

Towards a realistic design for a forward tracker at the ILC

I. Garcia

M.A. Villarejo

M. Vos



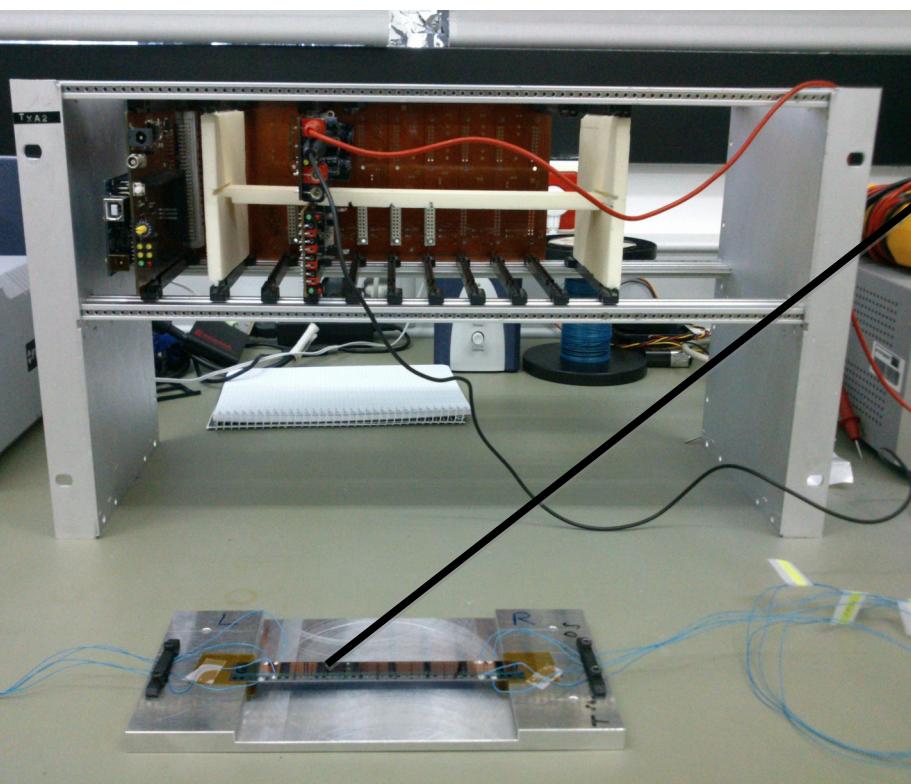
Outline

- 1. Power pulsing
 - 1.1 Barrel ladders
 - Set-up
 - Thermal measurements
 - 1.2 Petal ladders
 - Set-up
- 2. Micro channel cooling:
 - 2.1 Lab. Experiments
 - 2.2 CAE Simulations
 - 2.3 Comparison
- 3. CAD model
 - 3.1 First design of the services (cooling, cables)
 - 3.2 Assembly strategy
- 4. Material budget calculations
 - 4.1 Single Barrel ladder
 - 4.2 Vertex region in θ angle
 - 4.3 Vertex region in Φ angle
- 5. Future work
- 6. Conclusions



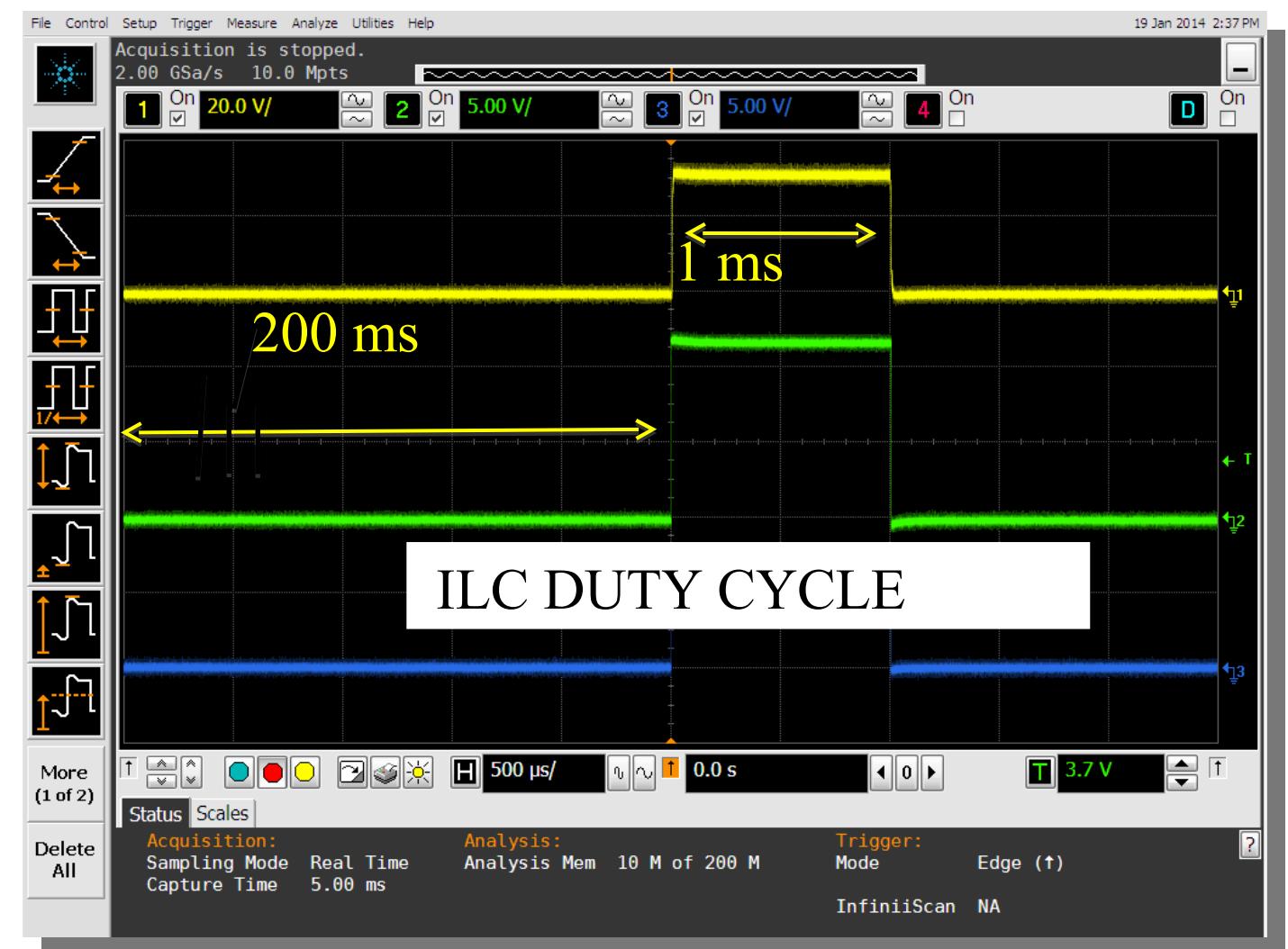
1. Power pulsing

- Pulsing power system developed at IFIC Valencia

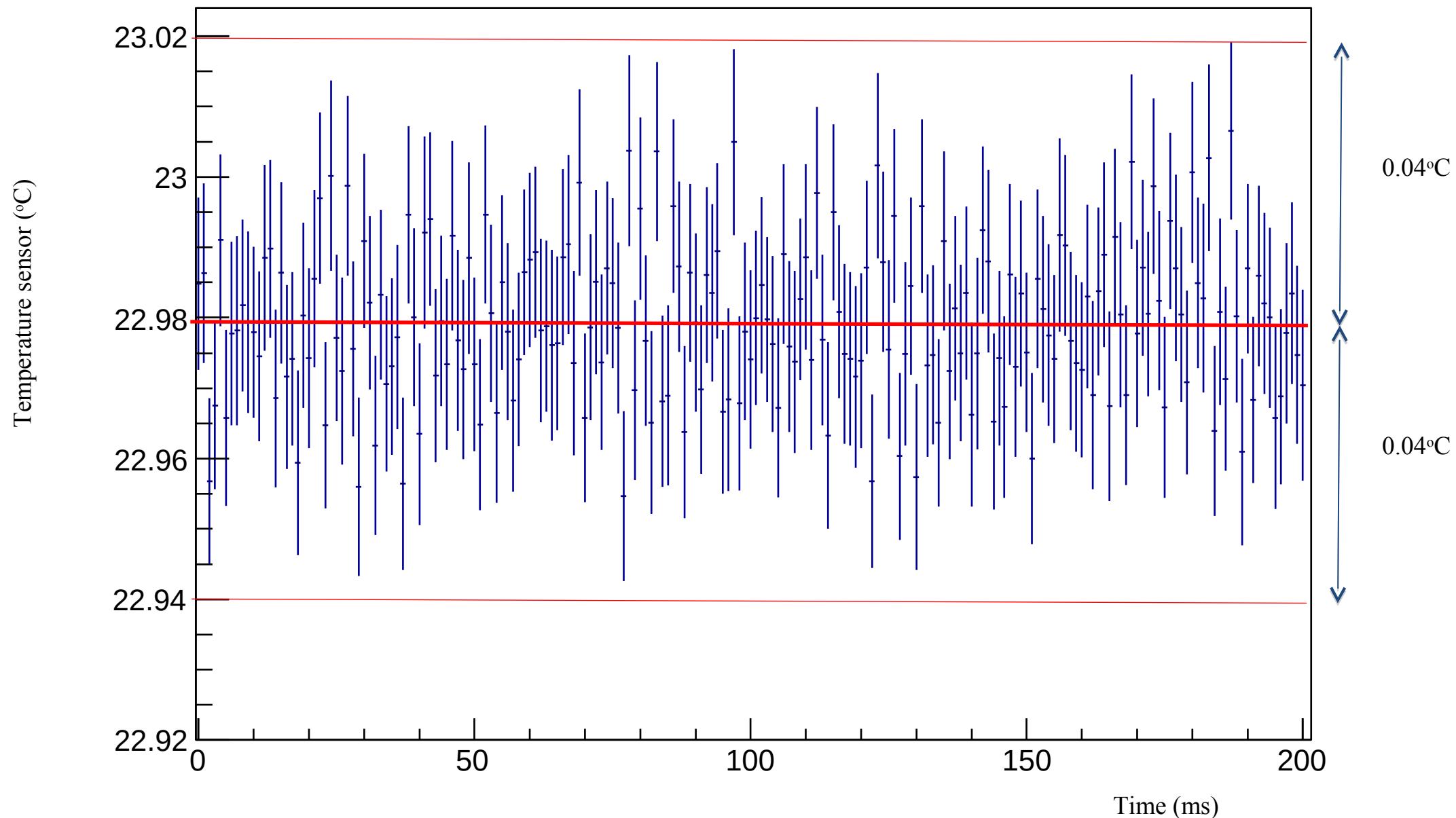


Mechanical ladder prototype
DEPFET technology

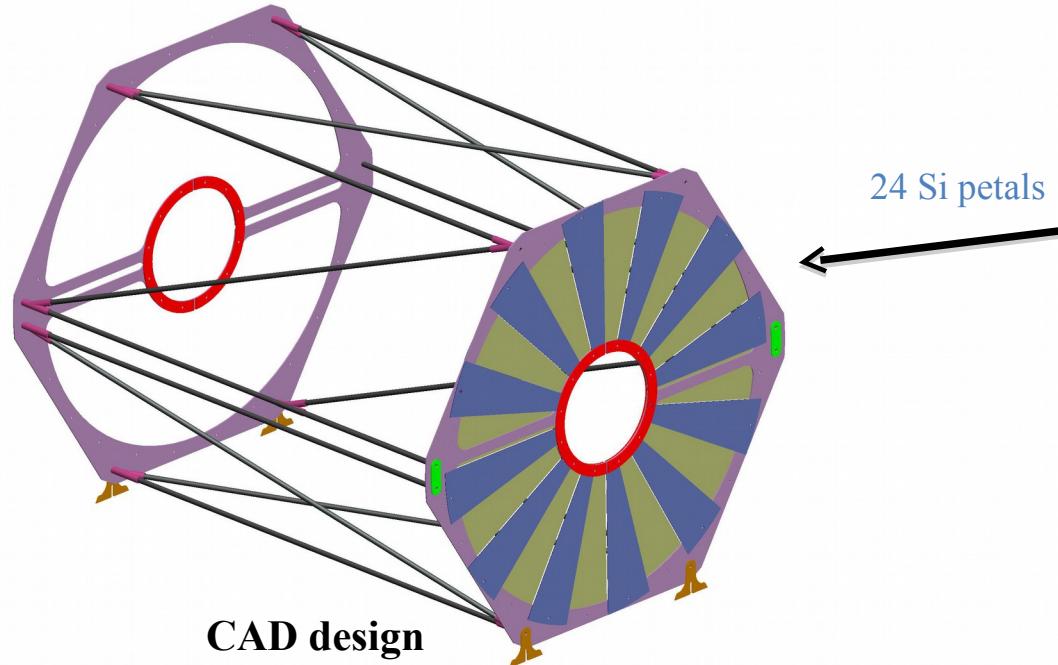
- Study of the thermo-mechanical properties of thin sensors with a pulsed power supply



1. Power pulsing

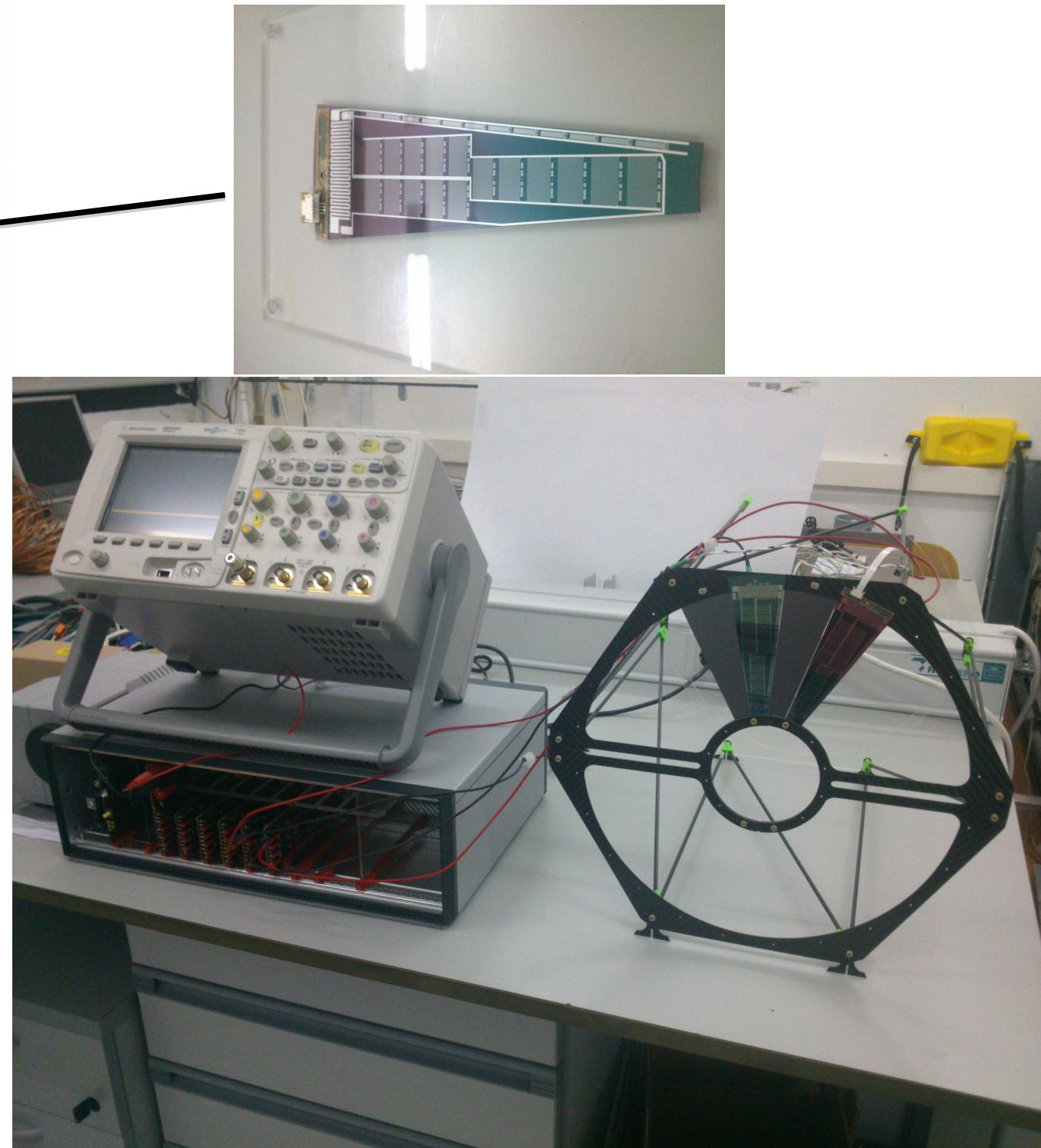


1. Power pulsing



FTD pixel disk mock-up

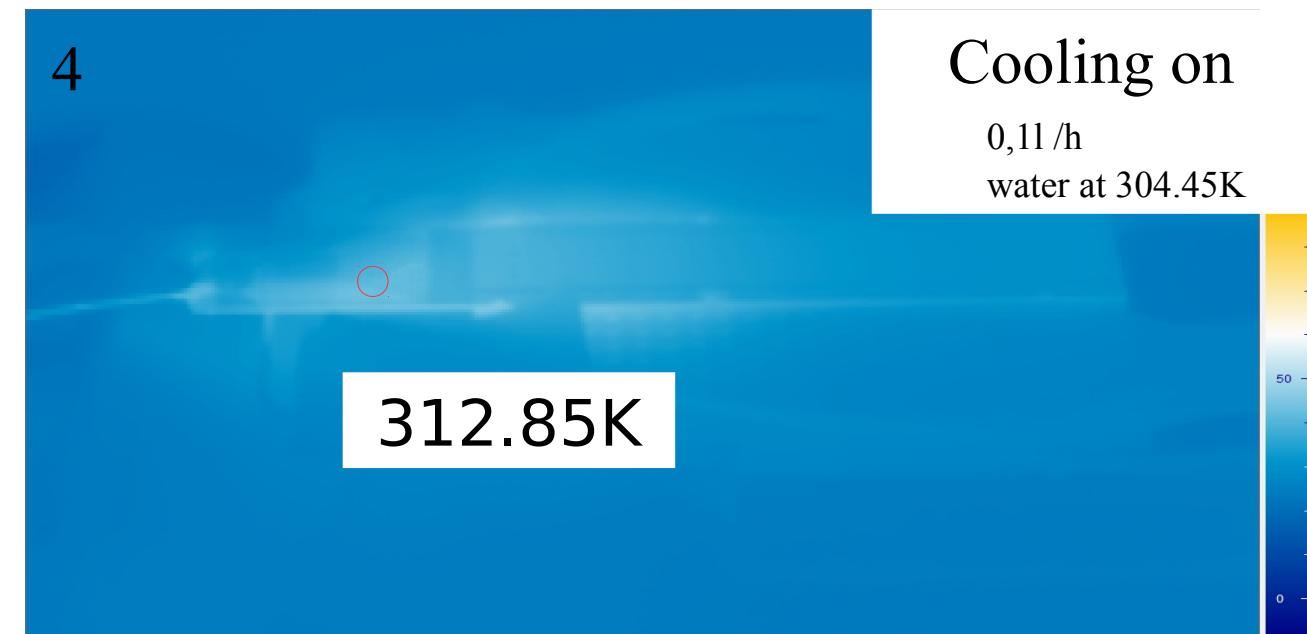
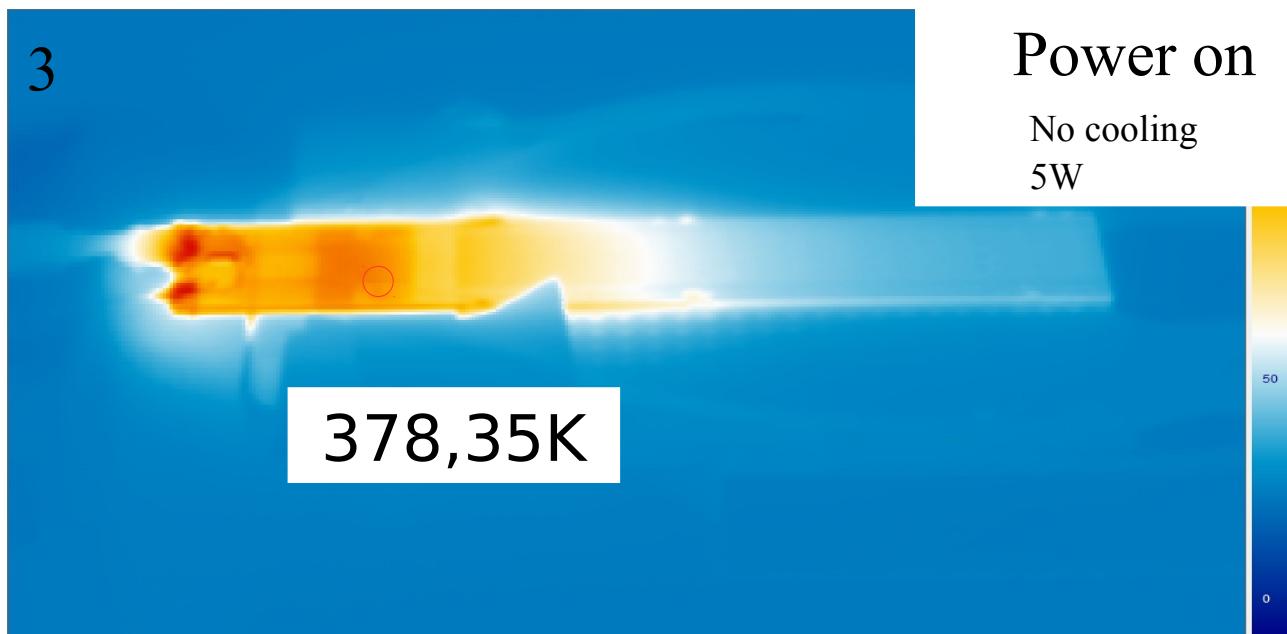
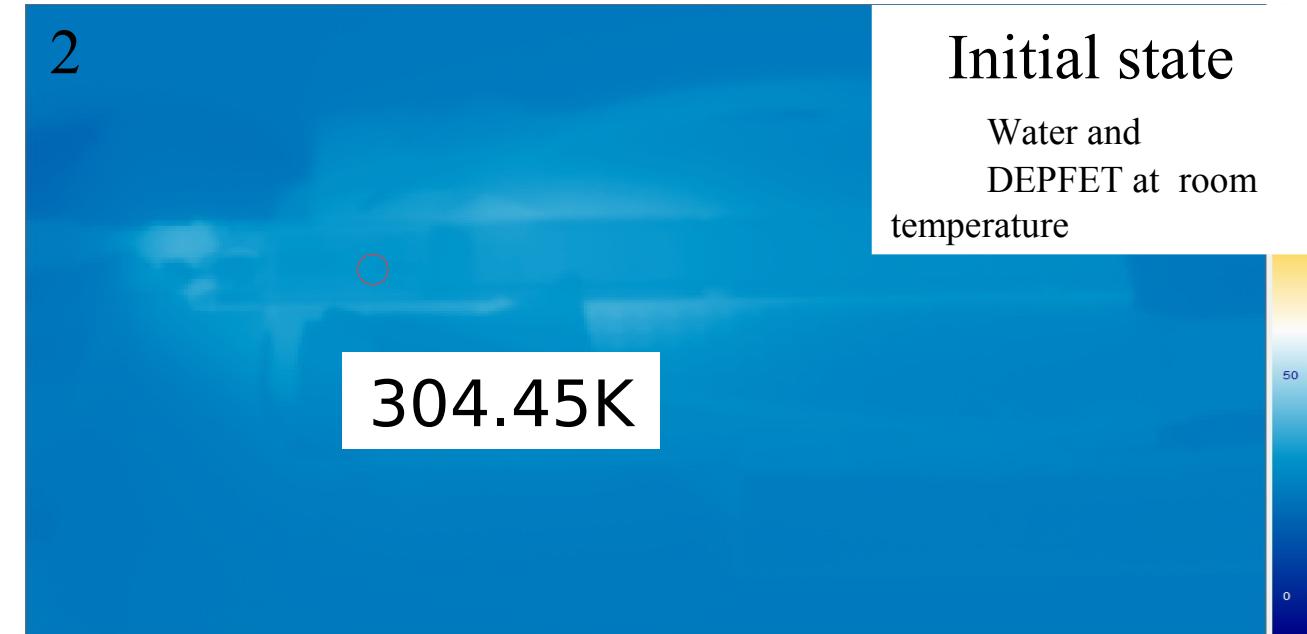
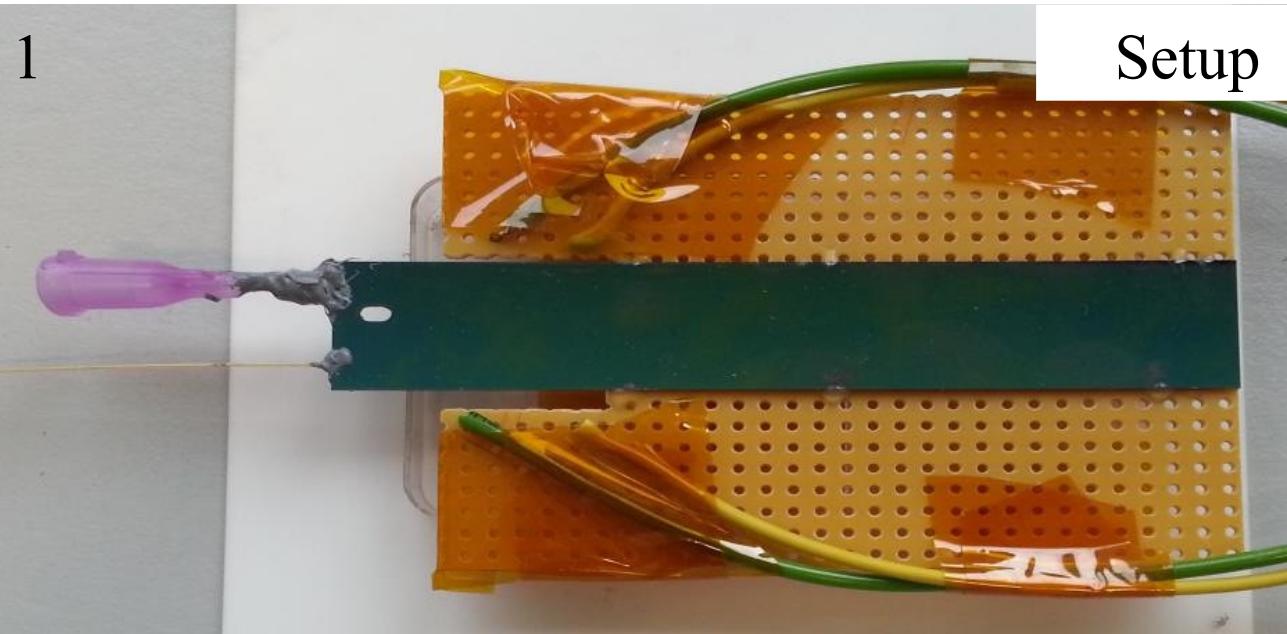
- DEPFET mechanical petals
 - 75 μm Silicon ($< 0.2\% \chi_0$)
- CFRP Support disks
 - 1mm ($0.09\% \chi_0$ avg. area)
- CFRP connection tubes
- Custom 3D printed joints



Mechanical support structure

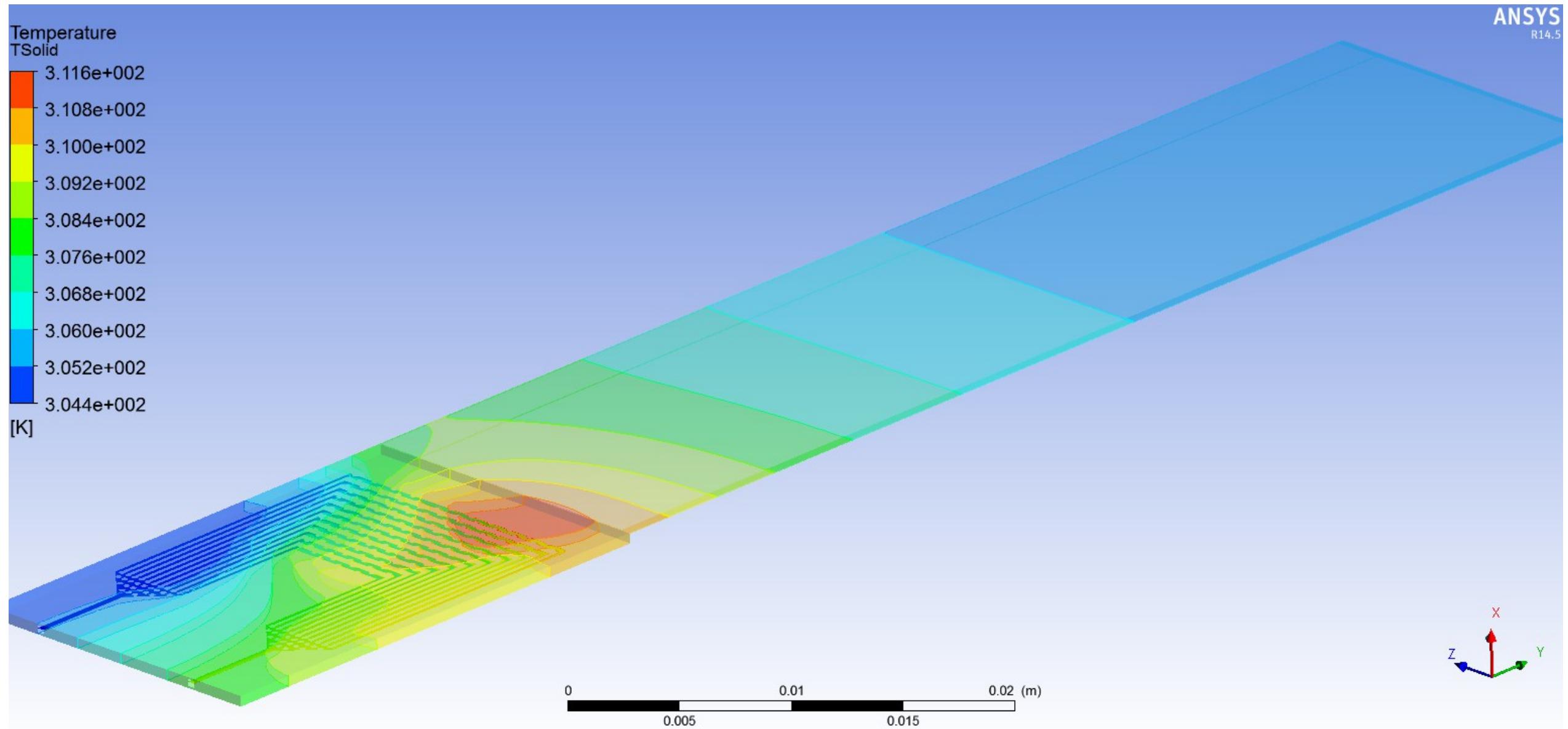
2.1 Micro channel cooling: Lab. Experiments

Tests made: 5W and water cooling



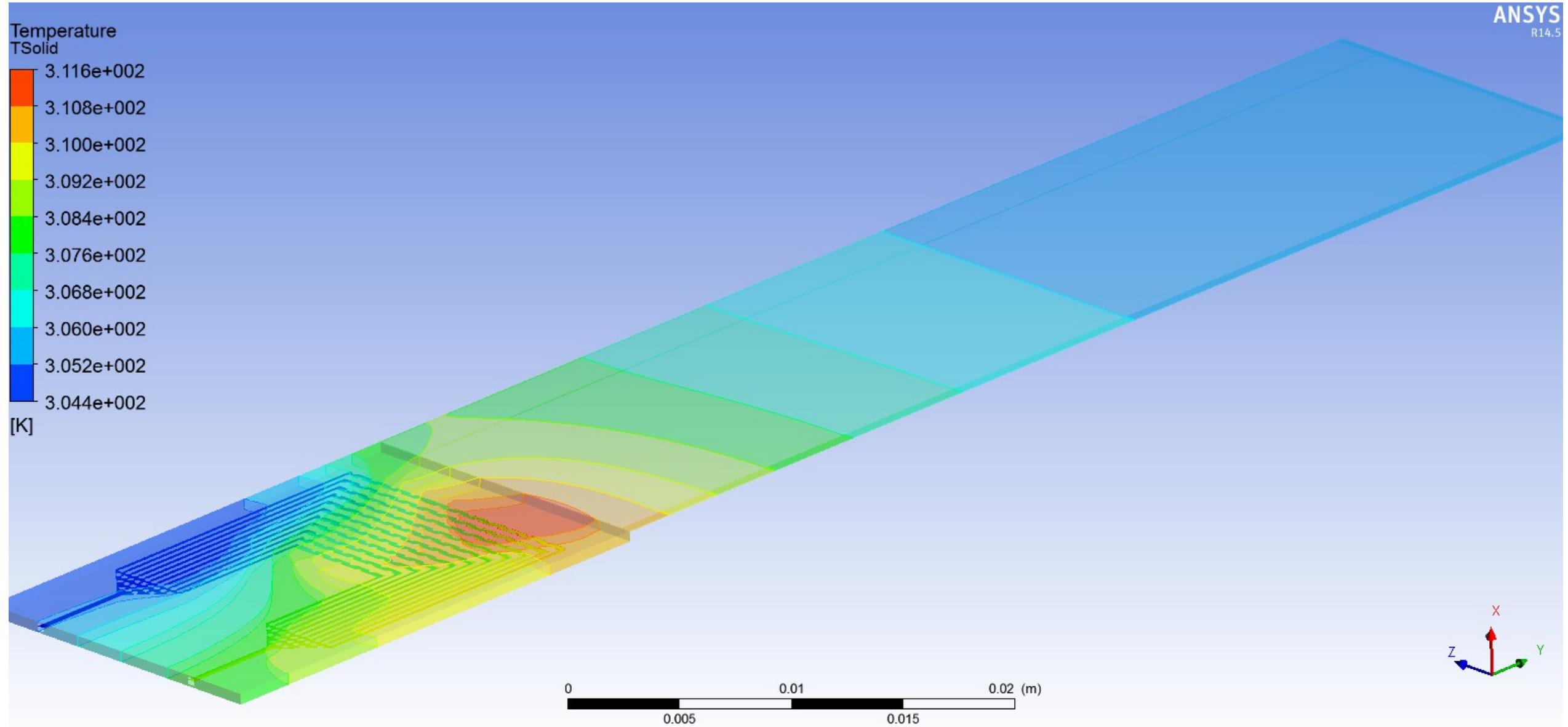
2.2 Micro channel cooling: CAE Simulations

Simulation made: 5W and water cooling with same initial conditions as test



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Simulation made: 5W and water cooling with same initial conditions as test



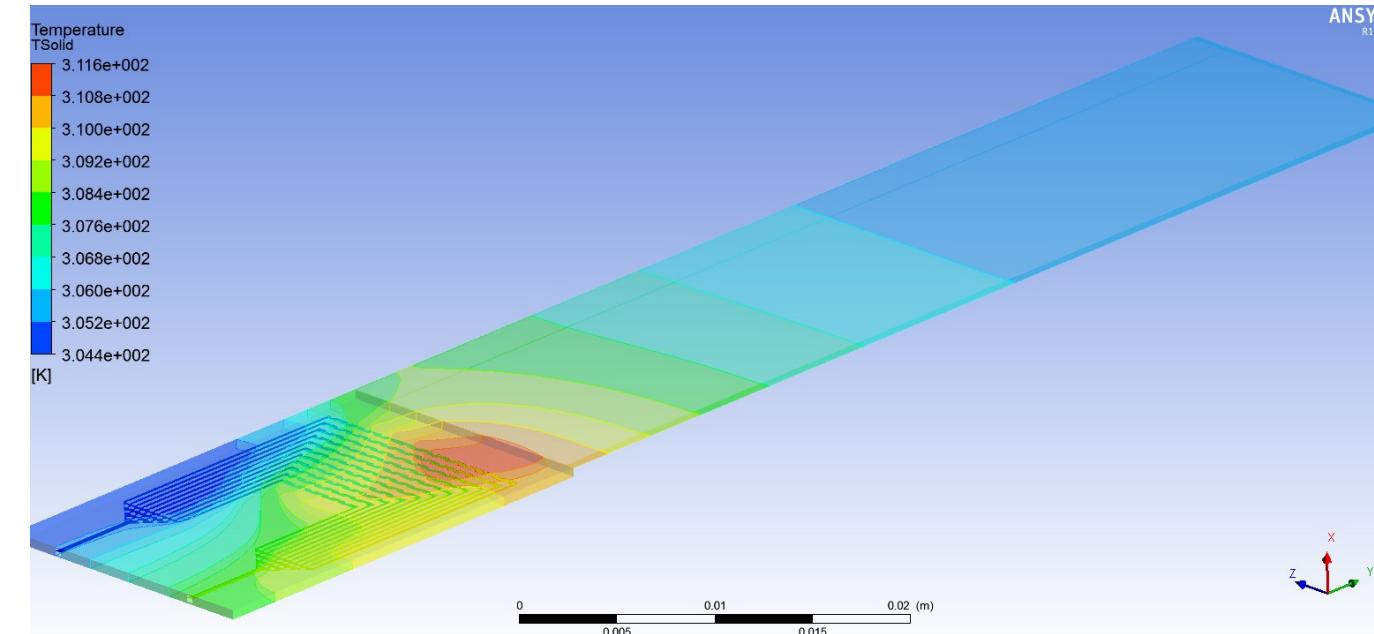
$$T_{\text{water_out}} = 308.6 \text{ K}$$

$$Q_{\text{water}} = C_p \cdot m \cdot \Delta T = (4186) \cdot (2.15 \cdot 0.00038 \cdot 0.00034 \cdot 997) \cdot (308.6 - 304.4) = 4.87 \text{ W}$$

97% of the 5W is absorbed by the cooling flow

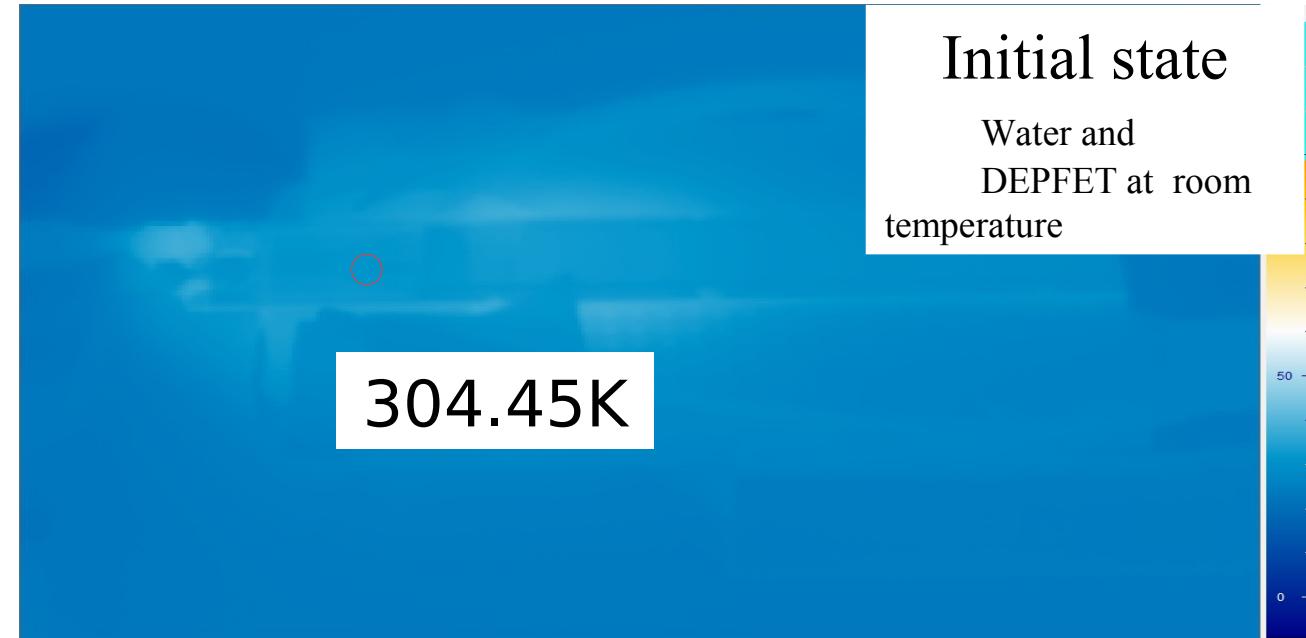


2.3 Micro channel cooling: Comparison



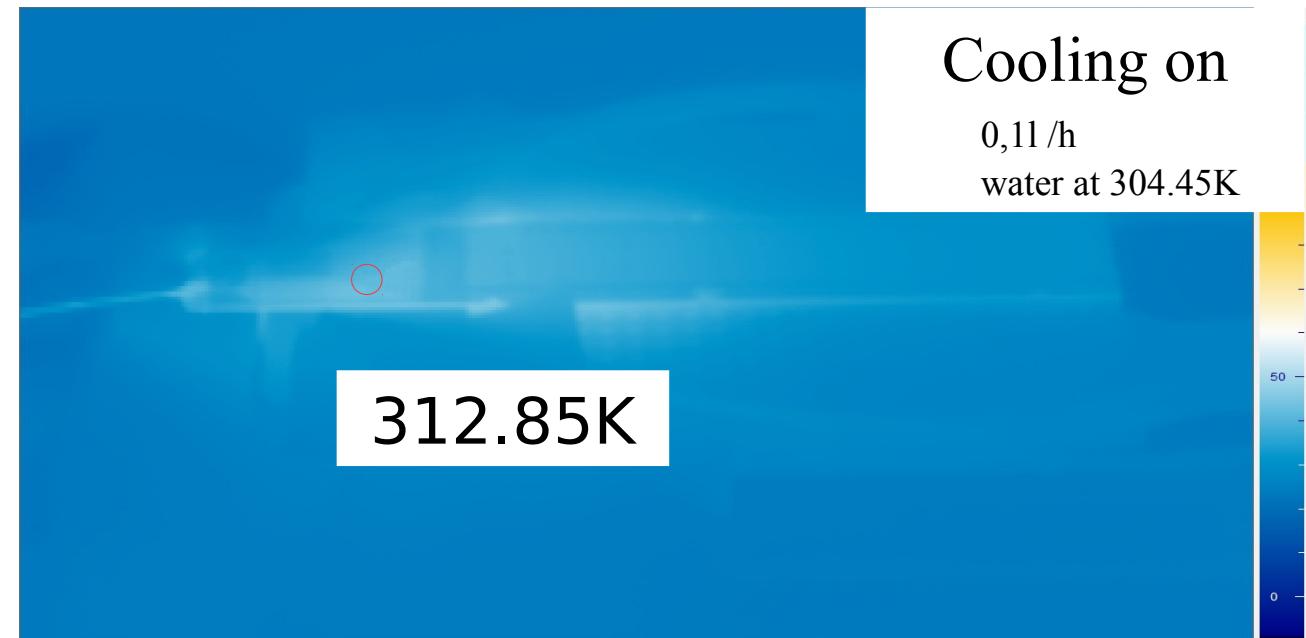
Simulation: $\Delta T = \textcolor{red}{7.15K}$

Test: $\Delta T = \textcolor{red}{8.4K}$



Initial state

Water and
DEPFET at room
temperature



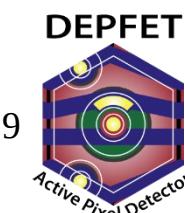
Cooling on

0,11 /h
water at 304.45K

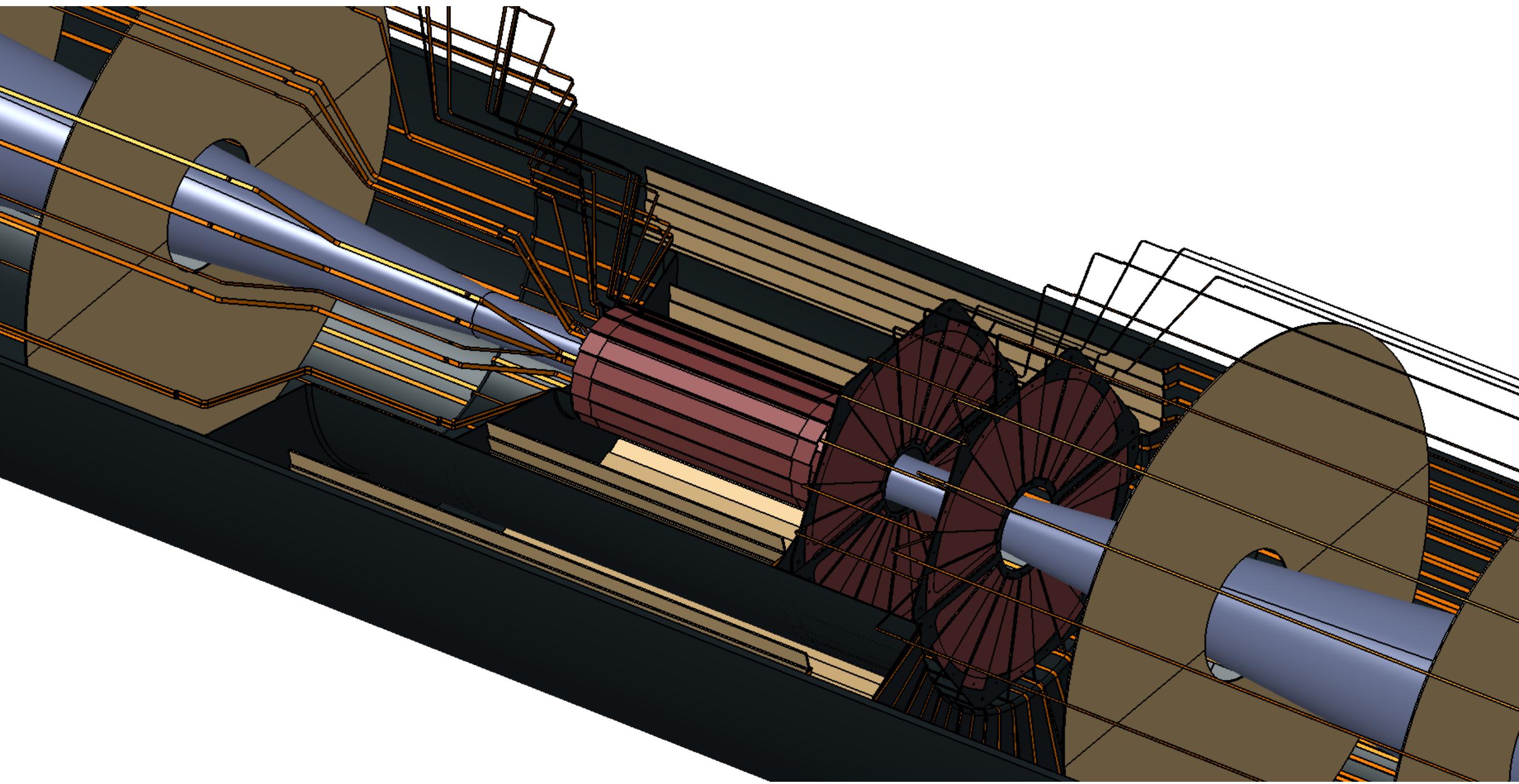


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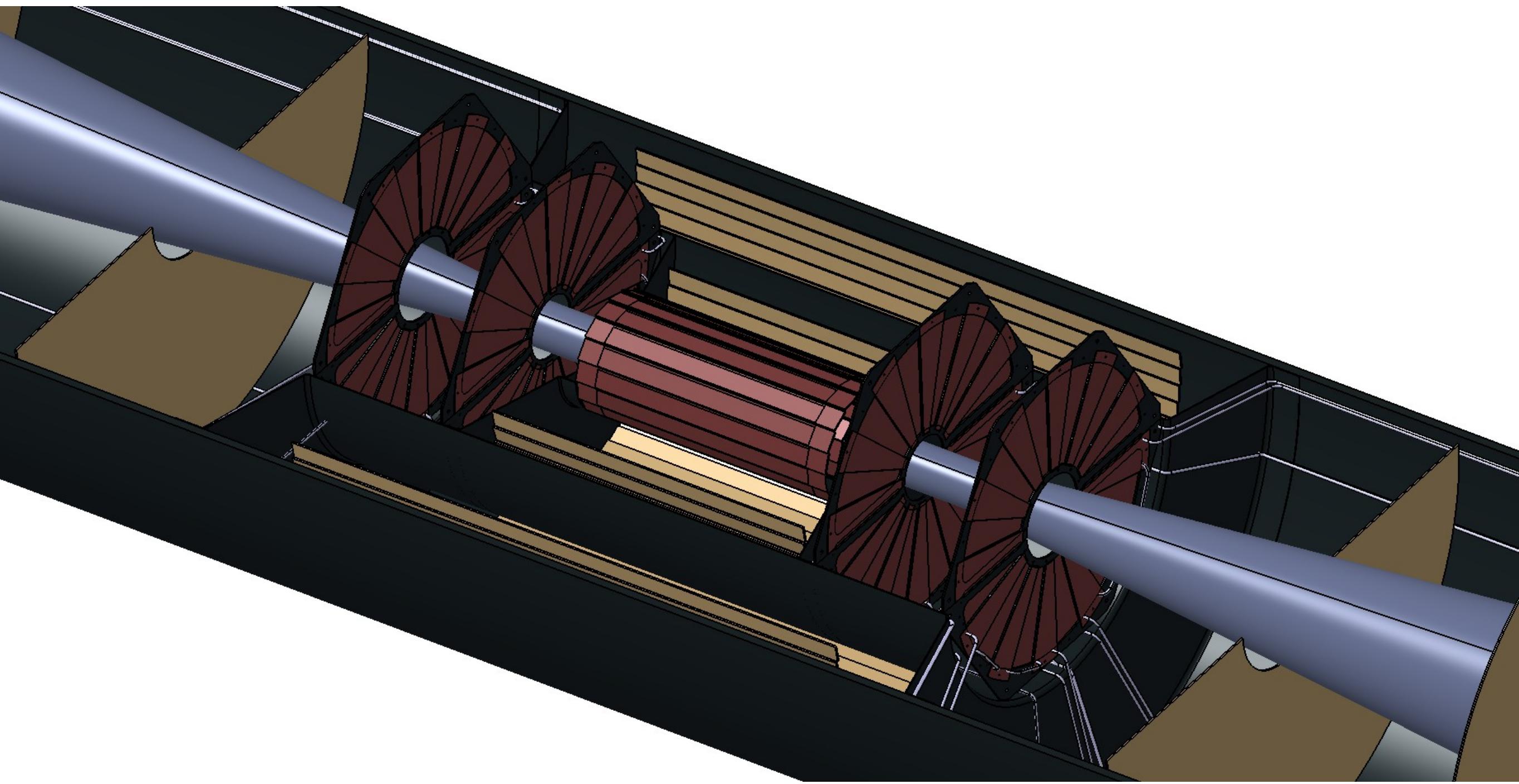
M.A. Villarejo Bermúdez



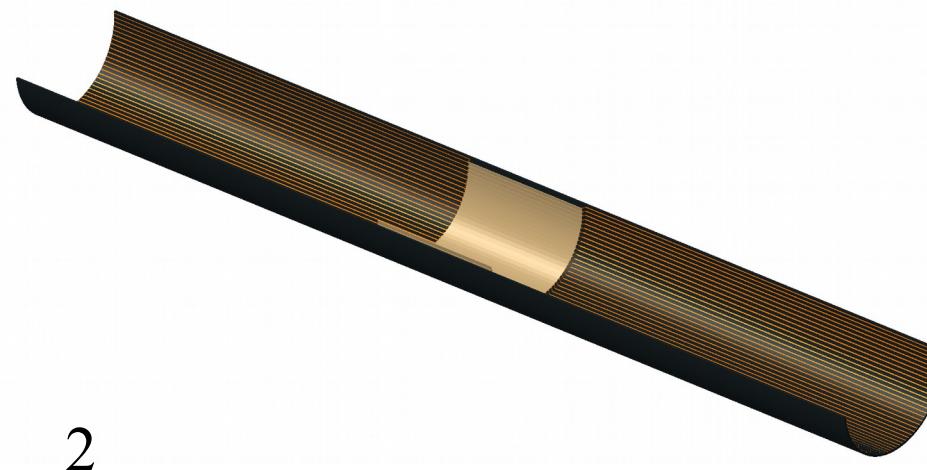
3.1 CAD Model: First design of the services (cooling, cables)



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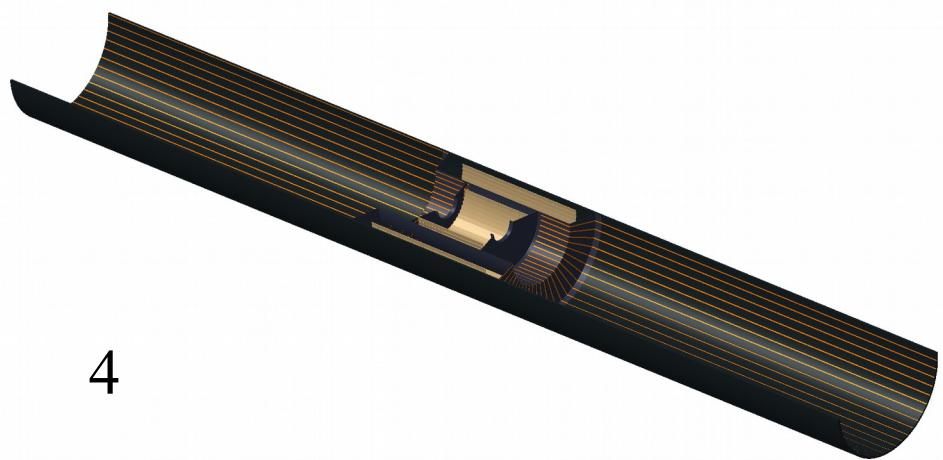


3.2 CAD Model: Assembly strategy

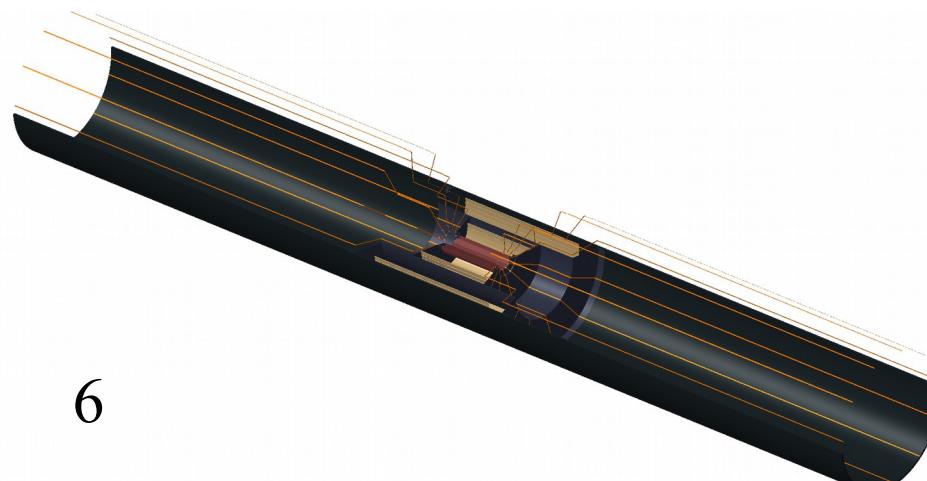
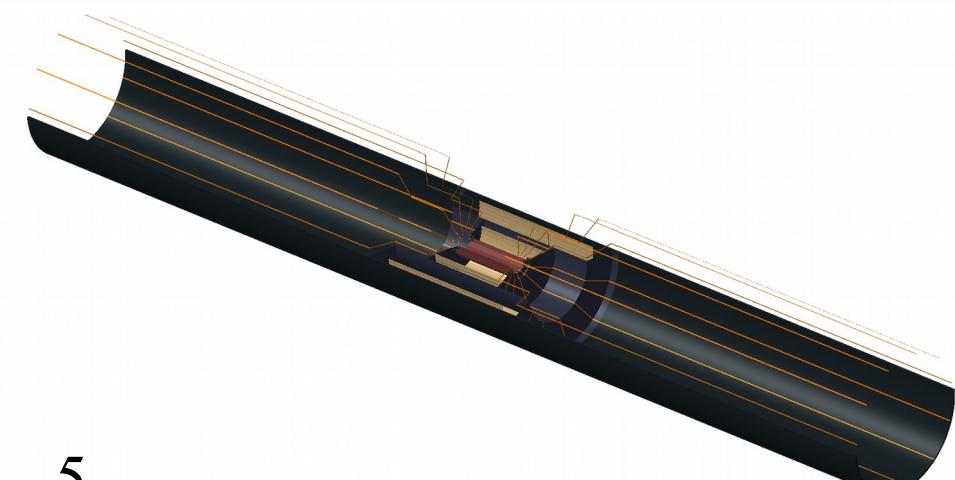


Steps:

$1 \rightarrow 2$ SIT2
 $2 \rightarrow 3$ CFRP



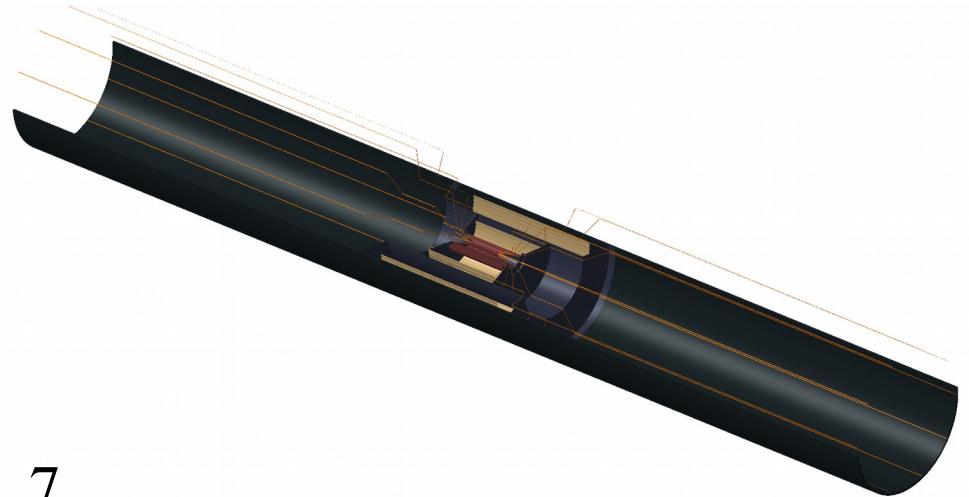
$3 \rightarrow 4$ SIT 1 & CFRP
 $4 \rightarrow 5$ VXBD 5-6 & CFRP



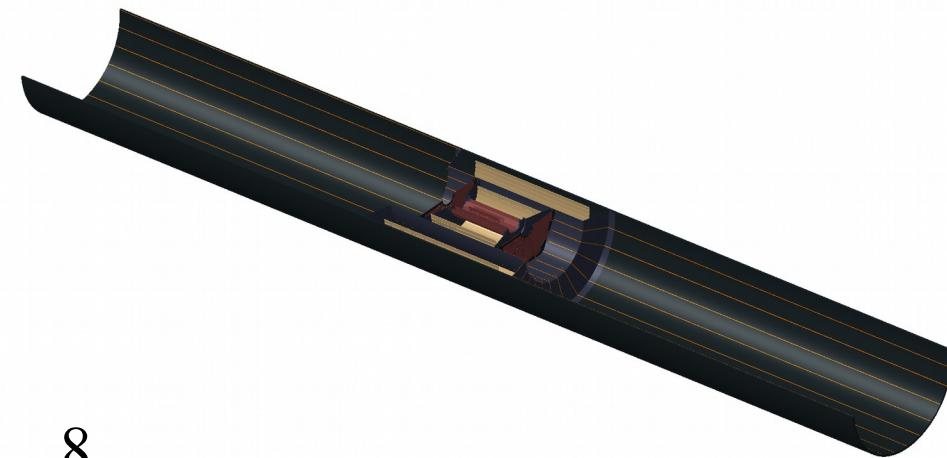
$5 \rightarrow 6$ VXBD 3-4& CFRP



3.2 CAD Model: Assembly strategy

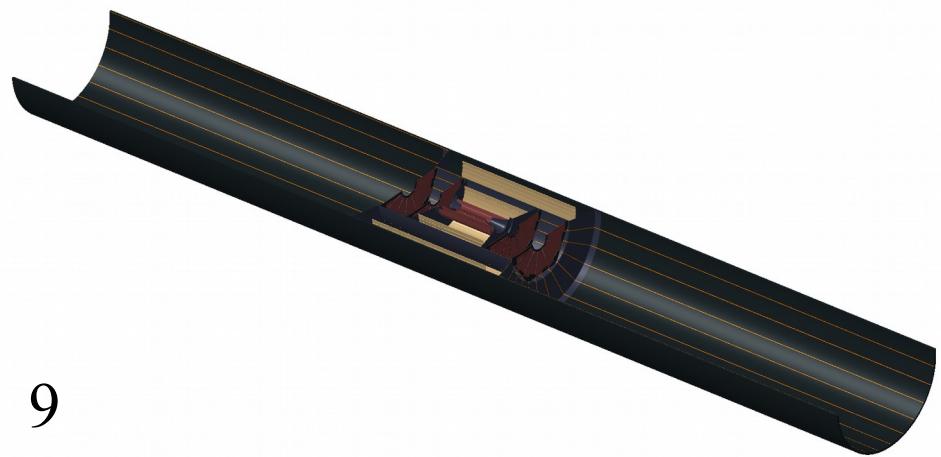


7

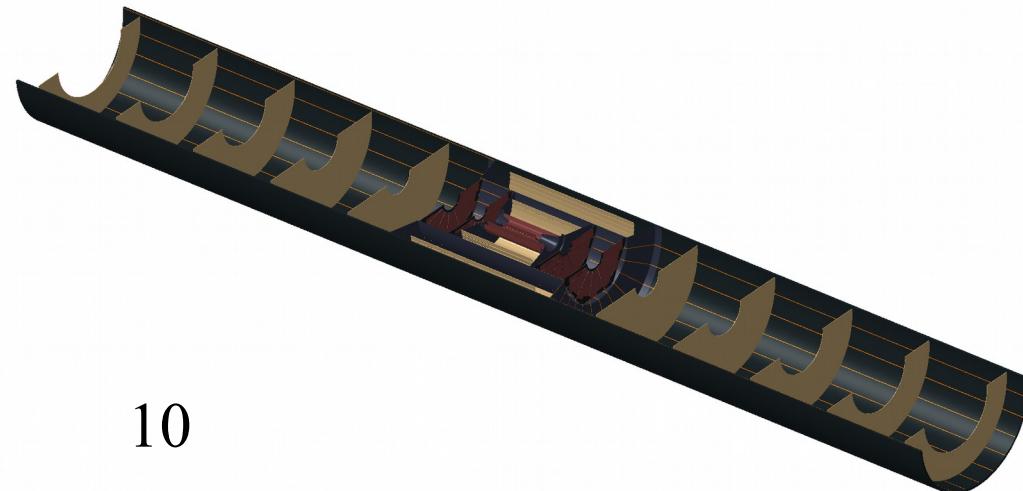


8

Steps:
6 → 7 VXBD 1-2 & CFRP
7 → 8 FTD1 & CFRP

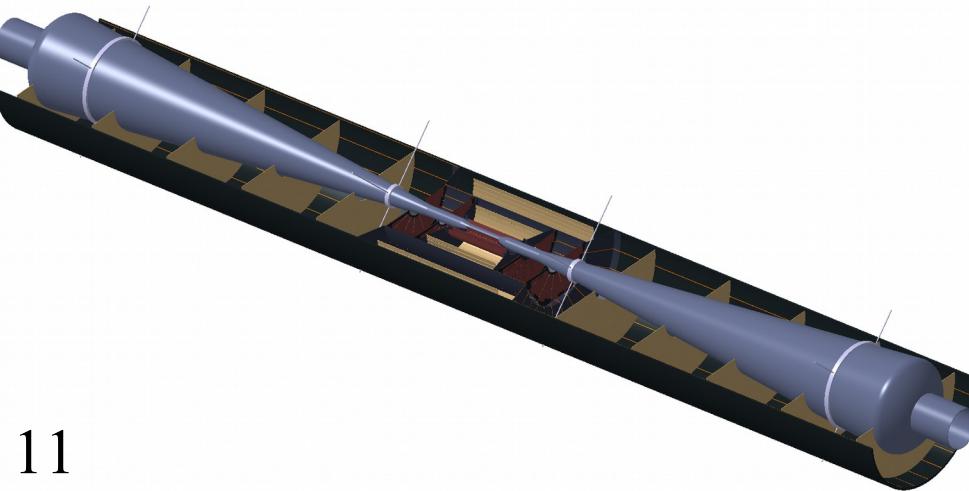


9



10

8 → 9 FTD 2 & CFRP
9 → 10 FTD 3-7 & CFRP (x2)



11



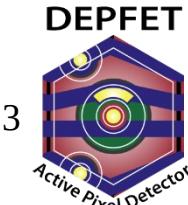
12

10 → 11 Beam Pipe
11 → 12 VXBD 3-4 & CFRP



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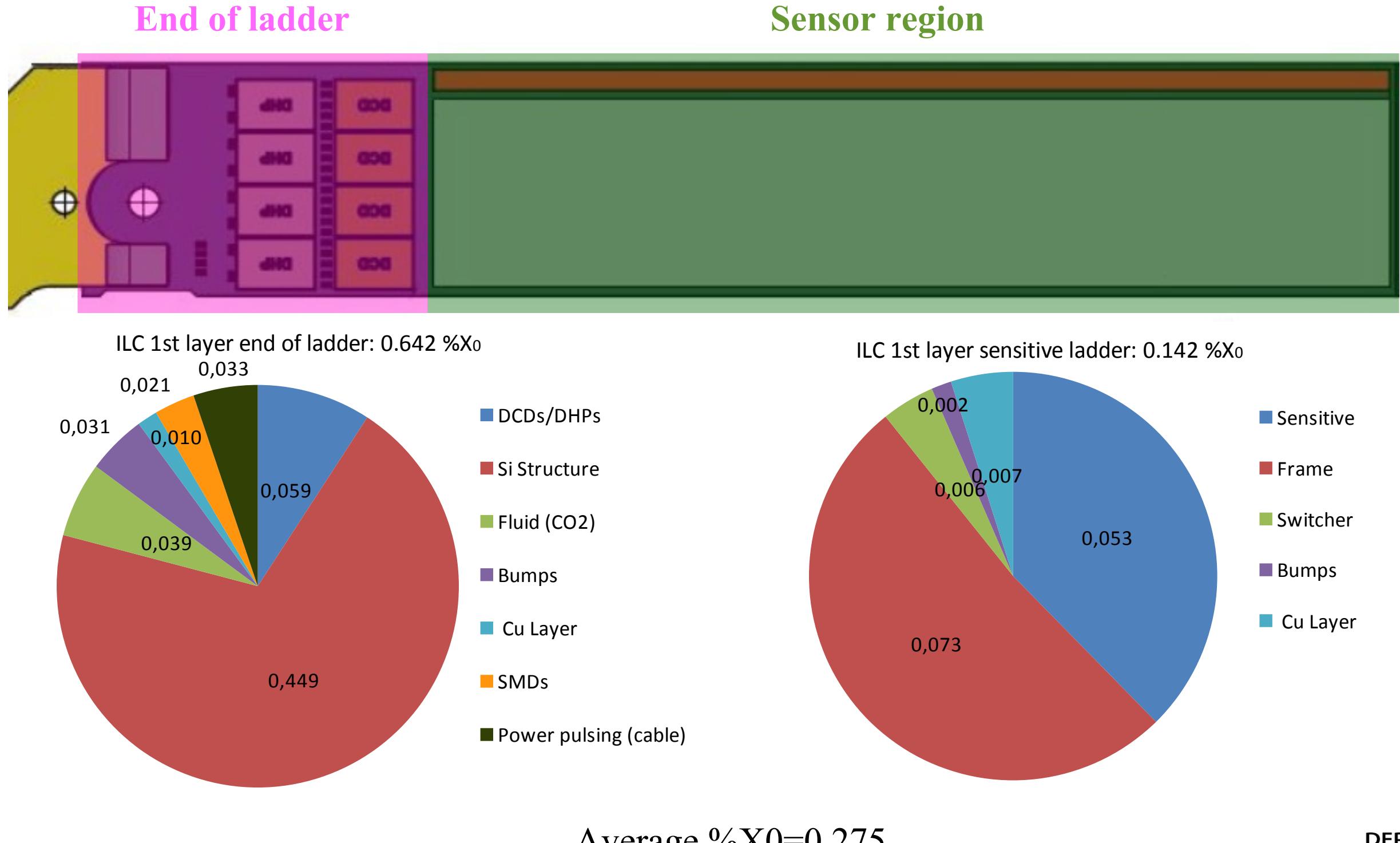


13

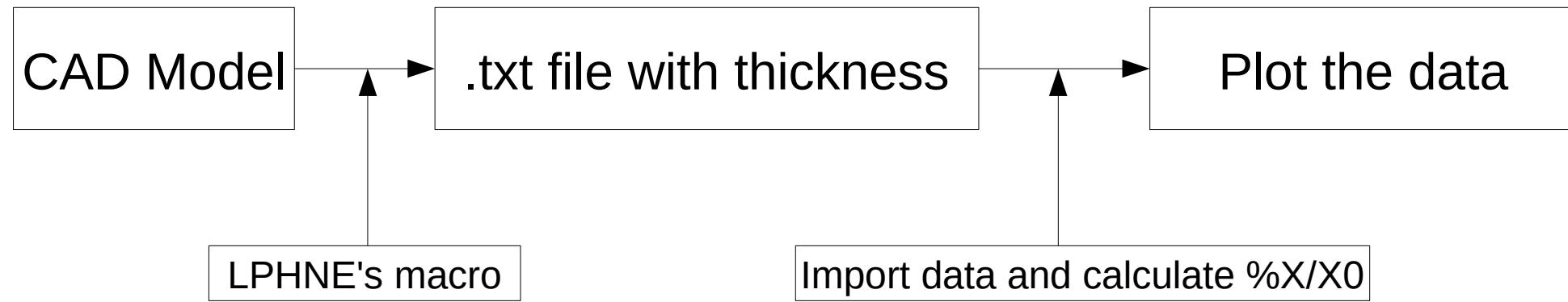
4.1 Material budget calculations: single barrel ladder

Thickness Si:

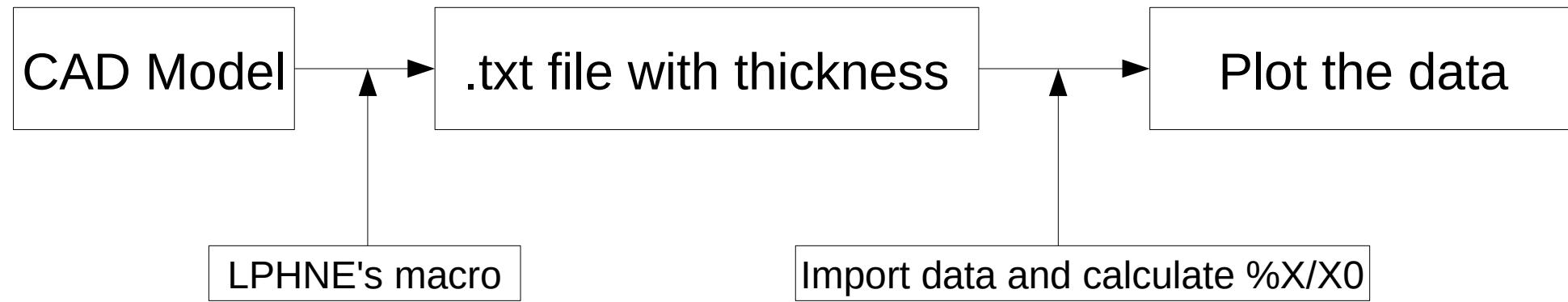
End of ladder: $0,103+0,340+0,076$ mm ; Sensitive area: 0,050 mm ; Balcon: 0,450mm (x0,66)



4.2 Material budget calculations



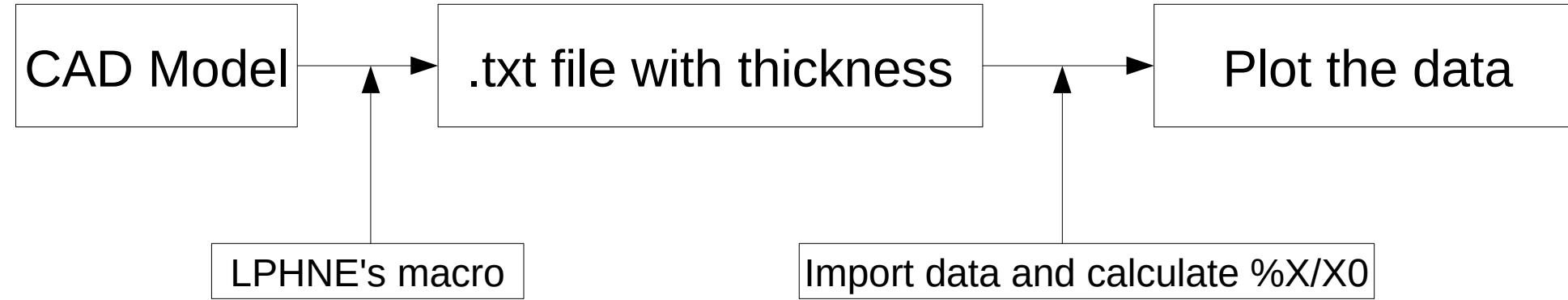
4.2 Material budget calculations



- No use of GEANT4
- Resolution of 0,01°
- The studies are done for:
 - $\Theta=[0,90]^{\circ}$ and $\phi=0^{\circ}$
 - $\Theta=0^{\circ}$ and $\phi=[0,360]^{\circ}$
- Good tools for complex geometries, but needing of data post processing



4.2 Material budget calculations

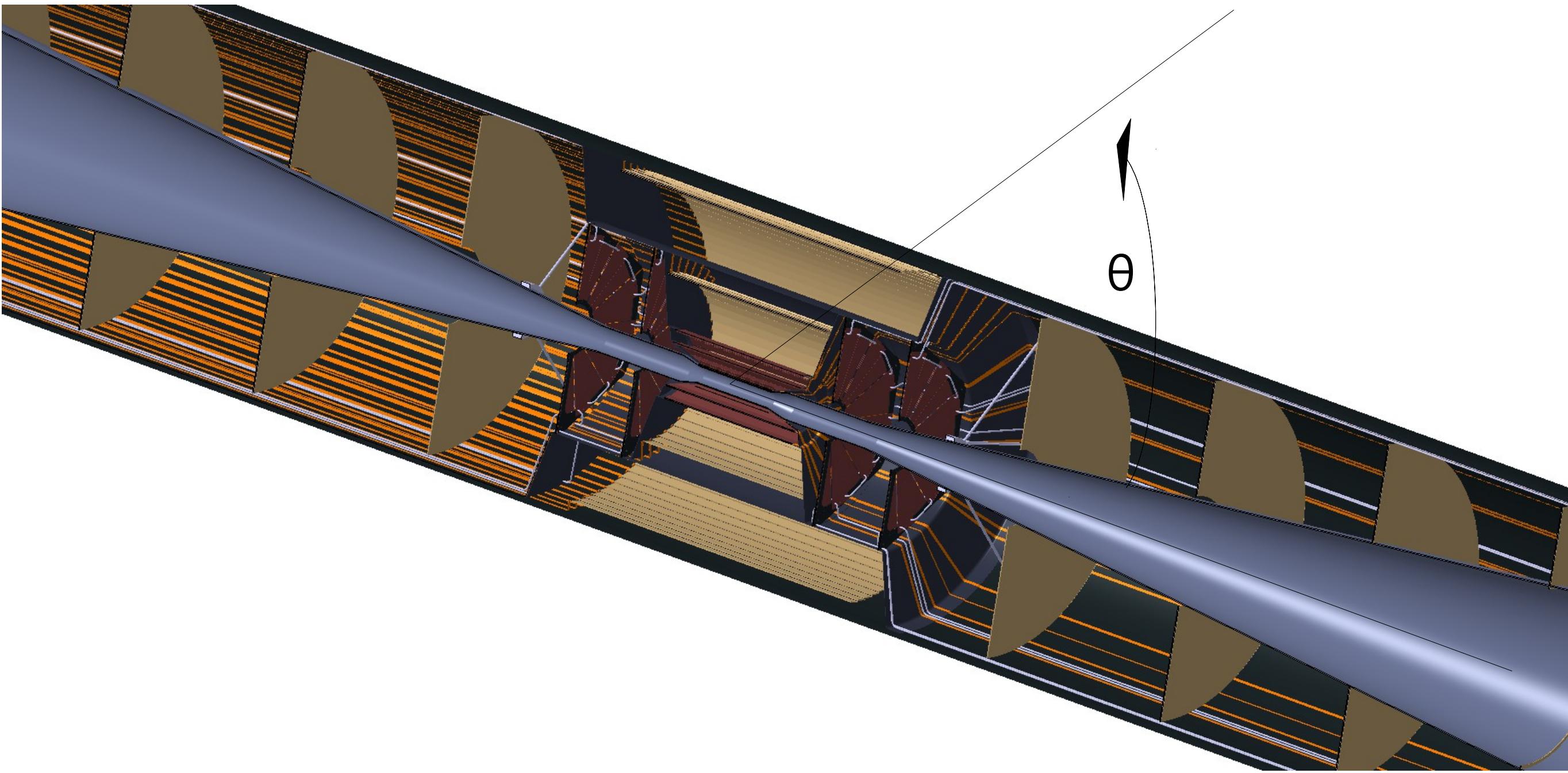


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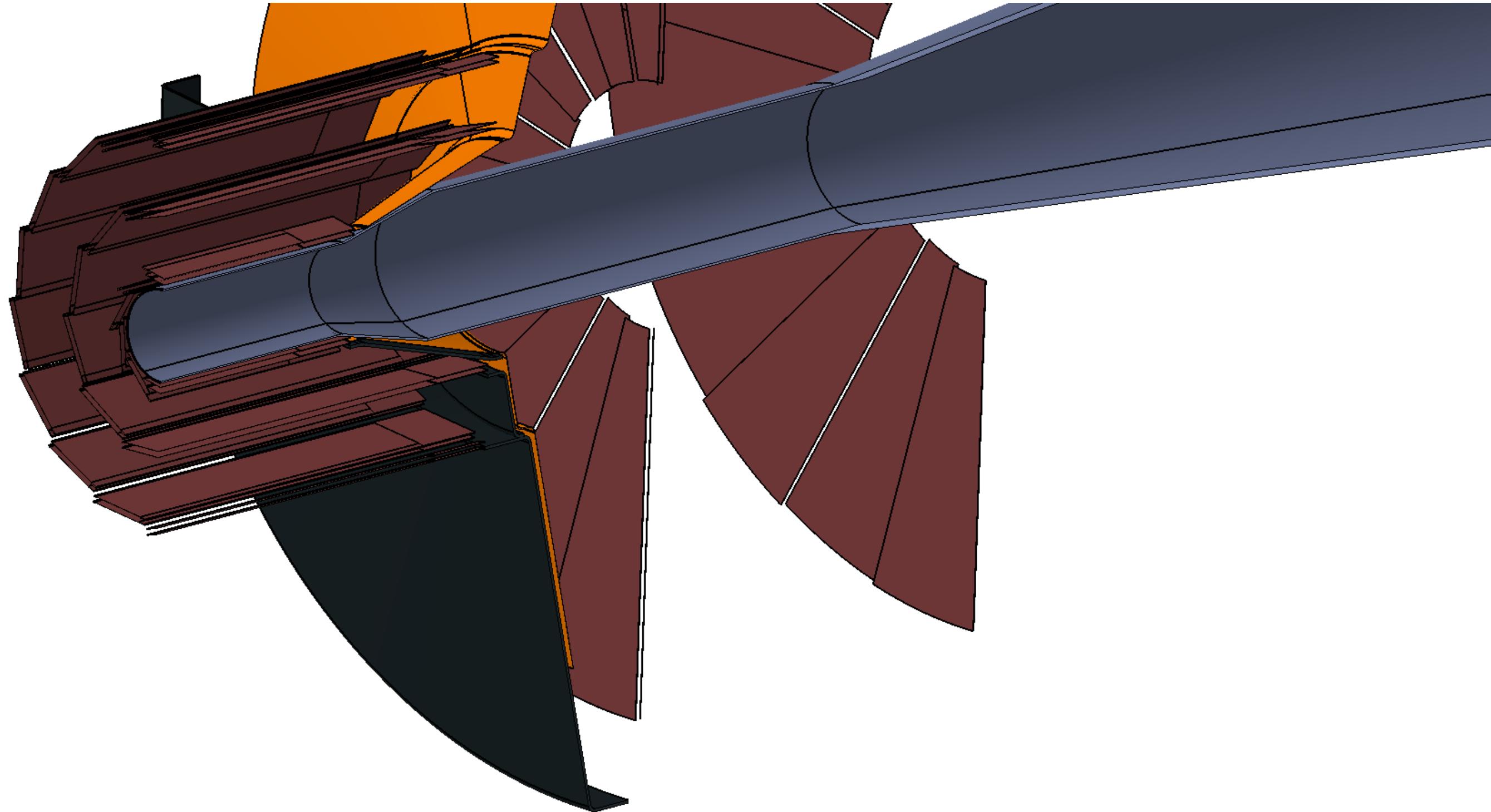
All of this has been possible because of the tool developed by:



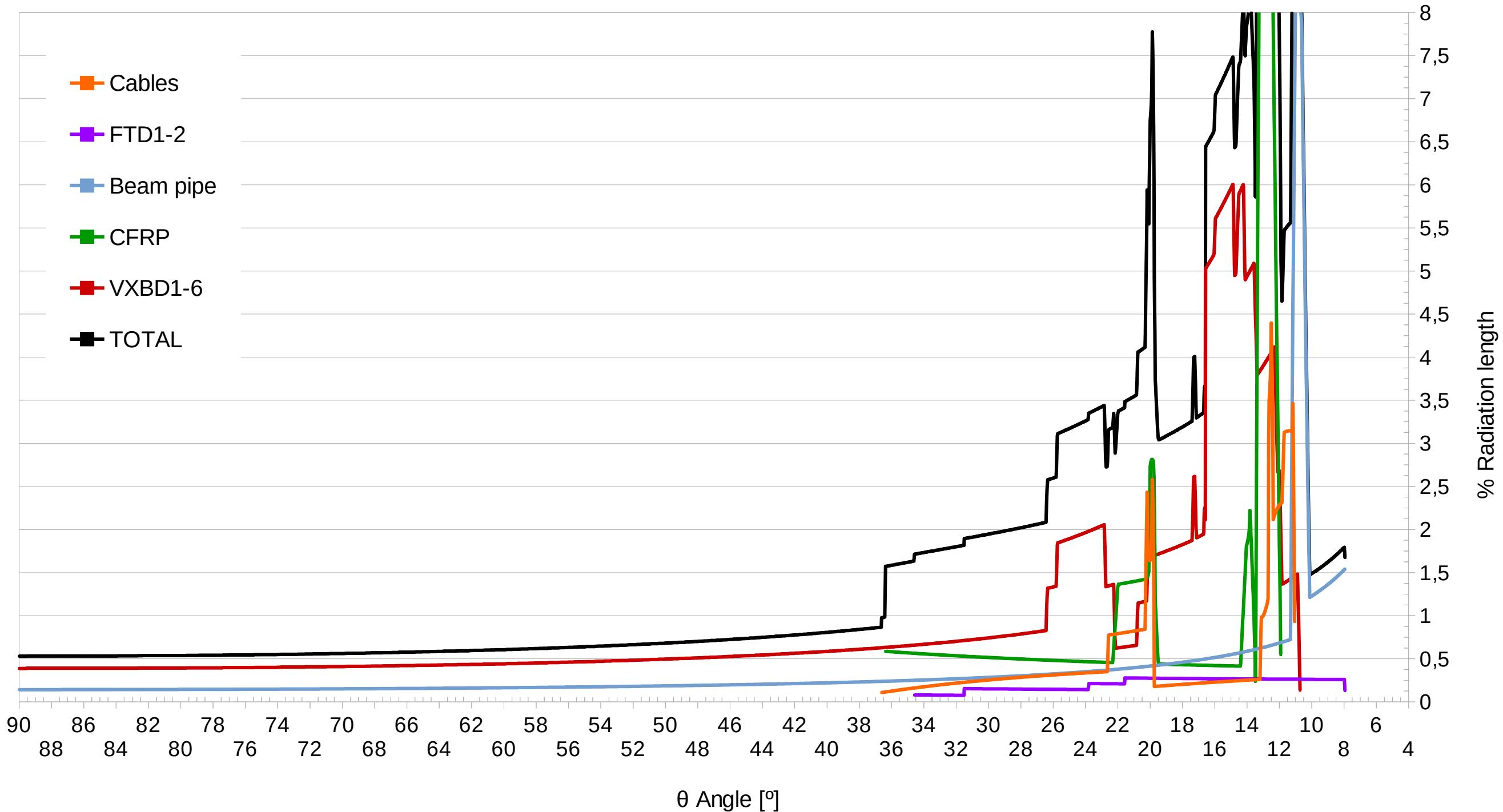
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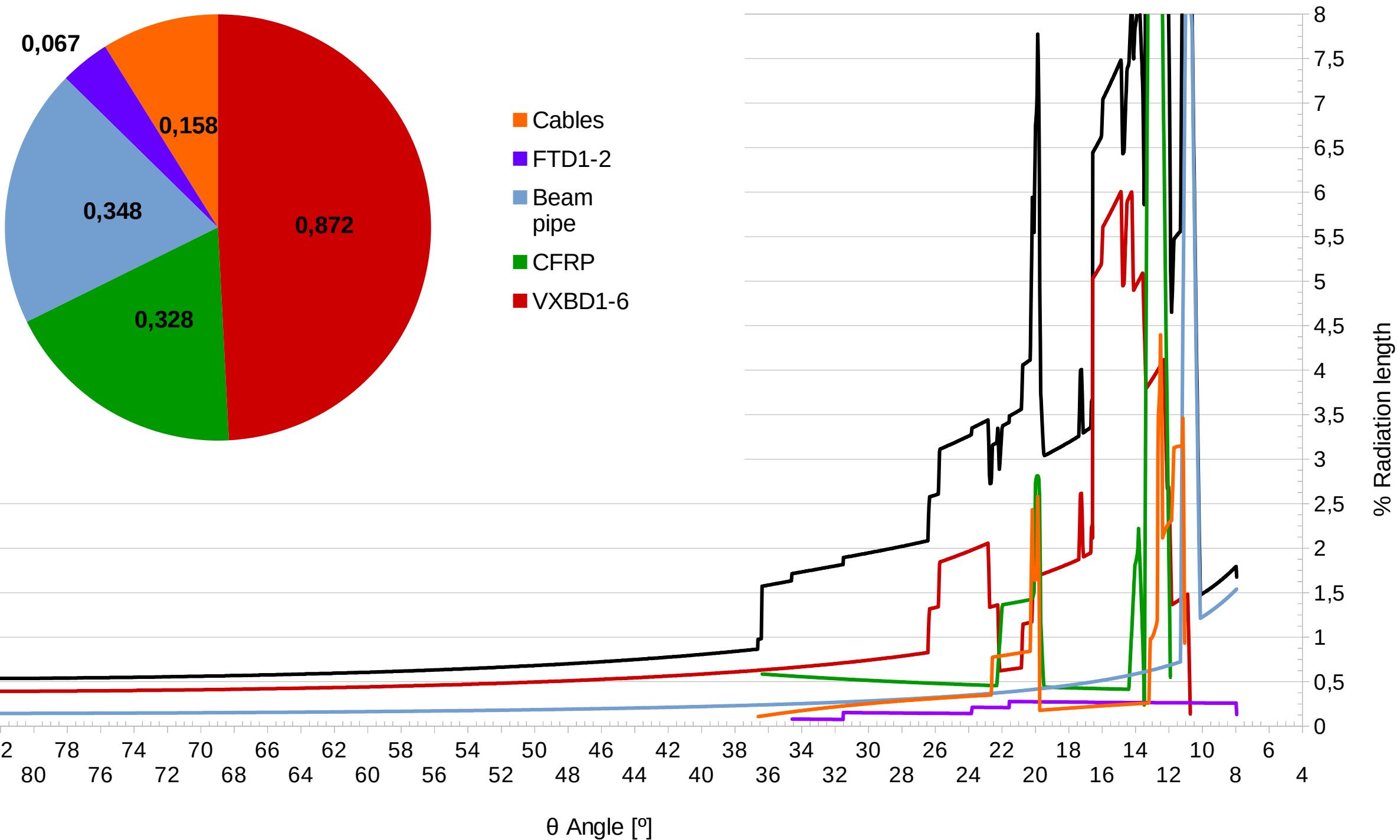


4.2 Material budget calculations

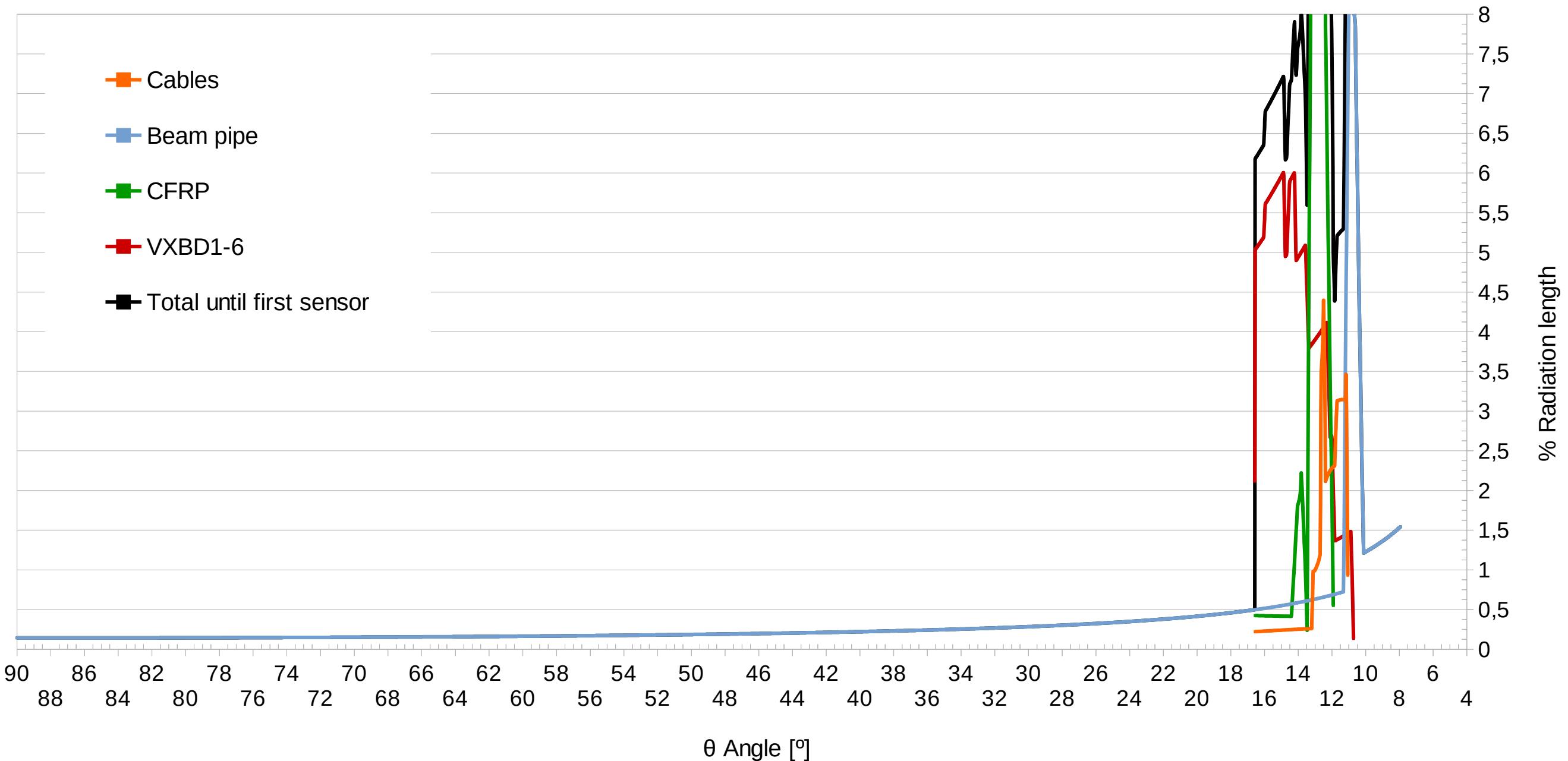


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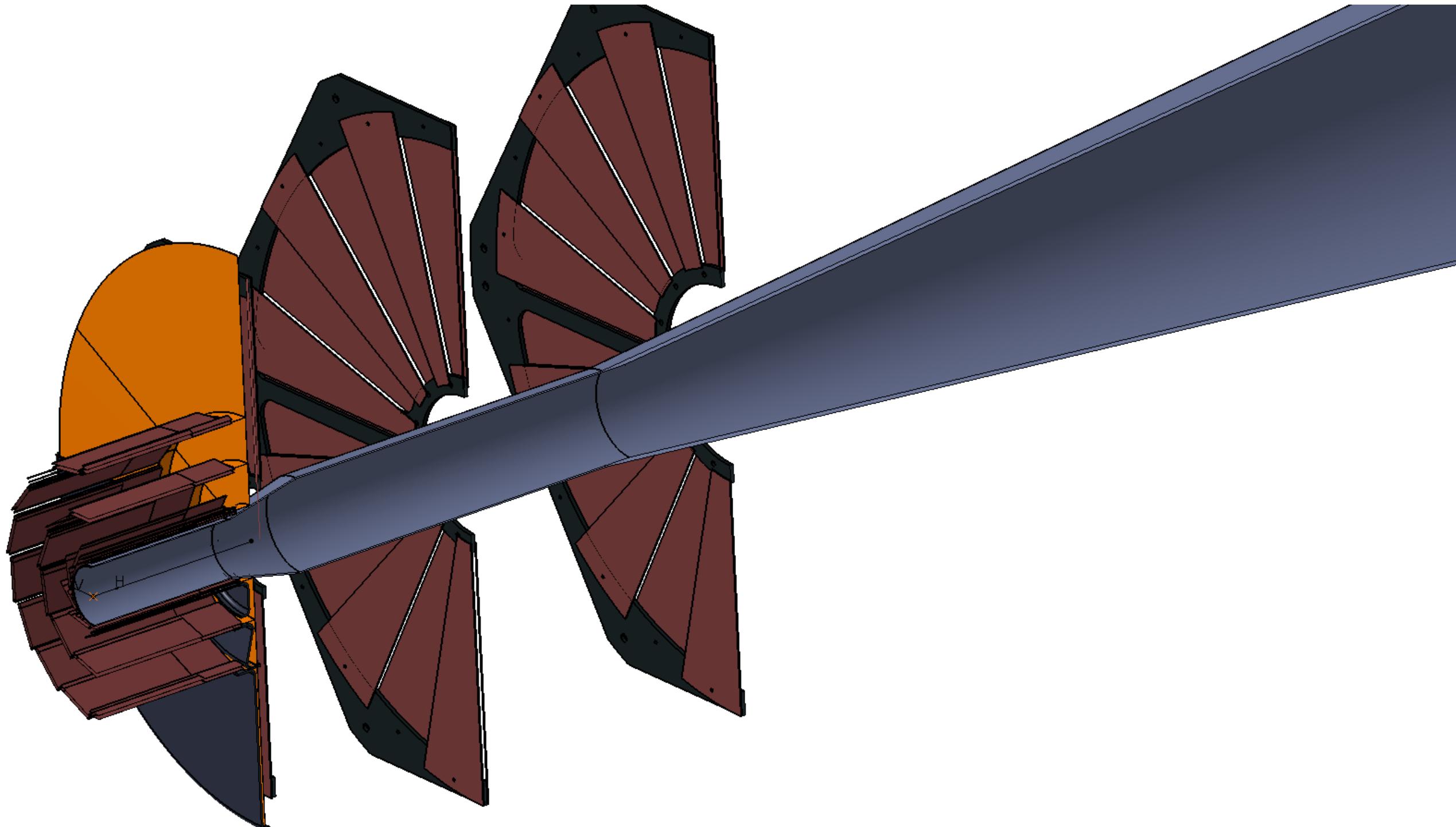
Average amount of % radiation length per material



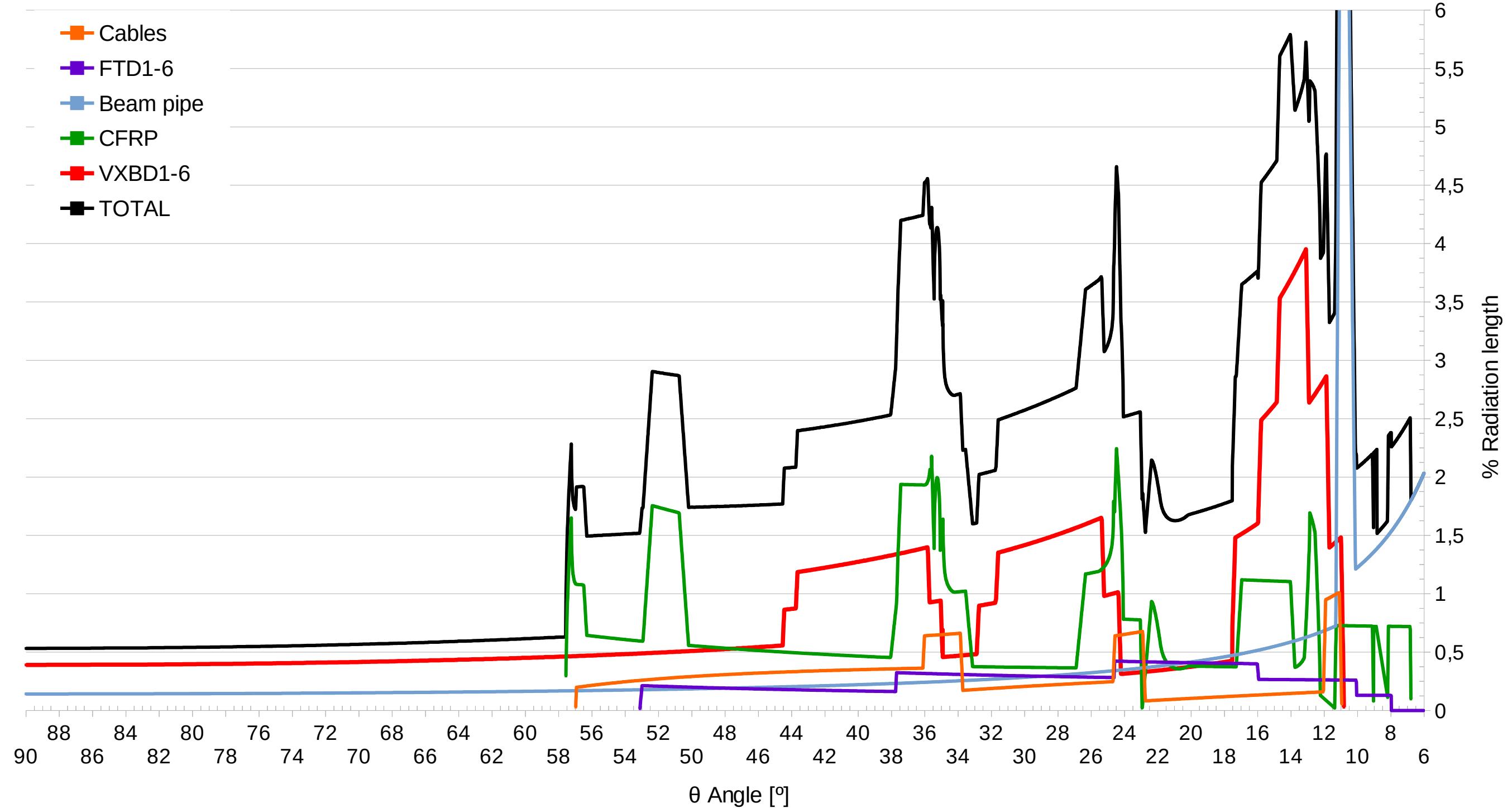
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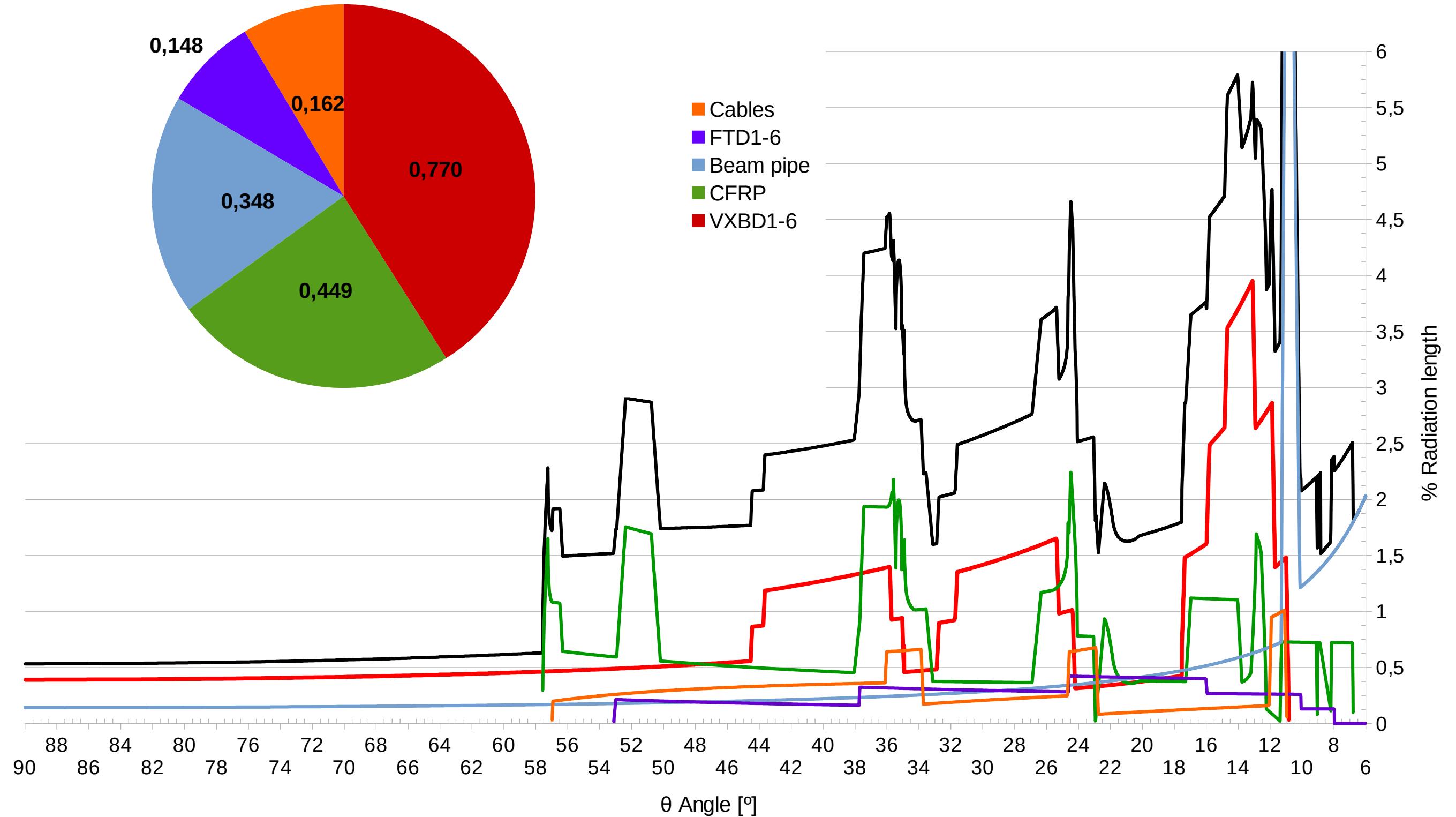


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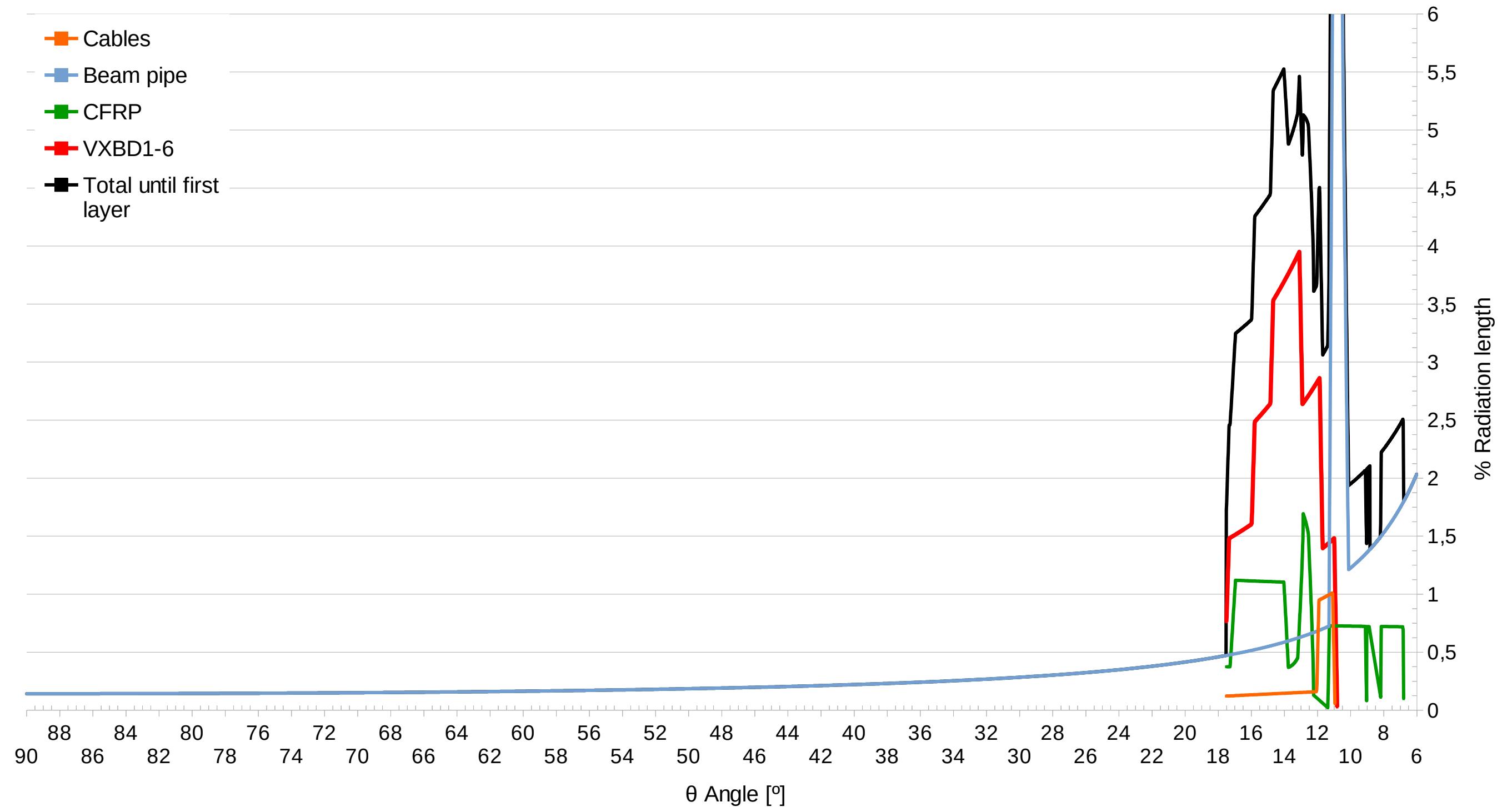


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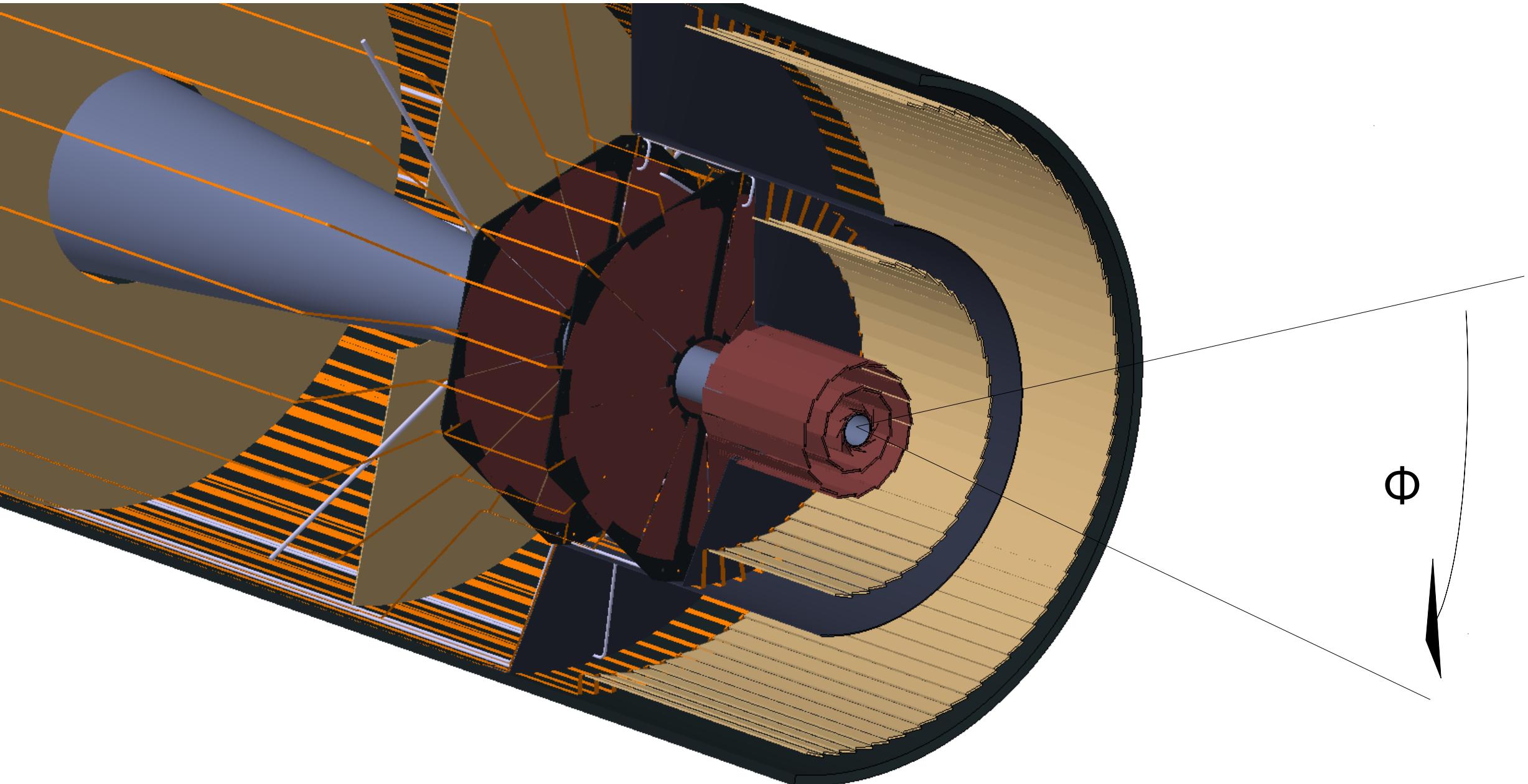
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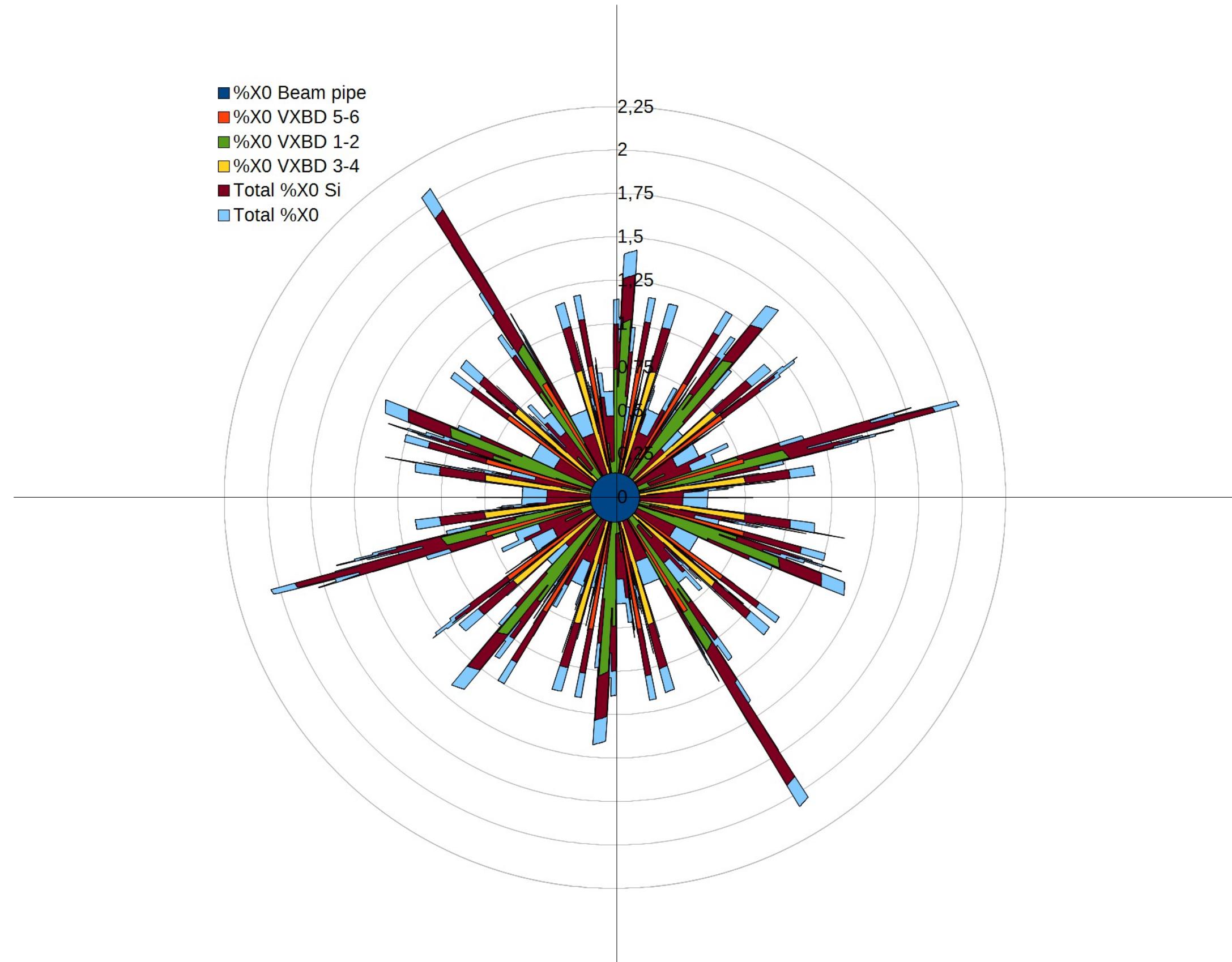
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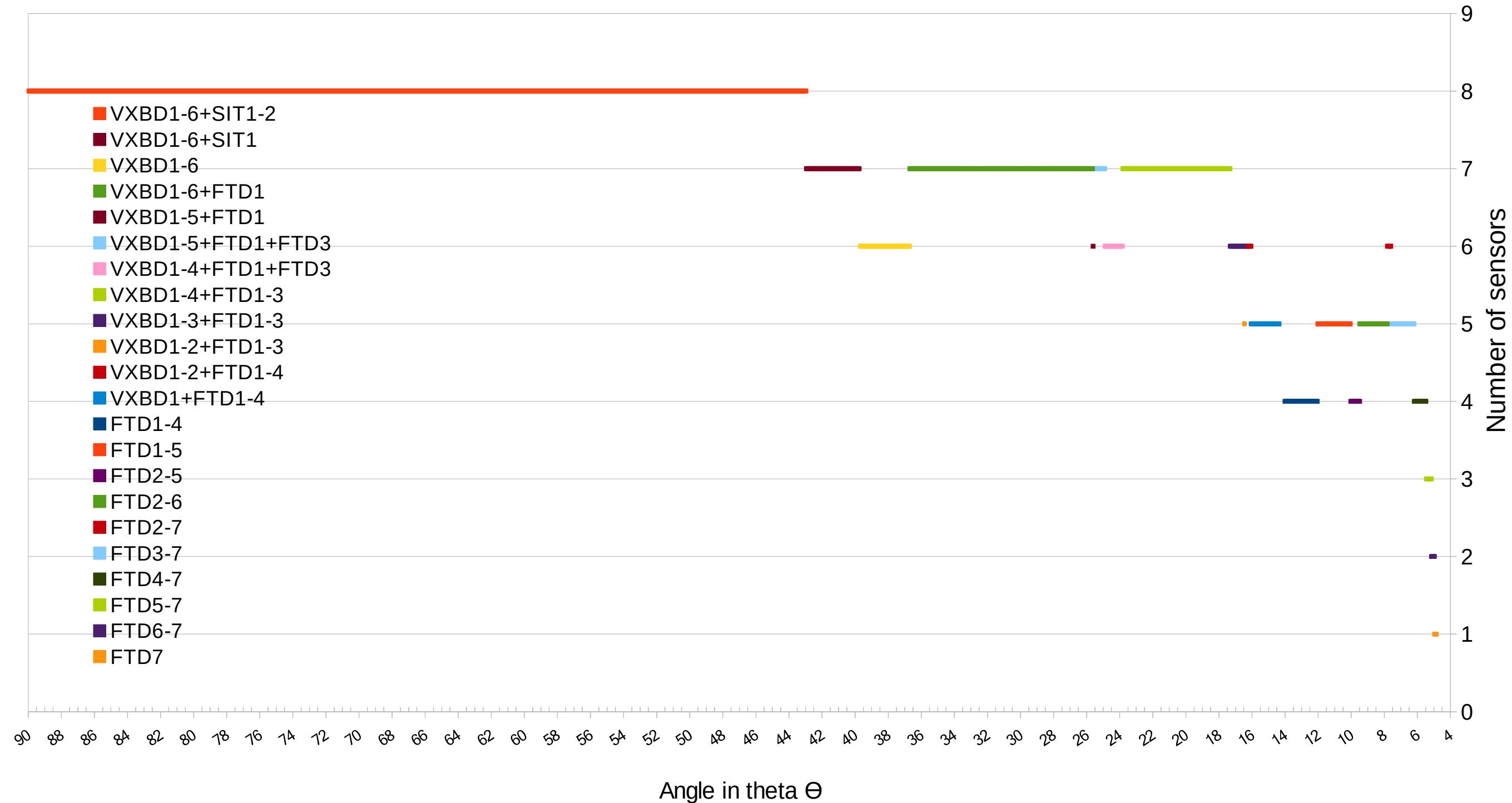
4.2 Material budget calculations



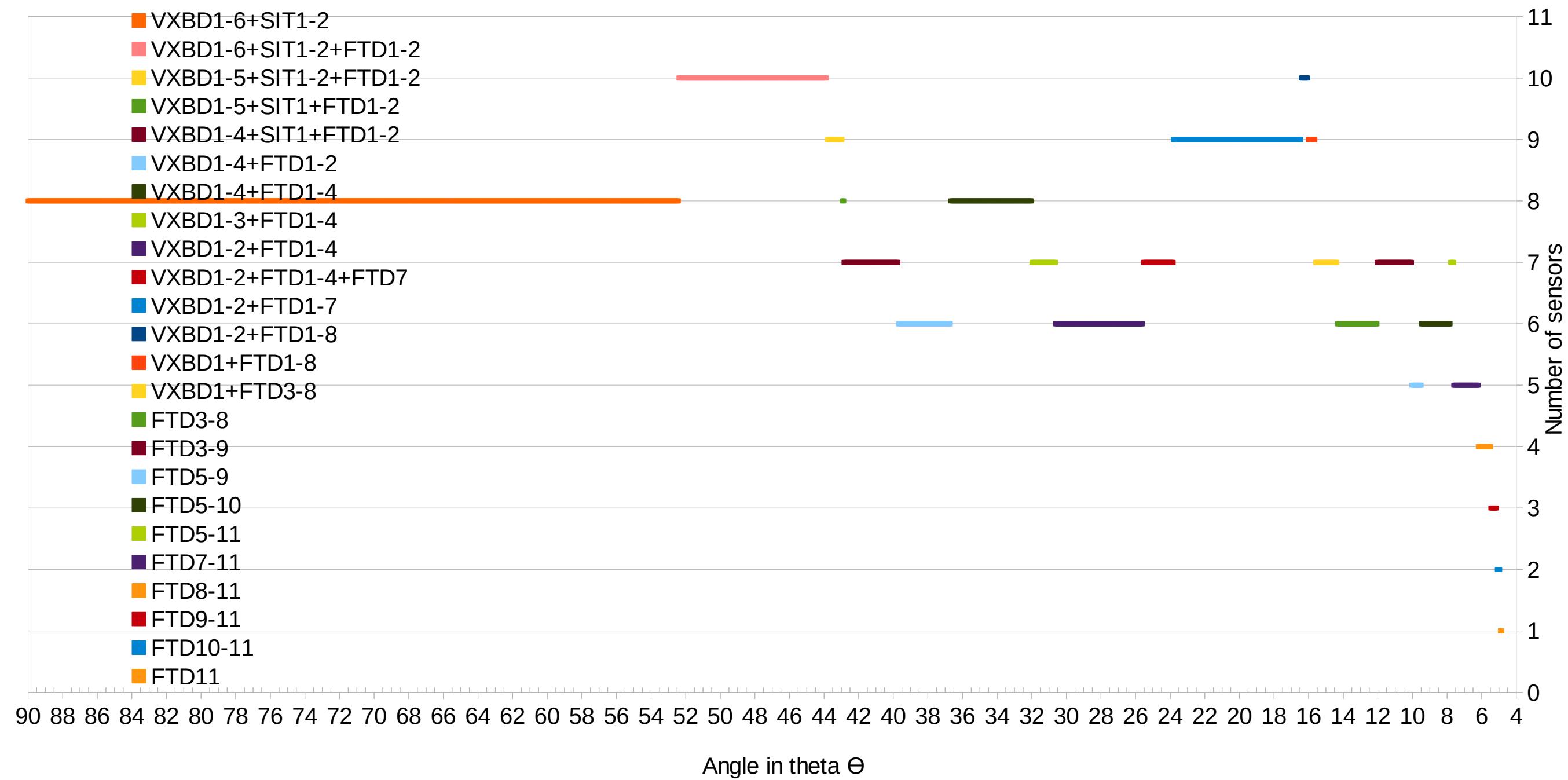
4.3 Material budget calculations: Vertex region in Φ angle



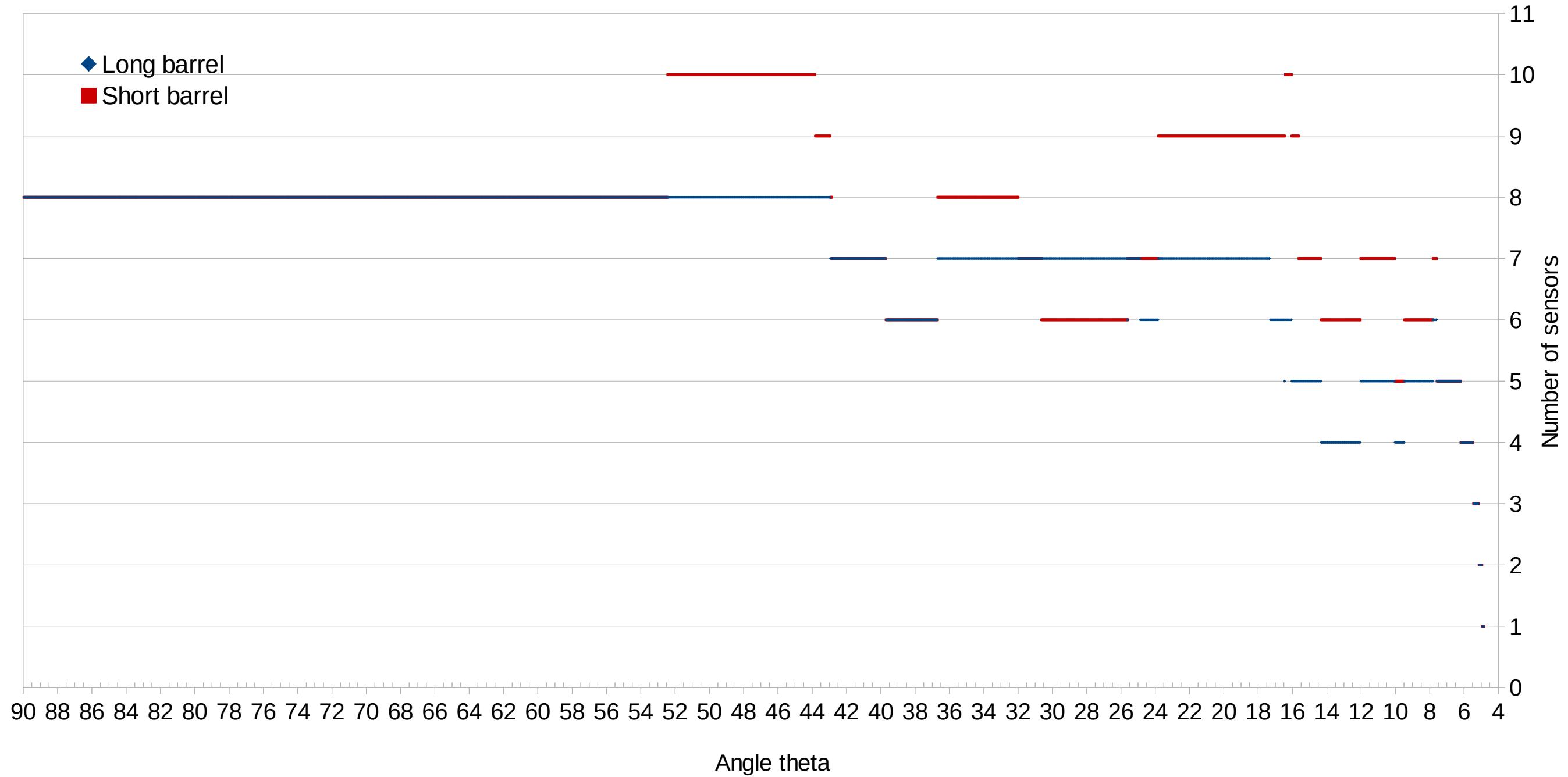
5 Bonus: long barrel sensor coverage in θ



5 Bonus: short barrel sensor coverage in θ



5 Bonus: comparison



4. Future work

- Thermal measurements of the power pulsing in ALL petals together
- Integrate the CAD design within the ILD design (any help?)
- More thermal studies about micro channel cooling:
 - Define the mechanical connexion
 - Define the coolant (CO₂)
- Parallel simulations as soon as the design changes
- Define a second iteration of the mechanical structure to hold up the petals and the barrel sensors.
- Reduce the material budget



5. Conclusions I

- No thermal variations observed due to the power pulsing (ILC cycle 1/200)
- CFX micro channel cooling simulations match with empirical results for water (5W is not the ILC cycle!).
- Assembly process studied and feasible with DEPFET sensors and its services (cables).
- Beam pipe not compromised: no element assembled to it.
- The most realistic material budget shown with DEPFET technology for the entire ladder.
- Calculated material budget for the first sensitive layer and or all the vertex region.
- Comparison presented between long barrel region and short barrel region.
- Sensor coverage studied for long and short barrel configurations.



Thank you

