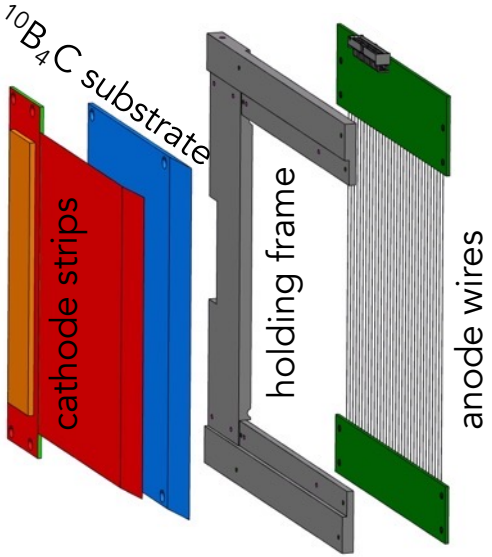
Multi-Blade detector project update

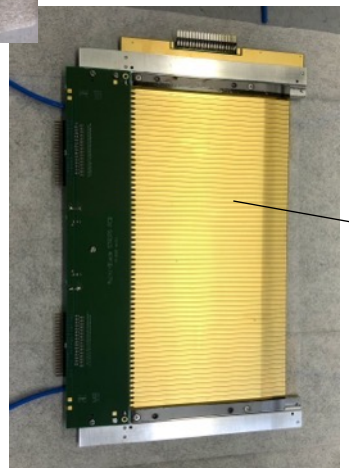
Francesco Piscitelli

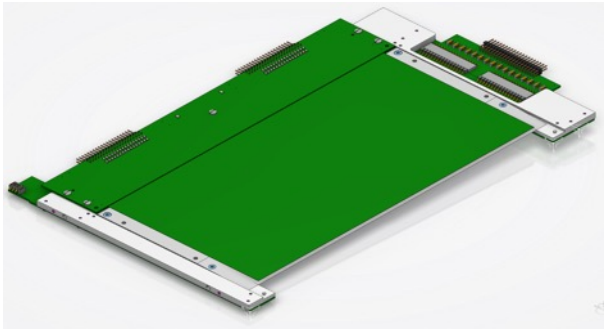
2023-09-19

Reflectometry STAP



A blade assembly (unit)

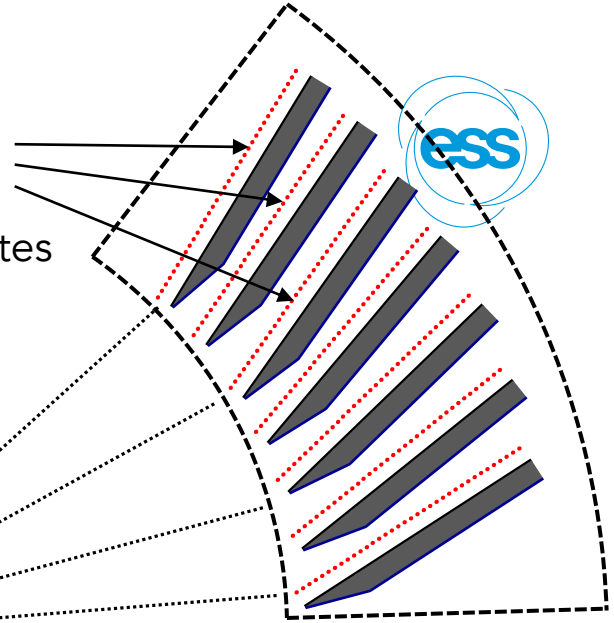




Multi–Blade

MB Detector is modular

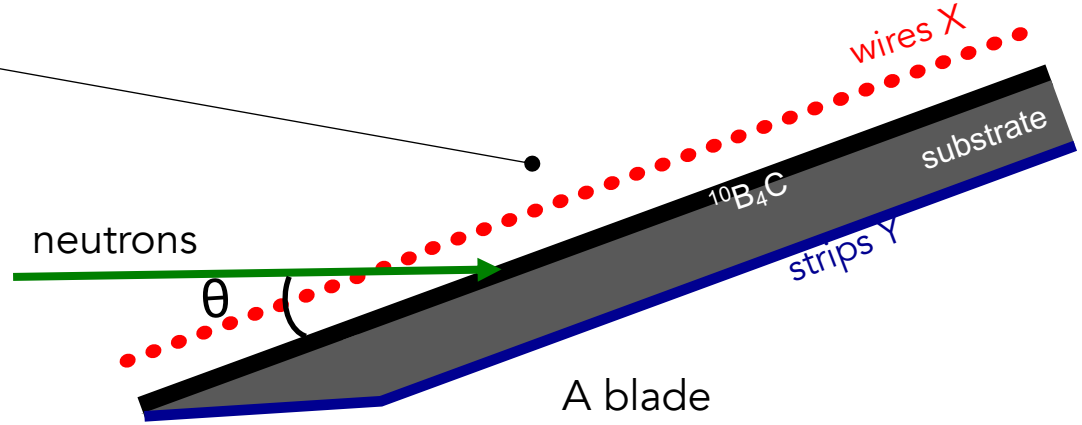
MWPC gaps are cassettes



Multi-Blade

neutrons

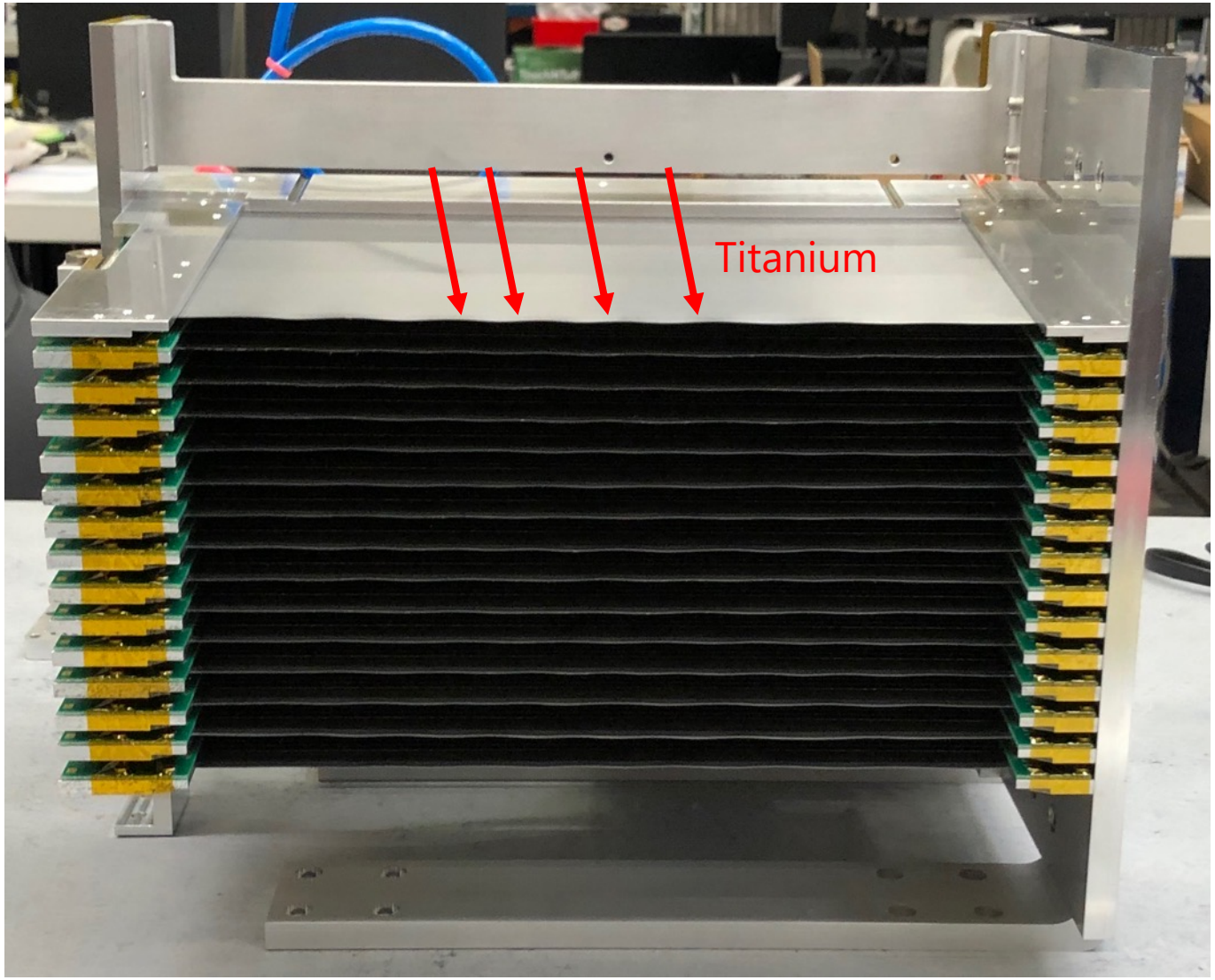
sample



θ = 5 degrees

A blade assembly (unit)

OCTOBER 2021 – AMOR (PSI) detector

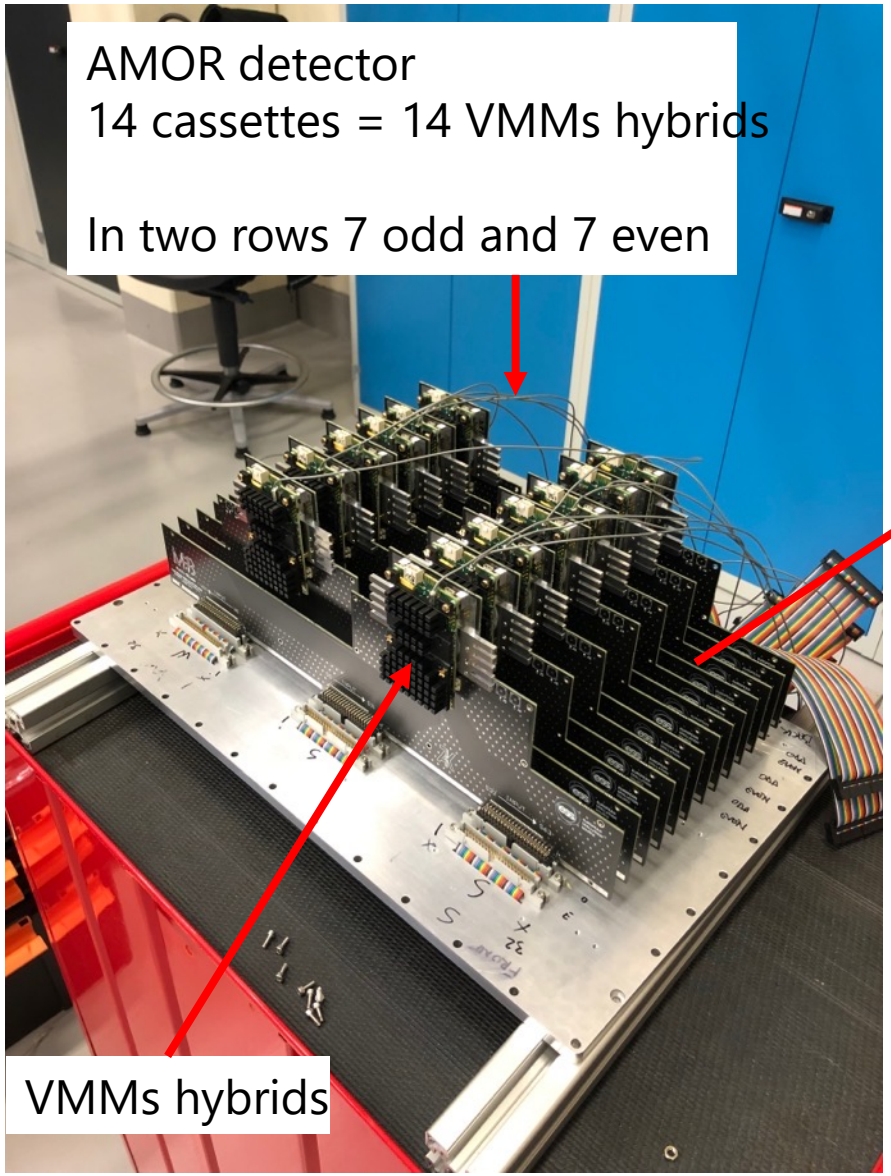


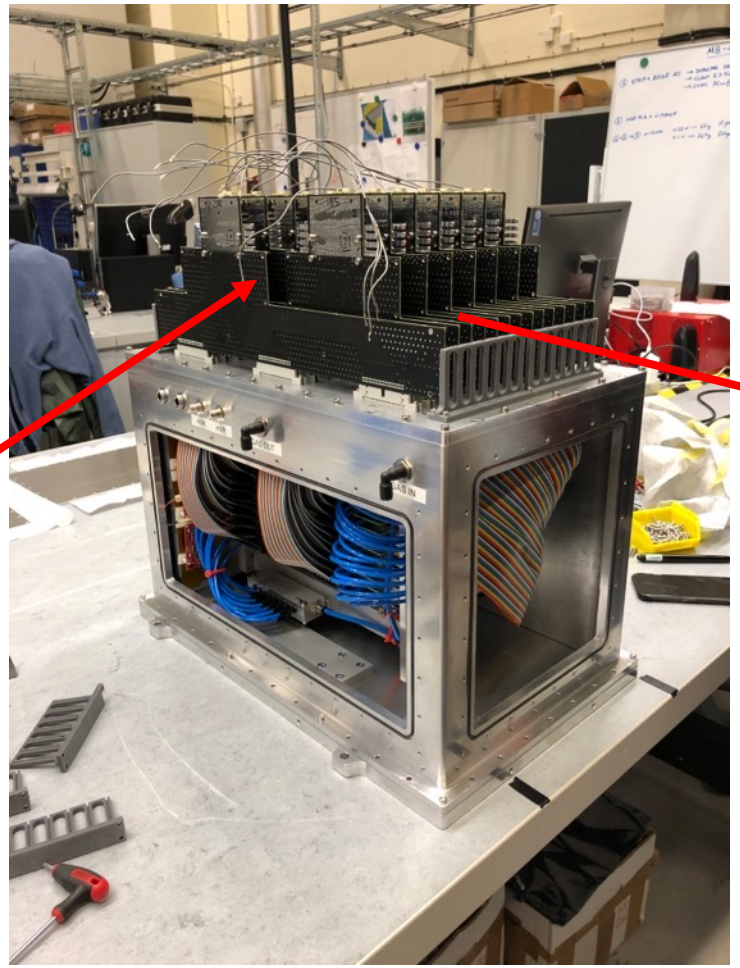
Either miss delivery or have
A wavy blade detector
We decided to continue and blades can be replaced later at any time

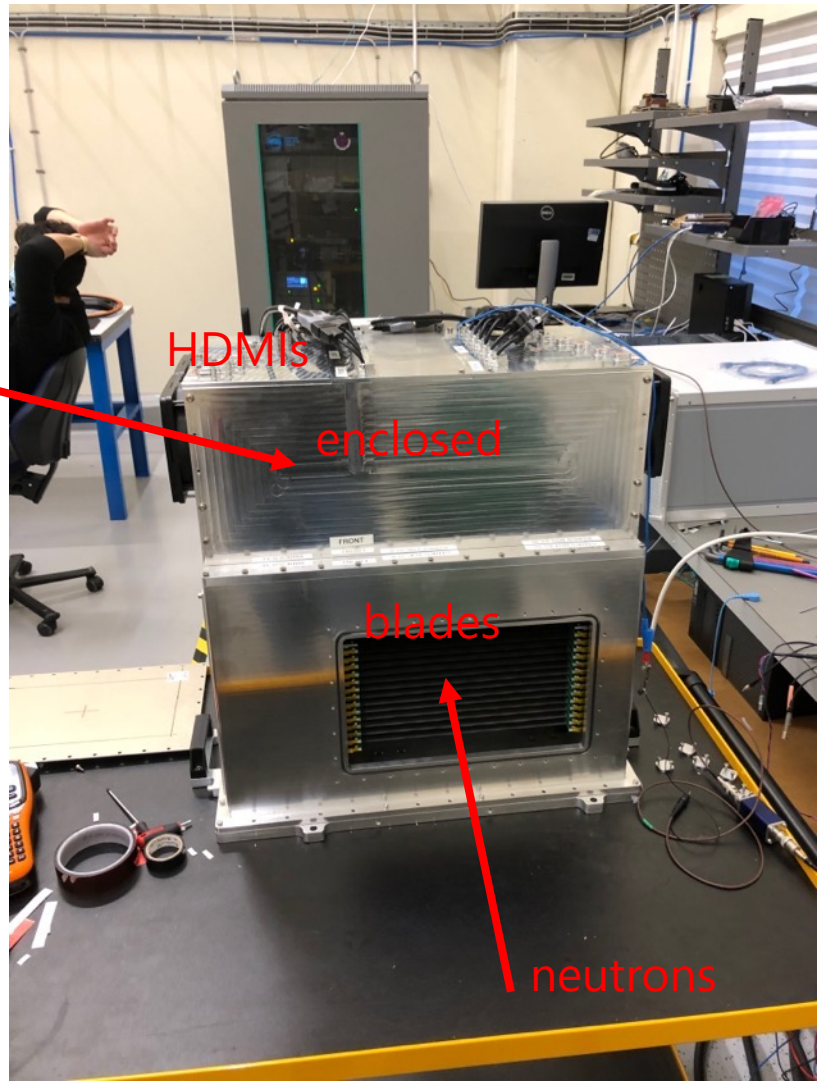
Multi-Blade @AMOR

14 UNIT DETECTOR FOR AMOR

VMM readout


AMOR detector
14 cassettes = 14 VMMs hybrids
In two rows 7 odd and 7 even
VMMs hybrids




HDMIs
enclosed
blades
neutrons

Previous Issues

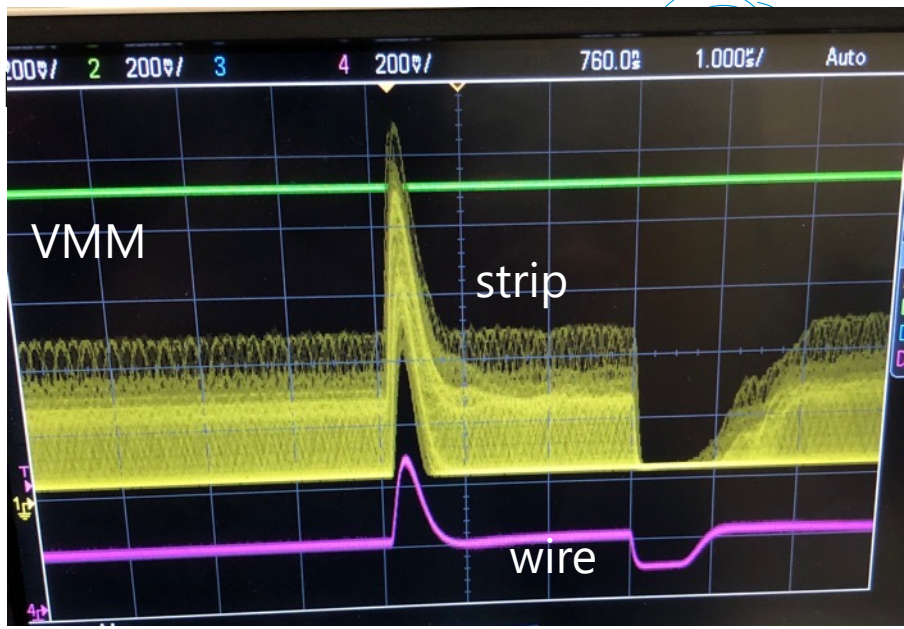
HV ON and COMMON FLOATING GND

As soon as HV is ON 1MHz osc on strips, amplitude proportional to the HV va

Wires look fine

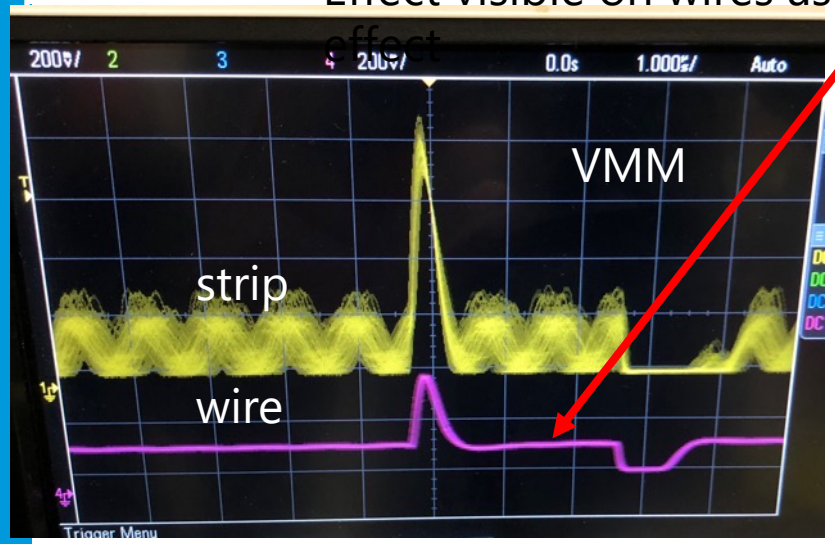
HV power supply CAEN NDT 1470

Common floating GND

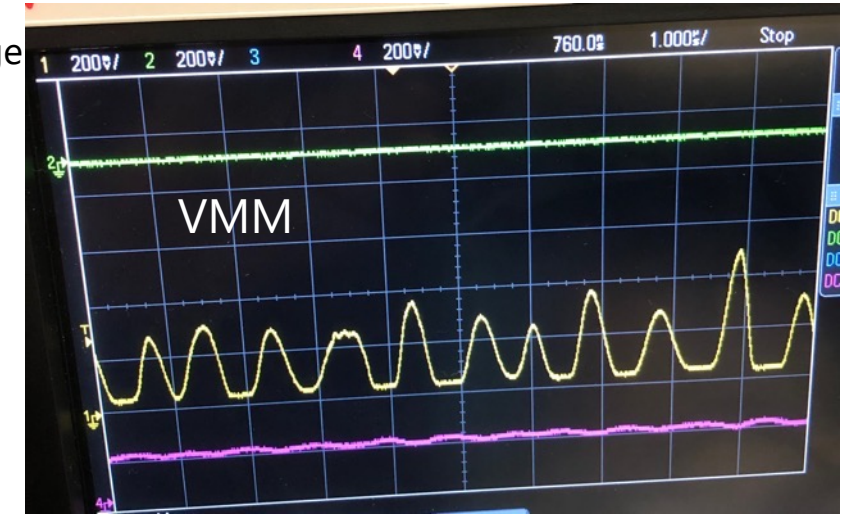


VMM hybrid

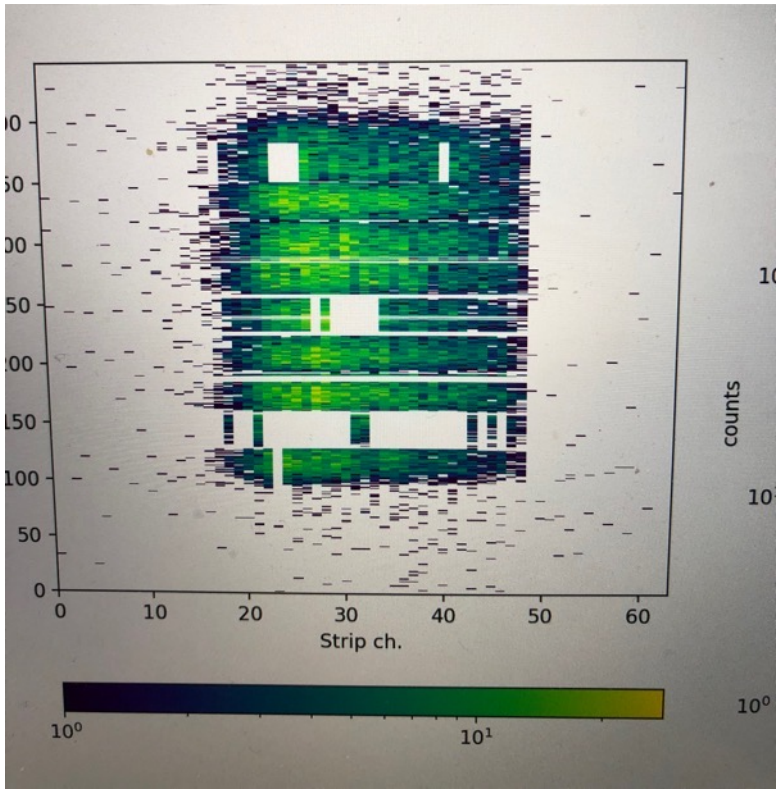
Effect visible on wires as well but parasitic capacitance is much smaller so smaller effect

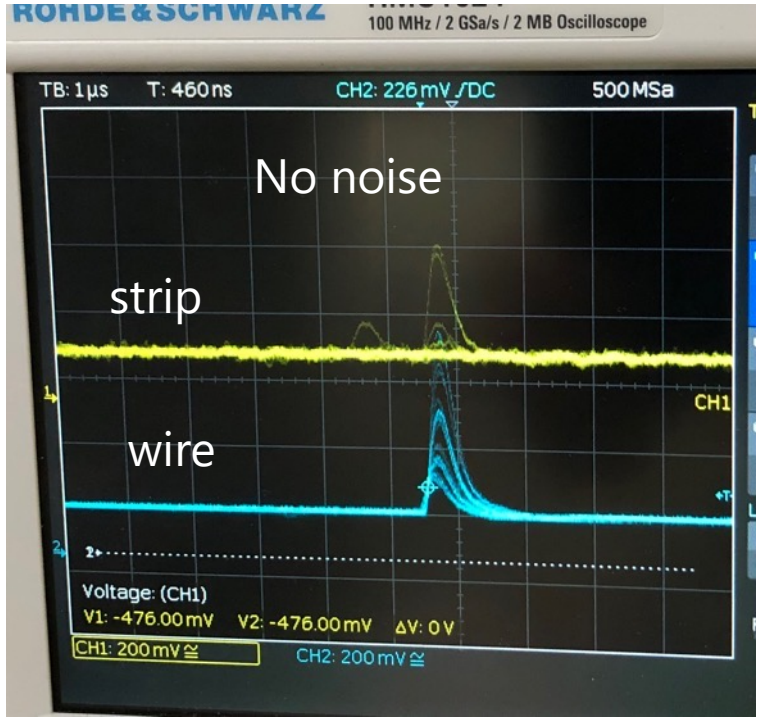


Analogue signal from VMM after preamp stage



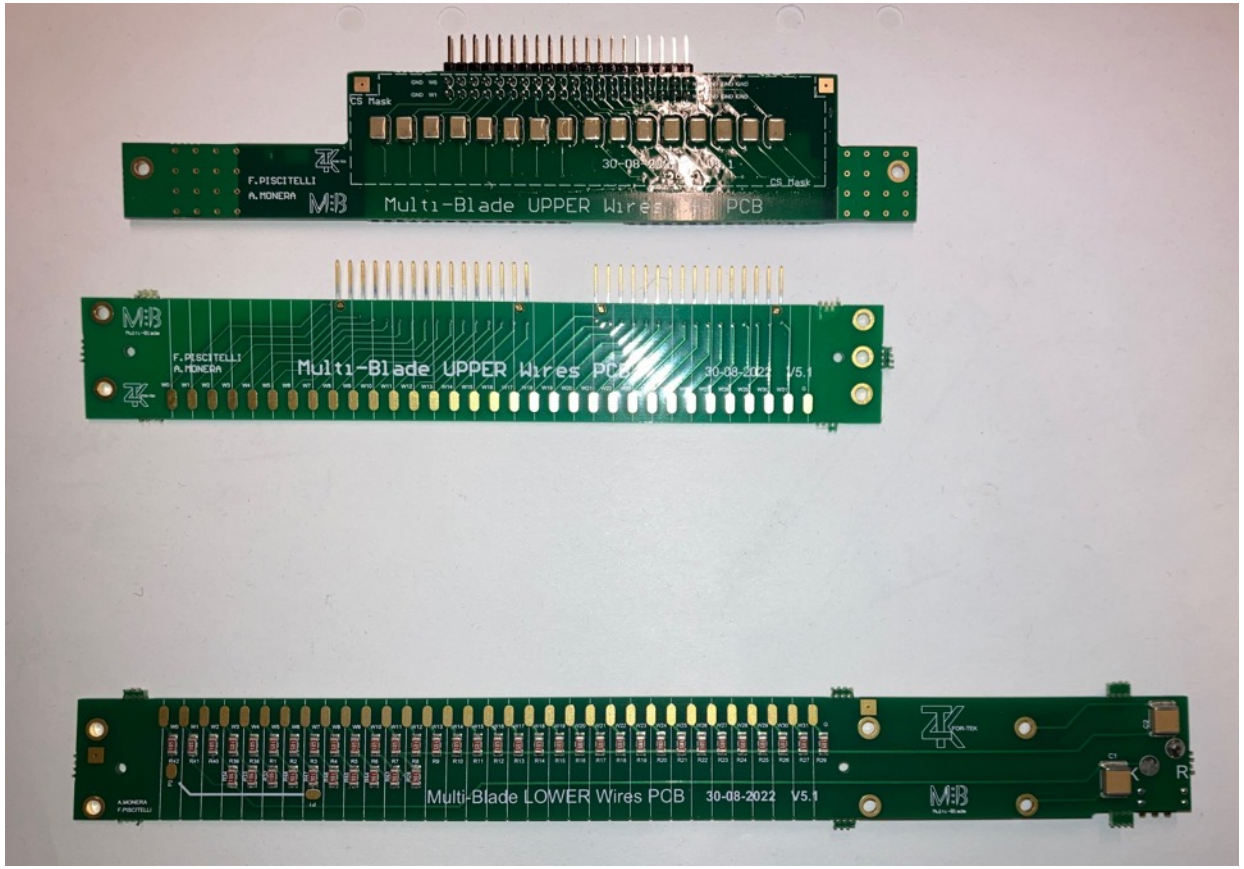
VMM readout



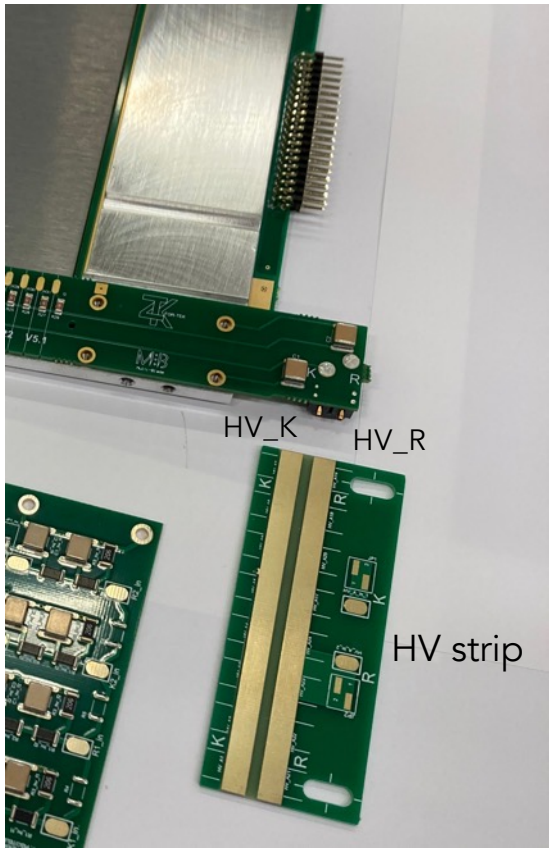


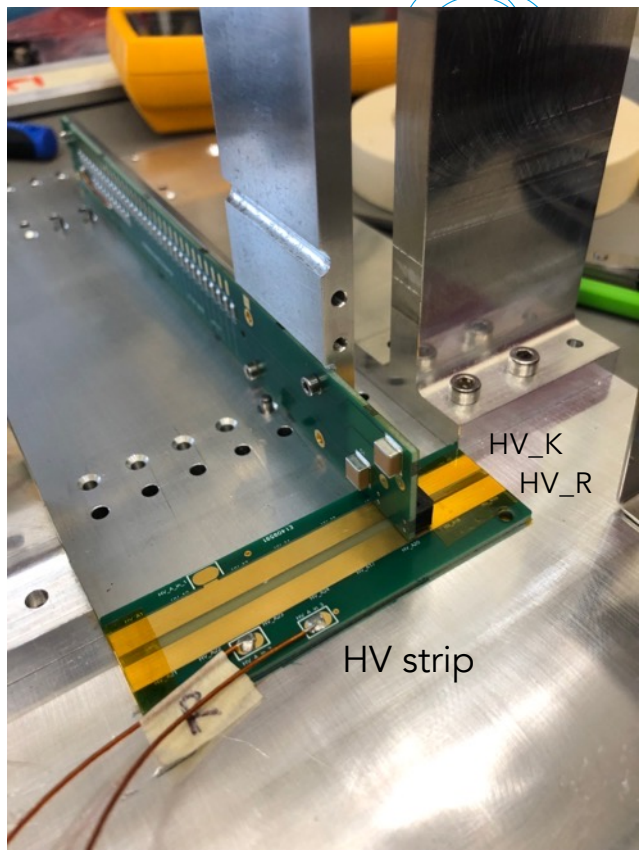
NOTE:
Direct beam on detector, missing pixels are due to changing noise over time.

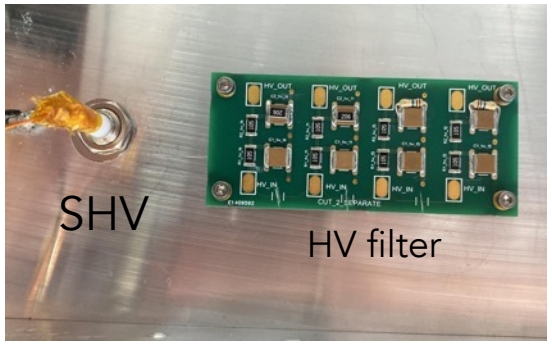
New circuitry

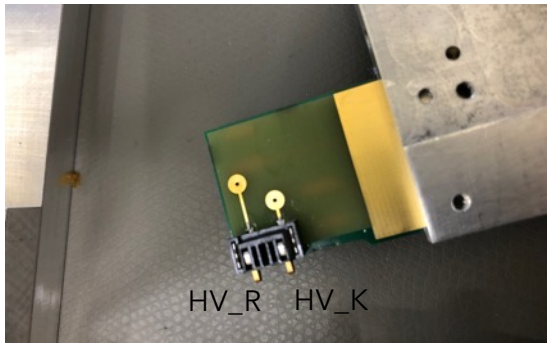


Improved filtering, HV distribution and noise



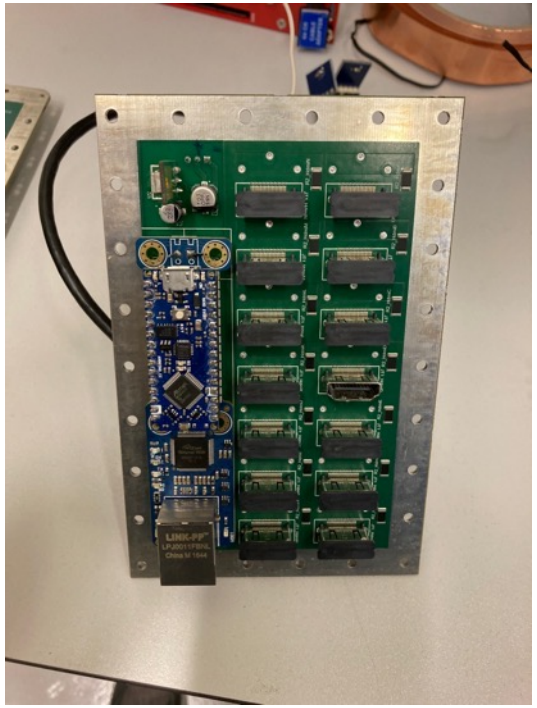


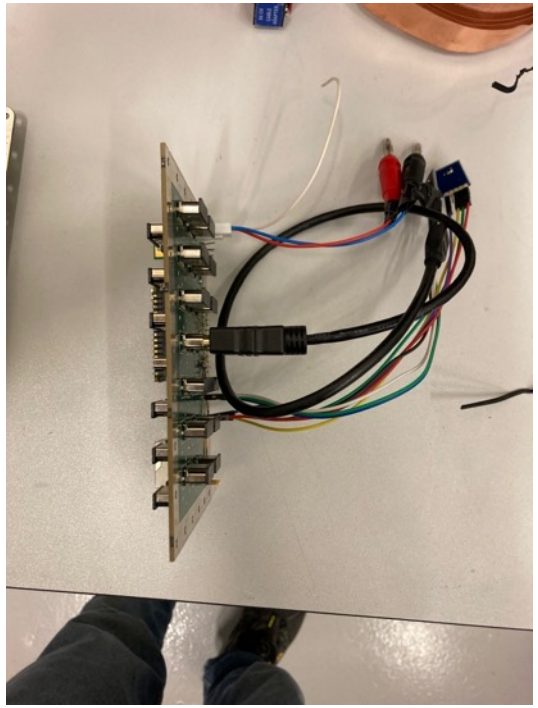


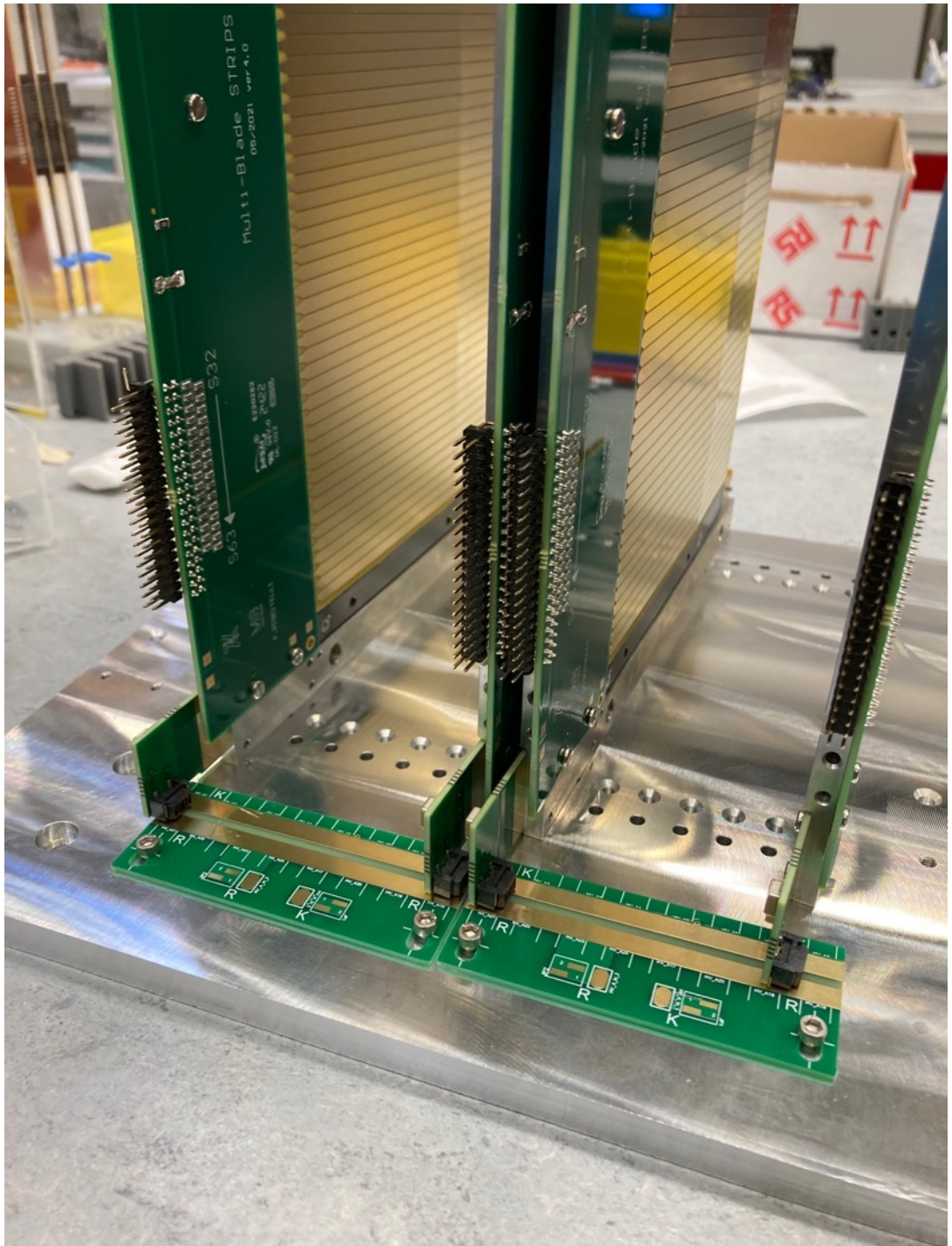


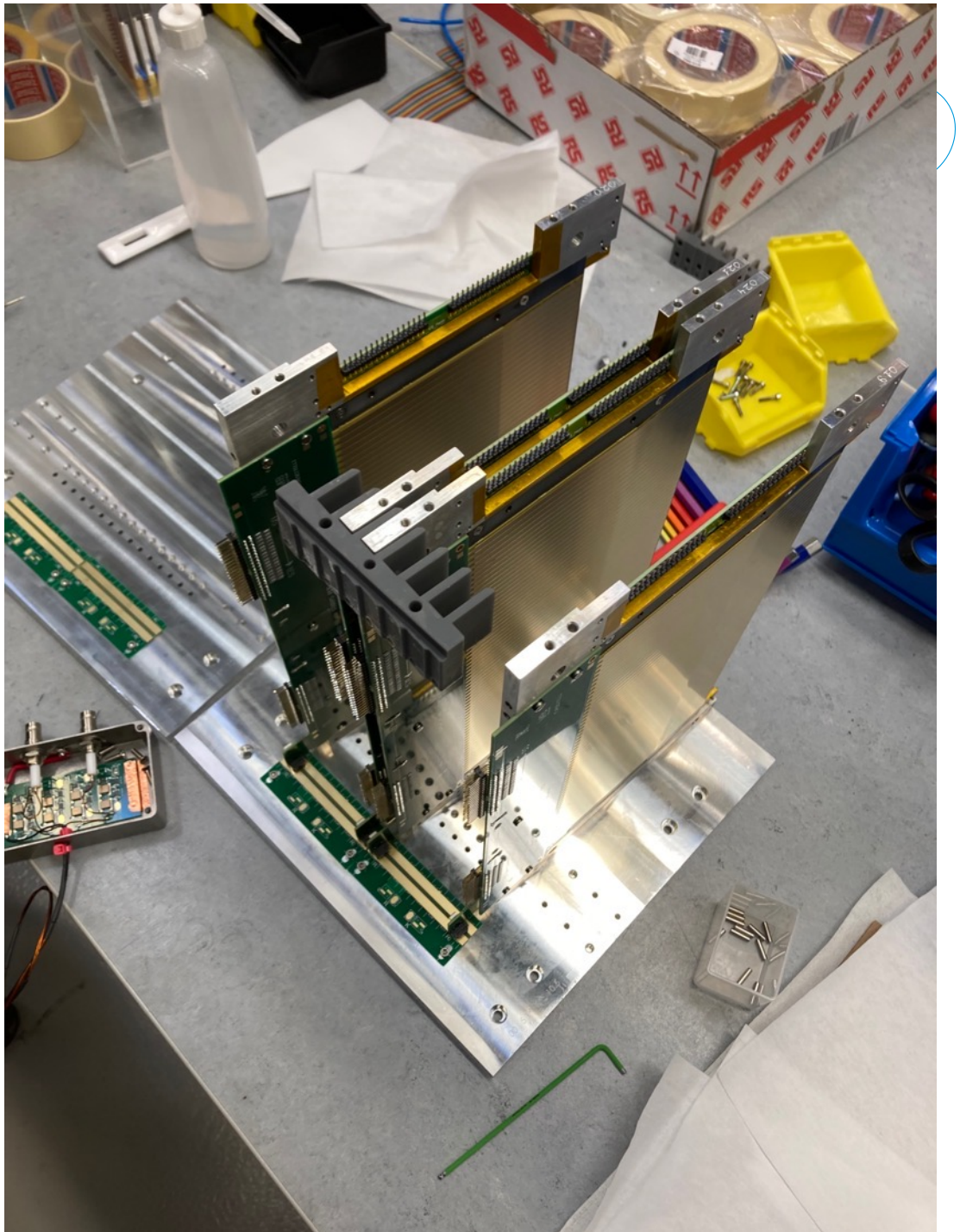
Previous Issues

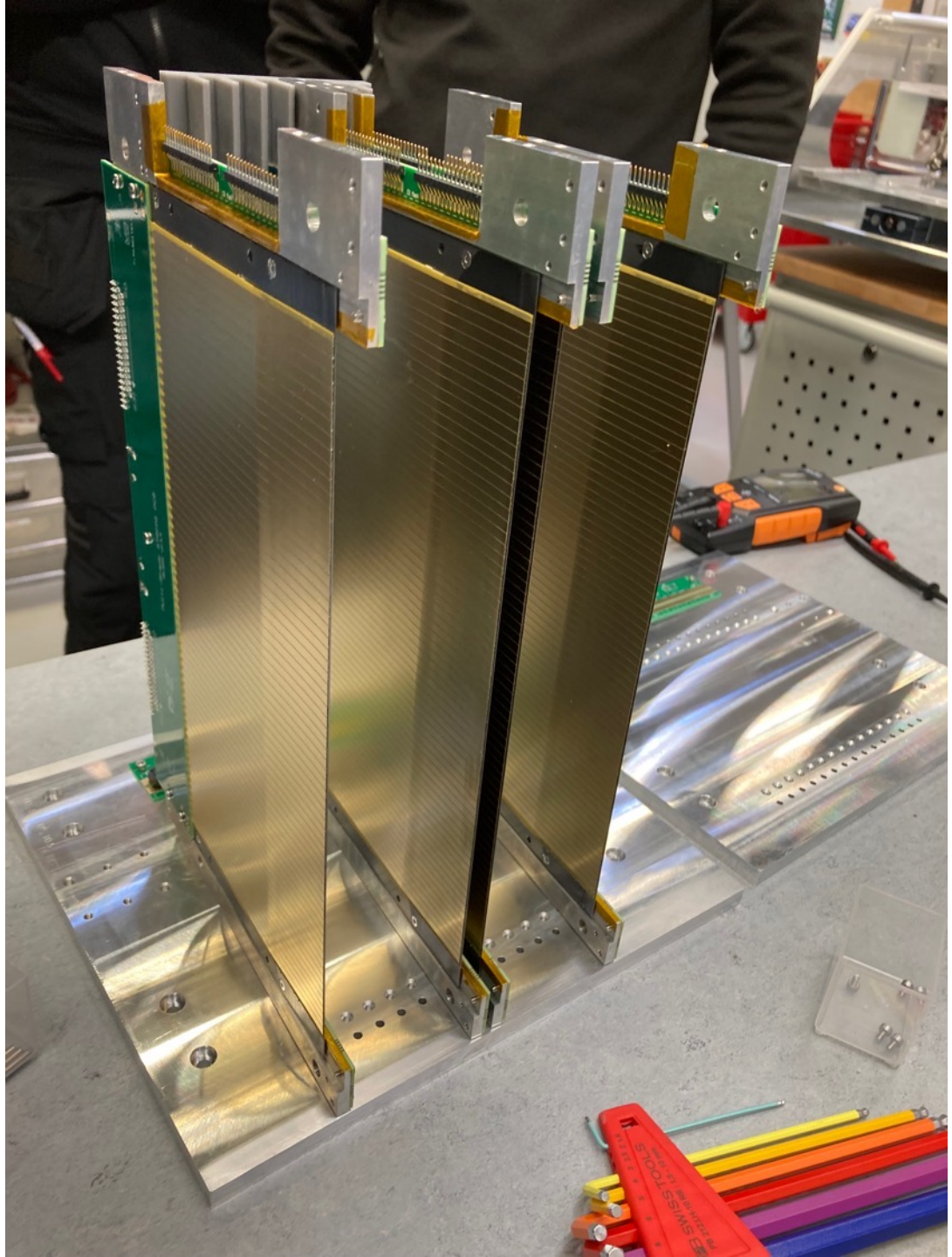
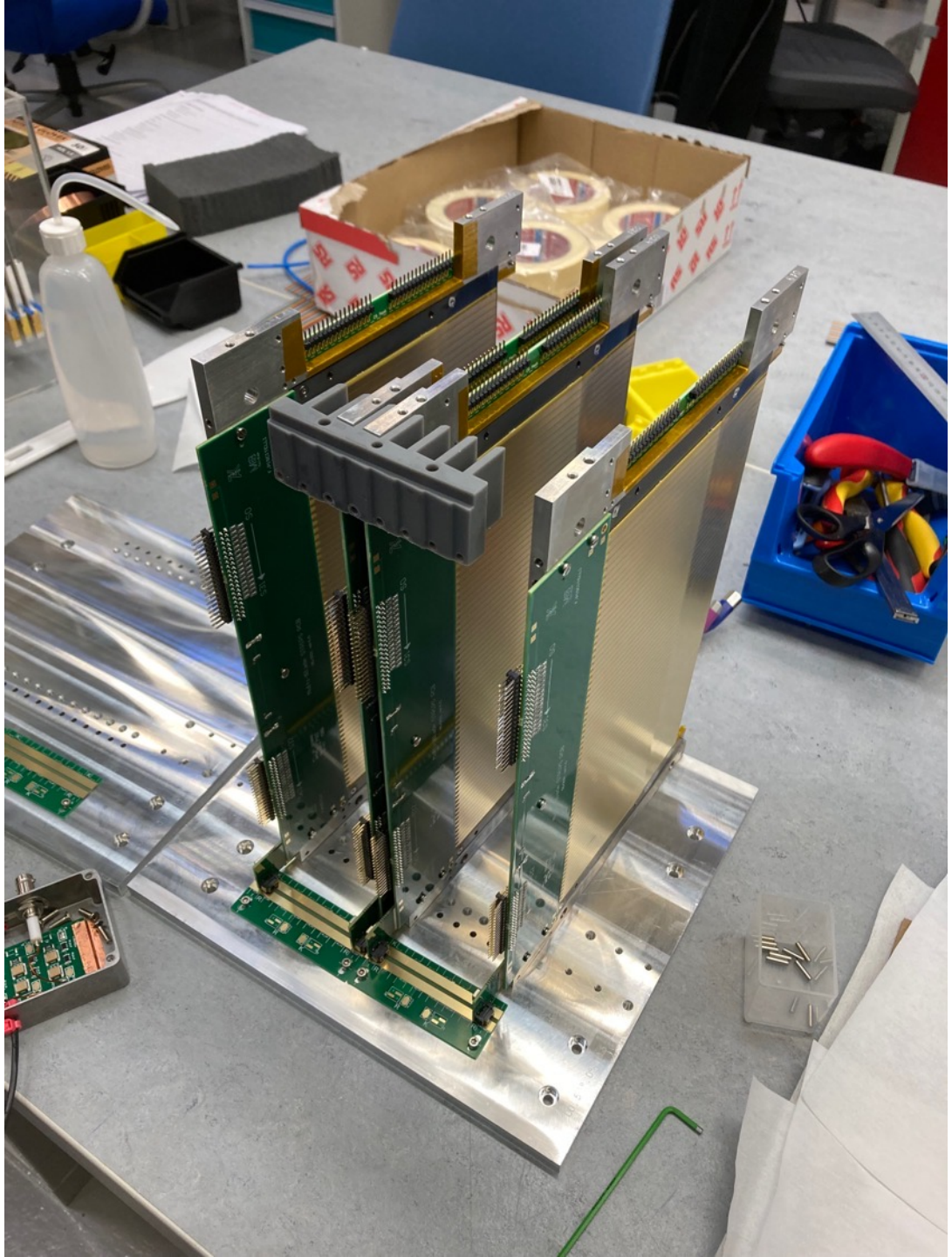
1. Strip channels disappearing → Due to GND instabilities, solved with new LV distrib
2. Wire channels damaged → Due to too poor protection circuit, solved with new protection
3. HV causes oscillations → GND filtering, new filter
4. HDMI GND causes instabilities → Due to shield of cable conencted to GND, solved with HDMI interface





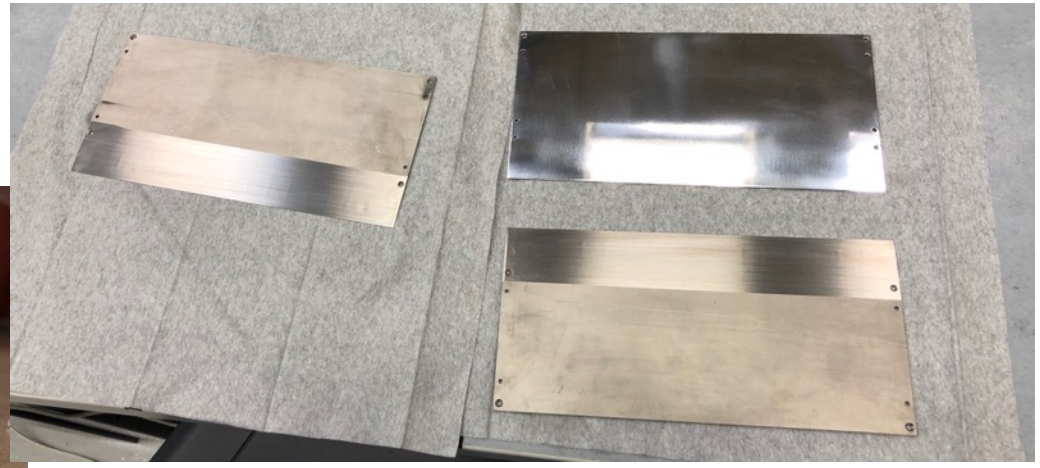

Multi-Blade STRIPS
S32
S63

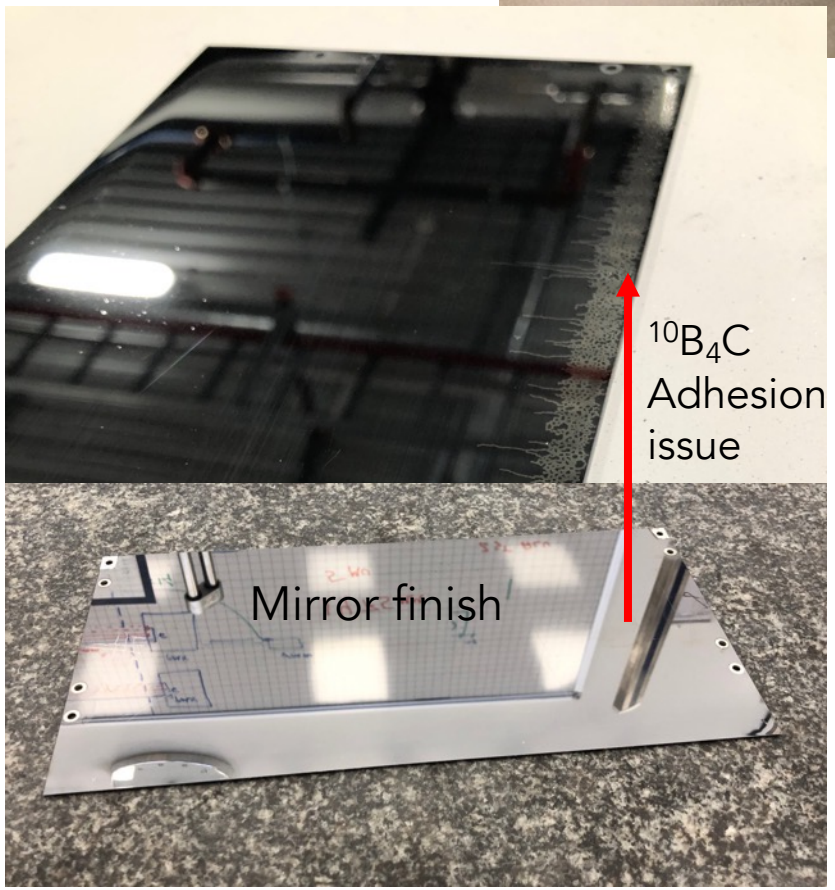


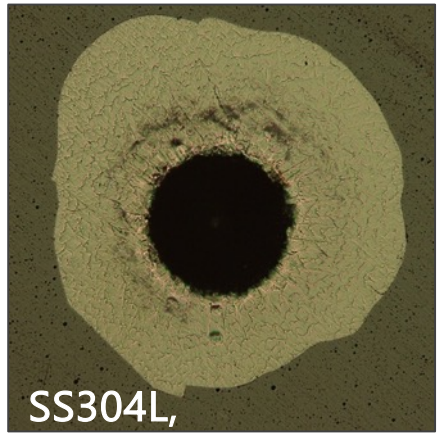
New blades

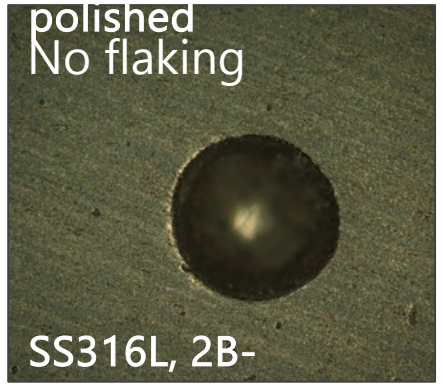
changed from Titanium to Stainless Steel, it has been tested and no issues on neutronic side





punch test



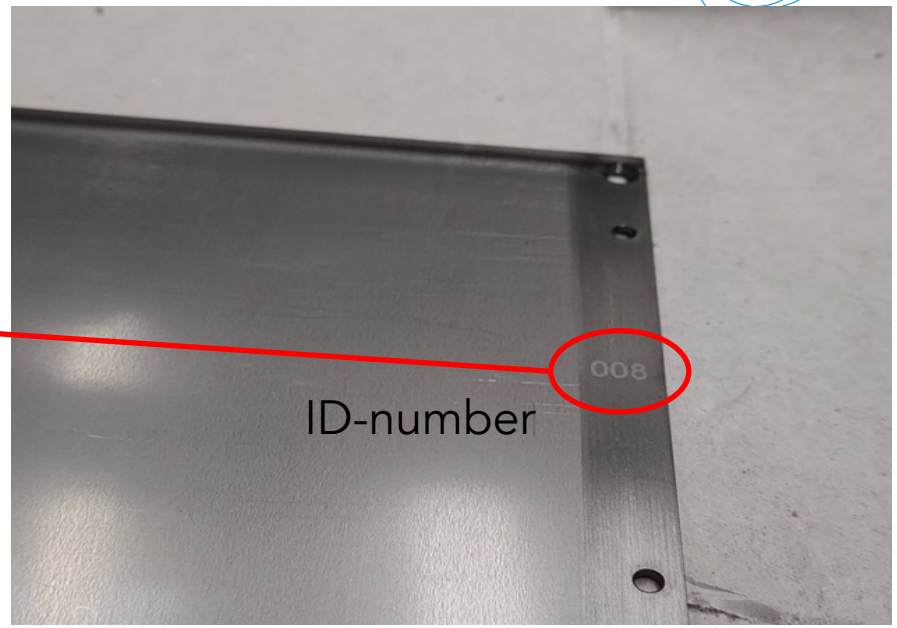


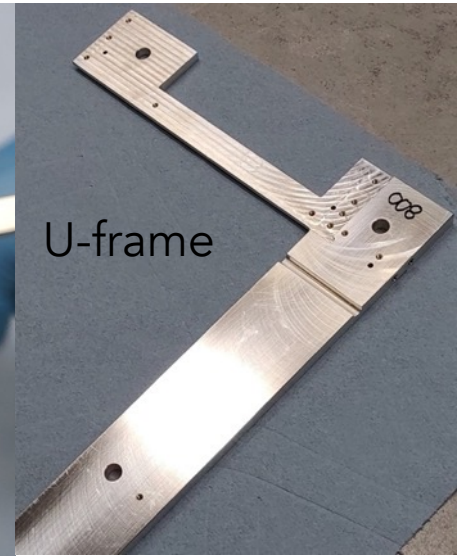
New blades

changed from Titanium to Stainless Steel, it has been tested and no issues on neutronic side

Measurement protocol: No. 1 - 55
Article no.: ESS-3422564.2
Material: Stainless steel EN 1.4307 - ESS
Flatness tolerance: 0,2 mm
Marked with etching.

Detail no.	Flatness after water cutting	Flatness after milling	the geom su	
1	Not checked	0,02	Co	
2	Not checked	0,03	Co	
3	Not checked	0,03	Cor	
4	Not checked	0,01	Cor	
5	Not checked	0,02	Co	
6	Not checked	0,03	Convex	2022-11-22
7	Not checked	0,14	Convex	2022-11-22
8	Not checked	0,01	Concave	2022-11-22
9	Not checked	0,02	Concave	2022-11-22
10	Not checked	0,22	Concave	2022-11-22
11	Not checked	0,05	Convex	2022-12-19
12	Not checked	0,05	Convex	2022-12-19
13	Not checked	0,08	Concave	2022-12-19
14	Not checked	0,04	Concave	2022-12-19
15	Not checked	0,09	Concave	2022-12-19
16	Not checked	0,07	Concave	2022-12-19
17	Not checked	0,03	Concave	2022-12-19
18	Not checked	0,08	Concave	2022-12-19





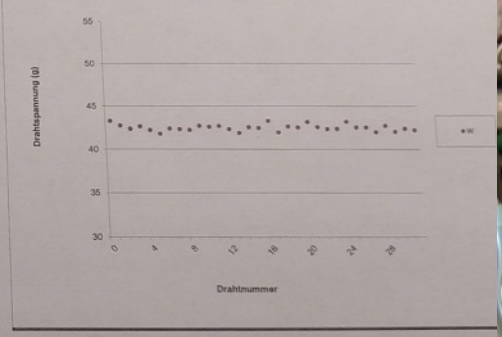
Wiring outsouced to CDT

Wire tension protocol blade by blade and traceability implemented

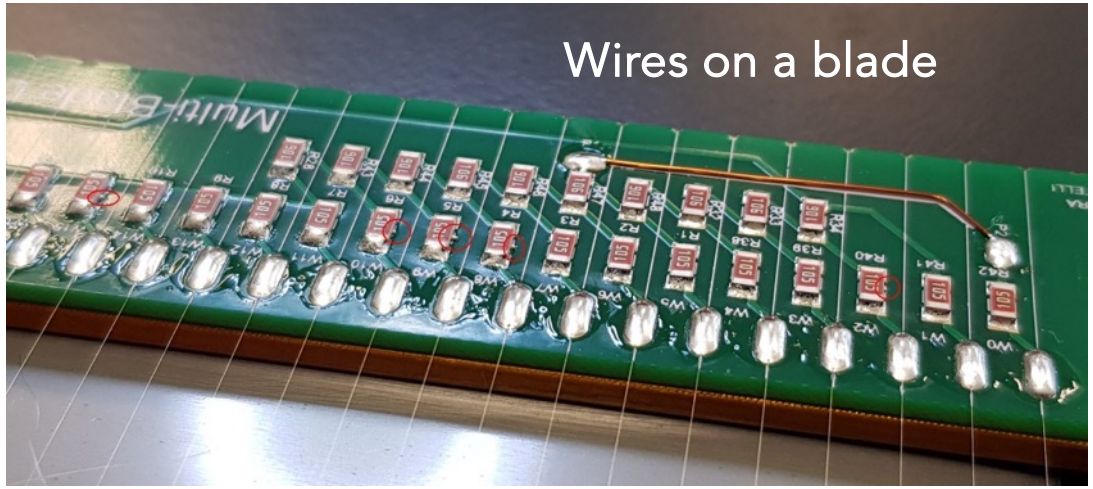
Bauteilnummer: MB-02 Rollennummer: 90758 Datum: 09.03.2023

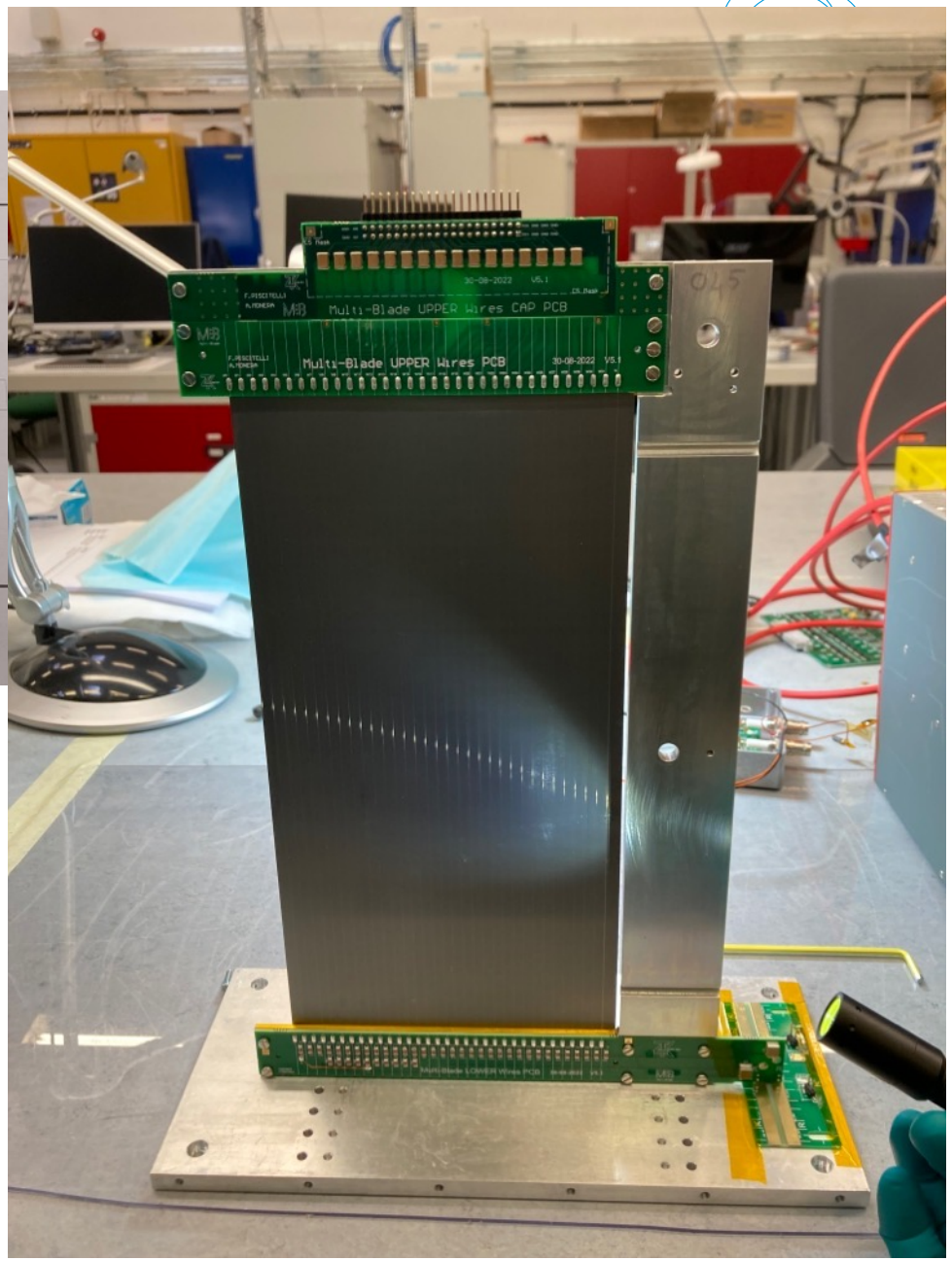
Drahtnummer	Drahtspannung [g]	Kontrolle	Drahtnummer	Drahtspannung [g]	Kontrolle
0	43,2943	ok	17	41,9608	ok
1	42,7609	ok	18	42,6499	ok
2	42,3611	ok	19	42,5389	ok
3	42,6499	ok	20	43,1833	ok
4	42,2275	ok	21	42,5831	ok
5	41,8056	ok	22	42,3611	ok
6	42,4058	ok	23	42,3832	ok
7	42,339	ok	24	43,2054	ok
8	42,2501	ok	25	42,561	ok
9	42,7167	ok	26	42,561	ok
10	42,6057	ok	27	42,0055	ok
11	42,6946	ok	28	42,7609	ok
12	42,339	ok	29	42,0497	ok
13	41,8945	ok	30	42,4053	ok
14	42,561	ok	31	42,2275	ok
15	42,4721	ok			
16	43,2943	ok	G	249,55	ok

Diagramm

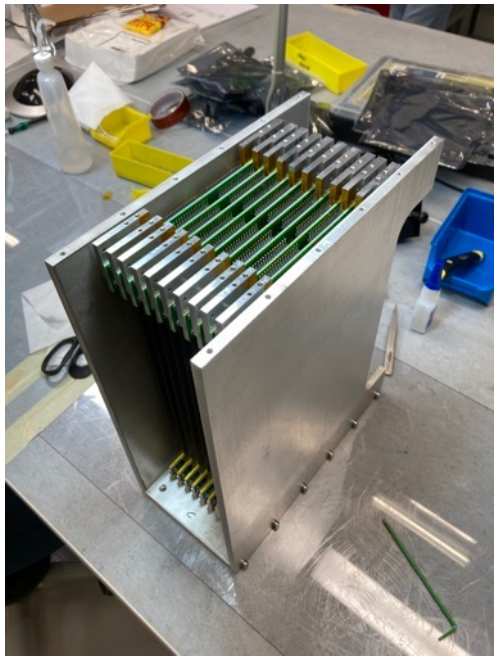


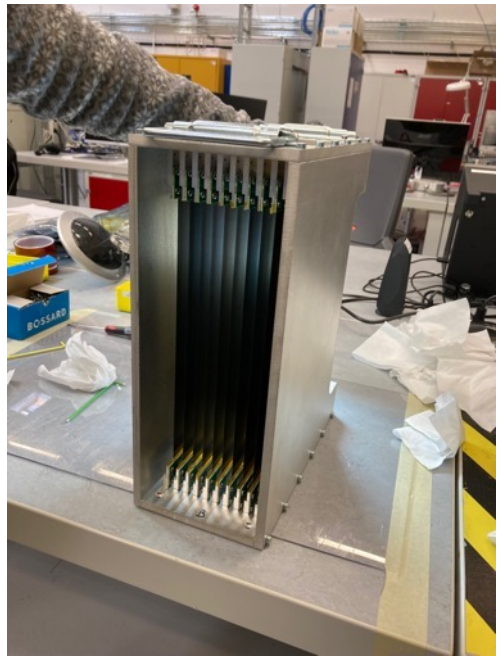
Fehler: 0
OK`s: 33



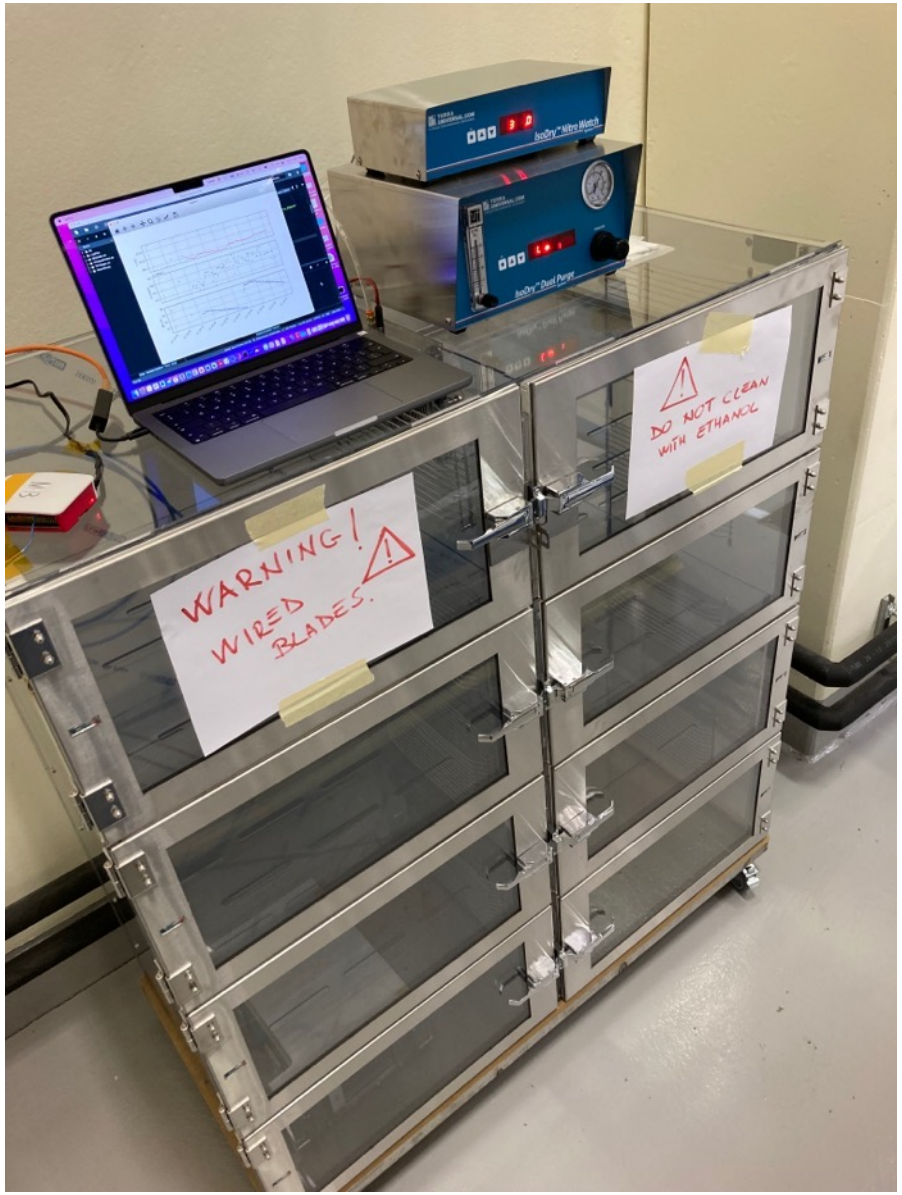


Production of 140 units and storage





Transported and stored in CABs (10 blades each)



Blades kept in Nitrogen atmosphere
Controlled via raspberry pi

Production of 140 units and storage

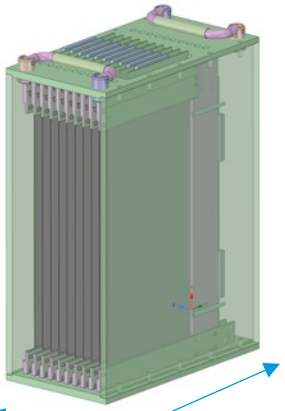
Shipment: this box can contain up to 3 CABS

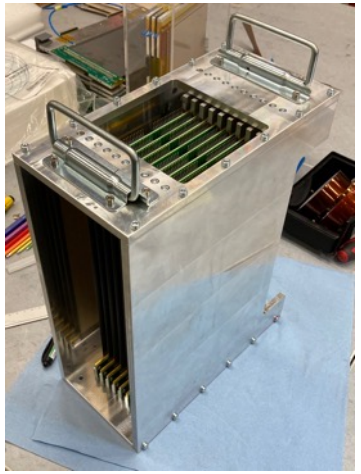
Shipment

Storage

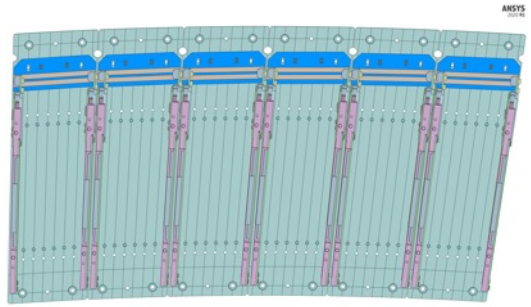
Storage under dry atmosphere N2

Cell Array Block (CAB)



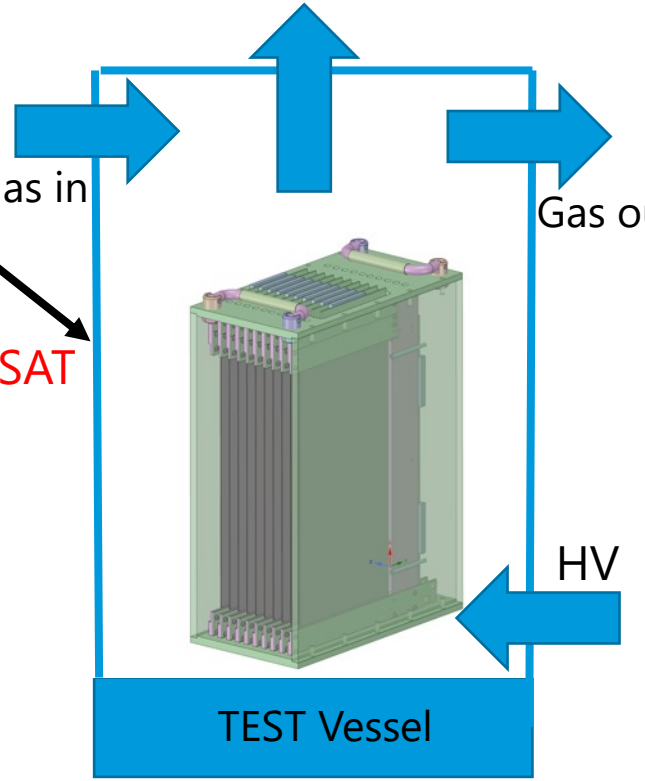


Containts/store 10 blades



Assembly into detector/sectors

Testing/SAT

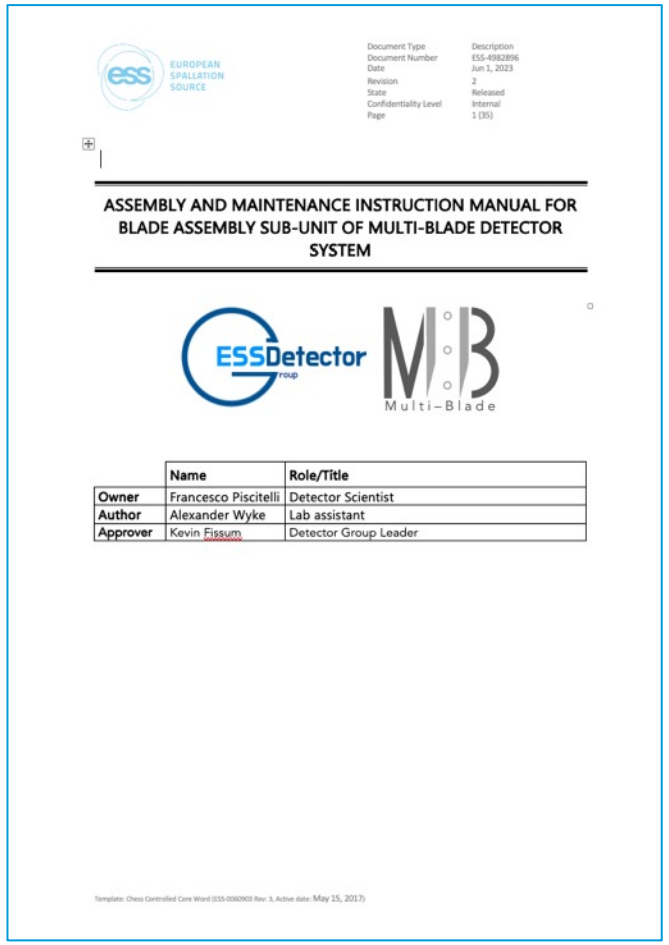


Latched box with feed-through and HV connection for testing with neutrons

Production of 140 units and storage

141 blades are ready to be tested and installed in detectors -> ESTIA (49), FREIA (33), TBL (15), AMOR (15)

CDRs are on-going



EUROPEAN SPALLATION SOURCE

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Confidentiality Level	Internal
Page	1 (35)

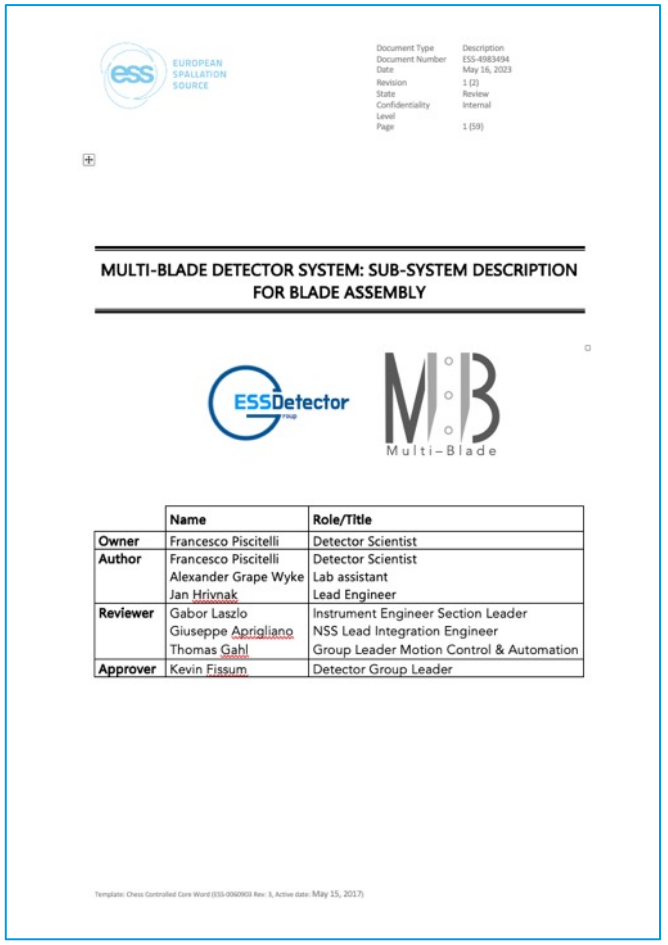
ASSEMBLY AND MAINTENANCE INSTRUCTION MANUAL FOR BLADE ASSEMBLY SUB-UNIT OF MULTI-BLADE DETECTOR SYSTEM

ESSDetector group

Multi-Blade

	Name	Role/Title
Owner	Francesco Piscitelli	Detector Scientist
Author	Alexander Wyke	Lab assistant
Approver	Kevin Fissum	Detector Group Leader

Template: Chess Controlled Core Word (ESS-0060903 Rev: 3, Active date: May 15, 2017)



EUROPEAN SPALLATION SOURCE

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Date	May 16, 2023
Revision	1 (2)
State	Review
Confidentiality Level	Internal
Page	1 (59)

MULTI-BLADE DETECTOR SYSTEM: SUB-SYSTEM DESCRIPTION FOR BLADE ASSEMBLY

ESSDetector group

Multi-Blade

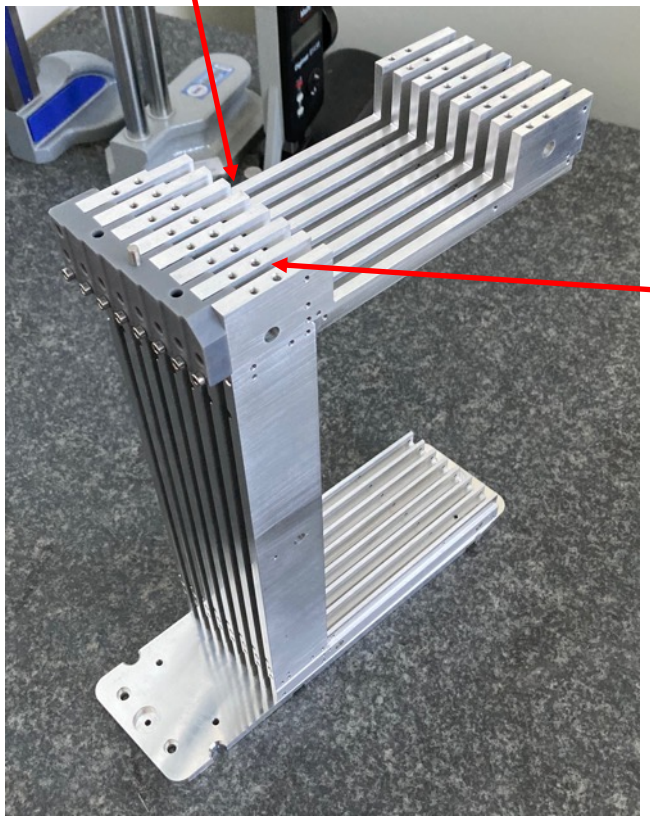
	Name	Role/Title
Owner	Francesco Piscitelli	Detector Scientist
Author	Francesco Piscitelli	Detector Scientist
	Alexander Grape Wyke	Lab assistant
	Jan Hrivnak	Lead Engineer
Reviewer	Gabor Laszlo	Instrument Engineer Section Leader
	Giuseppe Aprigliano	NSS Lead Integration Engineer
	Thomas Gahl	Group Leader Motion Control & Automation
Approver	Kevin Fissum	Detector Group Leader

Template: Chess Controlled Core Word (ESS-0060903 Rev: 3, Active date: May 15, 2017)

Multi-Blade desing is finished for AMOR and TBL, ESTIA almost done

- ESTIA and TBL detector internal mechanics under production
- First sector for ESTIA detector produced in Utgard

ESTIA detector has 48 blades but for maintenance reasons it is split into 6 sector of 8 blades.



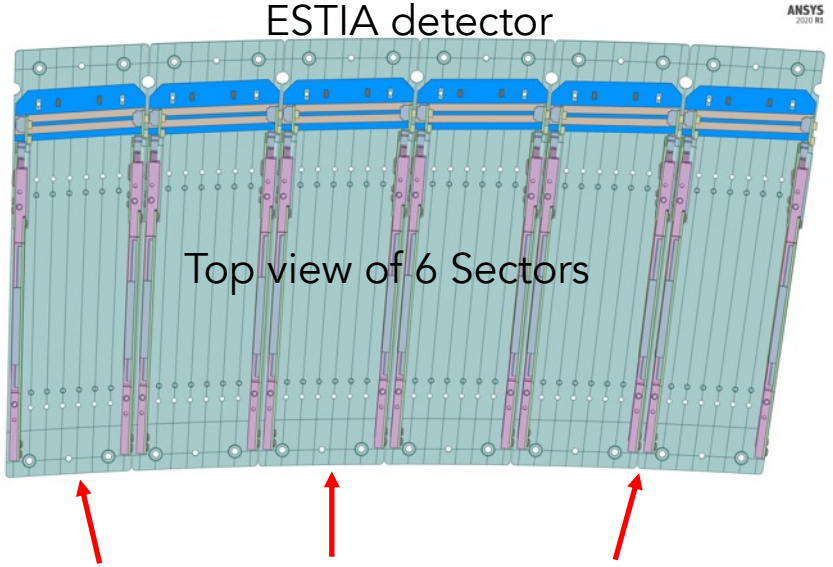
One ESTIA sector holding 8 frames

Sectors are electrically and mechanically independent.

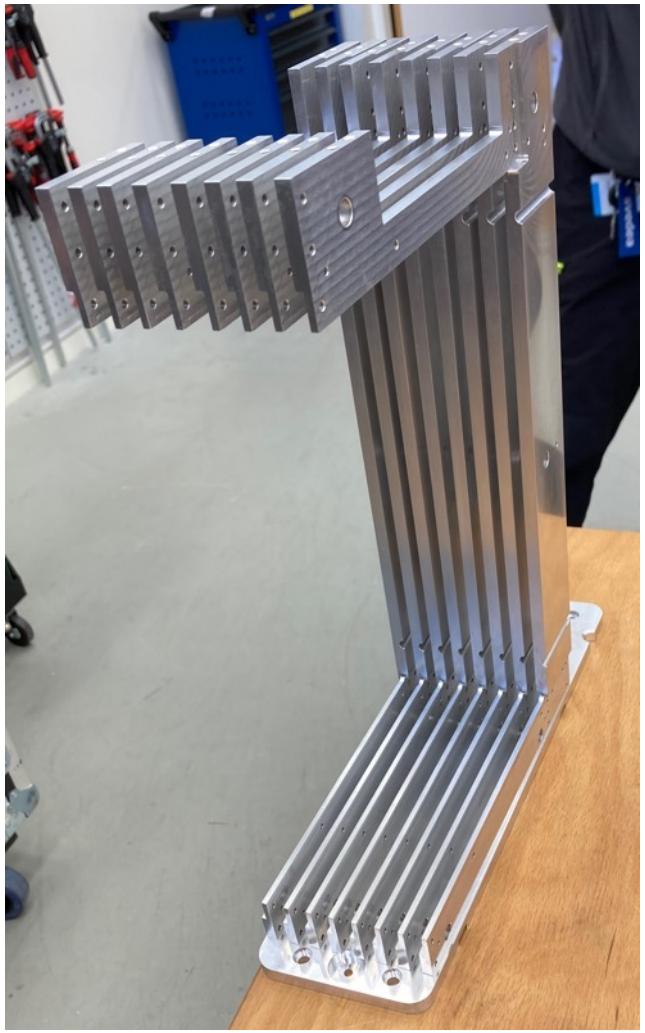
Blades are arranged around the sample at 4m radius.

Two adjacent blades (frames) are angularly spaced with a 0.15 degrees angle.

ESTIA detector

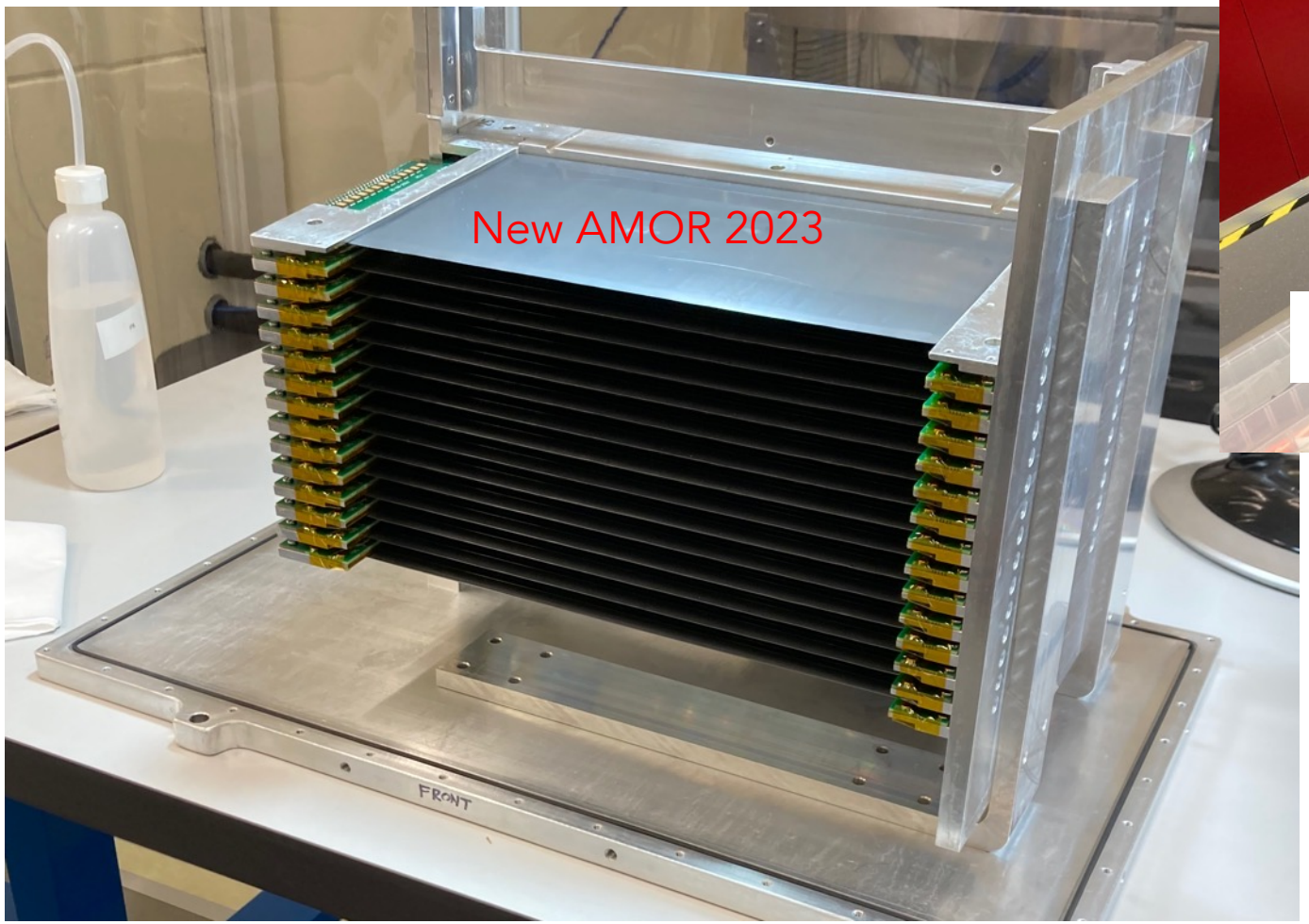


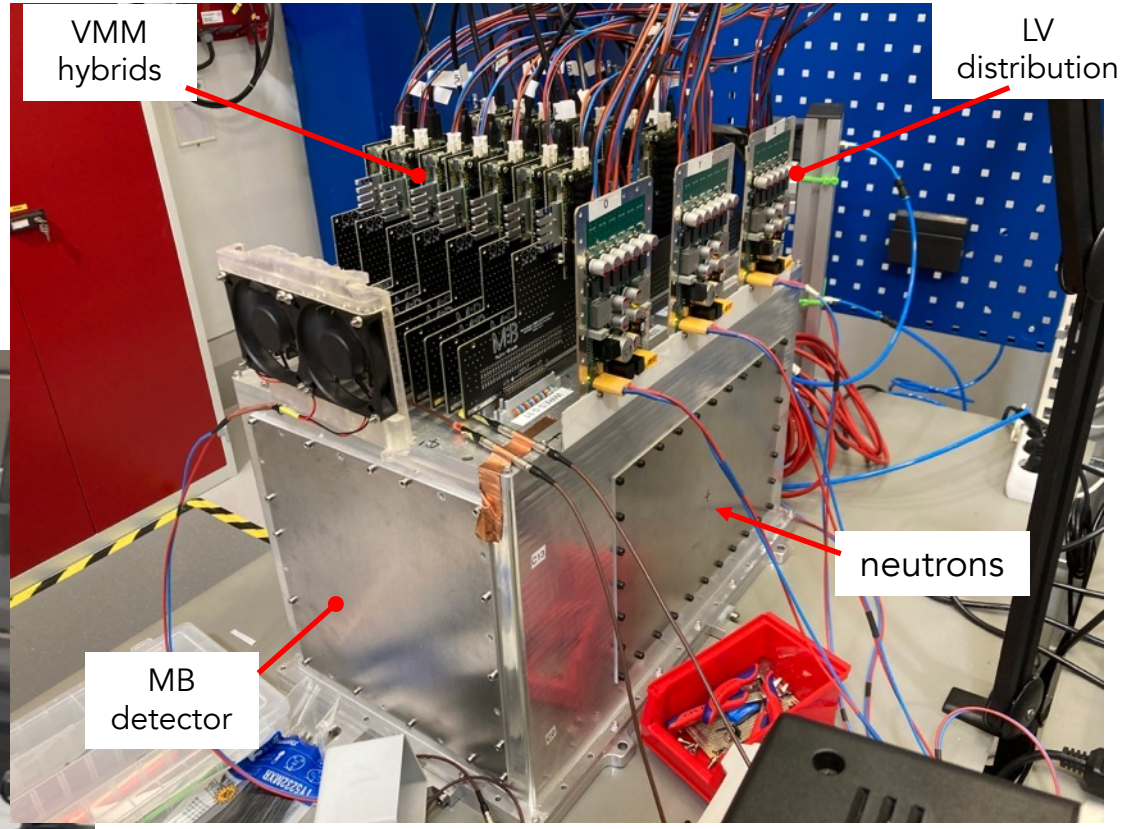
Neutrons from sample at 4 m distance

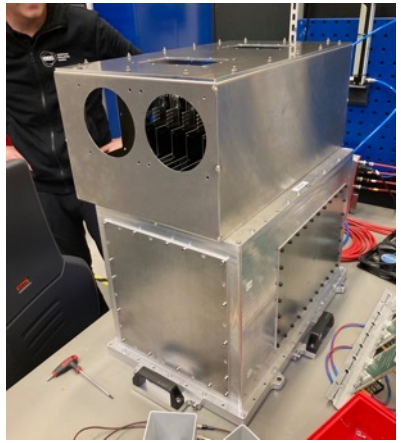


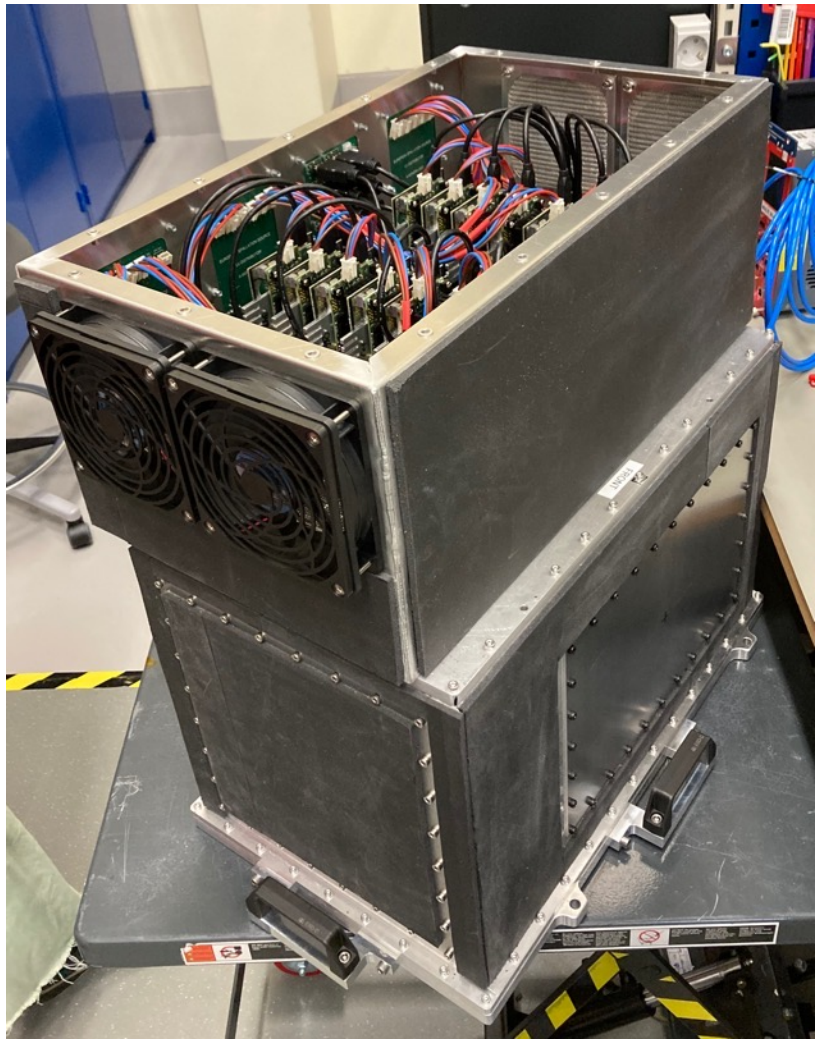
New AMOR 2023 – built in August 2023

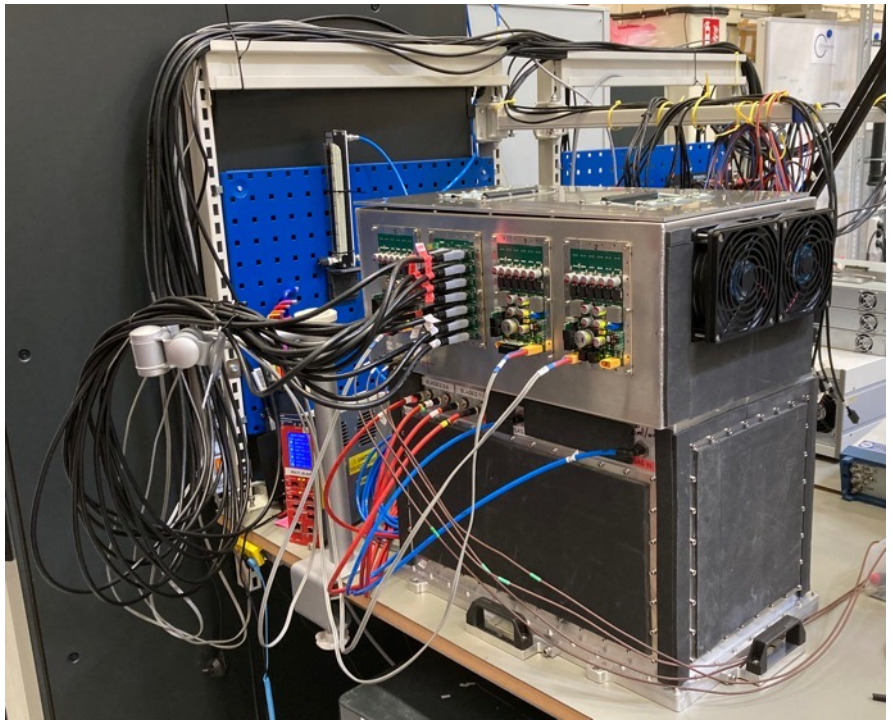
MB.AMOR is a 14 units MB detector 1:1 to TBL detector
Installation @ PSI (Nov 2023) to start user program
And demonstration of the full ESS readout system
(detG and ECDC)
TBL to be built in fall, then ESTIA

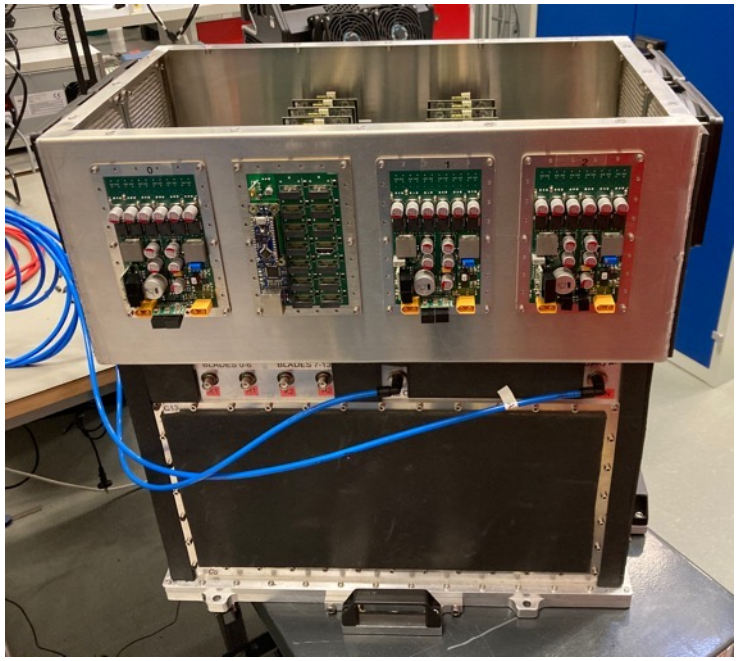












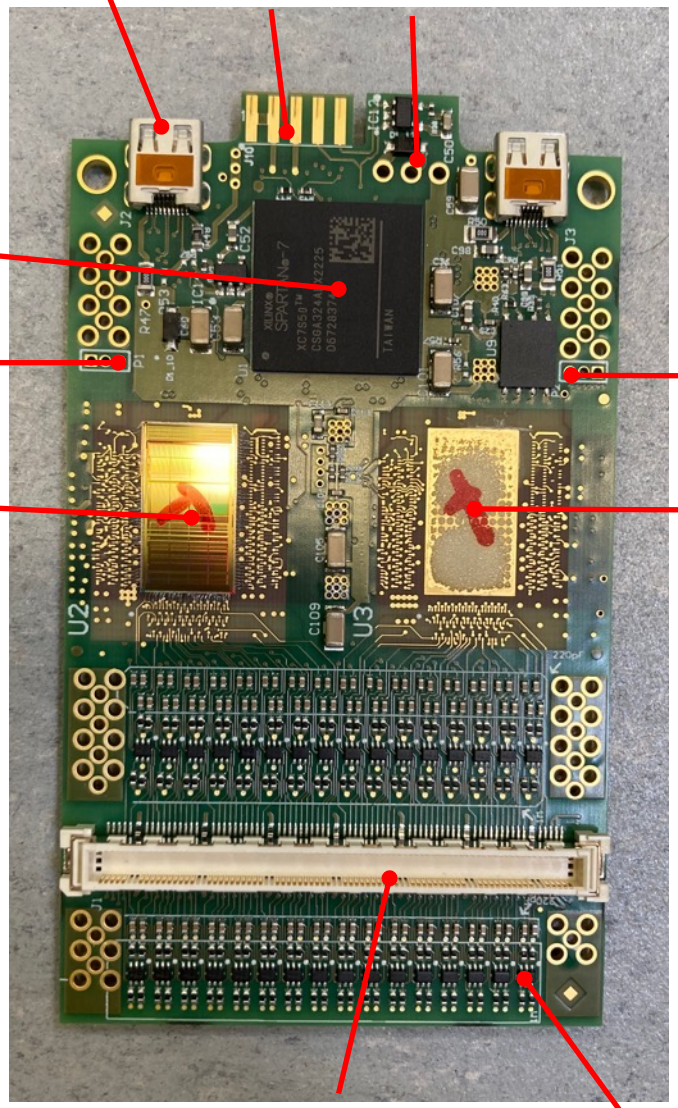
VMM

Dimensions 80 mm x 50 mm

PWR 2A @ 2V and 200mA @3.3V

Ch can be + or – polarity
(common per VMM)

Adjustable gain



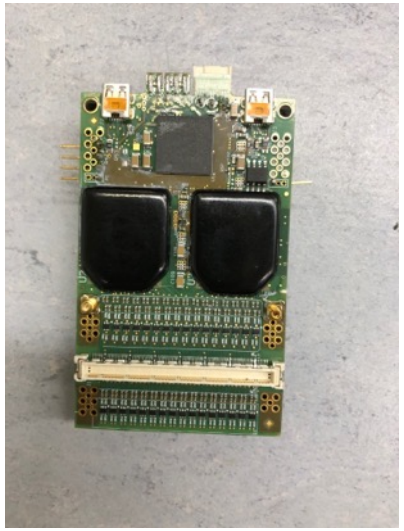
MO
VMM1

Monitor Output -> can be used to see analgue pulses of each channel, one at the time

VMM 1 (64ch)

Protection circuit
TVS = NUP4114

Not enough for wire chambers we added an extra layer



INTERNAL PULSER
Ch can be injected interanlly with a porgrammable pulser amplitude and a
C = 300fF

Yield

with SFM enabled

Sample of 129 hybrids (30 shown)

Type	Num	Hybrid #	Verdict w sfm
wing MB	1	304	0
wing MB	2	318	2
wing MB	3	251	0
wing MB	4	253	0
wing MB	5	029	2
wing MB	6	299	1
wing MB	7	328	1
wing MB	8	232	3
wing MB	9	223	0
wing MB	10	154	1
wing MB	11	151	0
wing MB	12	139	0
wing MB	13	141	0
wing MB	14	136	1
wing MB	15	065	1
wing MB	16	161	0
wing MB	17	120	64
wing MB	18	153	2
wing MB	19	402	0
wing MB	20	303	0
wing MB	21	220	0
wing MB	22	156	0
wing MB	23	413	0
wing MB	24	375	1
wing MB	25	198	1
wing MB	26	353	0
wing MB	27	086	0
wing MB	28	230	1
wing MB	29	143	3
wing MB	30	043	0

	Good O ch missing	Max 4 ch missing	> 4ch missing
w sfm	63%	34%	2%

Missing ch can be mapped to a specific detector that does not use them

In 2021 production yield was 40%

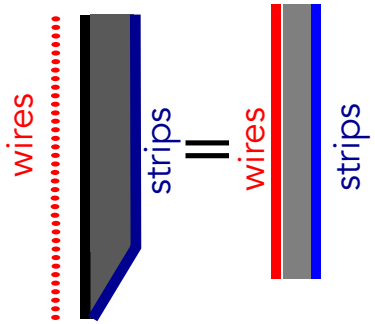
129+129 for MB+NMX in-hand (delivered 2023)

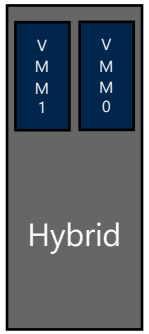
300+300 in production, delivery 2024

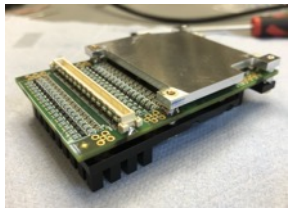
Multi-Blade detector readout chain for Test Beam Line

Cassettes = 14

A blade assembly (unit)



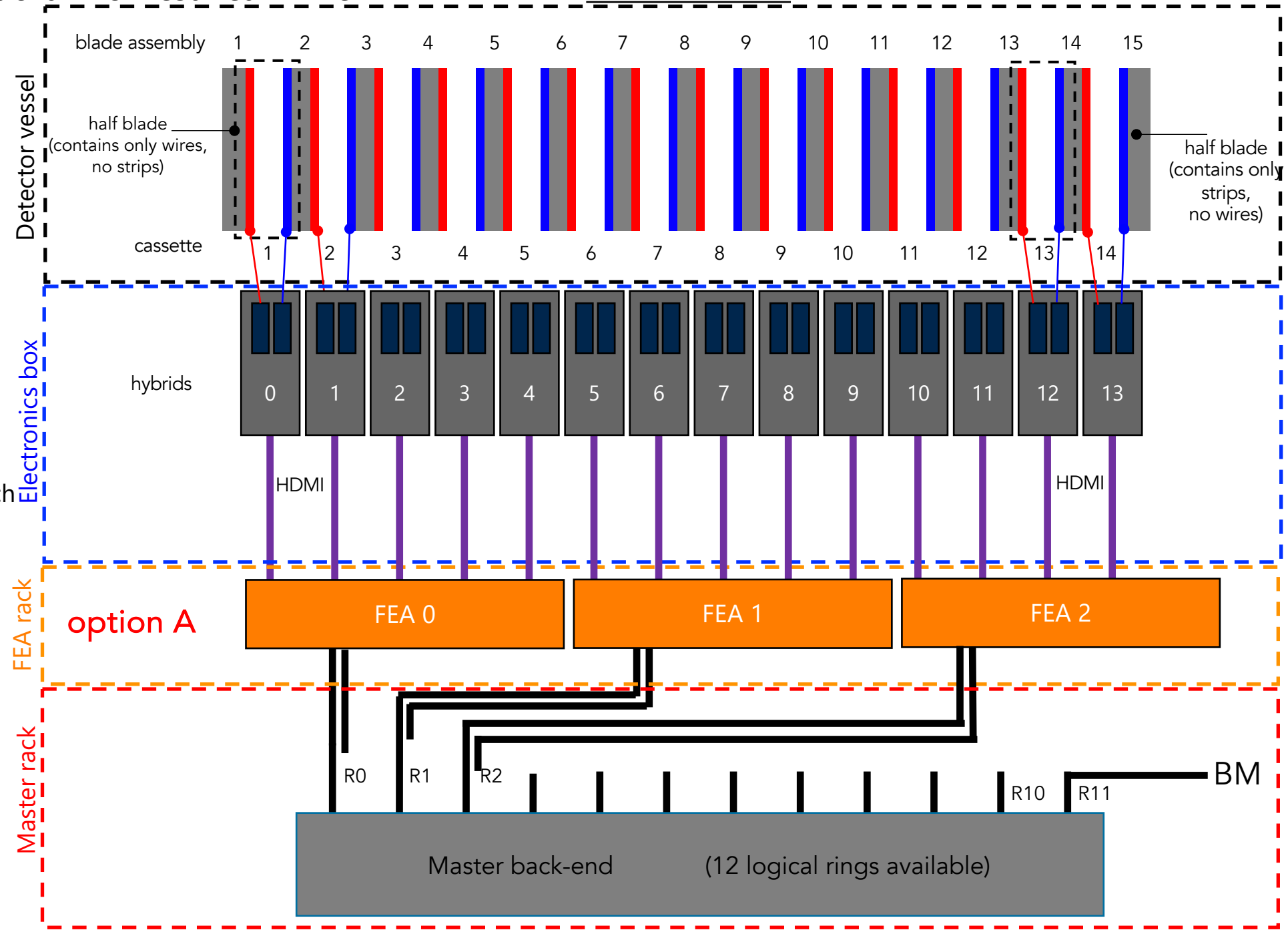


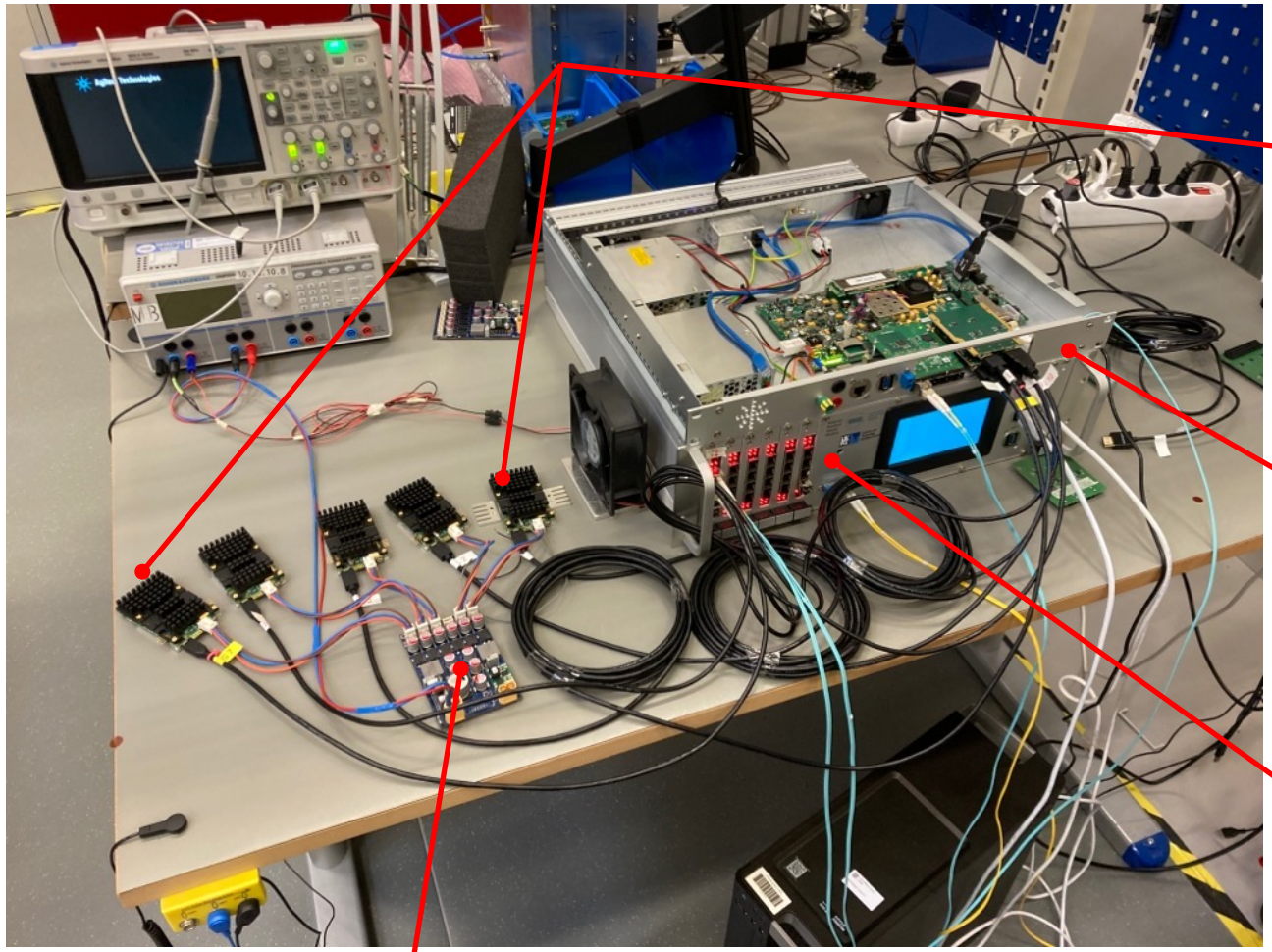


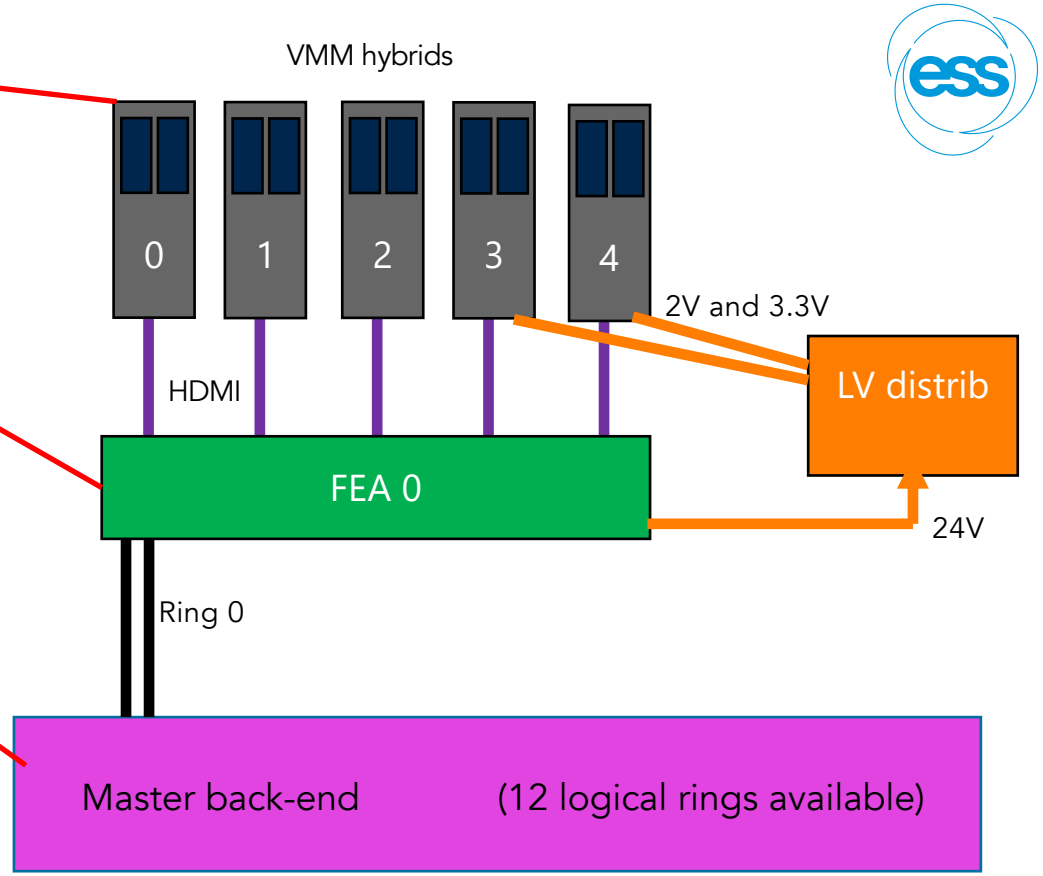
Hybrid = one board
with 2 VMM3A = 128ch

Front End Assiter

Master Module

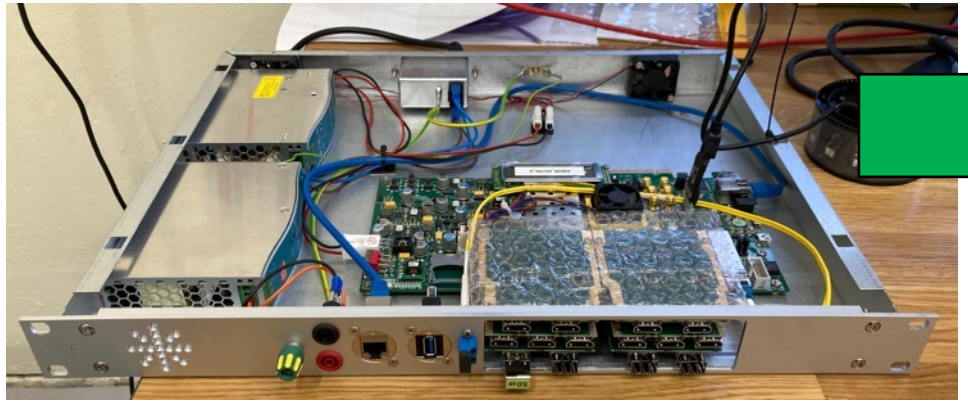






LV distrib

Designed by Angel, improved SNR
In 24V low current out 2V
and 3.3V high current

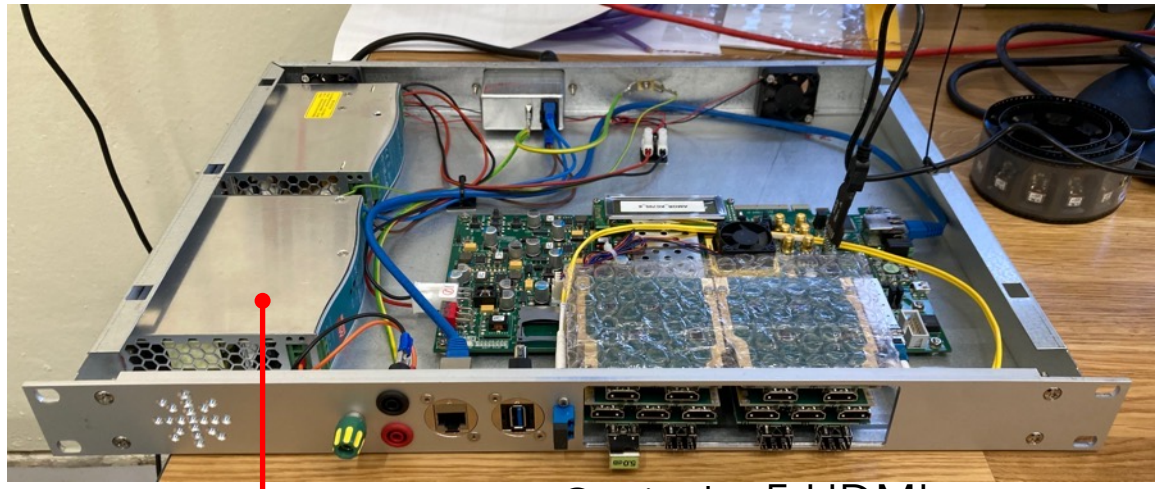


FEA 0

FEA front-end assister
For now 5 hybrids 1 assister
1U crate

Two options for Assister

Current Assister



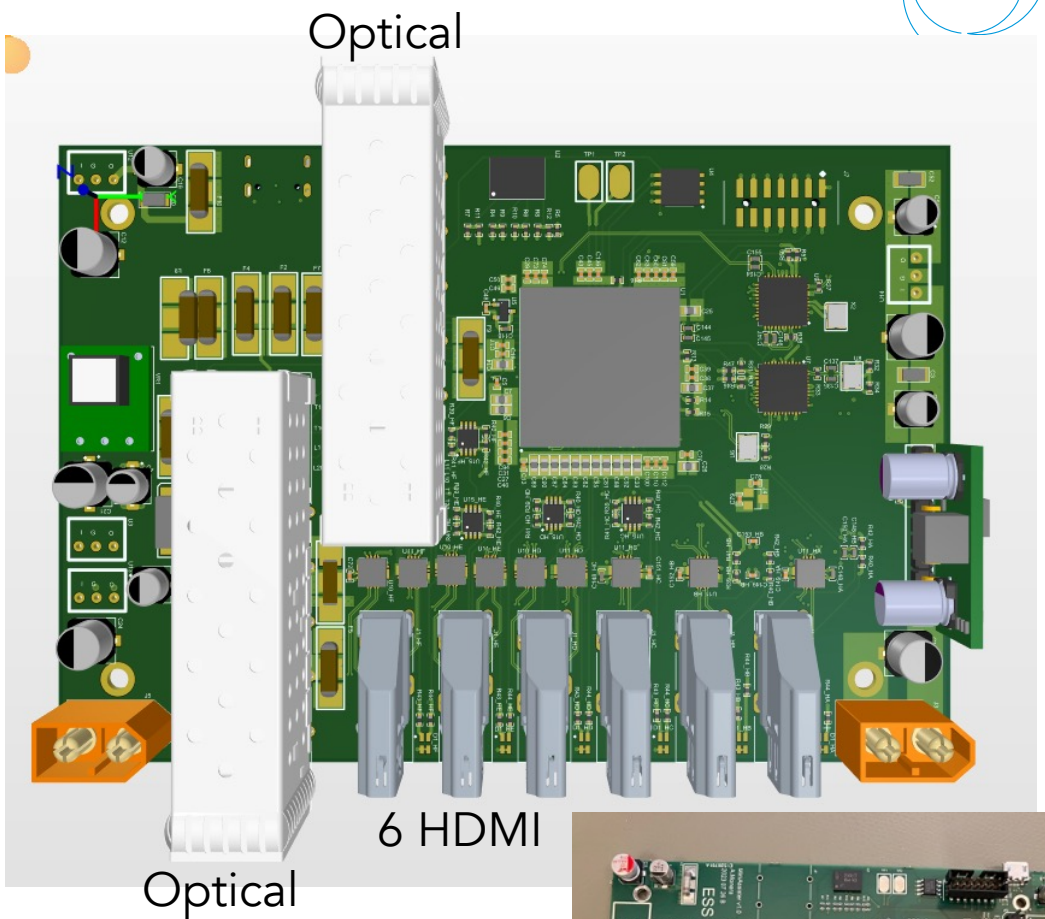
LV 24V for LV distribution board

kc705 board in a 1U crate

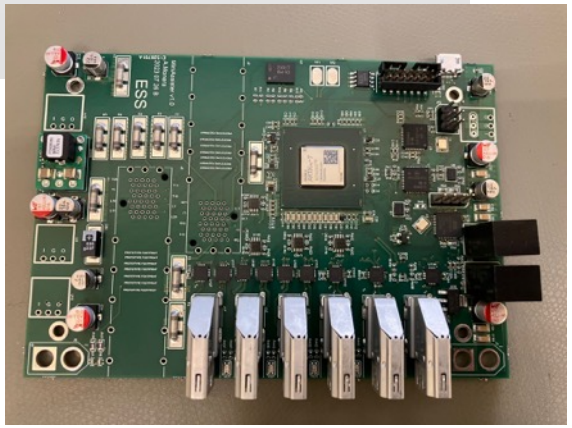
Now 5 hybrids per one FEA

Upgrade to 10 hybrids per FEA (as in pict)

MINI Assister



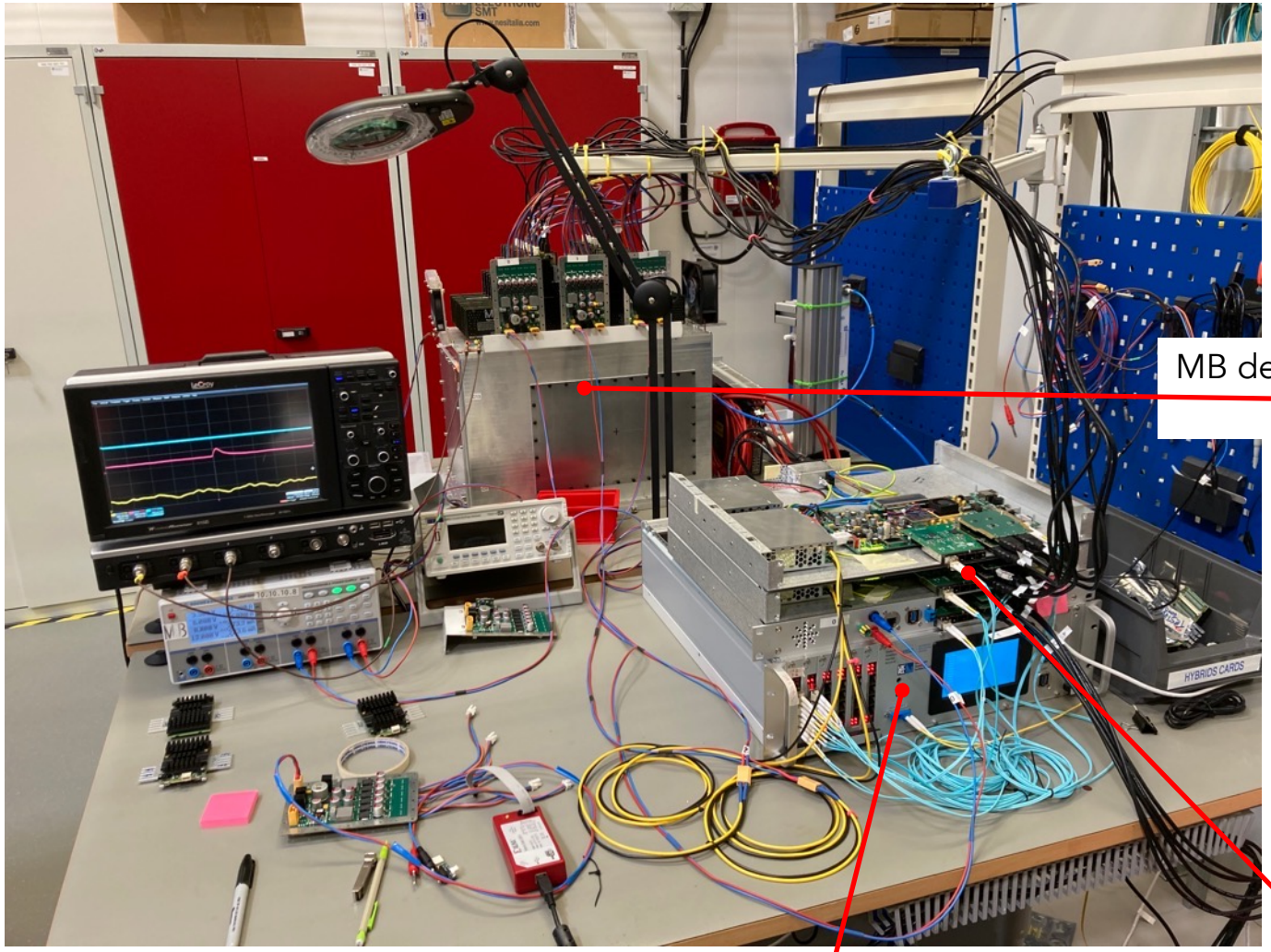
Designed by Angel,
6 hybrids per FEA
~ 13 x 9 cm2

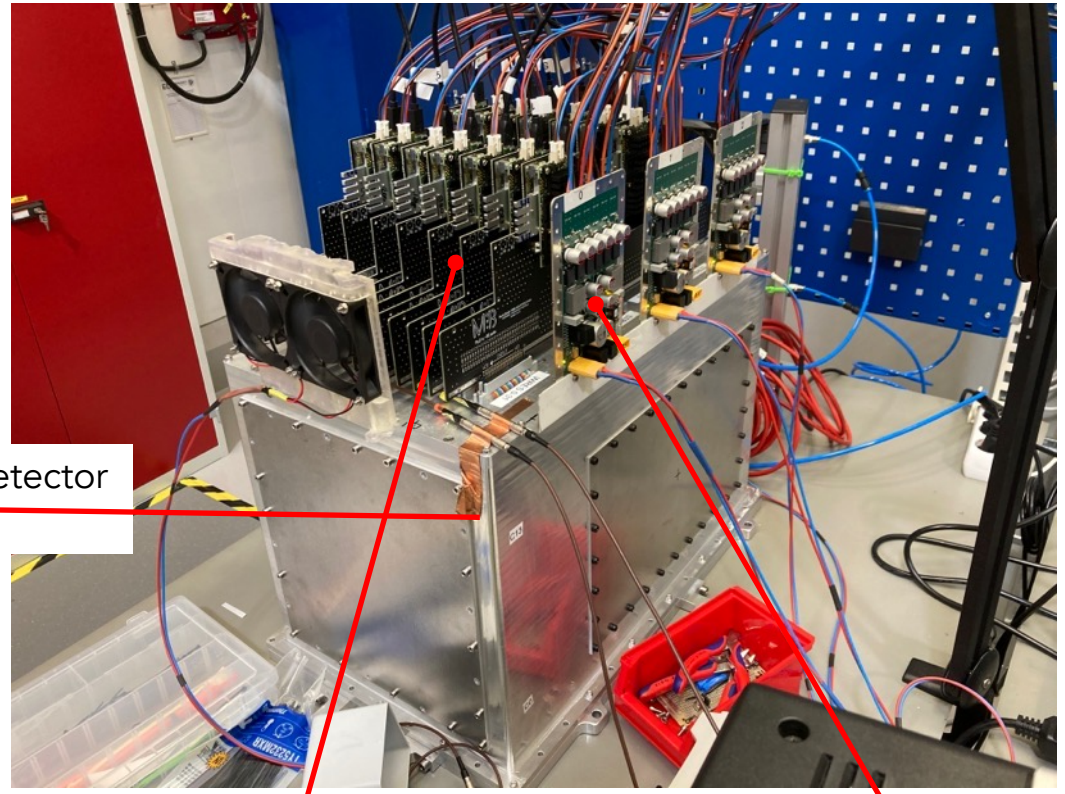


FEA 0

FEA front-end assister
For now 5 hybrids 1 assister
1U crate

Multi-Blade setup





MB detector

LV distrib

0

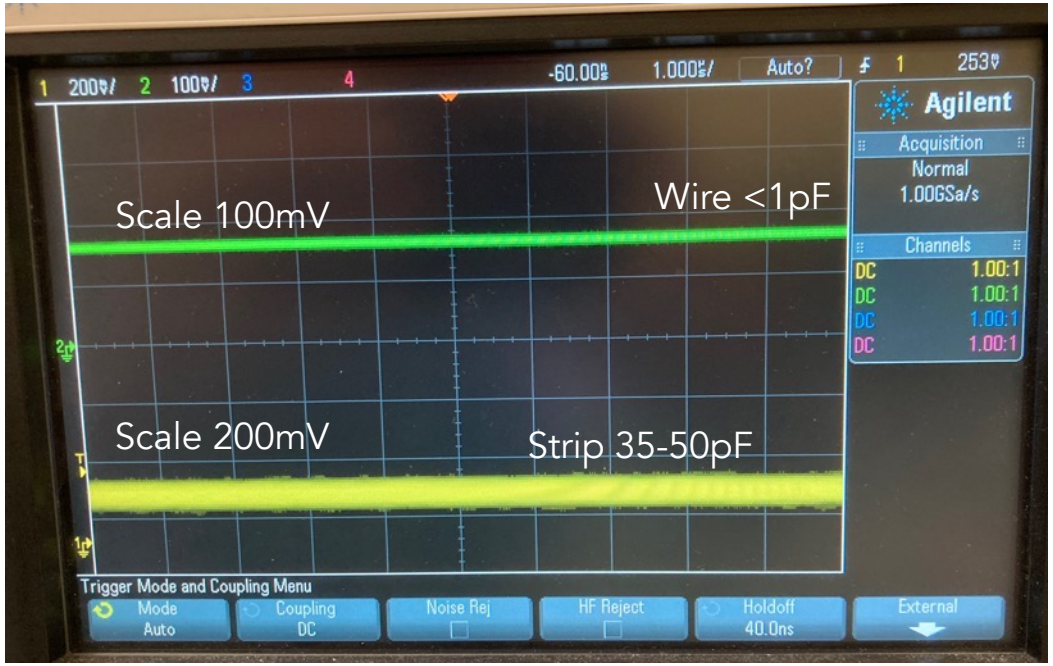
14 hybrids one on each cassette of MB

Master back-end (12 logical rings available)

3 FEA

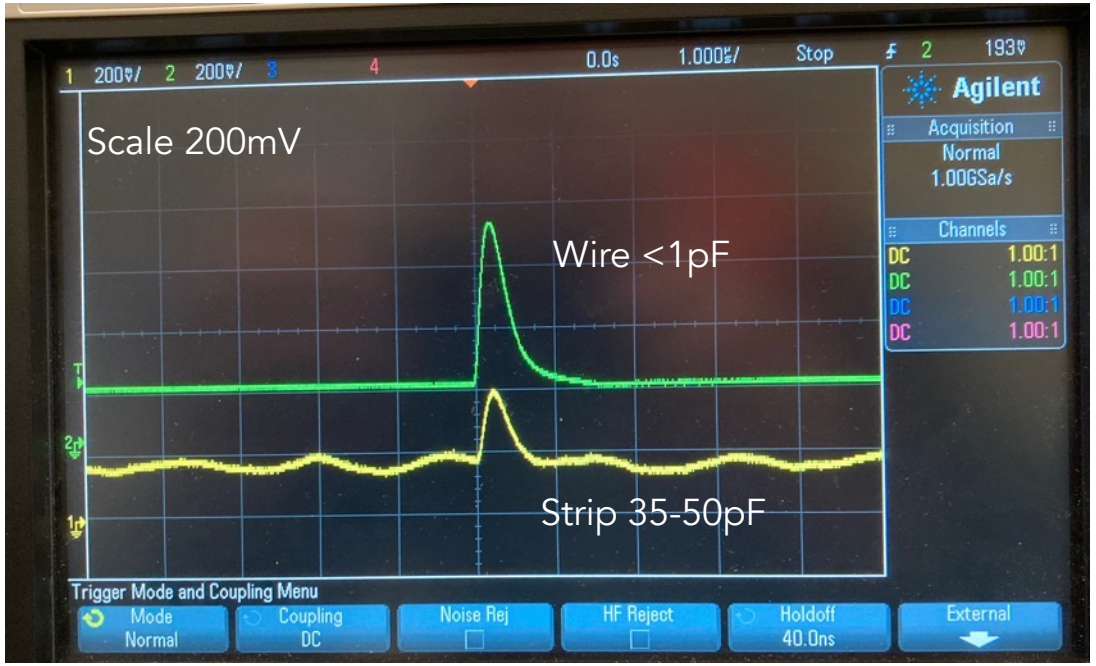
Multi-Blade

Noise on one hybrid connected to MB with HV ON



With the new LV distrib from Angel

Muon signal

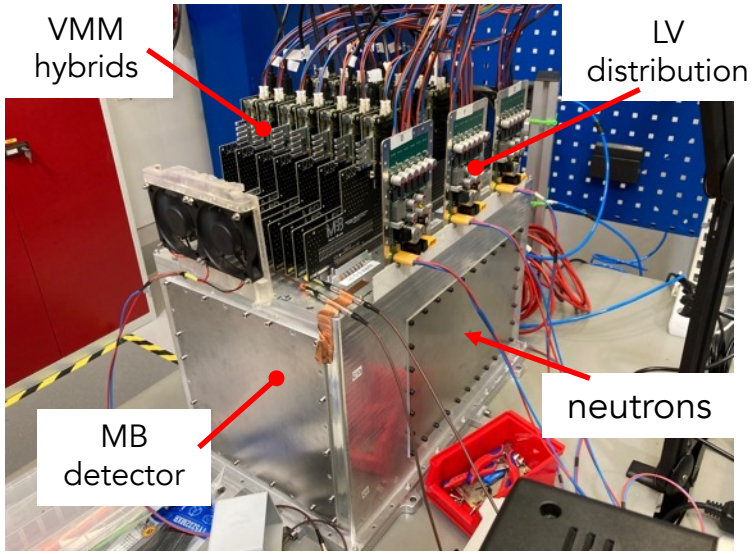


Ampli gain
- 1V/pC on wires
+ 3V/pC on strips

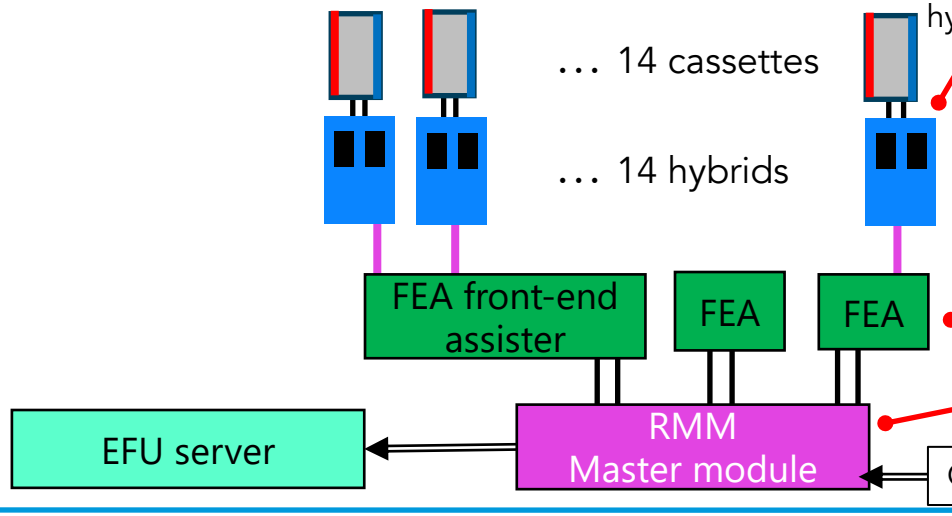
New AMOR 2023

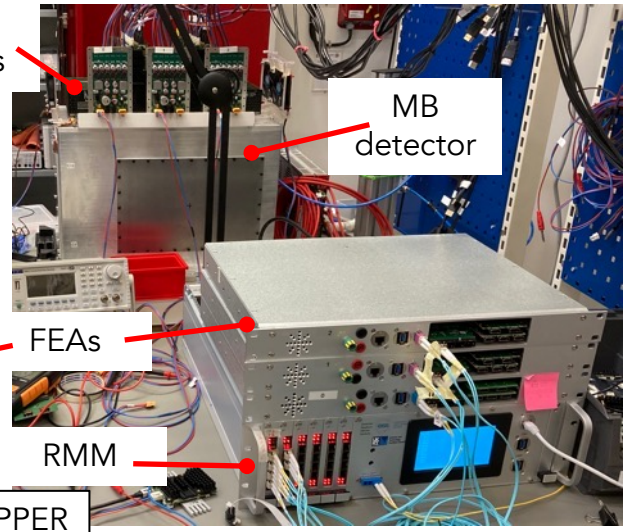
MB.AMOR is a 14 units MB detector 1:1 to TBL detector
Installation @ PSI (Nov 2023) to start user program

Commissioning @ Utgard

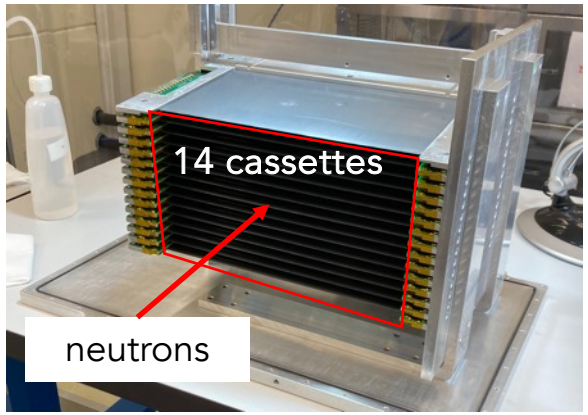


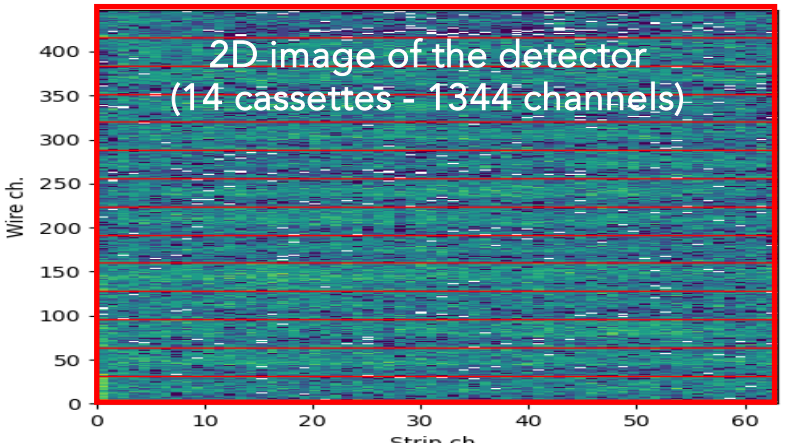
ESS readout chain

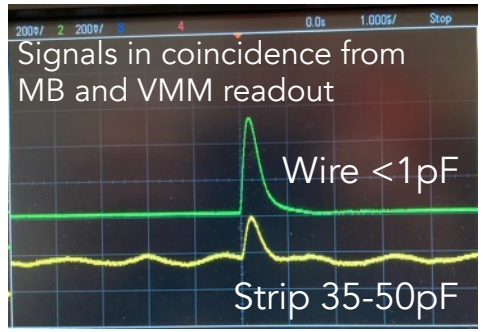


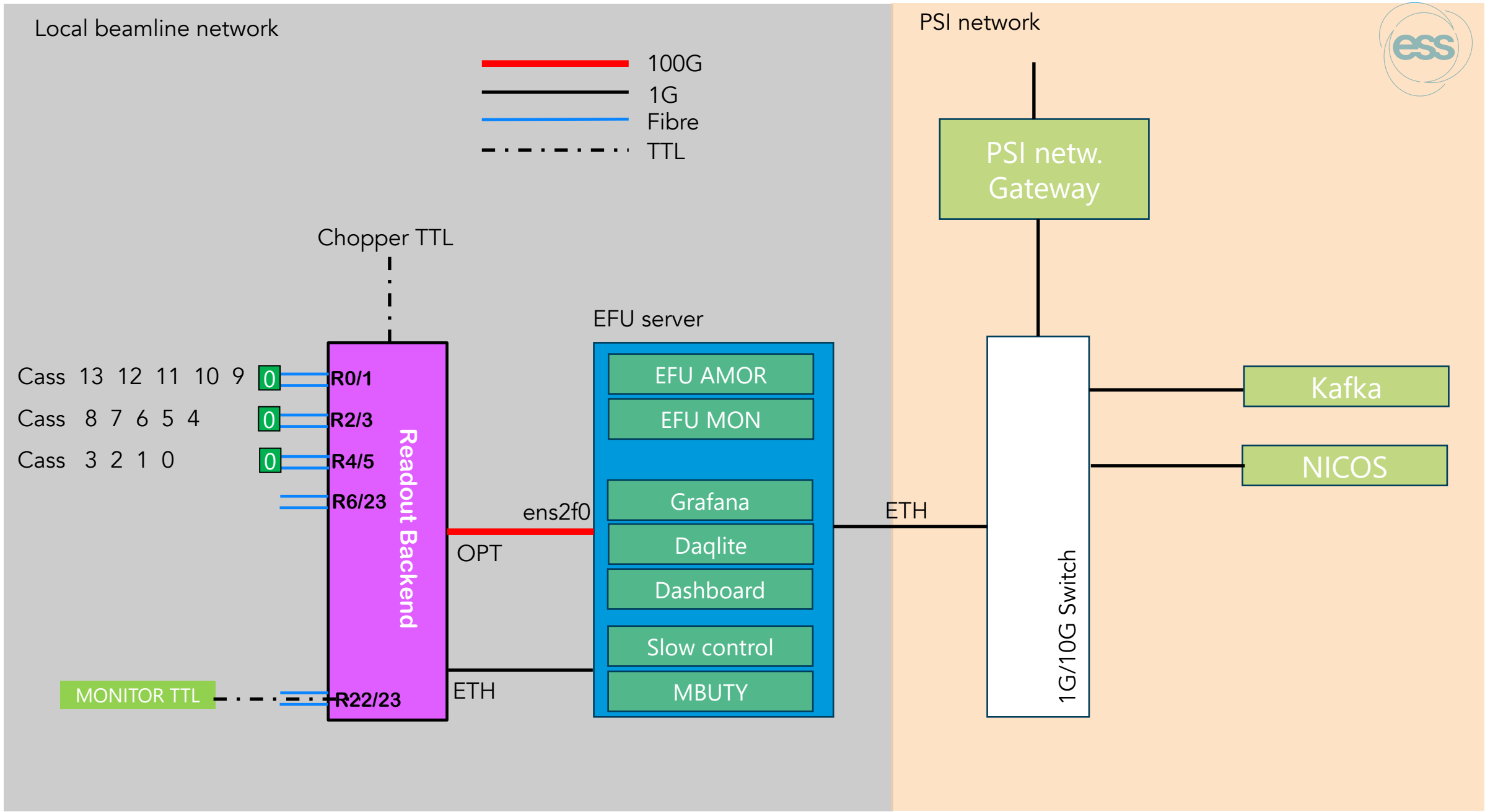


Commissioning @ Utgard with muons

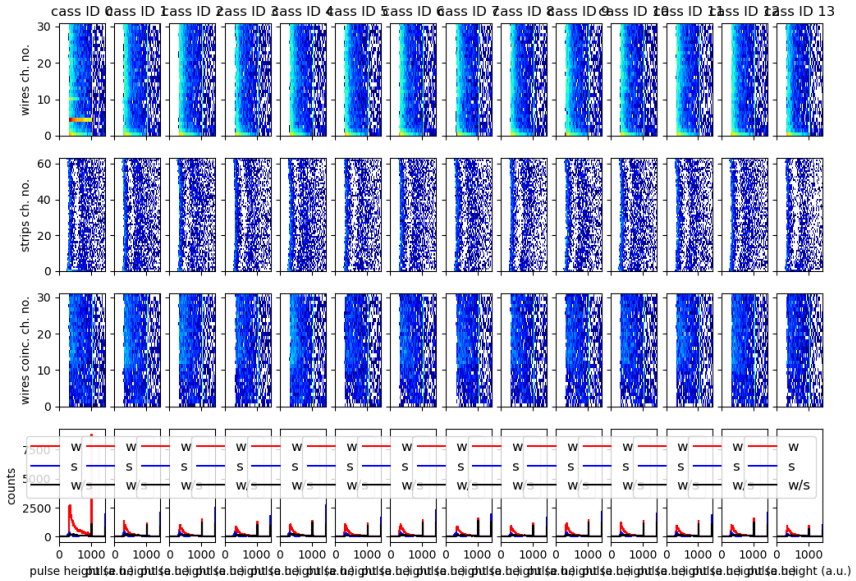




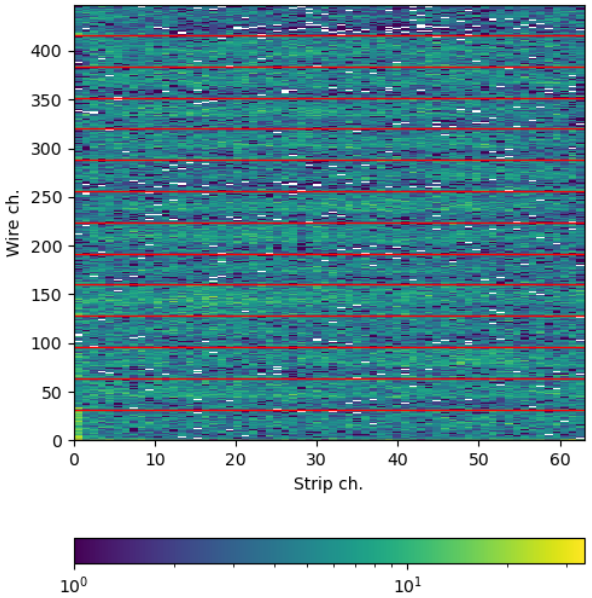



Local beamline network
PSI network
100G
1G
Fibre
TTL
PSI netw. Gateway
Chopper TTL
EFU server
Cass 13 12 11 10 9
Cass 8 7 6 5 4
Cass 3 2 1 0
0
0
0
R0/1
R2/3
R4/5
R6/23
Readout Backend
ens2f0
OPT
ETH
EFU AMOR
EFU MON
Grafana
Daqlite
Dashboard
Slow control
MBUTY
ETH
1G/10G Switch
Kafka
NICOS
MONITOR TTL
R22/23

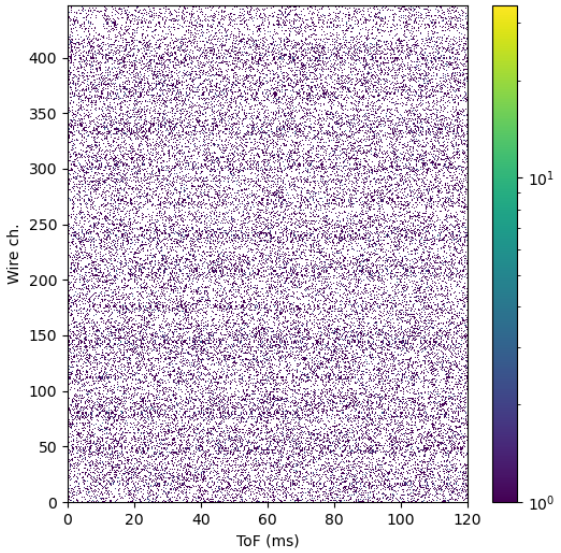
backup



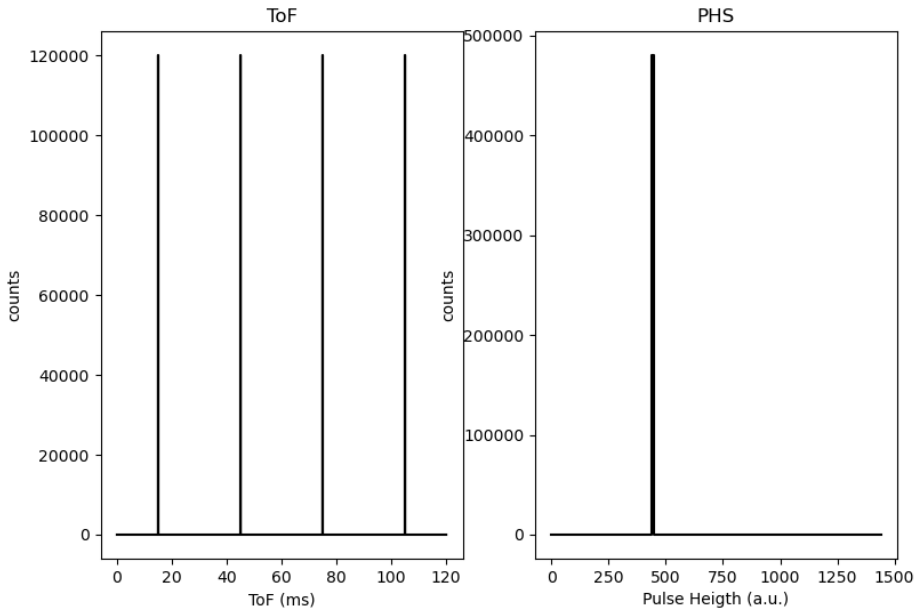
DET i



DET ToF



MONITOR



Yield

w/o SFM enabled

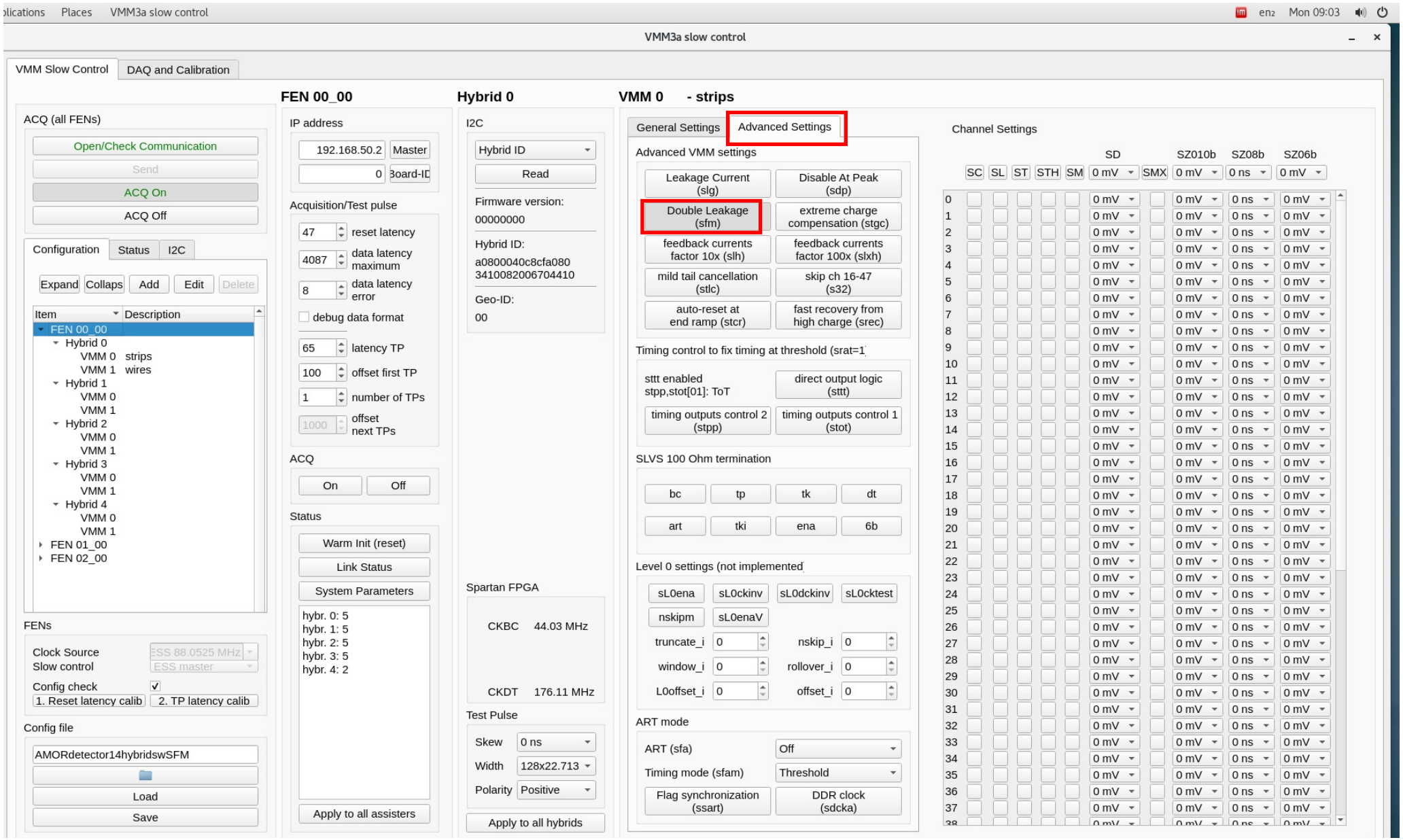
Sample of 129 hybrids (30 shown)

Type	Num	Hybrid #	Strips missing VMM0v	Wires missing VMM1
wing MB	1	304	1	0
wing MB	2	318	3	0
wing MB	3	251	1	0
wing MB	4	253	0	0
wing MB	5	029	2	0
wing MB	6	299	0	1
wing MB	7	328	2	0
wing MB	8	232	2	1
wing MB	9	223	1	0
wing MB	10	154	100	0
wing MB	11	151	100	0
wing MB	12	139	0	0
wing MB	13	141	100	0
wing MB	14	136	100	0
wing MB	15	065	1	1
wing MB	16	161	0	0
wing MB	17	120	64	0
wing MB	18	153	2	0
wing MB	19	402	100	0
wing MB	20	303	0	0
wing MB	21	220	0	0
wing MB	22	156	100	0
wing MB	23	413	100	0
wing MB	24	375	1	0
wing MB	25	198	64	0
wing MB	26	353	0	0
wing MB	27	086	0	0
wing MB	28	230	0	1
wing MB	29	143	1	100
wing MB	30	043	100	0

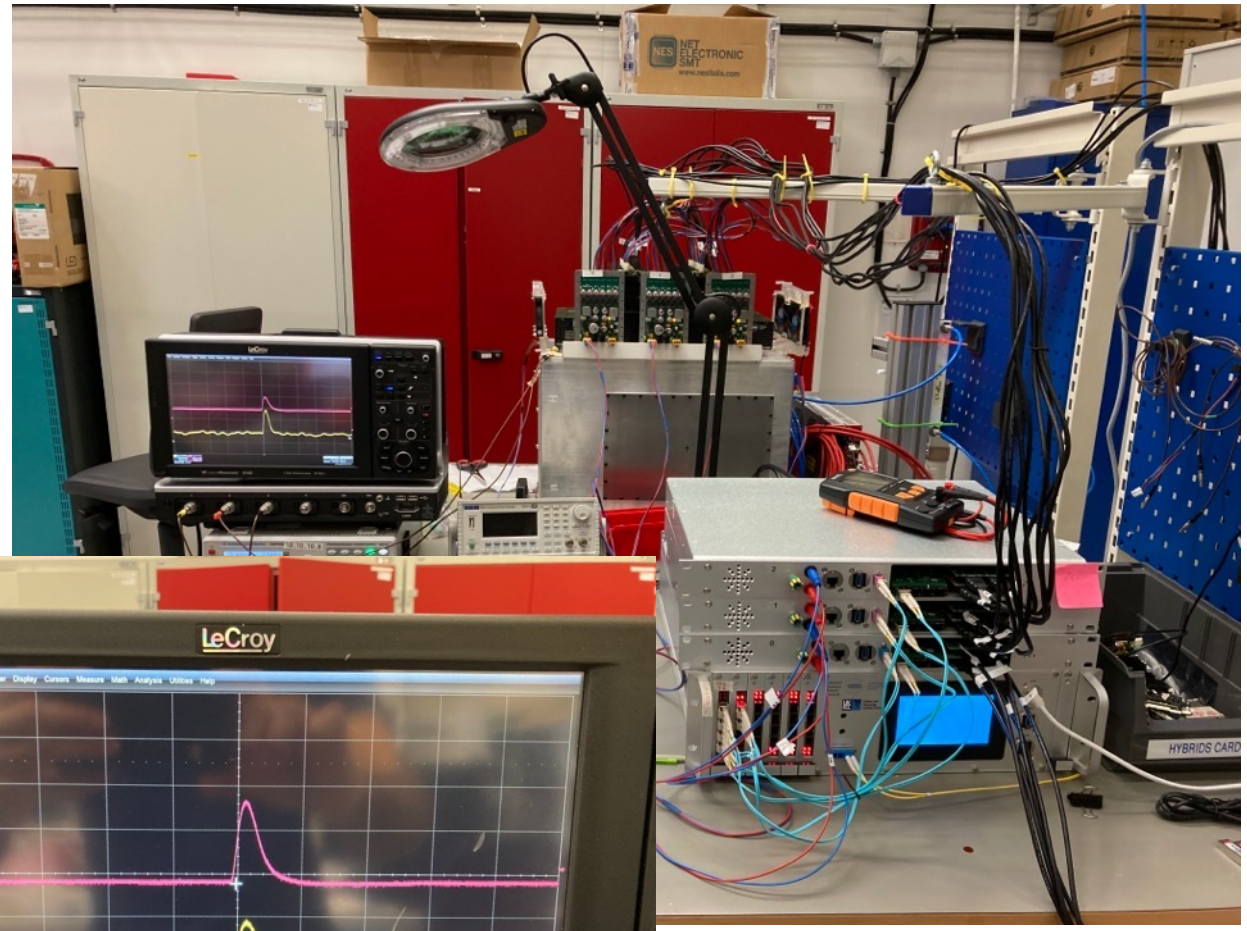
w/o SFM enabled

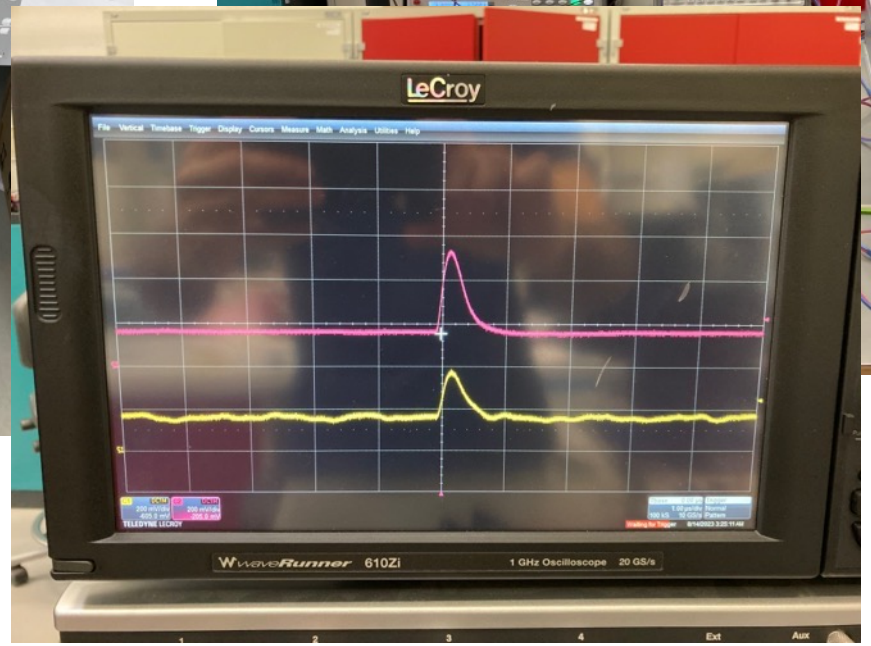
Verdict
0
3
1
0
2
1
2
3
1
100
100
0
100
100
2
0
64
2
100
0
0
100
100
1
64
0
0
1
101
100

	Good O ch missing	Max 4 ch missing	> 4ch missing
w/o sfm	20%	30%	50%


plications Places VMM3a slow control
en2 Mon 09:03
VMM3a slow control
VMM Slow Control
DAQ and Calibration
ACQ (all FENs)
Open/Check Communication
Send
ACQ On
ACQ Off
Configuration
Status
I2C
Expand
Collaps
Add
Edit
Delete
Item
Description
FEN 00_00
Hybrid 0
VMM 0 strips
VMM 1 wires
Hybrid 1
VMM 0
VMM 1
Hybrid 2
VMM 0
VMM 1
Hybrid 3
VMM 0
VMM 1
Hybrid 4
VMM 0
VMM 1
FEN 01_00
FEN 02_00
FENs
Clock Source
ESS 88.0525 MHz
Slow control
ESS master
Config check
1. Reset latency calib
2. TP latency calib
Config file
AMORdetector14hybridswSFM
Load
Save
FEN 00_00
IP address
192.168.50.2
Master
0
Board-ID
Acquisition/Test pulse
47
reset latency
4087
data latency maximum
8
data latency error
debug data format
65
latency TP
100
offset first TP
1
number of TPs
1000
offset next TPs
ACQ
On
Off
Status
Warm Init (reset)
Link Status
System Parameters
hybr. 0: 5
hybr. 1: 5
hybr. 2: 5
hybr. 3: 5
hybr. 4: 2
Apply to all assisters
Hybrid 0
I2C
Hybrid ID
Read
Firmware version:
00000000
Hybrid ID:
a0800040c8cfa080
3410082006704410
Geo-ID:
00
Spartan FPGA
CKBC 44.03 MHz
CKDT 176.11 MHz
Test Pulse
Skew 0 ns
Width 128x22.713
Polarity Positive
Apply to all hybrids
VMM 0 - strips
General Settings
Advanced Settings
Advanced VMM settings
Leakage Current (slg)
Disable At Peak (sdp)
Double Leakage (sfm)
extreme charge compensation (stgc)
feedback currents factor 10x (slh)
feedback currents factor 100x (slxh)
mild tail cancellation (stlc)
skip ch 16-47 (s32)
auto-reset at end ramp (stcr)
fast recovery from high charge (srec)
Timing control to fix timing at threshold (srat=1
sttt enabled
stpp,stot[01]: ToT
direct output logic (sttt)
timing outputs control 2 (stpp)
timing outputs control 1 (stot)
SLVS 100 Ohm termination
bc
tp
tk
dt
art
tki
ena
6b
Level 0 settings (not implemented
sL0ena
sL0ckinv
sL0dckinv
sL0cktest
nskipm
sL0enaV
truncate_i 0
nskip_i 0
window_i 0
rollover_i 0
L0offset_i 0
offset_i 0
ART mode
ART (sfa) Off
Timing mode (sfam) Threshold
Flag synchronization (ssart)
DDR clock (sdcka)
Channel Settings
SD
SZ010b
SZ08b
SZ06b
SC SL ST STH SM SMX
0 mV
0 ns

BACKUP


NET ELECTRONIC SMT
HYBRIDS CARD


LeCroy
WaveRunner 610Zi
1 GHz Oscilloscope 20 GS/s

EUROPEAN
SPALLATION
SOURCE