PPT File to be used for presentation on the Time-critical WPs to Lab Directors

Revised version of WPP_presentationV2.pptx

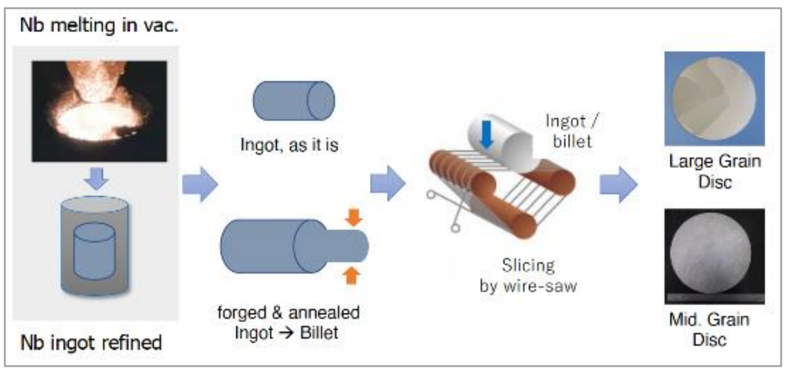
Caution: Revisions in other sections may not be reflected yet

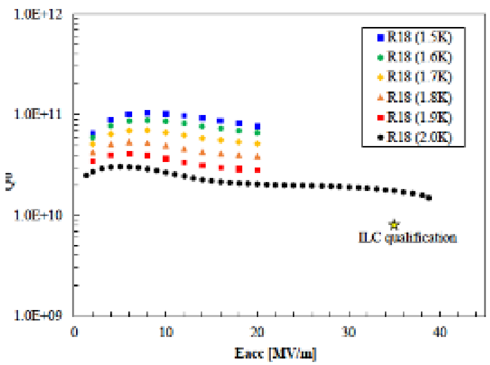
Sources Group Meeting, May 23, 2022

WP-prime 1: SRF Cavity
(Scoping the Industrial-Production Readiness)

- Research with single-cell cavities to establish the best production process
  - Advanced Nb sheet production method
  - Advanced surface treatment recipe
- Globally common design compatible with High Pressure Gas Safety (HPGS) regulation
- 24 nine-cell cavities are to be developed for industrial-production readiness
  - 8 cavities (4 / batch) in each region
  - Production process optimized in each region encouraged
- RF performance/success yield to be examined (at least including 2^{nd} pass)
  - 3^{rd} pass to be examined if effective

	# of cavities to be produced		
	Americas	Europe	JP/Asia
single-cell	2	2	2
nine-cell	8	8	8 (+ 12)





Material/Sub-component

↓

QA of Material/Sub-C

↓

Cavity Production

↓

Surface Process

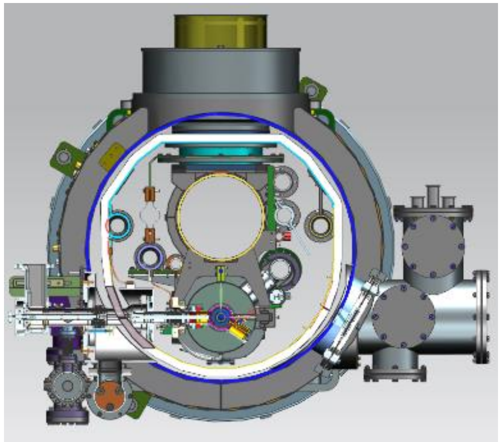
↓

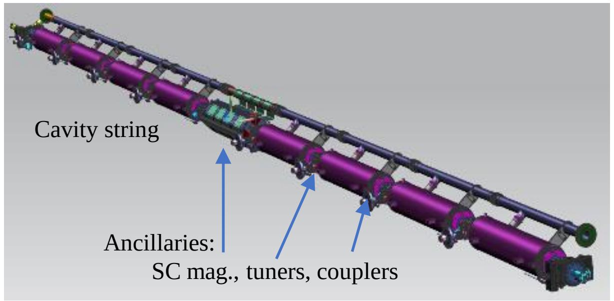
Vertical Test = Cavity RF Test

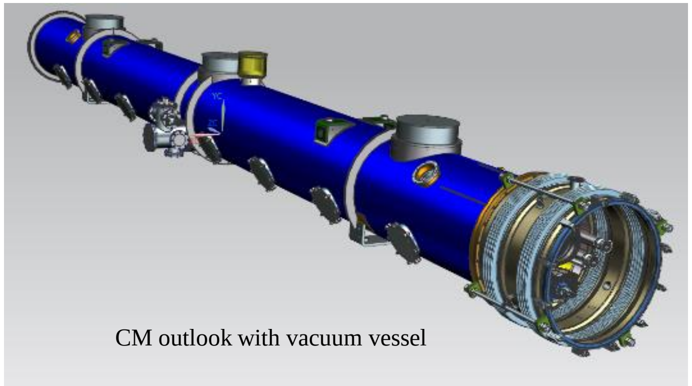
Production process

WP-prime 2: Cryomodule (CM) design
(Scoping the CM Global Transfer and Performance Assurance)

- ◆ Unify cryomodule (CM) design with ancillaries, based on globally common drawings and data-base, and
- ◆ Establish globally compatible safety design to be approved by HPGS regulations individually authorized in each region.







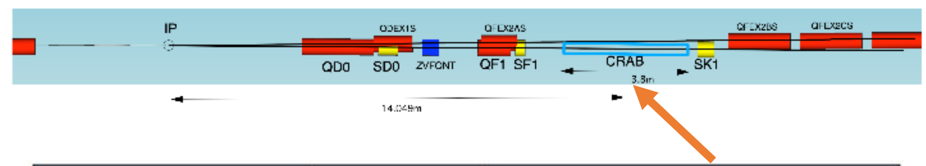
	Americas	Europe	Japan/Asia
CM tech. design base	LELS-II	Euro-XFEL	ILC-TDR
HPGS regulation base	ASME	TUV and EN	JP-HPGS act
ILC CM design	Common CM design globally adaptable to HPGS regulation in any regions		

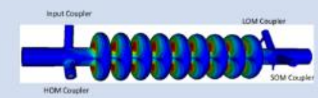
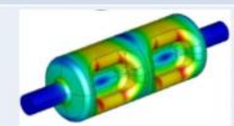
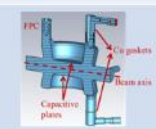
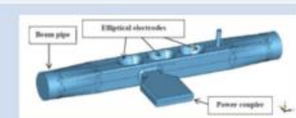
WP-prime 3: Crab Cavity Development with down-selection

- RF property simulation to optimize cavity design
- Pre-down-selection to choose two primary candidates
- Development and evaluation of two prototype cavities
- Demonstration of synchronized operation with two prototypes
- Down-selection to choose final cavity design
- Cryomodule design based on final cavity design

Item	Recent specification (after TDR)
Beam energy	125 GeV (e^-)
Crossing angle	**14 mrad**
Installation site	14 m from IP
RF repetition rate	5 Hz
Bunch train length	727 μsec
Bunch spacing	554 nsec
Operational temperature	2.0 K (?)
Cavity frequency	1.3/3.9 GHz
Total kick voltage	1.845/0.615 MV
Relative RF phase jitter	0.023/0.069 deg rms (49 fs rms)

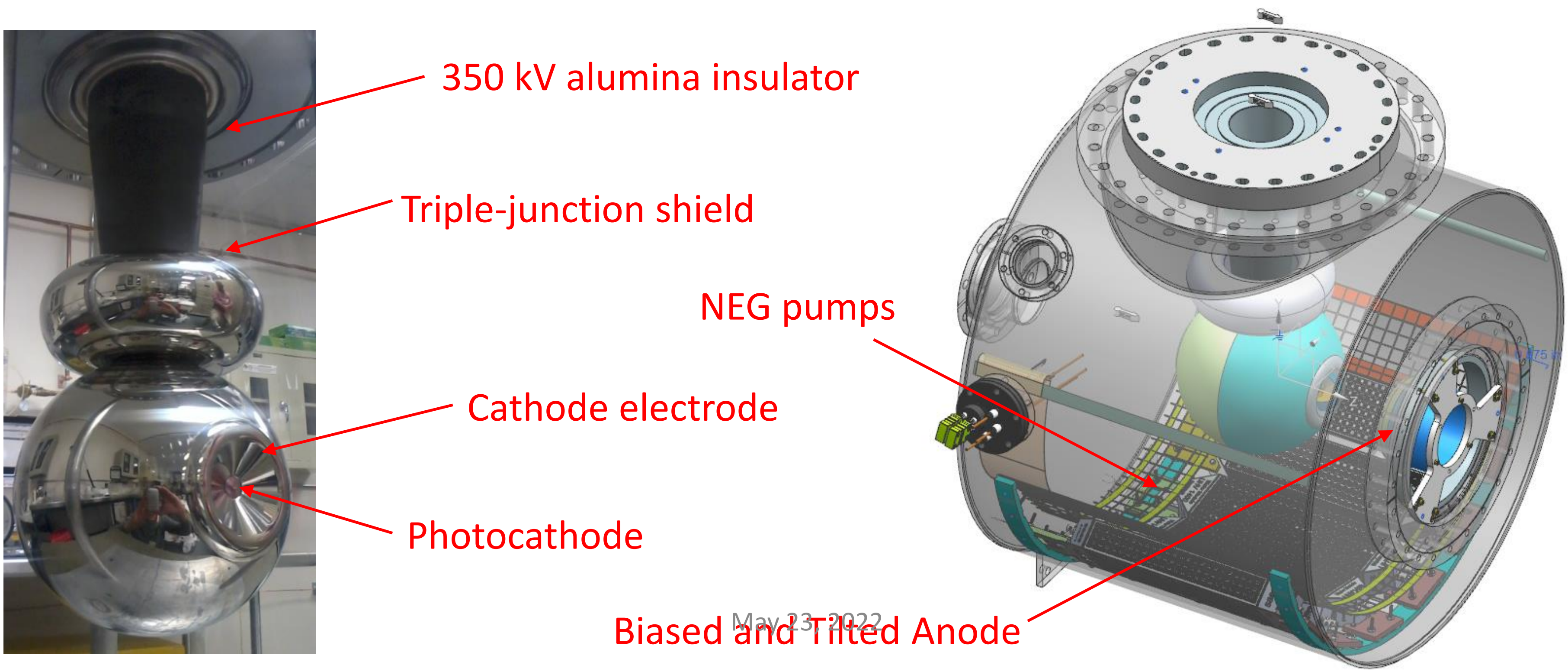
two beamline distance
14.049m x 0.014rad = **197mm**



Elliptical/Racetrack (3.9 GHz)	Lanc. Univ.	
RF Dipole (RFD)	ODU	
Double Quarter Wave (DQW)	CERN	
Wide Open Waveguide (WOW)	BNL	
Quasi-waveguide MultIcell Resonator (QMIR)	FNAL	

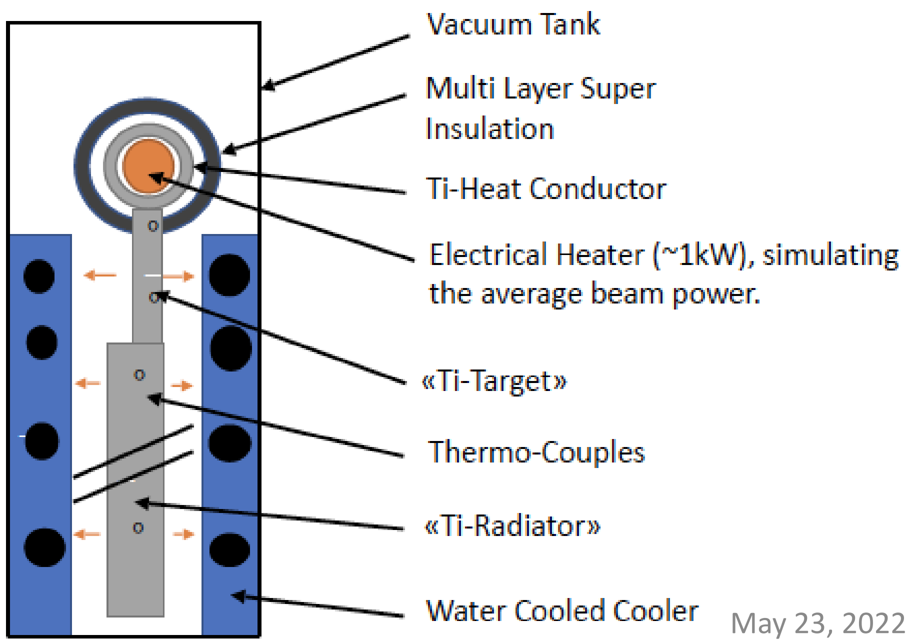
WPP-4: Electron Gun

- The electron gun consists of
  - High-voltage photo gun
  - Drive laser system
  - GaAs/GaAsP Photocathode
- High-voltage gun is the most urgent item
  - The gun voltage in TDR is 200 kV. A higher voltage desirable.
  - Meaningful technical progresses since TDR would be reflected in a new design
  - New GaAs gun based on lessons learned from 350 kV CsKSb magnetized dc photogun



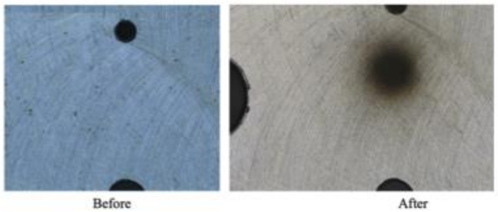
WPP-6: Rotating Target for Undulator Scheme

- ◆ Target specification
  - ➢ Titanium alloy, 7mm thick (0.2 X0), diameter 1m
  - ➢ Rotating at 2000 rpm (100 m/s) in vacuum
  - ➢ Photon power ~60 kW, deposited power ~2 kW
  - ➢ Radiation cooling
  - ➢ Magnetic bearings
- ◆ R&D to be done as WP-prime
  - ➢ Design finalization, partial laboratory test, mock-up design (in the first 2 yers)
  - ➢ Magnetic bearings: performance, specification, test (in the remaining years)

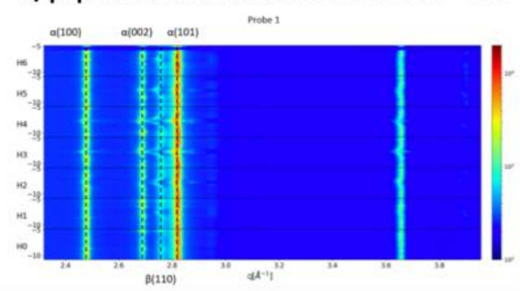


Target material test

Target before and after radiation:

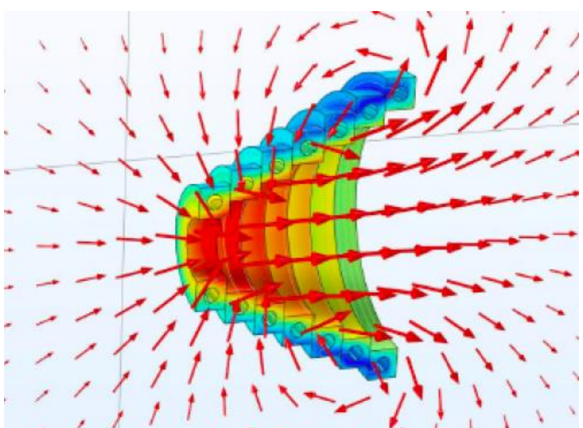


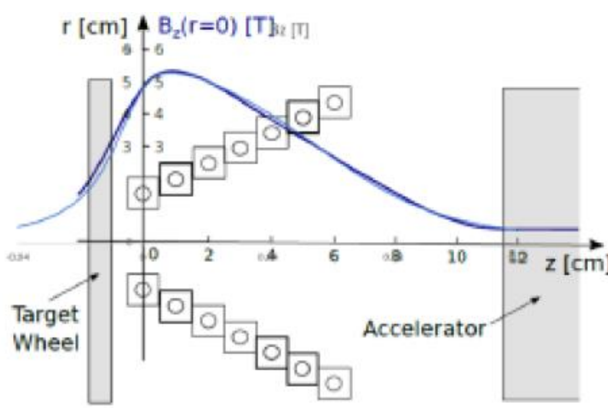
α/β phase transitions in Ti-6Al-4V:



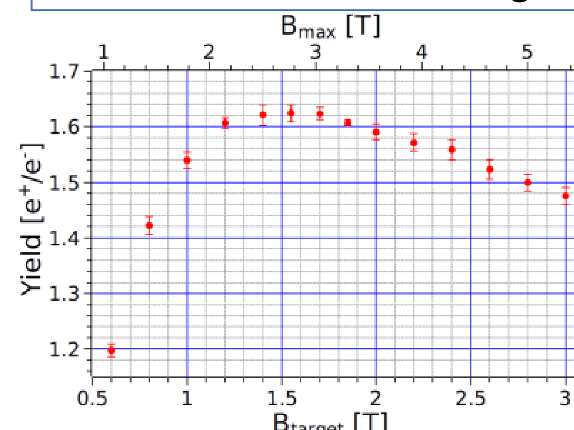
WPP-7: Focusing System for Undulator Scheme

- The critical item for the undulator scheme is the magnetic focusing system right after the target
- Possible cabdidates are: (a) Flux Concentrator, (b) Quarter wave transformer, (c) Pulsed solenoid, (d) Plasma lens
- The strongest candidate is (c) pulsed solenoid.
- R&D items to be done as WP-prime
  - ➢ Detailed simulations for (c) (already on-going)
  - ➢ Principal design for a prototype pulsed solenoid
  - ➢ Field measurements with 1kA (pulsed and DC) and with 50kA both in a single pulse mode and finally in a 5ms pulsed mode
  - ➢ Prototype plasma lens (study on-going)





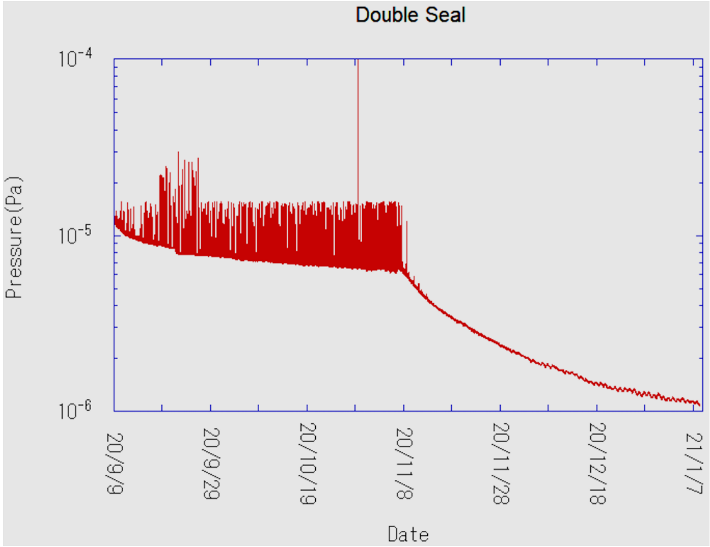
Yield versus field on the target

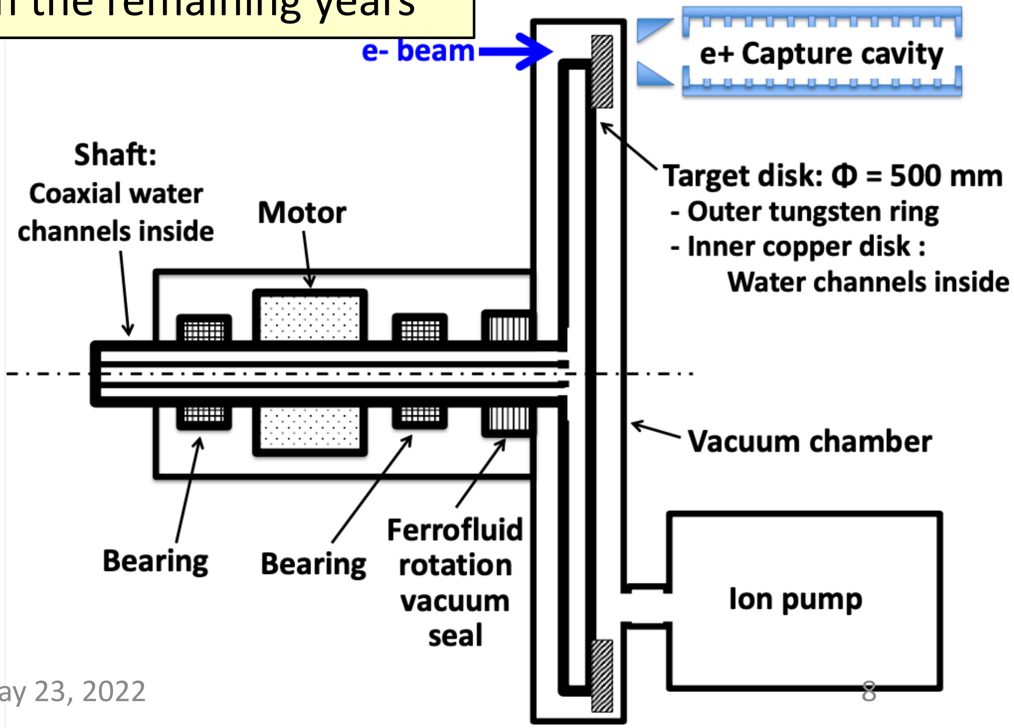


WPP-8: Rotating Target for e-Driven Scheme

- Target specification
  - W or W-Re, 16 mm (5 X0) thick, diameter 50cm
  - Rotating at 5 m/s in vacuum
  - Water cooled.
  - Vacuum seal by ferromagnetic seal
- R&D items to be done in 2 years
  - Target stress calculation with FEM
  - Vacuum seal
  - Target module design
- Target module prototyping can be done in the remaining years

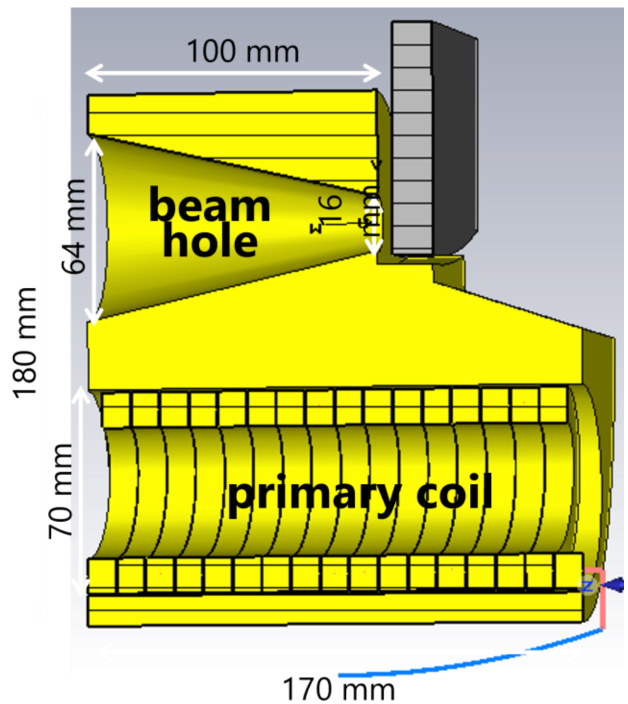
Vacuum test with double seal

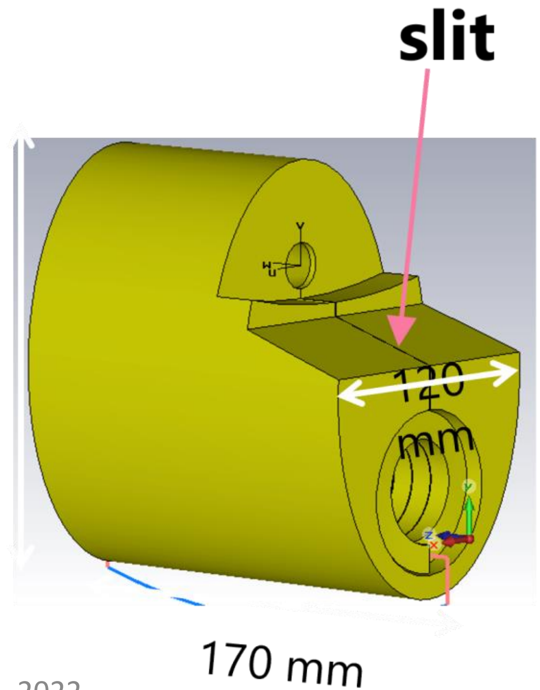




WPP-9: Focusing System for e-Driven Scheme

- Flux Concentrator is chosen as the focusing device after the target
- The specification parameters such as max field, electric current and the dynamic force are satisfied in existing target, but the pulse energy and the heat load are higher.
- A prototype necessary after detailed design study
- R&D items as WP-prime
  - Flux concentrator conductor design (in first 2 years)
  - Conductor prototyping (in the remaining years)

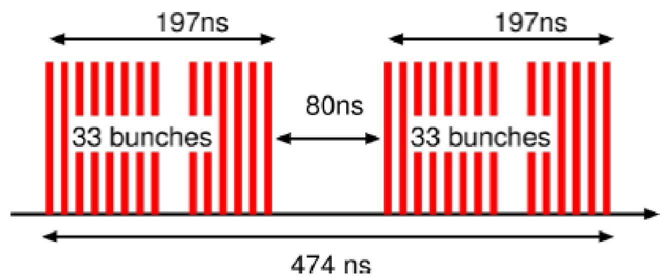




WPP-10: Capture Cavity and Linac for e-Driven Scheme

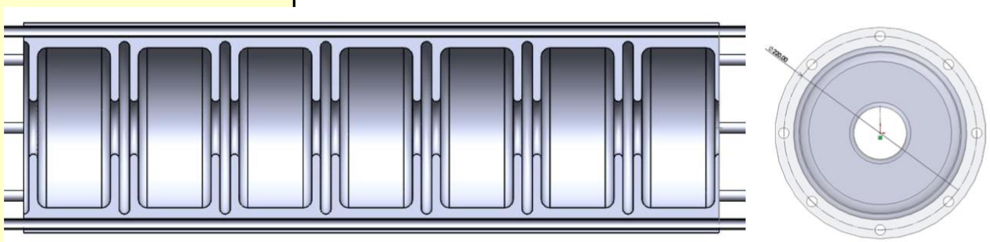
- The positrons after the magnetic focusing system are accelerated to 5GeV through various linacs (Standing wave, travelling wave, S-band, L-band) and injected into the damping ring.

- Technically the most critical element is the L-band, standing-wave structure right after the target and FC.
  - ➢ High beamloading (up to ~1A)
  - ➢ Special bunch pattern
  - ➢ Changing beam current (mixed electron-positron, capture process in RF bunckets)



- The technologies of the modulator and klystron for this region are known well but these are needed for the test of APS cavity

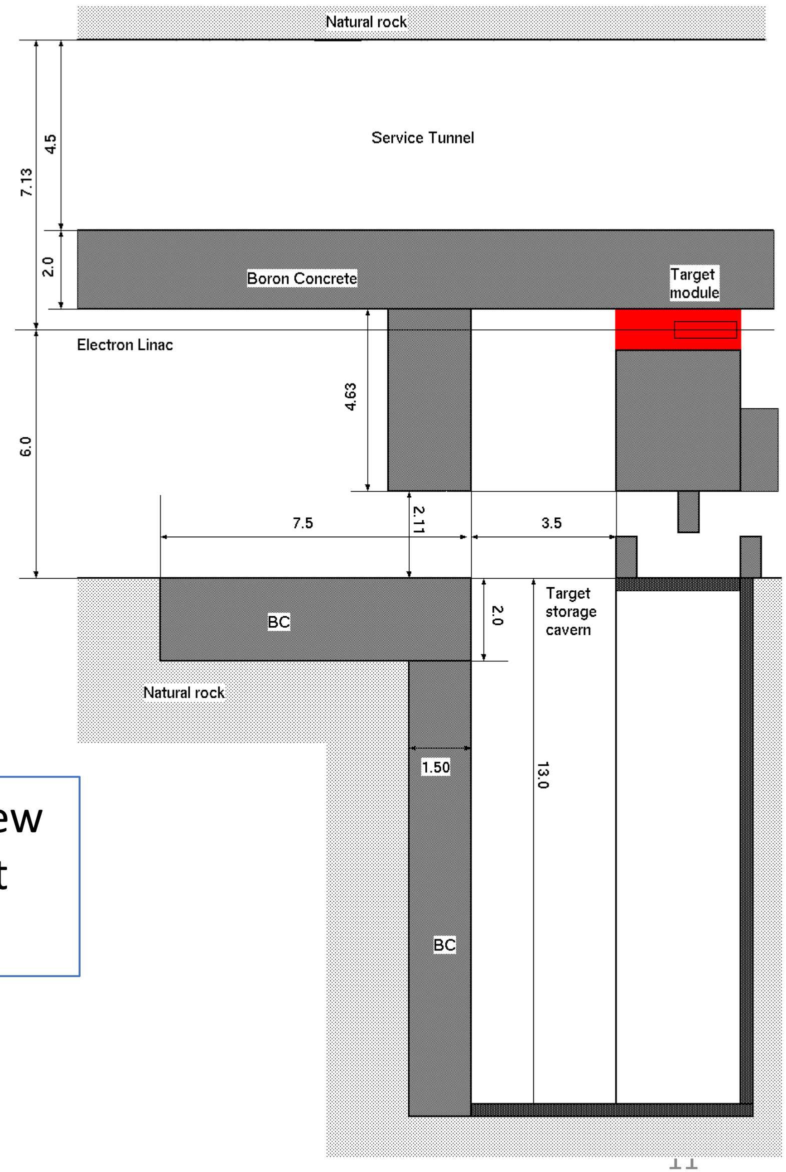
- R&D items as WPP-10 for the first 2 years
  - ➢ APS cavity design and cold model
  - ➢ Beam-loading compensation and tuning method
  - ➢ L-band klystron design
  - ➢ Power unit prototype design
  - ➢ solenoid design
- Prototyping of these components in later years

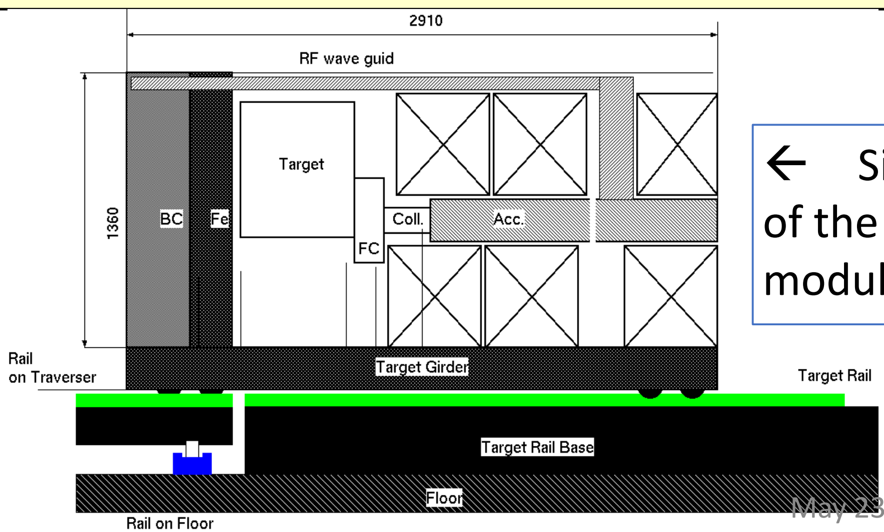


WPP-11:

- The radiation dose in the area around the target area is high in both undulator and e-driven system.
- Careful design of shielding is required
- The components near the target (target, flux concentrator, first cavity with solenoid) require replacement in every few years. The work must be done by remote control.
- The works to be done as WP-prime
  - Conceptual design
  - Fabricate Mockup
  - Prototyping of critical parts

Floor layout of the target section.





← Side view of the target module

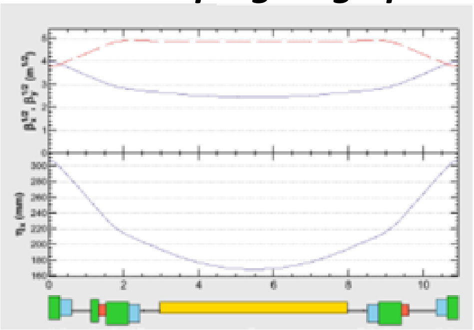
WP-prime-12: System design of ILC damping ring

◆The present design of the ILC damping ring (DR) is a simple design using hard edge magnet model with zero spacing between the magnets.

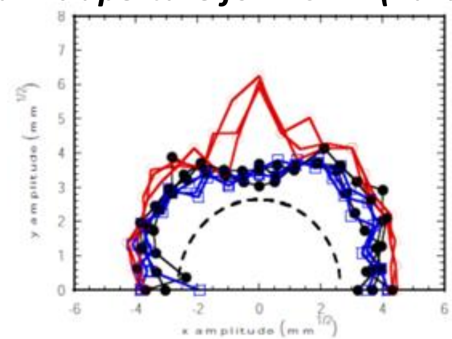
◆It is pointed out that the dynamic aperture of the circular accelerator decreases when the fringe field of the magnet is taken into account.

◆By quantitatively evaluating the effect of fringe field on the dynamic aperture of magnets in ILC damping, the method for evaluating fringe field in accelerator design will be established and the design of ILC damping ring will be optimized.

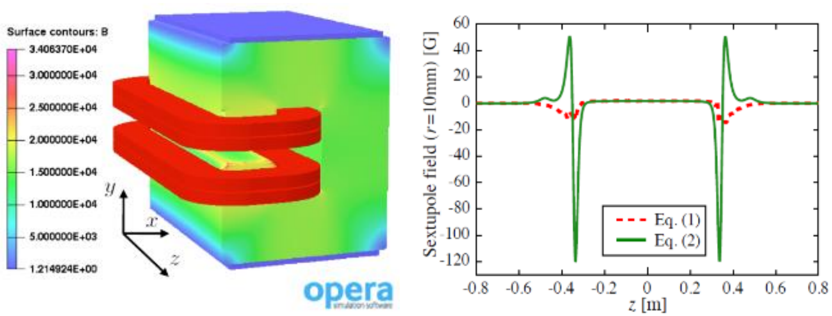
ILC damping ring optics



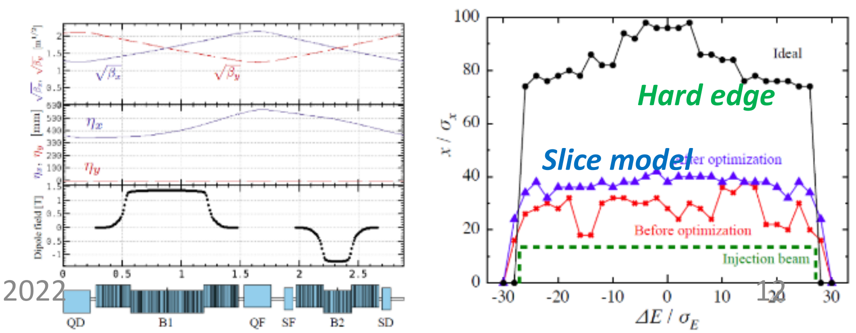
Dynamic aperture for ILC DR (hard edge)



Modeling of the fringe field for SuperKEKB DR



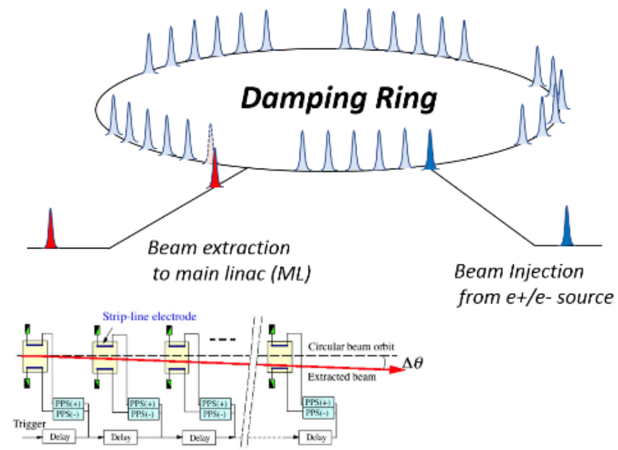
Dynamic aperture evaluation with fringe effect (SuperKEKB DR)



WP-prime-14: System design of ILC DR injection/extraction kickers

- ◆A fast kicker system using a semiconductor pulse power supply with nanosecond response was confirmed as proof of principle at KEK's ATF about 10 years ago.
- ◆Semiconductor technology has been evolving, and it is now possible to advance nanosecond response beam injection/excitation systems using the recent semiconductor technology.
- ◆The technical evaluation of the fast kicker power supply using the recent semiconductor technologies.
- ◆The evaluation of fast pulsed power supply technology will contribute not only to the fast kicker system but also to the performance and reliability of nanosecond-scale beam control technology and its application to a wide range of accelerator systems.

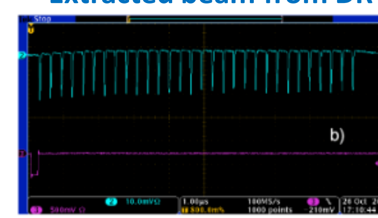
ILC fast injection/extraction system



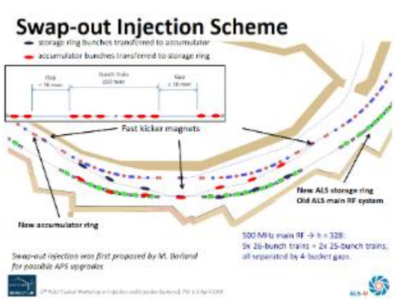
Beam extraction test at KEK ATF

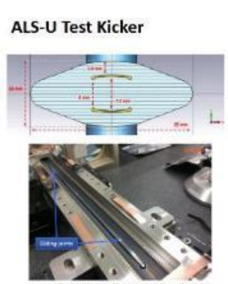
Stored beam in DR

Extracted beam from DR

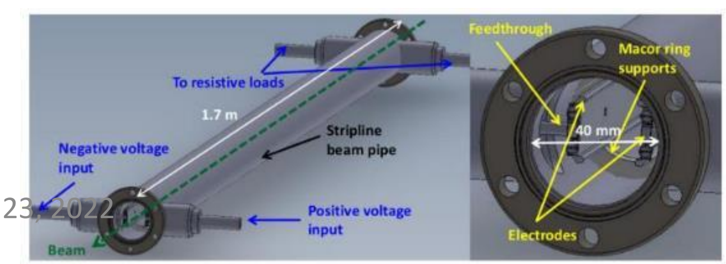


Swap-out injection system planned at LBNL





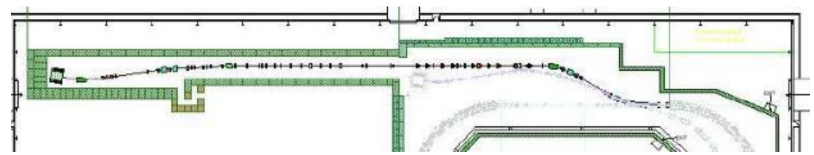
Beam injection/extraction system for CLIC damping ring



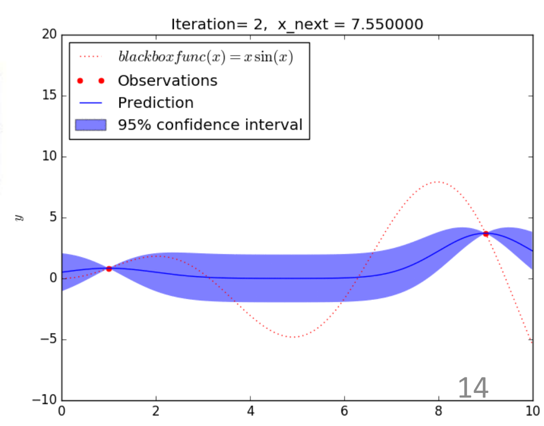
WP-prime-15: System design of ILC final focus beamline

- ◆ATF2 beamline is the only existing test accelerator in the world to test the final focus beamline of linear colliders.
- ◆The following 3 research topics are important topics to be pursued at the ATF.
  - ◆ wakefield mitigation
  - ◆ correction of higher-order aberration
  - ◆ training for ILC beam tuning
- ◆The technical research at ATF2 beamline has proceeded, and should continue to be based on the ATF international collaboration, or its extension (welcome to new partner).

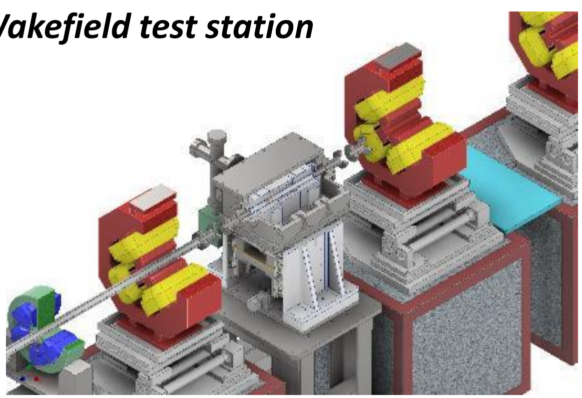
ATF2 beamline



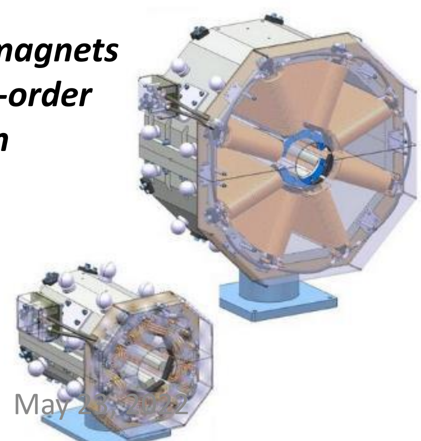
Maximum search algorithms to be applied to beam tuning (Machine Learning)



Wakefield test station



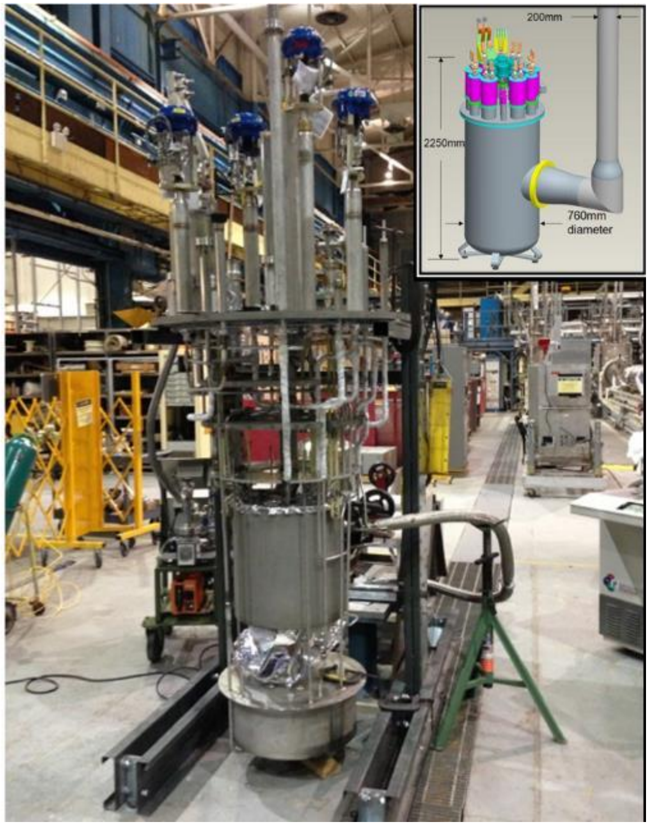
Octupole magnets for higher-order aberration



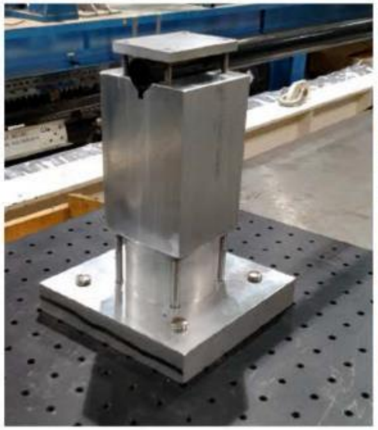
WP-prime-16: Final doublet design optimization

- ◆Cooling of the superconducting ILC final focus magnets will be performed using 2K superfluid helium to realize superconducting magnets with high oscillation stability.
- ◆Quantitative evaluation of the vibration generated by the 2K cooling system located on the side of the final focus magnets has not been completed.
- ◆We will measure and evaluate the vibration generated by the 2K cooling system by using the prototype.

Prototype of ILC service cryostat
(2K cooling system ; BNL)

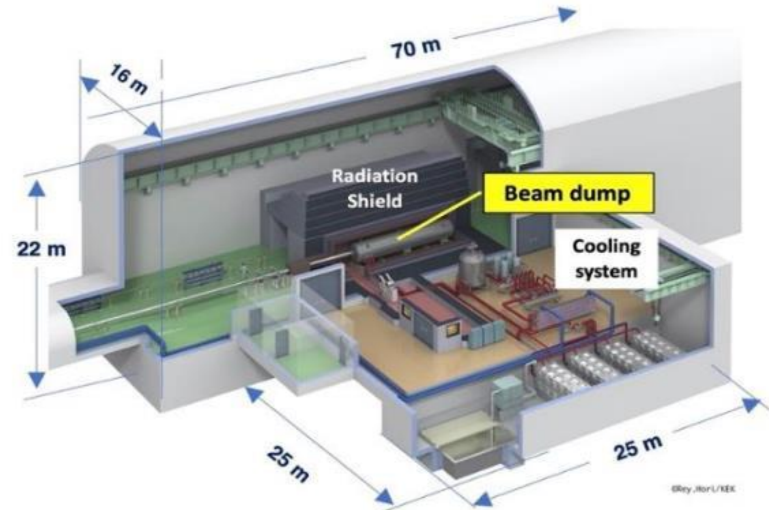


Vibration measurement system
for SuperKEKB final focus magnet (KEK)

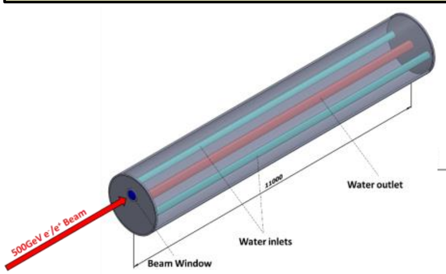


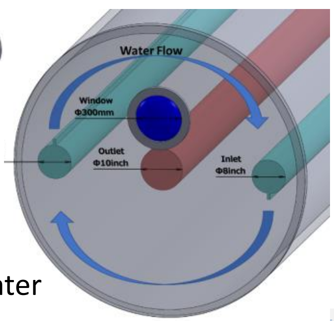
WP-prime 17: Beam Dump

- ◆ Finalize the engineering design of the main beam dump system
  - Vortex water flow in the dump vessel
  - Cooling water circulation and heat exchange
  - Remote exchange of the beam window
  - Countermeasure for failures / safety system



Imaginary view of the main dump section

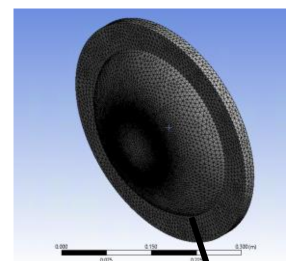




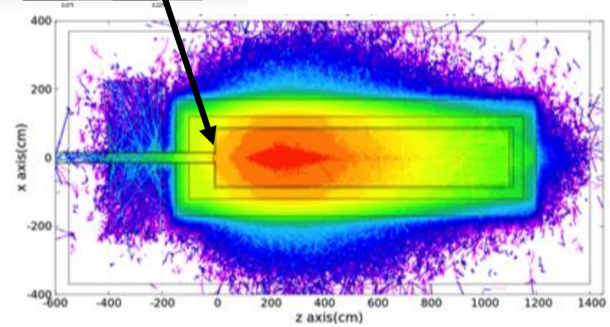
11m-long x 2m(diameter) water

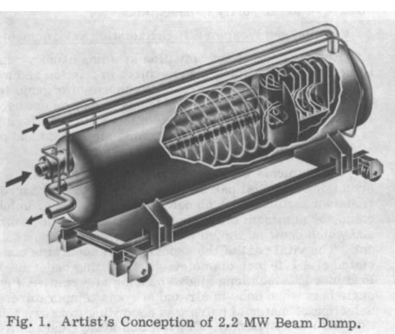
Vortex water flow

- **17 MW** at 500 GeV beam
- 1 MPa to prevent boiling

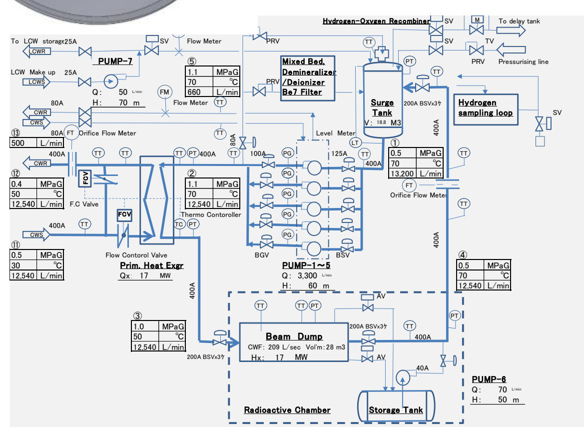


Beam window
- Ti-alloy
- 30 cm diameter
- Exchange every a few years





SLAC 2.2MW water dump (precedent)



Primary design of the beam dump water circulation and heat exchange

Remote exchange of the beam window

under high radiation dose