DEVELOPMENT OF A DRY WALL CONCEPT FOR LASER IFE CHAMBERS

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The goal is to design a dry chamber wall for the HAPL project

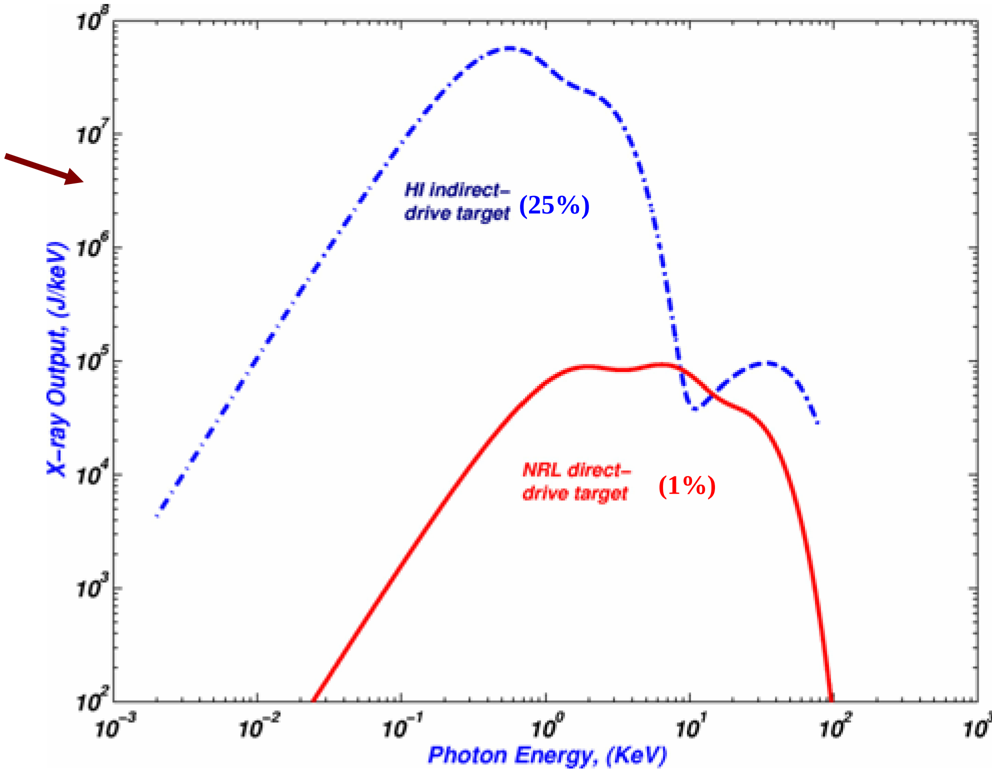
The emphasis here is on the thermomechanical aspects of the design

Energy Partitioning and Photon Spectra for Example Direct Drive and Indirect Drive Targets

Energy Partitions for Example Direct Drive and Indirect Drive Targets

	NRL Direct Drive Target (MJ)	HI Indirect Drive Target (MJ)
X-rays	2.14 (1%)	115 (25%)
Neutrons	109 (71%)	316 (69%)
Gammas	0.005 (0.003%)	0.36 (0.1%)
Burn Product Fast Ions	18.1 (12%)	8.43 (2%)
Debris Ions Kinetic Energy	24.9 (16%)	18.1 (4%)
Residual Thermal Energy	0.013	0.57
Total	154	458

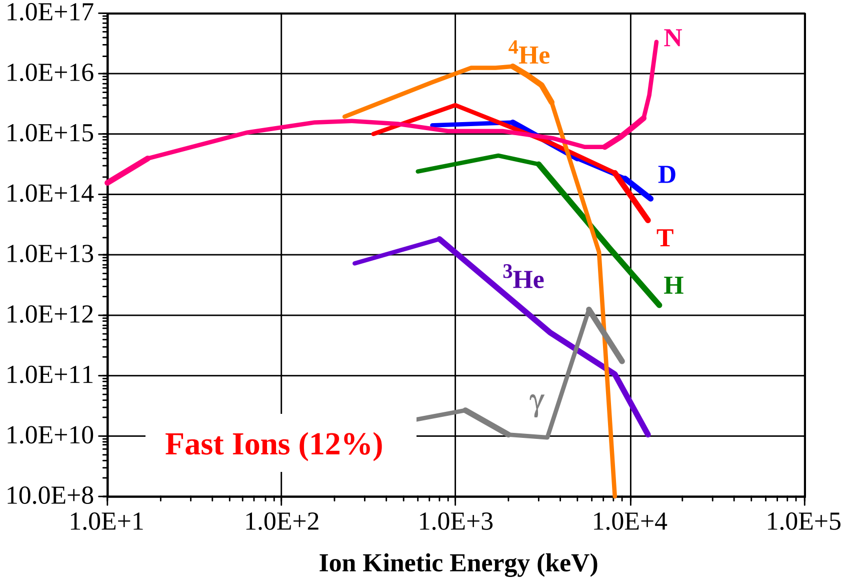
Photon Spectra for Example Direct Drive and Indirect Drive Targets



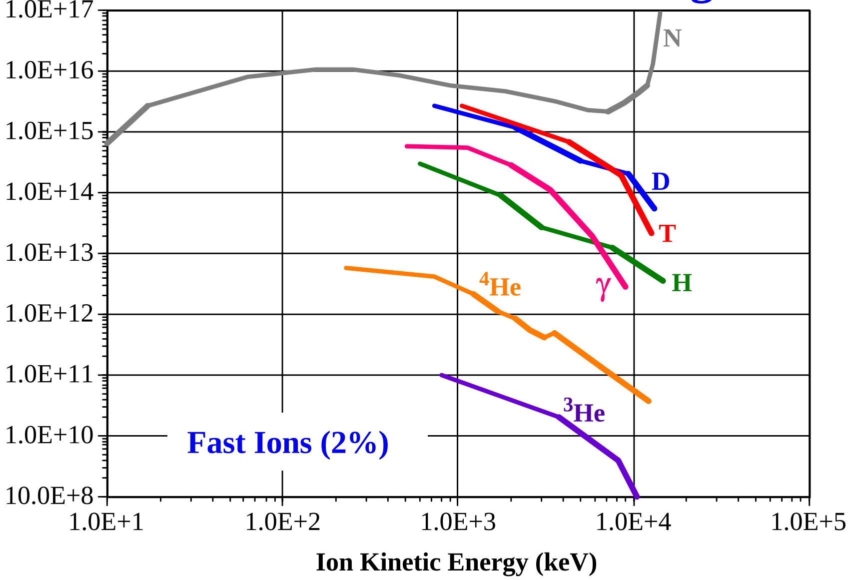
- Much higher X-ray energy for indirect drive target case (but with softer spectrum)
- More details on target spectra available on ARIES Web site: http://aries.ucsd.edu/ARIES/

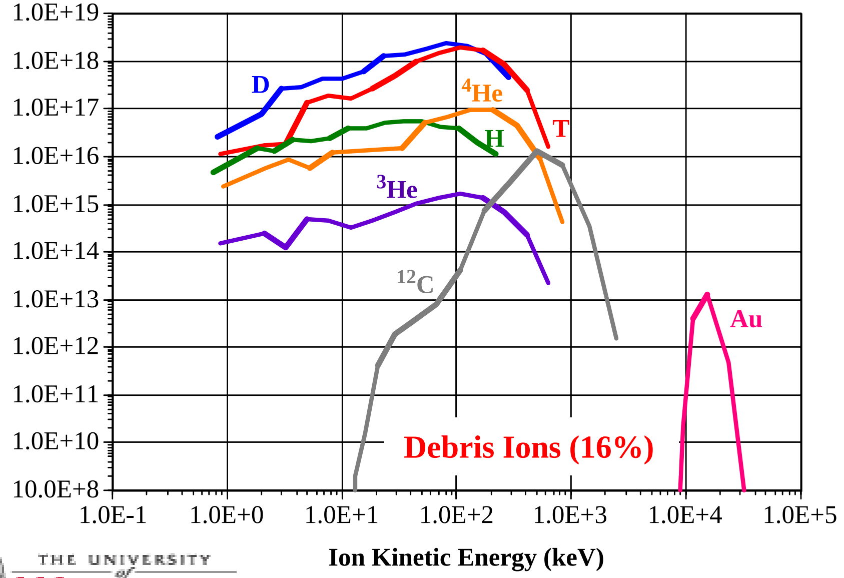
Example IFE Ion Spectra

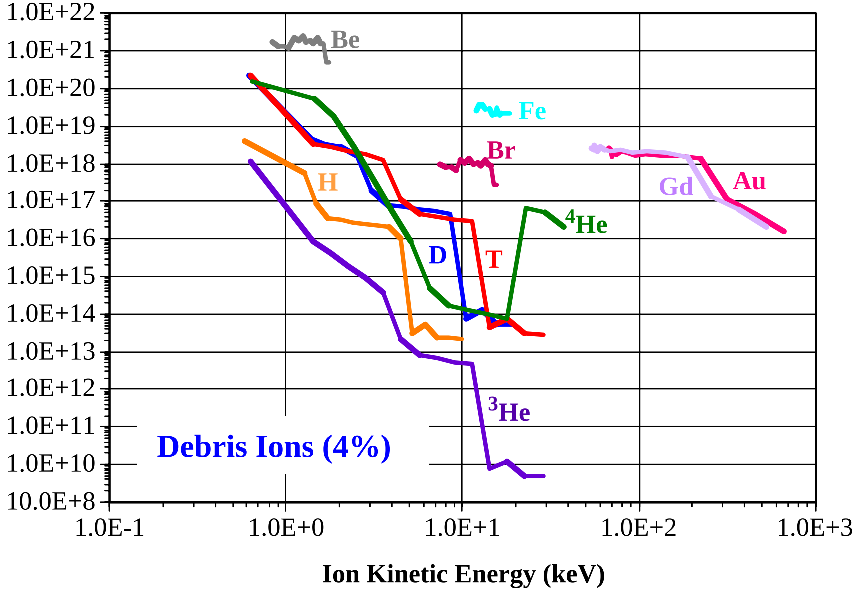
154 MJ NRL Direct Drive Target



458 MJ Indirect Drive Target







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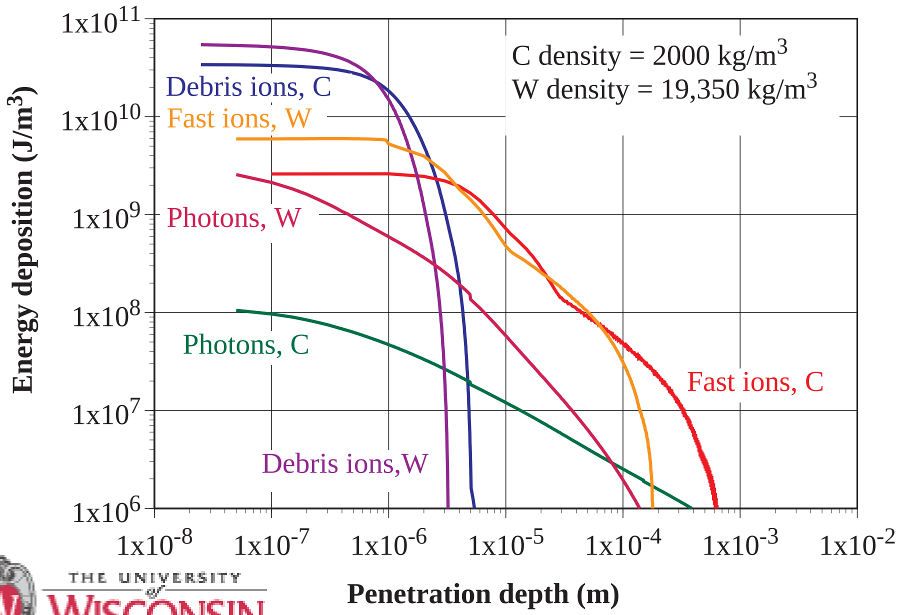
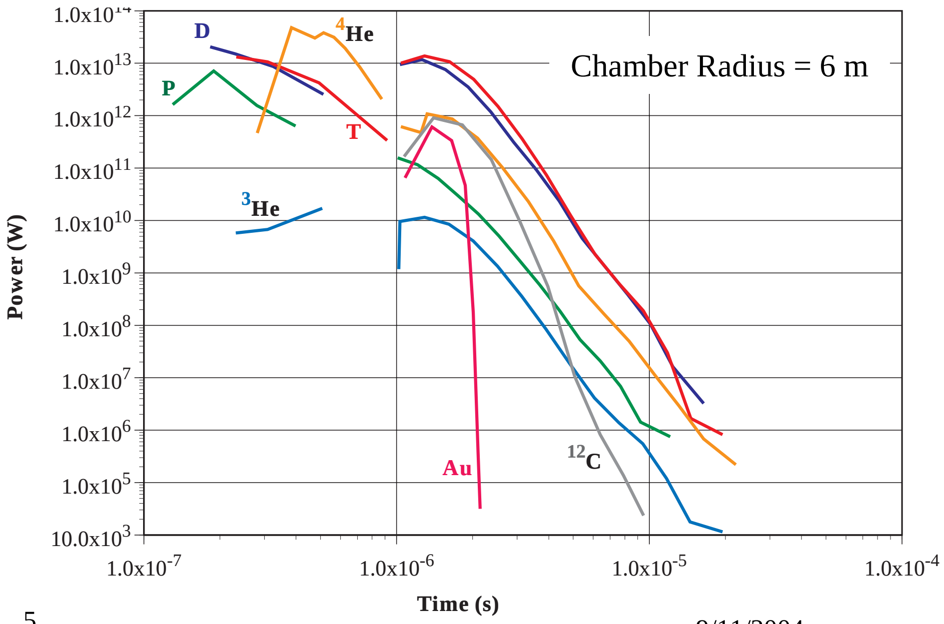
Characteristics of the Target Spectra Strongly Impact Chamber Wall Thermo-Mechanical Response

- **Penetration range in armor dependent on ion energy level**
  - **Debris ions (~20-400 kev) deposit most of their energies within μm's**
  - **Fast ions (~1-14 Mev) within 10's μm**
- **Important to consider time of flight effects (spreading energy deposition over time)**
  - **Photons in sub ns**
  - **Fast ions between ~0.2-0.8 μs**
  - **Debris ions between ~ 1-3 μs**
  - **Much lower maximum temperature than for instantaneous energy deposition case**

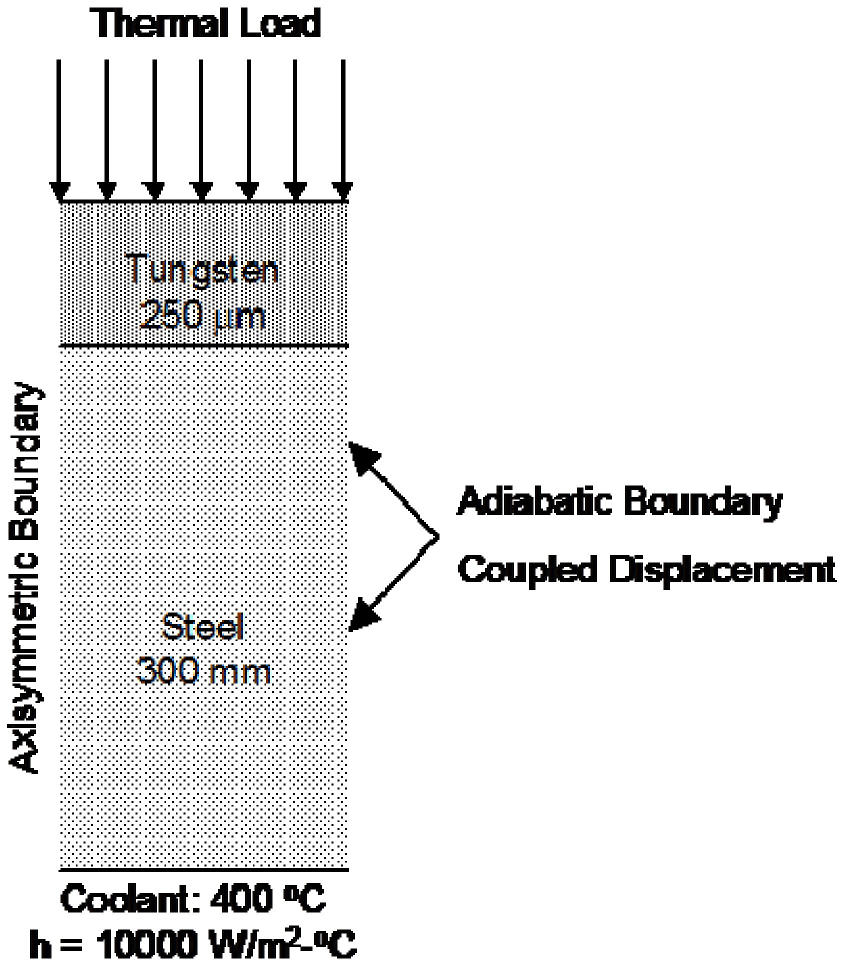
Energy Deposition as a Function of Penetration Depth for 154 MJ NRL DD Target



Ion Power Deposition as a Function of Time for 154 MJ NRL DD Target



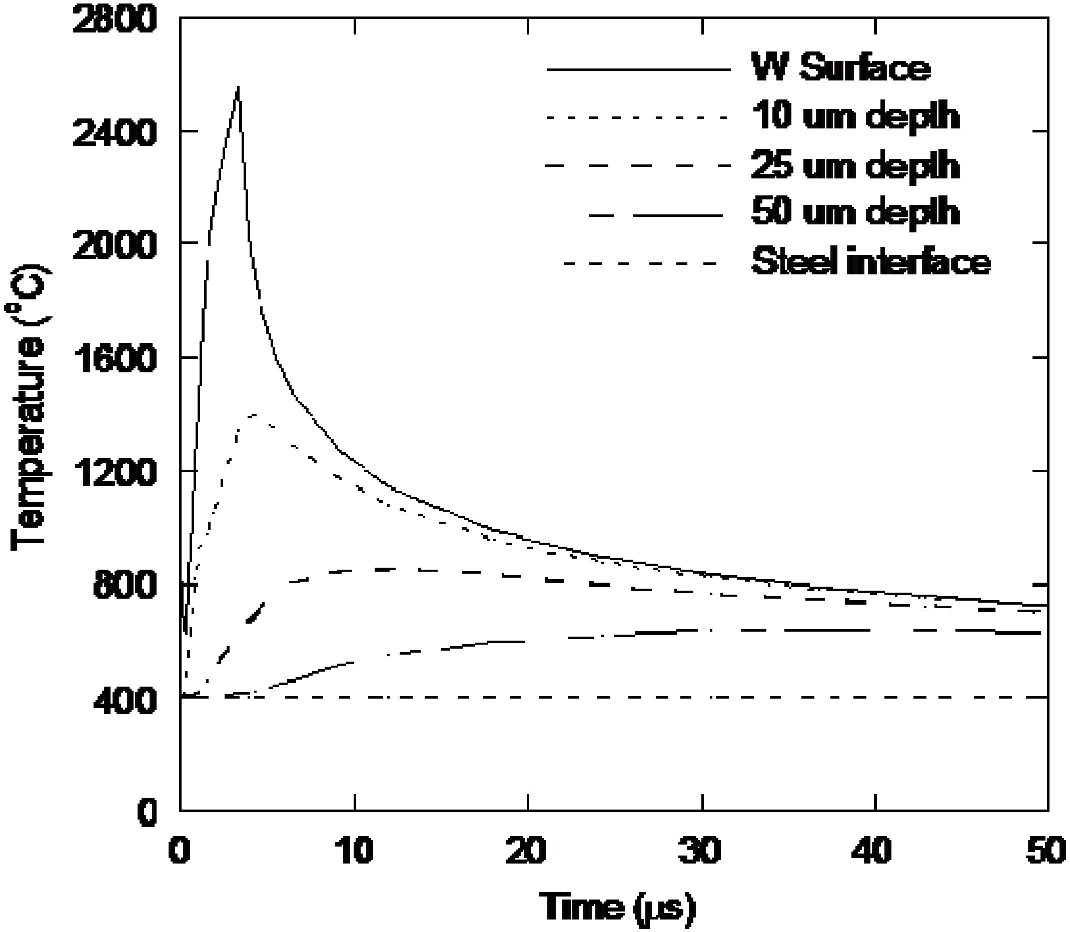
Model Layout



Why are Stresses Important?

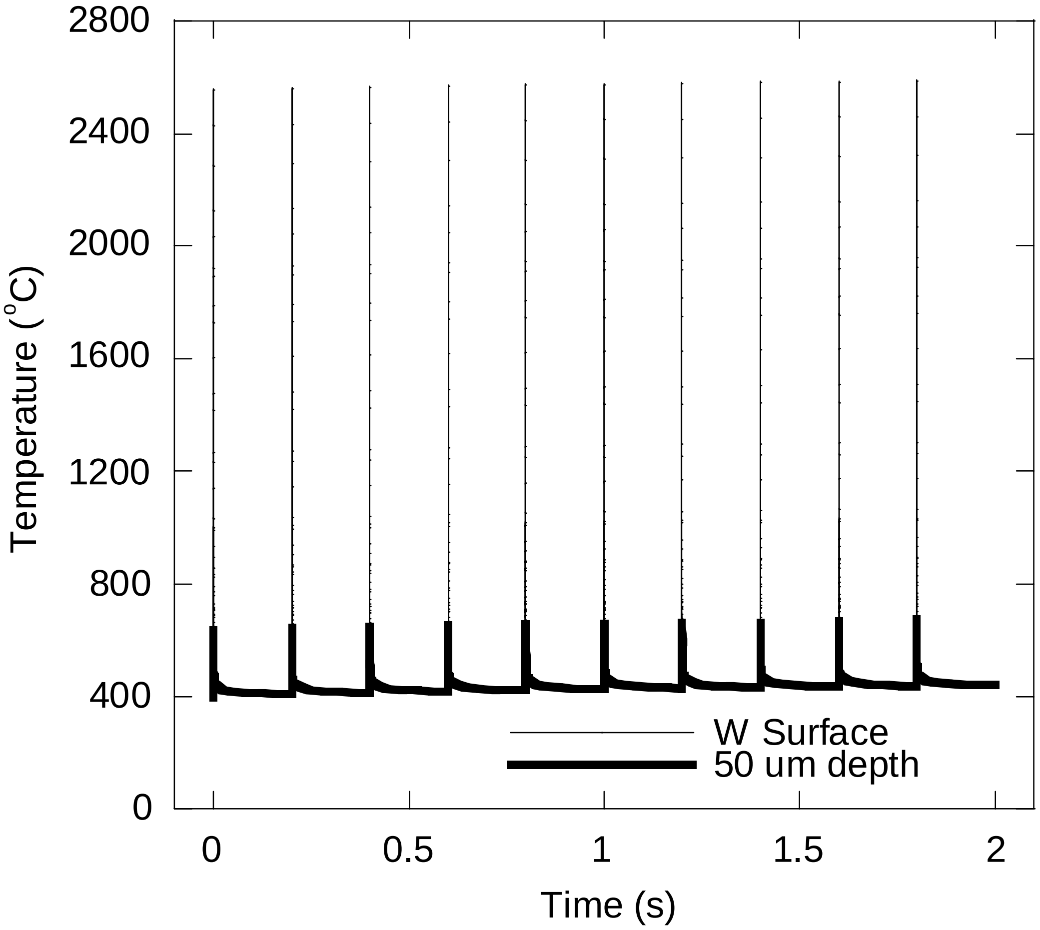
- Stresses contribute to:
  - **Yielding**
  - **Fracture/fatigue**
  - **Creep/swelling**
  - **Ratcheting**
  - **Roughening**
  - **Spalling**
- We must understand stresses to understand these phenomena

Temperature Histories - first cycle



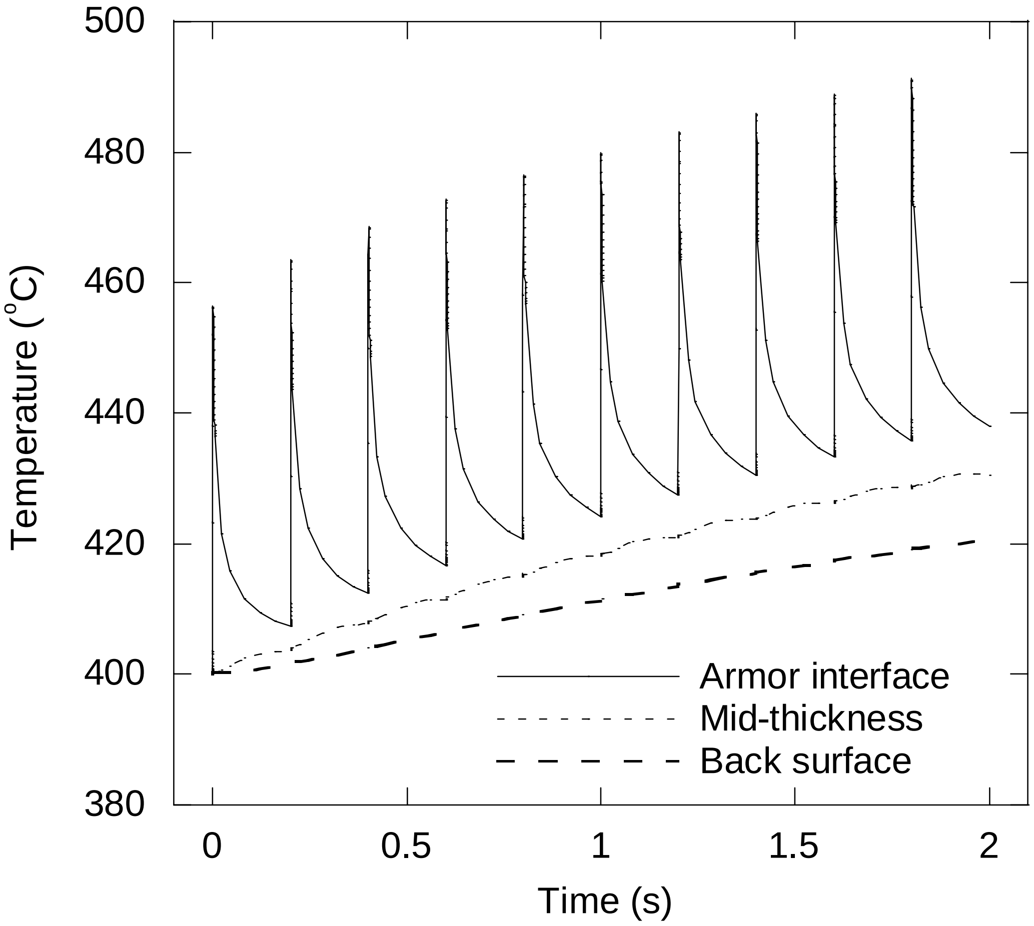
7 meter chamber
No gas
150 MJ target
250 microns tungsten

Temperature Histories – 10 cycles



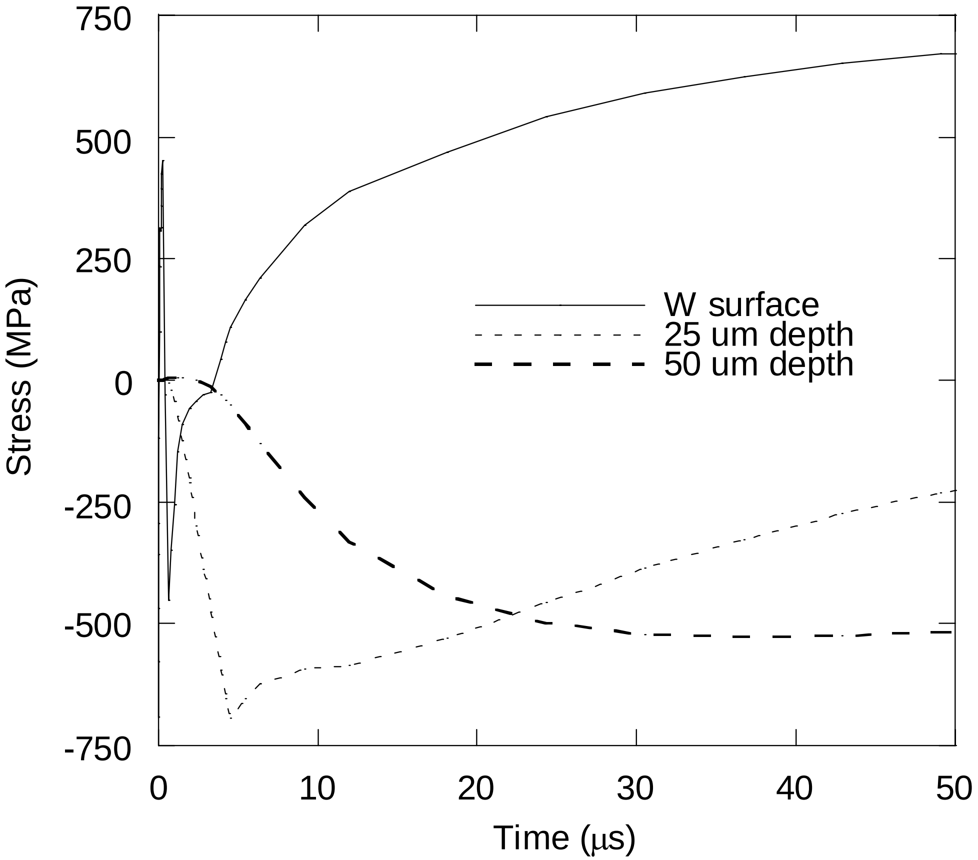
7 meter chamber
No gas
150 MJ target
250 microns tungsten

Temperature History at Surface of Steel



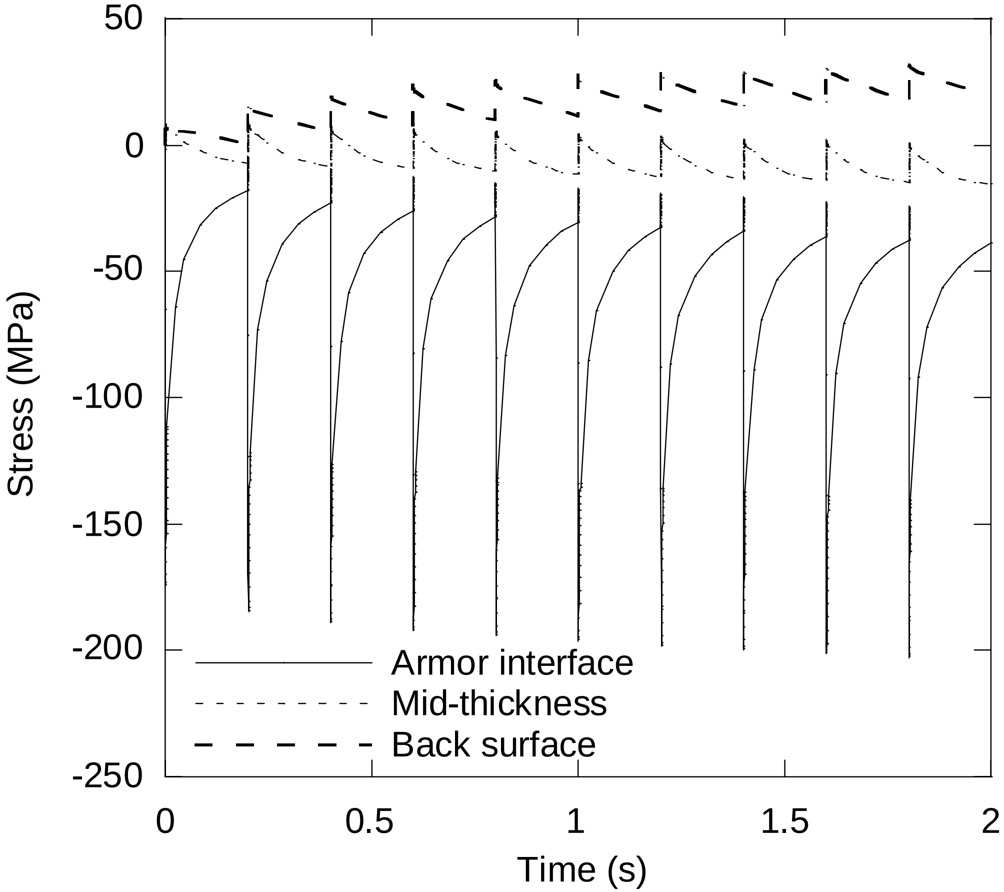
7 meter chamber
No gas
150 MJ target
250 microns W

Stress History in Tungsten



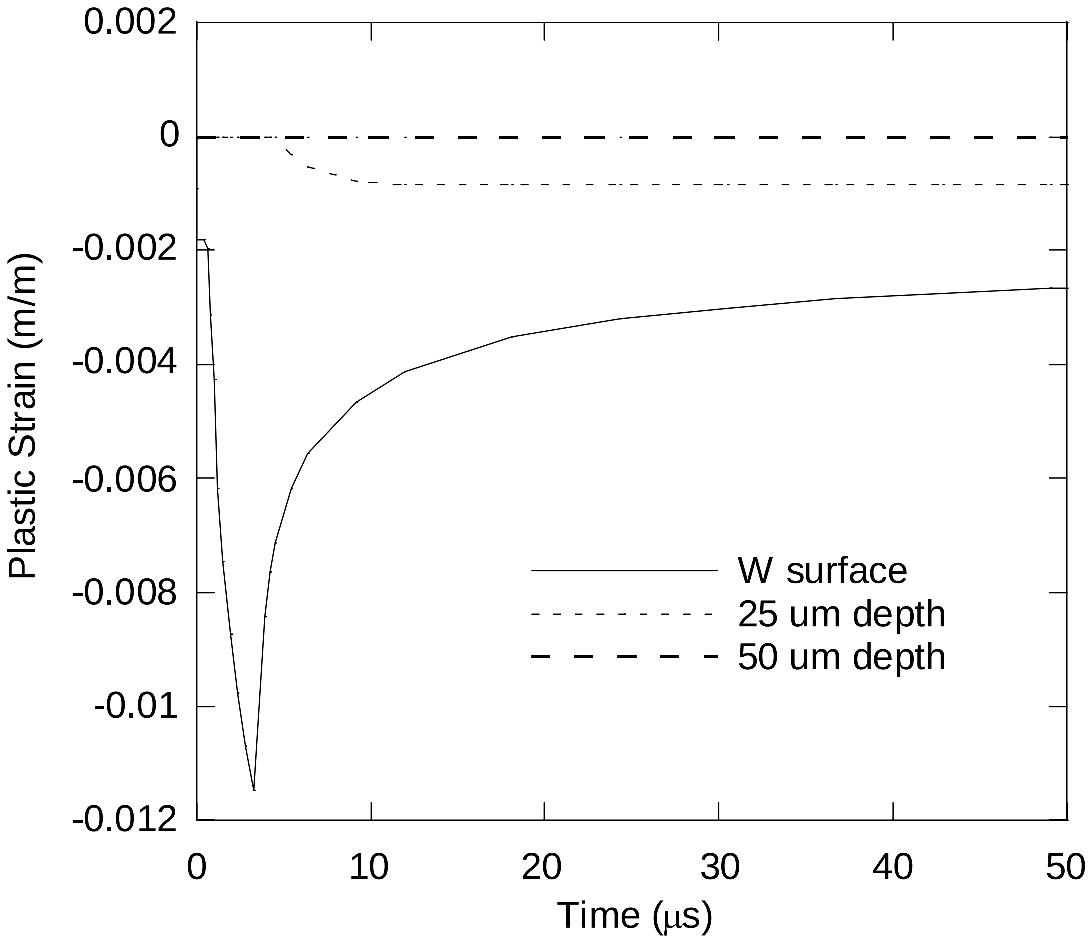
7 meter chamber
No gas
150 MJ target
250 microns tungsten

Stress History in Steel Wall



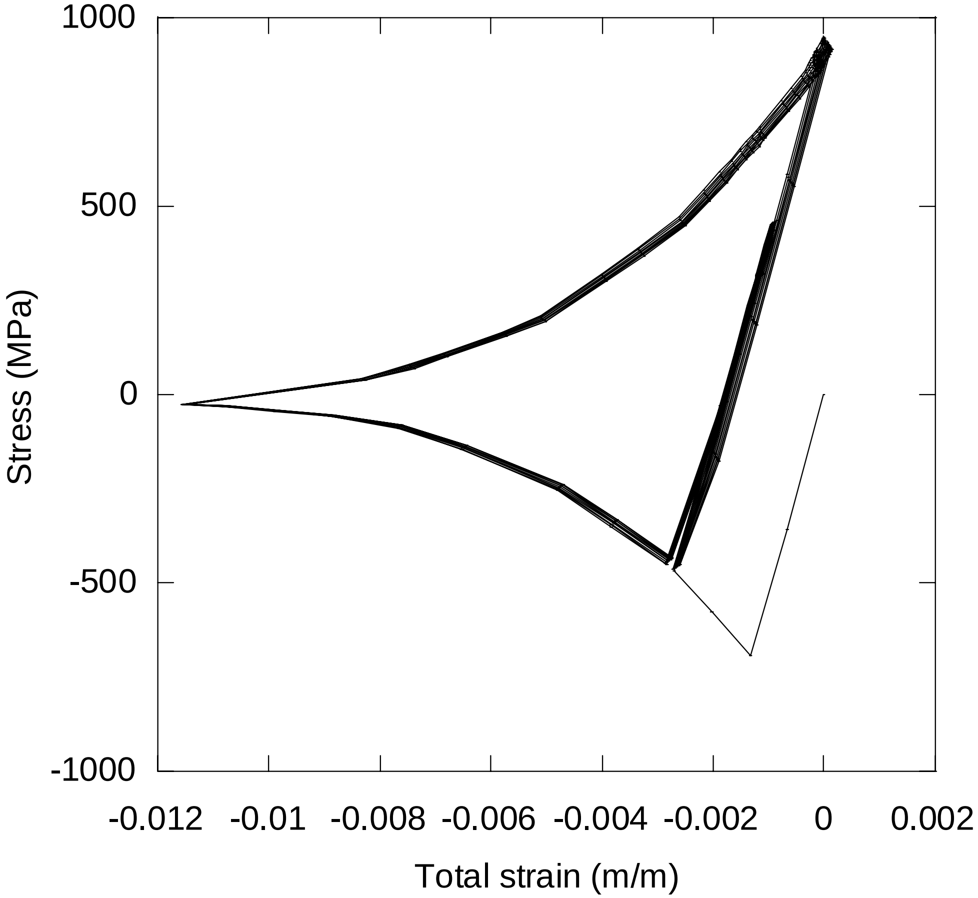
7 meter chamber
No gas
150 MJ target
250 microns tungsten

Strain History



7 meter chamber
No gas
150 MJ target
250 microns tungsten

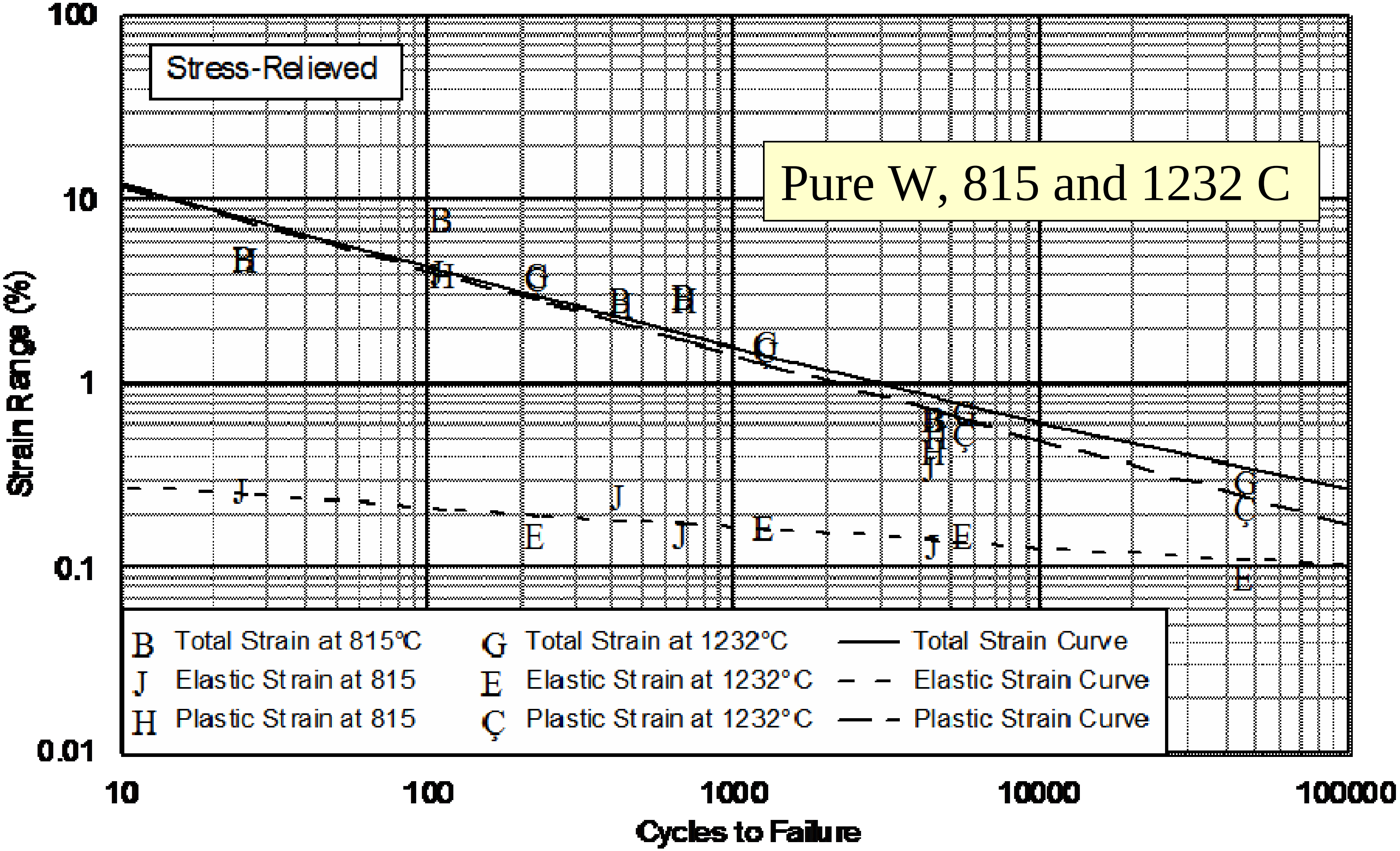
Stress-Strain Behavior at W Surface
10 Cycles



7 meter chamber
No gas
150 MJ target

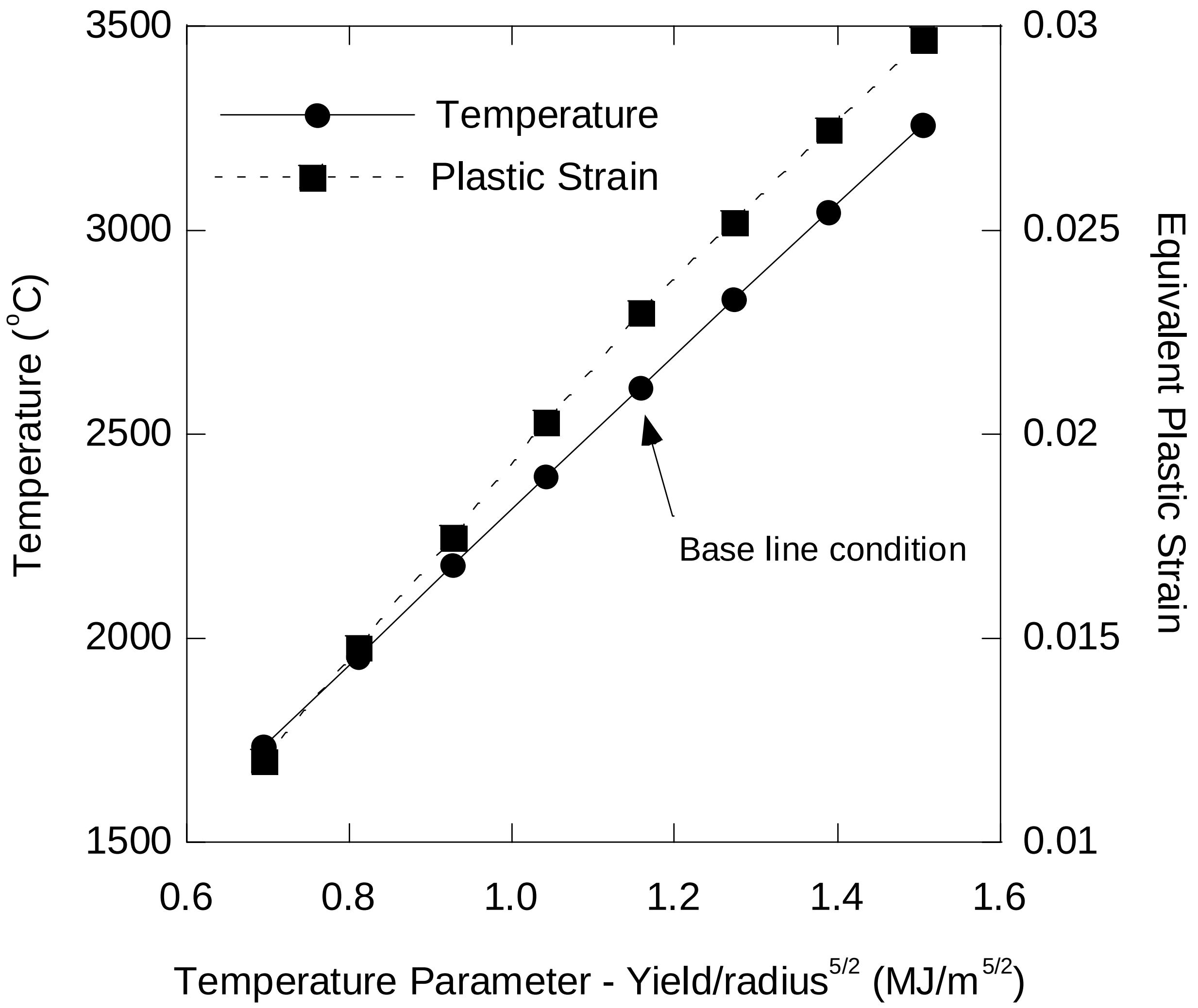
Fatigue Data for Stress-Relieved Tungsten

Cracking is expected in hundreds to thousands of cycles

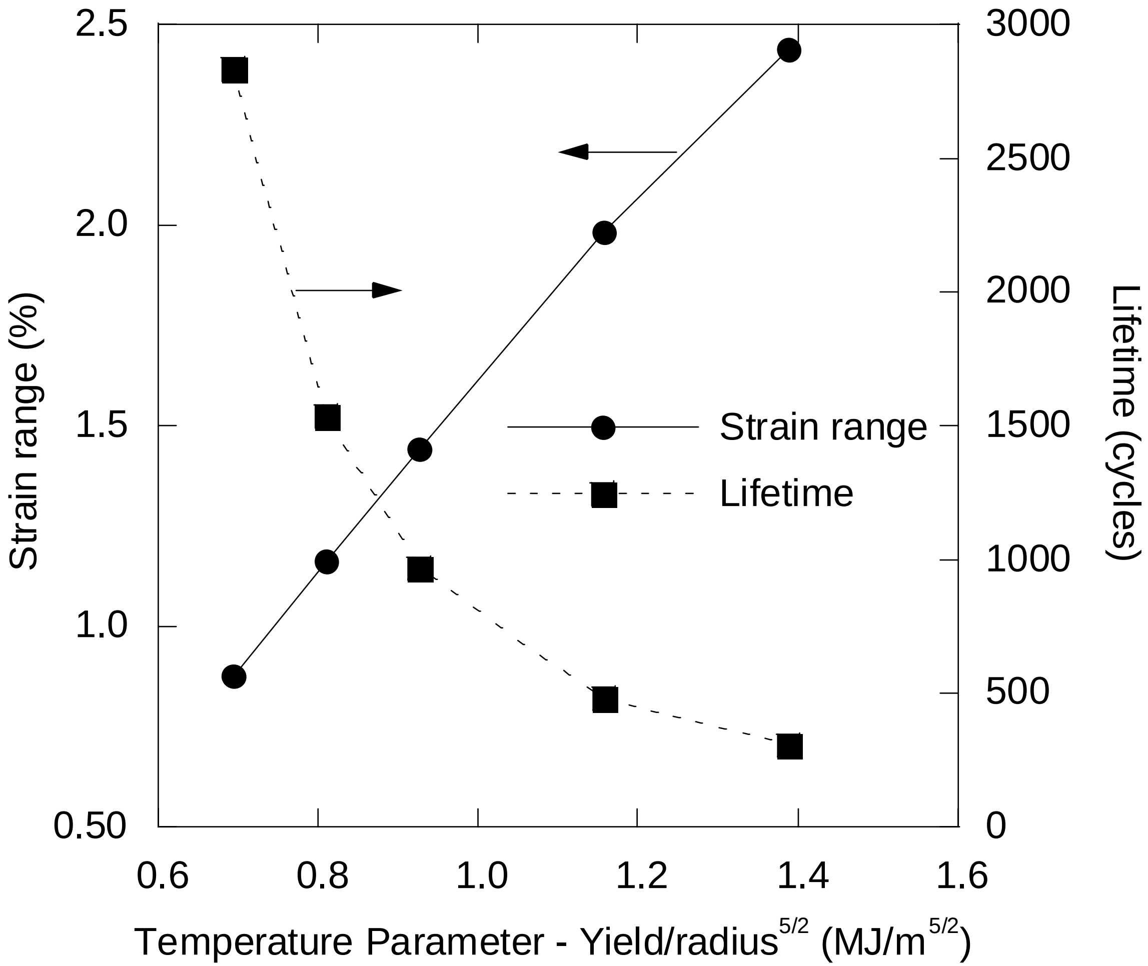


Pure W, 815 and 1232 C

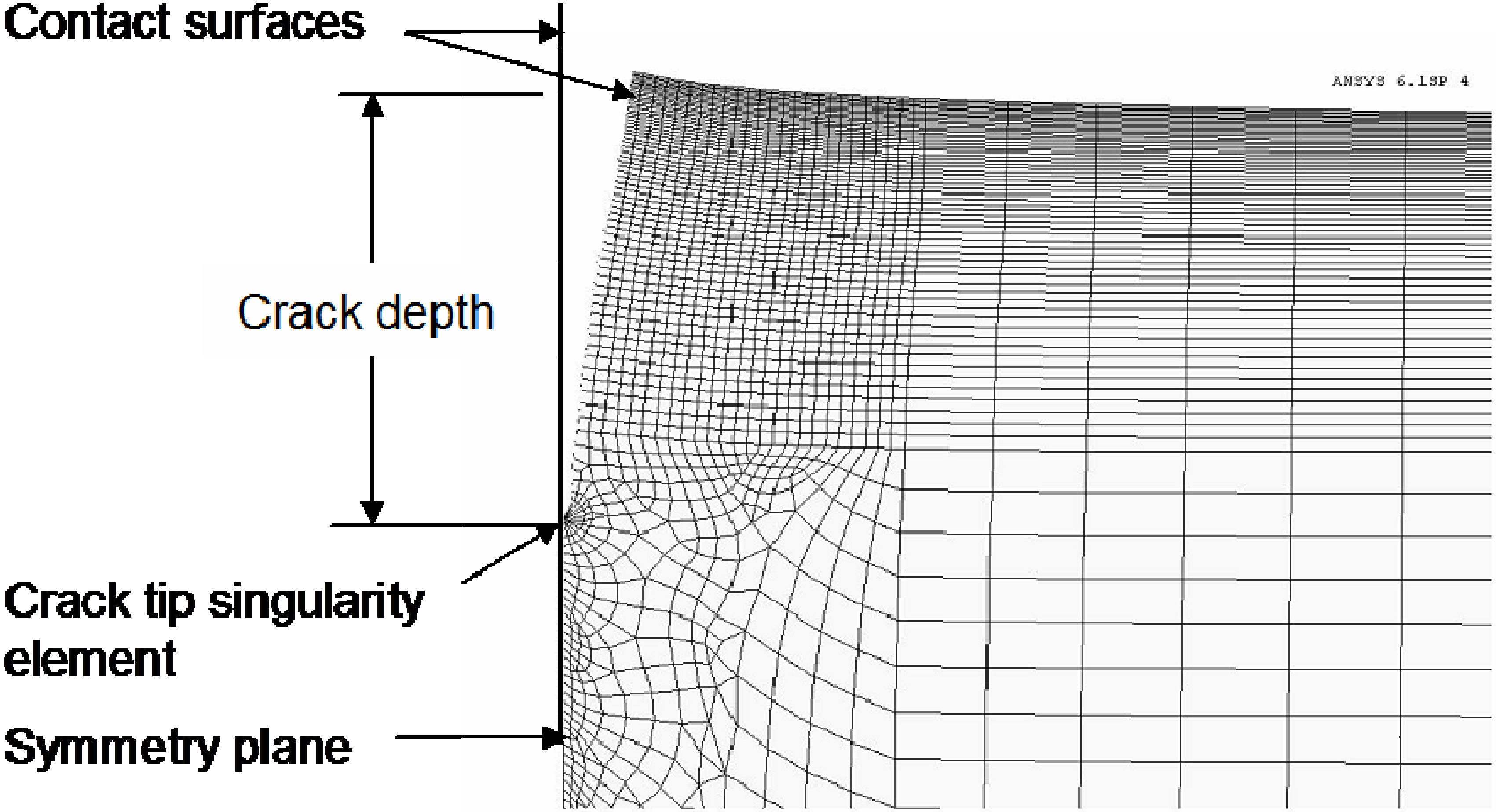
Scaling of Temperatures and Stresses



Scaling of Strains and Fatigue Initiation Life

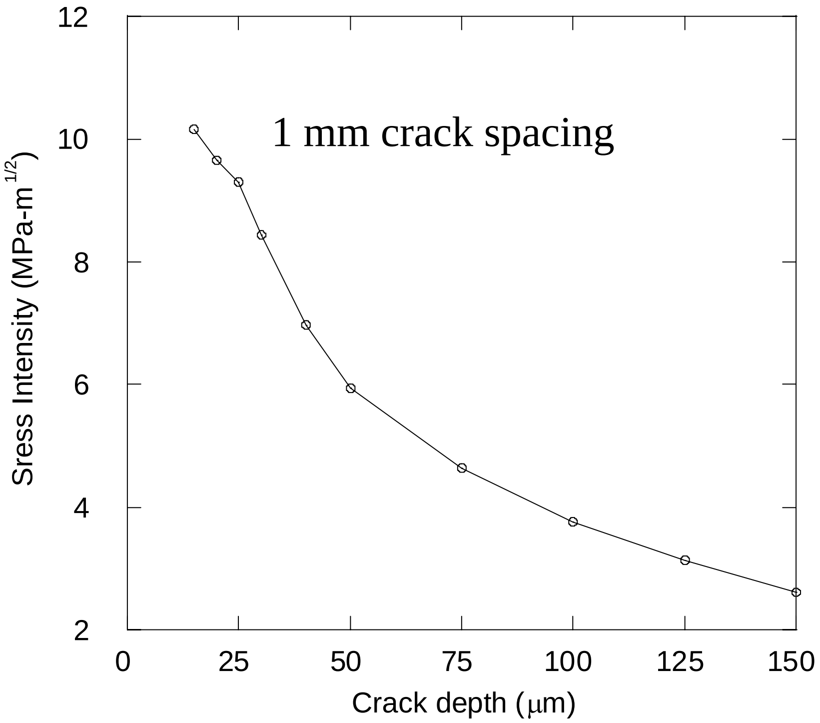


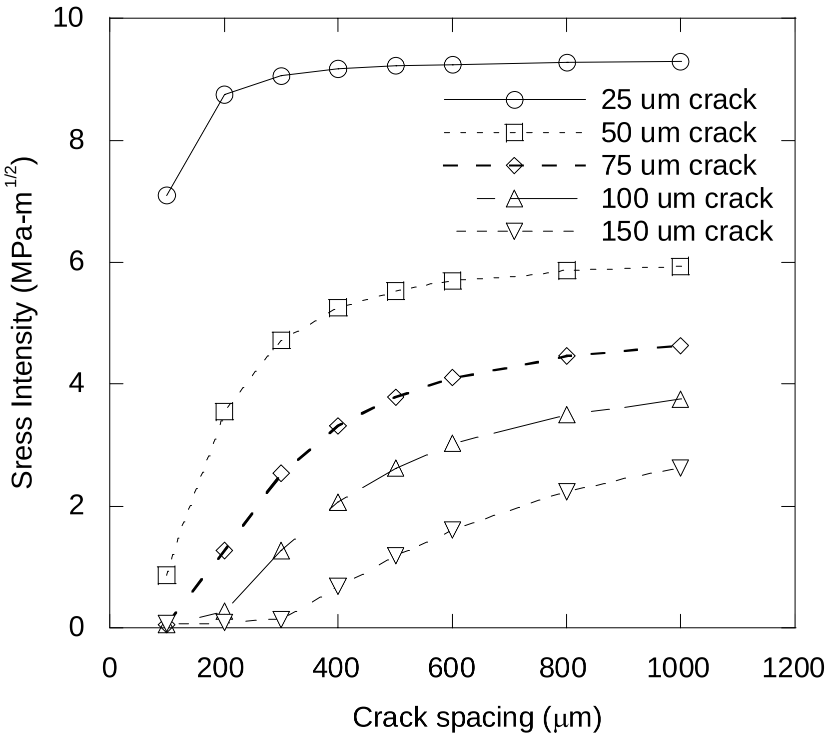
Fracture Model



Fracture Mechanics Analysis Results

250 microns W
7 m Chamber
150 MJ Target

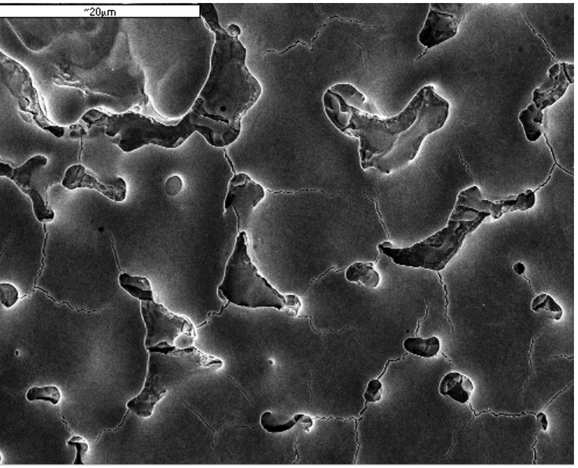




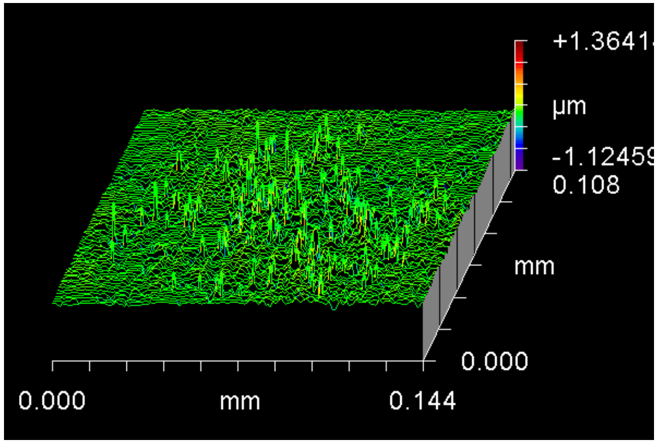
Validation Tests

- To validate modeling, several tests are under way
  - **Ions at SNLA**
  - **X-Rays at LLNL (XAPPER) and SNLA (Z-Machine)**
  - **Lasers at UCSD**
  - **Infrared at ORNL**
  - **[IEC experiments to study He Effects]**
- First three tests are shorter pulse times and higher intensity
- Infrared is longer pulse (excellent model for interface stresses)

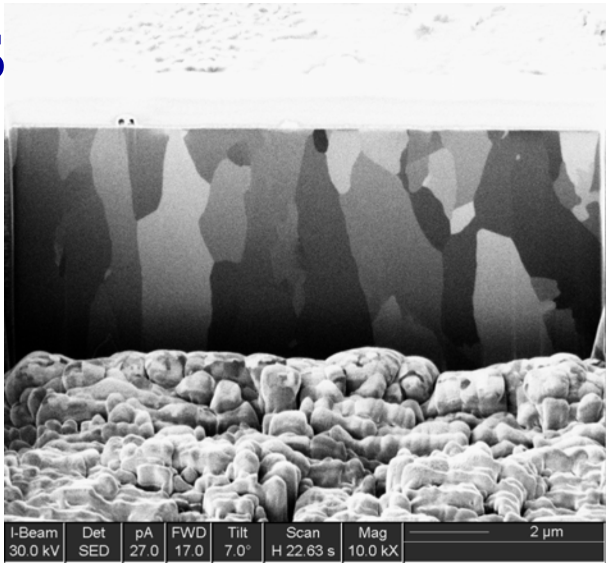
Validation Tests



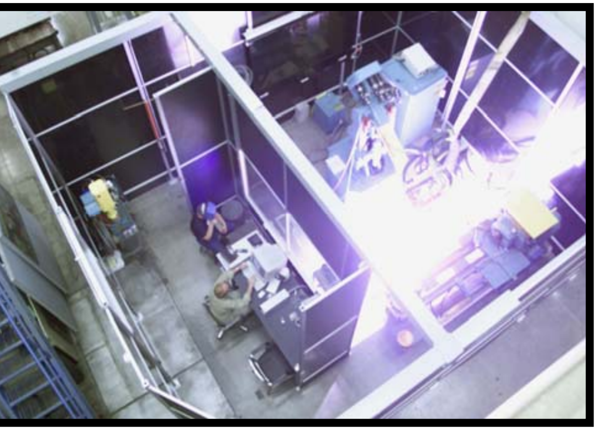
RHEPP – Renk – Oral Thu



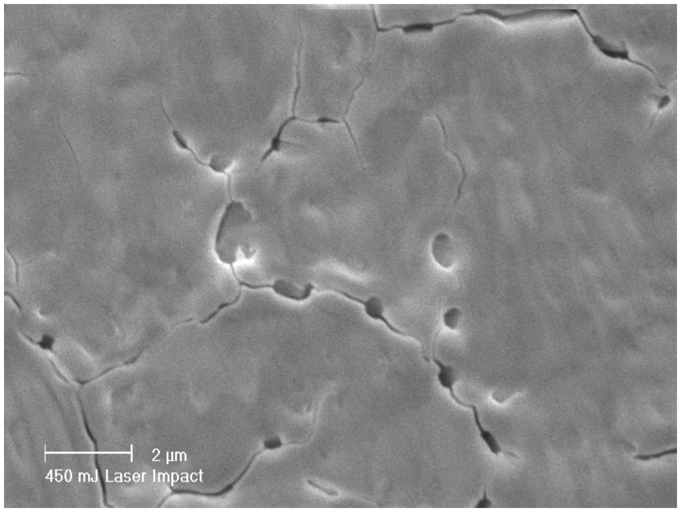
XAPPER – Latkowski – poster Wed



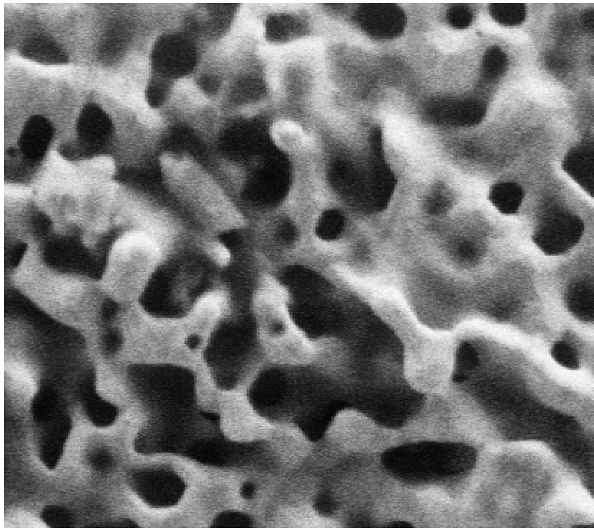
Z Machine - Tanaka



Infrared Snead – Oral Thu



Laser - Najmabadi



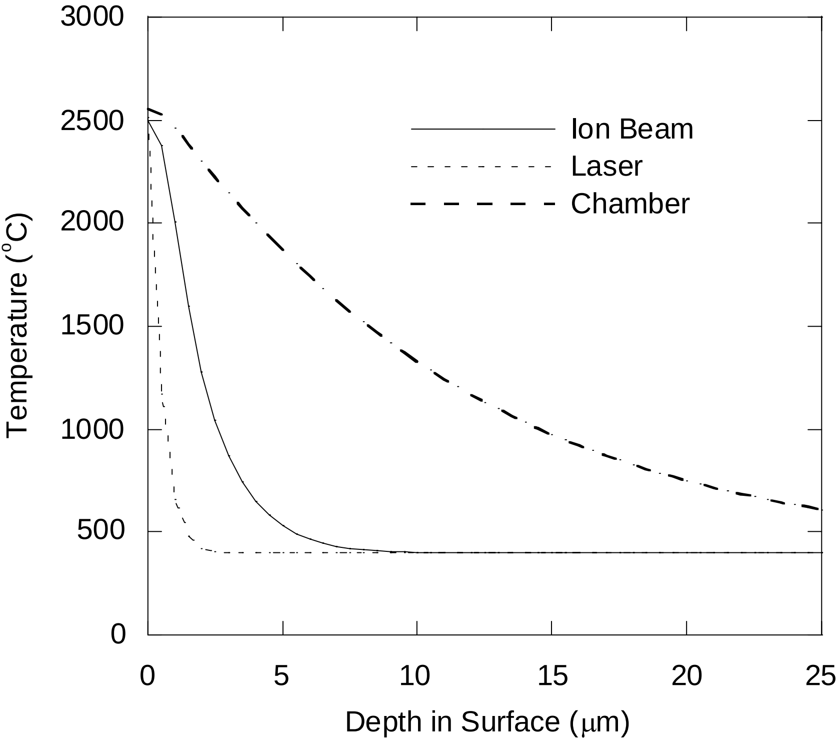
IEC – Cipiti - poster Wed

Test Parameters

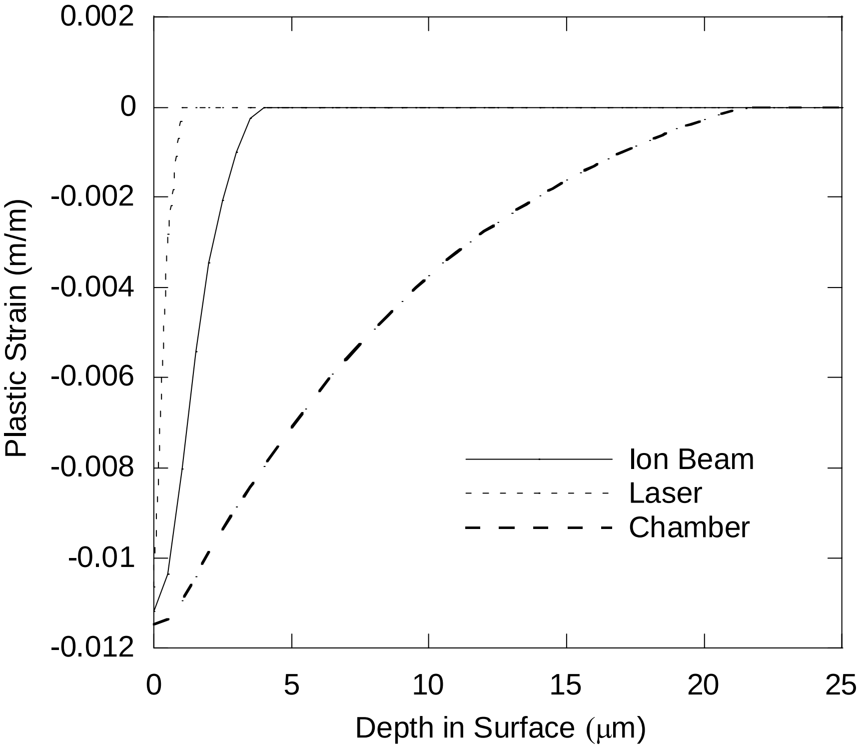
Type	Energy (keV)	Maximum Fluence per Pulse (J/cm^2)	Depth of Energy Deposition (microns)	Flat Top Pulse Width (ns)
Ion Beam	750	7	1-10	100
Pulsed Z-Pinch (X-Rays)	0.8-1.2	3000	1-2	6
Single Shot Z-Pinch (X-Rays)	0.1-0.4	7	1-2	30-50 (FWHM)
Laser		0.7	0	8

Representative Temperature and Strain Comparisons

Temperature

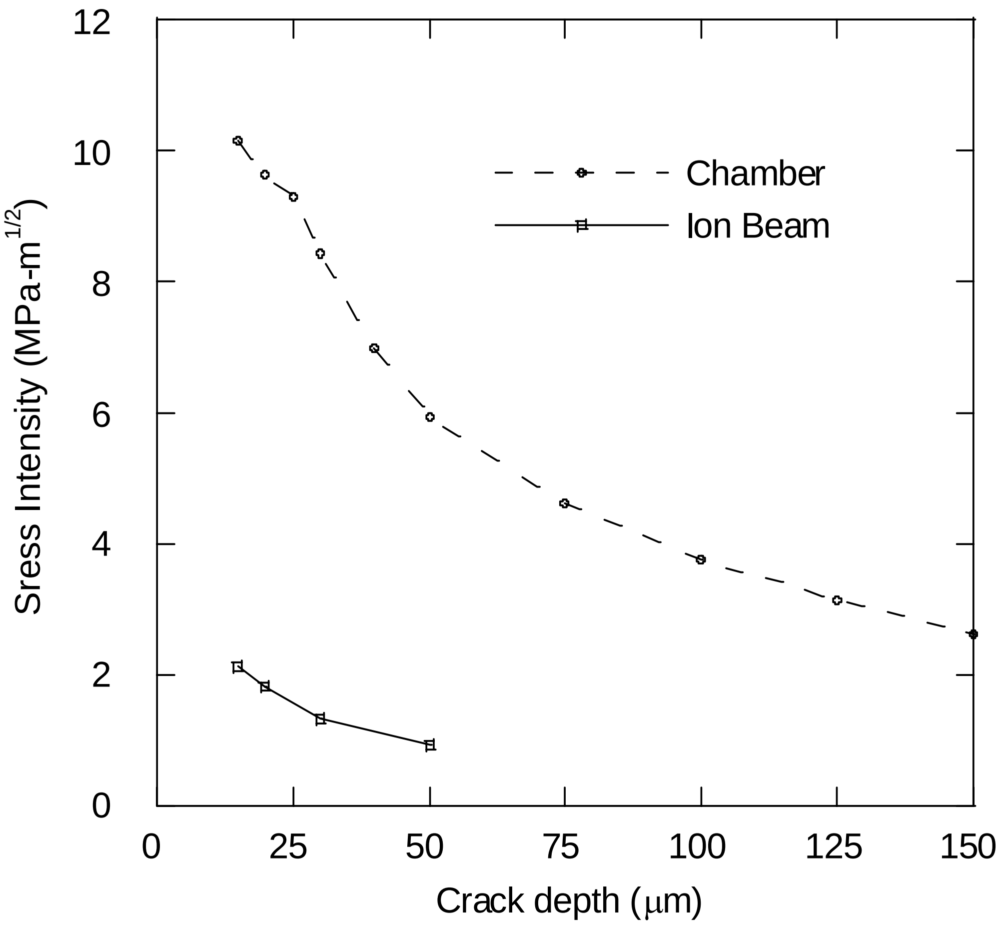


Strain



End of Pulse

Fracture



- Tests are not conservative from fracture point of view
- Cracks will stop at a more shallow position
- Simulations should allow us to correlate growth rates and make conclusions relevant to chamber

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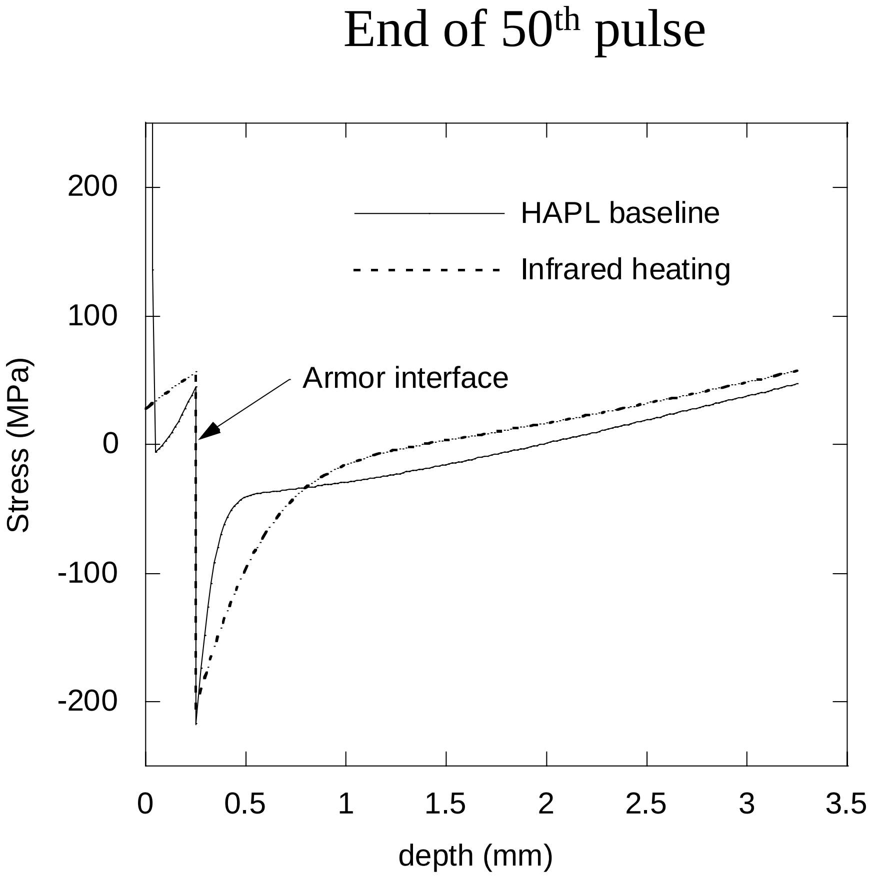
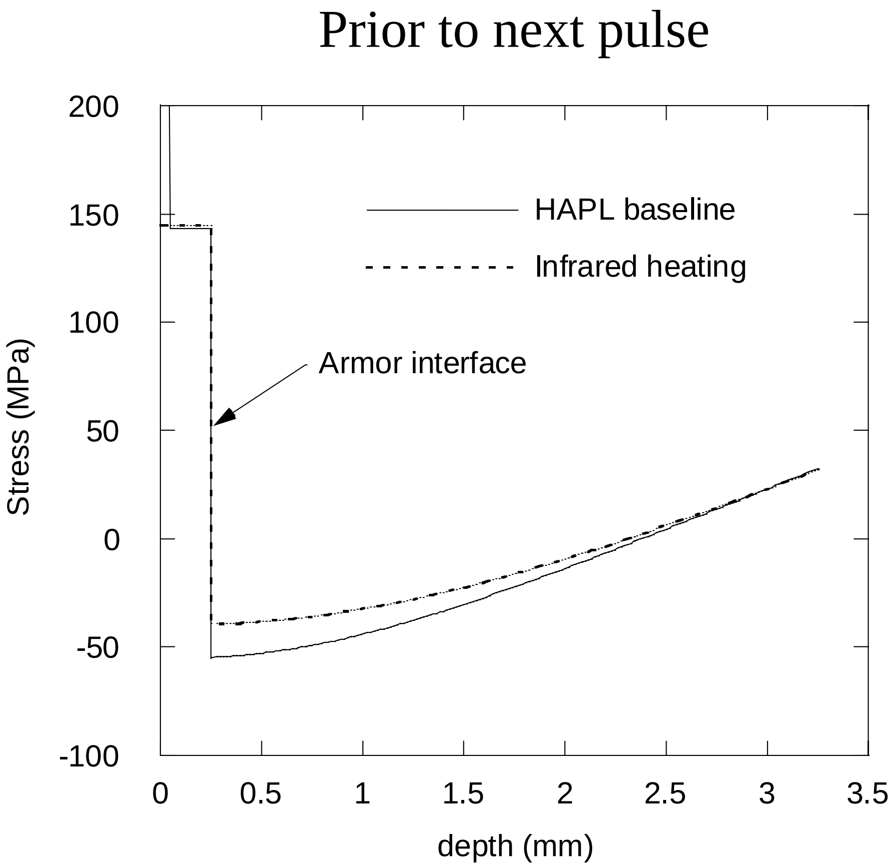
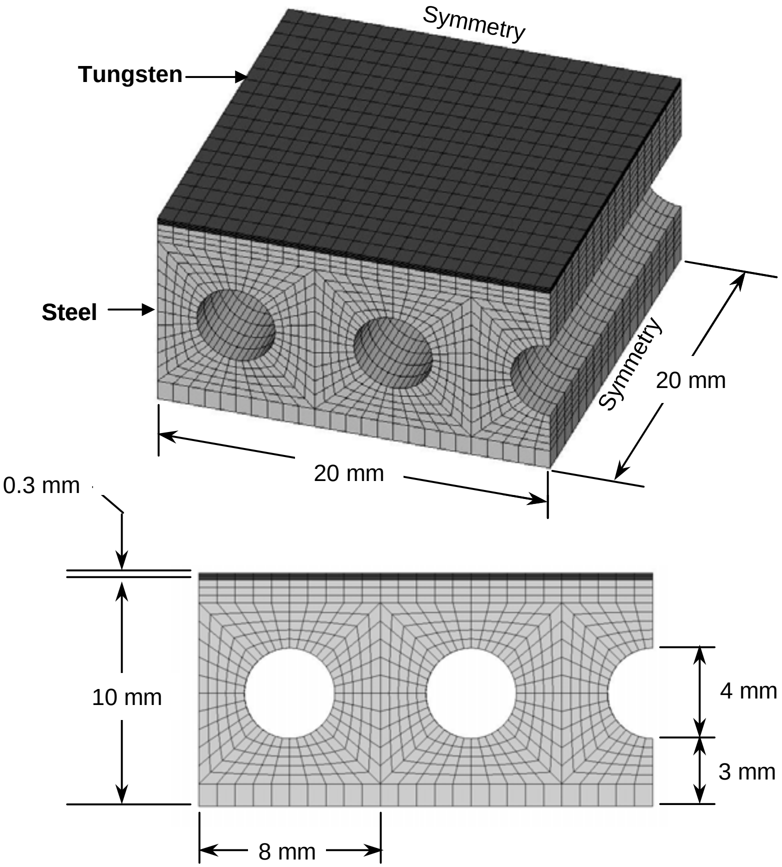
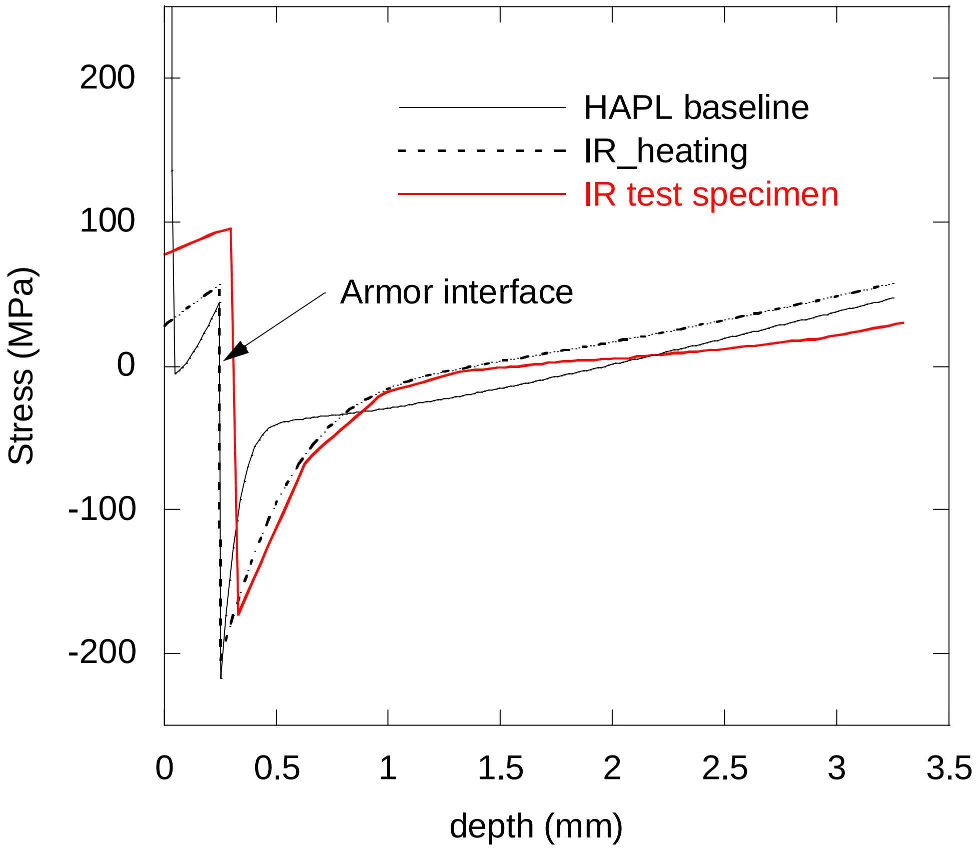
Infrared Testing



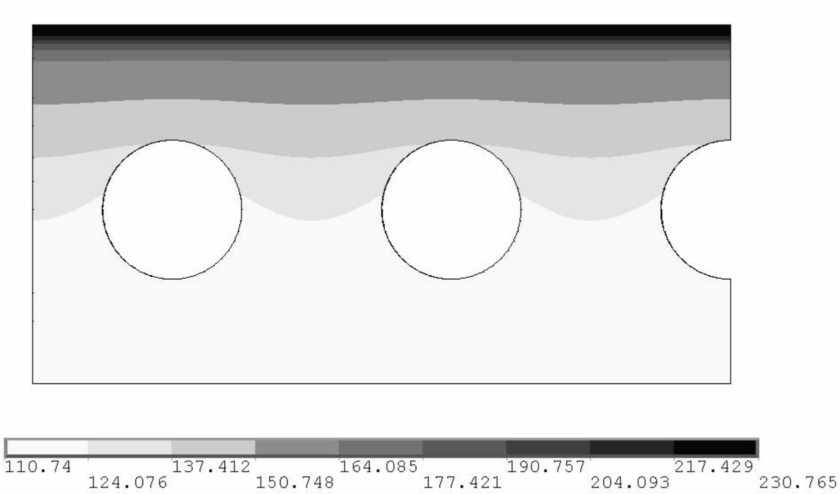


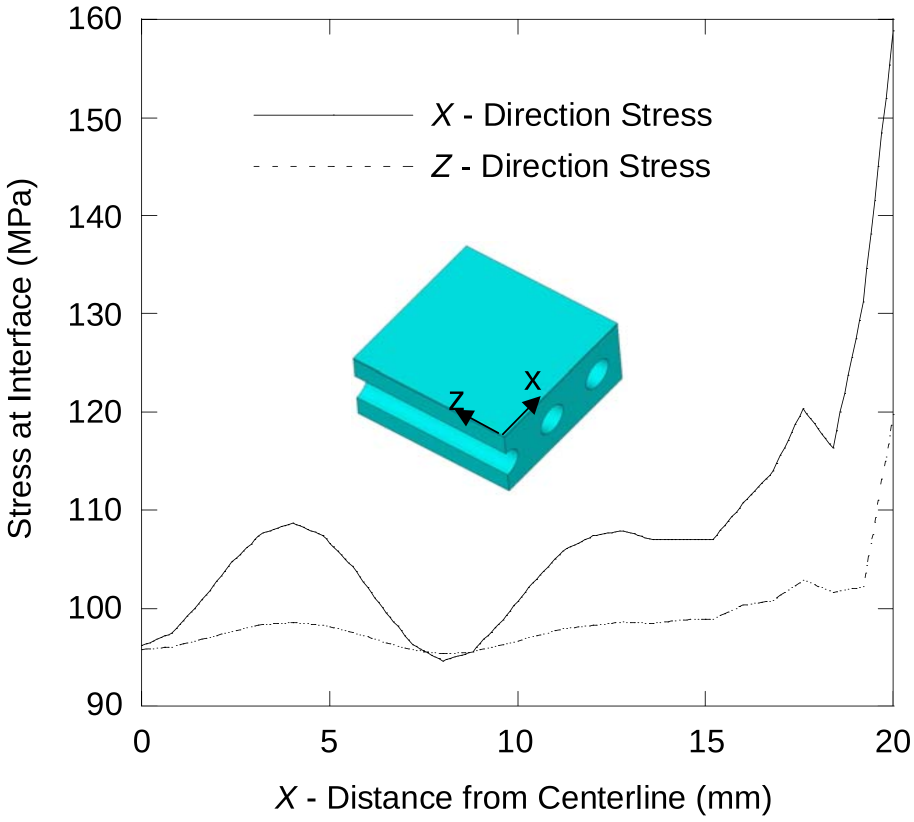
Cooled Samples





Cooled Samples (continued)





Conclusions

- The primary design for the HAPL chamber wall is tungsten-coated steel
- Modeling indicates surface cracking is expected, but that arrest is likely
- Testing is underway to investigate this
- Modeling indicates tests are good models for surface phenomena, but not for fracture
- Modeling will allow test data to support lifetime prediction for the HAPL wall