CYGNUS DOSE QUALITY

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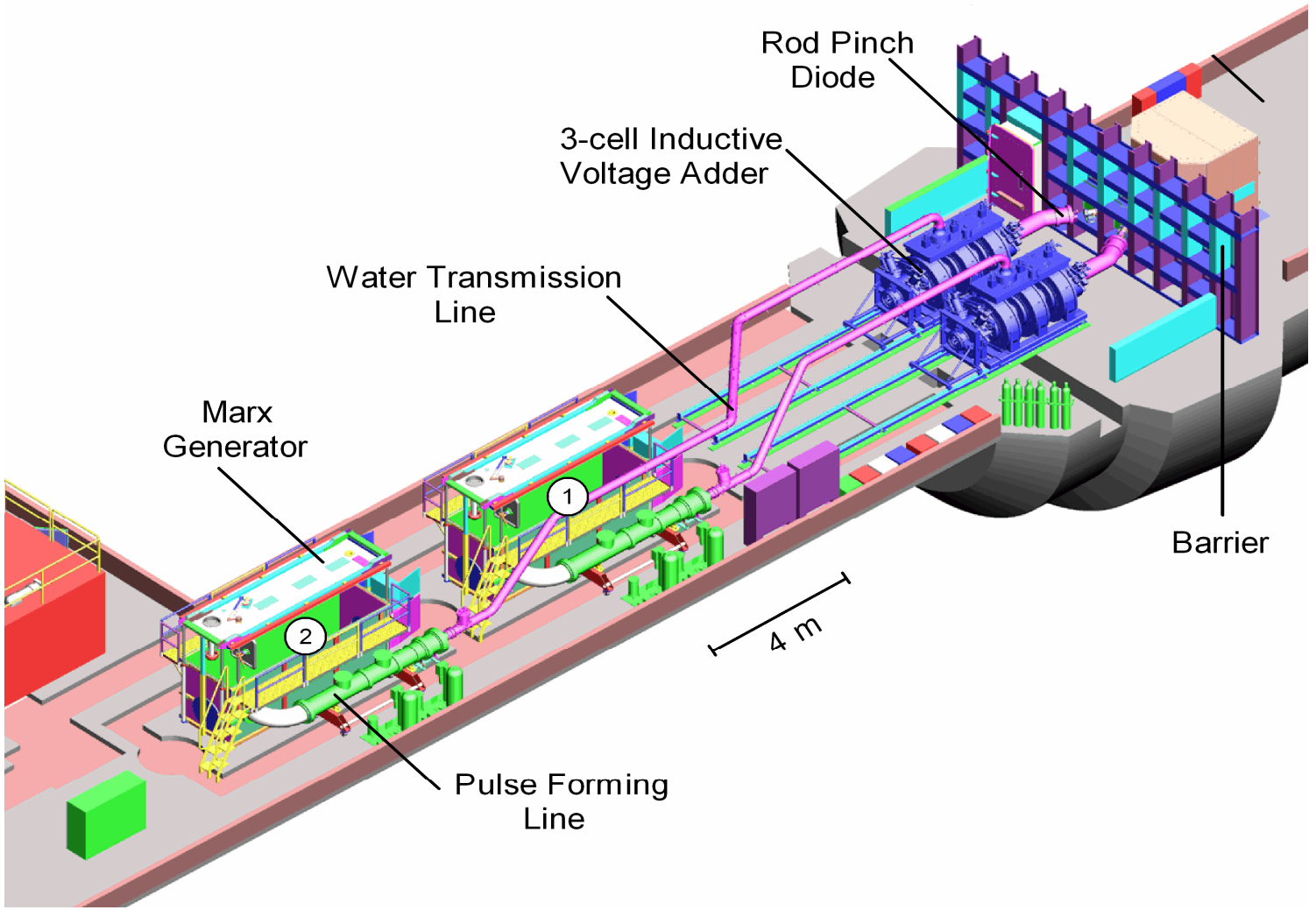
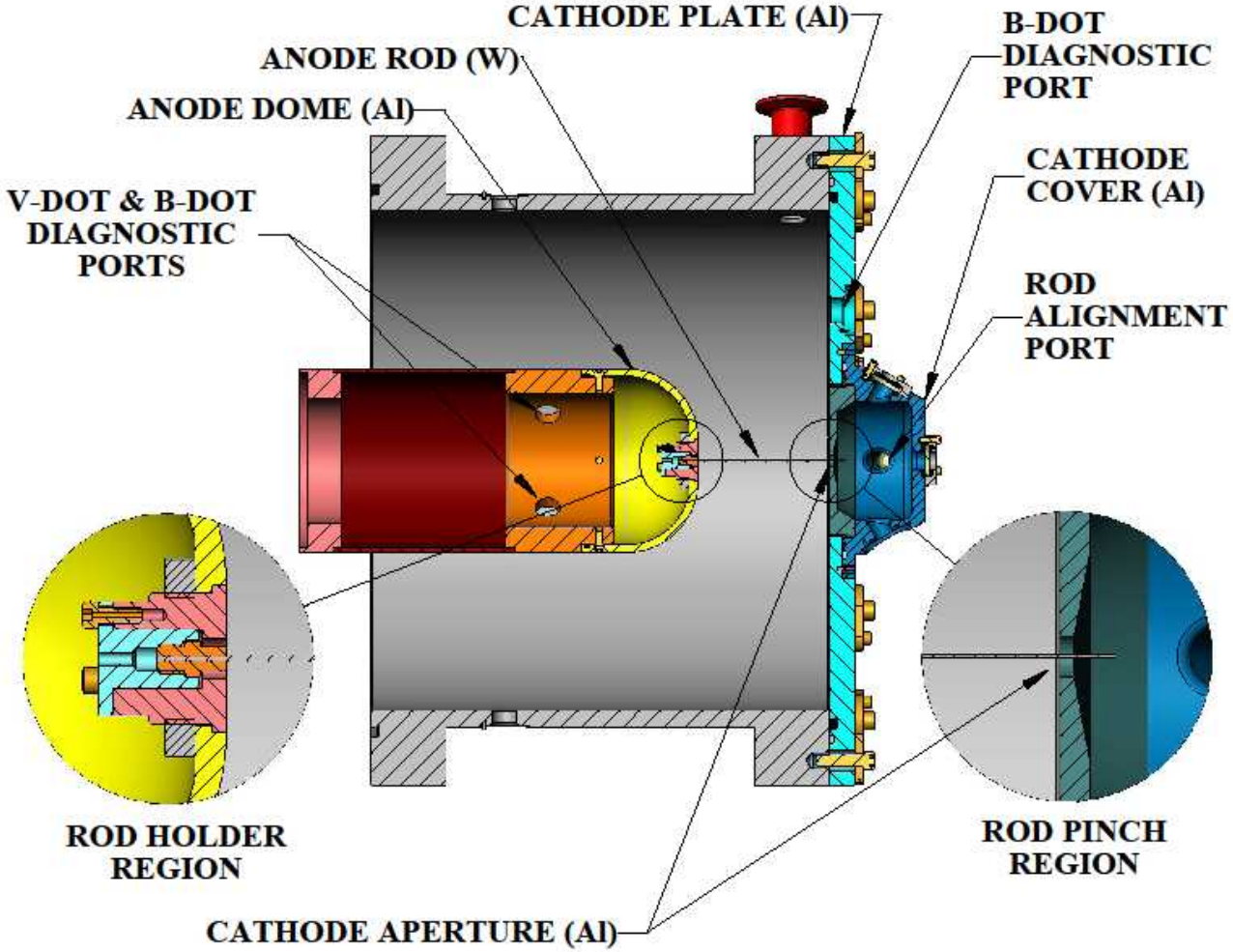
Overview

- Cygnus dose is measured with Lithium Fluoride (LiF) Thermoluminescent Dosimeters (TLDs) - since August, 2009. Previously Calcium Fluoride TLDs were used.
- Calibration of the LiF TLDs will be discussed.
- Long term reliability and accuracy with be analyzed.
- Cumulative dose measurements of both Cygnus 1 and Cygnus 2 will be analyzed.
- An array of 100 LiF TLDs has been fielded on the x-ray collimator face to measure the source characteristics.

Cygnus System Configuration



Rod Pinch Diode Configuration



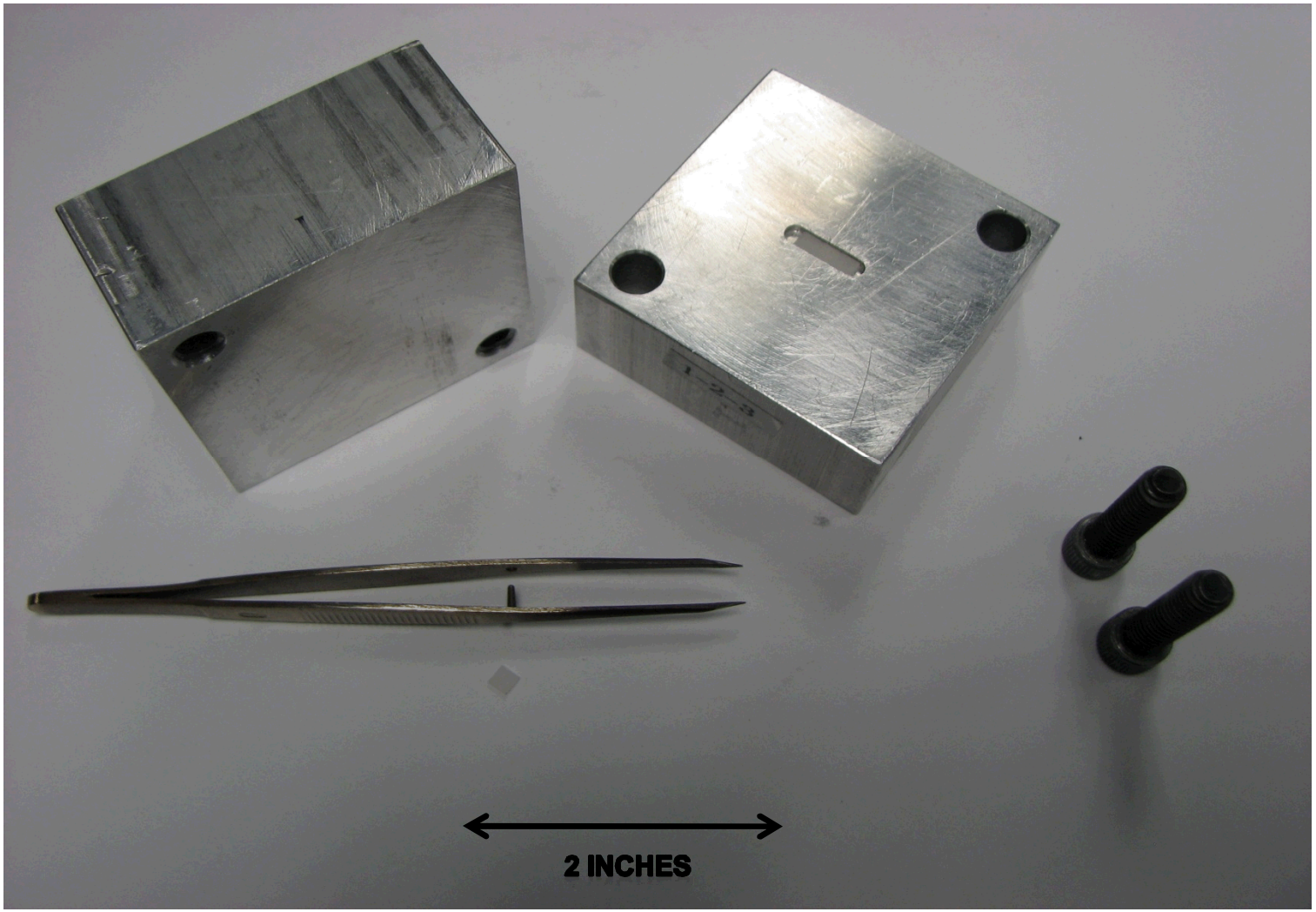
LiF TLD Calibration

- High precision Harshaw TLD-100 (5% tolerance) chips were individually calibrated by exposure to a NIST traceable Cesium 137 source.
- Attention to detail in TLD preparation and handling resulted in a high precision diagnostic.
- TLDs were annealed for one hour at 400°C followed by two hours at 100°C prior to calibration and use.
- Cooling of the TLD's following each heating cycle was controlled at five minutes in a brass quenching block.
- TLDs are read starting at 45 minutes after each shot.
- TLDs are calibrated yearly to maintain precision.

LiF TLD Calibration (Cont.)
(Calibrated at Different Exposure Levels)

Harshaw TLD Reader	Batch (100 TLDs)	Cs Exposure (Rad)	Batch Cal Factor (Rad/nC)
3000A	A2	40	1.63 ± 0.06
3500	A3	40	1.48 ± 0.05
3500	A4	20	1.46 ± 0.07
3500	B1	20	1.43 ± 0.05
3500	C1	20	1.41 ± 0.06
3500	D1	60	1.54 ± 0.06
3500	E1	60	1.55 ± 0.05

TLD Shielding Block



Harshaw 3500 TLD Reader

Standard 3-TLD Data Set

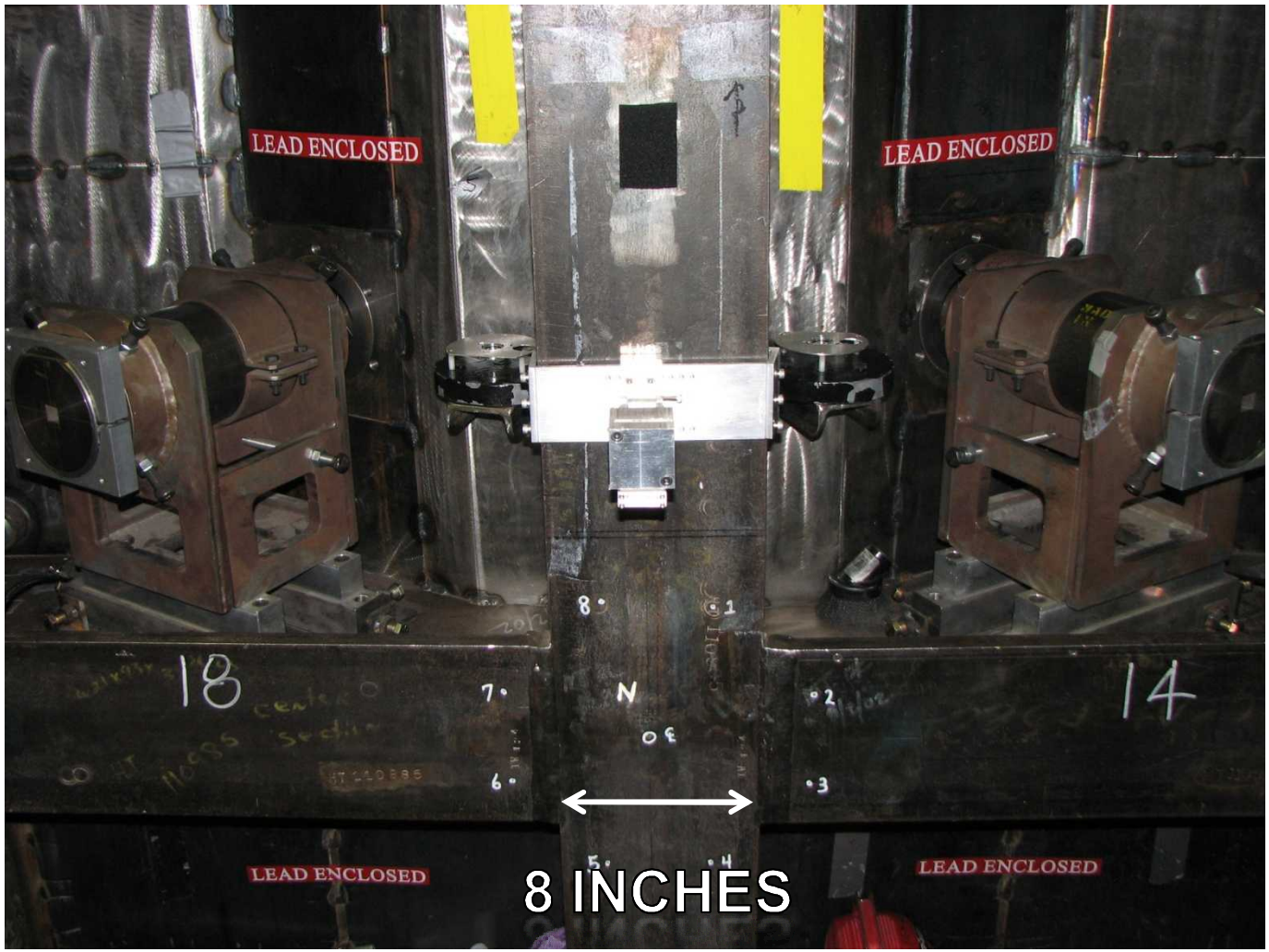
Harshaw Model 3500 TLD Reader settings: Time: 30 Seconds, Temp Max: 245C, Temp Integrate 100C, Temp Rate: 20C per second, HV: -500VDC.								
	Shot #	**Dose - 1m (Rad)**	**Std Dev (%)**	**TLD #**	**Reading (nC)**	**Cal Factor (Rad/nC)**	**Dose (Rad)**	**Dose - 1m (Rad)**
C-1	**1495**	**4.7**	**1.4**	B001	8.411	1.490	12.54	4.78
				B002	8.428	1.445	12.18	4.64
				B003	8.282	1.491	12.35	4.71
C-2	**1496**	**4.5**	**0.3**	B004	8.374	1.411	11.82	4.50
				B005	8.242	1.438	11.85	4.52
				B006	7.960	1.495	11.90	4.53
C-1	**1497**	**4.6**	**0.3**	B007	8.332	1.448	12.07	4.60
				B008	8.108	1.495	12.12	4.62
				B009	8.226	1.466	12.06	4.60
C-2	**1498**	**4.2**	**1.5**	B010	7.762	1.451	11.27	4.29
				B011	7.640	1.442	11.01	4.20
				B012	7.886	1.392	10.98	4.18
C-1	**1499**	**4.3**	**0.7**	B013	8.012	1.428	11.44	4.36
				B014	8.012	1.430	11.46	4.37
				B015	8.147	1.390	11.32	4.31
C-2	**1500**	***5.0**	**1.0**	B016	9.547	1.356	12.95	4.93
				B017	9.272	1.418	13.14	5.01
				B018	9.078	1.420	12.89	4.91

***No Ghost Buster, 100 TLD Array**

Percent Standard Deviation Comparisons
(Shot Results)

SHOT NUMBERS and PLANCHET	STD DEV % (Avg Multiple Shots)
Shots 1186-1204 (A)	1.01
Shots 1206-1238 (B)	1.40
Shots 1239-1270 (C)	1.74
Shots 1271-1302 (A)	2.65
Shots 1304-1332 (C)	1.99
Shots 1333-1365 (A)	1.63
Shots 1367-1398 (B)	1.33
Shots 1399-1430 (A)	2.03
Shots 1431-1460 (B)	1.26
Shots 1461-1494 (A)	1.94
Shots 1495-1526 (B)	1.36
Shots 1527-1540 (A)	1.68
OVERALL AVG	**1.67**

Cygnus 1 and Cygnus 2 Cumulative Dose
(Hardware)



Cygnus 1 and Cygnus 2 Cumulative Dose (Rad)

- The standard LiF fielding block was mounted in the center of the two sources.
- The standard fielding position is isolated from the dose of the other machine and measurements verified no measurable dose was evident.
- The expected results would be the two independent sources measured dose would be cumulative in the center position.
- Actual measurements indicated on following slide.

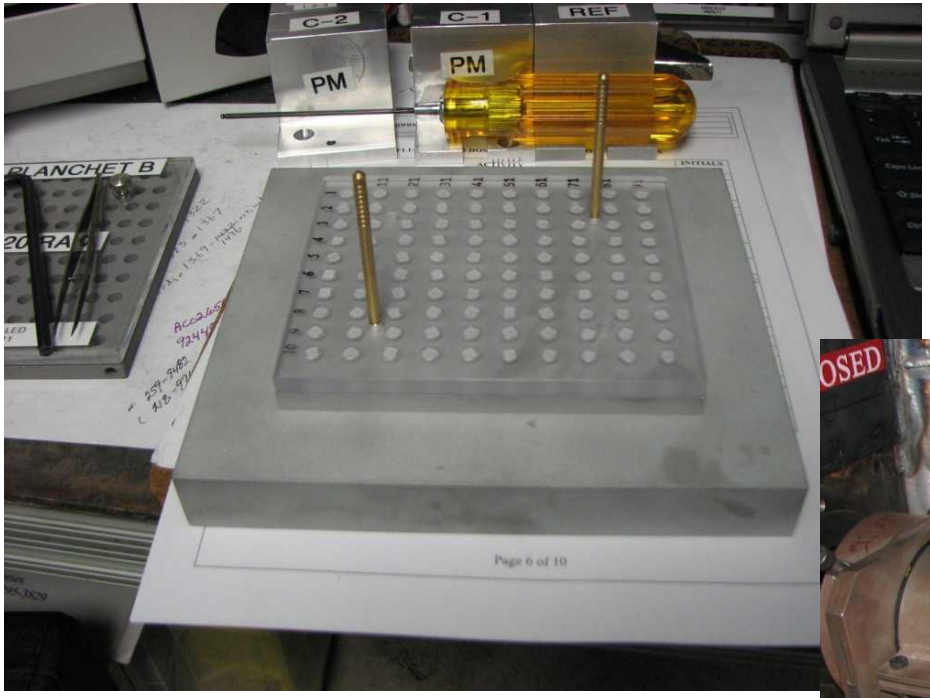
Cygnus 1 and Cygnus 2 Cumulative Dose (Rad)

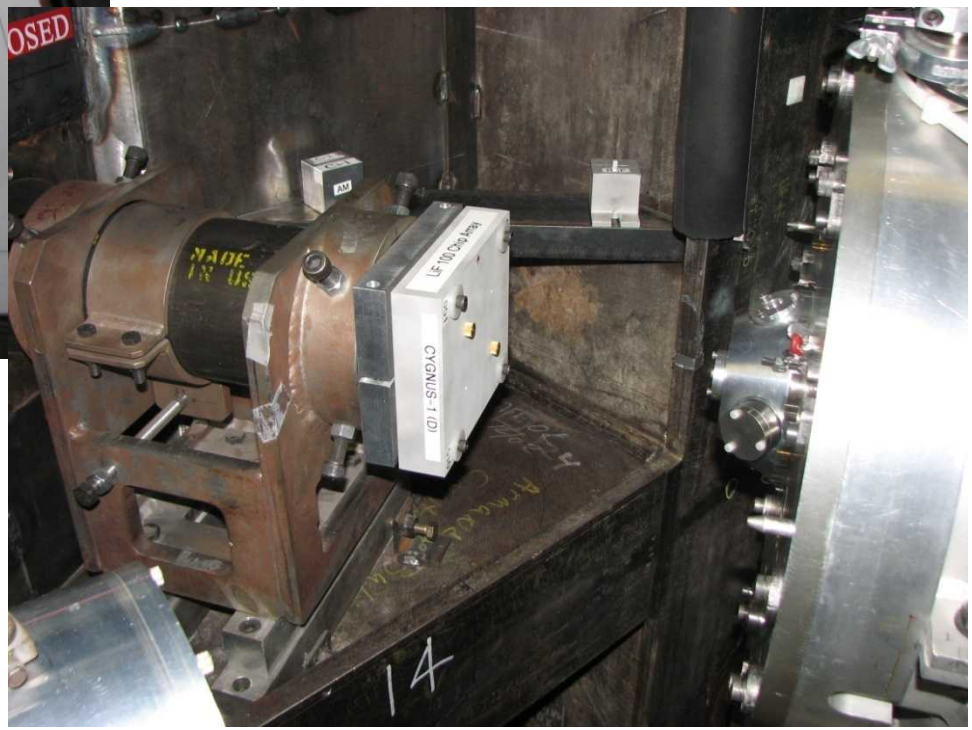
Shot #	C1 Dose at 1m (Individual)	C2 Dose at 1m (Individual)	C1 + C2	Cumulative Dose at 1m
1353	4.8	4.3	9.1	9.0
1354	4.4	4.0	8.4	8.3
1356	4.2	4.1	8.3	8.4
1357	4.1	4.3	8.4	8.6
1359	4.6	4.0	8.6	8.6
1360	4.4	4.1	8.5	8.4
1362	4.3	4.3	8.6	8.6
1365	4.3	4.1	8.4	8.3

100 LiF TLD Array

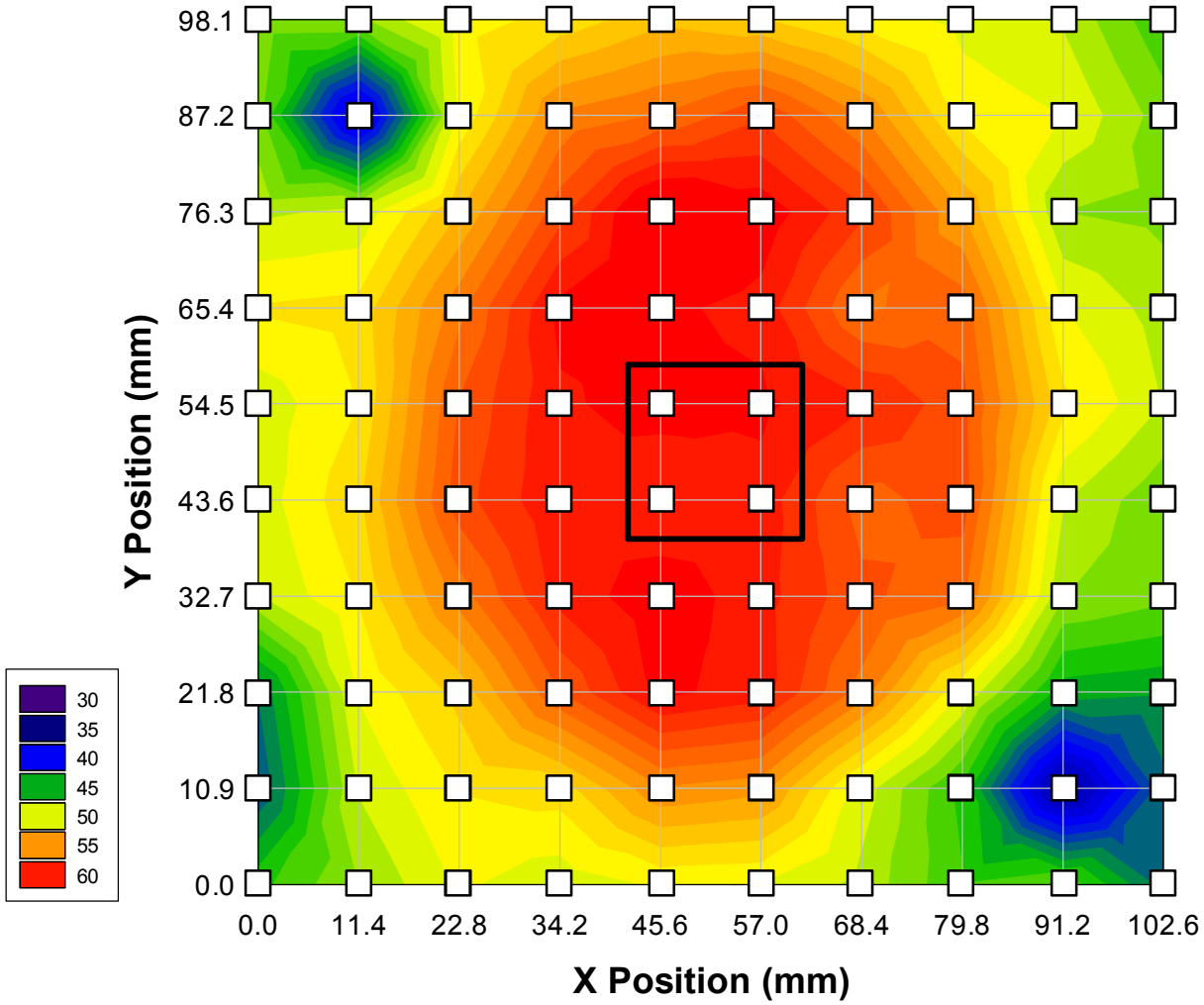
- TLDs were mounted on the face of the x-ray collimators of each machine to map source.
- TLDs were sandwiched between one inch of aluminum (including sides) and the steel collimation.
- A special array was manufactured with the standard collimation hole to allow concurrent experiments down line.

100 LiF TLD Array

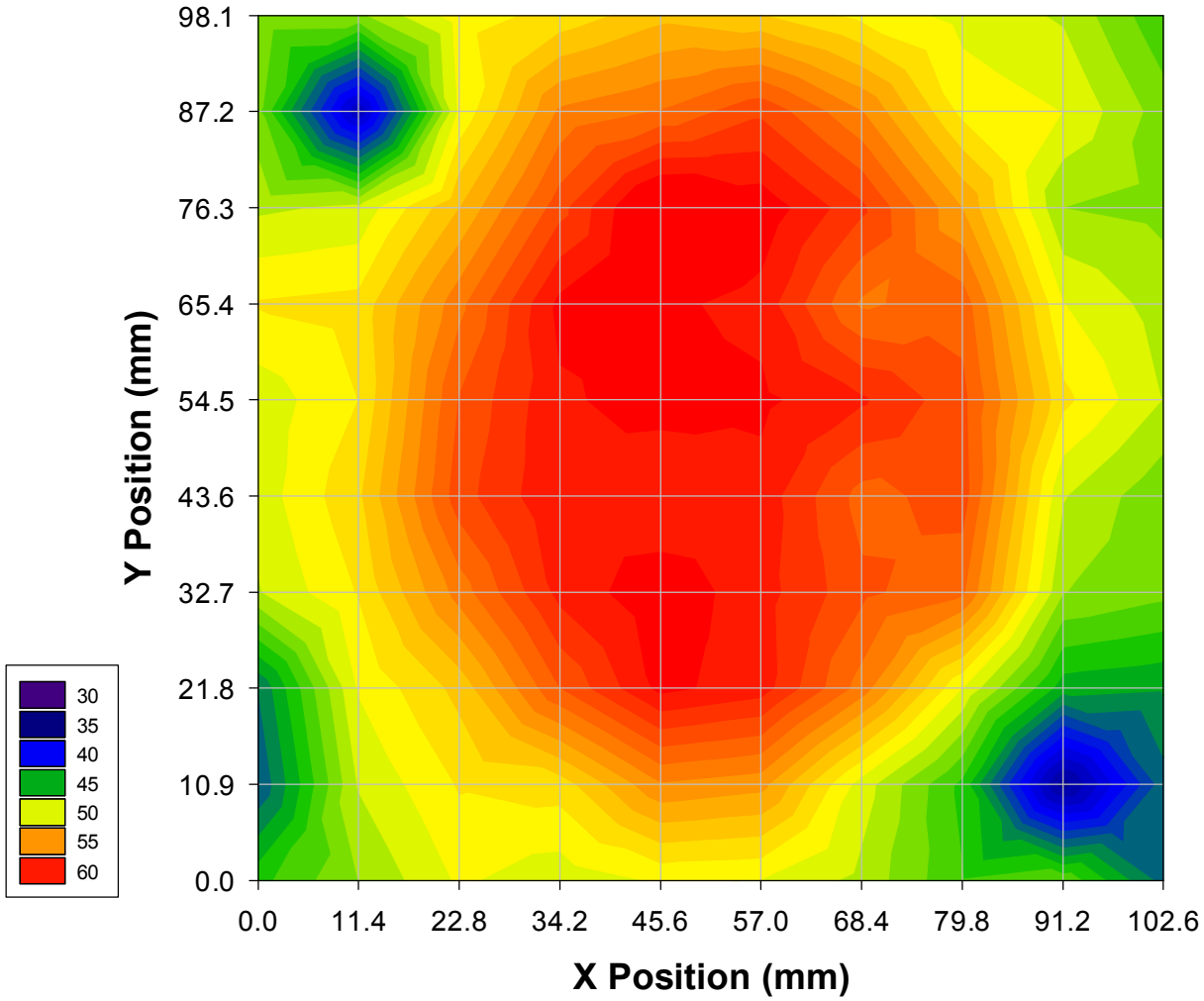




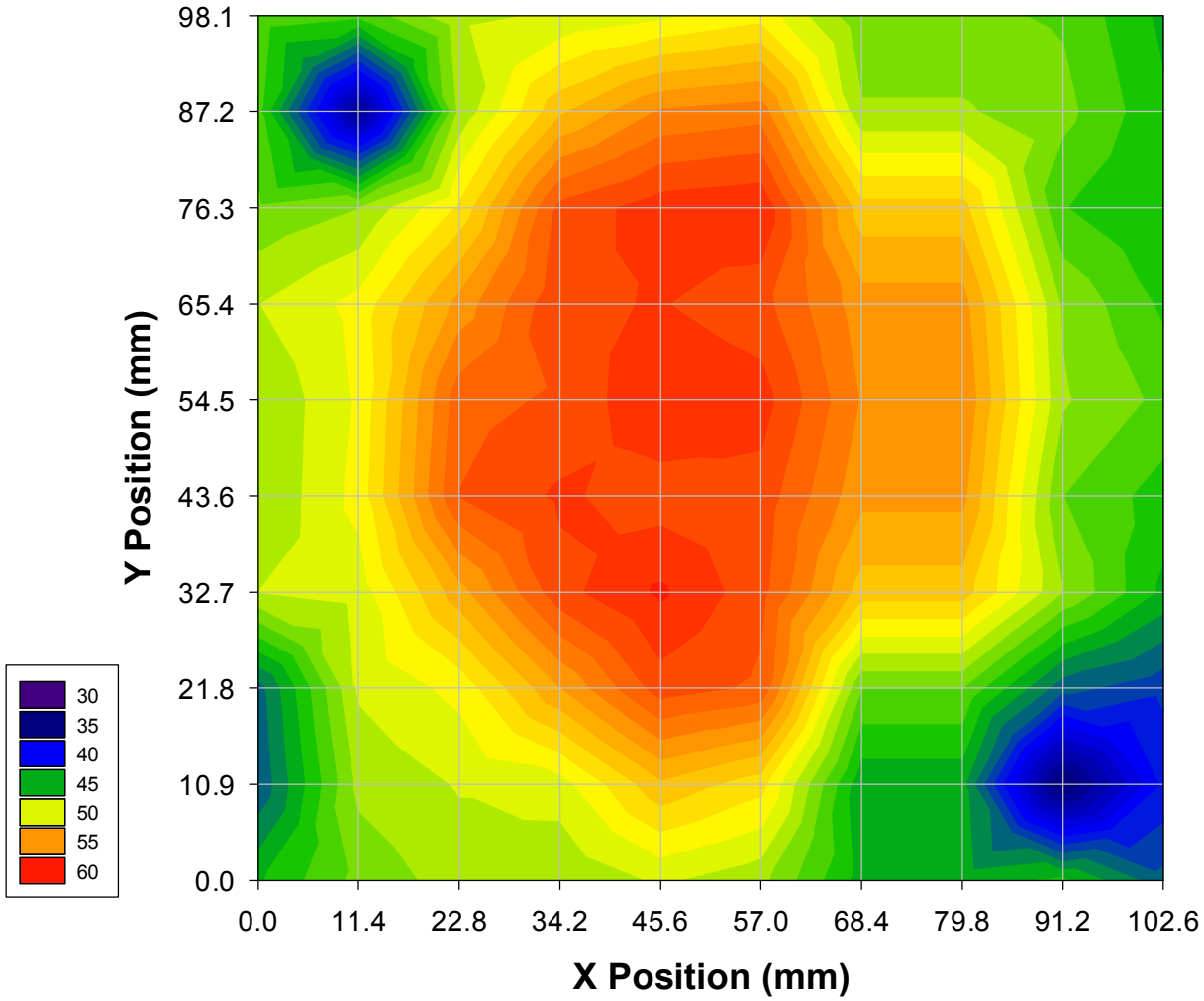
100 LiF TLD Array - Cygnus 1
(Shot 1457)



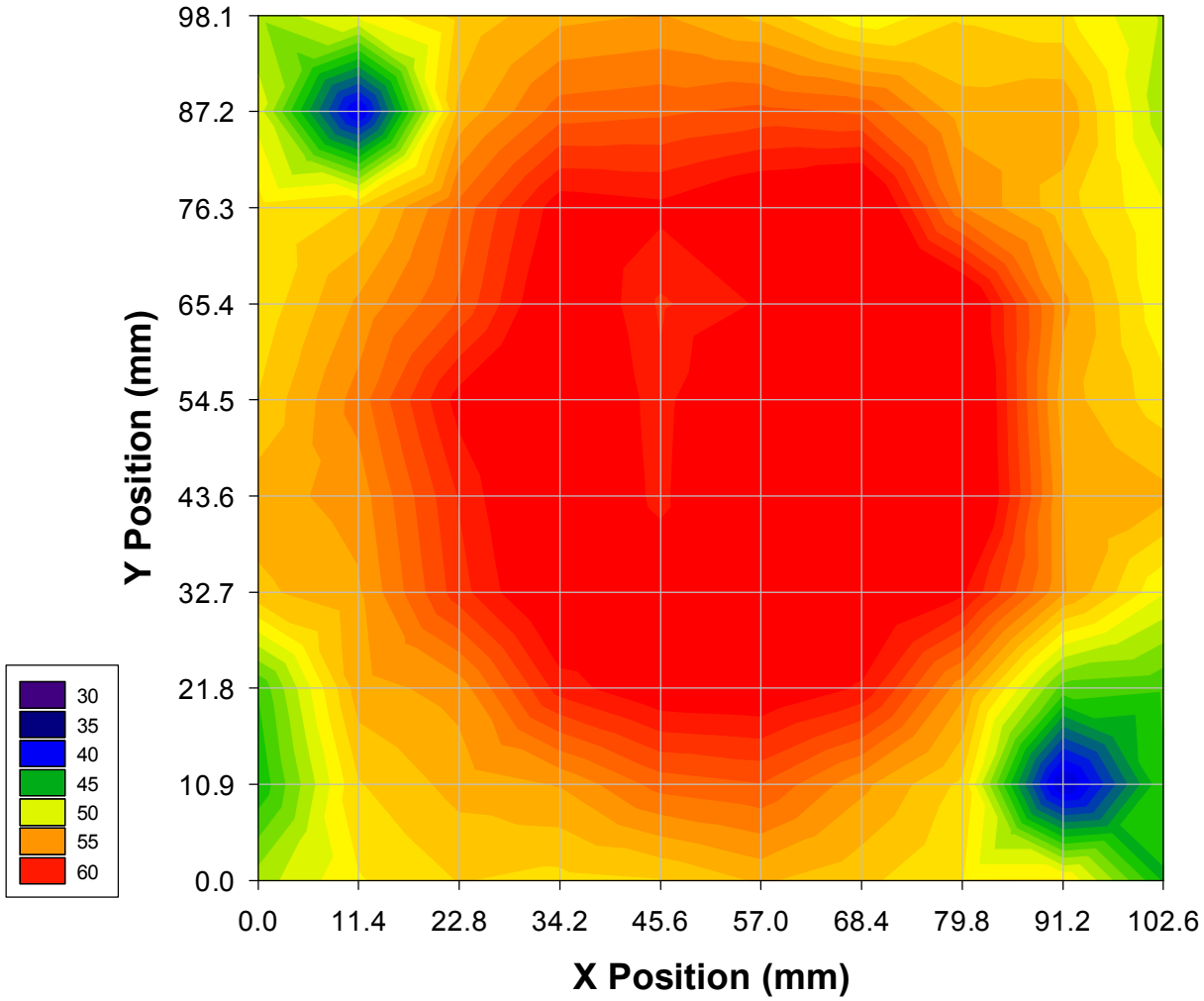
100 LiF TLD Array - Cygnus 1
(Shot 1457)



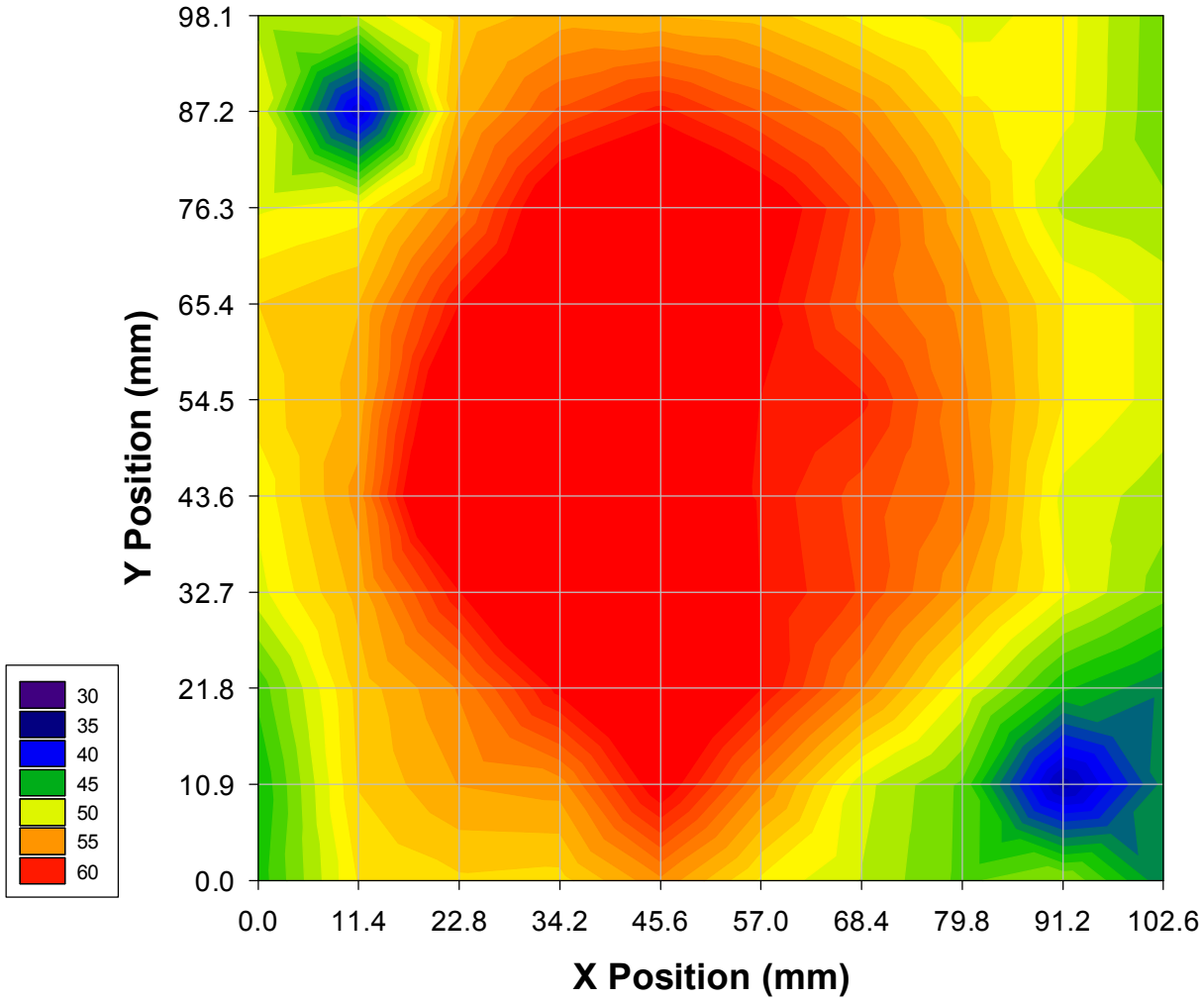
100 LiF TLD Array - Cygnus 2
(Shot 1500)



100 LiF TLD Array - Cygnus 1
(Shot 1537)



100 LiF TLD Array - Cygnus 2
(Shot 1538)



Dose Variation
(4 Central TLDs within Collimator Boundary)

Shot #	Machine	Variation
1457	Cygnus 1	1.1%
1500	Cygnus 2	1.1%
1537	Cygnus 1	4.5%
1538	Cygnus 2	2.6%

Conclusions

- LiF TLD's were an accurate and efficient means to measure dose on the Cygnus machines. Achieved ~ 1 % accuracy
- Measurements with three LiF chips between the two x-ray sources reliably measured the combined dose.
- This demonstrates a diagnostic which characterizes the performance of both machines in a single metric. The agreement of the summed and cumulative measurements indicates axial dose symmetry.
- There is evidence of asymmetric dose distribution as shown in the 100 LiF TLD chip arrays. This correlates with radial measurements performed in previous experiments. Variation in dose at the collimator entrance was of the order of 1 to 4%.

Looking Forward

- Calibration of Pin Diodes using TLDs.
- The on-axis dose will be measured on both sides of the collimator.
- Examination of asymmetric source distribution will be analyzed.
- Radial Dose will be analyzed from zero to 30 degrees.

Thank You!

- QUESTIONS?