TacBio: A UV-based Biological Aerosol Detector
TacBio Bio-Aerosol Trigger

- DoD technology licensed by RI in 2010
- Detailed technology transfer:
  - Engineering drawings, circuit board layouts, parts lists, and firmware
  - Cooperative Research and Development Agreement (CRADA) between ECBC and RI
- Detects and triggers in the presence of respirable biological aerosols
- Senses bio-aerosol fluorescence
- UV LED based; 20,000 to 30,000 hour source life; stable operation to 85°C
- Electro-optics is based on photon counting; minimal calibration drift
- Communication: RS-232 or wireless
- Windows software for setup and monitoring
- Removable data card - 5 yr capacity
- Will control RI air samplers/bio-identifiers
- 24+ hour operation with battery
- 8.8 pounds (4 kg)
What External Features Does a User See?

- Handle
- 1/4-20 female threaded mounting pad
- Battery door locks
- Battery power connector
- Battery
- Air Inlet Assembly
- Air Exhaust Assembly
- Audio Alarm
- Air Exhaust storage cover
- Air Inlet storage cover
- SD Card Access Port
TacBio History

- Basic concept developed in 2002-2003: Focus on soldiers in the field, robots, and UAV's
  - Compact
  - Lightweight
  - Low power
  - Low cost
- Final DoD embodiment with current features prototyped in 2007
- Refined through 13 field trials and field demonstration programs
- Supported by DARPA, DTRA, DoD Chemical Defense Program, DHS, Program Manager for Biological Defense, and U.S. Marines
- RI has done two comprehensive engineering upgrades since licensing to enhance function and serviceability
Many biological materials fluoresce when subjected to ultraviolet light.

This is not a common response for non-biological materials.

By subjecting particles in a moving air stream to UV light and monitoring both scattered and fluorescence light levels as particles pass through the light, non-biological and biological aerosol concentrations can be simultaneously monitored.
**TacBio’s Optical Approach**

**Principle of Operation**

Basic strategy: Monitor both scattered and fluorescent photons, and determine whether they appear in time coincidence or not.
**Photon Counting Circuitry**

Discrete Components

- Elastic Signal
- Fluorescent Signal
- Preset Threshold For Single Photon Events

Complex Programmable Logic Device

- Every 1 usec, determine if current from PMT exceeded pre-set limit, i.e. photon detected

Counts number of photons detected in 200 usec window

Atmel Microcontroller

- Mode Selection
- Adaptive Threshold
- Detection Rule
- Circular Buffers
- Time Stamp
- Data Storage
- Real-Time Output

Threshold Calculator (from calibration mode)
Alarm Variable Strategy

- There are three primary and six computed secondary alarm variables.
- These are based on scattering and fluorescence photon counts, and whether or not they are coincident in time.
- Through empirical testing in benign environments and with threat agents, a set of limits for these variables can be established. When a particular set of these alarm criteria are exceeded, an alarm signal is generated.
The Advantages of Photon Counting

- Photon counting is analogous to a Geiger Counter’s mode of operation, or to the difference between FM and AM radio operation.
- A particle’s fluorescence emission and scattering behavior is monitored photon-by-photon using high-speed analog electronics and counting algorithms.
- Photon peak height is not directly measured—only the number of photon events and correlated scattering and fluorescence events.
- Hence, moderate changes in electronic gain do not affect system calibration.
- Unit-to-unit uniformity of response is improved.
The Best Excitation Wavelengths

- Biological materials typically fluoresce in the 300 to 400 nm wavelength range.
- Optimum excitation wavelengths are <300nm. However, such solid state UV sources currently have lifetimes of only a few hundred hours.
- Research International has pioneered the use of stable 365nm UV LEDs as excitation sources.
- Older first-generation competitors use 405nm blue laser diodes. These only excite the biological fluorescence ‘tail,’ resulting in low sensitivity and large electric power demands.
Long-lived LED Light Source

Actual drive current is about 300 mA.
Conclusion: Operating life of 20,000 to 30,000 hours possible
LED Image at Nozzle Focal Plane

A square LED source and aperture provide a uniform UV intensity over the entire particle beam’s cross-section.
TacBio can directly control air samplers and other devices using its RS-232 serial output

- It is Bluetooth capable when used with the BioLink™ product

Windows software:
- Used for instrument setup
- Can monitor multiple devices
- Can control/modify TacBio operation

Local alarms:
- RED LED
- Horn

Data storage:
- micro-SD card with 5yr. data capacity

Built-in test:
- Upon startup
- During operation
- Yellow LED warning
The behavior of six TacBio units built by RI (T1021-T1026) are compared here with a reference ECBC unit, P007. Note the similarity of response.
Conclusions

- TacBio provides a low cost bio-detection solution
  - Refined over a six year period of development and testing with U.S. DoD and Department of Homeland Security support
  - Key low cost components have been developed
  - No consumables! Suitable for continuous 24/7 operation

- Performance at or better than original goals
  - In realistic environments, LOD in the 100-300 ACPLA range
  - Response time of 1 minute
  - Large background, simulant, agent data bases
  - Robust LED light source; Design flexible to receive new LEDs for better performance
  - Unique photon-counting strategy virtually immune to gain drift