OAK RIDGE National Laboratory | SECOND TARGET STATION

# CV Nozzle Extension Thermal Analysis

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U.S. DEPARTMENT OF ENERGY

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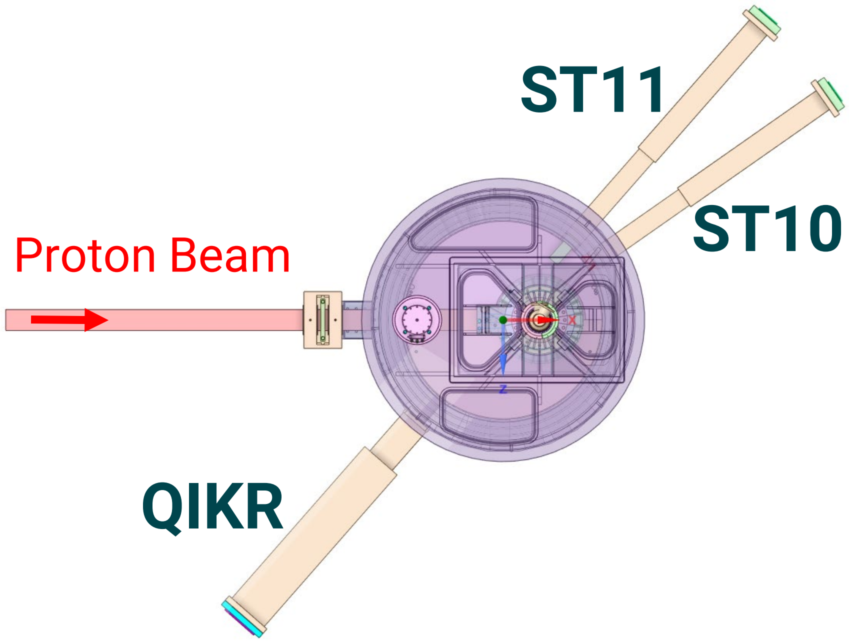
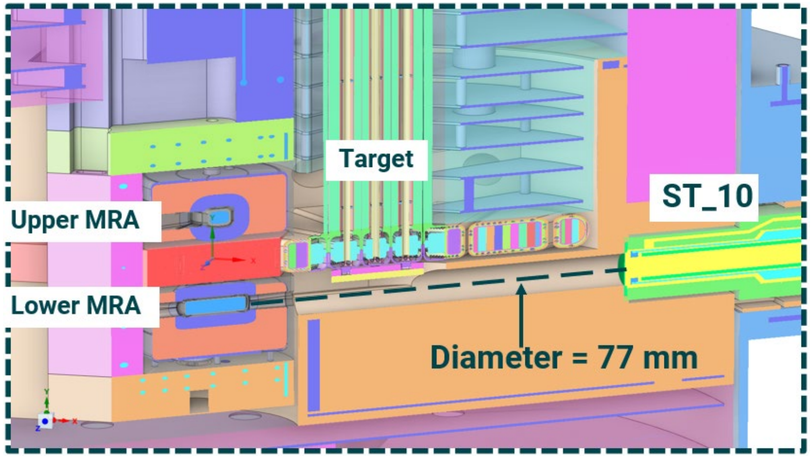
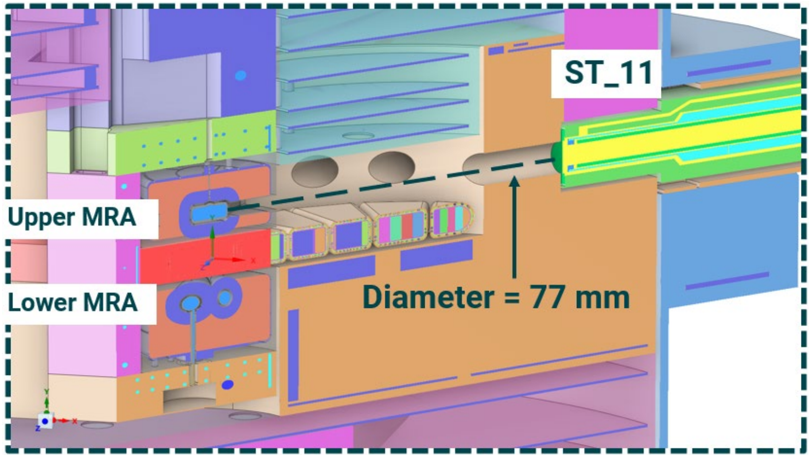
# CV Nozzle Extensions Analyzed in This Presentation



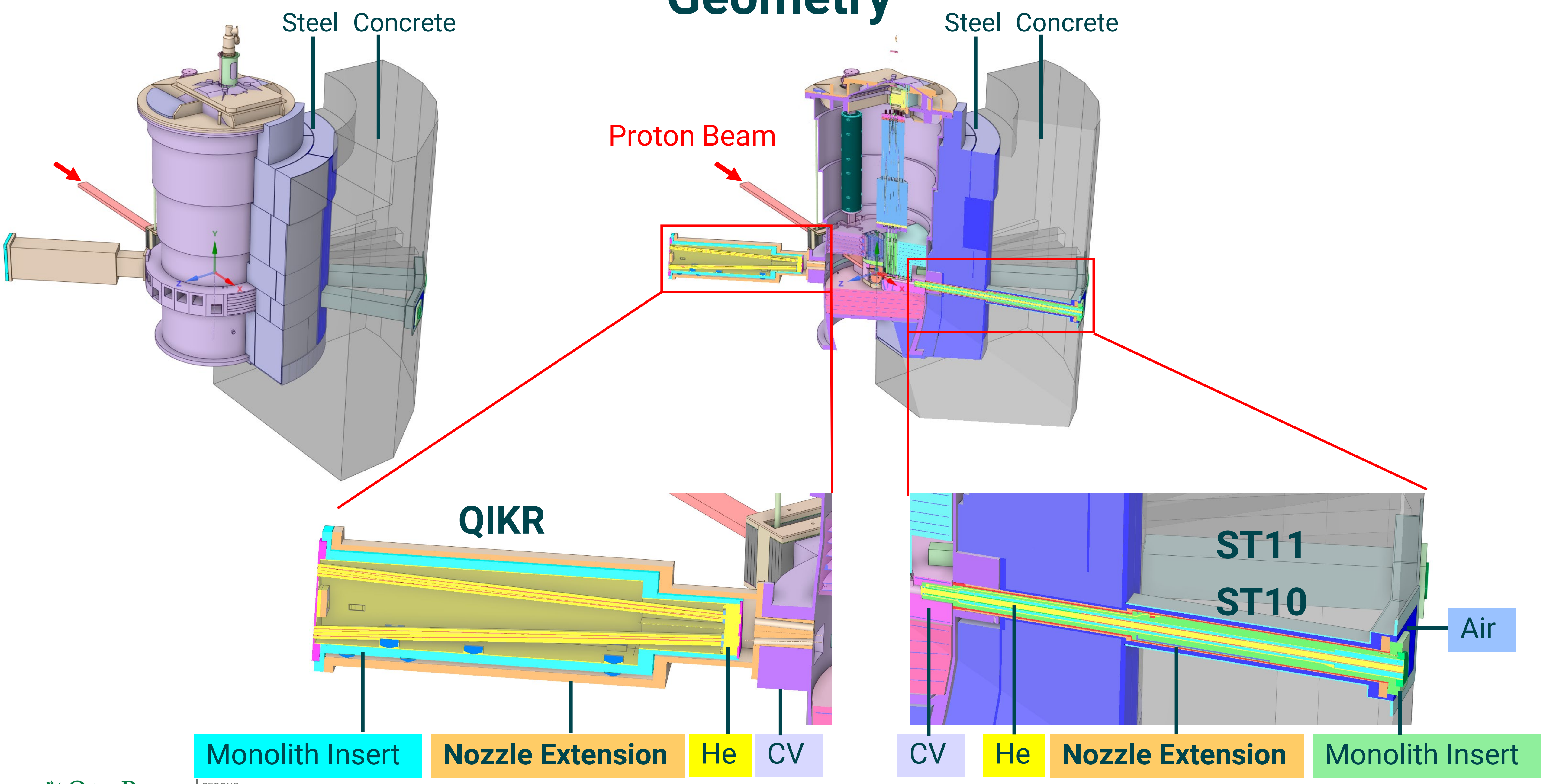



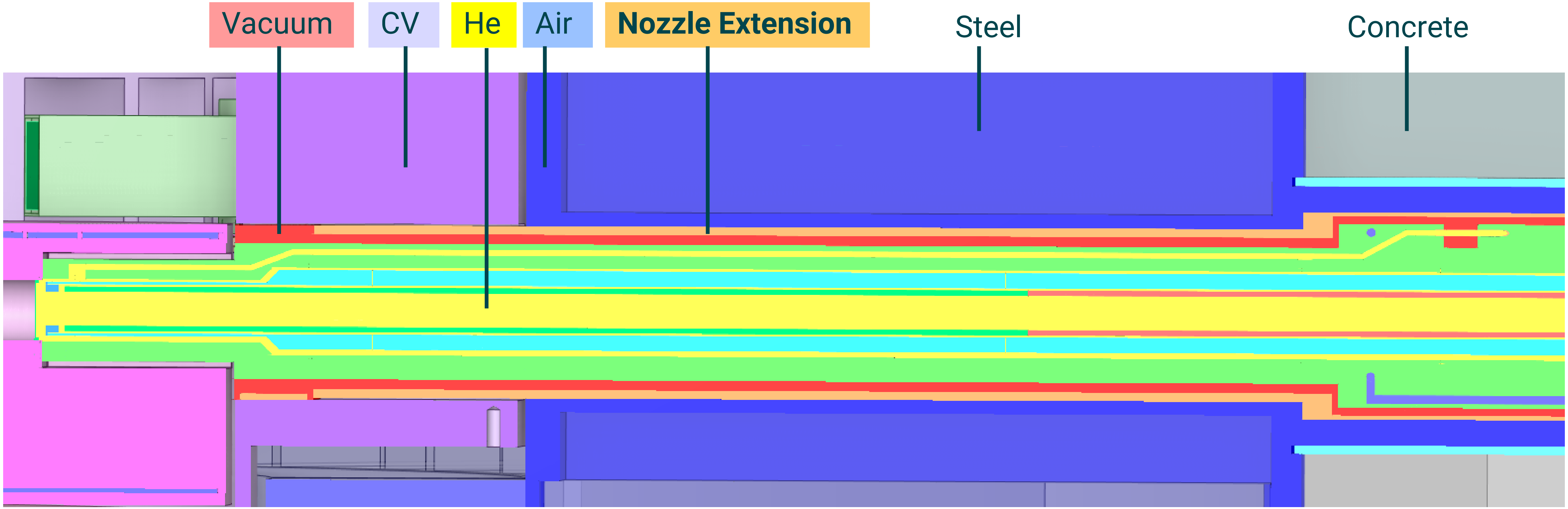

The **nozzle extensions** at **QIKR**, **ST10**, and **ST11** are chosen for the thermal analysis because:

- **ST10**: facing the **lower** MRA (**~1 m**), **forward** direction of proton beam, **higher** energy deposition, **active cooling**
- **ST11**: facing the **upper** MRA (**~1 m**), **forward** direction of proton beam, **higher** energy deposition, **active cooling**
- **QIKR**: **farther** away from MRA (**~1.9m**), **backward** direction of proton beam, **lower** energy deposition, **passively cooled**

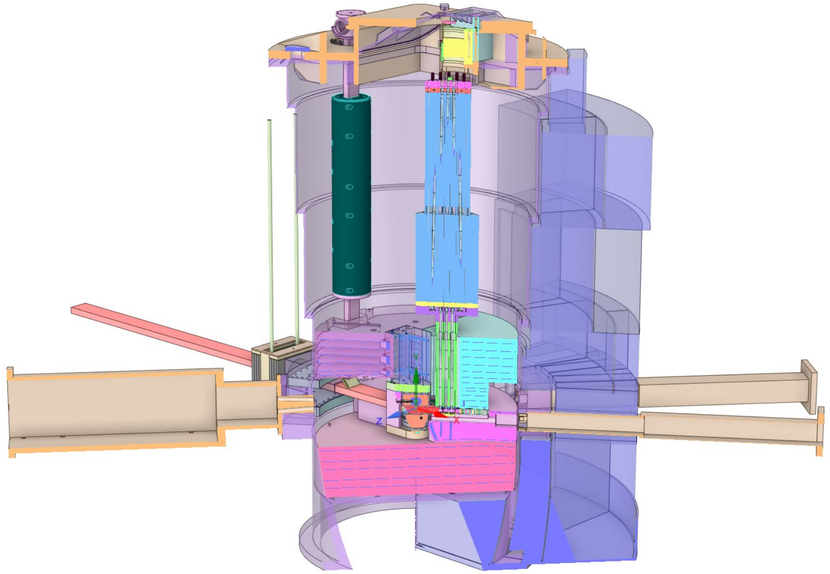
# Geometry

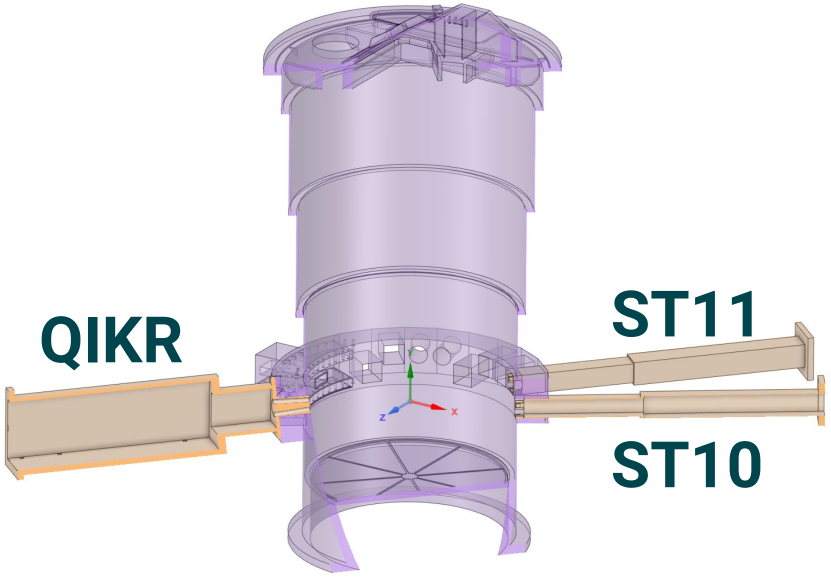

Steel
Concrete
Proton Beam
Steel
Concrete
QIKR
ST11
ST10
Air
Monolith Insert
Nozzle Extension
He
CV
CV
He
Nozzle Extension
Monolith Insert

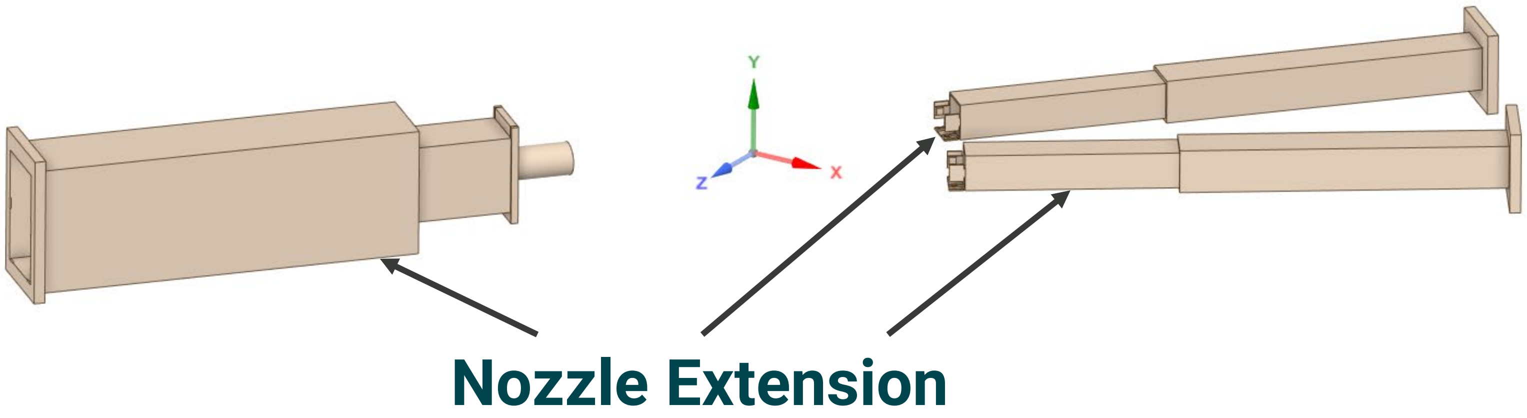
# Geometry (ST10)



# Geometry, Nozzle Extension @ ST10, ST11, and QIKR






- This presentation discusses the **temperature profile** of nozzle extensions.
- The results in this presentation are extracted from the thermal analyses done for the QIKR and Monolith Insert Modules at ST10 and ST11. More details can be found : Monlith_Insert_PDR_CFD_Analysis_06_25_2024.pptx
  MTK_QIKR_Heat_Transfer_Analysis_2025_03_07_Updated.pptx
- The front surface of the nozzle extension is welded to the well-cooled core vessel beltline (active cooling).
- A separate CFD analysis was done for the core vessel beltline, and the obtained temperature profile was used to set the boundary condition for the nozzle extension.

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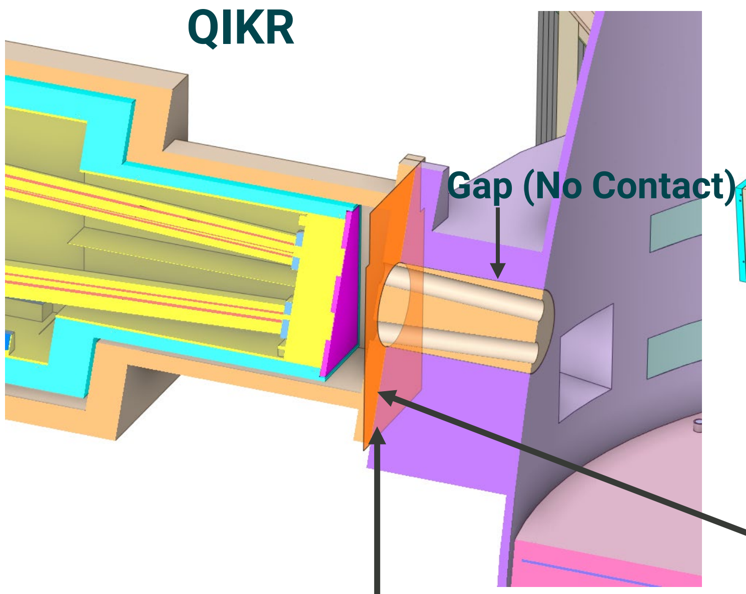
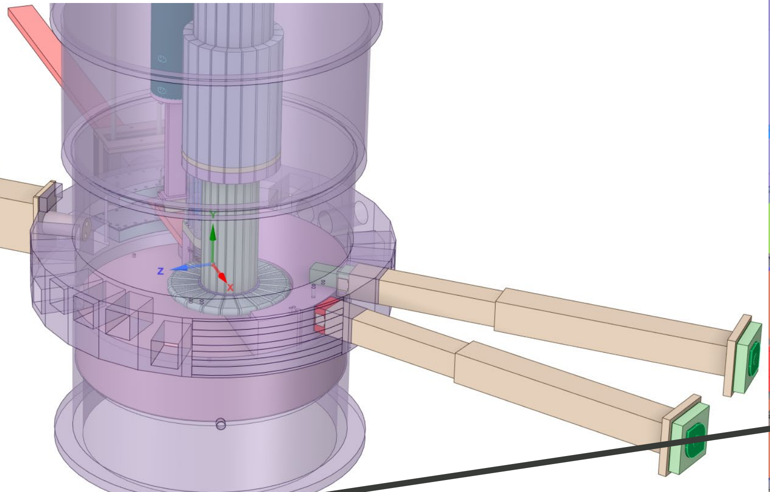
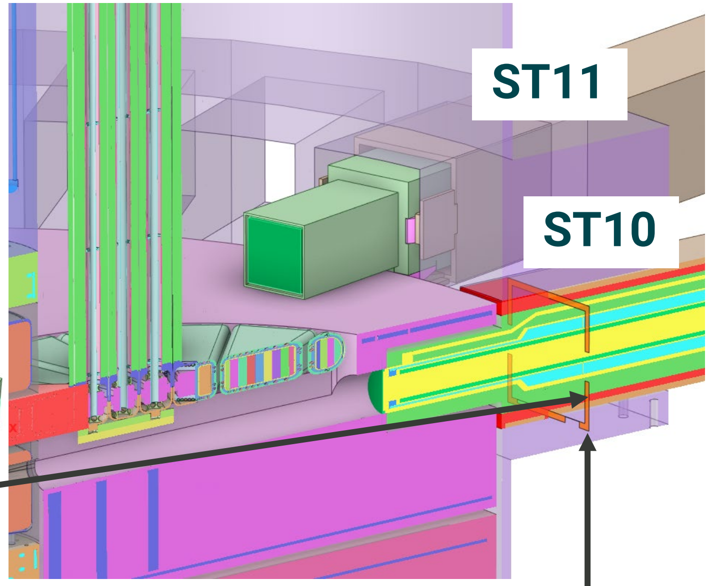
# Boundary Conditions



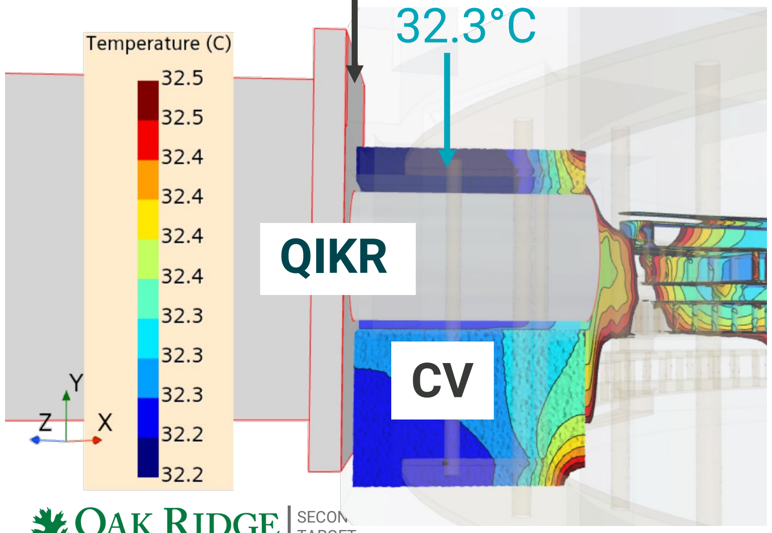



- **Front surface** is **welded** to the core vessel beltline.
- **ST10** & **ST11** have **active cooling** circuits.
- **QIKR** is only **passively cooled** through the contact with CV; therefore, its front surface is assumed at a higher temperature (35°C, conservative assumption).

**Boundary Conditions:**
- front surface of ST10 & ST11: **34°C**
- front surface of QIKR: **35°C**

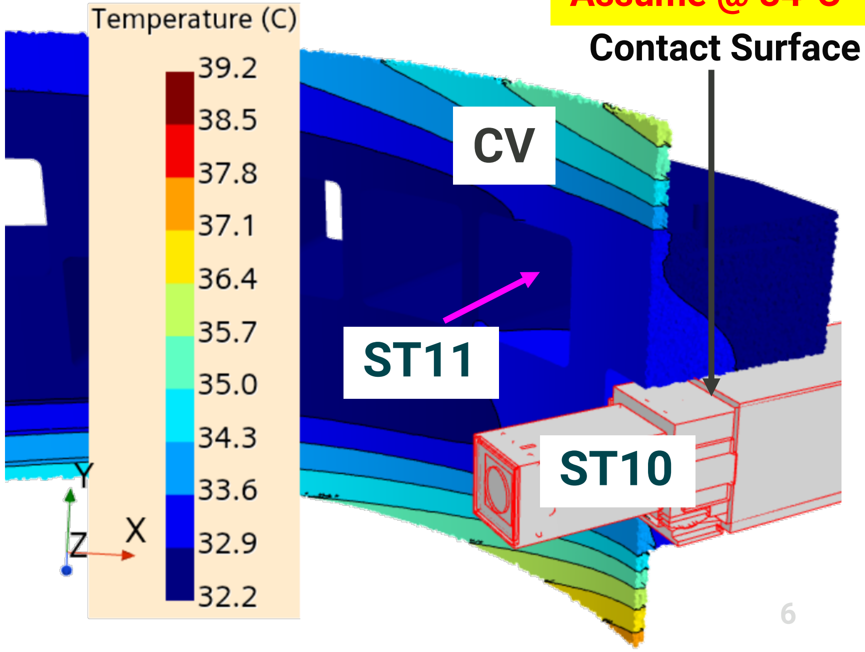
**Assume @ 35°C (conservative)**

**Contact Surface**




**Assume @ 34°C**

**Contact Surface**



# Thermal Properties

| Material | Thermal Conductivity, k (W/m-K) | Density, rho(kg/m^3) | Specific Heat, Cp (J/kg-K) | Viscosity (Pa-s) |
|---|---|---|---|---|
| Al1100 | 220.0 | 2700 | 900.0 | N/A |
| Al6061 | 155.3 | 2713 | 915.7 | N/A |
| Bronze | 77.35 | 8400 | 384.5 | N/A |
| Glass (Borosilicate) | **1.143** | 2230 | 750.0 | N/A |
| He | 0.154933 | 0.16352 | 5197.61 | 1.99E-05 |
| Inconel 718 | 11.4 | 8190 | 435.0 | N/A |
| Macor | **1.46** | 2520 | 790.0 | N/A |
| SS304 | 16.2 | 8000 | 500.0 | N/A |
| SS316 | 14.58 | 8000 | 486.1 | N/A |
| SS316L | 14.58 | 8000 | 486.1 | N/A |
| A36 Steel | 50.0 | 7850 | 470.0 | N/A |
| A572 Steel | 51.0 | 7800 | 470.0 | N/A |

The values of density for some materials are adjusted to match the values used in the neutronics energy deposition calculation.

**Reference:**

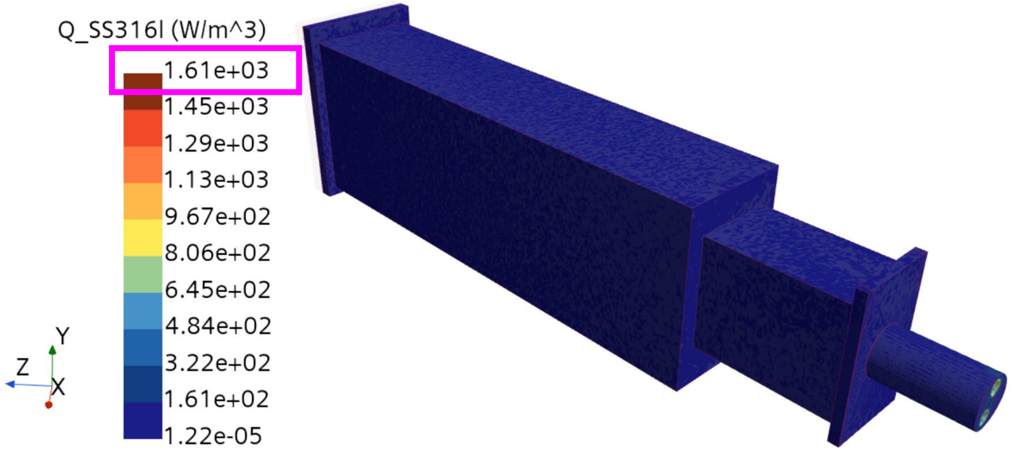

**Ansys, Inc. (2024). Ansys Mechanical 2024 R2. https://www.ansys.com**
**https://matweb.com/search/DataSheet.aspx?MatGUID=abc4415b0f8b490387e3c922237098da&ckck=1**
**https://matweb.com/search/DataSheet.aspx?MatGUID=e2147b8f727343b0b0d51efe02a6127e**
**https://www.matweb.com/search/datasheet_print.aspx?matguid=848bdecf89b74ef986925162e6a6255e**
**https://www.matweb.com/search/datasheet_print.aspx?matguid=7546f96147b847a5ab00091f3c36b8ce**
**https://www.makeitfrom.com/material-properties/ASTM-A36-SS400-S275-Structural-Carbon-Steel**
**https://www.makeitfrom.com/material-properties/ASTM-A572-HSLA-Steel**
**https://www.makeitfrom.com/material-properties/1100-Al99.0Cu-A91100-Aluminum**
**https://www.mit.edu/~6.777/matprops/pyrex.htm**

# Heat Source, Nozzle Extension of QIKR

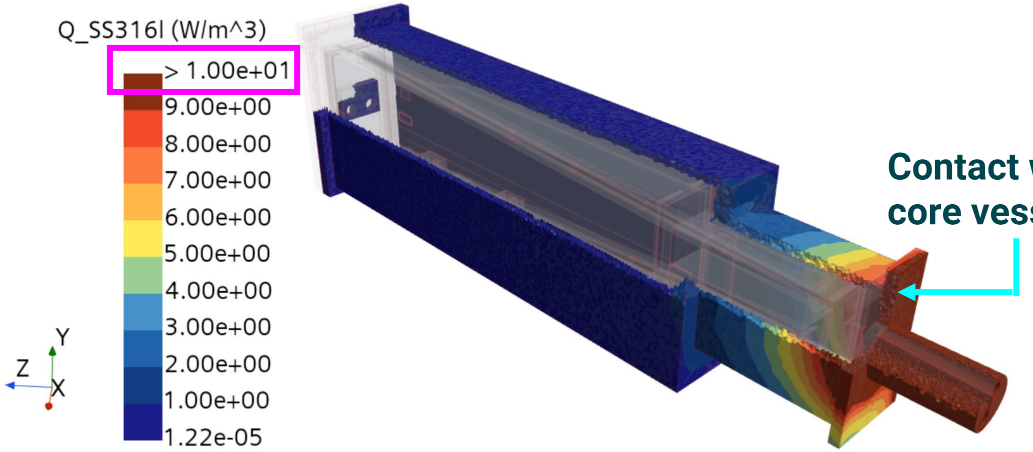
- Energy deposition of QIKR from Kristel Ghoos

**1 kW/m³ = 1 mW/cc**

**Total Heat: 1.77 W**



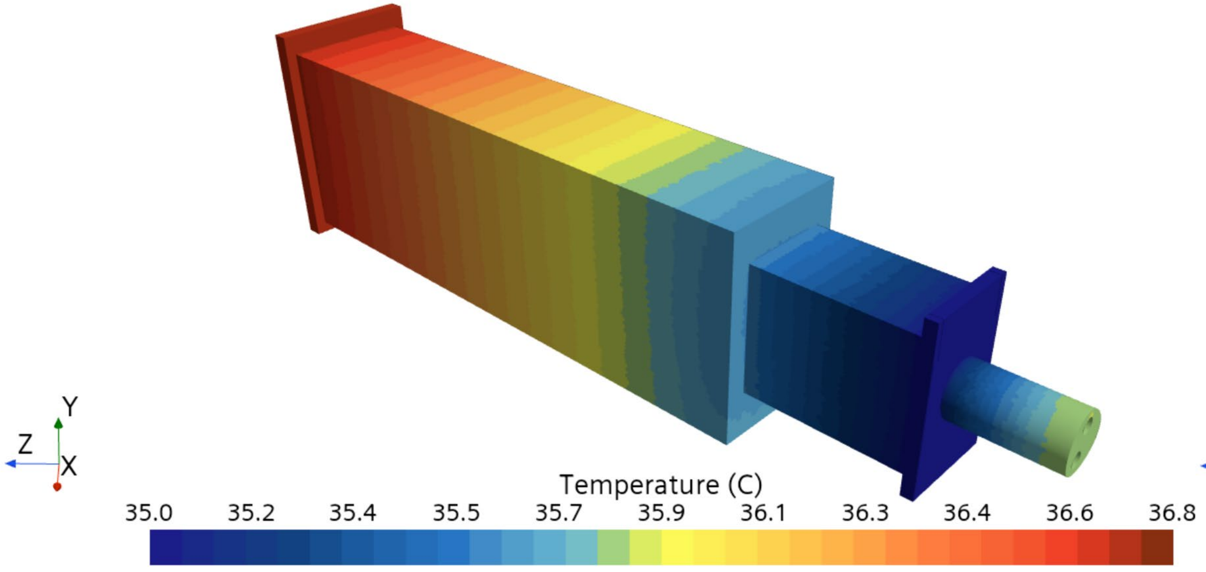


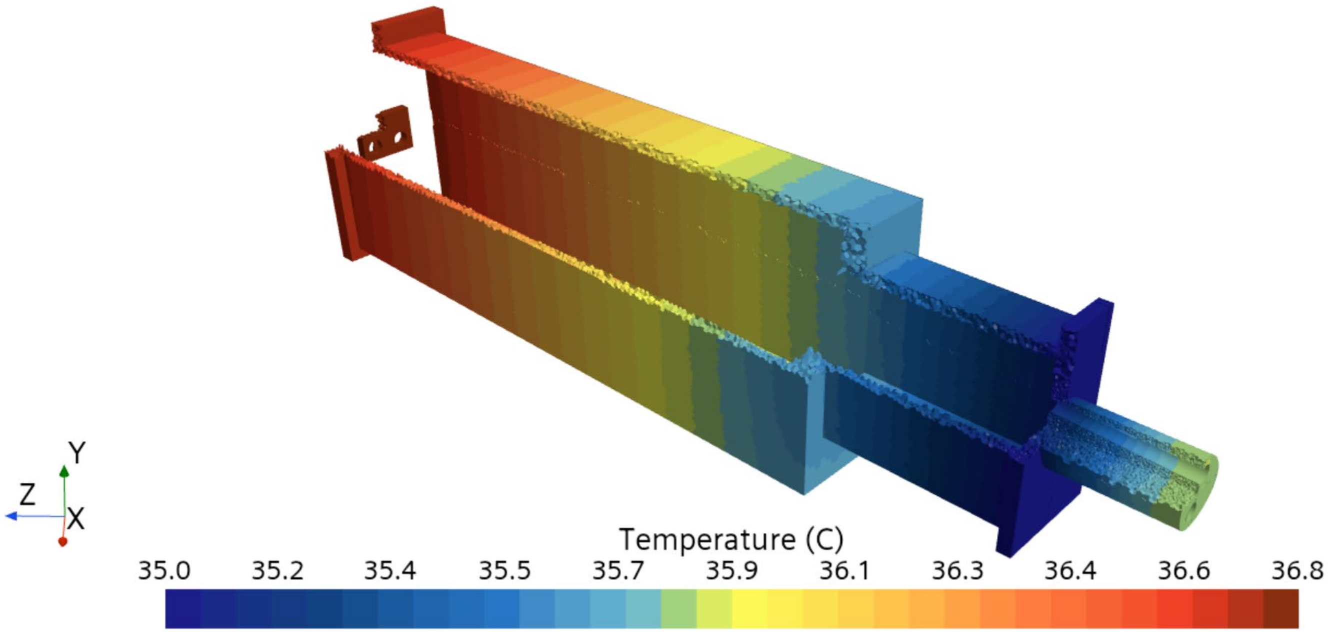




**Contact with well-cooled core vessel beltline**

# Temperature, Nozzle Extension of QIKR

## Peak: 36.8°C



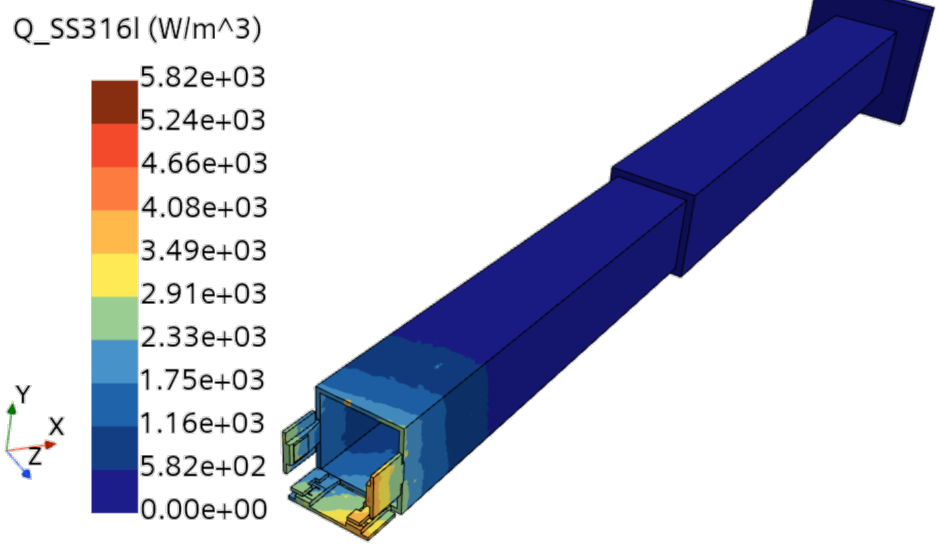



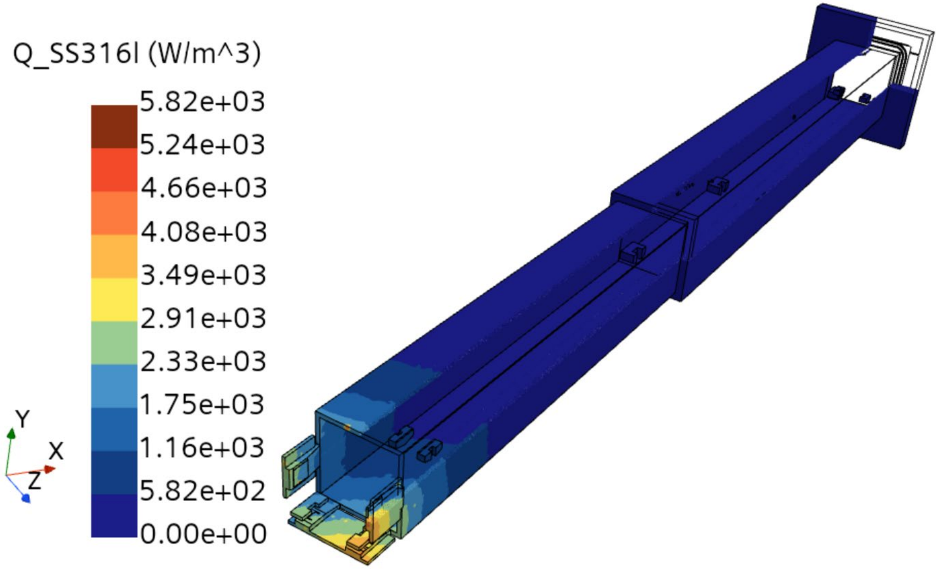
# Heat Source, Nozzle Extensions of ST10 & ST11

- **Energy deposition of ST10 & ST11 from Thomas Miller**

## ST10

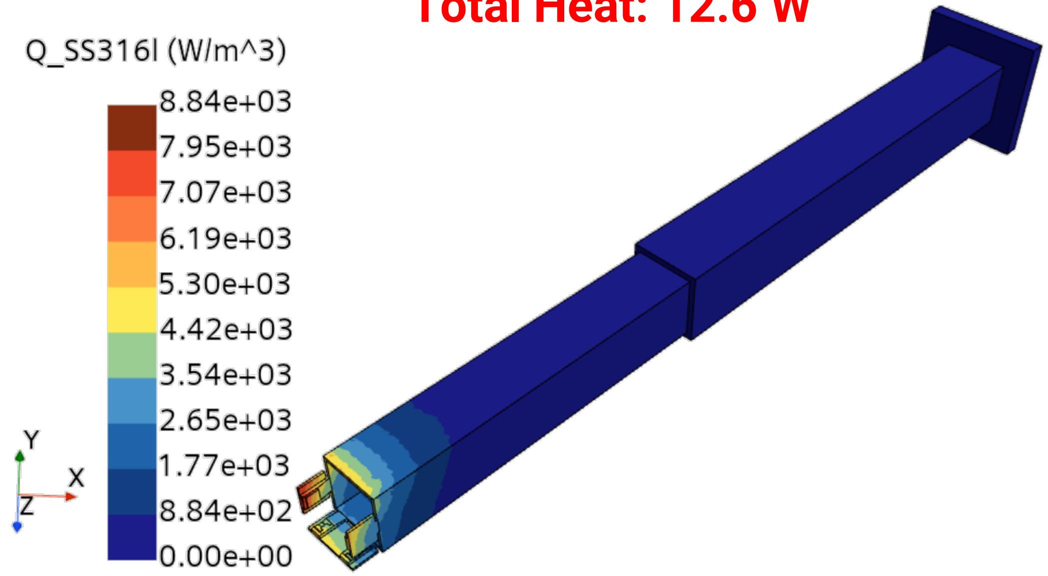
**Total Heat: 8.5 W**

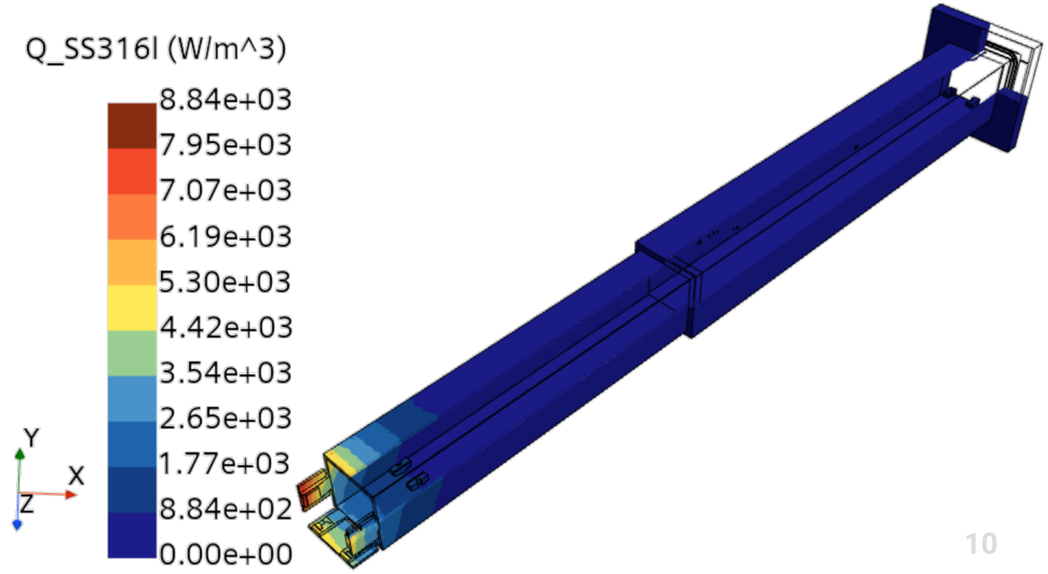



## ST11

**Total Heat: 12.6 W**



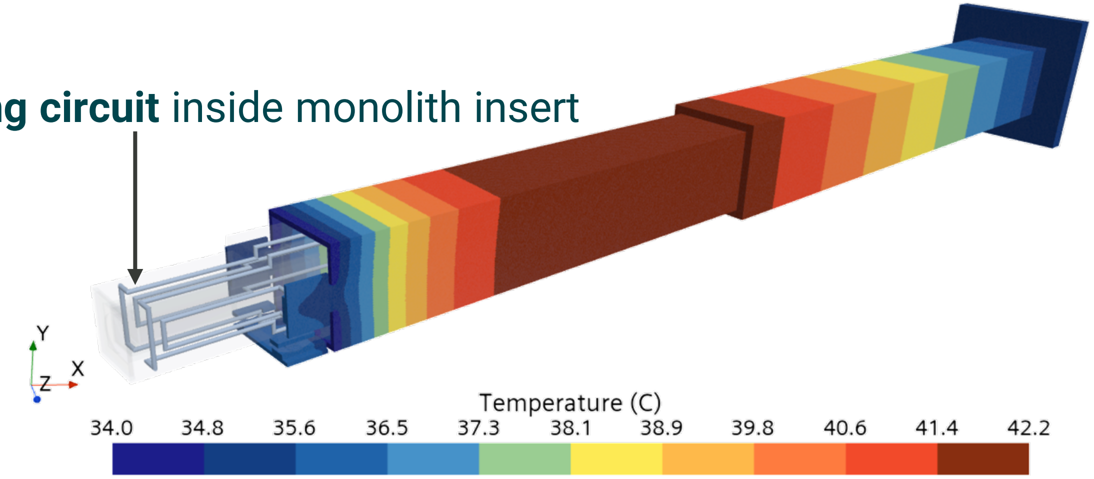



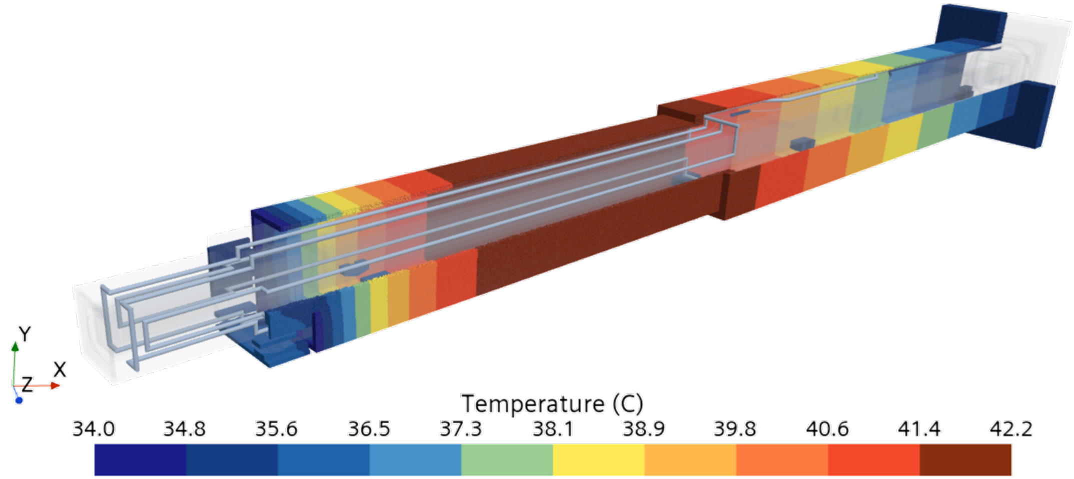
# Temperature, Nozzle Extensions of ST10 & ST11

**ST10**

**Peak: 42.2°C**

**Cooling circuit** inside monolith insert




**ST11**

**Peak: 46.6°C**