The Versatile Transceiver

Towards Production Readiness

Csaba Soos on behalf of
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Outline

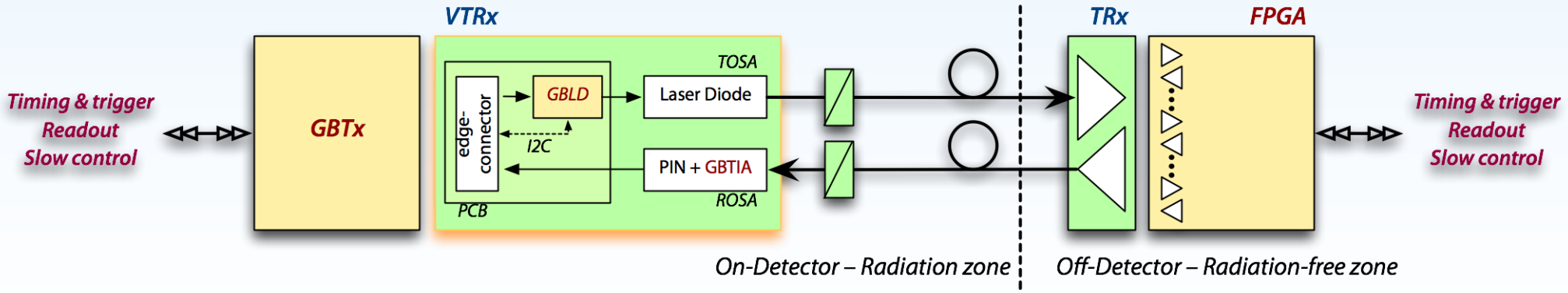
- Introduction
- VTRx and VTTx prototypes
  - Test results
- Towards production
  - Strategy
  - Production testing
- Something new
- Summary

Versatile Link Project

Versatile Link

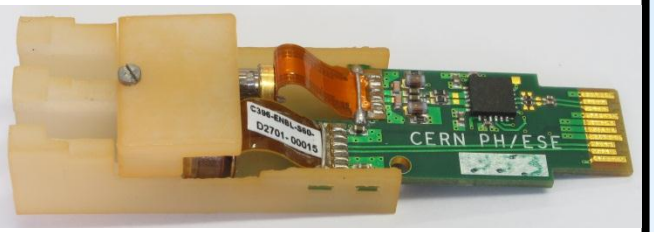
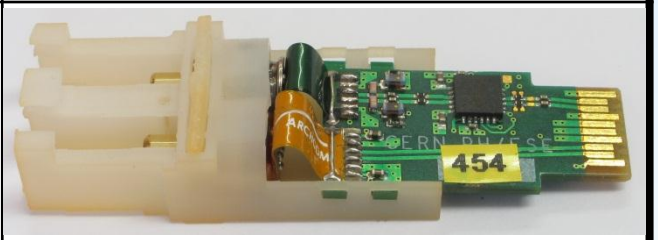
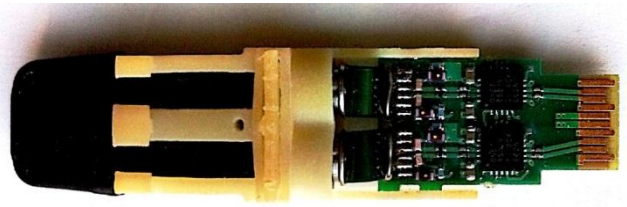
- Optical layer linking front-end to back-end up to 150 m distant.
- Bi-directional @ 5 Gbps
- Two Point-to-point solutions
  - 850 nm Multimode
  - 1310 nm Single-mode
- Front-end pluggable module
- Rad-hard front-end

- Joint Project Proposal submitted to ATLAS & CMS upgrade steering groups in 2007 and endorsed in 2008
- Project Kick-off: April 2008
  - Phase I: Proof of Concept (18mo)
  - Phase II: Feasibility Study (18mo)
  - (Consolidation)
  - **Phase III: Pre-prodn. readiness (18mo)**



Fully Functional Prototypes

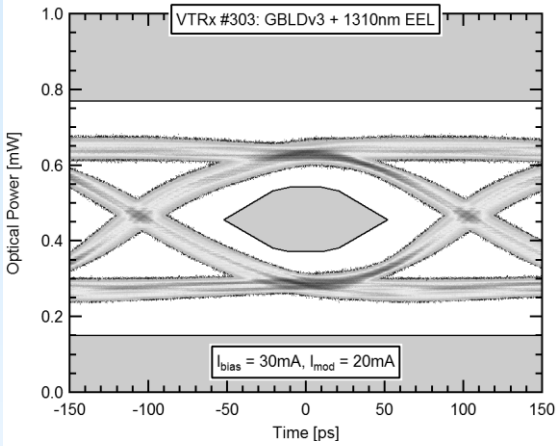
Versatile Link

Variant	Laser Driver	TOSA	ROSA	Picture
Single-mode VTRx	GBLD v4	Edge Emitter Laser	InGaAs GBTIA v1	
Multi-mode VTRx	GBLD v4	850 nm VCSEL	GaAs GBTIA v1	
Multi-mode VTTx	GBLD v4	850 nm VCSEL	-	

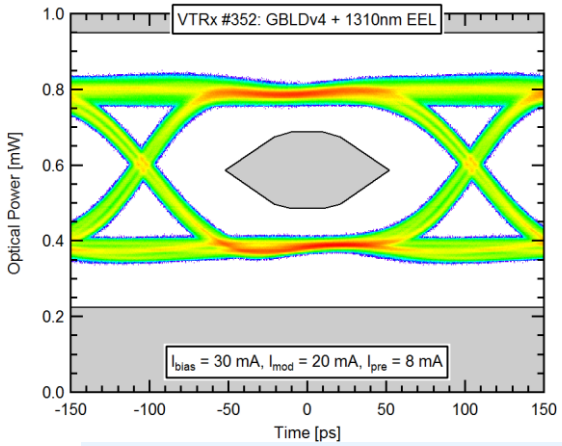
Single-mode VTRx

Versatile Link

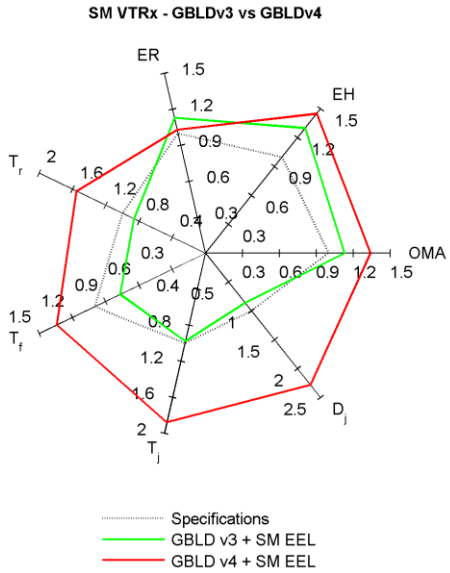
TX Eye of 2011 vintage



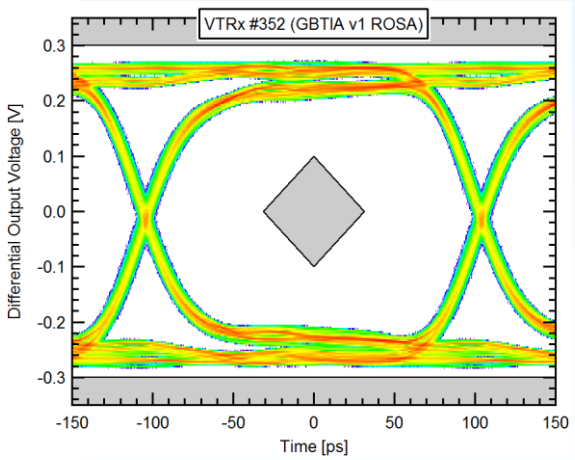
TX Eye

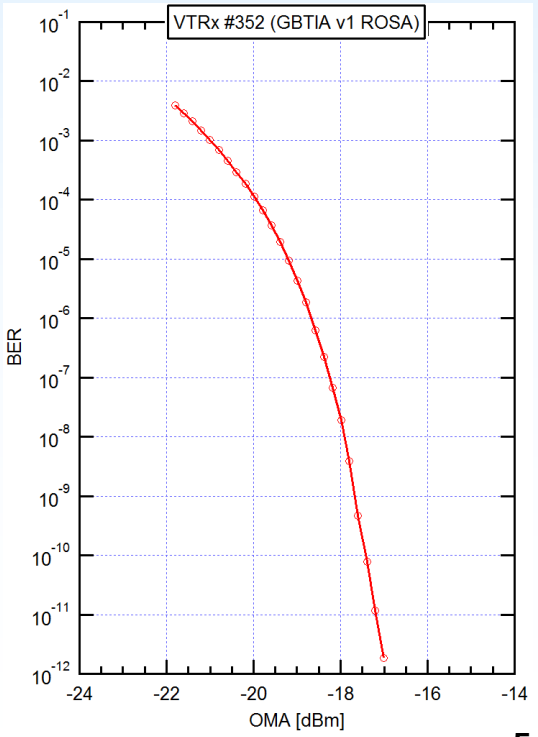


Parameter	Normalization	V3	V4
OMA	OMA/300uW	1.13	1.34
Eye Height	Eye Height/(0.6*OMA)	1.30	1.45
ER	ER/3	1.13	1.03
$1/T_r$	$(1/T_r)/(1/70ps)$	0.86	1.55
$1/T_f$	$(1/T_f)/(1/70ps)$	0.77	1.34
$1/T_j$	$(1/T_j)/(1/0.25UI)$	0.98	1.88
$1/D_j$	$(1/D_j)/(1/0.12UI)$	0.86	2.28
Note: Bit rate = 4.8 Gb/s, UI = 208 ps			



RX Eye

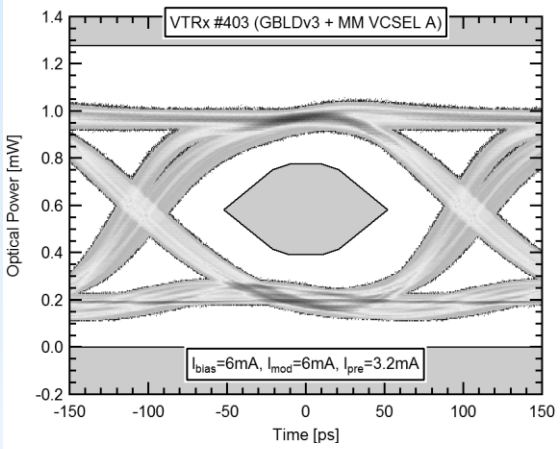




Multi-mode VTRx

Versatile Link

TX Eye of 2011 vintage



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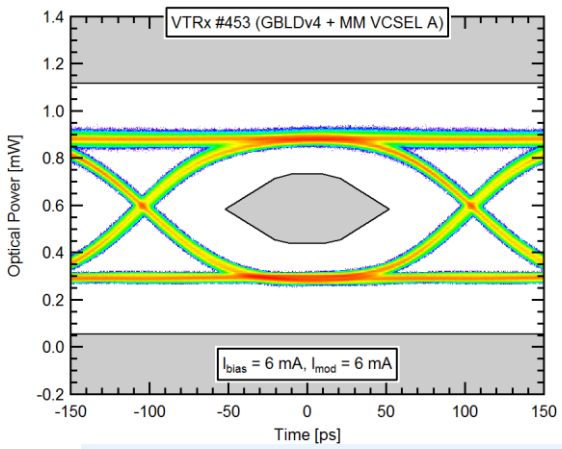
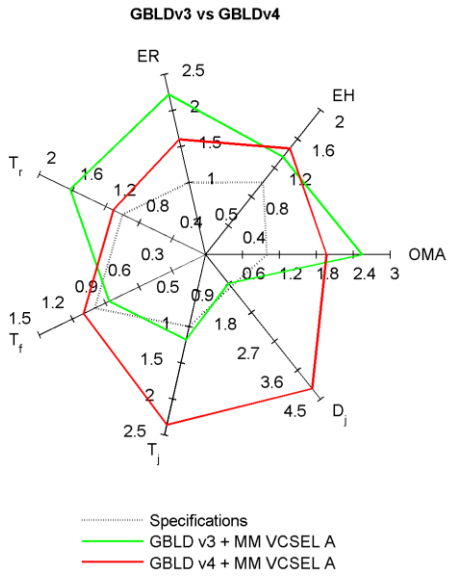
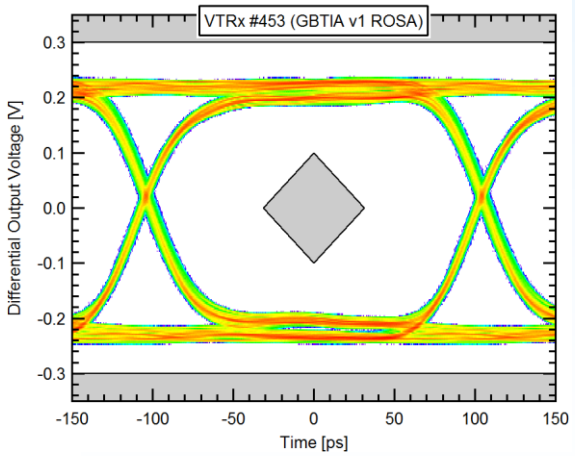
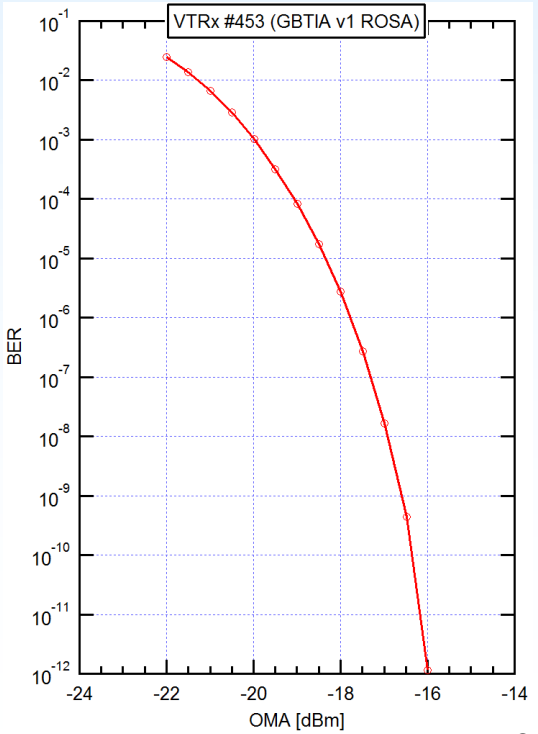


Parameter	Normalization	V3	V4
OMA	OMA/300uW	2.55	1.97
Eye Height	Eye Height/(0.6*OMA)	1.35	1.47
ER	ER/3	2.25	1.60
$1/T_r$	$(1/T_r)/(1/70ps)$	1.63	1.11
$1/T_f$	$(1/T_f)/(1/70ps)$	0.87	1.10
$1/T_j$	$(1/T_j)/(1/0.25UI)$	1.18	2.36
$1/D_j$	$(1/D_j)/(1/0.12UI)$	0.90	4.17
Note: Bit rate = 4.8 Gb/s, UI = 208 ps			



RX Eye

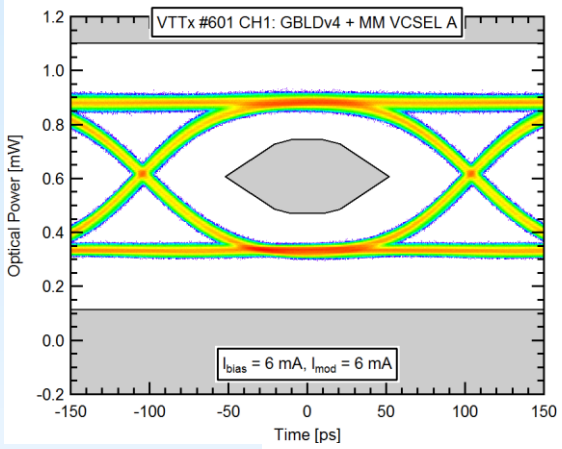




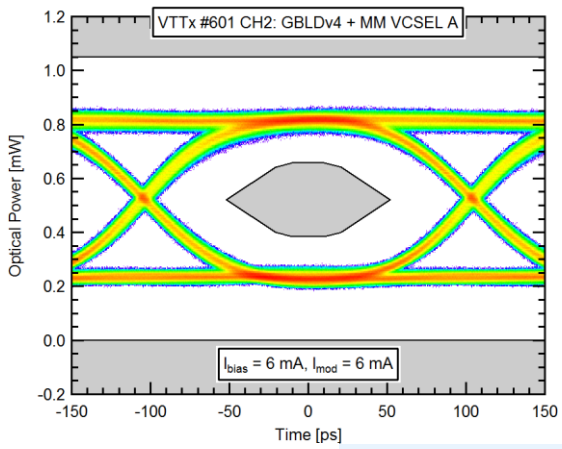
Multi-mode VTTx

Versatile Link

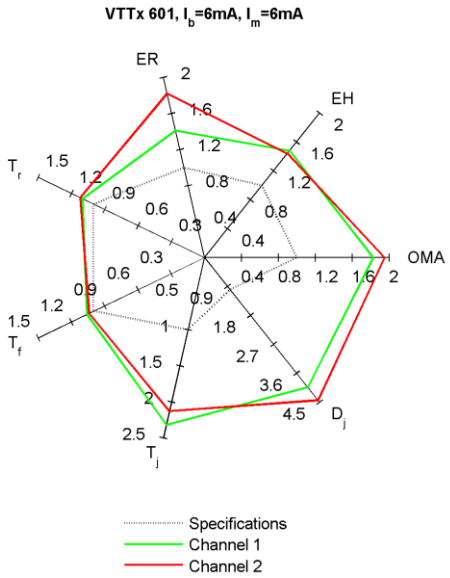
TX Eye Channel 1



TX Eye Channel 2



Parameter	Normalization	Ch1	Ch2
OMA	OMA/300uW	1.83	1.95
Eye Height	Eye Height/(0.6*OMA)	1.48	1.44
ER	ER/3	1.41	1.82
$1/T_r$	$(1/T_r)/(1/70ps)$	1.10	1.12
$1/T_f$	$(1/T_f)/(1/70ps)$	1.06	1.04
$1/T_j$	$(1/T_j)/(1/0.25UI)$	2.32	2.13
$1/D_j$	$(1/D_j)/(1/0.12UI)$	4.04	4.44
Note: Bit rate = 4.8 Gb/s, UI = 208 ps			



Towards Production

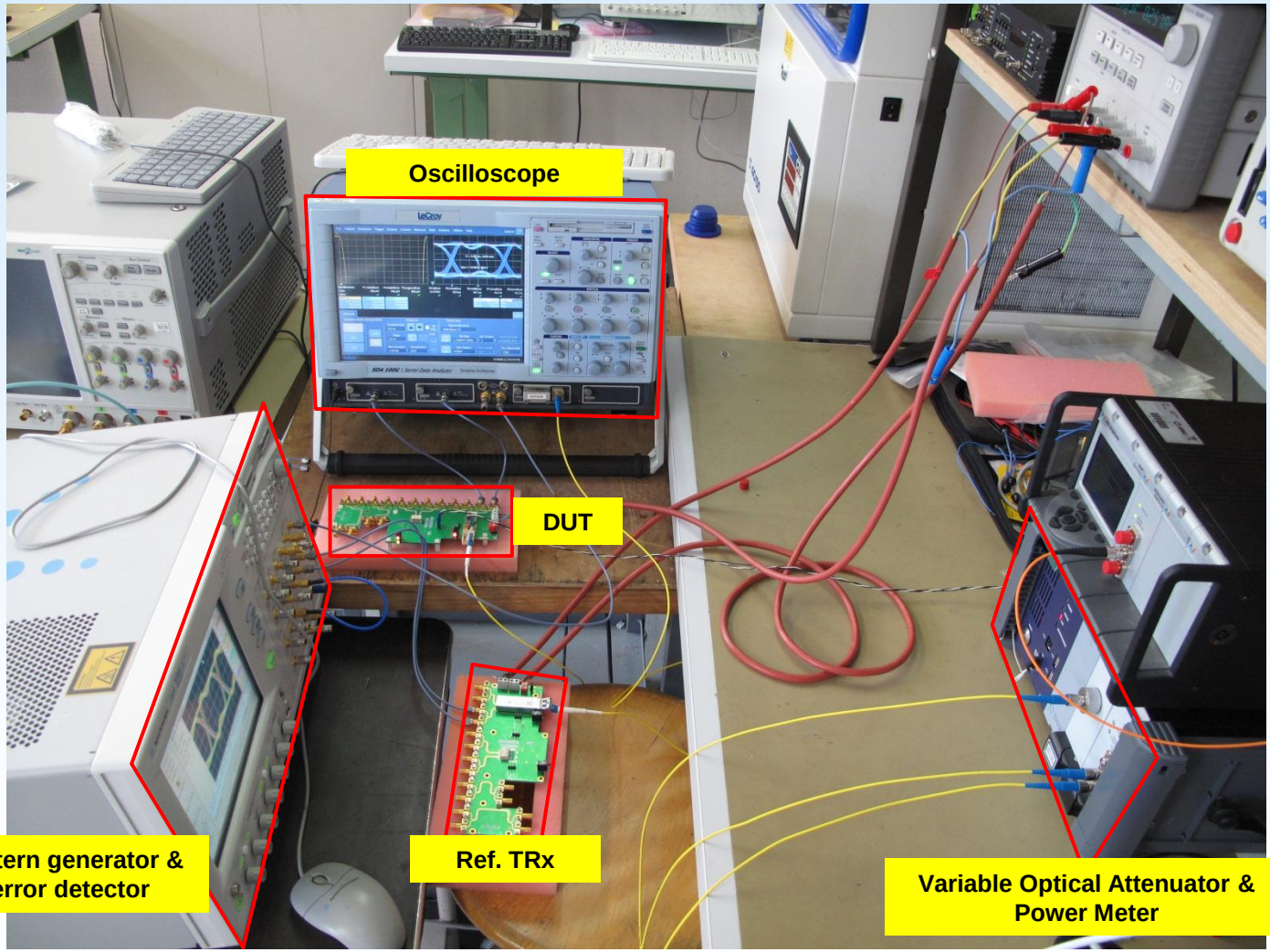
- Next steps
  - Propose purchasing strategy for LHCb, CMS HCAL, CMS Pix phI, ATLAS SmWh and ATLAS LArg upgrade
  - Quantities: 7750 VTTx, 1150 MM VTRx, 200 SM VTRx, 3000 SM TOSA
  - Cost estimates (CHF): VTTx 149, MM VTRx 199 , SM VTRx 249
  - Firm prices by mid 2013
- Procurement procedure with tentative schedule
- Quality assurance
  - Qualification (all components)
  - Lot acceptance/validation (all components)
  - Production testing (all manufactured modules)
- Test procedures for the above are being prepared

Production Test Procedure

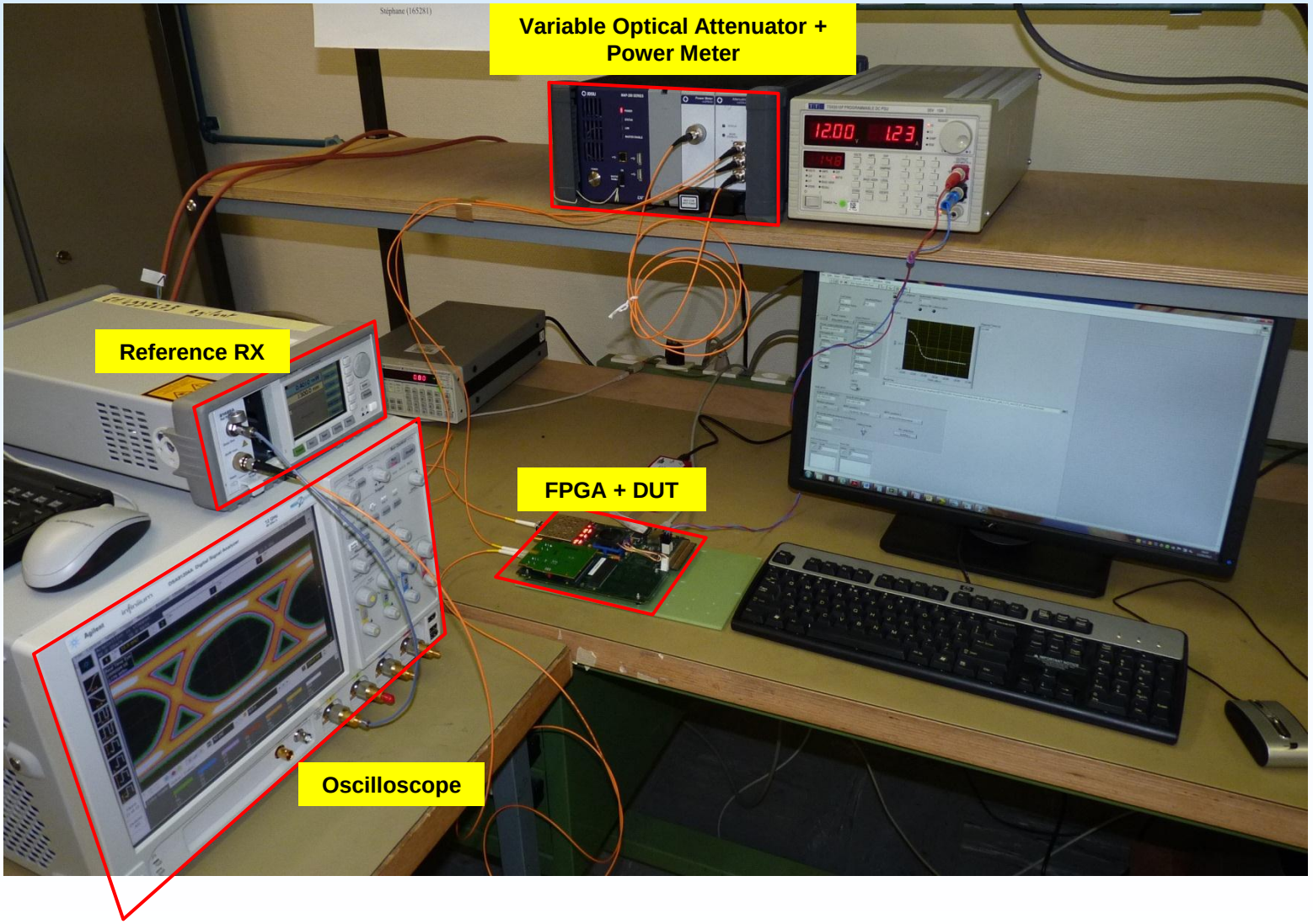
- Verify that manufactured modules meet the Versatile Link Specifications, Part 2.1 (EDMS 1140665)
  - Static: Light-current curve (LI)
  - Dynamic: Transmit Optical Eye (TP2), Receive Electrical Eye (TP4), Receiver sensitivity (BER)
- Test cycle should be optimized
  - No changes in electrical/optical connections between cycles
  - Target bit error rate of 10^{-10} instead of 10^{-12}
  - Measuring transmitter while receiver sensitivity is measured
- Test automation and report generation
  - Results to be stored in a database

Instrument-based Test System

Versatile Link

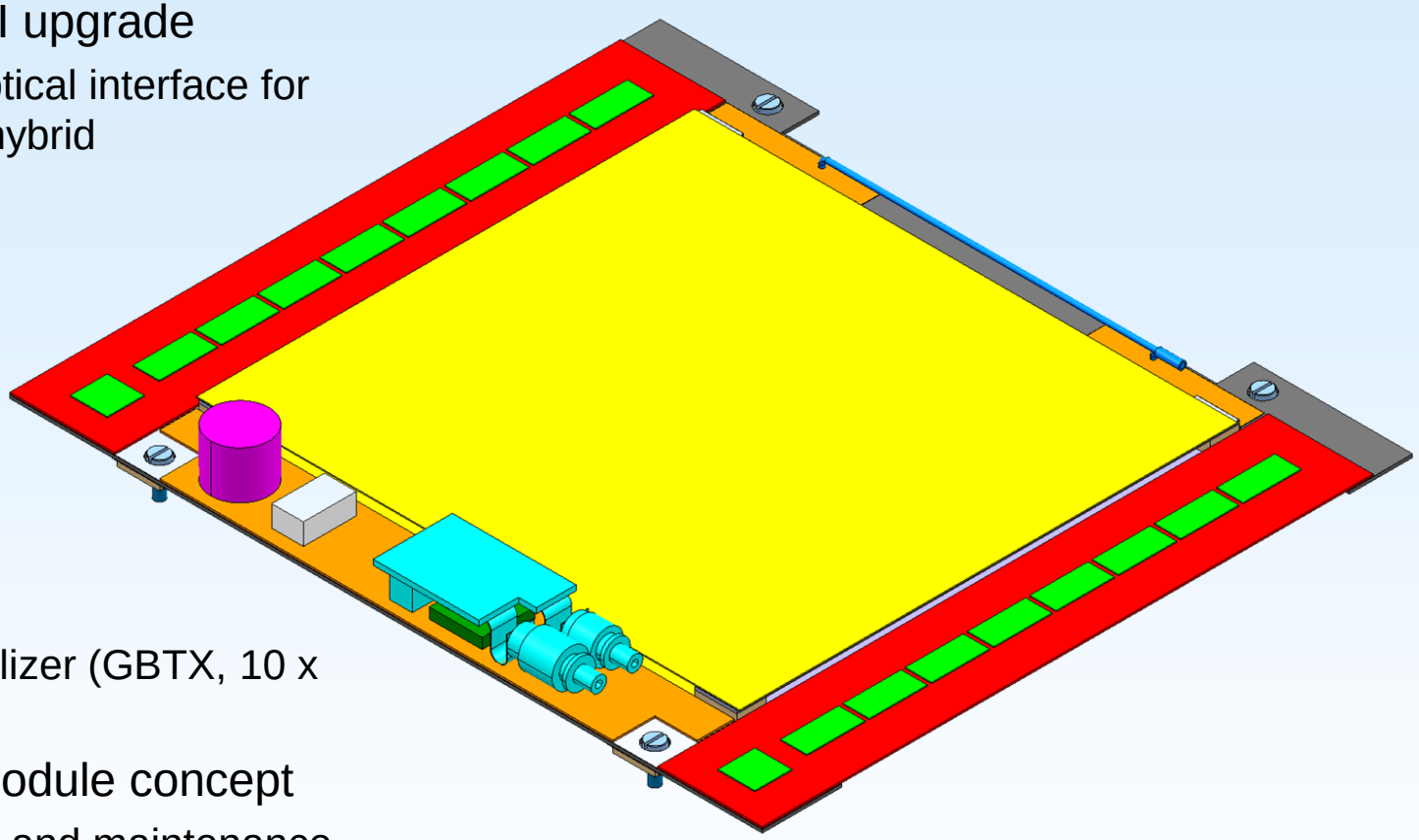


FPGA-based Test System



Small Footprint VTRx

- CMS tracker Phase II upgrade
  - Need low profile optical interface for the new front-end hybrid

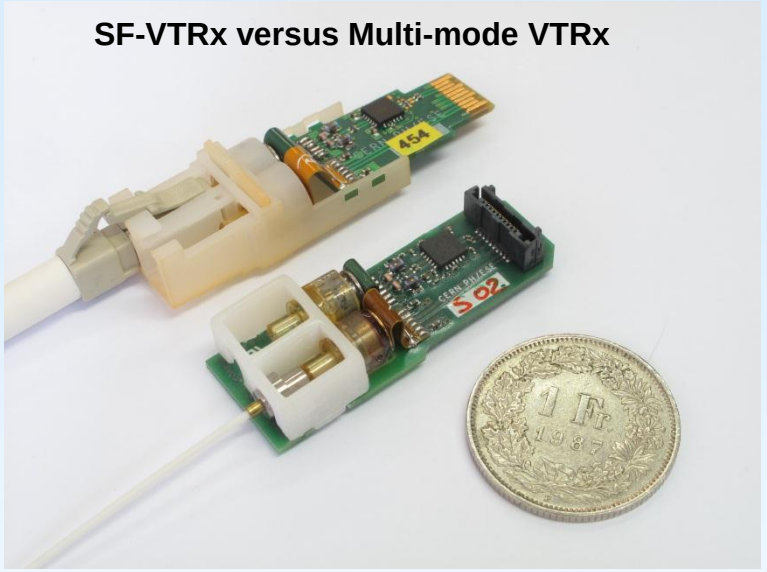


- Footprint constraint
  - 45 x 15 x 8 mm^3
  - Must include serializer (GBTX, 10 x 10 mm^2)
- Keep stand-alone module concept
  - Easier prototyping and maintenance
- Reuse work done in the framework of the Versatile Link project

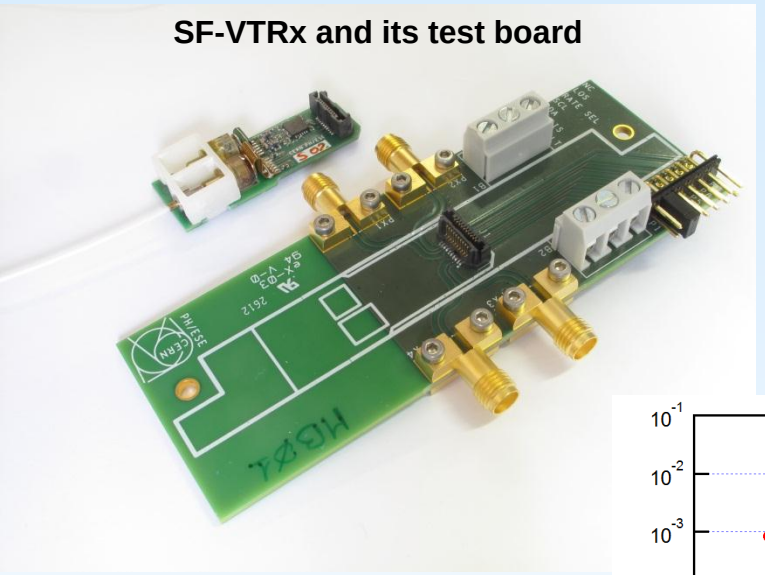
SF-VTRx Prototype

Versatile Link

SF-VTRx versus Multi-mode VTRx



SF-VTRx and its test board



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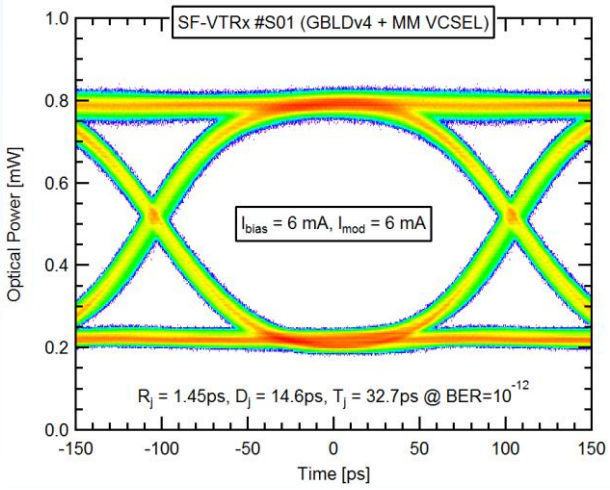
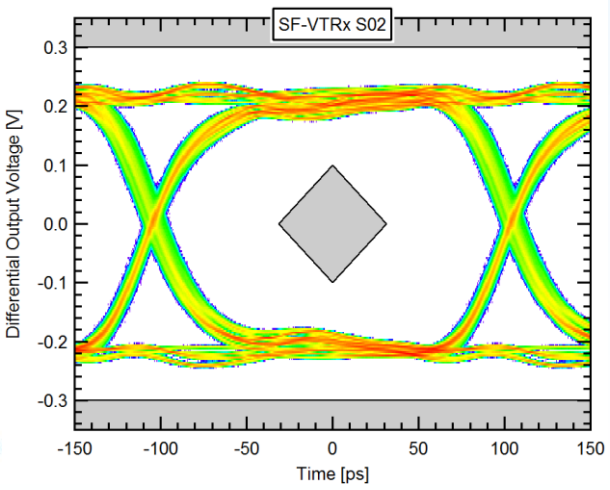
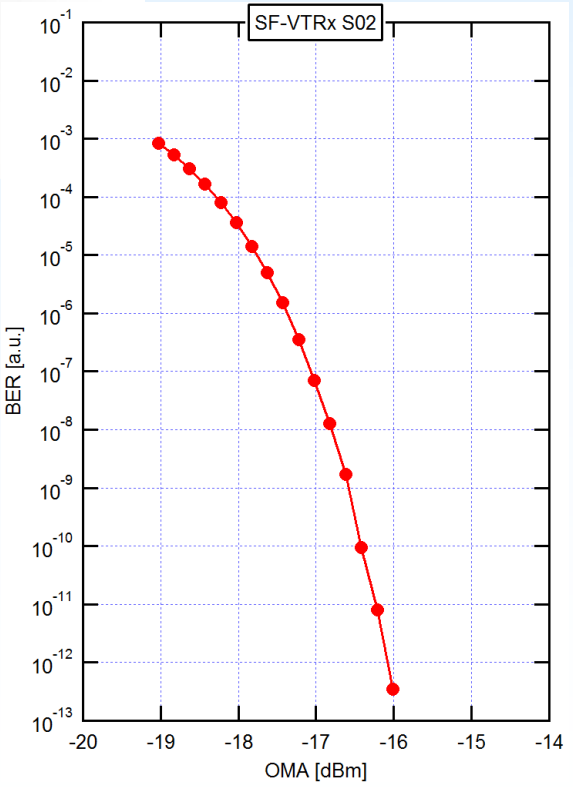




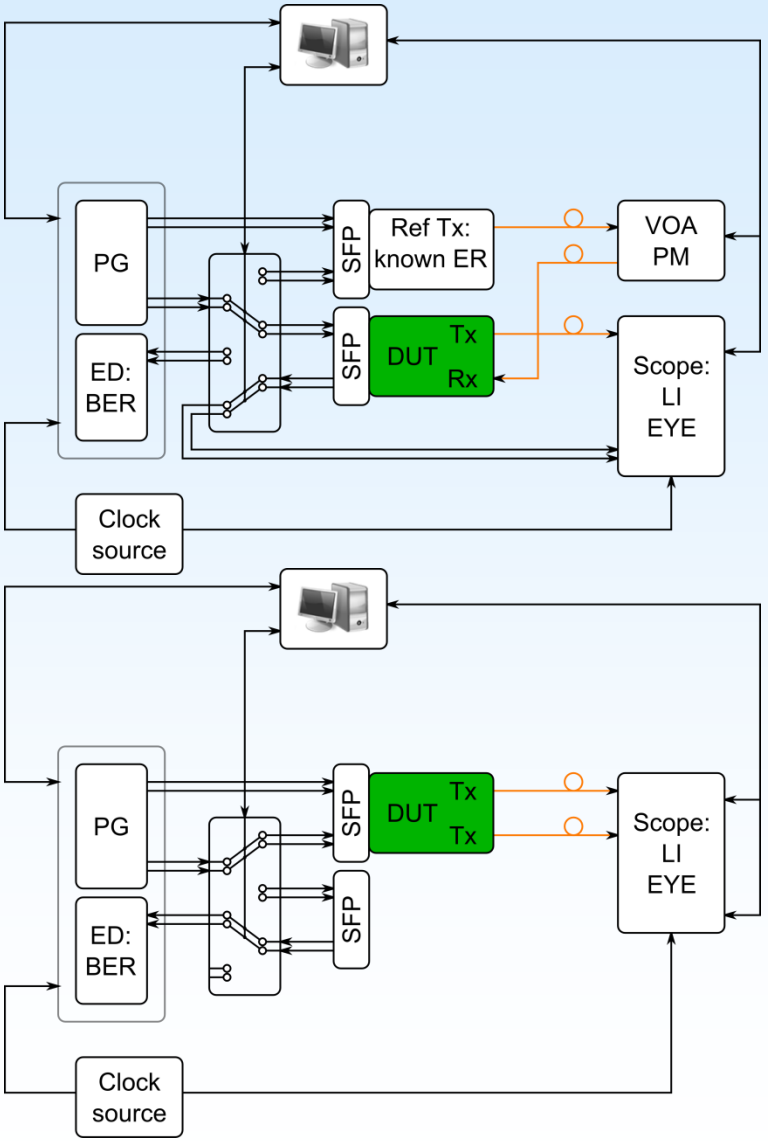
RX Eye



Summary

- Versatile Link moves to pre-production readiness phase
- Fully functional VTRx and VTTx prototypes have been manufactured and tested
  - Specifications are met
- Test procedure is being established
  - Test setup is being discussed
- New VTRx form factor has been introduced: SF-VTRx
  - Further size reduction might be needed
  - That will be difficult to achieve using standard LC TOSA/ROSA parts
  - More aggressive packaging options will be investigated

Test system



- Pattern generator and error detector (PG and ED)
  - Bench-top instrument, or
  - FPGA-based (e.g. GLIB)
- Precision clock source
- High-speed oscilloscope
  - Sampling scope with optical head
  - Real-time scope with reference receiver
- Variable Optical Attenuator (VOA)
- Optical Power Meter (PM)
- High-speed analog switch
- Optical switch

LC TOSA/ROSA Clip

Versatile Link

- Customized commercial solution