

pfRICH CERN Testbeam Summary

Brian Page – for the pfRICH Team



Five Weeks at CERN

Week	Description
May 20-27	Partial assembly & pre-commissioning
May 27 - June 3	Final assembly & SPS run (aka commissioning)
June 3 - 10	SPS -> PS transition; re-assessment of the PS run goals
June 10 - 24(27)	Re-assembly, PS run (main part of the beam test), dis-assembly

Personnel

Initial Setup and SPS Running

PS Running and Tear-Down

A1																																											
	A	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	
1		M19	M20	M21	M22	M23	M24	M25	M26	M27	M28	M29	M30	M31	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13	J14	J15	J16	J17	J18	J19	J20	J21	J22	J23	J24	J25	J26	J27	J28	
2	Person																																										
3	BNL																																										
4	Alexander	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
5	Bob								X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																	
6	Brian																					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
7	Jihee								X	X	X	X	X	X	X	X	X	X																									
8	Martin	X	X	X										X	X	X	X	X	X	X	X	X	X	X	X	X																	
9																																											
10	Glasgow																																										
11	Andrew Cheyne																				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
12	Kathleen Ramage																				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					
13																																											
14	Yale																																										
15	Brady																			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
16																																											
17	Purdue																																										
18	Sushrut									X	X	X	X																														
19																																											
20	Brussels																																										
21	Charlotte	03/06						X	X	X	X	X	X	X	X	X																											
22																																											
23	MSU																																										
24	Preet	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
25																																											
26																																											

SPS to PS Transition

Location Location Location



Overall Topics and Goals

- ❑ HRPPD performance in particle beam
 - Imaging photons
 - Window flashes
 - Timing
- ❑ Direct N_{pe} measurement (aerogel + filter + HRPPD PDE)
- ❑ Cherenkov angle resolution (comparison to MC)
- ❑ π/K and e/π separation
- ❑ FCFD first look
- ❑ Mirror evaluation (conical and pyramid)
 - ID reflected photons
- ❑ Laser monitoring system
 - Delay calibration using PiLas laser

Week of May 20 - 27

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May 20-27	Partial assembly & pre-commissioning
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Week of May 20 – 27: Summary

- ❑ Alexander, Martin, and Preet @ CERN
- ❑ Unpack crates
- ❑ Setup computing infrastructure
 - Local network, online monitoring, DAQ PC
- ❑ Setup DAQ hardware (NIM logic)
- ❑ Setup online monitoring tools
 - VNC sessions, tracker & imaging, GECO
- ❑ Assemble HRPPDs
- ❑ Assemble 8020 chassis
- ❑ Area infrastructure
 - Gas, DESY table, rack location, beam line Cherenkov instrumentation

Week of May 27 – June 3

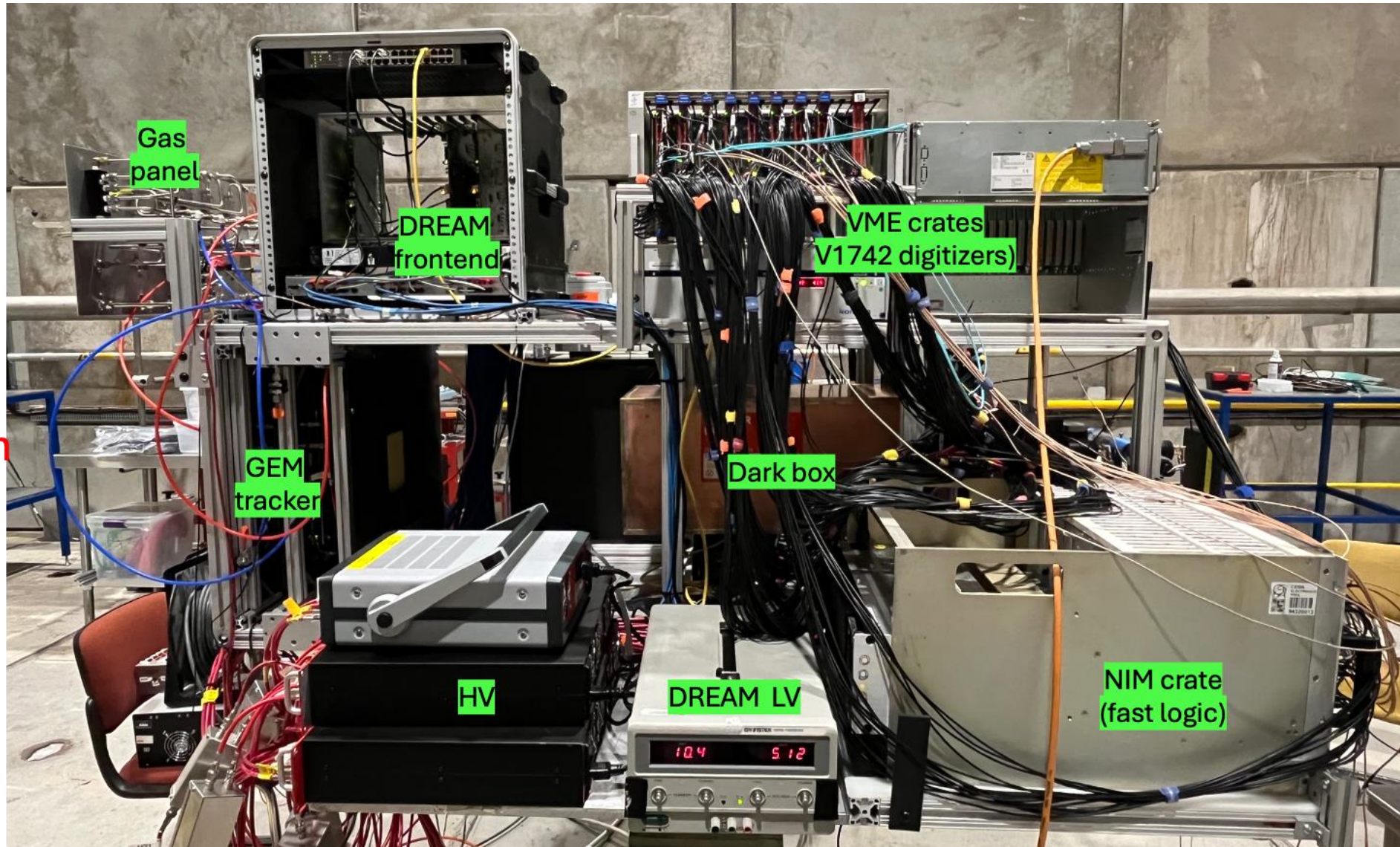
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Week of May 27 – June 3: Summary

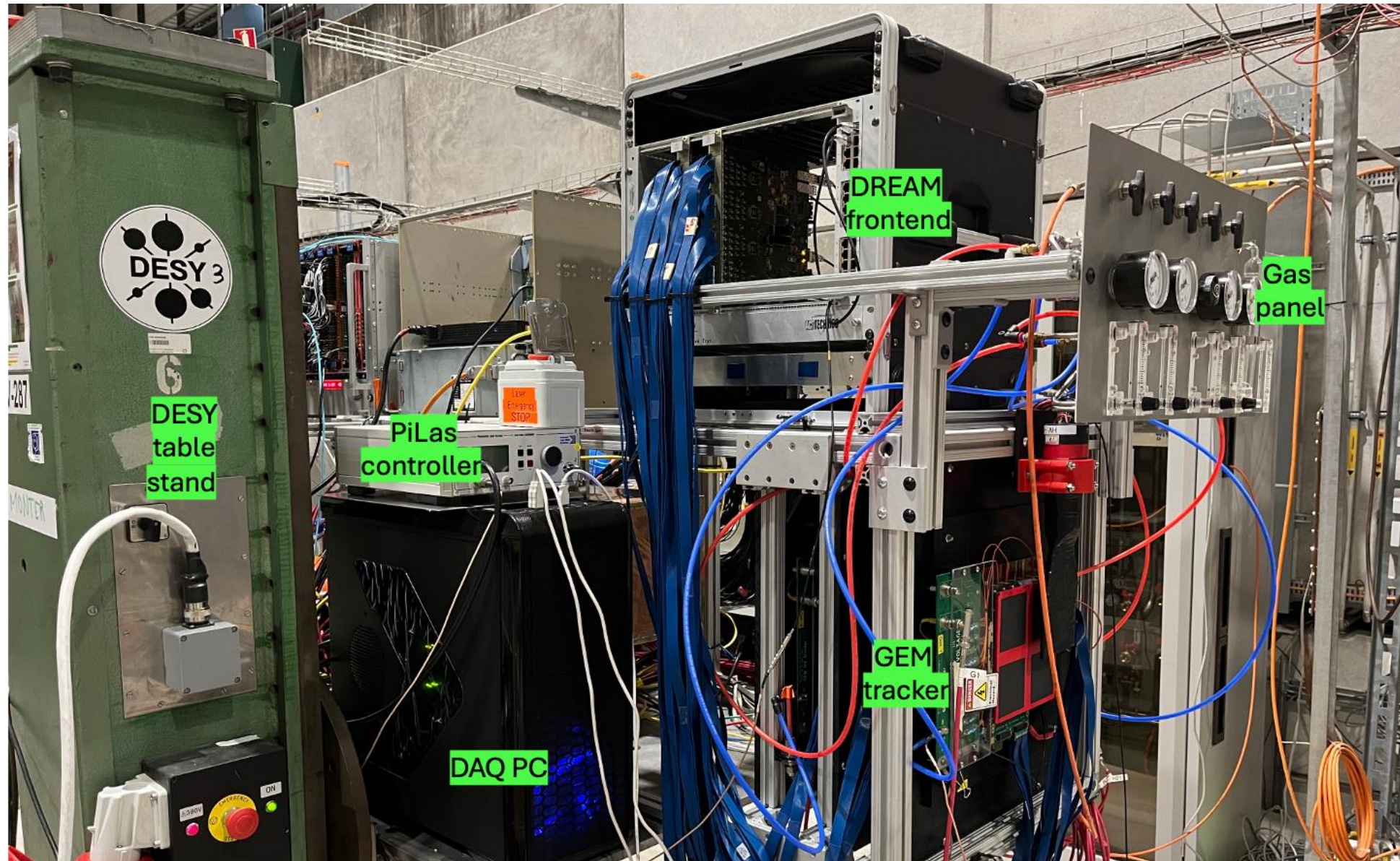
- ❑ Alexander, Bob, Jihee, Martin, and Preet @ CERN
- ❑ May 27 – 28: Move equipment into beam area and assembly
- ❑ May 29: Obtain safety clearance (for laser as well)
- ❑ ~Three days of commissioning work
 - Beam alignment and profiling
 - Collected data with window flashes in HRPPD 5
 - Collected data with laser monitoring system
- ❑ June 1 @ ~1 pm: Linac failure -> end of SPS run

SPS Installation

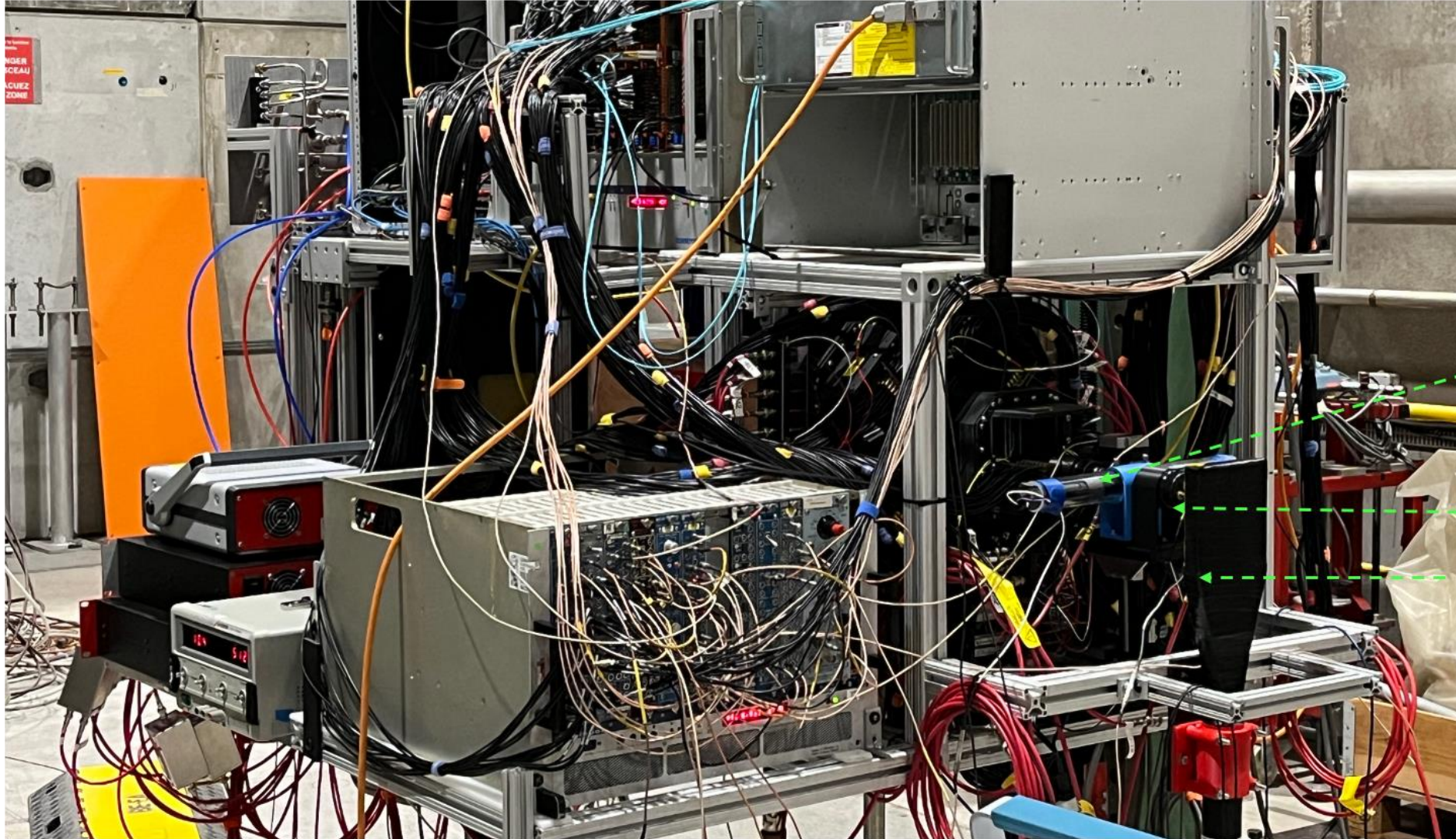
SPS beam
→



SPS Installation



SPS Installation

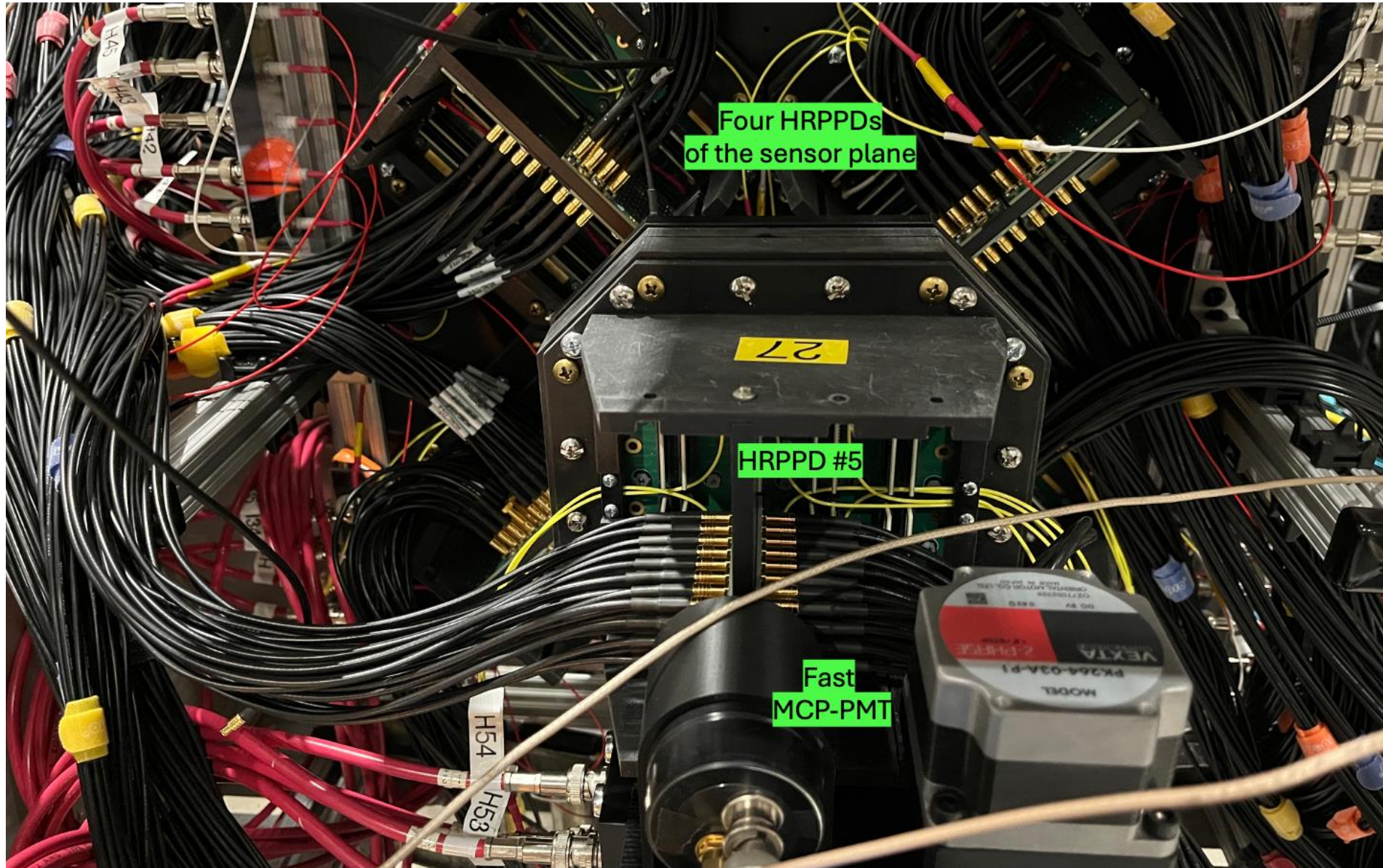


Finger
scintillators

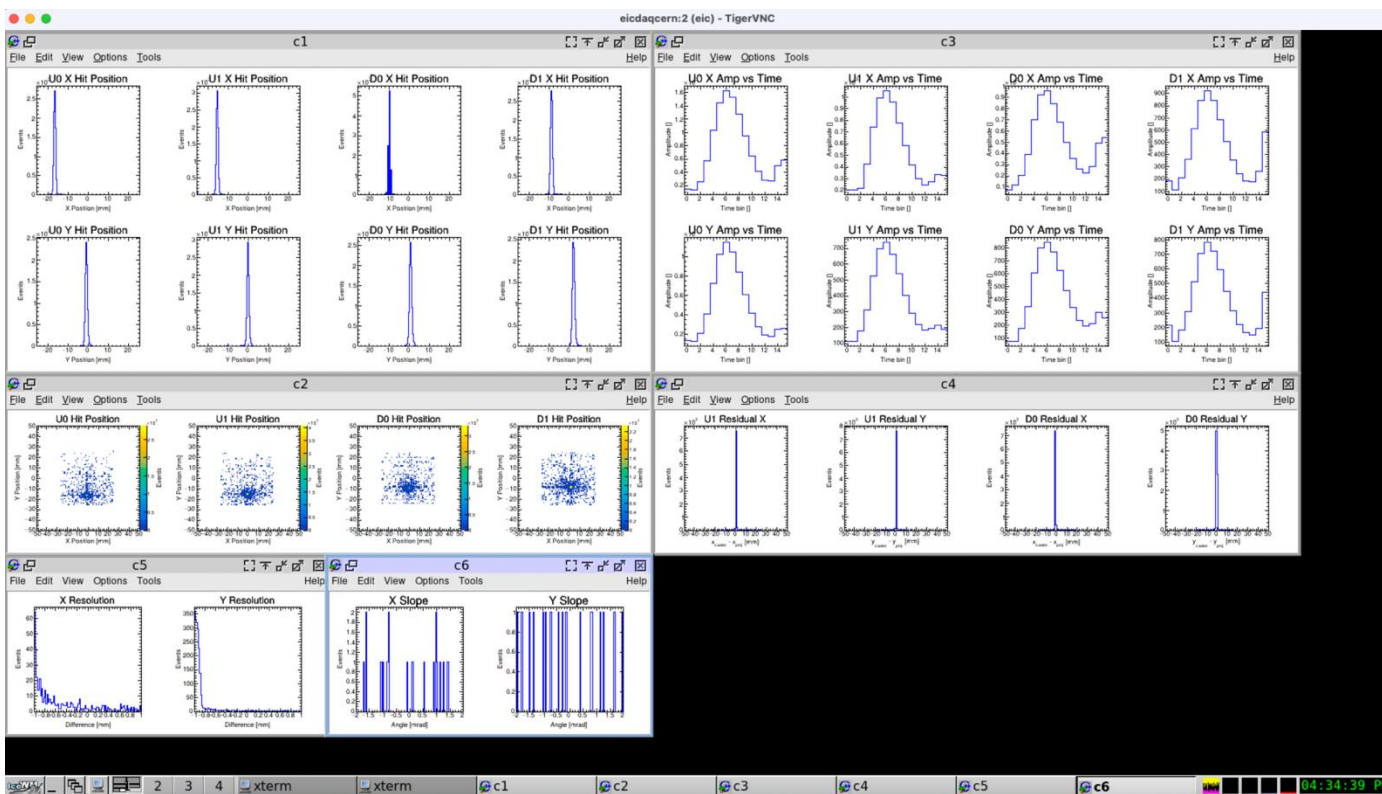
Fast
MCP-PMTs

Trigger
scintillators

SPS Installation

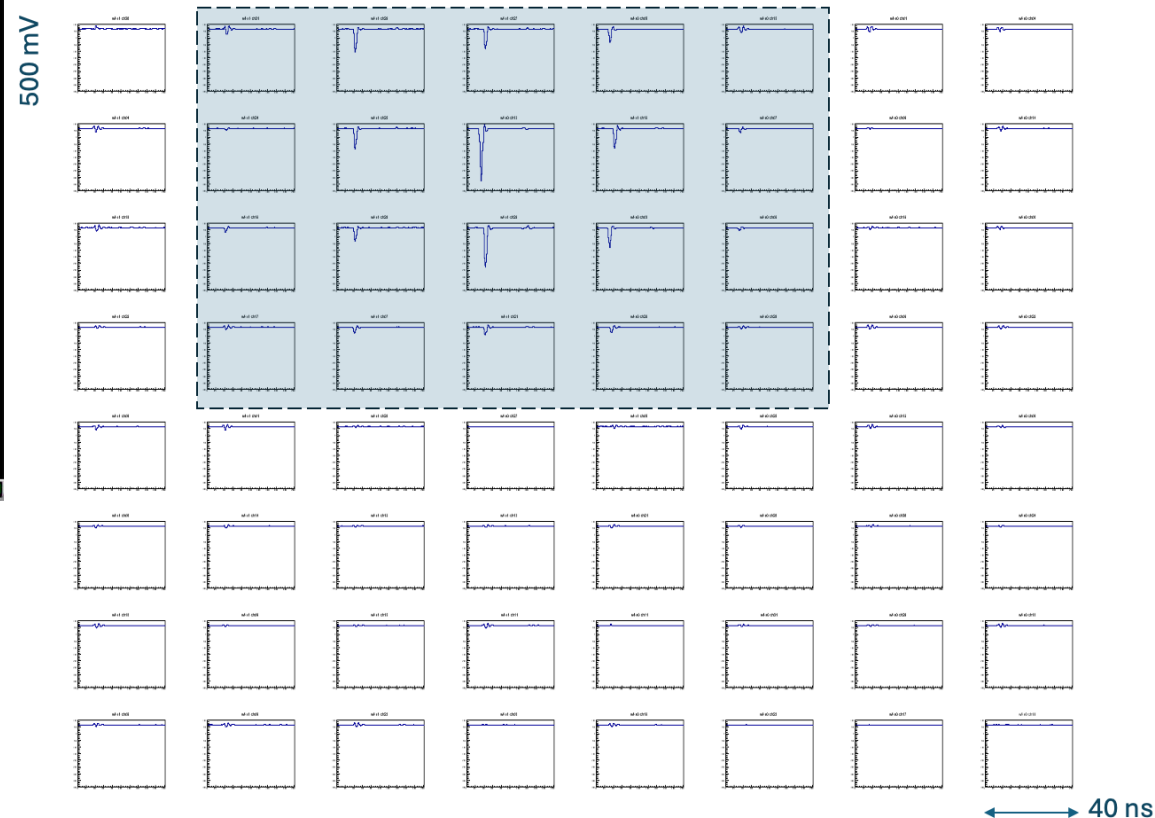


SPS Monitoring and Online Results



Above: Example of online monitoring plots for GEM trackers showing hit positions, amplitudes, residuals, etc.

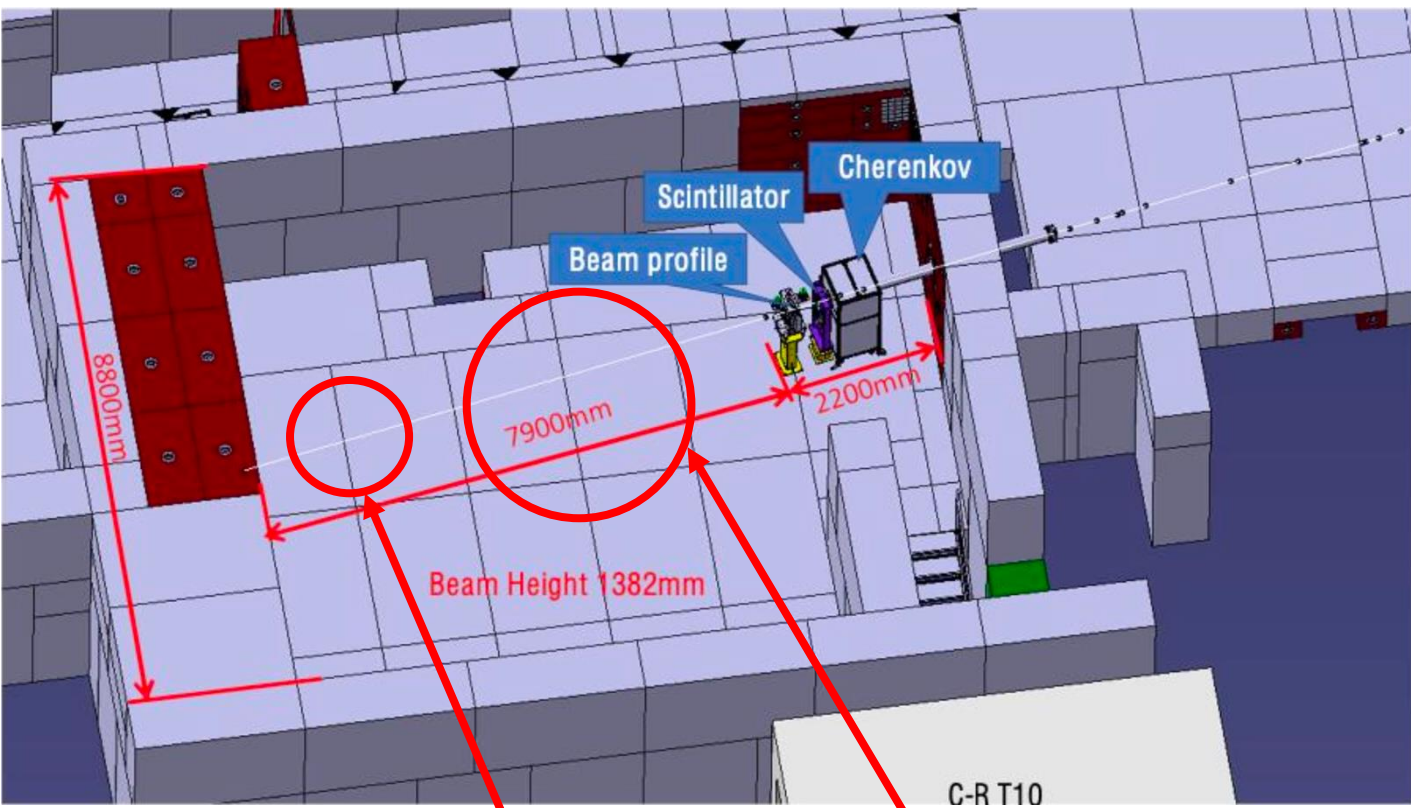
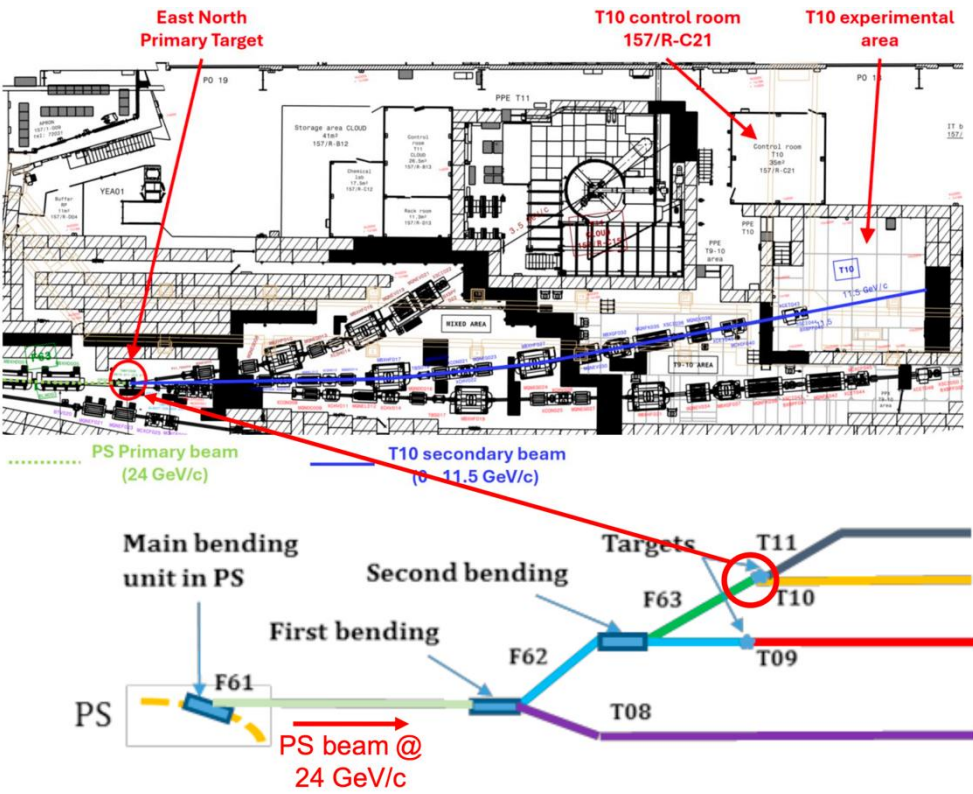
Below: A single events with waveforms of a multi-photon flash produced by a beam particle in the HRPPD #5 window (8x8 pad area)



Week of June 10 – 24(27)

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PS T10 Beam Line



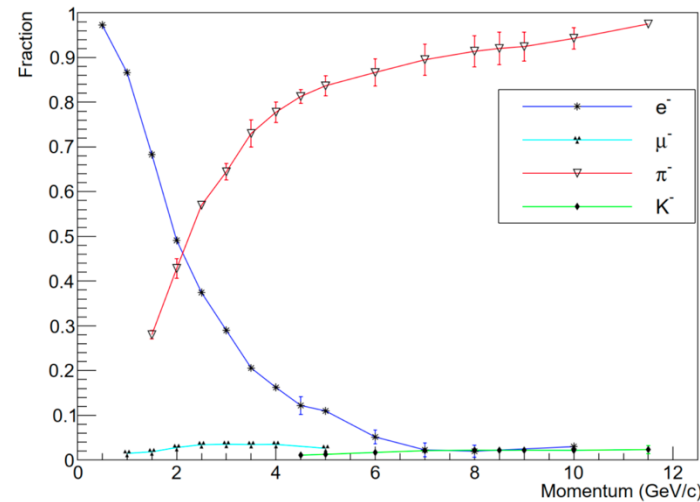
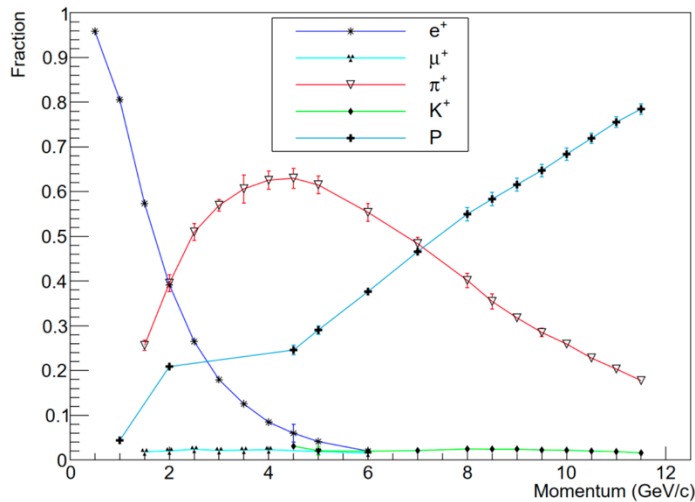
Parameter	T09 Target	T10/T11 Target	
Beam Line	T09	T10	T11
Secondary beam Max Momentum (GeV/c)	15	11.5	3.5
$\Delta p/p$ (%)	± 0.7 to ± 15.0	± 0.7 to ± 15.0	± 0.7 to ± 15.0
Maximum intensity/spill (hadrons/electrons)	$\sim 10^6$	$\sim 10^6$	$\sim 10^6$
Available particle types	Pure electrons (T09 only) or mixed/pure hadrons or muons		

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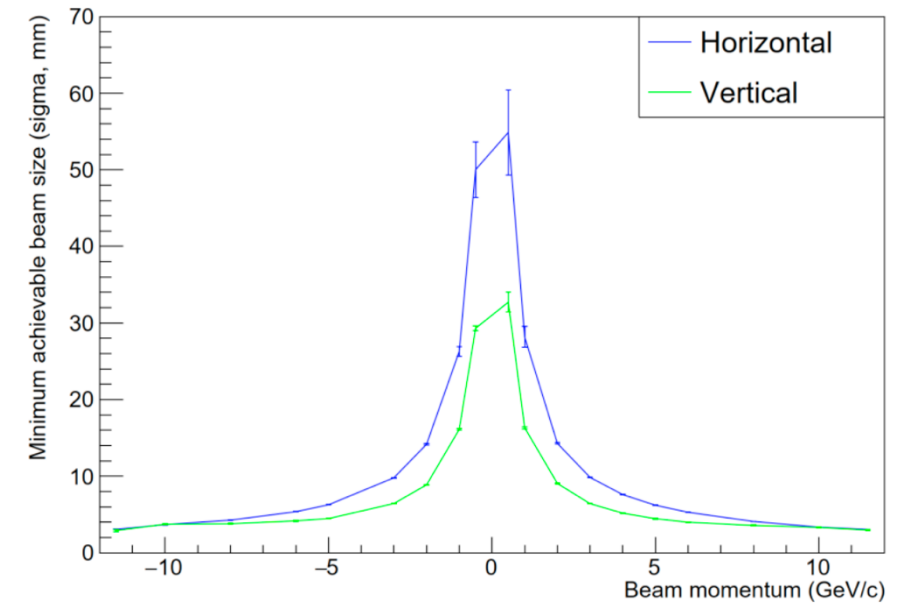
dRICH

PS T10 Beam Line

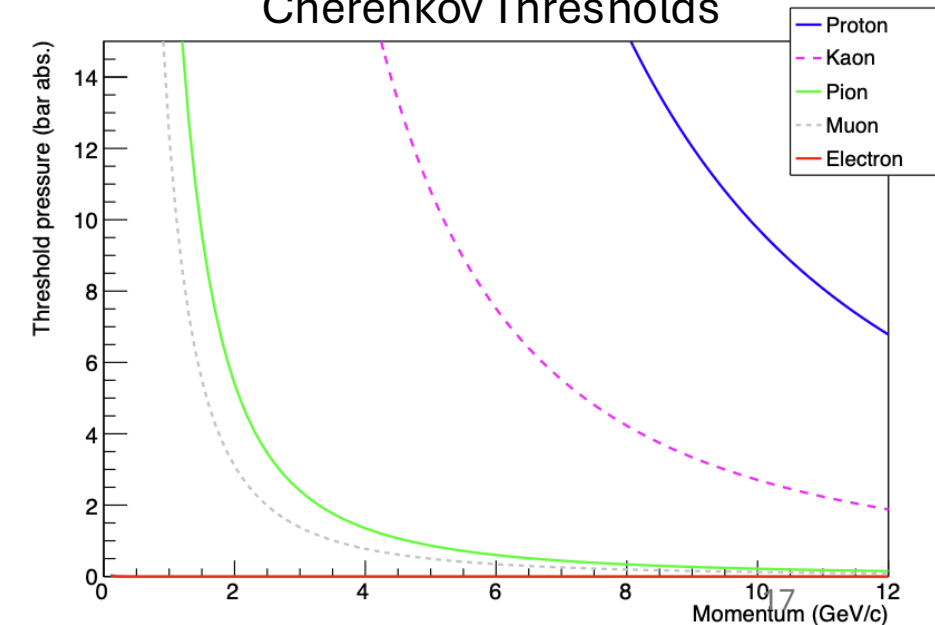
Beam Particle Content



Beam Size



Cherenkov Thresholds



- ☐ User control of many beam aspects, including charge sign, energy, intensity and focus
- ☐ Particle content of beam vs energy shown above – note the small kaon fraction
- ☐ Beam size largely determined by momentum selection with some influence from choice of focus position
- ☐ Access to beamline scintillator and Cherenkov signals and user control of Cherenkov gas pressure settings
- ☐ Challenging duty cycle – between 1 to 4 spills per minute / 0.4s flattop

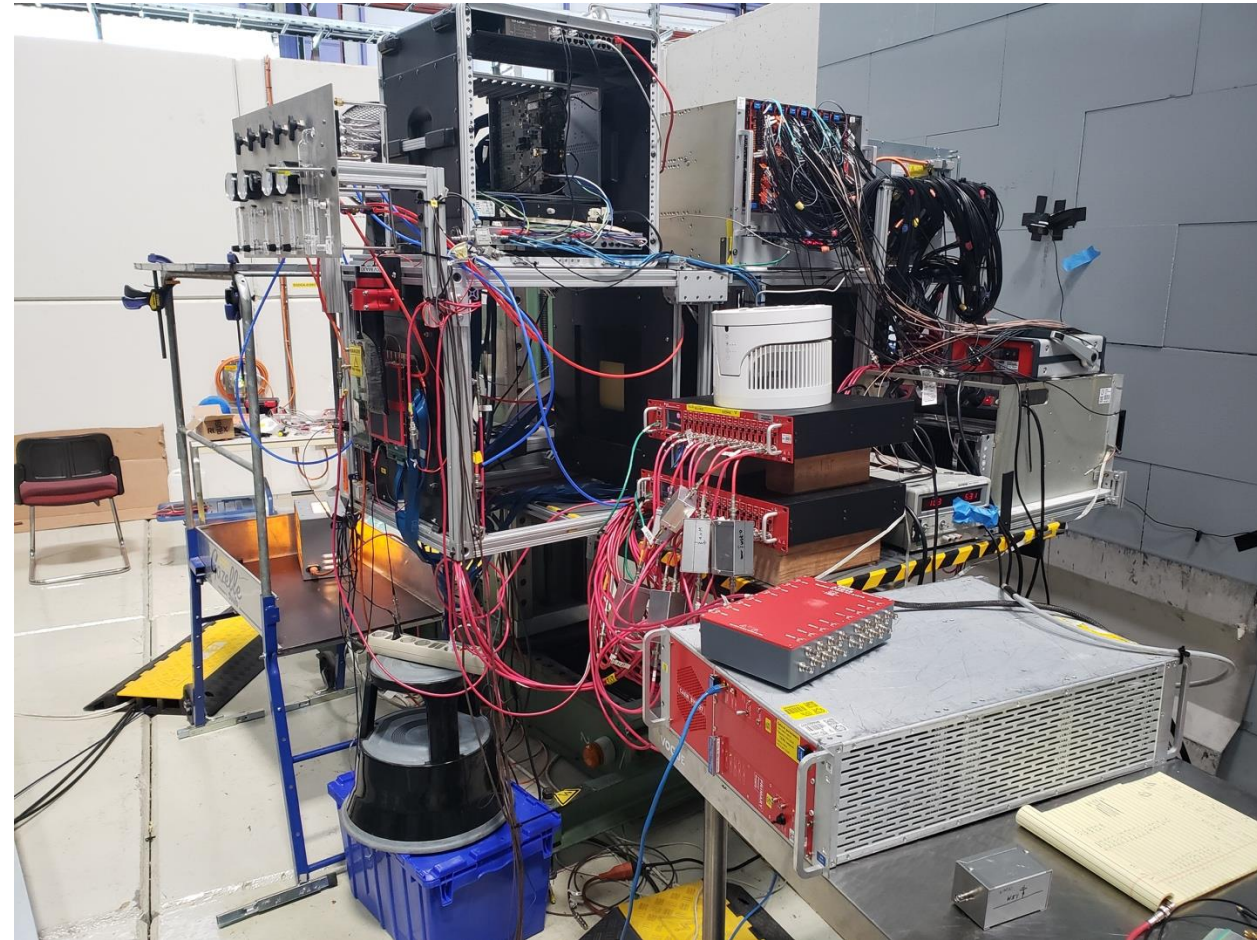
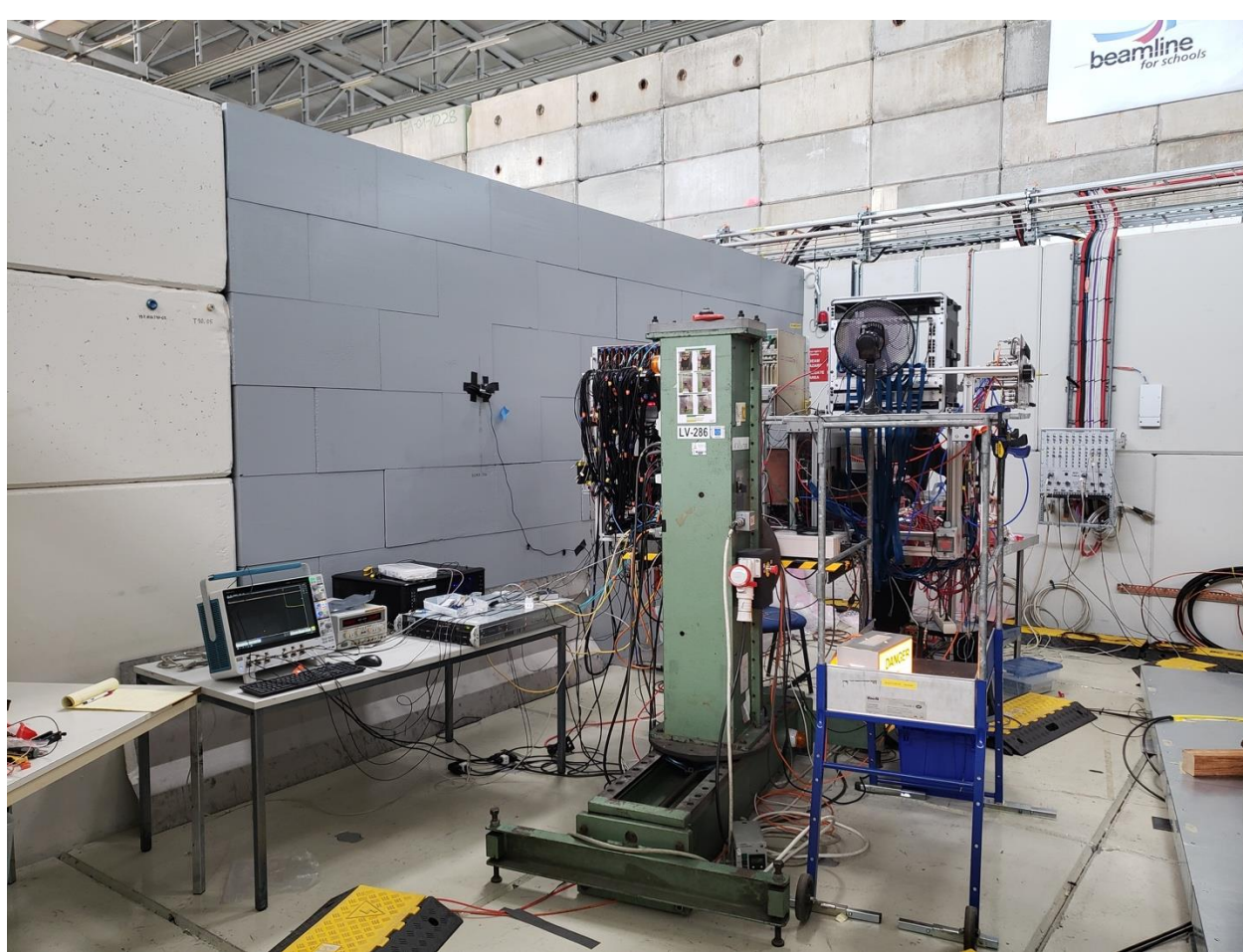
PS Installation



Week of June 10 – 24: Summary

- ❑ Jihee (6/4), Bob, and Martin (6/12) leave – Andrew, Bradyn, Brian, & Kathleen arrive
- ❑ June 10 & 11: Assemble test stand
 - Safety inspection passed ~ 3pm on the 11th
- ❑ June 12 – 19: Troubleshoot various issues
 - DAQ problems (computer crashes, computer swaps, synch issues)
 - Trigger setup / logic
 - Rate optimizations
 - Digitizer configuration
 - Power supply
- ❑ June 19 - 24: ~Stable running
 - Energy scans
 - Expansion volume scans
 - FCFD
 - Mirrors
 - Timing
 - Dedicated electron ID

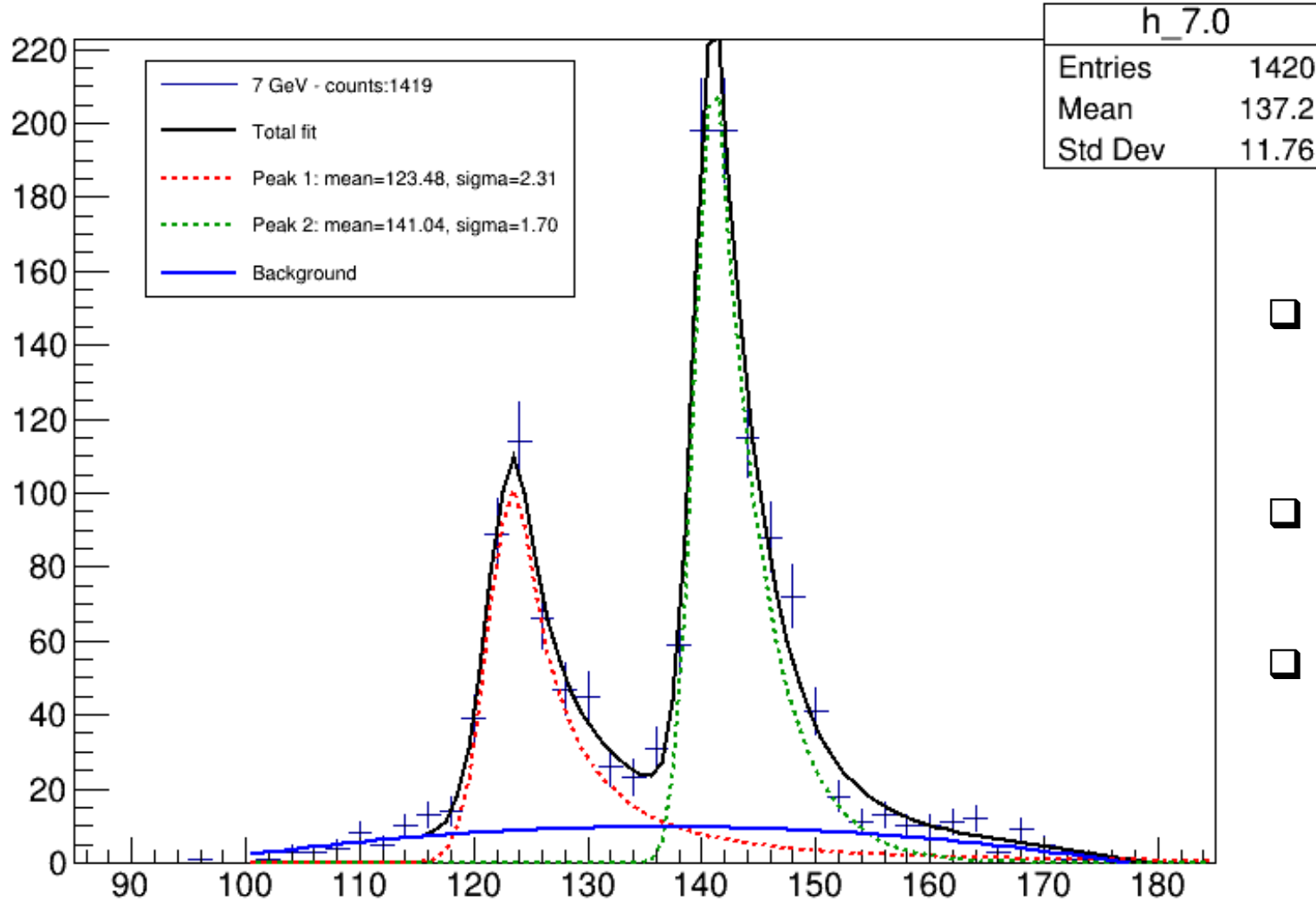
PS Final Configuration



PS Data Set

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
	Run Number	Start Time (MM/DD/YYYY HH:MM:SS)	End Time (MM/DD/YYYY HH:MM:SS)	Length (d)	Beam Energy (GeV)	Beam Charge (nC)	Number of Triggers	Events/Min	Beam Position (mm)	Laser Info	Aerogel Position (mm)	Values X,Y	Aerogel Values	HSPD Values	Quality Flag	Comments					
502	320270	6/23/2026 9:17:56	6/23/2026 9:54:22	36.43	12.175	32.706	10910	291.2163544	Completed X,Y	Off	Inserted			H1 (200-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5	Good	2 position not in beam, verify					
503	320271	junk			12.175	32.706	0		Completed X,Y	Off	Inserted			H1 (200-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5							
504	320272	junk			12.175	32.706	3		Completed X,Y	Off	Inserted			H1 (200-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5							
505	320273	junk			12.175	32.706	3		Completed X,Y	Off	Inserted			H1 (200-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5							
506	320274	6/23/2026 13:42:55	6/23/2026 13:50:44	7.82	12.175	32.706	194	252.573136	Completed X,Y	Off	Inserted			H1 (200-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5		trigger2 useless - gain very low, trigger 5 is off					
507	320275	6/23/2026 14:02:30	6/23/2026 14:05:02	2.53	12.175	32.706	596	235.2631084	Completed X,Y	Off	Inserted			H1 (200-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5							
508	320276	6/23/2026 14:05:32	6/23/2026 14:14:28	8.93	12.175	32.706	3142	351.7164178	Completed X,Y	Off	Inserted			H1 (200-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5							
509	320277	6/23/2026 14:15:10	6/23/2026 14:30:30	15.33	12.175	32.706	5399	352.1086956	Completed X,Y	Off	Inserted			H1 (200-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5							
510	320278	6/23/2026 14:38:15	6/23/2026 15:11:11	31.93	12.175	32.706	12086	378.4759917	Completed X,Y	Off	Inserted			H1 (200-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5		cpus 486 (13 script value)					
511	320279	6/23/2026 15:12:01	6/23/2026 15:41:58	29.95	12.175	32.706	6546	218.5642738	Completed X,Y	Off	Inserted			H1 (200-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5		cpus 487 (38 script)					
512	320280	6/23/2026 16:03:41	6/23/2026 16:11:19	7.43	12.175	32.706	0		Completed X,Y	Off	Inserted			H1 (200-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5							
513	320281	6/23/2026 16:16:43	6/23/2026 16:17:48	10.05	12.175	32.706	3194	316.7603394	Completed X,Y	Off	Inserted			H1 (200-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5		Mirrors are in, aerogel at 10 (88mm)					
514	320282	6/23/2026 16:18:54	6/23/2026 16:30:08	18.07	12.175	32.706	4731	341.9928186	Completed X,Y	Off	Inserted			H1 (200-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5							
515	320283	6/23/2026 16:33:47	6/23/2026 16:53:12	19.42	12.175	32.706	8650	445.493652	Completed X,Y	Off	Inserted			H1 (200-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5							
516	320284	6/23/2026 16:54:07	6/23/2026 16:59:41	15.87	12.175	32.706	7403	475.8886512	Completed X,Y	Off	Inserted			H1 (200-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5							
517	320285	6/23/2026 16:29:04	6/23/2026 16:35:36	6.53	12.175	32.706	2410	368.8775512	Completed X,Y	Off	Inserted			H1 (200-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5							
518	320286	junk			12.175	32.706	3		Completed X,Y	Off	Inserted			H1 (200-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5							
519	320287	6/23/2026 20:09:14	6/23/2026 20:13:38	4.40	12.175	32.706	1222	277.7272733	Completed X,Y	Off	Inserted			H1 (40-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5		H1 stopped PC, aerogel at 1					
520	320288	6/23/2026 20:16:35	6/23/2026 20:45:28	28.88	12.175	32.706	10859	375.9407618	Completed X,Y	Off	Inserted			H1 (40-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5							
521	320289	junk			12.175	32.706	0		Completed X,Y	Off	Inserted			H1 (40-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5		recreating data table					
522	320290	6/23/2026 20:50:49	6/23/2026 21:21:20	30.52	12.175	33.709	10466	349.5139268	Completed X,Y	Off	Inserted			H1 (40-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5		aerogel at 26					
523	320291	6/23/2026 21:22:48	6/23/2026 21:25:48	3.00	12.175	33.709	1130	376.6666668	Completed X,Y	Off	Inserted			H1 (40-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5		aerogel at 51, switched to -11					
524	320292	6/23/2026 21:27:22	6/23/2026 21:53:52	26.50	12.175	33.709	9107	343.6603773	Completed X,Y	Off	Inserted			H1 (40-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5							
525	320293	6/23/2026 22:18:39	6/23/2026 22:44:33	25.90	12.175	33.709	13407	440.4027105	Completed X,Y	Off	Inserted			H1 (40-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5		HSPD #1 PC trip, reduced PC layer by 50V					
526	320294	6/23/2026 22:44:58	6/23/2026 22:58:57	13.98	12.175	33.709	7099	507.4705845	Completed X,Y	Off	Inserted			H1 (40-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5		adjusted the sensor - aerogel at 1					
527	320295	6/23/2026 22:59:35	6/23/2026 23:30:30	30.92	12.175	33.709	10602	342.918329	Completed X,Y	Off	Inserted			H1 (40-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5		aerogel at 51					
528	320296	6/23/2026 23:31:22	6/23/2026 23:50:31	24.15	12.175	33.709	5008	297.3106004	Completed X,Y	Off	Inserted			H1 (40-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5							
529	320297	6/24/2026 0:08:20	6/24/2026 0:40:28	37.13	12.175	33.709	10093	271.8104038	Completed X,Y	Off	Inserted			H1 (40-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5							
530	320298	6/24/2026 0:45:52	6/24/2026 0:51:27	5.58	12.175	33.709	1551	277.791045	Completed X,Y	Off	Inserted			H1 (40-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5							
531	320299	6/24/2026 0:51:45	6/24/2026 1:04:31	12.77	12.175	33.709	4572	358.1201042	Completed X,Y	Off	Inserted			H1 (40-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5		aerogel was left at position 50 from access. Short run as a result					
532	320300	6/24/2026 1:44:43			12.175	33.709	99		Completed X,Y	Off	Inserted			H1 (40-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5		Aerogel moved to position 58, 440 mm					
533	320301	6/24/2026 1:46:40	6/24/2026 1:51:49	5.15	12.175	33.709	779	151.262136	Completed X,Y	Off	Inserted			H1 (40-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5		The cherenkov counters are set for 2 gev not 5gev. Cannot see separation. (currently @ 4 Bar on bc)					
534	320302	6/24/2026 1:52:56	6/24/2026 2:09:25	16.48	12.175	33.709	4151	251.8301313	Completed X,Y	Off	Inserted			H1 (40-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5	Bad						
535	320303	6/24/2026 2:12:01			12.175	33.709	6941		Completed X,Y	Off	Inserted			H1 (40-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5		endstapam crashed mid run.					
536	320304	6/24/2026 2:48:12	6/24/2026 3:01:59	13.78	12.175	33.709	4732	343.31318	Completed X,Y	Off	Inserted			H1 (40-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5							
537	320305	6/24/2026 3:03:12	6/24/2026 3:19:04	11.87	12.175	33.709	4441	374.2415731	Completed X,Y	Off	Inserted			H1 (40-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5		XCET pressure moving from 4 to 2 bar (not waiting for it to come down, just taking data) Collimators					
538	320306	6/24/2026 3:19:23	6/24/2026 3:34:36	8.17	12.175	33.709	2357	402.3309942	Completed X,Y	Off	Inserted			H1 (40-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5							
539	320307	6/24/2026 3:36:22	6/24/2026 3:47:36	23.28	12.175	33.709	10962	470.808761	Completed X,Y	Off	Inserted			H1 (40-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5							
540	320308	6/24/2026 3:47:58	6/24/2026 3:59:25	11.45	12.175	33.709	6171	536.9516553	Completed X,Y	Off	Inserted			H1 (40-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5							
541	320309	6/24/2026 4:01:20	6/24/2026 4:21:49	20.48	12.175	33.709	10056	490.9357201	Completed X,Y	Off	Inserted			H1 (40-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5		XCETs changed both to 1.0 Bar, not there yet. Collimators +12					
542	320310	6/24/2026 4:22:17	6/24/2026 4:48:42	26.42	12.175	33.709	10544	399.1415558	Completed X,Y	Off	Inserted			H1 (40-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5		Cherenkov Counters reached 1 bar.					
543	320311	6/24/2026 4:49:55	6/24/2026 5:01:42	11.78	12.175	33.709	6667	565.7991514	Completed X,Y	Off	Inserted			H1 (40-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5		Moving counters back to 2 bar					
544	320312	6/24/2026 5:02:05	6/24/2026 5:11:12	9.12	12.175	33.709	5129	562.9959778	Completed X,Y	Off	Inserted			H1 (40-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5		XCETs at 2 bar					
545	320313	6/24/2026 5:12:23	6/24/2026 5:20:36	8.22	12.175	33.709	2446	297.6876267	Completed X,Y	Off	Inserted			H1 (40-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5		Gas pressure set to 4 bar					
546	320314	6/24/2026 5:20:57	6/24/2026 6:11:26	50.88	12.175	33.709	16895	334.6440099	Completed X,Y	Off	Inserted			H1 (40-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5		Gas reached 4 bar					
547	320315	6/24/2026 6:11:44	6/24/2026 6:30:08	18.40	12.175	33.709	7585	412.2282607	Completed X,Y	Off	Inserted			H1 (40-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5							
548	320316				12.175	33.709			Completed X,Y	Off	Inserted			H1 (40-760-200-760-100) H2(200-615-200-615-200)H3(200-470-200-470-50)H4(200-430-200-430-50)H5							

Example Fast Offline Money Plot

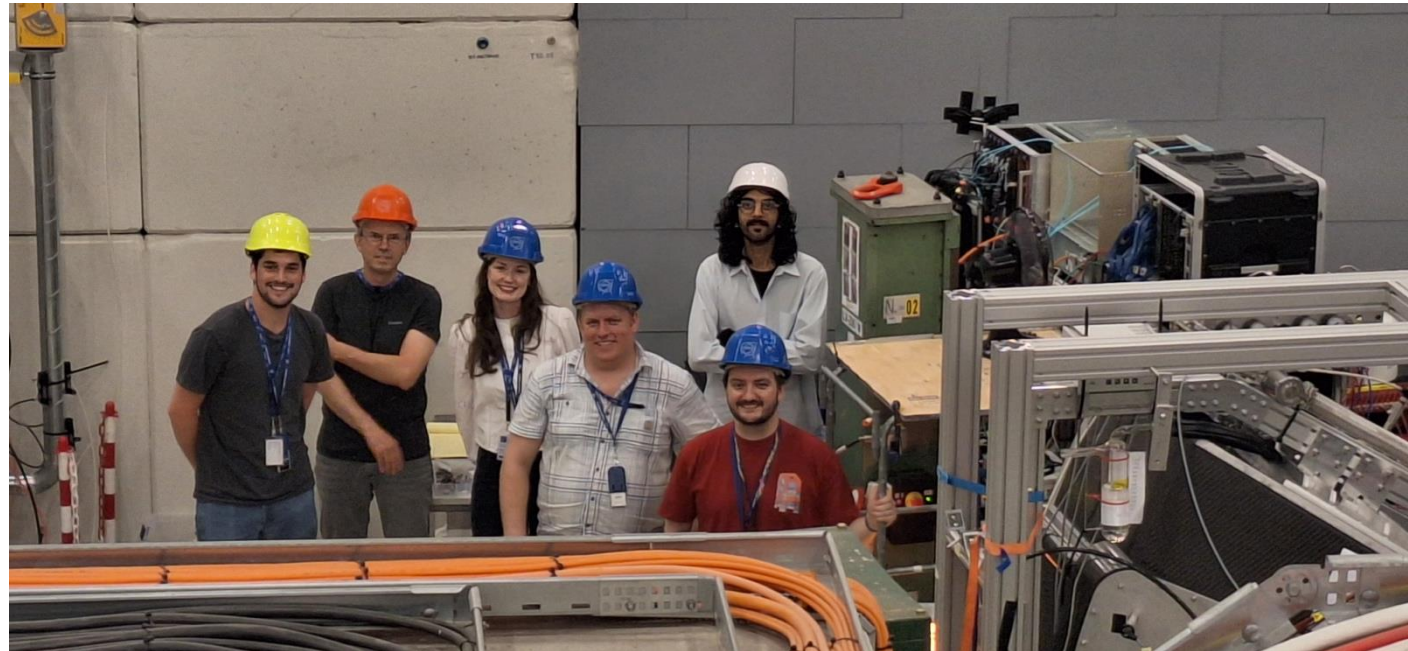


- Distance from track to photon at the sensor plane (in mm) from a 7 GeV run – Cherenkov ring radius at the HRPPDs
- Pion (right) and proton (left) peaks clearly visible – Kaon fraction will be tiny
- Peak positions roughly consistent with aerogel refractive index, expansion distance, and refraction at aerogel-gas boundary

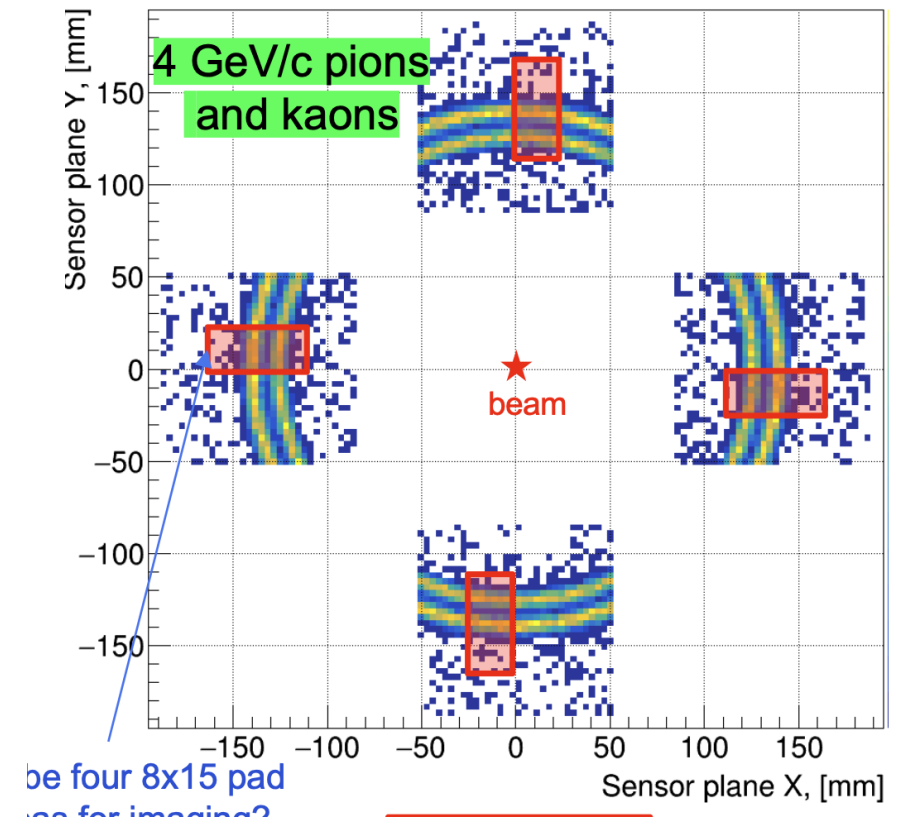
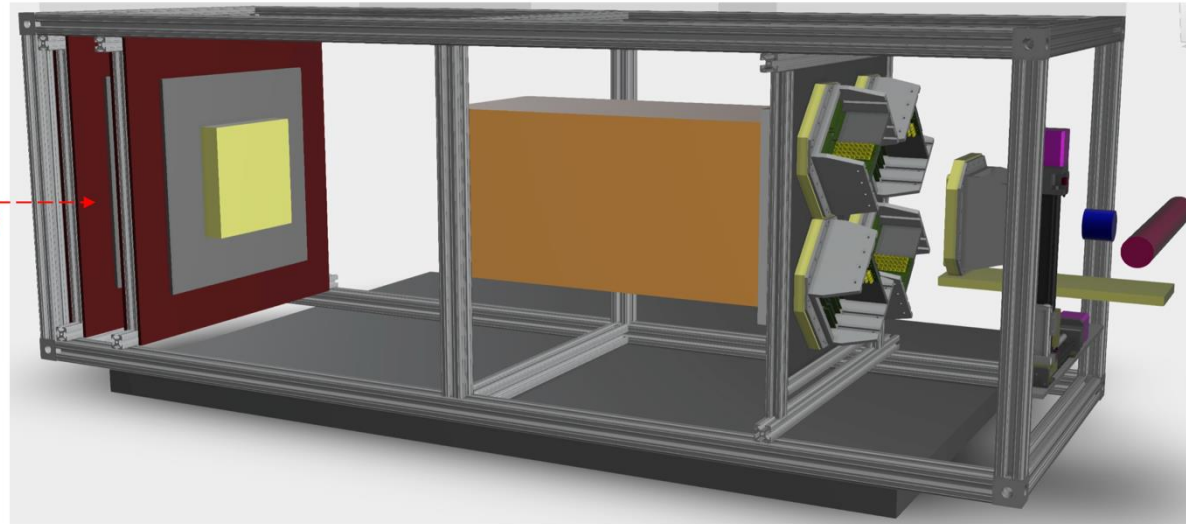
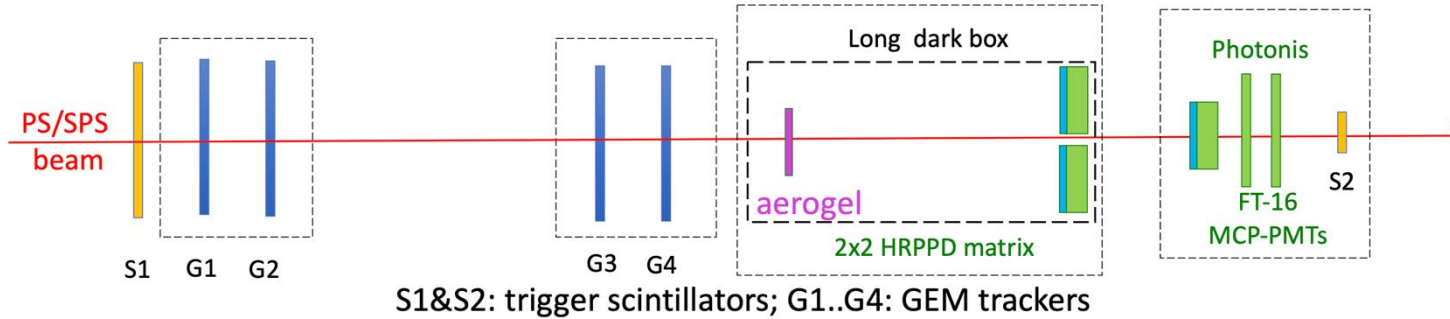
Summary

- ❑ HRPPD performance in particle beam ✓
 - Imaging photons
 - Window flashes
 - Timing
- ❑ Direct N_{pe} measurement (aerogel + filter + HRPPD PDE) ✓
- ❑ Cherenkov angle resolution (comparison to MC) ✓
- ❑ π/K and e/π separation ✓
- ❑ FCFD first look ✓
- ❑ Mirror evaluation (conical and pyramid) ✓
 - ID reflected photons
- ❑ Laser monitoring system ✓
 - Delay calibration using PiLas laser

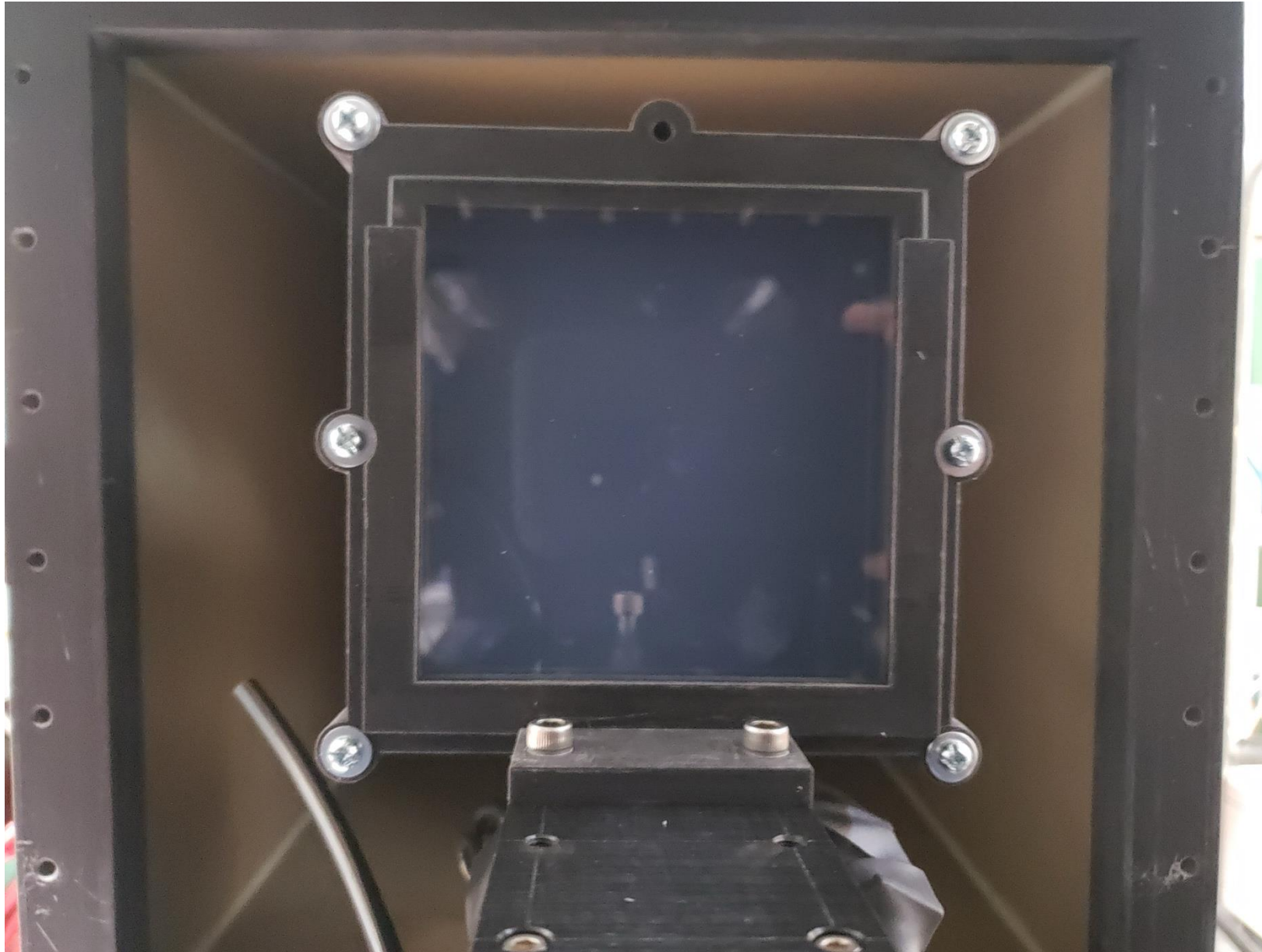
- ❑ Decision made to apply for CERN beam time in ~January, meaning we had < 6 months to fully implement a program at an entirely new facility – huge effort by all involved
- ❑ Despite loss of beam at SPS and difficult conditions at PS, we took significant data in most planned configurations
- ❑ Data analysis is just beginning and ultimate conclusions are not known – but indications are that we will be able to meaningfully address many of our goals
- ❑ PS should be back on-line in 2028...



Apparatus Layout and HRPPD Readout



Aerogel and Filter



View of the Hall



View of the Darkbox (During Disassembly)



Removal of the Chassis



dRICH Installation

