Front-end electrical high speed links.

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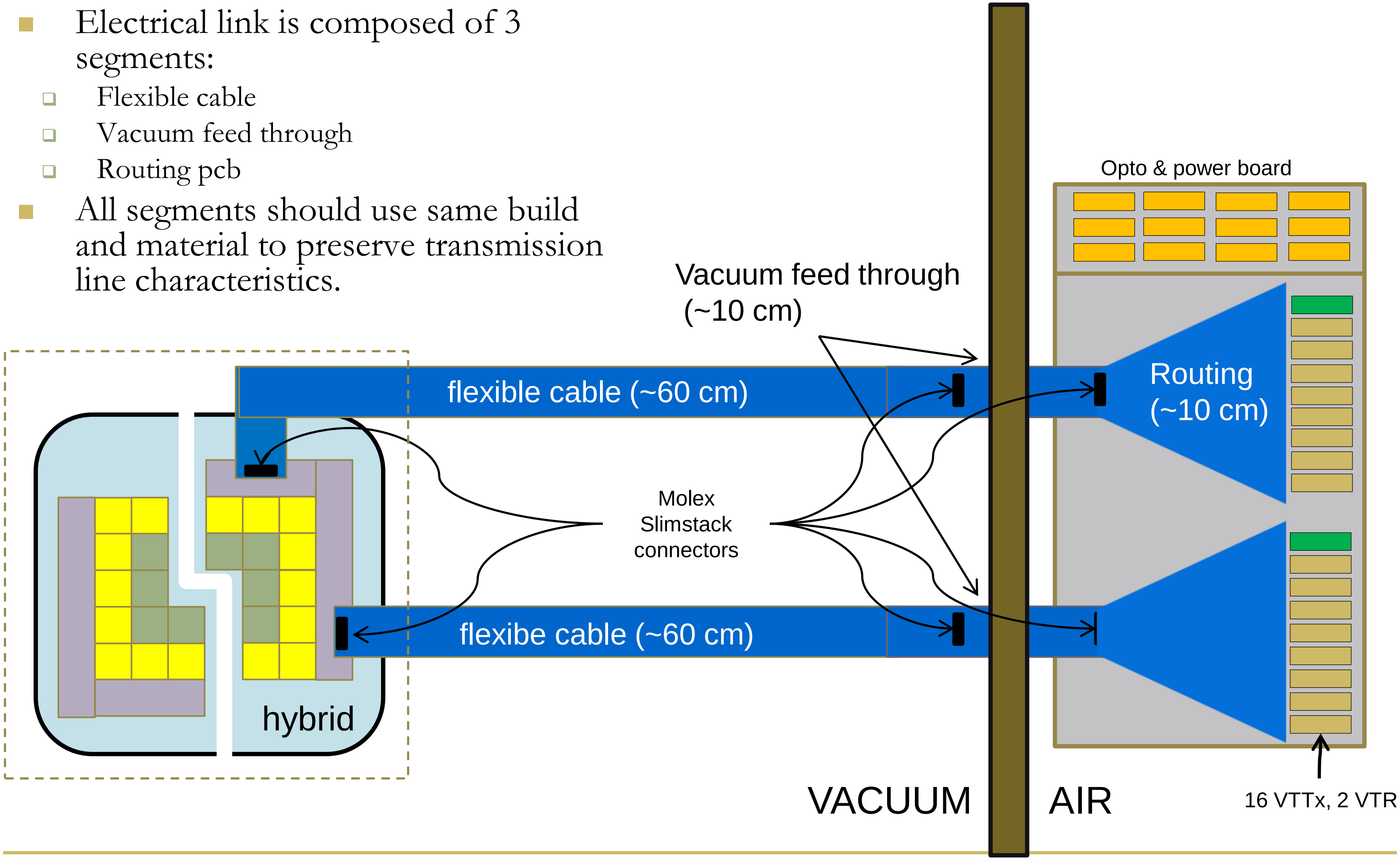
Motivation.

- A choice was made to not have optical components inside the vacuum tank.
- Reasons:
  - Delicateness & reliability of optical components & interconnects
  - Radiation sensitivity of lasers and fibers
  - Extra heat dissipation is problematic in vacuum.
  - Optical feed throughs (1600 !) more expensive then electrical. (single fiber)
  - Access for maintenance inside the tank is very difficult.
- But necessitates an electrical transmission cable with
  - Low material in particle acceptance
  - Low EMI/EMC & crosstalk
  - Minimized signal distortion
  - Sufficient flexibility to absorb motion during opening/closing of VELO halves

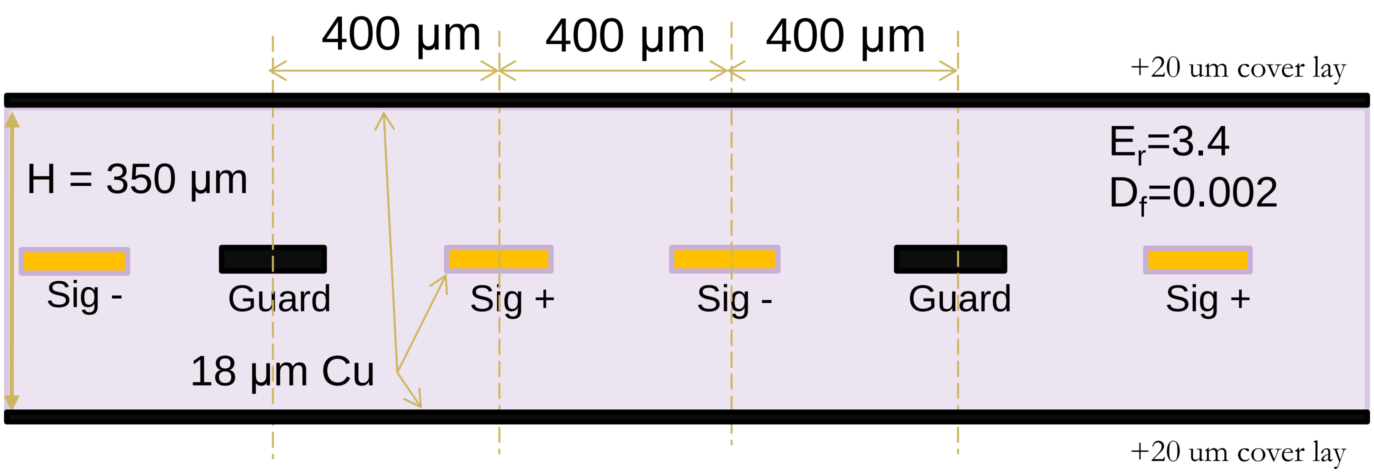
Implementation overview.

- Electrical link is composed of 3 segments:
  - Flexible cable
  - Vacuum feed through
  - Routing pcb
- All segments should use same build and material to preserve transmission line characteristics.



Cable construction

- Differential signals (CML or LVS)
- Edge coupled strip lines : reduces EMI/EMC
- Guard traces separating signal pairs: reduces crosstalk.
- All traces on a 400um pitch. Trace width/gap = 240/160 um.
- Total width ~ 430um gives reasonable flexibility.



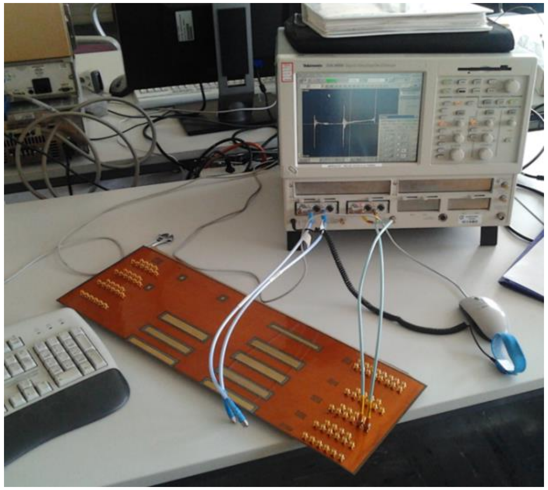
Laminates

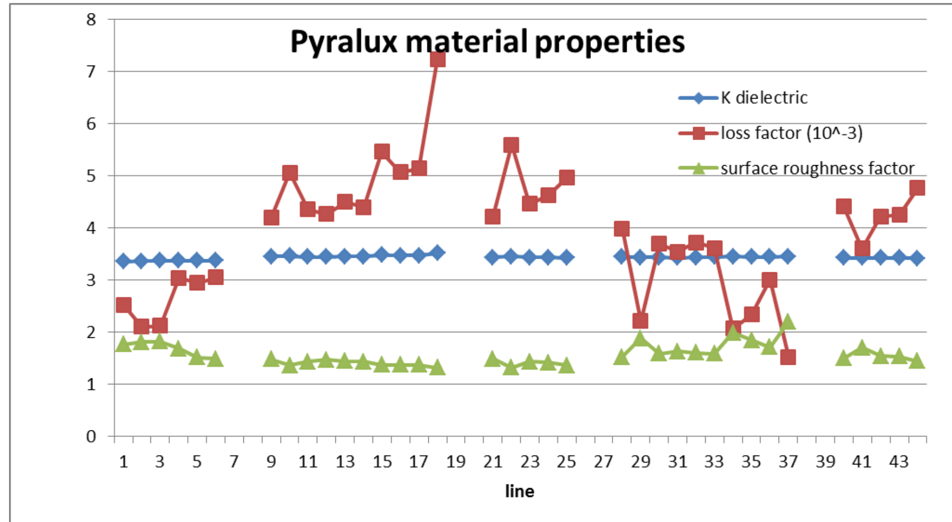
- Use polyimide "Pyralux AP-plus" from Dupont.
  - Targeted at high speed applications.
  - Dielectric thickness from 7 to 12 mil (175 to 300 um) :
    - avoids use of prepreg's for stacking thin layers.
    - Tightly controlled thickness (controlled impedance)
    - We have prototyped with 10 and 7 mil.
    - Dielectric loss is 0.002 @ 10GHz.
  - Copper clad layers with special low roughness surface (minimize skin effect) and thickness 5um -70um.
  - Available in large standard sheets 61cm x 91 cm

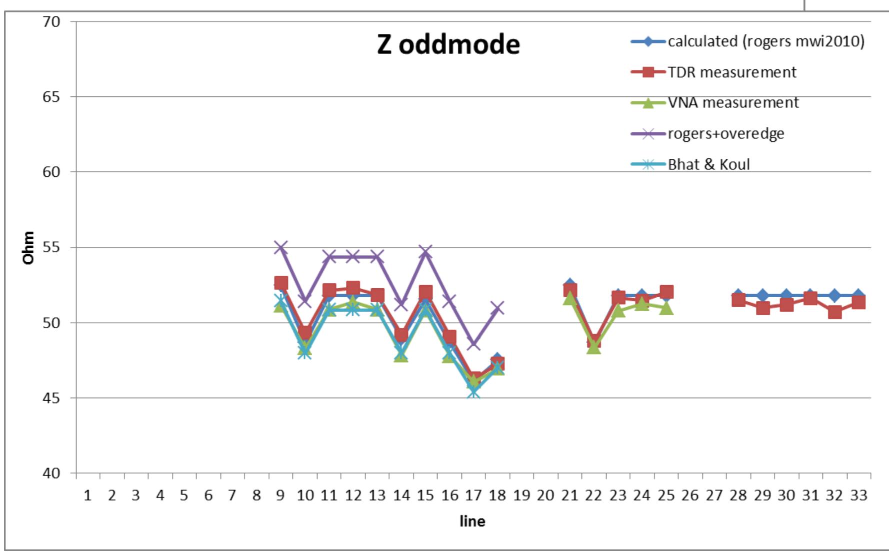
Signal distortion

- With Df=0.002, attenuation by skin effect loss dominates over attenuation due to dielectric loss up to 8Ghz.
- Therefore maximize trace width.
- But limited by aspect ratio W/H ~ 0.5 for obtaining ~100 Ohm characteristic impedance. H limited by flexibility.
- 2 Prototype production;
  - W=280um, H=500 um (1^{st} series)
  - W=240um, H=350 um (2^{nd} series)

First prototype series.



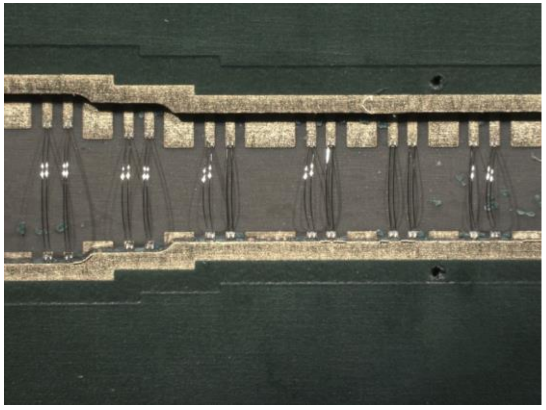


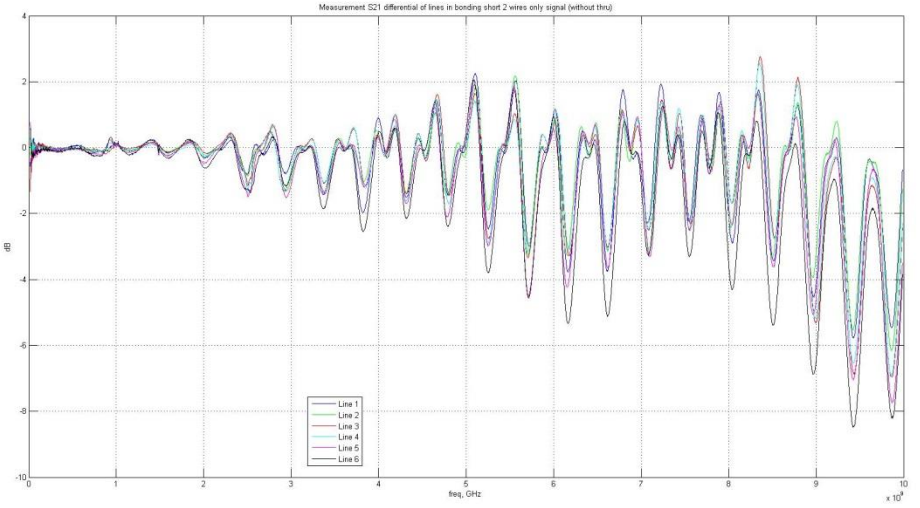


Eye diagram @ 4Gbps. 53 cm line including SMA cables.

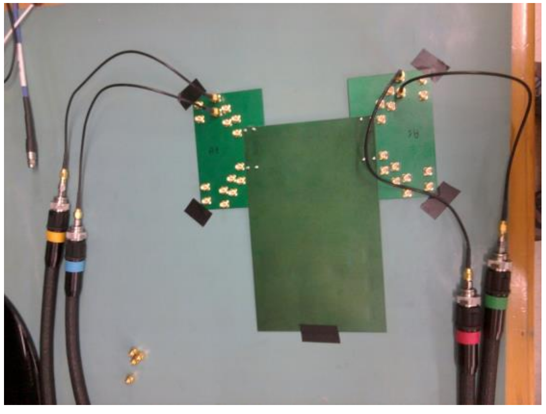
Second series

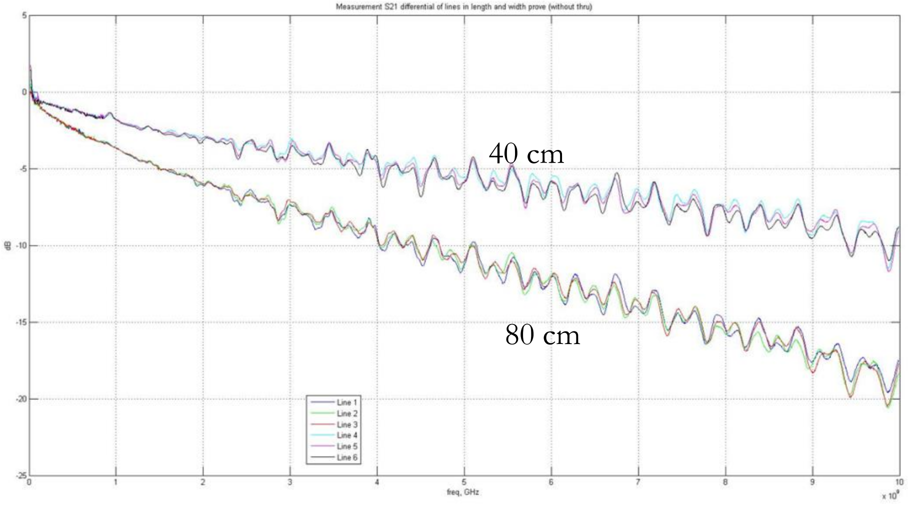
Measure S21 due to bonding wires





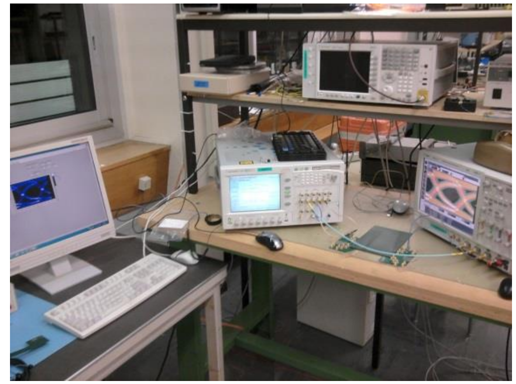
Measure S21 on 40 cm and 80 cm lines



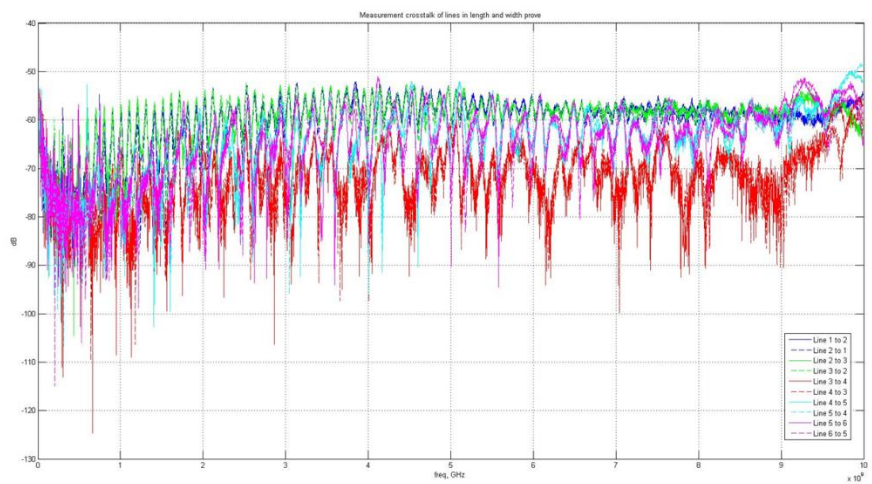


Second series

Eye diagram on 40 cm line , with clock recovery. Including test adapters and SMA cables

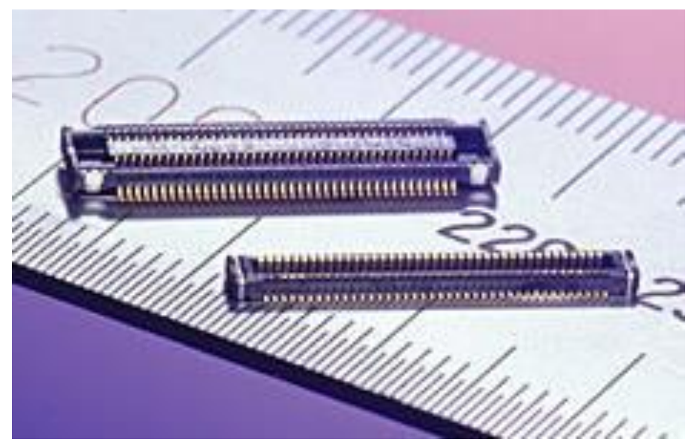


Crosstalk between lines. Below -55dB.



Interconnections.

- All interconnections use Molex Slimstack 0.4mm pitch board-to-board connectors.
  - Low mass: 1mm total mated height.
  - ‘Self locking’
  - 300mA current rating / pin
  - LCP housing material. Very radiation resistant (>1Grad).
  - Insertion loss ~ 0.1 dB up to 5 GHz.



Next steps.

- Need to prototype:
  - Feedthrough.
  - Routing on OPB board.
  - New cable, adapted to VeloPix hybrid.
- Measure a complete chain using GWT asics and VTTx.
- This will start very soon in collaboration Glasgow University & CERN.