European Organization for Nuclear Research

ILD workshop 2012

Air cooling and mechanical support of the CLIC_ILD vertex detector and inner tracking system

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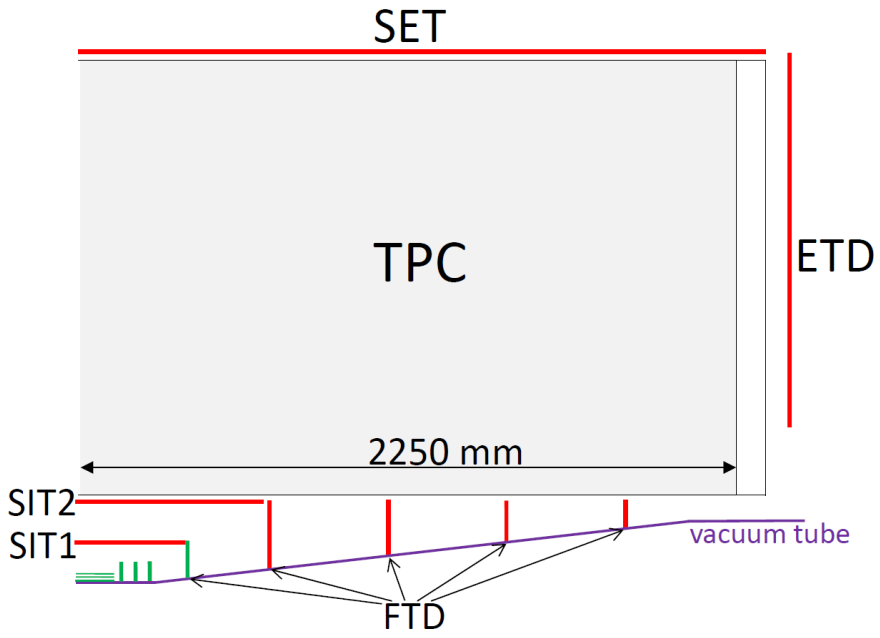
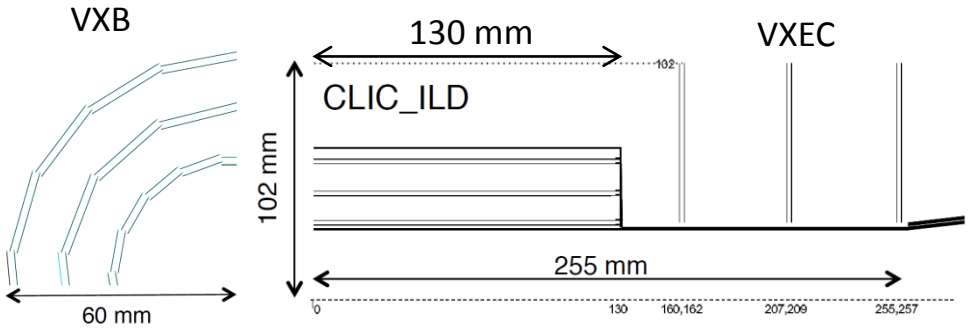
May 21st, 2012

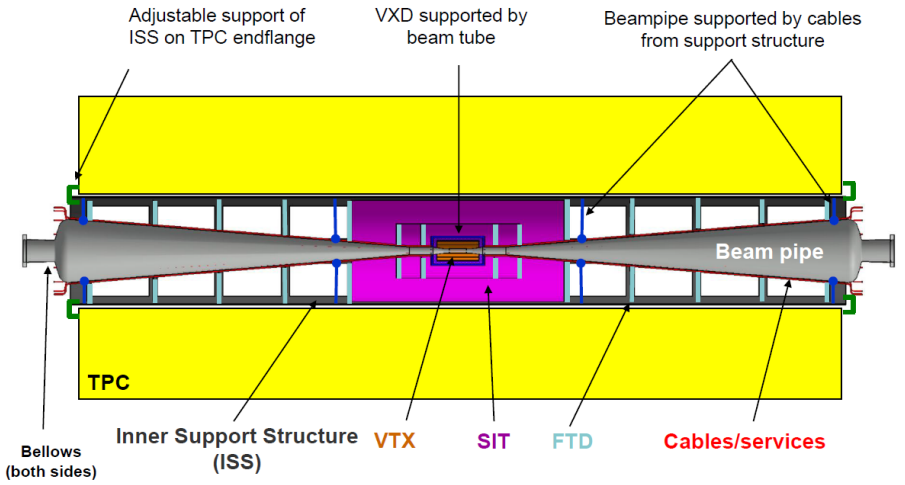
Similar designs

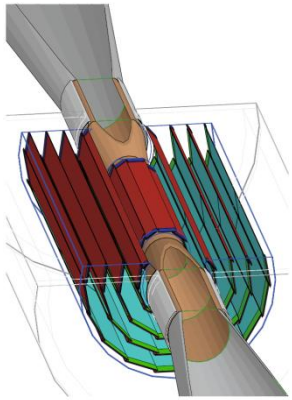
CLIC_ILD

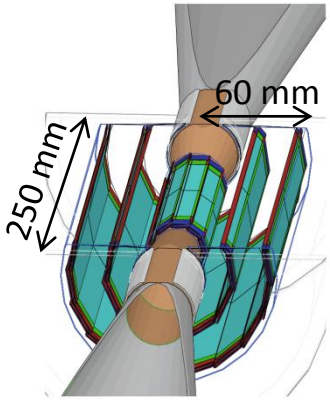




ILD

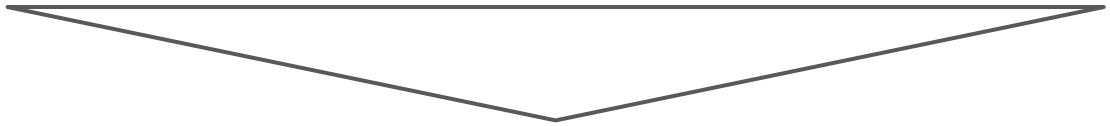






Similar challenges

Low material budget (CLIC_ILD: <0.2% X/X0 per double layer in VXB)
Proper sensor cooling
High dimensional stability
Integration & cabling
Assembly

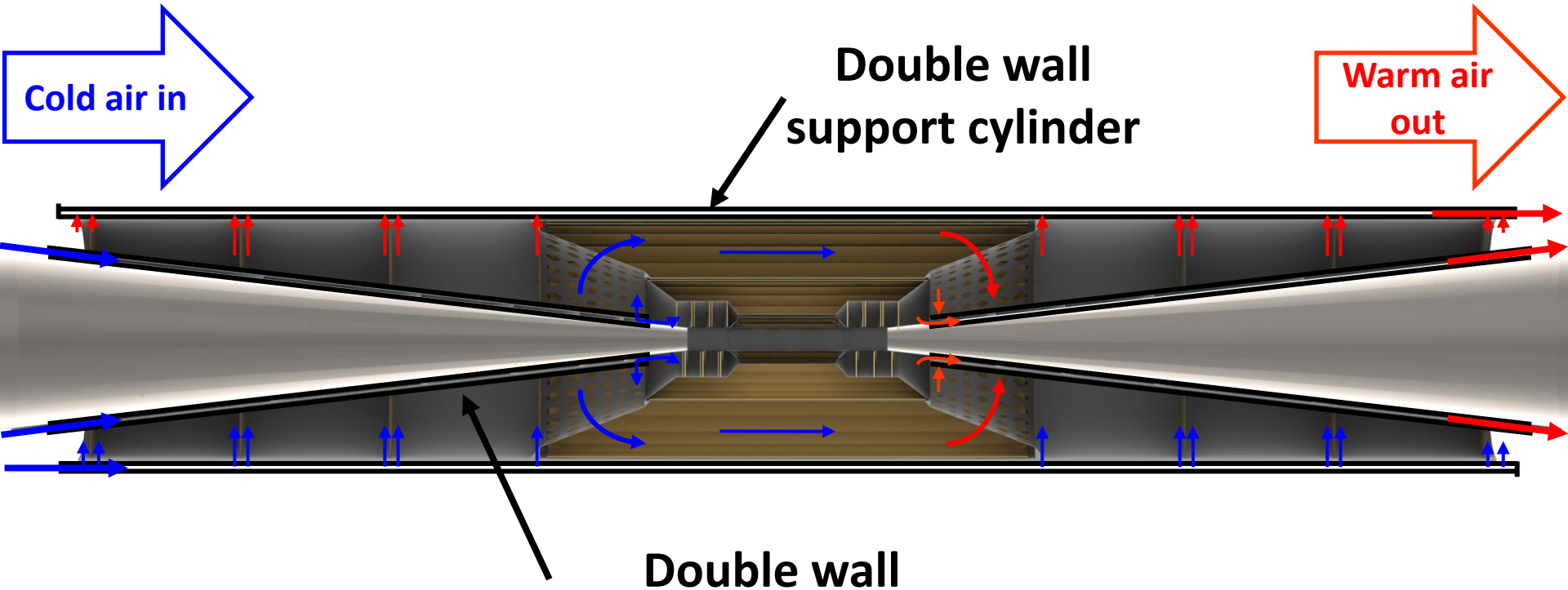


Use of light materials
Air cooling
Maximization of stiffness
Minimization of loads

Integrated design approach:

Cooling, support and cabling must be treated as one single problem.

Air delivery

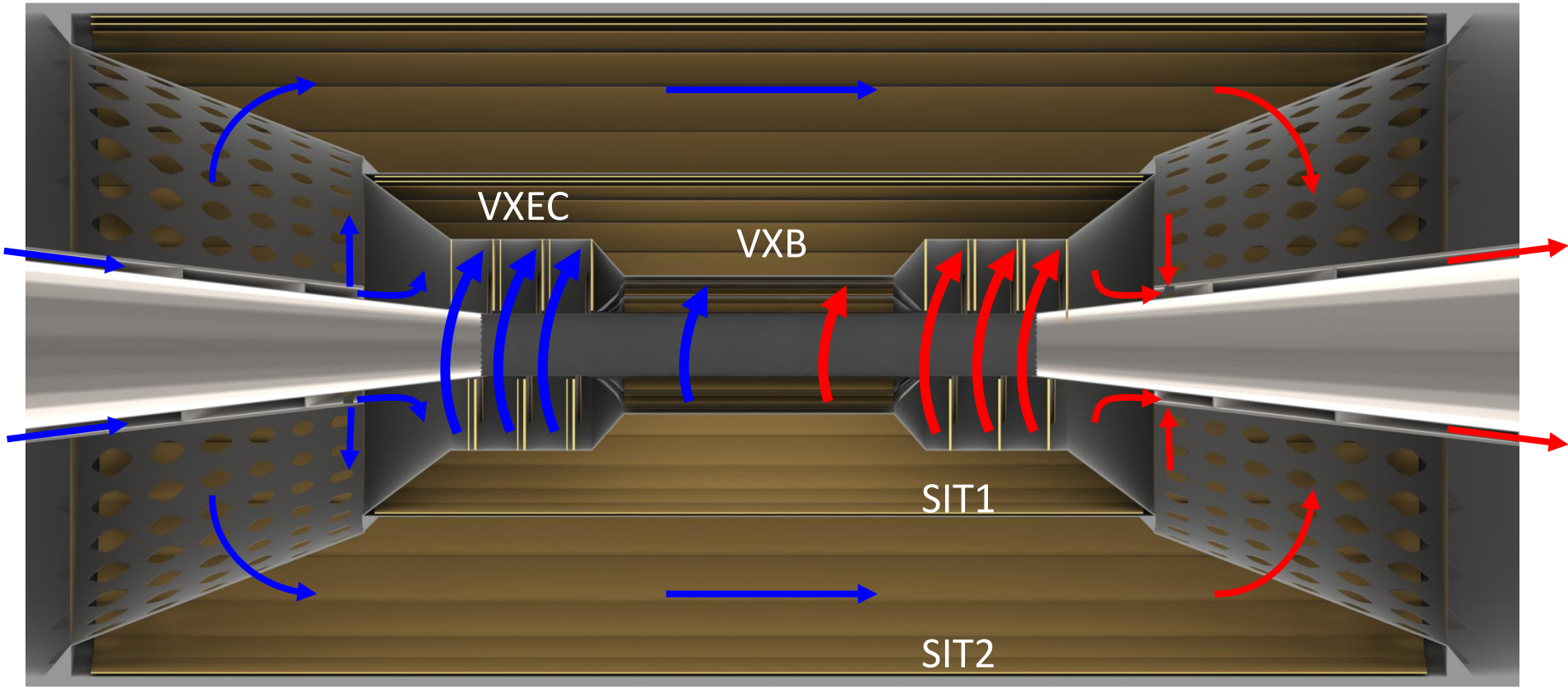


CLIC CDR: thickness=4mm SST

Proposed: thickness=1mm* SST +10mm gap+3mm* SST

*Exact value will depend on beampipe strength calculations

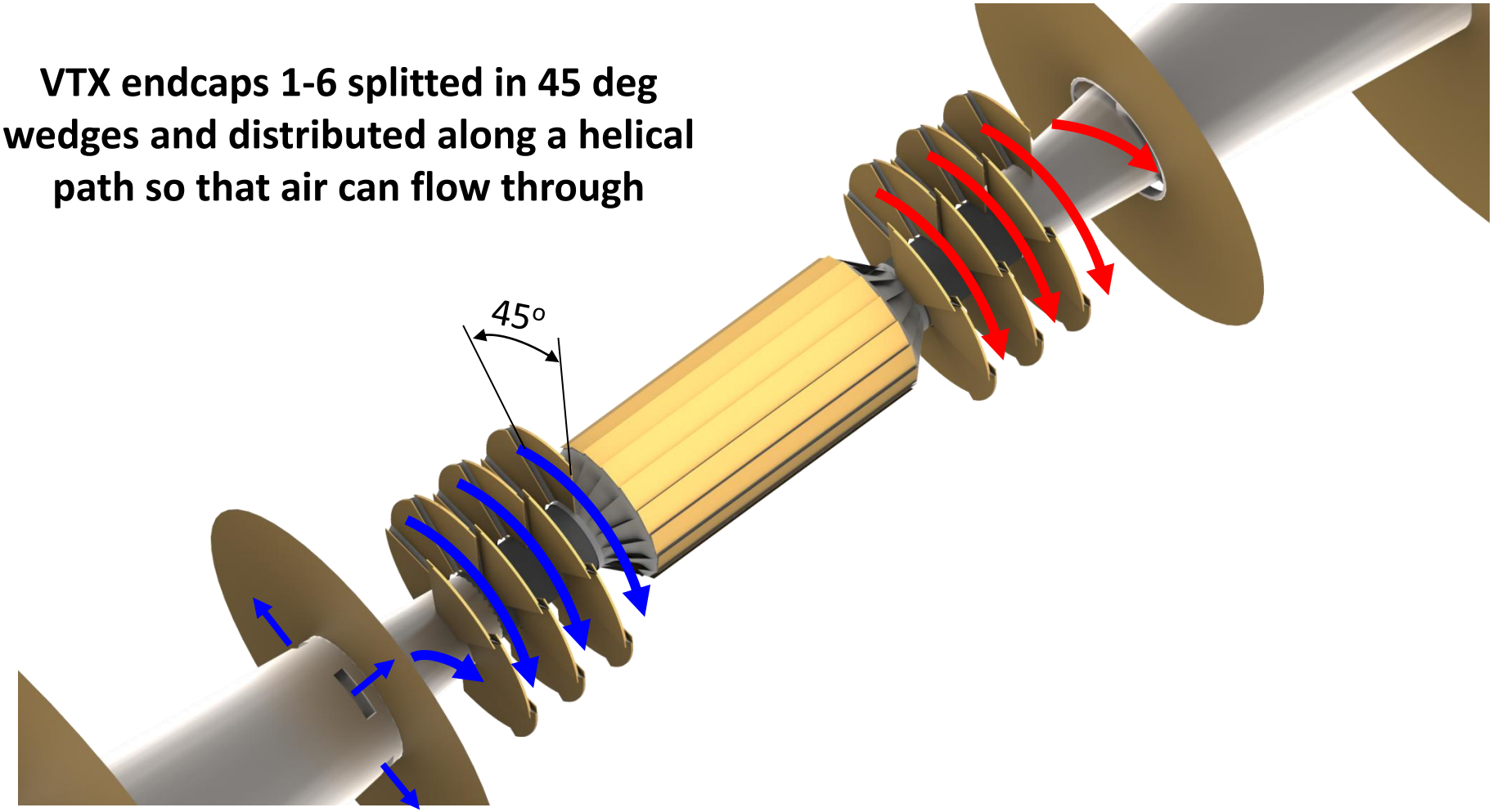
Air delivery



A rotating flow improves the heat transfer
and allows to cool both VTX barrel and endcaps with a single air stream

Air delivery

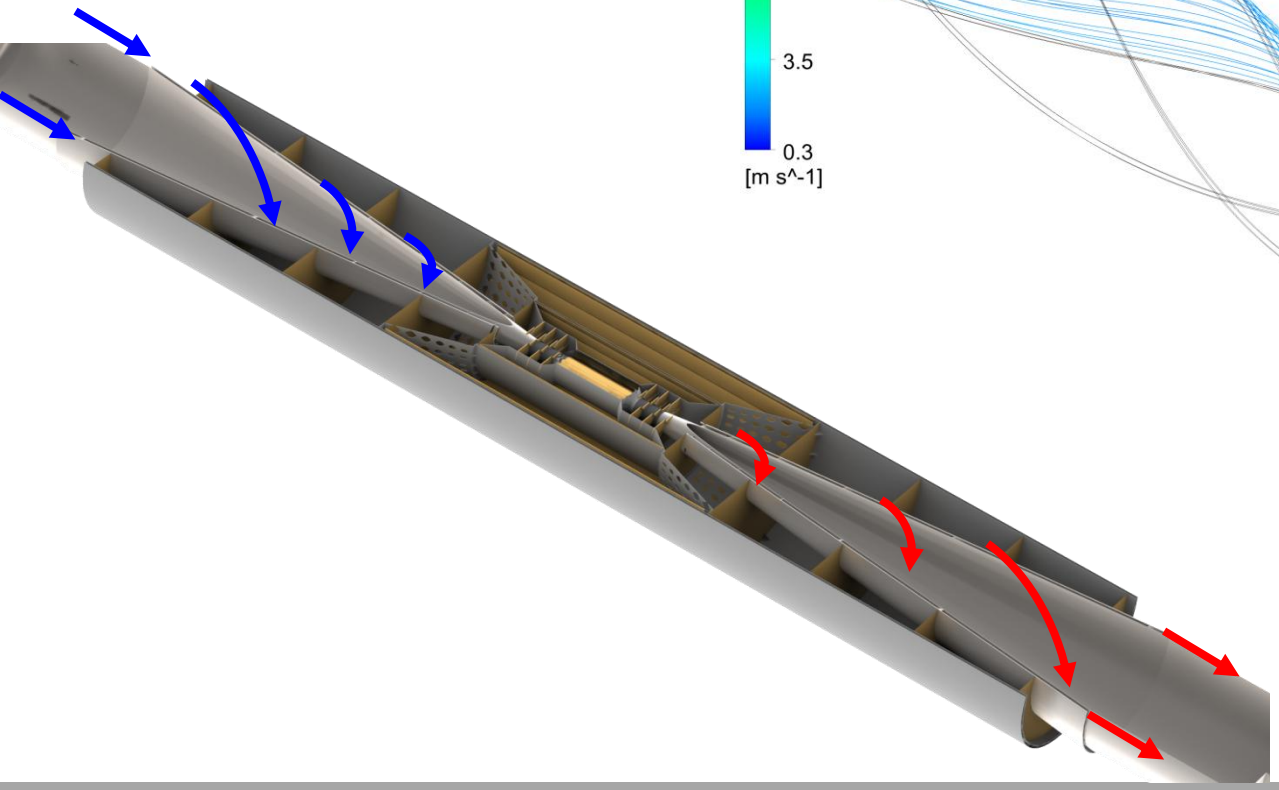
VTX endcaps 1-6 splitted in 45 deg wedges and distributed along a helical path so that air can flow through

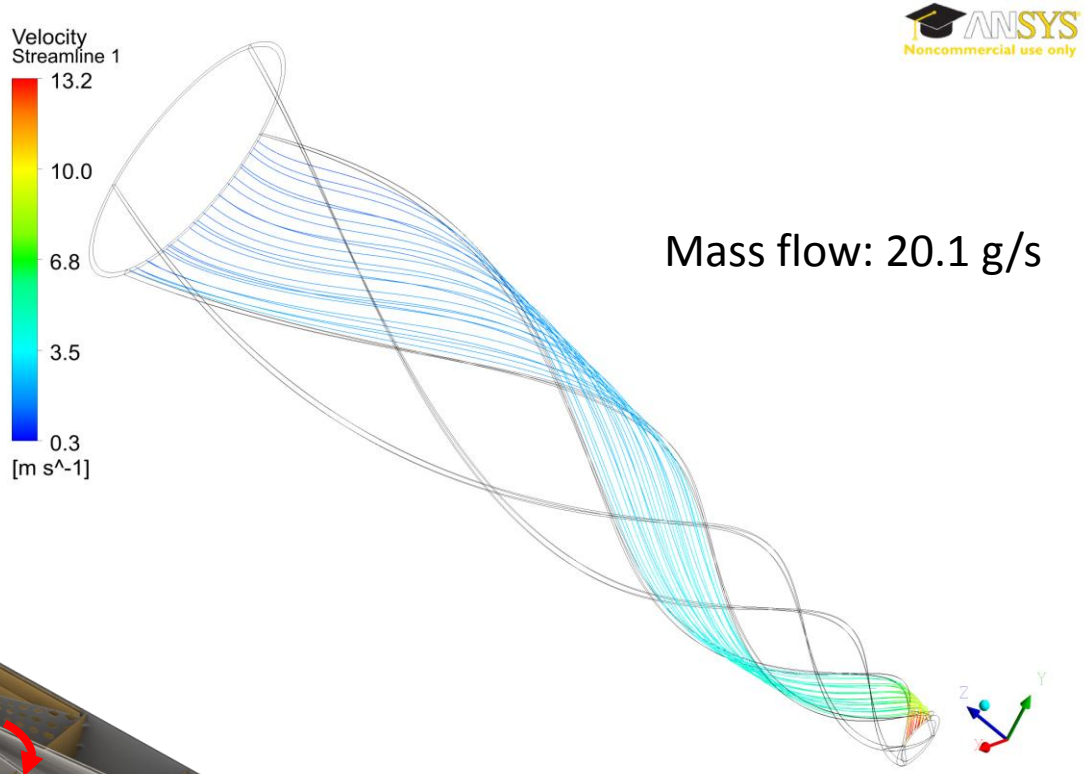


“No” extra material needed for the cooling (ducts, pipes, etc.).

Air delivery

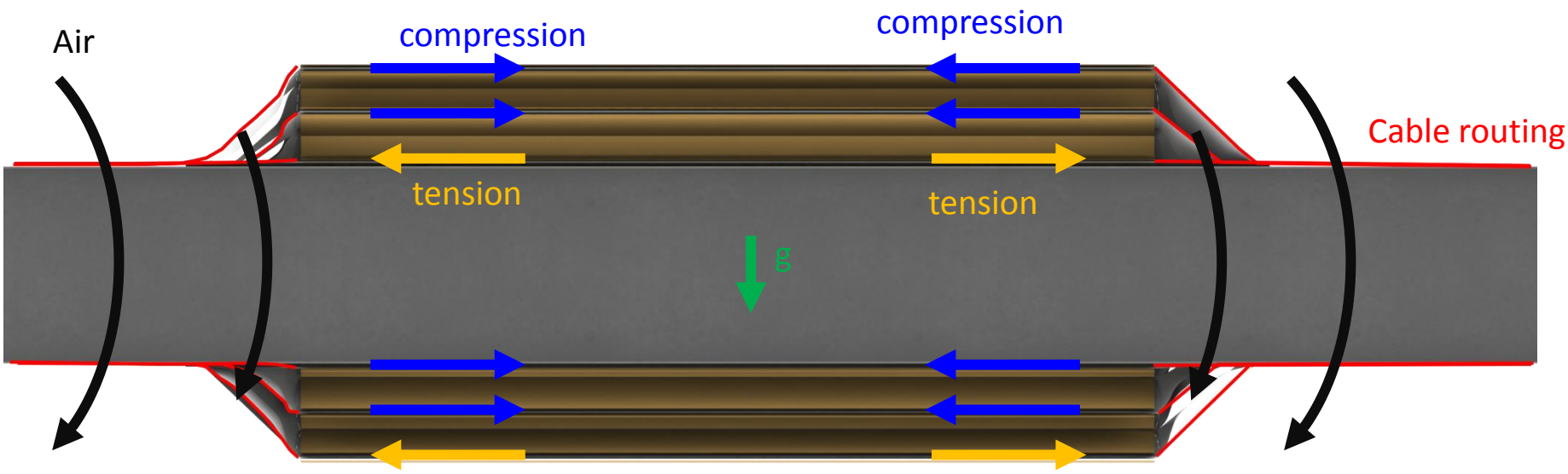
Air supply through double wall conical beampipe



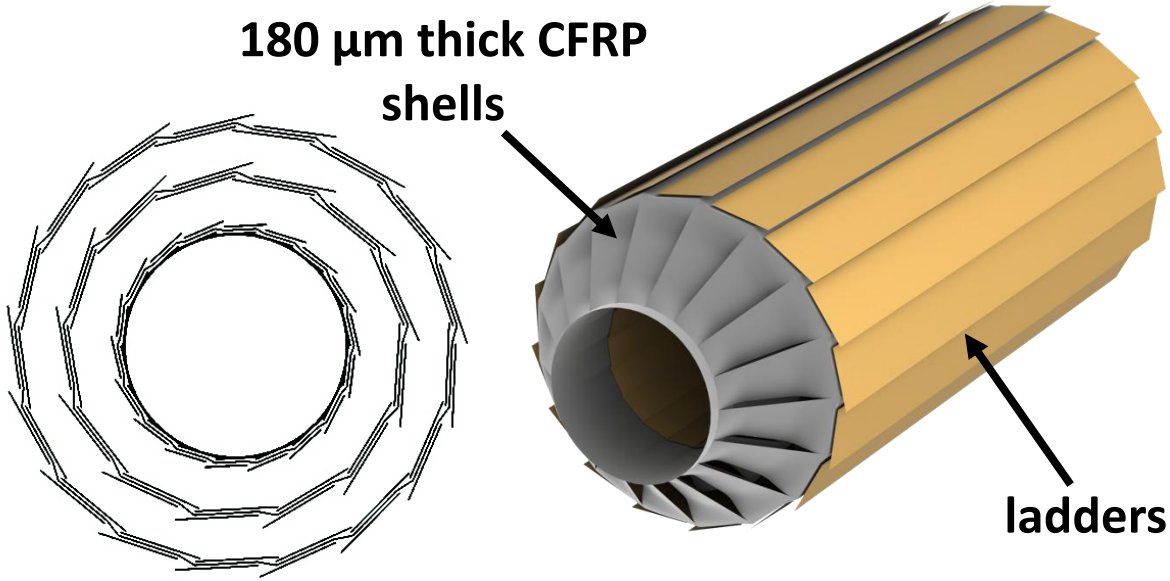


Mass flow: 20.1 g/s

VTX barrel ladder support

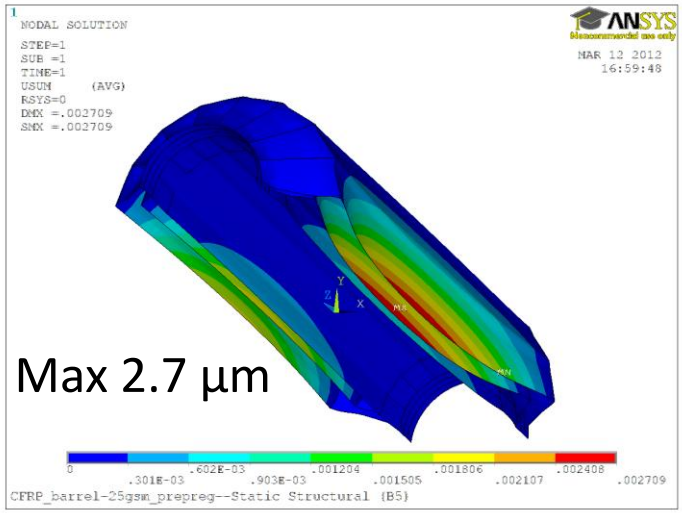


- ✓ Low material budget
- ✓ Proper sensor cooling
- ✓ High dimensional stability
- ✓ Integration & cabling
- ✓ Assembly



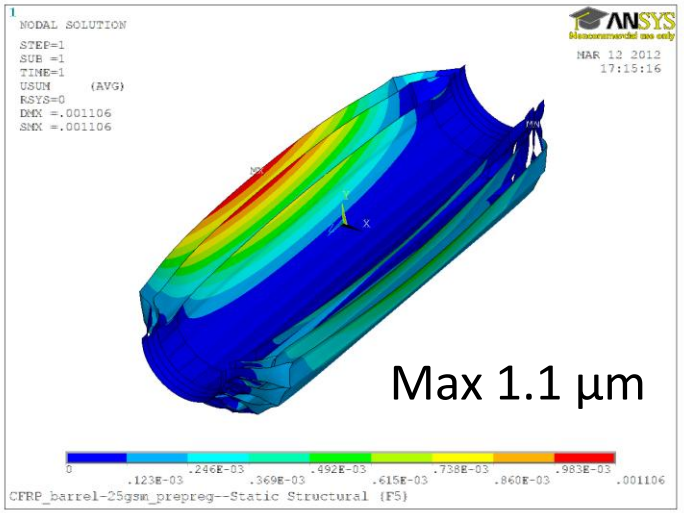
VTX barrel ladder support

Upper half



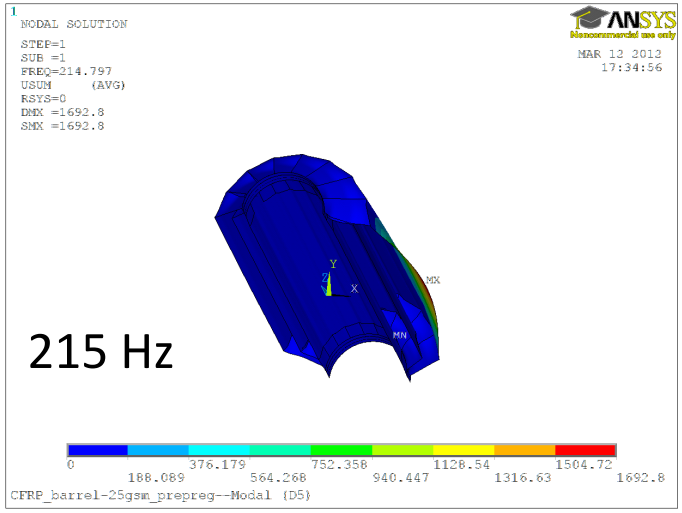
Max 2.7 µm

Lower half

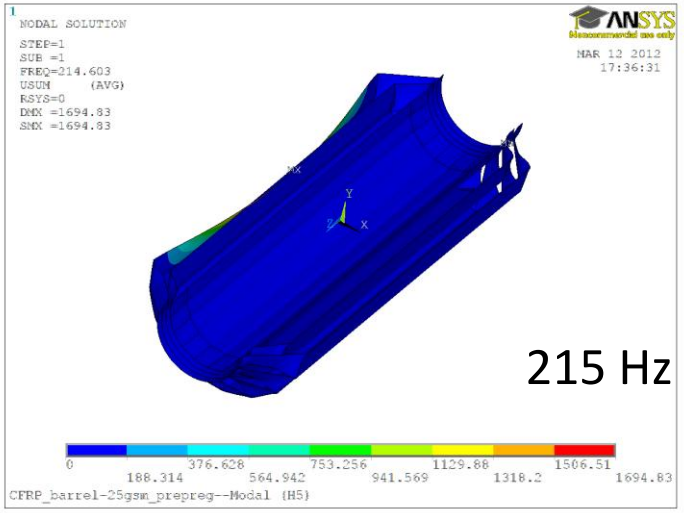


Max 1.1 µm

Deformation under gravity



215 Hz



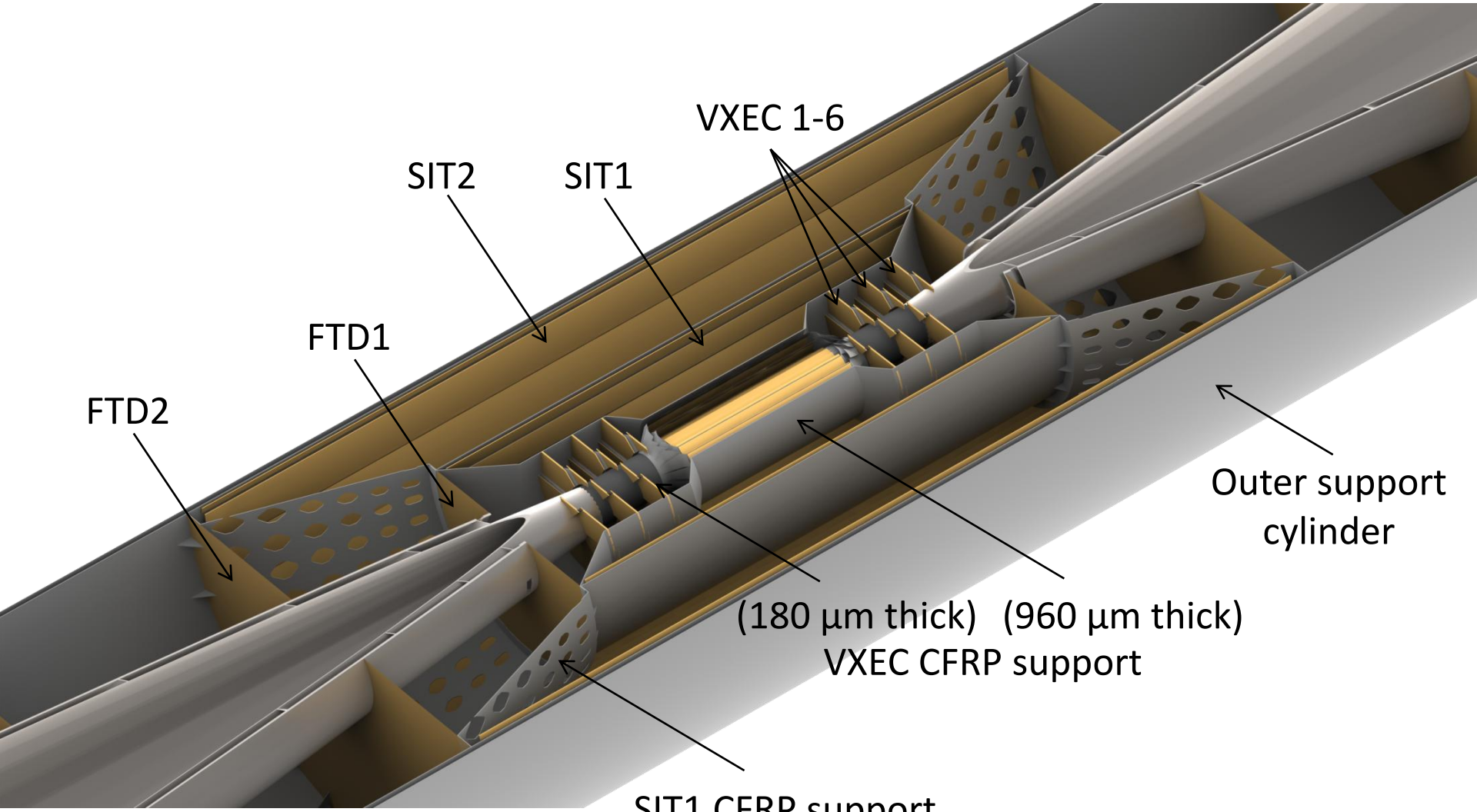
215 Hz

Natural frequency

✓ High dimensional stability

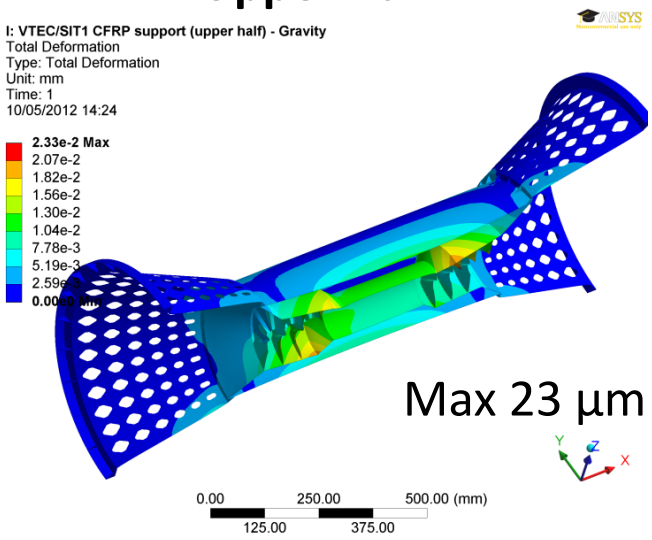
N.B.: Ladders not yet included

VTX endcaps/SIT1 support



VTX endcaps/SIT1 support

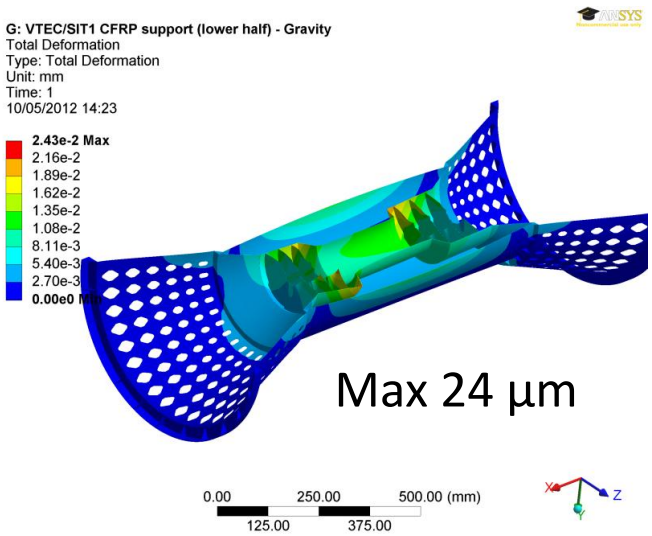
Upper half



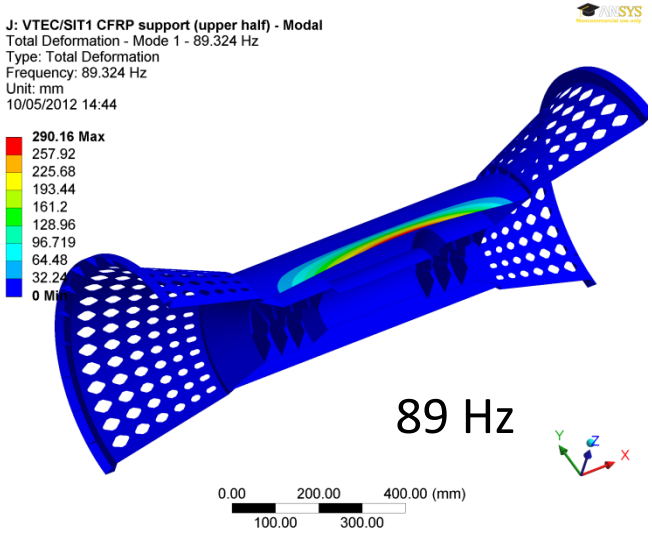
Max 23 µm

Deformation under gravity

Lower half

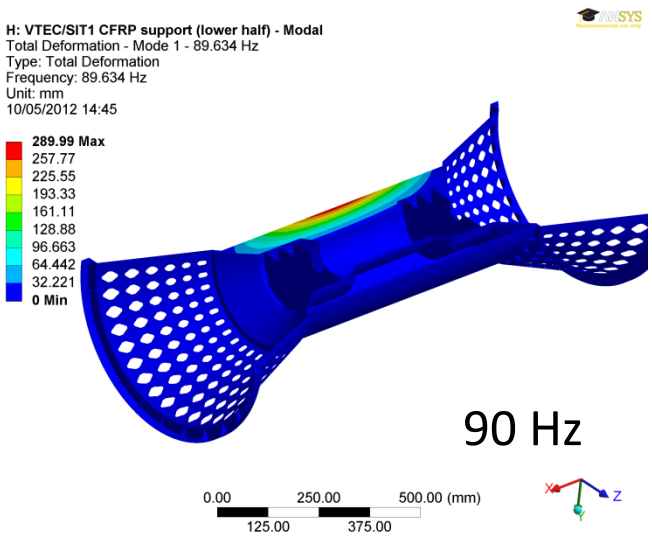


Max 24 µm



89 Hz

Natural frequency



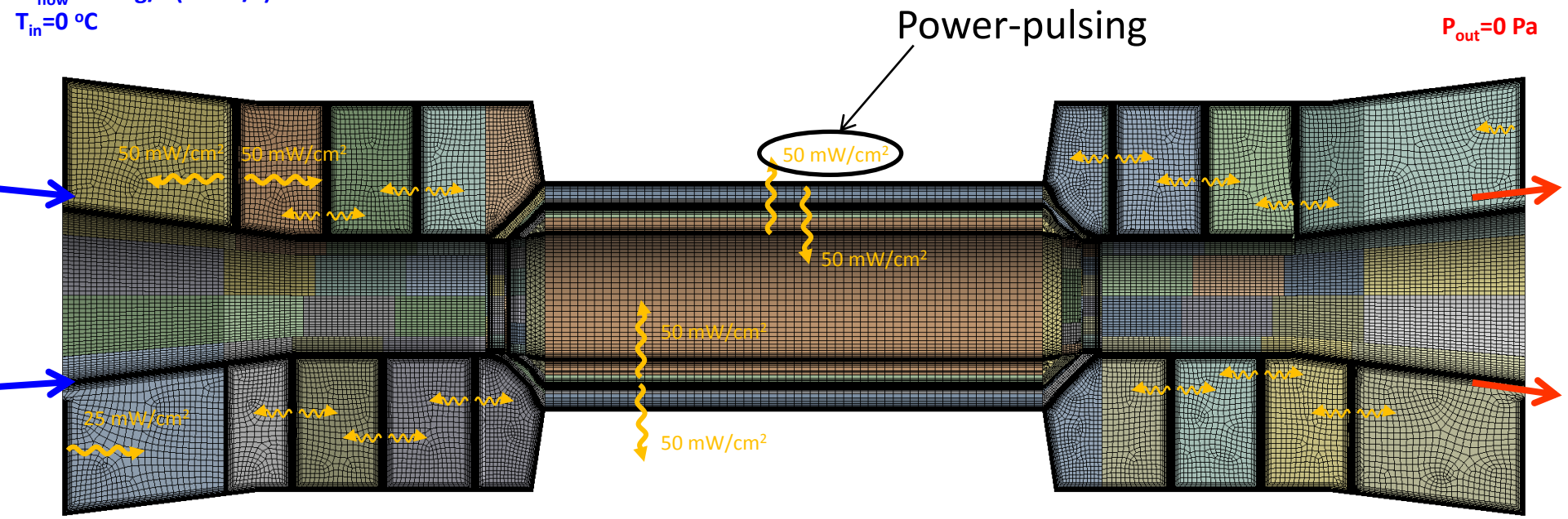
90 Hz

✓ Good dimensional stability

VTX detector air cooling

FEM boundary conditions

$V_{z\,in}$=5.4 m/s
$V_{\theta\,in}$=9.7 m/s
m_{flow}=20.1 g/s (16.2 l/s)
T_{in}=0 °C



Heat loads:

VXECs 1-6		179 W
FTD 1		16 W
Barrel layers 2-5	+	152 W
		346 W

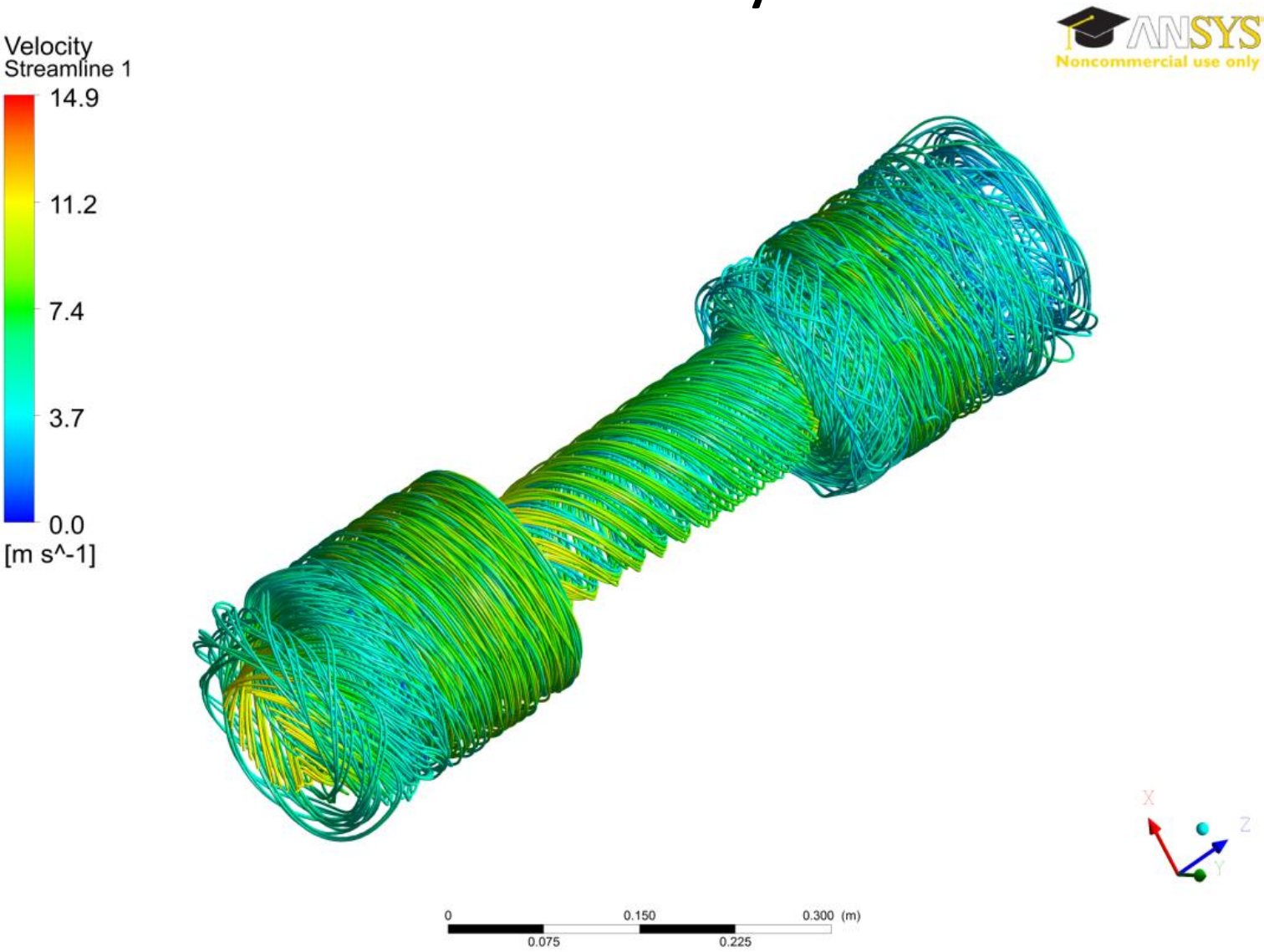
Model info:

- Steady-state analysis
- 2.55M cells
- SST k-ω turbulence model

N.B.: Barrel layers 1 & 6 not yet included

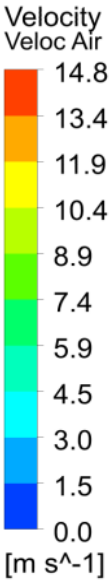
VTX detector air cooling

Air velocity

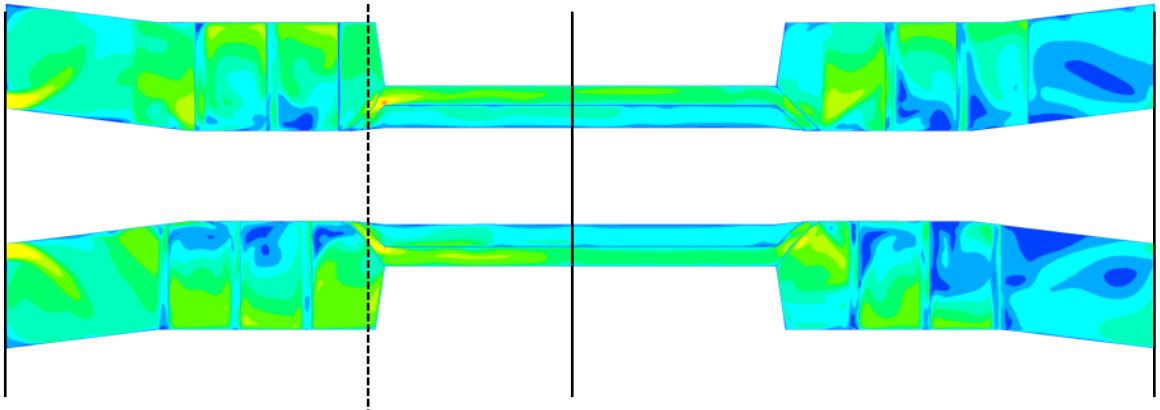


VTX detector air cooling

Air velocity



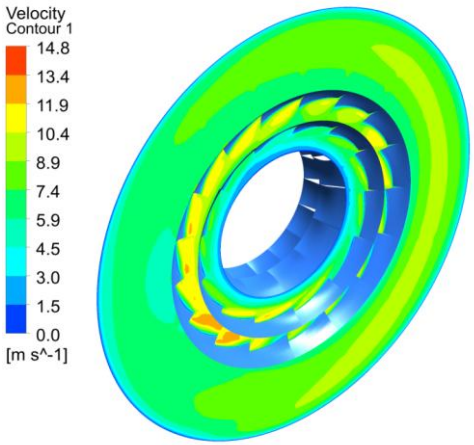
Mass flow: 20.1 g/s

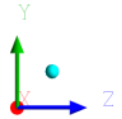


V_{avg} = 11.0 m/s

V_{avg} = 5.2 m/s

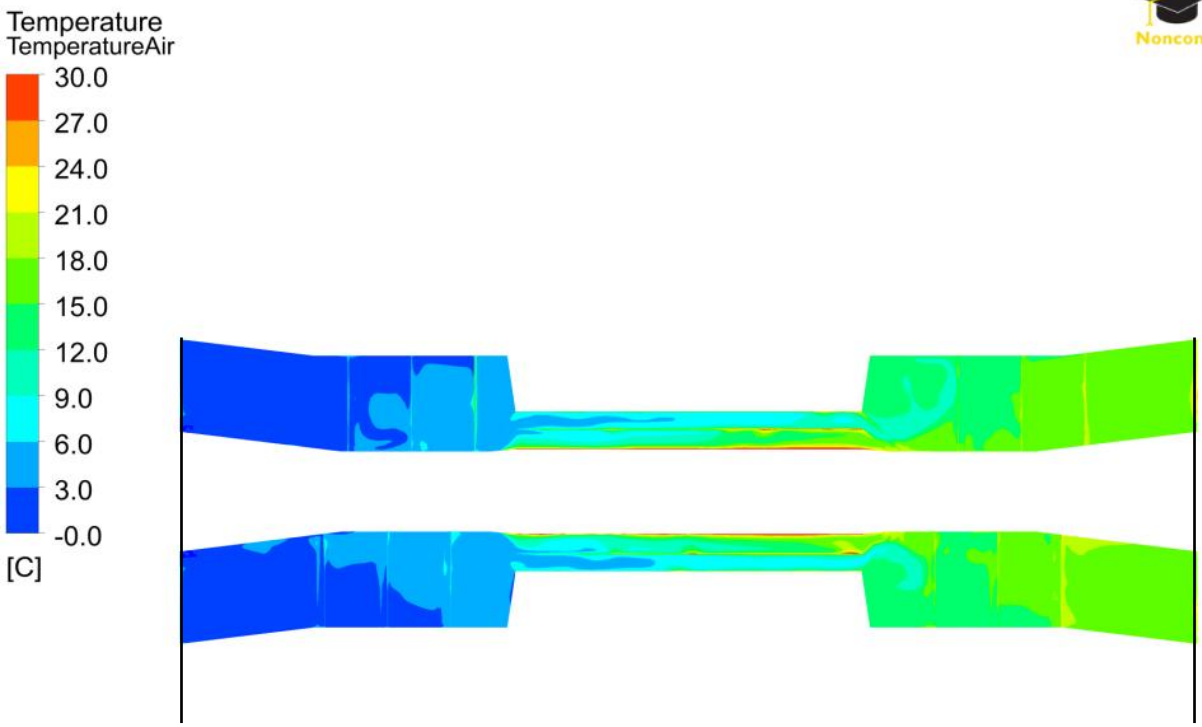
V_{avg} = 6.3 m/s





VTX detector air cooling

Air temperature

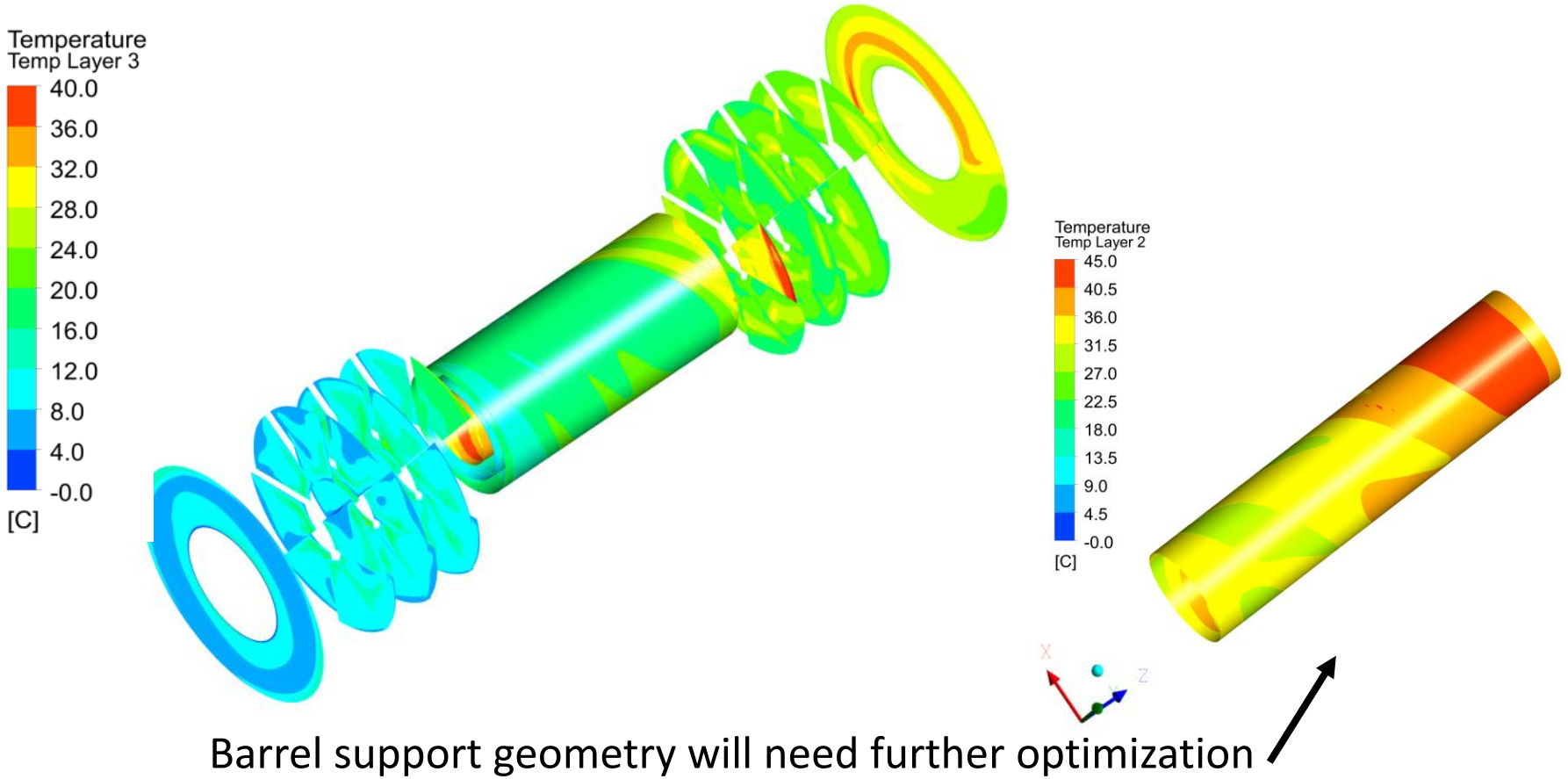


T_{avg} = 0 C

T_{avg} = 17.3 C

VTX detector air cooling

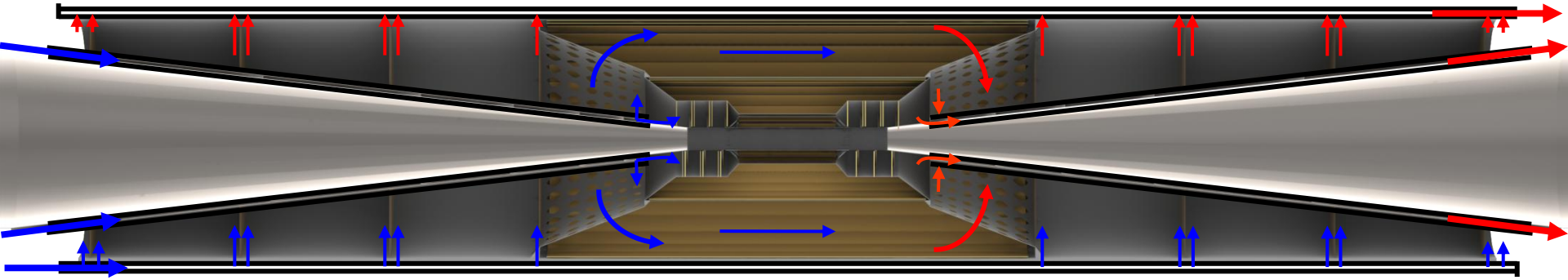
Si temperature

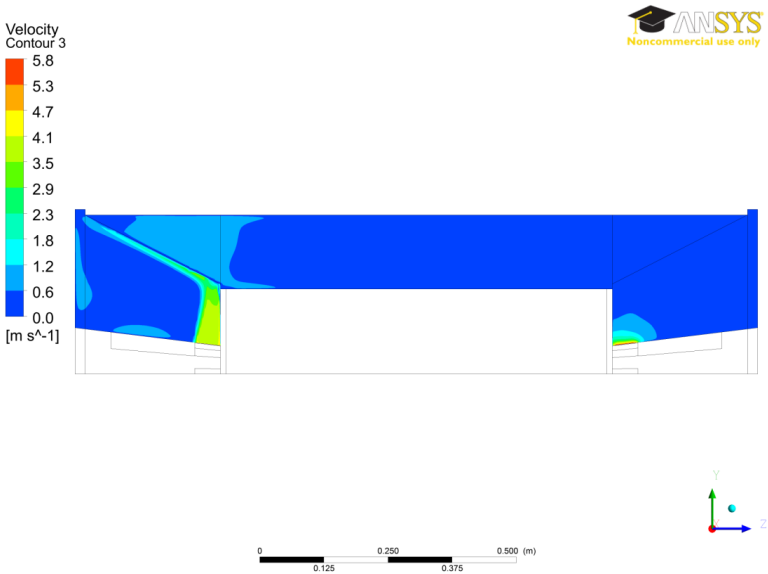


Barrel support geometry will need further optimization
(temperature at barrel layer 2 above 40 C)
Otherwise temperature is kept below 30 C

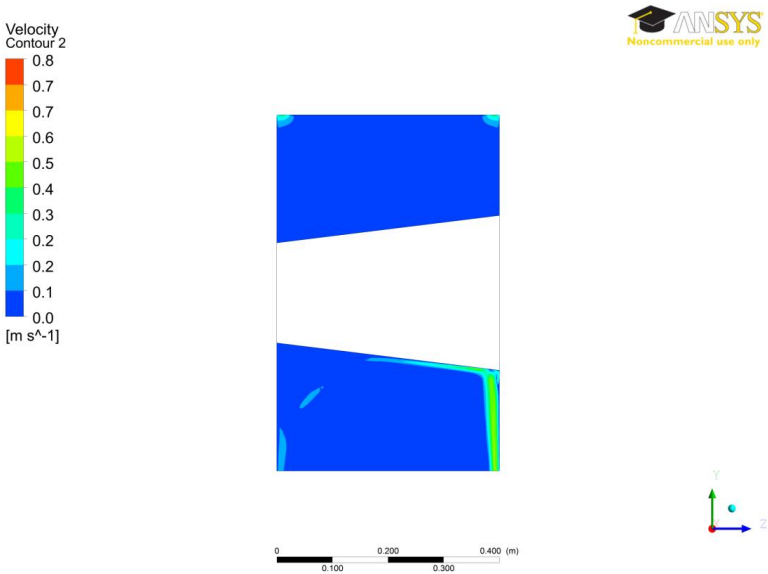
✓ Proper sensor cooling

Inner and forward tracking cooling





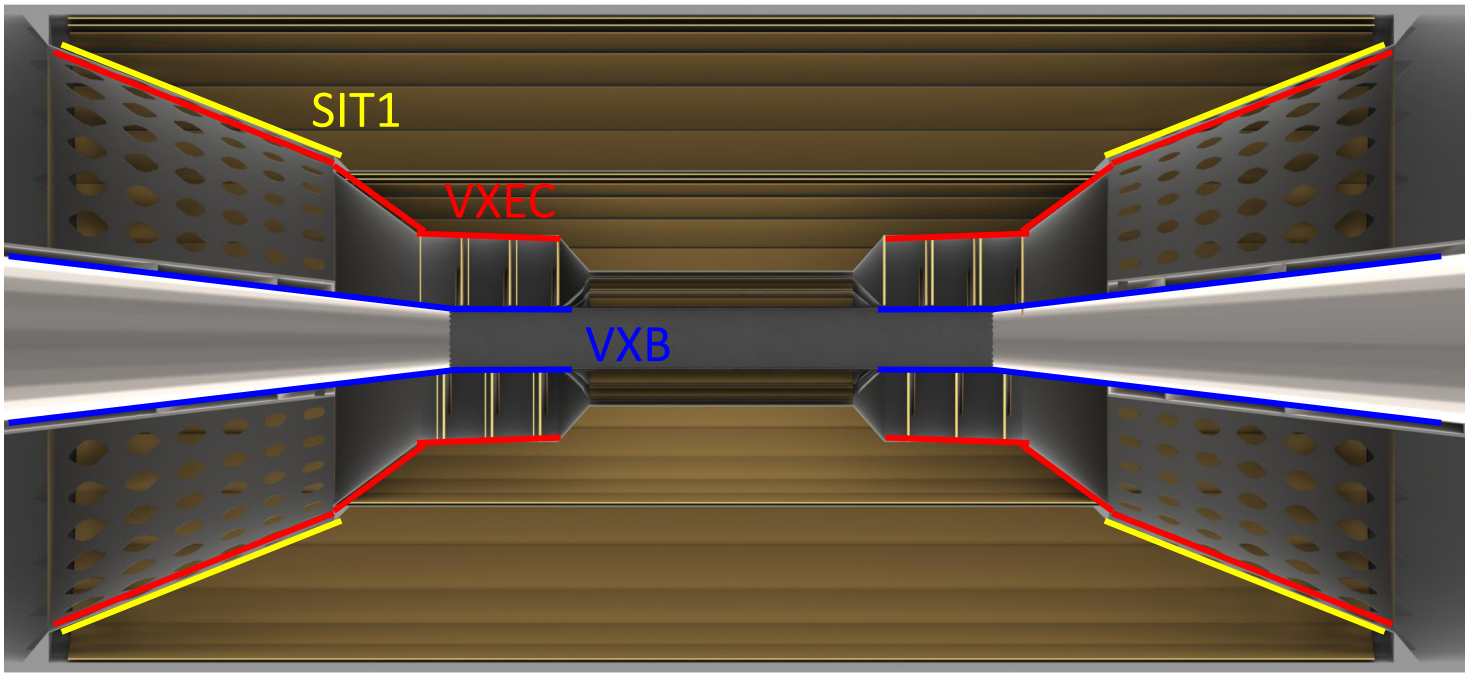
Avg. Si temperature: 3 C

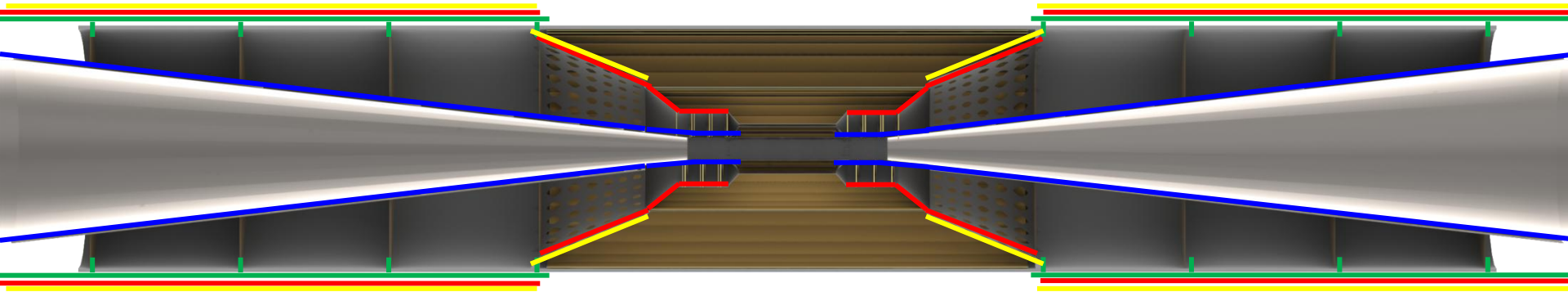


Avg. Si temperature: 24 C

✓ Proper sensor cooling

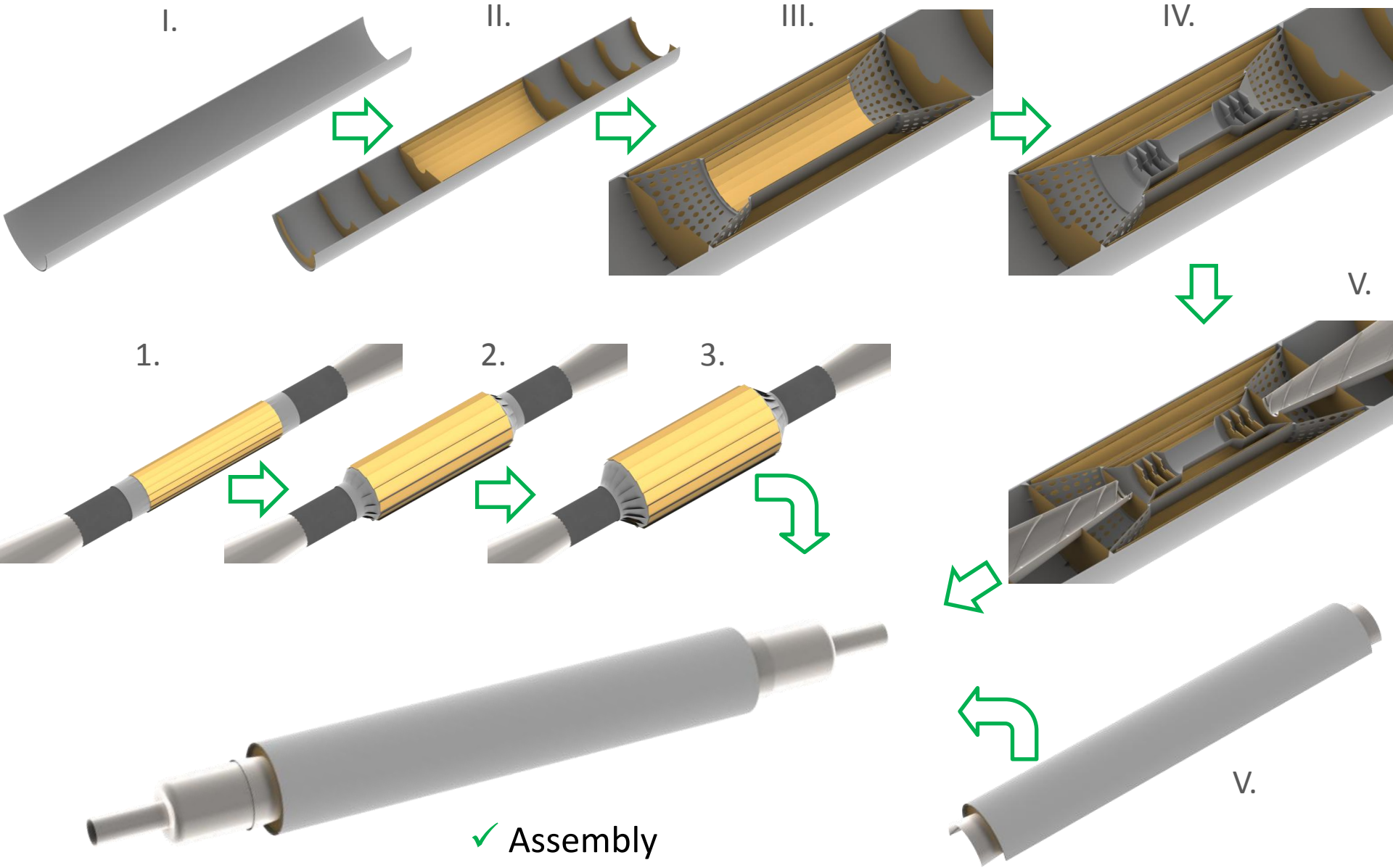
Cabling





✓ Cabling

Assembly sequence



✓ Assembly

Summary

• VTX detector design must cleverly solve support, cooling and cabling issues in an integrated way;

• Current design proposal has taken into account some of those issues (ongoing work);

• Air cooling seems feasible but vibration is still an unknown variable (to be checked experimentally);

• Proposed solutions need to be checked against their impact on physics.

Thank you