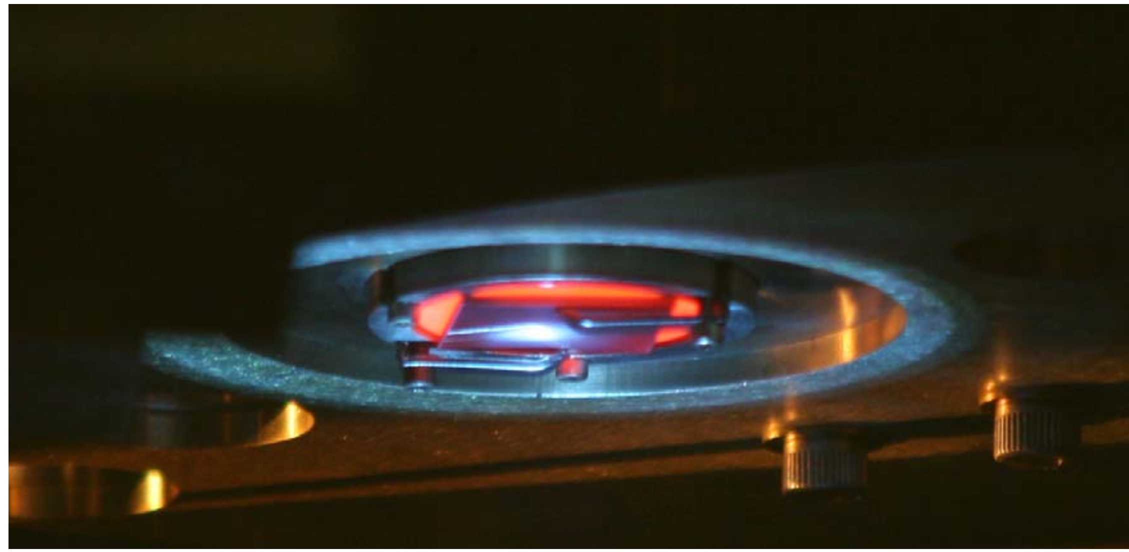
XAPPER Update: March 2005



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HAPL Program Workshop

Naval Research Laboratory

March 3-4, 2005

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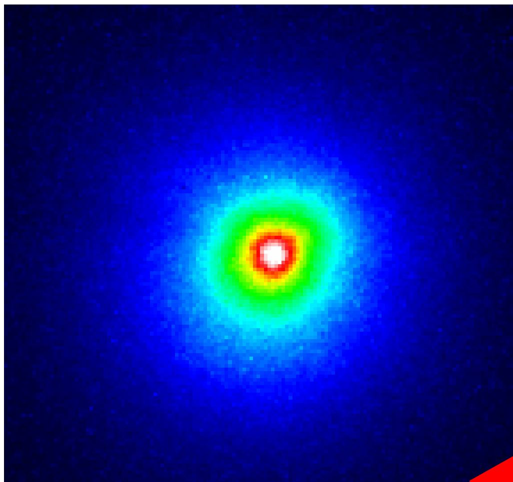
Overview

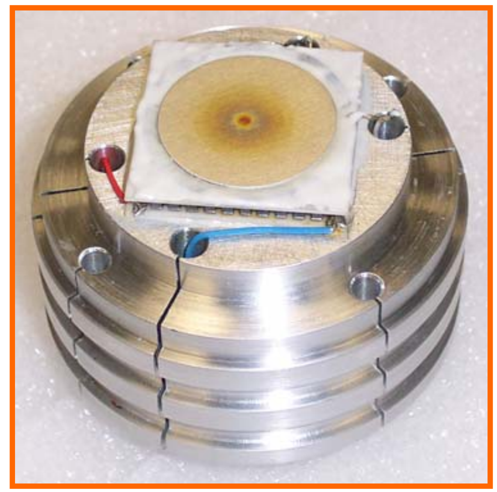
- X-ray fluence measurements:
  - How we measure the fluence
  - Problems with rep-rated measurements
  - Paths forward
- Sample heater operational
- Non-contact optical thermometer installed
- Heated tungsten exposure #1
- Next steps

How we measure XAPPER's x-ray fluence



CCD

+

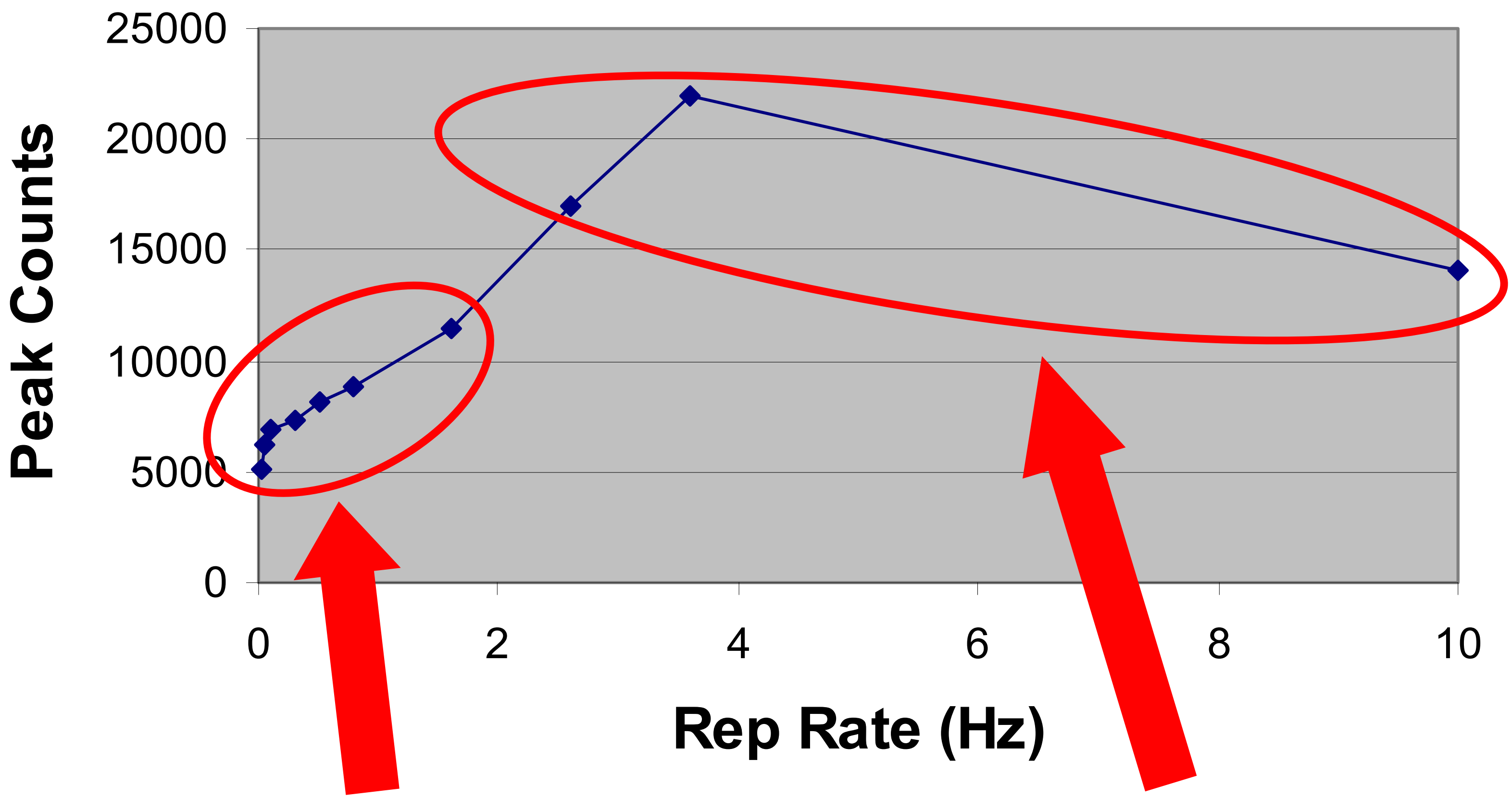


Calorimeter

= ***x-ray fluence***

CCD measurements are limited to ~2 Hz due to the time required to transfer the images

We recently realized that XAPPER output appears to be rep-rate dependent

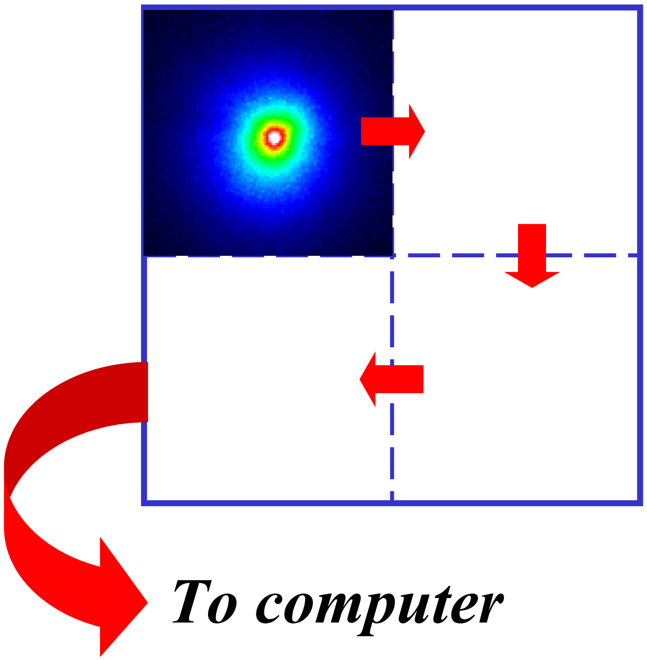


Results are believable, as CCD is able to keep up

Results are likely to be garbage; multiple shots arrive during image transfer; we observe "stars" and streaking

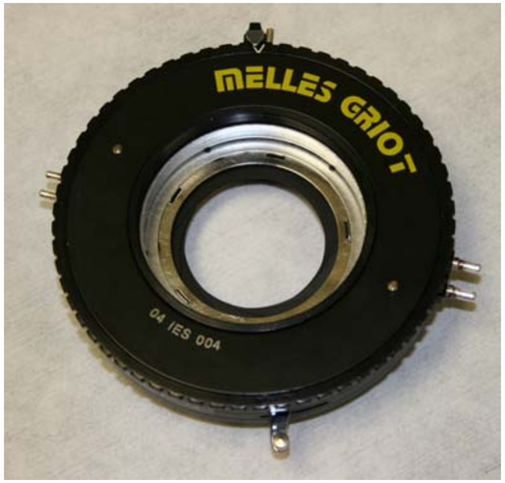
We have (at least) three paths forward to complete 10 Hz fluence measurements

1. Switch current CCD camera to "kinetics mode"
   - use ¼ of chip for current image
   - shift to next section and eventually out to CPU
   - issue: still may not get to 10 Hz



We have (at least) three paths forward to complete 10 Hz fluence measurements

2. Install shutter inside vacuum chamber
   - open for single image
   - close for next 2-5 seconds
   - open for next image
   - issues:
     - adequate space near camera
     - possible occlusion of beam on way to/from optic
     - need for shutter to remain open during irradiations
     - occupies another chamber port for power and control

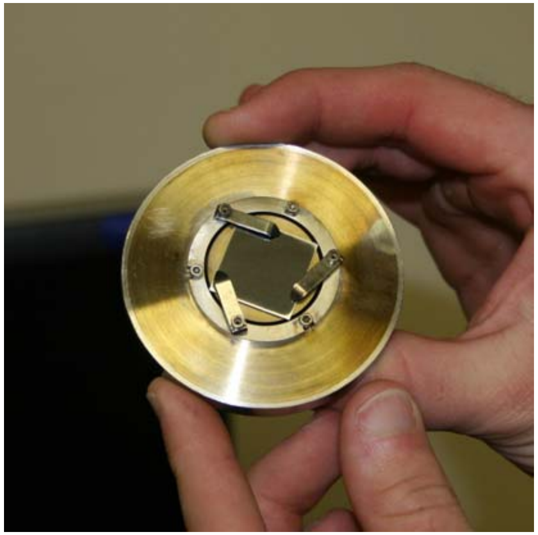


We have (at least) three paths forward to complete 10 Hz fluence measurements

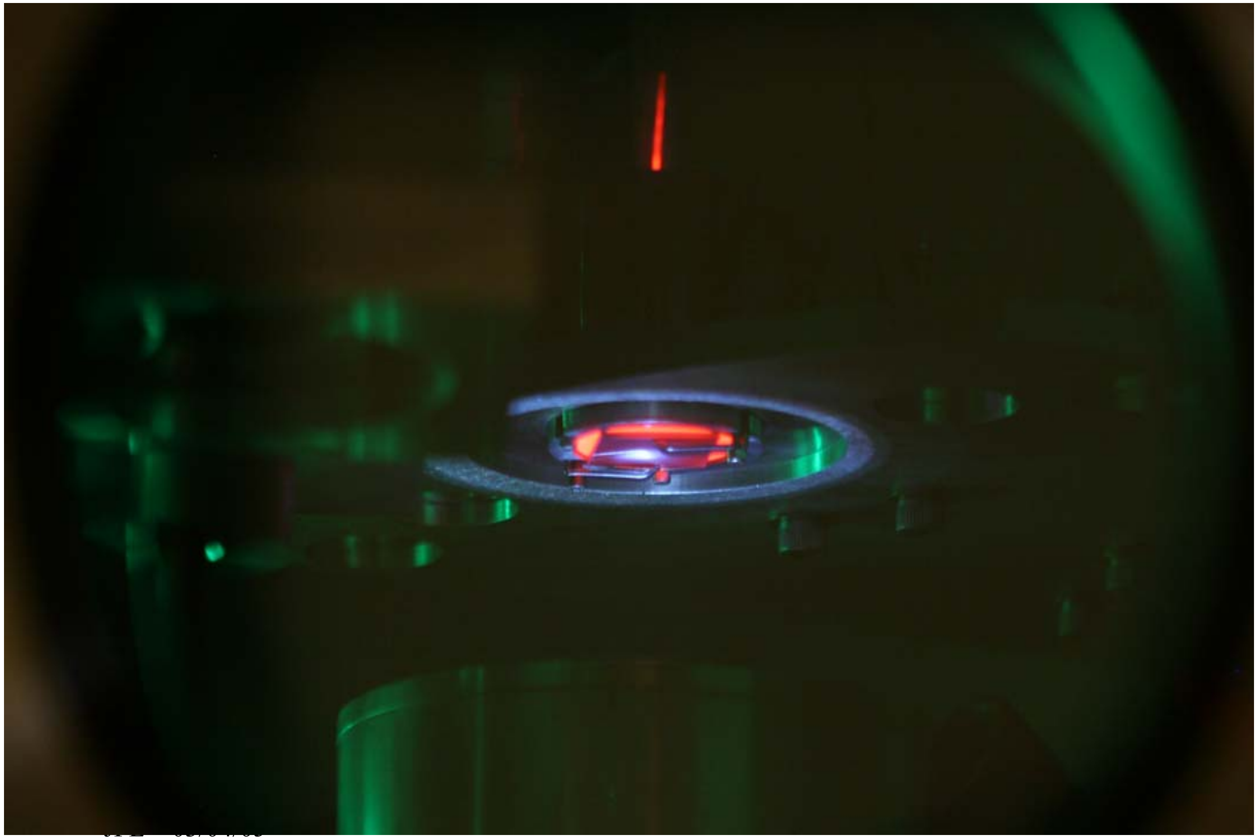
3a. Replace camera with one with a smaller chip
- 512 x 512 (vs. 1340 x 1300) is 6.6x smaller
- smaller camera capable of using 5 MHz (5x faster) ADC
- able to support 50-100 Hz imaging
- issue: additional expense & time

3b. NRL has demonstrated phosphor coating on CMOS sensors to make them x-ray capable:
- should be possible with 1/3” (640 x 480) CCD
- inexpensive (few k$) and fast (30 Hz)
- issue: cheaper procurement but some R&D

The sample heater is functional



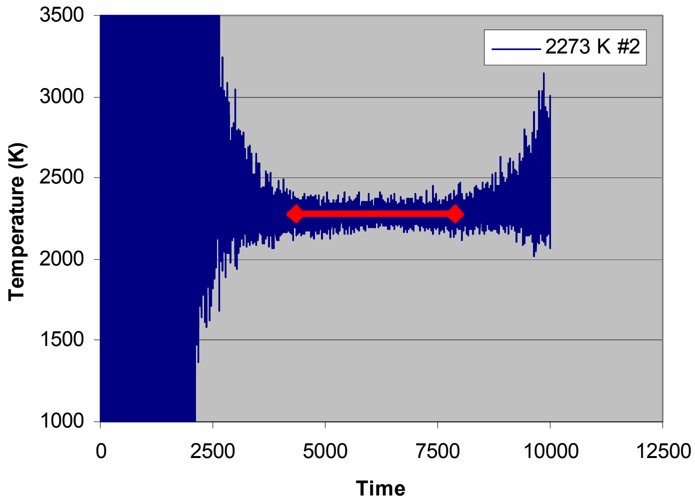
- HeatWave 1” diameter heater and controller
- Able to heat samples up to 1200 ºC

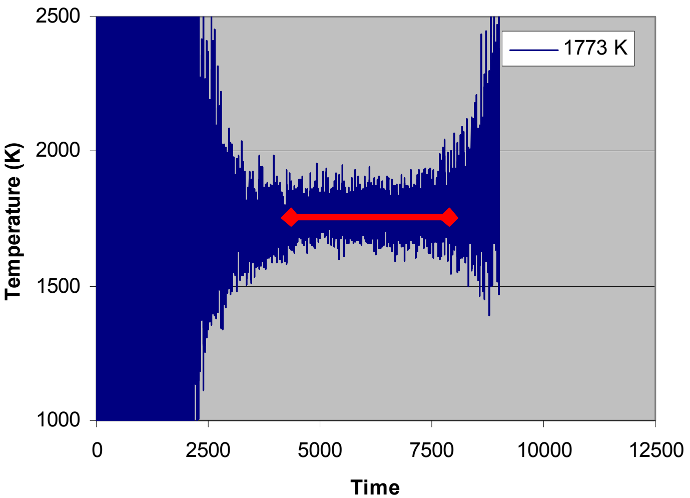


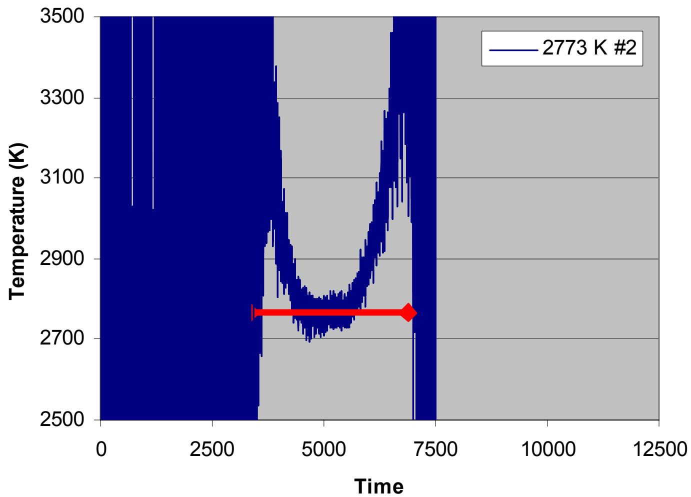
XAPPER, The Movie

The thermometer has been installed

- Contracted with UCSD for non-contact optical thermometer; installation just before Christmas
- Problems with Matlab "grabbing" traces from digitizing scope → switched to doing calculations within the scope
- Calibration outside the chamber looks great

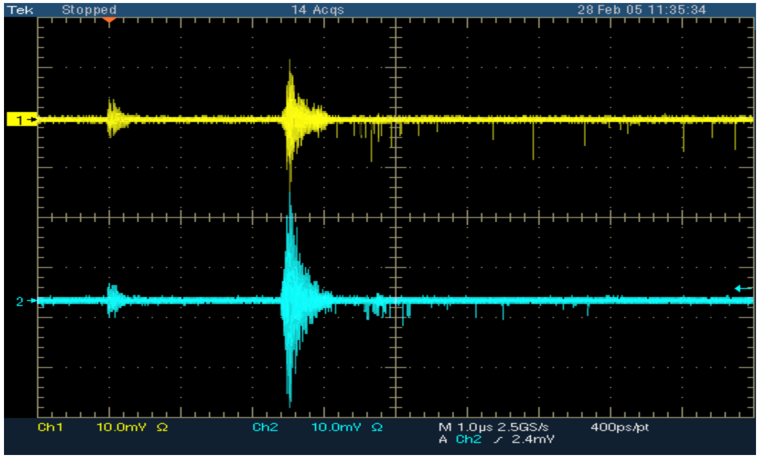




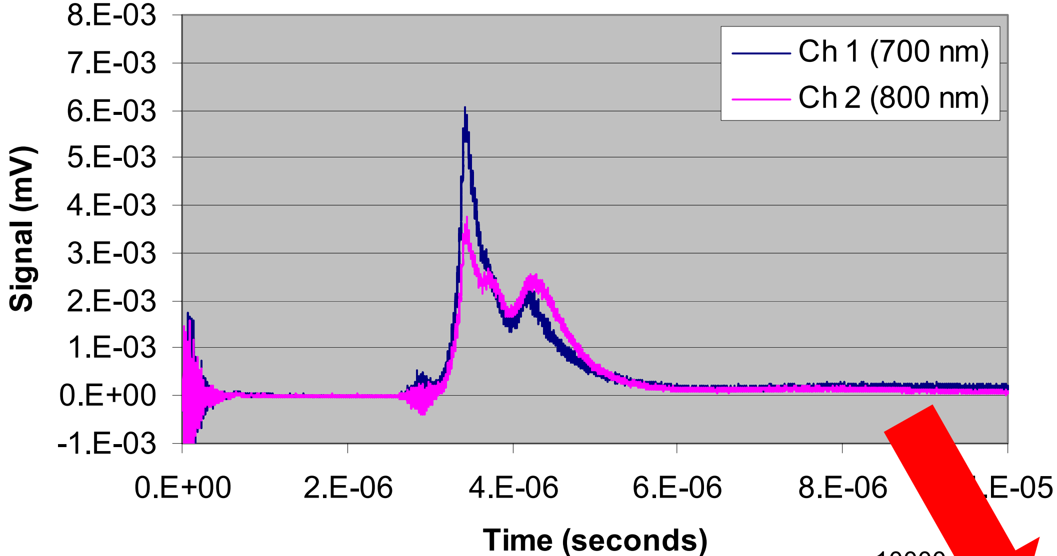


Electromagnetic noise has been a significant issue for the thermometer

- Lots of EM noise near XAPPER:
  - 200 mV peaks in single-shot near main chamber
  - Moved scope & PMTs across hall with extra 30 m of fiber
  - Enclosed PMTs & power supply in large Faraday cage (copper box)
  - Average readings over 100’s to 1000’s of pulses
  - Got noise down to ~0.5 mV
  - Signal ranges 1-5 mV



After noise reduction efforts, we obtain a (sort of) meaningful signal



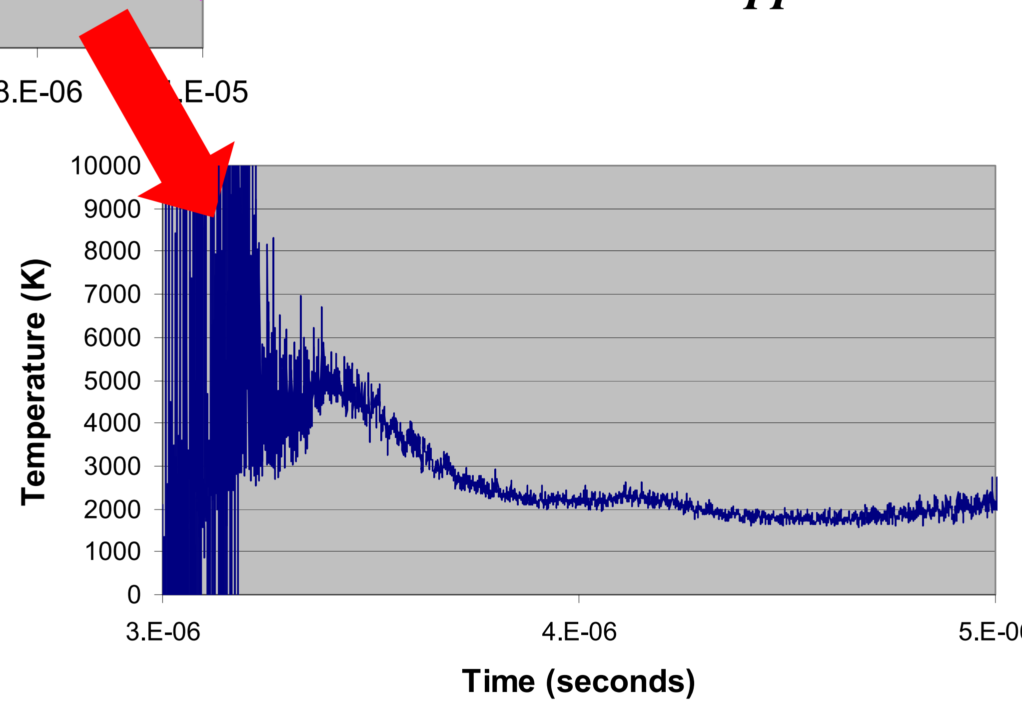
Noise considerably lower

Rise time too long (~300 ns)

What are extra ripples?

5000 K is higher than intended

Given uncertainties in fluence measurements and severe damage of sample, this is possible

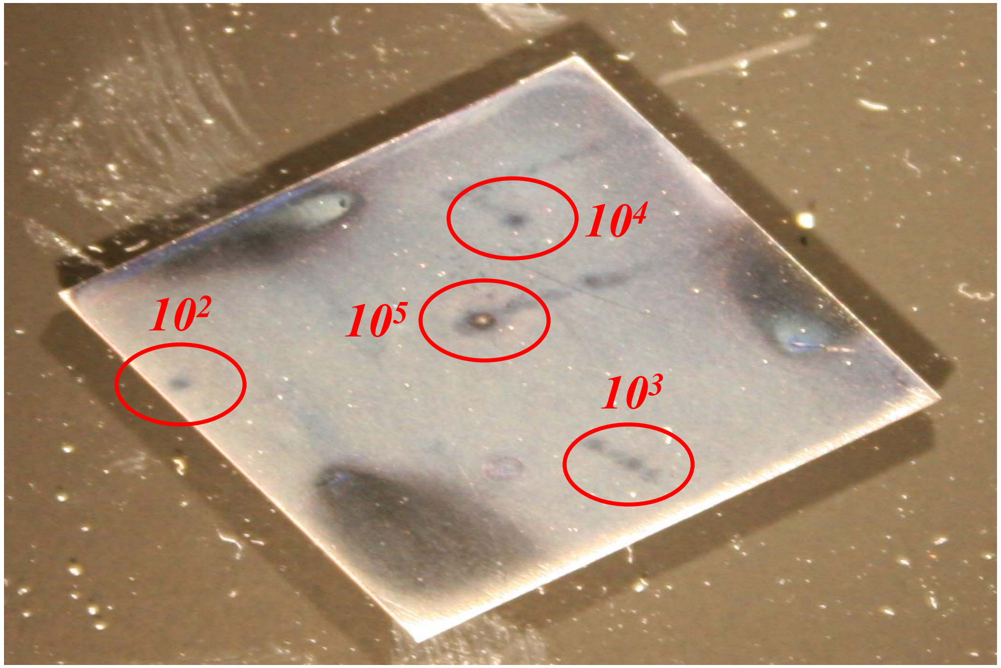


We have additional work to do before we can trust thermometer results

- Need to recalibrate PMTs to see if either might have a problem
- Need to complete our own fast photodiode measurements of the XAPPER source to confirm ~50 ns pulselength
- Have had discussions with Farrokh, and he has several ideas and has offered to help us out

Despite difficulties with fluence measurements, we do have some results

- Powder met tungsten:
  - Sample heated to 600 ºC
  - Hit with a fluence of ***at least*** 0.4 J/cm^2
  - Calculations indicate that each pulse would heat surface to ***≥2000 K***
  - 10^2, 10^3, 10^4, 10^5 pulses placed on sample
  - Pre-irradiation roughness was 22.9±1.5 nm



- Post-irradiation roughnesses:
  - 10^2 pulses: too close to edge
  - 10^3 pulses: 33.6 nm
  - 10^4 pulses: 26.0 nm
  - 10^5 pulses: 25.7 nm

This sample shows little, if any, change from the irradiation

Next steps...

- Diagnostics:
  - Implement solution for 10 Hz imaging / fluence measurement
  - Direct, time-dependent photodiode measurements to confirm x-ray pulse lengths from PLEX LLC
  - Get thermometer to the point where we trust it
- Complete 2000 & 2500 ºC exposures of powder met tungsten
- XTEM analysis of samples: crack density, depth, etc.
- Repeat and/or extend x-ray exposures:
  - Use alternate material(s):
    - Alternate types of tungsten (bonded, single crystal, etc.)
    - B_4C and/or SiC for magnetic deflection first wall
  - Complete additional post-irradiation evaluation (e.g., XTEM)
  - Provide additional shots:
    - 3 x 10^5 relatively easy / 10^6 possible (~28 hours)
    - Upgrades for higher rep rates (30-40 Hz), but obtain lower fluences (10^7 pulses possible with ~3 day run)
- Time to move on to aluminum mirrors and/or fused silica?