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A Summary of Investigations at Cambridge

Making the interconnections between the Slab component PCBs ("ASUs") is difficult.

We have been looking at ways to do it, and testing out our ideas.

- The general interconnect problem
- The way in which "Bridge" pieces could be used
- The initial design work
- Bits we have in hand
- Investigations and first results

ECAL SLAB Interconnect

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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 30-40 connections
Up to 4 Bridges fit in the width of an ASU
… 1 per path would be an ideal solution ☺☺

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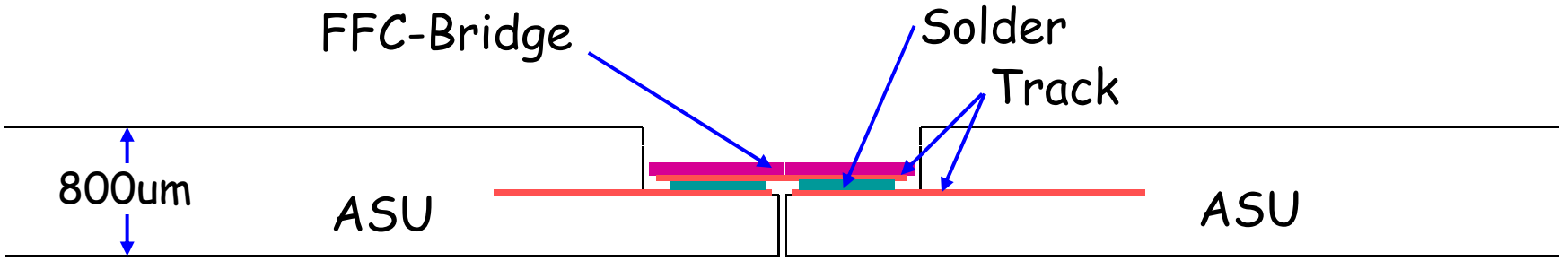
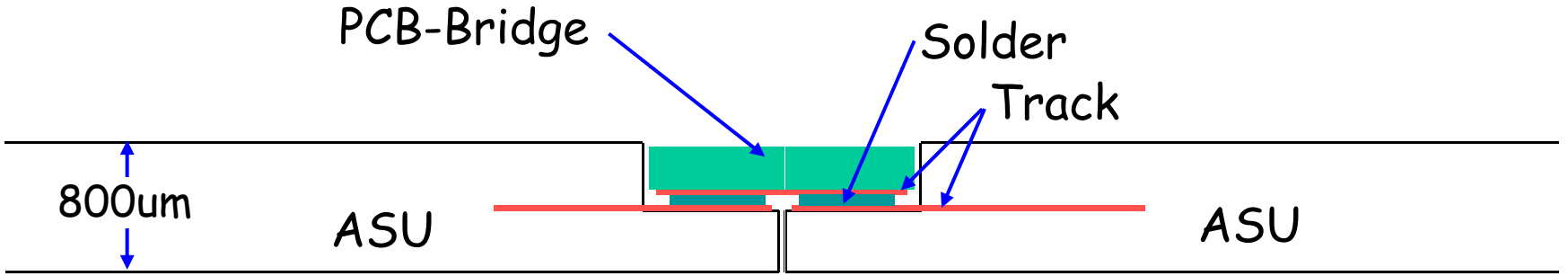
Short FFC (Flat,Flexible-Cable) Bridges make connections on a 1mm pitch – OK for at least 120 connections



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



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ECAL SLAB Interconnect - Bridge advantages

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- 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

ECAL SLAB Interconnect - Where we are

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The following slides give a glimpse of what we have … and some results

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ECAL SLAB Interconnect - Where we are

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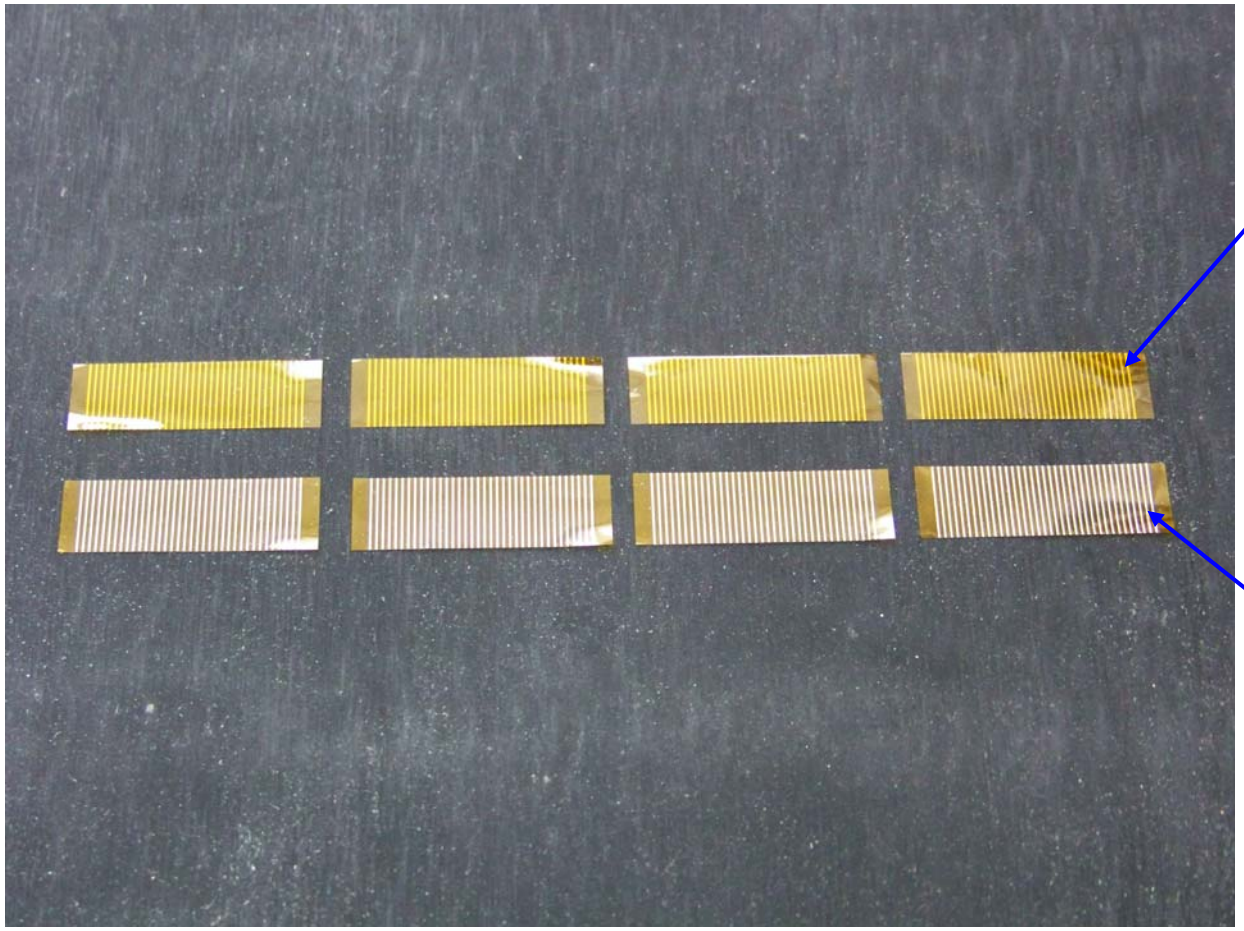

Top View

Thin traces on Kapton backing

Under View

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

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ECAL SLAB Interconnect - Where we are

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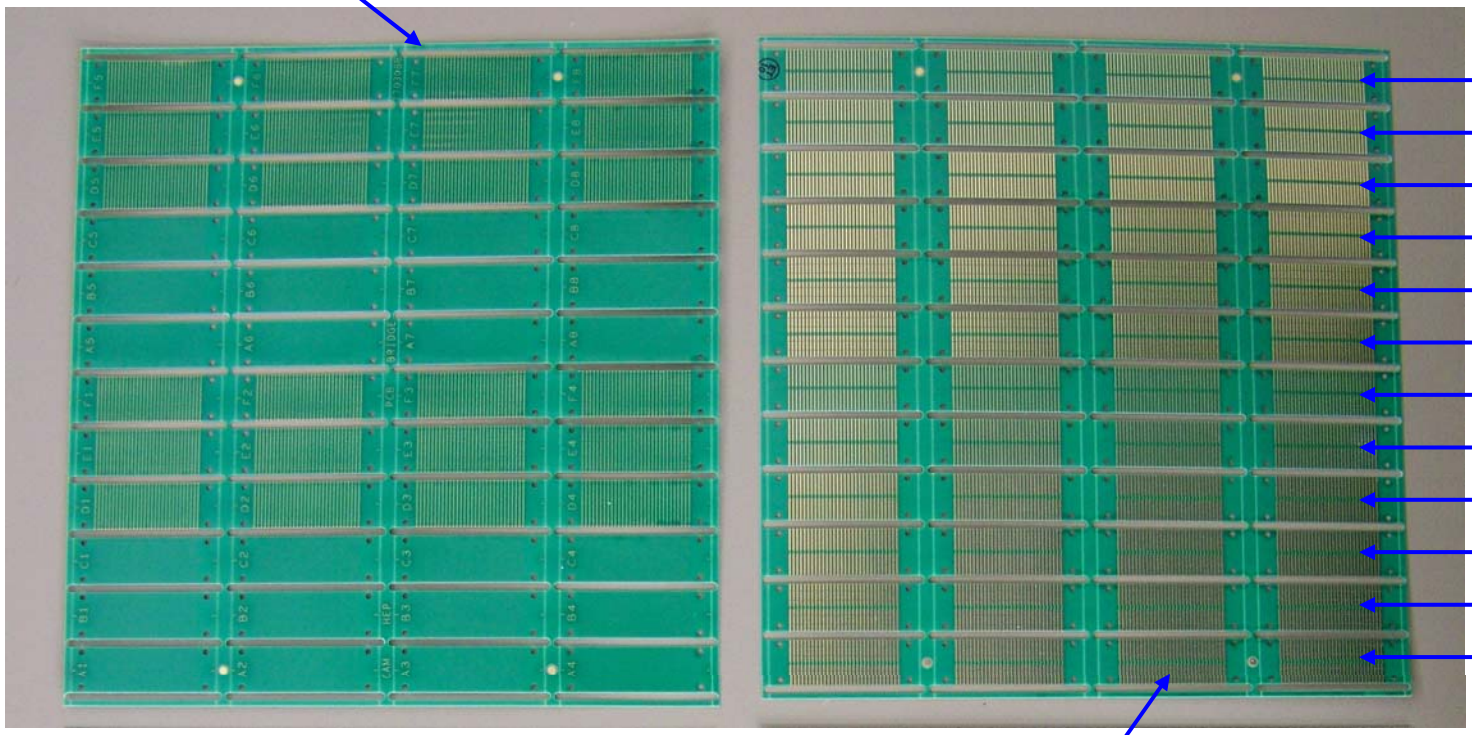
Top View



Under View

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

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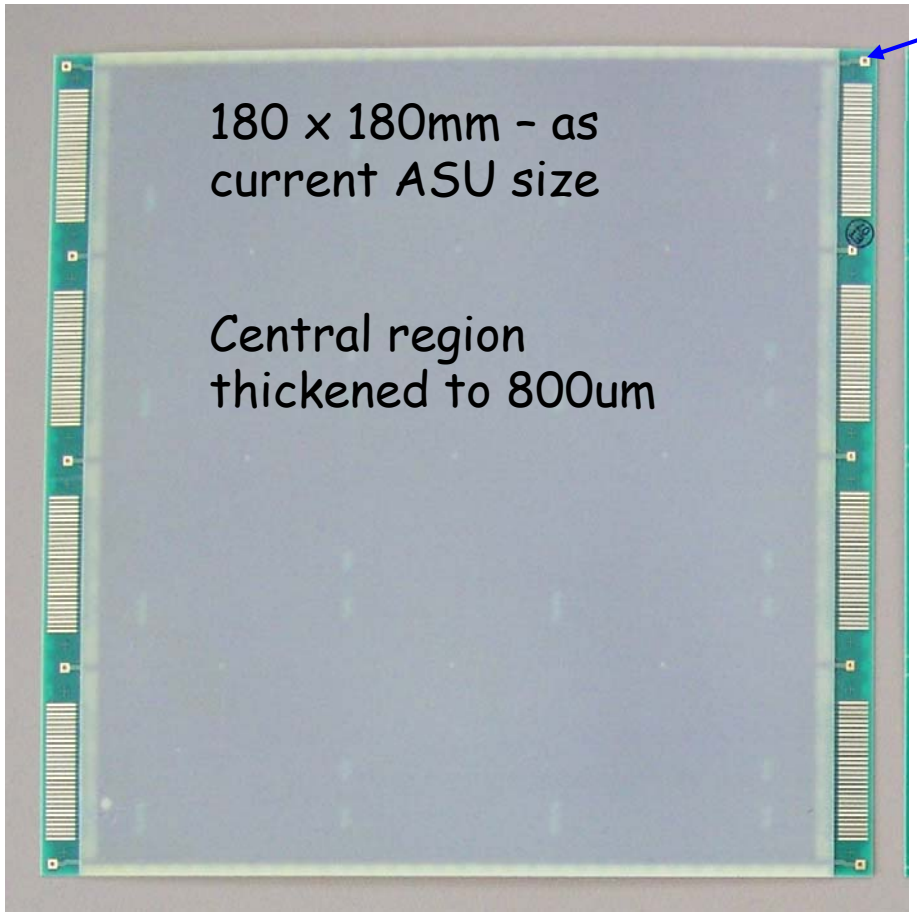
Top View



Interconnect region 400um

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 charcteristics to test signal propagation and cross-talk

ASU-Test PCB: we have 15

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ECAL SLAB Interconnect - Where we are

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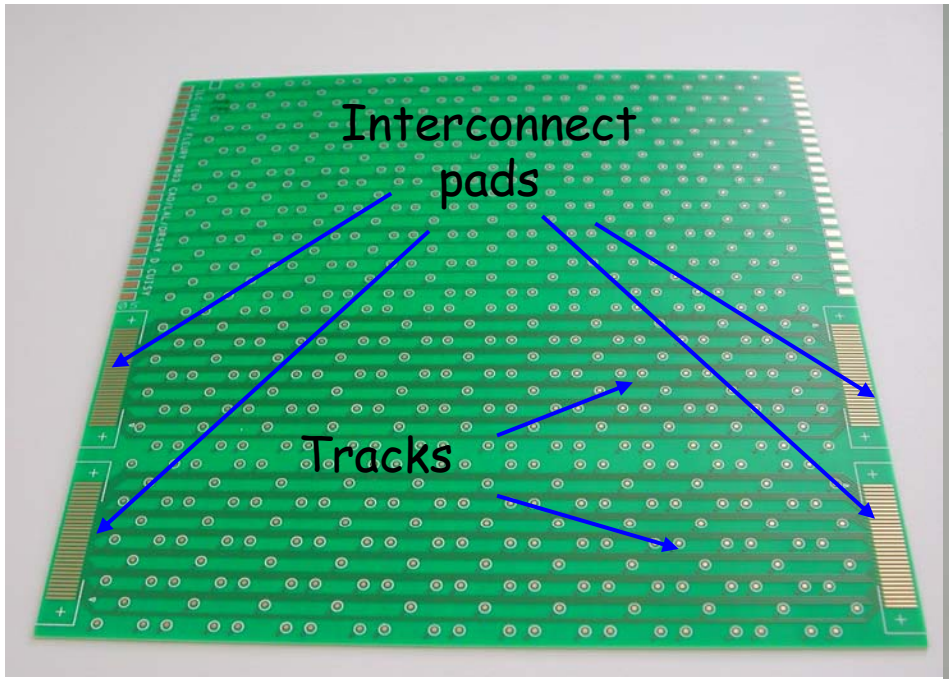
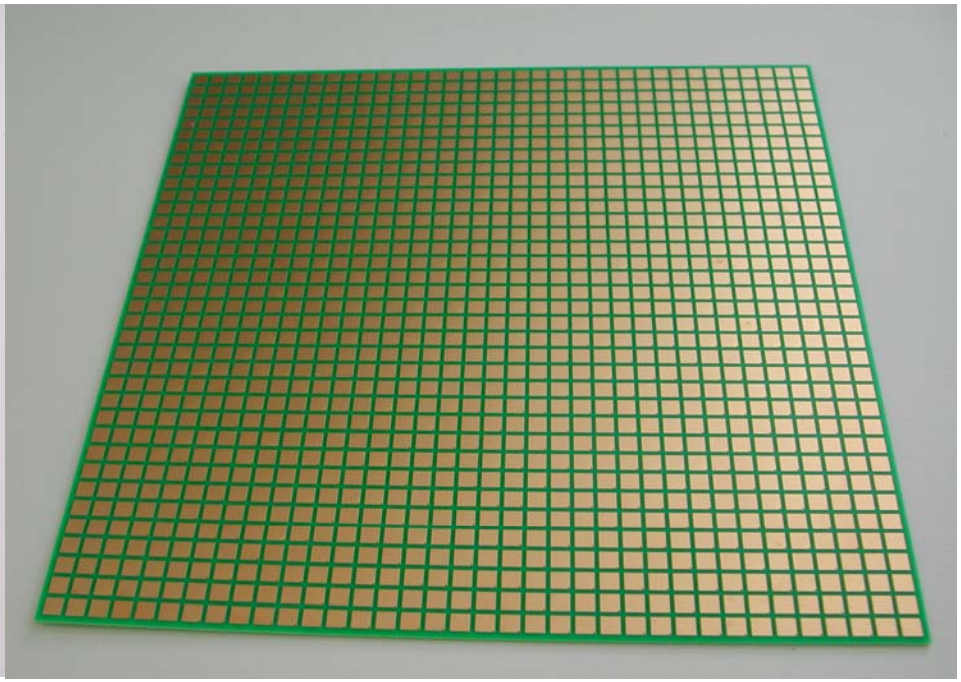
Top View



Bottom View



FEV6 Mechanical Prototype: (from Julien Fleury)

- we have 6, but how best to use them?
  - Plan A is:
    - get Manchester to add glass
    - then interconnect them
  - Plan B is: ????

ECAL SLAB Interconnect - Where we are

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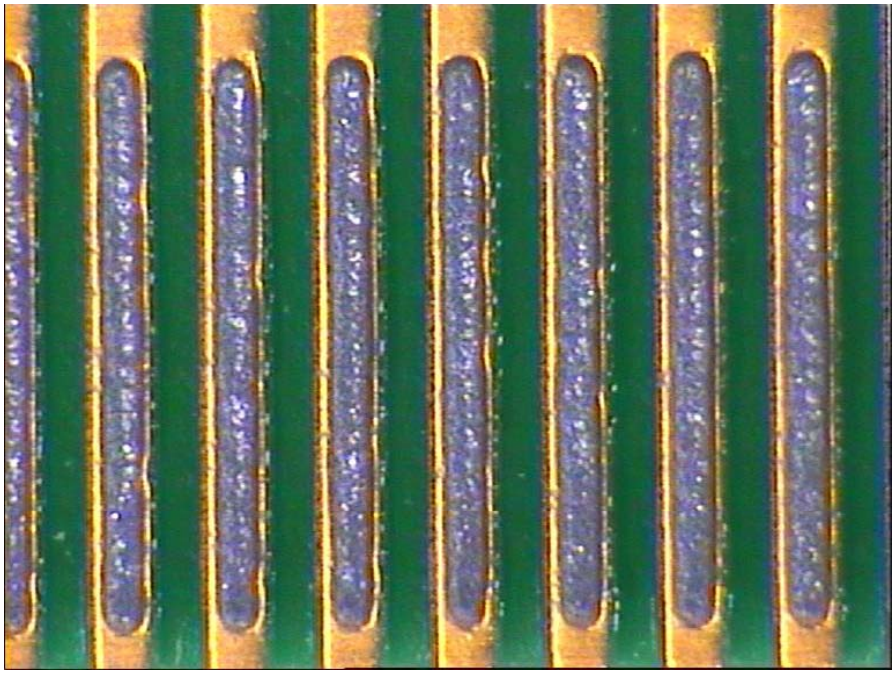

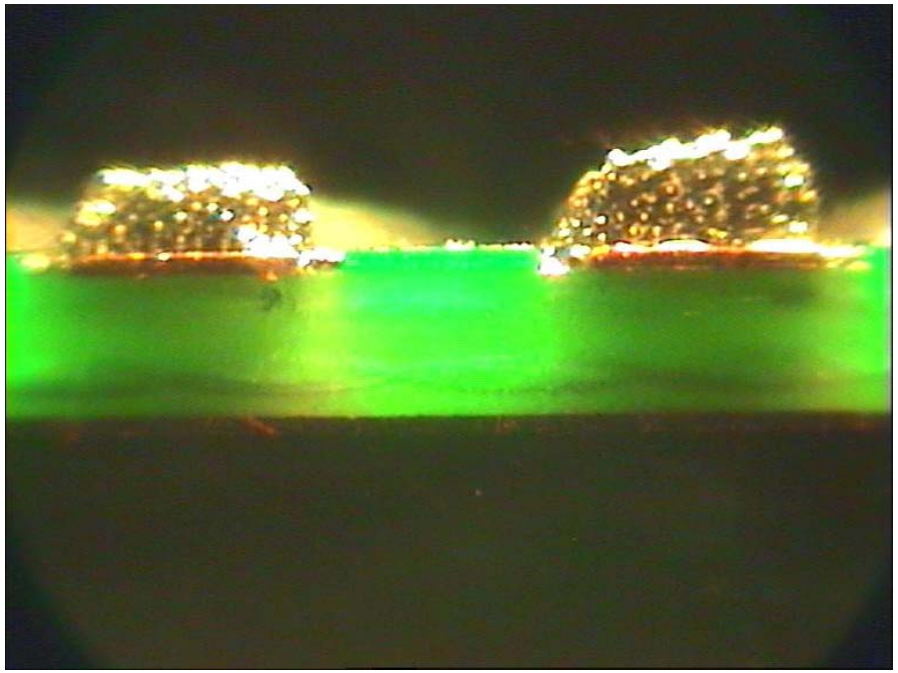

PCB-Bridges: solder pasting

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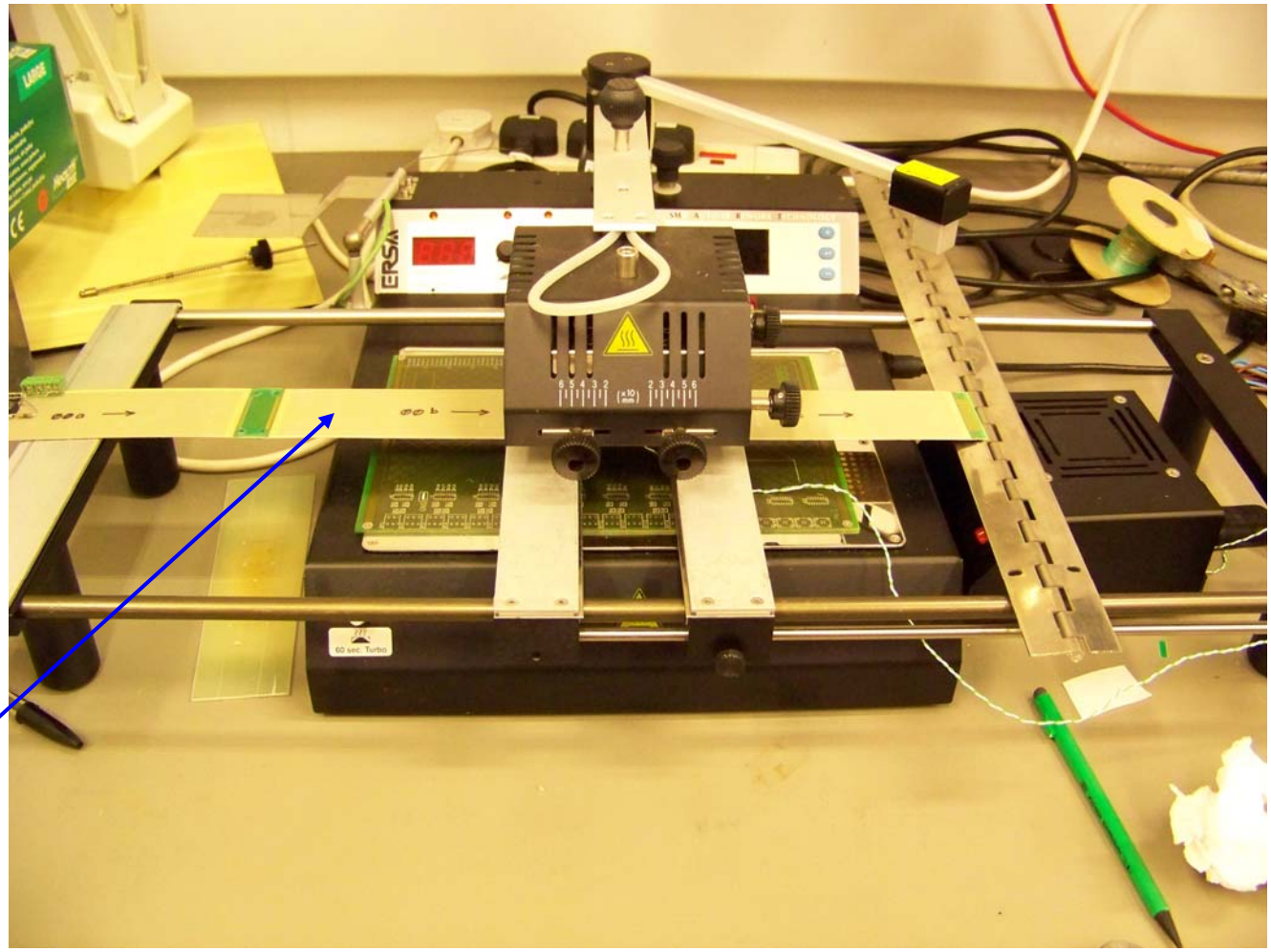

3 bits of ASU-Test being joined: reflow of 2nd and 3rd

Using the IR Re-work station

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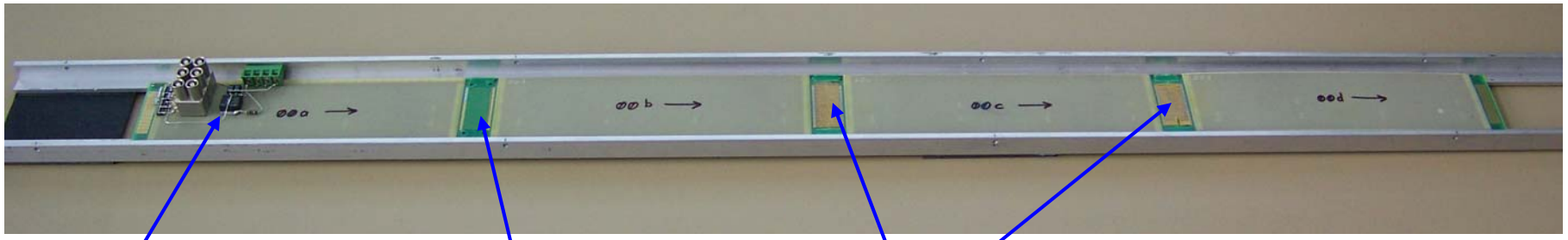
4 Section ASU-Test Assembly

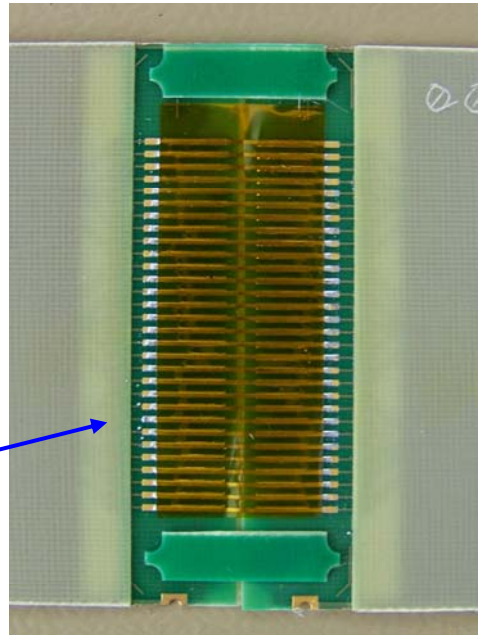


LVDS Drive Circuit

PCB-Bridge joint

FFC-Bridge joints

View of FFC-Bridge joint



ASU-Test: 4 Section Assembly

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ECAL SLAB Interconnect - Where we are

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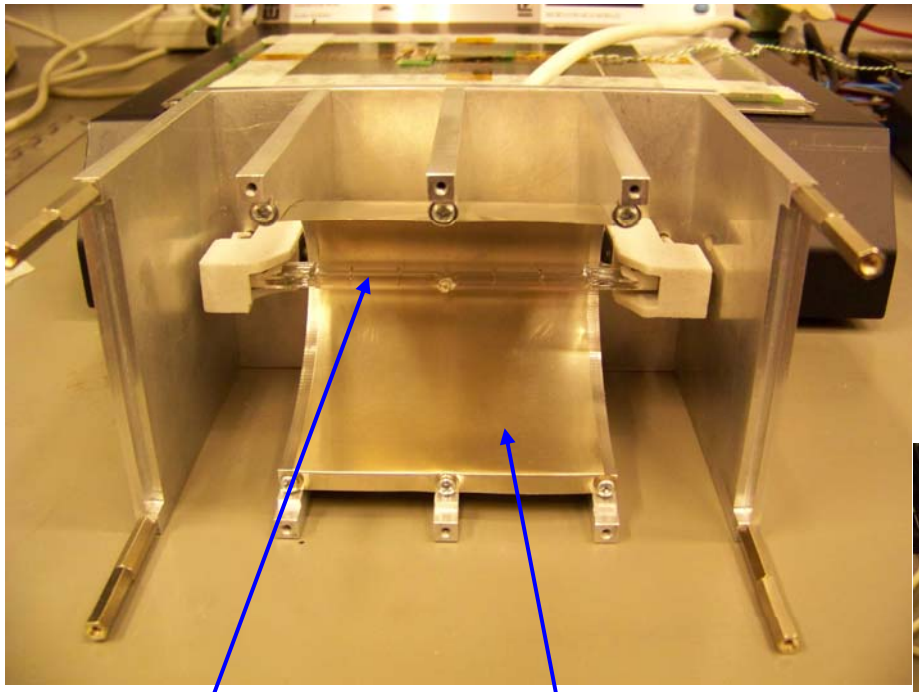
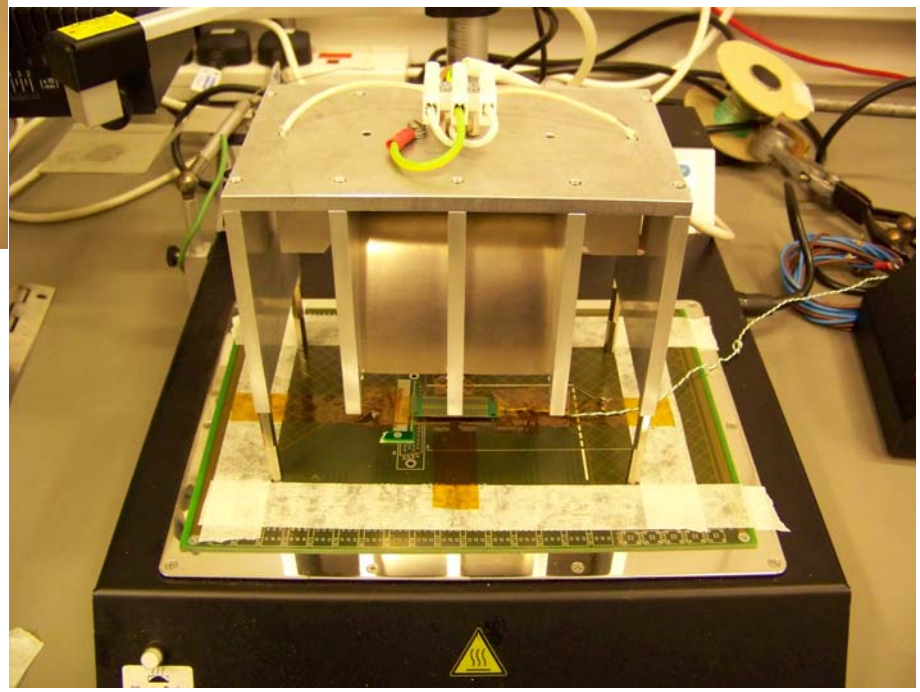


Linear Halogen Lamp

Elliptical Reflector

Re-flowing a PCB-Bridge



Imaging Halogen IR Source: first test

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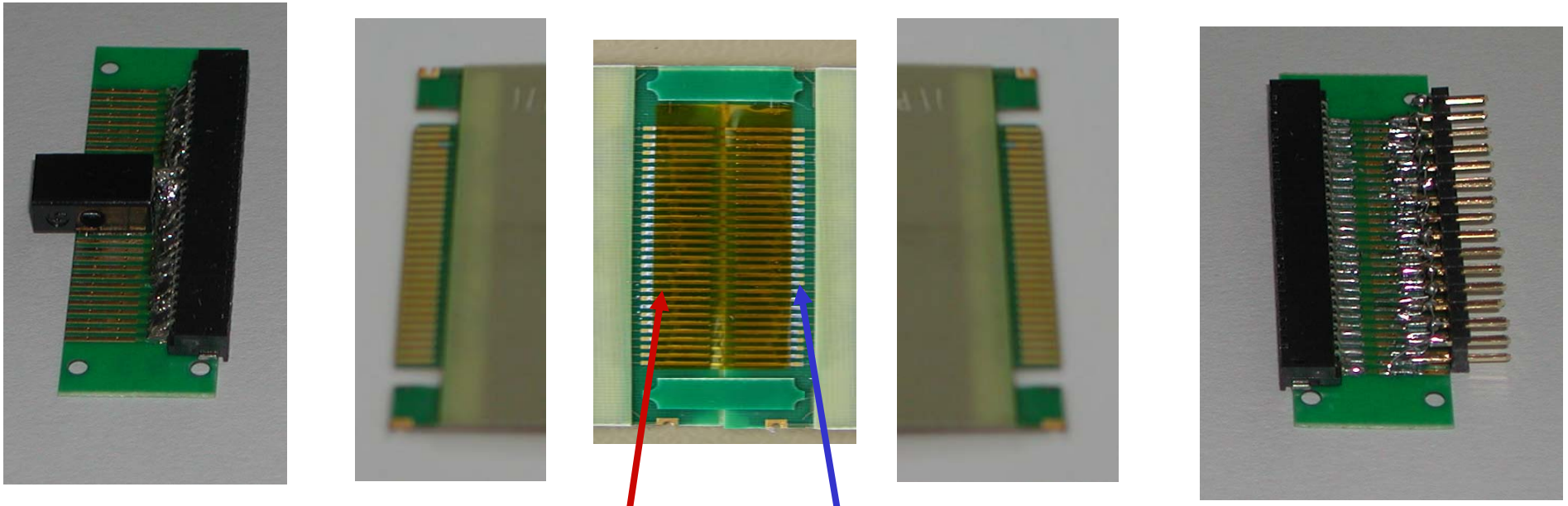
Current Inject

Notched ASU

Current Extract



Joint Quality - Voltage Drop

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ECAL SLAB Interconnect - Where we are

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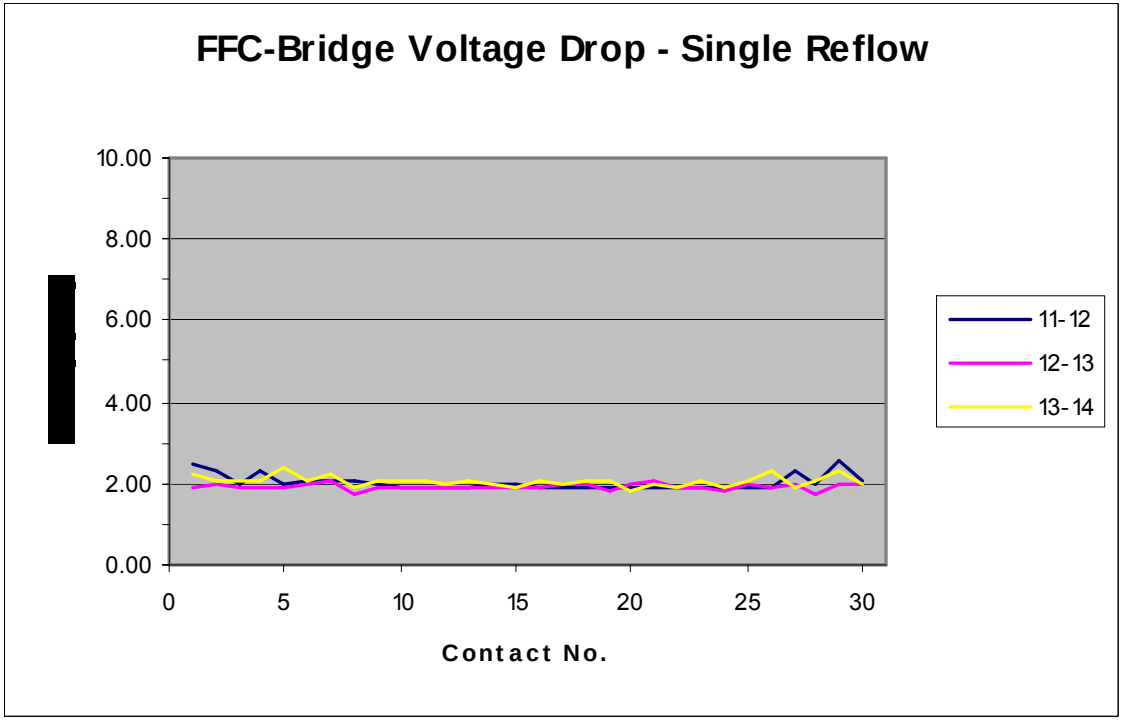
- mV for Current = 500 mA
- 4 ASU_Test2 slices
  - i.e. (3 joints)
- FFC-Bridge (Flexi)
  - Shortened to ~6mm
- Pb-free paste
- Qtz-Halogen source (300W)
- Single re-flow at 230°C



Joint Quality - Voltage Drop

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ECAL SLAB Interconnect - Where we are

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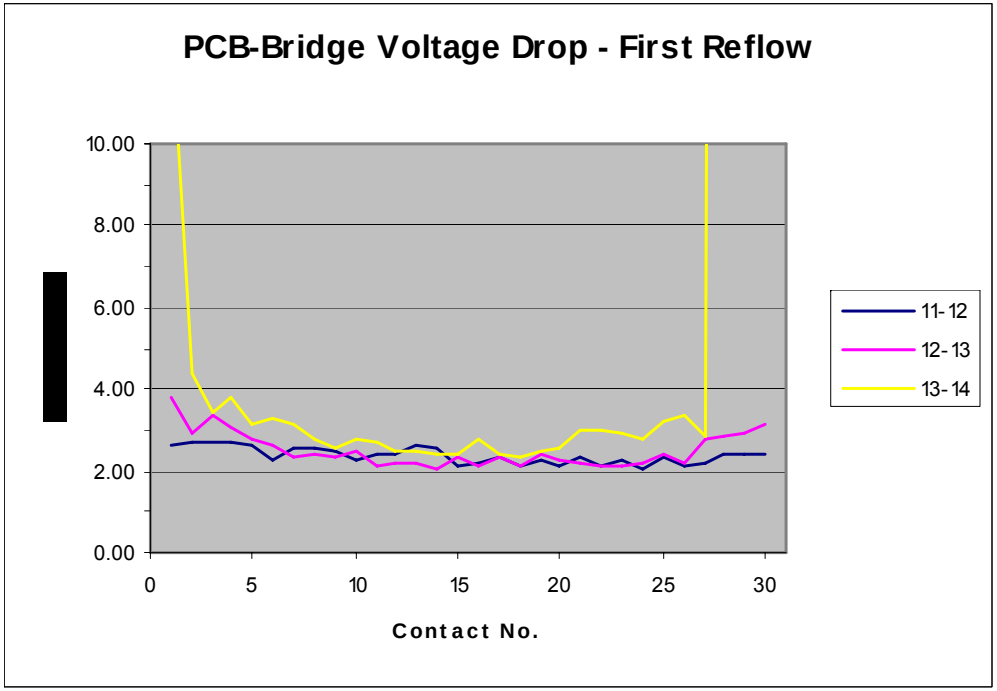
- mV for Current = 500 mA
- 4 ASU_Test2 slices
  - i.e. (3 joints)
- PCB-Bridge
  - Shortened to ~6mm
- Pb-free paste
- Qtz-Halogen source (300W)
- Re-flow at:
  * 230 °C for joint 11-12
  * 220 °C for joint 12-13
  * 210 °C for joint 13-14



Joint Quality - Voltage Drop

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ECAL SLAB Interconnect - Where we are

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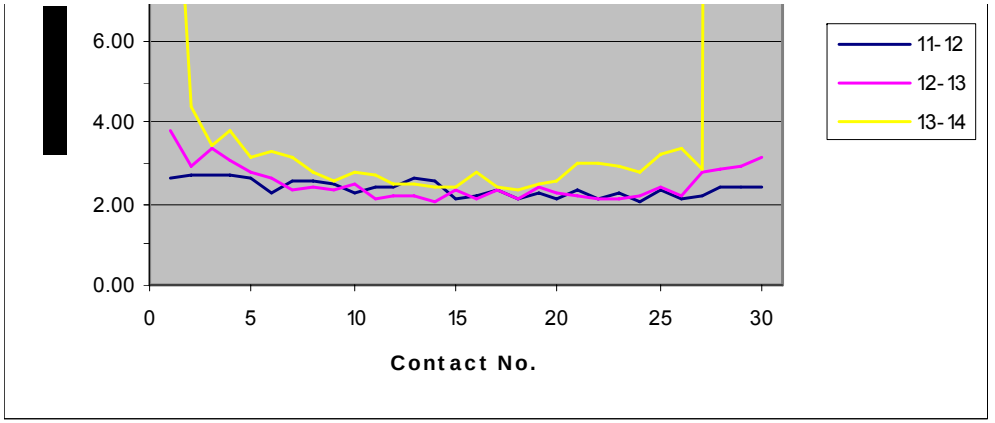

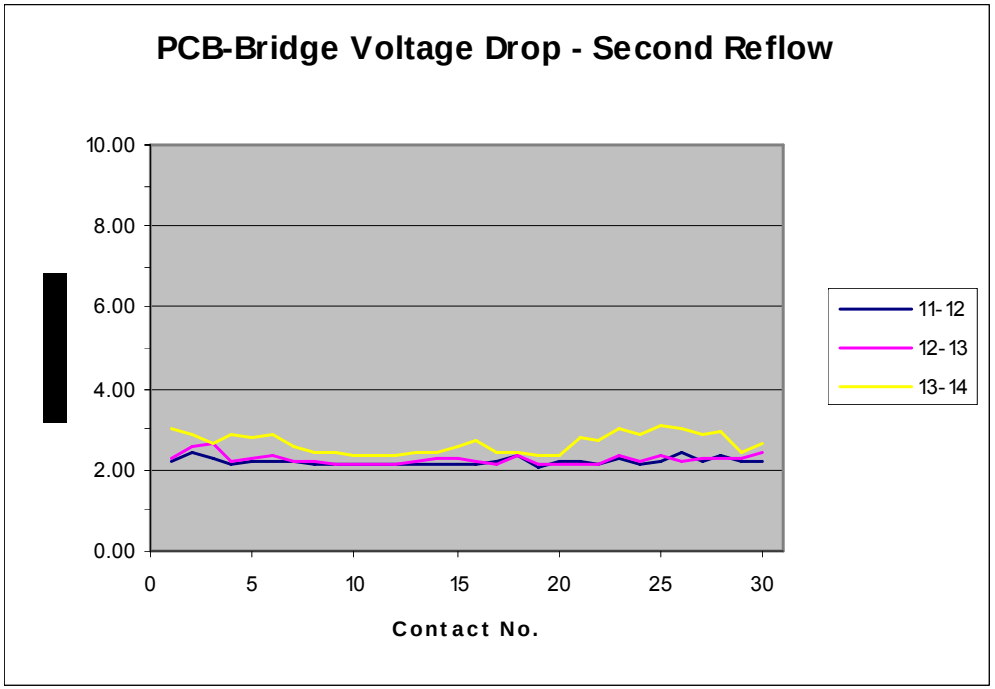

After Second Re-flow at 230 °C

Joint Quality - Voltage Drop

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ECAL SLAB Interconnect - Where we are

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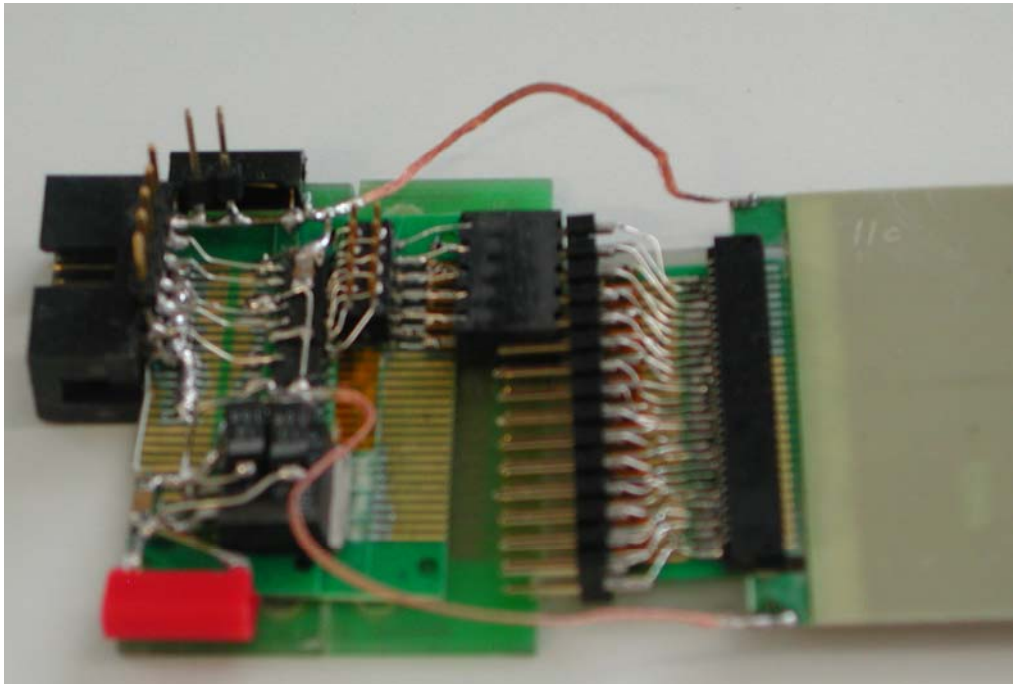
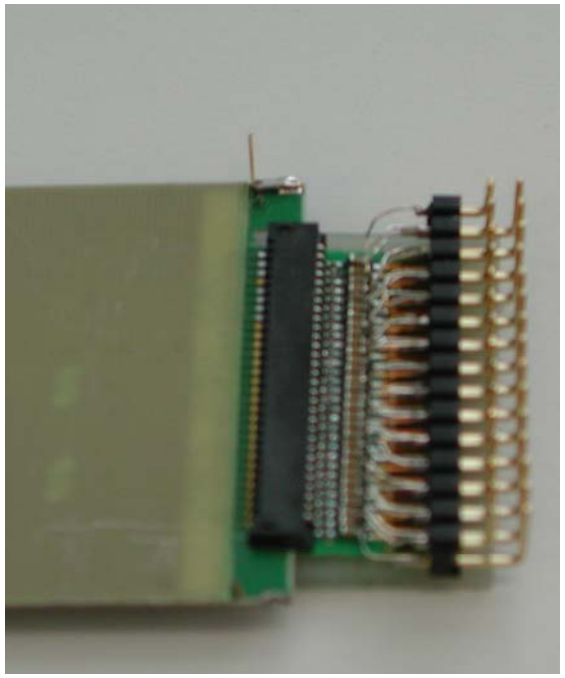
Signal Inject



Signal Select & Scope



Signal Propagation – Distortion and Cross-talk

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ECAL SLAB Interconnect - Where we are

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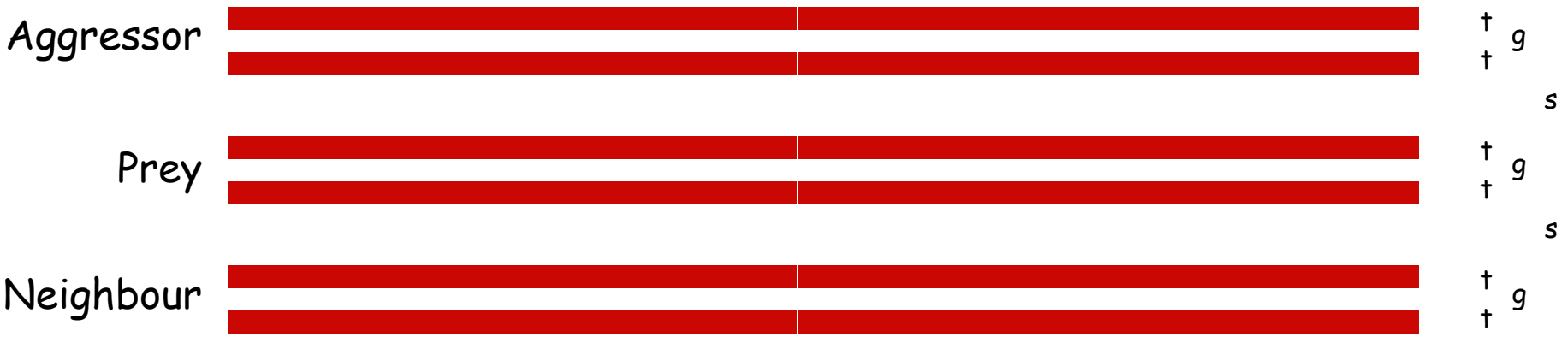

ASU-Test2 has range of different values for:

- track width **t**
- track-track gap for pair, **g**
- pair-pair separation, **s**

We are set up to drive the aggressor tracks while scoping the pray using an AC-coupled, differential scope probe with appropriate terminations.

Signal Propagation -Cross-talk

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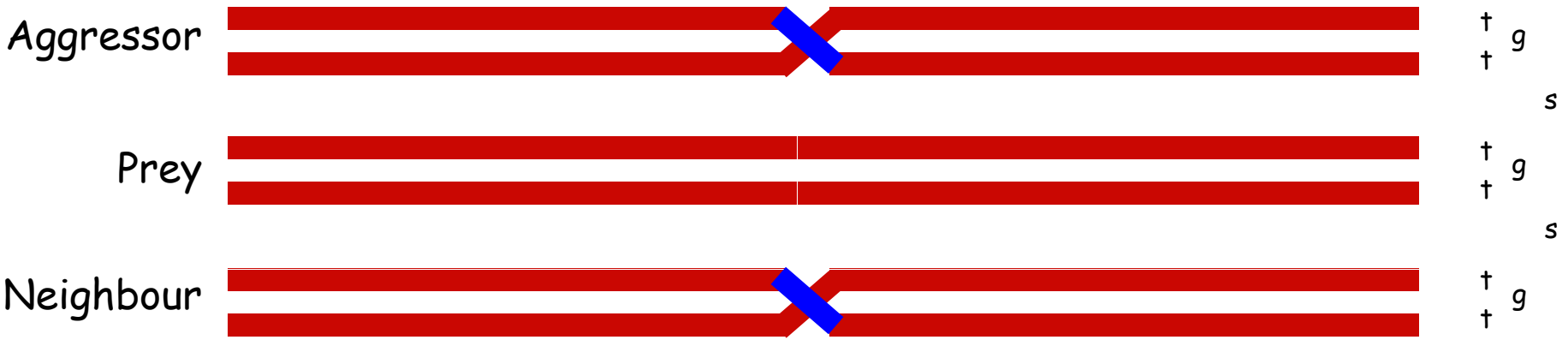

ASU-Test2 also has differential pairs with track cross-overs on adjacent pairs. The schemes used are somewhat more complicated to make all traces equivalent, and to avoid signal nett inversion across an ASU.

We will assess just how much these schemes reduce cross-talk

Signal Propagation -Cross-talk reduction

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ECAL SLAB Interconnect - Where we are

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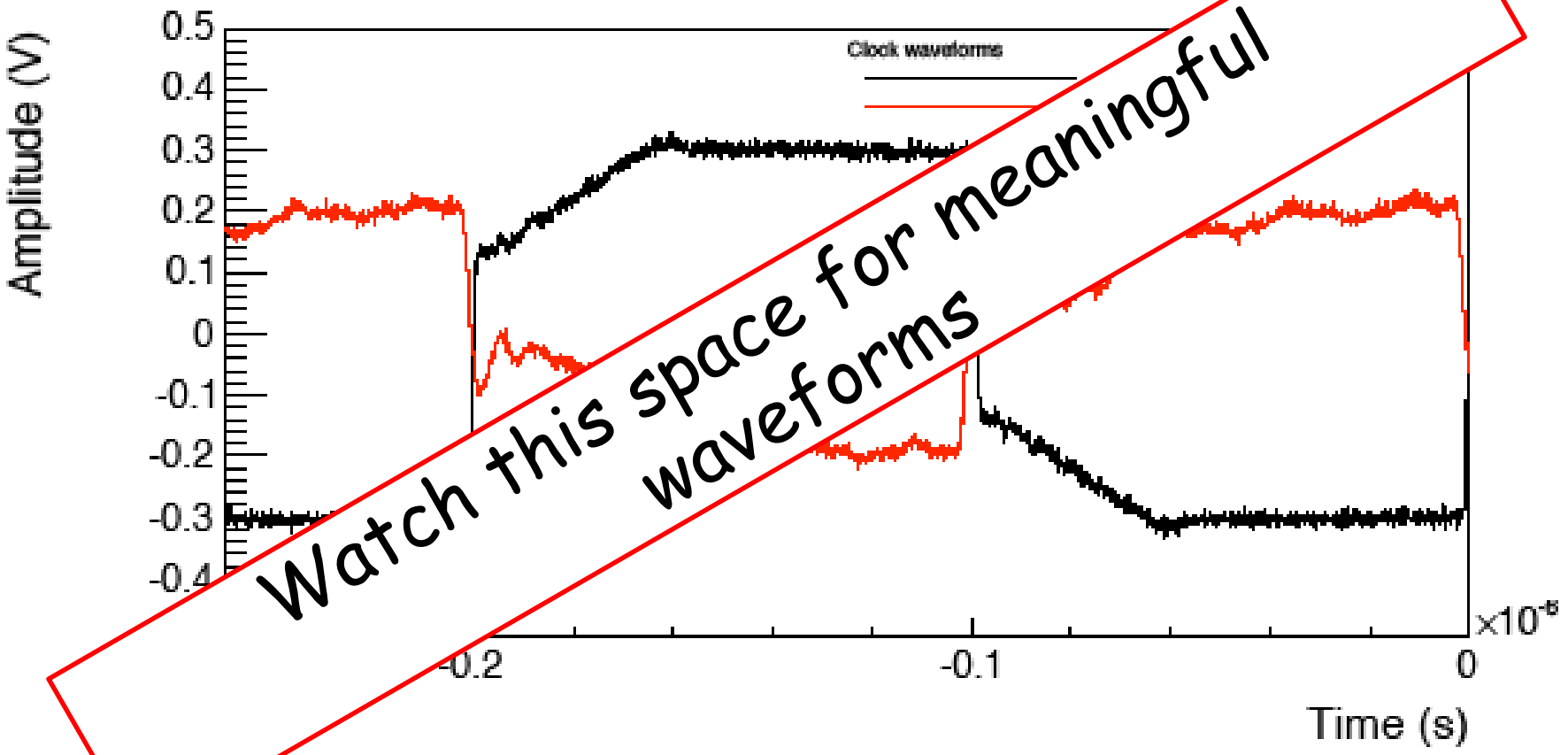

Signal Propagation – to come

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ECAL SLAB Interconnect: Conclusions

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There are major advantages in using Bridges:

- Removes major bottleneck in number of connections
- Promises greater reliability
- Rework likely to be easier

There's a lot to be done:

- We are trying out many things
- LAL Mechanical Prototype will also test PCB-Bridge mechanics
  - – FEV6 – we have 6
  - – what to do with them??
- Simulation studies of signal propagation (already in hand)

We are finding answers:

- 1mm pitch connections with continuity and no shorts
- IR re-flow looking very good:
  - ERSA Re-work station OK
  - Home-brew Imaging IR source working well, and…
    it may fit well into large-scale assembly procedures: full width re-flow, multiple heads,…

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ECAL SLAB Interconnect - Other Topics

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- Mechanical strength
- Re-work studies:
  - techniques: removal, clean-up, re-paste, re-re-flow
  - pad damage assessment
  - bond quality assessment
  - how many times can a bond be re-made ??
- Process tuning:
  - reduced lamp current for longer wavelength IR
  - temperature monitoring
  - how much pressure needed to flatten bridges
  - and how to apply it
  - multiple bonds at once

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The following are backup slides

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ECAL SLAB Interconnect - Where we are

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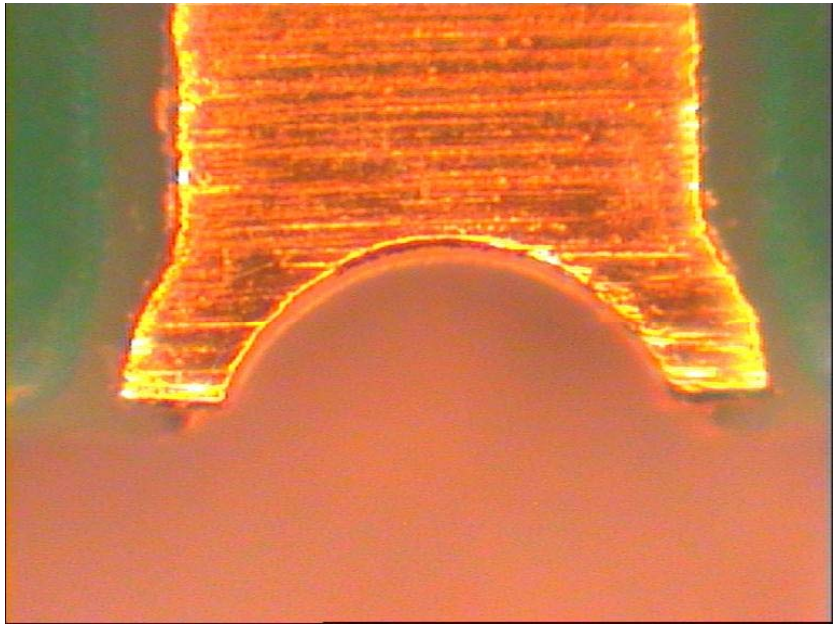

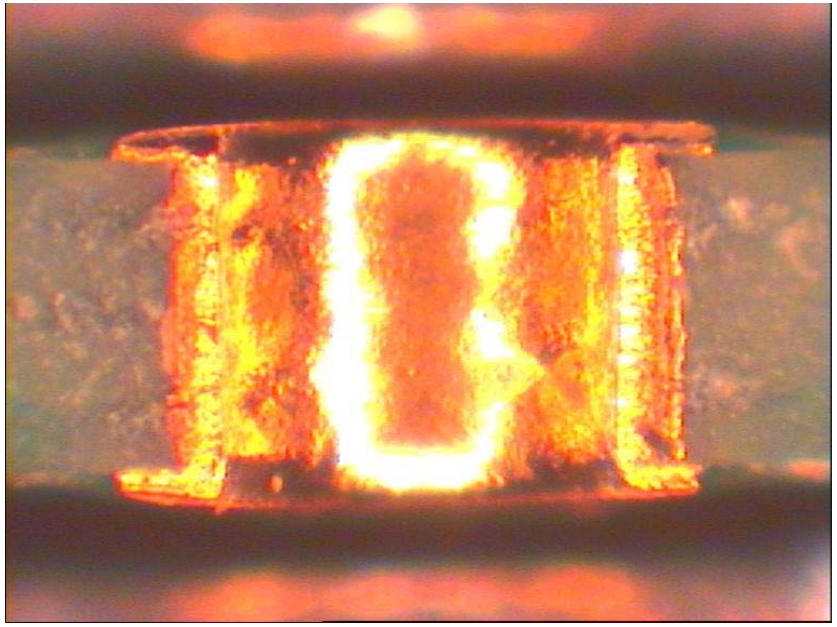

PCB-Bridges: half-via variant

We are building up a lot of pictures of bond quality and other features

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ECAL SLAB Interconnect

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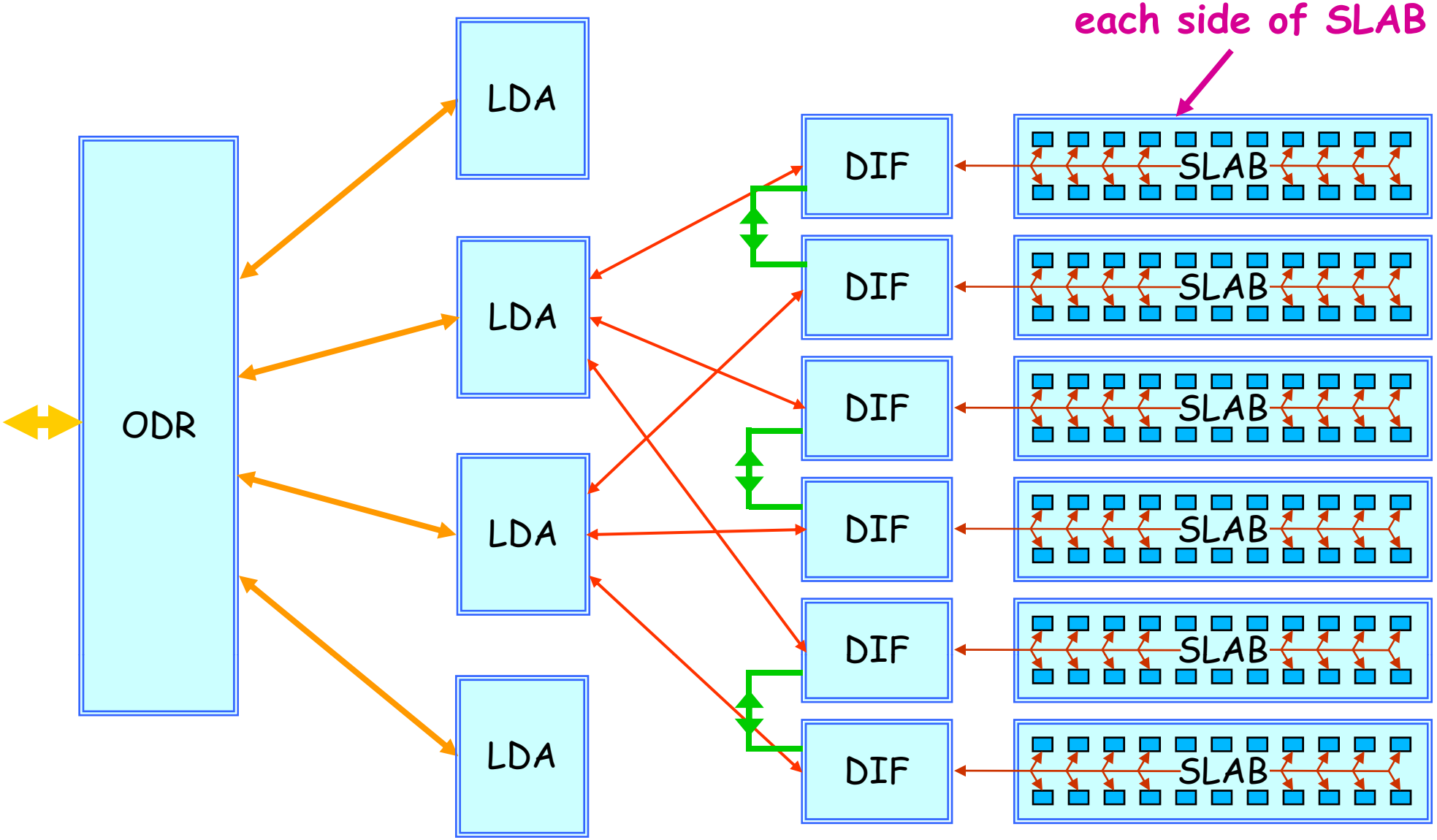
DAQ Architecture – Overall view

~150 VFE ASICs on each side of SLAB



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ECAL SLAB Interconnect – Why Multi-Rows?

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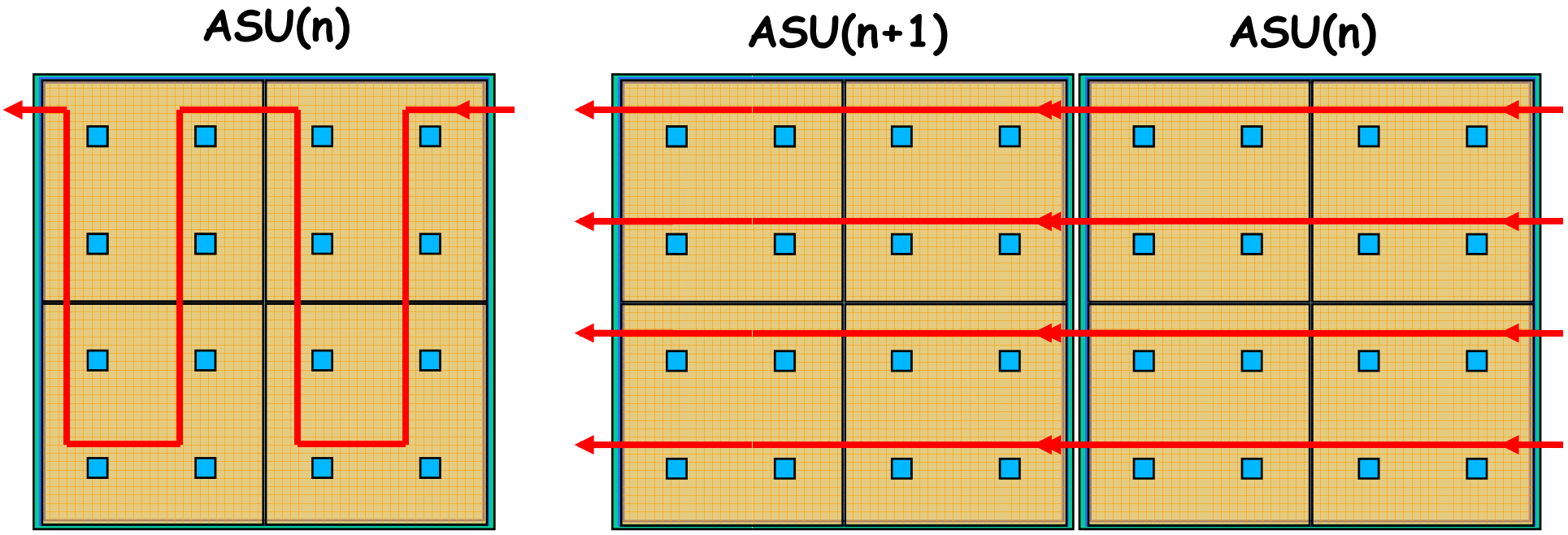
How to read them out – **single path** or in **4 rows?**



Single path

4 rows

Per ASU: L ~ 720mm, C ~ 72pF	Per ASU: L ~ 180mm, C ~ 18pF
Per Slab of 9 ASUs: L ~ 6.5m, C ~ 650pF	Per Slab of 9 ASUs: L ~ 1.6m, C ~ 160pF

Do these look **BIG ??**

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ECAL SLAB Interconnect – Why Multi-Rows?

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Multi Row is aesthetically **much more pleasing** ☺☺☺☺

- but what material advantages does it offer?

Clock and Control Lines: LVDS, controlled impedance

- length of each C&C trace reduced below $1/N_{ROWS}$:
  - less signal degradation
  - far cleaner routing – no need for stubs

Read-Out Lines: low voltage swing CMOS

- data load is shared between the rows, so lower rate needed
- length (and hence capacitance) of each readout trace reduced below $1/N_{ROWS}$
- power for R/O reduced in same ratio

The power savings not large compared to Slab power budget

But achieving data rates of several Mbits/sec over complex traces of several metres length will be **difficult** ☹ or **impossible** ☹☹☹

But Multi-Rows means lots of connections - **is this possible?** ☹ **or** ☺

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