Versatile Transceiver and Transmitter Production for Phase I Upgrades of LHC Experiments

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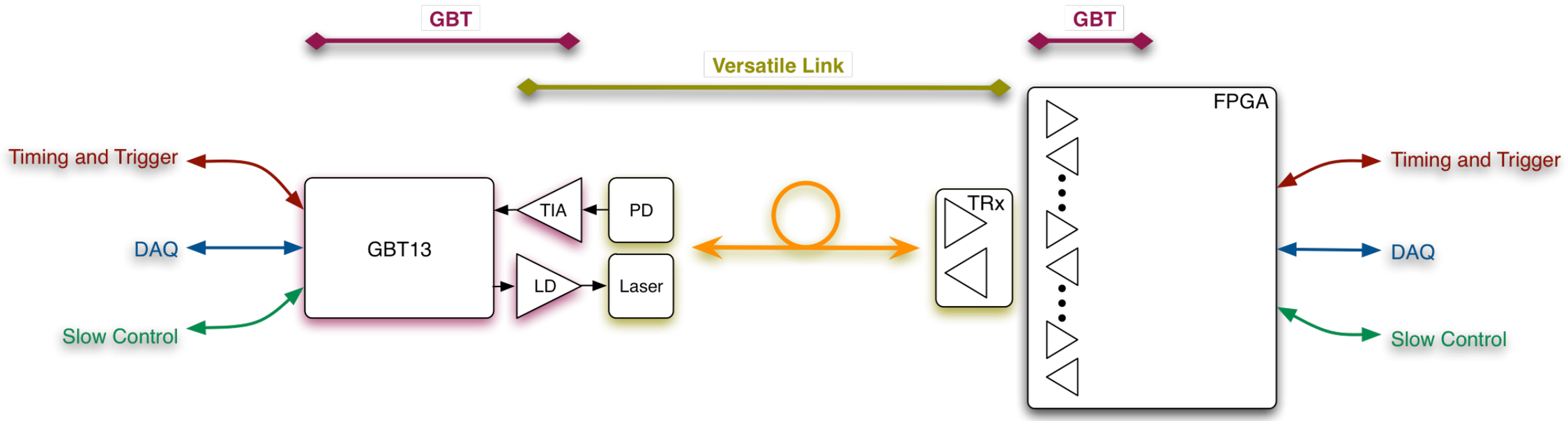
Outline

- Optical Link Common Project
- Versatile Link front-end module (VTXx) design status
- VTXx procurement status
- VTXx radiation validation
- VTXx quality assurance plan

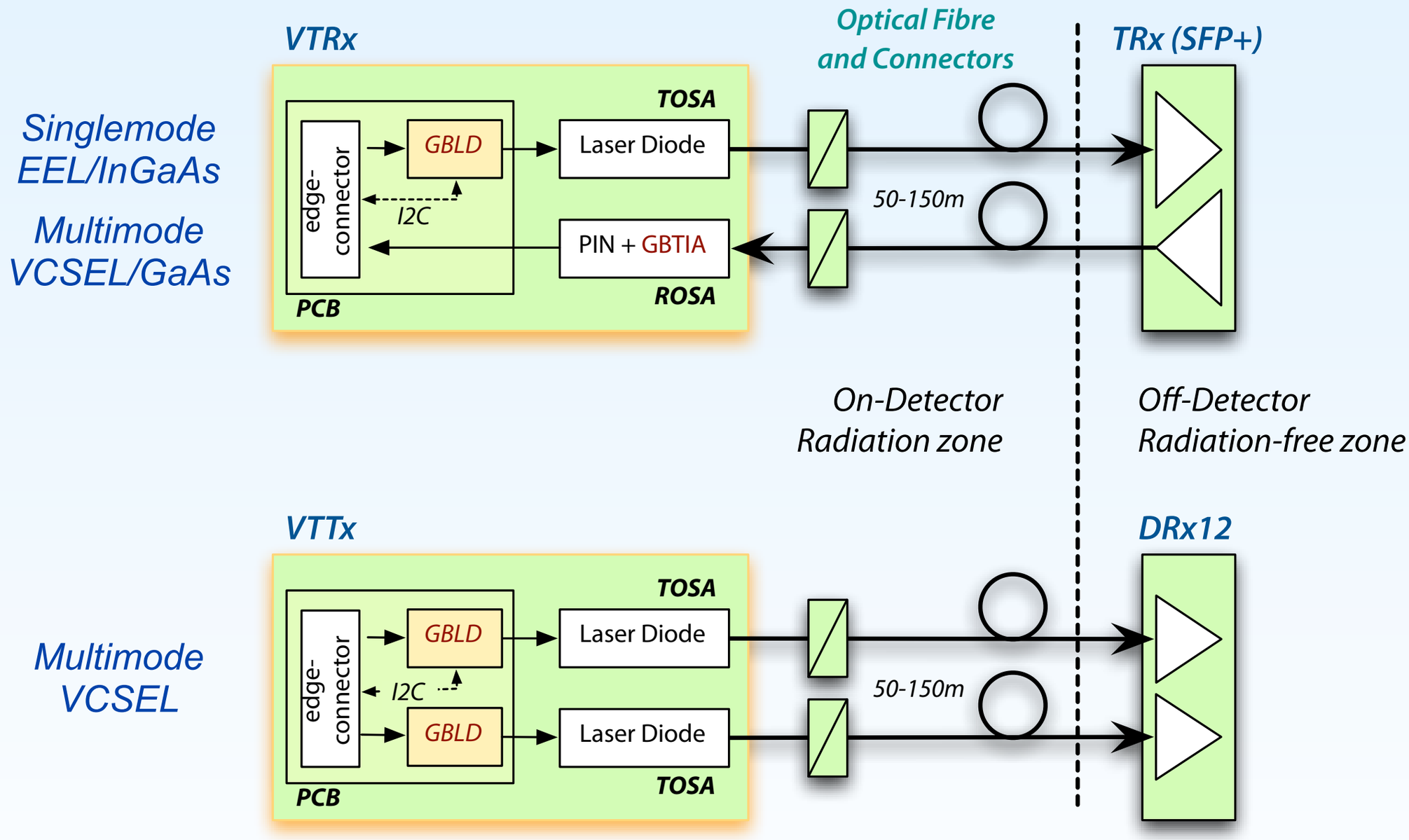
Optical Link Project

Versatile Link

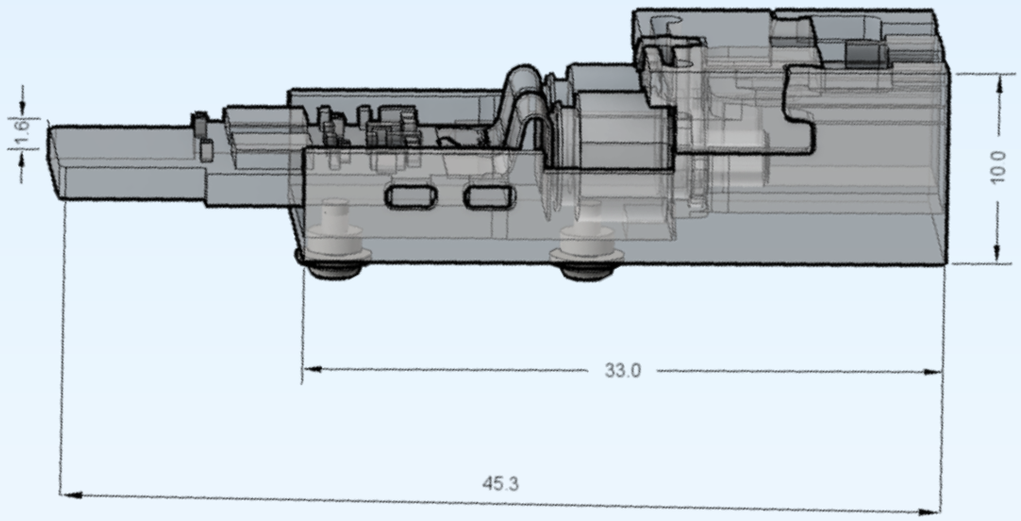
- CERN common project
- Bidirectional, ~5Gbps
- Versatile
  - Multimode (850nm) and Singlemode (1310nm) versions
  - Point to Point and Point to Multipoint architectures
- Front-end pluggable module
- CERN Common Project endorsed by LHC experiments
- Collaboration between CERN and partner institutes
- Kick-off mtg in April 2008
- Production planned for 2014/5
- Target LS2 upgrades

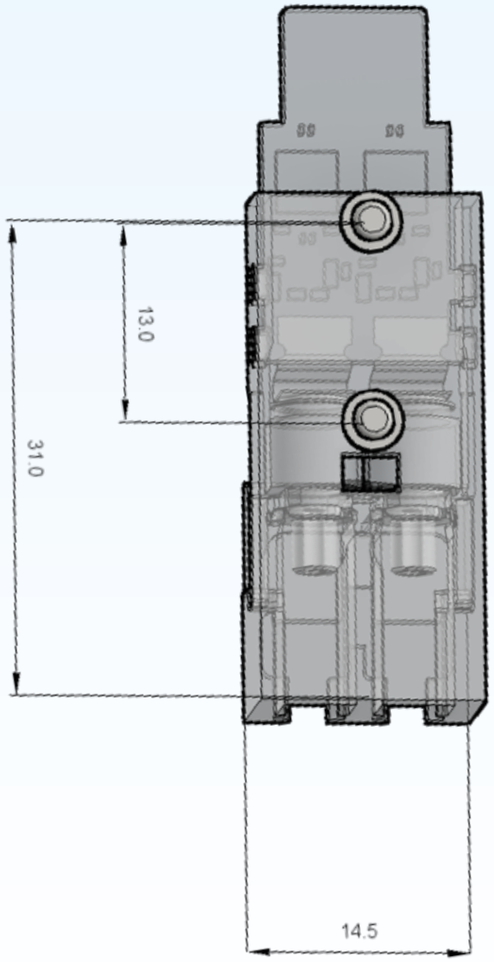


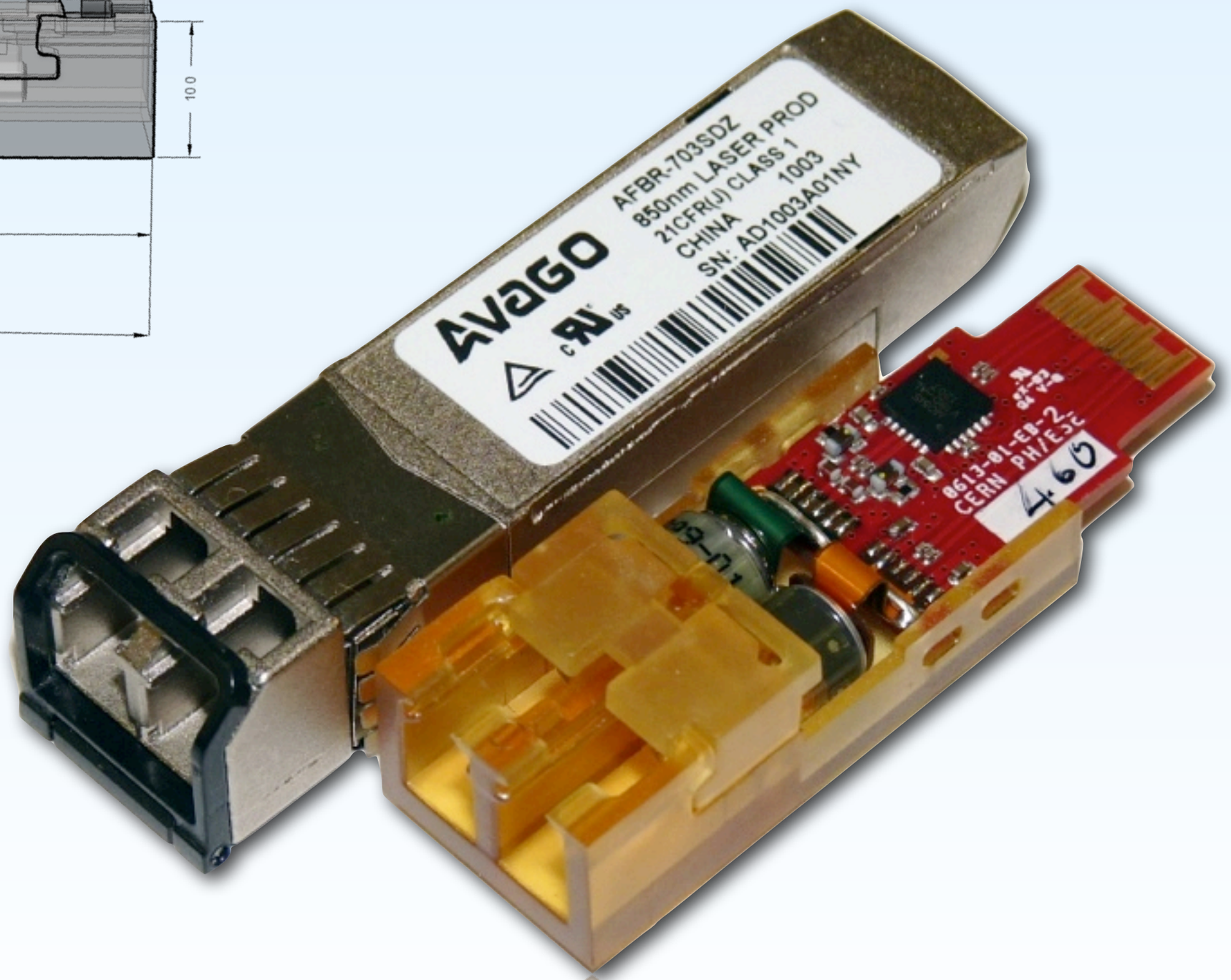
Versatile Link Overview



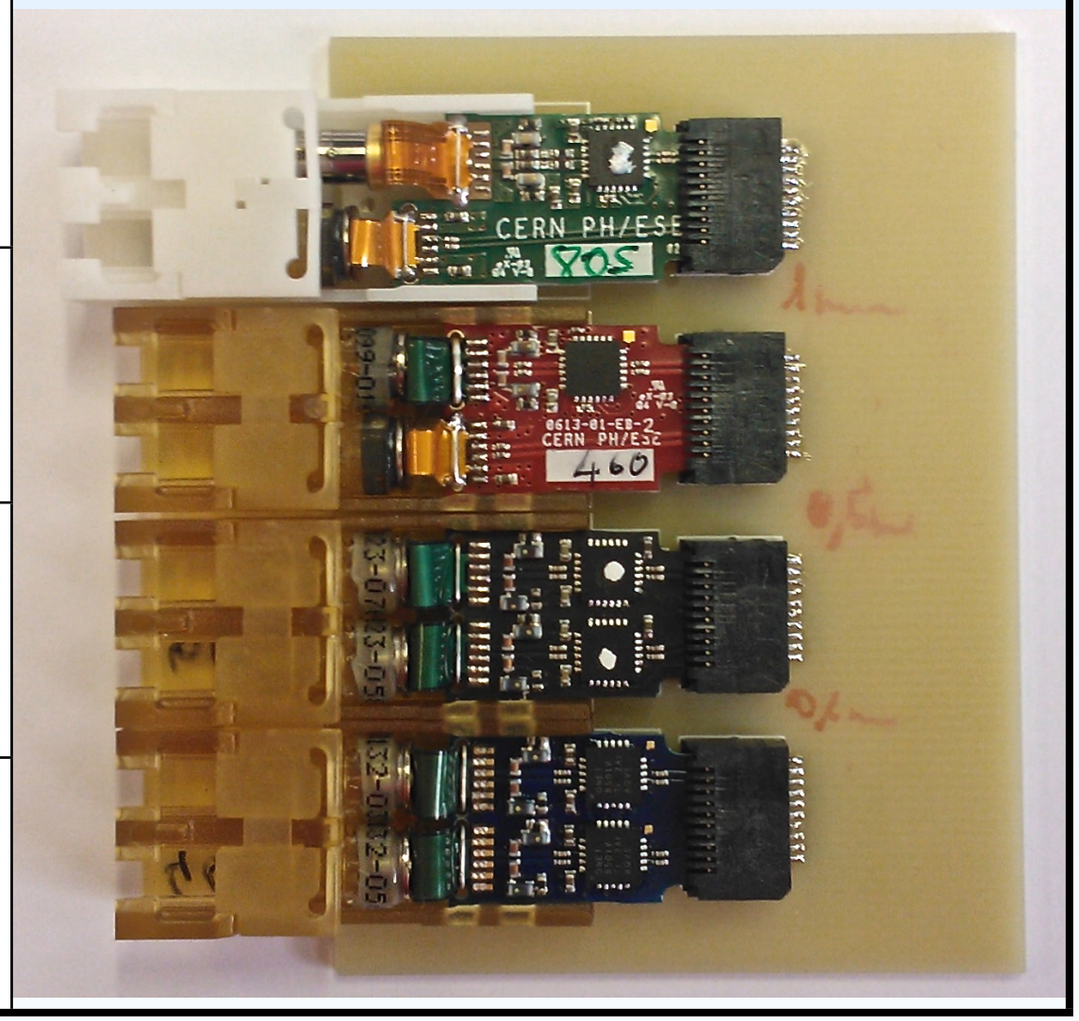
Front-end pluggable module







Design Status

Variant	Laser Driver	TOSA	ROSA	Picture
Single-mode VTRx	GBLD v4.1	Edge Emitter Laser	InGaAs GBTIA v2	
Multi-mode VTRx	GBLD v4.1	850 nm VCSEL	GaAs GBTIA v2	
Multi-mode VTTx	GBLD v4.1	850 nm VCSEL	-	
Rad-soft VTTx	ONET8501V	850 nm VCSEL		

- Performance demonstrated at TWEPP 2012
- Final circuit board layout complete
- Prototypes available

Procurement quantities

Experiment & User	VTRx SM	VTRx MM	VTTx MM
LHCb		2750	6830
CMS HCAL	200	270	2710
ATLAS SmallWh		650	600
ATLAS LArg		150	
ALICE		3550	3200
BE-BI-BL	500		
BE-BI-QP	500		
CBM@FAIR		1000	2000
Total	1200	8370	15340

- CERN organises procurement on behalf of users
- Overall budget for all items is around 2.8 MCHF

Procurement plan

- Procurement process defined and started
  - CERN will provide outlay
  - Tendering needs to be completed to know final cost
- Volume production starting early 2015

Radiation tolerance levels

- VL specifications define two tolerance levels depending on application

Table 4.1.1 Versatile link environmental requirements

	Tolerance level	Dose and fluence[1](1Mev neutron equivalent)
4.1.1.1	Calorimeter	10 kGy 5 x 10^{14} n/cm^2
4.1.1.2	Tracker	500 kGy 2 x 10^{15} n/cm^2 1 x 10^{15} h/cm^2

- All of the upcoming production will be qualified for the Calorimeter tolerance level
  - Nevertheless, up until now component qualification for selection purposes has been carried out up to HL-LHC Tracker levels

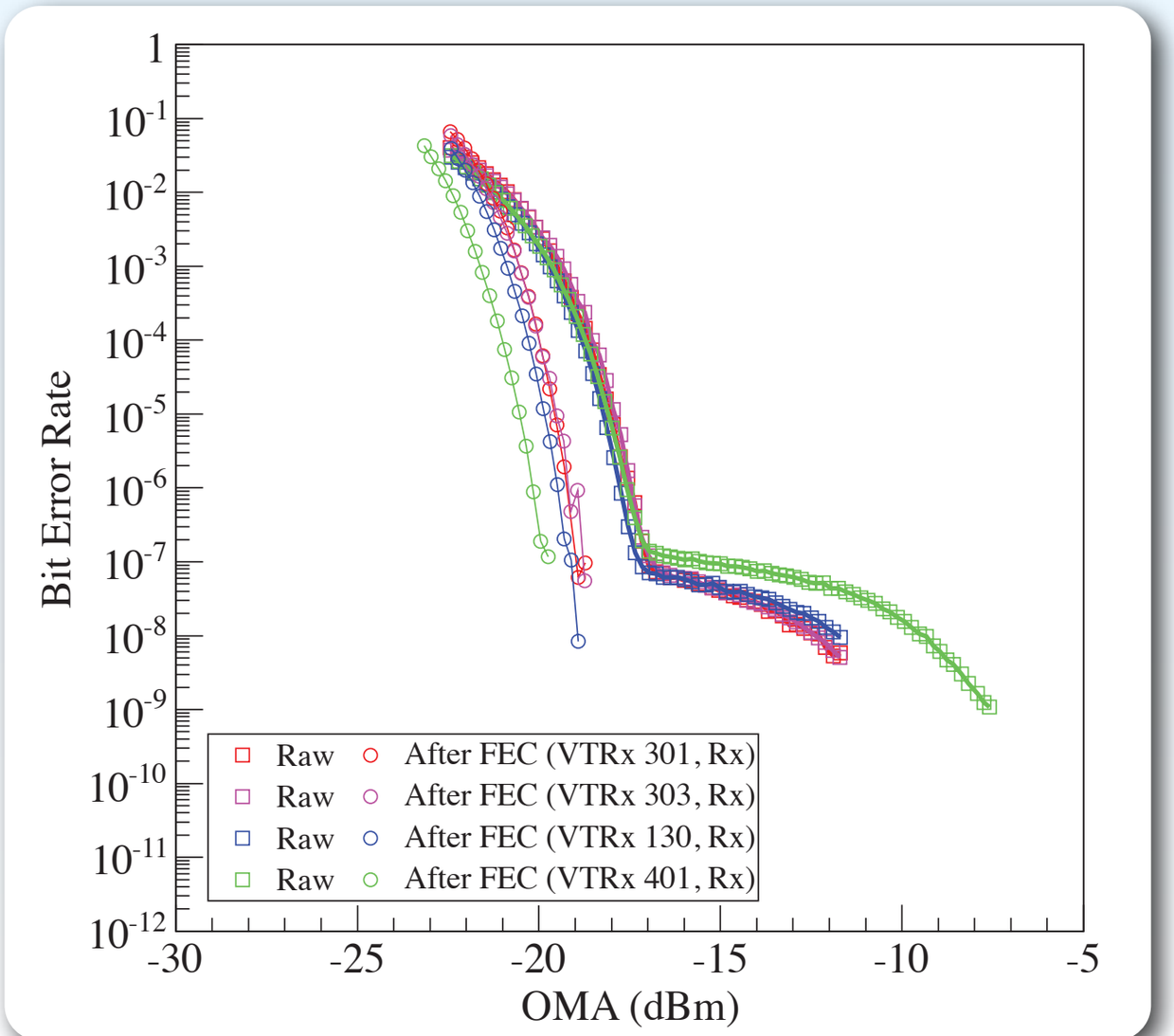
Component Radiation Testing

Versatile Link

- Radiation tolerance assessment mandatory for COTS parts
  - Laser diodes
  - Photodiodes
  - Fibre, Connectors
- Extensive online testing carried out over last years
  - Neutron total fluence irradiation at UCL, Belgium
  - Pion total fluence irradiation at PSI, Switzerland
  - Gamma total dose (passive) at Ionisos, France
  - Proton SEU at PSI, Switzerland
- No unexpected results obtained, devices will withstand Calorimeter grade production
  - For Post-LS3 Trackers this remains to be validated

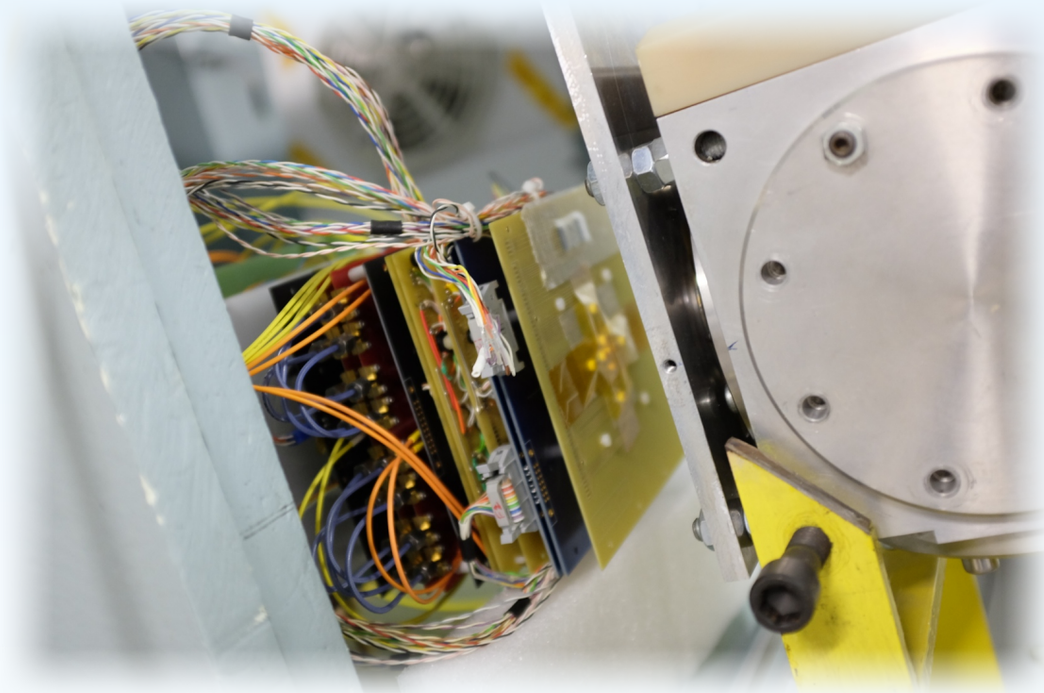
SEU mitigation with GBT protocol

- SEUs in the photodiode are unavoidable
  - GBT implements an interleaved Reed-Solomon Forward Error Correction (FEC) scheme to mitigate the induced errors

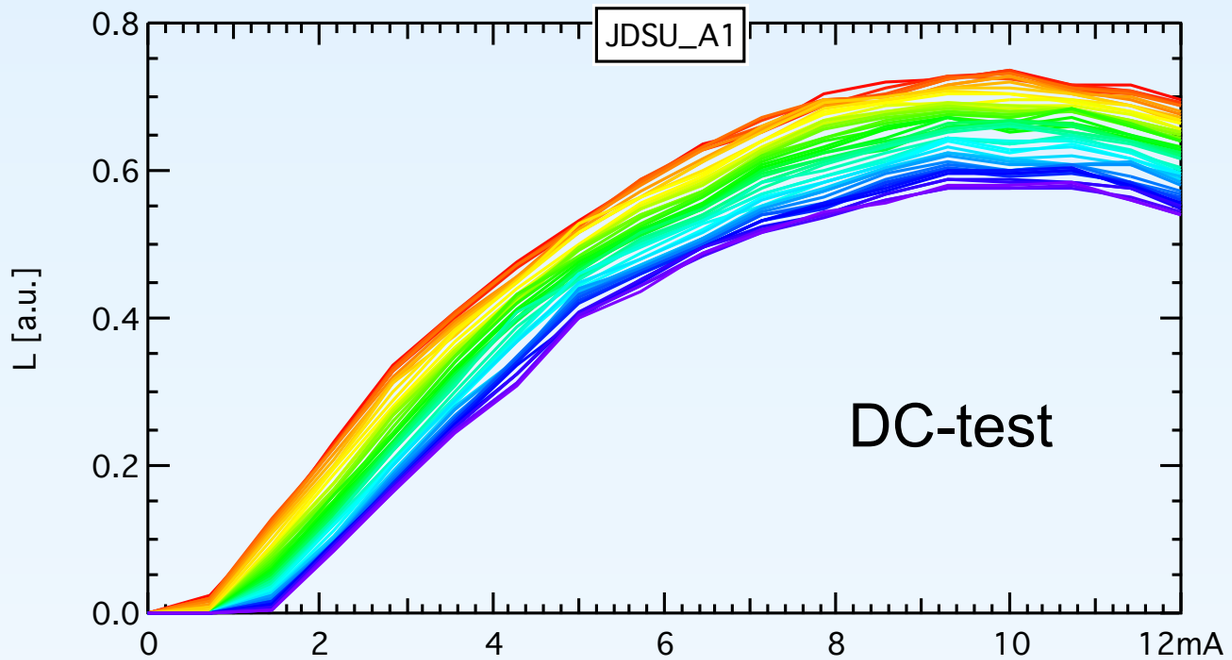


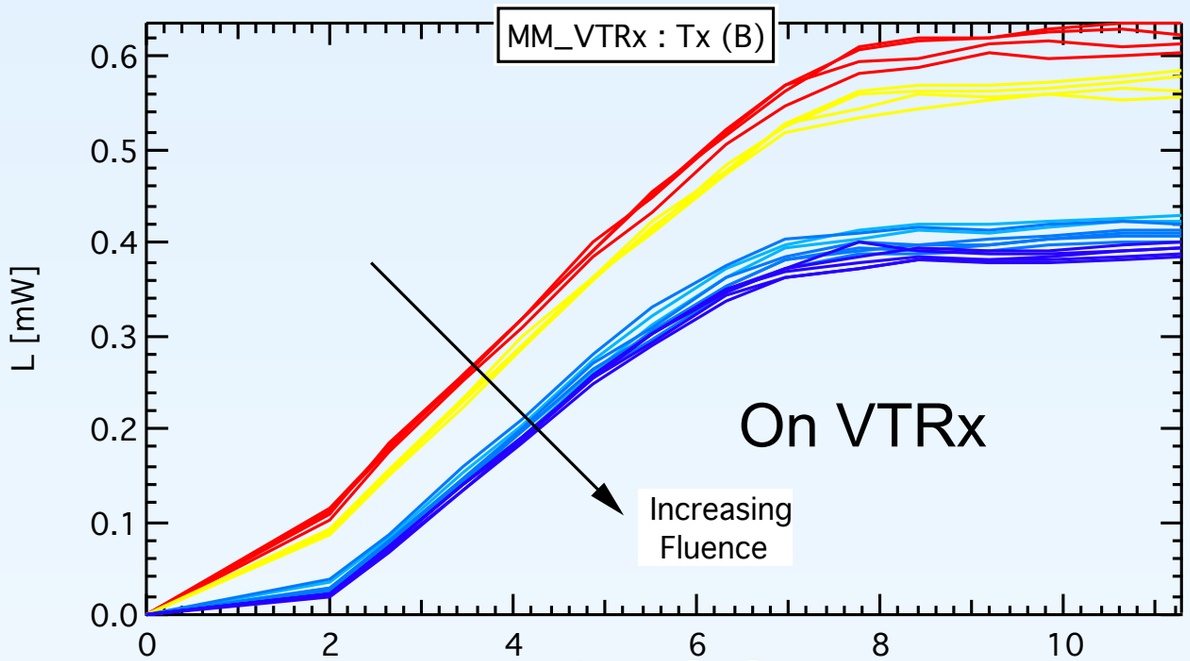
Final validation: VTRx in n-beam

- Final prototype VTRx (SM & MM) exposed to neutron beam at UC Louvain cyclotron facility in Nov. 2013
  - Complex test
  - VTRx in addition to lasers/pins
- Direct comparison between devices irradiated with DC measurements and AC measurements on VTRx
  - Large dataset still being evaluated
- Devices on VTRx behave as expected from static testing



Final validation: VTRx in n-beam (2)

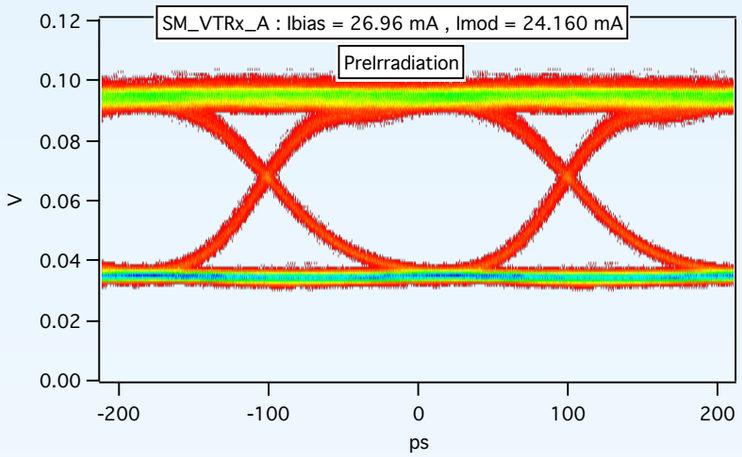


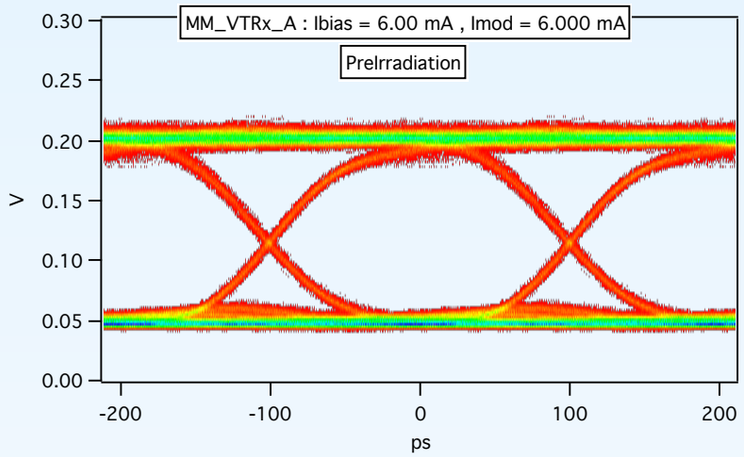


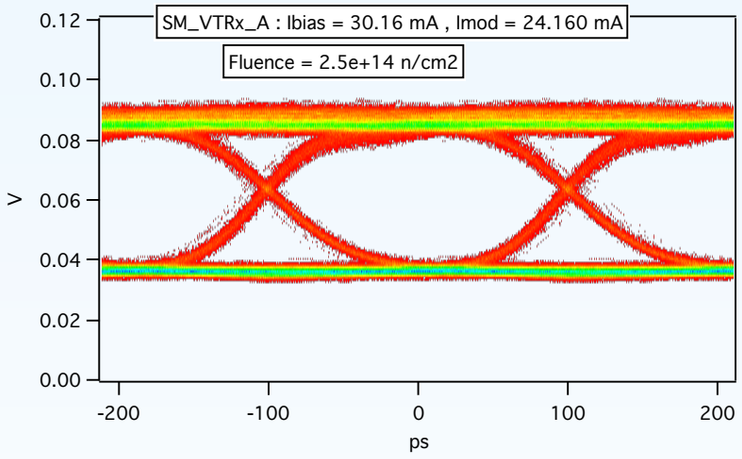
- Comparable results for intrinsic laser behaviour in standard irrad test setup and on VTRx
- Also true for responsivity drop and leakage current increase in photodiodes

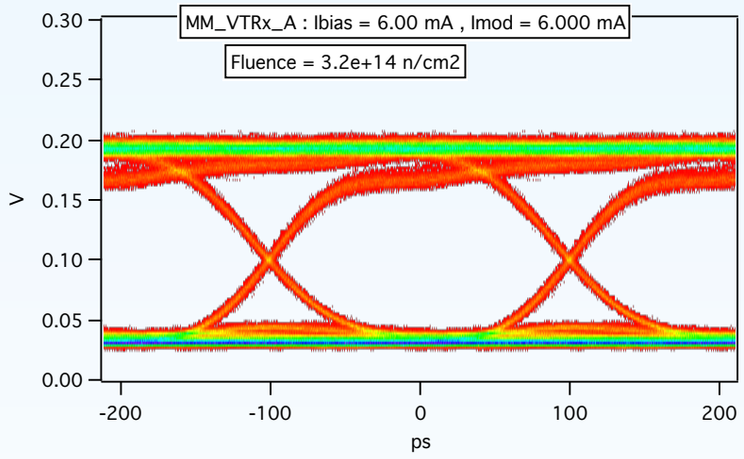
Final validation: VTRx in n-beam (3)

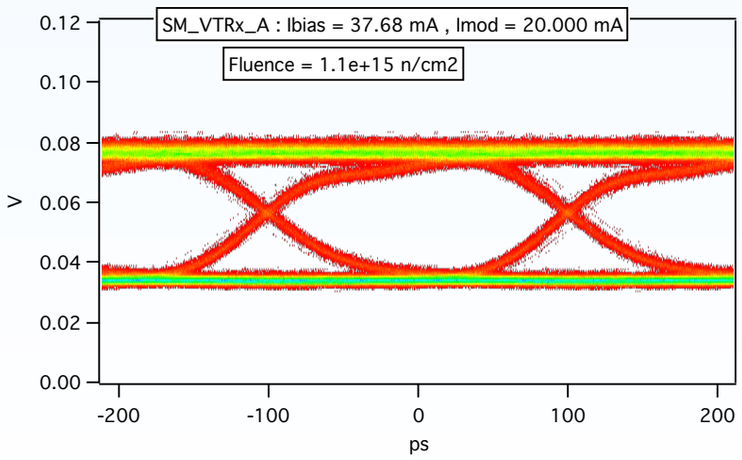
- Dynamic performance of lasers unchanged at 4.8 Gb/s

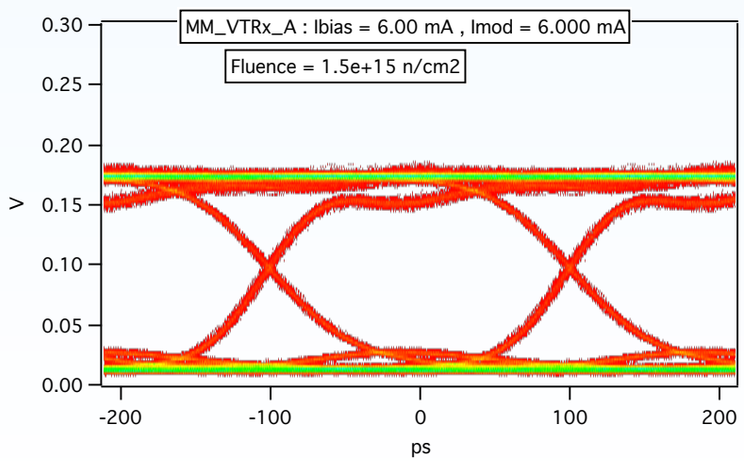












Quality Assurance

- Pre-series
  - Qualification through verification of all specifications
    - including environmental testing (temperature, radiation)
  - Long-term aging tests
- Production batches
  - 100% testing of reduced specification set
    - Power consumption
    - RX Sensitivity
    - Tx Eye diagram
  - Lot validation through sample testing of fuller set of specifications
    - Not including environmental testing

Testing & traceability

- Test stand for Qualification & Lot acceptance
  - Based on lab instruments (scope & BERT)
- Test stand to be located in Assembly House for 100% testing of modules
  - Based on FPGA evaluation platform
- All modules to be labelled with 2D barcodes

- Test stands communicate with a database
  - History of actions
  - Record of test results
    - Process tracking & statistics
  - Location

Conclusions

- Candidate components for Versatile Link front-end modules qualified
  - Will also verify wafer-wafer variations on production quantity
- VTXx procurement process proceeding
  - Volume production will begin in 2015
- Measured the performance/degradation of full VTRx module during neutron irradiation
  - O-E components behaved as expected, high-speed operation verified in-beam for the first time
  - SEU issue found with GBLD, to be fixed

Further Reading

- GBT
  - Presentation by Paulo Moreira at ACES 2014
    - http://indico.cern.ch/event/287628/session/1/contribution/12/material/slides/
- Versatile Link
  - Presentation by Francois Vasey at ACES 2014
    - http://indico.cern.ch/event/287628/session/1/contribution/13/material/slides/
  - Electronics Seminar 2014
    - http://indico.cern.ch/event/267423/

GBT Radiation Qualification

Versatile Link

- GBTIA
  - X-ray Total Dose validated to 1 MGy
  - Proton SEU tolerance at PSI, Switzerland
- GBLD
  - X-ray Total Dose validated to 1 MGy
  - Proton SEU at PSI, Switzerland
  - Neutron SEU at UCL, Belgium (see later)
  - Ion SEU at Legnaro, Italy identified some issues, being fixed