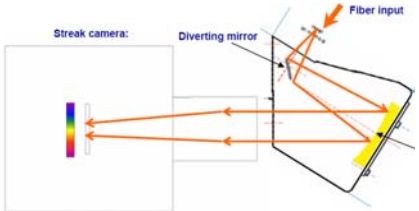
Scintillators and shot #10 (Au) data

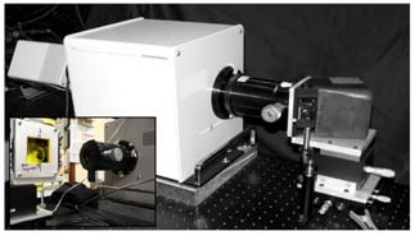
WDM & NDCX group

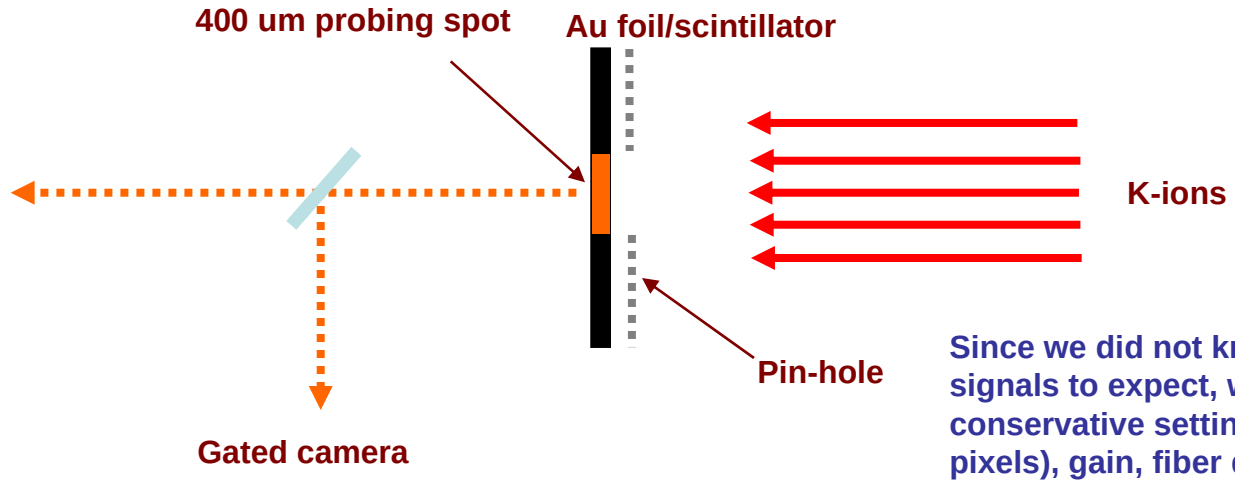
November 11th 2008

Scheme of experiment

Streak spectrometer



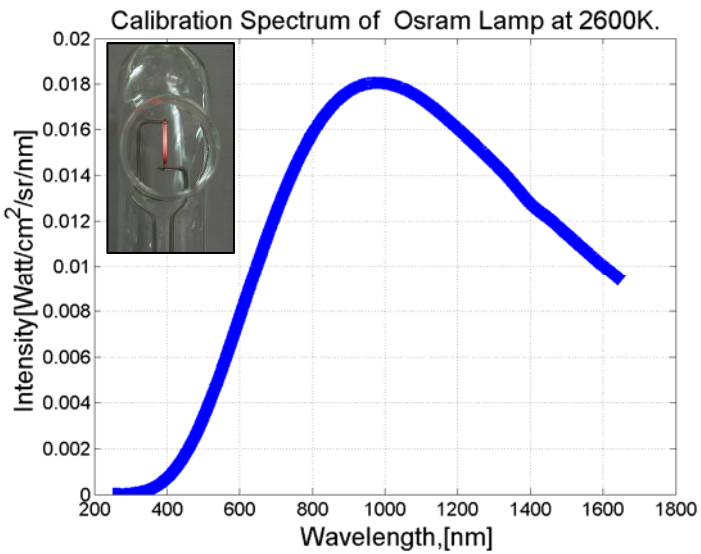


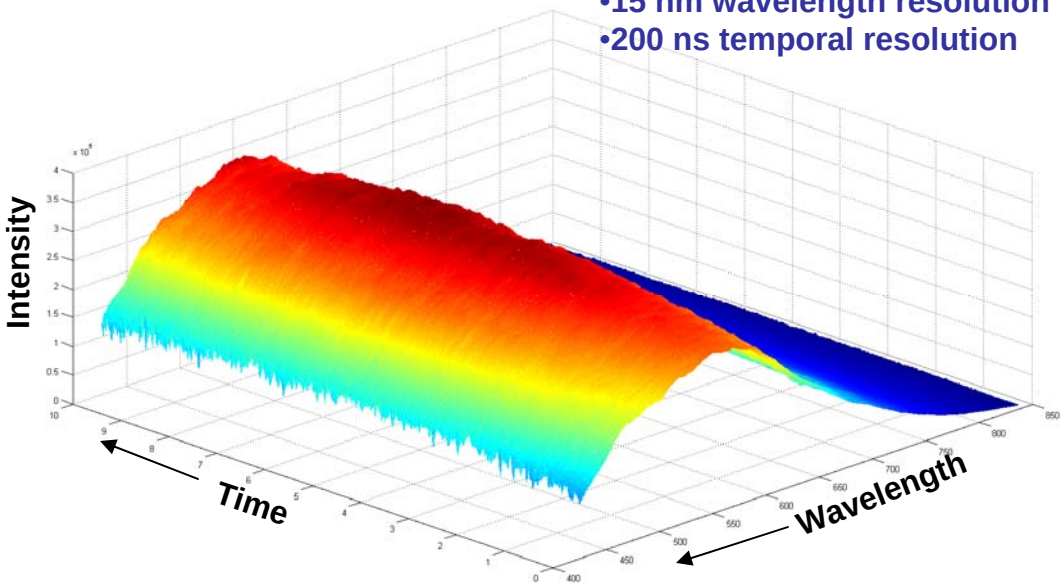


Since we did not know what signals to expect, we used conservative settings (slit (20 pixels), gain, fiber diameter (400 um)) to maximize the signal. This resulted in following instrumental parameters:

- 15 nm wavelength resolution
- 200 ns temporal resolution

Absolute calibration





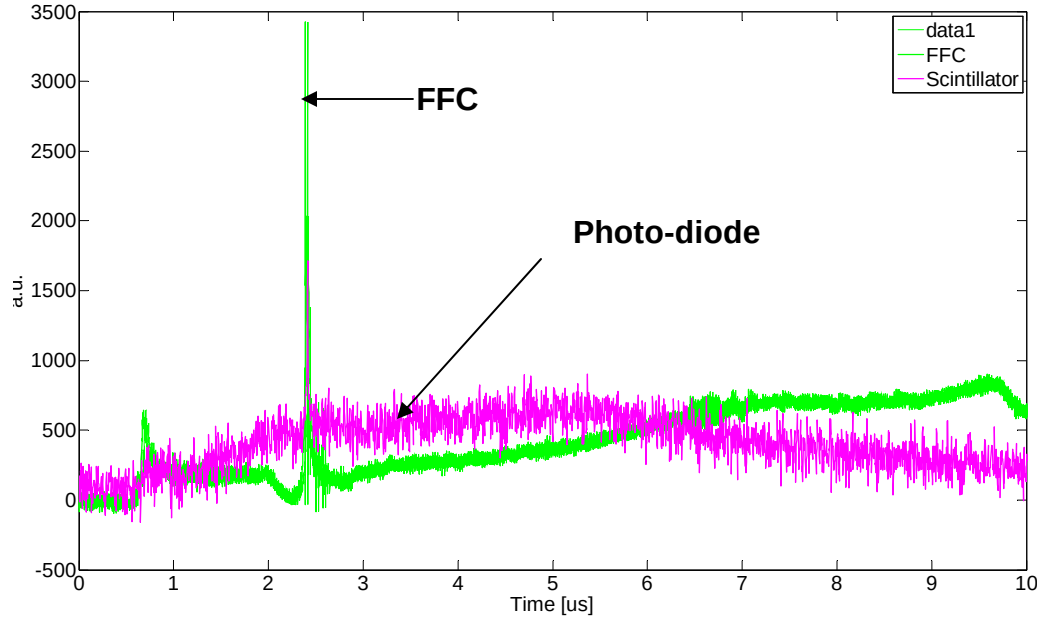
Beam current

3 ways to measure beam current:

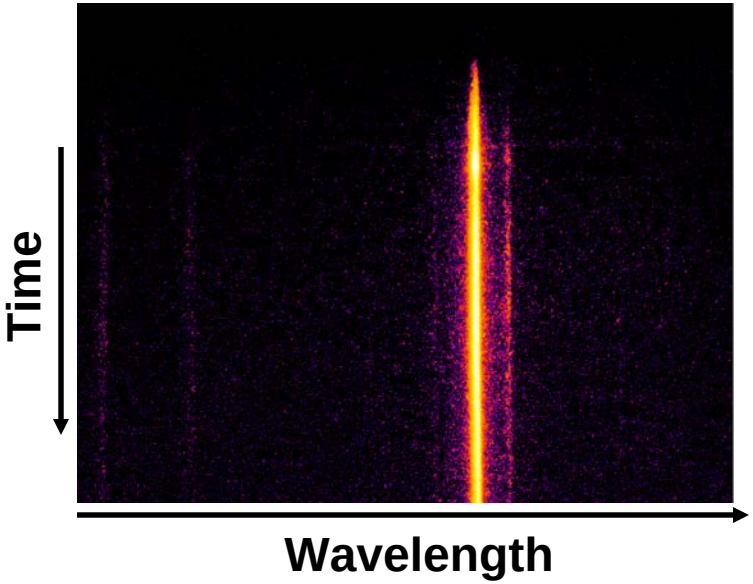
- FFC
- Photodiode (pyrometer)+scintillator
- Streak camera+scintillator`

The data used to synchronize NDCX and optical diagnostics

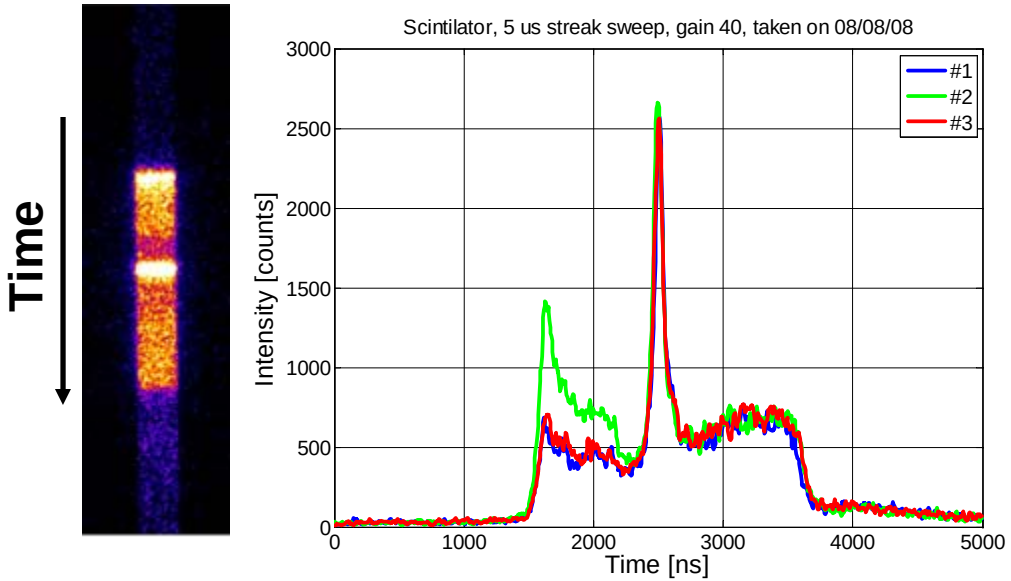
Overlay of photo diode and FFC measurements

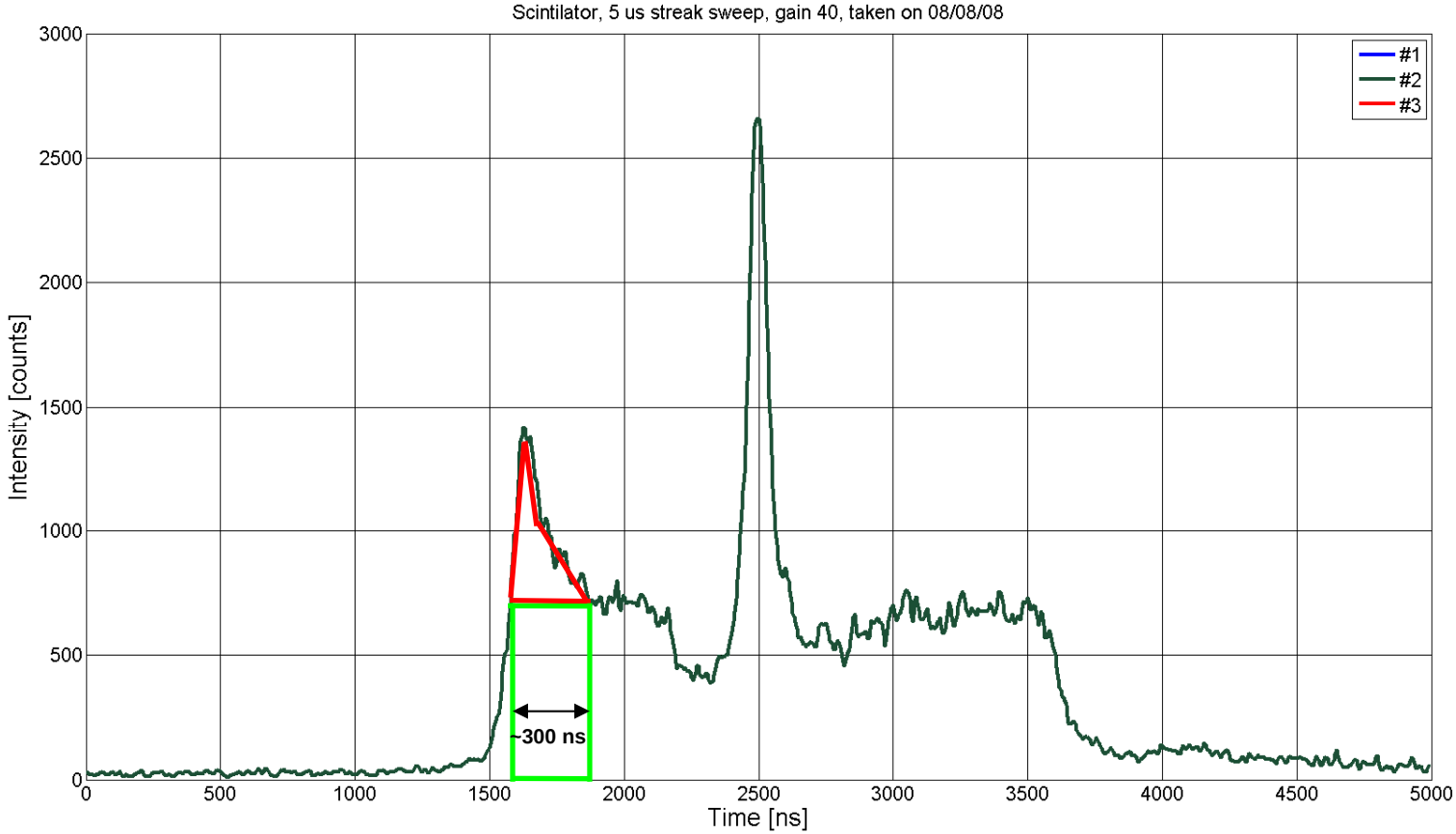


Streak camera (resolved spectrum)



Streak camera (integrated spectrum)



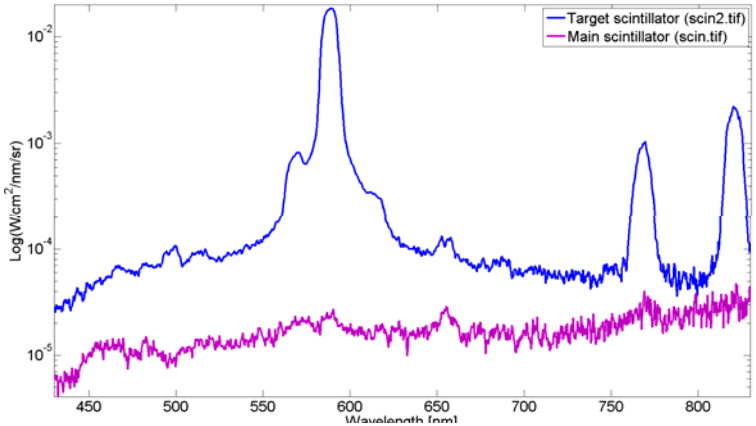


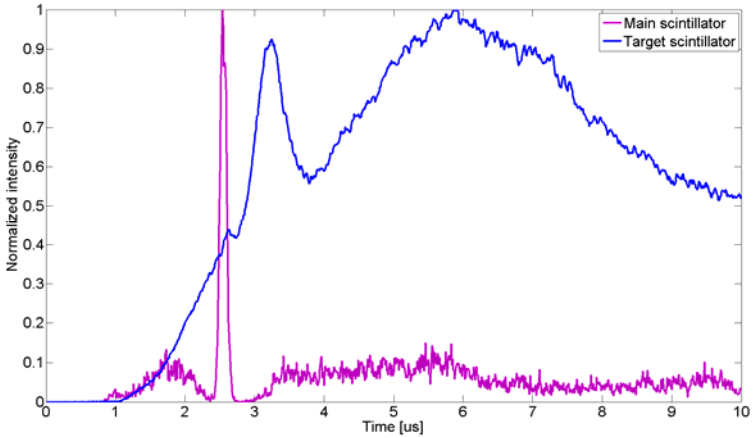
•Energy contained in the pre-pulse (red) is approx 50% of the flat-top (green), which makes effectively pre-heating pulse 150 ns longer

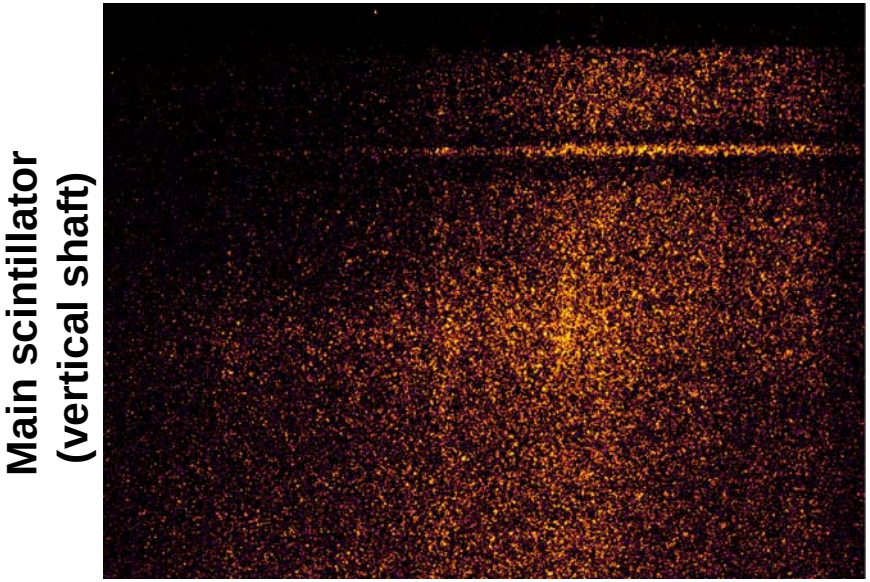
Scintillator comparison

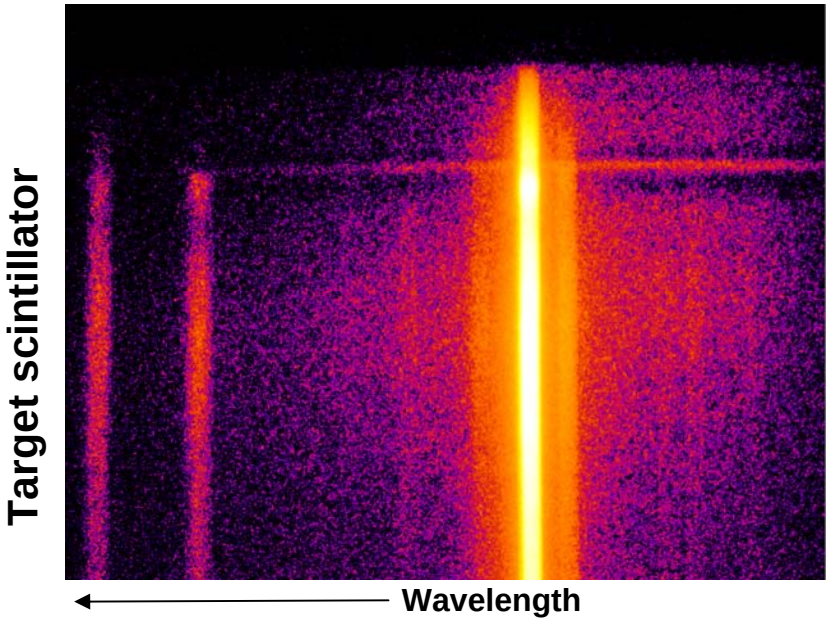
- Same machine and camera settings
- Identical scintillator materials
- Main scintillator has been shot >>100 times
- Target scintillator scintillator has been shot ~50 times

Integrated spectrum







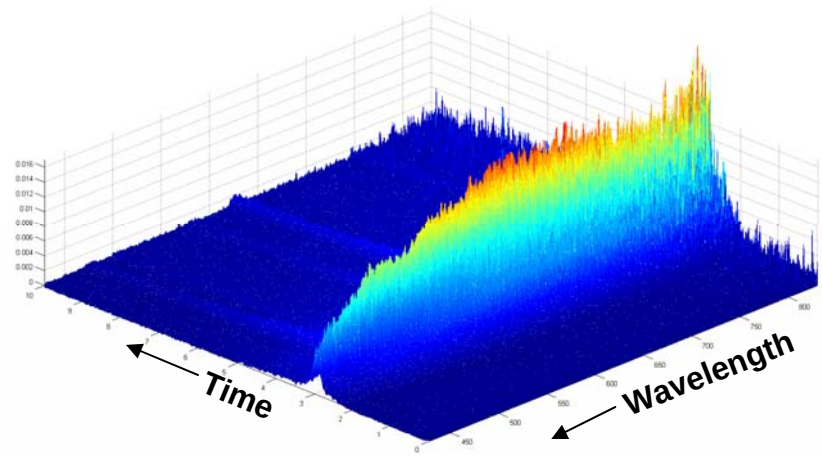


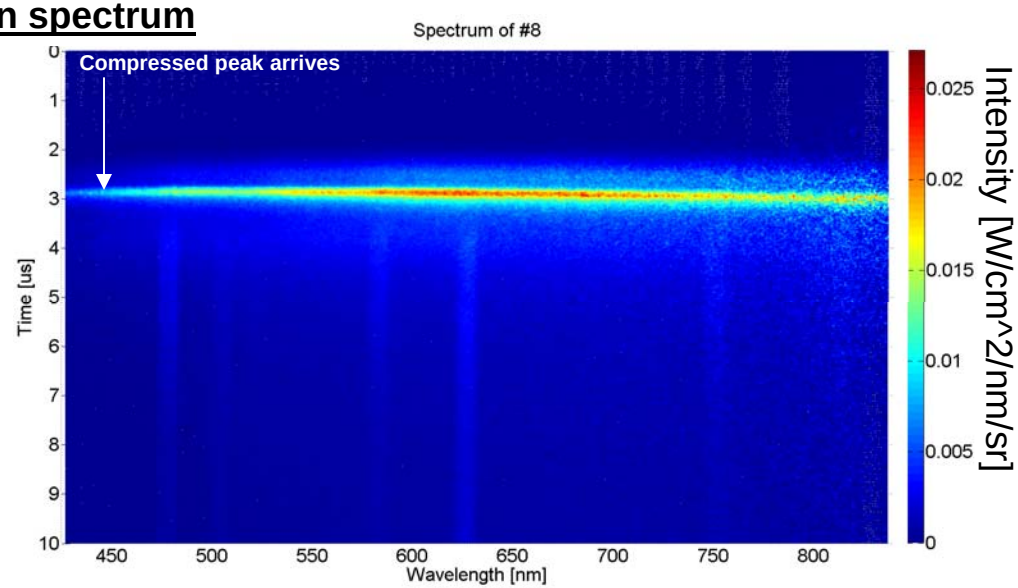
Opened questions:

- Why intensities are so different (x100)?
- Why temporal responses are different
- Why "lines-like" spectrum?
- Why IR lines show after compressed peak only?
- Why non-linear response
- Does the scintillator material degrade?

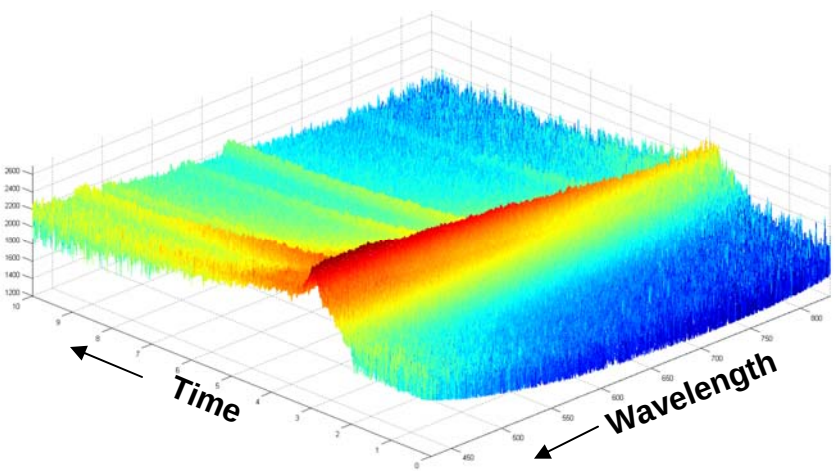
Shot#10

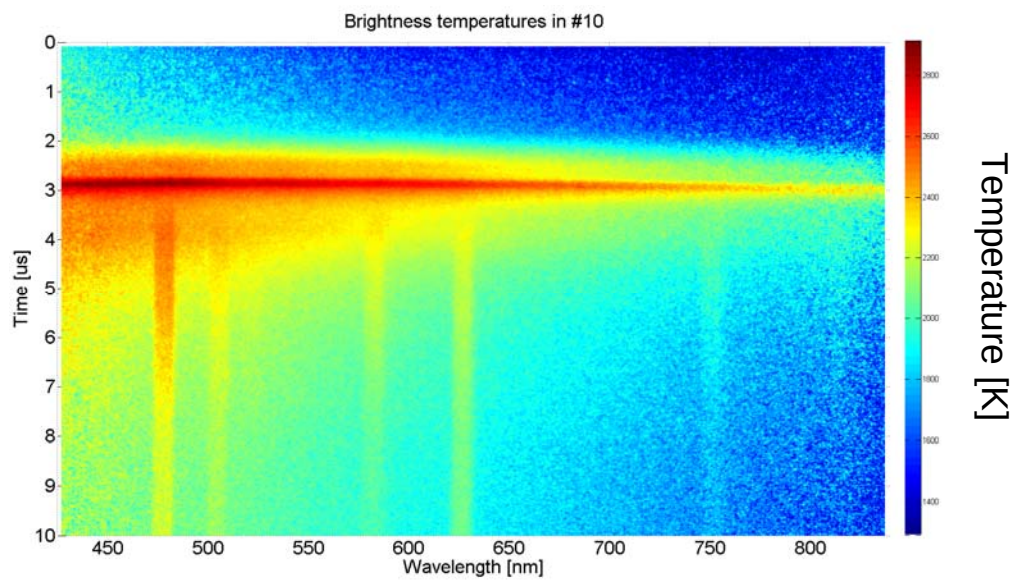
Absolute radiation spectrum





Brightness temperatures





Data processing (fitting)

$$I(\lambda, T) = \varepsilon(\lambda) \cdot \frac{C_1}{\lambda^5} \frac{1}{e^{\frac{C_2}{\lambda T}} - 1},$$

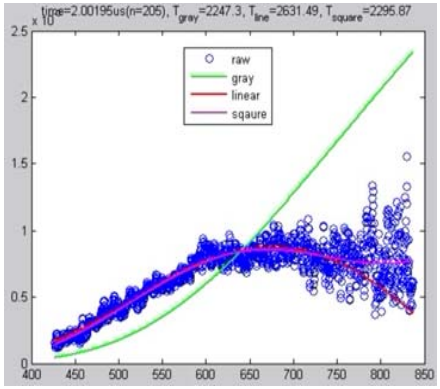
where emissivity $\varepsilon(\lambda, T) \le 1.$

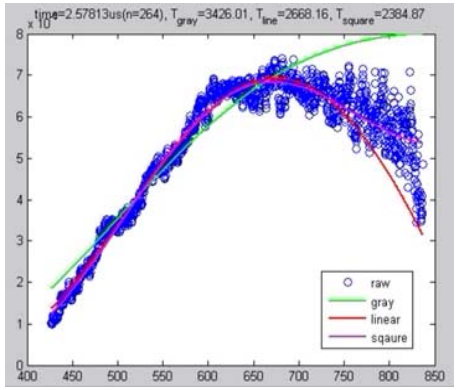
$$\begin{bmatrix} I_{experim}(\lambda_1) \\ \dots \\ I_{experim}(\lambda_N) \end{bmatrix} \xrightarrow{\text{nonlinear fit}} \begin{bmatrix} \varepsilon(\vec{A}, \lambda_1) \cdot I_{Planck}(\lambda_1, T) \\ \dots \\ \varepsilon(\vec{A}, \lambda_N) \cdot I_{Planck}(\lambda_N, T) \end{bmatrix}$$

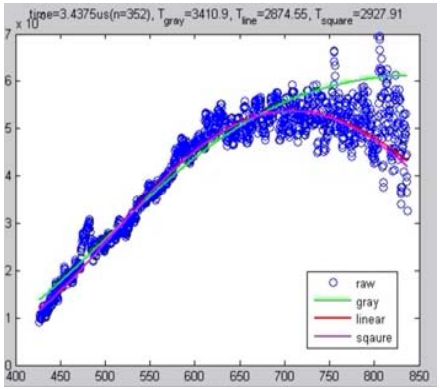
$\vec{A}$ and T are the fitting parmeters

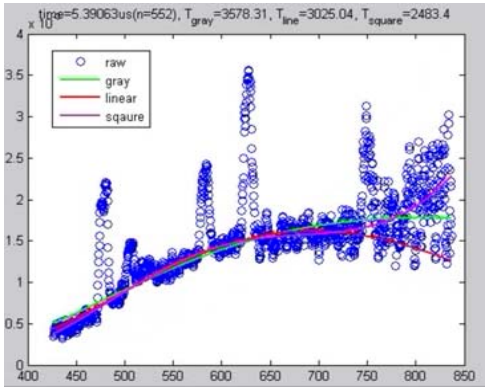
- **Attempted to fit "grey", "linear" and "square" laws of emissivity**
- **Performed non-linear least square optimization (Levenberg-Marquardt) with statistical weights.**
- **Used sensitivity of spectrometer as a weight function**
- **Fitting is a "Bonus" and serves as a reference only.**

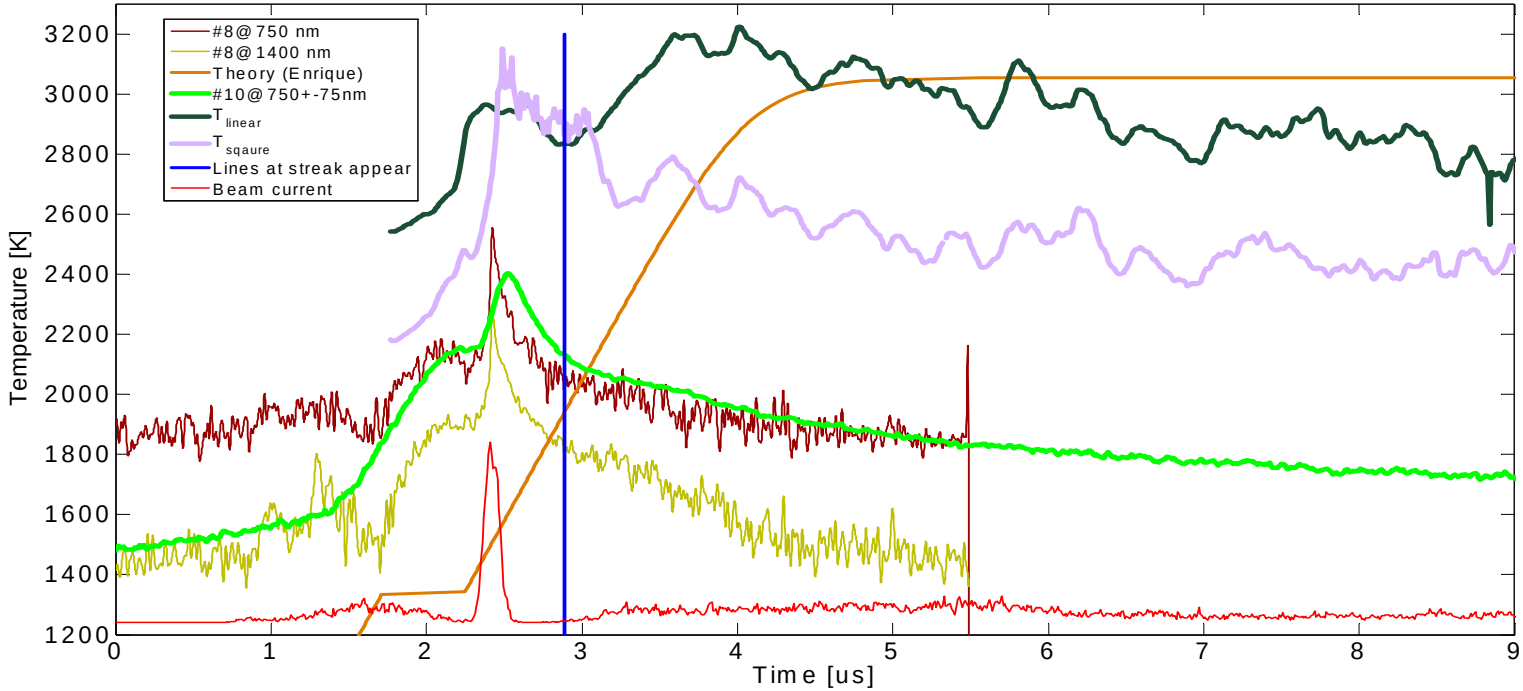
- **Discrepancy can be explained by many reasons: non-equilibrium, scintillation, low-level of signal, sample is not optically thick, screening hot vapor, gas-droplet mixture etc…**





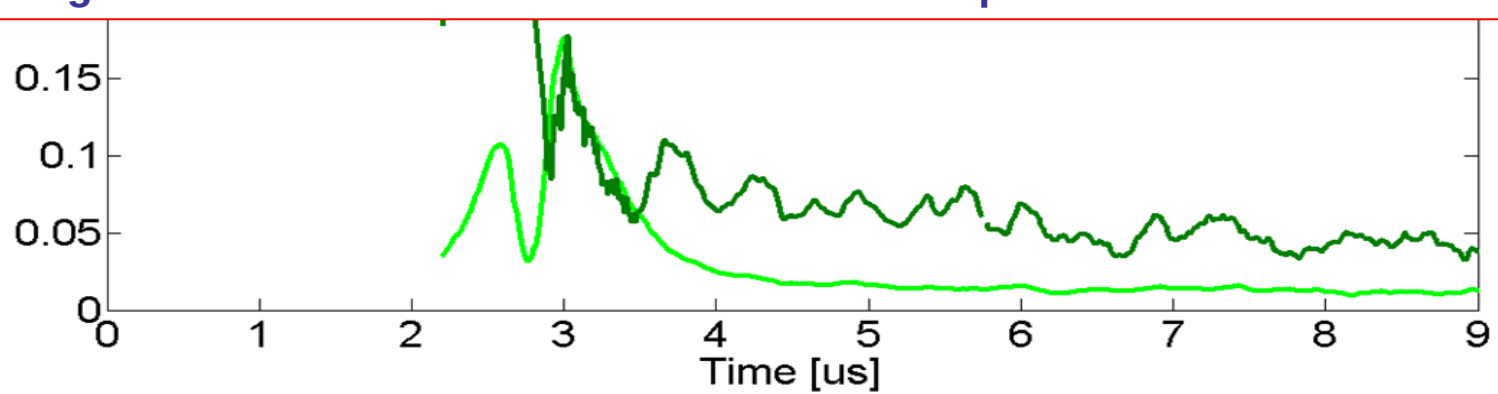






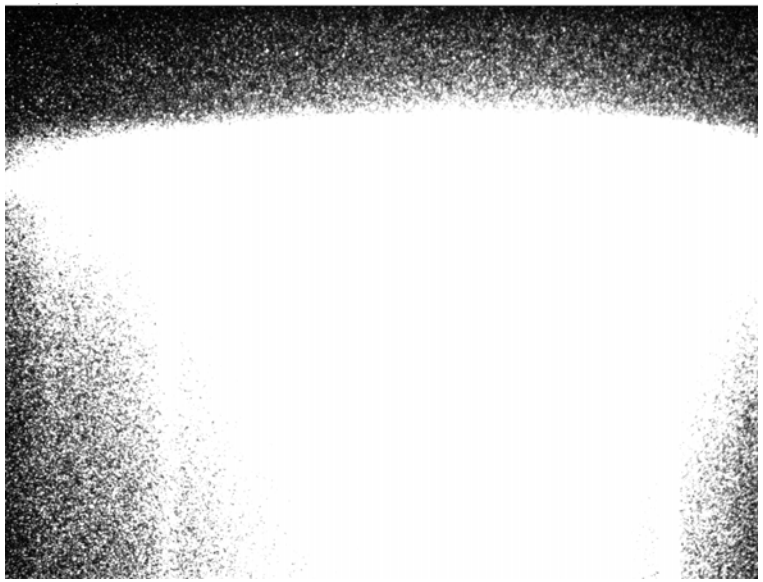
Remarkable features:

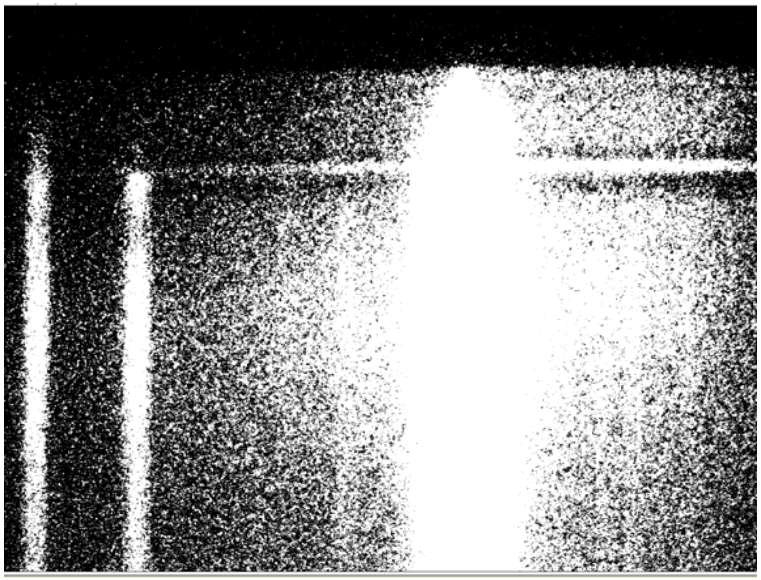
- **Streak registers radiation appearing before the beginning of the beam!**
- **Fitted T show different evolution in comparison to brightness T**
- **Fitted T falls-off much slower (nearly constant)**
- **Fitted "linear" and "square" T almost match around peak**
- **Heating rate from simulation does not match the experiment**



Possible reasons for “the early radiation”:

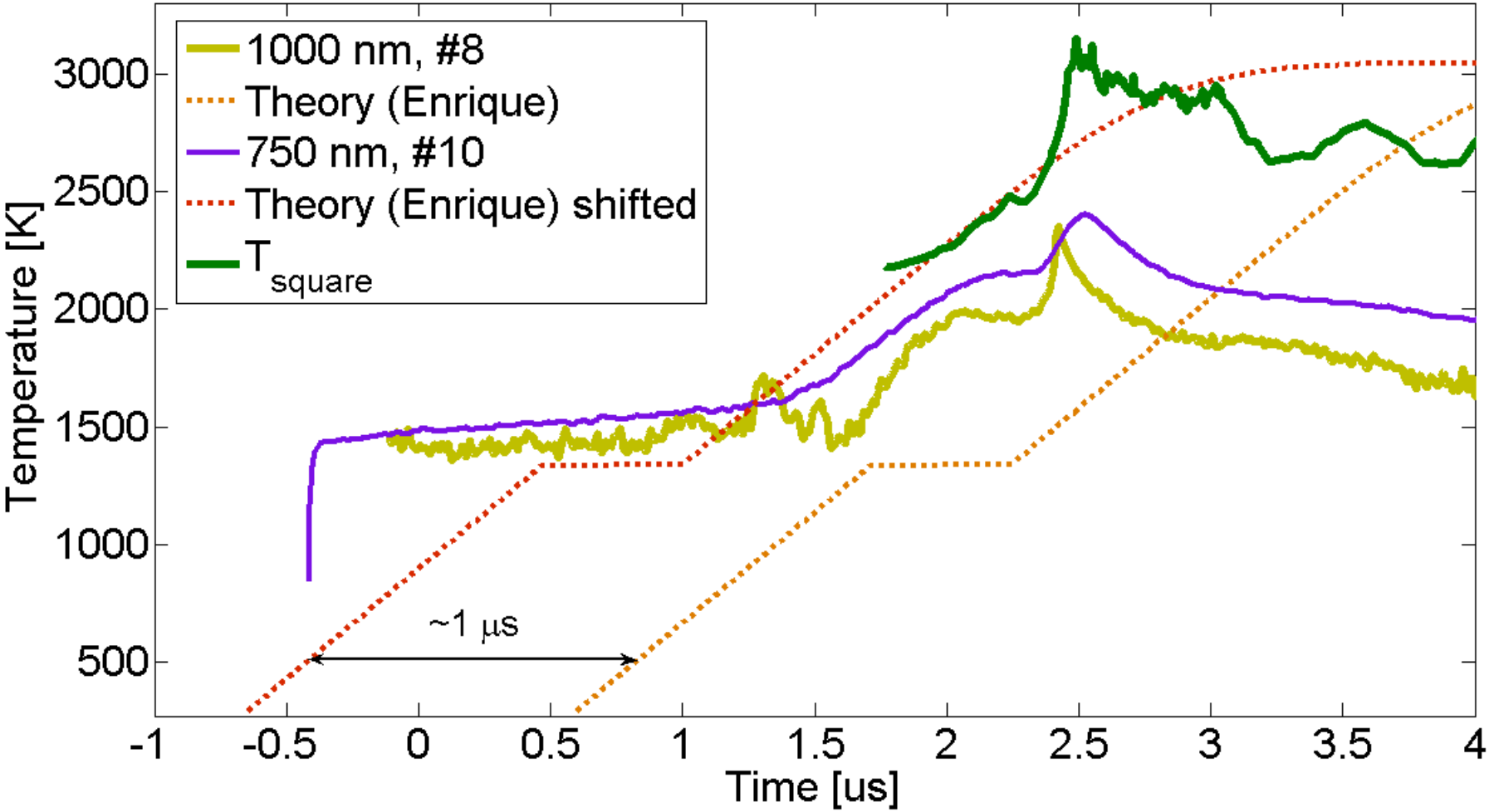
- Neutralization plasma->no, lines are x1000 weaker
- Target is preheated by plasma and radiates thermally-possible? Enrique says plasma will add +3K only
- Stray light within instrument-> see photos bellow
- What else?





Streak is x10 more intense than scintillator

Missing energy



Sources of pre-heat:

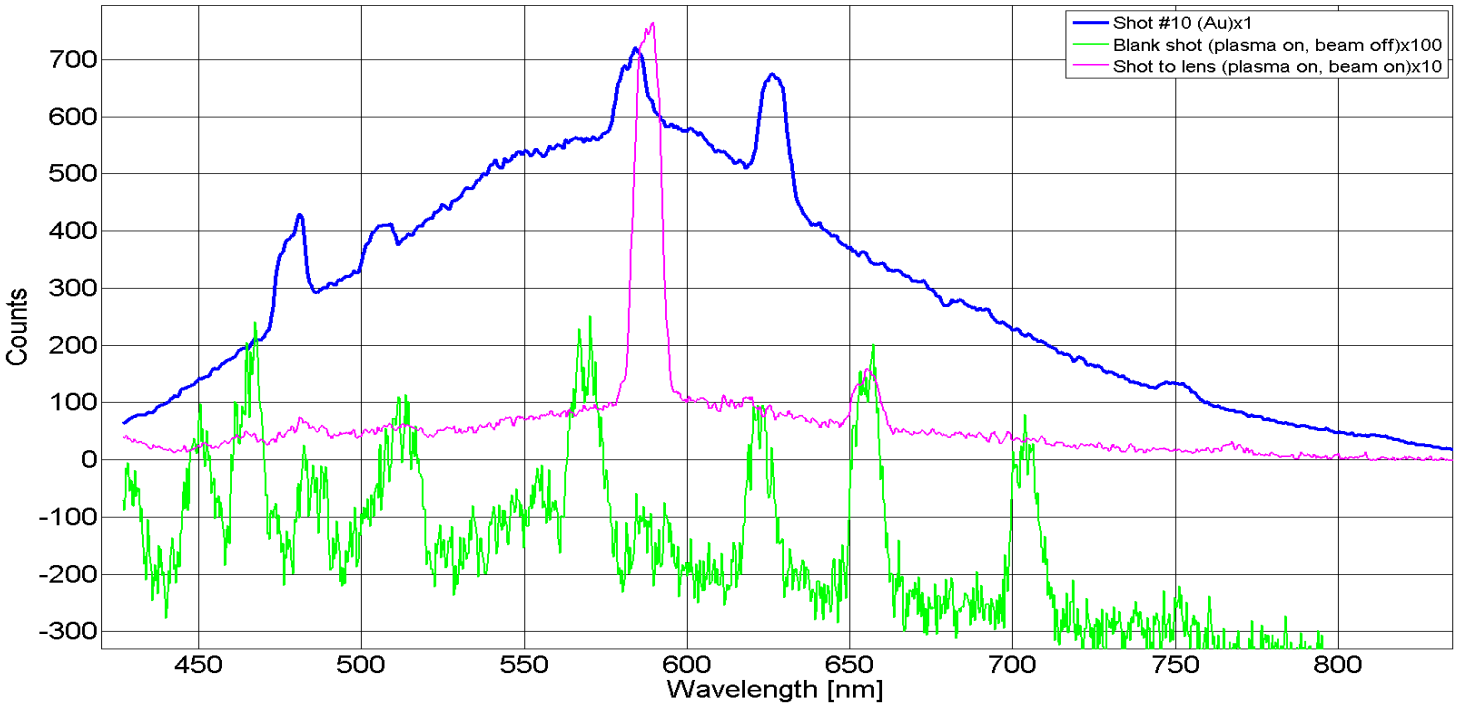
- **Eddie currents ΔT=?**
- **Neutralization plasma ΔT~3 K**
- **Pre-pulse peak ΔT~150 K**

Origin of spectral lines

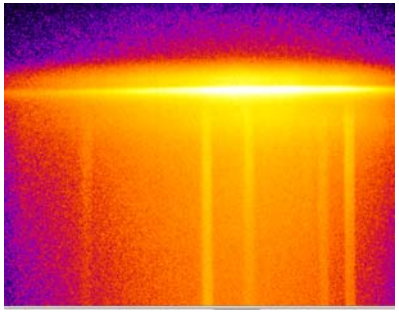
Potential sources of lines:

- **Neutralization plasma**
- **Lens (when ions pass through the foil and hit the lens)**
- **Target scintillation (due to ion beam or excitation of atomic level in gas)**

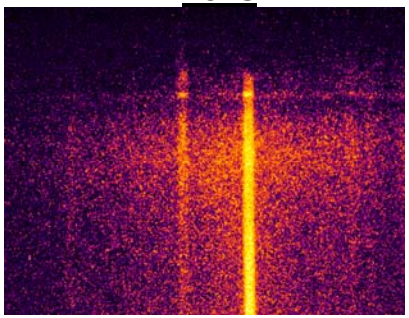
Spectrum recorded my streak camera in various scenarios (raw counts):



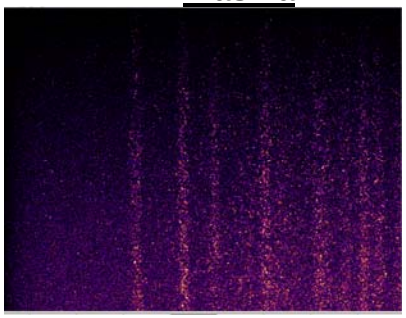
Gold



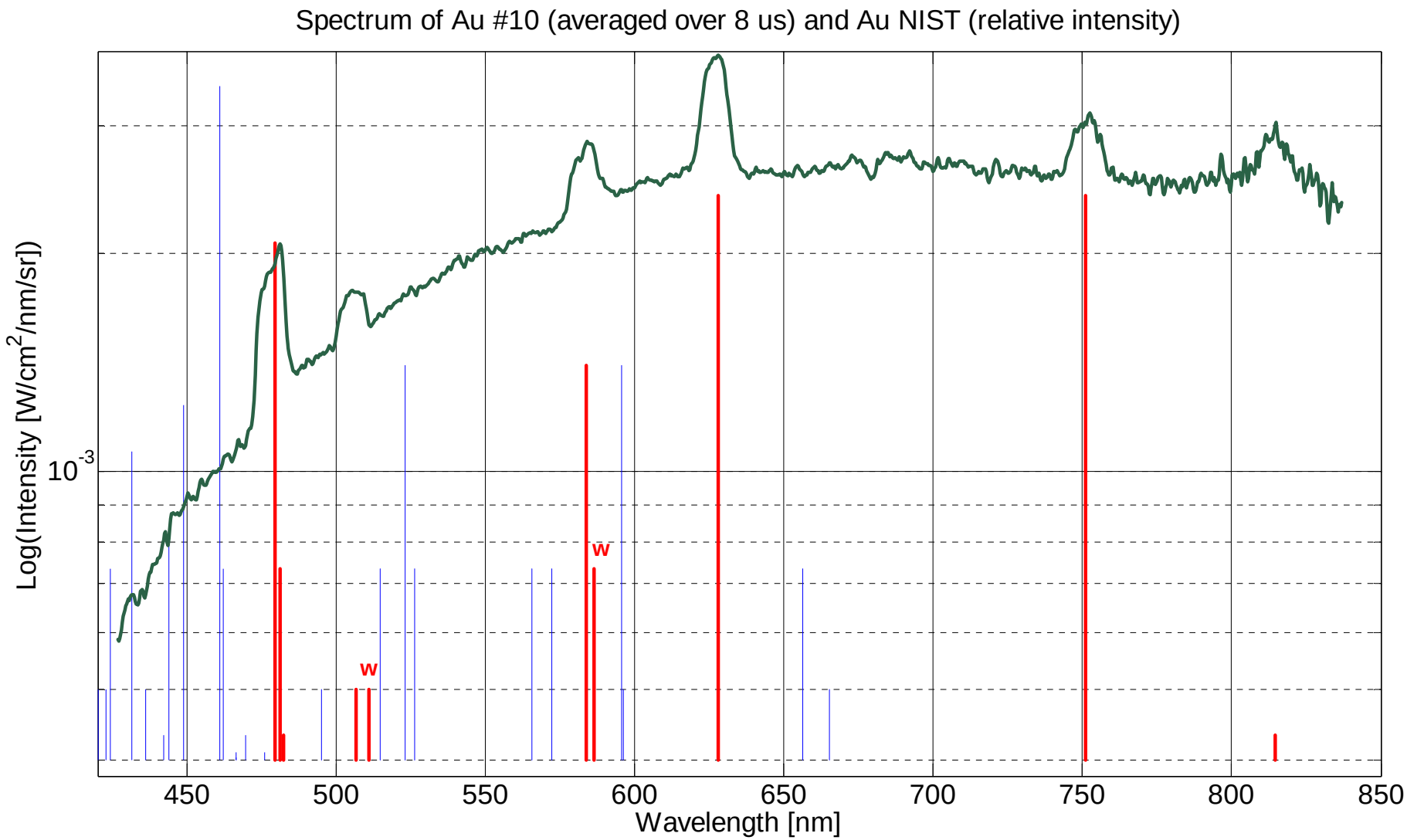
Lens



Plasma

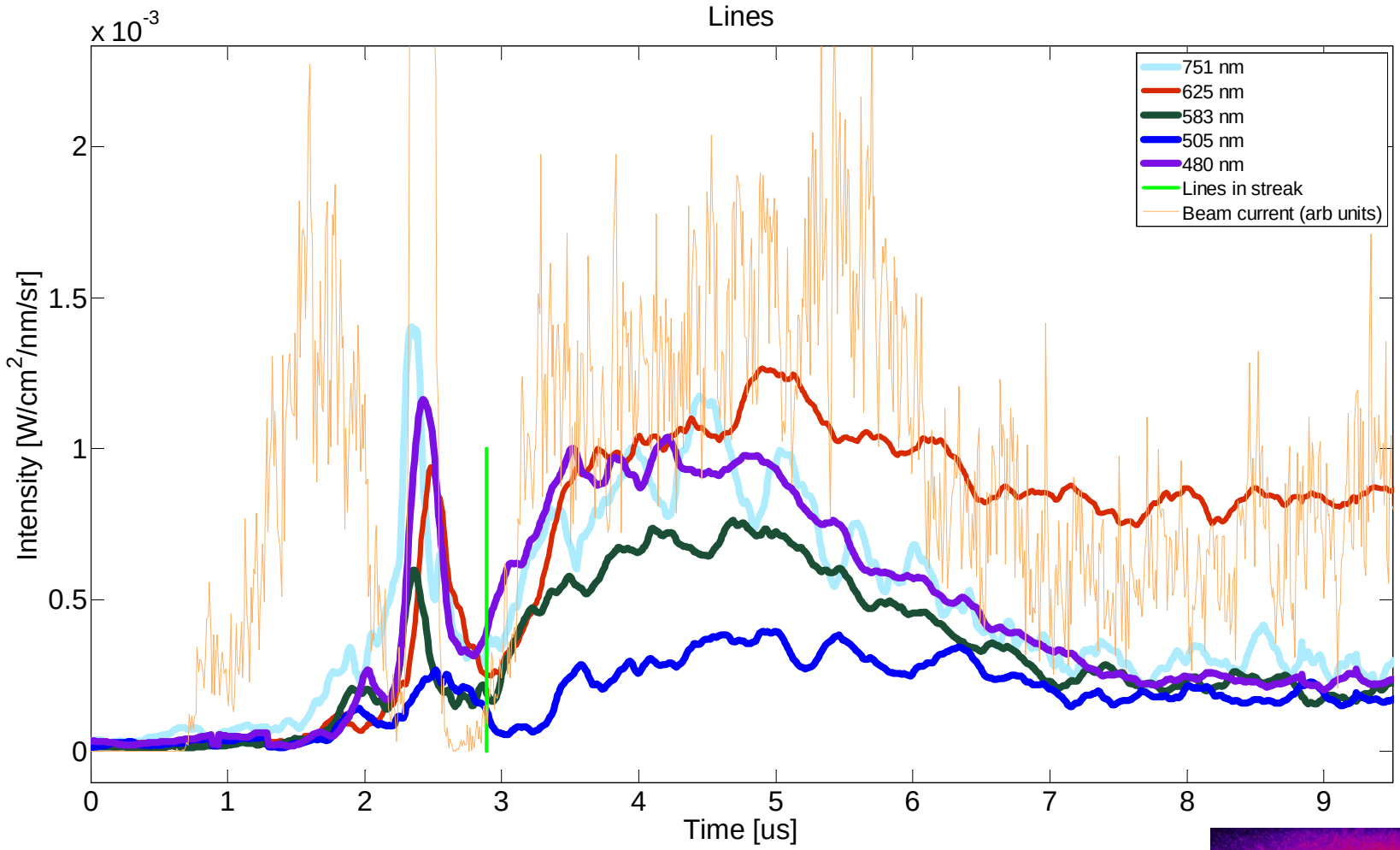


Summary: lines are coming from the Au target only!

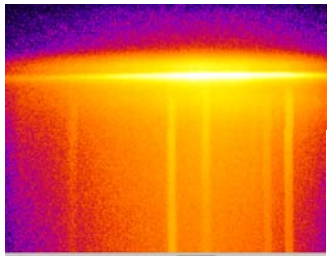


- **In red shown lines which overlap with experiment**
- **"w"-wide line**

<u>Summary: We could identify all lines as Au lines, but what is their nature?</u>



Lines are always present, they become remarkable when thermal radiation decreases after the peak.



Since lines "follow" the beam current, it is fair to assume that they are excited by ions of the beam?