Fermi National Accelerator Laboratory

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A Simple Method for Fusing Plastic Fibers

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Fiber tracking and calorimeters using scintillating plastic fibers may require bonding fibers together with good optical coupling. For this we have tried solvents and variety of epoxies with inconsistent results and substantial light loses. Recently we developed a technique that is very successful in fusing plastic fibers with consistently good optical coupling that transmits photons better than 95% efficiency.

The technique is simple but very effective in melting and fusing plastics in a small confined region. Fig. 1 shows the arrangement. The fiber pieces are inserted into a fused silica glass tubing with slightly larger inner diameter than the diameter of the plastic fibers. One of the fibers is fixed in position while a slight inward pressure is applied to the other fiber when the fusion takes place.

The junction area is heated by a small resistive coil surrounding the region. The resistance of the wire was 6.4 Ω, and about 1.3 amp. current was needed for less than 10 seconds. It is interesting to watch the plastic fibers melting and filling the confined glass volume during this short time. It takes about 15 seconds for the fiber to cool and be released from the glass tubing, due to the differential thermal contraction of the fiber and highly polished surface of the glass. Neither the heating temperature or the time is very critical. Too high a temperature may produce bubbles, and a low temperature may result in a weak joint. We note that if the temperature is sufficient to melt the PMMA cladding, but not the polystyrene core of the fiber, it is possible to make a joint which is visibly acceptable but mechanically weak. We estimate the proper temperature is around 250°C.

Using this technique we have made a variety of joints between scintillating fibers and scintillating and non-scintillating fibers with good success. The optical quality of the joints was tested by exciting the scintillating fiber before and after the joint using a mercury penlamp that emits UV light and measuring the amount of light after a 1 meter length of fiber. For the test we have used 3 HF with PTP (PMMA clad) fibers of 1 mm thickness. Figs. 2a and b have two measurements before (solid curves) and two measurements after the joints (dotted curves) for two typical samples. The results indicate very small transmission losses.

Another sample was prepared for measuring light attenuation through a 1 mm thick fiber having 3 fused joints. The sample was made of 4 pieces of 1 meter length. Fig. 3 shows the attenuation curve for the blue light of the fibers. The curve is smooth within the measurement error of the spectrometer. Light losses at the splices (indicated by arrows) would appear as step functions on this plot.

In conclusion we are convinced that our technique is successful in splicing plastic fibers in a short time using a small heating coil. We believe that the joint can also be heated using a small infrared laser. We plan to carry out tests with a CO_2 laser for fusing single fibers and multiple fiber ribbons for mass splicing in the near future and to develop automated equipment to perform the splicing.

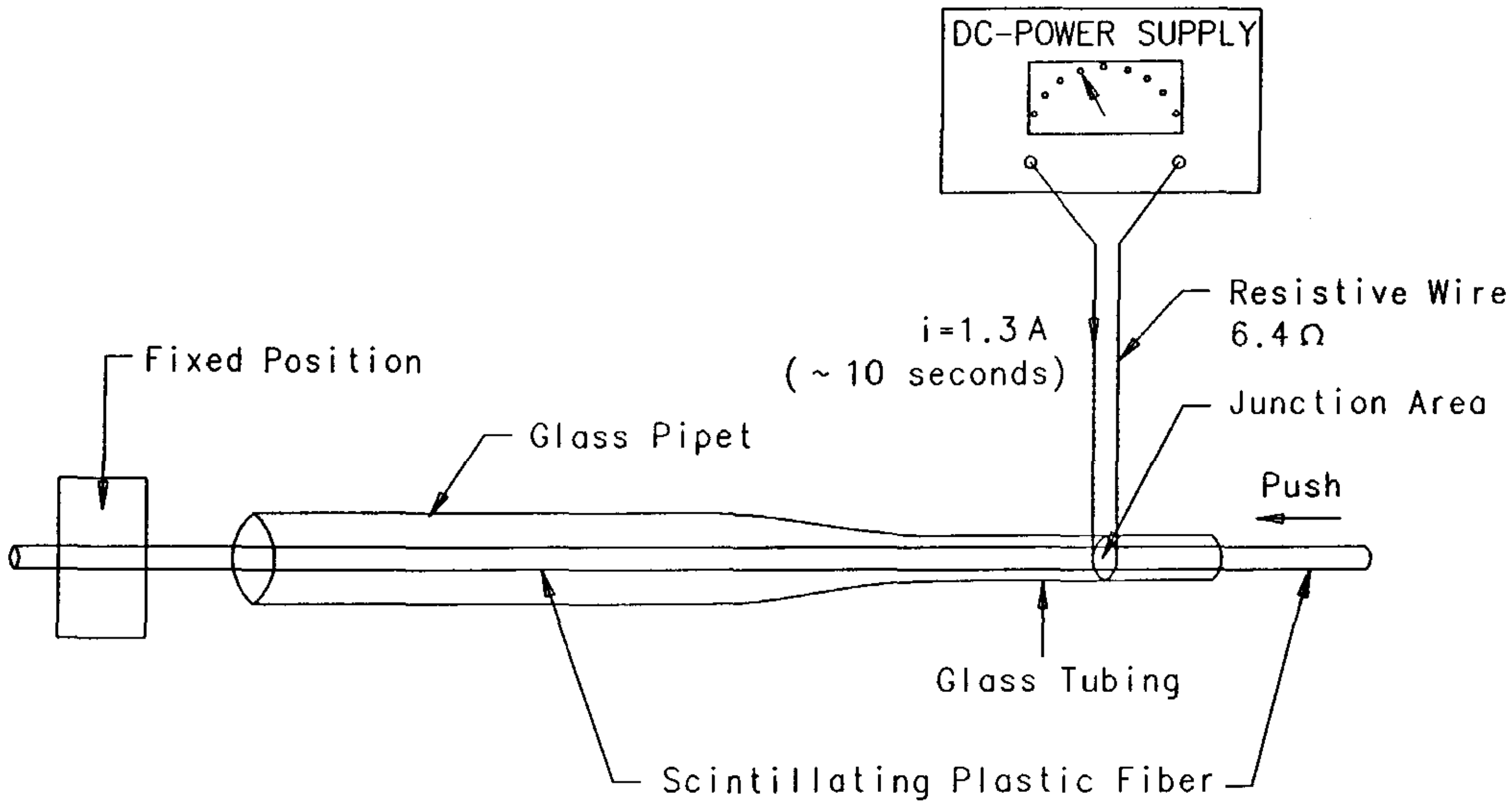

DC-POWER SUPPLY
Resistive Wire
6.4 Ω
i=1.3 A
(~ 10 seconds)
Fixed Position
Junction Area
Glass Pipet
Push
Glass Tubing
Scintillating Plastic Fiber

Fig. 1

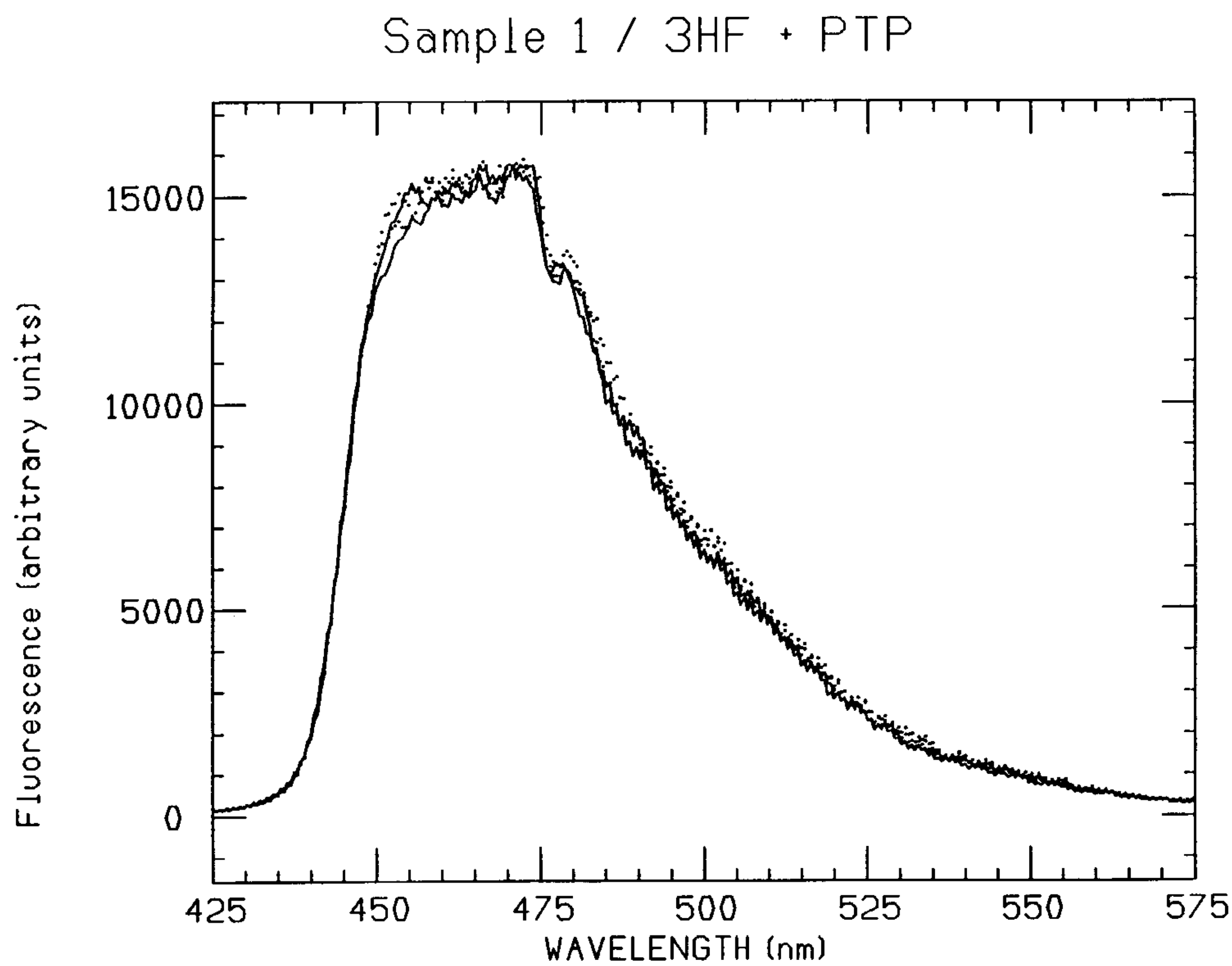
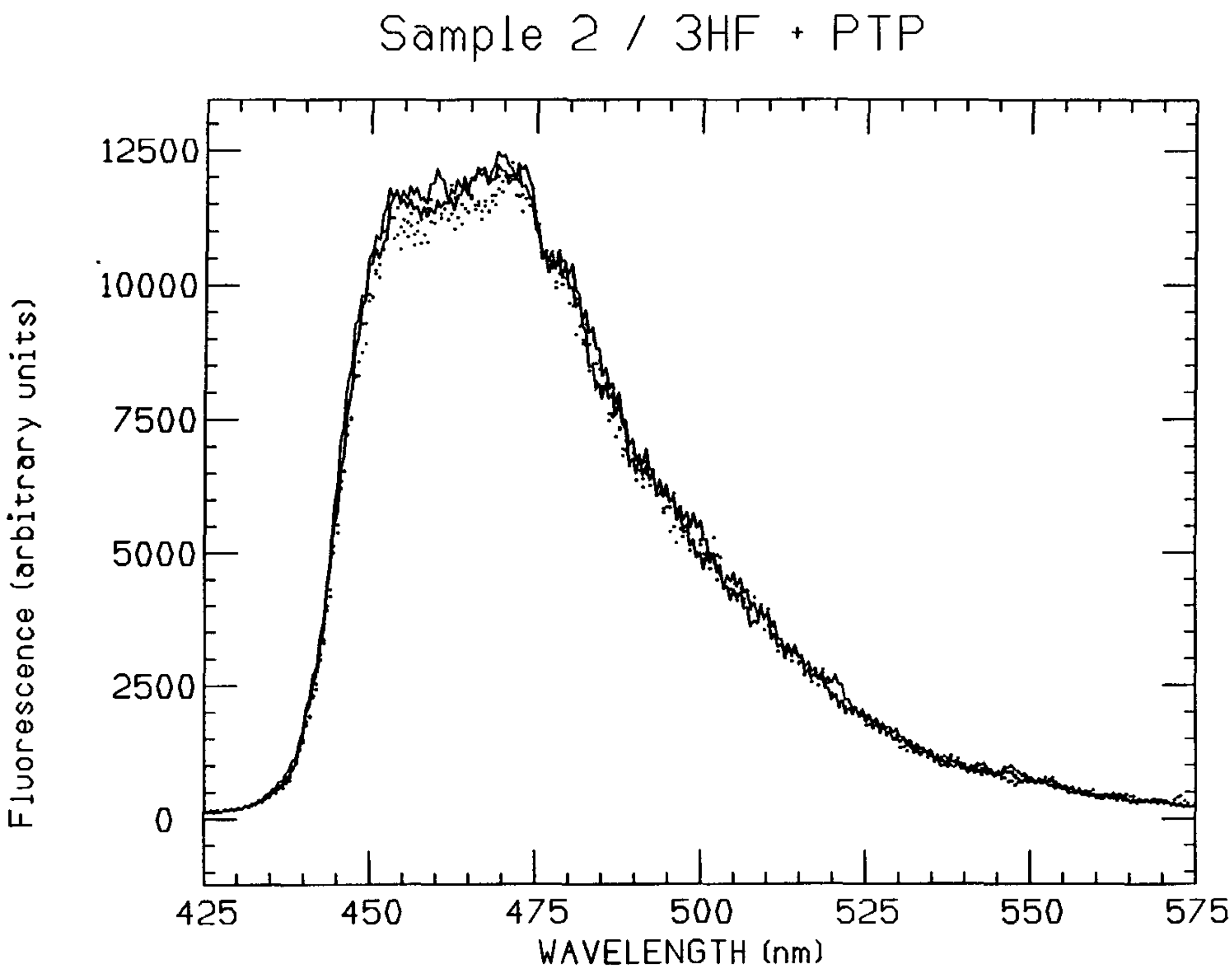

Sample 1 / 3HF + PTP
Fluorescence (arbitrary units)
15000
10000
5000
0
425
450
475
500
525
550
575
WAVELENGTH (nm)

Fig. 2a



Sample 2 / 3HF + PTP
Fluorescence (arbitrary units)
12500
10000
7500
5000
2500
0
425
450
475
500
525
550
575
WAVELENGTH (nm)

Fig. 2b

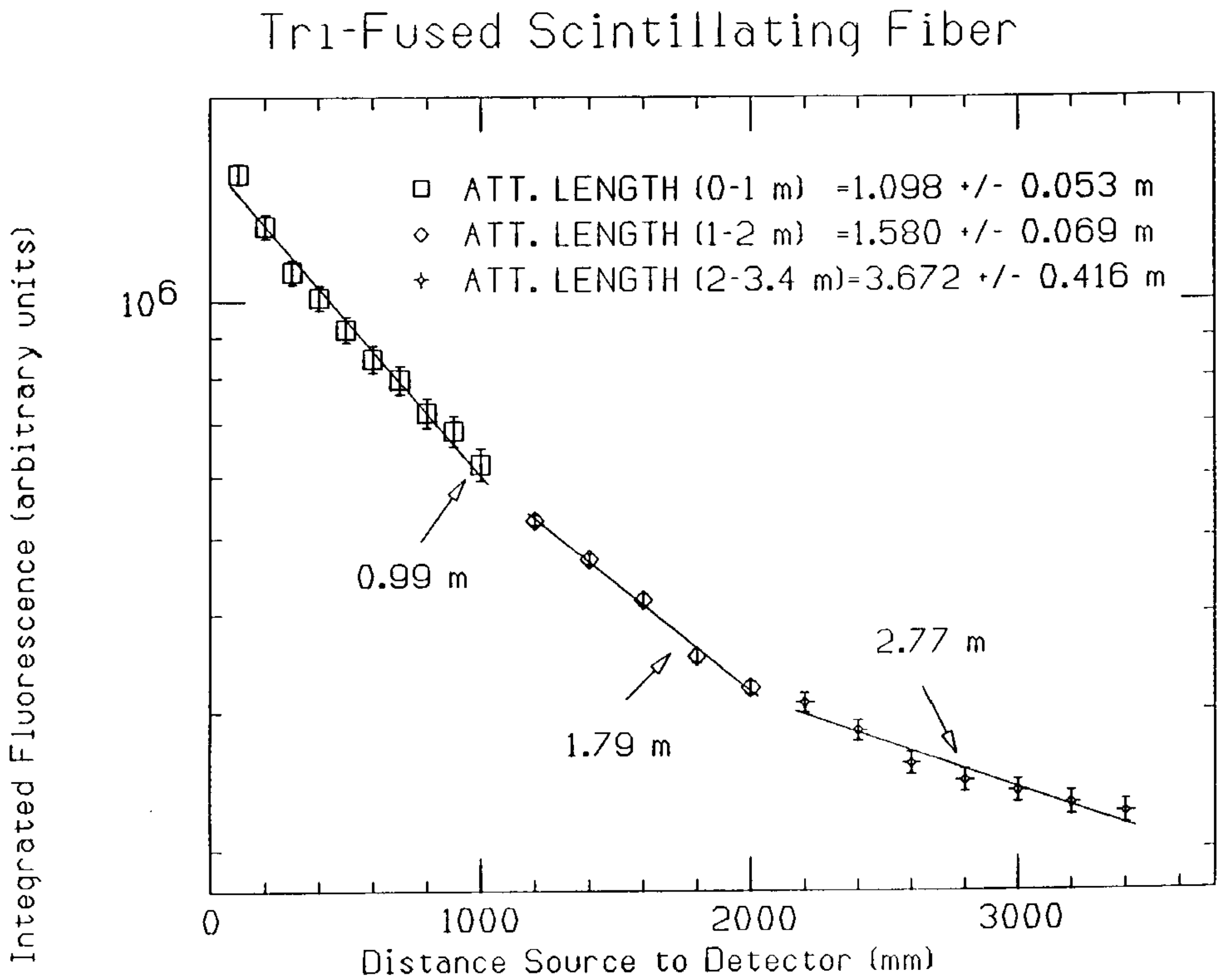

Tri-Fused Scintillating Fiber
ATT. LENGTH (0-1 m) =1.098 +/- 0.053 m
ATT. LENGTH (1-2 m) =1.580 +/- 0.069 m
ATT. LENGTH (2-3.4 m)=3.672 +/- 0.416 m
10^6
0.99 m
1.79 m
2.77 m
0
1000
2000
3000
Distance Source to Detector (mm)
Integrated Fluorescence (arbitrary units)

Fig. 3