

The Versatile Link

Feasibility Demonstration

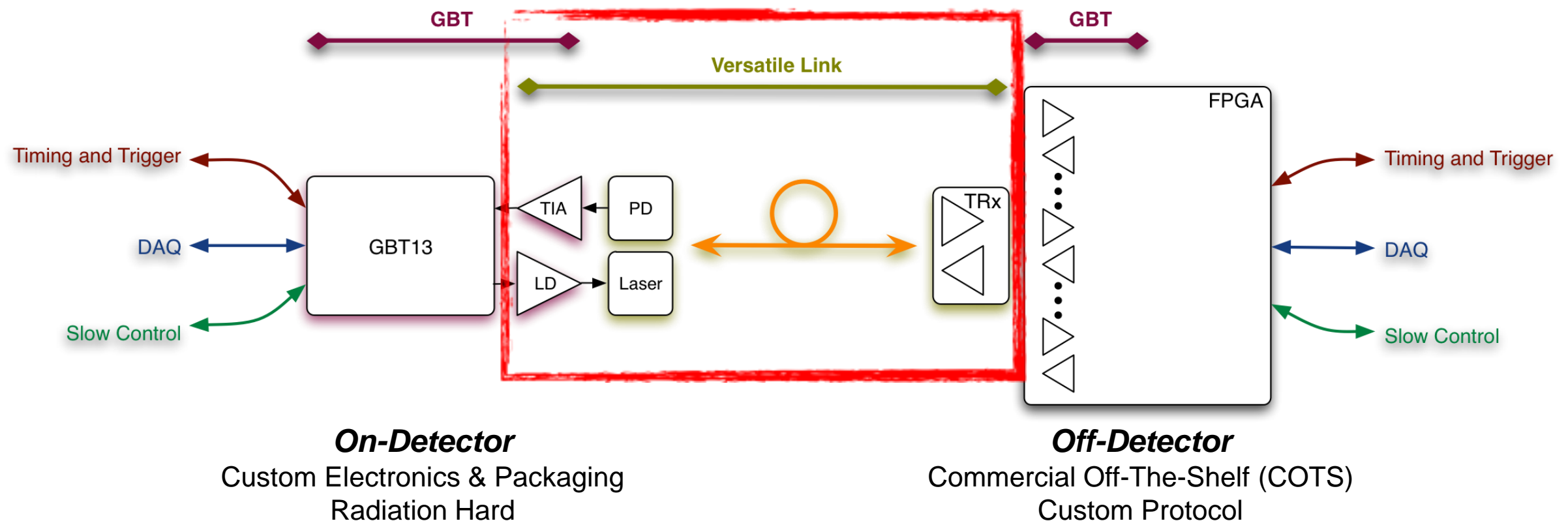
(Project phase II update)

Francois Vasey, on behalf of the Versatile Link Team

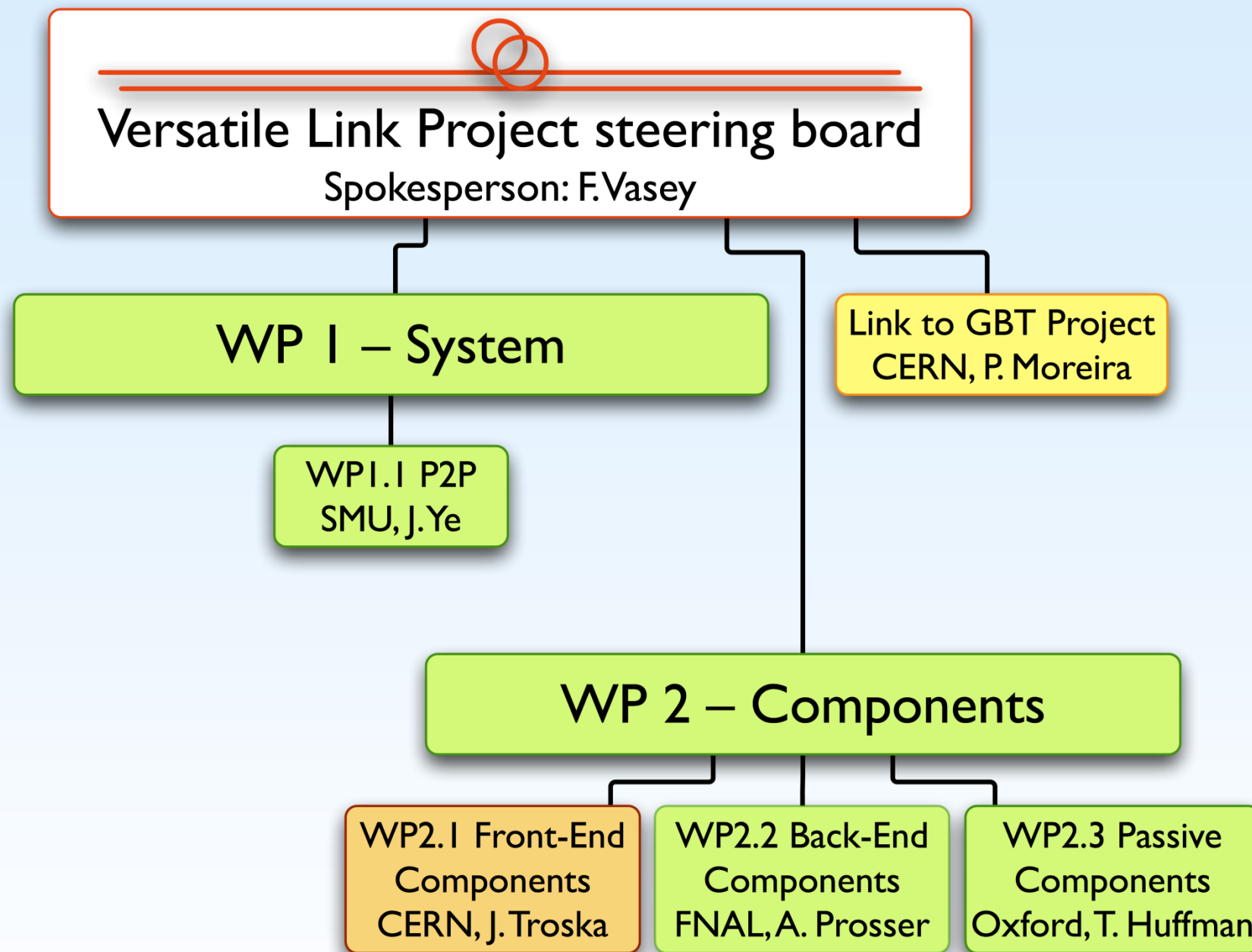


Versatile Link Project

- Optical Physical layer linking front- to back-end
- Bidirectional, ~5Gbps
- Versatile
 - Multimode (850nm) and Singlemode (1310nm) versions
 - Point to Point and Point to Multipoint architectures
- Front-end pluggable module
- 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)**
 - Phase III: Pre-prodn. readiness (18mo)



Project Structure and Partners



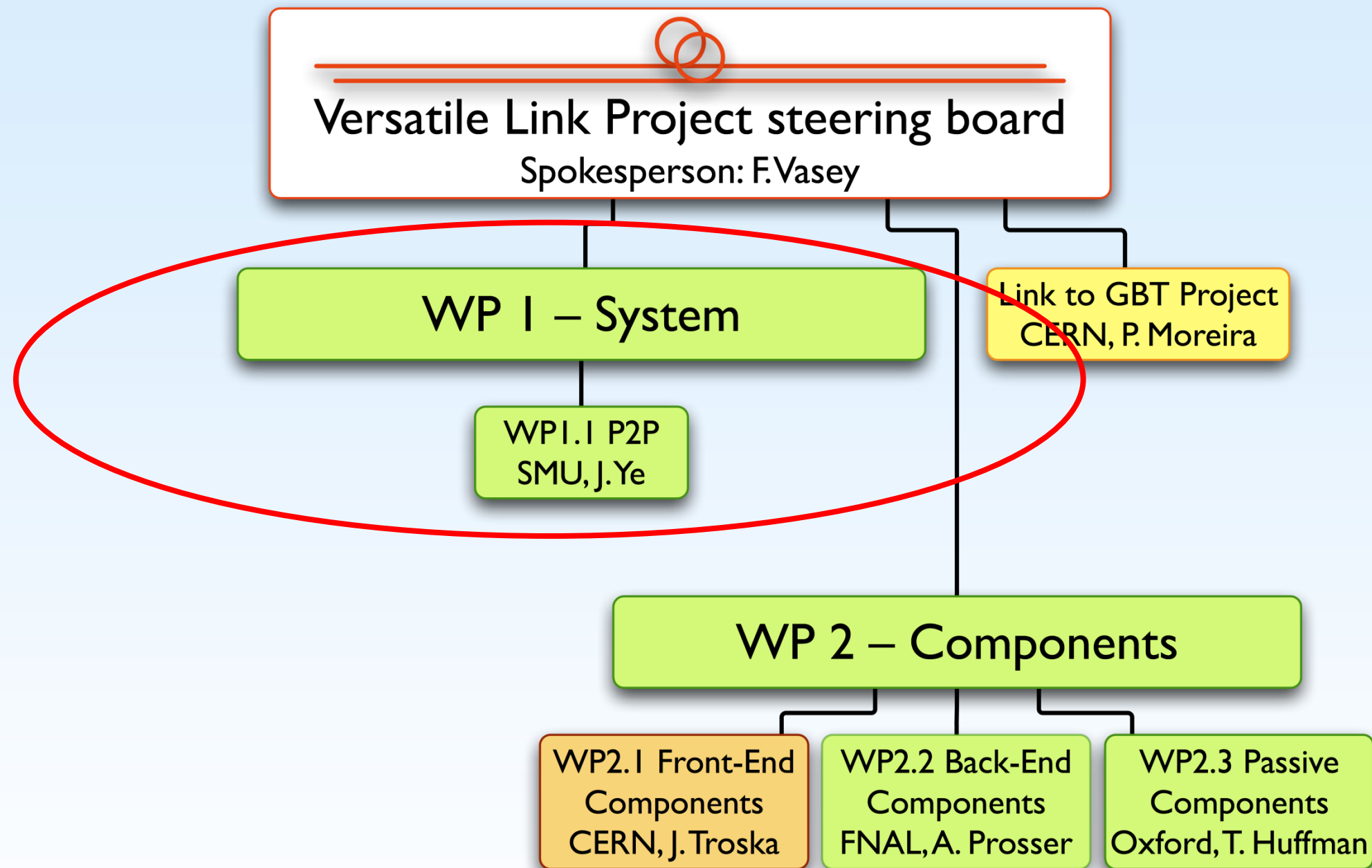
Dr. A. Xiang, “Link Model Simulation and Power Penalty Specification of Versatile Link Systems” – session B4

Prosser, “Parallel Optics Technology Assessment for the Versatile Link Project” – poster session

N. Ryder, “The Radiation Hardness of Specific Multi-mode and Single-mode Optical Fibres at -25 deg. C to full SLHC doses” – session B5b

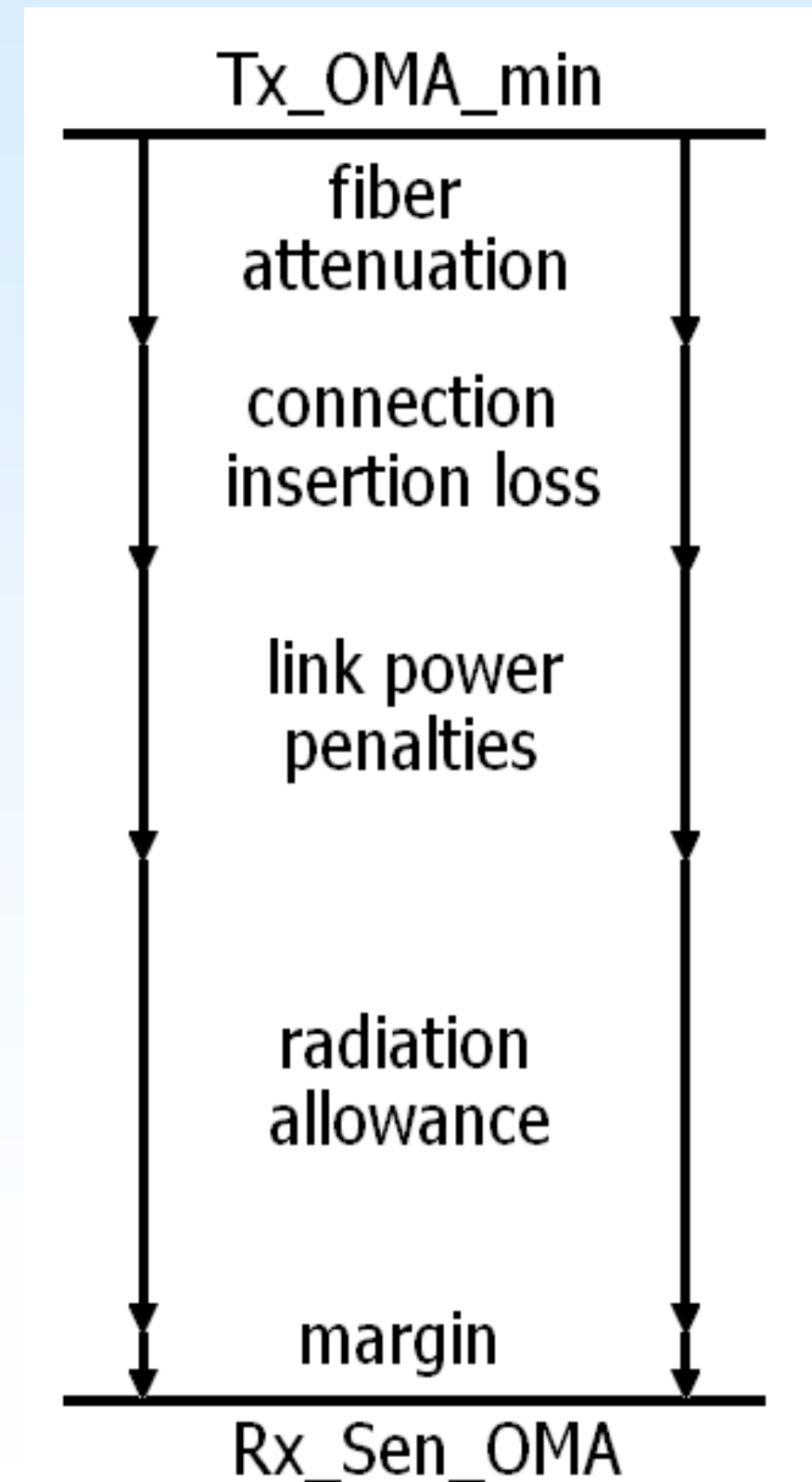
C. Soos, “Versatile Transceiver Developments” – session B4

WP 1 – System



VL Power Budget (SMU)

- Tx power and Rx sensitivity cap the amount of power for budgeting. They are first derived from vendor consensus, upon available technologies.
- Link penalties are simulated using 10GbE link model. http://www.ieee802.org/3/ae/public/adhoc/serial_pmd/documents/
- Based on simulation results, we propose to allocate 1.0 dB for MM and 1.5 dB for SM versatile link impairments. These results are verified by BER measurements on commercial transceiver modules.
- VL is specifically constrained by radiation degradation of front-end components.



Versatile Link Proposed Power Budget (SMU)

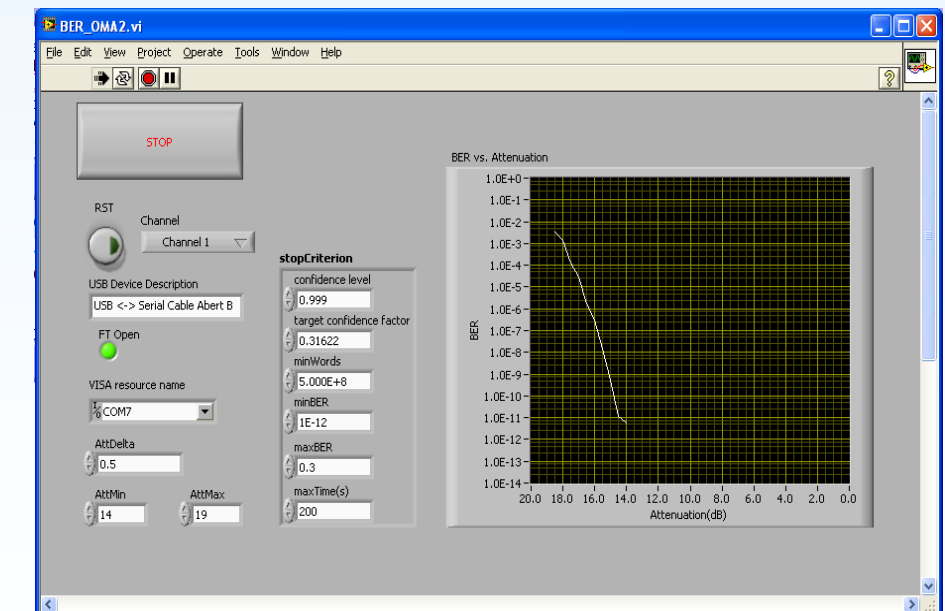
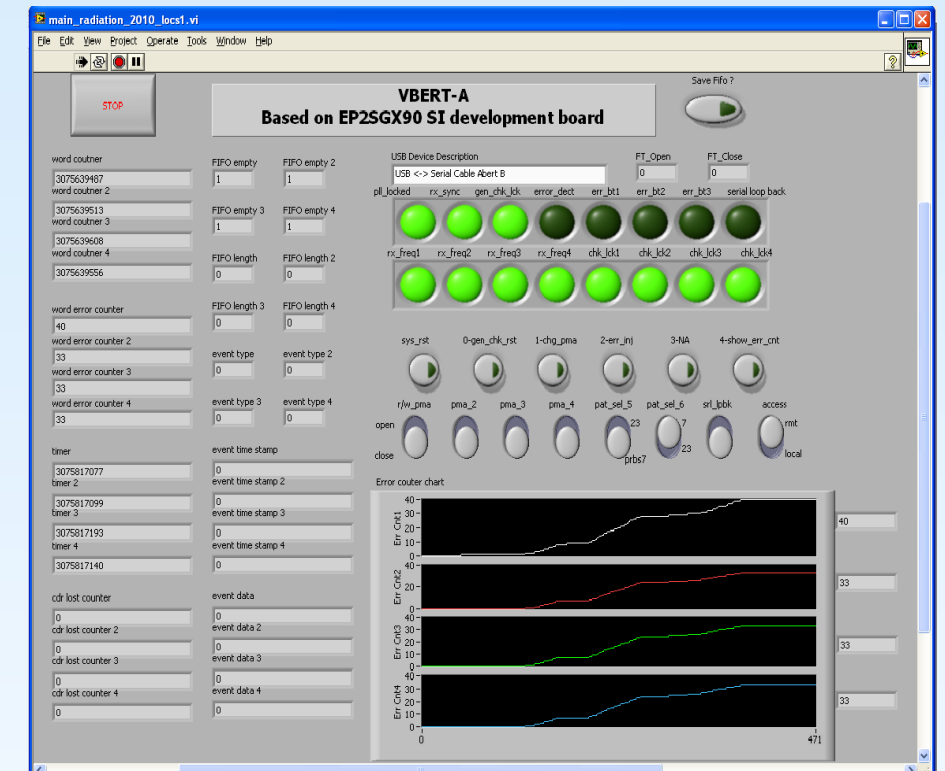
configuration/parameter	MM_VTx_Rx	MM_Tx_VRx	SM_VTx_Rx	SM_Tx_VRx
Transceiver power level				
Tx OMA min	-3.8 dBm	-2.0 dBm	-3.2 dBm	-2.8 dBm
Rx Sensitivity OMA	-11.1dBm	-13.1dBm	-12.6 dBm	-15.4 dBm
Power budget (Tx - Rx)	7.3 dB	7.3 dB	9.4 dB	9.4 dB
Fiber attenuation	0.6 dB	0.6 dB	0.1 dB	0.1 dB
Connection and splice loss	1.5 dB	1.5 dB	2.0 dB	2.0 dB
Link penalties	1.0 dB	1.0 dB	1.5 dB	1.5 dB
Tx irradiation degradation	-	-	-	-
Rx irradiation degradation	-	7.0 dB	-	9.0 dB
Fiber irradiation degradation	1.0 dB	1.0 dB	-	-
Margin	3.2 dB	0.0 dB	5.8 dB	0.0 dB

- Extrapolated sLHC irradiation degradation deduced. Two downlinks run deficit. Extra power needed from Tx/Rx.
- Increased Tx power means less yield or special order from vendor. Increased Rx sensitivity means measuring every module, but VRx by design should have good sensitivity.
- After more stringent requirements on downlink Tx/Rx., all links now meet budget.
- Excess uplink power budget allows for higher data rate or longer length.

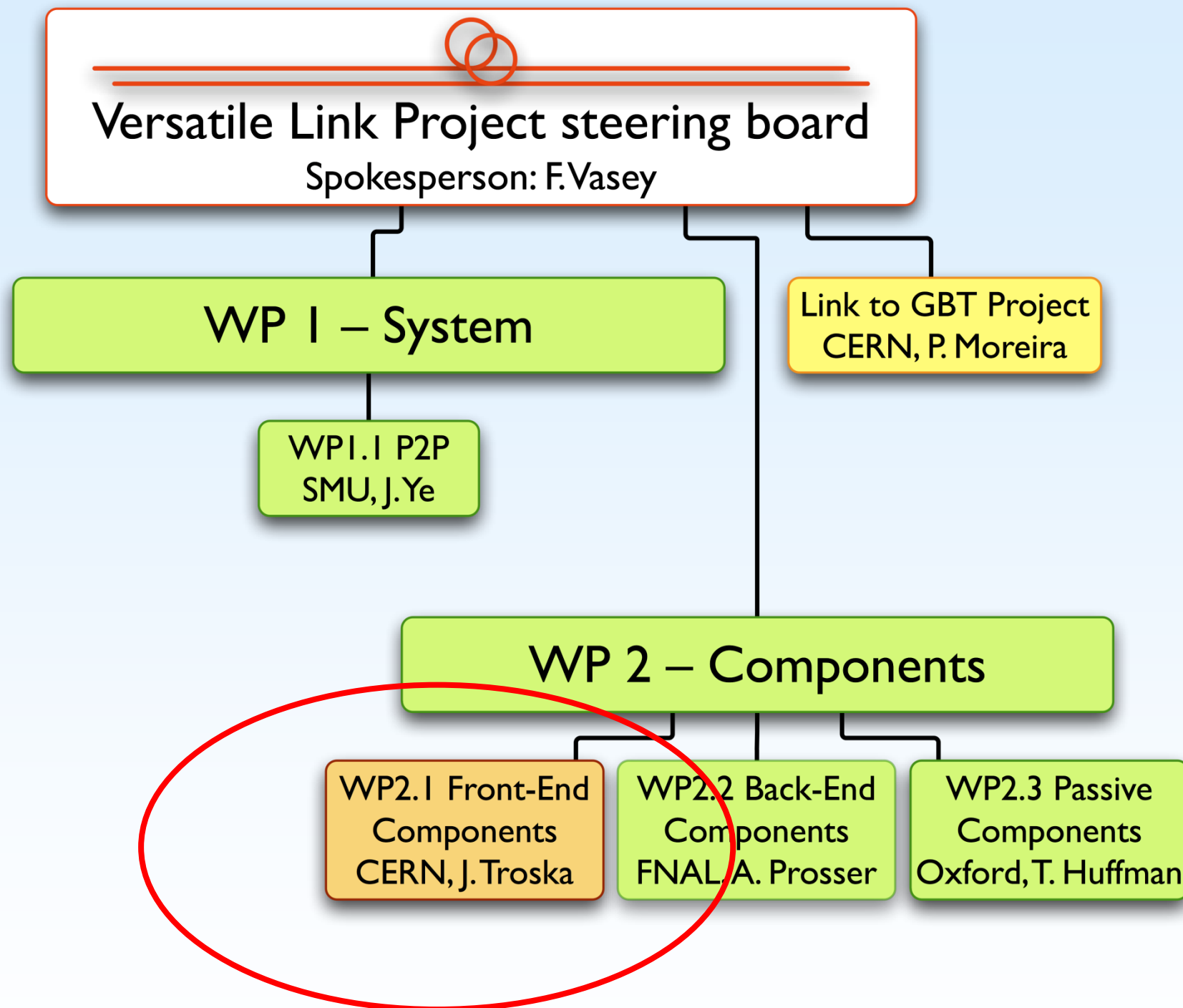
Versatile Link BER Tester

(SMU)

- Versatile EVM kit includes: SFP+ carrier board, BER tester IP (VHDL+LabVIEW) based on Altera Stratix II GX signal integrity board.
- Current VBERT features
 - Simple physical layer protocol. PRBS (7,23,31) generator and error detector.
 - Error logging FIFO with 5Mbps throughput. Reserved stack to save all link status info.
 - Four duplex channels, up to 6.25Gbps, with analog adjustment.
- Current VBERT tests
 - In lab BER vs. OMA test routine.

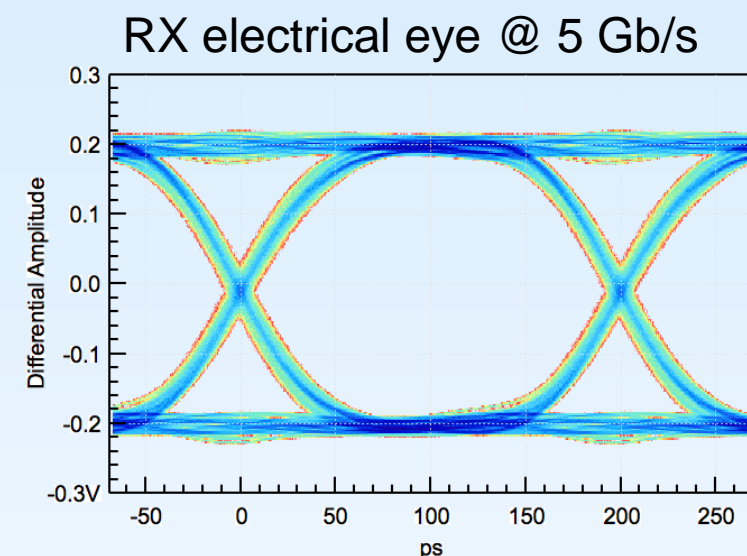
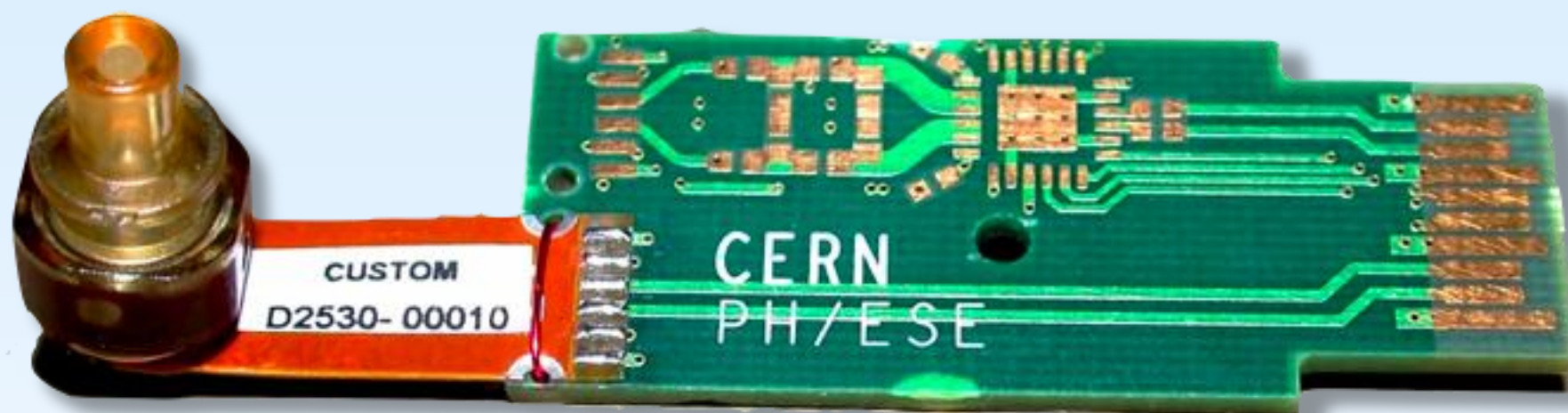


WP 2.1 – Front End Components

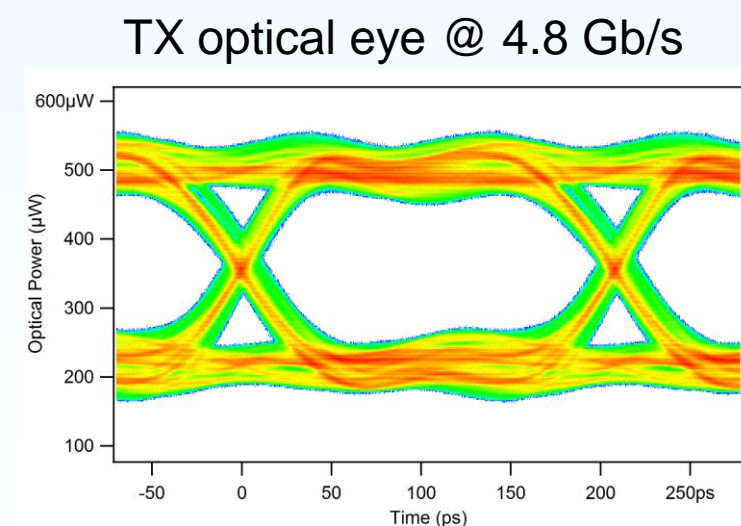
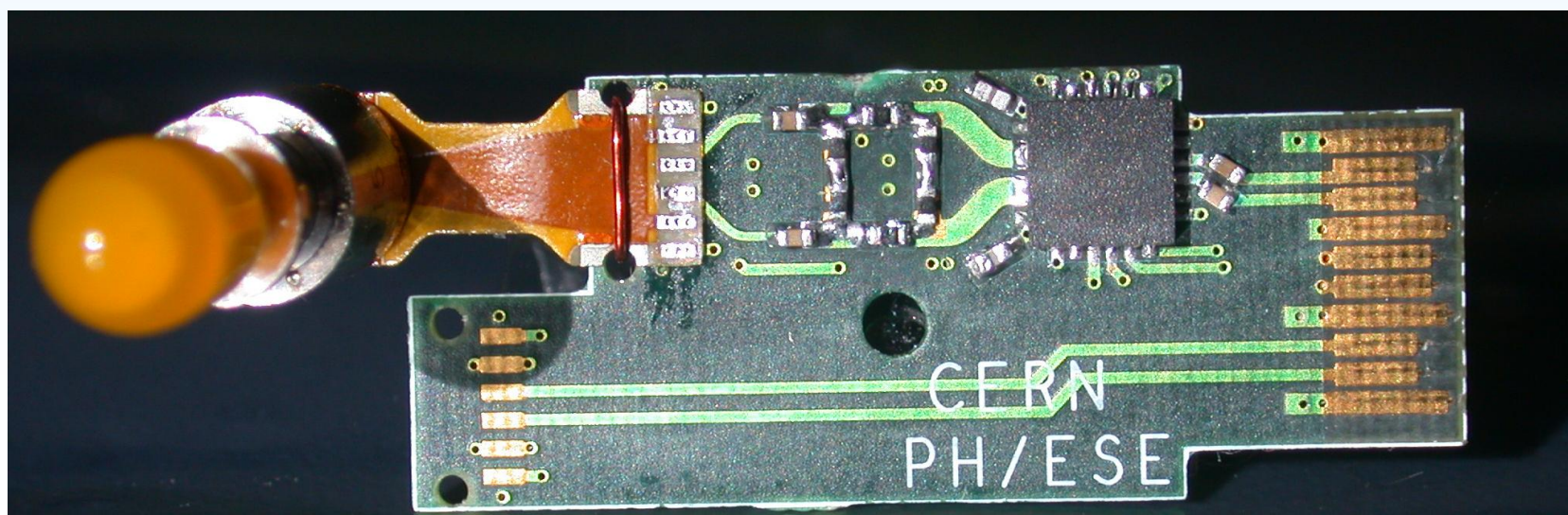


TOSA/ROSA integration on VTRx (CERN, Fermilab, SMU, University of Oxford, Versatile Link)

- GBTIA-ROSA on prototype VTRx PCB

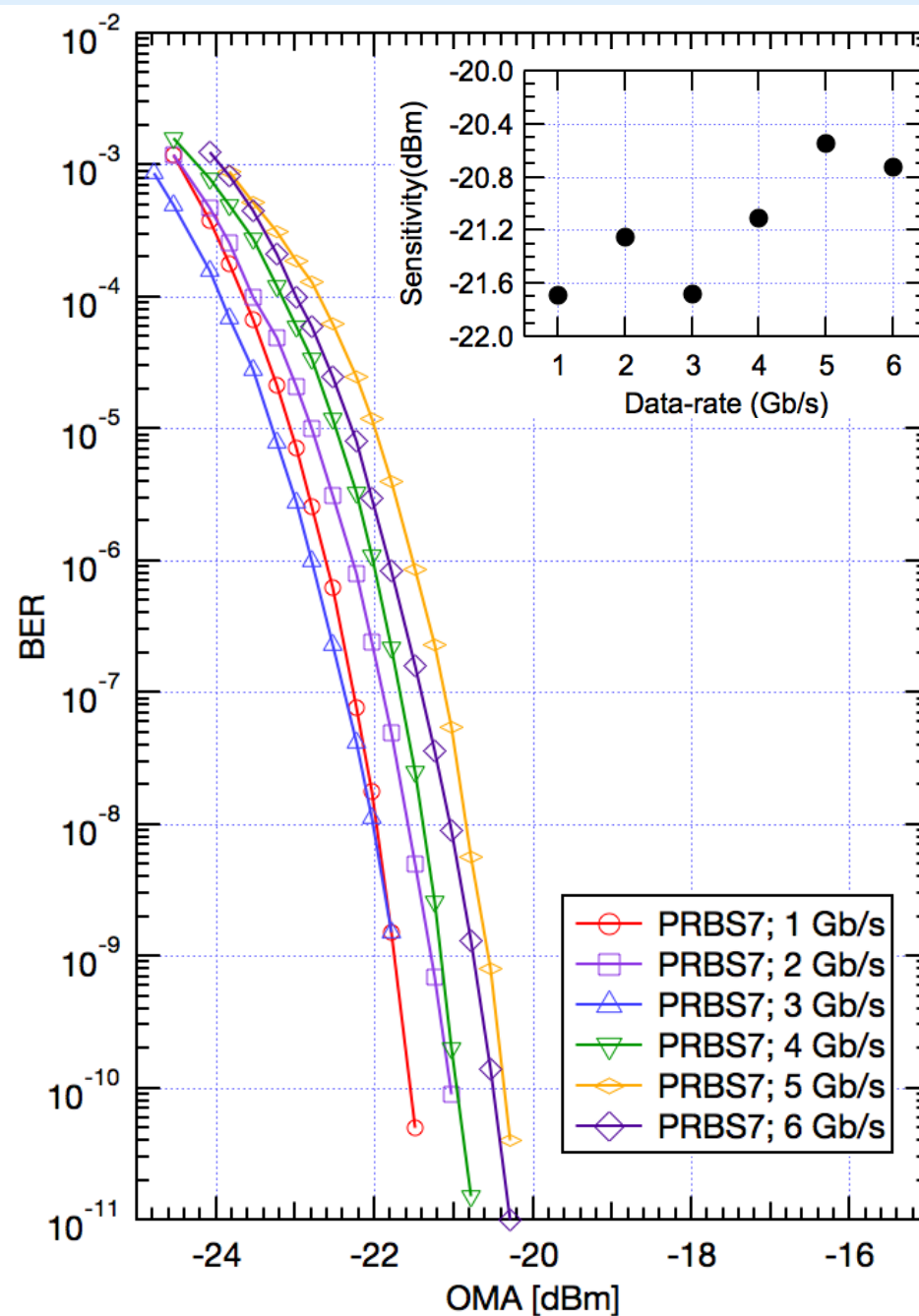
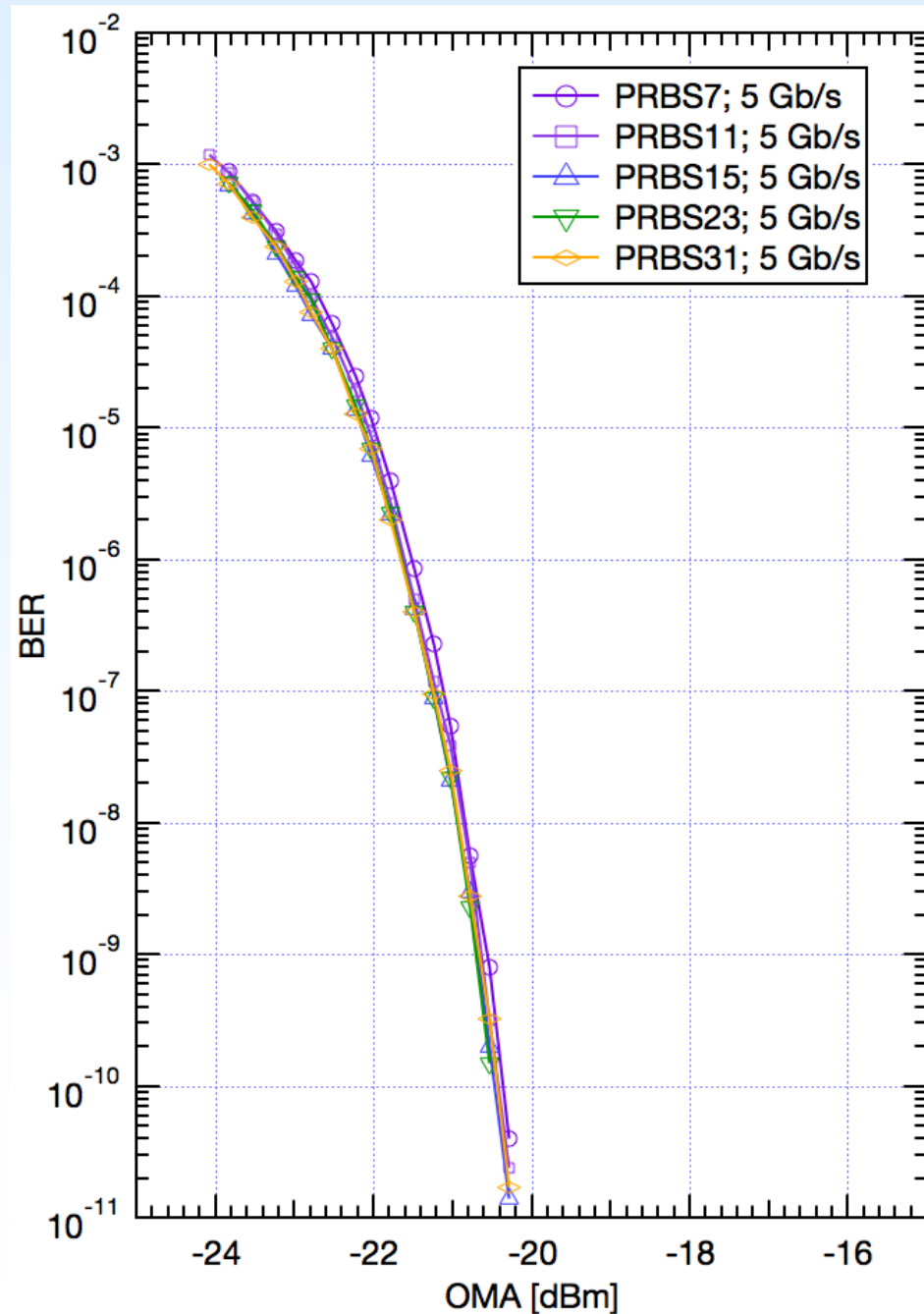


- TOSA and commercial Laser Driver on VTRx PCB



GBTIA ROSA performance (CERN)

- Evaluate impact of data-rate and pattern length on GBTIA ROSA sensitivity

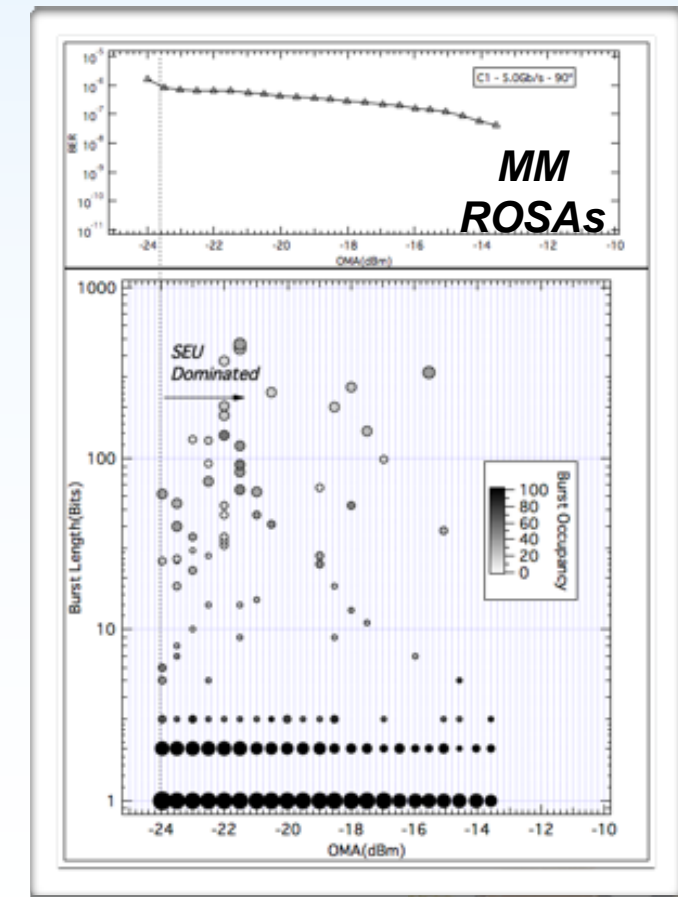
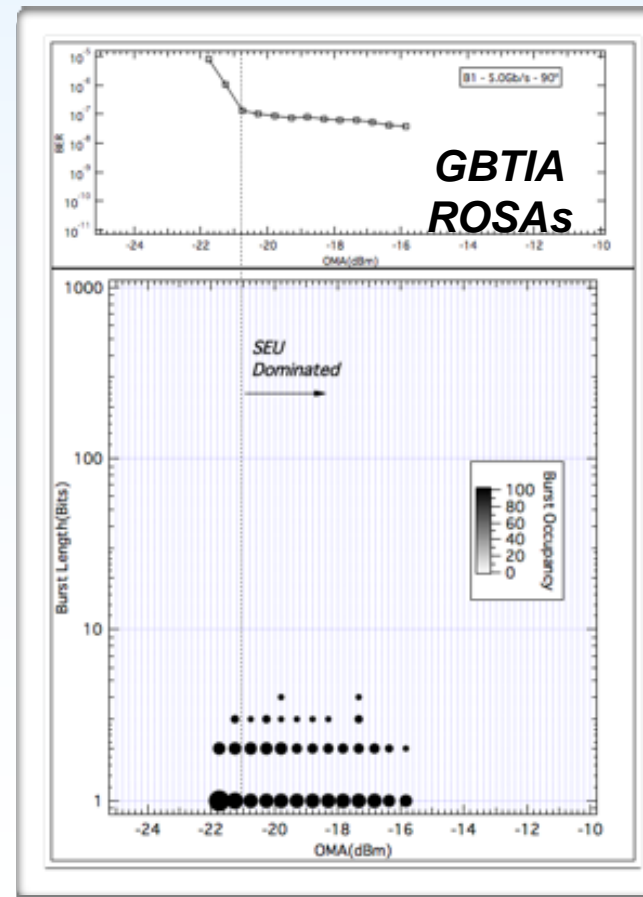
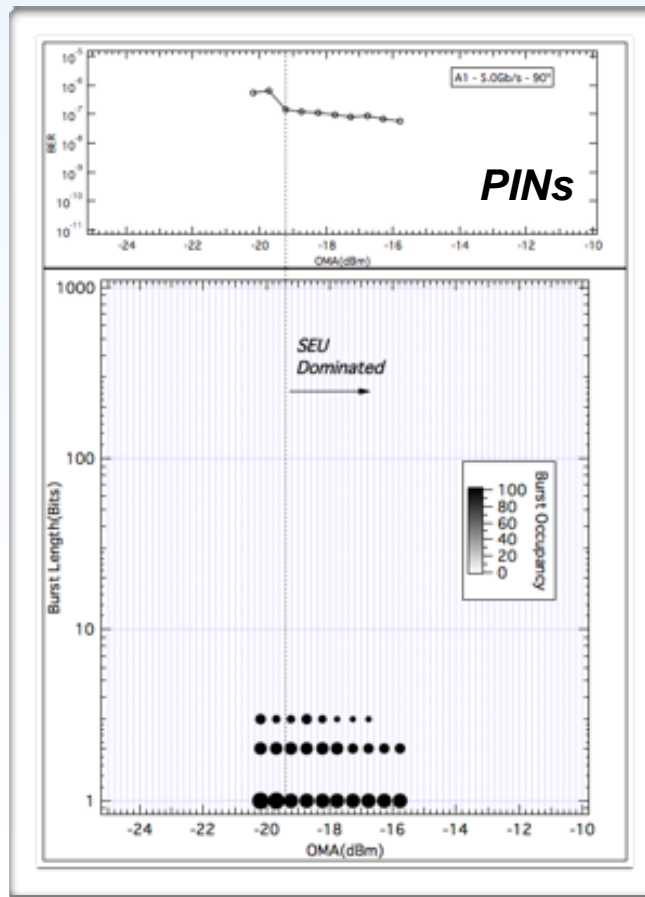
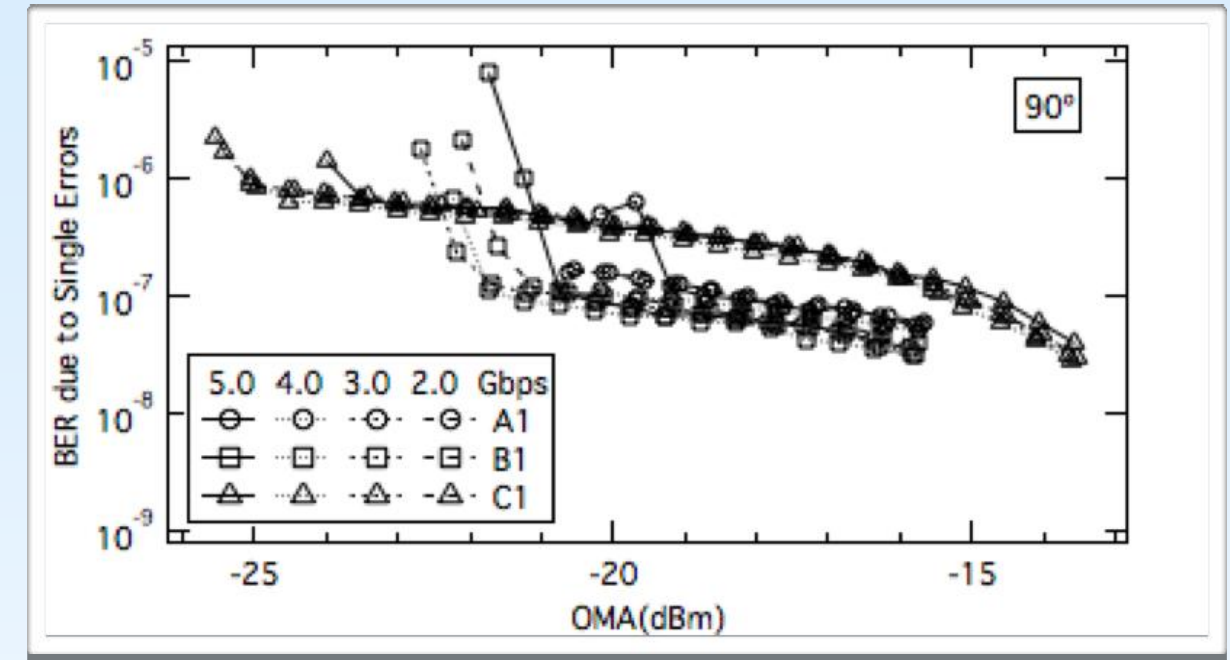


- Favourable comparison to bare-die tests
 - ROSA pkg not detrimental to functionality
- No pattern length sensitivity
- Expected reduction in sensitivity with data-rate
 - Acceptable magnitude



SEU test result preview (CERN)

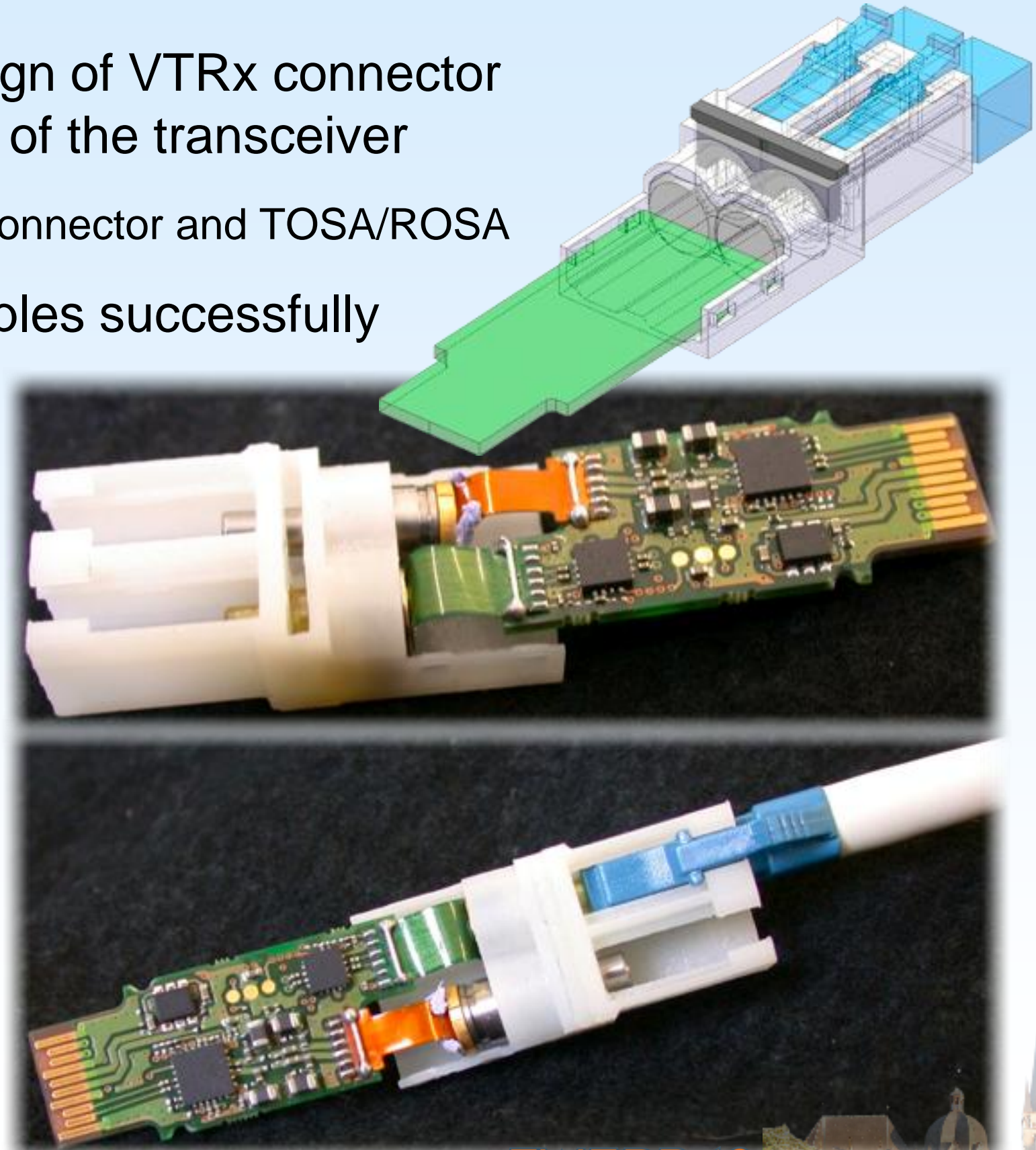
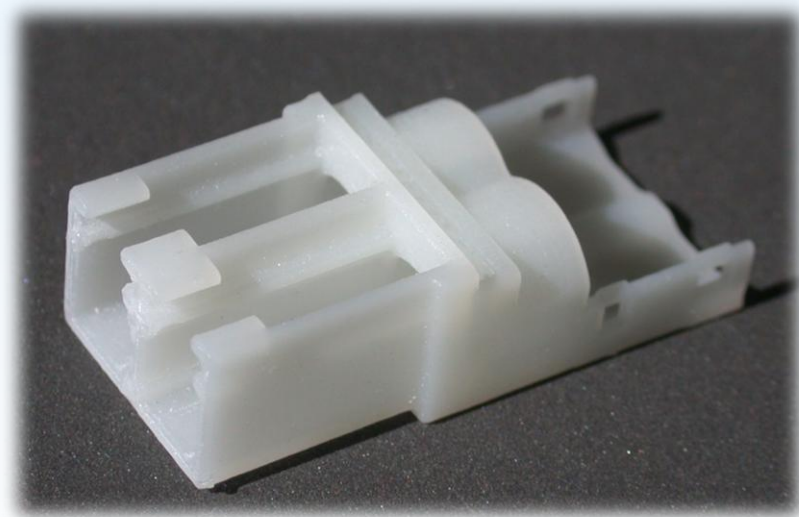
- BER due to single bit flips is similar for all devices
- BER is independent of data rate within the range of investigation
- Burst lengths limited in PINs and GBTIA ROSAs
- Longer bursts seen in ROSAs with unshielded amplifiers



VTRx low-mass latch design

(CERN)

- Working on mechanical design of VTRx connector latch to reduce overall mass of the transceiver
 - Part mechanically associates connector and TOSA/ROSA
- Rapid prototype plastic samples successfully tested

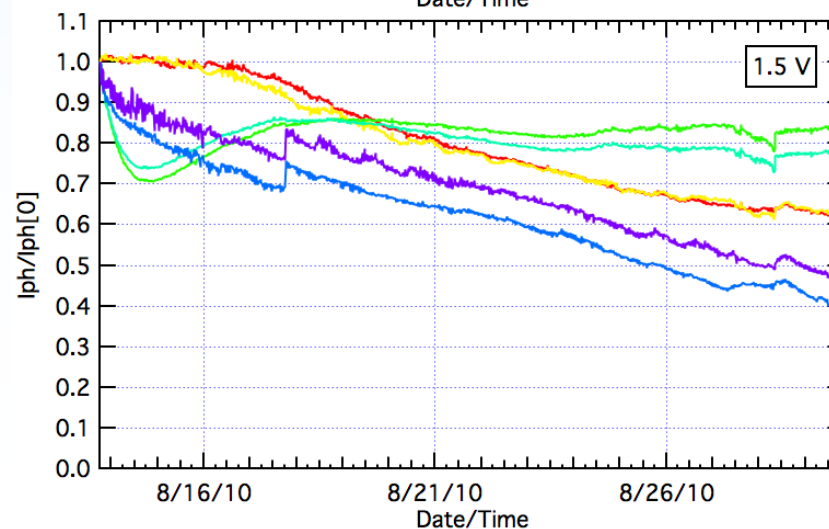
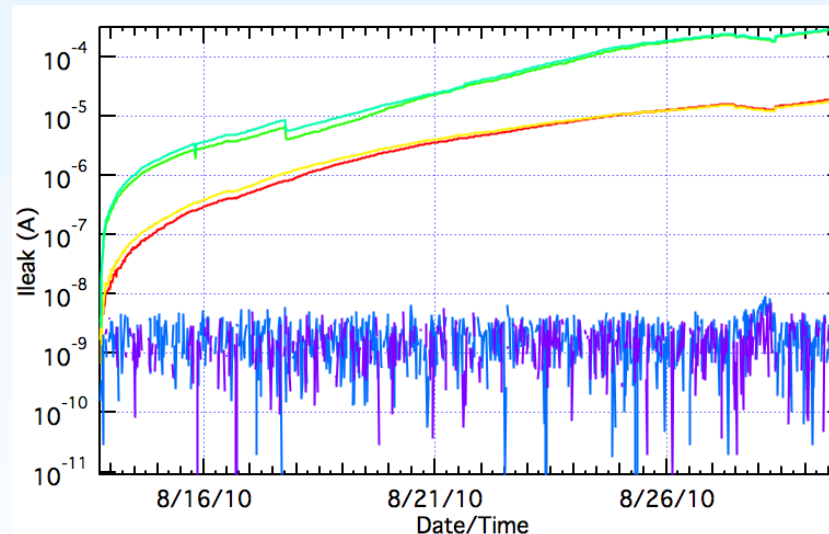


Pion Total Fluence Test (Aug. 2010)

(CERN, Fermilab, SMU, Versatile Link)

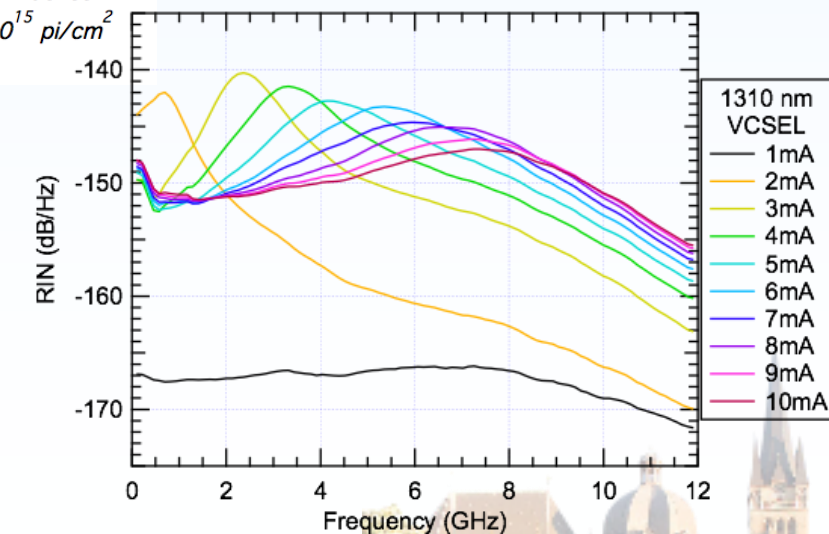


- Cross-check influence of particle species on damage
 - NIEL scaling unproven for complex laser stoichiometry
- End of life prediction
- Online measurement of optical spectra & RIN
 - Track temperature effects & high-speed performance
- Example PIN results show typical behaviour:
 - decreased response
 - increased I_{leak} (InGaAs)



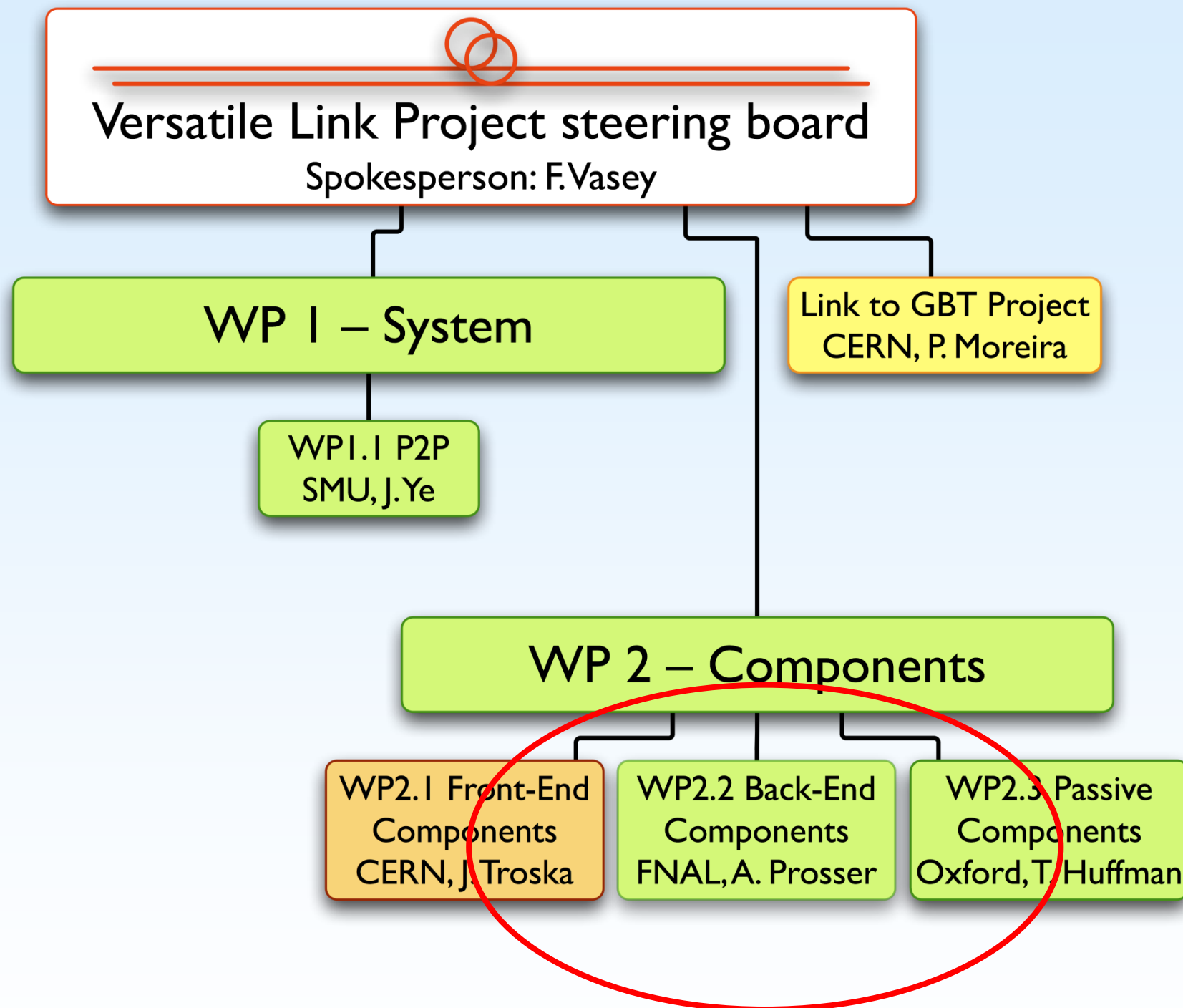
Vbias = 1.5V
 — InGaAs PIN
 — InGaAs PIN
 — CMS PIN
 — CMS PIN
 — GaAs PIN
 — GaAs PIN

Total Fluence
 $\sim 1 \times 10^{15} \text{ pi/cm}^2$

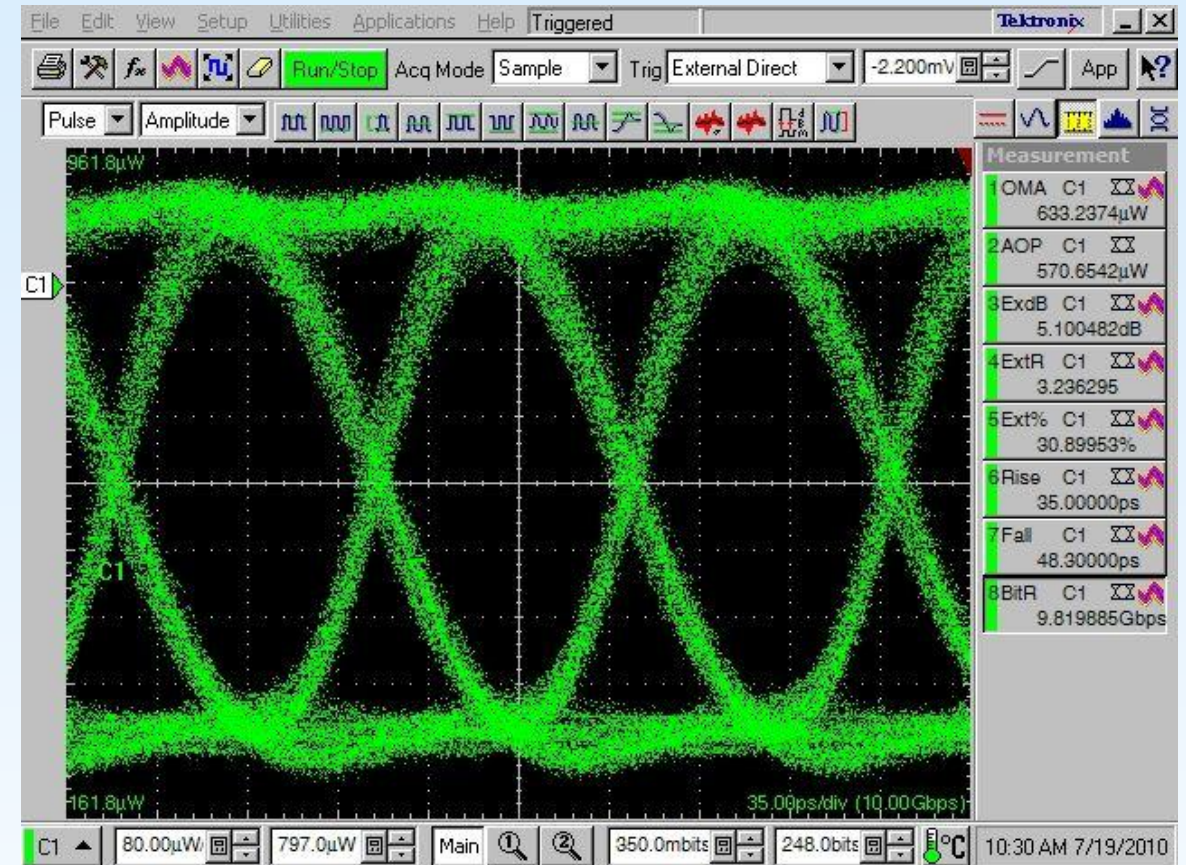
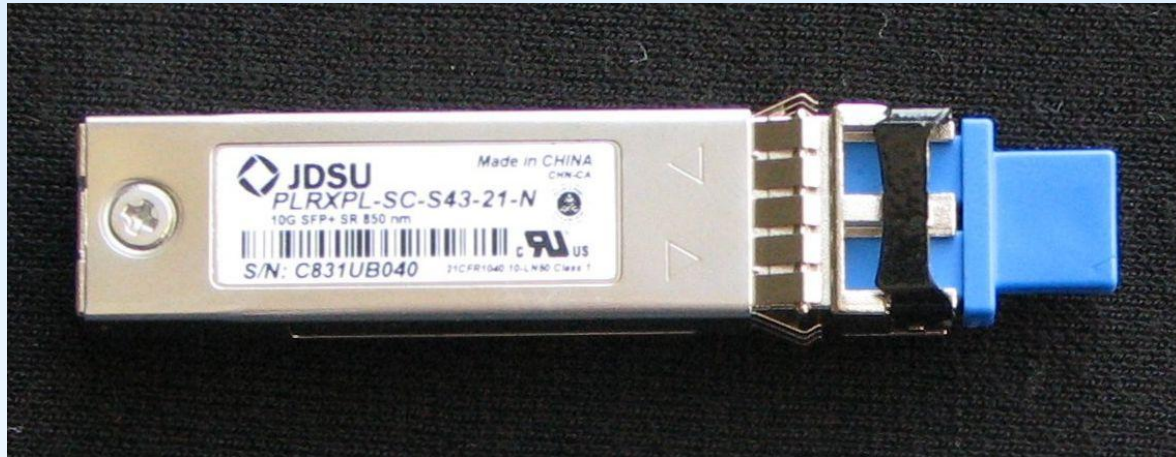


See Poster by P. Stejskal for discussion of laser results

WP 2.2 – Back End Components

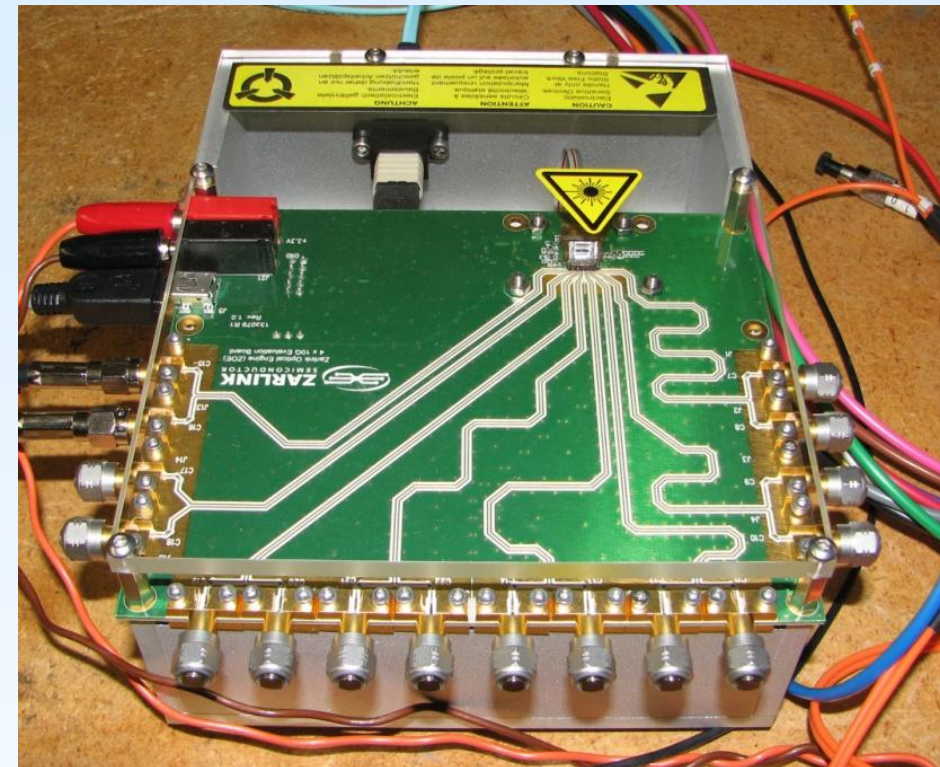
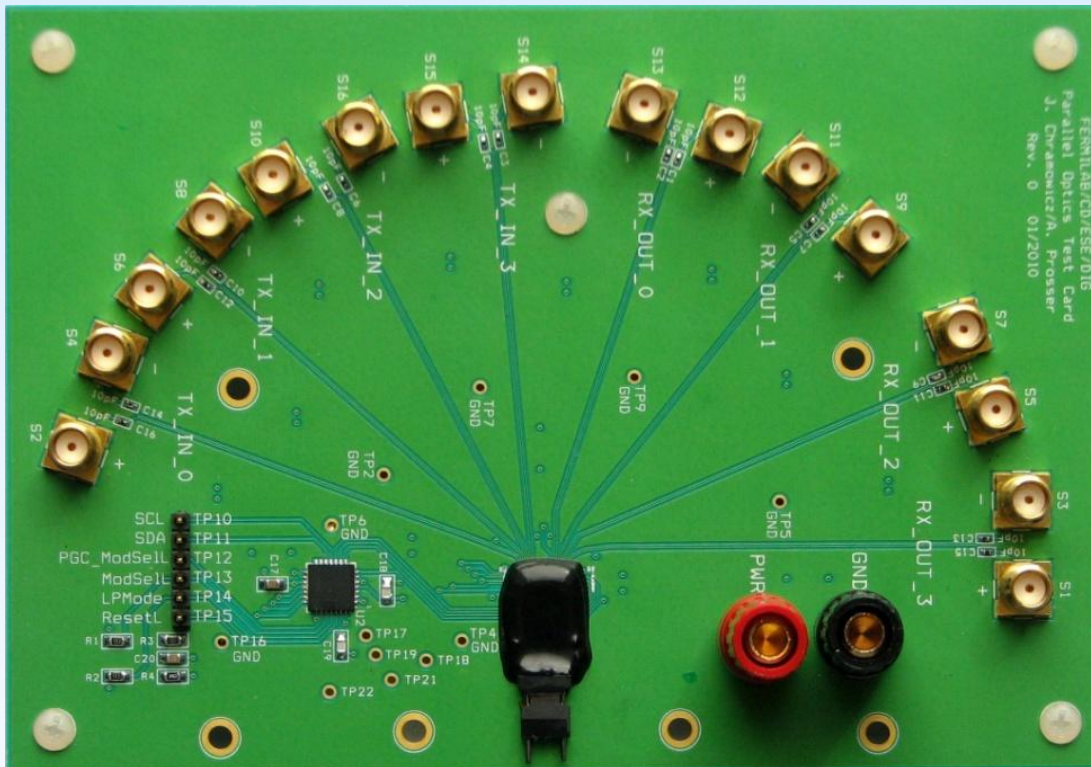


WP2.2 - SFP+ Testing (FNAL)



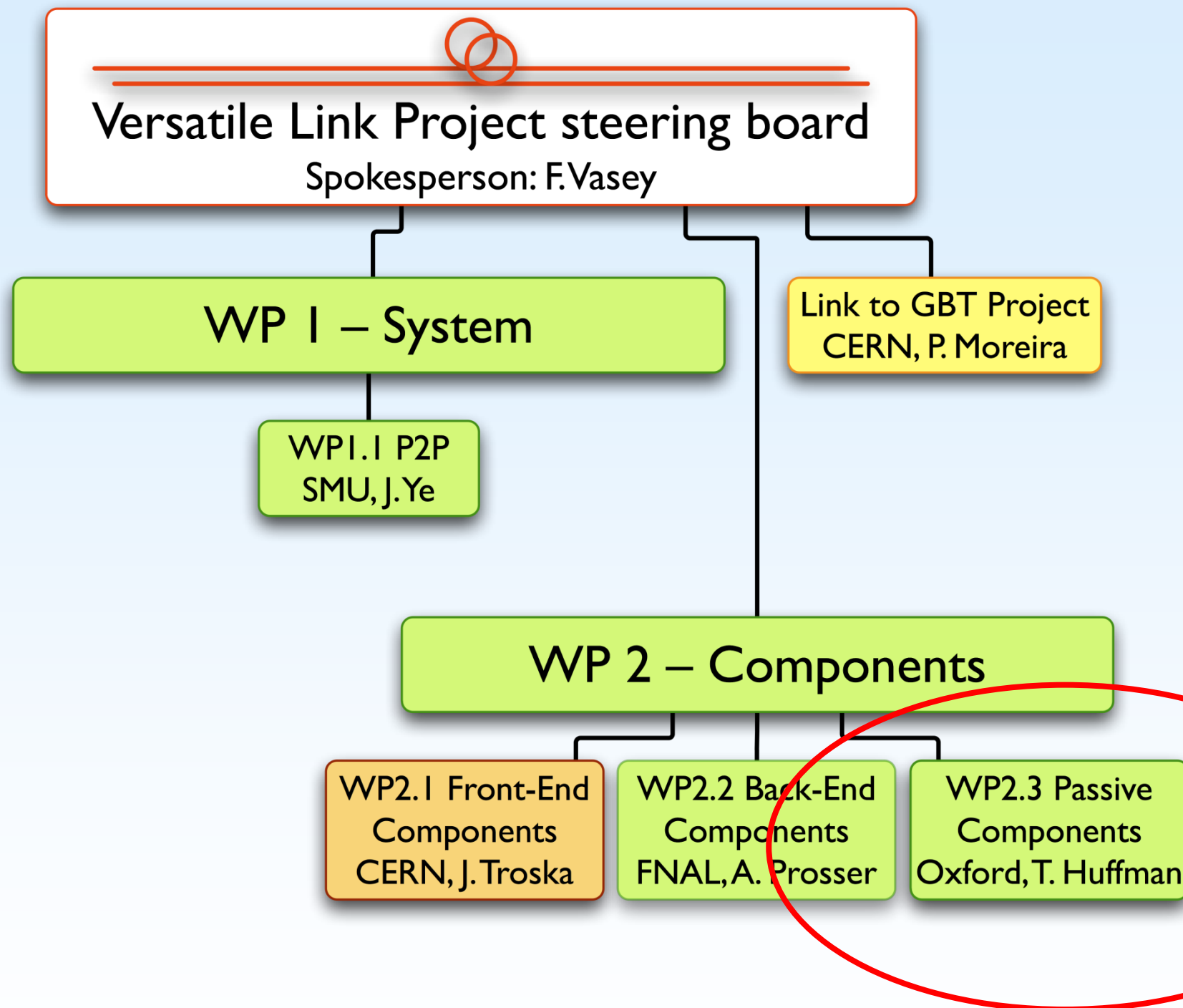
- Testing of SFP+ (850nm and 1310nm) up to 10Gbps
- Reference Components Identified and Procured for Team Use
- Future Work: Detailed Specification of Device Requirements for Versatile Link
- Future Work: Investigation of Higher Power SFP+ Variant

WP2.2 - Parallel Optics Evaluation (FNAL)



- Fermilab has tested 4x4 Parallel Optical Engines up to 10Gbps
- SNAP12 Tx/Rx Pair Tested at Rates up to 6.25Gbps
- Future Work: Includes the design of Parallel Optical Engine Customer Card

WP 2.3 – Passive Components



WP2.3 Optical Components (Oxford)

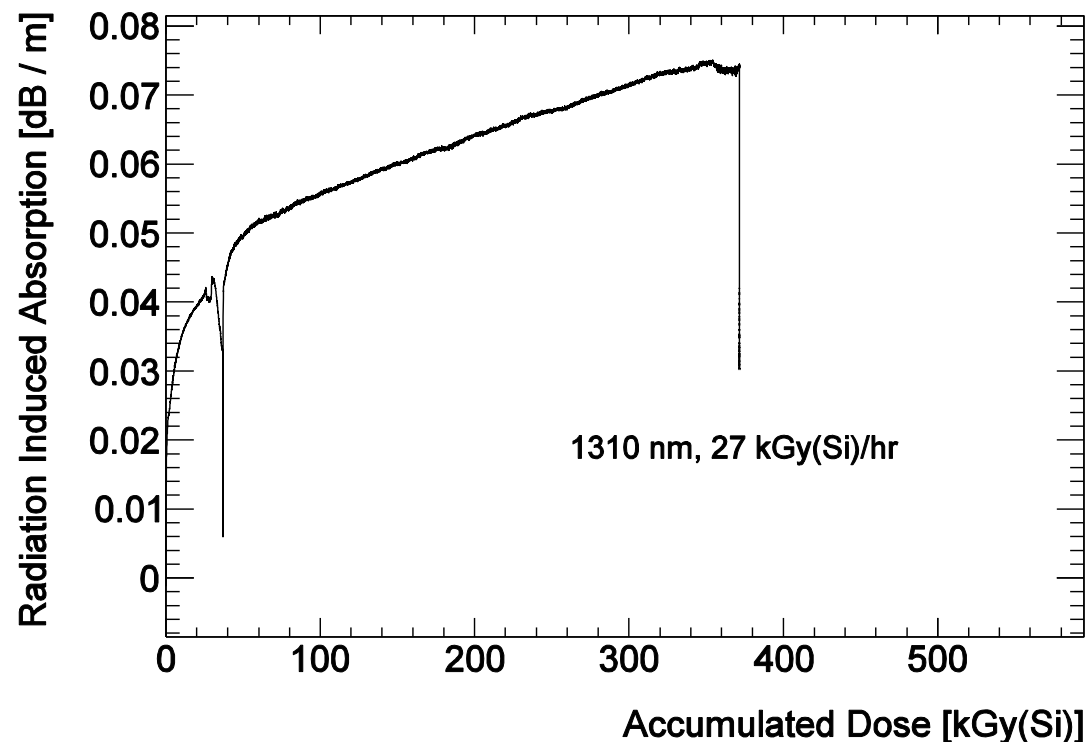
- Radiation Induced Absorption (RIA) in fibres is highly temperature dependent.
- Oxford has developed a CO₂ cooling system capable of keeping fibre samples cold (-26 deg C).
- Tests have been performed on five optical fibres. Two were MM graded-index fibres (850nm) while 3 were SM fibres (1310nm).

WP2.3 Optical Components (Oxford)

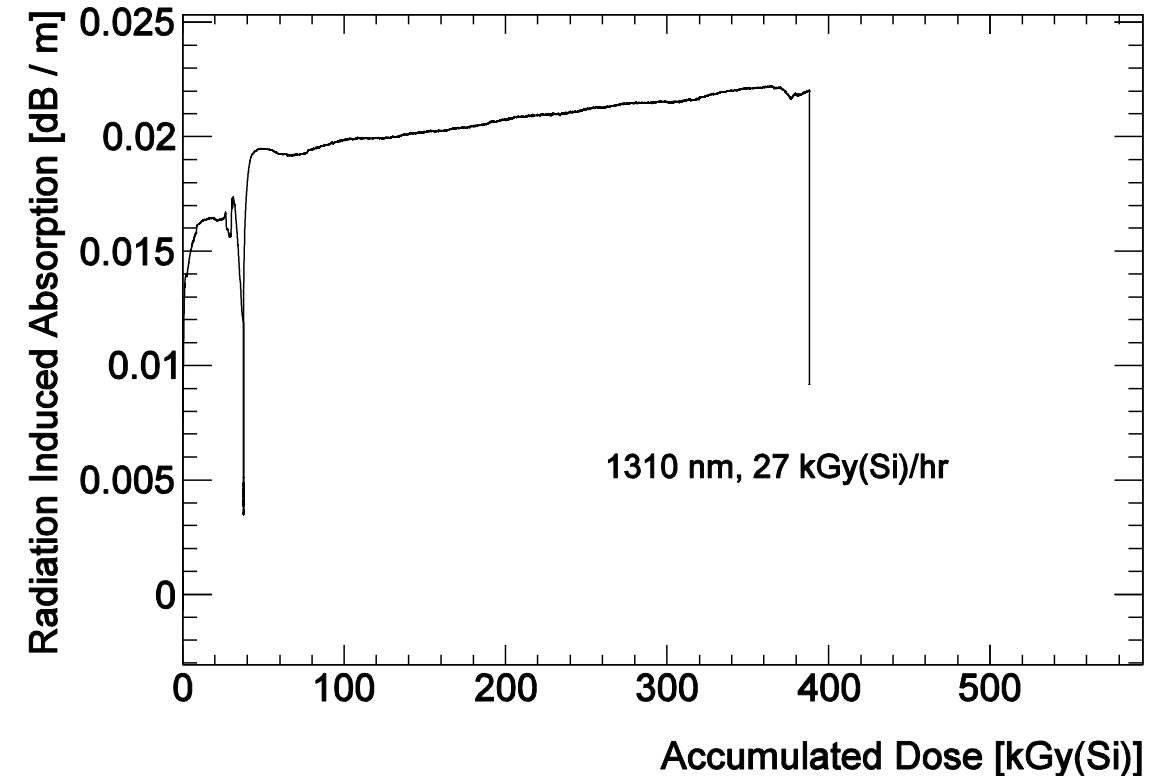
- Two of the SM fibres have shown acceptable performance over 500 kGy(Si) dose.
 - Product X
 - DrakaElite™ Super RadHard Fibre
- The Multimode fibres did not perform as well, showing more than 1 dB/m of loss.
 - At face value this is a problem
- The dose rate is very high in these tests
 - 27 kGy(Si)/hr

Fibre Radiation Test (Oxford)

Temperature of exposure = -26 deg. C



Draka SM fibre



Product X

Both of these SM fibres have small attenuation for a typical cable run
For ATLAS or CMS inner detectors. ~0.1 dB from RIA.

The MM fibres did not fare so well at these very high dose rates.
We are planning a run at a lower dose rate up to a full SLHC integrated dose.

If you want more details Please Go See Nick Ryder's talk tomorrow Morning!!

WP2.3 Optical Components (Oxford)

- Fibres are stressed in the cable trays of experiments.
- Radiation might degrade the mechanical properties of fibres changing the minimum bend radius requirements.
- Pull tester has been purchased to look at the mechanical effects of SLHC doses upon our candidate fibres.
- Initial tests of Corning InfinicorSX+ (MM) and Corning SMF-28 (SM) look promising.
 - They will be exposed to SLHC dose to see if we can detect any effect on mechanical strength.



- Status of PLC coupler and MPO connector radiation study
- Several commercially available PLC couplers have been pre-tested, irradiated, and post-tested.
 - Data analysis is on-going and will be the subject of a JINST paper
- Commercial MPO connectors have been pre-tested and are being irradiated.
 - Commercial LC connector tests will be next.

- Cable may suffer mechanically in a radiation environment as well.
 - Bulk damage and ionizing radiation damage.
 - Birmingham has agreed to let us use their proton beam to expose cable candidates
 - Scan-table is currently under test
 - Up to 1m of cable can be accommodated
- Current ATLAS ID cable (from Ericsson) will be first candidate.
 - Working with industry to perform the analysis.

- Phase II deliverables (Apr 2011):
 - Specifications for system and components
 - Shortlist of components meeting (?) the specifications
 - Front-end VTRx integrating GBT ASICs and validated optoelectronics in low mass package
 - Set of irradiation test results for front-end and passive components
 - System demonstrators based on validated components
 - First evaluation of production cost vs volume
- Phase III:
 - Pre-production readiness
 - To be replaced by interim Phase IIb
 - Consolidation? Arrays? Low power?