Start Counter

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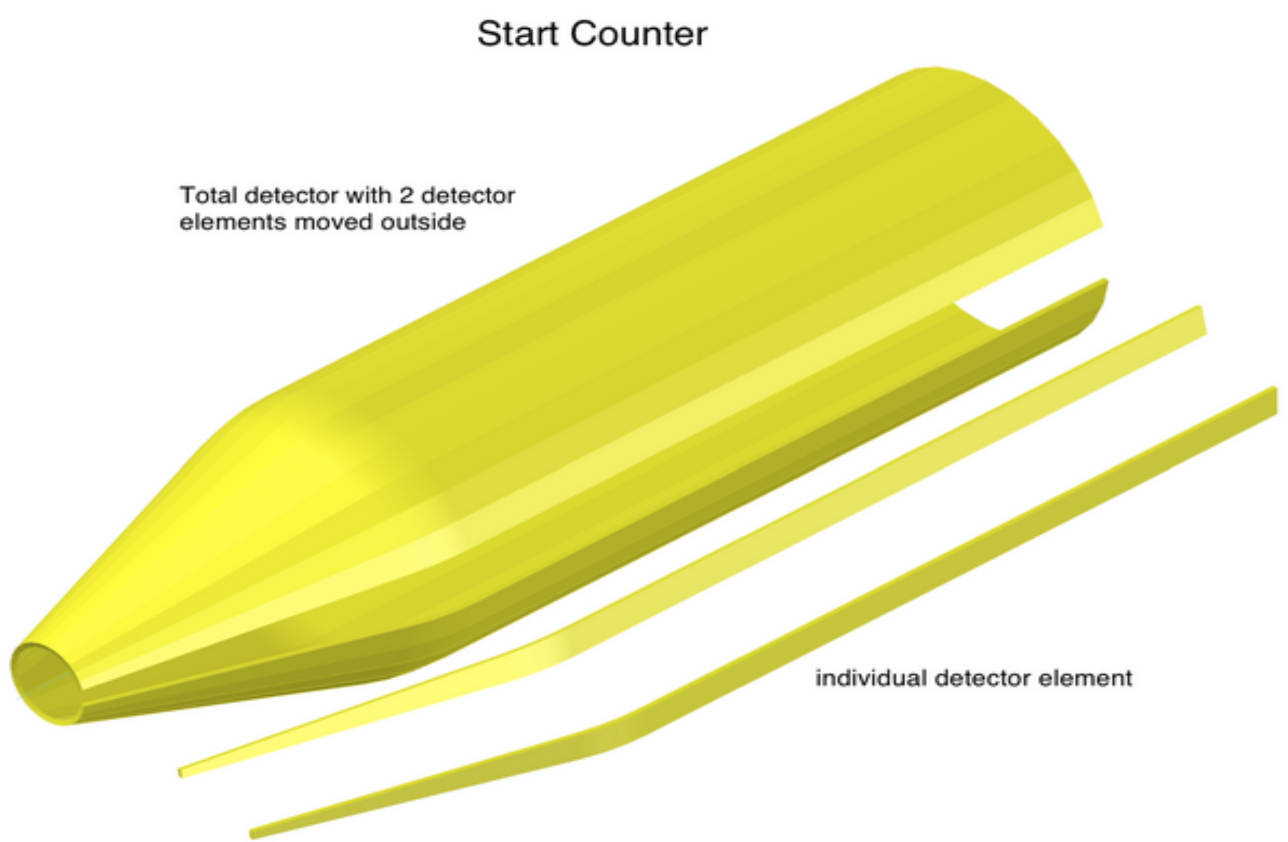
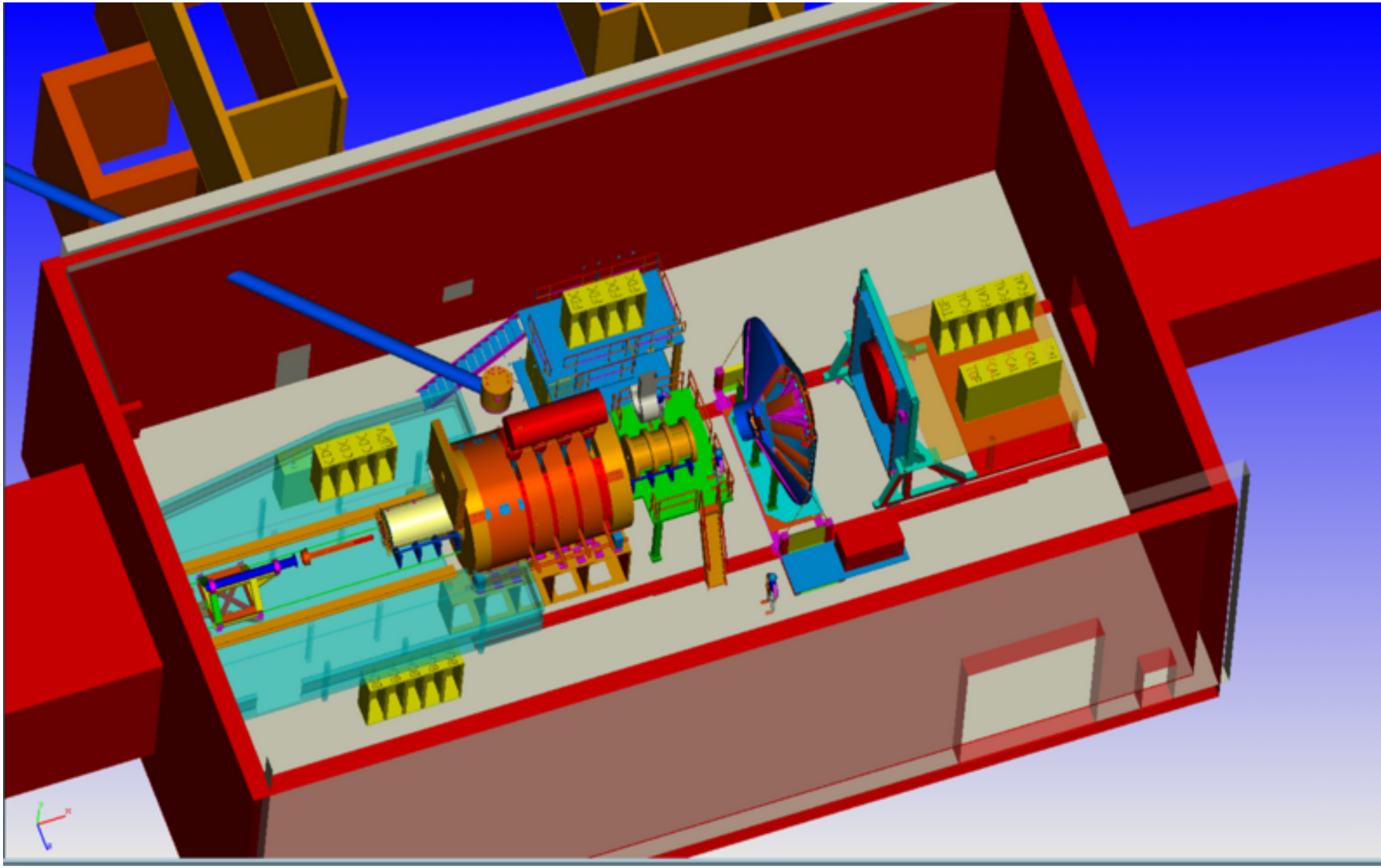
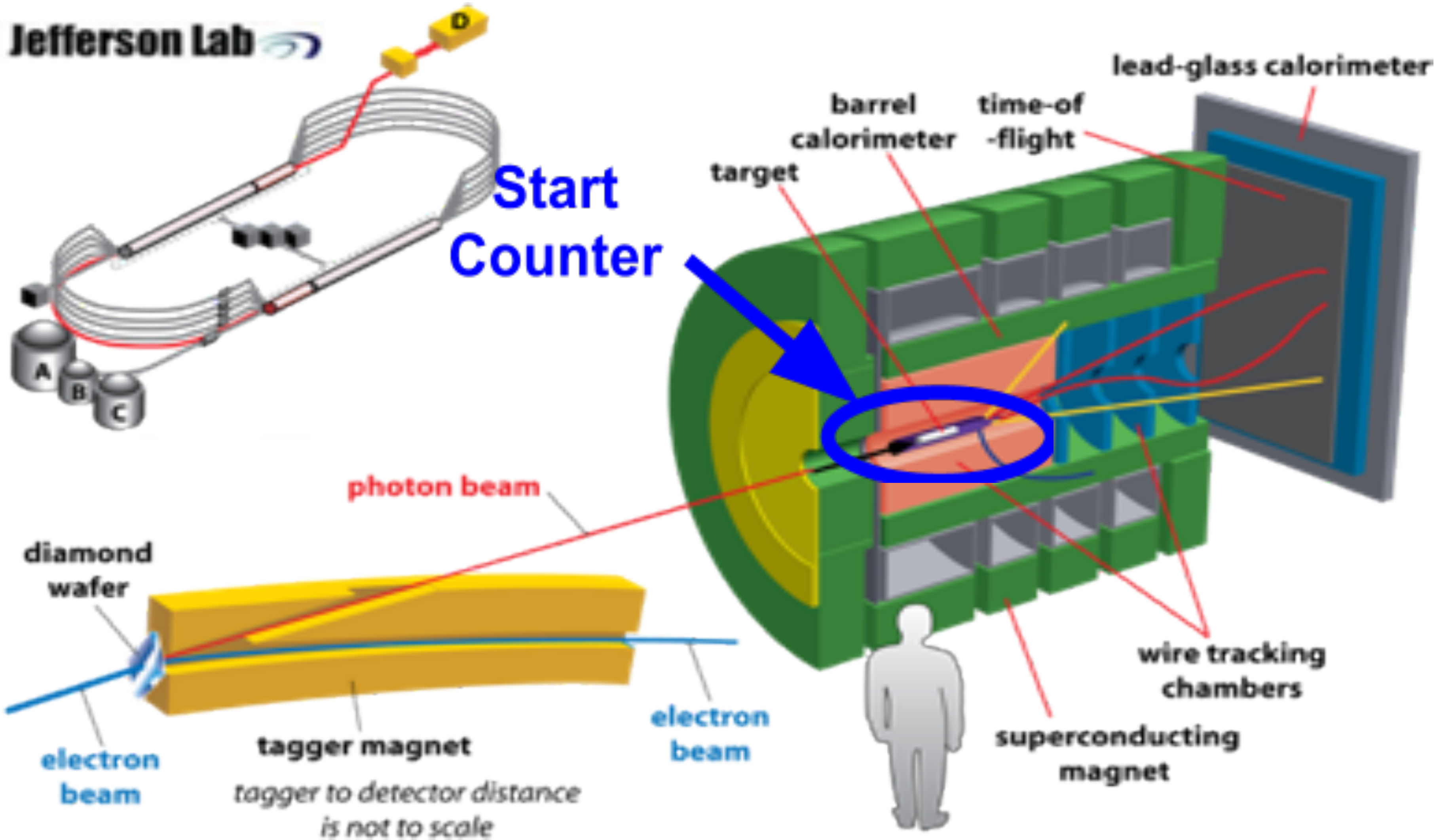
- What is GlueX?
- What are scintillators?
- How do they work?
- How we measure them?
- Our measurements
- Apparent defects
- Proper handling



GlueX (Hall D)

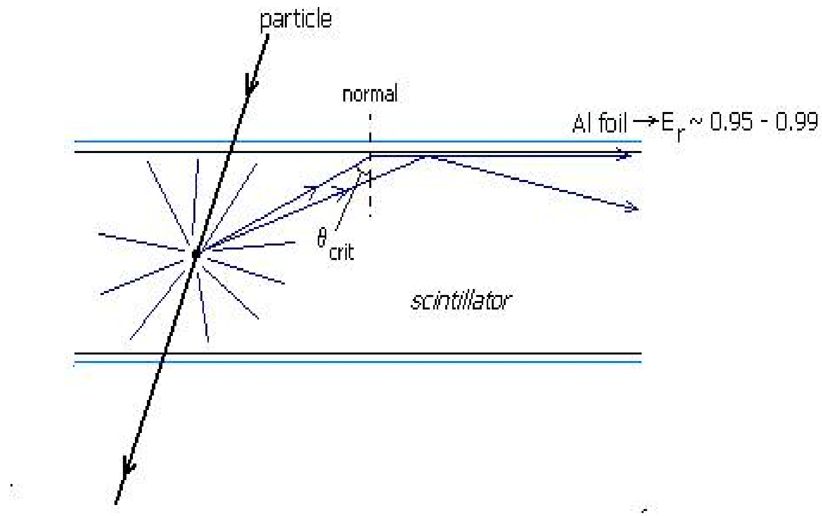


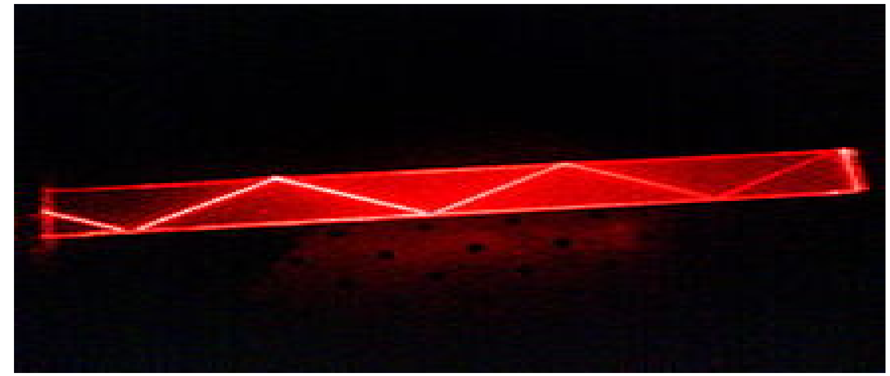
GlueX Detector

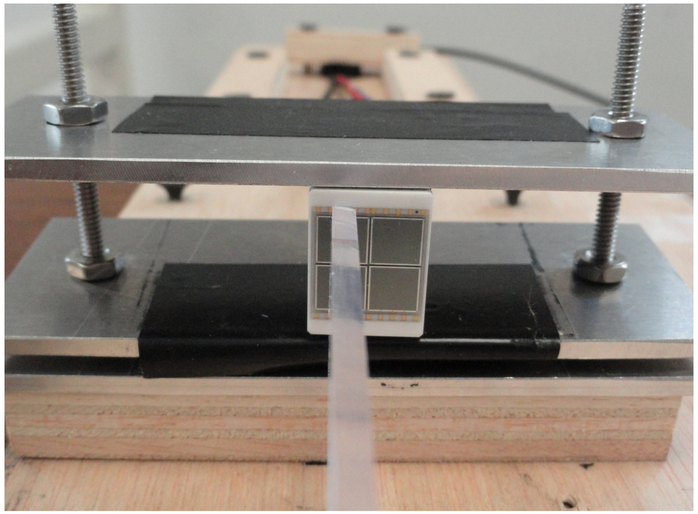


Scintillators

- Charged particles pass through the material and emit a small flash of light (i.e., scintillation)
- The light is transported in the material via total internal reflection
- When coupled to a detector, the scintillatons (light) are collected at the end of the scintillator and converted to electrical signals
  - These are analyzed electronically to obtain information concerning the incident particle and radiation
- The surface quality of the scintillator determines the amount of light collected in the detector, and is crucial to providing high precision measurements

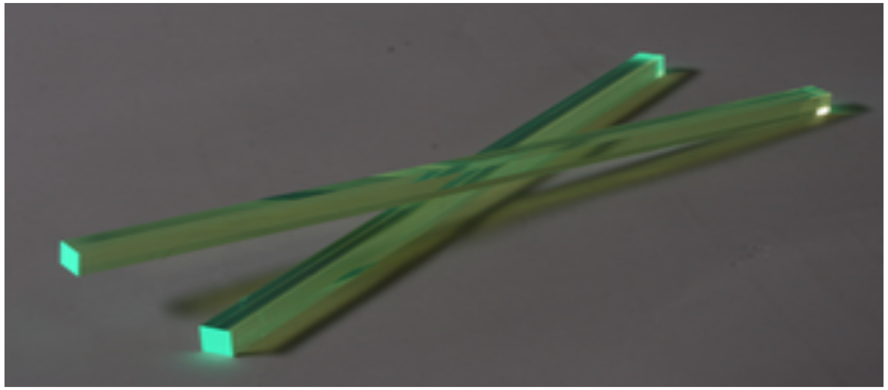


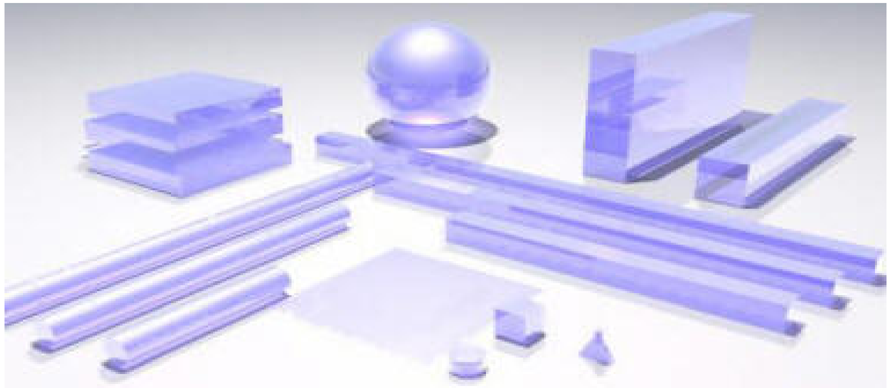


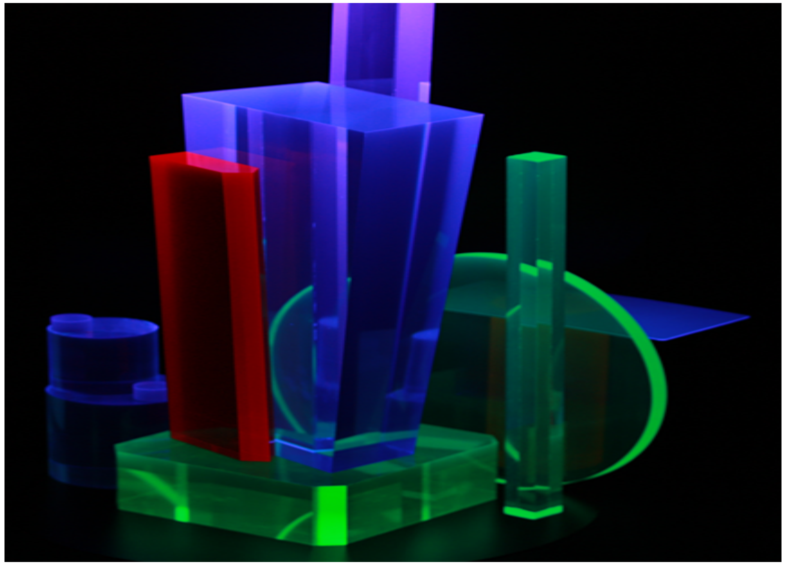


Scintillators

- Plastic scintillators are the most widely used organic detectors in nuclear and particle physics
- The EJ212 is a plastic scintillator
- They are solutions of organic scintillators in a solid plastic solvent
  - Polyvinyltoluene
- Plastics offer an extremely fast signal with a decay constant of about 2-3 ns and a high light output



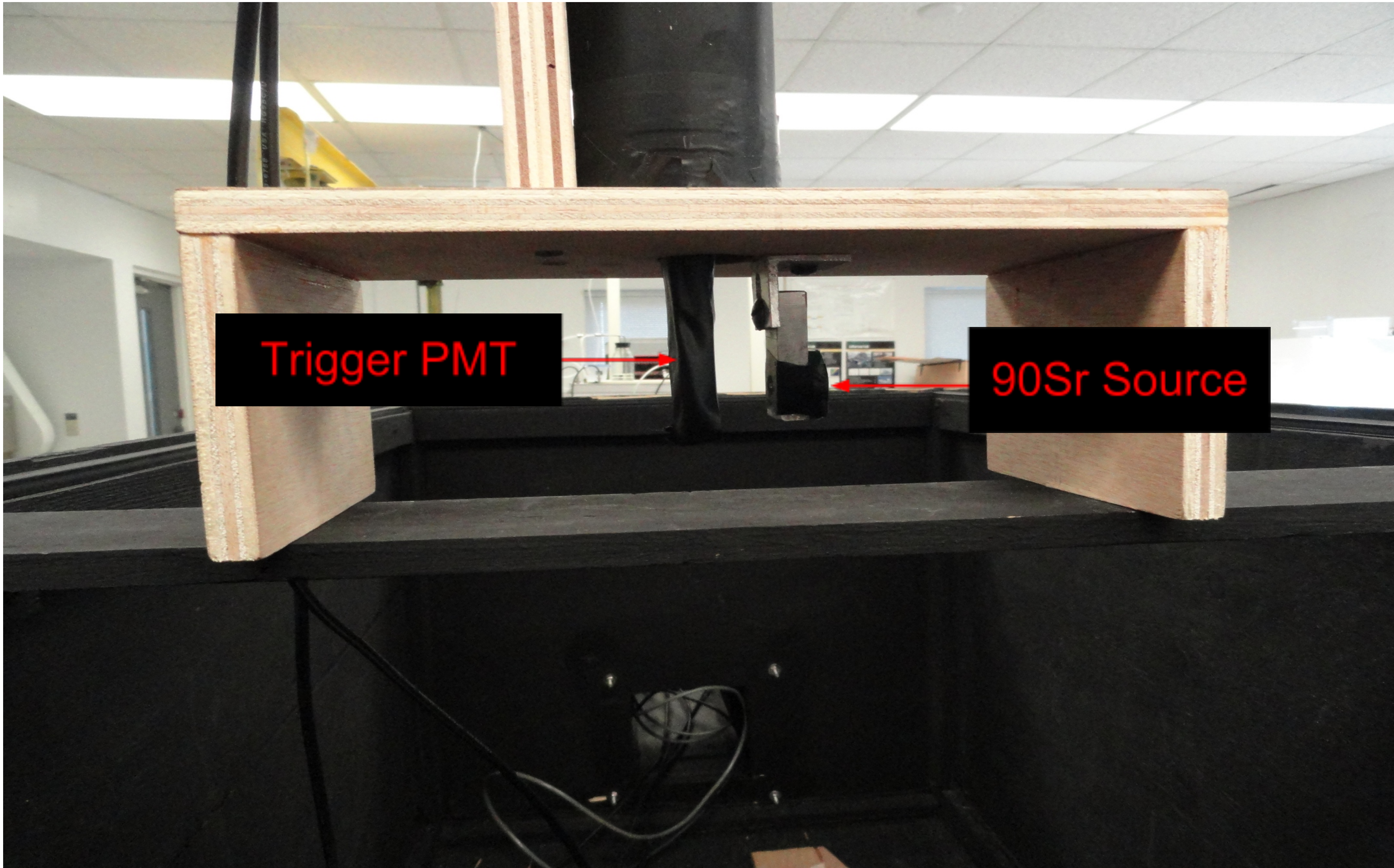




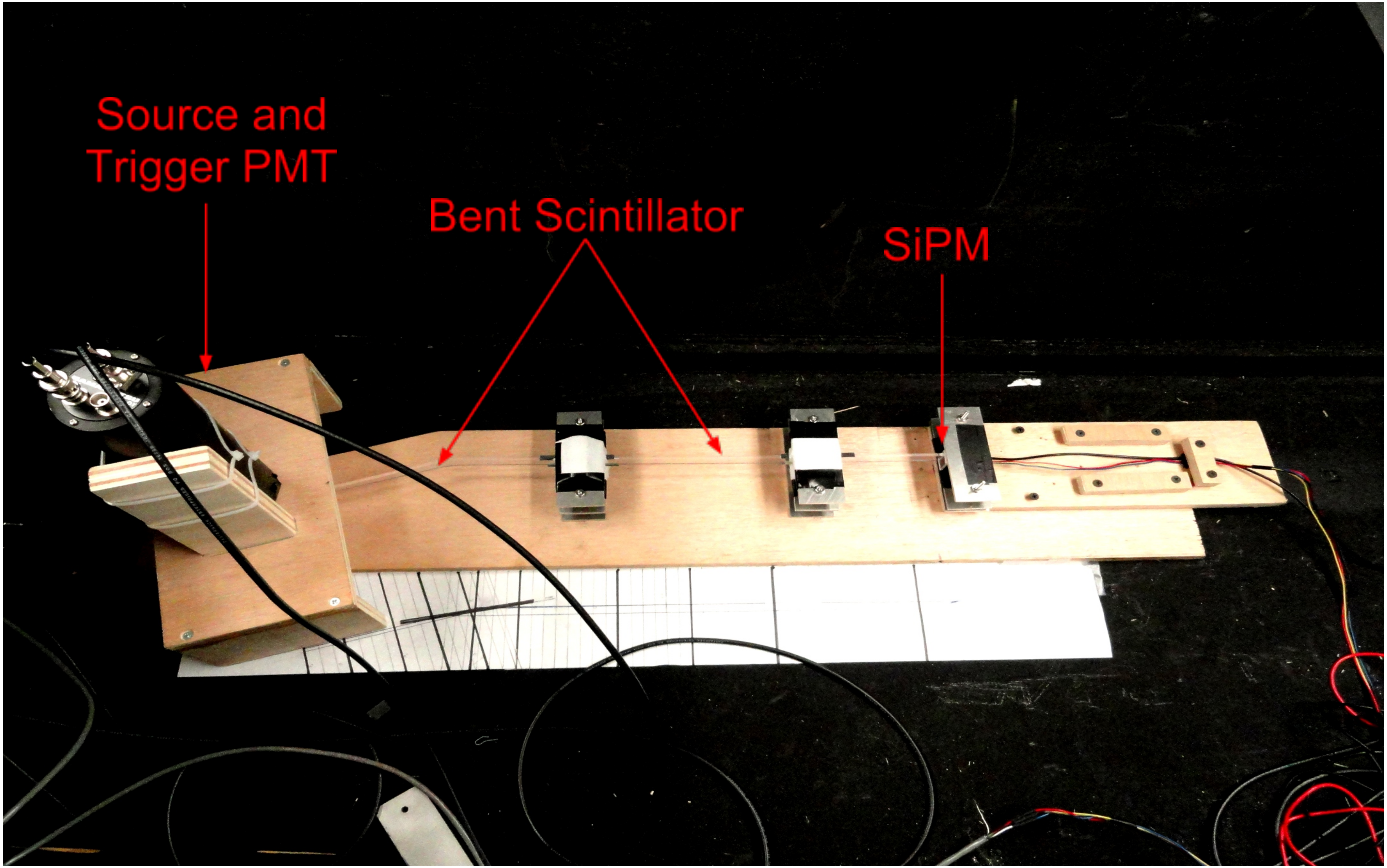
Surface Quality and Crazing

- Surface quality is characterized by:
  - Density of scratches on the surface
  - Reflective properties of the surface (amount of gloss)
- Crazing is the development of micro-cracks that rapidly destroy the capability of plastic scintillators to transmit light by total internal reflection
  - Most commonly seen on the surface
    - Occurs where oils, solvents, alcohols, and fingerprints have contacted the surface

Trigger PMT and ^{90}Sr Source

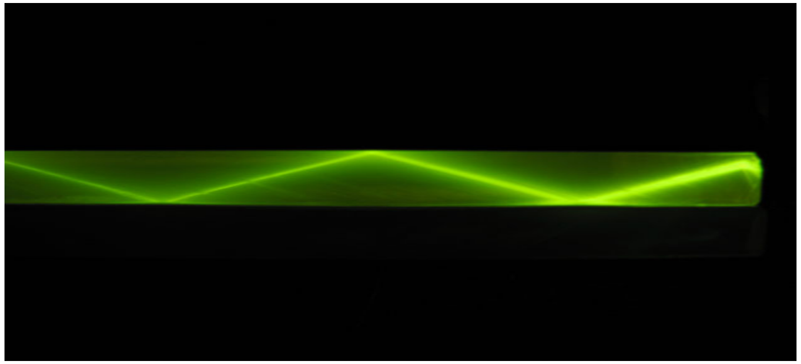


Experimental Set Up

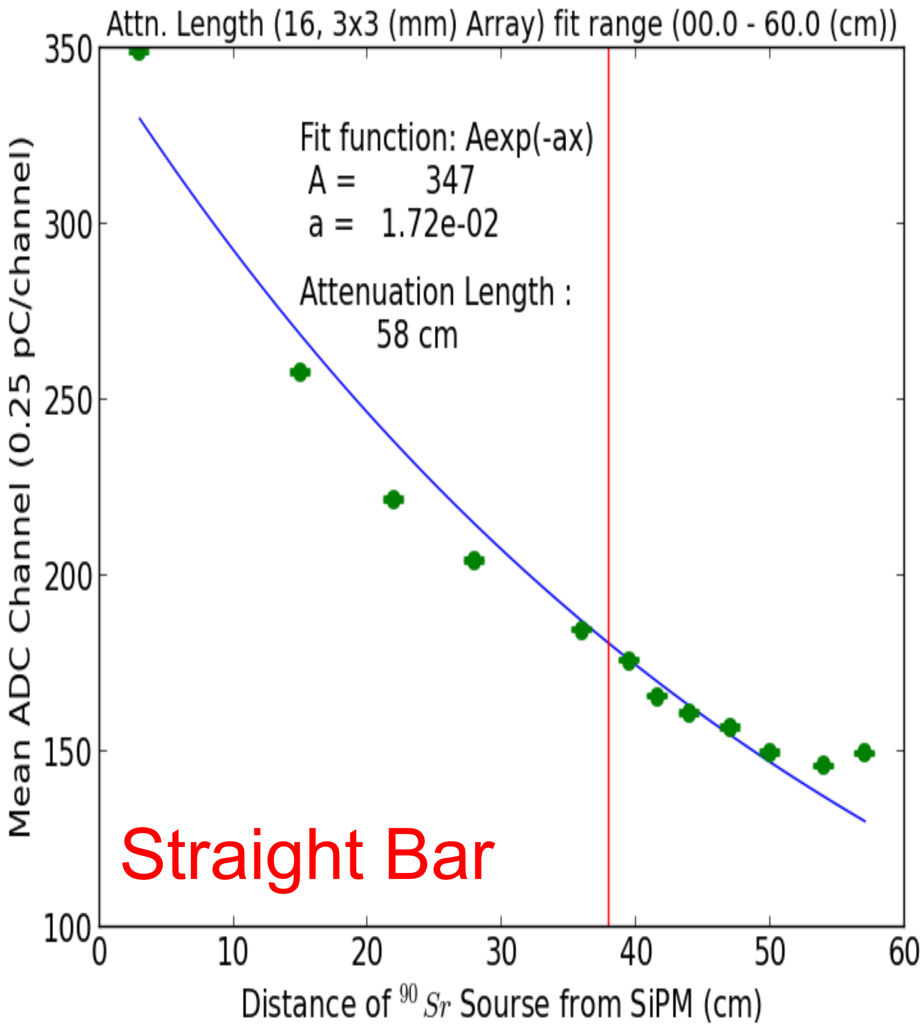


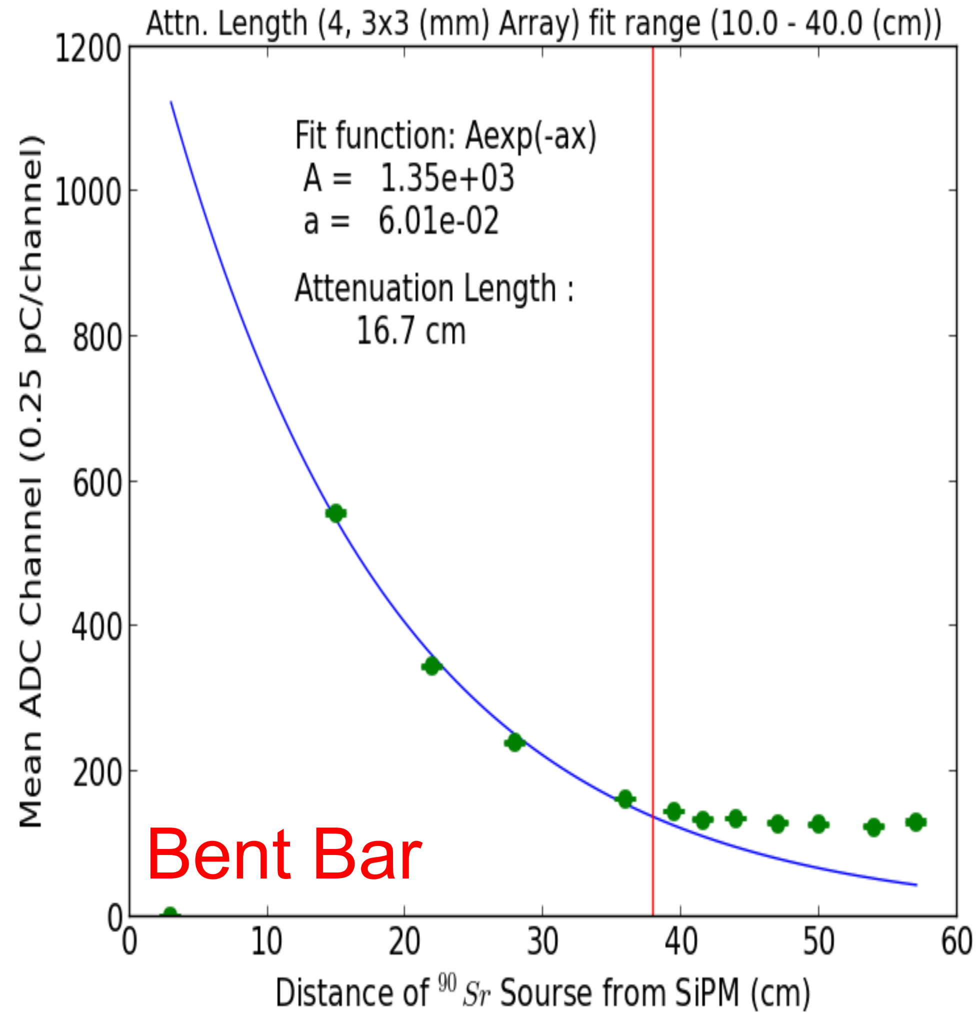
What We Measure

- What is attenuation length?
  - The loss of light from a scintillator can occur in two basic ways
    - Escape through the scintillator boundaries (the critical angle)
    - Absorption by the scintillator material
- When the dimensions of the scintillator are such that the total path lengths traveled by the photons are comparable to the attenuation length, absorption takes place
  - This is the case for our scintillators
- This parameter is defined as the length where the light intensity is reduced by a factor of 1/e (or, 36.8%)
- The light intensity as a function of length is: $A(x)=A_{o*}e^{(-x/a)}$
  - a = attenuation length
  - x = path length traveled by the light
  - A_o = initial light intensity
- Sensitive to crazing and surface quality



Attenuation Length



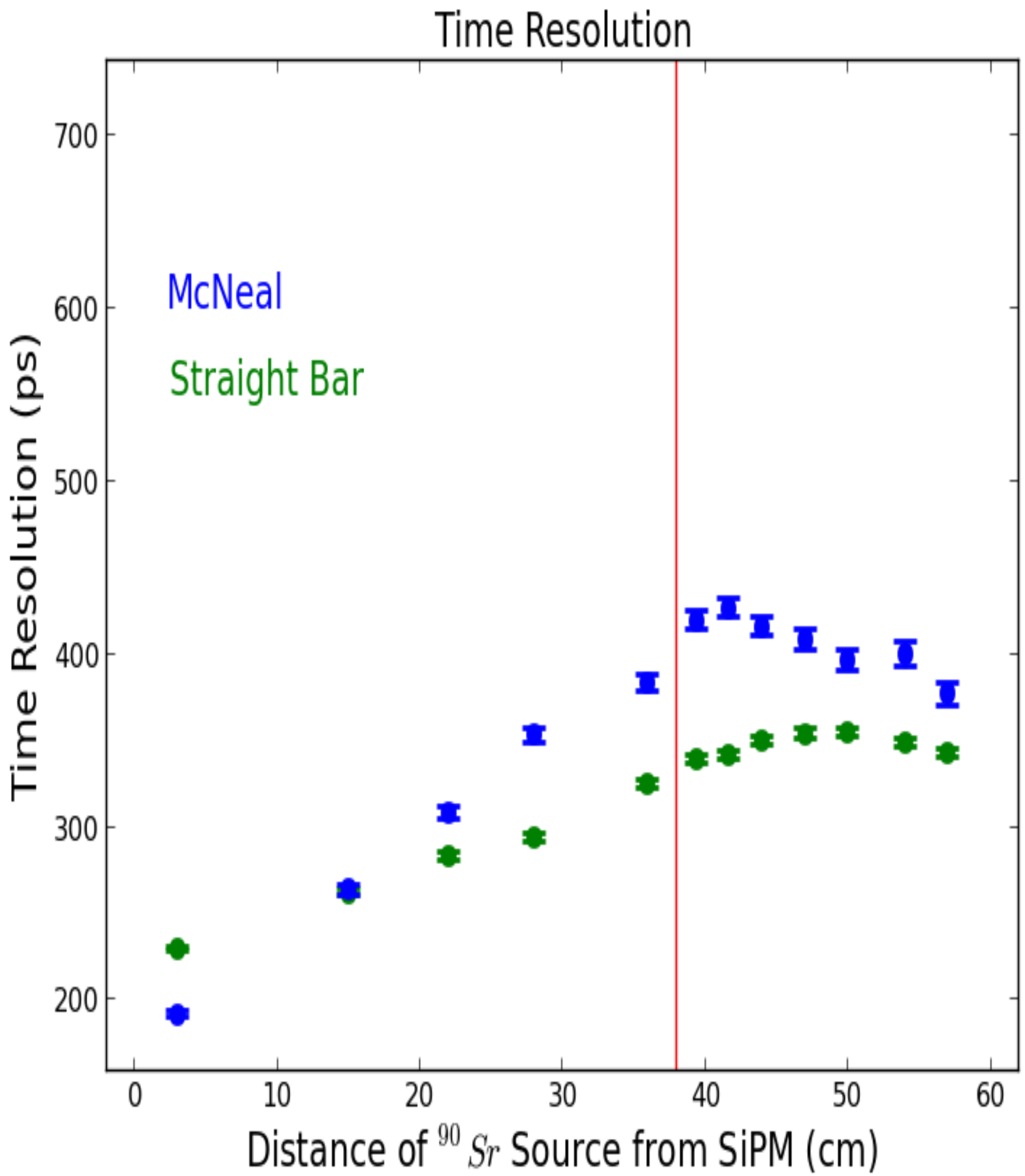


- Factor ~3.5 reduction of attenuation length
- Due to machining and handling
- Small factor due to geometry of bent paddle

What We Measure

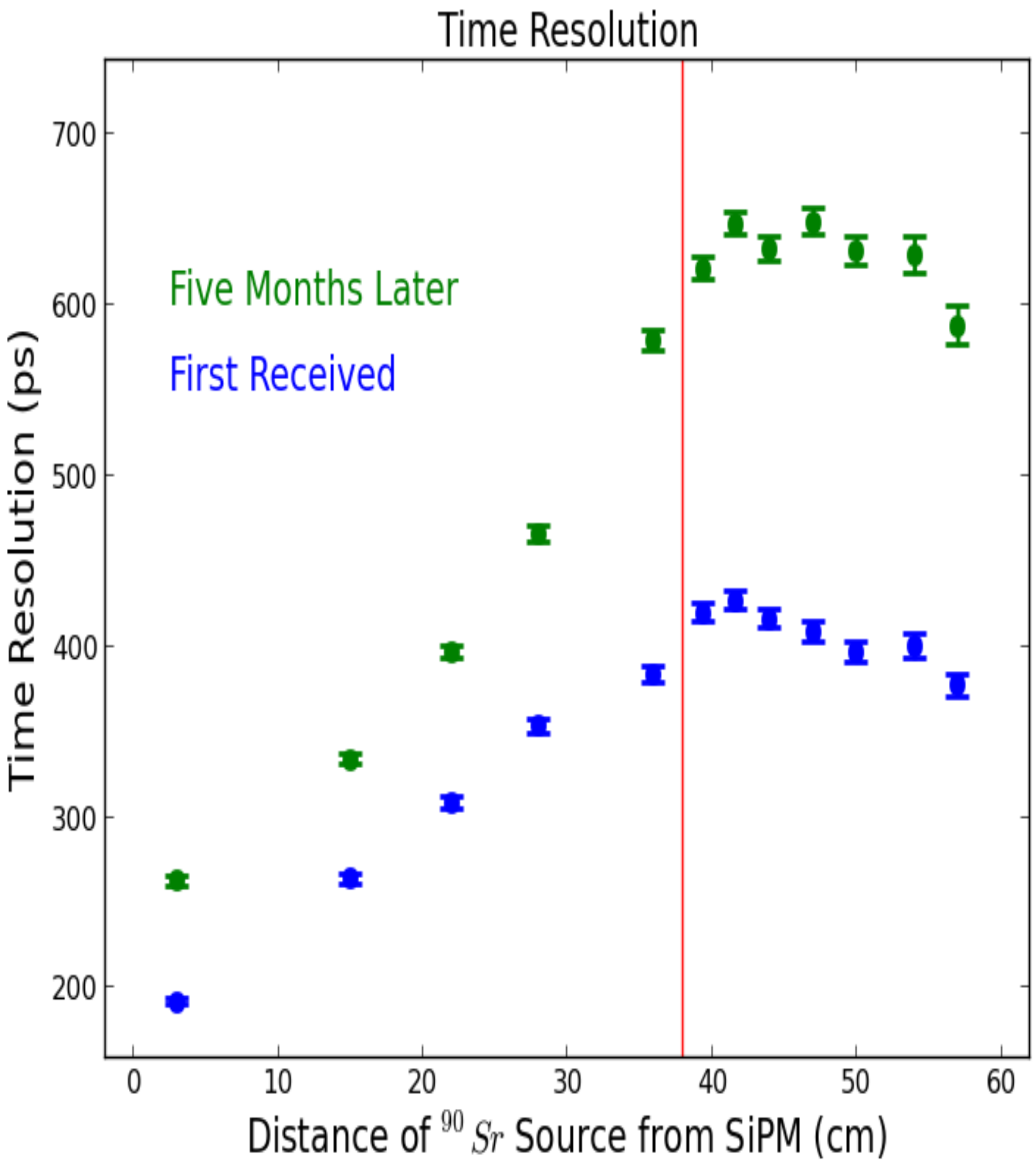
- What is time resolution?
  - Time resolution is the shortest duration in which two events can be clearly distinguished within the detector
  - Our purpose requires a time resolution of:
    - σ (rms) < 350 ps (10^{-12}s)
  - Time resolution is EXTREMELY sensitive to surface quality and crazing
    - This is the most important property of the scintillators for our purpose, so extreme care must be taken to maintain the surface quality
- Acceptable time resolutions have been observed!

Time Resolution Measurements (Comparison)



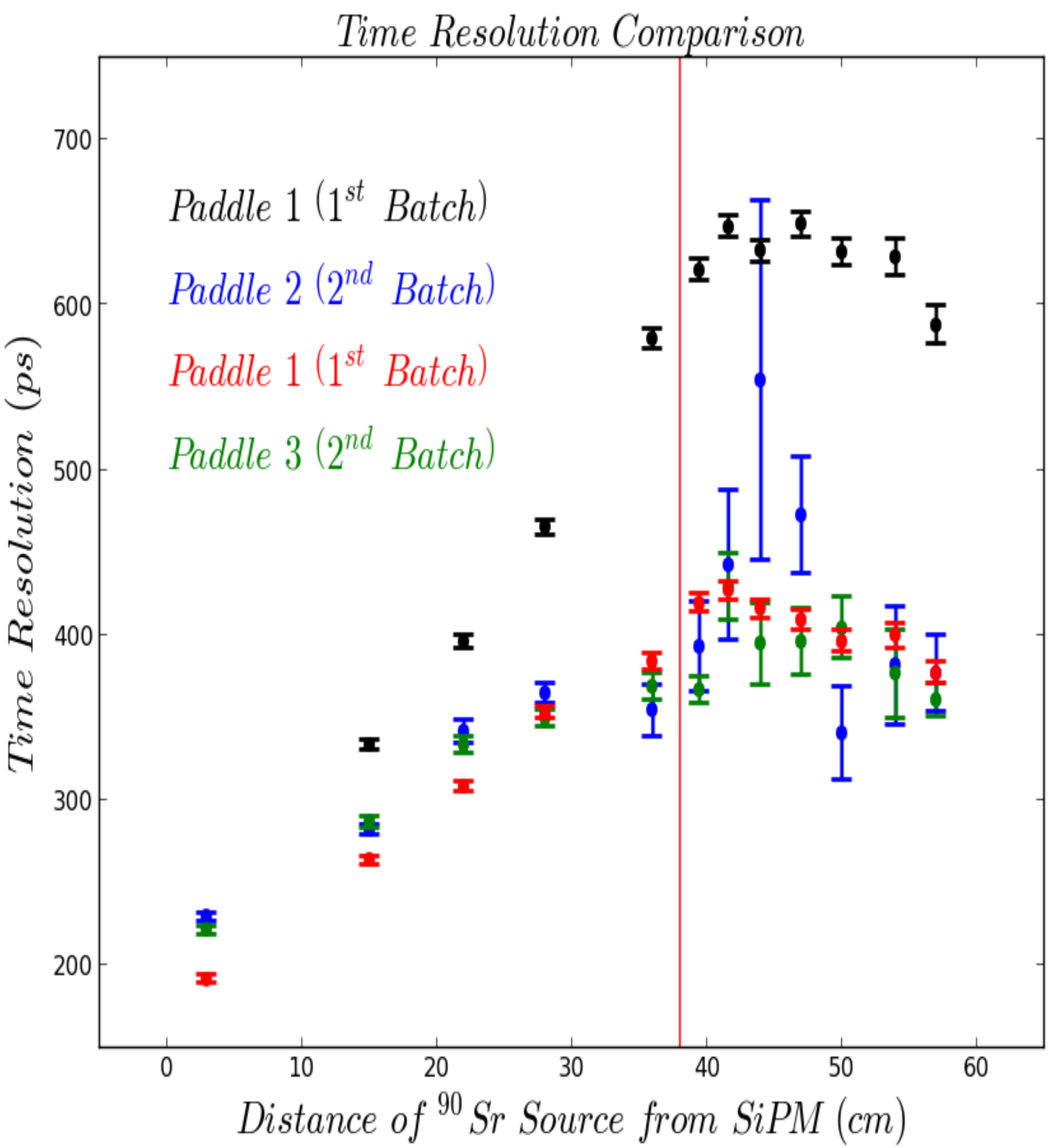
- McNeal bar (1st batch) measurements as soon as it was received
- Best time resolution of machined paddles observed to date
- No substantial difference (~40 ps) between the McNeal bar and the straight bar
- McNeal bar is suitable for timing measurements
  - If the initial quality is maintained

Time Resolution Measurements (McNeal)



- There is visible deterioration in the McNeal bar
  - Surface crazing
  - Poor surface reflection
- Average time res. increase of ~175 ps
- This is also observed in the attenuation length measurements

Time Resolution Studies



- Deteriorated paddle
  - Unacceptable
- Tape removed upon arrival and measured 1 month later
  - Unacceptable
- Suitable if this quality did not deteriorate over time
- Tape removed one month after arrival and measured immediately
  - Shows good surface quality except for the bent region and adhesive stuck to surface

Handling of Scintillators

- ELJEN scintillators are commonly shipped with adhesive paper protecting its surface
- Keep this paper on as long as possible until the scintillators are put into use to minimize abrading and touching of the polished surfaces
- Cutting and machining can be done with the paper in place
- During handling and assembly of counters, clean cotton gloves should be worn to minimize scratching and fingerprints

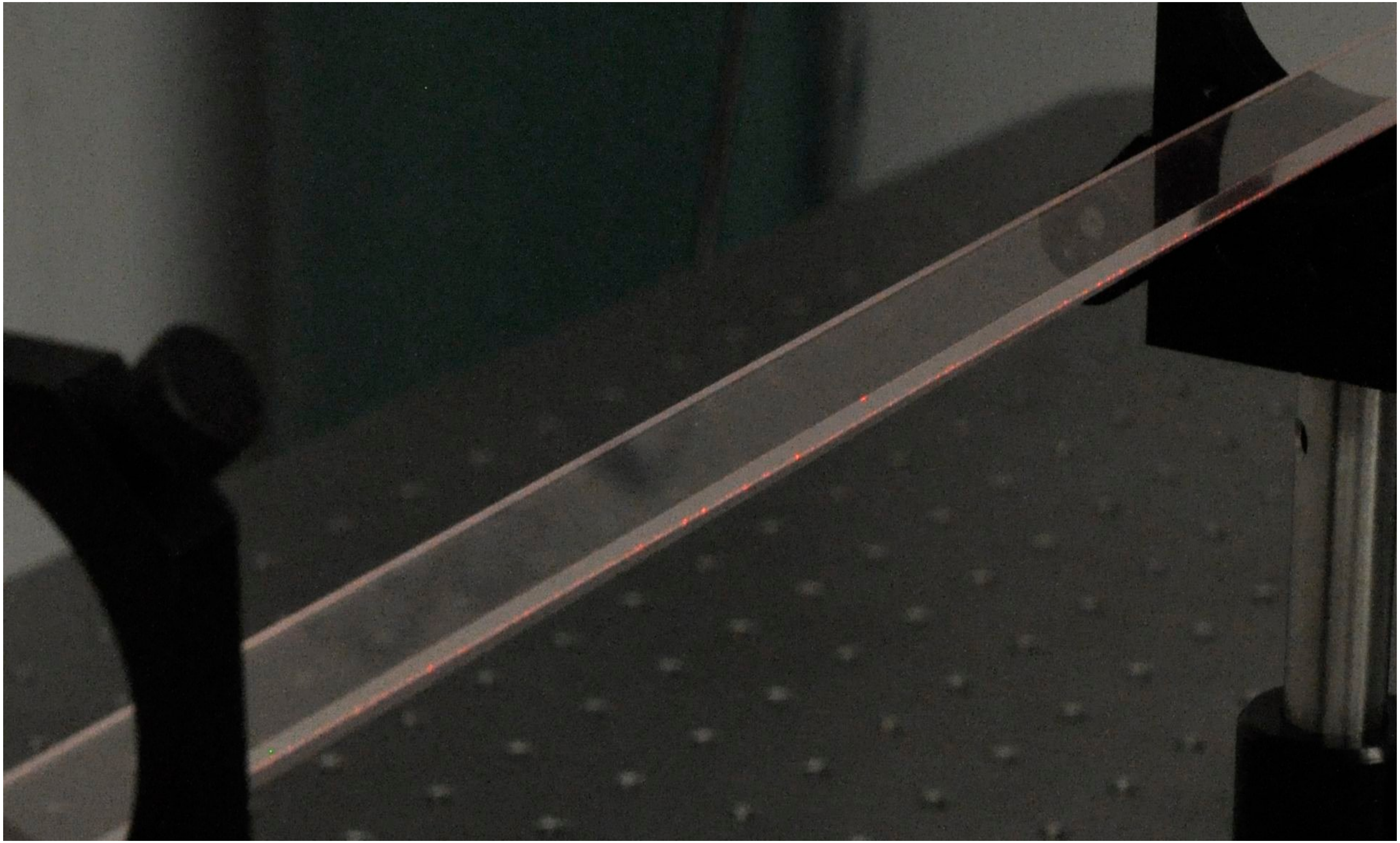
Storage of Scintillators

- Avoid storage conditions in which hard pressure points press against the scintillator surfaces
- Standard room temperatures in the range 65 – 80^{o}F (18 – 27^{o}C) are best
- Long-term storage above 100^{o}F is not recommended
- Exposure to UV light is not recommended
    - The common UV sources are fluorescent lights and sunlight
    - The Eljen supplied protective paper will adequately protect against common fluorescent light emissions
    - Extended exposure to direct sunlight should definitely be avoided

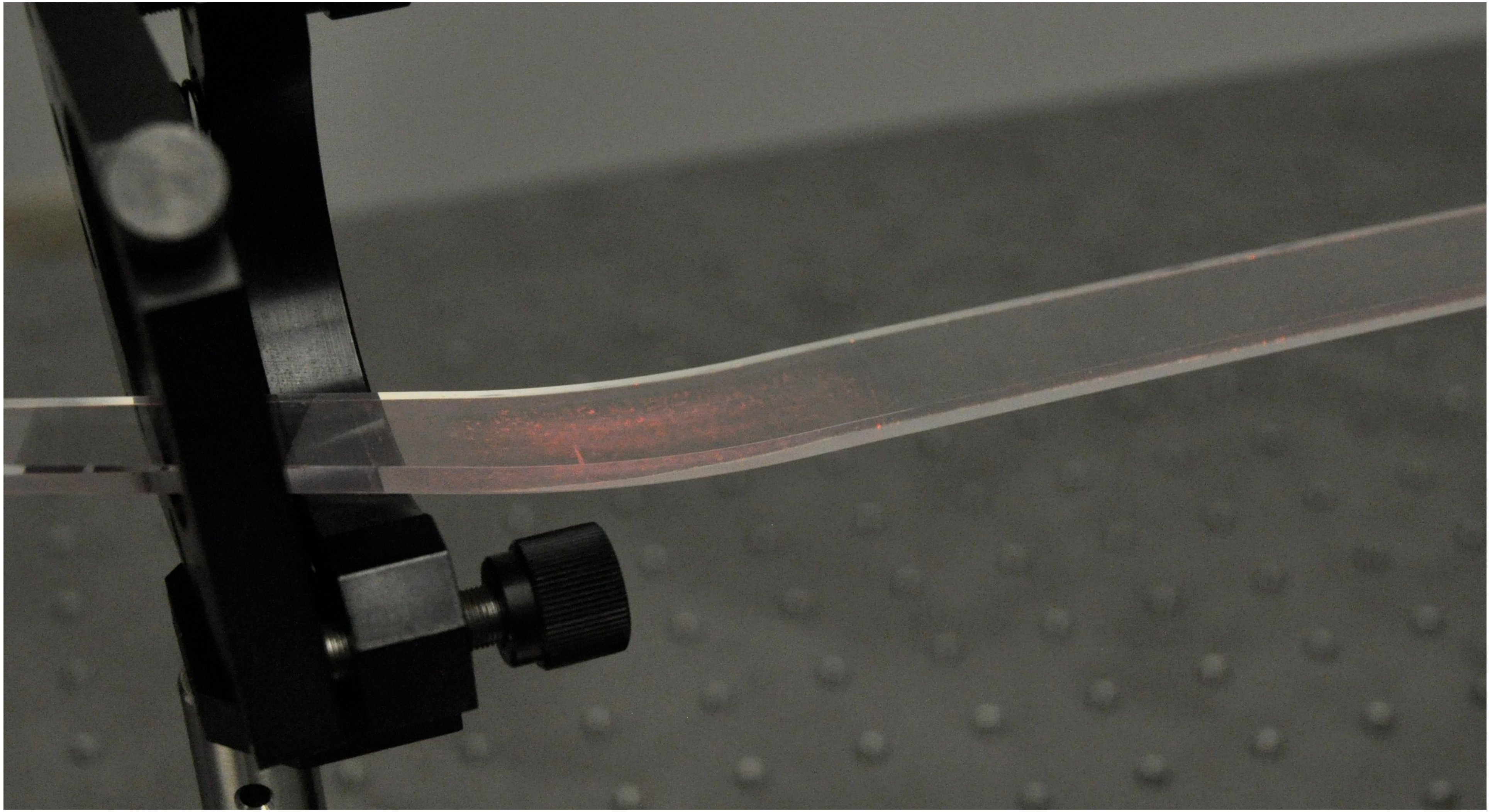
What to AVOID with Scintillators

- Absolutely avoid exposure to most organic solvents and their fumes
  - Such materials include paint thinners, de-greasers, acetone and ketones
- We strongly recommend using only a high grade of isopropyl alcohol (isopropanol) for general cleaning of the plastics
- DO NOT touch with bare hands!!
  - The body's oils contain acids that cause crazing after a period of time

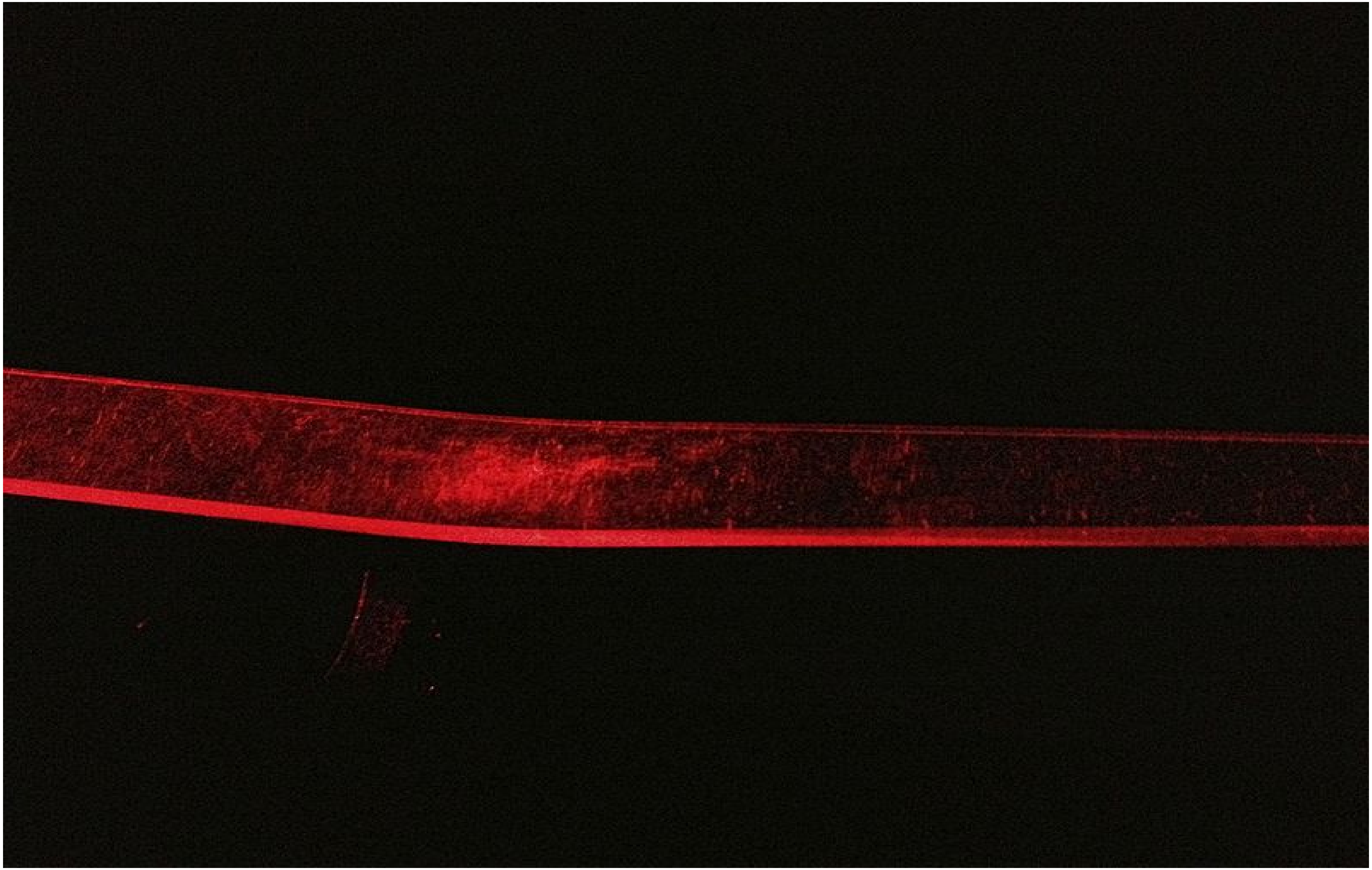
EJ204 Straight Bar



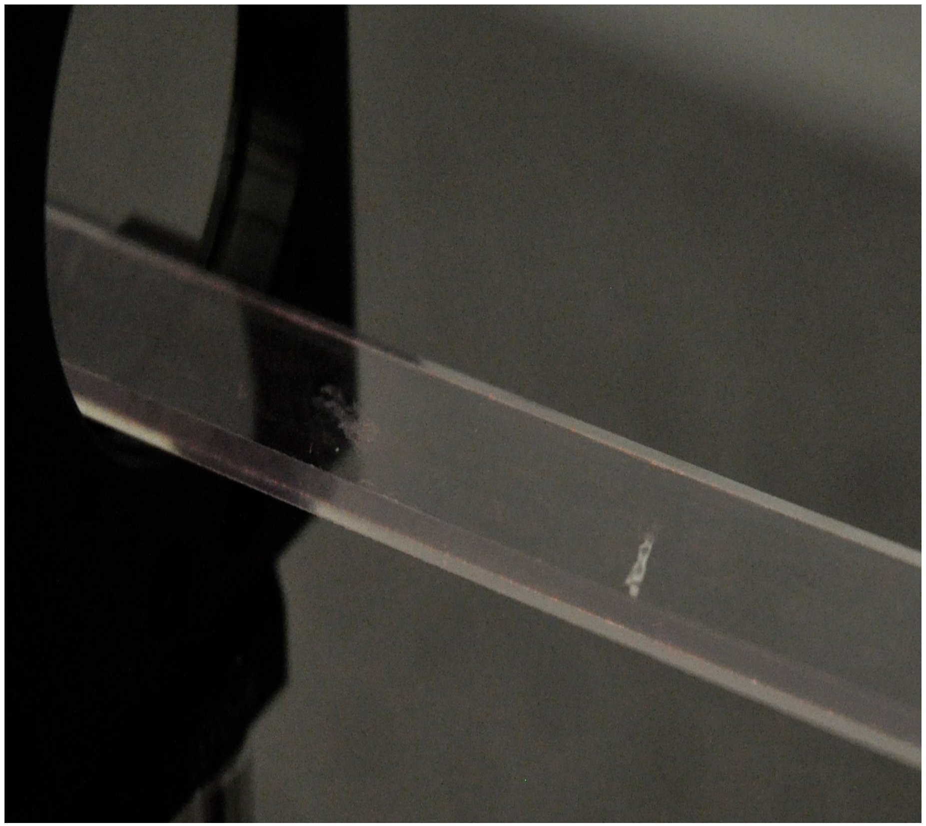
Paddle 2 (Bend region)

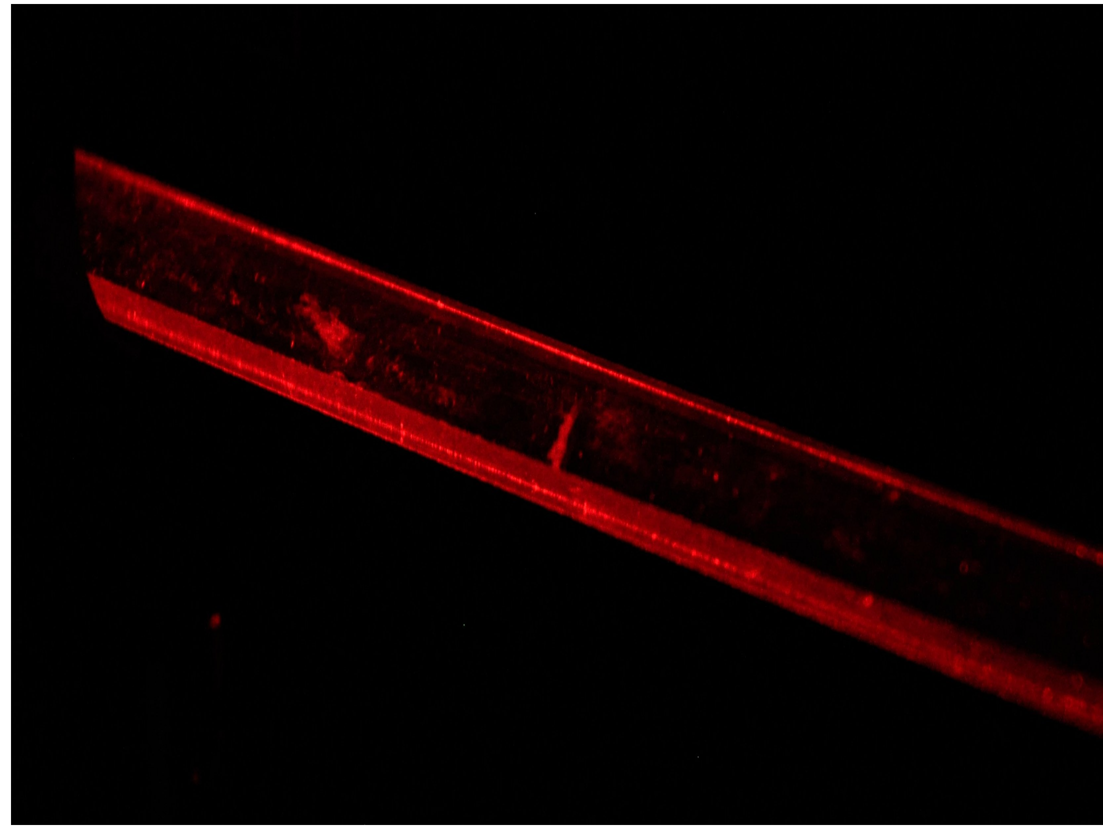


Paddle 2 (Bend Region)

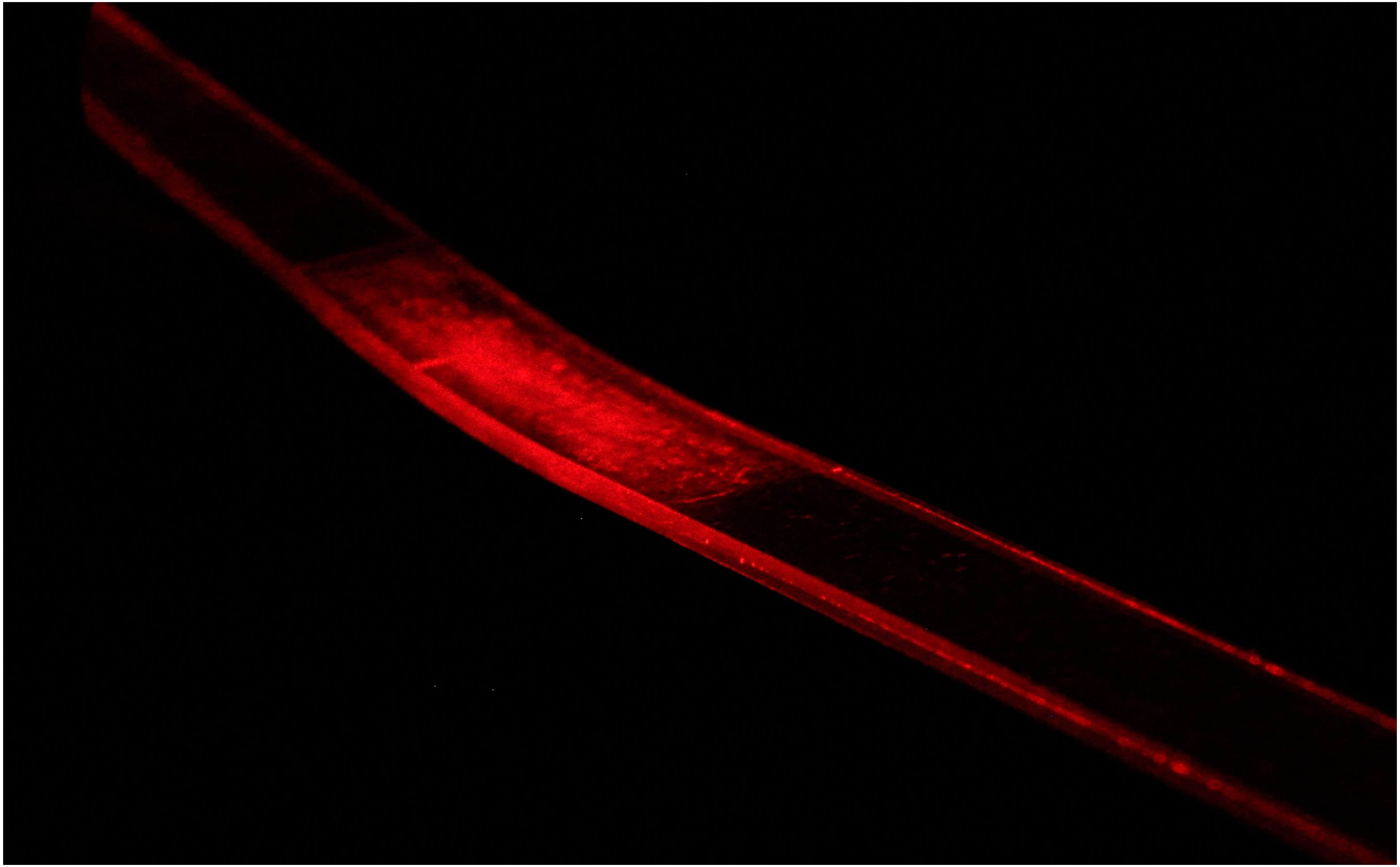


Paddle 3 (tape recently removed)

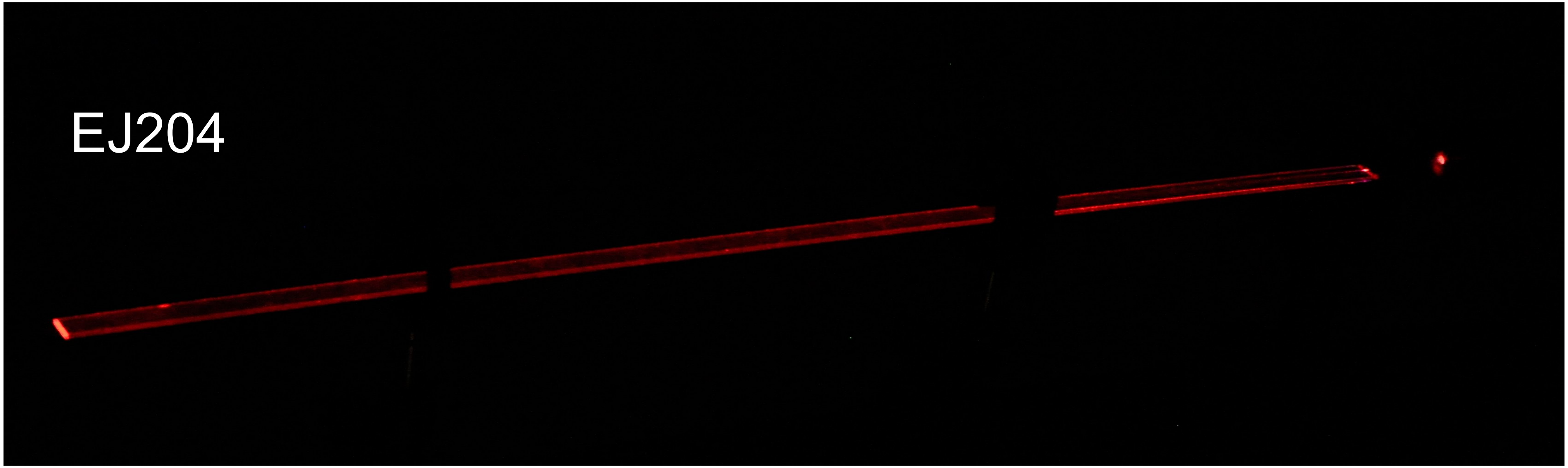


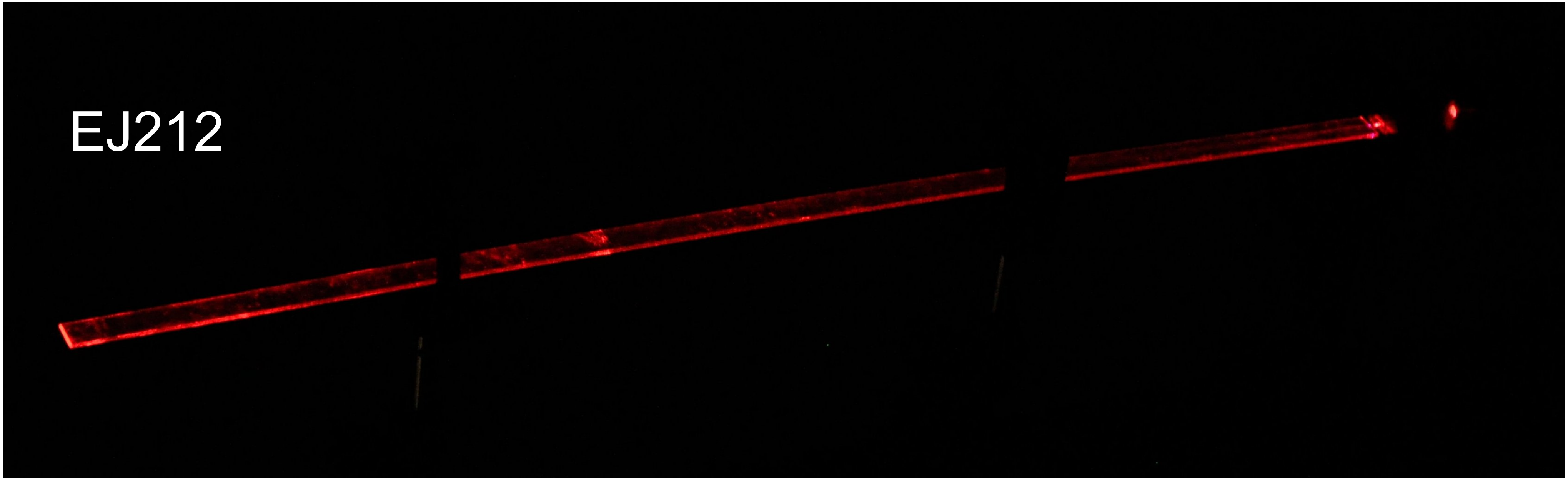


Paddle 3 (bend region)

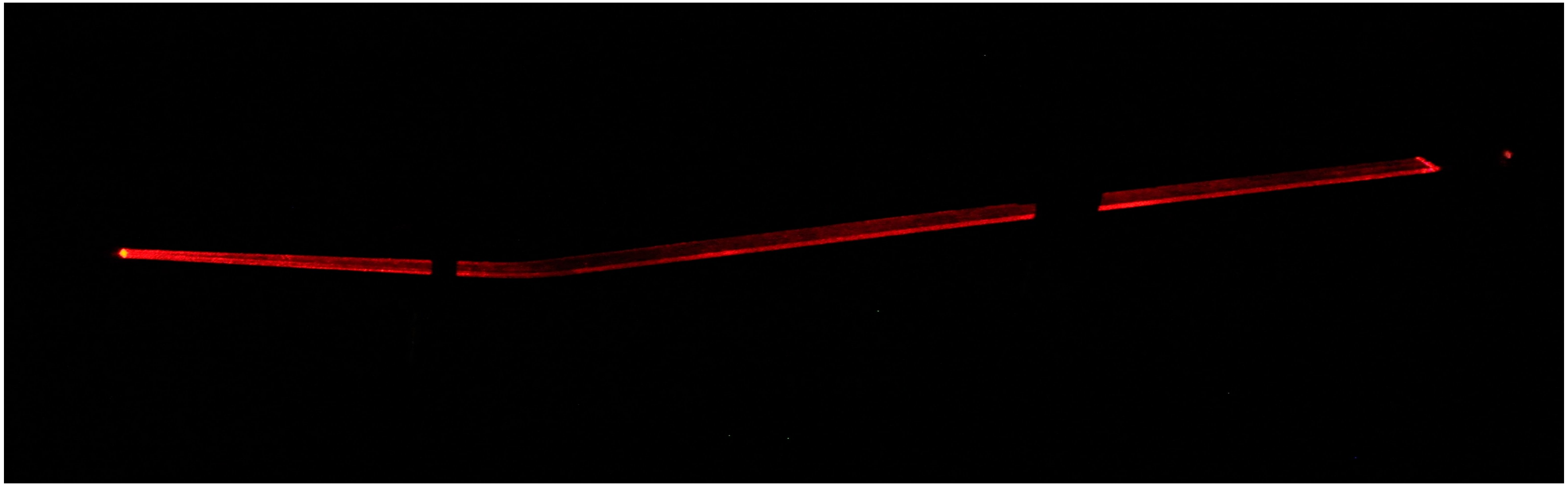


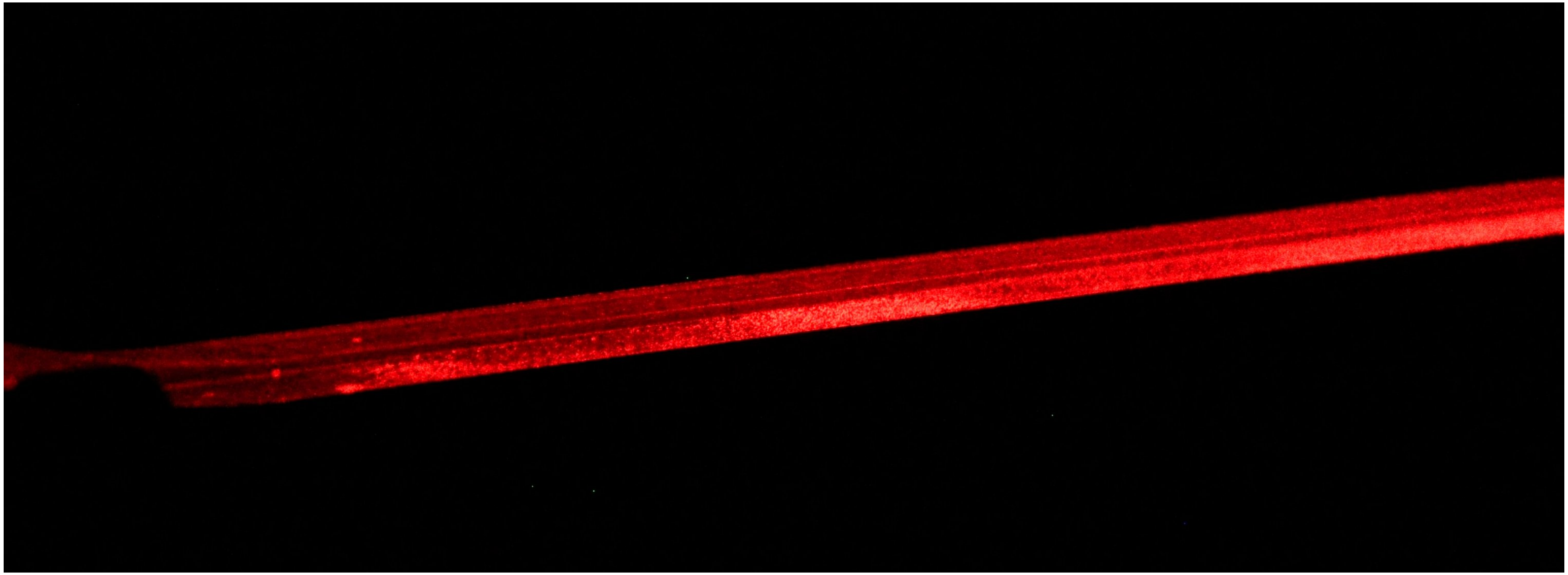
EJ204 (FIU) and EJ212 (McNeal)



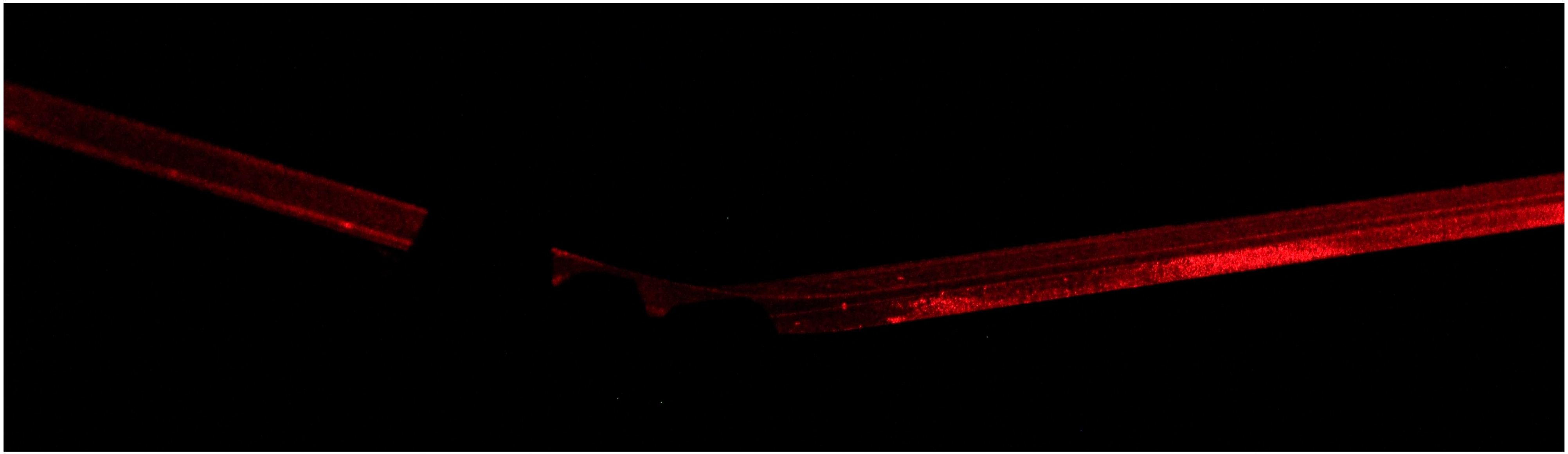


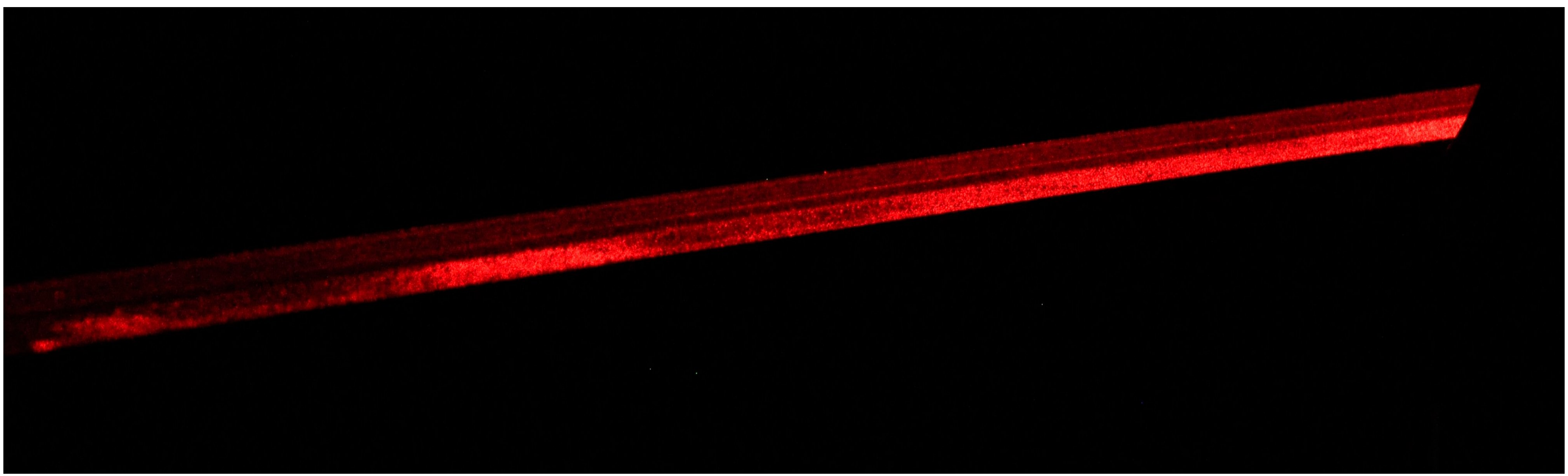
Paddle 1 (Deteriorated Paddle)





Paddle 1 (Crazing)





Thank you for your time!

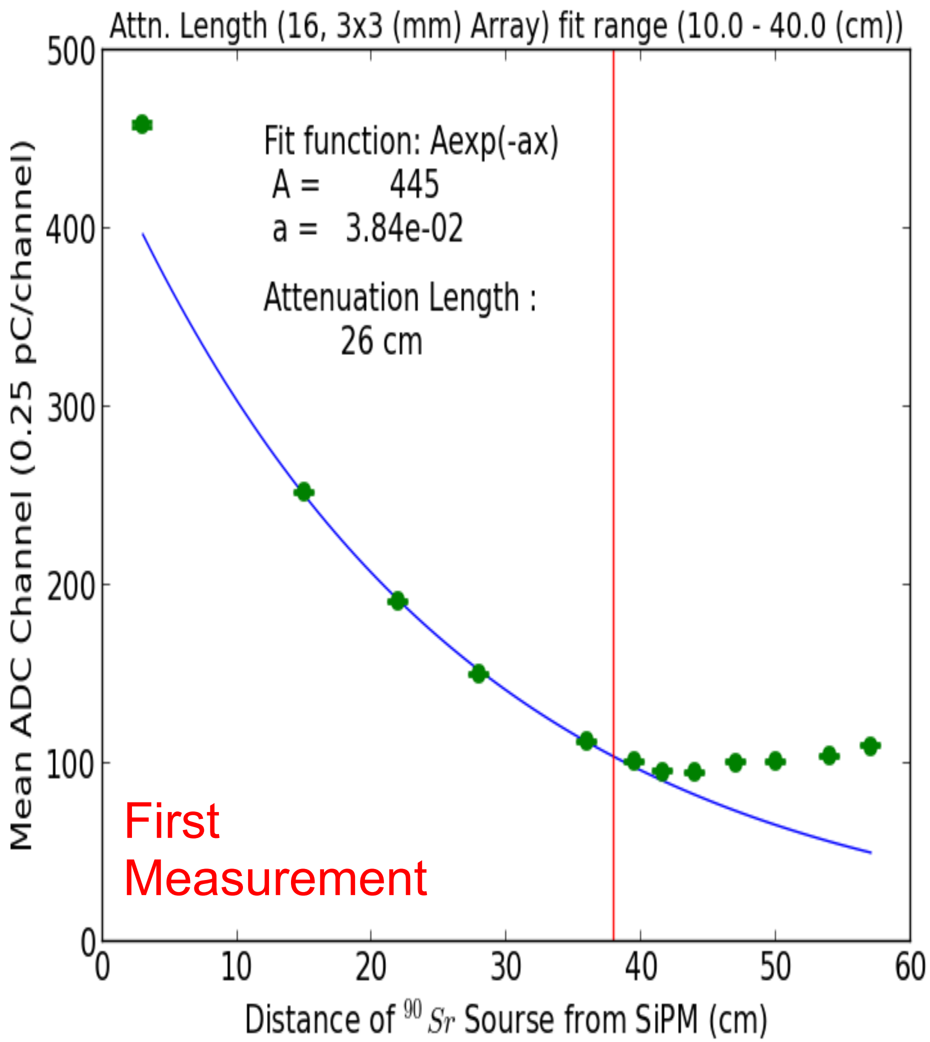
Questions?

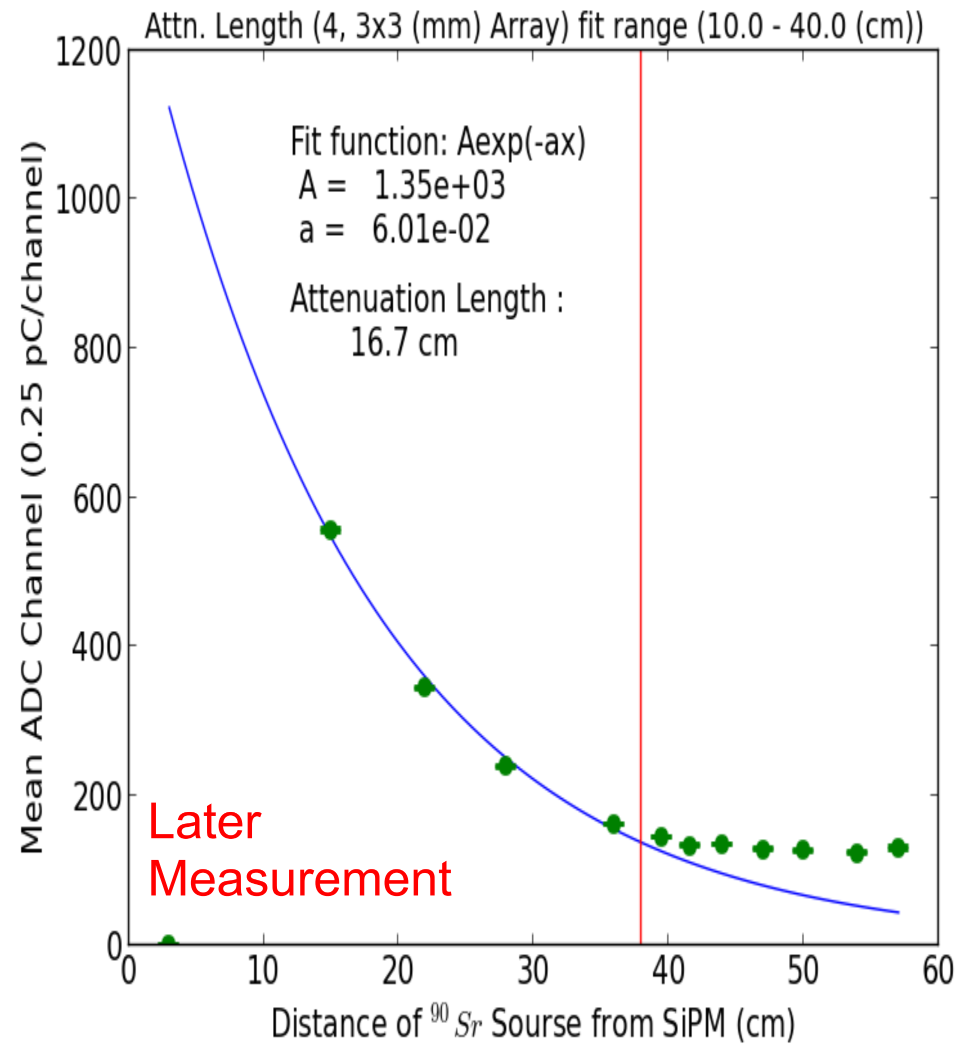
Back-up Slides

Time Resolution Studies

- Batch # 1:
  - 2 paddles received, 1 is ruined
  - Measurements:
    - Paddle 1: upon arrival
    - Paddle 1: after 5 months
- Batch # 2:
  - 3 paddles received, 1 is broken
  - Measurements:
    - Paddle 2: Tape removed upon arrival but measurements performed one month later
    - Paddle 3: Tape removed one month later but measured immediately

Attenuation Length (McNeal)





- Five months have elapsed between these two measurements
- ~35% change in attenuation length measurements

Machining of Scintillators

- Heat and Mechanical Stress
  - Avoid procedures that would introduce significant stress in the materials such as overheating during the machining and polishing or tight clamping stress with metal jaws on the plastic
- The protective adhesive paper should remain on during room-temperature fabricating and finishing of edges
- Use diluted soapy water and cotton or very soft flannel cloth to clean finished surfaces.
- Avoid exposure to all kinds of solvents except water or alcohol
  - Isopropyl alcohol (isopropanol) is preferred.

Machining of Scintillators

- Sawing
  - Band sawing is preferred among the many varieties available
  - Saw blades must be sharp
  - Four-pitch buttress type band saw blades are recommended
  - Recommended blade speed: 1800 ft. (500 m) per min
  - Saw Teeth/Inch: 14
- Machining Coolants
  - Do not use metal cutting oils
  - Fine soapy water sprays are recommended
  - When drilling only use water or soapy water coolants (with no lemon oils)

Machining of Scintillators

- Clamping
  - Avoid sharp pressure points
  - For turning and milling clamp lightly using suitable wood or plastic blocks to spread out the pressure
  - Avoid trapping dirt between the scintillator and other surfaces
- Milling
  - Use fly cutters where possible with cutter speeds and feed rates of: 0.0015” to 0.004” (0.04 – 0.2 mm) per revolution
  - When using end mills, use a two wing sharp helix cutter with compressed air blower to keep chips free.

Polishing of Scintillators

- Hand Polishing
  - Form a paste of alumina with water on a flannel cloth
  - Rinse away the alumina and use a general purpose non-abrasive plastic polishing liquid available from most plastic supply companies for final cleaning
  - Use a clean, soft flannel in this final step
- AVOID using polishing liquids on heat-bent pieces

Polishing of Scintillators

- Machine Polishing
  - Avoid lingering on any one spot and keep buffer speeds and pressures down in order to minimize surface heating
  - A suitable buffer wheel surface speed is 1400-1800 (400-500 m) per minute corresponding to about 750 RPM for an 8” (200 mm) diameter buffing wheel
  - Avoid rounding off the sheet edges by clamping a small strip of plastic on each side
- First Operation
  - Use a 1” wide unstitched ventilated-type buffing wheel with a brown #150 grade relatively dry compound bar
- Second Operation
  - Use a separate but similar buffing wheel as above but with a dry aluminum oxide compound bar
- Final Operation
  - Polish with a clean, soft, unstitched flannel wheel using no compound

Cleaning of Scintillators

- Clean water and soapy water are the best solvents to used
    - These are the only fluids to be used when cleaning scintillators that have had extensive machining and polishing
  - Wipe or pat dry with clean, soft, non-abrasive cloths or tissues
  - The lower alcohols may also be used
  - Isopropyl alcohol is preferred because of the less intense cooling from the slower evaporation
  - Avoid industrial grades of alcohols which may contain harmful impurities

Geometry Of Bent Scintillator