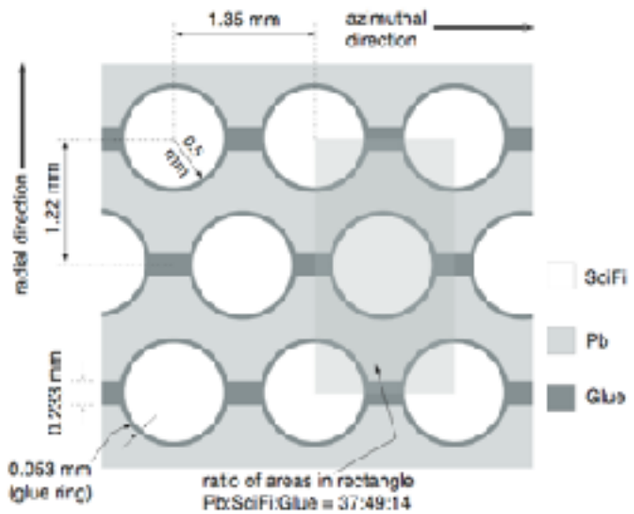
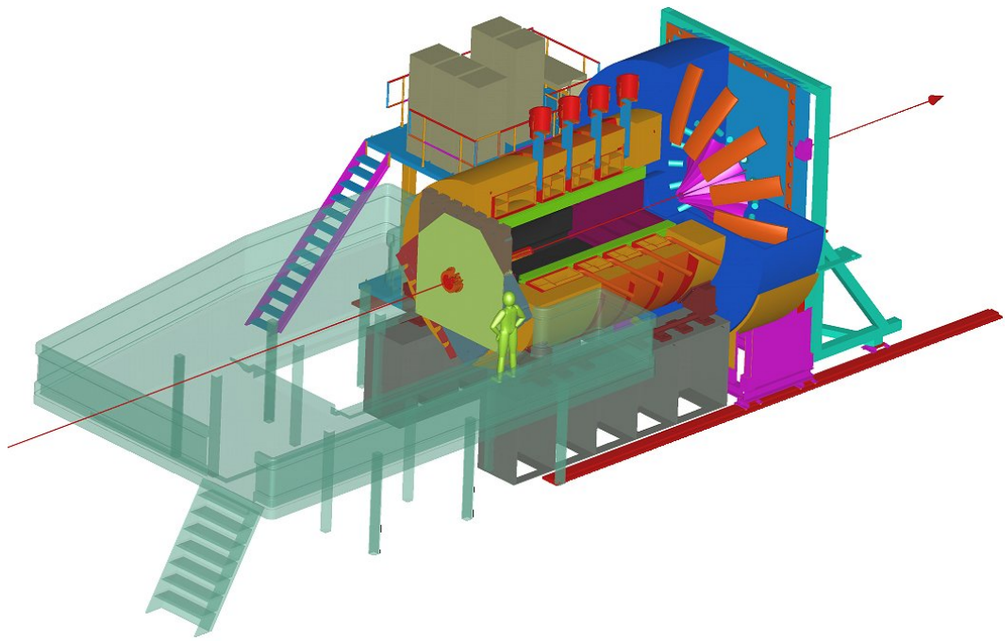




SciFi Review for ePIC/bECAL

GlueX-BCAL Pre-Brief Material

Z. Papandreou

September 6, 2023

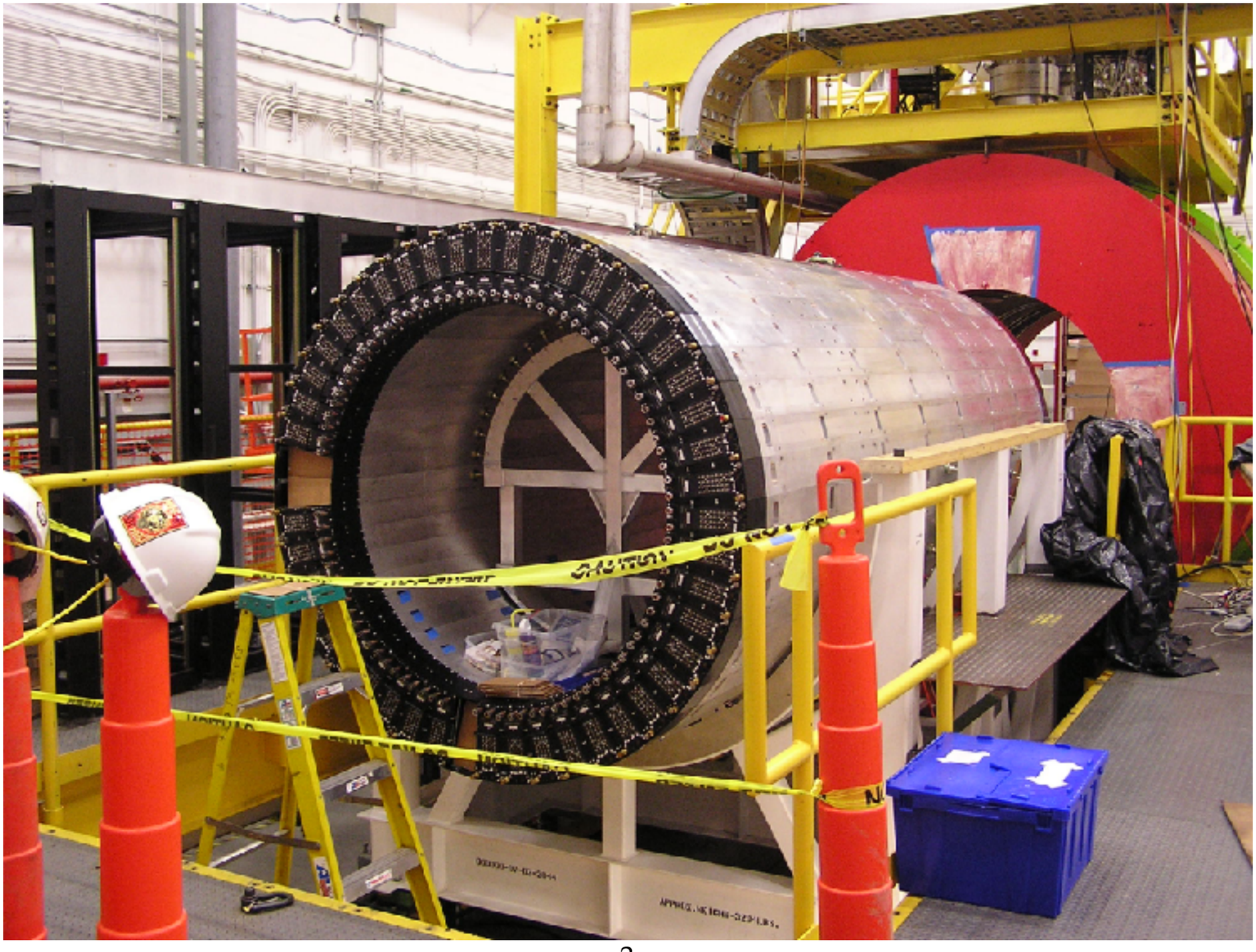
University of Regina | Faculty of Science

NSERC CRSNG

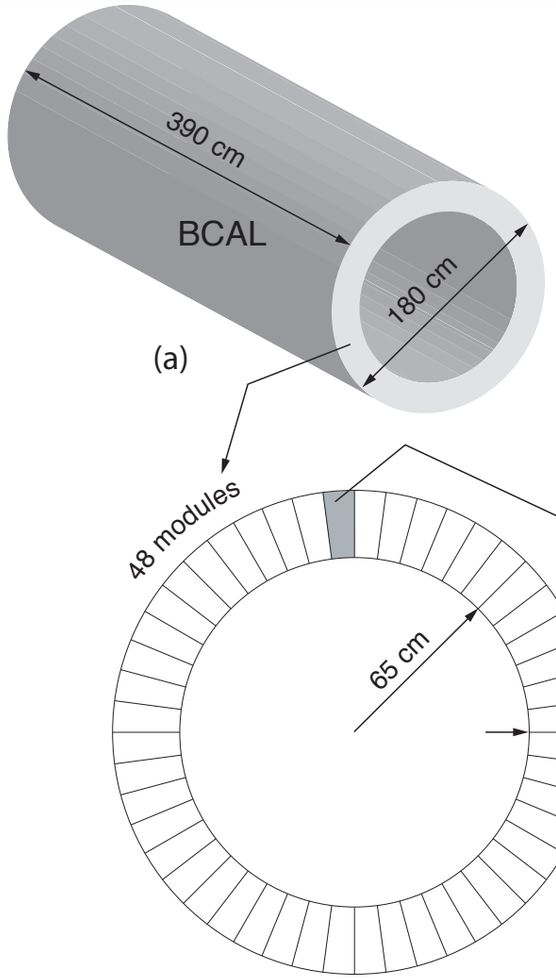
Overview

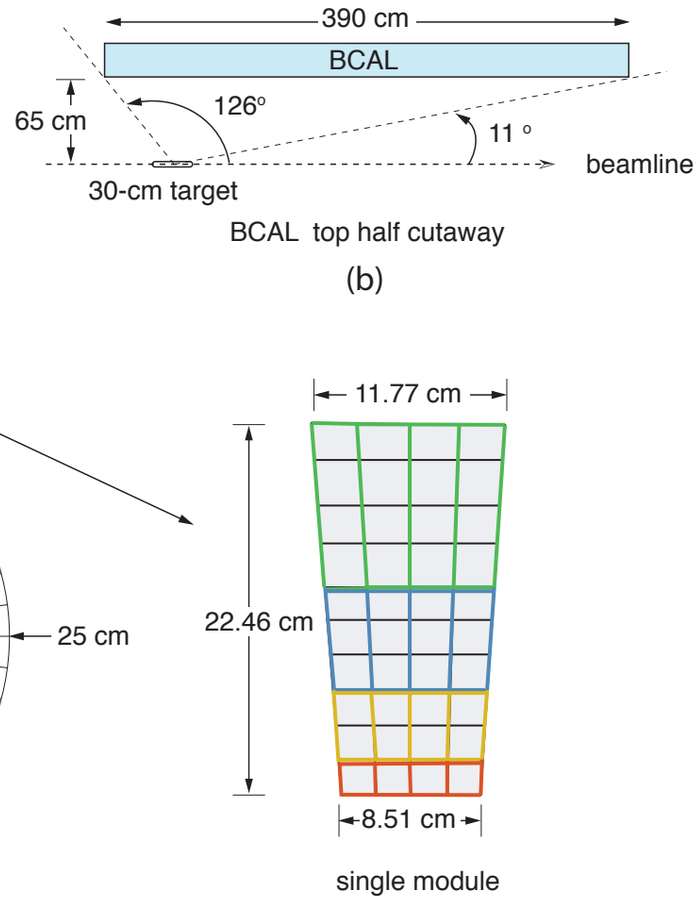
- GlueX BCAL description
- GlueX BCAL QA
  - fiber testing
  - PbSciFi construction
  - documentation
- Successful! (modelled after KLOE EMCal)

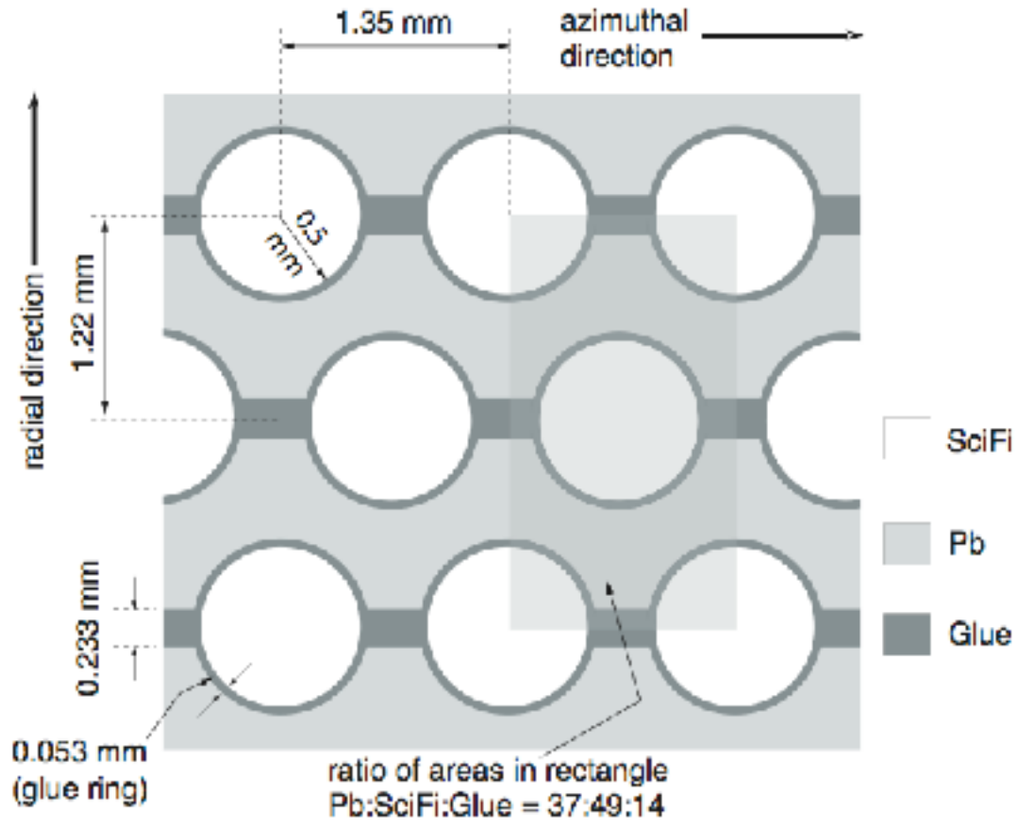
The GlueX BCAL



The GlueX BCAL







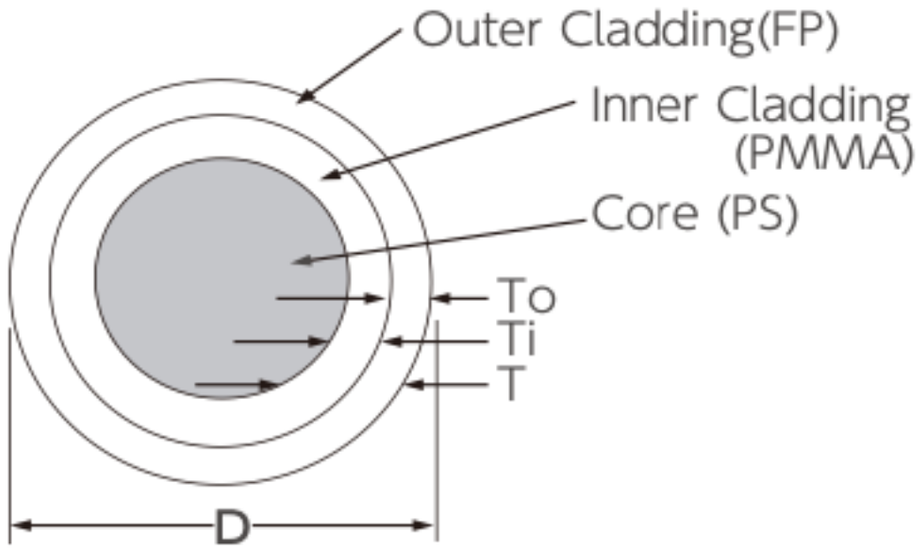
- 48 azimuthal sections (modules)
- Reconstructs γ showers from π^0 and η decays
- Provides timing information (neutrals/charged)
- With the CDC it provides charged particle PID

- Sampling calorimeter (10% sampling fraction)
- 750,000 double-clad scintillating fibers
- BCAL: 23 tonnes

Kuraray SCSF-78MJ

GlueX BCAL

Multi-Cladding (M)



Cladding Thickness[2]: T=2%(To)+2%(Ti)
=4% of D ← in 2009 6% of D

Numerical Aperture : NA=0.72

Trapping Efficiency : 5.4%

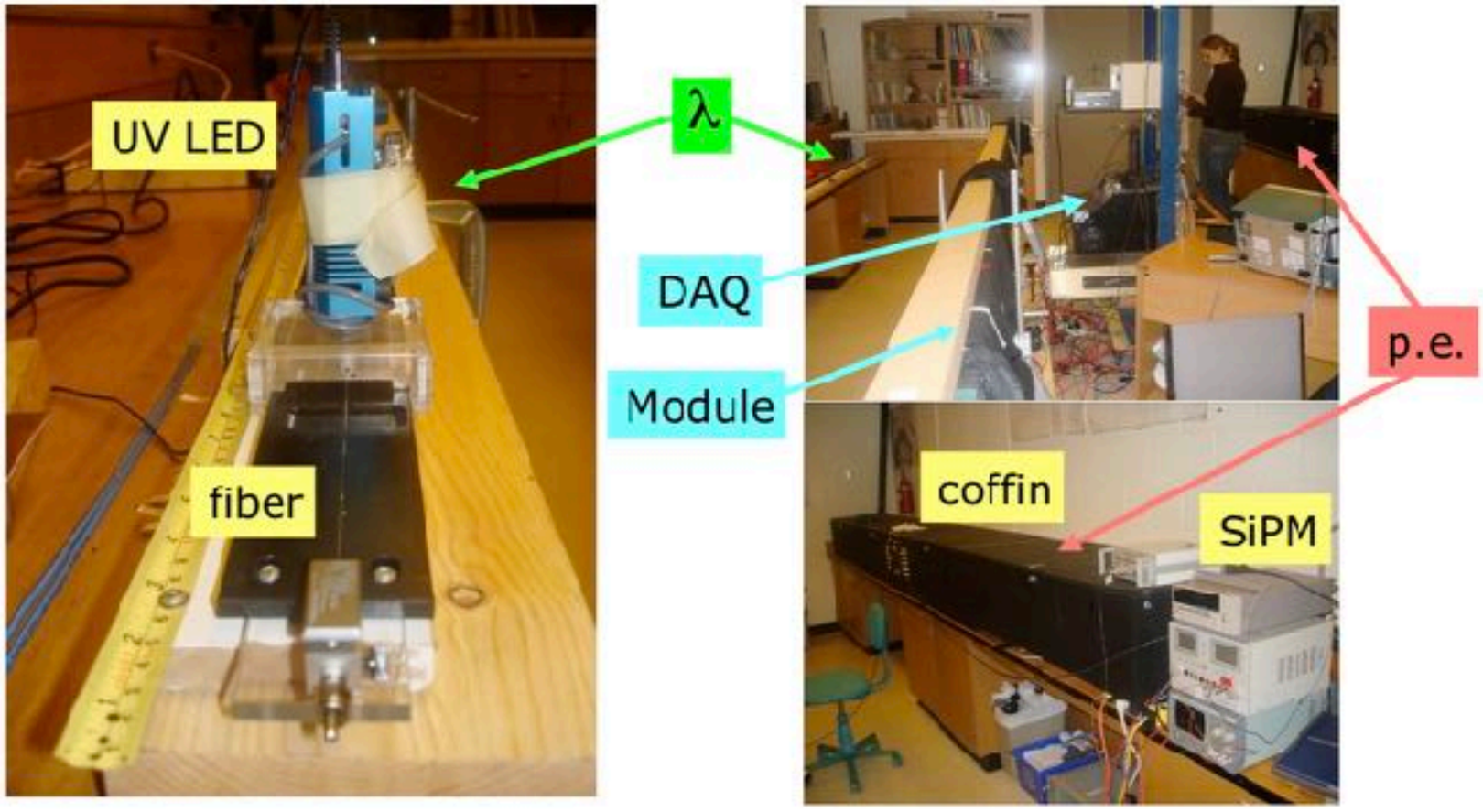
Formulations[1]

Description	Emission Color	Emission Spectra	Emission Peak[nm]	Decay Time [ns]	Att.Leng.[2] [m]	Characteristics
SCSF-78	blue	See the following figure	450	2.8	>4.0	Long Att. Length and High Light Yield
SCSF-81	blue		437	2.4	>3.5	Long Attenuation Length
SCSF-3HF(1500)	green		530	7	>4.5	3HF formulation for Radiation Hardness

1) Test fibers are Non-S type, 1mmϕ.
2) Measured by using bialkali PMT and UV light(254nm).
Quality control is made by another measurement of the transmission loss every batch.

Fibre Testing lab (Reactivated in summer 2023)

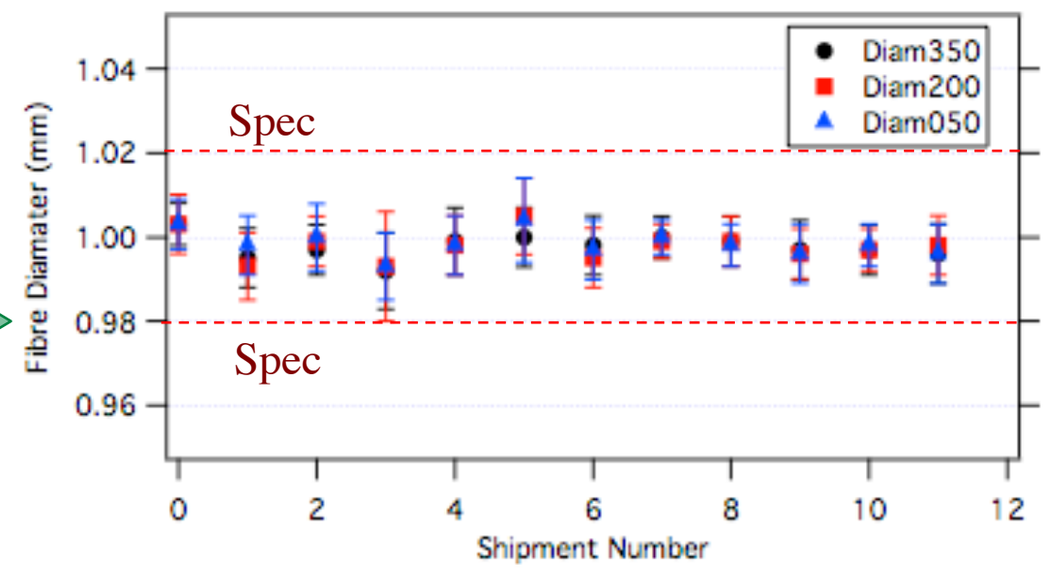
- First article
  - Regina data
  - JLab data
  - GlueX-doc-1317
  - Bench Reference
- Production (Regina)
  - ☑ Condition/packaging
  - ☑ Diameter
  - ☑ Attenuation length: LED, photodiode current
  - ☑ N_{pe} at 200cm: ^{90}Sr, PMT, external trigger



BCAL Construction QC/QA: Fibres

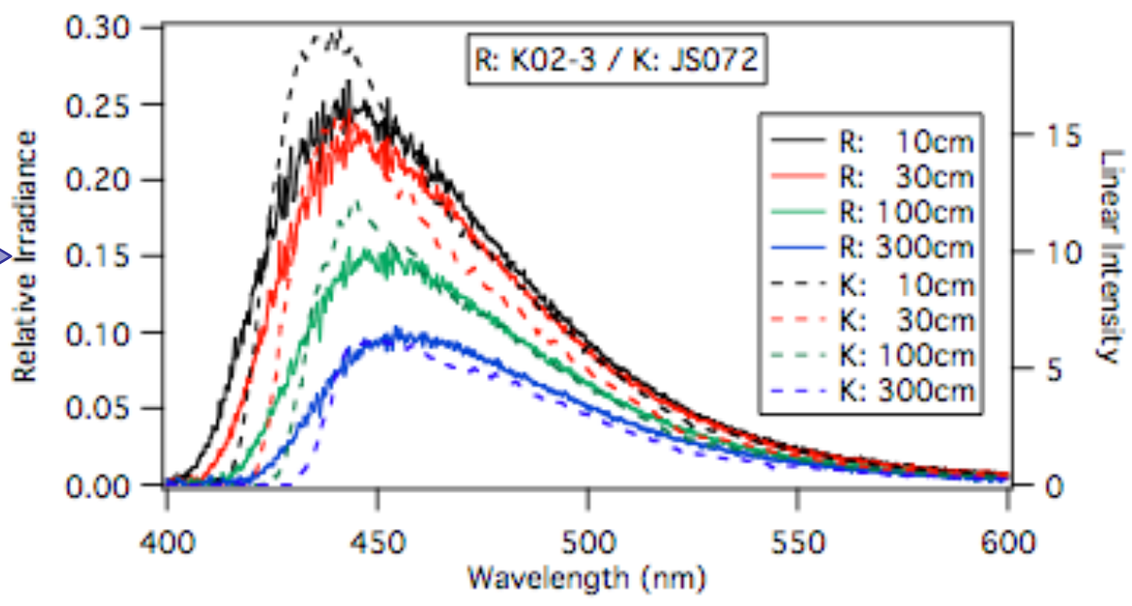
780,000 fibres!

- Kuraray SCSF-78MJ (blue-green); selected in late 2008
- diameters: within specs

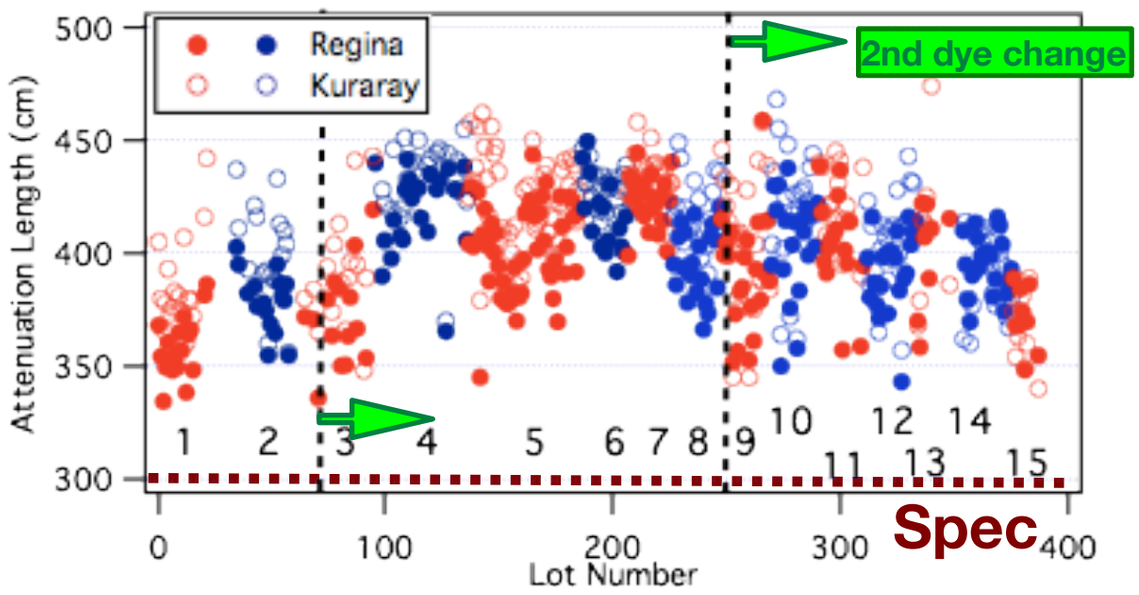


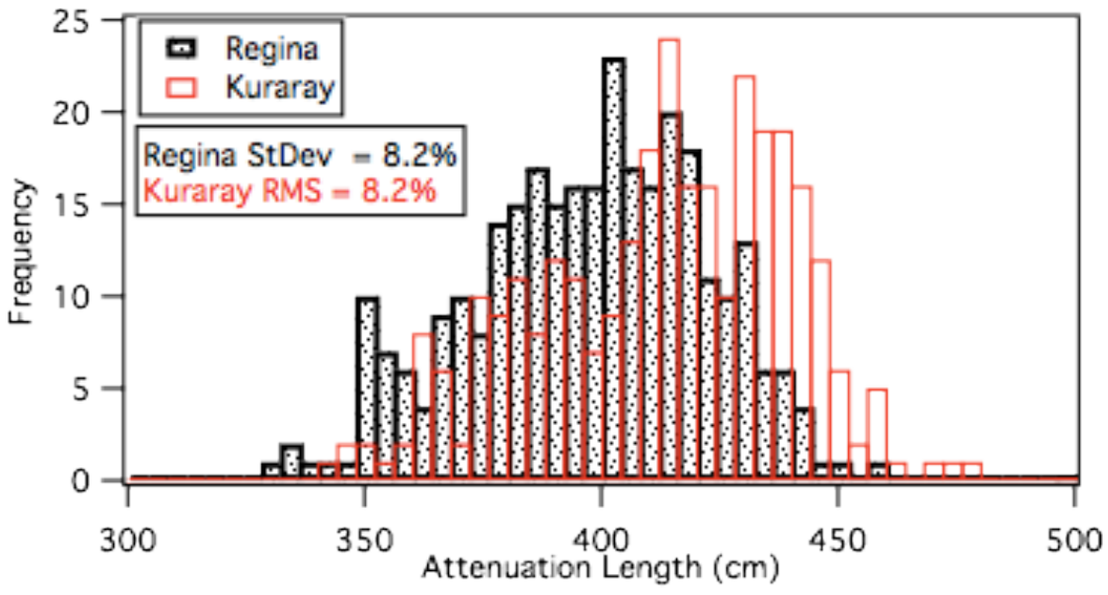
- Spectra measured at Regina qualitatively agree with Kuraray's

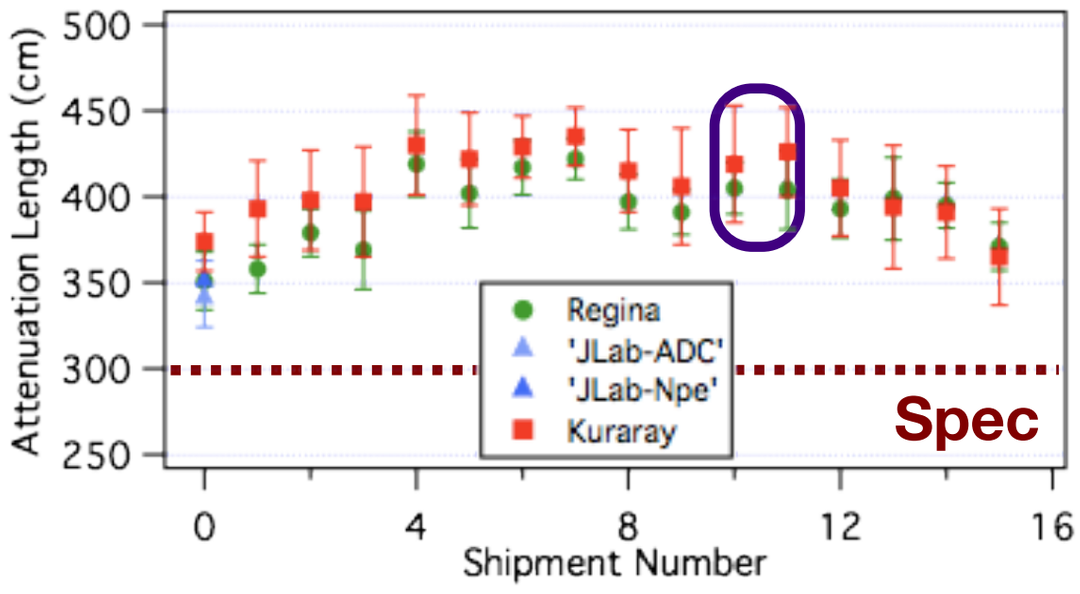
- integrals are close, but shapes are different; response is acceptable and scales by distance in a similar fashion

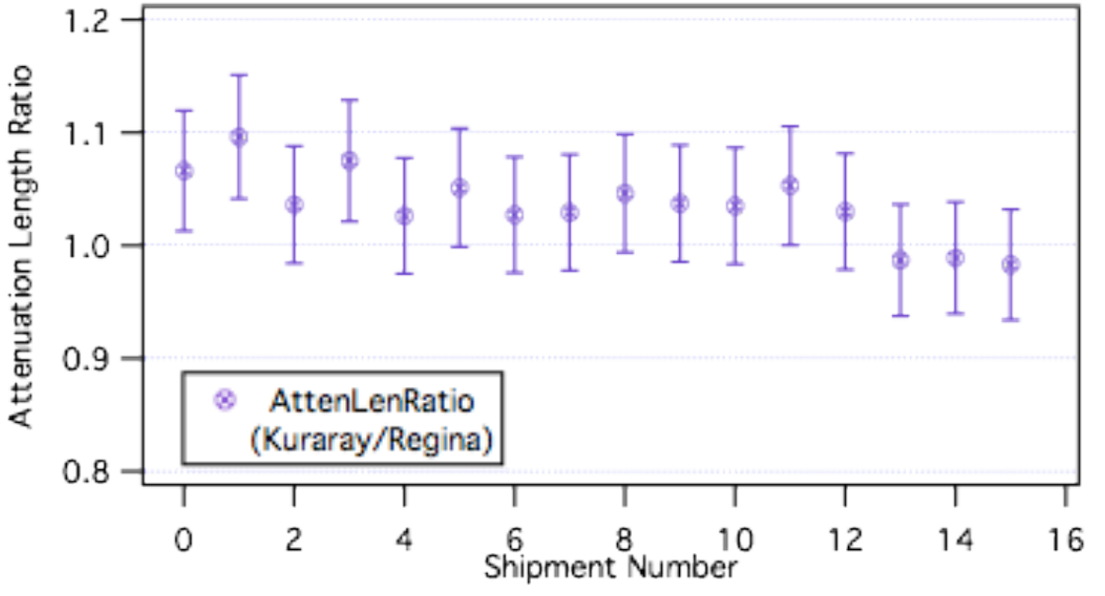


Fibre Attenuation Length





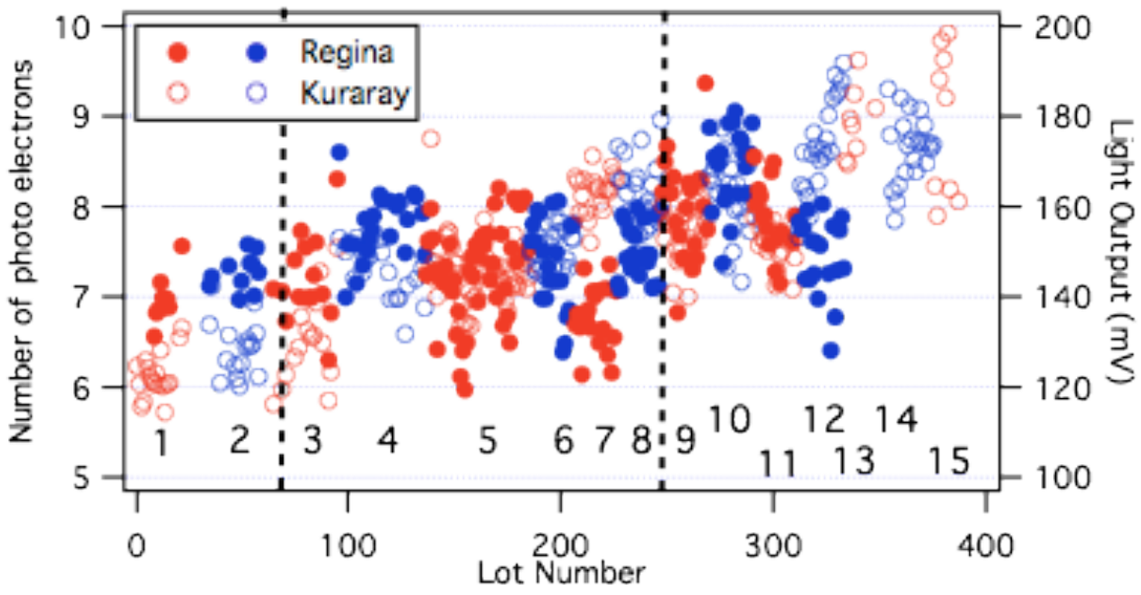


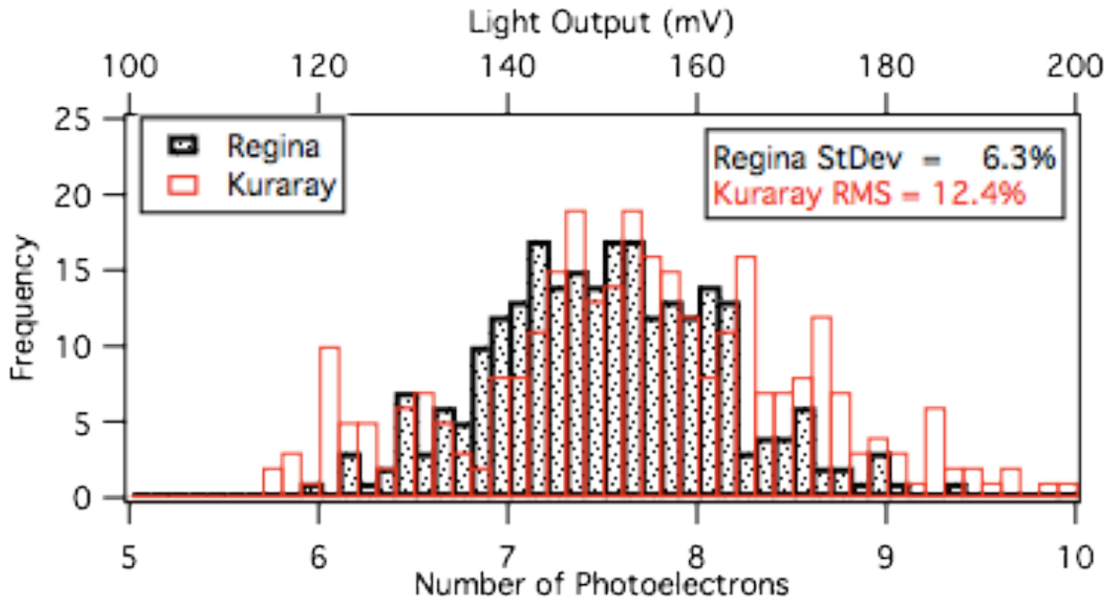


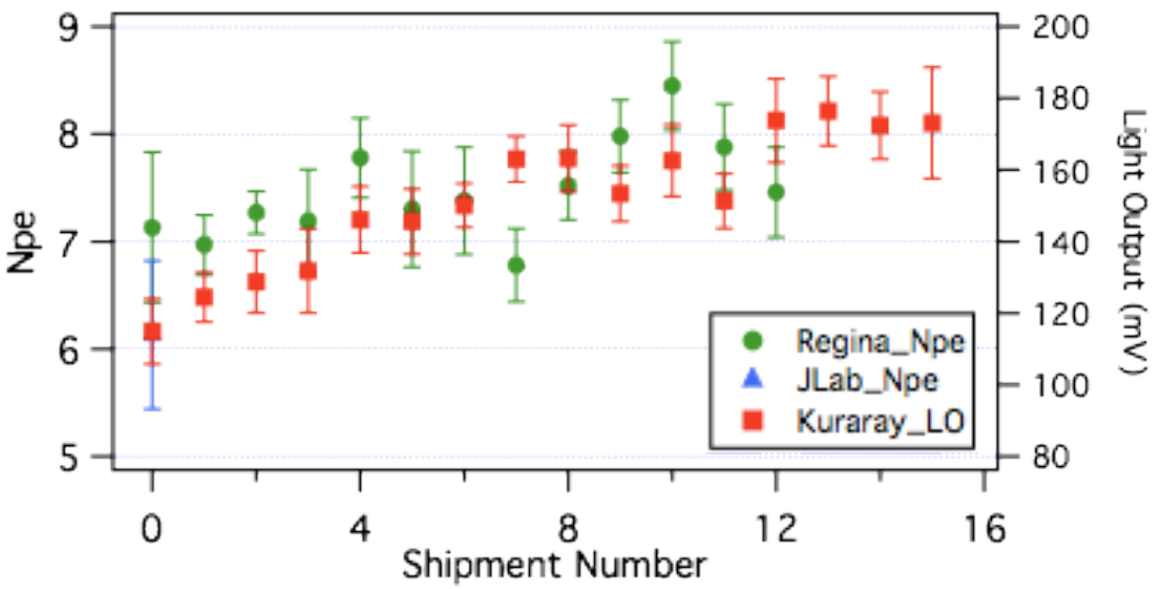
Per lot and shipment change; but Kuraray and Regina track

... and fibres meet specs

Fibre Light Output







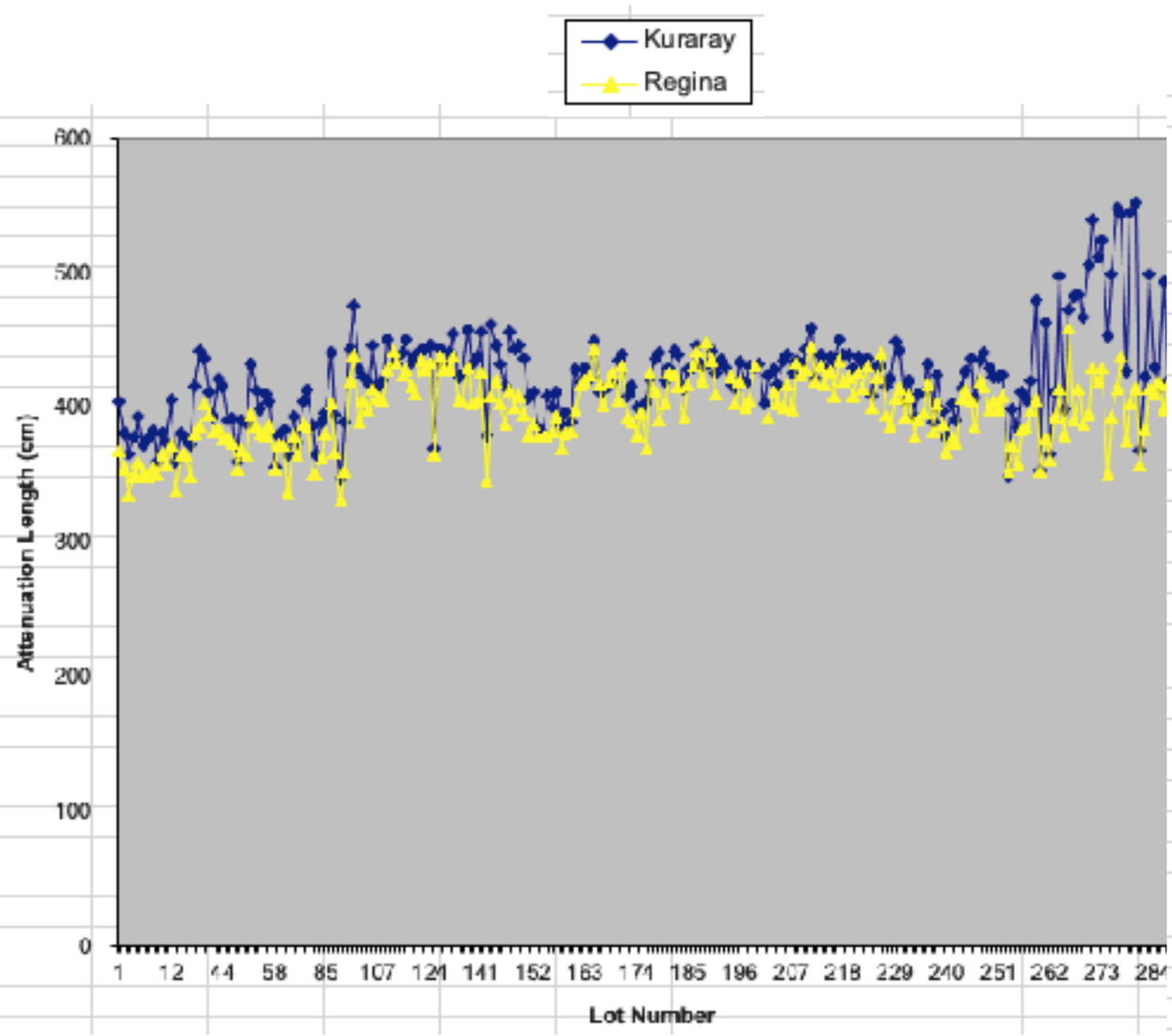
Methods are very different:

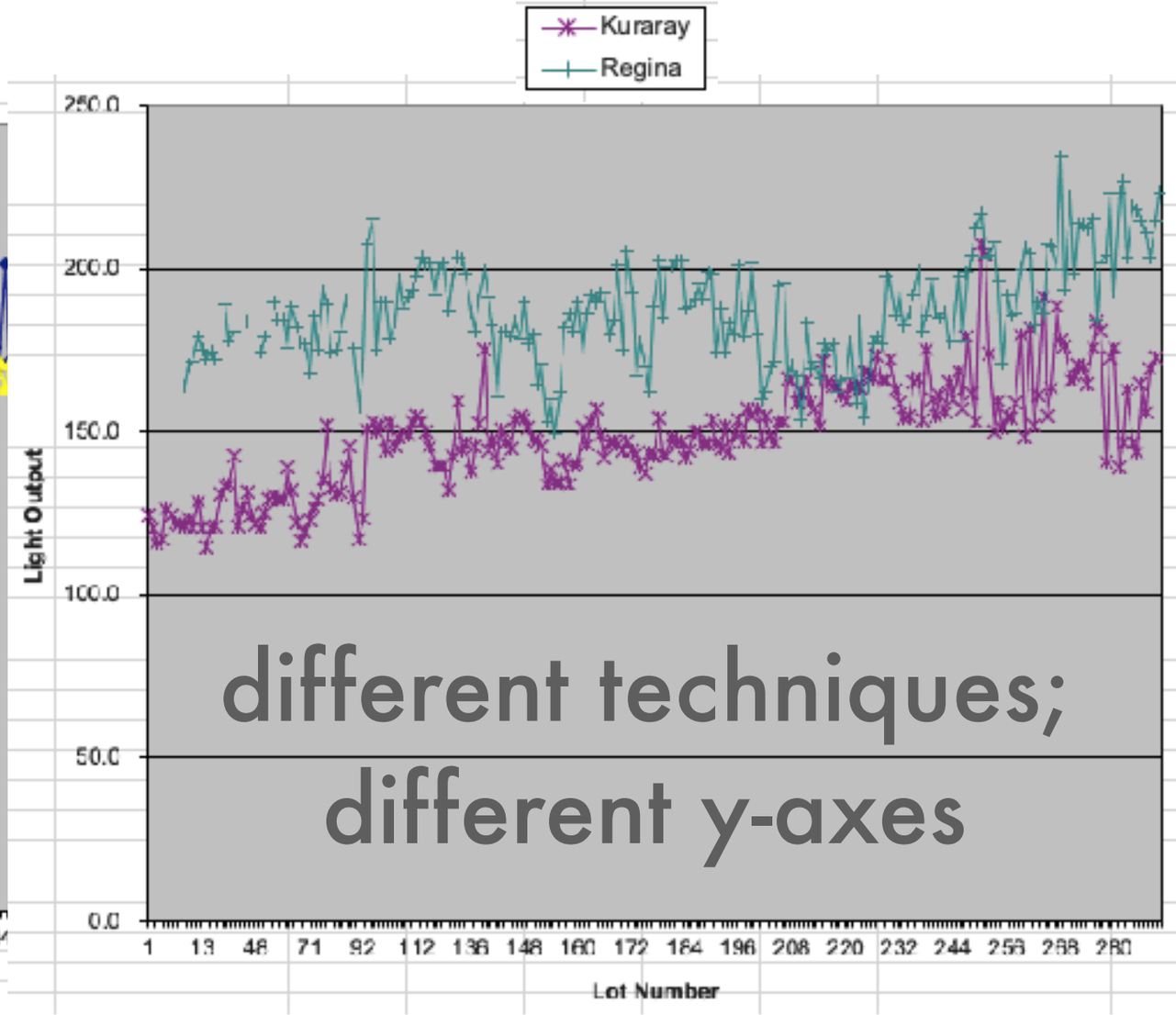
- K: scope
- R: Npe w. 90Sr

Per lot and shipment change; Kuraray and Regina roughly track

... and fibres meet specs

QA & QC - by Lot number





different techniques;
different y-axes

Testing & Construction

- Detailed step-by-step manuals on construction and fiber testing (1% of fibers, randomly selected)
- Eight different check lists
- Detailed spread sheets for tracking fibers, lead, epoxy, builds & module height
- Inspections & QA: in reports
- Condition/packaging/visual inspection/photos
- Diameter at 3 locations along each fiber
- Wavelength spectrum measured
- Attenuation length and light output measured

BCAL Module Construction Procedures

J. Chan and D. Kolybaba

WRITTEN: JUNE 22, 2010 → VERSION 1 (PRODUCTION MODULES)

Proper safety procedures, clothing, equipment, and materials must be used during the entire construction and all measuring equipment must be properly calibrated before use.

Preparing Base Plate

1. Clean the bottom of base plate with a water soluble degreaser followed by ethanol.
2. Check that the inserts (two sets of four) have been properly installed. Position is checked at Ross Machine Shop using the gauges that the UofR has provided.
3. Using a calibrated tape measure check the position of the bolt hole pockets, and report only out of specification measurements on the traveller for that specific base plate.
4. Measure the width of each bolt hole pocket with calibrated digital callipers at the top of the draft, and report only out of specification measurements on the traveller for that specific base plate.

CONSTRUCTION STATUS QUO

George J. Lolos and Zisis Papandreou

WRITTEN: JUNE 3, 2009 → VERSION 1
UPDATED: NOVEMBER 26, 2009 → VERSION 1 (MINOR CORRECTIONS TO TEXT)
UPDATED: JUNE 11, 2009 → VERSION 2 (MAJOR UPDATE TO CURRENT STATUS)

1. Introduction

The construction status quo of the 48 BCAL modules, as budgeted for in subcontract JSA 09-R280857-CR (for the construction of the Barrel Calorimeter – BCAL) and in Appendices 1 and 2, is described herein.

Construction Facility @ Regina

ROLLING

GLUING

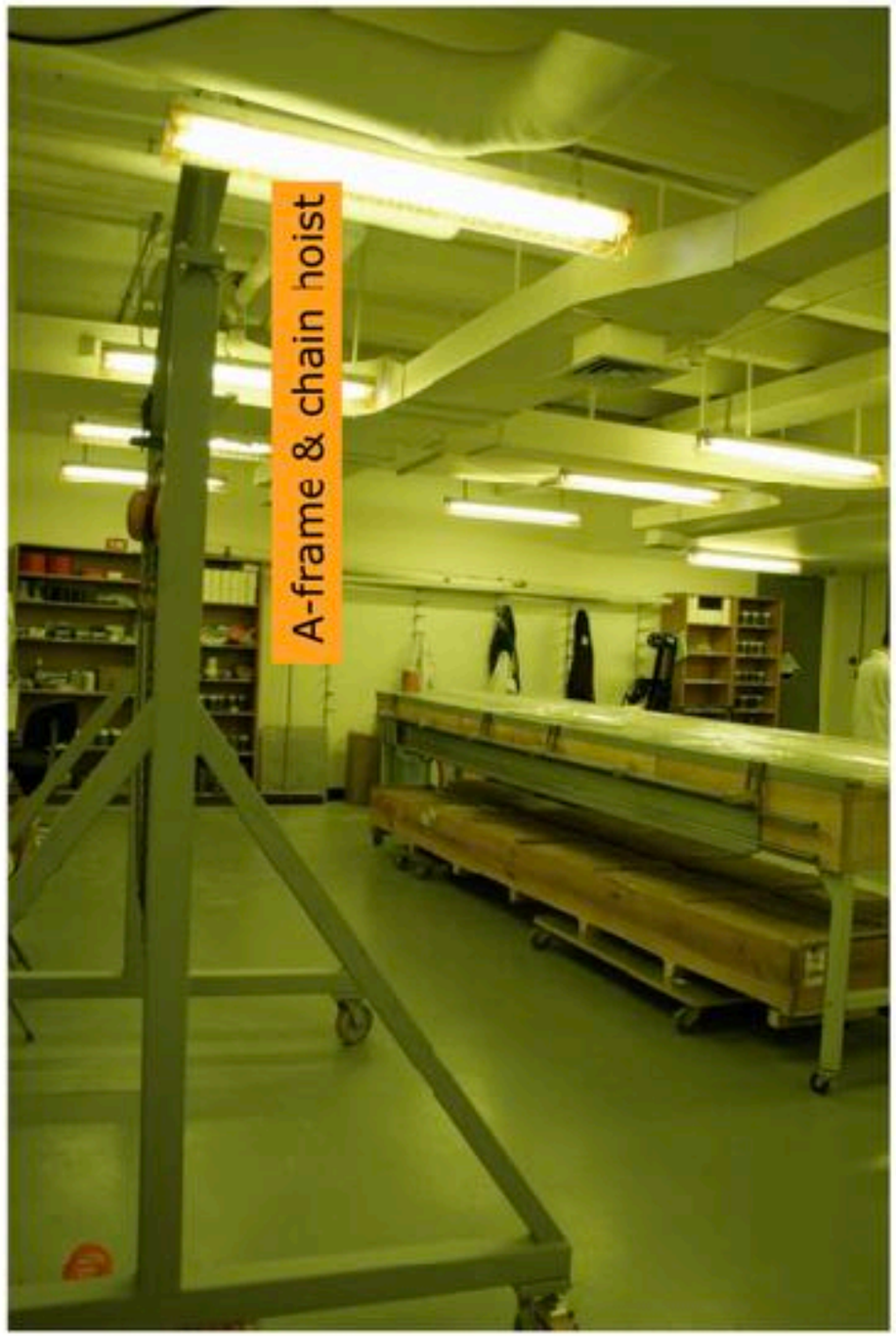
QUALITY CONTROL AT EVERY STEP

SWAGGING

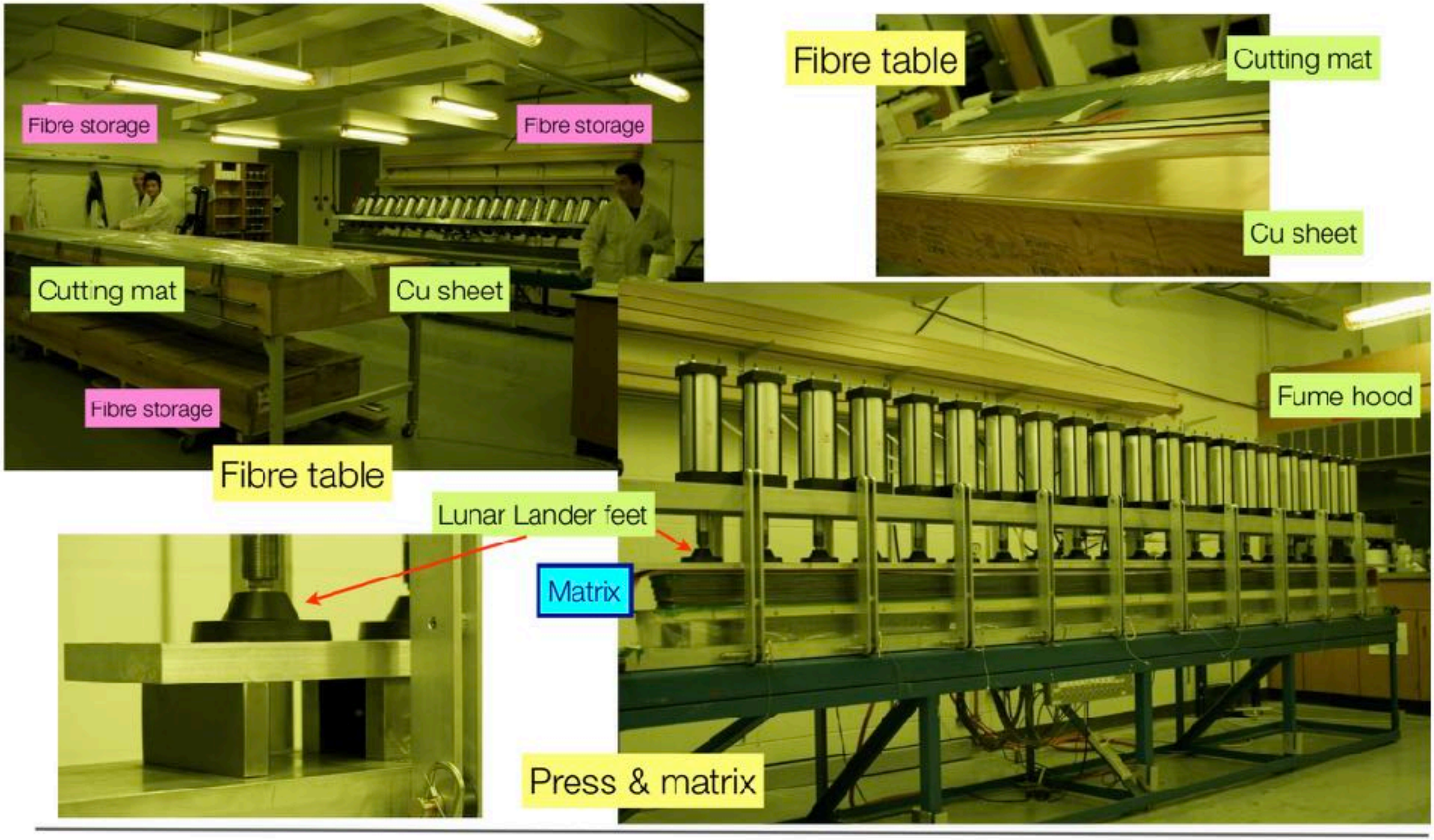
PRESSING

Matrix construction progress - details

- Press MAJOR adjustments
  - reassembly
  - casters
  - channel mismatch
  - 3/8” holes, 5/16” bolts
- A-frame hoist
  - UofR funds
- Fibre table adjustments
- Fibre crate storage
  - acute in Dec-Jan



Matrix construction progress - panoramic



QA & QC

Dedicated Traveller for each Module

BCAL Construction — Traveller version 1

Module No. **24** **Nonconformities:** Build & Machining — Fibres

Base Plate

Stamp/Segment No. 38 — Drawing — RMS Traveller

Matrix Build

Date Start	10/26/2010	Fibre Shipment	12 & 13	Epoxy Used (g)	14495.2
Date End	11/18/2010	Fibre Lots (JS-)	322-325, 326-331, 333, 335-336, 338, 343-346, 350-354	Epoxy Lost (g)	484.5
No. of Layers	183			Pb Sheets Lost	2
No. of Builds	16				
Temp Range	21-22 C	AttenLen Means	393-399	Build Stats	
Humid Range	21-29%	Npe Means	6.73-7.46	Epoxy Stats	
		Fibres Used	15277	Procedures	
		Fibres Lost	0	Photos	

Top Plate

Stamp No. 24 — Drawing — DC Rails: No

Machined Module

Module/Segment No. 24 — Drawing — RMS Traveller

Transmission Uniformity

Light Source:	UV-LED	**Coupling:**	Air gap	
Coupler:	Winston Cone	**Readout:**	Winston Cone	End 1 Image

Last Updated: 1/20/2011 14:57

QA & QC - Kuraray

Kuraray Scintillating fibers for University of Regina / SCSF-78MJ 1.00mmDiameter±2% 4.1m / 24th Shipment

Lot No.		Pack	Cane	KURARAY method														24th Shipment						
					Attenuation Length					Light Output (at200cm)					Light Output (at285cm)						Attenuation Length				
				n	Max [cm]	Min [cm]	Ave [cm]	rms [cm]	rms /Ave	Max [mV]	Min [mV]	Ave [mV]	rms [mV]	rms /Ave	Max [mV]	Min [mV]	Ave [mV]	rms [mV]	rms /Ave	n	Max [cm]	Min [cm]	Ave [cm]	rms [cm]	rms /Ave
3	JS576	11	1,050	12	623	525	548	28	5.1%	200.9	184.3	192.8	4.9	2.5%	178.3	161.9	168.5	4.8	2.9%	12	416	362	401	15	3.7%
4	JS577	11	1,100	12	501	410	472	28	5.8%	189.9	159.6	172.7	8.6	5.0%	160.4	136.0	147.7	7.3	5.0%	12	361	344	352	5	1.3%
5	JS578	11	1,100	12	568	416	477	45	9.4%	180.5	152.1	170.3	8.5	5.0%	160.2	129.0	148.0	9.0	6.1%	12	353	334	347	6	1.7%
6	JS579	11	1,100	12	666	540	589	34	5.9%	200.8	176.1	188.1	6.6	3.5%	176.5	156.0	165.6	6.2	3.8%	12	449	379	416	19	4.5%
7	JS580	11	1,100	12	659	473	564	52	9.2%	195.1	154.7	179.3	14.5	8.1%	175.7	134.4	159.5	13.3	8.4%	12	420	382	406	12	2.8%
8	JS581	10	1,000	11	525	455	489	24	4.9%	179.0	164.8	171.4	5.1	3.0%	156.3	142.7	148.2	4.7	3.2%	11	368	350	362	6	1.7%
9	JS582	11	1,050	12	592	518	547	25	4.6%	196.8	185.4	189.9	3.3	1.7%	172.8	160.9	166.2	3.3	2.0%	12	406	365	387	14	3.6%
9	JS583	11	1,100	12	586	520	554	22	3.9%	204.6	179.2	188.8	6.4	3.4%	176.0	152.4	164.7	6.0	3.6%	12	416	382	397	10	2.5%
10	JS584	11	1,100	12	496	429	457	23	5.1%	189.9	160.6	171.6	7.9	4.6%	160.7	137.5	146.7	7.2	4.9%	12	365	332	350	10	2.7%
11	JS585	11	1,100	12	530	446	481	27	5.6%	188.4	162.6	174.7	7.2	4.1%	168.1	139.3	150.9	7.7	5.1%	12	384	355	369	10	2.6%
12	JS586	11	1,100	12	531	412	483	36	7.5%	178.4	149.7	162.2	10.8	6.7%	157.0	125.7	140.5	11.0	7.8%	12	408	341	356	18	5.0%
13	JS587	11	1,100	12	559	471	517	27	5.3%	196.4	180.7	186.8	4.2	2.3%	169.9	154.5	161.2	4.7	2.9%	12	388	350	371	11	2.9%
14	JS588	11	1,100	12	547	467	507	27	5.3%	198.6	164.8	177.0	9.0	5.1%	159.1	139.9	151.5	6.2	4.1%	12	377	340	366	9	2.6%
15	JS589	11	1,100	12	557	430	497	39	7.9%	180.0	166.0	172.3	4.5	2.6%	155.7	139.0	148.2	4.8	3.3%	12	384	319	363	18	5.1%
16	JS590	11	1,100	12	545	484	517	20	3.9%	184.8	164.7	173.1	6.0	3.4%	160.1	143.2	150.5	4.7	3.1%	12	401	363	379	9	2.5%
17	JS591	8	750	9	575	483	514	28	5.5%	183.8	162.7	172.6	6.3	3.7%	160.7	141.5	150.8	5.7	3.8%	9	394	363	383	10	2.7%
18	JS592	8	750	9	595	491	531	37	7.0%	182.1	165.4	174.2	6.5	3.7%	160.9	143.4	151.9	6.7	4.4%	9	407	351	383	19	4.9%
19	JS593	11	1,100	12	550	427	499	34	6.8%	178.5	155.9	167.2	6.5	3.9%	151.1	134.3	142.0	4.4	3.1%	12	401	358	378	11	2.8%
20	JS594	10	1,000	11	565	476	533	30	5.6%	189.7	154.0	179.5	10.7	5.9%	163.6	134.0	155.1	9.6	6.2%	11	408	371	392	11	2.8%
21	JS595	11	1,100	12	580	501	526	20	3.9%	188.2	168.3	177.5	6.6	3.7%	161.5	144.0	152.8	5.1	3.4%	12	412	362	383	13	3.5%
22	JS596	11	1,100	12	636	471	533	42	7.9%	193.8	162.5	173.9	8.9	5.1%	177.0	139.8	152.4	10.1	6.6%	12	418	361	385	16	4.2%
23	JS597	7	700	8	530	435	496	30	6.0%	190.8	167.7	177.6	7.9	4.4%	162.6	140.9	154.4	7.2	4.6%	8	364	336	350	8	2.4%
Total		246	24,400	270	666	410	517	44	8.6%	206.4	149.7	178.3	11.6	6.5%	179.8	125.7	154.6	10.9	7.1%	270	449	319	378	23	6.0%
Overall Total		6669	658,760	7257	750	400	531	52	9.8%	252.7	98.6	174.4	20.5	11.7%	223.9	86.0	152.4	18.0	11.8%	7224	573	301	397	35	8.7%

Total	24,400	canes
	100.04	km
Overall Total	658,760	canes
	2,700.92	km

Kuraray tested fibers

QA & QC - Regina

XXX	YY	Z	Atten Le	Error	X^2	Atten lon	Atten sho	Npe	Error	Amplitud	error
1	1	1	360	3.7	1.2	418.4	76.2				
1	2	1	391.8	4.3	2.2	433.1	62.4				
1	3	1	381.9	4	3.9	430	55.7				
1	4	1	360.1	3.7	3	466.7	98.6				
1	5	1	371.6	3.8	3	397.2	37.3				
1	6	1	358.1	3.7	3.7	457.8	81				
1	7	1	373.9	4.1	2.1	438.6	78.6				
1	8	1	380.5	4	2.9	434.6	63.6				
1	9	1	337	3.3	2.1	819.6	190.4				
1	10	1	374.2	3.9	1.2	408.3	47.9				
1	11	1	360	3.7	1.2	418.4	76.2				
2	1	1	380.2	4.1	4	449.1	63.9				
2	2	1	368.1	3.9	3	477.8	91.4				
2	3	1	348.2	3.5	1.6	432.2	81.3				
2	4	1	377.2	4	2.4	424.8	53.7				
2	5	1	368.3	3.9	16.4	434	91.5				
2	6	1	354.1	3.5	2.3	398.8	66.1				
2	7	1	355.9	3.5	2.4	423.9	69.8				
2	8	1	339.2	3.8	1.7	479.5	80.4				
2	9	1	359.5	3.7	4	503.6	109.8				
2	10	1	361.6	3.8	2.5	460.7	87.8				
2	11	1	323.6	3.3	4.1	438.1	93.3				
2	12	1	314.9	3.1	1.9	476.3	123.2				
3	1	1	359.8	3.8	2.1	417.1	62.7				
3	2	1	355.2	3.7	2.5	404	46.9				
3	3	1	340.8	3.4	2.8	427	78.1				
3	4	1	346.3	3.5	1.3	383.1	59.4				
3	5	1	323	3.1	1.5	406.7	87.6				
3	6	1	301.2	2.8	1.4	364	70.1				
3	7	1	315.7	3.4	1.6	426.3	79.9				
3	8	1	322.4	3.3	2.9	477.4	93.9				
3	9	1	345.3	3.8	2	382.5	55.4				
4	1	1	364.4	4.1	5.7	432.2	60.2				
4	2	1	342.4	3.6	2	442.9	84.3				
4	3	1	357.4	3.7	1.2	404.5	51.3				
4	4	1	335.9	3.3	1	378.8	51.4				
4	5	1	356.3	3.8	1	406.5	63.5				
4	6	1	350.4	3.8	2.7	428.7	75.6				

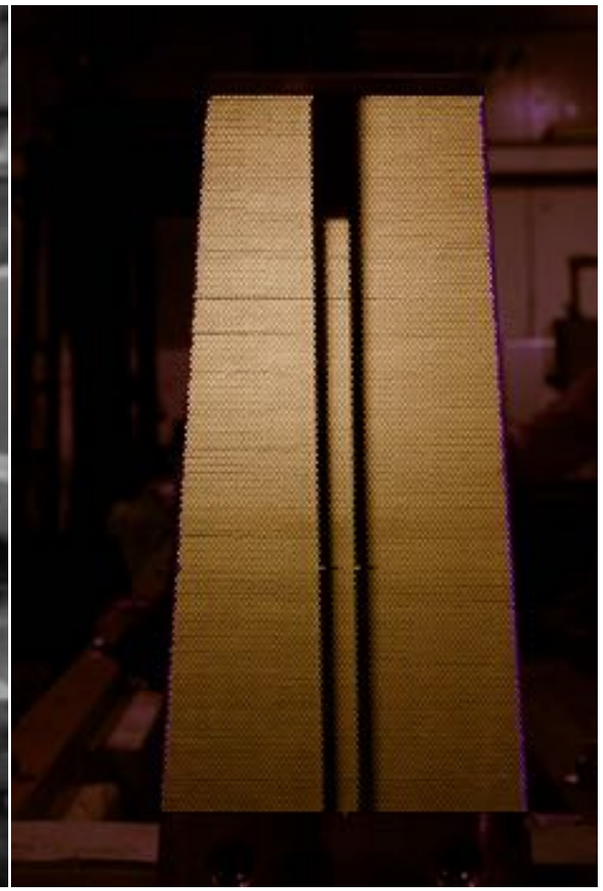
Regina | Batch | Comparison | Atten Chart | Light Out Chart | Shipment

Regina tested 1% of fibers

Machined Modules

Prototype

02



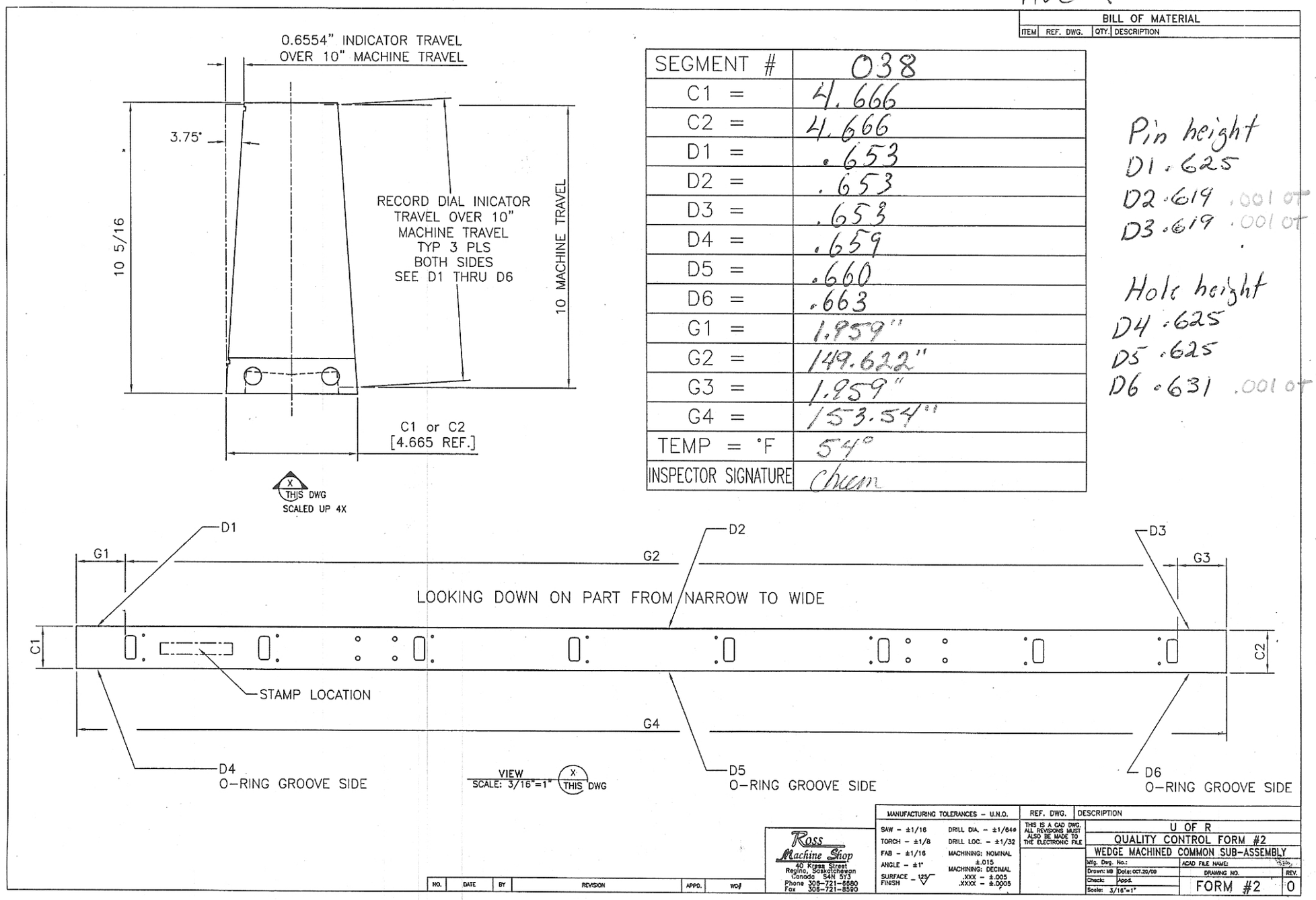
04

- Excellent finish of end faces & transmission uniformity
- 52 modules have been built & machined

QA & QC

Base Plate #38 - detailed measurements

Module # 24



BILL OF MATERIAL

ITEM	REF. DWG.	QTY.	DESCRIPTION

SEGMENT #	038
C1 =	4.666
C2 =	4.666
D1 =	.653
D2 =	.653
D3 =	.653
D4 =	.659
D5 =	.660
D6 =	.663
G1 =	1.959"
G2 =	149.622"
G3 =	1.959"
G4 =	153.54"
TEMP = °F	54°
INSPECTOR SIGNATURE	Chem

Pin height
D1 .625
D2 .619 .001 of
D3 .619 .001 of

Hole height
D4 .625
D5 .625
D6 .631 .001 of

NO.	DATE	BY	REVISION	APPD.	WO#

Ross Machine Shop
40 Kress Street
Regina, Saskatchewan
Canada S4N 5Y3
Phone 306-721-6880
Fax 306-721-8590

MANUFACTURING TOLERANCES – U.N.O.

SAW – ±1/16 | DRILL DIA. – ±1/64
TORCH – ±1/8 | DRILL LOC. – ±1/32
FAB – ±1/16 | MACHINING: NOMINAL ±.015
ANGLE – ±1° | MACHINING: DECIMAL .XXX – ±.005 .XXXX – ±.0005
SURFACE FINISH – 125

THIS IS A CAD DWG. ALL REVISIONS MUST ALSO BE MADE TO THE ELECTRONIC FILE

REF. DWG.	DESCRIPTION

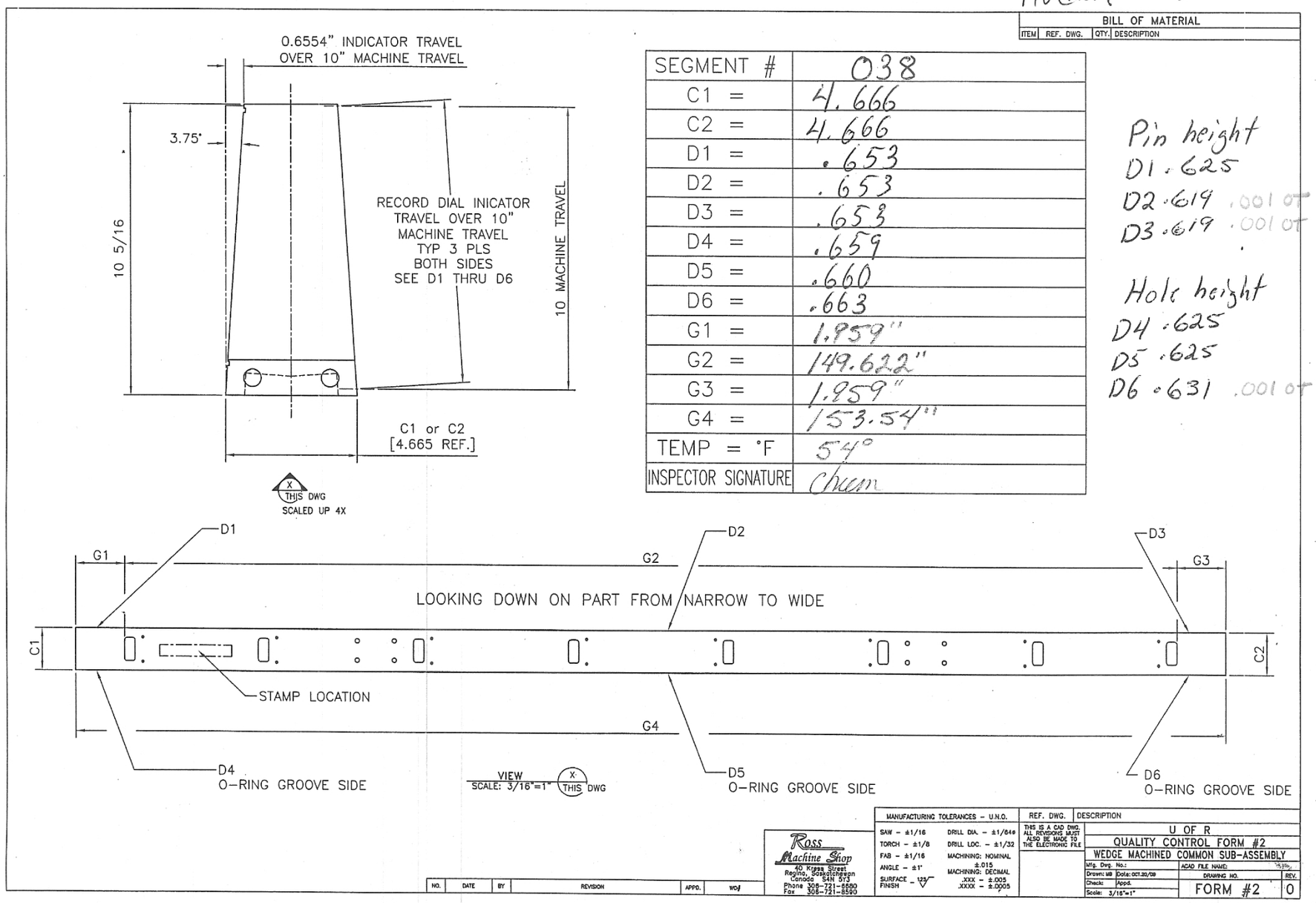
U OF R
QUALITY CONTROL FORM #2
WEDGE MACHINED COMMON SUB-ASSEMBLY

Mfg. Dwg. No.:		ACAD FILE NAME:	
Drawn: MB	Date: OCT.20/09	DRAWING NO.	REV.
Check:	Appd.	FORM #2	0
Scale: 3/16"=1"			

QA & QC

Machined Module #24 - detailed measurements

Module # 24



QA & QC

Epoxy Stats #24 - very detail

Date	Build No.	Sheet Width	No. Layers	Resin (g)	Resin / Layer	Resin Avg	Hardener (g	Hardener / Laye	Hardener Avg	poxy/Area (kg/m^2)
Oct 26, 2010	1	13	4	300	75		84	21		
Oct 27, 2010	2	13	16	1100	68.75	71.875	308	19.25	20.125	0.170601676
Oct 28, 2010	3	12	14	900	64.285714		252	18		
Oct 29, 2010	4	12	14	900	64.285714		252	18		
Nov 1, 2010	5	12	14	1000	71.428571		280	20		
Nov 2, 2010	6	12	13	900	69.230769		252	19.38461538		
Nov 3, 2010	7	12	7	400	57.142857	65.27473	112	16	18.2769231	0.174598105
Nov 4, 2010	8	12	14	770	55		215.6	15.4		
Nov 5, 2010	9	12	14	800	57.142857		224	16		
Nov 8, 2010	10	12	14	870	62.142857		243.6	17.4		
Nov 9, 2010	11	11	14	850	60.714286		238	17		
Nov 10, 2010	12	11	7	360	51.428571	57.28571	100	14.28571429	16.0171429	0.166845256
Nov 15, 2010	13	10	14	800	57.142857		224	16		
Nov 16, 2010	14	10	14	750	53.571429		210	15		
Nov 17, 2010	15	10	10	625	62.5	57.7381	175	17.5	16.1666667	0.18

Consumption Resin (g)	11325		Avg Resin Consumption (per layer)	61.98443
Consumption Hardener	3170.2			
			Avg Hardener Consumption (per la	17.34802
Consumption Total (g)	14495.2			
Consumption Total (gall	**3.245118**			

Length (cm)	Width (cr	Area (cm^2	Total Area (m^2)	
404	13	5252	10.504	
	12	4848	30.0576	
	11	4444	27.9972	
	10	4040	15.352	
			83.9108	Total glued area

QA & QC

Build Stats #24 - in detail

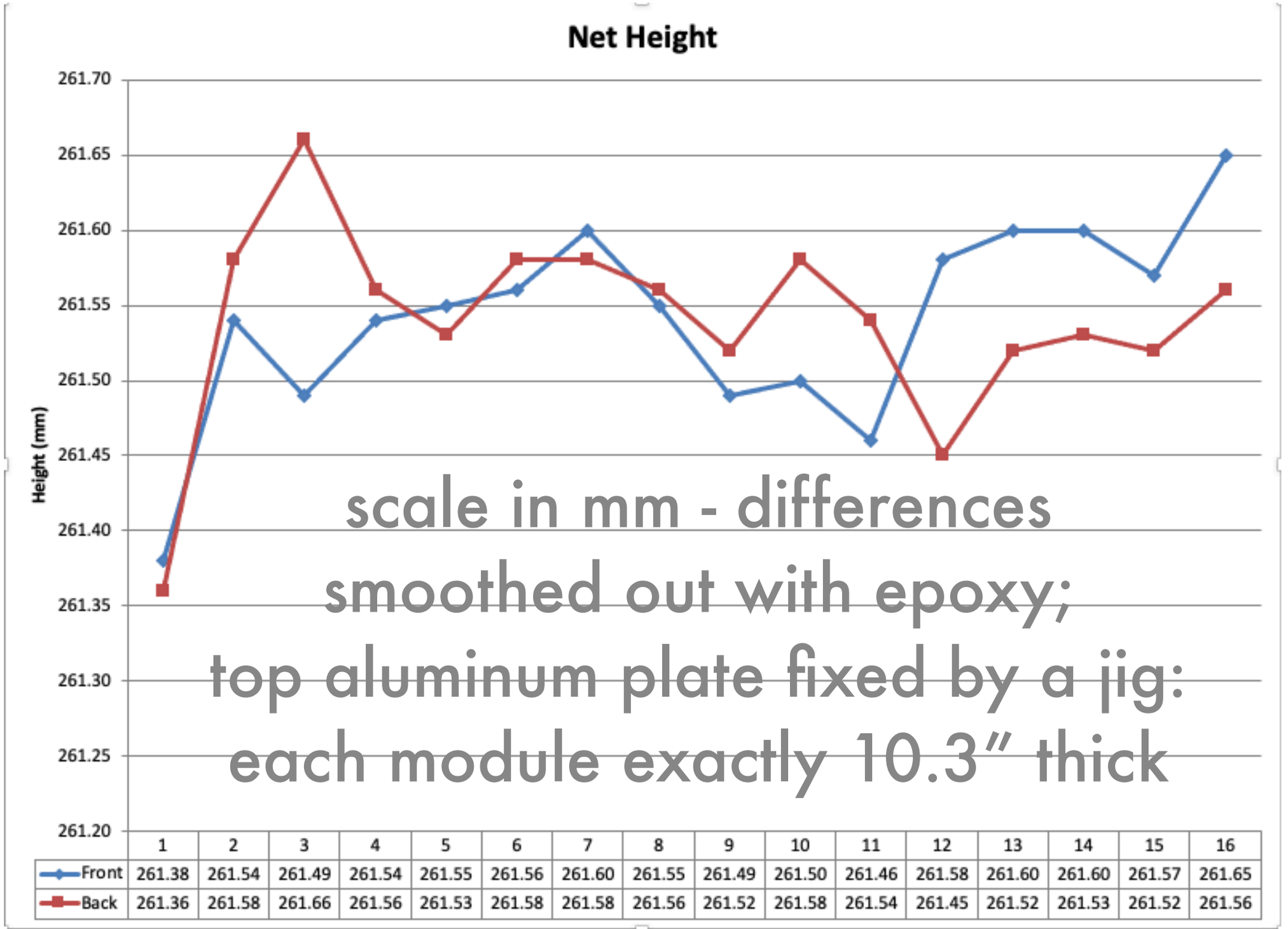
Module:	24			Stamp:	38	
	Front Thickness			Back Thickness		
Position	Side	Top	Difference	Side	Top	Difference
1	31.23		-31.23	31.24		-31.24
2	31.27		-31.27	31.25		-31.25
3	31.27		-31.27	31.27		-31.27
4	31.22		-31.22	31.16		-31.16
5	31.25		-31.25	31.20		-31.20
6	31.25		-31.25	31.21		-31.21
7	31.14		-31.14	31.19		-31.19
8	31.10		-31.10	31.24		-31.24
9	31.13		-31.13	31.21		-31.21
10	31.14		-31.14	31.25		-31.25
11	31.17		-31.17	31.25		-31.25
12	31.20		-31.20	31.19		-31.19
13	31.20		-31.20	31.22		-31.22
14	31.23		-31.23	31.26		-31.26
15	31.25		-31.25	31.24		-31.24
16	31.25		-31.25	31.23		-31.23

Build 1	Date:	Oct. 26-10	Build 1		Sheet Size:	13	
	Time:	P.M.			Layers Lain:		
	Front				Back		
Position	Measured	Net	Total		Measured	Net	Total
1	4.68	35.91	35.91		4.67	35.91	35.91
2	4.71	35.98	35.98		4.67	35.92	35.92
3	4.70	35.97	35.97		4.62	35.89	35.89
4	4.70	35.92	35.92		4.64	35.80	35.80
5	4.72	35.97	35.97		4.63	35.83	35.83
6	4.76	36.01	36.01		4.68	35.89	35.89
7	4.84	35.98	35.98		4.66	35.85	35.85
8	4.84	35.94	35.94		4.65	35.89	35.89
9	4.82	35.95	35.95		4.66	35.87	35.87
10	4.82	35.96	35.96		4.62	35.87	35.87
11	4.83	36.00	36.00		4.54	35.79	35.79
12	4.76	35.96	35.96		4.61	35.80	35.80
13	4.75	35.95	35.95		4.63	35.85	35.85
14	4.74	35.97	35.97	Difference	4.62	35.88	35.88
15	4.69	35.94	35.94	Front to	4.64	35.88	35.88
16	4.74	35.99	35.99	Back	4.66	35.89	35.89
Mean		35.96		0.10		35.86	

build height measured at 32 points around perimeter

QA & QC

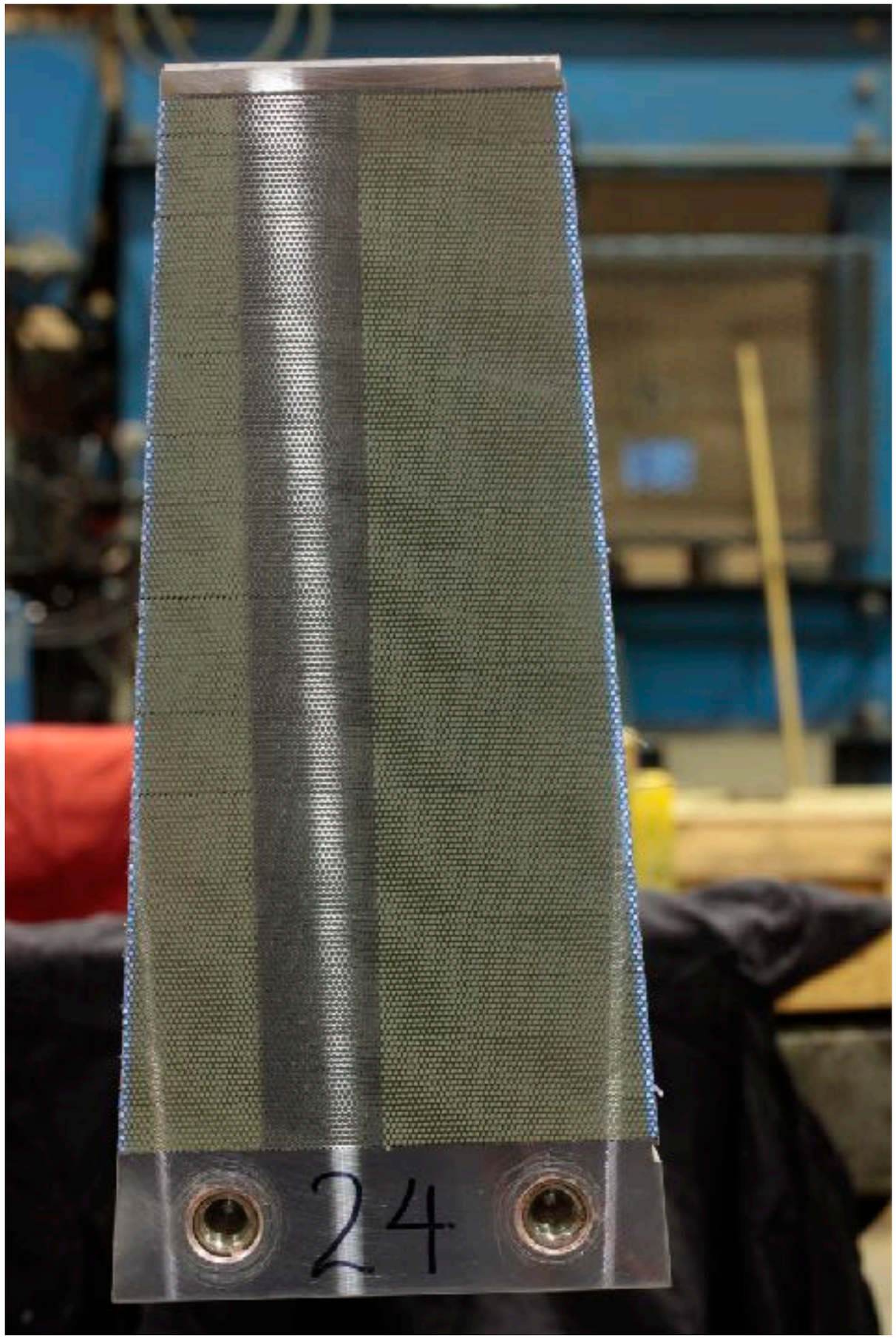
Build Stats #24



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Front	261.38	261.54	261.49	261.54	261.55	261.56	261.60	261.55	261.49	261.50	261.46	261.58	261.60	261.60	261.57	261.65
Back	261.36	261.58	261.66	261.56	261.53	261.58	261.58	261.56	261.52	261.58	261.54	261.45	261.52	261.53	261.52	261.56

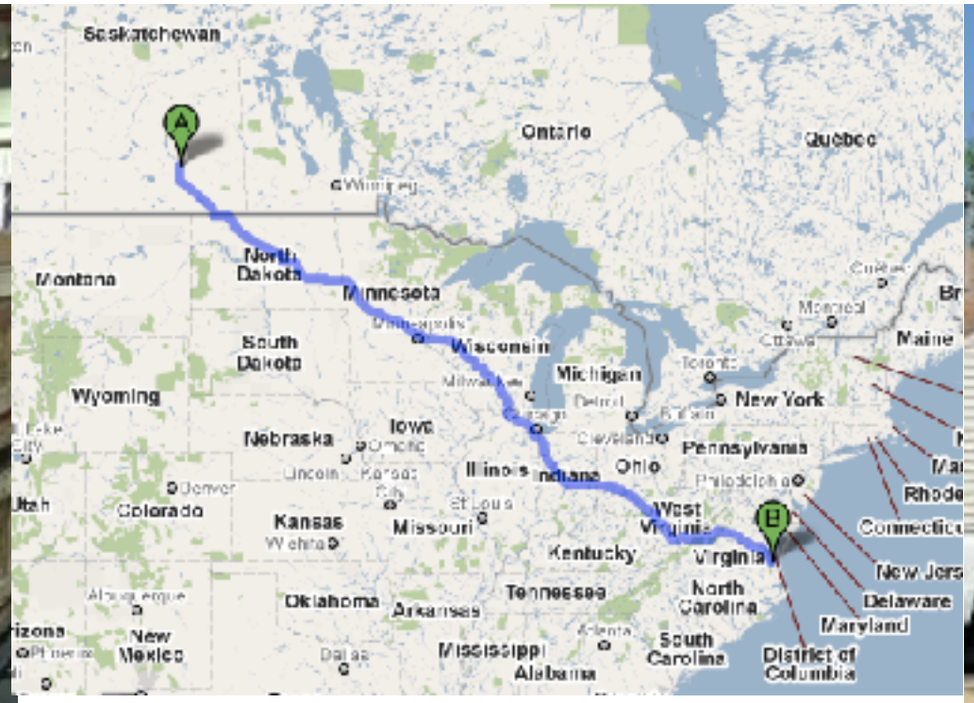
QA & QC

quality build!



Module Delivery to JLab

Left Regina
(April 22, 2023)



~3,300 km
in refrigerated truck

Arrived at JLab
(April 26, 2010)

Modules 01-04: 1st detector delivery for 12 GeV program!