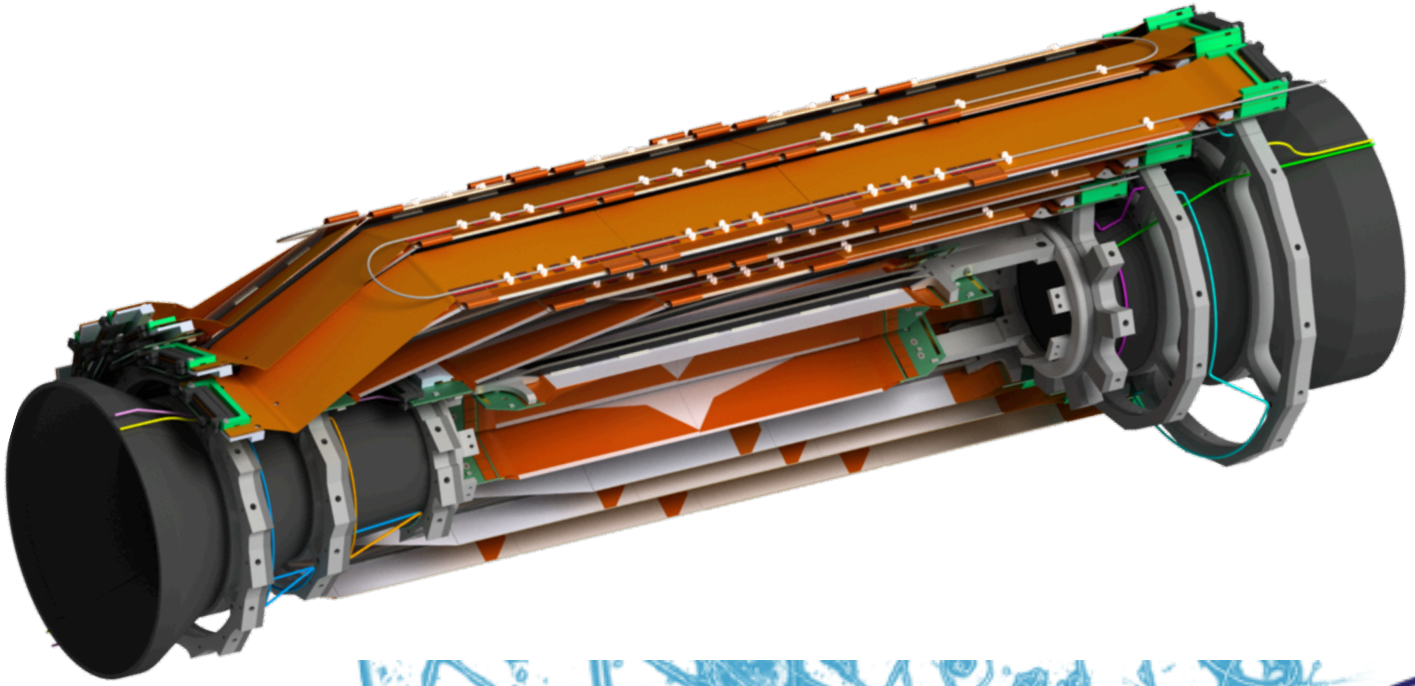
Status Update on SVD module construction



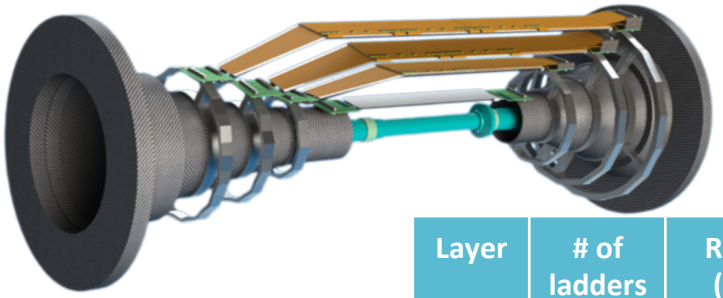
Stefano Bettarini
Universita' di Pisa & INFN

On behalf of the Belle II SVD Group

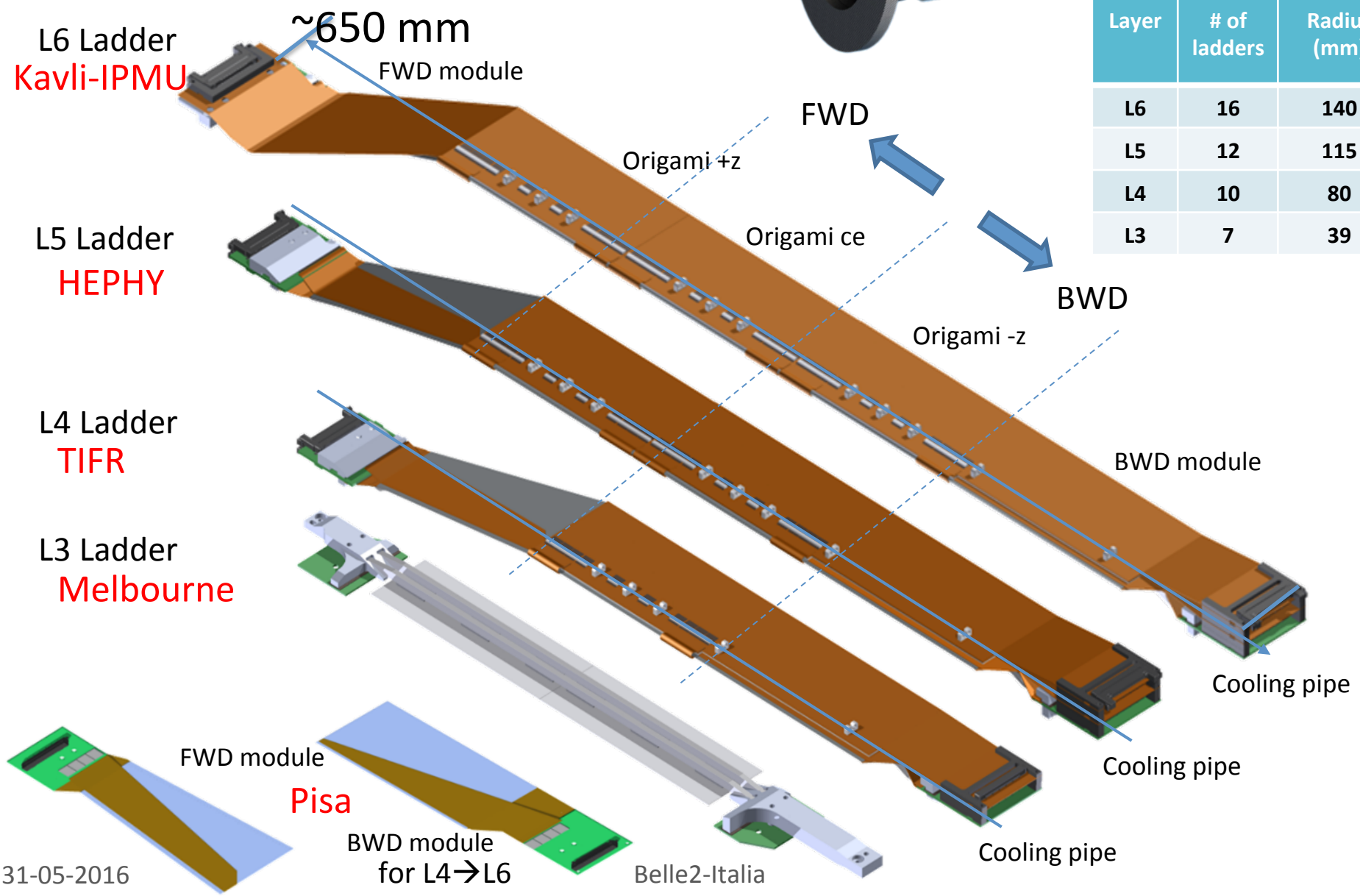
OUTLINE

- **SFW & SBW production status in Pisa**
  - Schedule
  - Electrical problems on some modules
- **Origami production (L4→6)**
- **Overview of the Ladder Production sites:**
  - Layer 3, 4, 5 and 6
- **Mechanics:**
  - Ladder mount, cooling-pipe mount
- **Conclusions**

The SVD ladder design

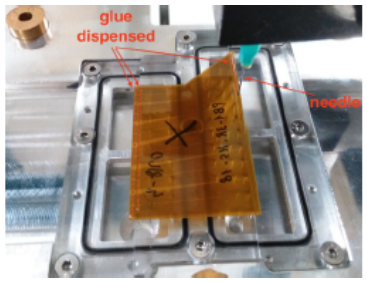


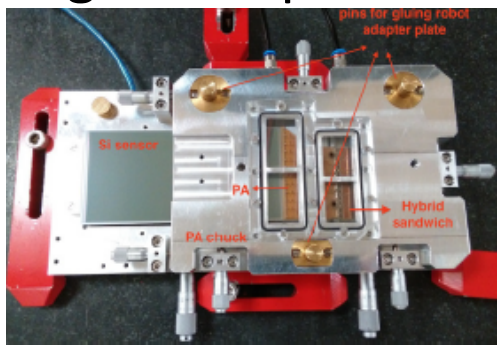
Layer	# of ladders	Radius (mm)
L6	16	140
L5	12	115
L4	10	80
L3	7	39



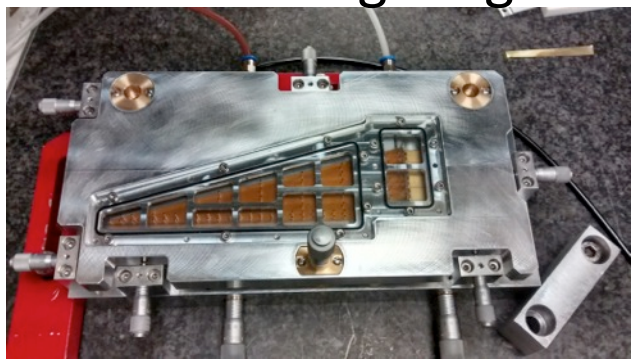
FW/BW subassembly

- Flex phi-side gluing:
  - alignment of the detector and hybrid boards on the gluing jig
  - Alignment, gluing of the phi-PA

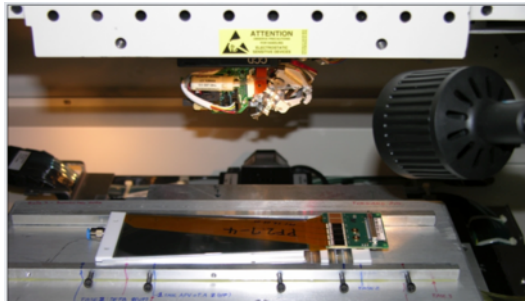




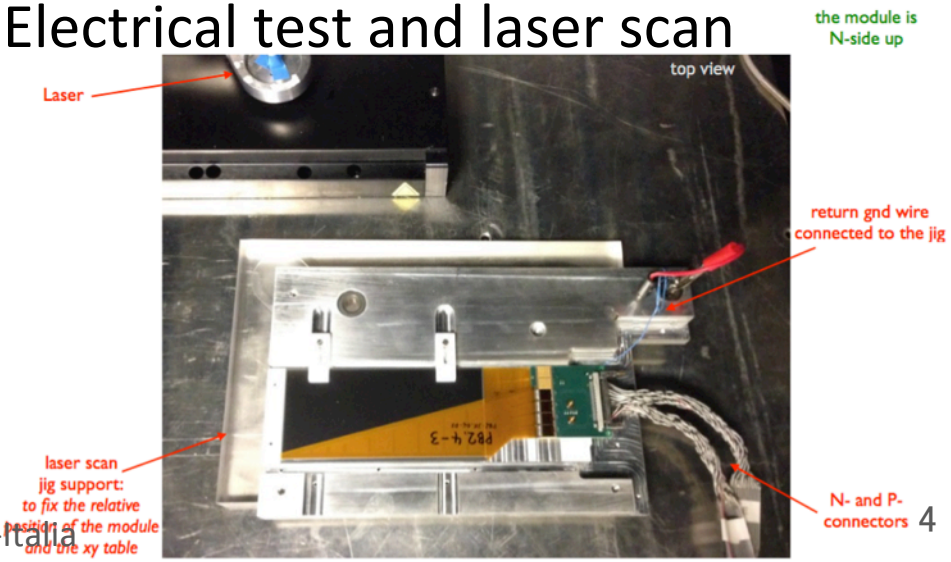
- Z-side gluing:



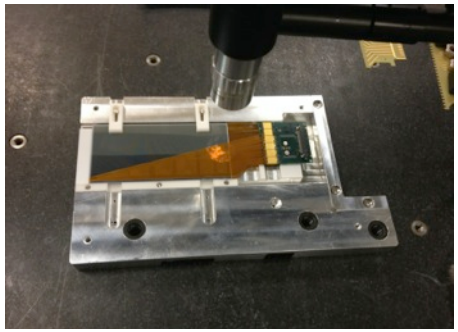
- Microbonding



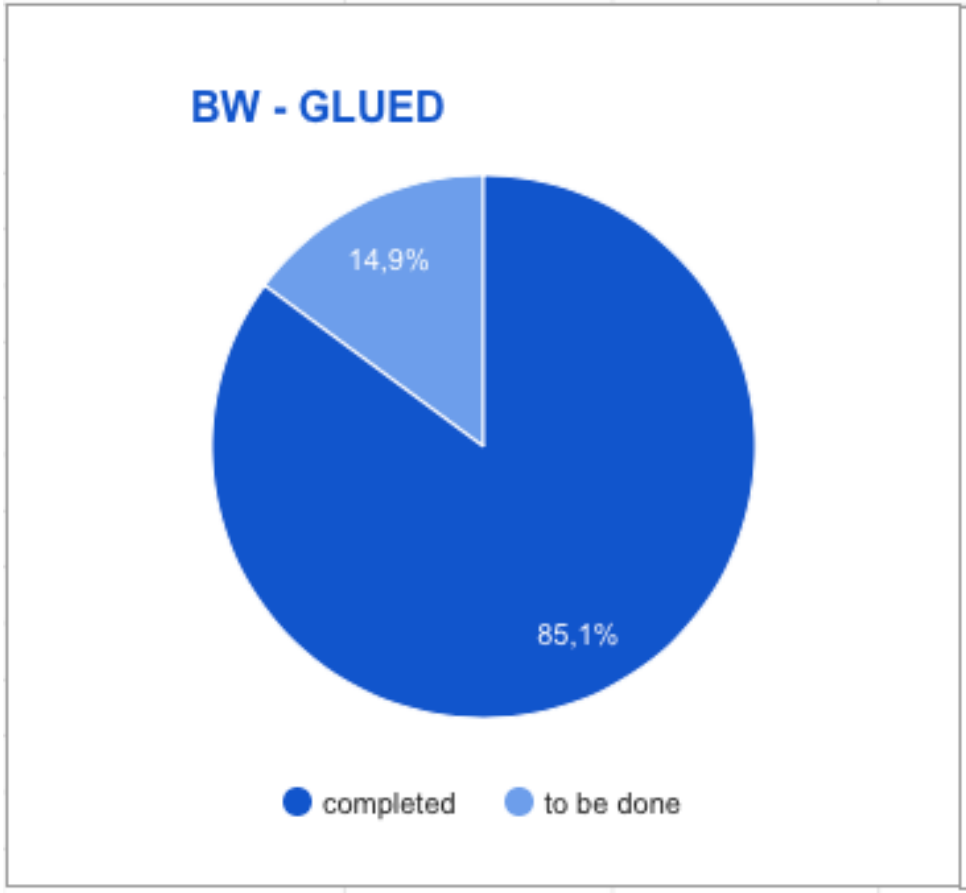
- Electrical test and laser scan

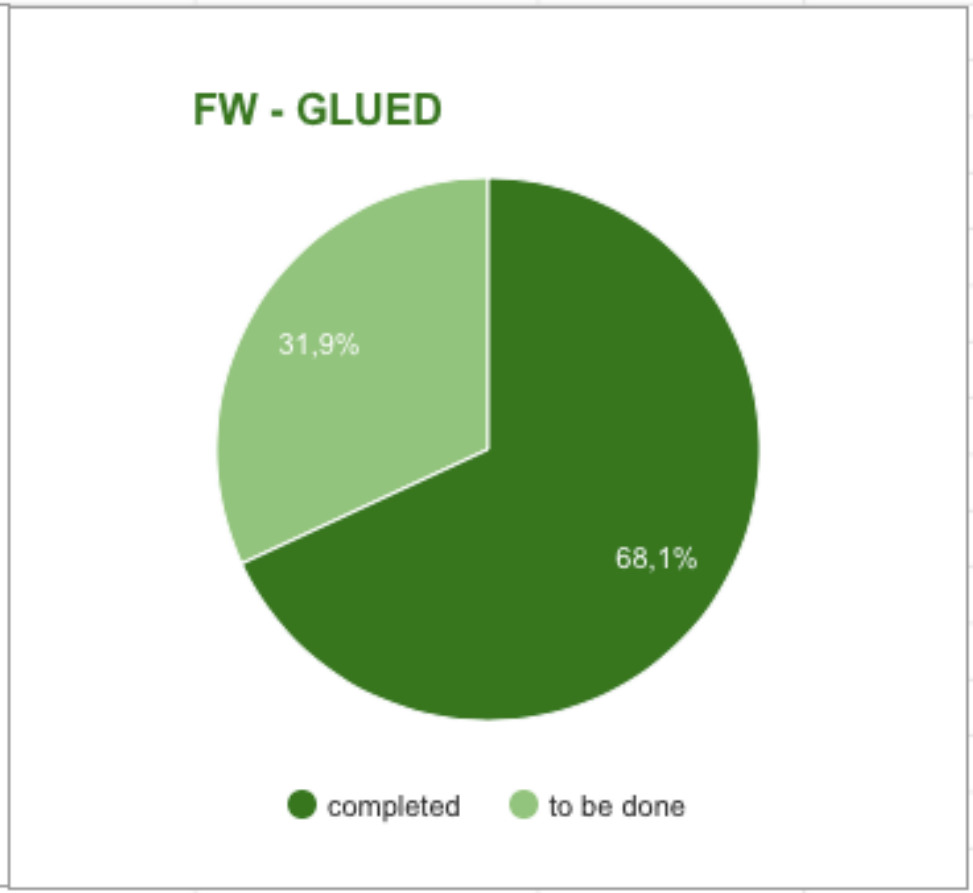


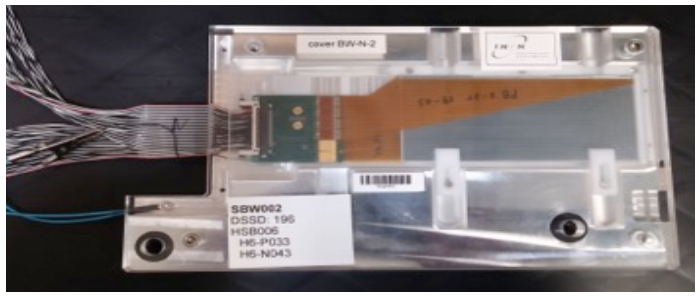
- Shipping (survey)

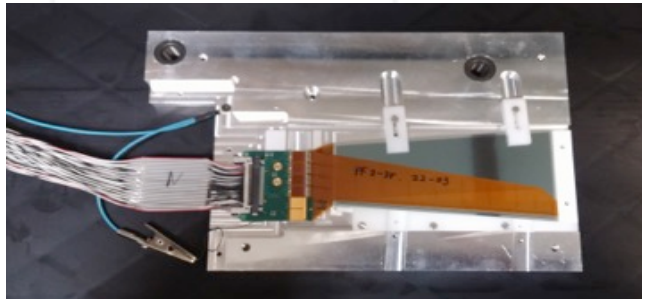


Current Production Status SBW/SFW

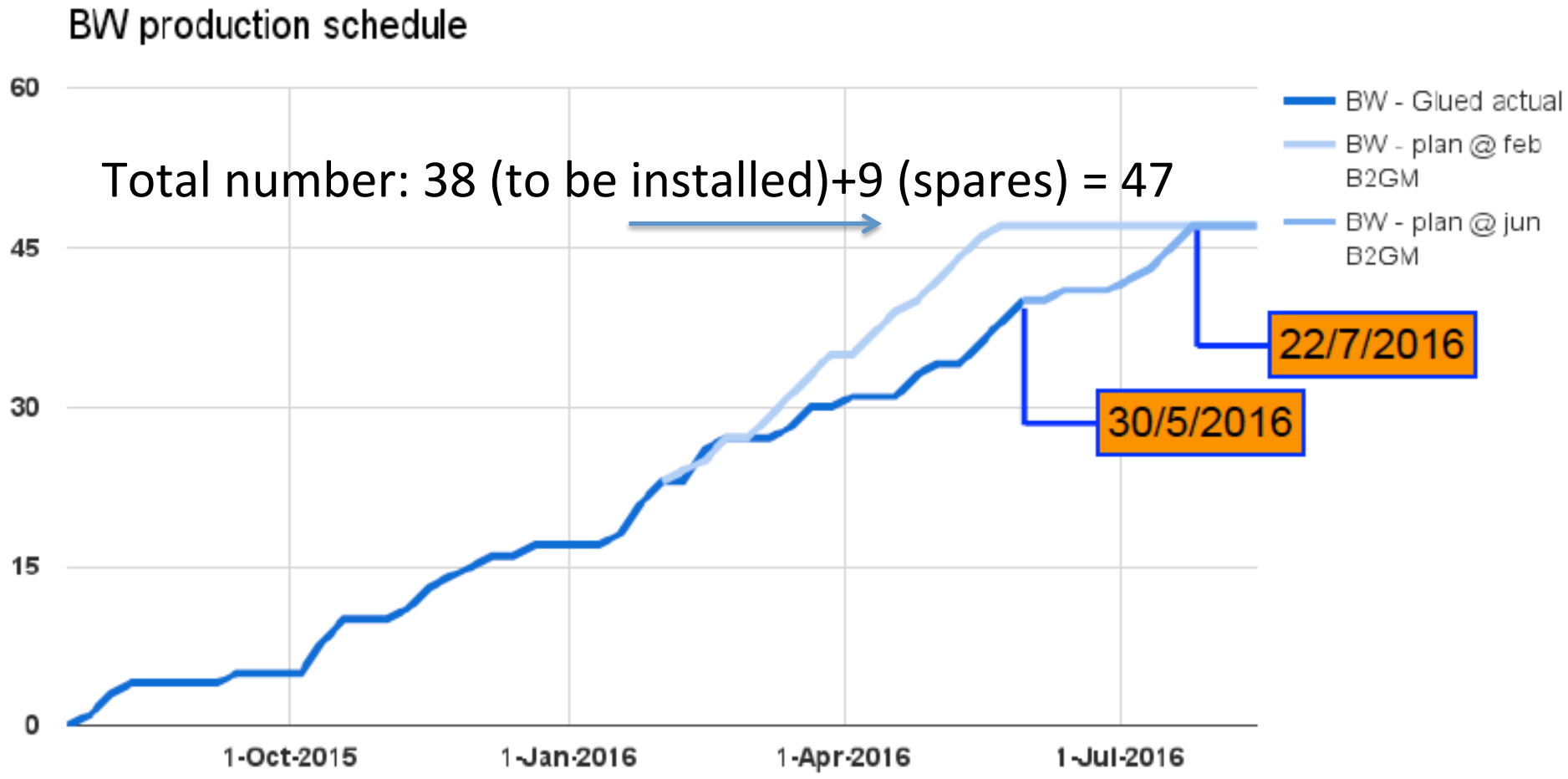








Backward Subassembly

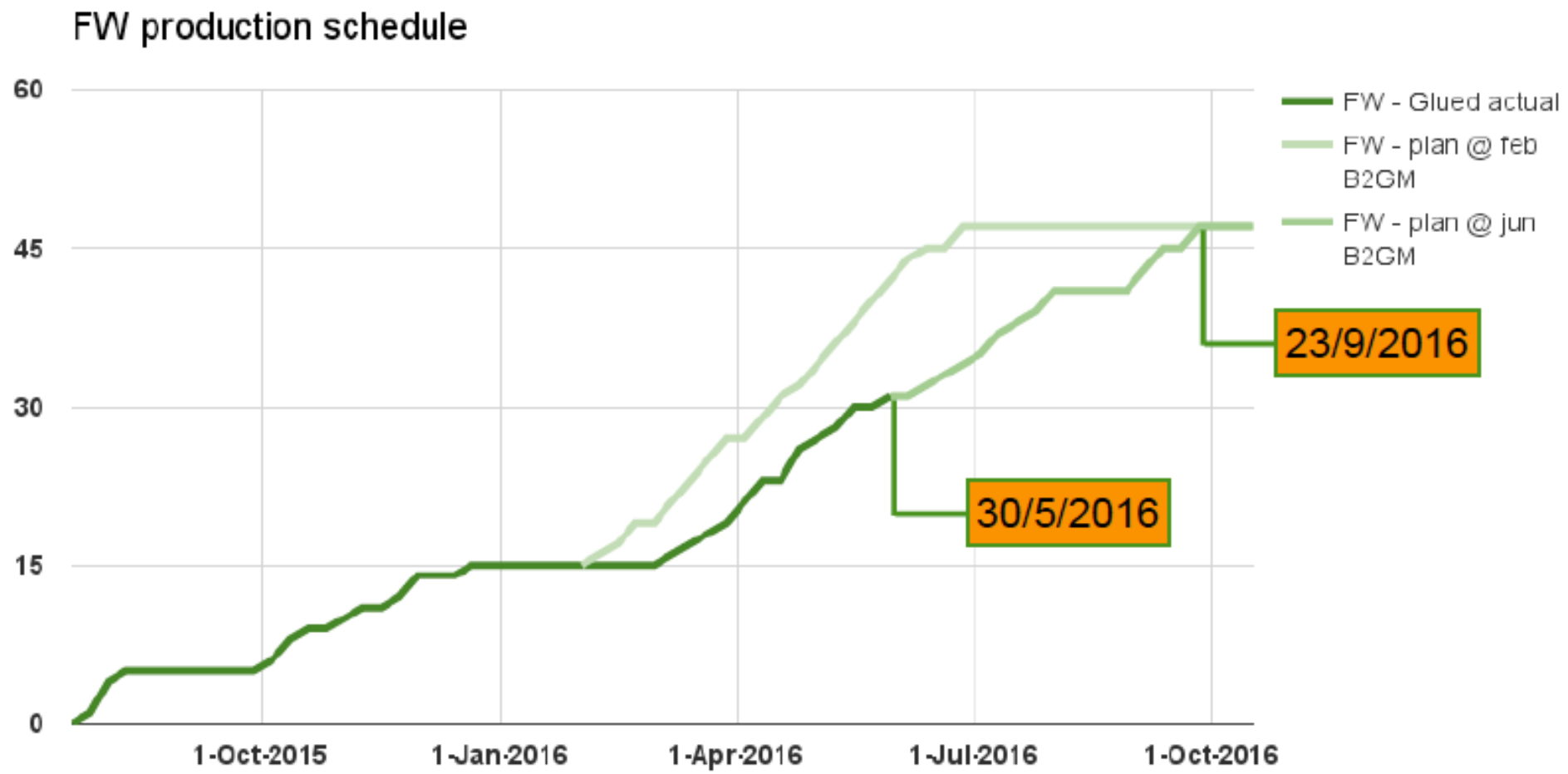


No failure experienced so far

End of SBW prod. expected in late July

Then all the remaining HPK sensors will be returned to KEK to be used in the ladders.

Forward subassembly



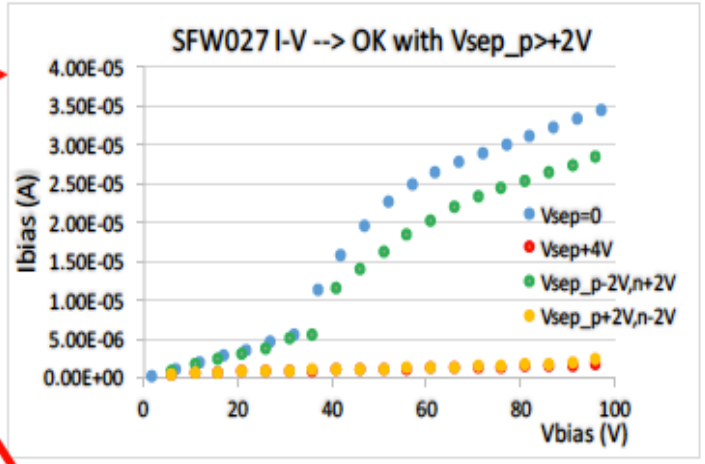
Experienced:

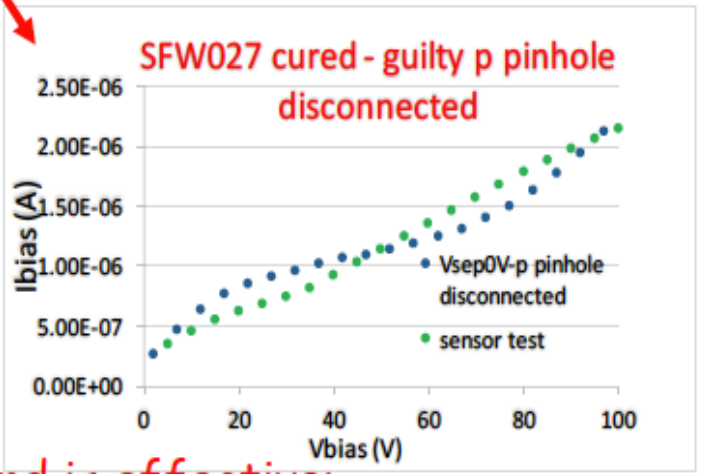
- 3 gluing failures (hardly recoverable)
- 1 failure in electrical test (SFW008)

As wedge sensors are use only in SFW, probably some more (class B) SFW will be produced!

Bias current problem on few assembled sensors

- A few modules (see below) have shown a huge increase in sensor bias current (2uA → 40 uA) after connections to the APV chips with sensitivity to Vsep (i.e. APV extra voltage w.r.t sensor bias)
- The cure was found empirically on first bad module in Nov 2015: disconnect the guilty pinhole(s) fix it
- After more problematic modules found (2 Micron + 1 HPK) we started a deeper investigations to explain the effect.
- Connecting to APV chips a defective strip that has both a pinhole AND high leakage current, due to a DC defect, could cause the high leakage current since the DC defect sits at a different Voltage (APV input) w.r.t its voltage when the strip is only connected to the bias ring via R_bias.
  - Some tests also done in TS to confirm this hypothesis.

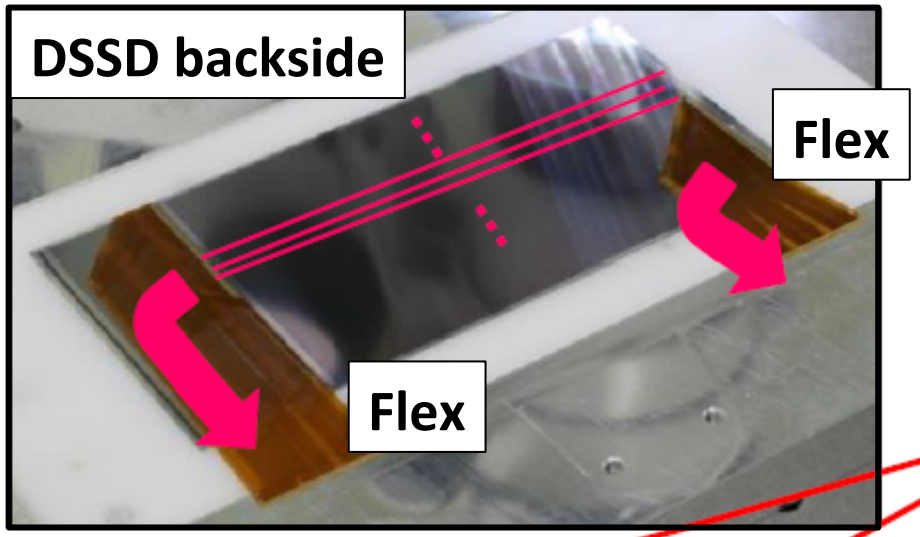


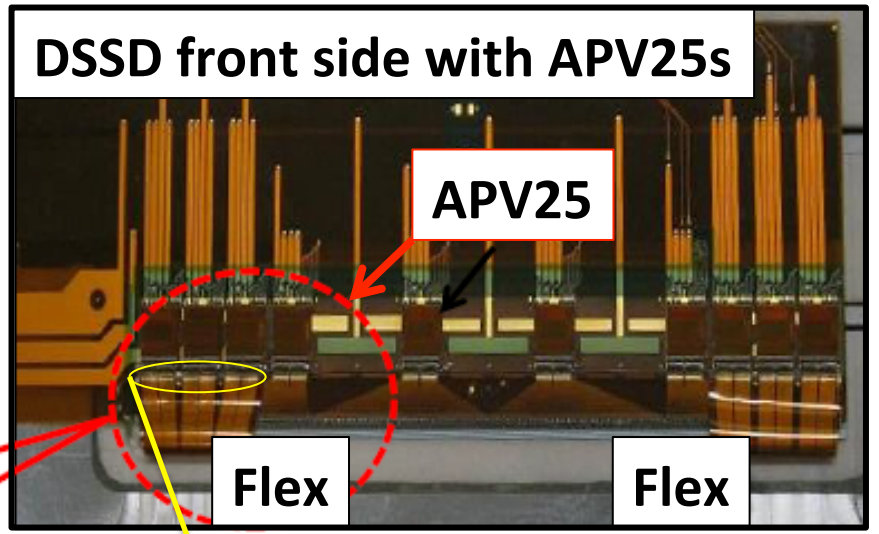


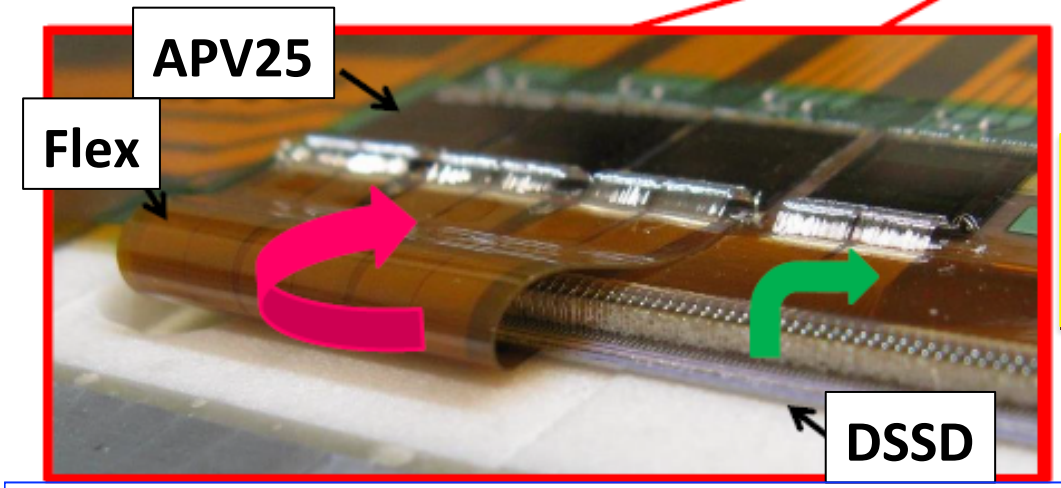
Only few affected modules (~6%) and the cure found is effective:

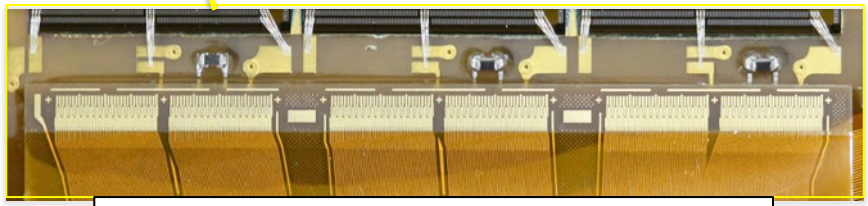
- Micron: 3 out of 33 assembled on SFW: 2 cured, 1 still to be fixed
- 6 more out the 19 still to be tested/assembled, can be affected
- HPK: 2 (1 in L4 fixed + 1 in Pisa still to be fixed) out of ~ 50 HPK assembled
- HPK sensors probably less affected: no high leakage strips declared by HPK during sensor test and fewer pinholes w.r.t Micron sensors…but many still to be assembled.

Snapshot of the "Origami" Concept







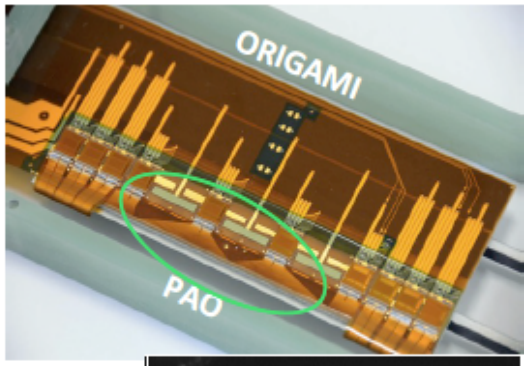


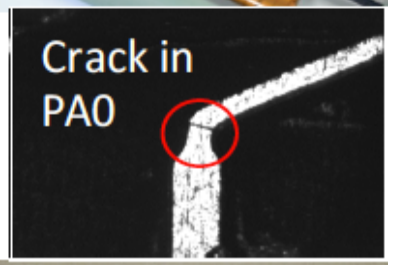
Flex glued before bonding

The backside (phi-side) signals are transmitted to the APV25 via ***wrapped*** Flex Circuits, glued above the μ-bondings of the Z-side

ORIGAMI - A Never Ending Story!

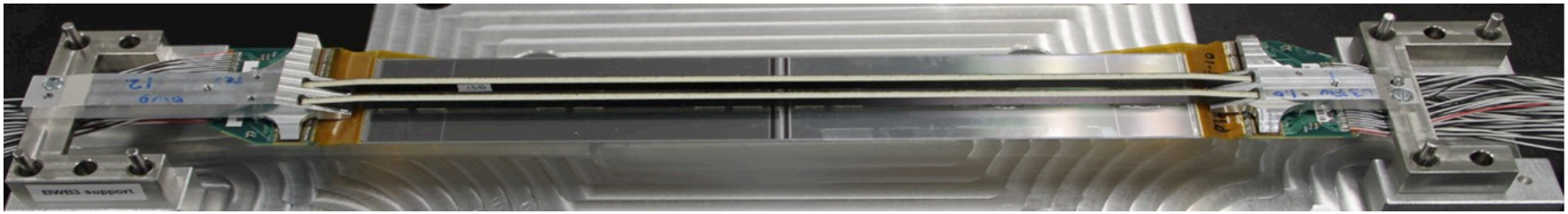
- Aug 2014: PA0 cracks on ORIGAMI →
  - new ORIGAMI and PA0 reproduction needed
  - PATF in place: 1 year of investigations, optimization of the process, new design of the PA0, specs documents written.
- Aug 2015: PA0 pre-prod. (batch0) OK
  - successfully produced & assembled on 12 ORIGAMI: no cracks on PA0 and full test on a L5 class B ladder OK.
  - PA0 mass production started in Aug.-Sept. 2015: tested & no cracks.
- Oct 2015 ORIGAMI assembly started:
  - divided in 3 batches with delivery expected in Dec 2015-Feb 2016-March2016…BUT
- End Nov 2015: new major crisis
  - formation of large bubbles during reflow on first ORIGAMI/batch1
  - Humidity absorbed in the flex & explosion at high temperature!
  - Several months of investigation and tests to recover existing flexes: 2 options studied prebaking & hand soldering
- Mid Feb 2016: restart production of few circuits
  - to test options for mass production completion and allow to start ladder assembly at the sites.
  - Additional issues with small bubbles due too high iron temperature!
- Mid May 2016: mass production restarted
  - with hand soldering expected completion by end of Sept 2016 …
- Last week 4 ORIGAMI out of 11 failed e-test due to bad chips…to be continued!





Challenges of ladder assembly

- In the layer3 ladder sensors are placed head to head, conventionally read-out outside the sensitive region.

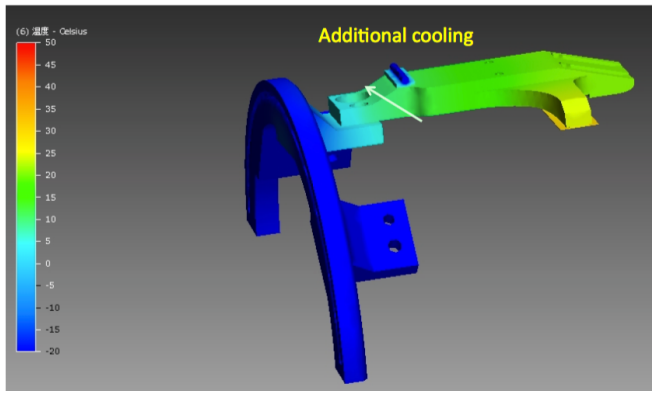


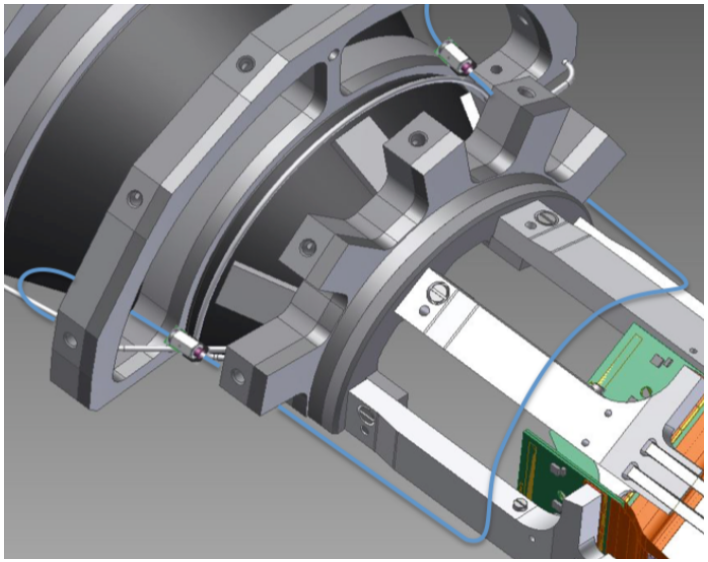
- The other layers (L4→L6) have a lantern shape, with the slanted subassembly on the forward, a backward subassembly and different numbers of origami subassemblies in the middle:
  - L4 one Backward Origami (O-z)
  - L5 " + one central (Oce)
  - L6 " " + one forward (O+z)
- All the components have to be properly aligned and positioned (i.e. glued) on the support structure (C.F. ribs), matching tight geometrical tolerances.
- The jigs and chucks used during the assembly phases have been checked to have precision falling within the design limits.

Status of the ladder sites

- Each site passed the internal SVD reviews, by assembling SVD modules with electrical functionality: all qualified to build class A ladders.
- The L3 site already produced a class B (high Q), and they discovered a problem in the cooling efficiency of the current design → needed improvement to reduce the L3 temperature gradient towards the APV25 (50°C)→ an additional cooling pipe within an existing cooling channel. This solution would require no modification of existing parts.
- L3 production will start in early June, full production (12 ladders) completed by end of Sep

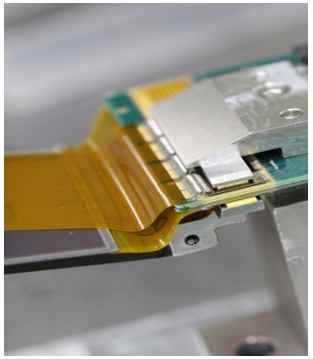
Minimum temperature -20°C
Maximum Temperature 28°C





Status of the external layers (L4→6)

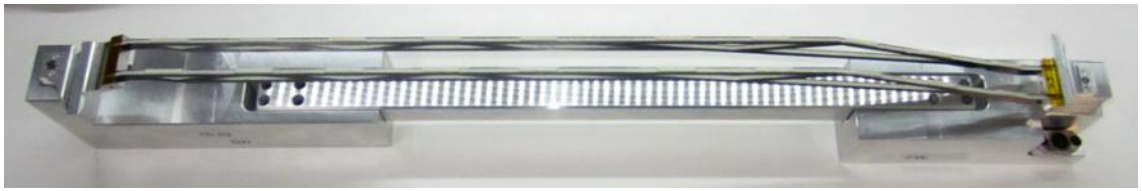
- L4 already assembled a class A, but the final mech. survey found a misplaced (~500 um) corner for the SFW, perhaps due to the PA tension.

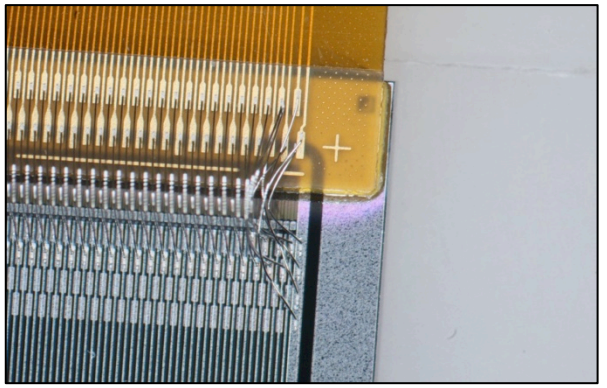


- L5 is the most advanced: already produced 3

class A within the mech. Tolerances (<200 um).

- L6 is assembling the 1st class A, to be finished before the B2GM. An issue on the rib-assembly jig has been solved.





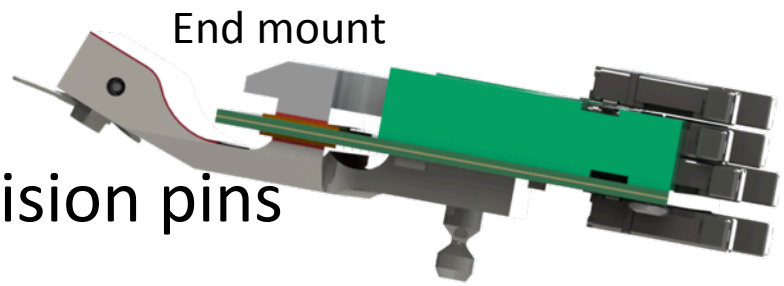
- L6 experienced an accident

(SBW dropped down because of an accidental vacuum failure).

- Enough expert manpower for L6 is the real issue.
- L6: 3→ 4 weeks/ladder means x (16+4spares)

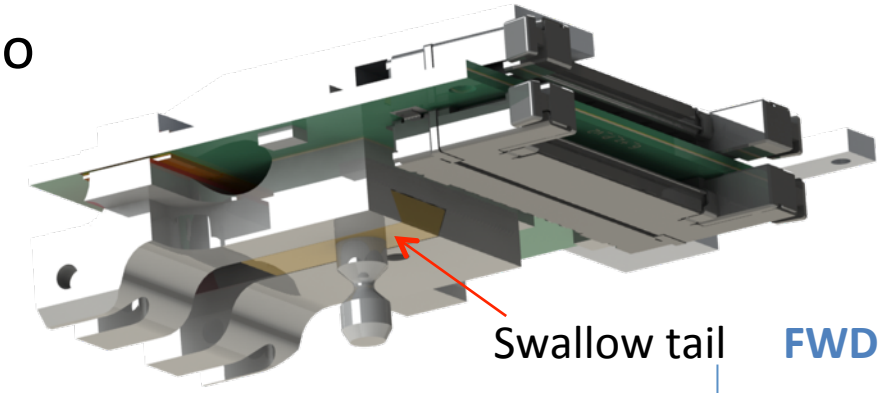
one year and a half. A 2nd production line (in Japan) is required.

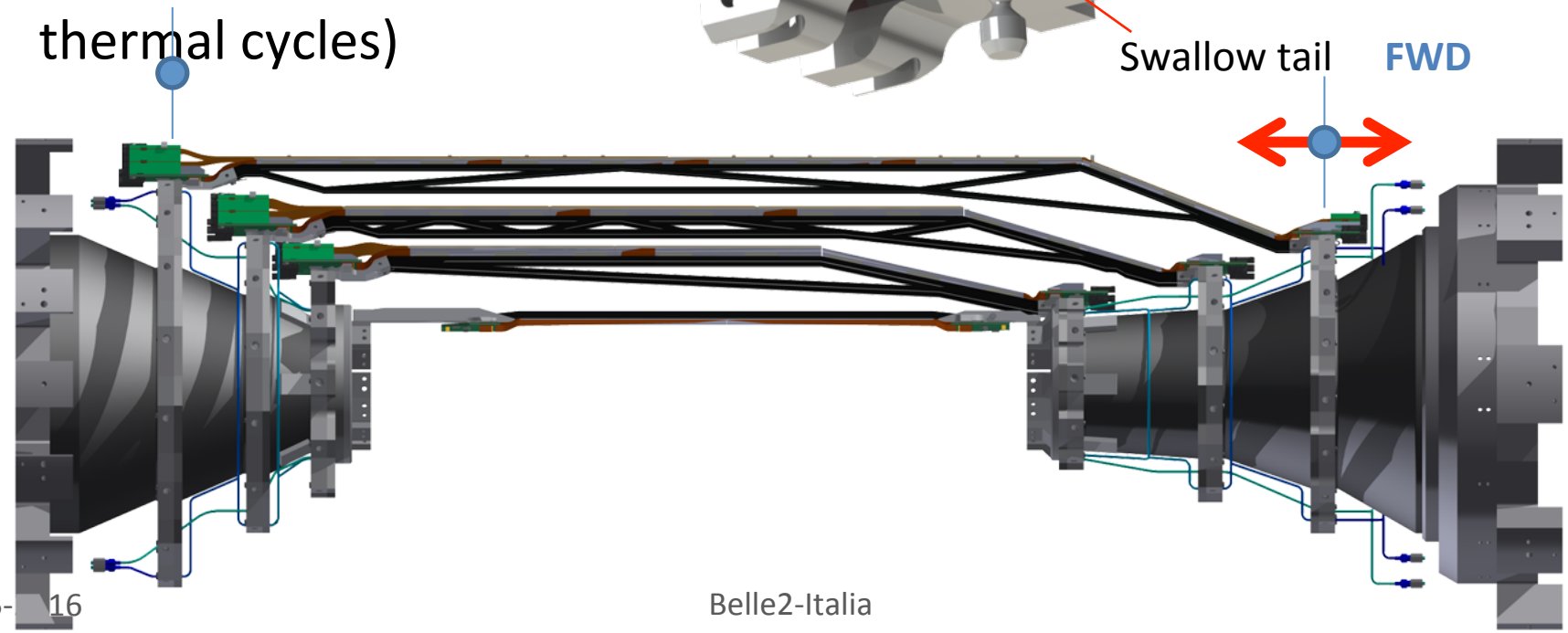
Mounting a Ladder



Ladders are positioned by two precision pins

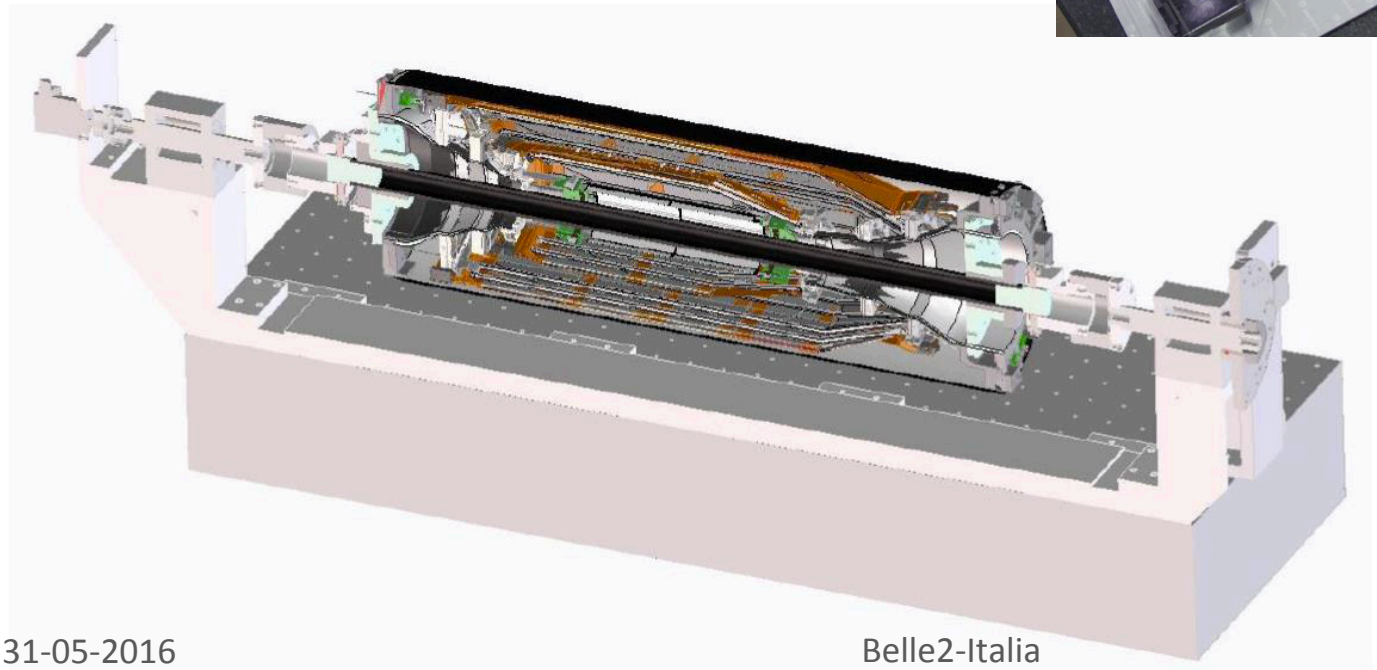
- Fixed on backward side (origin)
- Sliding on forward side to allow thermal movement (verified effective with thermal cycles)





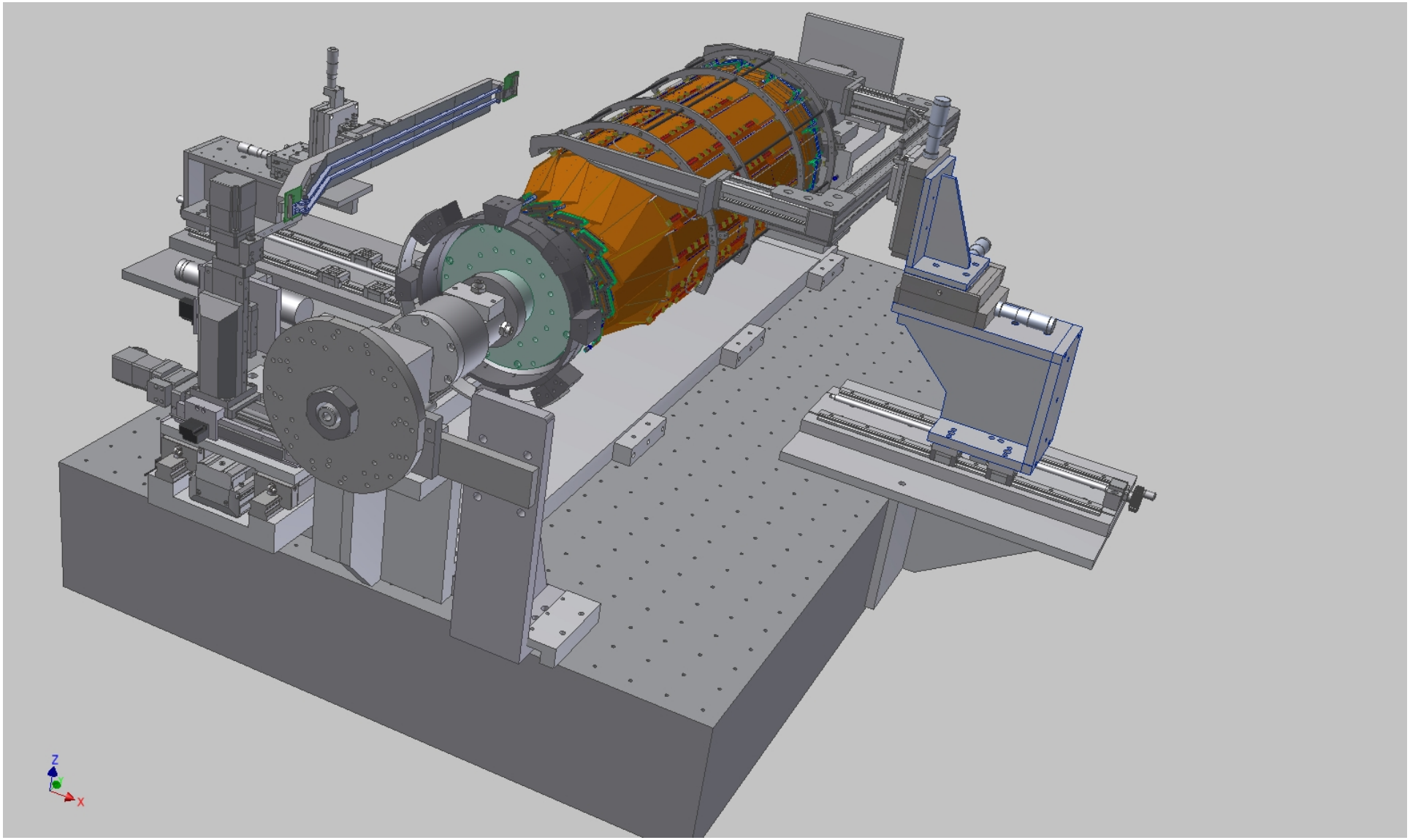
Ladder mount tools

Ladder mount jigs for all layers have been prepared.
Stage of the ladder mount jigs adjusted for the new jigs

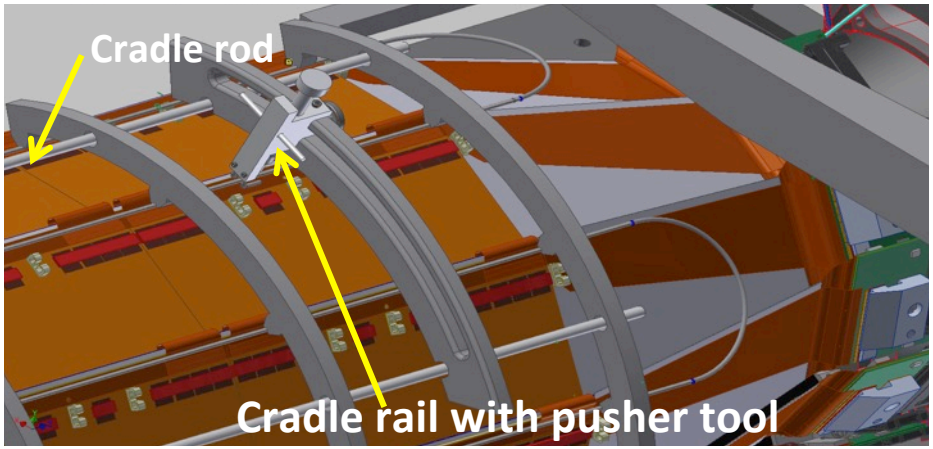


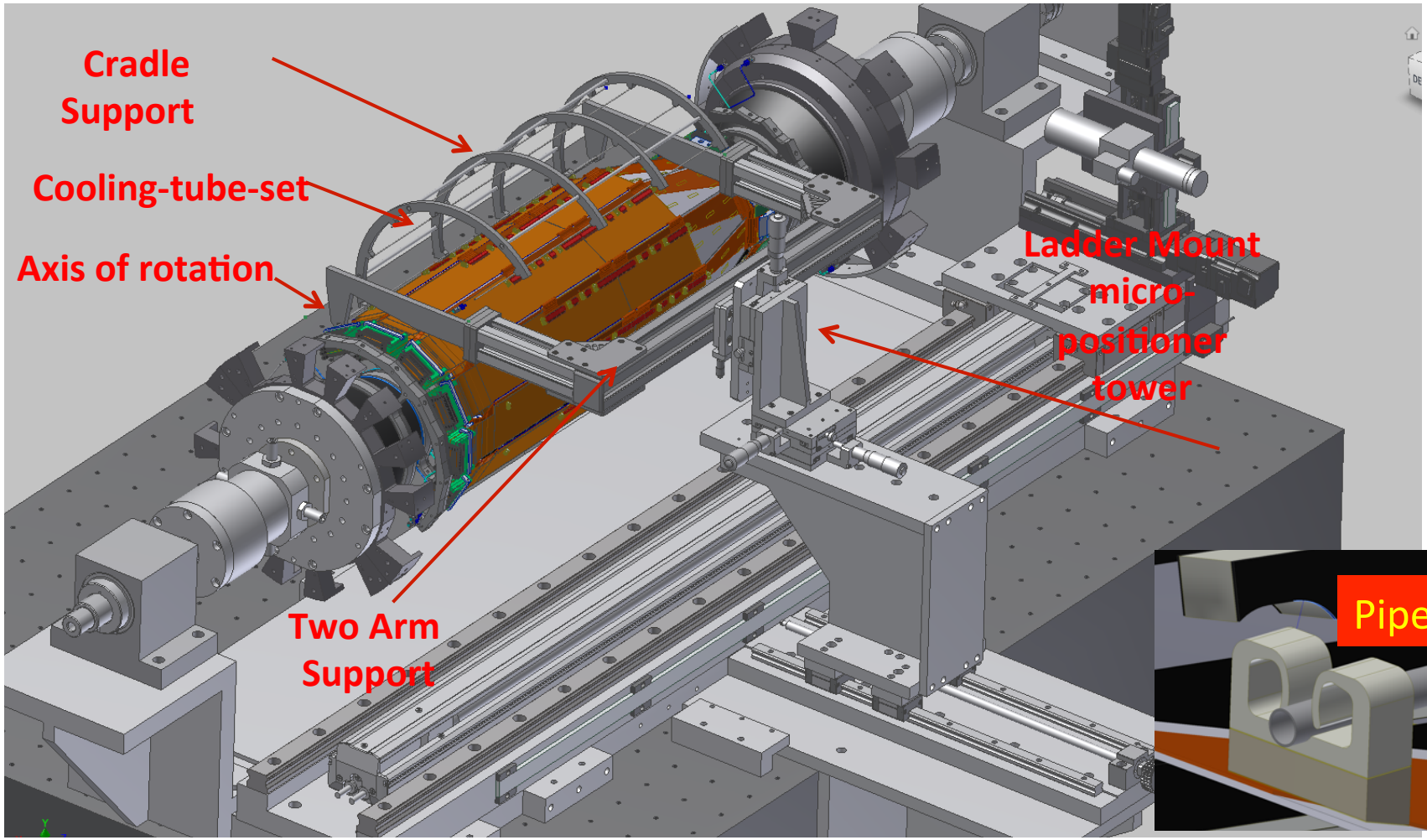
(SVD+external experts) Review at KEK on 17th of June

Ladder Mount Table



Cooling pipe attachment





Global Schedule
(to be updated for the B2GM)

High level milestones	Date
Mass production ladder	STARTED
2nd beam test (PXD+SVD combined)	Apr. 2016
Start of Ladder mount to support structure	Feb. 2017
SVD readiness in KEK	Dec. 2017
Start of PXD+SVD integration	Dec. 2017
Start of VXD installation into Belle II	Jun. 2018
Start of physics run	4Q 2018

Conclusions

- The completion of the SBW (SFW) construction is foreseen in late July (October) in Pisa. Then some help could be given to the sites in troubles … (tbd).
- In mid June a review of the ladder mount (and cooling pipe mounting) will take place. We'll have more clear the "whole picture".
- The Layer5 is the most advanced site in production.
- The Layer 4 and 6 ladder sites experienced some problems ...
- The Layer6 is expected to arrive to the B2GM with the 1st class A ladder and with a revisited schedule.

From the latest BPAC Report:

Production of the Layer 6 ladders at IPMU is clearly on the critical path. The committee encourages strongly the idea of opening a second production line at IPMU and securing the necessary resources for this.