



WP2 activities – SVD

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For the Belle II SVD group

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Components of the Belle II SVD

VXD requirements

- Fast – to operate in high background environment
- Better resolution at IP – to compensate reduction of boost wrt. Belle I
- Radiation hard (up to 100 kGy)
- Self-tracking capable – to track particles down to 50 MeV in p_T

Carbon fiber (CF) cone

Outer CF shell

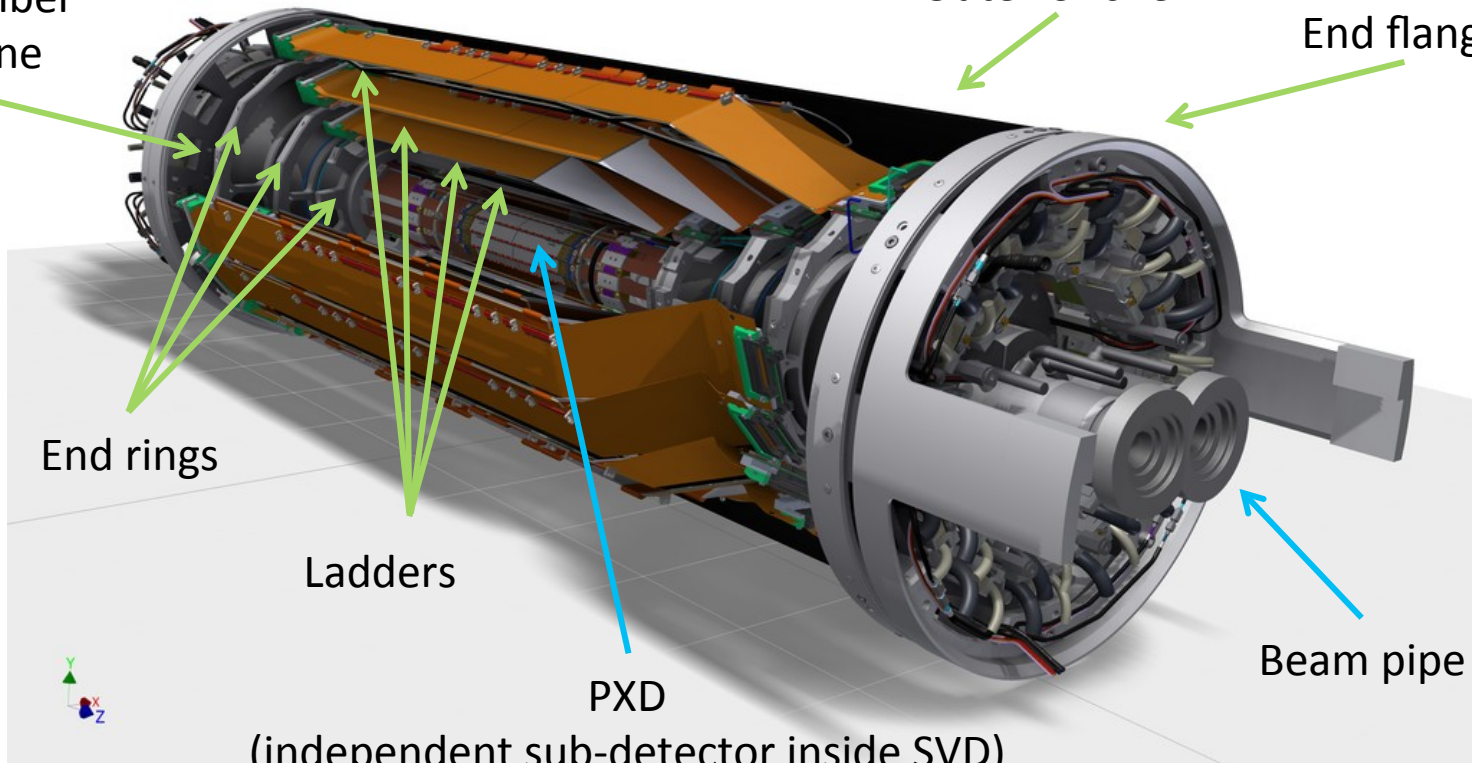
End flange

End rings

Ladders

PXD

Beam pipe



(independent sub-detector inside SVD)

SVD ladders

Layer	Ladders (spares)	DSSDs / ladder
6	16 (4)	5
5	12 (3)	4
4	10 (2)	3
3	7 (2)	2

L6 Ladder
(Kavli IPMU)

FWD module

L5 Ladder
(HEPHY)

L4 Ladder
(TIFR)

L3 Ladder
(Melbourne)

FWD module
(Pisa)

BWD module
(Pisa)

FWD

Origami +z

Origami ce

Origami -z

BWD

BWD module

47 FW/BW
+ spares
(4)

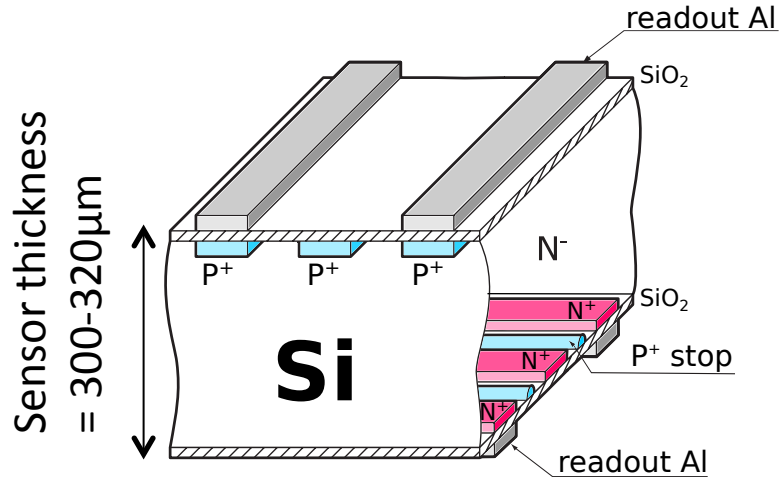
Cooling pipe

Cooling pipe

Cooling pipe

SVD silicon sensors

DSSD (Double-sided Si strip detector)

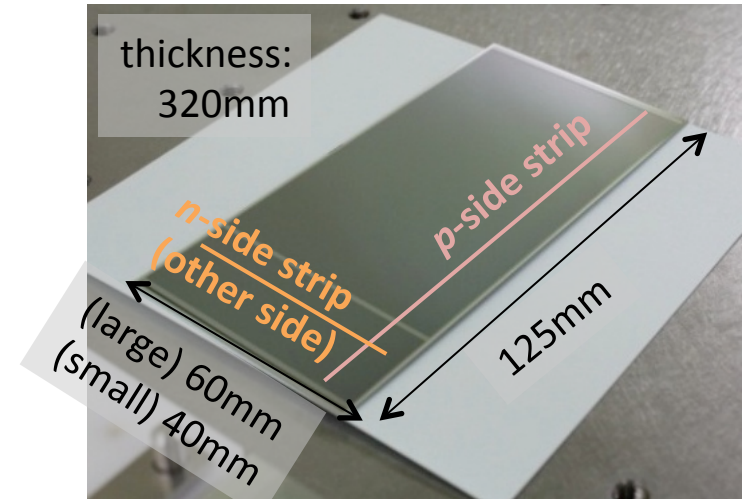


Strip numbers and pitches

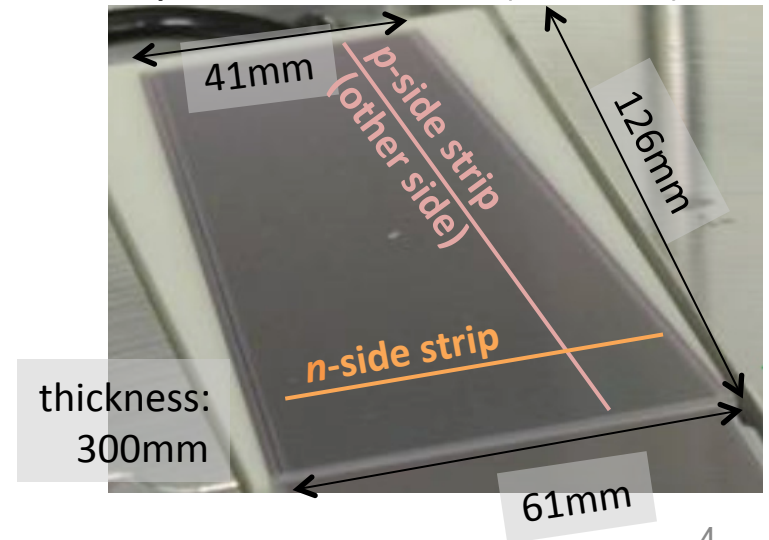
- 3 types of DSSD sensors

Sensors	Rectangular (Large)	Rectangular (Small)	Trapezoidal
# of p-strips	768	768	768
p-strip pitch	75µm	50µm	50...75µm
# of n-strips	512	768	512
n-strip pitch	240µm	160µm	240µm

Rectangular sensor (HPK)

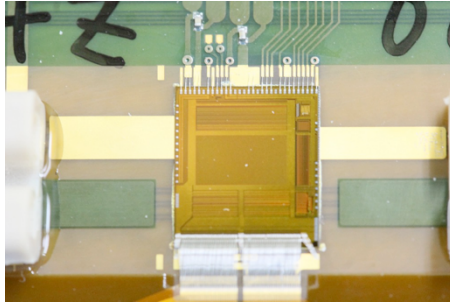


Trapezoidal sensor (Micron)

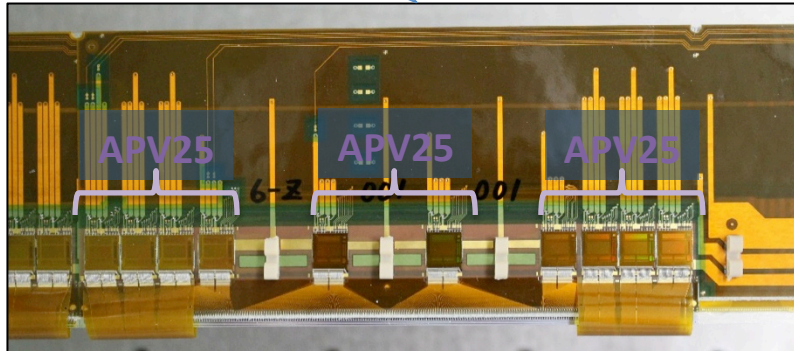
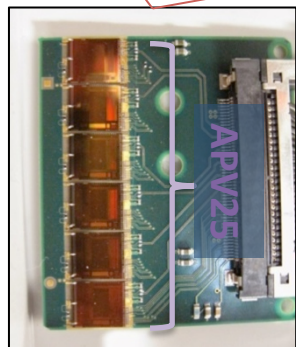
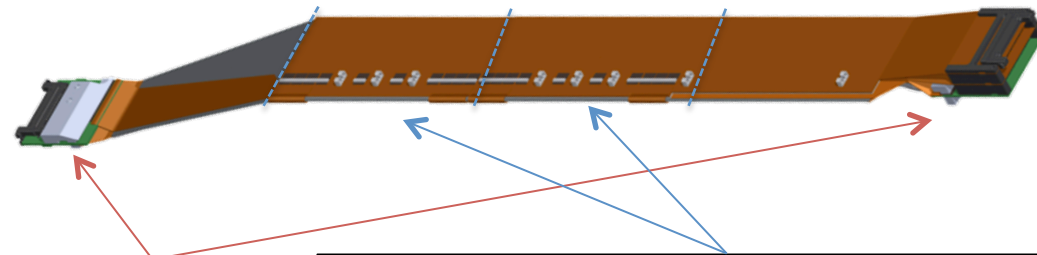


APV25 – front end readout ASIC

APV25 chip



APV25 chips in ladder

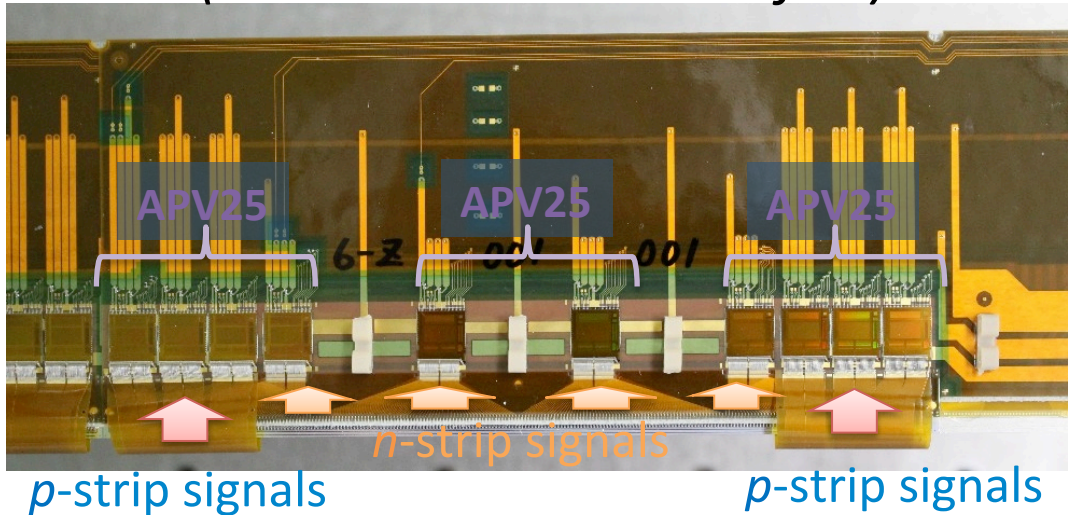


- Specifications

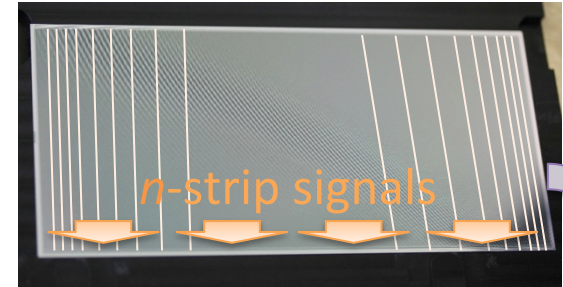
- # of input channels: 128 ch.
- shaping time: 50nsec
- radiation hardness: > 1MGy
- max heat dissipation: 0.4W
 - necessity of cooling
- Within acceptance thinned to 100 μ m for reduction of the material budget

“chip on sensor” concept

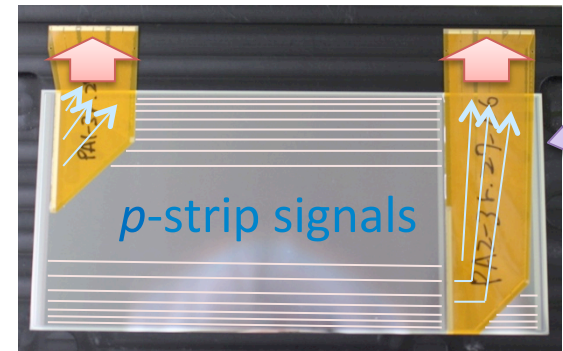
ORIGAMI flex
(Si sensor is under the flex)



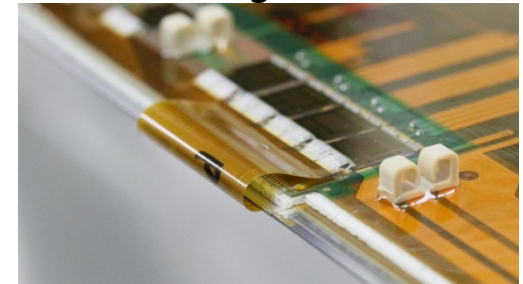
Sensor under ORIGAMI (n-strips)



Sensor from other side (p-strips)



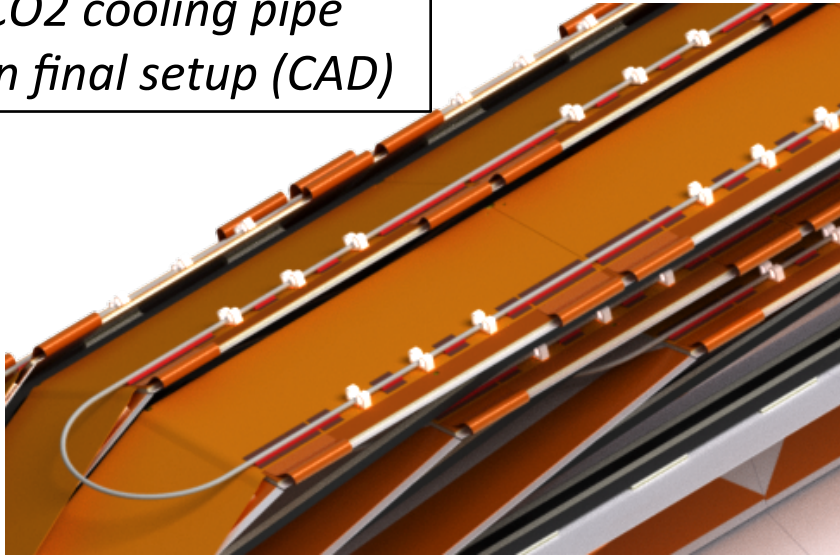
Wire bonding with Al wires.



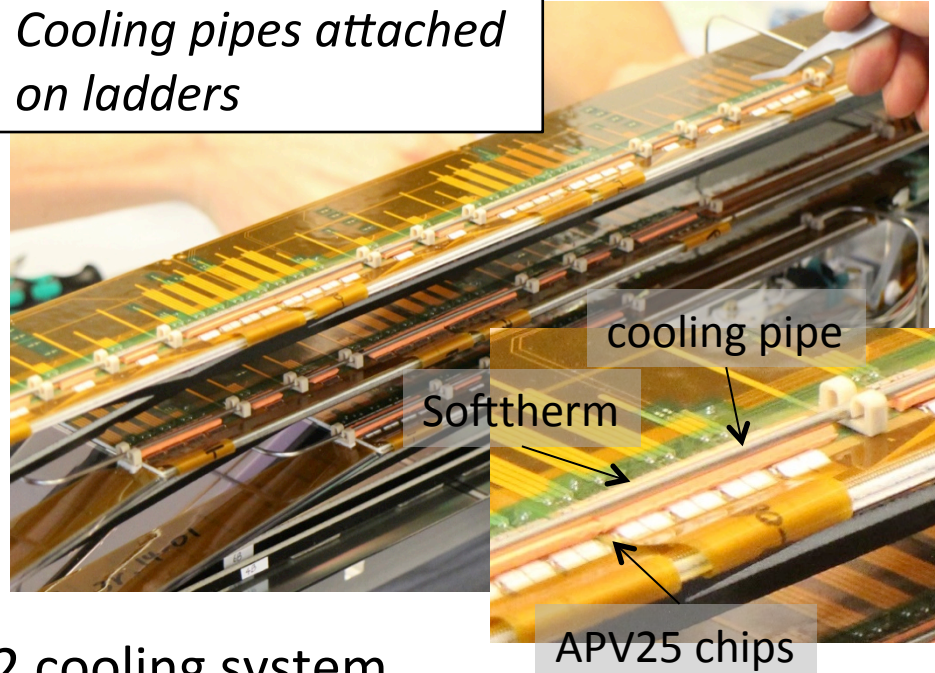
- Flex circuit (ORIGAMI flex) is glued onto sensor *n*-side on an isolation foam
- APVs are placed directly onto the ORIGAMI flex to minimize the analog path length (capacitive noise)
 - Sensor strips and ORIGAMI flex are connected with Al wire-bonding ($\phi 25\text{mm}$).

CO2 ladder cooling

CO2 cooling pipe in final setup (CAD)



Cooling pipes attached on ladders



- 2-phase (liquid and gas mixture) CO2 cooling system
 - Efficient and low mass cooling
 - Simple control of coolant temperature (only with pressure)
 - Small pressure loss in the pipe
- Thin stainless tube (OD:1.6mm, thickness:0.1mm) used to minimize material

Softtherm 86/125



Distributed SVD assembly

@HEPHY (Austria):

- Layer-5 assembly

@Kavli IPMU (Japan):

- Layer-6 assembly
- Layer-4 assembly by TIFR

@KEK (Japan):

- SVD assembly
- SVD installation

@Univ. of Pisa (Italy):

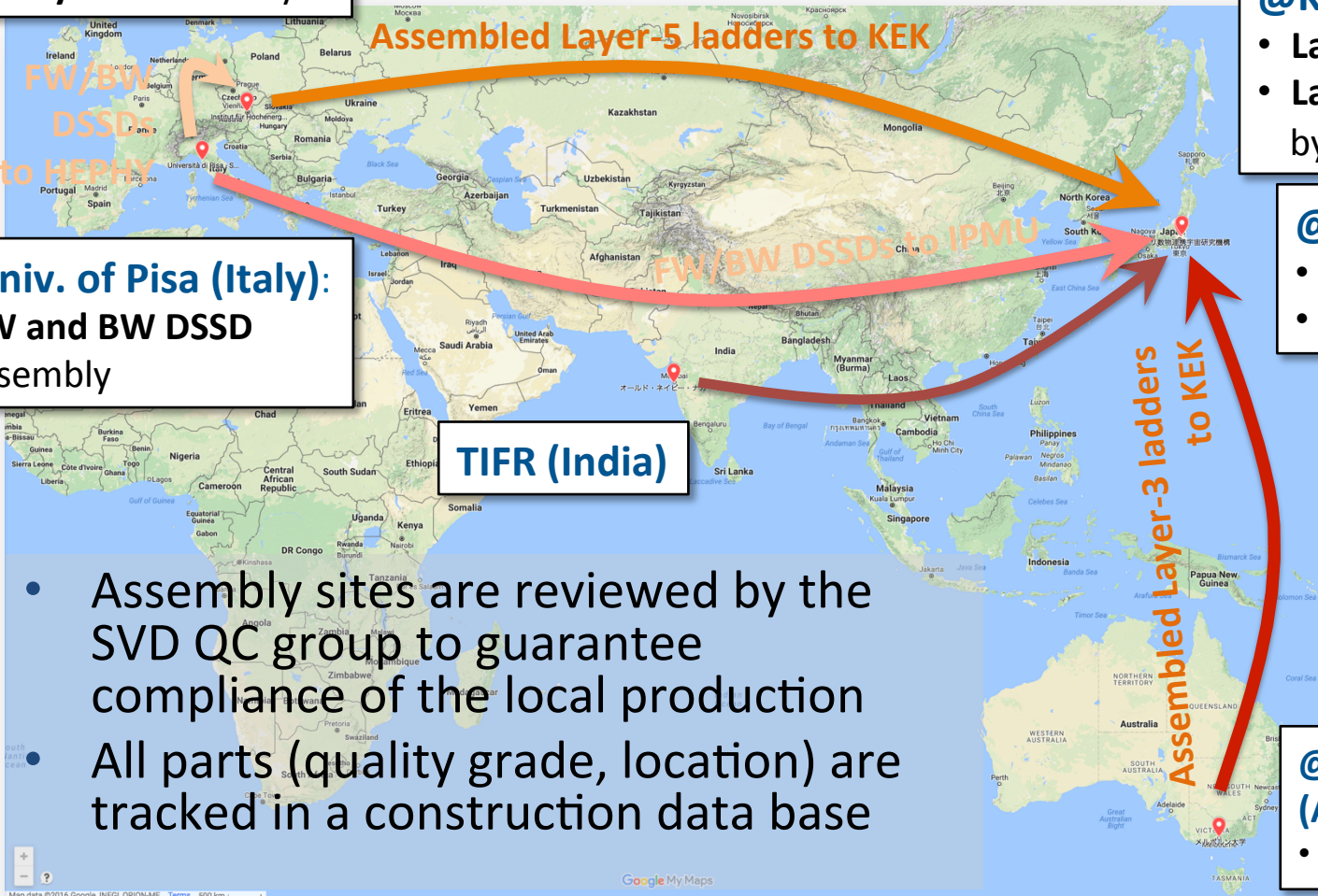
- FW and BW DSSD assembly

TIFR (India)

- Assembly sites are reviewed by the SVD QC group to guarantee compliance of the local production
- All parts (quality grade, location) are tracked in a construction data base

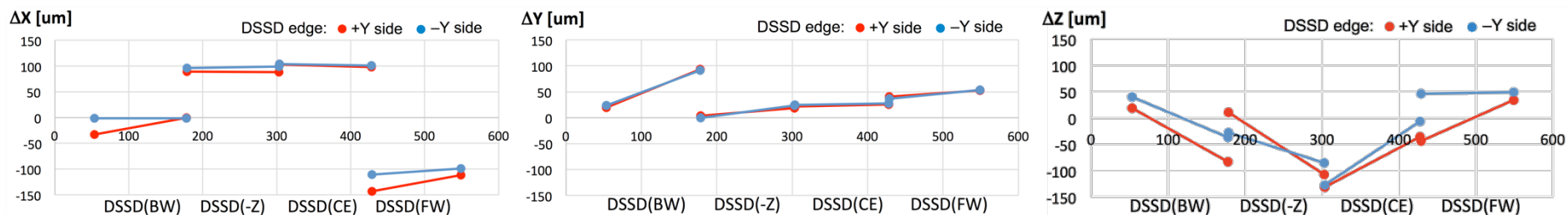
@Univ. of Melbourne (Australia):

- Layer-3 assembly

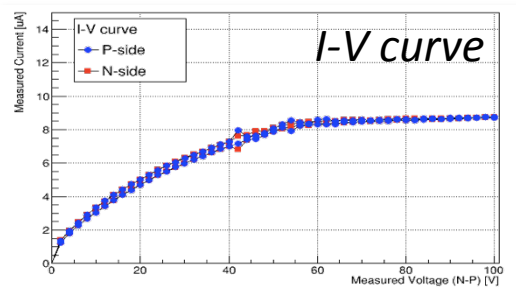


Ladder quality assurance

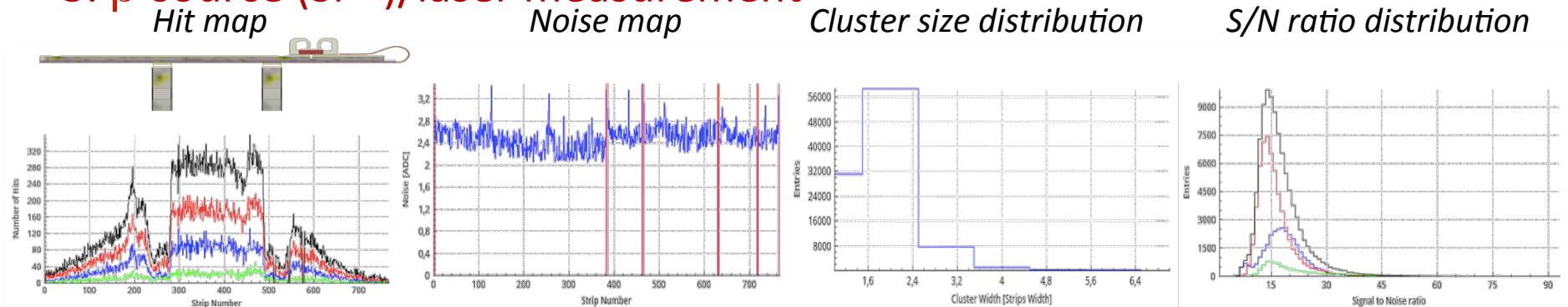
- 1. Mechanical precision measurement with CMM
 - Control reference point positions on DSSD sensors in 3-dimensions



- 2. I-V curve measurement
 - Confirm the sensor functionality for biasing.

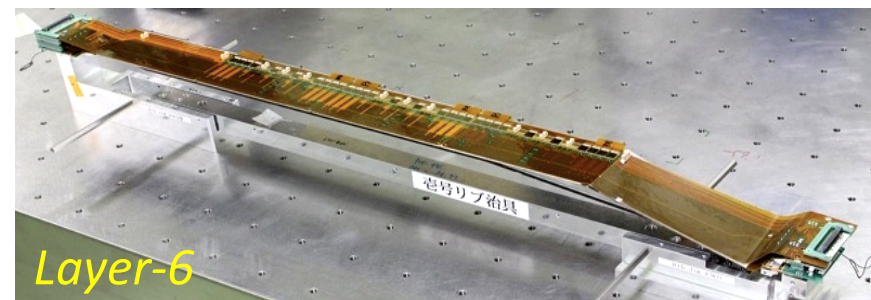
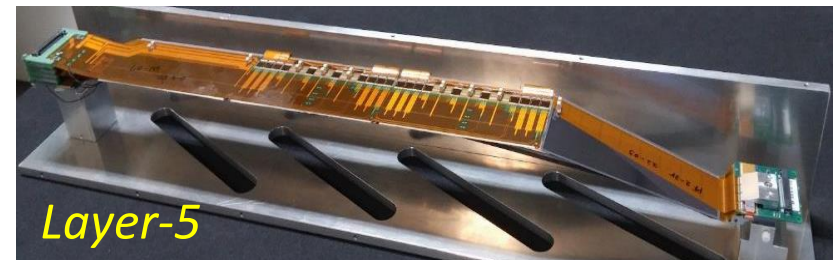
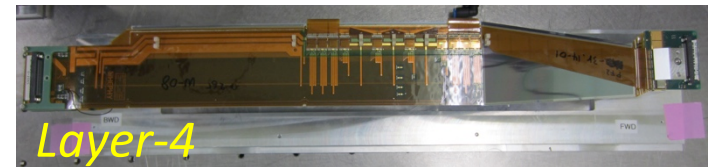
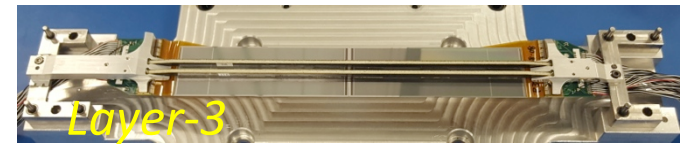
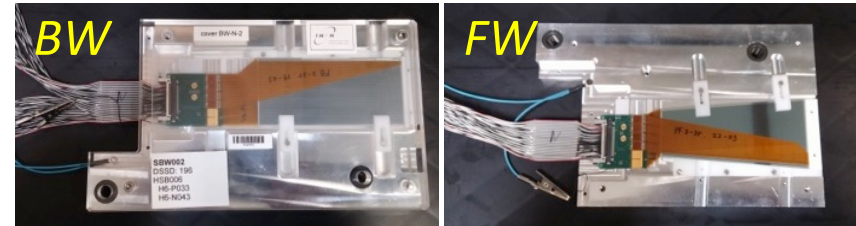


- 3. β -source (Sr^{90})/laser measurement



Ladder production status

- Now all the ladder assembly sites are in mass-production stage
- FW/BW DSSD
 - BW: 100% completed
 - FW: 93% completed
- Layer-3 Ladder
 - 5 out of 7+2 ladders (56%) completed
- Layer-4 Ladder
 - 3 out of 10+2 ladders (25%) completed
- Layer-5 Ladder
 - 4 out of 12+3 ladders (27%) completed
- Layer-6 Ladder
 - 3 out of 16+4 ladders (15%) completed
- Completion of the ladder production by Nov. 2017 is expected



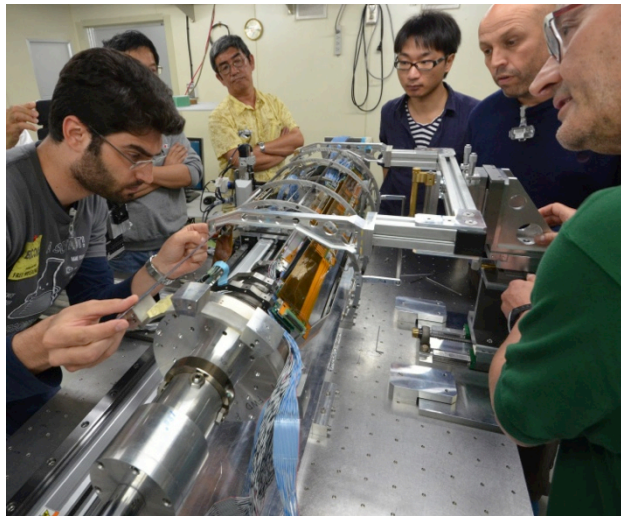
SVD assembly at KEK

- SVD assembly at KEK is the final step to complete construction of SVD
- Prototypes of all mount tools are available
- **We will finalize the tools by February 2017**

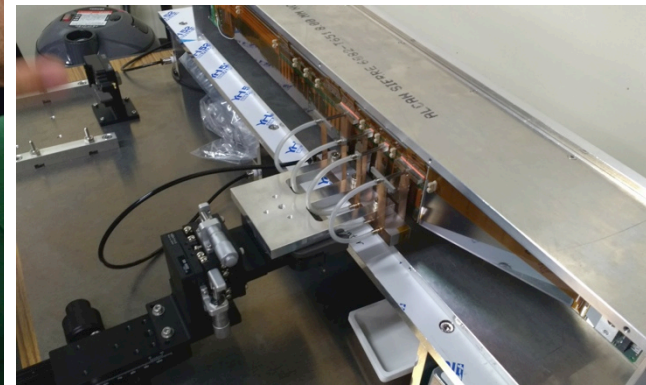
Ladder mount tool



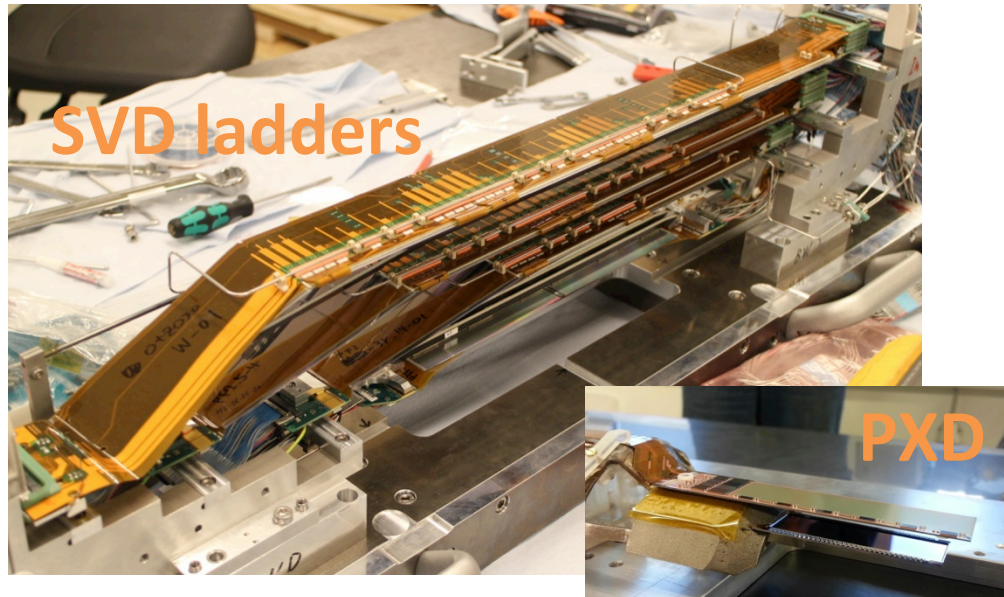
CO2 pipe attachment tool



Softtherm attachment tool

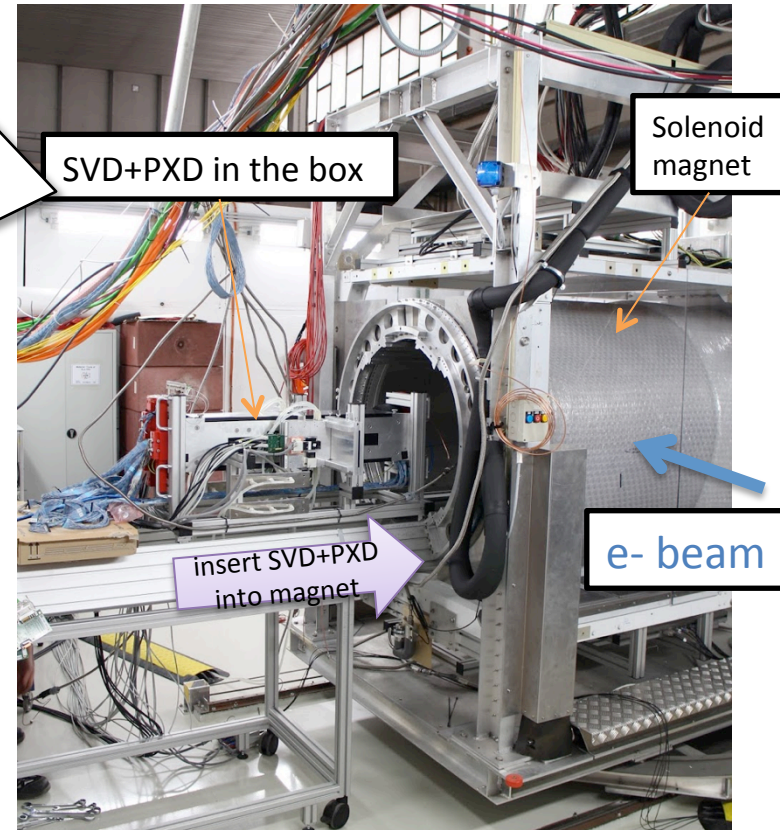


Beam test at DESY in April 2016



SVD + PXD detector setup Apr 2016

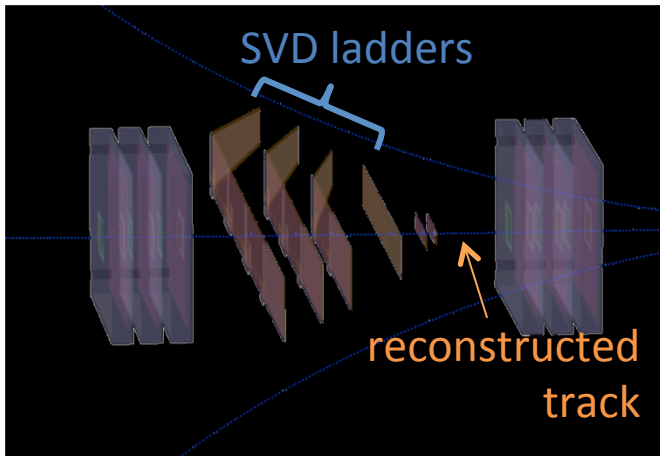
- 2-5 GeV/c e^- beam at DESY
- Simultaneous operation of SVD layers L3 to L6
- SVD + PXD combined setup



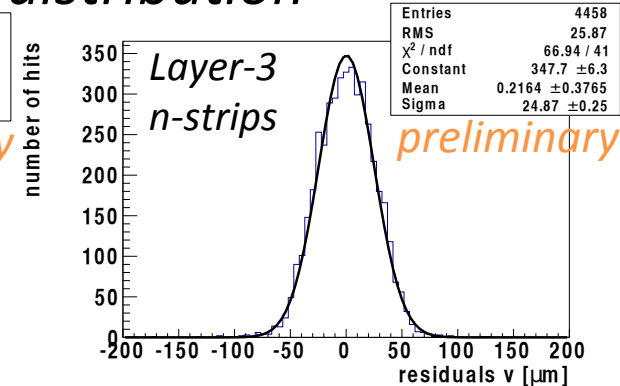
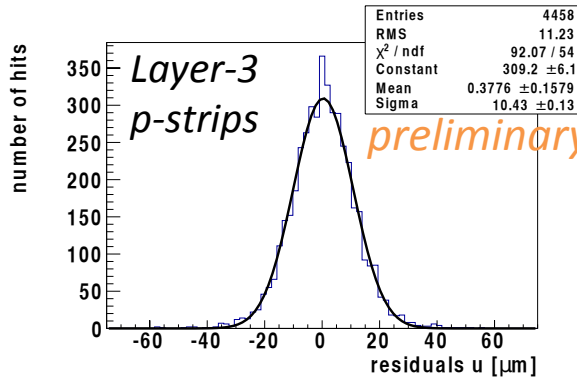
*Beam test setup
(@ DESY T24/1 hall)*

Ladder Performance for Tracking (DESY results)

Tracking event display



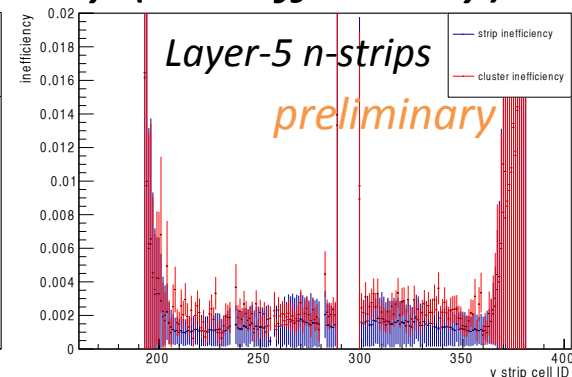
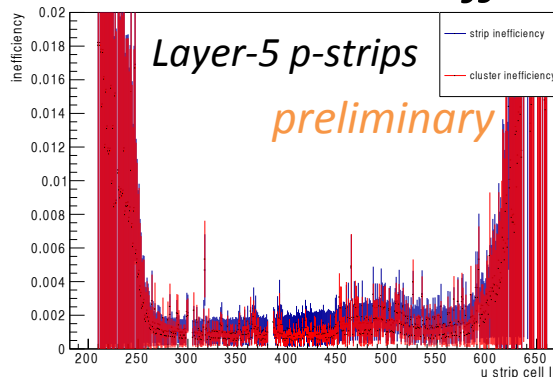
Residual distribution



Consistent with expectation

- Excellent SVD performance was confirmed during the April 2016 testbeam @ DESY

DSSD hit inefficiency (= 1-efficiency)



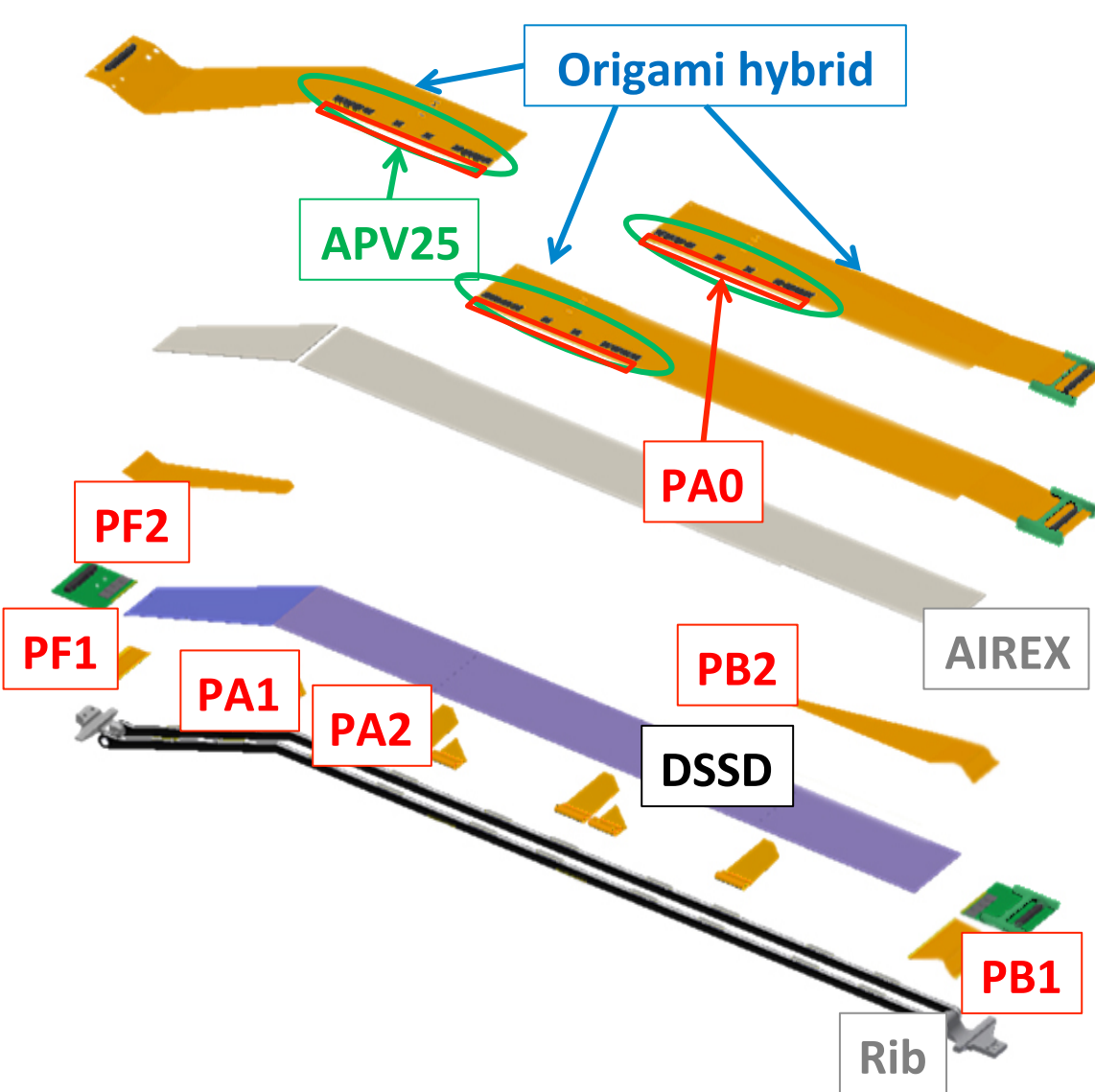
Single hit efficiencies above 99%

Summary

- SVD ladder construction is now in full swing
 - Expect to finish by November 2017
- SVD assembly at KEK
 - Procedures are now being finalized
 - Final assembly at KEK will start in February 2017
- SVD will be ready for integration with PXD by the end of 2017
- Full BEAST phase 2 geometry has been successfully tested in DESY in April 2016

BACKUP

Ladder Anatomy (L6 ladder)



DSSDs

- 2 small rectangular (L3)
- 2-4 large rectangular (L4-6)
- 1 trapezoidal (L4-6)

Origami hybrid

Flexible circuit to transmit detector signals to the ladder ends

APV25

Readout ASIC of the strips

FlexPA (PA/PF/PB)

Flexible circuit to transmit detector signals to the APV25

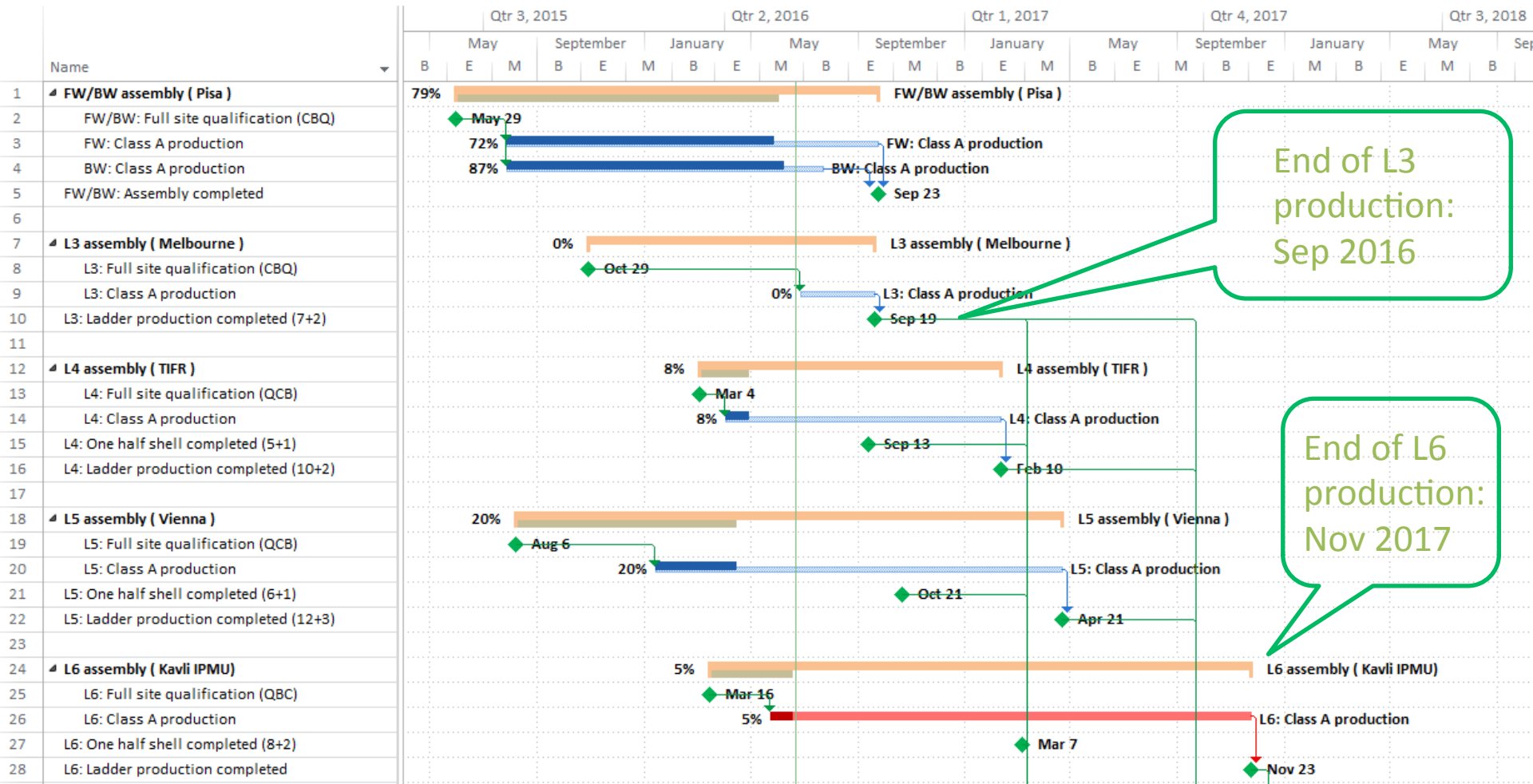
PA0

Flexible circuit glued on the Origami hybrid to transmit n -side detector signals to the APV25

AIREX

Thermal insulator between the DSSD and APV25

Ladder production schedule



End of L3 production: Sep 2016

End of L6 production: Nov 2017