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Advances in X-Ray Generation at SNL

29th International Workshop on Physics of High Energy Density in Matter

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Sandia National Laboratories

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Z Backlighter

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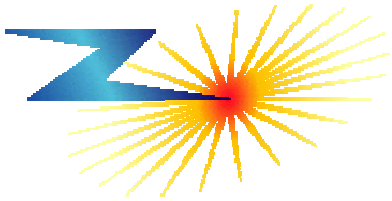
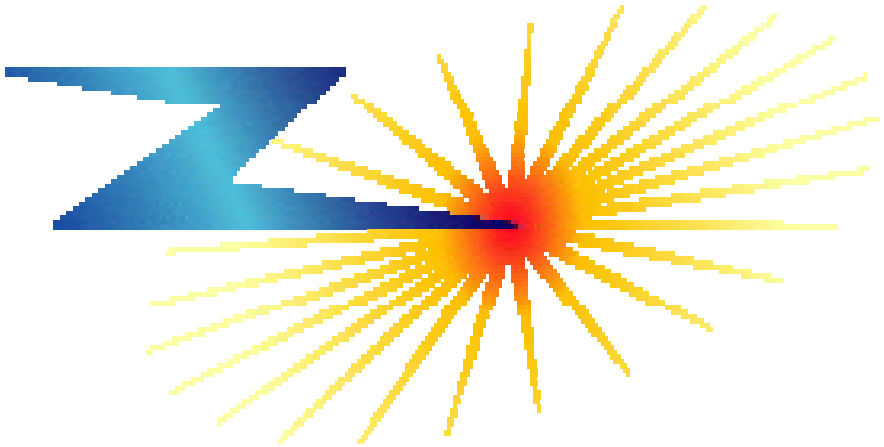
Outline

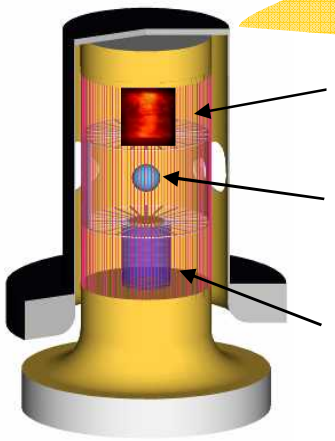
- The 2007/2008 upgrade of 
- Re-Design of the Z Backlighter Facility
- Double Frames / Double Color with Z Beamlet
- Higher X-ray Energies with Z Petawatt

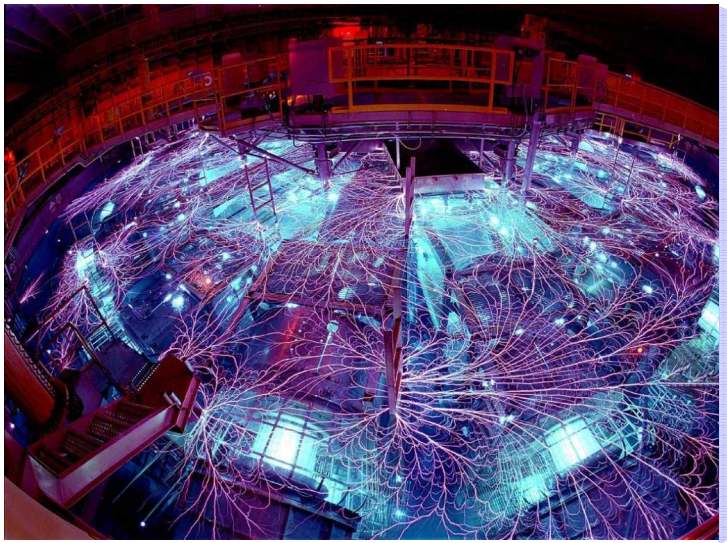
The Z-Accelerator



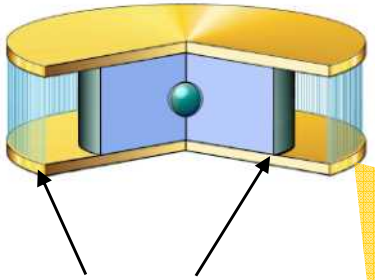
Original Z-Performance

- Peak density ~ 40 g/cc
- CR up to 20
- T_e up to 100 eV (10^6 °C)





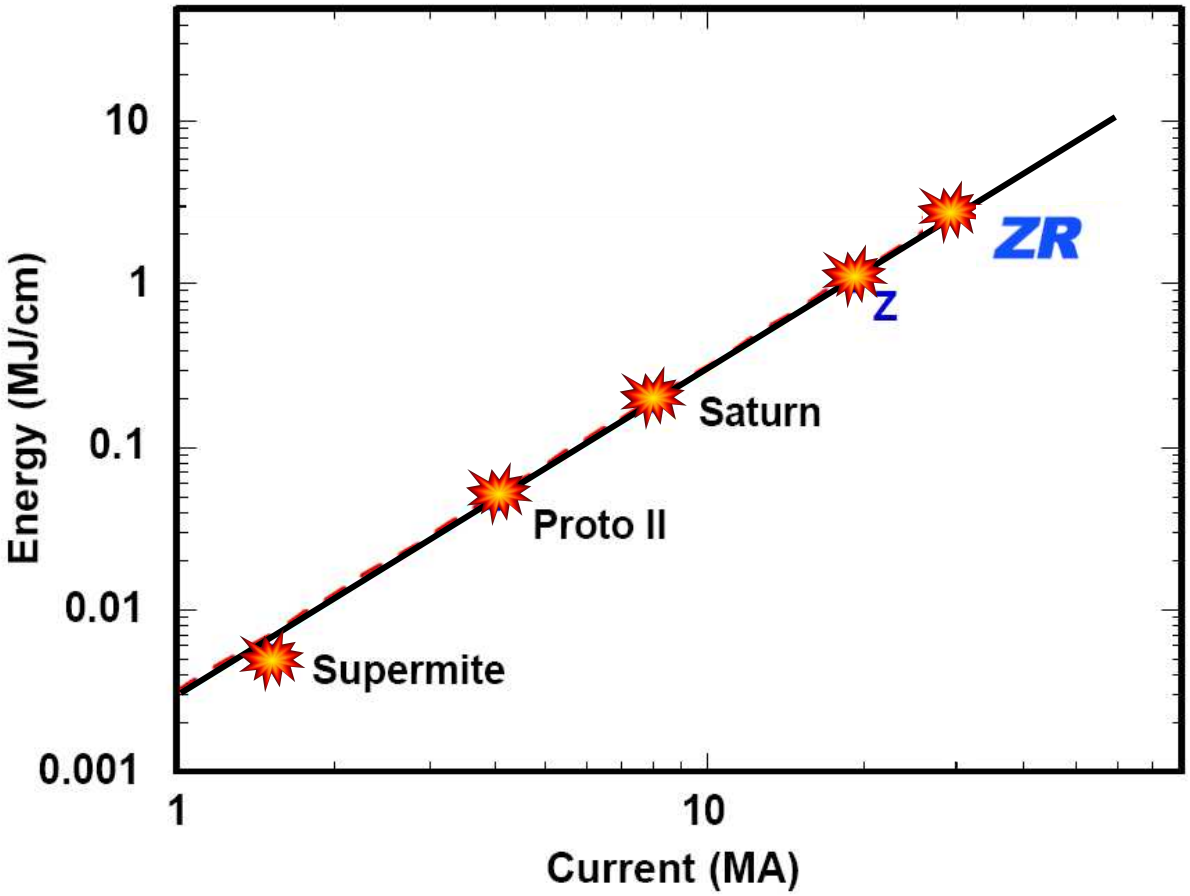
- $E_{x\text{-}ray}$ = 1.8 MJ
- I_{max} = 18 MA
- $P_{x\text{-}ray}$ = 250TW



Two nested, colliding, current carrying liners (pinches)

- Demonstration of D-D neutrons
- Maximum yield: > 10^{11} neutrons
- Convergence ratio: ~ 10
- Hohlraum temperature: ~ 220 eV
- Absorbed X-ray energy: ~ 24 kJ

Upgrading from Z to ZR



The ZR upgrade:

ZR = Z Refurbishment

New Design Parameters:

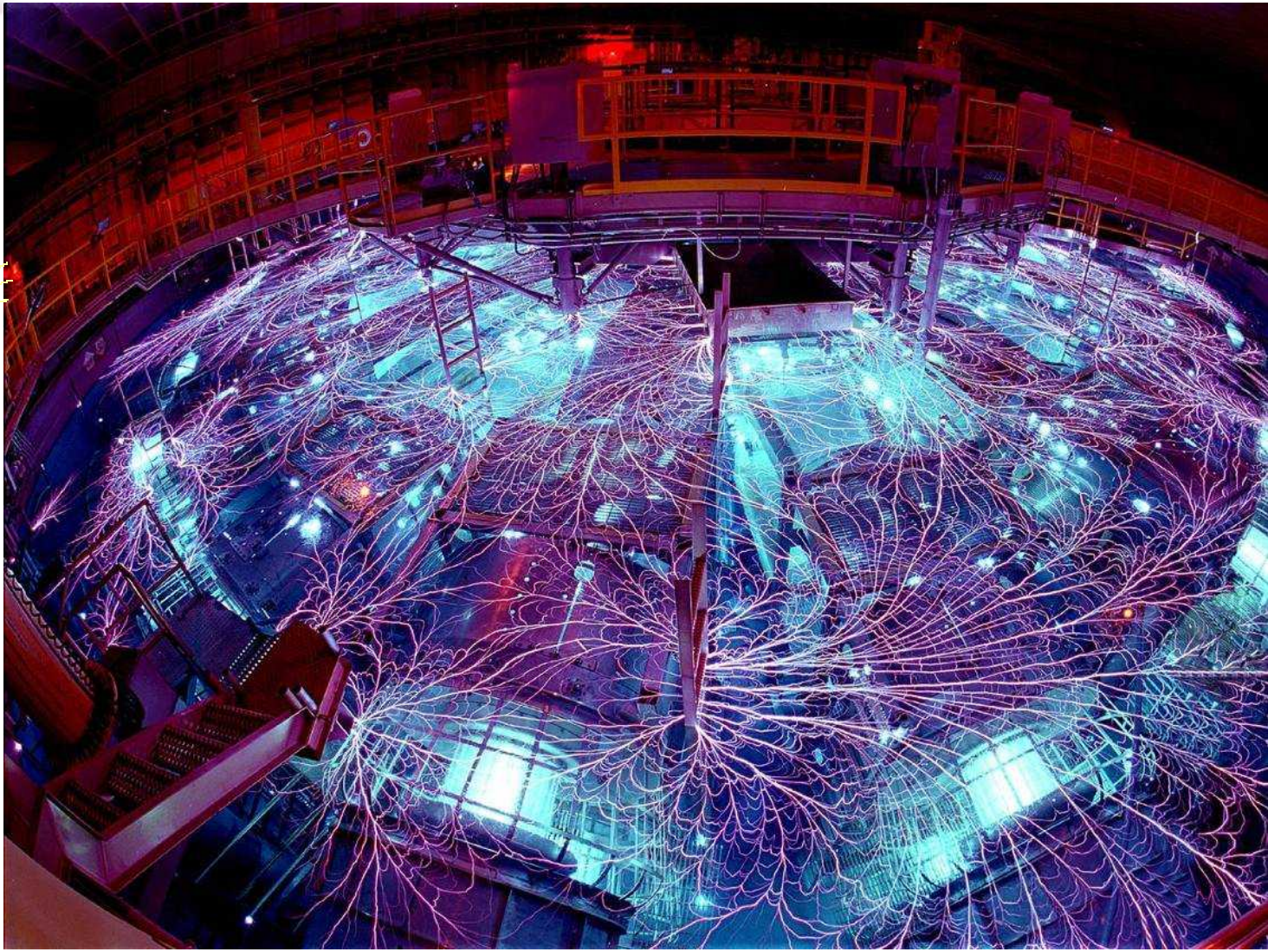
X-ray power: 350TW

X-ray energy: 3 MJ

Max. current: 26 MA

Conv. Ratio ~ 25

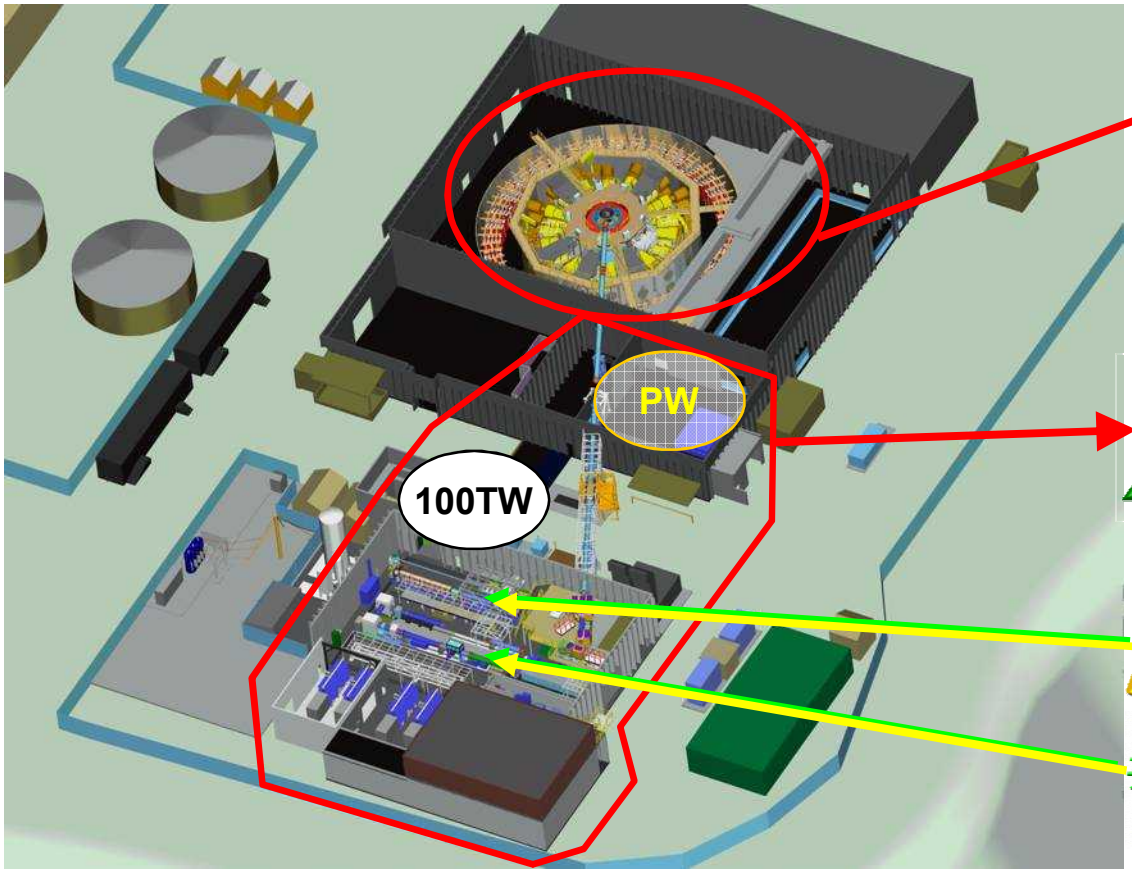
Completion of ZR



95 kV /
26 MA

The Z-Backlighter Facility

Facility Overview



Z

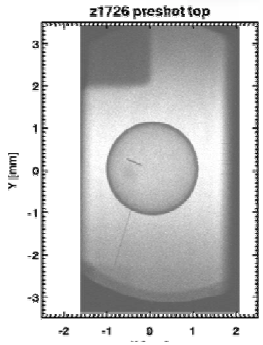
Z Backlighter

Z Petawatt

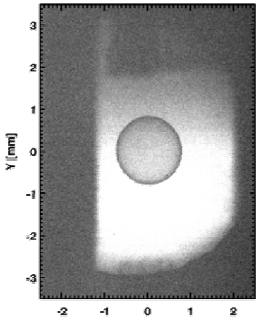
Z Beamlet

Two Frame Backlighting

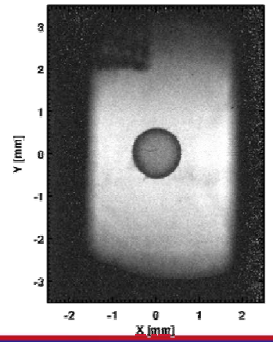
ZBeamlet



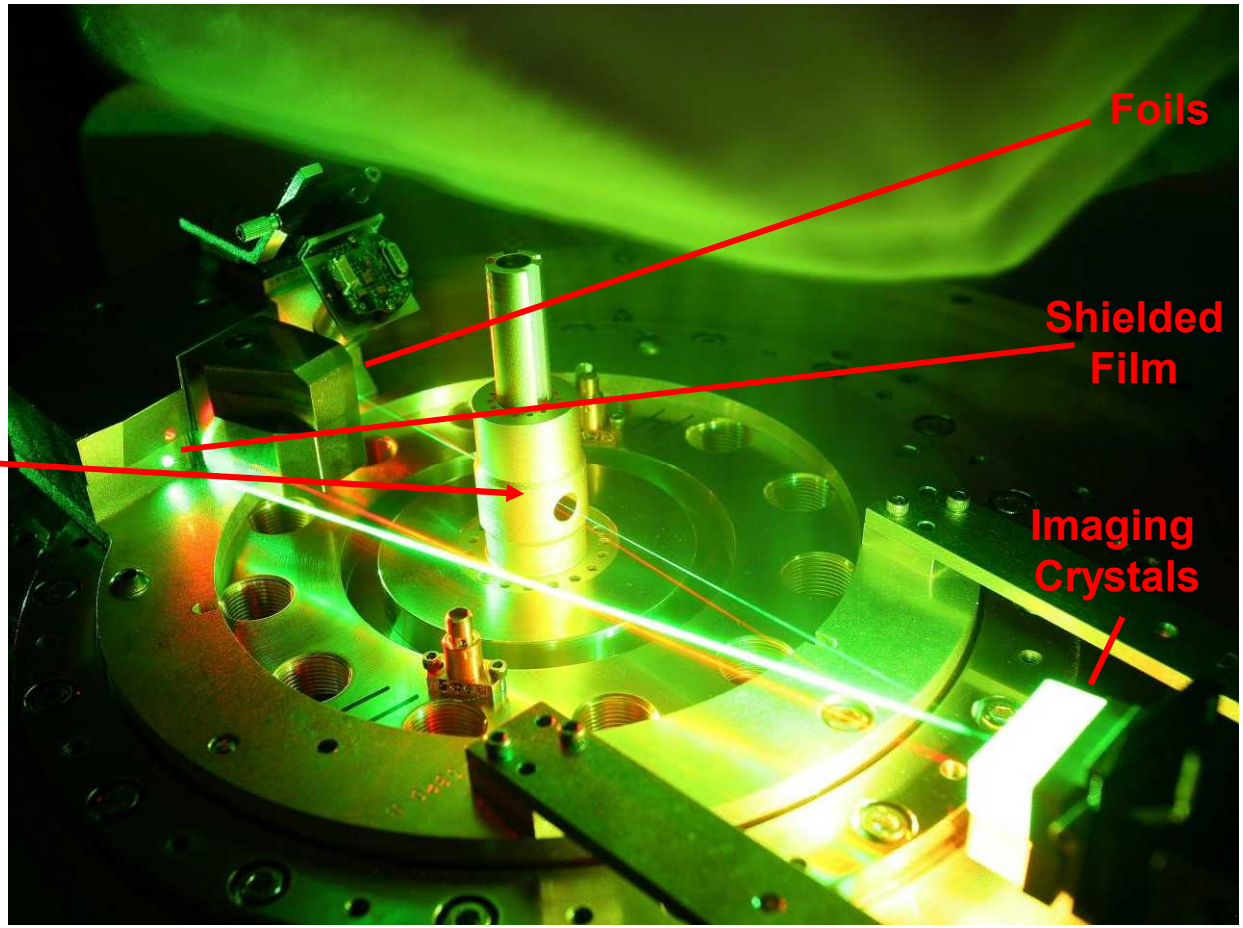
Δt=8ns



Δt=8ns



Two separate pulses go through the system at slightly different angles:



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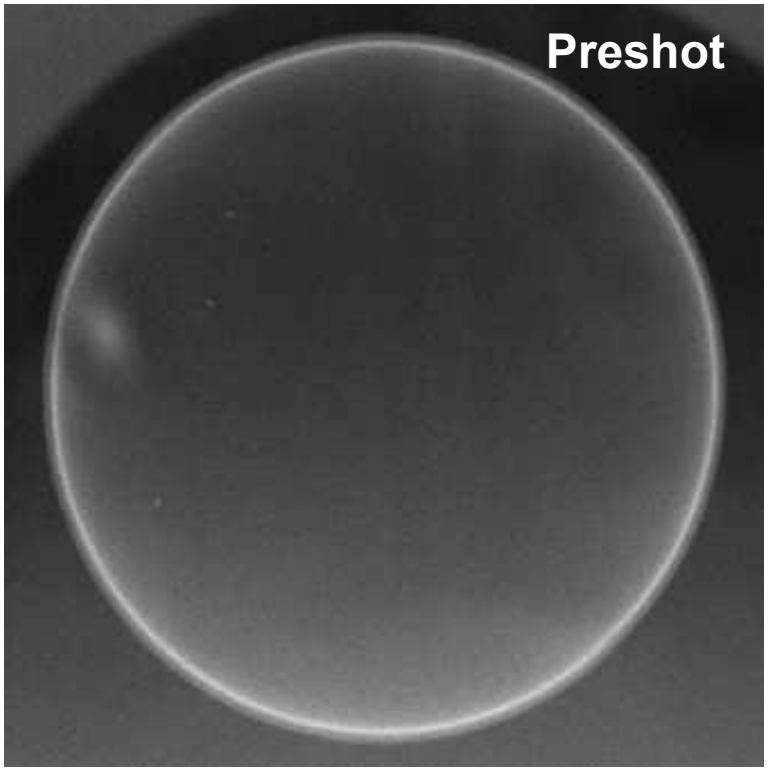
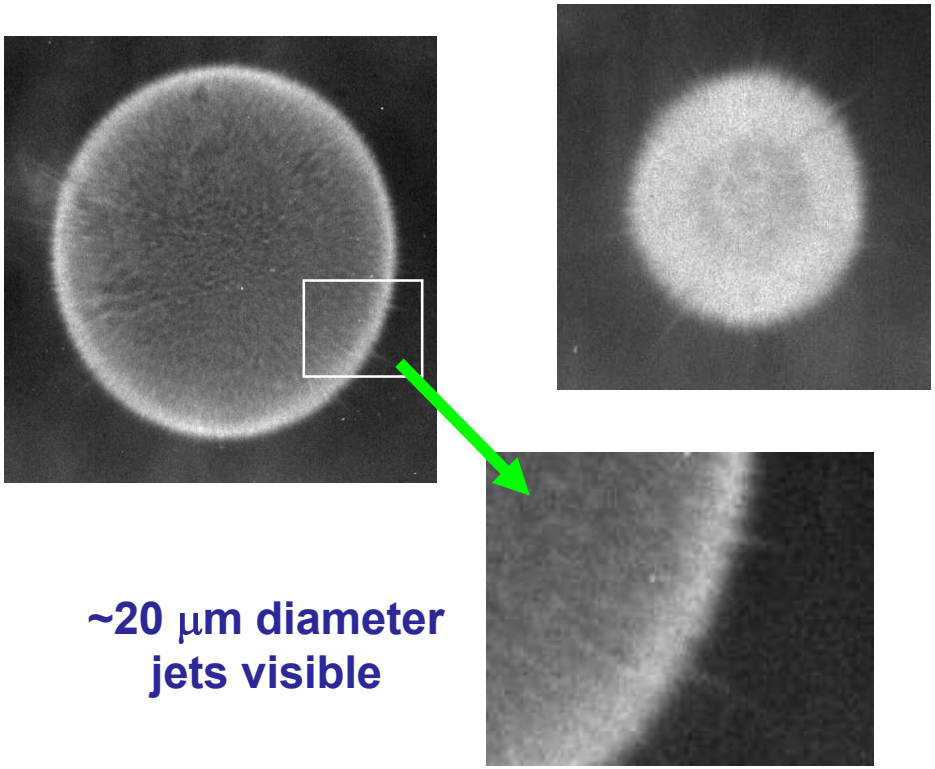
High spatial resolution bent-crystal imaging system revealed new features in imploding capsules

3.4-mm diameter plastic ICF capsule

Capsules had 100s of known defects on surface that apparently produced a myriad of small jets





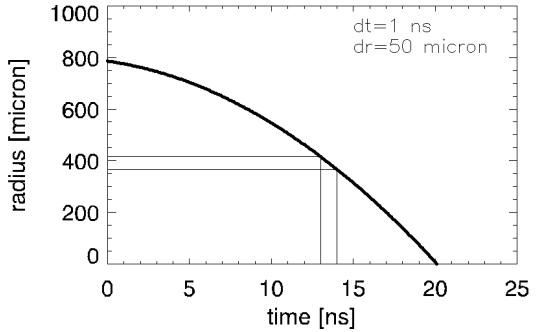
~20 μm diameter jets visible

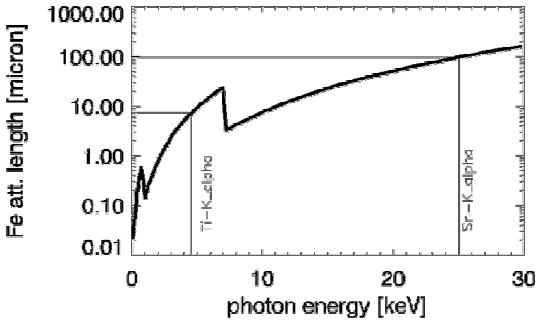
Challenges for Improved Backlighting

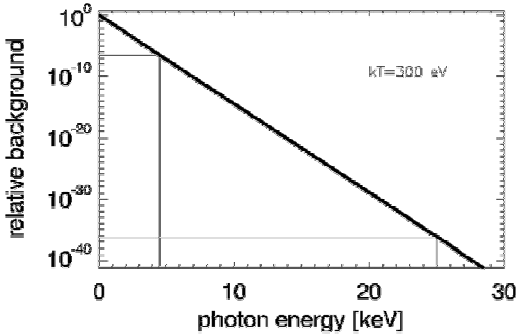
Motion Blur
- ➢ Shorter Pulses

Higher Densities
- ➢ Higher Photon Energies
  - ➢ Higher Laser Intensities

Higher Source Background
- ➢ Higher Photon Energies
  - ➢ Higher Laser Intensities







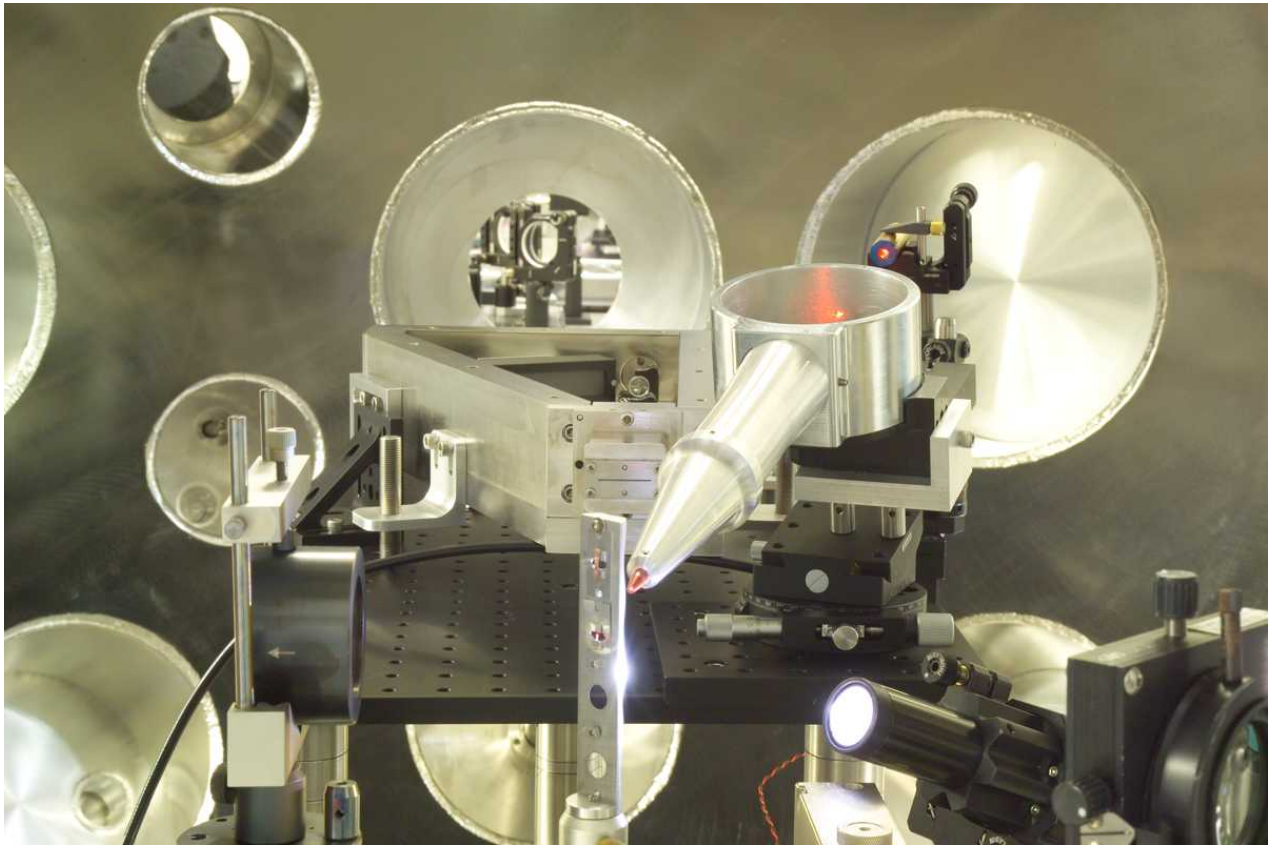
A New Beamline to Z

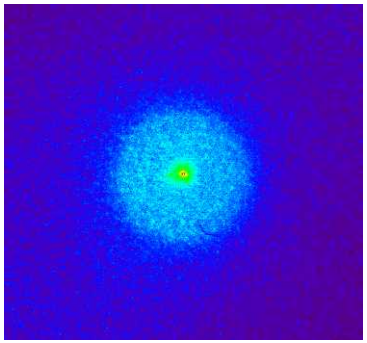
A 60m throw is needed to couple the Z-Backlighter to the Z-Accelerator.

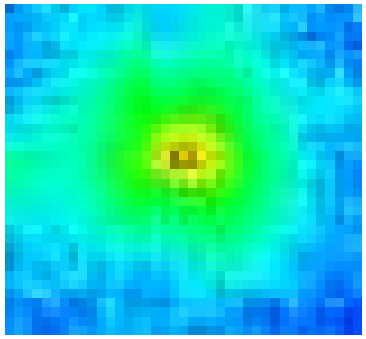
The original connection bridge between the two buildings had space for only one beam tube.

ZBeamlet

Characterization of X-Ray Sources



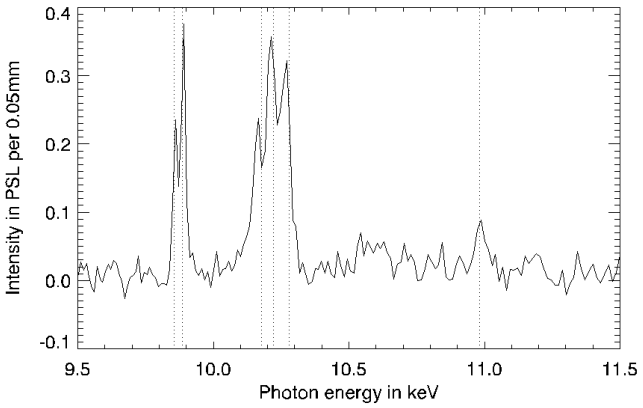




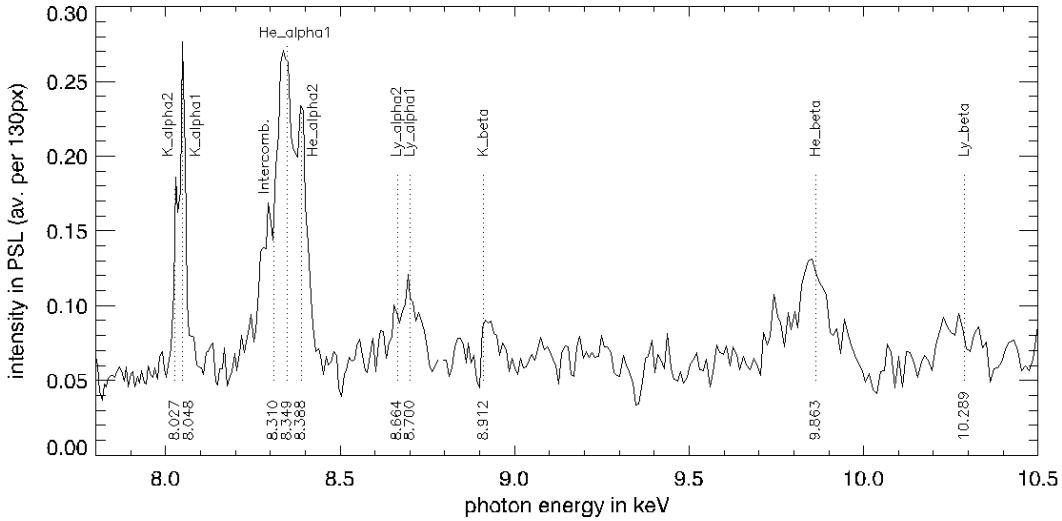
45 J shot on 100 μm Cu,
FWHM = 11 μm,
-> 8E19 W/cm²

Characterization of X-Ray Sources

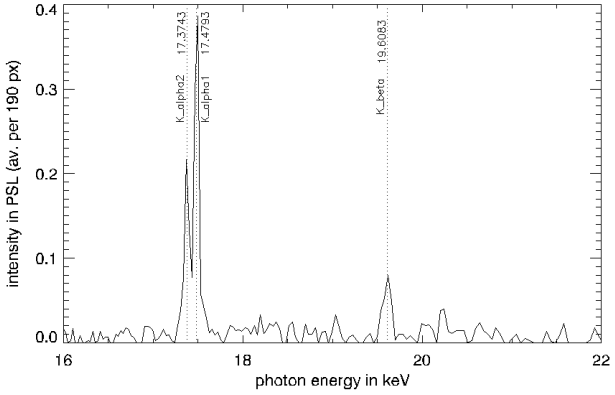
500 µm Ge



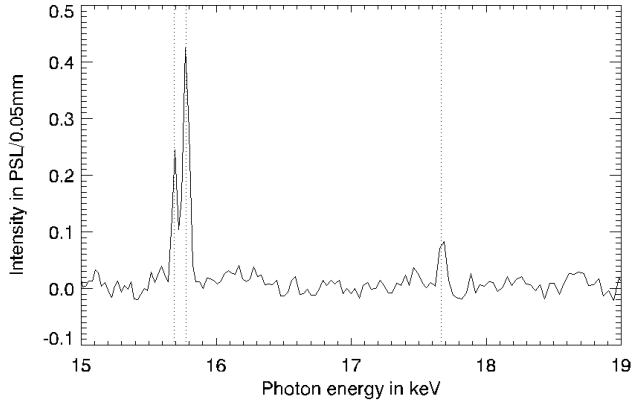
100 µm Cu



20 µm Mo

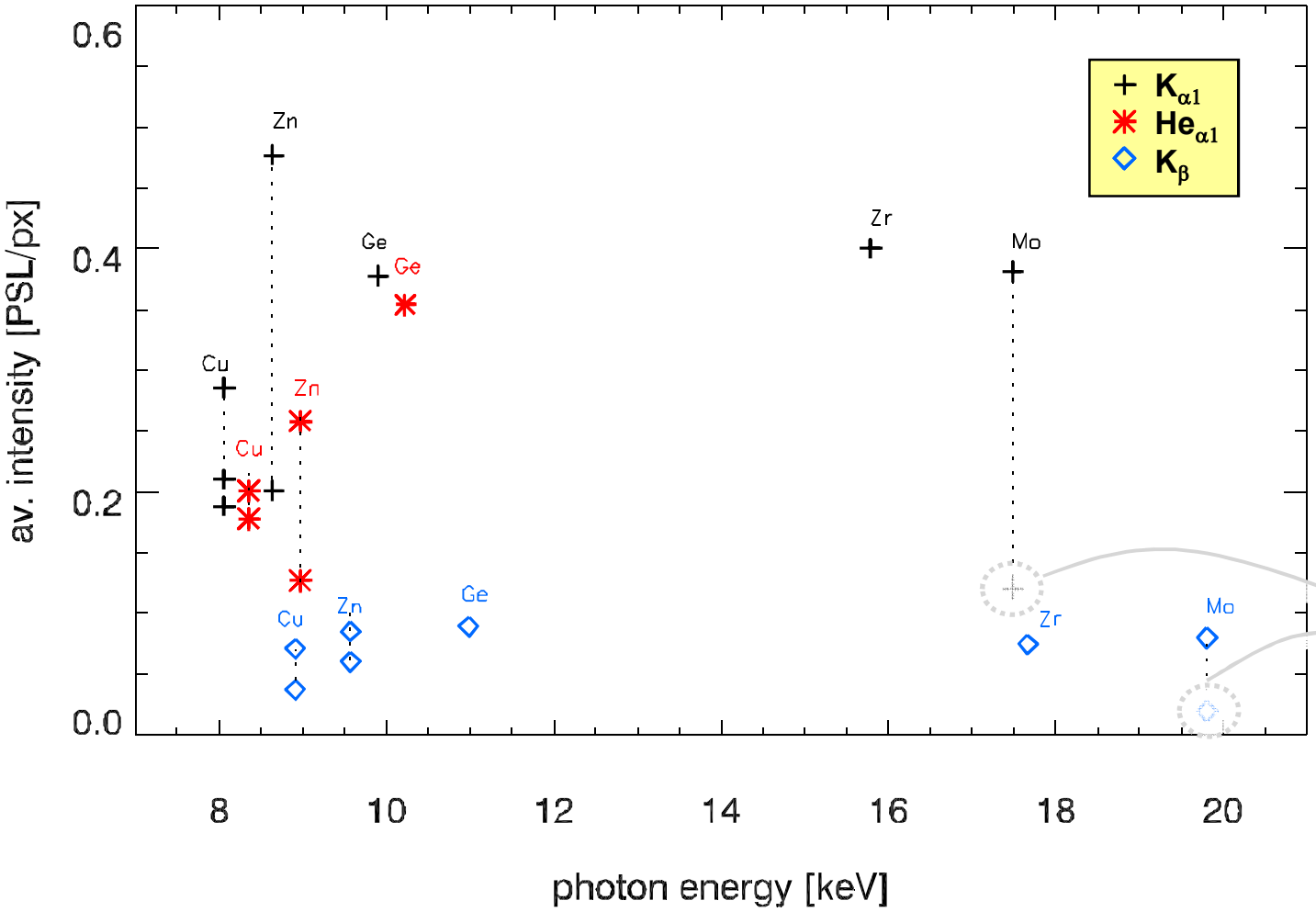


100 µm Zr



Characterization of X-Ray Sources

Maximum Line Intensities (normalized to 41J Laser Energy*)



Shot series performed at 41±3.8J

3-day readout delay