

Gaseous Helium Cooling of a Thin Silicon Pixel Detector for the Mu3e Experiment

Adrian Herkert

on behalf of the Mu3e collaboration

Institute of Physics
Heidelberg University

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The Mu3e Experiment

Search for the decay $\mu^+ \rightarrow e^+ e^- e^+$



Goal:

- Sensitivity for the branching ratio of 10^{-16}

Requirements:

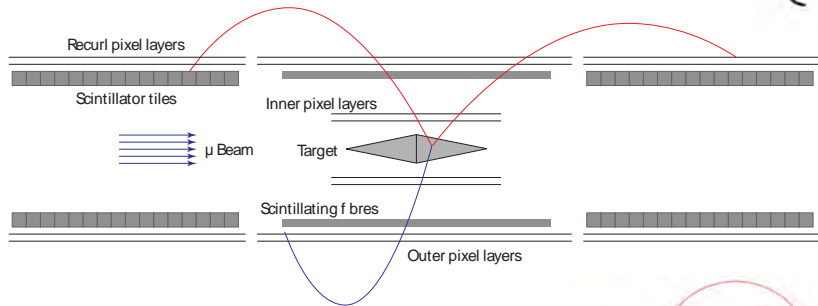
- High muon decay rates
- High momentum, vertex, and time resolution of the tracking detector

Met by:

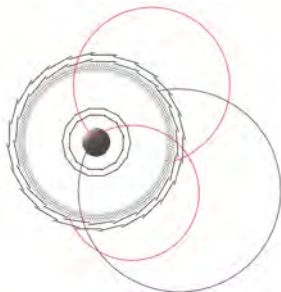
- Low material budget in the acceptance region
- Use of HV-MAPS
- Additional timing detectors

The Mu3e Experiment

Detector Concept

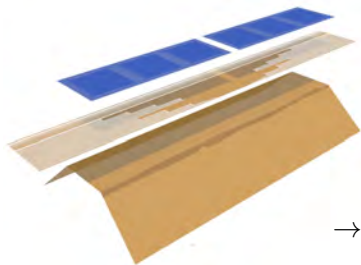


- $B = 1\text{ T}$
- Pixel detector:
4 cylindrical layers of HV-MAPS
- Timing detectors:
 - Scintillating fibres ($\sigma_t < 1\text{ ns}$)
 - Scintillating tiles ($\sigma_t \sim 100\text{ ps}$)



The Pixel Tracker

Optimized for Low Material Budget



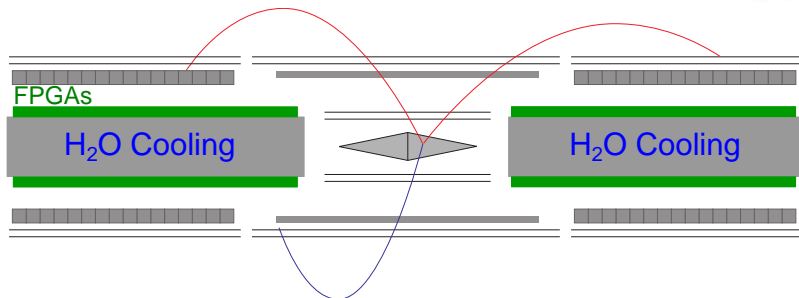
- HV-MAPS
 - $50\ \mu\text{m}$
- Flexprint
 - $25\ \mu\text{m}$ Kapton
 - $25\ \mu\text{m}$ aluminum traces
- Support structure
 - $25\ \mu\text{m}$ Kapton

$$\rightarrow \frac{x}{X_0} \approx 0.1\%$$





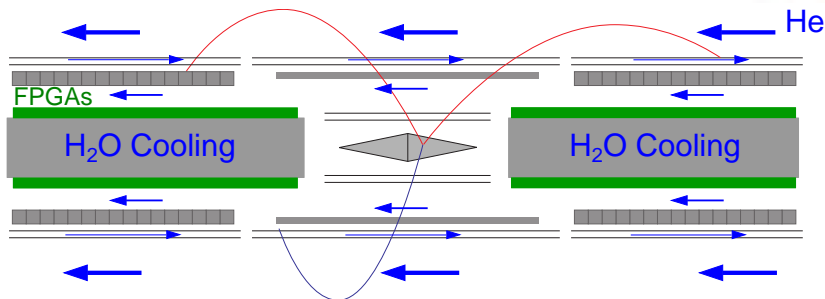
Cooling Concept



Inactive region:

- Water cooling system integrated in beampipe

Cooling Concept



Inactive region:

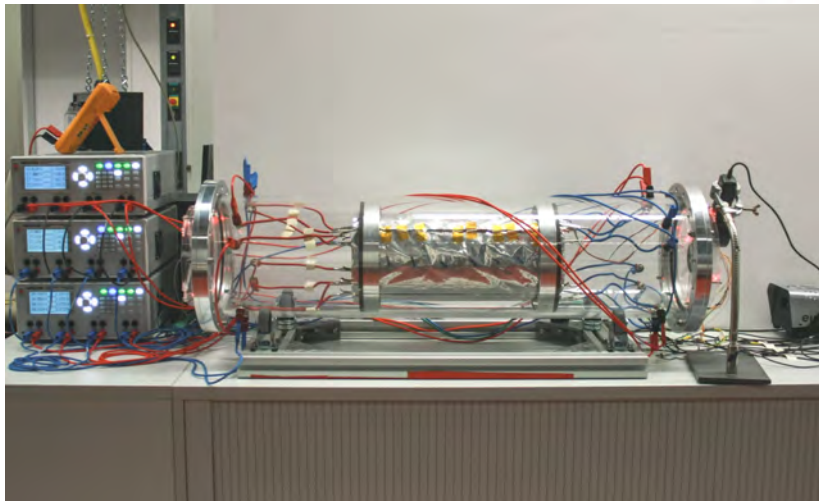
- Water cooling system integrated in beampipe

Acceptance region:

- Gaseous helium cooling (global + local)

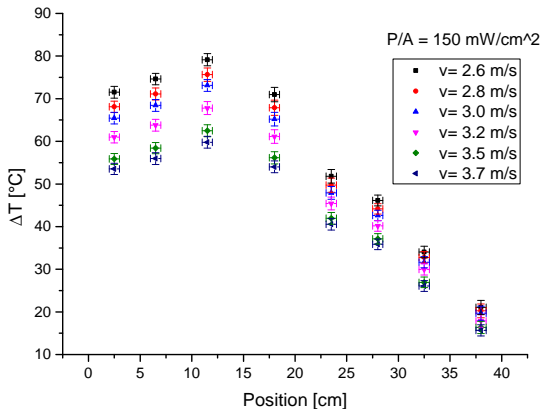
Experimental Cooling Tests

Cooling of One Detector Station with Global Gas Flow



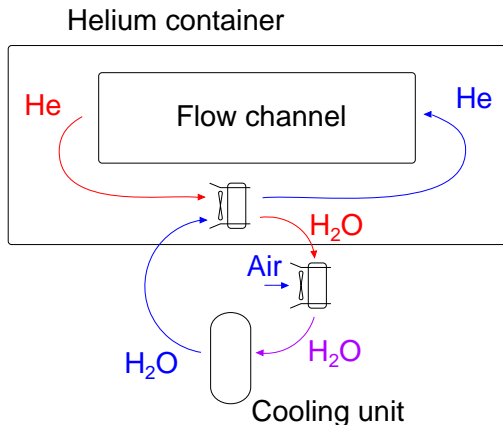
Experimental Cooling Tests

Cooling of One Detector Station with Global Air Flow



Experimental Cooling Tests

Cooling of One Detector Station with Global Helium Flow

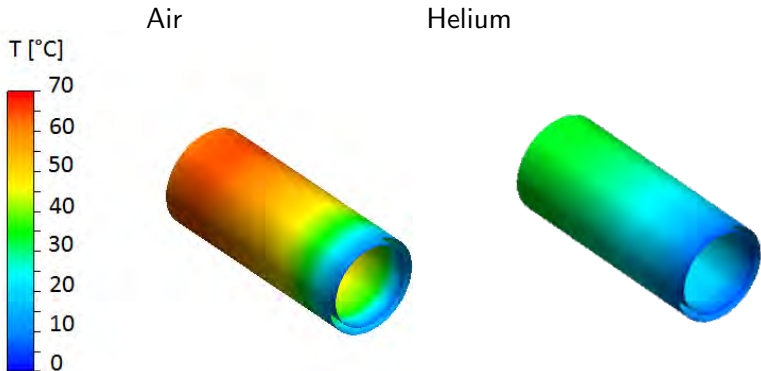


CFD Simulations

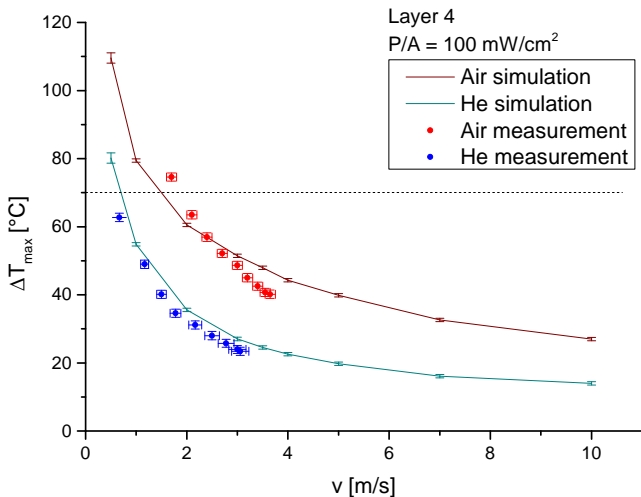


Cooling of One Detector Station with Global Gas Flow

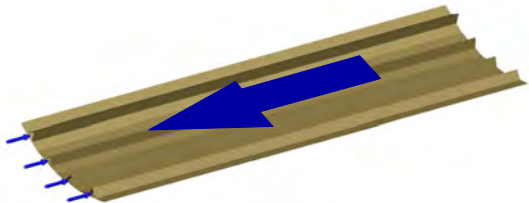
- $P/A = 150 \text{ mW/cm}^2$
- $v = 3 \text{ m/s}$



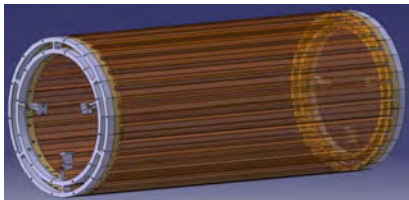
Cooling of One Detector Station with Global Gas Flow - Summary



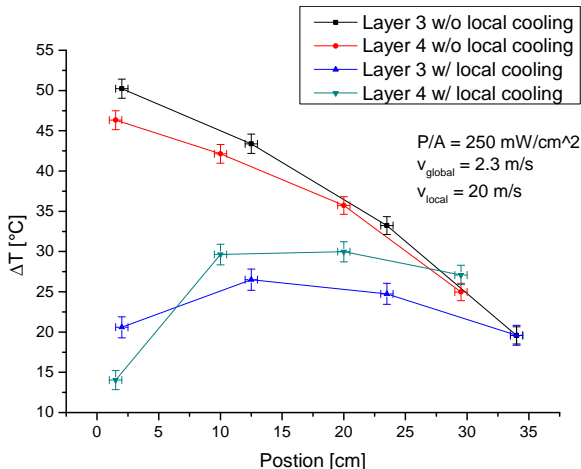
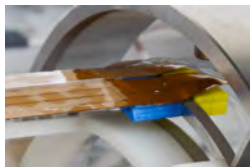
Local Cooling System



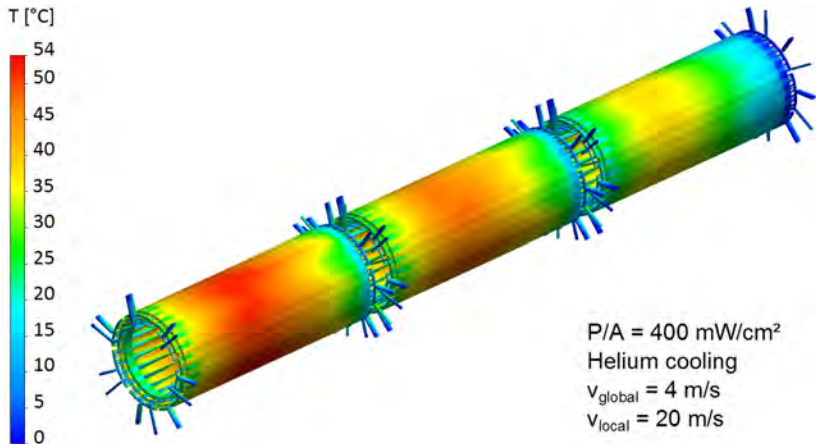
- Cooling from both sides simultaneously
- Supplying helium directly to pixel layers of each individual detector station



Local Cooling Tests with Helium



Further Simulations



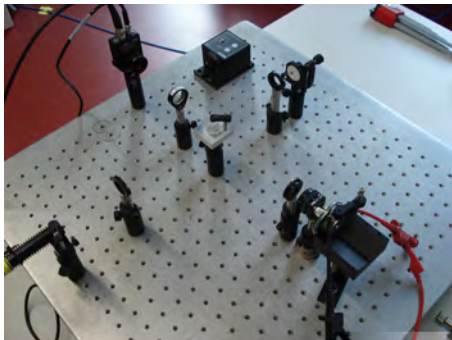
Summary

- The proposed cooling concept seems to be suitable for the Mu3e experiment



Outlook

- Simulation of the cooling of the full Mu3e detector
- Investigation of potential flow induced vibrations



x/X_0 for Different Components of One Tracker Layer



Component	Thickness [μm]	x/X_0 [%]
Support structure	25	0.018
Flex-print	25	0.018
Aluminum traces	12	0.013
HV-MAPS	50	0.053
Adhesive	10	0.003
Full layer	122	0.105