

Preparation status of INTT and sPHENIX for Run23

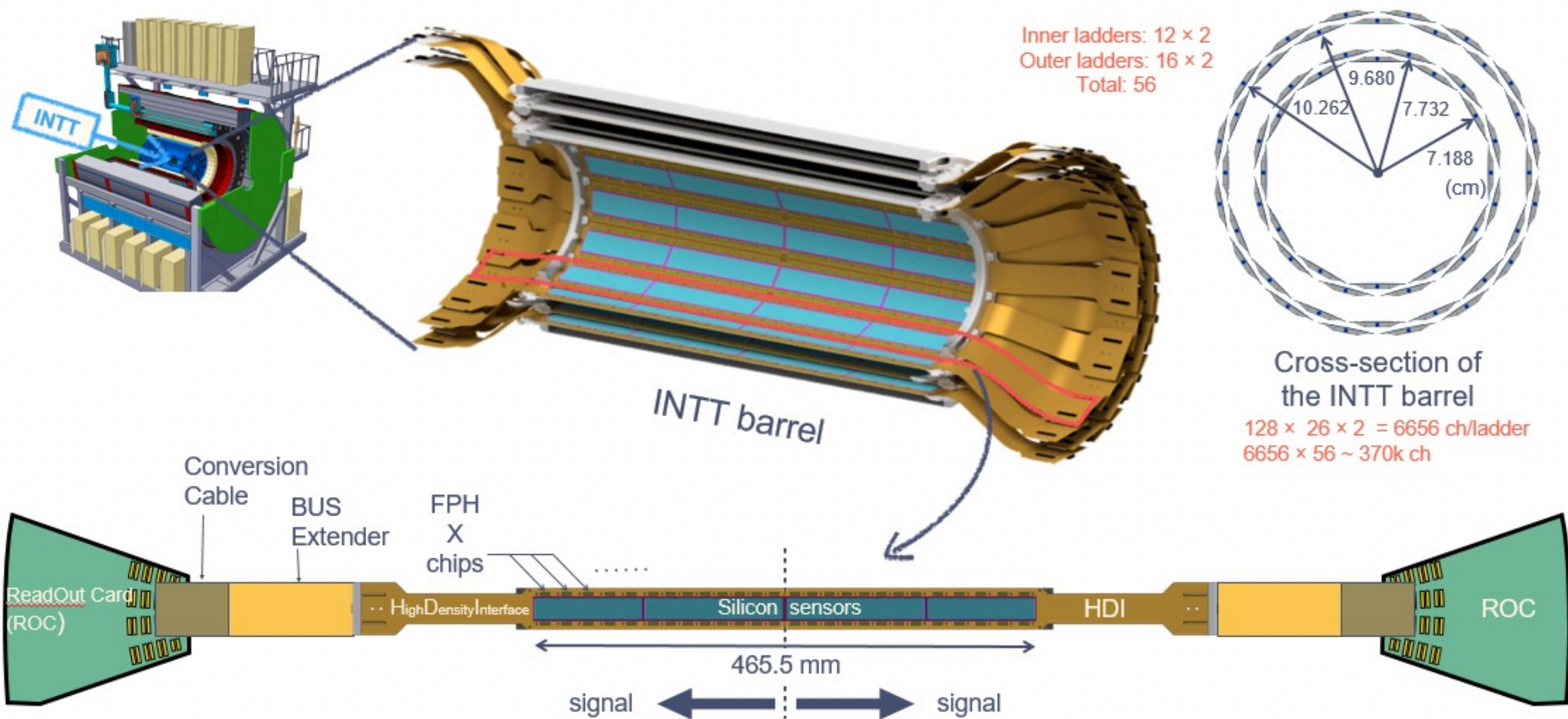
RIKEN/RBRC

Itaru Nakagawa

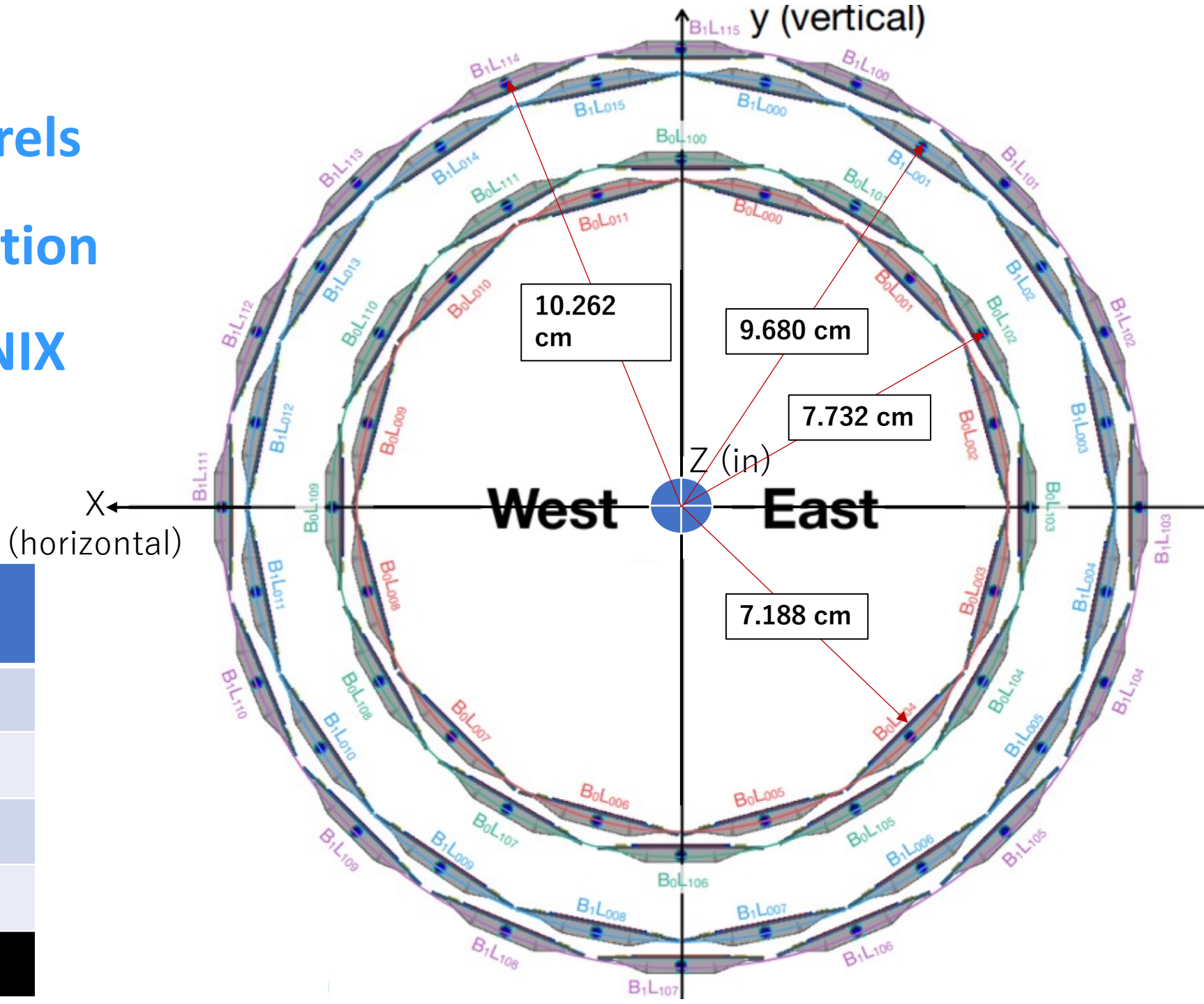
On behalf of **INTT Team**



Overview of Intermediate Silicon Tracker (INTT)



INTT Barrels Configuration in sPHENIX



Layer	Total Ladders
B0L0	12
B0L1	12
B1L0	16
B1L1	16
Total	56

Overview of Intermediate Silicon Tracker (INTT)

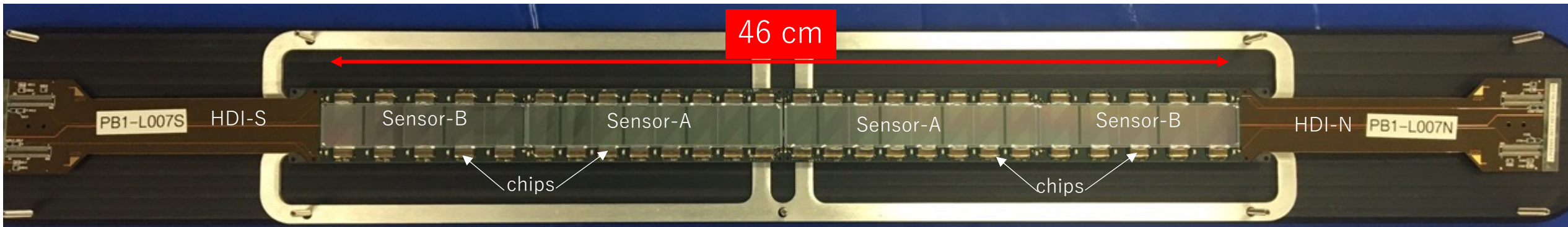
Silicon Strip Sensor:

- Very fine pitch ($9.984/128 = 78 \mu\text{m}$ in ϕ),
for good spatial resolution
- High efficiency ($>99\%$) and low noise
for excellent tracking
- Excellent time resolution $[-20 \text{ ns}, 60 \text{ ns}]$
for no pileup
- Thin-sensor/low mass, $320 \mu\text{m}$ ($\sim 0.34\% X_0$),
for less multiple scattering

Detector Requirements

Barrel	Center of Sensor Tangent Radius (mm)	Pseudo rapidity	QTY of Ladders	Angle (deg)	Coverage (PHI) (%)	Overlap (%)	Clearance (mm)	Chip Power Dissipation (W)	Stave Rad Length (%)	Barrel Rad Length (%)
1	-	-	24	-	100	2	2.00	62.30	0.80	2.20
1a (Inner)	71.88	1.37	12	0	53	0	0.60	31.15	0.40	1.10
1b (Outer)	77.32	1.31	12	0	49	0	3.80	31.15	0.40	1.10
2	-	-	32	-	100	2	2.22	83.07	0.80	2.20
2a (Inner)	96.80	1.12	16	0	53	0	0.60	41.53	0.40	1.10
2b (Outer)	102.62	1.07	16	0	49	0	3.12	41.53	0.40	1.10
Total	-	-	56	-	-	100	11.22	145.37	1.60	4.40

Stave: Carbon-Fiber-Support



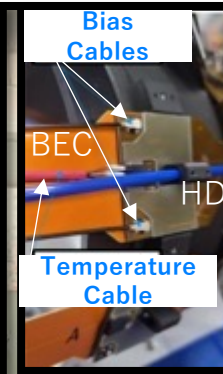
Ladder Mass Production : **done** (March 15, 2022): 120 ladders, 56 needed

Status and Highlights: INTT Construction

INTT Construction : done September 15, 2022

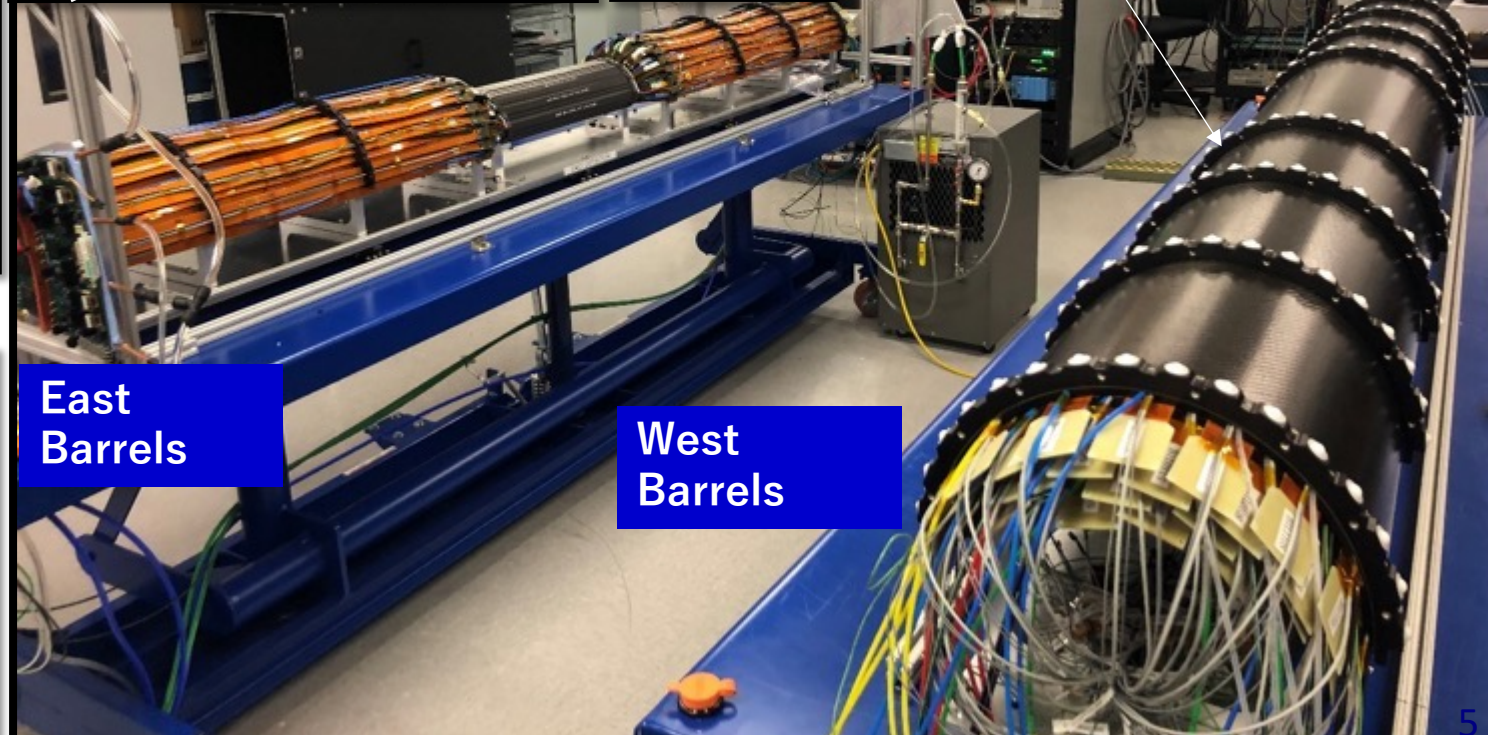


Silicon Strip Layers Mounted on CFC Support

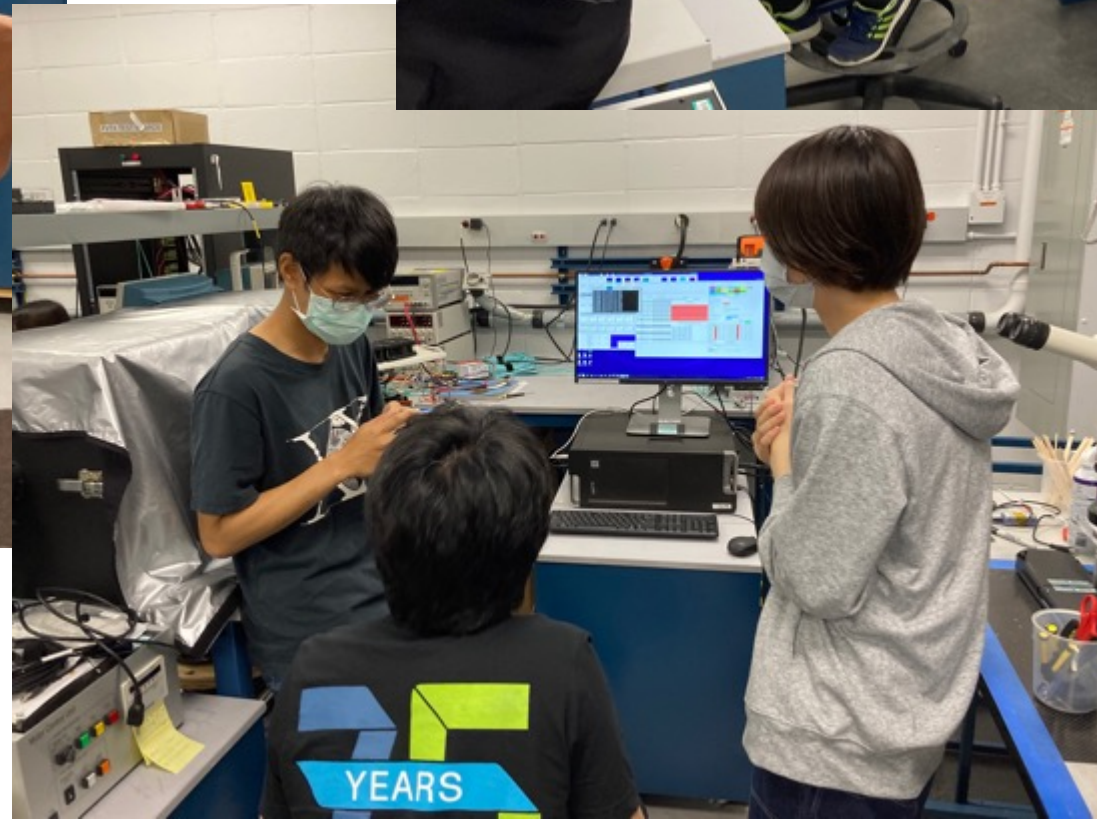
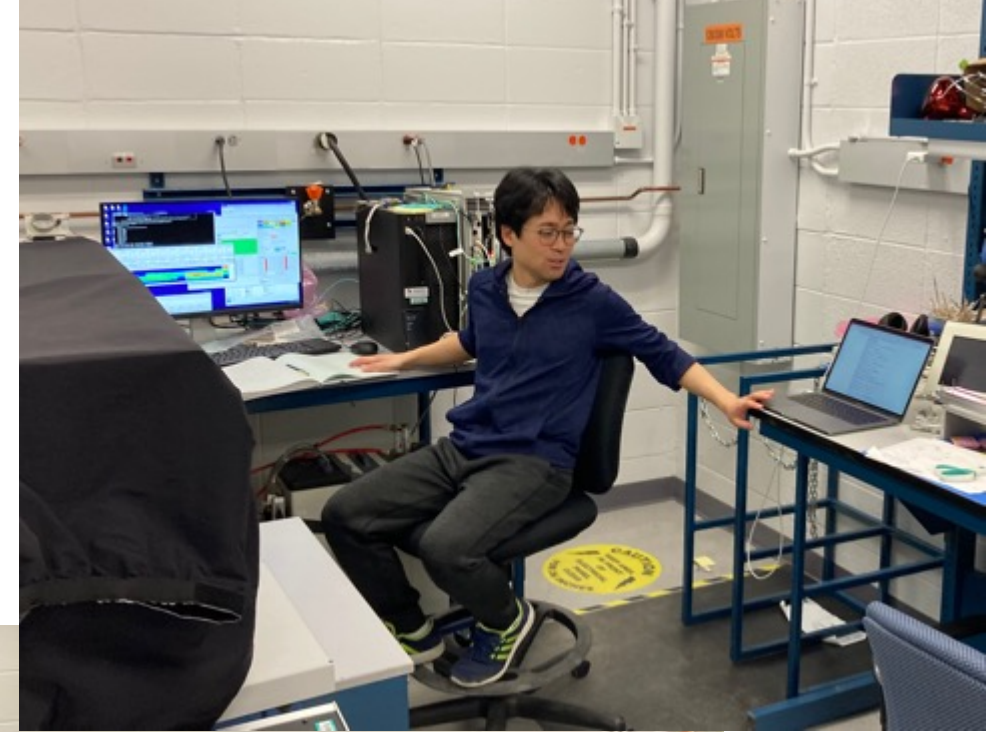
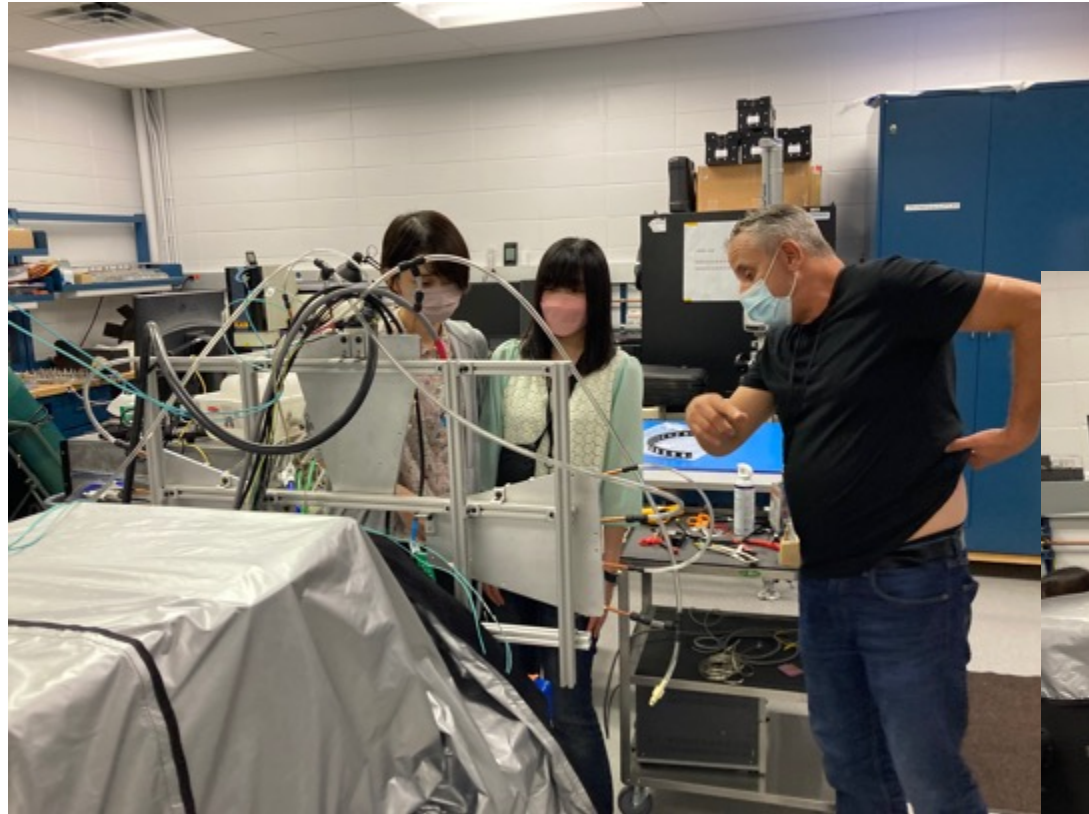


Working Channels > 99.9%

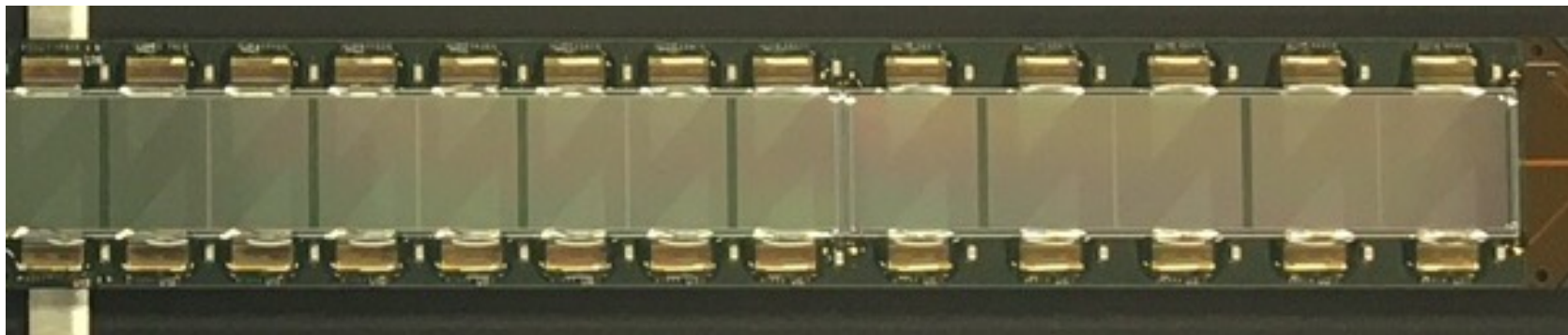
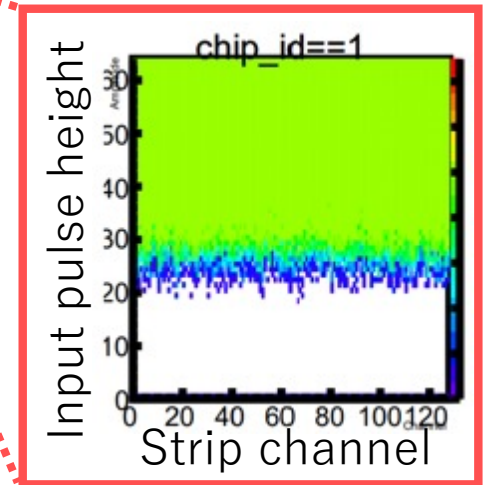
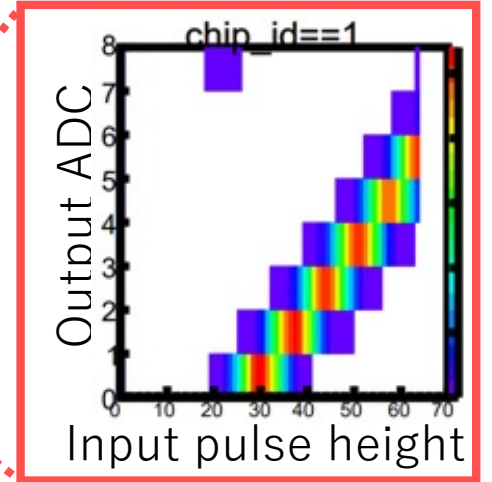
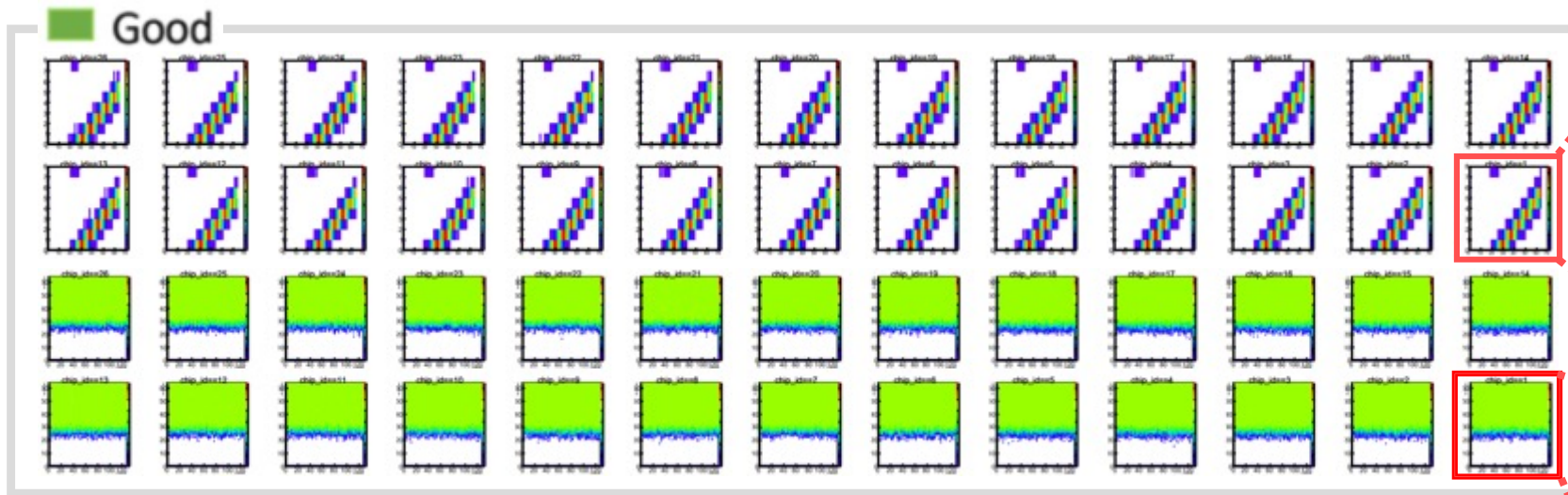
CFC Outer Service: used to insert INTT into TPC



Barrel Ladder Testing



Half Ladder Good Calibration Test Result



Silicon Sensor

Status and Highlights: INTT Construction

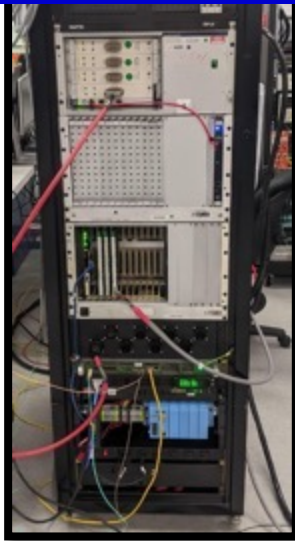
Barrel ladders were fully tested one-by-one successfully: working channels > 99.9%

B1L1		Harware Components				Calibration Test								Survey, Cooling, and Grounding						Final		
ID	Ladder Position	Ladder Name	HDI South/North	BEX South/North	South				North				Survey Status	GND Wire Stave	Glue TC Connector	Cooling Test	Silver Epoxy	Grounding Confirmed	Conversion Cable S/N	Pulse Test	Barrel Status	
					Current SA/SB [nA]	TA/TB [Celsius]	File Name	Status	Current SA/SB [nA]	TA/TB [Celsius]	File Name	Status										
1	EAST	B1L100	PB2-L010	230/231	99/102	345/349	23.1/23.2	20220914-1520,8	1	324/322	23.2/22.9	20220914-1132,8	1	1	1	1	1	1				
2		B1L101	PB2-L015	240/241	101/104	380/360	23.0/23.0	20220914-1530,8	1	299/367	23.3/22.8	20220914-1124,8	1	1	1	1	1	1				
3		B1L102	PB2-L022	286/287	103/106	374/375	22.9/23.2	20220914-1552,8	1	397/323	23.0/22.5	20220914-1438,8	1	1	1	1	1	1				
4		B1L103	PB2-L050	377/378	105/108	686/289	22.8/23.1	20220914-1609,8	1	257/222	22.8/22.3	20220914-1147,8	1	1	1	1	1	1				
5		B1L104	PB2-L039	354/355	107/110	320/385	23.1/23.0	20220914-1830,6	1	295/229	23.2/22.7	20220913-1103,8	1	1	1	1	1	1				
6		B1L105	PB2-L048	372/373	109/112	230/93	20.8/21.0	20221006-1241,6	1	65/252	22.8/22.5	20220914-1154,8	1	1	1	1	1	1				
7		B1L106	PB2-L036	180/318	111/114	574/426	21.4/21.4	20220914-1808,8	1	100/257	23.2/22.7	20220914-1207,8	1	1	1	1	1	1				
8		B1L107	PB2-L041	358/359	113/116	290/610	23.0/23.1	20220915-1215,6	1	440/390	22.8/22.4	20220913-1558,8	1	1	1	1	1	1				
9	WEST	B1L108	PB2-L037	384/385	86/83	316/250	22.4/22.3	20220826-1704,6	1	360/298	23.2/22.8	20220826-1928,6	1	1	1	1	1	1				
10		B1L109	PB2-L006	36/37	88/85	399/325	22.6/22.6	20220826-1640,8	1	407/334	21.4/21.4	20220826-1918,6	1	1	1	1	1	1				
11		B1L110	PB2-L021	166/167	90/87	420/310	22.7/22.8	20220826-1630,8	1	408/122	21.4/21.5	20220826-1840,8	1	1	1	1	1	1				
12		B1L111	PB2-L025	289/290	92/89	400/312	22.1/21.9	20220826-1622,8	1	392/346	21.4/21.5	20220826-1836,8	1	1	1	1	1	1				
13		B1L112	PB2-L023	189/244	94/91	400/300	22.9/23.2	20220826-1617,8	1	409/327	23.1/22.9	20220826-1847,8	1	1	1	1	1	1				
14		B1L113	PB2-L012	234/235	96/93	400/300	22.5/22.3	20220826-1606,8	1	389/337	21.6/21.6	20220826-1811,8	1	1	1	1	1	1				
15		B1L114	PB2-L007	224/225	98/95	415/315	22.9/23.0	20220826-1600,8	1	388/338	23.9/22.6	20220826-1806,8	1	1	1	1	1	1				
16		B1L115	PB2-L017	192/193	100/97	416/342	23.1/23.4	20220826-1542,8	1	371/343	22.2/22.0	20220826-1754,8	1	1	1	1	1	1				

Cooling System



Rack: LV/HV/Noise Filters



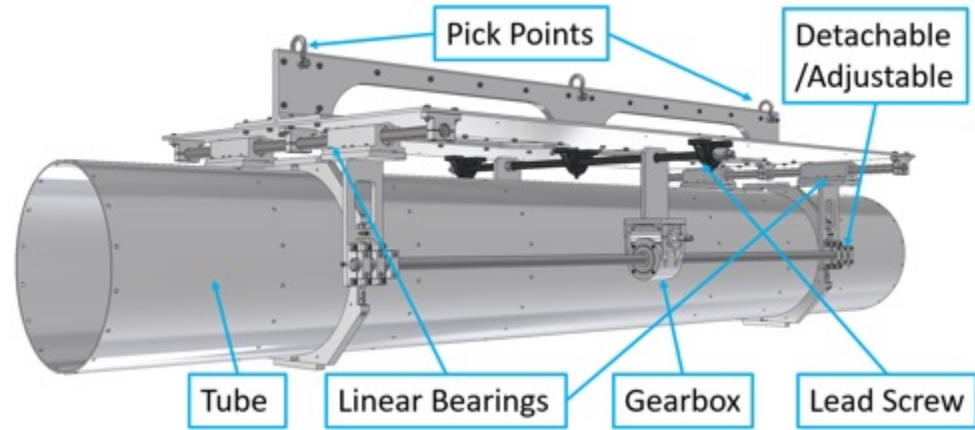
BNL Survey Team



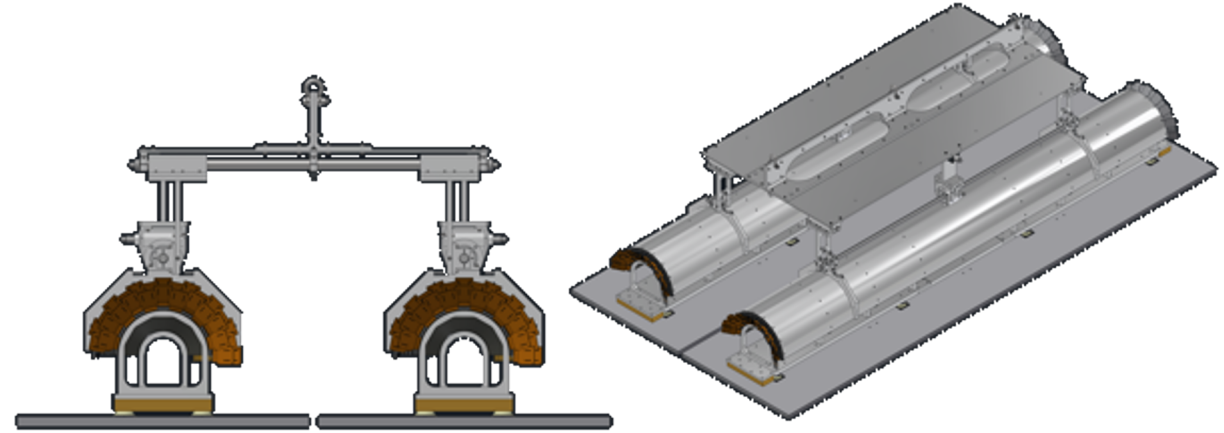
Each ladder/barrel was surveyed → Ideal Geometry for day-1 ph

Integration of the Two INTT Halves in the Lab

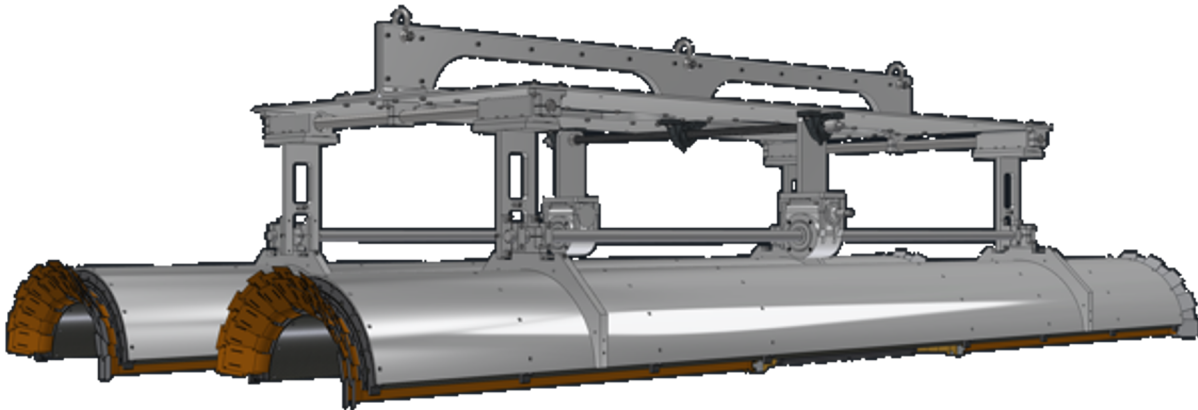
- 1. Inspect Fixture



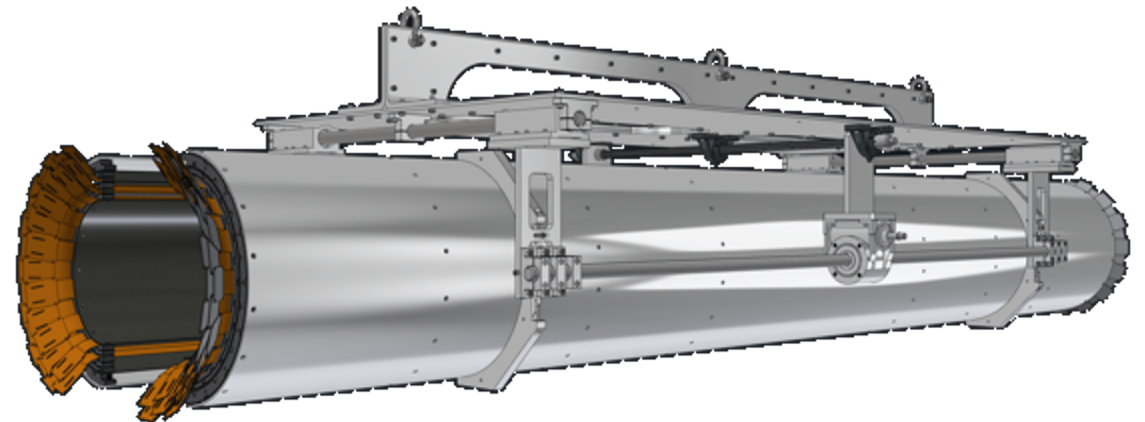
- 2. Attach to INTT



- 3. Pick up INTT



- 4. Rotate Halves



Integration of the Two INTT Halves in the Lab



Integration of the Two INTT Halves in the Lab



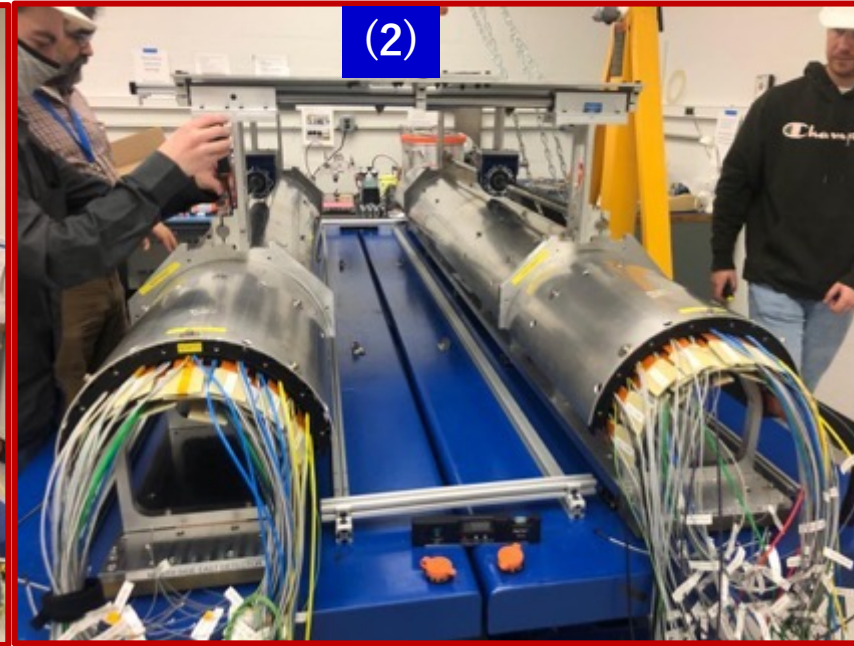
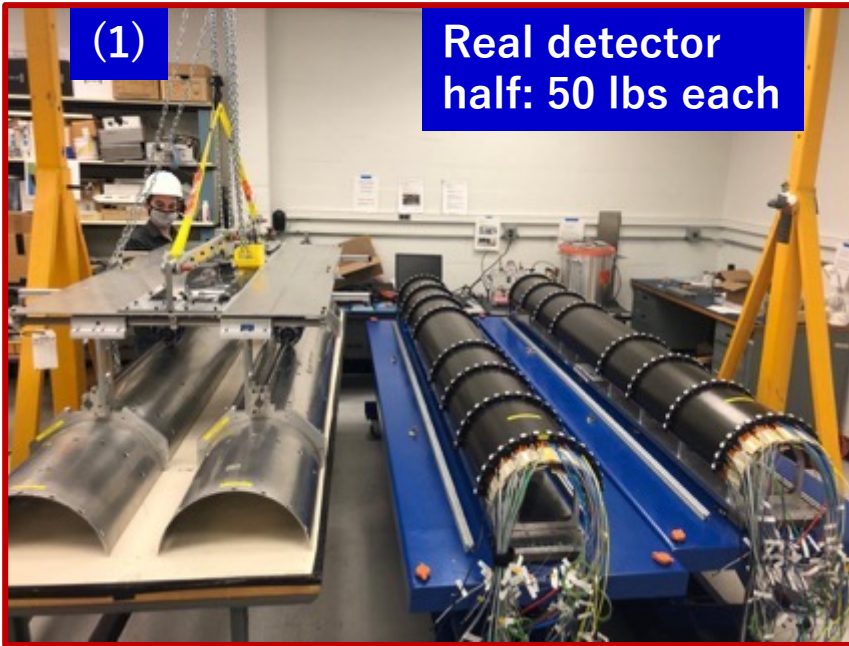
Integration of the Two INTT Halves in the Lab



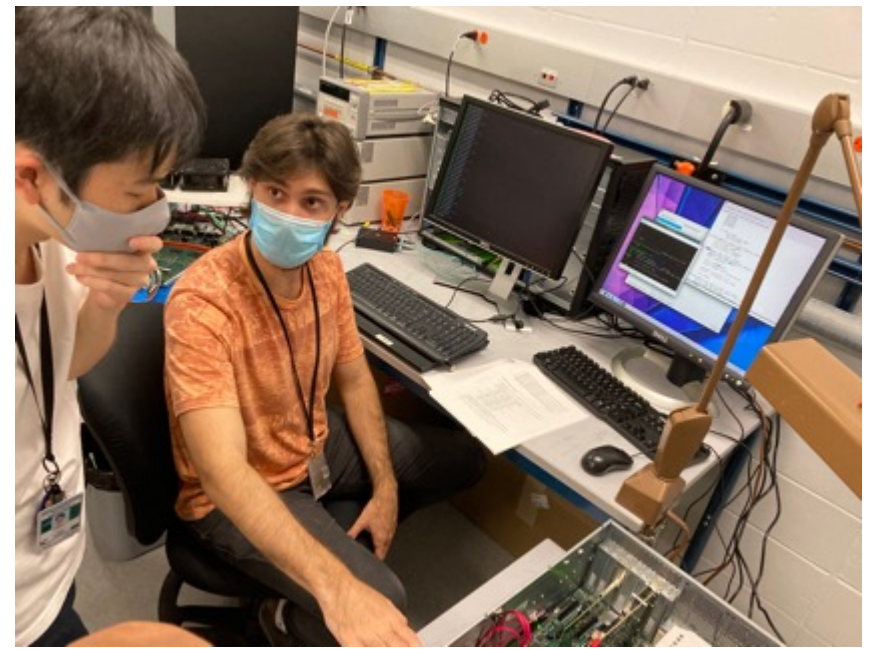
Step 2:
Real detector
half: 50 lbs each

October 20, 2022

Integration of the Two INTT Halves: Real Detector



The INTT two halves closed successfully



INTT Readout System Upgrade

FVTX Readout Chain

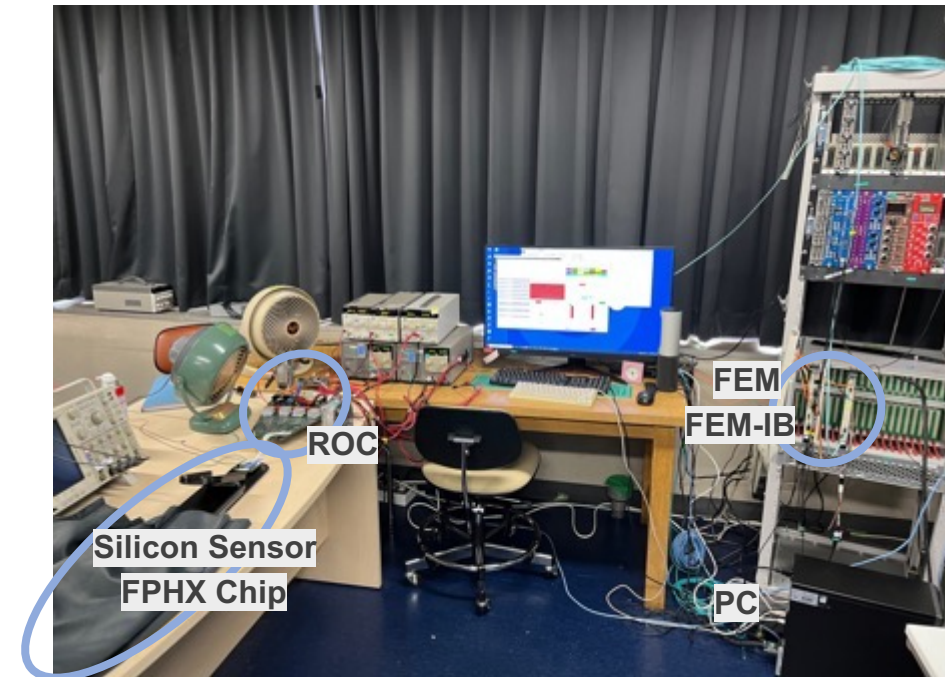
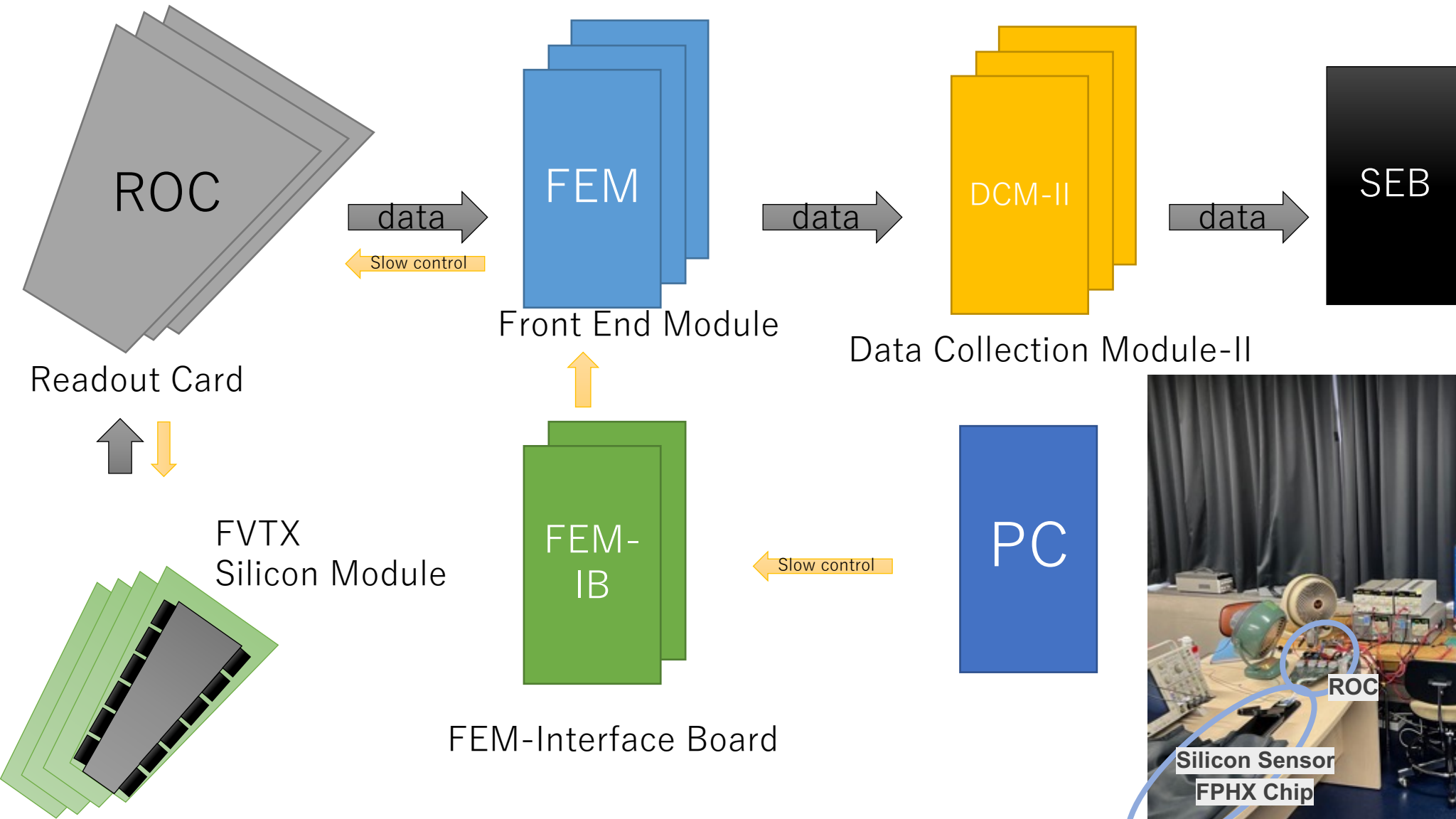
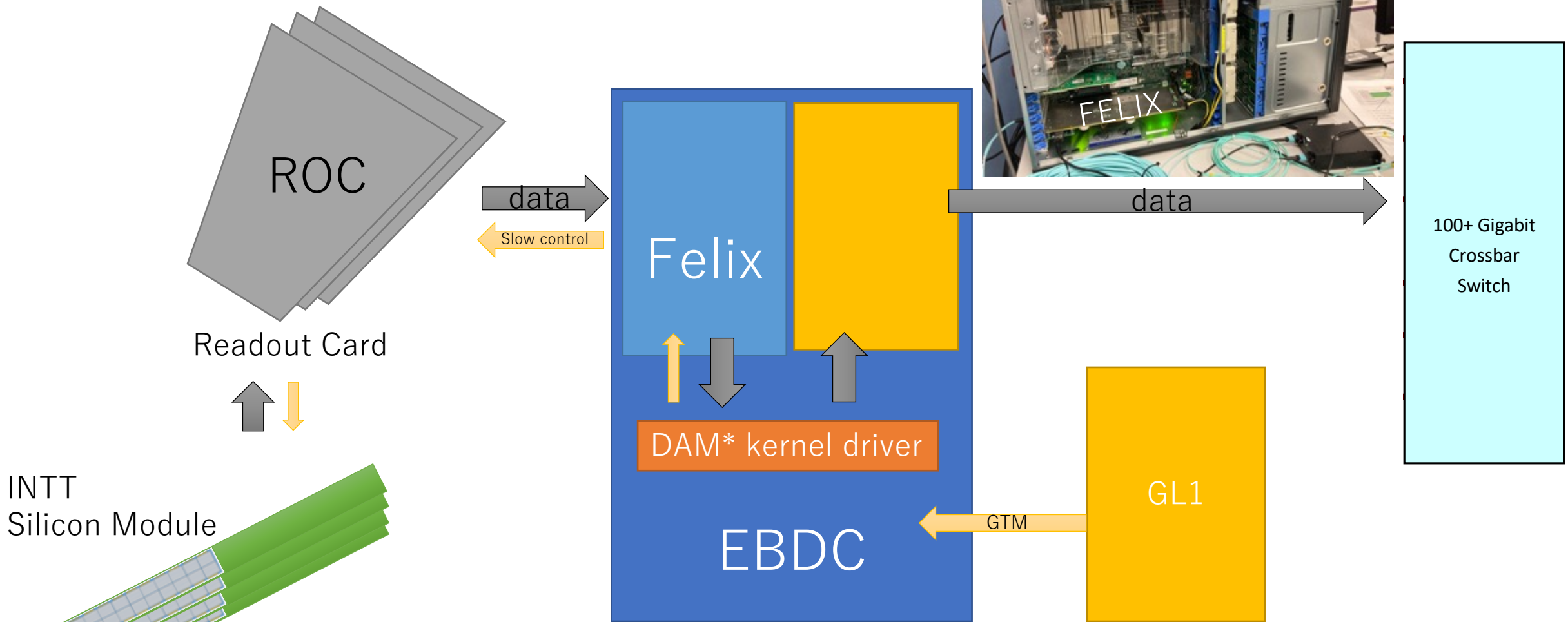


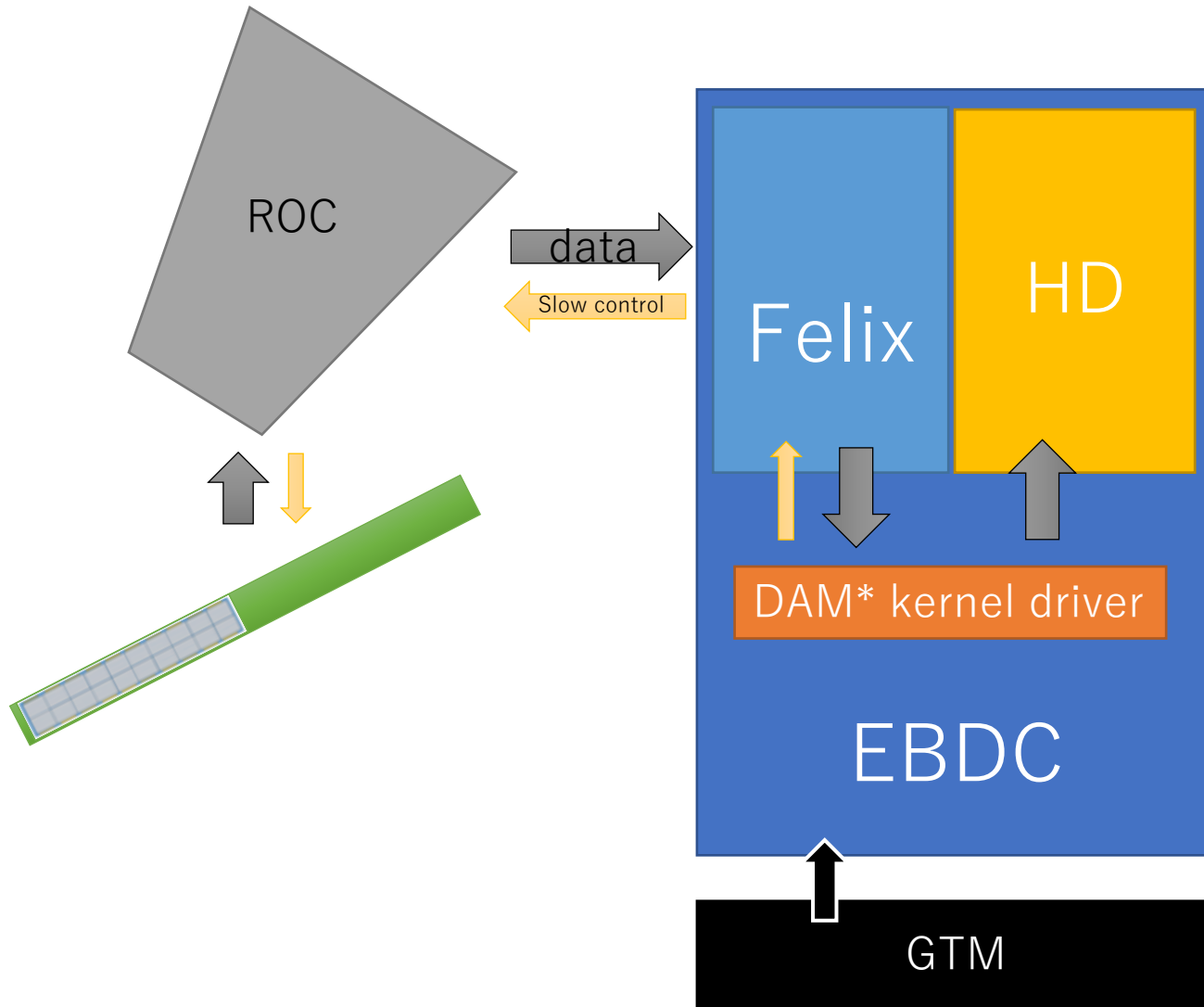
Photo by Kazuma Fujiki

INTT-Felix Readout Chain



Felix is the readout card developed by ATLAS group, which allows stream readout. MVTX, INTT, and TPC are to be readout by Felix in sPHENIX.

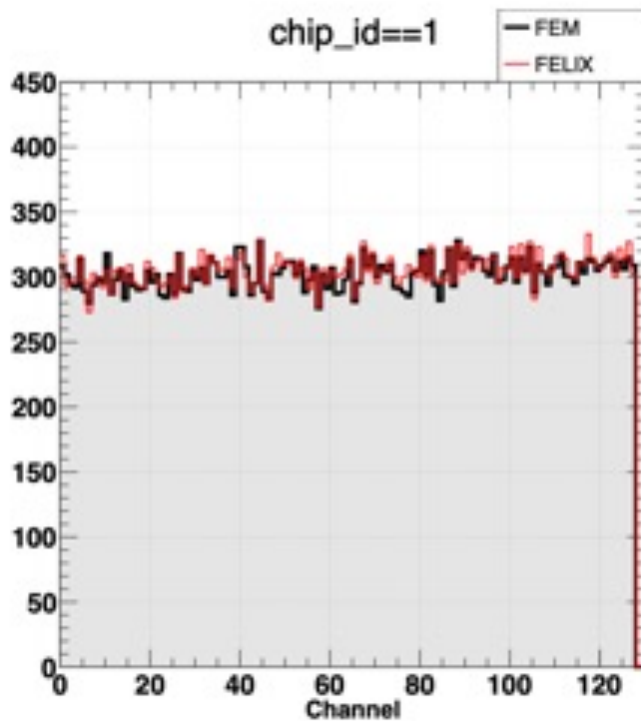
Load Map of Felix Development



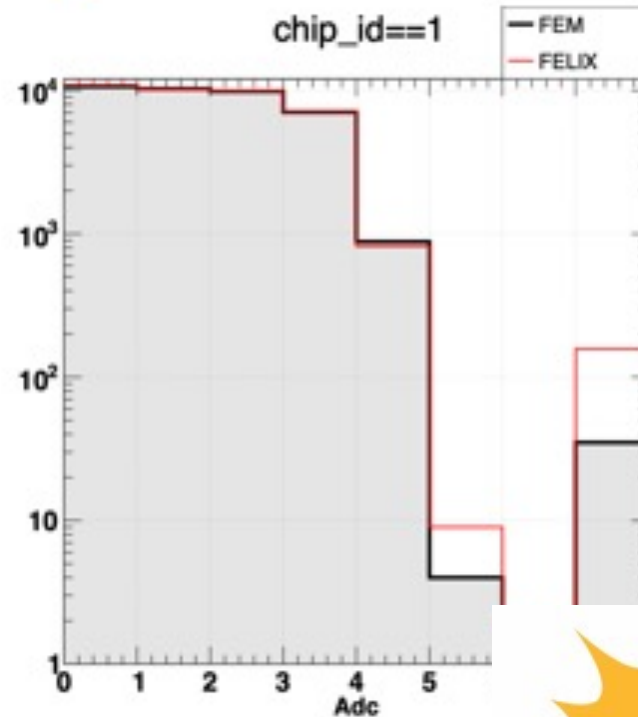
- Single Felix
- Single ROC
- Single Ladder
- In house custom DAQ runs on EBDC
- Save data in Hard disk in custom format

Consistency Between Two Readout Systems

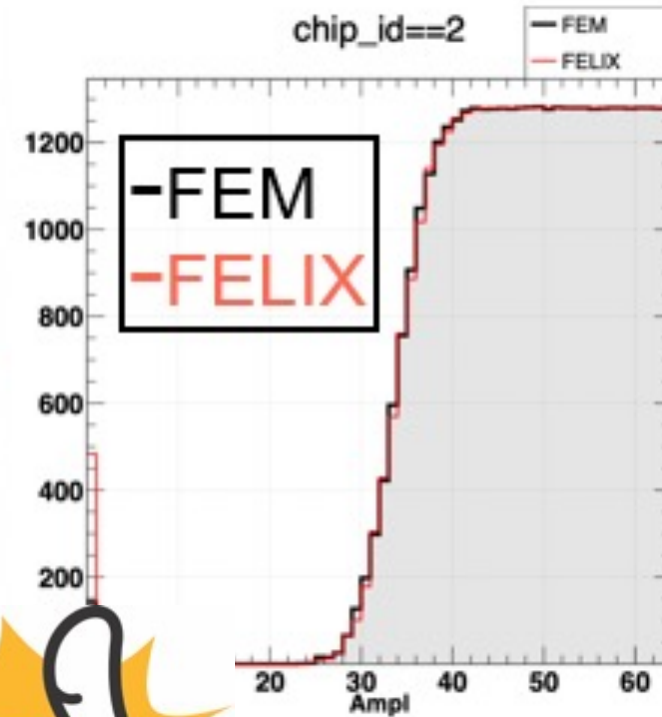
The results from the FELIX system are consistent with FEM's.



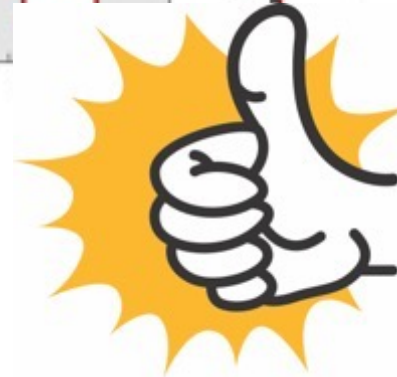
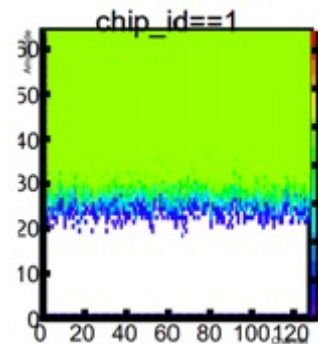
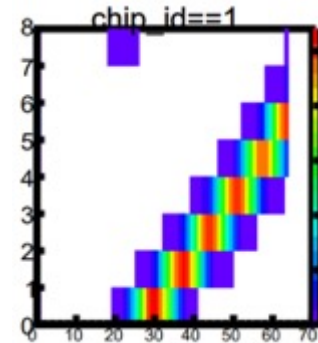
Channel dist.



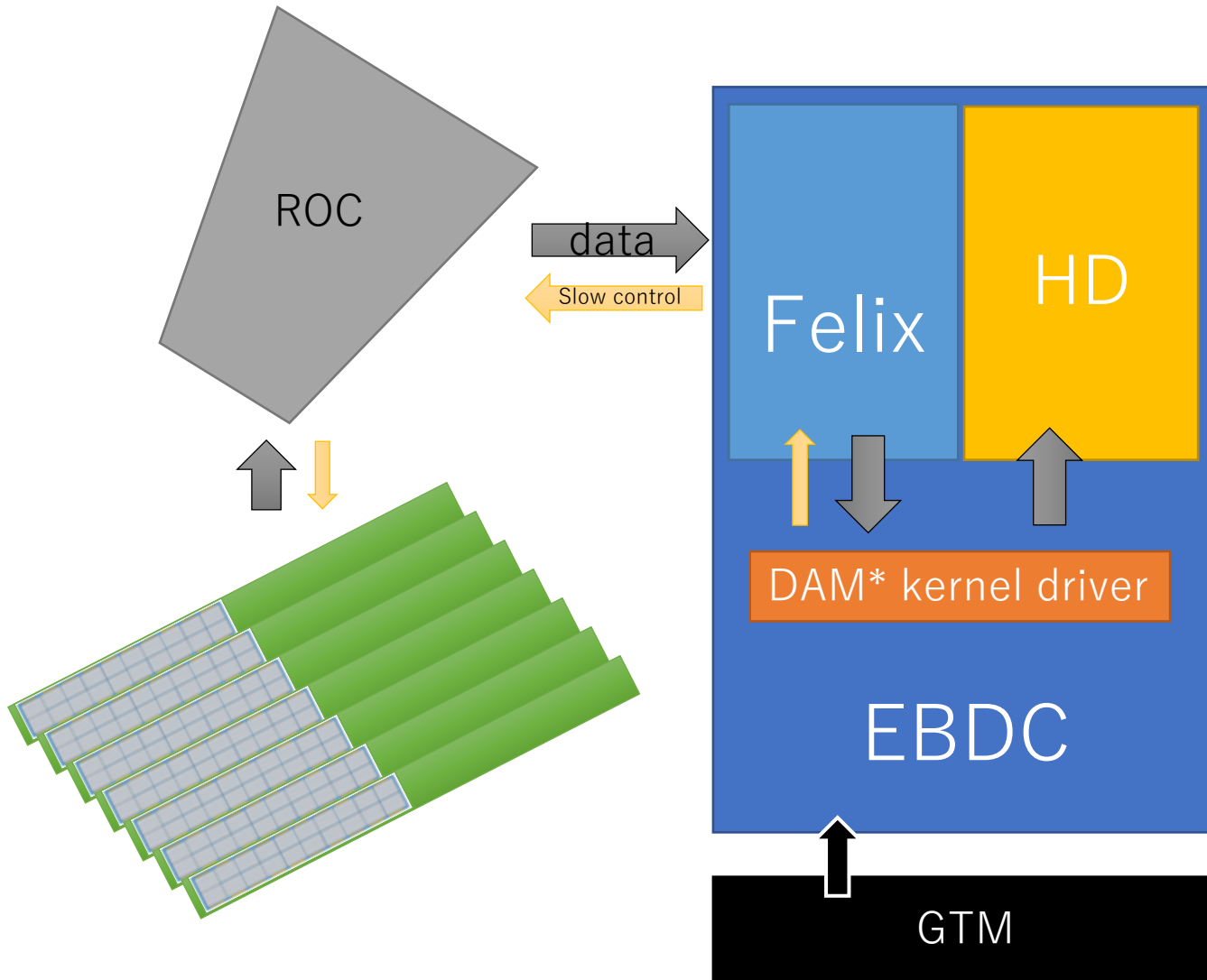
ADC dist.



Amplitude dist.



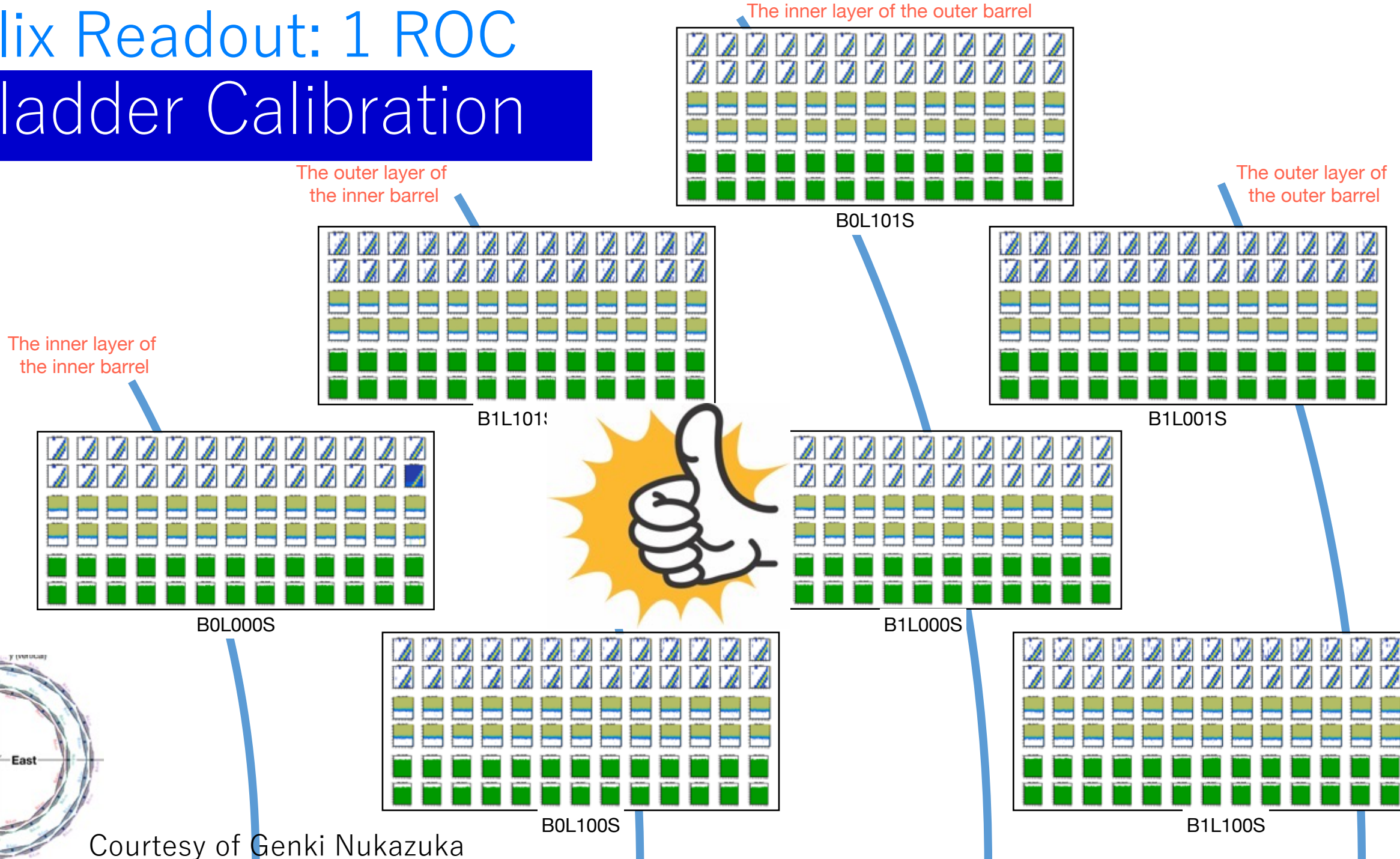
Load Map of Felix Development

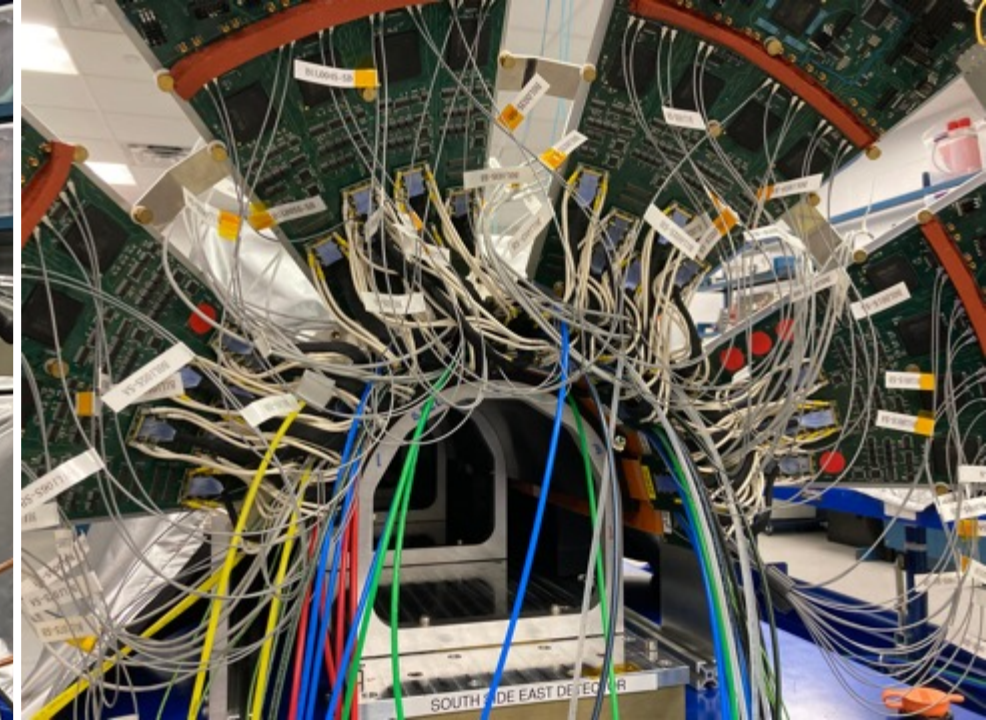
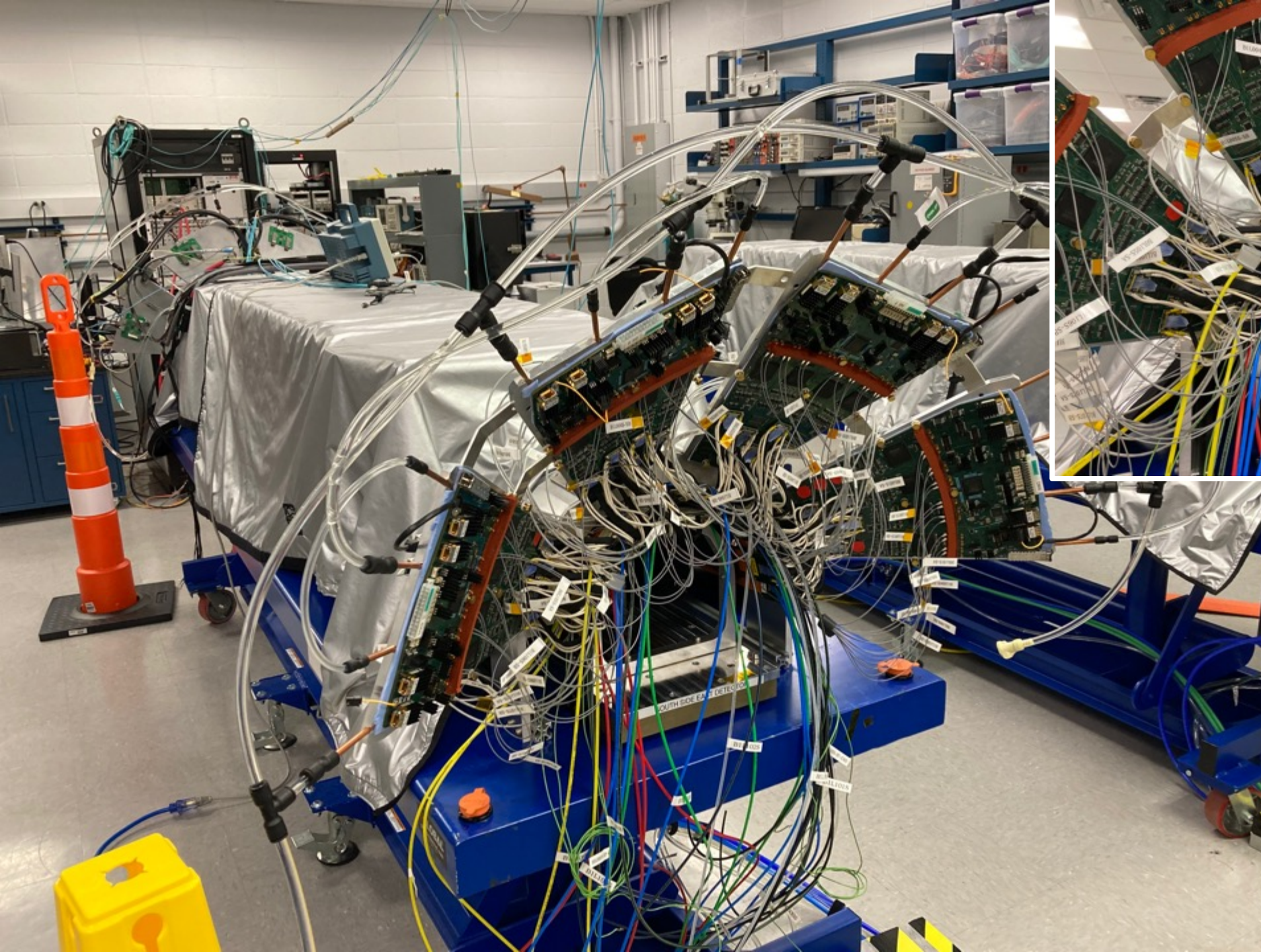


- Single Felix
- Single ROC
- **Multiple Ladder**
- In house custom DAQ runs on EBDC
- Save data in Hard disk in custom format

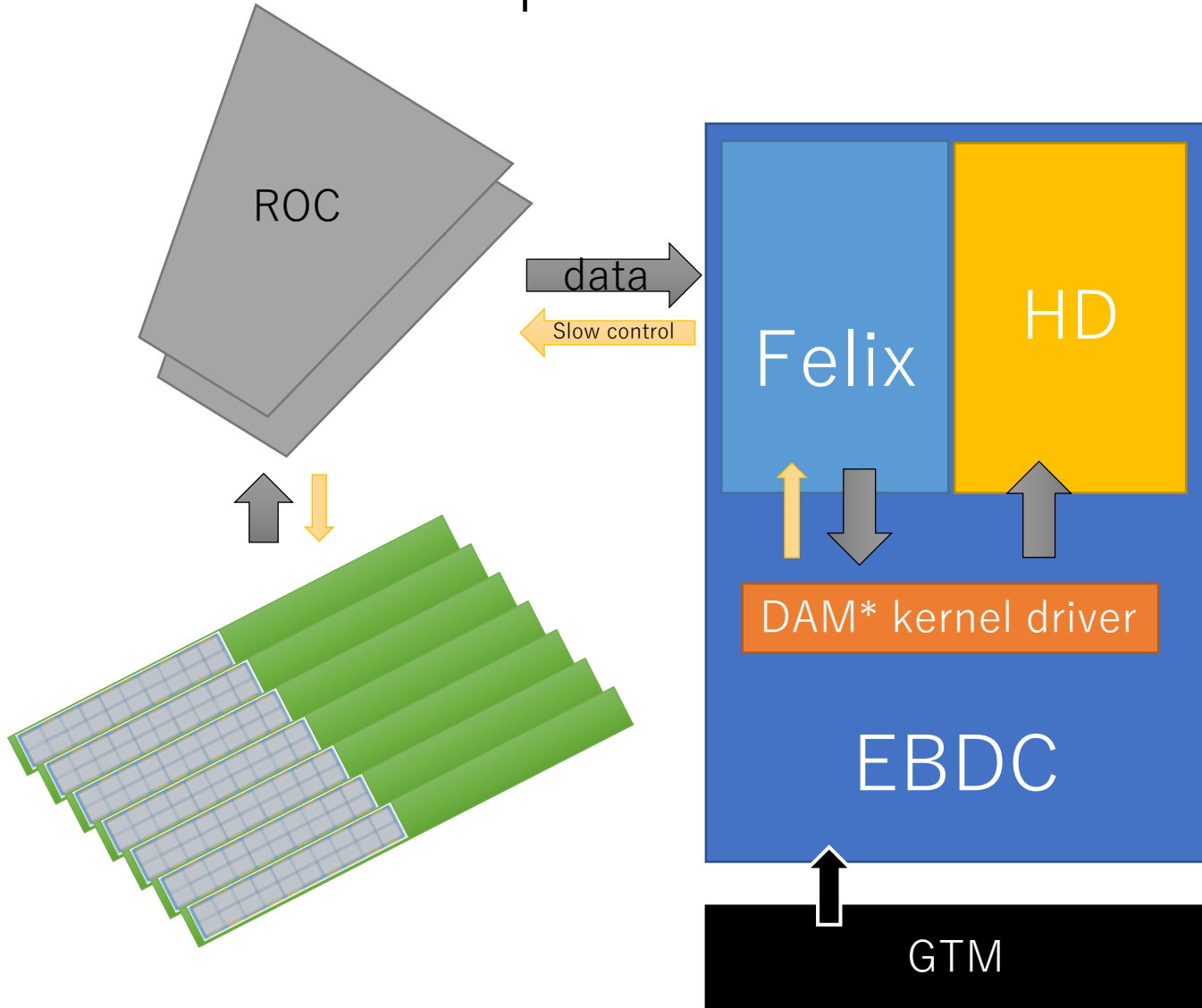
Felix Readout: 1 ROC

7-ladder Calibration





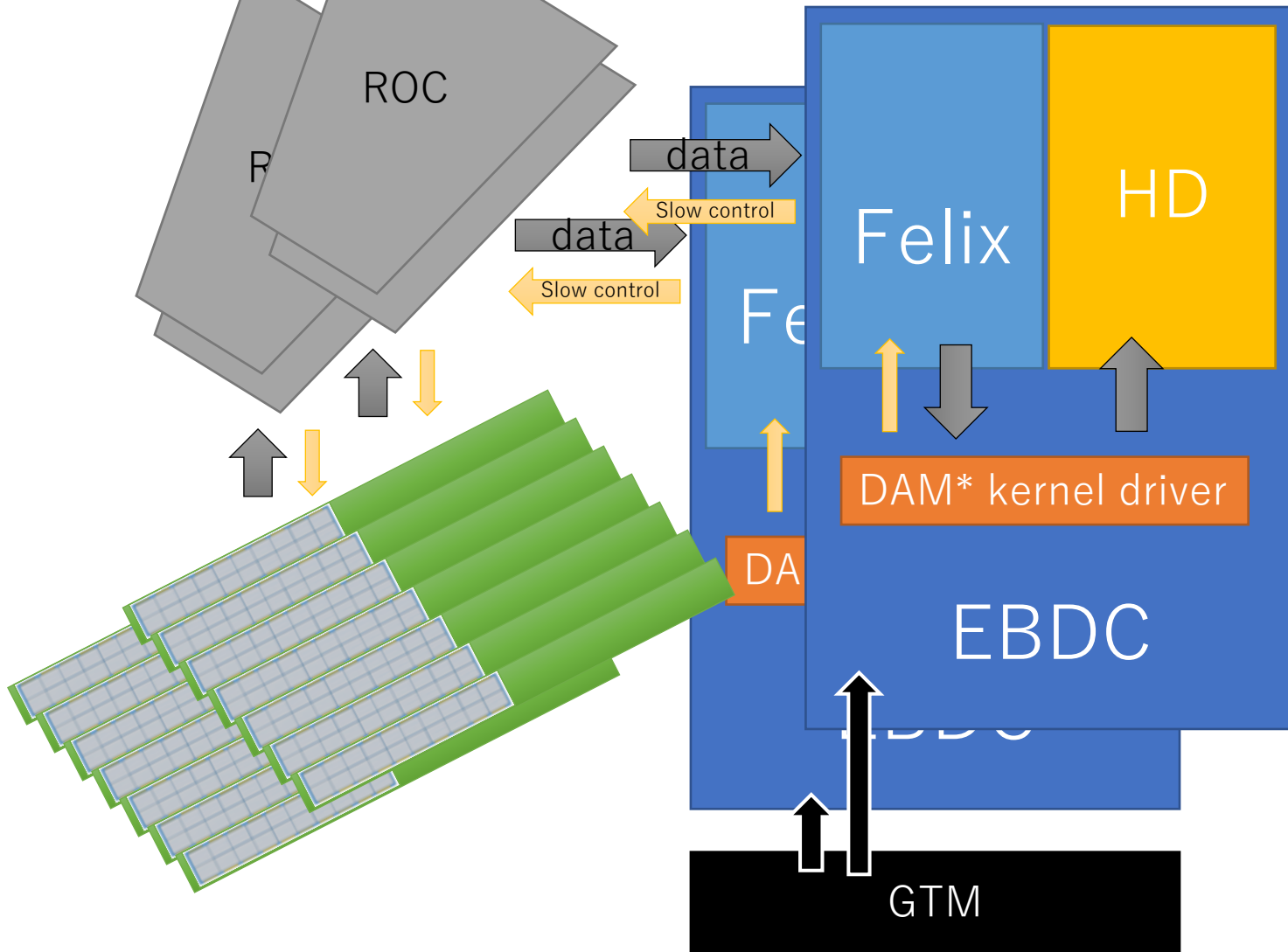
Load Map of Felix Development



- Single Felix
- **Double ROCs**
- **Multiple Ladder**
- In house custom DAQ runs on EBDC
- Save data in Hard disk in custom format

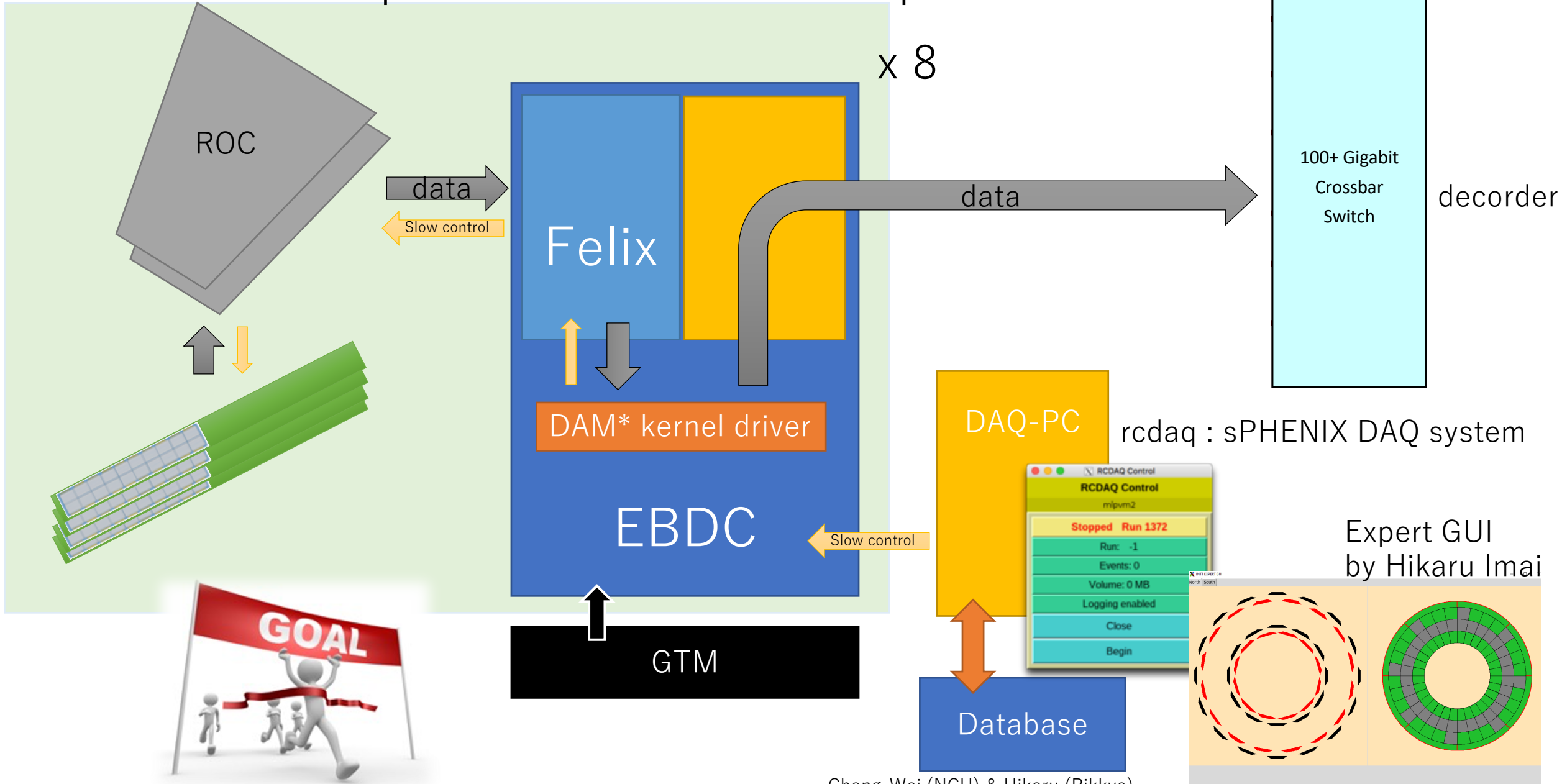
Where we are now

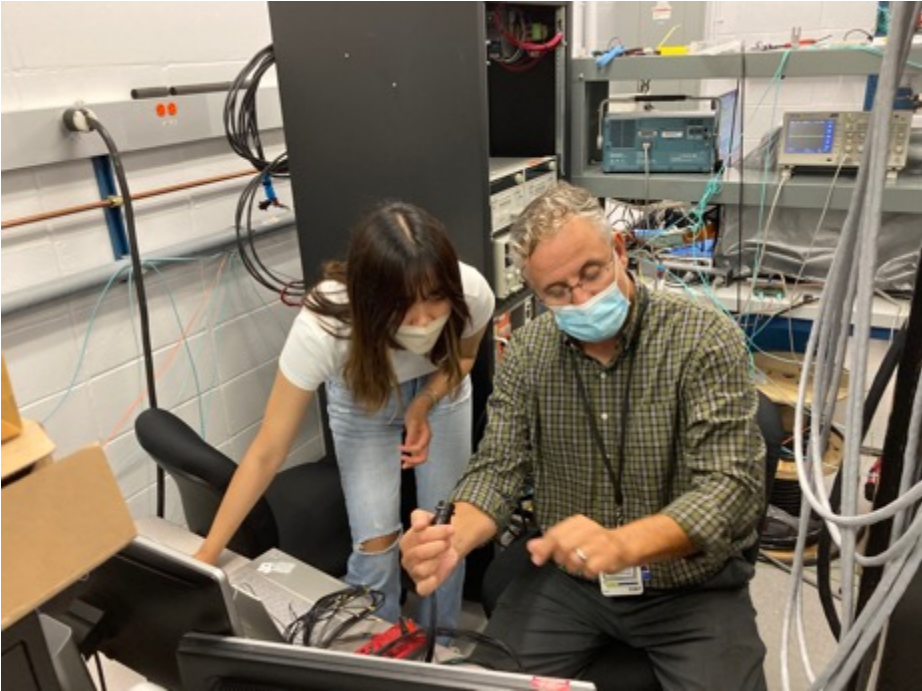
Load Map of Felix Development



- **Double Felix**
- **Double ROCs**
- **Multiple Ladder**
- In house custom DAQ runs on EBDC
- Save data in Hard disk in custom format

Load Map of Felix Development

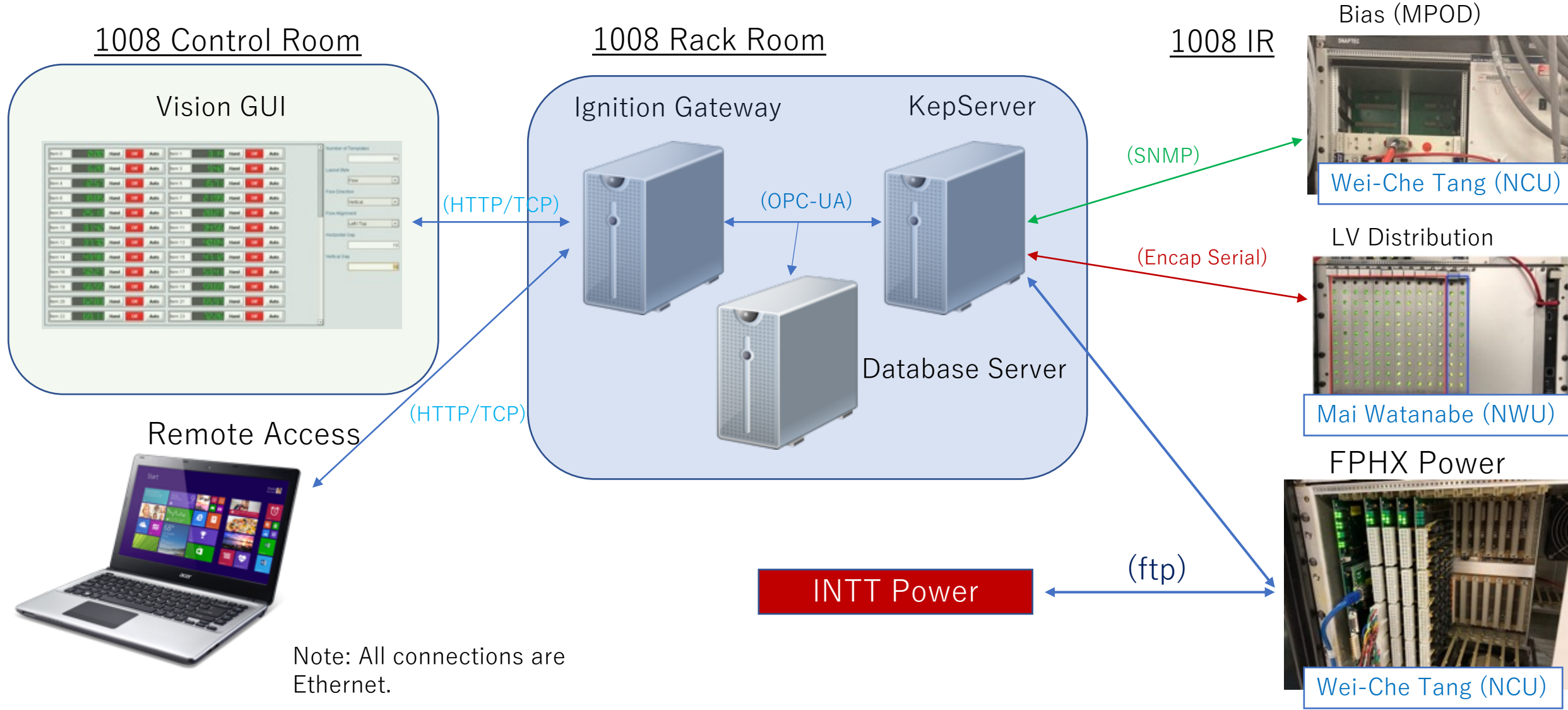




INTT Power System

INTT LV Control Flow (as of now)

Person in Charge



Note: All connections are Ethernet.

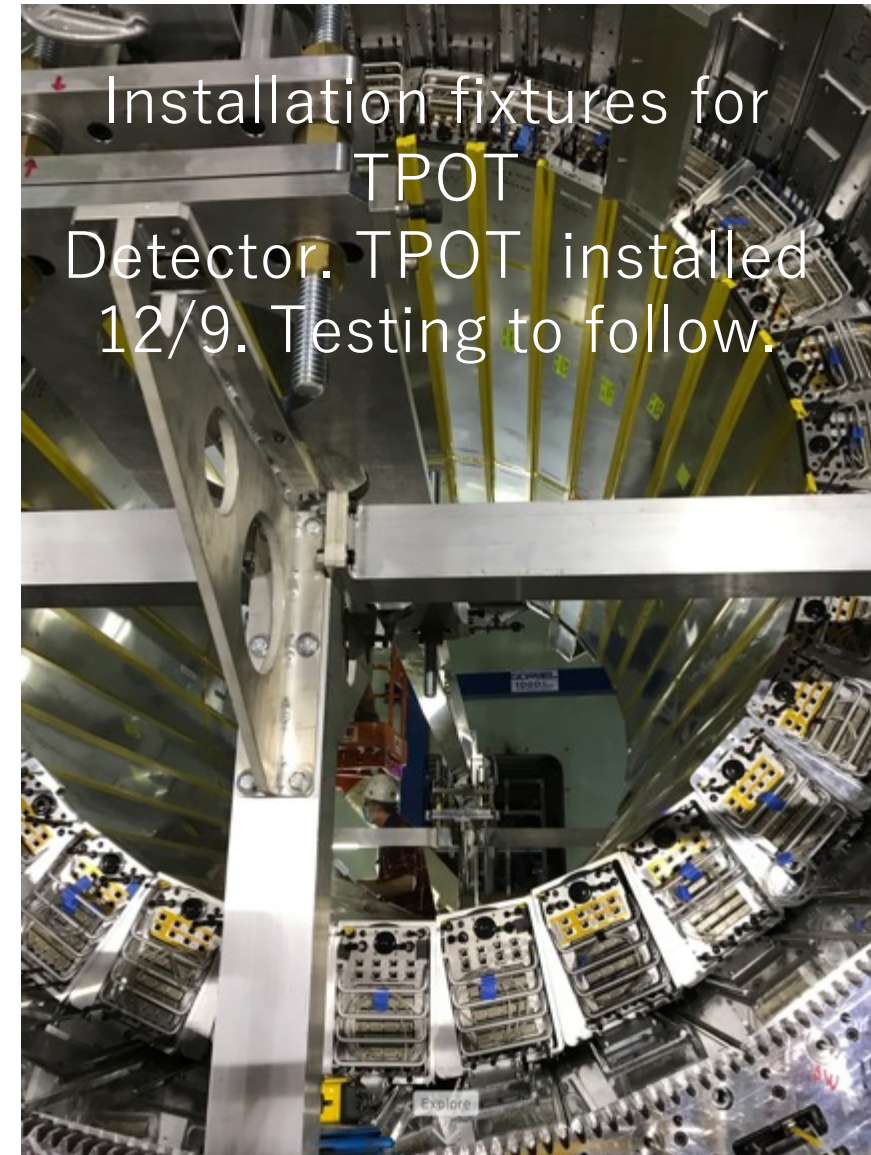
INTT Power Control System Load map

	Protocol	Communication w/ KepServer	1008 Channel Map	GUI	Person in Charge
Bias	SNMP	△ Steve can read, but cannot write	?	×	Wei-Che
LV Distributor (ROC, FPHX)	Encap Serial	○	○	△	Mai
FPHX Power	?	○ Steve installed firmware	?	×	Wei-Che

sPHENIX and Installation Schedule



sPHENIX Installation Status



sPHENIX Magnet Mapping Complete

CERN Team in front of sPHENIX detector w/
magnet mapper installed

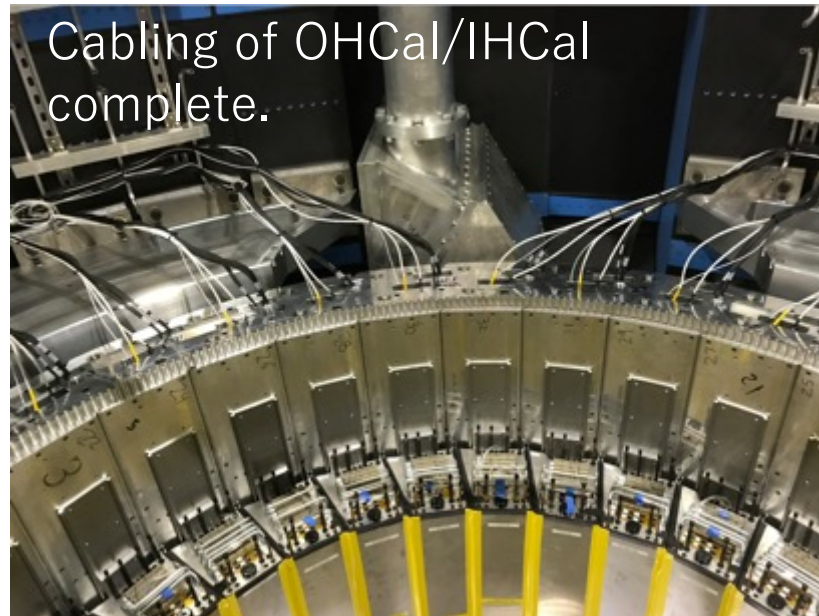
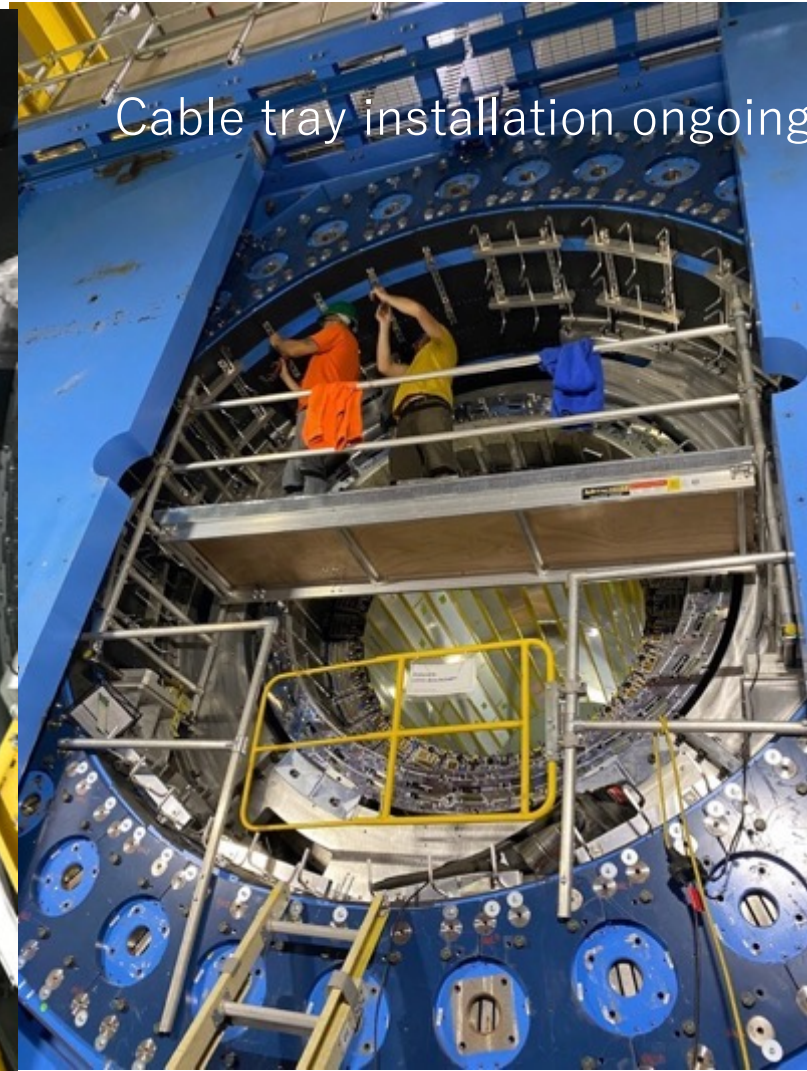
- We performed multiple successful maps to full field and recorded a baseline full field map, a finer granularity map and a 50% field map.
- The measured field matched the simulation prediction to high accuracy.

B-Field at TPC location = 1.4T

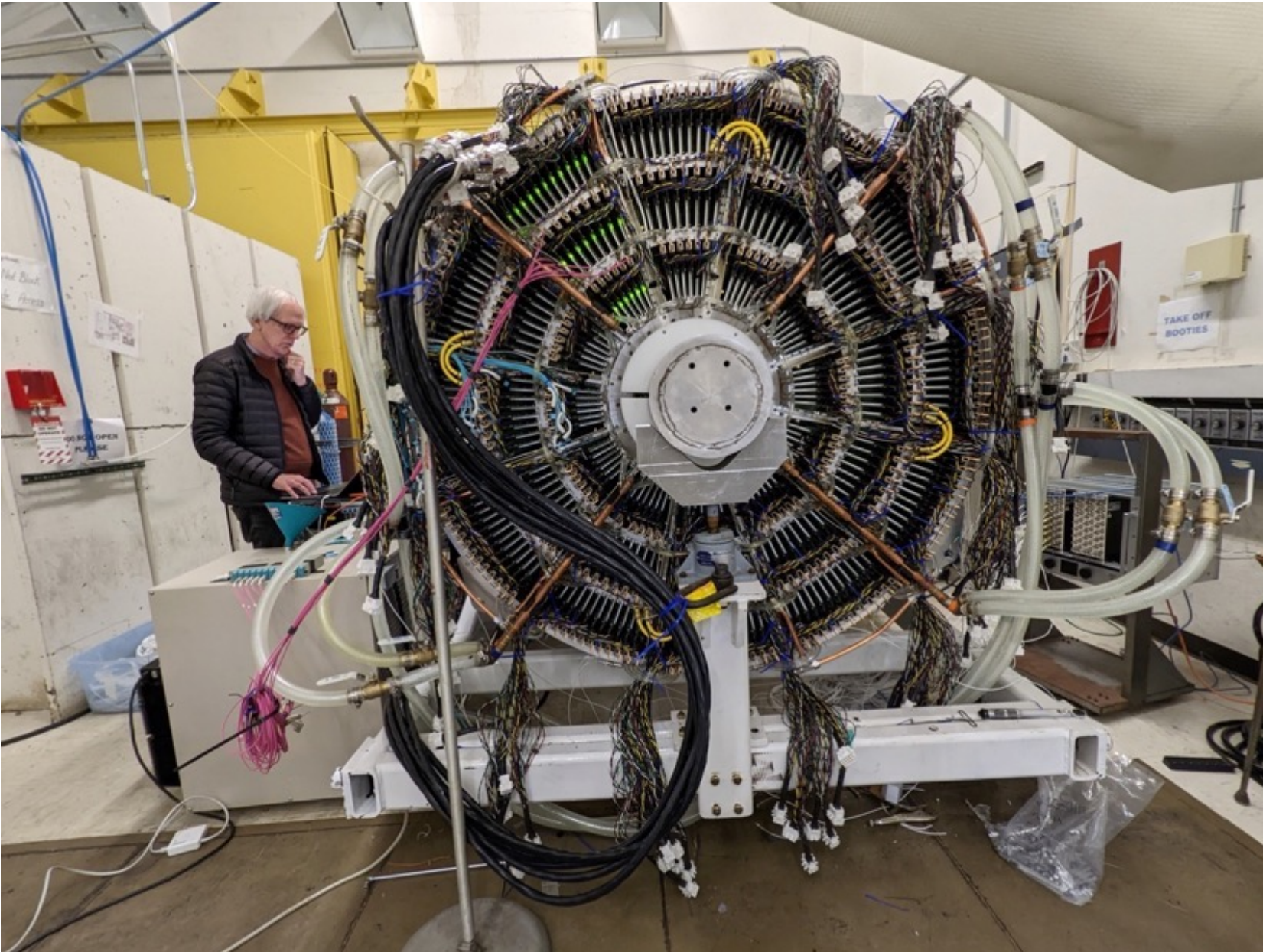
the B-field rows (Bx, By, Bz) :

```
BValT = -1.411592, -0.004703, 0.005511
BValT = -1.401875, 0.004362, 0.005242
BValT = -1.397893, 0.002913, 0.009079
BValT = -1.399307, 0.003422, 0.009062
BValT = -1.406711, 0.006496, 0.008555
BValT = -1.409695, 0.008401, 0.008233
BValT = -1.394770, 0.005816, 0.008268
BValT = -1.396441, 0.005674, 0.008015
BValT = -1.403802, -0.002153, 0.009974
BValT = -1.410893, -0.000813, 0.008565
BValT = -1.395020, 0.001417, 0.005830
BValT = -1.402785, -0.007759, 0.006783
```

Other I&F Highlights



The sPHENIX TPC @ SBU



The sPHENIX TPC

- Fully instrumented w/ electronics
- Is gas tight and filled with the operating gas mixture Ar/CF₄
- Holds voltage
- Low noise
- No water leaks
- Sees cosmic rays
- **Is Awesome !**

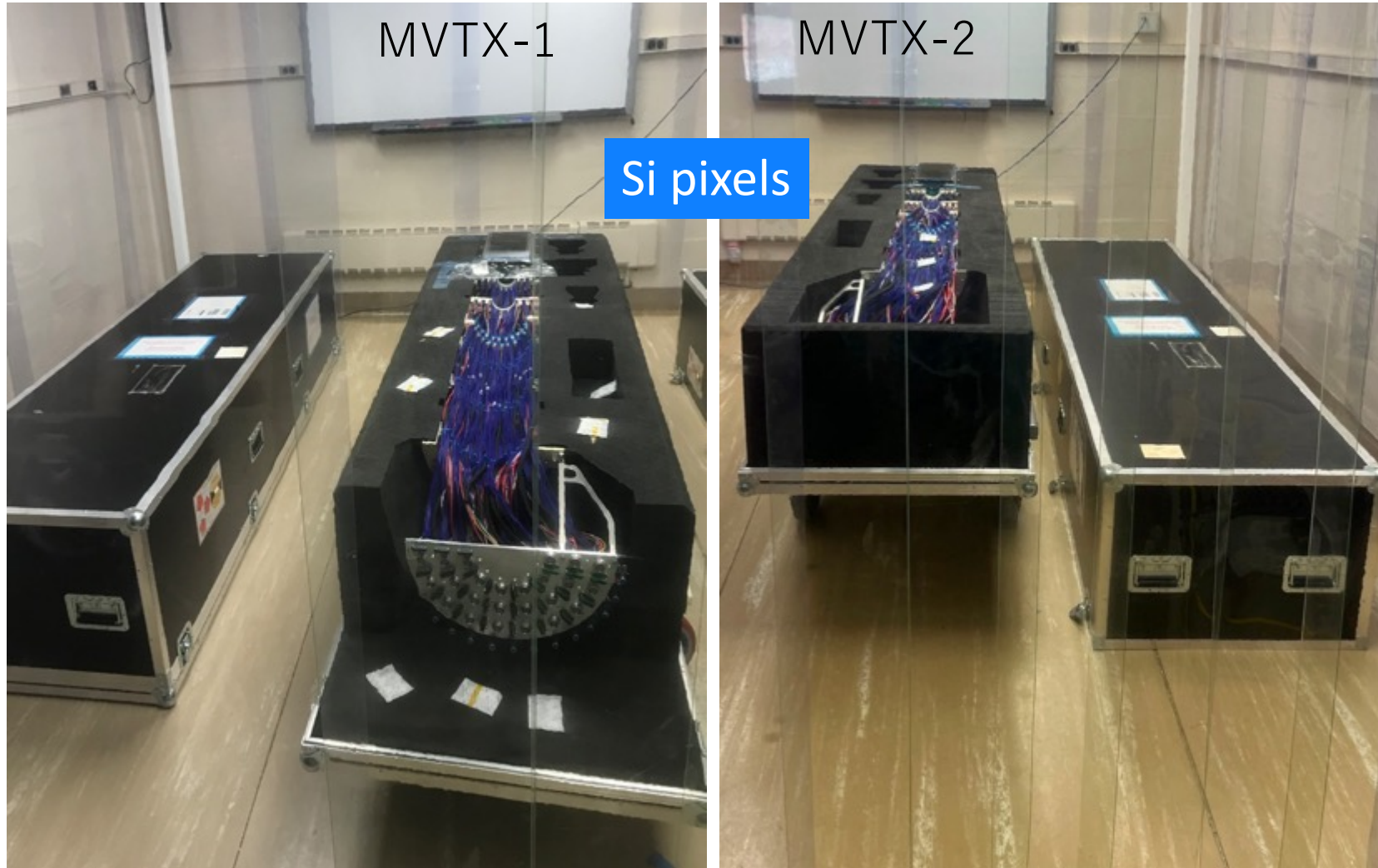
1008 Infrastructure & Facility Upgrade Status

- SC-Magnet cooled, ramped to full field many times, mapped
- HCal Installed. Cabling complete to racks
- EMCal completely installed. Cabling begun
- TPOT installation underway
- 33/36 instrumented racks installed in IR
 - Two missing racks ready to install.
 - One rack in use at SBU
 - Internal/external plumbing advanced.
- TPC testing near complete at SBU
- TPC installation in sPHENIX in Jan
- Beam pipe installed in Feb
- IRR in Feb
- Silicon detectors installed in Mar
- Trigger detectors (small) Mar-Apr
- Majority of remaining work installation/cabling/plumbing



Top of sPHENIX Carriage platform

sPHENIX silicon detectors @ BNL: MVTX



MVTX installation tests ongoing at BNL

Tasks to Go

- Install/Cable/Plumb TPOT
- Cable/Plumb EMCaI
- Install/Cable/Plumb TPC
- Complete rack installation
- Complete internal/external rack plumbing
- Complete gas connections between Gas Mixing House & sPHENIX detector
- Complete chiller platform. Plumb chiller lines to the detector
- Complete safety systems (smoke detection)
- Install/Bake out beam pipe
- Install/Cable/Plumb INTT
- Install/Cable/Plumb MVTX
- Install/Cable MBD
- Install/Cable sEPD

INTT Installation/Commissioning

LV/HV/Noise Filters in IR (2 racks N and S)



INTT power cables

function	item	length	Qty. needed (available)	spares	Cable reference	Status
HV	HV module-Filter	1.5m	16 (16)	1 (1)	REDEL S (SAA.H51.LLAB1G)	✓ on hand
HV	Filter – ROC, trunk	10m	16 (0)	2 (2)	Belden 1050A 18 AWG 8 Pair Individually Shielded/Overall Foil Shield Tray Cable 600V, 180 *2=360 m, \$6.82 ft	on hand
HV	Trunk– ROC, flex	2m	32 (32)	2 (15)	RG-174, 36 m (*8)	✓ on hand
LV	ROC power, trunk	10m	16(0)	2	#14-25C THHN-PVC Shielded Tray 200 m => 700 ft → 1kft	✓ PO 420432
LV	ROC power, flex	2m	16(0)	2	#18-25C TRAYCONTROL Tray, 63055. 40 m =>150 ft	✓ on hand
LV	Chips power, trunk	11m	64(0)	4	#16-8 pair PVC jacket Shielded Tray Cable KC electronics P/N 6608SPOS, ADVANCED DIGITAL CABLE Inc 800 m => 2700 ft	✓ on hand
LV	Chips power, flex	1m	64(0)	4	#22-9pair BELDEN 9520 100 m => 500 ft	✓ PO 420432

Schedule Baseline

Tasks	Nov 2022	Dec 2022	Jan 2023	Feb 2023	Mar 2023	Apr 2023
Magnet Mapping	3 wks					
Finish Install EMCal/Cable IHCAL		2 wks				
Install/Cable TPOT		6 wks				
Cable EMCal		6 wks				
Install/Cable TPC			6 wks			
Install/Bakeout <u>Beampipe</u>				3 wks		
Install/Cable INTT					3 wks	
Install/Cable MVTX						3 wks
Install MBD						2 wks
Ready for commissioning with beam						

Schedule Early Completion

Tasks	Nov 2022	Dec 2022	Jan 2023	Feb 2023	Mar 2023	Apr 2023
Magnet Mapping	3 wks					
Finish Install EMCal/Cable IHCAL		2 wks				
Install/Cable TPOT		4 wks				
Cable EMCal		4 wks				
Install/Cable TPC			3 wks			
Install/ <u>Bakeout Beampipe</u>				2 wks		
Install/Cable INTT				2 wks		
Install/Cable MVTX					2 wks	
Install MBD					1 wk	
Ready for commissioning with beam						●

Installation Commissioning Plan

- **Post Integration test in the Lab (Phy-lab 2-82): December/January**

- After Integration of the two INTT halves in the lab, the INTT will be moved to the Si-Lab to be fully tested with:

- Final survey of the two INTT halves (**done**)
- Conversion cables (cable detector to ROC: 15 cm) (**in progress**)
- Simultaneous test of two ROCs with Felix readout (**in progress**)
- Cosmic-Data and offline Analysis

These tasks moved from commissioning in the IR to be done in the lab. We developed infrastructure in the Si- lab (many thanks to Steve Boose).

- **Pre-installation@IR: February 2023**

- Full INTT test at the sPHENIX-IR assembly hall using INTT bench test: LV/HV/DAQ rack

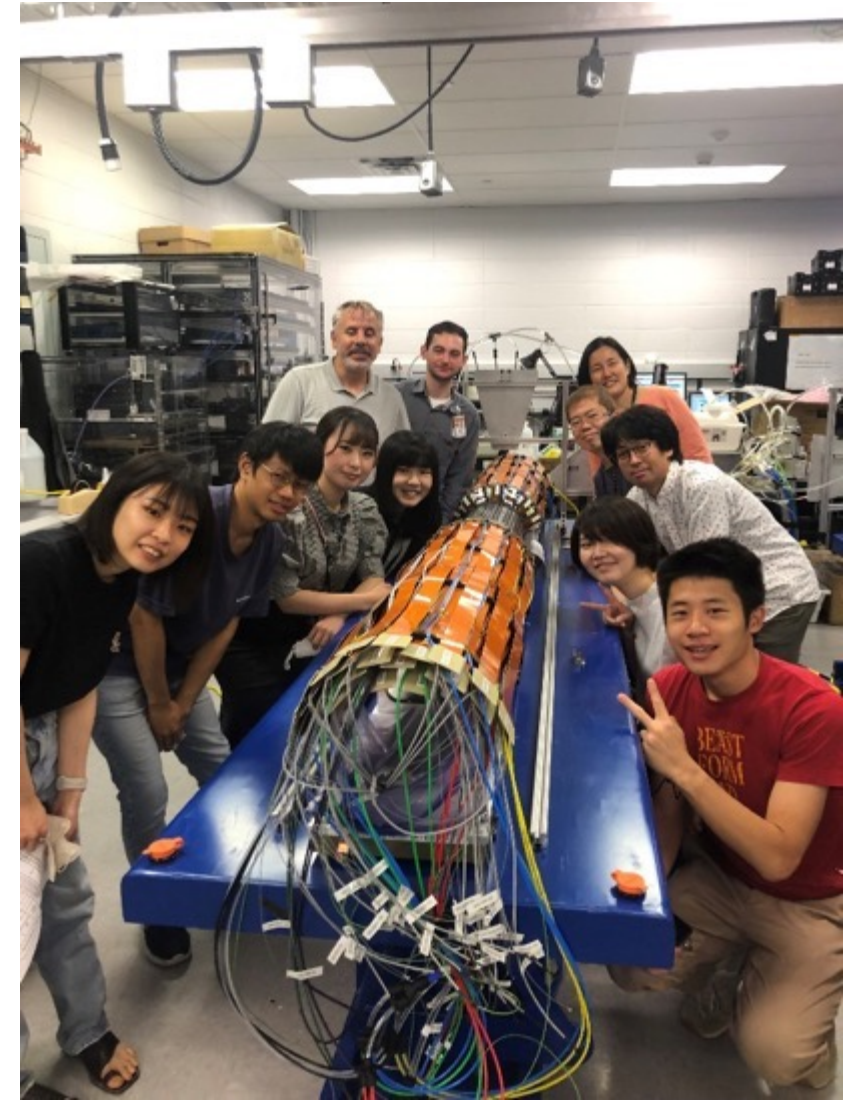
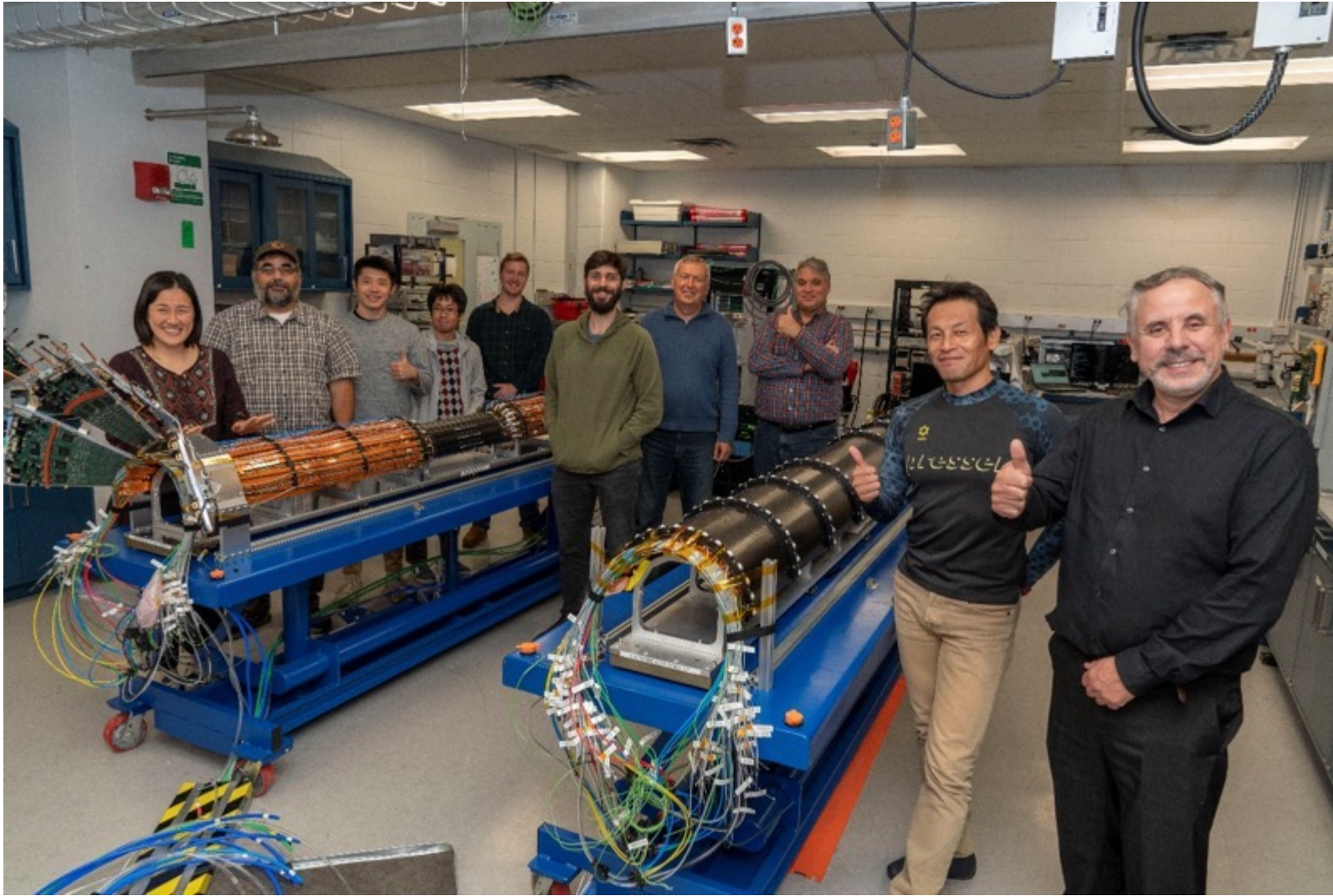
- **Installation@IR: March 17, 2023**

- **Post-installation@IR:**

- INTT integration in the IR: using sPHENIX infrastructure @IR

- Installation ROCs, optical cables ROCs-IR rack
- Cooling powered
- LV/HV racks powered
- Electrical test of barrels North and South (pulse test calibration)

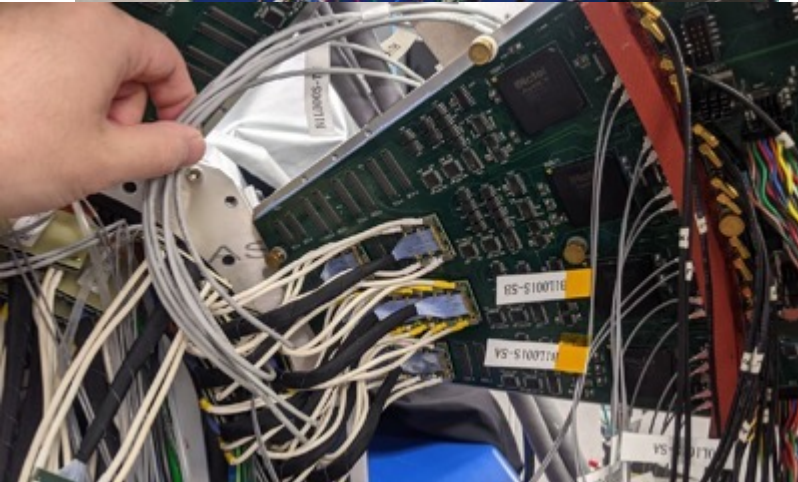
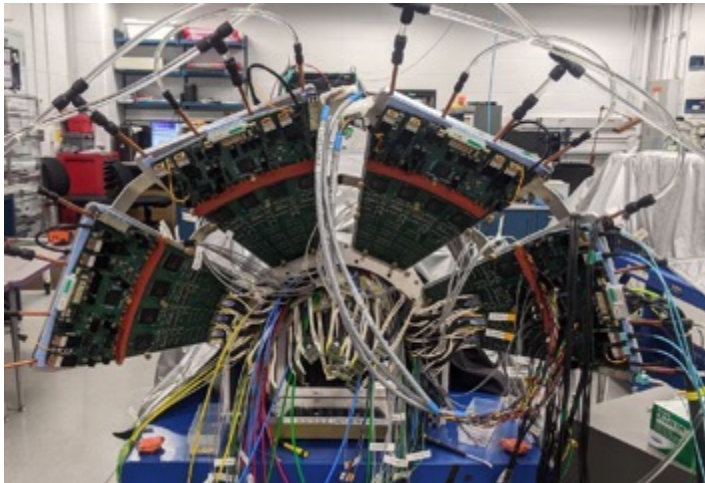
INTT Team



Thank you for your contributions to the INTT Barrel construction and testing!

Backup

The new DAQ for the Felix system at the silicon lab.



WIENER MPOD - 1287029	Status	On/Off	Vset [V]	Iset [nA]	Vmeas [V]
WIENER MPOD - 1287029	-	<crate>	<crate>	<crate>	-
EOBFO - 741570 - slot 0	-	<module>	<module>	<module>	-
Channel 0	Constant Volt	100	100	1e+06	100.01
Channel 1	Constant Volt	100	100	1e+06	99.9901
Channel 2	Constant Volt	100	100	1e+06	100.006
Channel 3	Constant Volt	100	100	1e+06	100.001
Channel 4	Constant Volt	100	100	1e+06	100.001

The interface also includes a 'Simple GUI for the Felix server in local use' on the right with various control buttons like 'start_sm', 'reset_fpga', and 'enable_channel'. At the bottom, there is a 'Contents' window showing a grid of plots.

All operations (DAQ, HV, LV) were driven in the new Felix server at the silicon lab.

ladder Calibration, B1L000S

