# Belle II Silicon Vertex Detector dry volume development for cooling test @ JPS 03/2017

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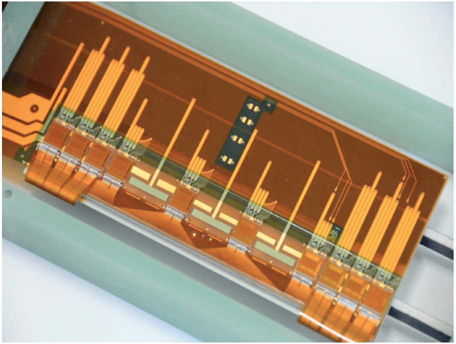
Belle II

# Outline

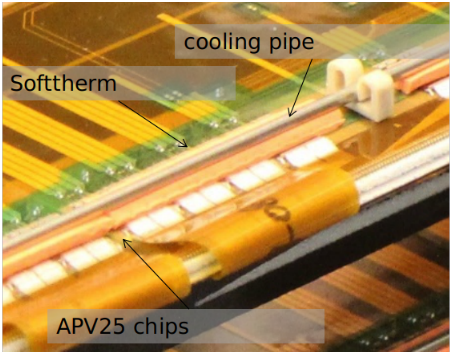
1. Assembly Procedure
2. Dry Volume
3. Dew Point Evolution
4. APV Inspection
5. Conclusion

# Analog Pipeline [Voltage Mode] in 0.25 $\mu$m silicon, APV25(CMOS technology)

James David George Leaver Blackett Laboratory Imperial College London - PhD Thesis 2005



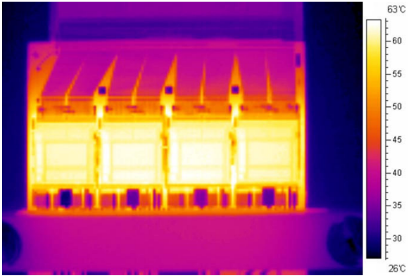
SVD group, KEK, 2011

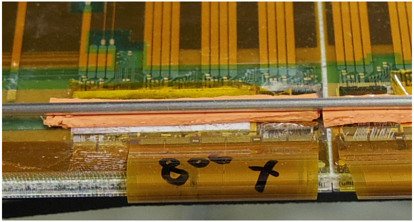



Katsuro-san's slide 19

# APV temperature measurement

APV25 without cooling pipes



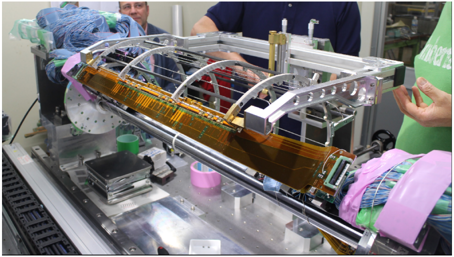



- APV generates heat during assembly DAQ
- CO2 cooling will be at **-20°C**
  - Chip on sensor
  - Cooling pipe on chip
- **Temperature Check**
- **Components Arrangement Check**

# Belle II SVD Assembly Procedure

1. Half of a SVD layer, tested independently, will be mounted
2. The cooling pipes are mounted after the half layer is set
3. A trial DAQ(Data Acquisition) with the APV chips will be started with the CO2 cooling system running
4. APV chip temperature check, so that each are distinguishable from the other

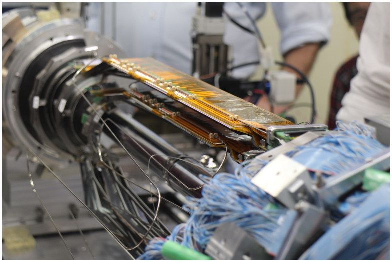
- the **environment** of the mounted half layer might damage the components **which need to be protected** from:
    - humidity
    - dust
    - vibrations



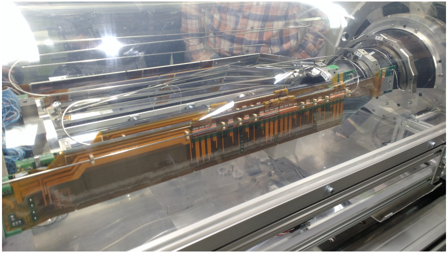
# Dry Volume Requirements

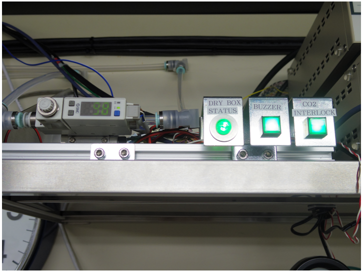
1. The Dry Volume will be set up to contain the SVD half layer completely, **isolating it** from the outside environment
2. Dry air will be pumped inside the dry volume
3. **Interlocked** Dew Point sensors with the cooling system guarantee that it will be started **only** when the Dew Point is lower than -40$^\circ C$

- Dry Volume requirements
  - it needs to be kept dry
  - **transparent** to **visible** and **infrared** radiation
  - compatible with a lot of cabling
  - mobile and settable



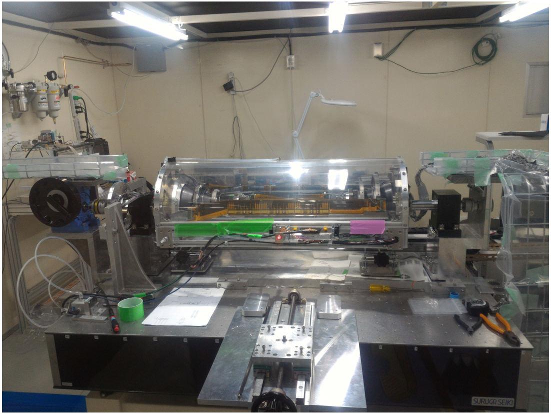
# Assembly completion requirements and difficulties






- 3 main requirements
  - Overpressure $> 0$ Pa
  - Dew Point $< -40°$C
  - Visible and Infrared Radiation Transparent walls
- Difficulties
  - More Cables = more leaking
  - more leaking $\rightarrow$ dew point reduction inefficiency
  - Sensor distribution
  - Thermal camera inaccuracy

# Dry Volume



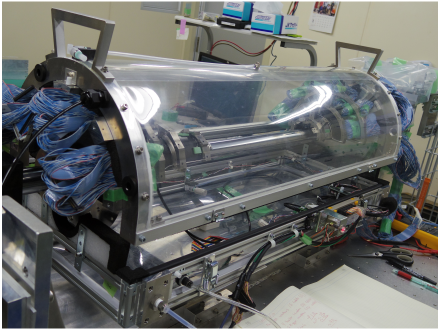

- Dry volume can protect SVD components from outside
- Control internal environment
- Must abort operation if needed in **emergency**
  - Dry air influx stop
  - Unexpected leak
  - Anything leading to an increase in the DP

# Dry Volume

## Description

- Divided into two modules, upper module is a **half cylinder** and the lower one, a **box**
- Receiving an influx of 50 or 100 $L/min$ of dry air through the lower module
- Vacuum pump sucking the air at -9$L/min$ through the top module
- Overpressure of at least 1 Pa measured
- Aluminum Frame, covered with viscoelastic foam to reduce air leakage
- GAT (旭化成製赤外線透過絶縁保護カバー) Plastic Walls so that the internal temperature of each origami module APV may be monitored with a Thermal camera

# Dry Volume Design and Monitoring Sensors

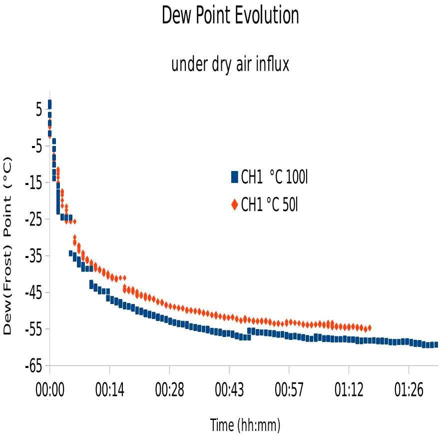


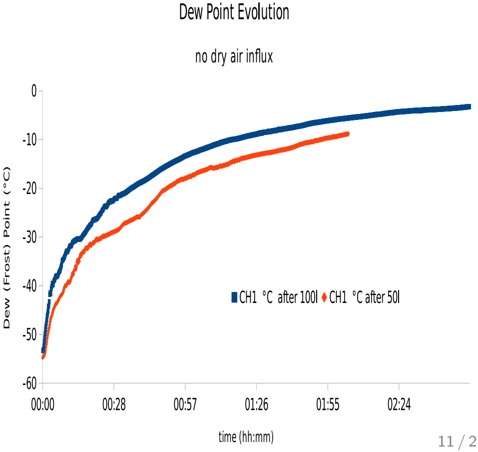
- To check humidity dispersion inside Dry Volume
- Sound and light alarms activation if -40°C DP threshold is crossed

Open air → Compressor → Dryer
**Dry Volume** ⟵ Filters ↩

- Vaisala DMT 143
- Orion MG40
- Honeywell HIH-4030/31
- Datalogger GRAPHTEC GL840
- Pressure Sensor MANOSTAR WO81
- $CO_2$ sensor TAND TR-76Ui

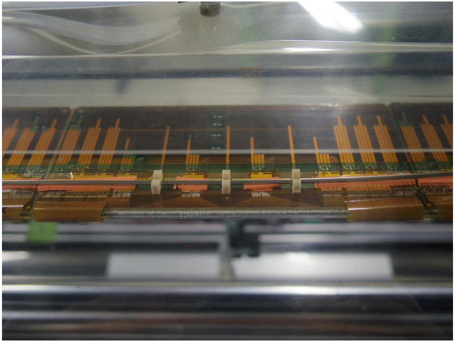
# Dew Point Evolution with all cabling “windows” filled (realistic leakage scenario)



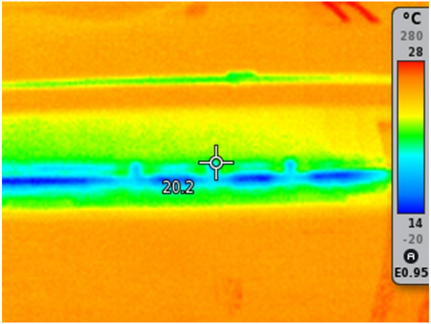



# Thermo Image

Camera picture of the ladder



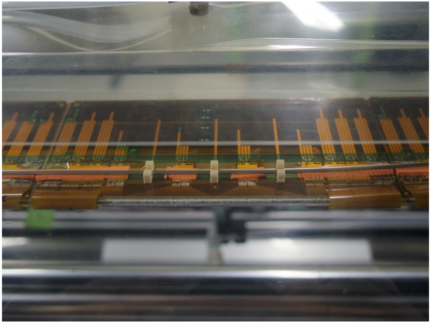
Thermal Camera picture

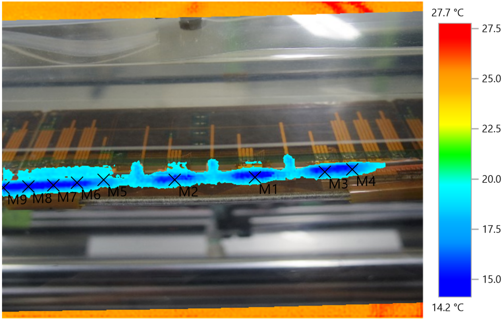



An overlay of both pictures make the APV distinction clearer and allow to check if the **cooling pipe is touching the chips** or **not**

# Thermo Picture and APV identification

**Not powered APVs with liquid CO2 at -8.6°C running in the cooling pipes, not in perfect contact with the APVs, and Frost Point lower than -50°C**






M1,2,3... are APV marks

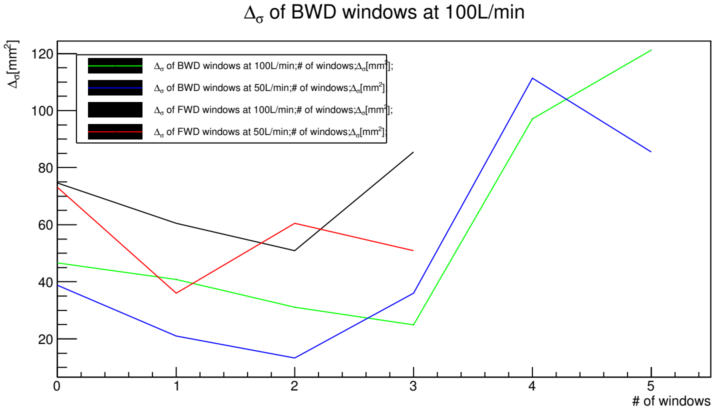
# Conclusion

- Dry Volume **works achieving significant overpressure and reducing the humidity**
- The humidity takes longer than 10min to penetrate the Dry volume,**ladders would be safe in the time need to abort** operations
- **APV identification** and **temperature monitoring** is **possible**

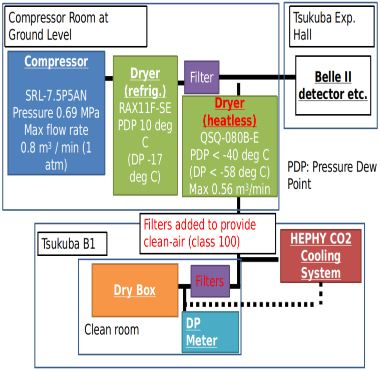
# Overpressure changes

Considering the cross section dependence of the measured overpressure as

$$S = \frac{Flow}{240} \frac{1}{\sqrt{\Delta P \times 0.1}}$$



# Dry Air Filters

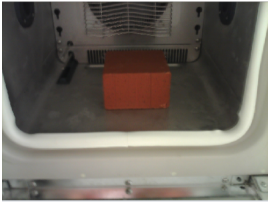



# Dry Air Filters

- Mist Filter (Orion MSF 200B)
- Vapor Filter (activated charcoal filter) (KSF200B)
- Final filter (OFF-050-04-A)
- 3 outlets: CO2 cooling, Dry Volume and others
- *no equipment using oil in air system*

# Measurement of a Red Brick, heated by an isolated oven, temperature using a thermocamera

Testo website, 2016



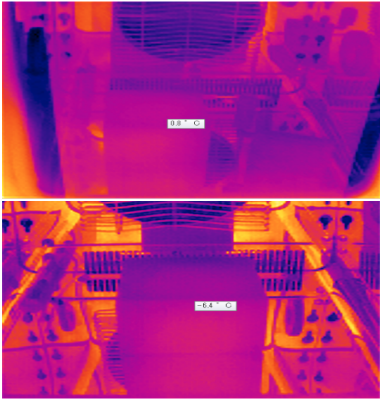
Yamato website, 2016

- Thermocamera Testo 870-2
- Red Brick with a Thermal Conductivity of 0.732 $\left[\frac{W}{mK}\right]$

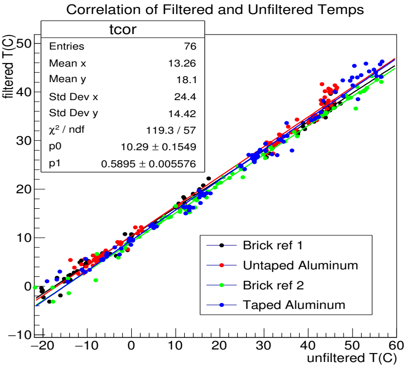
  THERMOPHYSICAL AND ELECTRONIC PROPERTIES INFORMATION ANALYSIS CENTER LAFAYETTE IN, 1971
- Yamato Constant Temperature and Humidity IW 242 Oven

# Thermo pictures and Filter effect

with filter



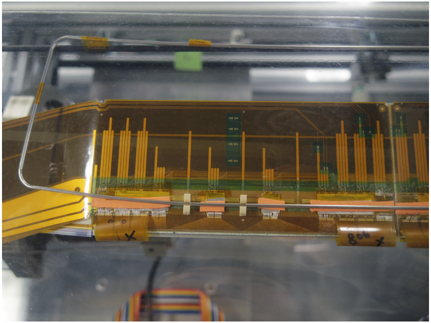

without filter

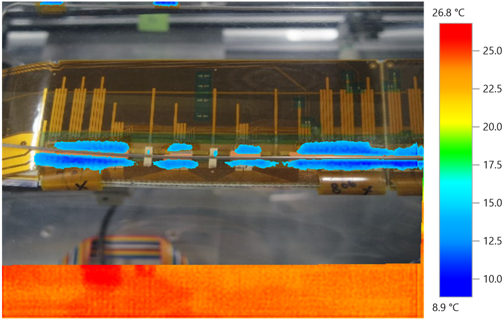



At higher temperatures the difference between measured T is about 10 C, as for lower than 0 C it is about -10 C

# Thermo Picture and APV identification 2

**Not powered APVs with liquid $CO_2$ at -12°C running in the cooling pipes and Frost Point lower than -50°C**





# CO2 cooling pipes contact with APV