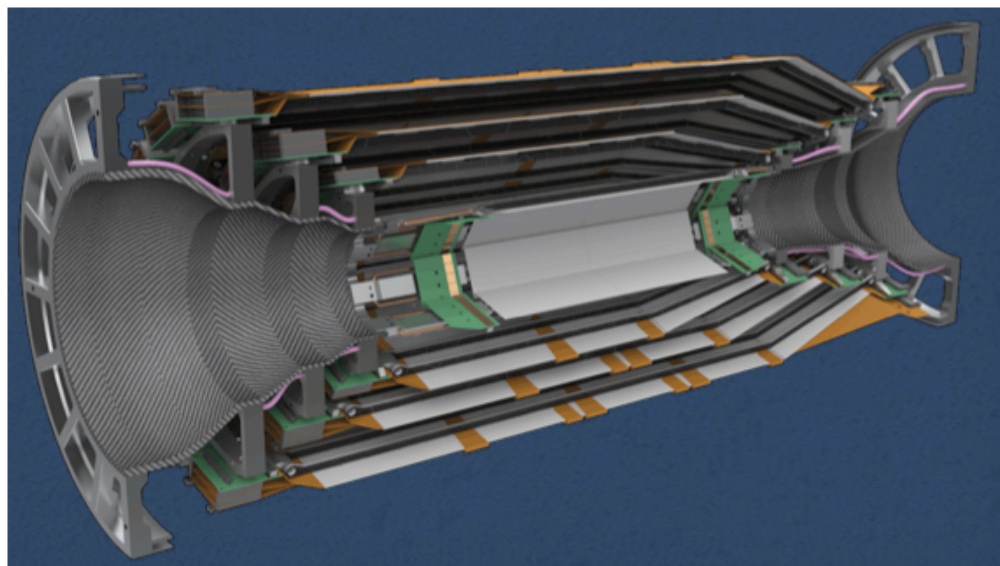
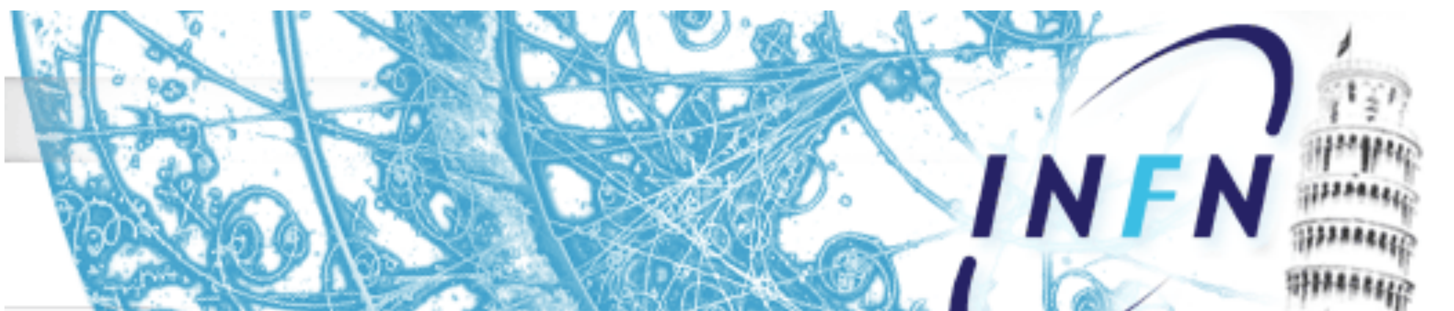
FW/BW Subassembly Report
(an update since June B2GM)



S. Bettarini on behalf of the Pisa SVD Group



VXD Workshop, SVD session – Trieste, Sept. 10, 2015

Introduction

- Class A Subassembly production started in mid-July at the foreseen rate
- Standard production conditions such to verify rate at "regime" not yet reached:
  - Interleaved some class B+ subassemblies
  - Need to build one more class C SFW+SBW for TIFR
  - Summer holidays
- So far, parts in Pisa are such to arrive well beyond Christmas. To reach the completion of the SA production:
  - Already agreed on the 3rd small hybrid production (32 hybrids 8 of each type for the end 2015)
  - 3rd PA-Flex production to be received

Recent shipments

- Before the summer holidays:
  - 2 class B+ SFWs (001,002) + 2 SBWs (003, 005) all built with parts under IPR sent to KEK using the final custom "procedures"

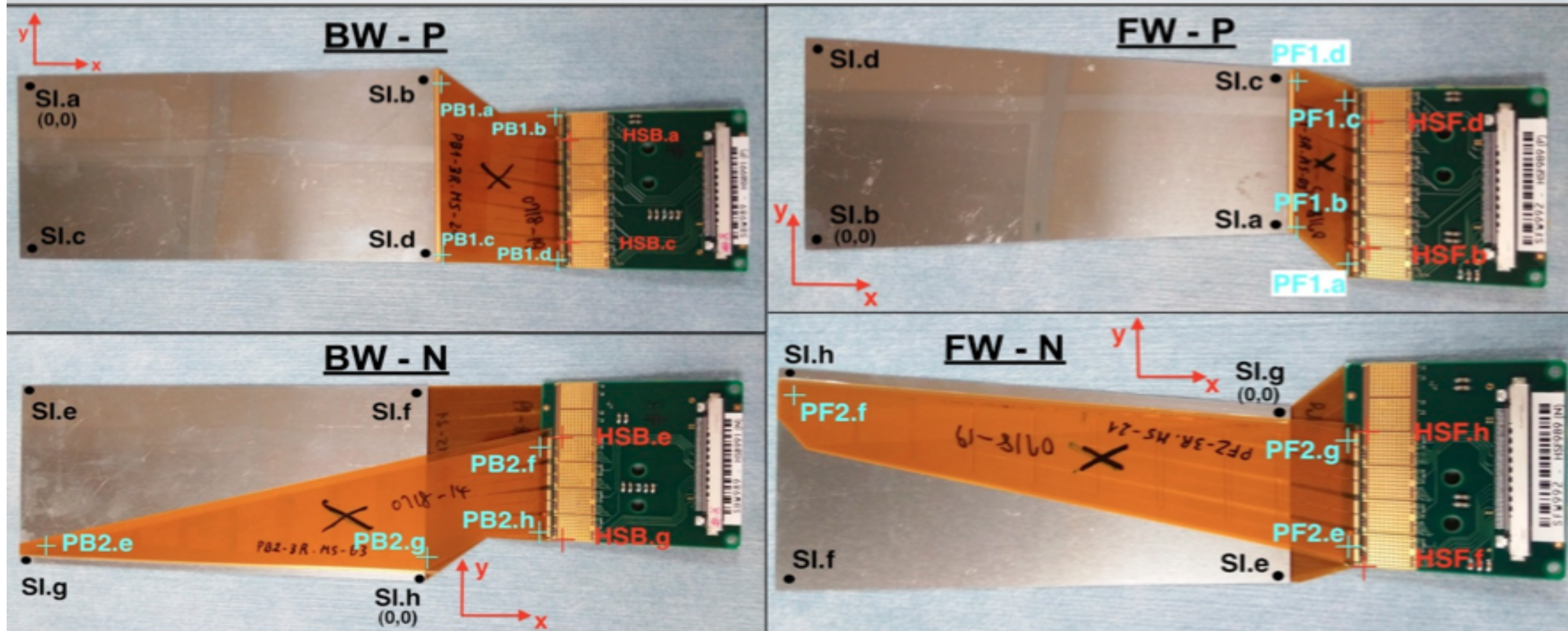
- Cost optimization mandatory: in future, shipments will be optimized, by sending 9 SA at the same time (using new bigger boxes).

Iterated Request to the ladder sites

- Each subassembly leaving Pisa has stored (DB):
  - the mechanical measurements by the survey after the gluing
  - the results of the el. characterization, laser scan and the output of the automatic defect finder
- It's important to perform asap at destination:
  - Quick optical survey on the MPC (z-side up)
  - I-V curve (assessing no severe damage due to shipping)
  - El. Characterization (no bonding pulled off due to vibration/ mechanical stress during the shipping): please upload the calibration data into the DB
  - The SA check-list has been extended to host these tests at the sites
  - Spotting new opens should be straightforward also in case of different noise levels due to the different set-up @ the sites.
- We need to monitor continuously any (un-expected!) failure caused by an abnormal handling during the shipping.

Mechanical measurements

Sub-assembly - Reference systems



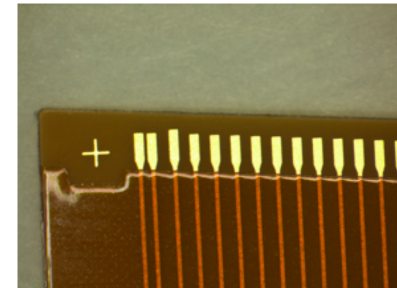
All reference systems were changed, using as new origin one of the F-marks of the sensors. They are marked with “(0,0)” in the pictures above. Also the new nomenclature of reference points was set. A file which contains all the gluing coordinates of every sub-assembly is always used.

So far, all the subassembly we produced matched the mech. tolerances!

The latest and upcoming shipments

- Shipped (31st Aug) the class C for L5:
  - SBW to Vienna
  - SFW(closing IPR) to CERN

- Shipment planned (14th Sept.) the class C for L4:
  - SBW to IPMU
  - SFW(closing IPR) to KEK



- In mid-August Received the 2nd prod. batch of Flex-PA from KEK (IPR):
  - The cover-layer/glue survey is in progress this week (so far all the 36 PB1 and 39 PF1 are ok, continuing this week)

- The whole picture of the site schedule is needed to optimize the future shipment.

SFW production status
(updated on Tue. 8th Sept.)

	Code	Tags	State	Item Quality	
☐	SFW009		N-side glued	Class A	FAILURE
☐	SFW984		N-side measured	Class C	Under bonding; to be shipped to KEK (closing IPR) for L4 on Sept. 14th
☐	SFW008		N-side measured	Class A	To be bonded
☐	SFW007		N-side measured	Class A	To be bonded
☐	SFW006		P-side bonded	Class A	Under el. test (*)
☐	SFW005		P-side bonded	Class A	Under el. test (*)
☐	SFW004		ready for shipment	Class A	El. Characterized
☐	SFW986		fully tested	Class C	To be used for mech. tests in Pisa (not IPR)

(*) delay due to teststand problems

SBW production status
(updated on Mon. 8th Sept.)

	Code	Tags	State	Item Quality	
	SBW009		N-side measured	Class A	To be bonded
	SBW983		P-side bonded	Class C	Bonded; to be shipped directly to IPMU (no IPR) for L4 on Sept. 14th
	SBW008		N-side measured	Class A	To be bonded
	SBW007		P-side bonded	Class A	Under el. test (*)
	SBW006		laser scanned	Class A	El. Characterized
	SBW004		laser scanned	Class A	El. Characterized
	SBW001		P-side bonded	Class B	El. Characterized; many noisy channels. To be further studied
	SBW988		unset	Class C	To be used for mech. tests in Pisa

Results

SFW004 SUMMARY

P-Side

number of defects = 4 / 768 (0.52%)

pinholes = 1 / 768 (0.13%)

opens = 0 / 768 (0.00%)

shorts = 0 / 768 (0.00%)

noisy strips = 2 / 768 (0.26%)

N-Side

number of defects = 10 / 512 (1.95%)

pinholes = 3 / 512 (0.59%)

opens = 0 / 512 (0.00%)

shorts = 0 / 512 (0.00%)

noisy strips = 3 / 512 (0.59%)

SBW004 SUMMARY

P-Side

number of defects = 9 / 768 (1.17%)

pinholes = 1 / 768 (0.13%)

opens = 1 / 768 (0.13%)

shorts = 0 / 768 (0.00%)

noisy strips = 7 / 768 (0.91%)

bad laser strips = 0 / 768 (0.00%)

N-Side

number of defects = 8 / 512 (1.56%)

pinholes = 0 / 512 (0.00%)

opens = 0 / 512 (0.00%)

shorts = 0 / 512 (0.00%)

noisy strips = 7 / 512 (1.37%)

bad laser strips = 1 / 768 (0.13%)

SBW006 SUMMARY

P-Side

number of defects = 9 / 768 (1.17%)

pinholes = 0 / 768 (0.00%)

opens = 0 / 768 (0.00%)

shorts = 2 / 768 (0.26%)

noisy strips = 7 / 768 (0.91%)

bad laser strips = 0 / 768 (0.00%)

N-Side

number of defects = 5 / 512 (0.98%)

pinholes = 0 / 512 (0.00%)

opens = 0 / 512 (0.00%)

shorts = 0 / 512 (0.00%)

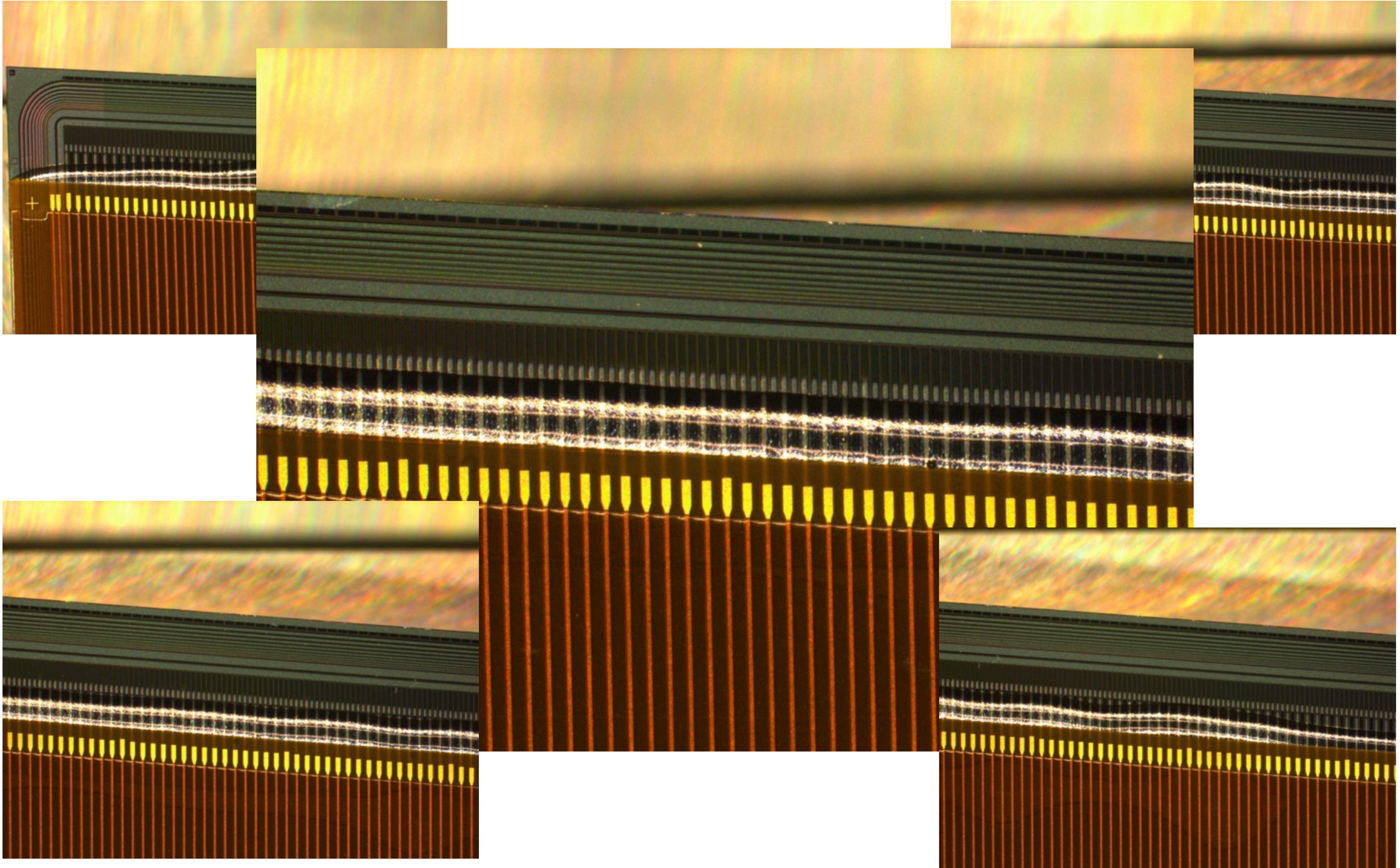
noisy strips = 5 / 512 (0.98%)

bad laser strips = 0 / 768 (0.00%)

Preliminary Report on the failure of SFW009

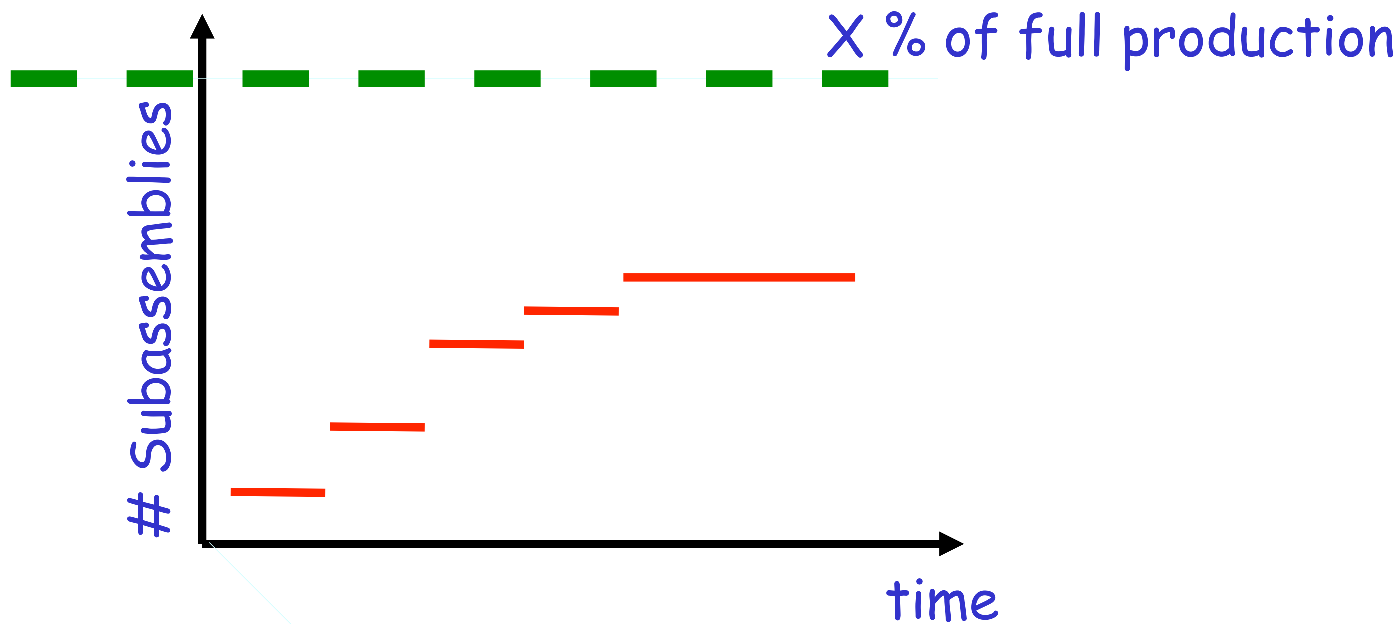
- In the survey performed on Tues. 8th Sept. we discover that half the subassembly is un-bondable because glue spread on almost half the bonding pads on the z side.
- We are investigating:
  - The Z gluing was performed on Mon. 7th afternoon by the "best team" (on SB's opinion).
    - The mechanical alignment of PA-Det-Hybrid was correctly done (see survey before gluing);
    - the glue deposition didn't show any problems.
    - The Z gluing operations finished with the team apparently "happy" of the result.
    - The glued was seen to spread uniformly and it reach the 1st pad's row in the few most critical regions (as usual).
  - The day after we found that the vacuum (on the det's chuck) was wrongly switched off. Clearly the detector raised when the glue was still liquid (i.e. not cured) and it caused the abnormal squeezing of the glue.
  - Some-ONE inadvertently switched OFF the vacuum after the final positioning of the jigs was reached
  - From the survey after the gluing the final relative position AP-Det-Hybrid didn't change wrt what recorder before the gluing
- We have still to understand more to take the right action to prevent that such a thing might happen again.
- Somehow we have to re-think and modify our procedures to make them more robust against (this kind of) accidents.

Some snapshots of the accident on SFW009



Future plots monitoring production

When a greater statistics is available (i.e. for the next B2GM) I will preparing integrated “luminosity” plots, i.e.:



Also useful a similar plot for needed parts:

- Hybrids/sandwiches (tested)
- Flex-PA (surveyed)

	Subassembly Gluing: Rate = 2 SBWs + 2 SFWs / week				
h	Monday	Tuesday	Wednesday	Thursday	Friday
9	Gluing SBW1-P	CMM survey+photo SBW1-P	CMM survey+photo SBW1-N	CMM survey+photo SBW2-P	CMM survey+photo SBW2-N
		Tranfer to Z jig SBW1-P	Transfer to MPC SBW1-N	Tranfer to Z jig SBW2-P	Transfer to MPC SBW2-N
10		Gluing SBW1-N	Gluing SBW2-P	Gluing SBW2-N	
	P-Glue dispensing				
11					
		N-Glue dispensing	P-Glue dispensing	N-Glue dispensing	
12					
13					
14	Gluing SFW1-P	CMM survey+photo SFW1-P	CMM survey+photo SFW1-N	CMM survey+photo SFW2-P	CMM survey+photo SFW2-N
		Tranfer to Z jig SFW1-P	Transfer to MPC SFW1-N	Tranfer to Z jig SFW2-P	Transfer to MPC SFW2-N
15		Gluing SFW1-N	Gluing SFW2-P	Gluing SFW2-N	
	P-Glue dispensing				
16					
		N-Glue dispensing	P-Glue dispensing	N-Glue dispensing	
17					

Spare Time (prepare shipments)				
Glue curing time:	22.5h	21.5h	22.5h	21.5h
Glue curing time:	22.5h	21.5h	22.5h	21.5h
P-side gluing: 2.5h				
N-side gluing: 3h				

Needed: 8 x (4h)-shifts + 2 x (1h)-shifts

Shift Crew: 1 Physicist+1 technician OR 2 Physicists

	Microbonding				
h	Monday	Tuesday	Wednesday	Thursday	Friday
9	SBW0-Z bonding	SFW0-Z bonding	Hybrid sandwch	SBW1-P bonding	SFW1-P bonding
			assembly(3HSB+3HSF)		
10					
11					
12					
13					
14	SBW0-P bonding	SFW0-P bonding	SBW1-Z bonding	SFW1-Z bonding	Hybrid sandwch
					assembly(3HSB+3HSF)
15					
16					

Legenda:

SBW0	the 2nd SBW glued the previous week
SFW0	the 2nd SBW glued the previuos week
SBW1	the 1st SBW glued the current week
SFW1	the 1st SFW glued the current week
Spare Time	

ManPower:	0.9 AProf
(technicians)	0.2 PMam

In the first period of production we are experiencing a low bonding speed …

Not easy to match the technician holidays with production, especially during the summer.

h	Electrical Test and Laser Scan				
	Monday	Tuesday	Wednesday	Thursday	Friday
9					
	SFW-1		SBW0	SFW0	SBW1
10					
11					
12					
13					
14		Hybrid			
		Sandwiches			
15		Test			
		6HSB+6HSF			
16					
17					

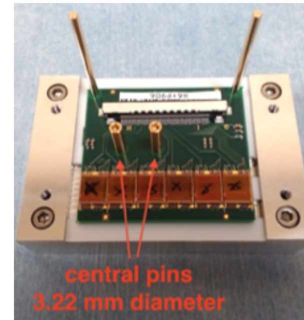
Legenda:

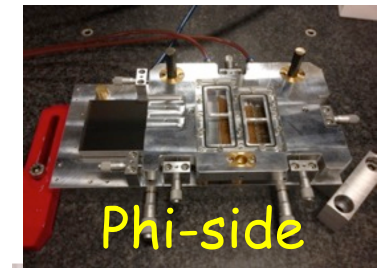
SFW-1	the 1st SFW glued the previous week
SFW-0	the 2nd SFW "
SBW-0	the 2nd SBW "
SBW1	the 1st SBW glued the current week
Spare Time	

Needed:	8 x (3.5h)-shifts	w/o automatic	procedure
	4 x (3.5h) shifts	w "	"
	1 x (3.5h) shift	for HS test	
Shift Crew:	2 Physicists		

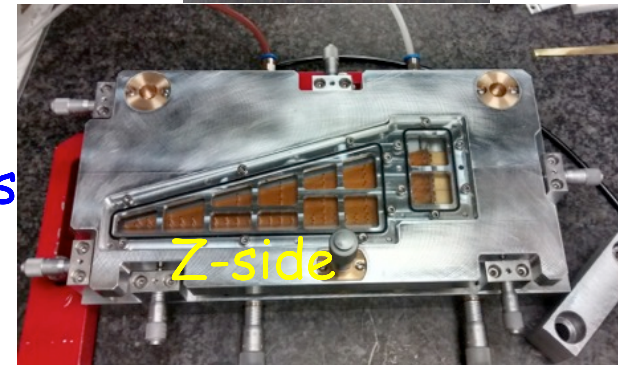
With the introduction of the automatic procedure in the SA el. tests, 1! Shift is needed to characterize a subassembly and resources can migrate to gluing.

BW/FW sub-assembly developed tools



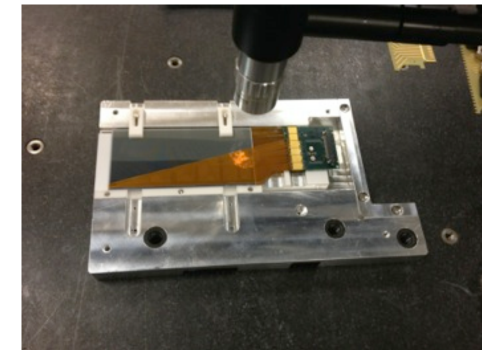


- Hybrid gluing jigs: sandwich single side hybrids

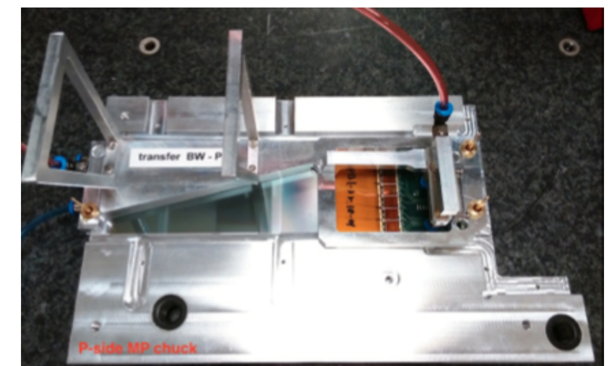


- Gluing jigs: det<->PA<->hybrid
Required high planarity for the chucks
Two (detector and hybrid) towers raising to squeeze the glue on the PA

- Multi Purpose Chuck: designed for bonding/ testing sub-assemblies in Pisa and their safe shipment (Z-side up). P-side up MPC are used to perform upside-down operation.



- Tranfer jigs: to safely transfer the subassembly
  - after the the P-side gluing to the MPC, perform the upside-down operation and take that on the Z gluing jig
  - after the Z-side gluing to the MPC



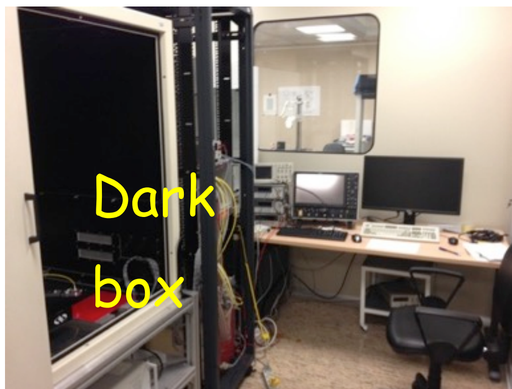
FW/BW sub-assembly production status (8 Sept.)

So far, not considering the class “D” subassemblies, Pisa produced (with final procedure and jigs):

- Backward
  - 3 class C SBW (before Pisa review in Oct. 2014)
  - 6 class C SBW (5 for the Ladder Sites + 1 for Pisa mech. Test, 1 under bonding)
  - 3 class B SBW
  - 4 class B+ SBW (1 to be further studied)
  - 5 class A SBW (2 el. characterized, 1 under el. test, 2 to be bonded)
- Forward
  - 3 class C SFW (temporary jigs used)
  - 1 class B SFW (the test-beam one, temporary jigs used)
  - 6 class C SFW (5 for the Ladder Sites + 1 for Pisa mech. Test, 1 under bonding)
  - 2 class B SFW
  - 3 class B+ SFW
  - 6 class A SBW (1 ready, 2 under el. test, 2 to be bonded, 1 failure)

Sub-assembly electrical characterization and laser-scan

- After the unique bonding phase (N&P side w/o any intermediate test) a complete electrical test is foreseen with the sub-assembly Z-up on the MP chuck, to eventually spot new defects (and verify the known ones!).
- The final qualification of the sub-assembly is the functional characterization by a laser scan.



- Giulia reported that on Sept. 3rd between the calibration tests and the laser scan the test-stand experienced a “failure”:
  - ADC Delay Scan returns delays with differs up to 4 ns;
  - with Internal Calibration Run on the reference hybrids, several warnings (one each event) arose.
- Standard working condition found on Sept. 8th by Eugenio without any modification/actions!

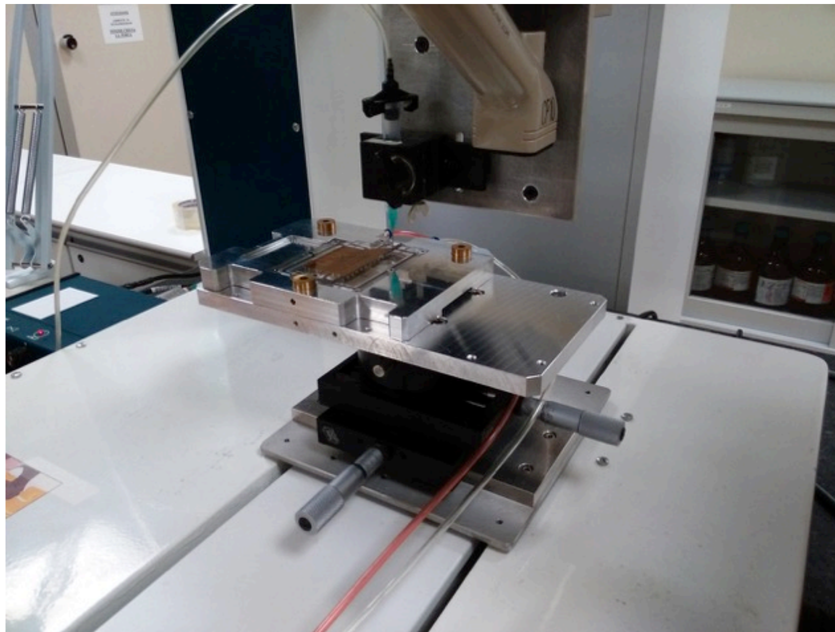
Micron det's ESD packaging
(left Pisa on June 24)

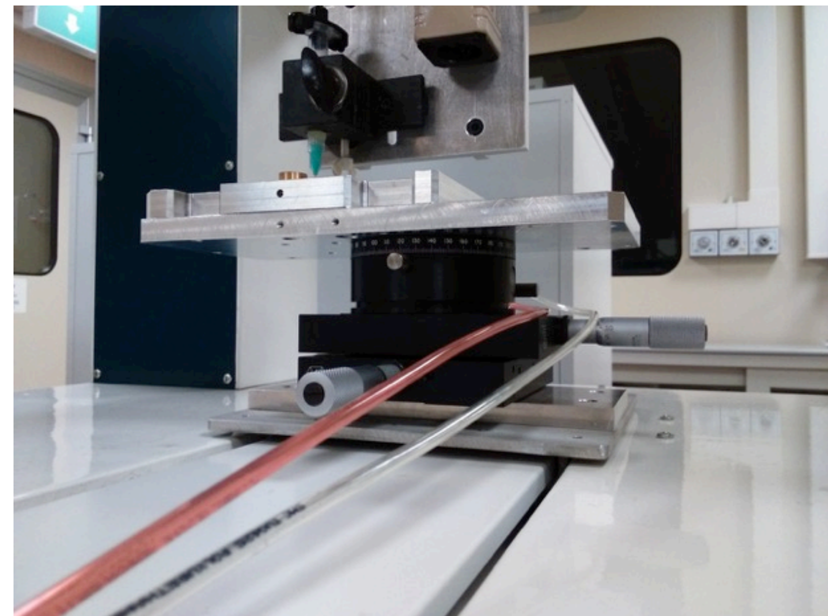
+ HPK # 83 to be tested (after wrongly using that to tune chucks)

These detector will be returned to Pisa (not shipped but safely carried by hand) on Fri. 11st September, with some mechanical piece (cooling pipe, MPCs) received from Vienna.

PA chuck under the gluing robot

The positioning of the PA chuck(s) under the gluing robot can be precisely moved, by installing the x-y/theta stages:





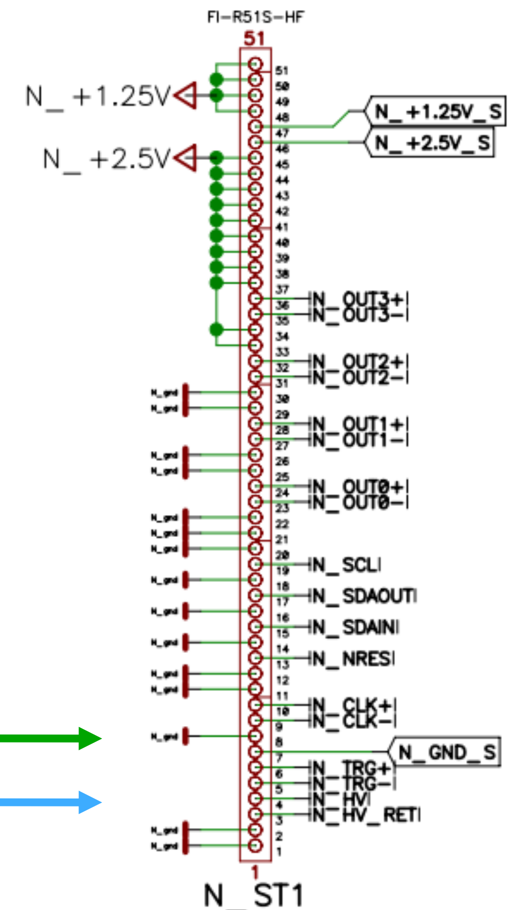
Now small variations of the position of the PAs on their chucks can be easily accommodated (the 2 holes on the PA are precise at 50 um level) w/o touching the tip of the syringe. Test program have also been improved.

Measurement of trigger and clock resistors on hybrids

For L5.001 class B ladder in the SVD meeting Sept 1st has been announced:

- Defect resistor on SFW003
  - Defect appeared during electrical test after it was glued onto ribs.
  - Worked fine during incoming inspection.
  - Extra samples in row data of p-side APV25 chips.
  - Calibration run was no more possible.
  - Caused by reflections due to broken 100 Ohm resistor (terminator) between trigger lines.
  - Resistor could be replaced.
  - Now the module works fine again.

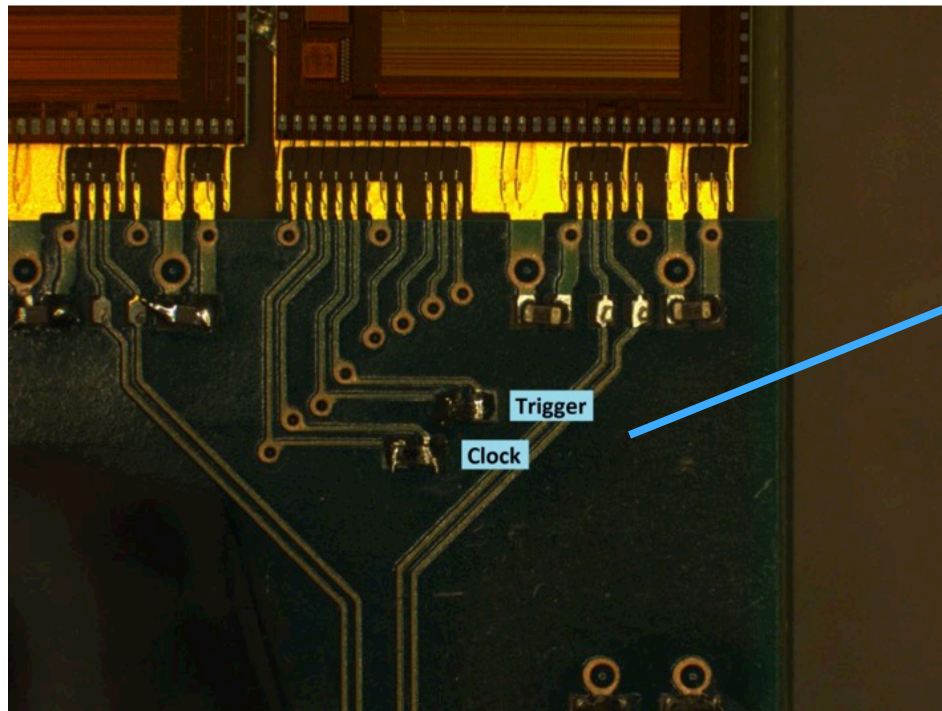
The defect has been found on HSF005 hybrid sandwich (p-side) = H6+P067 single hybrid



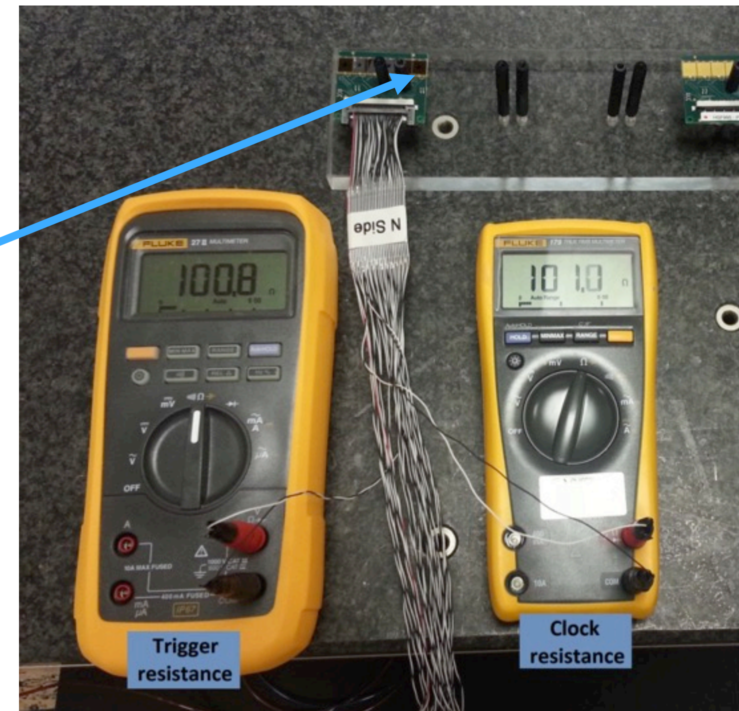
After that warrisome failure, we started a campaingn of measurements of the resistors between trigger lines (5-6) and clock lines (9-10)

Measurement of trigger and clock resistors of FW+BW hybrid sandwiches

All available hybrid sandwiches (class A, not yet used for subassemblies) have been tested: 20 forward + 20 backward = 80 resistors



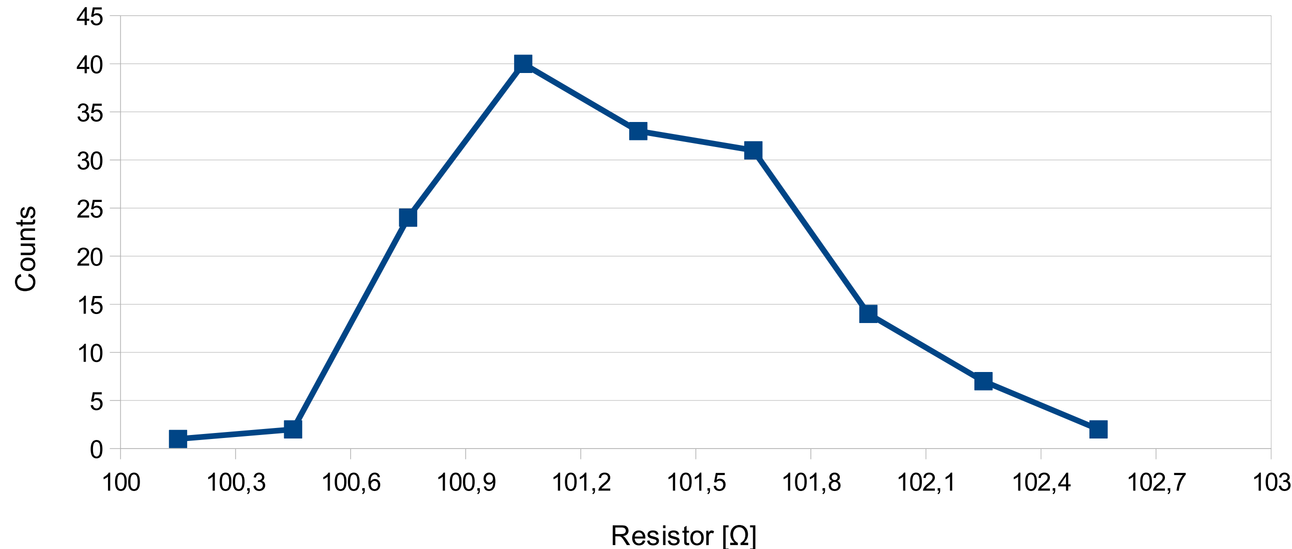
The resistors that have been measured (100 Ω, with 1% of nominal tolerance)



The setup used to perform the measurement

No broken resistors have been found (so far...)

Measurement of trigger and clock resistors of FW+BW hybrid sandwiches

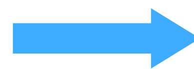


From this sample:

average = μ = 101.3 Ω
st. deviation = σ = 0.5 Ω

The single distributions (e.g. forward p-side trigger, etc.) have a similar trend

The lead resistance (cables, connectors, etc.) has been evaluated with the 4-wires probes method (by Keithley 2001)1.2 Ω



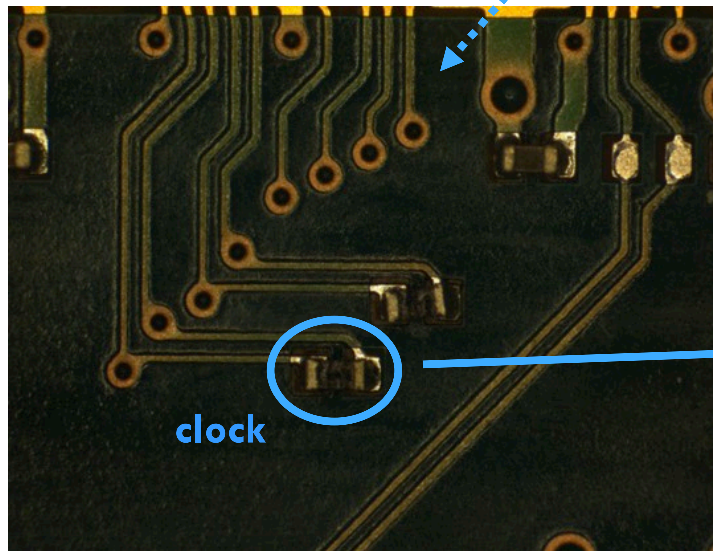
R = 100.1 ± 0.5 Ω

Only one measured resistor (not shown in the plot above!) is far more 3σ from the average value (see next slide)

Measurement of trigger and clock resistors of FW+BW hybrids

The clock resistor of HSF010 p-side (= H6+P065) is 104.1 Ω (5.4σ from the average value!)

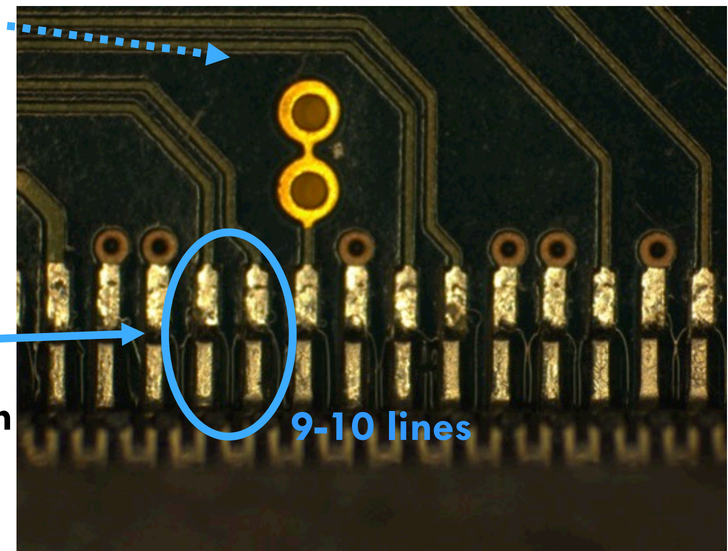
An optical inspection has been made under the microscope



The resistor seems "sane"

HSF010 has passed the electrical test

All other resistors as well observed are OK under optical inspection (there aren't visible defects)



Still to do the measurements on:

1. the 2nd batch hybrid boards (before the el. test and sandwich gluing)
2. the class A SFW and SBW already produced(please do the same @IPMU on the new 4 class B+ subassemblies)

Finger-print of the sandwich mask (with white paint)

A "mechanical" damage by the sandwich mask can be excluded