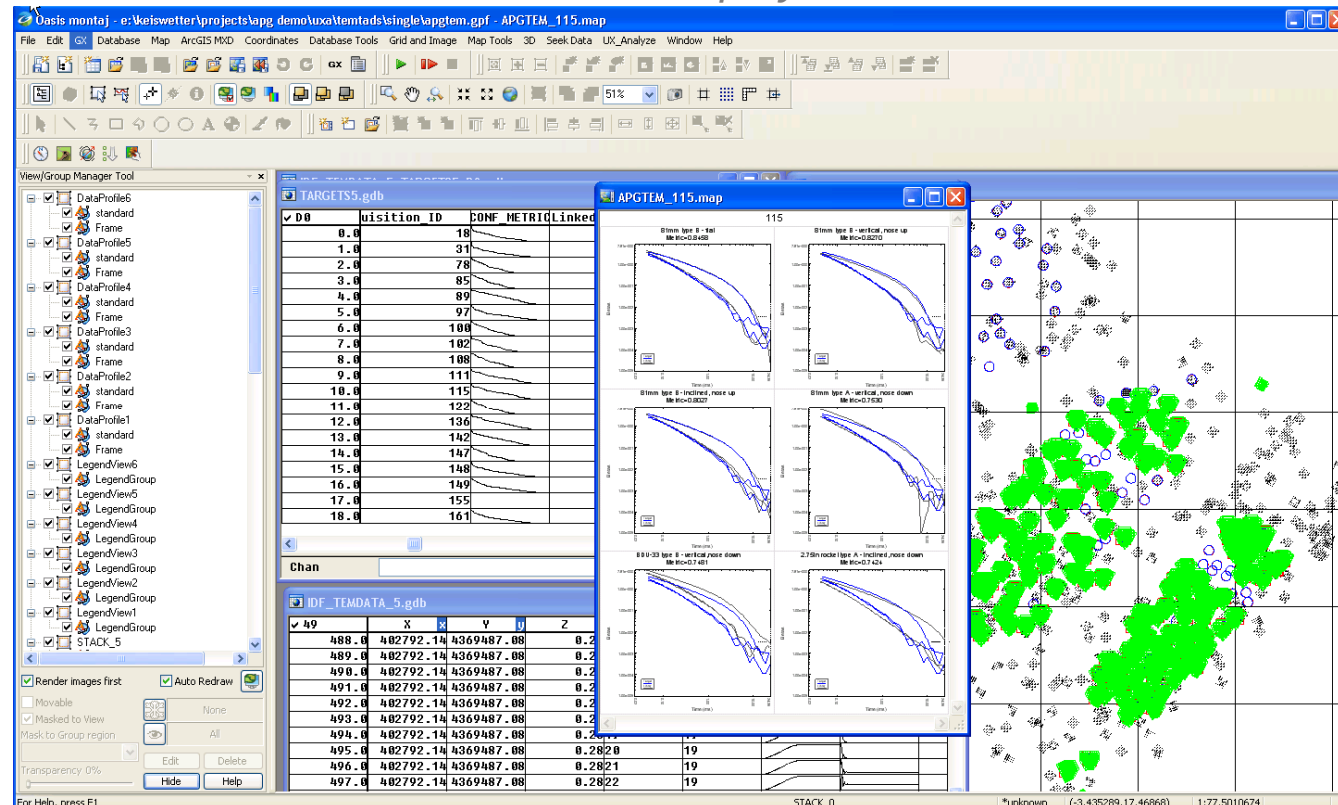


UX-Analyze

Stop by Poster #60 for more details

Oasis montaj

- High performance database
- Advanced data processing
- Dynamic linking (maps, data, profiles, etc.)
- Professional map production
- Audit trail



Single target solvers

Standard dipole model

- Location (X,Y,Z), orientation (Ψ , Θ , Φ), & intrinsic polarizabilities

Utilized two single source, but multi-stage solvers – each designed to avoid local minima

- ◆ Generally produce the same answers
- ◆ Subtle difference in recovered polarizabilities are sometimes observed
- ◆ Excellent data for establishing best practices

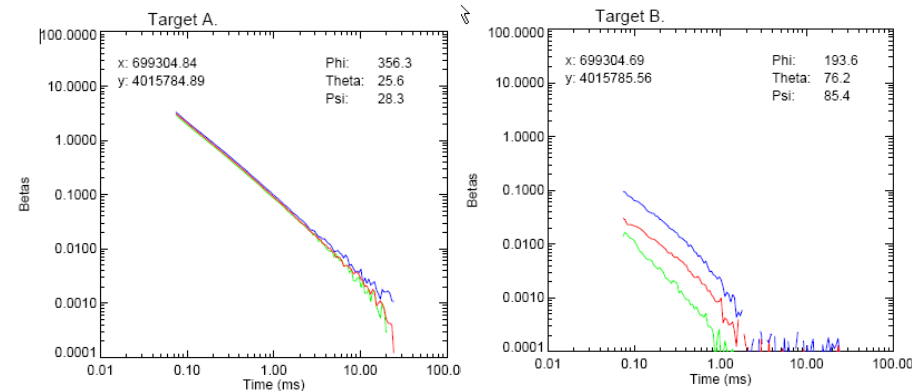
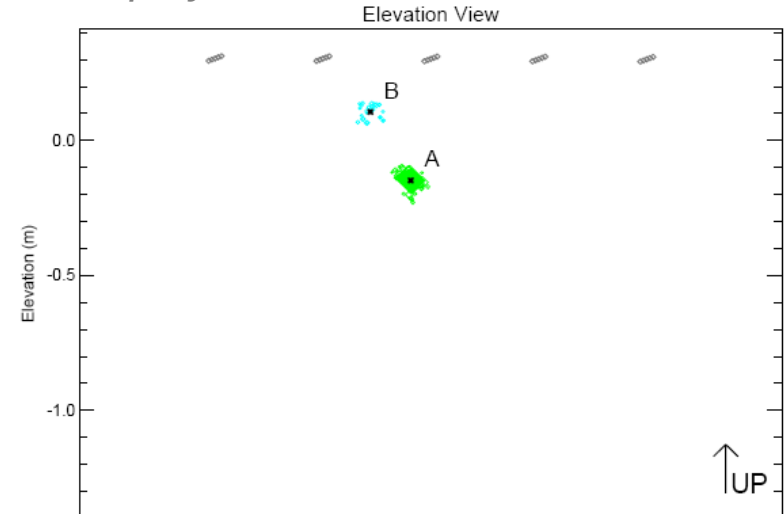
Multi-source Solver

Multi-source solver for handling multiple objects within the sensors' field of view (MM-1662)

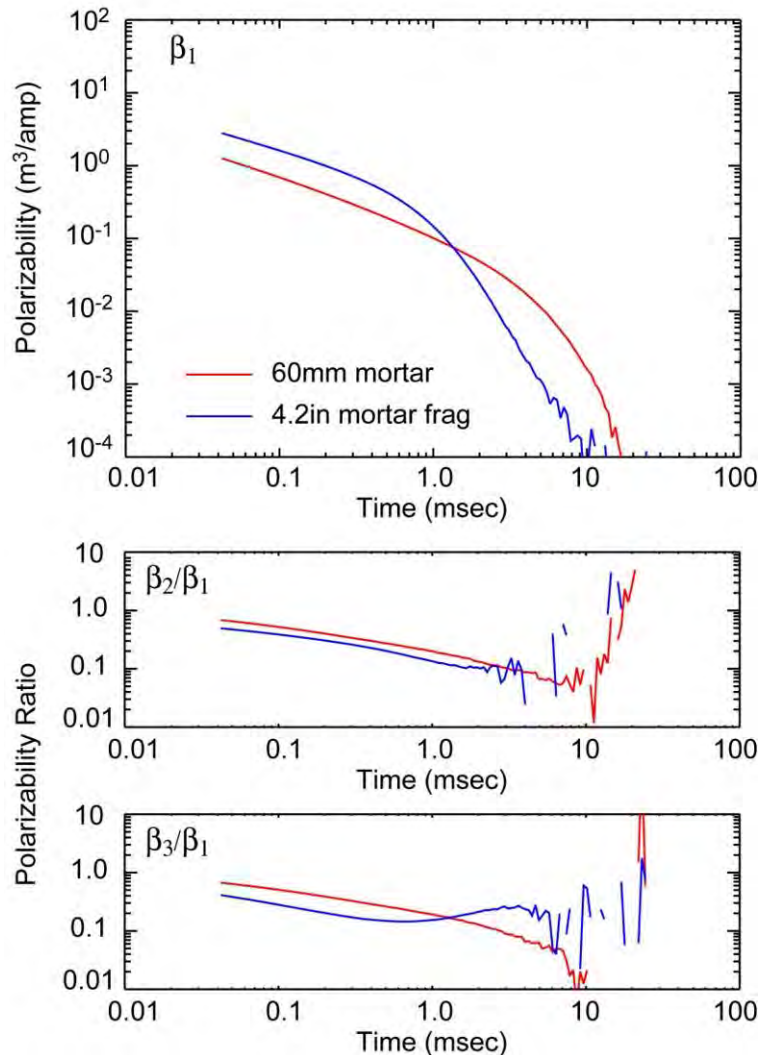
- ◆ Seed the area with sources
- ◆ Predict signals with forward model
- ◆ Find a linear combination that best match observed signal using sparse solution solver
- ◆ Add new seeds
- ◆ Iterate

Perform multi-dipole inversion on derived target locations

Stop by Poster #62 for more details



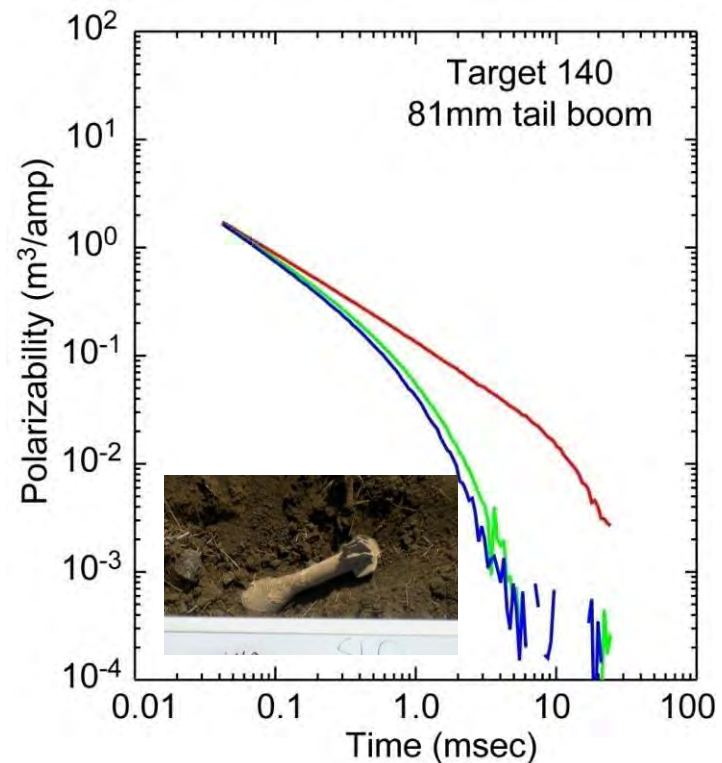
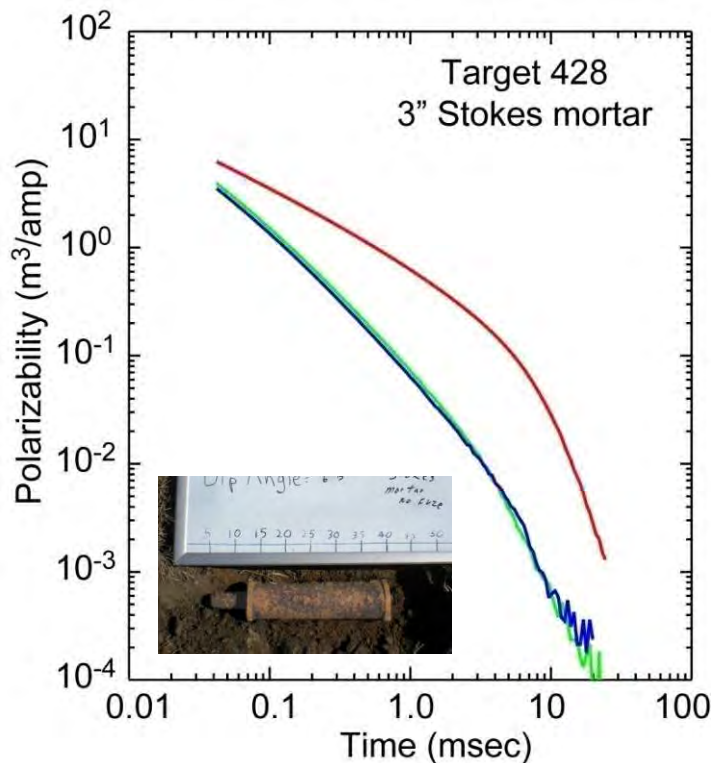
Classification Approach



- Compare unconstrained polarizabilities for the target under investigation to a signature library
- “Library match” metric
 1. Primary polarizability (β_1)
 2. Ratio secondary to primary (β_2/β_1)
 3. Ratio tertiary to primary (β_3/β_1)
- Decision boundary chosen to accommodate training data

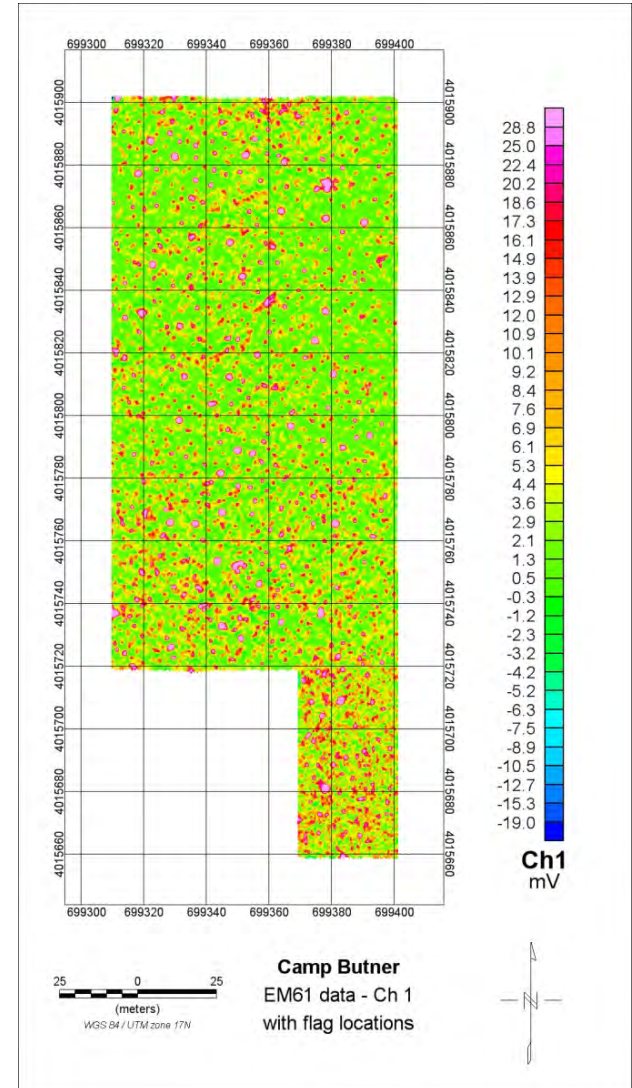
Axial Symmetry

- Targets with axially symmetric response that do not match expected munitions included in “can’t decide”
 - ◆ Hedge against unexpected munitions (e.g. 3” Stokes mortar)



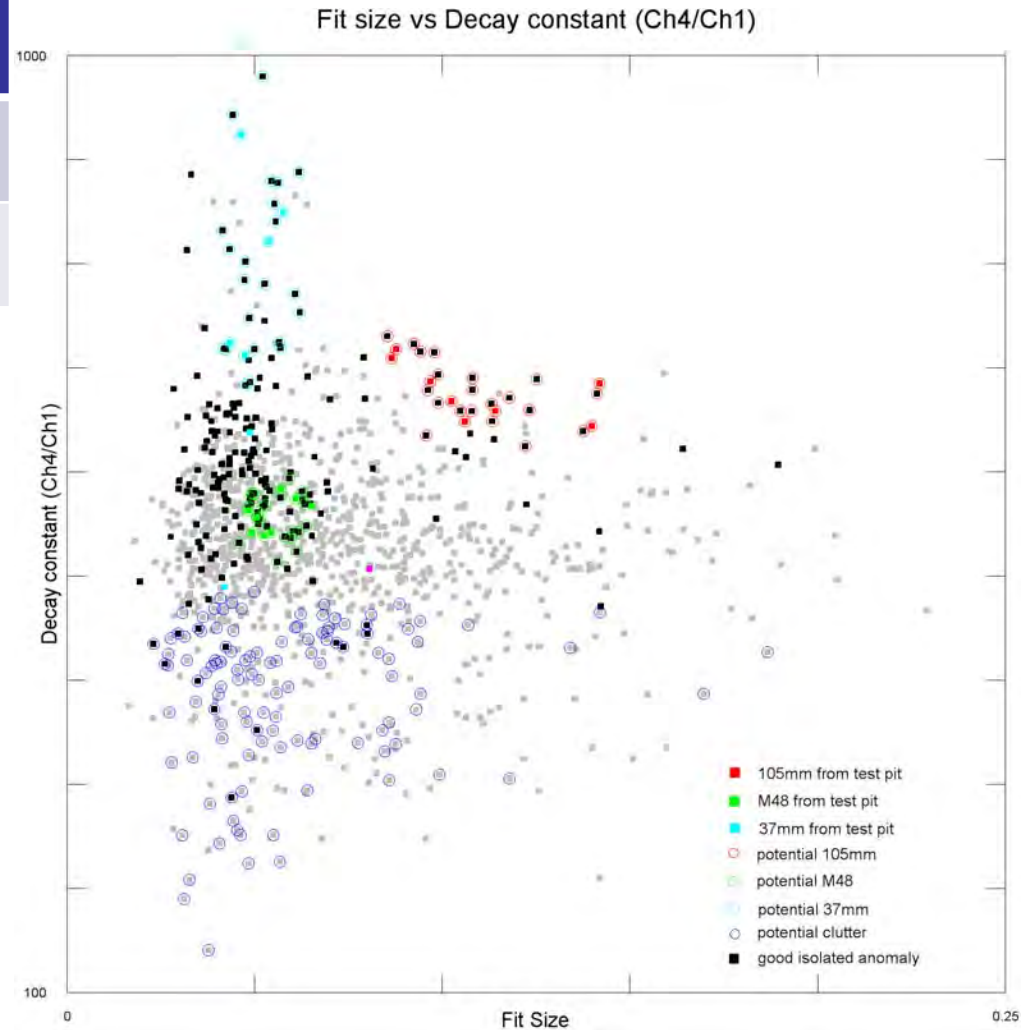
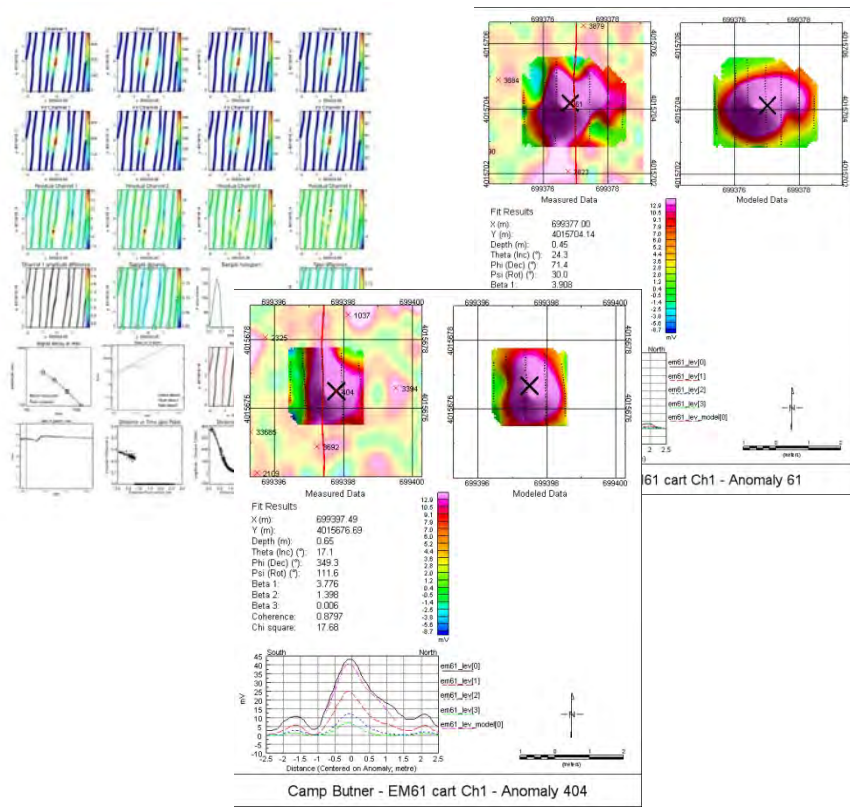
EM61 as pre-screener

- Lower coil only, four gates
- Unconstrained 3-polarization
- Identified high confidence
 - UXO → dig
 - Clutter → leave
- All others request cued data
- Classification based on
 - ◆ Size ($\sum \beta$ 1st time gate)
 - ◆ Measured decay
 - ◆ Screen on fit quality
 - ◆ Generalized likelihood ratio test to assign probabilities

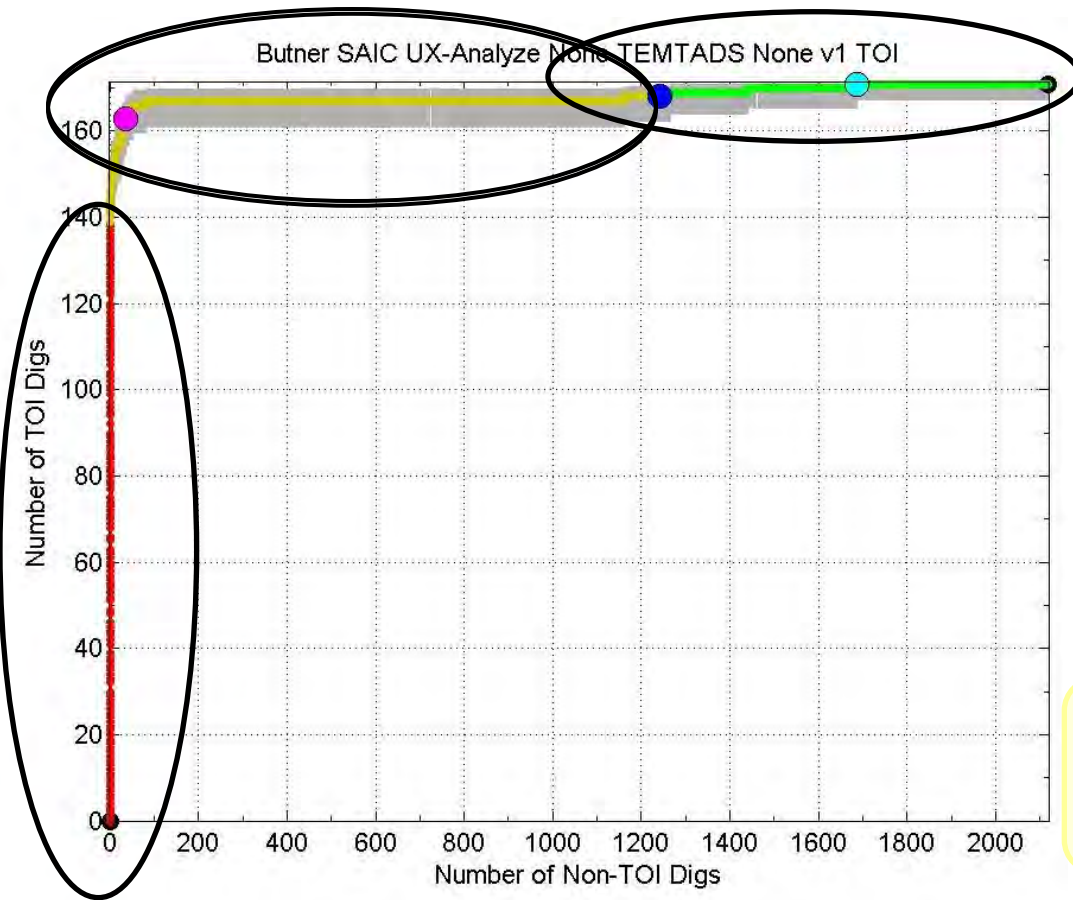


EM61 as pre-screener

	UXO	CLUTTER
Declared	68	251
Actual	59	249



Classification Performance



2,290 anomalies

- ◆ 0 training
- ◆ 0 can't analyze

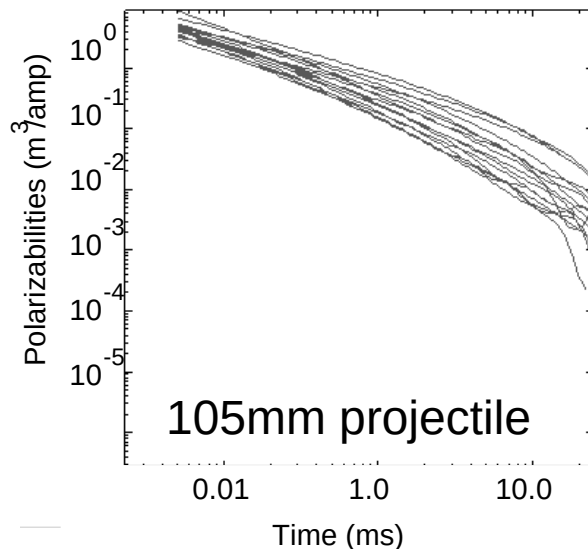
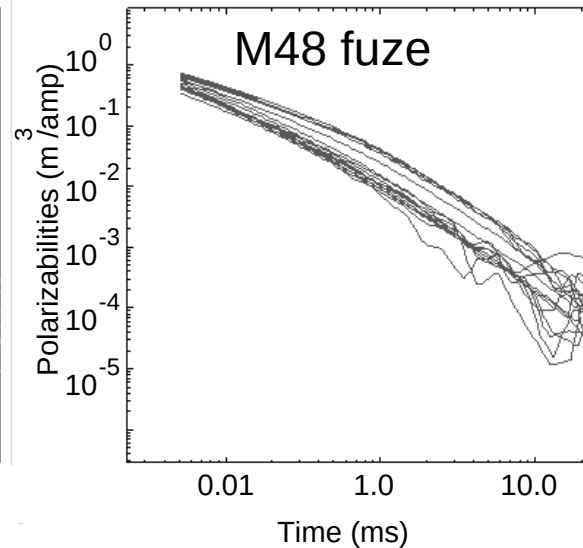
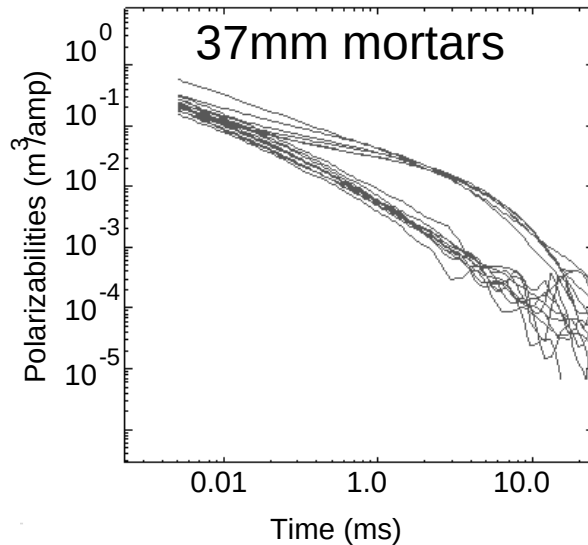
1,021 classified

- ◆ 139/142 munitions correctly classified (97.9%)
- ◆ 877/879 clutter correctly classified (99.8%)

1,269 can't decide

- ◆ 29 UXO, 1,240 clutter

Signature Variability



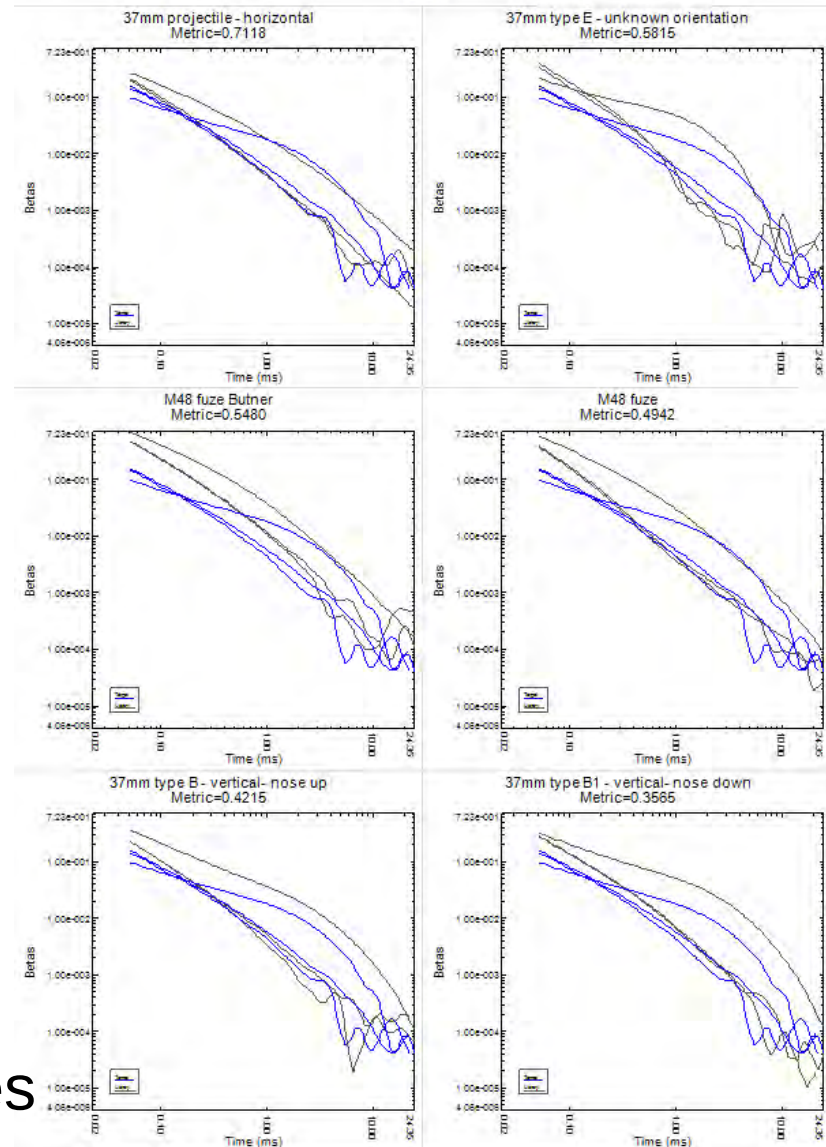
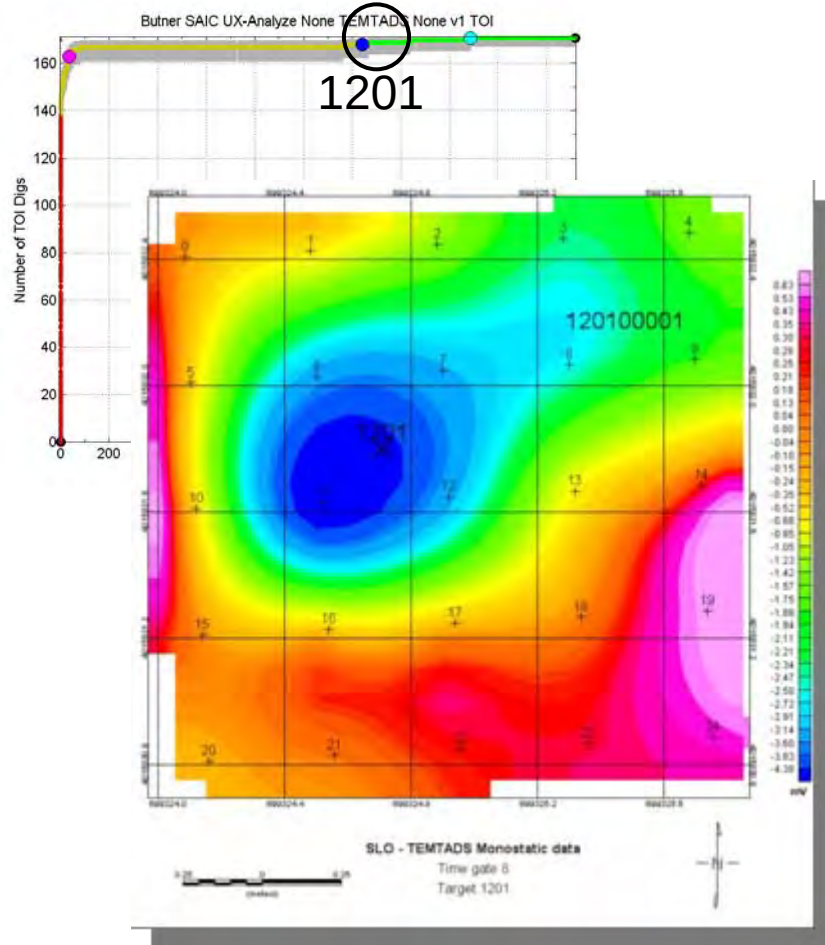
- Munitions in each class (37mm, M48, 105mm) are not identical
- Response curves can vary due to target condition: different model, fuze & tail boom present/absent, *etc.*

Correctly Classified as UXO

37mm	118
M48 fuze	24
105mm	26

Misclassified Munitions (1 of 3)

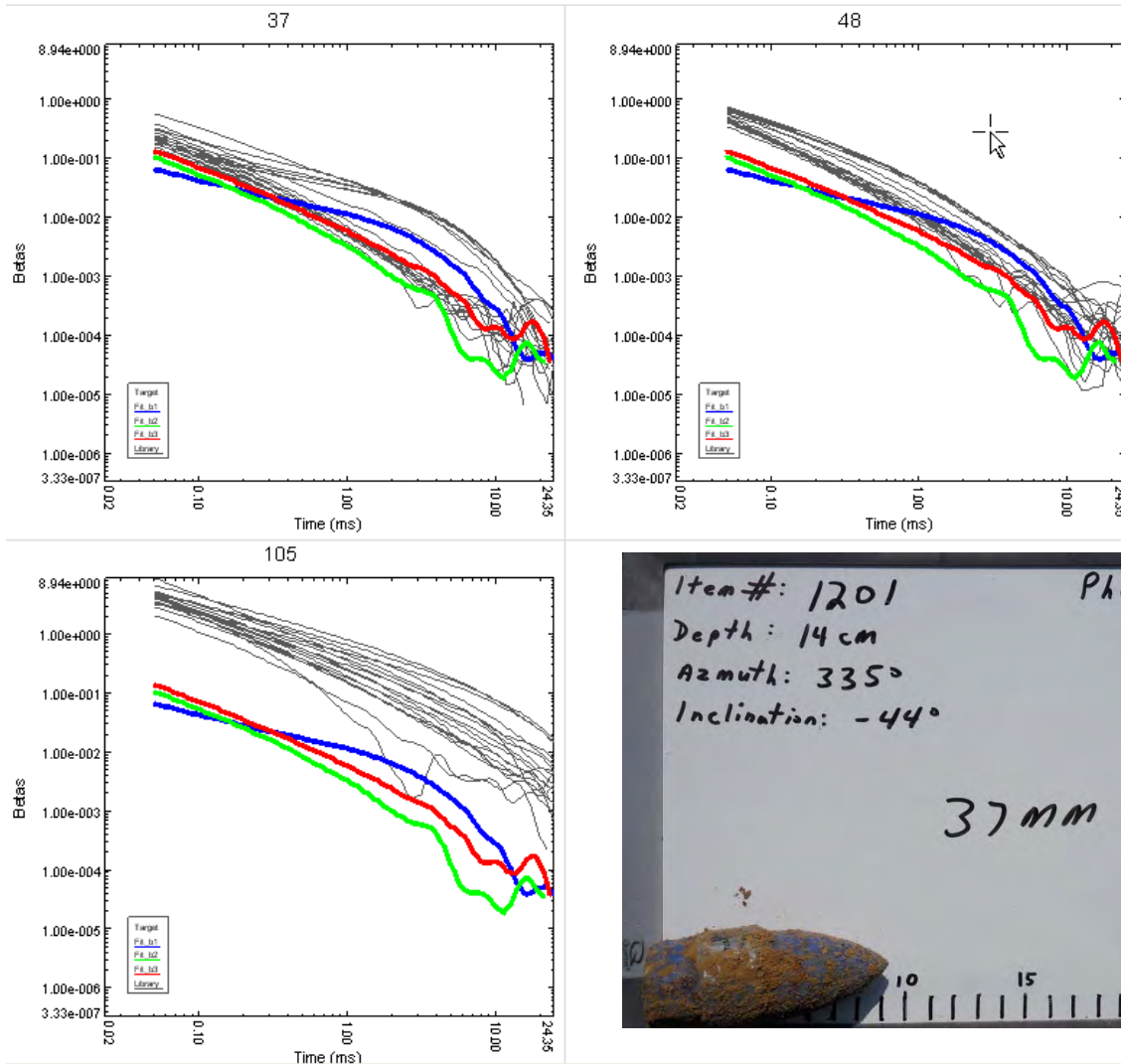
1201



Signature Comparison:
ID 1201 versus library signatures

Misclassified Munitions (1 of 3)

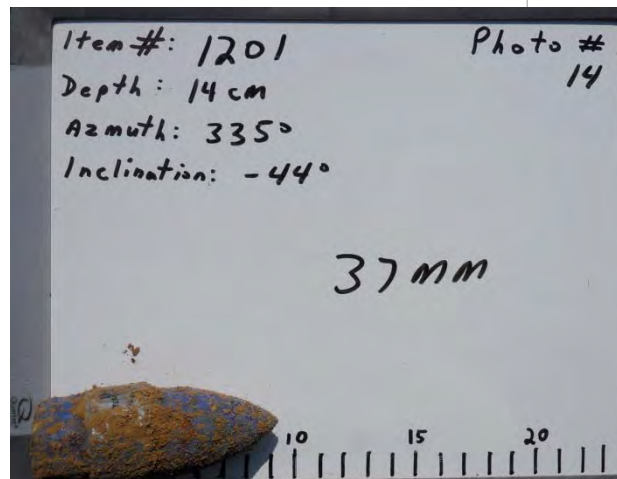
1201



Principal polarizability crosses the other two

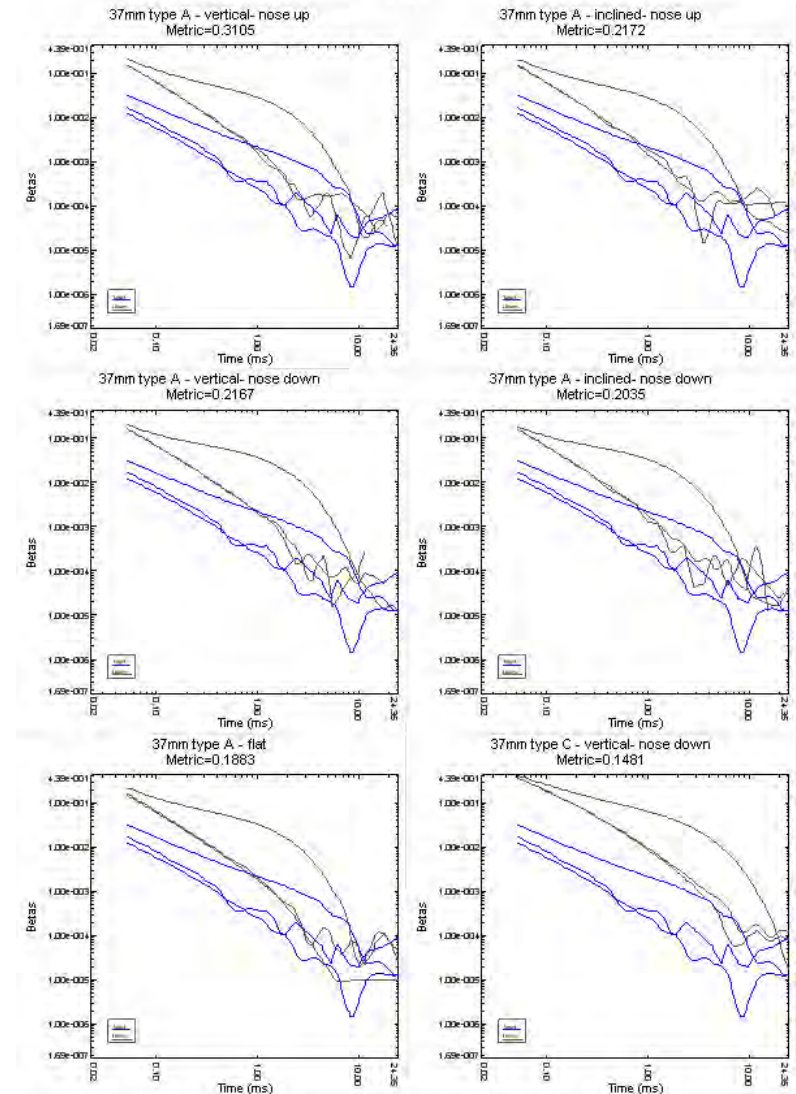
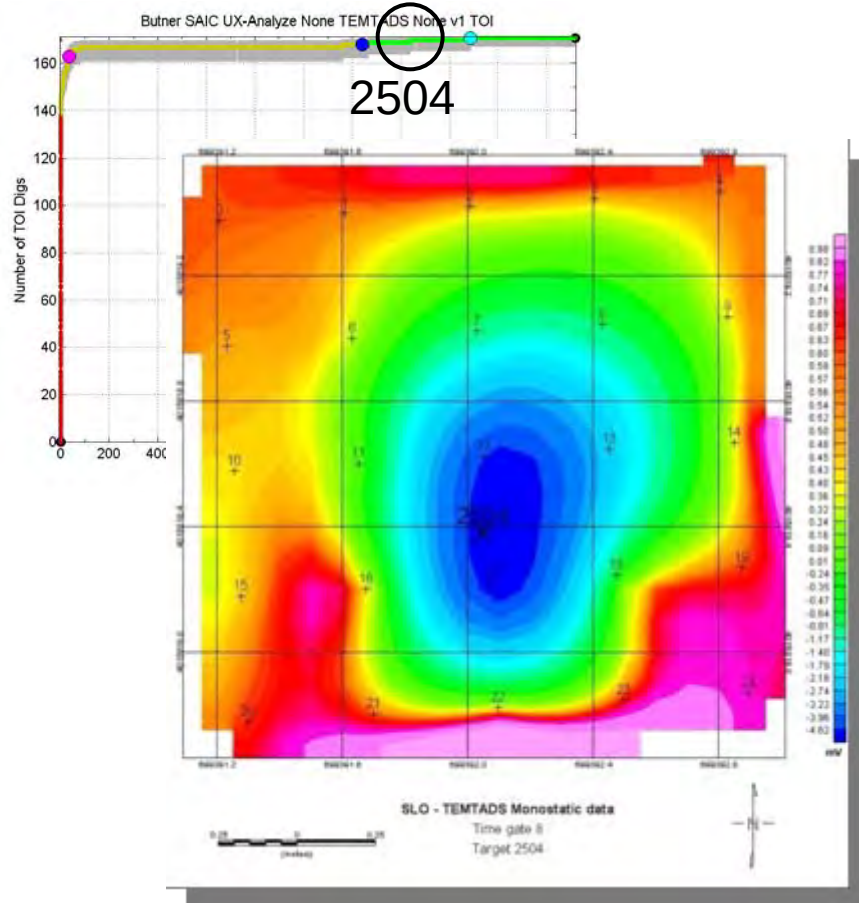
Not in our library

Symmetry metric based on polarizations 1 & 2 instead of 2 & 3



Misclassified Munitions (2 of 3)

2504



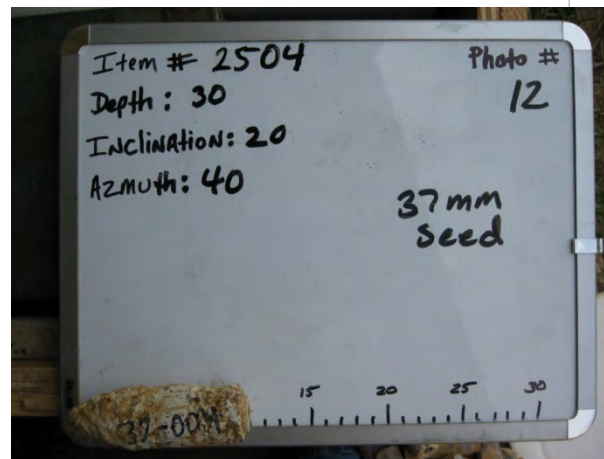
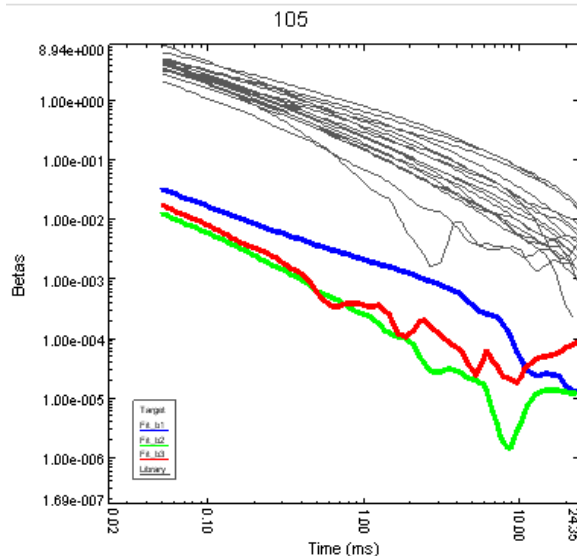
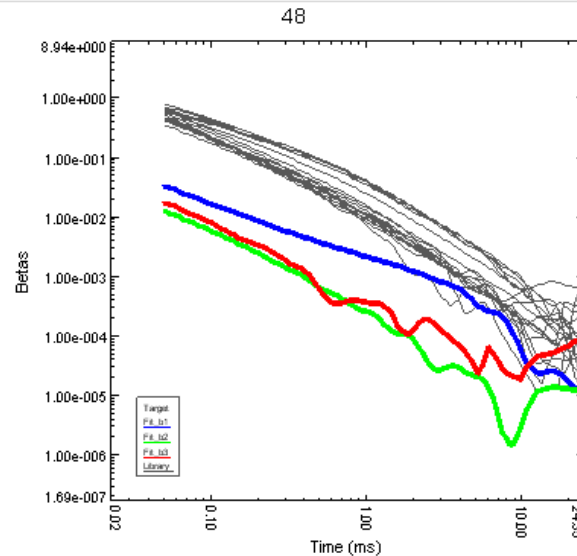
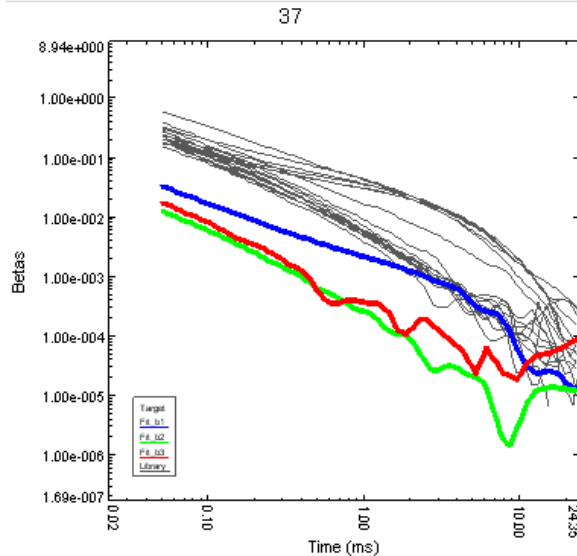
Signature Comparison:
ID 2504 versus library signatures

Misclassified Munitions (2 of 3)

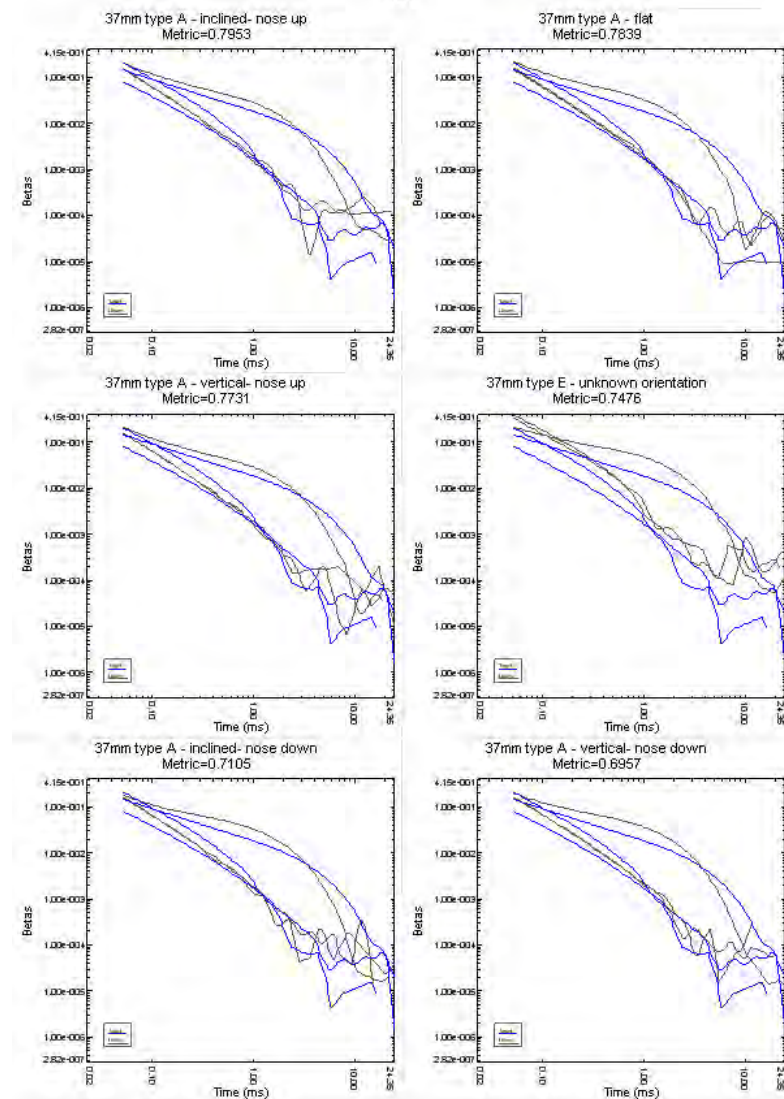
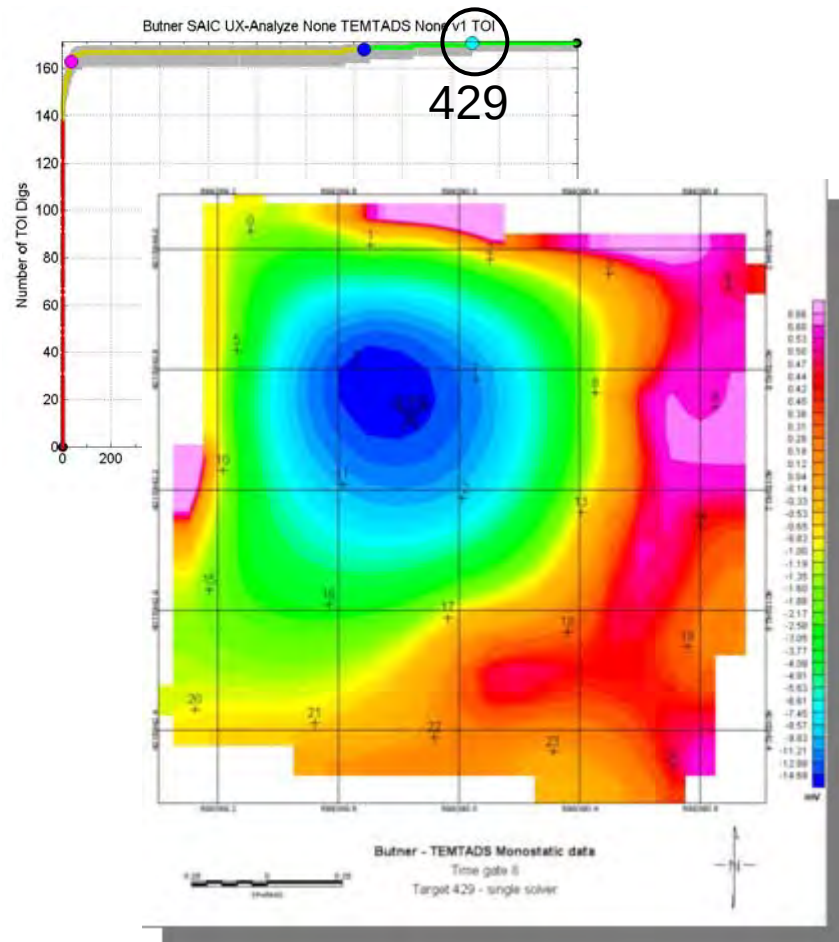
2504

Classified as clutter
based on size

Inverted depth and
polarizabilities too small



Misclassified Munitions (3 of 3)



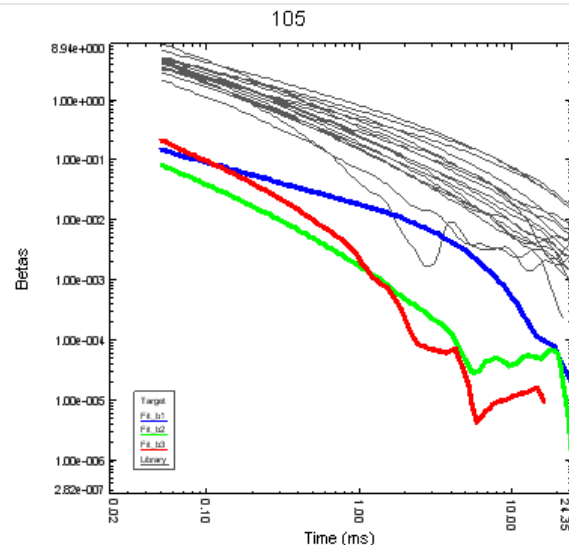
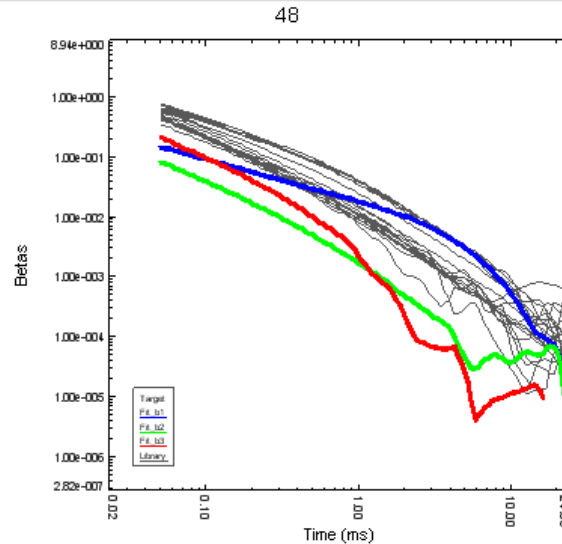
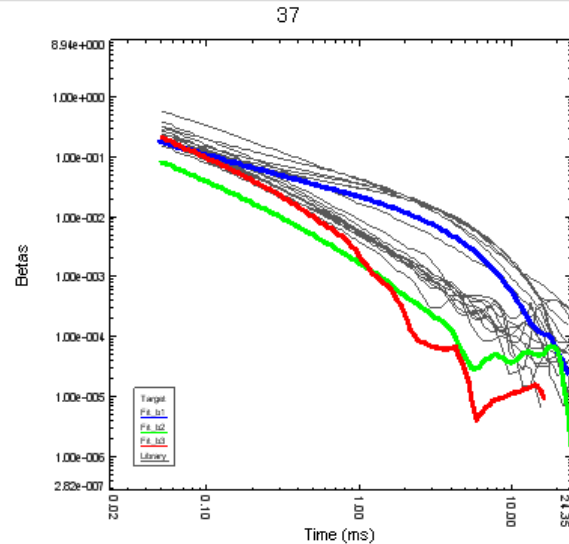
Signature Comparison:
ID 429 versus library signatures

Misclassified Munitions (3 of 3)

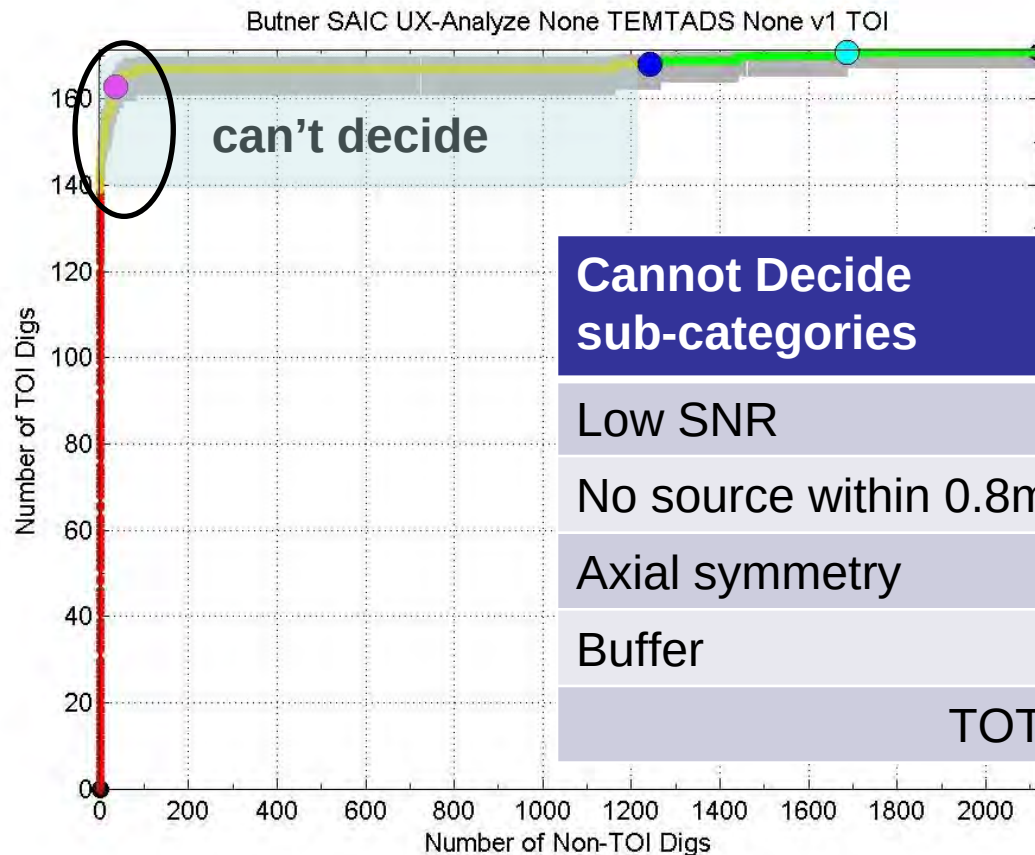
429

Decision metric of 0.80,
just below our threshold
of 0.81.

Decent signal strength
put it in the high
confidence clutter
category



"Can't Decide" Category



Cannot Decide sub-categories	Total Count	No. of UXO
Low SNR	141	1
No source within 0.8m	25	0
Axial symmetry	1059	8*
Buffer	44	20
TOTAL	1269	29

*modifying our UXO/clutter threshold and not hedging for unexpected munitions types (viz., axial symmetry) would have reduced the unnecessary digs by 951

Summary/Conclusions

Our attempt to conservatively pre-screen using EM61 data (inverted size & measured decay) resulted in two false negatives

Classification based on intrinsic polarizabilities is effective

The vast majority of UXO were readily classified

- ◆ 37mm showed the most variability and were the most difficult for us

Areas for classification performance improvement

- ◆ Low SNR targets – Longer stacks, more robust classifier
- ◆ Multiple targets – Adaptive array positioning, improved multi-target solvers
- ◆ Misclassified munitions – Consolidate and adopt program-wide best practices for recognizing and dealing with outliers

Analysis Interface

Modeling Parameters

Sensor type: TEMTADS

Database: MetalMapper
MetalMapper-Geometrics
TEMTADS

Subset database: Update

☐ Multiple object solver
☐ Multiple shots

Survey Database

Target Database

Parameters

* Name: IDF_TEMDATA_5.gdb

* Sensor channel: Data_lev

* Sensor height:

☒ Variable channel: Z
☐ Constant:

* Tx coil channel: Tx

* Rx coil channel: Rx

More

OK

Modeling Parameters

Sensor type: TEMTADS

Database: Chronological

Subset database: Update

☐ Multiple object solver
☐ Multiple shots

Survey Database

Target Database

Parameters

* Name: TARGET55.gdb

* Group: D0

* ID channel: ID

* Start ID: 983

* End ID: 983

* Mask channel: MASK

Starting depth channel:

More

OK

Modeling Parameters

Sensor type: TEMTADS

Database: Chronological

Subset database: Update

☐ Multiple object solver
☐ Multiple shots

Survey Database

Target Database

Parameters

Gates to fit:

☐ 0
☐ 1
☐ 2
☐ 3
☐ 4
☐ 5
☐ 6
☒ 7
☒ 8
☒ 9
☒ 10
☒ 11
☒ 12
☒ 13
☒ 14
☒ 15
☒ 16
☒ 17
☒ 18
☒ Simultaneous inverse

More

OK

Modeling Parameters

Sensor type: TEMTADS

Database: Chronological

Subset database: Update

☐ Multiple object solver
☐ Multiple shots

Survey Database

Target Database

Parameters

Coil Geometry

Tx coils array:

Enabled	Index	X	Y	Z	Yaw	Pitch
☒	0	-0.8	0.8	0	0	0
☒	1	-0.4	0.8	0	0	0
☒	2	0	0.8	0	0	0
☒	3	0.4	0.8	0	0	0
☒	4	0.8	0.8	0	0	0

Set

Factory Setting

Preview

Rx coils array:

Enabled	Index	X	Y	Z	Yaw	Pitch
☒	0	-0.8	0.8	0	0	0
☒	1	-0.4	0.8	0	0	0
☒	2	0	0.8	0	0	0
☒	3	0.4	0.8	0	0	0
☒	4	0.8	0.8	0	0	0

Set

Factory Setting

Preview

More

OK

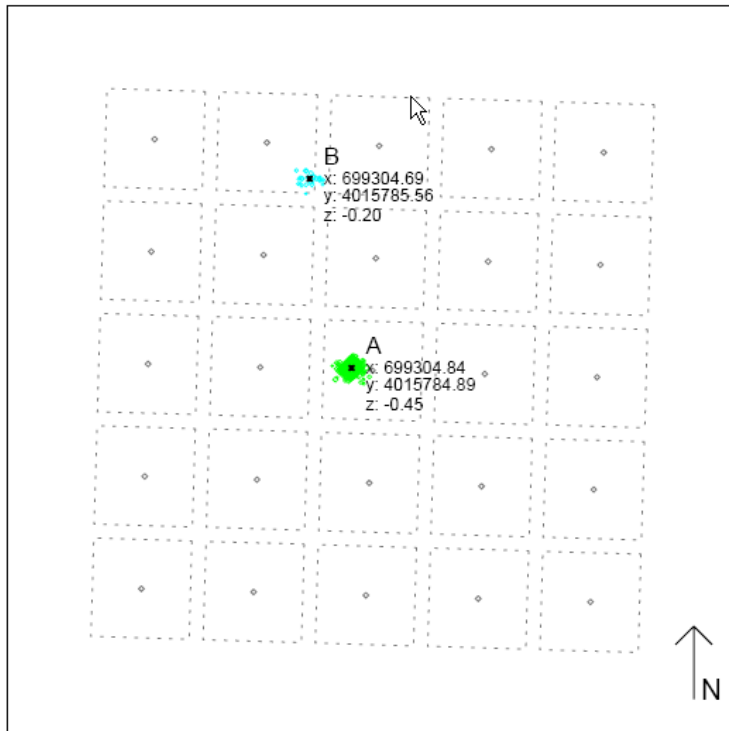
Cancel

Solver Documentation (*.pdf)

NRL TEM array

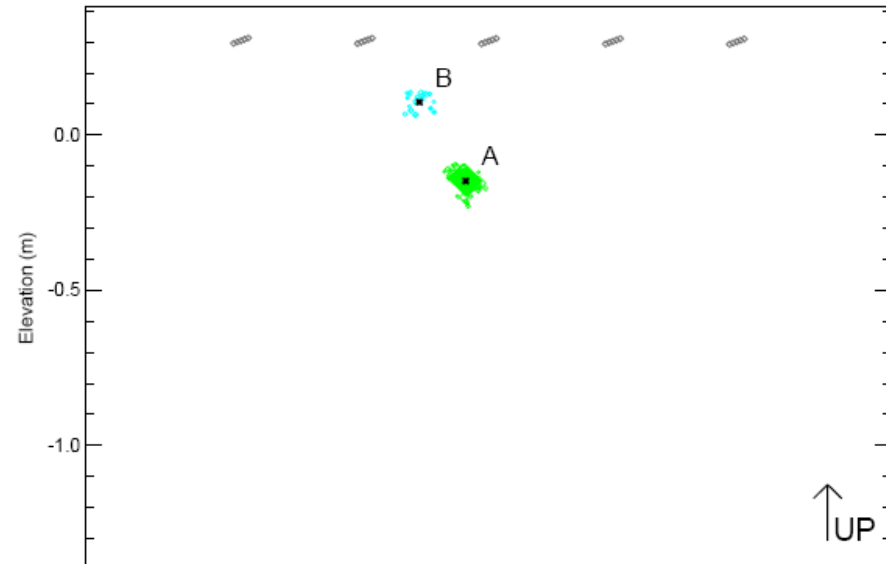
Number of targets: 2

Plan View

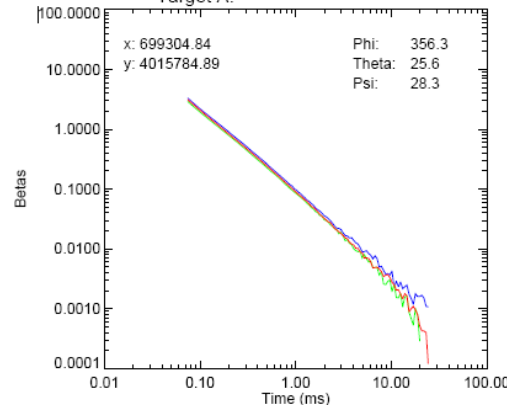


*Archive Documentation for
each anomaly processed*

Elevation View



Target A.



Target B.

