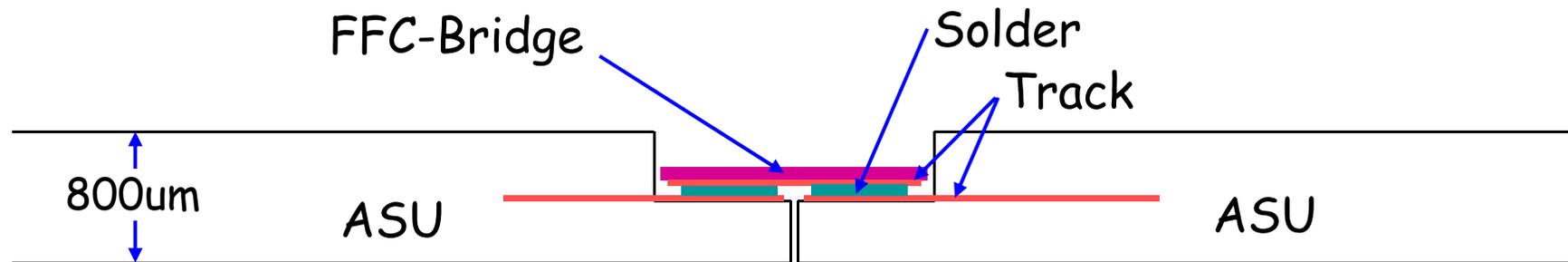
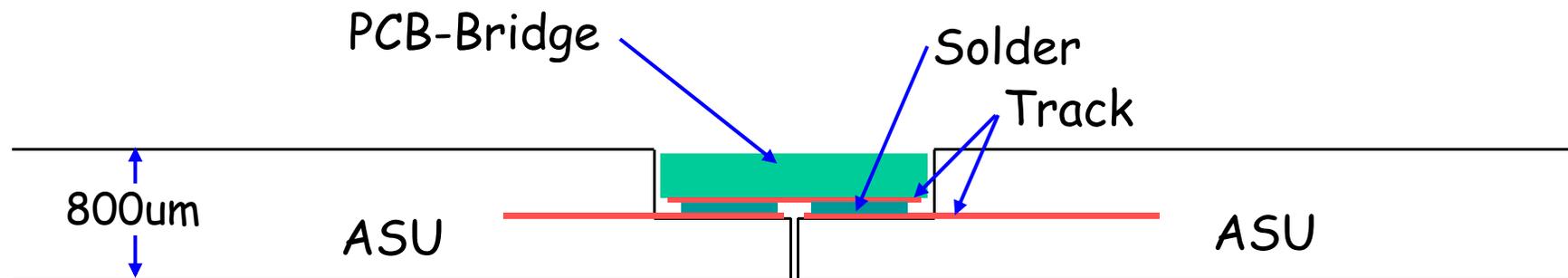


- **Flexi and Rigid Bridges shown to be viable:**
 - Compatible with 0.8mm (and thicker) ASU
 - > 120 connections across ASU
 - Halogen lamp soldering system
 - 2-3m Ω per bond
 - Good signal propagation
 - Lead-free, leaded, and Sn/Bi options (220°, 183°, 150° C)
 - Re-work possible
 - Cheap

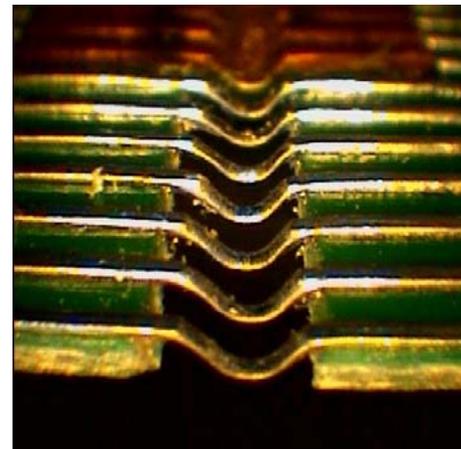
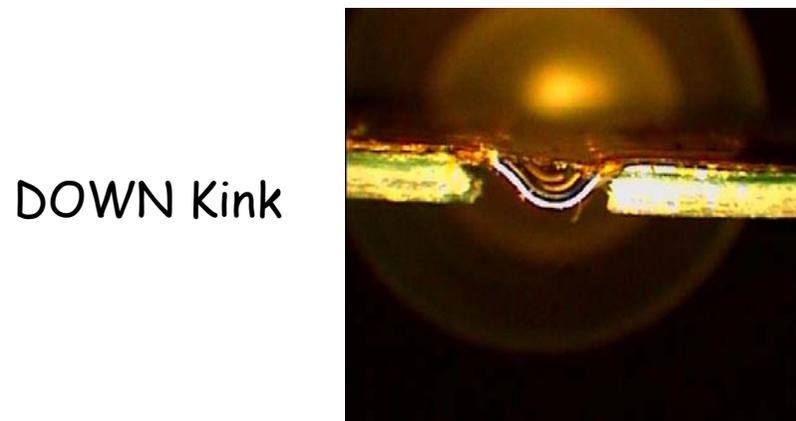
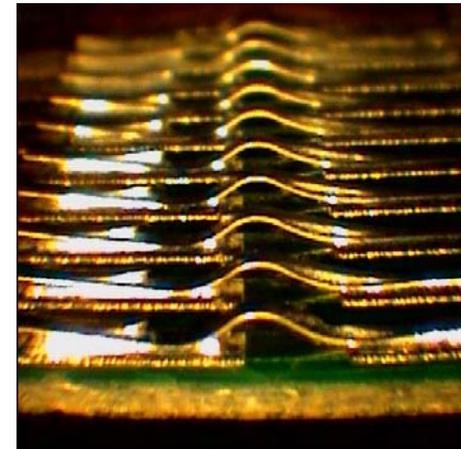
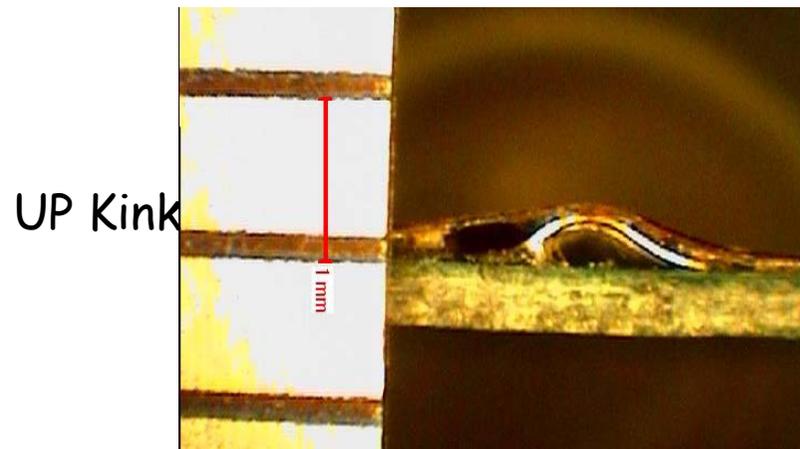
Short FFC (Flat, Flexible-Cable) Bridges make connections on a 1mm pitch - OK for at least 120 connections



Alternatively the Bridges can be thin PCBs, also with 1mm pitch connections. This gives a mechanical as well as electrical joint



- Pre-formed kink for increased flexibility
 - Up-kink and Down-kink options
 - Needs ~1mm gap between ASUs (is this a problem?)



Kapton in place

Kapton removed

Maurice Goodrick & Bart Hommels , University of Cambridge

- **Halogen heat source :**
 - Good heating profiles have been established using:
 - 140mm filament with elliptical reflector
 - Variac power control, Manual timing
 - Video observation and Temperature recording
 - Easy to make on-line, USB based computer control ?
 - Should be possible to scale for full production

- **Effect on Detector Glue Connections**
 - Does soldering cause joint deterioration?
 - If not, what about rework?
- **Preliminary findings**
 - Before soldering:
 - Need $\sim 4\text{V}$ to form connection (oxide breakdown?)
 - Even then, fraction of an Ohm connection
 - After soldering (Sn/Bi solder):
 - Re-forming required
 - Similar formed joint resistance
- **Does this matter for a real detector?**
 - Plenty of Volts, but low current

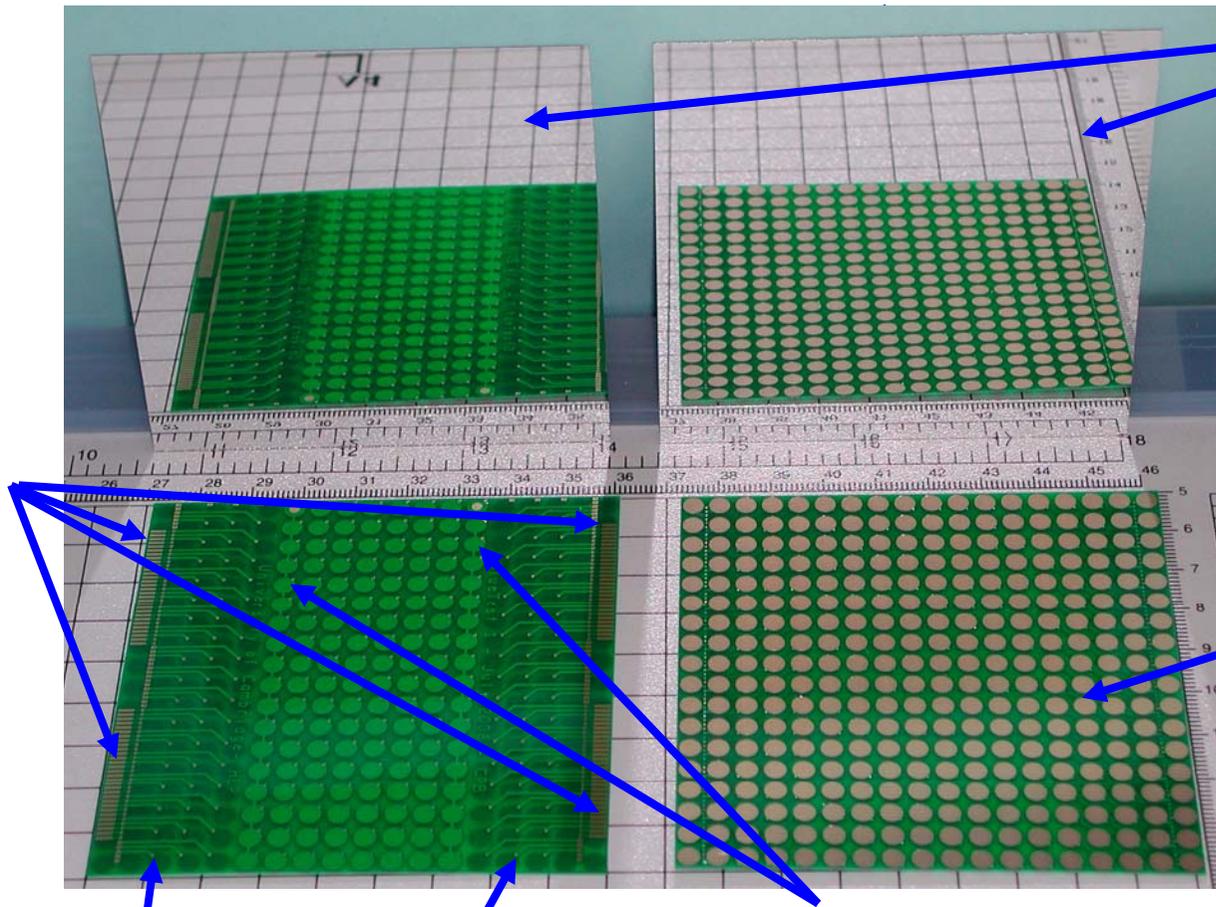
ECAL SLAB Interconnect - **GlueTest PCBs**

Top View

Under View

Aluminised 300um
Glass plates: we
have 9 (plus more
un-coated)

30-way Interconnect
Footprints (4 per PCB)



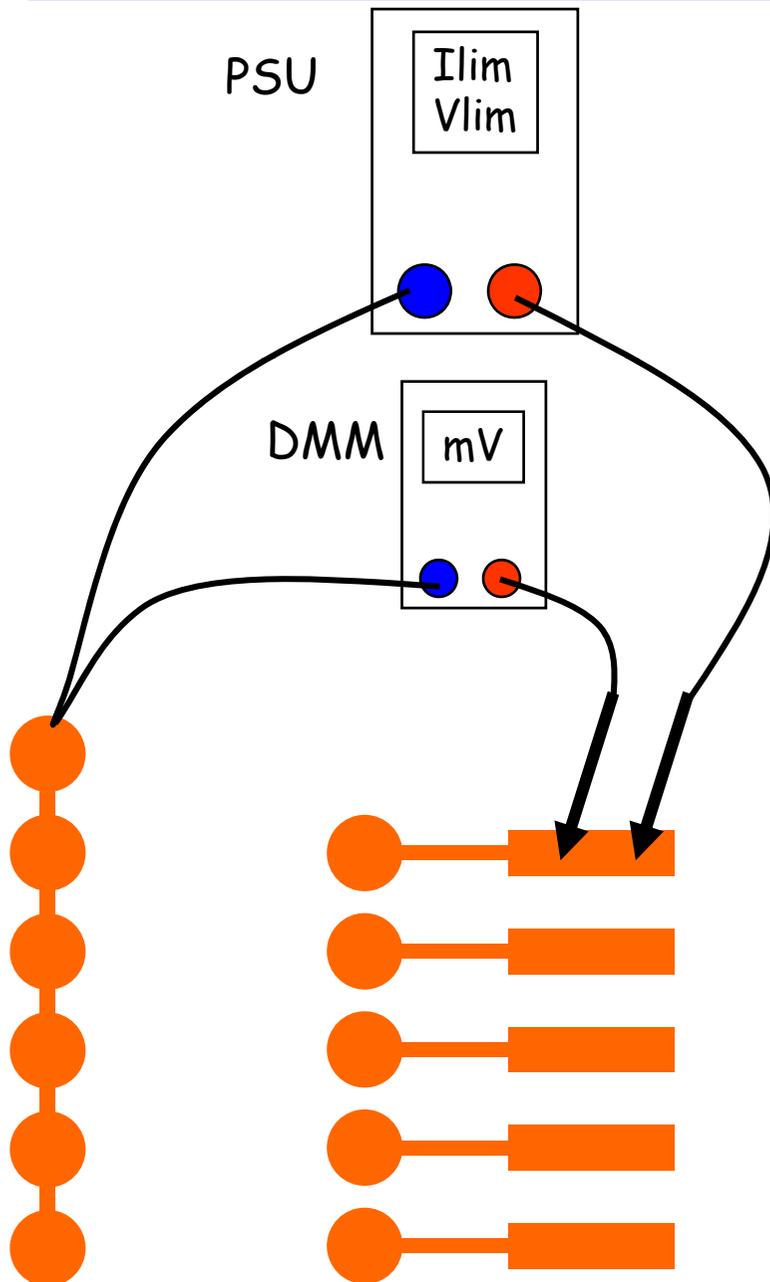
Pads on 5mm pitch

5 columns joined
to fingers/pads

These 2 columns
"commoned"

GlueTest PCB & aluminised glass plate

ECAL SLAB Interconnect - GlueTest Initial



GlueTest - PCB #1						
Connector #1						
I Lim(mA)	50	50	50	50	50	100
V Lim (V)	1	2	3	4	1	1
Finger						
0	9.2	9.2	9.2	9.2	9.1	18
1	9	9	9	9	9	18
2	9.6	9.6	9.6	9.6	9.6	19
3	9.1	9	9	9.1	9	18
4	1000	2000	3000	22	21	43
5	1000	114	66	18	17	35
6	1000	2000	3000	20	20	40
7	1000	2000	3000	23	23	46
8	1000	2000	3000	28	27	56
9	1000	160	18	19	19	38
10	1000	87	18	18	18	37
11	1000	2000	22	24	24	49
12	470	31	15	15	14	30
13	180	31	17	17	16	33
14	1000	2000	33	29	29	58
15	1000	2000	3000	22	22	44
16	1000	31	16	16	16	32
17	1000	2000	3000	18	19	38
18	120	27	28	16	16	33
19	1000	38	18	18	18	36
20	1000	2000	3000	18	18	36
21	1000	2000	3000	20	20	41
22	1000	2000	3000	18	17	35
23	1000	2000	15	15	15	30
24	1000	2000	19	19	19	39
25	215	124	49	40	39	78
26	1000	2000	23	16	16	33
27	1000	2000	34	24	24	49
28	1000	2000	20	21	21	42
29	12	12	12	12	12	24

- **Effect on Detector characteristics**
 - Does soldering or re-work degrade detector?
 - Working on Czech 6x6 cm detectors with 10mm pads
 - Already characterised at LAL
 - We are building probe card to repeat bare detector characterisation (I-V and C-V)
 - Then detector will be glued to GlueTest PCB (4 pads to 1) at Manchester
 - Then same card will be used to check characteristics
 - Solder interconnect to neighbour
 - Re-check characteristics

Laser Soldering:

- Precise heat delivery
- Promises lower heating of glue joint
- Initial tests at Hull have made joints through the Kapton of the Flexi Bridge
- Possibly going to be a bit slow



James Gilbert
University of Hull
Hull, UK

Laser Soldering: plans

- Not expensive to purchase 40W semiconductor laser
- Would need X-Y table and interlocked enclosure
- Control software required
- This is a not inconsiderable package of work
- We would like to await the detector-damage results, and for the UK funding to clarify

Backup slides follow

Update on Investigations at Cambridge

- Recap
- Lines of Enquiry
- Bits and Boards
- Where we are

We have been looking at using "Bridges" to jumper multiple connections between adjacent ASUs

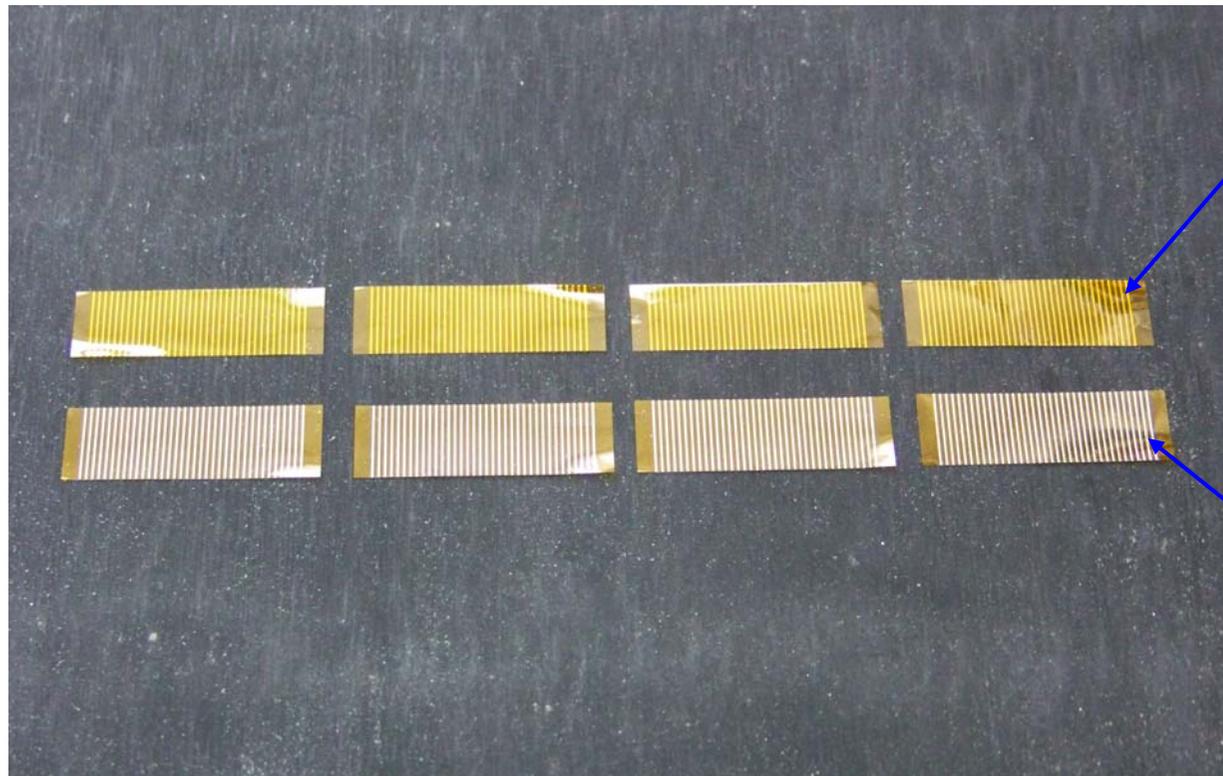
The Bridge would be soldered onto pads on the ASU (or DIF) PCB

Each Bridge would provide ≥ 30 connections
Up to 4 Bridges fit in the width of an ASU
... 1 per path would be an ideal solution 😊😊

- Provides copious connections (4 x 30 across ASU)
 - plenty for Power Planes
 - would allow 4 or more rows of connections
- Solder joints well proven electrically
- Signal transmission likely to be less compromised
- Rework possible

- Using an FFC-Bridge would make the mechanical joint independent: this might appeal to the mechanical designers
- Using a PCB-Bridge combines mechanical and electrical joint

- How to solder the joints
 - IR using linear Quartz-Halogen lamp
 - Laser Soldering
- Signal Integrity
 - Signal delivery along LVDS lines
 - Crosstalk
- Effect on Detector Glue Connections
 - Does soldering cause joint deterioration?
 - If not, what about rework?



Top View

Thin traces on
Kapton backing

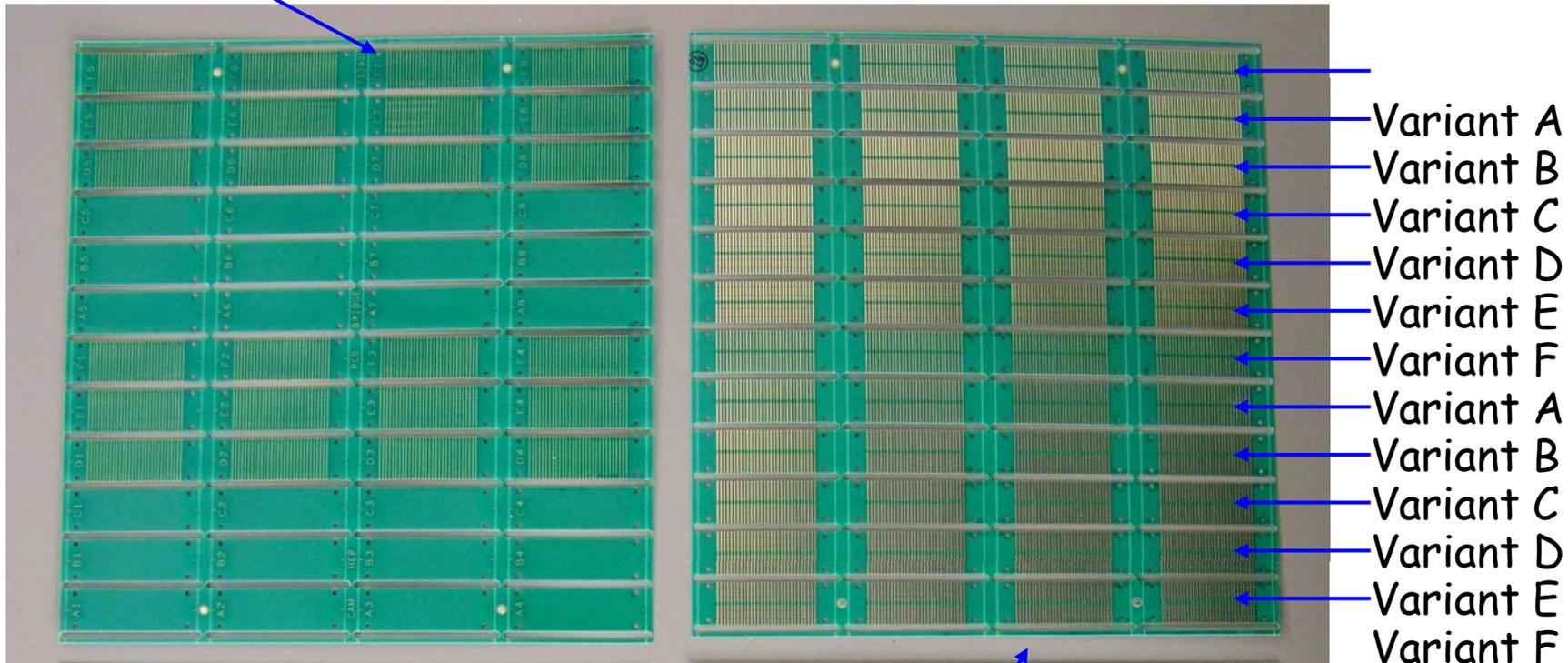
Under View

FFC-Bridges: we have 250 cut, 250 on roll

We now cut them in half: only ~6 mm long

ECAL SLAB Interconnect - Bits

Top View



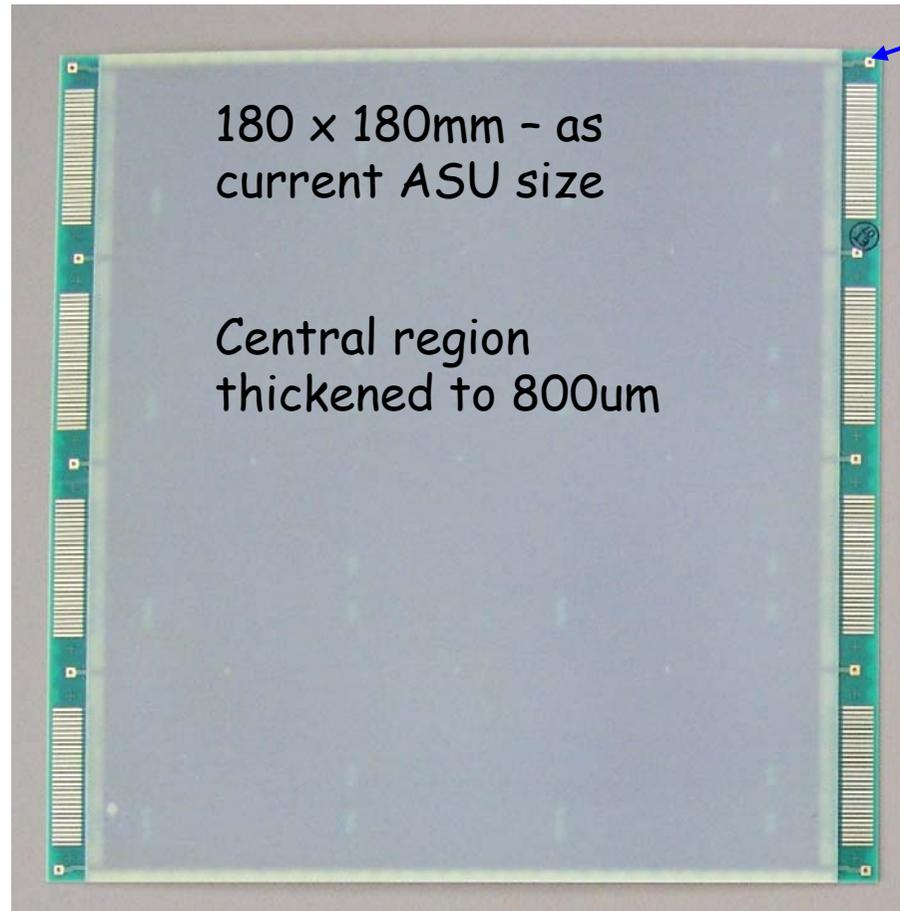
0.4 mm FR4, Au Plated

Under View

PCB-Bridges: have 15 Panels of 8 lots of 6 variants

We cut these in half too: only ~6 mm long

Top View



4 identical rows of differential
tracks connecting 36 way
interconnect pads on left and right

Can be sliced into 4 sections, so
provides for many trials

Differential tracks have a range of
spacings & other characteristics to
test signal propagation and cross-
talk

ASU-Test_2 PCB: we have 15

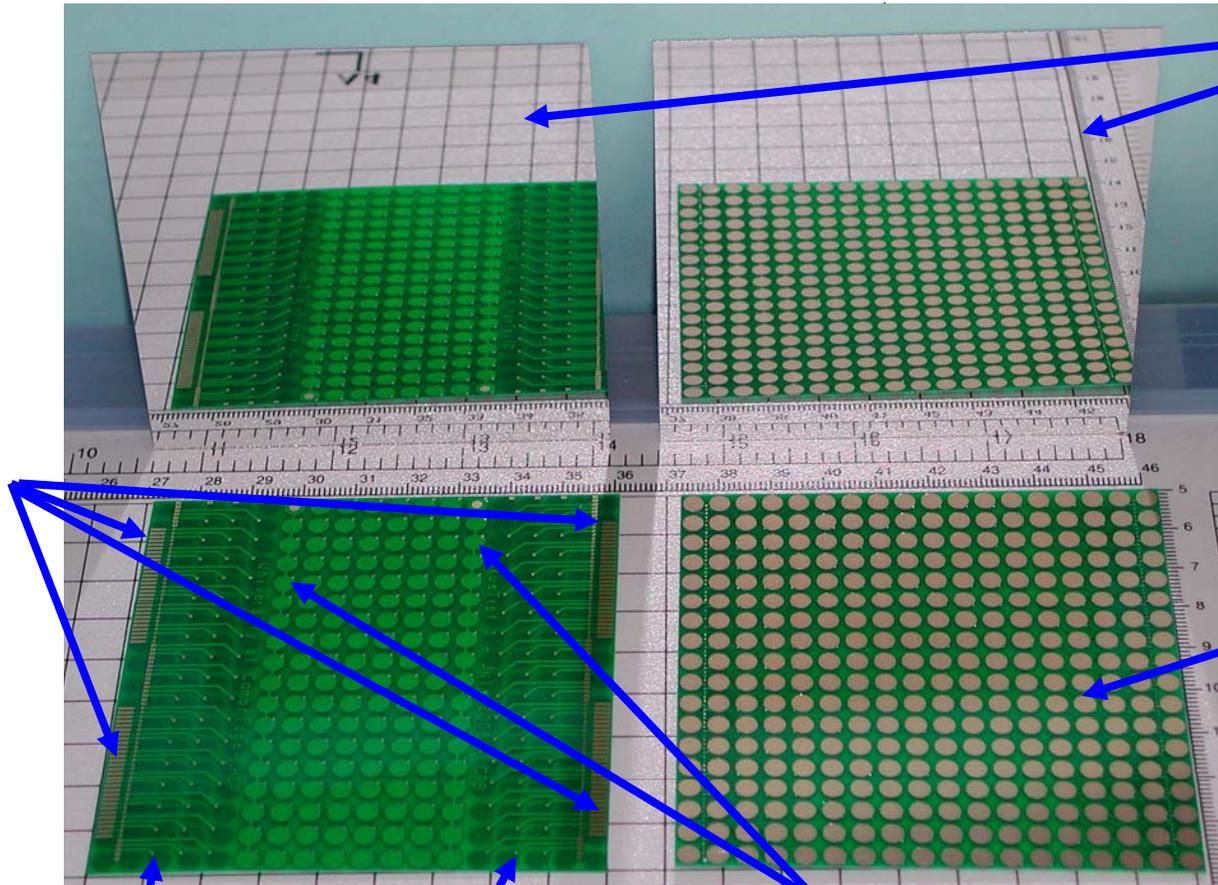
ECAL SLAB Interconnect - PCBs

Top View

Under View

Aluminised 300um Glass plates: we have 9 (plus more un-coated)

30-way Interconnect Footprints (4 per PCB)



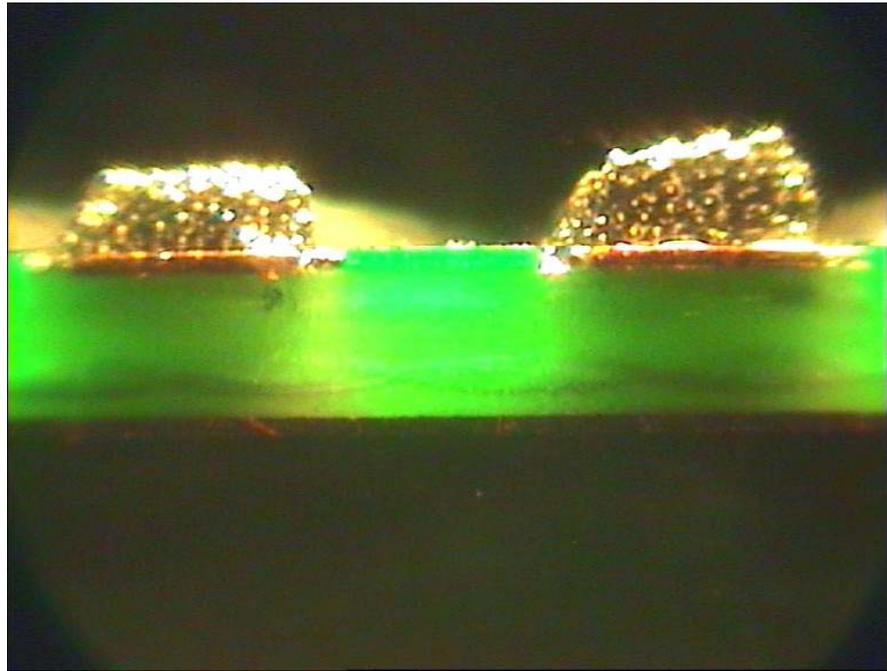
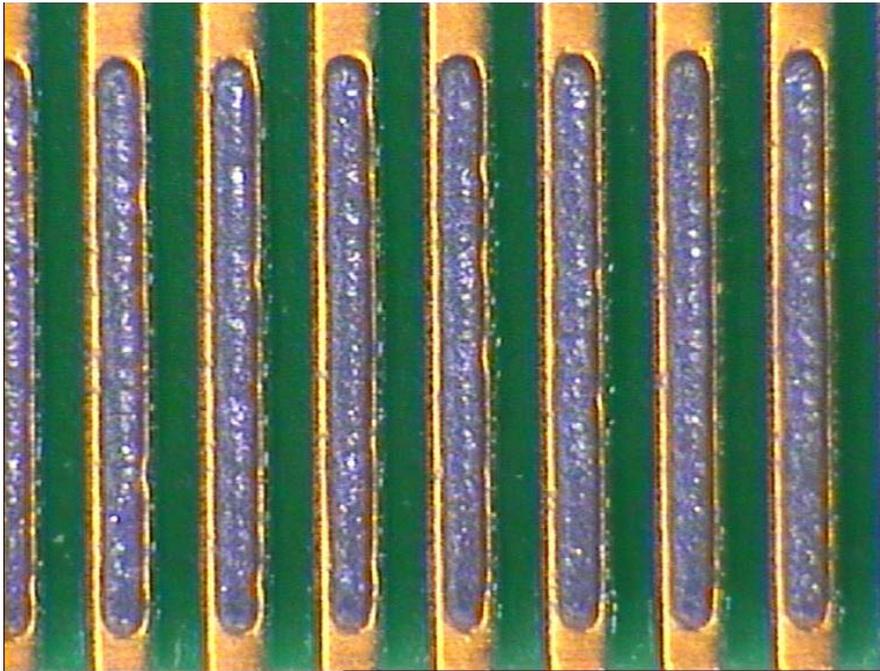
Pads on 5mm pitch

5 rows joined to fingers/pads

These 2 rows "commoned"

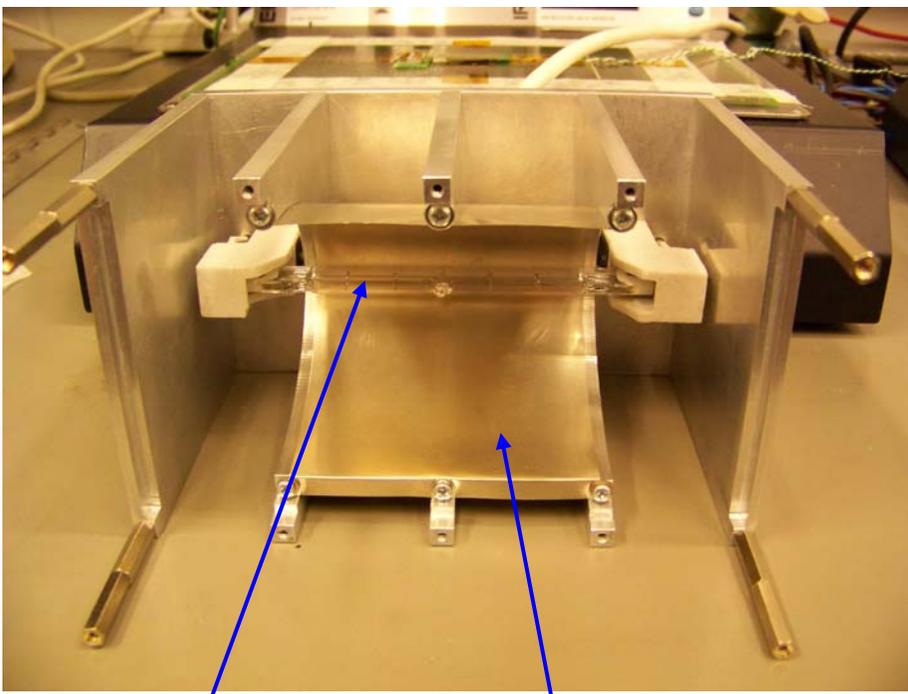
GlueTest PCB: we have 28

ECAL SLAB Interconnect - **Soldering**



PCB-Bridges: solder pasting

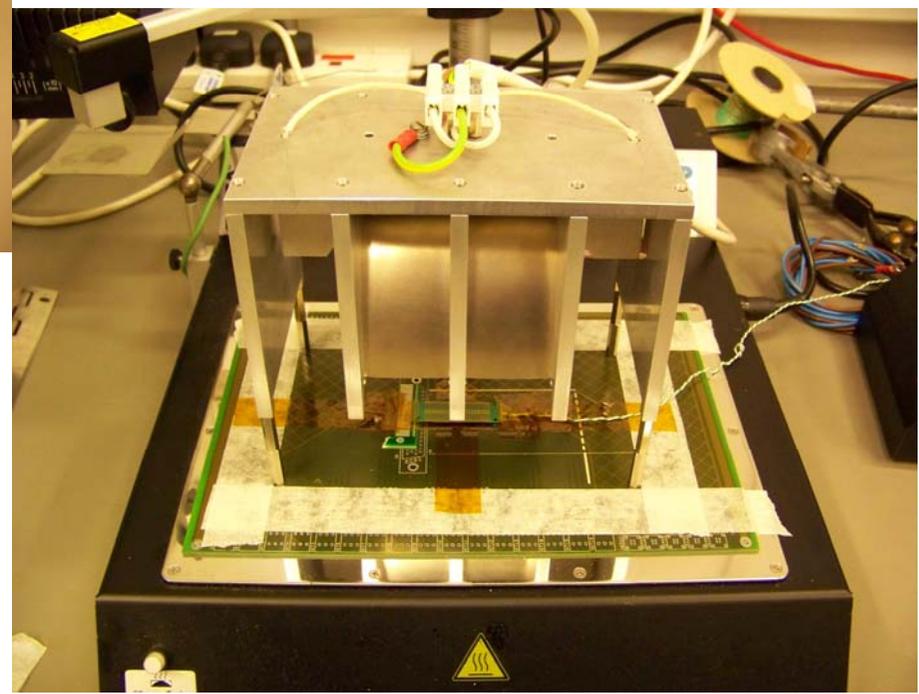
ECAL SLAB Interconnect - **Soldering**



Linear Halogen Lamp

Elliptical Reflector

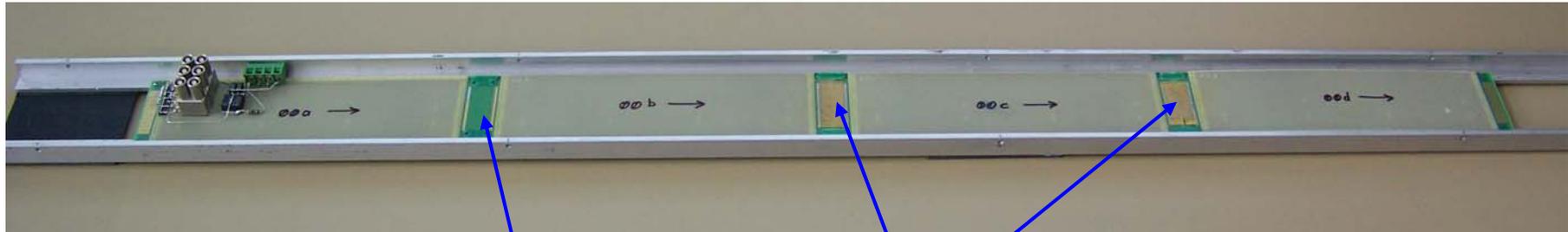
Re-flowing a PCB-Bridge



Imaging Halogen IR Source

Maurice Goodrick & Bart Hommels , University of Cambridge

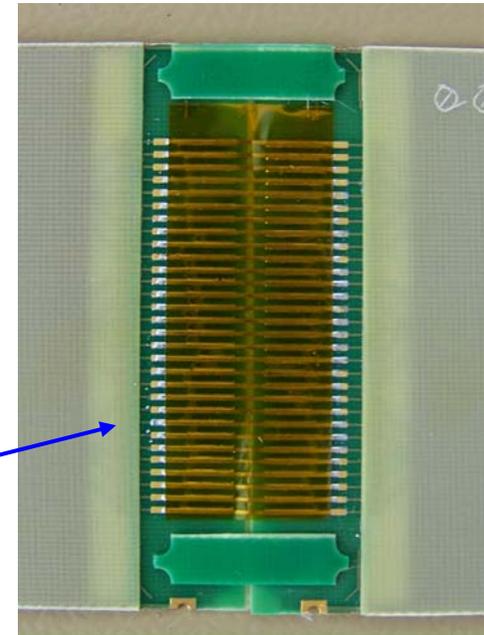
4 Section ASU-Test Assembly



PCB-Bridge joint

FFC-Bridge joints

View of FFC-Bridge joint



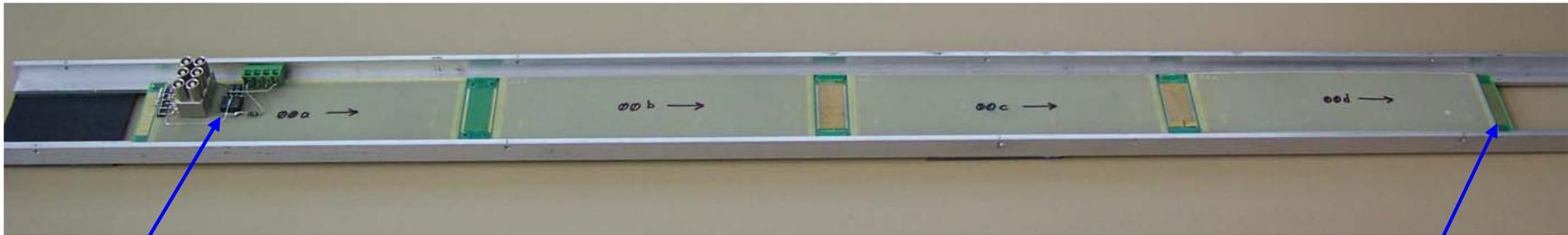
ASU-Test_2: 4 Section Assembly

ECAL SLAB Interconnect - **Soldering**



ASU-Test_2: 10 Section Assembly in Progress

Using the 4 Section ASU-Test_2 Assembly



LVDS Drive Circuit:
Back Term'n = 100R

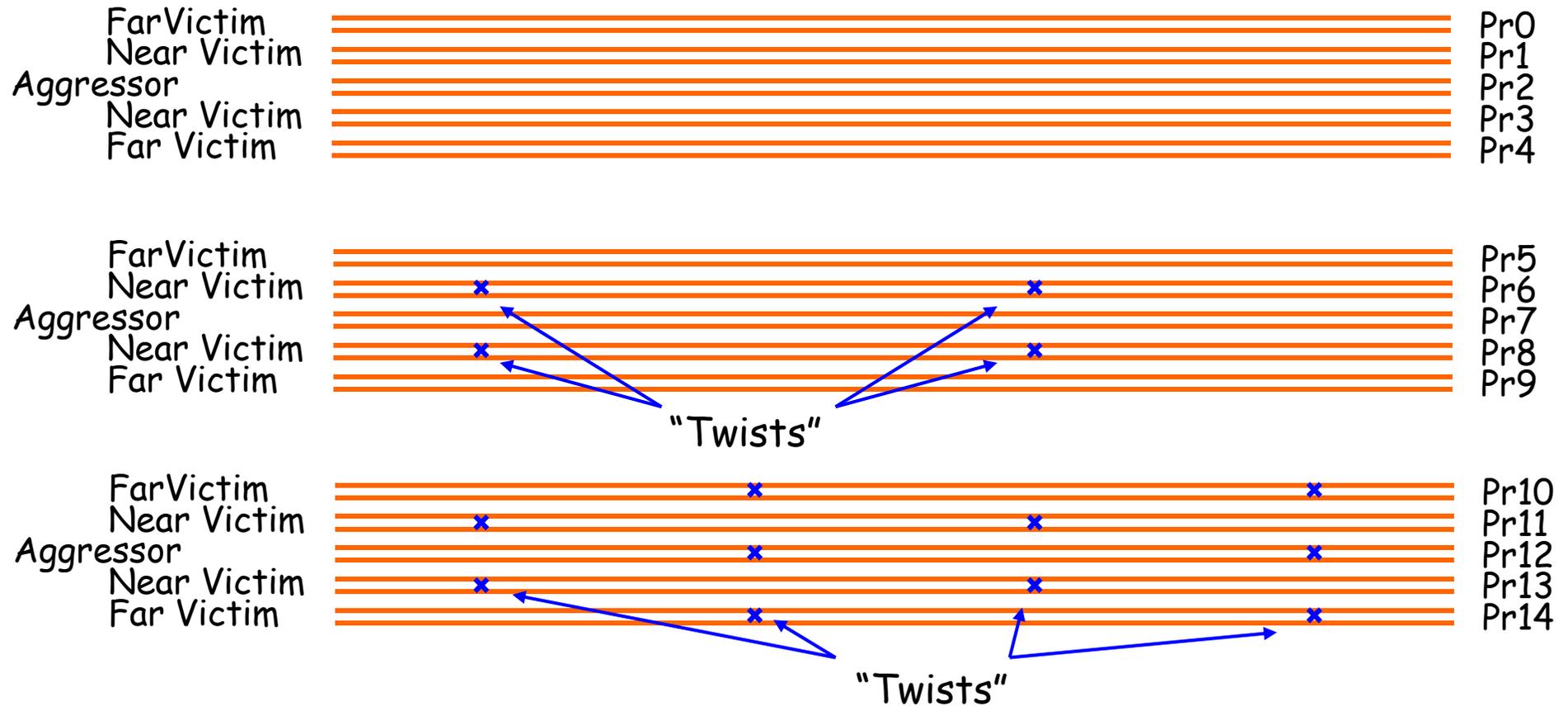
Track Series Res $\sim 8R$

End Term'n = 82R

Length = $4 \times 180\text{mm} = 720\text{mm}$

Crosstalk Setup

ECAL SLAB Interconnect - Crosstalk

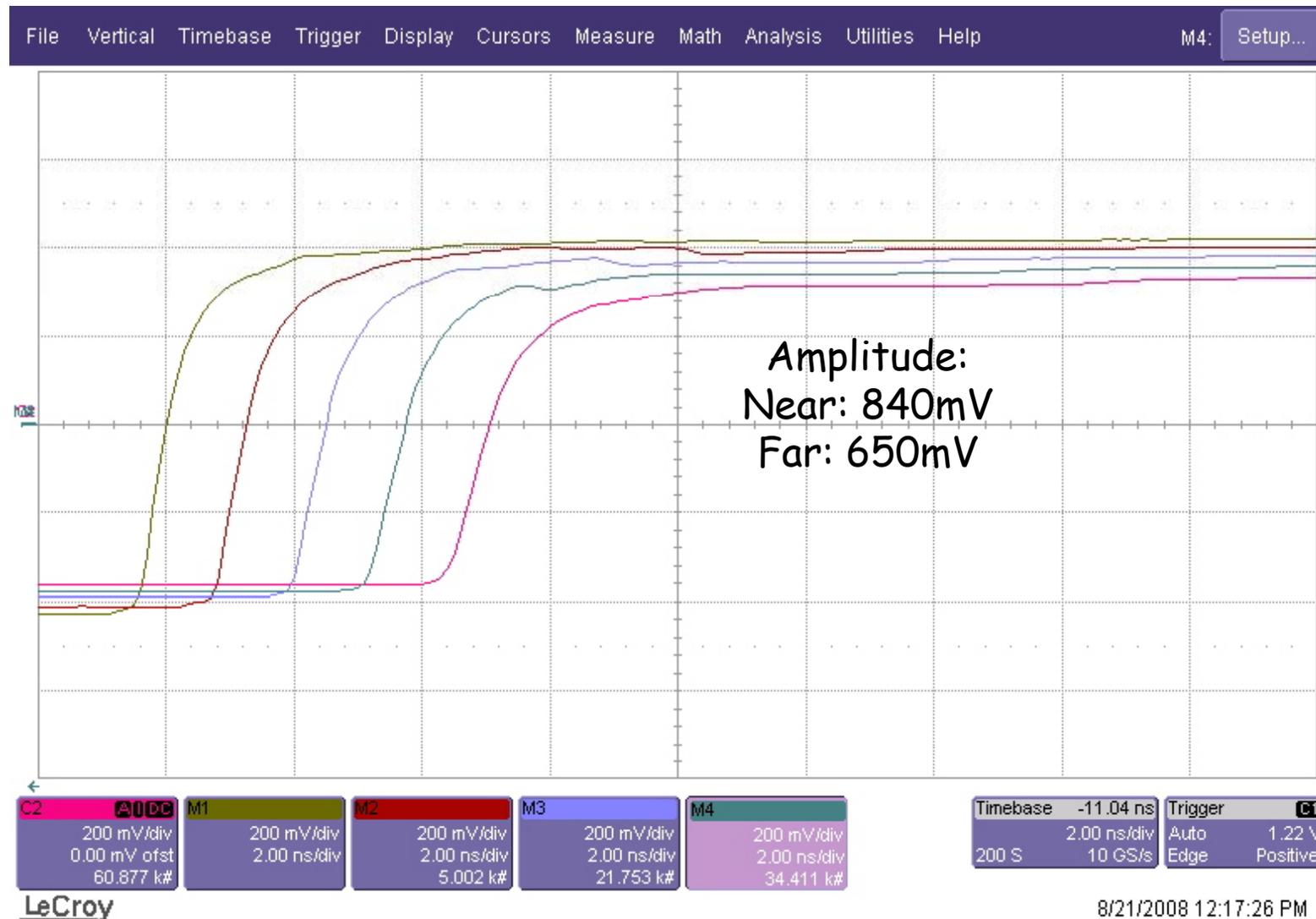


ASU-Test_2: Traces

Group	Pair Separation/ (Track & Gap)
A	1
B	1.5
C	2
D	3

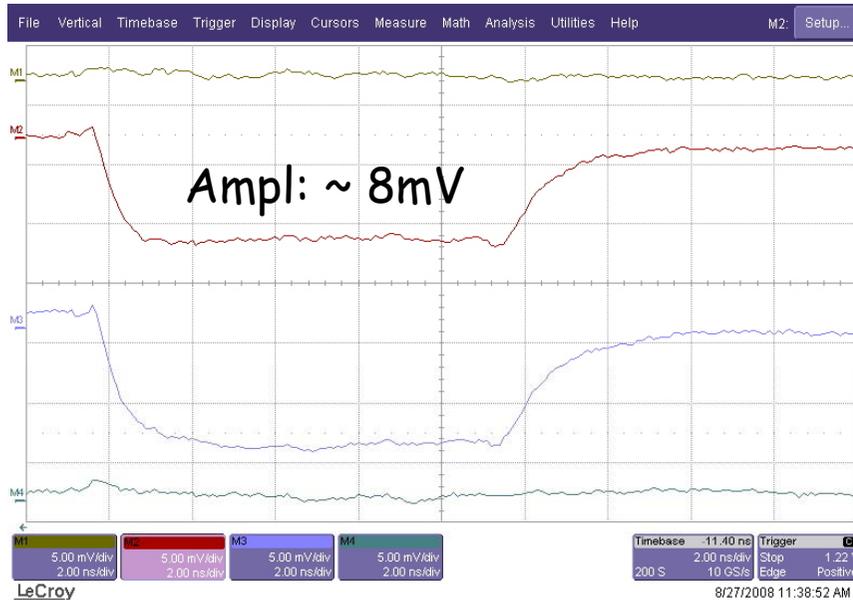
ASU-Test_2: Traces

ECAL SLAB Interconnect - Crosstalk

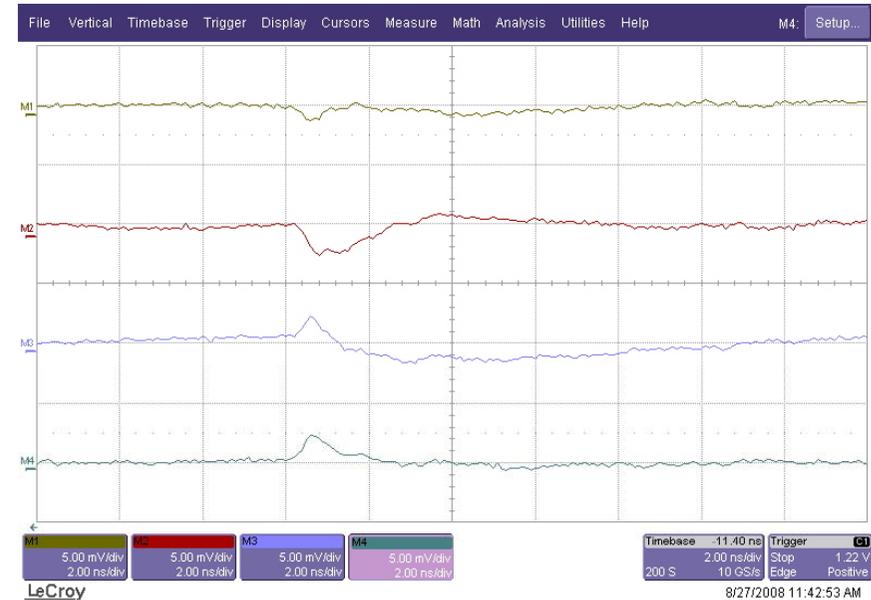


ASU-Test_2: Aggressor Signal Propagation (Pr2, Group A)

ECAL SLAB Interconnect - Crosstalk



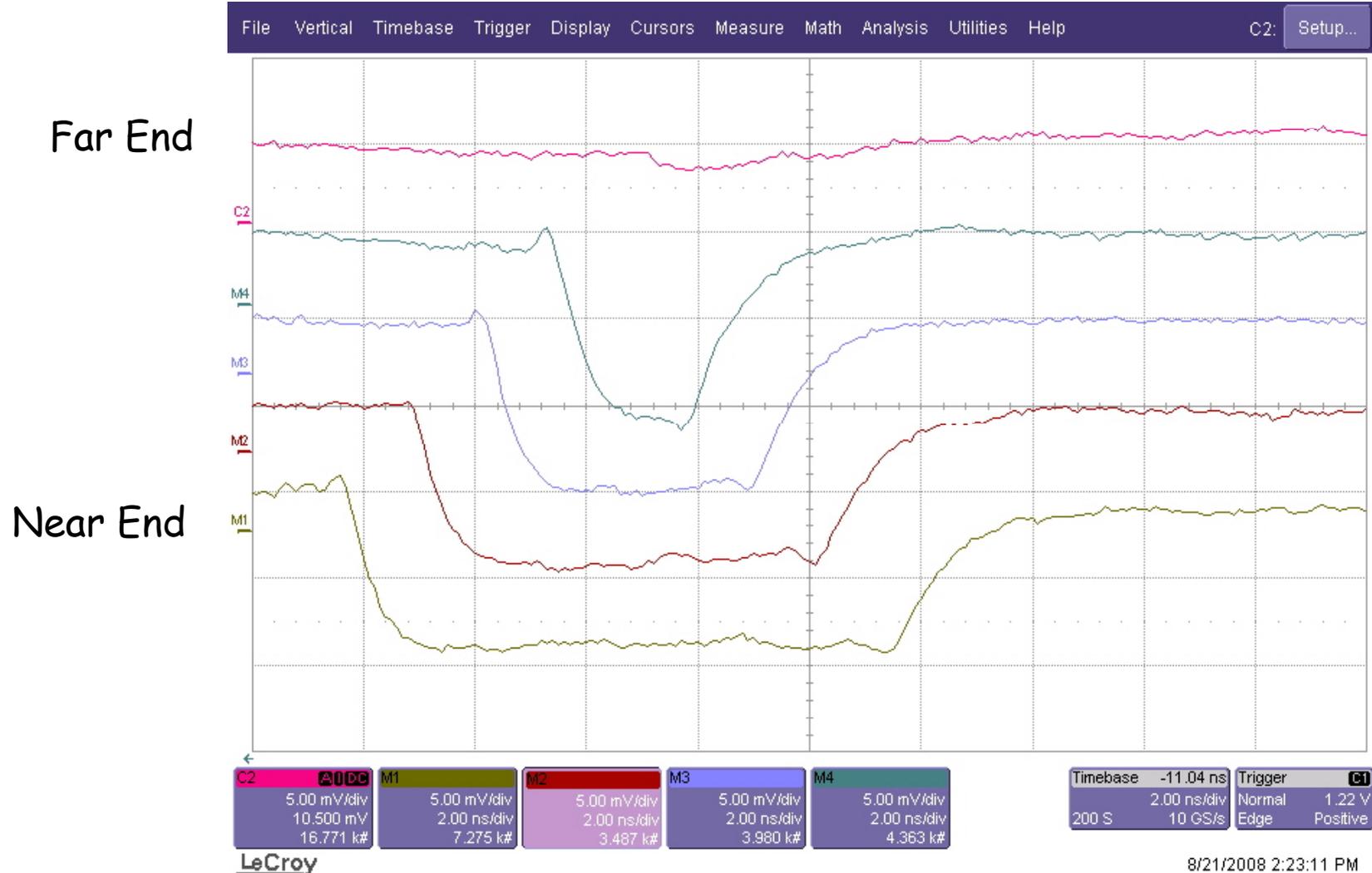
Driver End



Far End

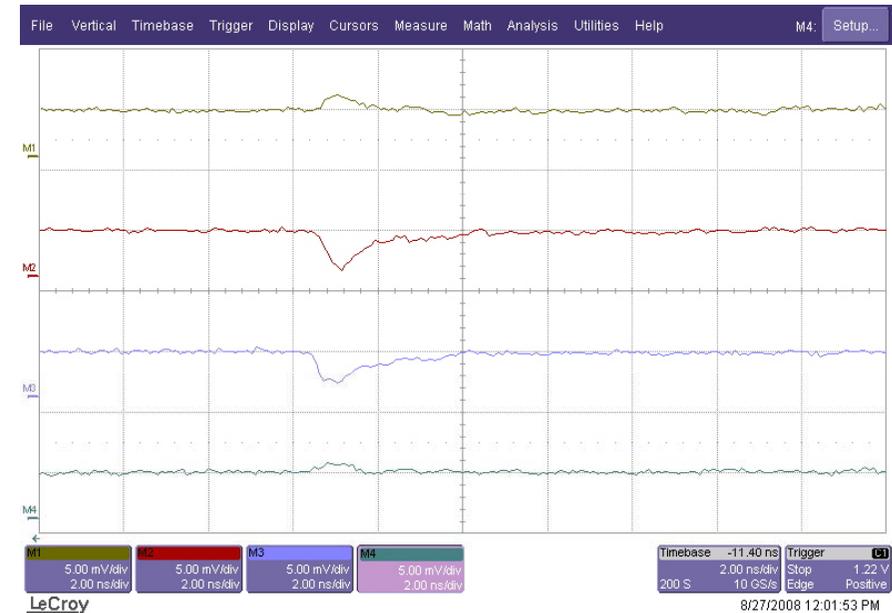
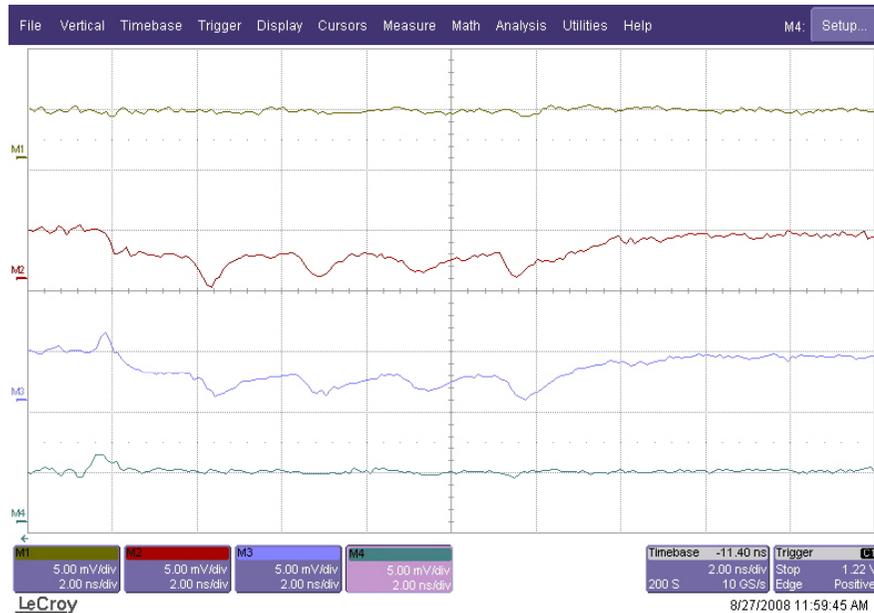
ASU-Test_2: Victim Crosstalk (Prs 0,1,3,4, Group A)

ECAL SLAB Interconnect - Crosstalk



ASU-Test_2: Victim Crosstalk Along Slab (Pr 1, Group A)

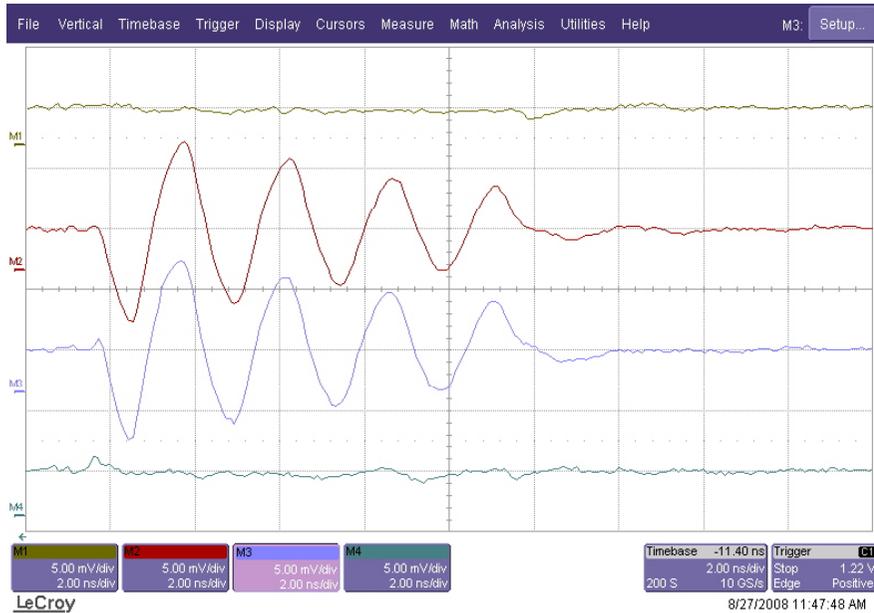
ECAL SLAB Interconnect - Crosstalk



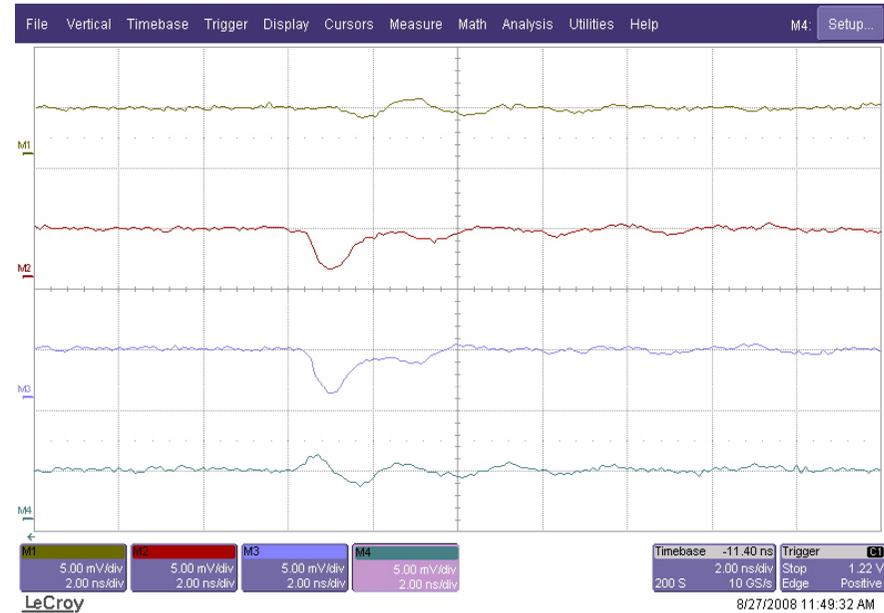
Greater Pair Separation => Far Less Crosstalk

ASU-Test_2: Victim Crosstalk (Prs 0,1,3,4, Group C)

ECAL SLAB Interconnect - Crosstalk



Driver End

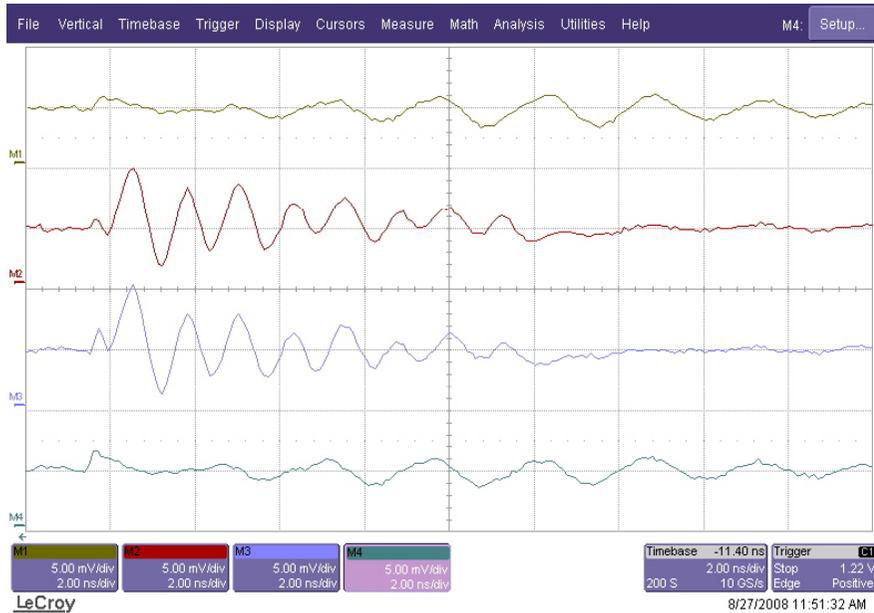


Far End

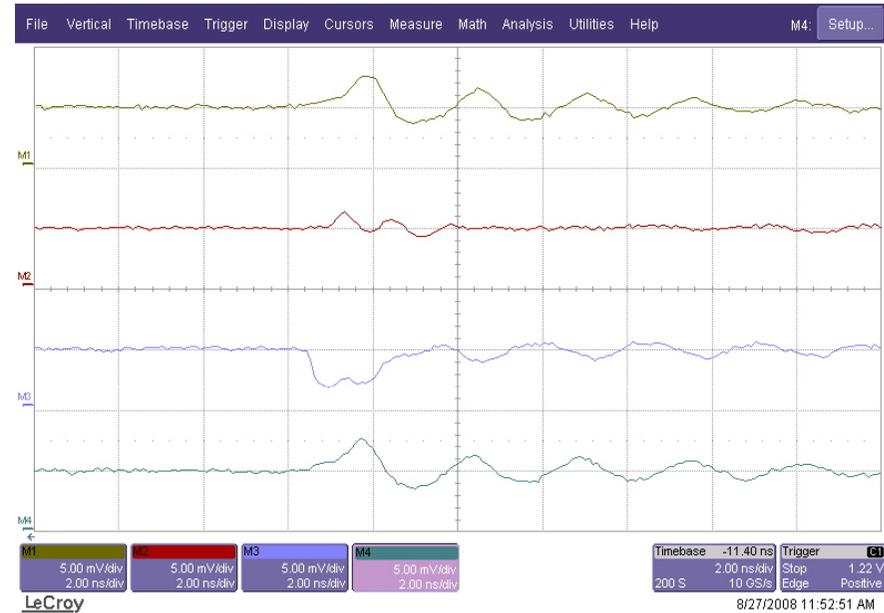
"With Twists"
Crosstalk alternates sign

ASU-Test_2: Victim Crosstalk (Prs 5,6,8,9, Group A)

ECAL SLAB Interconnect - Crosstalk



Driver End

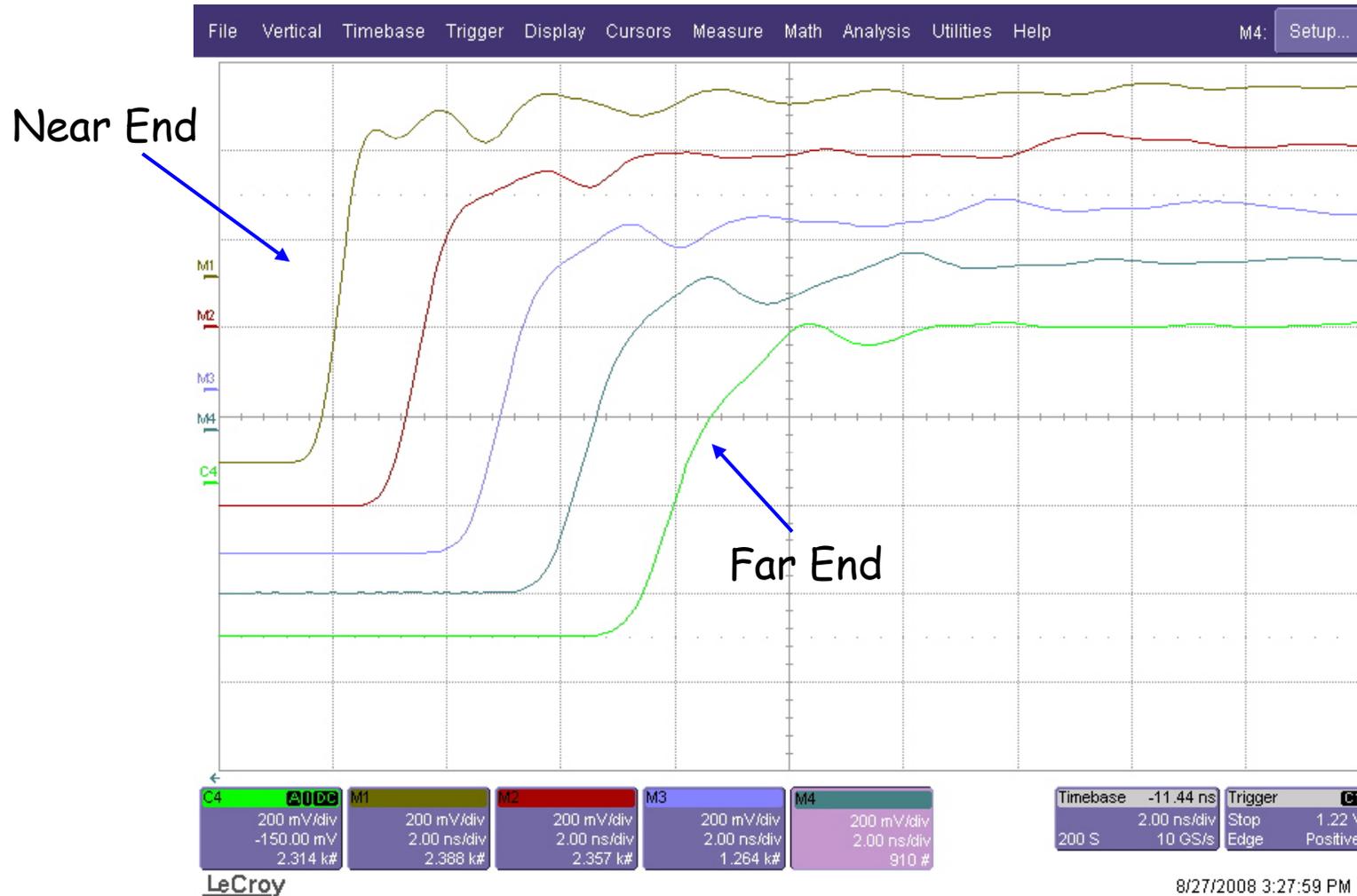


Far End

"With Extra Twists"
Crosstalk alternates sign twice as fast

ASU-Test_2: Victim Crosstalk (Prs 10,11,13,14, Group A)

ECAL SLAB Interconnect - Crosstalk



ASU-Test_2: Propagation with Added 10pFs at ASU Joints (Pr 2, Group C)

Conclusions: for the 750mm Assembly

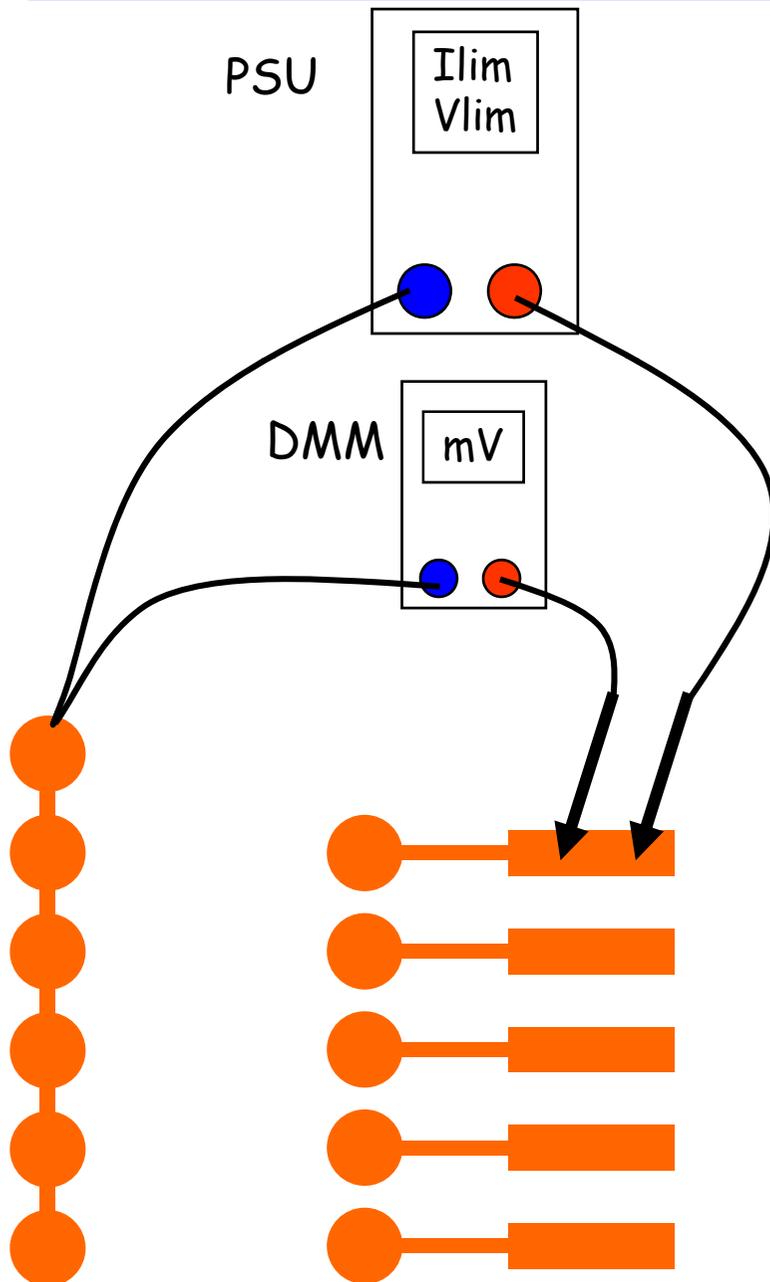
- Signal degradation and crosstalk look relatively small, even with closely spaced pairs ($\sim 10\text{mV}$)
- Pair separation of $2 \times \text{Track \& Gap}$ reduces crosstalk dramatically (confirming folk lore)
- "Twisting" pairs doesn't really help
- Periodic capacitive loads do have a perceptible effect ($\sim 100\text{mV}$) - this will have to be watched

- What happens with 1700mm Slab? (10 ASU Slab being assembled)

- Marc Anduze provided a number of 300um 90x90 glass plates (plus some of 500um)
- We had 9 of them aluminised
- Manchester glued 2 of these to Gluetest PCBs
- We have made initial resistance measurements
- Plan is to subject these to the IR soldering process, and to re-check the resistances

- We find that glue joints are not simple!
- Ray Thompson of Manchester has written a very useful note on this
- We will use both leaded (183 deg) and Sn-Bi solder (150 deg)
- If these temperatures are a problem, it might push us to Laser Soldering

ECAL SLAB Interconnect - GlueTest Initial



GlueTest - PCB #1

Connector #1						
I Lim(mA)	50	50	50	50	50	100
V Lim (V)	1	2	3	4	1	1
Finger						
0	9.2	9.2	9.2	9.2	9.1	18
1	9	9	9	9	9	18
2	9.6	9.6	9.6	9.6	9.6	19
3	9.1	9	9	9.1	9	18
4	1000	2000	3000	22	21	43
5	1000	114	66	18	17	35
6	1000	2000	3000	20	20	40
7	1000	2000	3000	23	23	46
8	1000	2000	3000	28	27	56
9	1000	160	18	19	19	38
10	1000	87	18	18	18	37
11	1000	2000	22	24	24	49
12	470	31	15	15	14	30
13	180	31	17	17	16	33
14	1000	2000	33	29	29	58
15	1000	2000	3000	22	22	44
16	1000	31	16	16	16	32
17	1000	2000	3000	18	19	38
18	120	27	28	16	16	33
19	1000	38	18	18	18	36
20	1000	2000	3000	18	18	36
21	1000	2000	3000	20	20	41
22	1000	2000	3000	18	17	35
23	1000	2000	15	15	15	30
24	1000	2000	19	19	19	39
25	215	124	49	40	39	78
26	1000	2000	23	16	16	33
27	1000	2000	34	24	24	49
28	1000	2000	20	21	21	42
29	12	12	12	12	12	24



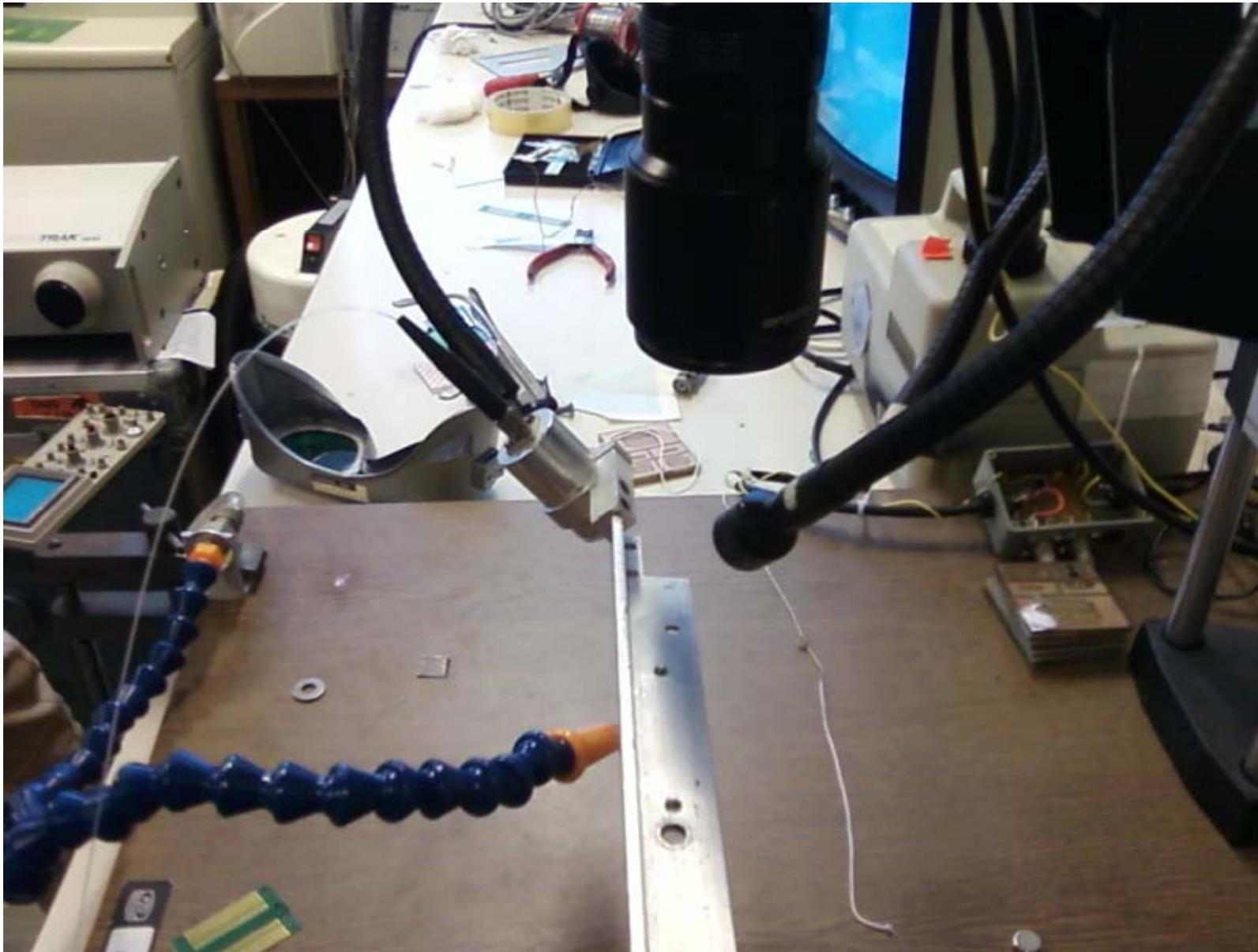
James Gilbert
University of Hull
Hull, UK

ECAL SLAB Interconnect - Laser Soldering



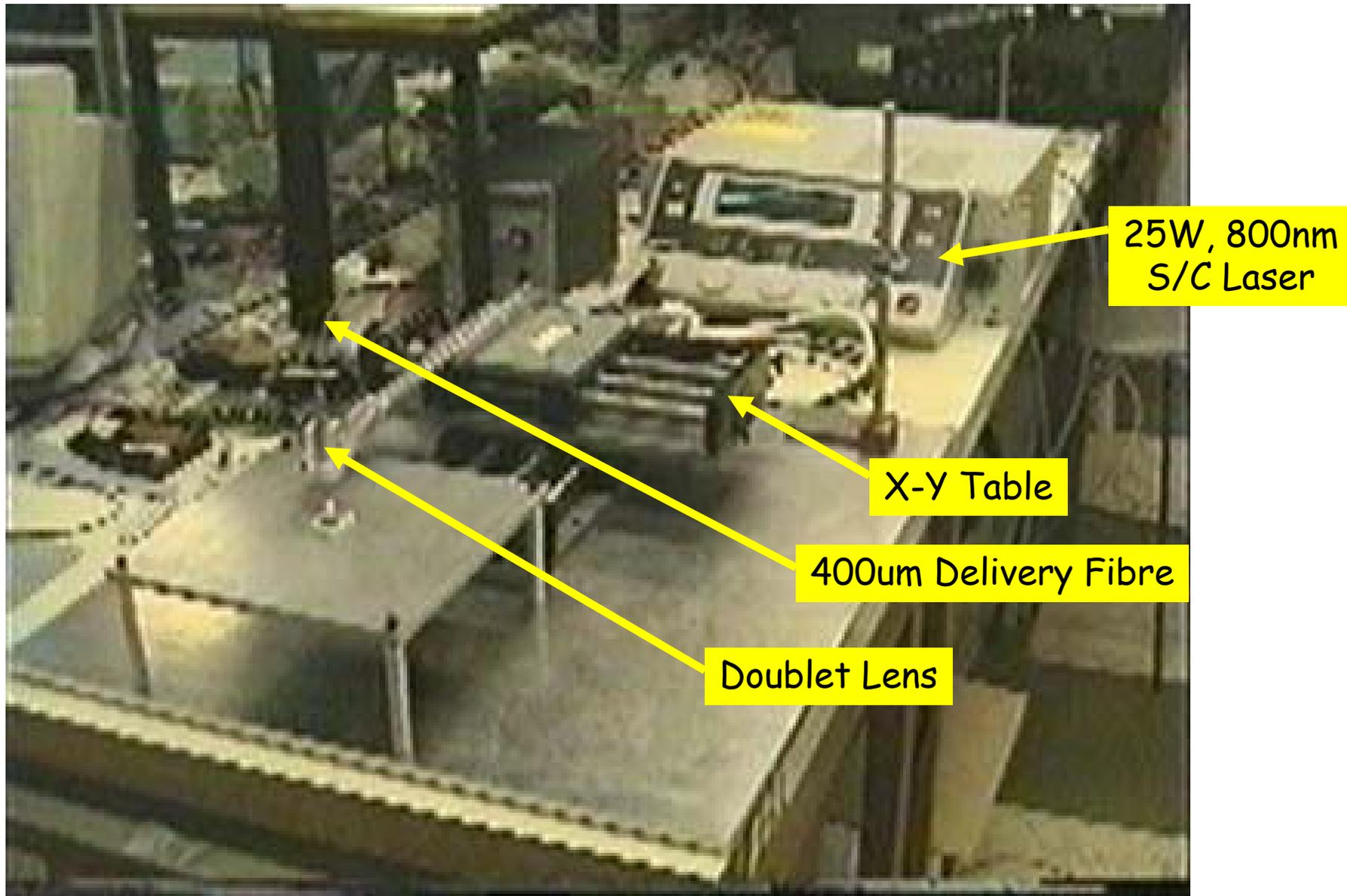
Maurice Goodrick & Bart Hommels , University of Cambridge

ECAL SLAB Interconnect - Laser Soldering

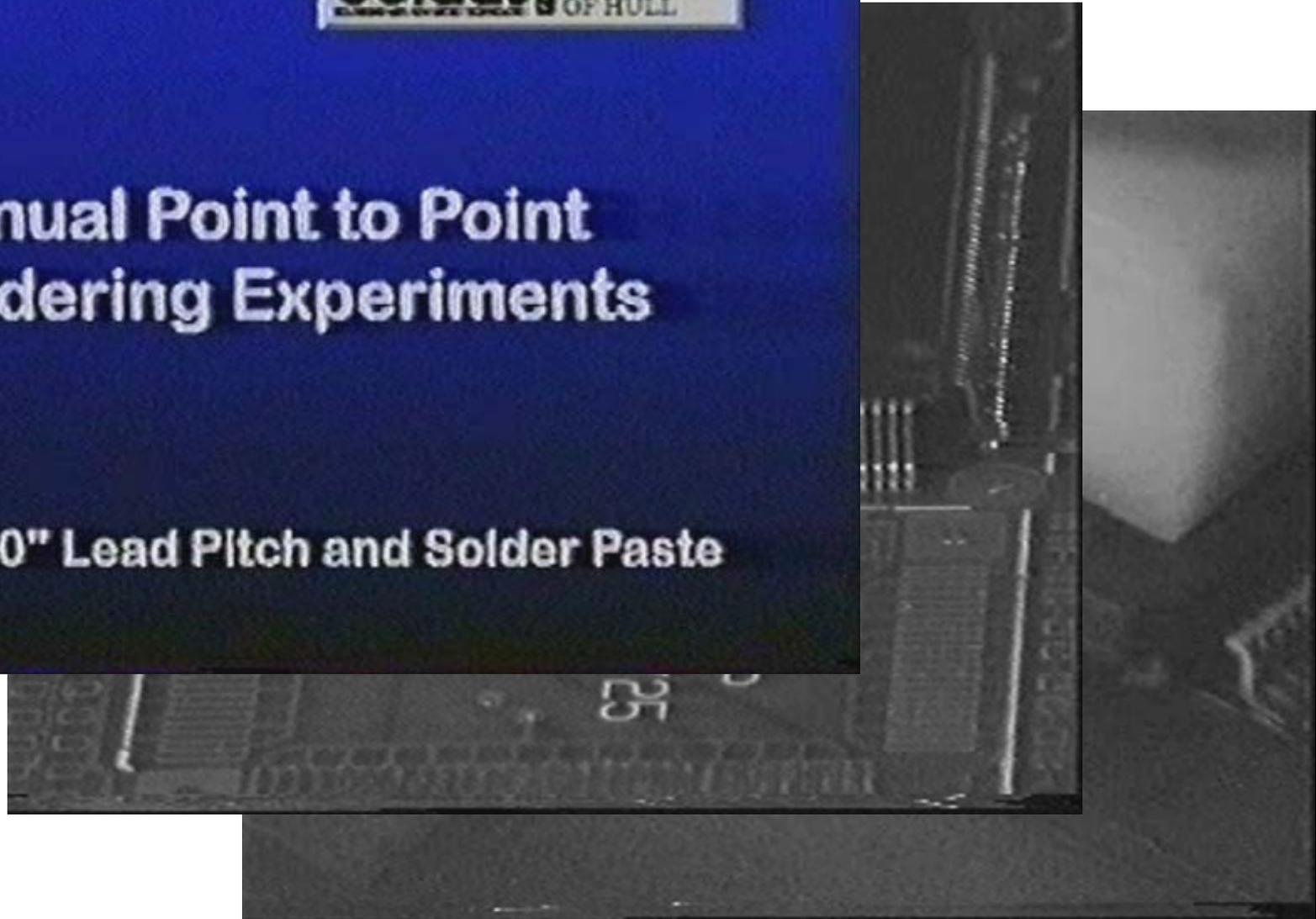
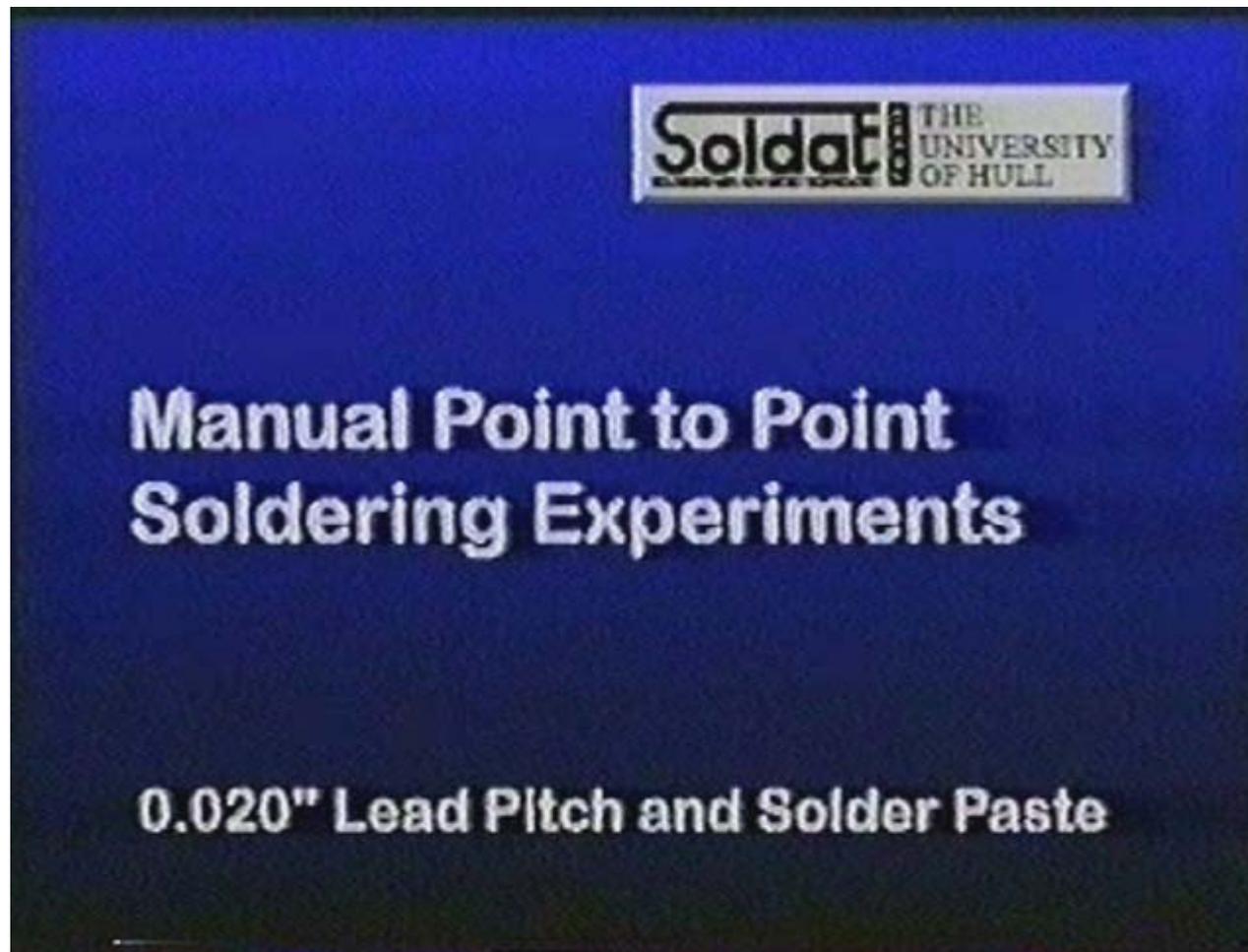


Maurice Goodrick & Bart Hommels , University of Cambridge

ECAL SLAB Interconnect - Laser Soldering



ECAL SLAB Interconnect - **Laser Soldering**



Laser Soldering: Conclusions

- Promises low damage
- ~ 600 Euro/W: might need 10 - 25 W, so > 6000 Euro for laser
- Possibly going to be a bit slow
- Hull willing to do initial trials F.O.C.