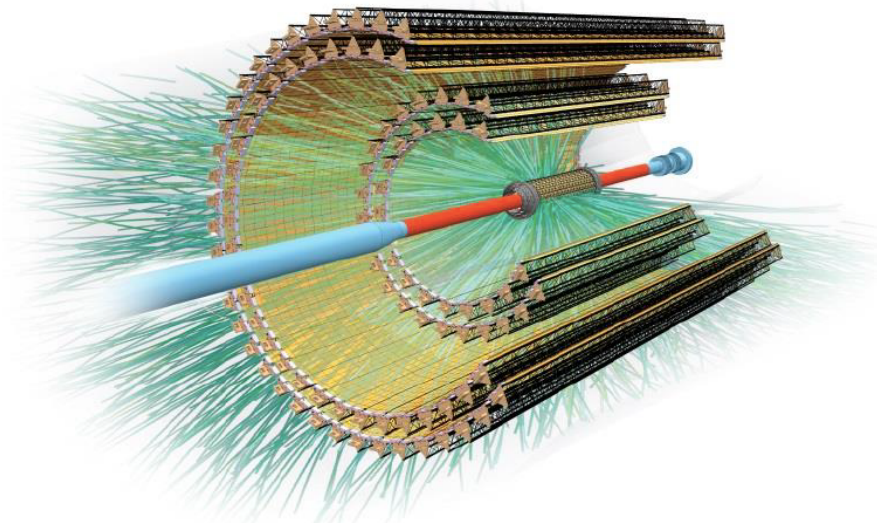


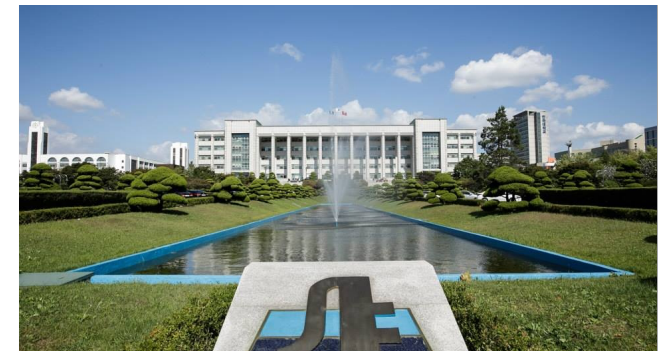
# ITS OB HIC Production - Status and Plans

*Vito Manzari - INFN Bari*



12th ALICE ITS upgrade, MFT and O2 Asian Workshop

19-21 November 2018 Inha University



# Outline

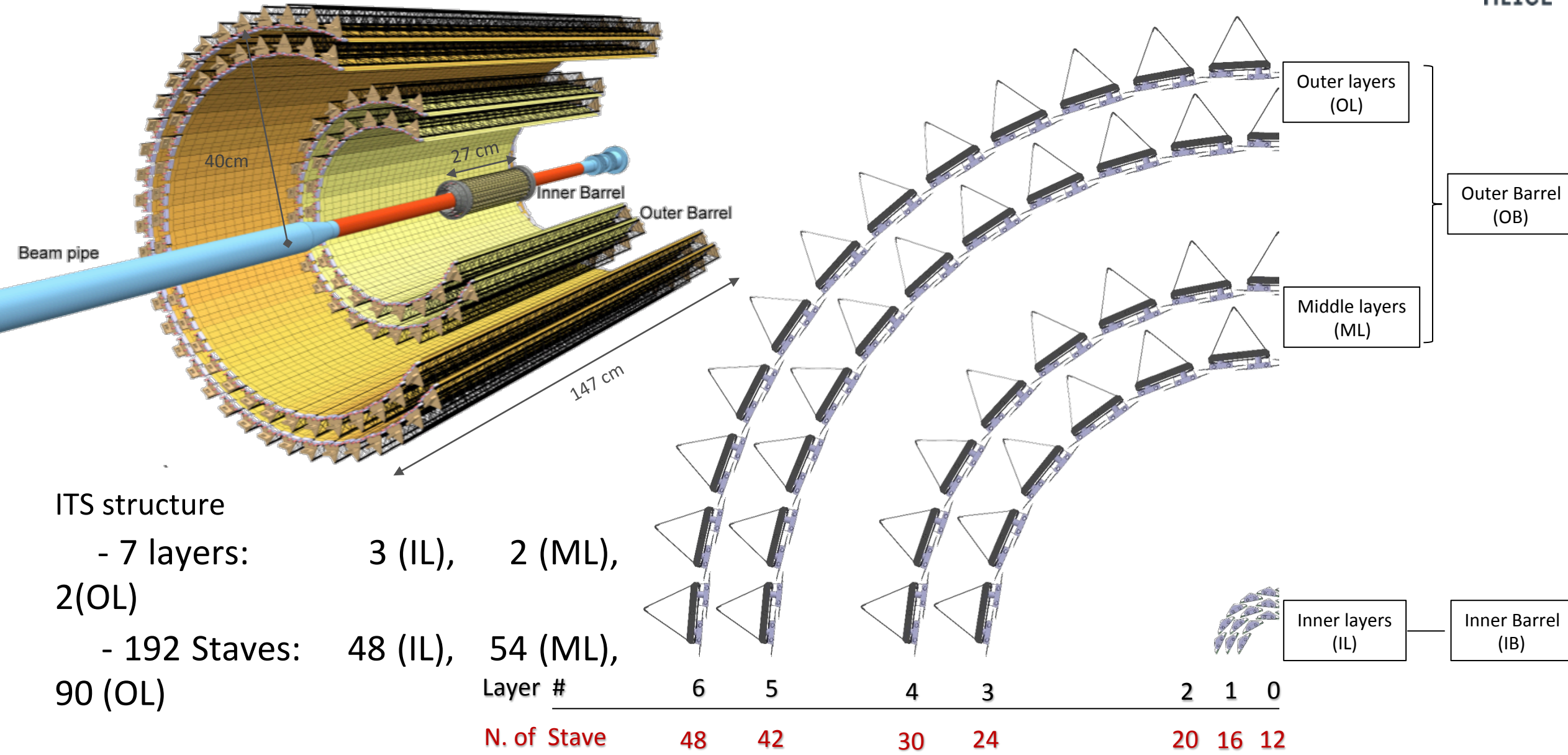
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ALICE ITS Upgrade



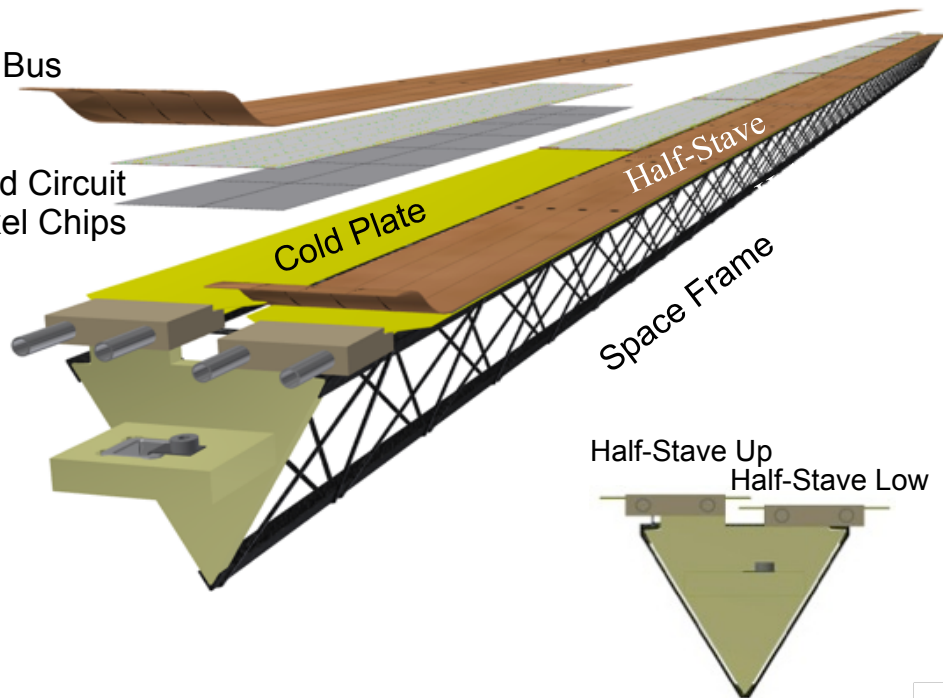
- ① Detector Layout
- ② HIC Construction overview
- ③ FPC Production
- ④ HIC Production and Plans
- ⑤ HIC Yields
- ⑥ HIC Distribution
- ⑦ Remarks
- ⑧ Conclusions

# Detector Layout

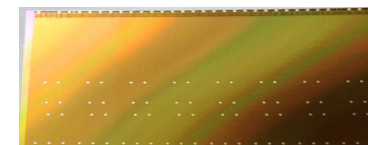


Power + Bias Bus

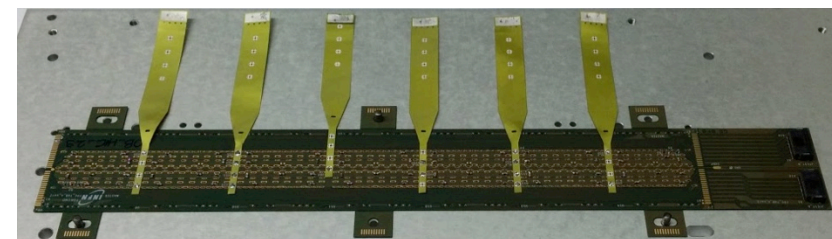
**HIC:**  
Flexible Printed Circuit  
2x7 Pixel Chips



Middle and Outer Layers are equipped with identical HICs



14 ALPIDE chips

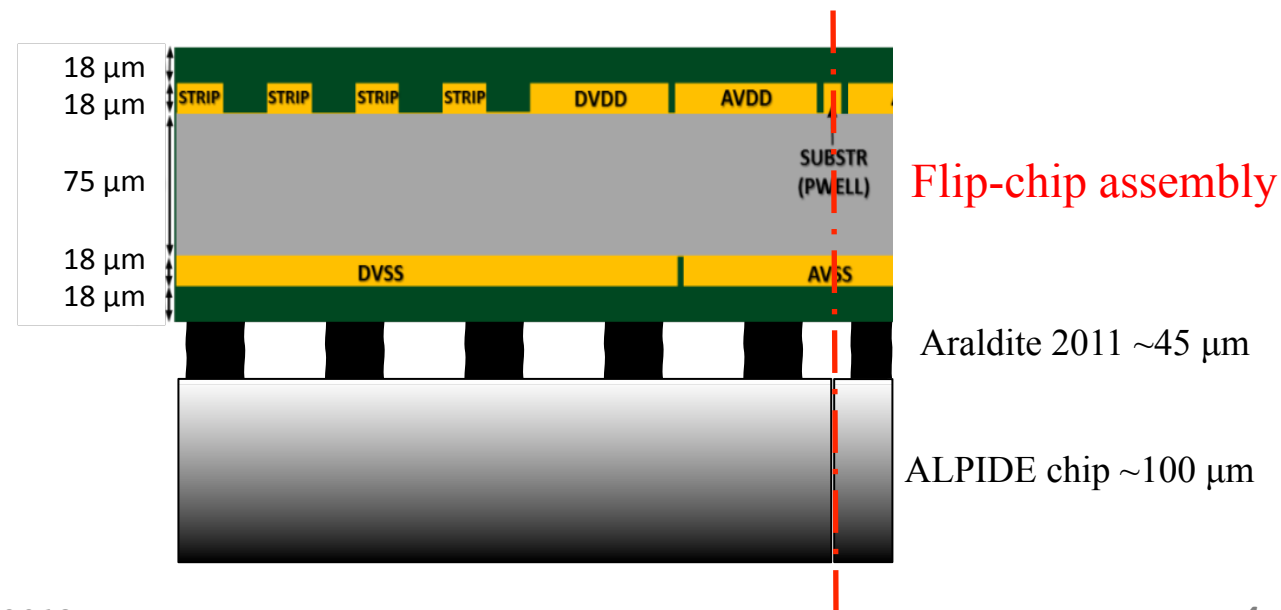
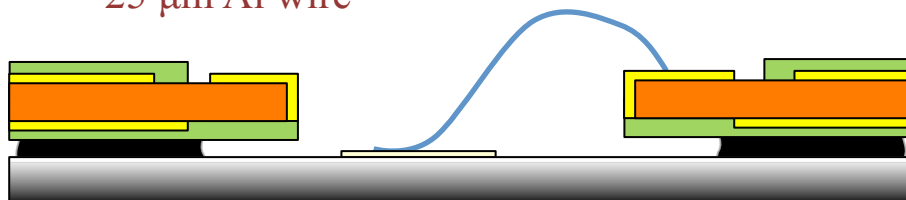


1 FPC

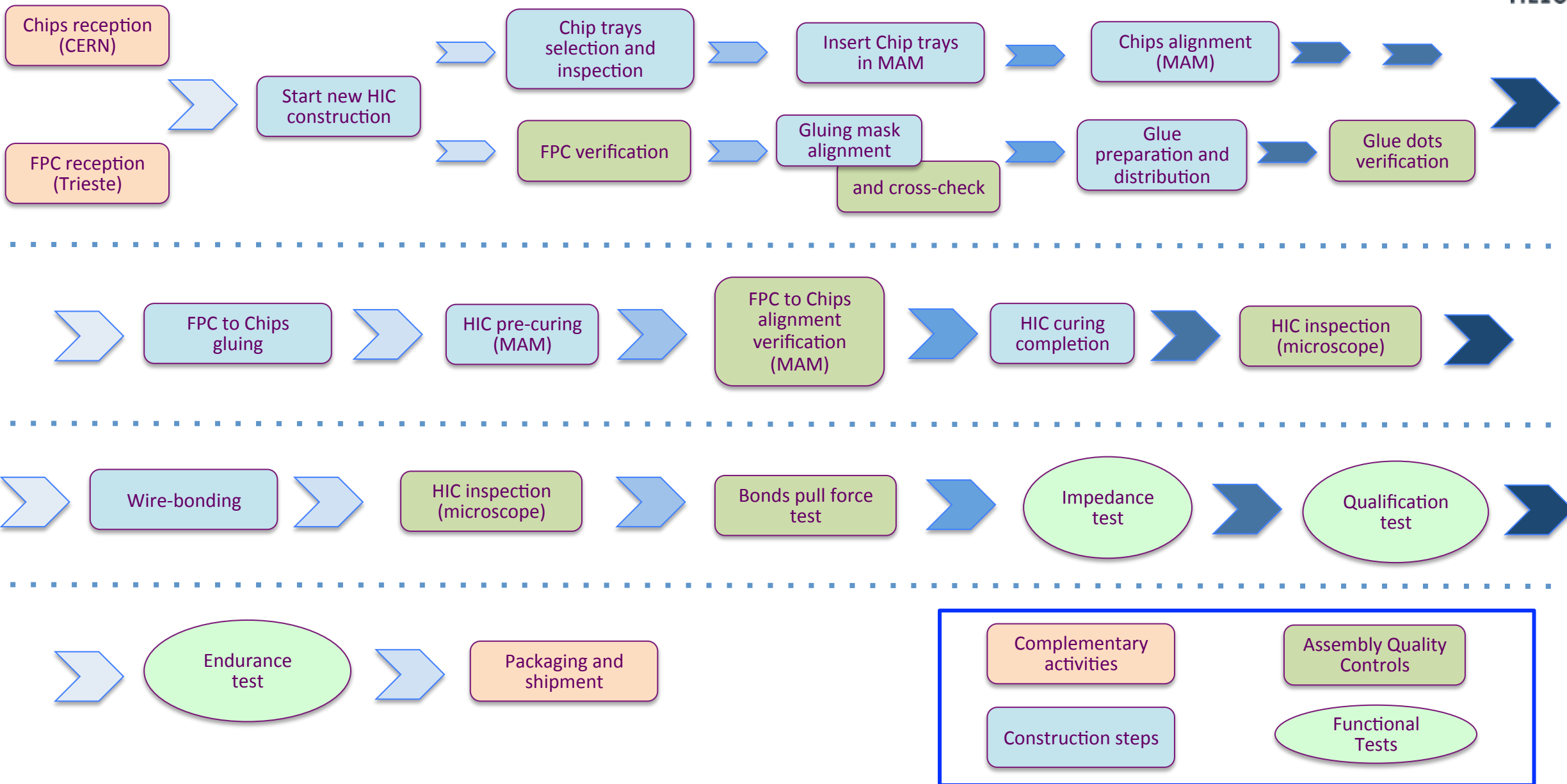
## FPC-to-ALPIDE interconnection

Wire-bonding through vias

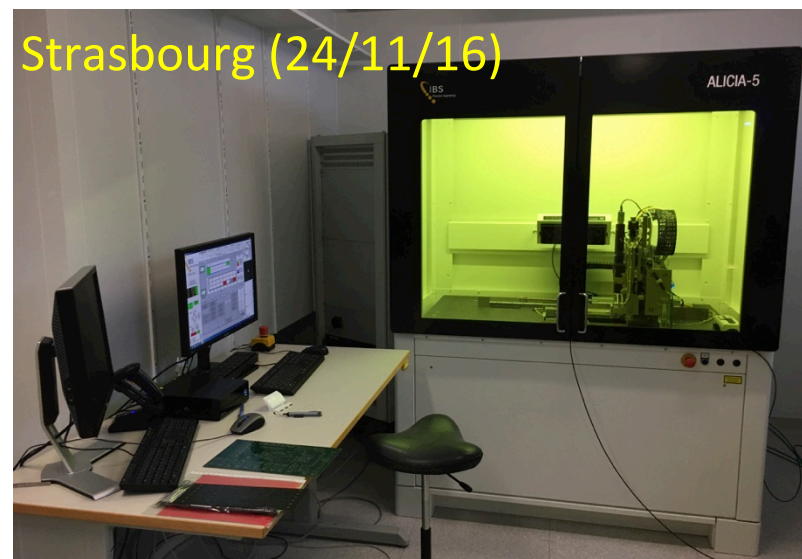
25  $\mu\text{m}$  Al wire



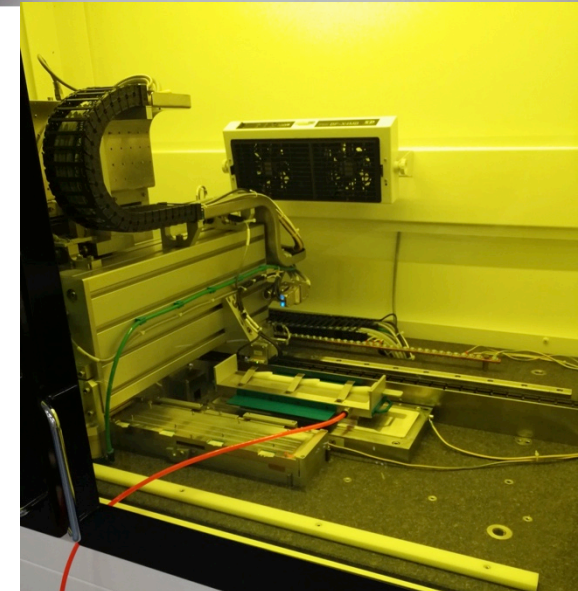
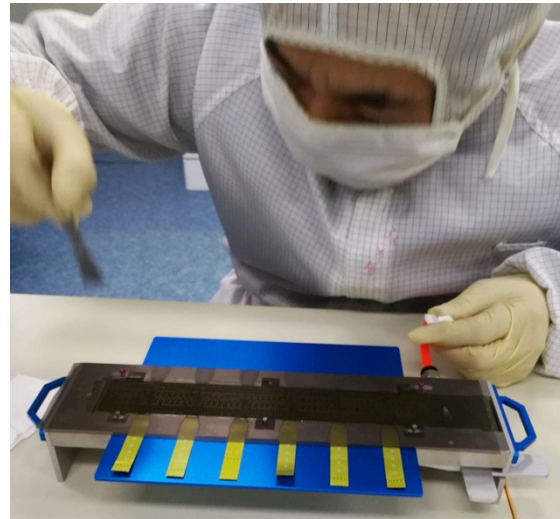
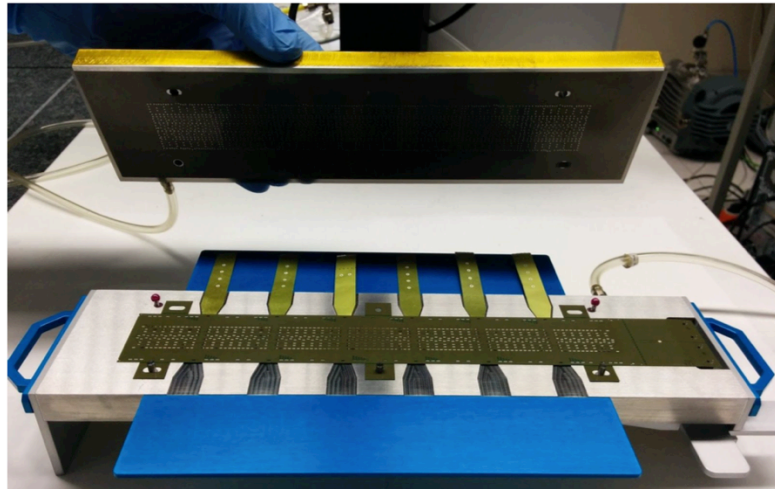
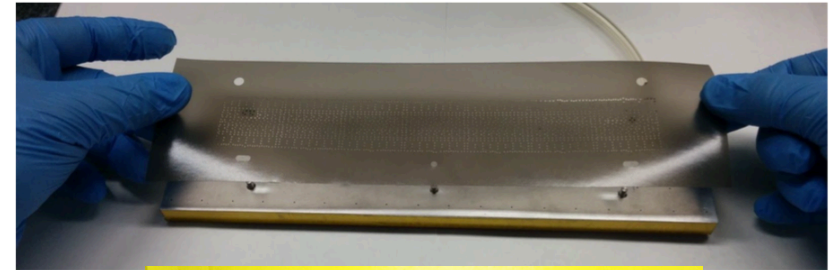
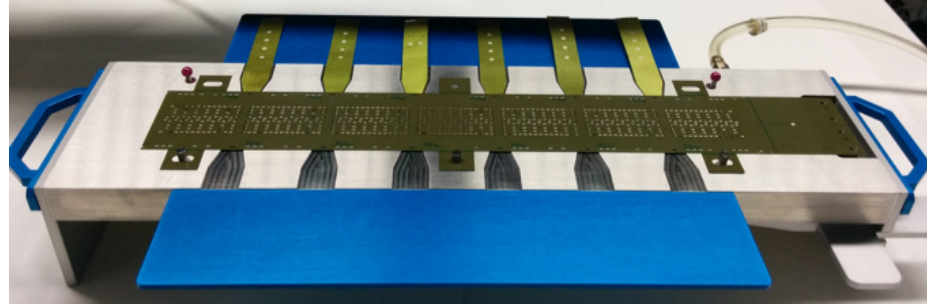
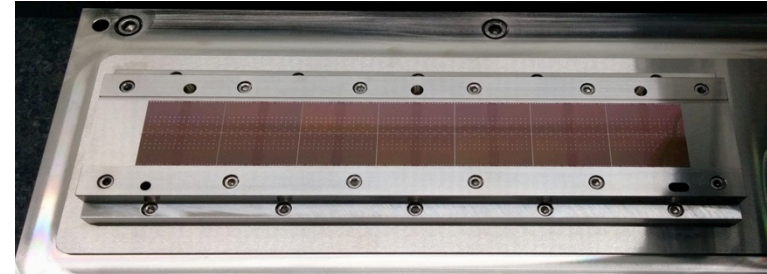
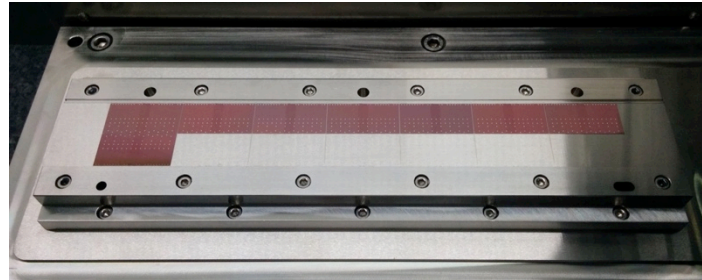
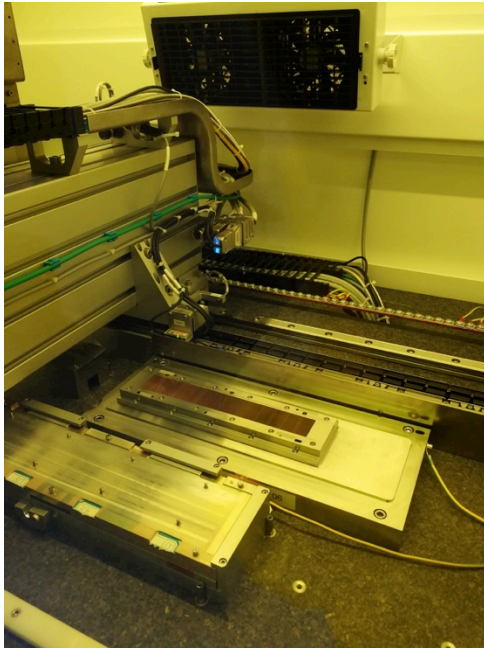
# HIC construction process



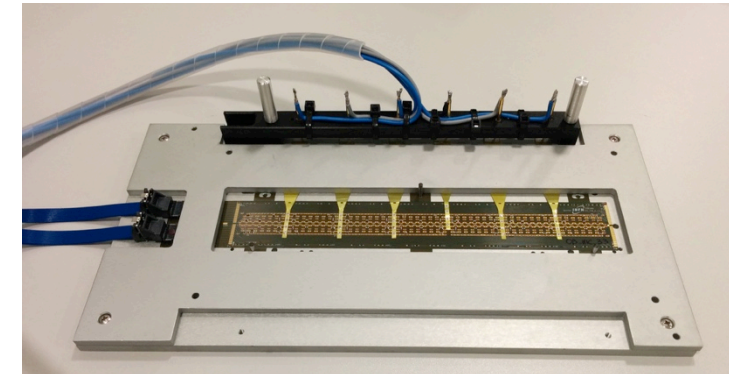
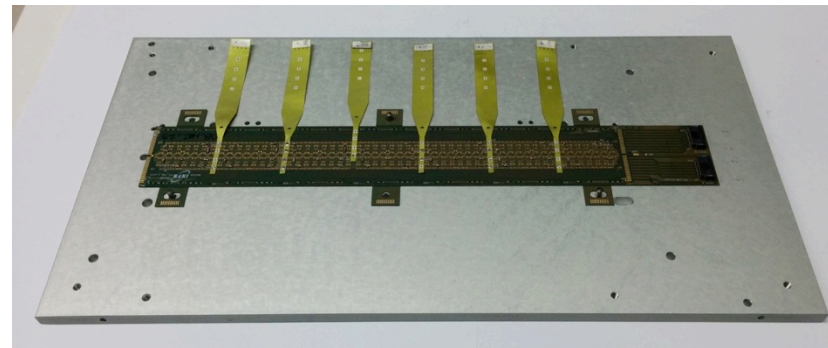
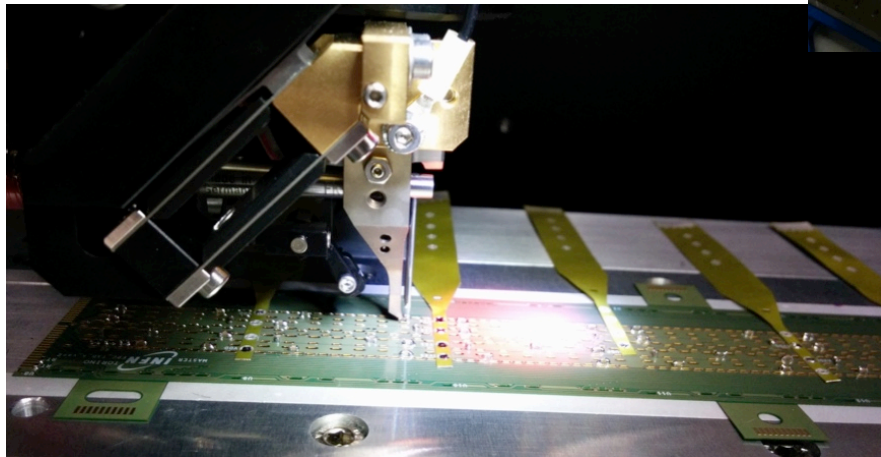
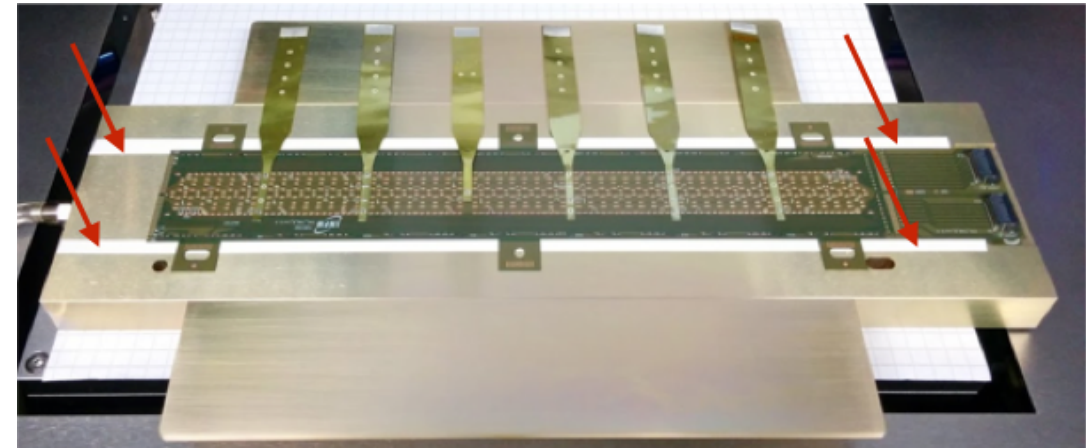
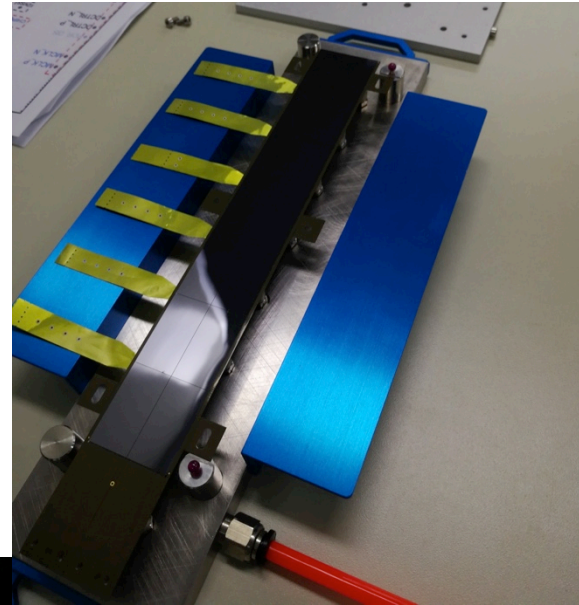
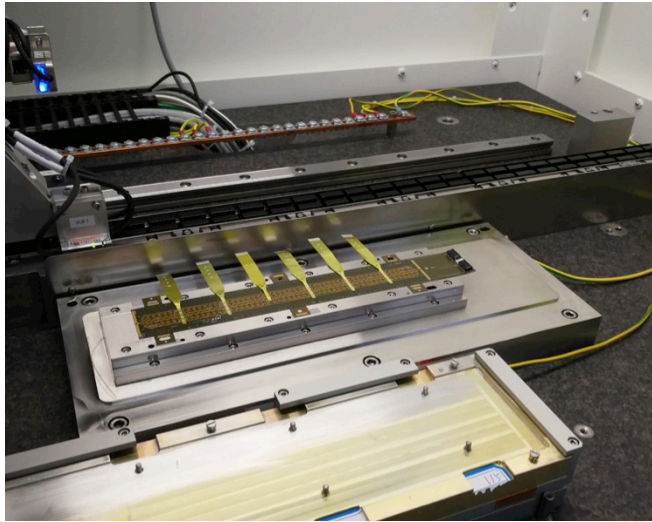
# OB HIC construction sites (MAM site acceptance test)



# OB HIC construction - Tooling, Procedures and Training



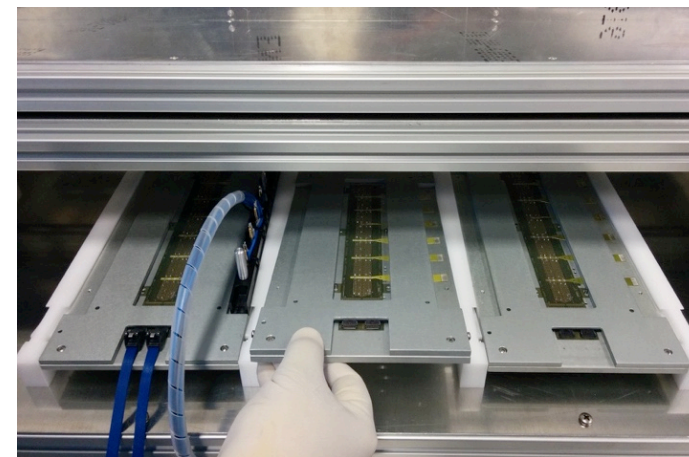
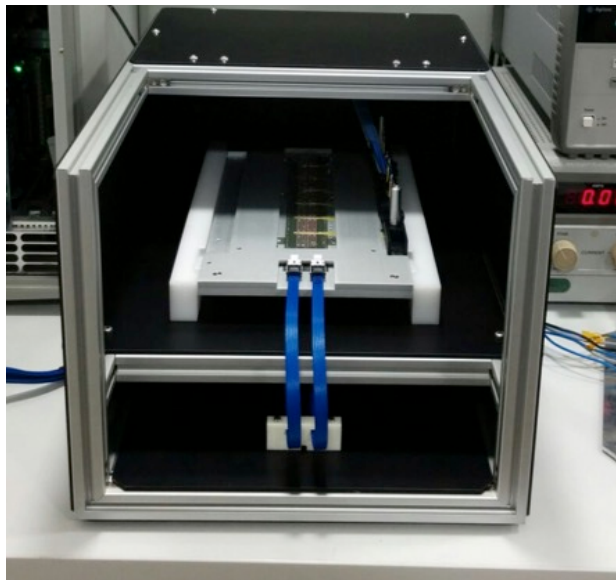
# OB HIC construction - Tooling and Procedures



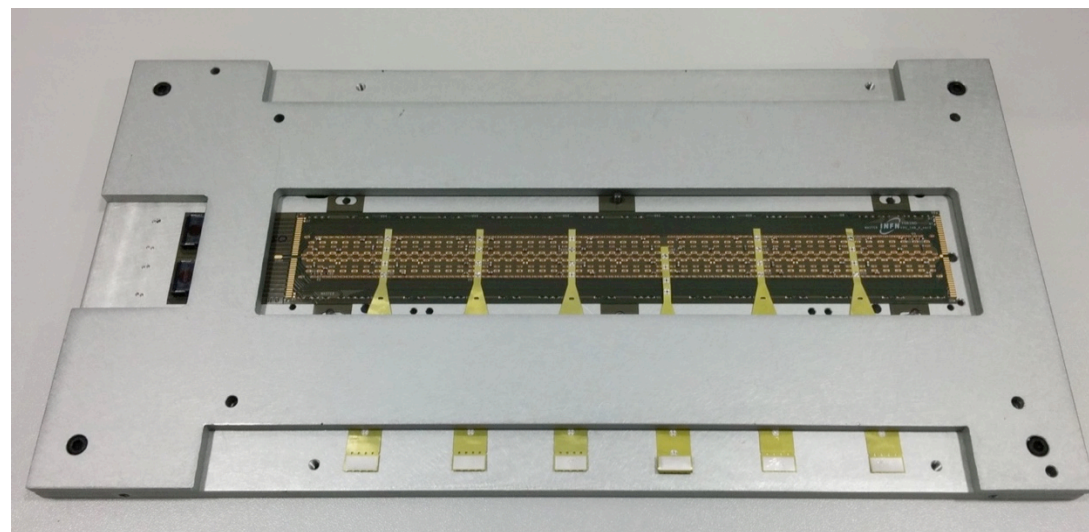
Ultrasonic wedge bonding for FPC to chip interconnection:

new bonding machine procured for Bari, Strasbourg and Wuhan; a supply contract signed with Sejung company for Pusan; resources allocated by the laboratory management for Liverpool





## Qualification and Endurance test systems



Nominal quantity of FPCs needed: 2700 (including spares, yield, quality control)

Production at GS Swiss will be completed by the end of 2018

Pre-production and 1<sup>st</sup> ÷ 5<sup>th</sup> production batches:

2014 FPCs (1607 Tab-A and 407 Tab-B type) produced, validated and distributed to HIC sites

6<sup>th</sup> production batch:

308 FPCs (276 Tab-A and 32 Tab-B type) Cross-Cables mounting and validation ongoing, distribution will start this week

7<sup>th</sup> production batch: ~470 FPCs, production at GS Swiss just started, delivery expected before Christmas

**Extra batch: ~350 FPCs, purchasing order in preparation**

~970 FPCs still available (~200 already distributed + 770 from 6<sup>th</sup> and 7<sup>th</sup> batches) and ~1200 HICs still to be produced (see following slides)

Quality controls and preparation:

Extensive **quality assurance** tests (metrology, electrical tests, visual inspection) at **Trieste** and **Catania**

**Metal quality** verification via sample **wire bonding/pull tests** @ CERN and assembly sites

Soldering of **cross cables** (for connection to power and bias cables), test, **drying** and cleaning at Trieste

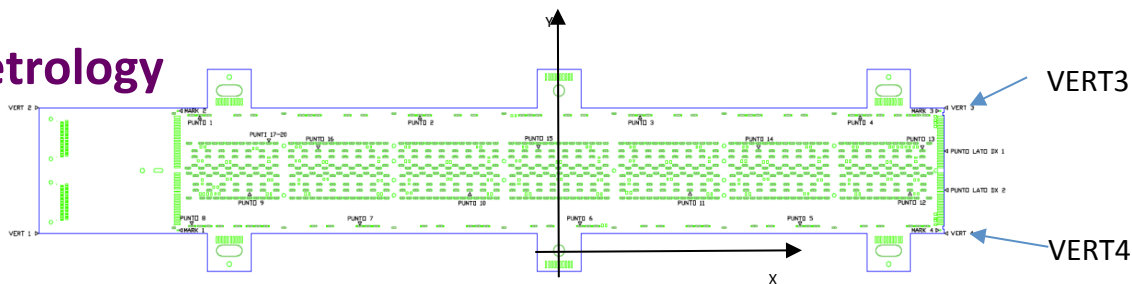
Stable production yield per batch: 93% ÷ 97%

~1% metrology out of specs

<1% electrical out of specs

2% ÷ 6% optical inspection: bending, local deformations and/or defects

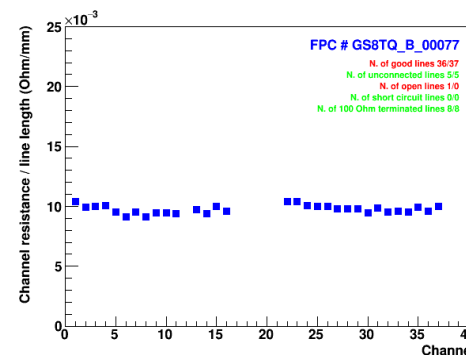
## Metrology



Verification of position of selected structures and edges with respect to center of central dowel pin hole

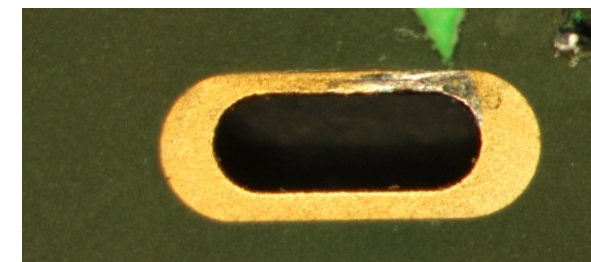
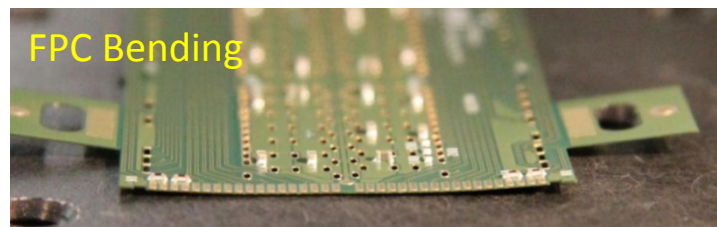
## Electrical tests

Check for short or open lines at different stages



## Optical inspection

Main source of found defects  
Few random problems  
Structural bending



*N.B.: In the following plots and tables, Pusan → Pusan/Inha*

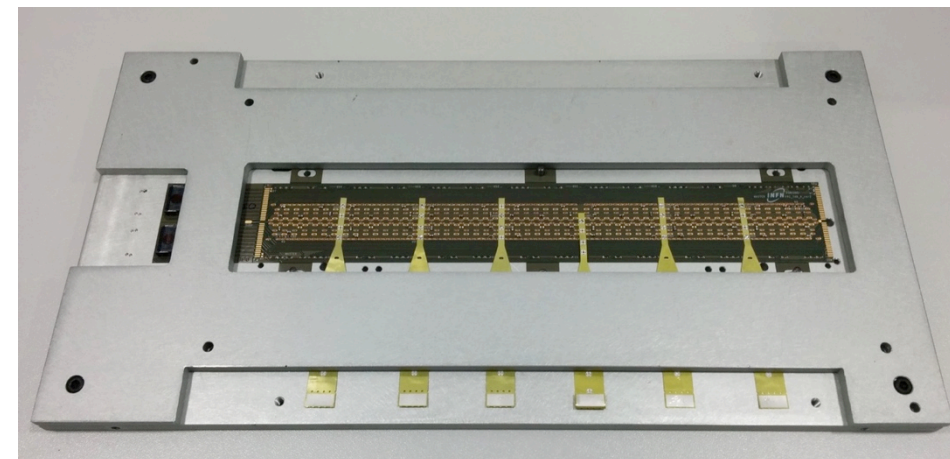
Number of HICs to equip the OB layers: **1692**

Assuming a convoluted HIC (~83%) & Stave (~90%) Yield: ≈75%

Number of HICs to build to equip the OB:  $1692/0.75 = \mathbf{2256}$

HICs built so far: **1388 (~62%)**

Additional spare HICs to build: ≈250 → ≈**2500 HICs overall**



	PRODUCED	QUALIFIED	NOT QUALIFIED	WORKING	NOT WORKING	ENDURANCED
Bari	367	346	21	293	53	270
Liverpool	397	375	22	317	58	300
Strasbourg	365	321	44	270	51	255
Pusan	64	3	61	0	3	0
Wuhan	195	185	10	142	43	108
<b>TOTAL</b>	<b>1388</b>	<b>1230</b>	<b>158</b>	<b>1022</b>	<b>208</b>	<b>933</b>

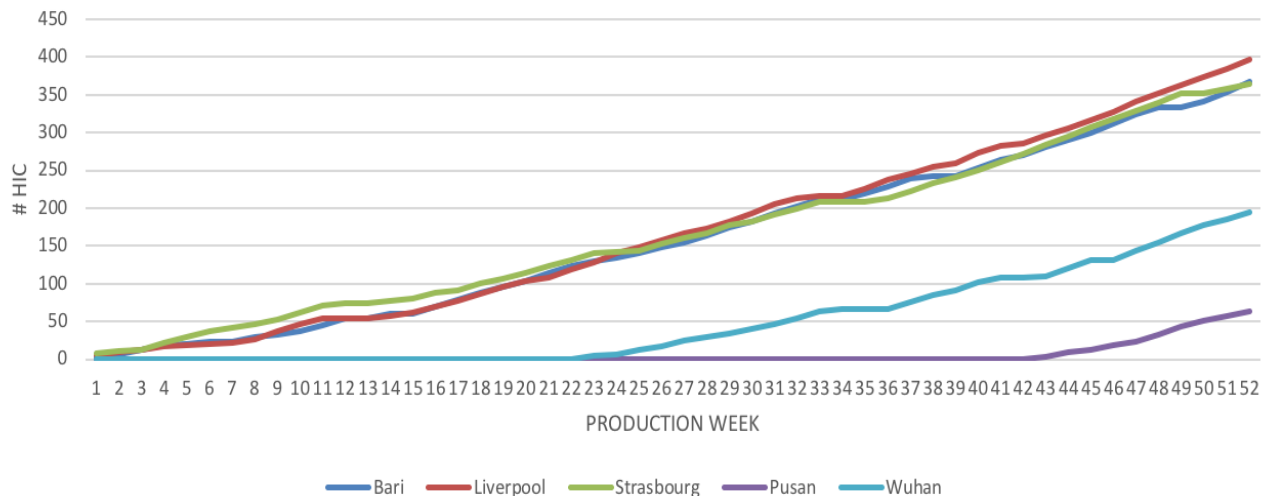
**End of HIC production  
Mar 2019**

Target production rate: **50 HICs/week**

**2 HICs/day/site** assuming 5 working day/week

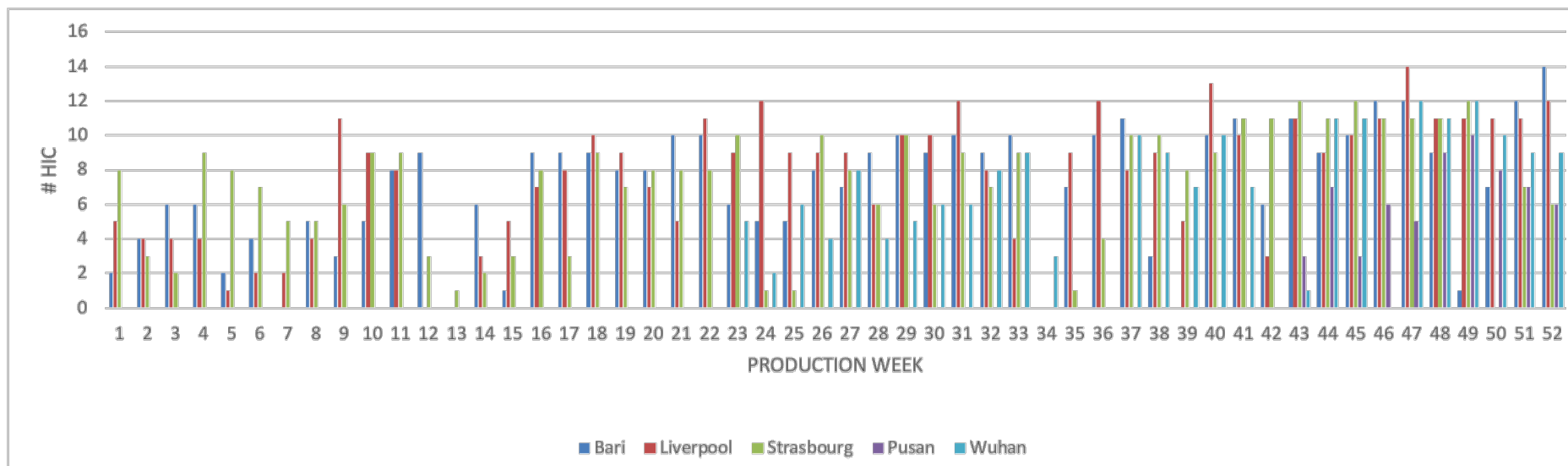
Modified procedure, based on a shorter curing time inside MAM, allows to increase the weekly production rate

## Steady production in Bari, Liverpool, Strasbourg, Wuhan and ramping-up in Pusan/Inha

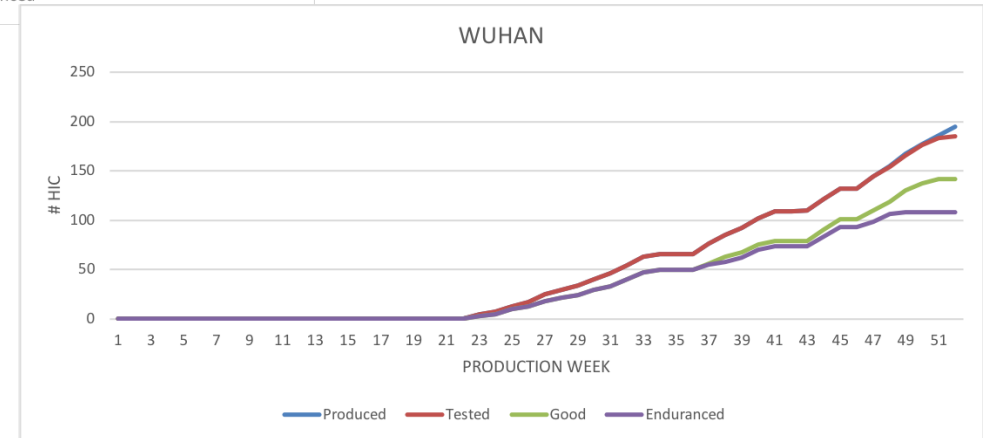
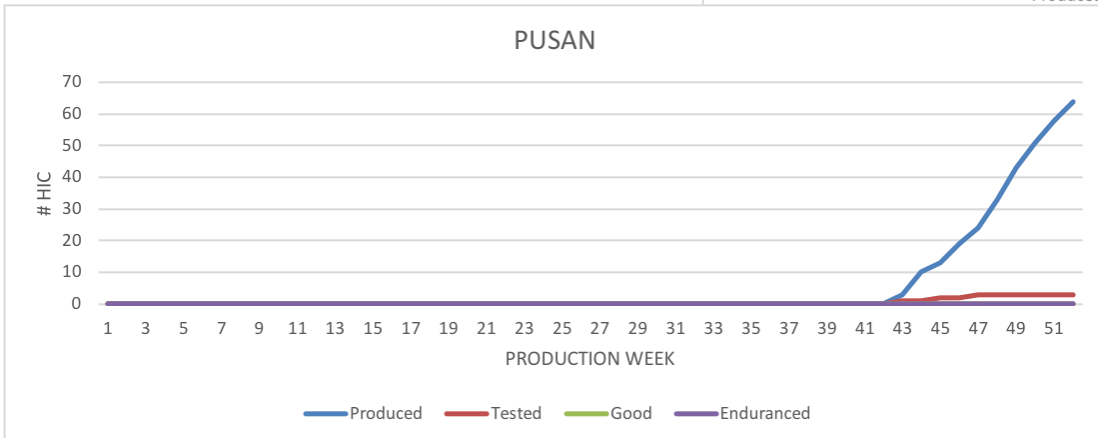
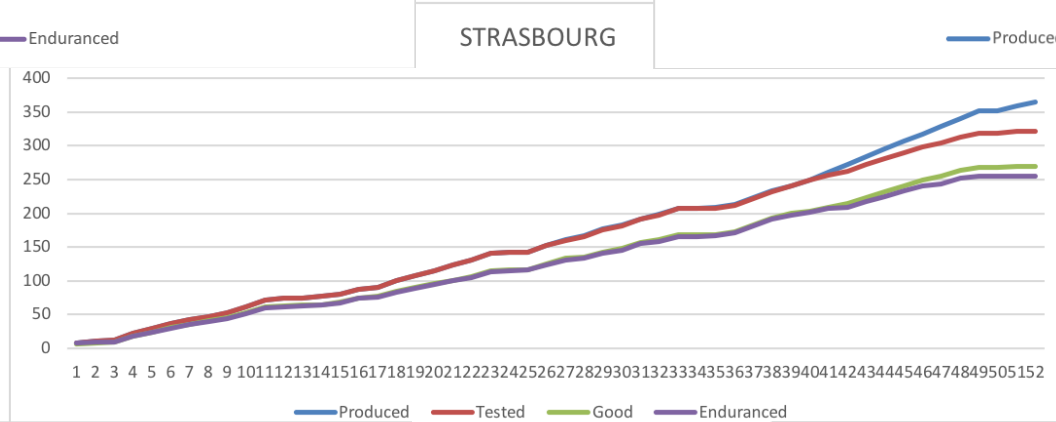
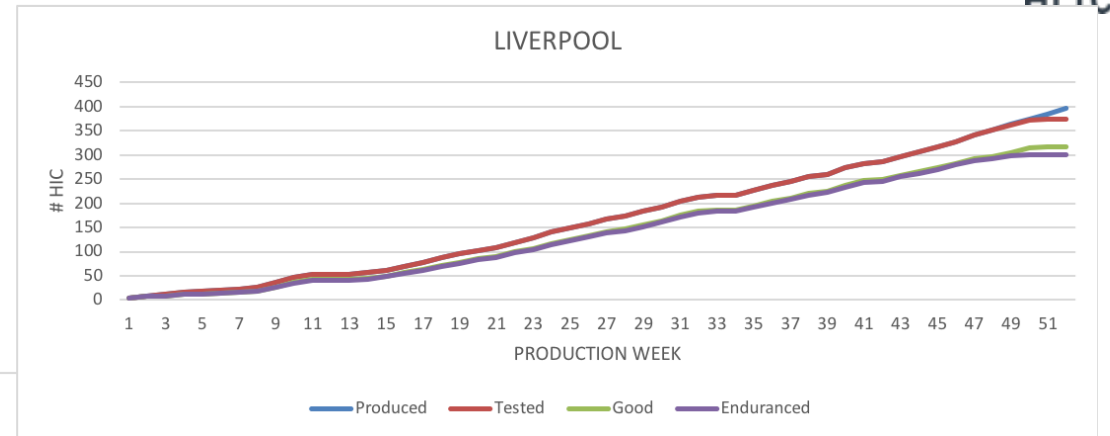
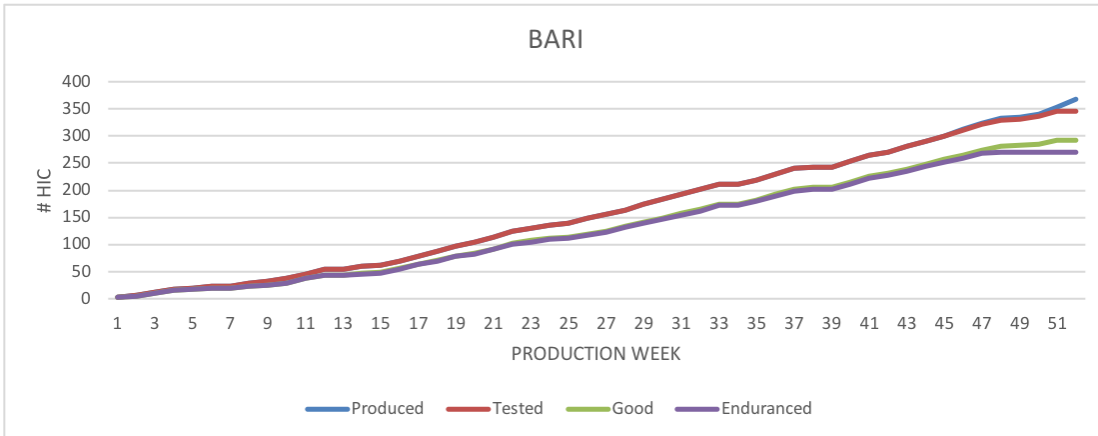


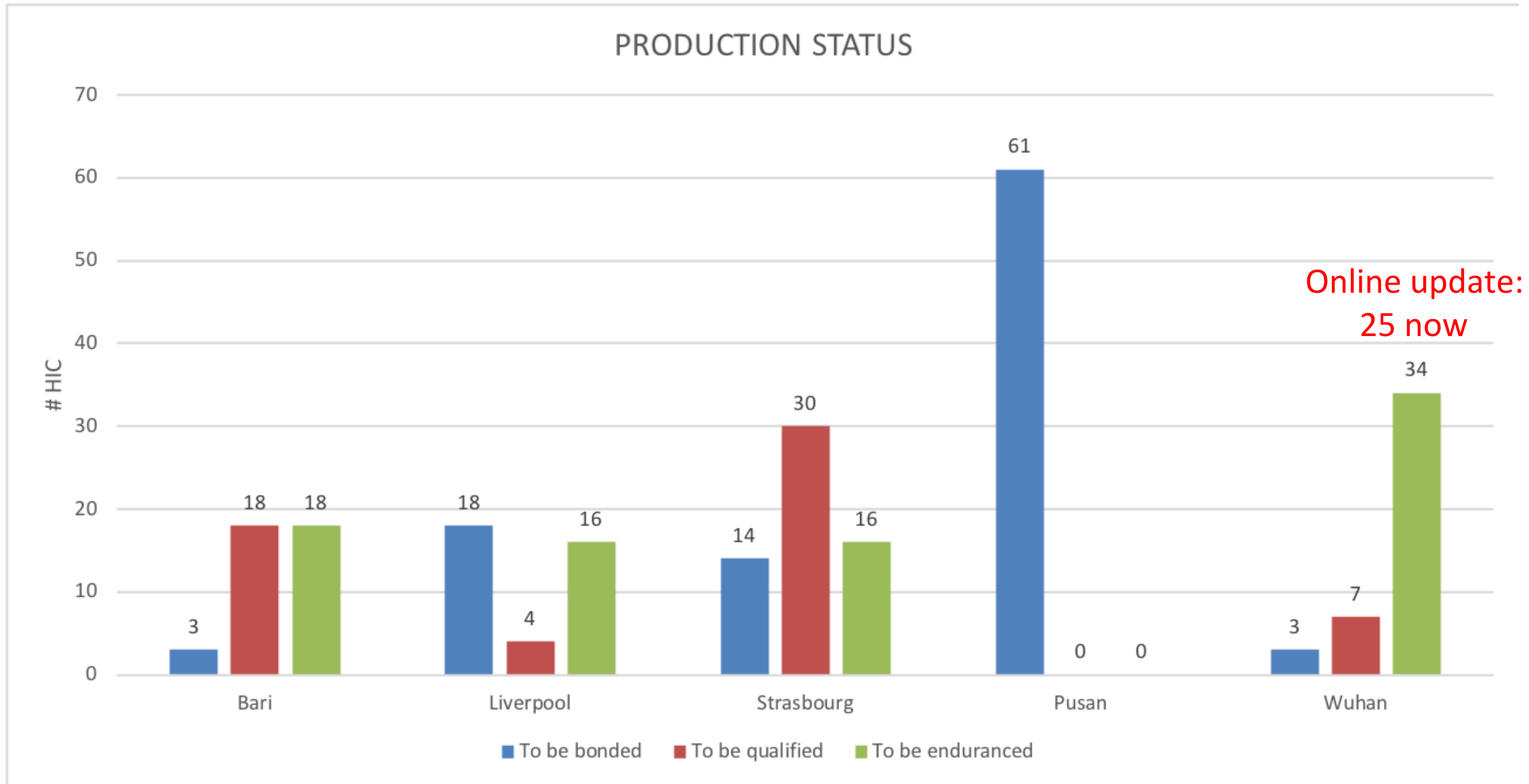
	week 41 pr. week 47	week 42 pr. week 48	week 43 pr. week 49	week 44 pr. week 50	week 45 pr. week 51	week 46 pr. week 52
<b>Bari</b>	12	9	1	<del>7</del>	12	14
<b>Liverpool</b>	14	11	11	<del>11</del>	11	12
<b>Strasbourg</b>	11	11	12	<del>6</del>	6	6
<b>Pusan</b>	5	9	10	<del>8</del>	7	6
<b>Wuhan</b>	12	11	12	<del>10</del>	9	9
<b>TOTAL</b>	54	51	46	<del>36</del>	45	47

Production rate of ~49 HICs/week in the last 5 weeks  
w44 excluded because of holidays in Italy and France

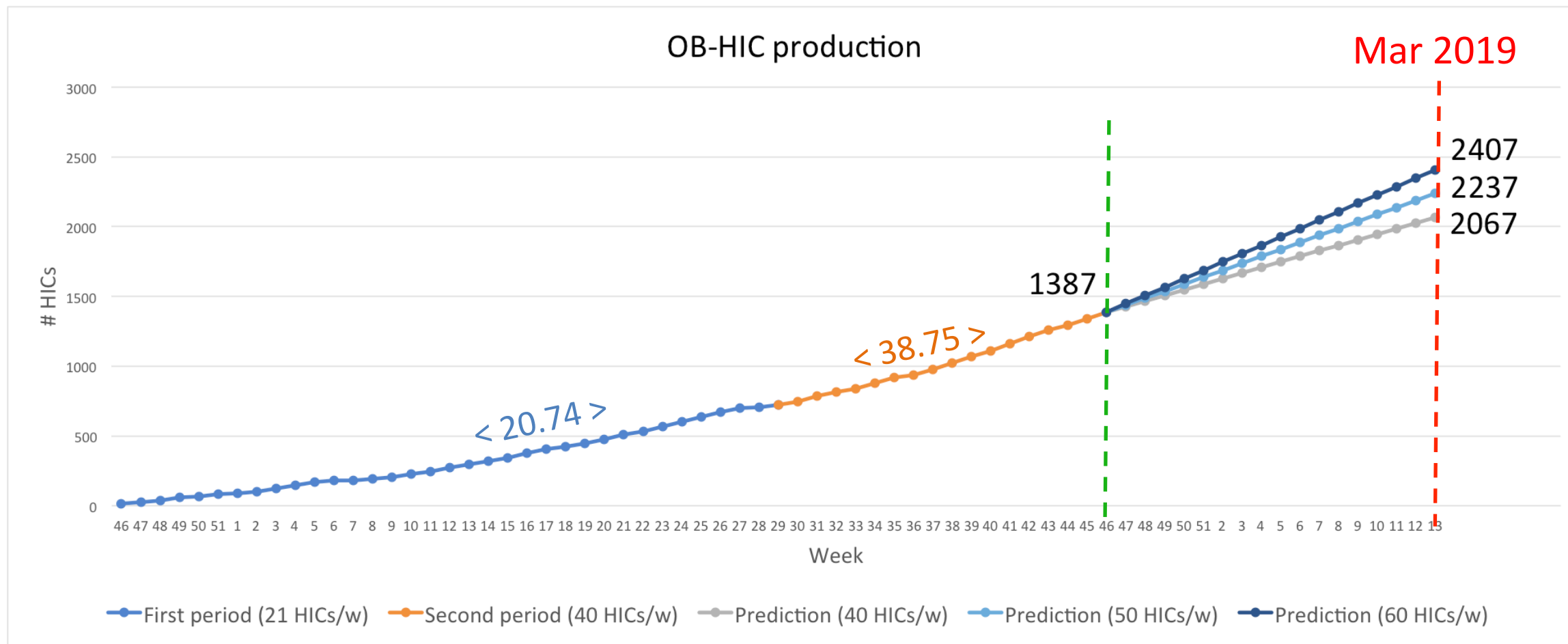


# OB HIC production



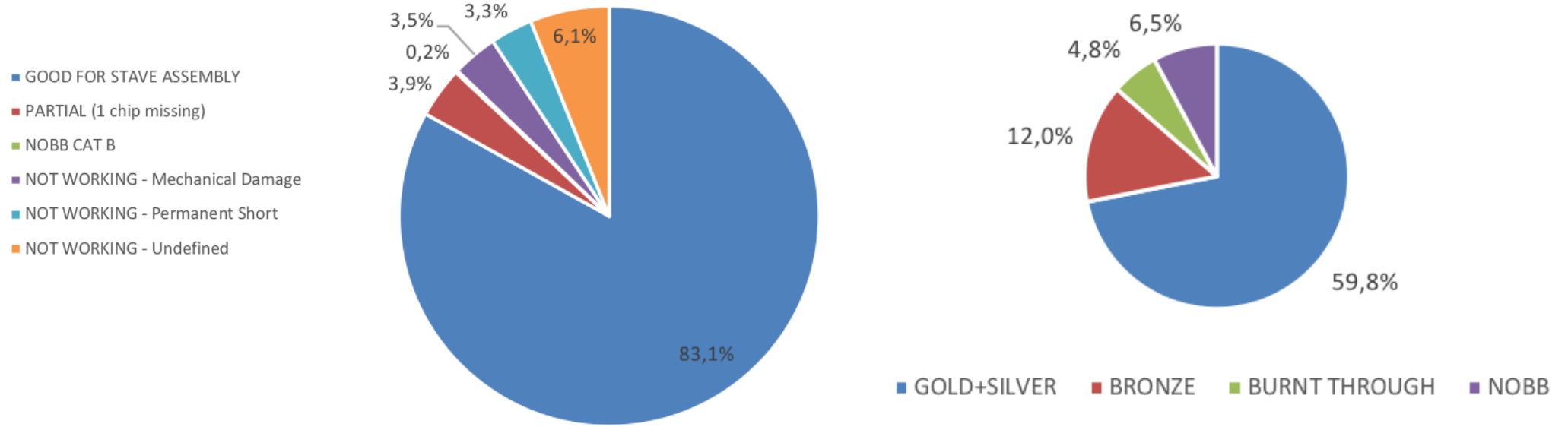


HIC Production End milestone Mar 2019 → 17 weeks left

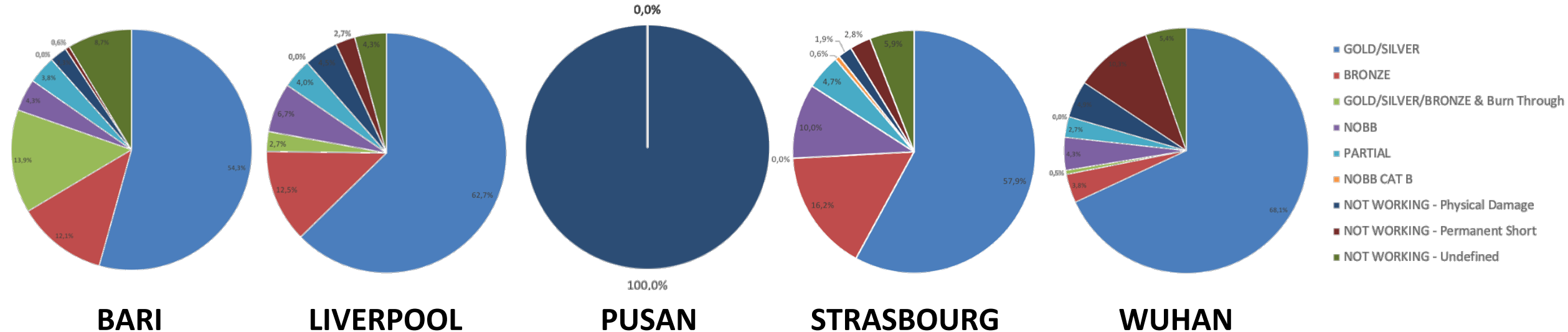


Exploit the modified procedure (reduced MAM downtime due to pre-curing) to fulfill the milestone

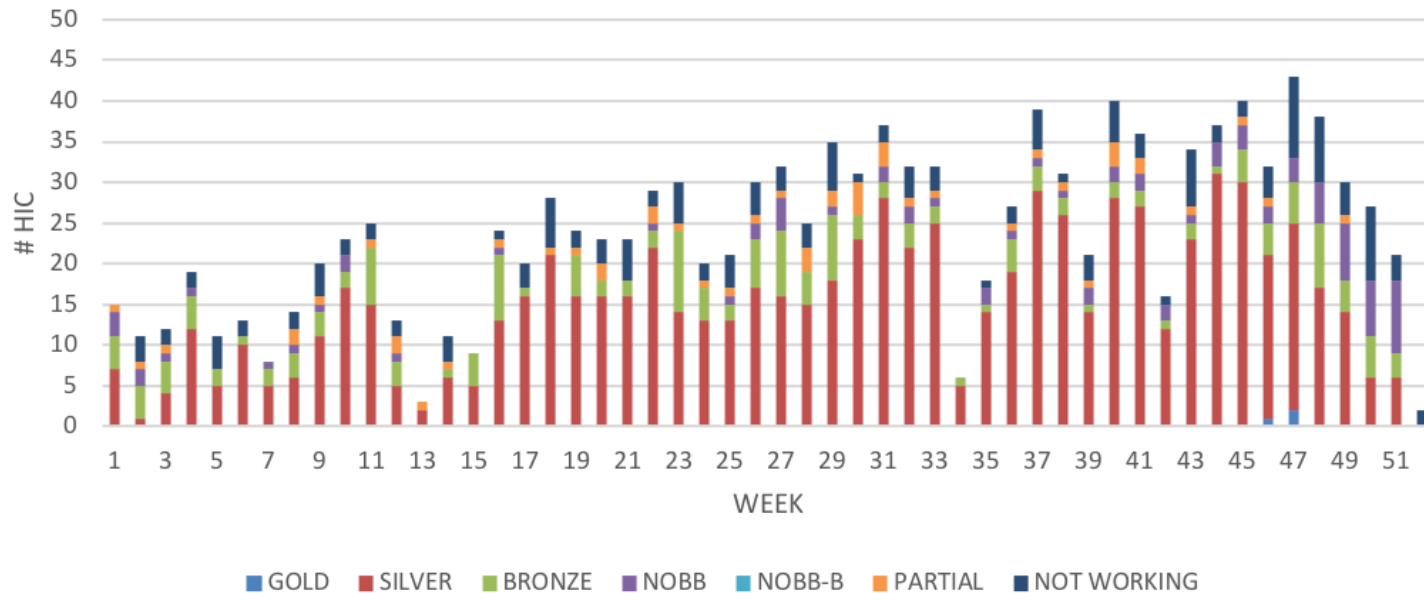
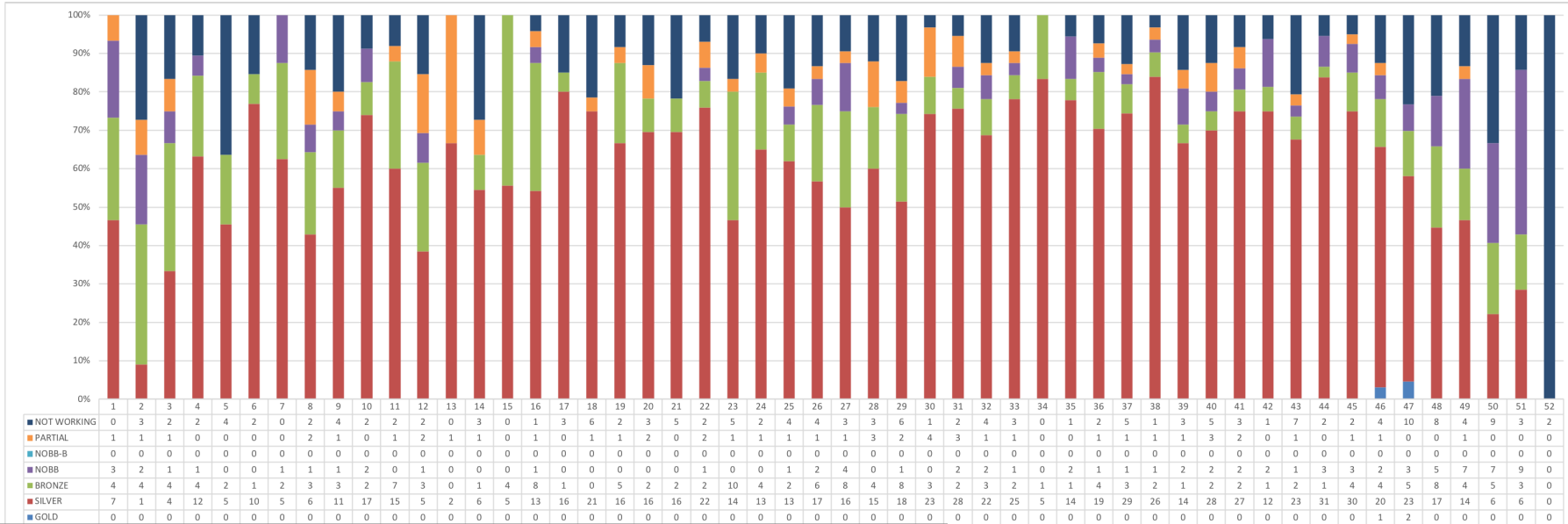
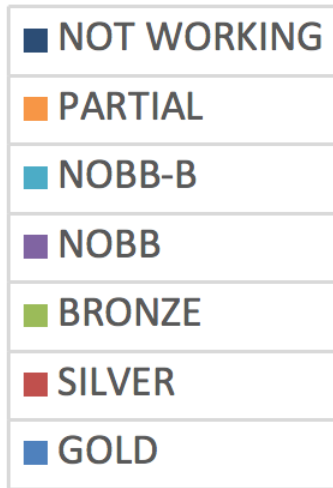




Yield figures and quality quite uniform across the sites

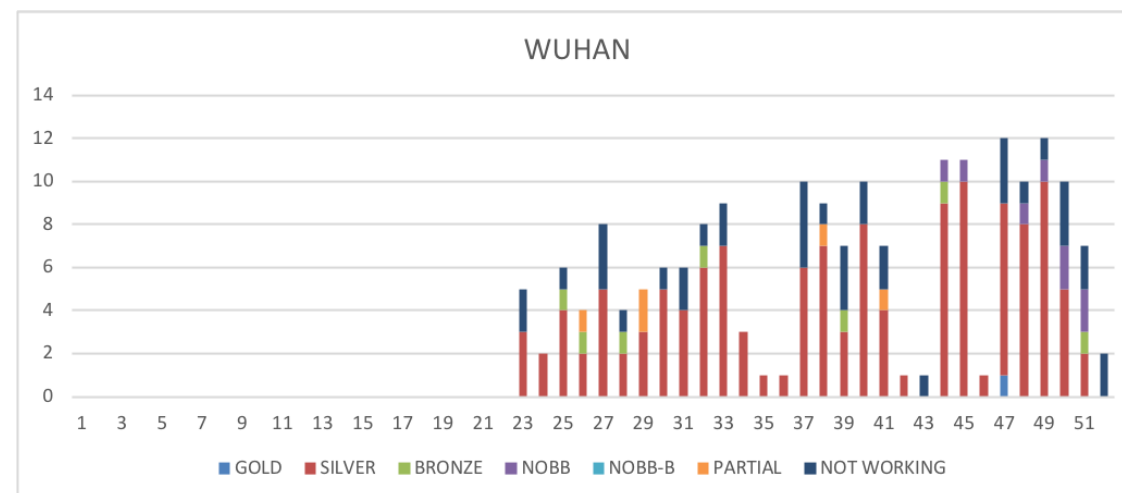
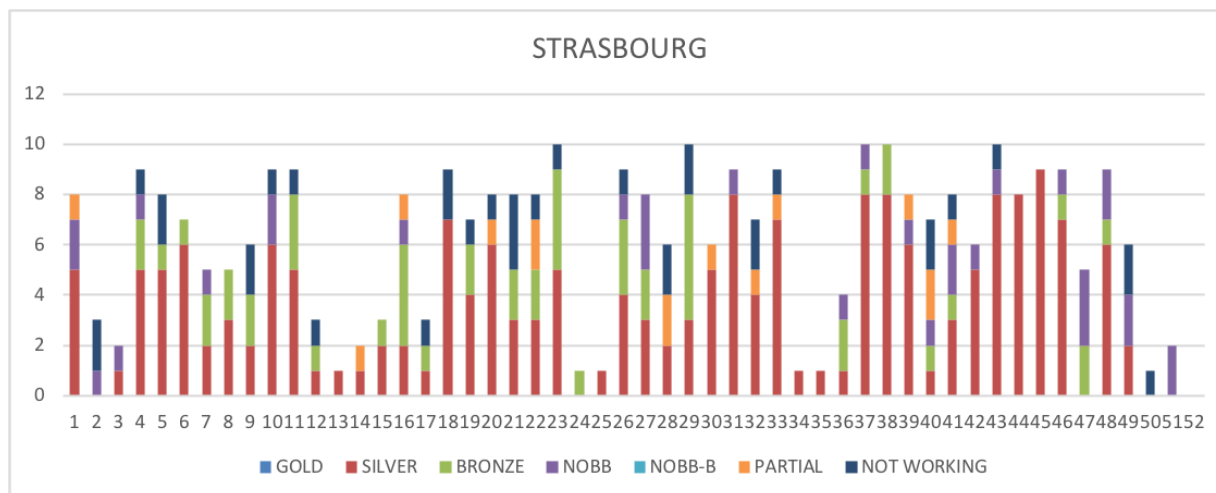
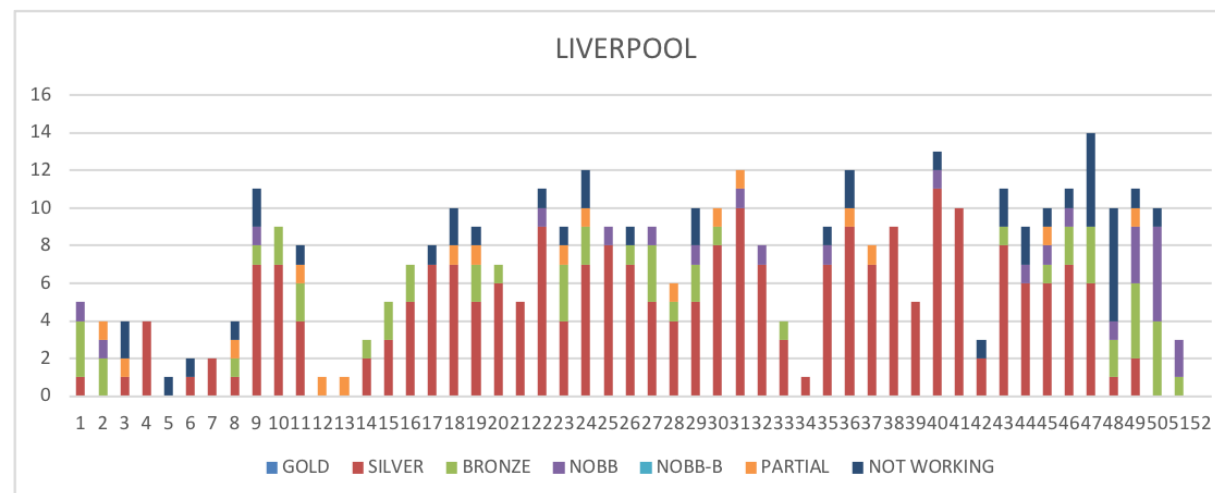
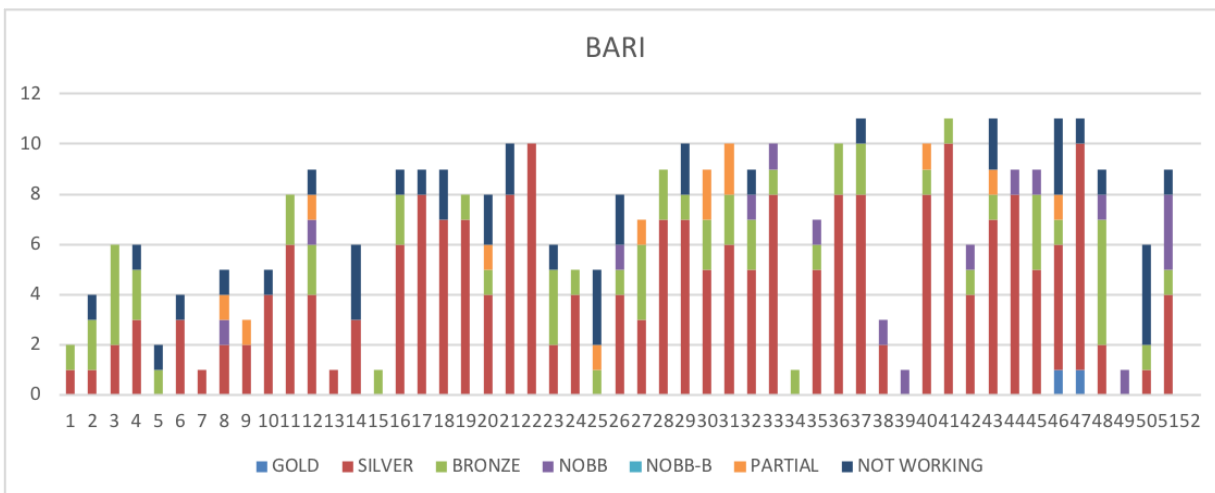


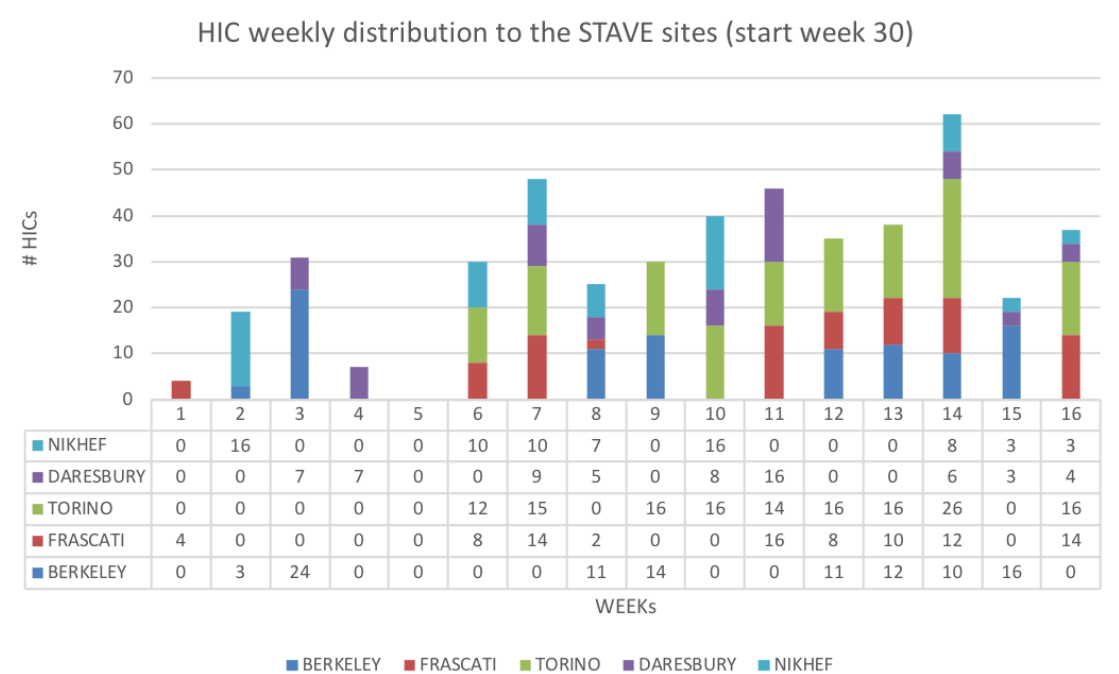
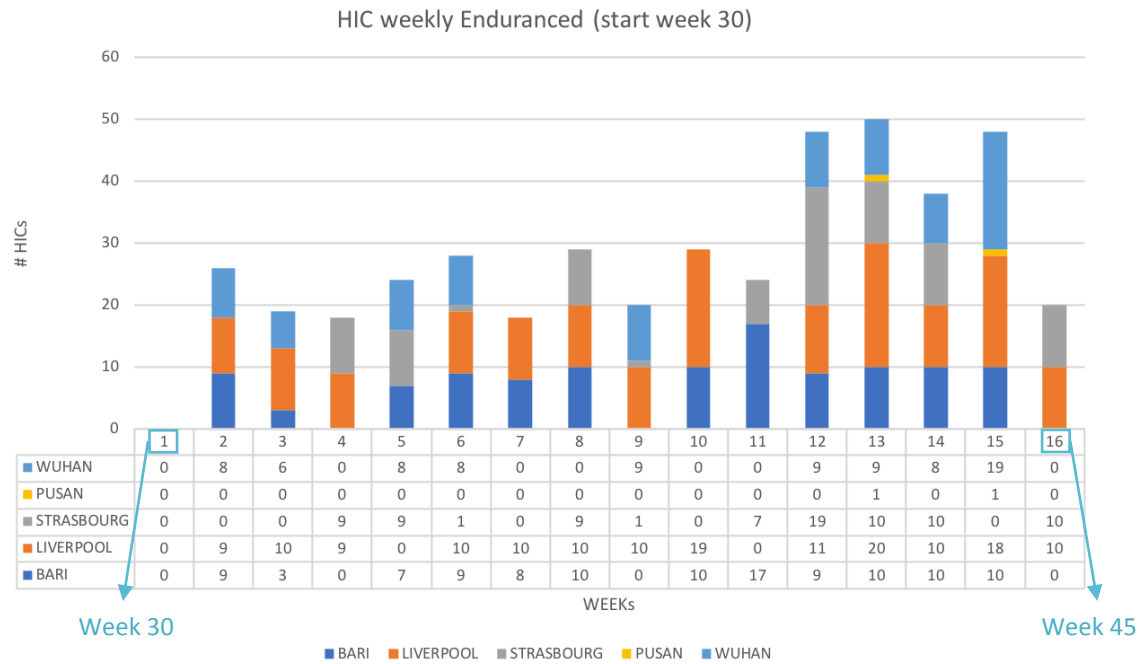
# OB HIC weekly yields



Average number of qualified HICs per week is substantially below the nominal production rate of 50 HICs/week

# OB HIC weekly yields



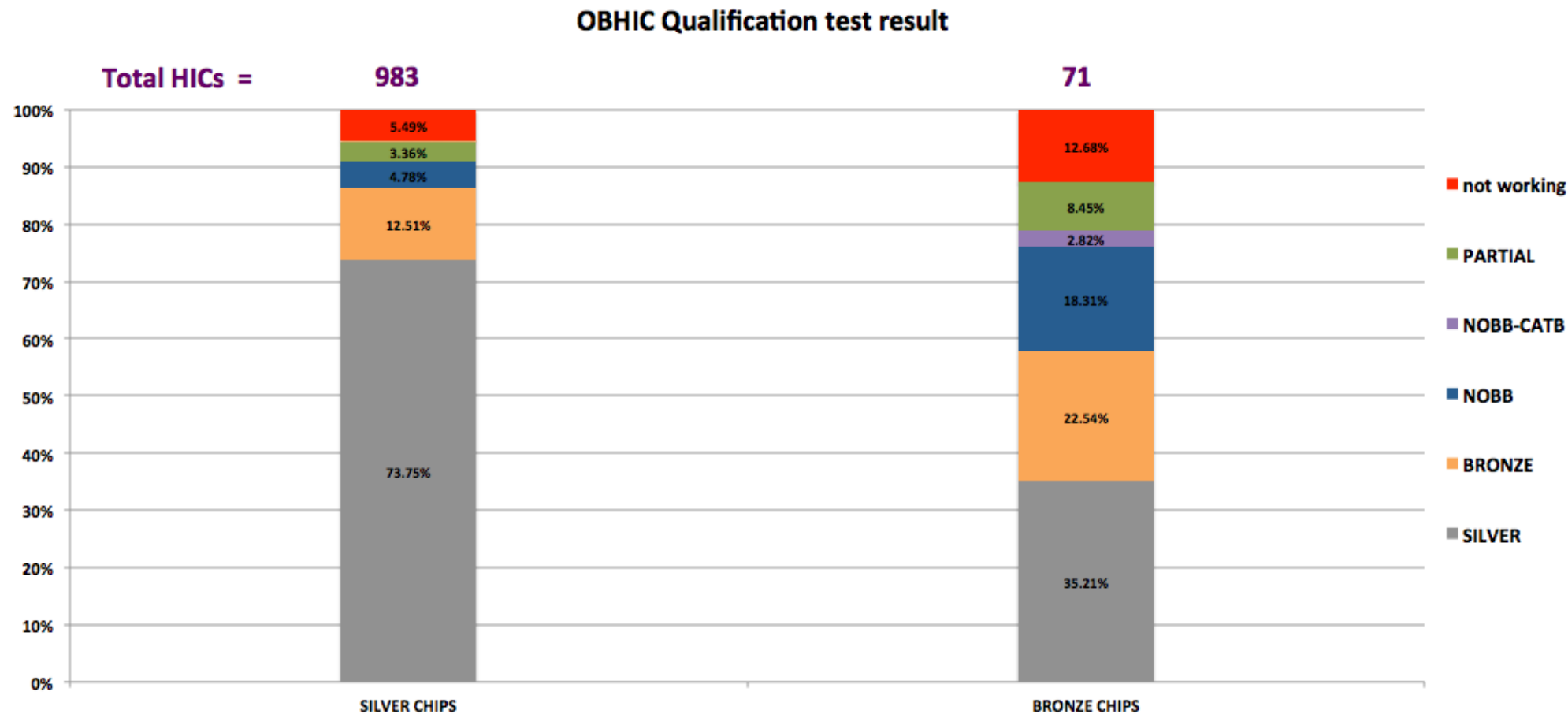


	week 41	week 42	week 43	week 44	week 45
<b>Enduranced</b>	48	50	38	48	20
<b>Distributed</b>	35	38	62	22	37

	HICs AVAILABLE FOR SHIPMENT																							
	SILVER ASSEMBLED						BRONZE ASSEMBLED						"BURNT THROUGH"				"NO BACK BIAS"							
	BL	AL	BR	AR	TOTAL	LAST UPDATE	BL	AL	BR	AR	TOTAL	LAST UPDATE	BL	AL	BR	AR	TOTAL	LAST UPDATE	BL	AL	BR	AR	TOTAL	LAST UPDATE
BARI	0	0	0	0	0	18/11/2018	0	0	0	1	1	18/11/2018	0	4	0	5	9	18/11/2018	0	1	0	0	1	18/11/2018
LIVERPOOL	3	5	0	0	8	18/11/2018	0	2	0	2	4	18/11/2018	0	5	1	3	9	18/11/2018	1	7	1	3	12	18/11/2018
STRASBOURG	3	0	1	0	4	18/11/2018	1	0	0	1	2	18/11/2018	0	0	0	0	0	18/11/2018	0	1	1	0	2	18/11/2018
PUSAN	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0	
WUHAN	0	0	0	0	0	18/11/2018	0	0	0	0	0	18/11/2018	0	0	0	1	1	18/11/2018	0	0	0	0	0	18/11/2018
<b>TOTAL</b>	<b>6</b>	<b>5</b>	<b>1</b>	<b>0</b>	<b>12</b>		<b>1</b>	<b>2</b>	<b>0</b>	<b>4</b>	<b>7</b>		<b>0</b>	<b>9</b>	<b>1</b>	<b>9</b>	<b>19</b>		<b>1</b>	<b>9</b>	<b>2</b>	<b>3</b>	<b>15</b>	

1 AR NOBB is also BT

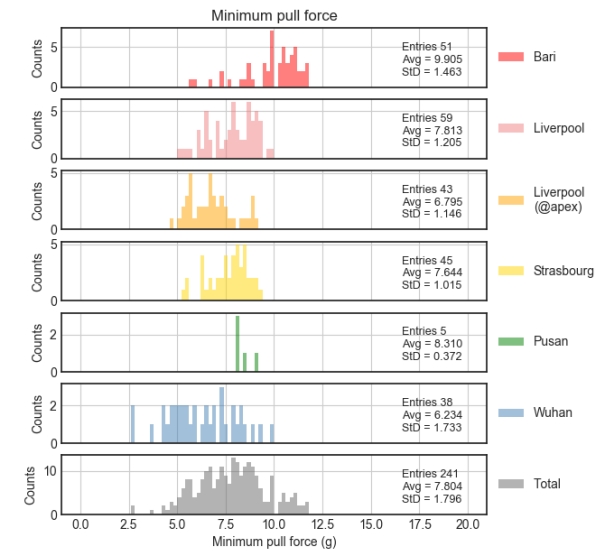
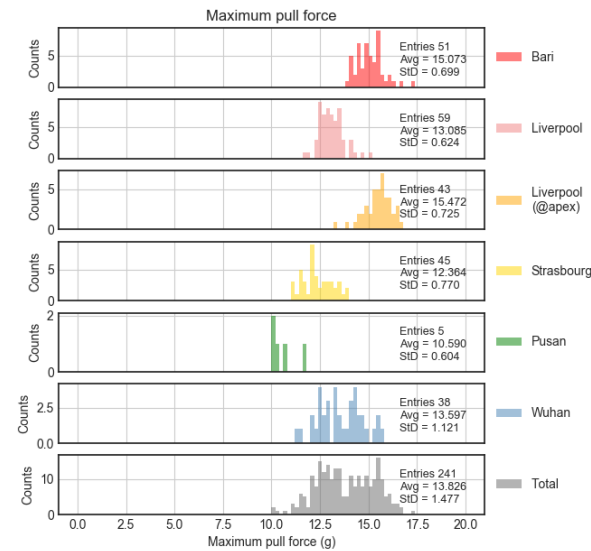
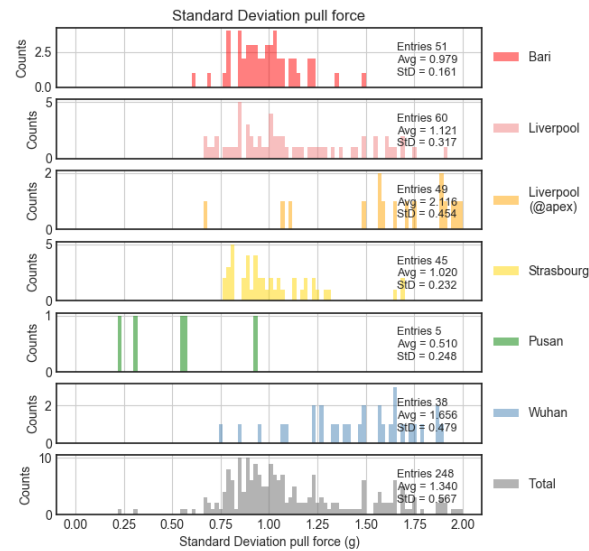
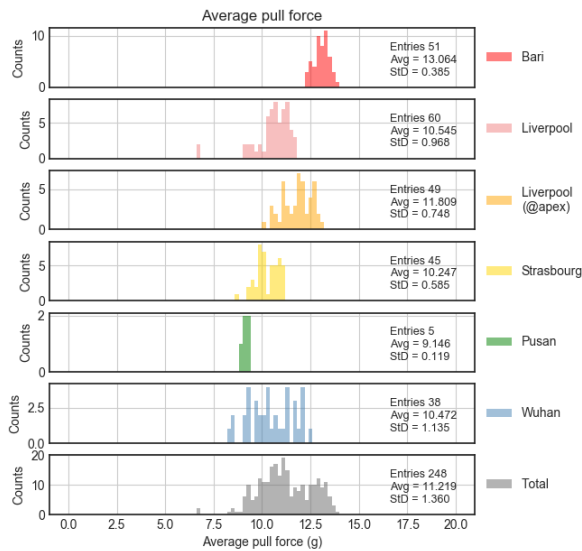
	HICs DISTRIBUTED TO THE STAVE SITES						HICs IN TRANSIT					HICs MOUNTED ON STAVEs					HICs STILL AVAILABLE AT THE STAVE SITES					HICs REJECTED				
	BL	AL	BR	AR	TOTAL	LAST UPDATE	BL	AL	BR	AR	TOTAL	SHIPMENT DATE	BL	AL	BR	AR	TOTAL	LAST UPDATE	BL	AL	BR	AR	TOTAL	LAST UPDATE	TOTAL	LAST UPDATE
DARESBURY	10	50	10	60	130	18/11/2018	0	0	0	0	0	18/11/2018	8	48	9	54	119	18/11/2018	0	0	1	1	2	18/11/2018	5	18/11/2018
LBNL	22	64	23	67	176	18/11/2018	2	6	2	4	14	18/11/2018	16	48	17	52	133	12/11/2018	3	5	2	5	15	12/11/2018	6	12/11/2018
LNF	12	70	15	68	165	18/11/2018	1	7	0	0	8	18/11/2018	8	48	9	54	119	23/10/2018	1	3	2	2	8	15/10/2018	8	15/10/2018
NIKHEF	15	60	13	56	144	18/11/2018	1	2	1	5	9	18/11/2018	7	42	7	42	98	13/11/2018	4	3	4	1	12	13/11/2018	4	13/11/2018
TURIN	20	109	19	110	258	18/11/2018	1	7	1	7	16	18/10/2018	14	84	15	90	203	26/10/2018	2	6	1	3	12	31/10/2018	5	09/10/2018
<b>TOTAL</b>	<b>79</b>	<b>353</b>	<b>80</b>	<b>361</b>	<b>873</b>		<b>5</b>	<b>22</b>	<b>4</b>	<b>16</b>	<b>47</b>		<b>53</b>	<b>270</b>	<b>57</b>	<b>292</b>	<b>672</b>		<b>10</b>	<b>17</b>	<b>10</b>	<b>12</b>	<b>49</b>		<b>28</b>	



# OB HIC quality monitoring - Bond Pull Test

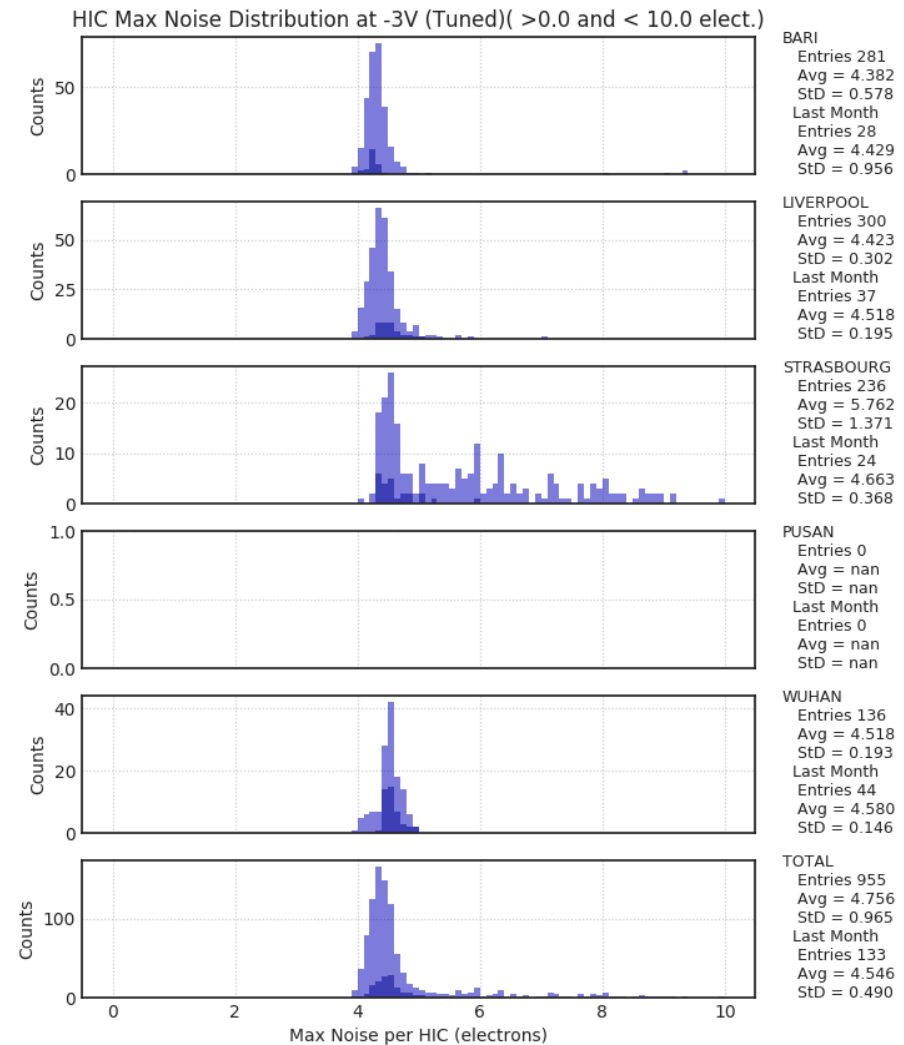
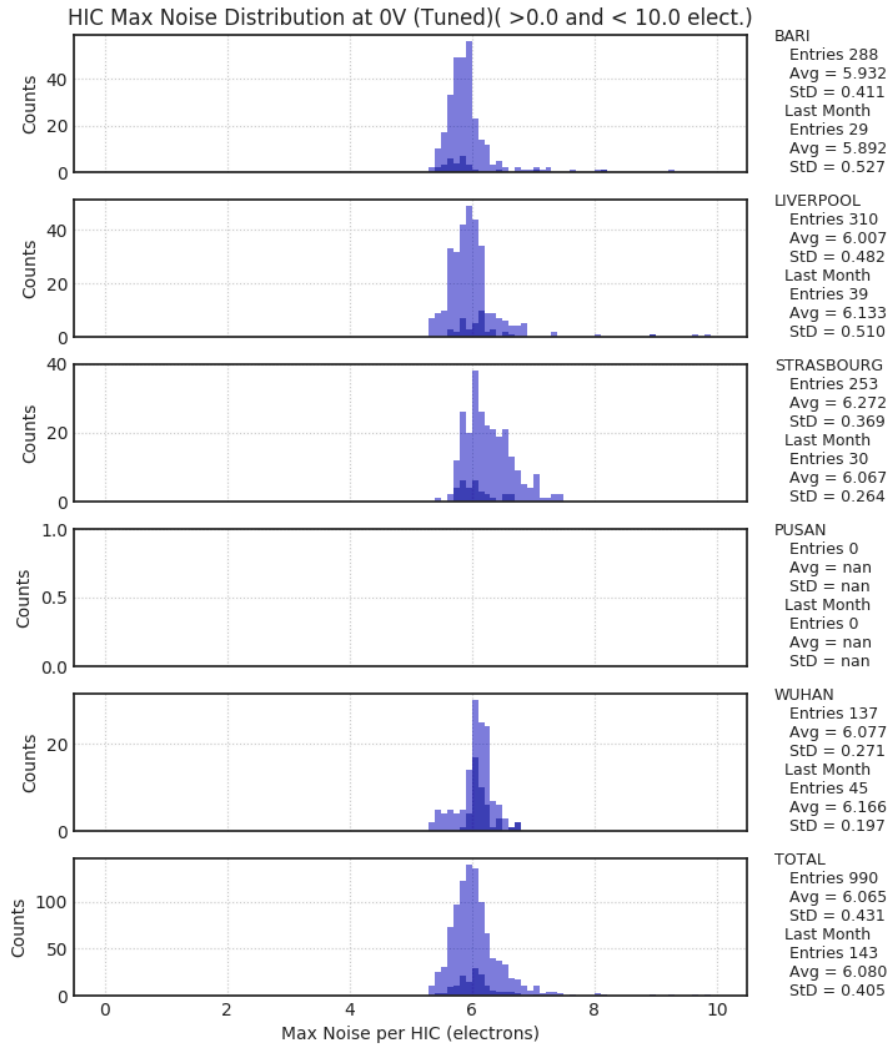


	TEST	AVG - AVERAGE (g)	AVG - STD.DEV. (g)	AVG - MINIMUM (g)	AVG - MAXIMUM (g)	MIN - MINIMUM (g)
<b>BARI</b>	51	13.06	0.98	9.90	15.07	5.63
<b>LIVERPOOL APEX</b>	49	11.81	2.12	6.79	15.47	4.72
<b>LIVERPOOL</b>	60	10.55	1.12	7.81	13.08	5.07
<b>STRASBOURG</b>	45	10.25	1.02	7.64	12.36	5.20
<b>PUSAN</b>	0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.00
<b>WUHAN</b>	38	10.47	1.66	6.23	13.60	2.69



Standard set of plots in preparation

See Markus Keil's talk





Careful cleaning of environment and jigs as well as careful manipulation of the components is mandatory to ensure good quality HICs over the production

Wire-bonding process requires constant check of possible interconnection pad contaminations and evaluation of the bonding quality by visual inspection and bond pull test

Regular cleaning of the wedge tool (~every second HIC) and replace (~50k bonds)

The outcome of the Impedance test has been reconsidered: *See Markus Keil's talk*

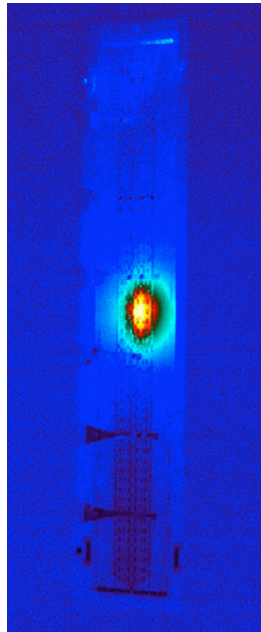
Now used to identify the occurrence of shorts only, which should be tried to remove by mean of the burn through procedure, and not to asses the HIC classification

If impedance value below 10 Ohm, HIC physical status is set to NOK

All HICs, regardless the results of the impedance test, should undergo the Qualification Test

FPCs rejected upon the visual inspection should be promptly returned back to Trieste with their own carrier plates

Double check HIC components availability to prevent interruption of the production



Steady production in Bari, Liverpool, Strasbourg and Wuhan, ramping up in Pusan

≈60% of the production already done

Target to achieve a production rate of 60 HICs/week exploiting the modified procedure

Quality Control and Assurance is extremely important to ensure HICs of proper quality throughout the whole production

Bond Pull Test and Qualification plots

Prompt upload of assembly and test data in the database

Attend the HIC weekly meeting on Thursday at 10h:00am CET and report on the production status

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This was and still is a challenging and exciting enterprise

now we just see the top of the mountain but we are not yet there

let us make the final effort to reach it



## Back-up

