Value and Use of Simple Statistical Techniques in Multibeam Sonar Performance Analysis

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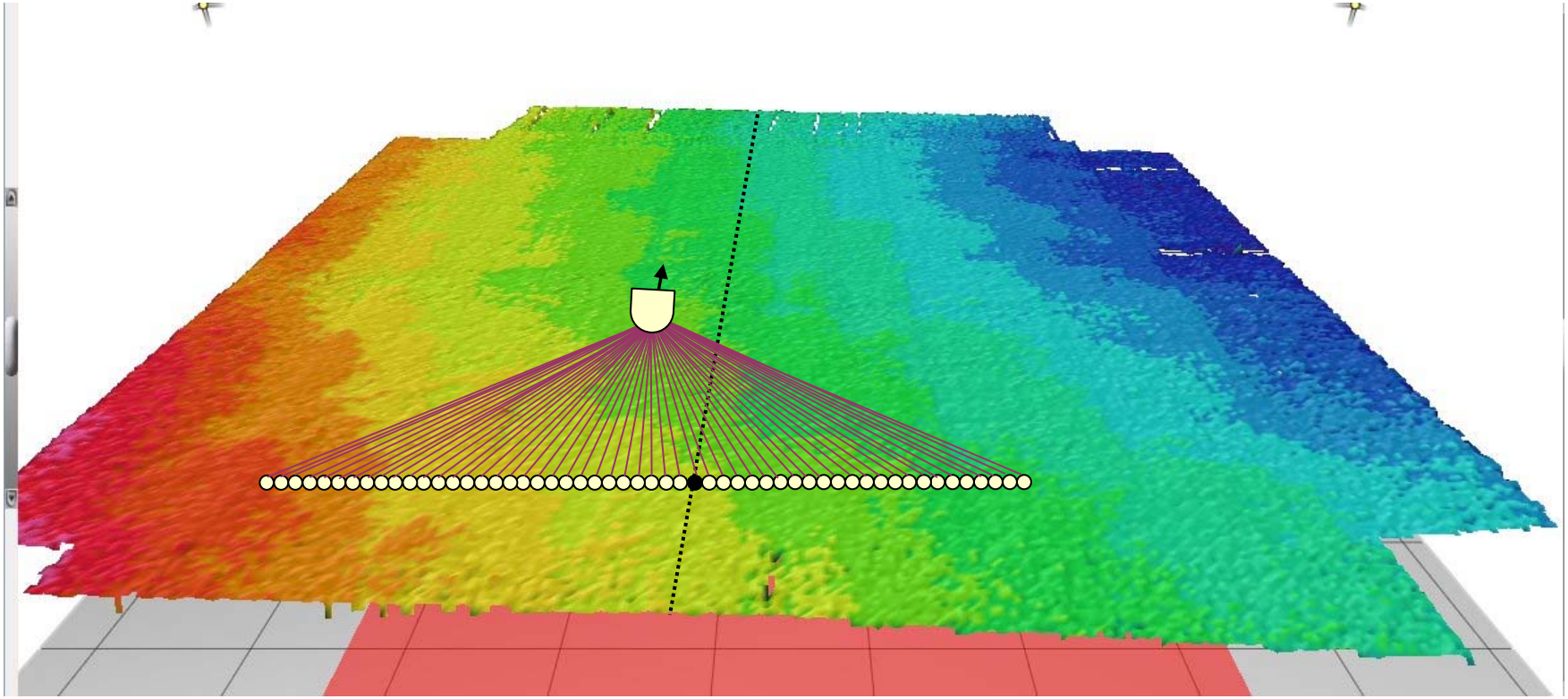
Beam Statistics Purpose

- Used for evaluating multibeam sonars
  - –Beam-wise characterization
    - •Artifact detection
    - •Across track trends
  - –Overall performance
    - •Contractor specs
    - •IHO specs
    - •Other requirements

Beam Statistics Process

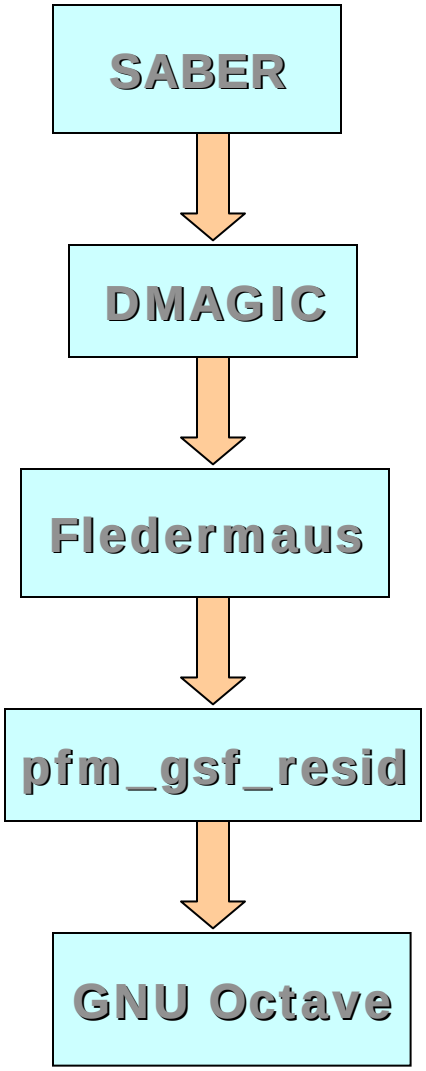
- **Create Reference Surface**
  - Run series of parallel lines
  - Overlap
  - Apply reducers
- **Generate beam statistics**
  - Run test lines over surface
  - Open swath width
  - Apply reducers
  - Execute beam statistics program

Lines Run Over Reference Surface



Each beam's depth is tracked across the surface

Data Processing for Beam Statistics



- Swath Editor
- Nav Editor
- Reducers
- Cutoff angle

- Grid files
- Cell size

- Filter grids
- Further edits

- Generate beam statistics

- Generate beam statistics plots

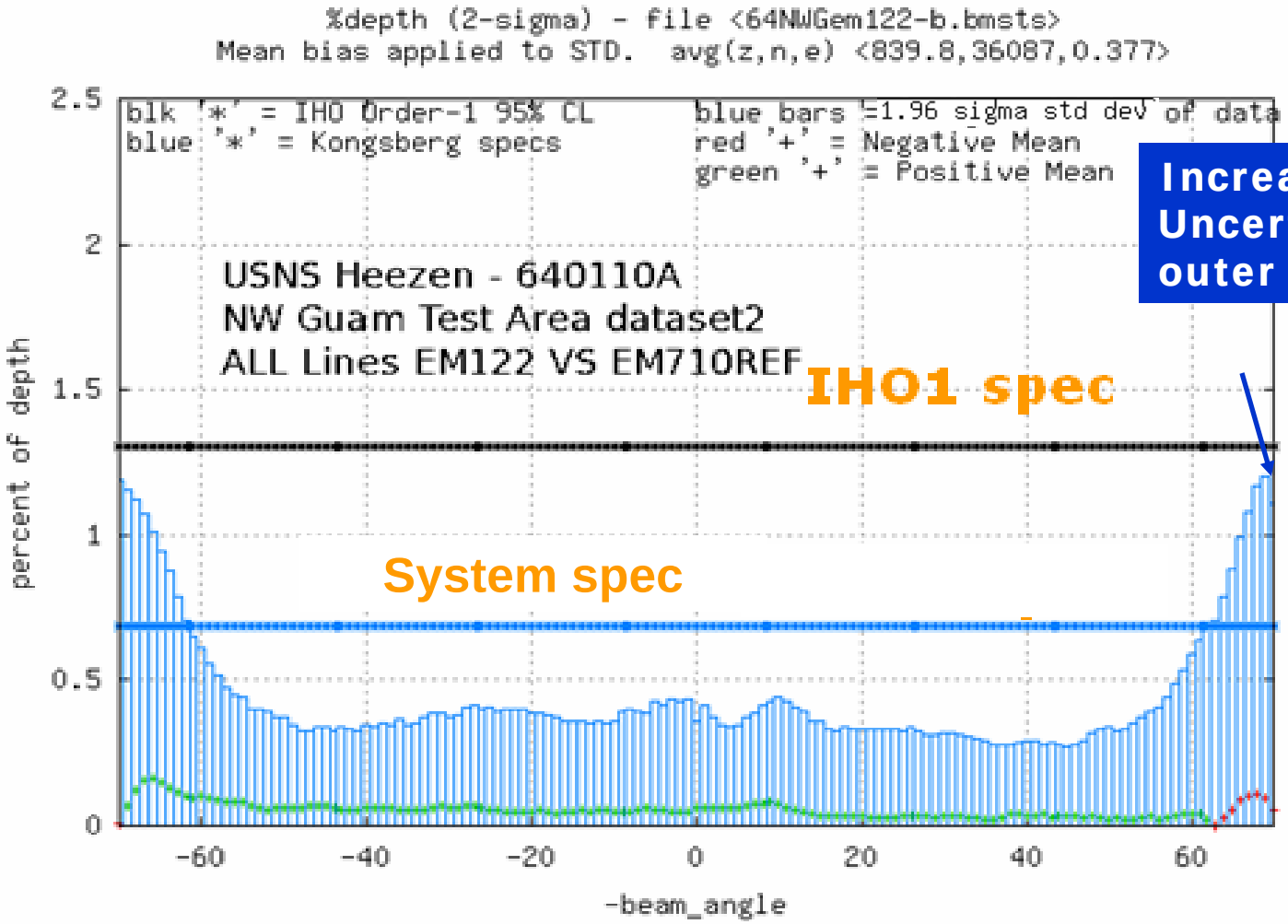
Beamstats File Output

#MASTER PFM file : ../../../em122_penetration_test/pfm/NW_Guam/PFM/NWGem122-a.pfm
#SLAVE PFM file GSF data: ../../../em122_penetration_test/pfm/NW_Guam/PFM/NWGem122-a.pfm

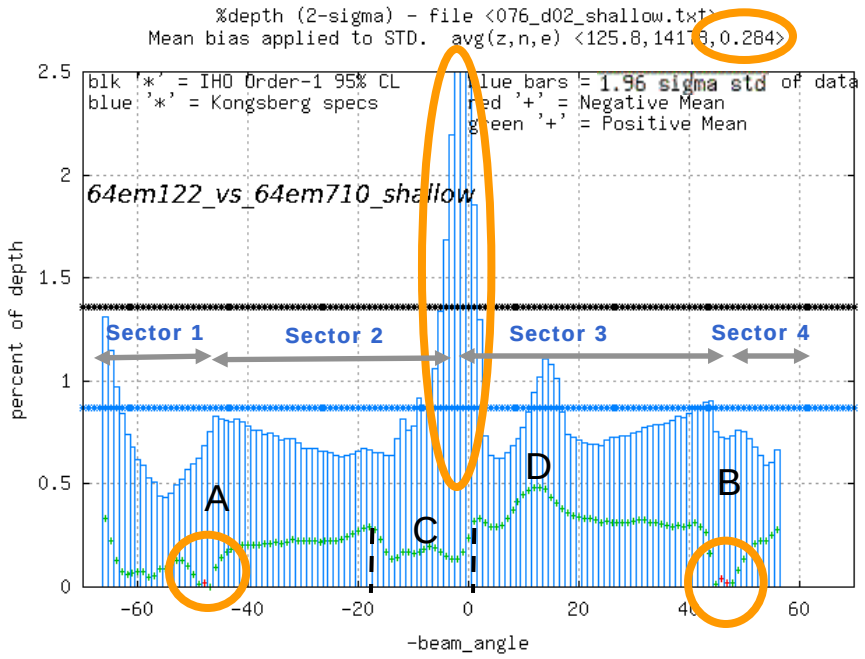
# BEAM ANGLE #	RMS	MEAN DIFF	STD	STD%	NEG%	POS%	MAX RESID	MEAN DEPTH	# POINTS
10.000	1.633	0.618	1.512	0.1865	27.4	72.6	41.762	810.448	13217
9.000	1.749	0.599	1.643	0.2033	27.5	72.5	57.384	808.382	13291
8.000	1.800	0.612	1.693	0.2091	27.0	73.0	59.538	809.575	13045
7.000	1.788	0.595	1.686	0.2081	27.3	72.7	53.470	810.004	13126
6.000	2.012	0.559	1.933	0.2389	26.5	73.5	109.208	809.124	12949
5.000	2.342	0.529	2.282	0.2814	25.5	74.5	110.732	810.916	12970
4.000	2.172	0.467	2.122	0.2621	26.6	73.4	108.004	809.418	13053
3.000	1.988	0.411	1.946	0.2401	26.3	73.7	46.908	810.504	12864
2.000	2.325	0.392	2.292	0.2825	26.1	73.9	111.489	811.308	12887
1.000	2.555	0.376	2.528	0.3124	26.4	73.6	110.616	809.105	12971
0.000	1.162	0.486	1.056	0.1303	24.7	75.3	26.573	810.520	12823
-1.000	1.126	0.479	1.019	0.1257	25.4	74.6	18.738	810.469	13000
-2.000	1.284	0.459	1.199	0.1481	27.4	72.6	63.785	809.618	12900
-3.000	1.416	0.431	1.349	0.1663	29.0	71.0	93.288	811.013	12904
-4.000	1.244	0.474	1.150	0.1420	29.6	70.4	20.851	809.710	13073
-5.000	1.466	0.503	1.376	0.1698	30.2	69.8	47.268	810.446	12985
-6.000	1.477	0.520	1.382	0.1704	31.5	68.5	38.951	811.197	13065
-7.000	1.505	0.512	1.415	0.1749	33.0	67.0	32.977	809.199	13135
-8.000	1.487	0.495	1.402	0.1729	34.7	65.3	16.370	810.799	13039
-9.000	1.486	0.376	1.401	0.1728	38.0	62.0	25.114	810.809	13199

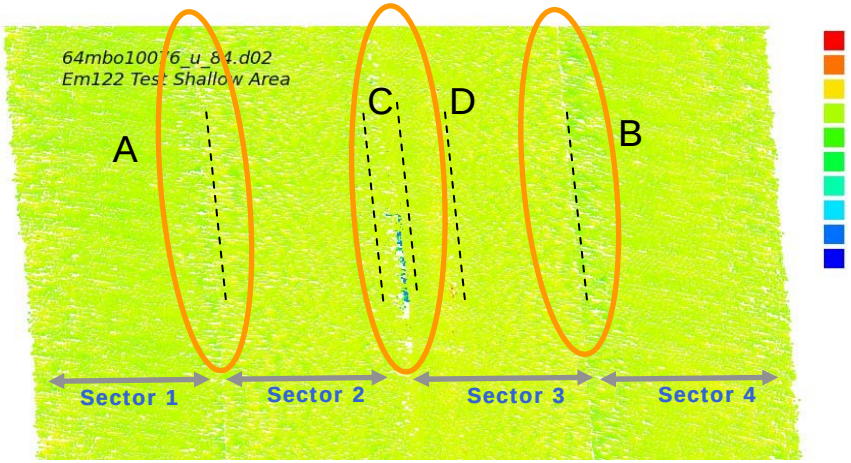
PLOT Beam Angle vs.. %STD

The Plot of Beam Statistics: Expected/Typical EM122 Performance, 800m



Plot Correlation to Data Features/Artifacts

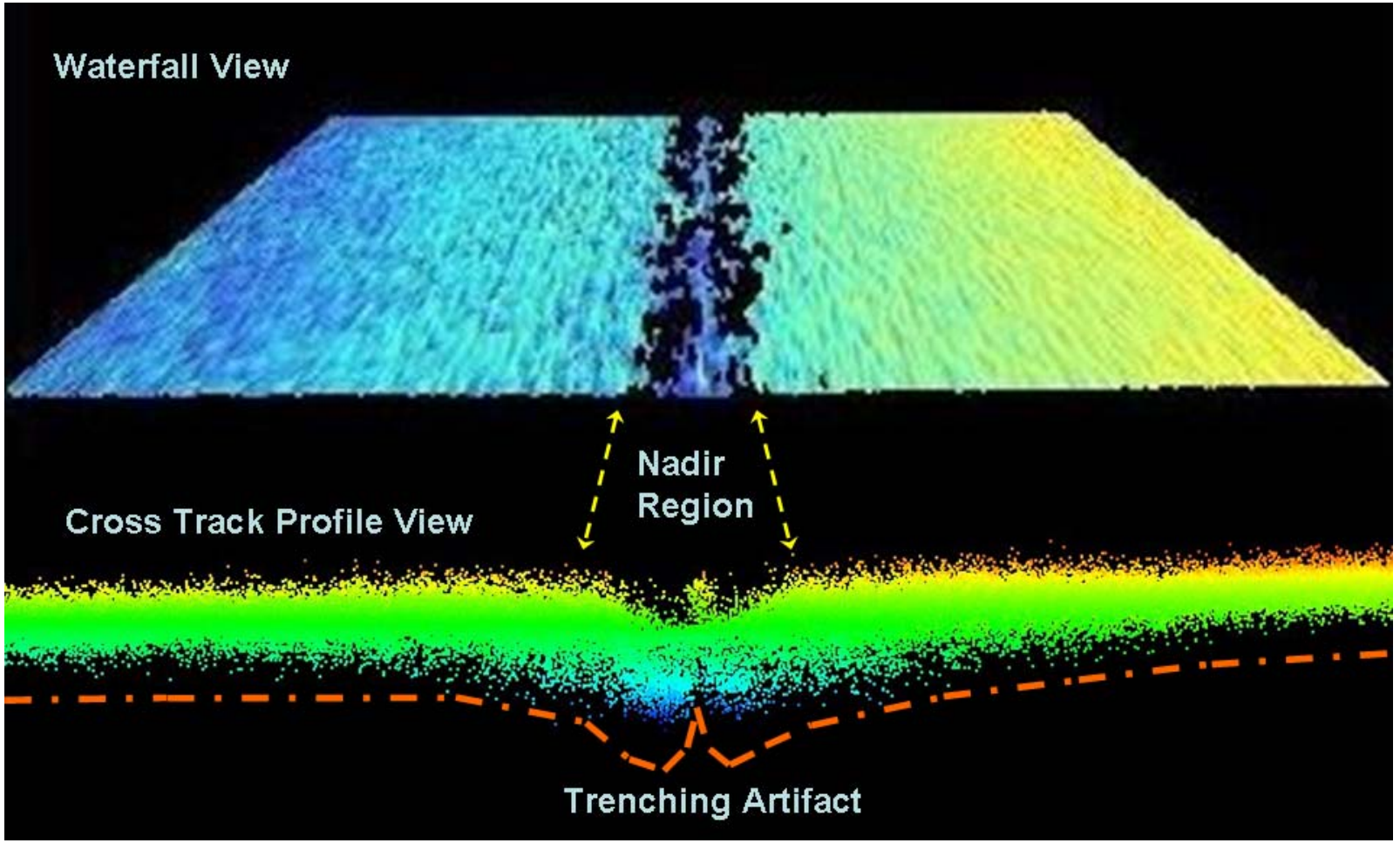




Example of deep system in shallow depths (atypical use).

- ***Beam-wise characterization***
  - ***Artifact detection***
  - ***Across track trends***
- ***Example***
  - ***A, B: Strong sector boundary effects***
  - ***C: Minor penetration in nadir area causing some minor trenching and dropouts***
  - ***Nadir region depth variation causes significant STD peak***
  - ***D: starboard rise – bathy artifact, UNK cause***
  - ***Overall uncertainty performance***
    - ***Contractor specs***
    - ***IHO specs***
    - ***Other requirements***

EM122 CASE STUDY:
Acoustically Soft Bottom



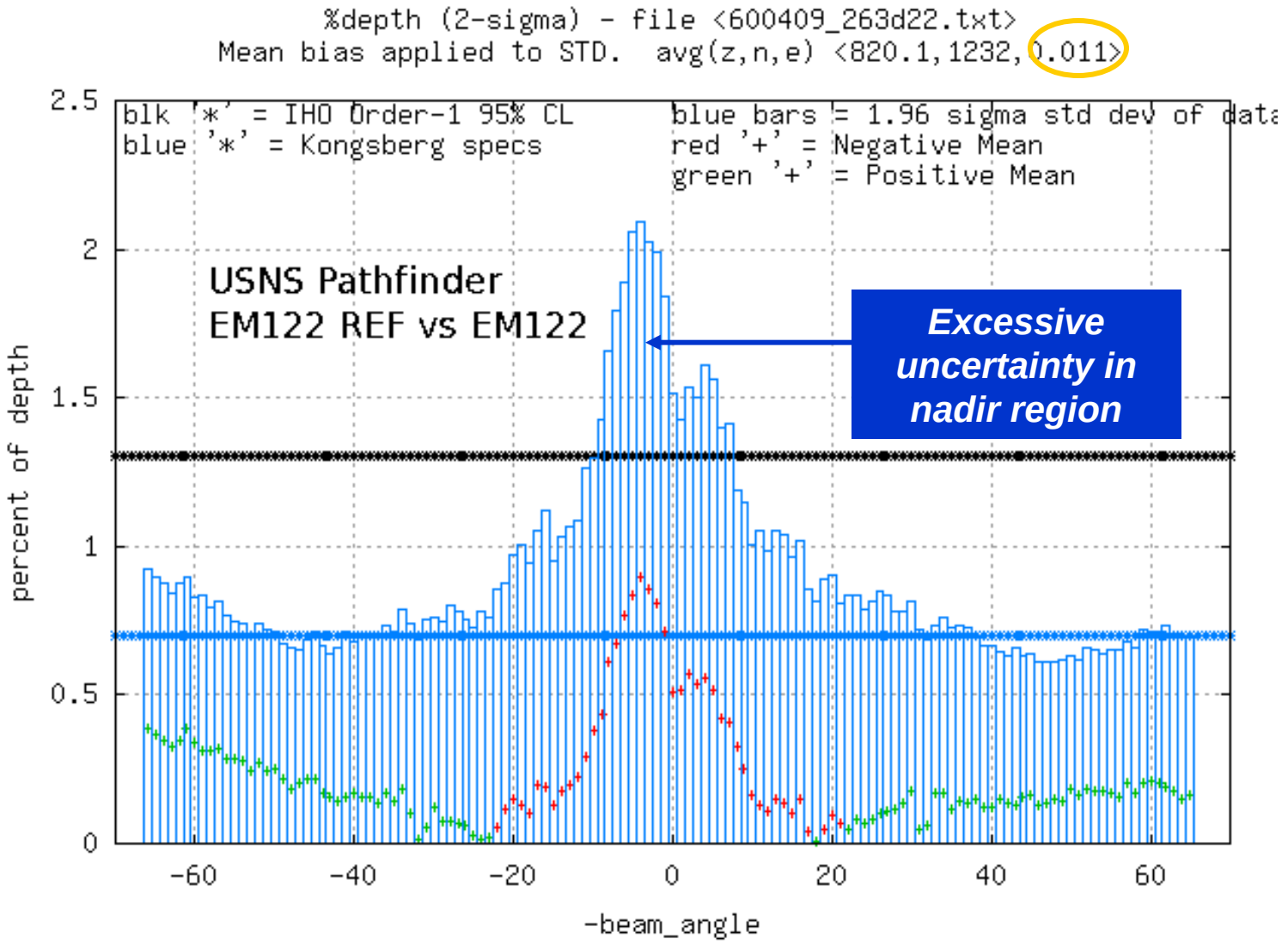
Case Study Conditions

Case Study Compares

80 KHz (EM710) Reference vs. 12 KHz (EM122)

"greenish-brown sticky clay-mud"

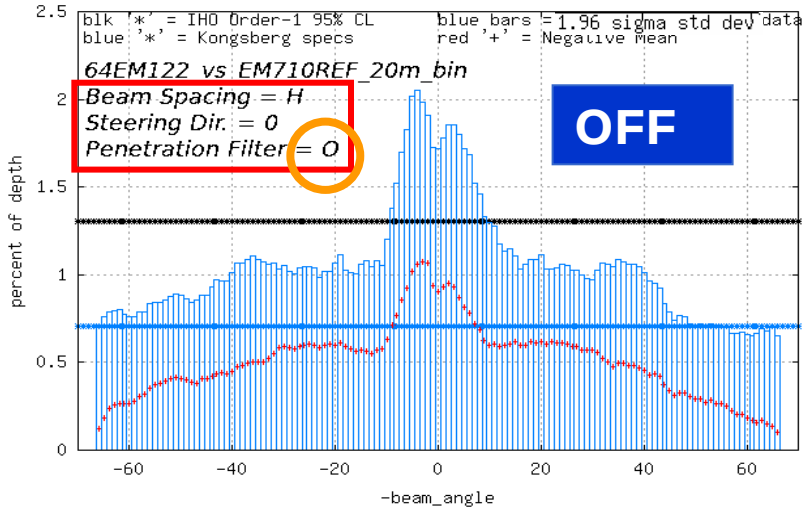
EM122 Before Upgrade

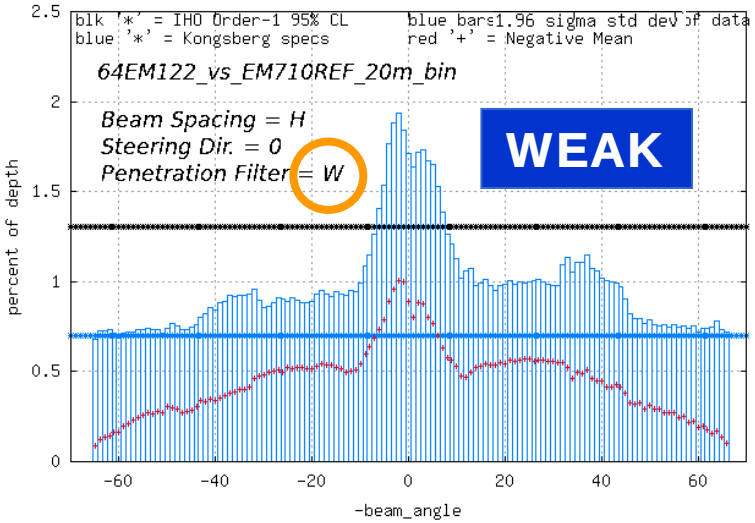


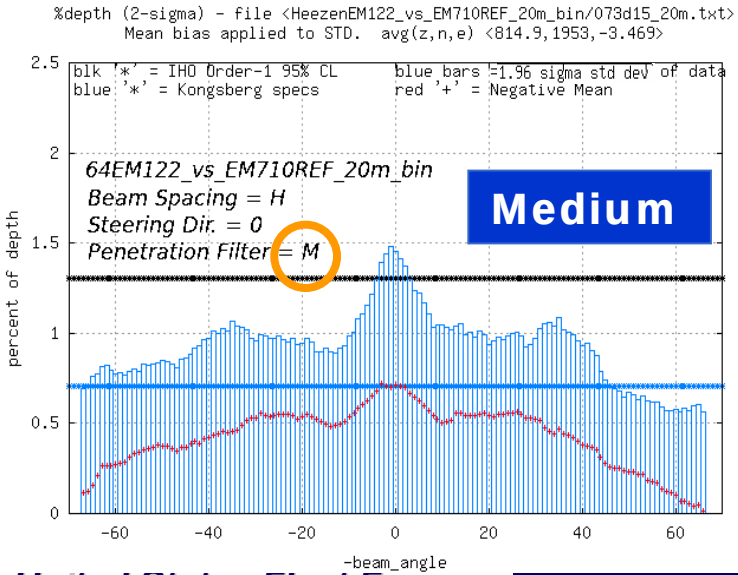
Mitigating Penetration Problem – Parameters Tested

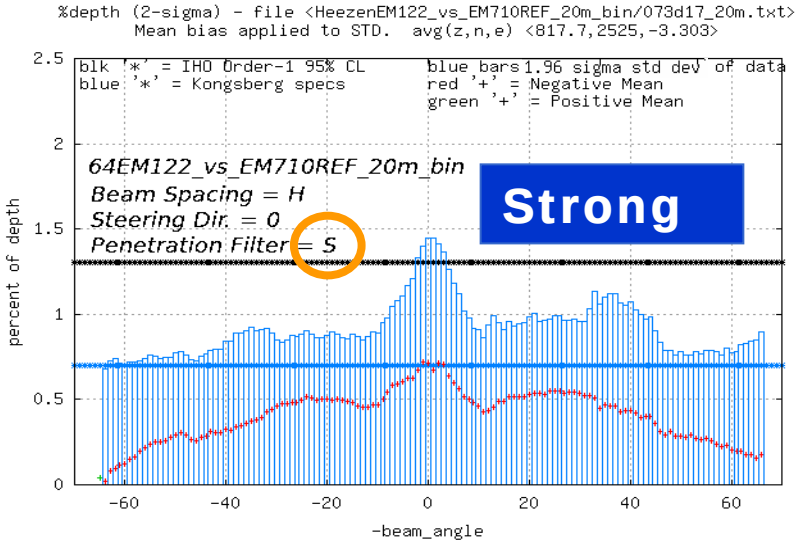
- ***Penetration Filter***
  - ***Receive adjustment***
  - ***Shoaler bottom detection bias***
  - ***Selectable: Off, Weak, Medium, Strong***
- ***<u>Automated</u> Along Track Steering***
  - ***Transmit adjustment***
  - ***Non-nadir steering +/- 4 degrees***
  - ***Reduces specular return***

Penetration Filter Effect

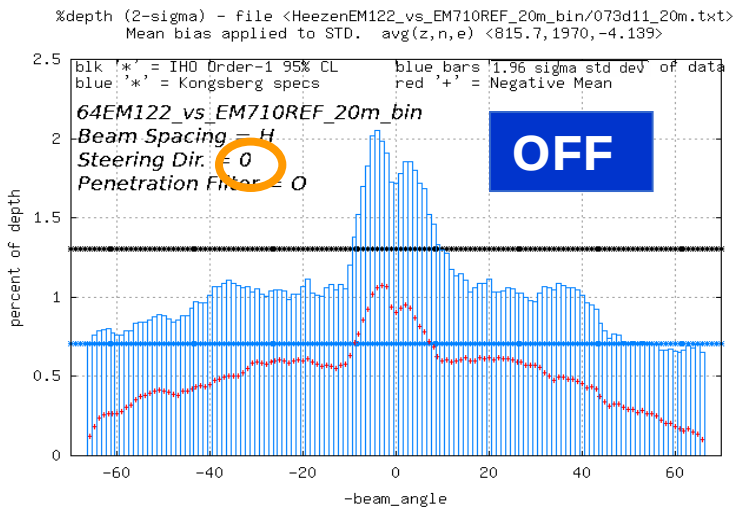


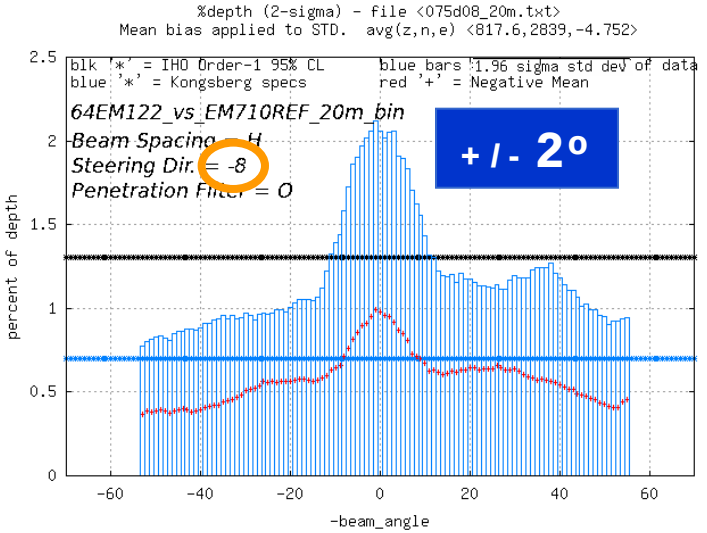


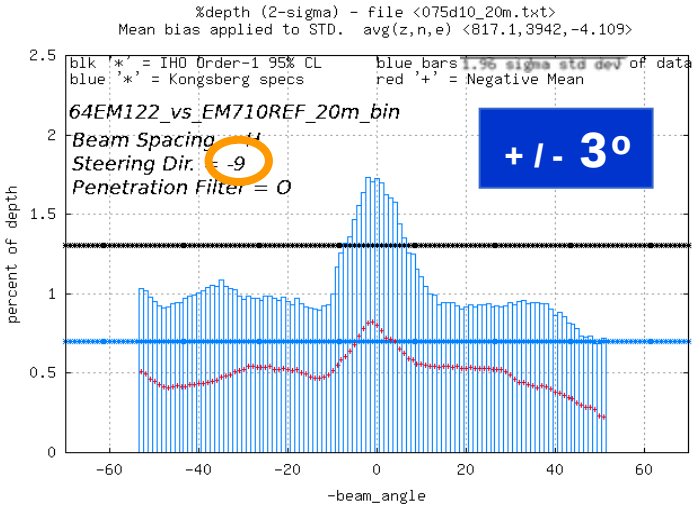


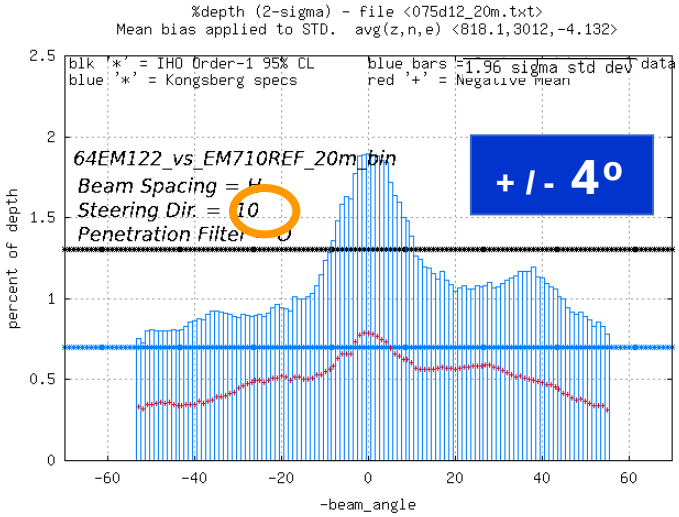


Along Track Steering Effect

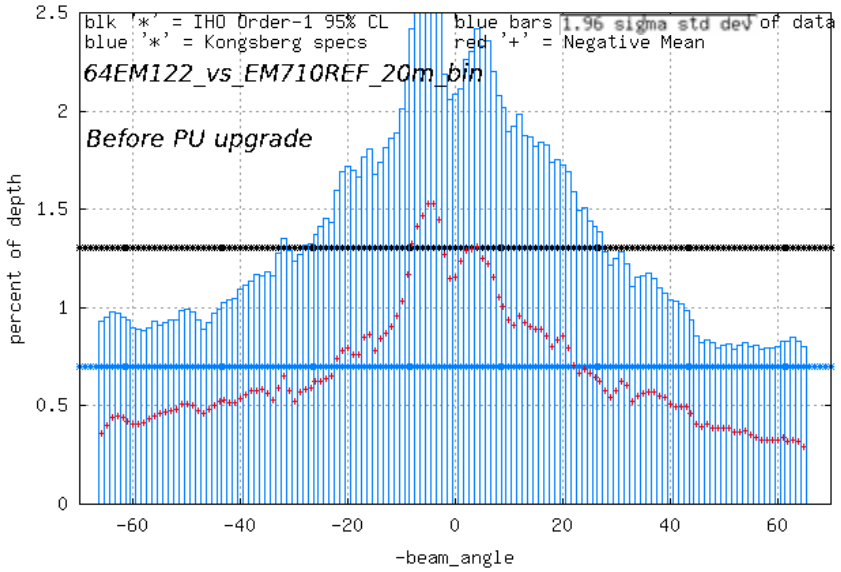


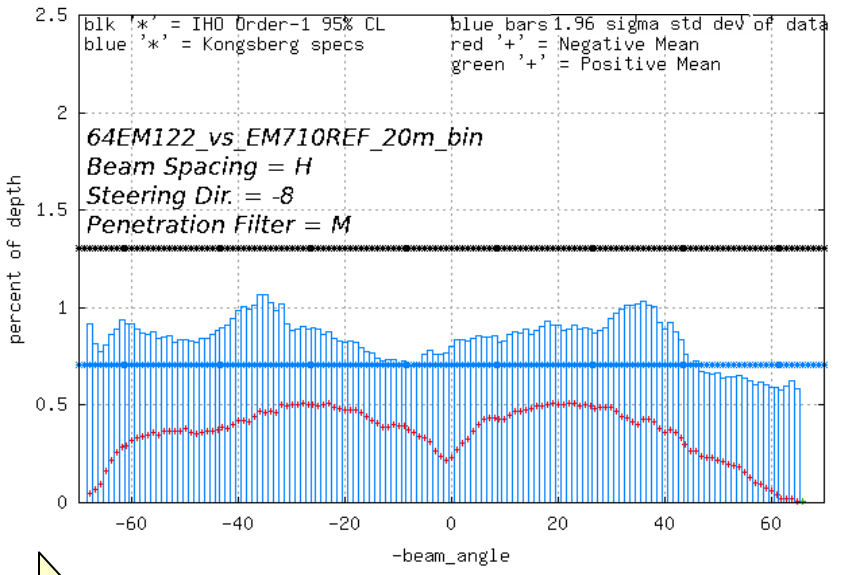




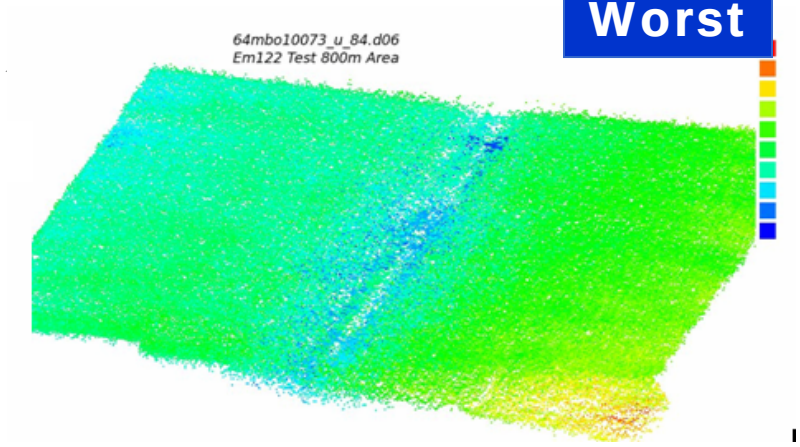


Best Results: Combined Parameters

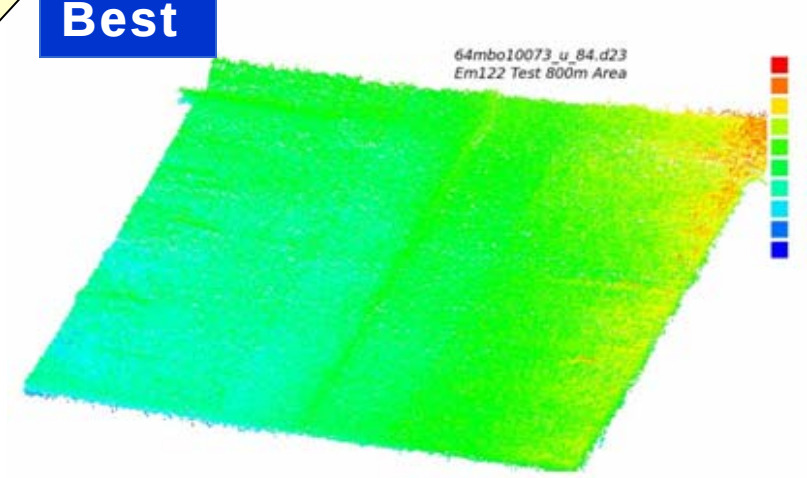




Worst



Best



Conclusions

- **Beam Statistics**
  - Evaluate system performance
  - Characterize problems
  - Assess solutions
  - More industry use recommended
- **Case Study Investigation**
  - Bottom penetration effect quantified
  - Solution performance quantified
- **Case Study Results**
  - Investigation and testing continuing