

Design and Construction Components of Scintillating Fibre Tracking Detectors

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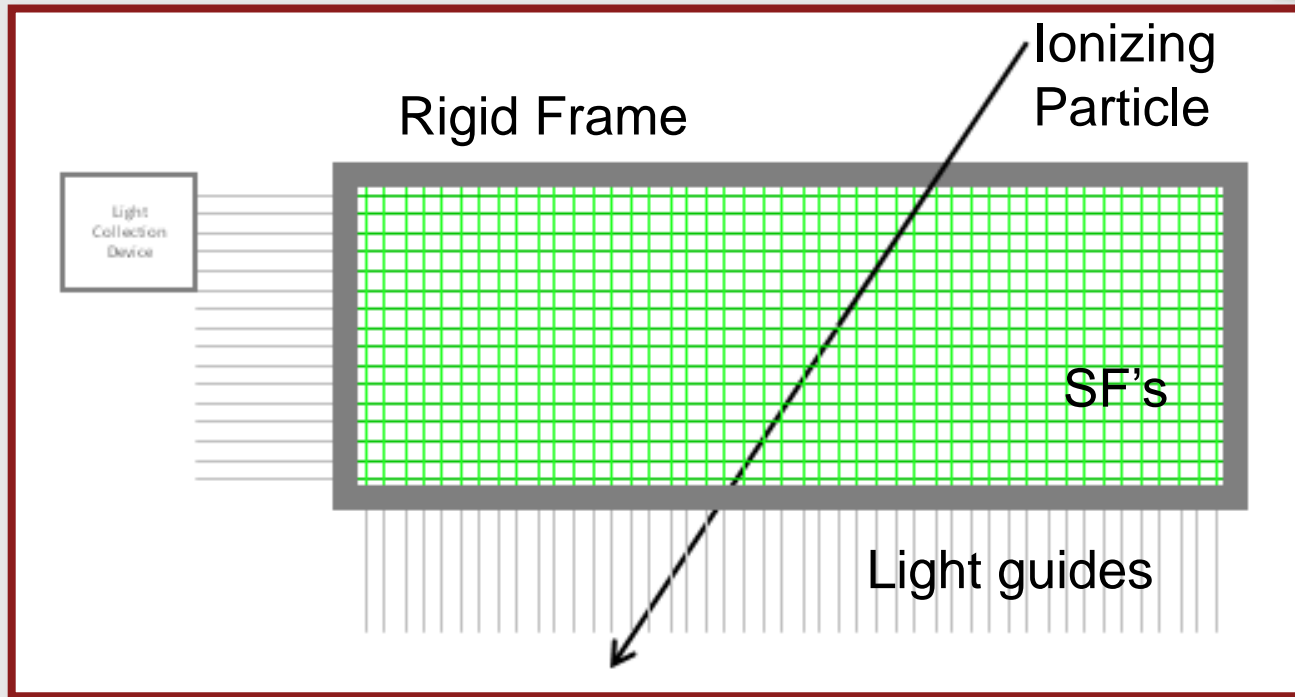
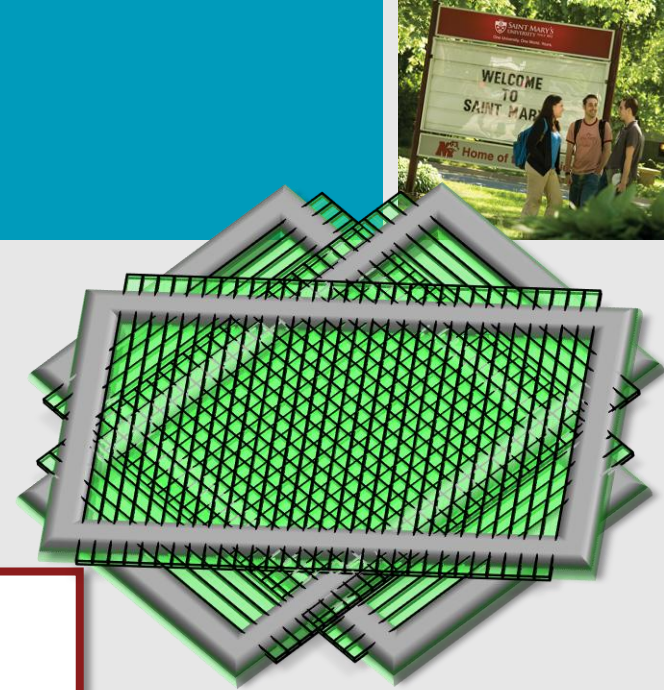
Outline



1. What is a Scintillating Fibre Tracking Detector (SFT)?
2. Common design components of SFTs that should be the same/similar between SFTs
(ie. Do most toothbrushes need brushes to... brush?)
3. Do SF need coating to reduce cross-talk?
 1. Experiment -> Results -> Conclusion
4. What couplant/fibre-end finish combination allow best light transmission between SF's and light guides?
 1. Experiment -> Results -> Conclusion

An SFT – More Detail

- SFTs are made up of planes of SFs.
- Planes at angles to each other

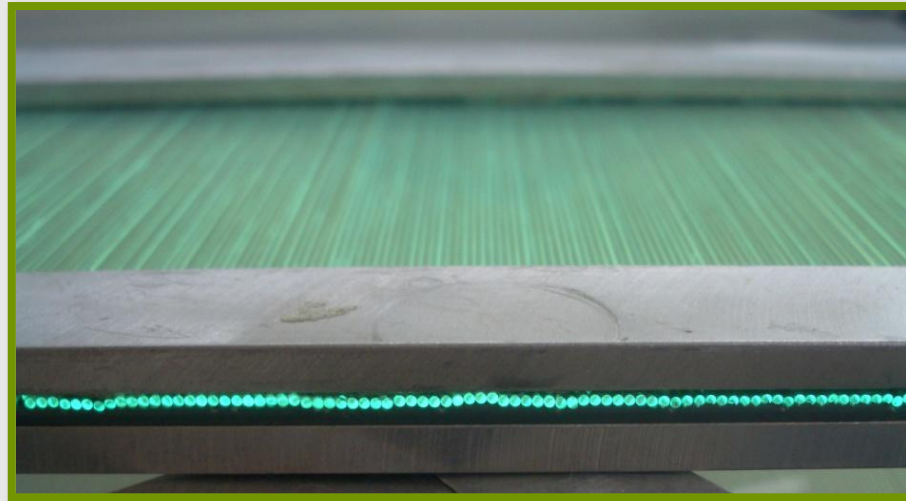


Basic SFT

Common Design Characteristics



- In SFTs, SF are touching
- Scintillation light is released isotropically
- Photons may leak into adjacent SFs
- =CROSS-TALK!



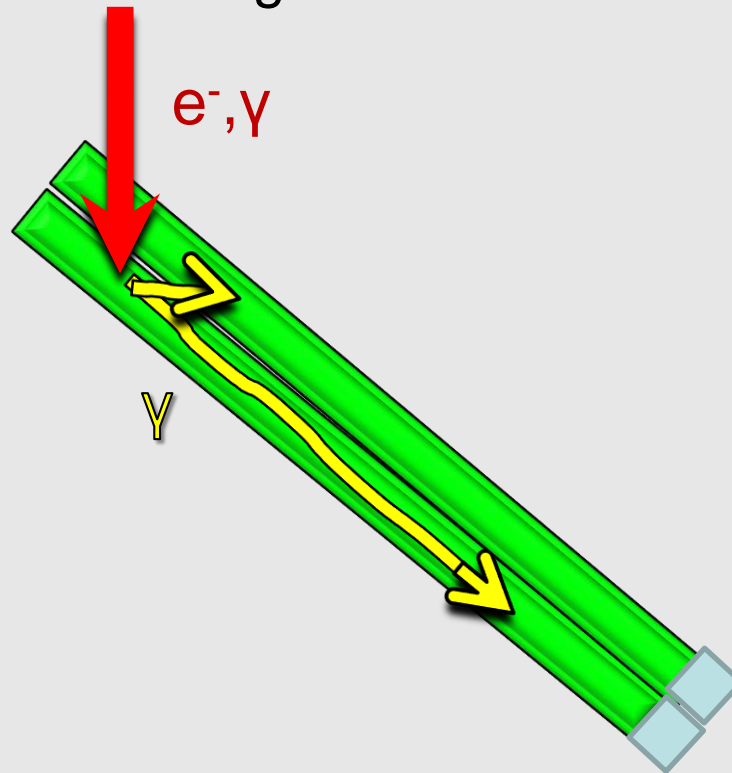
- Can coating the SFs reduce cross-talk? Or is there a measurable effect?
 - =**Experiment #1 !!!**

Coating to Reduce Cross-talk

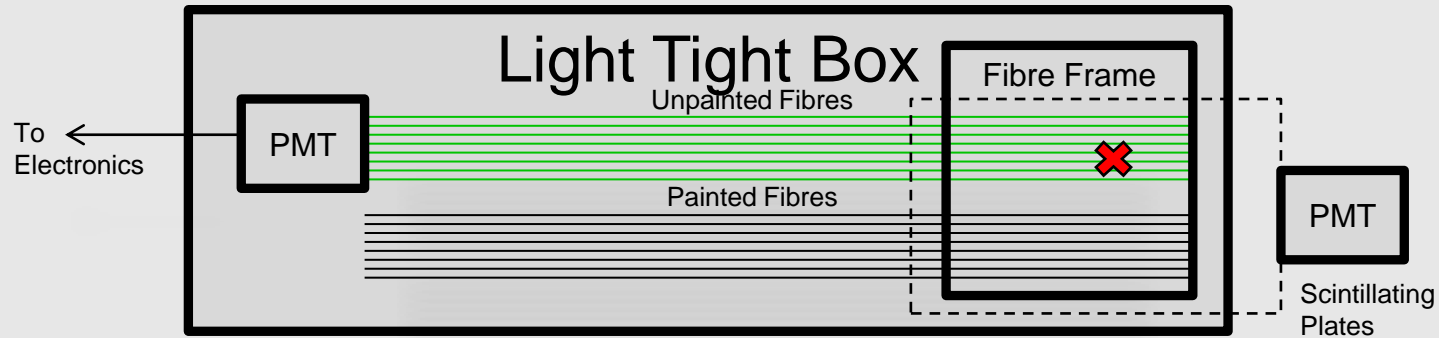
Experiment 1 - Purpose



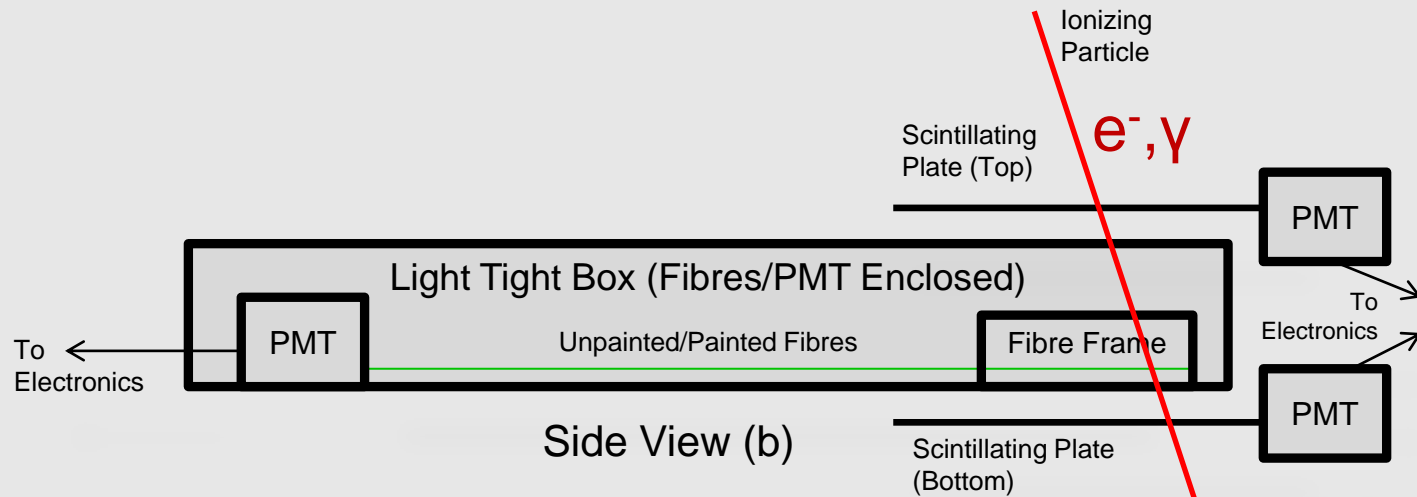
- Purpose – To determine if coating SFs reduces adjacent fibre cross-talk.
- Hypothesis – Coating fibres will decrease cross-talk



Coating to Reduce Cross-talk Experiment 1 - SETUP

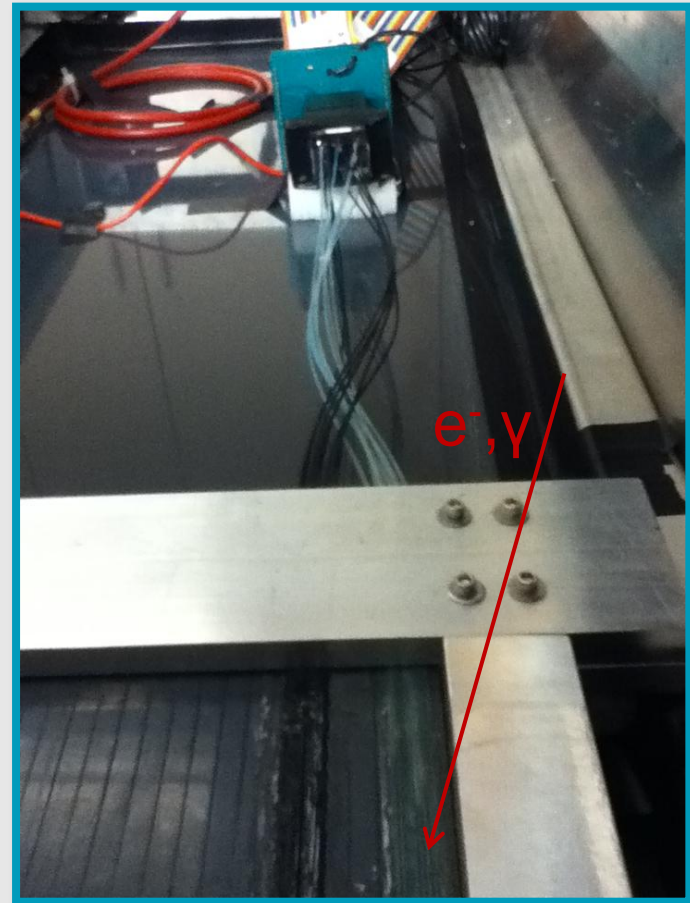
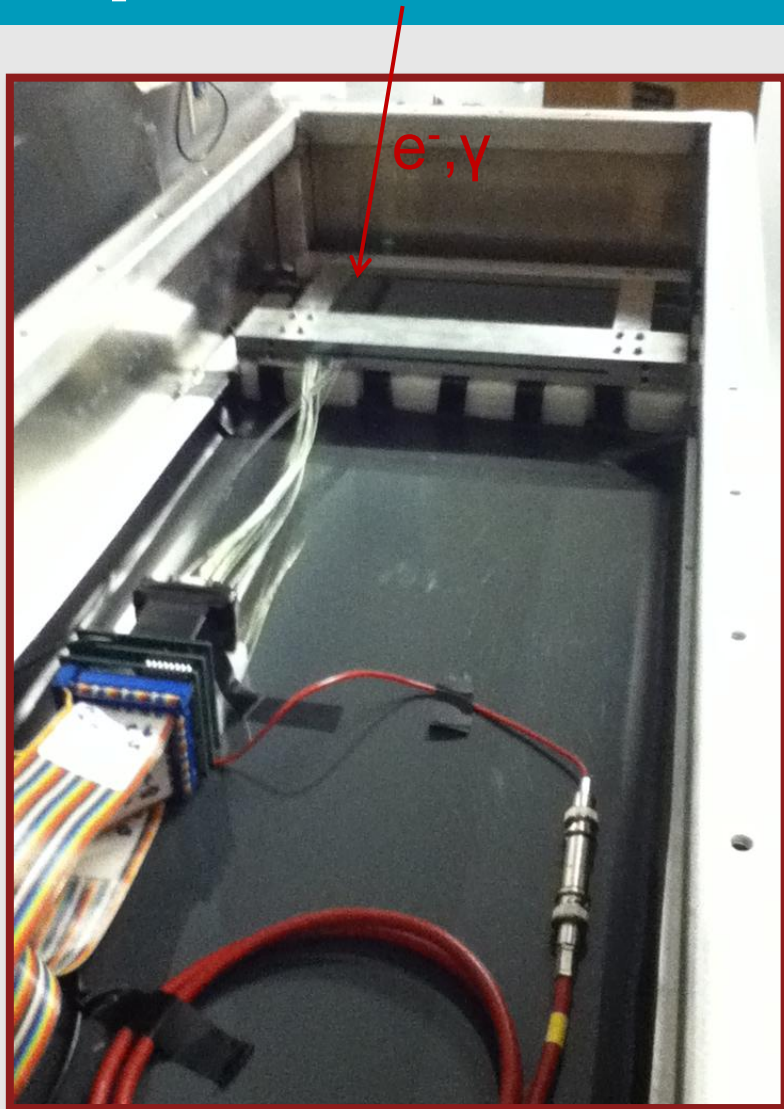


Top View (a)



Side View (b)

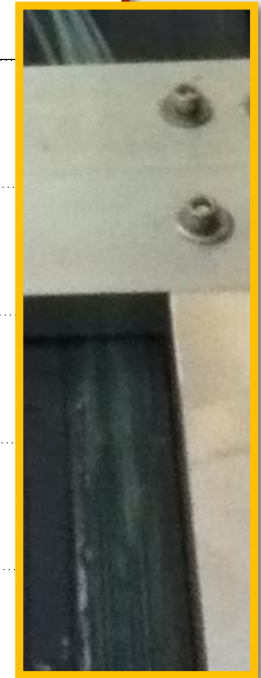
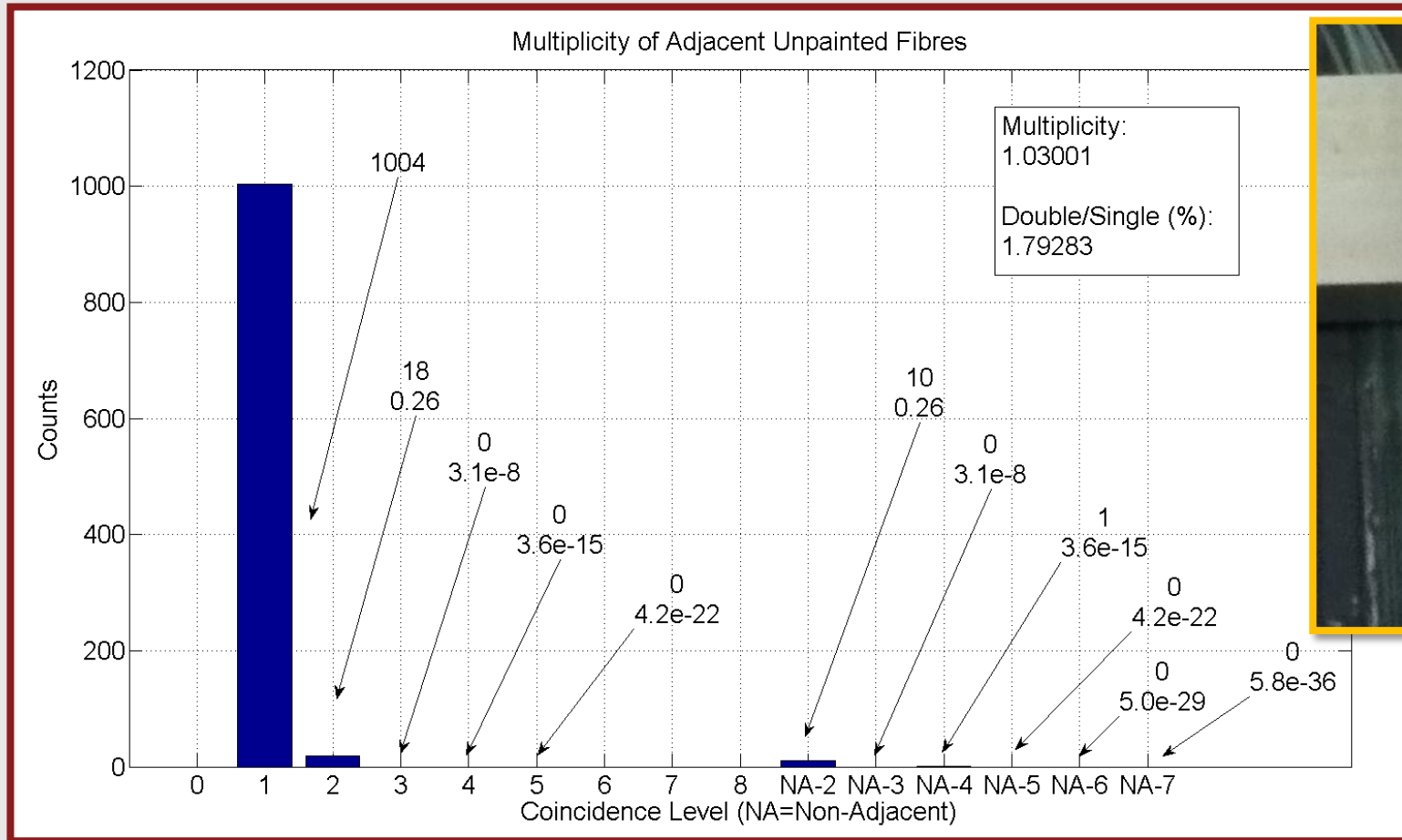
Coating to Reduce Cross-talk Experiment 1 – SETUP Pictures



Coating to Reduce Cross-talk Experiment 1 – Results



Unpainted SFs

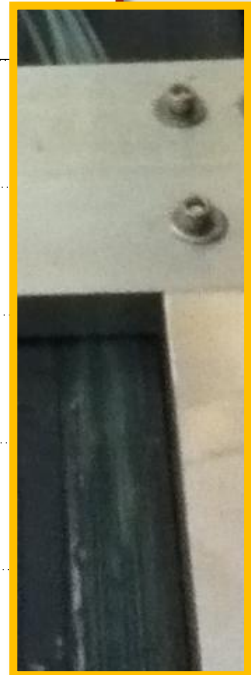
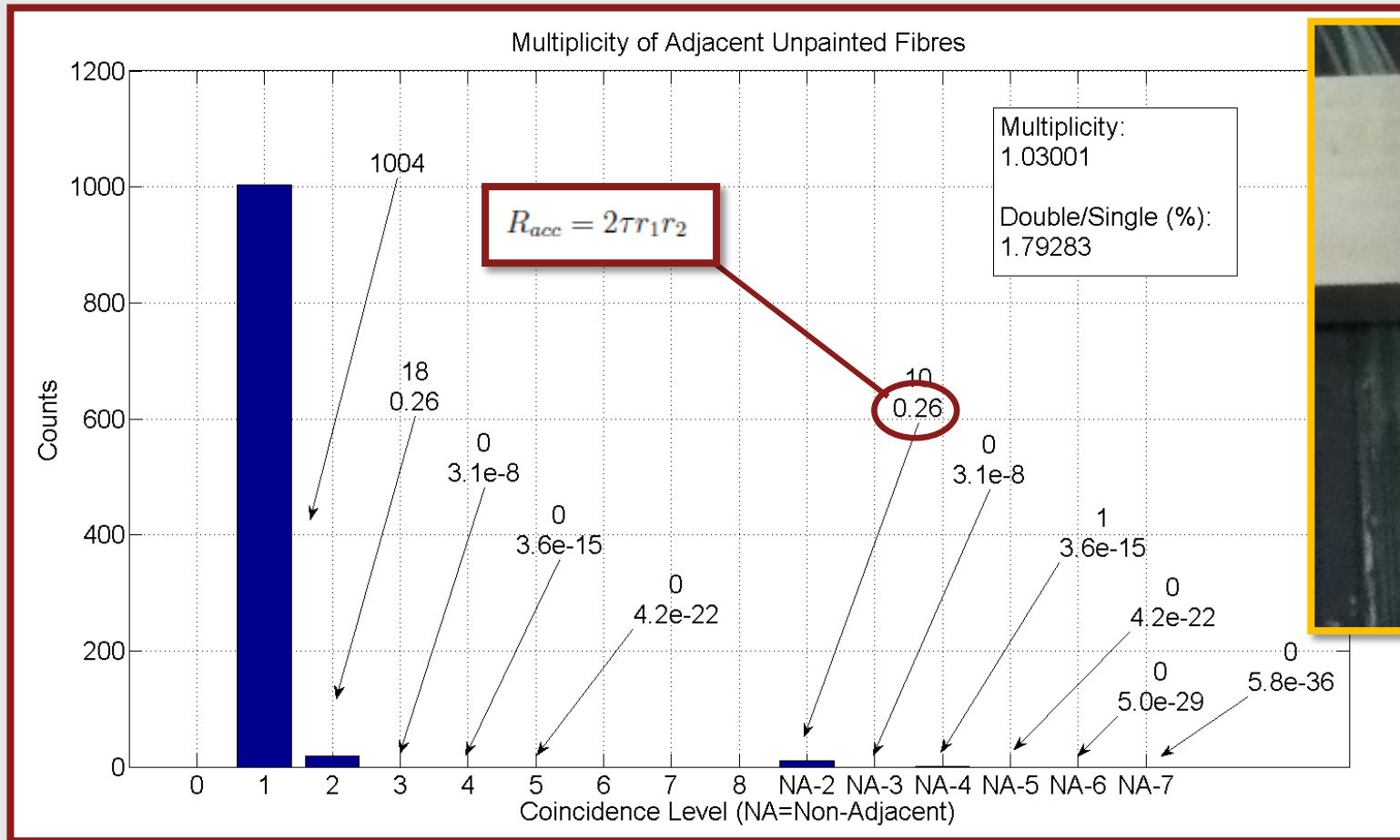


Multiples/1s = (2.9 ± 0.6) %
 Mavg = 1.03 ± 0.08 (abs.)

Coating to Reduce Cross-talk Experiment 1 – Results

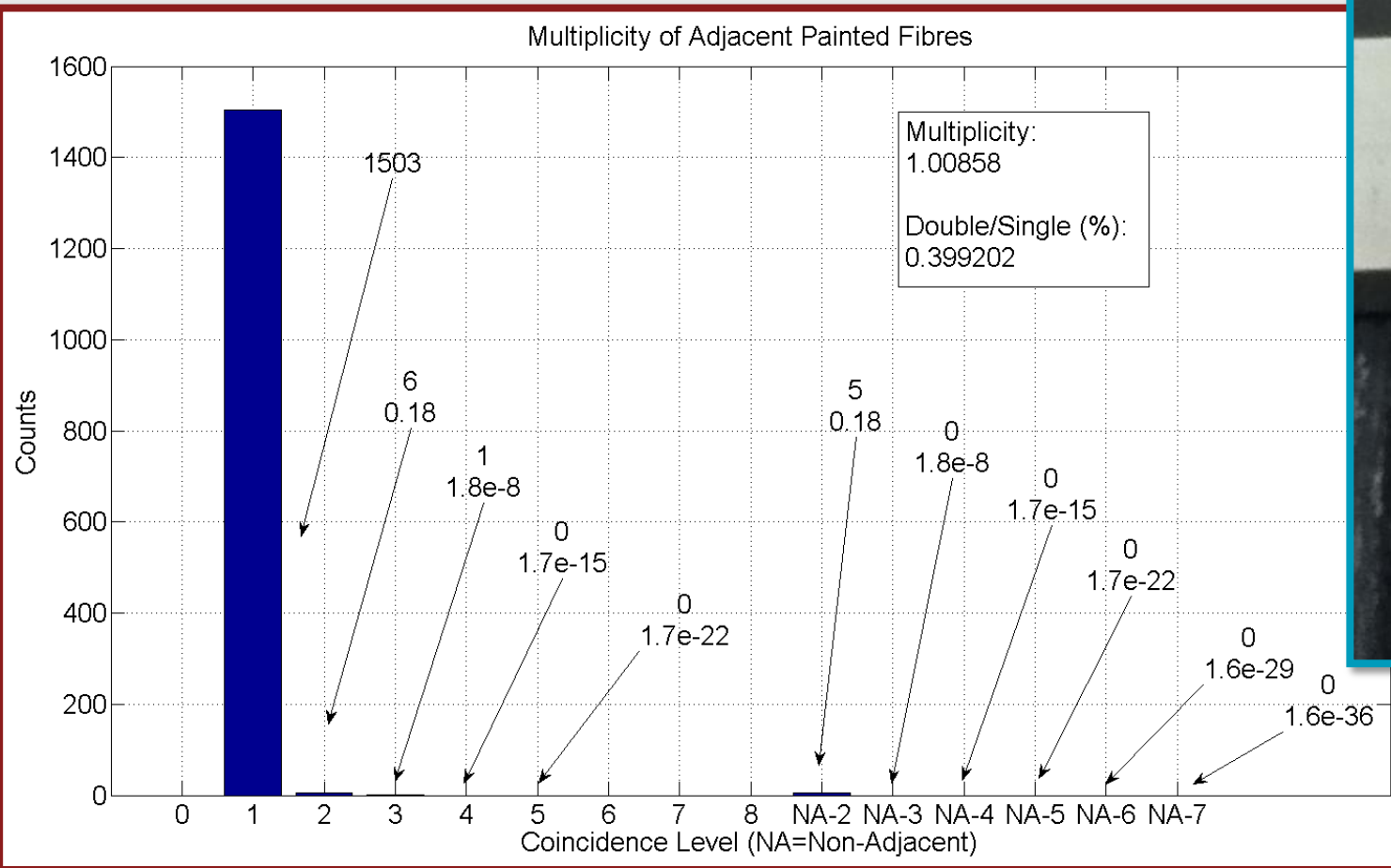


Unpainted SFs

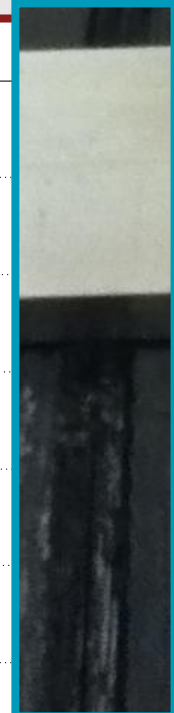


Multiples/1s = (2.9 ± 0.6) %
 Mavg = 1.03 ± 0.08 (abs.)

Coating to Reduce Cross-talk Experiment 1 – Results



Painted SFs



Multiples/1s = (0.80 ± 0.25) %
 $M_{avg} = 1.01 \pm 0.06$ (abs.)

Coating to Reduce Cross-talk Experiment 1 – Conclusion



Cross-talk

- Conclusive - Painting fibres decreases cross-talk by $(2.10 \pm 0.85)\%$
- SFs should be painted to reduce cross-talk

Common Design Characteristics



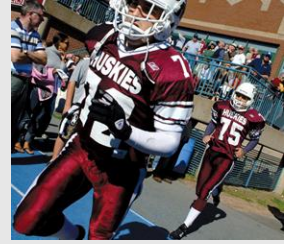
1. SFs are expensive – 1mx1mm dia. BCF-20 = 18\$
 - With 15 000 SFs = \$270 000
2. Using SF outside the active area can allow unwanted noise from background rad, and scattering of main beam.
 - Light guides route the light from SF to PMT
 - To reduce costs (they are about ½ the price of SFs)
- How do you connect a SF to a light guide?
 - Optical epoxy, optical grease, silicon connectors, fuse them together, or... air
 - No current empirical evidence exists that incorporates fibre finish with couplants
 - **=EXPERIMENT #2 !!!**

Couplant/Finish Combo. to increase light transmission - Experiment 2 – Purpose

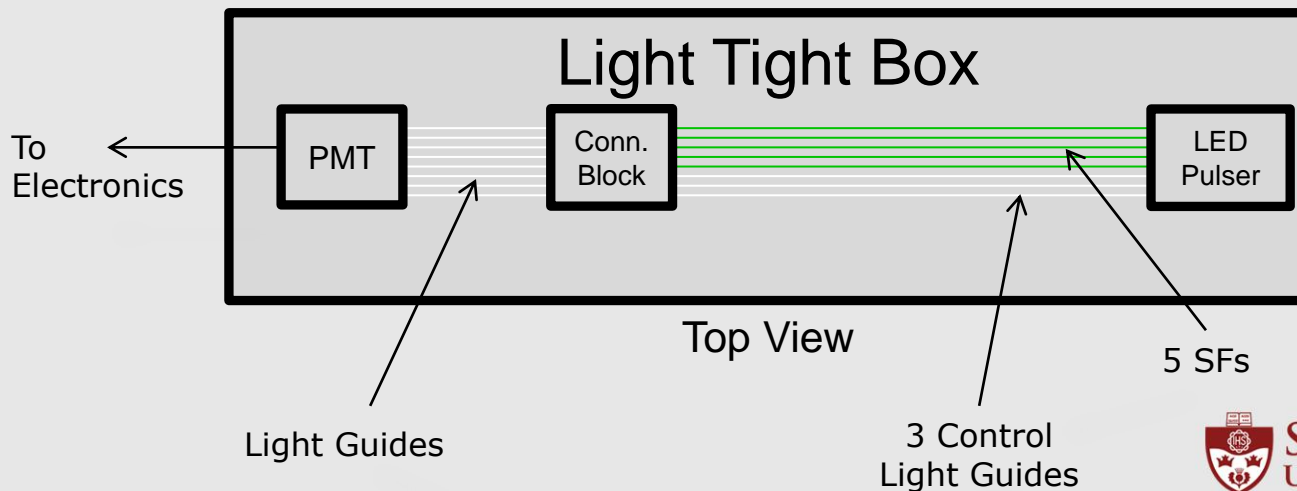


- Purpose – Determine what optical couplant + fibre-end finish maximize light transmission at the SF/light guide junction.
- Hypothesis – The combination of smooth fibre-end finishes and optical epoxy should maximize light transmission

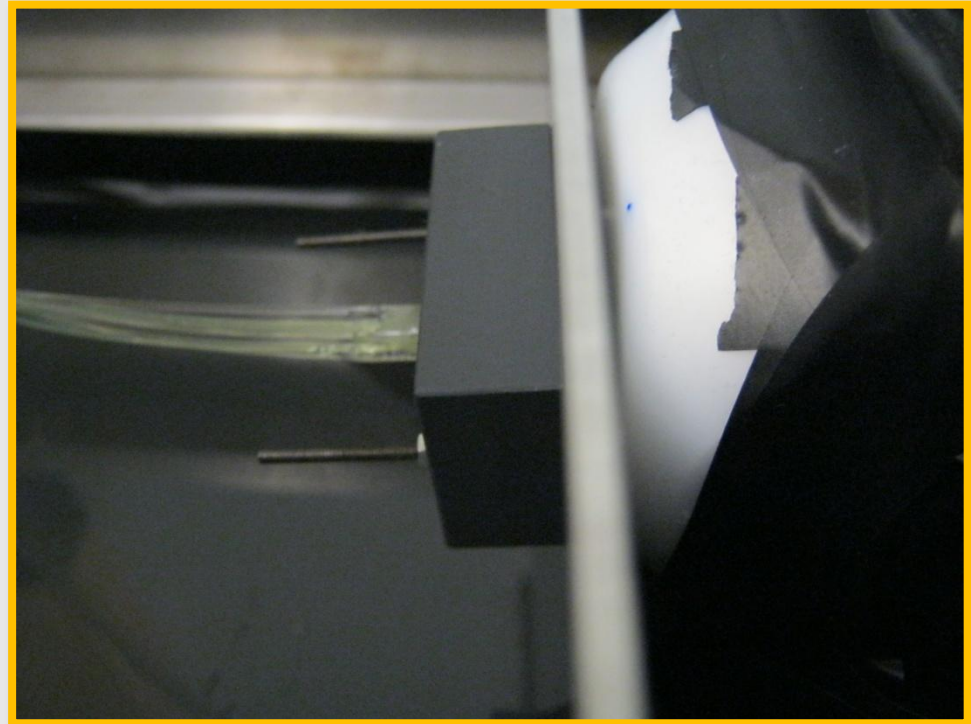
Couplant/Finish Combo. to increase light transmission - Experiment 2 – SETUP



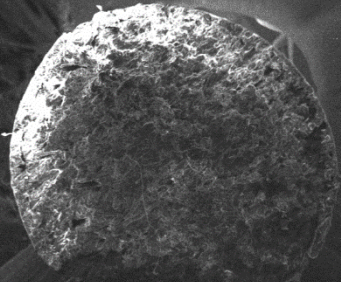
1. LED Pulses with 200 ns gate at 10kHz (Blue light)
2. Photons travel down SFs and Control light guides
3. At Connection block photons are transmitted through an optical couplant and fibre-ends
4. Photons arrive at PMT
5. Signal travels to electronics



Couplant/Finish Combo. to increase light transmission - Experiment 2 – SETUP Pics

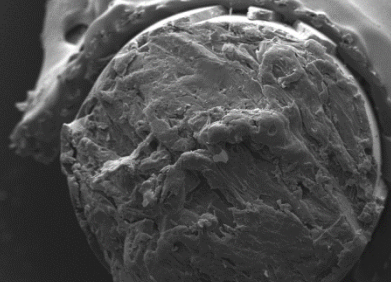


Couplant/Finish Combo. to increase light transmission - Experiment 2 - Qualitative Analysis



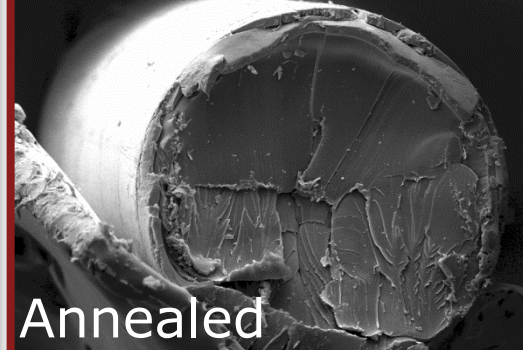
Sandpaper (300 grit)

200µm EHT = 20.00 kV WD = 15 mm Signal A = SE1 Date :16 Feb 2012 Photo No. = 1804 Time :12:56



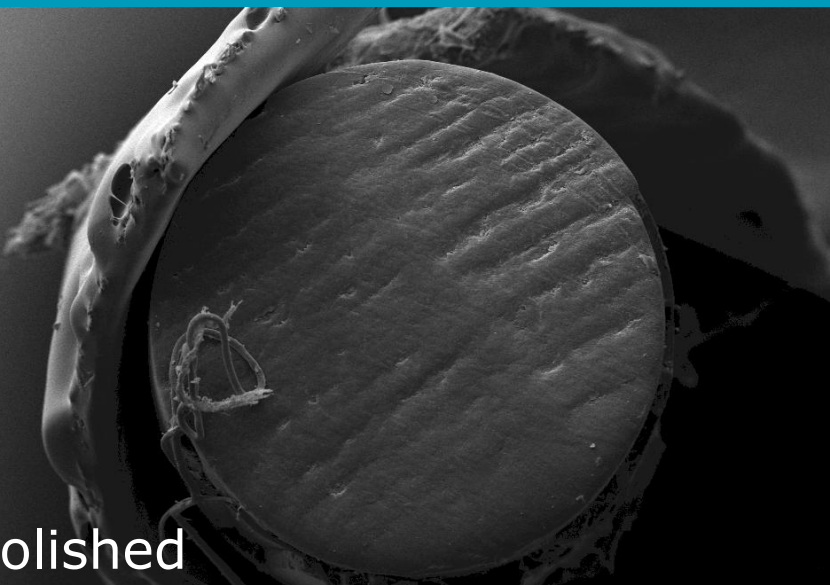
Sandpaper (420 grit)

200µm EHT = 20.00 kV WD = 16 mm Signal A = SE1 Date :13 Feb 2012 Photo No. = 1773 Time :15:04



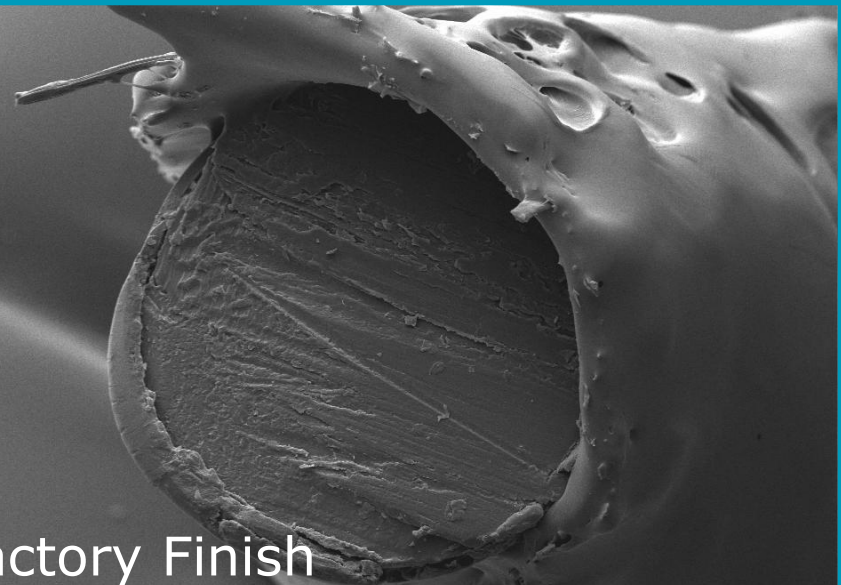
Annealed

200µm EHT = 20.00 kV WD = 16 mm Signal A = SE1 Date :13 Feb 2012 Photo No. = 1758 Time :14:31



Polished

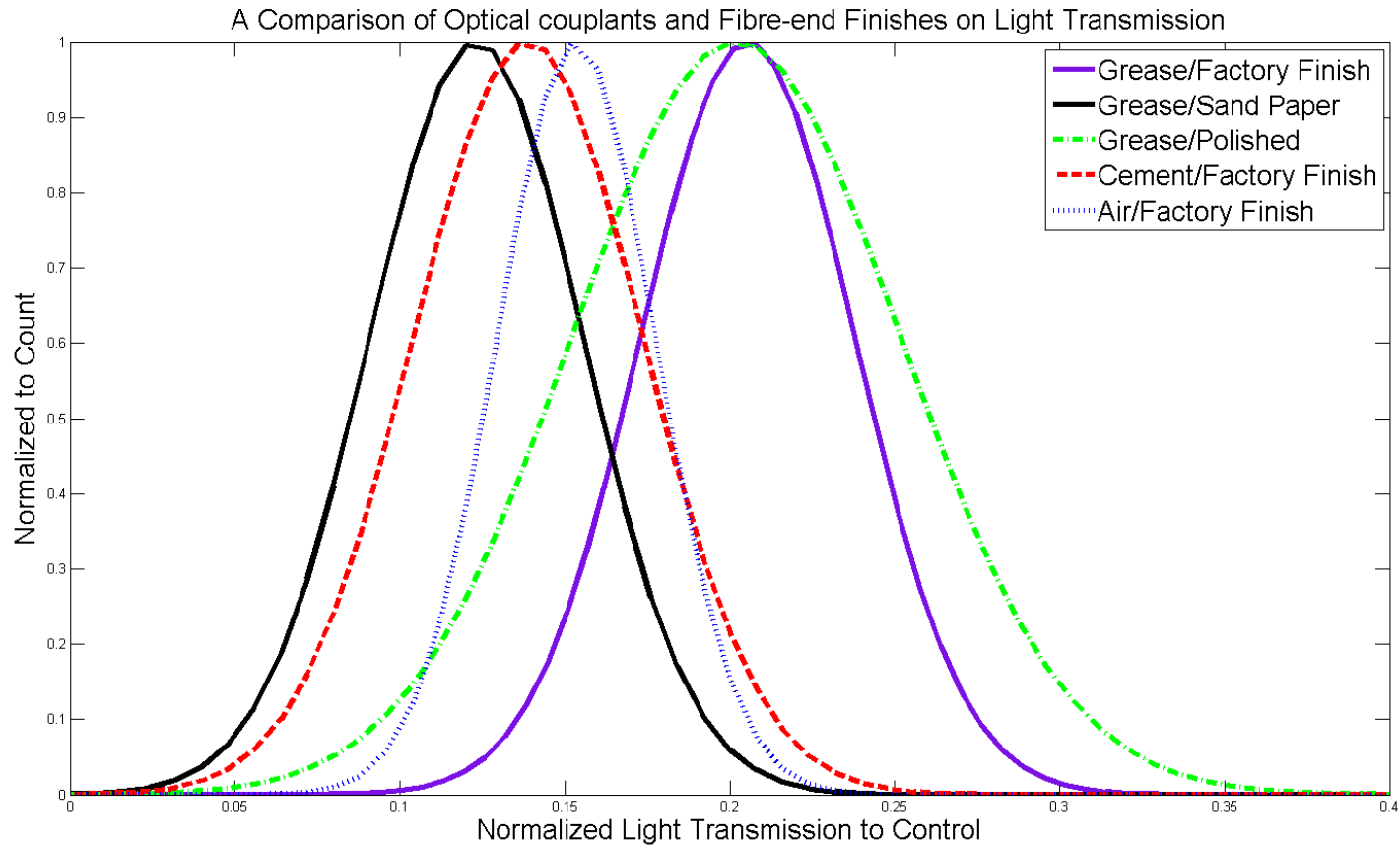
200µm EHT = 20.00 kV WD = 17 mm Signal A = SE1 Date :13 Feb 2012 Photo No. = 1764 Time :14:46



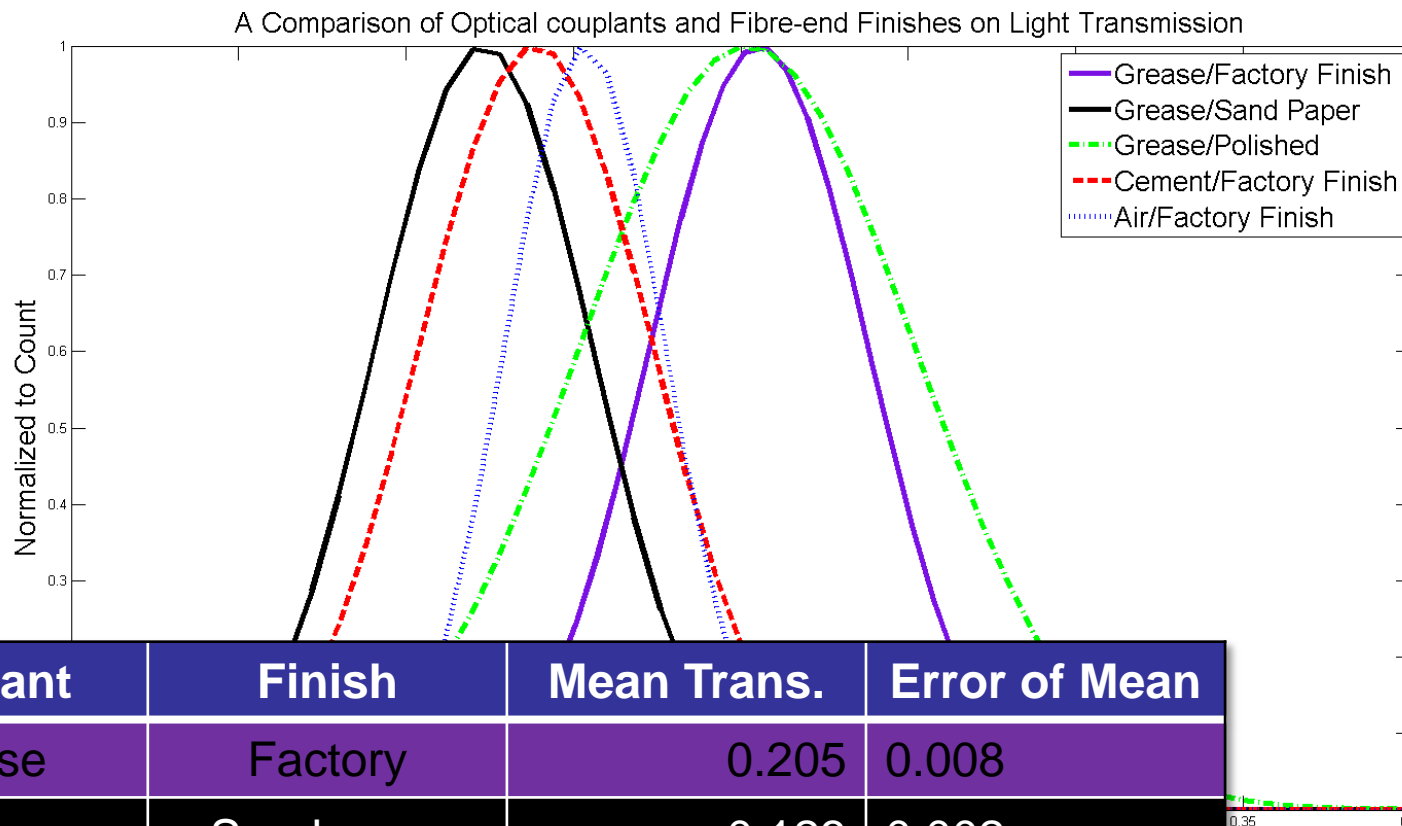
Factory Finish

200µm EHT = 20.00 kV WD = 16 mm Signal A = SE1 Date :13 Feb 2012 Photo No. = 1768 Time :14:54

Couplant/Finish Combo. to increase light transmission - Experiment 2 – Results



Couplant/Finish Combo. to increase light transmission - Experiment 2 – Results



Couplant	Finish	Mean Trans.	Error of Mean
Grease	Factory	0.205	0.008
Grease	Sandpaper	0.123	0.002
Grease	Polish	0.202	0.004
Cement	Factory	0.139	0.004
Air	Factory	0.153	0.002

Couplant/Finish Combo. to increase light transmission - Experiment 2 – Conclusion



- **Grease/factory** finish and **grease/polish** maximize light transmission.
- These results are inconclusive at this preliminary stage, more tests will be done.
 - Optical cement/polish
 - Air/polish
 - And a new technique of annealing fibres using a 300°C stream of hot air to melt the ends of fibres

Preliminary Conclusion



- Preliminary results from the two experiments:
 - Cross-talk: **Painting SFs reduces the cross-talk** between adjacent SFs
 - Best Fibre-end/Couplant Combo:
 - Grease/Factory Finish and;
 - Grease/Polish
- Read my Paper in NIM A once I get the final results in!

Future Work



- Design/Build an SFT for Hall A experiments at JLab.
 - Implement results that were found with Crosstalk and light transmission
 - For: “Large Acceptance Proton Form Factor Ratio Measurements at 13 to 15 (GeV/c)² Using Recoil Polarization Method”



Thank you! Questions?



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