Overview of Mechanical Engineering Design Progress for LC 18MW Beam Dump

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SLAC-BARC Dump Group

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(From left)
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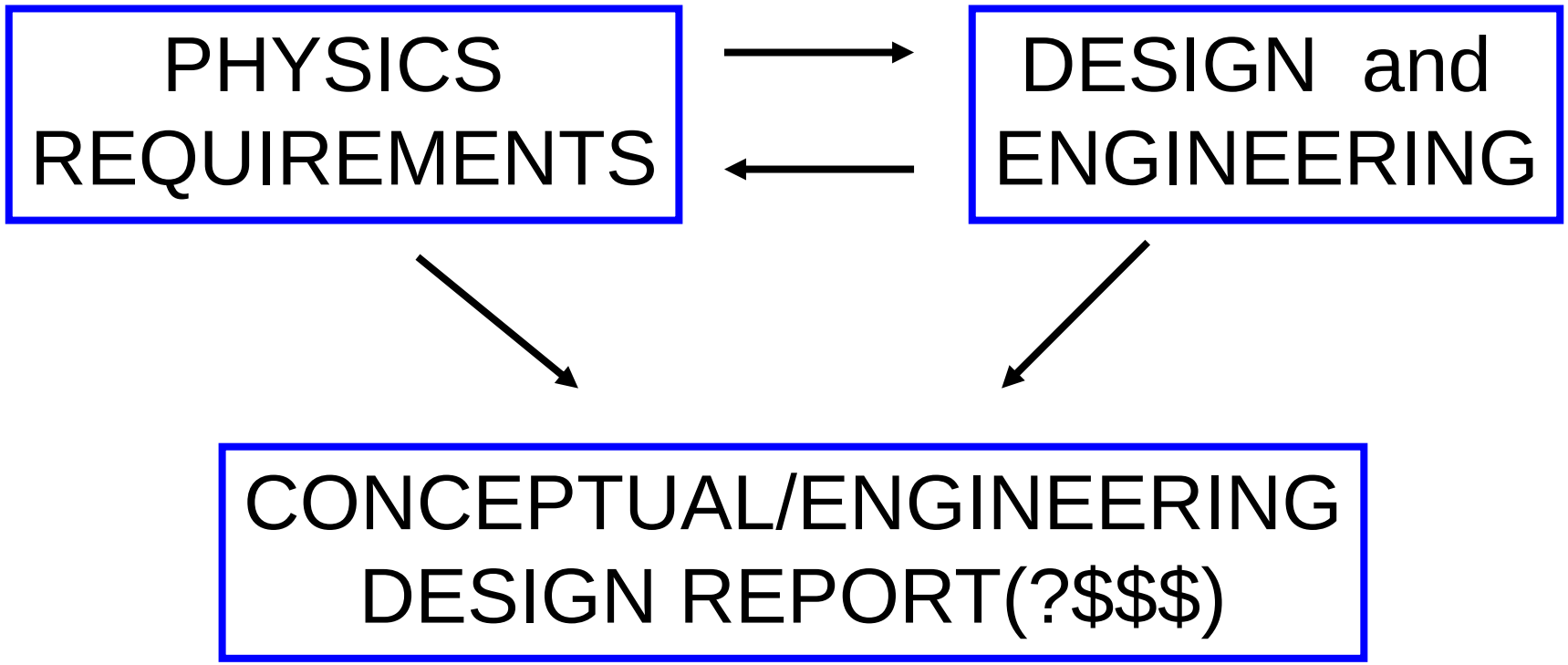
Beam Dump Design Process



Limited resources – main focus on dump window and vessel at this time.

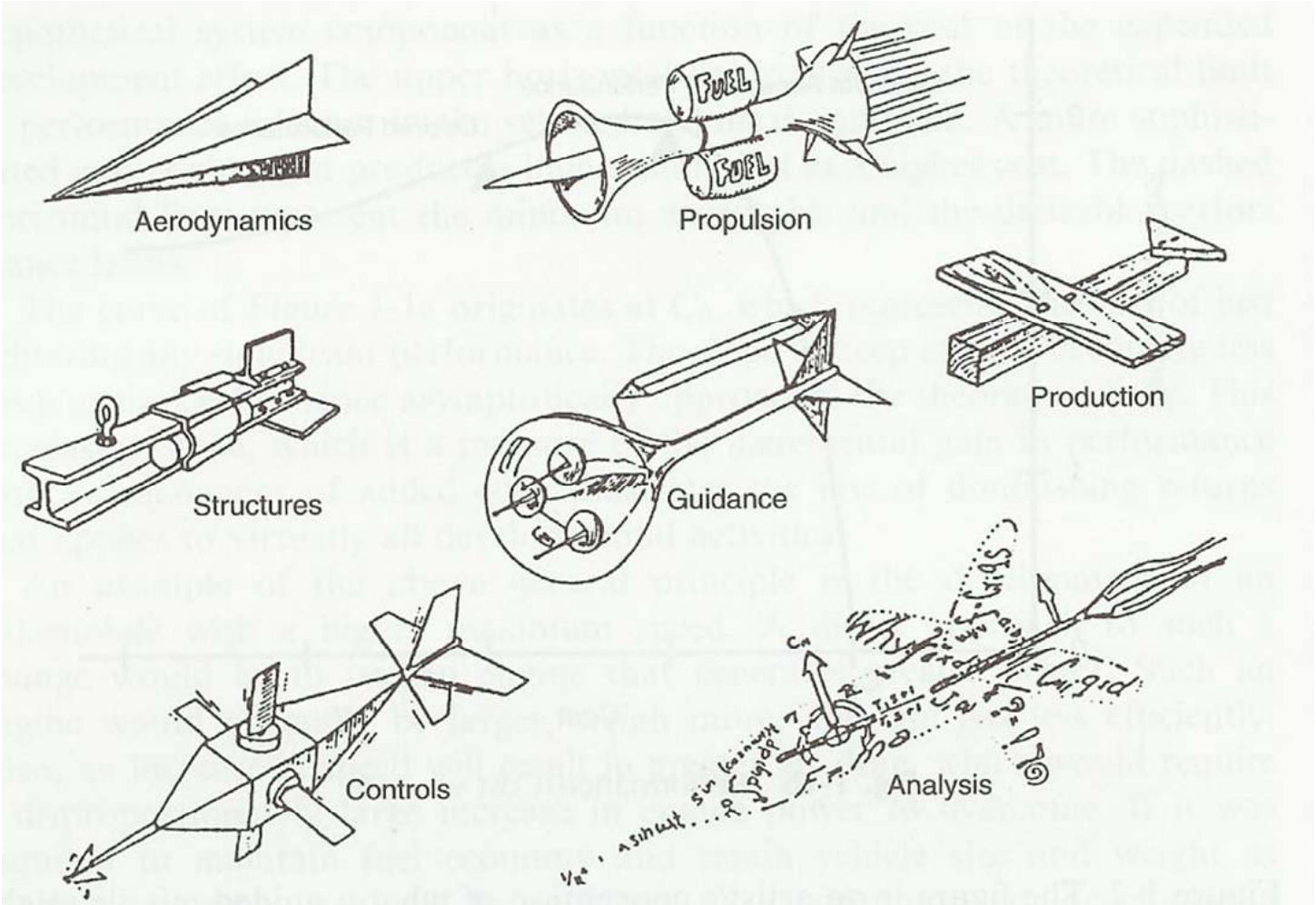


Fig. 1-2 The ideal missile design from the viewpoint of various specialists.

Some Design Constraints

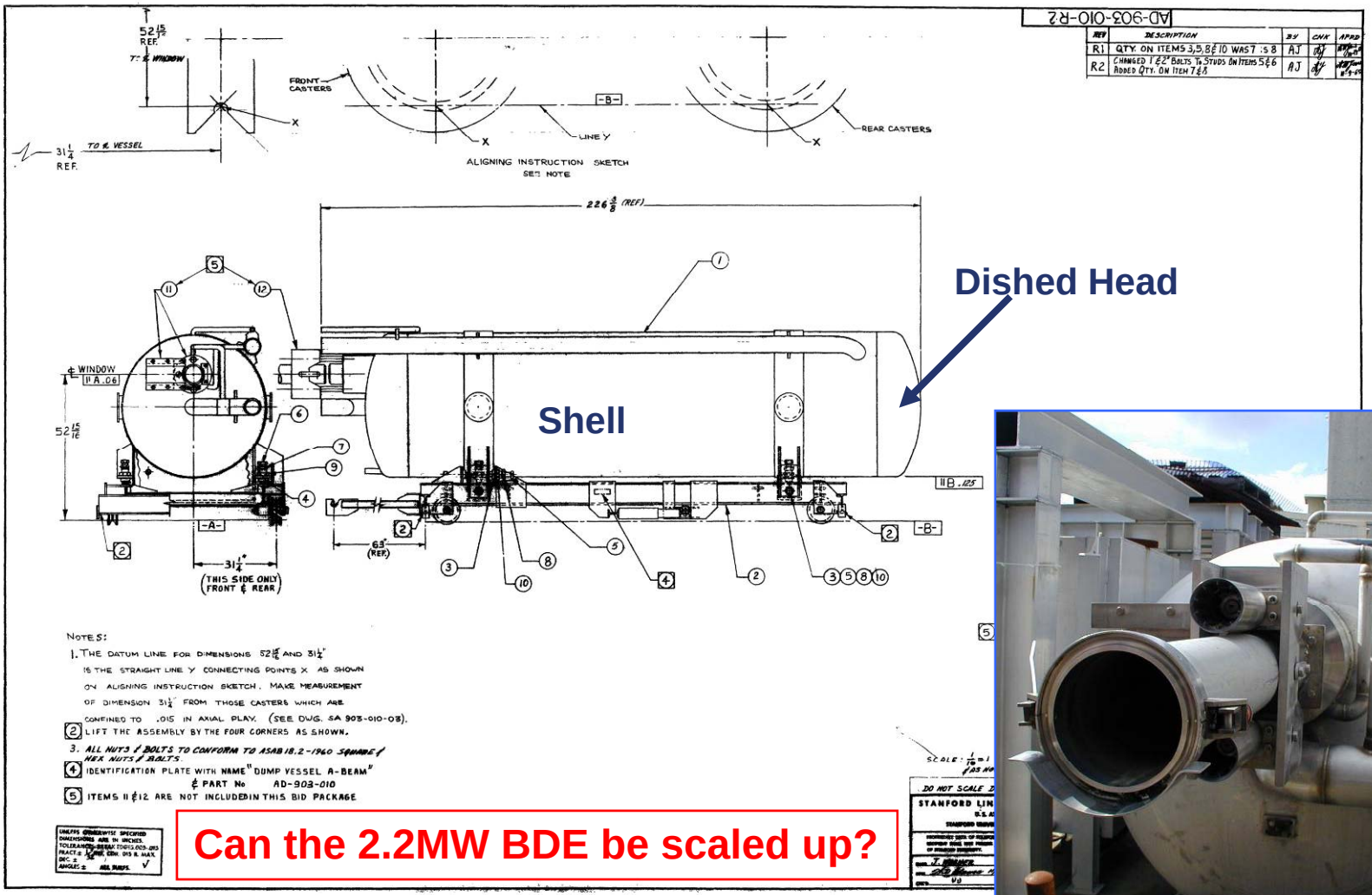
- Must fit in beam dump vault space between incoming and outgoing beam lines, very tight space in RDR.
- Minimum material at downstream end of dump vessel.
- Remote/robotic window interchange due to activation.
- Separate machine vacuum from dump water.
- Remote/robotic service of other items possibly needed, radioactive filters for one.
- All metal construction, avoid lubricants, polymers.
- Manufacturability.
- Very High Reliability.
- Beam Spot Rastering - Required!

Comments on ASME BPVC

(Boiler Pressure Vessel Code)

- May be required to follow BPVC if operated in US, but in general provides us with a guide for best practices and designs. May be able to argue that it is unique scientific equipment, in order to gain exceptions to BPVC.
- We are using Division VIII rules for mechanical design of vessel and window. Division III (nuclear power facilities) for welds and inspection methods.
- Scope – We think Division VIII is applicable as this is not a power or steam boiler and is not for use at a nuclear facility.
- Division III rules used for 2.2MW BDE welds and inspection, seems to be a good practice as one can argue that the beam dump system is a radioactive containment vessel.

Baseline Mechanical Design
SLAC 2.2MW BDE



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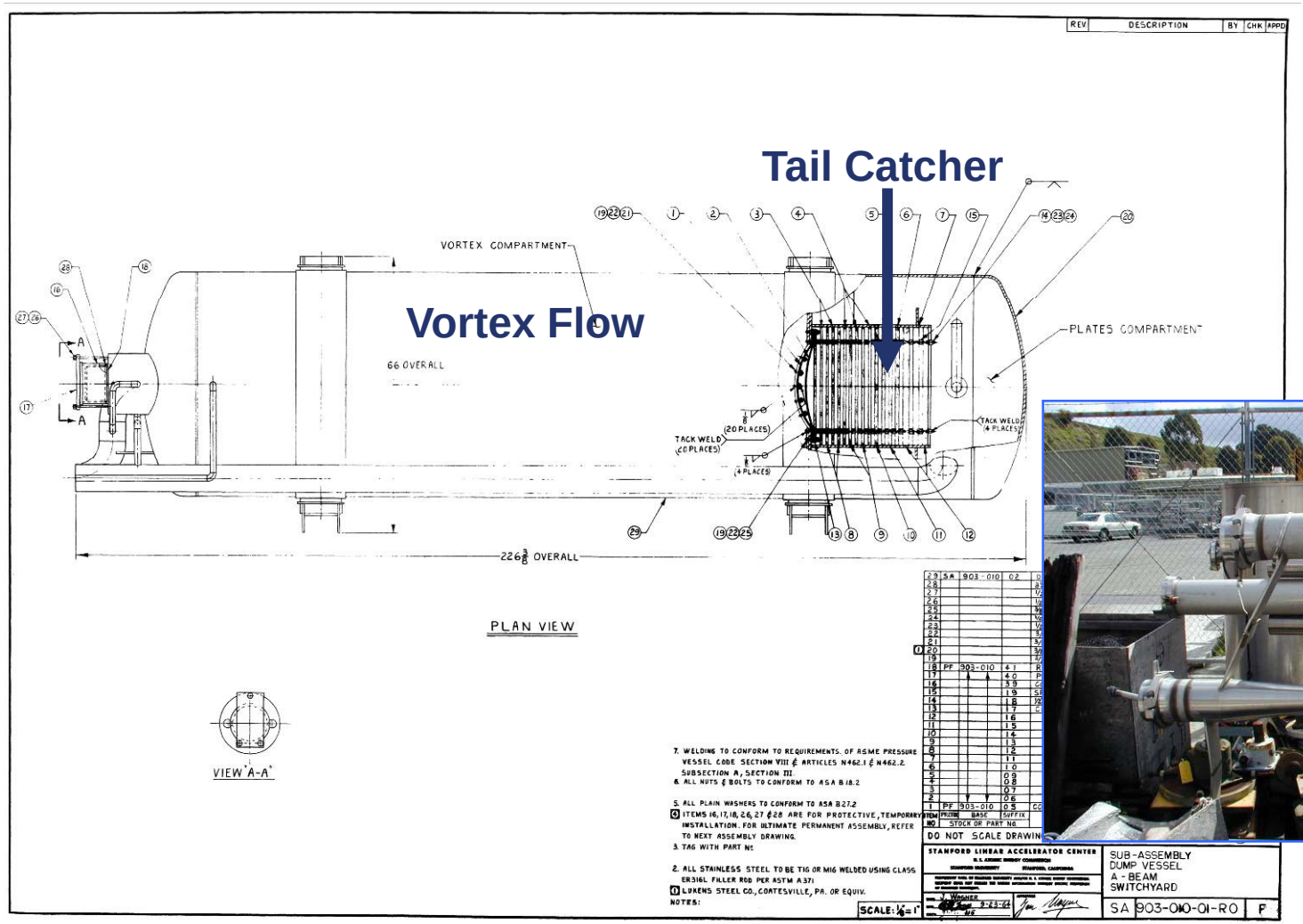
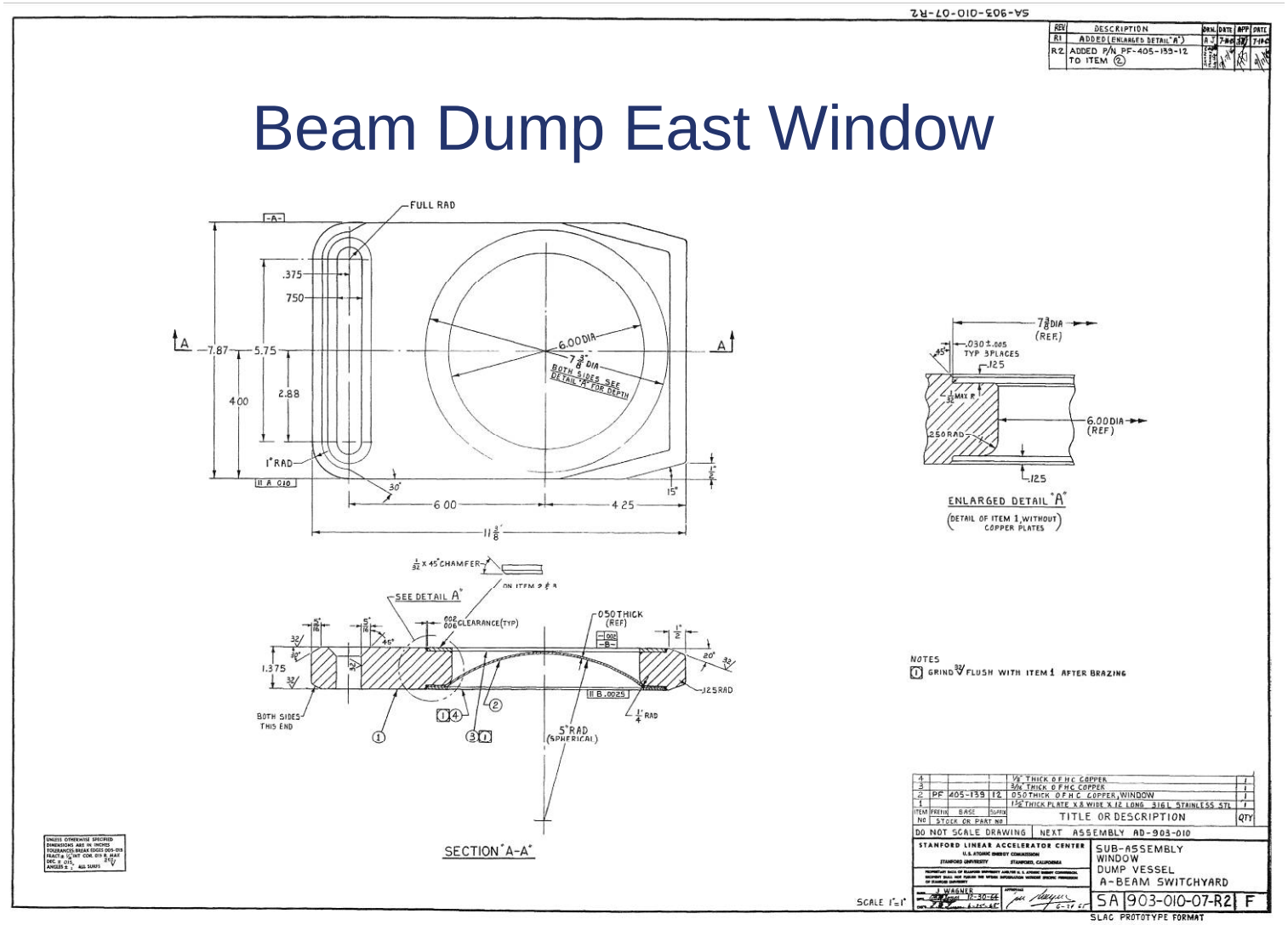
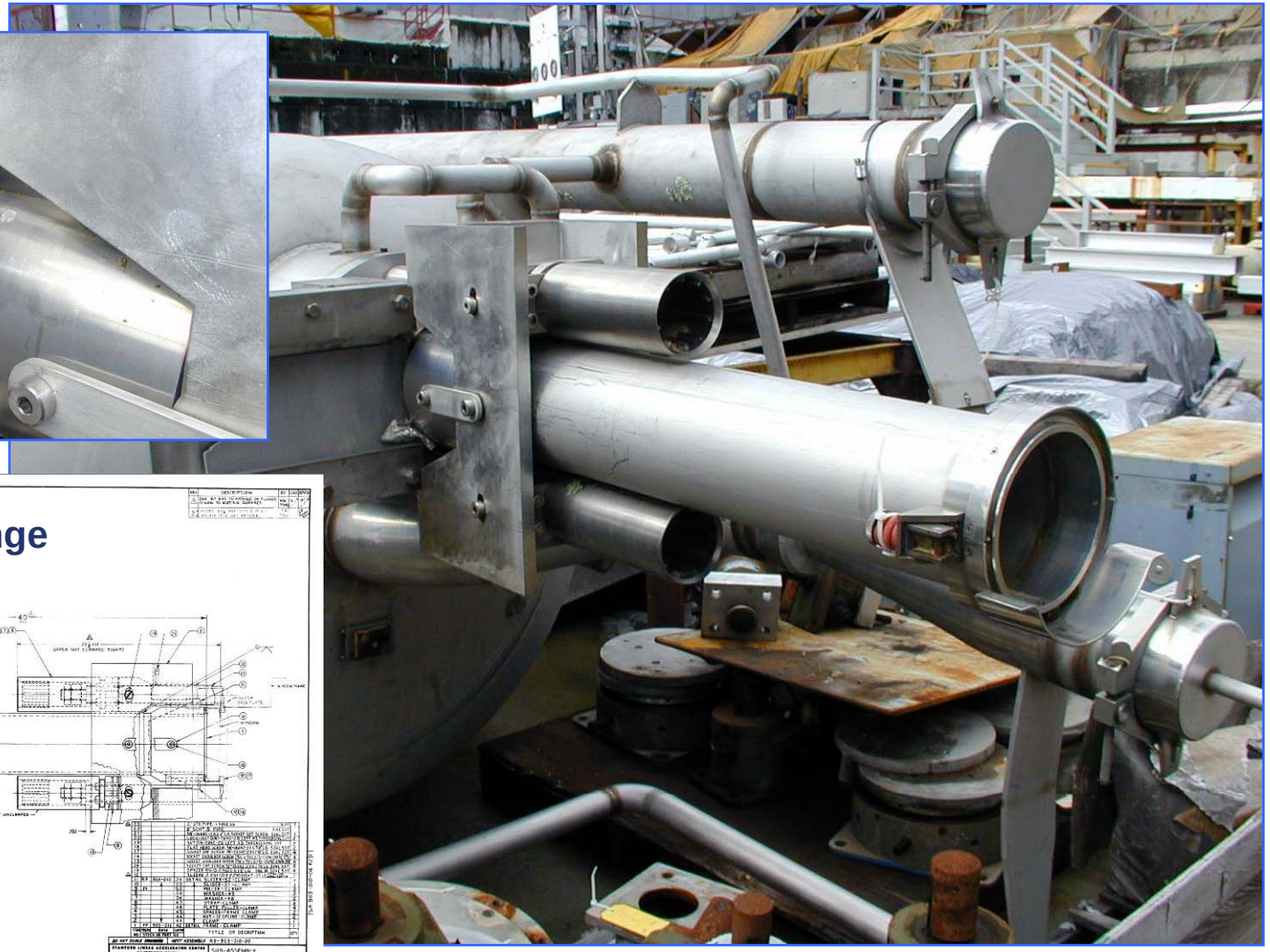


Baseline Mechanical Design
SLAC 2.2MW BDE

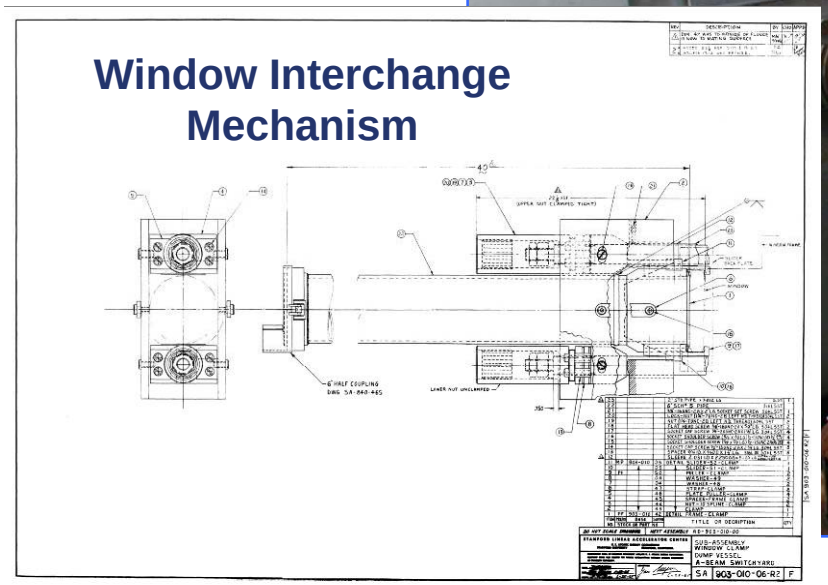
Beam Dump East Window



Baseline Mechanical Design
SLAC 2.2MW BDE



Window Interchange Mechanism

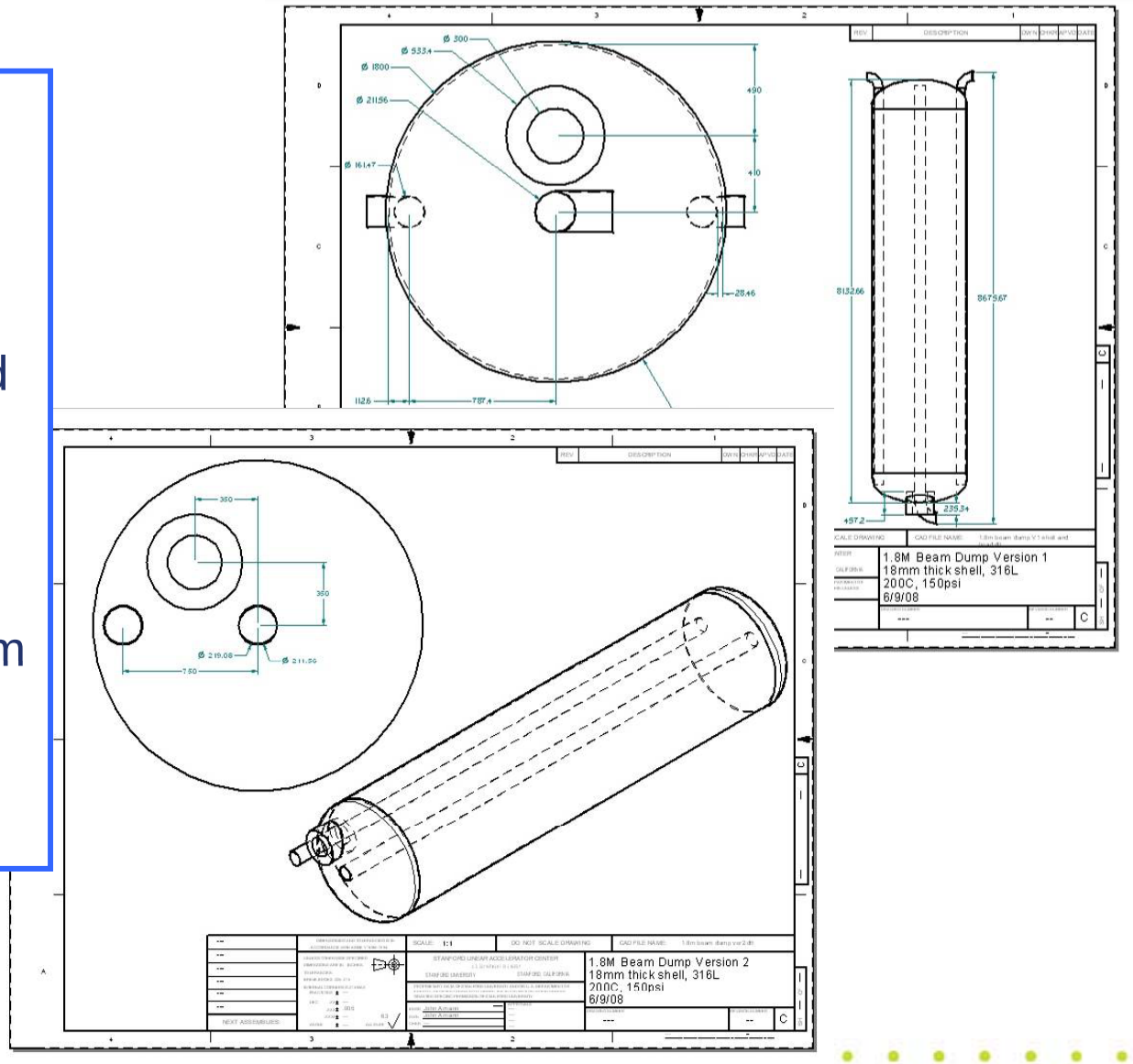


Beam Dump – Basic Parameters

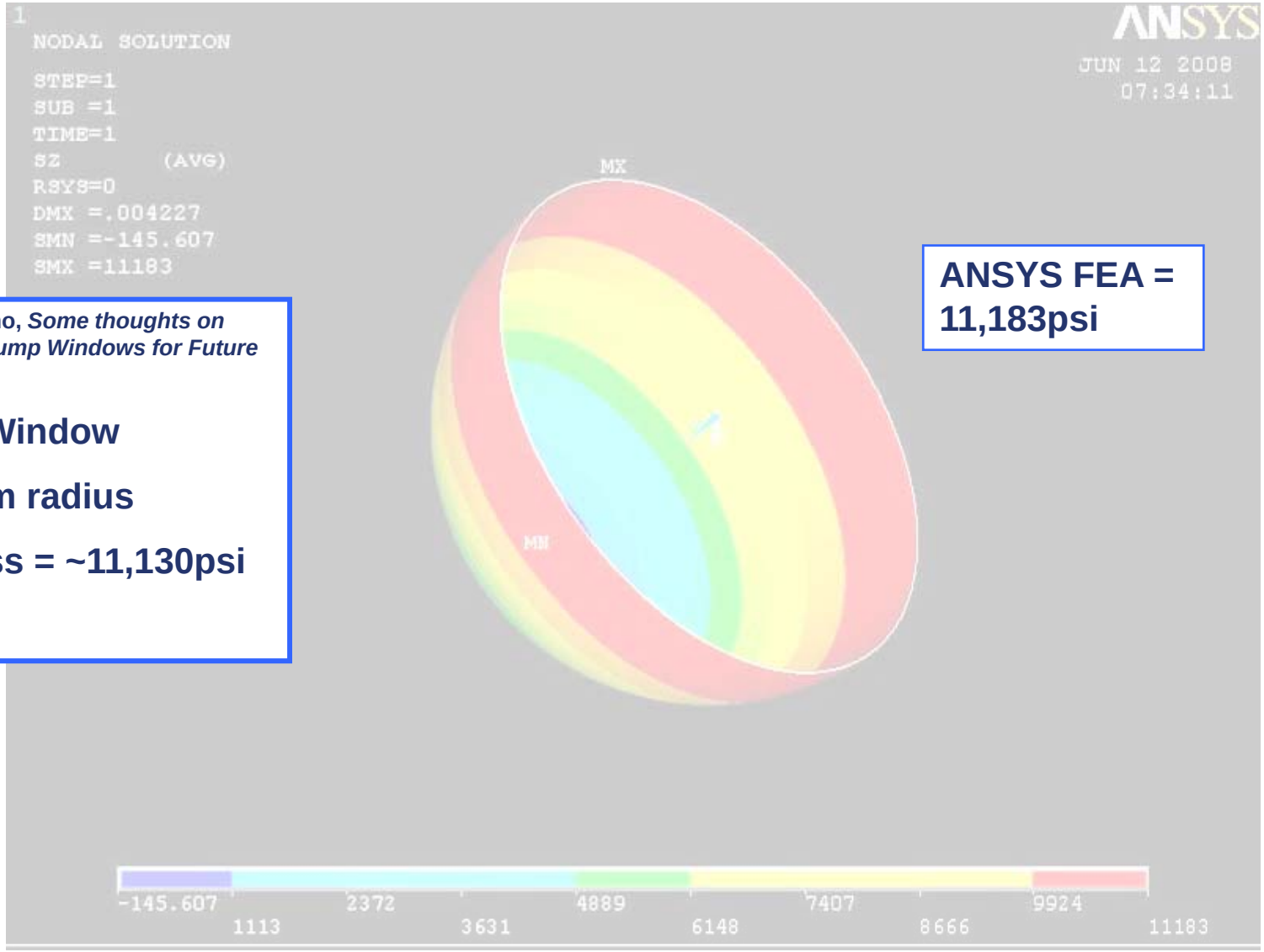
Dump Vessel 316L SS

Diameter (1.8m) and length (~8m) determined from physics analysis.

Minimum thickness of shell (18mm) derived from ASME BPVC Div VIII given operating parameters.



Beam Dump Window



From: D. Walz SLAC memo, ***Some thoughts on Very High Power Beam Dump Windows for Future Lepton Colliders***:

Hemispherical Window

1mm thick, 15cm radius

Max Static Stress = ~11,130psi

ANSYS FEA = 11,183psi

Beam Dump Window Designs

Ideal shape – Hemispherical

Easier to manufacture – Ellipsoidal

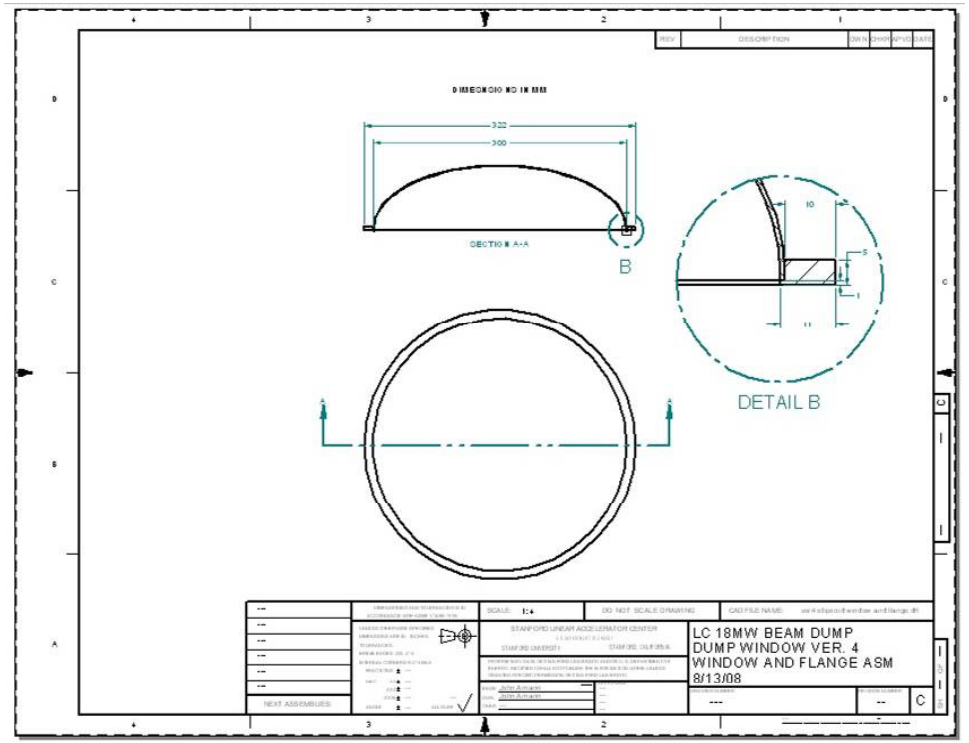
Other options –

- Toro-spherical (limits max allowable stress = much thicker)
- Hemi-cylindrical (more difficult gasket design, interchange)

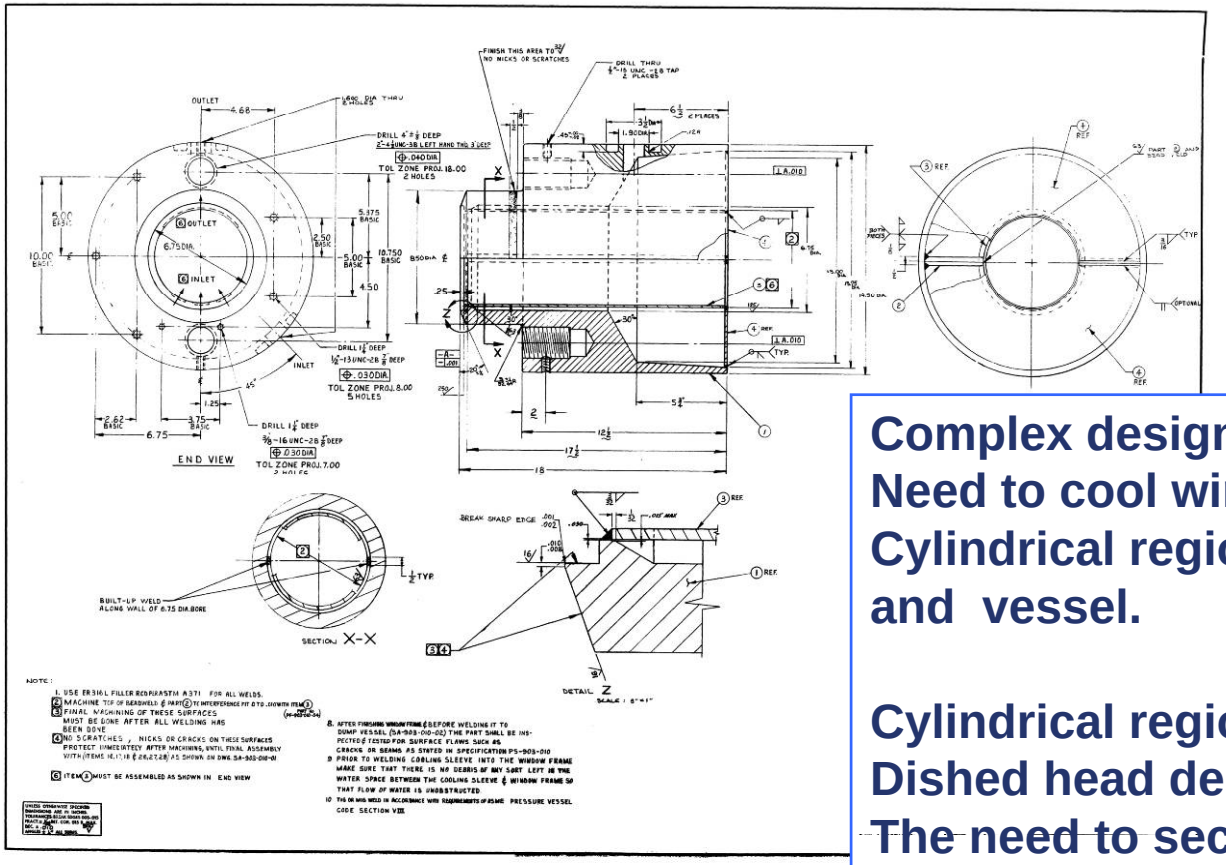
Materials – D. Walz suggests Ti alloy Ti-6Al-4V or Ti-13V-11Cr-3Al

Designed under BPVC as "flanged cover".
Minimum Thickness for annealed Ti-6AL-4V

- Hemispherical - .31mm
- 2:1 Ellipsoidal - .63mm



Baseline - Dump Window Cooling



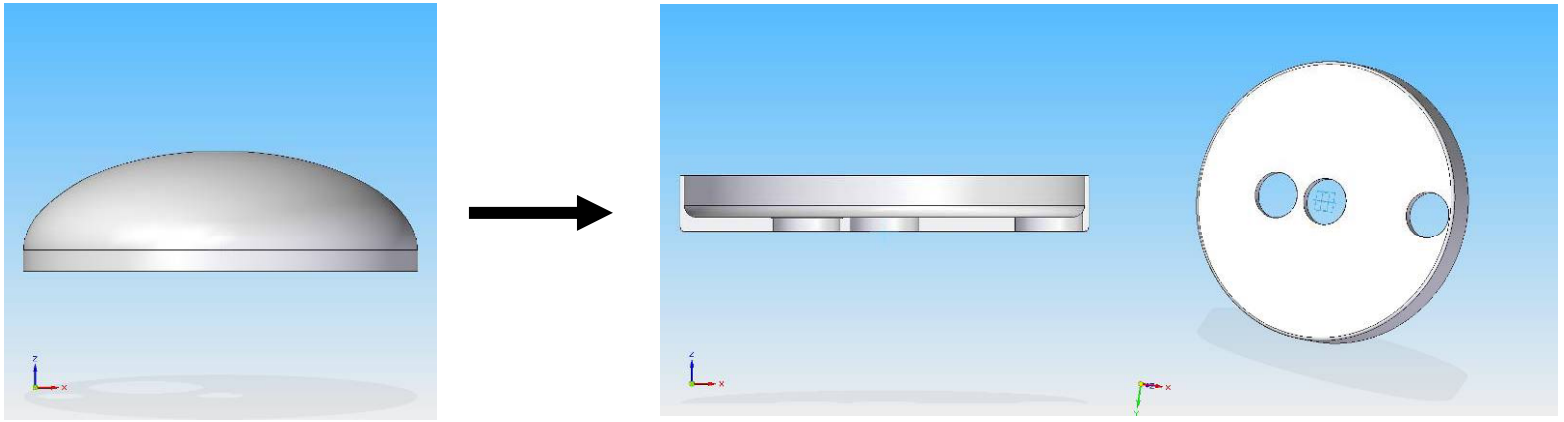
Complex design:
Need to cool window surface.
Cylindrical region between window and vessel.

Cylindrical region is long due to:
Dished head design of vessel.
The need to secure window clamp to frame.

Due to beam rastering , required cooling jet pattern is more complex.

Deviation from Baseline Design
Latest Developments

- High activity, need simple, robust, robotic maintenance.
- Desire to eliminate cooling sleeve and bring window surface near to vortex flow of main tank.
- Flat head design under investigation. Min. thickness ~61mm vs. ~15mm 2:1 ellipsoidal.



Work in Progress

- Still lots to do in terms of design optimization and iteration with physics analysis.
- Thermo-mechanical studies will begin as FLUKA results become available. Interested in thermal shock stress effects.
- Need to start investigating window beam damage (crystal grain boundary failure due to radiation damage), corrosion, fabrication methods, scale models of CFD simulations.
- Once design is frozen, then we can proceed with detailed engineering design to generate a cost estimate.

Concluding Remarks

Much of this work could be applied to beam dumps for CLIC type collider. I hope we have given a glimpse as to how beam parameters drive mechanical design.

SLAC/BARC have the critical resources needed for beam dump projects:

Satyamurthy Polepalle - expert in CFD and thermal hydraulic analysis with numerous successful projects in nuclear physics and power and large technical resources at BARC. This sort of expertise in not generally common at HEP labs.

Dieter Walz - an expert in beam dump design, materials performance and engineering for particle accelerator applications.

Ability to make prototypes and do reduced scale testing on site. Beam damage testing a possibility in the near future.

Successful operational experience in a variety of beam dumps and collimators.