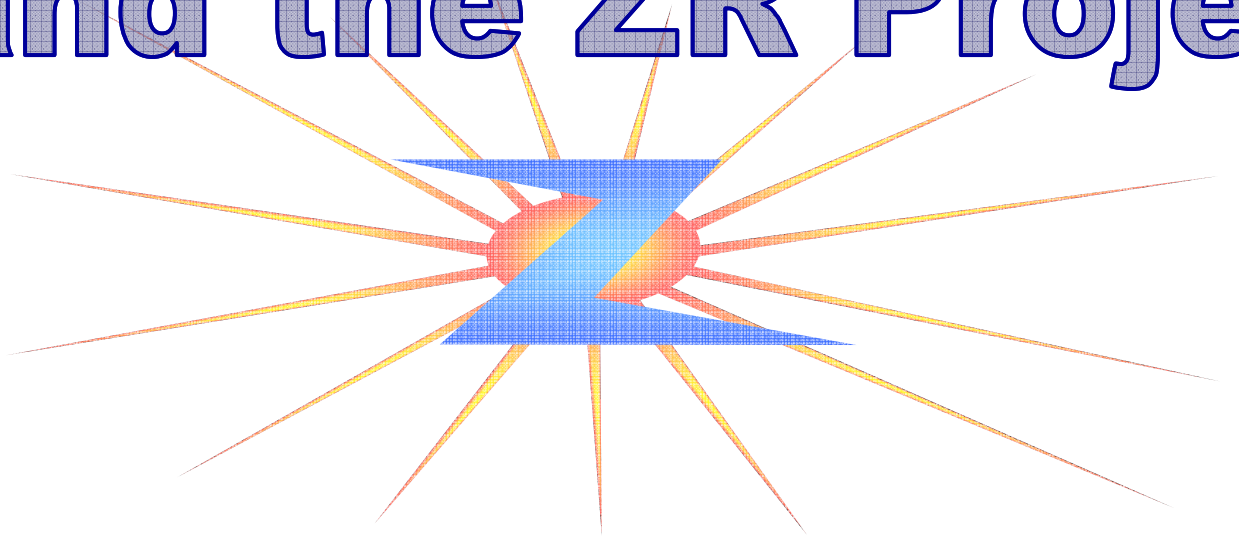
SAND2008-1312P

Powered up: Z and the ZR Project



Sandia Technology Symposium Presentation

March 3, 2008

Ed Weinbrecht representing the Pulsed Power Sciences Center

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under contract DE-AC04-94AL85000.

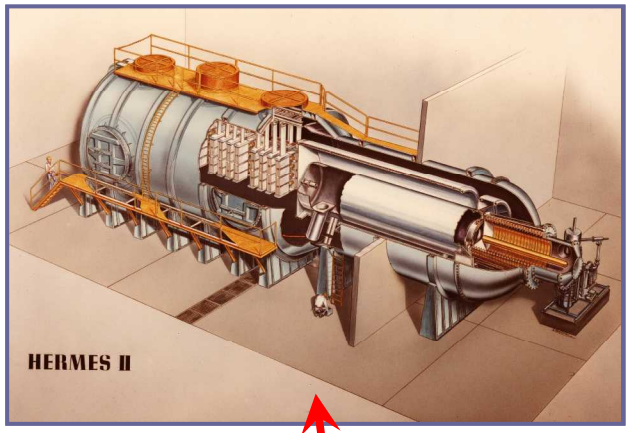
Sandia National Laboratories

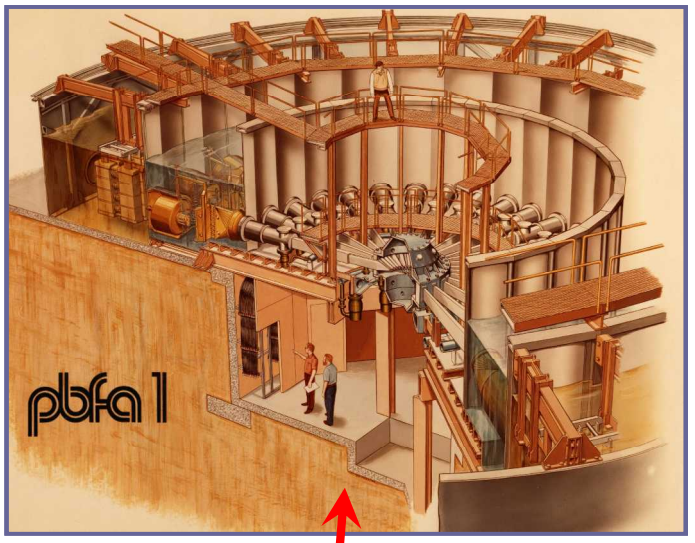
“Readers Digest” Overview of Z

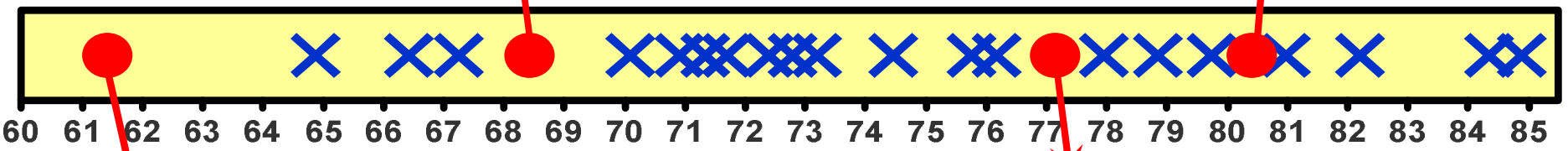
- Short history of Z
- How Z works and what we do with it
- Refurbishing Z -- challenges and successes
- A fusion future

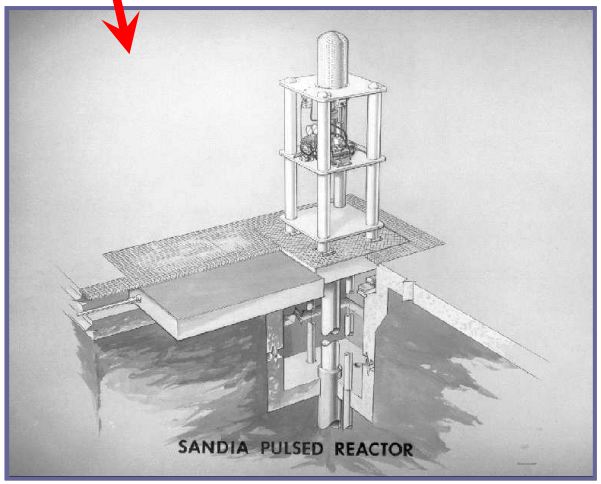
History

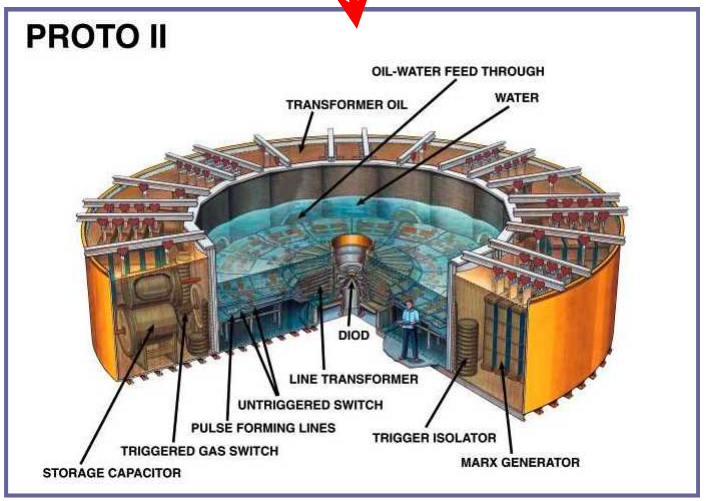
Z: Steeped in History



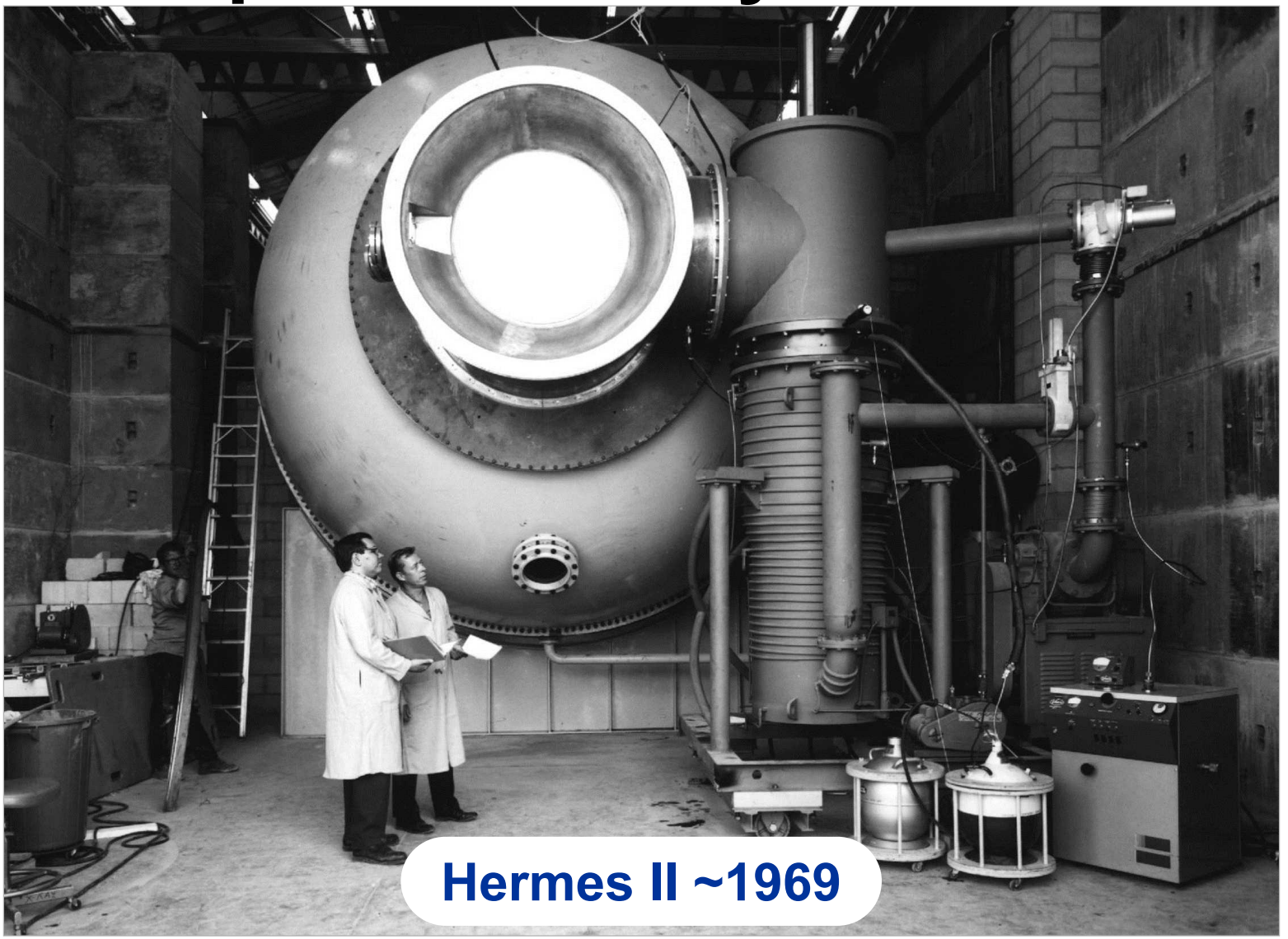




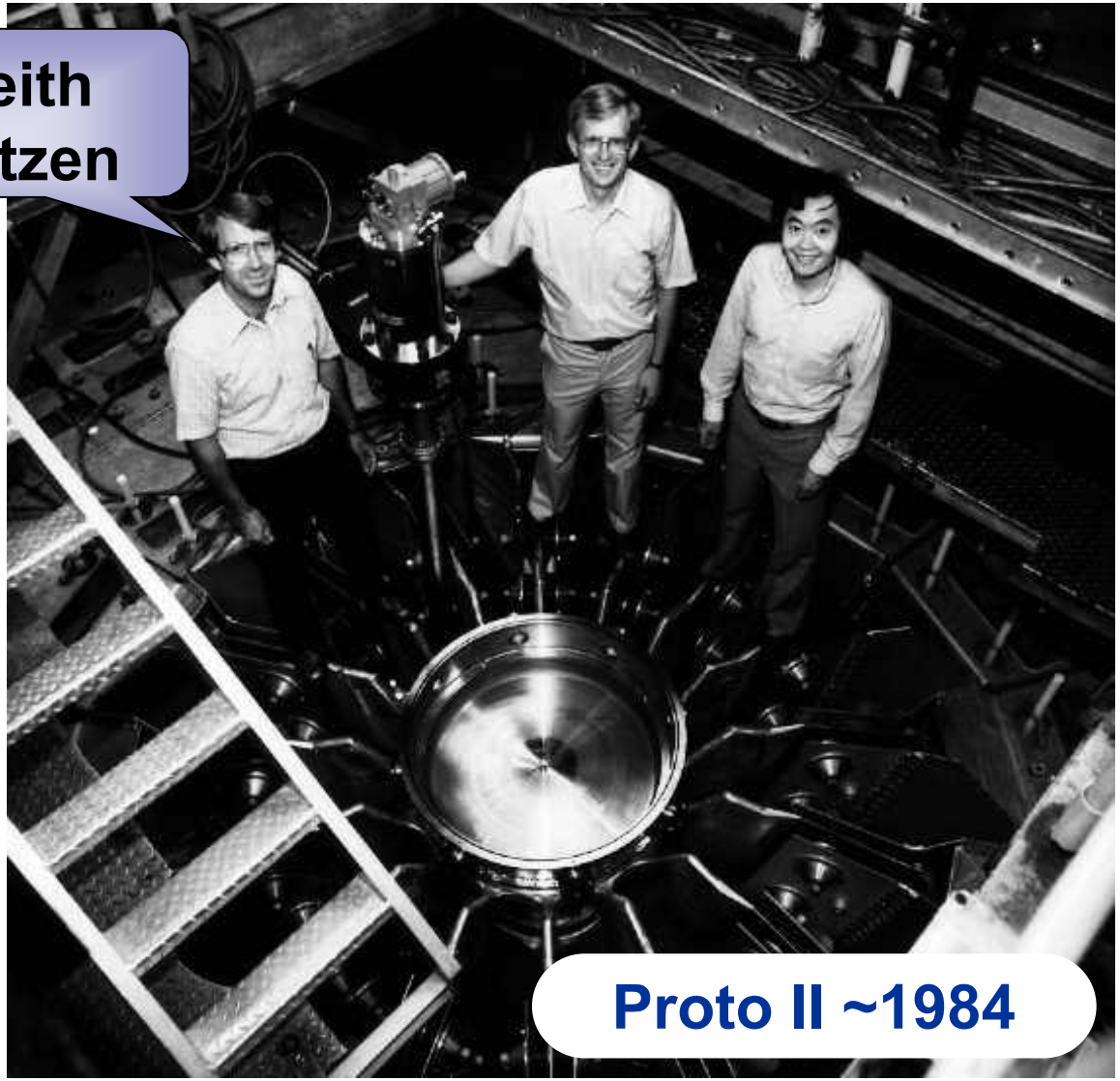




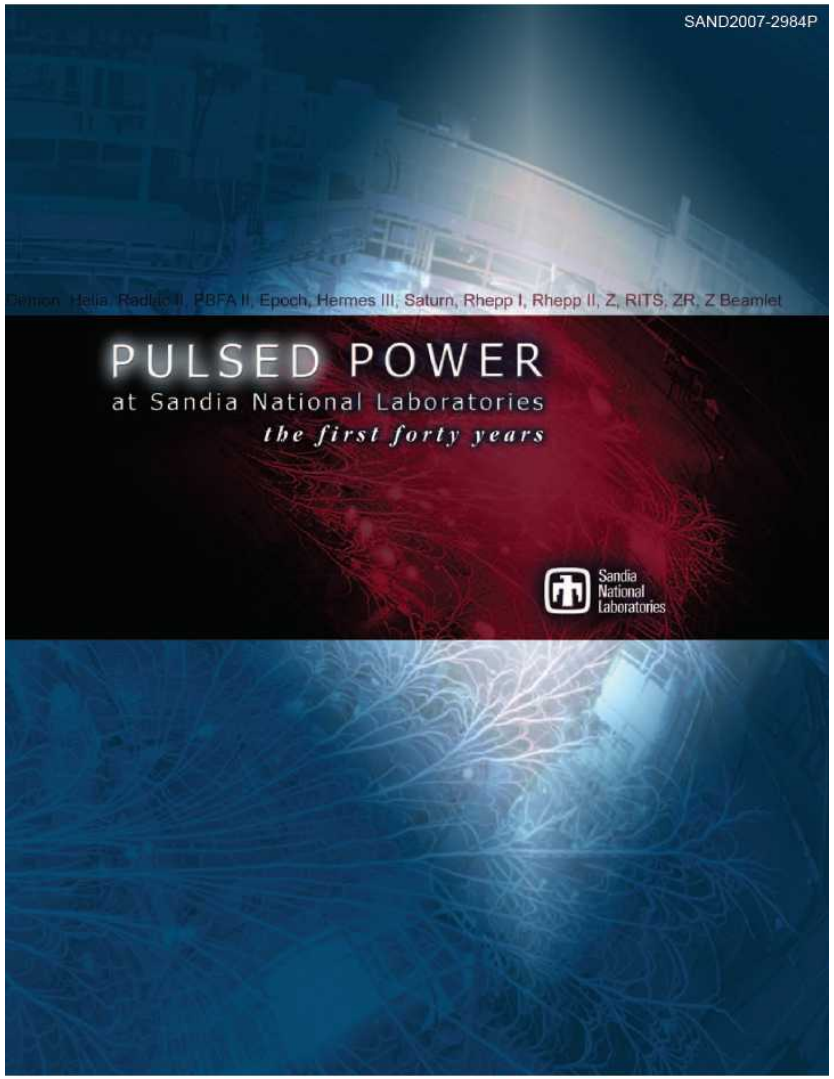
Z: Steeped in History



Z: Steeped in History



Wonderful History Resource



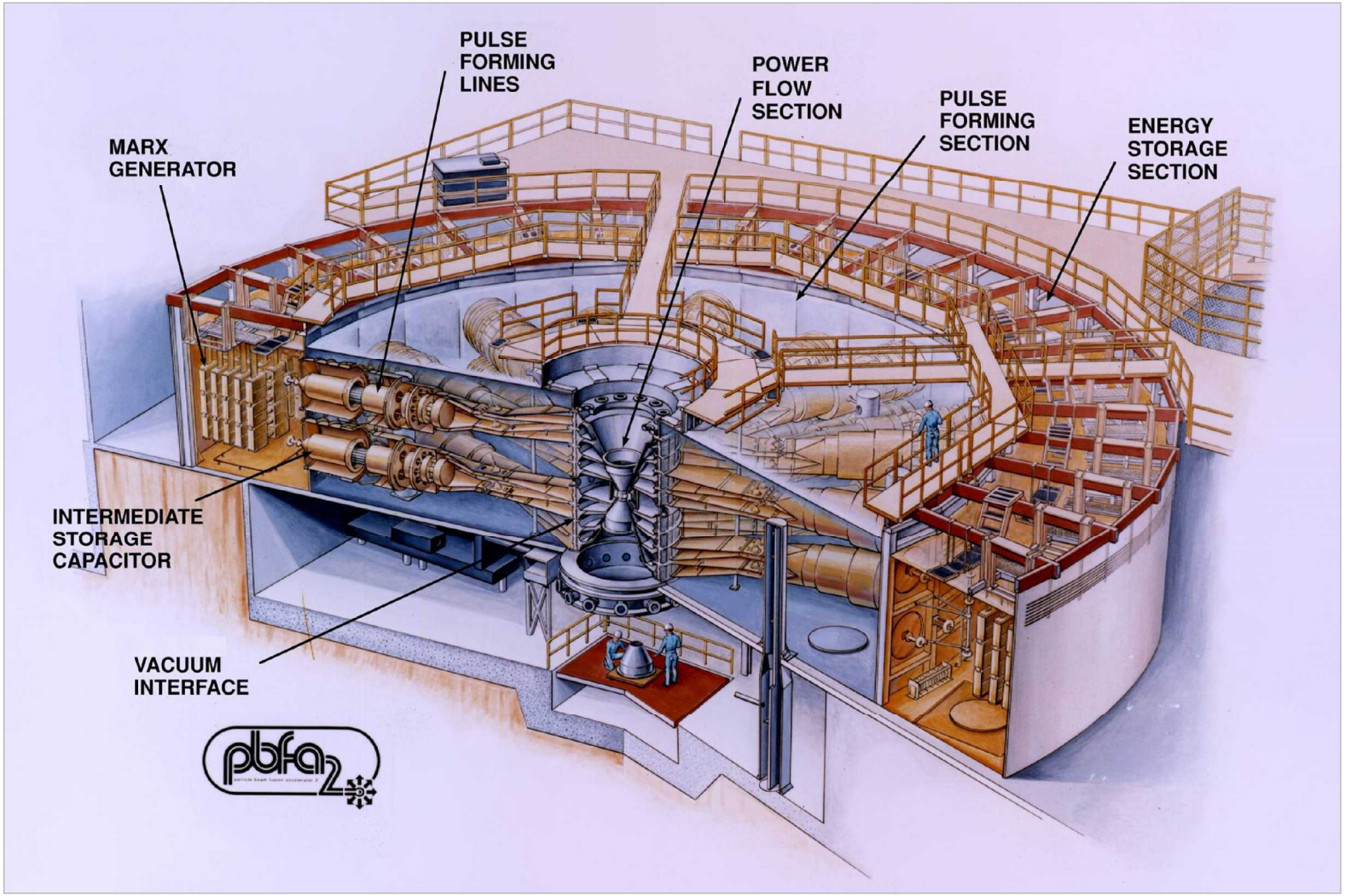
Compiled by

Ann Van Arsdall

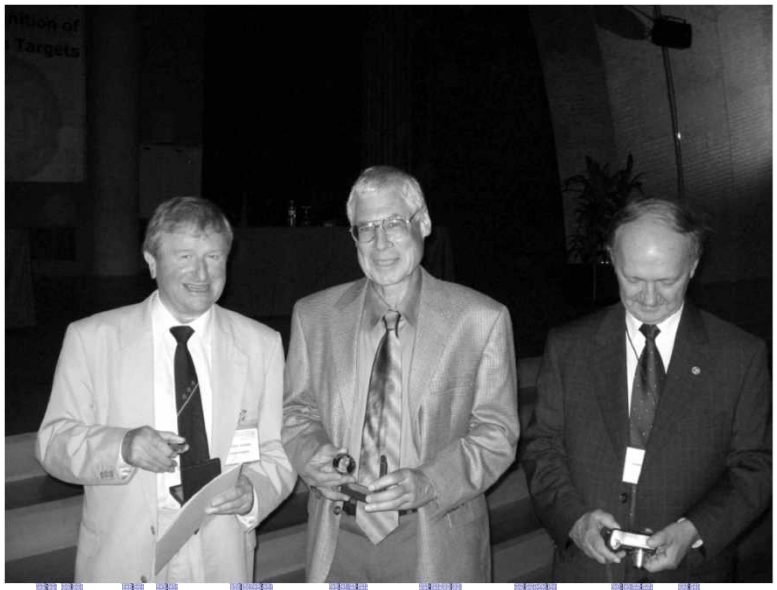
With support from:

Myra O'Canna
Rebecca Ullrich
Laura Martinez
Also Ramona Abeyta
Shirley Aleman
Anna Nusbaum
Michael Ann Sullivan
Peggy Warner

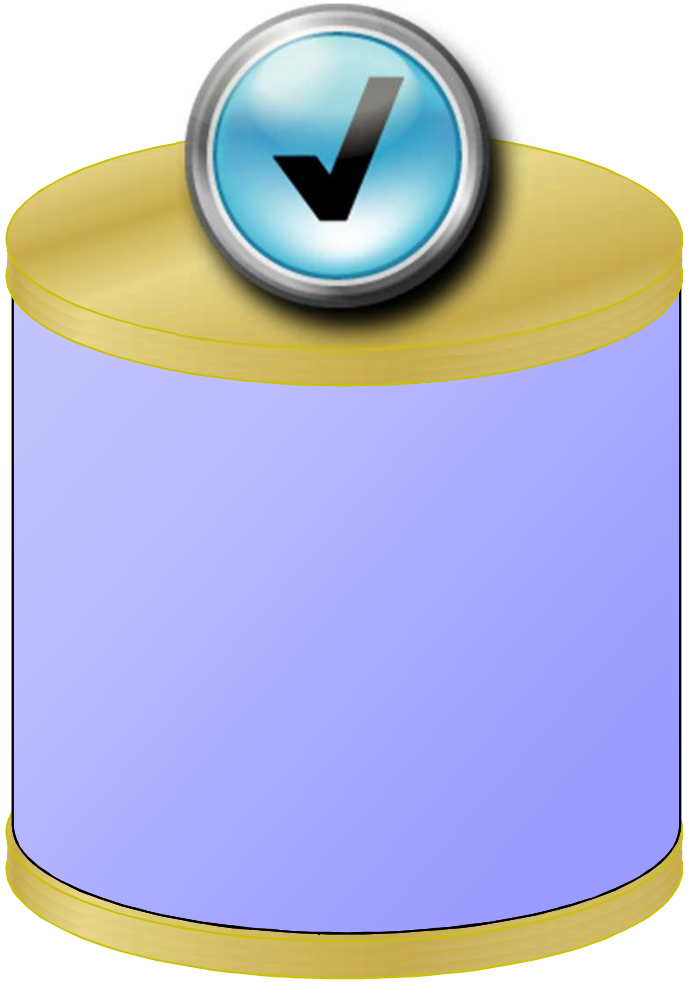
1985: Z Began Service as PBFA II



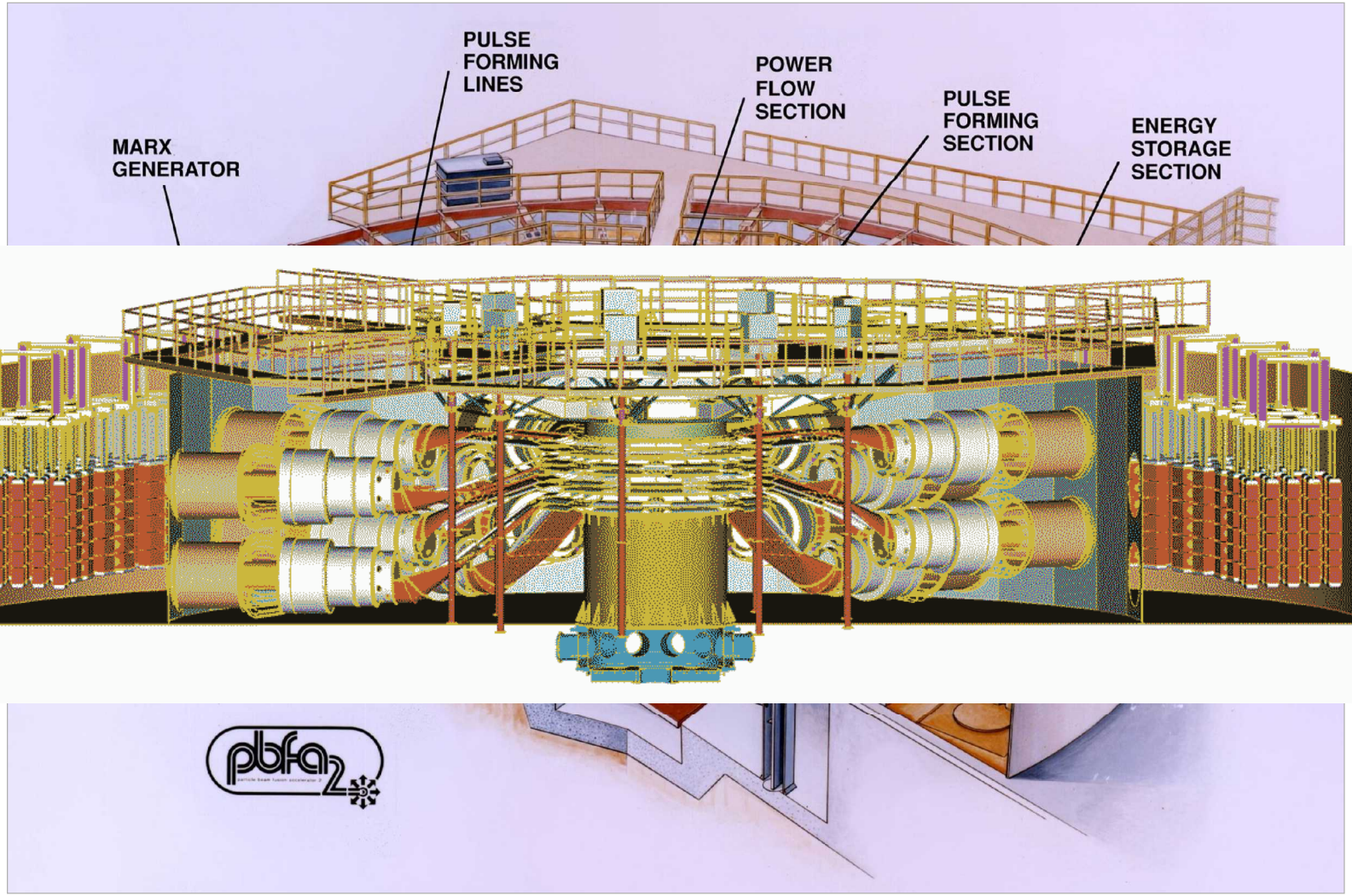
1995: Z-Pinch Breakthrough



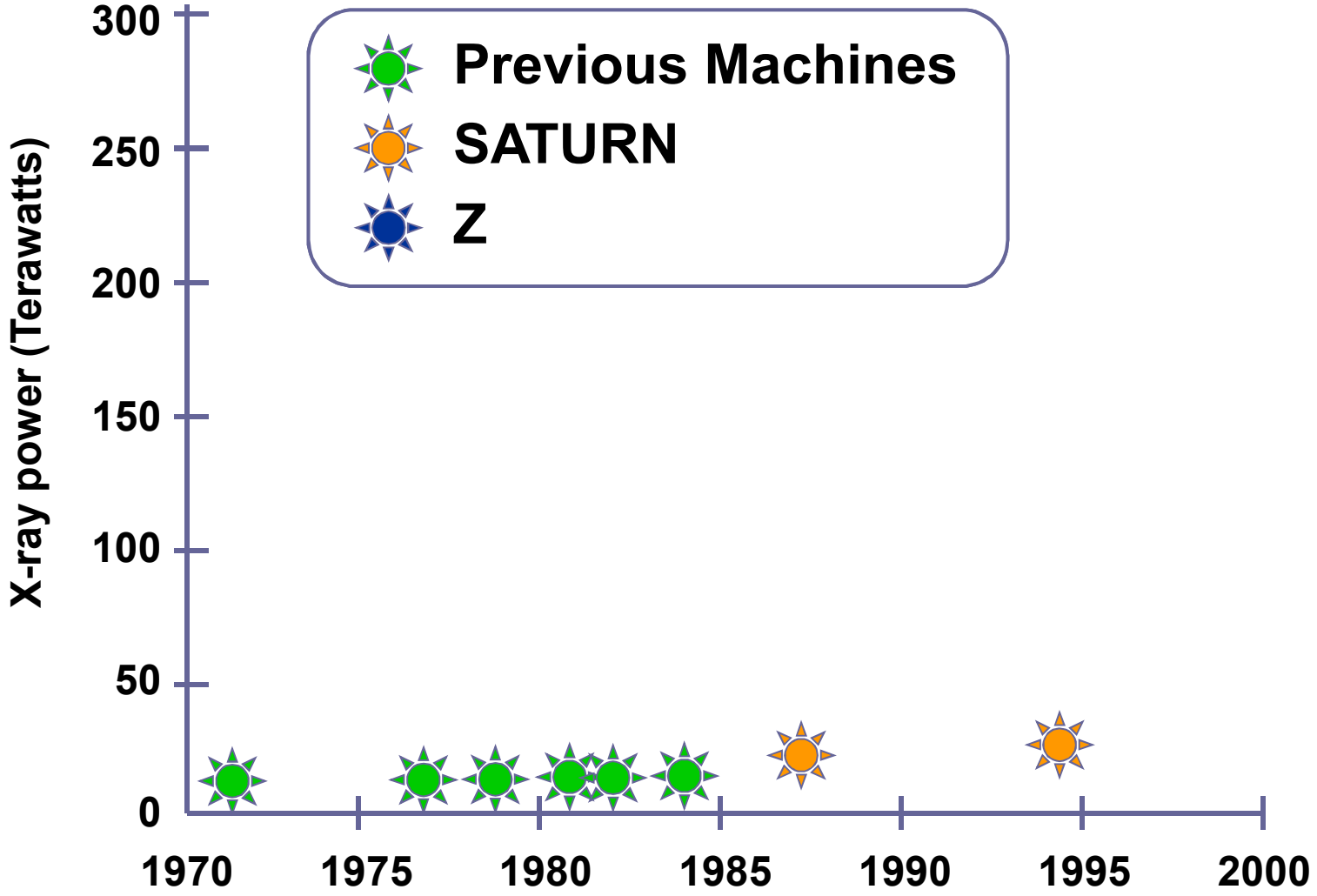
Sanford, Haines, Smirnov receive
European Physical Society
Hannes Alfven Prize, 2005



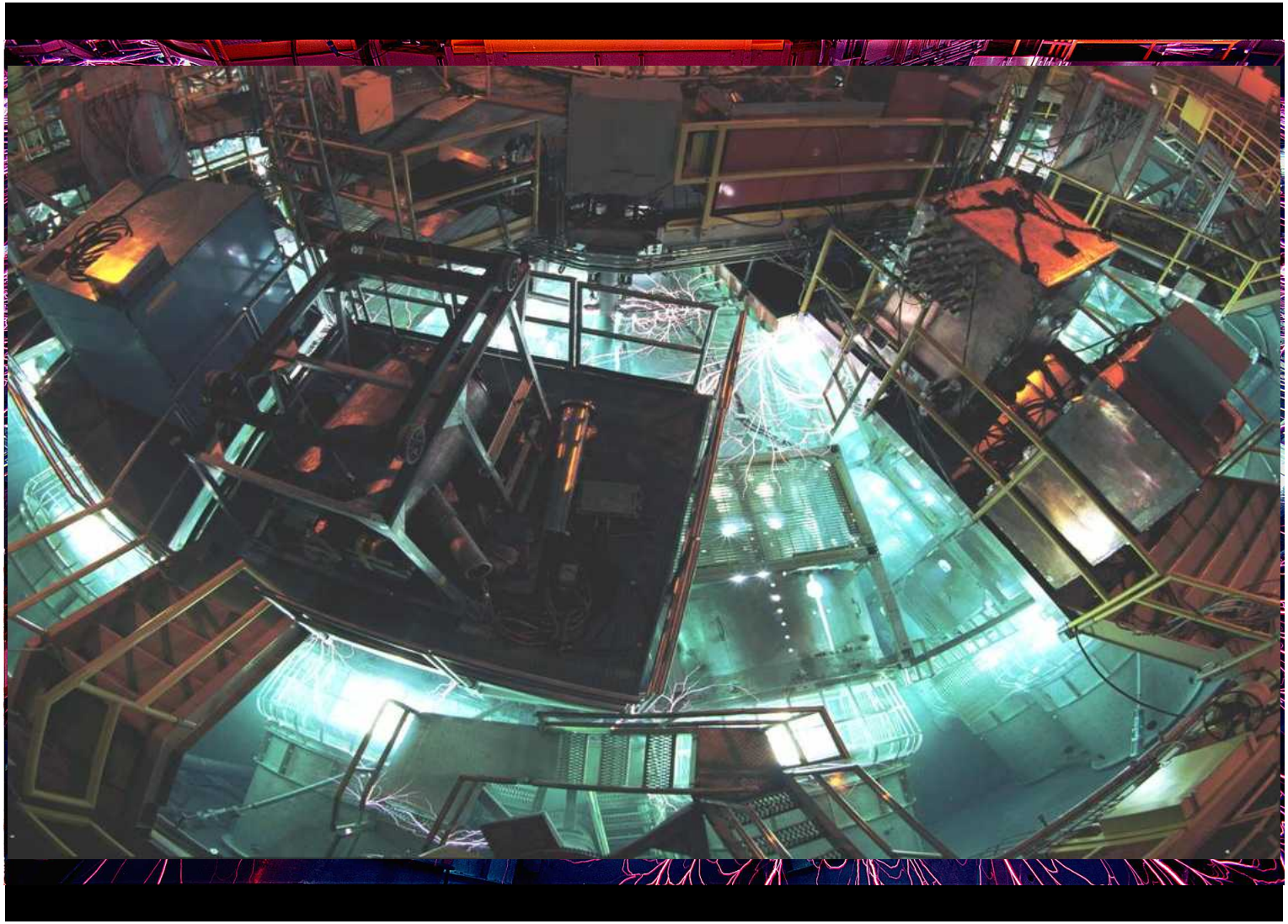
1996: PBFA -- Z Pinch Version



Stunning Results



“Arcs and Sparks” thru the Years

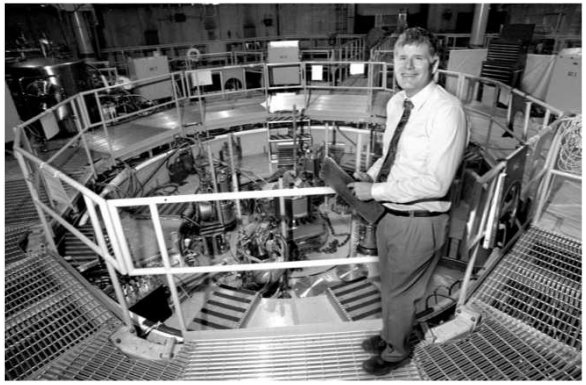


Directors thru the Years

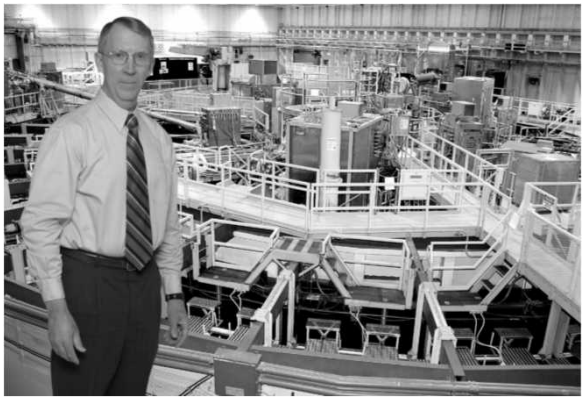
Yonas

VanDevender

Cook



Quintenz



Matzen

Pulsed Power 101

What is Pulsed Power?

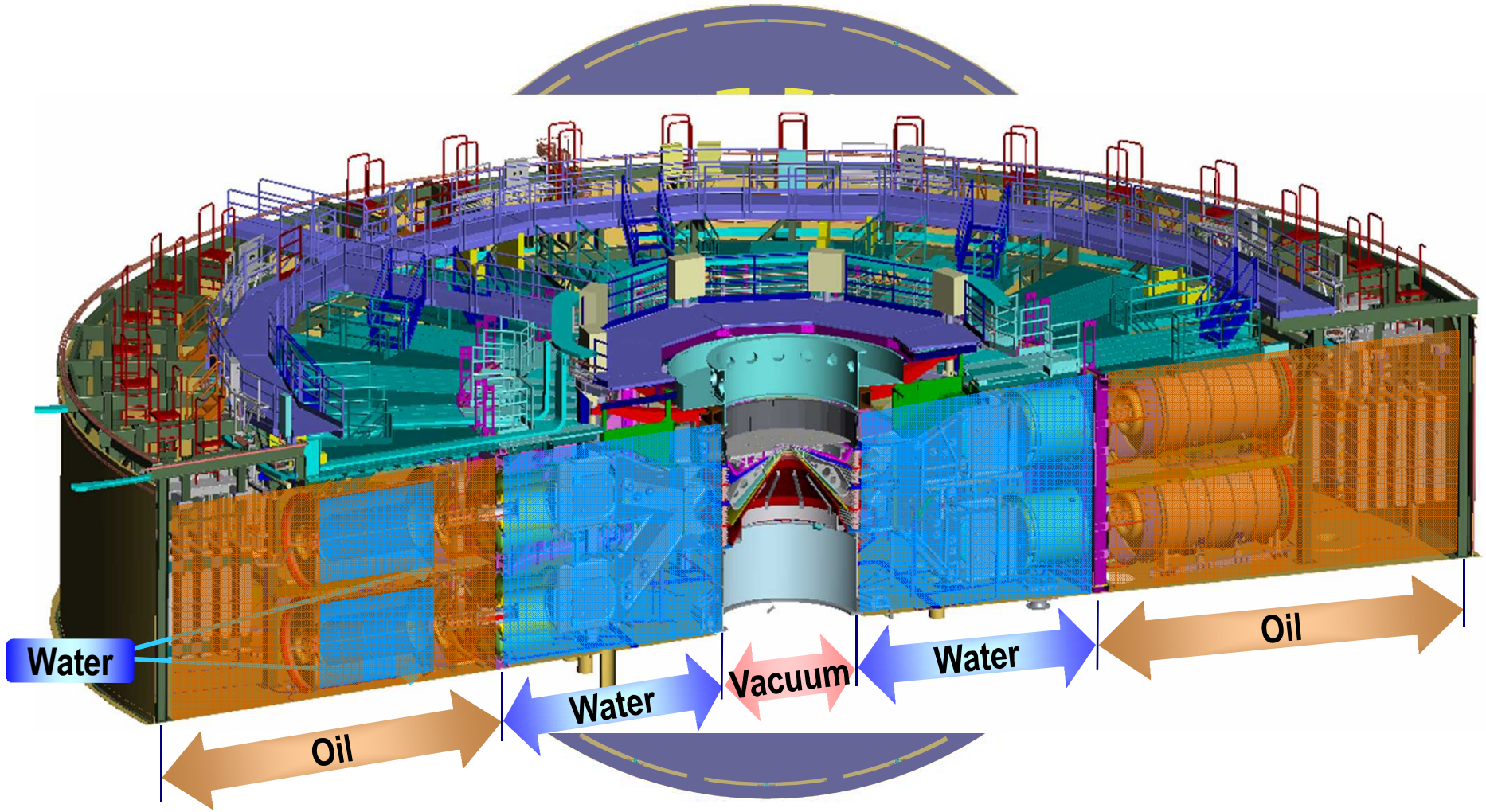
pulsed pow•er (pŭlsd) (pou‘ar), *n*. compression of energy in time and space, resulting in large instantaneous power levels

$$Power = \frac{Energy}{Time}$$

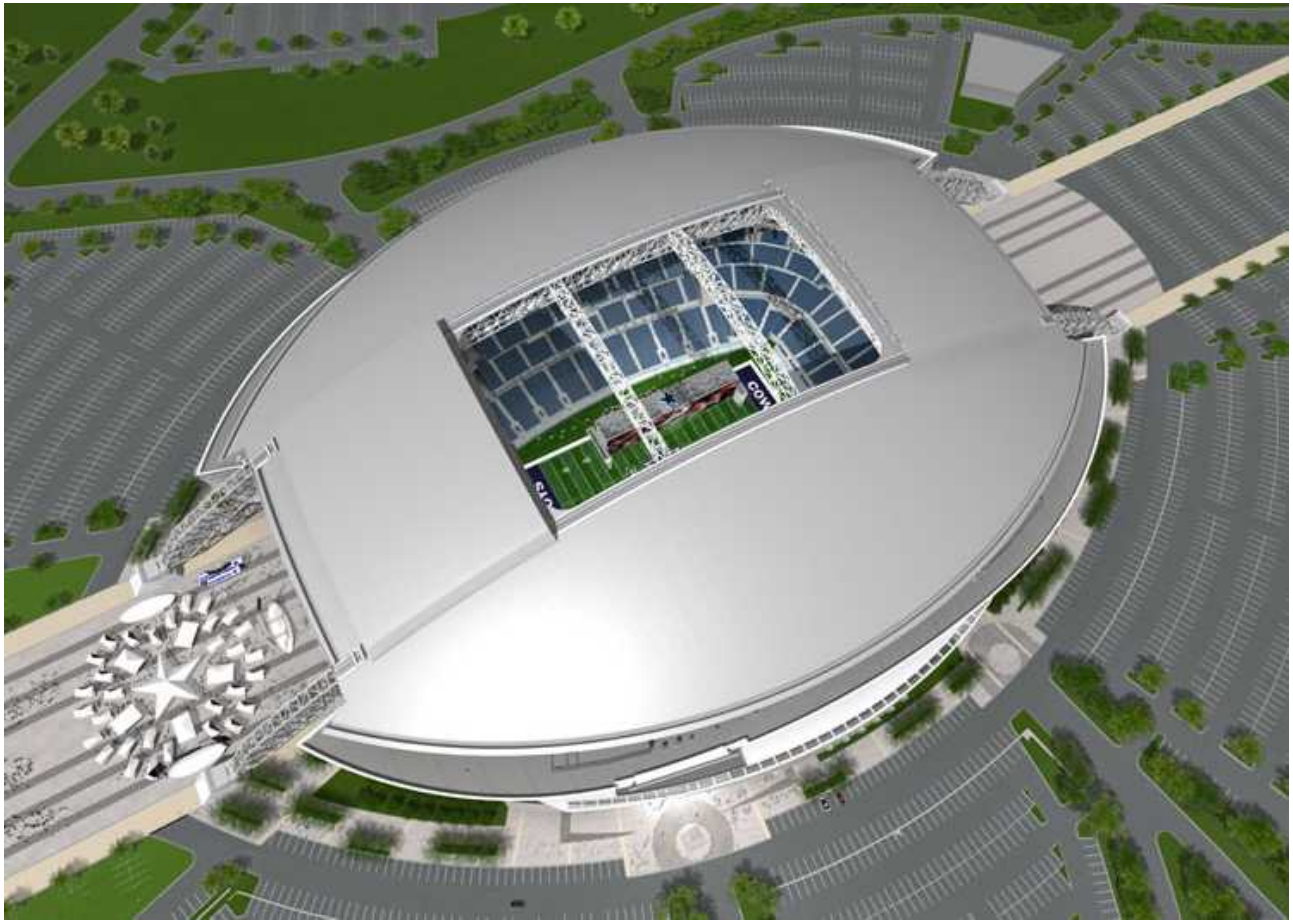
Fast Pulsed Power ≈ < 1 microsecond

$$\left[\frac{1}{1 \text{ million sec}}\right]$$

Z's Pulsed Power Architecture

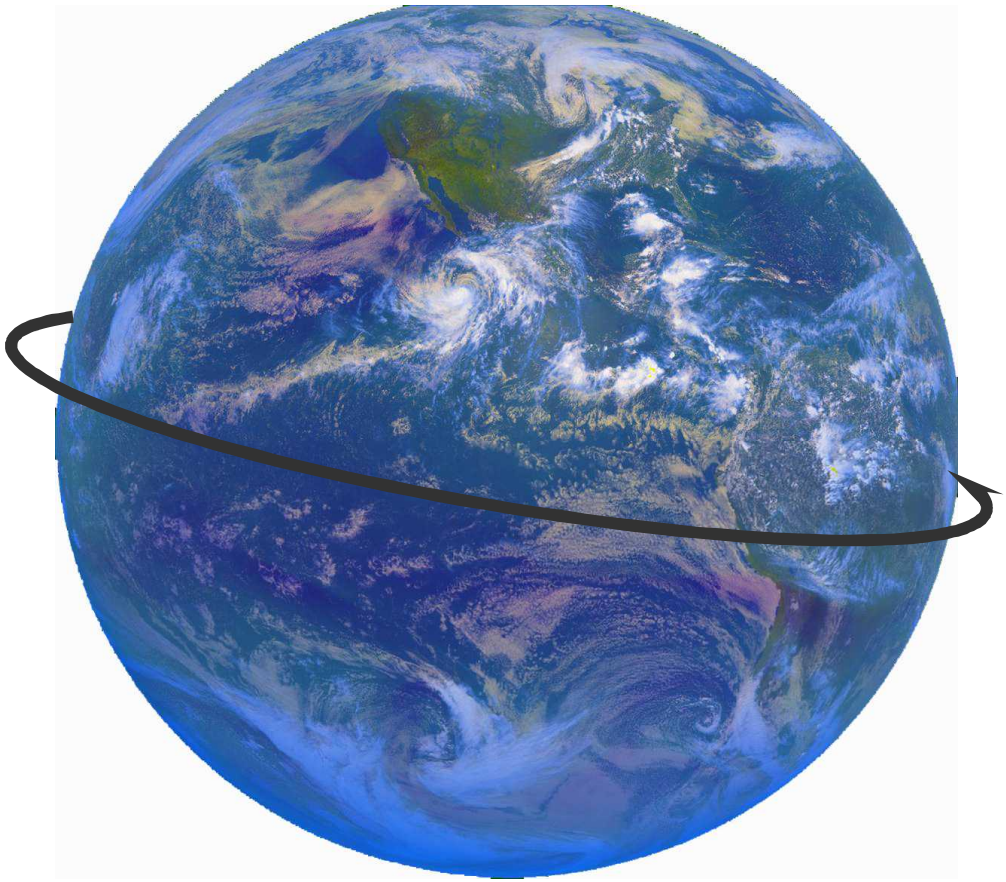


Compression in Space



New Dallas Football Stadium Under Construction
104,000,000 ft^3

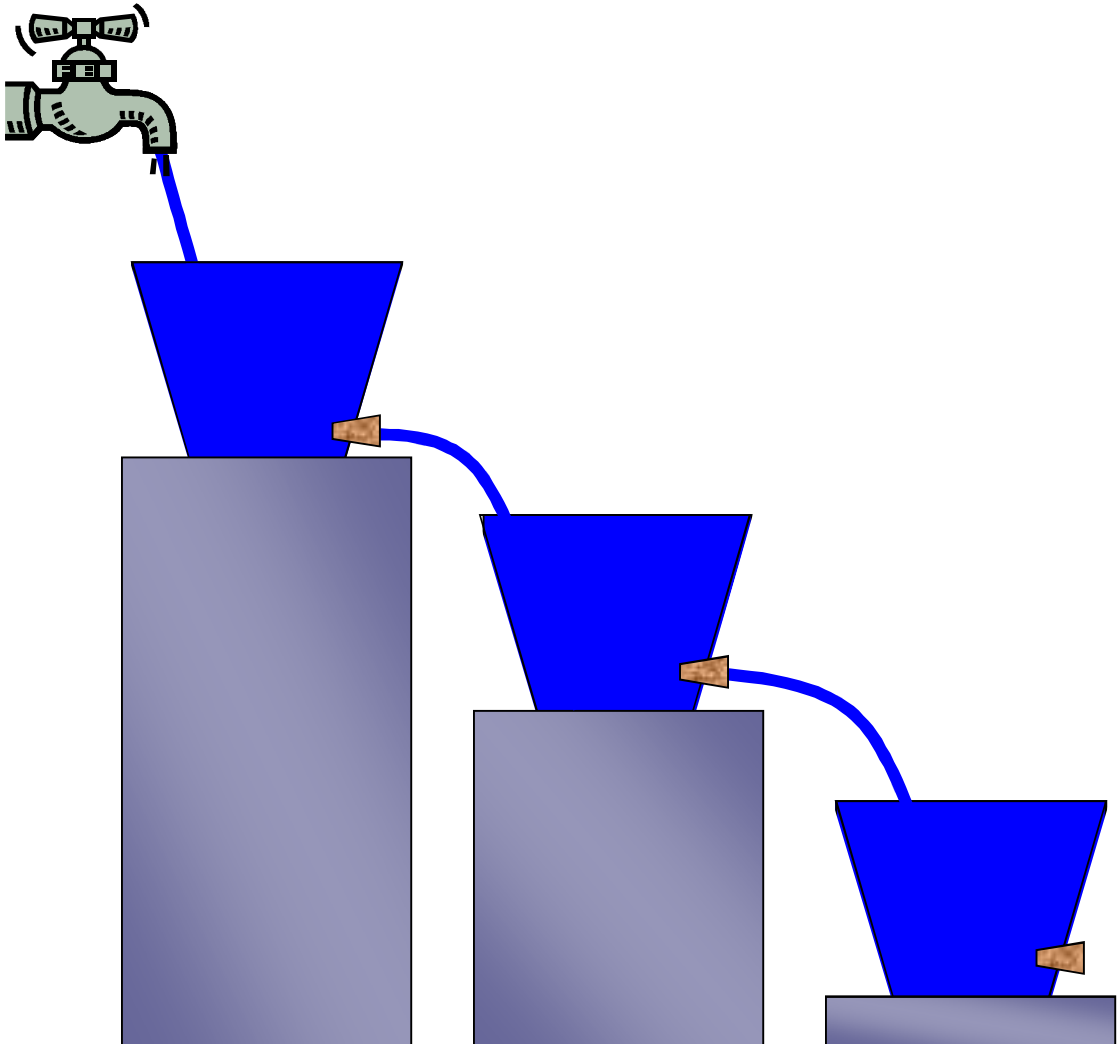
Compression in Time



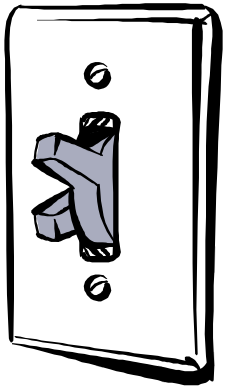
24,900 miles

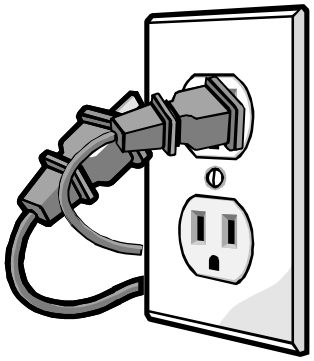
1 ½ ”

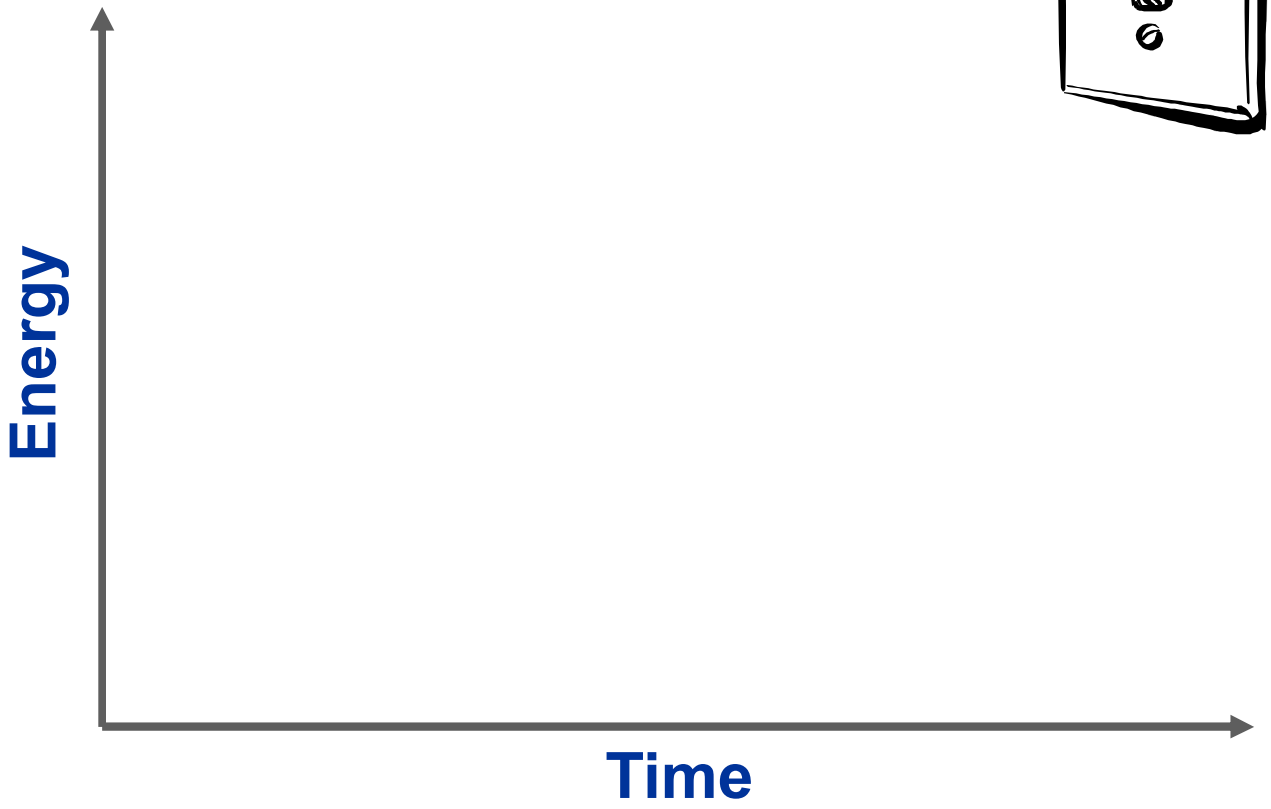
Capacitor Charge/Discharge



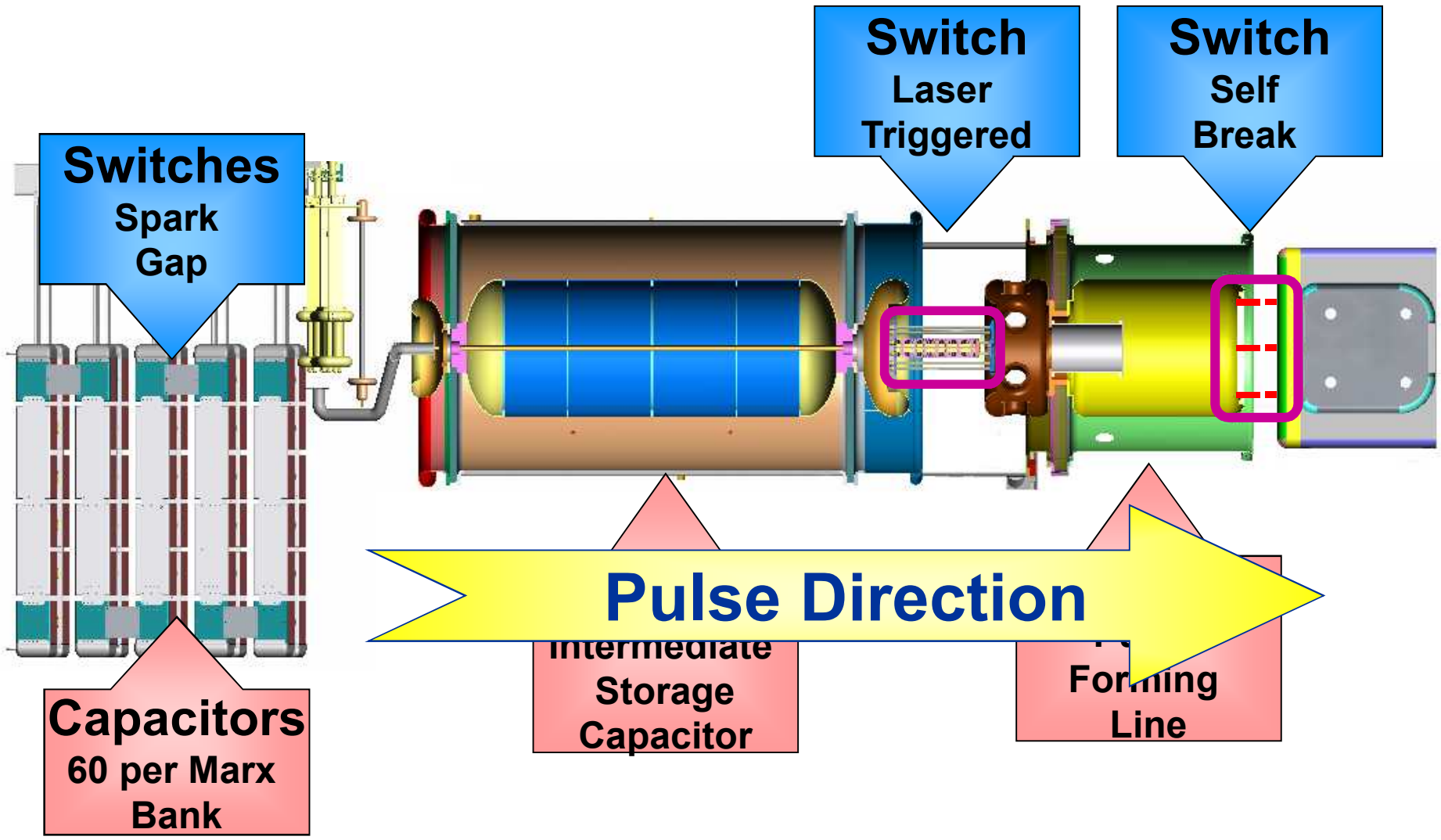
Pulse Compression





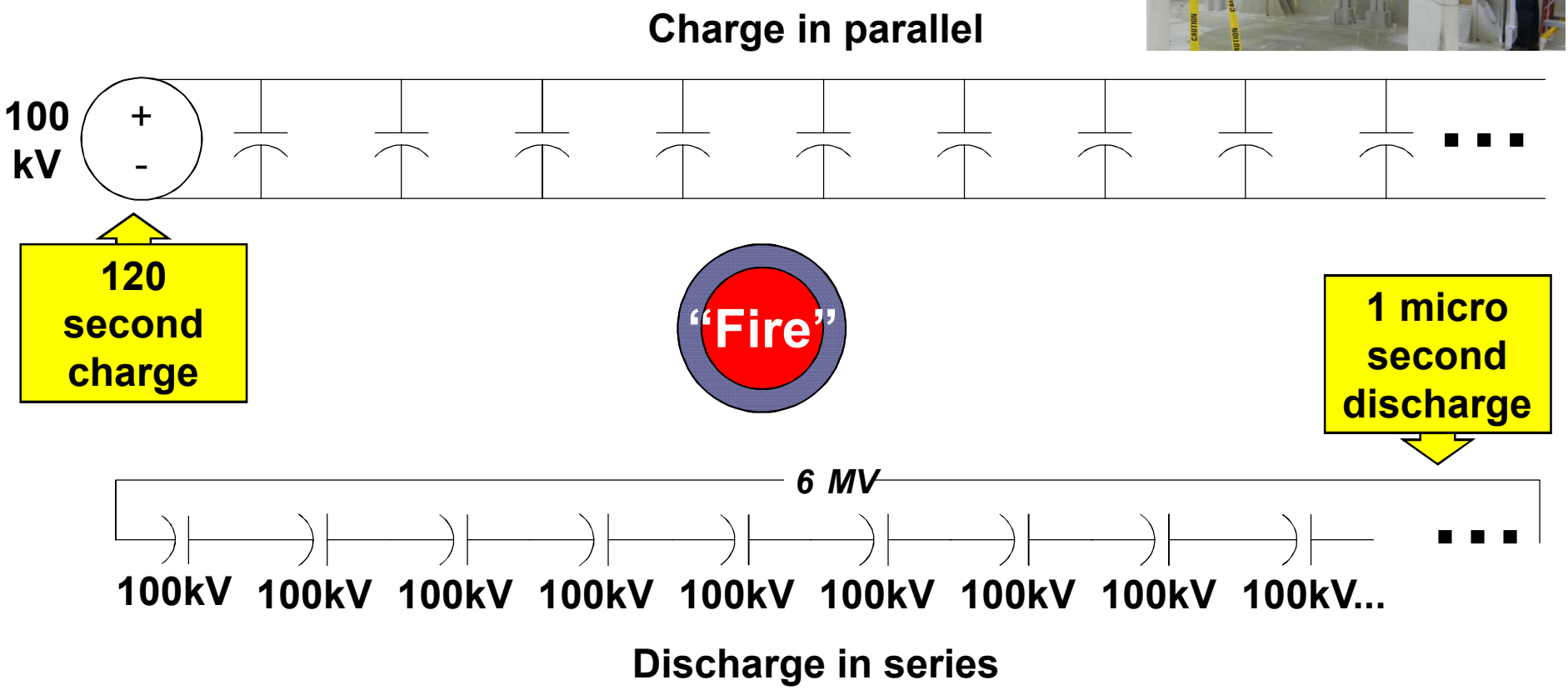


Z's Capacitors & Switches



Marx Generators

~90% of pulse compression is here…



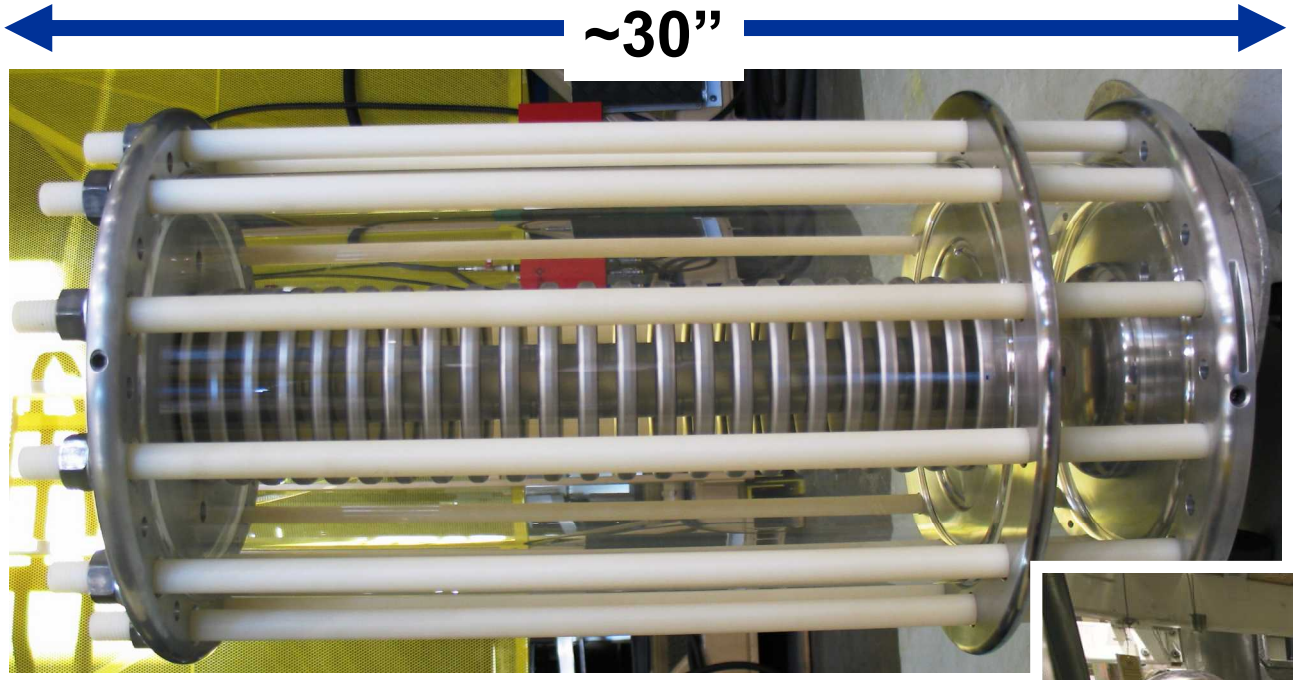
Intermediate Storage Capacitor

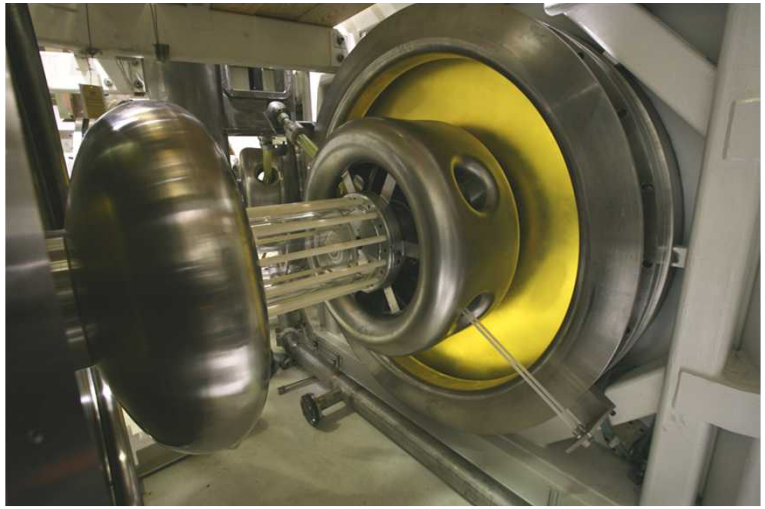
1 micro second charge

350 nano second discharge

Each capacitor holds 2,900 gallons of water

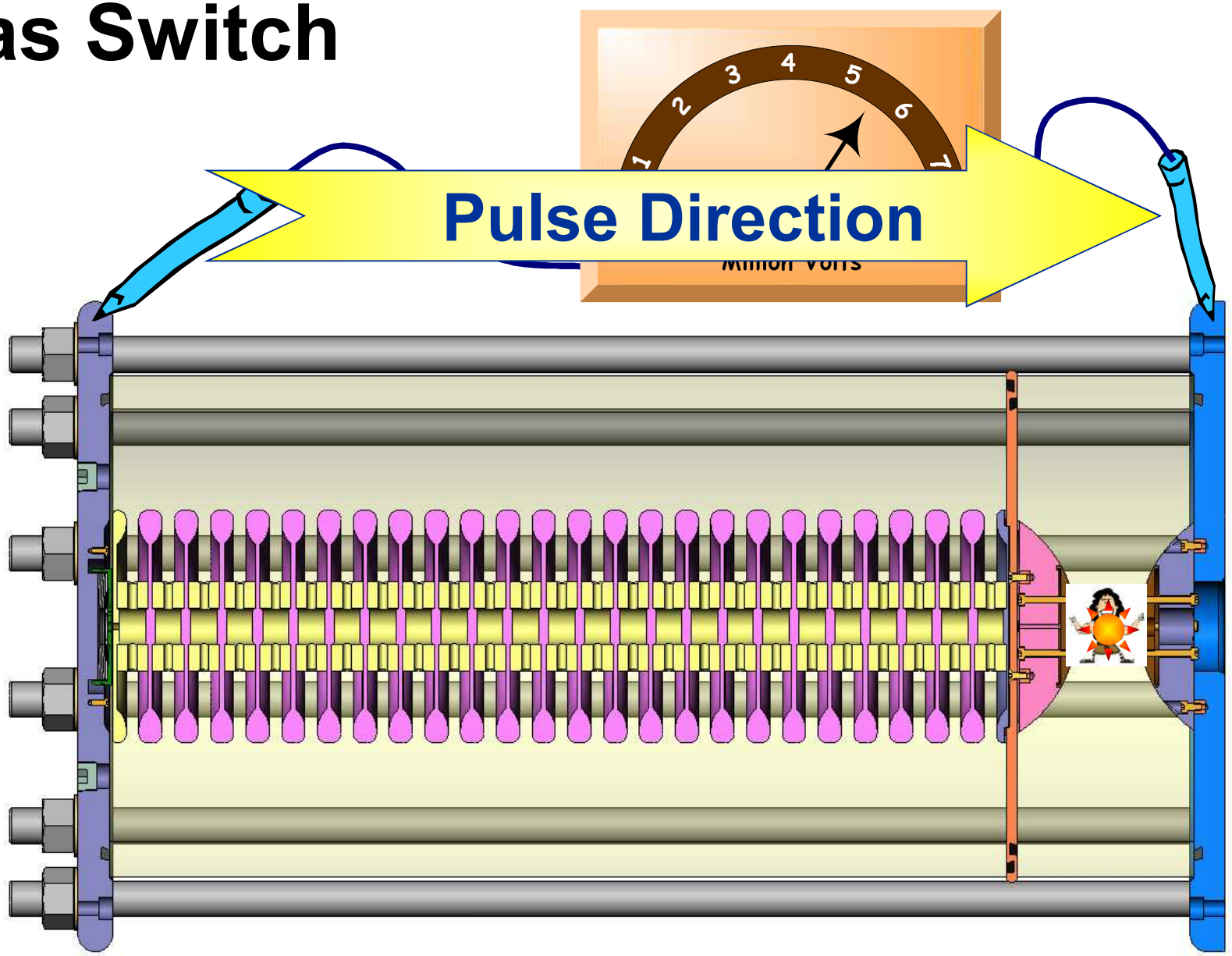
Laser Triggered Gas Switch



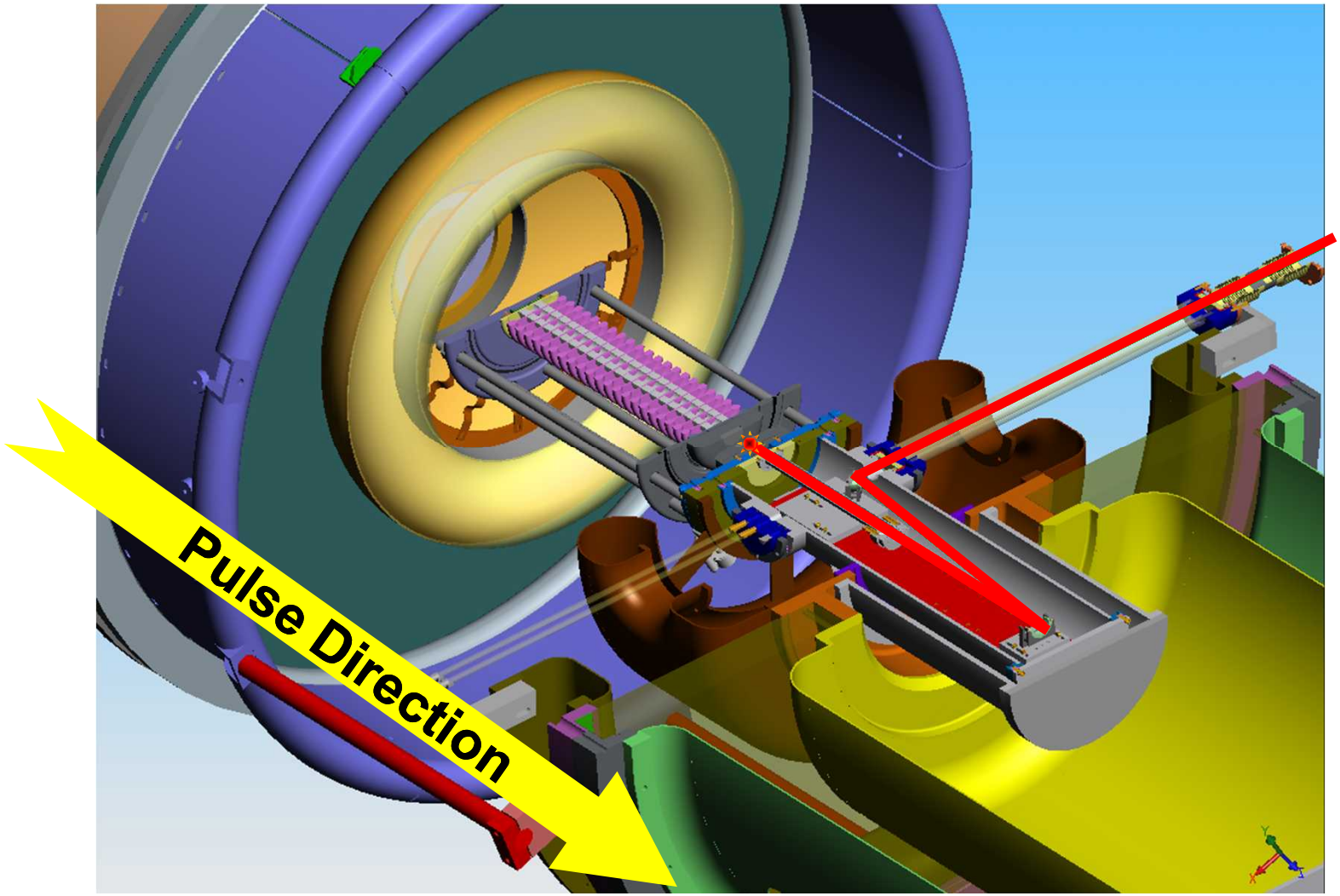


Synchronizes the 36 Modules

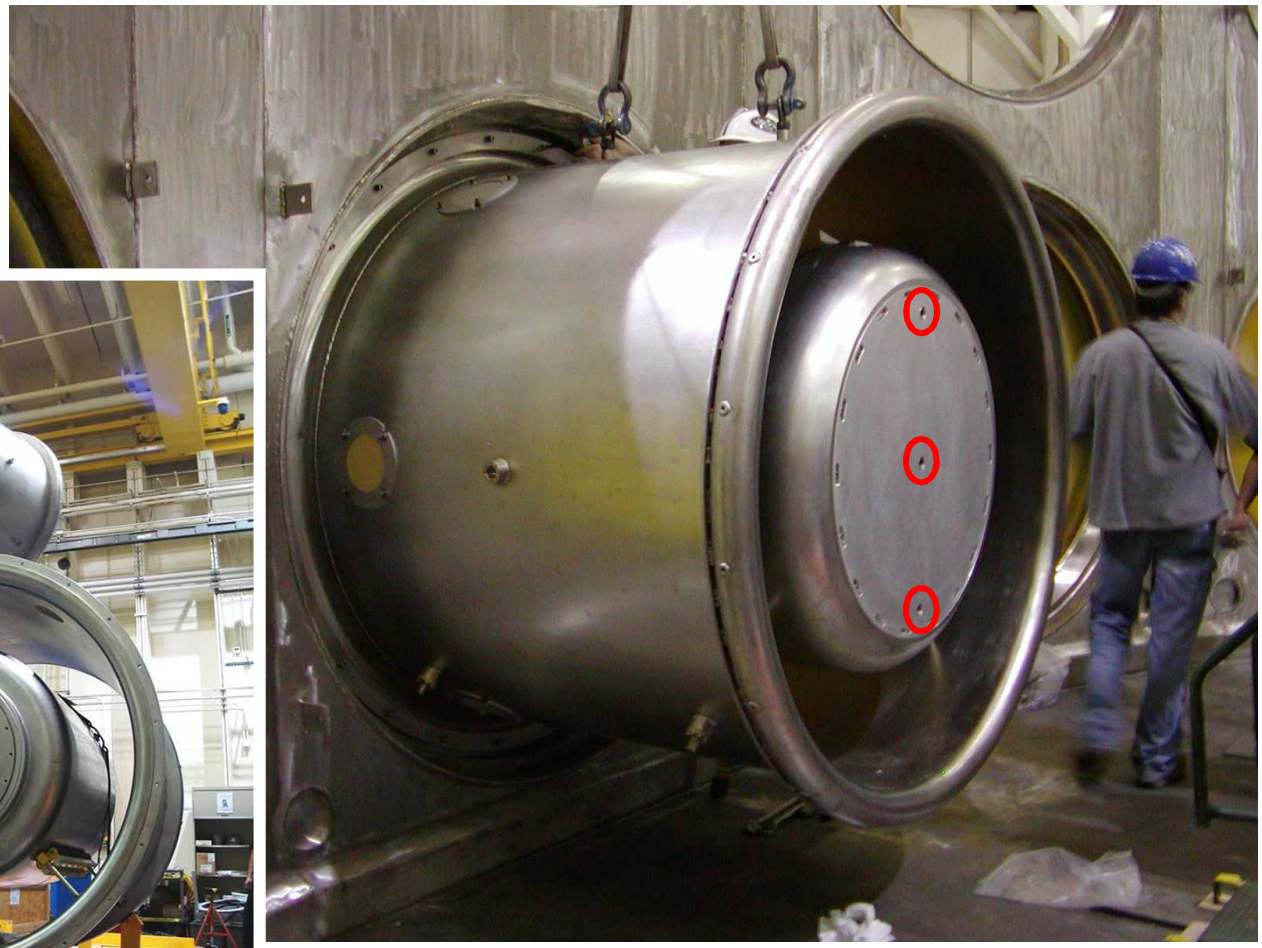
Gas Switch



Getting Laser Light Into the Switch



Pulse Forming Line

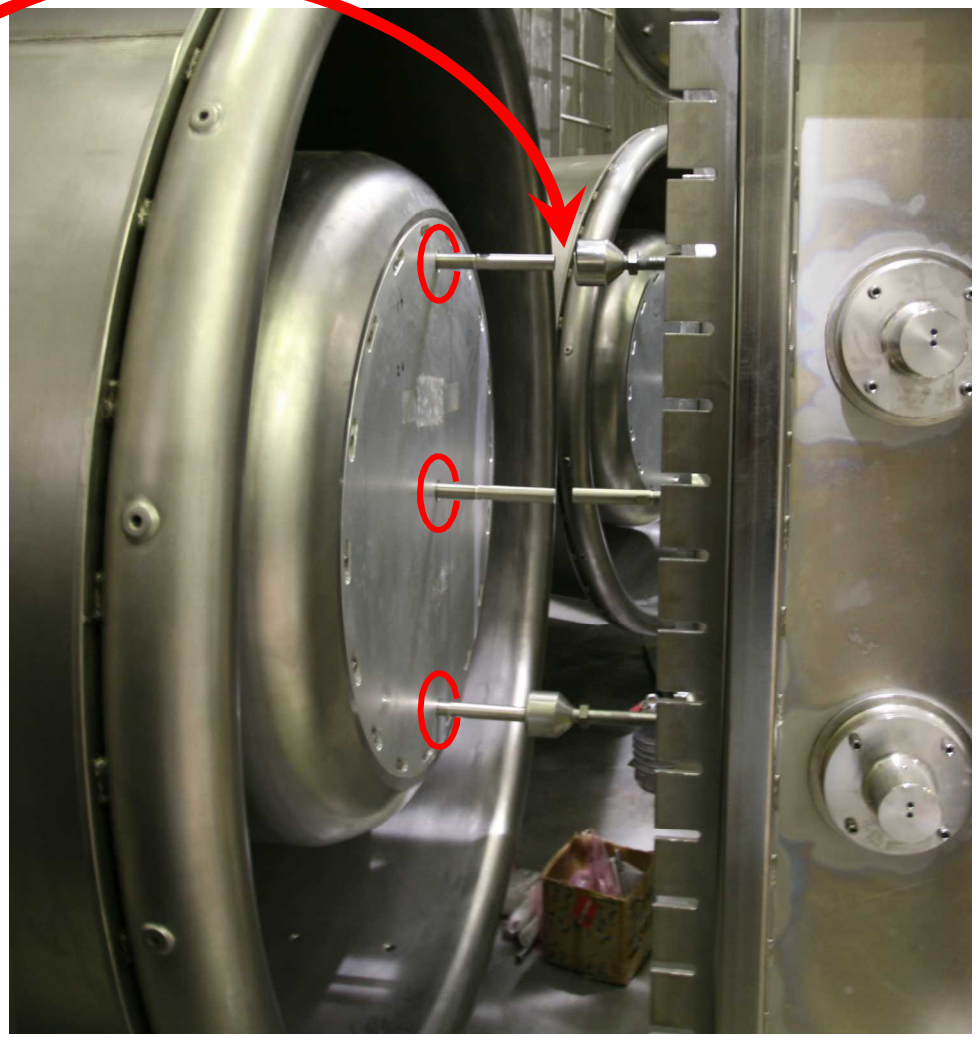


350 nano second charge

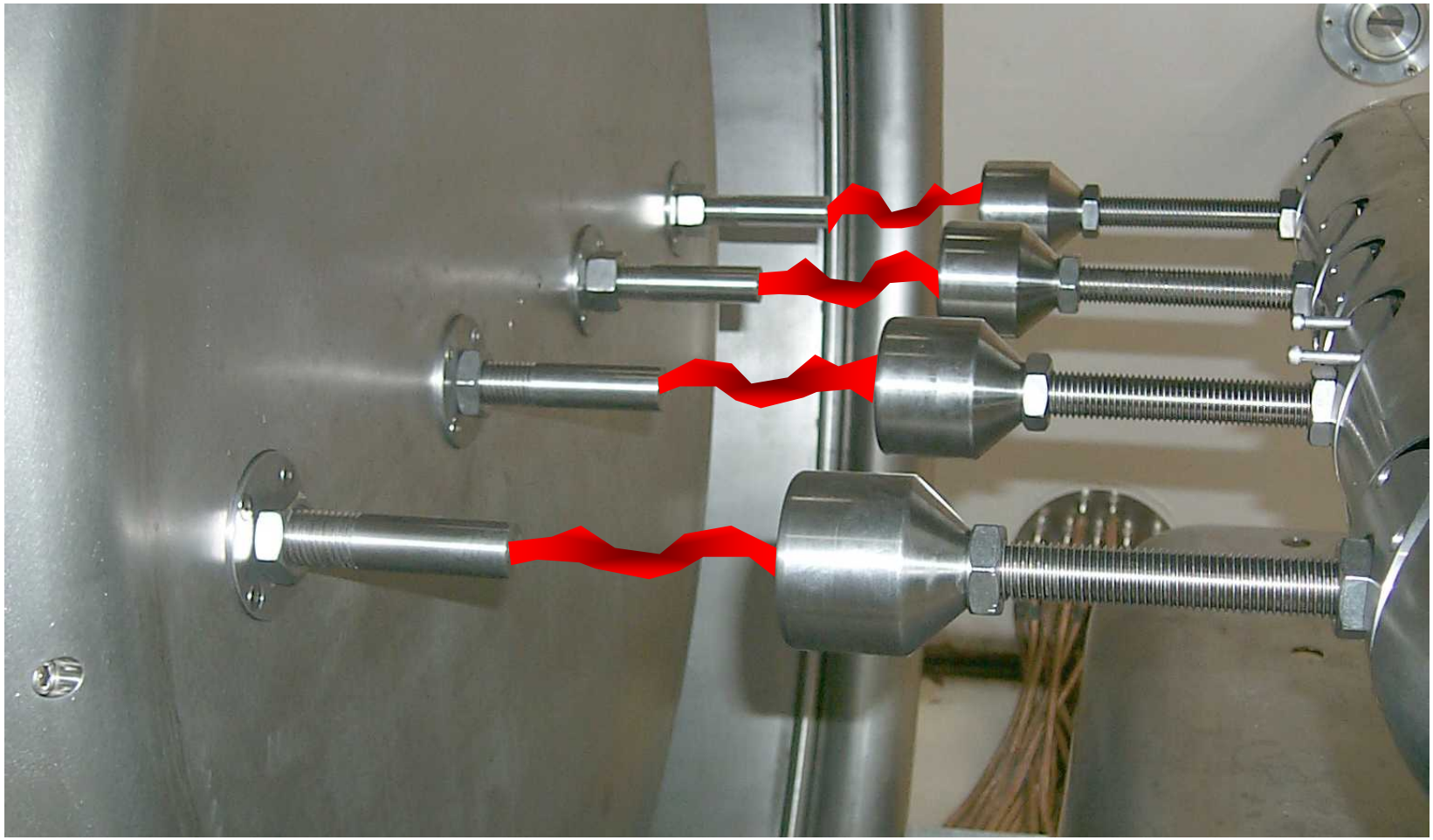
120 nano second discharge

Z Self-Break Water Switch

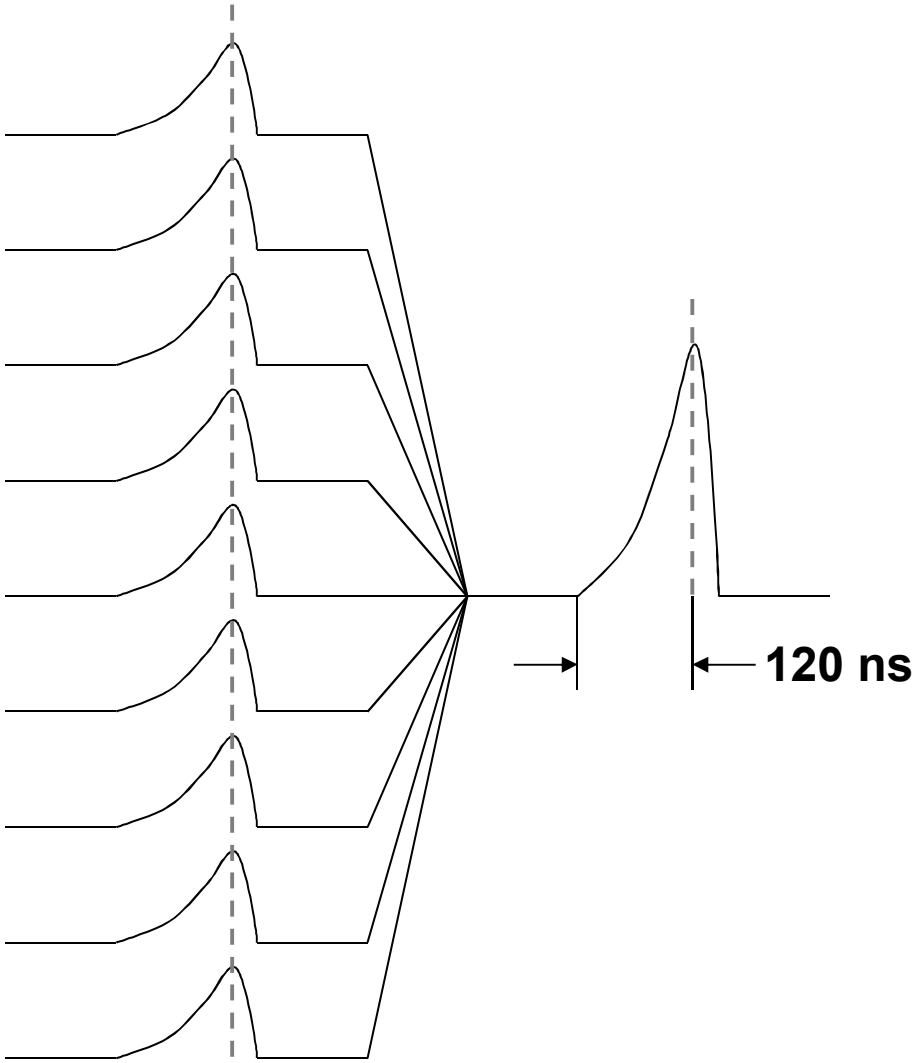
Gap is set to ~2 to 5”



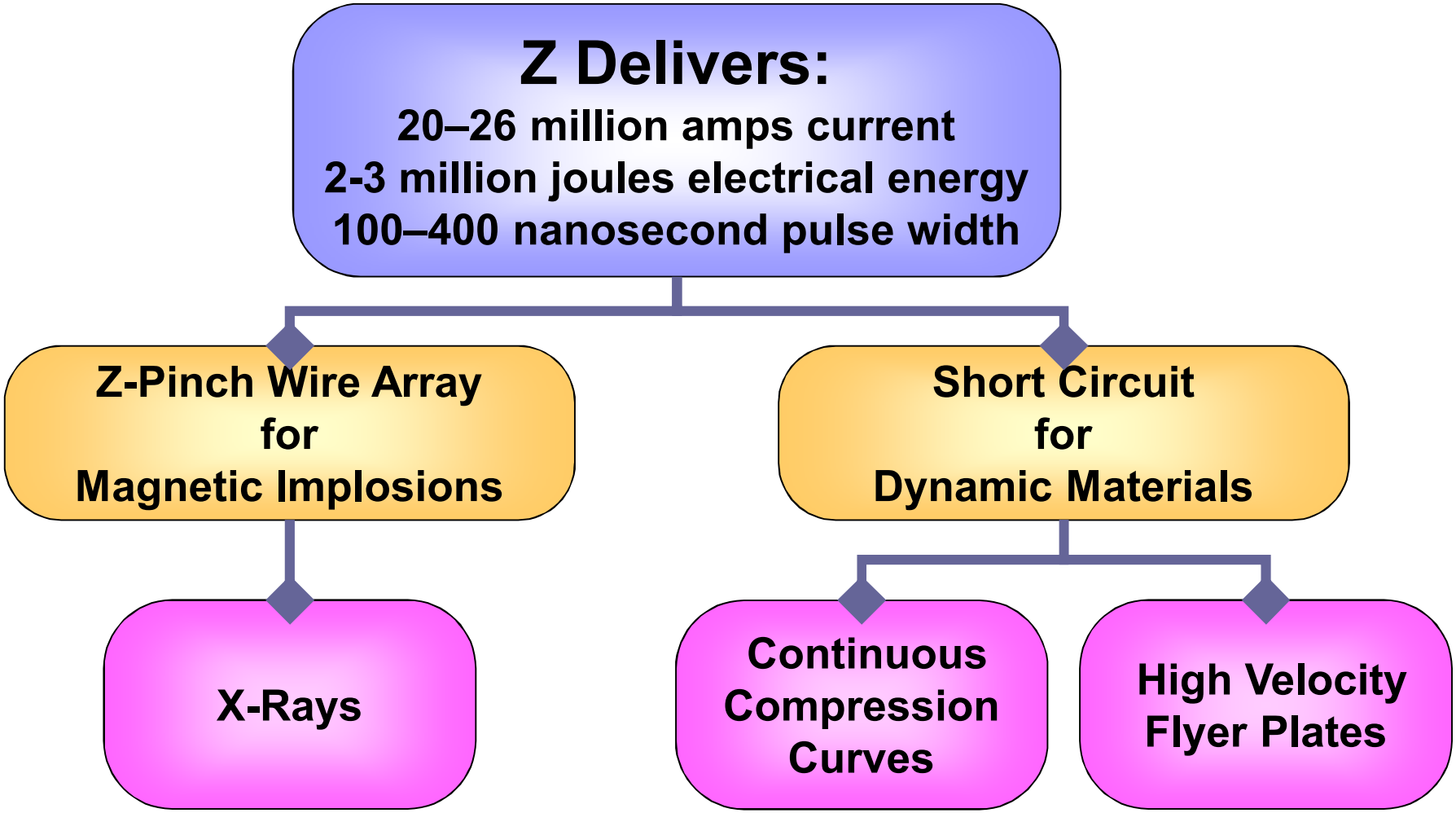
Gap Predictably Breaks Down



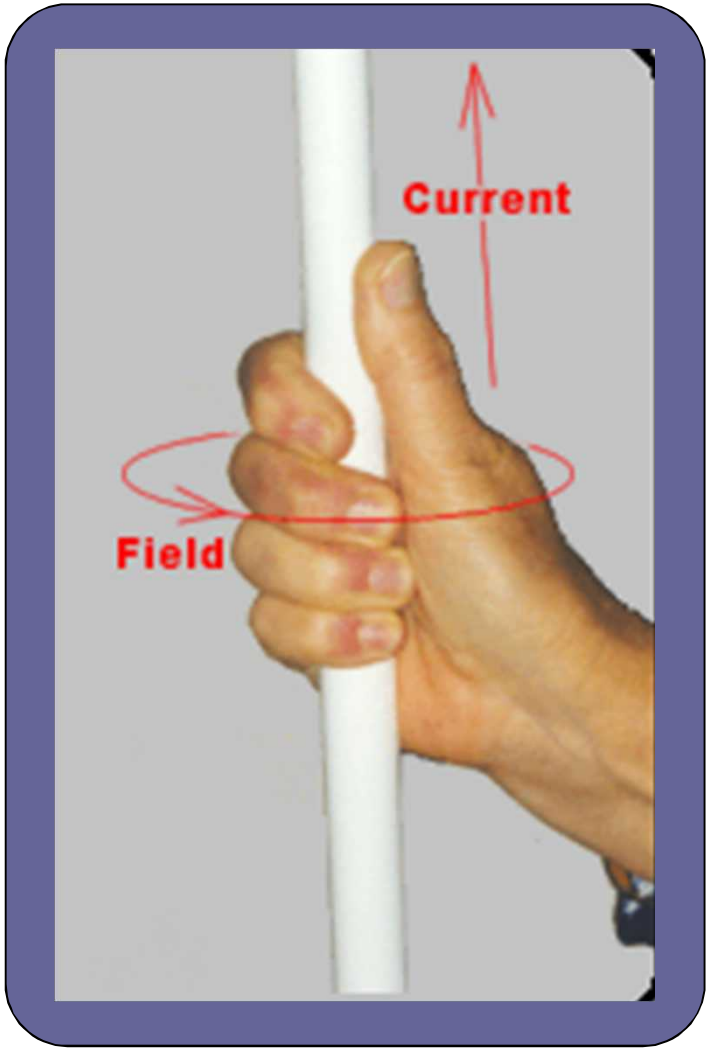
Pulse Shaping on Z



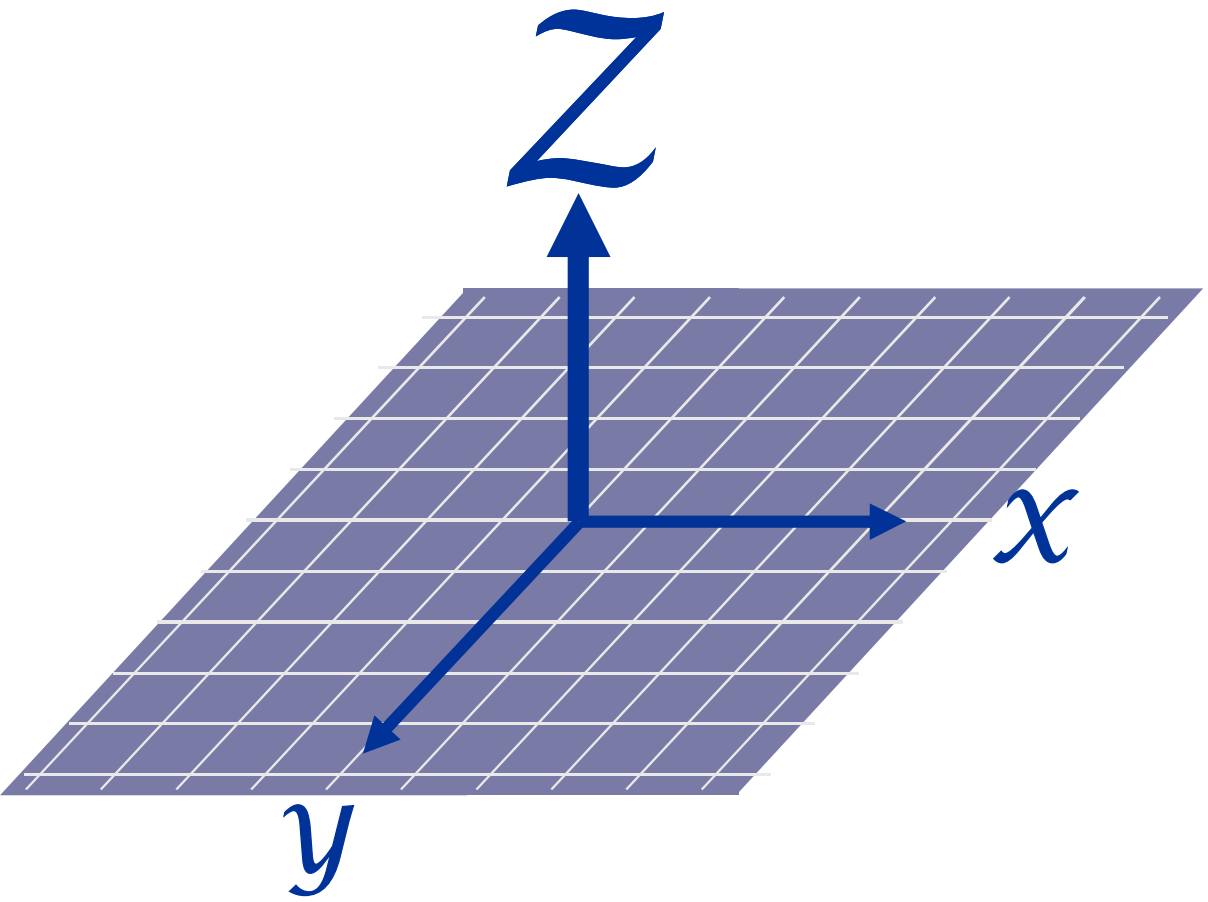
1 Machine – Many Applications

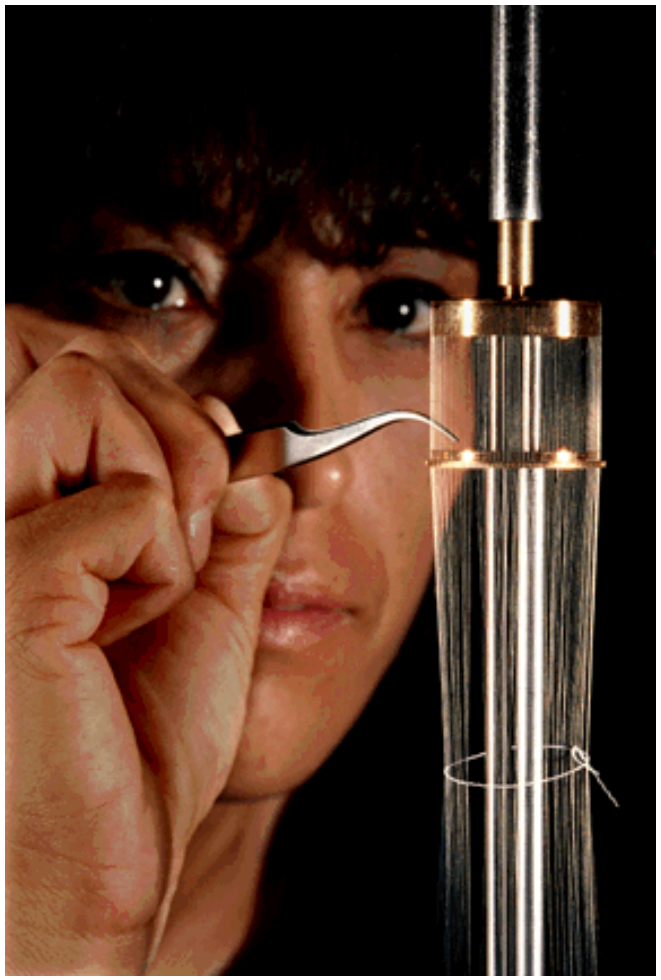


Right Hand Rule is Key to Z Pinch



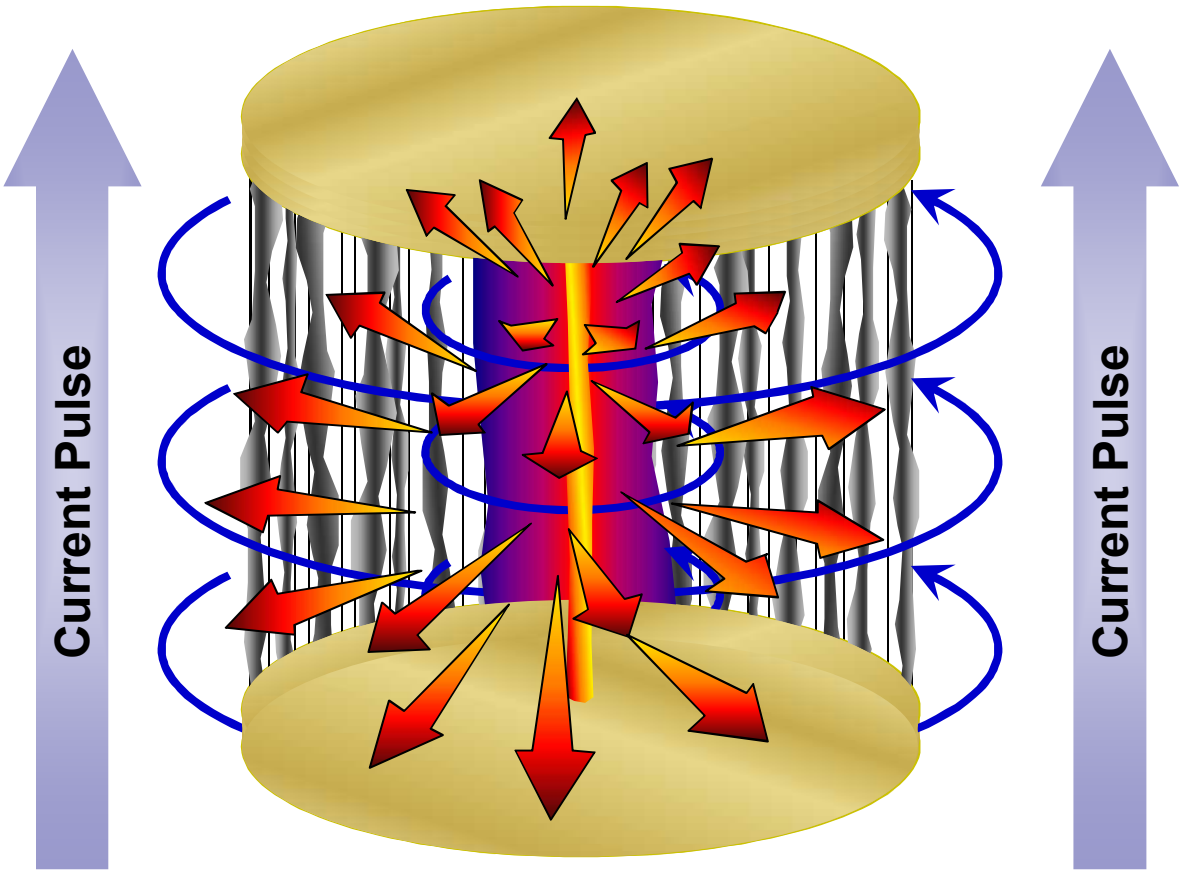
Why is Z called “Z”?



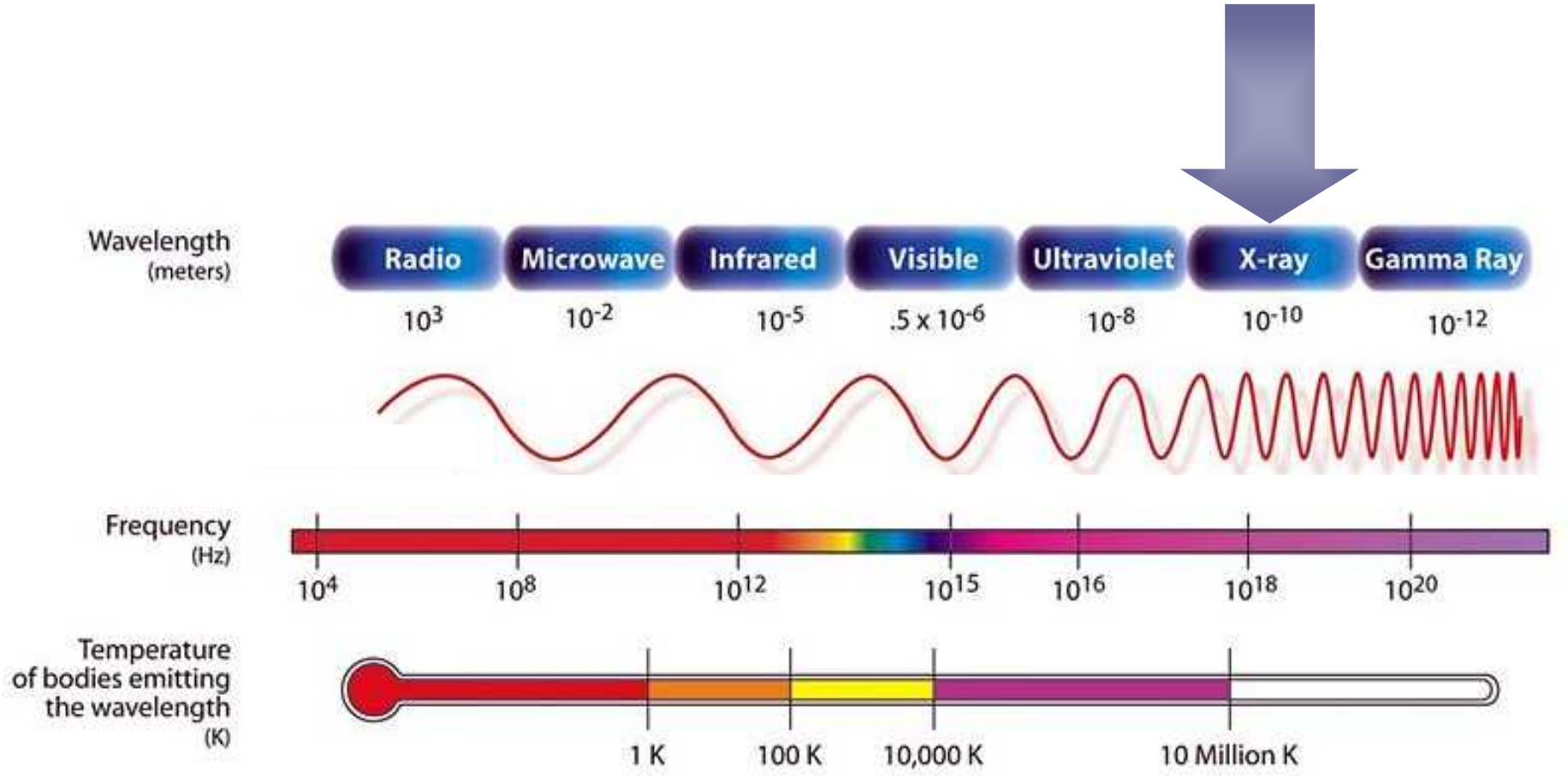


Current at the load flows in the “Z” (⇧) direction

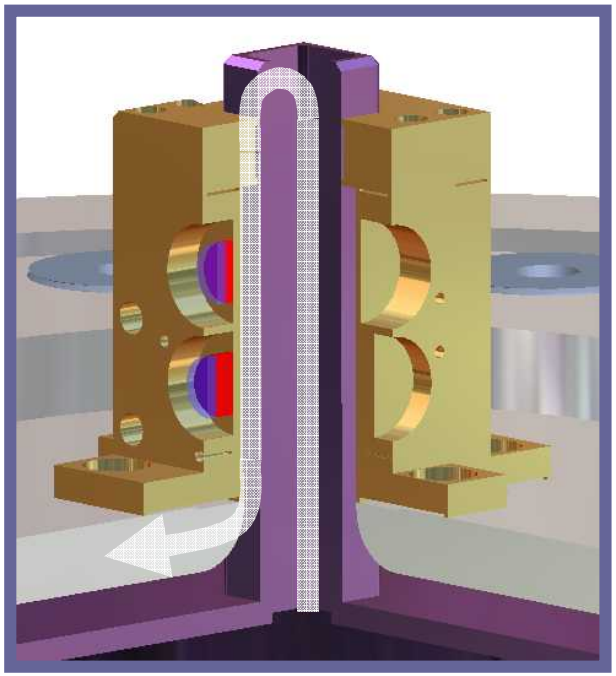
Z-Pinch ➡ Magnetic Implosion

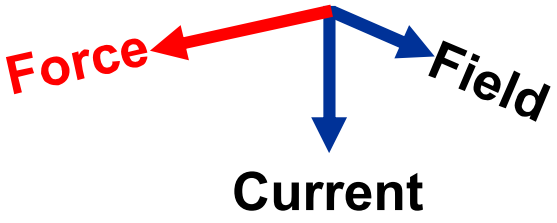


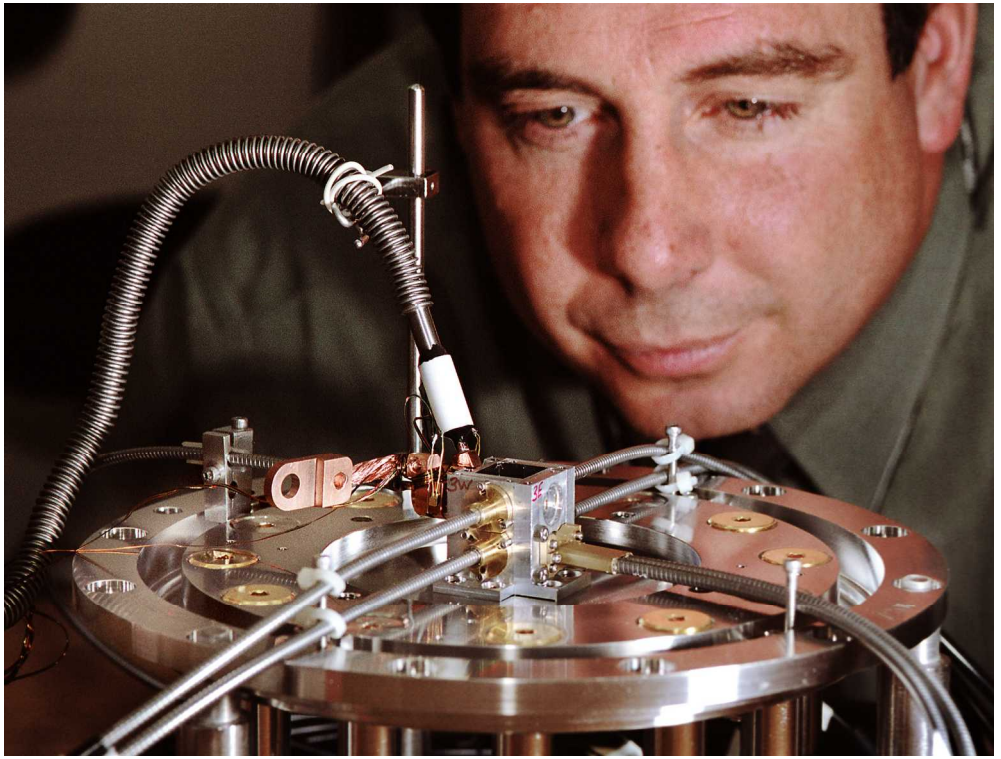
Kinetic Energy Becomes X-Rays



Short Circuit ➡ Magnetic Pressure

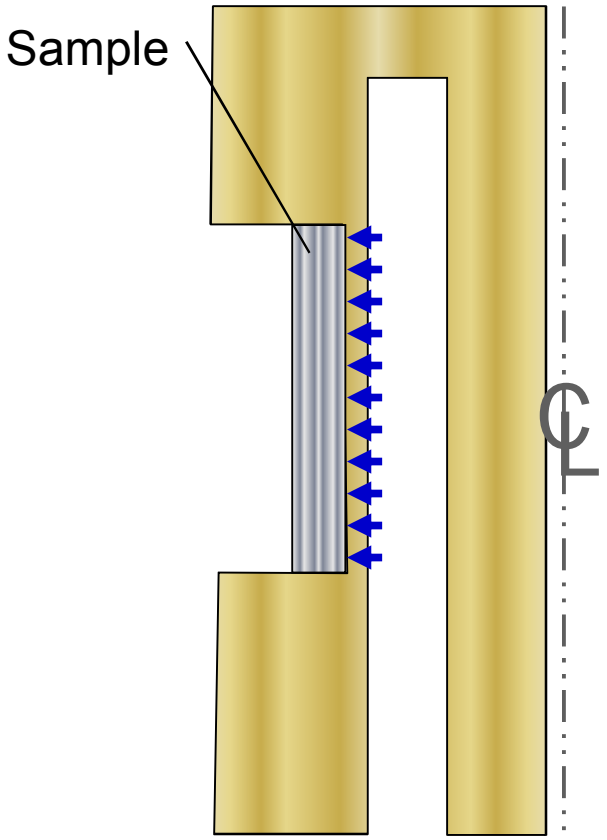


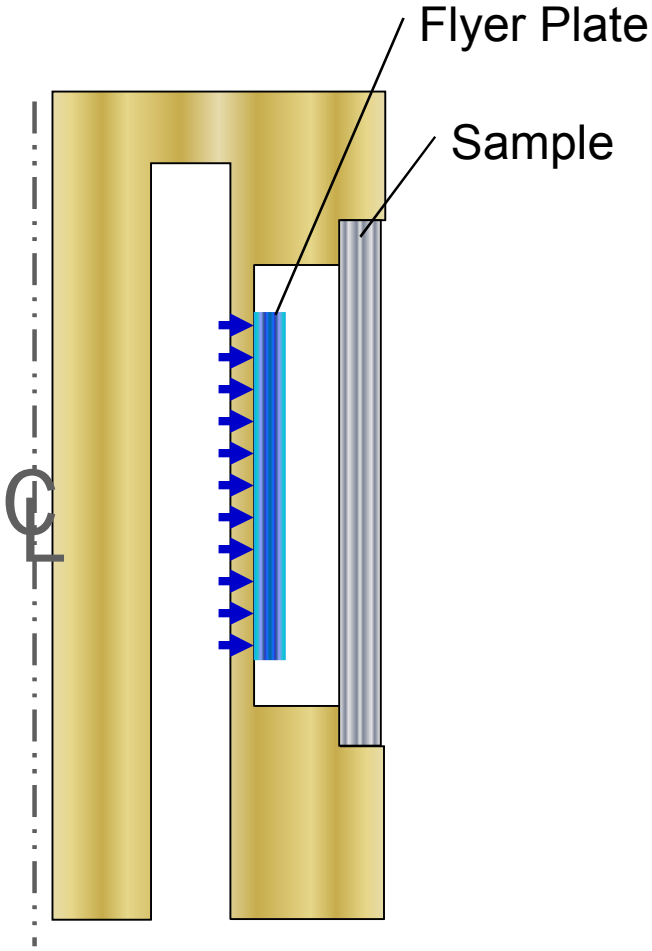




Clint Hall with an early “ICE Cube”

Dynamic Material Properties





Isentropic Compression Experiments: direct pressure wave through sample

Shock Hugoniot Experiments: flyer plate launched to impact sample

ZR Project

ZR: Balanced Objectives

Capability

More Energy & Current Delivered

- ✓Double energy stored
- ✓Design for z-pinch and material property applications

Capacity

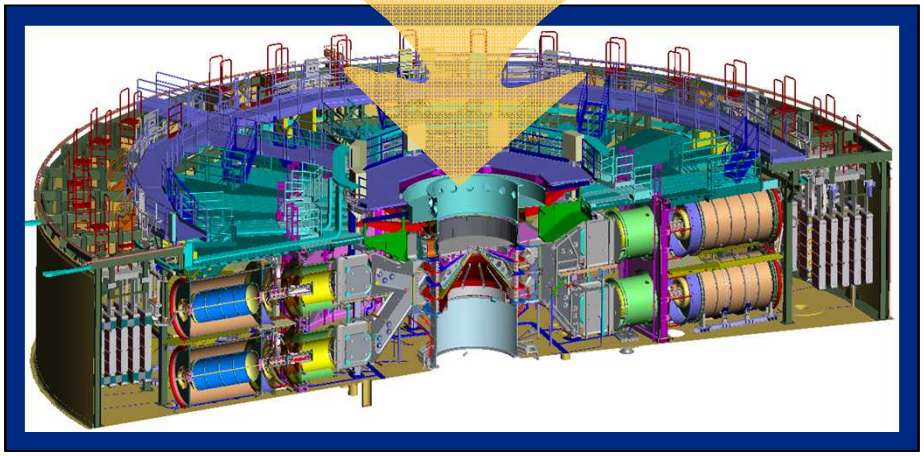
High Operational Reliability

- ✓Design drive system conservatively
- ✓Fabricate parts from stainless steel

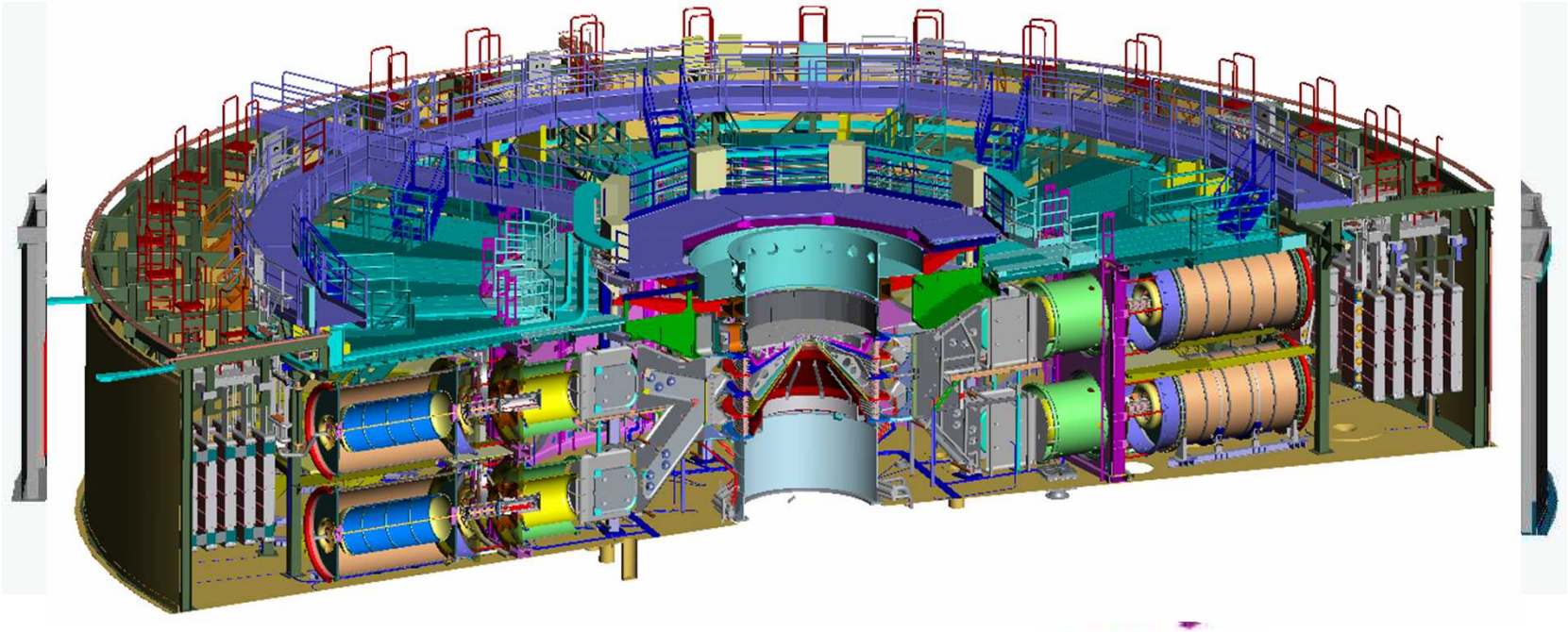
Precision

Better Repeatability, Pulse Shaping

- ✓Individual lasers
- ✓Longer Intermediate Storage Capacitors



ZR Project Timeframe



Planning & Architecture Development	Single Line Design & Fab	Single Line Test	Production Design & Fab	Installation & Test

2000	2001	2002	2003	2004	2005	2006	2007

Extreme MAKEOVER HOME EDITION

“Family” in Need

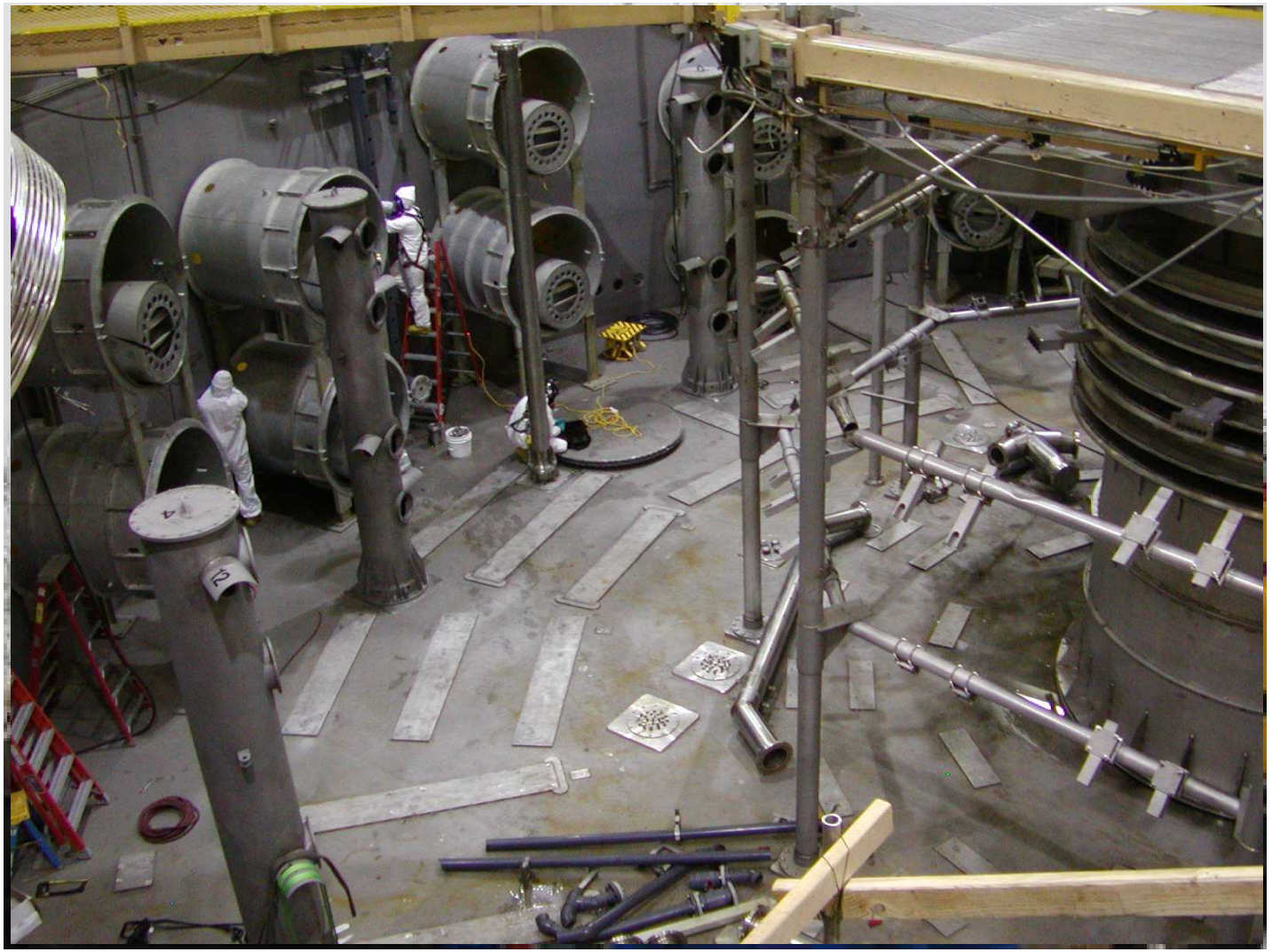
The Vacation

Design Teams

Construction Teams

Guy

Demolition



“Resources”

Extreme MAKEOVER HOME EDITION

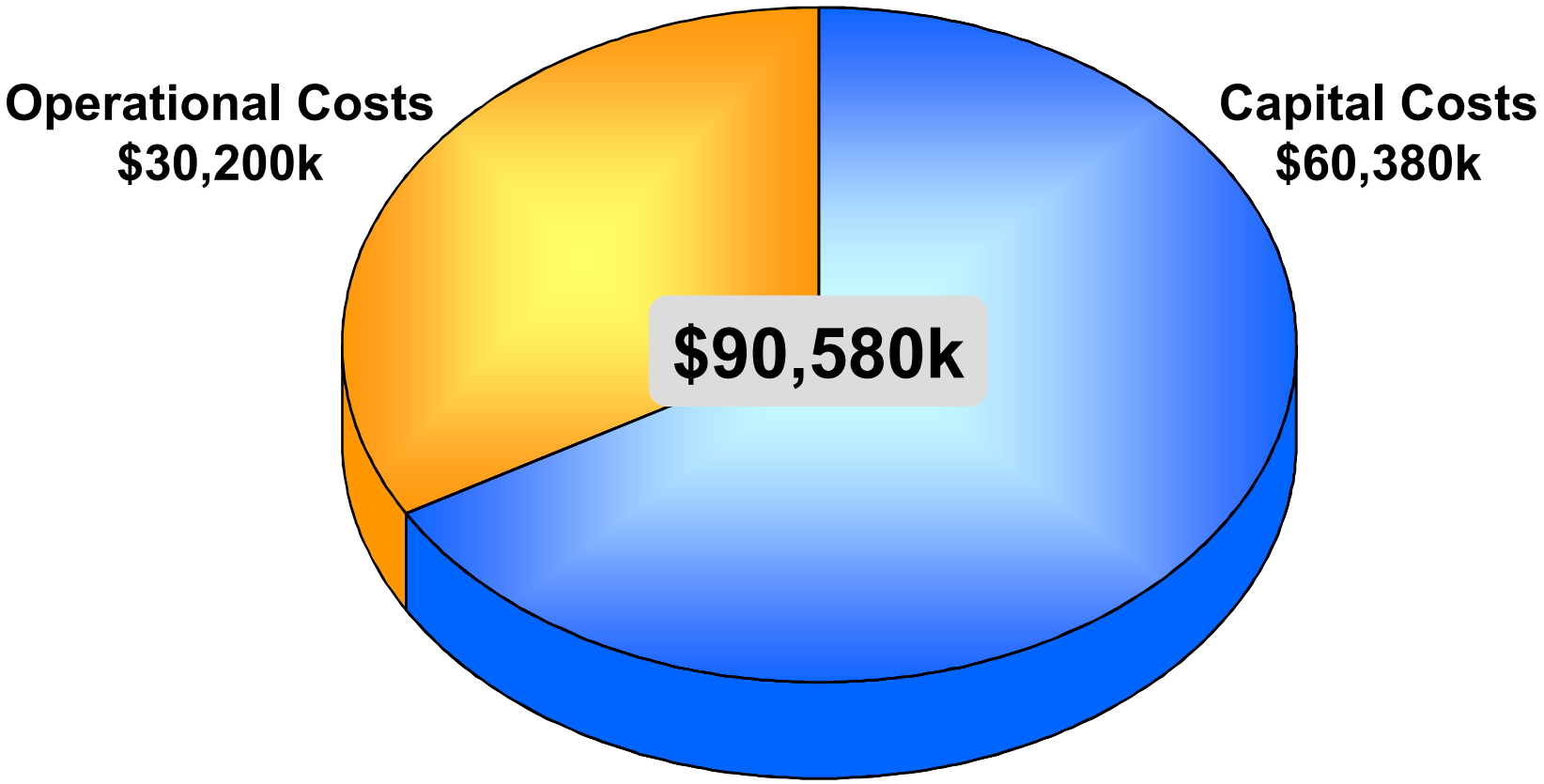
Sears

Appreciation to Many

“Move That Bus”


Z Refurbishment Project
Comprehensive DVD
• Long version
• Medium version
• Short version
• Long version 2
• Construction time lapse
DVD VIDEO
January 2008
Sandia National Laboratories
A DOE/NNSA National Laboratory
Copyrighted. Please contact Video Services at (505) 844-7167 for copies or footage.

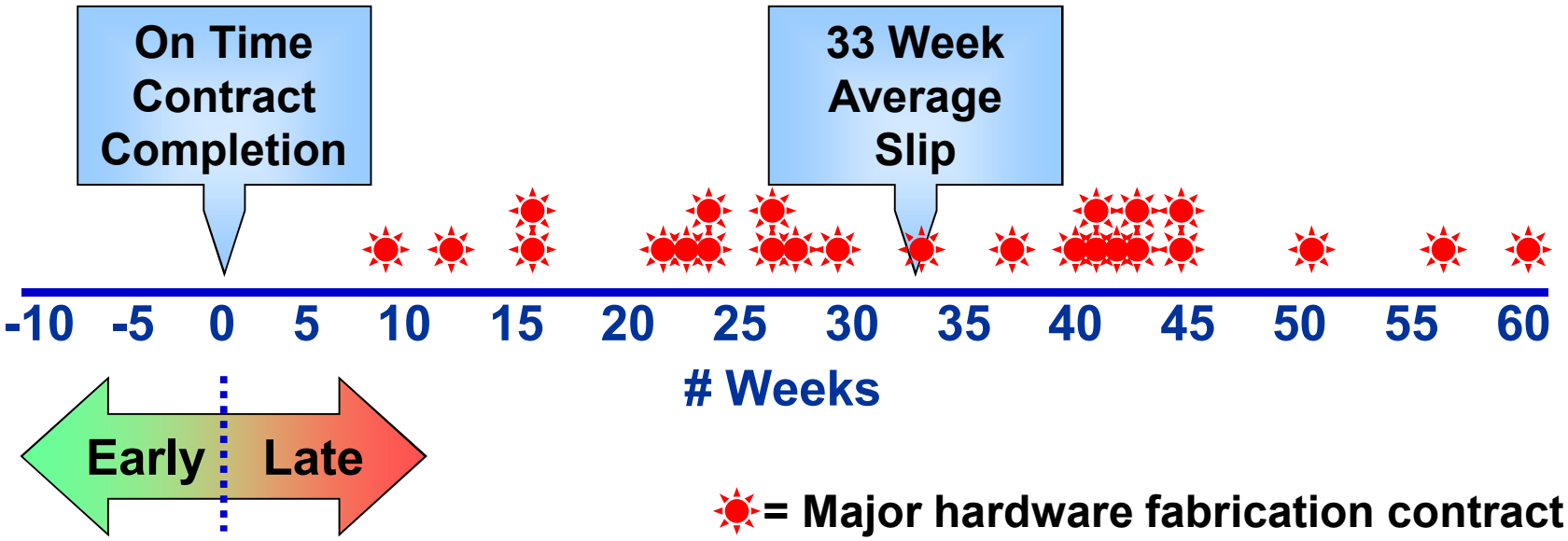
ZR Costs



Over 70% of $34M in manufacturing was with small businesses

Challenge: Tank Modifications

Challenge: Fabrication Deliveries



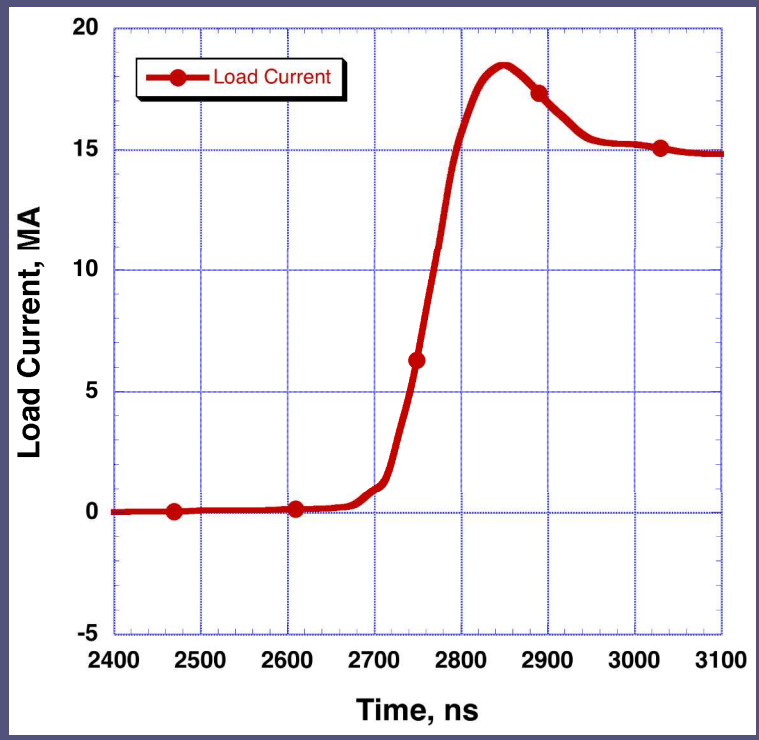
- Quality generally good
- Required agility during installation phase

Challenge: Workforce Coordination

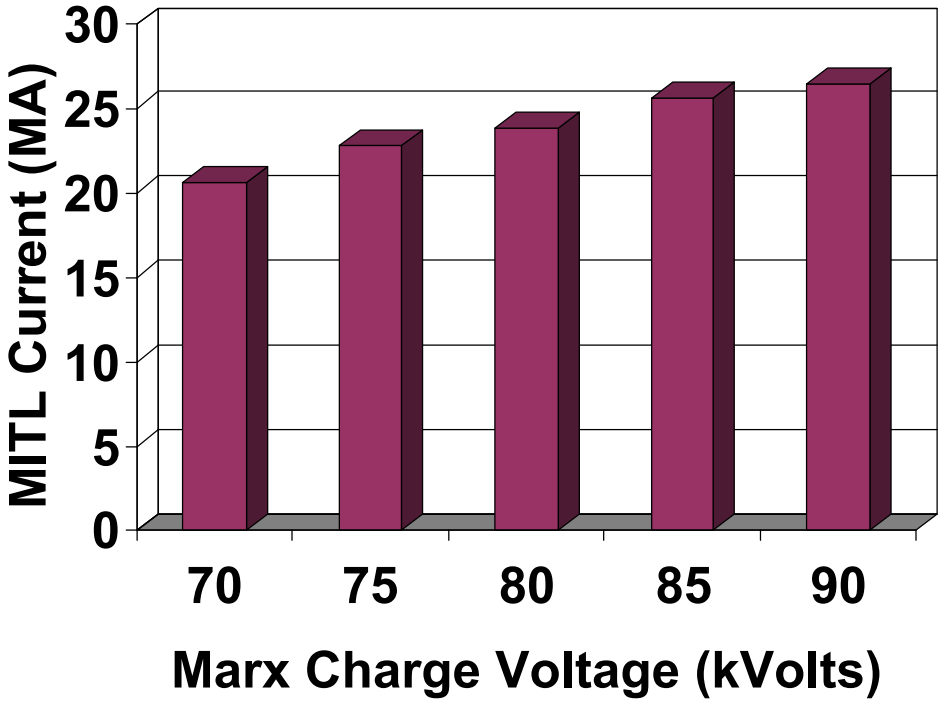
Success: Lasers & Pulse Shaping

- Individual lasers installed early 2003
- Key experiments 3 years ahead of upgrade

Success: In the End, It Works…



First Shot
September 17, 2007



Future

Inertial Confinement Fusion

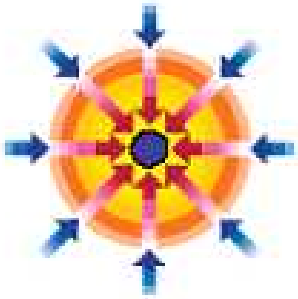
Target heating

X-rays rapidly heat surface, forming plasma envelope

Compression

Fuel compressed by blowoff of hot surface

Ignition

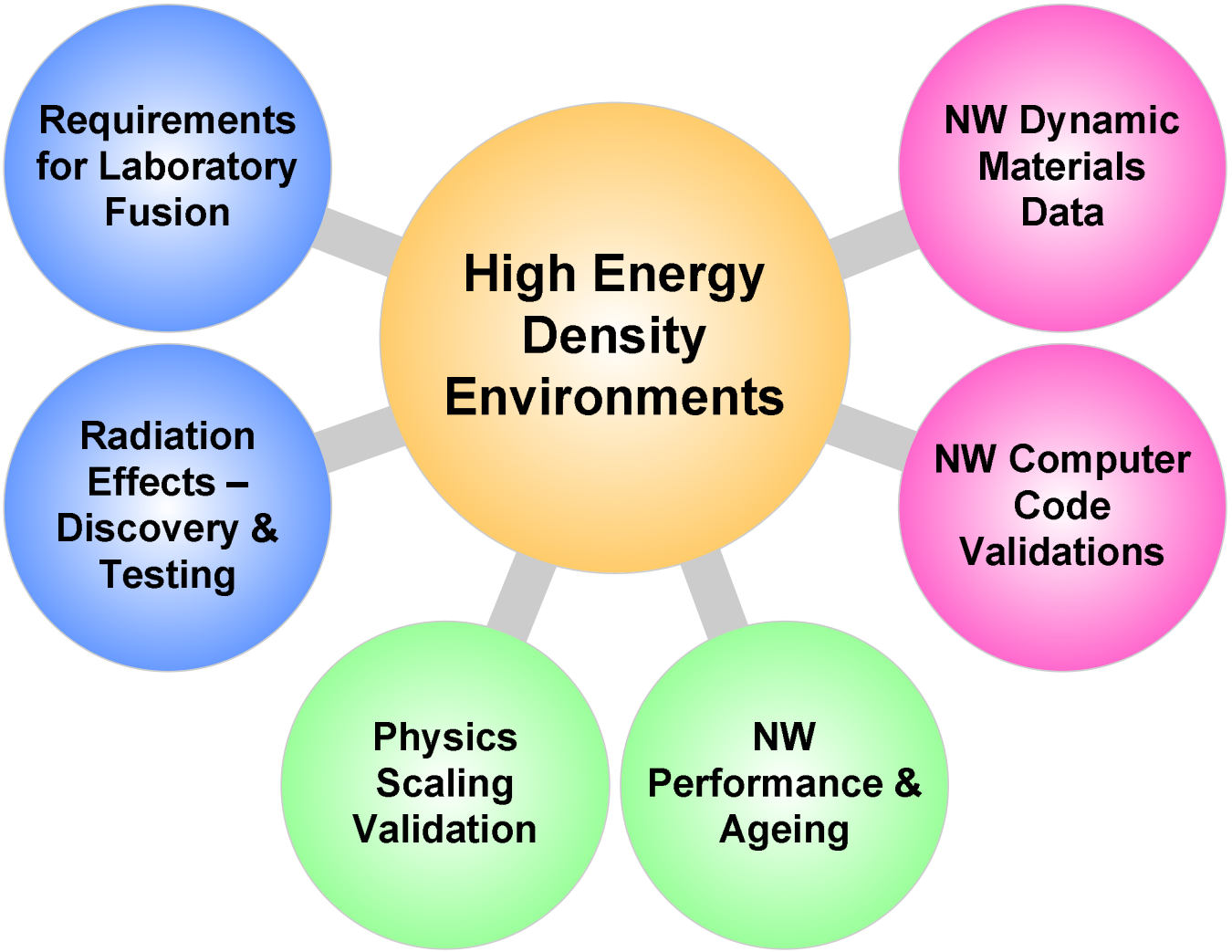


Density and temperature reach fusion ignition levels

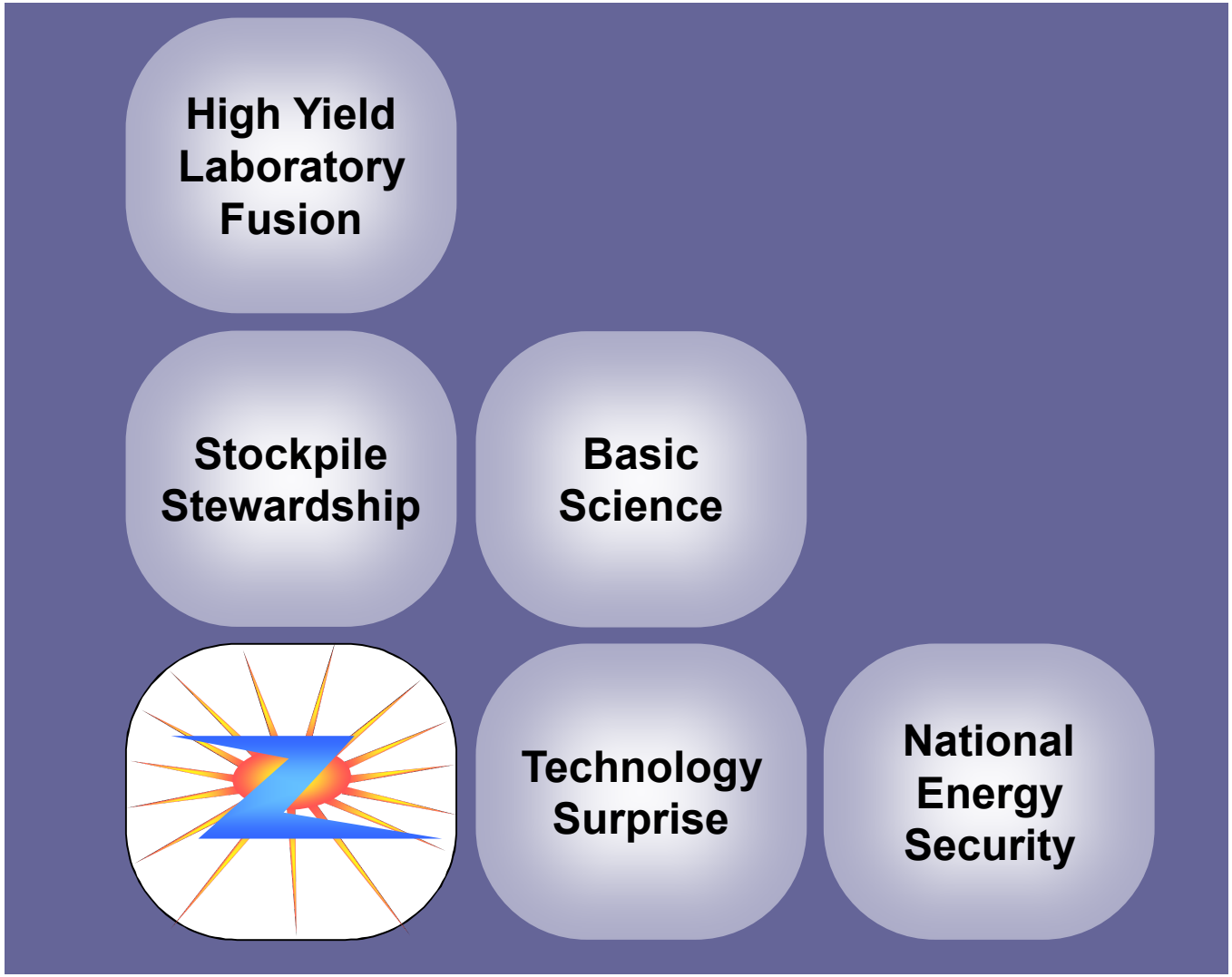
Burn

Thermonuclear burn spreads rapidly through fuel

Z's Near-Term NW Mission Support

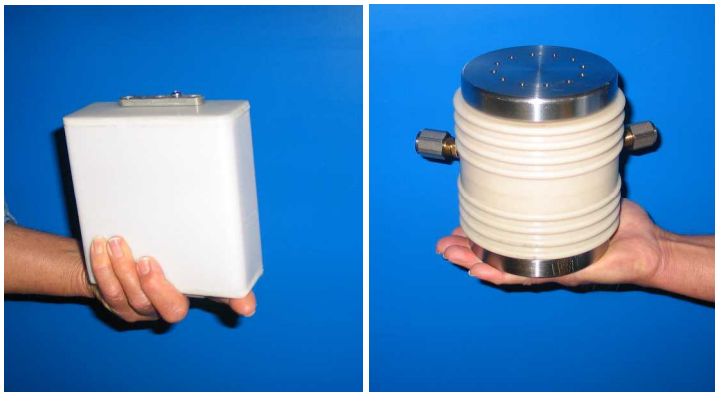


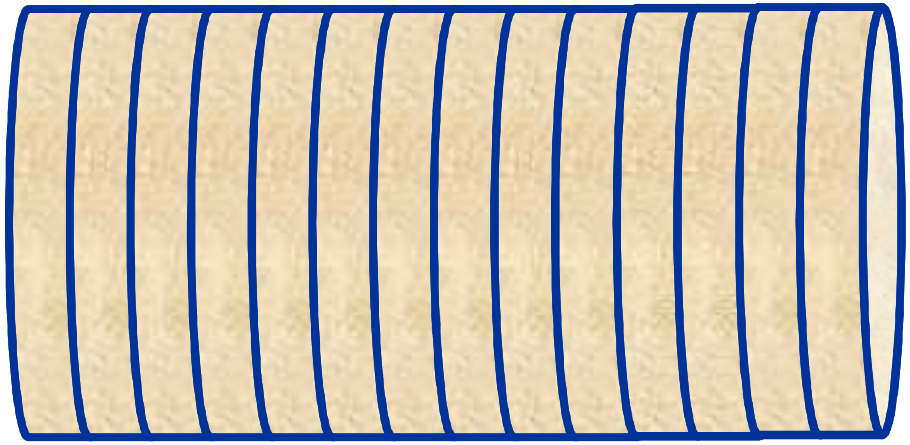
Stockpile in Focus, Fusion in View



Linear Transformer Driver

- May be revolutionary
- Compresses in 1 stage
- Simple modules
- Efficient
- Shoots 6 times/minute

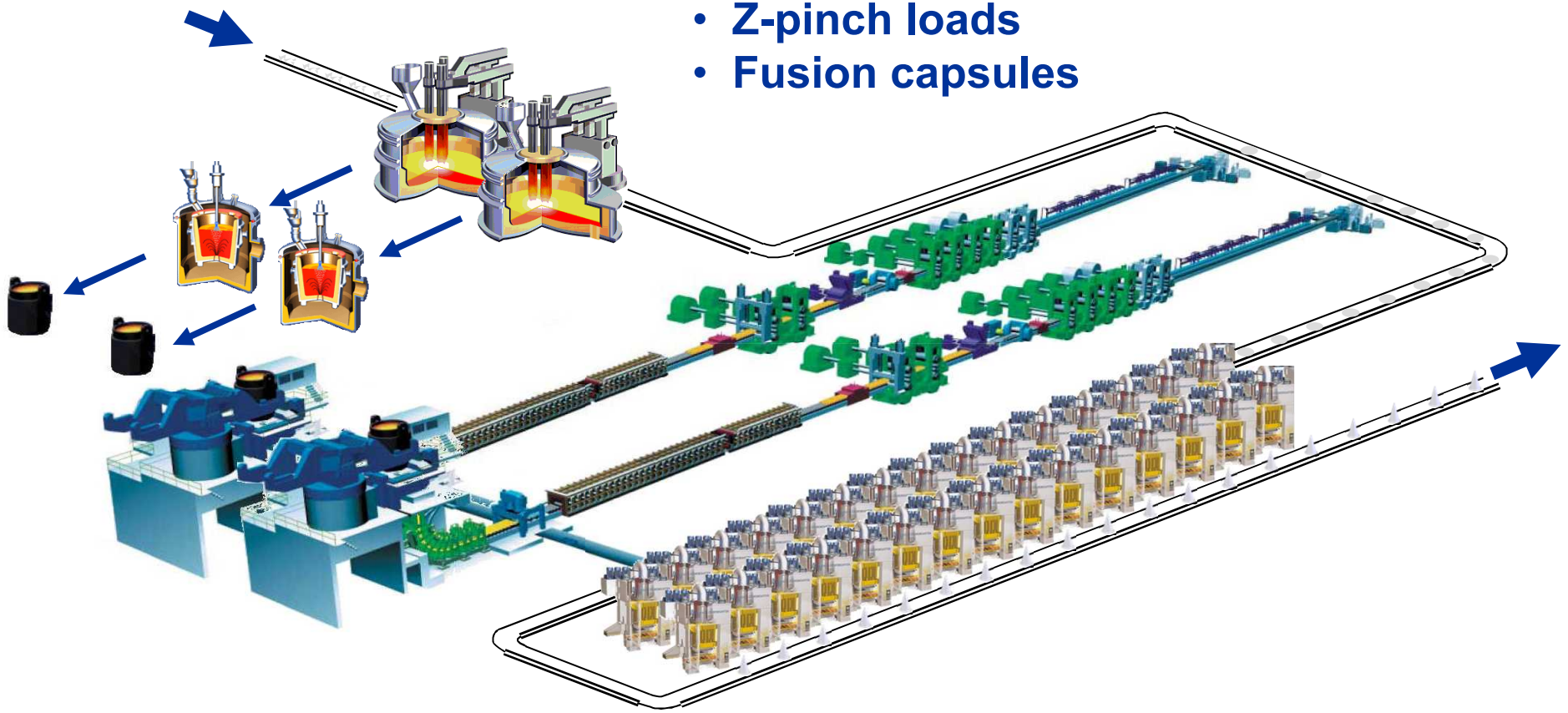




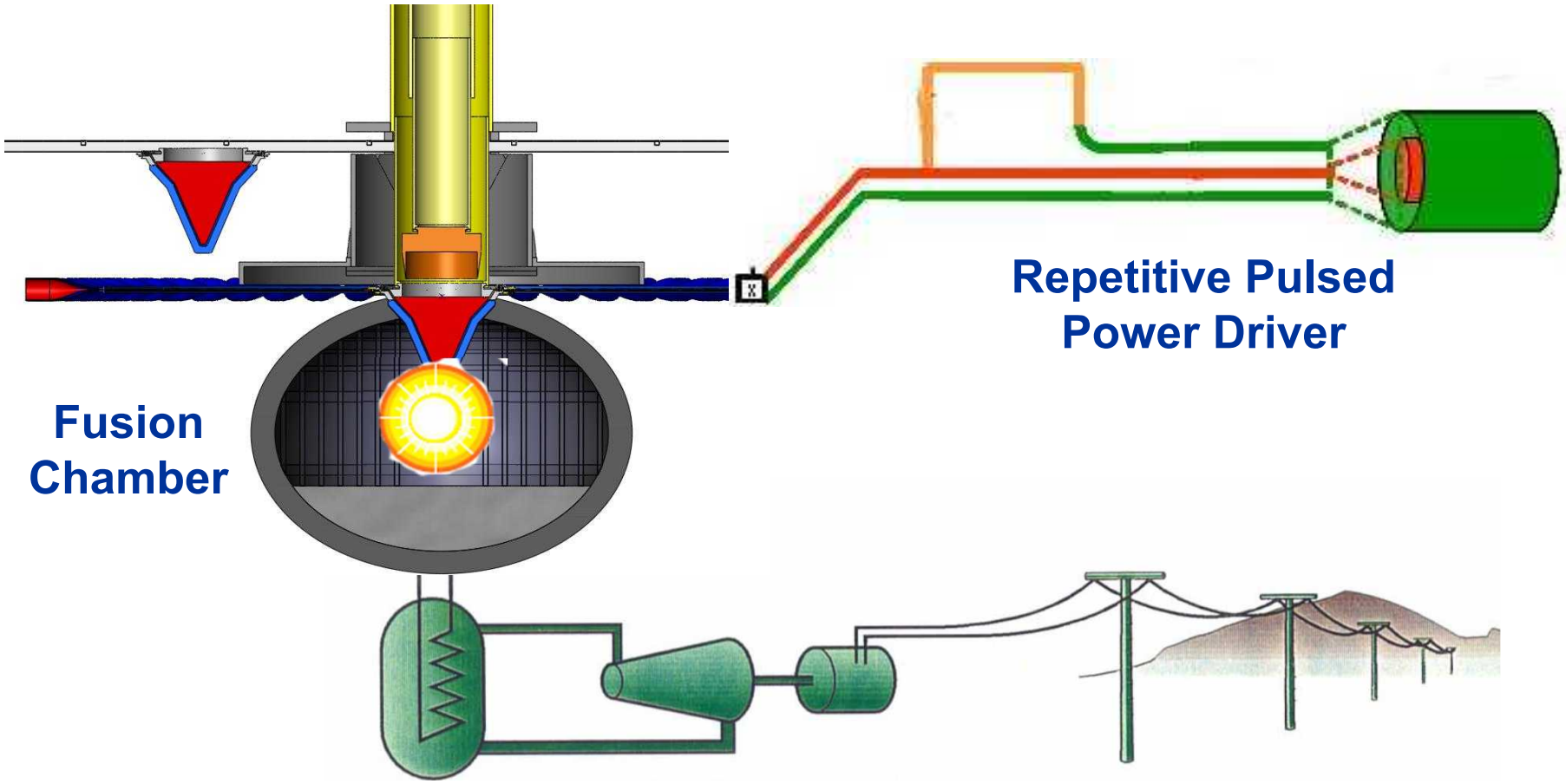
Practical Hurdles to Fusion Future

Consumables Factory

- Recyclable Transmission Lines
- Z-pinch loads
- Fusion capsules



Practical Hurdles to Fusion Future



Thanks!

Questions?