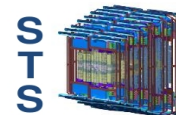
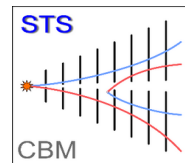
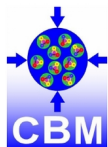


Characterization and test of STS modules for the E16 experiment

Dairon Rodríguez Garcés for the CBM collaboration
GSI & Goethe University of Frankfurt

DPG2023, Dresden
March 23rd, 2023

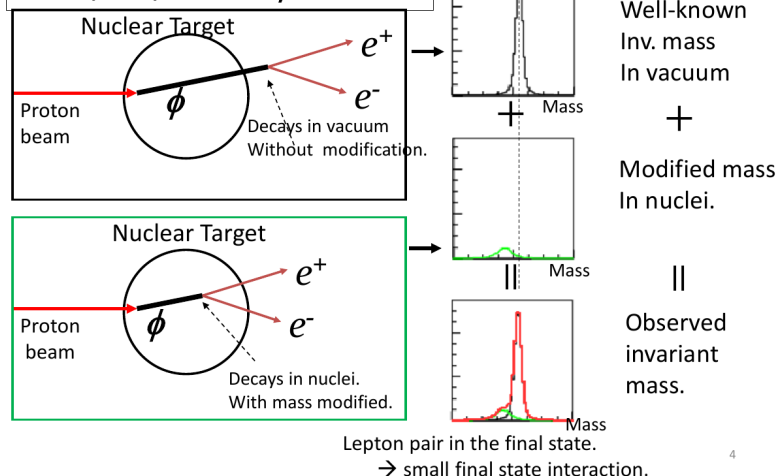


Outline

- E16 experiment at J-PARC
 - Physics motivation
 - Setup
- Module assembly at GSI, testing and results
- Projections for the STS

Physics motivation for E16 at J-PARC and goals

Example: $p + A \rightarrow \phi + X$



VECTOR MESONS

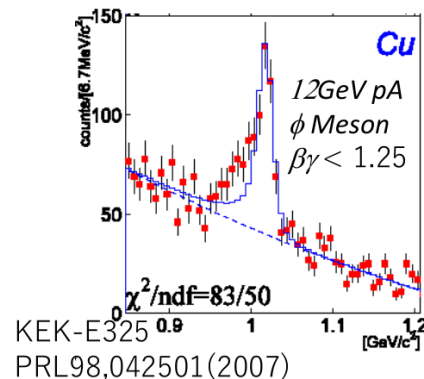
- decay into e^+e^- pairs
- e^+, e^- do not interact strongly
- they leave the medium without re-interaction

AA: CERES/ NA45, NA60 @SPS
 HADES @ GSI
 PHENIX, STAR @ RHIC
 pA: CLAS @ Jlab
 E325 @ JPARC

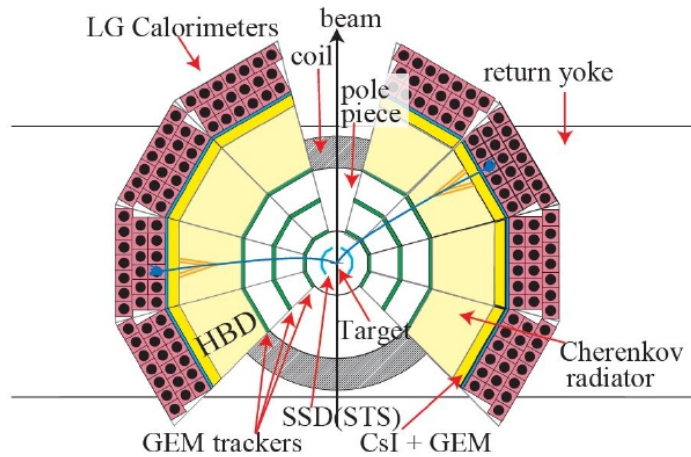
E16 wants to measure

- $p + A @ 30 \text{ GeV} \rightarrow \phi + X, \phi \rightarrow e^+e^-$
- With large statistics (100x E325) and better resolution $\sigma=5\text{MeV}$ for ϕ

Proton beam: 10^{10} spill $\rightarrow$ high rate capability 5kHz/mm^2



The E16 experiment



SETUP:

- Target chamber in the center

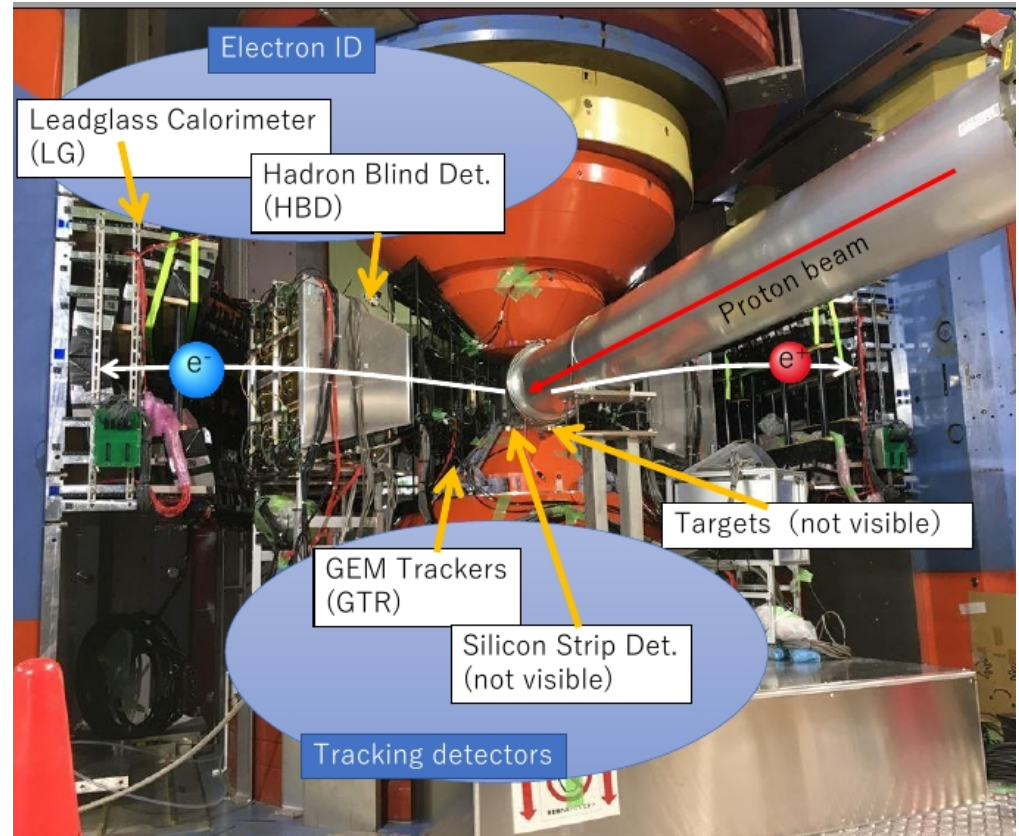
DETECTORS:

tracking:

- Silicon Strip Detector
- GEM tracker

electron identification:

- Hadron Blind (Cherenkov)
- PbGl calorimeter



K.Aoki, STS session at 41st Collaboration Meeting

STS in the E16 experiment

SSD thick and large frames

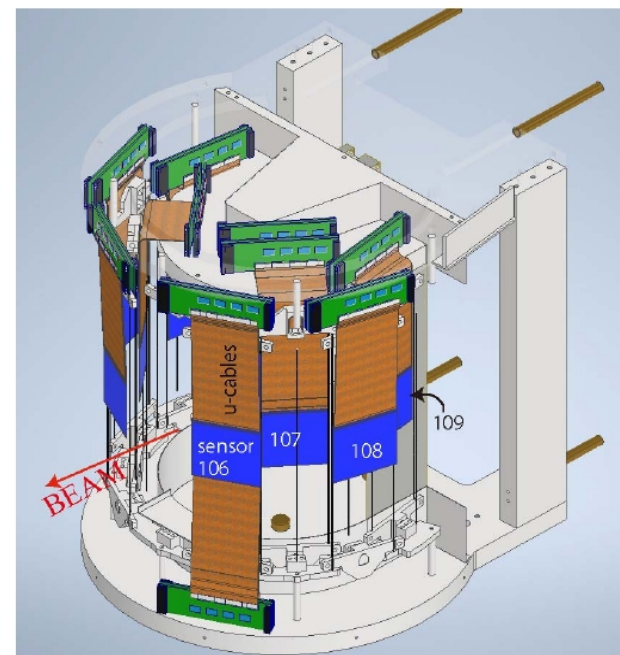
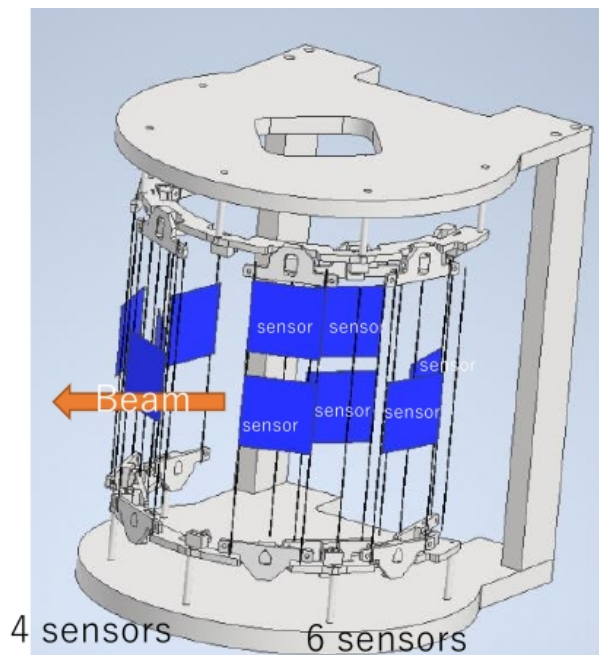
STS modules!!!

- light weight
- high rate capability
- fine segmentation
- double-sided readout
- position resolution $30\mu\text{m}$
- time resolution 6ns

10 x 6x6 sensors with FEB8-2v3
mounted onto 8 ladders
(Ladder: 231 mm, can
accomodate 3 sensors)

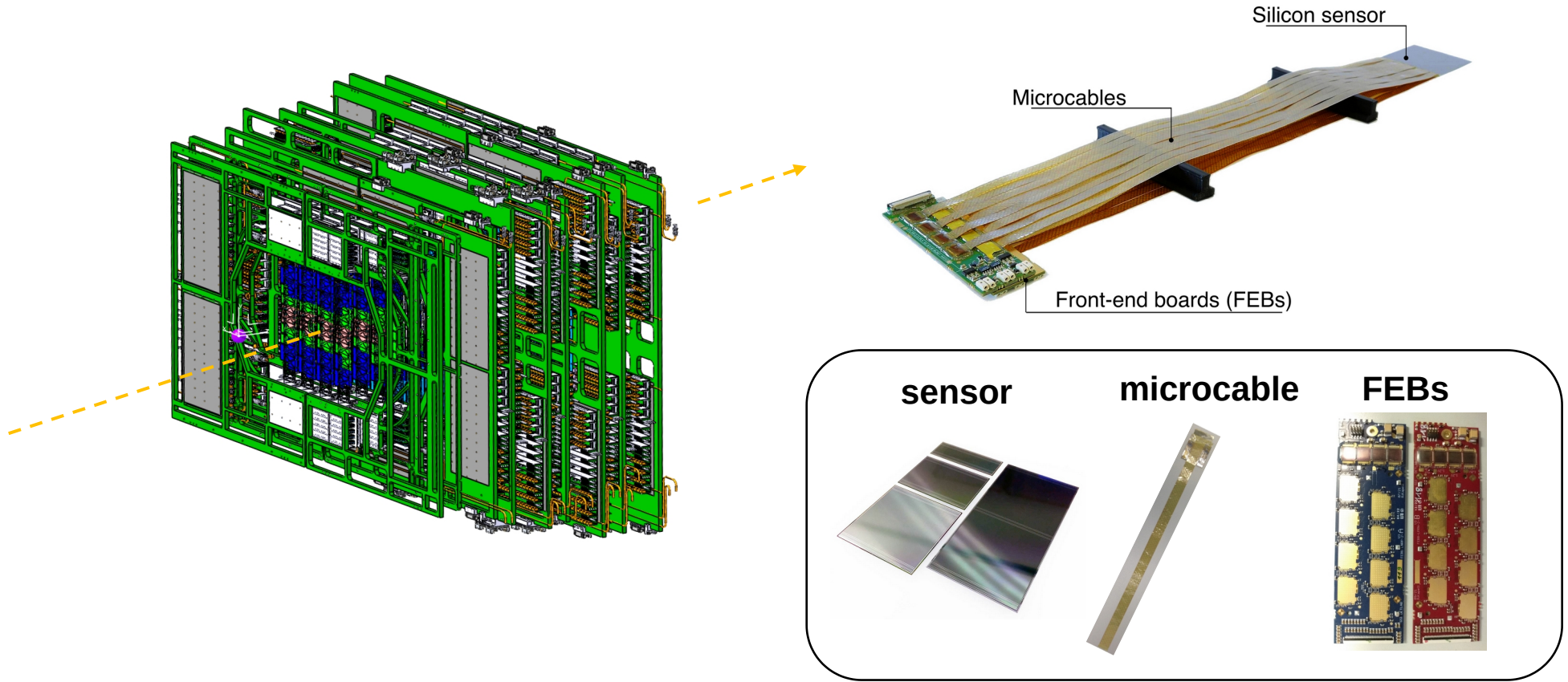
Support: 2 pillars

Cooling: 2 copper pipes

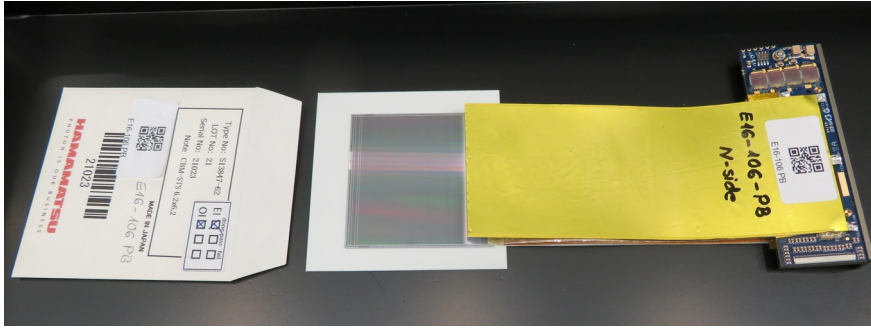


Silicon Strip Detector in the E16

STS module in STS detector



E16 module



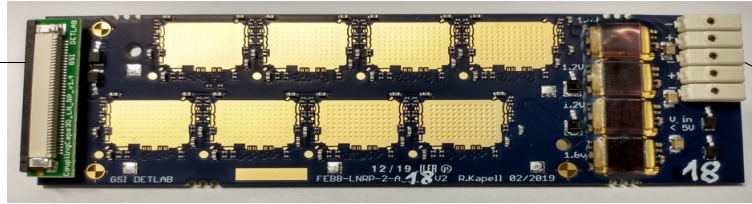
The E16 module

- HV filtering integrated onto the FEB
- Array of coupling capacitors
- Redesigned LV and HV power connectors
- ZIF data cable connector

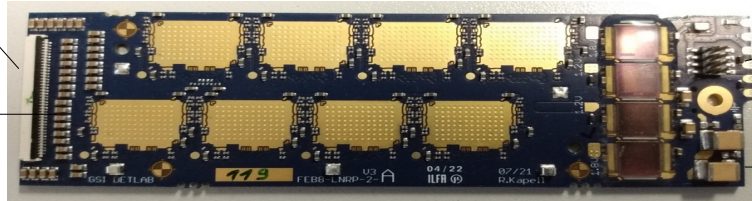
FEB8-2v2

New ZIF data
cable connector

Array of coupling
capacitors



New power connection schema

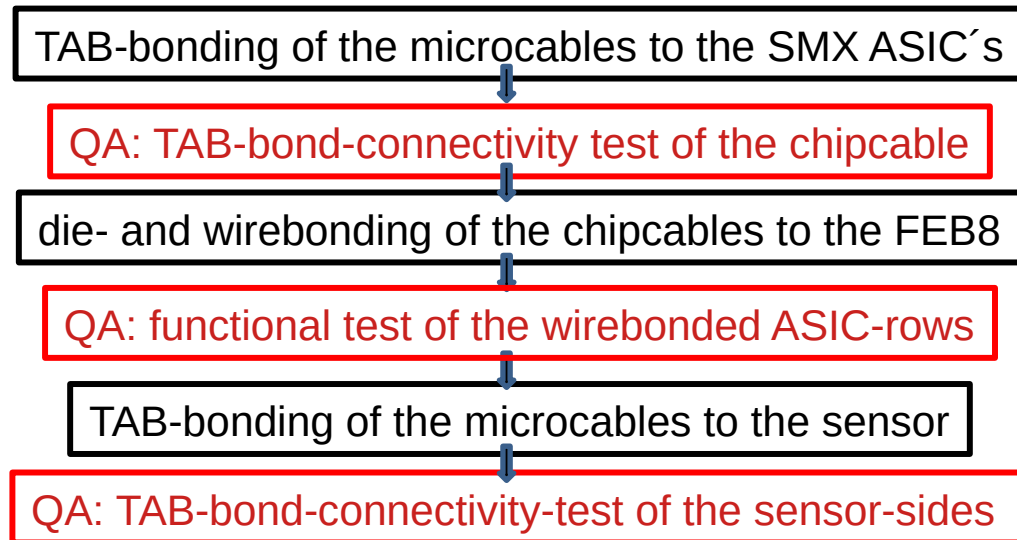


HV filtering onto the PCB

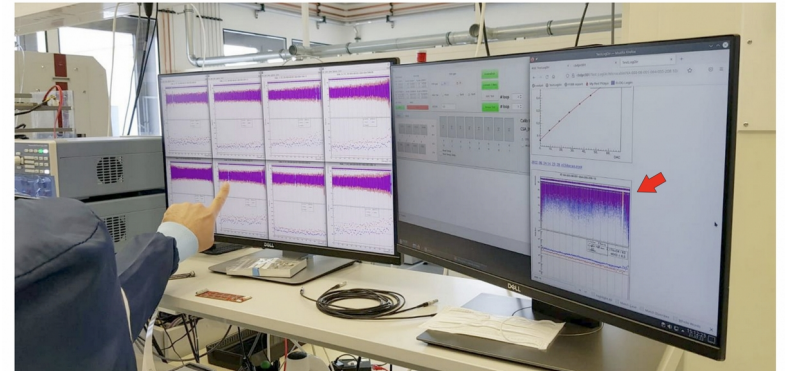
FEB8-2v3

Pre-series module assembly. What is new?

First opportunity for the assembly team to exercise a full scale assembly and testing protocol for pre-series production



BLACK: the steps of the assembly
RED: the steps of the QA protocol



Pre-series module assembly. The outcome

#	Module	FEB8	Addr_0	Addr_1	Addr_2	Addr_3	Addr_4	Addr_5	Addr_6	Addr_7	SUM	DATE
1	E16-101_PB	FEB8-LN-RP-A N side FEB_NS_125			1		4			12	17	27 Jul
		FEB8-LN-RP-B P side FEB_NS_124		2				1	1		4	21 Jul
2	E16-102_PA	FEB8-LN-RP-A P side FEB_NS_133			2	1			1		4	2 Nov
		FEB8-LN-RP-B N side FEB_NS_127	1		1	1					3	6 Oct
3	E16-103_PB	FEB8-LN-RP-A N side FEB_NS_118	1				1	1	1		4	29 Jul
		FEB8-LN-RP-B P side FEB_NS_125	2			2	2	1		1	8	21 Jul
4	E16-104_PA	FEB8-LN-RP-A P side FEB_NS_129				1					0	23 Sep
		FEB8-LN-RP-B N side FEB_NS_131				1					1	10 Oct
5	E16-106_PB	FEB8-LN-RP-A N side FEB_NS_130	2		1			1		1	5	4 Oct
		FEB8-LN-RP-B P side FEB_NS_132		1				1			2	29 Sep
6	E16-107_PA	FEB8-LN-RP-A P side FEB_NS_117	1	4	2		1		3	7	18	26 Jul
		FEB8-LN-RP-B N side FEB_NS_128							1		1	29 Jul
7	E16-108_PB	FEB8-LN-RP-A N side FEB_NS_131				1					1	5 Oct
		FEB8-LN-RP-B P side FEB_NS_133				1		1			2	4 Oct
8	E16-109_PA	FEB8-LN-RP-A P side FEB_NS_126					5			1	6	2 Aug
		FEB8-LN-RP-B N side FEB_NS_130			5	1	1	1			8	1 Aug
9	E16-206_PA	FEB8-LN-RP-A P side FEB_NS_134		1		1			1	1	4	10 Oct
		FEB8-LN-RP-B N side FEB_NS_129	2			1				3	6	22 Sep
10	E16-207_PA	FEB8-LN-RP-A P side FEB_NS_127	1	1				15		2	4	4 Oct
		FEB8-LN-RP-B N side FEB_NS_133						1			1	4 Oct



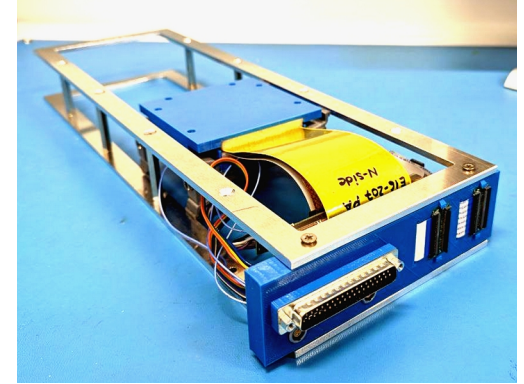
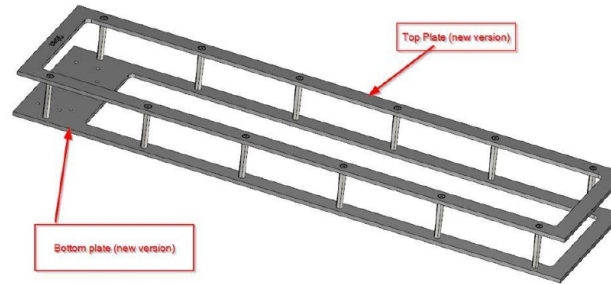
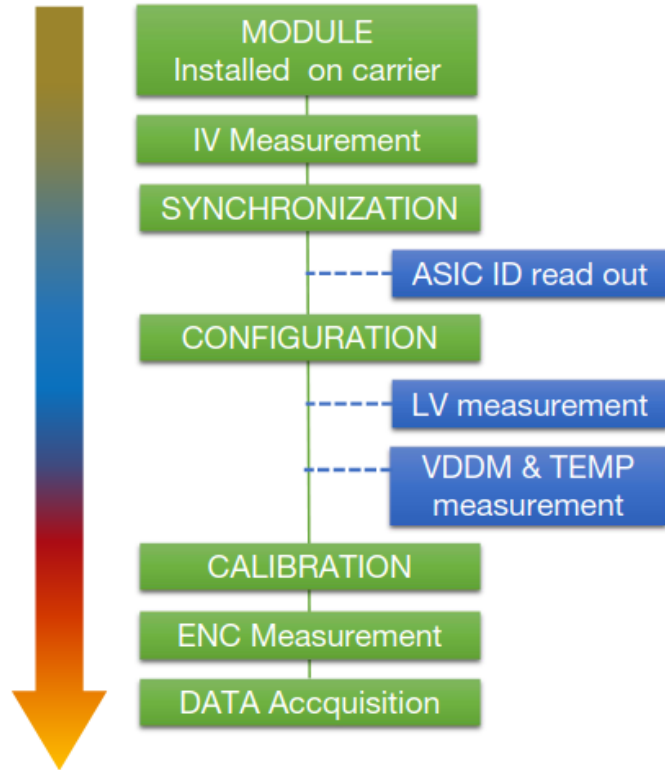
Status early November 2022:

- all 10 modules assembled
- test results during module assembly in clean room:
 - all in specs, (<1,5% missing channels)

Very good results
Congrats to the assembly
team!!!

Module testing. Why, how and where?

Simplify module testing protocol



Sensor and cable supports:

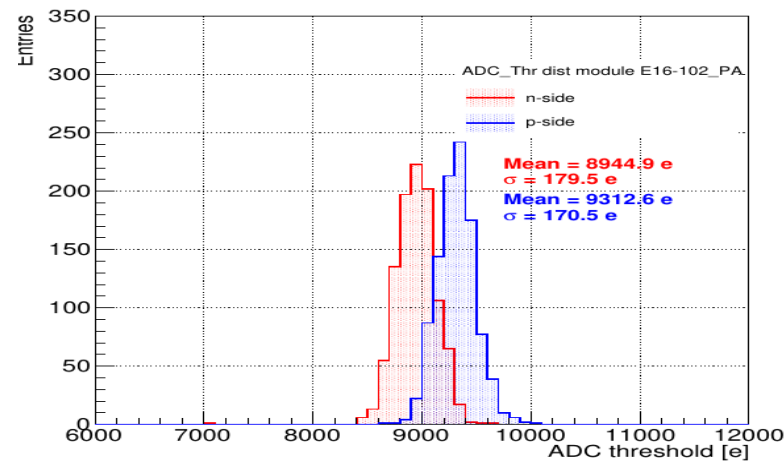
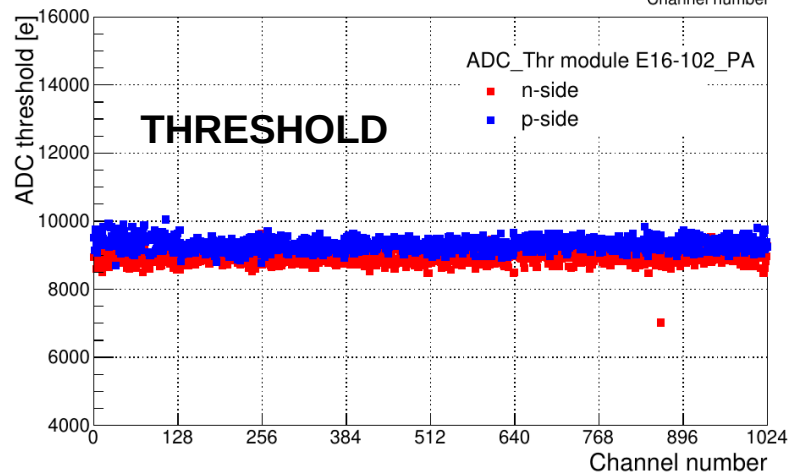
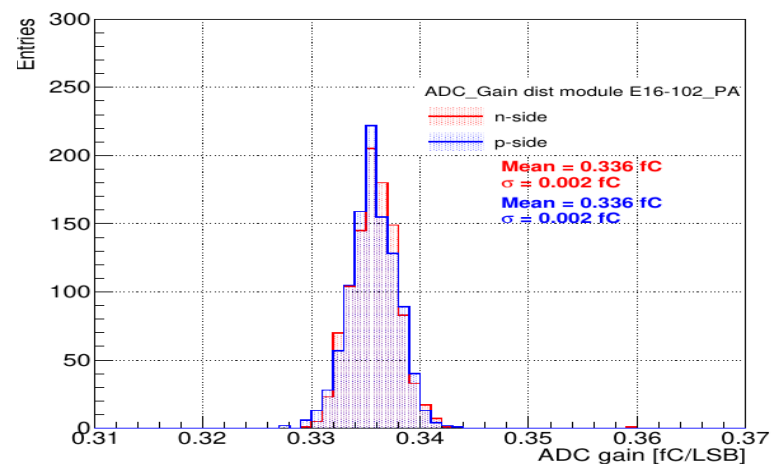
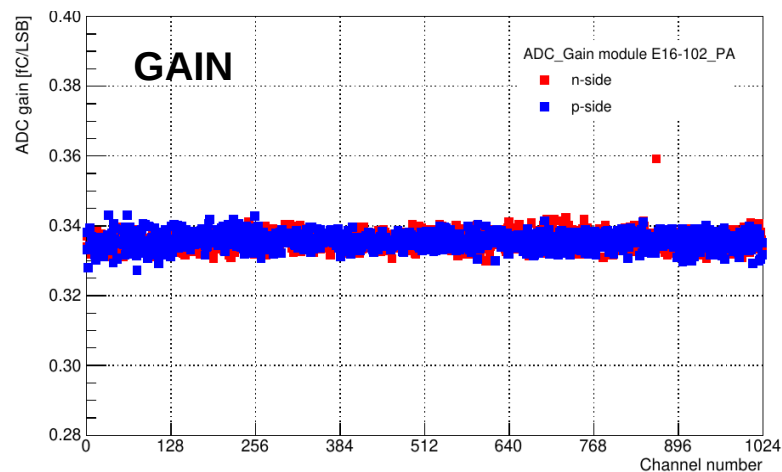
- Adjustable sliding supports made of ESD plastic
- Different form-factors for different sensor sizes + microcables
- ESD foam for contact with fragile components

Robust connectors with virtual infinity cycles:

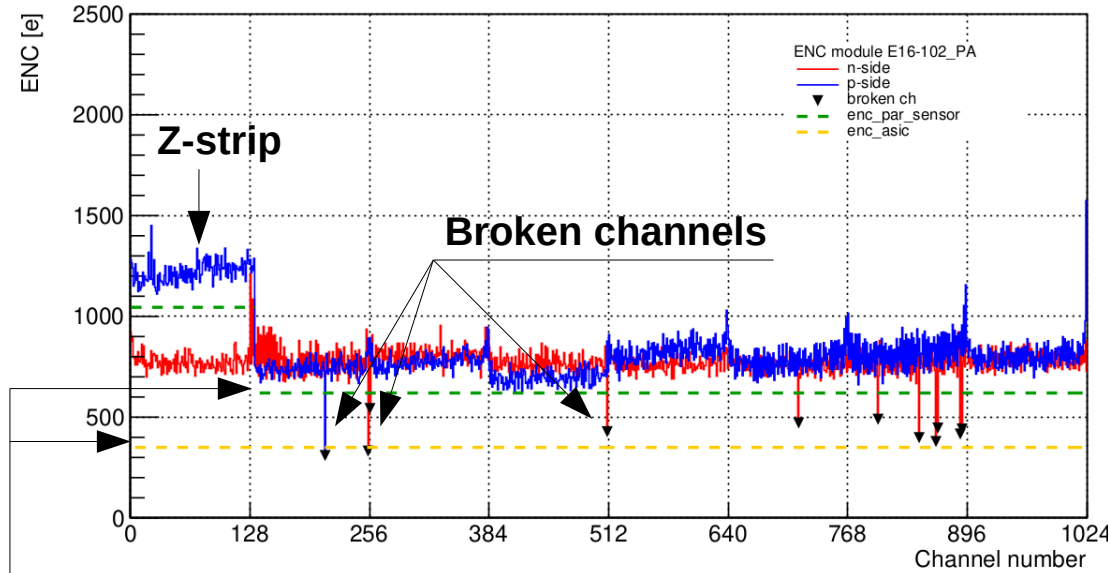
- LV: 1 D37 connector
- HV: 2 LEMO connectors
- data: 2 ZIF-connectors extension

M.Teklishyn, STS retreat 2023

ADC calibration: gain & threshold



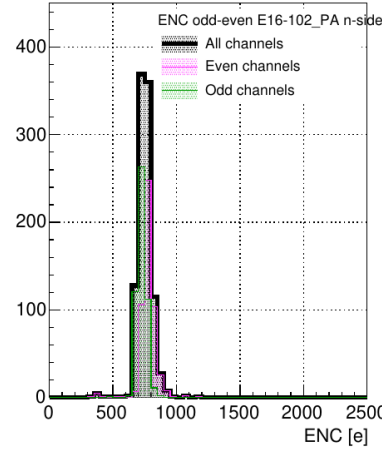
Equivalent Noise Charge



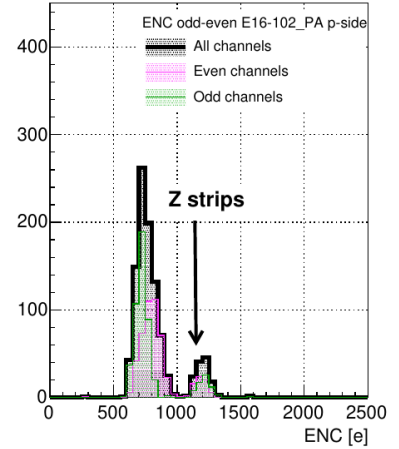
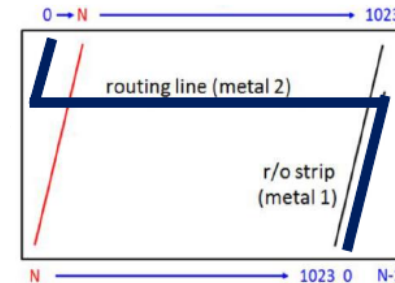
$$ENC = \left[\underbrace{L_{\text{sensor}} \cdot 1.02 \frac{\text{pF}}{\text{cm}}}_{\text{sensor}} + \underbrace{L_{\text{cable}} \cdot 0.38 \frac{\text{pF}}{\text{cm}}}_{\text{microcable}} \right] \cdot 25 \frac{e}{\text{pF}} + \underbrace{350}_{\text{ASIC}} e$$

Z-strip: 17 pF extra from the double metal routing

I. Panasenکو, PhD thesis



Z channels interconnected via a double metal layer

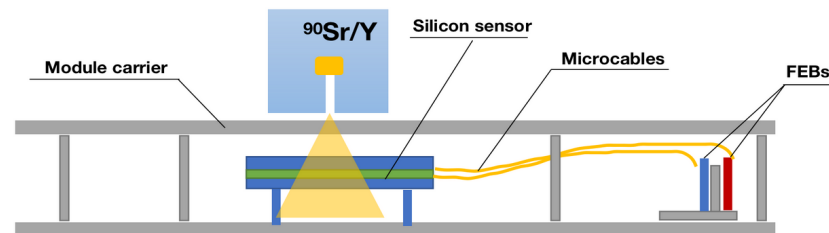
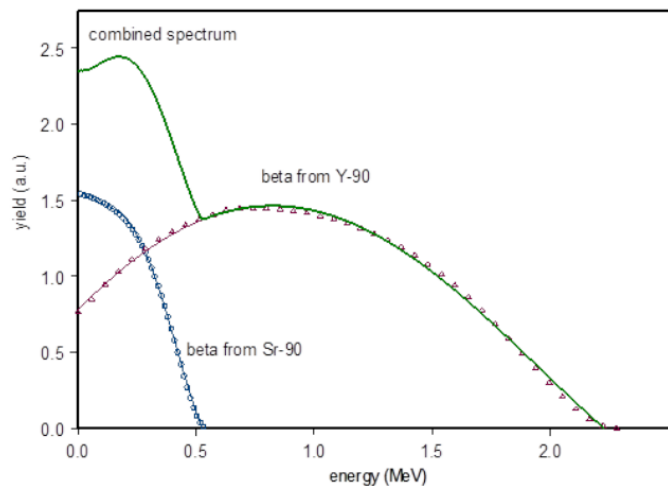


Estimate the extra capacitance Z-strip:
 $\Delta(ENC_{\text{Z-strip}} - ENC_{\text{ave}})$

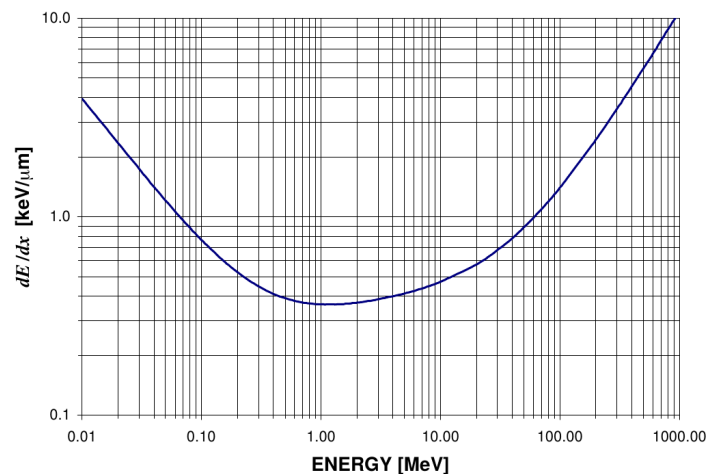
Module testing: response function to $^{90}\text{Sr}/\text{Y}$ source

Source $^{90}\text{Sr}/\text{Y}$

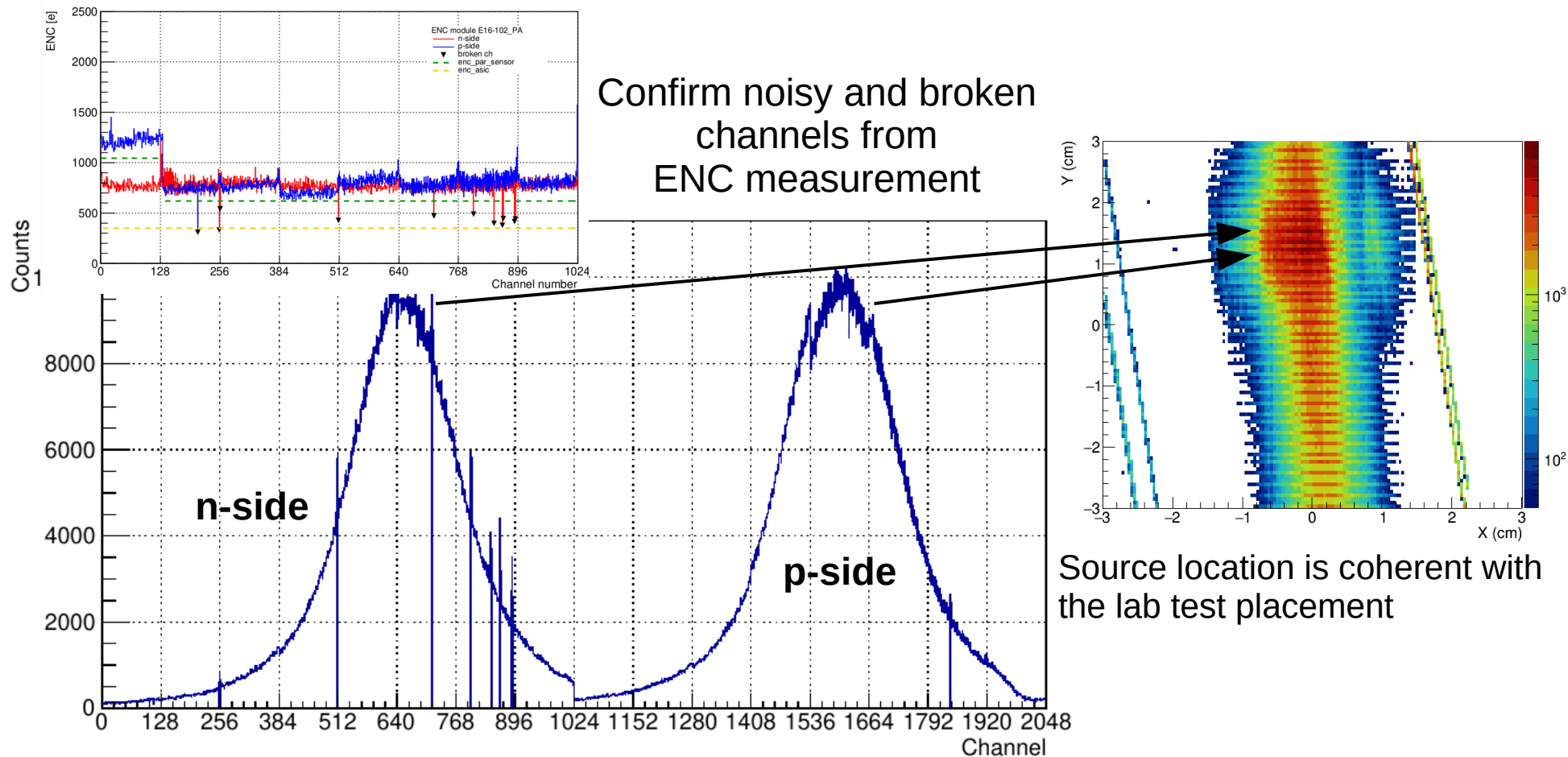
- Beta-emitter
- electron with spectrum larger than 1 MeV
- placed at the center of the sensor



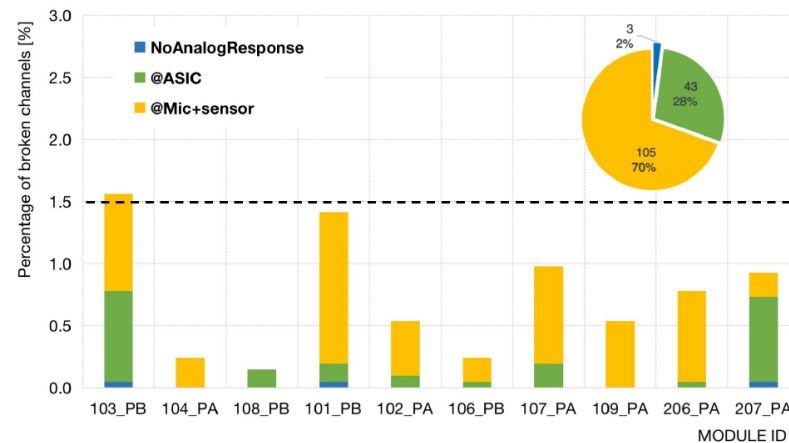
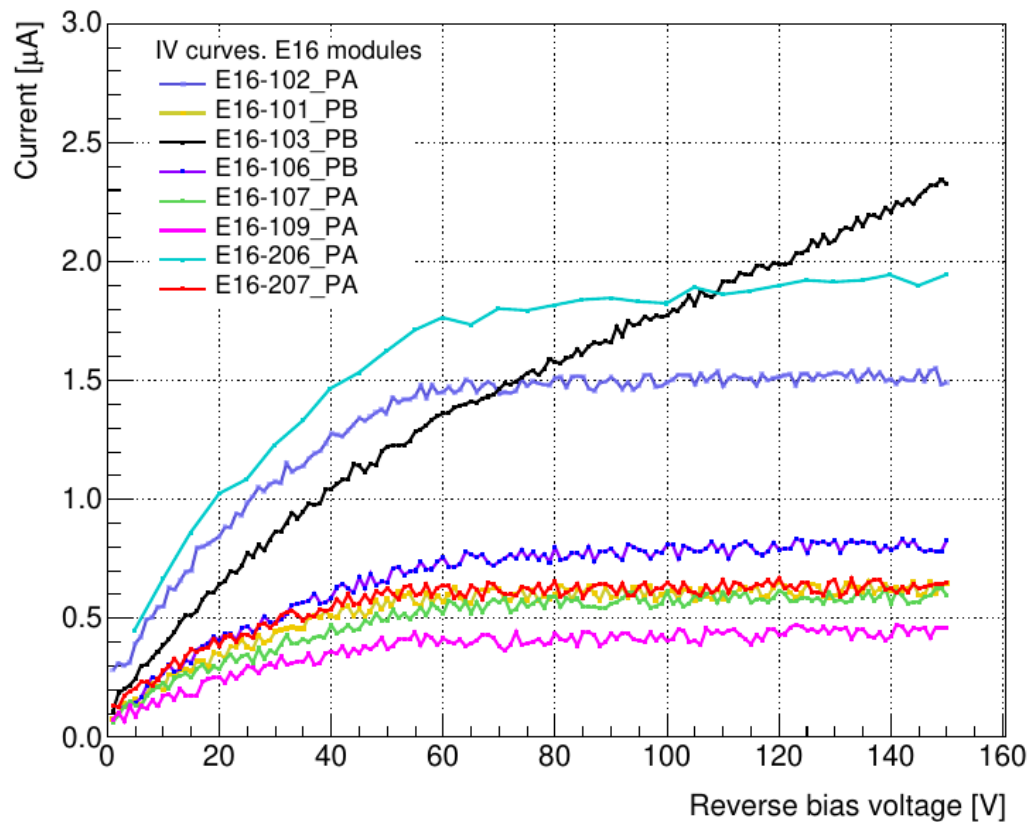
Experimental setup



Signal response: a tool for broken channels identification

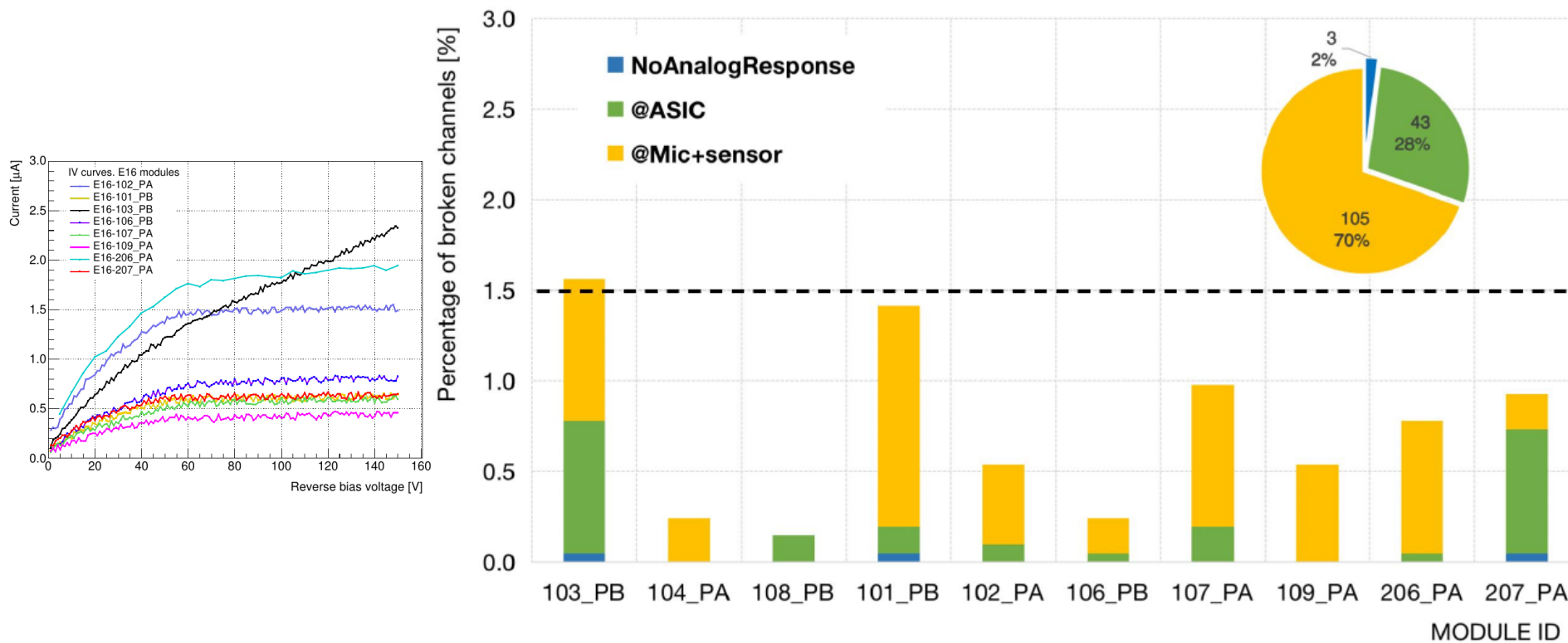


E16 module testing summary



All modules successfully tested. All passed the acceptance criteria

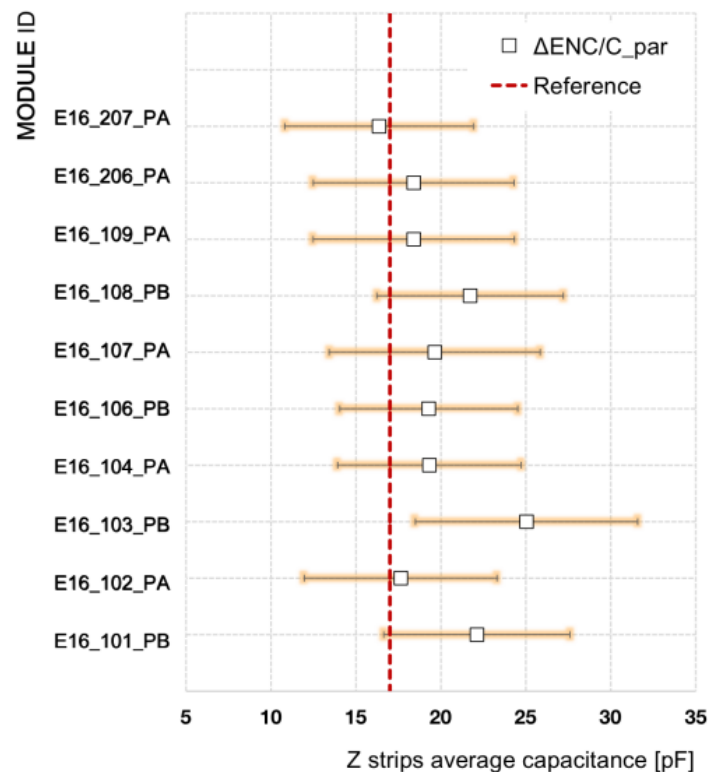
E16 module testing summary



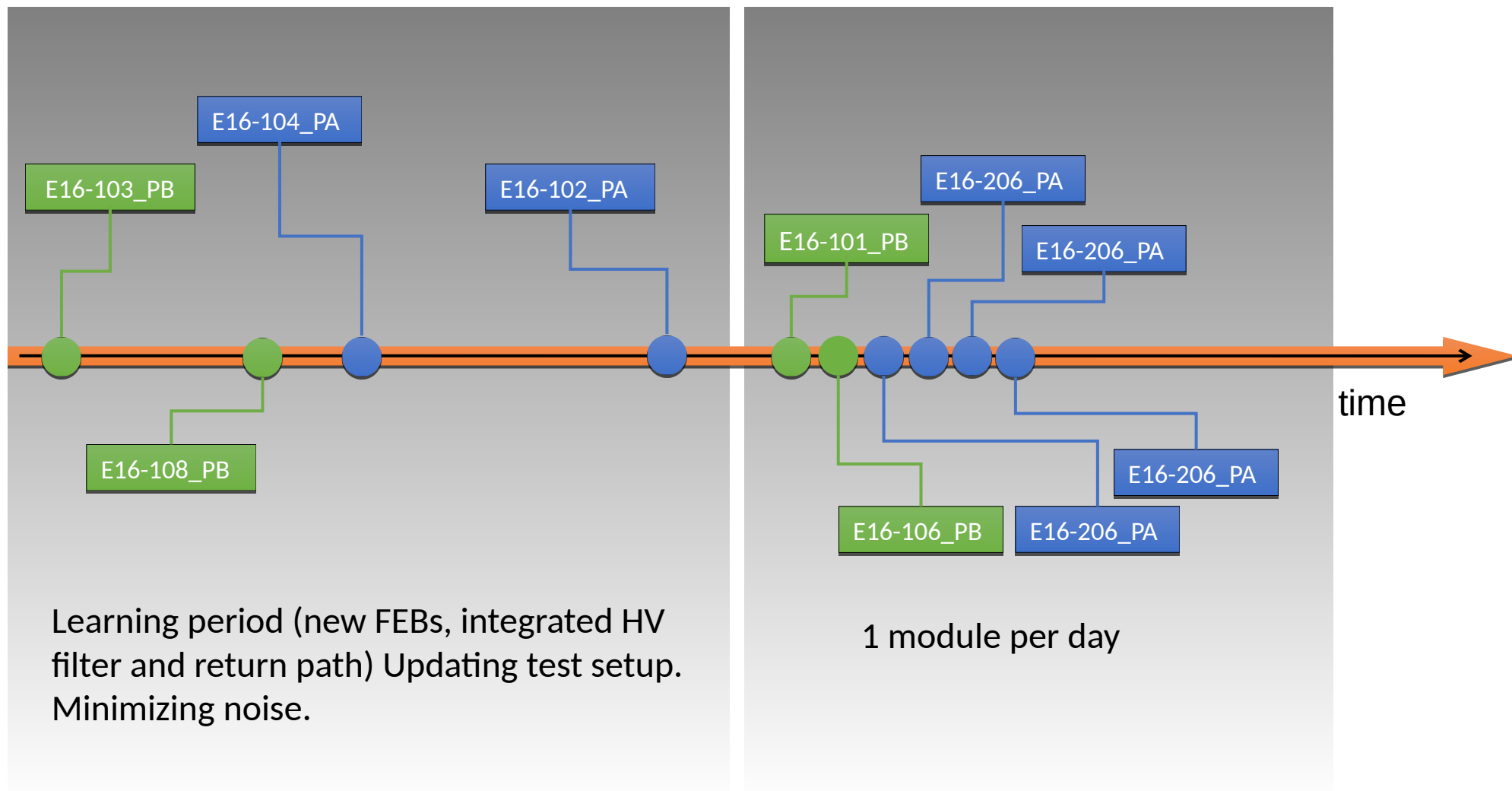
All modules successfully tested. All passed the acceptance criteria

E16 module testing summary

		<ENC> [e]	Gain [fC/LSB]	$\sigma_{\text{ADC_thr}}$ [e]
E16-101_PB	P-side	722	0,336	242
	N-side	945	0,336	186
E16-102_PA	P-side	781	0,336	172
	N-side	776	0,336	183
E16-103_PB	P-side	789	0,336	165
	N-side	929	0,336	177
E16-104_PA	P-side	748	0,336	167
	N-side	744	0,337	224
E16-106_PB	P-side	711	0,336	230
	N-side	770	0,336	180
E16-107_PA	P-side	819	0,336	212
	N-side	819	0,335	193
E16-108_PB	P-side	695	0,336	238
	N-side	795	0,336	168
E16-109_PA	P-side	799	0,336	181
	N-side	734	0,336	200
E16-206_PA	P-side	854	0,335	200
	N-side	758	0,336	159
E16-207_PA	P-side	769	0,336	175

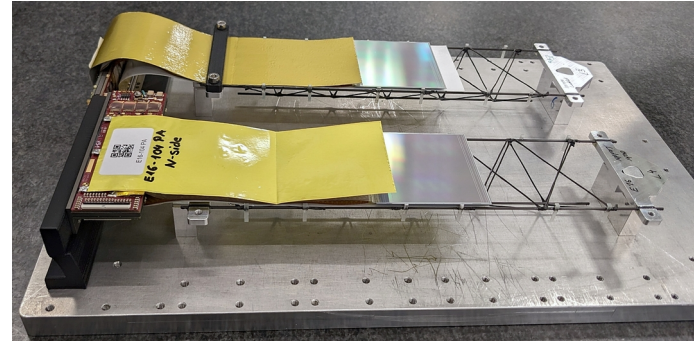


Reference value: 17 pF from **I.Panasenko**, PhD thesis



Ladder assembly for the E16 and shipping

After module testing, modules are mounted onto a carbon fiber ladder.



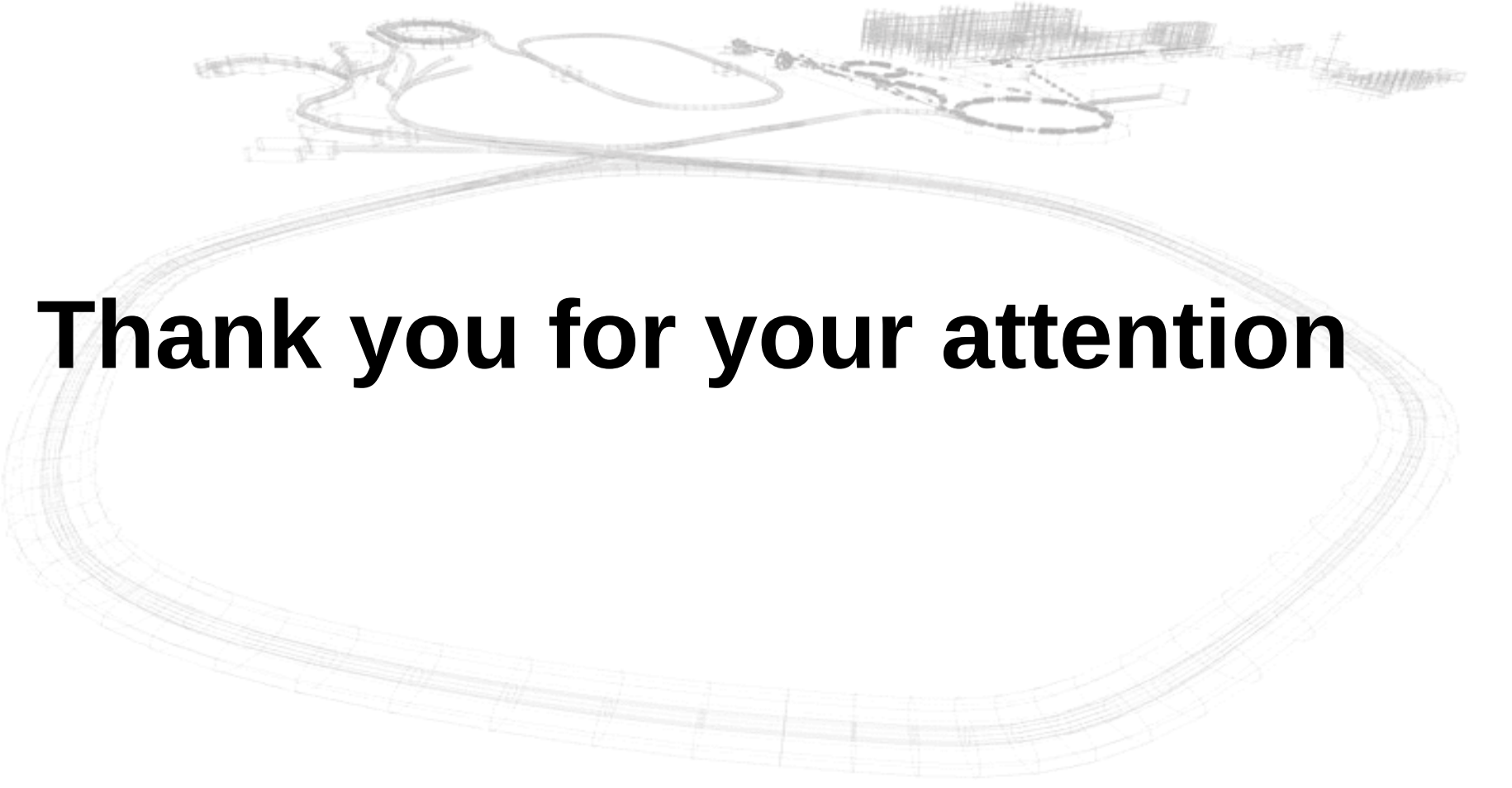
packing in transportation box - shipment from GSI warehouse

In the STS session on Tuesday, we knew that the E16 modules are already in Japan and under testing

Summary & Outlook

- New collaborators from the E16 experiment
 - Similar physics interest and complementary measurements
- Full scale pre-production assembly
- Module testing: learning new test environment
- Good projections for the final STS construction

- E16 commissioning and running this year
 - Results from beamtime



Thank you for your attention