Progress in UCSD Chamber Simulation Experiments – Initial Results from Fast Thermometer

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Real-time Temperature Measurements Can Be Made With Fast Optical Thermometry

- Spectral radiance is given by Planck's Law (Wien's approximation):

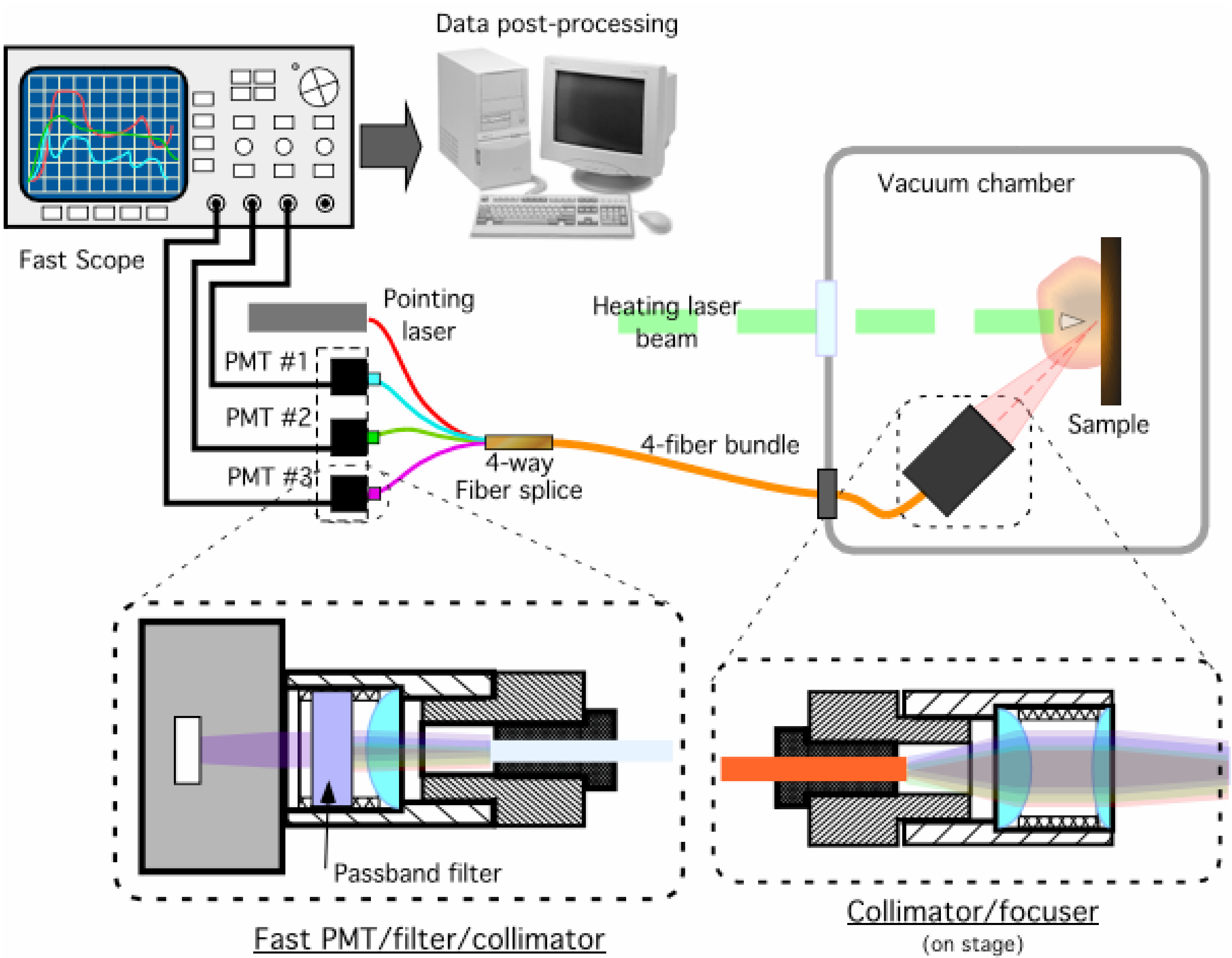
  $L(\lambda,T) = C_1\, \varepsilon(\lambda,T)\, \lambda^{-5} \exp(-C_2/\lambda T)$

- Since emittance is a strong function of λ, T, surface roughness, etc., deduction of temperature from total radiated power has large errors.

Temperature deduction by measuring radiance at fixed λ

- One-color: Use tables/estimates for $\varepsilon(\lambda_1,T)$
- Two colors: Assume $\varepsilon(\lambda_1,T) = \varepsilon(\lambda_2,T)$
- Three colors: Assume $d^2\varepsilon/d\lambda^2 = 0$ [usually a linear interpolation of Ln(ε) is used]

Schematic of Multi-Color Fiber Optical Thermometer

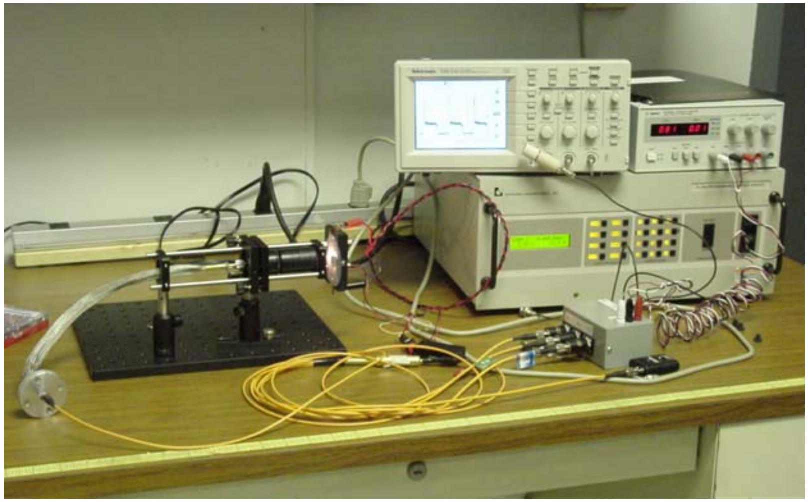


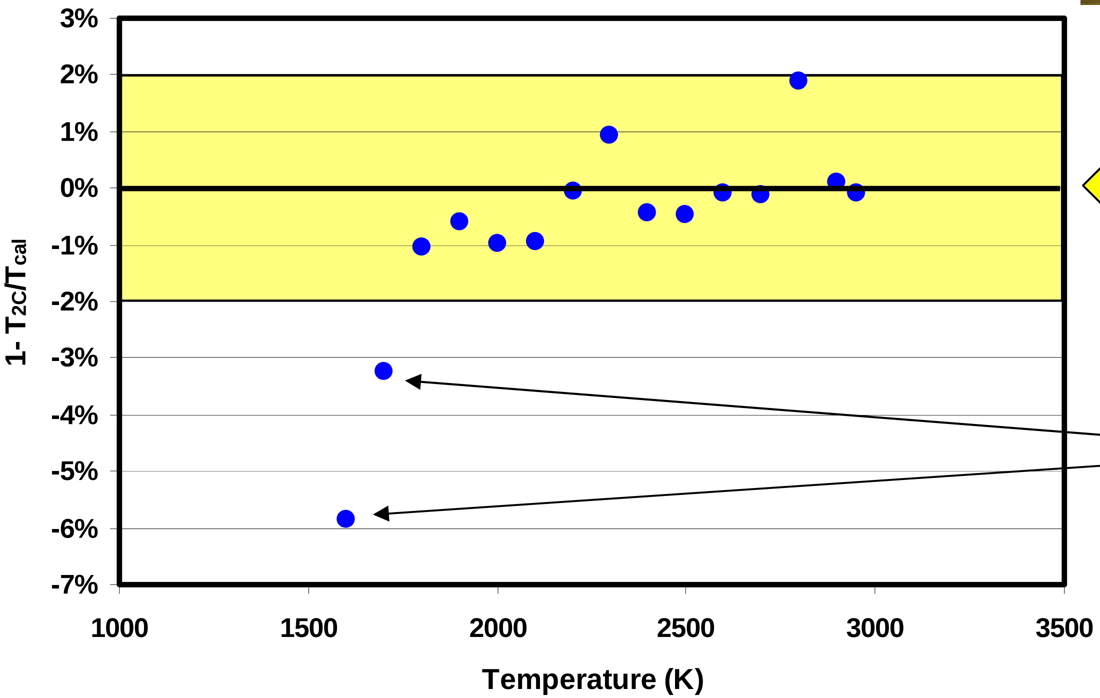
MCFOT Progress Report

- MCFOT is configured such that it can perform one 3-color and three 2-color temperature measurements. Comparison of the results from these 4 measurements indicated:
  - ✓ The response of one of PMT was not linear. That PMT was sent back to manufacturer for replacement. New PMT arrived at UCSD last week.
  - ✓ Calibration results from 2-color measurement using the remaining PMT was excellent.

MCFOT is calibrated using the Optronics UL-45U lamp (Rated Lamp Calibration is <2%)

- 14 Calibration points
- One adjustable parameter (c_2/c_1)
  - ✓ $c_i = V_i$ (PMT) / L_i (Sensor head)





- Rated accuracy of calibration Lamp

- Calibration signal strength was too low

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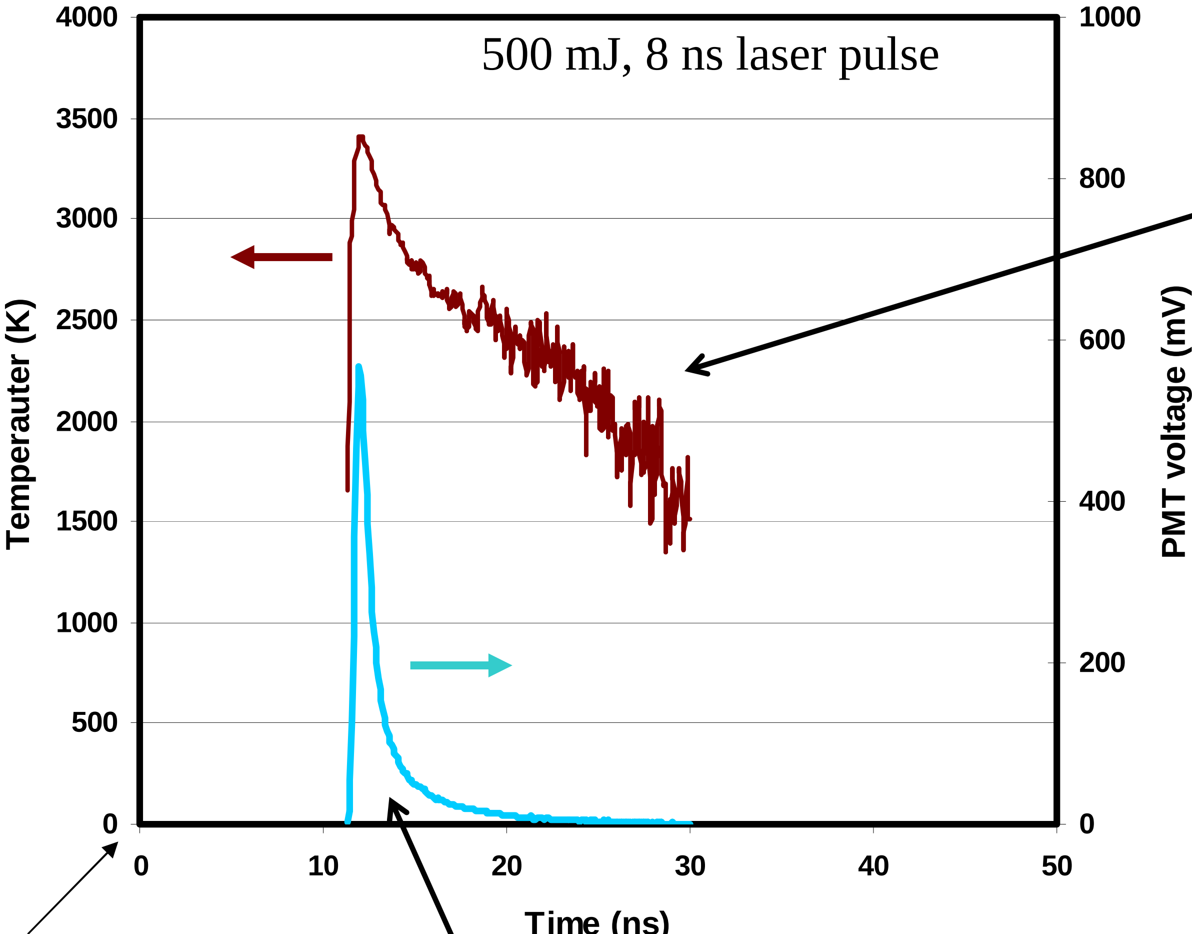
- Major question: Is PMT response similar between calibration and experiment?
  - ✓ Calibration is done at low light intensity and low frequency (0-100 Hz);
  - ✓ Experiments are performed at higher light intensity and high frequency.
- Lowering PMT bias voltage (and gain) helps in the low-frequency range.
- MCFOT fast response was checked by examining the melting of sample.

MCFOT – Verification Experiments

- A series of shots with different laser energies (200 to 700 mJ) was performed with W samples. Laser energy was increased beyond needed for melting the sample (600 mJ). Sample temperature was measured with MCFOT.
- Results were compared with thermal analysis runs with ANSYS.
- Experiments were intended to verify MCFOT operation at nano-second time scale.
- Experiments were performed in air for simplicity.
- Thermo-physical properties of sample were unknown. In particular, W samples were not 100% dense.

MCFOT Has Measured Temperature Response of W Samples with ns Resolution



t = 0 is the Data Acquisition trigger point

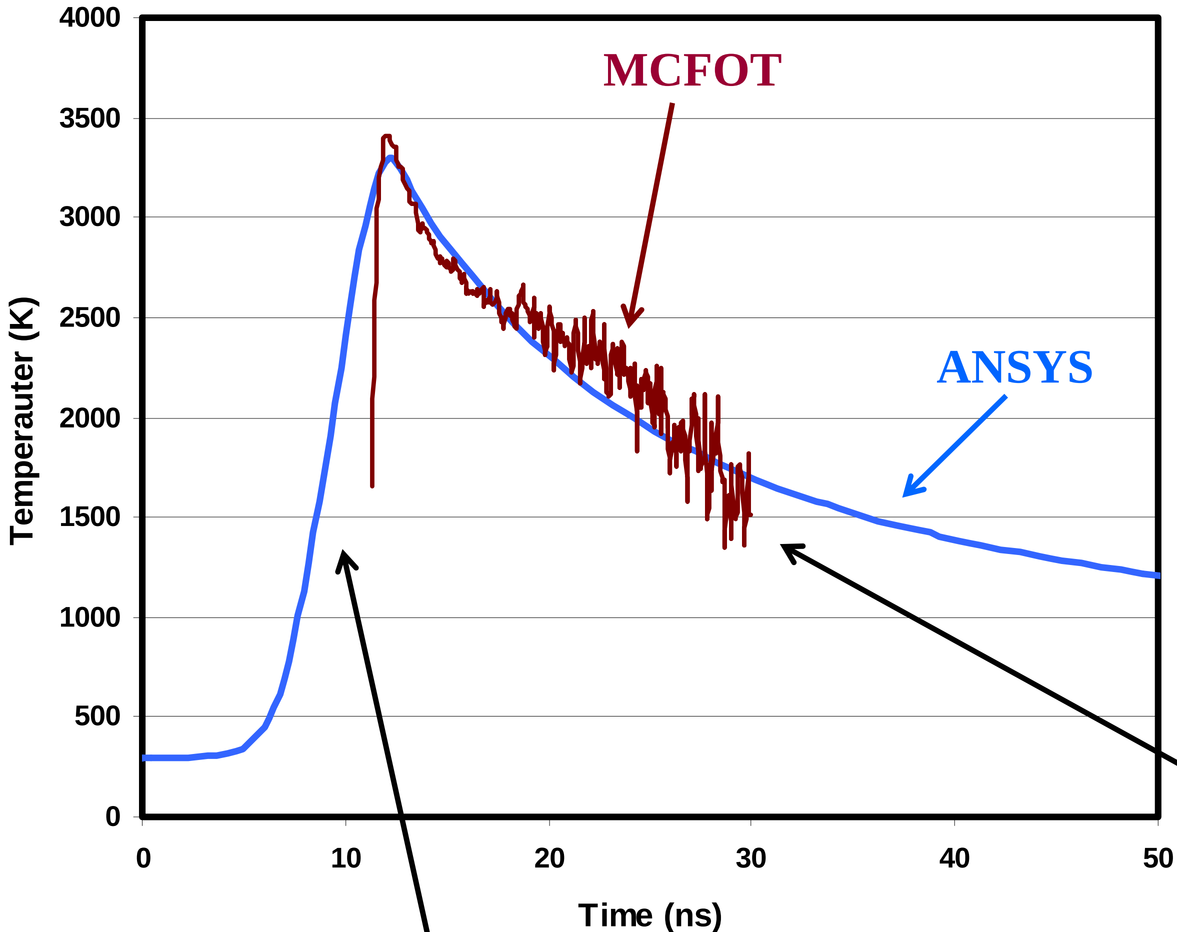
“Noise” in measured temperature can be due to:

- ✓ Data acquisition system
- ✓ Data Sampling algorithm
- ✓ Cross talk in PMTs’ circuits

Causes are under study.

PMT pulse is much sharper than laser or temperature pulse because L ~ exp $(-c/\lambda T)$

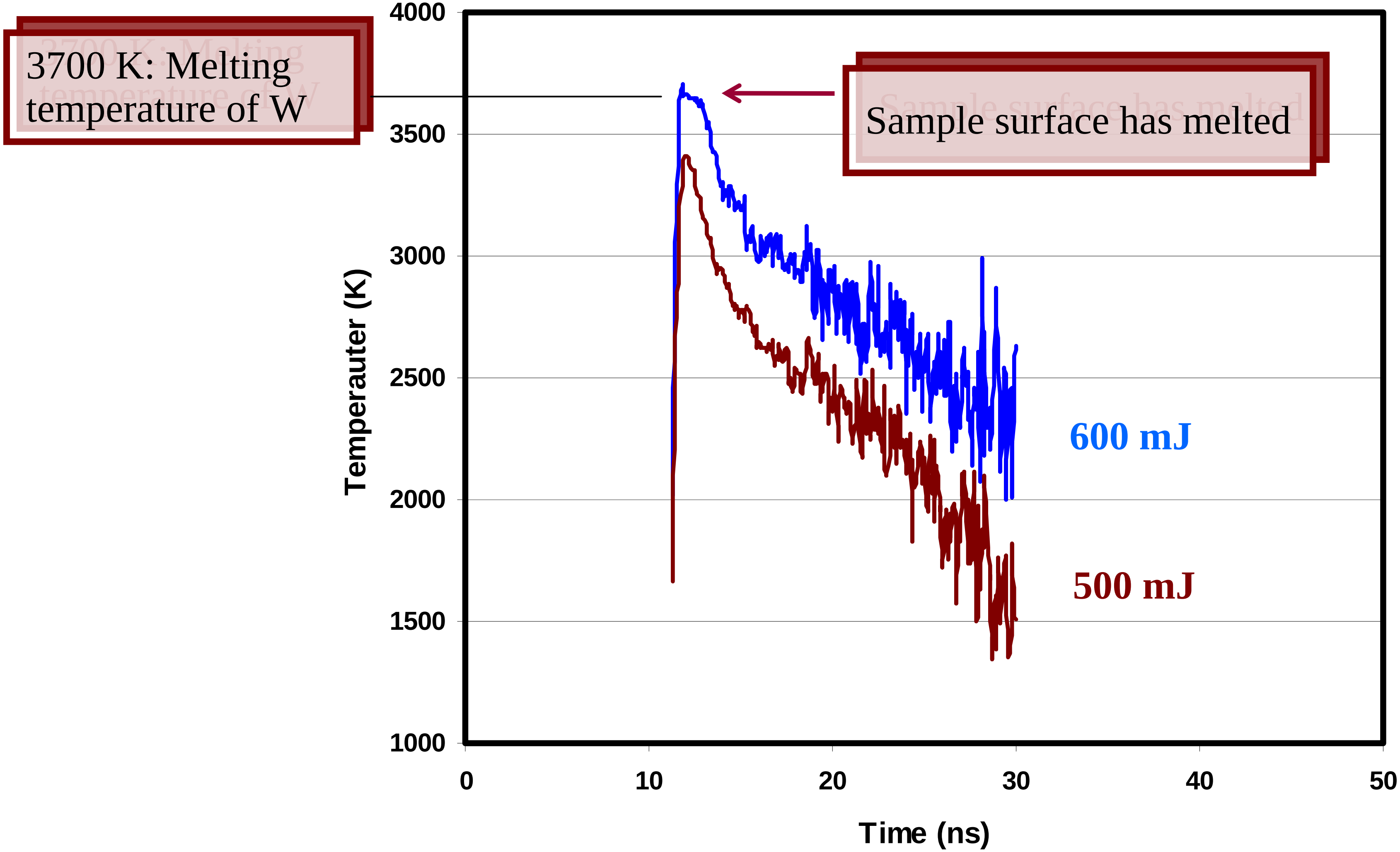
MCFOT Measurements of “Thermal Diffusion” Agrees with ANSYS Results



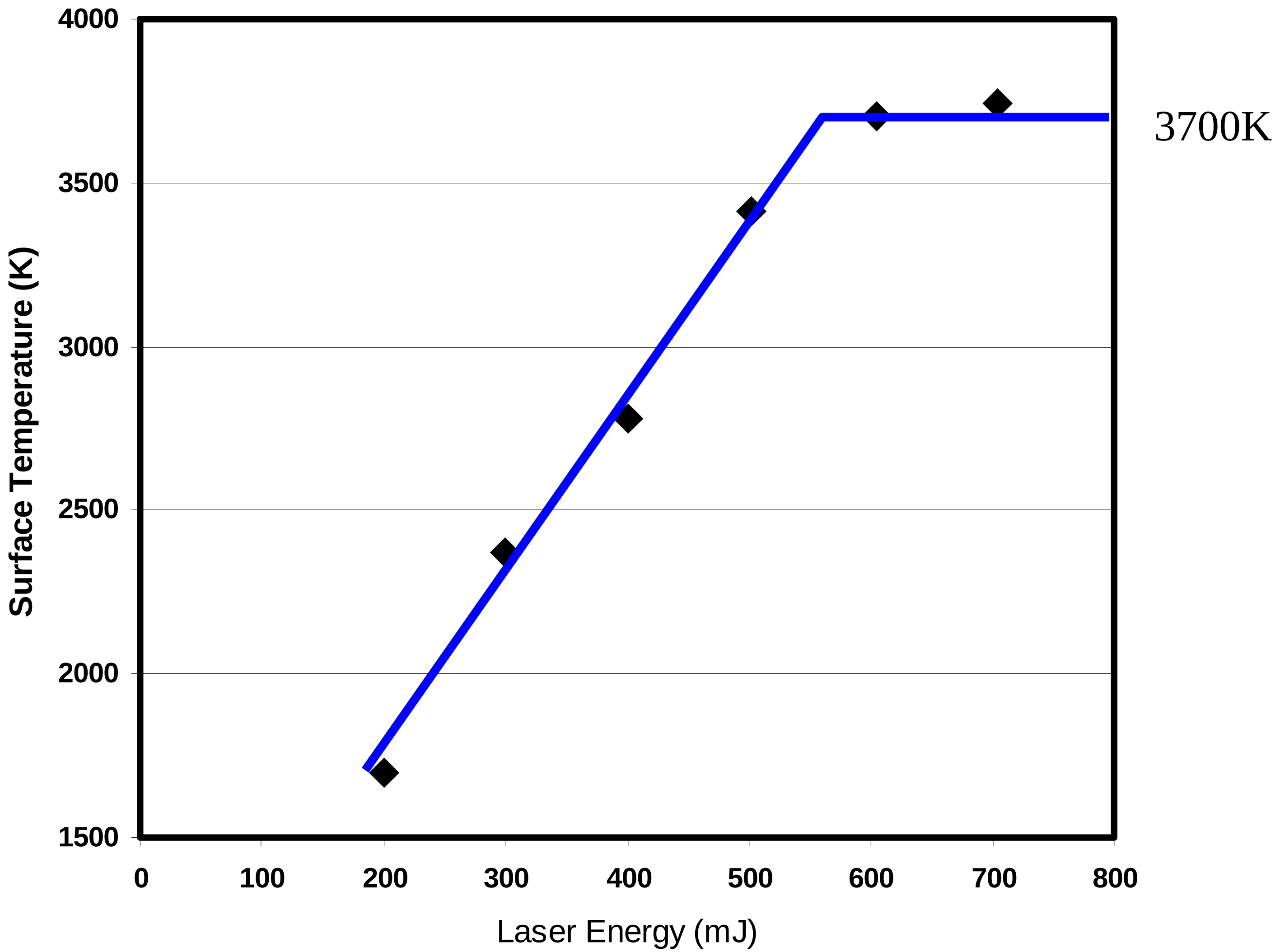
- The peak temperature of the sample depends on thermo-physical property of the sample (mainly ρC_p) and laser pulse shape.
- Thermal Diffusion time constant, $k/\rho C_p$, of the sample, however, should be close to pure W.
- MCFOT measurements are compared with ANSYS calculations with similar “peak” sample temperature and good agreement has been found.

Temperature rise time is sharper than ANSYS because of difference in laser pulse shape.

Melting of Sample Surface is Captured by MCFOT Measurements



Initial Scan of Sample Peak Surface Temperature with MCFOT Has Uncovered No Surprises



"Near-Term" Experimental Plans

MCFOT:

- Assemble MCFOT's 3rd PMT and compare three 2-color and one 3-color temperature measurements. Choose between 2-color and 3-color techniques.
- Resolve noise problem during the sample cool down period.
- Repeat W sample temperature scan with ORNL samples in vacuum and with different equilibrium sample temperature.
- Compare with ANSYS results using "real" thermo-physical properties of sample and experimental laser pulse shape.
- Repeat melting "calibration" tests with Mo and Steel samples.

RGA:

- Install and commission RGA system. Establish background constituent levels in the vacuum chamber.

- **Research Plan is presented in the First Wall Battle Plan Session.**