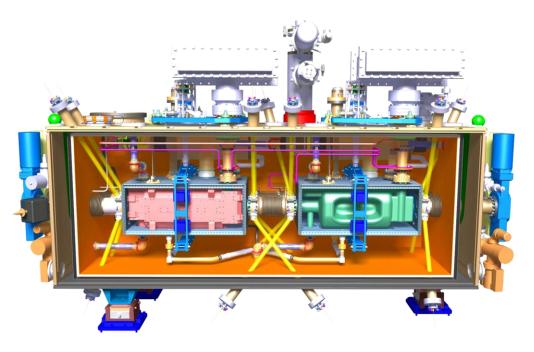


Engineering Issues TRIUMF RFD CM Production

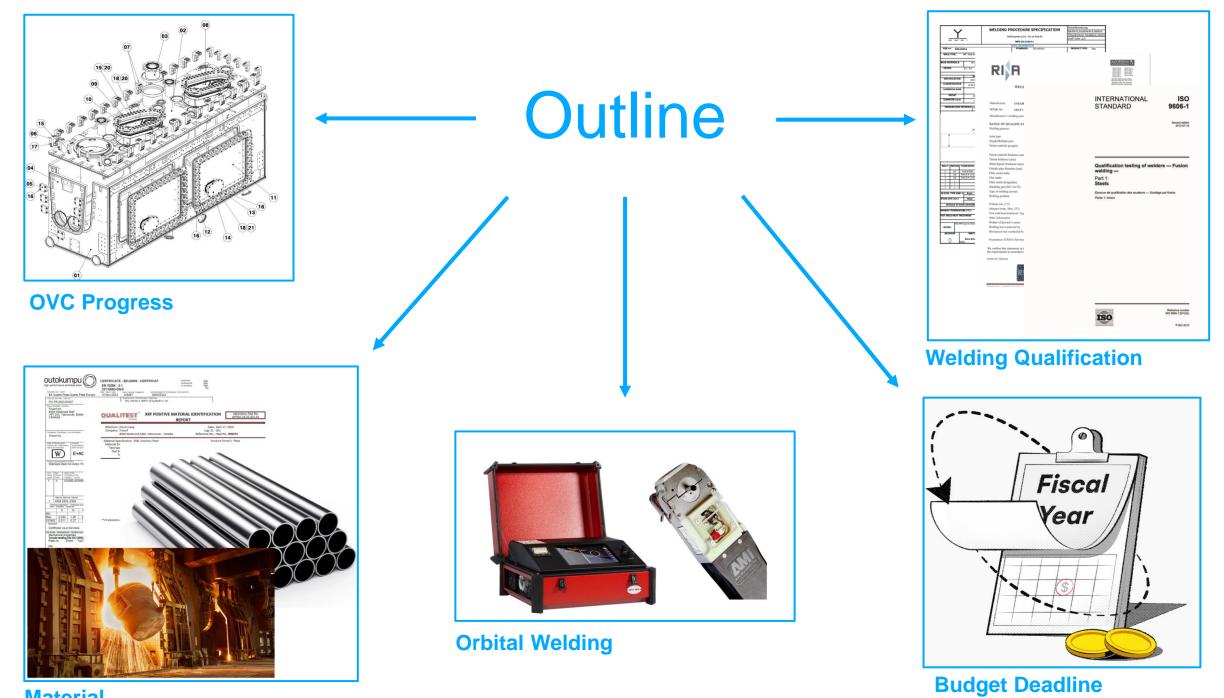
Oliver Law

Project Engineer – HL-LHC collaboration TRIUMF



Discovery, accelerated

1



Material



OVC Status

Document Name	Action	Status 2023	Status 2024	
3D Models	N/A	Completed	Completed	
2D Drawings	N/A	Completed	Completed	
Manufacturing drawings	TRIUMF	In Progress	Completed	
Manufacturing and Inspection Plan (MIP)	Axton	In Progress	Completed	
Welder Certification	Axton	In Progress	In Progress	
Welding Procedure Specifications (WPS)	Axton	In Progress	In Progress	
Welding Procedure Qualifications Records (WPQR)	Axton	In Progress	In Progress	
Raw material certificates	TRIUMF	In Progress	Completed	
Filler material certificates	CERN	In Progress	Completed	
Material samples	TRIUMF	In Progress	In Progress	
Scheduling (incl. preliminary dates)	Axton	In Progress	Completed	
Traceability procedure	Axton	In Progress	Completed	
Cleaning procedure	TRIUMF	In Progress	Completed	
Leak test procedure	TRIUMF	In Progress	Completed	



Weld Documentation and Qualification

1			weidin		re Specifica 15609-1:2019	tion (v	VPS)				
WPS No.: WPQR No(s) Manufacturer	s).:: AX	-GTAW-B1 -GTAW-6G-3 TON Incorpo	R2	Dat Par		tion: Gro					
			a BC V3M 5Y9		lerial thickness:		mm to 6 mm				
Welding proc Mode of met					Welding P		ure Specification	n (WPS	6)		
Joint Type ar	ind Weld: Fu	WPS No.: WPQR No(s).:		AW-B2 R2			Date:	Sept-25			
	Square gr backing n	Manufacturer:		Incorporate	d		Parent Material designation: Parent Material specification				
Weld prep. d		manufactor of .	441 Derwent F				laterial thickness:	2 mm to			
	s, tears, crack						Diameter OD:		and over		
Alls	surfaces sha	Welding process		TAW)			Veld metal thickness:		5/32 in) m	ax.	
loint Design:		Mode of metal to Joint Type and V		Penetration Bu	utt welds		Throat thickness: Welding position:	N/A All posi	tions (Up	ward)	
G - Root op		some type and t	Vee groove w				Product forms:			s (plate and pip	es)
G = 0 - 3 mr							lethod of preparation		ng, grindi		,
	_	Weld prep. deta			s shall be free f	rom	and cleaning:			all be of stainle	
			ears, cracks or				Weld joint area (25				
	Τ	All su	rfaces shall be	wire brushed	prior to welding		The grinding discs	shall be	kept exc	lusively for use	on stainless steels.
	▲	Joint Design:					Welding Sequence:				
	1	T - Plate Thick	ness				E - Weld metal thicknes	s			
		Rf - Root face;		a			E = S			Multi Run	weld
Welding D		S - Depth of Pr	rep. 🚽		Ž↓ Side	1		7		→ ↓ si	de 1
Run	Weldir	S = T - Rf α = 60°-90°		\sim	s]			6	E	
Layer Pas		α = 6090-	イエ		ÎRf	2		7⊺		1 t	2
2-n 2-i			L.		+	ļ		L_			
		Root opening	G=0 1		– G Side	2		Ť		▶ ∢ — G	de 2
							Number of runs may	slightly	vary to acc	commodate the v	velding position.
		Welding Det									
iller metal de	lesignation: W	Run Layer Pass	Welding process	Size of filler metal mm (in)	Current	Voltage	Current type Polarity	Wire feed m/min		Travel speed mm/min (ipm)	Heat input kJ/mm
iller metal de iller material		1 1	141 (GTAW)	1.6 (1/16)	[A] 90 - 110	[V] 11 - 16	DC EN(SP)	N/		75 - 120 (3-5)	0.52 - 1.40
iller metal F	No./A No.: F6	2-n 2-n	141 (GTAW)	1.6 (1/16)	90 - 110	11 - 16	DC EN(SP)	N//		75 - 120 (3-5)	0.52 - 1.40
shielding gas											
Backing gas: Shielding gas								<u> </u>			
Backing gas f	flow: 4.							<u> </u>			_
ungsten eler		Filler metal desig	nation: WZ18	16 5 Mn N L		F	Post heating [C]:	· •	None		
ungsten electors lack gouging		Filler material ma	ake: Voestal	pine Bohler		F	Post Weld Heat Treatment (I		None		
letails of bac		Filler metal F No					-lold time / Heating- & Coolin		N/A		
	perature [C]: 16	Shielding gas: Backing gas:	100% A	rgon			Veaving (max. width of run): Dscillation (amp., freg., dwel		N/A None		
iterpass tem Notes:	nperature [C]: 16	Shielding gas flo		0 l/min (25 - 42	cfh)		Pulse weld details:		N/A		
	moisture, gre	Backing gas flow					Contact tube to work distance			n (3/8 -1/2 in)	
		Tungsten electro		2 (2% Thoriate (3/32 in), 3.2 r			Pasma welding details: Forch angle:		N/A	way from the di	rection of travel
Contact				(5/52 11), 5.2 1	iiii (170 iii)		Drifice, cup, or nozzle size:		19 mm (3/		rection of travel
Contact The	e edges or su	Tungsten electro Back gouging m					Peenina:		None		
Contact The		Back gouging me Details of backin	g: N/A						Vone		
Contact The	e edges or su	Back gouging me Details of backin Preheat tempera	g: N/A iture [C]: 16°C (6				Jse of thermal process:		vone		
Contact The Where ha	e edges or su and cutting is	Back gouging m Details of backin Preheat tempera Interpass temper	g: N/A		5°F)		Jse of thermal process: Other:	1	vone		
Contact The Where ha	e edges or su and cutting is	Back gouging m Details of backin Preheat tempera Interpass temper Notes:	g: N/A iture [C]: 16°C (60 rature [C] 16°C (60	0°F) - 85°C (18		(-		ctionable fume	s, shall be removed.
Contact The Where ha	e edges or su and cutting is	Back gouging m Details of backin Preheat tempera Interpass temper Notes: All mo Contact wit	g: N/A ture [C]: 16°C (60 rature [C] 16°C (60 bisture, grease th lead, zinc, o	or other foreig	in material that	would p	Other: revent proper weldin ided due to the poten	g or pro	duce obje ot crackir	ng.	s, shall be removed
Contact The Where ha	e edges or su and cutting is	Back gouging m Details of backin Preheat lempera Interpass temper Notes: All mo Contact wi The ec	g: N/A iture [C]: 16°C (60 rature [C] 16°C (60 bisture, grease th lead, zinc, or dges or surface	or other foreig r lead or zinc o s of parts to b	n material that compound shall be joined by wel	would p be avoi ding sha	Other: wevent proper weldin ded due to the poten all be prepared by she	g or pro	duce obje ot crackir	ng.	s, shall be removed.
Contact The Where ha Manufacture Name:	e edges or su and cutting is er: <u>A</u>	Back gouging m Details of backin Preheat lempera Interpass temper Notes: All mo Contact wi The ec	g: N/A iture [C]: 16°C (60 rature [C] 16°C (60 bisture, grease th lead, zinc, or dges or surface	or other foreig r lead or zinc o s of parts to b	in material that	would p be avoi ding sha	Other: wevent proper weldin ded due to the poten all be prepared by she	g or pro	duce obje ot crackir	ng.	s, shall be removed.
Contact The Where ha	e edges or su and cutting is er: <u>A</u>	Back gouging m Details of backin Preheat lempera Interpass temper Notes: All mo Contact wi The ec	g: N/A iture [C]: 16°C (60 rature [C] 16°C (60 bisture, grease th lead, zinc, or dges or surface	or other foreig r lead or zinc o s of parts to b	n material that compound shall be joined by wel	would p be avoi ding sha	Other: wevent proper weldin ded due to the poten all be prepared by she	g or pro	duce obje ot crackir	ng.	s, shall be removed.
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Contact The Where ha Manufacture Name:	e edges or su and cutting is er: <u>A</u>	Back gouging mi Details of backin Preheat tempera Interpass tempera Notes: All mo Contact wi The eo Where hanc	g: N/A ture [C]: 16°C (6/ rature [C]: 16°C (6/ bisture, grease th lead, zinc, o dges or surface d cutting is inve	PF) - 85°C (18 or other foreig r lead or zinc o es of parts to k olved the edge	n material that compound shall be joined by wel will be ground	would p be avoi ding sha	Other: wevent proper weldin ded due to the poten all be prepared by she	g or prot tial for h ear or pla Examiner SKC Er	duce obje ot crackir asma arc agineering	ng. cutting.	s, shall be removed.
Contact The Where ha Manufacture Name:	e edges or su and cutting is er: <u>A</u>	Back gouging mi Details of backin Preheat lempera Notes: All mo Contact wi The ec Where hand	g: N/A ture [C]: 16°C (6/ rature [C]: 16°C (6/ bisture, grease th lead, zinc, o dges or surface d cutting is inve	PF) - 85°C (18 or other foreig r lead or zinc o es of parts to k olved the edge	n material that compound shall be joined by wel will be ground	would p be avoi ding sha	Other: wevent proper weldin ded due to the poten all be prepared by she	g or pro tial for h ear or pl Examiner SKC En 19165 - 9	duce obje ot crackir asma arc gineering th Avenue 2 V3N 3S4	ng. cutting.	s, shall be removed.

AXTON	AW-6G											
					Examiner:	SKC	Enginee	ring				
	rwent P	lace. Delta BC V	3M 5Y9		L'Administra	SILC	Linginiee	ing	-0-	1		
	614-1:20		511 51 5		Date:	Sept-2	5,2024		SKC	1		
2	014-1.20				Duit.	oebt-r	01014			I		
				Welding Pro	ocedure	Qualif	icatio	n Record	(WPQR)			
				°,	85	per ISO 156	14-1:2017					
All prod	Manufac	turer's WPQR no.:	AX-GTAW-	1F-20 R1								
	Manufac	turer:	AXTON Inc	corporated				Exam	iner:	SKC E	ngineering	
	Address:		441 Derwe	nt Place, Delta E	BC V3M 51	'9						
8	Code/Te	sting Standard:	ISO-15614	1:2017				Date:		Sept-25	2024	SKU
No restr	Level:	-	2					Refer	ence no.:	W16170	-D2	
Single, I	Date of v	velding:	Mar-20-2024									
WZ 18 1	Test Pie	ice			Range of	Qualifica	ation					
Voestal			All product f	orms				eld - Tee, Co	rner, Lap Joi	ints		
F6 / A8	Welding F	Process(s):			and weld:							
Any	Base mat	lerial L: Group:	8		Subgroup:	8.1		Thickness:	3 mm to 40	mm (0	.118 in to 1.57	1 in)
N/A			8			8.1		Thickness:				
All posit				n		Weld met	al thicknes	18	N/A			
16°C (60			Multi Run			Pipe OD:				9 in) ar	d over - rotate	d pipes, or
16°C (60				Mn N L								
						Designatio	on of Shiel	ding gas:			ore:	1.000
Axton In												
								polarity:				
				(Unhill)				, and any			rameters	
				(opinit)				atment (C)-		119 14		N/A
				85°C (185°E)				aunan [0].			- rioid unic printy.	1674
	merpuss	temperature [0].	10 6 (00 1)	05 0 (105 1)	De				None			
	Location	Monufacturer	Avton Incorr	orated shop	Ne			•	CKC Engin			
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45*	Welding	meilion		tal)		-	THIC DI	asticu betwe	en passes. o	tannes	a ateer bruane	<i>a</i> .
	riciding p	poonton.		any					Wolding Sog	00008		
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	1 mot wo	au - Tee pain		-	a	Fillet Thro	at	-	T1 4		For a = 7,4 mm	
	T1 = T2	= 20 mm		-				-				
Filler me Size (m)										1	8 layers, 6 passes	
1.6				100					L			
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					1	Velding d	letails					
	Run	Welding Process		Current	Voltage	Curr	rent/					Metal transf
	1	141 (GTAW)		198	17	DC Et	Inty N(SP)	(nvmin)				N/A
	2		2.4	211					152 (6.	0)	1.50	
	3	141 (GTAW)	2.4	211	18	DC EI	N(SP)	•	168 (6.	6)	1.36	
	4-6	141 (GTAW)	2.4	211	18	DC EI	N(SP)	•	152-168 (5-6.6)	1.36-1.50	
N/A												
N/A									None			
	Tungsten	electrode type/ size:		in) EWTh-2		Shielding	gas/flux:		& Argon		Flow rate (I/min)	14.2 (30 c
	Preheat t	emperature [C]:	15°C (59°F)			Backing g	as/flux:	N/A			Flow rate (I/min)	N/A
			15°C (59°F) -	85°C (185°F)				ng:	N/A			
	Post-heat		None						N/A			
		d Heat Treatment:	No PWHT					le, frequency, du			None	
		Hold time [min]:	N/A	Temperature [C]:	N/A	Pulse wel		,			None	
				- manage [0].								
			N/A	Cooling rate [C#w]-	N/A	Contact In	the distance	10 - 10 - ·	12 mm (3/8 -4	1/2 in\		
		Heating rate [C/hr]:	N/A	Cooling rate [C/hr]:	N/A	Contact tu			12 mm (3/8 -1		direction of tra	vel
		Heating rate [C/hr]:	N/A	Cooling rate [C/hr]:	N/A	Contact tu Torch ang		15º -		m the	direction of tra	
	Feb-11 All prod 141 (67) 8 No restr Single.1 Prod All position All position All position All position 16°C (60) 16°C (60) 16°C (60) 16°C (60) 1141 (67) 116°C (60) Non PW No PY	Feb:1 All proof 111 (G) 131 (G) 8 Manufac Advess 8 No restr Single, Date of No restr W2 181 Test Pk Voestali Podu 1 Date of Node Field	Feb:11 All prod All prod Minufacturer's WPCR no.: 141 (G) Minufacturer's WPCR no.: 142 (G) Adress 8 Code' (reining Standard) 80 (Code' (reining Standard) Minufacturer's WPCR no.: 90 (Code' (reining Standard) Minufacturer's WPCR no.: 90 (Code' (reining Standard) Minufacturer's WPCR no.: 90 (Code') (reining Standard) Minufacturer's WPCR no.: 90 (Code') (reining Standard) Minufacturer's WPCR no.: 91 (Code') (reining notion: Filler model and code standard) 91 (Code') (reining notion: Filler model and code standards notice: 91 (Code') (reining notion: Minufacturer (C) 91 (Code') (reining notion: Filler Minufacturer (C) 91 (Code') (reining notion:	Feb-11 Manufacture's WFOR no: AX-GTAW: 141 (GT Manufacture's WFOR no: AXTON Immediate Address: Address: Address: Address: Address: ISO-15614 Single: Date of wedding: Mar-20-2024 Voestal Date of wedding: Mar-20-2024 Voestal Product form: Fall product f F6 / A8<	Feb:15 Welding Pro All prod. AX-GTAW-IF-20 R1 Attront AX-GTAW-IF-20 R1 Attront AX-GTAW-IF-20 R1 Attront Incorported Attront Incorported Attront Incorported Single. Date of welding Warefulcater: ISO-15614-12017 Voestal Phone Voestal Mar-20-2024 W2 18 Tele Phone Voestal Phone Voestal Phone Voestal No restriction Ary Base methenil 1: Goops Base methenil 1: Goops 8 Attorn Pice (corps of points) No restriction MA Base methenil 1: Goops Any Axtort A Markabare Mether Markabare Attorn Filter methal resolution Any Axtort A Markabare Markabare MA Base methal resolution Any Axtort A Markabare Markabare MA Base methal resolution Any Axtort A Markabare Markabare	Feb:15 Welding Procedure All prod Manufachers' WPOR no: AX-GTAW-IF-20 R1 Implementation of the second of the seco	Feb-11 Welding Procedure Qualifier All prod mprifs01 f80 141 (GT Address Address AXTON Incorporated Address ATTON Incorporated Single. Date of welding Marufacturer's WPOR no: Attross Single. Date of welding Marufacturer's WPOR no: Attross Single. Date of welding Marufacturer's WPOR no: Attross Single. Date of welding Marufacturer's WPOR no: All product forms FIG Field Revel Vestatif These Vestatif These Vestatif Field Revel Ary Base methani I: Field Revel Nahr no: No restriction Skeprover 8.1 NA Base methani I: Field Revel Nahr NL Voestatifier Bohler Field Revel Nahr NL Field AB NA Reservel Nahr Atton Incorporated shop Nahr Hier metal is no: Atton Incorporated shop	Welding Procedure Qualification as per ISO 15014-12017 are per ISO 15014-12017 All productor: Attross Code/Testing Standard Attross AX-GTAW-IF-20 R1 ATTON Incorporated 441 Derivent Piace, Deita BC V3M 5Y9 ISO-15614-12017 Attross Single, Date of welding Vestatik Productors: Single, Date of welding All product forms 441 Derivent Piace, Deita BC V3M 5Y9 ISO-15614-12017 Vestatik Productors: Single, Date of welding All product forms 411 GTAW Attross Subgroup Range of Qualification Figure weld Figure Multi Run Piece (State State) Run Process() Not restriction Run Piece (State) Run Run Run Piece (State) Run Piece (State) Run Piece (Stat	Welding Procedure Qualification Record an per ISO 15614-12017 All pool All pool AX-GTAW-1F-20 R1 Adress AX-GTAW-1F-20 R1 Adress AX-GTAW-1F-20 R1 Adress AX-GTAW-1F-20 R1 Adress AX-GTAW-1F-20 R1 Adress AX-GTAW-1F-20 R1 Adress ATTON Incorporated SO-15614-12017 Date of welding Workship Colspan="2">Colspan="2">Colspan="2">Date of welding Mar-20-2024 Range of Qualification Type of print REF (RF Ref Mell Circup) All pools R1 (Colspan="2">Bit Process(): R1 (Colspan="2">Range of Qualification Type of print REF (RF Ref Mell Rink) Mar-20-2024 All position (Colspan="2">Range of Qualification Type of print REF (RF Ref mell Rink) No restriction Wid mell Rinkness: No restriction REF (RF Ref mell Rink) Mar-20-2024 Range of Qualification Type of print REF (RF Ref mell Rink) Mar-20-2024 Range of Qualification Type of print REF (RF Ref mell Rink) Mar-20-2024 Range of Qualification Type of print REF (RF Ref mell Rink) Mar-20-2024 Attor the Second Colspand Rink) Mar-20-2024	Welding Procedure Qualification Record (WPQR) an ports wardscher? AX-GTAW-IF-20 R1 an portsol (19514-12017 Attrom Incorporated Attrom Incorporated Date: Date: Date: Single, Uard Load / Infing Standard Attrom Incorporated Date: Date: Date: Vestal Incort Attrom Incorporated Representation Date:	Welding Procedure Qualification Record (WPQR) ap or S0 15914-12017 All prod Minufacturer's WPCR roz. ACOTAW-15-20 R1 Code/Testing Standard Strong Standard Strong Standard Strong Standard Code/Testing Standard 2 Test Strong Standard 2 Strong Standard 2 Strong Standard 2 Test Strong Standard Strong Standard Strong Standard Test Strong Standard Atom to Standard Sta	Welding Procedure Qualification Record (WPQR) are r80 1694-12017 All poot Munufactor: AX-GTAW-1F-20 R1 Atron Incorporated Atron Incorporated State Stat



Weld Documentation and Qualification







Material

- 316LN procurement
 - Large mill runs from EU suppliers
 - Bi-Phase Support, Thermal Screen, Cavity Support Structure, Cryo Jumper Internal Support
 - Status: CERN agreed to supply 316LN material



316LN Material	Length (mm)	Width (mm)	Qty
Ø25mm Rod	1000	N/A	5
2mm Sheet	1100	1100	1
8mm Plate	1500	2200	1
8mm Plate	400	2200	1
10mm Plate	1500	2000	1
12mm Plate	1000	650	1
15mm Plate	1500	700	1
20mm Plate	1100	700	1
30mm Plate	800	600	1
40mm Plate	600	400	1
50mm Plate	500	500	1



Material

- EN 10204 type 3.1 inspection certificate requirement
 - Mandatory! Use Harmonized Standards for pressure equipment or welded components to a pressure equipment
 - Materials in question for CERN: Grade 5 & 23 Ti, 6061-T6 AI
 - Example: Thermal Screen
 - North American certificates satisfy requirements related to form, alloy designation, temper state, etc. except EN 10204 type 3.1
- Status:
 - North American material certificates must include material information required for specific component (chemical composition and mechanical properties)
 - Must be submitted for CERN review with a **Deviation Request** containing the list of components to be manufactured with material of concern



Orbital Welding

- AMI Model 217 (supersedes CERN: Model 207A)
- MIT Wolfram Tungsten electrode (equiv. Wolfram Orbistar)
- Modified weld head clamps (8mm/10mm)
- Goal: Familiarize TRIUMF team with equipment and joint prior to certification process and CERN demonstration







			COPYRIGH 24 AP 12 /0	7/202
WELD		RT_JEROME	_1205	
		L: 9-500		
	HEAD SN:			
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000	10.00		1 110/1	0007
20	20	0.5		J 3.5
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			0.10	
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SECT.	PULSE	ROT	HTTPM 3.50 3 HTPULS	1BAS
з	ON	CONT	3.50	
	SEC HT-	AMPBAS	B HTPULS	BE-BAS
3	4.3 53	.0 18.0	0.10	0.10
SECT.	PULSE	ROT	HTTPN	1BAS
4	ON	CONT	HTTP№ 3.50	
	SEC HT-	AMPBAS	6 HTPULS	E-BAS
4	4.3 52	.0 18.0	0.10	0.10
SECT.	PULSE	ROT	HTTPM 3.50 6 HTPULS	1BAS
5	ON	CONT	3.50	
	SEC HT-	AMPBAS	B HTPULS	E-BAS
5	4.3 50	.0 18.0	0.10	0.10
SECT.	PULSE	ROT	HTTP№ 3.50	1BAS
6	ON	CONT	3.50	
	SEC HT-	AMPBAS	6.10 6 HTPULS 7 0.10	E-BAS
6	1.6 49	.0 18.0	0.10	0.10
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Orbital Welding





Orbital Welding



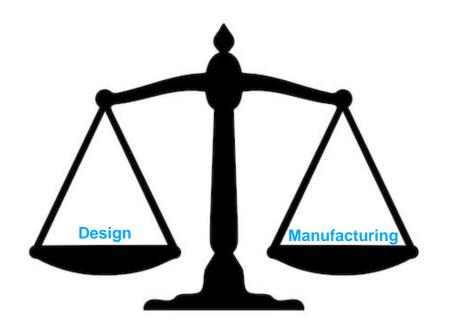
10

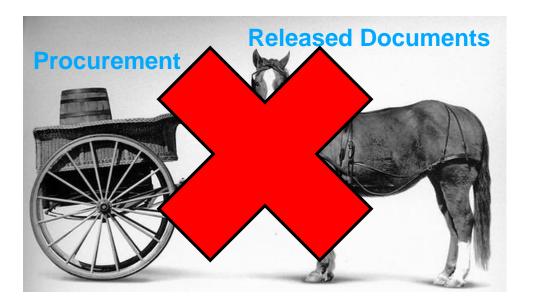


Budget Deadline

TRIUMF's fiscal year ends March 2025

- Ordered parts must be through the door for funds to be spent
- Unreleased drawings (ex. out of vacuum tuner)
- Hardware & Instrumentation lists of released assemblies
- Revisions to released drawings







Conclusion

- OVC Weld documentation qualification (Axton)
 - Expected to be approved this week (pending CERN action)
- Material procurement to EN/ISO standards
 - CERN's relaxation of requirements or supply of material
- Orbital welding
 - Demonstration at CERN
 - Further testing
- TRIUMF's end of fiscal year deadline March 2025

Future Outlook

- OVC welding & dimensional checks
- Launching procurement of remaining assemblies/hardware/instrumentation
- Receiving parts @ TRIUMF
- TRIUMF welders' certifications



Thank you Merci

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