



ALICE ITS UPGRADE

Outline

ALICE Upgrade



- FPC
- HIC
- STAVE
- MECHANICS



ITS Production Activities (non exhaustive list)



Pixel Chip Production

MEMC (Italy) ⇨ Tower (Israel) ⇨ Furex (South Korea)

Pixel Chip Test

CERN, Pusan/Inha, Yonsei, (SUT+MEMC)

IB HIC/Stave Production

CERN

OB FPC Production

SWISS GS ⇨ Hybrid SA ⇨ Trieste, Catania

OB HIC Production

Bari, Liverpool, Pusan/Inha (+ Sejung), Strasbourg, Wuhan

IB/OB Stave Mechanics

CERN and St. Petersburg

OB Power Bus

Berkeley, LTU (Ukraine)

OB Stave Production

Berkeley, Daresbury, Frascati, Nikhef, Torino

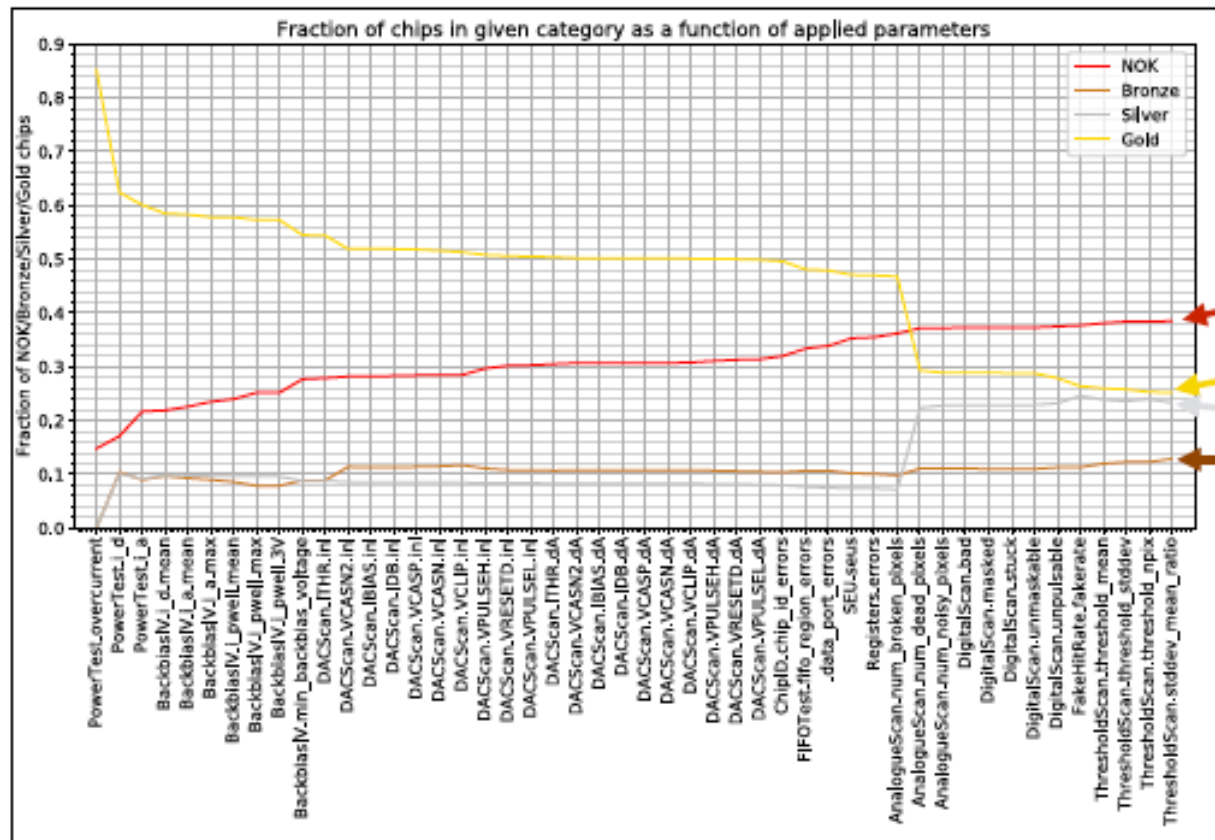
Global Mechanics

Berkeley, CERN, Padua

Electronics

Austin, Bergen, Berkeley, CERN, Kosice, Padua, Prague





Comprehensive yield extraction
(tuned cut parameters)

Inner Barrel: only gold!

OB FPC production

2500 Flexible Printed Circuits (FPC) being produced @GS Swiss for the OB of the ITS (**includes spares, Yield, QA needs**).

FPCs tested @ GS Swiss but before HIC assembly

1. Extensive quality assurance tests [Trieste, Catania]
2. Soldering of cross cables (for later connection to power and bias cables) [Trieste]

- **Pre-production** batch (300 FPCs; 230 Type-A, 70 Type-B). Validation of FPC and of HICs and staves assembly procedures
- **1st production batch** (312 FPCs; 260 TYPE-A , 52 TYPE-B). Present status: **used** for HICs assembly.
- **2nd production batch** (295 FPCs; 231 TYPE-A , 64 TYPE-B); Present status: **used** for HICs assembly.
- **3rd production batch** (320 FPCs; 265 TYPE-A , 55 TYPE-B); QA finished. 2/3 sent to assembly sites.
- **4th production batch** (320 FPCs; 256x FPC A and 64 TYPE B): QA to start
- **5th production batch** Expected within July

OB FPC production QA

Quality Assurance

All fpcs:

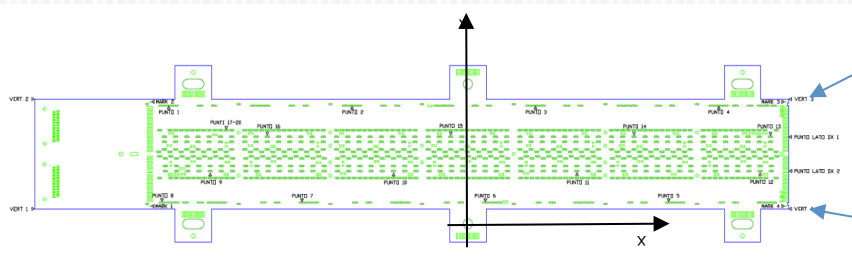
- Metrology
- Electrical tests
- Optical inspection

Sample tests

- Metallization quality based on wire bonding tests (under revision)

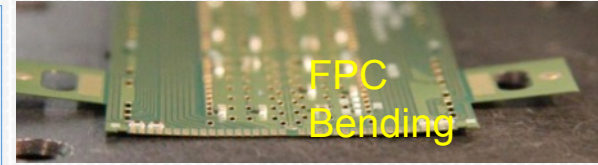
Some metrology results (update)

Metrology (by Mitutoyo MM):
Verification of position of selected structures and edges
wrt center of central dowel pin hole
2° batch quality: stable



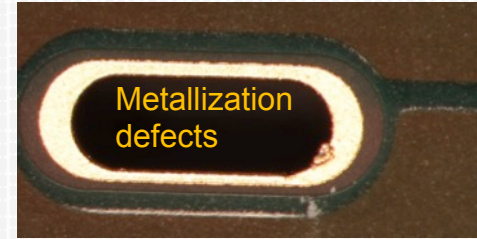
Optical inspections.

Some photos of defects.

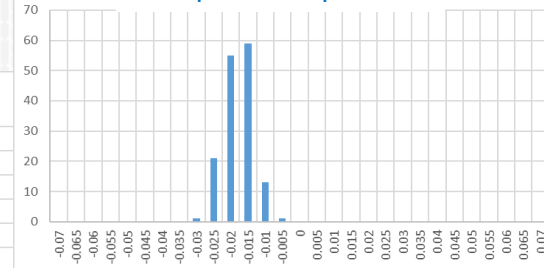


Optical inspection results

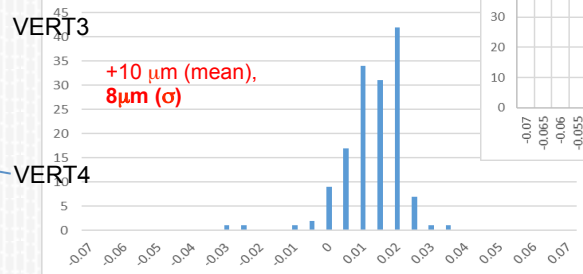
- Few random problems
- Structural bending
- No major problem



Sample holes position



Edge (VERT3) position



OB FPC production: quality assurance results

QA RESULTS SUMMARY

Pre-prod batch:

Metrology: ~15% (slightly) out of specs
Electrical: 1.5% out of specs
Other (bending, local deformations, local defects): ~5%
Final Yield: ~80%

• 1st batch:

Metrology: <1% out of specs
Electrical: 1/300 out of specs
Other (bending, local deformations, local defects): 6%

• 2nd batch:

Metrology: ~3% out of specs
Electrical: 1/300 out of specs
Other (bending, local deformations, local defects): 2%

• 3rd batch:

Metrology: ~0% out of specs
Electrical: 2/320 out of specs
Other (bending, local deformations, local defects): 6.5%

Production quality: STABLE

Production yield: ~ 93%

FPC metallization

Dedicated tests:

evidence of potential problems recently spotted on 1st batch FPCs affecting wire bonding quality

Ongoing checks show 2 types of possible problems:

- Pad surface morphology
- Discolored pads

Actions being put in place for closer and faster monitoring of metallization quality

NEW: ageing tests, climatic chamber Pavia

OB FPC production: quality assurance results

Proposed actions:

1. FAST FEEDBACK to FPC manufacturer right after production

Verification of pad surface morphology and quality/contaminations (optical + w. bonding test) @ different production stages

WHAT : 3 not-assembled + 3 assembled (smd and no cc) for each batch

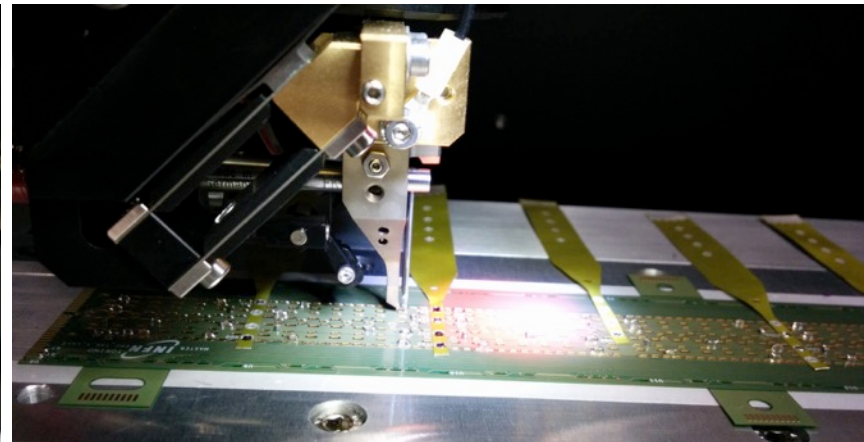
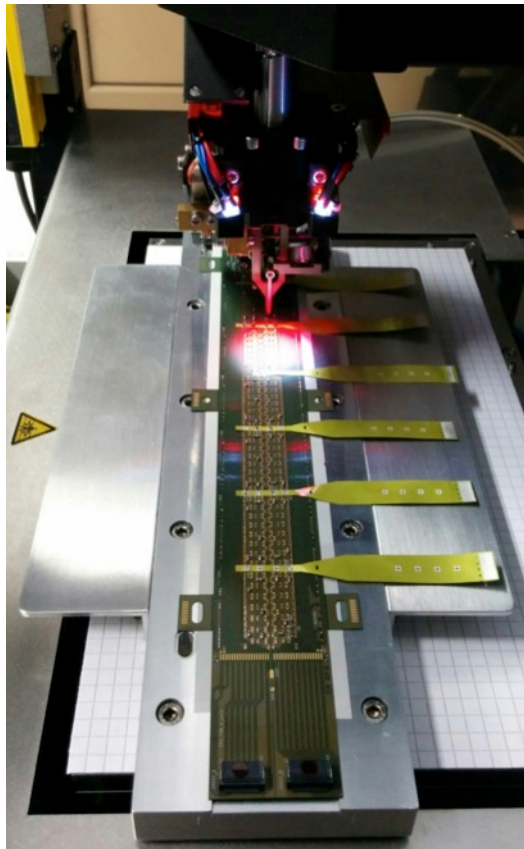
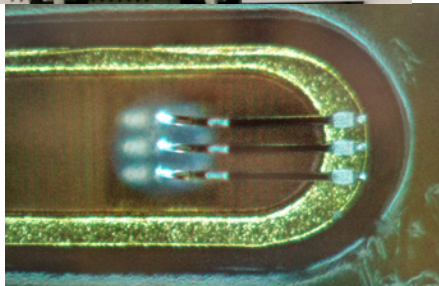
When: asa FPCs are delivered at cern from GS Swiss, before shipping to Trieste for further qualification

2. CONTINUOUS MONITORING during production

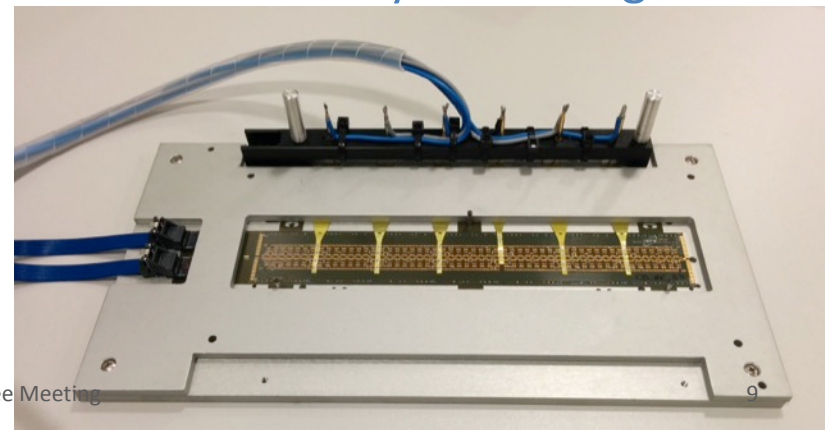
Verification of surface quality/contaminations (optical + w. bonding test) after cc mounting

WHAT : 1 fully assembled FPC

When: once a week



HIC ready for testing

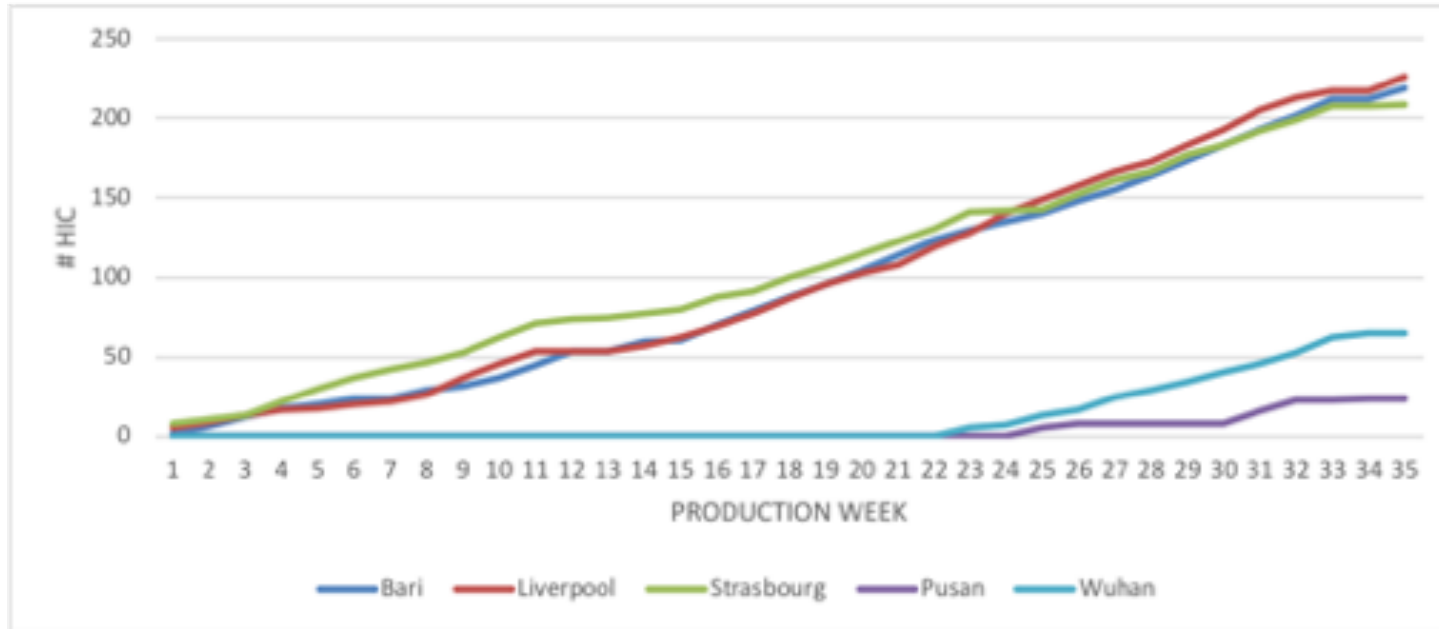


OB HIC production status: OVERALL PRODUCTION

OB HIC Production in numbers

- Nr of OB HIC to be produced: 2115 → 1692 (assuming 80% yield)
- 5 production sites: Bari, Liverpool, Pusan, Strasbourg, Wuhan
- Production rate per site: 2 HICs / day (5 working dd / week)

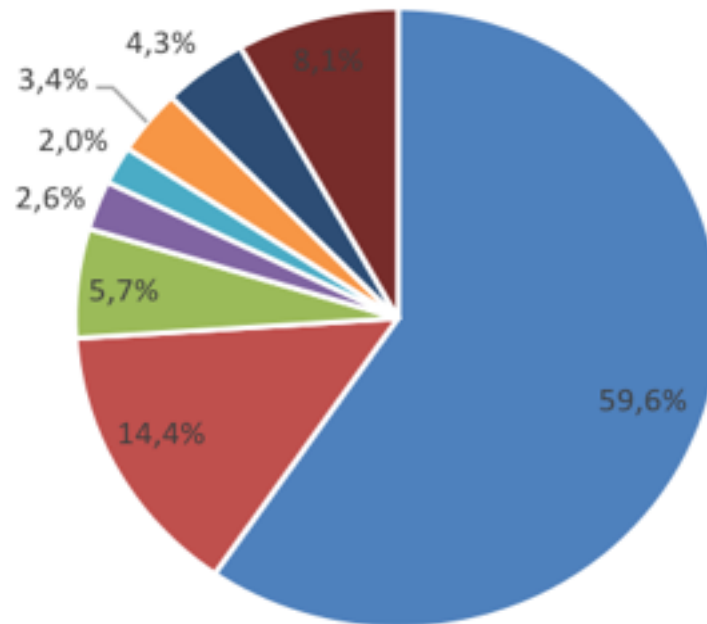
	PRODUCED	QUALIFIED	NOT QUALIFIED	WORKING	NOT WORKING	ENDURANCED	DISTRIBUTED TO STAVE SITES		AVAILABLE (ENDURANCED)
Bari	212	210	2	134	76	120	117	19	3
Liverpool	217	217	0	175	42	130	125	14	5
Strasbourg	208	200	8	151	49	134	116	32	18
Pusan	17	8	9	7	1	0	0	0	0
Wuhan	66	65	1	50	15	16	0	0	16
TOTAL	720	700	20	517	183	400	358	65	42



- Bari, Liverpool, Strasburgo: #HIC prodotti > 200
- Wuhan: #HIC prodotti > 50
- Pusan: produzione cominciata da poco

Good HICs for OB stave construction: SILVER (52%) + BRONZE (21%) + BB "burnt" (6%) = 79%
NOBB (4%) will be used for the construction of spare staves:

- production yield 79%
 - production rate slower than expected
 - chip availability
 - Asian sites have just started production
- delay in Stave production

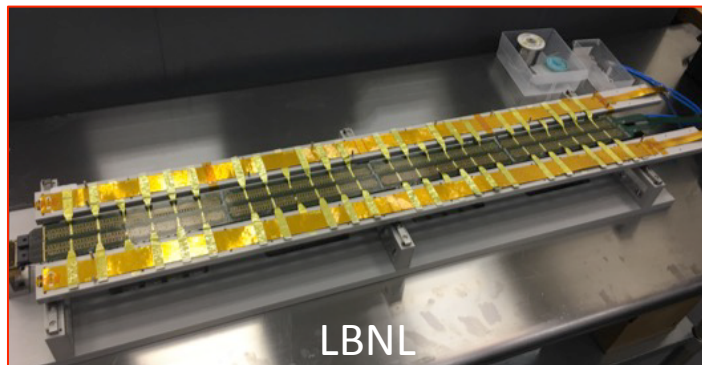
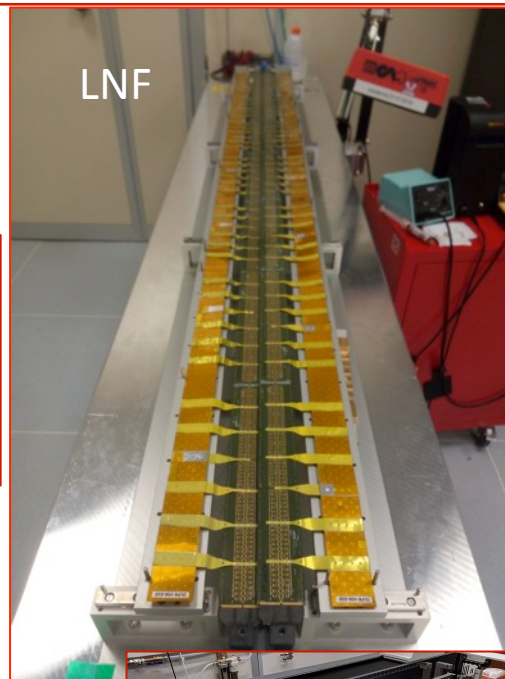
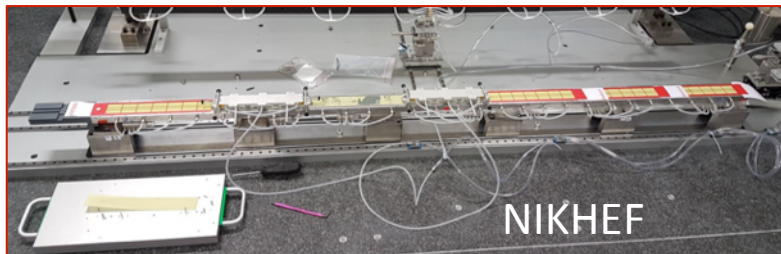


Outer Barrel Stave Production

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- Production sites: Daresbury, LBL, LNF, NIKHEF, Torino



STATUS OF STAVE PRODUCTION SITES

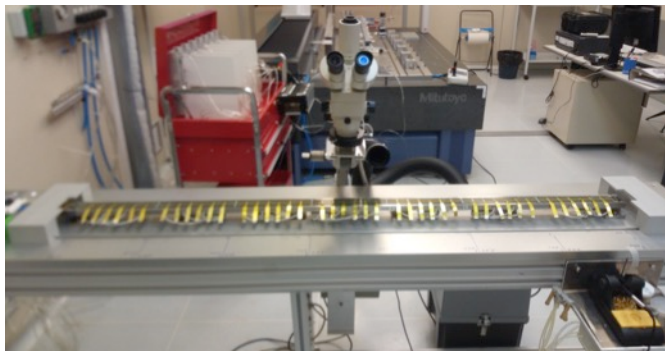
All sites started the production of functional staves.

- HIC reception test (2-3% HICs rejected due to malfunctioning)
- TAB cutting, wire bond inspection and fast powering test
- Half Stave assembly (no issues – metrological surveys show reference marker position residuals within $20\mu\text{m}$ in x,y and $50\mu\text{m}$ in z)
- HIC to HIC interconnection (100% connections are ok – improved tool under test in Nikhef)
- test set-up completed
- Stave qualification test, interfaced to DB, running in all sites
- no change in the ALPIDE performance

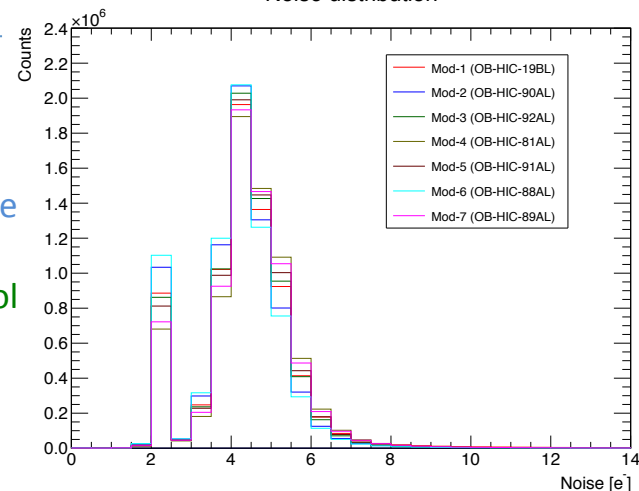
HS assembled on the CMM



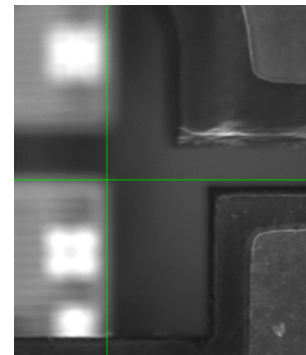
HIC to HIC interconnection on the test station



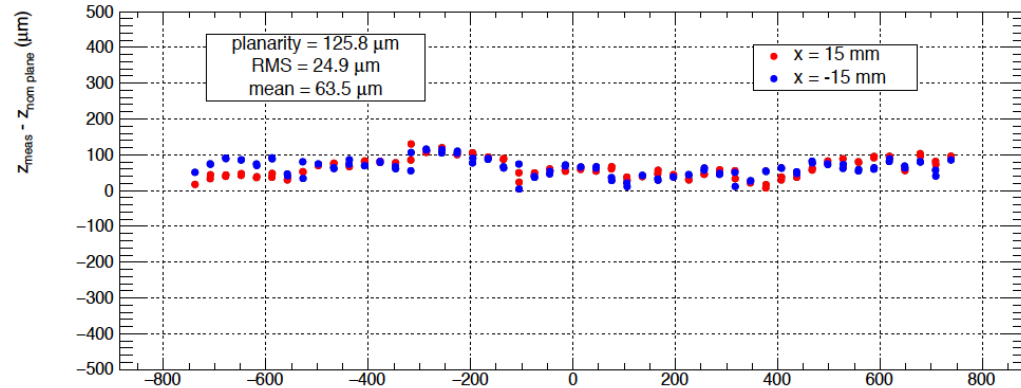
Noise distribution



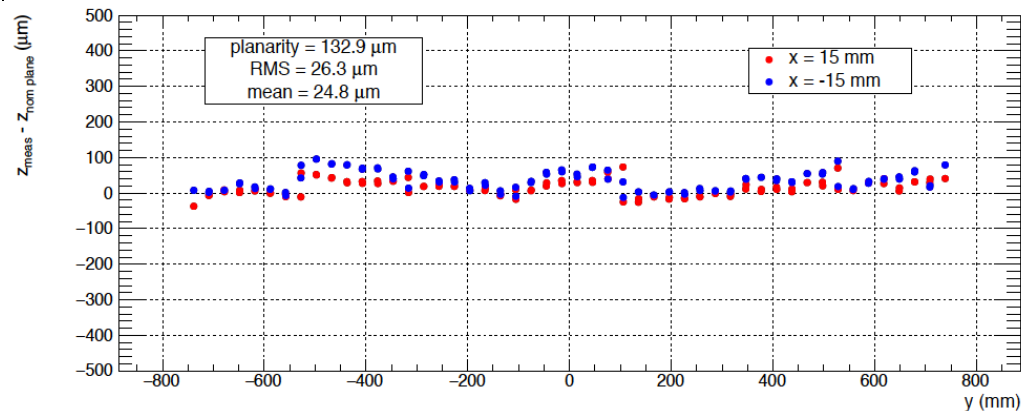
Close view on 2 adjacent HICs: their distance is $\sim 150\mu\text{m}$



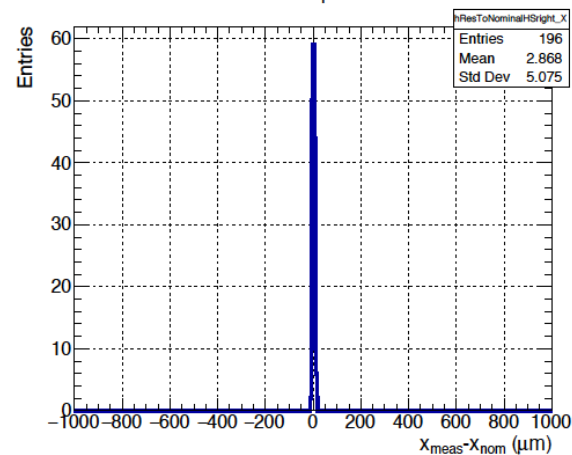
HSL planarity (bss metrology)



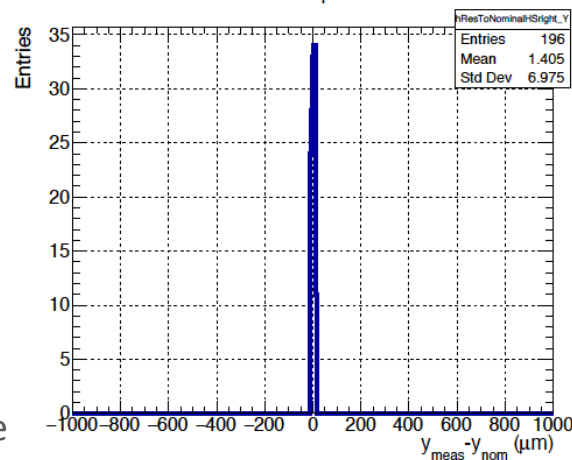
HSR planarity (bss metrology)



Residuals to X nominal positions on HSR



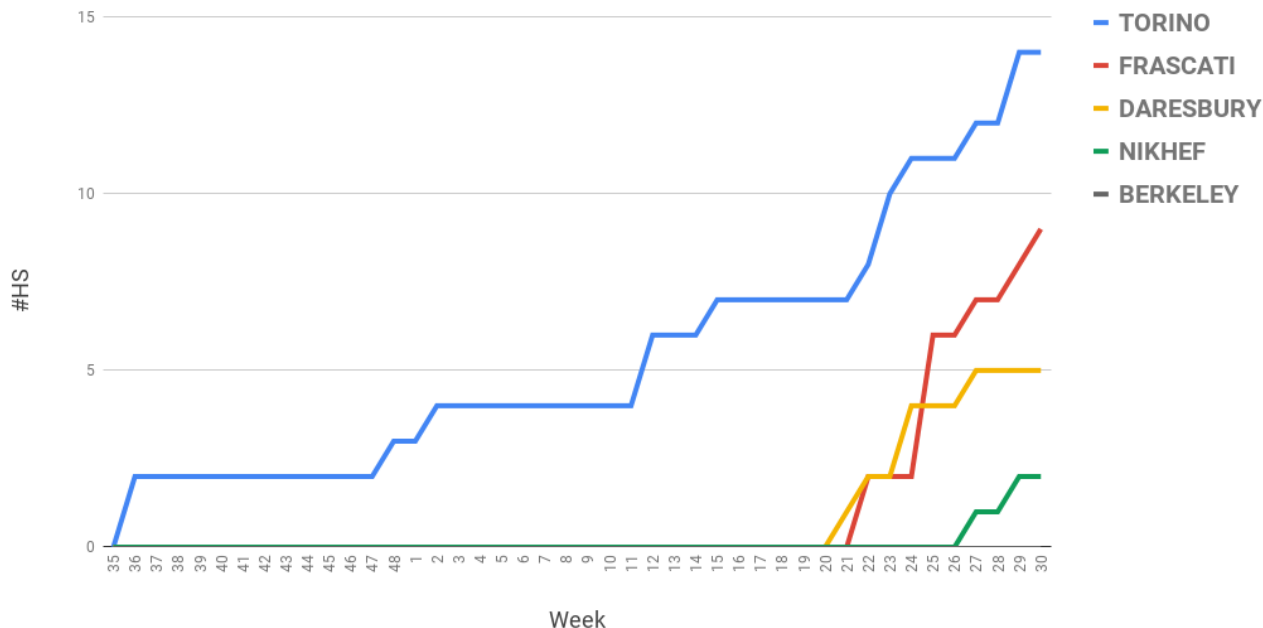
Residuals to Y nominal positions on HSR



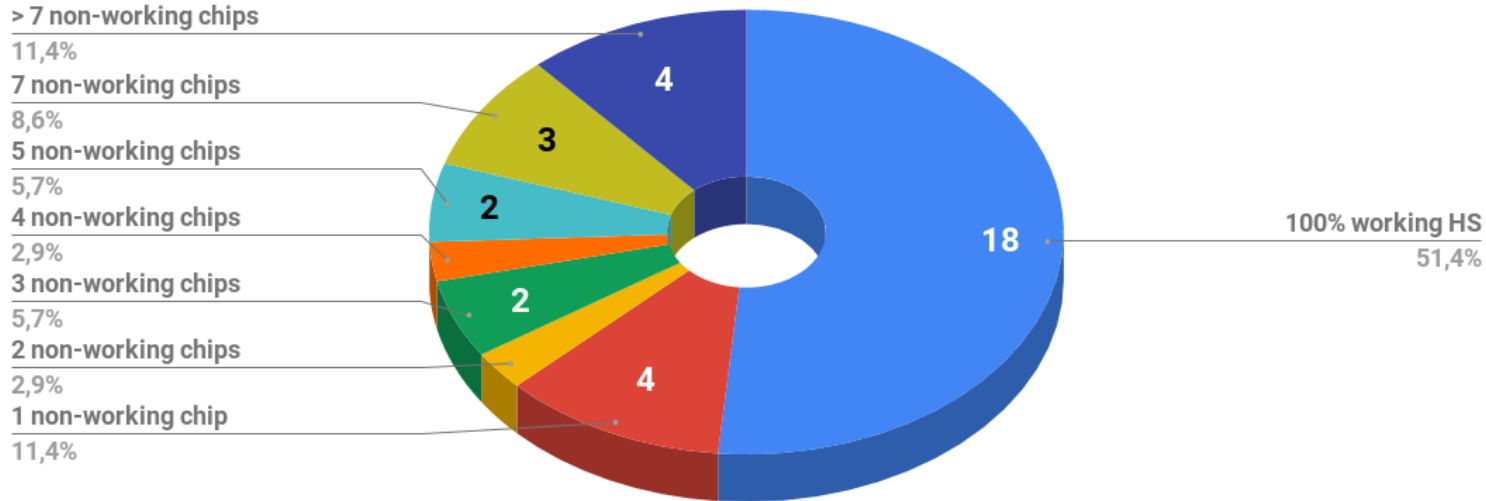
FULL PRODUCTION

- started in Torino in January – 8 staves produced
- from JUNE production rate has reached nominal value of 2 Staves per month in all site, BUT
- MISSING COMPONENTS (HICs, PB, end of staves components, Al boxes for storage and transport...)

ALL SITES - HS STATISTICS



ALL SITES FOR OL-HS PRODUCTION - Percentage of OL-HS with different characteristics



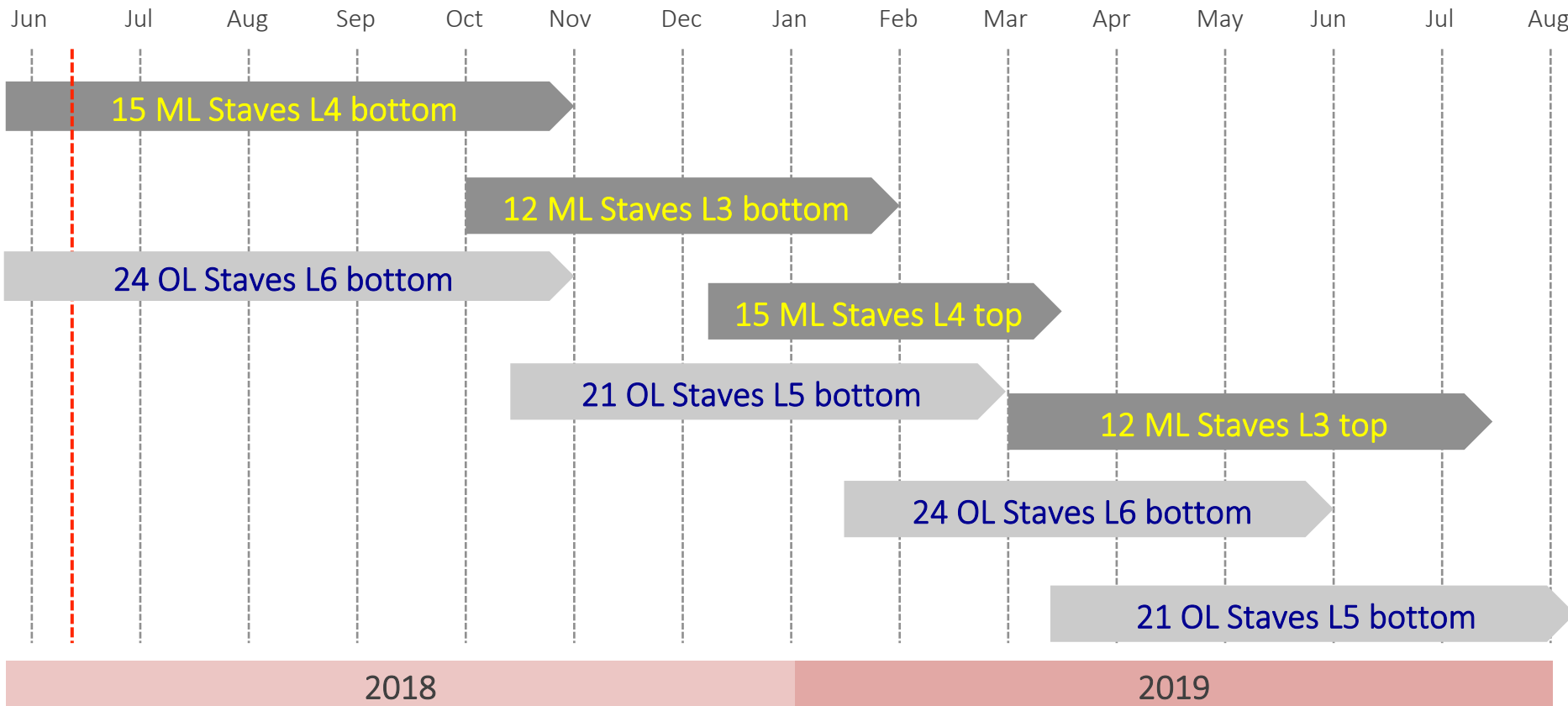
- Statistica comprensiva di tutti gli stave costruiti
- Yield aumenta progressivamente con il tempo

la statistica raccolta finora ha permesso di identificare 3 problemi principali:

- rottura di wire bond
 - critico per connessione DATA o CHIP ID, comporta la perdita da 1 a 7 chip
 - soluzione: uso di colle conduttive per ristabilire la connessione. Campagna di test avviata su strutture dedicate e su moduli OB low grade
- malfunzionamento del chip ALPIDE in modalità MASTER: driver per trasmissione dati e slow control signals danneggiato in modo irreparabile durante la caratterizzazione
 - comporta la perdita di $\frac{1}{2}$ modulo ovvero 7 chip ALPIDE
 - soluzione: sostituzione del modulo danneggiato (procedura preliminare provata a LNF, in fase di ottimizzazione)
- connettori difettosi su FPC extensions (~5%):
 - comporta la perdita di $\frac{1}{2}$ HS ovvero 49 chip
 - soluzione: sostituzione dell'extension (procedura provata a LNF, Torino)
 - ditta contattata, produzione nuovo batch per sostituire extension difettose (visual inspection su tutti i componenti)

PRODUCTION PLANS 2018-2019

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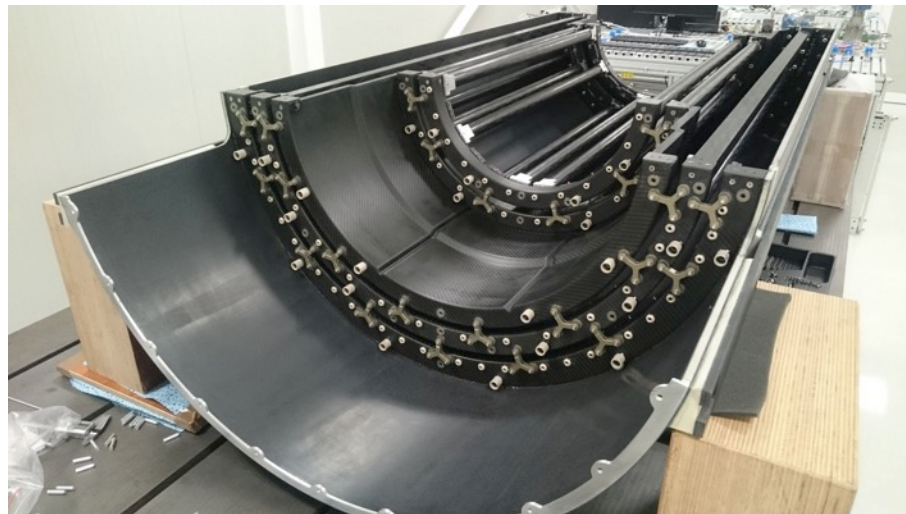
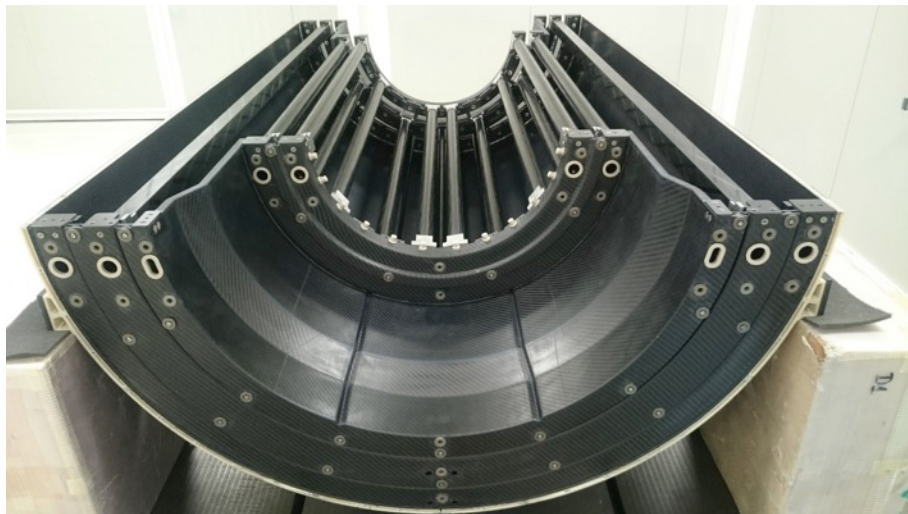
31/07/18

S. Beolè - INFN Referee Meeting

19

- Responsible Andrea Dainese
- Mechanical design team: M. Benettoni, M. Turcato
- Mechanical workshop team: D. Agguaro, A. Benato, D. Mazzaro

M. Benettoni



Full structure of outer half-barrel (from layer 3 to layer 6) produced in Padova and assembly tested at Cern wk 10/2018

ITS OB OB DETECTOR BARREL Mechanics: Half Barrel dry assembly

The Detector Barrels COSS, that joins the ML to the OL are produced at INFN Padova

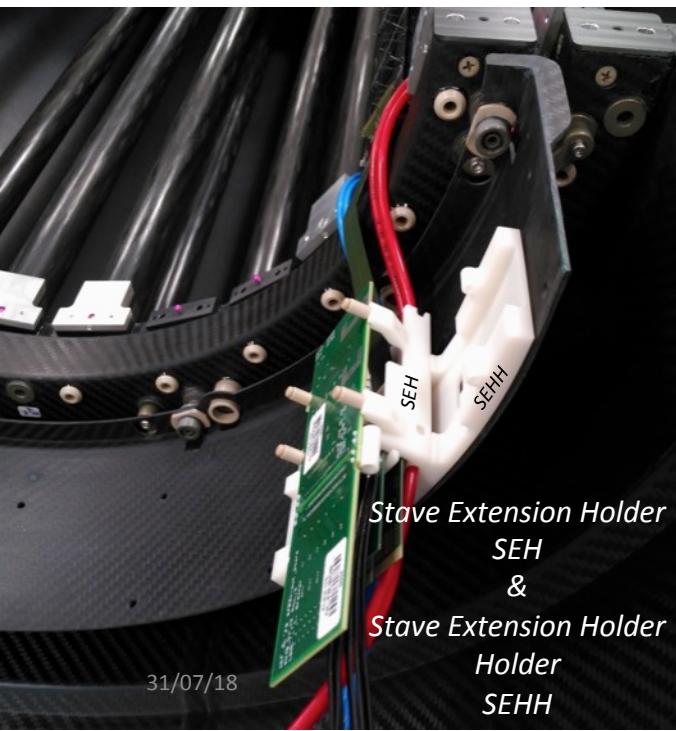


Full structure of both outer half-barrels delivered

Dry assembly test of the full structure of both outer half-barrels done at Cern

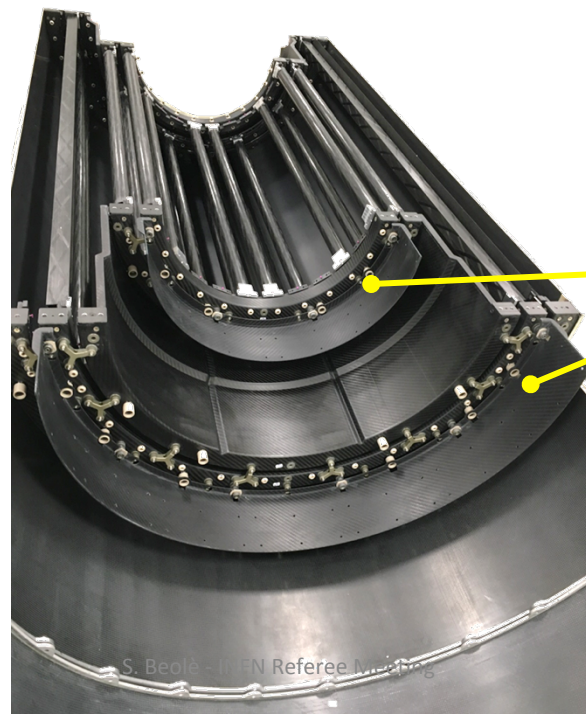
Service trays of hL5 and hL3 delivered, some adjustment needed for proper assembly, fit check with SEH and SEHH ongoing

Massimo Benettoni,
Matteo Turcato, ...

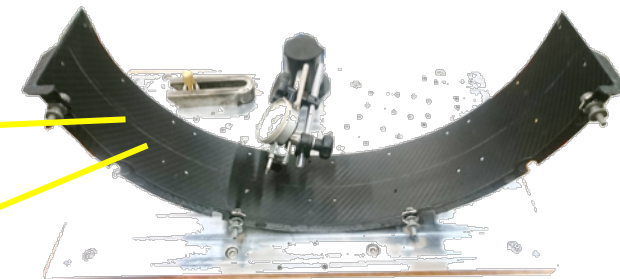


Stave Extension Holder
SEH
&
Stave Extension Holder
Holder
SEHH

31/07/18



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Service trays

Dry Assembly and Insertion Tests: Outer Barrel



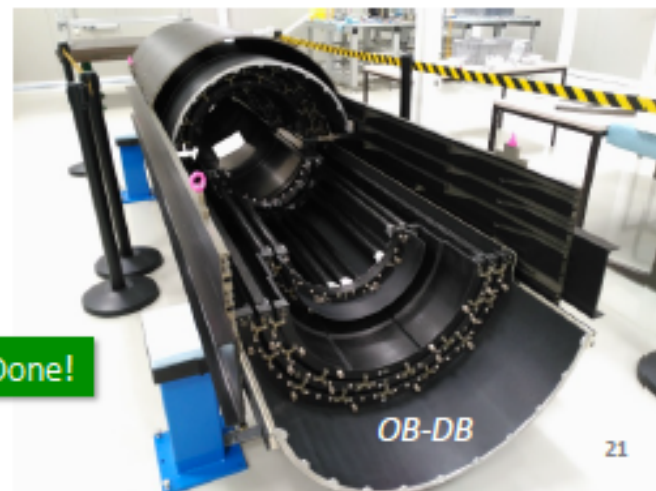
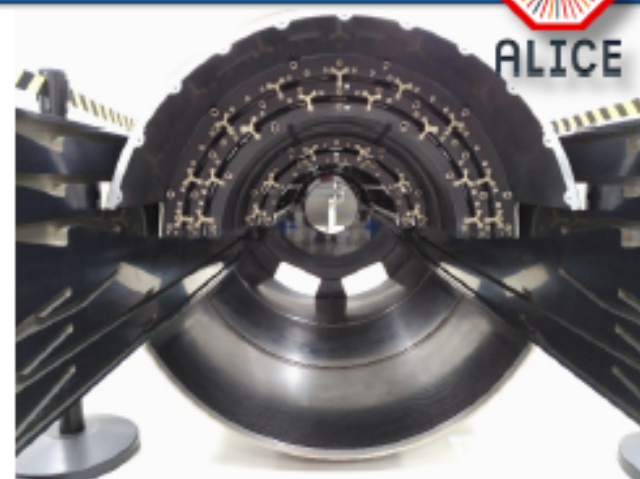
ALICE

Dry insertion OB DB 1&2 no service barrels



L. Musa (CERN) - ALICE Week, 16 July 2018

Dry Assembly Test Done!



ITS OB DETECTOR BARREL Mechanics: jigs

The Detector Barrels jigs for staves and layers assembly are in production at INFN Padova

Half Layer support frames

produced n. 4x2,

WK 12- 2018 (n.4), WK 18 -2018 (n.4)

Stave installation jig

in production n. 2

WK 26

Half Layers handling jig

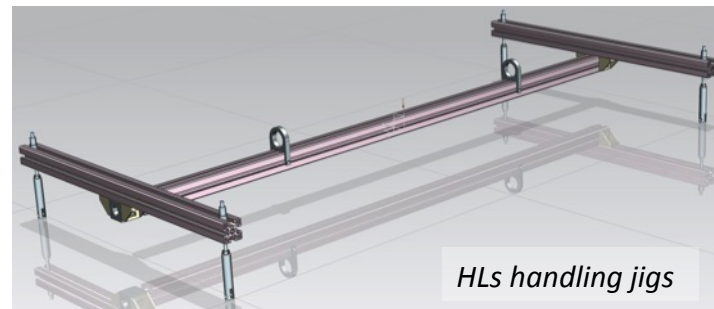
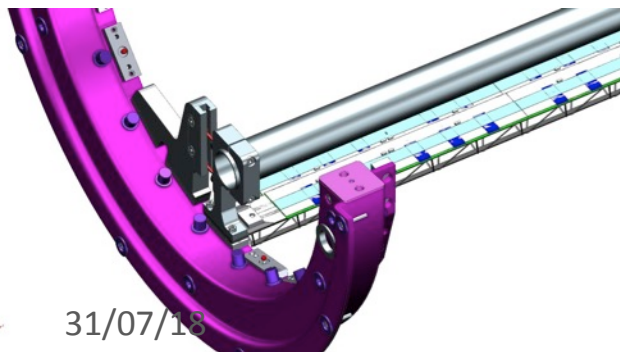
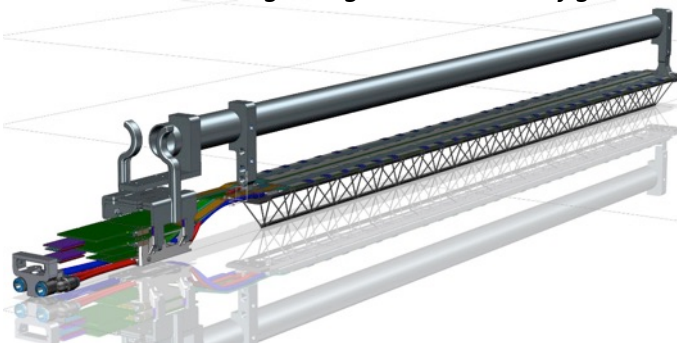
parts procurement n. 2 WK 30 (n.2)

Stave replacement jig

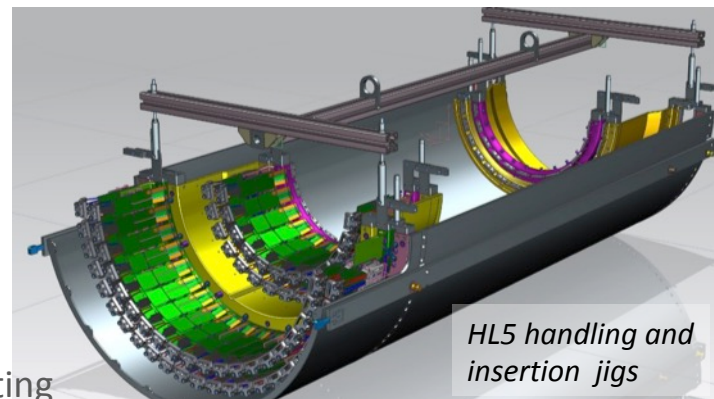
reviewing design n. 2 WK 40 (n.1) WK 44 (n.2)

Massimo Benettoni,
Matteo Turcato, ...

Stave handling and guided insertion jig



HLs handling jigs



HL5 handling and
insertion jigs

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S. Pele - INFN Referee Meeting

ITS OB DETECTOR BARREL Mechanics: jigs

The Detector Barrels jigs for staves and layers assembly are in production at INFN Padova

Half Layer support frames

produced n. 4x2, 4 delivered

WK 12- 2018 (n.4), WK 18 -2018 (n.4)

Stave installation jig

in production n. 2

WK 26

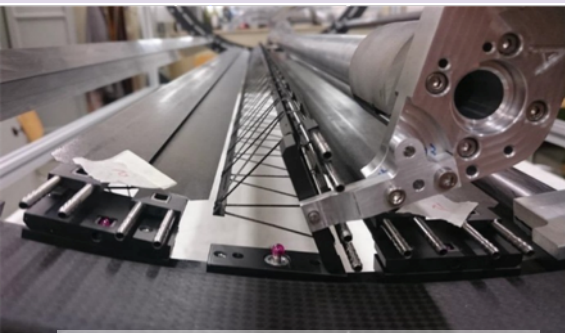
Half Layers handling jig

parts procurement n. 2 WK 30 (n.2)

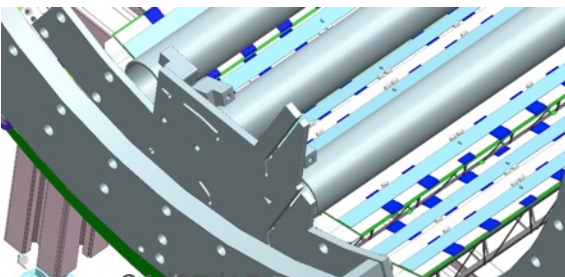
Stave replacement jig

reviewing design n. 2 WK 40 (n.1) WK 44 (n.2)

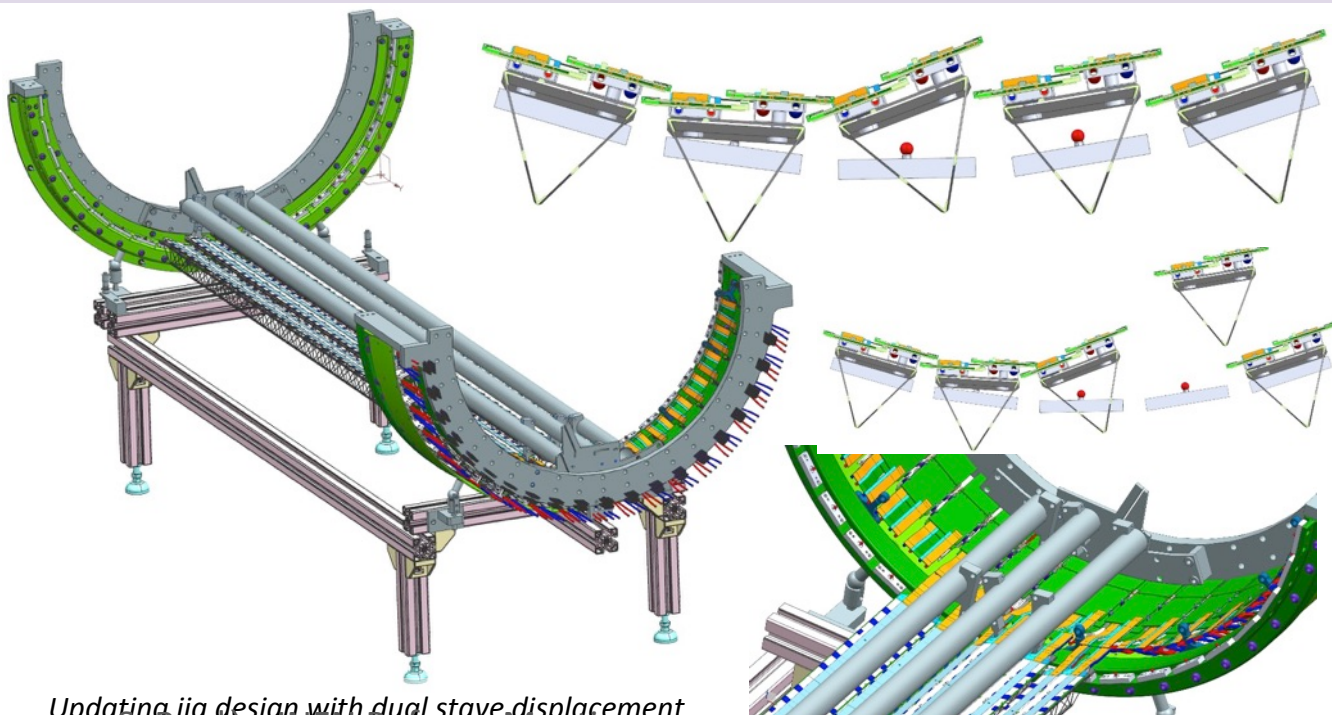
Massimo Benettoni,
Matteo Turcato, ...



Stave replacement prototype jig



31/07/18



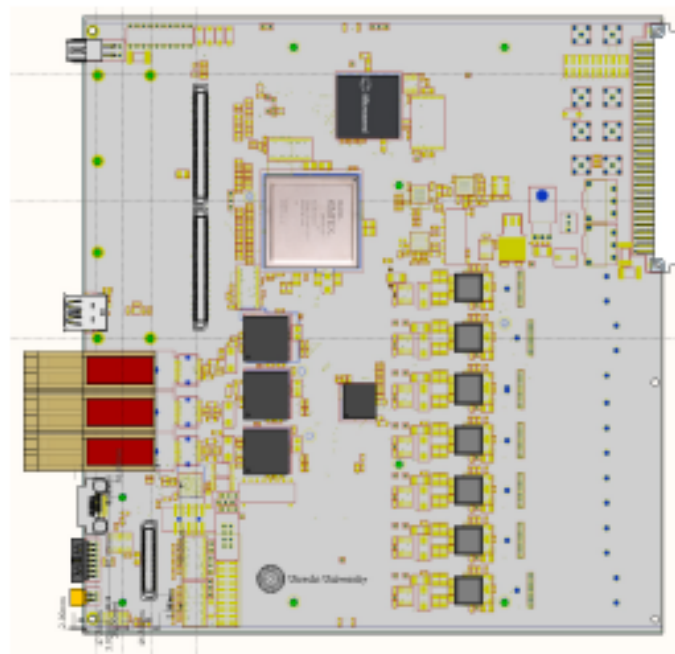
Updating jig design with dual stave displacement

S. Beole - INFN Referee Meeting

RU V1 (21 prototype boards)
fully validated in 2017 – 18

RU V2 (final) – only minor changes

- 4 prototypes are being tested
- tendering for production of 300 units started

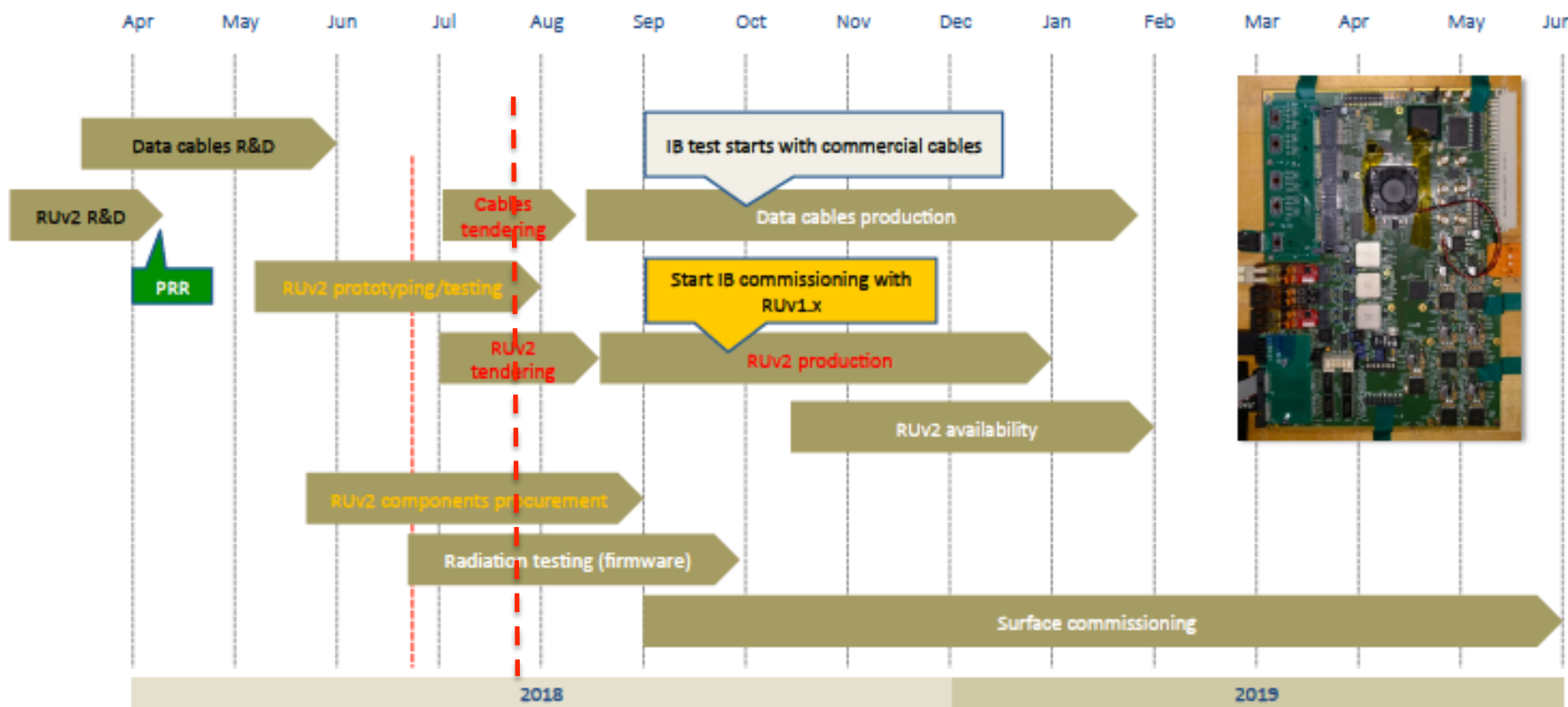


Electronics – Readout Unit Production Timeline



Development Completed Production of RUv2 (222 boards + 88 for MFT) will take 3-4 months (batched) **ALICE**

Procurement of the Readout Electronics: **additional delay of one month**



Assembly and Commissioning on Surface (1)

Task	Location	Expertise	2019				2020				2021			
	CERN / Institute / Remote	PH/ME/MT /EE/ET	Q1 (FTE)	Q2 (FTE)	Q3 (FTE)	Q4 (FTE)	Q1 (FTE)	Q2 (FTE)	Q3 (FTE)	Q4 (FTE)	Q1 (FTE)	Q2 (FTE)	Q3 (FTE)	Q4 (FTE)
Coordination	CERN	any	1	1	1	1	1	1	1	1	0	0	0	0
Assembly of Layers in Barrels	CERN	any	1.5	1.5	1.5	1.5	0	0	0	0	0	0	0	0
Routing of services in Service Barrels	CERN	any	2	2	2	2	0	0	0	0	0	0	0	0
Connection of Service Barrels to Detector Barrels	CERN	any	2	2	2	2	0	0	0	0	0	0	0	0
Detector Metrology and Survey	CERN	any	1	1	1	1	1	1	1	1	0	0	0	0
Detector Barrel Commissioning	CERN	any	3	3	3	3	1	1	1	1	0	0	0	0
Readout Electronics Commissioning	CERN	EE/ET	2	2	2	2	1	1	1	1	1	1	1	1
Power System Commissioning	CERN	EE/ET	0.2	0.2	0.2	0.2	0.1	0.1	0.2	0.2	0	0	0	0
Cooling System Commissioning	CERN	ME/MT	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0	0	0	0
Commissioning of Detector Installation Tooling	CERN	ME/MT	0.5	0.5	0.5	0	0	0	0	0	0	0	0	0
Global Commissioning	CERN	any	0	0	6	6	6	0	0	0	0	0	0	0

- **Global Commissioning:**

- Permanent operation of the full detector → 24/7 shifts necessary
- 3 shifts per day, 2 shifters at a time → 6 persons / day

- produzione avviata per tutti i componenti, meccanica di supporto consegnata al CERN, in fase di ottimizzazione
- Stave:
 - produzione sta raggiungendo il ritmo atteso, ritardo nella consegna di componenti -> accumulato ritardo di 4 mesi
 - produzione deve essere completata entro Luglio 2019, completamento assembly Agosto 2019
 - necessaria ottimizzazione:
 - procedure HIC production per aumentare il numero di HIC prodotti per settimana
 - ottimizzazione procedure e nuovi tools per consentire re-work di componenti malfunzionanti senza interrompere la produzione

Tabella Richieste

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sede richiesta	BARI	k€	TORINO	k€
CONSUMO	Filtri e altri materiali x camera pulita Materiale di consumo per la costruzione dei moduli: maschere adesive, colla, filo e punte per il bonding, buste antistatiche KIT di scatole ESD	26	colla, siringhe, carta per maschere adesive, materiale per la pulizia e altro materiale di consumo per la camera pulita	10
TRASPORTI	Spedizione moduli ai centri di costruzione degli Stave	8	trasporto stave prodotte da Torino al CERN e spedizione carrier plate al sito di produzione dei moduli	8
MANUTENZIONE	CMM e sistema di condizionamento clean room	4	CMM e sistema di condizionamento clean room	6
APPARATI	Completamento produzione dei jig a seguito dell'ottimizzazione della procedura per la costruzione dei moduli Costruzione di 600 piastre per il trasporto moduli corredate di contropiastra e coperchio	71	Completamento produzione jig per la caratterizzazione elettrica degli stave (25 basi HS) Produzione di 2 power bus folding tool per parallelizzazione attività di produzione Completamento produzione FPC extension Contributo Thinning & Dicing ALPIDE chips	82.5

Tabella Richieste

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sede richiesta	CATANIA	k€	LNF	k€	PADOVA	k€	TRIESTE	k€
CONSUMO	Spese specifiche di funzionamento della camera pulita e per i test di caratterizzazione degli FPC	12.5			Minuteria meccanica per ottimizzazione jig installazione stave ITS-upgrade e per assemblaggio ITS-upgrade	9	Spese di funzionamento della camera pulita per la conclusione produzione degli FPC (saldatura e test	3
TRASPORTI			spedizioni dedicate per trasporto stave da LNF a CERN	10			Spedizioni e trasporti FPC + SSD	8
APPARATI					Completamento tooling per la sostituzione degli stave difettosi	10		
INVENTARIO			- sigillatrice per spedizione stave - sostituzione telecamera CMM - deumidificatori camere pulite					