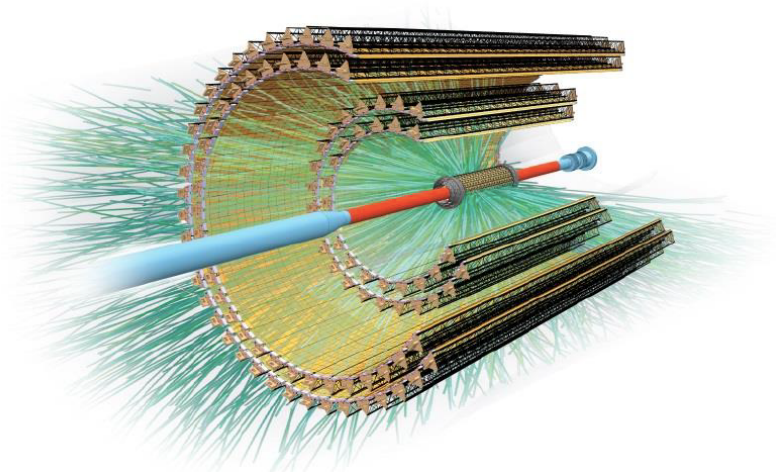
ITS Project Status

L. Musa - CERN



12th ALICE ITS upgrade, MFT and O2 Asian Workshop

19-21 November 2018 Inha University

Outline

① Introduction

- Motivations, deign and performance overview

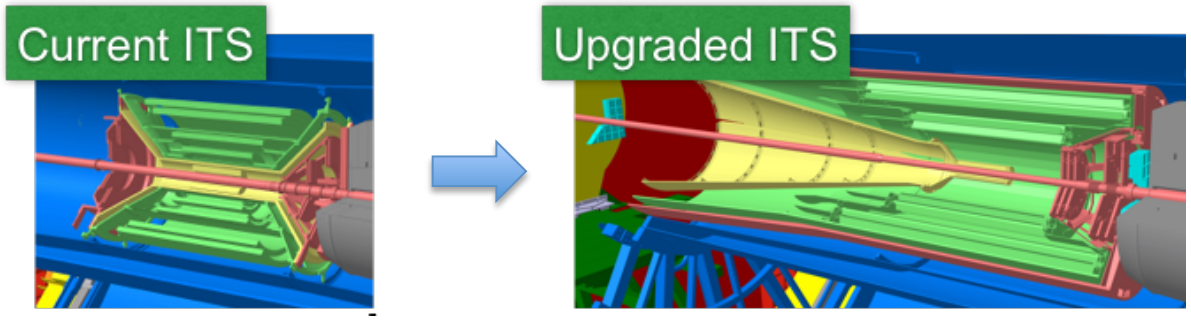
② Detector Construction

- Inner Barrel
- Outer Barrel HIC Production
- Outer Barrel Stave Production
- Electronics Procurement

③ Preparation for Detector Assembly and Commissioning

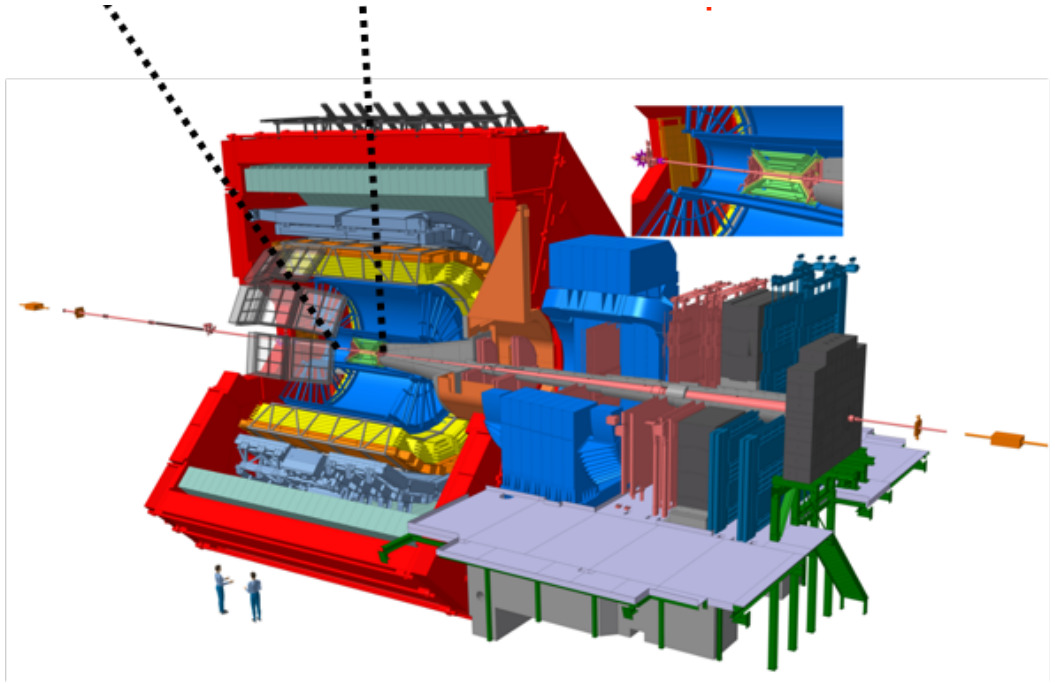
- Preparing for assembly of half-layer 6 and 4

ITS Upgrade in LS2 (ITS2)



6 layers (39mm < r < 440mm)
$-1 \leq \eta \leq 1$

7 layers (22mm < r < 400mm)
$-1.5 \leq \eta \leq 1.5$

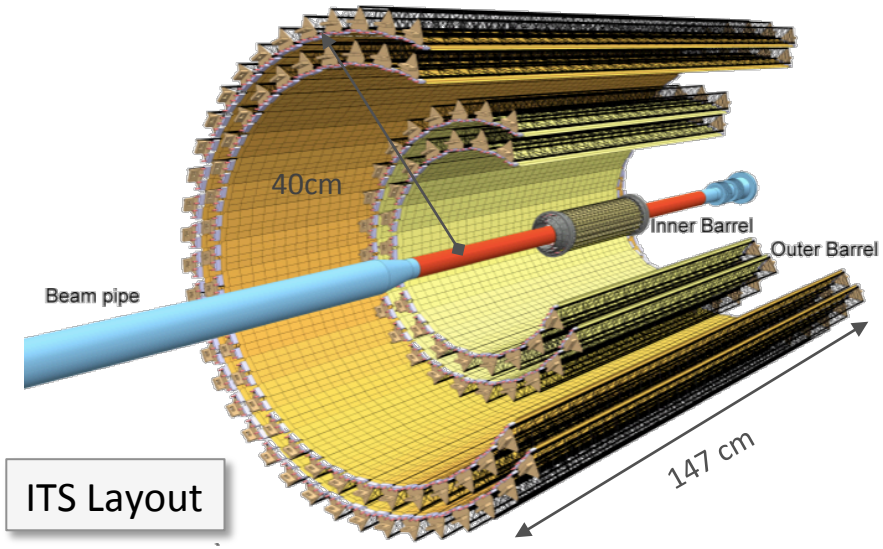


Motivations and goals

- Improved vertex and tracking precision
  closer to IP, smaller pixels, less material
- Faster readout

Parameter	Current ITS	ITS Upgrade
N Layers	6	7
Inner Radius	3.9 cm	2.3 cm
Layer material (innermost layers)	~1.1% X_0	~ 0.3% X_0
Spatial resolution	12 x 100 μm^2	5 x 5 μm^2
	35 x 20 μm^2	
	20 x 830 μm^2	
Max readout rate	1 kHz	100 kHz (Pb-Pb) 1MHz (pp)

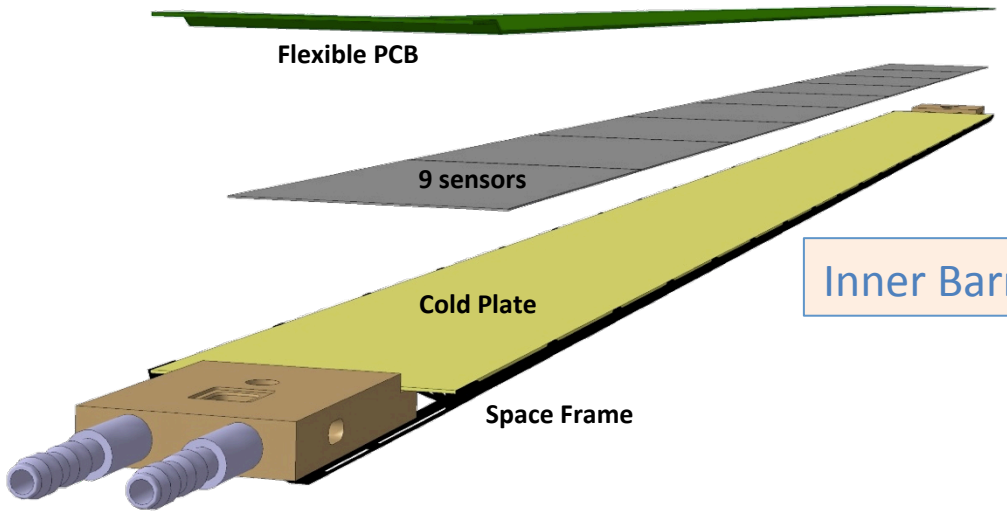
ITS Upgrade Overview



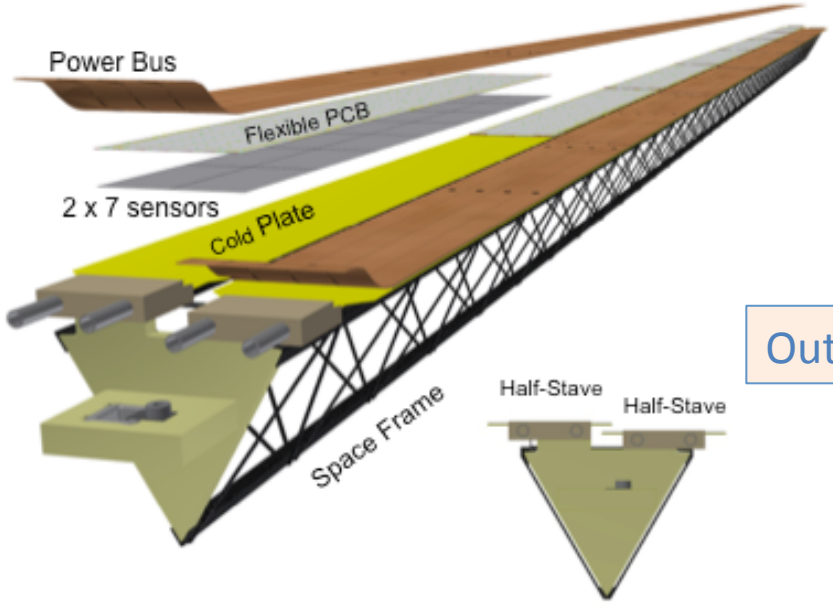
ITS Layout

Based on novel CMOS Pixel Sensor (ALPIDE)

- 10 m^2 active silicon area (12.5 G-pixels)
- Spatial resolution ~5μm
- Power density < 40mW / cm^2
- Max particle rate ~ 100MHz /cm^2 (pile-up)
- Max readout rate ~ 10 MHz/cm^2 (bandwidth)



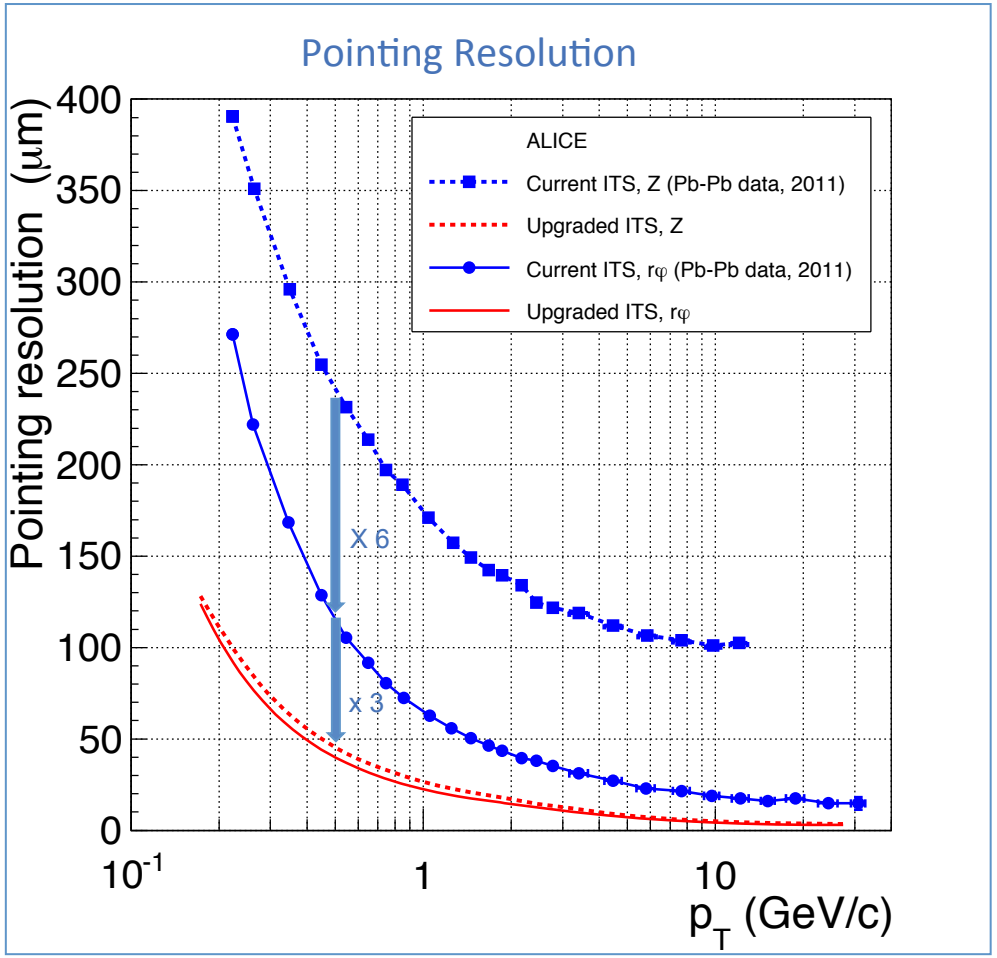
Inner Barrel



Outer Barrel

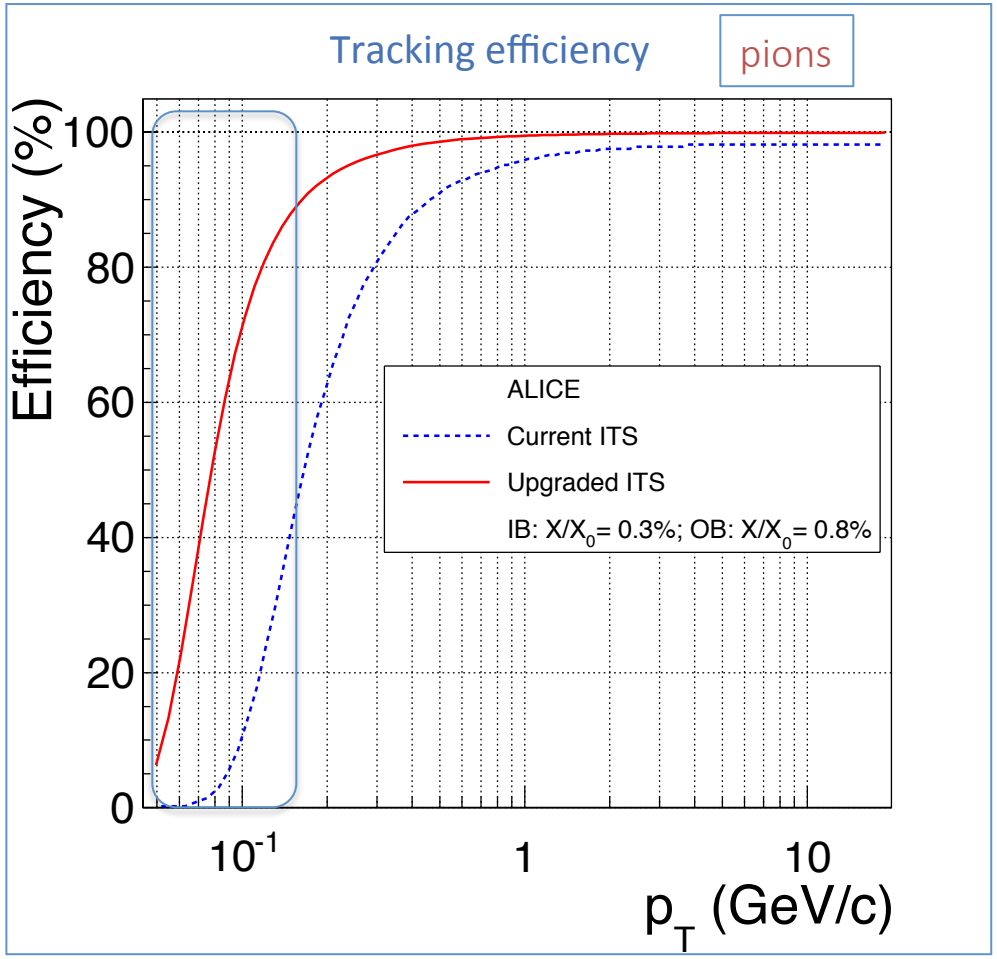
ITS Upgrade in LS2 (ITS2)

Impact parameter resolution

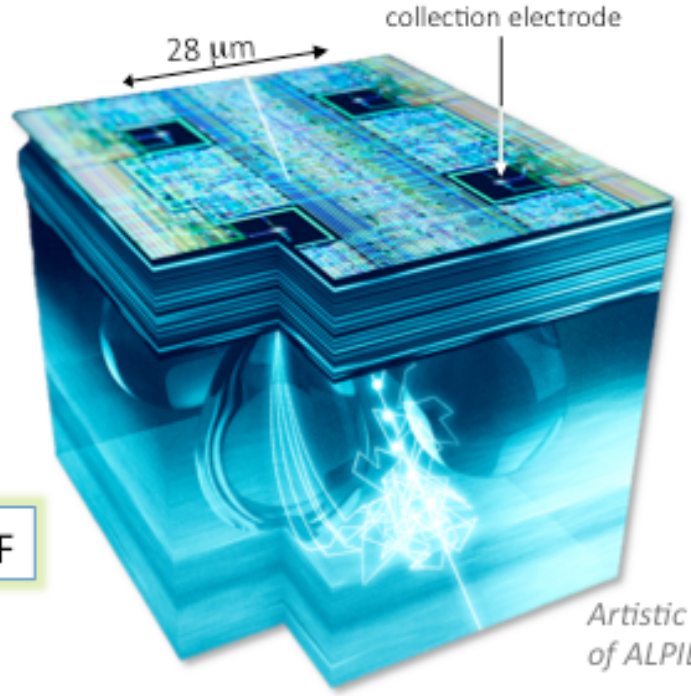


~40 μm at p_T = 500 MeV/c

Tracking efficiency (ITS standalone)



ALPIDE - Transfer of ITS technology to other applications



Artistic view of a SEM p of ALPIDE cross section

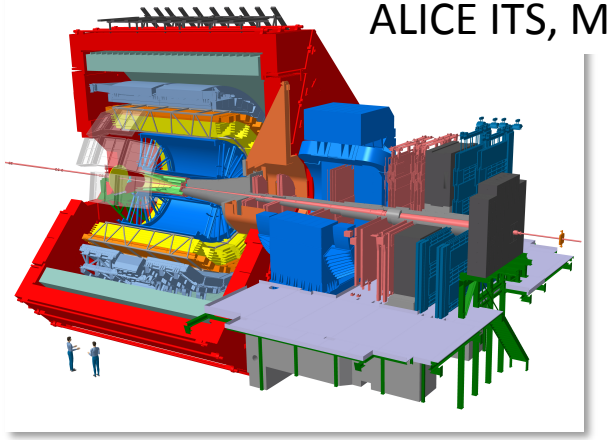
ALPIDE (**AL**ICE **Pi**xel **De**tector) Technology

Developed for ALICE (ITS and MFT) will be used by several other HEP detectors and non HEP applications

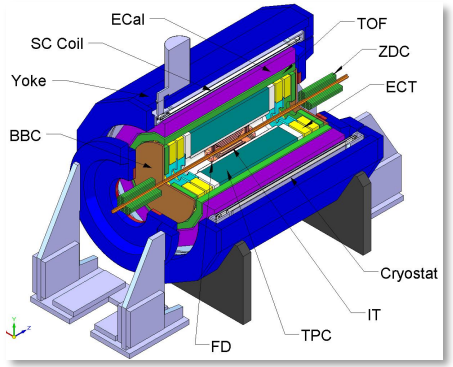
- ALICE Production will end by Dec 2018
- Production and chip series test for NICA, sPHENIX and pCT (750 wafers) in 201

Magnus, Youngil, Wanchaloem - Chip characterization and series test
Dieter – proton CT

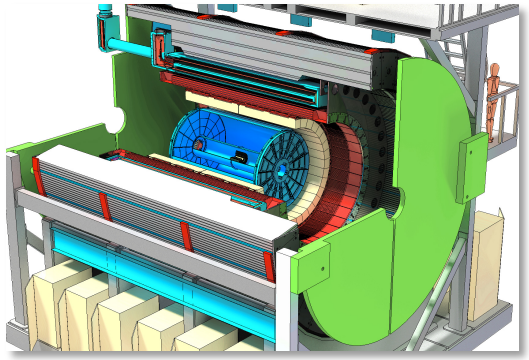
ALICE ITS, MFT



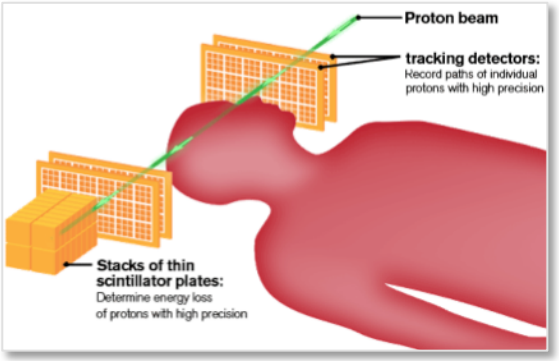
NICA MPD (@JINR)



sPHENIX (BNL)

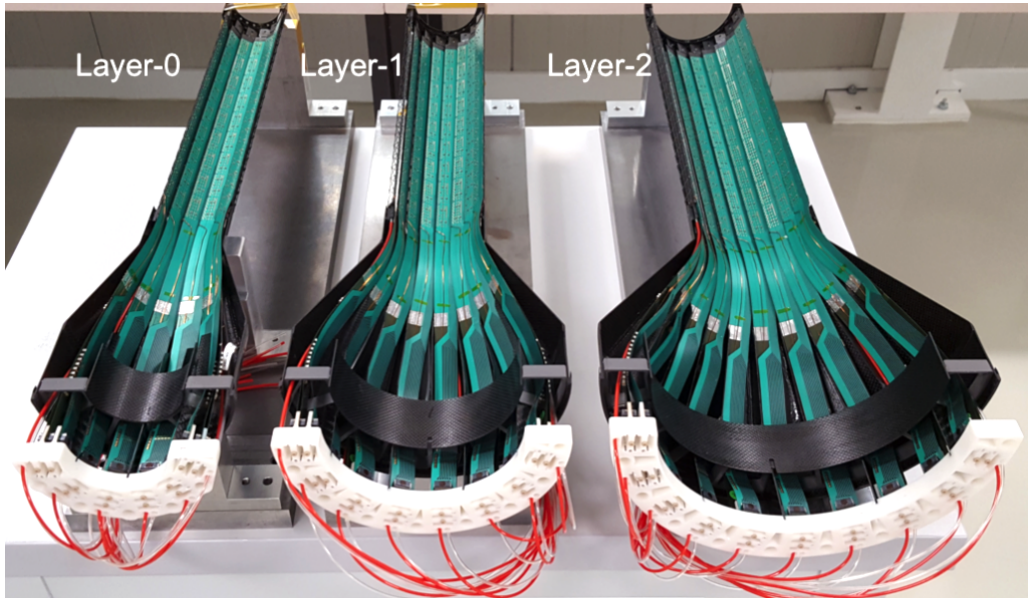


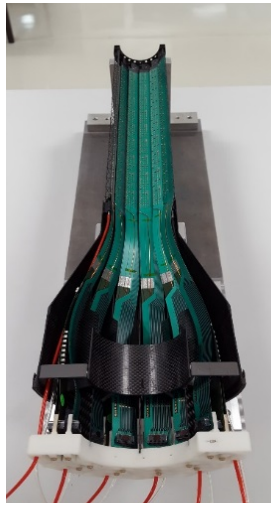
proton CT (tracking)

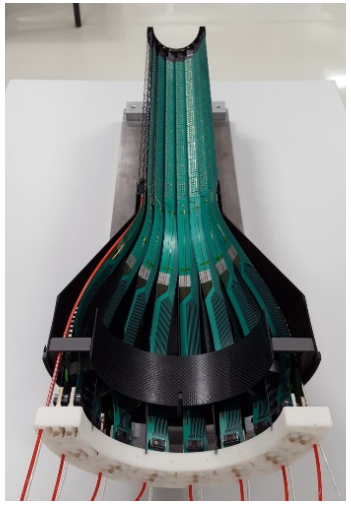


Inner Barrel HIC Production

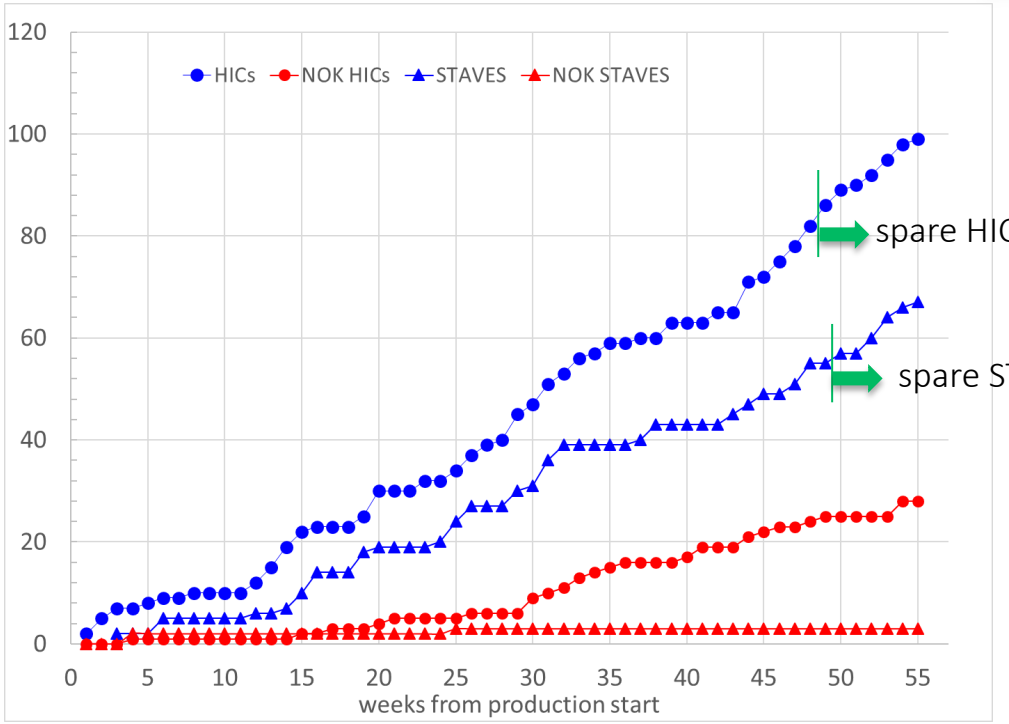
Inner Barrel Production completed and all layers assembled







Magnus – IB commissioning



Construction of spare staves continues till Dec 2018

- ✓ IB-2 Half-Barrel
- ✓ 10 additional spares

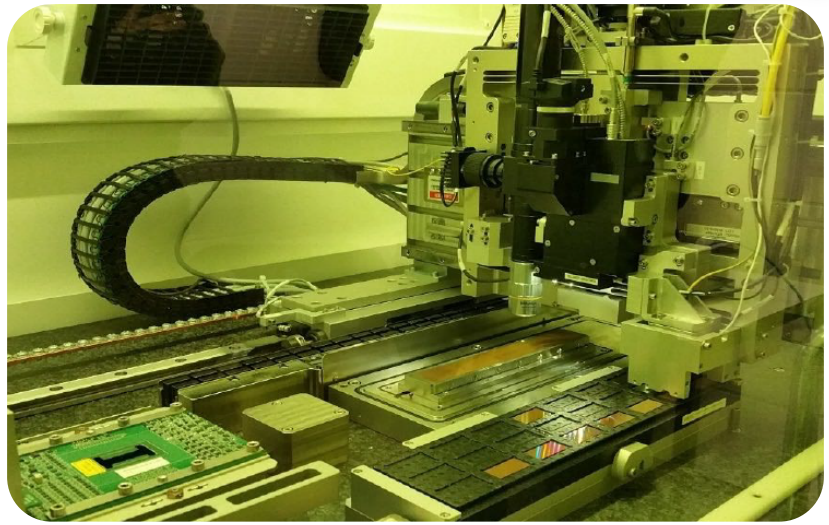
The second IB-2 half-barrel will be completed at a later stage

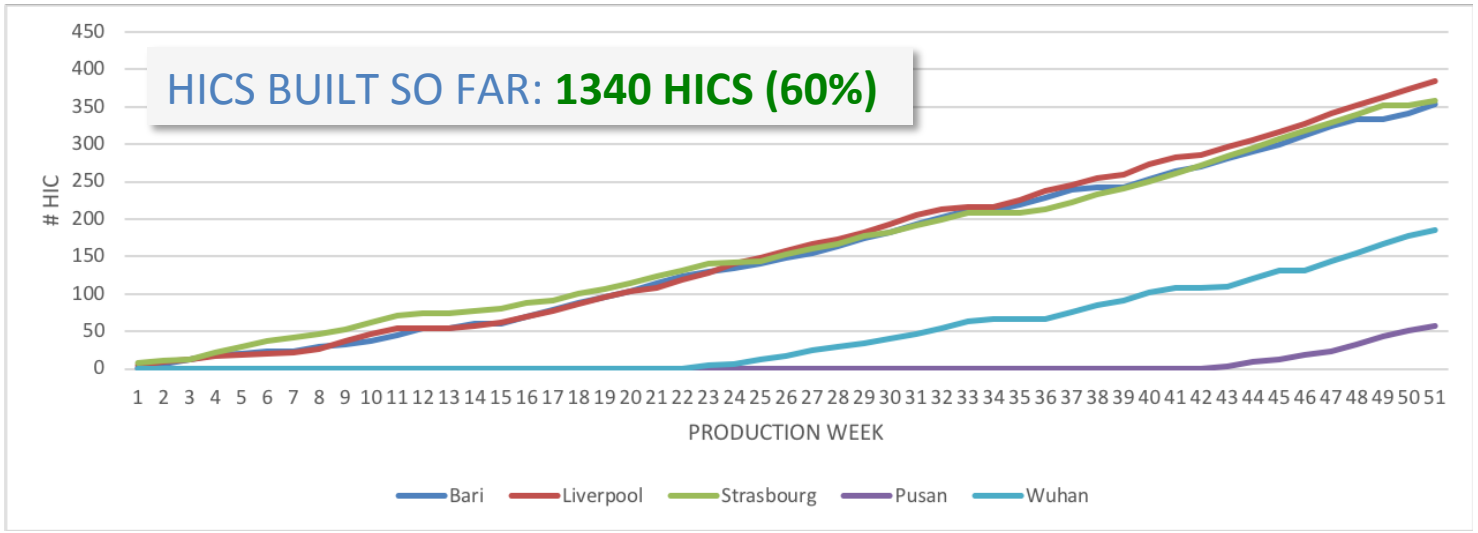
Outer Barrel HIC Production

OB HIC production in numbers

- Nr of HICs to build the detector: 1692 → 2238 (≈76% yield)
- Nr. of spares: 250
- 5 production sites: Bari, Liverpool, Pusan/Inha, Strasbourg, Wuhan
- Target production rate per site: 2 HICs / day (5 working dd / week)

Production ongoing in Bari, Liverpool, Strasbourg, Pusan/Inha and Wuhan





Steady production in Bari, Liverpool, Strasbourg, Wuhan …

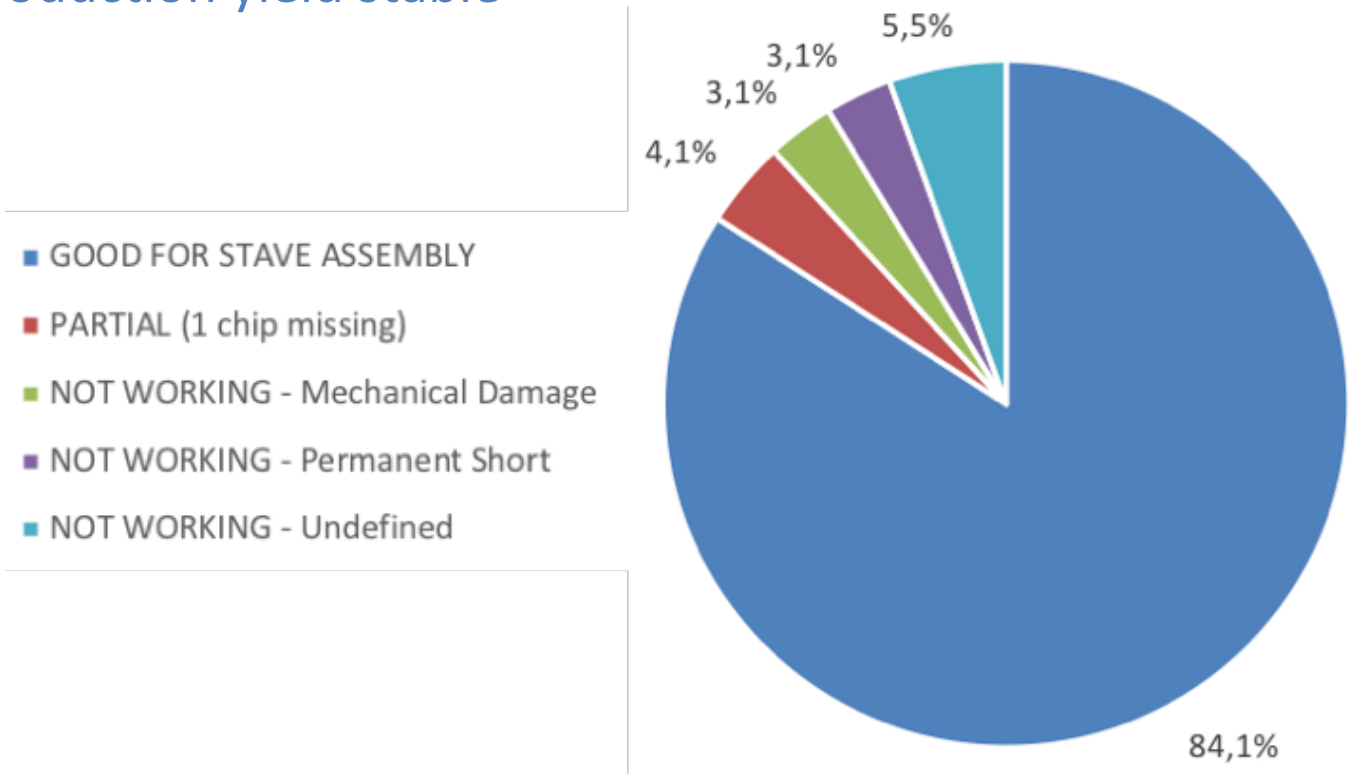
… ramping-up in Pusan/Inha

production rate of 49 HICs/week in the past 4 weeks

Vito, Yaping, Jongsik – OB HIC

Outer Barrel HIC Production Yield

OB HIC production yield stable



OB HIC Production Yield

- Total (TB Aug): 83.4%
- Total (TB Sep): 84.4%
- Total (TB Nov): 84.1%

	September TB	November TB
SILVER	62.5	61.9
BRONZE	12.3	11.7
NO BACK-BIAS	4.7	5.8
BURNT THROUGH	4.9	4.7
TOTAL	84.4	84.1

yield figures, performance, stability are to be monitored carefully

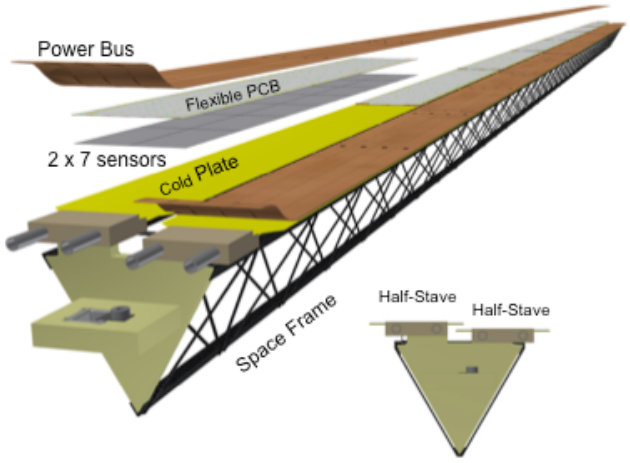
M. Keil and P. Riedler – Test and QA

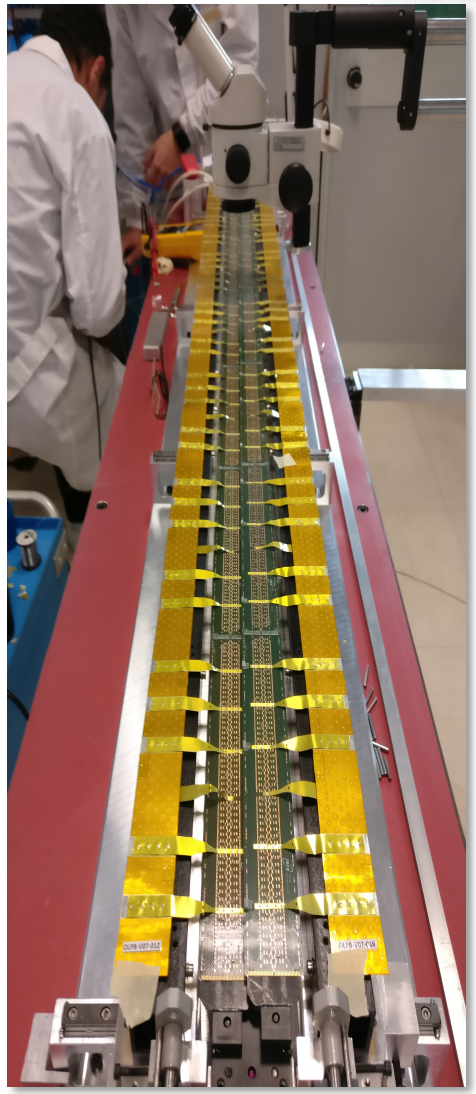
Outer Barrel Stave Production

Construction sites: Torino, Frascati, Daresbury and Nikhef (for OL), Berkeley (for ML)

OB Staves: 90 + 10 (OL), 54 + 6 (ML) (# spares in green)

Production has reached cruise speed in all sites





Cumulative number of staves

Site	June	July	August	Sep	15 Nov
Outer Layers	7	12	20	28	39
Middle Layers	1	3	5	9	18

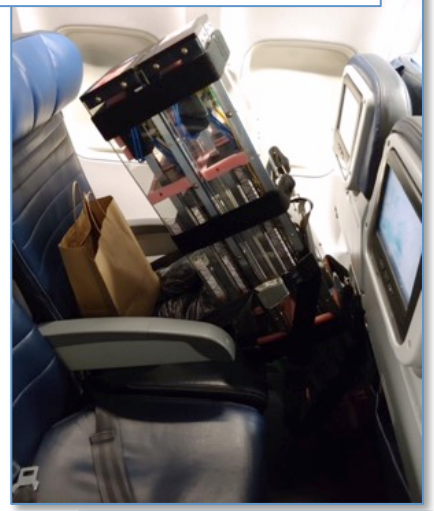
- Production rate in Torino > 1.8 nominal, close to **1 OL stave / week**
- Daresbury, Frascati and Nikhef are all above 0.5 stave/week (nominal rate)
- Very good prospects for a production throughput > 8/month (basis for our current baseline schedule)
- Berkeley continues with a production throughput of **1 ML stave / week**

Middle Layer Stave Production @ Berkeley

Assembly Status, *Nikki Apadula, ITS Plenary, Tue 13 Nov*

Assembly Step	Stave 0	Stave 1	Staves 2-5	Staves 6-10	Stave 11	Stave 12	Stave 13	Stave 14	Stave 15	Stave 16	Stave 17	Stave 18
Assemble HS - U	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Assemble HS - L	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Solder bridges/ext	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Glue to space frame	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Solder on PB/BB	✓	✓	✓	✓	✓							
Add clips/fold PB	✓		✓	✓								
Test/fix	NA		✓	✓								
Ship to CERN	✓		✓									
CERN reception test	NA											

transport of staves



Stave nominal production rate:

- 10 OL staves/month, 4 ML/month

➡ HIC production rate ≥ 54 HICs/week (assuming yield of 80%)

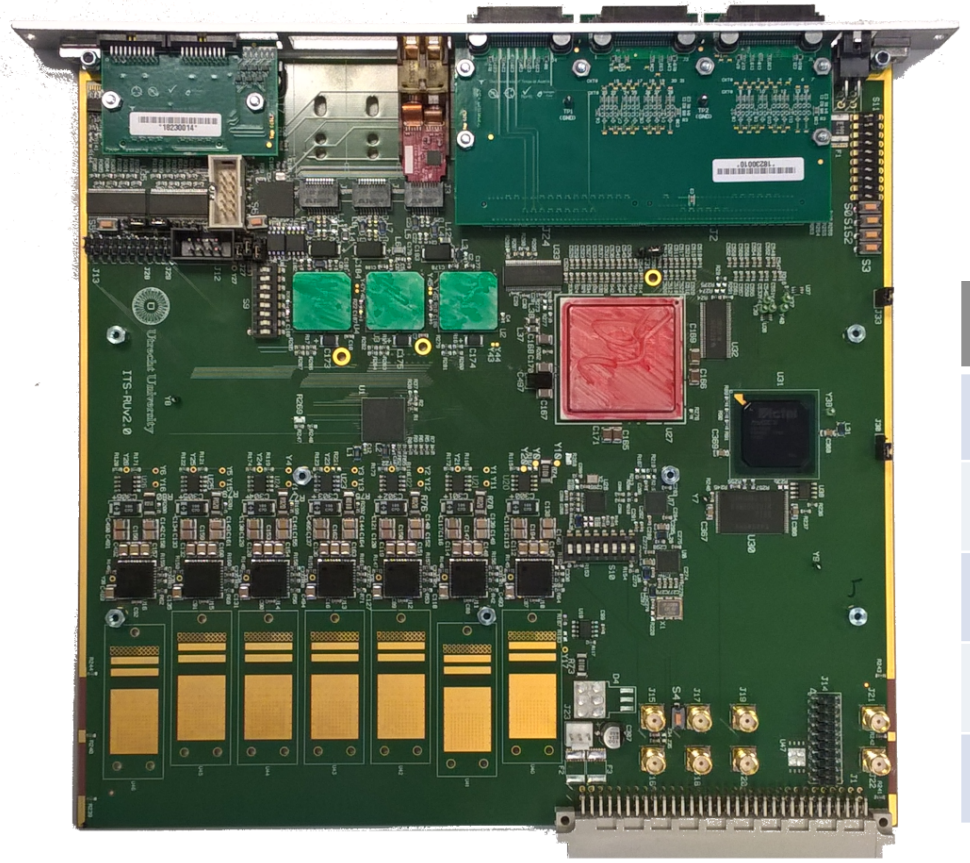
Upcoming Plans

- Steadily building at 1 Stave/week
- Catching up with PB/BB/FB soldering/folding
  - At ~2-3 days per stave on average
- Week 46: Assemble Stave 18; fold Staves 11, 12
- Week 47: Assemble Stave 19; US holiday
- Week 48: Assemble Stave 20; fold Staves 13, 14, 15
- Week 49: Assemble Stave 21; fold Staves 16, 17, 18
- Week 50: Assemble Stave 22; fold Staves 19, 20, 21

Readout Electronics

- RU2 production ongoing: as of today bottom layer of 20 PCBs populated (pre-series)
- 2 bare PCBs arrived at CERN and preliminary quality inspection ok
- All details (cold plate integration, labels placements, etc..) worked out

Piero – Readout
Peter and Paolo – DCS



First 20 boards expected by November 21
Production test system ready (Nikhef)

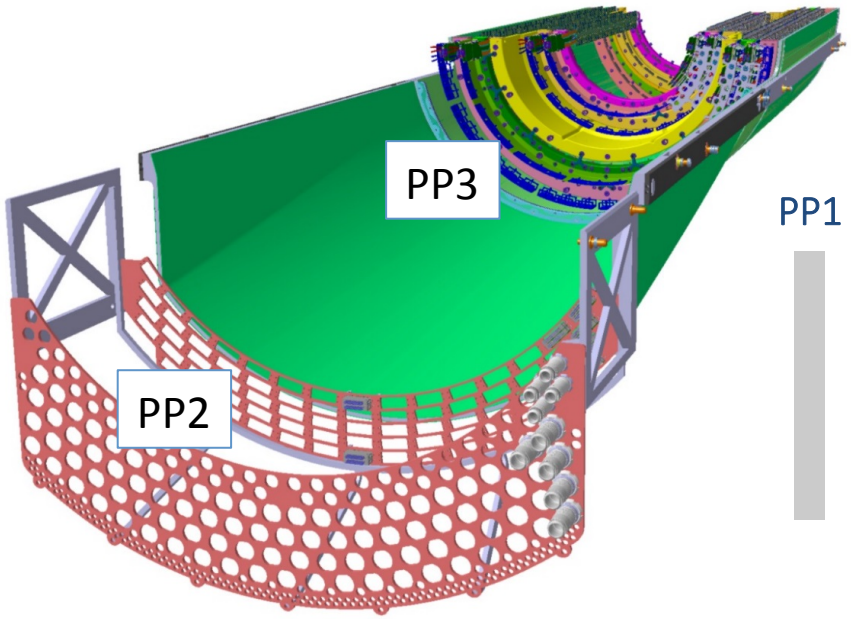
Production schedule (confirmed)

Phase		Qty	Week	Due
Purchase Order	T0			14 Sept 2018
Pre-series delivery	T0 + 10w	20 (4 MFT)	47	21 Nov 2018
Acceptance of pre-series	T0 + 13w	20 (4 MFT)	48, 49, 50	14 Dec 2018
Batch 1 delivery	T0 + 22w	140 (36 MFT)	7	15 Feb 2019
Batch 2 delivery	T0 + 29w	150 (48 MFT)	14	5 apr 2019

Readout Electronics

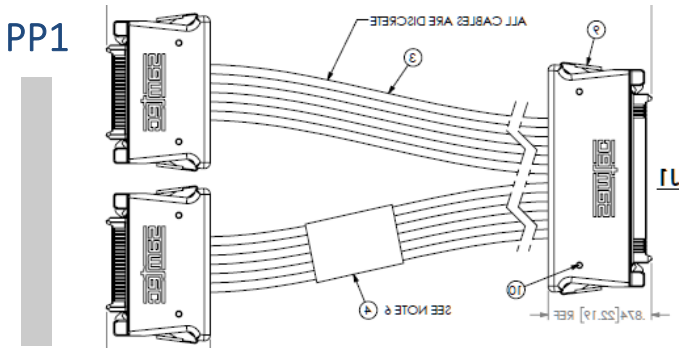
- Contract awarded to Samtec
- Some issues are delaying the industrialization of the production process (see backup slides)
- Samtec confirmed production scheduled even with the above mentioned delay
- Still on track to get 24 assemblies (48 cables) before Christmas break

Production schedule (confirmed)

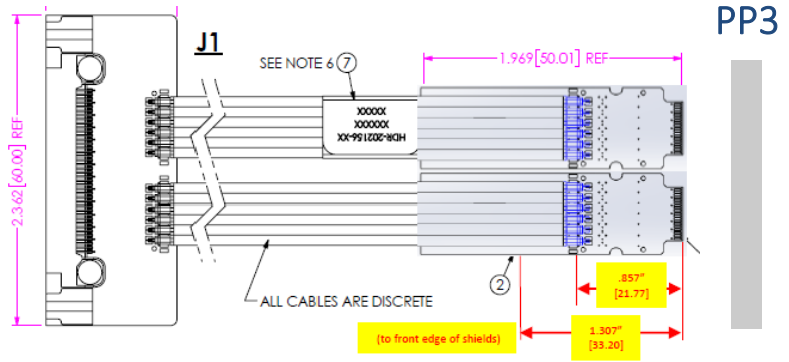


PP1 (ALICE Miniframe)

HDR-203194 (Type B)

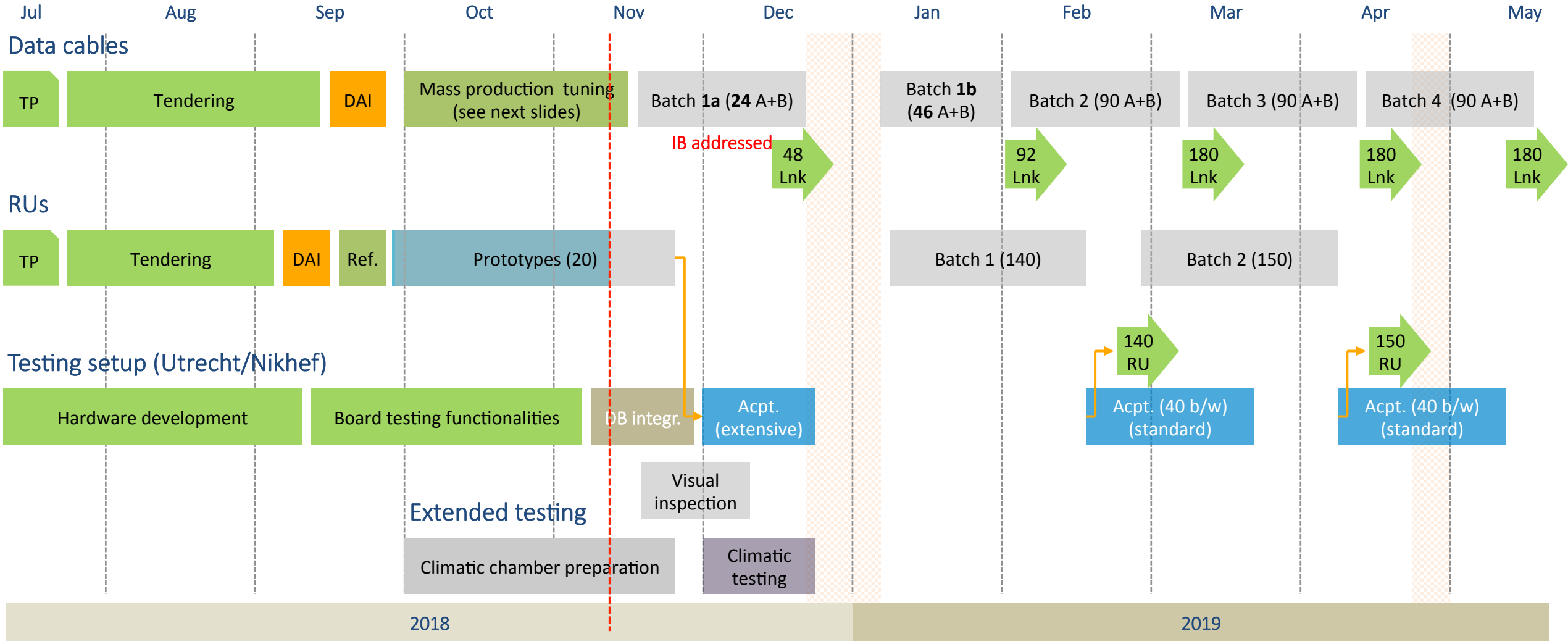


HDR-206142 (Type A)



Readout Electronics

Goal is having 20 RUs before Christmas Break, as well as enough data cables to connect the whole IB (24 assemblies, equal to 40 data cables).



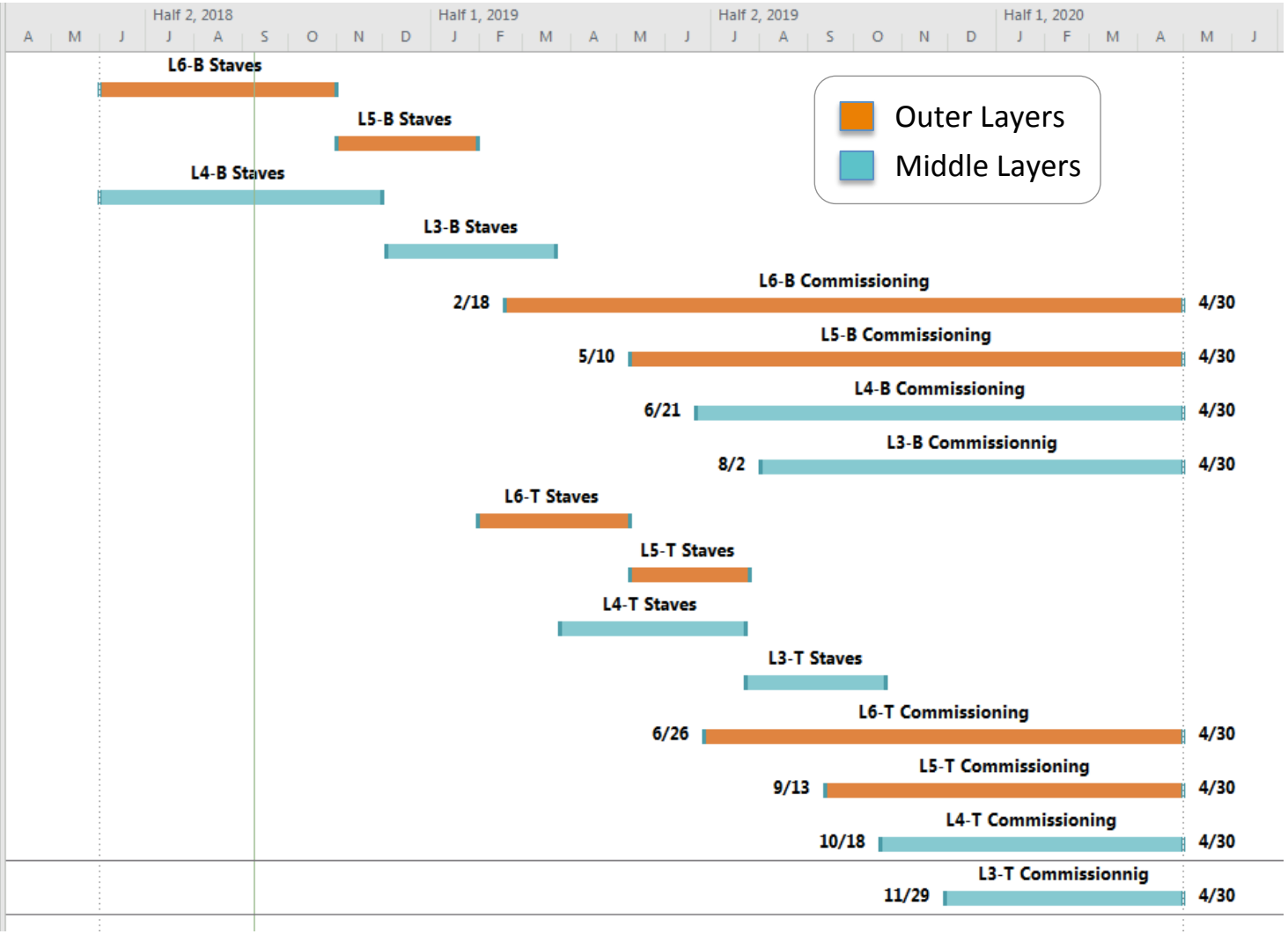
OB Assembly and Commissioning Schedule

Pre-commissioning on surface over a period of time of 5 to 14 months

F. Reidt – Commissioning

	Task Name	Duration	Start	Finish
1	L6-B Staves	109 days	Fri 6/1/18	Wed 10/31/
2	L5-B Staves	65 days	Thu 11/1/18	Wed 1/30/19
3	L4-B Staves	131 days	Fri 6/1/18	Fri 11/30/18
4	L3-B Staves	80 days	Mon 12/3/18	Fri 3/22/19
5	L6-B Commissioning	314 days	Mon 2/18/19	Thu 4/30/20
6	L5-B Commissioning	255 days	Fri 5/10/19	Thu 4/30/20
7	L4-B Commissioning	225 days	Fri 6/21/19	Thu 4/30/20
8	L3-B Commissionnig	195 days	Fri 8/2/19	Thu 4/30/20
9	L6-T Staves	71 days	Thu 1/31/19	Thu 5/9/19
10	L5-T Staves	55 days	Fri 5/10/19	Thu 7/25/19
11	L4-T Staves	86 days	Mon 3/25/19	Mon 7/22/19
12	L3-T Staves	65 days	Tue 7/23/19	Mon 10/21/19
13	L6-T Commissioning	222 days	Wed 6/26/19	Thu 4/30/20
14	L5-T Commissioning	165 days	Fri 9/13/19	Thu 4/30/20
15	L4-T Commissioning	140 days	Fri 10/18/19	Thu 4/30/20
16	L3-T Commissionnig	110 days	Fri 11/29/19	Thu 4/30/20

GANTT CHART



Half-Barrel Bottom

14 months

12 months

10 months

9 months

Half-Barrel Top

10 months

7.5 months

6.5 months

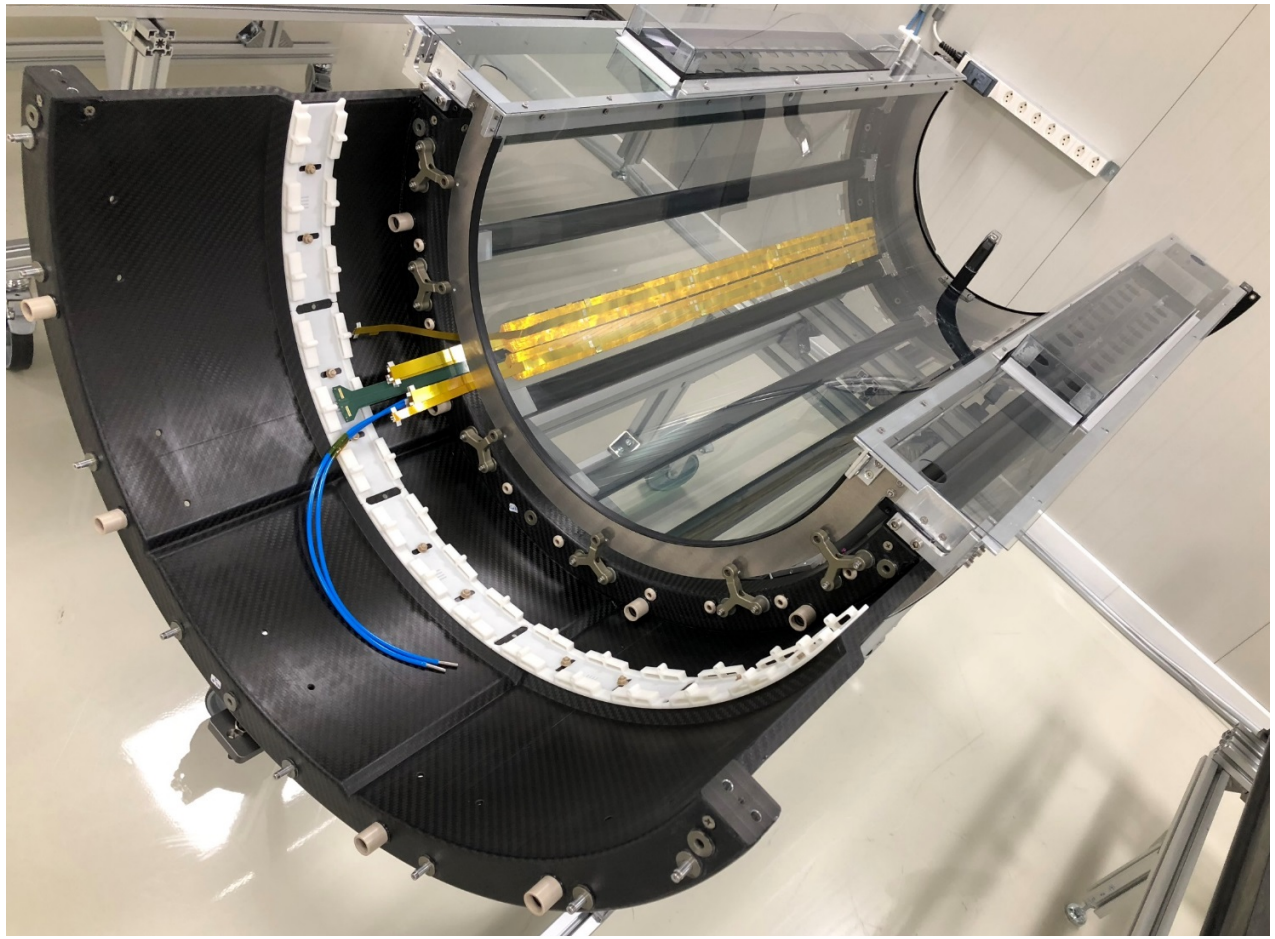
5 months

Outer Detector Barrel Assembly – half-layer enclosure

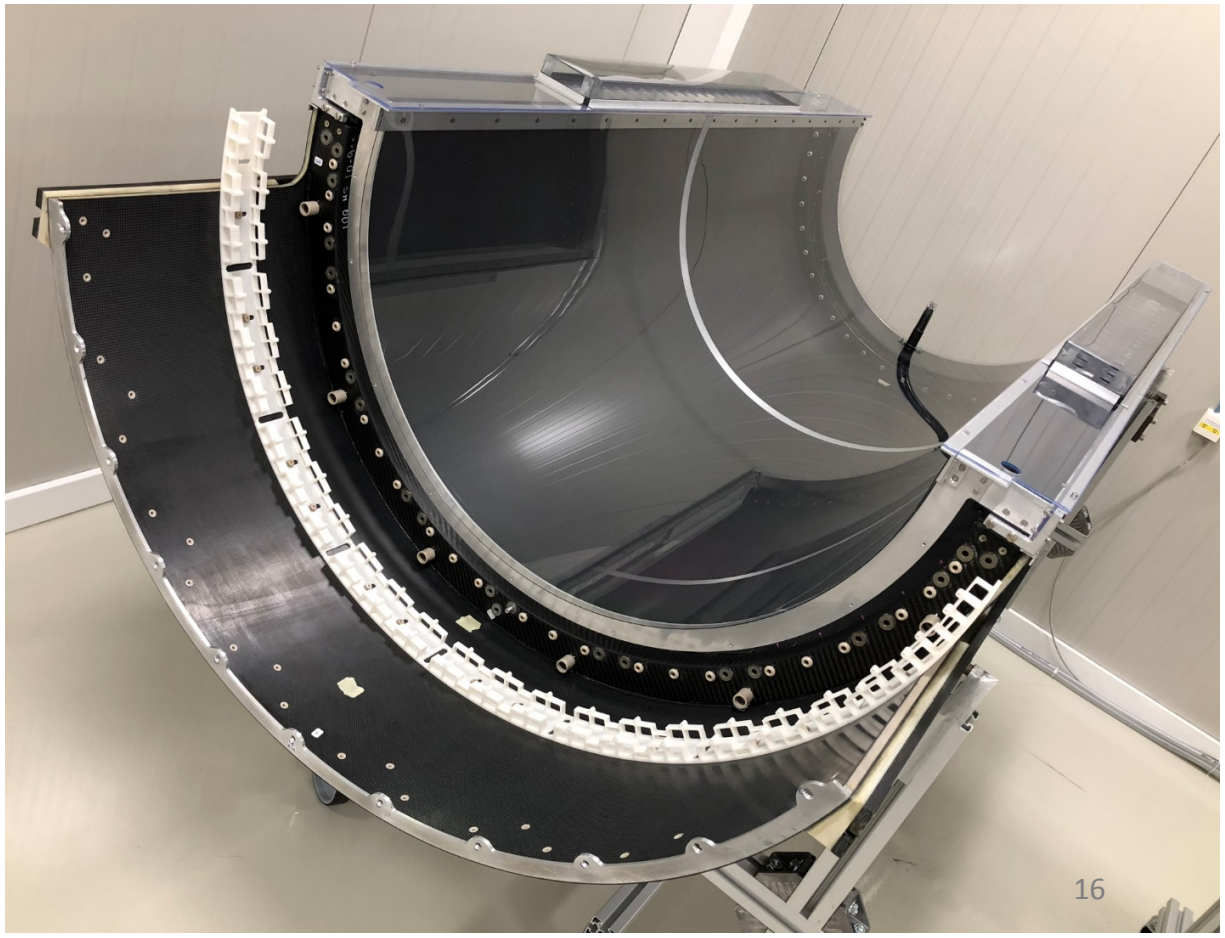
Thin plastic (antistatic) enclosure to protect the layers and ensure a controlled dry air volume

- production of enclosures for H-Layer6 and H-layer4: done!
- dry installation H-Layer6 and H-layer4: done!

Layer 4 dry air enclosure



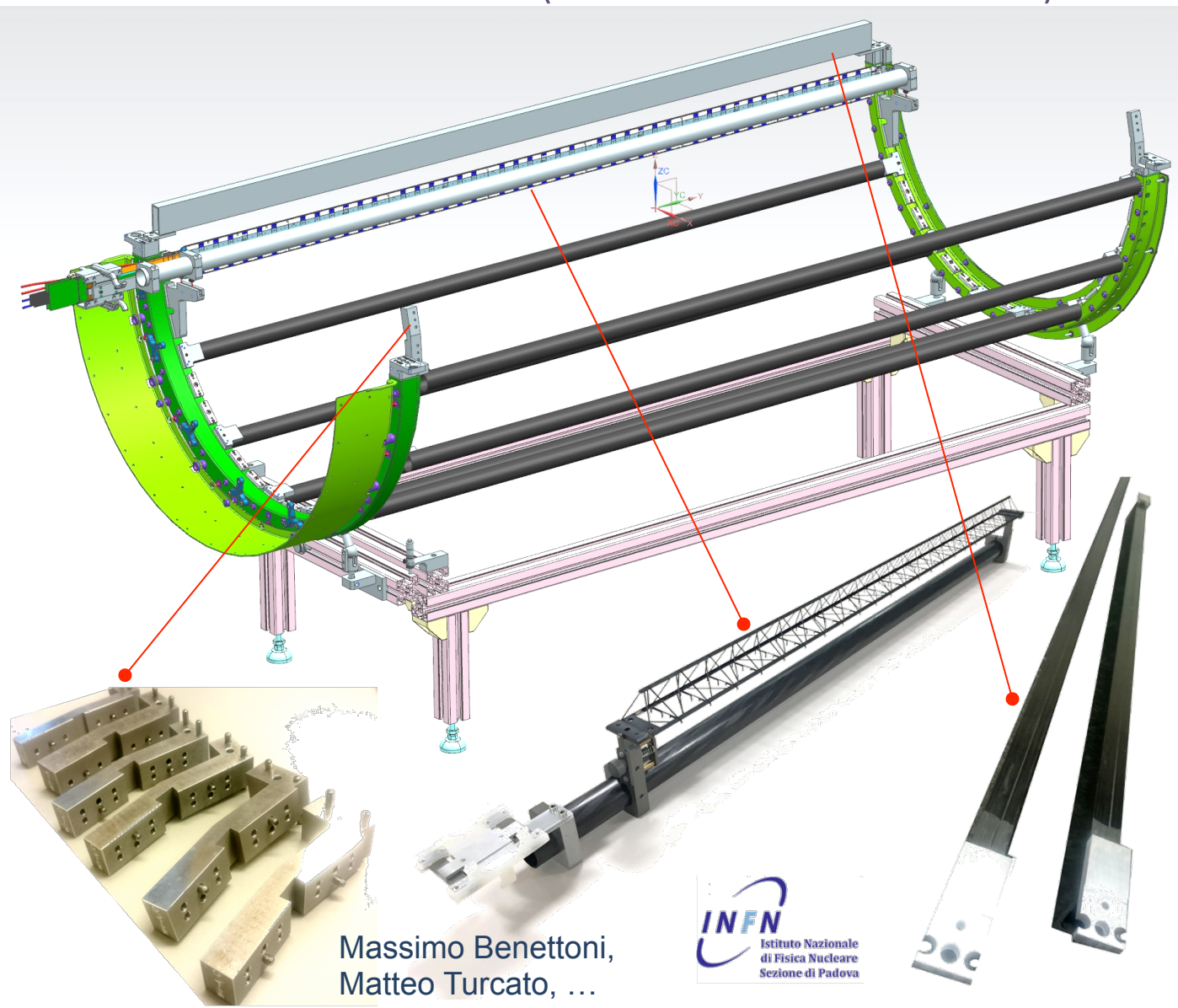
Layer 6 dry air enclosure

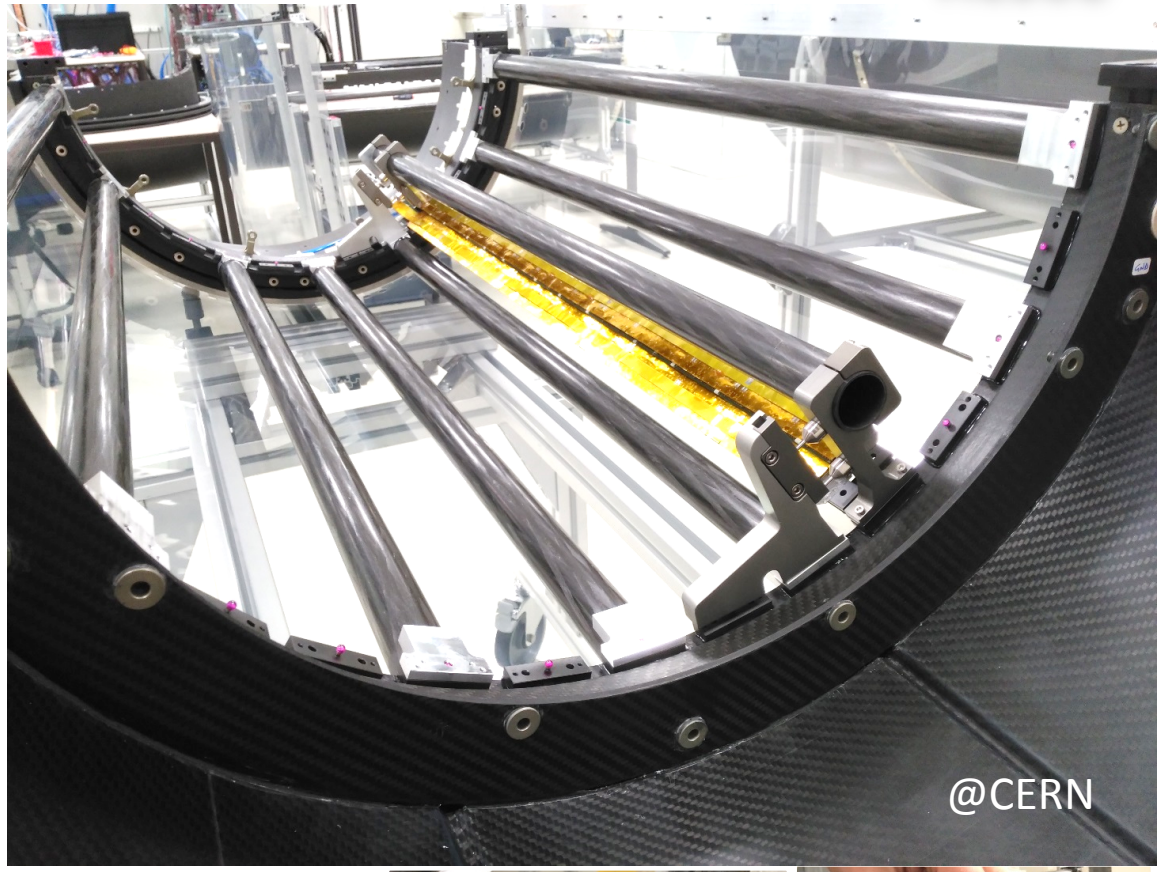


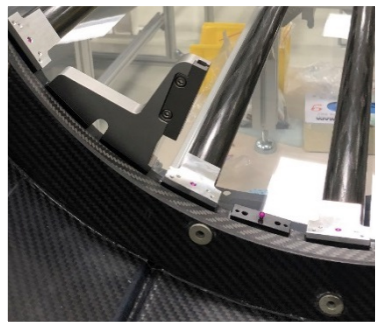
Outer Detector Barrel Assembly – installation jigs and procedures

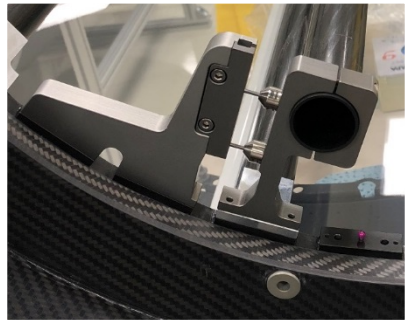
The stave installation jigs and procedure validation continues at CERN

Next exercise 14-15 Nov with (Corrado + Massimo Benettoni)





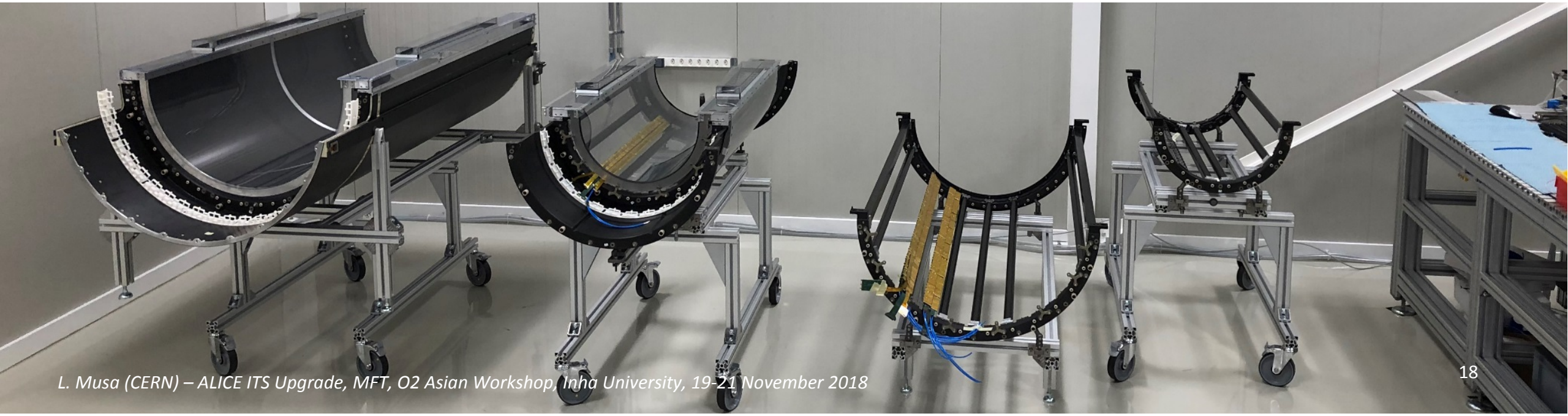




Massimo Benettoni,
Matteo Turcato, …

Outer Detector Barrel – Assembly area in bld. 167

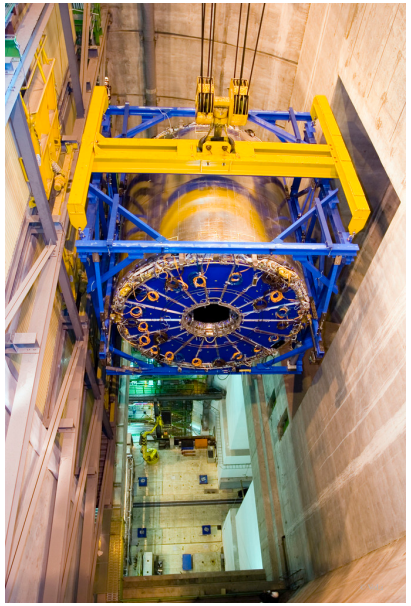
Set-up assembly area in bld. 167: large marble removed, new trays for layers handling produced



ITS Assembly Area – layout on 12 Nov 2018

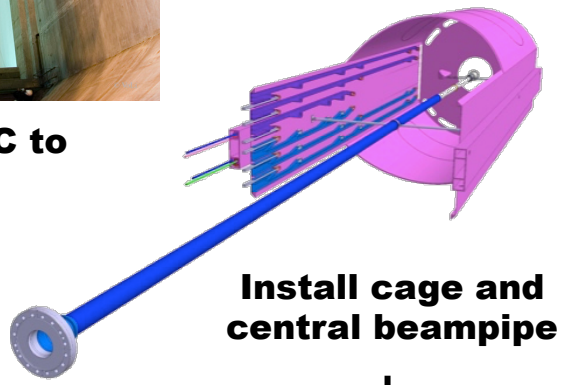
Installation & Commissioning Timeline

Activities in the ALICE PIT in 2020



Bring TPC to UX25

3 Feb ‘20

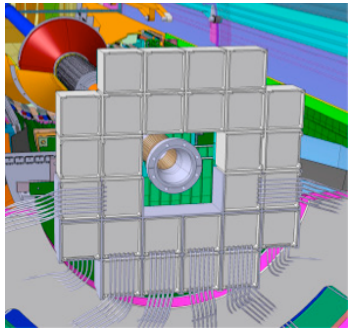


Install cage and central beampipe

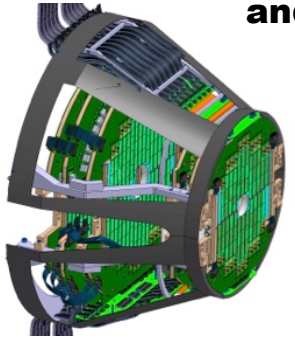
26 Feb

Reinstall Miniframe

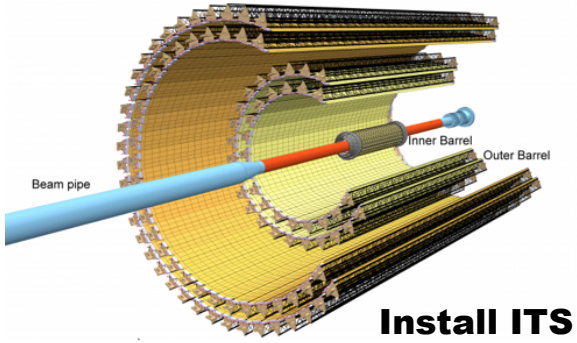
7 Apr



Install MFT and FIT-C

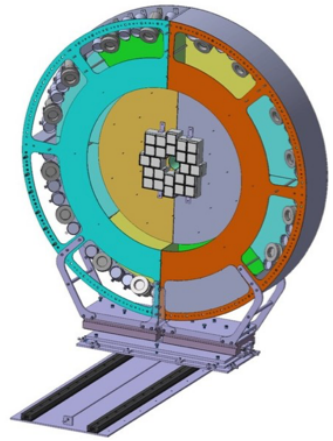


15 Apr



Install ITS

27 May



Install FIT-A

19 Aug

6 months commissioning

22 Feb ‘21

LS2 ends

ITS Commissioning in 2019 and 2020

Commissioning activities will start in April 2020

- Running of the detector 27/7 (6 people /day)
- Data quality
- Alignment using cosmic rays

We count on the participation of all ITS teams in the commissioning activities

- on surface: Jan 2019 – Apr 2020
- in the ALICE cavern: Sep 2020 – Feb 2021

Note

- ⇨ **no ALICE Running in 2019-2020**
- ⇨ **no construction in 2020**

Each team should contribute a minimum of 6 man-months

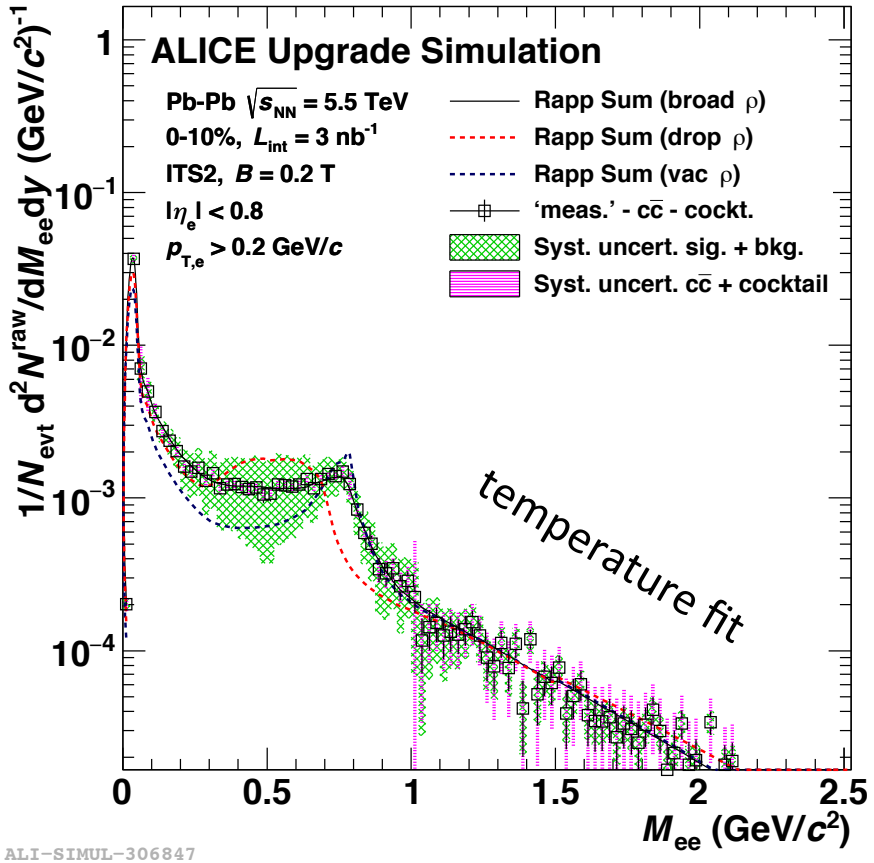
Minimum period per person: 2 months

Thank You

ITS Upgrade in LS2 (ITS2)

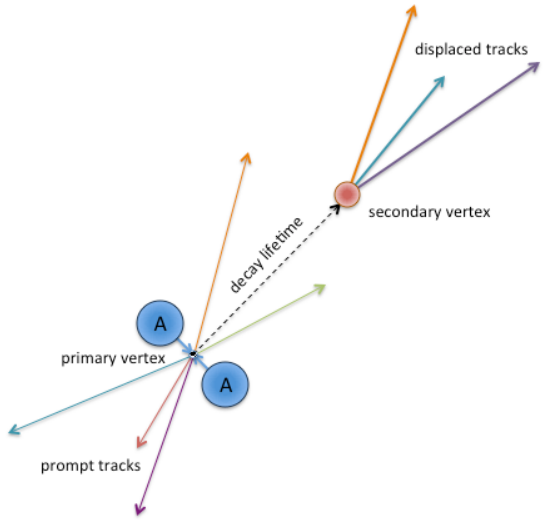
Low-mass dielectrons

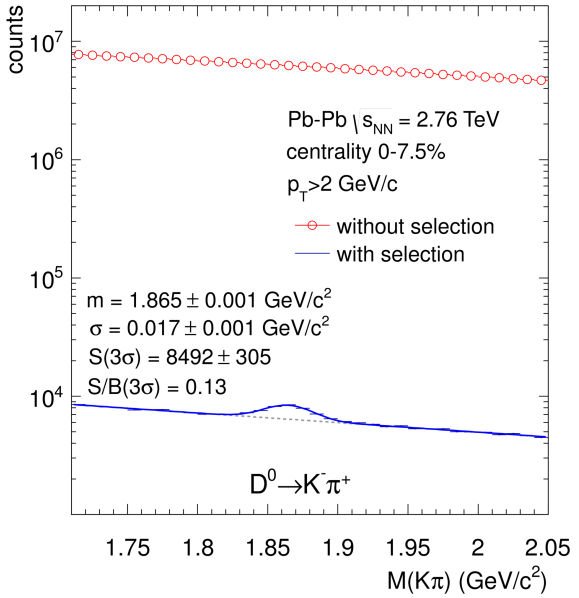
- ⇨ vertexing (better charm rejection)
- ⇨ material thickness (less conversion)
- ⇨ Higher low-p_T efficiency (better conversion rejection)



Open charm (➔ QGP hard probe)

Particle	Decay Channel	cτ (μm)
D^0	$K^-\pi^+$ (3.8%)	123
D^+	$K^-\pi^+\pi^+$ (9.5%)	312
D_s^+	$K^+K^-\pi^+$ (5.2%)	150
Λ_c^+	$pK^-\pi^+$ (5.0%)	60

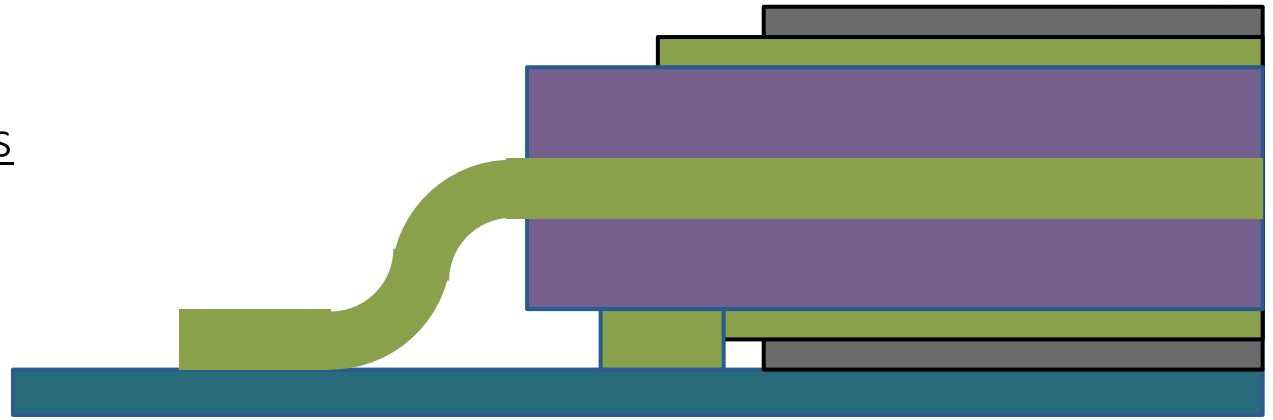




Data Cables – Development Status

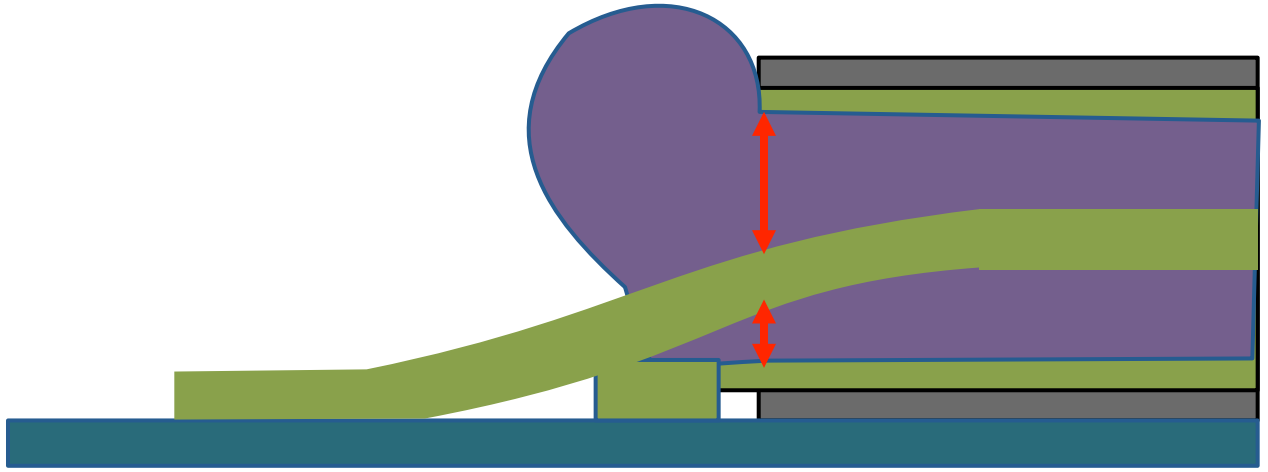
Overview

- Samtec committed 2 engineers (US based) full time on our cables, with the further support of a production expert and a project manager (Jason). Total team size is 5, with 2 full-time members.
- Material taken to the meeting was very good, clearly illustrating the status of the process development and the problems encountered so far: it seems they put resources on the task.



The issue so far

- Melting of the custom made dielectric while soldering the cable to the PCB, as it has lower melting point respect the standard one, which:
  1) may short the central conductor with the shielding,
  2) even if no short happens, the change in geometry (extreme in the first prototypes) affects the z0 of the cable



Data Cables – Development Status

Solutions tried so far involves:

- use of Bismuth soldering (lower temperature, and compliant with CERN safety rules),
- pre-forming the cable end before soldering to counter-act the plastic deformation,
- use of newly-developed low-pressure fixtures to partially relief the mechanical strain on the dielectric during the soldering process

Results

- The single solutions listed above work, but Samtec still has to implement them all together in an automatic production process (each single solution has been already tested in automatic process on its own).
- We have been shown images (actual water-cut sections) of the latest prototypes where the short issue has been already solved, yet the engineer in charge of Z verification is still not completely happy due to the non perfect uniformity of the dielectric at the soldering point (yet it is far better than early prototypes). *It is likely that this prototype is already better than those we have, and compliant with our specs.*