Mechanics and Cooling of the Mu3e Detector

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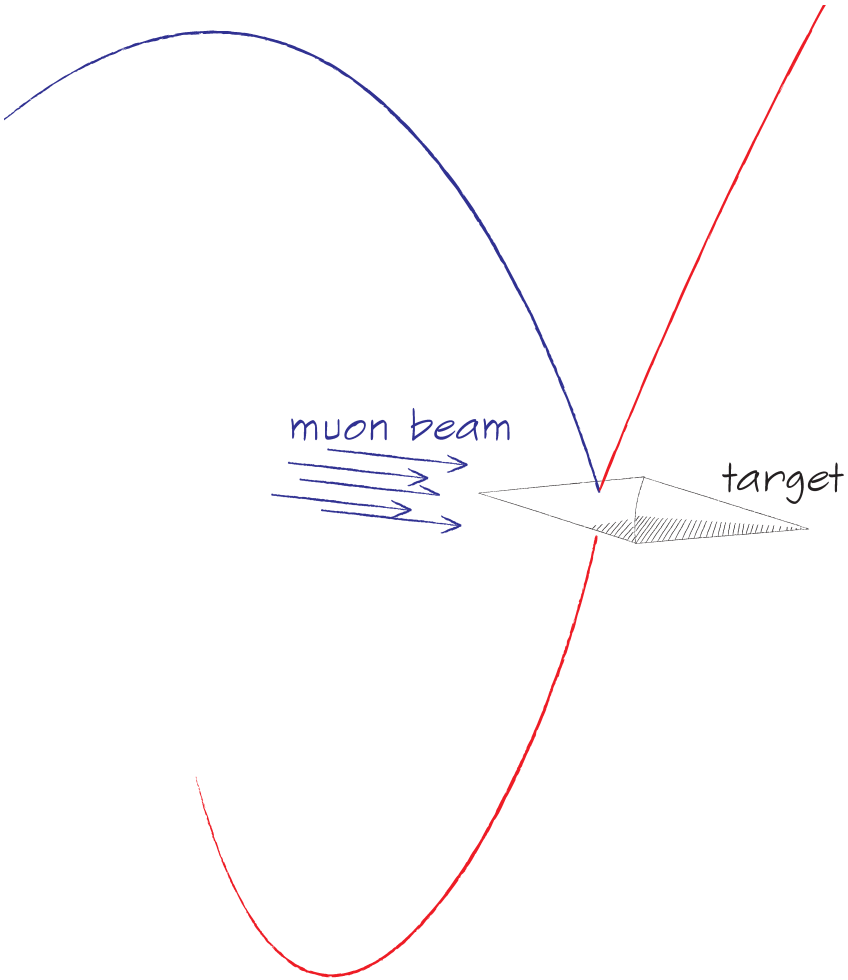
The Mu3e Experiment

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



B = 1 T

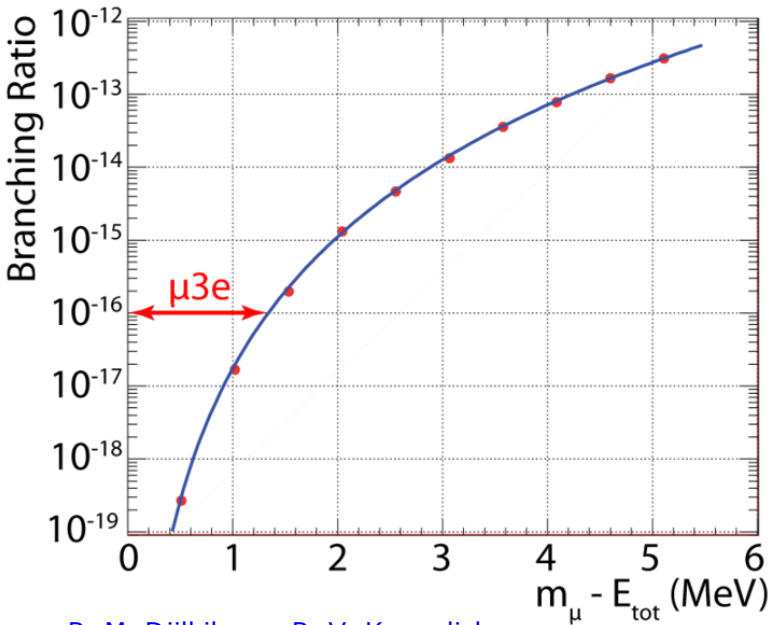
- Standard Model:
  BR $< 10^{-54}$
- Current upper BR limit:
  1.0×10^{-12} at 90 % CL
  (SINDRUM, 1988)

  U. Bellgardt et al., Nucl. Phys. B 299 1, 1988
- Mu3e sensitivity goal:
  1 in 10^{16} μ-decays
- μ-rate:
  $10^7 - 10^9 \, \frac{1}{\mathrm{s}}$

Backgrounds

Internal Conversion

- $\mu^+ \to e^+ e^- e^+ \nu_e \overline{\nu}_\mu$

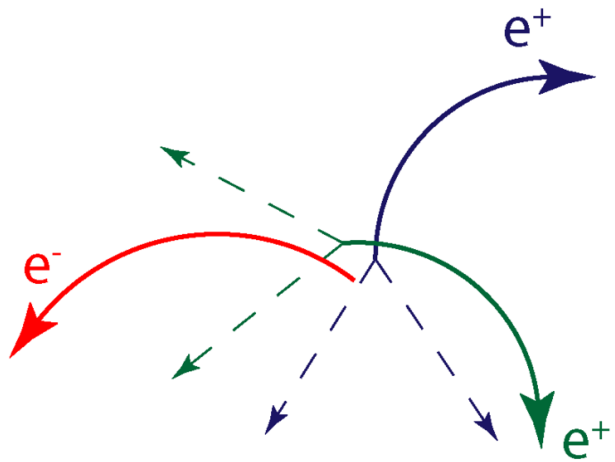


R. M. Djilkibaev, R. V. Konoplich,
Phys. Rev. D 79, 073004, 2009

→ High momentum resolution needed

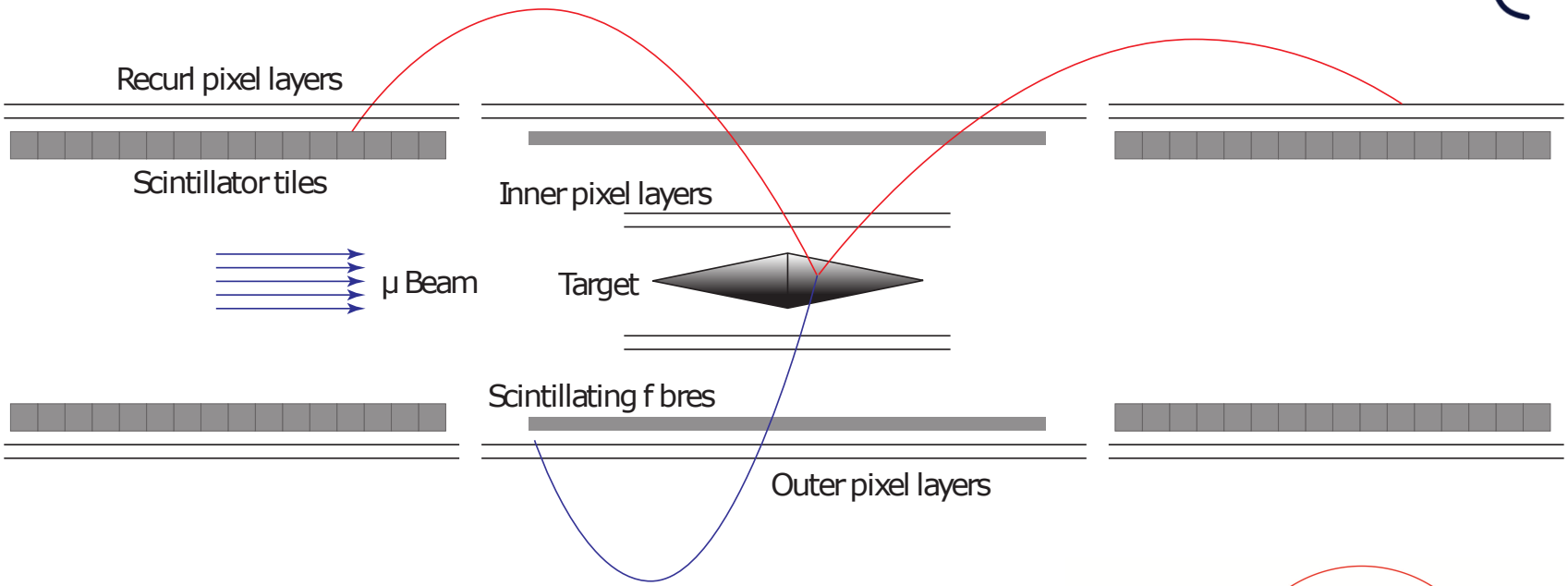
Accidentals

- Ordinary Michel decays plus additional e^-

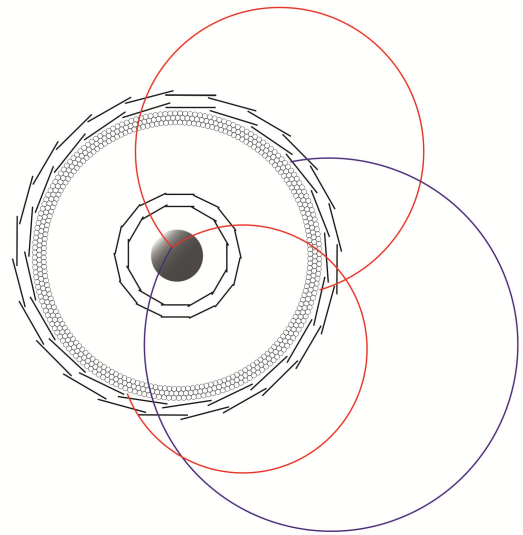


→ High momentum, time, and vertex resolution needed

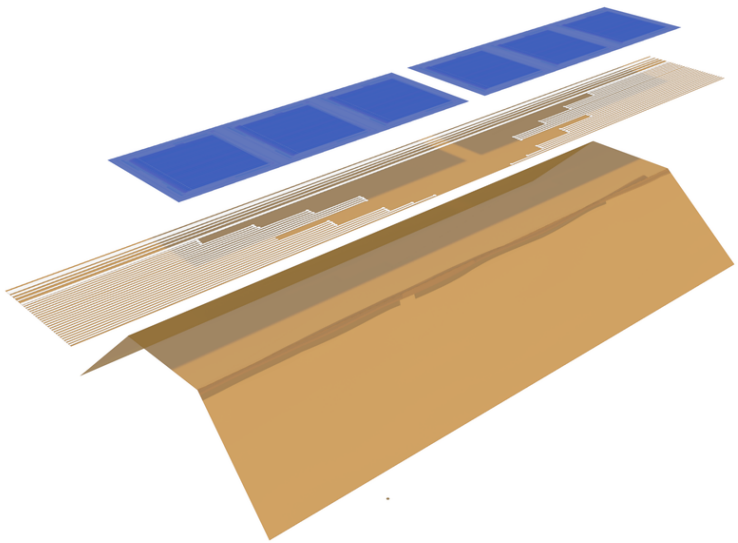
Detector Design for Minimum Material Budget



- Pixel tracker: 4 barrels of thin pixel sensors
- Timing detectors:
  - Fibre tracker inside central detector
  - Scintillating tiles inside recurl stations
- 1 T solenoid



Pixel Tracker Mechanics

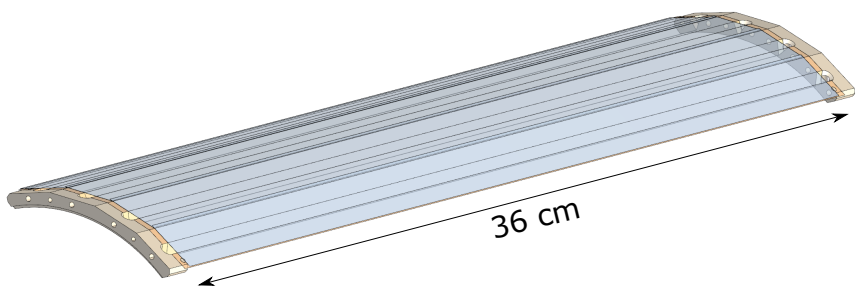


- HV-MAPS
  - can be read out fast
  - can be thinned to 50 μm

L. Huth, T99.5

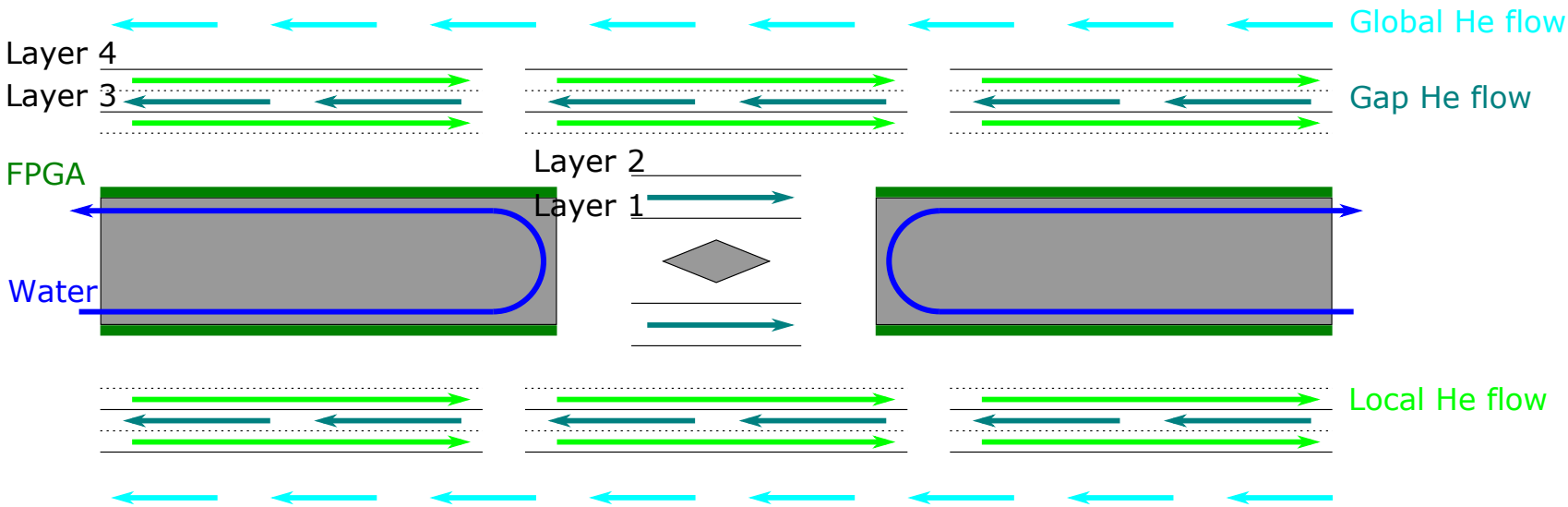
- Flexprint
- Kapton support structure
  - 25 μm thin

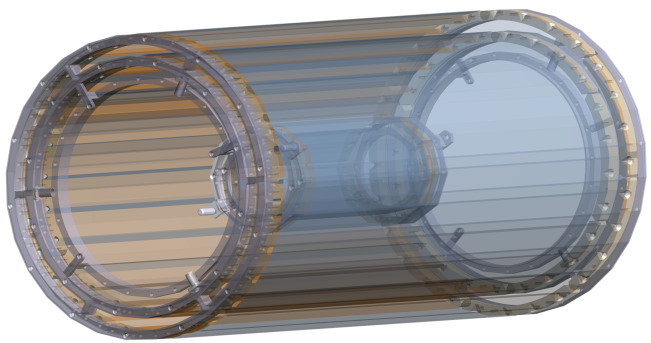
$\rightarrow x/X_0 \approx 0.1\,\%$



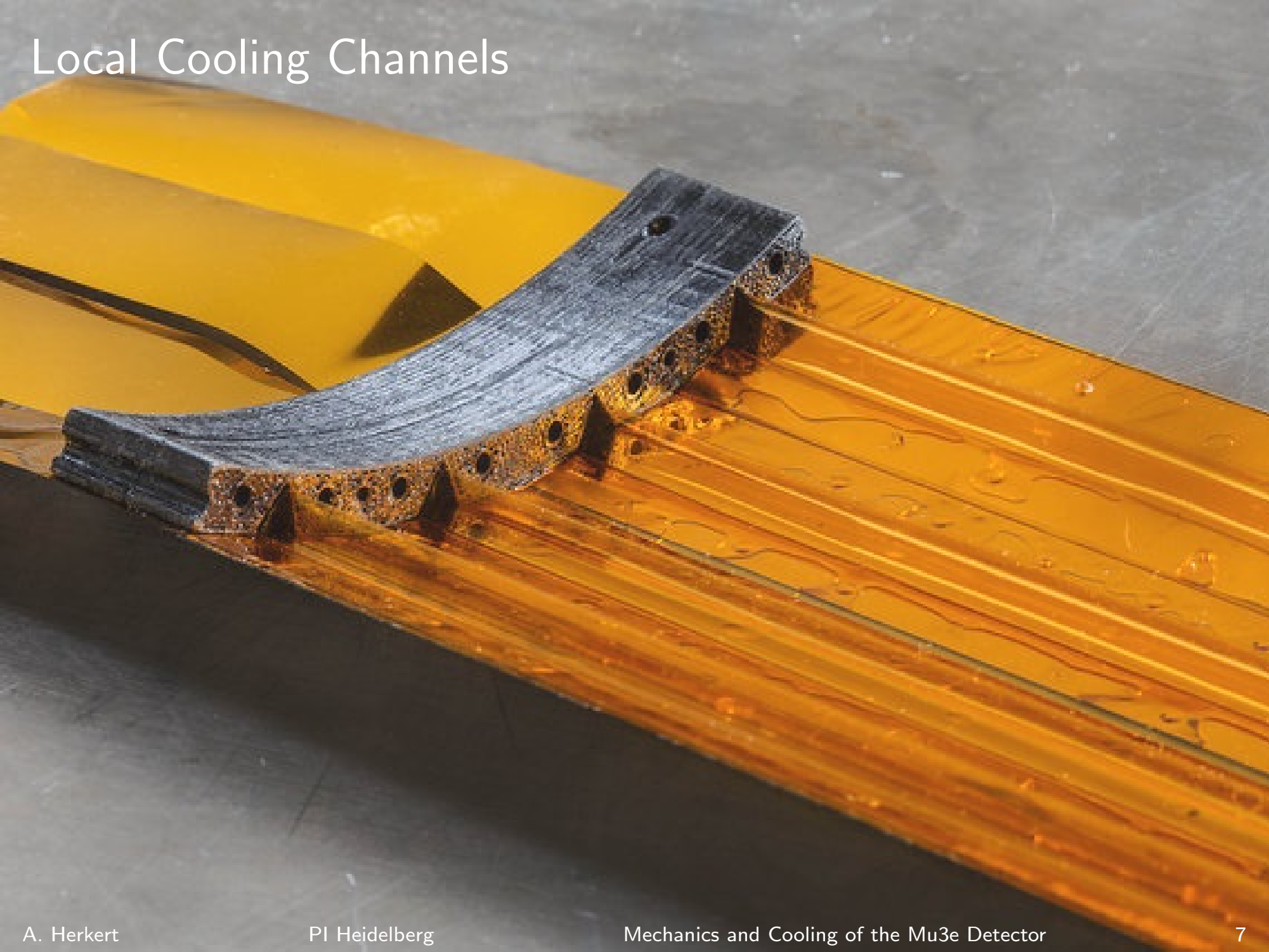
Cooling Concept

Goal: $T_{\text{HV-MAPS}} < 70\,^{\circ}\text{C}$



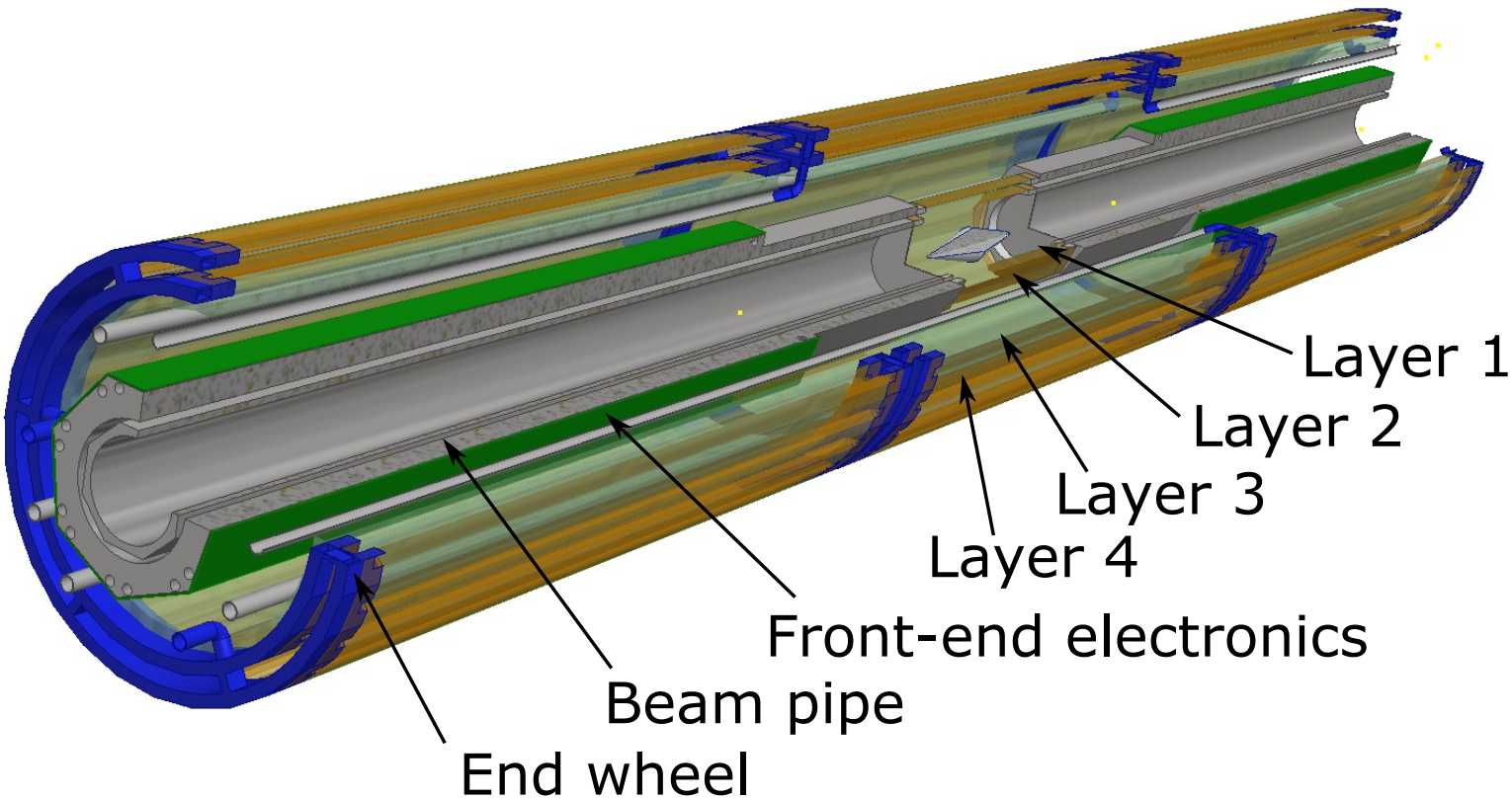


Local Cooling Channels



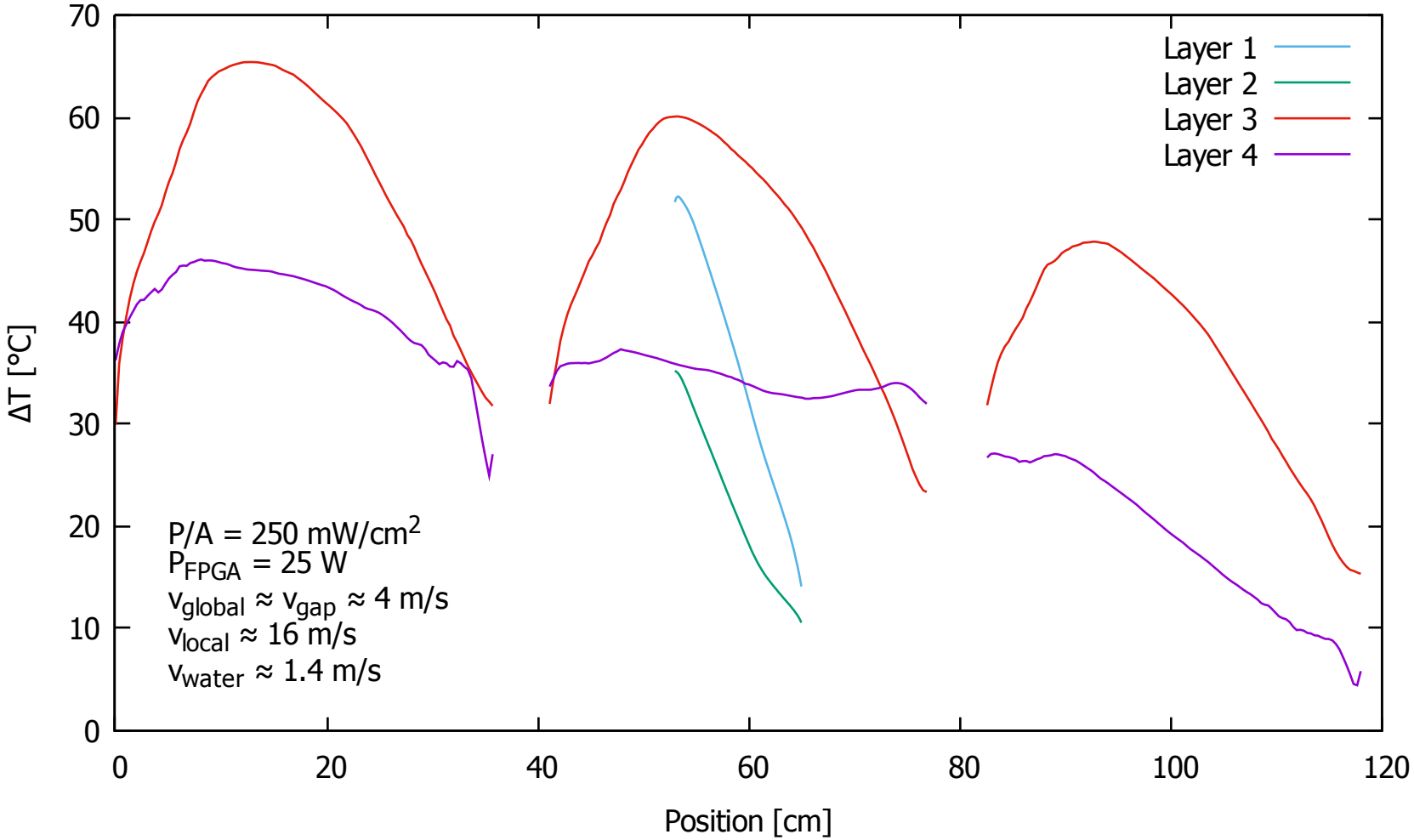
CFD Simulations of the Cooling System

Detector Model



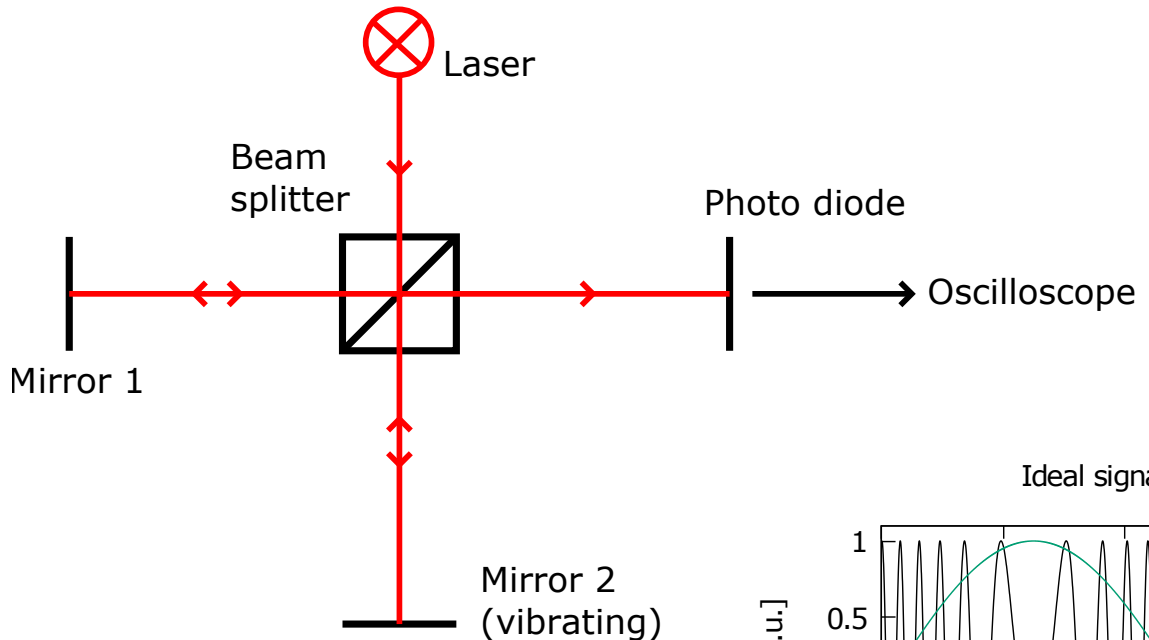
CFD Simulations of the Cooling System

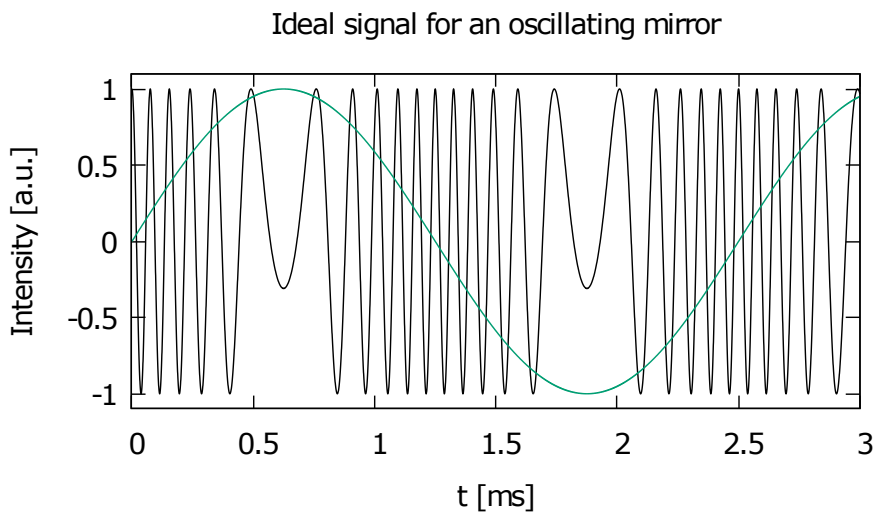
Results



Measurement of Flow-induced Vibrations

Michelson Interferometer





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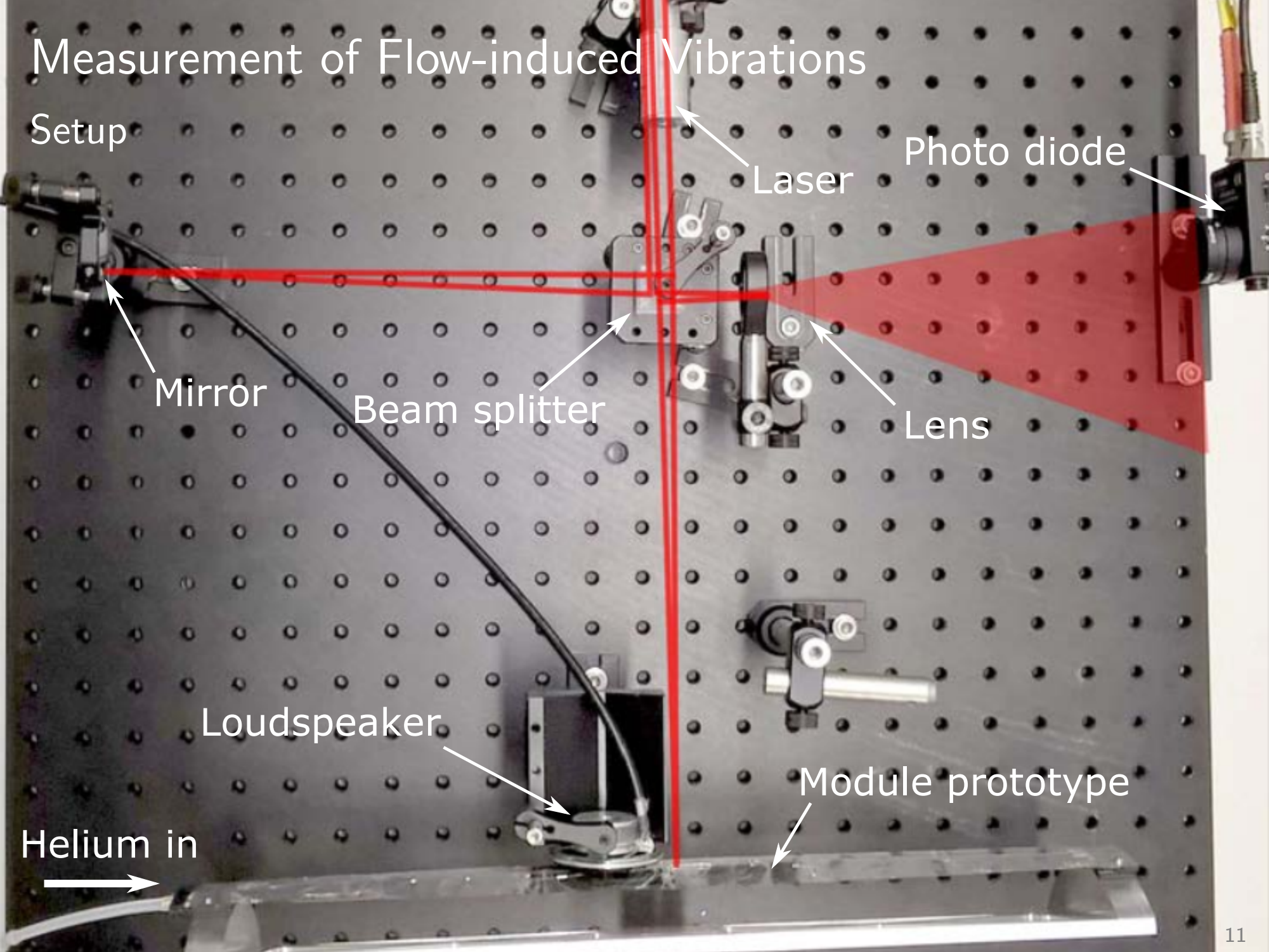


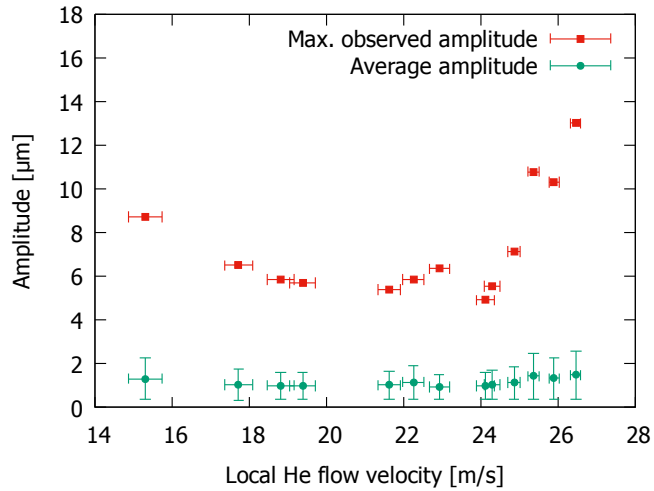
Measurement of Flow-induced Vibrations

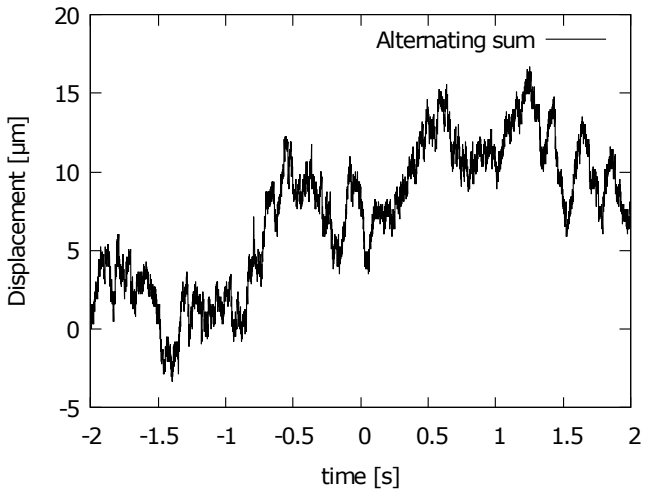
Results

Superpositions?

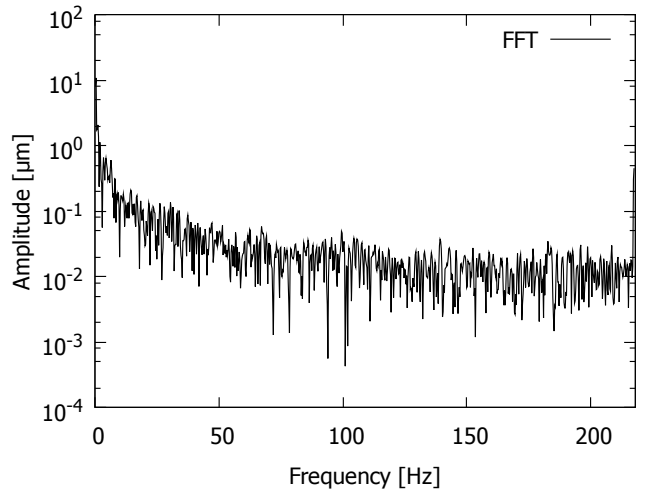
$\rightarrow$ Alternating sum

$$\sum_n (-1)^n x_n$$





FFT



Summary

- Minimum material cooling system was designed
- CFD simulations give promising results
- Flow-induced vibrations were measured to be of neglectable size

Outlook

- Lab tests of helium cooling of layers 1 & 2 are planned
- Modifications of interferometer setup are planned for more reliable results