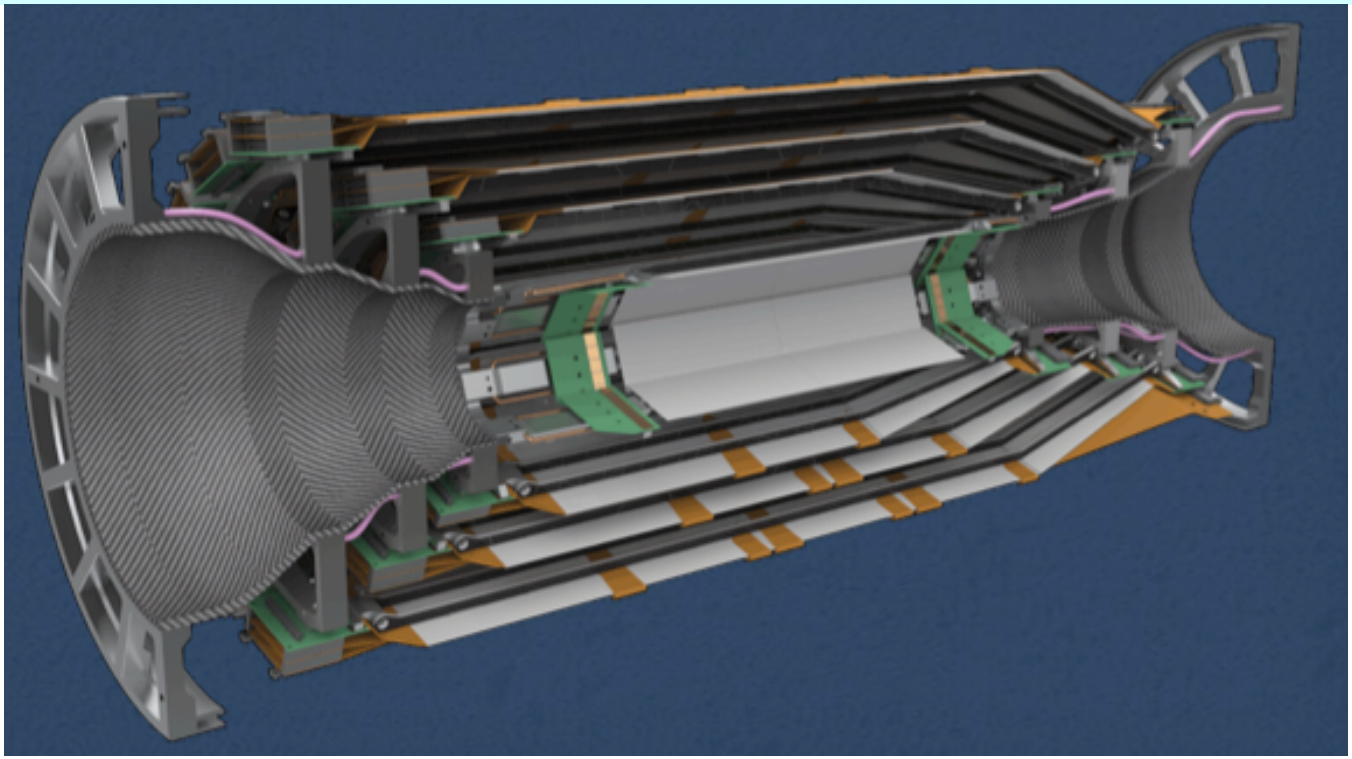
The SVD module production in Pisa



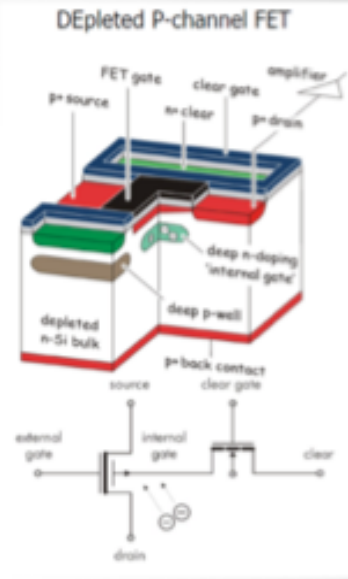
I meeting Belle2-Italia
Roma La Sapienza, 9-10 Giugno 2014

S.Bettarini
Per il gruppo SVD Italia

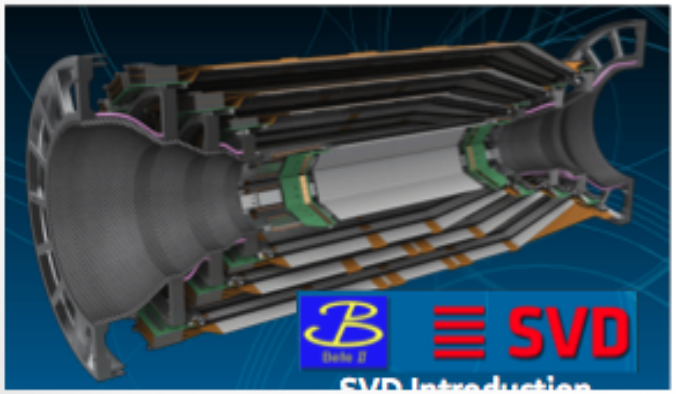
Vertex Detector

- **Pixel Detector (PXD)** – 8M pixels
  - 2 DEPFET layers at r = 14, 22 mm
  - Excellent and unambiguous spatial resolution (~15 µm)
  - Coarse time resolution (20 µs)

Mechanical mockup of pixel detector

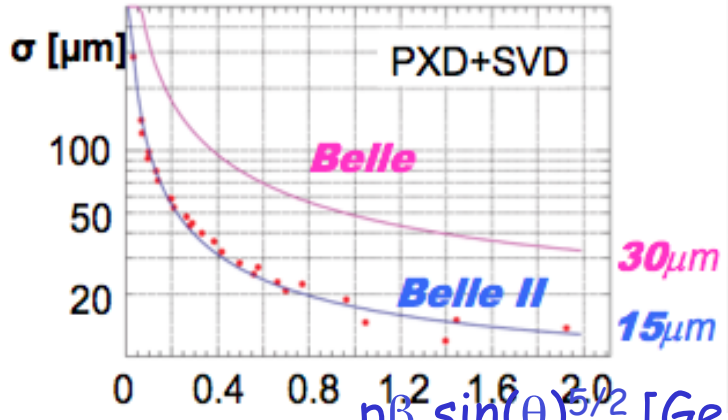


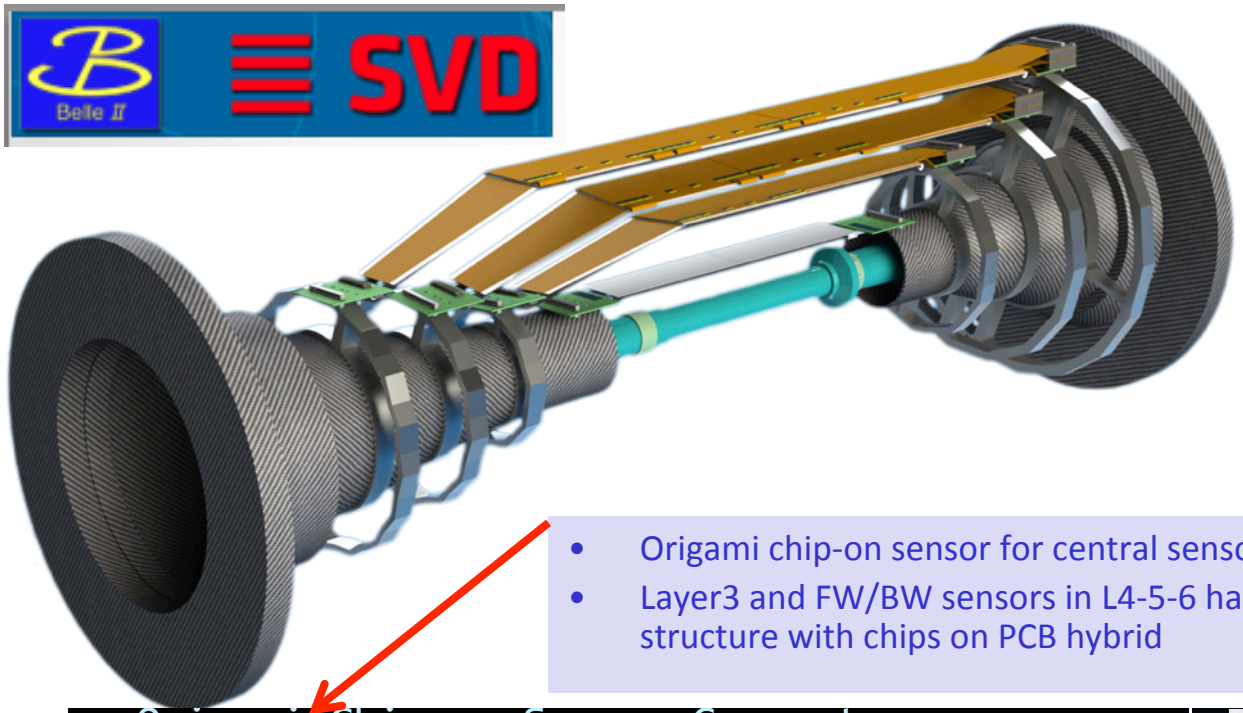
- **Silicon Vertex Detector (SVD)** – 220k strips
  - 4 DSSD layers at r = 38, 80, 104, 135 mm
  - Good spatial resolution (~12/25 µm) but ambiguities due to ghosting
  - Excellent time resolution (~3 ns)



Combining both parts yields a very powerful device!

Significant improvement in z-vertex resolution



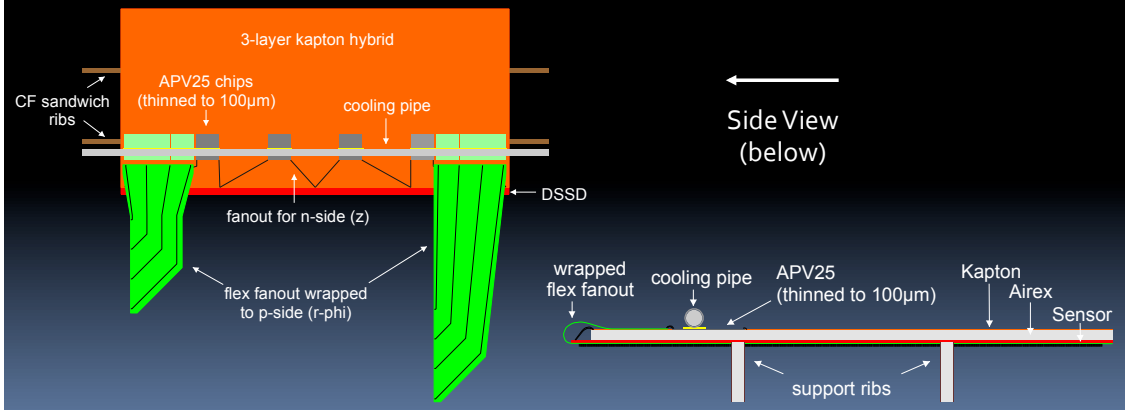


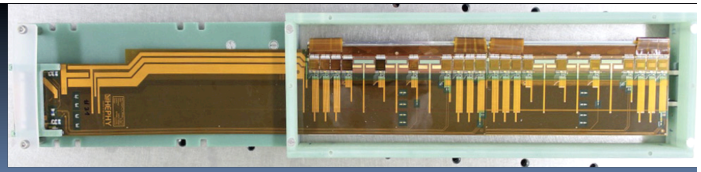
- 4 layers with silicon strips (DSSD) with APV25 read out
- Individual sensors connected to APV25 chips, to reduce capacitive load

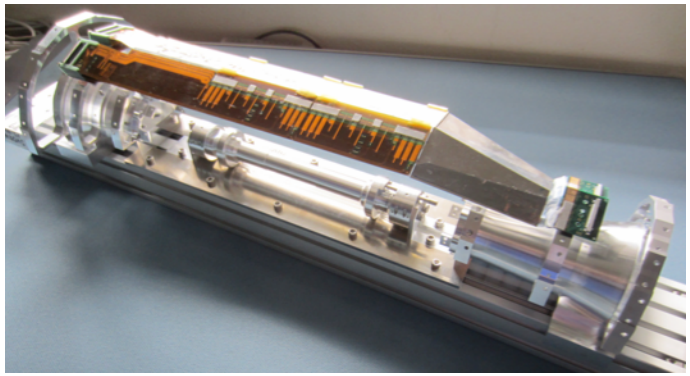
- Origami chip-on sensor for central sensors in L4-5-6
- Layer3 and FW/BW sensors in L4-5-6 have more conventional structure with chips on PCB hybrid

Origami Chip-on-Sensor Concept

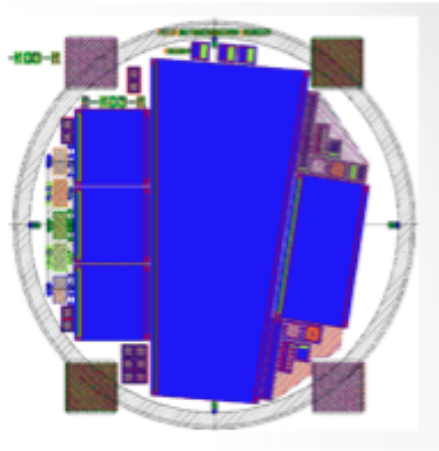
- Low-mass double-sided readout
- Flex fanout pieces wrapped to opposite side
- All chips aligned on one side → single cooling pipe (D = 1.6 mm)







Vertex Detector (PXD+SVD)

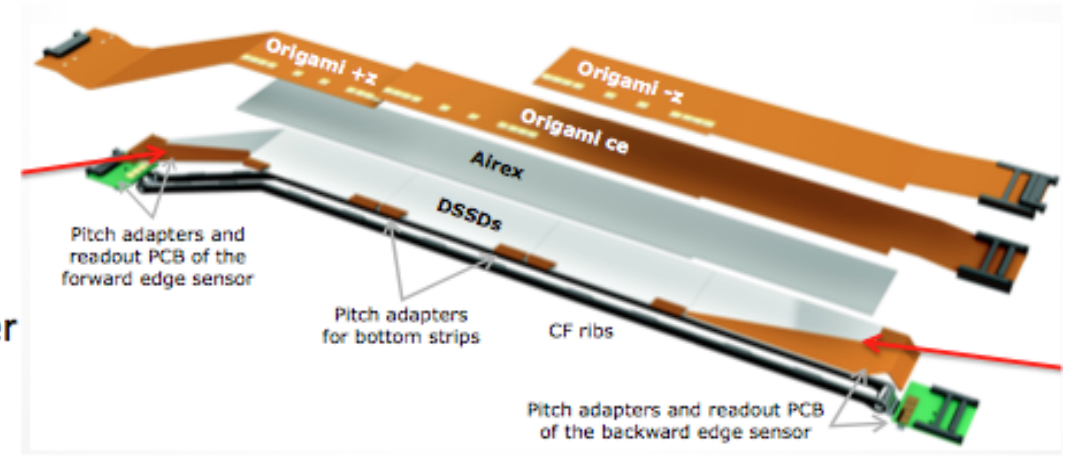


Trieste:

- Contribution to silicon detector testing (Micron)
- Environmental & Radiation Monitoring
  - Take advantage of development funded in SuperB for diamond detectors with fast remote readout

Pisa:

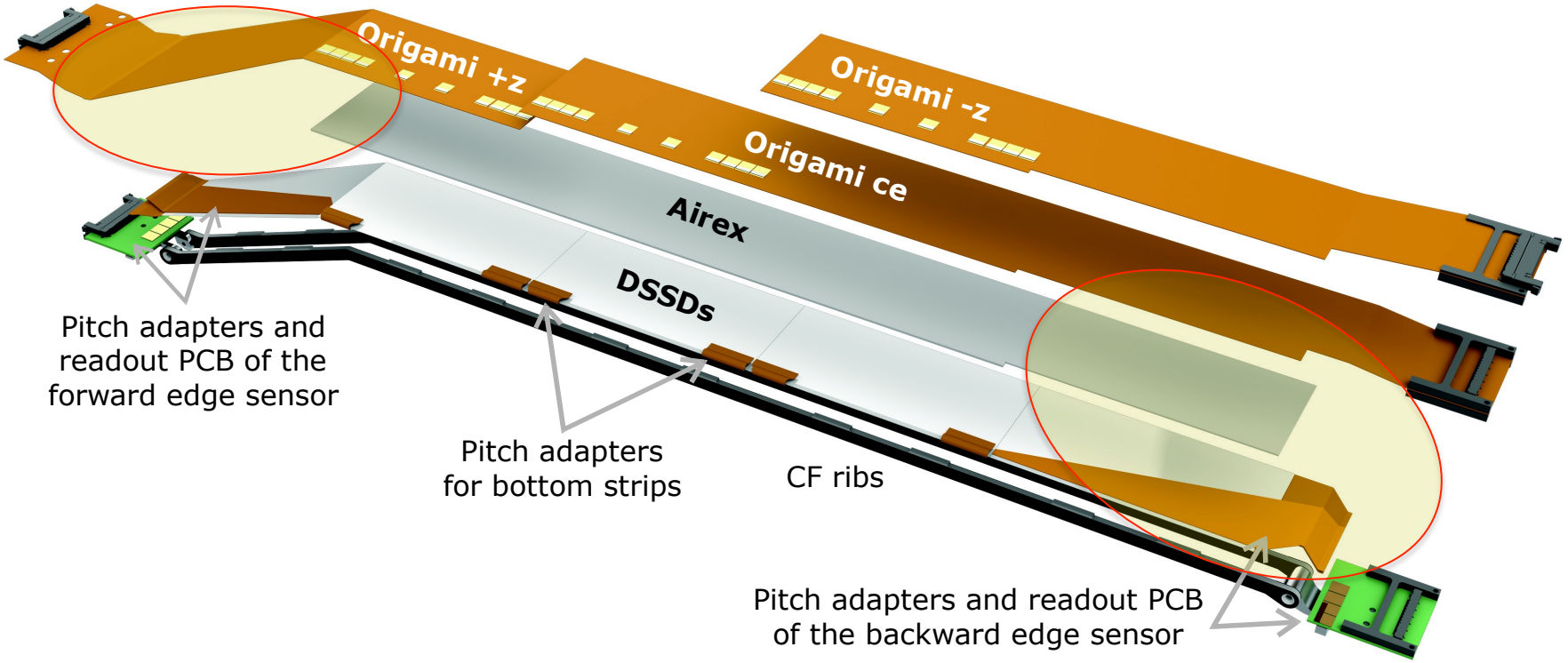
- Contribution to assembly of strip detector modules:
  - On critical path
  - Assemble FW and BW sensors of Layer 4-5-6 & ship to other assembly sites (Vienna, IPMU-Tokyo, TATA at IPMU lab)



- Replacement of the old Power-Supply
- SVD software development:
  - Si only tracking & PXD data reduction with ROI (region of interest) selection
  - Alignment

Assembly procedures

- Produce single-sensor subassemblies of the forward and backward sensors.
- Connect sensor to pitch adapter, pitch adapter to hybrid
- Ship the tested sensor sub-assembly to the module assembly sites



Option "P" viability

- Build the L4-5-6 BW and FW assembly (i.e. glue the PA to det's and hybrids and u-bonding) and do their electrical characterization.

  Review FW/BW Assembly Procedures & updates on jigs status, gluing & bonding tests, teststand.

- Safely shipment of the BW/FW assemblies to ladder production sites and sustain a proper production rate

  Multi Purpose jig designed for shipment (bonding & testing during assembly in Pisa).

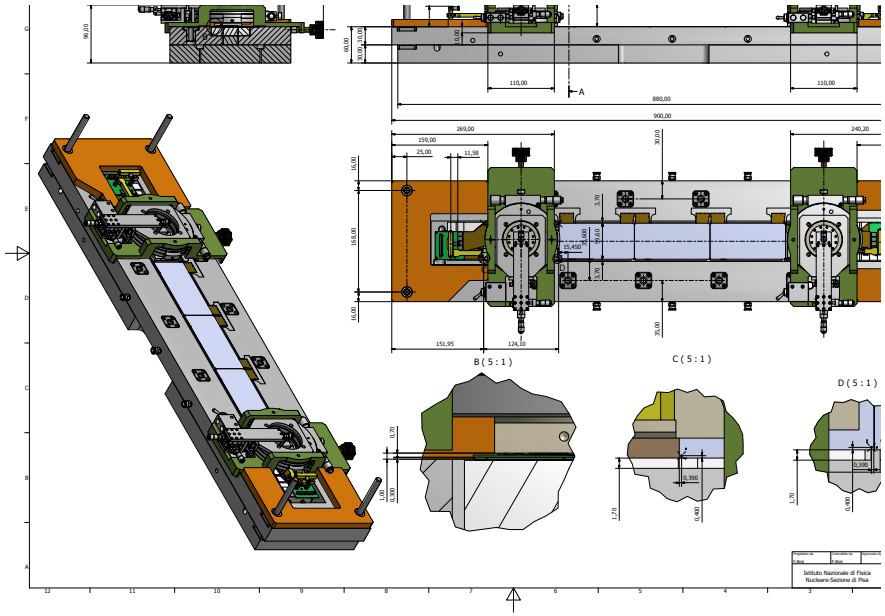
- Align the BW/FW on the assembly bench(es) and go back in stream with the original procedures

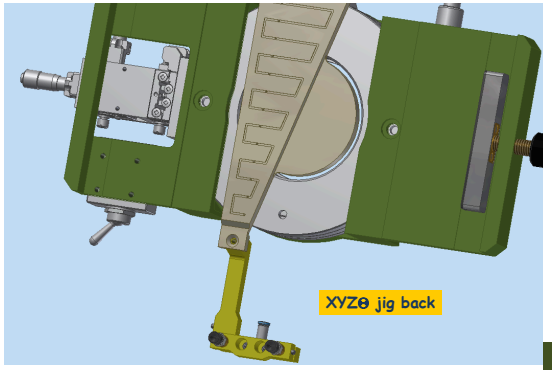
  Modified xyz-θ stage built to safely align the BW/FW subassembly with the other detectors on the bench masks

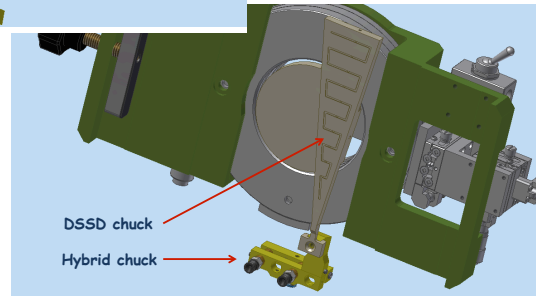
At the last (Feb.) B2GM the SVD group decided that the option "P" becomes the baseline for the module prodution.

Modified xyzθ stage (2FW+2BW)

- Jig redesigned to allow a fine alignment of the FW/BW subassembly on the assembly mask
  → Picks up the sensor _after_ it is glued to the PA and wirebonded.
- Requirements:
  - Need to be compatible with the assembly procedures
  - Need to guarantee good alignment/precision of the FW or BW assembly to the other sensors
- Added features:
  - safety mechanical stop to ensure jig cannot hit the wirebonds
  - A locking knob to make sure the jig cannot move

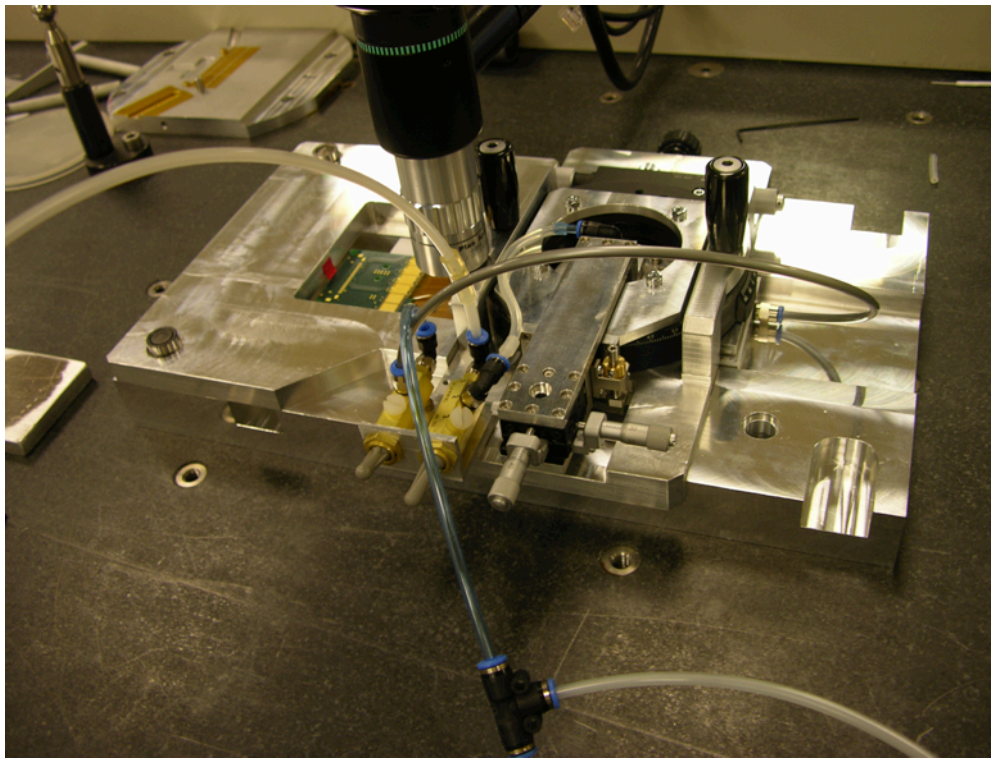


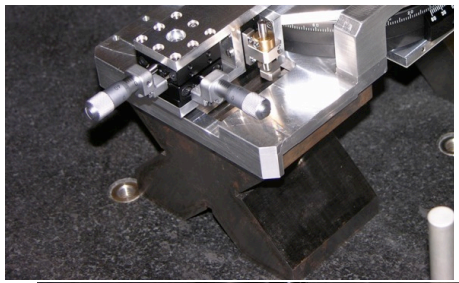


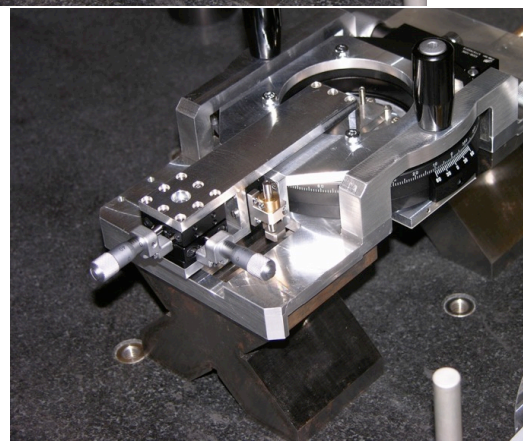


Modified xyzθ stage assembly & test in Pisa

- The 1st prototype (BW) produced and inspected under the CMM after mounting the stages. Within specs:
  - teflon chuck planarity ~20 um
  - vacuum chuck set parallel to foothold plane with 3 screws + cup springs (30 um)
- First test of the jig in Pisa using a BW subassembly prototype on a dummy bench-mask

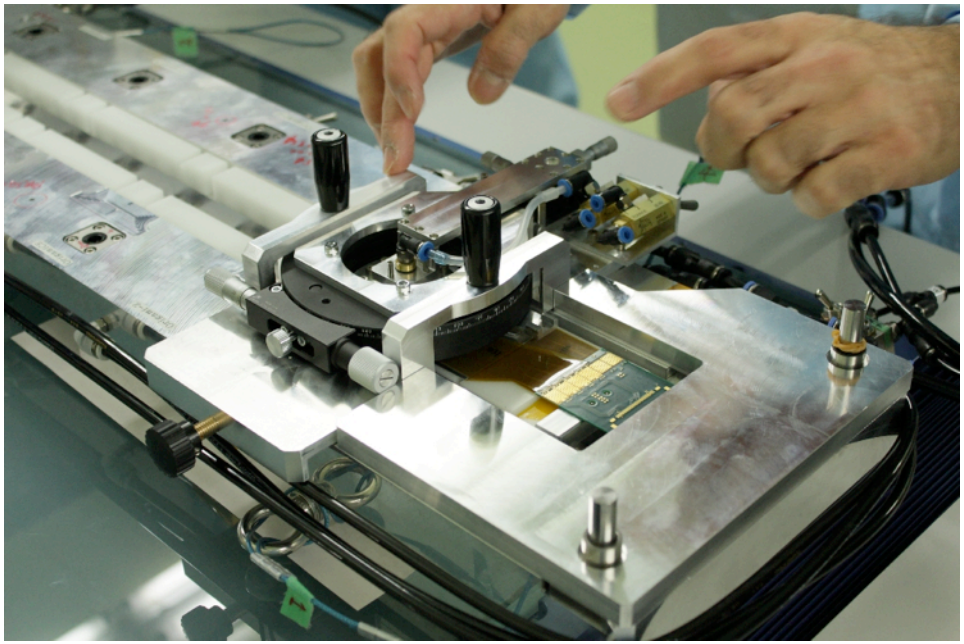






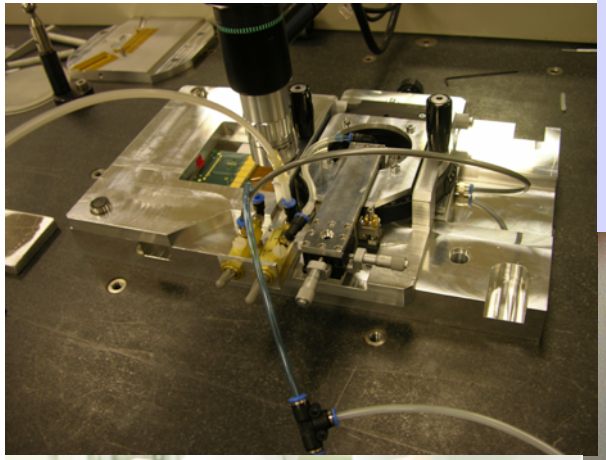
Modified xyzθ stage test @ IPMU

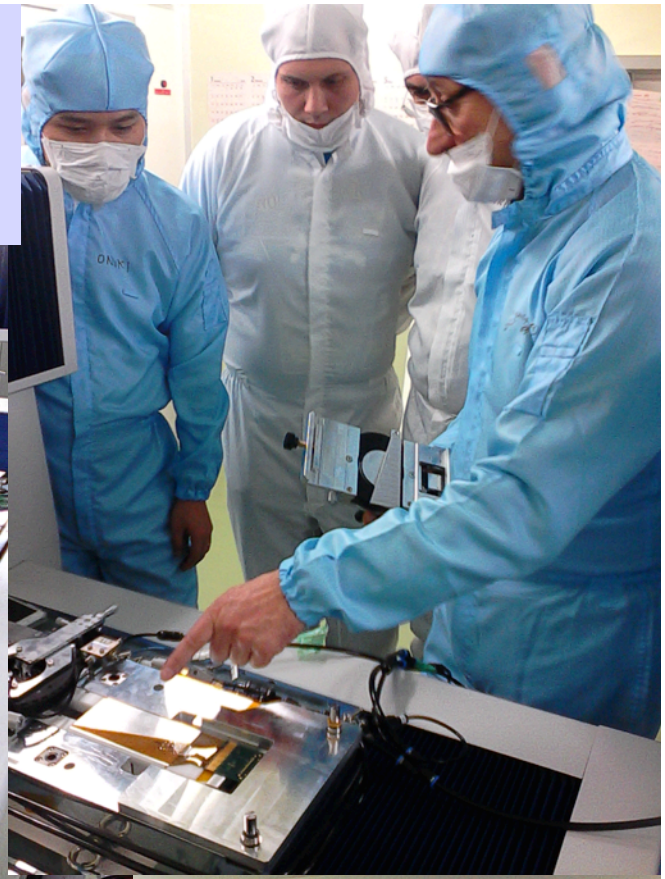
- Succesful test done during the B2GM at IPMU to check the functionality of the jig on the real ladder bench mask and look for possible interference.
  1. Test angle alignment capability
  2. Test capability of positioning to nominal position
  3. Test position when assembly is dropped .

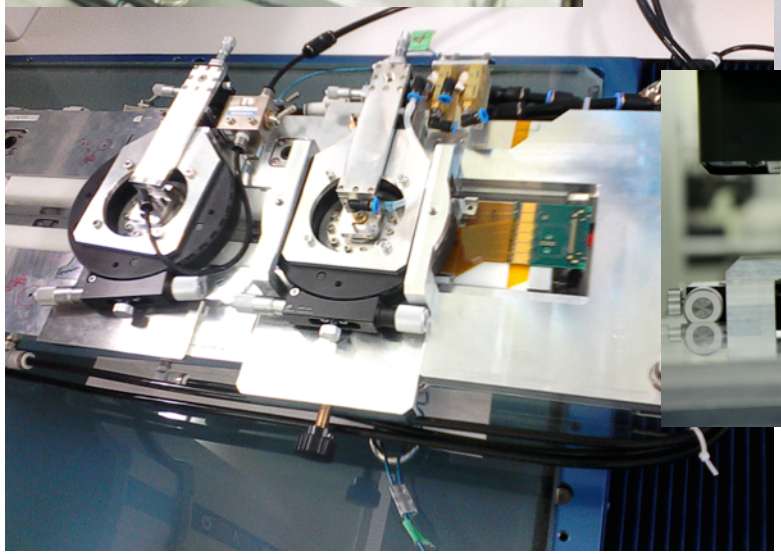


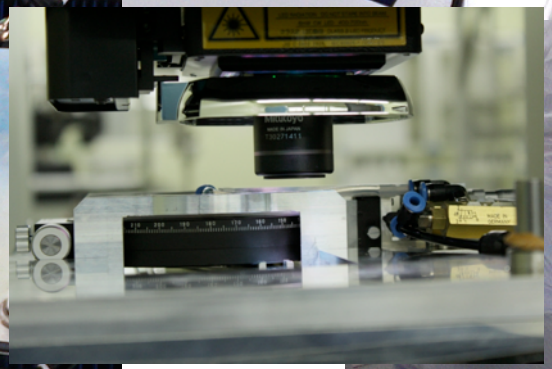
- The jig has demonstrated very good alignment capabilities, it is mechanically compatible with the real bench mask and adds some safety features
  - Minor modifications to improve usability
  - Small rotation in dropping from 250um but (displacement from nominal position ~ 5-15 um is acceptable) Some optimization may be required in dropping height/ procedure.
  - No need for bridge to hold the hybrid, since sensor chuck is strong enough.

The xyz-θ stage from Pisa to IPMU









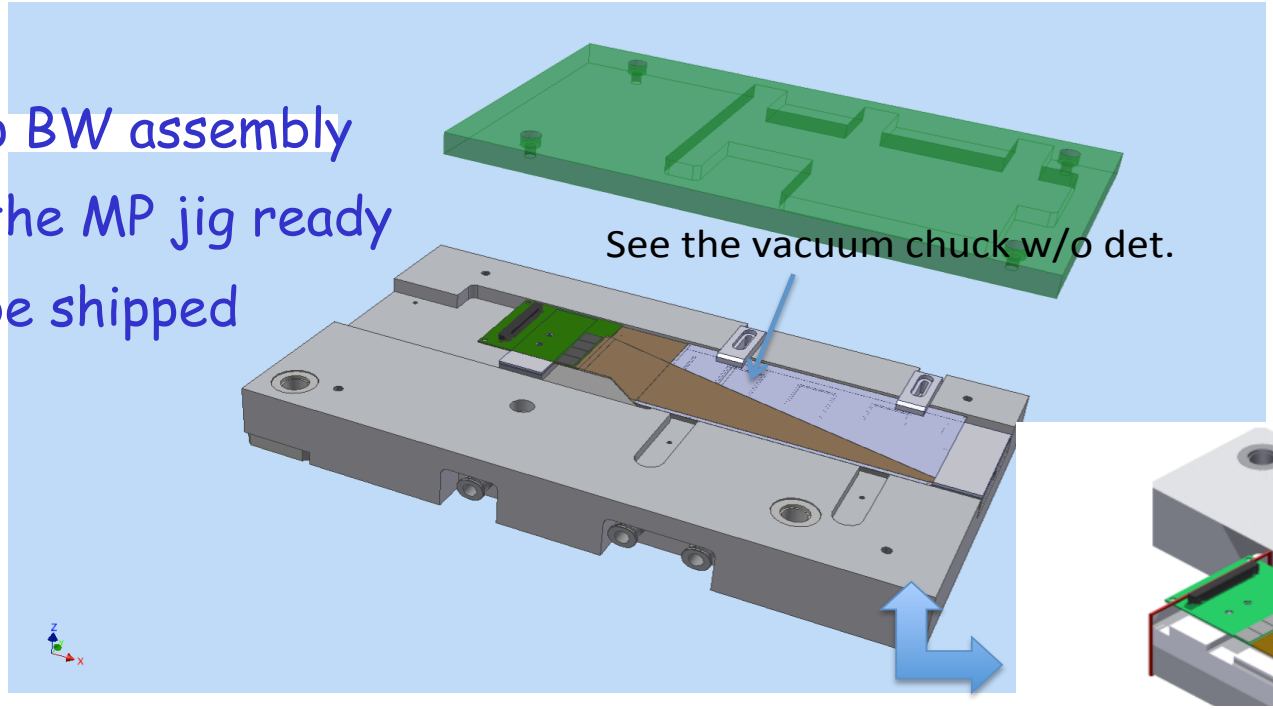
Multi Purpose jig

- The MP jigs are used for bonding/testing & rework operation on both sides.
- It has a holder in which to insert a teflon chuck that can be both phi or z up; the detector can be held with clamps and vacuum.
- The MP jig is also used for the final shipment of the BW/FW subassembly to the ladder construction sites with an appropriate cover.

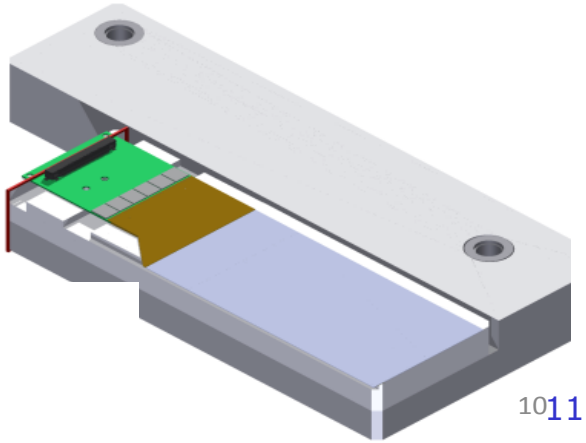
Z-up BW assembly

On the MP jig ready

To be shipped

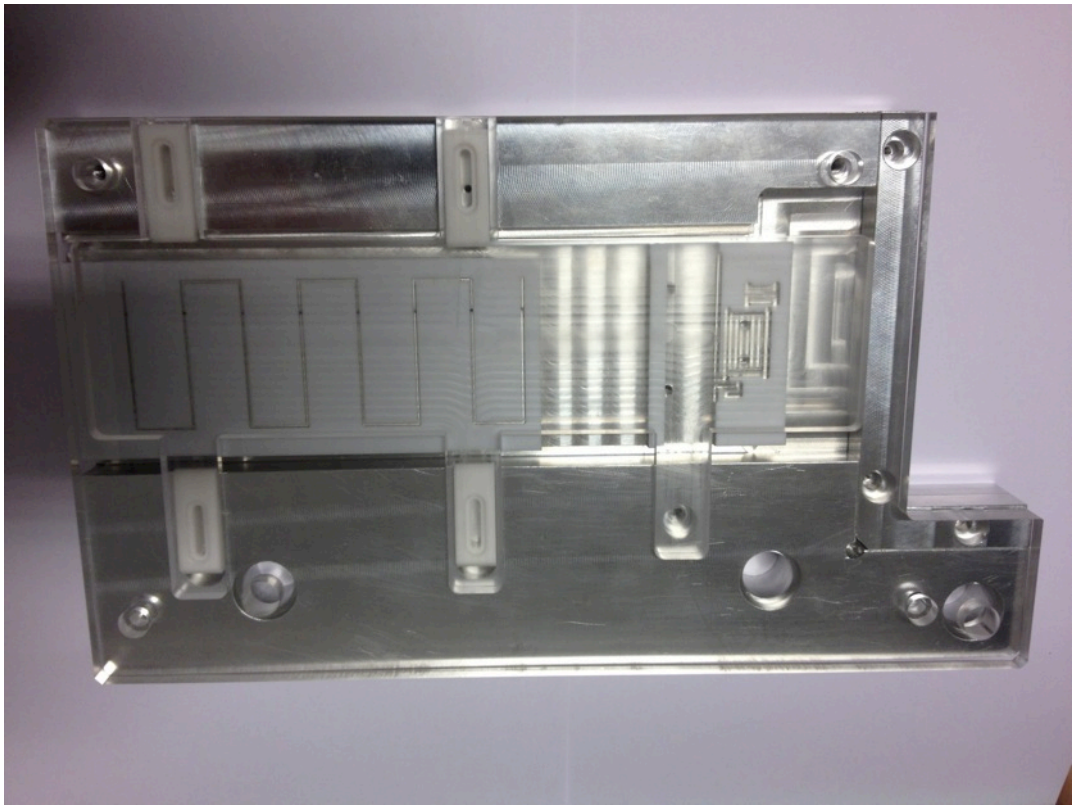


To be used with PB2 chuck to take the BW assembly and place tha the assembly bench



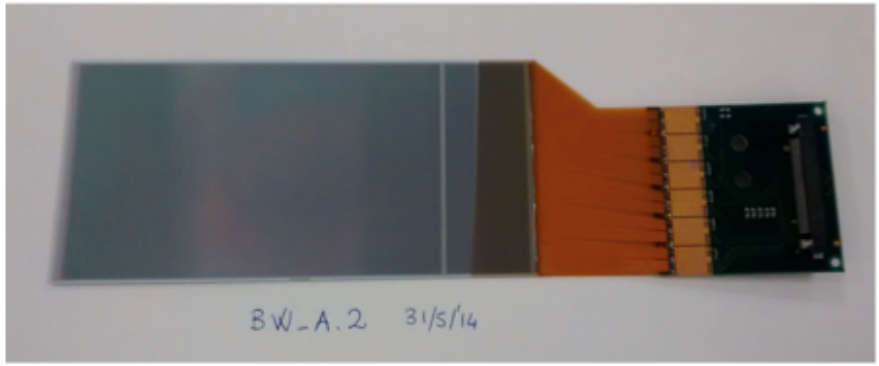
In production, delivery expected by mid-May.

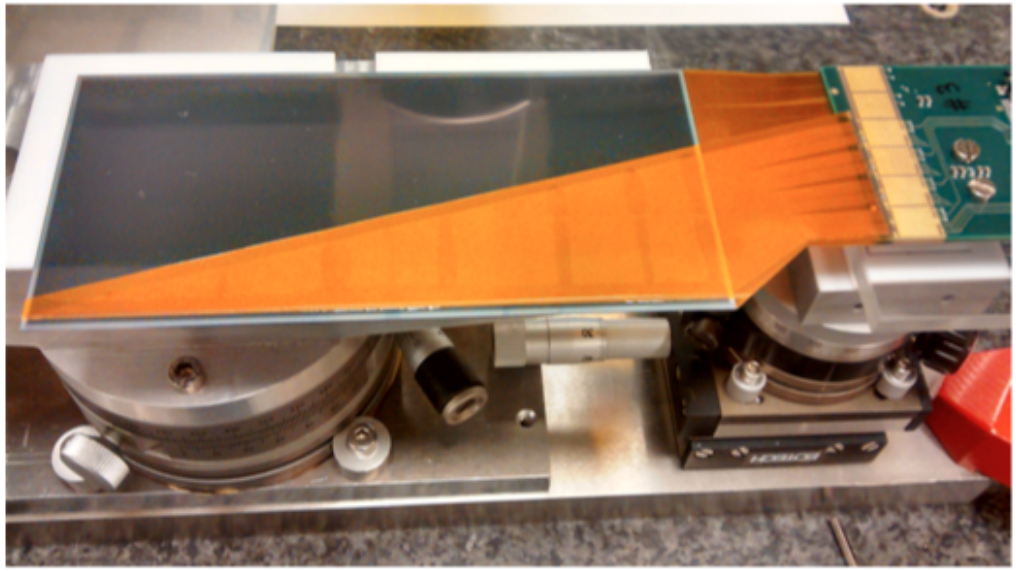
Received 1st MP BW-Zup



- The chuck is under survey
- We plan to use that to take the mech. prototype (with Si-det) to IPMU for the B2GM

BW_A.2 (Si mechanical-naked Hybrid)

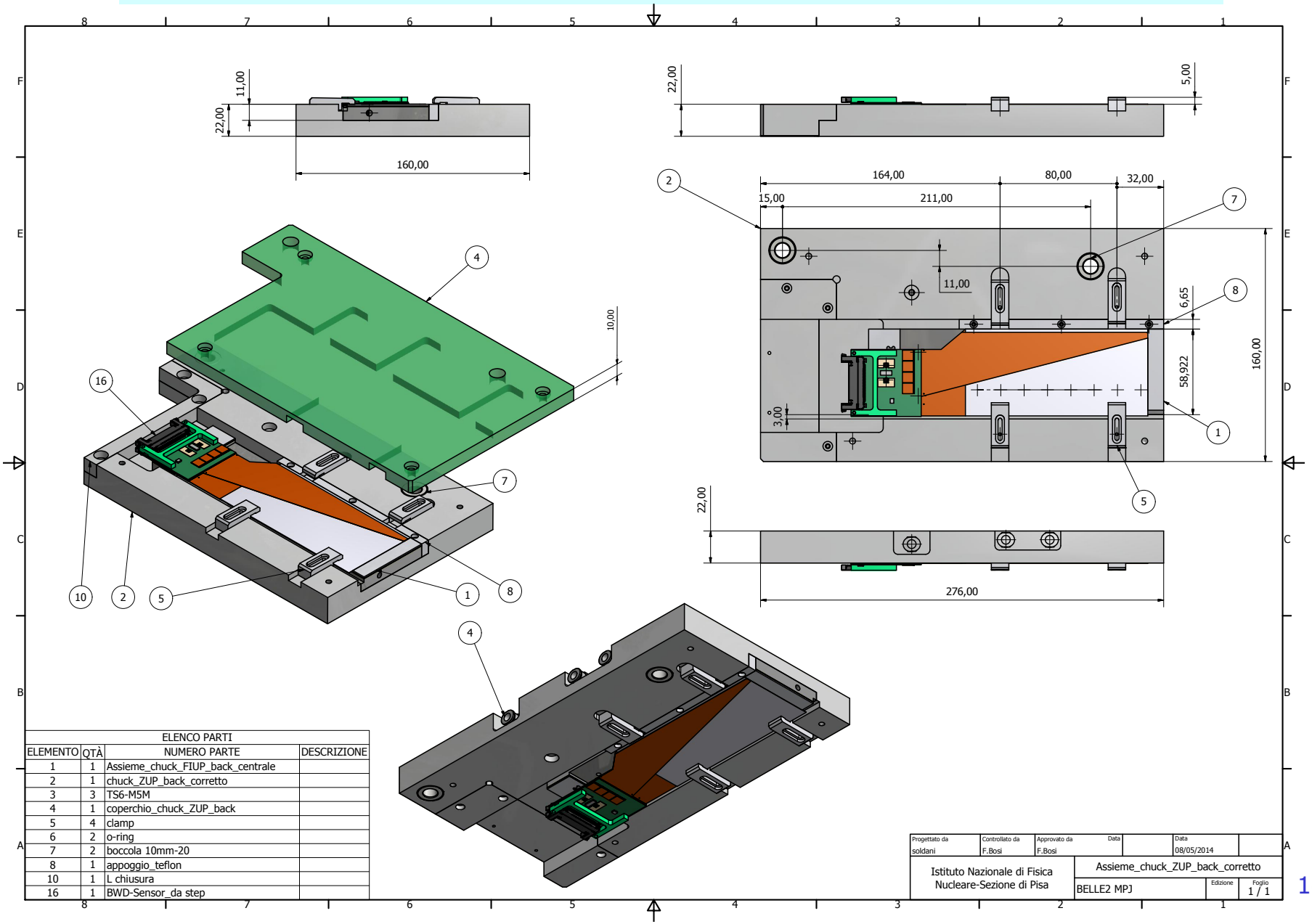




- First module with Silicon, important experience to check glue spread close to bonding pads.

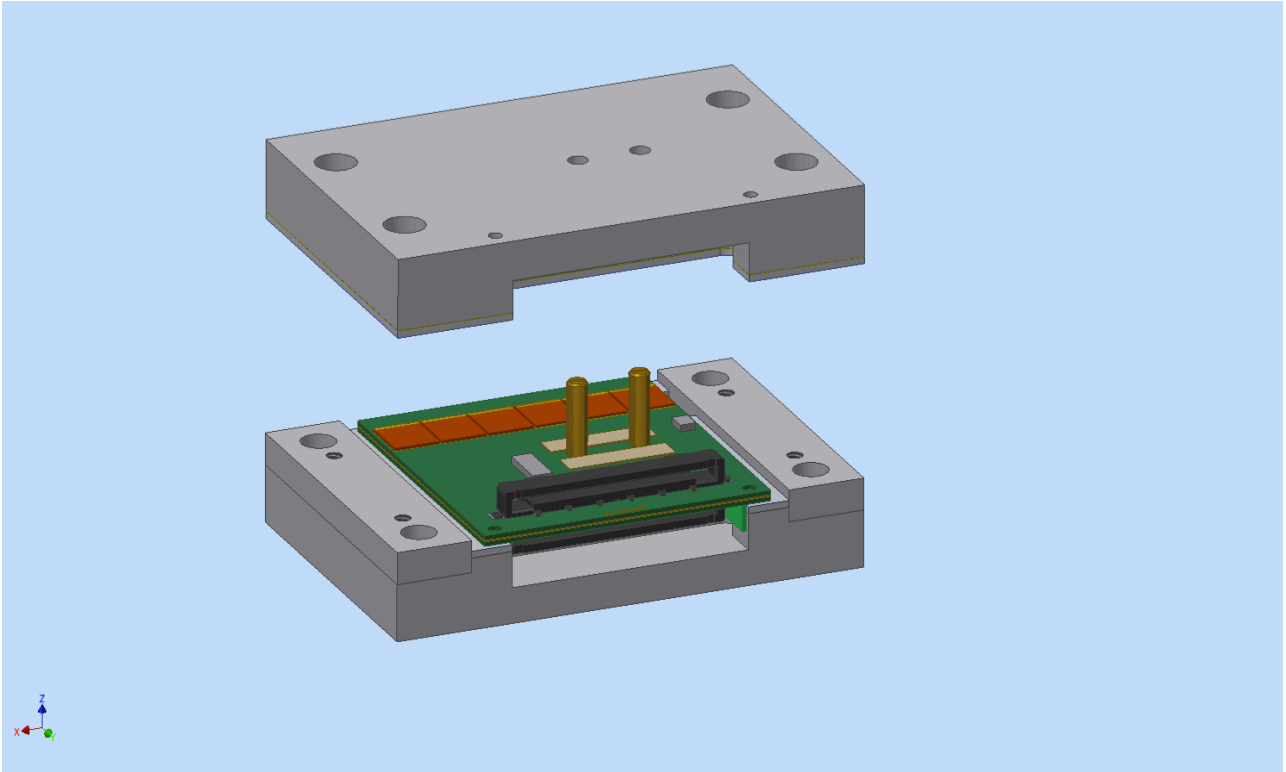
- Phi gluing: very good on Silicon side, a bit too much glue on HDI side (glue lines might be further optimized, part of the problem due to aplanarity of the chucks)
- Zed gluing: very good on both sides (Si/Hybrid)
- Mechanical precision: 20 um on phi gluing, ~ 100 um on z gluing.
  - On z gluing the n hybrid is rotated w.r.t. p hybrid (displacement ~100 um)
- Alignment of the Si/PA bonding pads still fine!

… i MP jig non sono semplici scatole



HDI gluing chuck

- Single face L4-5-6 hybrids are equipped with chip, u-bonded by Vienna and sent to Pisa.
- After testing the halves, the double faced hybrid is assembled by inserting a SilPad (electrical insulator, thermal conductor) interposer.



FW/BW Assembly: general strategy

- The procedures are independent from the gluing technique, stamping or syringe dispensing: we will go under the stamping facility or the glue dispenser with the chuck hosting the PA.
- We will start with the phi side, put the hybrid on a base-chuck in the nominal position through pins and align the detector in order to reach the needed mechanical precision to easily/safely allow the bonding.
- There are two independent towers, one for the detector and one for the hybrid, that can reach the right height.
- The PA is first aligned by the reference pins on a top-chuck, partly transparent (plexi-glass), and, after depositing the glue, the PA is "lowered" realizing the PA-to-detector and PA-to-hybrid gluing at a once, with all the surfaces lying on an unique plane.
- The quota of the PA chuck (w.r.t. det. & hybrid) is calibrated and can be adjusted, when lowering the chuck.
- First we realize all the gluing (phi side and then z side) then we make the micro-bonding
- The electrical tests must be foreseen after each bonding loop (low & high, on phi side), when reworking is still possible (i.e. detach/redo bondings).

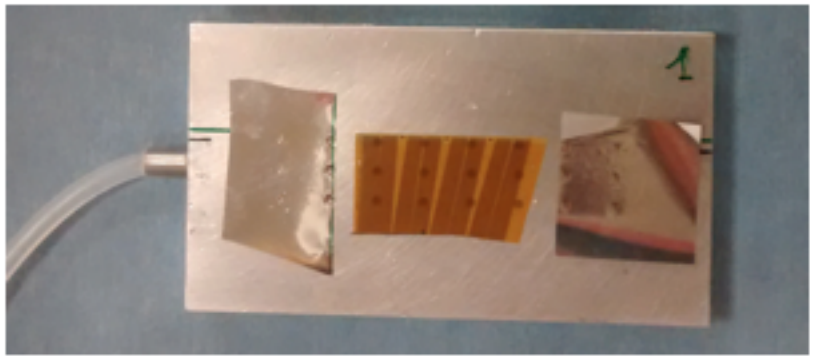
The gluing jigs

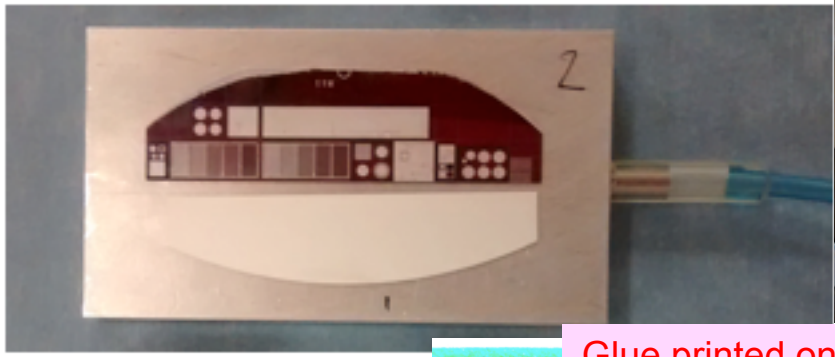
•Several gluing tests done with available chuck: we found that the definition of the quota is critical in such a gluing.

- The detector/PA design implied some difficulties:
  - Very small overlap between PA and det's on phy side (1.3 mm)
  - Also small overlap between PA and hybrid (3.2 mm)
  - PA pads very close to the boundary

- To cope with all these aspects, extensive gluing test performed and many critical aspects identified → a very complex gluing jig has been designed.

PA to Silicon phi side gluing: successfully realized

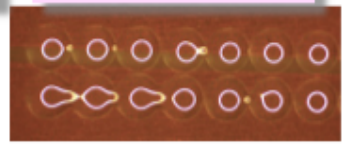




- Glue dispensed with a stamping tool with 2 rows of teeth (pitch=800 μm)

Stamping tool with 2 rows

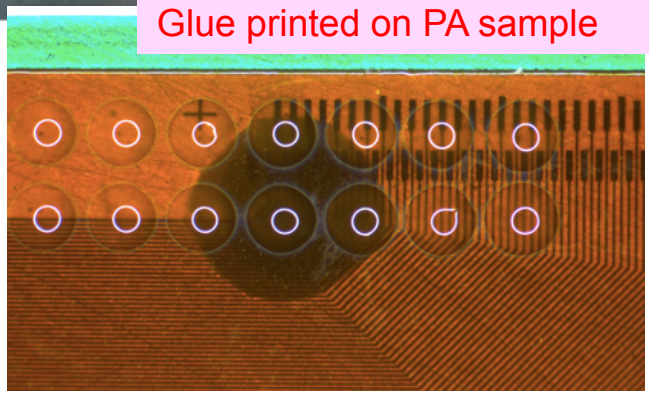
Glue printed on PA



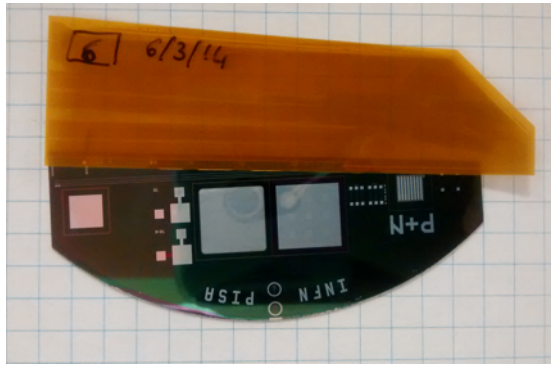
Pitch=800 μm ↔

Typical dimensions of the glue spherical cap:
- Diameter=700-800 um
- Height= 50-70 um

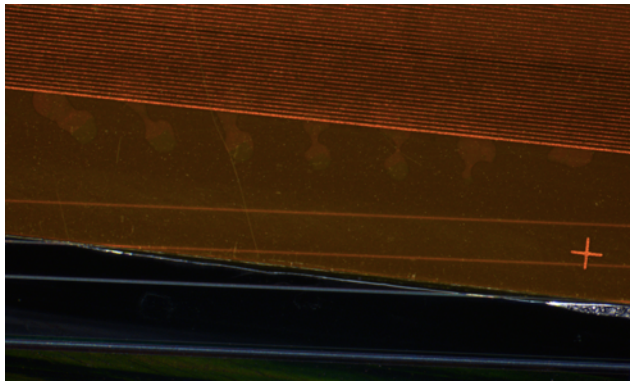
Glue printed on PA sample



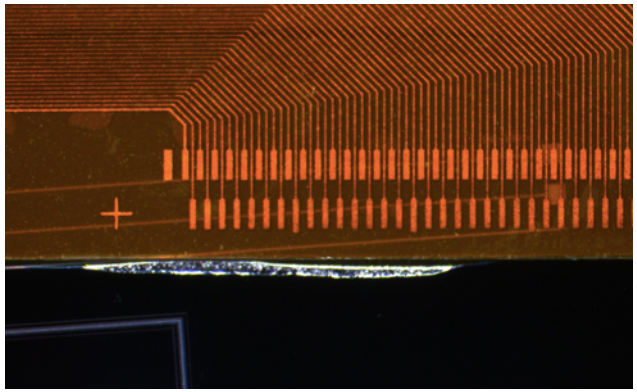
PA & Si chucks put in contact with no spacer for this test.



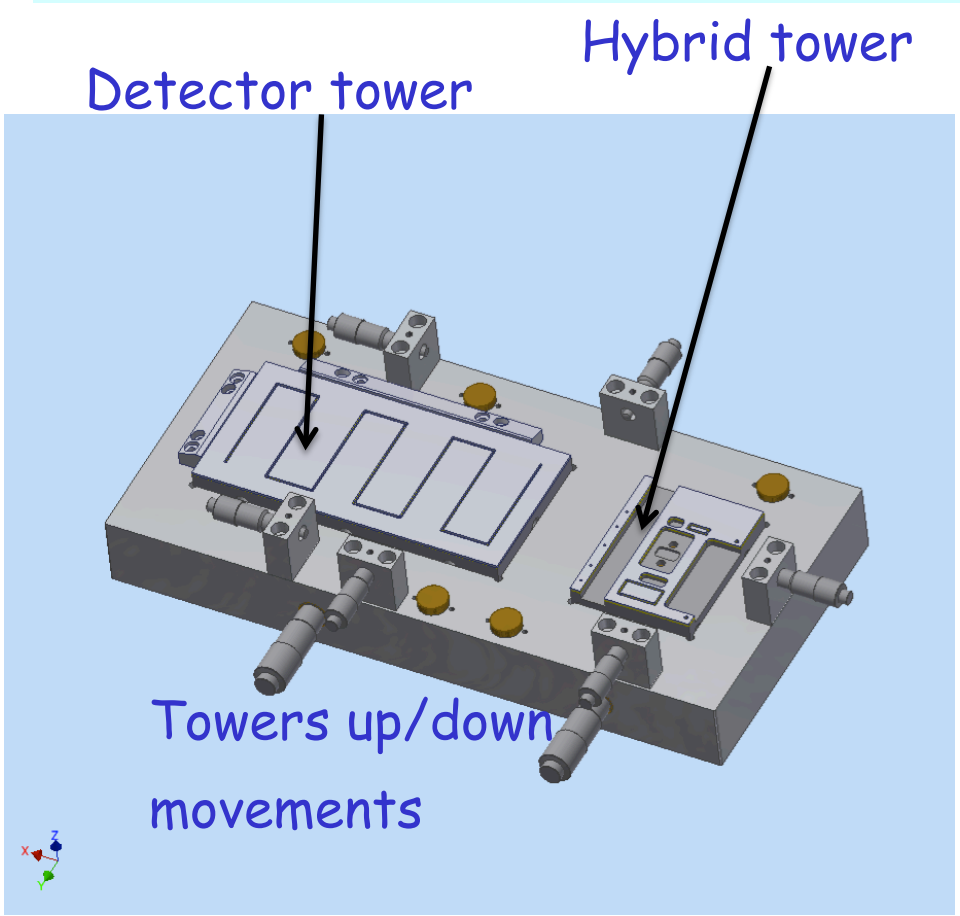
Glue squeezed to ~ 15 um → only few spots without glue on one corner.

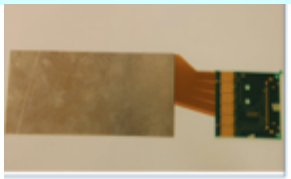


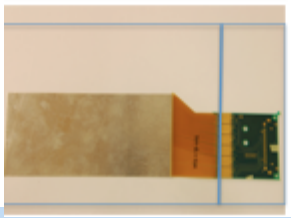
Glue extends at the edge of the PA only by ~ 300 um & no glue above PA pads.

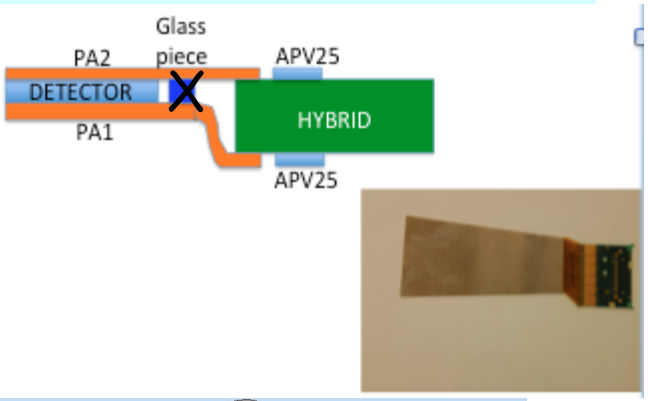


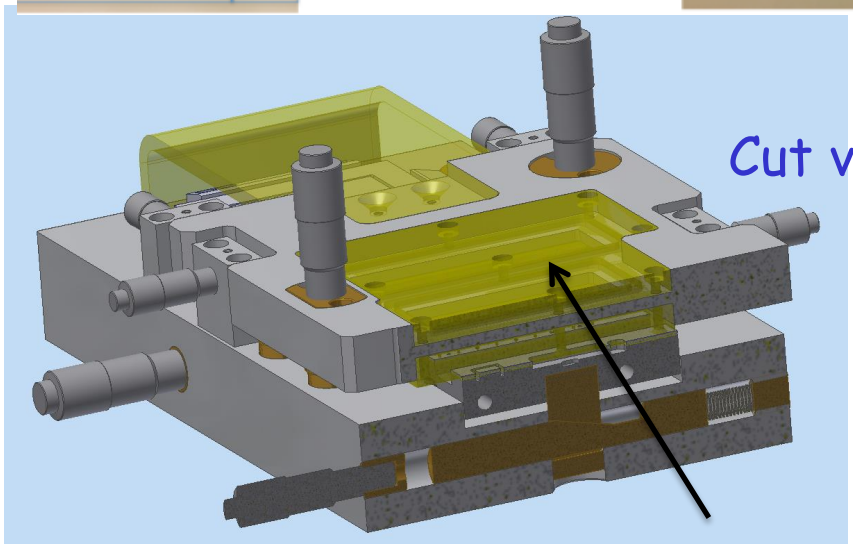
The final Gluing jig (BW-phi)







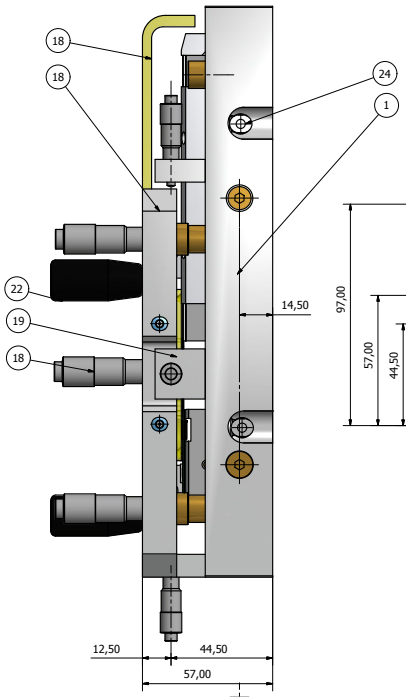


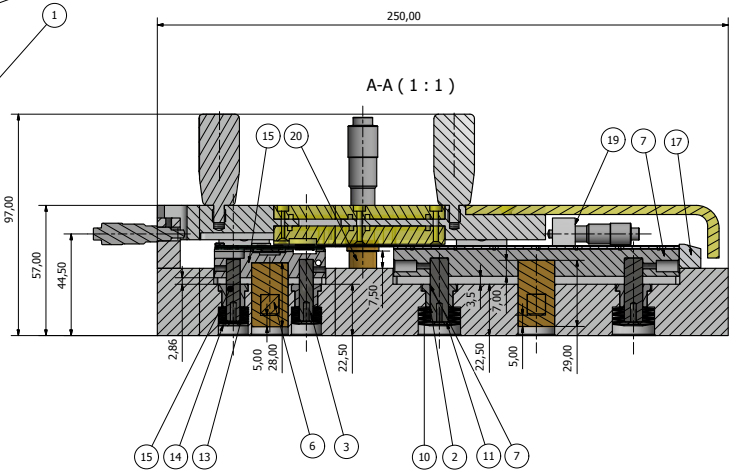


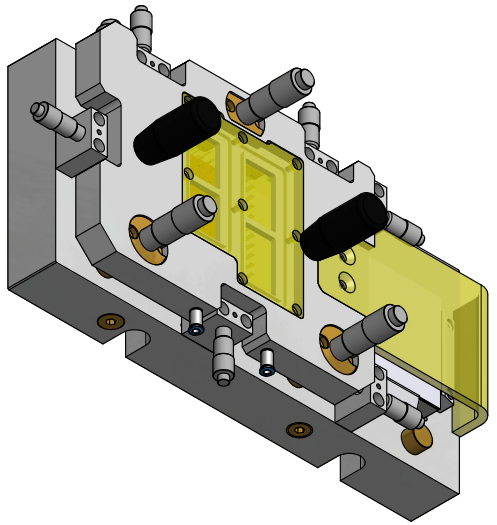
Other (similar) 3 jigs are required: BW-z, FW-phi and FW-z.

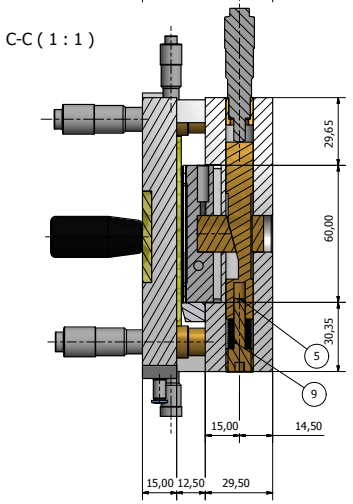
Possible home-made fine mech. adjustment/modifications.

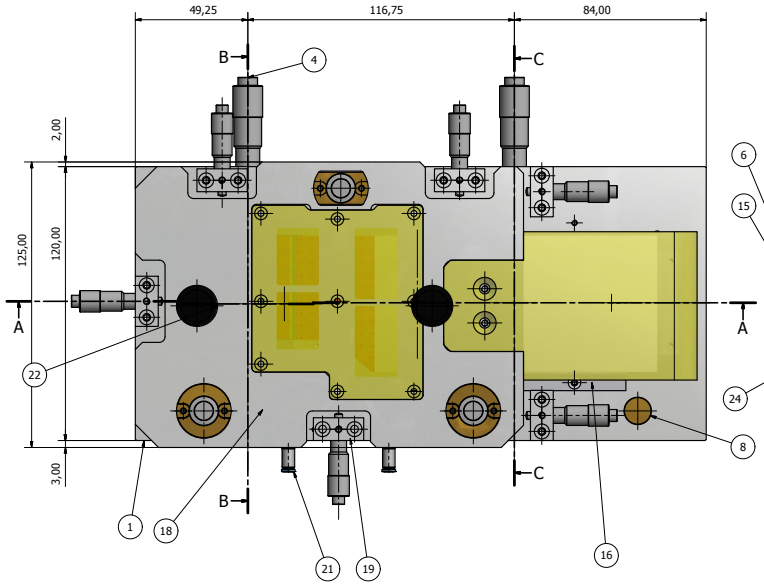
The Gluing jig

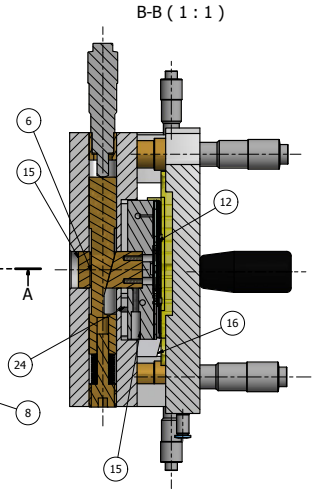












ELENCO PARTI			
ELEMENTO	QTÀ	NUMERO PARTE	DESCRIZIONE
1	1	gluing bottom jig PB1	
2	2	boccola 8mm	
3	2	boccola 6 mm	
4	2	Assieme_micrometro_rinboccolato	
5	2	perno_di_regolazione	
6	2	albero_orizzontale	
7	1	Assieme_gluing_torretta_si_PB2_UP	
8	3	boccola piena	
9	2	Assieme molle tazza albero orizzontale	
10	2	Assieme molle tazza albero verticale 8,2x18x1,1	
11	2	rondella molle tazza 18	
12	1	BWD-Sensor_da step	
13	2	Assieme molla tazza albero verticale 6,35x12,7x0,43	
14	2	rondella molle tazza 13	
15	1	Assieme_gluing_torretta_Hy_PB1_UP	
16	1	blocchetto battuta lungo PB1_fori dritti	
17	1	blocchetto battuta corto_fori dritti	
18	1	Assieme gluing PA_jig PB1_FIUP	
19	6	Assieme blocchetto micrometro piccolo	
20	2	boccola piena speciale	
21	2	raccordo festo diritto m3 lavorato	QSM-B-Push-in fitting
22	2	pomello dritto	
24	2	connettore angolo	

Progettato da	Controllato da	Approvato da	Data		Data
F.Bosi		F.Bosi			22/04/2014

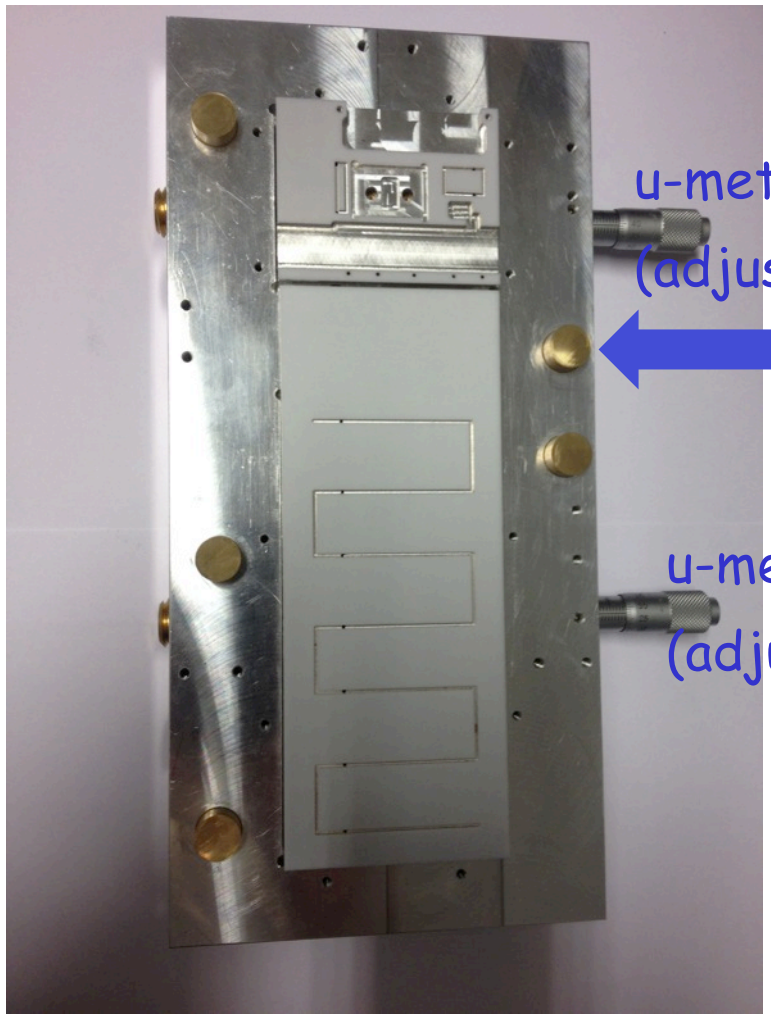
Istituto Nazionale di Fisica Nucleare-Sezione di Pisa

Assieme_gluing_jig_back_PB1_UP_generale

BELLE2

Edizione | Foglio

Gluing jig BW-phi

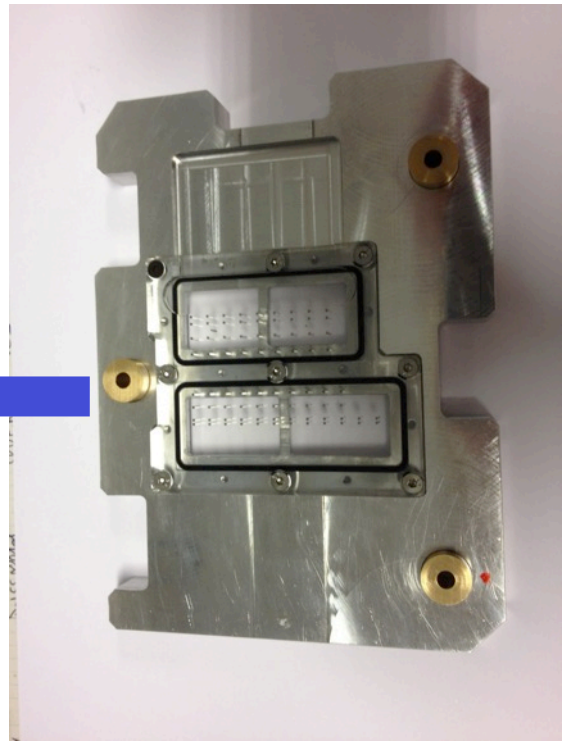


u-metric screw

(adjust z hybrid)

u-metric screw

(adjust z det)



•PA chuck

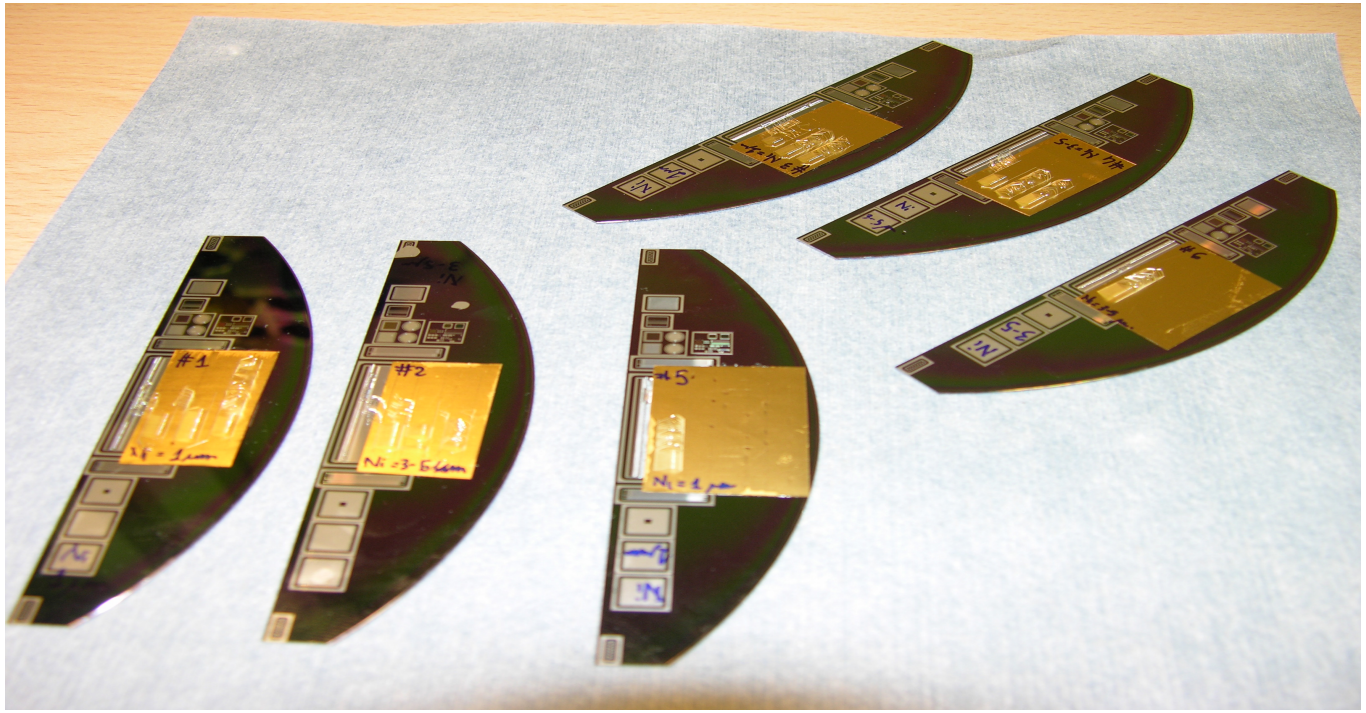
to be lowered on the base

•Base chuck, before mounting x-y mechanical stops

Bonding tests on PA samples with full metalized surface and different Ni plating

Bonding test on the PA with inside a layer of nickel at 1um and 3-5 um thickness

For the bonding test have been assembled six silicon "half-moon" with PA:
3 Half-Moon with glued 1um thicknessl Ni layer
3 Half-Moon with glued 3-5um thickness Ni layer

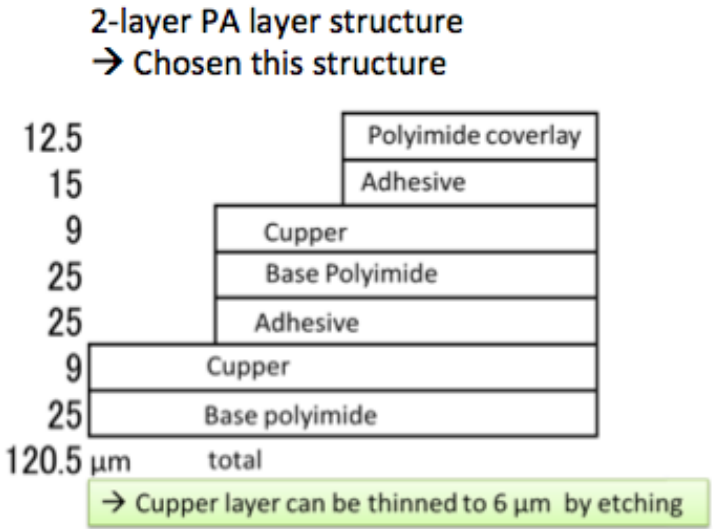


Il problema sui PA: 2 soluzioni

- Da Nov. scorso individuati (Pisa) problemi sulle larghezza (<30 um) delle pads dei PAs (specialmente zona vs chip: 44 um pitch).
- Sono state rivisti i requirements, fatte varie serie di prototipi sottoponendoli a test di bonding. Esito negativo: o cattiva bondabilita' oppure bassissimo yield (→no good for production!)
- Ad oggi le soluzioni messe in campo sono:
  - 1. presso la stessa compagnia giapponese (Tokay Denshi) e' stato sottoposto un design a sempre 1 layer ma a 3 file di pads (invece di 2) per consentire la giusta larghezza delle pads (almeno 35 um);
  - 2. presso la compagnia che ha prodotto gli origami Taiyo (i lunghi circuiti stampati) e' stato sottoposto un design a 2 layers.
- I tempi per i PA nelle due soluzioni

sono comparabili e prevedono circa 1.5 mesi per la loro produzione.

- Primi tests su (1) →buoni risultati
- KEK ci sta investendo risorse importanti.
- Impatto importante sulla schedule …

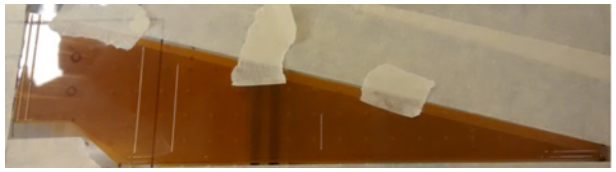


FW/BW mechanical prototypes

- The FW/BW mechanical prototypes are needed to feed the ladder production sites, who can exercise their alignment and pass through the full ladder construction process.
- Even if realized without the final gluing jigs, they have precision of O(20 um).
- Useful for us to gain confidence

on the glue-dispensing

- So far we produced:
  - 2 BW (1 with Si)
  - 1 FW (with Si)



FW/BW Schedule

- The FW/BW detailed schedule has been revisited, after the PA problem. At the next June B2GM all the SVD Institutions will review the site-readiness for the SVD module production.
- We plan to build the 1st BW mech. assembly in mid-July with the new jigs and soon after the 1st electrically working assembly, with a pre-production sample of PA.
- The production is going to start in September and last 6→8 months.
- The current schedule still foresees SVD ready and assembled @KEK in August 2015.

Conclusion

- The FW/BW assemblies are the first link of the whole production chain for the ladders of the layers 4,5,6
- We don't have yet in our hands the final PAs but the complex (with relative movements, strict spec's on planarity, …) jigs we designed and produced are such that they can manage their gluing.
- We prepared the tools (mod. xyz-theta stage, MP) needed to start the ladder production in september 2014.