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# Vertexing at the LHCb Upgrade(s)

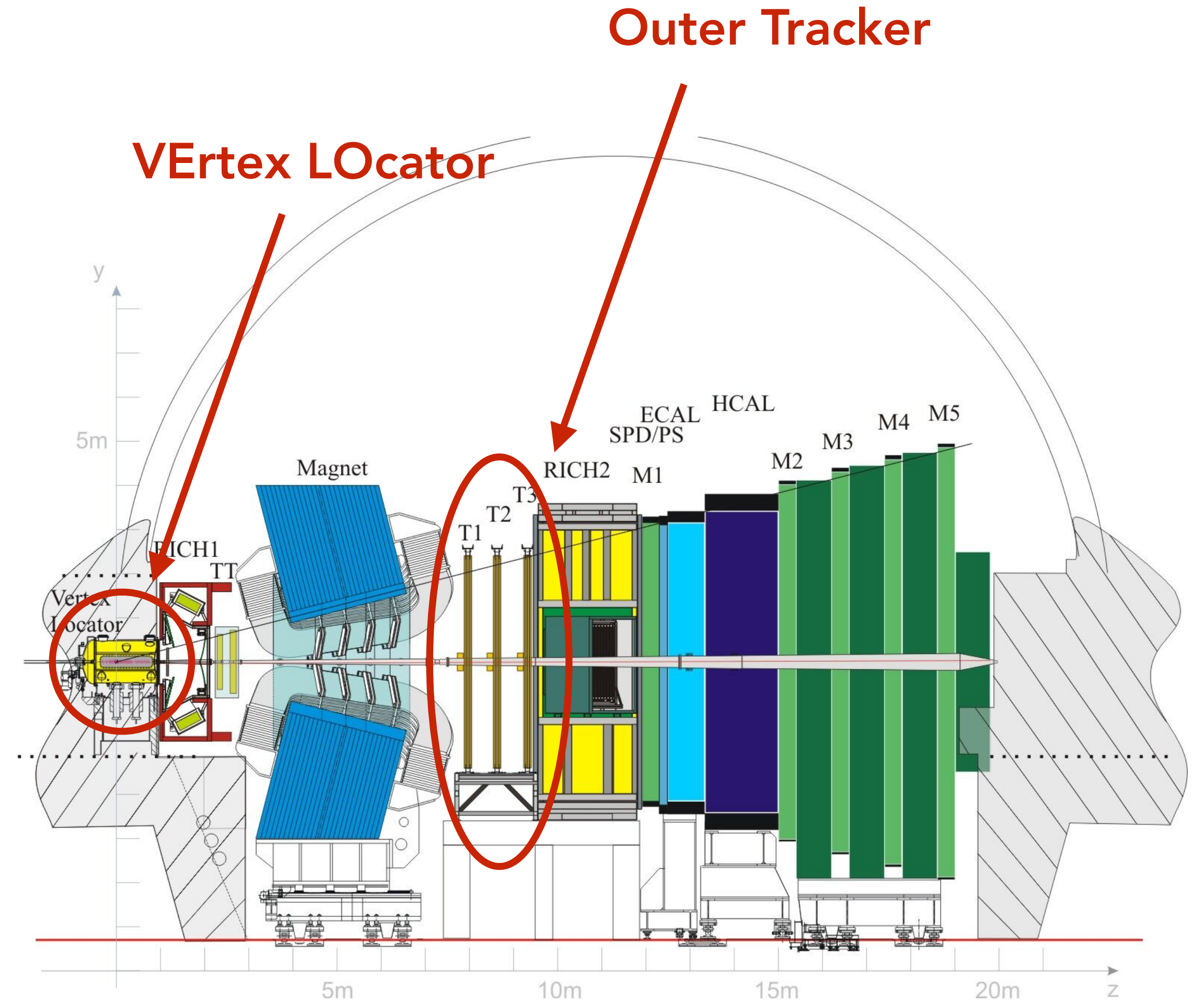
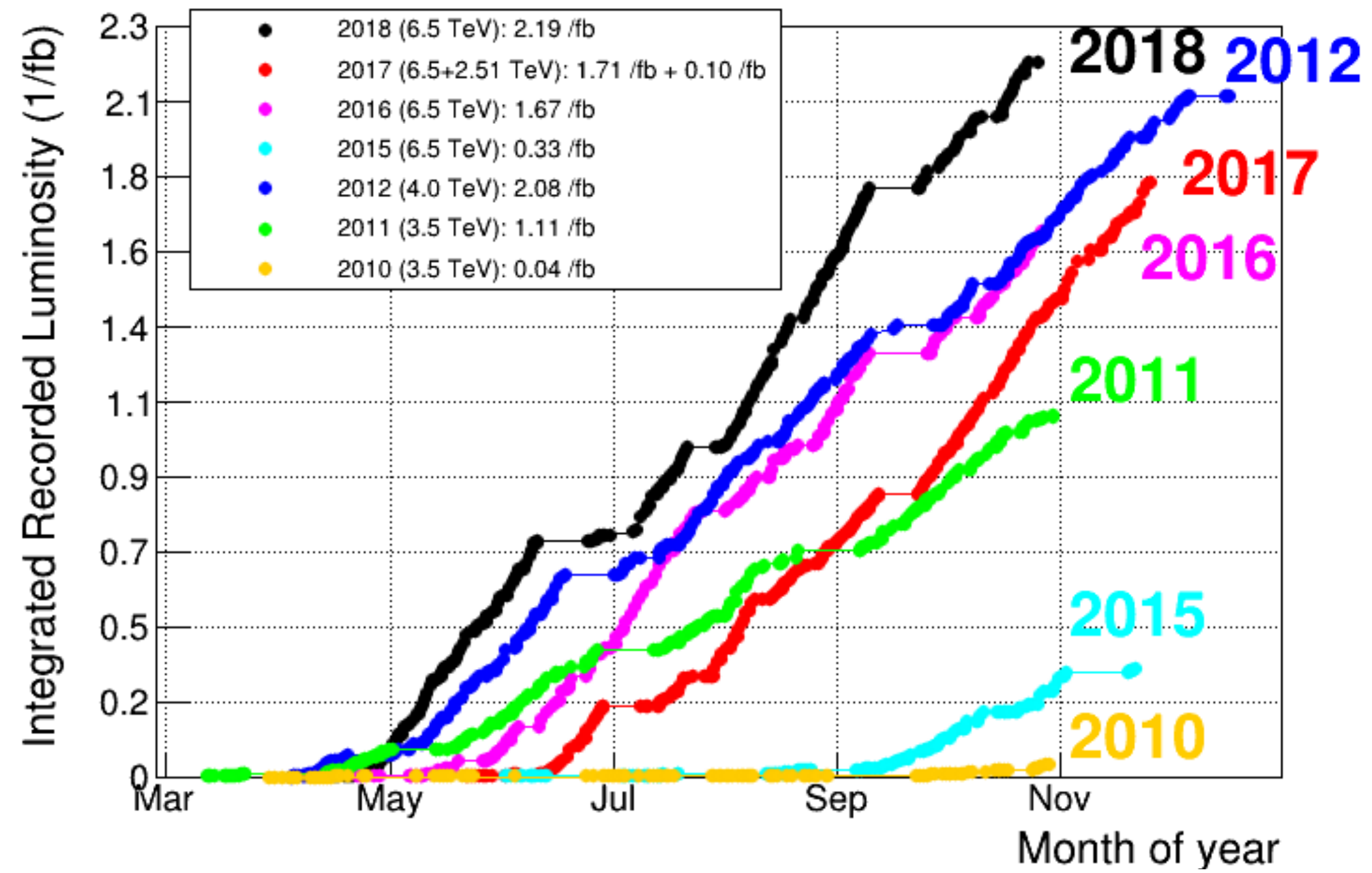
The prose and cons...

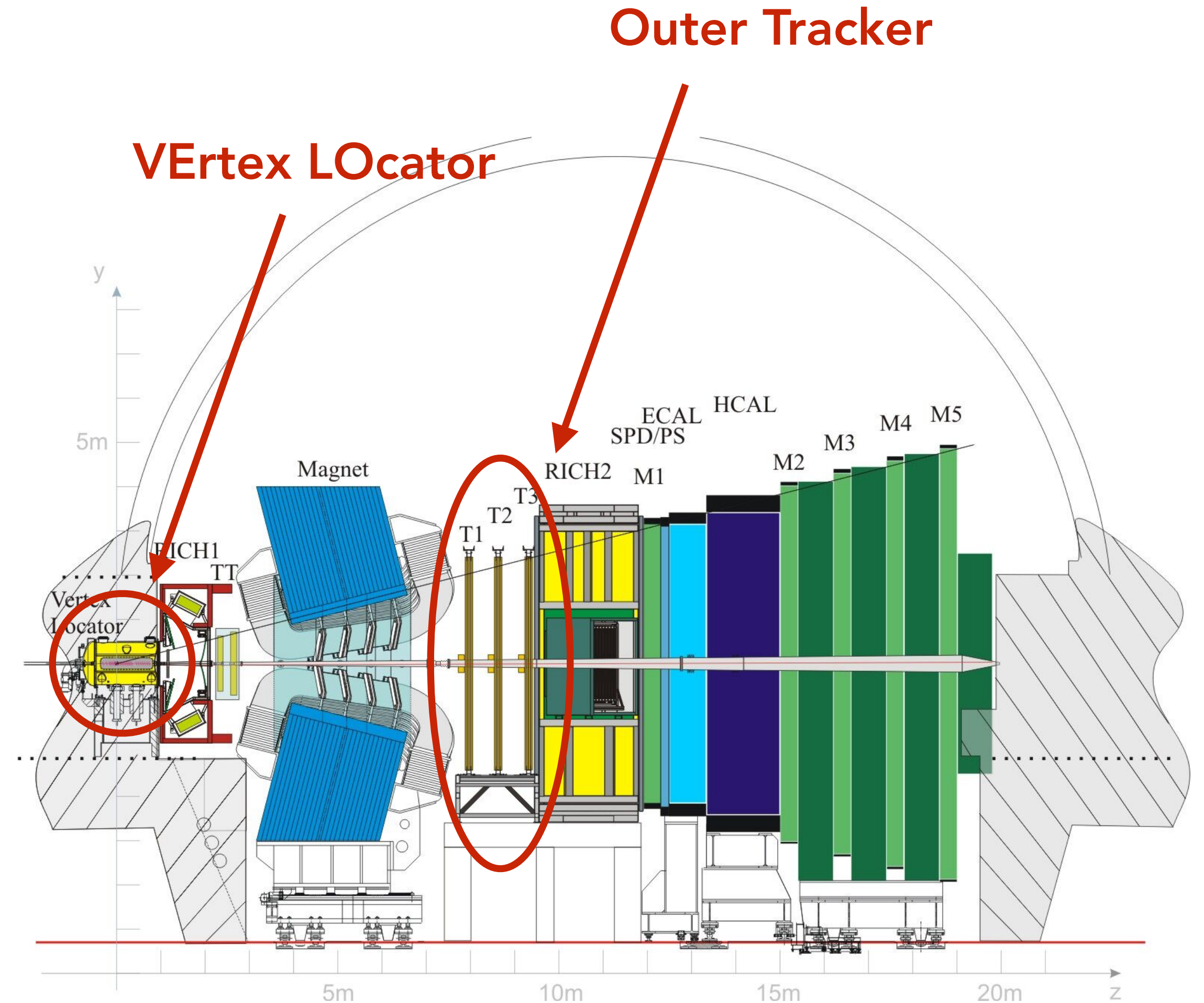
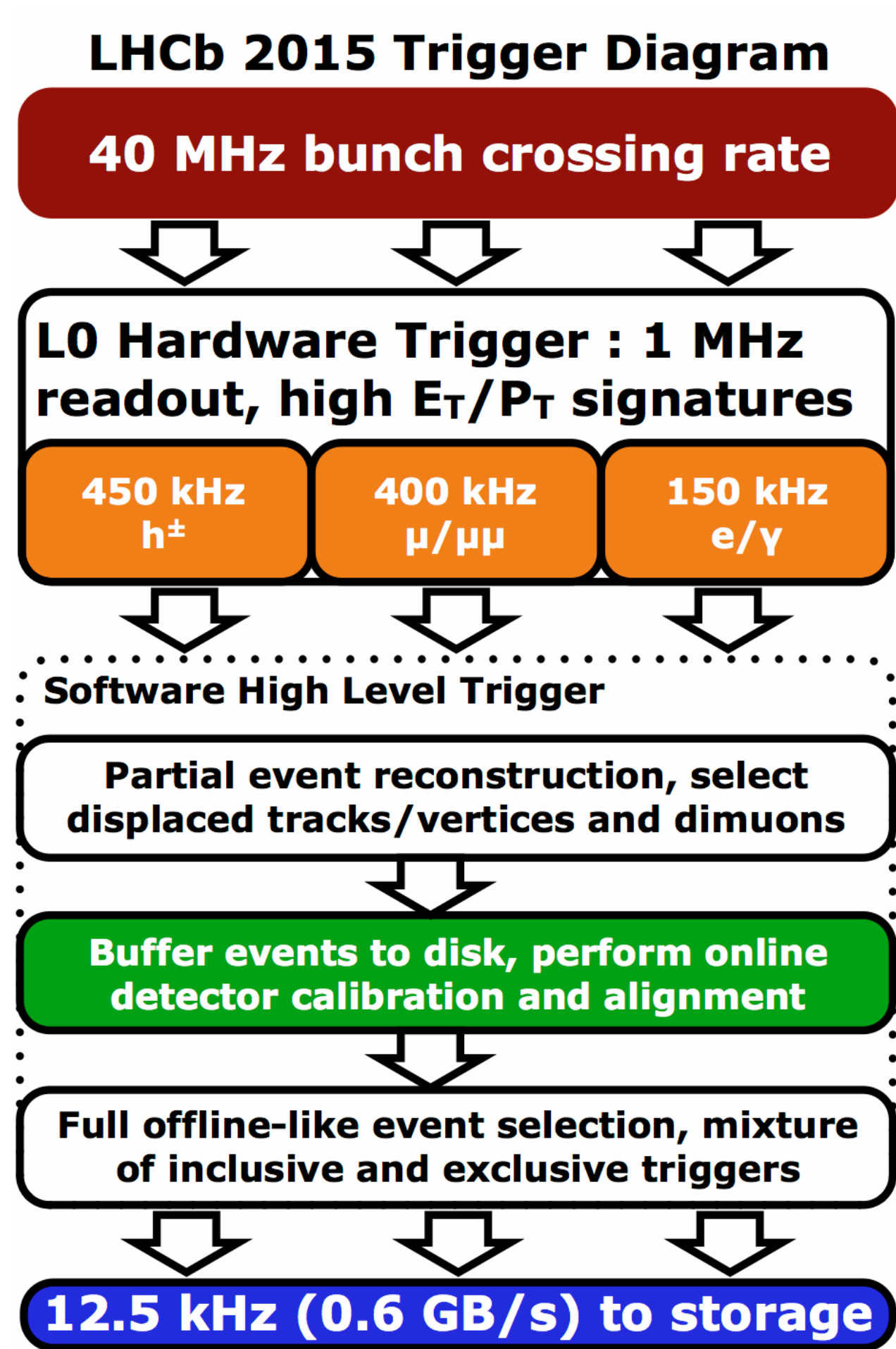
**Daniel Hynds**

On behalf of the BFYS group

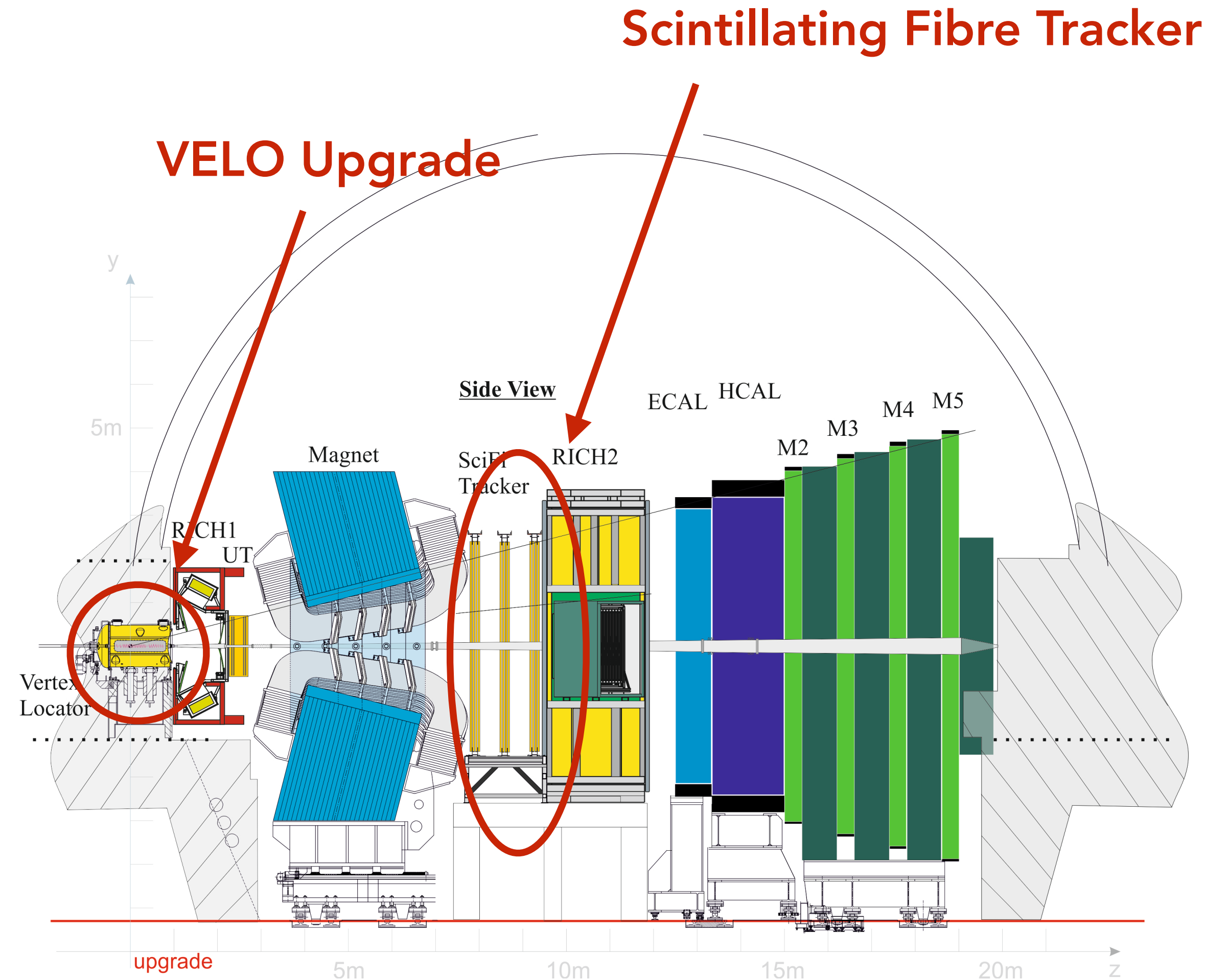
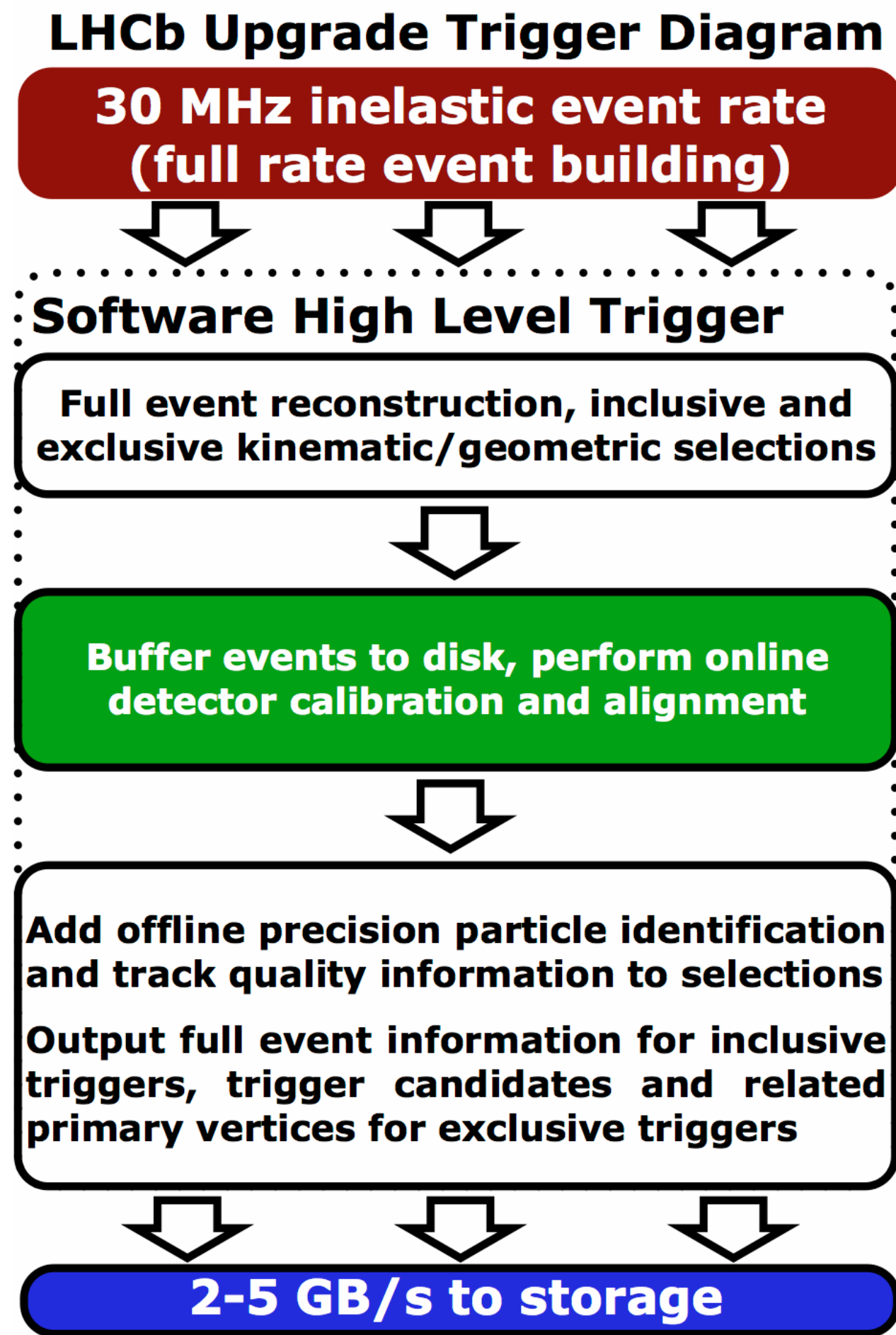
# Disclaimer







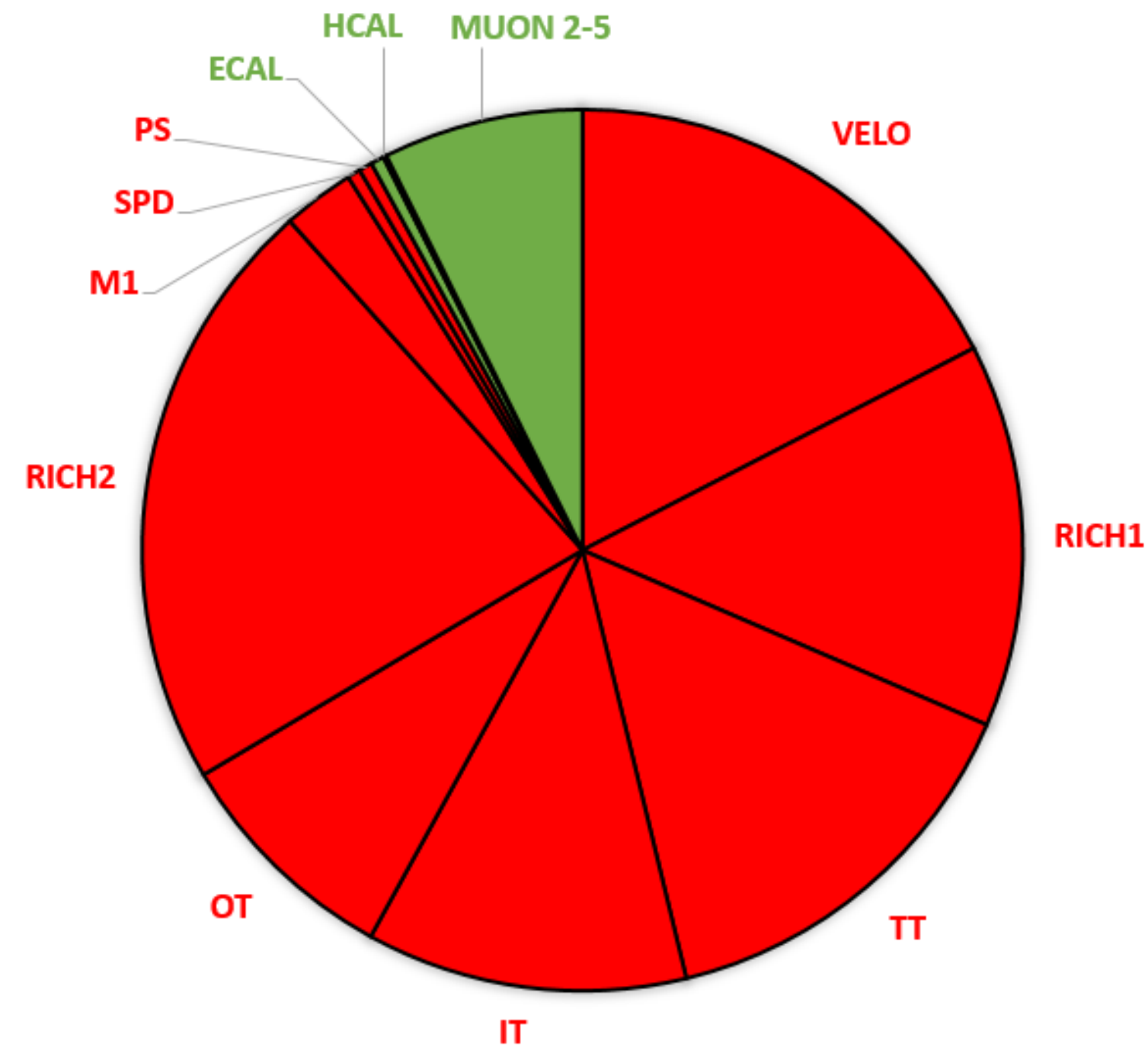
# The LHCb Upgrade



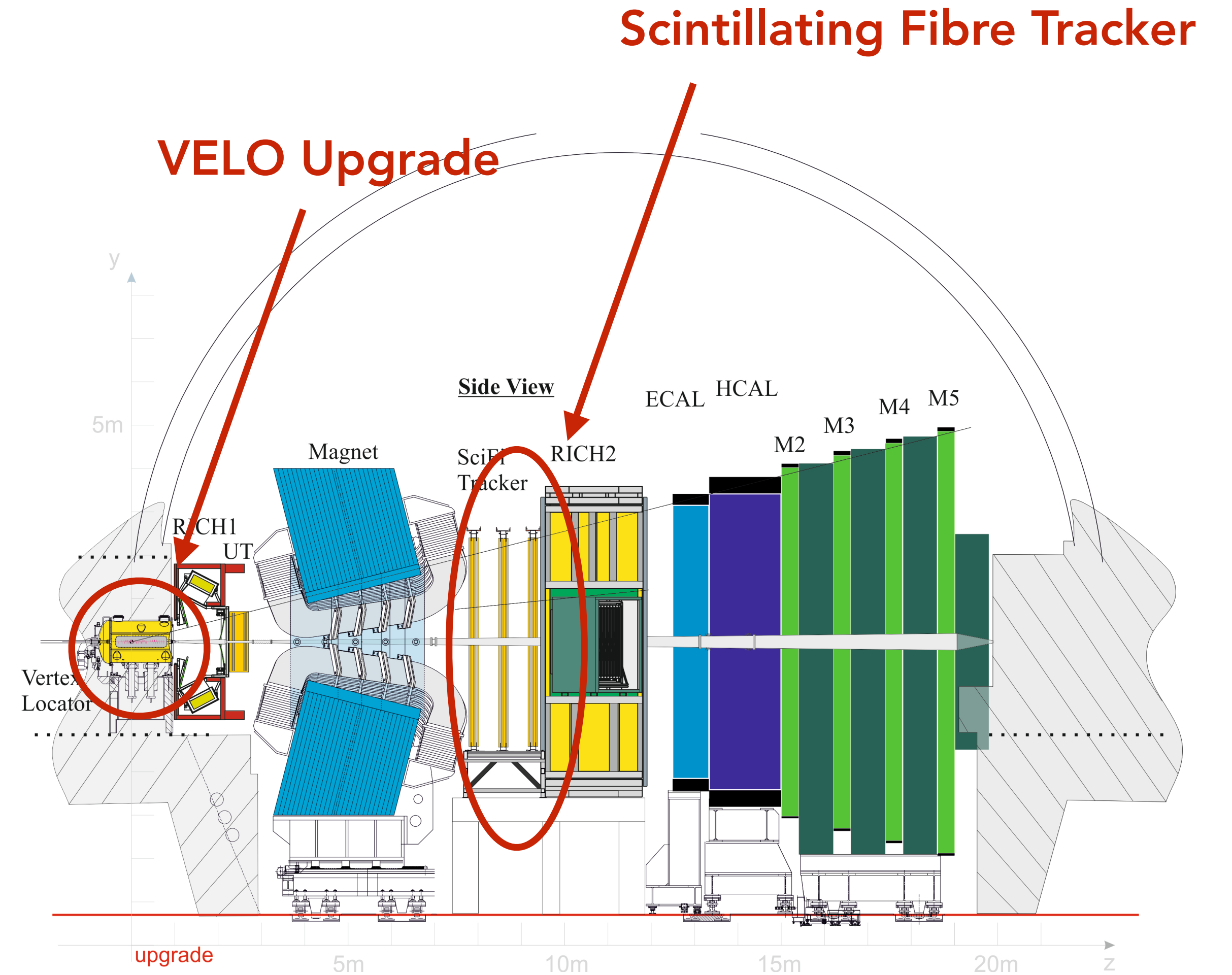
# The LHCb Upgrade

To be kept

To be replaced

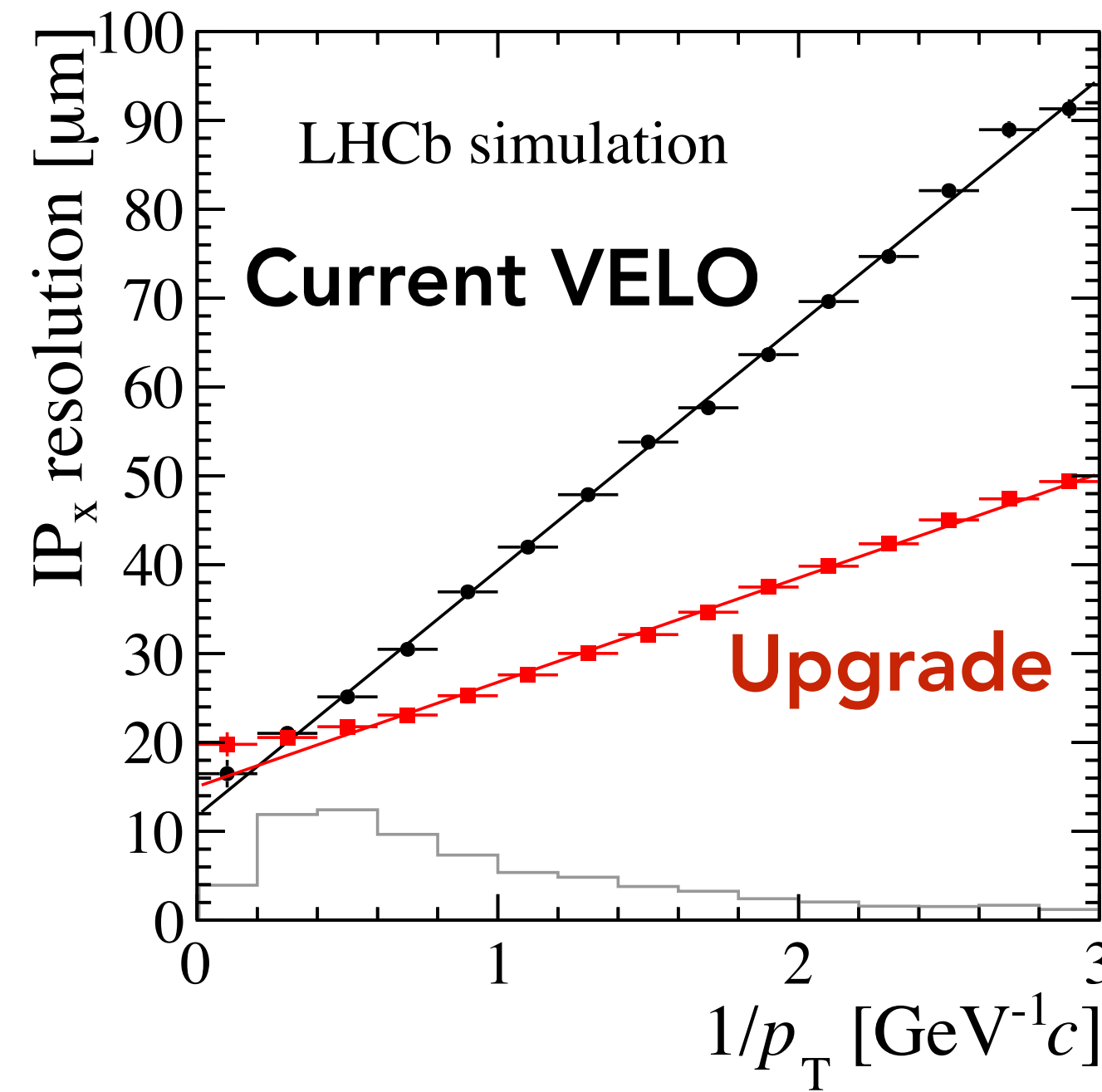


Detector Channels

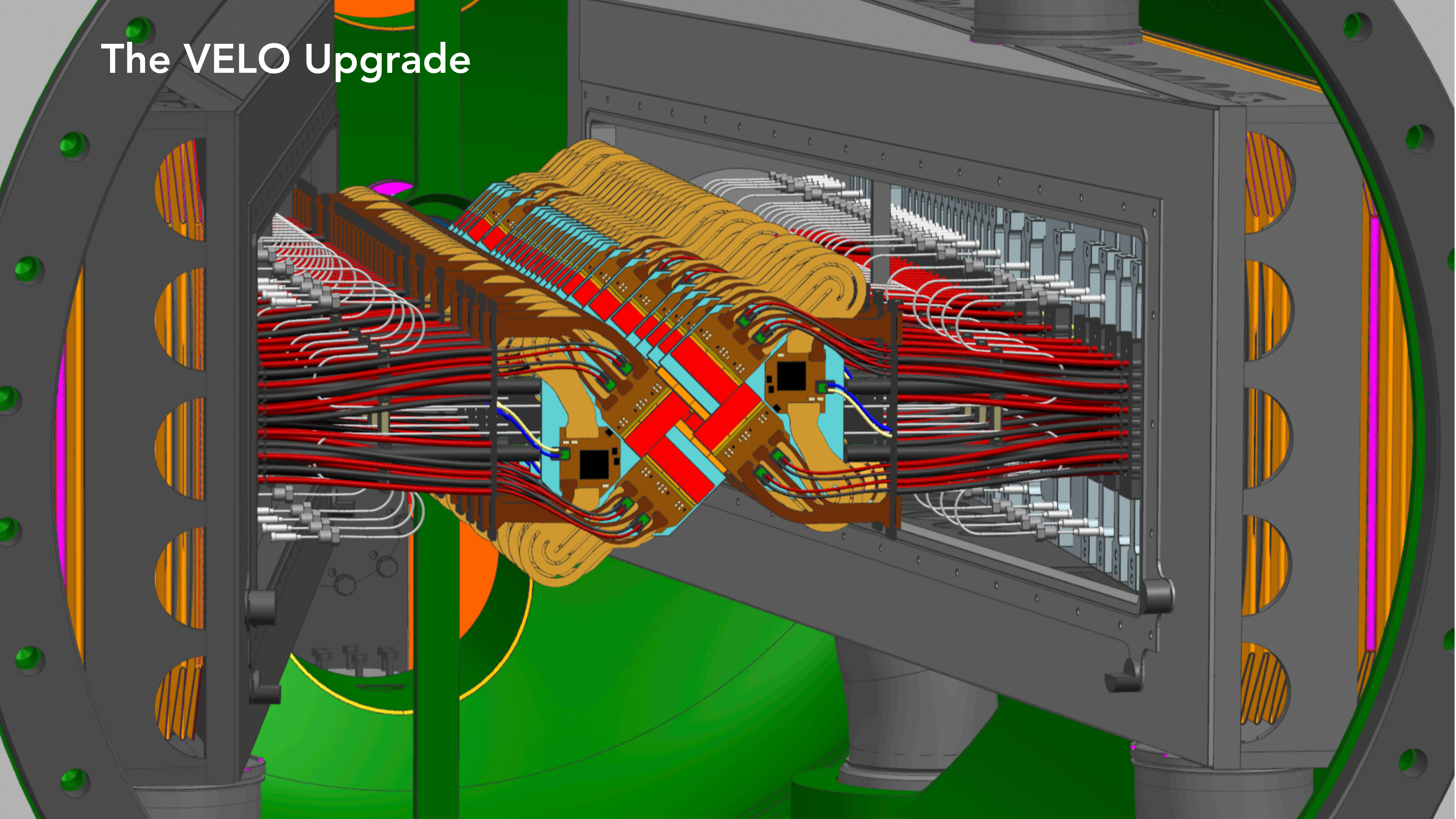


# The VELO

Silicon sensors  
Seeking answers, look precise  
Beauty seeks beauty  
  
Utmost performance  
Yet all things end, be re-born  
On to the upgrade!



# The VELO Upgrade





# The VELO Upgrade modules

**Silicon canals**

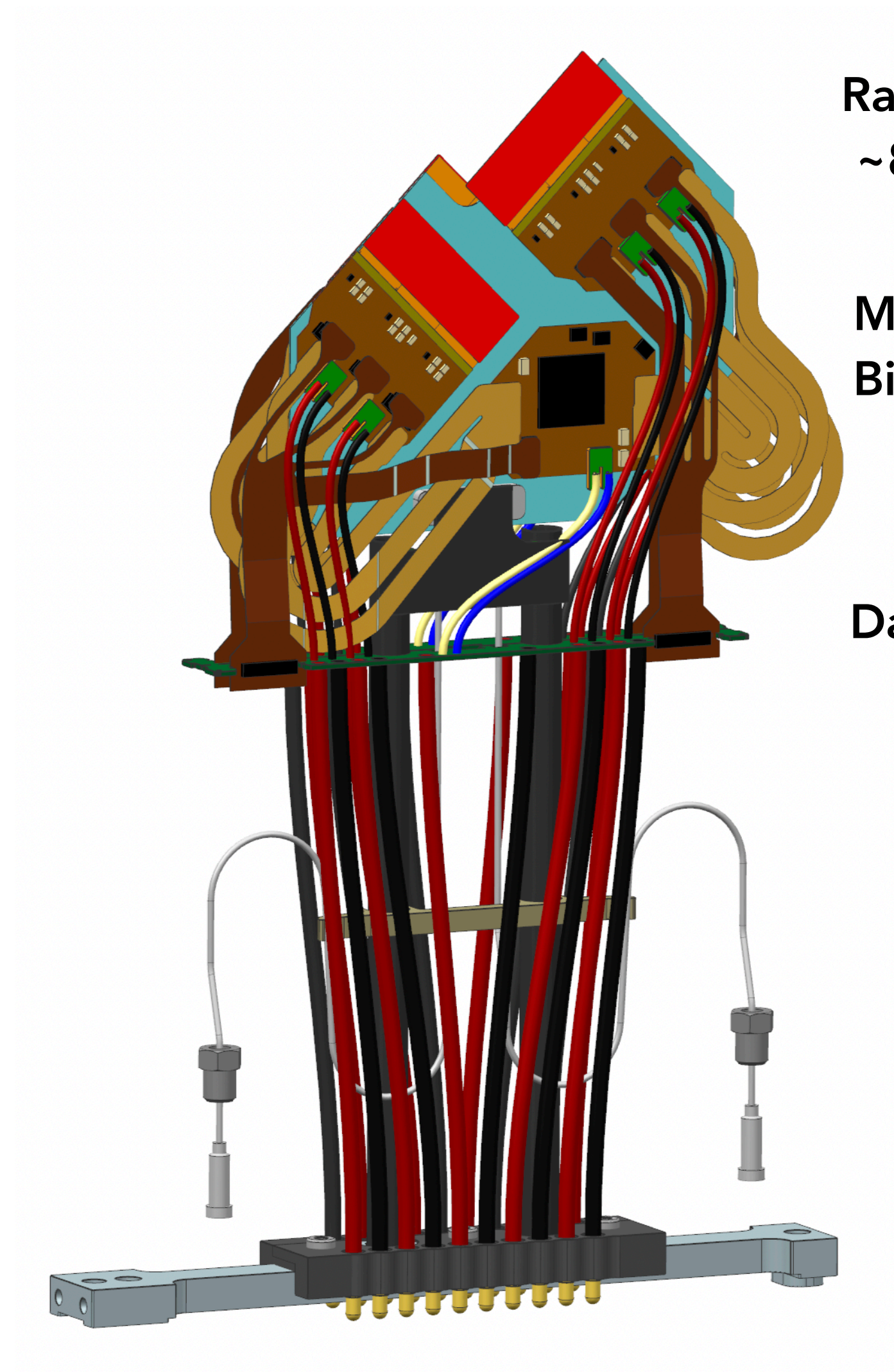
**Cooling flows, caress sensor**

**Protect from damage**

**Torrents of data**

**The Raven quivers, and asks:**

**How to reconstruct?**



**Radiation dose:**

$\sim 8 \times 10^{15} \text{ 1 MeV n}_{\text{eq}} \text{ cm}^{-2}$

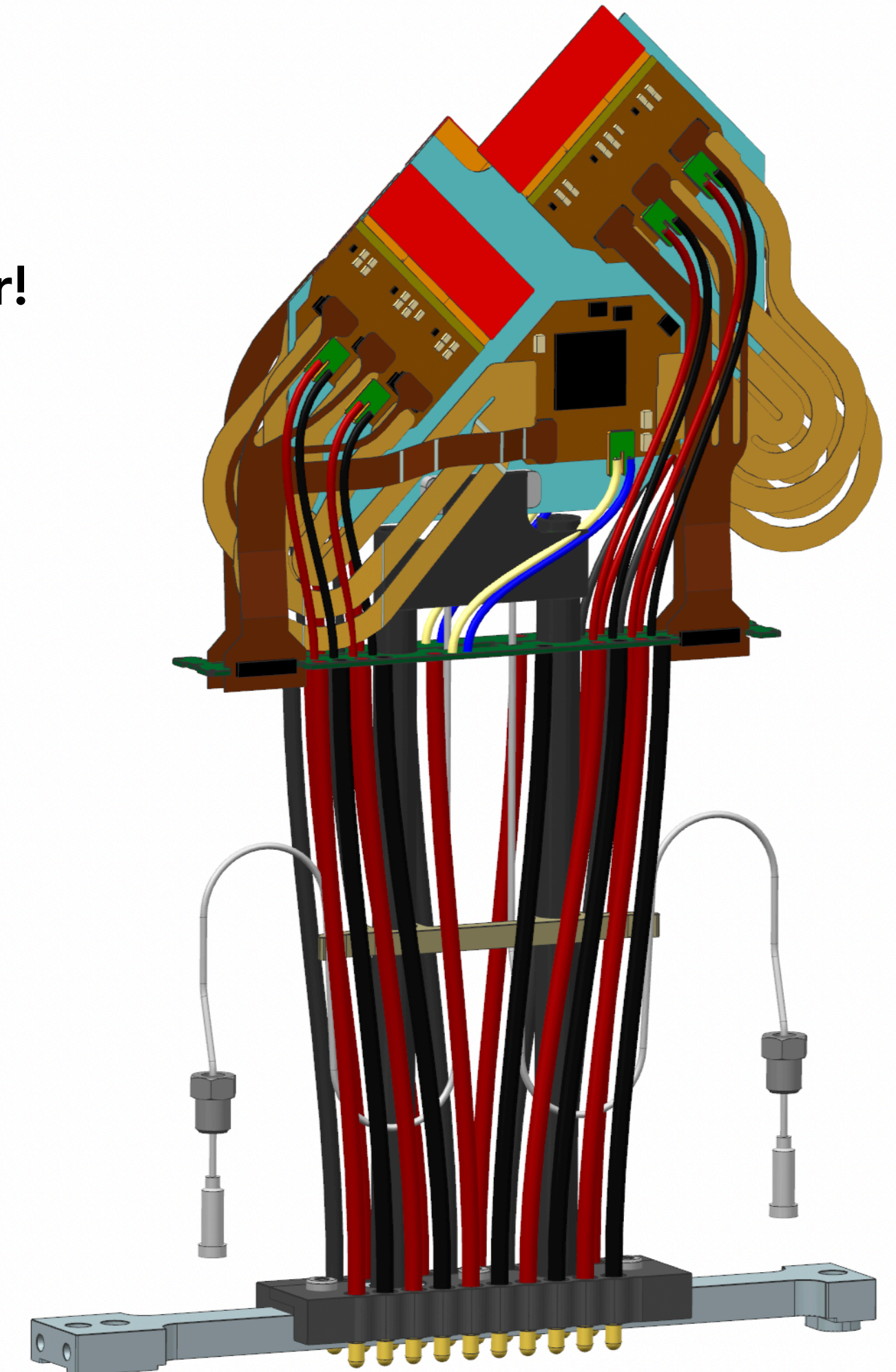
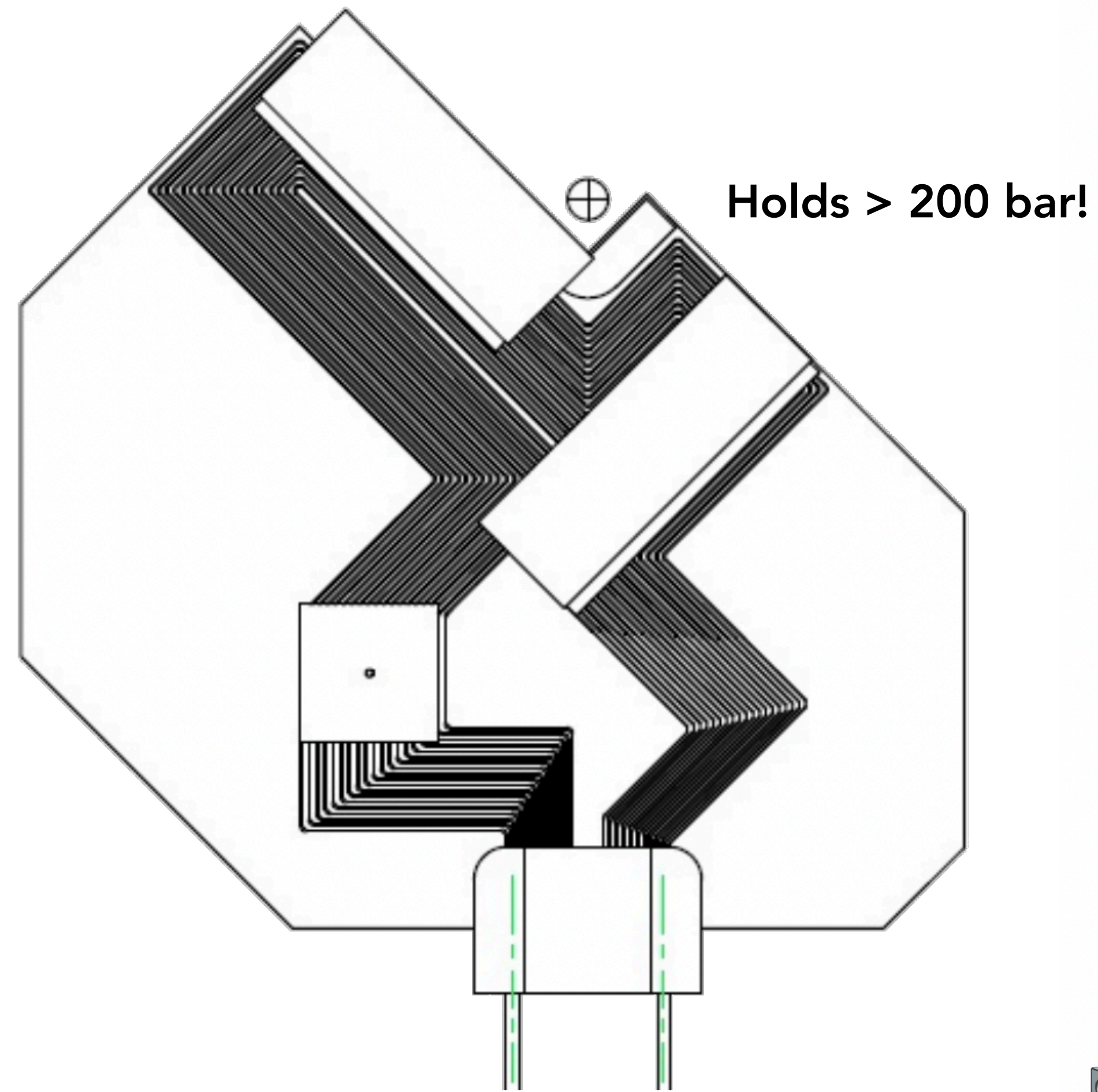
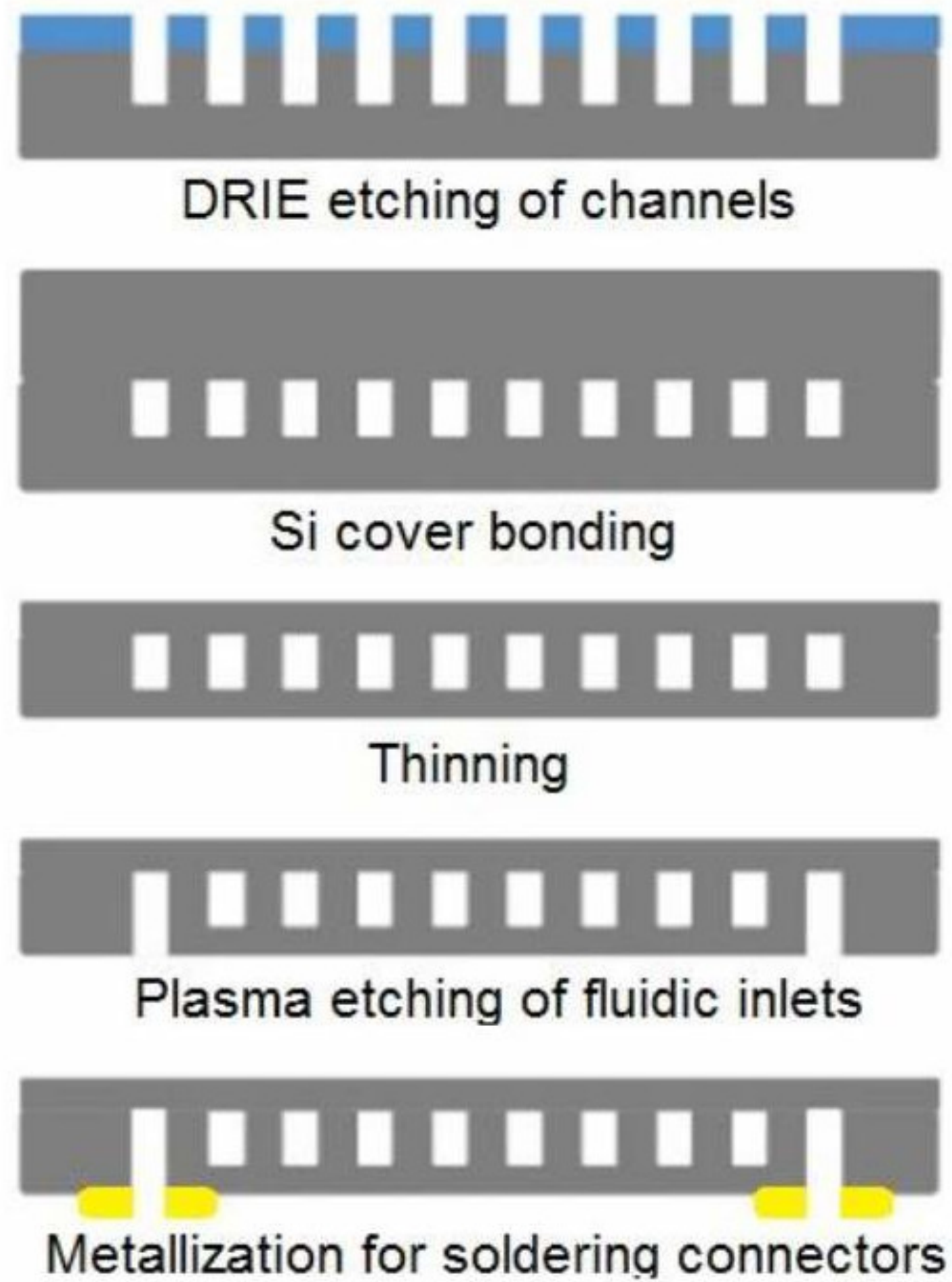
**Microchannel substrate**

**Bi-phase CO<sub>2</sub> cooling**

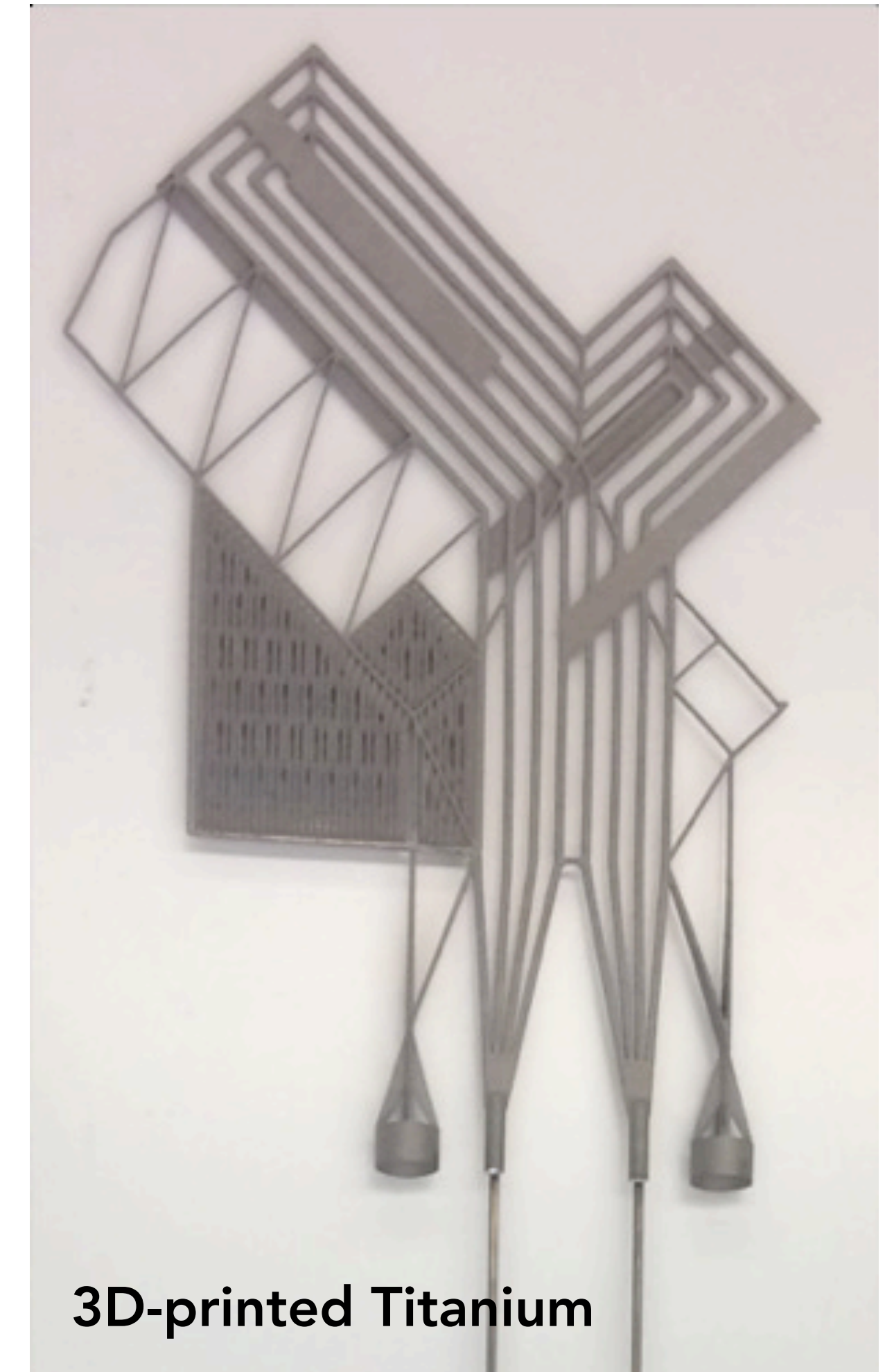
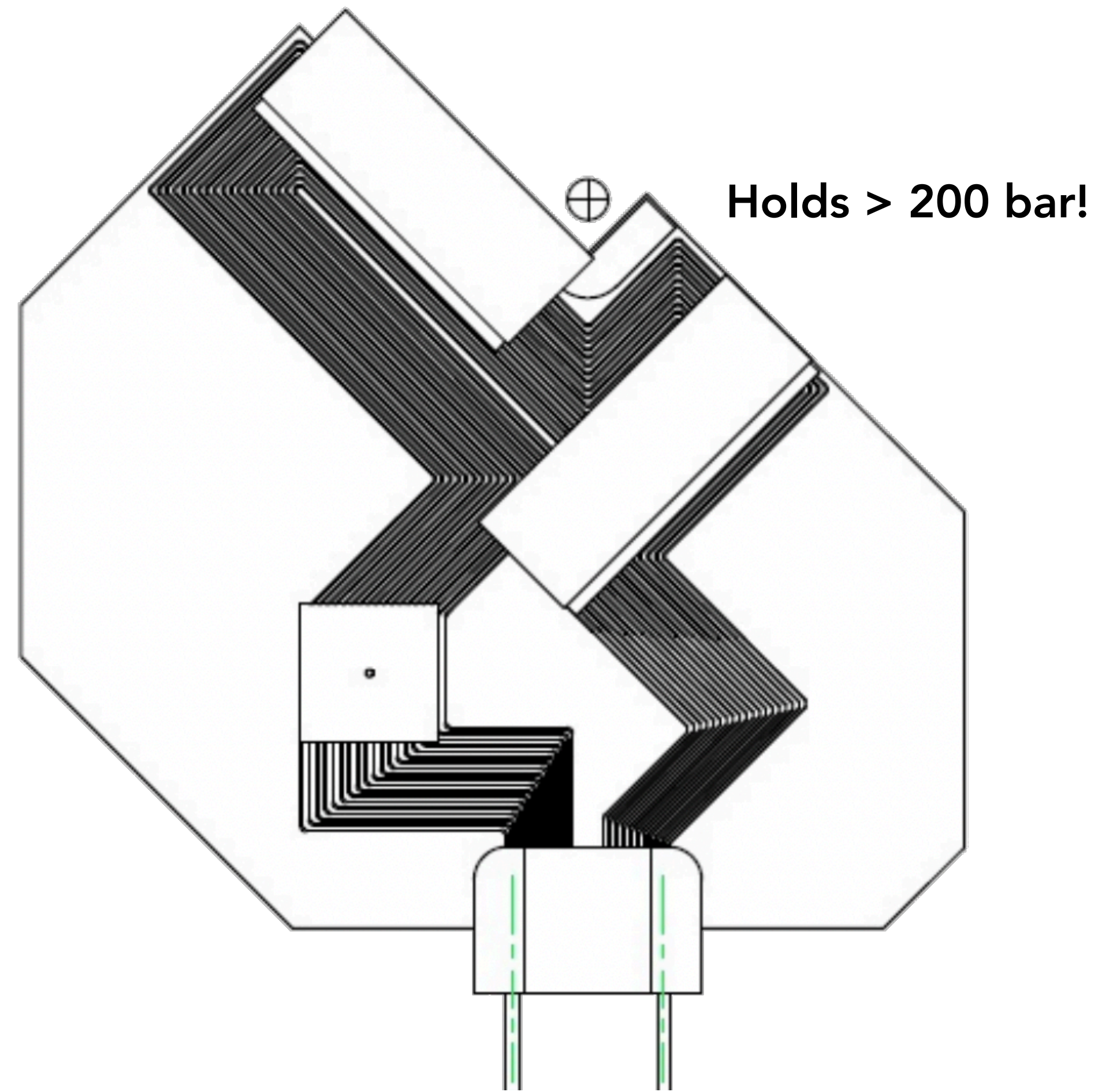
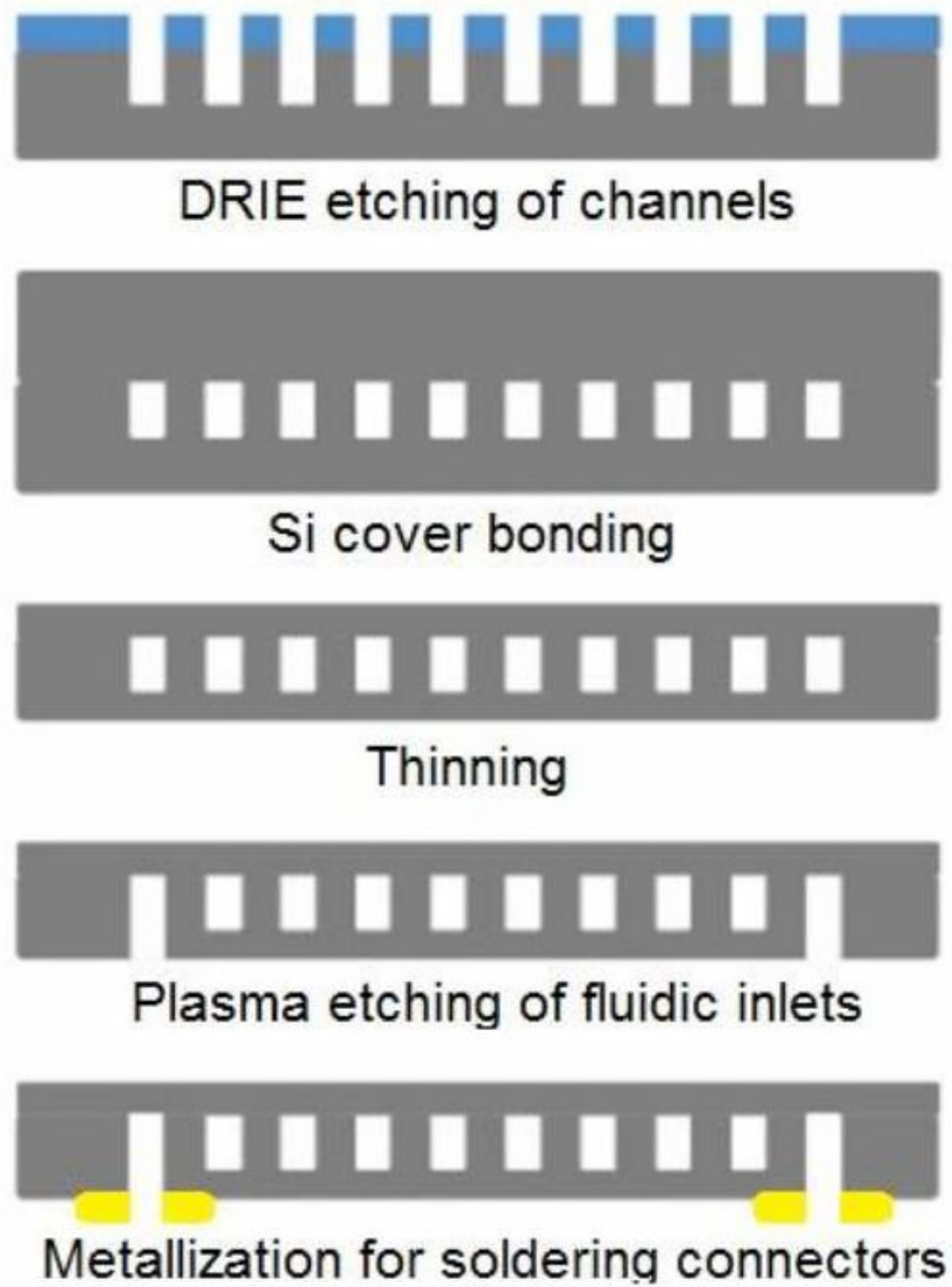
**Data: > 60 Gb s<sup>-1</sup> for hottest module**

**> 2 Tb s<sup>-1</sup> for sub-detector**

# Microchannel cooling

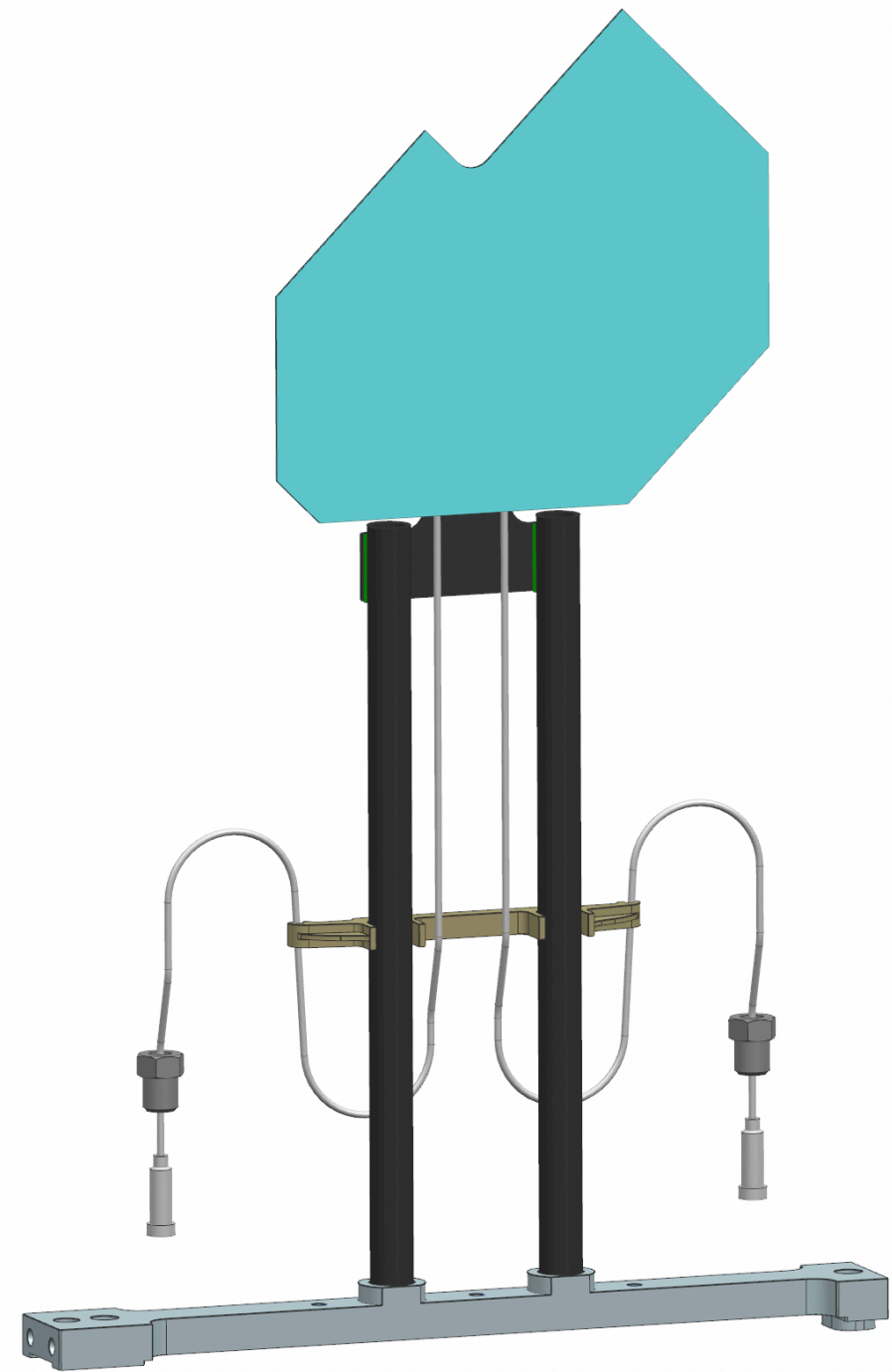


# Microchannel cooling

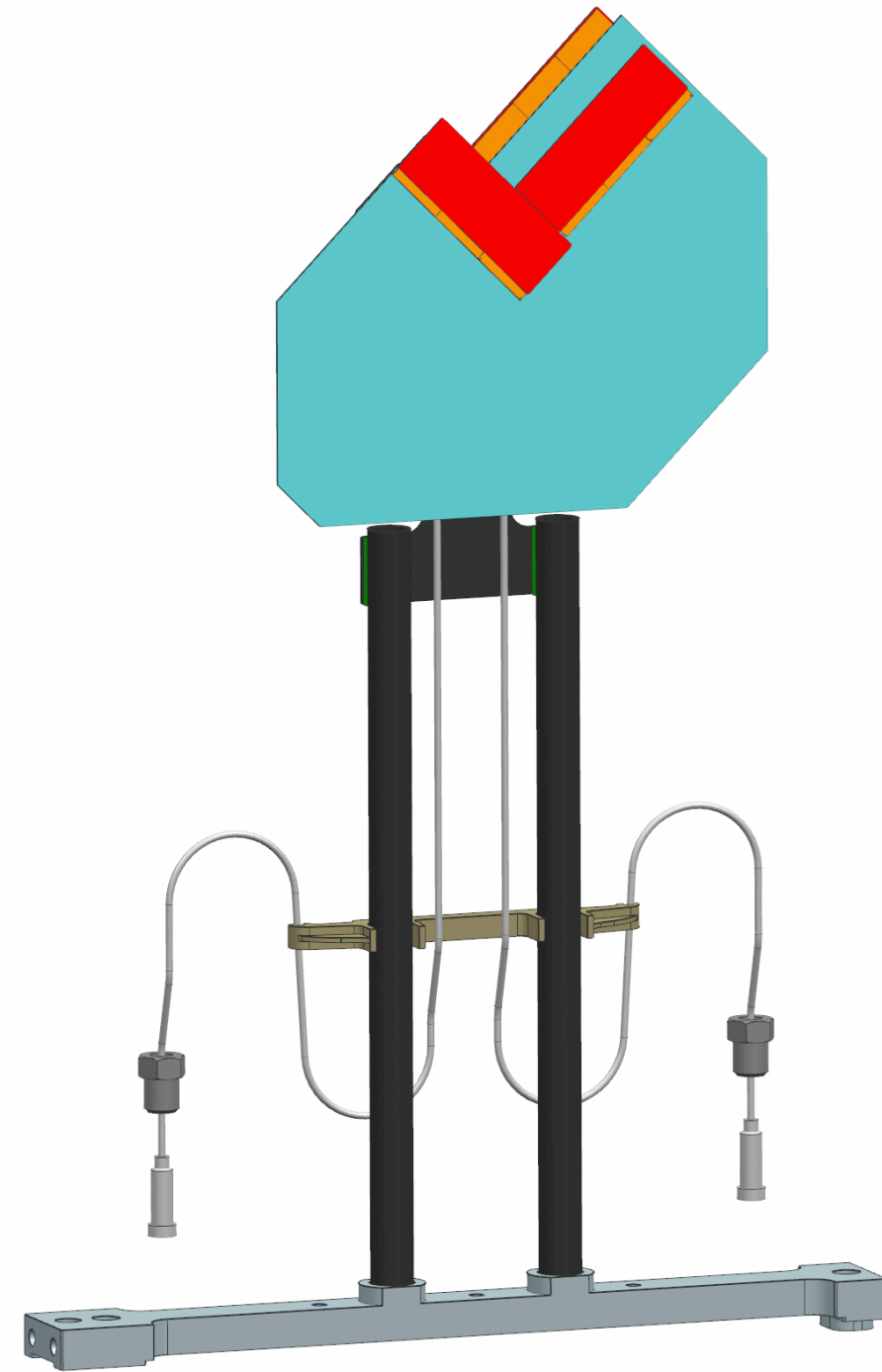


# Module Construction

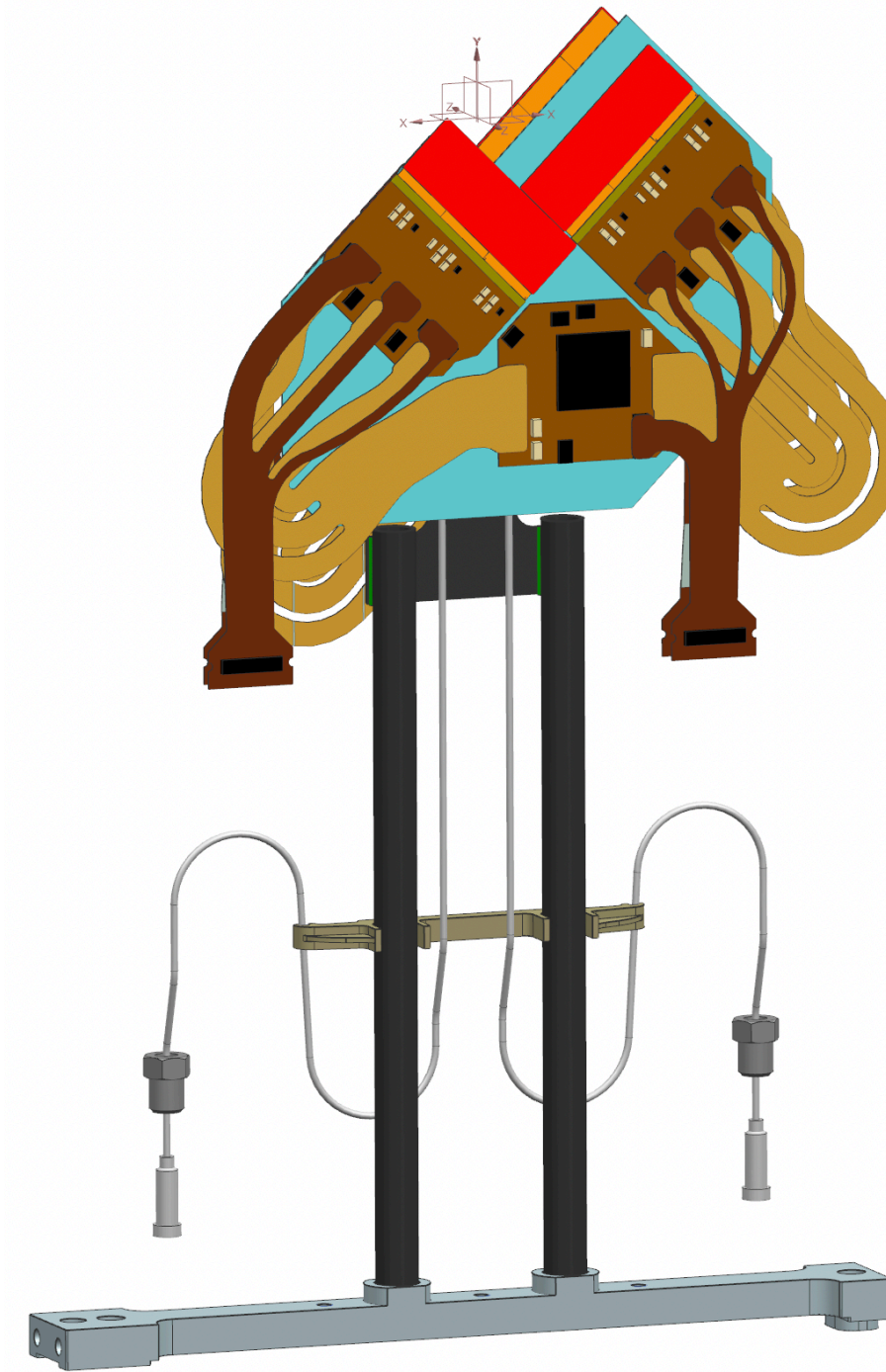
Mechanical construction



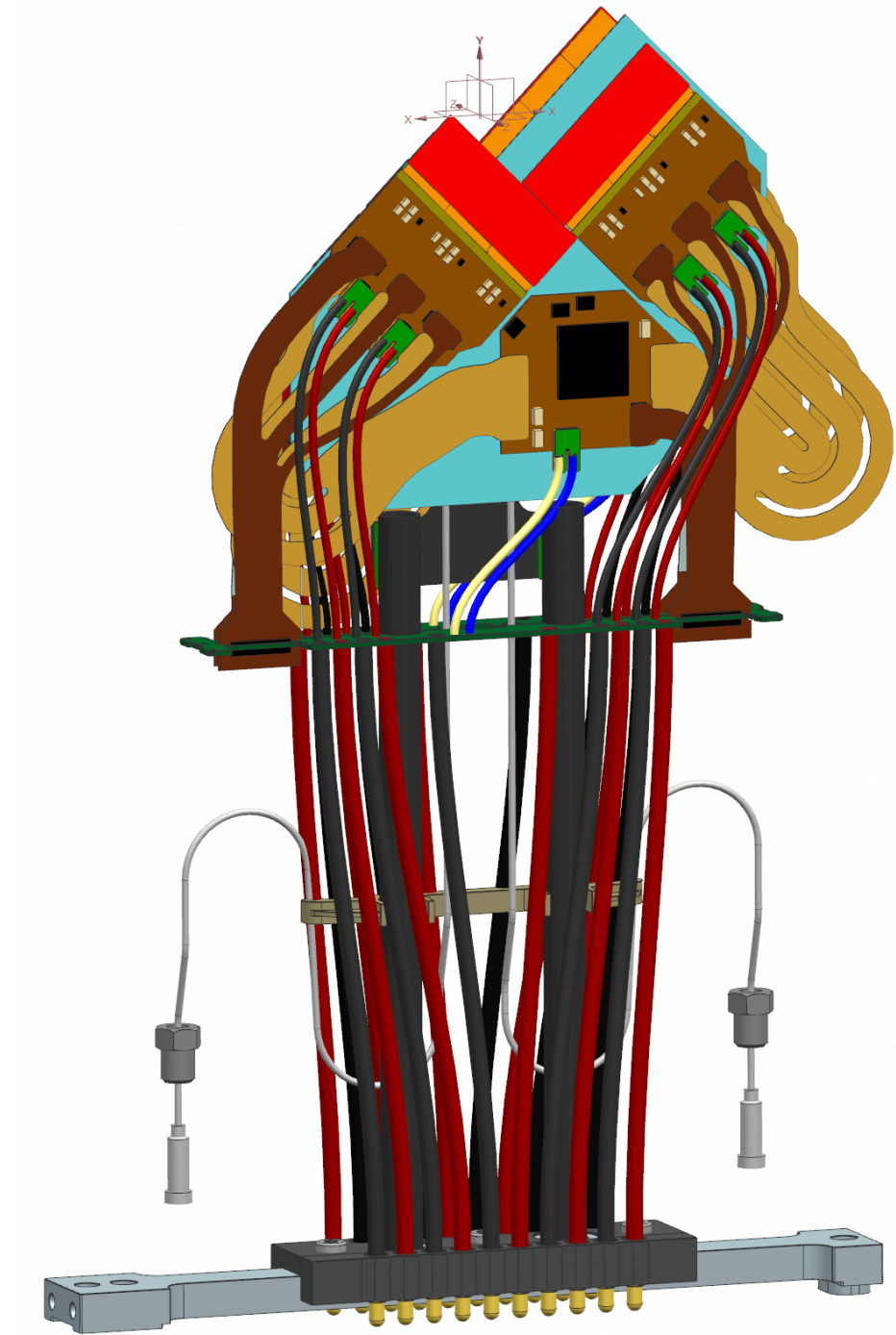
Precision tile placement  
ASICs placed to  $\sim 10\mu\text{m}$



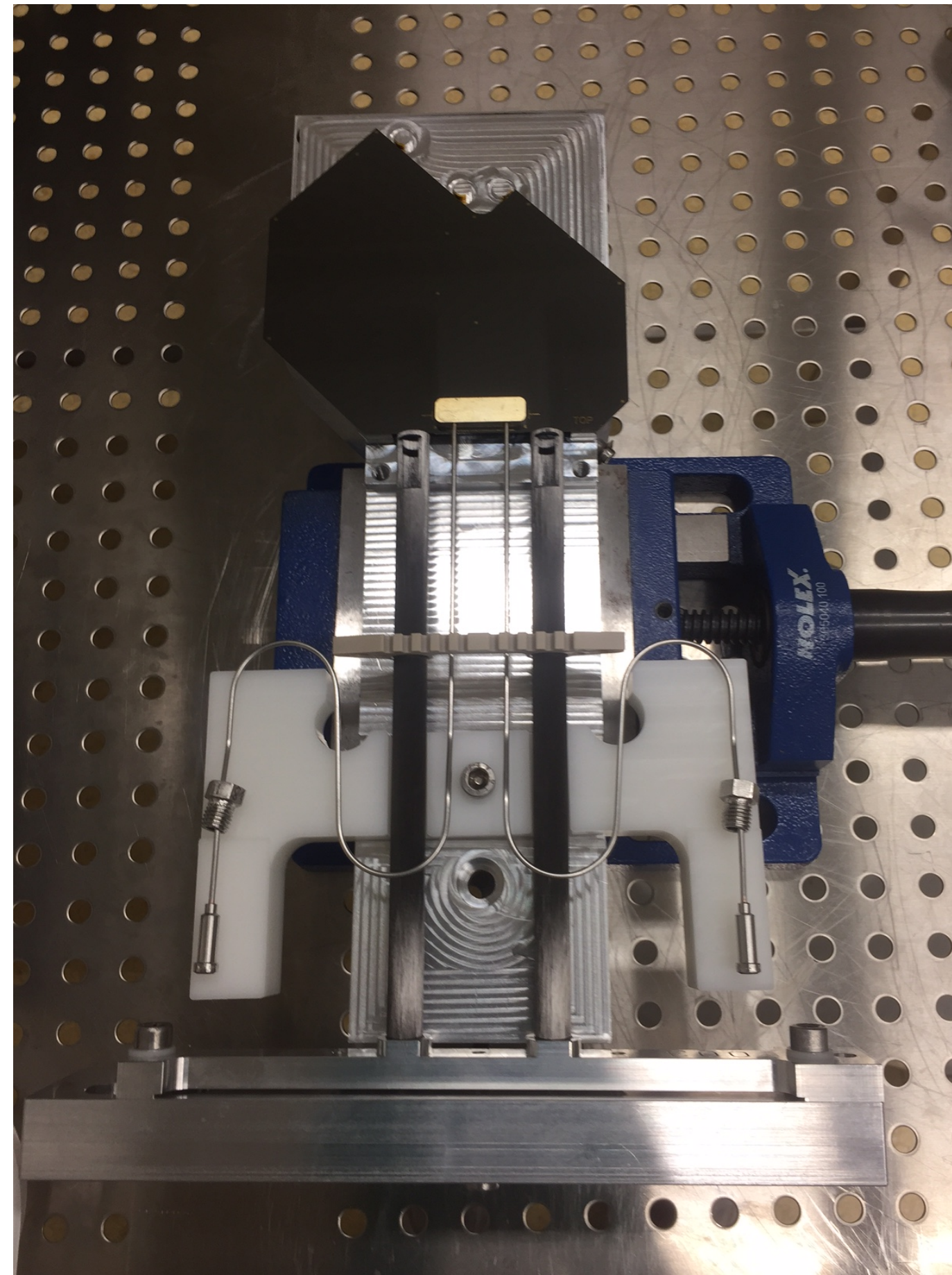
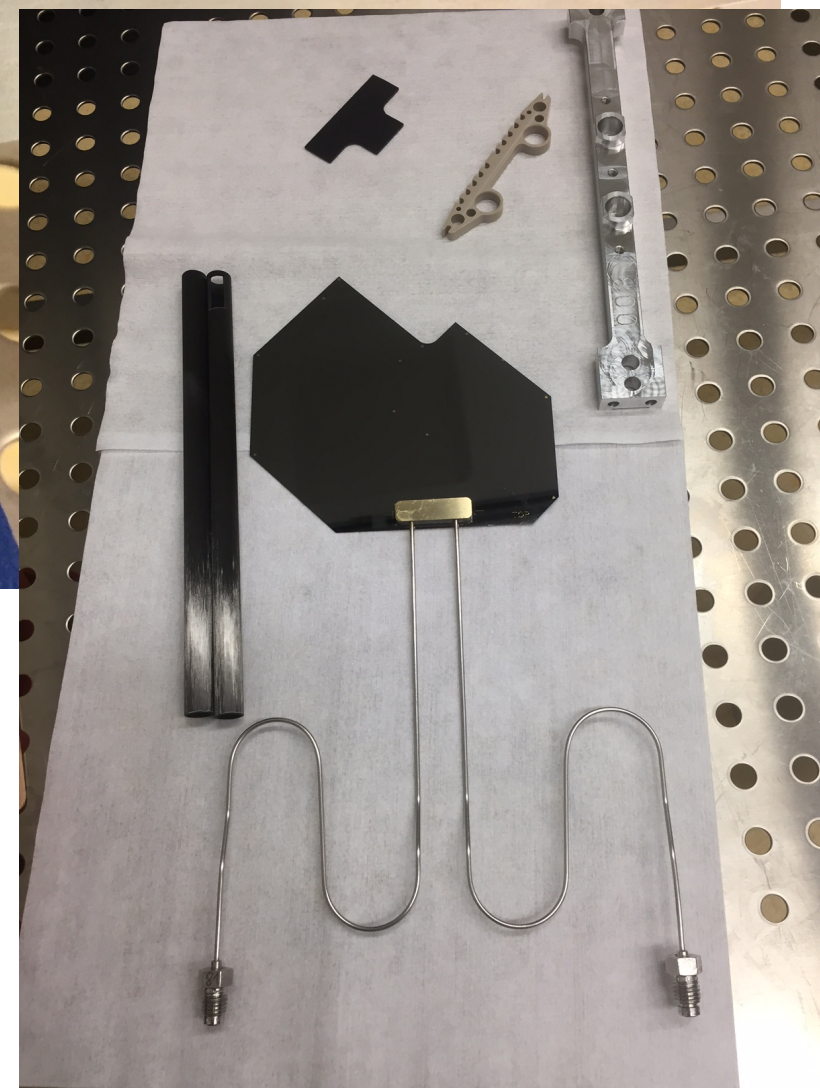
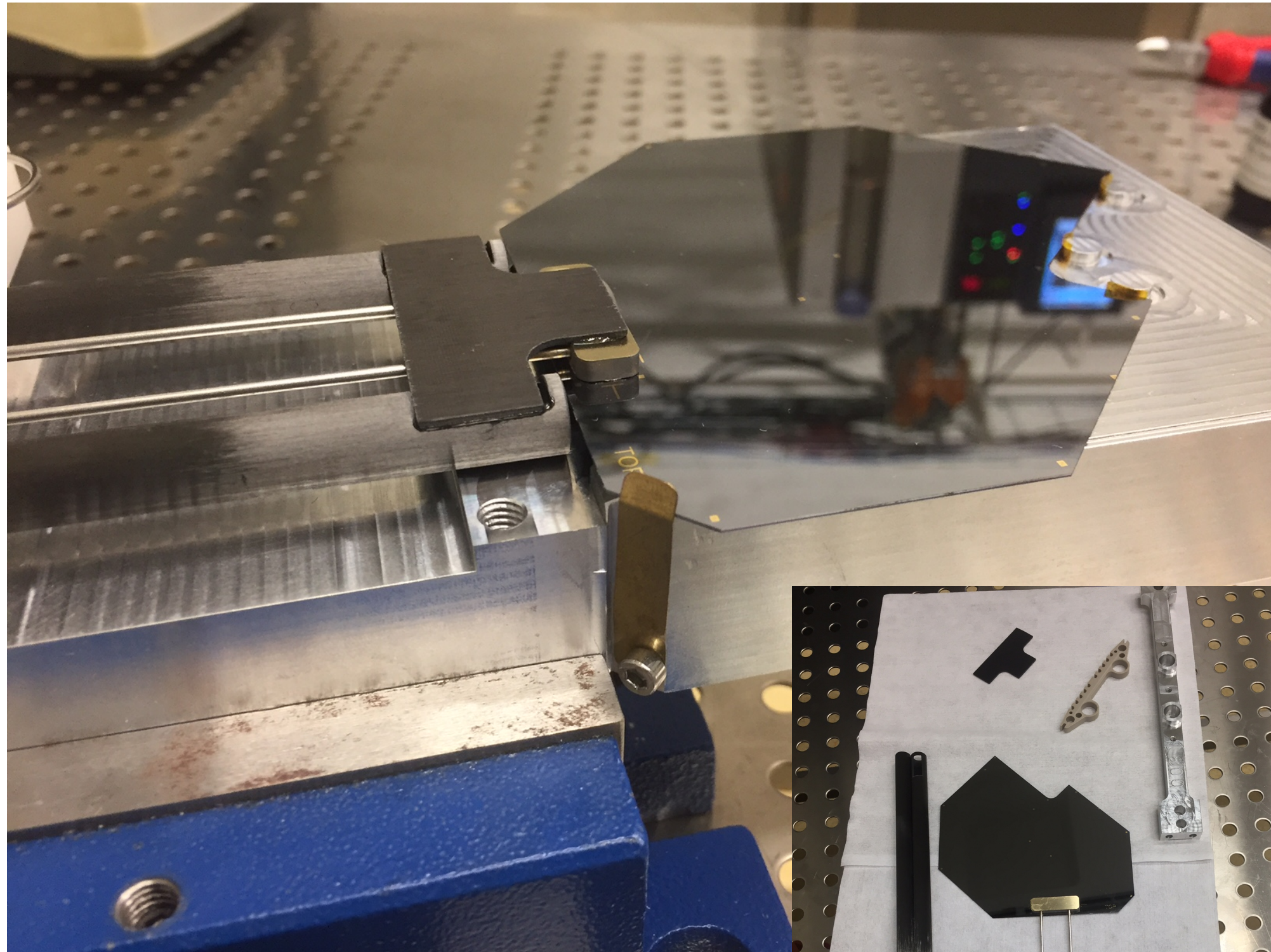
Hybrid placement



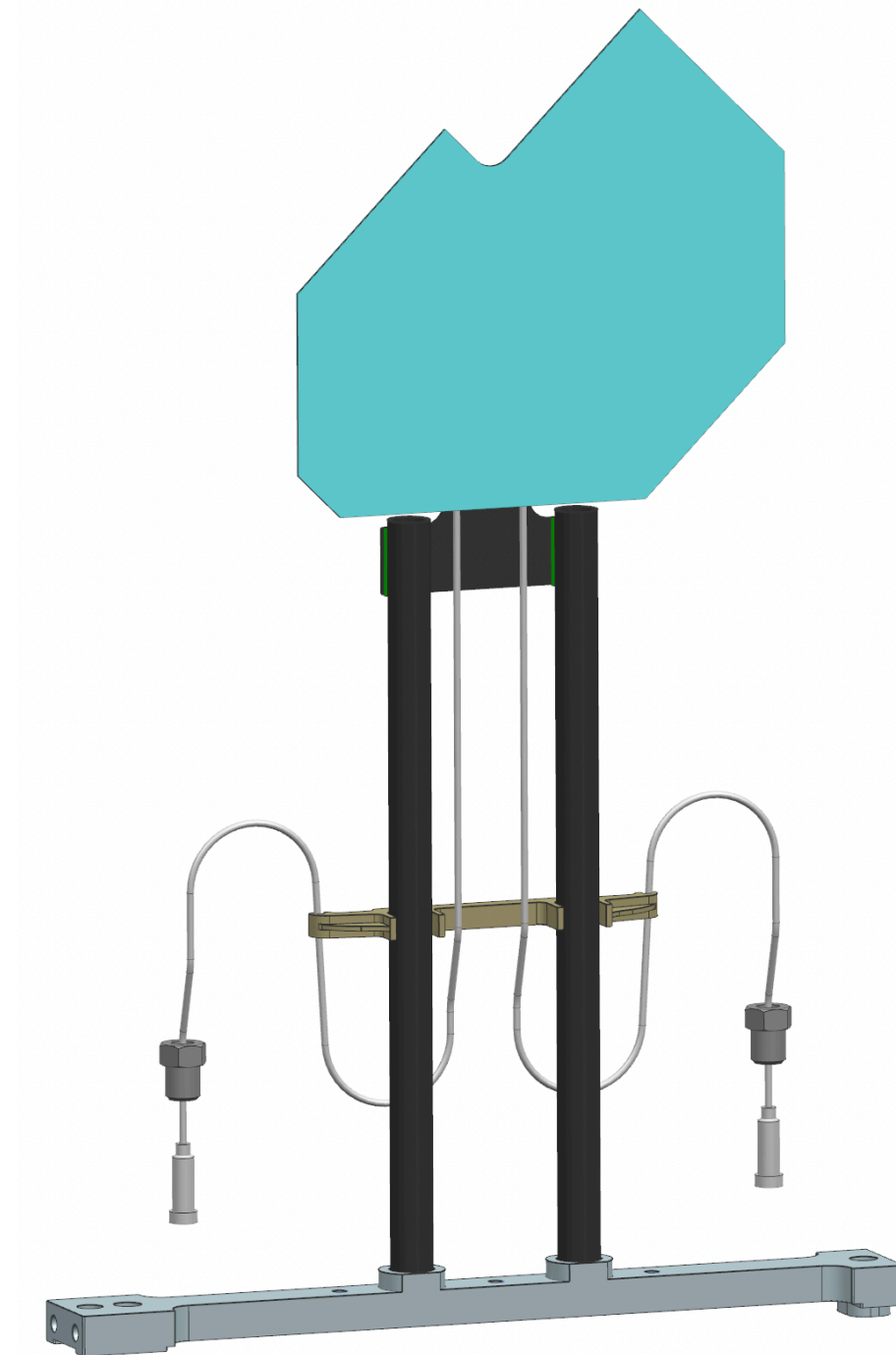
Low voltage attachment  
Wire bonding



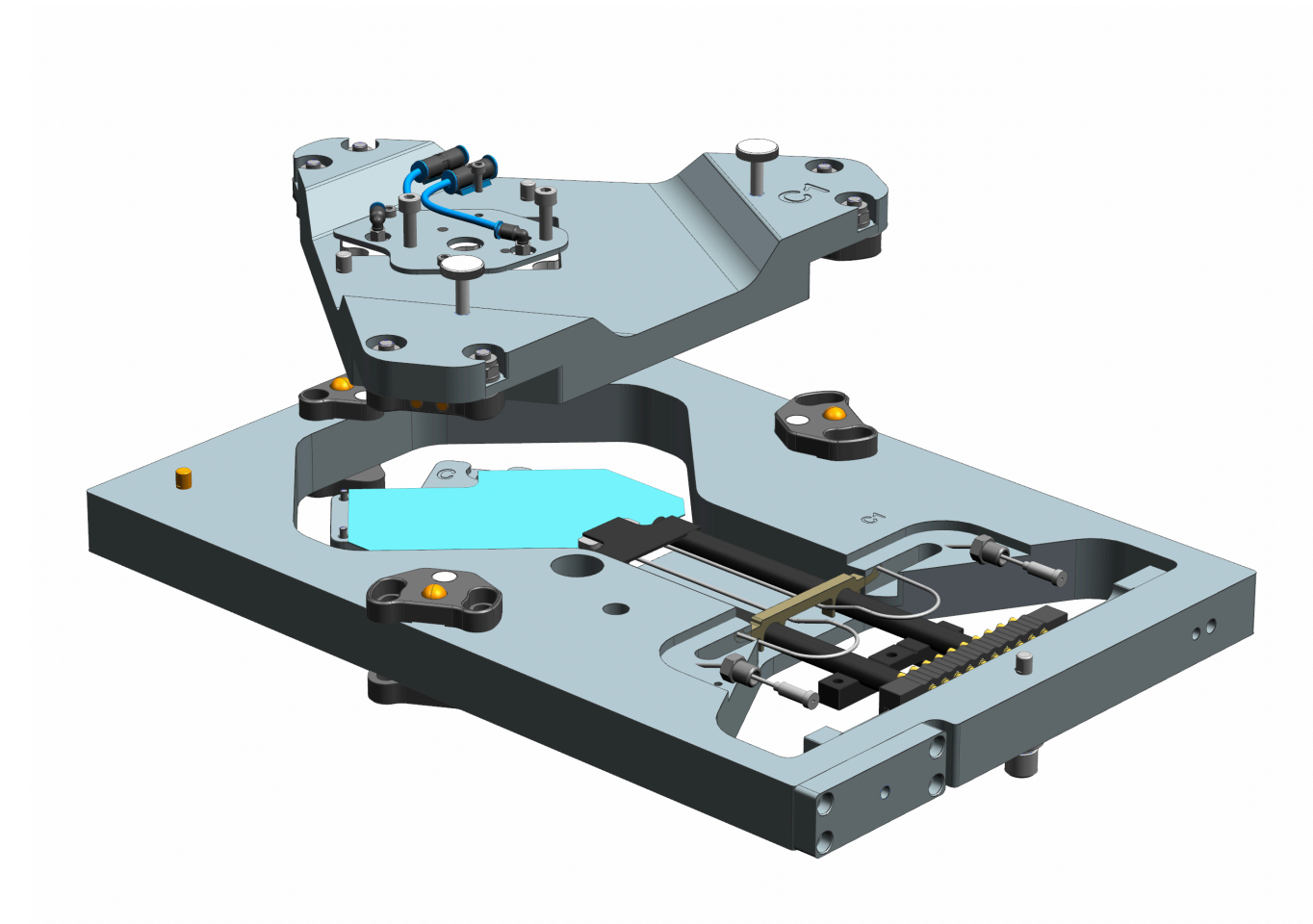
# Module Construction



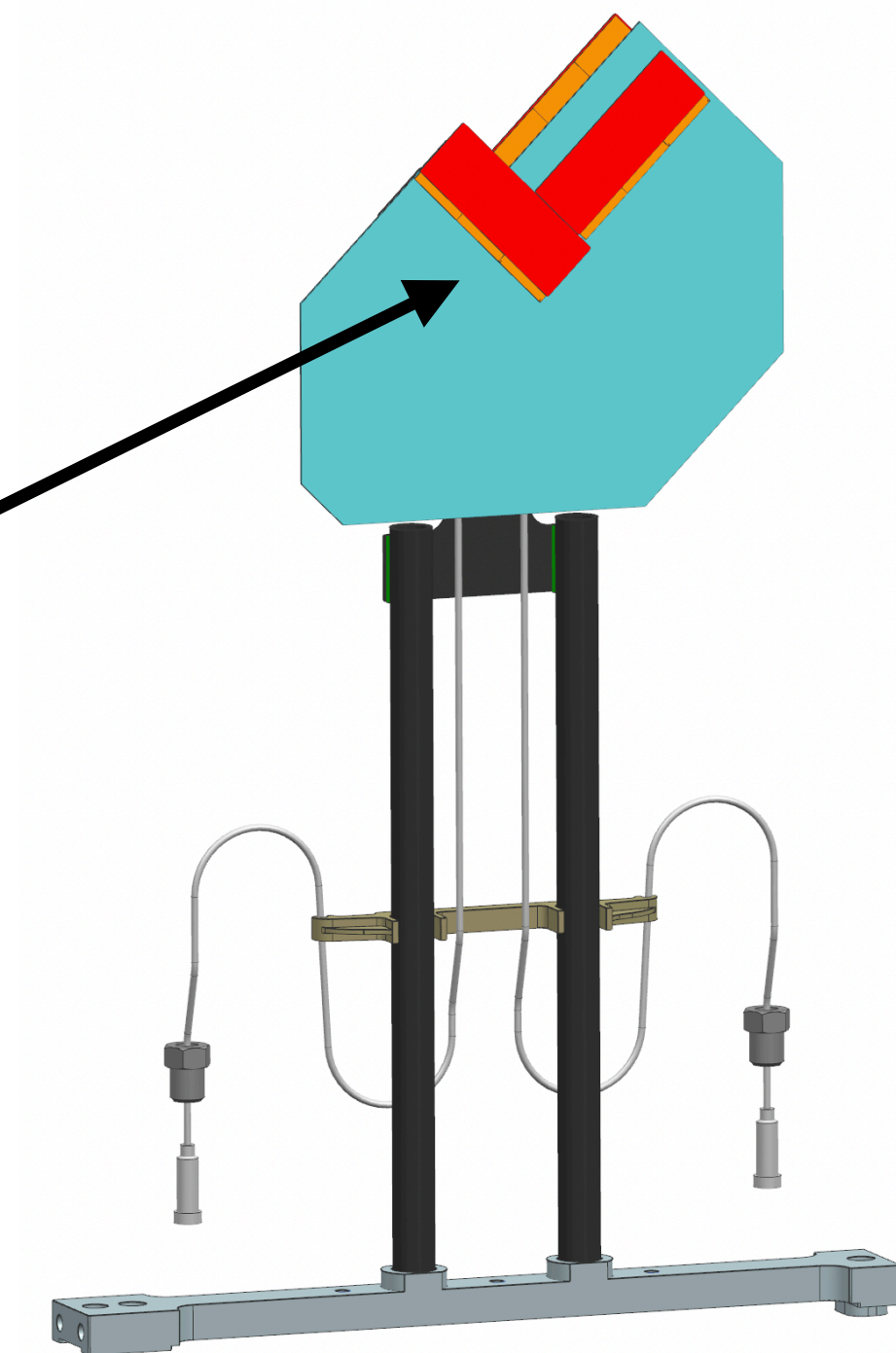
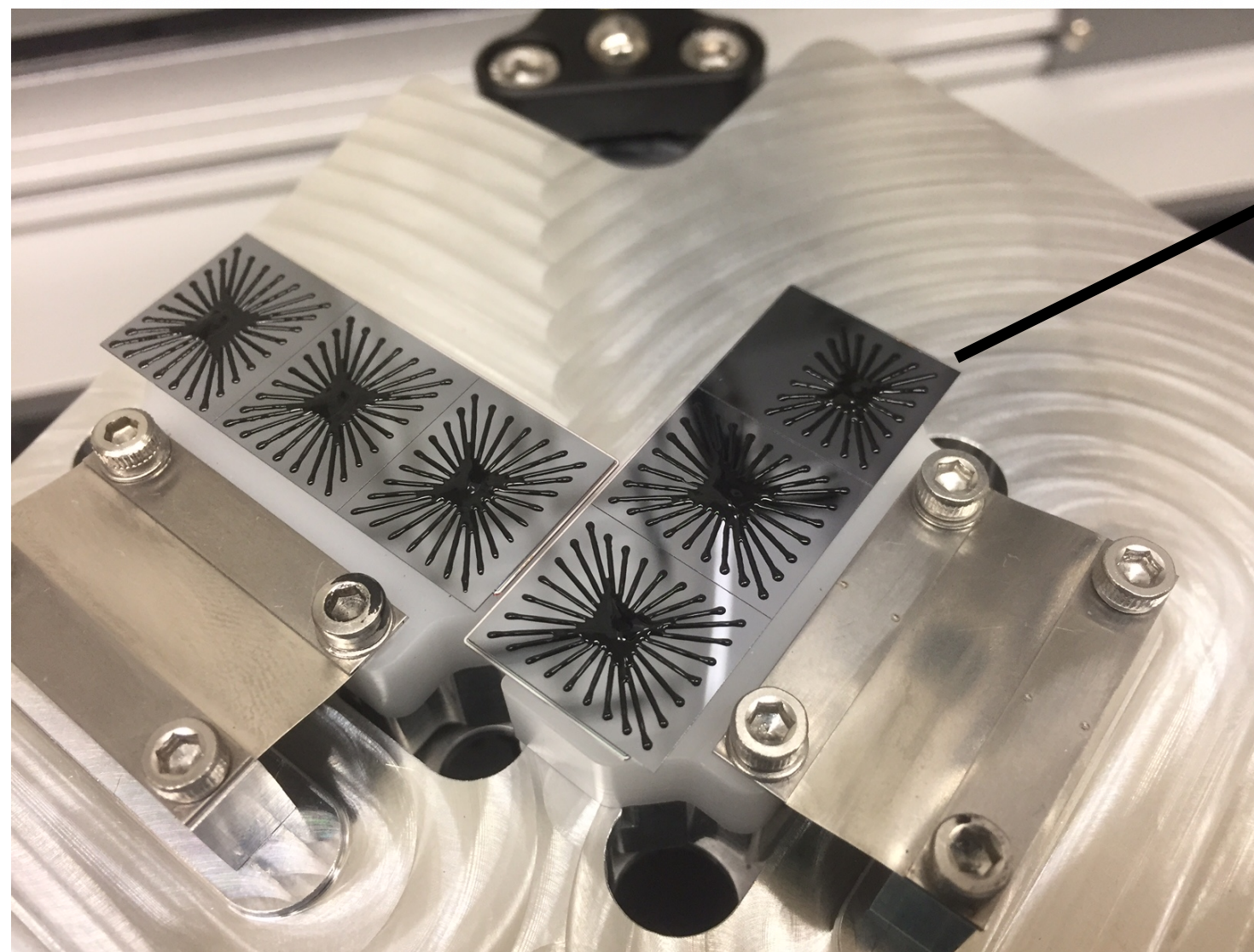
Mechanical construction



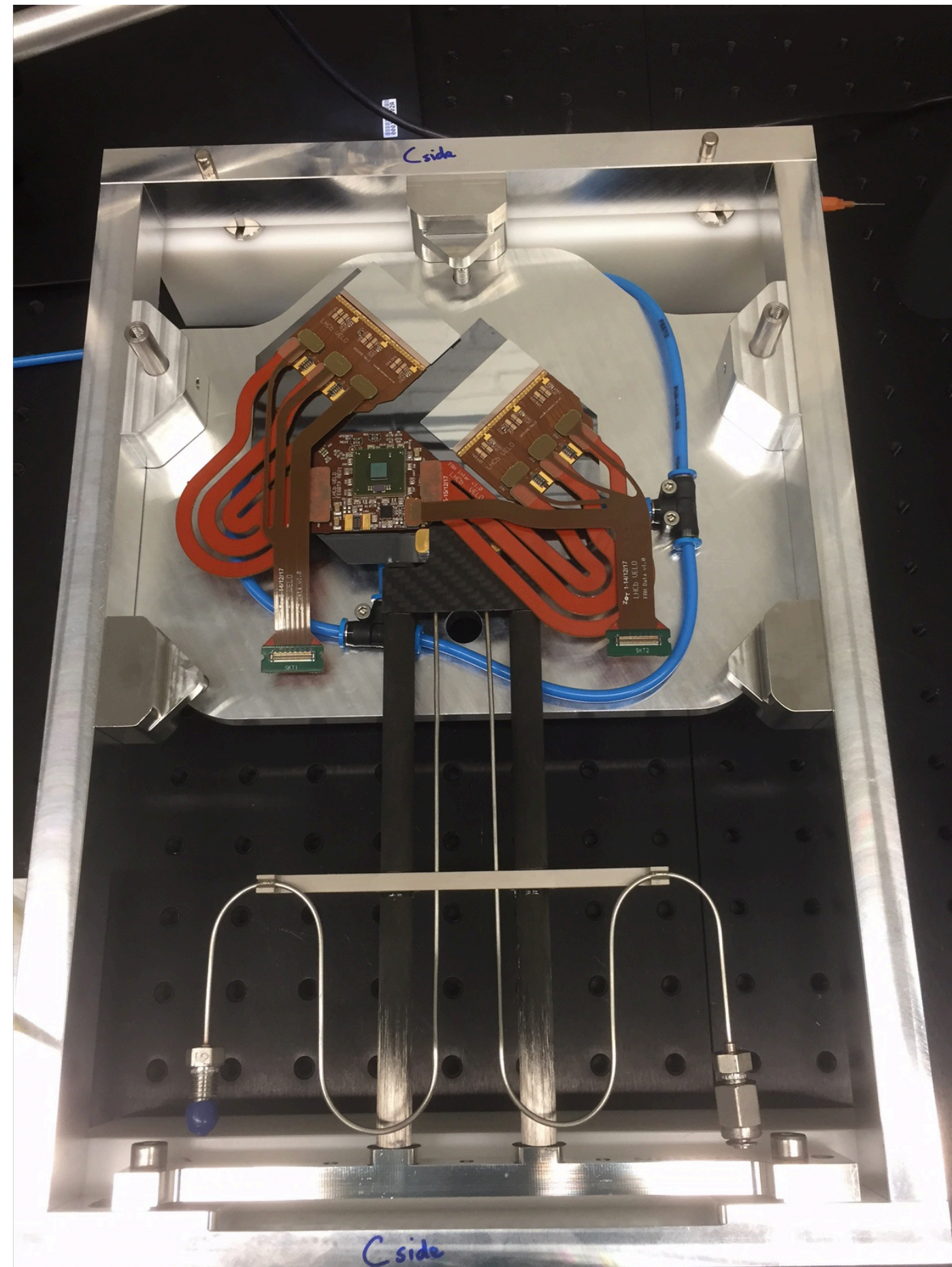
# Module Construction



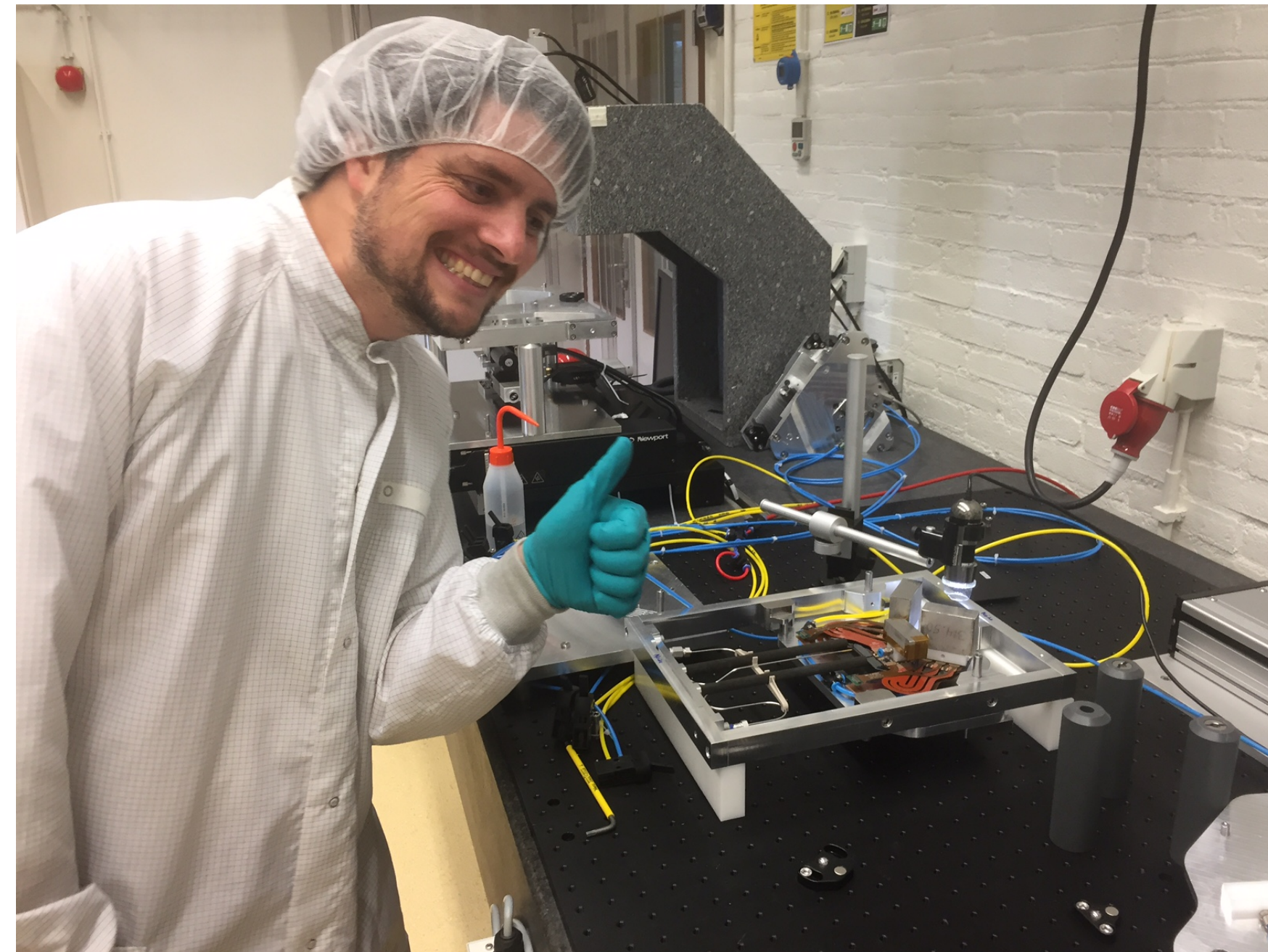
Precision tile placement  
ASICs placed to  $\sim 10\mu\text{m}$



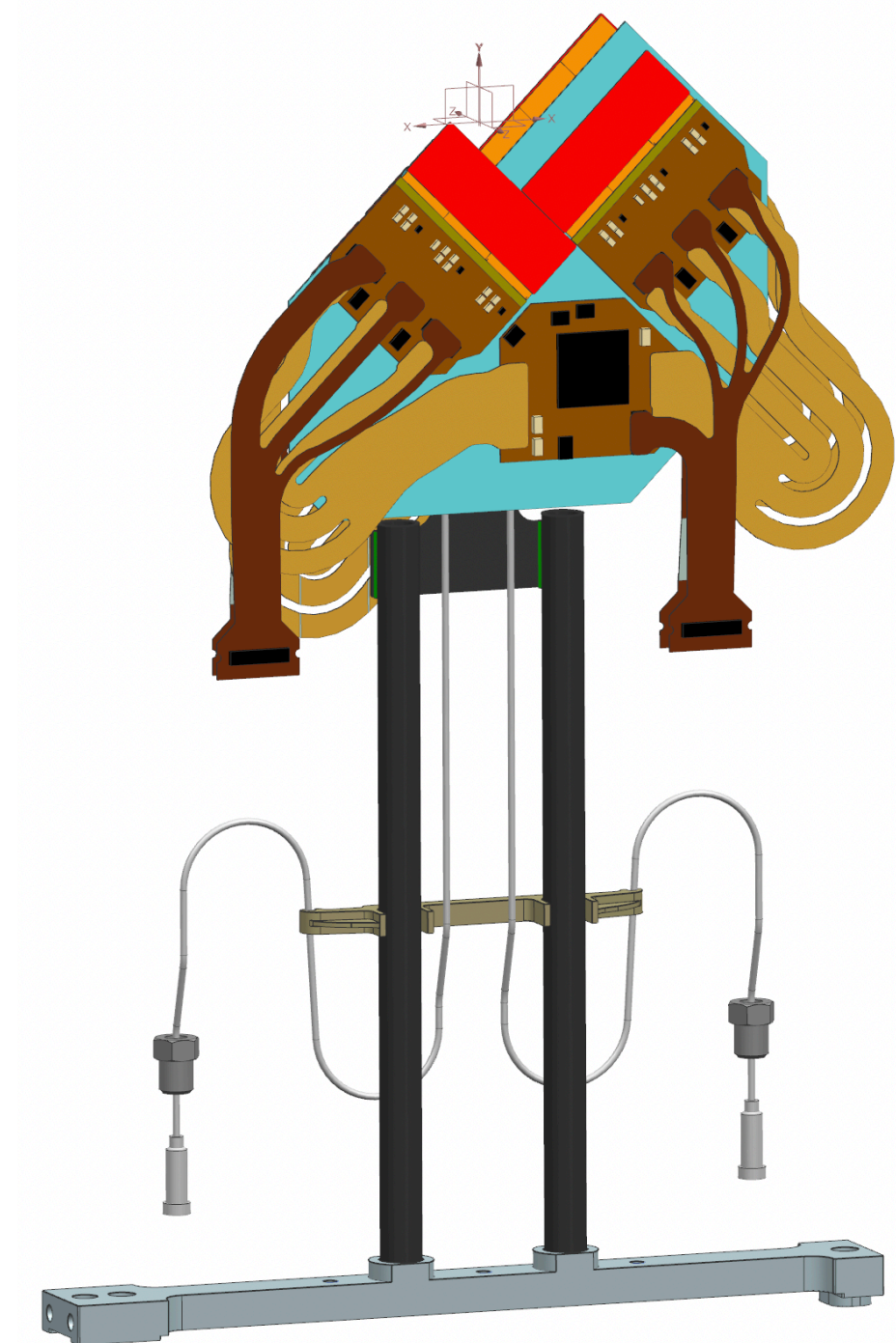
# Module Construction



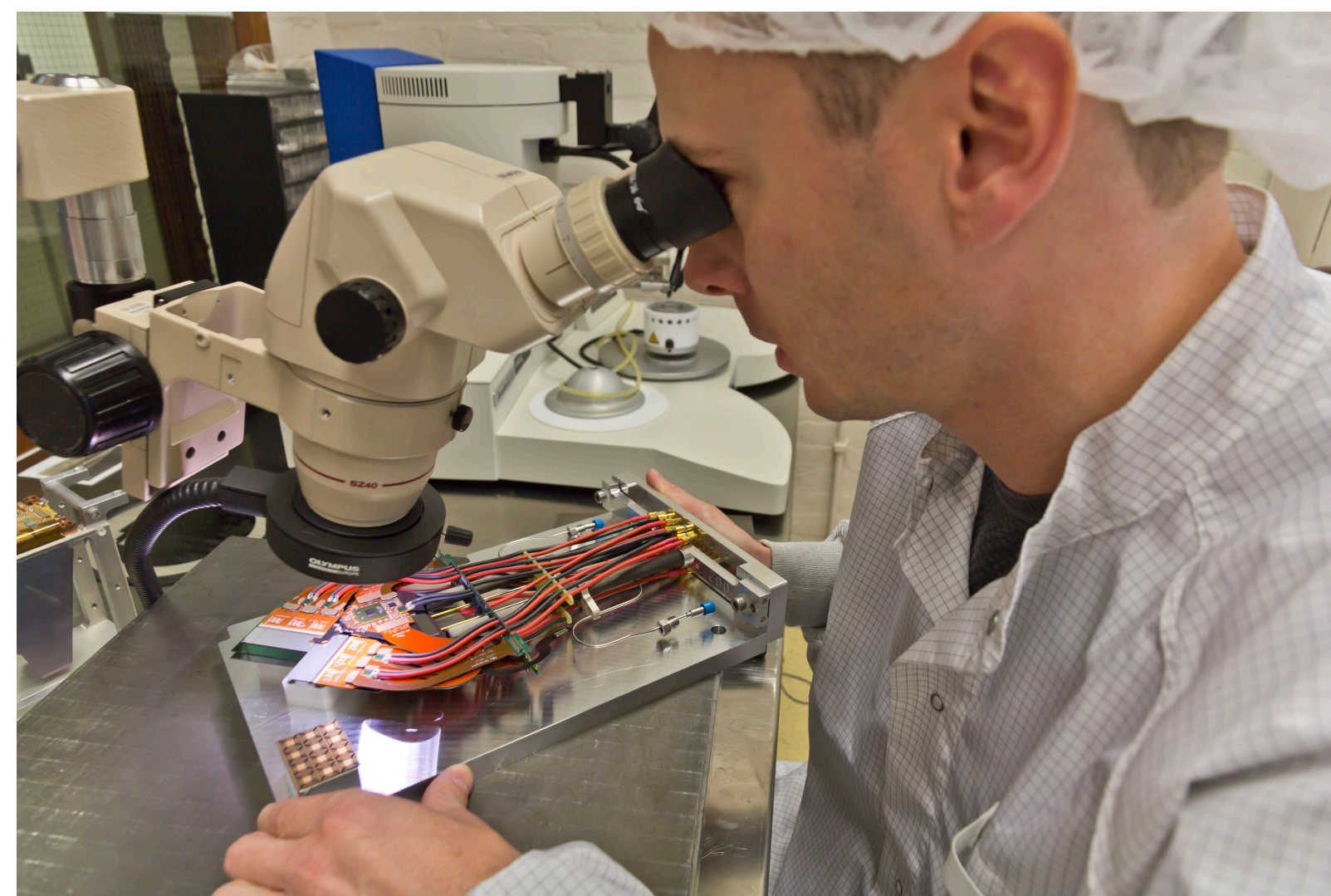
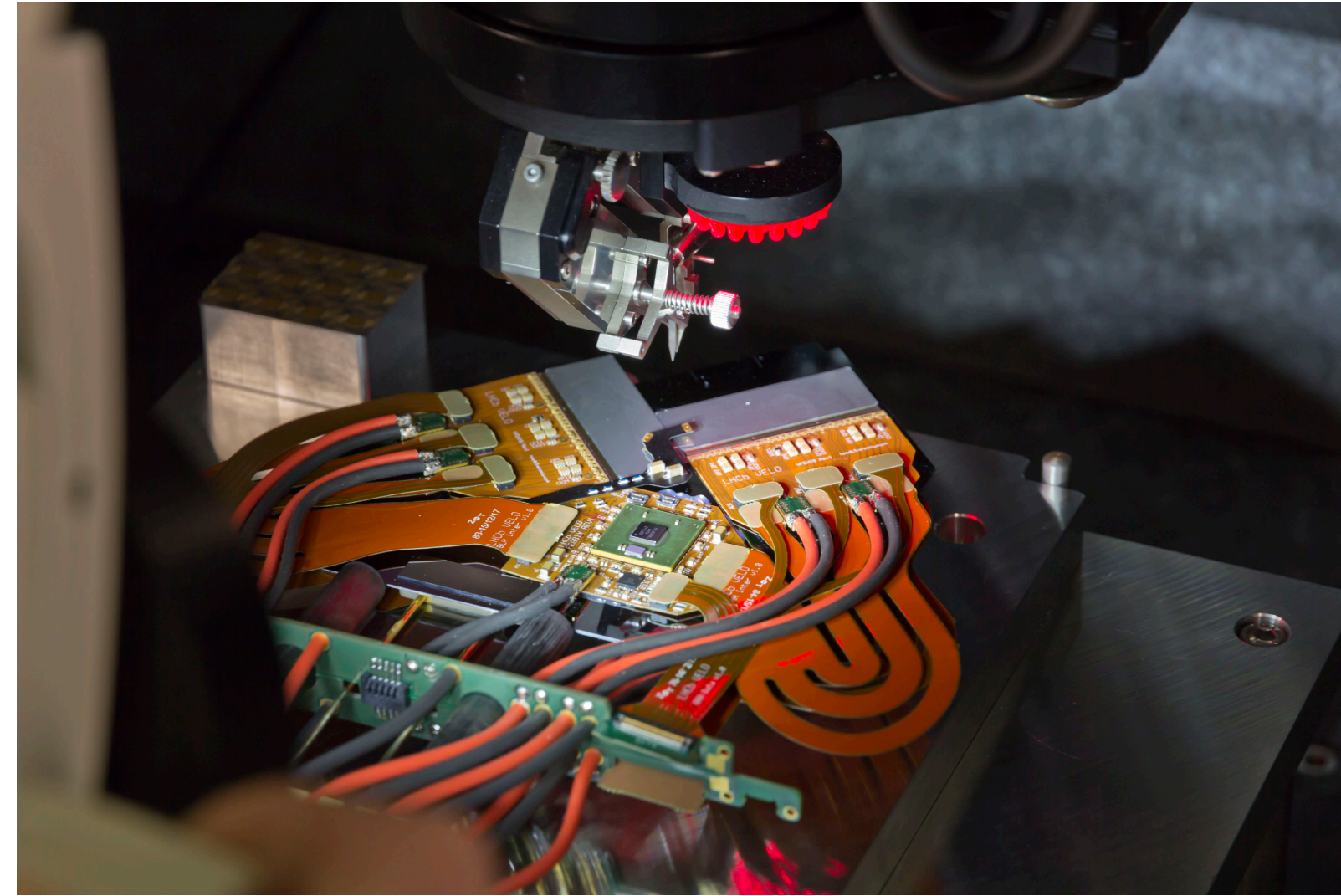
"If it doesn't work this time, I quit..."



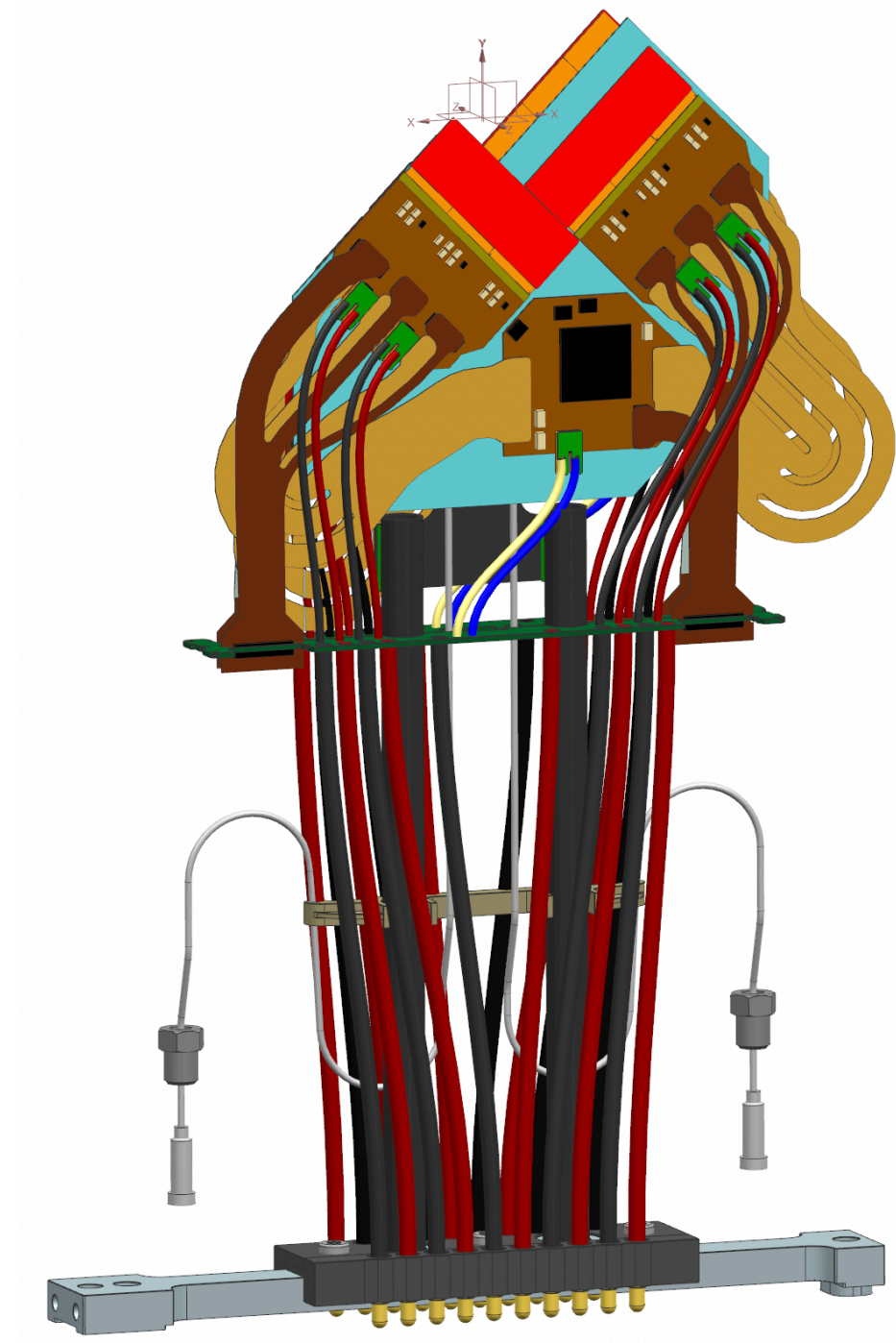
Hybrid placement



# Module Construction



Low voltage attachment  
Wire bonding

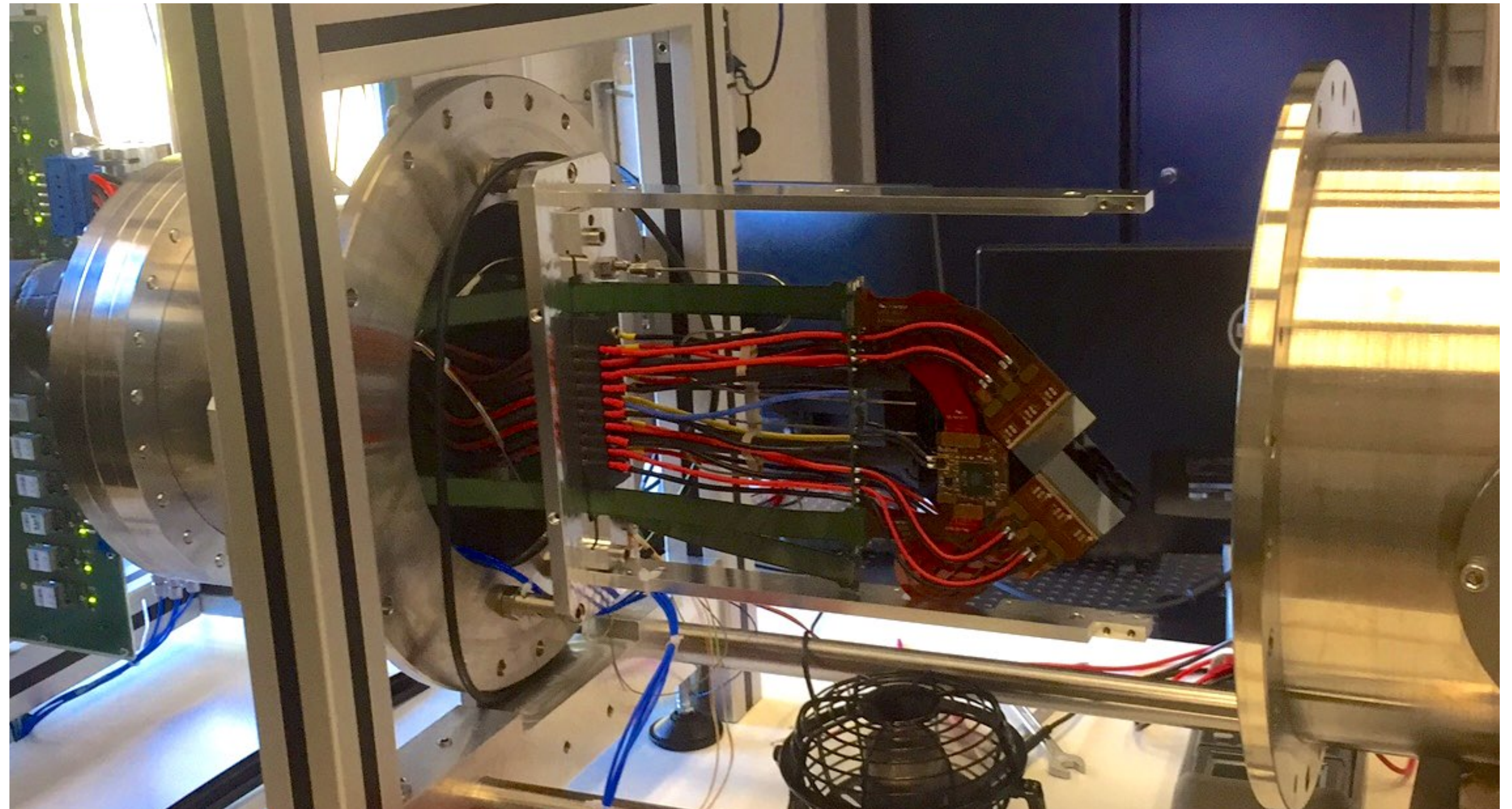




# Qualification

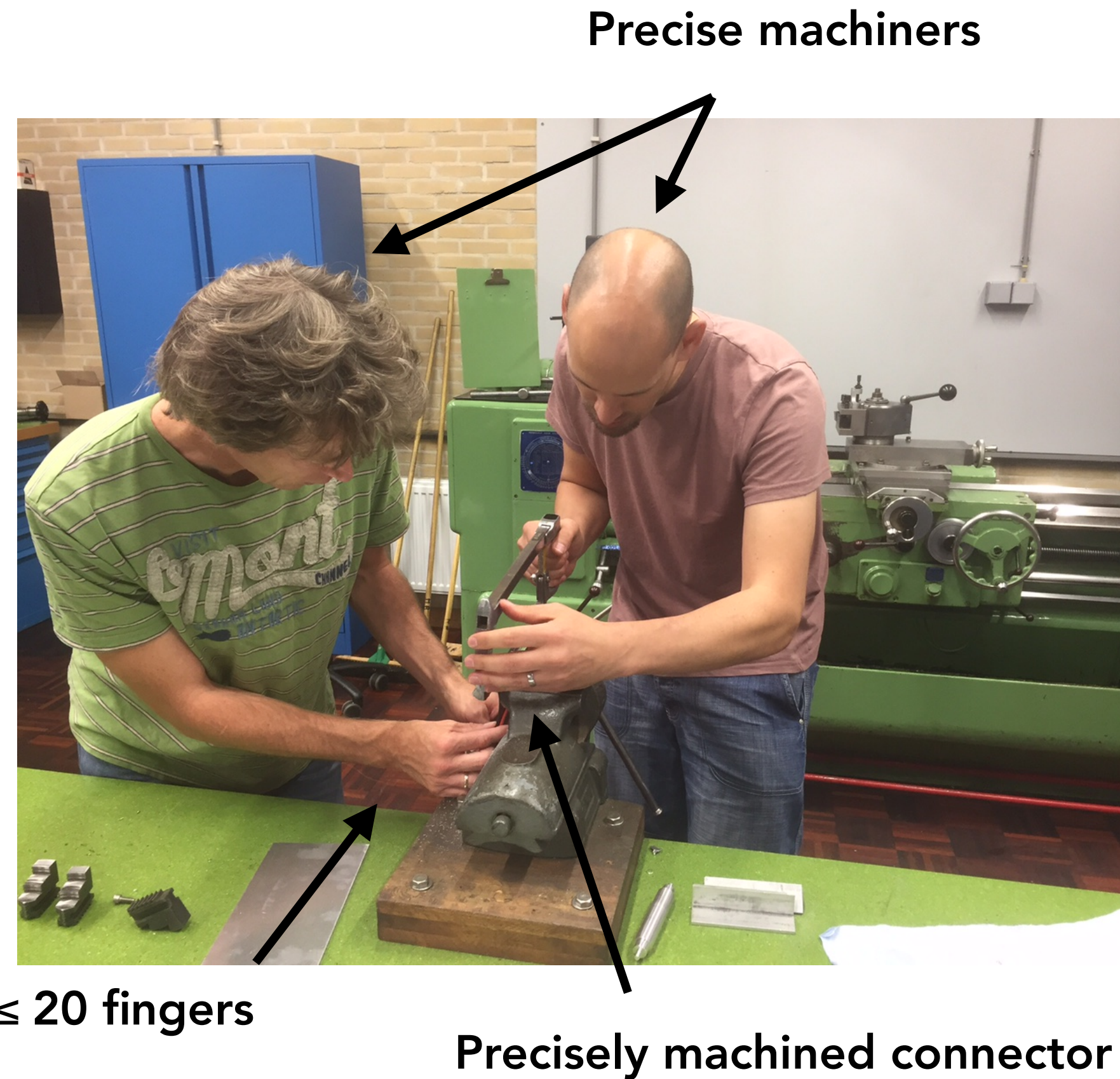
**At last constructed  
But how well? How will it last,  
Entombed in darkness?**

**Extensive testing  
What surprises there await?  
Anticipation**



# The long road

Path is always long  
At all men the scarecrow laughs  
Improvisation...



# Enthusiasm abounds

**Enthusiastic student**



**Enthusiastic engineer**

**Enthusiastic measurements**

# Enthusiasm abounds

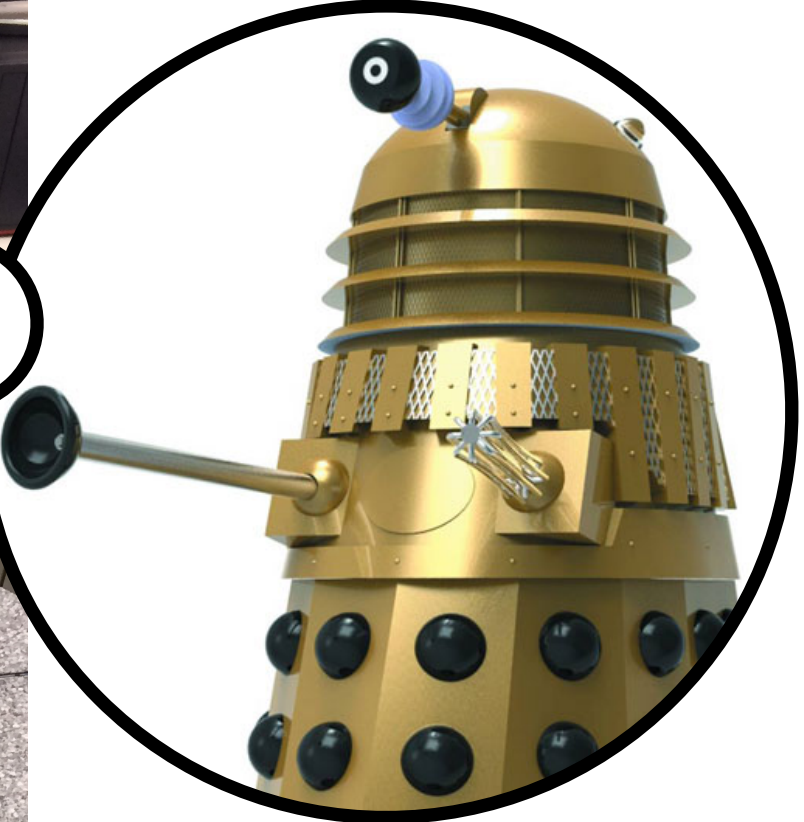
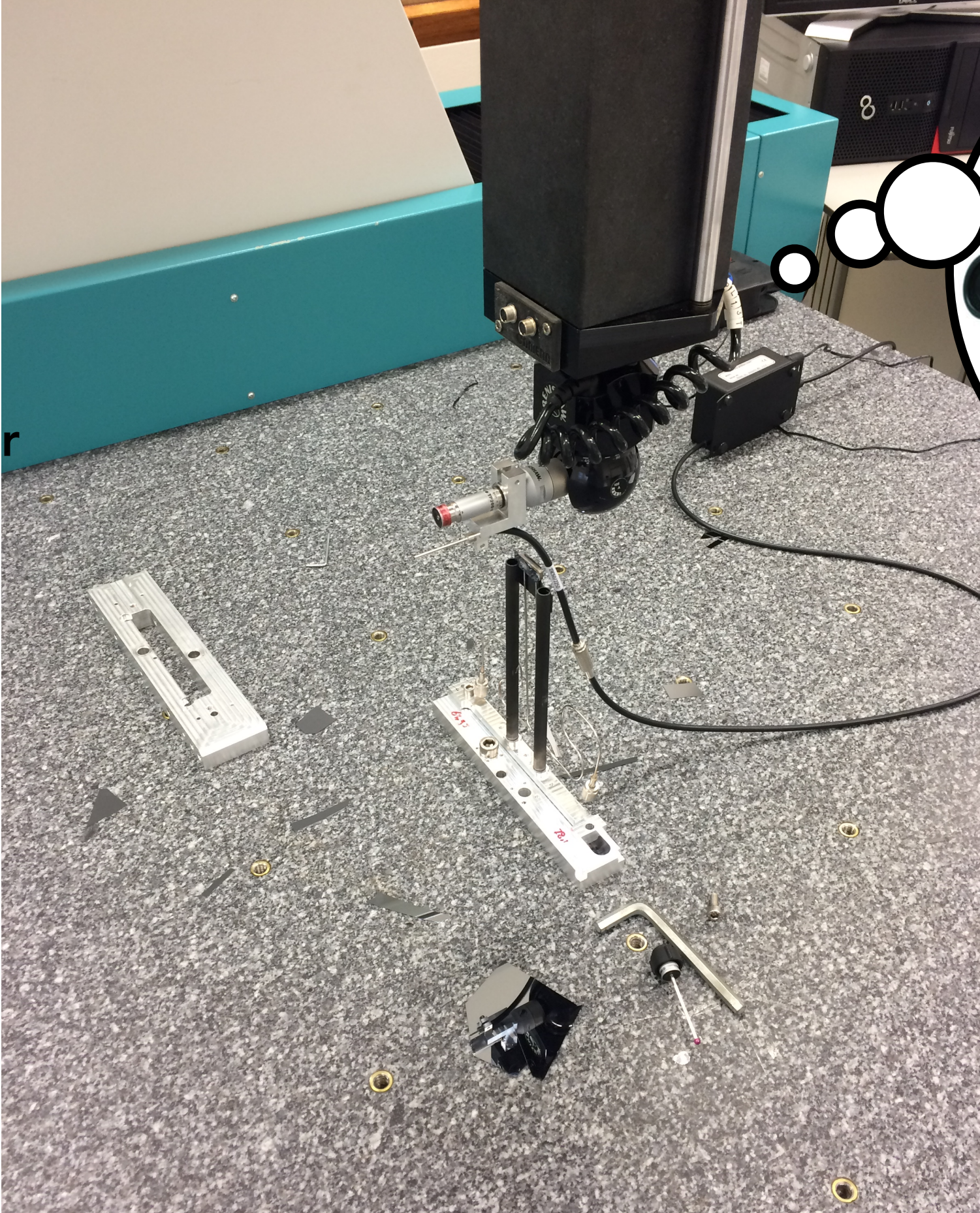
**Enthusiastic student**



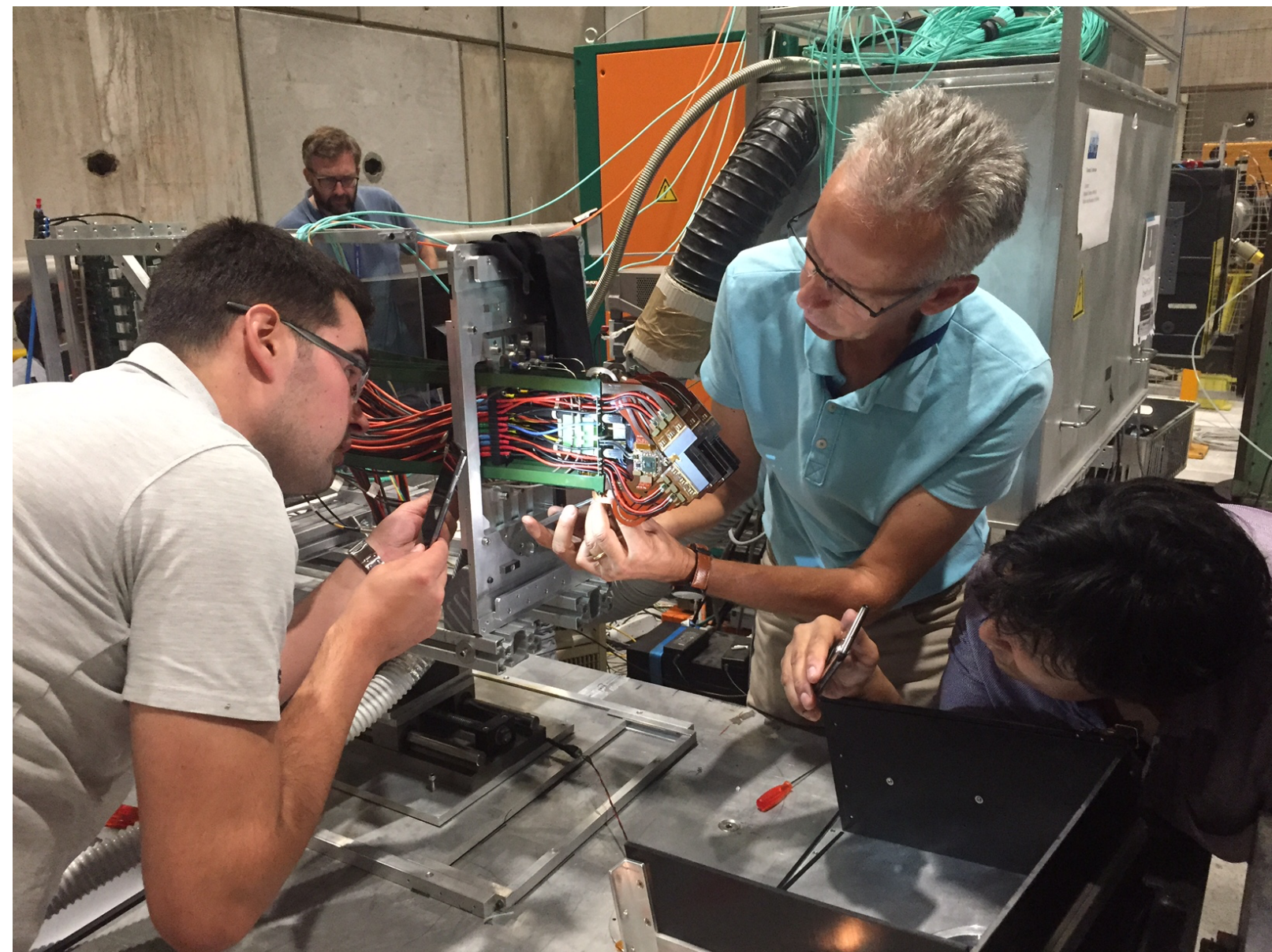
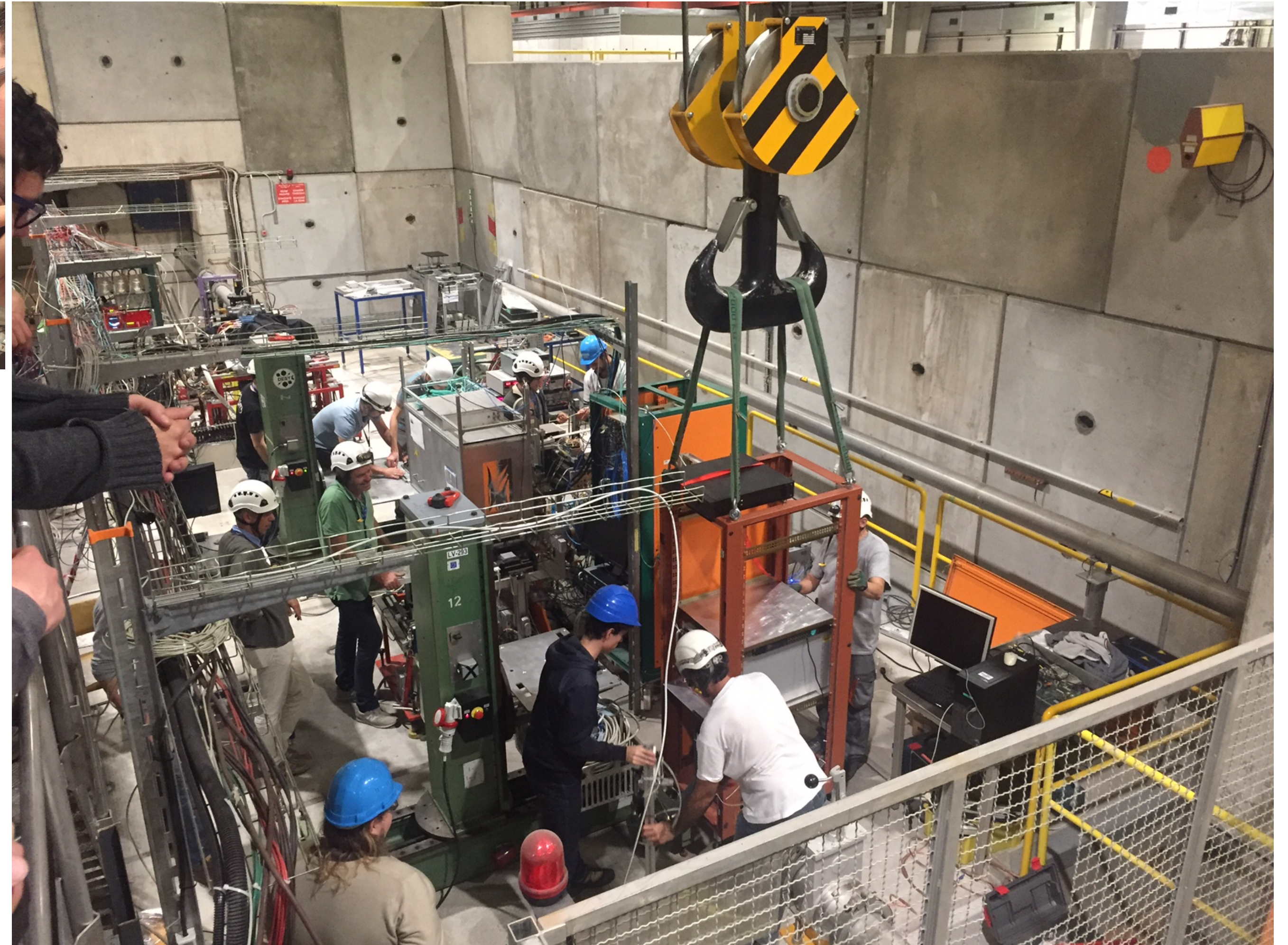
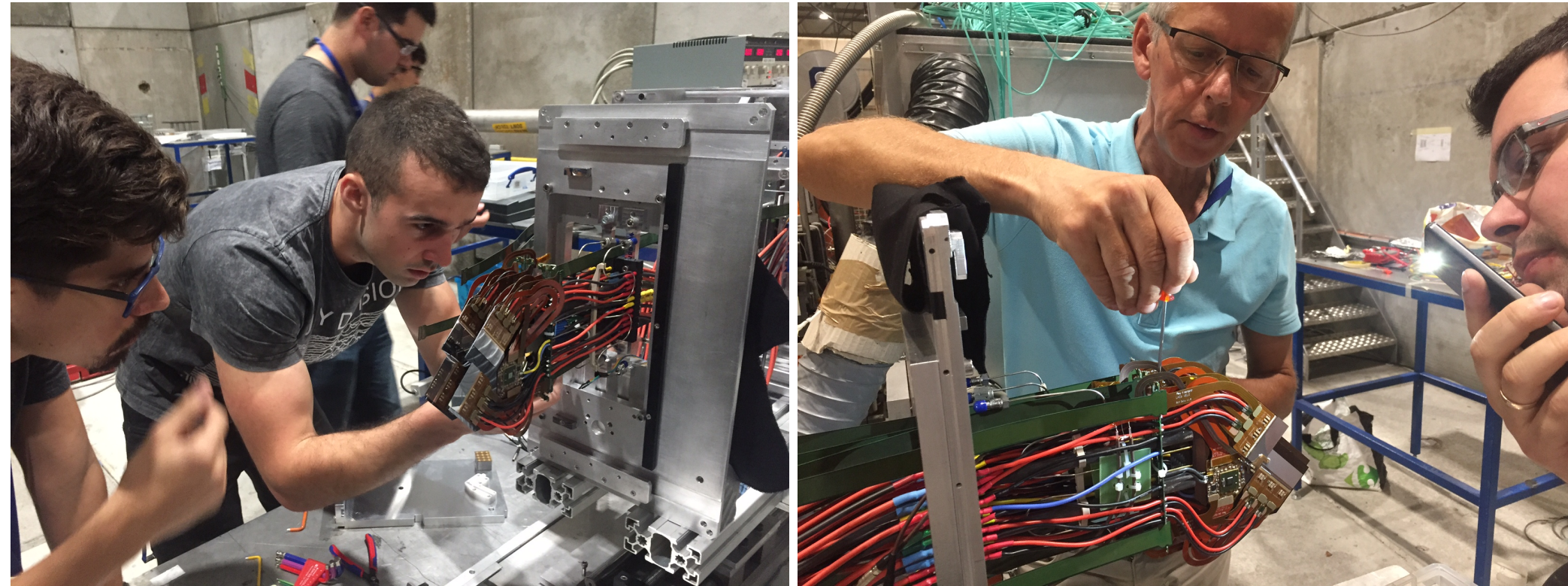
**Enthusiastic engineer**

**Enthusiastic measurements**

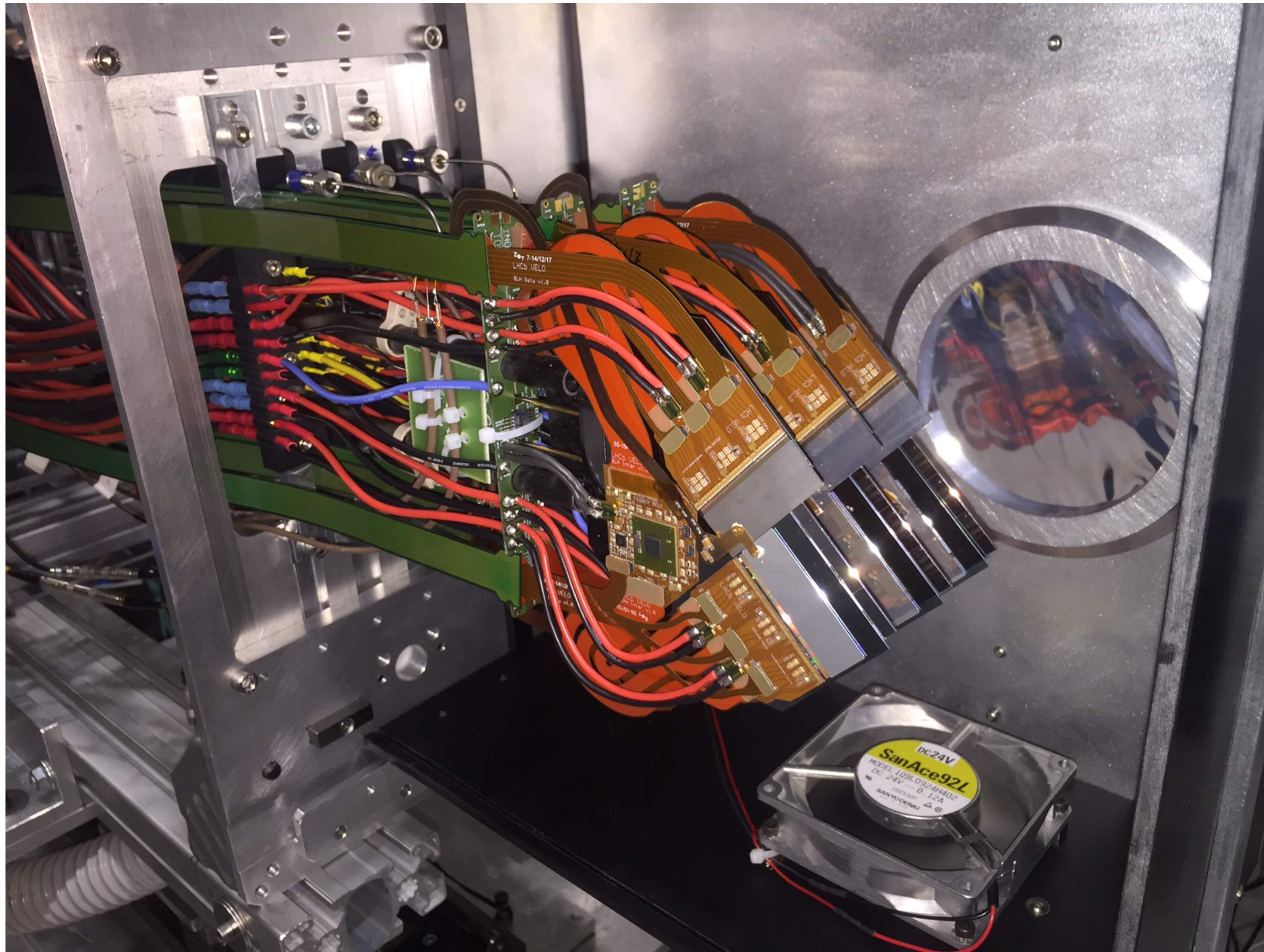
**Enthusiastic robot!**



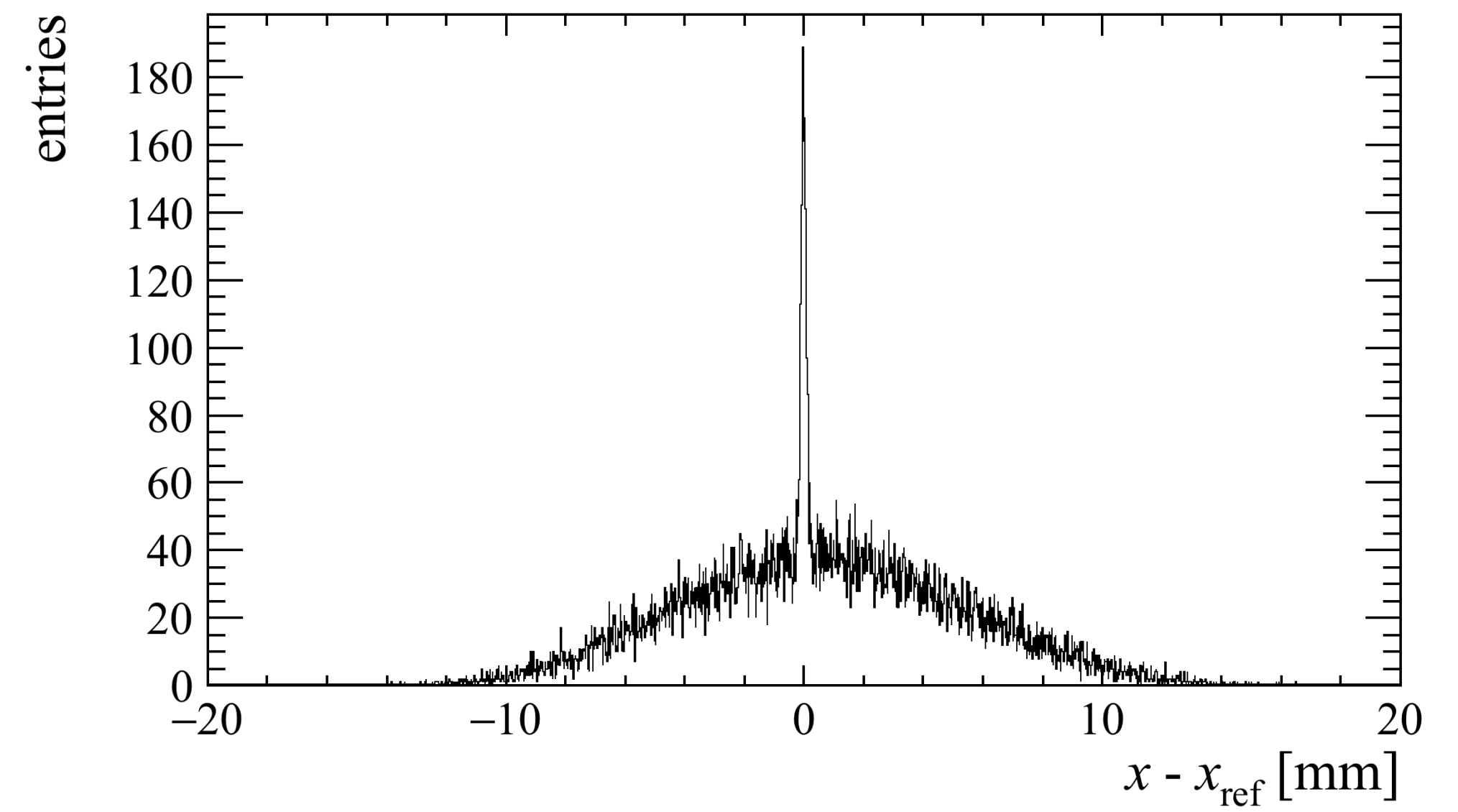
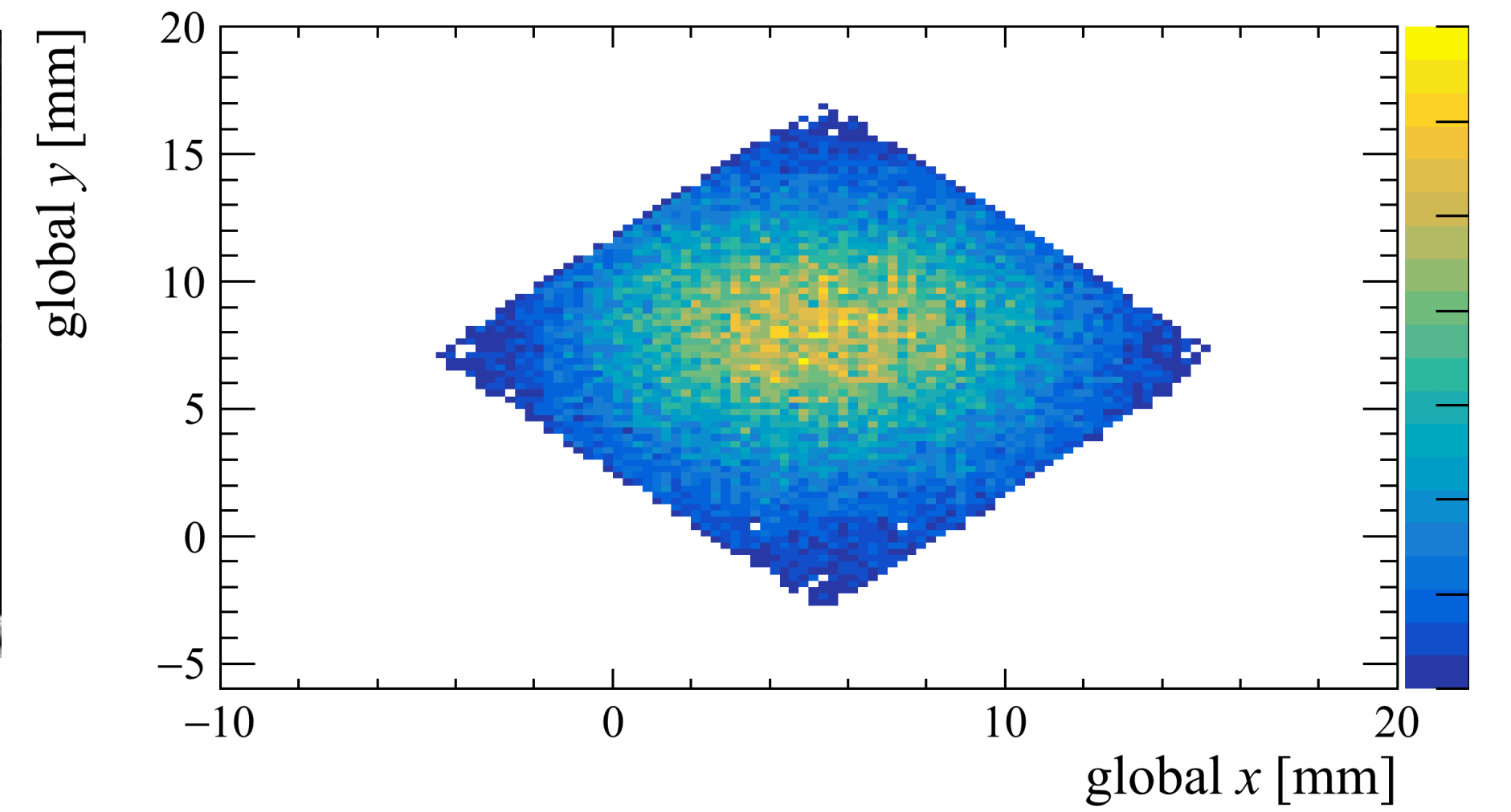
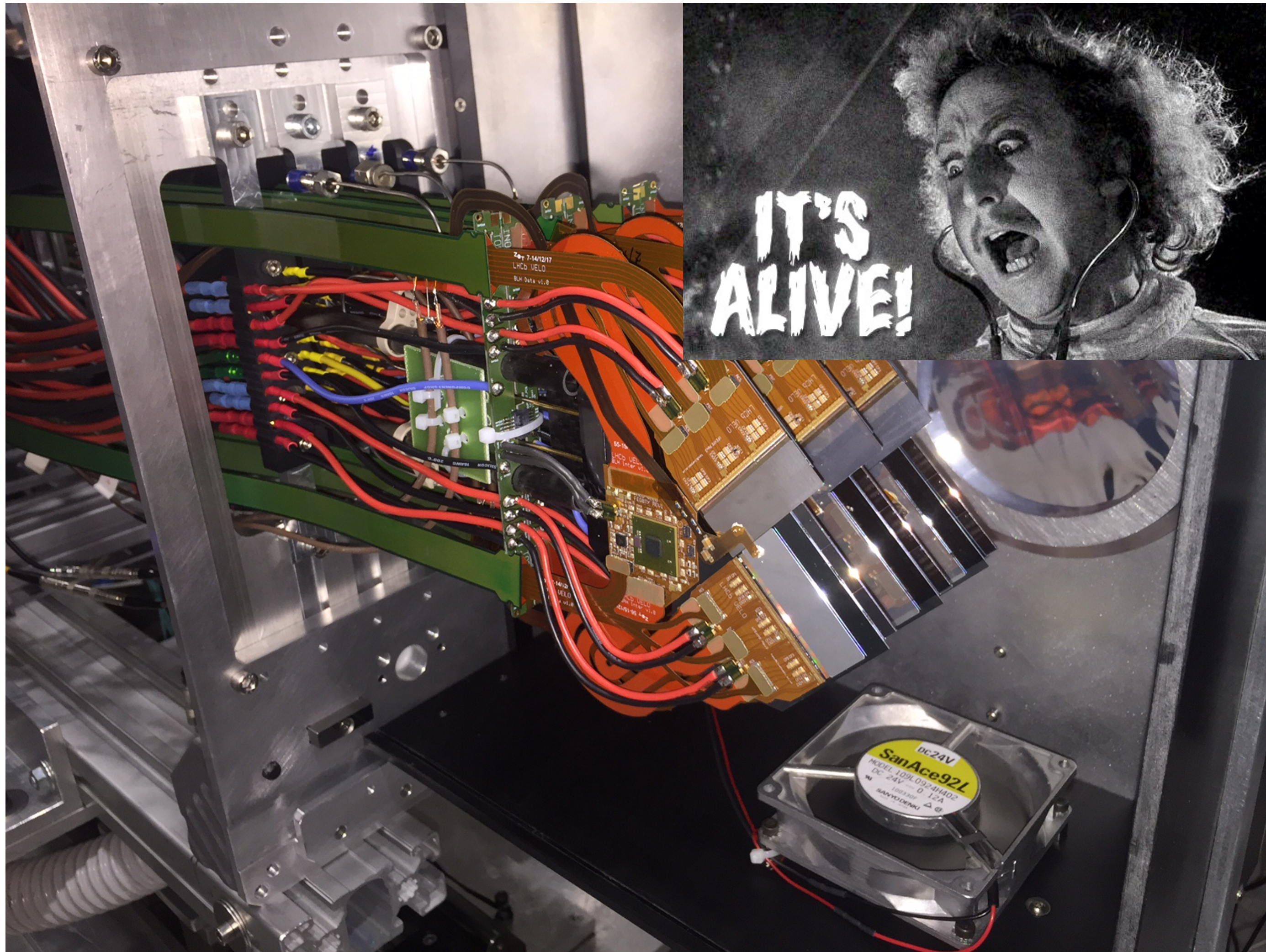
# The real test - October 2018



# VELOscope



# VELOscope

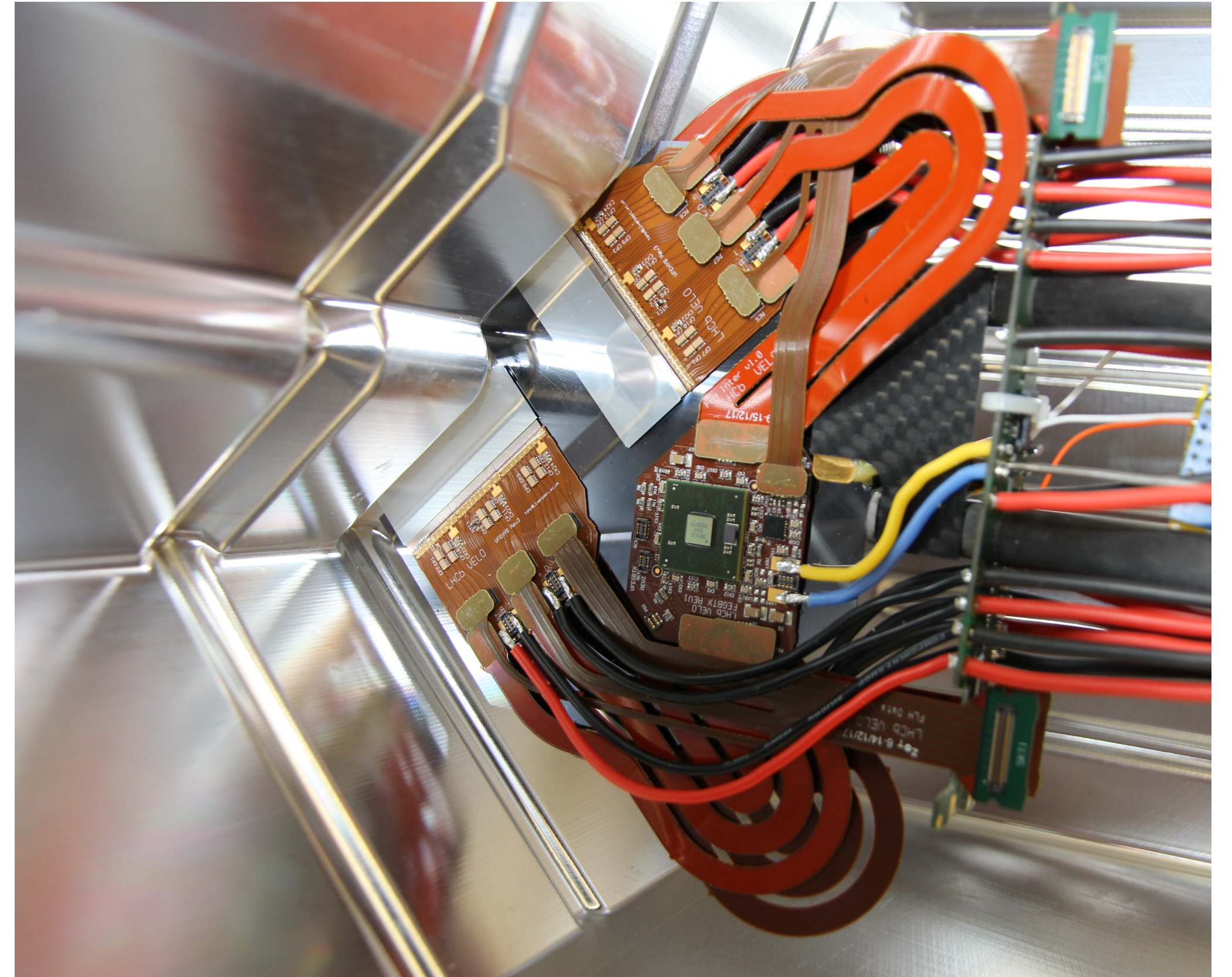
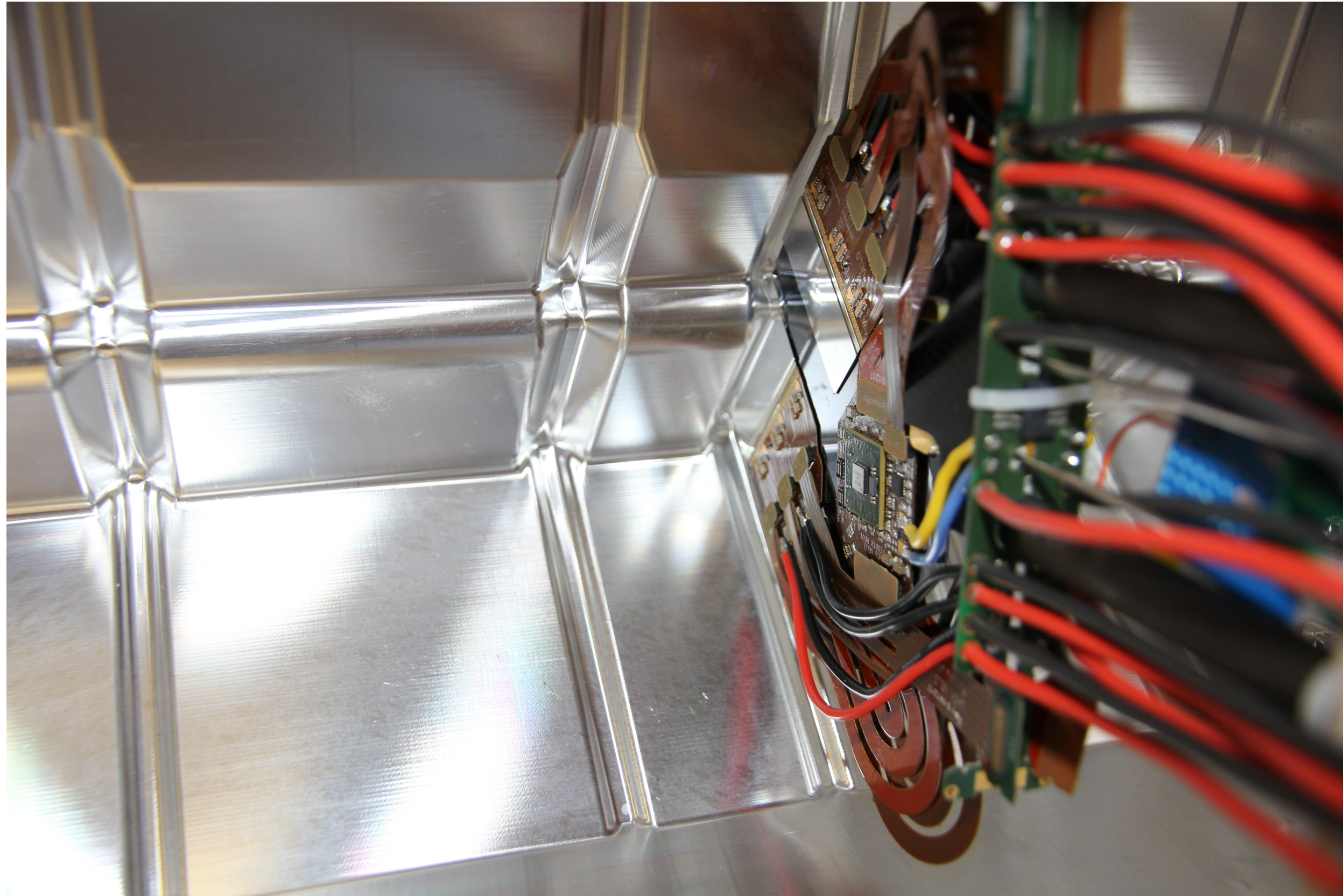


# Celebration all round!





# The RF foil



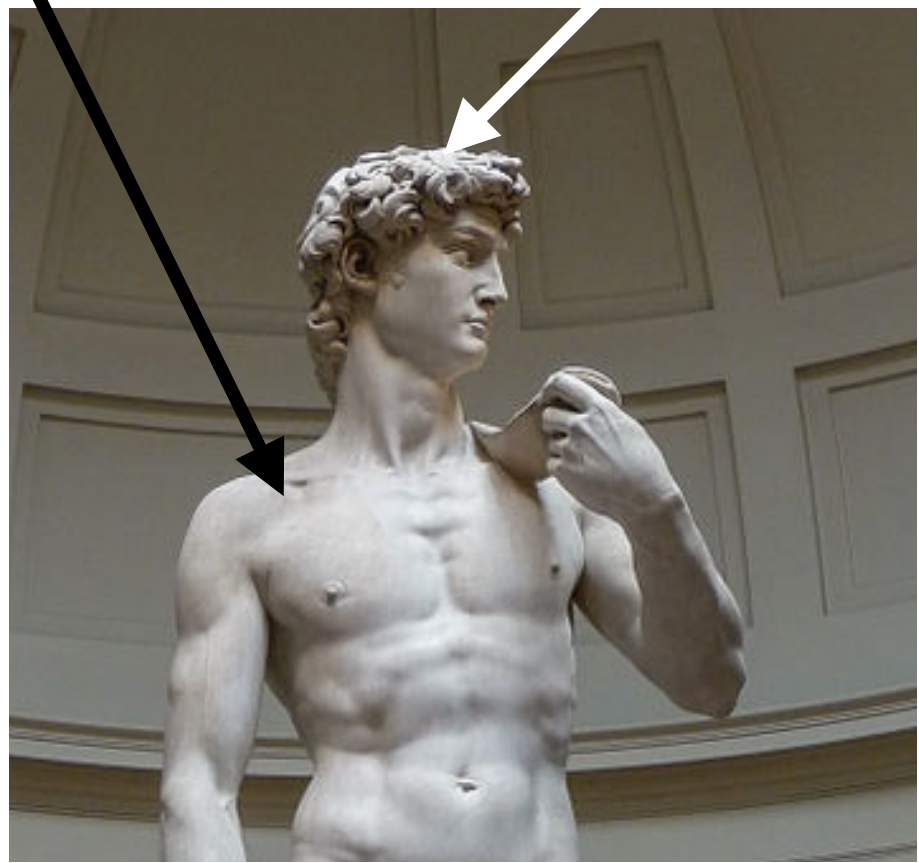
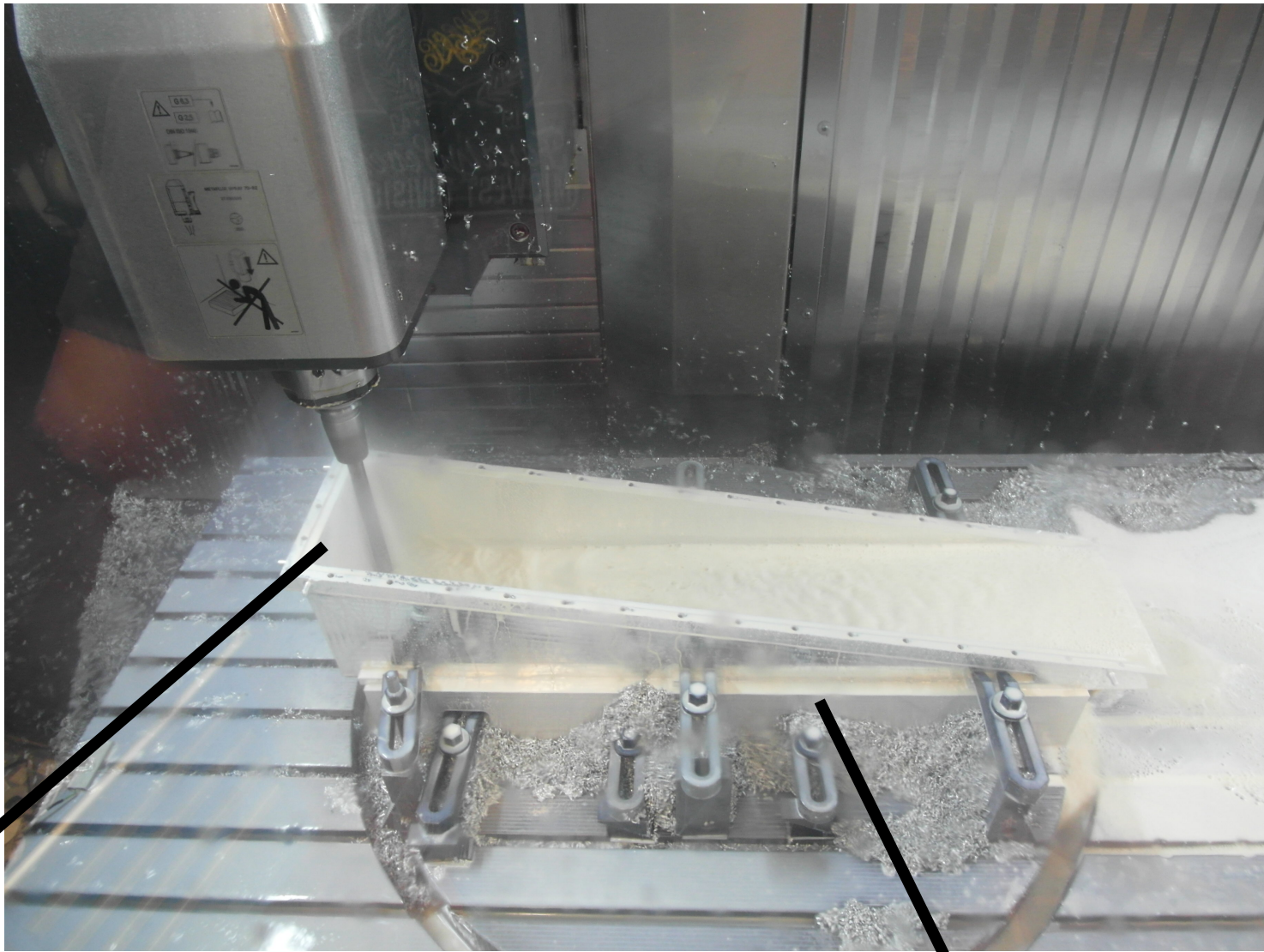
# Antique sculpting



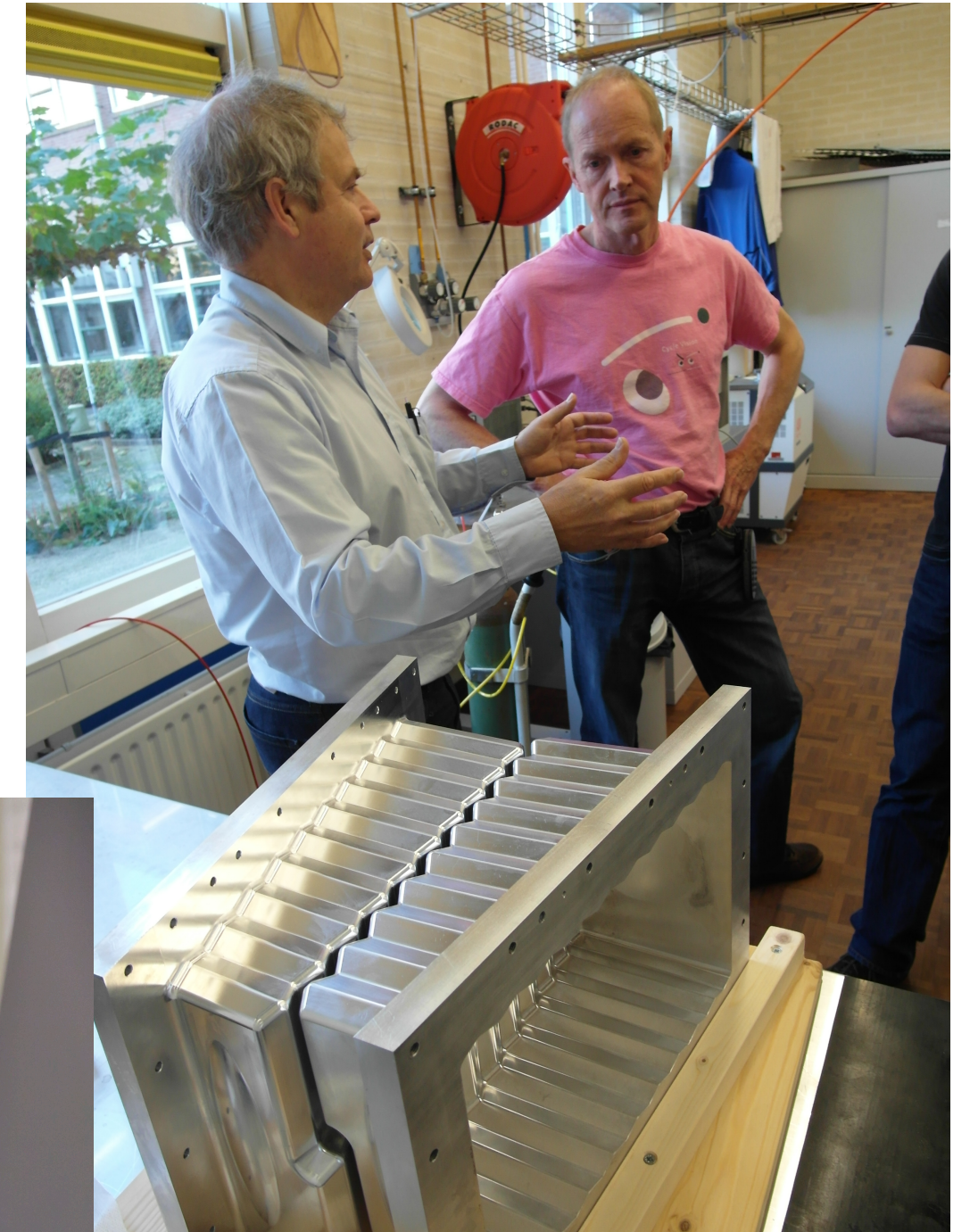
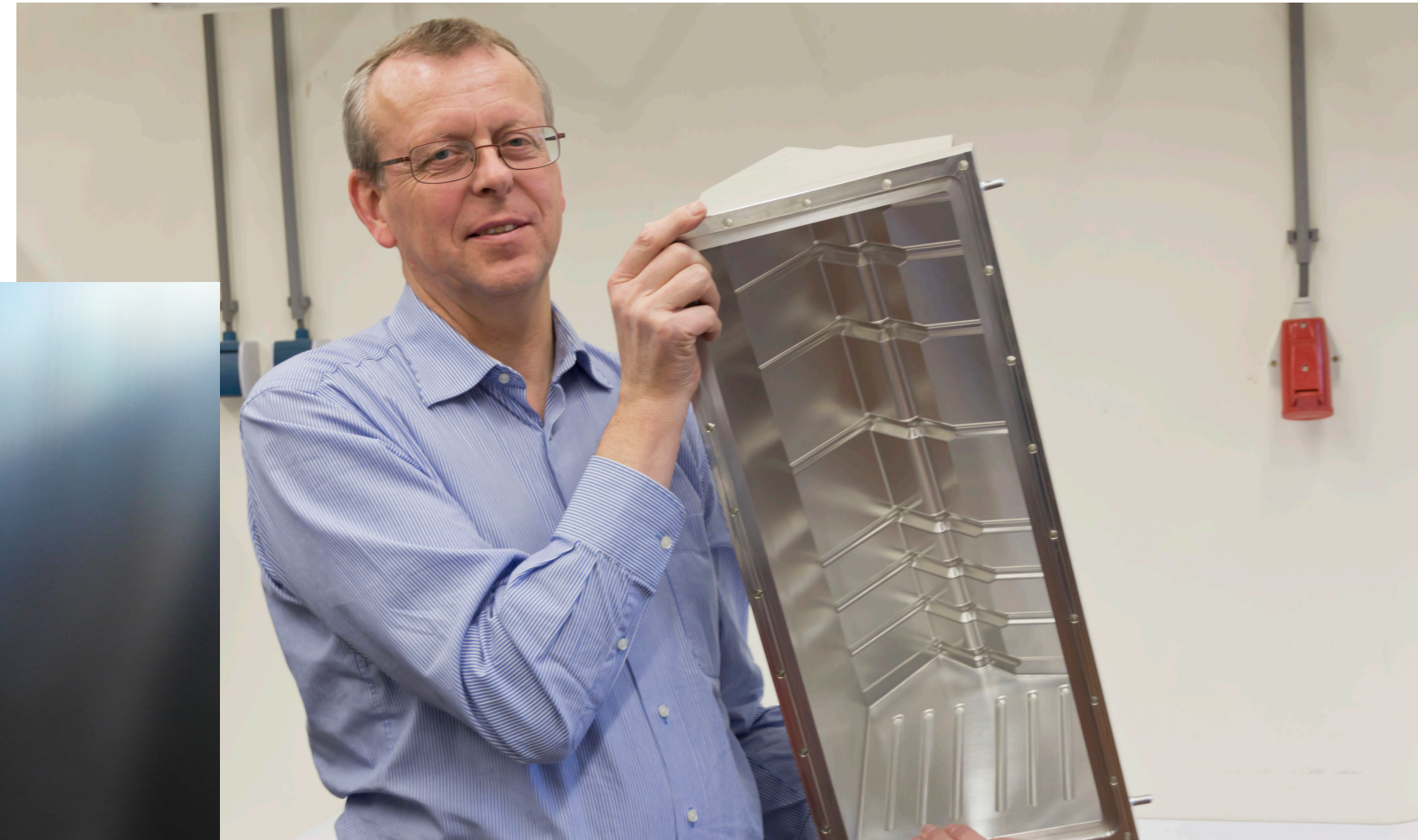
# Modern day sculpting



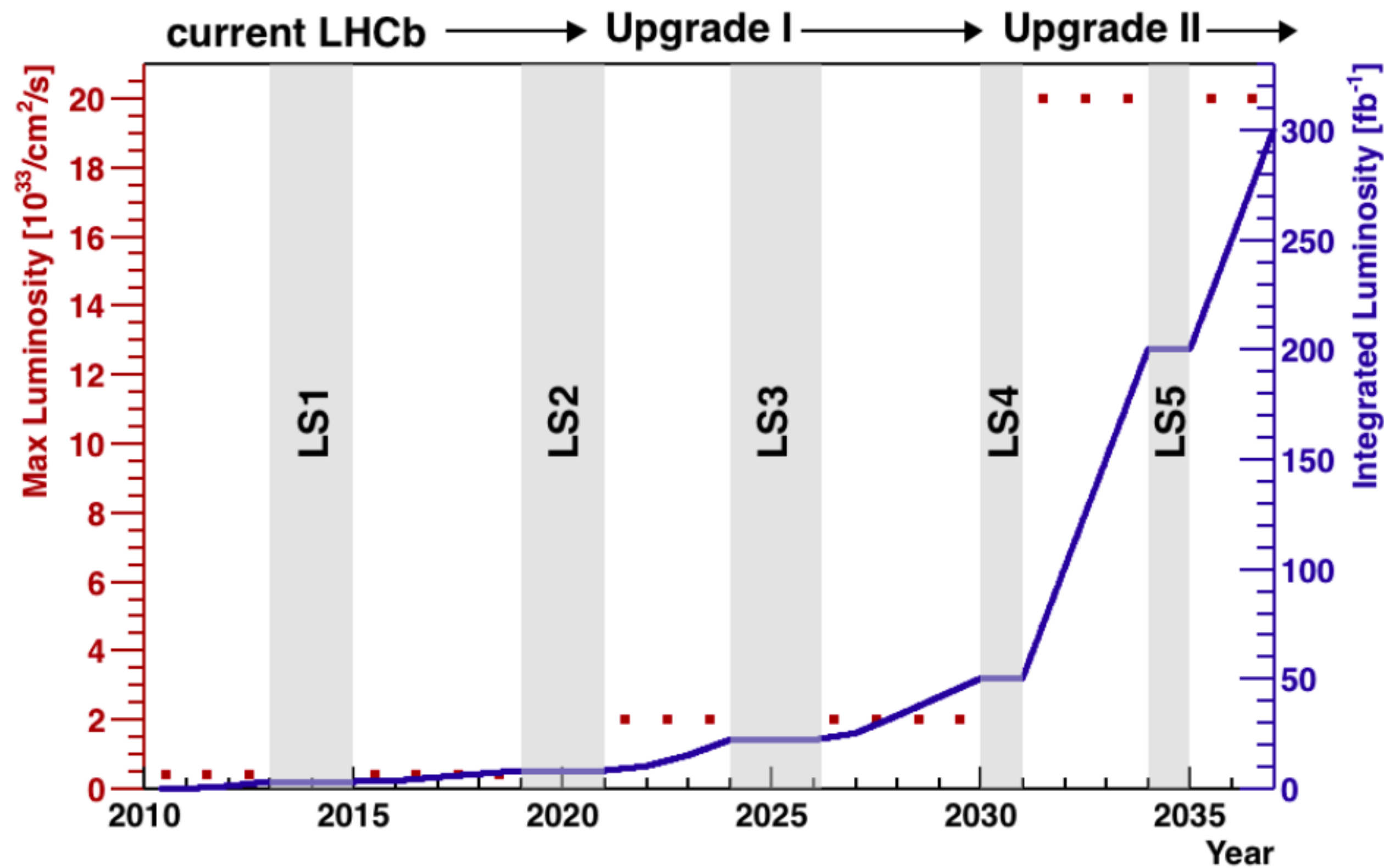
# Modern day sculpting



# The RF foil

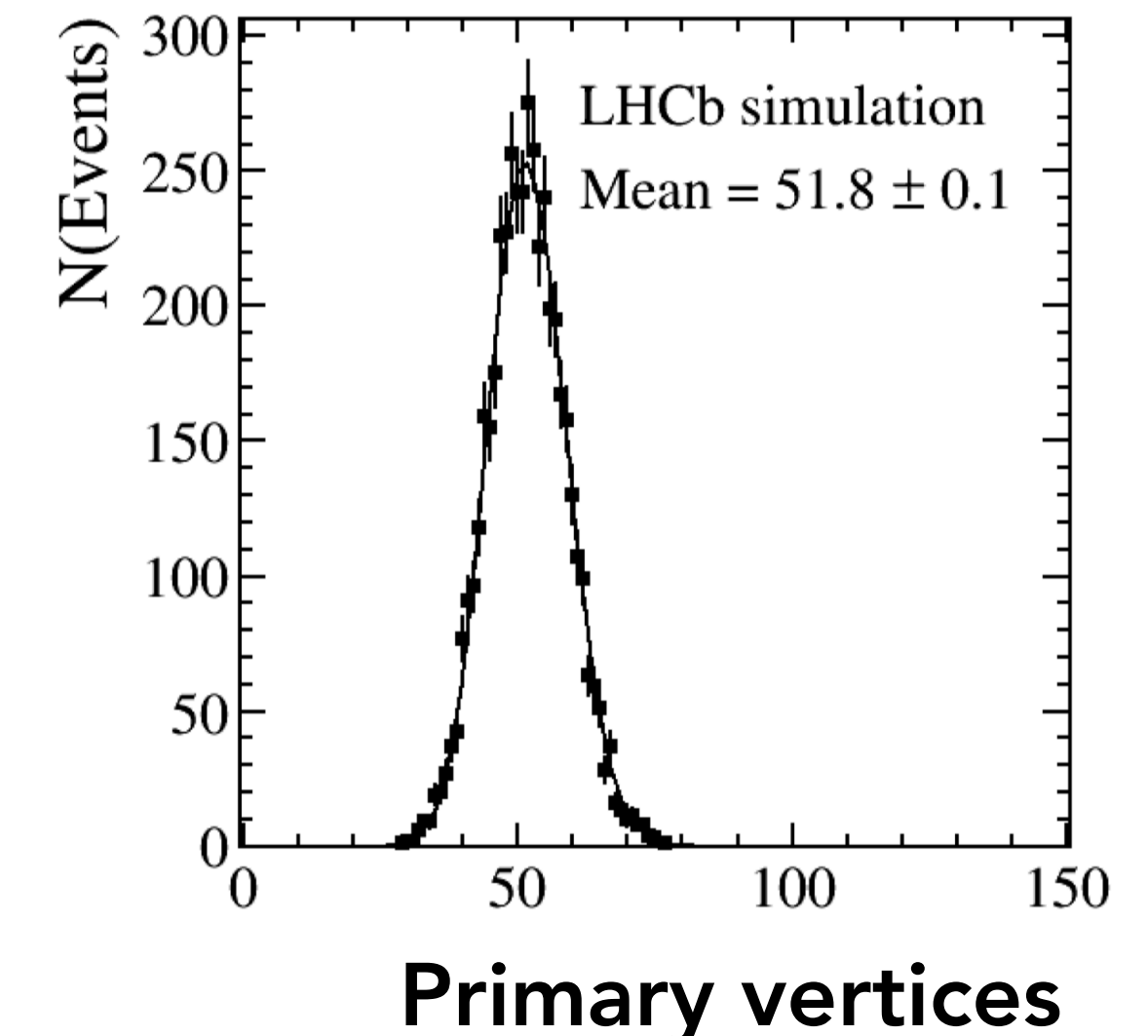
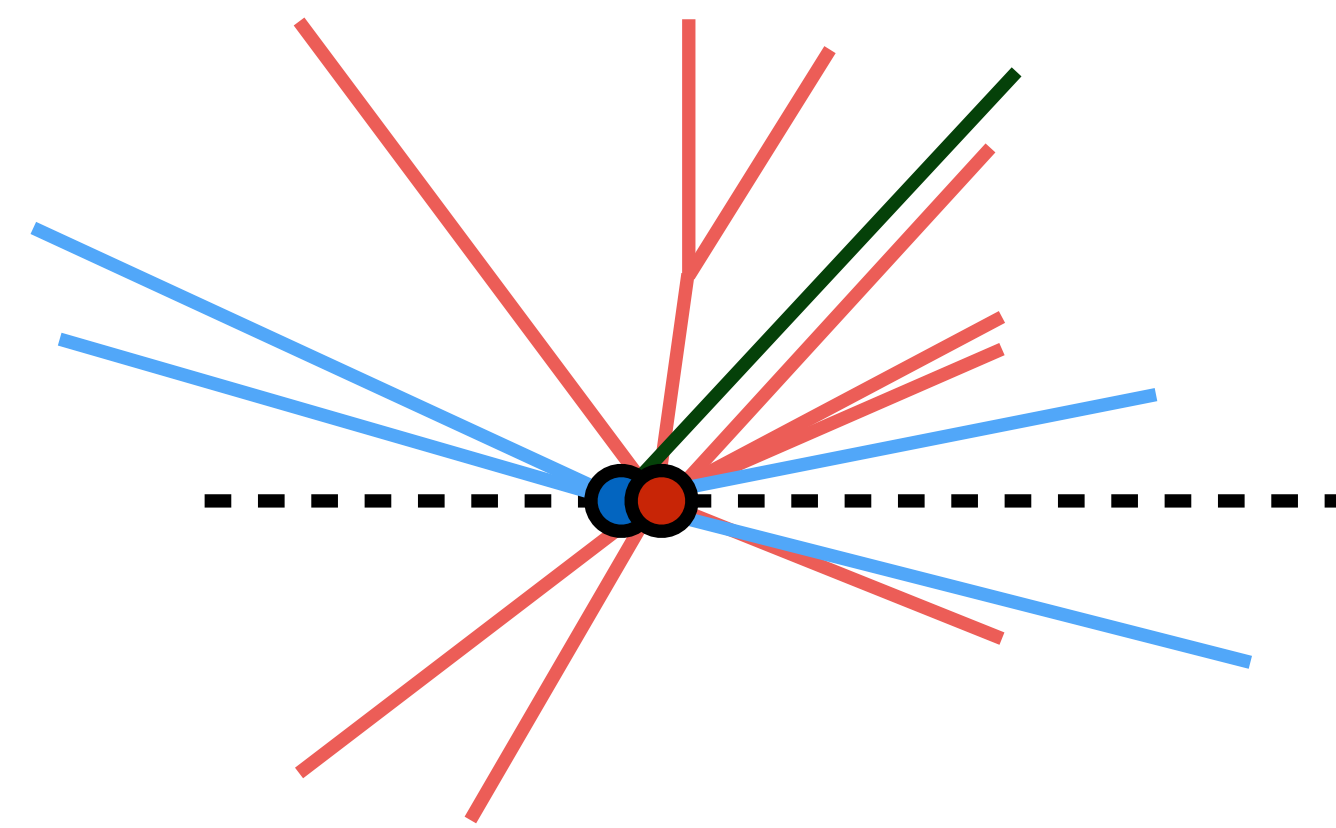


# LHCb Upgrade II

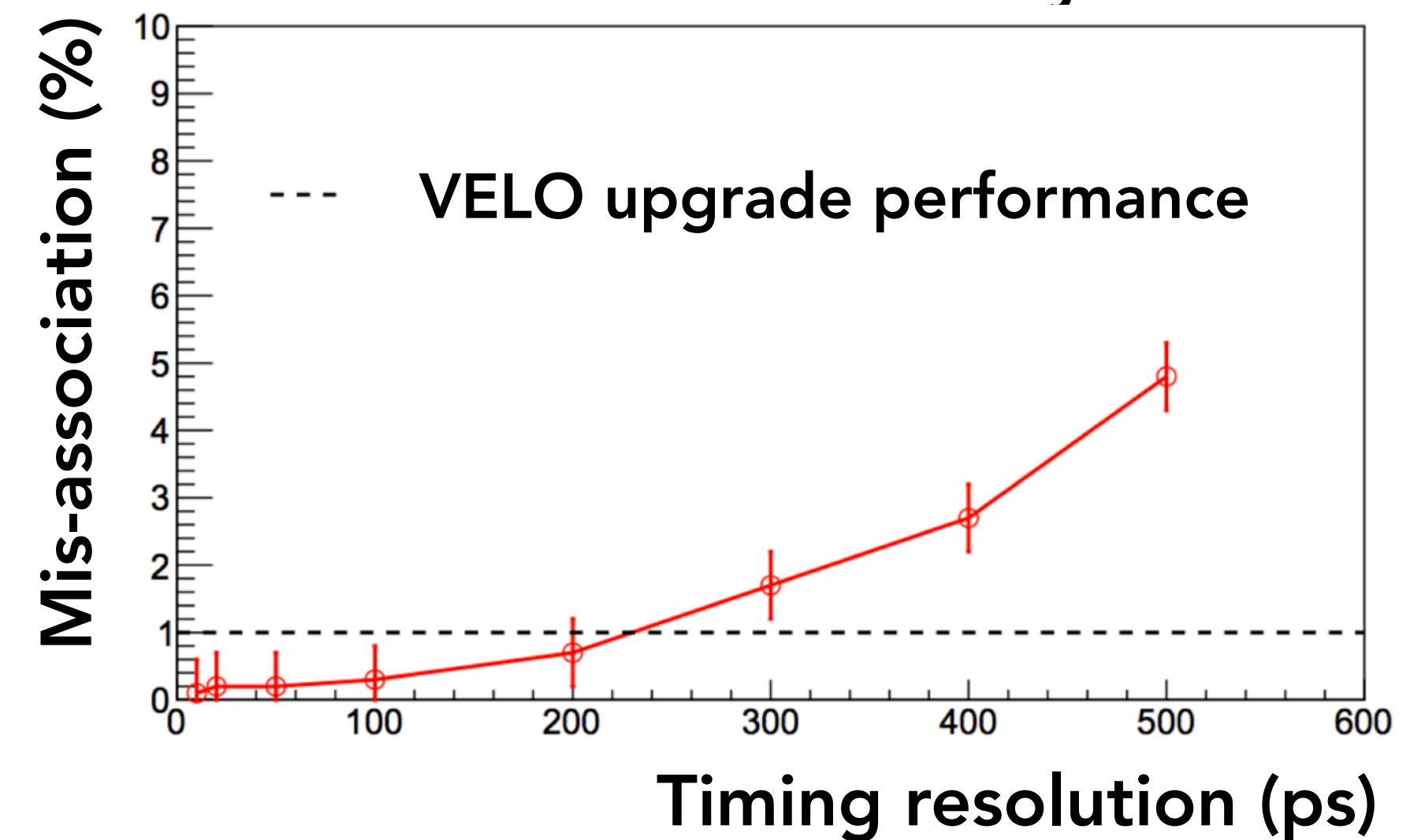


Target: Run LHCb at  $2 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$

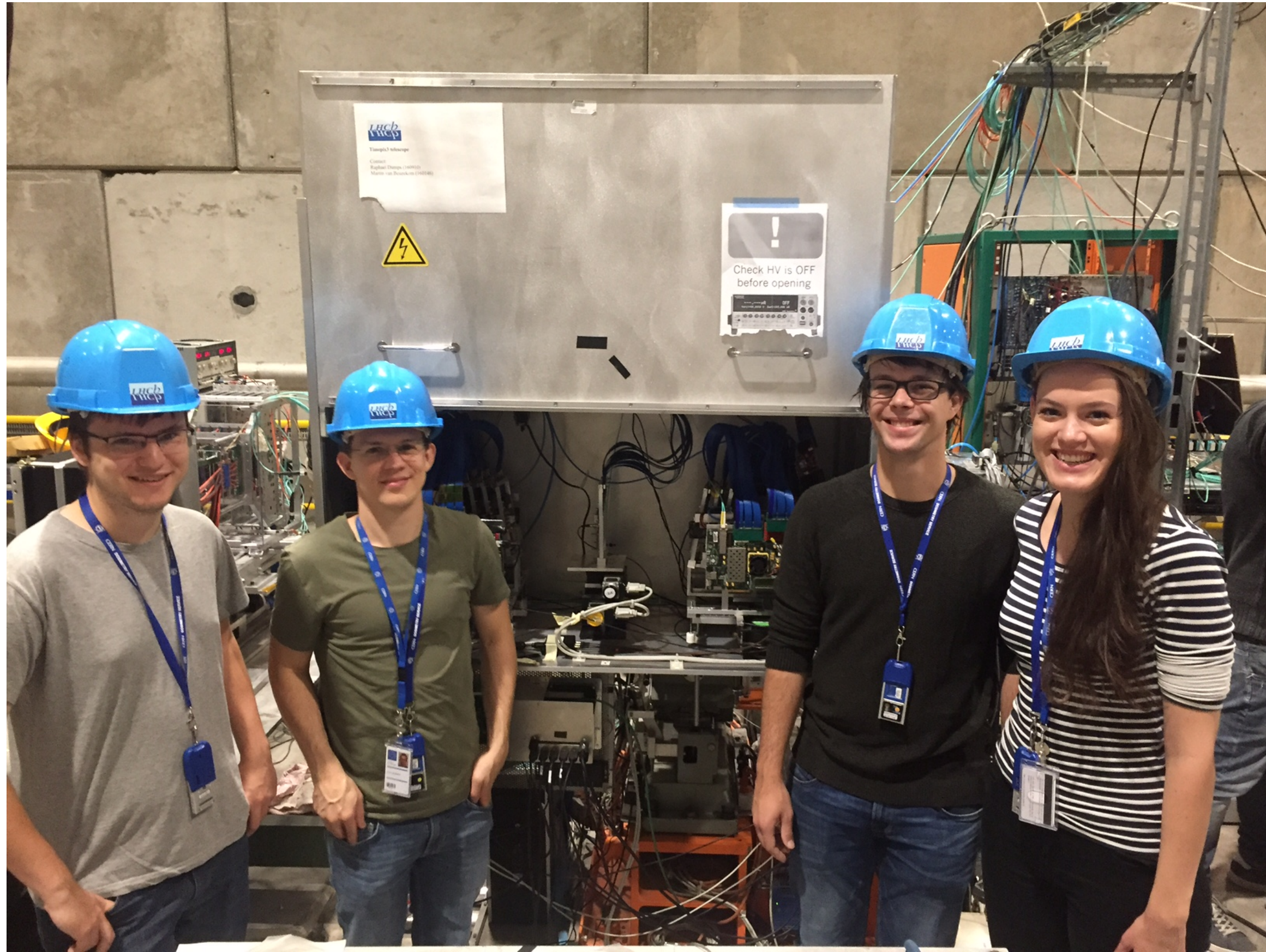
The old stork divines  
Track origins, which vertex?  
Ambiguity



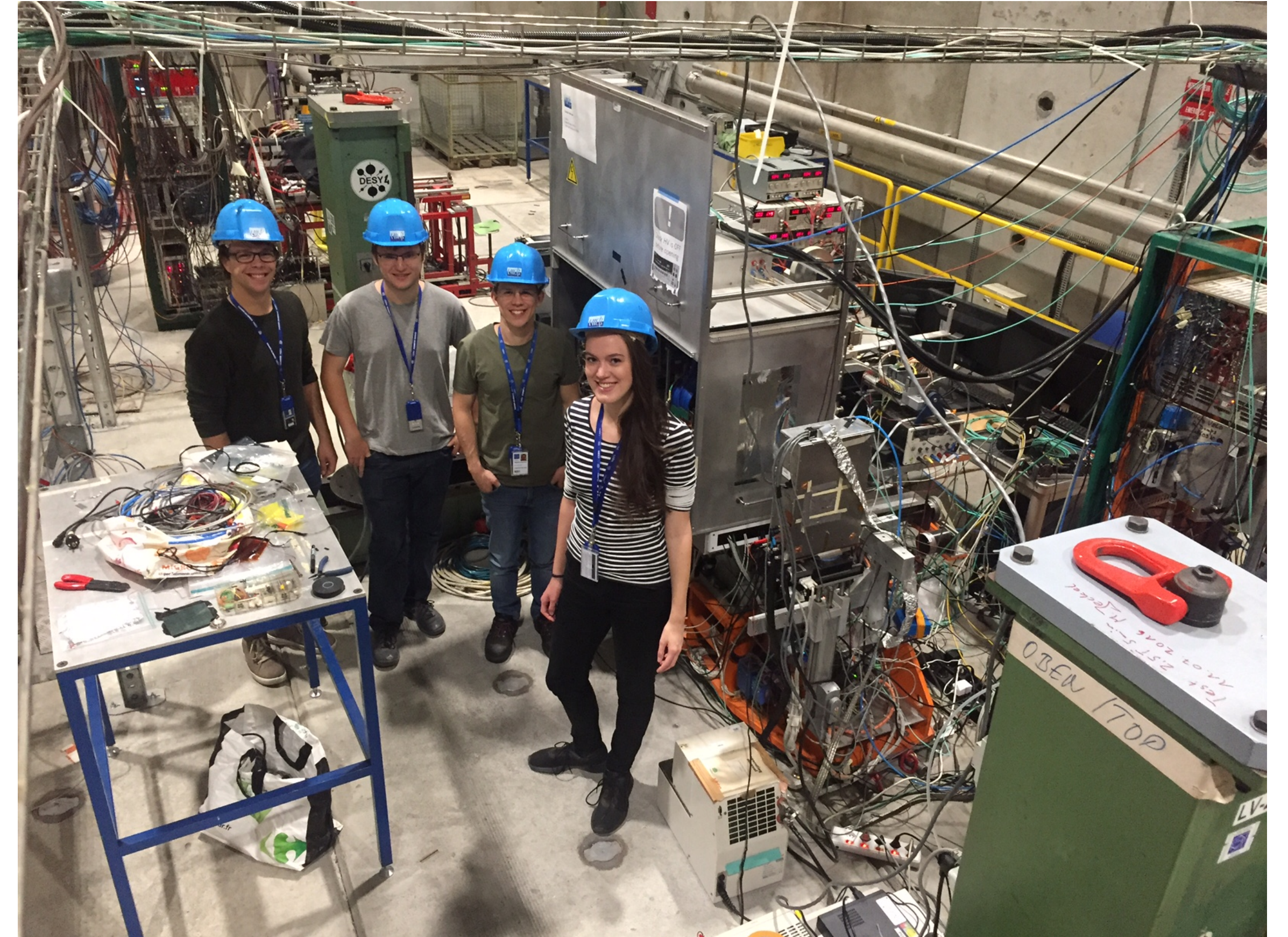
Our philosophy:  
Keep performance going forward  
No trigger, much work



# Collaboration on fast timing

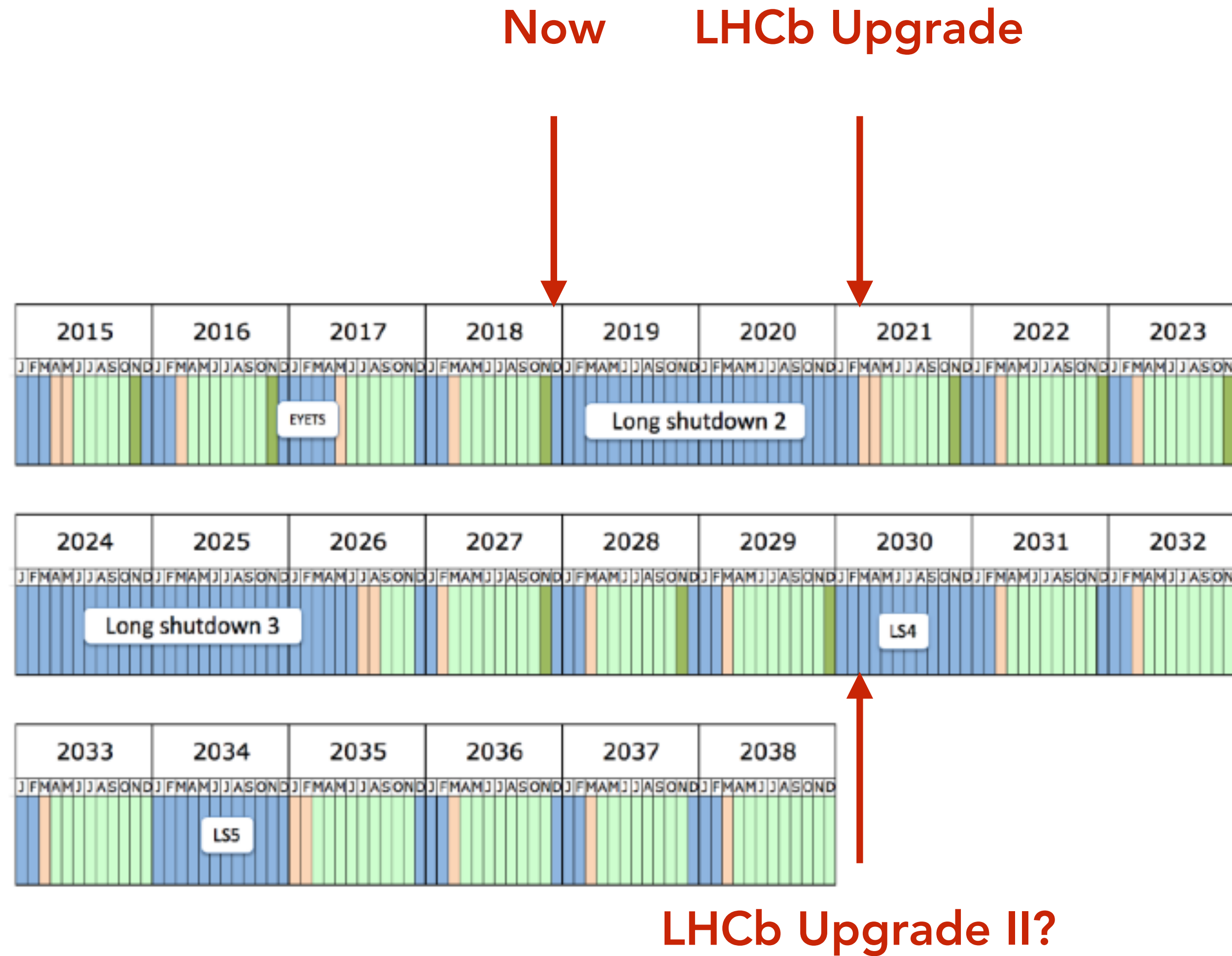


More in talk by Martin Fransen





# Looking forward



VELO Upgrade II Workshop 2019



LHCb Upgrade II Workshop 2019 Amsterdam

Thank you for your attention!

**Bright eyes look forward  
Much excitement begins now  
Multiple Yoda**



**VELO Upgrade II Workshop 2019**



**LHCb Upgrade II Workshop 2019 Amsterdam**