Progress Report B-TOF

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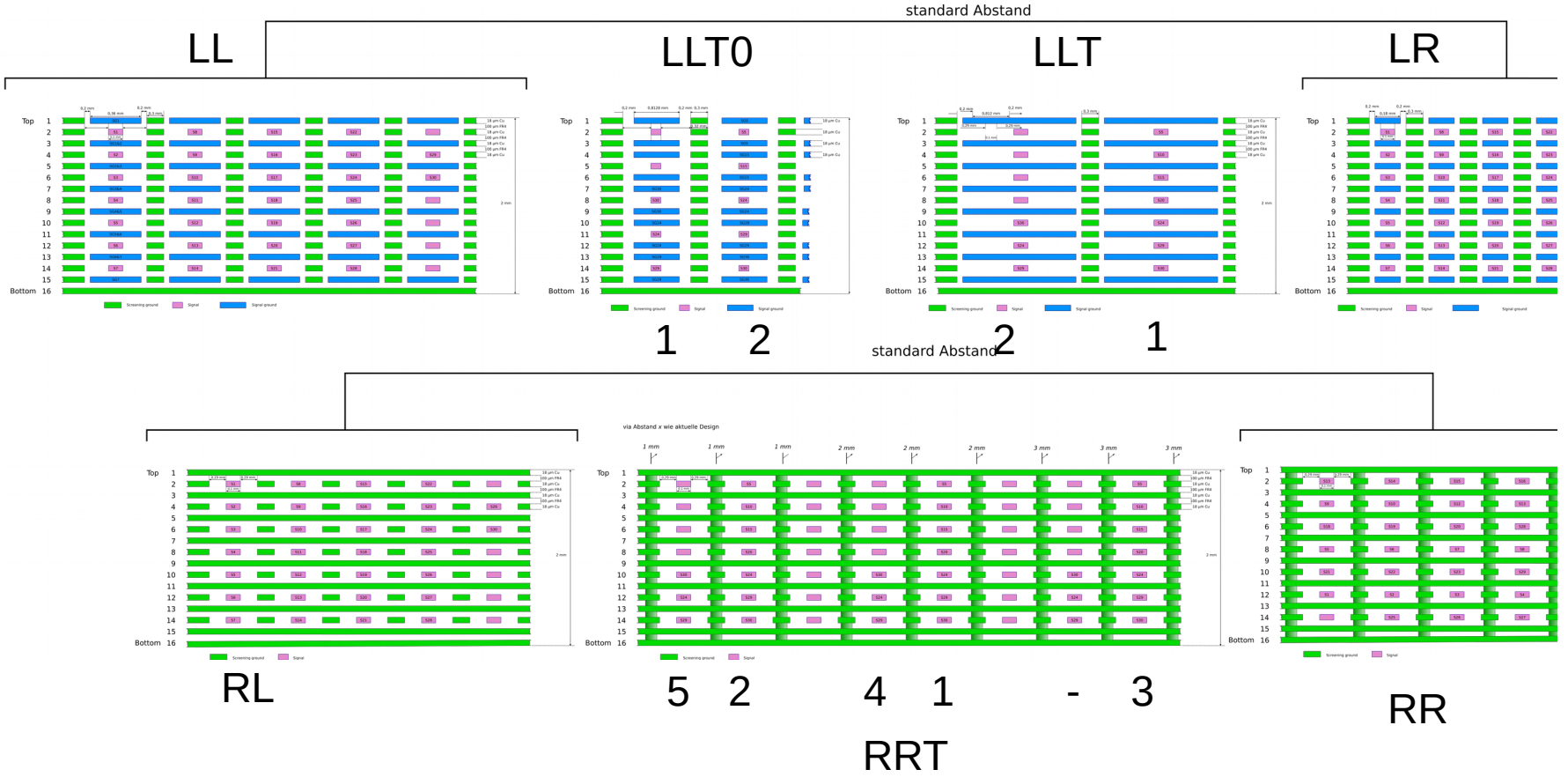
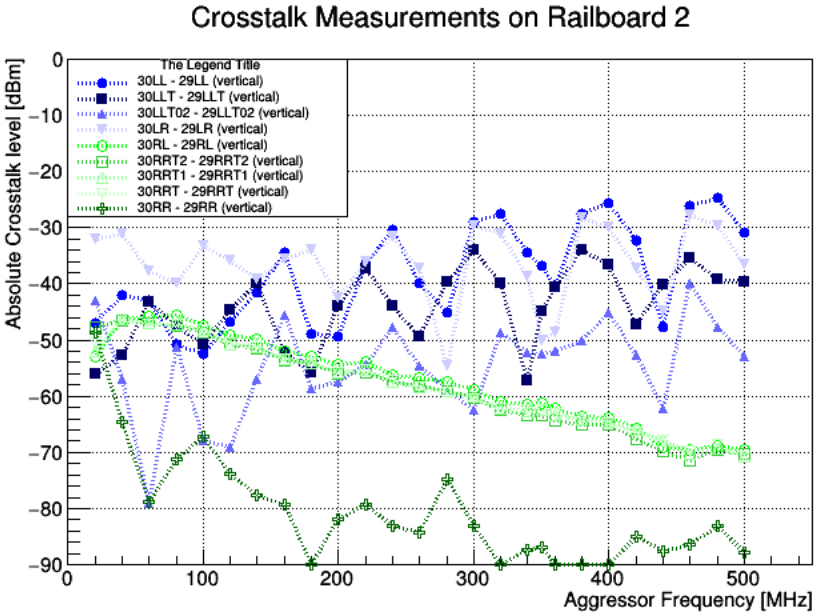
Railboard Structure



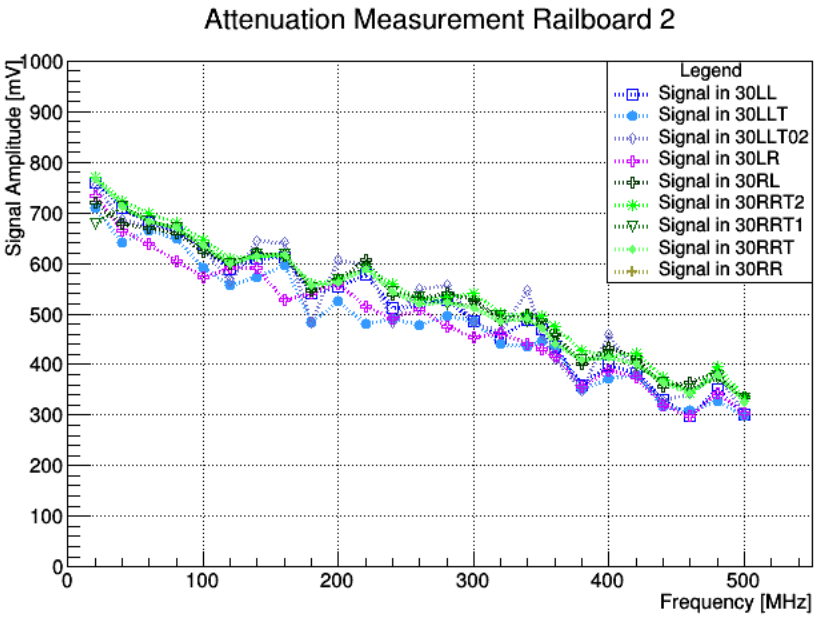
Crosstalk

- Measurements done with Keysight 81160A, Pulse Fuction Arbitrary Generator
- Signal in on sensor side
- CT measured at FEE side
- All in/outputs connected to scope
- Structure of 1 Ground crosstalk is drastically different from the 2 and 3 ground designs
  - No resonances, just decreasing steadily
- 30RR – 29RR are physically separated further that the other lines
- Crosstalk measured with spectrum analyser (LeCroy 6 GHz scope)
  - Measured in absolute values (dBm)

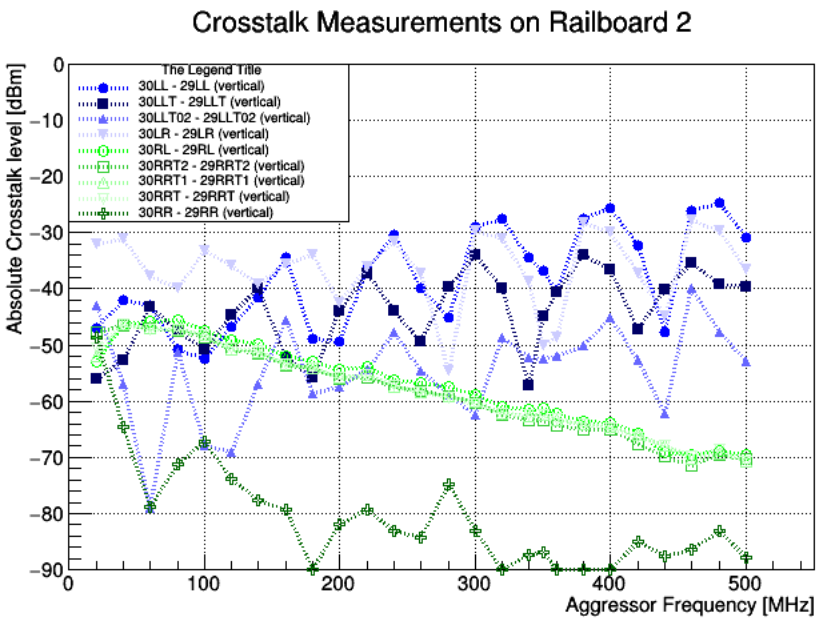


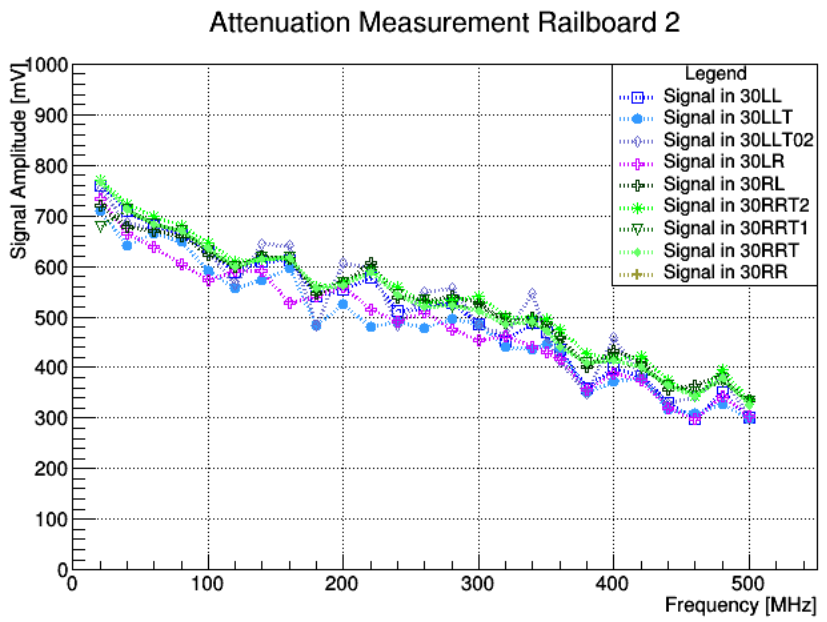
Attenuation

- Measurements done by measuring the amplitude of the sinusoidal input signal after transmission through the Railboard
- No systematic differences between the designs
  - 1 Ground might have slightly lower attenuation than the other two



Crosstalk & Attenuation





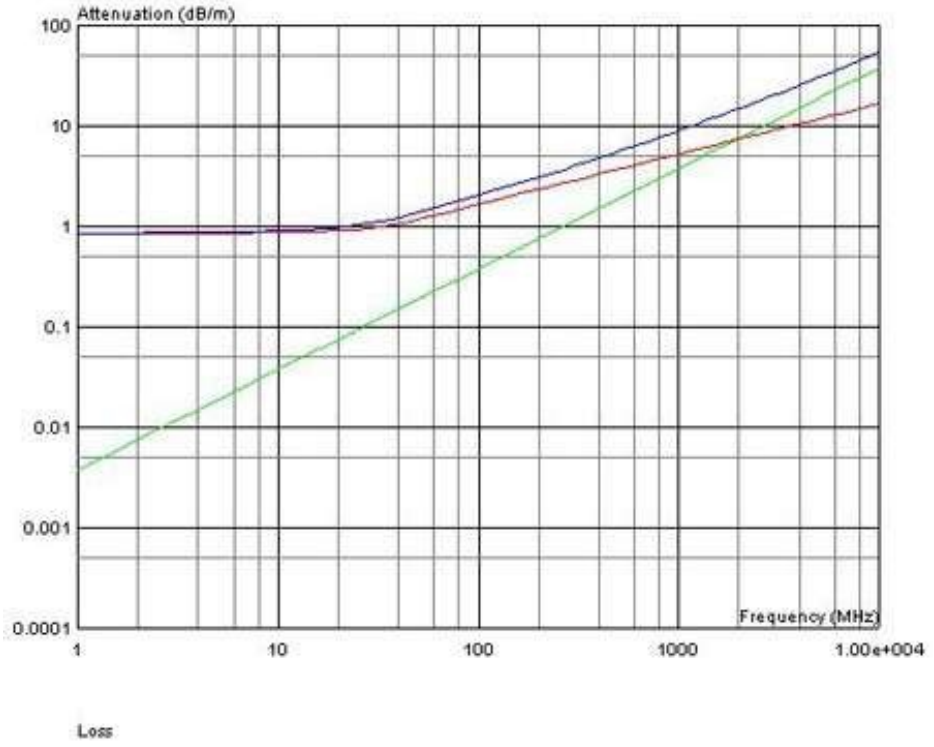
Further improvements to the Railboard

- The crosstalk performance is not an issue
- The attenuation with a drop of ~50% signal strength is too high at the moment

- Attenuation dominated by two effects
  - Resistance of the material (skin effect)
  - Permeability of the surrounding material
- Weighting of these effects is frequency dependant
  - Resistance effect slightly dominating at ~350 kHz

Signal Attenuation in PCBs

- Signal attenuation for resistive losses (red) & dielectric losses (green)
- Expected frequency ~350 kHz
  - Resistive losses only slightly higher than dielectric
- Solutions for both problems will improve performance



Reduce Attenuation

- Resistive losses
  - Dominated by skin effect
  - Low loss materials on the surface (Gold, extra pure copper)
    - costly
  - Increase the signal line cross-section
    - Use split lines joined together at beginning and end
      - Technically hard to produce
    - Increase line thickness
      - Adds unnecessary material
    - Increase line width
      - Most efficient solution

- Dielectric losses
  - FR4 is not optimized for high frequency signals
  - Other materials with lower permittivity ε perform better at high frequencies
  - Optimized materials increase cost
  - Size constraints for more exotic materials
  - Difficult to solve
    - Needs knowledge of costs and supplier availability

Railboard Producer

- In contact with two potential producer
- CERN (micro pattern technologies) is able to produce long boards
  - > 2.4 m is possible
  - More confident with a >1800 mm split board (electronics, sensors)
  - Does not recommend using advanced techniques to reduce attenuation except increasing line cross-section
- Global PCB production leader (austrian company) AT&S not able to produce boards >500mm
  - But otherwise very interested in the project
- Thales Group Competence Centre PCB in the Netherlands is interested in pursuing this project
  - Have expertise (working on radar systems with similar requirements)
  - Suggested to split the boards into at least two parts
  - NDA was just signed days ago

CERN Offer

Subject: Price Offer

Long PCB :

-B version
-size 1.8m x 18cm
-16 metal layers
-18um CU on each inner layer
-40um CU on the 2 outer ones
-100 um dielectric between each layer
- minimum Line 0.15mm
- row of GND PTH every 5cm
- Mask both sides
- selective NI/AU on pads for connectivity

Price : 6110 CHF/piece for 2 pieces
4080 CHF/piece for 16 pieces

Tooling cost : 2650 CHF if the 8 signal layers are different and grounding similar

Transportation cost to be define (wooden box ?)
Delivery : 2 pieces in 3 months (can be discussed)
14 pieces in 6 months (can be discussed)
CERN is the producer of these parts.

Vague statement from Thales:
cost before production >10 k€

Parasitic Beamtime CERN

- Were able to take data during the PANDA DIRC beam time at CERN
- Took most data with B-DIRC readout (padiwa boards)
- Measurements done:
  - SciTil at different angles
    - Hypothesis: real performance improves compared to the test with orthogonal particle beams
  - Sensorboard with 6 SiPMs
    - Hypothesis: performance increase without cost increase by using more cheap sensors
  - Different SiPM manufacturers tested
    - Hamamatsu, AdvanSiD, Ketek
    - For performance comparison

- Half a day of data taken with the TOF-PET ASIC v2 by the disc DIRC group from Gießen
  - Study influence of the TOF PET ASIC on the performance
- Currently still working on the data analysis
- No results yet

Summary

- The Railboardv2 was tested
  - Crosstalk seems fine for all designs
    - Best performance with 1GND design
  - Attenuation is still an issue (extrapolated 50% loss at 2m)
- Full length Railboard production is moving forward
  - Two potential producers: Thales, CERN
- Testbeam data from August at CERN still needs to be analysed
  - Includes data from the TOF-PET ASIC v2 by Gießen

Thank you for your attention