Current Status of Flex Tail and High Voltage module

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outline

Flex tail R&D

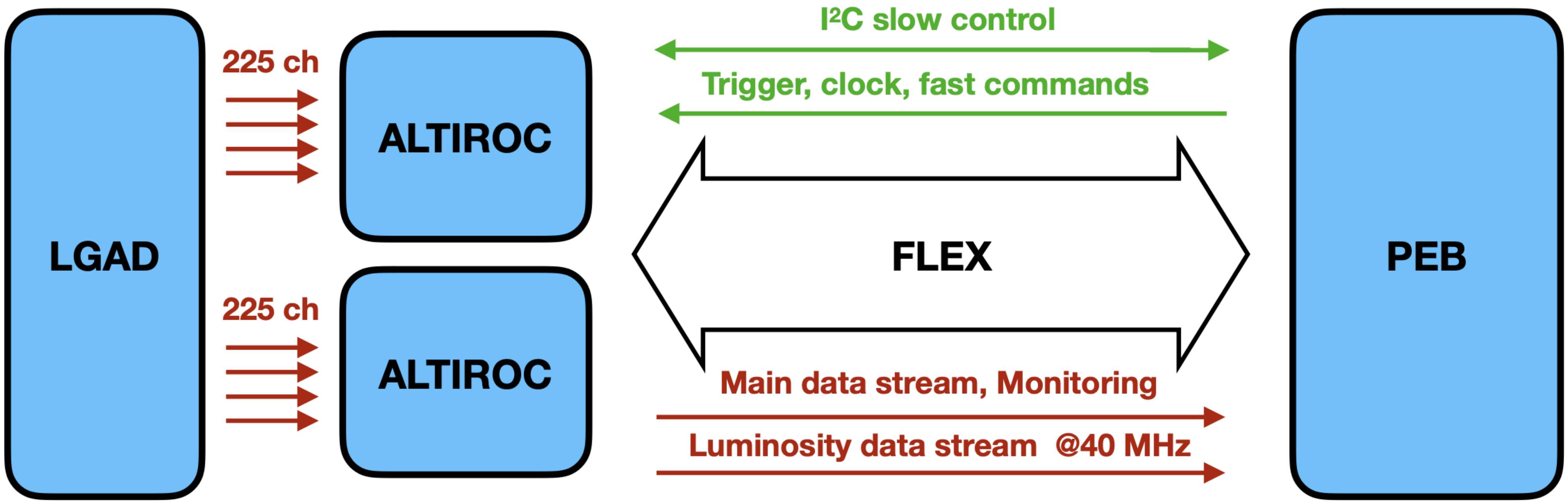
- ✓ PCB Structure
- ✓ Testing: width & thickness, voltage drop, etc

High voltage R&D

- ✓ HV crate
- ✓ HV testing

High granularity timing detector (HGTD):

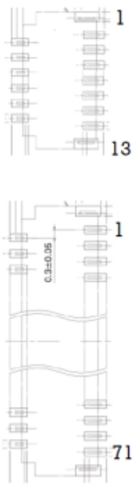
- ✓ Flexible PCB between low-gain avalanche detector (LGAD) and peripheral electronics board (PEB)： 1/3 mass production;
- ✓ High Voltage (HV) module： ~18% ;



pin layout in flex tail

		1	HV
HV	2	3	HV
HV	4	5	HV
HV	6	7	HV
HV	8	9	HV
HV	10	11	HV
HV	12	13	HV

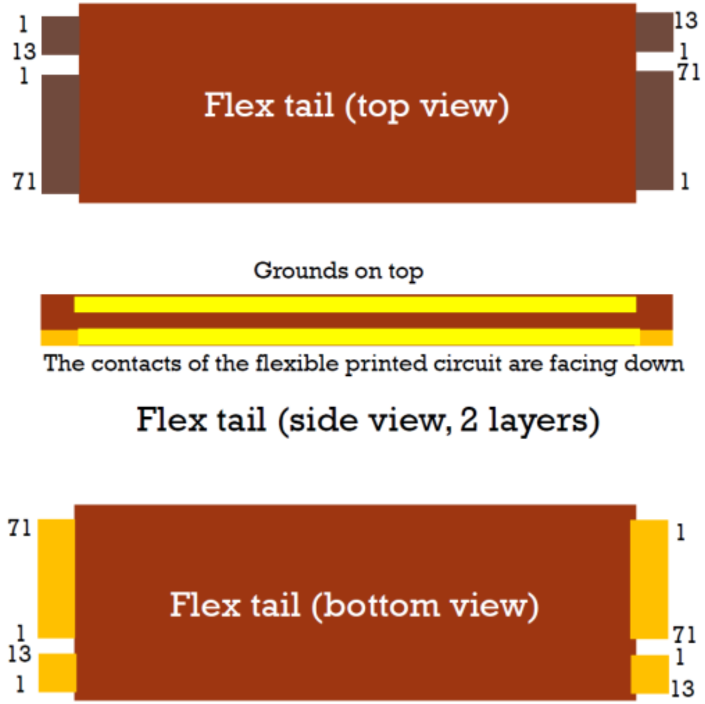
		1	HV_gnd
HV_gnd	2	3	vdda
vdda	4	5	vdda
vdda	6	7	vdda
vdda	8	9	vdda
vdda	10	11	vdda
vdda	12	13	gnda
monitoring_probe1	14	15	gnda
monitoring_probe0	16	17	gnda
monitoring_vdda	18	19	gnda
monitoring_vddd	20	21	gnda
monitoring_gnda	22	23	gnda
gnda	24	25	gnda
NC0	26	27	gnda
NC1	28	29	gnda
LpGBT_ck40p	30	31	gndd
LpGBT_ck40n	32	33	gndd
timing_doutp0	34	35	gndd
timing_doutn0	36	37	gndd
lumi_doutp0	38	39	gndd
lumi_doutn0	40	41	gndd
fast_cmdp	42	43	gndd
fast_cmdn	44	45	gndd
timing_doutp1	46	47	gndd
timing_doutn1	48	49	gndd
lumi_doutp1	50	51	gndd
lumi_doutn1	52	53	gndd
LpGBT_hard_rstb	54	55	ASIC_add<3>
ASIC_add<2>	56	57	ASIC_add<1>
I2C_SDA	58	59	I2C_SCL
vddd	60	61	vddd
vddd	62	63	vddd
vddd	64	65	vddd
vddd	66	67	vddd
vddd	68	69	vddd
NTC+	70	71	NTC-



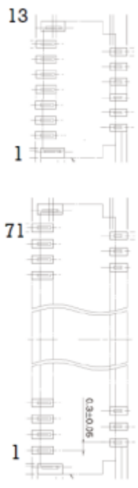
FH26

Center to center distance: **15.6mm**

Module flex(top view)



Flex tail



FH26

Center to center distance: **15.6mm**

HV	13	12	HV
HV	11	10	HV
HV	9	8	HV
HV	7	6	HV
HV	5	4	HV
HV	3	2	HV
HV	1		

HV_gnd	71	70	HV_gnd
vdda	69	68	vdda
vdda	67	66	vdda
vdda	65	64	vdda
vdda	63	62	vdda
vdda	61	60	vdda
gnda	59	58	monitoring_probe1
gnda	57	56	monitoring_probe0
gnda	55	54	monitoring_vdda
gnda	53	52	monitoring_vddd
gnda	51	50	monitoring_gnda
gnda	49	48	gnda
gnda	47	46	NC0
gnda	45	44	NC1
gnda	43	42	LpGBT_ck40p
gndd	41	40	LpGBT_ck40n
gndd	39	38	timing_doutp0
gndd	37	36	timing_doutn0
gndd	35	34	lumi_doutp0
gndd	33	32	lumi_doutn0
gndd	31	30	fast_cmdp
gndd	29	28	fast_cmdn
gndd	27	26	timing_doutp1
gndd	25	24	timing_doutn1
gndd	23	22	lumi_doutp1
gndd	21	20	lumi_doutn1
gndd	19	18	LpGBT_hard_rstb
ASIC_add<3>	17	16	ASIC_add<2>
ASIC_add<1>	15	14	I2C_SDA
I2C_SCL	13	12	vddd
vddd	11	10	vddd
vddd	9	8	vddd
vddd	7	6	vddd
vddd	5	4	vddd
vddd	3	2	NTC+
NTC-	1		

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PEB (top view)

FT Parameters:
Width : 36 mm
thickness at two ends: ~200 um (<220m)

Impedance:
Single-ended 50 Ohm +/-10%
Diff 100 Ohm +/-10%

FT R&D

Last time

		Ends		Flex				
13	um			Coverlay Yellow				
25	um			Coverlay Adhesive				
28	um	Base Copper	18	um +	Plated	Plated	10	um min.
50	um	Polyimide						
28	um	Base Copper	18	um +	Plated	Plated	10	um min.
25	um	Coverlay Adhesive						
13	um	Coverlay Yellow						
25	um	Adhesive						
50	um	PI						

Last time

This time

		Ends		Flex				
13	um							
25	um							
28	um	Base Copper	18	um +	Plated	Plated	10	um min.
50	um	Polyimide						
28	um	Base Copper	18	um +	Plated	Plated	10	um min.
25	um	Coverlay Adhesive						
13	um	Coverlay Yellow						
25	um	Adhesive						
25	um	PI						

This time

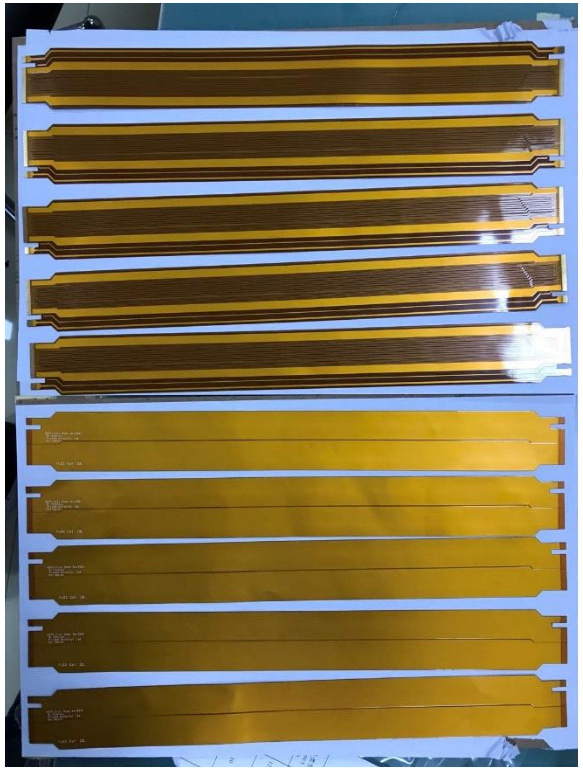
Two ends: flex+ stiffener=219 um ;
Flex =182 um

Line Parameters:
Differential pairs: 90 um line - 335 um gap
Single lines: 90 um
Impedance:
Single-ended 50 Ohm +/-10%
Diff 100 Ohm +/-10%

Two ends: flex+ stiffener=194 um ;

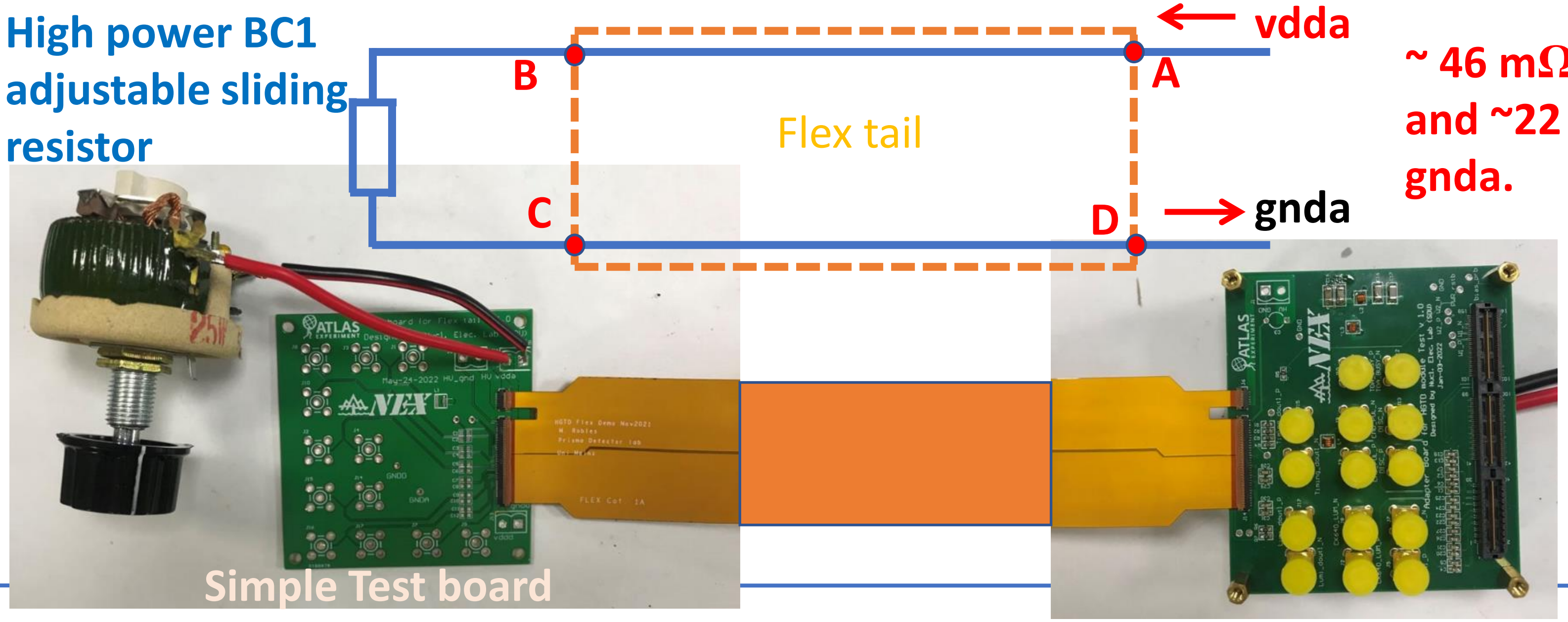
Flex =182 um

Stiffener layer on the bottom was decreased by 25 um.



Impedance of Power & Gnd Plane

	Current (A)	Applied Voltage(V)	Voltage between A and B	Voltage between C and D	R value for vdda (mΩ)	R value for gnda (mΩ)
Current version	1.053	1.4	0.048	0.024	45.6	22.3
	0.977	1.3	0.045	0.022	46.1	22.4
	0.904	1.2	0.041	0.020	45.4	22.1
Previous version	1.034	1.4	0.071	0.033	68.6	31.9
	0.961	1.3	0.066	0.031	68.7	32.2
	0.888	1.2	0.061	0.029	68.7	32.6



~ 46 mΩ for vdda and ~22 mΩ for gnda.

Adapter board v1

Impedance test results

New stackup: 45 um Cu

Flex tail Cat. 12L: 32.3 cm

Specifications

Power planes: <2.7 mΩ/cm

Ground planes: <0.7 mΩ/cm

	R_{plane} [mΩ]	R_{plane} [mΩ/cm]
vdda	45.6	1.41
	46.1	1.43
	45.4	1.40
gnda	22.3	0.69
	22.4	0.69
	22.1	0.68

	R_{plane} [mΩ]	R_{plane} [mΩ/cm]
vddd	42	1.30
	41.8	1.29
	41.8	1.29
gndd	19.5	0.60
	19.3	0.60
	19.7	0.61

The test results meets the requirement of the PDR specifications.

54 FT production for demonstrator

L[mm]	Category
646,6	1
640,5	2
637,6	3
614,5	4
608,4	5
605,5	6
582,2	7
576,1	8
573,2	9
550,1	10
544,0	11
541,1	12
518,0	13
511,9	14
509,0	15
483,0	16

L[mm]	Category	Serial Number	Nr or pieces to be produced	Company	Funding
646, 6	1	20WFTC11F01	2	China	China
640, 5	2	20WFTC11F02	2	China	China
637, 6	3	20WFTC11F03	2	China	China
614, 5	4	20WFTC11F04	2	China	China
608, 4	5	20WFTC11F05	2	China	China
605, 5	6	20WFTC11F06	2	China	China
582, 2	7	20WFTC11F07	2	China	China
576, 1	8	20WFTC11F08	2	China	China
573, 2	9	20WFTC11F09	2	China	China
550, 1	10	20WFTC11F10	2	China	China
544, 0	11	20WFTC11F11	2	China	China
541, 1	12	20WFTC11F12	2	China	China
518, 0	13	20WFTC11F13	2	China	China
511, 9	14	20WFTC11F14	2	China	China
509, 0	15	20WFTC11F15	2	China	China
483, 0	16	20WFTC11F16	2	China	China

Totally, the demonstrator has 54 flex tails. The first 16 flex tails are relatively longer. German and Slovenian cover the cost of the others.

FT plan

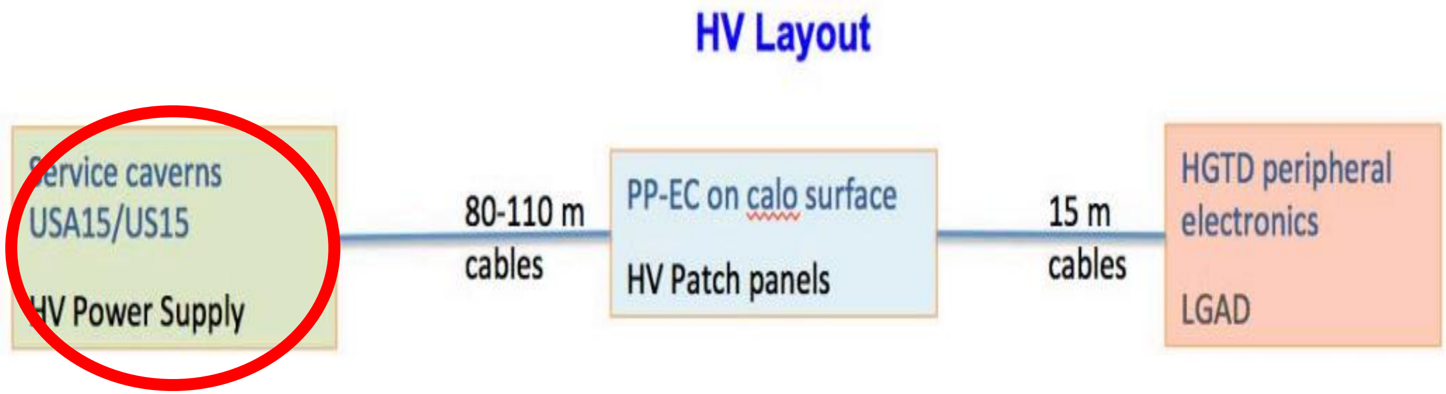
Status & Plan：

- ✓ module demonstrator needs 54 FT with different lengths， used to validate the detector performance。 First 16 FT with longer lengths are produced and tested and had been sent to CERN.
- ✓ Discuss with Lucia (Germany) and Gregor (Slovenia) about the lowest possible quotations. We may discuss the specifics very soon.

caliper

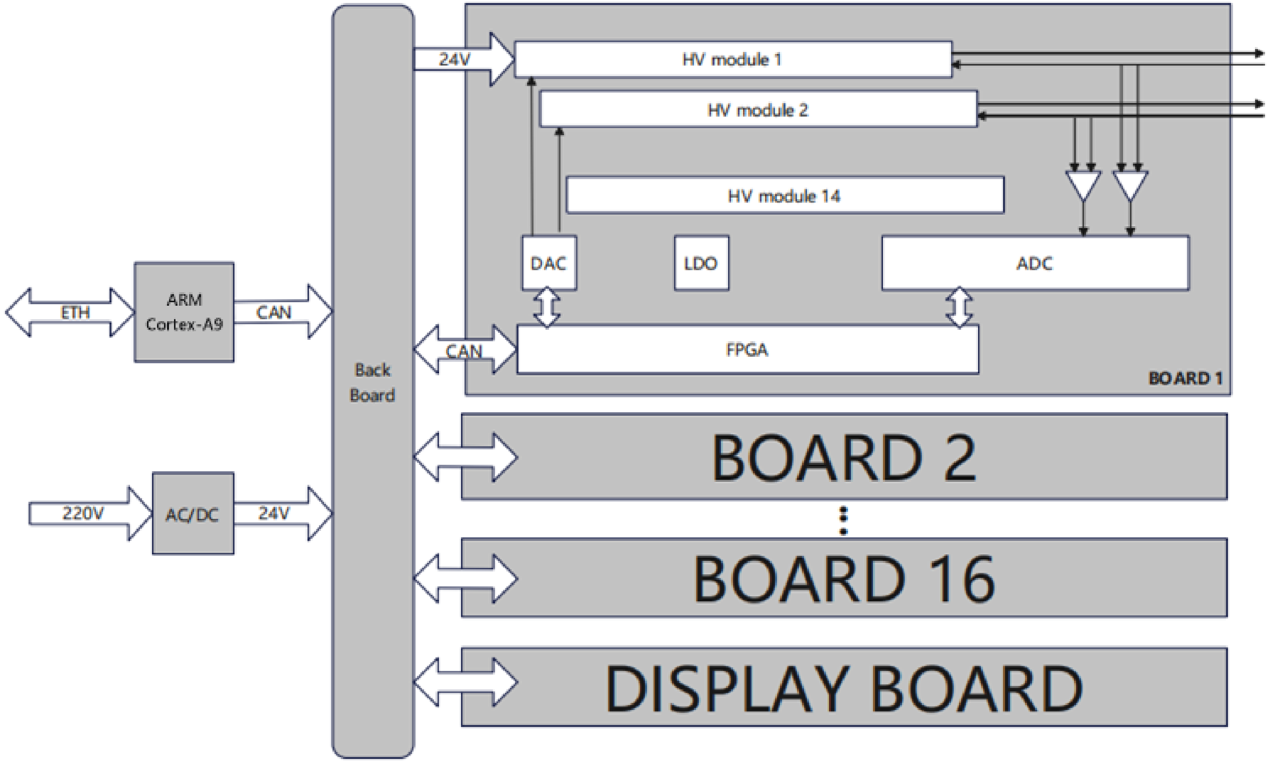
micrometer

The overall design of HV PS



- High Voltage power supply is to power each module with a separate individual floating HV channel, and the bias voltage of the sensors must be adjusted due to the gain degradation with the received fluence.
- **8512** channels in total will be required.

HV framework



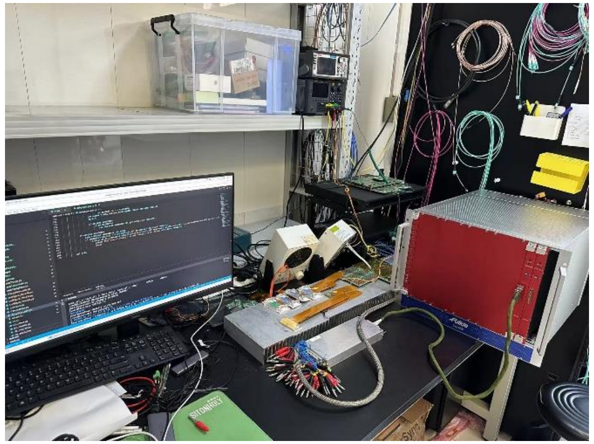
HV power supply

- One high voltage power supply has 16 HV modules. Each HV module has 14 HV channels.
- The crate is made of aluminum and each HV module can be removed and replaced.

HV prototype Test

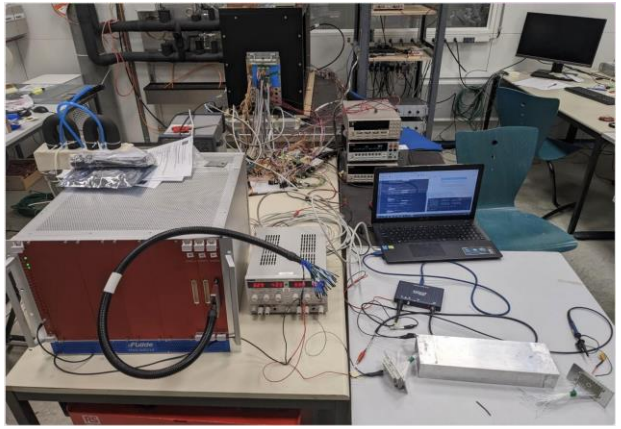
- After the PDR, we got two HV power supplies prototype with 3 modules. The supplies was tested in IHEP firstly. Then one HV prototype was sent to CERN.
- 1 **individual grounding HV PS crate** and two common grounding HV modules are **in IHEP**.

  1 common grounding HV PS crate and one individual grounding HV modules are **in CERN**.
- The two types of HV PS were tested with filter, PEB and sensor module.

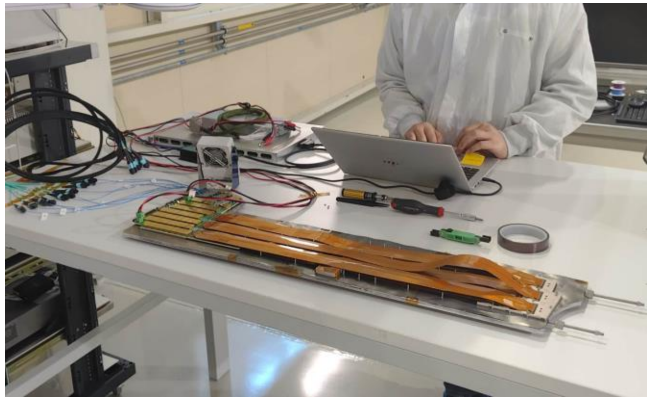


Individual crate

Common module



Common crate

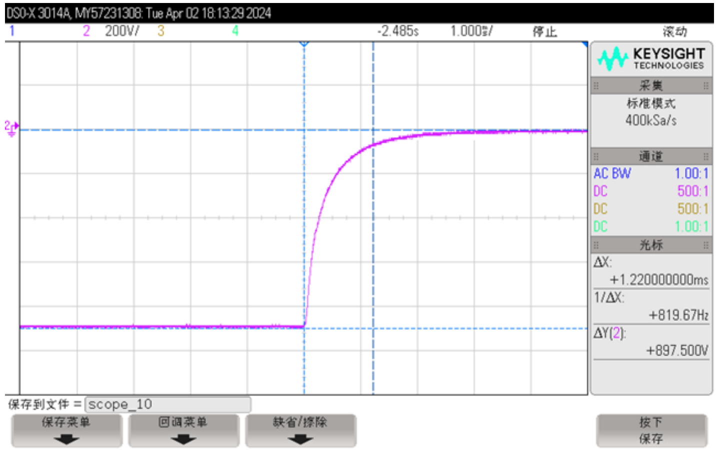


Individual module

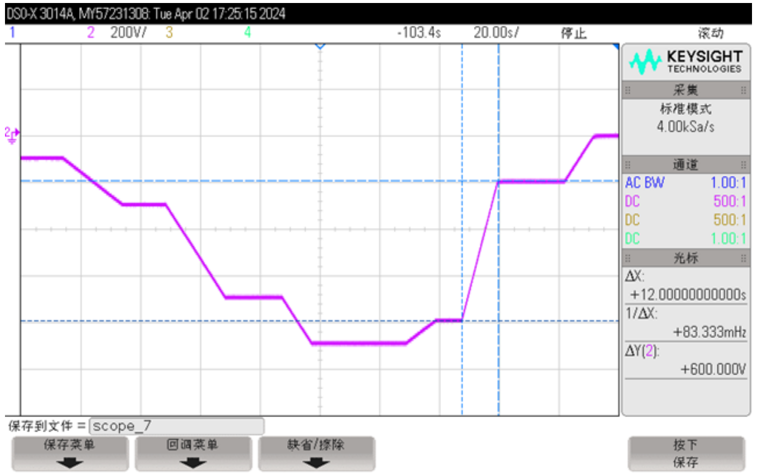
In IHEP

In CERN

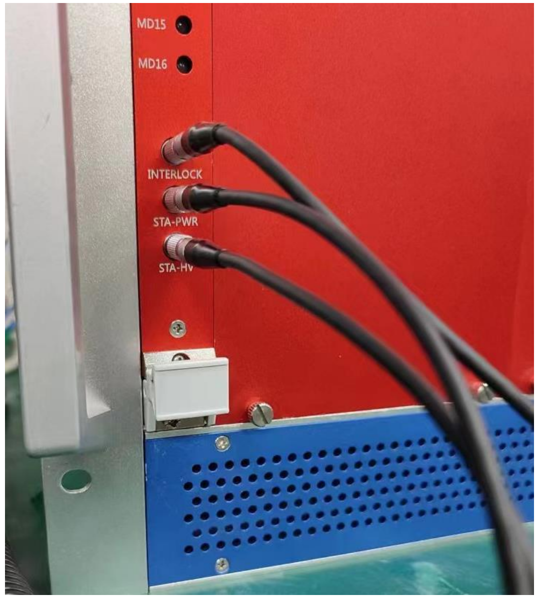
HV prototype Test in IHEP



Interlock



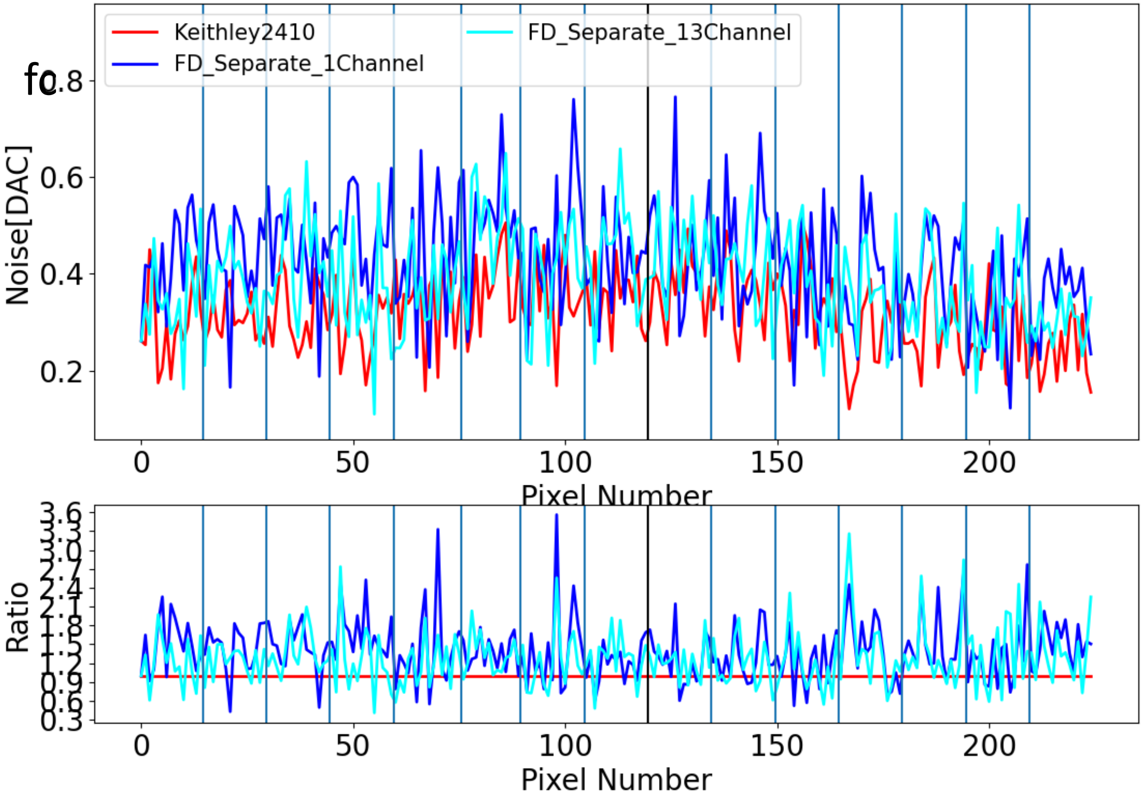
Ramp up/down



Interlock connector

- When interlock is 3.3V, the HV supply can be operated.
- After the high voltage loses the interlock signal, the time required to decrease from -900V to -50V is about 500us. About 1ms to -1V (without loading)
- Ramp up/down speed can be adjusted based on the requirements
- By testing, STA-PWR and STA-HV can correctly display the status of the device.

HV prototype Test in IHEP



1 sensor module is tested with HV PS and filter. Other 13 channels are running with resistors.(300K&3mA)
Nosie level is almost same compared with 2410.

HV power supply bidding result

- The bidding process for the high-voltage power supply project, involving IHEP and Shandong University, has been completed.
- The bidding result is showed on the China Government Procurement Network.

https://www.ccgp.gov.cn/cggg/zygg/zbgg/202501/t20250122_24105341.htm

http://www.cgw.sdu.edu.cn/zb/jggghwl/15849.chtml

- The contract was also finished.

Manpower in China

The HV manufacturer is producing PCB and the **first two crates will be ready in July**. Mass production will start once the two crates pass all the testings:

- 1, After the **Pre-production(2 crates)**, Shandong University students and IHEP will go to the HV company for Factory test.

- 2, During the **Mass production(38 crates),** 1~2 students from Shandong will go to Fullde four times and stay at the company for testing.

Manpower in CERN

- 1 After the Pre-production, the acceptance test is very important for the PRR. There will be module 0 testing. I believe a lot of person in IHEP and Shandong will go to test together.

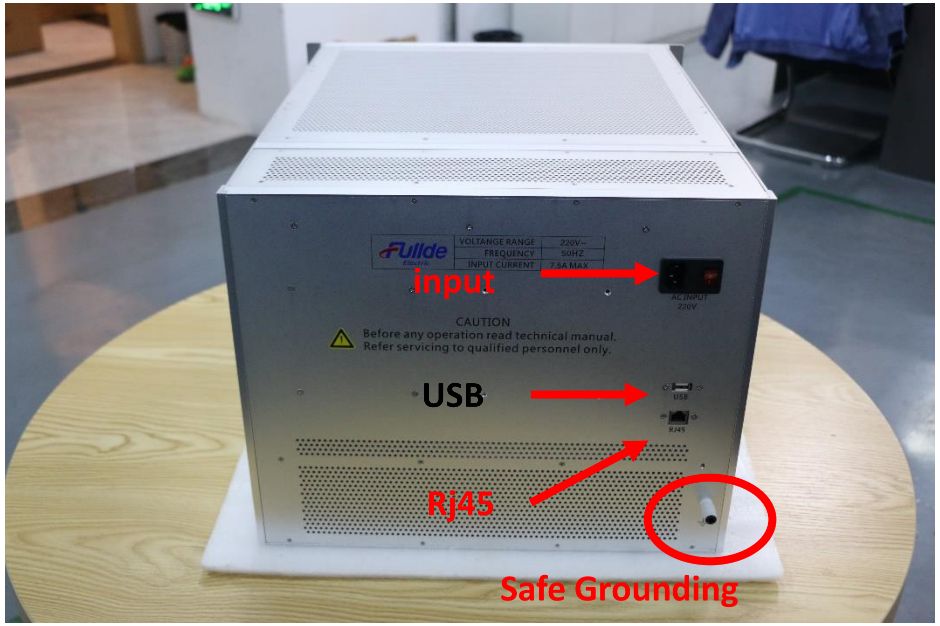
- 2 During the **Mass production,** 1 or 2 students from Shandong or IHEP will go to CERN four times to test HV PS together.

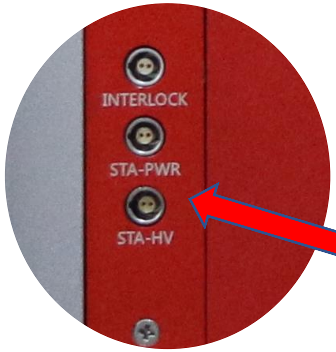
Training at IHEP

Thank you for your listening!

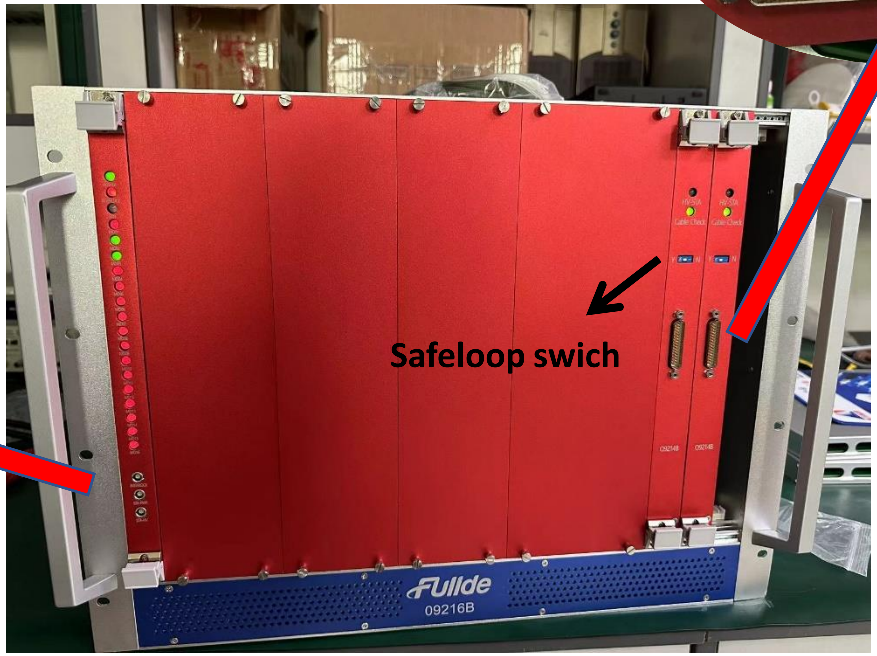
Backup

Function





Interlock interface
Lemo connector



HV connector

- Rj45 is used for communication. USB is used for updating the firmware.
- Each high-voltage connector has 16 pairs of pins. 14 pairs are used for high voltage output（HV/GND）. 1 pair of pins would be used safe loop.
- STA-PWR and STA-HV can show the status of the device by level signal.
- LED show the working condition.

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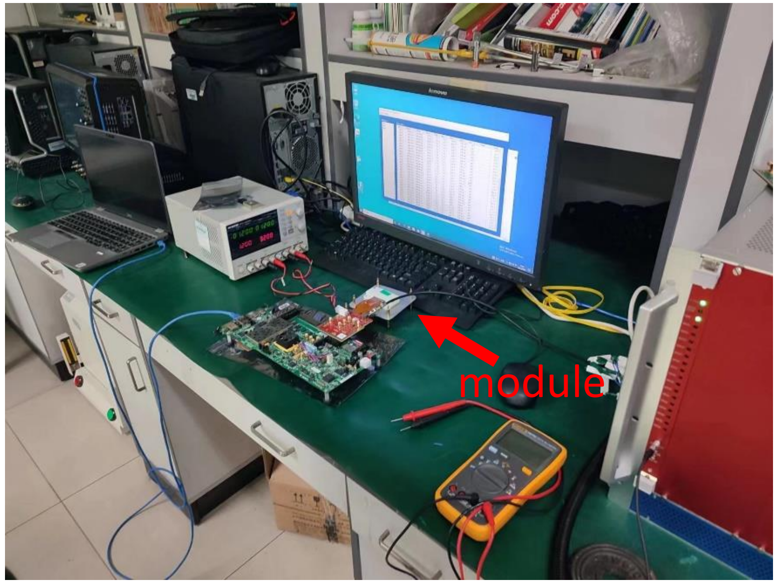
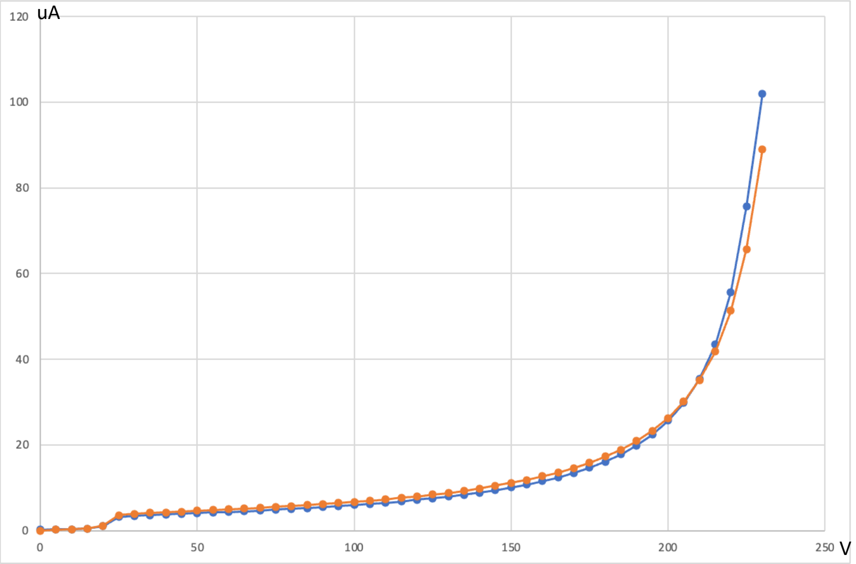
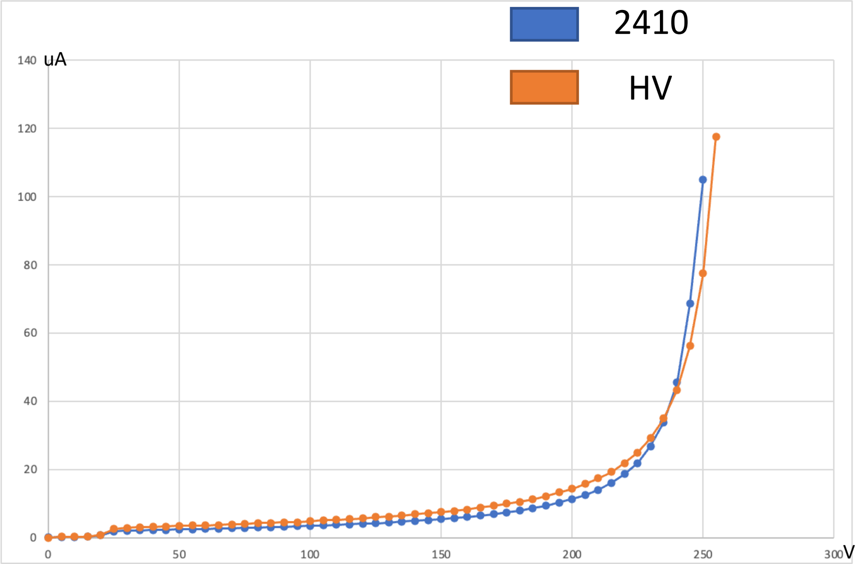
HV prototype Test in IHEP







Test Module #8 Module #9

- Test the IV characteristic curve of two real sensor modules(#8 and #9) with HV PS and Keithley 2410(1pA). The test results are also very similar.
- By comparing the results of the noise levels , there is no difference between the test results of 2410 and HV PS.

HV power supply bidding result

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http://www.cgw.sdu.edu.cn/zb/jggghwl/15849.chtml

- The contract was also finished.

	CHs	Cost for one channel	Total cost
IHEP	8174(mass-production)	876.4 RMB/channel	7163000.05RMB
Shandong University	448 （pre-production） + 338(mass-production)	876.7 RMB/channel	689141.8RMB
total	448(pre)+8512		7852141.85RMB=950887.27 CHF