SAND2017-6252C

Cygnus Precision Dosimetry – Calibration and Measurements

PPC 2017

18-22 June, 2017

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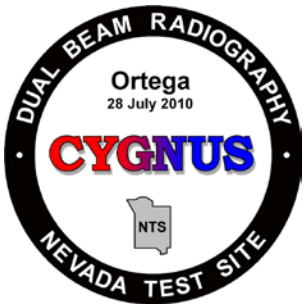

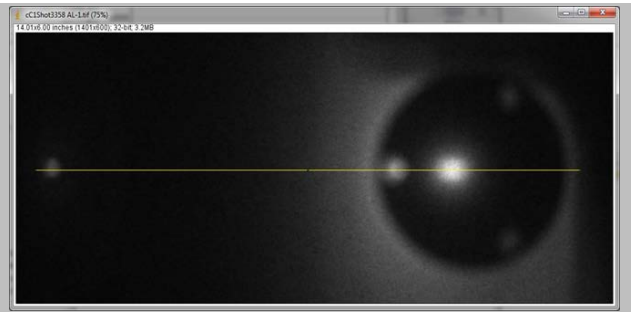

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PPC 2017, Brighton UK

Cygnus Precision Dosimetry – Calibration and Measurements*

June 19, 2017

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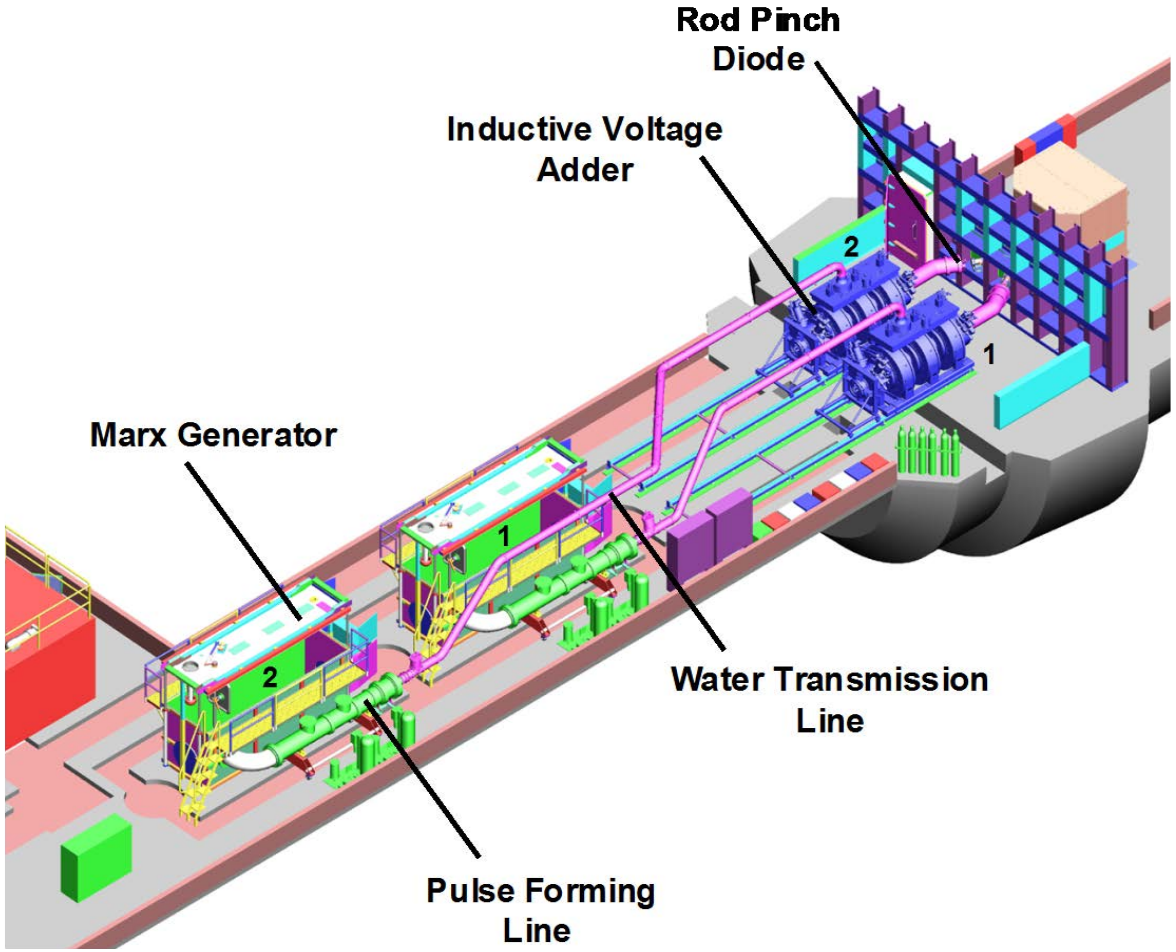
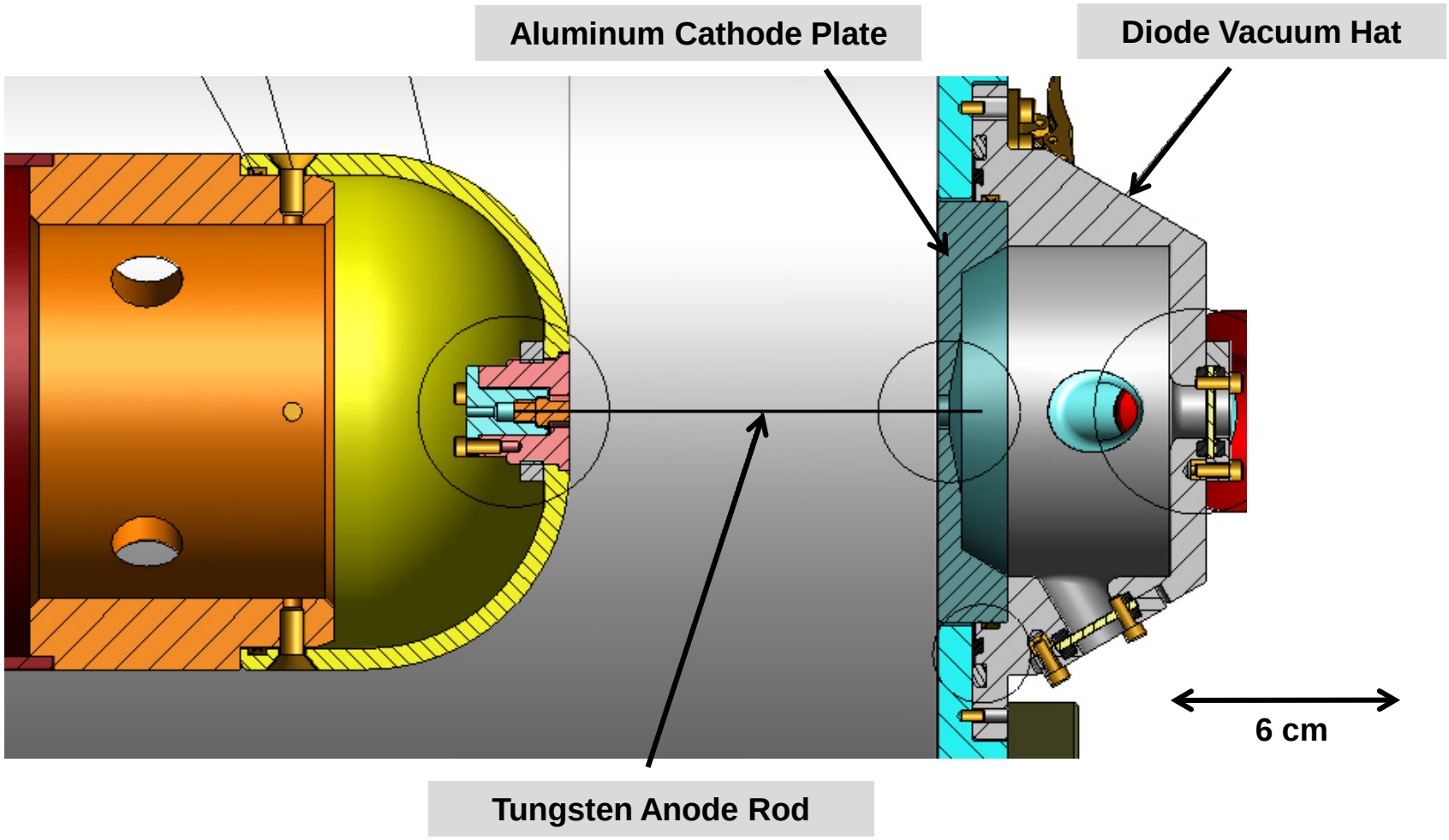
Cygnus Precision Dosimetry

- **GENERAL SYSTEM DESCRIPTION**
- **LiF TLD CALIBRATION**
- **LONG TERM LiF MEASUREMENTS**
- **MARX AND DIODE CURRENT MONITORS**

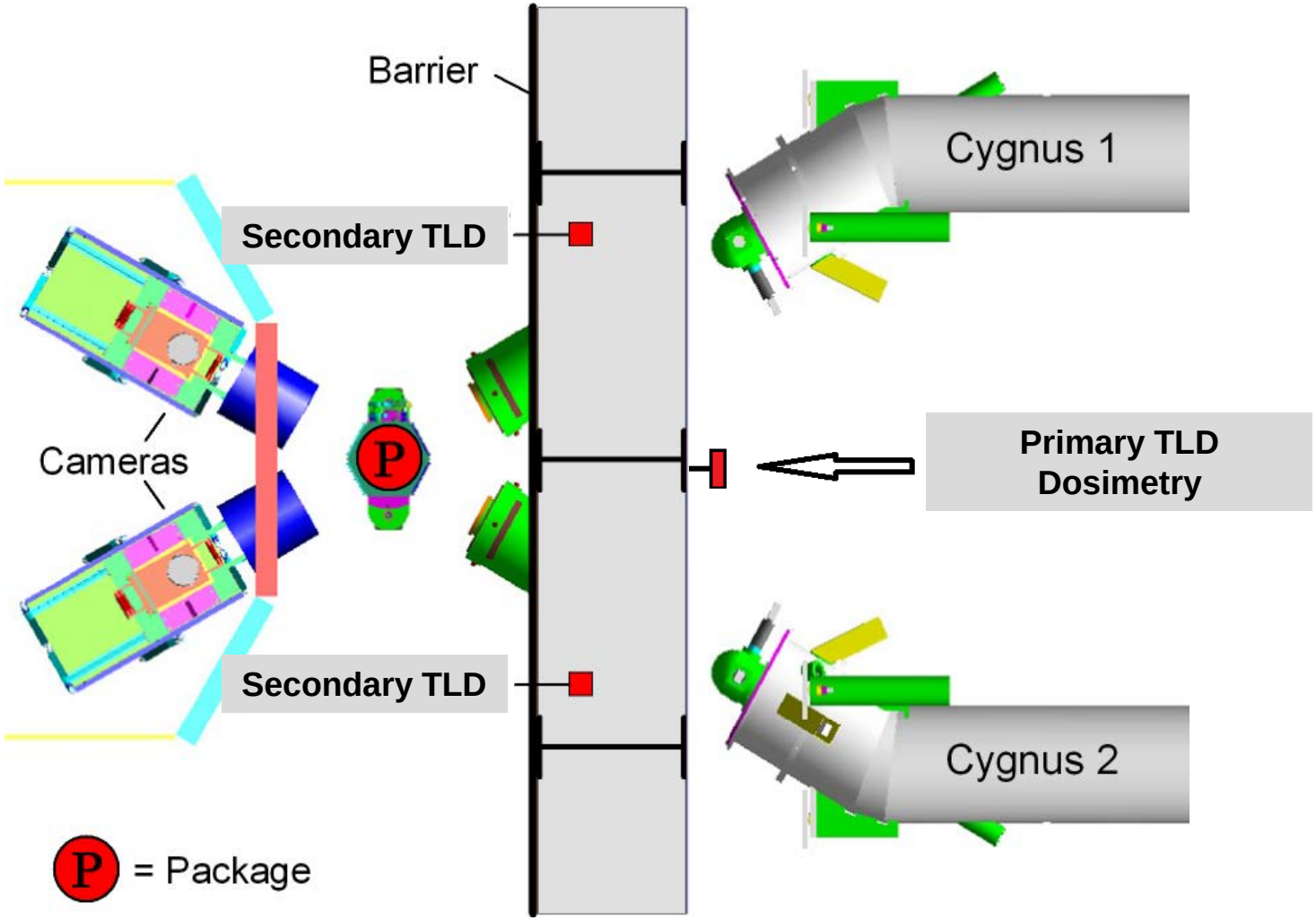
U1a - Cygnus 1 & 2 Layout



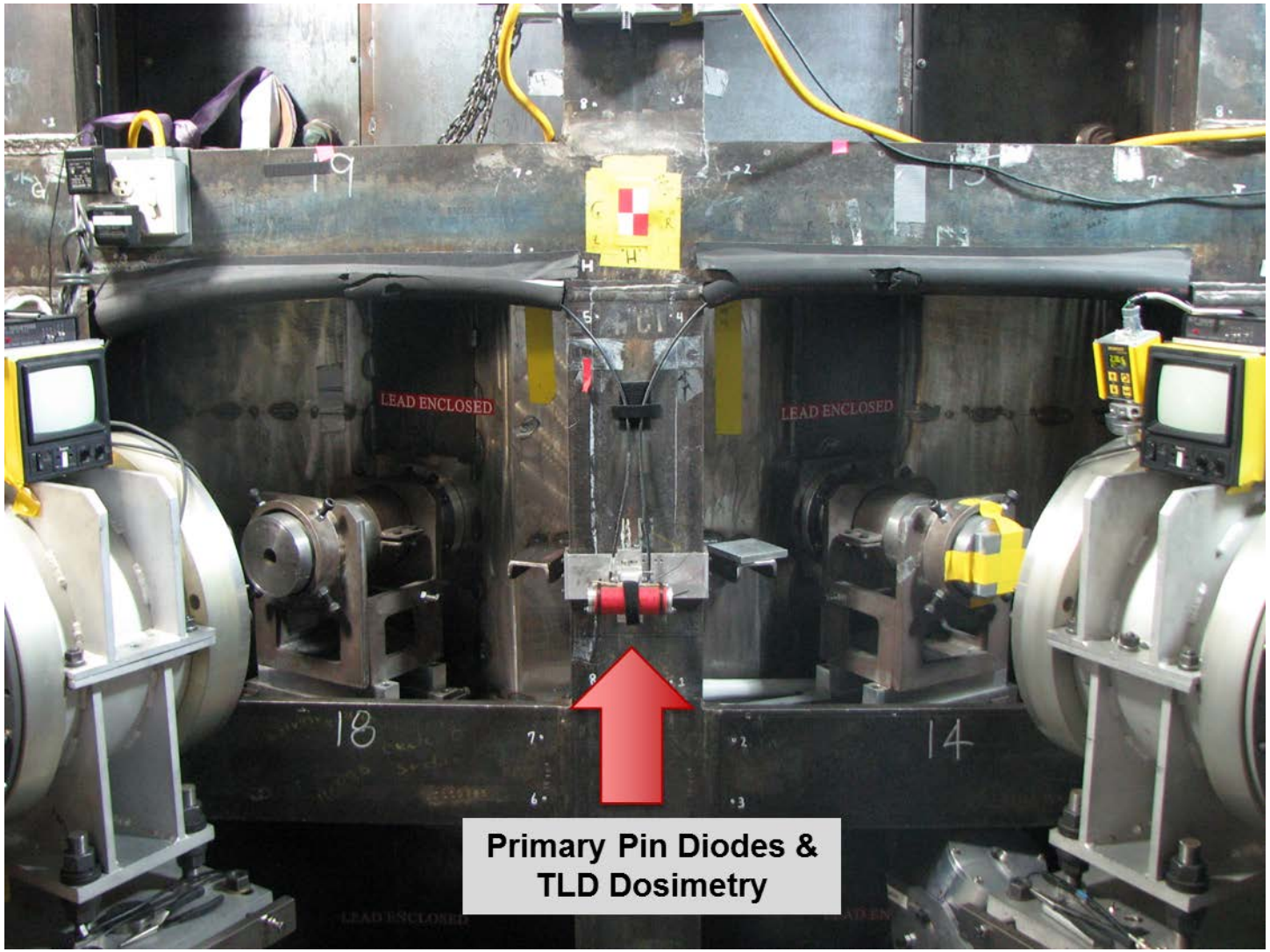
Rod Pinch Diode



TLD Locations



Cygnus Diodes



LiF TLD Calibration

- TLD-100 chips were purchased at a 5% tolerance and individually calibrated by exposure to a Cesium 137 source.
- TLD's 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 was controlled at five minutes in a brass quenching block.
- Exposures were completed at two, 20 and 70 Rads. 20 is used for standard measurements as actual raw exposure is over 10 rads.
- **TLD's are replaced when standard deviation approaches, or exceeds 5%.**

LiF TLD Calibration (Cont.)

TLD Reader - Harshaw Model # 3500		
Cs Exposure (Rads)	**Batch Name (100 TLDs)**	**Calibration Factor 100 TLDs (Rad/nC)**
20	D7	8.44 ± 0.22
70	E7	8.35 ± 0.23
2	F6	7.88 ± 0.19
20	H5	8.32 ± 0.19
20	J5	8.42 ± 0.19
20	K1	7.49 ± 0.19
20	L1	7.64 ± 0.19

Number after batch letter indicates number of calibrations.

LiF TLD Calibration (Cont.)

Cs Exposure (Rads)	Batch Name (100 TLDs)	Calibration Deviation (%)
20	D7	2.62%
70	E7	2.74%
2	F6	2.37%
20	H5	2.33%
20	J5	2.29%
20	K1	*2.52%
20	L1	*2.48%

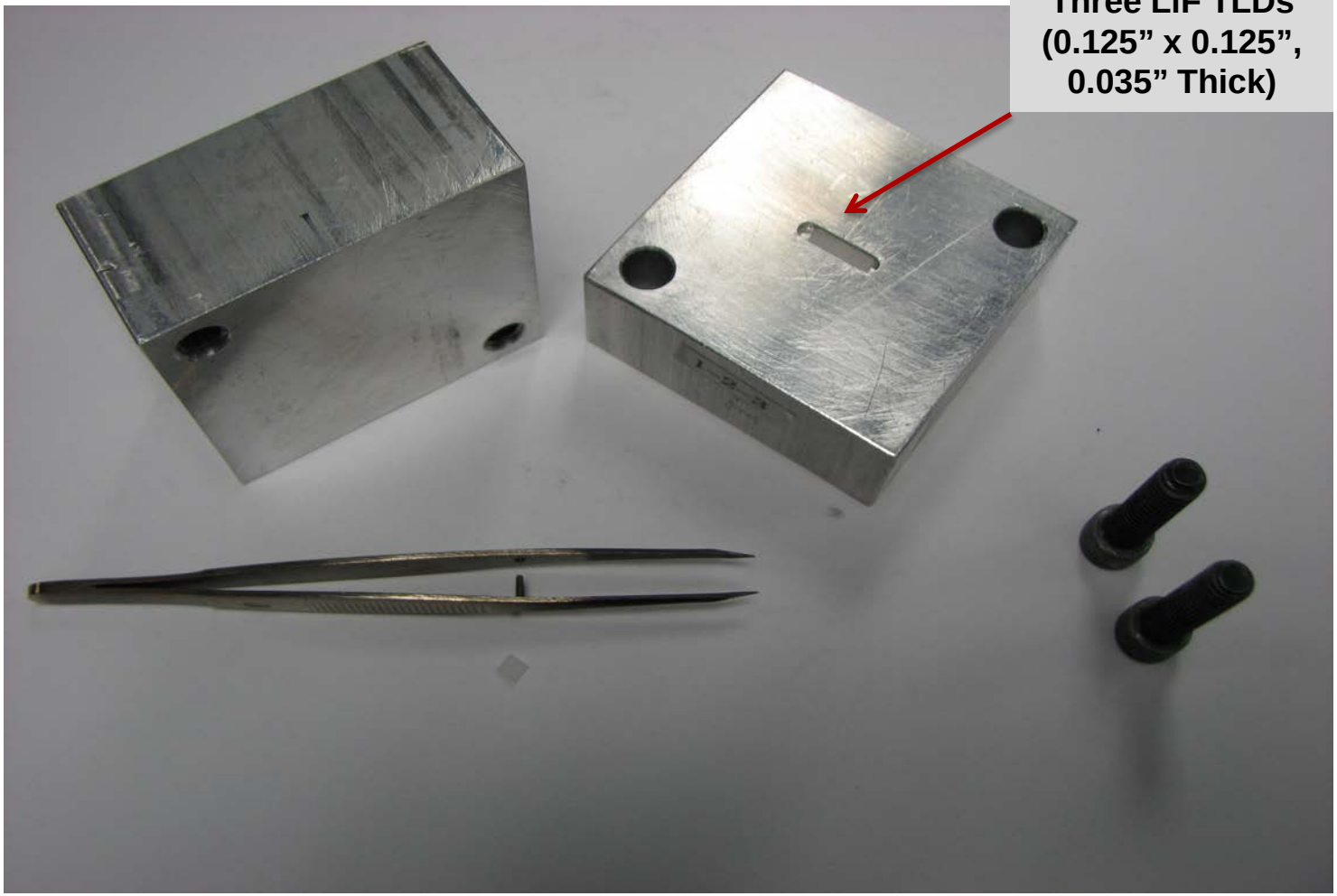
TLD's are replaced when deviation approaches/exceeds 5%.

*Manufacturer matched lots as hand sorting no longer offered.

Long Term Measurements

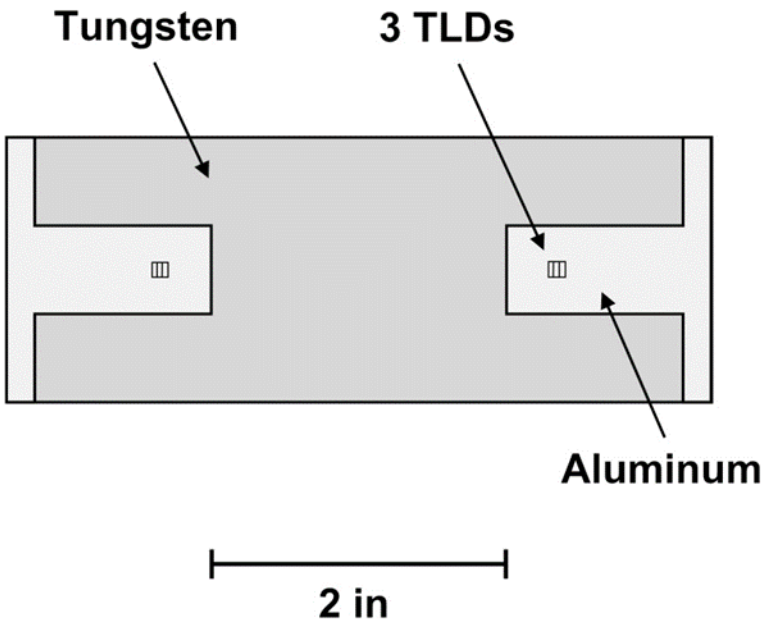
- LiF TLD's have been the primary metric for Cygnus performance since 2009 .
- A standard fielding block was used for single point dose measurements. This hardware, shown on next slide, consisted of three side-by-side LiF TLD's shielded by one inch of aluminum on all sides.
- The one-inch aluminum shielding is defined as a standard for the class of radiography tests executed in our facility.
- A Tungsten collimated center location was added to monitor performance of staggered and dual shots.

Standard TLD Hardware

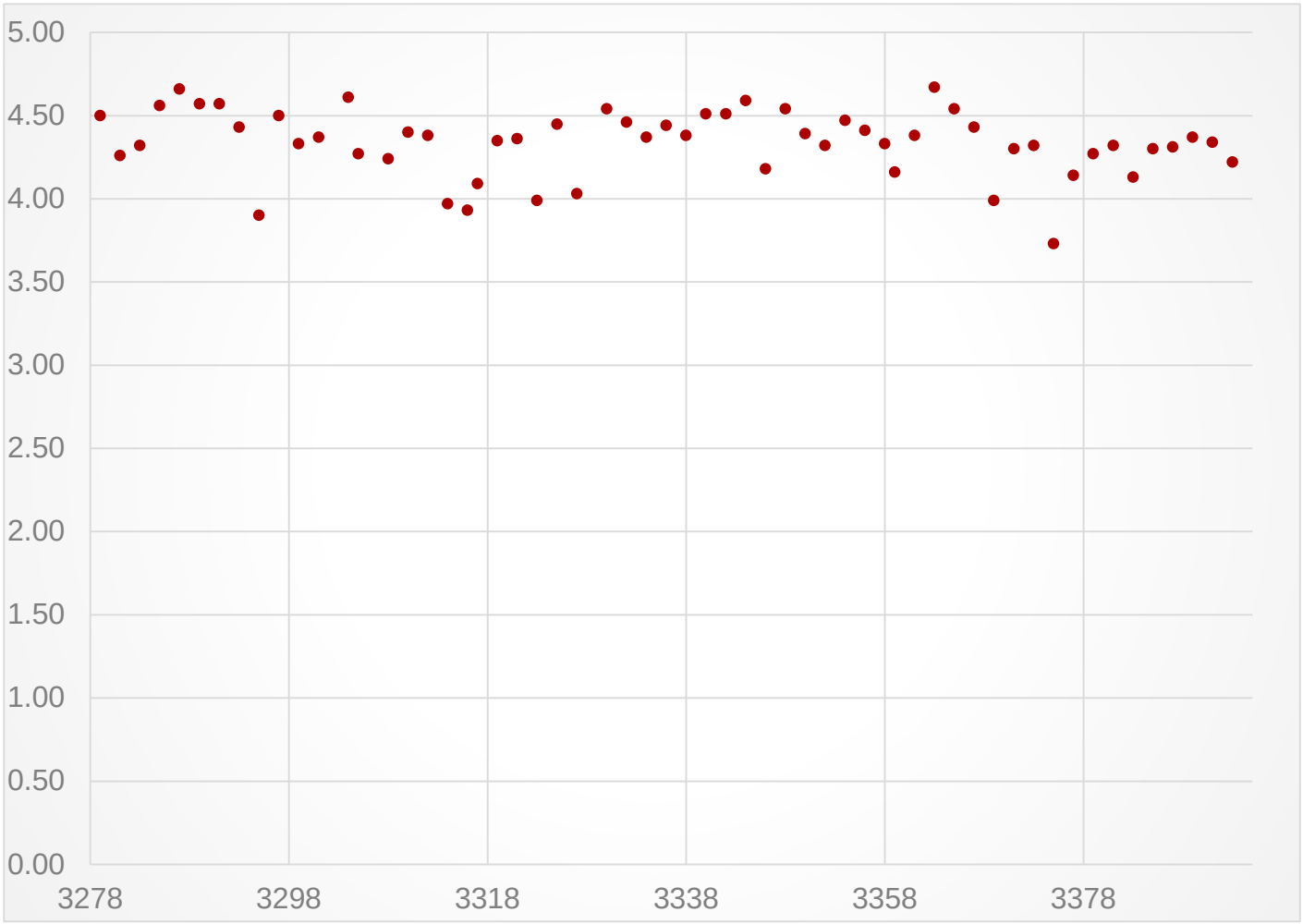


LiF TLD’s are 0.125” x 0.125” x 0.030”

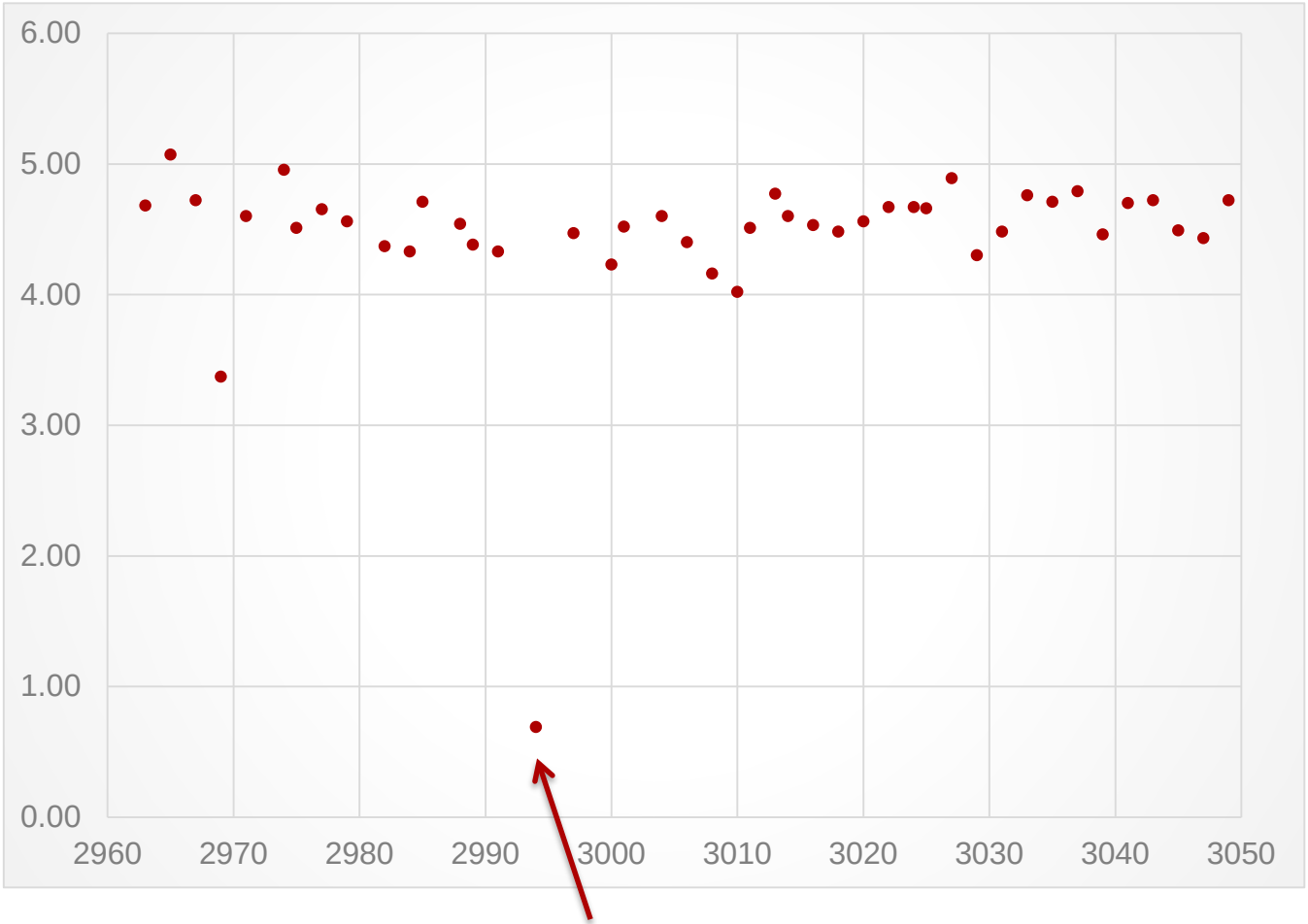
Center TLD Fixture



Eurydice Series - Cygnus 1

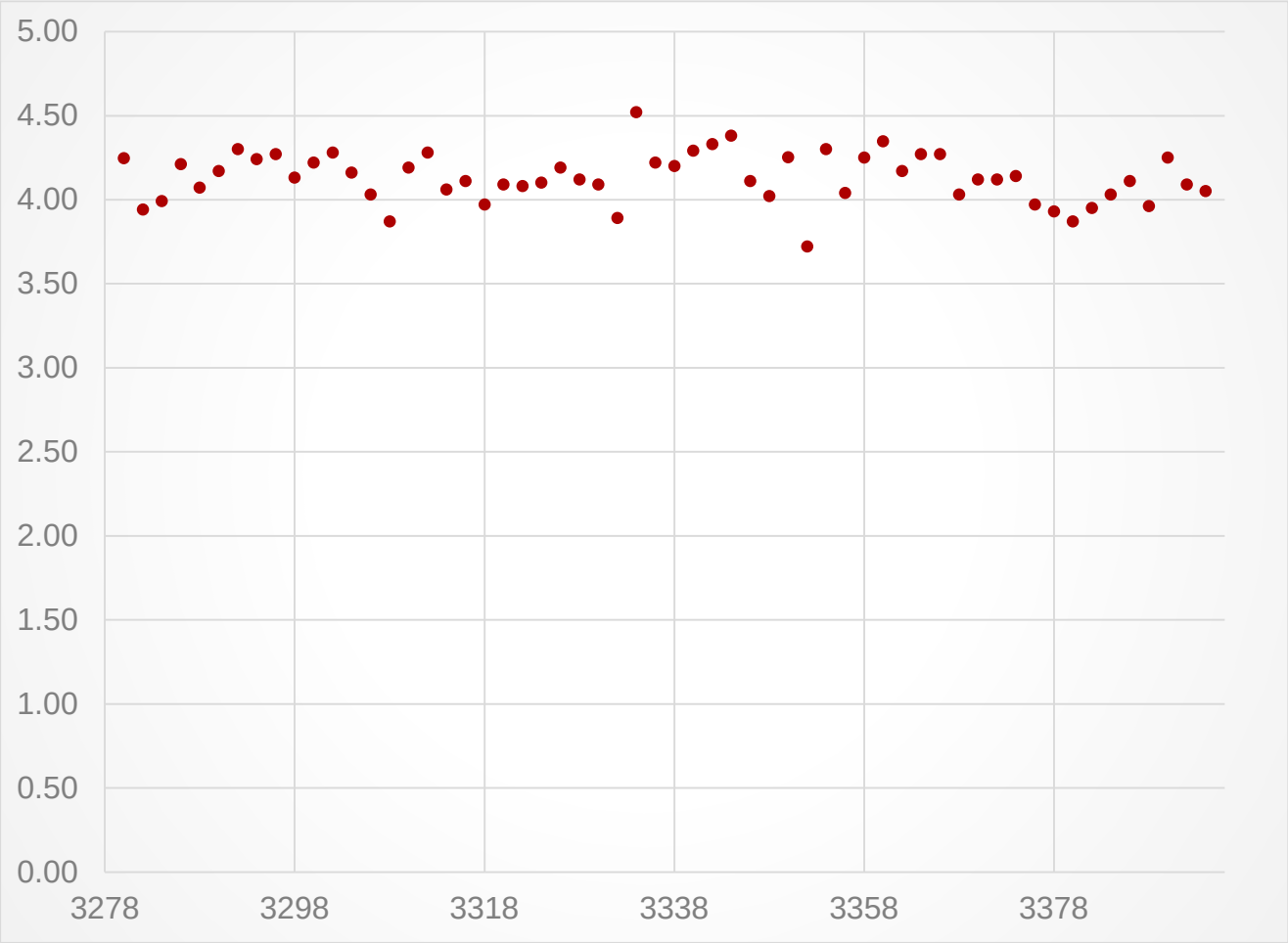


Orpheus Series – Cygnus 1

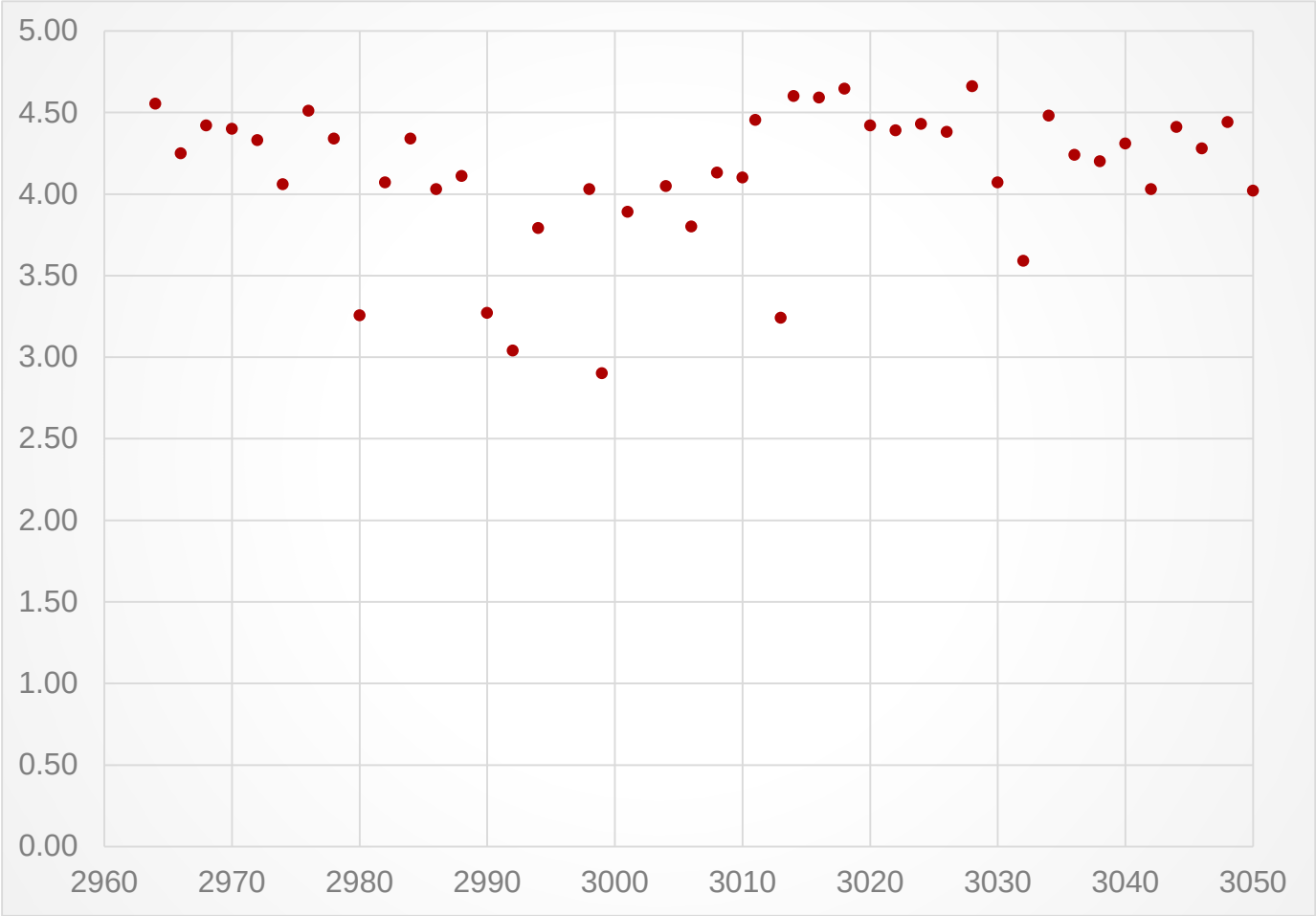


Shot 2994 had broken torlon rod shorting water coax!

Eurydice Series – Cygnus 2



Orpheus Series – Cygnus 2



Multiple shots below 3.6 rads likely due to improper setting of Pre-Pulse Suppression Switch gap (Short vs. 0.125”)

Pin Diode to TLD Comparison

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Cygnus 1

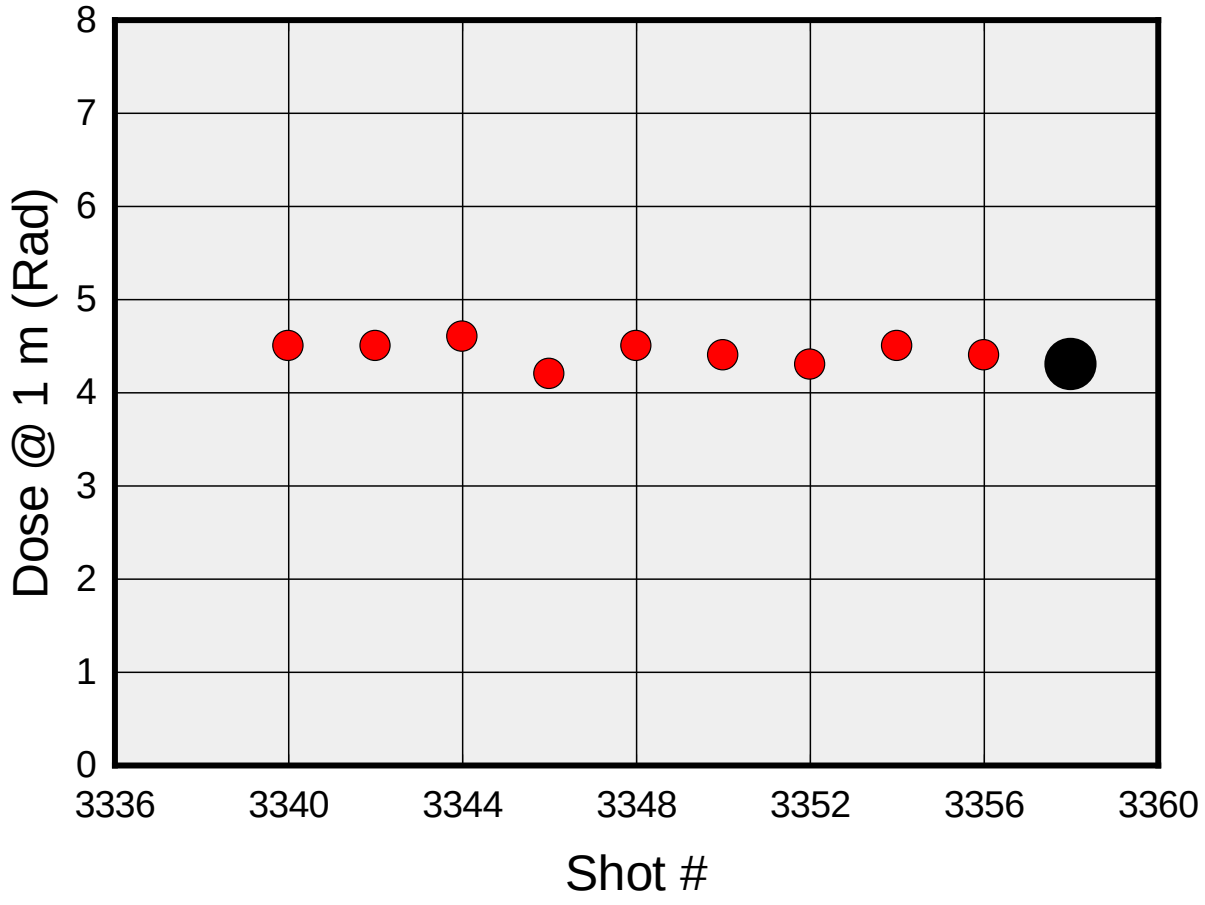
Shot #	Center TLD (Rad)	Center Pin (Rad)
1956	4.28	4.1
1958	4.33	4.1
1960	4.76	4.7
1962	4.23	4.2
1964	4.54	4.5
1966	4.32	4.0
1968	4.19	3.9
1970	4.35	4.2
AVG	**4.42**	**4.32**

Cygnus 2

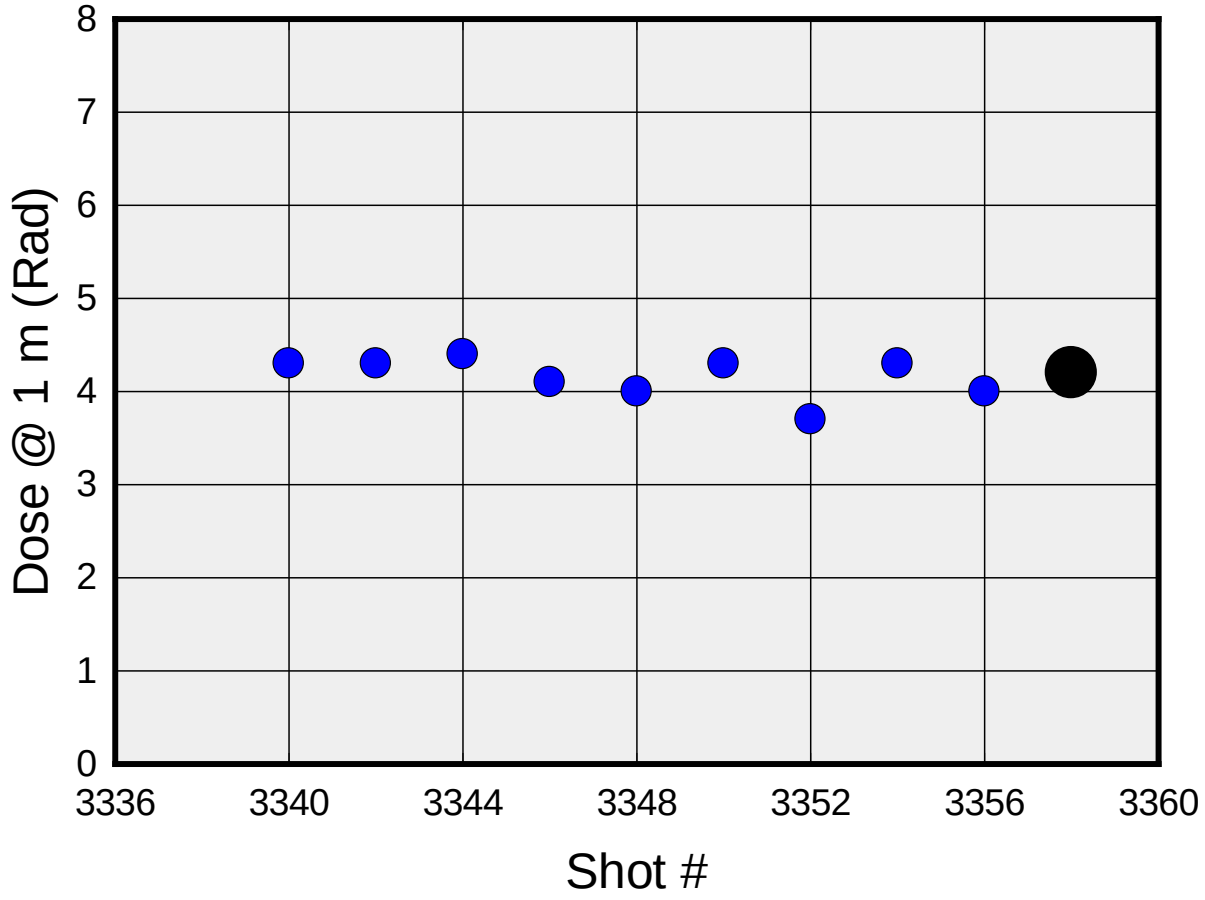
Shot #	Center TLD (Rad)	Center Pin (Rad)
1956	4.22	4.1
1958	4.27	4.5
1960	4.06	4.0
1962	3.90	3.8
1964	4.27	4.1
1966	4.20	4.3
1968	4.06	3.9
1970	4.34	4.4
AVG	**4.16**	**4.21**

Data in red indicates greater than 100 mRem difference!

Cygnus 1 Dose (Shot 3358 = Eurydice, 4.33 Rads)



Cygnus 2 Dose (Shot 3358 = Eurydice, 4.25 Rads)



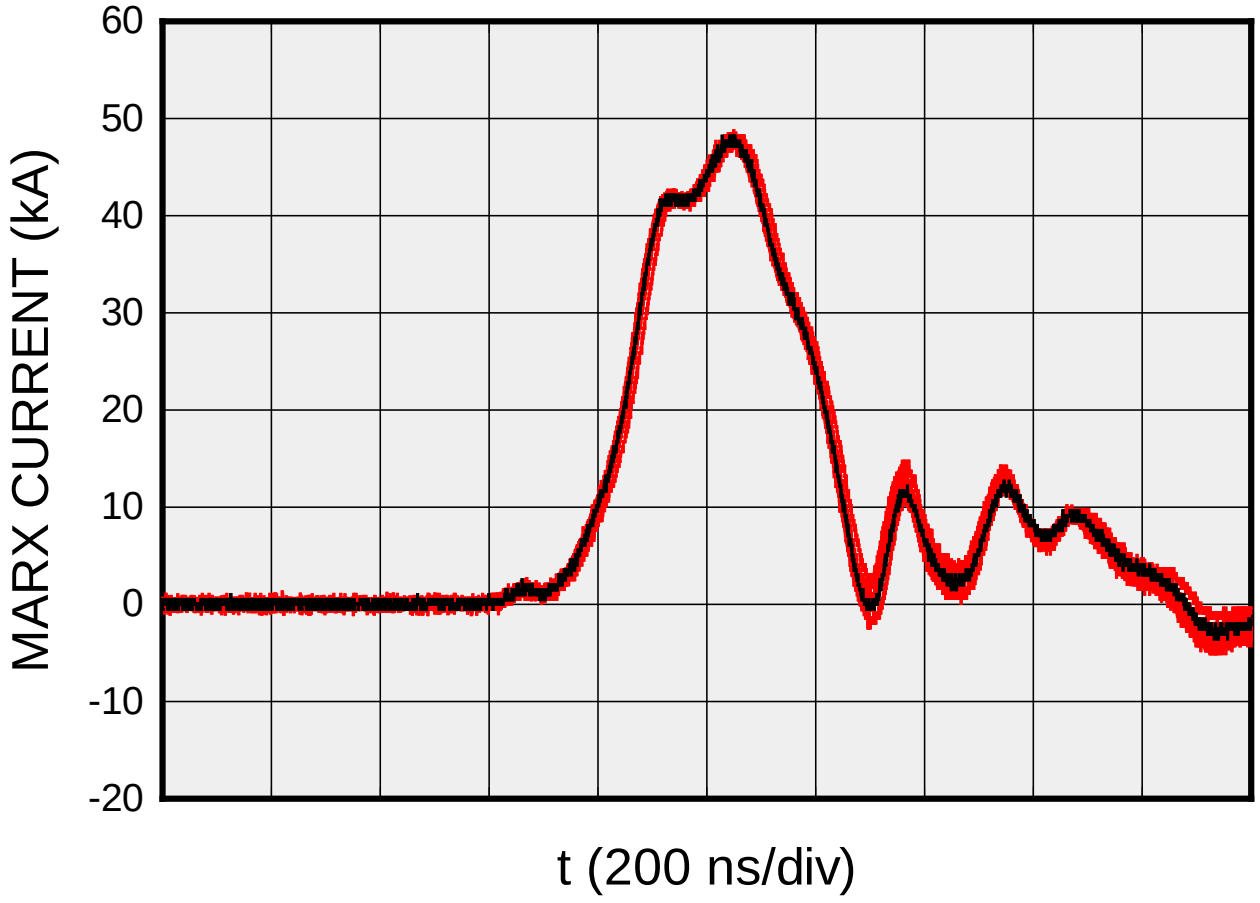
Marx and Diode Current Monitors

- The primary diagnostics used in conjunction with the LiF TLD's are current monitors in the Marx and Diode.
- A ten shot overlay of these signals are presented for each experimental series.
- Diode current traces are time shifted to correct for jitter in the self-break water switch.

Cygnus 1 – Marx Current

(10 Shot Overlay – Eurydice Trace is Black)

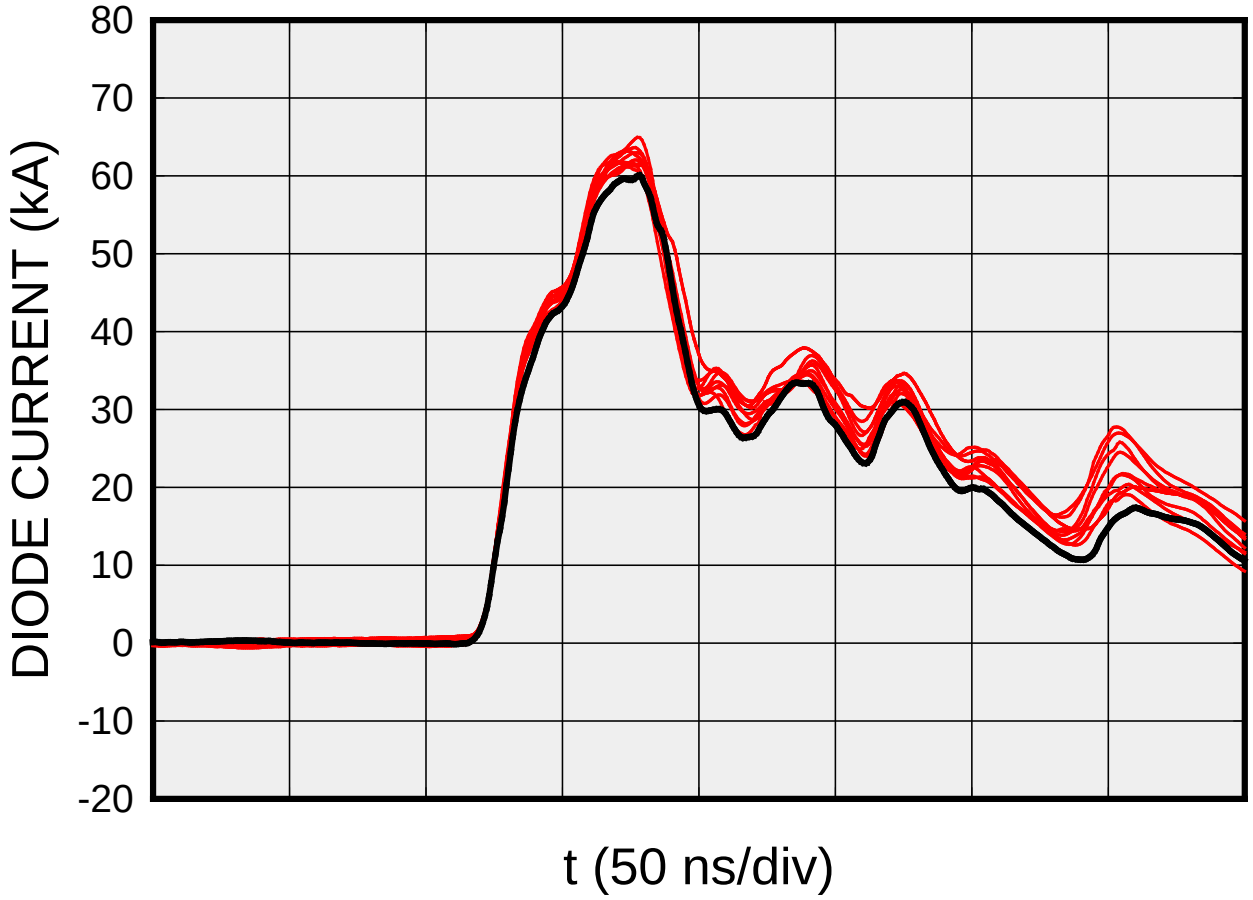
Shot #'s: 3340 3342 3344 3346 3348 3350 3352 3354 3356 3358



Cygnus 1 – Diode Current (Time Shifted)

(10 Shot Overlay – Eurydice Trace is Black)

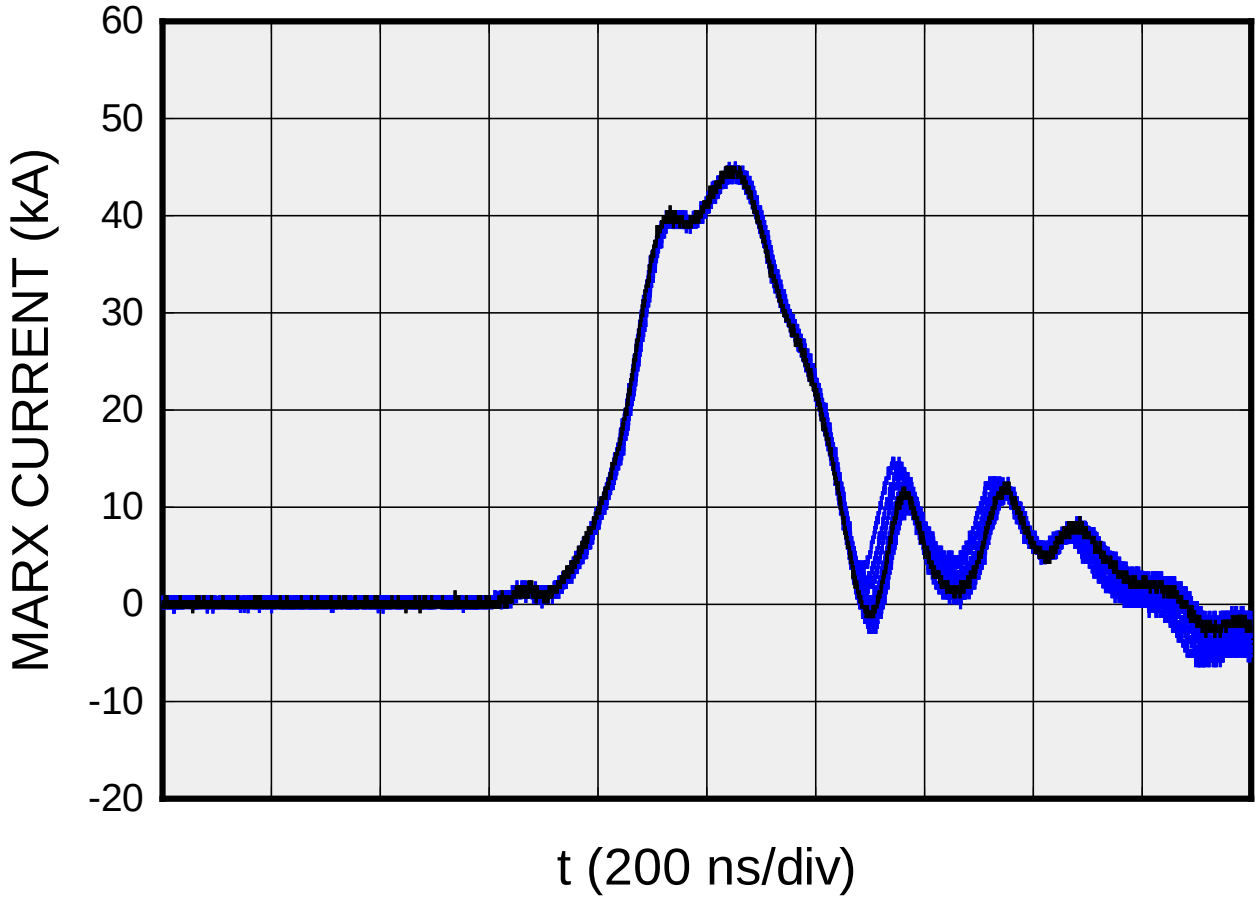
Shot #'s: 3340 3342 3344 3346 3348 3350 3352 3354 3356 3358



Cygnus 2 – Marx Current

(10 Shot Overlay – Eurydice Trace is Black)

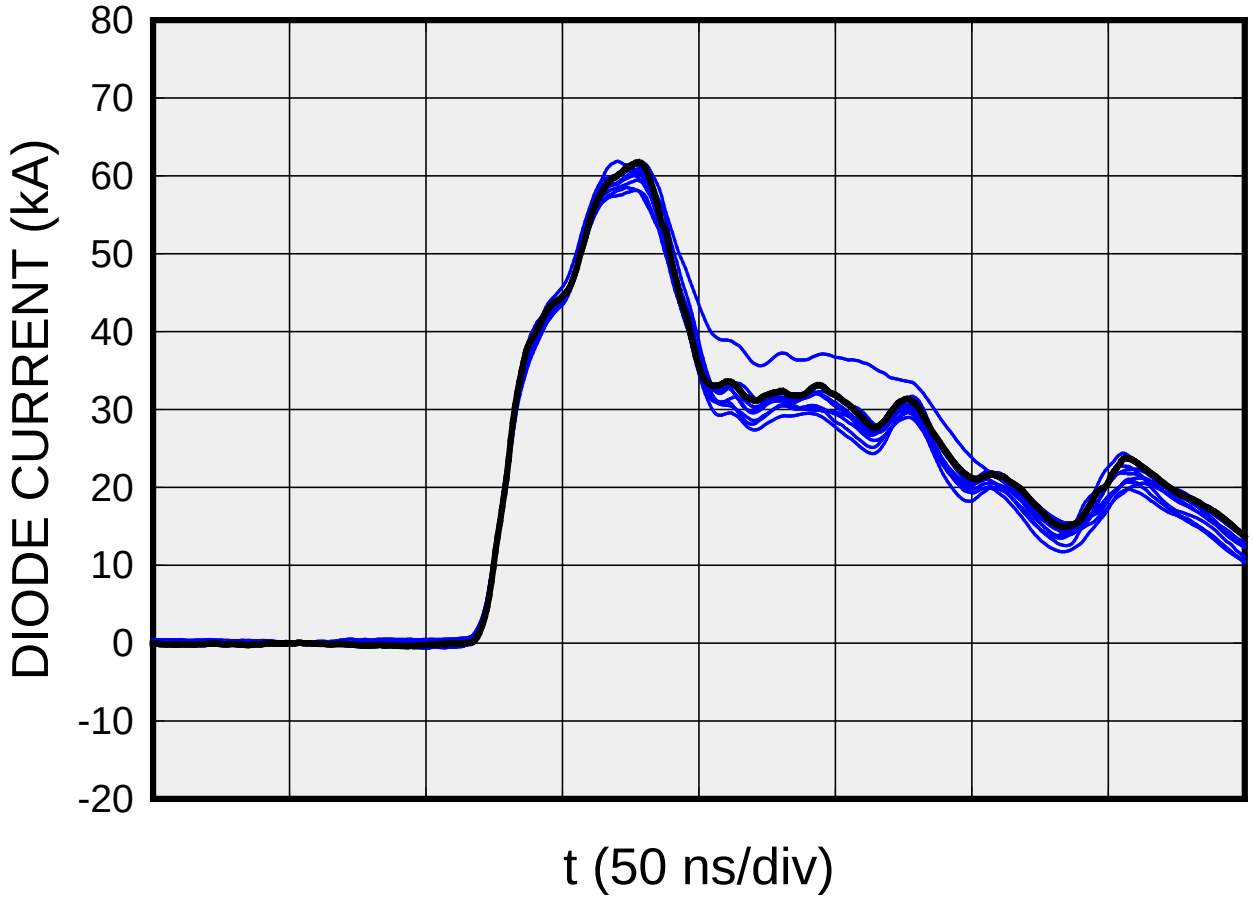
Shot #'s: 3340 3342 3344 3346 3348 3350 3352 3354 3356 3358



Cygnus 2 – Diode Current (Time Shifted)

(10 Shot Overlay – Eurydice Trace is Black)

Shot #'s: 3340 3342 3344 3346 3348 3350 3352 3354 3356 3358



Summary of Cygnus Performance

- Shot-to-shot reproducibility of x-ray parameters is an important demonstration that source quality is consistent and that good radiography performance will likely be delivered.
- The reproducibility of the LiF TLD measurements has ensured they stay our main diagnostic, along with Marx Voltage and Diode Current diagnostics. The pin diodes are a quick look after the shots, but reproducibility has relegated them to a secondary diagnostic as seen in the presented data.
- The correlation between precision calibration methods and reliability and reproducibility has proven to be an accurate metric for measuring Cygnus performance.