Optical Link Common Project

Jan Troska

for Versatile Link and GBT Project Teams

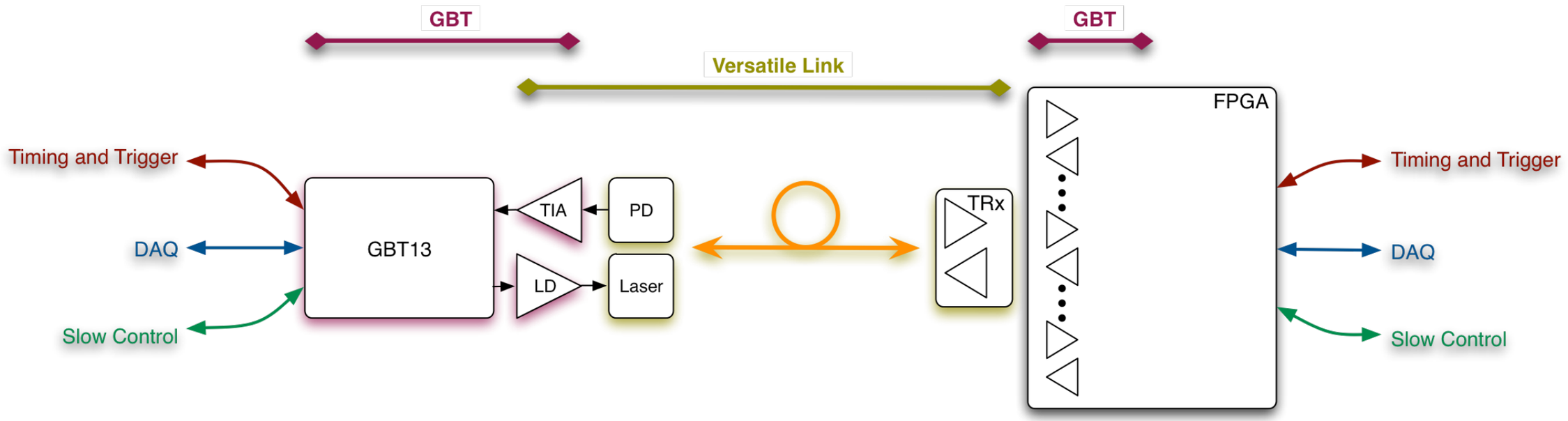
Outline

- Optical Link Common Project
- GBT Status
- Versatile Links status and Radiation testing

Optical Link Project

Versatile Link

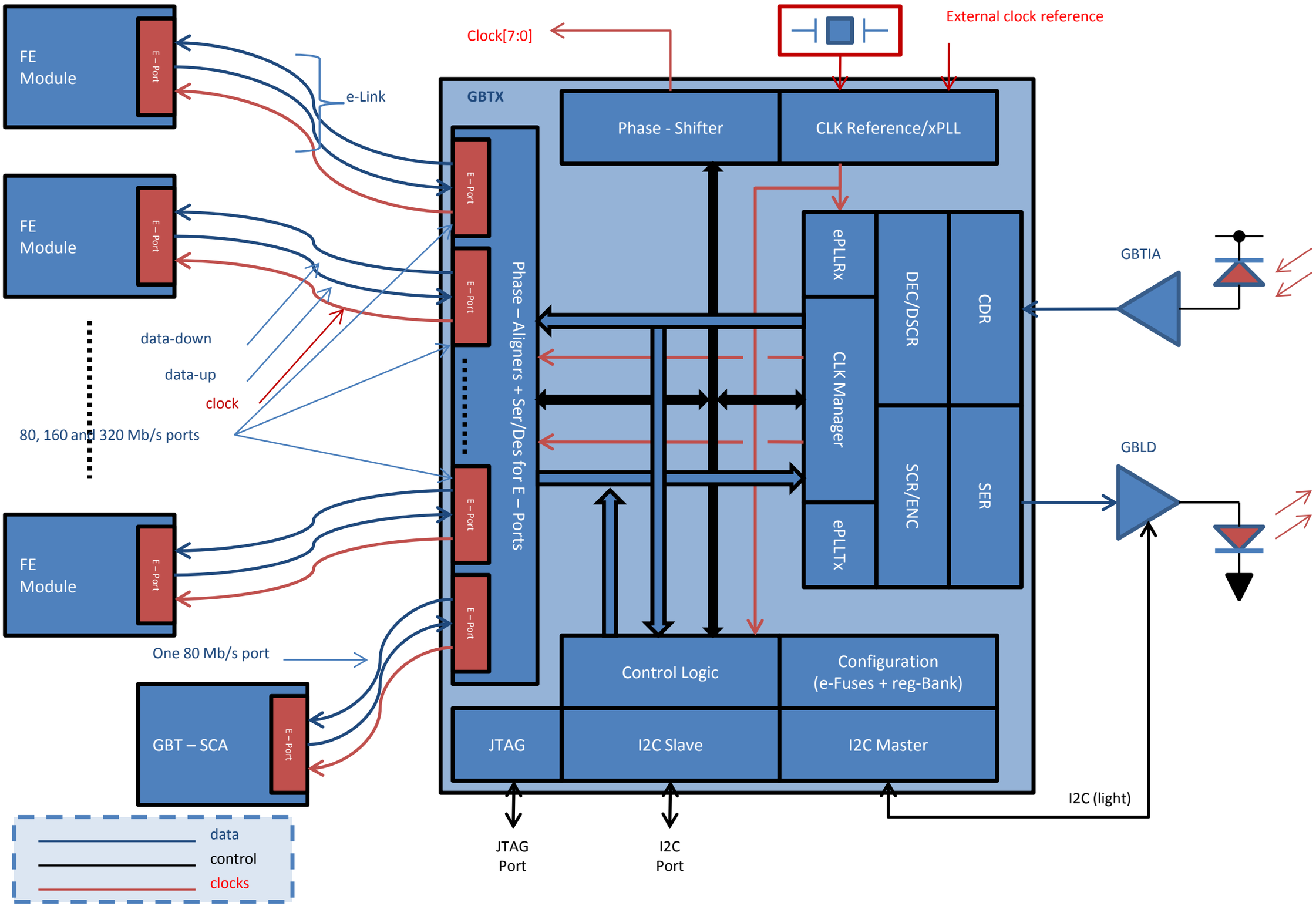
- CERN common project
- Bidirectional, ~5Gbps
- Versatile
  - Multimode (850nm) and Singlemode (1310nm) versions
  - Point to Point and Point to Multipoint architectures
- Front-end pluggable module
- CERN Common Project endorsed by LHC experiments
- Collaboration between CERN and partner institutes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



On-Detector
Custom Electronics & Packaging
Radiation Hard

Off-Detector
Commercial Off-The-Shelf (COTS)
Custom Protocol

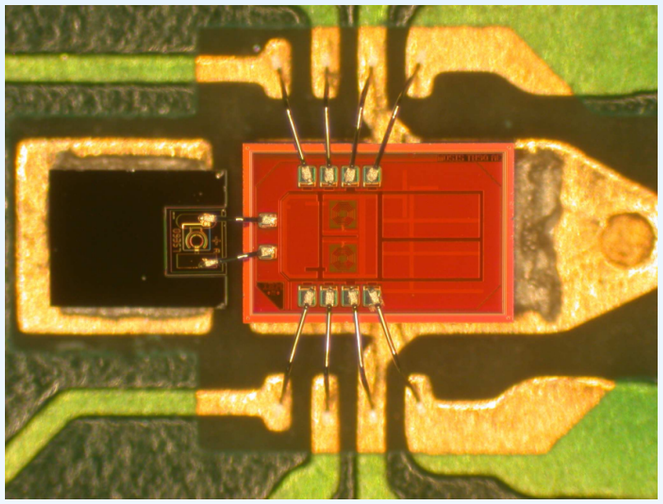
The GBT System



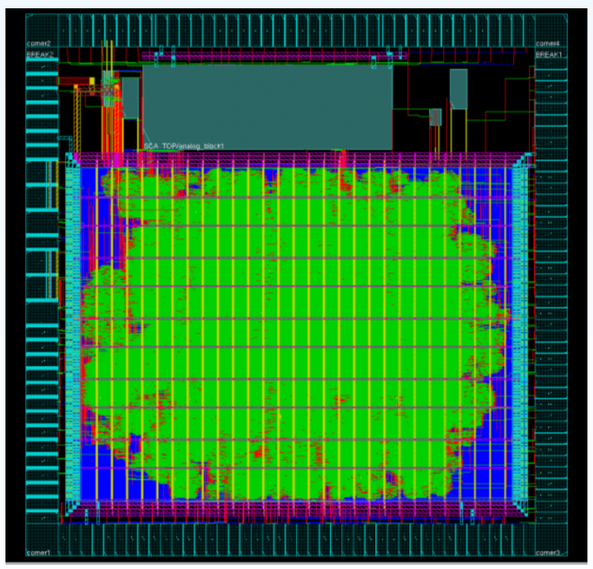
GBT Status

- Chipset nearing production readiness
  - Production-ready submission May/June 2014
  - GBTx minor bug fixes
  - GBLD SEU immunity improvement
  - GBTIA design ready
  - GBT-SCA first prototype

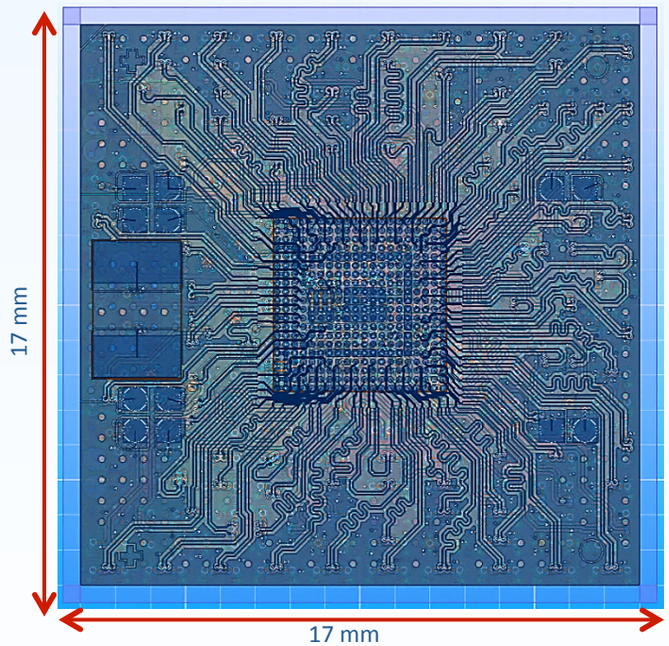
GBTIA



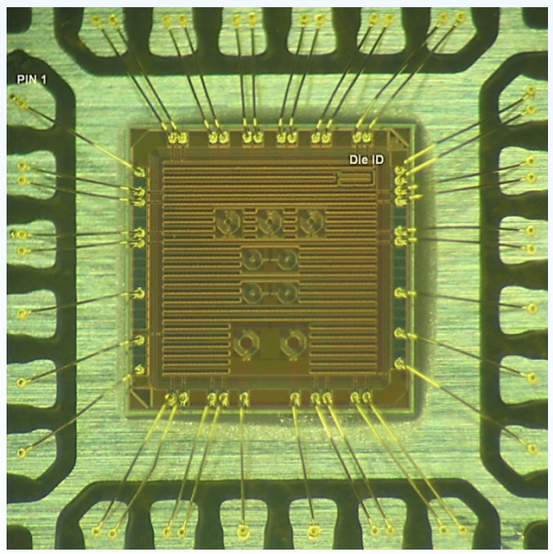
GBT-SCA



GBTx



GBLD



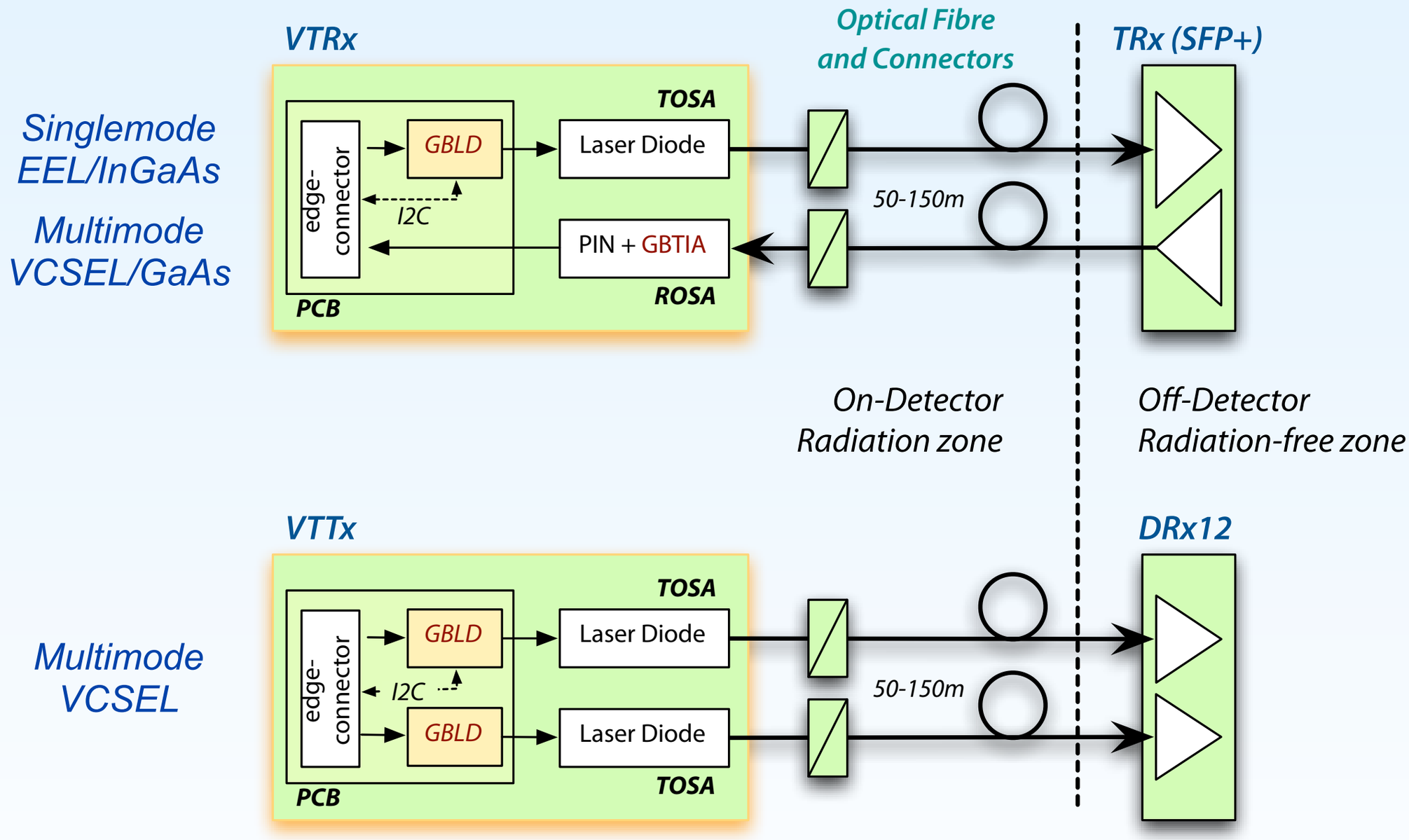
jan.troska@cern.ch

GBT Radiation Qualification

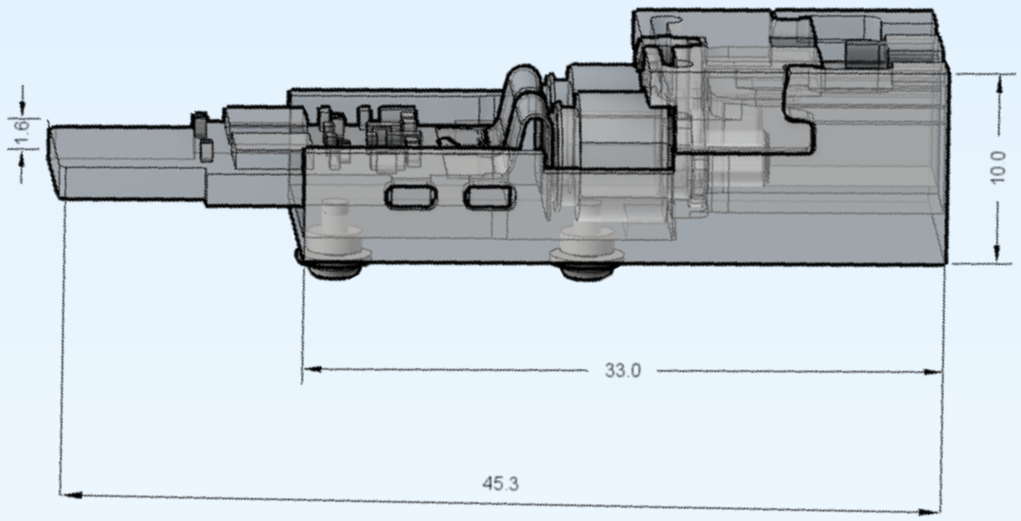
Versatile Link

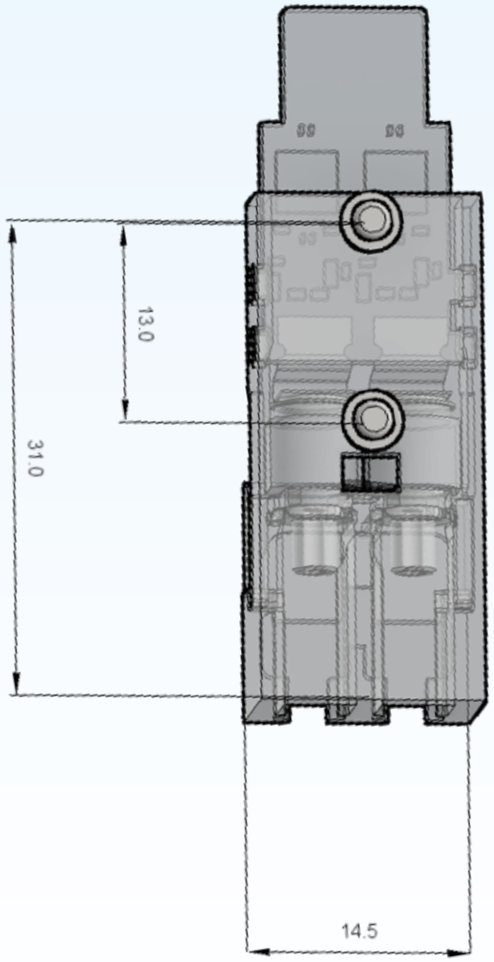
- GBTIA
  - X-ray Total Dose validated to 1 MGy
  - Proton SEU tolerance at PSI, Switzerland
- GBLD
  - X-ray Total Dose validated to 1 MGy
  - Proton SEU at PSI, Switzerland
  - Neutron SEU at UCL, Belgium (see later)
  - Ion SEU at Legnaro, Italy identified some issues, being fixed
- GBTx
  - X-ray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

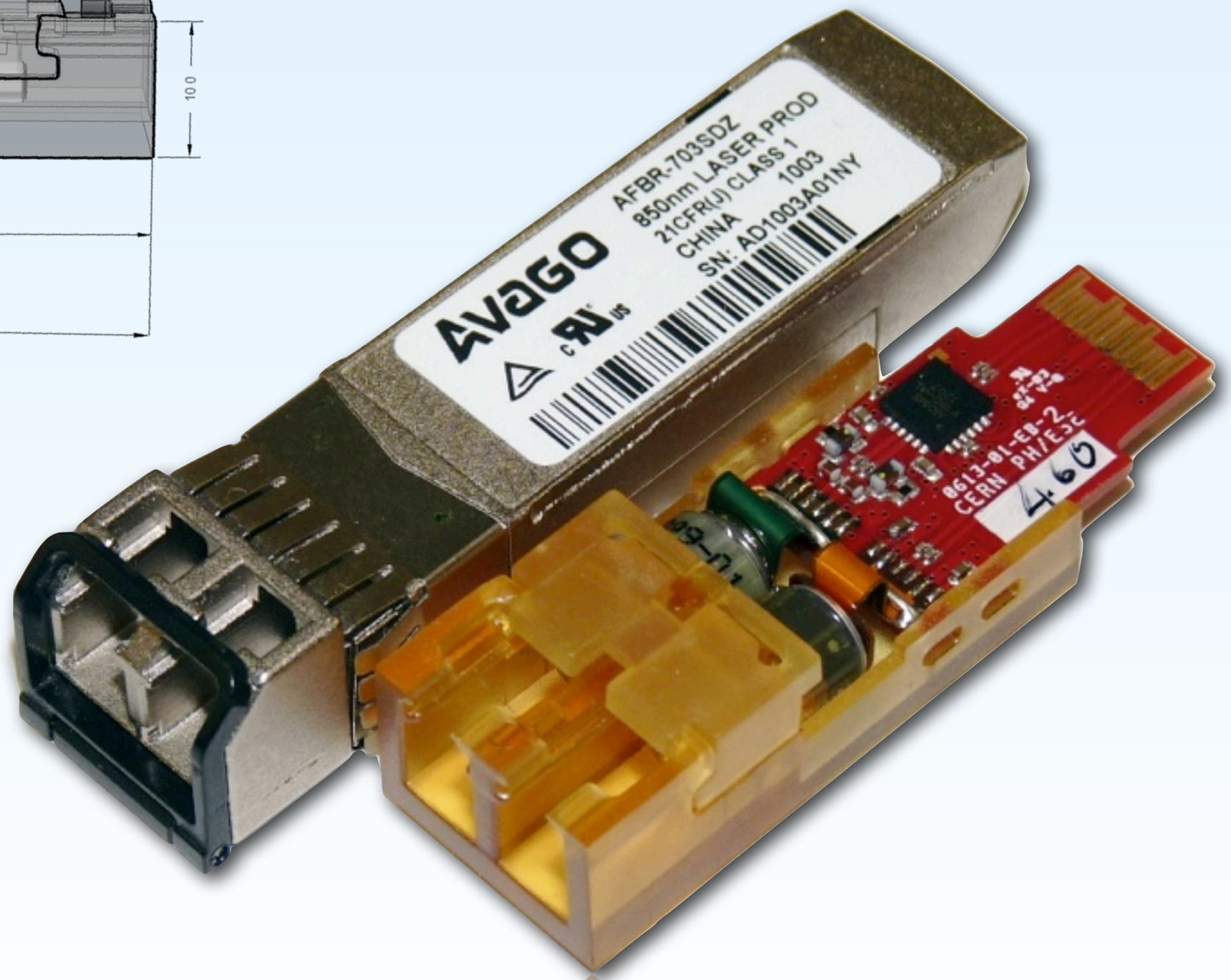
Versatile Link Overview



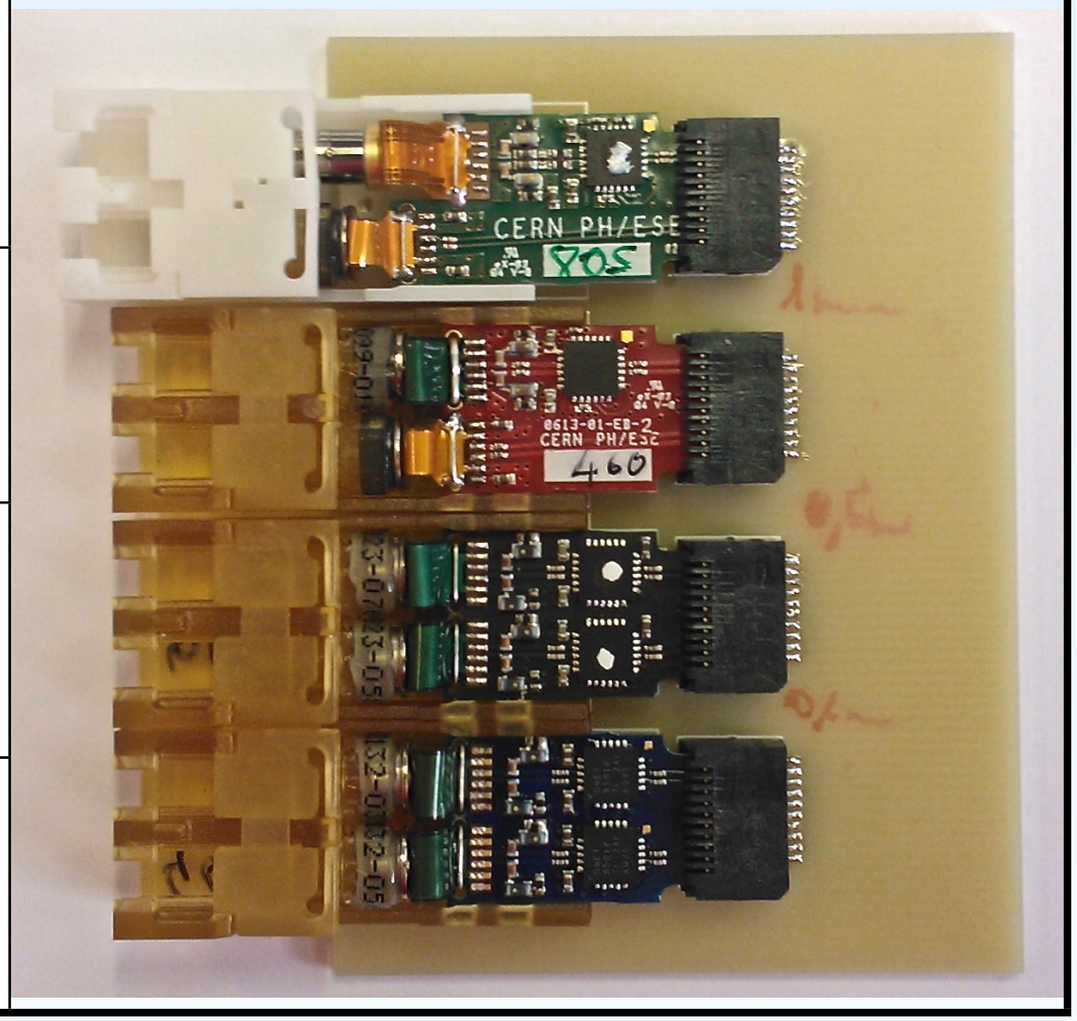
Front-end pluggable module







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 now complete
- Prototypes available

Procurement quantities

Versatile Link

Expt	TOSA		ROSA		Latch		VTRx		VTTx
& User	SM	MM	SM	MM	SM	MM	SM	MM	MM
CMS PIXph1	3000								
CMS HCAL	200	4400	200	400	200	2400	200	400	2000
ATLAS SmWh		1850		650		1250		650	600
ATLAS LArg		150		150		150		150	
LHCb		16900		2900		9900		2900	7000
Alice		9950		3550		6750		3550	3200
BE-BI-BL	500		500		500		500		
BE-BI-QP	500		500		500		500		
Totals	4300	33250	1200	7650	1200	20450	1200	7650	12800

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

Procurement plan

- Procurement process defined and started
  - Need to take funding into account to finalize timing of commercial actions
  - Tendering needs to be completed to know final cost
  - Contract must be placed reasonably soon after tender
- One year from TOSA contract placement to first delivery of VTXx
- Volume production to kick-off by the end of 2014

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

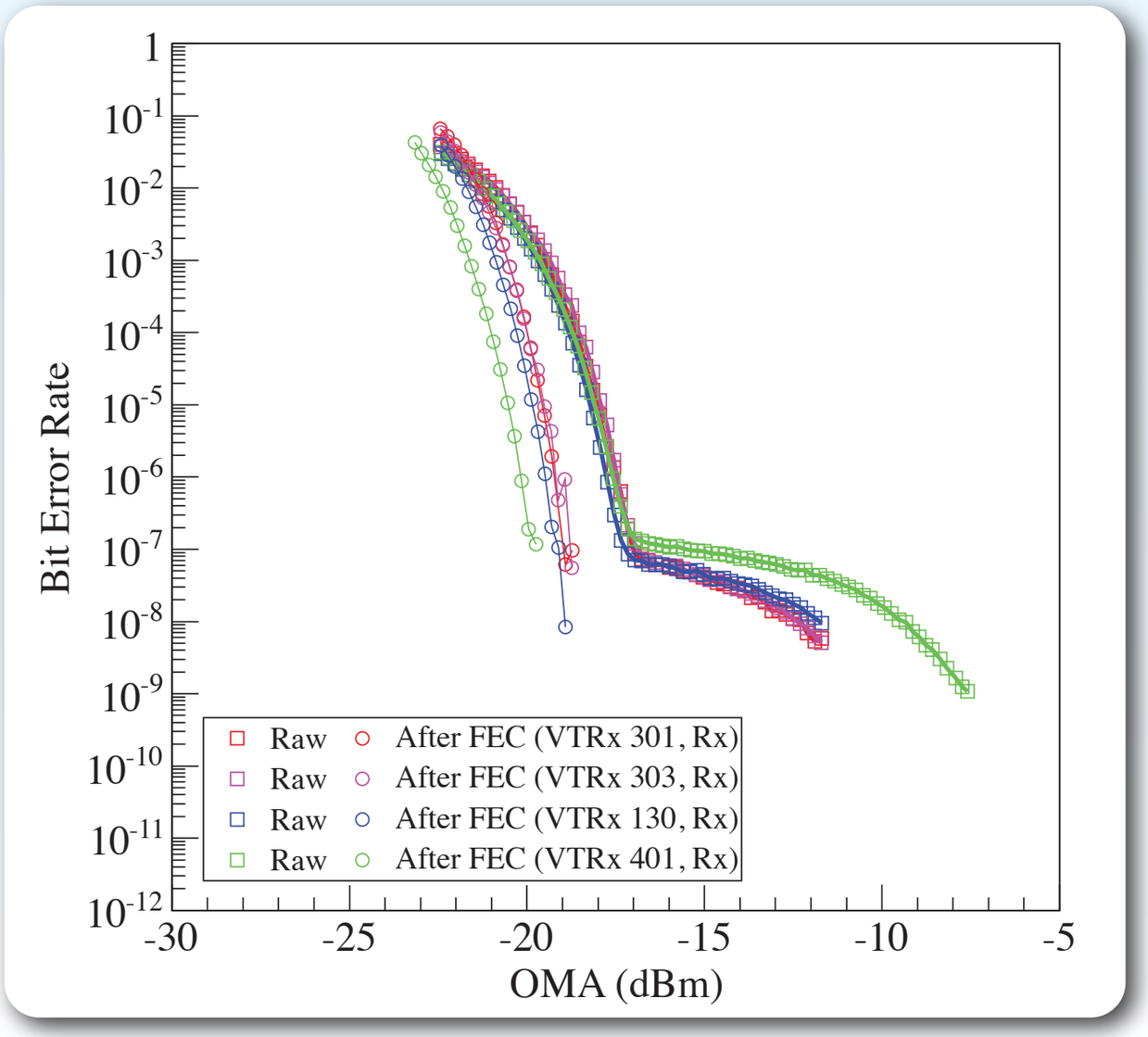
Component Radiation Testing

- 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

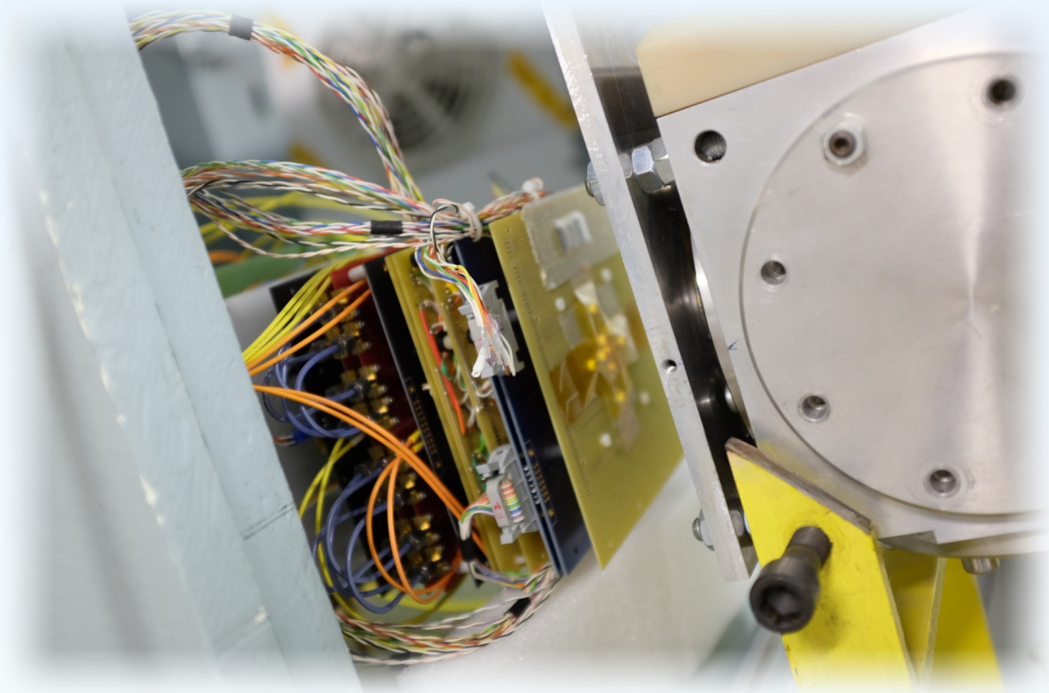
Versatile Link

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

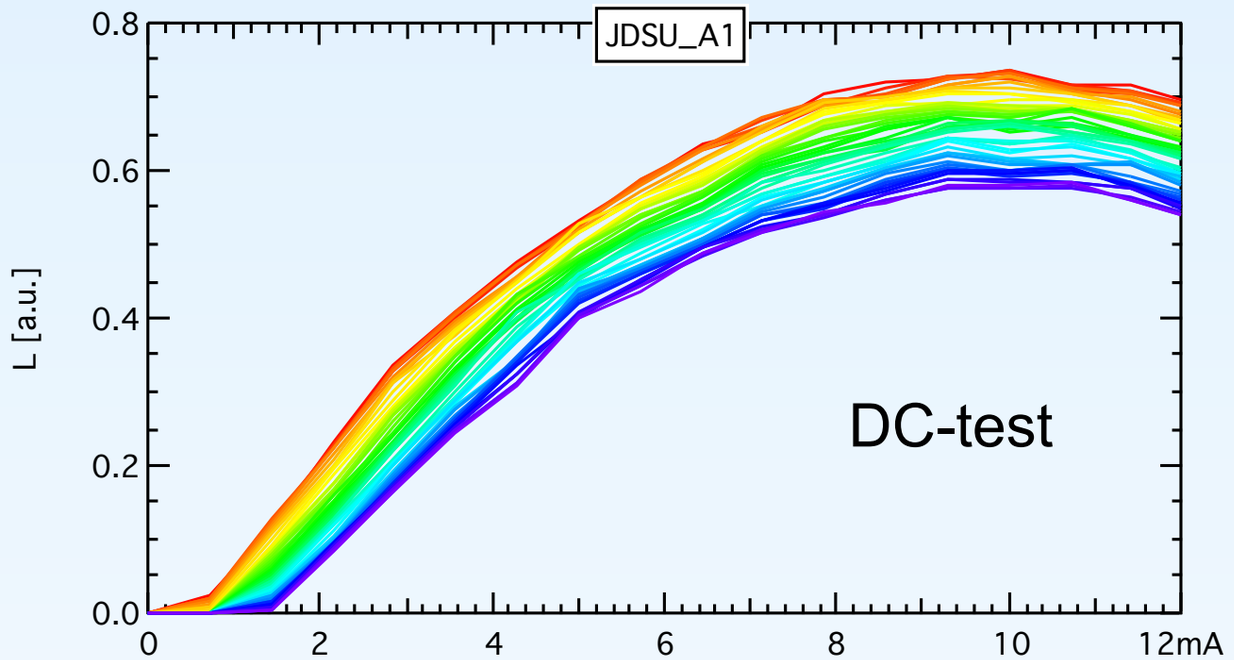


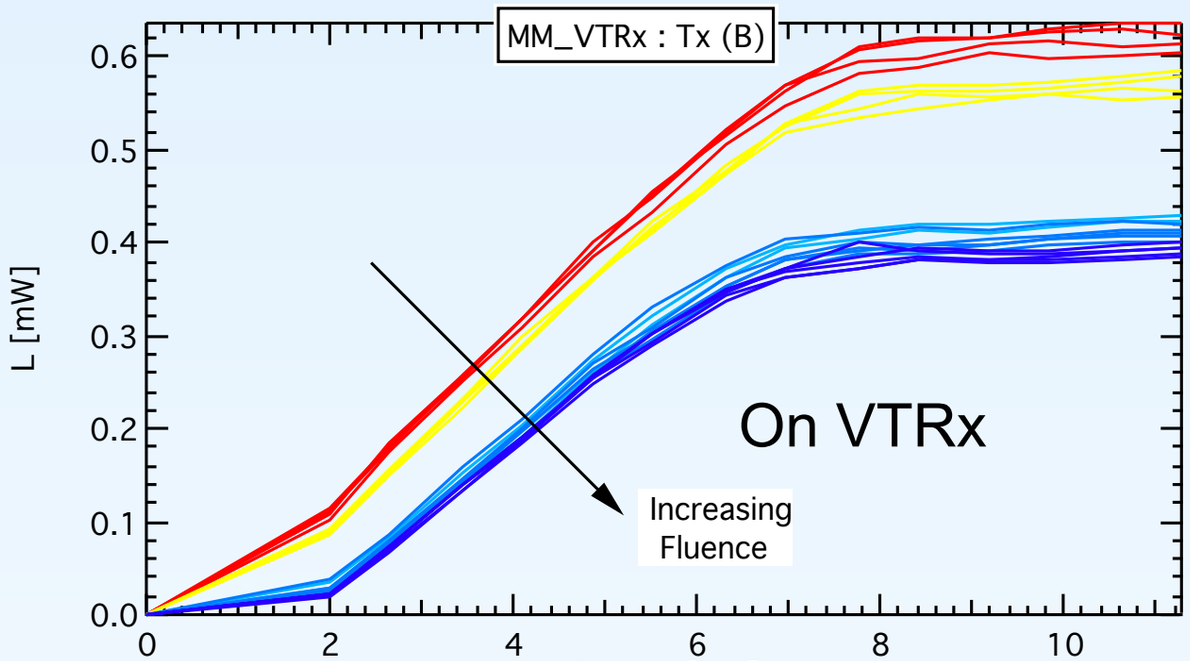
Final validation: VTRx in n-beam

- 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
- Early results show devices on VTRx behave as expected from static testing



Final validation: VTRx in n-beam (2)

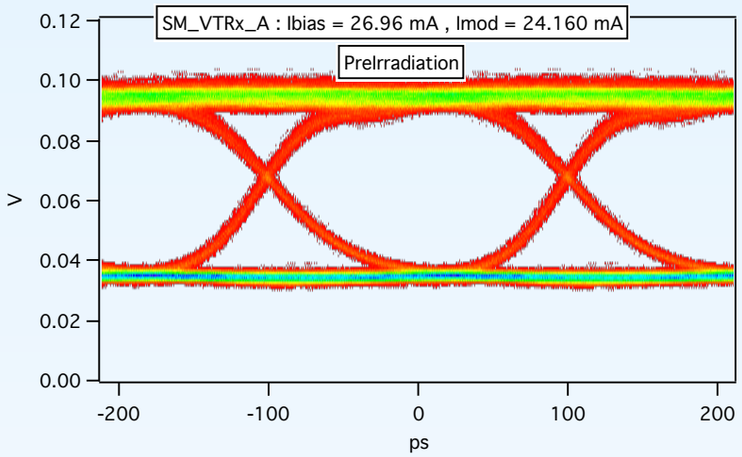


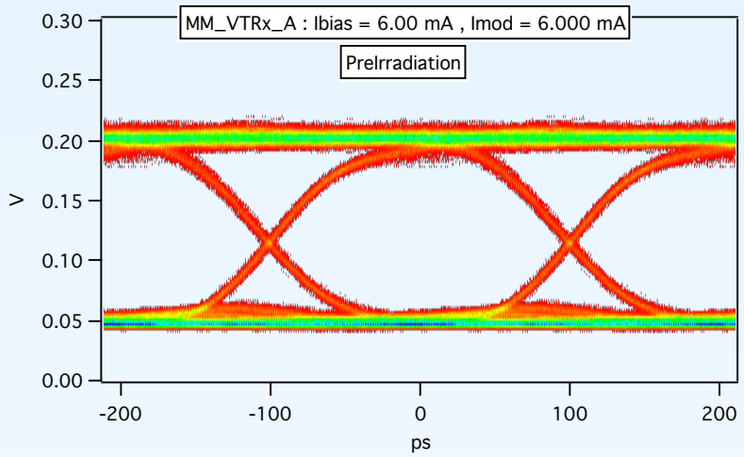


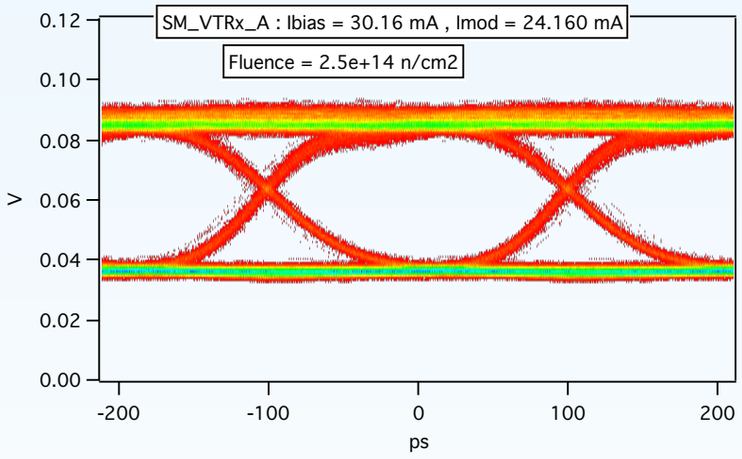
- Qualitatively similar results for intrinsic laser behaviour
- Also true for responsivity drop and leakage current increase in photodiodes
- Detailed analysis still ongoing

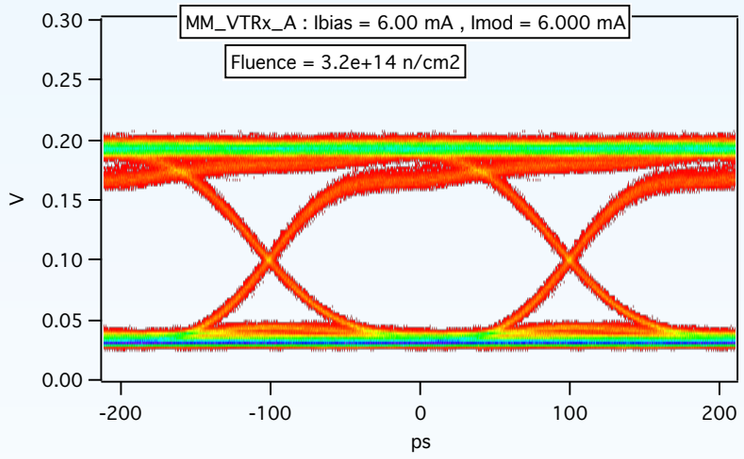
Final validation: VTRx in n-beam (3)

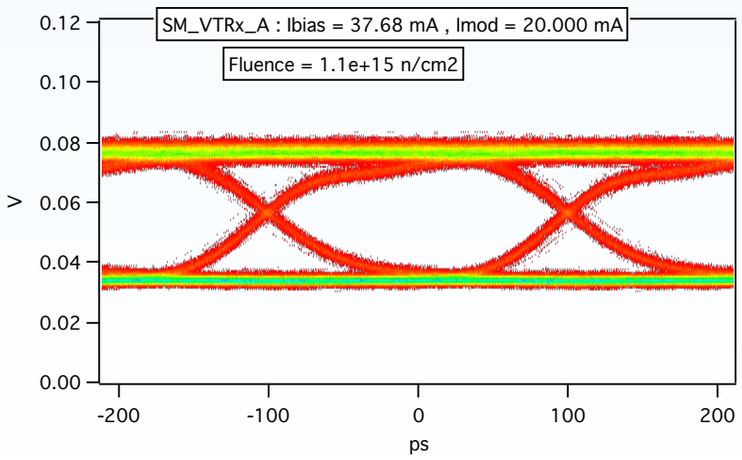
- Dynamic performance of lasers unchanged at 4.8 Gb/s

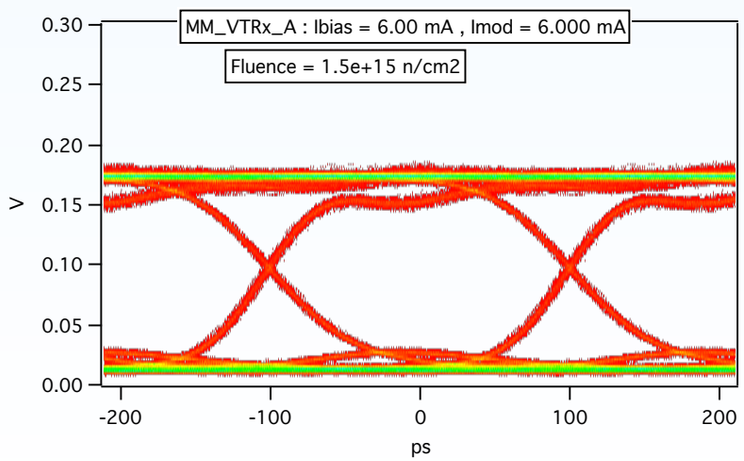












Final validation: VTRx in n-beam (4)

- Single-event upsets observed in GBLD registers
  - Not seen previously in proton testing at PSI
  - Flux in Louvain was 3 x 10^{10} n/cm^2/s (two orders of magnitude higher than at PSI)
- Observed single bit errors in the control registers
  - Cross-section is 1.2x10^{-14} errors/n/cm^2
- In a system of 10000 links operating at a luminosity of 10^{35}, this would be equivalent to
  - 1 error every 8 seconds at the level of the Trackers
  - 1 error every 14 minutes at the level of the Calorimeters
- Most likely due to the circuit topology of a reset line in the control registers
  - To be fixed in final submission (low-risk change)

Conclusions

- GBT chipset nearing production readiness
- Candidate components for Versatile Link front-end modules qualified
  - Will also verify wafer-wafer variations on production quantity
- 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
- Investigating new technologies to be able to survive innermost regions of HL-LHC Phase 2 upgrades

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/