The Versatile Link: Feasibility Demonstration (Project phase II) and Preparing for ATLAS, CMS and LHCb production (Project phase III)

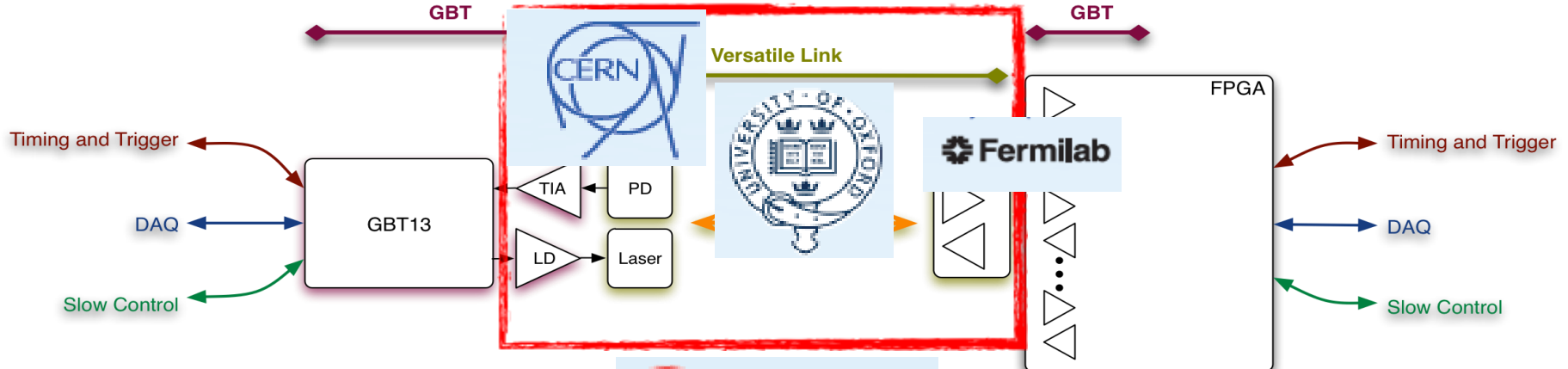
Versatile Link

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

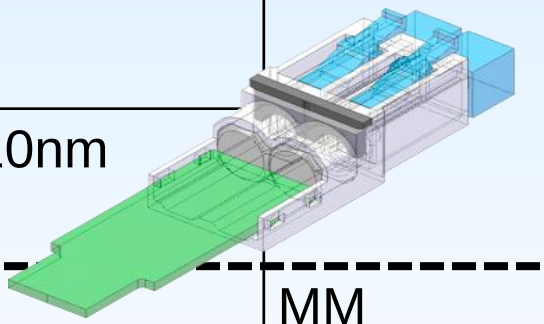
- Joint Project Proposal submitted to ATLAS & CMS upgrade steering groups in 2007 and endorsed in 2008
- Project Kick-off: April 2008
  - Phase I: Proof of Concept *(18mo)*
  - Phase II: Feasibility Study *(18mo)*
  - Phase II: Consolidation *(6mo)*
  - Phase III: Pre-production readiness *(18mo)*



VL Versatility

Versatile Link

Front-End VTRx	Fibre	Back-End TRx
EE laser, 1310nm	SM	LR-SFP+ TRx
VCSEL, 1310nm		Board-edge Tx, Rx
InGaAs PIN, 1310nm		Mid-board Rx
VCSEL, 850nm	MM	SR-SFP+ TRx
GaAs PIN, 850nm		Board-edge Tx,Rx, TRx
InGaAs PIN, 850nm		Mid-board Tx, Rx, TRx



Versatile Link Radiation Tolerance

- Two Versatile Link radiation tolerance grades defined

Fibre Type	Radiation Tolerance Grade	
	Calorimeter-grade	Tracker-grade
	10 kGy, $5x10^{14}$ n/cm^2	500 kGy, $2x10^{15}$ n/cm^2,$1x10^{15}$ h/cm^2
SM		
MM		

- Power budget specified with margin for all flavours
- Jitter budget adapted from FC 4G standard
- Specs available as EDMS document CERN-0000090391

VL project status, June 2012

Versatile Link

Front-End VTRx	Fibre	Back-End TRx	
EE laser, 1310nm GBLD Drive current OK	SM	LR-SFP+ TRx	TK grade
VCSEL, 1310nm GBLD compliance Voltage OK		Board-edge Rx, Tx SM TRx not (yet) available	
InGaAs PIN, 1310nm		Mid-board Rx SM Tx or TRx not (yet) available	
VCSEL, 850nm GBLD compliance Voltage OK	MM	SR-SFP+ TRx Tx OMA NOT OK: Tk grade	Calo & Tk grade
GaAs PIN, 850nm Responsivity drop: Calo grade OK		Board-edge Tx,Rx, TRx Tx OMA meets Tk pow. budget OK	
InGaAs PIN, 850nm Assembly to be confirmed: Tk grade	RIA in cold at low dose rate OK	Mid-board Tx, Rx, TRx Tx OMA meets Tk pow. budget OK	

VL project status, June 2012

Versatile Link

Front-End VTRx	Fibre	Back-End TRx	
EE laser, 1310nm	SM	LR-SFP+ TRx	TK grade
VCSEL, 1310nm		Board-edge Rx, Tx SM TRx not (yet) available	
InGaAs PIN, 1310nm		Mid-board Rx SM Tx or TRx not (yet) available	
VCSEL, 850nm	MM	SR-SFP+ TRx Tx OMA NOT OK: Tk grade	Calo & Tk grade
GaAs PIN, 850nm		Board-edge Tx,Rx, TRx	
InGaAs PIN, 850nm Assembly to be confirmed: Tk grade		Mid-board Tx, Rx, TRx	

Versatile Link Feasibility Demonstrated

Prototype VTRx Variants

Variant	LDD	TOSA	TIA	PIN
1	ONET1101L	EEL	GBTIA	InGaAs
2	ONET8501V	850 VCSEL	GBTIA	InGaAs GaAs
2b	ONET8501V	1310 VCSEL	GBTIA	InGaAs
3	GBLD	EEL	GBTIA	InGaAs
4	GBLD	850 VCSEL	GBTIA	InGaAs GaAs
4b	GBLD	1310 VCSEL	GBTIA	InGaAs
5 (bi-Tx)	2x ONET8501V	2x 850 VCSEL	–	–

Prototype VTRx451

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Versatile Link Project

VTRx451

Test report

Configuration	
TOSA	JDSU 850 nm VCSEL LC 10G PL-FLD-00-S40-C5
ROSA	Enablence Multi-Wavelength GBTIA ROSA (PX10F7-T01-LC00)
LD	GBLD v.4
Board	
Latch	

Production history				
Board delivered	–	18 August 2011	by	Csaba Soos
TOSA mounted	–	1 March 2012	by	Csaba Soos
ROSA mounted	–	11 April 2012	by	Csaba Soos
Board tested	–	25 April 2012	by	Lauri Olanterä
Inventory	Inventory/boards/VTRx/GBLDV4-boards/serial_451.htm			

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Prototype VTRx451

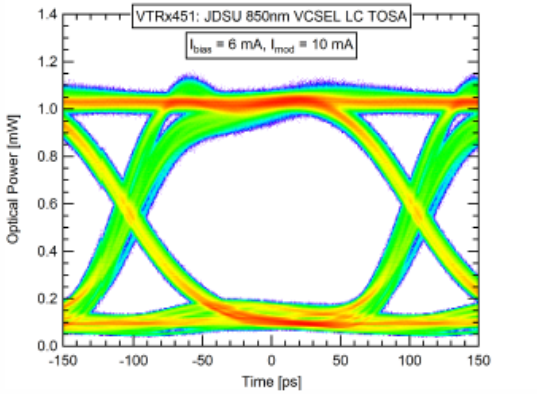

Figure 2: Transmitter eye diagram using recommended bias and modulation currents. All dynamic parameters of the transmitter are determined using the eye diagram.[4]

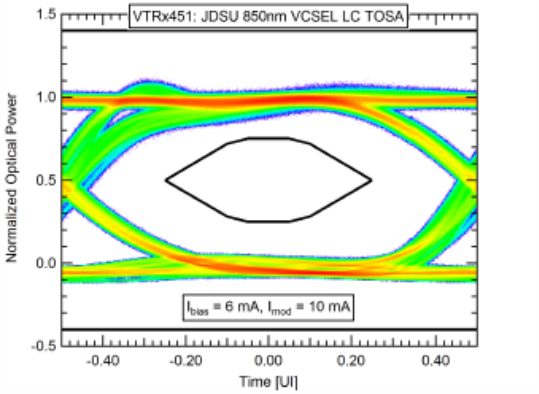

Figure 3: Normalized transmitter eye diagram, where power levels P_0 and P_1 are equal to 0 and 1, is compared to the specified eye mask.[4]

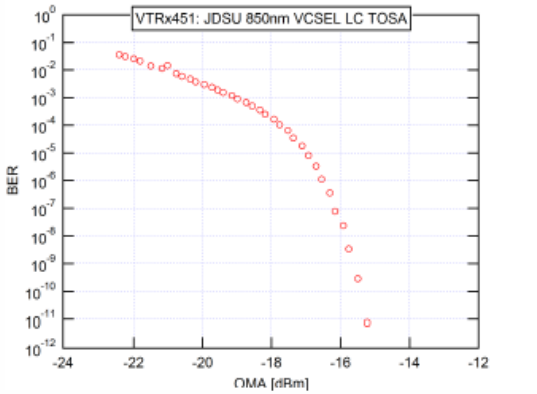

Figure 4: BER curve used to measure the sensitivity of receiver, which is determined by the crossing point of the BER curve and the level of BER=10^{-12}.[4]

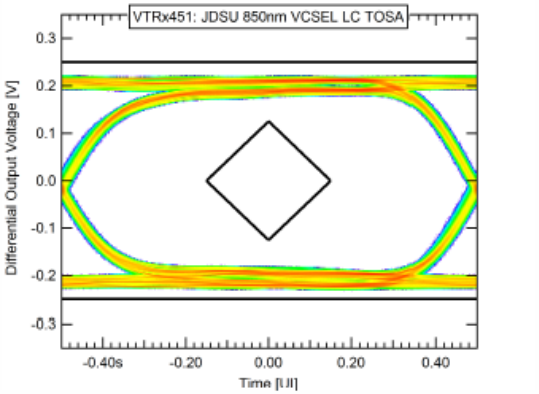

Figure 5: Electrical output eye diagram of the receiver is compared to the eye mask.[4]

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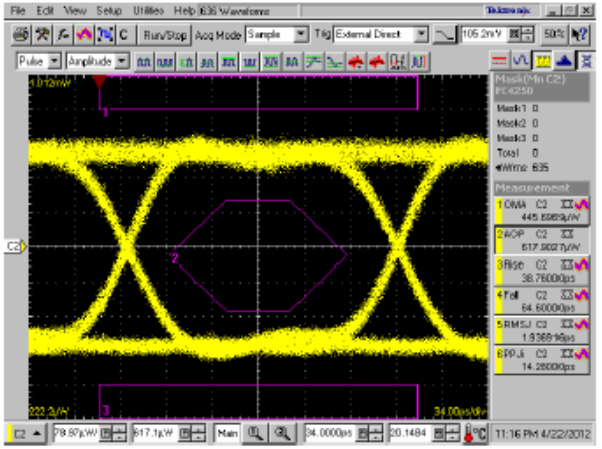
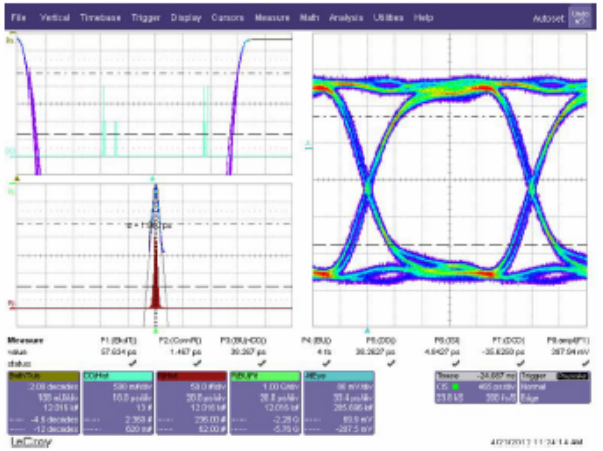
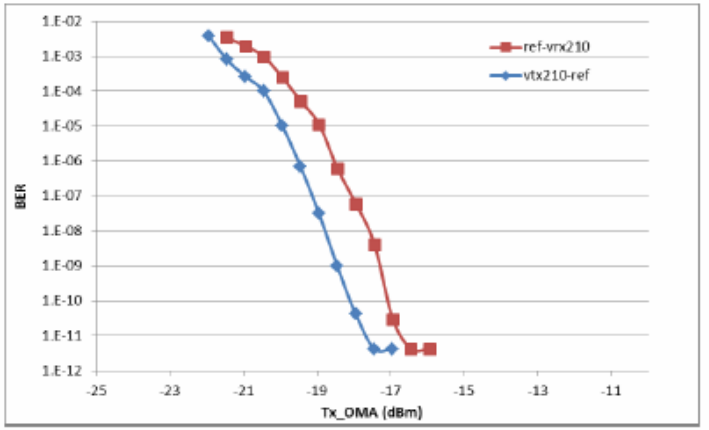
In System testing

Tests on VTRx 210





- Imod 10mA, Ibias 7mA
- Comparable performance with VTRx 208
- Good repeatability with MM latch

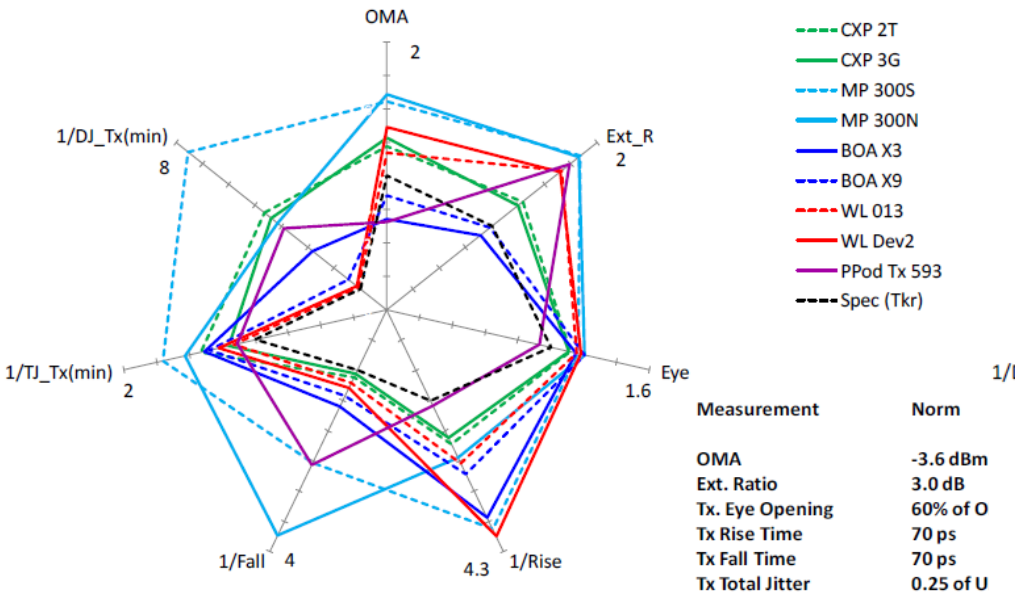


SMU

Parallel Optics Radar Plots

Versatile Link

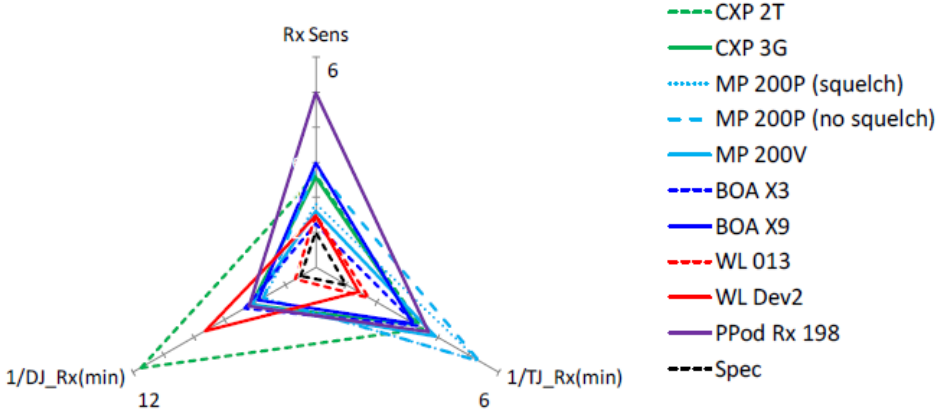
Parallel Optics Transmitter Radar Plot



Measurement	Norm
OMA	-3.6 dBm
Ext. Ratio	3.0 dB
Tx. Eye Opening	60% of O
Tx Rise Time	70 ps
Tx Fall Time	70 ps
Tx Total Jitter	0.25 of U
Tx Deterministic Jitter	0.12 of U

*Tracker Grade Spec

Parallel Optics Receiver Radar Plot



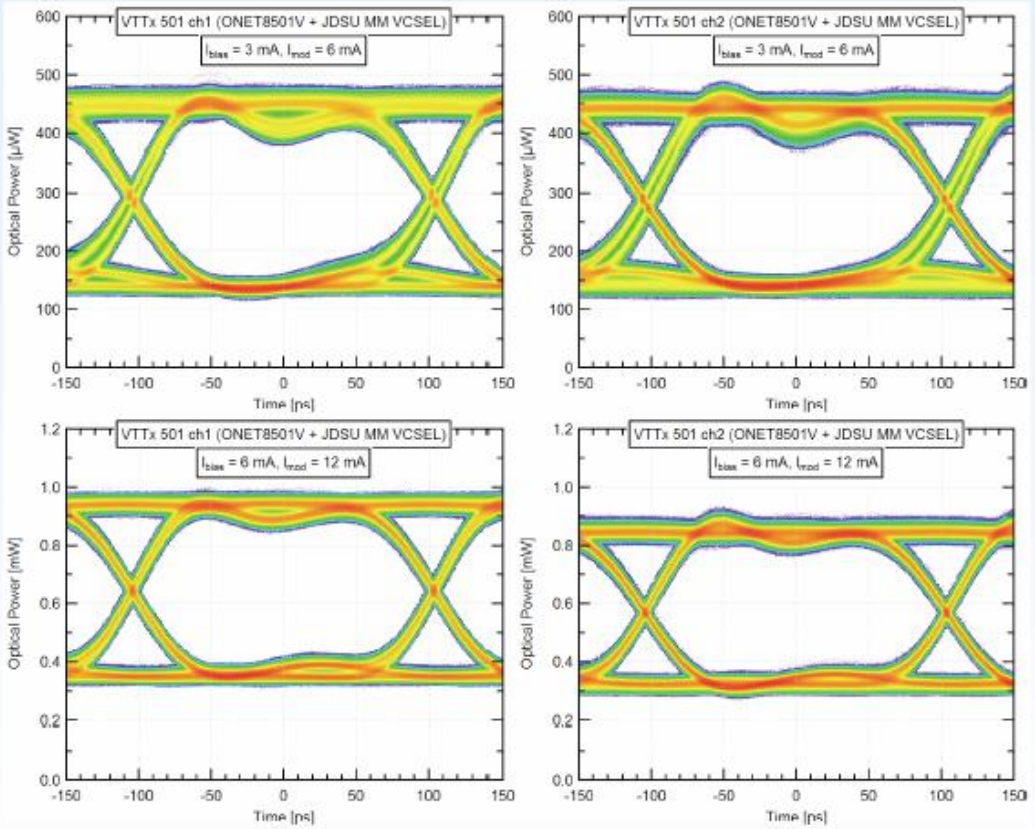
Measurement	Norm
Rx Sensitivity	-11.1 dBm*
Rx Total Jitter	0.34 of UI
Rx Deterministic Jitter	0.14 of UI

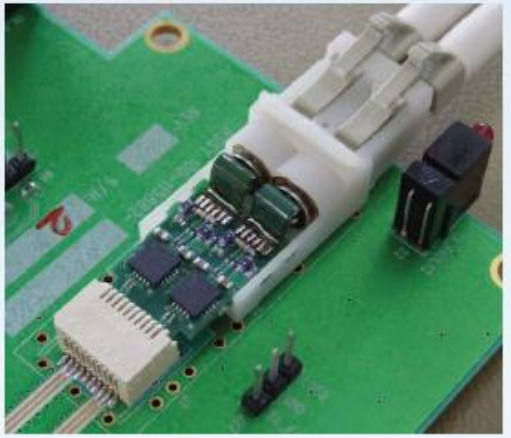
*Multimode Fiber System Spec

FNAL

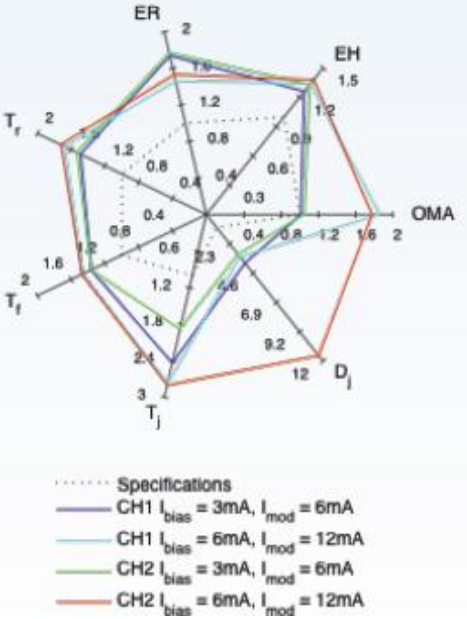
VTTx

- First fully assembled VTTx
  - ONET8501V based circuit, 850 nm VCSEL





VTTx, S/N 501



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Phase III: Preparing for Production

- Interested users
  - LHCb
  - CMS HCAL, MU-GEMs
  - ATLAS MU-small wheels
- System Type
  - MM, calorimeter grade
  - SM, calorimeter grade (few pieces for HCAL)
- Timescale
  - Phase I upgrade, 2017 (installation)
- Quantities
  - o(15’000) VTTx channels
  - o(3’000) VTRx channels
- Devices
  - Only front-end components sourced from VL team
  - Passive and back-end components to comply with VL specification

Phase III Plans

- Procurement Plan
  - Under discussion with CERN purchasing office

2012

- Commitment and Resource Plan
- Qualification Plan
  - Functional
  - Environmental
    - Derrived from prototype evaluation work
    - To be turned into systematic procedures

2013

- Consolidation of CERN loose ends
  - GBLD and GBTIA ASICs production
  - Latch design, qualification and production
  - Documentation

- Production & Assembly

2014-15

Conclusion

- Versatile Link feasibility demonstrated
  - Detailed specifications
  - Components shortlist
  - Full set of irradiation test results
  - Range of VTRx prototype
  - System demonstrators
  - Cost book

- Versatile Link phase III now running until 2013
  - Prepare production for Phase I upgrade applications
    - if commitment from experiments
  - Launch detector specific R&D for Phase II upgrade applications

- https://espace.cern.ch/project-versatile-link/public/

Credits

- CERN
  - Jan Troska, Vincent Bobillier, Christophe Sigaud, Csaba Soos, Sarah Storey, Lauri Olantera, Yoann Fusco et al.
- Fermilab
  - Alan Prosser, Simon Kwan, Mark Bowden, John Chramowicz, et al.
- Oxford
  - Todd Huffman, David Hall, Nick Ryder, Tony Weidberg, et al.
- Southern Methodist University
  - Annie Xiang, Andy Liu, Kent Liu, Jingbo Ye, et al.