



US LHC Accelerator Research Program

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Insulation Options for HQ and LHQ Cables

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LARP CM16

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Short Term – Insulation Options

- Tape wrapped onto cable
 - Aerospace Composite Products
 - FNAL has developed technique to insulate cables.
 - E-glass (thinnest 0.075 mm), perhaps an issue with boron)
- Sleeve options (LBL)
 - Nitivity – Style SV-16-F2/96
 - 70% Al₂O₃, 30% SiO₂ (Mullite)
 - Revolution Composites – Style 272
 - S2-glass with 636 sizing, plan to try Silane coated fibers
 - A&P Technologies – (nominally Style 272, need to confirm)
 - S2-glass with 636 sizing

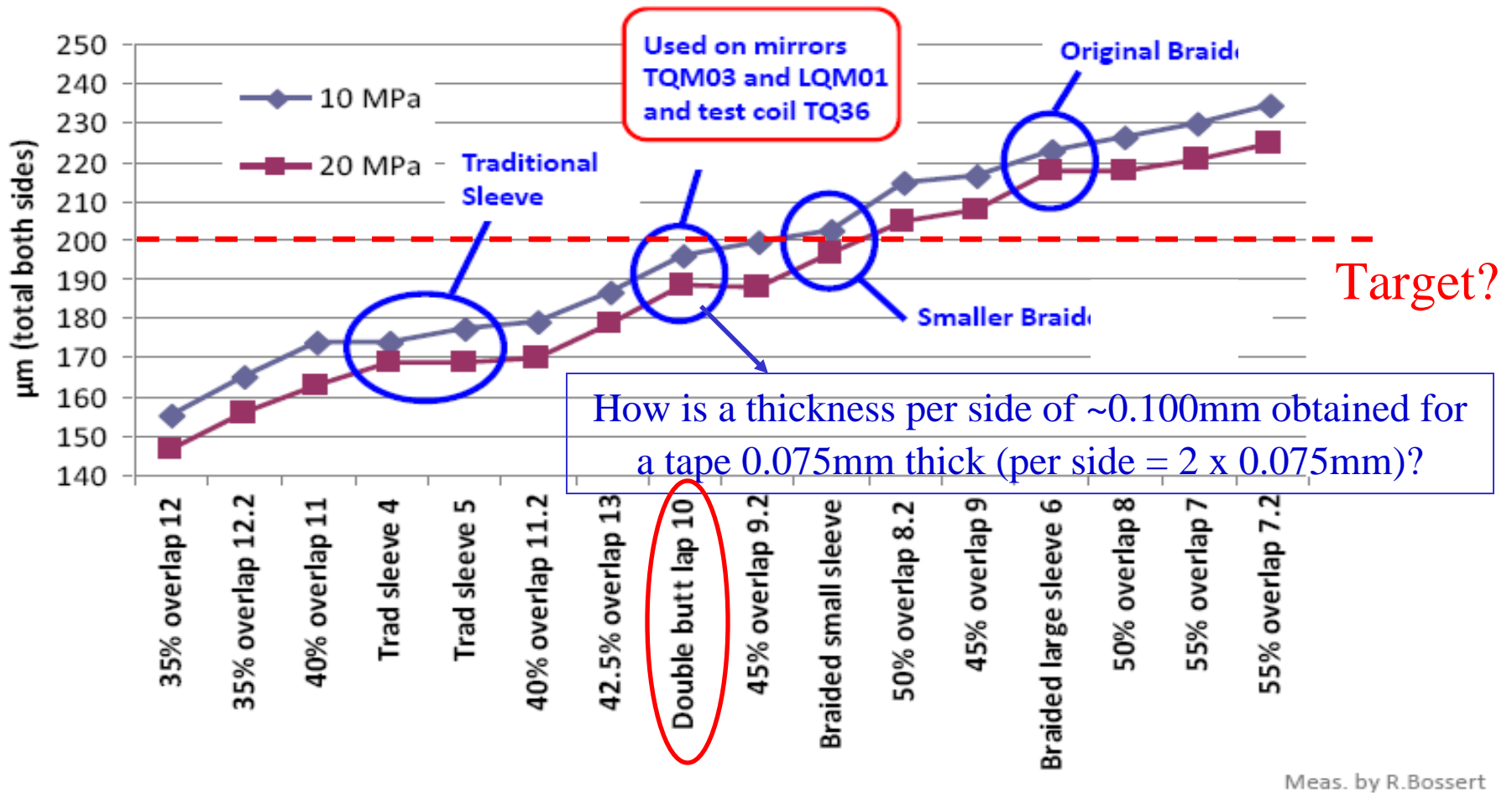


Long Term – Insulation Options

- Braided insulation onto cable
 - New England Wire (BNL)
 - S2-glass with 636 sizing, (insulated ~80m, 0.100 mm thick)
 - Plan to braid fibers coated with Silane sizing
 - Revolution Composites (LBL)
 - New company with staff from EDO Fiber Innovations
 - A&P Technologies (TAMU)
- Tape options
 - There is no long term option at this time
 - E-glass has boron
 - S-glass tape is too thick



FNAL Insulation Thickness Data – Cured 10-Stacks





Insulation Requirements

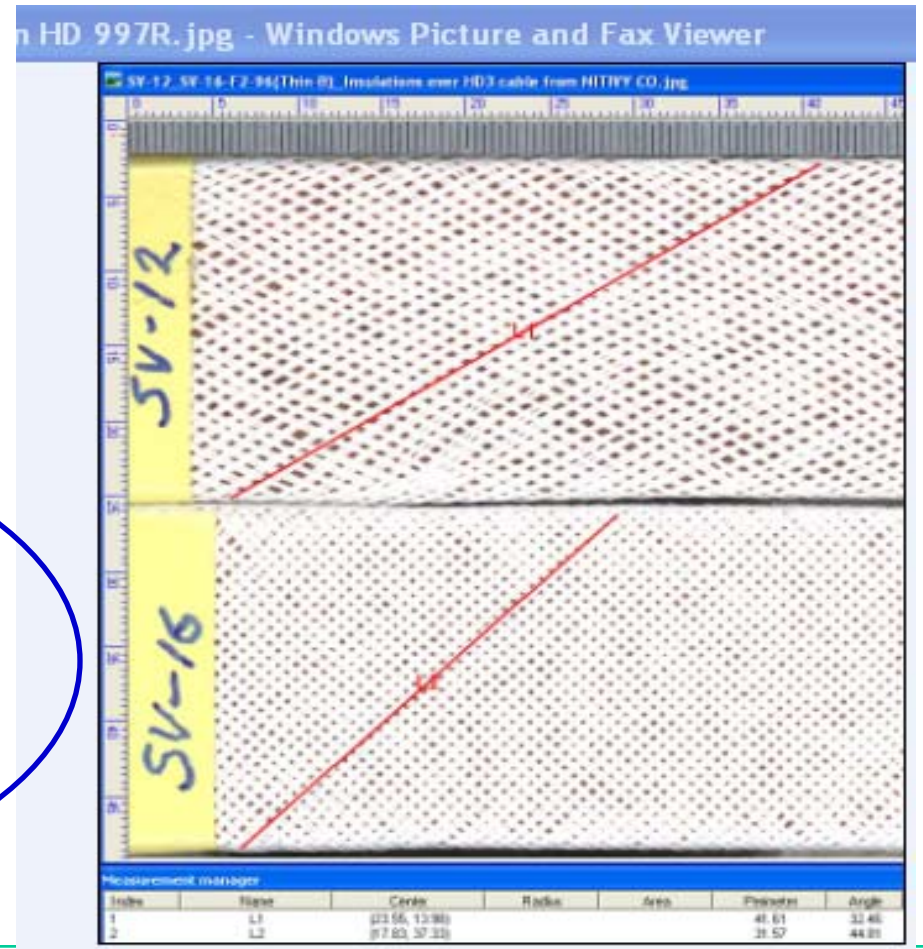
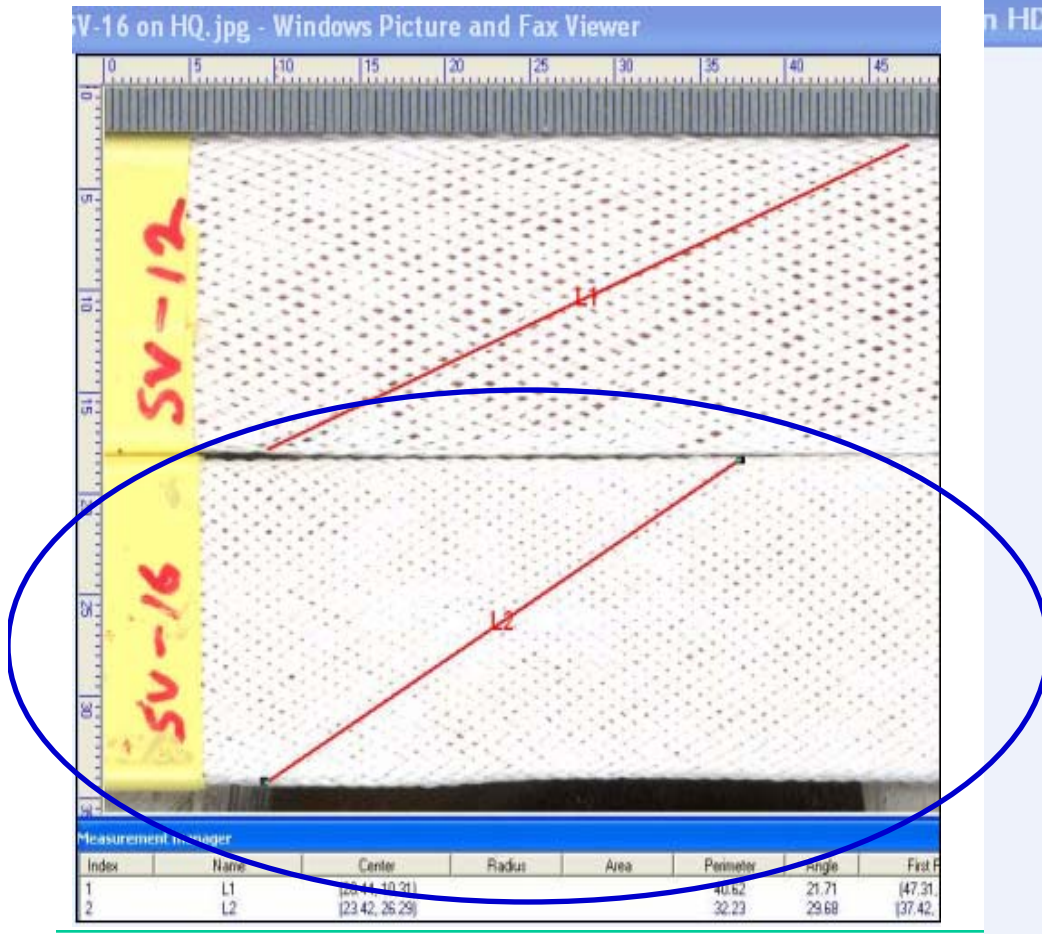
- Thickness
 - HQ/LHQ Target
 - [0.100 mm per side](#)
- Coverage of cable
 - Not defined
- Robustness during coil winding and handling
 - Not defined
- Interaction with coil matrix material
 - [Is S-glass good enough? Does LARP need another material?](#)
- Topic for another time: Radiation issues –
 - Is S-glass insulation good for radiation environments? Boron an issue?
 - Does LARP need to transition from CTD-101?
 - Are present insulation materials compatible with next generation “epoxies” that are Rad-Hard?



Nitivity Alf (Mullite 70-30) – Cable Coverage

HQ 15 mm

HD 22 mm





Nitivy Alf – SV Thicknesses

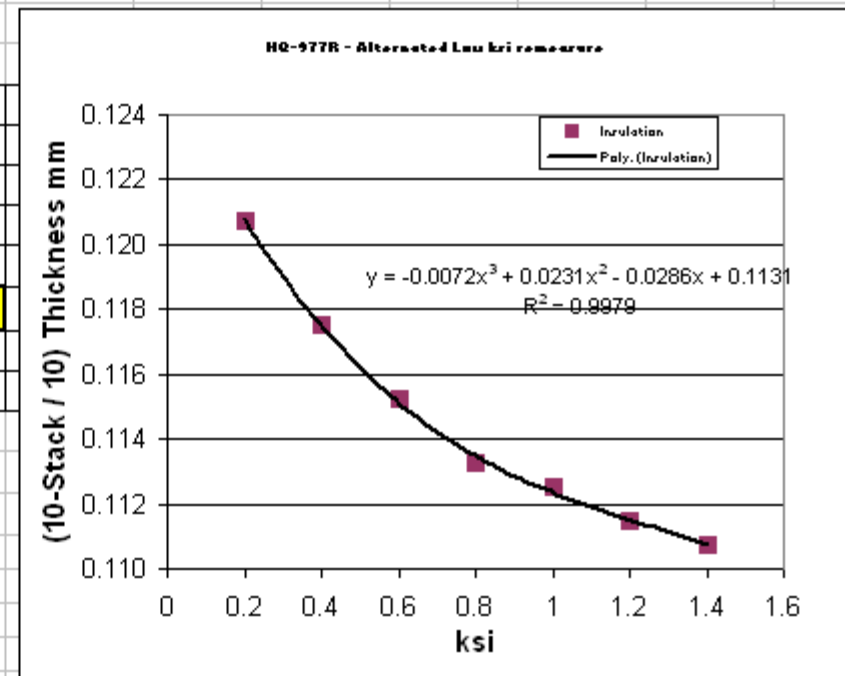
Measurement load	1ksi = 6895 kPa			
		SV12	SV16	
Cable	Cable Width (mm)	Thickness per side (mm)		Comments
HD-997	22	0.083	0.096	Old insulation lots
HD-997 Re-Measurment	22	0.085	0.097	Old insulation lots
HD-997 at 0 m	22	n.a.	0.095	SV-16-F2/96[thin-b]-Lot No. 01126TU -- FE
HD-997 at 150 m	22	n.a.	0.096	SV-16-F2/96[thin-b]-Lot No. 01126TU
HQ-992_NEW	15	0.089	0.099	

- Thickness decreases by only 3-4 μm
 - Going from a 15 mm wide cable to a 22 mm wide.
- SV16 has good coverage on HQ cable.



A&P Tech. Sleeve

Summary					
kPa	ksi	Cal Gage	Bare	Insulated	Insulation
1379	0.2	1.468	1.441	1.683	0.121
2758	0.4	1.468	1.440	1.675	0.118
4137	0.6	1.468	1.439	1.669	0.115
5516	0.8	1.468	1.438	1.664	0.113
6895	1	1.468	1.437	1.662	0.113
8274	1.2	1.468	1.436	1.659	0.112
9653	1.4	1.468	1.435	1.656	0.111





Insulation Braided onto Cables

New England Wire
S-glass with 636
TQ/LQ Cable 10 mm wide
Braid angle 34.1 deg.
A. Ghosh - BNL



A&P Tech
S-glass with Silane
Cable 13mm wide
A.D. McInturff - TAMU





Proposed LARP Insulation Plan

- Target 0.100mm thickness
- Short Term 1-2 years
 - Have sleeve and E-glass tape options
- Long Term after 2 years
 - Braided insulation option only
 - S-glass or other material if appropriate
 - Within 1 year qualify NEW
 - Within 2 years qualify another 1 or 2 vendors
 - A&P, Revolution Comp., Nitivy (Mullite or S-glass)



Discussion I

- Presently have both S-glass sleeve and E-glass tape options at 0.100 mm thickness.
 - Is this the thickness that LARP wants to target?
- Status of braided insulation
 - Almost have S-glass braid option with NEW
 - Almost have S-glass sleeve and braid option with A&P Tech.
- Only S-glass sleeve and braid options can achieve a thickness of 0.100 mm.
 - **For the long term only braided S-glass insulation.**
- Long term does LARP want both braid and tape options?
 - If yes, then LARP must have a thicker target.
 - **S-glass tape, and tapes of other materials, are too thick.**



FNAL Insulation Thickness Data – Cured 10-Stacks

