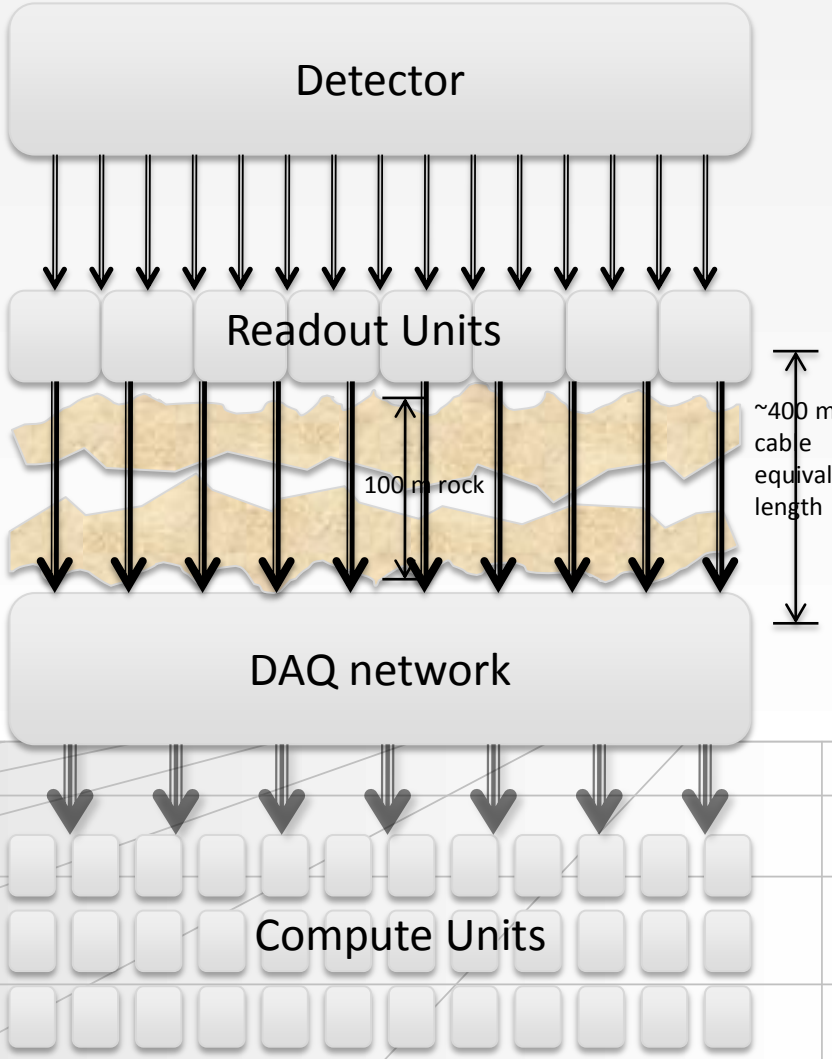
Update on Optical Fibre issues

Rainer Schwemmer

Key figures

- Minimum required bandwidth: 32 Tbit/s
  - # of 100 Gigabit/s links > 320, # of 40 Gigabit/s links > 800, # of 10 Gigabit/s links > 3200
  - # of 5Gbit GBT links (3.2Gbit effective): > 10000
- Option 1: BE downstairs
- Option 2: BE upstairs

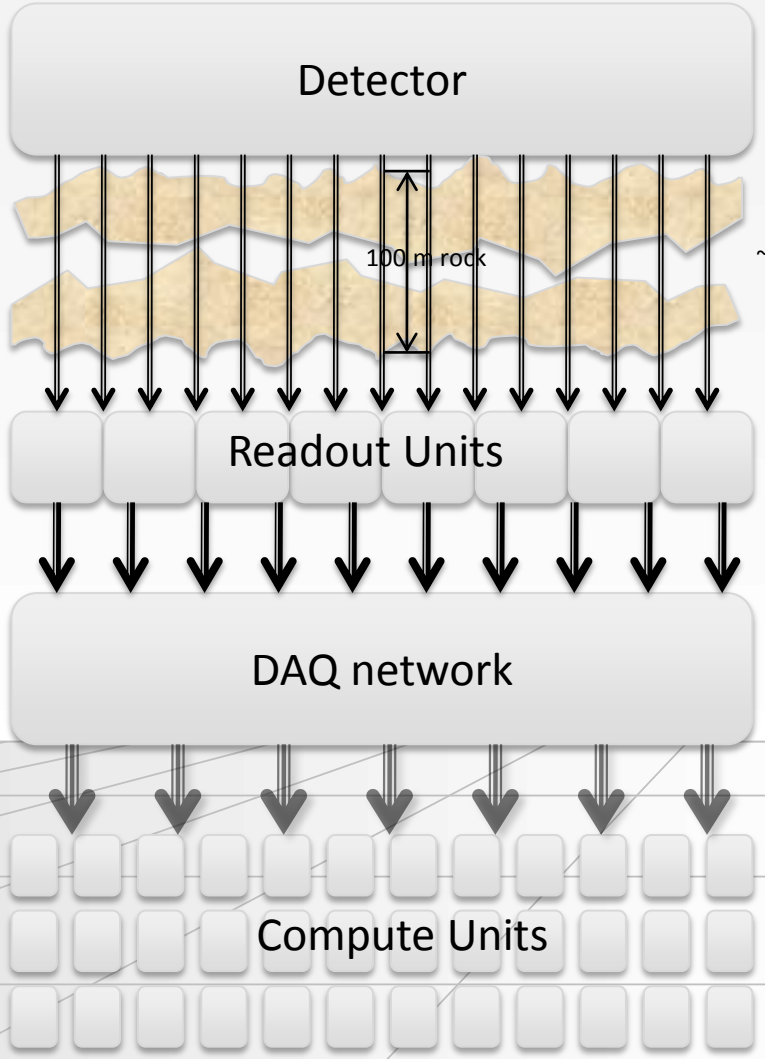
BE Downstairs



Short Distance links from Detector to Tell40
Long Distance commercial network links to upstairs

- Pro:
  - Detector → BE is within current versatile link specs
- Cons:
  - Currently no affordable commercial solution for BE to DAQ
  - When it comes it will not be cheap
  - All the little annoyances that come with having the electronics downstairs
  - Limited space, limited power, limited cooling, access

Preferred Solution: GBT all the way



Long distance covered by low-speed links from detector to Readout Units.
☺ Cheap and links required anyhow

- Pros:
  - DAQ Network + Readout Units in one place
  - (Almost) no space constraints on BE installation
  - All cots based interconnects are very short → cheap
- Cons:
  - See this presentation

Furukawa Fibre/Avago MiniPOD test

- Versatile Link, like 10Gbit Ethernet is specified for 150m
- Assumes rather high radiation levels which don't really apply to us
- VL only runs at 5Gbit/s signaling rate
- Lower radiation levels
- Commercial components are already capable of reaching much longer distances

➔ Test if we can find a fibre + receiver/transmitter which can reach the necessary 400m

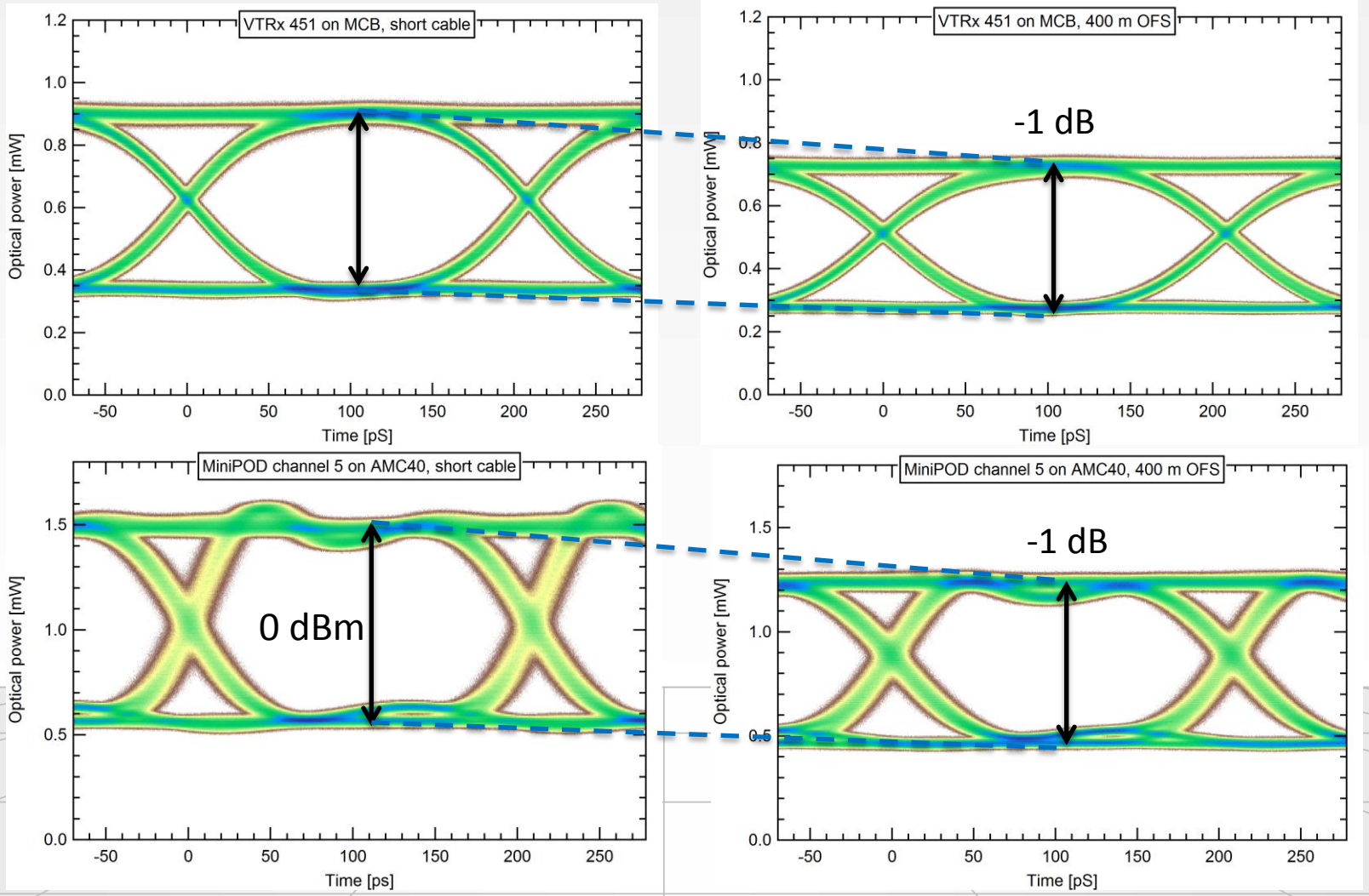
Early Optical Link Budget estimate

Description	Unit	VTx to Rx	Tx to VRx
Transmitter OMA	dBm	-5.2	-3.2
Fiber loss (2.3 dB/km)	dB	0.6	0.6
Connectors (0.75 dB/pair)	dB	1.5	1.5
Penalties (400m, 4.8G)	dB	1.0	1.0
Tx Radiation penalty	dB	0	–
Rx Radiation penalty	dB	–	2.5
Fibre Radiation penalty	dB	0.1	0.1
Receiver sensitivity	dBm	-11.1	-13.1
Margin	*dB*	*2.7*	*4.2*

Measure these values to see if we can do better

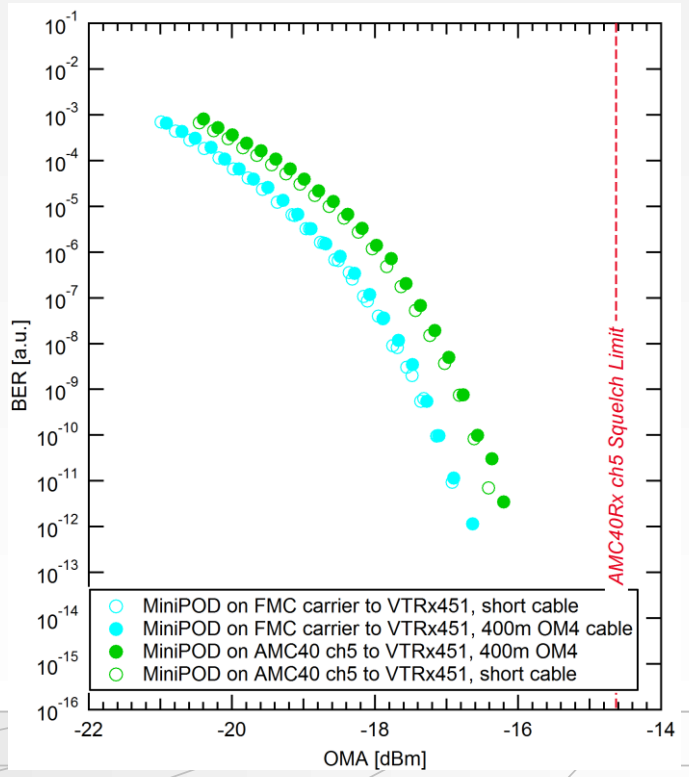
First Estimate of available link quality in both directions, based on fibre estimates and worst case receiver tests done by Avago in early 2011

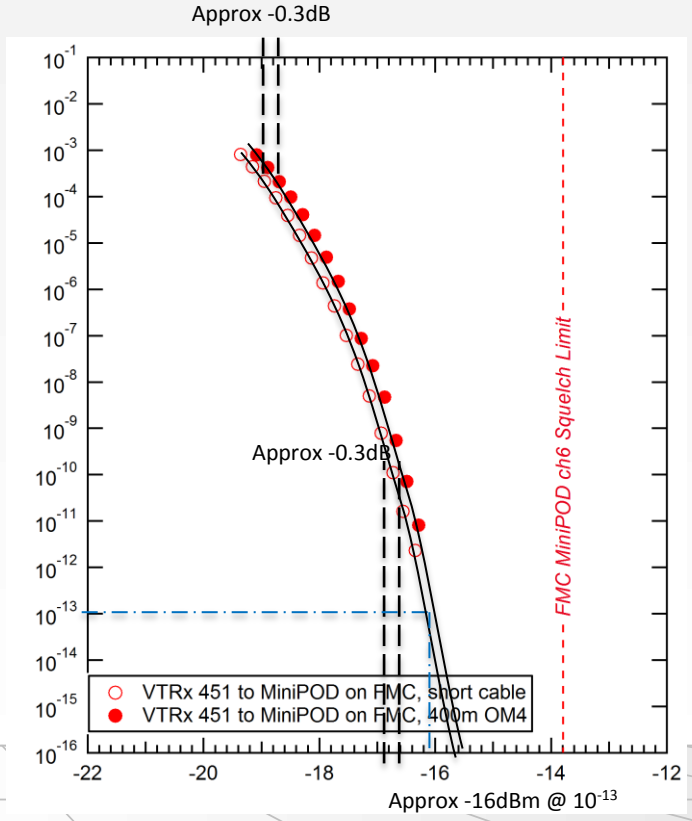
Eye Diagram Measurements



- Attenuation is actually -1dB
- Optical launch power of MiniPOD can be turned up to almost 0 dBm

BERT for Mode Dispersion and Receiver sensitivity





- Penalty due to Mode Dispersion @ 5Gbit/s is much better than anticipated
  - -0.3dB instead of -1dB
- Receiver sensitivity also seems to have improved
  - -16dBm @ BERT of 10^{-13}
  - -14dBm according to receiver noise detection threshold

New Optical Link Budget @ BERT 10^{-13}

Description	Unit	VTx to Rx	Tx to VRx
Transmitter OMA	dBm	-5.2	-0.4
Fiber loss (2.3 dB/km)	dB	1.0 (1.2)	1.0 (1.2)
Connectors (0.5 dB/pair)	dB	1.5	1.5
Penalties (400m, 4.8G)	dB	0.5	0.5
Tx Radiation penalty	dB	0	–
Rx Radiation penalty	dB	–	2.5
Fibre Radiation penalty	dB	0.1	0.1
Receiver sensitivity	dBm	-14.0	-13.1
Margin	*dB*	5.7(5.5)	7.1(6.9)

- Current GBT FEC will add another 6-7dB to this Margin !
- We have not used any equalizer cleanup yet

To do

- Gather more statistics
  - We are going to set up a more automated set-up to measure a larger amount of MiniPOD devices
- If these values persist
- Go for small scale installation at P8
  - Install cable holding infrastructure
  - Install small amount of long distance fibres
  - Terminate with MPO connectors
  - Install Tell40 and VTRx boards upstairs/downstairs
- Do a long running system test

The network options

- Two local area network technologies are investigated: Ethernet and InfiniBand
- Speed-grades
  - Ethernet 10 Gbit/s, 40 Gbit/s and 100 Gbit/s (only for up-links and interconnects)
  - InfiniBand QDR 32 Gbit/s FDR 54 Gbit/s (in the future: EDR ~ 100 Gbit/s)
- Both technologies will use the same physical link technology

The case for a long distance DAQ network

- 450m SR version of Ethernet and IB transceivers is going to be released within the next 2 years (at least by Avago)
- They will of course be more expensive than the 100m versions
- Similar measurements we did at 10Gbit/s show that it will work
- Keep in mind though:
  - Long distance GBT will also profit from 10Gbit improvements
  - If we go for long distance network, we might have to buy twice the amount of optical equipment (can most likely get away with copper if BE upstairs)
  - Increasing the amount of TELL40s upstairs is easy. Downstairs will be a nightmare

Summary

- Fiber attenuation is more than expected, but mode dispersion is less strong
- Performance of MiniPOD seems to be much better than advertised
  - To be expected, since the manufacturer has an agenda of increasing range with these devices
- Long distance GBT solution looks very feasible
- Vendors will most likely not commit to this usage though
  - They anyway don't for 5 GBs
  - We will have to qualify the components ourselves
- Work on a test with more devices to gather more statistics
- If this test checks out → Small system installation at P8 with and long time test to determine real BER