Measuring Uniformity of UV on Complex Surfaces

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WHY MEASURE?

Bake at 350°F for 30 minutes

Oven Temperature (°F)

Bake Time (minutes)

Toothpicks

WHY MEASURE?

Bake at 350°F for 30 minutes

(350 x 30 = 10,500 Degree Minutes)

Option for Equal Degree Minutes:

- **700°F for 15 minutes?**
- **175°F for 60 minutes?**

Doubling the temperature from 350°F to 700°F doesn't bake the cake in half the time……..

WHY MEASURE?

Cake

Time & Temperature

UV Reaction

Wavelength, Energy (Irradiance) &
Time (Energy Density)

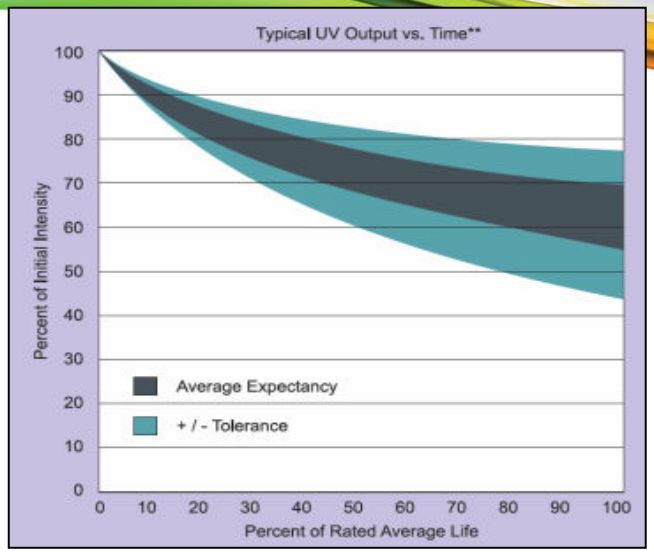
Oven Temperature (°F) is similar to Irradiance (Watts/cm^2)

Bake Time (Minutes) is similar to Energy Density (Joules/cm^2)

WHY MEASURE?

System Related

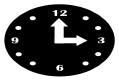
- Lamps Age
- Reflectors become dirty or damaged
- Equipment failure



Operator/Production Related

- Lack of Maintenance
- Controls are inadvertently changed
- Conveyor speed changed
- Part fixtures changed
- Lamps are misaligned

WHY MEASURE?



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Time **Both** **Money**

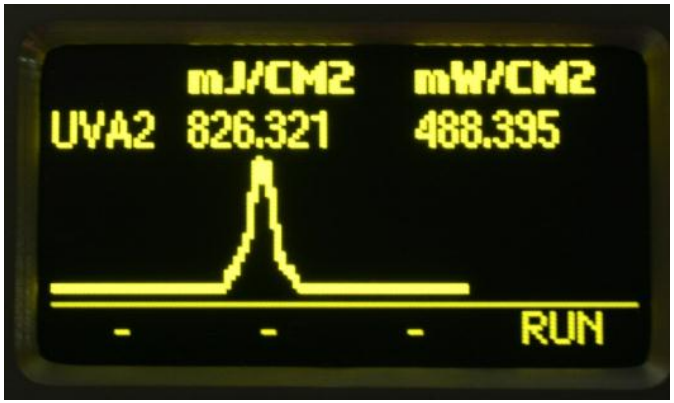
- Repeatability, Reliability, Verification, Documentation, ISO, Training, Quality, Certificate of Conformance, Customer Requirement
- Drive maintenance programs (simple, routine, major)

HOW TO MEASURE?

UV Measurement Strategies

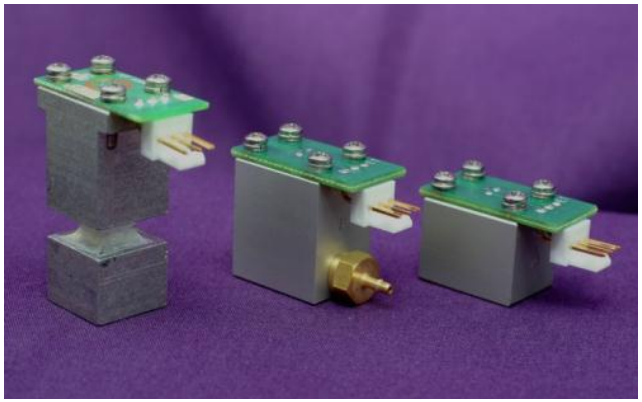
Absolute Measurement

- Want a “number”
  - Match a specification
  - Troubleshoot
  - Optimize a process
  - Compare multiple lines
  - Communicate data



Relative Measurement

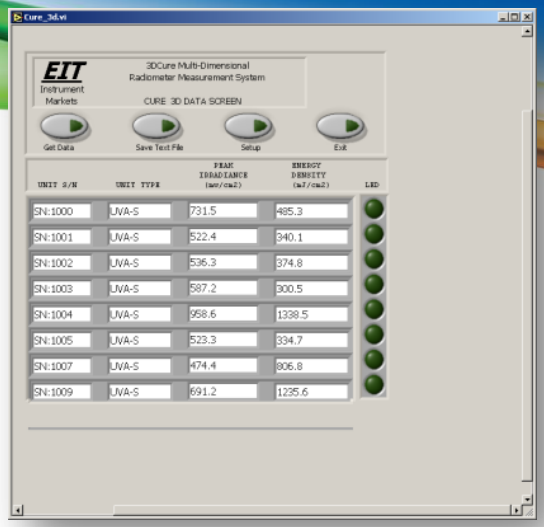
- Want to compare
  - UV changes with time
  - Alarms
  - Constant monitoring
  - Simultaneous readings

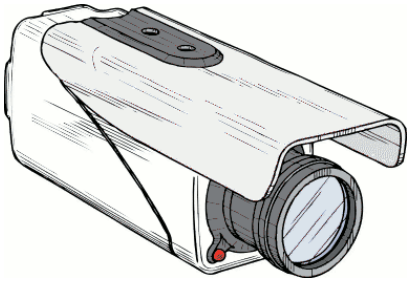


HOW TO MEASURE?

Absolute Measurement

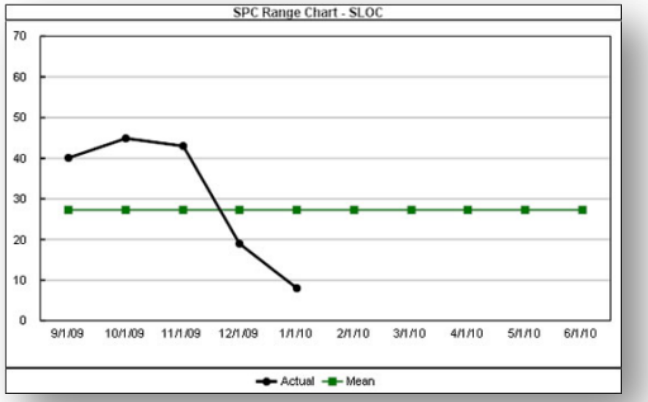
- Snap-Shot of the Line
- Data Logging





Relative Measurement

- Surveillance of the Line
- Real-Time Monitoring



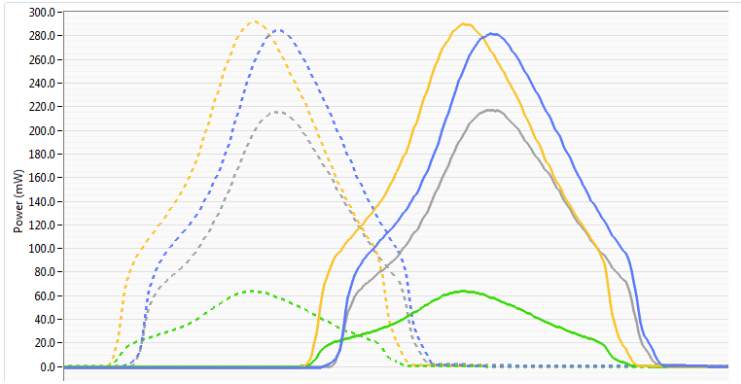
Line Speed? Process Window?
Liability? Quantity?

HOW TO MEASURE?

Absolute Measurement Strategies

Radiometers

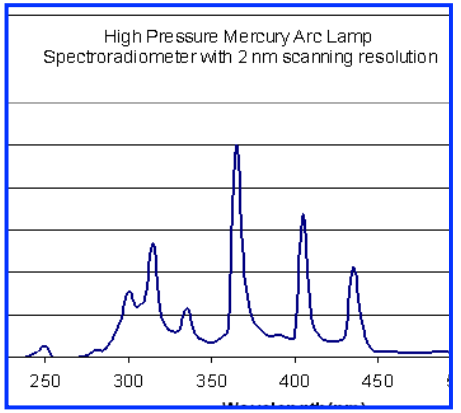
- Display of Irradiance (W/cm^2) & Energy Density (J/cm^2)



Profiling Radiometers

- Profile the peak irradiance as a function of time
- Measure the peak irradiance and total energy density

Spectral Radiometer



- Irradiance as function of wavelength
- Available from UV bulb/equipment supplier
- R&D value vs. production value?

Radiochromatic Strips

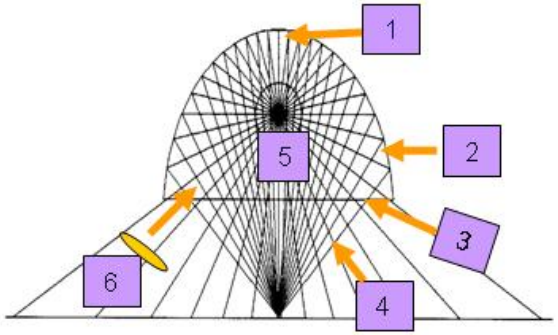
- Web press option
- Correlate to radiometer or color?

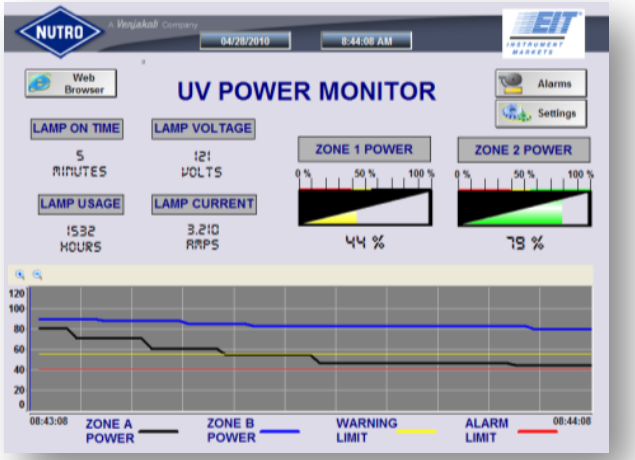
HOW TO MEASURE?

Relative Measurement Strategies

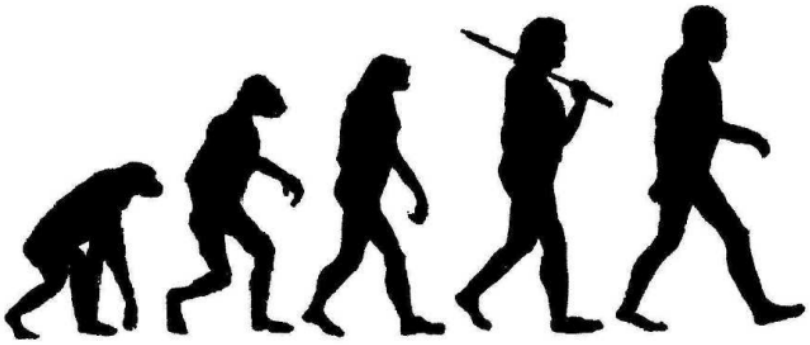
Online Monitoring

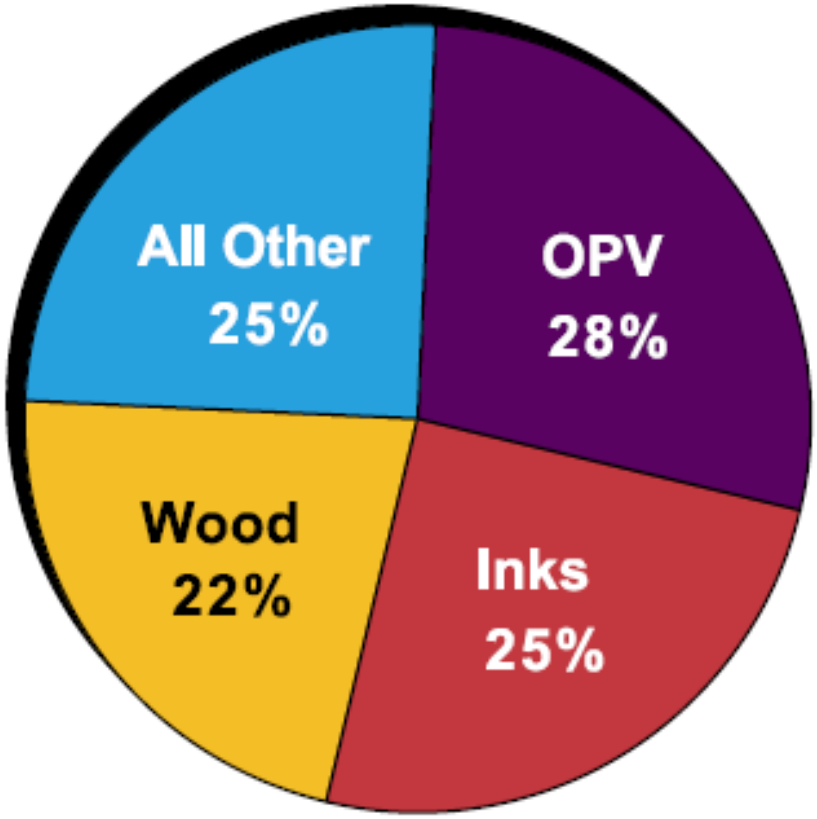
- Sensor
- Display
- Electronic signal proportional to lamp brightness (% intensity)





THE EVOLUTION OF UV CURING





RadTech has conducted ongoing surveys of the most popular uses for UV curing.

THE EVOLUTION OF UV CURING

Traditionally, most of these applications are for flat looking parts

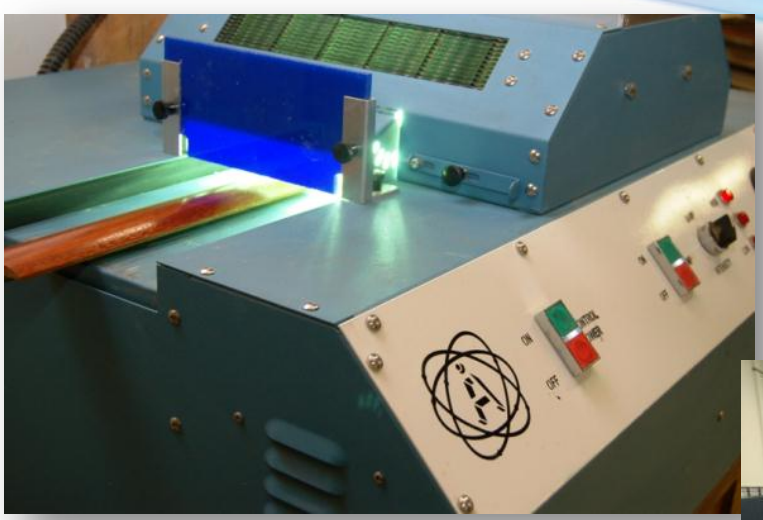
THE EVOLUTION OF UV CURING

Equipment is designed for flat applications

THE EVOLUTION OF UV CURING

Even much of the growth in UV comes from flat applications

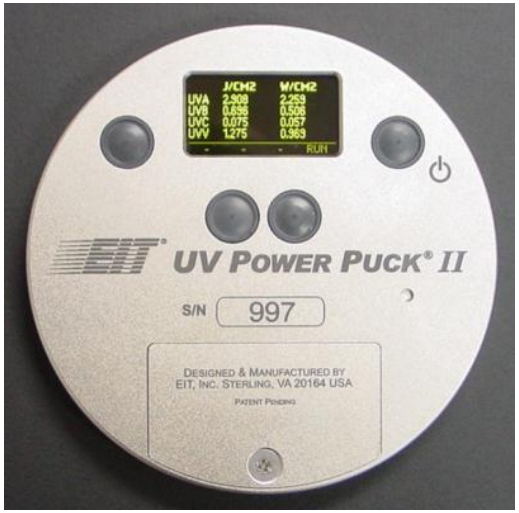
THE EVOLUTION OF UV CURING

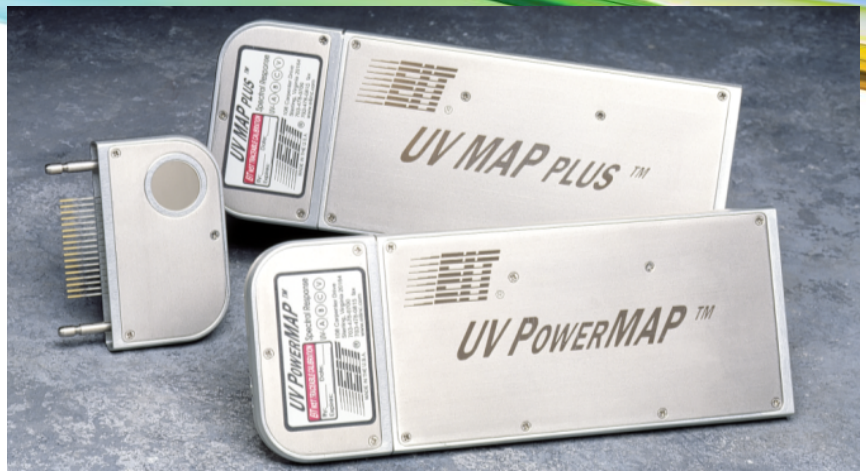


Process Control

UV is measured the same way the part is produced

THE EVOLUTION OF UV CURING



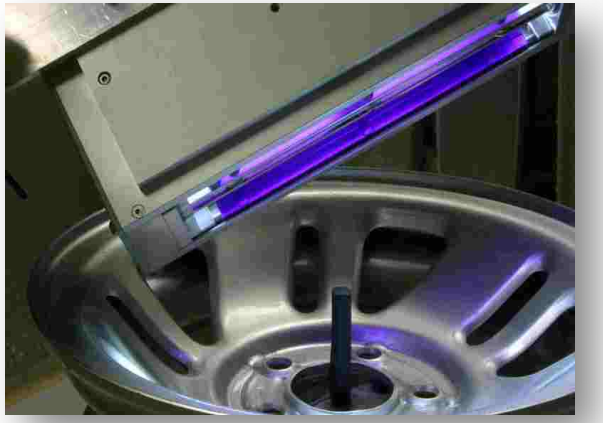


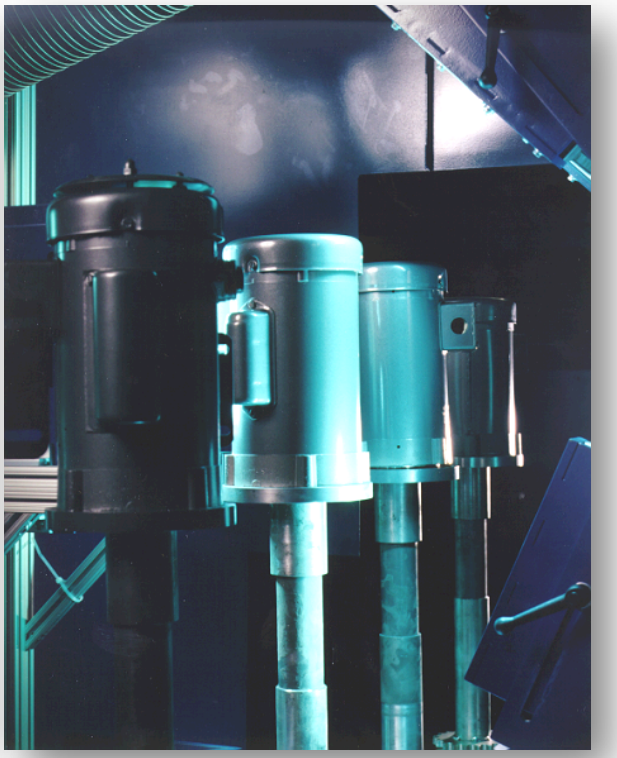
UV radiometers designed to mimic products cured on belts & conveyors

THE EVOLUTION OF UV CURING

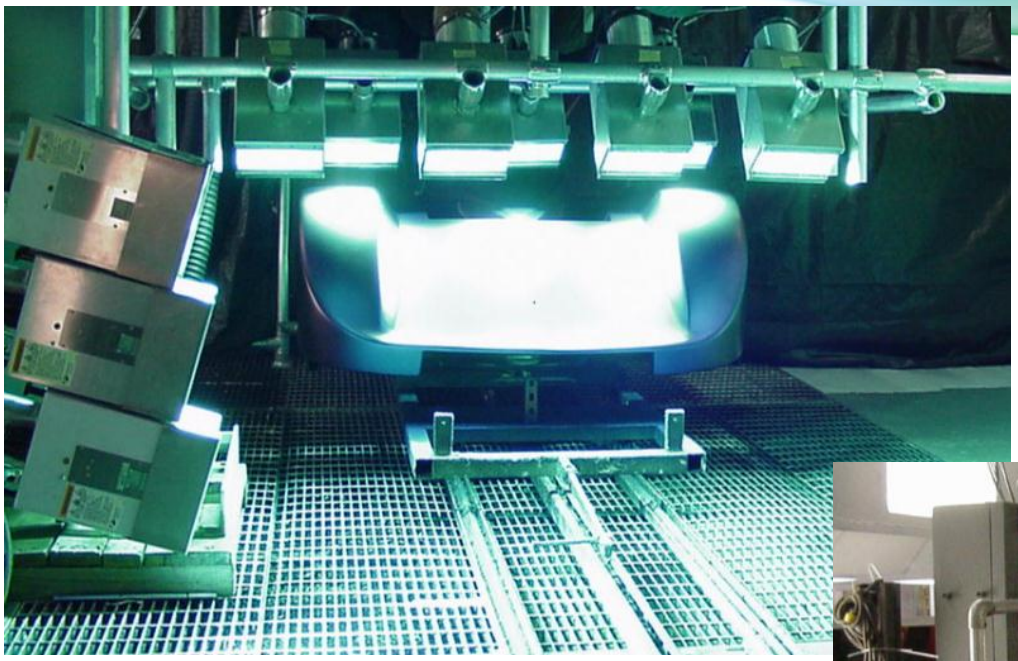
But the World is not flat

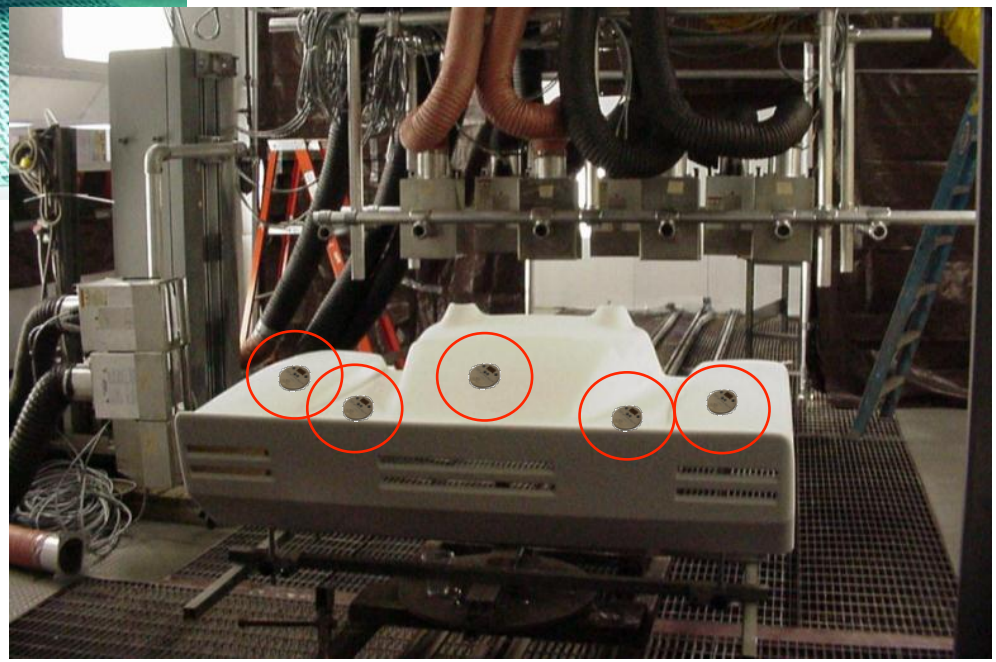
THE EVOLUTION OF UV CURING





A BRUTE FORCE APPROACH





Using multiple puck instruments to measure exposure of a complex 3D part

Aiming visible lamps is easier

3-D MEASUREMENT
RADIOCHROMIC FILMS

System with test strips and a densitometer

The New UV Intensity Labels begin as a bright yellow color (left). As they are exposed to UV, they become increasingly more green.

After continued UV exposure, the Labels take on a deeper shade of green, eventually reaching their maximum exposure color, solid blue.

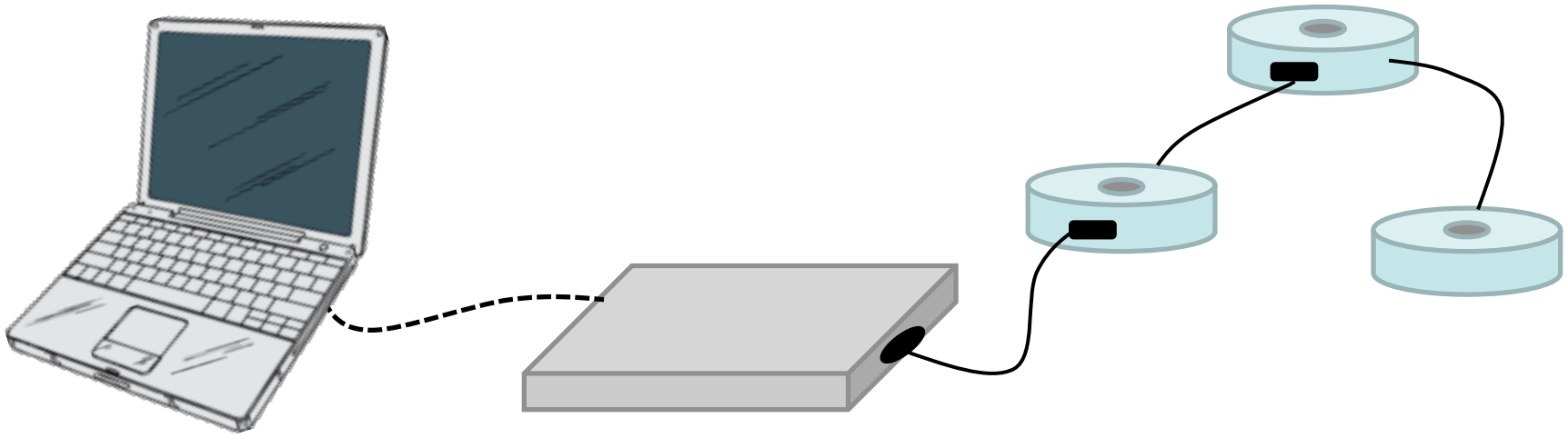
Radiochromic films (labels) that change color with UV exposure provide a convenient means of measuring UV on complex surfaces.

3-D MEASUREMENT RADIOCHROMIC FILMS

- Per label cost can make repeated measurements of dimensional objects costly.
- Labels change with time, temperature, exposure to ambient UV. Evaluate for your application
- Coordinate with calibrated radiometer?
- Labels are prone to blowing off part, or distorting with exposure to high temperatures.
- Without an analytical device such as a densitometer the color change subjective.

3-D MEASUREMENT RADIOMETER

- Multiple sensors that can be mounted at substrate level
- Sensors can be daisy-chained to simplify the wiring
- A single high capacity data collection module



3-D MEASUREMENT RADIOMETER

Radiometer purpose built for Complex Surfaces (3D)

3-D MEASUREMENT RADIOMETER

Sensors:

- Calibrated, Single Spectral Bandwidth Radiometer
- UVA, UVB, UVC, UVV
- Mix & Match Bandwidths in the same string
- Provides mW/cm^2 and mJ/cm^2
- Connect up to 32 sensors in a daisy-chain digital network
- A small LED allows for communications verification of each sensor during setup.
- Powered by a DCM

3-D MEASUREMENT RADIOMETER

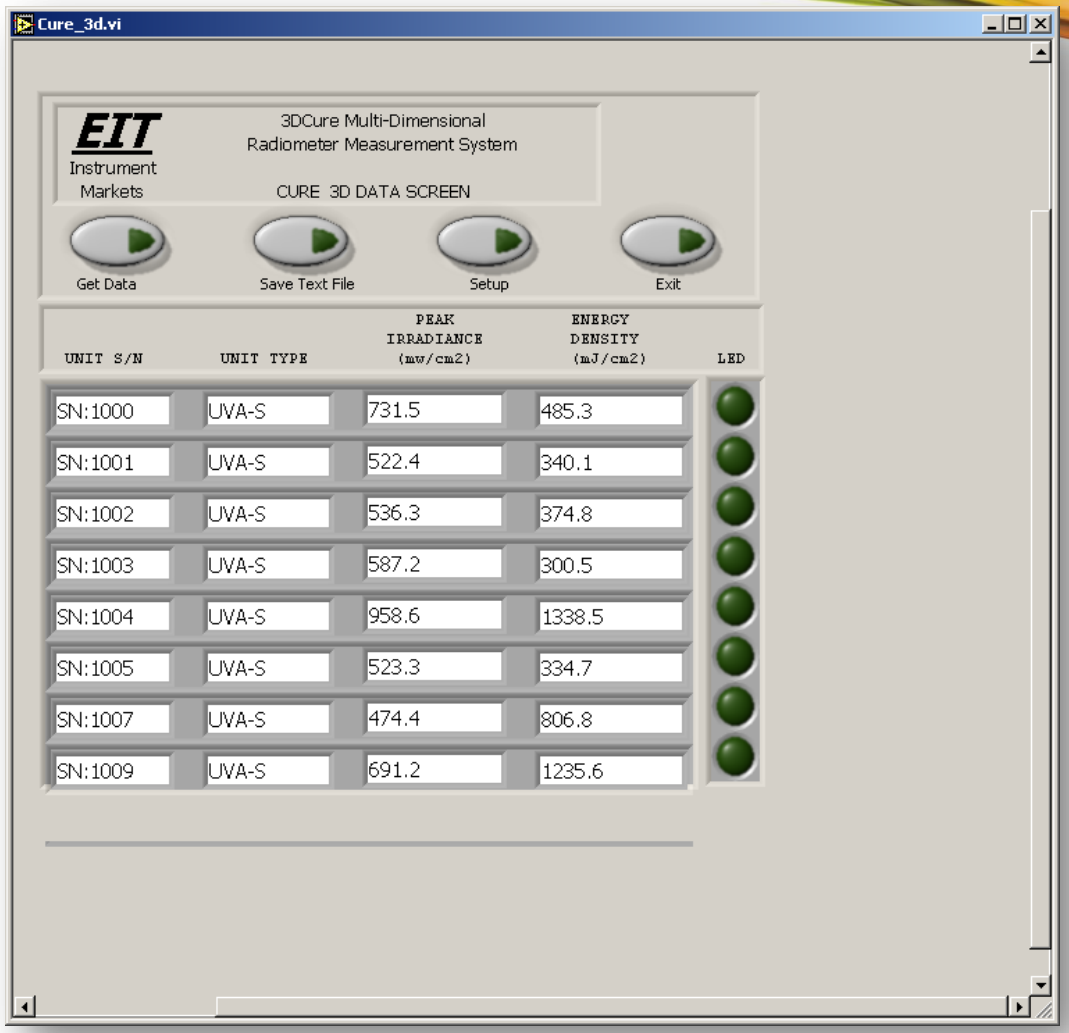
DCM-Data Collection Module:

- Collects and transfers data to a PC via EIT Cure3D Software
- Provides power to the sensors
- Portable, or tethered
- Rechargeable battery

3-D MEASUREMENT RADIOMETER

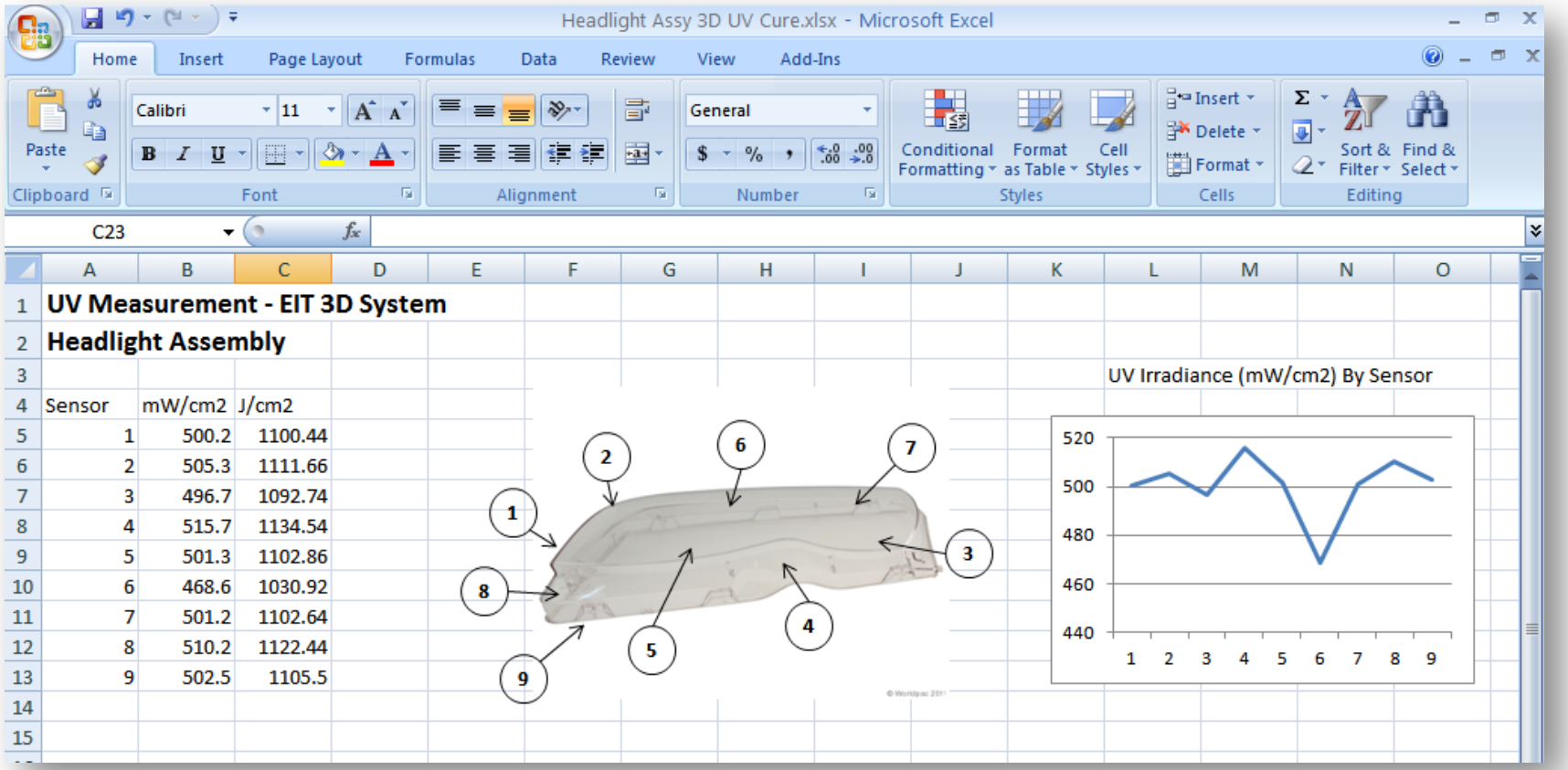
Software

- Easy to read interface provides the identity and type of each sensor
- Peak irradiance and energy density measured for each.



3-D MEASUREMENT RADIOMETER

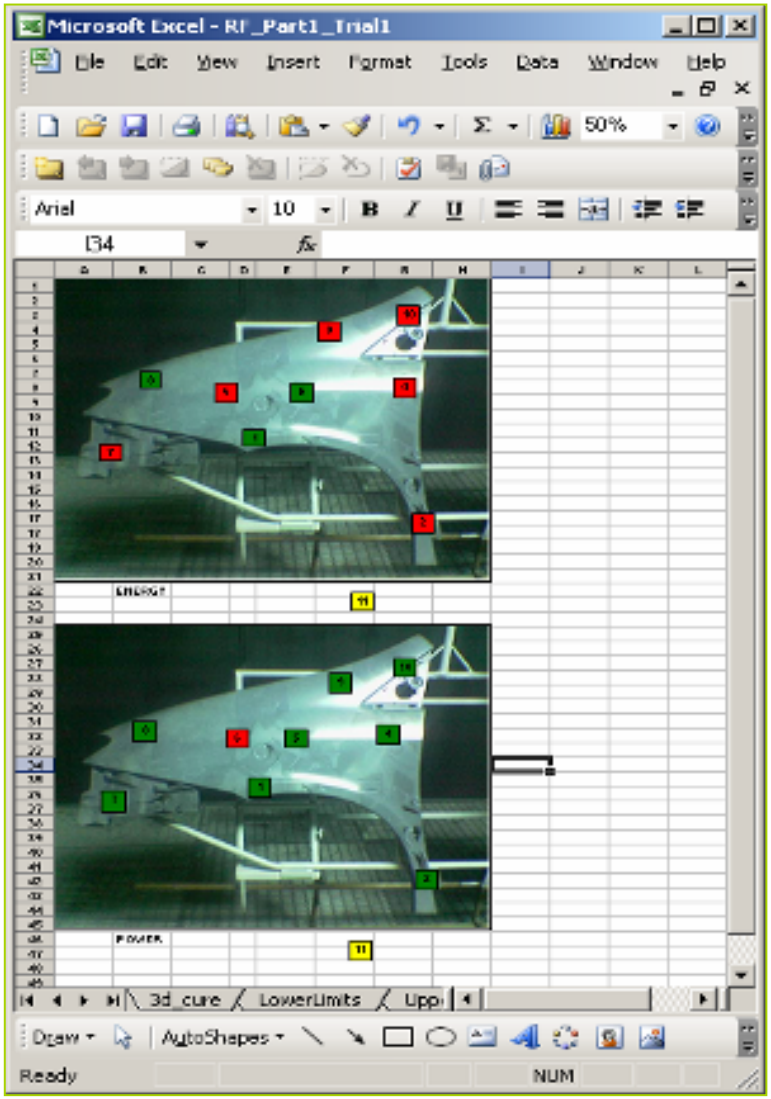
Software

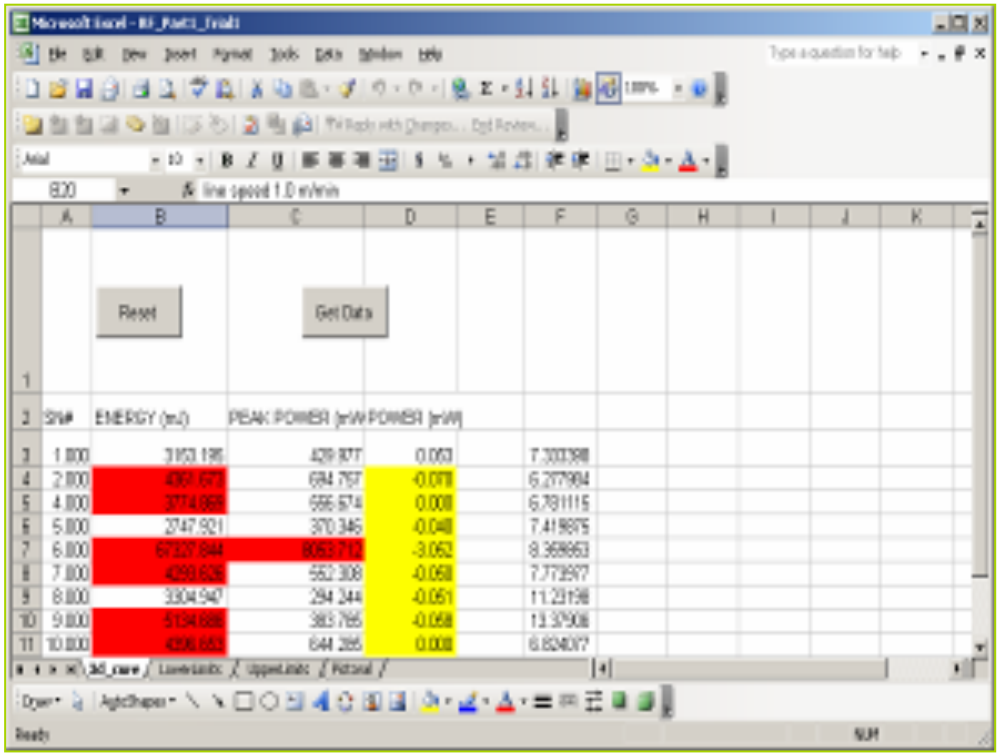


Data is easily exported to Excel for analysis and record keeping

3-D MEASUREMENT RADIOMETER

Software





Ability to use Active-X to develop custom models

3-D MEASUREMENT RADIOMETER

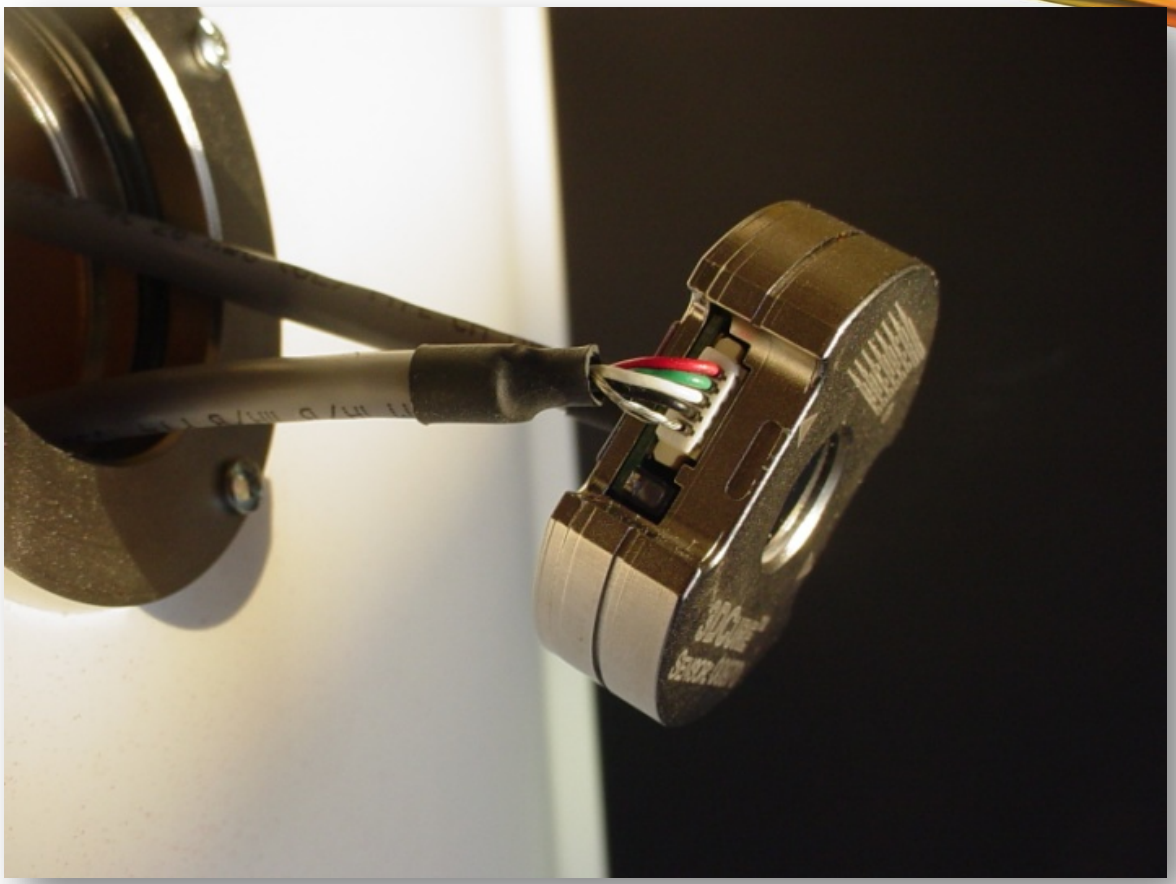
Sensors mounted to the surface using Velcro®

Headlight Bezel

3-D MEASUREMENT RADIOMETER

Positioning Rings

- Allow sensors to mount flush with the surface
- Share sensors between different work pieces



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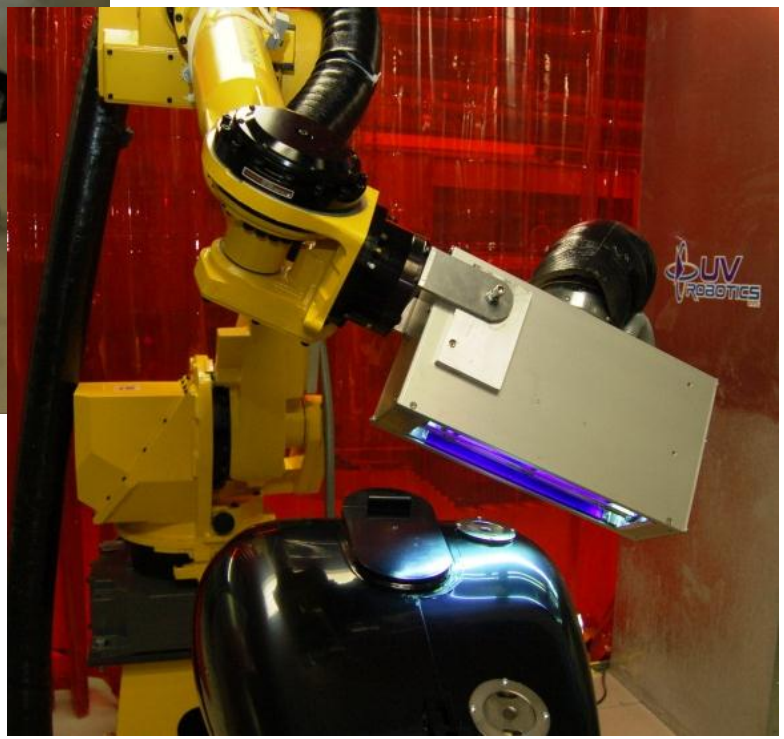

3-D MEASUREMENT RADIOMETER

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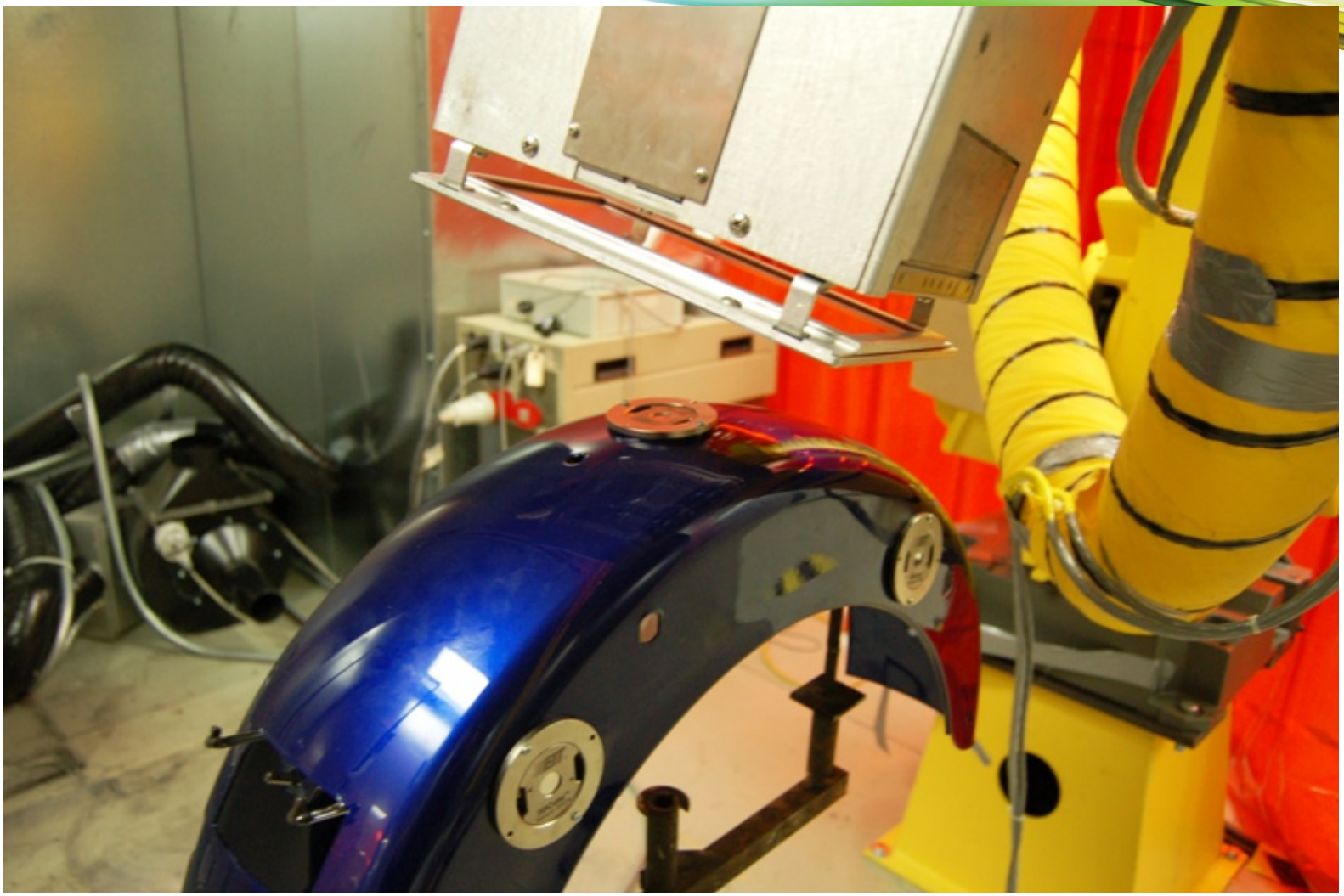

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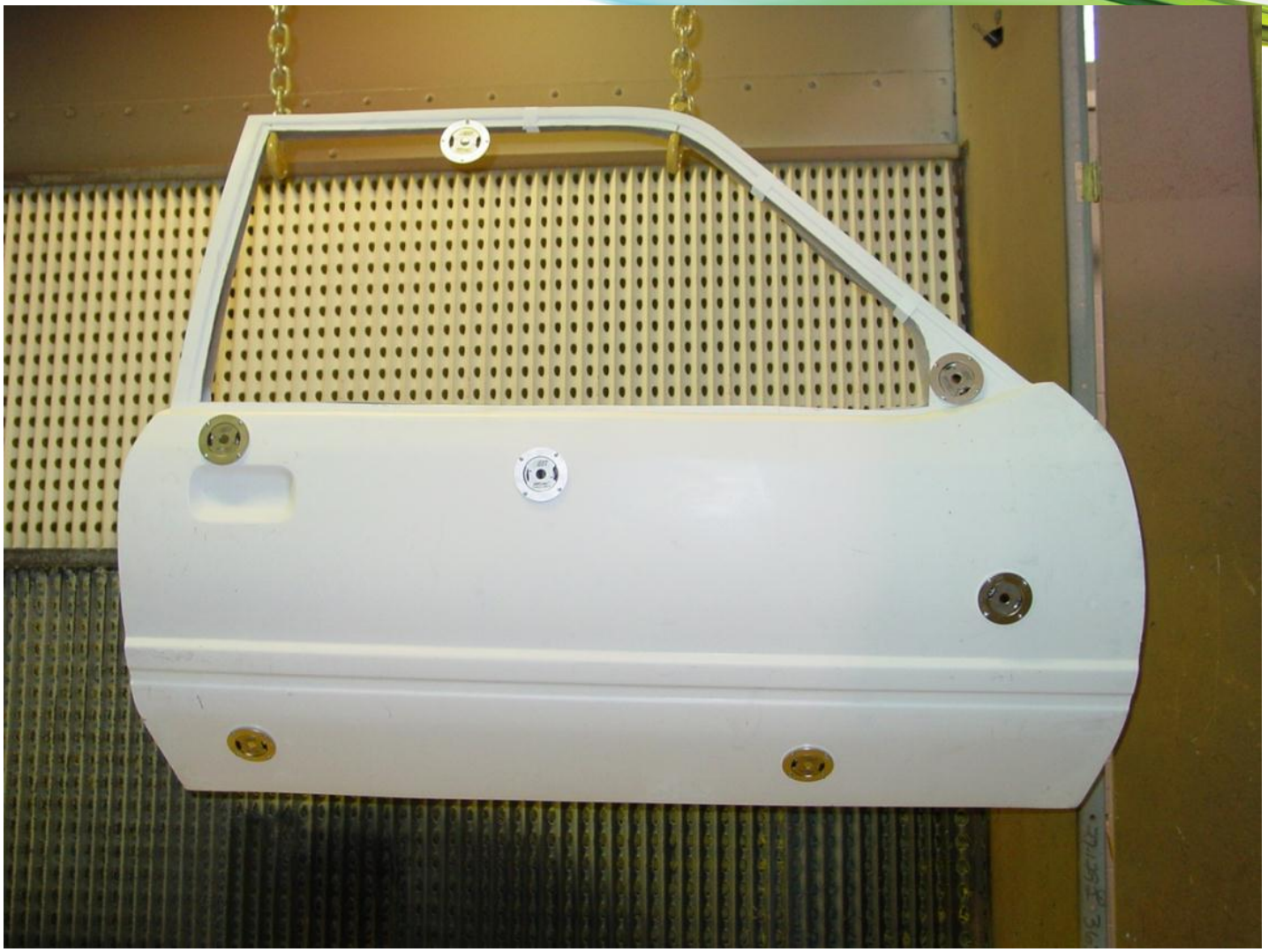

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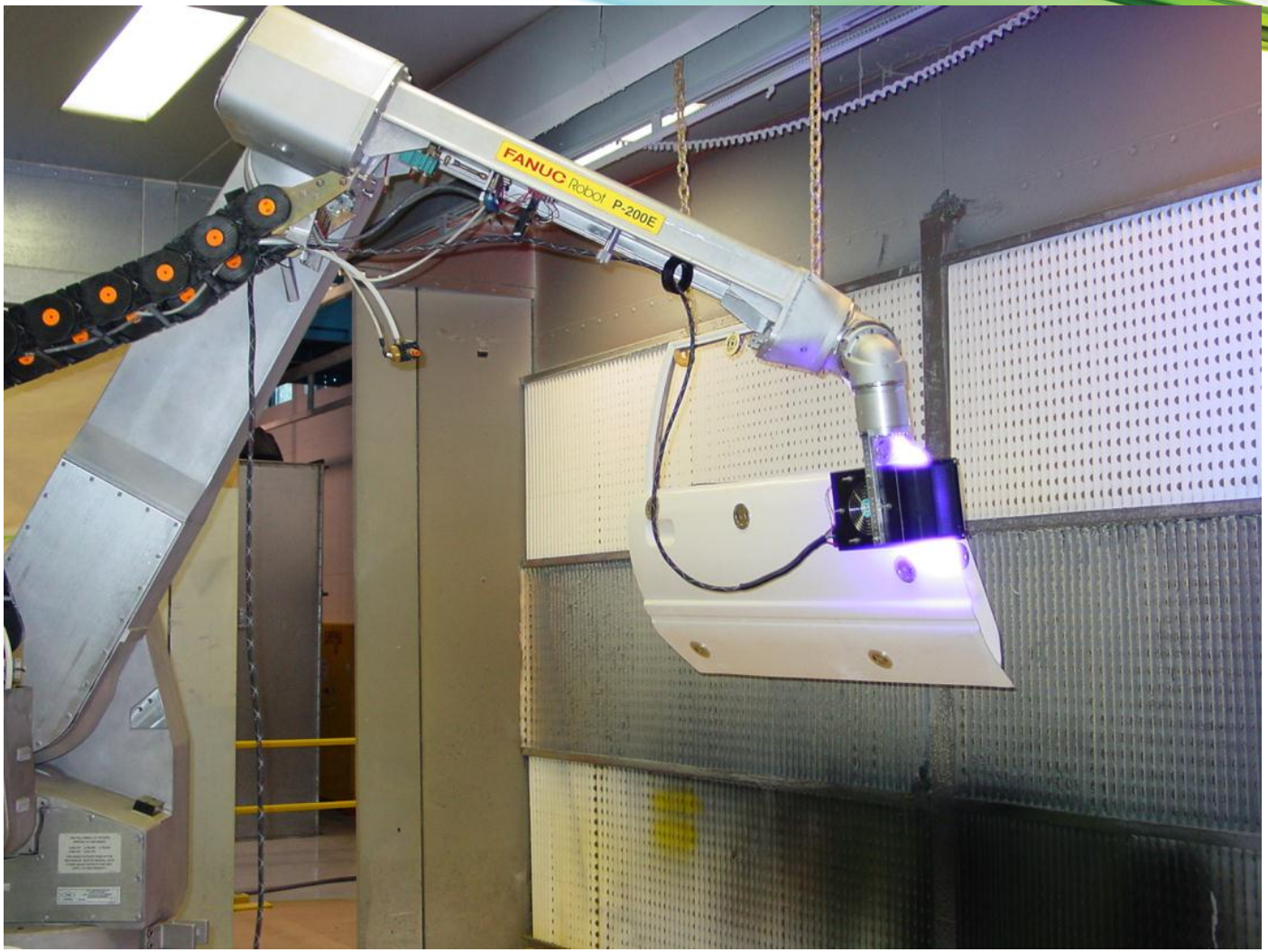

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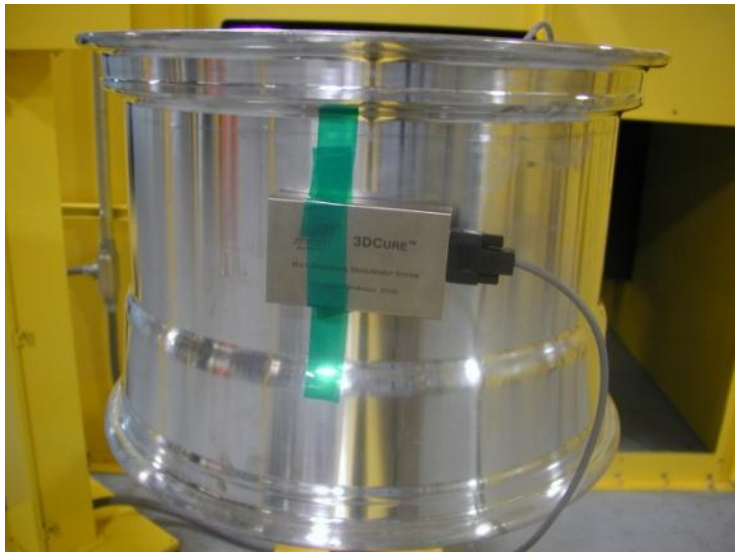

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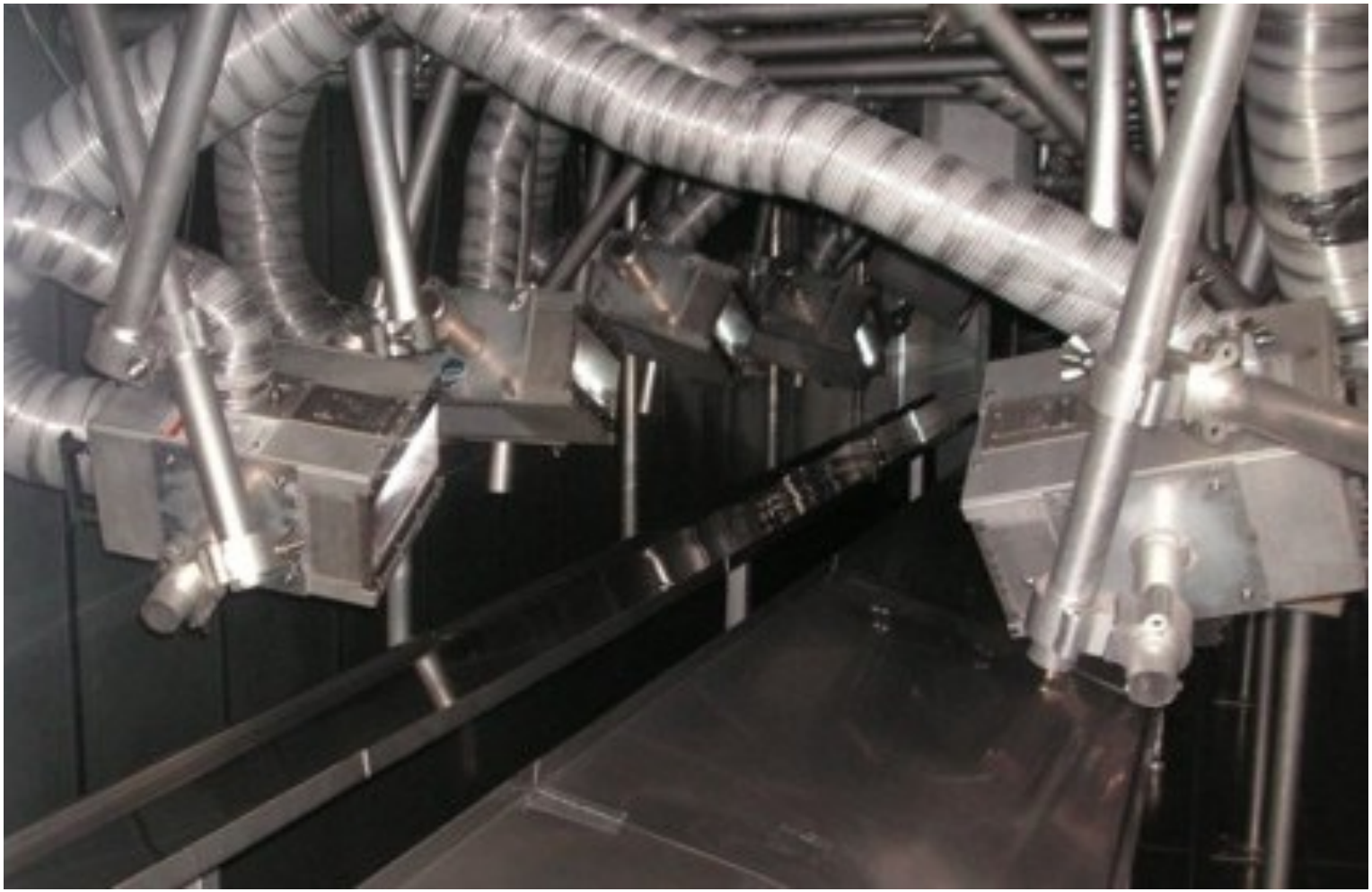
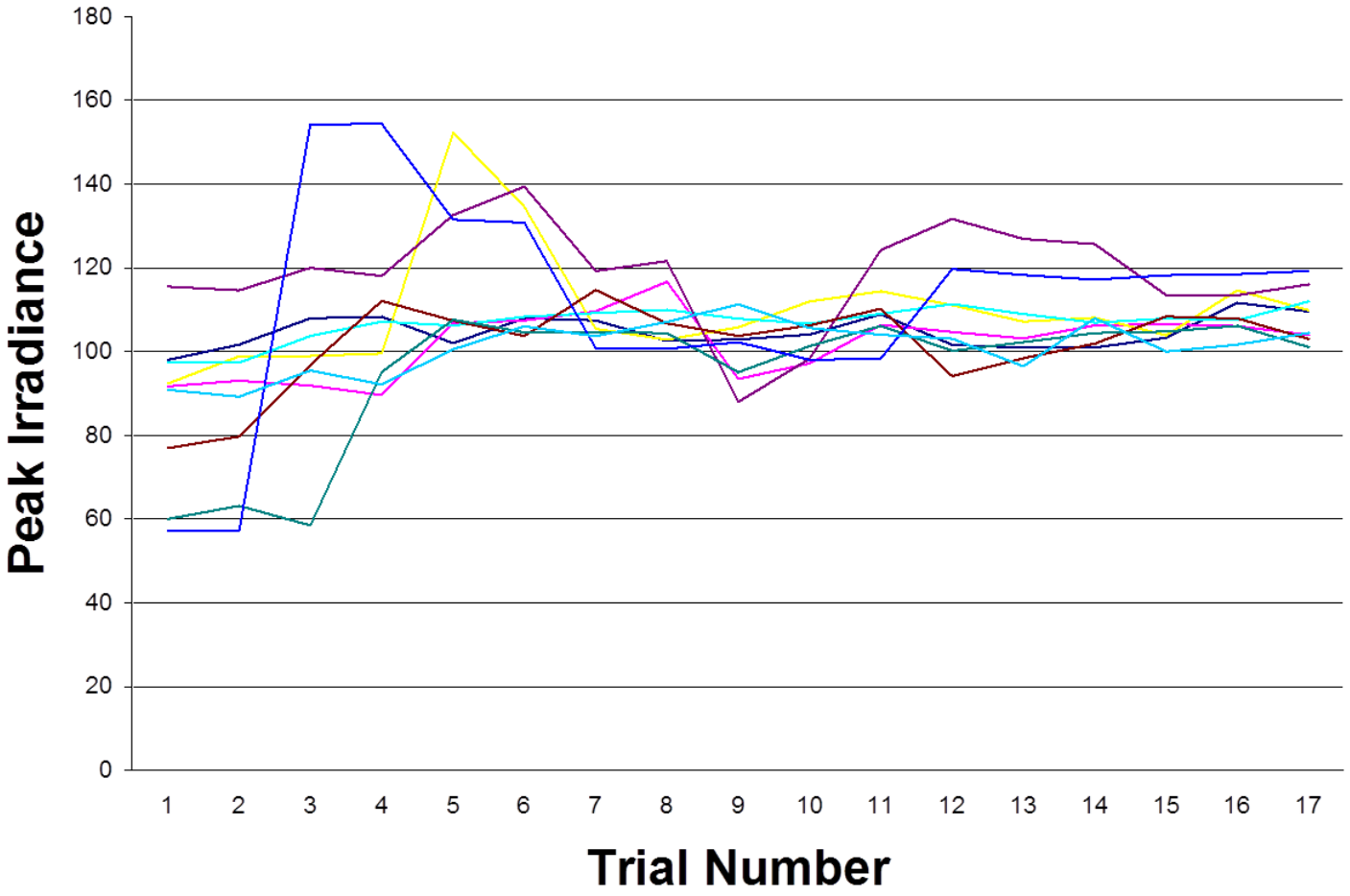


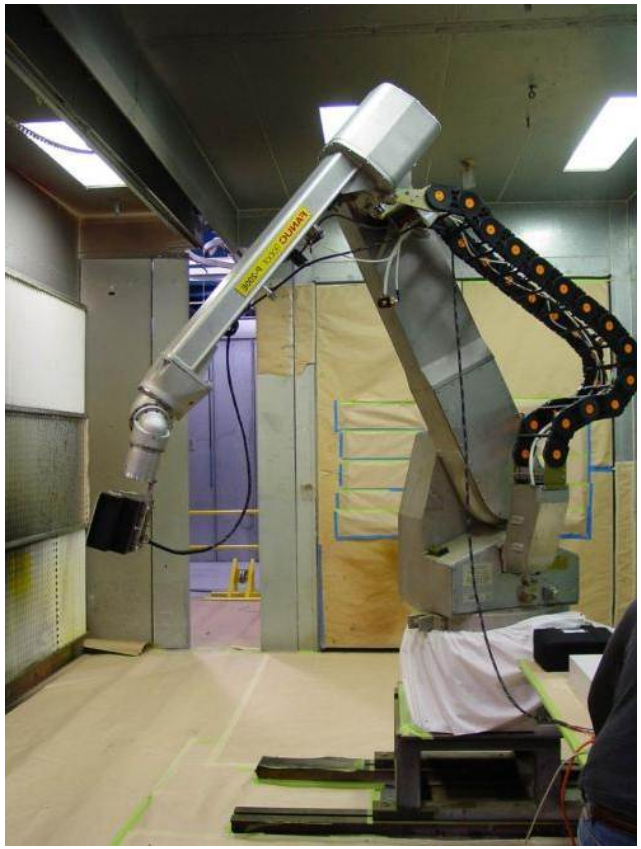
3-D MEASUREMENT RADIOMETER

Tuning the path of UV source over multiple sensors



Summary

- UV process window needs to established and maintained for complex (3D) shapes
- Multiple options for 3D measurement
- Combine absolute measurements with relative measurements?



Thank You

RADTECH UV&EB 2012

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