

# Cooling

## 7.4: EXTREME ENVIRONMENT AND LONGEVITY

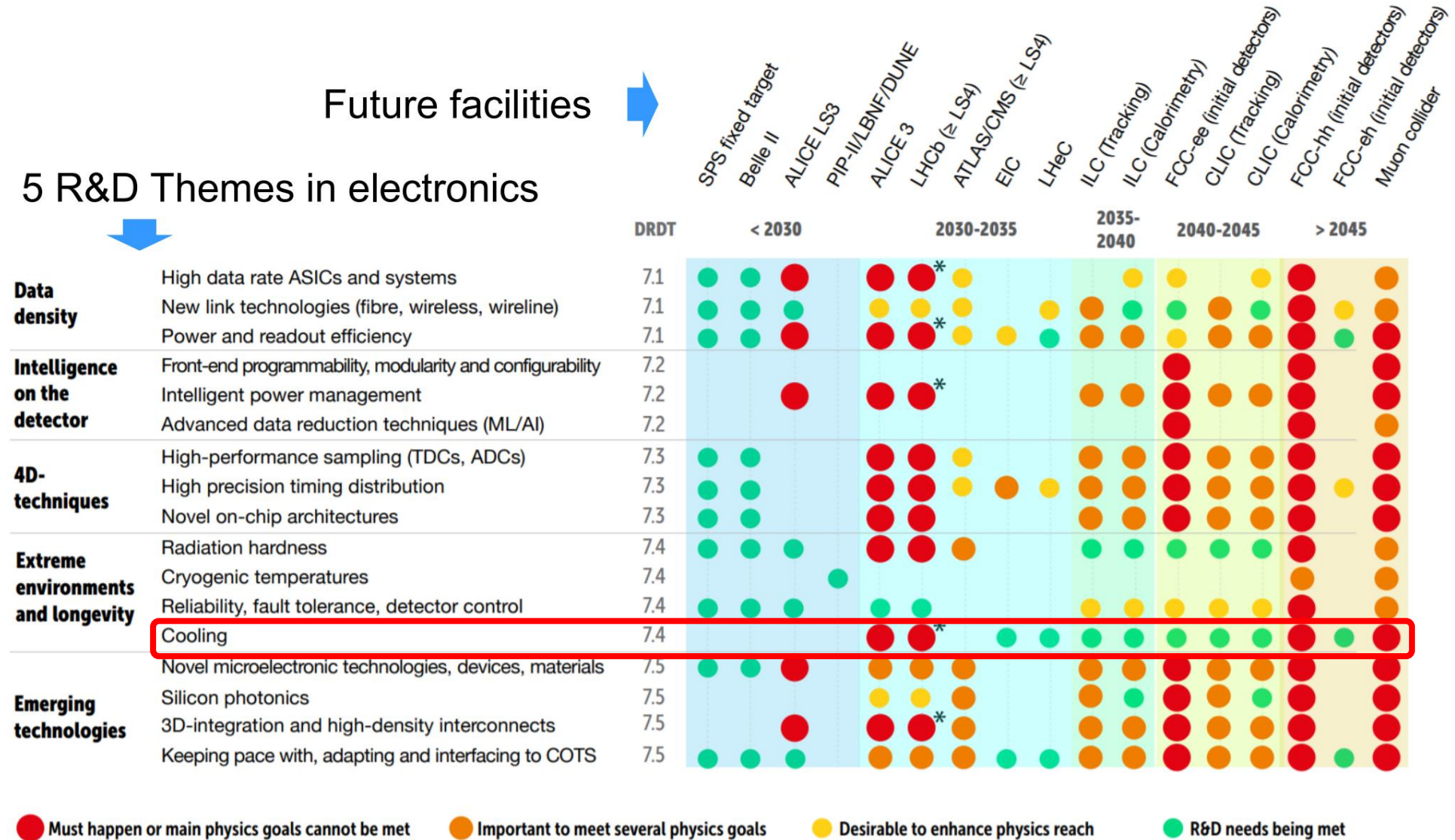
IMPLEMENTING DRD7:

AN R&D COLLABORATION ON ELECTRONICS AND ON-DETECTOR PROCESSING

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## Future facilities

## 5 R&D Themes in electronics



● Must happen or main physics goals cannot be met    ● Important to meet several physics goals    ● Desirable to enhance physics reach    ● R&D needs being met

\* LHCb Velo

# Cooling

Vacuum

Operating Temperature

Material Budget

Power density

Thermal figure of merit

Integration

Area/Cost

### NA62 GTK

[Bennett, Sophia Elizabeth \(CERN\)](#) [arxiv](#)

The diagram shows a cross-section of the cooling structure with layers: KOVAR, NiAu (~3 μm), SnPb, TiNiAu (~1 μm), and Silicon. Labels include Capillaries, Cooling Plate, Connector, and Manifold.

0.5% X0, 200 × 70 μm<sup>2</sup> micro-channels, C6F14 liquid coolant, 0.32 W/cm<sup>2</sup> in the pixel matrix, Sensor < 5C, Vacuum

### LHCb VELO Upgrade

[Brice, Maximilien; Ordan, Julien Marius \(CERN\)](#) [arxiv](#)

The diagram shows a cross-section of the sensor stack with layers: Silicon, PCB, bumps, adhesive, copper, and coolant. Dimensions include 5 mm, 200 μm, 500 μm, 700 μm, and 200 μm. Labels include Sensor, Hybrid with 4 copper layers (12:35:25:35 μm), and VeloPix.

0.4-0.9% X0 (innermost region)  
ASIC/Sensor overhangs by 5 mm,  
Microchannels 120x200 μm<sup>2</sup>,  
CO2 bi-phase, 1W/cm<sup>2</sup>,  
Sensor < -20C, vacuum

### Mu3e

[SciPost Phys. Proc. 5, 020 \(2021\)](#)

0.1% X0, Helium gas cooling, 0.4W/cm<sup>2</sup>, Temperature < 70C

The diagram shows a cross-section of the sensor assembly with layers: MuPix sensor 50 μm, HDI ~100 μm, SpTA-bonds, polyimide 25 μm, and MuPix periphery. A 4 mm dimension is also indicated.

### LHCb Mighty Tracker (2032)

[FTDR](#)

Mighty Tracker = Silicon + Scintillating fibre

Upgrade 1b (1080mm x 600 mm), Module (528 mm x 200 mm), Upgrade 2, Geometry 2-3-4-5-5-4-3-2

18m<sup>2</sup>, 1-2% X0, Kapton tubes, Liquid cooling (Novec?), 0.3W/cm<sup>2</sup>, Temperature ≤ 0C

The diagram shows a cross-section of the detector stack with layers: Cooling tube, Service Hybrid, Wire bonds, Flex tape, Silicon sensor, Carbon Sheet, and Carbon foam.

## Remarks

- On the coolant side
  - CO<sub>2</sub> has an temperature operational limit ( -47C cooling plant [ATLAS Baby demo](#), solidification at -56C)
  - New R&D will be required to push this limits observing the environmental restrictions ([Krypton Cooling](#))
- **No single solution for the cooling structure nor coolant**
- How to narrow down to fewer options?
  - Please fill this quick survey: [here](#)
  - Feel free also to contact the section 7.4 conveners if you have suggestions/comments
- Invited talk: “**On-detector cooling systems based on low-mass carbon dioxide evaporators**” by Desiree Hellenschmidt