Technical Preparation : Main beam dump

Outline : SCJ and MEXT's ILC Advisory Panel stated technical concerns regarding: reliability, earthquake protection, and stability of the window of the main beam dump; reaction between the high energy beam and water; and containment of activated water. This plan is proposed to proceed the designs of main beam dump and demonstrate the stability of window and its handling procedure.

The design work will be carried out with the collaboration of experts from the field of high-power target and dump in the world. CERN operates beam dumps for large accelerators and high-power beam dumps, SLAC and JLAB have experiences on the water-circulated beam dumps. KEK will lead the system design of the beam dump facilities, ensuring environmental and radiation safety with cooperation from the government, industry, and the scientific community. The engineering design of the vortex flow system in the water dump vessel and overall water circulating system will be done following the experiences at SLAC and JLAB. Stability of the window will be confirmed by a point of view on radiation damage and by a mechanical robustness. The Ti-alloy, Ti6Al4V is selected as a material of window following the experiences of the high-power target and dump in the world, mostly conducted by proton beams. Further studies increasing a robustness will be continued through a collaboration. The mechanical robustness of window will be confirmed through the prototyping of sealing and demonstration of the remote exchange. The scheme for monitoring the integrity of the window will also be studied. The design for safety, i.e., earthquake protection, containment of activated water including the countermeasure for failures, are mostly issues of engineering. These will be conducted through the collaboration with industries.

Goals of the technical preparation:

Establish the engineering design of whole dump system.

Items:

- System design of the water flow system including the vortex flow in the main dump vessel.
- Optimization of the beam window material and robustness test
- Engineering design and prototyping of window; sealing of water and vacuum, remote exchange
- Countermeasure for failures; safety system design including a beamline to the dump

Expected cost:

Issue	*Tasks*	*Cost*	*Human Resources (FTE)*
Beam window	*Robustness test/ prototyping of sealing and remote exchange*		
Water circulating system	*System design, prototyping of components, safety system*		

(not including corresponding cost of human resources)

Candidates:

CERN, RAL, ESS-Bilbao, SLAC, JLAB

Appendix

(Current status)

The design of the ILC main beam dump had been developed since the mid-2000s by experts in Europe and US. In 2012, the basic design was established as an 18-MW water dump and compiled into the TDR.

This design was based on the 2.2 MW water dump designed at SLAC, which was operated at 0.75 MW. JLAB has another water dump, which is a 1 MW design and is currently used for CEBAF operations.

The design at this point is a conceptual one that meets the basic parameters and must proceed with its embodied design.

The water that serves as an absorber for the beam is supposed to rotate in the tank as a vortex flow to sweep out the heated portion. Although there is a conceptual design of the inlet and outlet, there is no operational design yet.

Tritium accumulates in the water due to activation by the beam. Although the radiation of tritium is weak, a solid water leakage countermeasure is desired. A detailed design of the beam window and water circulation system considering these factors remains to be done.

The dose of radiation in the dump room will become high due to severe activation of the dump vessel and its surrounding shielding over the years of operation. Therefore, the periodic replacement of the beam window will be done by remote operation. This mechanism, including the structure for mounting the window, has not yet been designed.

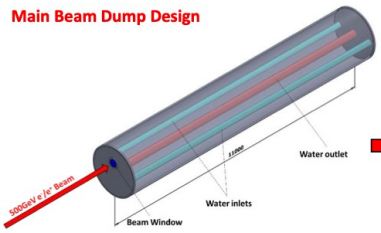
The maximum power based on the latest beam parameters is 14 MW for a 500 GeV beam and 2.6 MW for a 125 GeV beam. The beam dump is designed to be up to 17 MW, assuming a 20% margin.

In 2017, a group was set up at KEK to advance the design of the ILC beam dump and is exchanging information and consulting with beam dump experts at CERN, SLAC, and JLAB.

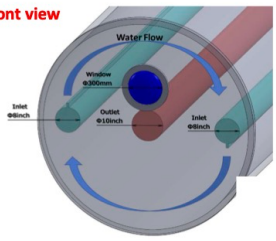
In addition, the design of the dump system for the radiation safety management at the candidate site and the design of a large underground cavern for the main dump and its utilities are currently being carried out in collaboration with industry and academia.

Main Beam Dump (Water , type D&E)

Main Beam Dump Design



Front view



【Beam Power @ 1TeV Beam operation】

・500GeV × 2.79nC × 2450Bunches × 4pulses/sec : **13.7MW** + **20% safety margin** ≒ **17MW**

【Base Design*】

・**Water power absorber** and **forced convection** to extract the heat.

* Water is compressed **1 MPa** ⇒ **boiling temp 180℃**

* Vortex water flow ⇒ Mass flow rate : **104.5kg/s** each inlet, flow velocity **2.17m/s**

・**1mm thick** Beam Window made of **Ti-6Al-4V**.

* Base design of ILC Main Beam Dump : P. Satyamurthy, et.al., NIM A 679 (

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Yu Morikawa, LCWS2019

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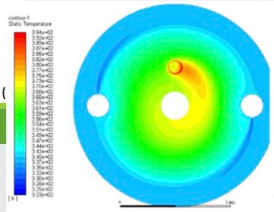
Main Beam Dump (Water , type D&E)

Many simulations have been performed on this beam dump performance.*

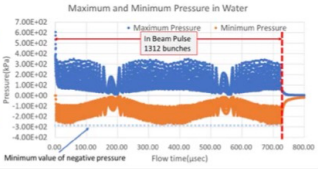
Temperature simulation
@1TeV Status (500GeV, 2450bunch/pulse, 4pulse/sec)



【Max Temperature】

250GeV-nominal : 68℃ , 1TeV : 121℃

Pressure wave simulation
@250GeV-nominal(125GeV, 1312bunch/pulse, 5pulse/sec)



Highest Pressure : 6.2 bar , Lowest Pressure : -2.8bar

* Design check of ILC Main Beam Dump :Y. Morikawa, LCWS2018

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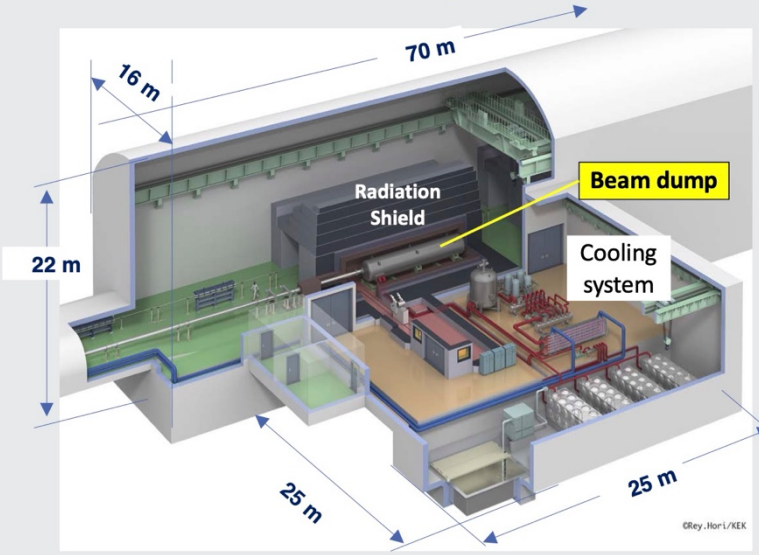
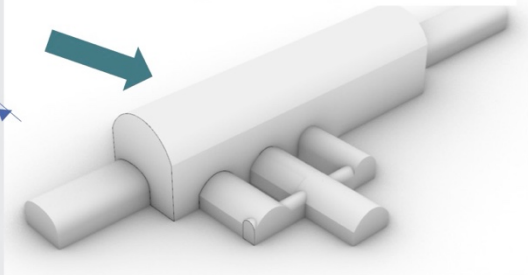
Main beam dump



- **Big cavern to install the 5m-thick shields.**
- Water dump capable for 17MW beam power (1TeV).
- **Optimization of cavern is ongoing with Civil Team in Japan.**
- Avoid big-flat utility cavern



2020/10/13 IDT-WG2 DR/BDS/Dump subgroup meeting, N.Terunuma (KEK)