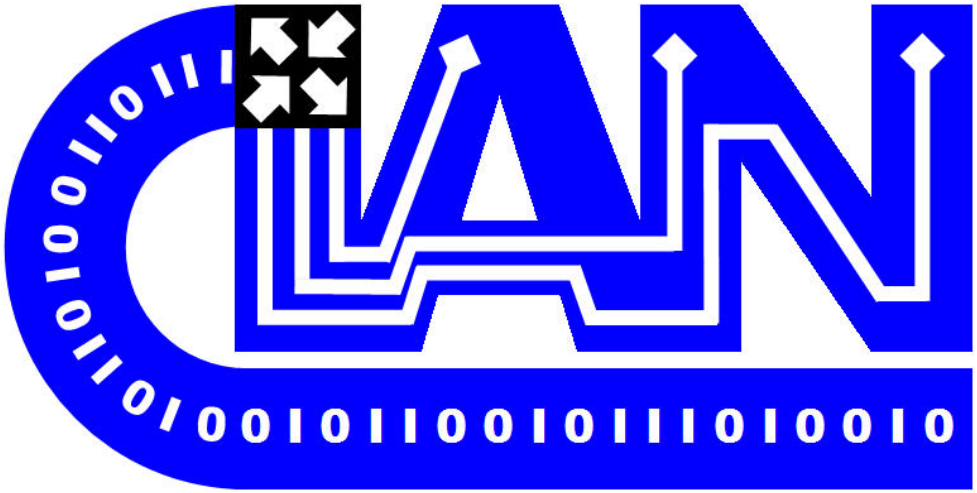
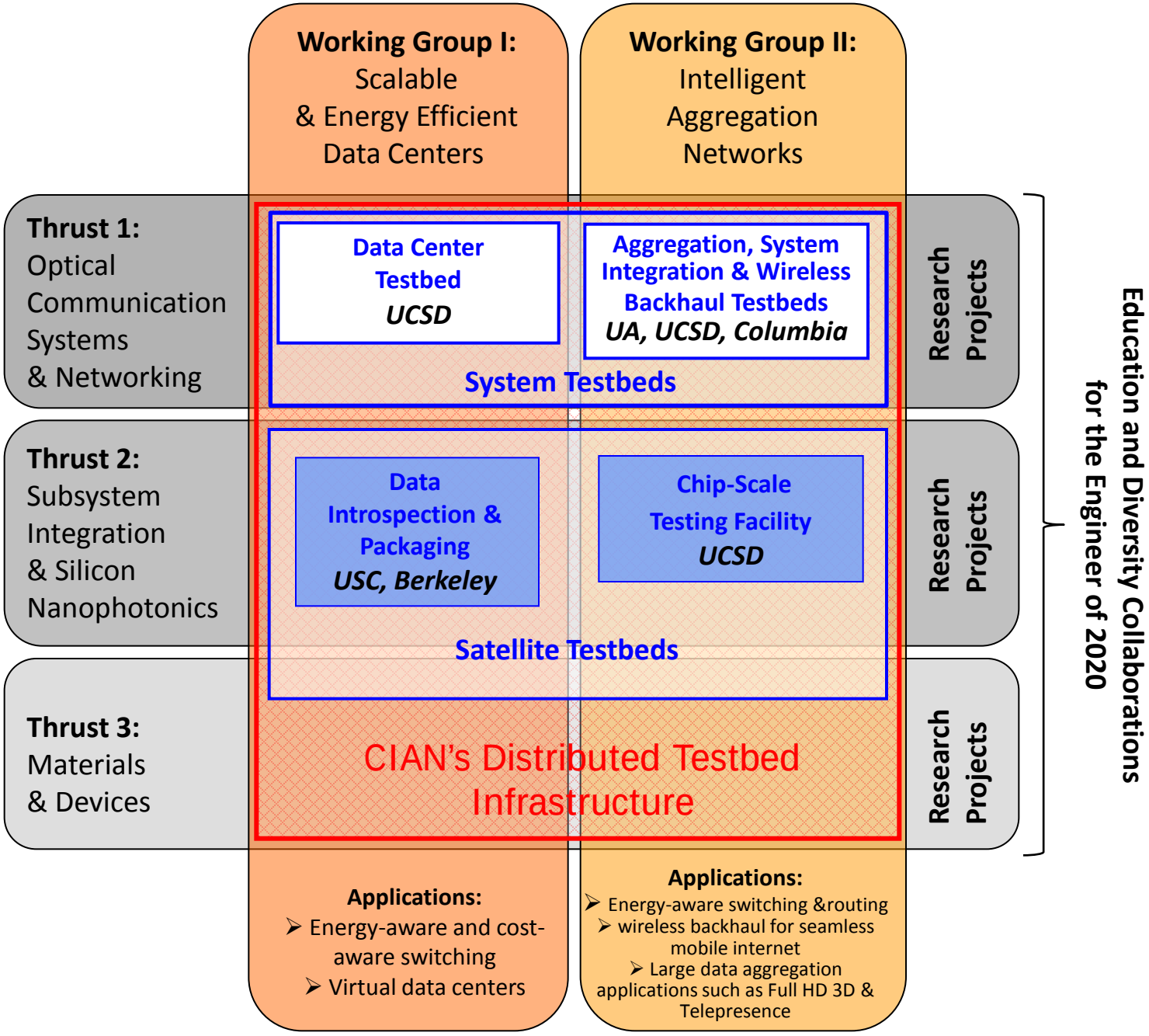


Testbed


Working Group I:
Scalable
& Energy Efficient
Data Centers
Working Group II:
Intelligent
Aggregation
Networks
Thrust 1:
Optical
Communication
Systems
& Networking
Thrust 2:
Subsystem
Integration
& Silicon
Nanophotonics
Thrust 3:
Materials
& Devices
Data Center
Testbed
UCSD
Aggregation, System
Integration & Wireless
Backhaul Testbeds
UA, UCSD, Columbia
System Testbeds
Data
Introspection &
Packaging
USC, Berkeley
Chip-Scale
Testing Facility
UCSD
Satellite Testbeds
CIAN's Distributed Testbed
Infrastructure
Research
Projects
Research
Projects
Research
Projects
Education and Diversity Collaborations
for the Engineer of 2020
Applications:
➢ Energy-aware and cost-aware switching
➢ Virtual data centers
Applications:
➢ Energy-aware switching &routing
➢ wireless backhaul for seamless mobile internet
➢ Large data aggregation applications such as Full HD 3D & Telepresence

Introduction to “the” Testbed

- **The Testbed** is to be the first research facility to target cross-disciplinary research on integrated access/aggregation networks spanning from fundamental devices to (sub-) systems to network functionalities.
- **The Testbed** will be a literal ‘common ground’ where all three CIAN research thrusts intersect, stimulating effective research collaborations among CIAN participants (including the Industrial Affiliates) and the wider research community.
- **The Testbed** acts as a physical and metaphoric center to CIAN efforts, supporting the multi-directional information flow essential to connect researchers across disciplines.

System Integration and Hybrid Network Testbed

Stojan Radic, Co-Lead
UCSD, System TB

New: Data Center & Chip-Scale Testing

George Papen, Co-Lead
UCSD, System TB

New: TOAN

Franko Kueppers, Lead
UA, System TB

Data Introspection

Alan Willner
USC, Satellite TB

Cross Layer and Wireless Backhaul

Keren Bergman
Columbia, System TB

New: Device Packaging

Susant Patra
UC Berkeley, Satellite TB

Progress and Current Status

- Associated project funded (NSF MRI) and started [UCSD]:
  System testbed **“Scalable Energy Efficient Data Centers (SEED)”**
- Associated project funded (from ARRA 2009 through NSF) and started [UC Berkely]:
  Satellite testbed **“Device Packaging” – Susant Patra, Professor of Practice, hired.**
- Associated project funded (from ARRA 2009 through NSF) and started [UA]:
  “Testbed on Optical Access/Aggregation Networks (TOAN)” under construction in collaboration with Industrial Affiliates Agilent, Fujitsu, and Yokogawa.

System Integration and Hybrid Network Testbed

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UCSD, System TB

New: Data Center & Chip-Scale Testing

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New: Device Packaging

Susant Patra
UC Berkeley, Satellite TB

Device Packaging for Testbed Insertion

Goals:

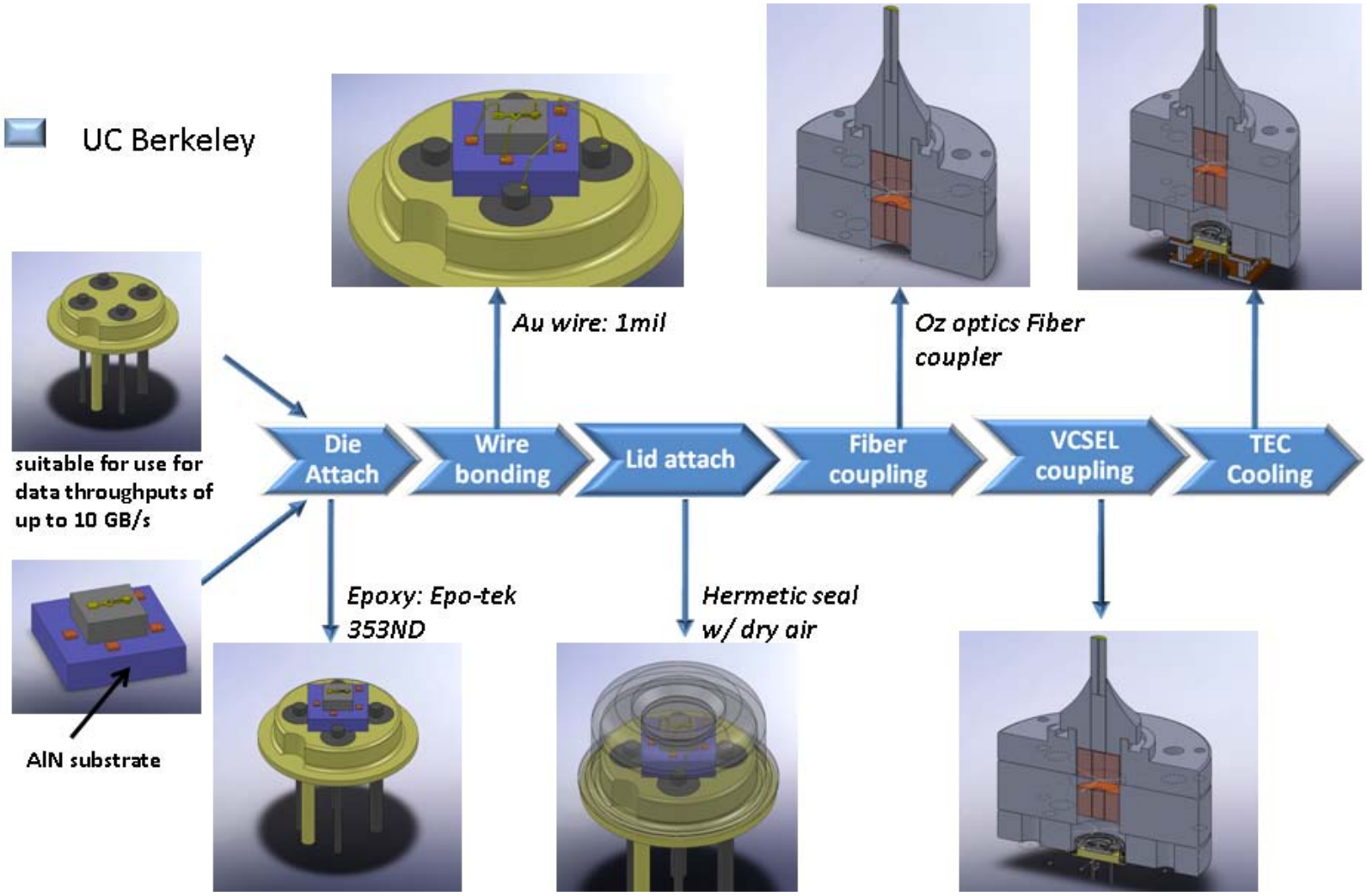
- Develop a scalable process and a common platform to assemble diverse optoelectronic devices and a range of electrical signal frequencies for CIAN's system testbed.
- Assist in diffusing a culture of industry practice to CIAN.
- Work with research groups to develop components suitable for advanced characterization in systems and testbeds.

Impact:

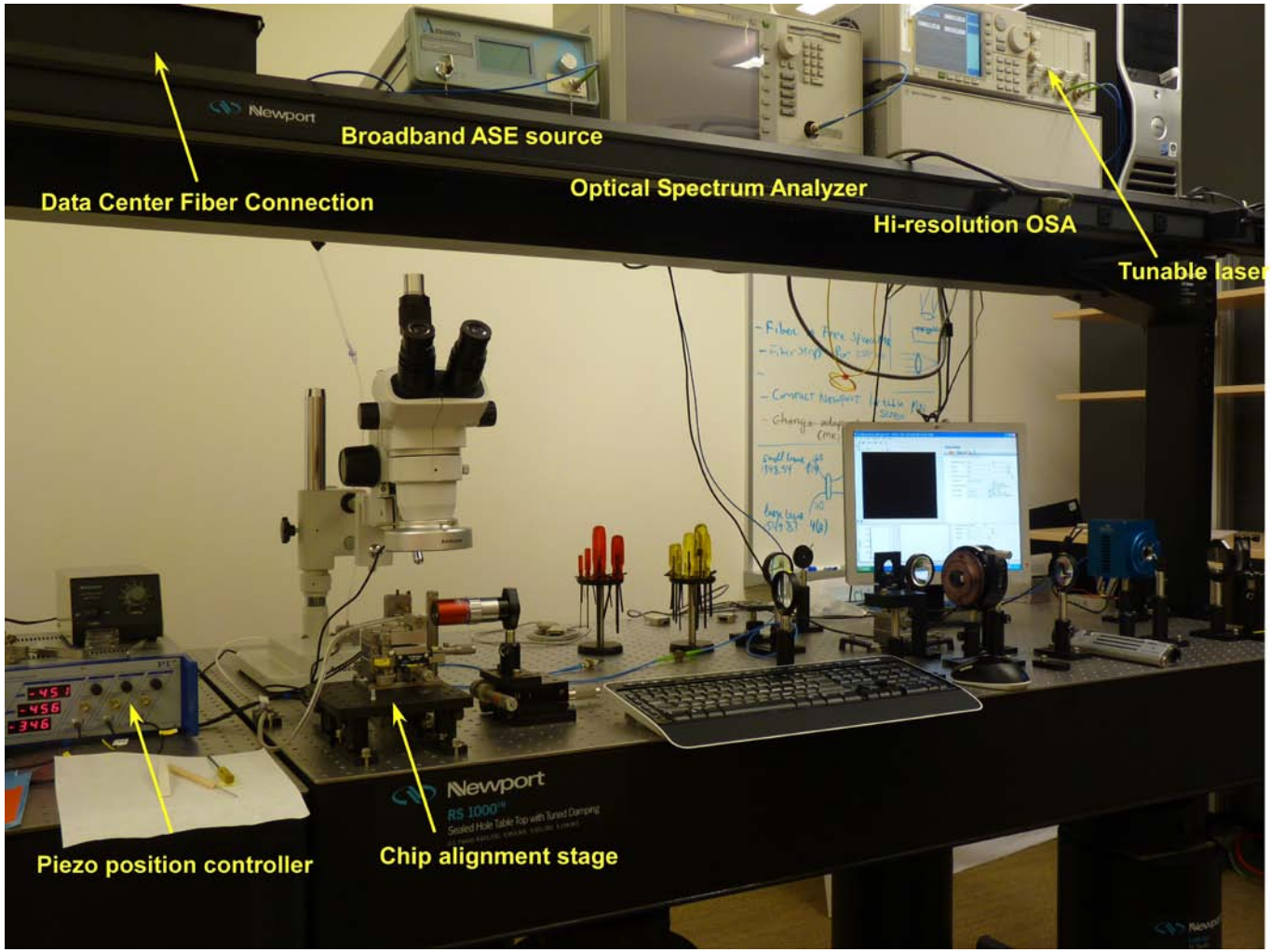
- Bridge the gap between optoelectronic devices and systems by providing a universal packaging platform, and
- Train the future engineers in an industrial oriented academic environment.

- Associated project funded (from ARRA 2009 through NSF) and started.
- Dr. Susant Patra, Professor of Practice, UC Berkeley, hired: 16 years of industrial experience in optoelectronics and optical micro-electro-mechanical systems.
- Infrastructures available at UC Berkeley and at UA will be used for the packaging.
- Two devises from UC Berkeley identified to be packaged for Testbed:
  - Tunable Filter & VCSEL

Example: VCSEL Packaging Process Flow



Chip-Scale Characterization Testbed



Capabilities:

- 67 GHz Lightwave component analyzer (Agilent N4373C)
- 13 GHz realtime oscilloscope (Agilent Infiniium)
- Tunable laser , 100fm resolution (Agilent 81600B)
- Hi-resolution (8fm) optical spectrum analyzer (Agilent 83453B)
- Grating based Optical Spectrum Analyzer
- Simulation and design software (COMSOL & RSoft)
- Simulation server (donated by SUN micro systems), 128 GB memory, 8 CPU cores.

System Testbed on "Scalable Energy Efficient Data Centers (SEED)"

SEED is a facility that provides a platform for integrating research *across* focused research on Data Centers including study of physical layer hardware, protocols, and topologies that can provide the expected size and performance scaling for future data centers at low cost and energy "per bit".

Description

- SEED connects 200+ servers each operating at 10 Gb/s
- Use a non-blocking and scalable switch
- SEED uses commodity components
- Hybrid electrical packet/optically circuit-switched network (optical switch)
- Hosted in CalIT2 - leveraging from ongoing networking research

Benefits

- SEED will be guiding the development of the next generation of photonic technologies in the CIAN ERC → encourage innovation + creation of IP
- Serve the needs of industry for both small and large companies
- Graduate and undergraduate students involvement
- Unique outreach opportunities via interactions with ongoing ERC activities

System Integration and Hybrid Network Testbed

Capabilities

- 50-GHz real time oscilloscope
- 10-GHz and 40-GHz signal generati
- MHz-resolution true heterodyne optical spectrum analyzer
- Dispersion characterization
- 50-Gbps parallel BERT system
- Four 12.5-Gbps BERT systems
- Four 60-GHz digital analyzers
- 250-λ DWDM channel bank
- In-house amplifier fabrication facility
- Fiber plant: 2000km SMF/NZDSF/LEAF
- Commercial OC-768 terrestrial system

TOAN: Progress and Current Status

Associated project funded (from ARRA 2009 through NSF) and started:
"Testbed on Optical Access / Aggregation Networks (TOAN)" under construction
in collaboration with Industrial Affiliates Agilent, Fujitsu, and Yokogawa.

- Will synergistically complement the existing facilities, especially those serving "cross-layer optimization," "optical data intro-spection," and "system integration."
- Provides a new controllable, multi-node, and flexible link configuration "network emulation platform" and networking-oriented testing capabilities for CIAN researchers and industrial collaborators.
- Allows for testing components, devices, and networking concepts developed within CIAN in a close-to-reality aggregation network test environment.

CIAN researchers and Industrial Affiliates will be able to perform the following activities at TOAN:

- Set up various topologies, various domain and layer structures, with link and ring lengths comparable to actual aggregation networks.
- Emulate various switching, processing, and transmission impairments.
- Include optical data introspection, and implement and test impairment-aware reconfiguration of optical paths throughout the entire network.
- Investigate network stability in an increasingly transparent and flexible environment.

Nasser Peyghambarian
PI

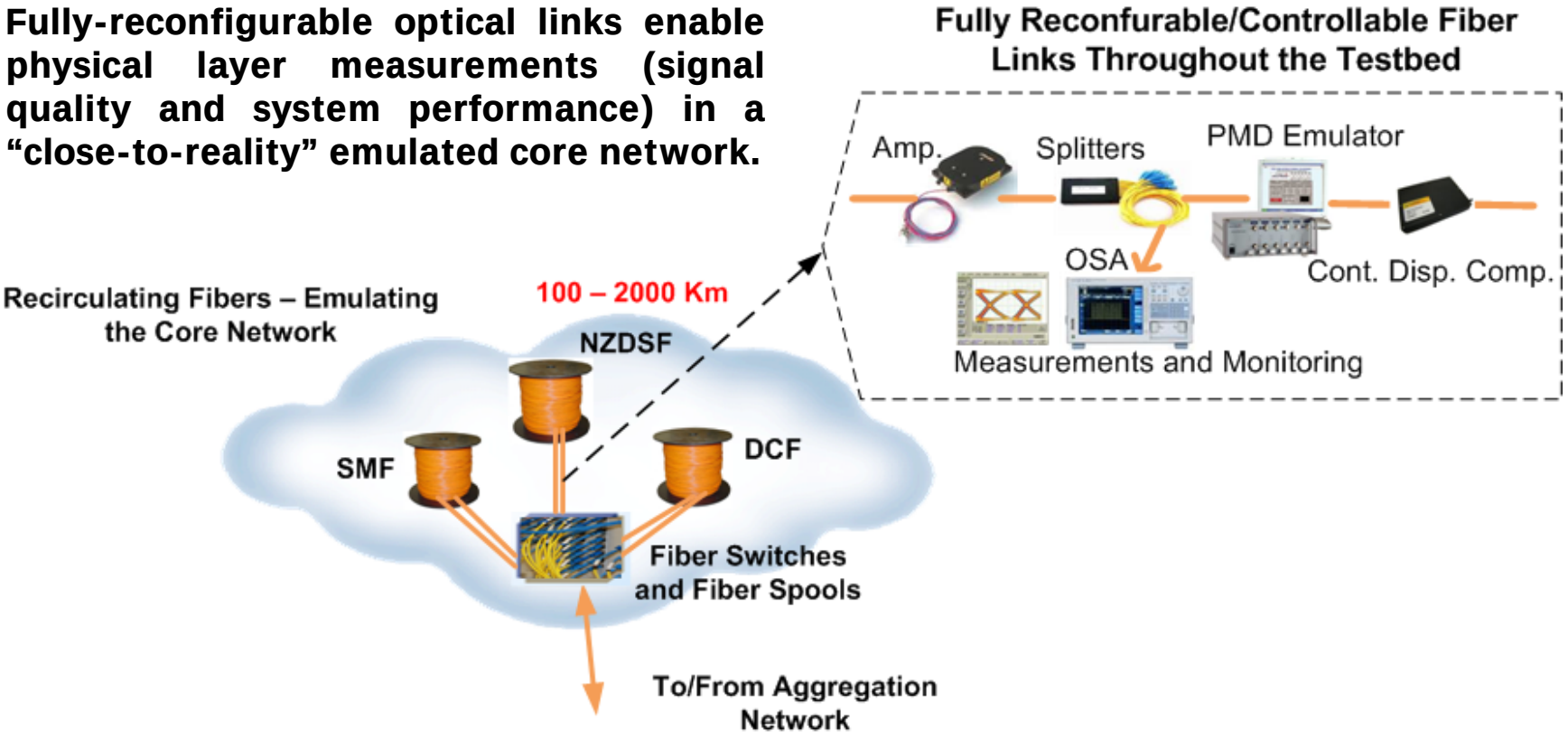
Robert Norwood
Co-PI

Franko Kueppers
Co-PI

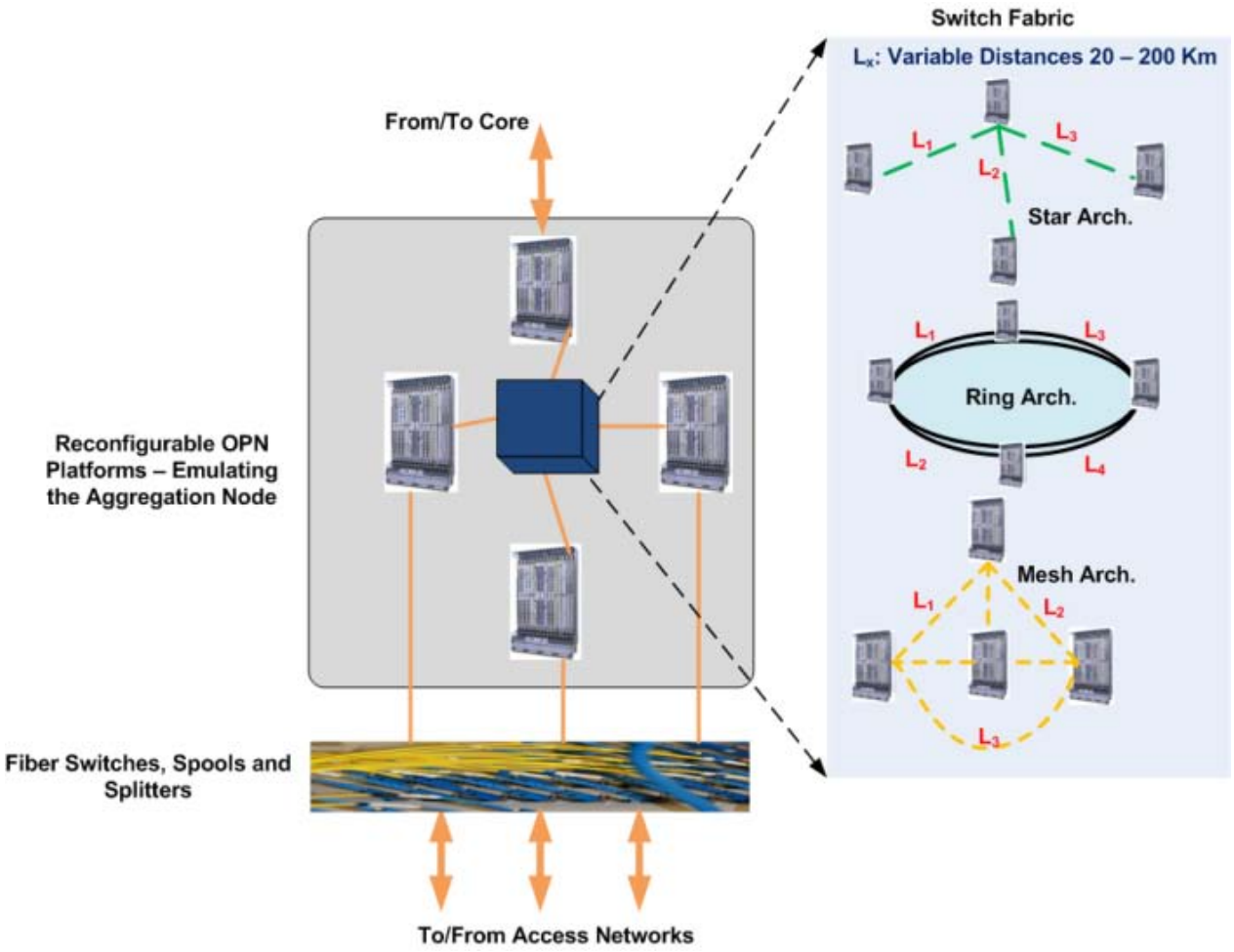
Massoud Karbassian
Lead Scientist, TOAN
Coordinator, WG 2

TOAN – Core Network Partition

Fully-reconfigurable optical links enable physical layer measurements (signal quality and system performance) in a "close-to-reality" emulated core network.

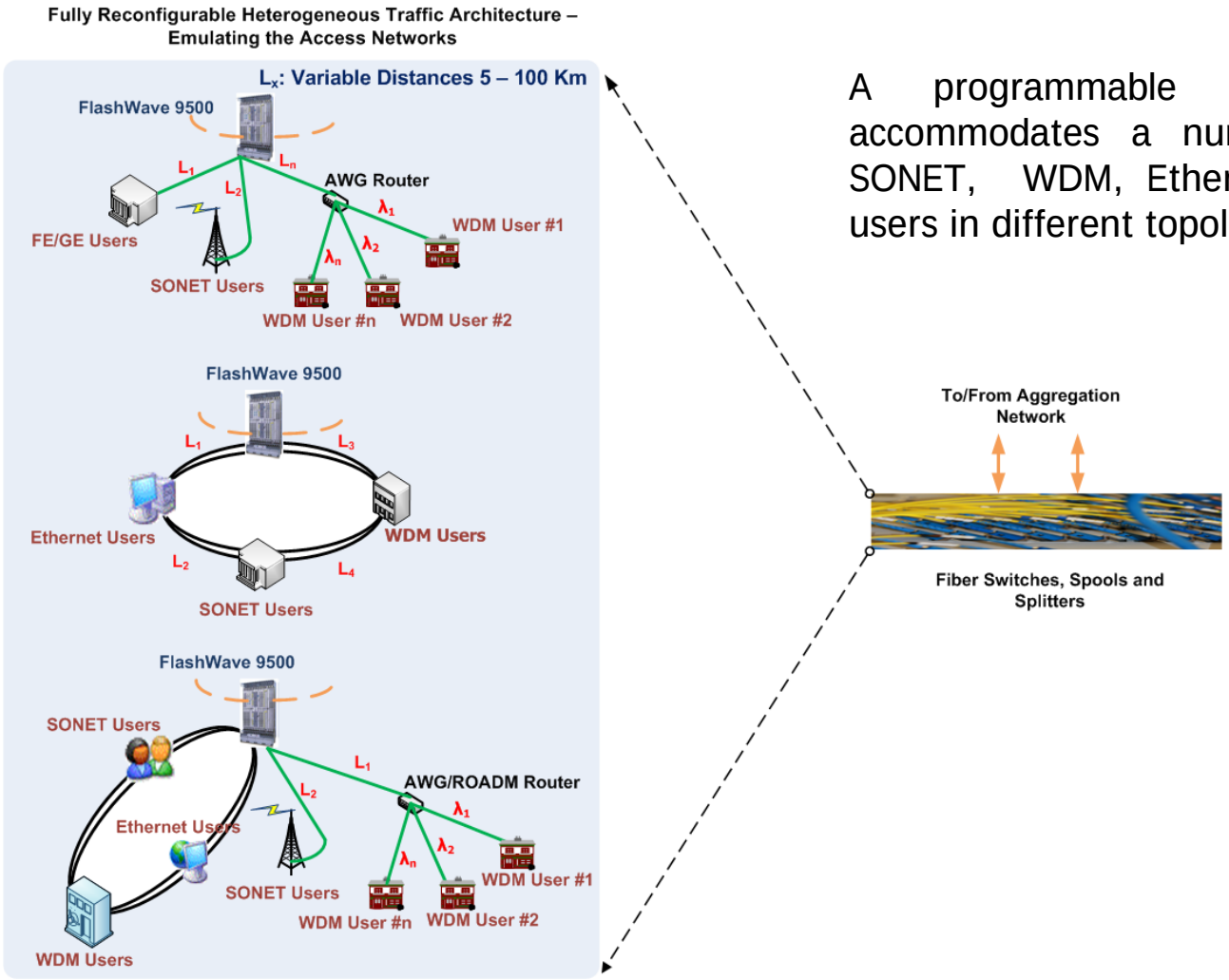


TOAN – Aggregation/Metro Network Partition



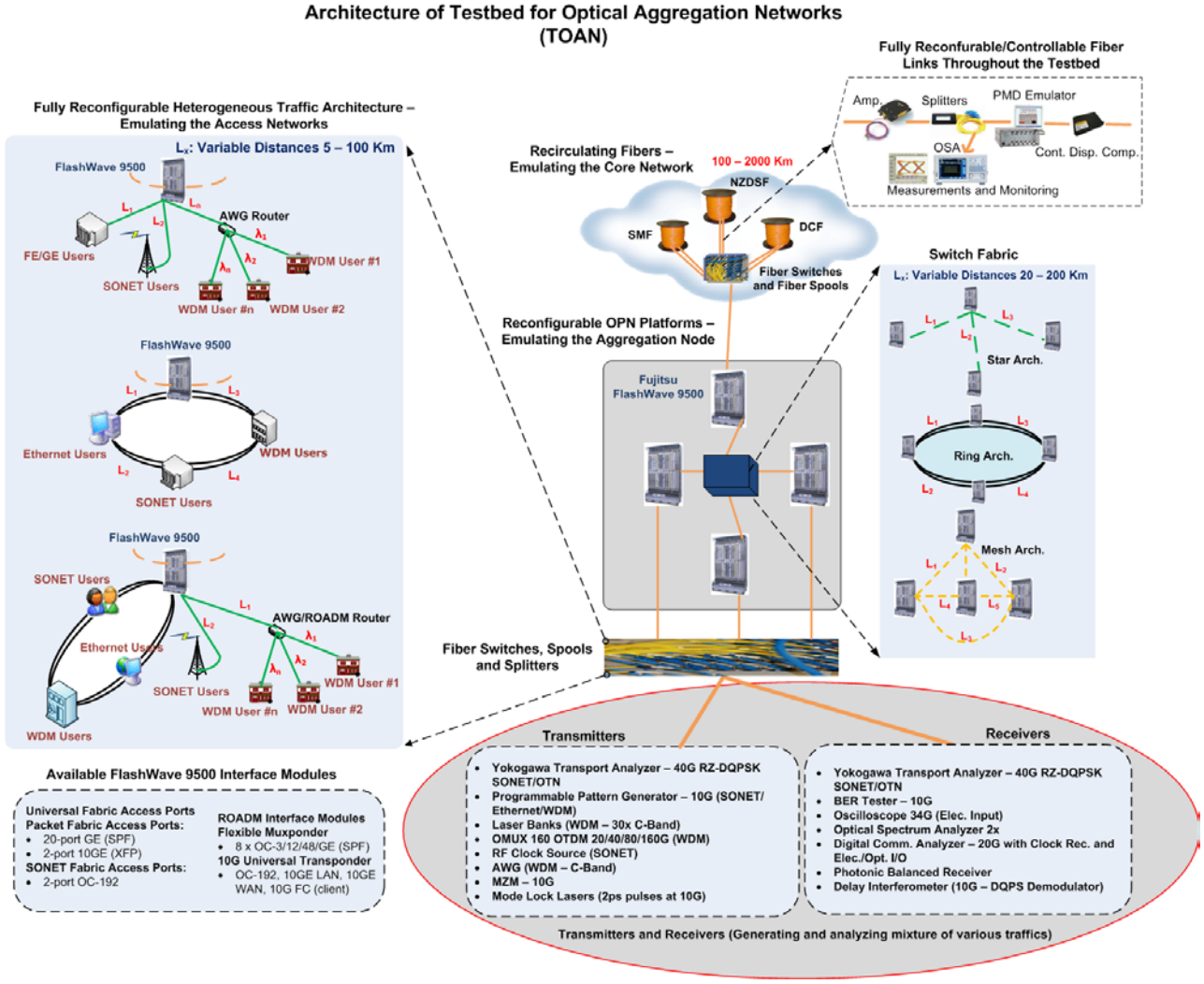
- Fully-programmable switching fabric allows the Fujitsu FlashWave 9500 node to be configured in various architectures, such as star, ring, and mesh topologies.
- Allows researchers to investigate their components, sub-systems, concepts, and algorithms in a braod varity of terms ranging from noise characteristics to energy efficiency “on scale.”

TOAN – Aggregation/Access Network Partition

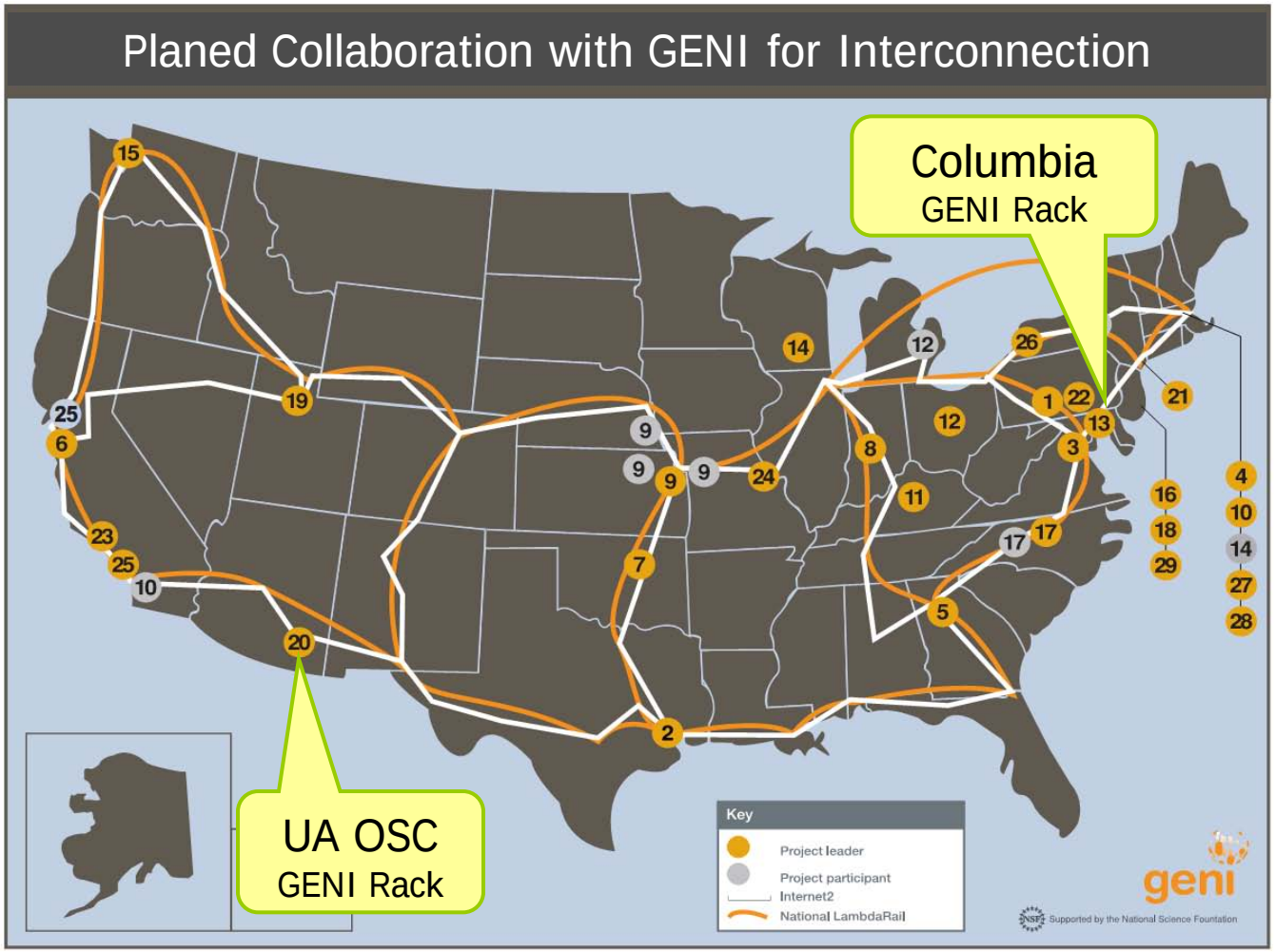


A programmable switching fabric accommodates a number of different SONET, WDM, Ethernet, and Wireless users in different topologies.

TOAN – Entire Architecture



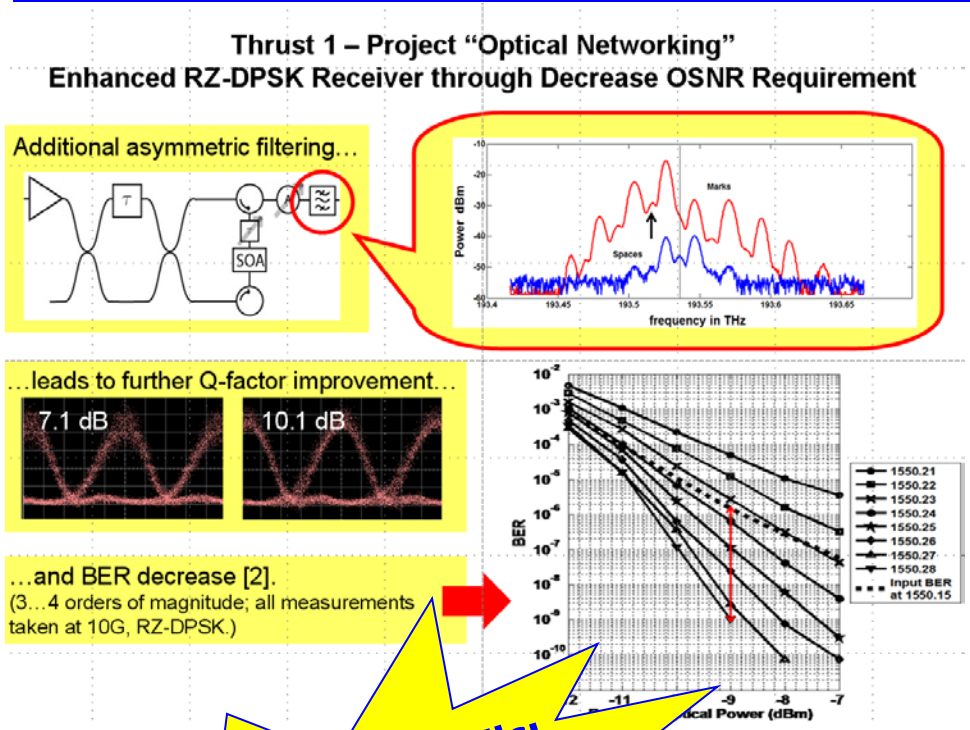
Year-3 Plan: Interconnection from Colombia to UA



- Distributed infra-structure of specialized Satellite and System Testbeds at Columbia and UA.
- "Local" device, subsystem, and/or proof-of-concept testing and characterization at Columbia and UA.
- "Global" integration and network demonstration through GENI and/or Internet2.

Nice Slides – Any Evidence It Works?

Nice Slides – Any Evidence It Works?



CIAN-enabled collaboration of a Satellite testbed (USC), a System Testbed (UA), and an Industrial Affiliate lead to

- Proof-of-concept (presented at ECOC 2009)
- Subsytem demonstration (presented at OFC 2010)
- Prototype development (presented at ECOC 2010)

and subsequent lab-/field test with major network operators (scheduled).

For technical details: Hacene Chaouch – student poster and presentation.

- "Four-port PON Amplifier with over 8-dB Power Budget Improvement, Negligible ASE Noise, and Supporting 30 dB Dynamic Range," ECOC 2010
- "BER Improvement for RZ-DPSK Receivers Using Saturated Asymmetric Filtering," OFC 2010
- "Photonic Balancing in DPSK Detection Using Pulse Collision in a Semiconductor Optical Amplifier," ECOC 2009

Thank You for Your Attention!

P.S. Service Agreements Available!