KyaTera project

Prof. Hugo L. Fragnito
UNICAMP - IFGW, Centro de Pesquisa em Óptica e Fotônica (CePOF)

KYA = “net” (tupi-guarani – the language of native Brazilian people)
TERA = “monster, marvel” (greek)

What is the KyaTera Project?

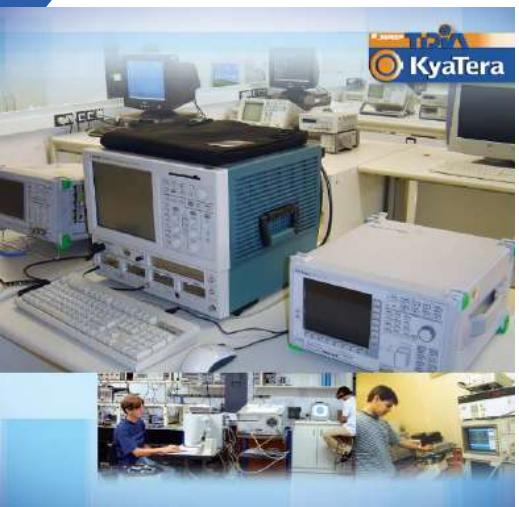
- A testbed for Internet research, a distributed lab facility to test ideas in
  - Transmission and Networking technologies
  - Advanced Internet applications
- Groups of experts on Internet enabling technologies and applications, working together
- Multiple networks interconnecting laboratories (FTTLab):
  - Optical cables with multiple fibers (single mode)
  - Fibers with multiple wavelengths (WDM)
  - Flexible testbed: any technology, topology, application
  - No (tangible) bandwidth limit, high quality Internet

KyaTera Goals

- **To do research in Internet enabling technologies**
  - **Communications**
  - **Networking**
  - **Remote control of lab instruments**

- To design and (partially) implement a state-wide fiber optic network interconnecting laboratories
  - FTTLAb: Fiber-To-The-Lab

- To develop advanced applications and special uses of the INTERNET
  - WebLabs
  - Open to suggestions



Three KyaTera Layers

Applications Layer

- Web enabled Laboratories (WebLabs)
  - ➔ Control and automation, robotics
  - ➔ Multimedia communications

Networking Layer

- Telecom Networks
- Computer Networks
  - ➔ IP, SDH, Protocols, QoS, Network Security

Physical Layer

- **Fiber-Optic Transmission Systems**
- **All-Optical Networks**
  - ➔ **DWDM, CWDM, photonic devices**

Multiple Networks

- **Interconnects laboratories from KyaTera and oher projects funded by Fapesp**
  - Fiber-To-The-Lab
- **Stable Gigabit-Ethernet network**
  - 1 Gbps ~end-to-end for all participants
  - DWDM backbone, 10 Gb/s/channel – 2 lambdas initially
  - DWDM ring in Sao Paulo
  - Connections to other academic networks (International at 2.5 Gb/s)
- **Experimental networks**
  - Experimental research on optical devices, systems, network architectures, communication strategies
  - 1 fiber pair for Applications Layer projects
  - 2 fiber pairs for Networking Layer projects
  - > 2 (typically 6) fiber pairs for Physical Layer projects
  - Stable and experimental networks coexisting

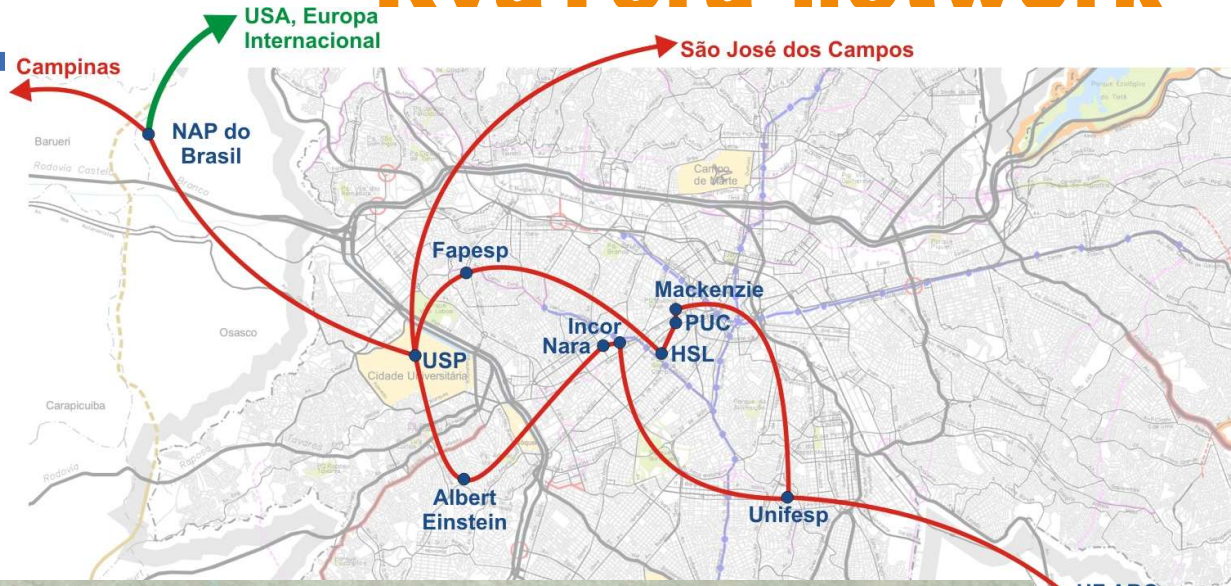
KvaTera network

Dark Fibers

KyaTera: 1050 km

Telefonica: 3300 km

Total: 4350 km



KyaTera

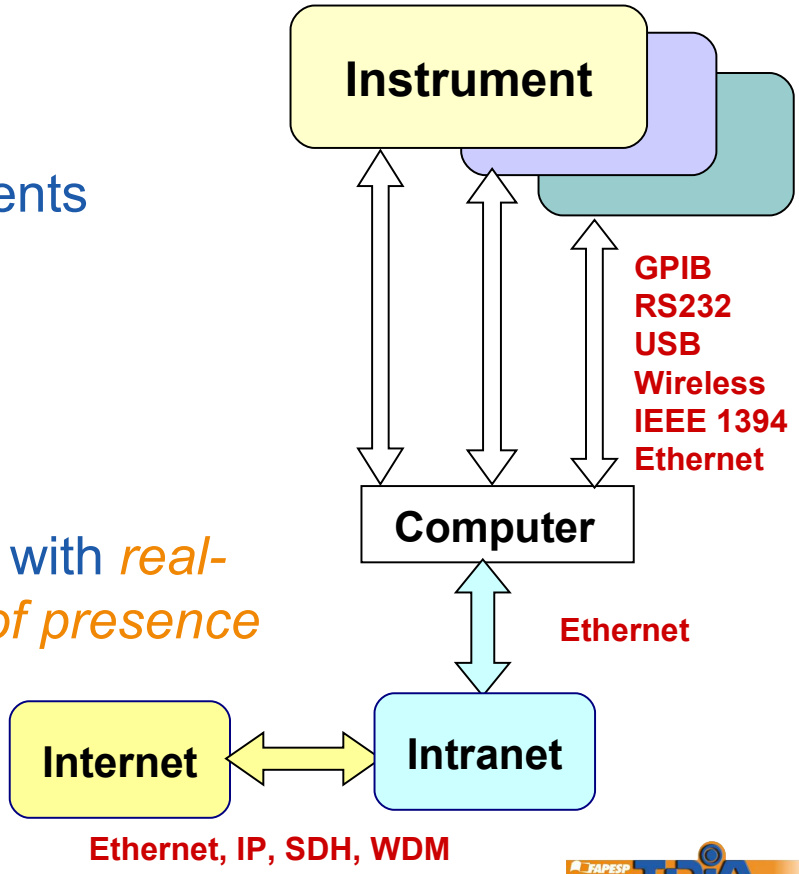
WebLab

- **Real Laboratories accessed via INTERNET**
- **E-Learning in ALL EXPERIMENTAL SCIENCES**
- **Tele-Research, Tele-Collaboration**
- **Distant training**

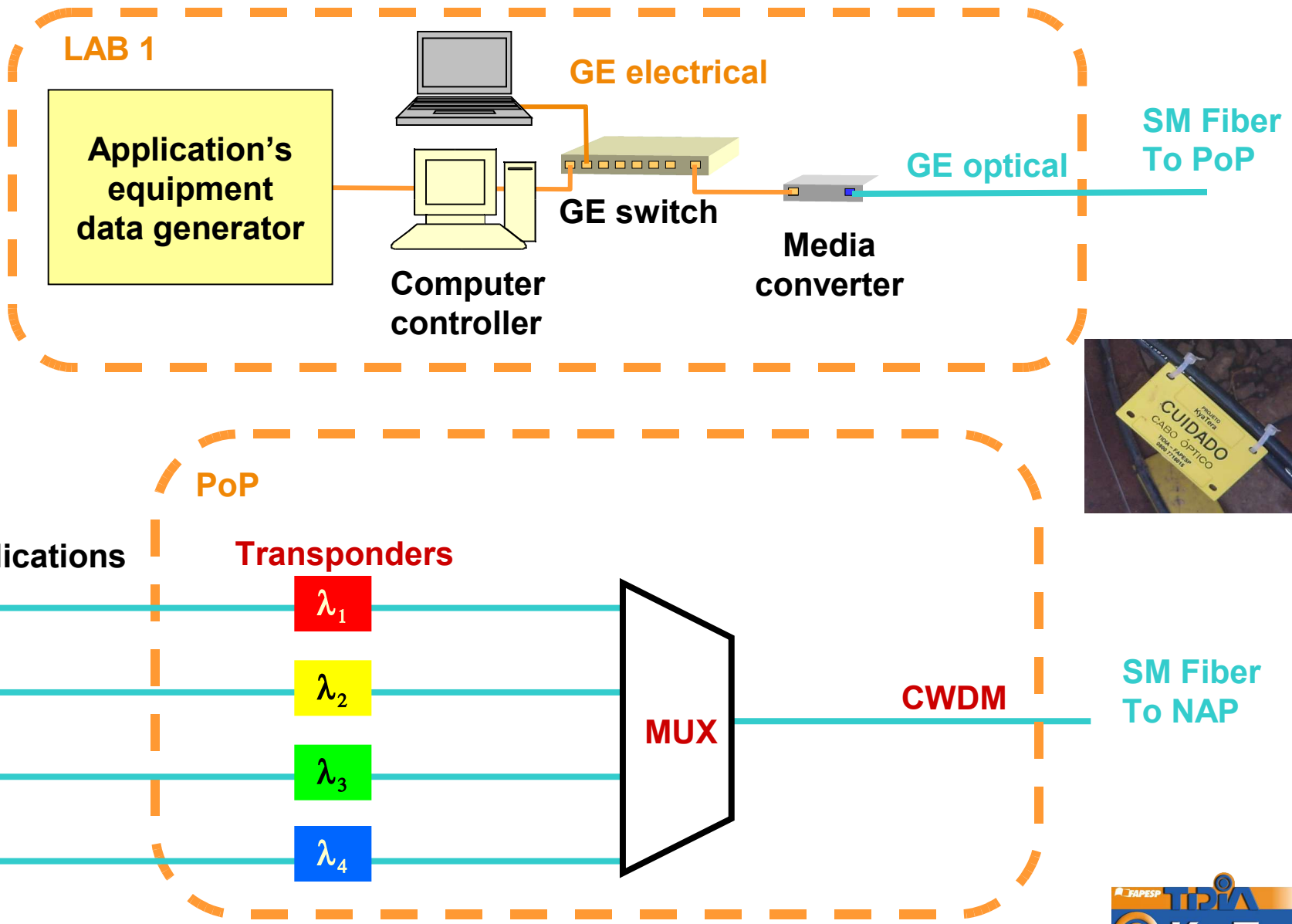
- *Non-presencial*, but *real* experiments

- We need to understand
  - automation, control, HD video,…
  - … and, specially, the Network

  … in to order to develop weblabs with *real-time control* providing *sensation of presence*

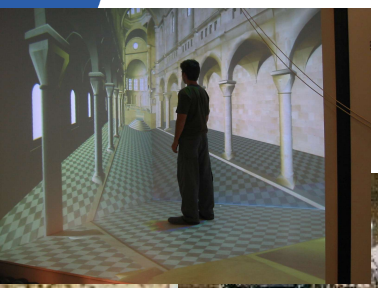
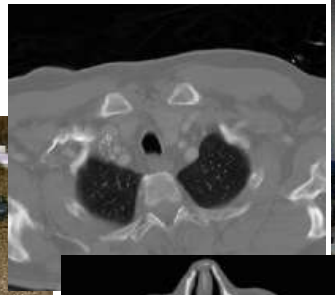


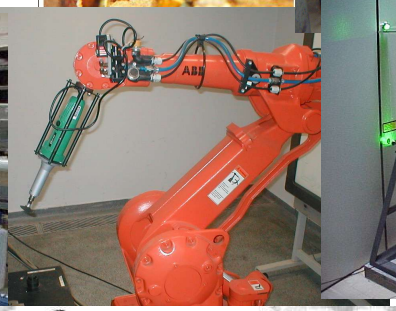
Applications Layer - WebLabs



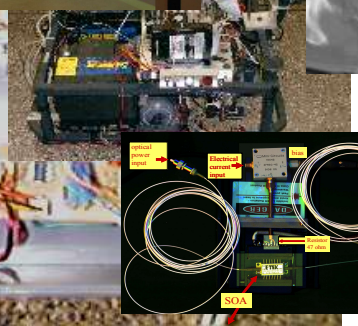
KyaTera WebLabs

- Chemical engineering
- Photonic devices
- Optical communications
- Microwaves communications
- Biology
- Advanced manufacturing
- Medicine
- Psychology
- Robotics
- Atmosphere monitoring (Lidar)
- Virtual reality



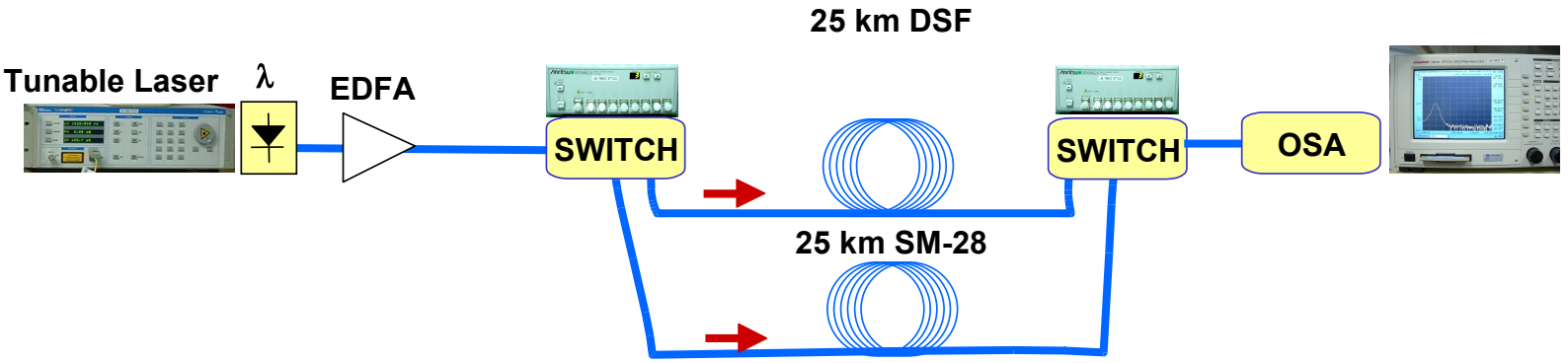


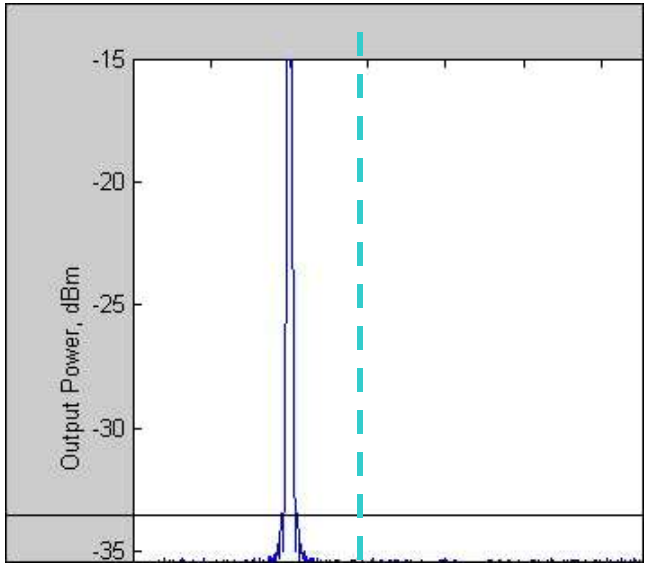



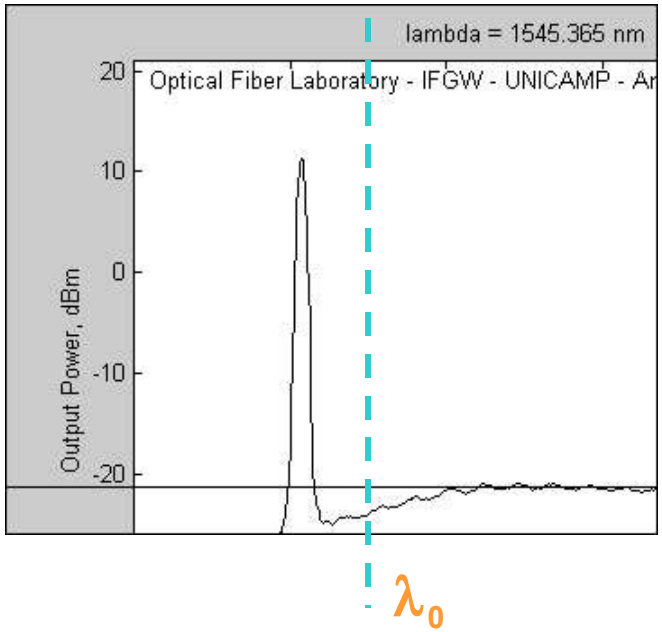


Modulation Instability WebLab

Campinas – São Paulo, Nov. 2004



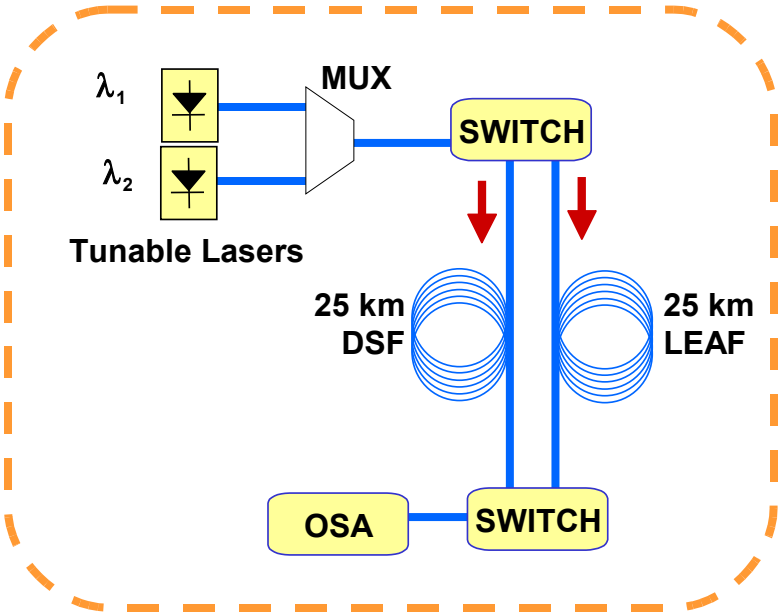




Simulation versus experiment

Four Wave Mixing WebLab

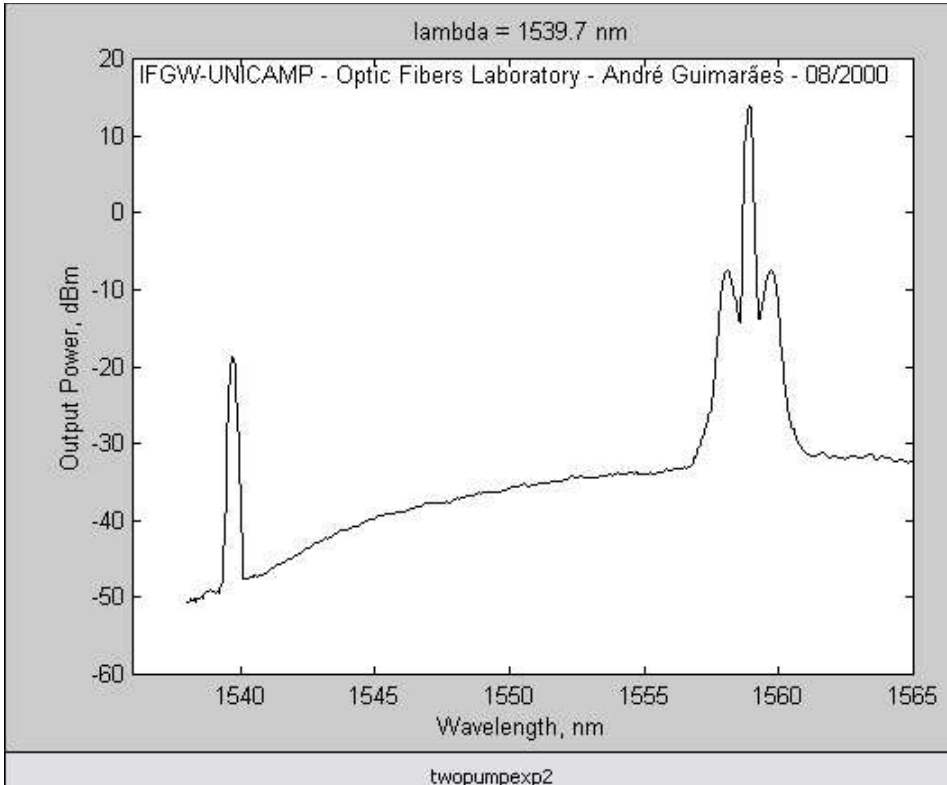
IFGW - Optical Comm Lab



Unicamp – Mackenzie: Ago 2005
Via ANSP

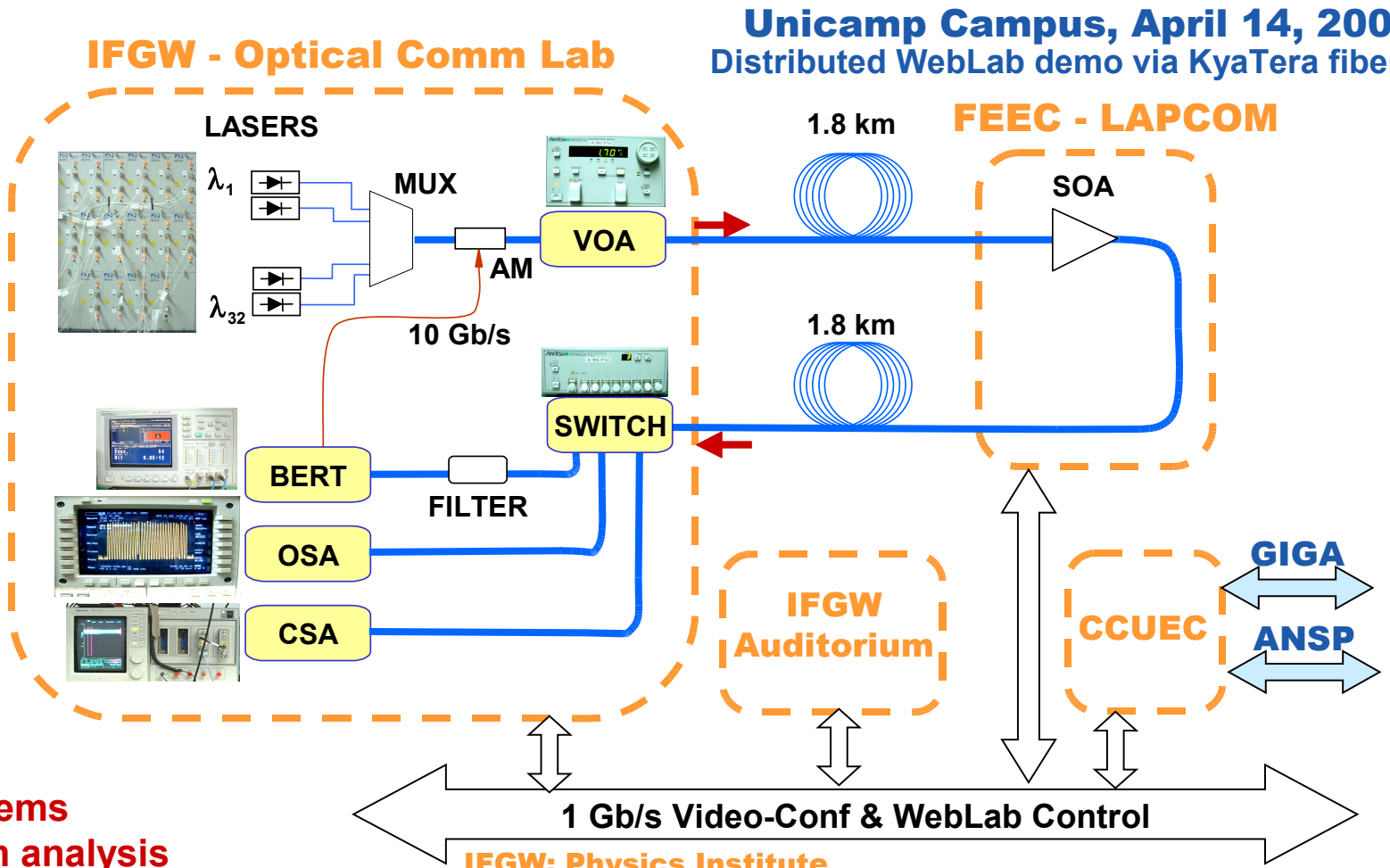
Unicamp – PUCC: Sept 2005
Via KyaTera

Unicamp - TIDIA Workshop: Nov 14
Via KyaTera fibers (to SP) + radio



Nonlinear effects in WDM systems

320 Gb/s DWDM System WebLab

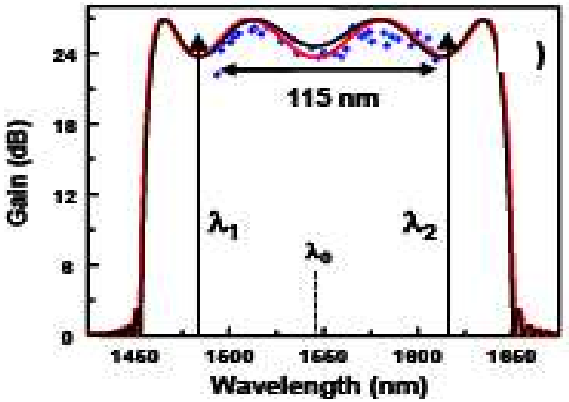


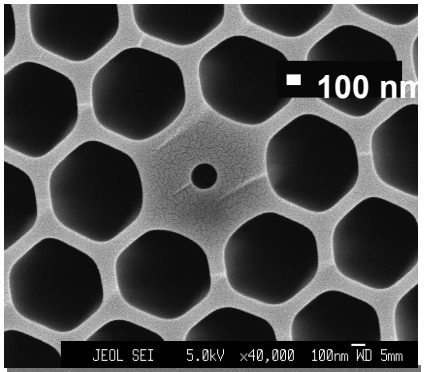
DWDM systems
Eye diagram analysis
Optical amplifiers
Optical spectrum analysis
10 Gb/s systems

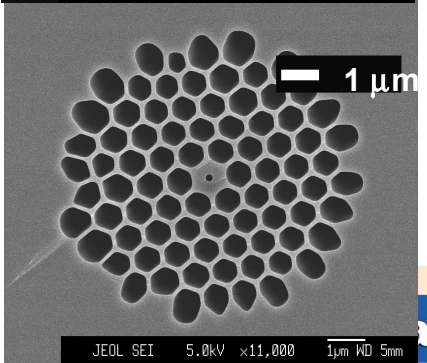
IFGW: Physics Institute
FEEC: Faculty of Electrical and Computing Engineering
CCUEC: Computing Center
GIGA: Giga Project (CPqD+RNP)

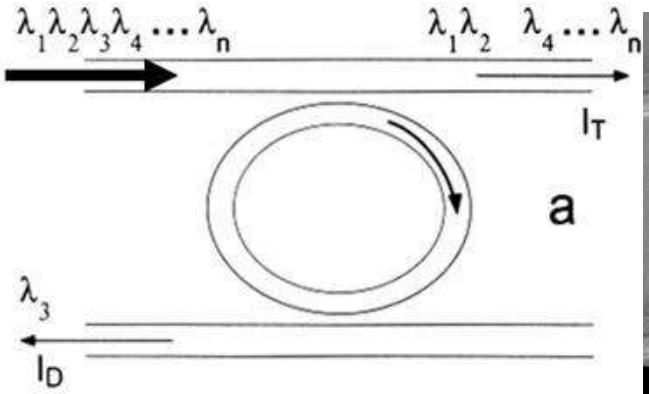
Physical Layer

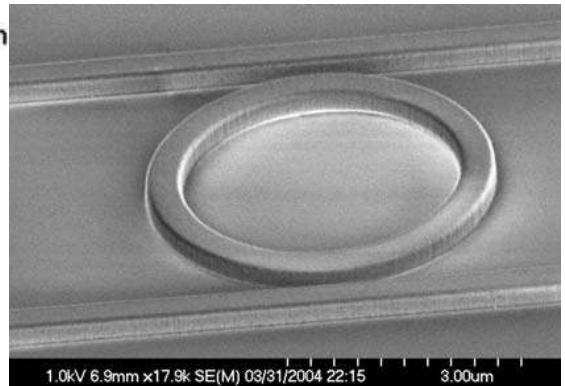
- Fiber Optic Parametric Amplifiers
- Wavelength Converters
- Semiconductor Optical Amplifiers
- 40 Gb/s Systems
- Quaternary Systems
- Raman Amplifiers
- Photonic Crystal Fibers
- Silicon Photonics Devices
- Optical Burst Switching
- Phase & Amplitude of Optical Fields
- Hi-Bit-Rate Femtosecond Systems





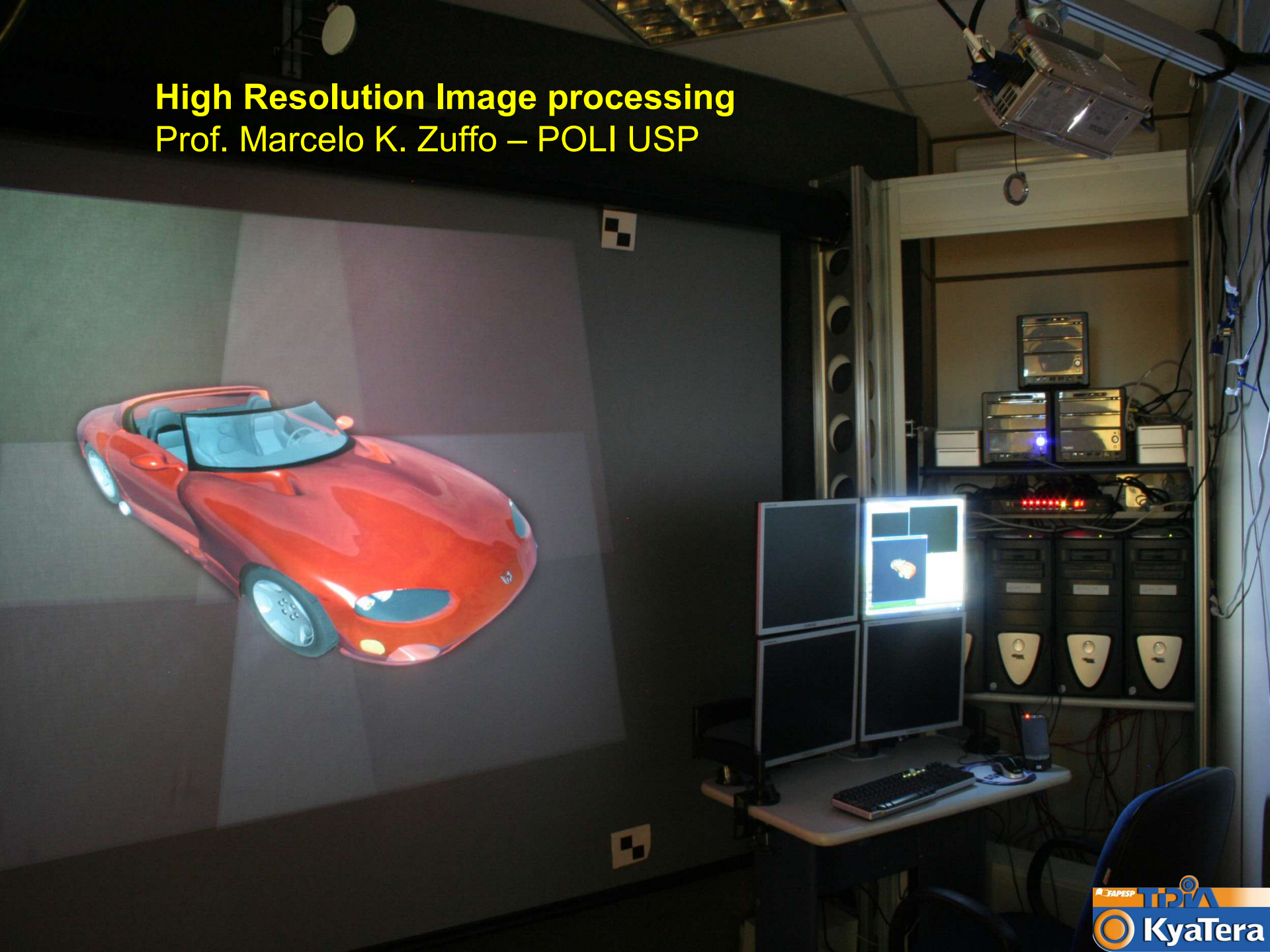




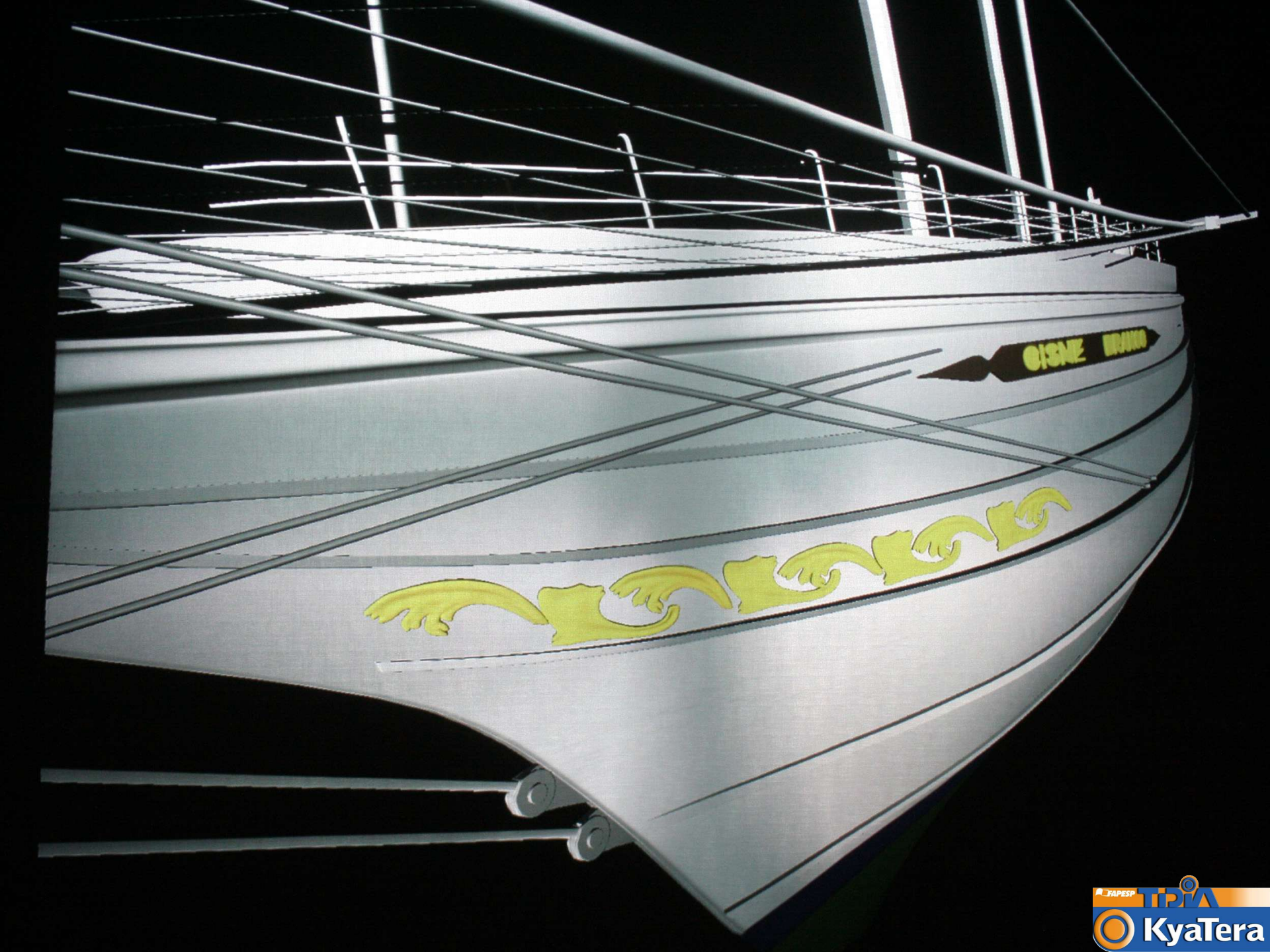


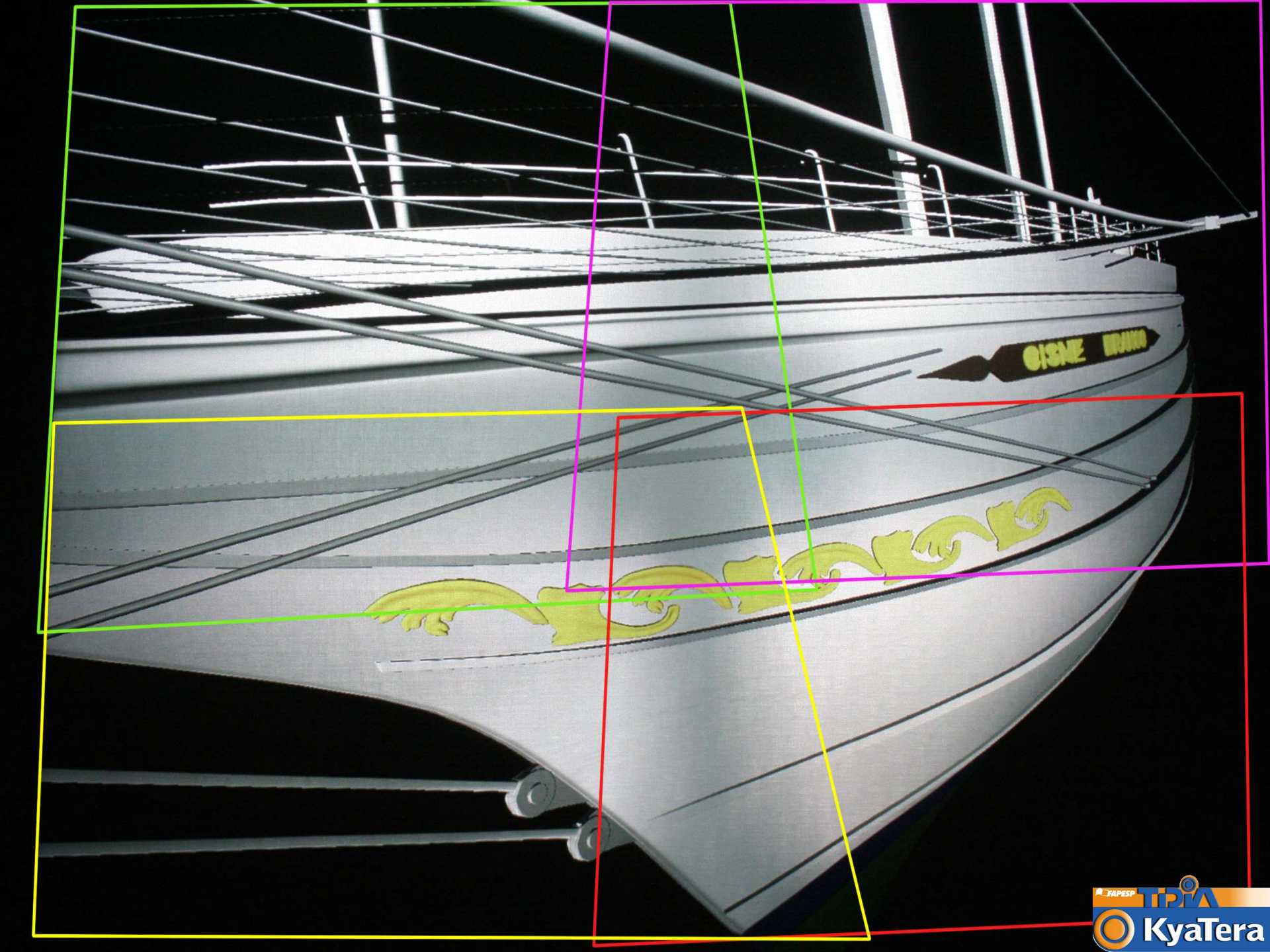
Networking Layer

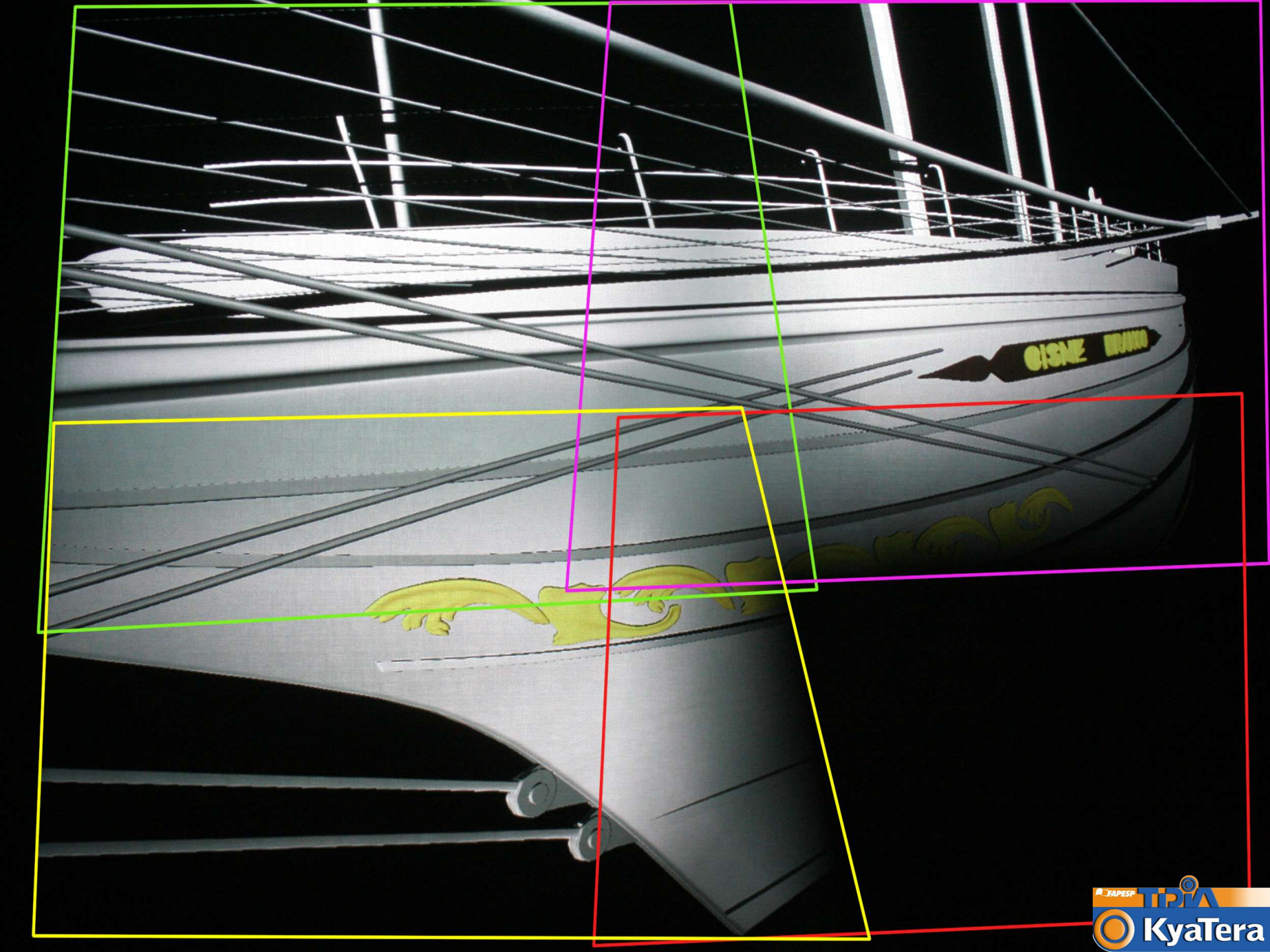
- Multiple networks
- All optical networks
- IPTV
- Routing and Wavelength Assignment
- Ant networks
- Complex Networks
- Radio-To-The-Fiber
- Mobile networks
- Network emulation (Emulab/Planet-Lab)
- Network monitoring
- Multicasting


High Resolution Image processing
Prof. Marcelo K. Zuffo – POLI USP


inFocus
inFocus






FAPESP
KyaTera

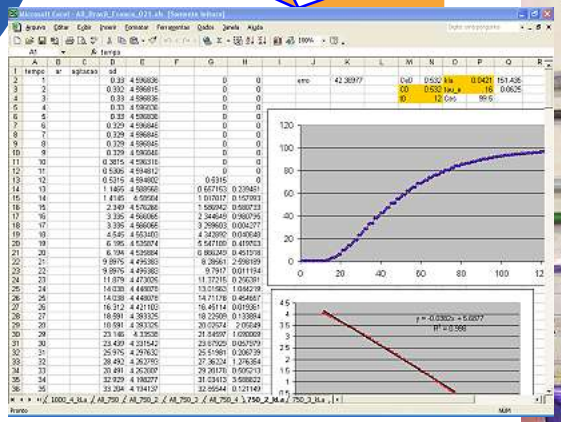
WebLab on Biochemical processes

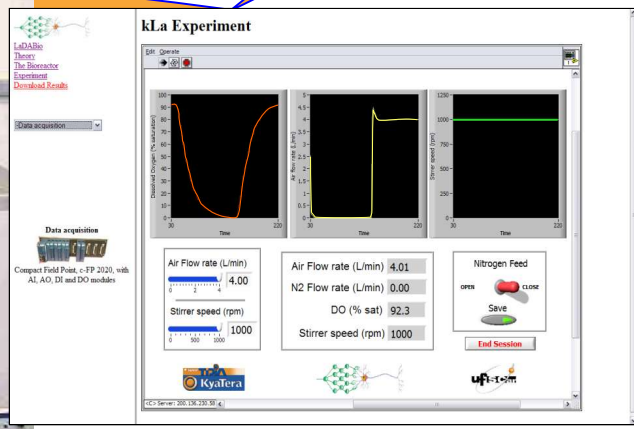
UFC, Depto Eng Quimica, Brasil
Profa. Luciana R. B. Gonçalves

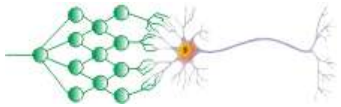
INP ENSIACET A7

ENSIACET - Toulouse, França
Profa. Marion Alliet,
Prof. Galo Le Roux (EPUSP)

UFBA, Depto Eng Quimica, Brasil
Profa. Silvana Mattedi e Silva



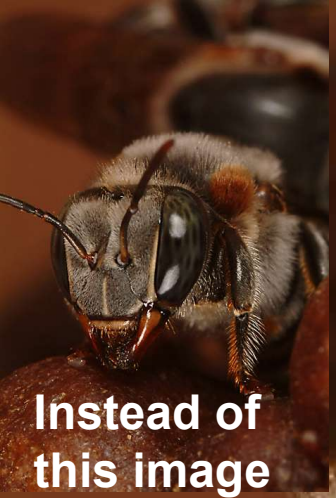




Prof. Roberto de Campos Giordano UFSCar

FAPESP TIPIA KyaTera

High resolution images for bee identification and classification



Instead of this image

Bees WebLab Requires HD (high definition) images and video

Real-time HDV for behavior studies

Remote researcher can zoom and count the number of hears on leg (characteristic of specimen)

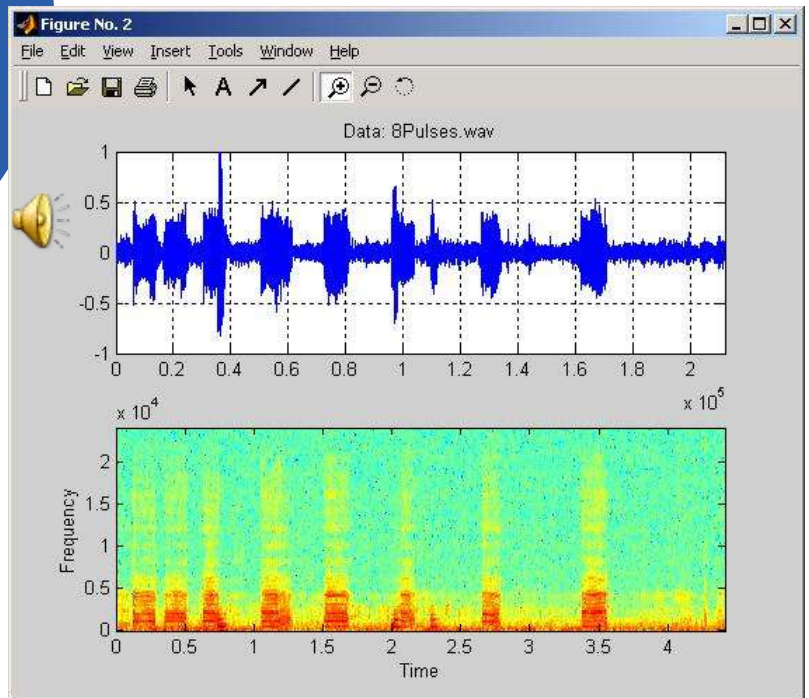
HD image may replace the real specimen (which is usually sent by air-mail)

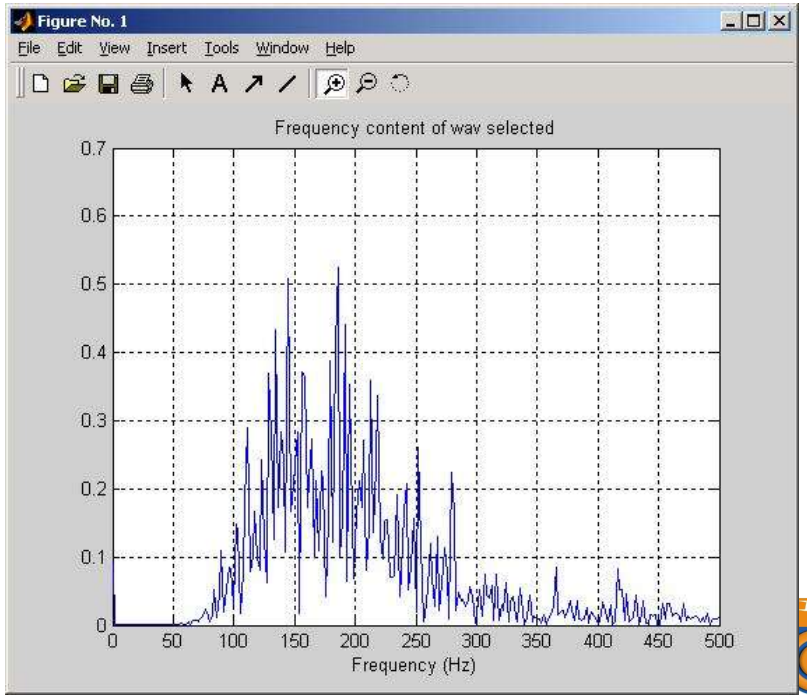
Prof. Antonio M. Saraiva, USP

Weblab on audio monitoring in a colony

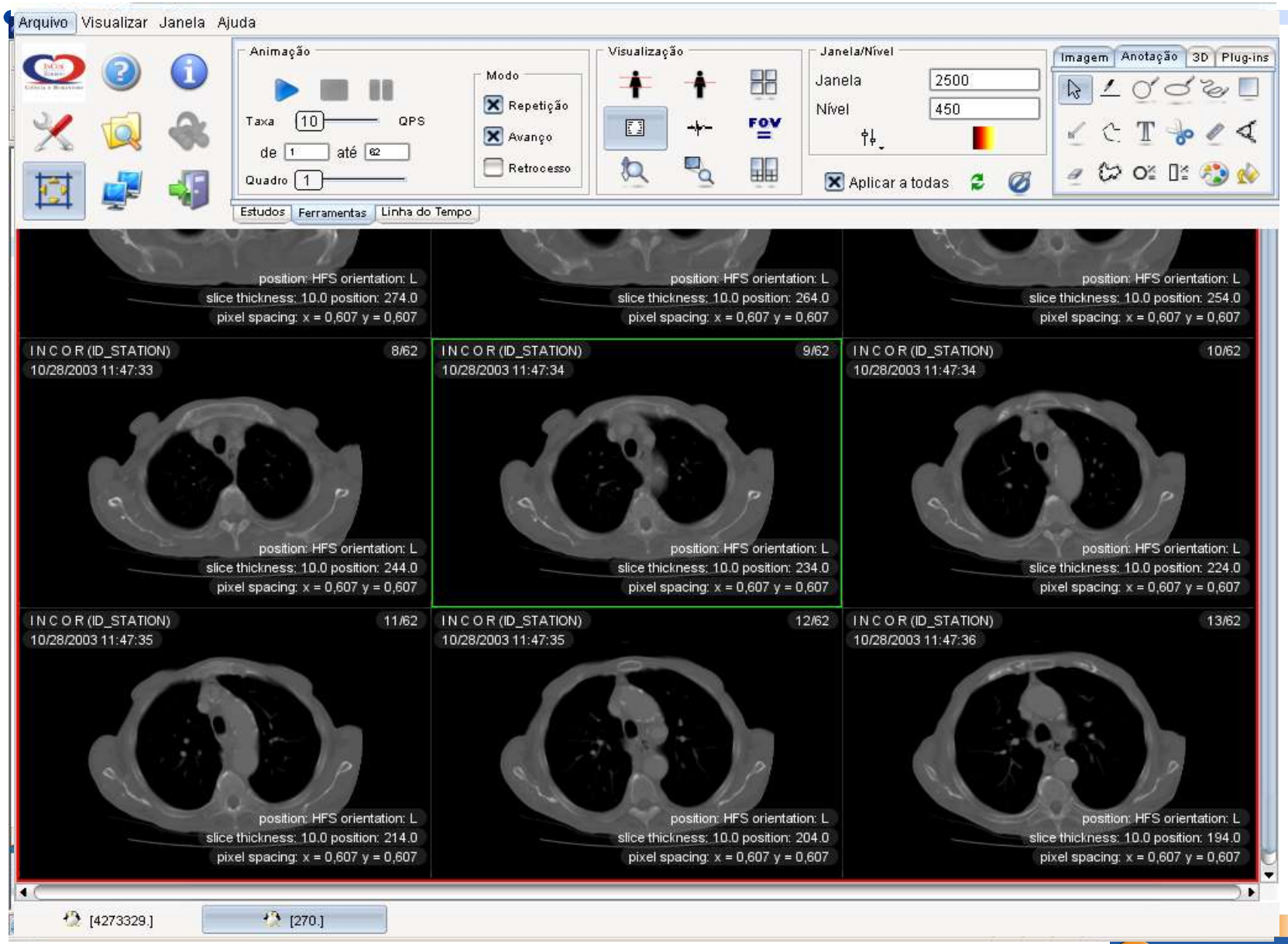
- **Audio acquisition inside a colony and analysis**
  - Studies on audio inside a colony (communication)
  - x other conditions (weather, food availability, threats).
  - Patterns, spectra, level

- **WebLabs to improve International Collaborations:**
  - Prof. Antonio M. Saraiva – USP and Dr. James C. Nieh – University of California, S. Diego





WebLab on Medical Images



Psychology WebLab

Teaching the learning process

High Definition Video (to see the water drop) would improve the experiment

How do we train the rat to change its habits?

Low network latency required to train the rat remotely

We need full understanding and control of the network:
Bandwidth allocation; low latency; application priorities;…

LSC
Laboratório de Sistemas de Computação

Modeling rat responses, Drausio Capobianco, Cesar Teixeira, Maheus Barbosa, Felipes S. Santos, Cássio Prazeres - LSC-UFSCar/COC

Numbers (Jan 2005 – Oct 2007)

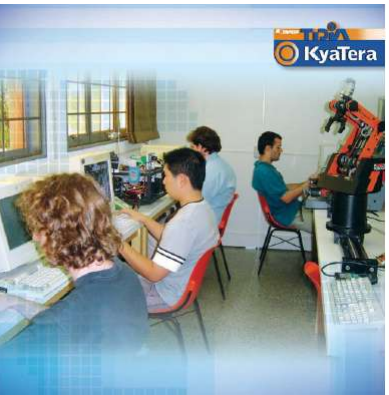
Publications, Theses, and Patents

Type	Number
Journal papers, International	170
Journal papers, National	36
Conference papers, International	220
Conference papers, National	213
Books or Chapters in books	5
Patents, International	1
Patents, National	2
Theses, PhD.	28
Theses, MSc	49

Participants

Research Groups	Number
Principal Laboratories	6
Associate Laboratories	35
FTTLabs	84
WebLabs	29

People	Number
Principal Investigators	21
Faculty Professors	150
PhD or Pos-Docs	24
PhD Students	83
Masters Students	83
Undergraduate Students	80
Technicians/Engineers	13
Fapesp TT fellowships:	11
Support (Nara)	6
Total People	471



Partnerships and collaborations

Industrial Partners

- **Telefonica**, CPFL
- Terremark, Akamai,
- Corning, OFS, Metrocable,
- **Padtec**, **Datacom**
- National Instruments, …

National and International Networks

- ANSP, RNP, GIGA, LILA, WHREN, NLR, i2CAT, …

Time line (pre-history)

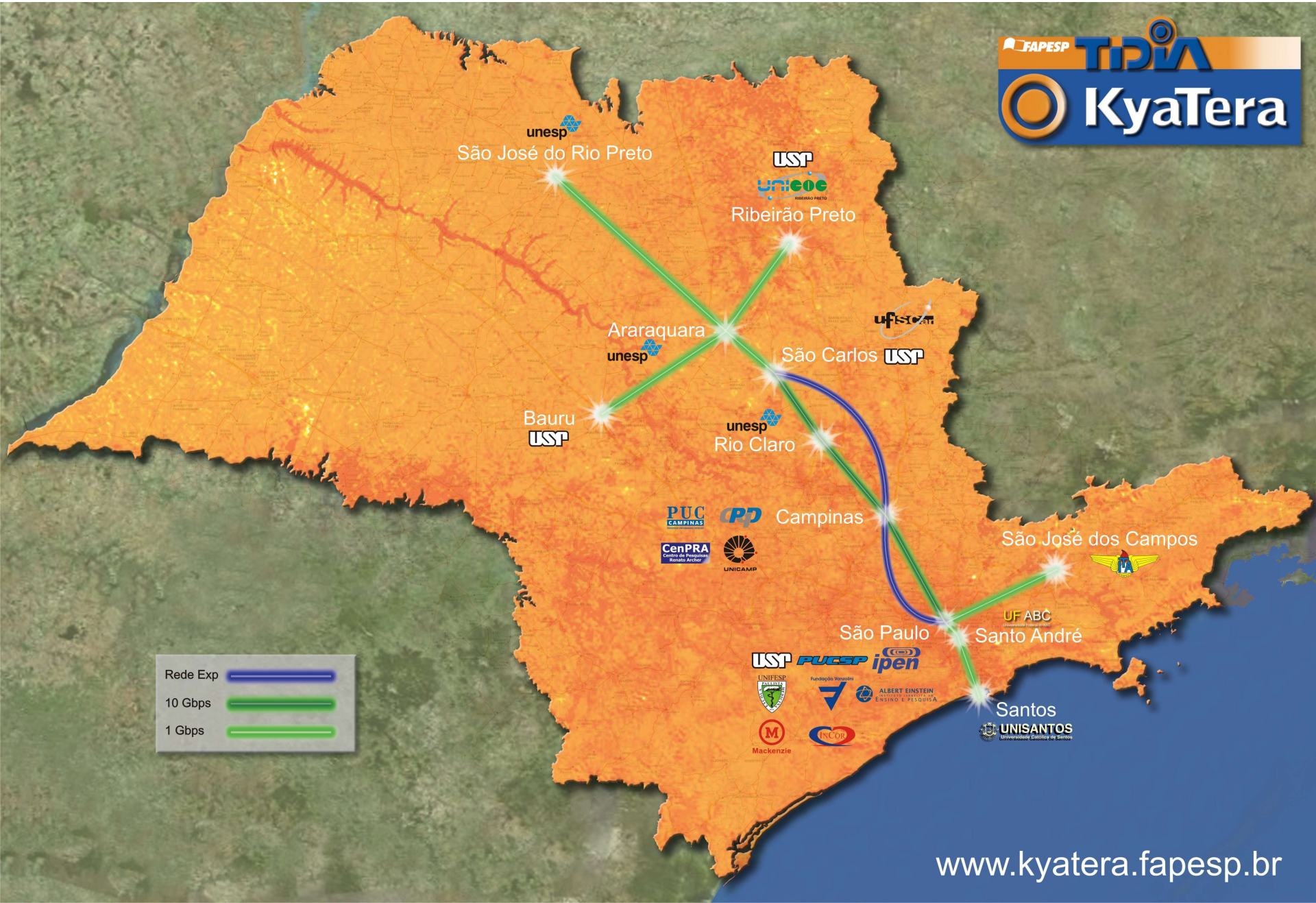
- 2000 – CePOF presents draft proposal for a DWDM testbed to Fapesp
- 2001 – Fapesp calls the scientific community to discuss a new funding program around the testbed
  - Feedback: capillarity and content
- 2001 – Fapeps TIDIA program approved
  - Tecnologia da Informação no Desenvolvimento da Internet Avançada (ICT on the development of advanced Internet)
  - The internet as object of research
  - Collaborative Projects
  - Generate HUMAN RESOURCES in quantity and quality
  - Generate KNOWLEDGE, IDEAS
  - Promote Academy – Industry COLLABORATIONS
- 2004 – Call for proposal to participate in the KyaTera project
  - 27 groups were selected to:
  - Design and partially deploy the optical network
  - Demonstrate in-campus FTTLab connections
  - Demonstrate inter-campi connections
  - Demonstrate intercity connections
  - Develop and demonstrate WebLab technology
- 2005 – KyaTera subprojects signed

FAPESP TIDIA KyaTera

Time line (history)

- **2005: Intra-capus fibers deployed (41 FTTLabs)**
  - First geographically distributed WebLabs demonstrated
- **2006: Dark fibers from Telefonica**
  - 2 fiber pairs Campinas-Sao Paulo (4x130 km)
  - 1 Gb/s
  - HD video over IP and IPTV demonstrated (Sao Paulo and Campinas)
- **2007: Fapesp - Telefonica Agreement**
  - Dark fibers in the State of Sao Paulo + R$ 420,000 for scholarships
  - 3year co-funding projects – R$ 12 million
- **2007: Fapesp-Padtec Agreement**
  - 5 years co-funding projects – R$ 20 Million
- **2007: Dark fibers from Telefonica 3300 km**
  - Fiber measurements (OTDR and PMD)
  - DWDM end 10 Gb/s network equipment fully specified
  - 84 FFTLabs
  - 3 multiple networks demonstrated in Sao Carlos
- **2007: 29 WebLabs demonstrated in many areas of experimental sciences**

Thank you


FAPESP
TIDIA
KyaTera
unesp
São José do Rio Preto
USP
unicoc
Ribeirão Preto
ufscar
Araraquara
unesp
São Carlos
USP
Bauru
USP
unesp
Rio Claro
PUC
CAMPINAS
CPqD
Campinas
CenPRA
Centro de Pesquisas Renato Archer
UNICAMP
São José dos Campos
UF ABC
São Paulo
Santo André
USP
PUCSP
ipen
UNIFESP
Fundação Vanzolini
ALBERT EINSTEIN
Santos
UNISANTOS
Mackenzie
INCOR
Rede Exp
10 Gbps
1 Gbps
www.kyatera.fapesp.br

The Future

(Round Table on Testbeds)

"Prediction is very difficult, especially
if it's about the future."

Niels Bohr
1922 Nobel Prize in Physics

Edwin Smith Papyrus (Imhotep?)

The **Edwin Smith Papyrus** is the world's earliest known medical document, written in hieratic around the 17th century BCE, but thought to be based on material from a thousand years earlier. It is an ancient textbook on trauma surgery, and describes anatomical observations and the examination, diagnosis, treatment, and prognosis of numerous injuries in exquisite detail. The papyrus contains the first descriptions of the cranial sutures, the meninges, the external surface of the brain, the cerebrospinal fluid, and the intracranial pulsations.[1] The surgical procedures in the Egyptian Edwin Smith Papyrus were quite rational given the time period.[2] As well as having magical incantations against pestilence [3] it also contains a prescription for a wrinkle remover using urea, which is still used in face creams today.

http://en.wikipedia.org/wiki/Edwin_Smith_papyrus

Plates vi & vii of the Edwin Smith Papyrus at the Rare Book Room, New York Academy of Medicine

Imhotep (circa 1600 BC)

Statuette of Imhotep in the Louvre

The mummy returns (2001)

The mummy (1999)

Ibn al-Haytham (965-1039)

The prominent Iraqi Arab Muslim scientist Ibn al-Haytham (Alhacen) pioneered the modern experimental scientific method to obtain the results in his *Book of Optics* (1021).[4] In particular, he combined observations, experiments and rational arguments to show that his modern intromission theory of vision, where rays of light are emitted from objects rather than from the eyes, is scientifically correct, and that the ancient emission theory of vision supported by Ptolemy and Euclid (where the eyes emit rays of light), and the ancient intromission theory supported by Aristotle (where objects emit physical particles to the eyes), were both wrong.[5] Ibn al-Haytham's scientific method was similar to the modern scientific method and consisted of the following procedures:[6]

- Explicit statement of a problem, tied to observation and to proof by experiment
- Testing and/or criticism of a hypothesis using experimentation
- Interpretation of data and formulation of a conclusion using mathematics
- The publication of the findings

Internet in the future

- **20 years ago**
  - Telephony network
  - 64 kb/s per voice circuit
  - Passive user

- **Today**
  - Network with variety of uses/services (voice, data, video, radio,…)
  - User generated content (wikis, youtubes, blogs, mushups,…)
  - Mb/s per user
  - > 1 billion internauts

  - But, a jungle of different technologies (with different languages) – Tower of Babel
  - Increasing socioeconomic dependence of the Internet
  - 100 billion spam/day, viruses, insecure, vulnerable, fragile

- **Tomorrow**
  - Infinity of applications and content
  - Super high resolution video
  - 5 billion users – Gb/s per user (and we humans will be minority…)
  - FTTH
  - Secure, robust, inexpensive broadband Internet, convergence of technologies
  - 100 to 1000 increase in capacity

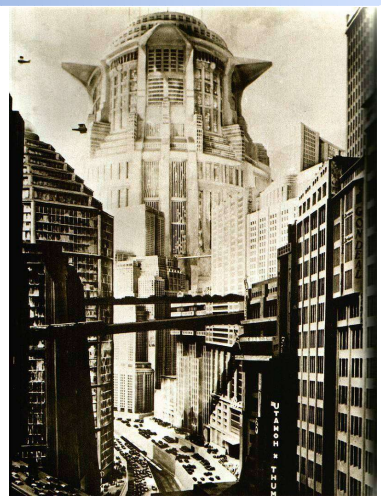
- **Which scientific advances will enable such future?**
  - This is what we try to answer in KyaTera

FAPESP TIPIA KyaTera

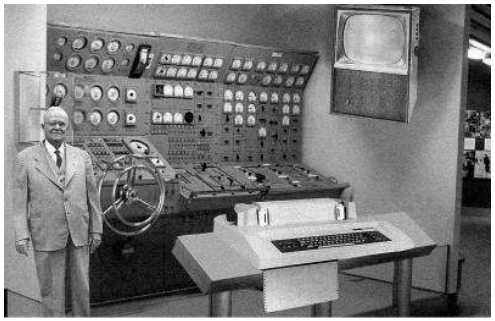
Visions of the Internet

- Secure, trustworthy,
- ubiquitous,
- low-cost,
- open infrastructure suited for sensors and controllers;
- robust against attack, crisis proof;
- 1000-fold reduction in energy/bit;
- reconfigurable;
- qubits compatible
- … in 10 years.

"Making the world [of communications] a different place," D.D. Clark, et. al., End-To-End Research Group, March 24, 2005



Metropolis, Fritz Lang (1927)



Home computer predicted for 2004 (1954)

Challenges for the research community

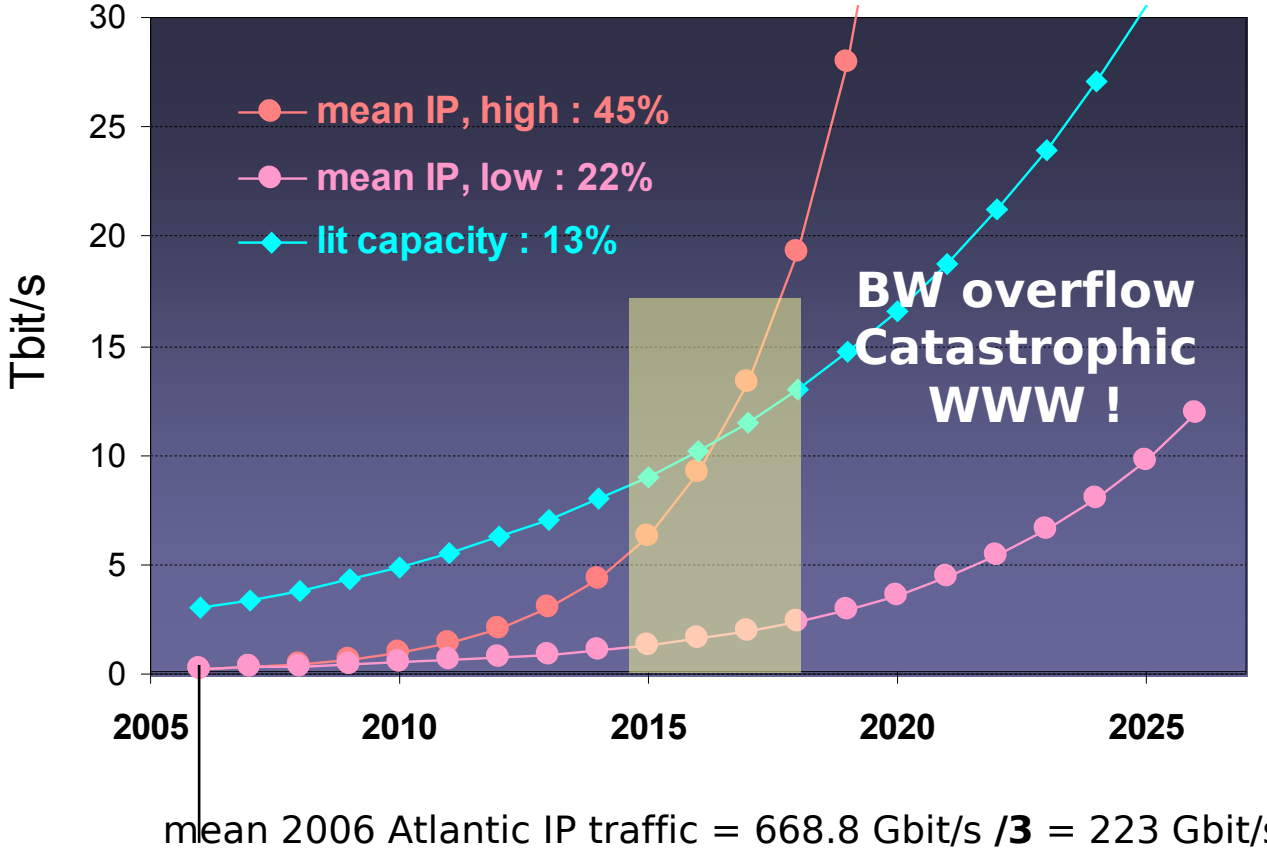
- To validate and demonstrate any of these visions, it will be necessary to build some sort of prototype, testbed, or experimental infrastructure. So part of the challenge in achieving these visions is to agree, as a community, what sort of infrastructure would best serve us in our experiments. Some of the objectives in this list might be met as part of a fundamental redesign of the Internet itself, and this research objective would call for a testbed that can demonstrate a new network architecture.

- …So we offer two challenges to the research community:
  - first, to set itself some *long-range visions* and work to achieve them, and
  - second to agree *as a community* on the test infrastructure necessary to support those visions.

End-To-End Research Group, March, 2005

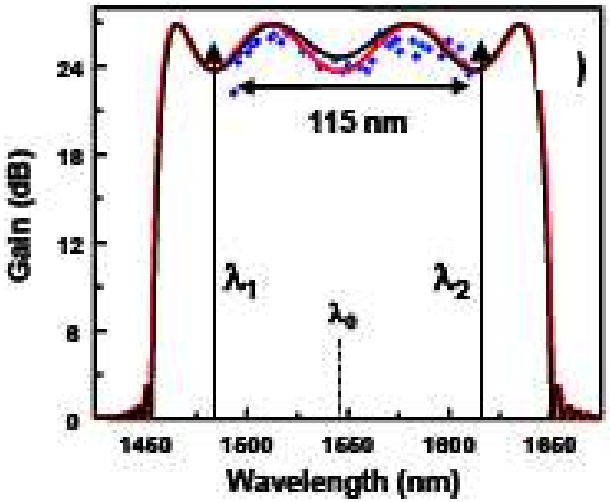
(this originated NSF's GENI project)

Lit capacity growth vs. IP bandwidth growth

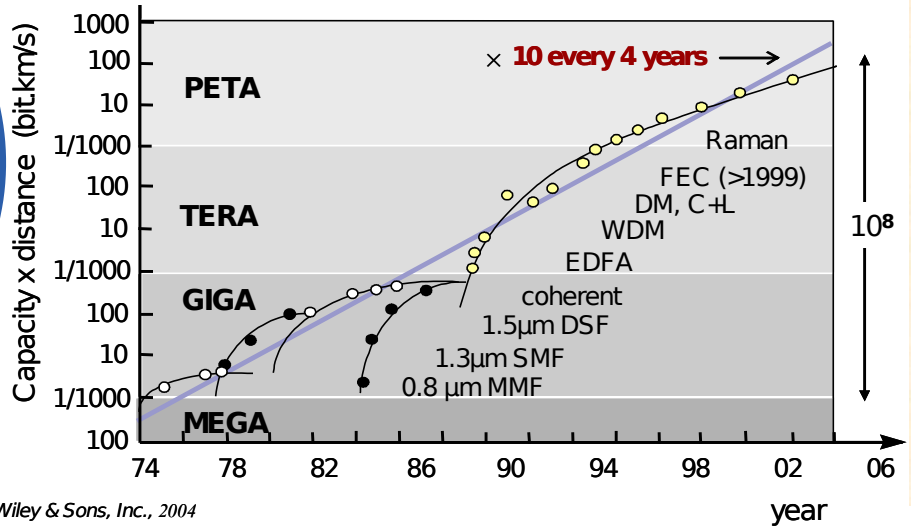


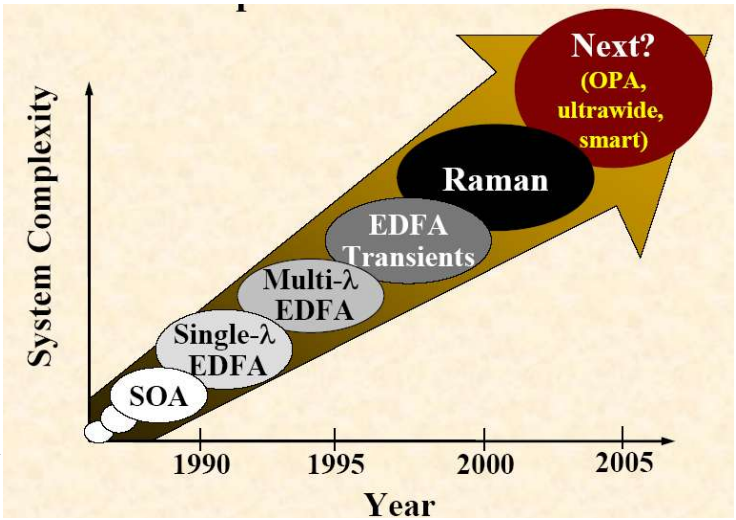
Emmanuel Desurvire, *Capacity Demand and Technology Challenges for Lightwave Systems in the Next Two Decades*, JLT, 4697-4710, Dec. 2006

Technology Roadmap



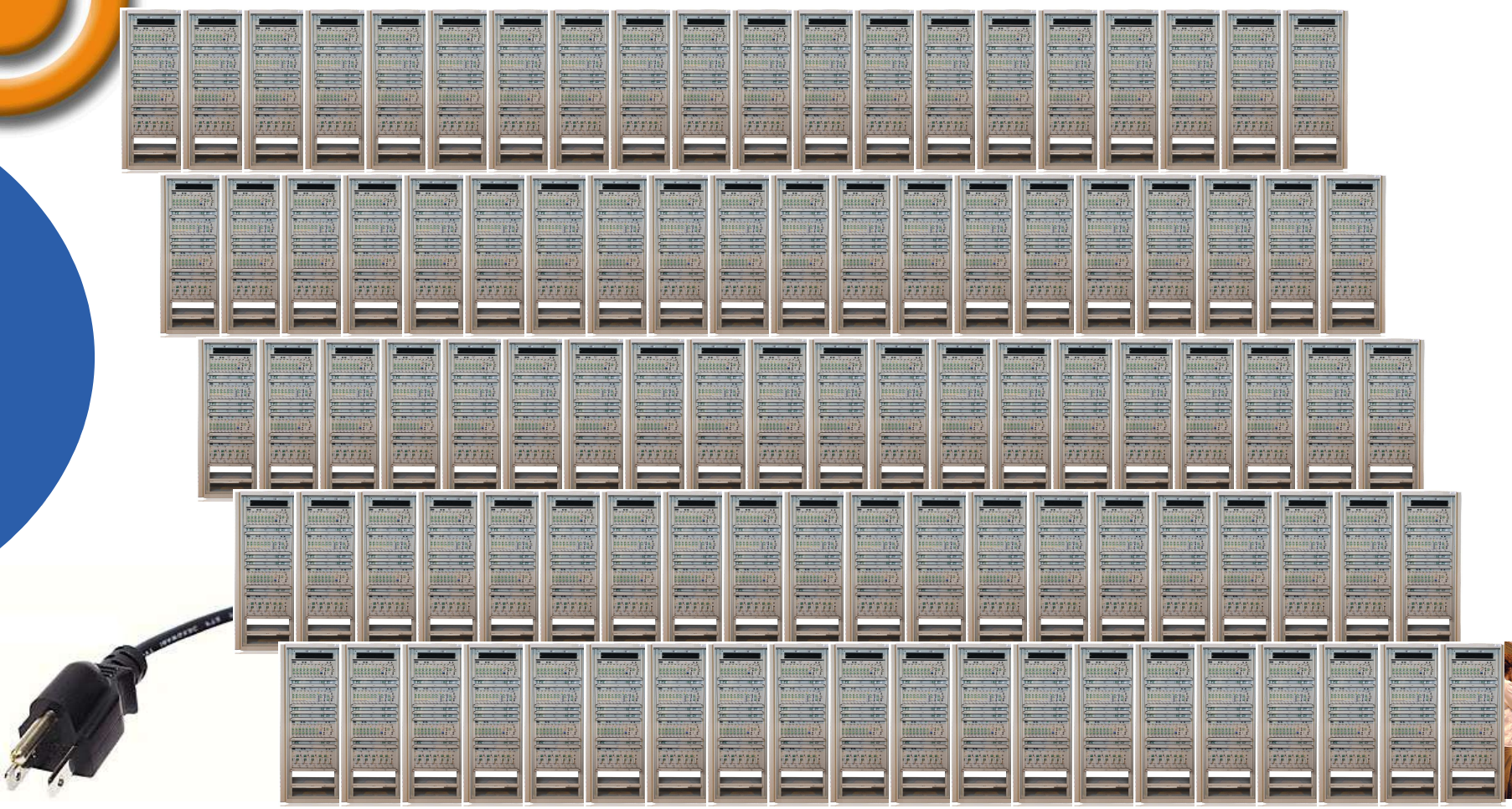
Fiber Optic Parametric Amplifiers





Evolução da capacidade dos sistemas de comunicação óptica (cortesia: Dr. Emmanuel Desurvire, 2006) e da tecnologia de amplificadores ópticos (Prof. Alan Willner, 2006).

X 100 ?

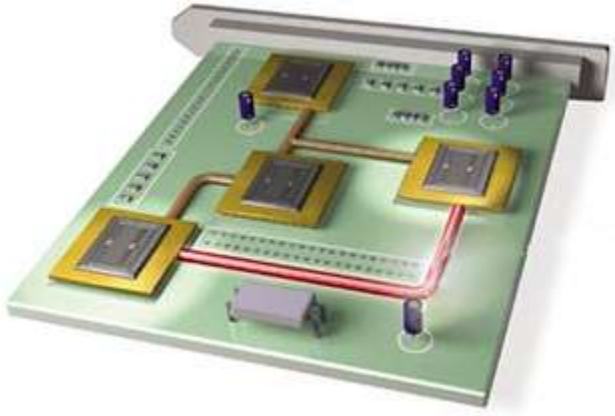


50 kW
400 A

100 m² footprint

100 to 1000 times the present capacity?

- DWDM today 40 channels – does it scale to 4000 channels?
  - Today's amplifier technology does not scale
  - Electronic routing technology does not scale
- Real state problem
- Energy consumption problem
- Costs big problem



- Great Challenges
  - Optical amplifiers for the whole high-transparency window of silica
  - Integrated optical circuits (hundred lasers in a chip)
  - All optical networking
  - High performance software
  - Convergence optical-microwaves (IMOC)

- IMOC: International Microwaves and Optoelectronics Conference
- IMOC: Internet Microwaves and Optoelectronics Convergence

FAPESP TIDIA KyaTera

Expectations

- **Consolidating research**
  - Dissemination to attract vocations for ICT
  - Develop project management skills and tools for large, cooperative research projects
  - Spin-off sub-projects (WebLabs, Thematic Networks)
  - Spin-off small businesses
- **New research subjects**
  - New technologies and new advanced Internet applications
- **Advancements in all sciences**
  - Advanced Internet networks will allow researchers in Brazil to collaborate easily and efficiently with researchers abroad.
  - Present challenges in science need be tackled by several groups scattered around the world, sharing their competences (and lab resources) through the web.
- **A new Internet (?)**
  - Is the Internet broken?
  - How it would be The new Internet?
  - What kind of Tesbed do we need to test it?

Outside Plant Status – November 2005

Coordinated by CePOF

KyaTera Proprietary Optical Fiber Plant Deployment

City MAN	Campus LAN	Labs in campus	Cable (m)	Fiber (m)	Fusion splices	PC / APC connectors	Splicing boxes
São Paulo							
	USP-SP	19	11,586	282,2136	694	502 / 192	2+4
São Carlos							
	USP Scar	9	2,769	42,992	168	144 / 0	1
	UFSCar	4	763	5,724	42	42 / 0	0
	USP-UF Link		6,110	14,664	72	24 / 24	1
Campinas							
	Unicamp	16	7,211	169,418	592	424 / 144	2+2
	PUC-Camp	1	4,502	108,048	48	24 / 24	0
	CPqD	1	5,203	124,872	96	24 / 24	3
	TOTALS	54	38,144	747,854	1,712	1184 / 408	15

Eng. Marco Aurélio Fortes 26-Oct-05

+ 30 Labs (other Fapesp projects)
+ 450 researchers