Microchannel Cooling Characterization in VELO Detectors

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LHCb: An Overview

- Primary physics objective: CP violation characterization through heavy flavor decay
  - B meson decays
    - Branching fraction suppression
    - Rare decays
    - CP phase measurement
  - Linear design
  - Notable discoveries
    - Pentaquarks
    - Excited $\chi$ baryons
    - $B_s \rightarrow \mu^+\mu^-$ branching fraction
VELO Subdetector

• VELO – Vertex Locator
  • Tags primary decay vertices
  • Used to reconstruct primary decays before magnet

• Design/Requirements
  • Dynamic pixel detector
  • ~10 year lifespan
  • High bandwidth (~15 Gbit/s)

• Microchannel cooling
  • Liquid-vapor CO2 mixture
  • Substrate integration
    • ‘µ-channel’ principle
Production

1) Connector Quality Assessment
2) Planarity Measurements
3) Polishing/Cleaning
4) Metallization
Production

5) Pre-Tinning
6) Alignment and Soldering
7) Final Quality Assessment
Overall

• Detector Soldering
• Mitigating production slowdowns
  → Tight schedule
  → Varying/inconsistent problems
    > Offsite production
• Database management
  → Automate/organize uploads
Experiences

• Geneva:
  > Record Stores/Coffee Shops
  > Art Exhibitions

• Travel:
  > Rome
  > Annecy
  > Vienna
  > Montreux
  > Zermatt
  > Bern
  > Gruyères
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Backup
New module design

- Module foot (aluminium)
- GBTx (Transceiver)
- Legs (Carbon Fiber)
- Midplate
- Fluidic connector
- CO₂ capillary routing
- Hybrid (copper+kapton)
- Sensor bump-bonded to 3 ASICs (tile)
- Microchannel cooling substrate
- Beam

Cables and supports not shown!
Cooling safety system

Secondary Vacuum

“O” bent capillaries to absorb the motion of the detector

Module

Positronic connector

Vacuum feedthrough board

Isolation Vacuum (Cooling safety system)
CO2 Enthalpy
Full Soldering Process

• → Chips delivered from NIKHEF
  • 1) Detape/separate substrates and PT chips
  • 2) Pressure test substrate samples
  • 3) Substrate planarity measurement
  • 4) Substrate visual inspection
  • A. Cleaning/recleaning/investigation
  • 5) Storage

• → Connectors delivered from Oxford
  • 1) Visual inspection under microscope
  • 2) Polishing
  • 3) Visual inspection
  • 4) Grinding
  • 5) Visual inspection
  • 6) Metallization
  • 7) Planarity measurement
  • 8) Visual inspection
  • 9) Cleaning
  • 10) Visual inspection
  • 11) Pre-tinning
  • 12) Visual inspection
  • A. Reflow as necessary
  • 13) Alignment
  • 14) Visual inspection/confirmation of alignment
  • 15) Soldering
  • 16) X-ray tomography
  • 17) Pressure test
  • 18) Helium leak test
  • 19) Final visual check
  • 20) Packing