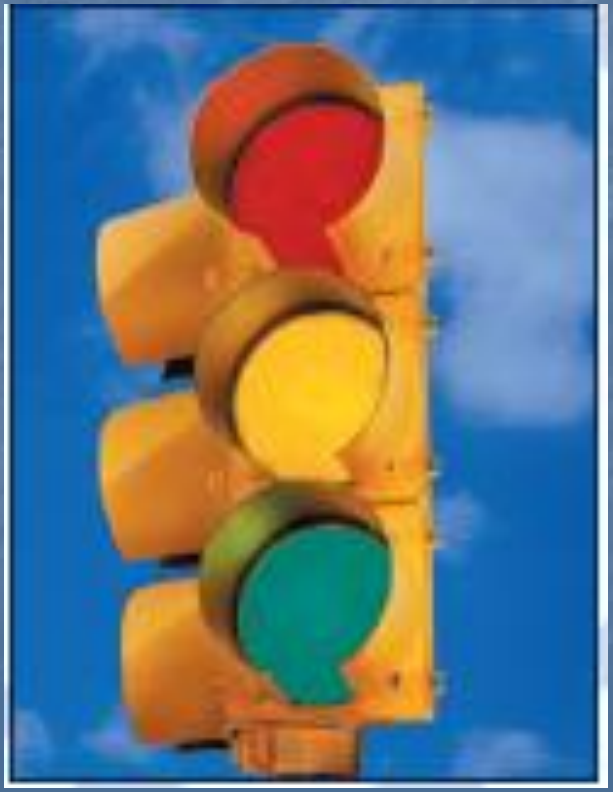
Vehicle Traffic Control Signal Heads –

Light Emitting Diode (LED) Circular Signal Testing



What is an LED?

LEDs are more closely related to computer technology than they are to traditional forms of lighting, as an LED is basically a semi-conductor.

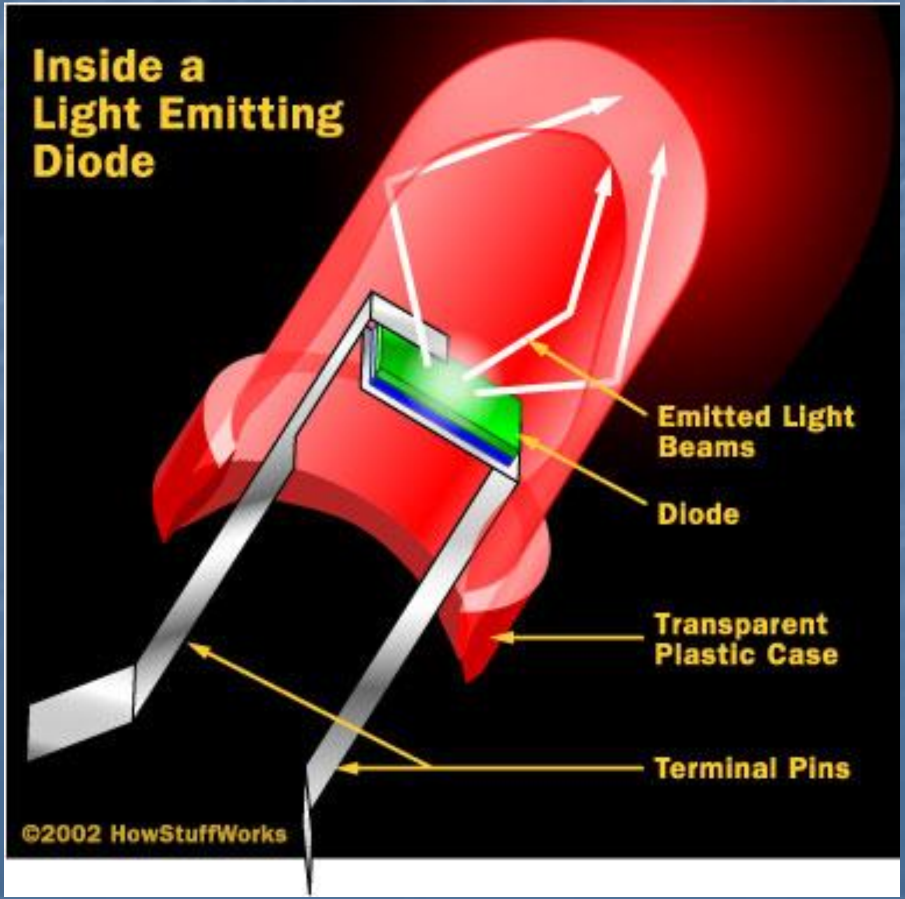
When energy passes through two electron-charged materials, electrons jump from one material to the other. As an electron jumps, it emits energy in the form of a photon.

The color of light created by a given LED depends on the amount of energy in that photon. This, in turn, depends on the material used for the layers.

-Living on Earth

www.LOE.org/Series/LED

While all diodes release light, most don't do it very effectively. In an ordinary diode, the semiconductor material itself ends up absorbing a lot of the light energy. LEDs are specially constructed to release a large number of photons outward. Additionally, they are housed in a plastic bulb that concentrates the light in a particular direction. As you can see in the diagram, most of the light from the diode bounces off the sides of the bulb, traveling on through the rounded end.



LEDs have several advantages over conventional incandescent lamps:

- They don't have a filament that will burn out, so they last much longer.
- Their small plastic bulb makes them a lot more durable.
- They also fit more easily into modern electronic circuits.
- The LED’s are much more efficient

VS.

More Benifits

- Up until recently, LEDs were too expensive to use for most lighting applications because they're built around advanced semiconductor material. The price of semiconductor devices has plummeted over the past decade, however, making LEDs a more cost-effective lighting option for a wide range of situations.
- LEDs generate very little heat, relatively speaking. A much higher percentage of the electrical power is going directly to generating light, which cuts down on the electricity demands considerably.
- While they may be more expensive than incandescent lights up front, their lower cost in the long run can make them a better buy.

Why are they replacing all the traffic signal lights?

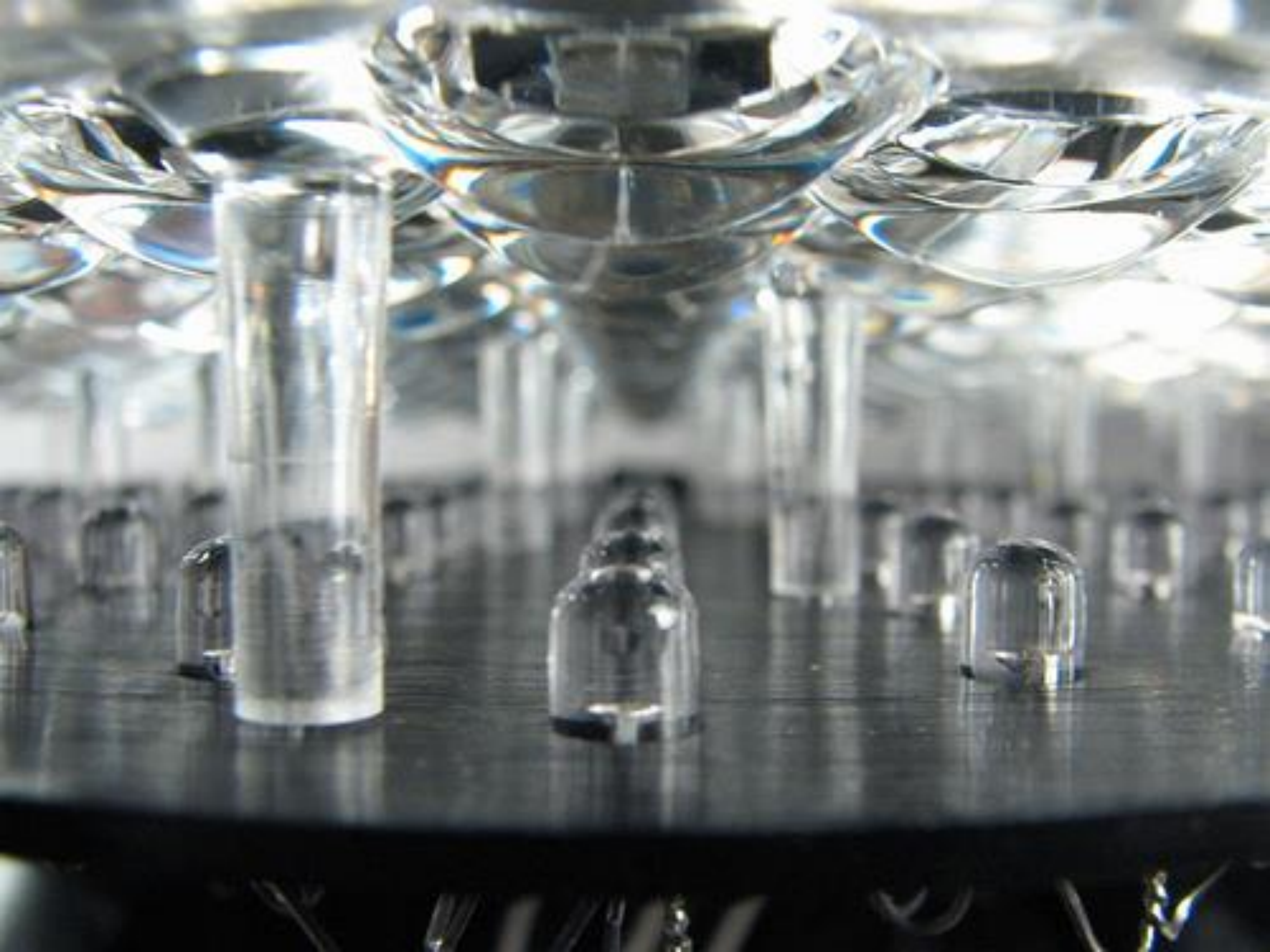
The new traffic lights you are seeing installed are made of an array of LEDs. Each LED is about the size of a pencil eraser. The LEDs are replacing the old-style incandescent halogen bulbs rated between 50 and 150 watts.

Cost Comparison

Assume that a traffic light uses 100-watt bulbs today. The light is on 24 hours a day, so it uses 2.4 kilowatt-hours per day. Assume power costs 8 cents per kilo-watt-hour, it means that one traffic signal costs about 20 cents a day to operate, or about $73 per year. Figure there are about eight signals on at any one time per intersection and that is $600 per year in power per intersection.

LED bulbs consume 15 watts instead of 100, so power consumption drops by a factor of 6.6. The same intersection only costs $90.

The state can save millions of dollars in power consumption by using LED units. Plus the need for maintenance is reduced drastically.



How will Materials and Tests be Involved?

The Traffic Signals Group has asked Materials and Tests to aide them in the testing of the LEDs. We will be serving two functions:

1) Test new LED for compliance with specification and add them the approved list.

2) Perform routine checking of LED brought in from the field and track the Intensity and color over time. This will enable the Traffic Signals Group to develop a useful live expectancy of the LEDs and develop a replacement program.

What specifications will be followed?

The Institute of Transportation Engineers (ITE) has developed a specification called Vehicle Traffic Control Signal Heads (VTCSH) - Light Emitting Diode (LED) Circular Signal Supplement

•The purpose of this specification is to provide the minimum performance requirements for 200 mm (8 in) and 300 mm (12 in) LED vehicle traffic signal modules while in service.

- **We will be testing for Luminous Intensity and Chromaticity**

Definitions

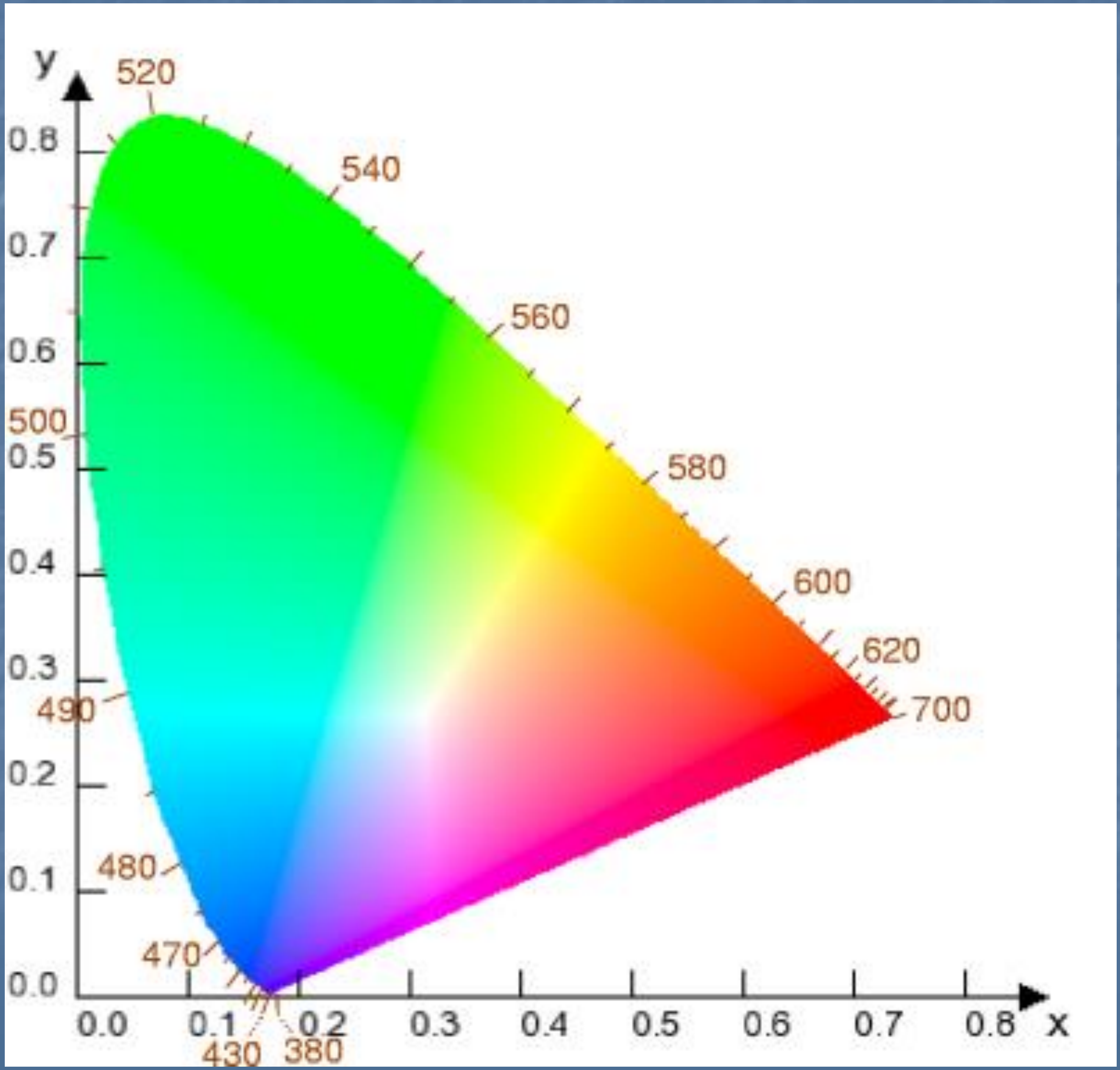
Chromaticity: The color of the light emitted by a module, specified by the x, y chromaticity coordinates on the 1931 Commission Internationale d'Eclairage (CIE) chromaticity diagram.

Luminous Intensity: The luminous flux emitted in a given direction from a source, per unit solid angle, expressed in candelas (cd).

Luminous flux: The rate of flow of light per unit of time.

1931 CIE Diagram

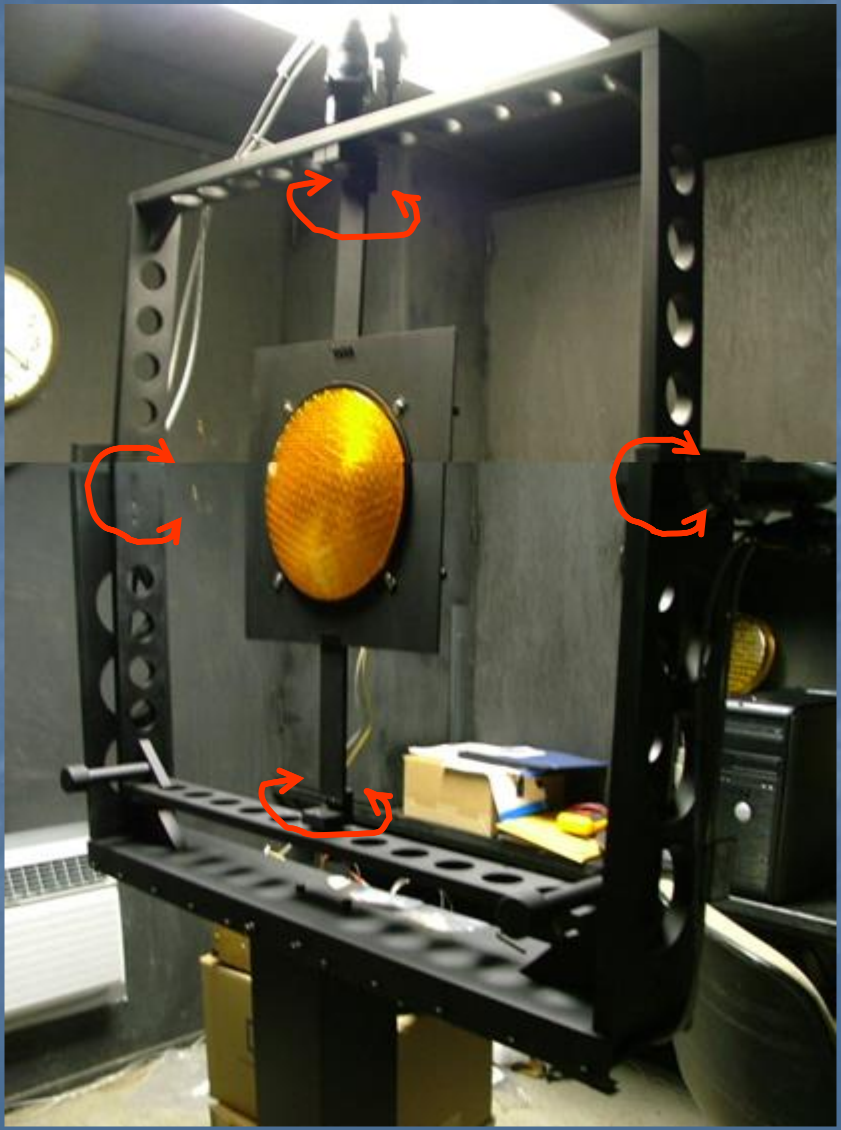
The diagram represents all of the chromaticities visible to the average person. These are shown in color and this region is called the gamut of human vision. The gamut of all visible chromaticities on the CIE plot is the tongue-shaped or horseshoe-shaped figure shown in color. The curved edge of the gamut is called the *spectral locus* and corresponds to monochromatic light, with wavelengths listed in nanometers. The straight edge on the lower part of the gamut is called the *line of purples*. These colors, although they are on the border of the gamut, have no counterpart in monochromatic light. Less saturated colors appear in the interior of the figure with white at the center.



Our Testing Equipment

Model 940 DG
2-Axis Goniometer

An instrument which allows an object to be rotated to a precise angular position. This instrument rotates the LED module in both the horizontal and vertical direction.



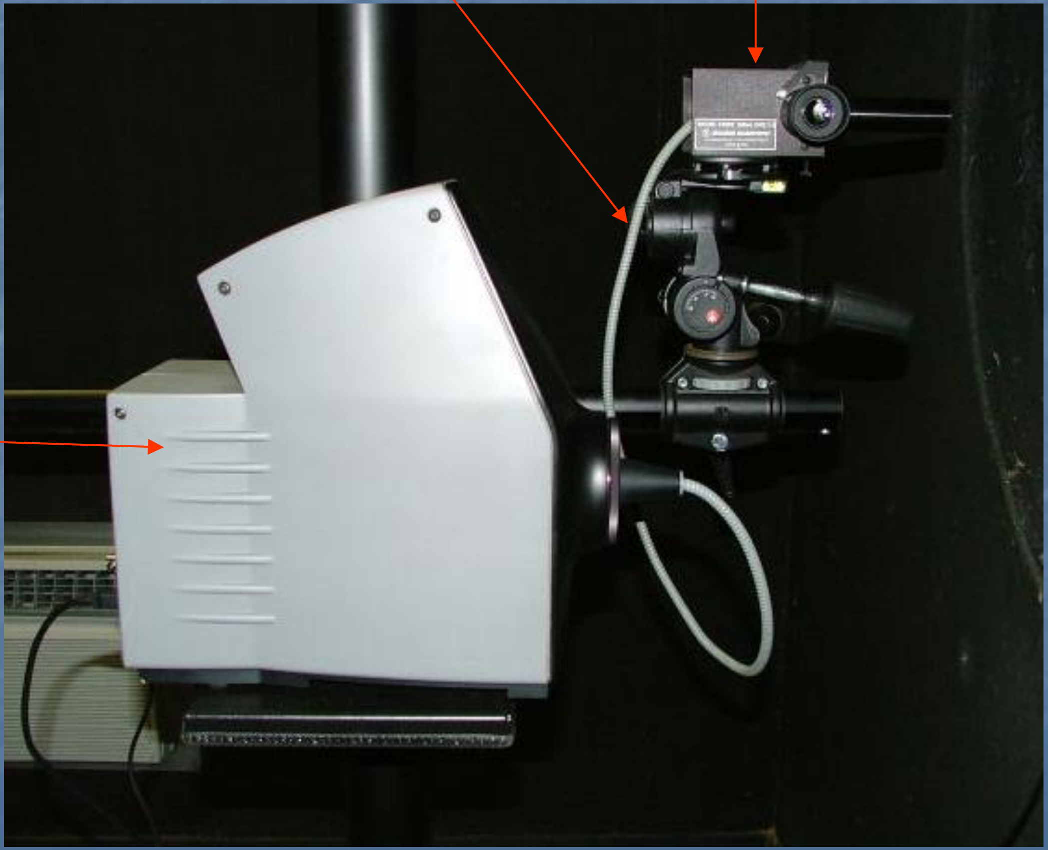
Our Testing Equipment

RadOMA Spectral Measurement System

Fiber Optic Cable

Scope

RadOMA



Our Testing Equipment

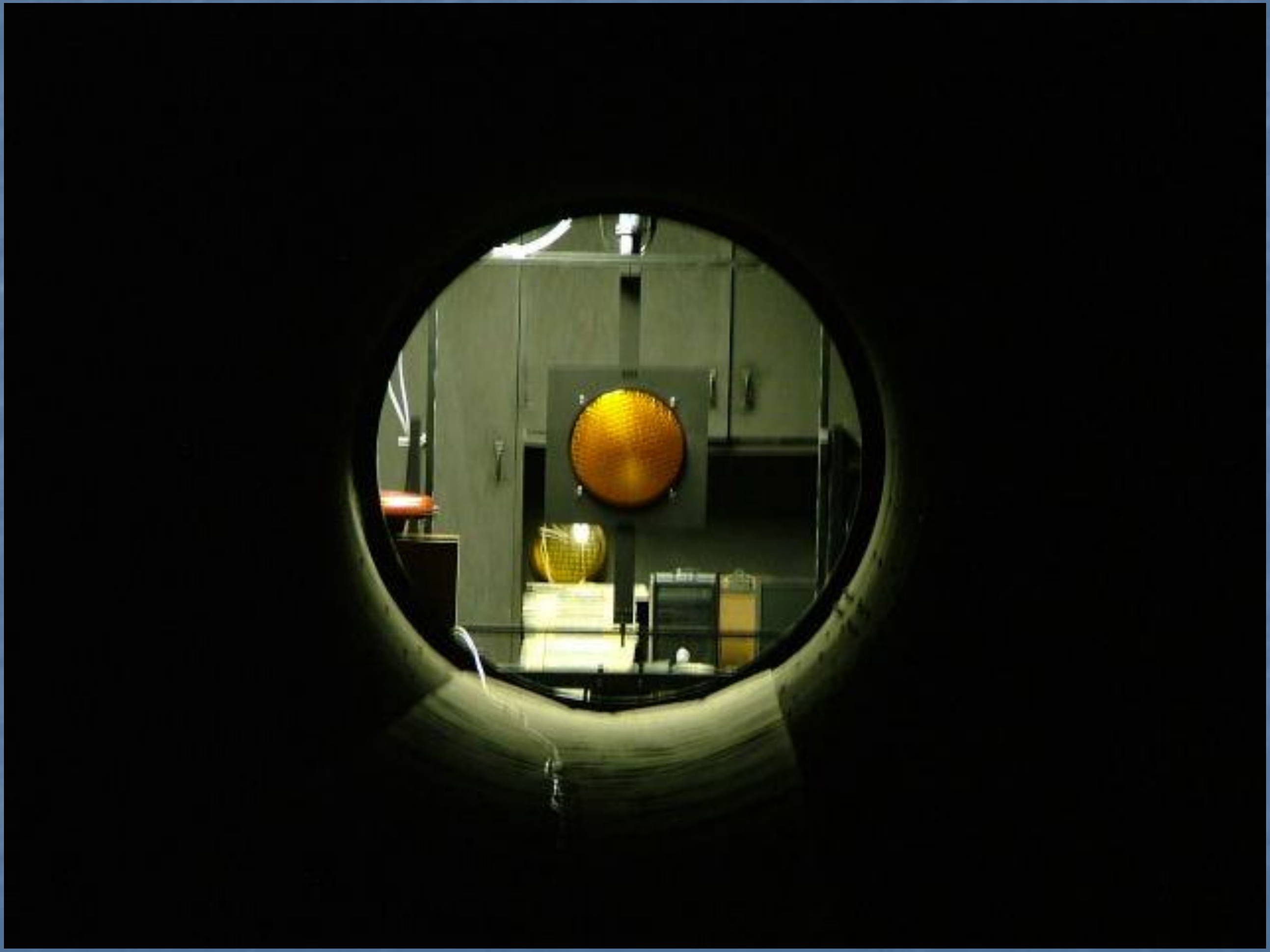
RS-10B Spectral Irradiance Head

The RS-10B calibration light source is a precision source of radiant flux, used primarily to calibrate light-measuring instrumentation and as stimuli to measure detection devices.

Our Testing Equipment Set Up

Looking down the tunnel

The tunnel is 50 feet long and is connected by two sheds which house the equipment. A laser is used to perfectly align the center of the LED with the center of the barrel of the scope.

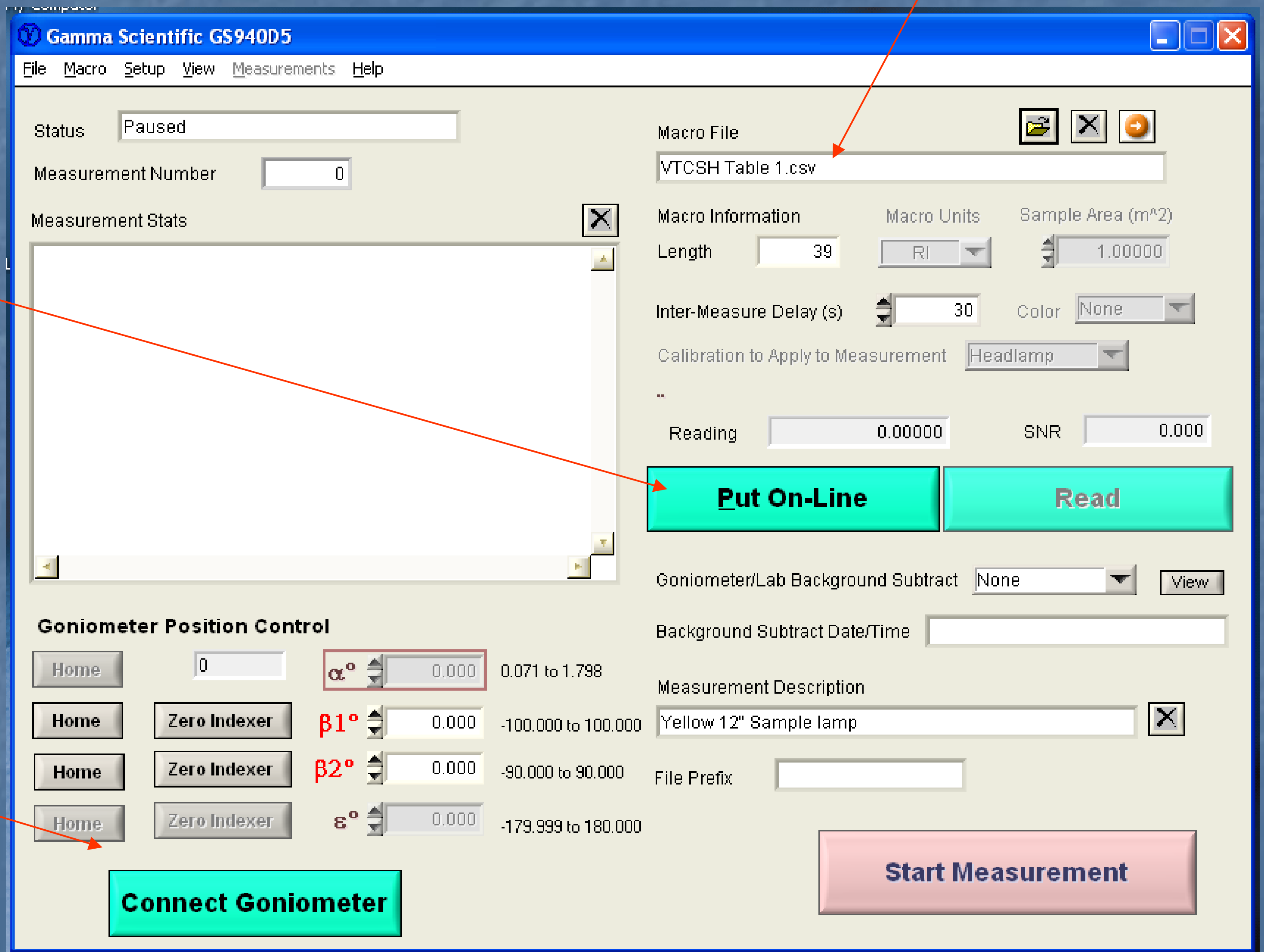


What does the software look like?

Create a macro file to tell the computer what angles to take the Goniometer through

Turns the RadOMA on

Turns the Goniometer on

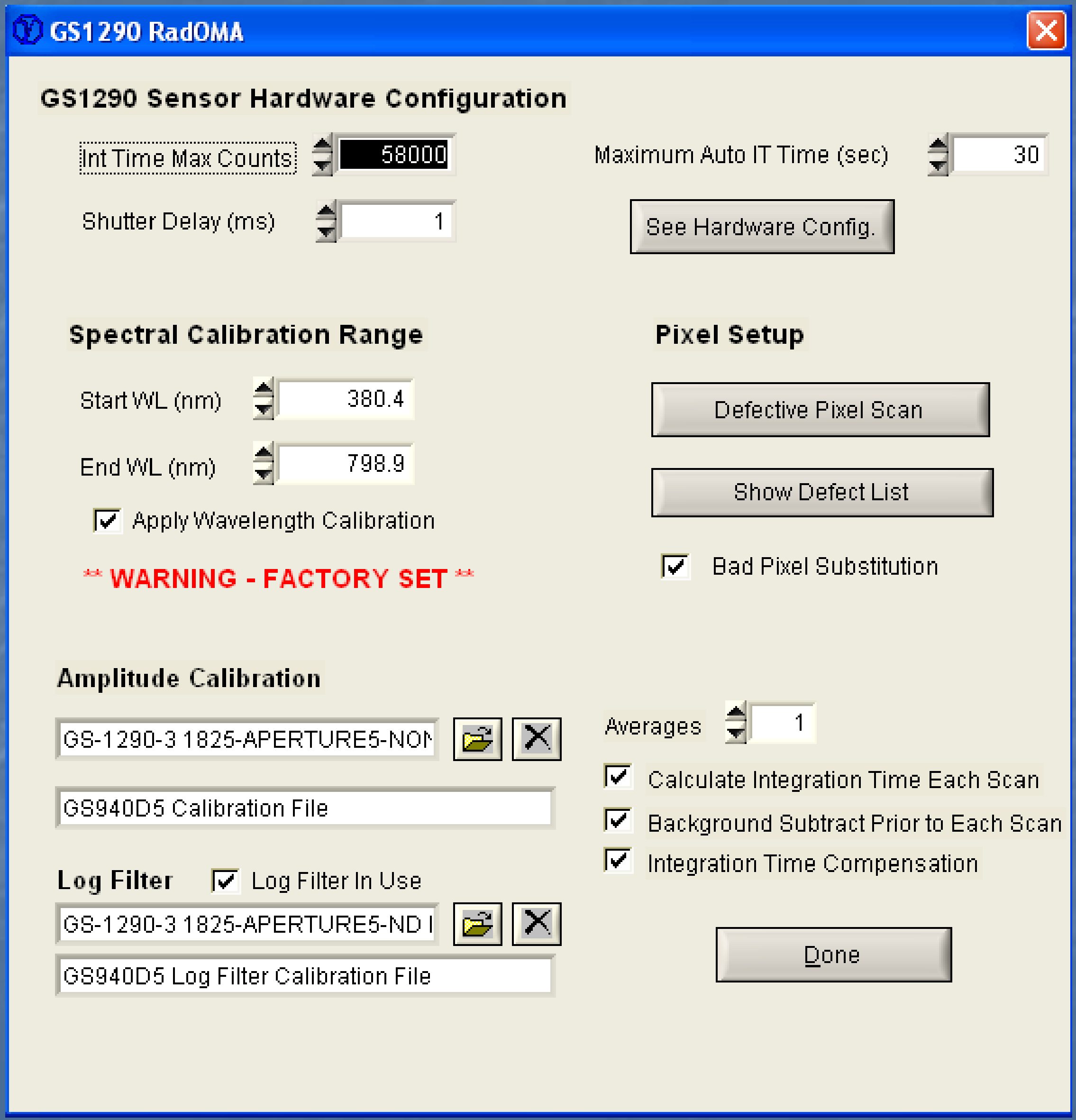


Changing the calibration file

The calibration file has to be changed when you switch between testing 200 mm LEDs and 300 mm LEDs

- When looking through the scope you should see the entire lens of the LED if not you have to change the aperture until you can.

- When you change the aperture you must change the Amplitude Calibration file and the Log Filter file to match the aperture.



What happens when you click on the Start Measurement Button?

1) The Goniometer will start traveling through the specified combinations of angles from the macro file stopping briefly at each point.

2) When the Goniometer stops at each measurement the RadOMA takes a reading.

3) Once all of the angles have been travel through the program will open Excel and generate a data file

Example of What Raw Data Looks Like

alpha	beta1	beta2	epsilon	irradiance	lux	candelas	x	y
0	12.5	2.5	0	0.432944	0.634265	160.8329	0.7002	0.298
0	12.5	7.5	0	0.402634	0.588629	149.2608	0.7004	0.2978
0	12.5	-2.5	0	0.421294	0.615217	156.0029	0.7000	0.298
0	12.5	-7.5	0	0.384865	0.561468	142.3735	0.6997	0.2981
0	7.5	2.5	0	1.023241	1.490401	377.9265	0.7011	0.2975
0	7.5	7.5	0	0.827179	1.203841	305.2624	0.7010	0.2976
0	7.5	12.5	0	0.55718	0.809915	205.3733	0.7010	0.2976
0	7.5	-2.5	0	0.986388	1.432253	363.1818	0.7011	0.2974
0	7.5	-7.5	0	0.756486	1.095837	277.8754	0.701	0.2975
0	7.5	-12.5	0	0.483172	0.701097	177.7798	0.7006	0.2977
0	2.5	2.5	0	1.879144	2.775514	703.7977	0.6996	0.2989
0	2.5	7.5	0	2.331013	3.437084	871.5544	0.6994	0.2984
0	2.5	12.5	0	0.994236	1.442658	365.8202	0.7010	0.2975
0	2.5	17.5	0	0.636464	0.923002	234.049	0.7010	0.2976
0	2.5	22.5	0	0.402985	0.58535	148.4294	0.7009	0.2976
0	2.5	-2.5	0	1.894287	2.78337	705.7896	0.6998	0.2987
0	2.5	-7.5	0	1.542146	2.224295	564.0228	0.7012	0.2974
0	2.5	-12.5	0	0.925279	1.333776	338.2105	0.7011	0.2974
0	2.5	-17.5	0	0.563465	0.814609	206.5635	0.7009	0.2976
0	2.5	-22.5	0	0.372132	0.538155	136.4619	0.7006	0.2977
0	-2.5	2.5	0	2.274081	3.332381	845.0043	0.6994	0.2983
0	-2.5	7.5	0	1.353483	1.94878	494.1595	0.7012	0.2974
0	-2.5	12.5	0	0.861911	1.24006	314.4466	0.7012	0.2974
0	-2.5	17.5	0	0.528294	0.760711	192.8963	0.7011	0.2974
0	-2.5	22.5	0	0.322556	0.464595	117.8091	0.7011	0.2975
0	-2.5	27.5	0	0.175716	0.253277	64.22434	0.7009	0.2977

An additional spreadsheet has been created to:

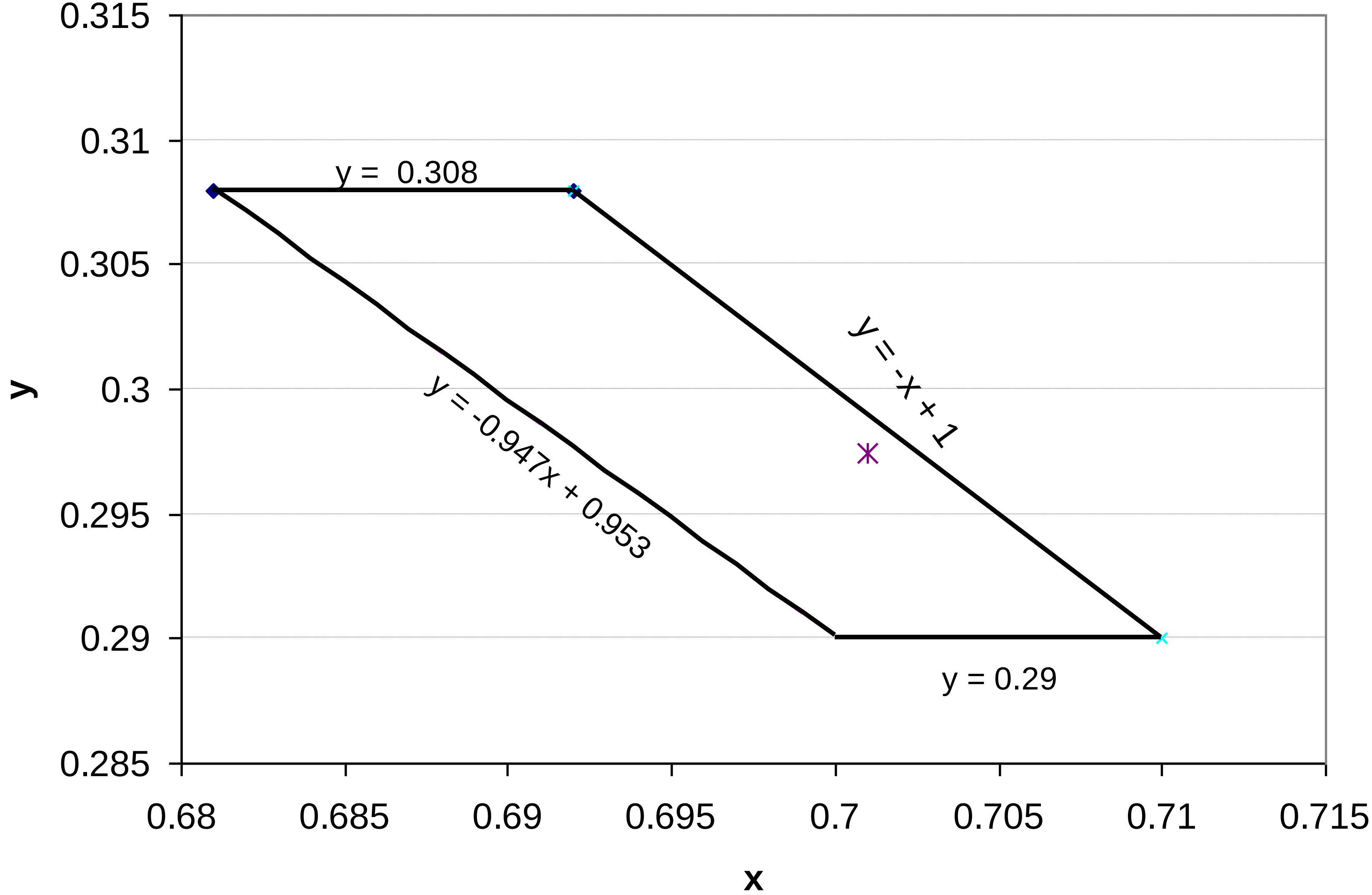
1) Organize the data into an more user friendly format.

2) Highlight values that are above or below the required values. The value will be highlighted Red if it exceeds the maximum value. The Value will be highlighted blue is it is below the minimum required value. The value will remain black if it falls between the minimum and maximum values.

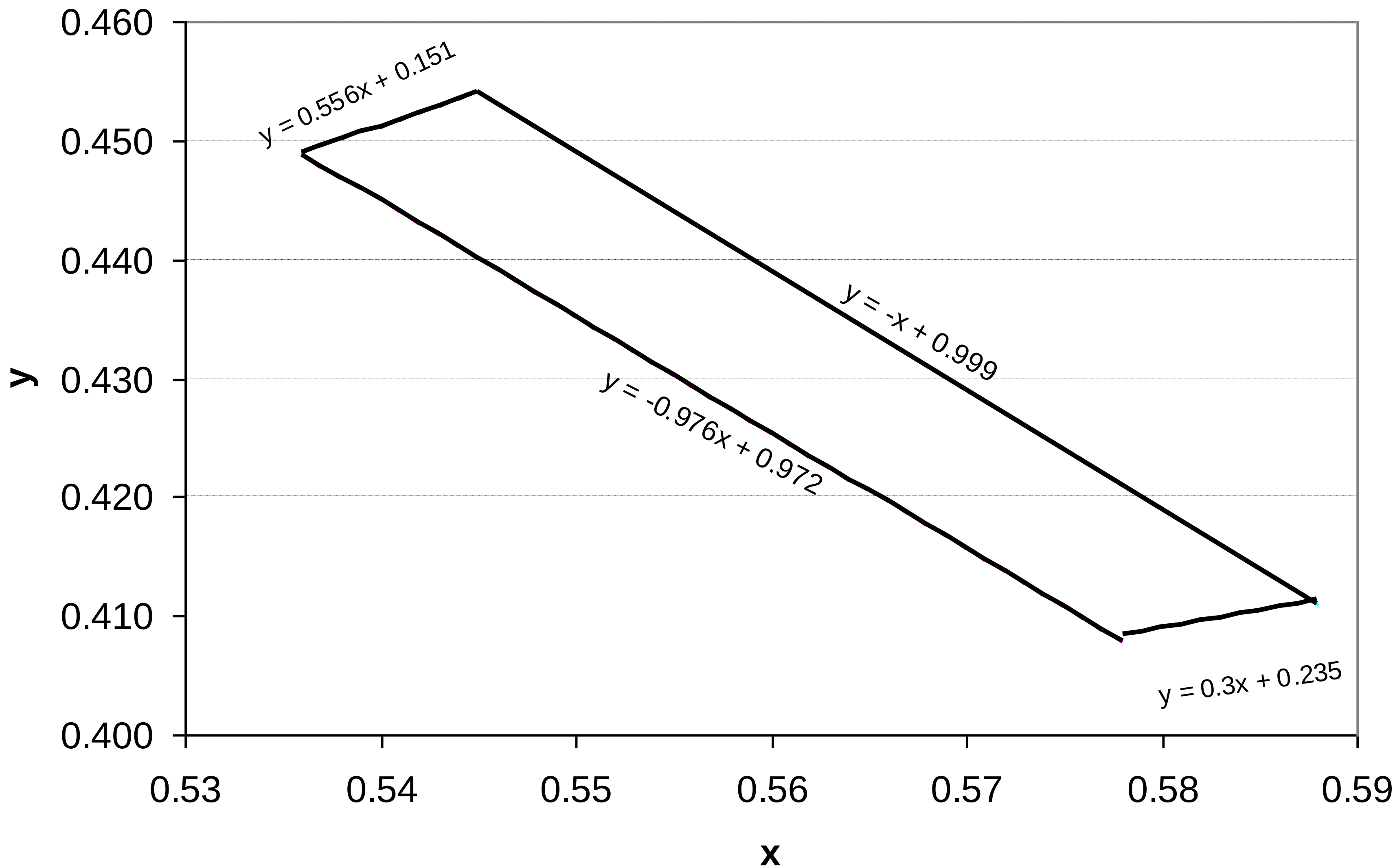
3) Plot the average X and Y chromaticity value on the 1931CIE diagram and compare it to the required region per the specifications.

Position		Luminous Intensity			Chromaticity	
Vertical Angle	Horizontal Angle	Measured Candela	Minimum Candela	Maximum Candela	x	y
12.5	2.5	32	38	113	0.7002	0.2980
12.5	7.5	149	31	93	0.7004	0.2978
12.5	-2.5	52	38	113	0.7000	0.2980
12.5	-7.5	142	31	93	0.6997	0.2981
7.5	2.5	50	69	206	0.7011	0.2975
7.5	7.5	305	57	170	0.7010	0.2976
7.5	12.5	100	39	116	0.7010	0.2976
7.5	-2.5	363	69	206	0.7011	0.2974
7.5	-7.5	115	57	170	0.7010	0.2975
7.5	-12.5	48	39	116	0.7006	0.2977
2.5	2.5	320	149	446	0.6996	0.2989
2.5	7.5	320	122	367	0.6994	0.2984
2.5	12.5	366	83	250	0.7010	0.2975
2.5	17.5	234	48	145	0.7010	0.2976

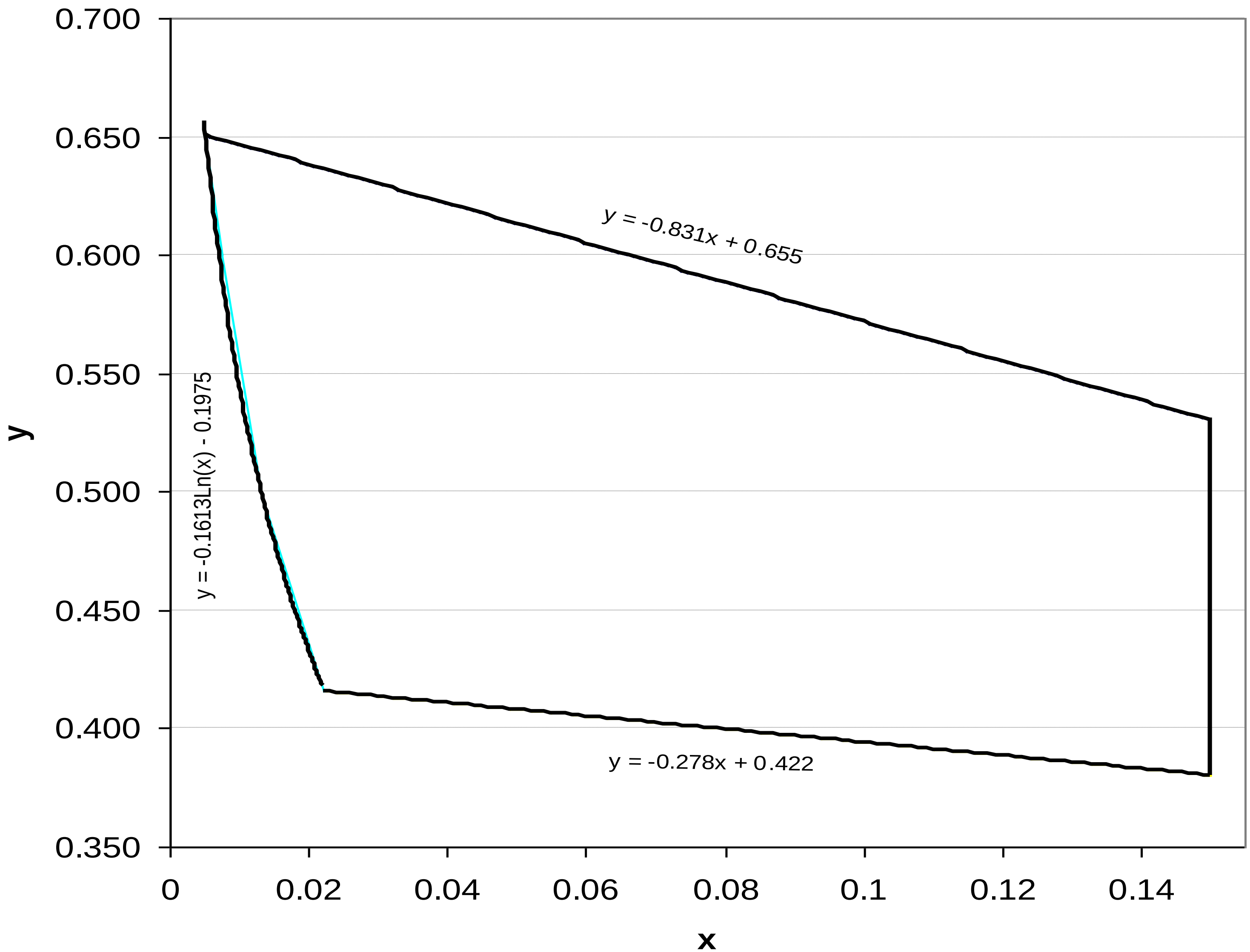
Color Region for Red Traffic Signal Lights



Color Region for Yellow Traffic Signal Lights



Color Region for Green Traffic Signal Lights



Questions