

Recent Studies on the Main Beam Dump

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- Structural concerns regarding long-term operation
- Alternative approaches for generating vortex flow
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A Look Back at the Beam Dump

- Accept the 500 GeV beam, **14 MW, in ILC-1TeV-lumi parameter**
- then designed with 20% margin → **assume 17 MW beam**
- **A water based beam dump is proposed in TDR.**

  P.Satyamurthy et al., NIM A679(2012) 67-81
- Located directly in the path of the colliding beams

  Beamstrulang at 1 TeV becomes a few MW !!
- and located at 300 m from IP

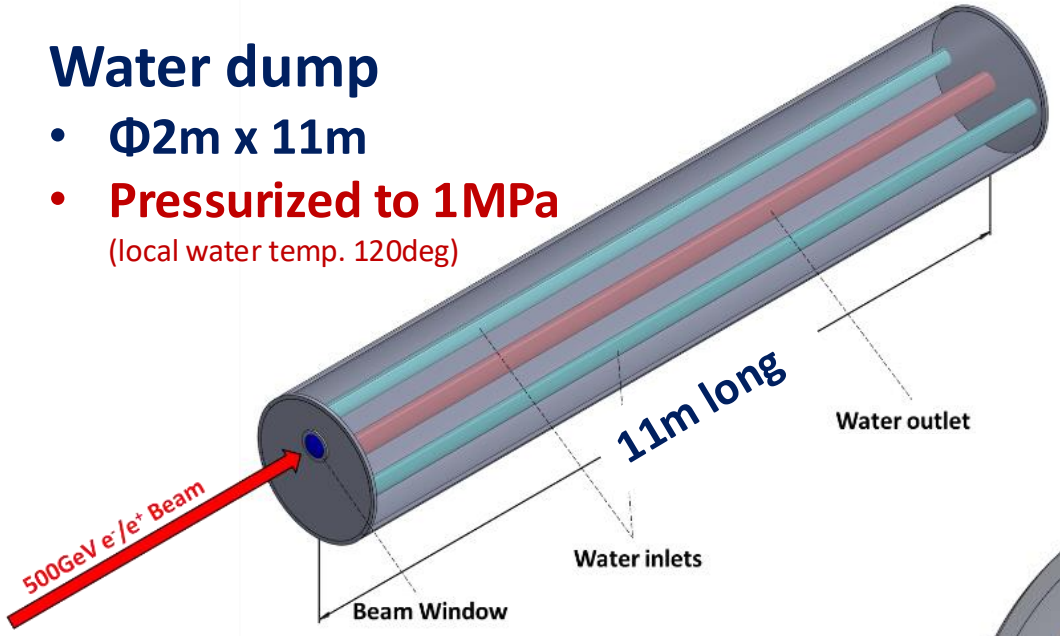
  Maintain a distance from the BDS and install radiation shielding.
- Civil engineering requests the push of LTR/RTL from dump cavern.
  → one of the TDR update

  A large cavern is required to install shielding material at least 5 m thick in all directions.

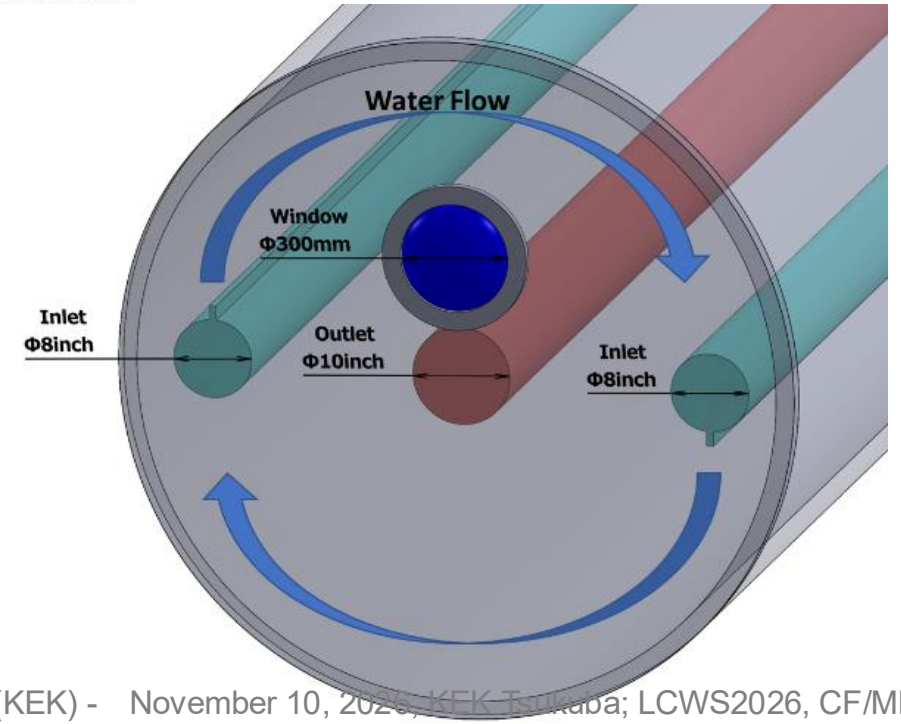
Main Beam Dump

Water dump

- **Φ2m x 11m**
- **Pressurized to 1MPa**
  (local water temp. 120deg)

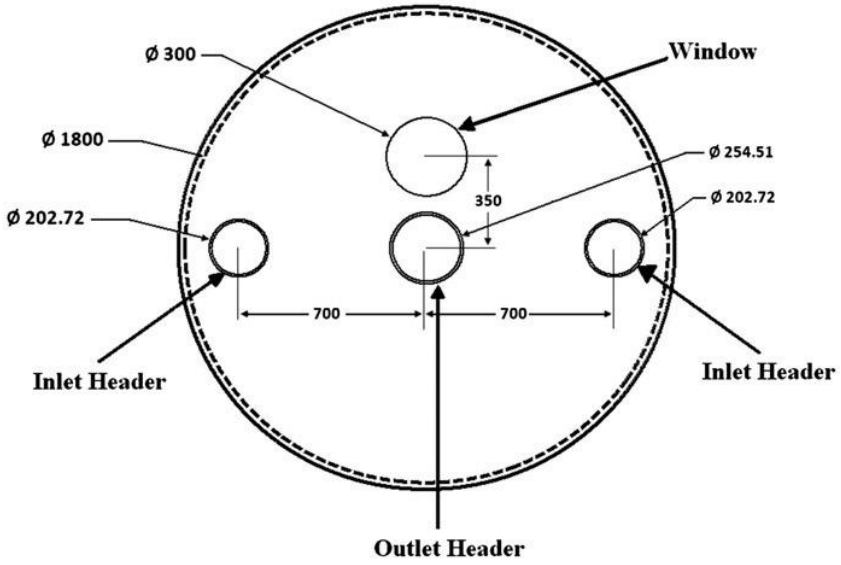


- **Designed for 500 GeV, 17 MW beam**
- **Water absorber for the MW beam**
  - The ILC's fundamental design was published in 2012 and is **based on the 2.2 MW water dump at SLAC.**
  - **Vortex flow is a key of the design**

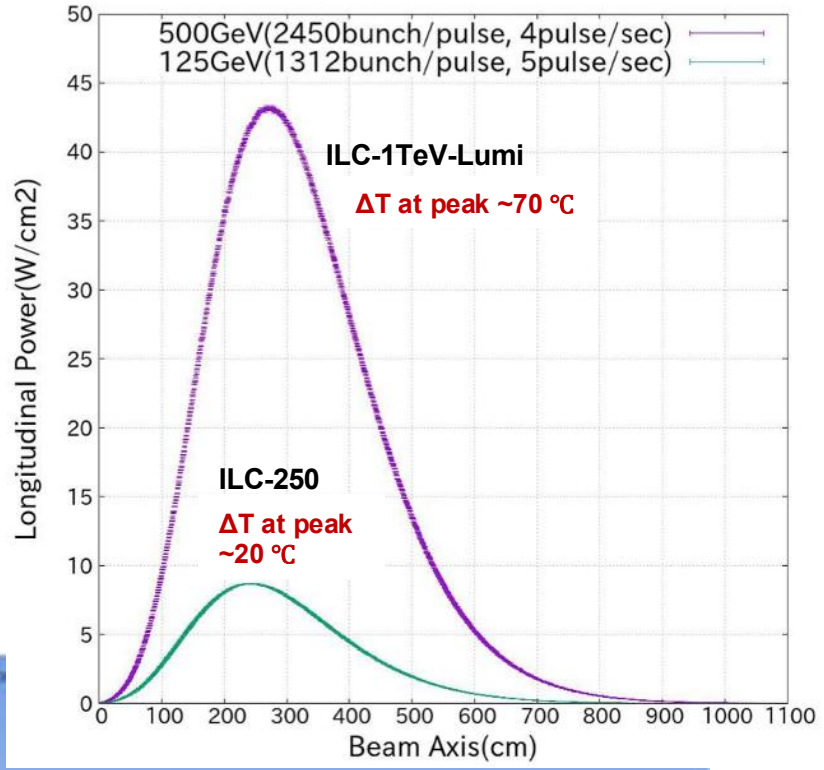


- Move heated water effectively
- The beam is injected at a point offset from the center of the tank.

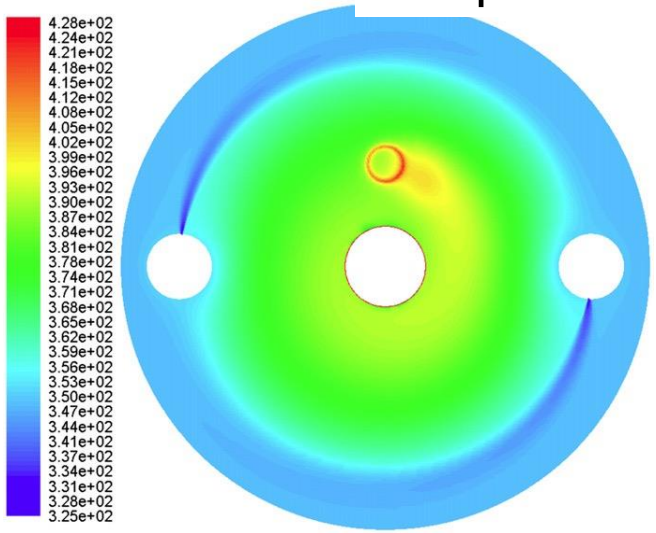
Primary design (TDR ver.)

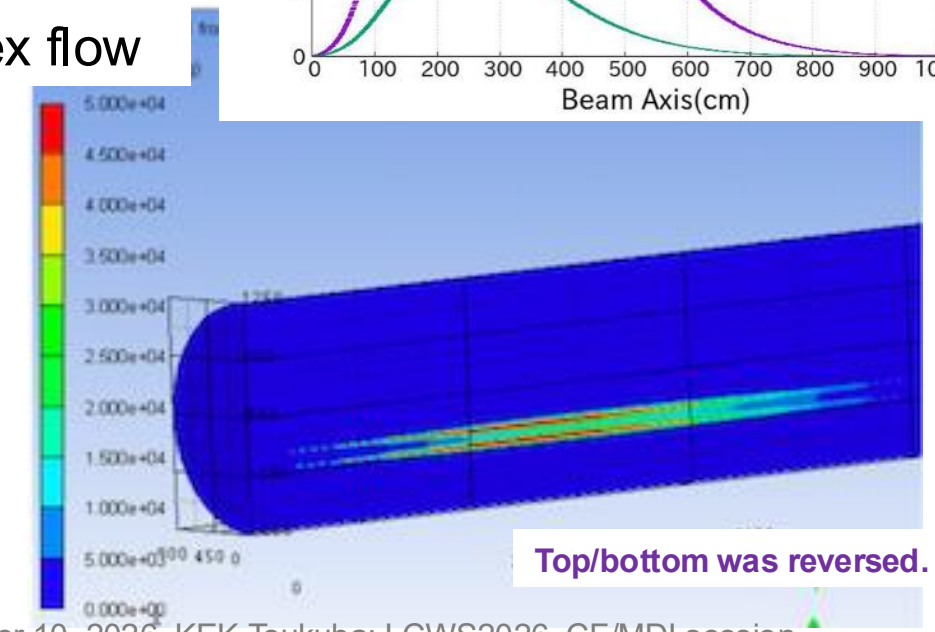


Longitudinal power deposition



Temperature map under vortex flow





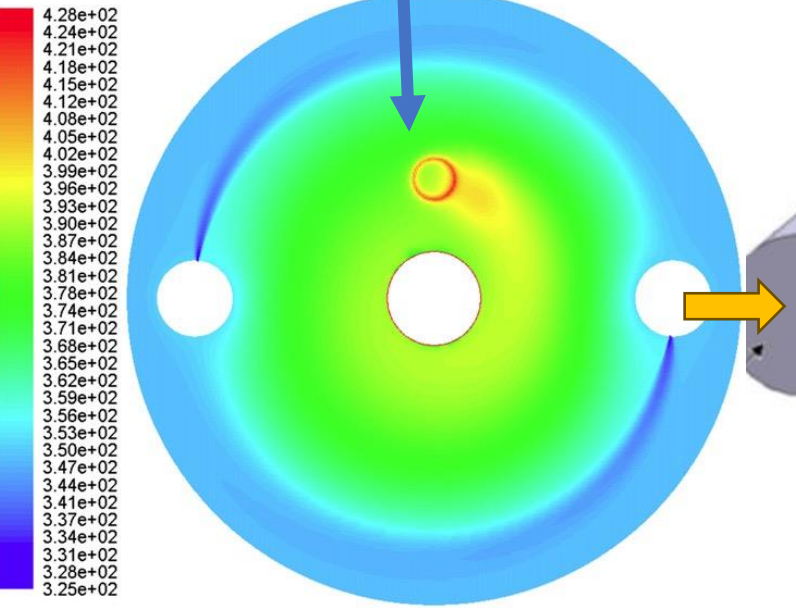
Top/bottom was reversed.

Structural concerns regarding long-term operation

■ **Rasterized beam injection**

- 2560 bunches/1ms in 6 cm radius
- repetition 5 Hz

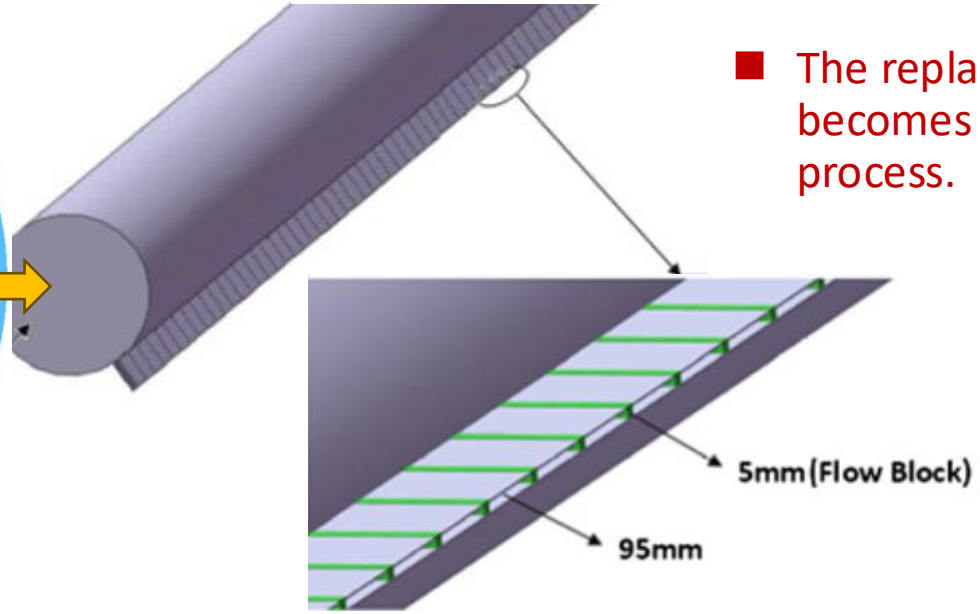
$2x10^{10}$ e-/bunch
σ_x = 2.42mm,
σ_y = 0.27mm.



■ Vortex flow generation

Primary design in TDR asuumes **two inlet pipes with slits** and **an outlet pipe**.

- water out speed: 2.2 m/s
- **mass flow rate per inlet pipe becomes 105 L/s**



■ The replacement of a beam dump that becomes highly radioactive is a challenging process.

It is imperative to ensure the **long-term robustness** of the vortex generation mechanism.

- **Damage of slits**
- **Damage of 10m-long pipes and especially their supports**

Alternative approaches for generating vortex flow

Studies have been conducted since 2023.

- **Several water handling structures were designed and simulated.**
  - Reduce the risk of mechanical failure caused by high water flow at the structure.
  - Maintain water flow velocity in areas with high thermal loads similar to the the primary design.

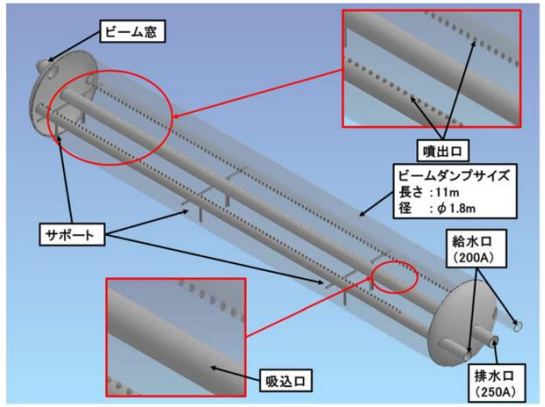


図 1　（案 1）2 本配管ノズルモデル

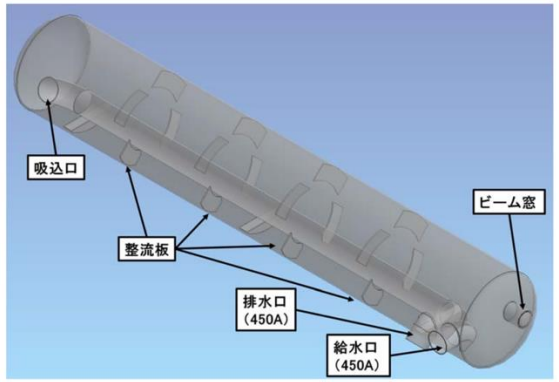


図 2　（案 2）整流板モデル

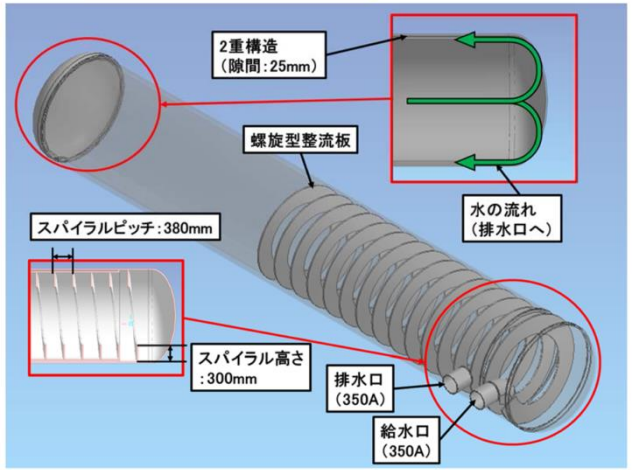


図 3　（案 3）螺旋型整流板モデル

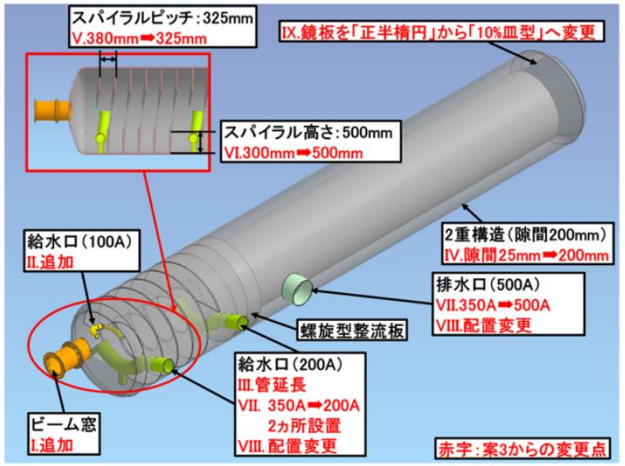


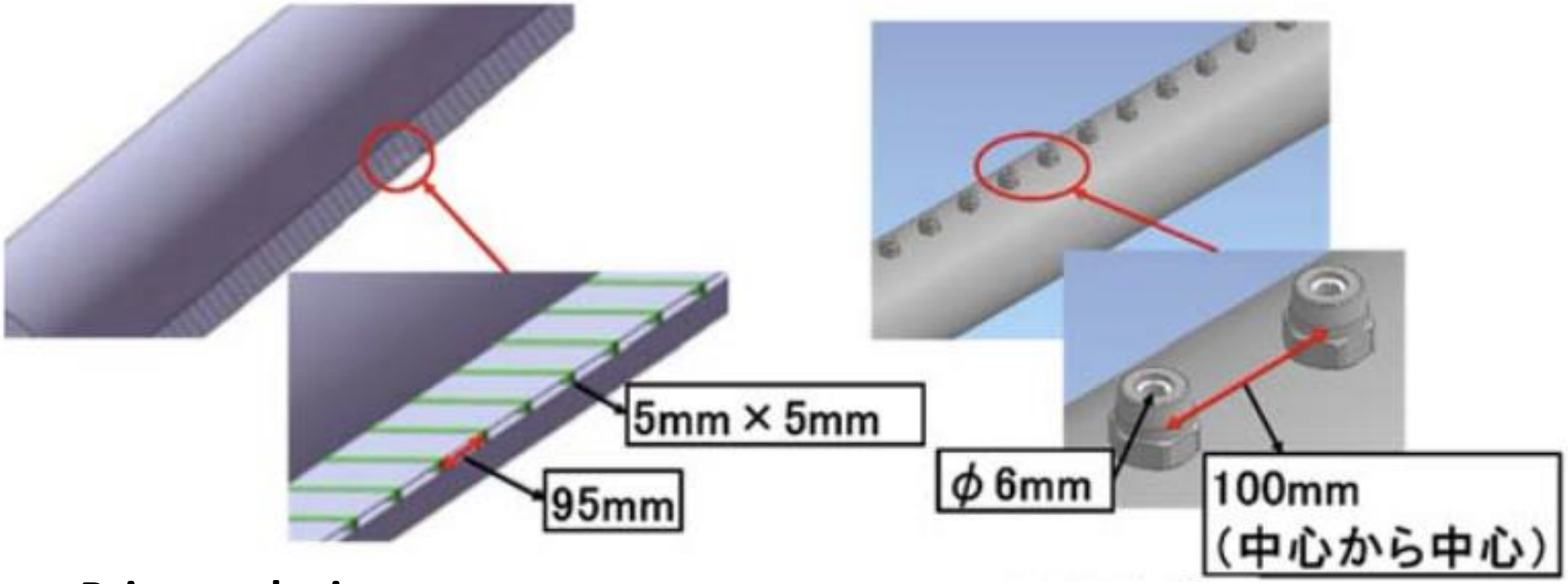
図 4　（案 4）改良螺旋型整流板モデル

model-1
similar to the primary design
except inlet header slits
->**industrial nozzles**

model-2
Remove inlet header
Simple water flow with guide fins

model-3
Helical water guide
single inlet/outlet

model-4
Helical water guide
Updated



Primary design

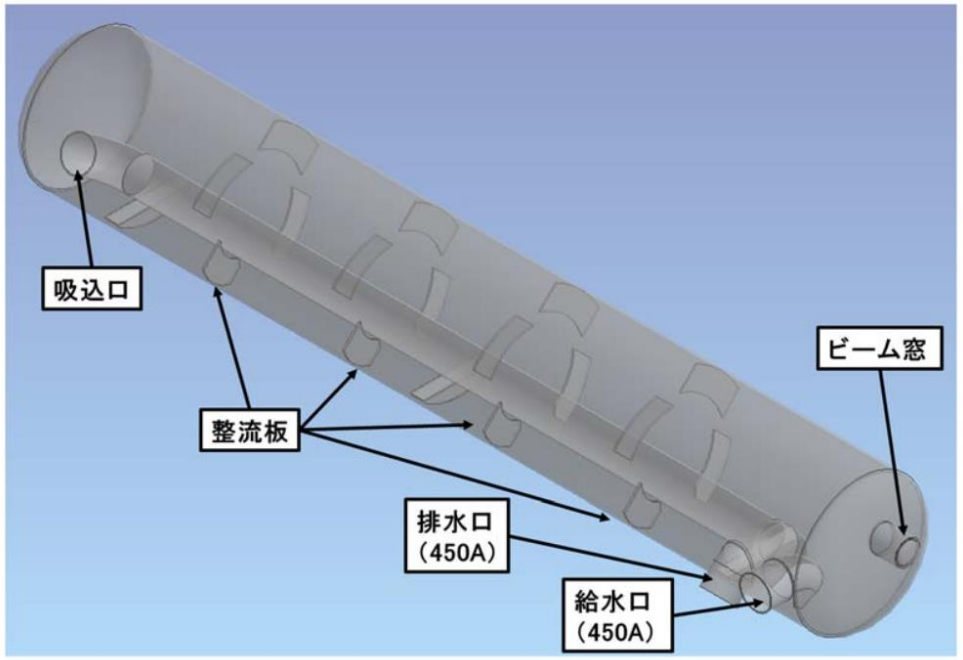
Water header: slit

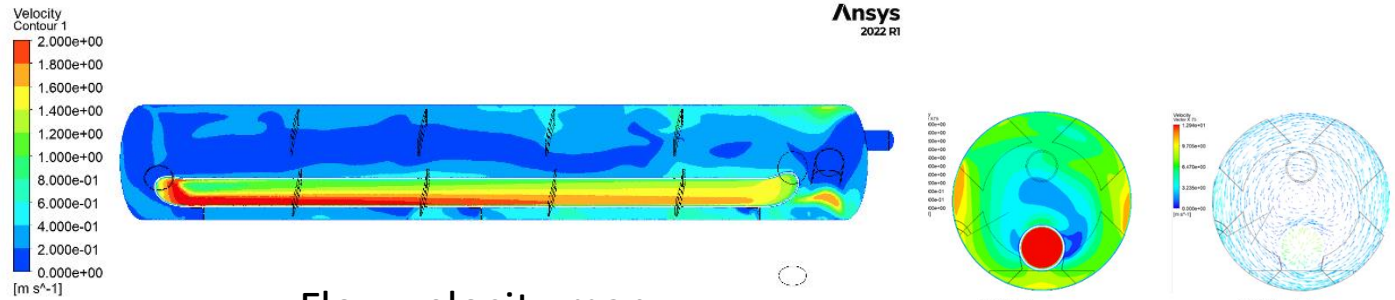
- manufacturing difficulty?
- need maintenance?

model-1

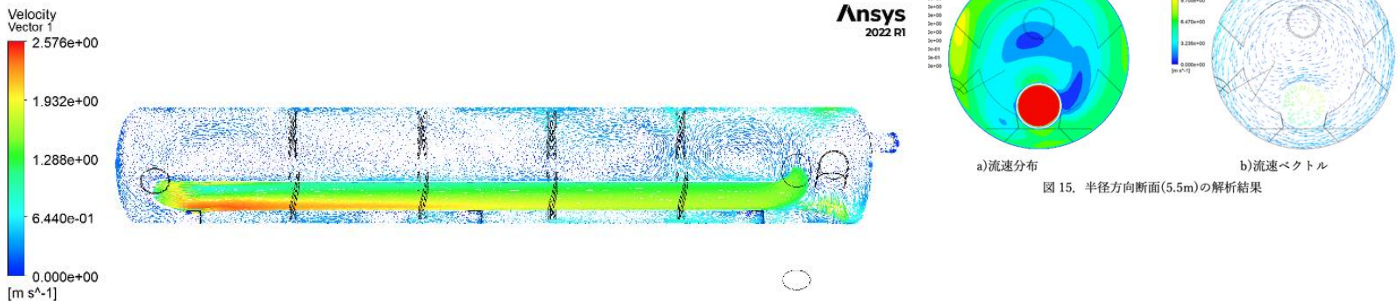
Water header slits->**industrial nozzles**

- **Almost similar result as primary design was obtained.**
- **Concerns remain regarding the durability of the nozzles and the support of the piping.**





Flow velocity map



Flow vector map

model-2

- **Remove inlet header/pipes**
- **Simple water flow with guide fins.**
- Simulation results were not satisfied requirements.

Guide fins will be welded on the dump vessel.→less vibration

Simulation results show **no vortex flow** on the beam axis. This is the first study model of guide structure.

model-3

Helical water guide

single inlet/outlet

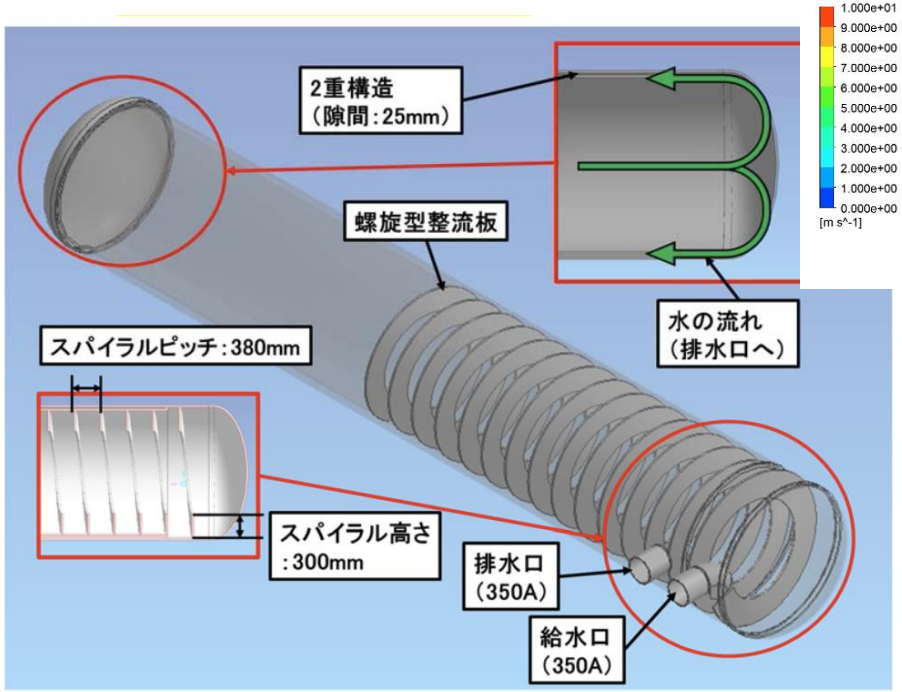


図 3　（案 3）螺旋型整流板モデル

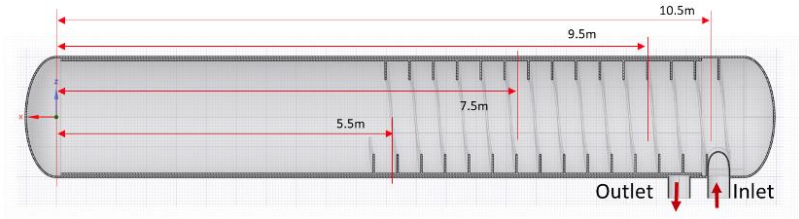
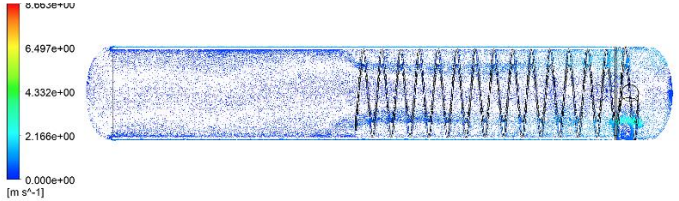
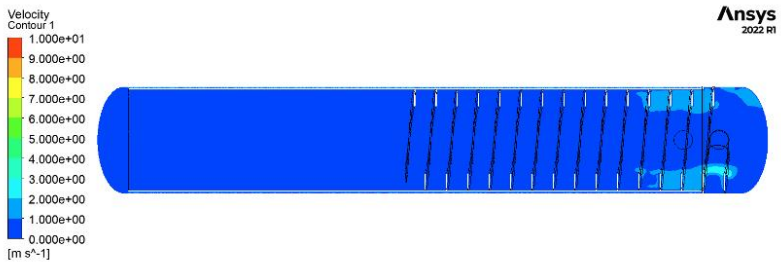


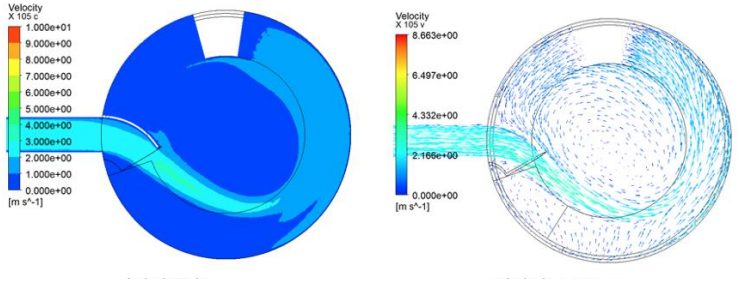
図 35. 半径方向断面の位置



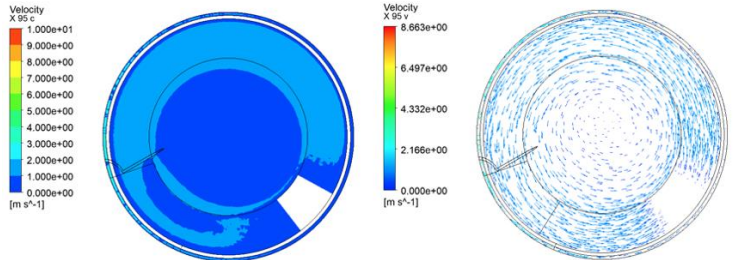
flow vectors map



flow velocity map



flow velocity and flow vector at inlet



flow velocity and flow vector at peak deposit

Vortex flow on the beam axis was obtained.

- **Almost similar result as primary design were obtained.**

model-4

Helical water guide

double inlet

- **add second inlet at the peak power deposit area**

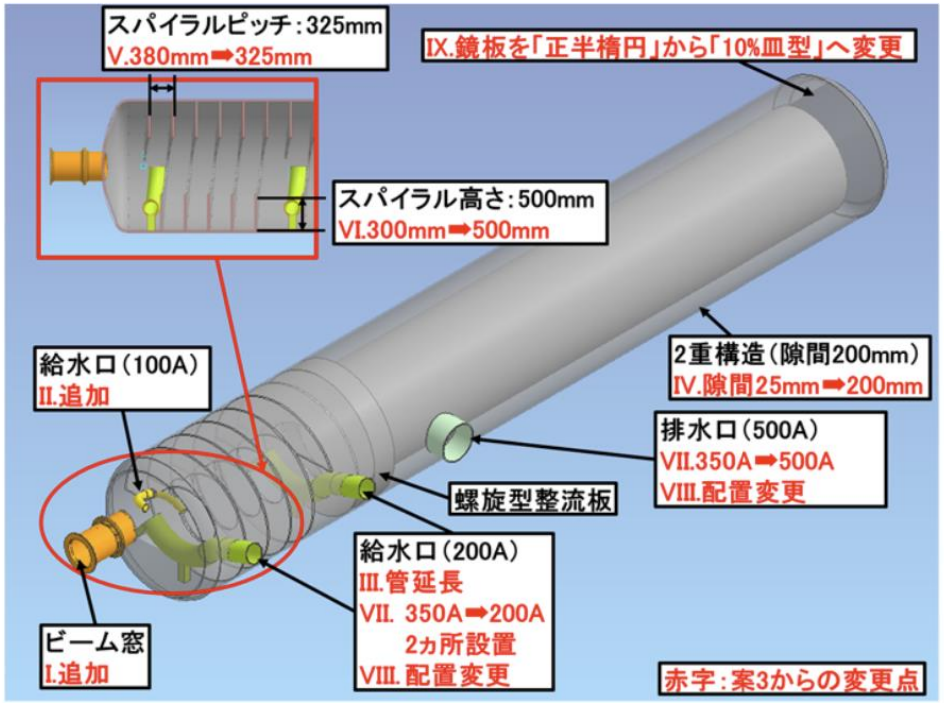


図 4　（案 4）改良螺旋型整流板モデル

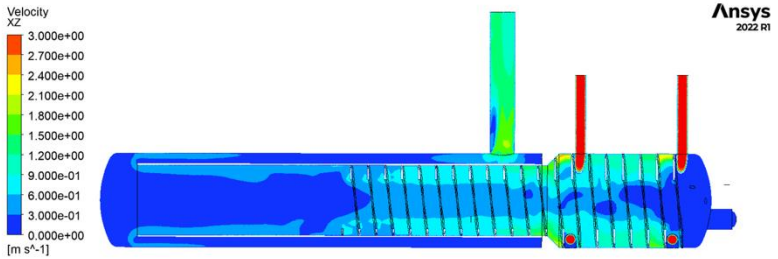
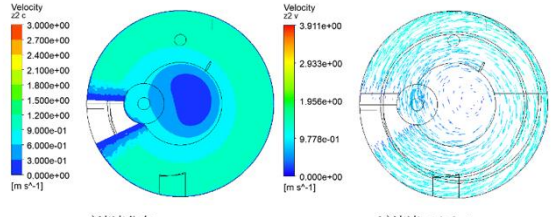


図 52. 軸方向断面の流速分布



flow velocity and vector at middle of inlets

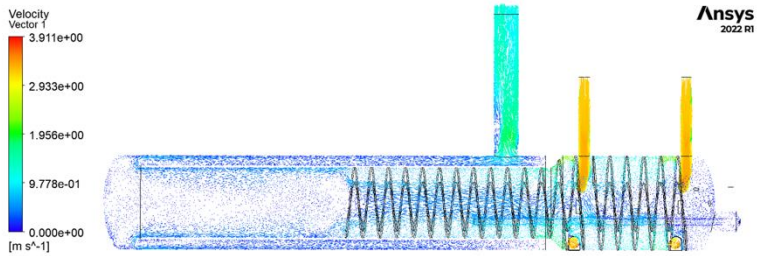
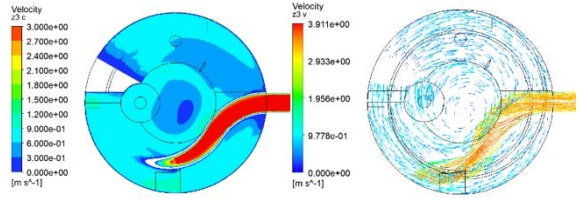


図 53. 軸方向断面の流速ベクトル

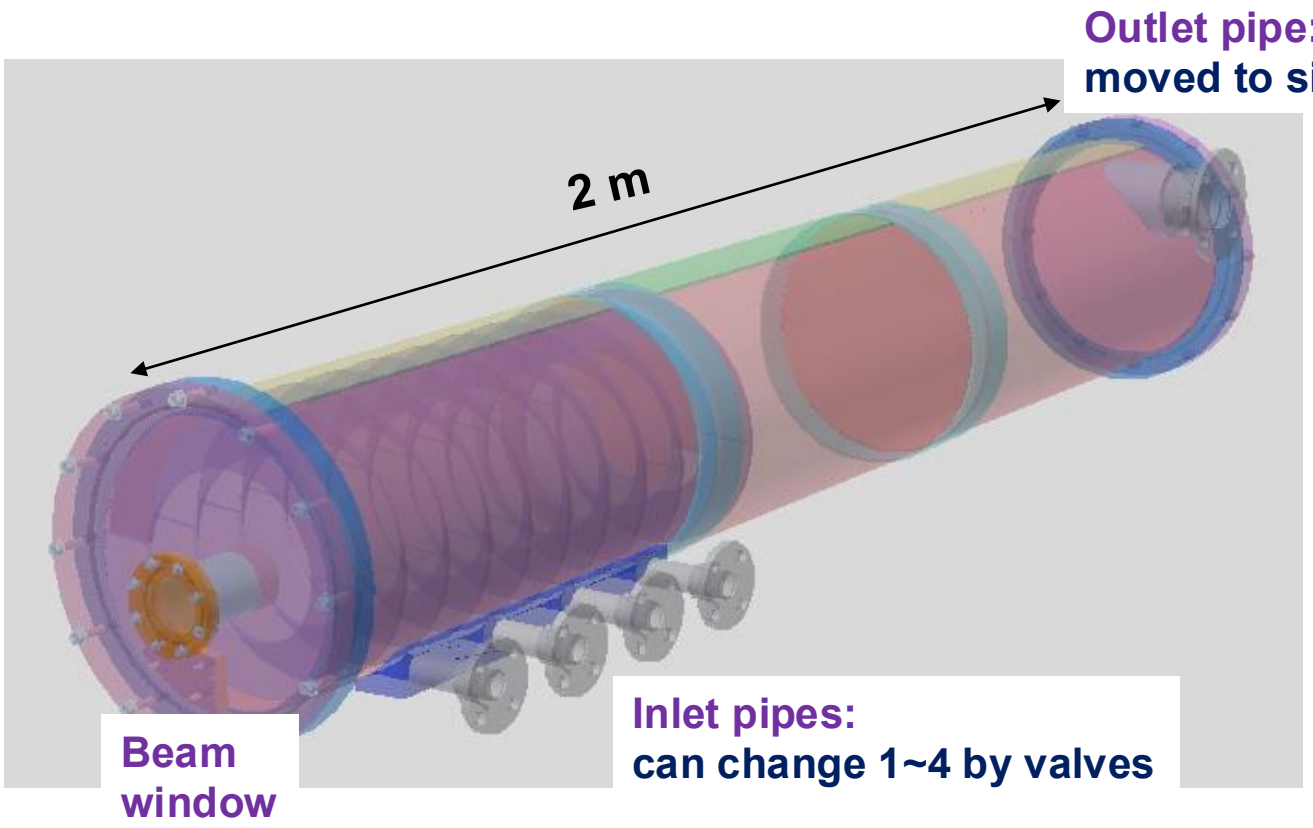


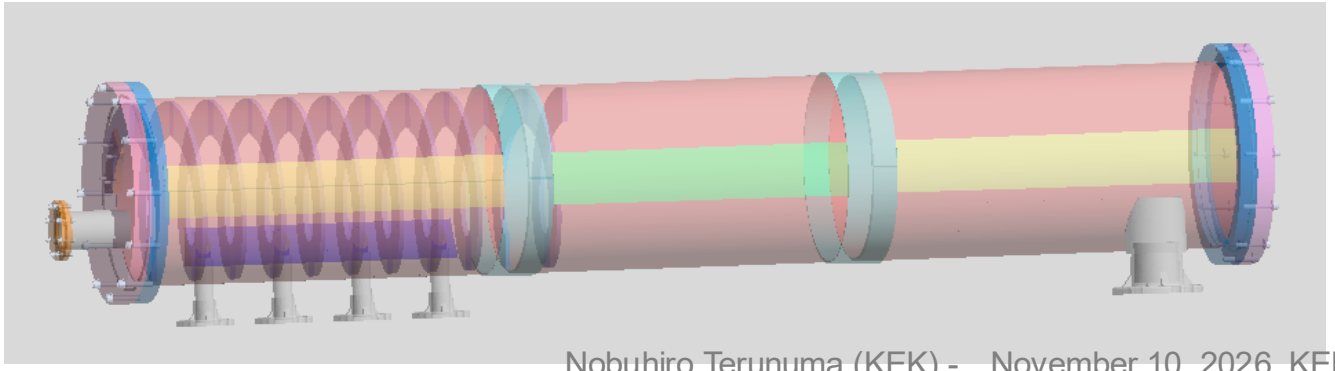
flow velocity and vector at peak deposit

A better Vortex flow on the beam axis than primary design was obtained.

- **Primary design: 0.6 m/s, delta-T ~50℃,**
- **model-4: 0.9 m/s delta-T ~24℃**

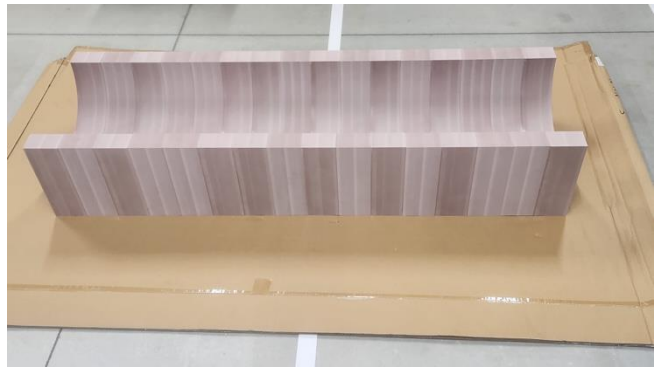
Preparations for verification using a 1/5-scale prototype





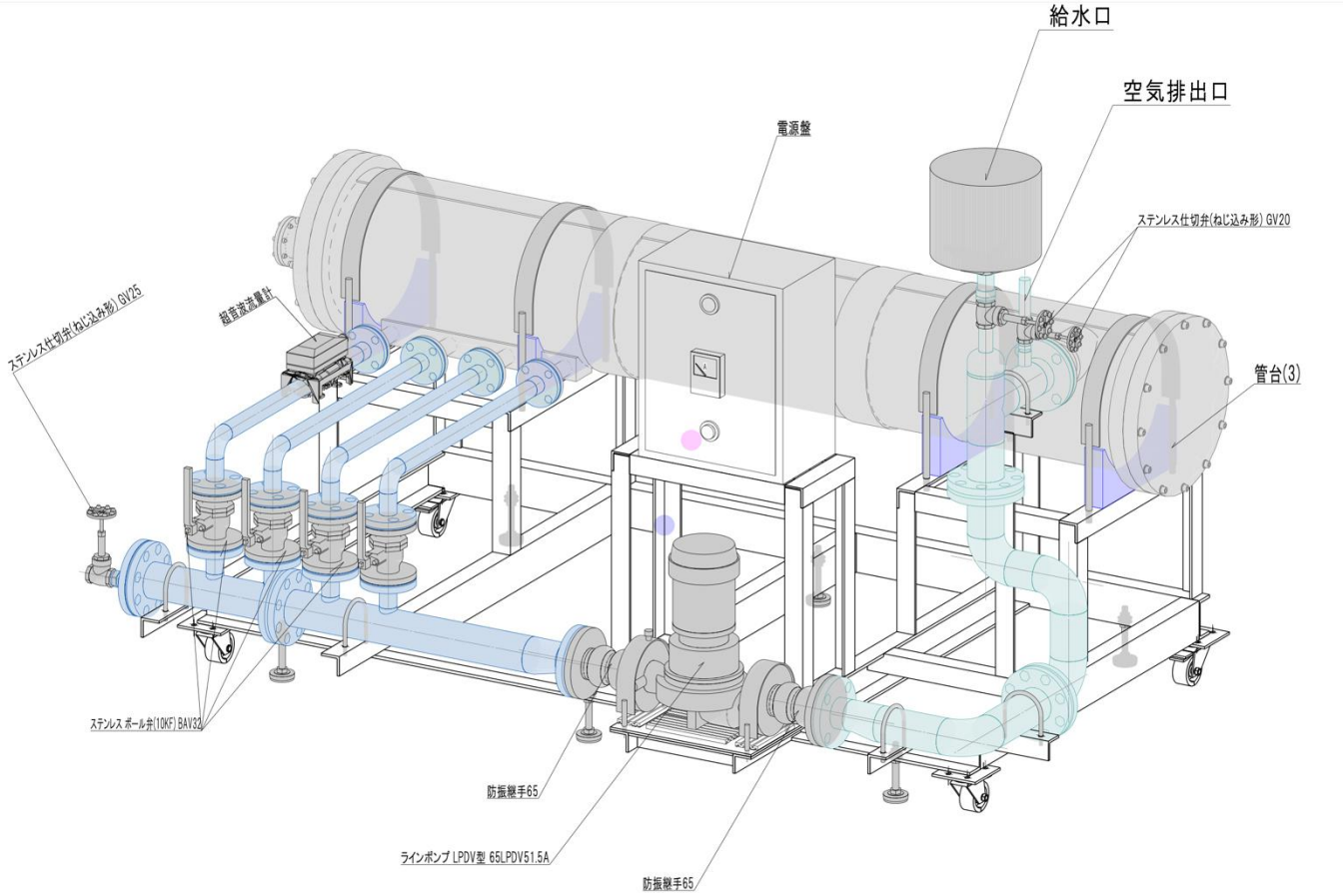
Acrylic prototype

- The flow is verified by monitoring tracer particles using a sheet laser imaging technique.
- The validity of the design will be confirmed through a comparison with simulations of the prototype model.
- The equipment is currently being manufactured.



The mold for manufacturing the acrylic tank has been completed.

Water circulation system is also being manufactured.





Summary

- The 17 MW water dump design requires reliable vortex flow for long-term operation.
- The original slit headers and long inlet pipes raise durability and maintenance concerns.
- A helical water guide with dual inlets (model-4) improved simulated flow and cooling:

  Beam-axis velocity: 0.6 → 0.9 m/s; temperature rise: ~50 → ~24 ° C.

- Following the simulation results, a 1/5-scale acrylic prototype and a water circulation system are being manufactured.

Next step:

- Visualize the flow and validate the simulations against prototype measurements.