Status of PXD2

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Deutsches Elektronen Synchrotron, DESY
Belle II Experiment, KEK

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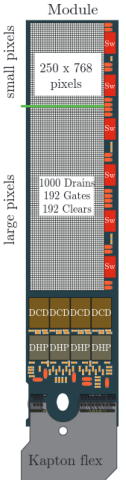
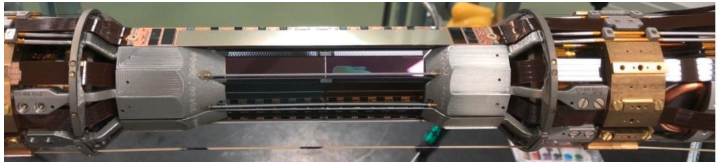
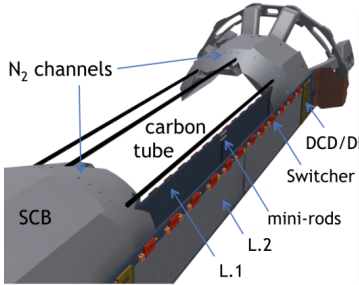
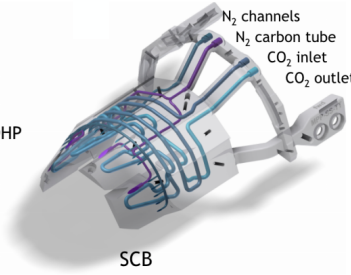
HELMHOLTZ

PXD overview







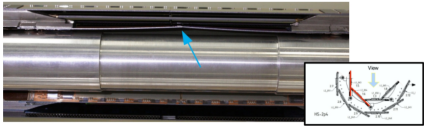


- 2 modules → 1 ladder
- Two layers
- Screwed on support cooling block (SCB)
- Two half shells (HS)
- 4 inner, 6 outer ladders per HS
- Cooled by C02 and N2
  - End of stave (ASICS) → Thermal contact
  - Matrix area + SW → N2 flow
- SCB screwed to brass pieces (electrically isolated)
- Brass pieces mounted on BP

→ PXD2 consists of two fully equipped HS produced by MPI

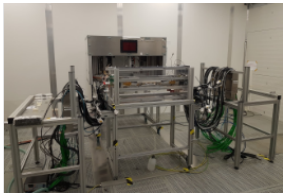
Pre-commissioning of PXD2 at DESY

- Both HS tested at DESY
  - Two inner ladders of 1st HS broke
    $\rightarrow$ Rebuild HS with additional optimizations
  - Applied also modifications to 2nd HS

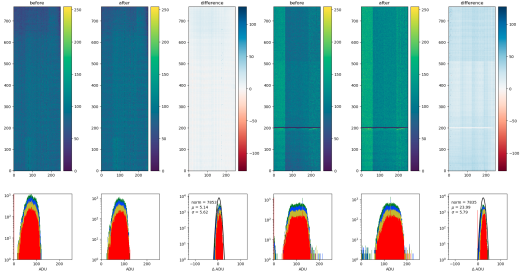


- Pedestals and source scan taken
- Stable working conditions for both HS found
- For one HS isolation to beam-pipe broken
- Significant bending observed for edge L2 ladders
  $\rightarrow$ Unclear if caused by setup
- De-commissioning at DESY
- Transport of both HS and services to KEK

Pedestal comparison before and after HS Commissioning - Module W67_IF



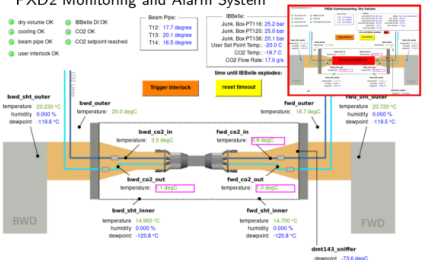
Pedestal comparison before and after HS Commissioning - Module W59_IB

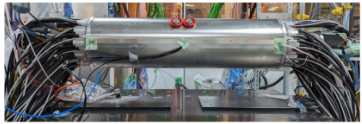


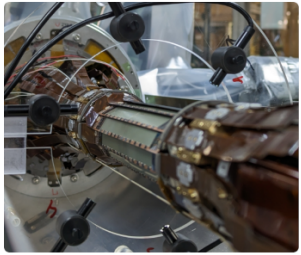
Commissioning preparations in B4 clean room at KEK

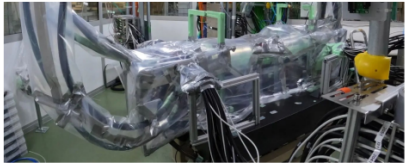
- PXD2 mounted on new BP with isolating foil
- Installed camera ring to study bending
- Closed heavy metal end flange
- Environment monitoring and interlock system
- Cooling (CO2 and N2)
- Dry volume

PXD2 Monitoring and Alarm System





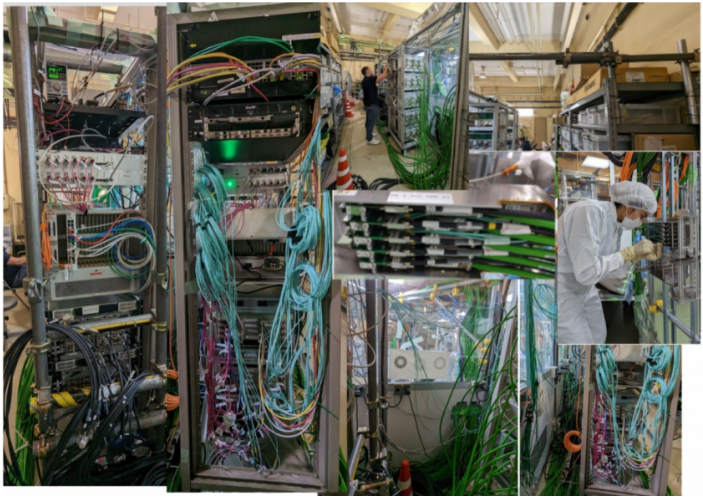




Commissioning preparations in B4 clean room at KEK

- Setup of DHH system and connection
- Preparation of power supplies
  - Needed power supplies (PS) has been doubled
  - Several modification and updated necessary for PXD1 PS
  - With big effort 40 (+10) PS has been collected and modified
  - Setup of slow control and interlock system

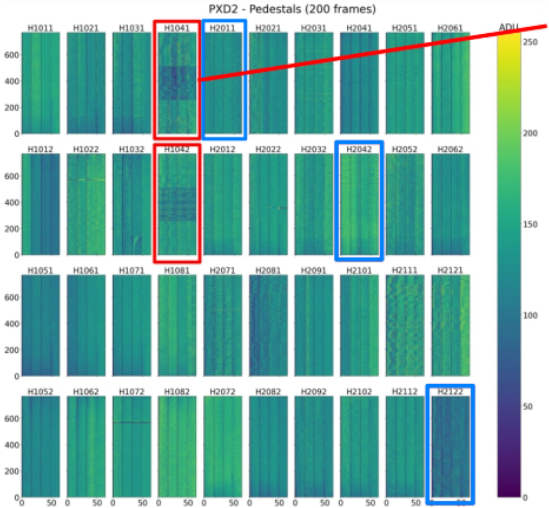
  → Talk in hardware session by Jannes



Electrical functionality:

- Turned on of PXD2 step by step
  - All modules functional
  - Three L2 modules with known issues
  - One L1 ladder with new issue

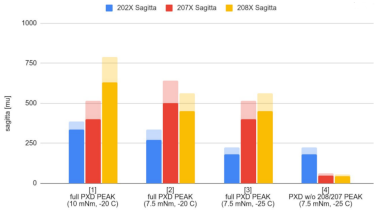
All 40 modules operational

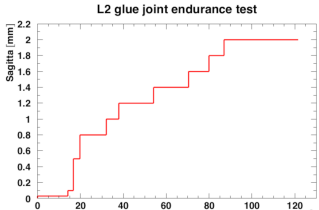


Standalone commissioning of PXD2

Mechanical behavior:

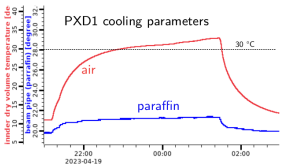
- Significant ladder bending for L2.7 and L2.8
- Reduced fwd screw torque for these ladders
- Acceptable bending of 500 um remained
- Bending studies at DESY and PXD1

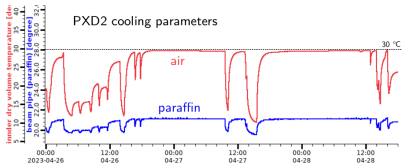




Temperature behavior:

- Air temperature increased above 30°C
- To high temperature for long term operation
- Reduced CO2 temp. from -20°C to -25°C
- Increased N2 flow rate
  → Air temperature stabilized below 30°C





→ Decision to extract PXD1 and install PXD2

VXD assembling

Preparation of SVD:

- VXD extracted from Belle2
- SVD de-attached from PXD1

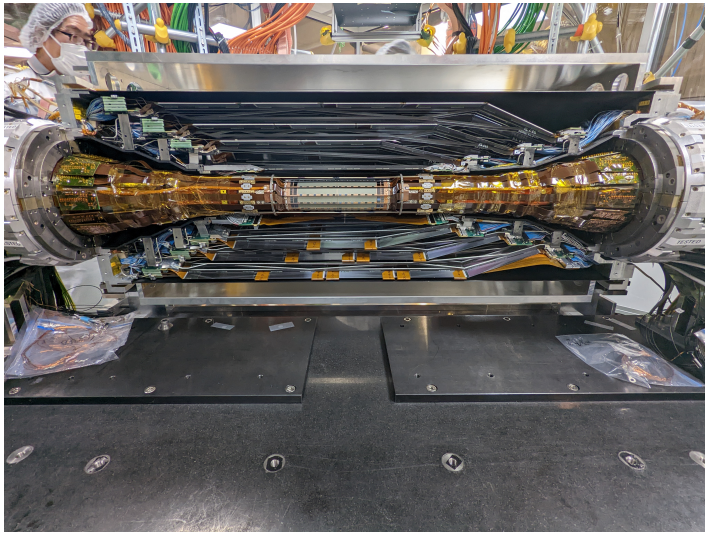
Final preparations of PXD2 for SVD assembling:

- Re-movement of environment monitoring and cameras
- Installation of 4 FOS fibers (3 from PXD1)
- Preparation of grounding scheme
  - Isolation to BP again broken
  - Decision to ground PXD2 to BP
- Solving possible conflicts with SVD

Attachment of SVD:

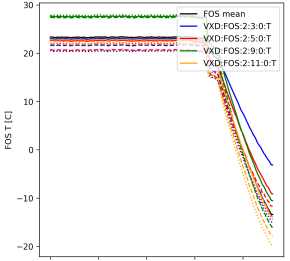
- SVD was successfully attached

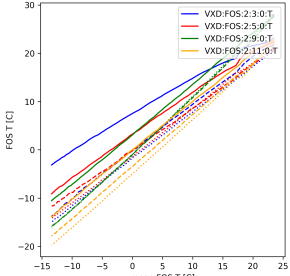
→ Start of VXD commissioning

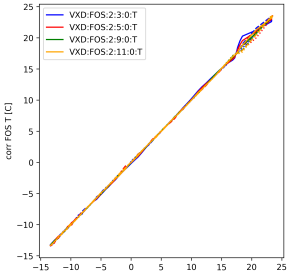


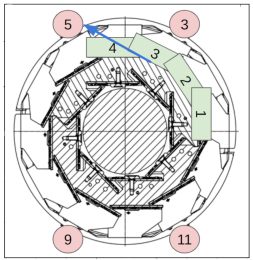
PXD FOS fibers

- New produced FOS fibers for PXD2 calibration issues
- Installed 3 FOS fibers from PXD1 + 1 new FOS fiber (2.9)
- Use cross-calibration for more reliable values
- Use working points at which all FOS fibers should have same temperature
  - After establishing dry volume
  - At room temperature
  - After cooled down when temperature stabilized (before PXD is powered)









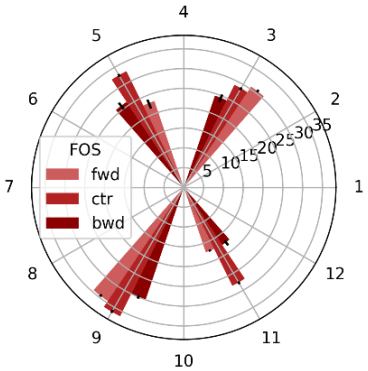
VXD commissioning in B4 clean room

Step by step test of both systems:

- Both systems in same state as before

Operation of full system:

- Temperature further increased
  - Cross-calibrated FOS fibers
    → No direct comparison to NTCs temp.
  - CO2 reduced to -30°C
  - FOS 2.9 center up to 38°C
  - Optimization of cooling in commissioning setup limited



Conclusion of commissioning:

- Both systems are functional
- PXD2 relative hot (FOS2.9 center)
  - N2 flow can be further optimized in Belle2
  - Estimate exact bending with cosmic data
  - Possibility to not power all modules

→ Continue with VXD installation

Insertion of VXD and service installation

Insertion of VXD:

- Successful without any issues

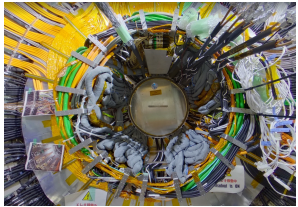
Installation of cabling:

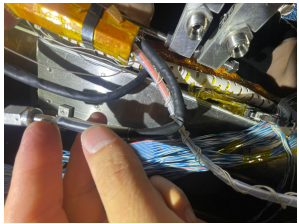
- Number of PXD cable doubled
- Unused PXD1 space overtaken by other groups
- Esp. on BWD more environment cables as designed
  → Very challenging due to the limited space

Installation of cooling system:

- One CO2 pipe broke twice → Replaced by spare
- Combination of pre-damage and strong bending
- All pipes in final position and pressure tested
  → No further damage likely

→ Start with VXD commissioning in Belle2





Space testing for QCS and ECL (ARICH)

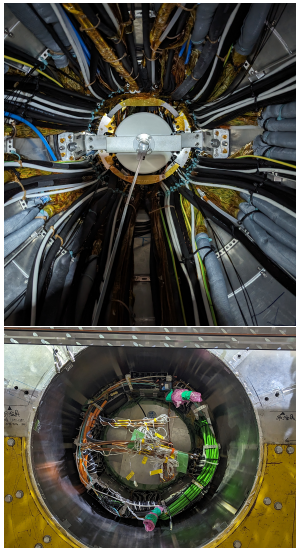
Conflicts between new PXD cables and other systems?
→ Perform several space tests

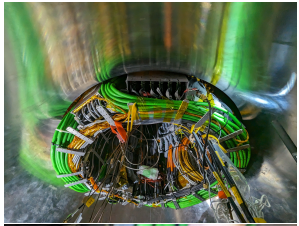
Conflicts to QCS:

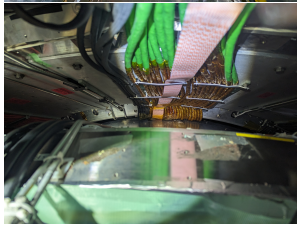
- Check with tools possible conflicts of inner cables
- Several iteration with optimizations needed

Conflicts to ECL and ARICH:

- Test insertion of ECL (+ARICH) on both sides
- Apart from small optimization smooth insertion
  → Overall much less problems than before phase 3



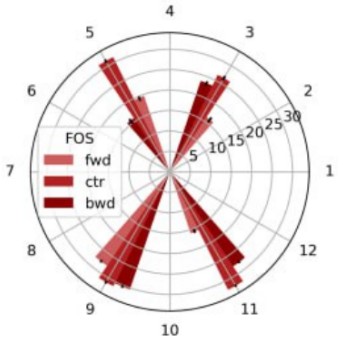




Thermal behavior:

- Temperature slightly reduced ($\approx 1^\circ$C)
- Extensive studies to further optimize cooling
- Optimize N2 flow rate
  - Increase PXD flow rate
  - Decrease SVD flow rate
    $\rightarrow$ Similar total amount compared to phase 3
- FOS 2.9 center could be reduced to 32°C
- Further optimization for beam operation
  (New hardware will be installed)

$\rightarrow$ Temperatures stabilized at acceptable values



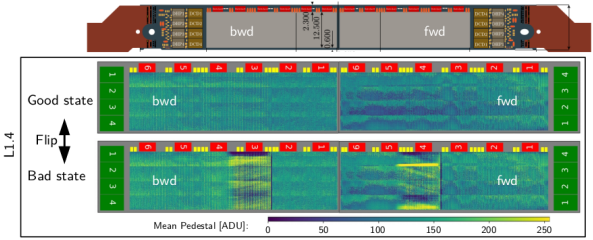
Unstable Switcher States in L1.4:

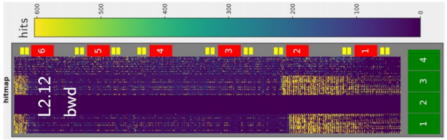
- "good" and "bad" mode
- Problematic gate(s) or switcher?
- Temporary solution by reducing gate-on voltage

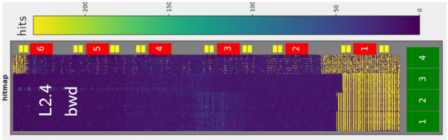
Pedestal Glitches:

- Significant pedestal shifts within indiv. frames
- Dominant structure in L2.4 bwd and L2.12 bwd
  → Large noise

→ Needs further investigations





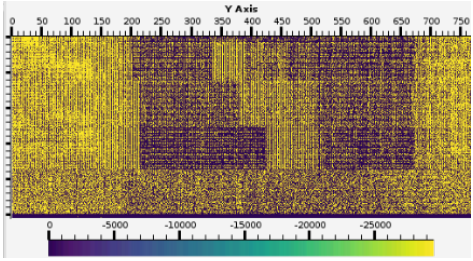


VXD cosmic data taking

Module performance:

- Esp. L2.12 introduce high noise
  - DHPs have to reset in short intervals
  - Increase for now noise threshold
  - Needs further investigations
- Other modules perform as expected

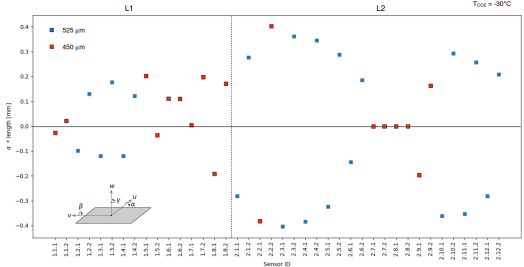
→ More time need for detailed studies



Alignment data:

- Estimate bending of ladders (esp. L2.7, L2.8)
- Different PXD2 configuration
  - With(out) partial L2.7 and L2.8

  → Final decision if both ladders will be powered
- First results (36/40) and reduced temperature promising
  → Hopefully L2.7 and L2.8 can be fully operated



Summary

PXD2 installation very successful:

- PXD2 installed on new BP and SVD attached
- New VXD inserted into Belle2
- PXD1 services extended for PXD2 → No conflicts

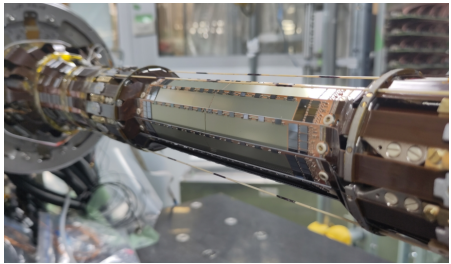
PXD2 behavior:

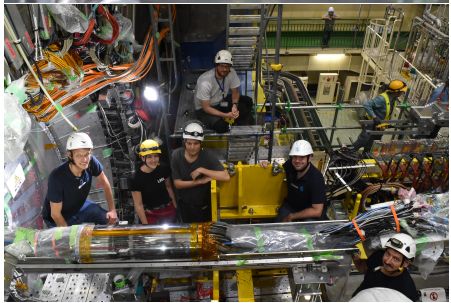
- All modules are electrical working
- PXD2 produces more head than expected → Cooling optimizations
- Finally temperatures in an acceptable range
- L2.7 and L2.8 ladders with significant bending in B4
  - First cosmic data and reduce temperature are promising
- Two L2 modules have noise issue
- Two L1 modules have broken gate(s) or switcher

Outlook:

- Cosmic data taking ongoing
- Small modification of N2 hardware will be installed
- Further investigations in problematic modules

→ PXD2 is installed and ready for data taking

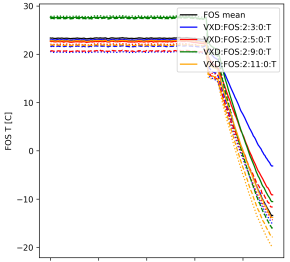


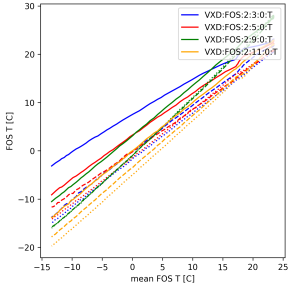


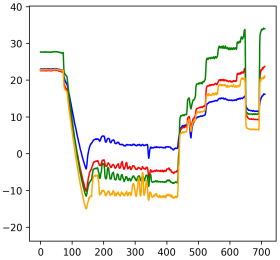
Backup

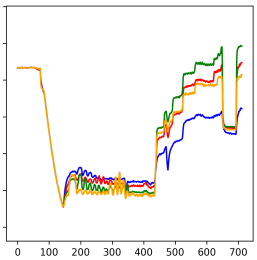
PXD FOS fibers

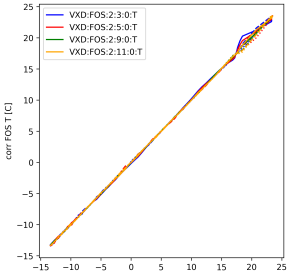
- New produced FOS fibers for PXD2 calibration issues
- Installed 3 FOS fibers from PXD1 + 1 new FOS fiber (2.9)
- Use cross-calibration for more reliable values
- Use working points at which all FOS fibers should have same temperature
  - After establishing dry volume
  - At room temperature
  - After cooled down when temperature stabilized (before PXD is powered)

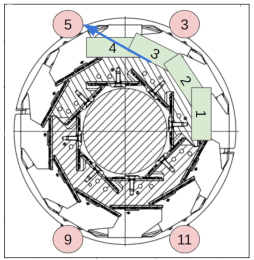




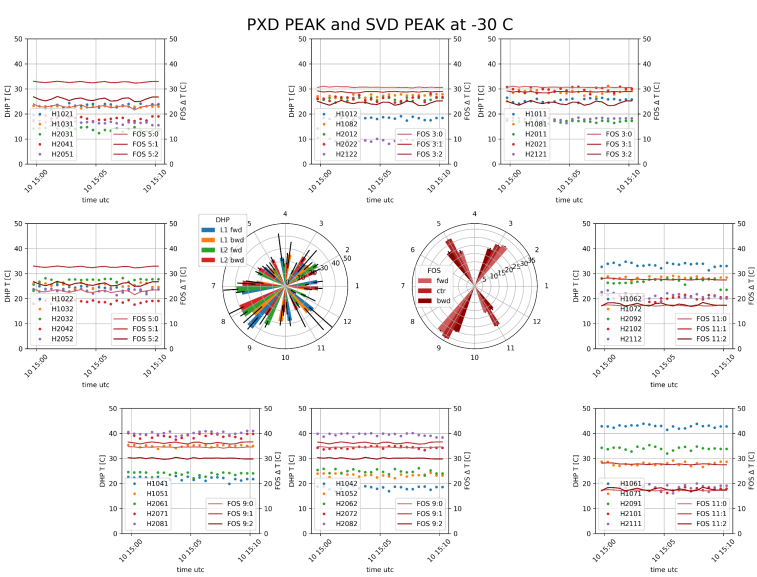




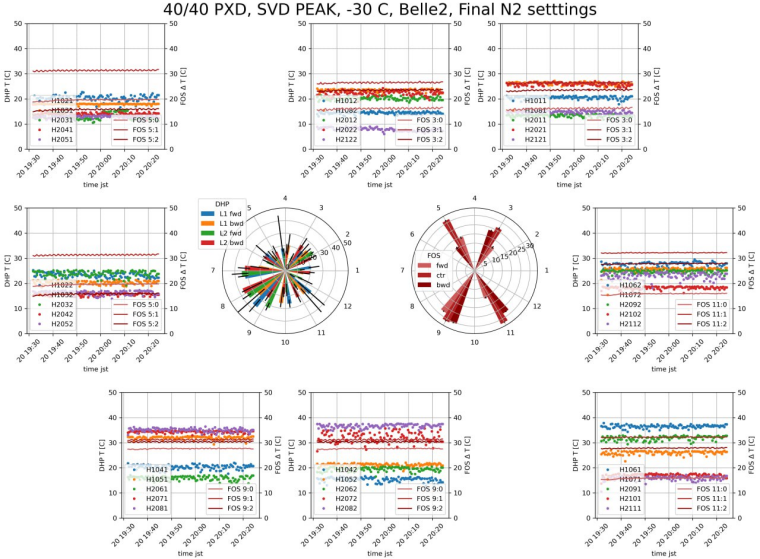




Temperature in B4



Temperature in Belle2

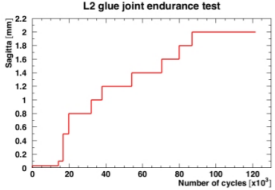


Bending studies

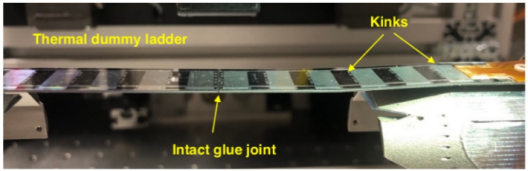
Thermal dummy L2 ladder bent with gradually increasing sagitta

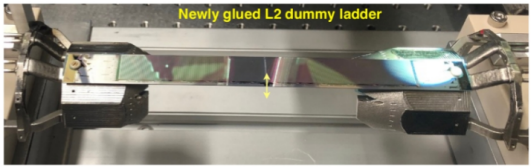
- $\sim$ 4500 cycles at Δ 0.9 mm
- $\sim$ 2500 cycles at Δ 1.1 mm
- >100 cycles at 1.8 mm
  -> ladder developed two kinks

$\rightarrow$ Thermal dummy ladder mechanically different
$\rightarrow$ Both kinks at resistor lines
Repeat with recently glued L2 dummy ladder



After more than two months with more than 90k cycles with sagitta >1mm $\rightarrow$ Ladder still intact





Raiding the Thermal Mock-up

- Dummy Si ladder with resistors for heating
  - 8.9 W the design power consumption
  - 8 W DHP/DCD

Thermal Impact of the Screw Torque

- Screwed Ladder to cooling block
  - 0.2 cNm → 1.4 cNm → 0.2 cNm
- IR camera:Temperature measurement of DHP/DCD area
  - 4 ROIs: 3 DHP/DCD, 1 glue joint
  - Kapton: emission 0.9
- Impact observed: < 2 °C