TETRA TECH

Measurement Uncertainty in Predicting Diameter from Polarizabilities during Anomaly Resolution

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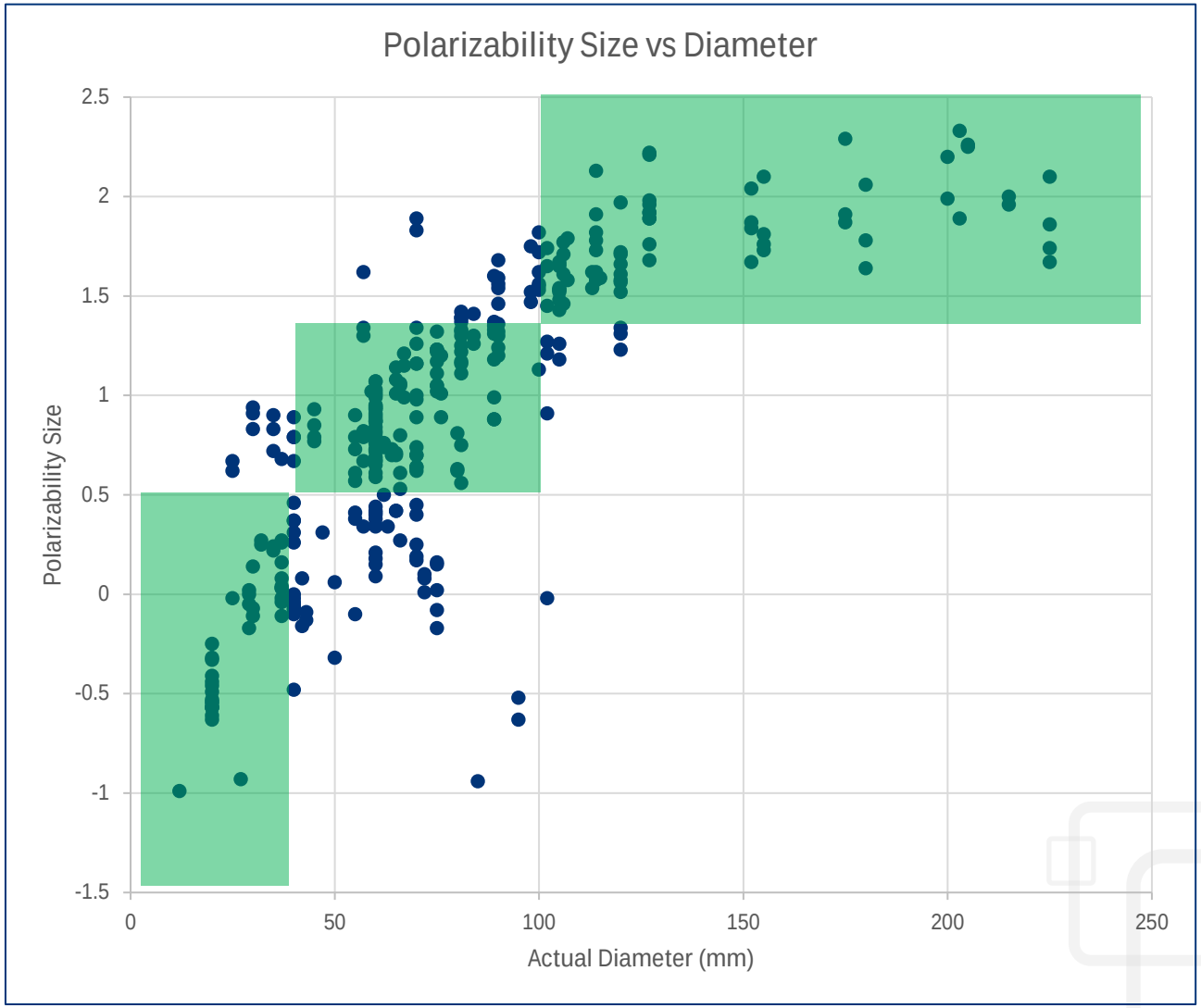
SAGEEP 2025

Objectives

- Determine the reliable limits for predicting source size from polarizability matches
- Highlight some limits on predicting source parameters from polarizability curve interpretation
- Determine the root cause of any discrepancies
- Communicate those limits to avoid disagreements

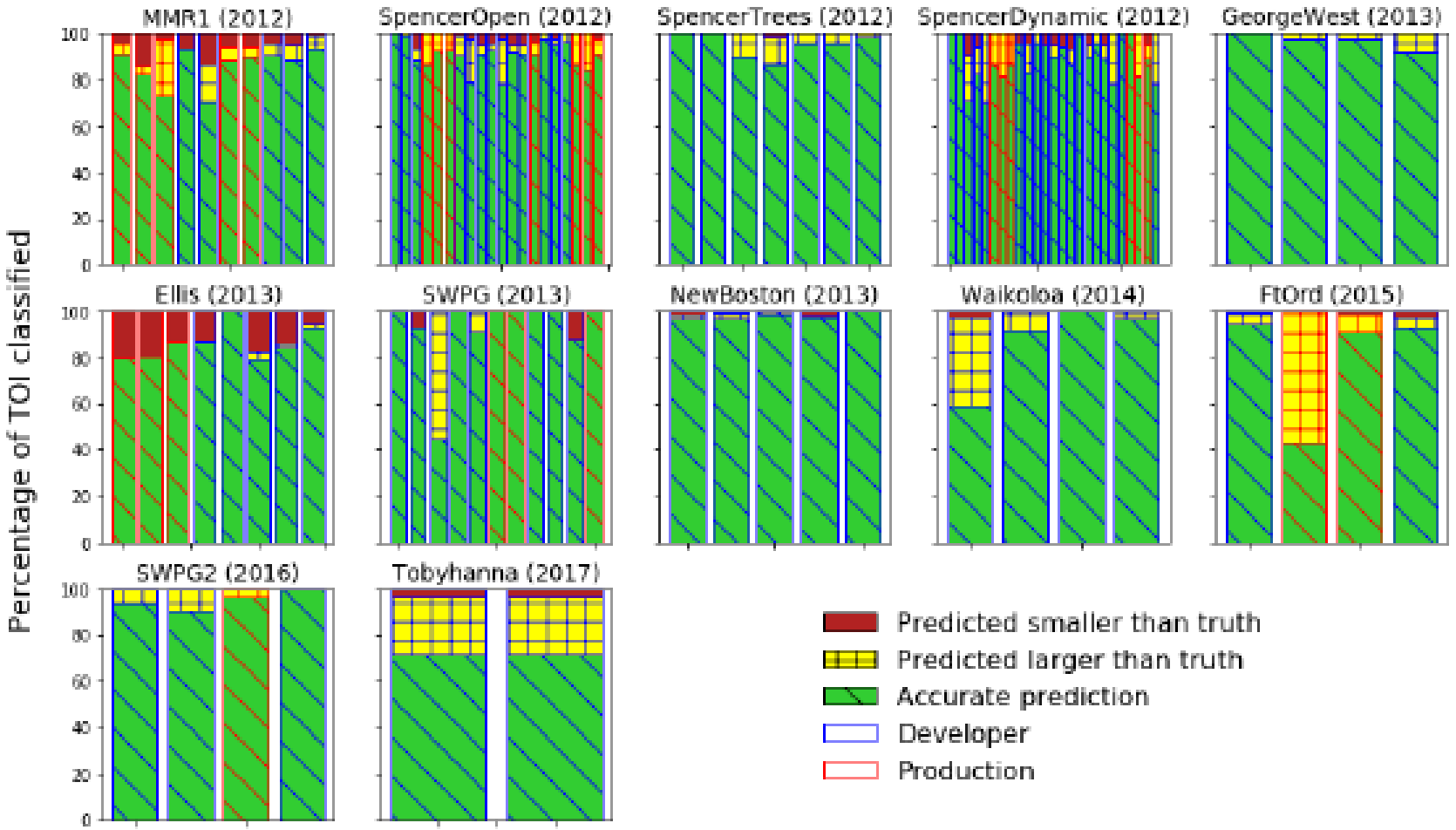
Polarizability Size Metric

- UX-Analyze uses polarizability size rather than diameter size
- Divided into bins at 40mm and 100mm
- Diameter for a given pol size is roughly +/-30mm
- 32% failure rate
- 60mm M5 mortar may be Small or Medium depending on orientation



Diameter Size Metrics

- Early ESTCP tests achieved 90% correlation
- Used 50mm and 100mm as dividing line between bins
- But inconsistent quality, variable thresholds, different libraries

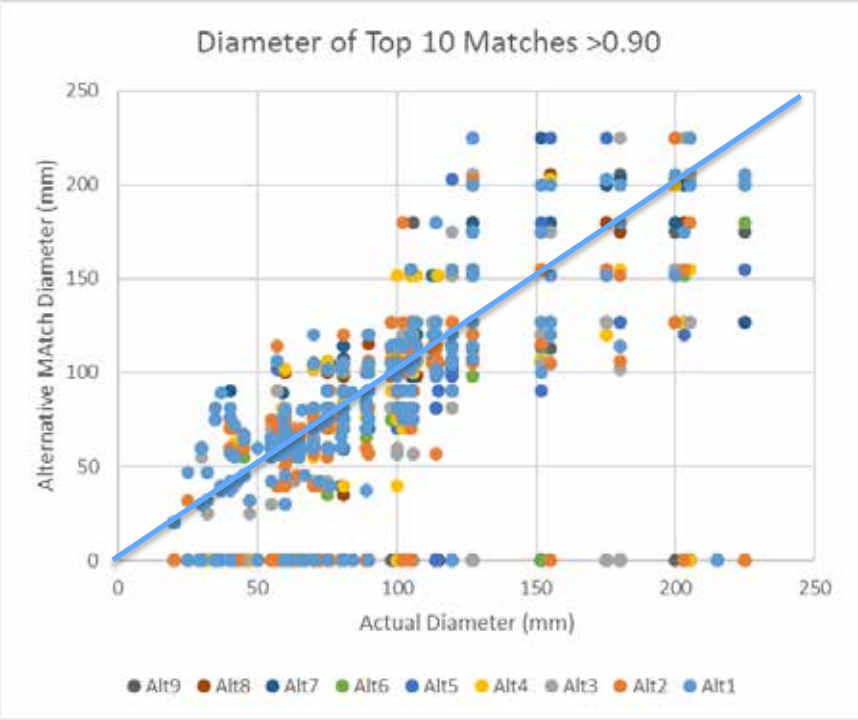


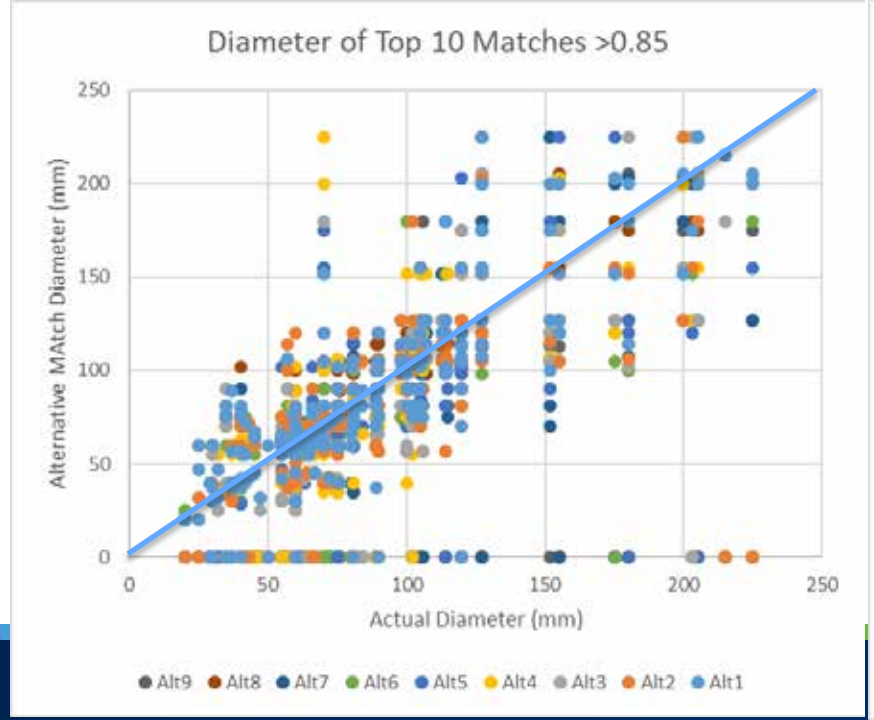
Methodology

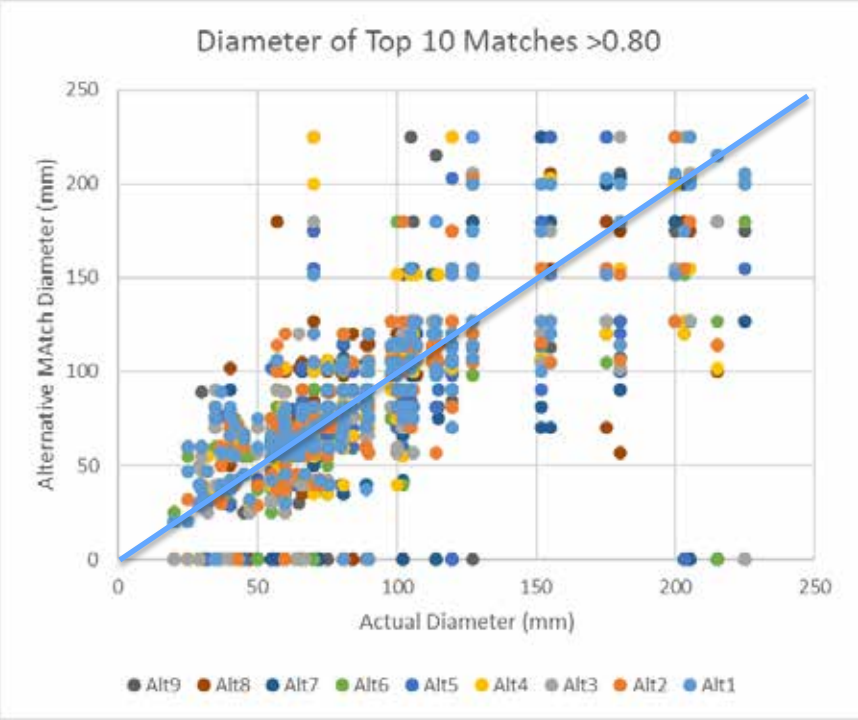
- Repeat this test using DoD test stand measurements
- Self-match the DoD Library items to each other and compare the original diameter to the diameter of the matching item
- This is near perfect data, if we can’t get this to meet the MQO then there’s something wrong with the MQO
- Test different match metrics
- Examine the correlation for trends
- Apply various size matching approaches to determine how many fail

Results

- All of these targets pass the metric for a match to the original pols
- Correlation decreases as Match decreases
- Even less correlation with larger targets

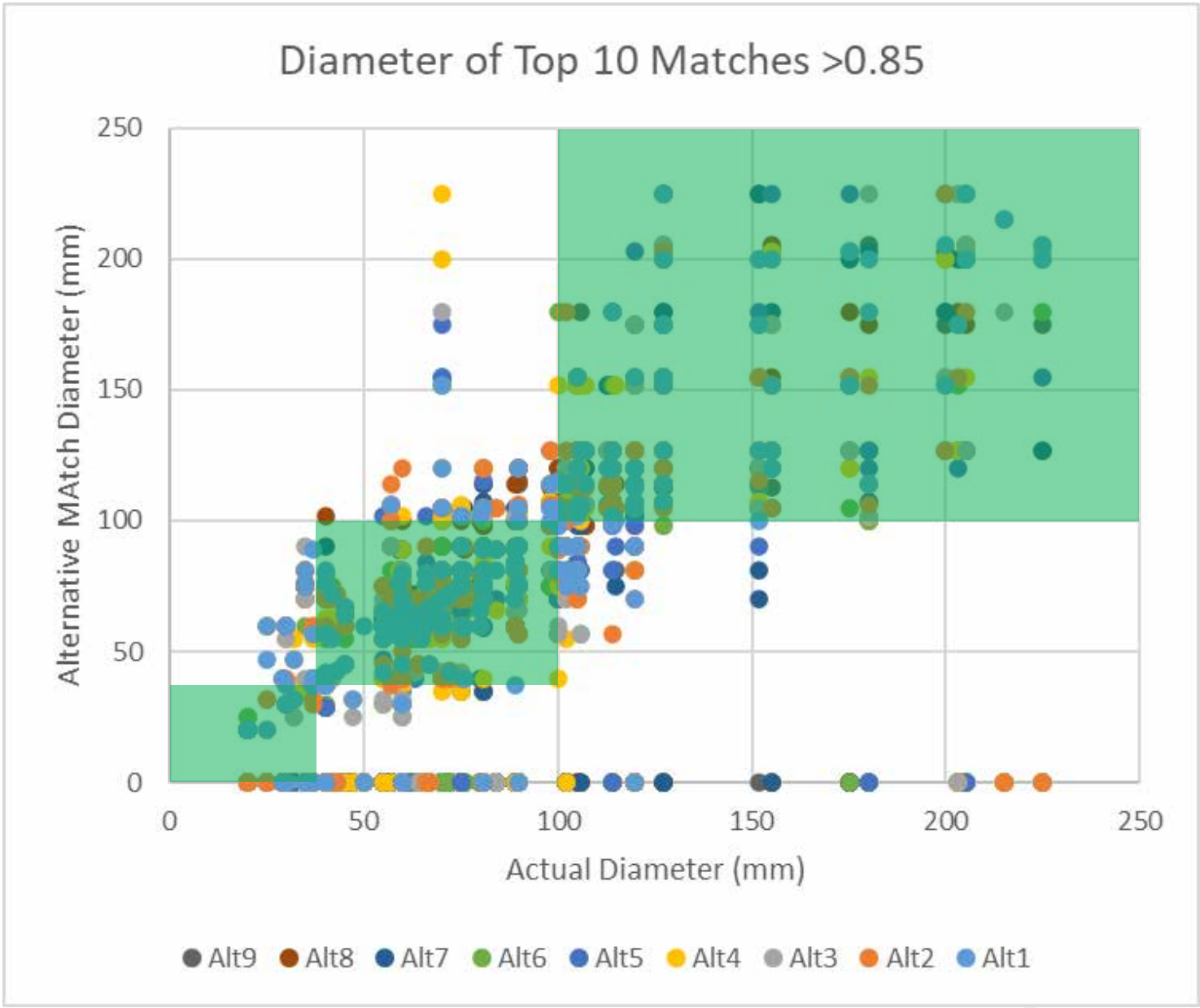






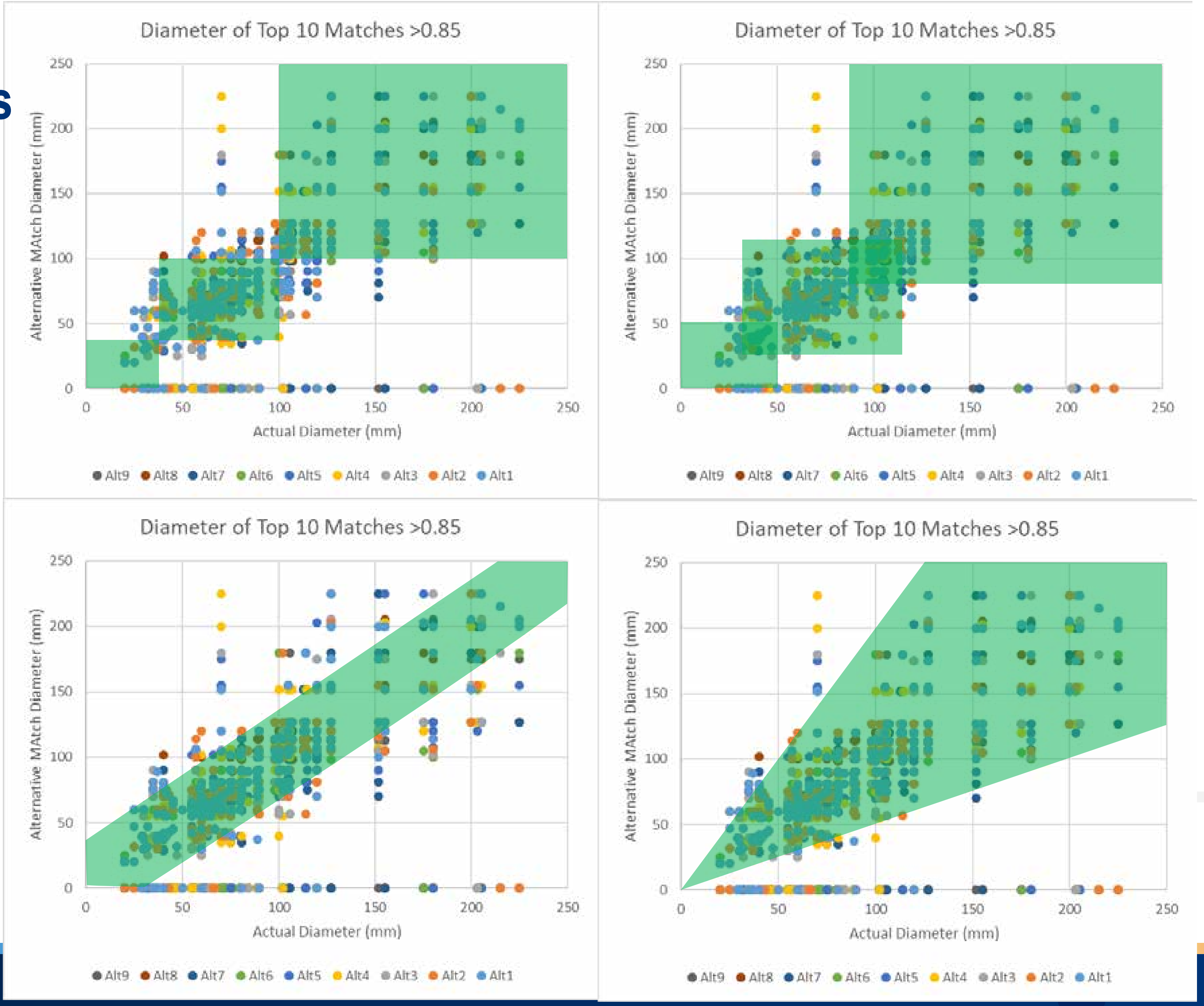
Default Approach

- Fixed size bins
  - § S 0-40mm
  - § M 40-100mm
  - § L 100-250mm
- At 0.85 match metric success rate with v1.1 Library data is 81% (19% nonconformance)



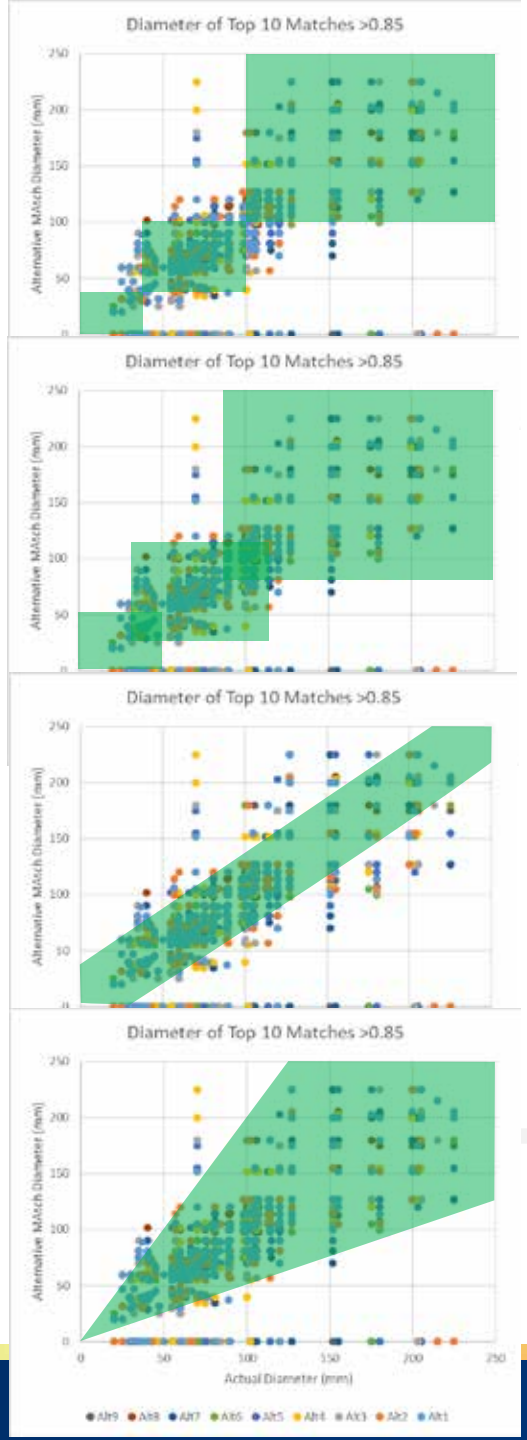
Alternate Approaches

- Fixed bins
  19% failure
- 20mm overlap
  4% failure
- +/-30mm
  17% failure
- 50%-200%
  3% failure



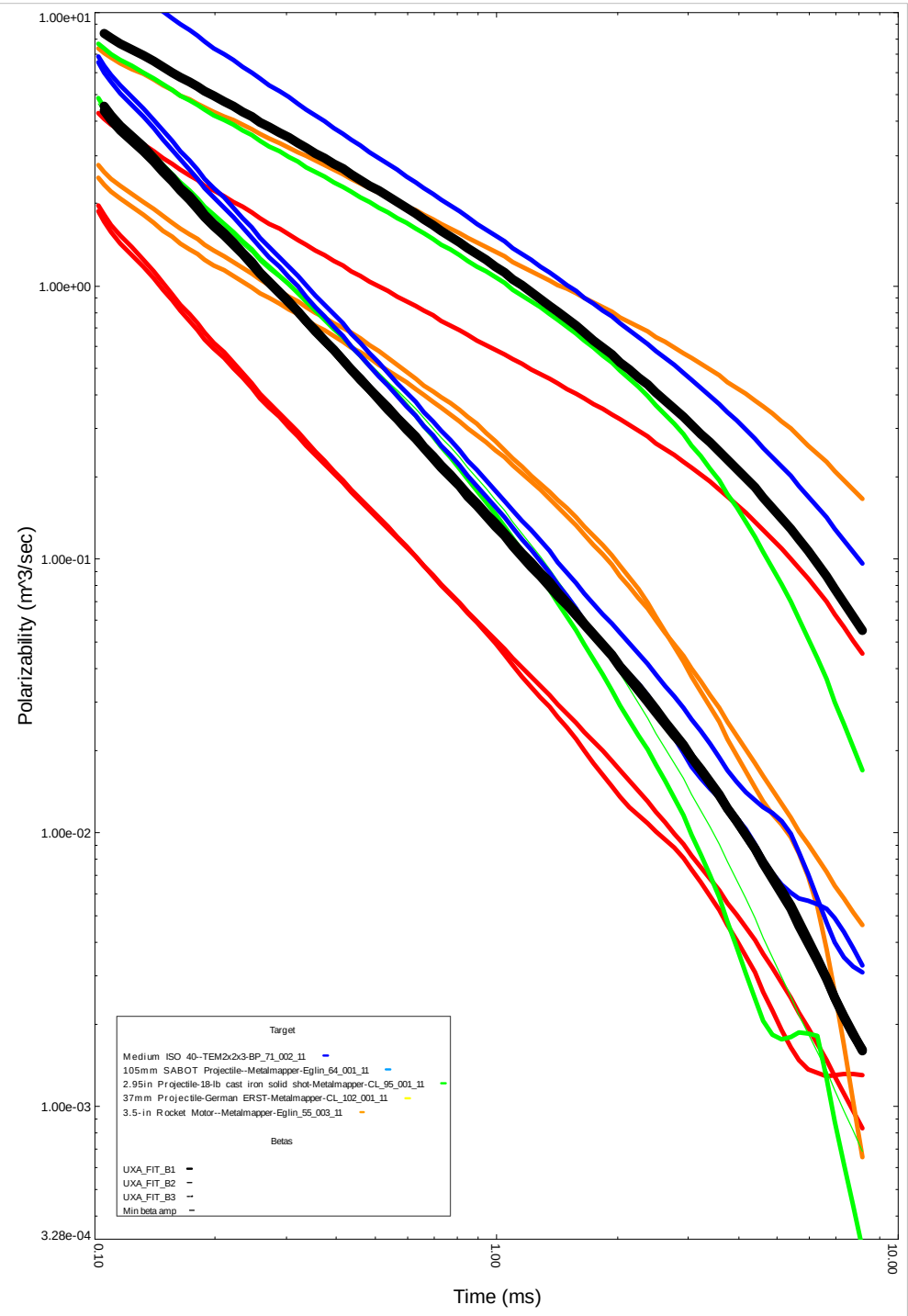
Alternate Approaches

- Fixed bins
  - § Shifting boundary lines doesn't really improve anything
  - § What you gain on one bin you lose on another
- Overlapping bins
  - § Overlap produces very loose tolerances, SM bin (predicted 30mm-50mm) extends from 0mm-110mm of source diameter
- +/-30mm
  - § Simpler to implement but failures increase with target size
  - § Improved failure rate in small targets only
- 50%-200%
  - § Simple to implement
  - § Consistent improvement across all size ranges



Example – MISO40

TOI	Match	Orient	Diam	Pol Color
MISO40	1.00	H	59mm	**Black**
76mm HEAT	1.00	V-U	76mm	Not shown
MISO80	0.96	H	60mm	Not shown
18-lb solid shot	0.95	V-U	75mm	**Blue**
81mm projectile	0.94	V-U	81mm	Not shown
2.75in rocket WH	0.93	V-D	70mm	Not shown
AP landmine	0.92	V-U	65mm	Not shown
3.5in rocket motor	0.91	H	89mm*/53mm**	**Green**
81mm mortar	0.91	V-D	81mm	Not shown
3in mortar	0.88	V-D	81mm	Not shown
18-lb solid shot	0.87	H	75mm	Not shown
105mm Sabot	0.86	H	35mm*/105mm**	**Orange**
3.5in rocket	0.86	V-D	89mm	Not shown
3.5in rocket motor	0.84	V-U	89mm*/53mm**	Not shown
81mm mortar	0.83	H	81mm	Not shown
37mm projectile	0.81	H	37mm	**Red**




1.00


1.00
654


0.96


0.95


0.94


0.93


0.92


0.91


0.91


0.88


0.87


0.86


0.84

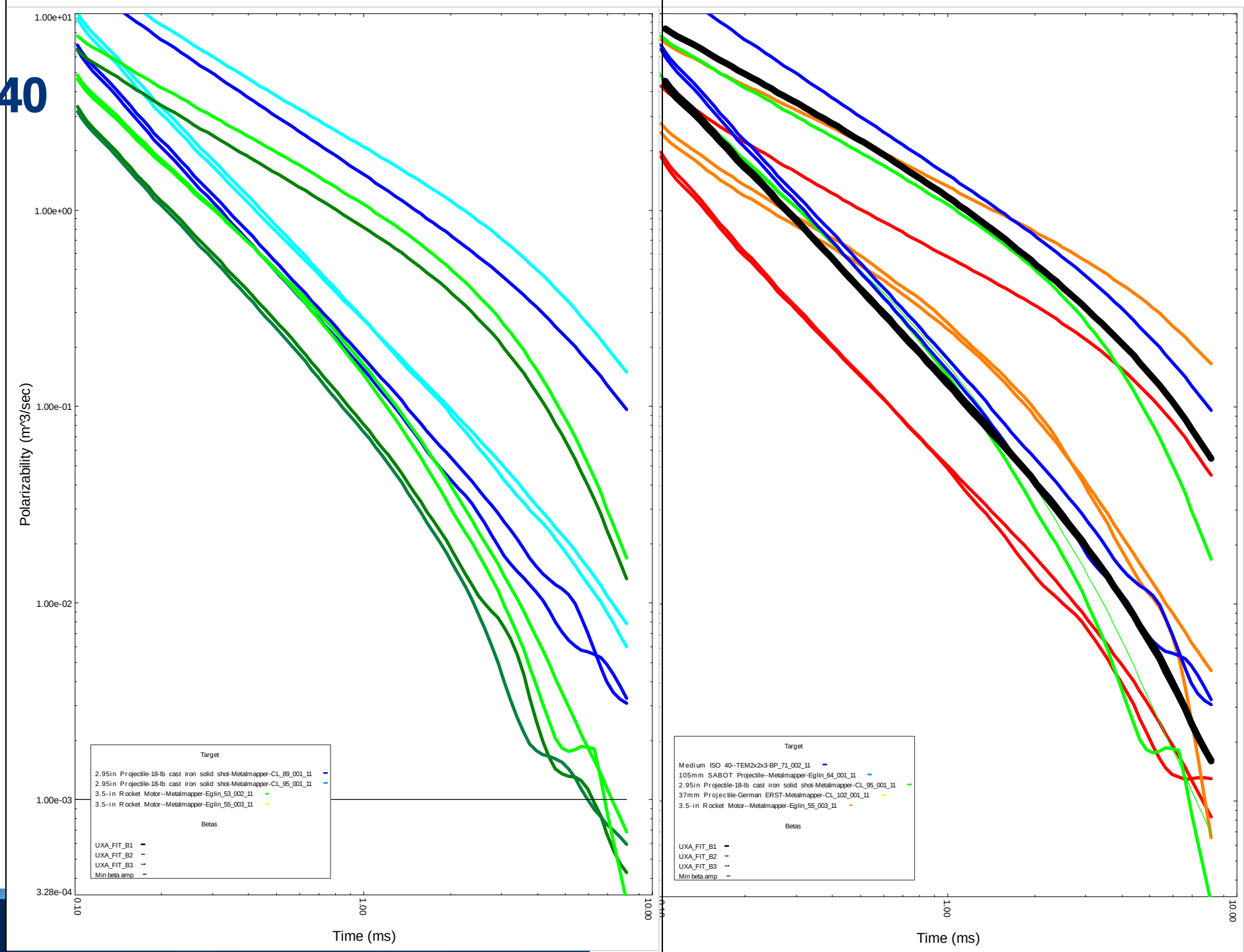

0.83


0.81

0.86

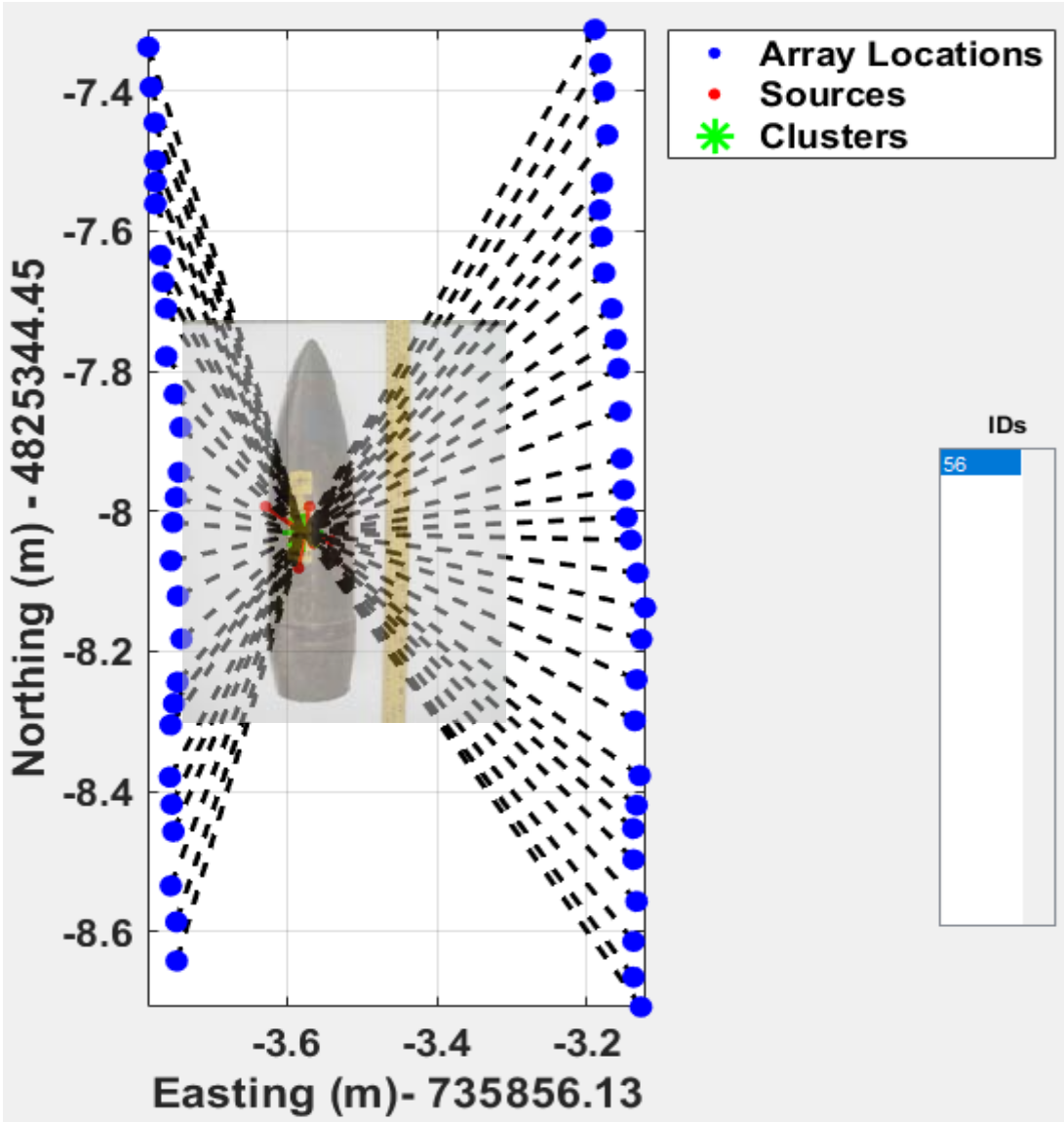
Example – MISO40

- Differences in pols on right are not necessarily diagnostic of diam
- Difference in pols on left are extrinsic
- Two identical items in different orientations, both pass the match metric



Root Cause

- Sensors do not measure diameter, they measure EM response to stimulus
- Inversion does not measure diameter, it assumes the source is a dipole
- The more the target deviates from a dipole, the more the assumption is invalid, even if the fit and match meet the predefined metrics
- Classic spherical cow problem



Conclusion

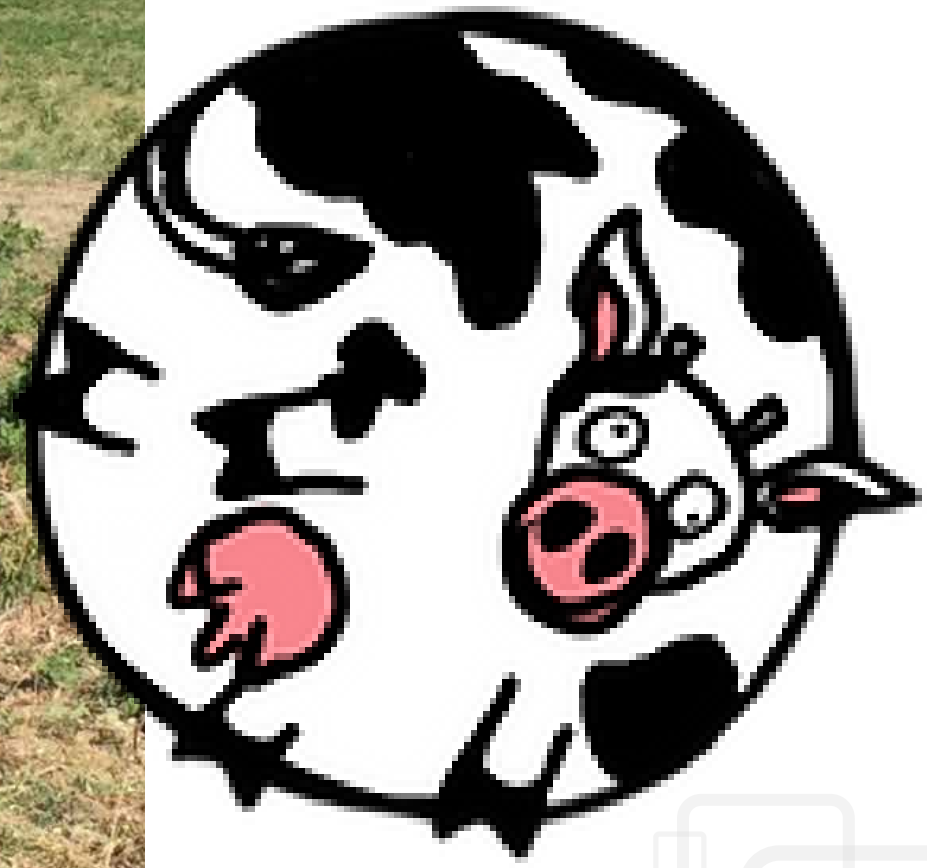
- Polarizabilities are affected by more than just target size and shape, including some extrinsic properties
- Extrinsic properties may have an equal or greater impact on polarizability than size/shape, even when passing fit and match metrics
- The only intrinsic property measured by inversion is electromagnetic induction, size and shape are second order estimates
- Diameter estimates come with large error bars
- A 50%-200% size metric is recommended to reflect the level of accuracy that can be supported by test stand data

Corrective Actions

- As an industry we need to be more transparent about how AGC works

- Pols are a function of intrinsic properties
  (*if you ignore the effect of extrinsic properties)
- Pols are a function of the source size/shape/thickness
  (*plus other things, as long as it's not too complex, or too large, or too shallow)
- Pols can make predictions about the source diameter
  (*within 50%-200% error for test stand data)

Thank you



REALITY PHYSICS