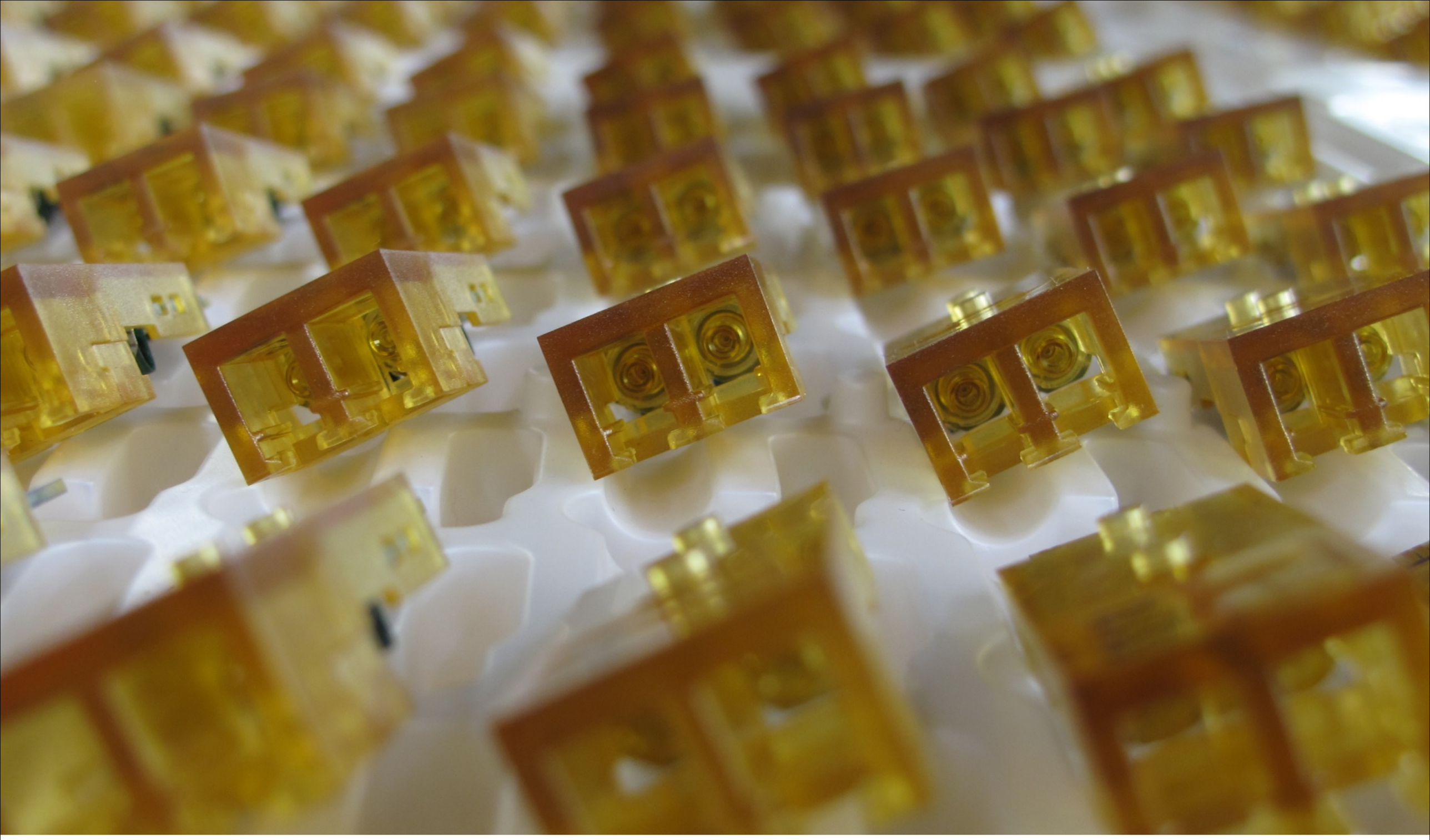


Opto Working Group - Mini Workshop

# VTRx and VTTx pre-production status and plans

21.3.2014

Lauri Olanterä

# Introduction

- VTRx/VTTx project has *almost* reached the production phase
- Easy-to-use test tools are required
- Not only to measure but also to
  - qualify devices
  - store data
  - analyse data
  - read out later on

| | VTRx SM | VTRx MM | VTTx MM |
|---|---|---|---|
| LHCb | | 2900 | 7000 |
| CMS | 200 | 400 | 2000 |
| ATLAS | | 800 | 600 |
| ALICE | | 3550 | 3200 |
| BE-BI | 1000 | | |
| **Totals** | **1200+** | **7650+** | **12800+** |

# Production Tests

- During earlier phases of the Versatile Link project extensive prototyping and environmental testing has been carried out (radiation, magnetic field, temperature…)

- Individual components and the full assembly has been qualified

- The purpose of the production tests is to guarantee the functionality of every single device before the delivery

- In lab environment but as complete as possible with the given time constrains

# Specifications

- Versatile Link components are specified in great detail
  - Specifications are based on commercial standards (Fiber Channel and IEEE), which are modified to fit our special requirements (data rate, radiation, magnetic field, size…)
  - Stored in EDMS

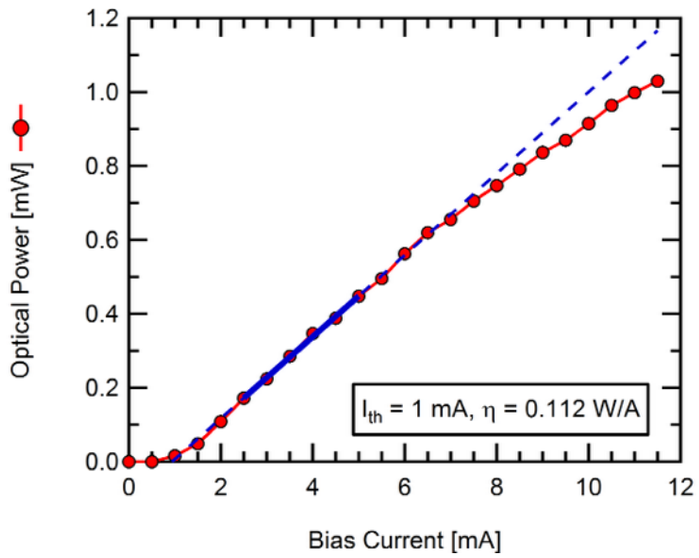
- For production testing (100% of devices) the main parameters are selected:

# Parameters: transmitter side

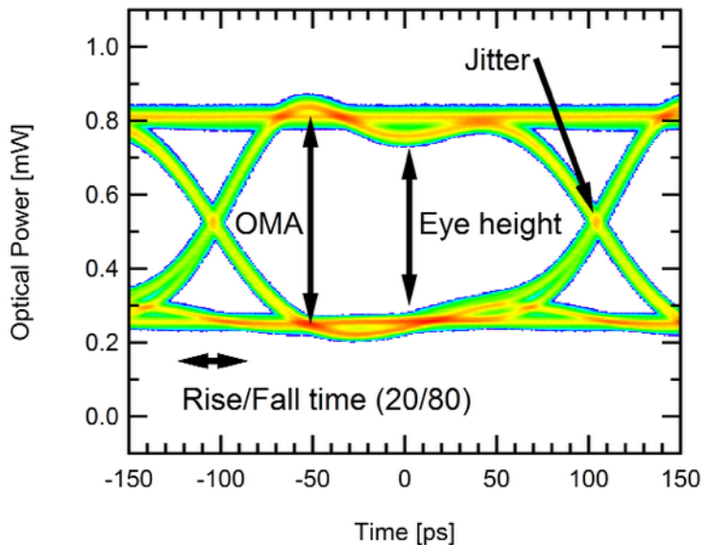
Transmitter specifications at 4.8 Gbps

| Specification | Min | Max | Unit |
|---|---|---|---|
| Threshold EEL/VCSEL | | 10/2 | mA |
| Slope Eff. EEL/VCSEL | 0.034/0.06 | 0.06/0.2 | W/A |
| OMA | 300 | | uW |
| Extinction Ratio | 3 | | dB |
| Eye Opening | 60 | | %OMA |
| Rise/Fall Time | | 70 | ps |
| Total Jitter | | 52 | ps |
| Deterministic Jitter | | 25 | ps |

1. Tx: LI measurement (power meter)




2. Tx: Eye diagram measurement (scope)

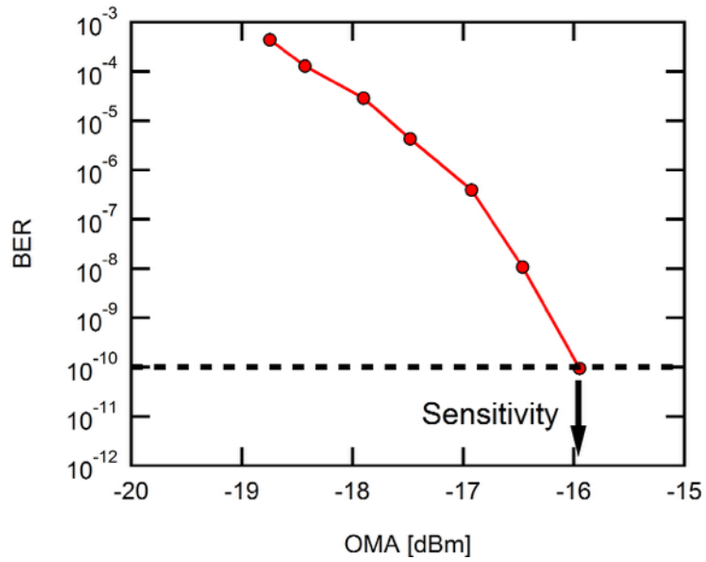


# Parameters: receiver side

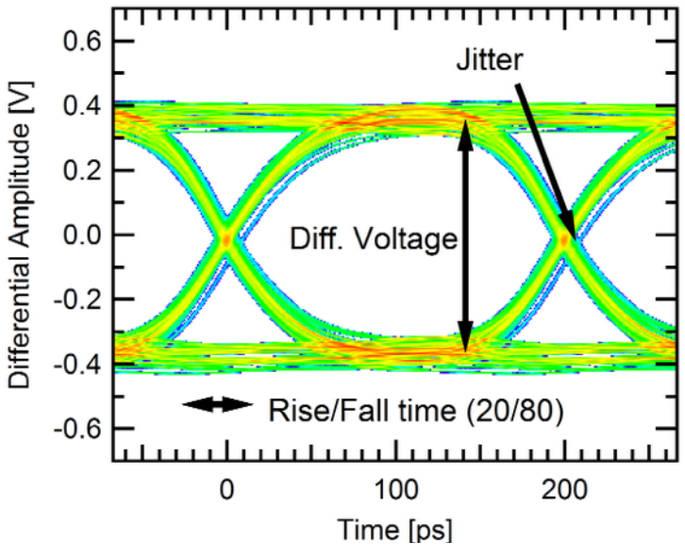
Receiver specifications at 4.8 Gbps

| Specification | Min | Max | Unit |
|---|---|---|---|
| Sensitivity SM/MM | | 29/49 | uW |
| Diff. Output Voltage | 200 | 600 | uW |
| Rise/Fall Time | | 50 | ps |
| Total Jitter | | 71 | ps |
| Deterministic Jitter | | 29 | ps |

## 3. Rx: BER measurement (BER tester)




## 4. Rx: Eye diagram measurement (scope)



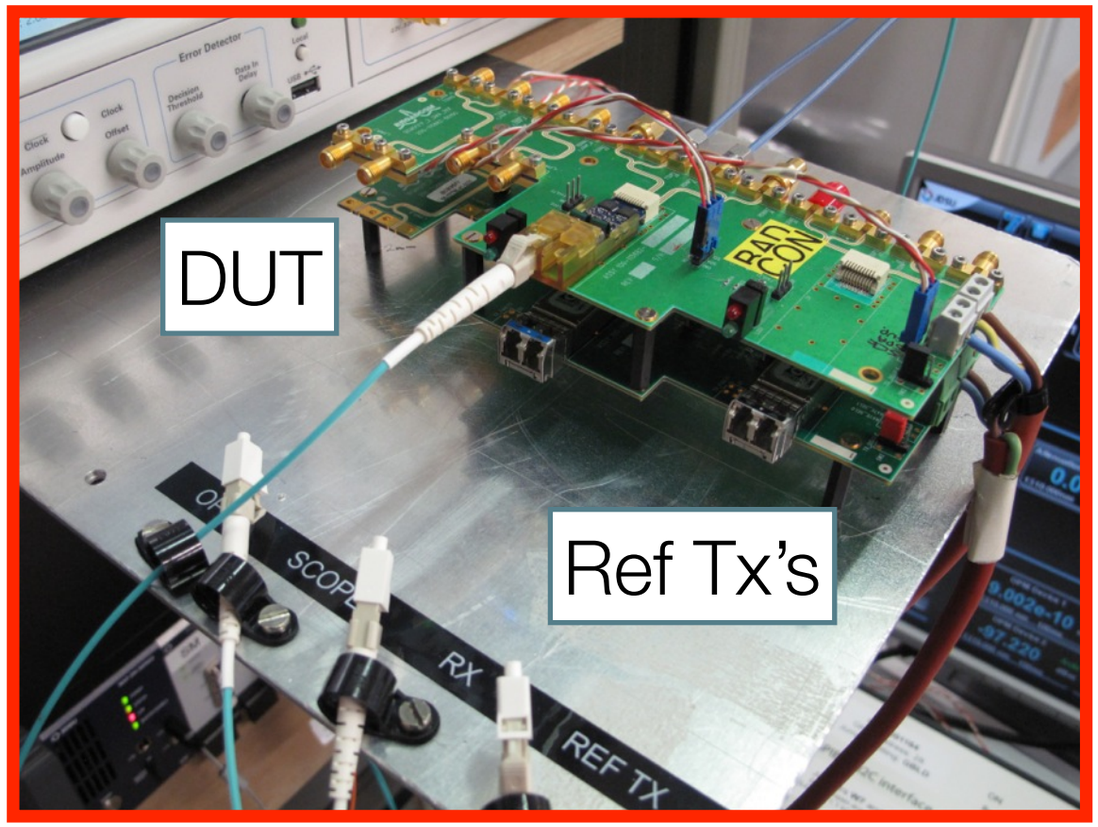
# Traceability & data storage

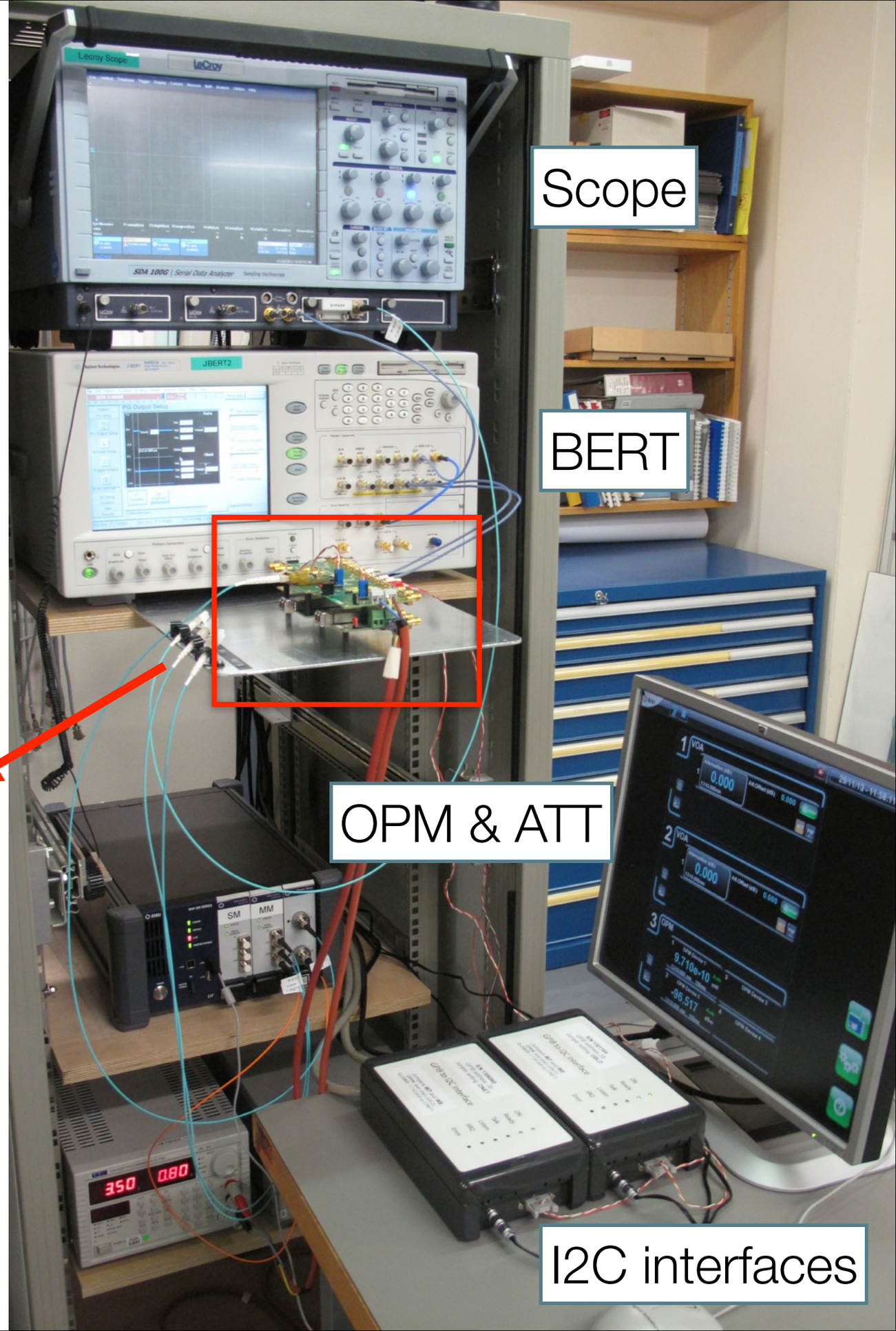
- In addition to just carrying out the measurements, the results must be identified and stored for later use
    - IDs (barcodes)
    - Database
    - Read out and analysis tools

# Test Setup

# Test Setup

- The first setup version consists of only commercial lab instruments



# Test Setup: Control Software

- IGOR (a scientific data analysis software, numerical computing environment and programming language)
- Controls all instruments
- Reads and writes to a database
- Shows the results and notifies the user

## Device Configuration Info:

Device ID: 455 [+] [-]  Ch: 1

Device Type: VTRx  Wavelength [nm]: 850

TOSA Mfr: JDSU  TOSA Model: PL-FLD-00-S4...

Laser Driver: GBLDv4

ROSA Mfr: Hamamatsu  ROSA Model: G12072-1909

PCB Type: VTRx_v3  Latch Type: v3_2013

## LI Charasteristics:

Ibias Max [mA]: 12  Ibias Step [mA]: 1

Measure LI  Upload LI Data

## EYE Diagram Charasteristics:

Ibias [mA]: 6  Imod [mA]: 6

Measure EYE  Upload EYE Data

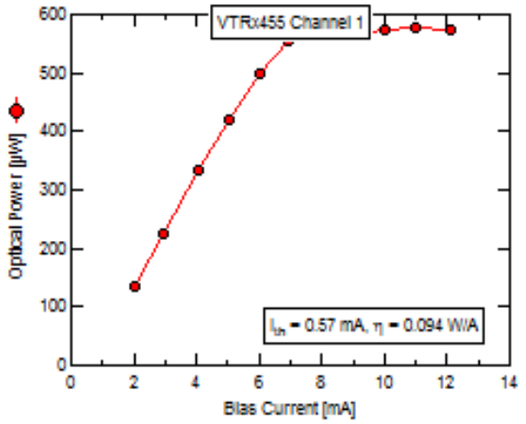
## Receiver Charasteristics:

Reference Tx: TRX10GVP2010  S/N: EM0921-00127  Update

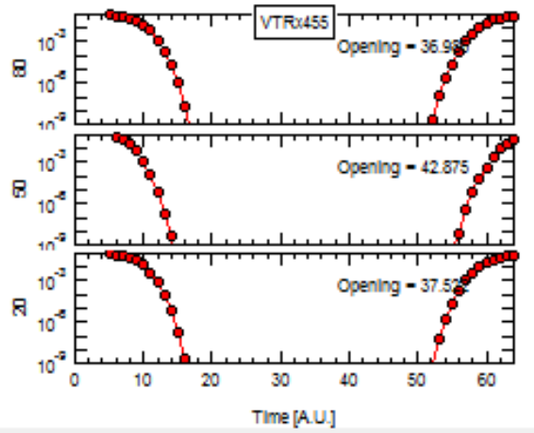
Measure SCAN  Upload SCAN Data

Measure BER  Upload BER Data

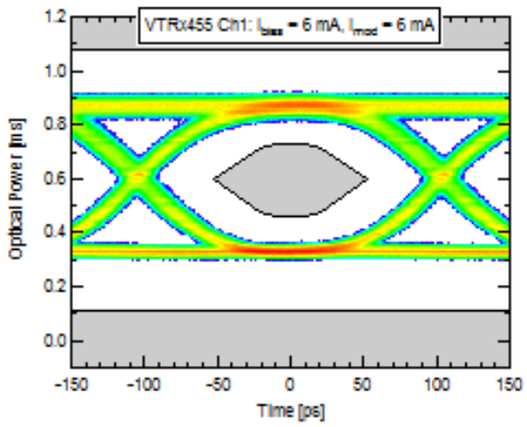
### Channel 1 LI measurement:



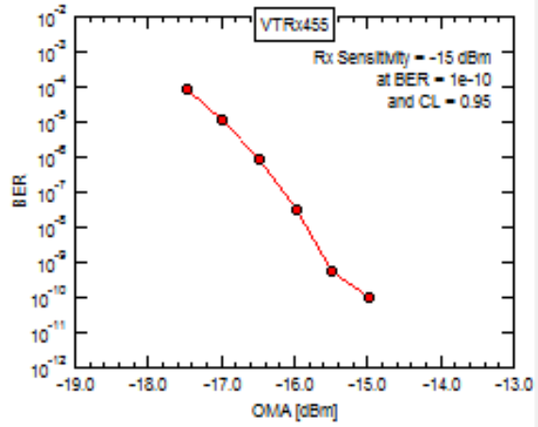

### Channel 2 SCAN measurement:




### Channel 1 EYE measurement:




### Channel 2 BER measurement:




| | | |
|---|---|---|
| Ith [mA] | 2 | 0.57 |
| SlopeEff [W/A] | 0.06/0.20 | 0.094 |
| OMA [uW] | 300 | 5.3e+02 |
| EyeH [%OMA] | 60 | 84 |
| ER [dB] | 3 | 4.2 |
| tr [ps] | 70 | 66 |
| tf [ps] | 70 | 67 |
| Tj [ps] | 52 | 55 |
| Dj [ps] | 25 | 10 |

| | | |
|---|---|---|
| Opening [A.U.] | TBA | 43 |
| Rise [A.U.] | TBA | 5.8 |
| Fall [A.U.] | TBA | 5.5 |
| Sensitivity [dBm] | -13.1 | -15 |

```
Getting parameters
No Input Eye Parameters measured. Default values of kBERT source are used.
TOTAL JITTER DOES NOT MEET THE SPECIFICATION: 55 ps (limit 52 ps)
- - - - - - - - Measuring Rx SCAN - - - - - - - -
Eye scan at lavel of 20% measured
Eye scan at lavel of 50% measured
Eye scan at lavel of 80% measured
- - - - - - - - - - Measuring BER - - - - - - - - - -
Data Rate is 4.800000 Gbps
Target BER is 1.0e-10
Confidence level is 95 %
6 data points recorded in 54 seconds
```

# Test Setup: Communication with the database

- Reads from the database:
    - All the components and their manufacturers (TOSAs, ROSAs, laser drivers…)
- Writes to the database:
    - Device configuration and used instruments
    - Measurement settings: bias/modulation currents, data rates…
    - Raw data and extracted parameters

# Database

- MySQL database on the servers of CERN's *Database On Demand* service
  - database engine updates, access to backup and recovery services etc.

- Our responsibilities: configuration, maintenance and administration

# Database includes

- Configuration
  - Types and manufacturers (TOSAs, ROSAs, drivers…)
- Test results
  - Measurement data
  - Raw data
- Location log
  - to keep track on the device locations
- Repair history

# Database website: cern.ch/optodb

## Test Result Search

Device Type: VTRx Device ID: 801 Submit Query Generate eye diagrams (takes approx. 20 seconds)

Device Location Log (Restricted access: only for Opto Team members)

### Device Configuration:

| Device ID | Channel | OSA Model | Laser Driver | PCB type | Latch Type |
|---|---|---|---|---|---|
| 801 | 1 | Mitsubishi FU-466RLD-6M2 | GBLDv4.1 | VTRx SM (green) | SM3dProto |
| 801 | 2 | Hamamatsu G12072-1908 | - | VTRx SM (green) | SM3dProto |

### LI characteristics:

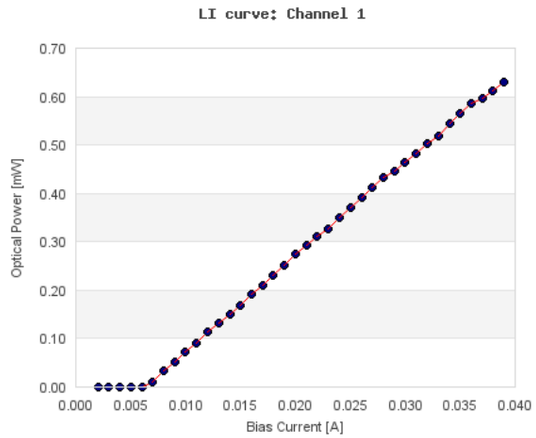
| Device ID | Channel | Threshold Current [mA] | Slope Efficiency [W/A] | Measured |
|---|---|---|---|---|
| 801 | 1 | 6.4 | 0.02 | 23 October 2013 |

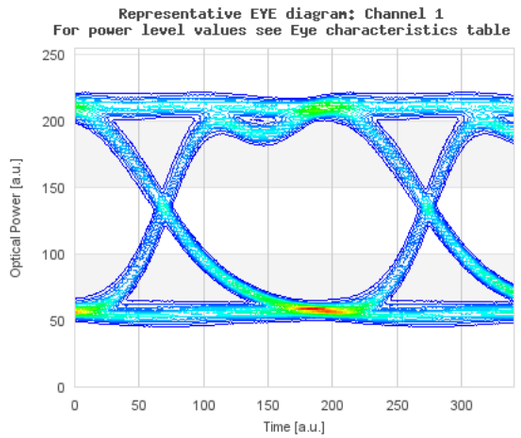
### EYE characteristics at 4.8 Gbps using current settings: bias = 24 mA and modulation = 24 mA

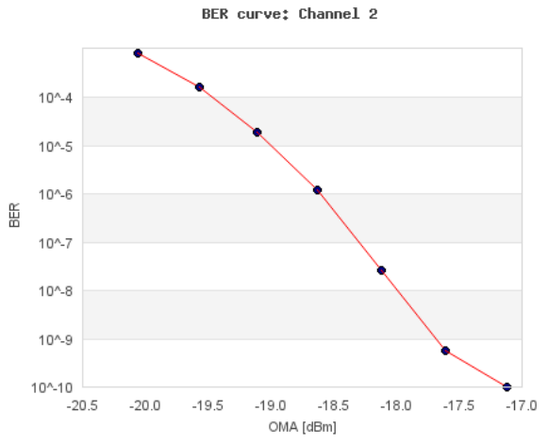
| Device ID | Channel | OMA [uW] | Level 0 [uW] | Level 1 [uW] | Eye Height [%OMA] | ER [dB] | Rise Time [ps] | Fall Time [ps] | Total Jitter [ps] | Deterministic Jitter [ps] | Measured |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 801 | 1 | 304 | 90 | 394 | 78 | 6.4 | 40 | 70 | 33 | 10 | 23 October 2013 |

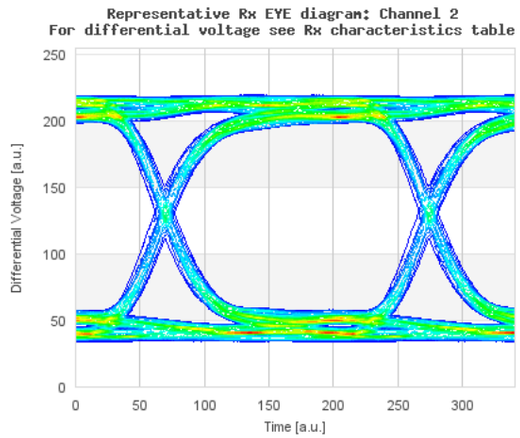
### Rx characteristics at 4.8 Gbps:

| Device ID | Channel | Diff. Voltage [mV] | Rise Time [ps] | Fall Time [ps] | Total Jitter [ps] | Deterministic Jitter [ps] | Receiver Sens. [dBm] | Measured |
|---|---|---|---|---|---|---|---|---|
| 801 | 2 | 342 | 46 | 45 | 22 | 13 | -17.1 | 23 October 2013 |




Note! The eye diagram presentation slightly filters out jitter and amplitude noise. However, the shape of the eye is presented correctly.

In case of any problems or if you would like to have raw data please contact: lauri.olantera@cern.ch

# Results (so far)

# VTTx's: The first batch

- 650 VTTx's with a commercial laser driver and a VCSEL laser for CMS oSLB (a part of the calorimeter trigger upgrade)

- Assembly done by four different companies

  - Components selected by CERN and sent to the assembly houses. Assembled PCB's back to CERN.

- "Finishing touches" and latch assembly by us

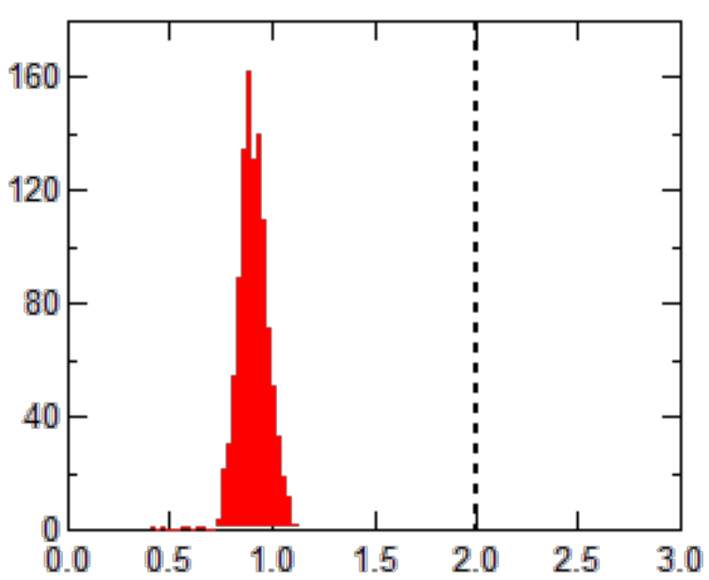
# VTTx's: The first batch

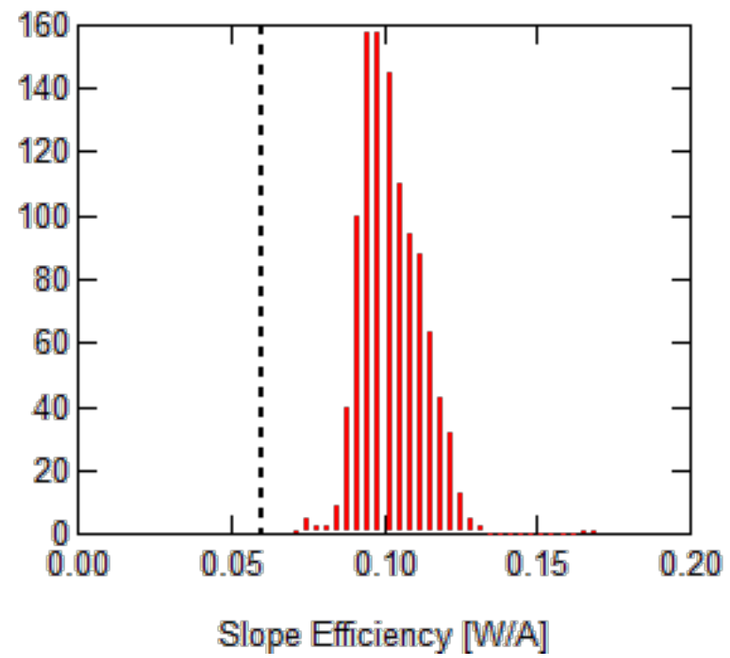
- Devices tested with the setup:

| Assembled by: | Tested | Failed | Failure % | Fixed | Notes |
|---|---|---|---|---|---|
| CERN | 410 | 36 | 9% | 24 | Bad quality assembly |
| Hapro | 100 | 2 | 2% | 2 | Both TOSA problems |
| AWS | 90 | 11 | 12% | 9 | Bad quality assembly |
| Norcott | 50 | 25 | 50% | 24 | TOSA solder pads |

- Realistic speed for latch assembly and testing: 100/day

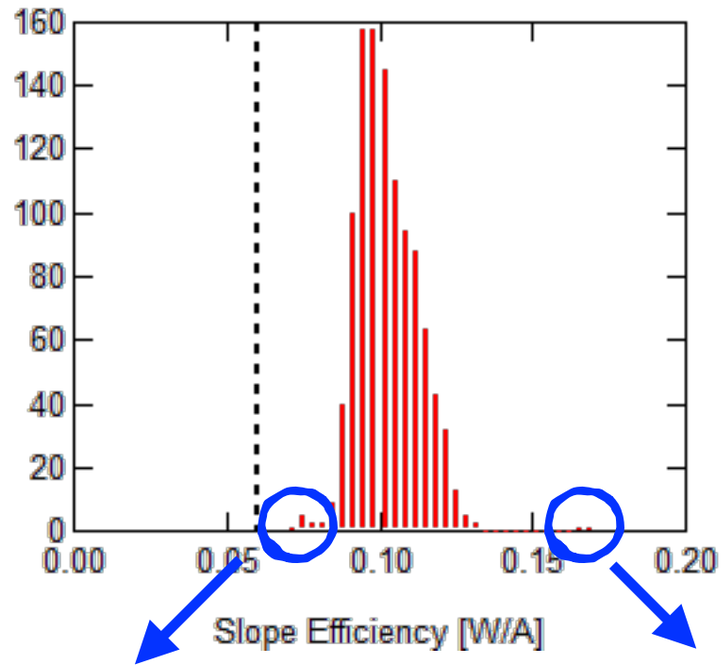
# VTTx's: The first batch - static parameters

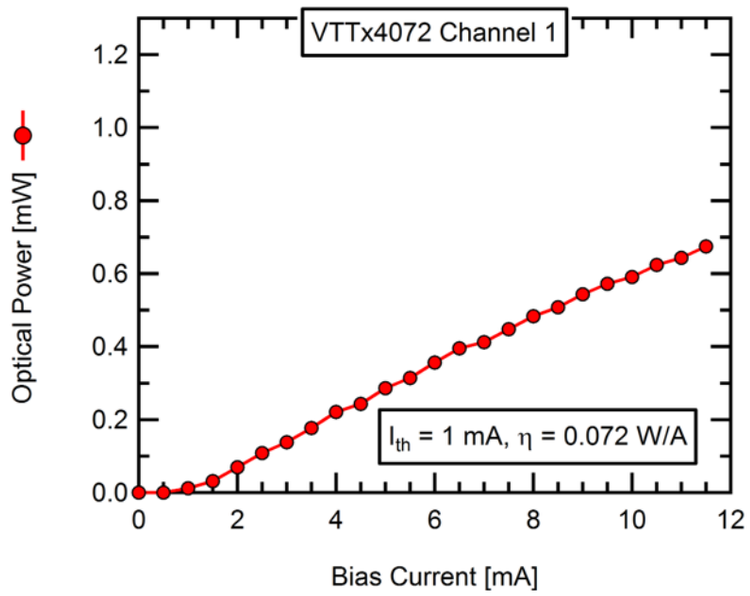


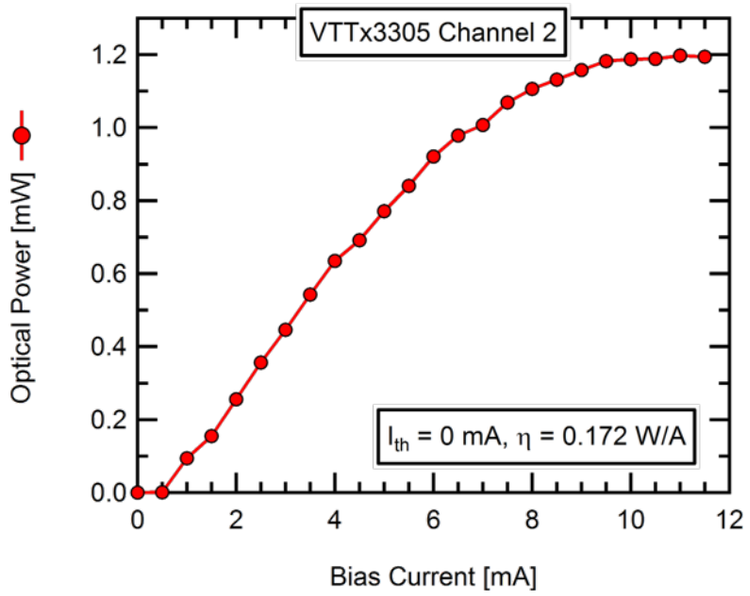



# VTTx's: The first batch - static parameters

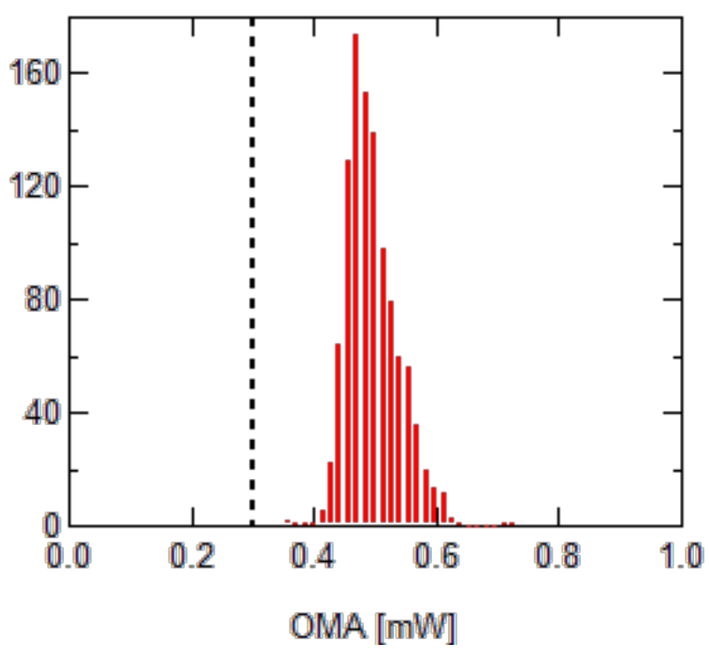
Examples of min and max slope efficiencies (both still meet our specs!)

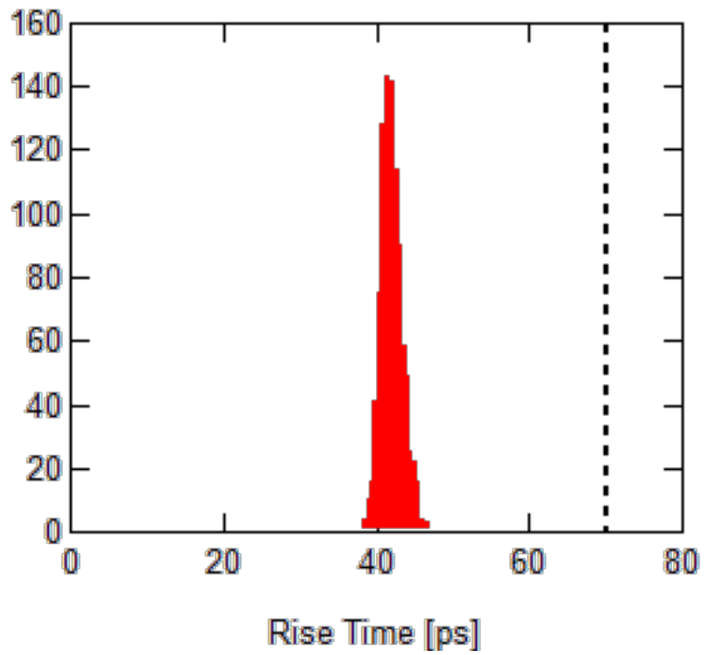


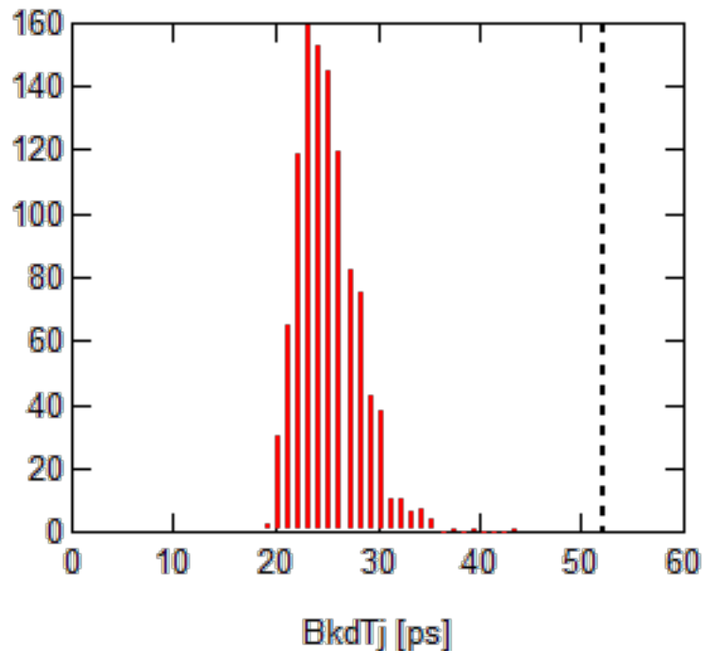



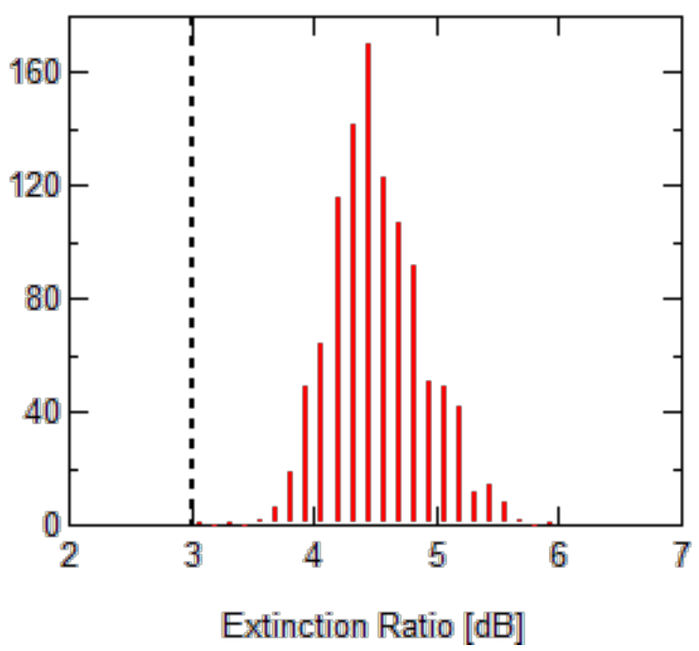



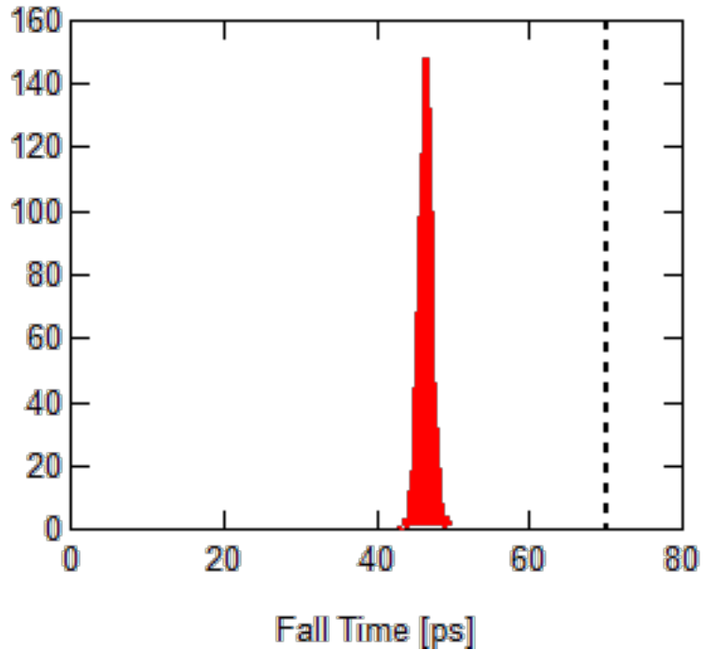
# VTTx's: The first batch - dynamic parameters

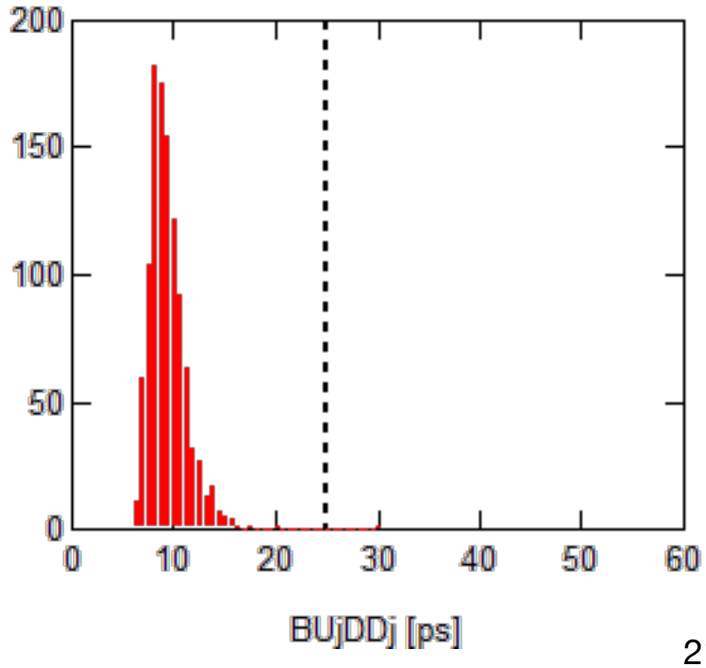


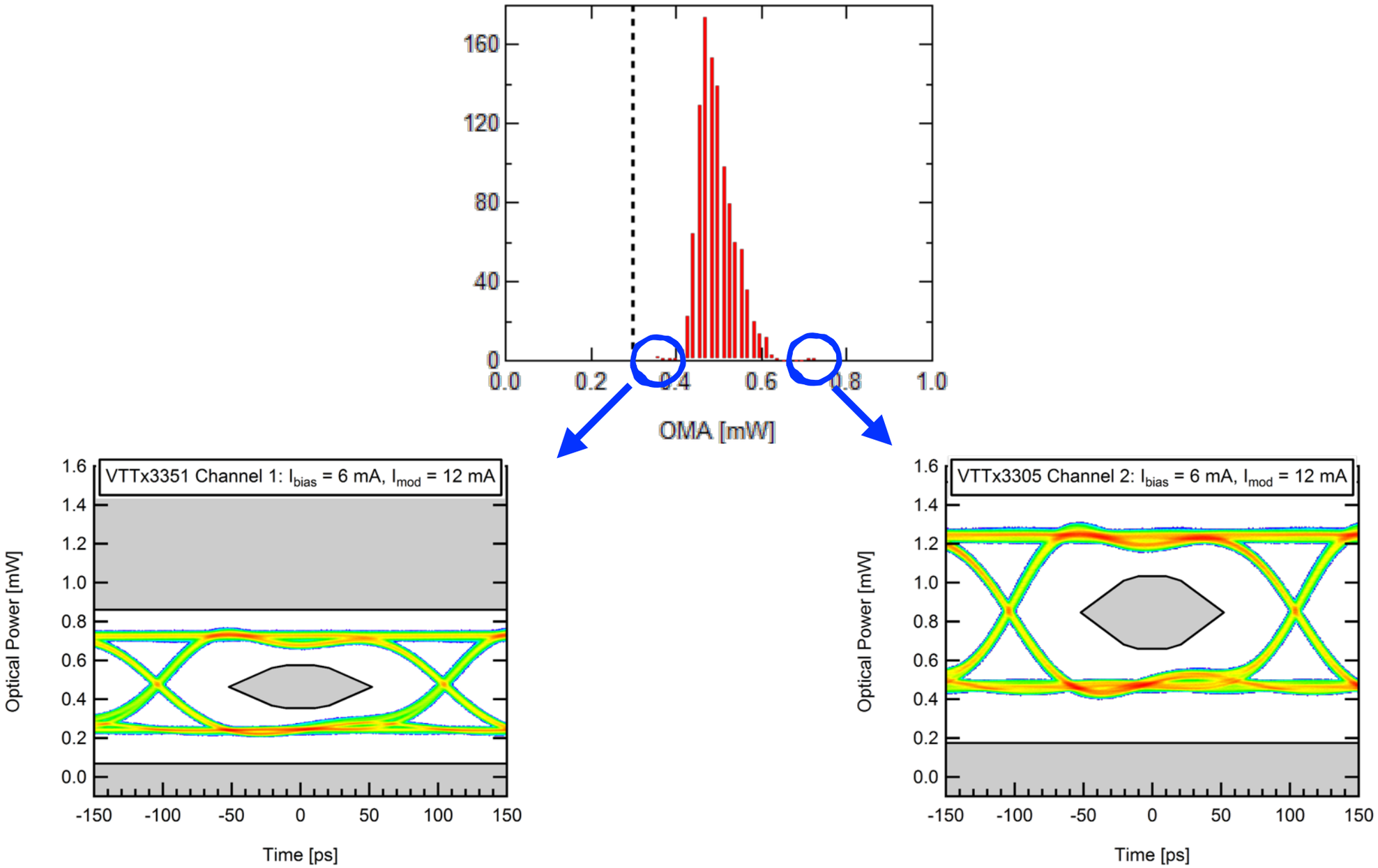



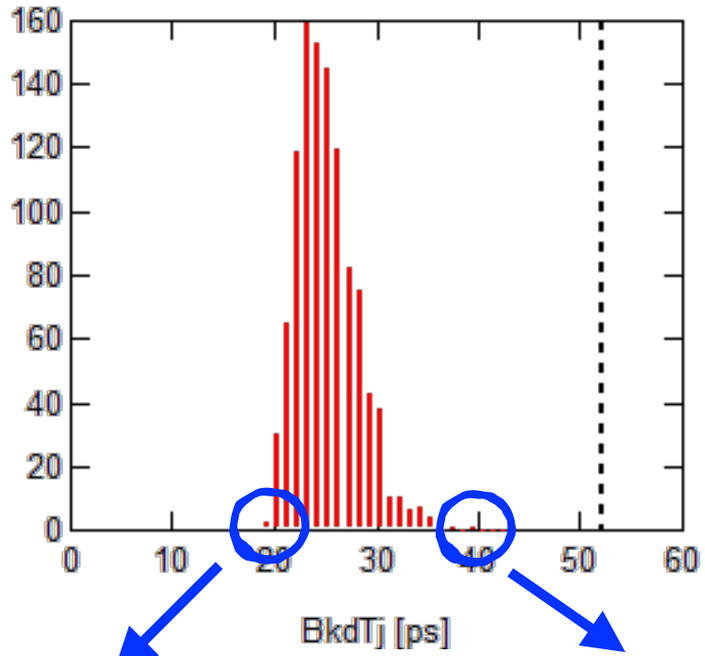
# VTTx's: The first batch - dynamic parameters

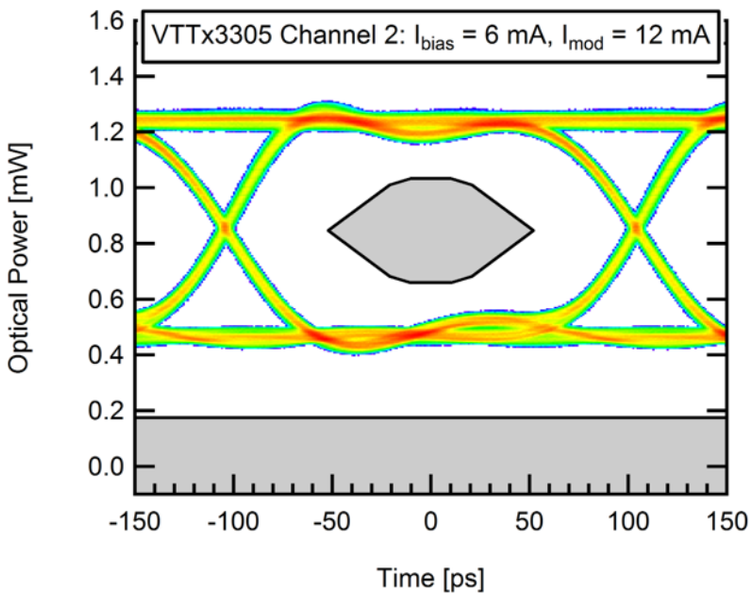
Examples of min and max OMA

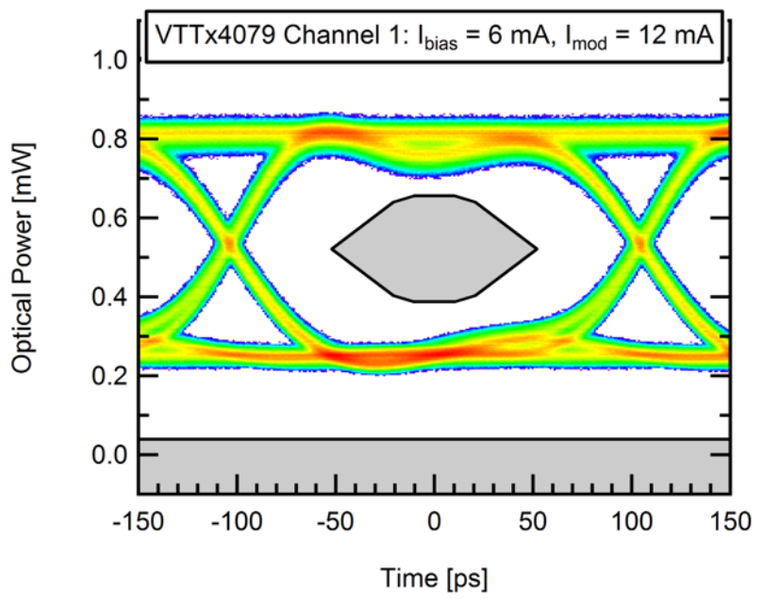


# VTTx's: The first batch - dynamic parameters

Examples of min and max jitter



# Lessons learnt during the first test run

- Significant differences between assembly houses:
  - CERN and AWS: unacceptable failure rate
  - Hapro shows that the assembly can be done right!

- Specs are always met, provided the device works in the first place
  - Performance variations in the TOSAs and drivers are small enough

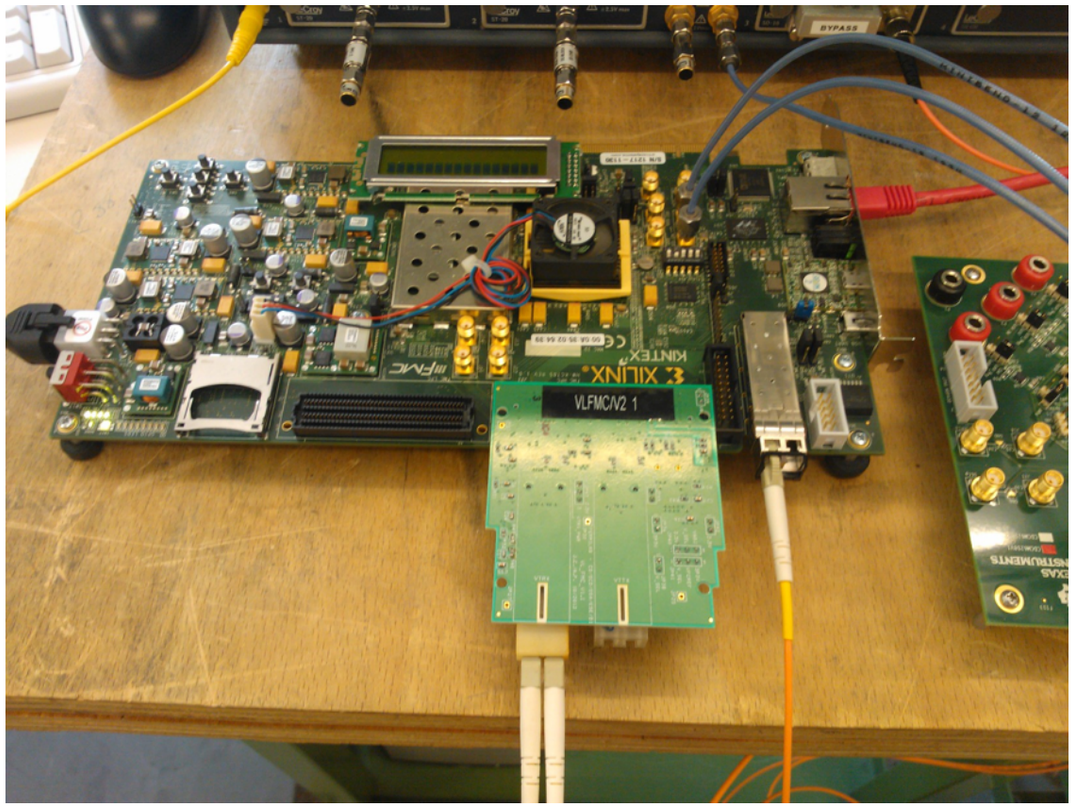
- Most of the problems due to bad component assembly
  - we have found and fixed tens of bad solder joints and broken components

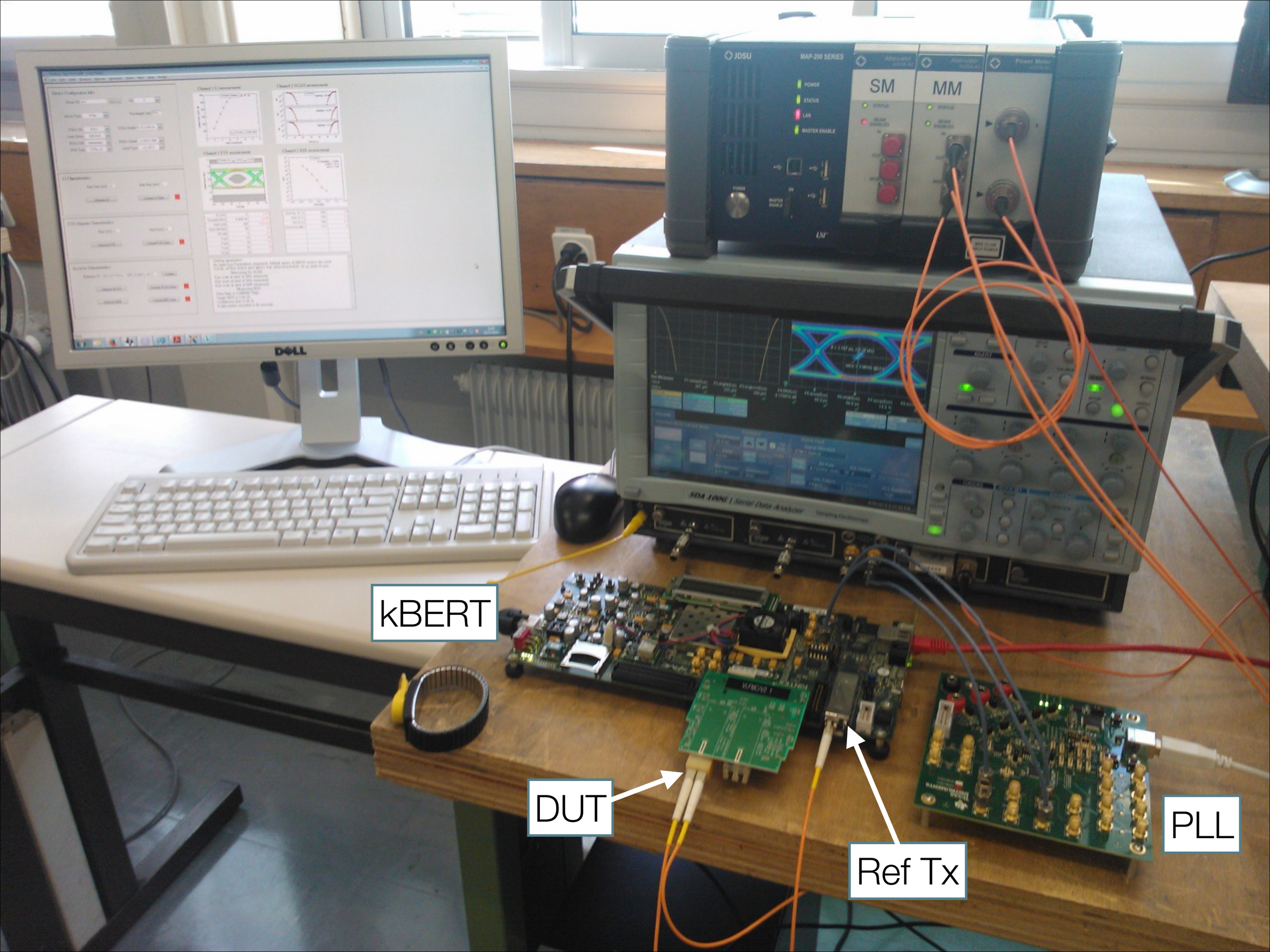
- In the future PCB's must be well finished to avoid problems in latch assembly!

# The next step

# The next step

- Replace J-BERT with kBERT
  - we don't want to keep J-BERT occupied for an extended period of time
  - kBERT is a FPGA-based BER tester
  - in our setup it replaces pattern generator, I2C interfaces, BER tester, receiver eye measurement
  - external PLL board delivers the clock for both kBERT and scope




JDSU
MAP-200 SERIES
POWER
STATUS
LAN
MASTER ENABLE
SM
MM
DELL
kBERT
DUT
Ref Tx
PLL

# The next step

- All receiver side measurements with kBERT
- Sensitivity -> BER
- No more Rx eye diagram -> Rx eye scan

Receiver specifications at 4.8 Gbps

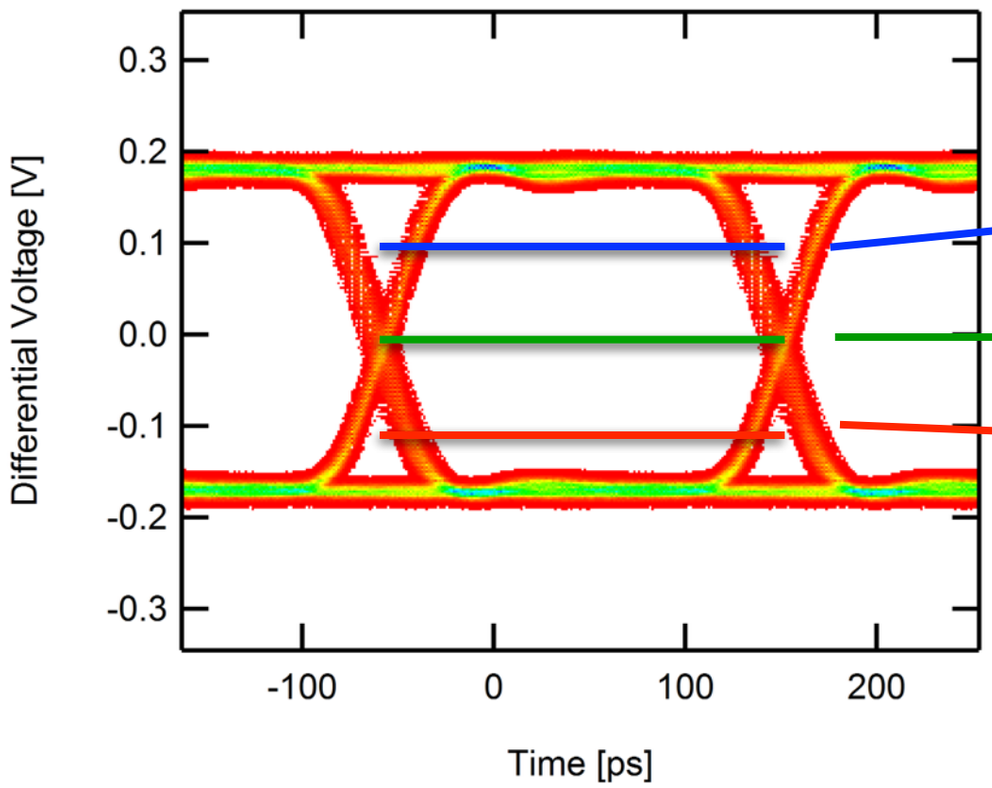
| Specification | Min | Max | Unit |
|---|---|---|---|
| Sensitivity SM/MM | | 29/49 | uW |
| Diff. Output Voltage | 200 | 600 | uW |
| Rise/Fall Time | | 50 | |
| Total Jitter | | 71 | ps |
| Deterministic Jitter | | 29 | ps |

Receiver specifications at 4.8 Gbps-1

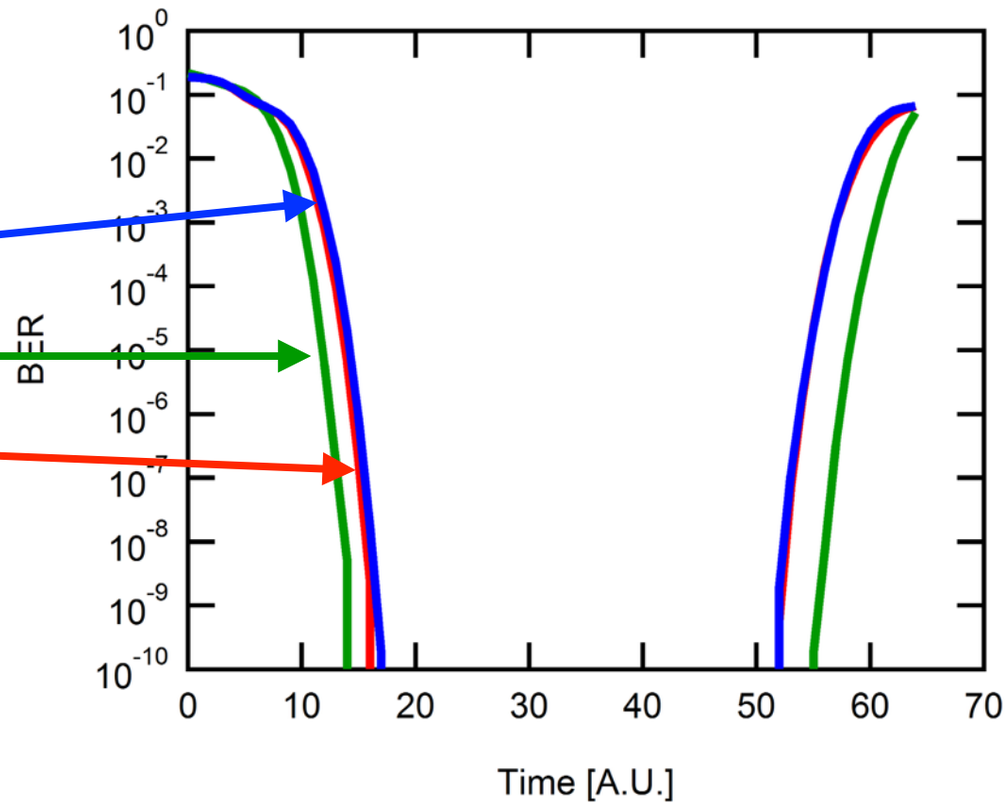
| Specification | Min | Max | Unit |
|---|---|---|---|
| Sensitivity SM/MM | | 29/49 | uW |
| Horizontal opening | TBC | | ps |
| “Rise time” | | TBC | ps |
| “Fall time” | | TBC | ps |

# Eye scan

Rx eye diagram:




Rx eye scan:



# Barcode IDs

- DataMatrix 2D codes
- Due to lack of space on the PCB we are forced to put 2D codes on latches
  - transparent plastic > contrast issues
  - DPM (direct part marking) readers
- Goal:
  - read the barcode from the device
  - place the device on the test board and plug in the optical fibre
  - press play on the test GUI
  - repeat 25728 times

# Summary

- Production test procedure has been realised including:
  - test setup
  - control software
  - database
  - basic analysis and read-out tools
- It has been used with individual devices and a bigger batch
- Even though the setup is ready for “plug and play” operation changes and optimisation are done all the time