
A NEW HIGH-THROUGHPUT DEEP UV RAMAN SPECTROMETER

June, 2009



Objective: Standoff Trace Detection of Energetic Materials

Signal To Noise Ratio (SNR) rules the day when Distance and Sensitivity is desired...

One approach to achieve high resolution AND Maintain light throughput is multiplexing.

Spectrometers built around Fourier Transform mathematical models are not practical for the Kinds of transient signals encountered in this Application.



Hadamard mathematics work best where the encoding is implemented spatially.



Comparison

Industry Standard (Czerny-Turner)	Alakai Deep UV Spectrometer
Single Slit	500 + slit multiplexed mode Single slit conventional mode Computational sensing mode
Resolution decreases with throughput increase (slit size)	No losses in throughput at highest resolution given even light distribution at entrance aperture And a bunch of other assumptions
Always a spectrum.....only a spectrum.....	Many mathematical models possible.... Direct or optically computed measurement of compounds of interest.



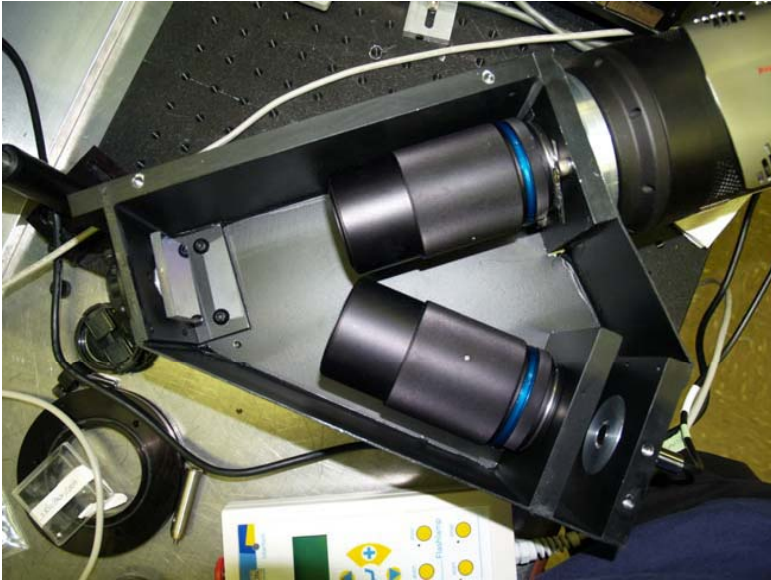
SPOTS the Spectral Computer

Spatially Programmable Optical Test System (SPOTS)

- Leverages DUSRS and AMTSS development
- Target market: Universities Teaching and Research
 - Applications benefiting from throughput.
 - Field Programmable optical computation of end members.
- Easy to use optical system for testing new optical algorithms.
- Optical Mask Starter Kit includes software support for.
 - conventional slit configuration
 - Hadamard Low resolution encodment
 - Hadamard High resolution encodment
 - Test patterns for alignment and calibration
- Custom fit to your camera of choice.



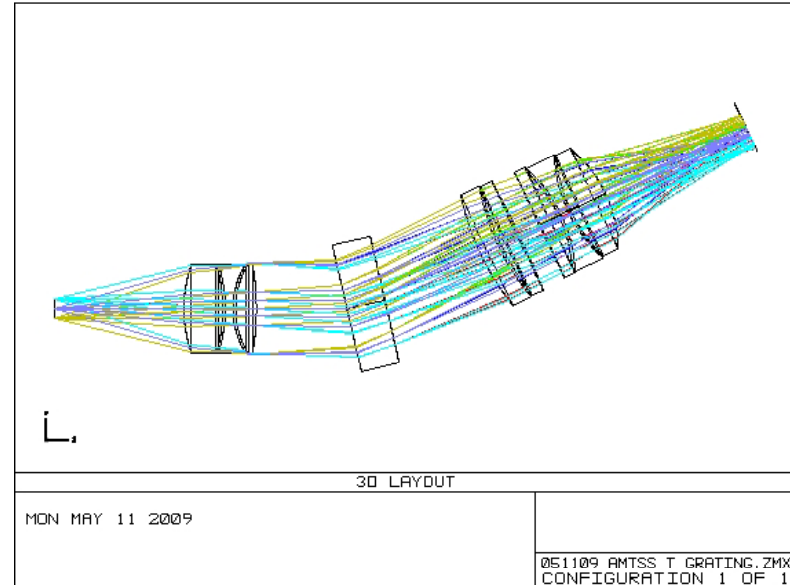
DUSRS and AMTSS



DUSRS

- OFF-AXIS SPECTRAL IMAGING
- PROGRAMABLE APERTURE ENABLED
- LOWER THROUGHPUT WITH SINGLE SLIT
- HIGHER THROUGHPUT MULTIPLEXED MODE

Thanks to Dr. Sharma's laboratory for DUSRS photo



AMTSS

- Builds on DUSRS lessons
- DUAL SPECTRAL RANGE UV _VIS / LIBS/RAMAN
- Spatial Imaging Extent Optimized
- Commercial grade
- Custom Alakai C&E optical solution
- Throughput competitive in single slit mode
- Ultra-high throughput in multiplexed mode
- Large area entrance aperture
- Special fiber bundle coupling to accommodate non-uniform sources

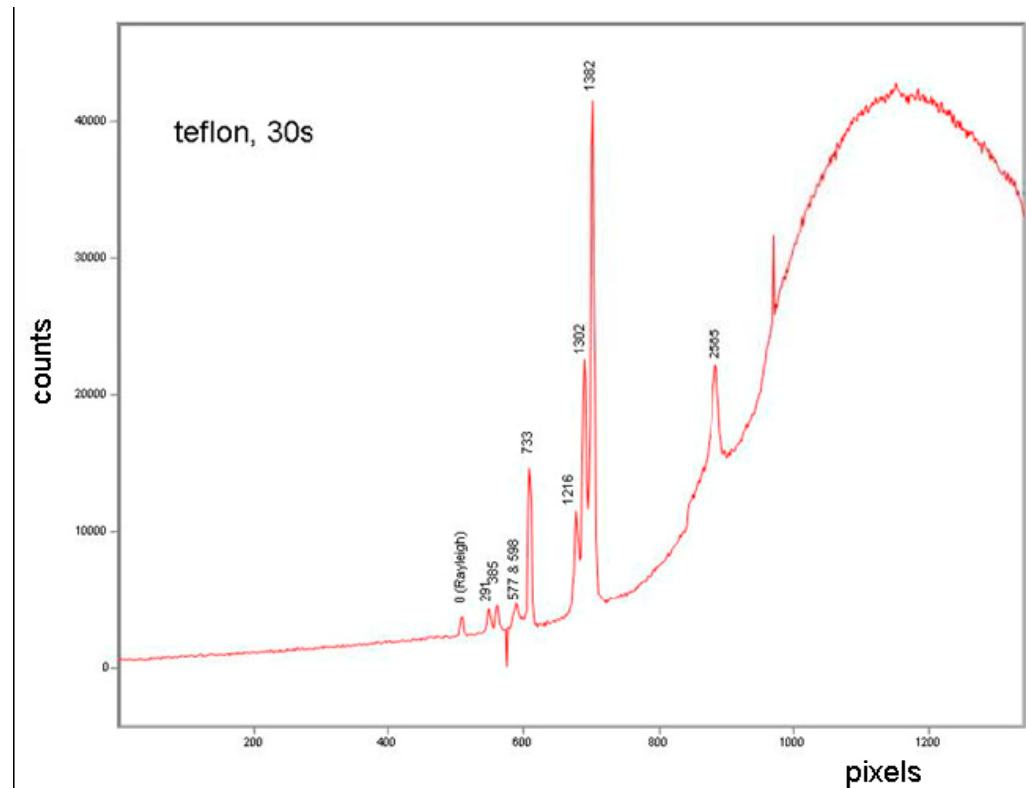


DUSRS and AMTSS

- DUSRS built as test bed for custom Alakai optical solution: AMTSS
- AMTSS improves on lessons from DUSRS and optimizes optics
- AMTSS is pre-production prototype system for first product offering
- AMTSS will prove out breakthrough in spatial source matching for maximum possible throughput.



DUSRS TESTING



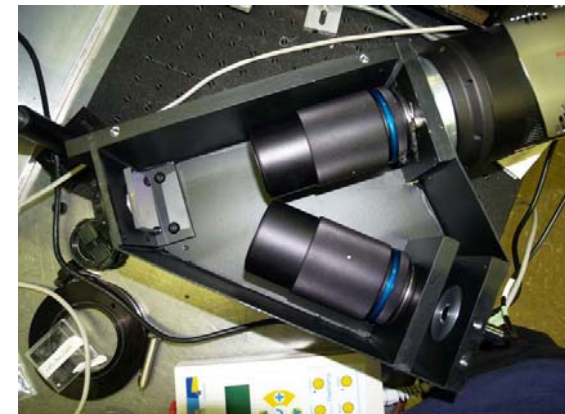
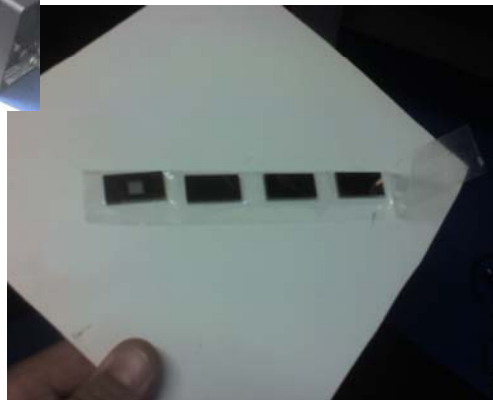
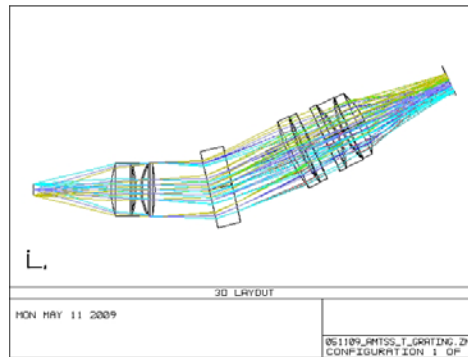
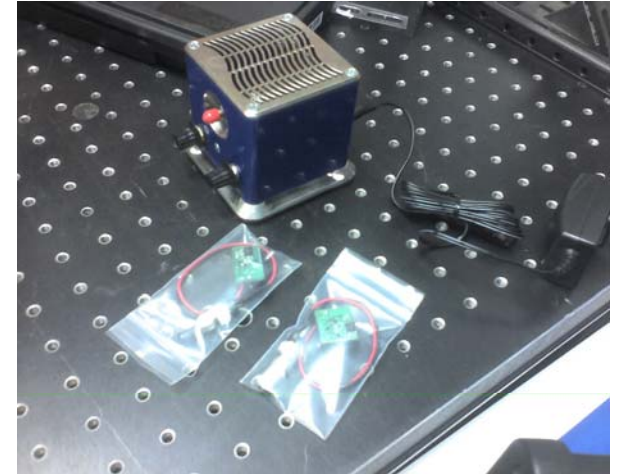
Typical Raman spectrum of Teflon at 8 m measured with DUSRS equipped with 3600g/mm grating. Laser = 266nm, 25 mJ/pulse, 15 Hz, integration time was 30 s. The peak positions are marked in cm⁻¹.

Thanks to Dr. Sharma's laboratory for data



AMTSS TESTING

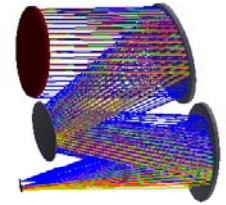
- Optical Masks
- Fiber optic sources
- ICCD
- DUSRS Optical Bench



Appendix

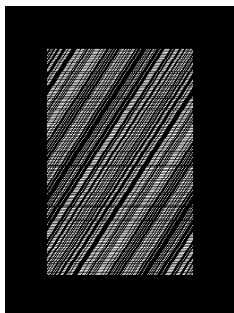


IMPROVING SNR



1. In simple case SNR can improve as much as $\text{SQRT}(N)$ or 44X in a typical spectrum of 2000 resolution elements
2. Optical domain programming of detection algorithms creates an “instant detect” mode with dramatic bandwidth reduction.
3. Implemented using an optical mask and an imaging spectrograph as a first step in a fully optimized encoded system for active source spectrometric measures.

SHORT STORY: We can achieve a 10X improvement in throughput over industry standard without loss of resolution.



ENCODED OPTICS 101: OPTICAL MULTIPLEXING

MULTIPLEXING IS ONE WAY TO IMPROVE SNR

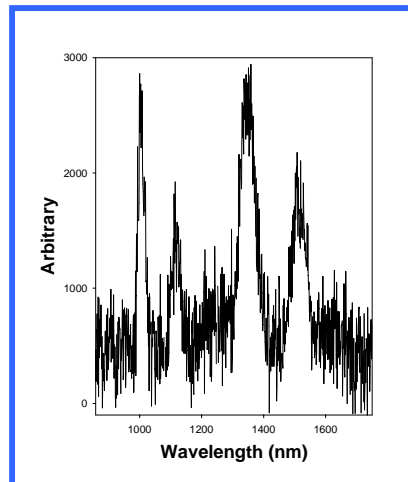
- Scanning Multiplexing methods will not work for us:
 - Fourier Transform
 - Hadamard Transform
- A First Step in the development of Alakai's patent pending design.
- Instant multiplexing spectrometry for pulsed and transient signals.
- Alakai's first design is a programmable encoded aperture system for Deep UV Raman measurements of energetic materials.



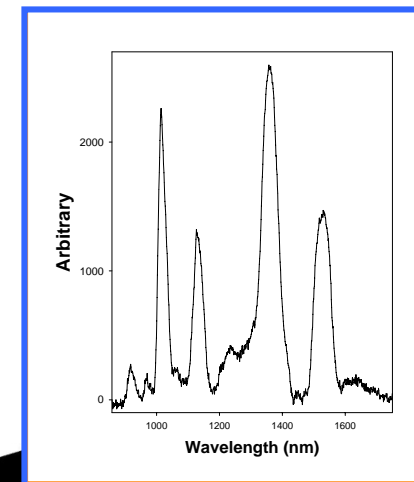
MULTIPLEXING USING A HADAMARD MODEL

Peak Wavelength (nm)	Hadamard Transform SNR	Conventional Raster SNR	SNR Improvement
1014.7	132.4	10.1	13.1
1029.4	77.0	6.4	12.0
1368.2	152.2	10.4	14.6
1530.5	85.7	7.4	11.6

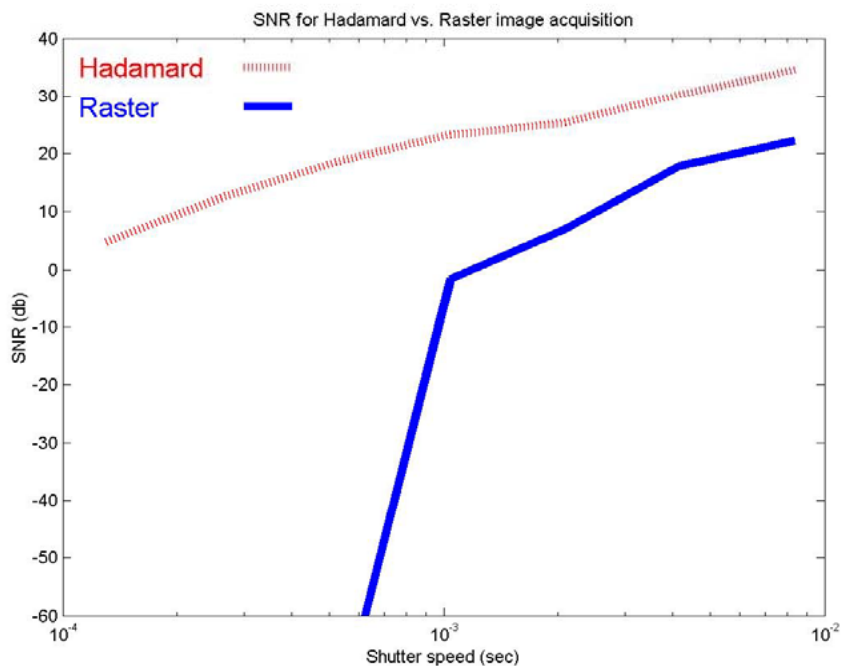
Raster Scan
(800 resolution elements)



Multiplexed Scan
(800 resolution elements)

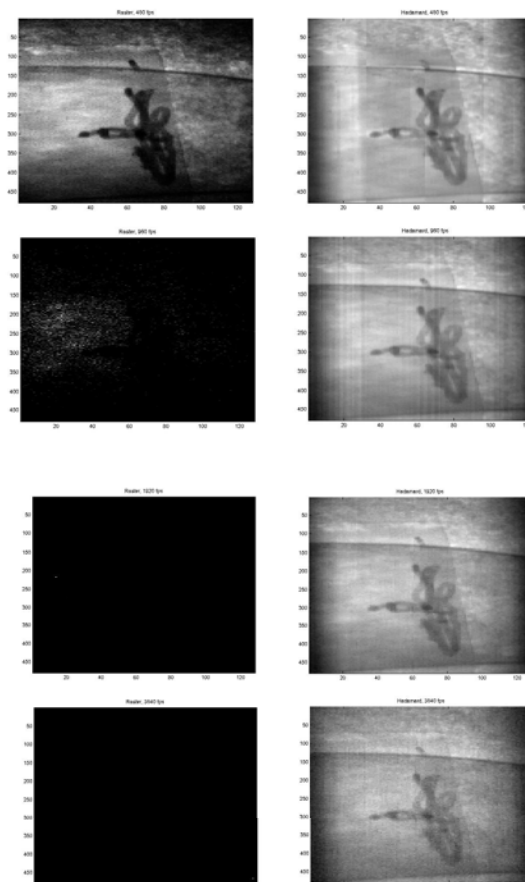


PRACTICAL EFFECTS: ABILITY TO COLLECT LIGHT WHEN OTHERS FAIL



Conventional

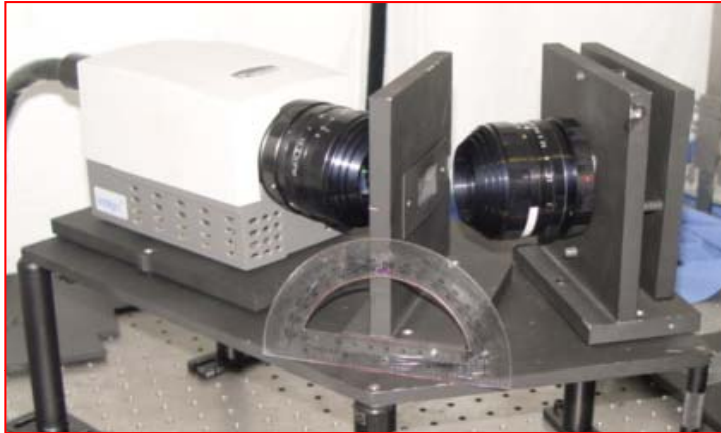
Multiplexed



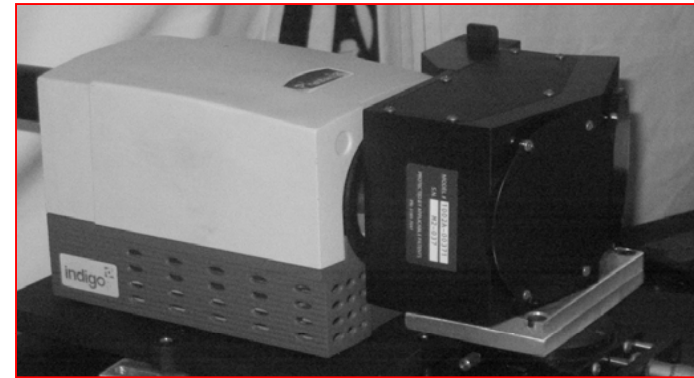
INTEGRATION
TIME



400nm – 1500nm Working Examples



Refractive embodiment
1300nm-1500nm
Prototype by RAD
Using special Kaiser NIR
Transmission grating



900nm-1700nm
And 400nm-1000nm
Using Headwall spectrograph

