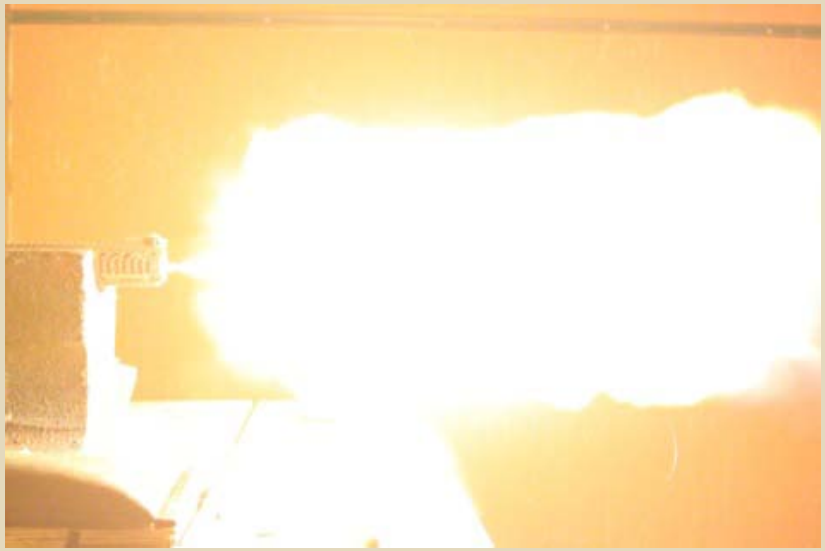
NAVSEA
WARFARE CENTERS
CRANE

CRANE DIVISION

NAVAL SURFACE WARFARE CENTER

Small Arms Flash Measurement



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Background

- **SOF Operators are seeking to decrease weapons signature**
  - **Sound**
  - **Flash**
- **Requirements documents include flash reduction**
  - **Phrased as “80% reduction in muzzle flash from baseline”**
- **There is no industry-wide standard for measuring muzzle flash**

Current Methods

- **Photography – three methods**
  - **Subjective rating**
    - **Photograph with open shutter**
    - **Sort from best to worst by looking at the photos**
  - **Measure Size**
    - **Photograph against grid of known size**
    - **Leave shutter open – long exposure**
    - **Count grid squares**
    - **Adjust for parallax**

Photographic Methods

- **Fails to account for brightness**
  - **Chinese Lantern vs. Weapon Light**
- **Works best for large flashes**
  - **Measurement with a 1” grid lacks resolution**

– **Pixel Counting**
  - **Leave shutter open – long exposure**
  - **Convert image to black and white**
  - **Count the white pixels with image processing software**
  - **Fails to account for brightness**

Impulse Photometer

- **Legacy system at Crane**
  - **Uses two arrays of photocells**
    - **Each array consists of 3 photocells**
    - **Photopic - approximates response of human eye**
    - **IR - 750-1100 nm**
    - **Magnitude of output controlled by distance**
  - **Signal processing**
    - **Each array processed by an amplifier that adds the three signals together**
  - **Output and Data Logging**
    - **An oscilloscope**
      - **Output in Volts**
    - **A piece of paper**

Issues with Original System

- **An oscillowhat?**
  - **Not used often**
  - **Learning curve**
- **Output in Volts**
  - **Not a unit of light measurement**
  - **Response of photocells is not linear**
  - **Output added together and averaged before conversion to physical units**
- **No calibration method**

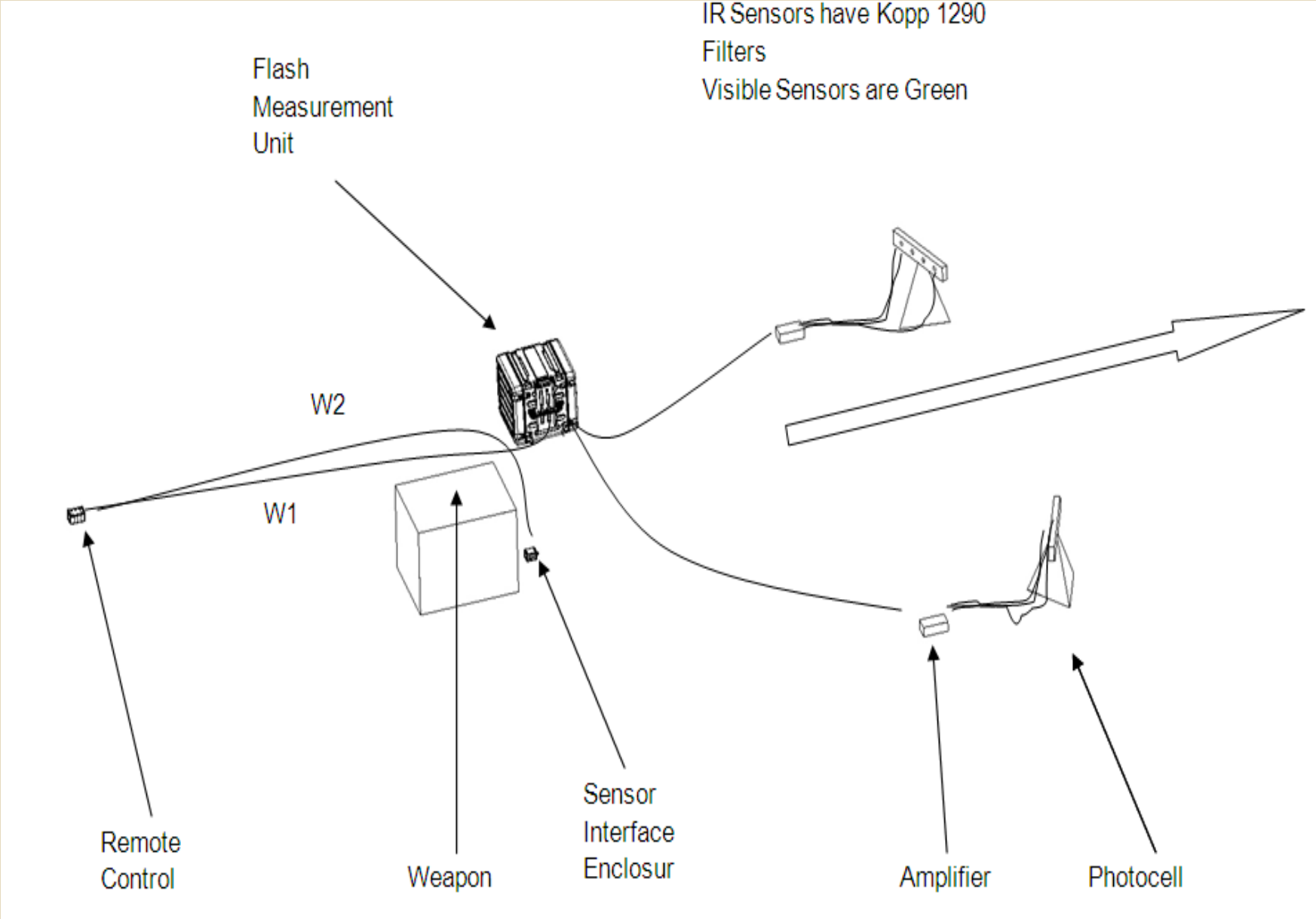
Updated Impulse Photometer

- **Re-use existing equipment**
  - **Original system bought in early 1990s.**
- **Objectives**
  - **Automate data collection**
  - **Scripted set ups**
    - **Equipment not used often**
    - **Technicians performing test may have never seen the equipment before**
  - **Capable of measuring full auto muzzle flash**
  - **Method of Calibration**
  - **Reporting in appropriate units**
  - **System Diagnostics**
    - **Is everything working?**

Updated Impulse Photometer

- **New Amplifiers**
  - **Original Amplifiers had to much noise at required gain levels**
- **New Data Acquisition Modules**
  - **National Instruments Signal Processing**
- **Laptop with Data Acquisition Software**
  - **Software built in Labview**
- **Manual Trigger**
- **Laser Proximity Sensor**
  - **Automatic trigger**
- **Calibration Method**

System Overview



Units of Measure – Visible

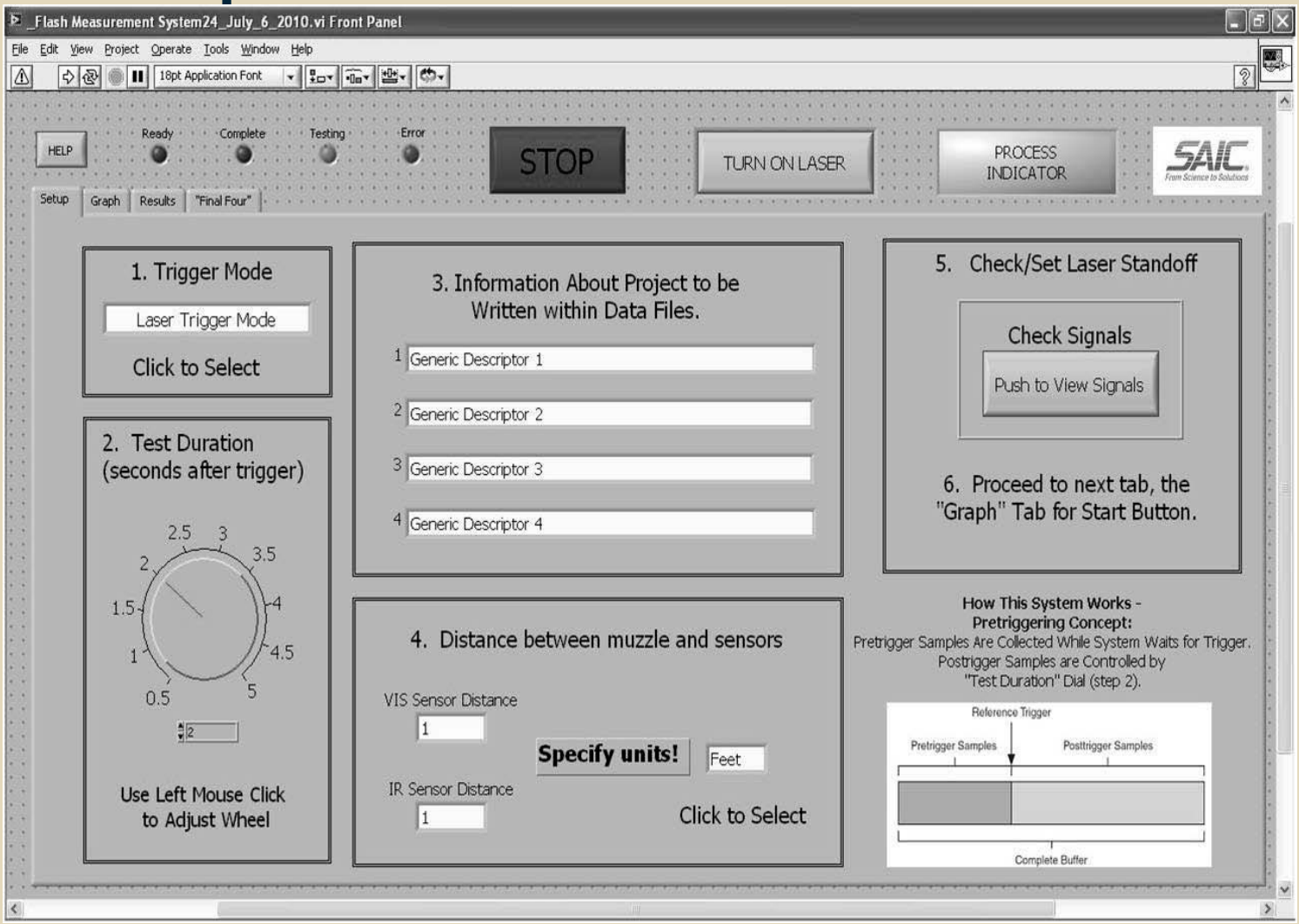
- **Lumens/Steradian (aka Candela)**
  - **Lumens is a measure of luminous flux that can be seen by the human eye**
  - **Steradian is a solid angle**
    - **4π steradians in a sphere**
      - **Similar to 360 degrees in a circle**
    - **Total luminosity = 4π * measurement**
      - **Assumption of uniform spherical emission**
- **Lumen-Seconds (aka Talbots)**
  - **Measure of total visible light emitted**
  - **Calculated with piecewise integration**

Units of Measure - Infrared

- **Watts/Steradian**
  - **Lumens are only in the visible range**
  - **Intensity**
- **Watts-Seconds (aka Joules)**
  - **Measure of total energy emitted in the 750-1100nm band**
  - **Calculated with piecewise integration**

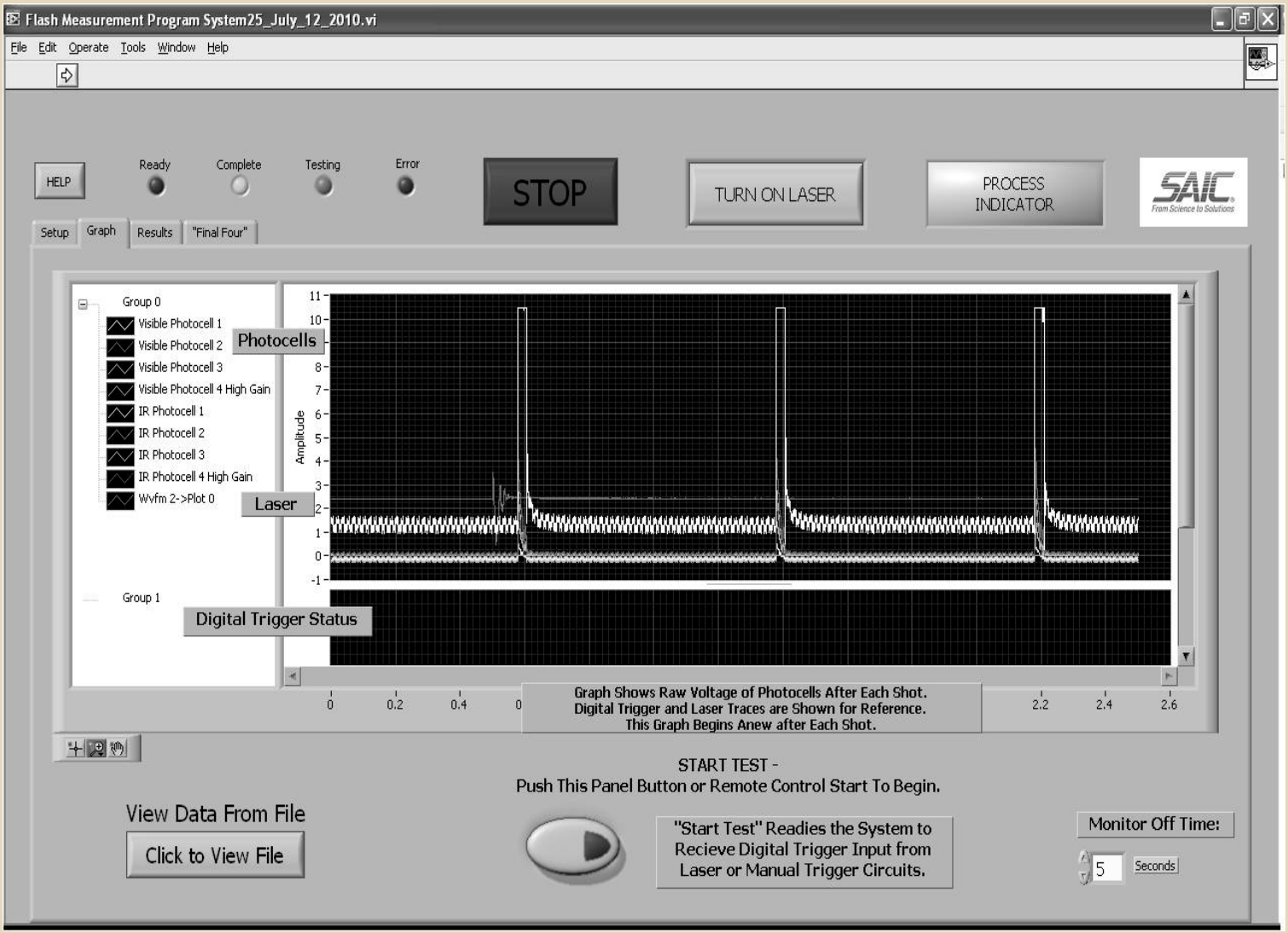
Software Interface

- **Setup**



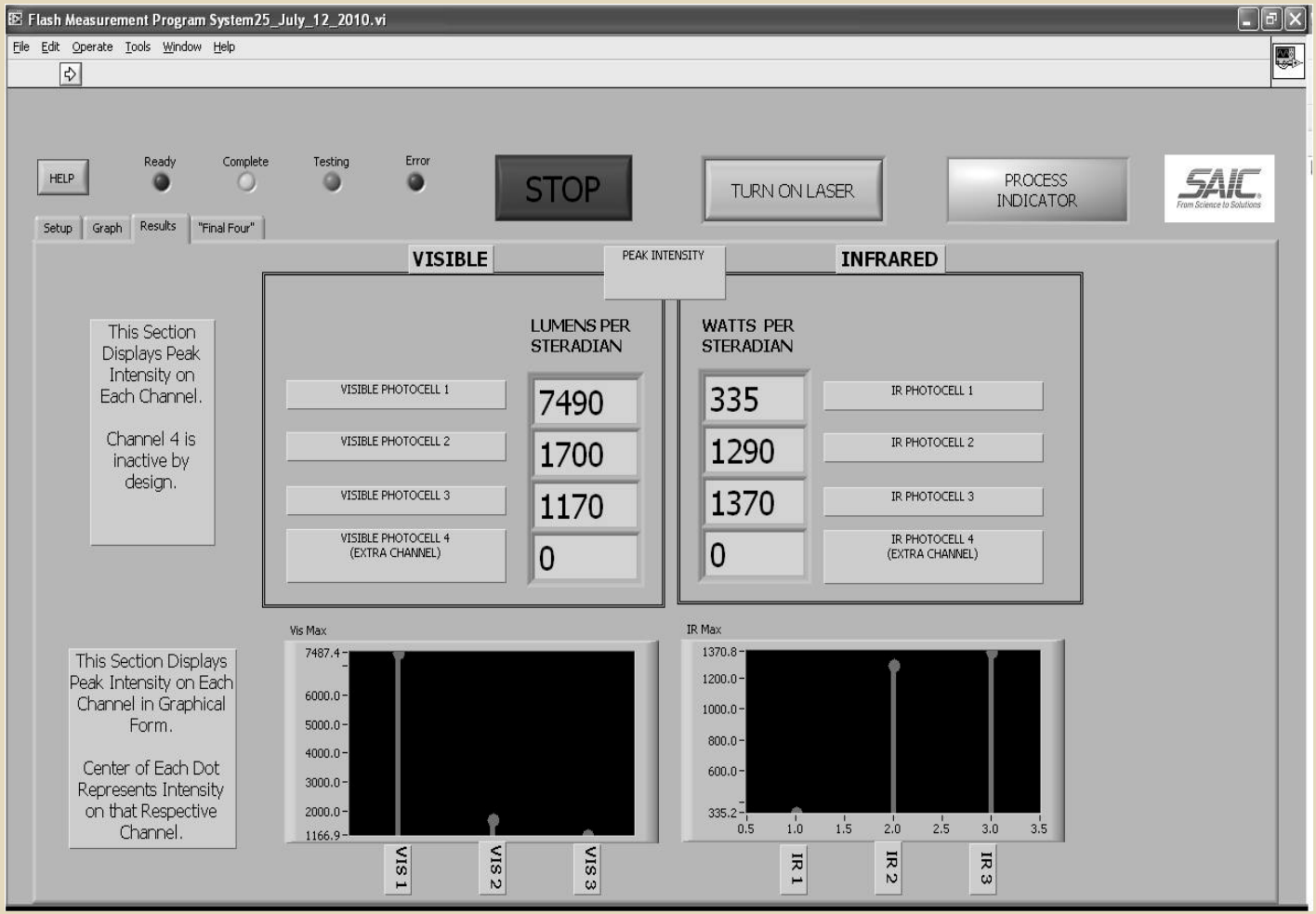
Software Interface

- **Graph Tab**



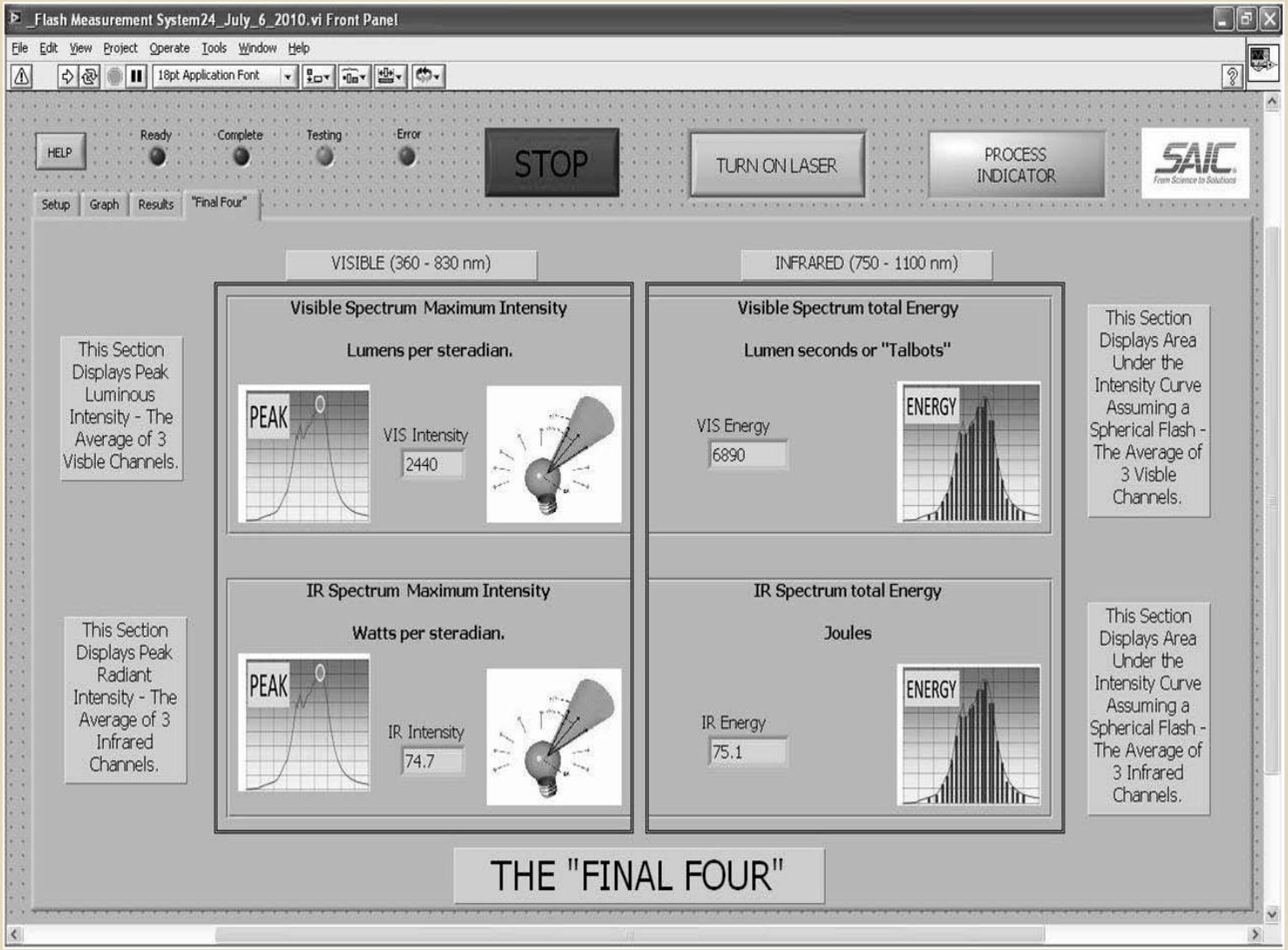
Software Interface

- **Results Tab**



Software Interface

- **Final Four**



Sample Measurements w/ Flash Suppressor

	Lums/srad	Lum-sec	W/srad	Joules
1	.557	1.573	.107	.001
2	.568	.835	.190	.003
3	.559	.809	.190	.003
4	.565	.835	.218	.003
5	.572	.826	.208	.003
5 Rnd Burst	.586	1.109	.254	.019

Sample Measurements w/ Sound Suppressor

	Lums/srad	Lum-sec	W/srad	Joules
1	.029	.55	.194	.005
2	.016	.251	.033	0
3	.016	.256	.013	0
4	.023	.287	.015	0
5	.022	.287	.015	0
5 Rnd Burst	.065	.808	.048	.003

First Round Pop

Second Round

Lessons Learned

- **Muzzle Flash is Temperature Sensitive**
- **There is always another source of light**
  - **Just when you think you put tape over the last LED…**
- **Shooting in the dark is much easier with a chem-light on the backstop**
- **Sensors in the arrays should be at different gains because sound suppressors have highly variable flash**

Sample Measurements Issues

	Lums/steradian	Lum-sec	Watts/steradian	Joules
1	.434	.31	2.412	.005
2	.0	0	.025	.003
3	.0	0	.024	.003
4	.0	0	.031	.003
5	.0	0	.024	.003
5 Rnd Burst	.045	.024	.066	.019

Wishlist

- **Change User Interface to decrease flipping through tabs**
- **More scripting**
- **Auto-ranging**
  - **First shot pop is several orders of magnitude brighter than follow on shots**
  - **Excess brightness currently handled by moving the sensors farther away**
- **Scotopic Sensors**
  - **Scotopic duplicates human night vision**

Questions