



Lima & fast 2D Detector DAQ

NOBUGS 2024



Software Group @ ISDD

Vicente Rey-Bakaikoa

BACK IN 1998

NEWS STORIES

- President Bill Clinton denies he had "sexual relations" with former White House intern Monica Lewinsky, but later admits it
- The Search Engine Google is founded
- Europeans agree on a single currency the Euro
- Apple Computer unveils the iMac
- The FDA approves Viagra for use as a treatment for male impotence
- The concert by the Three Tenors for the opening of the World Cup In France is seen by 100,000 live and 3 billion around the world

 **THE PRESID**
Bill Clin

 **WORLD POPULA**
5.984 BILLION

AVERAGE INCOME PER YEAR
\$37,005

Mou
ARMAGE
SAVING PRIV
GODZI
THERE'S SOMETHIN
A BUG'S

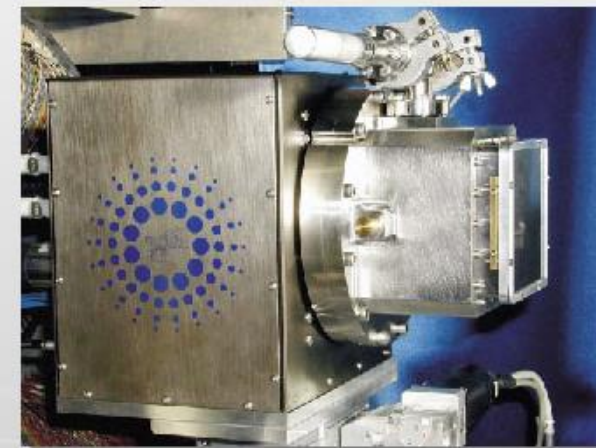
FReLoN – Fast Readout & Low Noise

FReLoN 1000 (1996):

- 1024 x 1024 - 14 bit
- 4 parallel readout channels
- Readout time: 100 ms

FReLoN 2000 (1998):

- 2048 x 2048 - 14 bit
- Readout time: 220 ms



Next - "Too Close"

Brandy and Monica - "The Boy Is Mine"

Aerosmith - "I Don't Want to Miss a Thing"

Céline Dion - "My Heart Will Go On"

All Saints

Marilyn Manson

Green Day

Spice Girls

WHAT ARE YOU *Wearing?*
Men **Women**

Loose-fitting jeans
Shirts untucked
Blazers
Frosted tips
Colorful sunglasses

Tube tops
Capi pants
Slip dresses
Plastic chokers
Hoop earrings

Slang!

bangin' - awesome or cool
word - an expression of affirmation

dude - a man, a woman, a person, an animal, or an expression of excitement, happiness or condemnation

★ ★ ★ ★ ★
Born this year

Xxxtentacion
Khalid
Peyton List
Tana Mongeau
Jaden Smith
Shawn Mendes

★ ★ ★ ★ ★

SI

DENVE



NEW YC

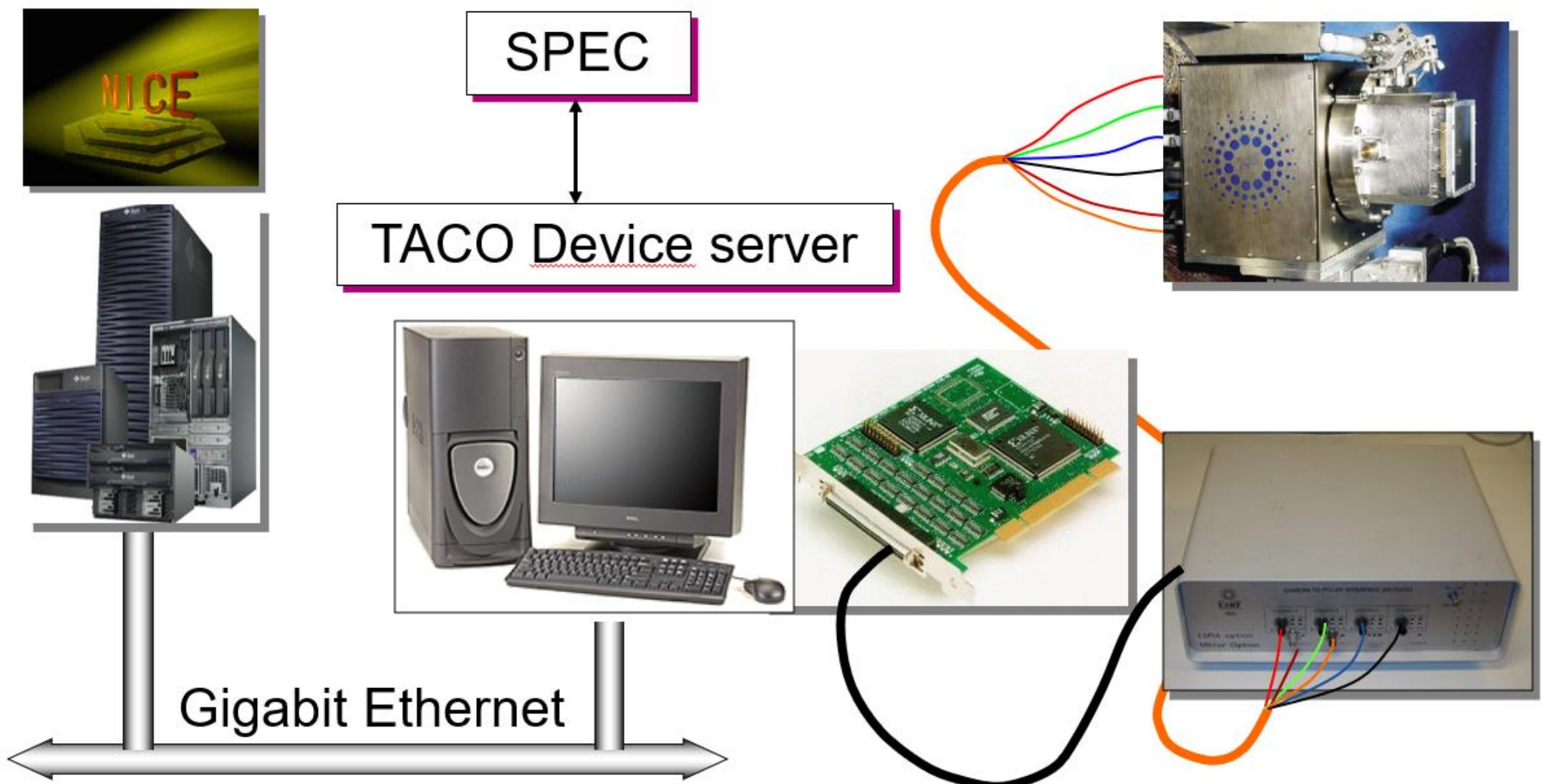


NBA FINALS

CHICAGO BULLS - UTAH JAZZ
(4-2)

STANLEY CUP

DETROIT RED WINGS - WASHINGTON
CAPITALS (4-0)



BACK IN 2008

USA population: 304.1 million President: George W. Bush

BORN in 2008

Coco Quinn
Lilliana Ketchman
Emily Dobson
Mia Talerico
Sky Brown

Inventions

Large Hadron Collider
Orbital Internet
Blockchain
Thin-Film Solar Panels
Camera for the Blind

Top Baby NAMES

Jacob Emma
Michael Isabella
Ethan Emily
Joshua Olivia
Daniel Ava

NEWS STORIES

- Barack Obama is elected U.S. president
- The 2008 NHL All-Star Game occurs in Atlanta
- California becomes the second state after Massachusetts in 2004 to legalize same-sex marriage
- NASA's Phoenix spacecraft becomes the first to land on the northern polar region of Mars
- The 60th Primetime Emmy Awards are presented

MUSIC

Low - Flo Rida featuring T-Pain
Bleeding Love - Leona Lewis
No One - Alicia Keys
Lollipop - Lil Wayne
Apologize - Timbaland

SPORTS

- World Series Champion Philadelphia Phillies
- NBA Champions Boston Celtics
- Super Bowl Champion New York Giants
- Stanley Cup Champion Detroit Red Wings

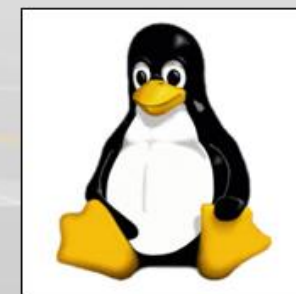


BLISS

European Synchrotron Radiation Facility

Other CCD-like devices supported

- ✓ Princeton
- ✓ Sencam, PCO
- ✓ Photometrics
- ✓ Matrox Meteor II [H. Witsch, J. Meyer]
- ✓ Trixell Pixium [L. Claustre]
- ✓ Andor
- ✓ ImagePro [A. Gotz]
- ✓ Direct-Show
- ✓ Mar CCD [L. Claustre]
- ✓ IDS Falcon [D. Miraut, J. Meyer]
- ✓ Firewire (IEEE 1394) [A. Gotz]
- ✓ Dalsa Dalstar



The European Light Source

A. Homs-Puron, NOBUGS 2008, Sydney, 3-5 Nov 2008

Common CCD acq. Library

- ✓ Reuse of common code ⇒ generic procedures + interfaces
- ✓ Software “features” fallback if hardware has limited capabilities
- ✓ High level Python implementation
- ✓ Common TACO CCD interface
- ✗ Interfaces: implicit ⇒ explicit
- ✗ Image processing and data reduction as plugins (C++)
- ✗ Extensible interface through user-defined “features” (Maxipix)
- ✗ Generic TANGO interface
- ✗ Collaboration framework (ALBA)

BACK IN 2012

USA population: 313.9 million

President: Barack Obama

Average income



European Synchrotron Radiation Facility

BORN in 2012

- Everleigh Soutas
- Blue Ivy Carter
- Ava Foley
- Penelope Disick
- Riley Curry

NEWS STORIES

- The first licenses for autonomous cars in the U.S. are granted in Nevada to Google
- MIT researchers Ramesh Raskar and Andreas Velten demonstrate an augmented reality apparatus
- The U.S. compete at the Summer Olympics in London, England and win 46 gold, 29 silver, and 29 bronze medals
- Neil Armstrong, an American astronaut and the first person to walk upon the Moon, dies at age 82
- Washington becomes the first state to legalize marijuana

What's Hot

- Gasolin
- Kia Sportage \$23,445
- Jeans, L
- Banana
- House (bedroom)



Inventions

- Self-inflating Tires
- Tesla Model S
- Inkling Pen
- Google Project Glass
- Selfie Stick

MUSIC

- Somebody That I Used to Know - Gotye
- Call Me Maybe - Carly Rae Jepsen
- We Are Young - Fun
- Payphone - Maroon 5
- Lights - Ellie Goulding



- The S
- The Dark
- Ice Age: C
- The I
- Unexpe



Top Baby NAMES

- | | |
|---------|----------|
| Jacob | Sophia |
| Mason | Emma |
| Ethan | Isabella |
| Noah | Olivia |
| William | Ava |

SPORTS

- World Series Champions San Francisco Giants
- NBA Champions Miami Heat
- Super Bowl Champions New York Giants
- Stanley Cup Champions Los Angeles Kings

Toys

- LEGO Friends
- Monster High

The European Light Source

LIMA: A Generic Framework for 2D Detector Data Acquisition

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Beamline Control Unit – Software Group
ISDD – ESRF

A. Homs-Puron, SRI-2012 X-Rays Detectors Workshop, Zurich, 4-7 Jul 2012

LIMA first deployment in 2010

By 2012:

A dozen of detectors had been integrated

International collaboration spontaneously created (7 institutes and industrial suppliers)

Context

- Multiple detectors \Rightarrow different TACO servers
- Different hardware capabilities \Rightarrow specific APIs
- Very basic Online Data Analysis (ODA) performed by SPEC & server
- Performance degraded when reading files offline

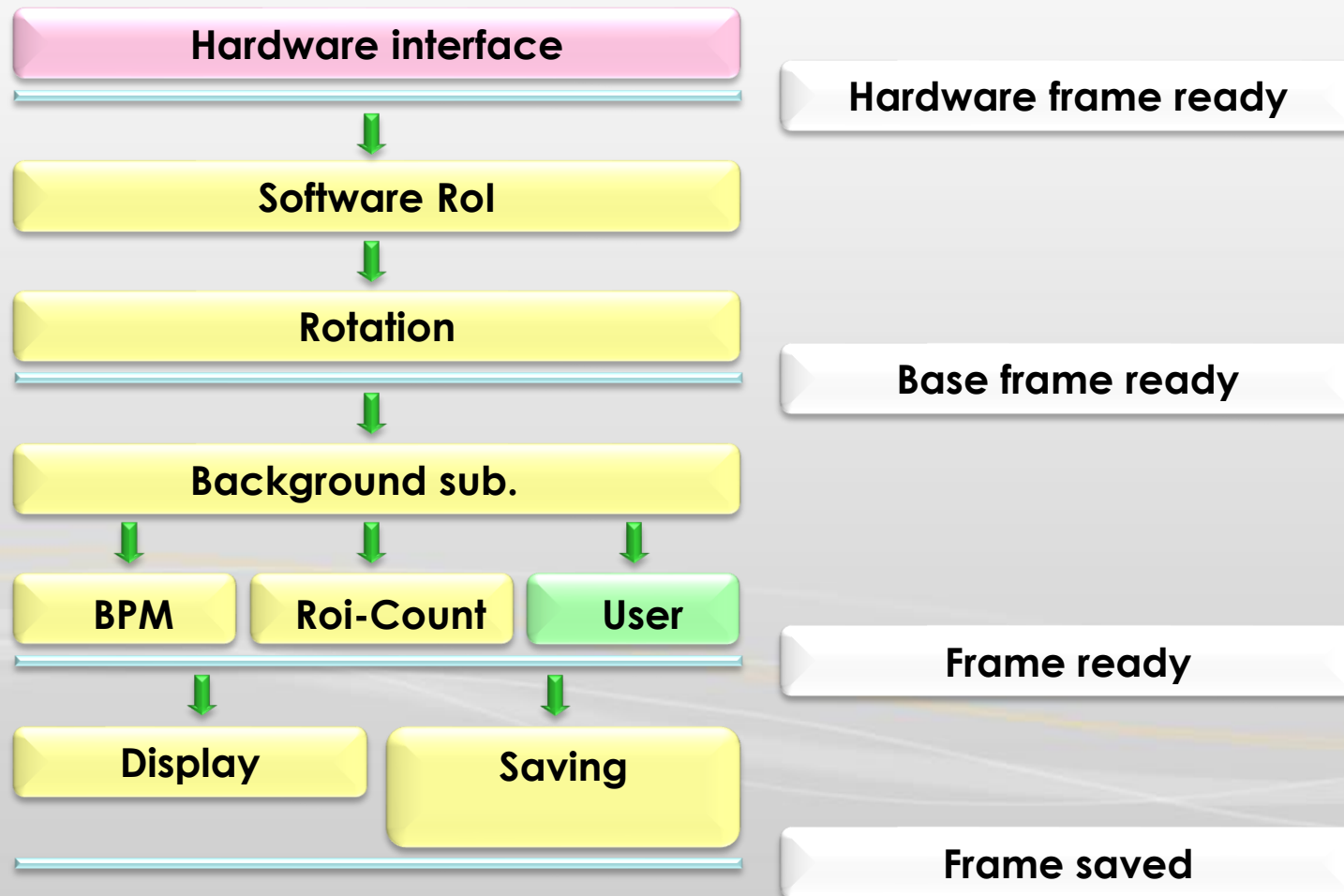
Goals

- Identify common processing for high-performance 2D DAQ
- Exploit the hardware resources:
 - Detector: pixel binning, region-of-interest (ROI), image flip
 - Computer: memory, CPUs/cores/threads
- Optimisation:
 - Prepare in advance time-consuming operations, like buffer allocation
 - Minimize memory copies
- Provide software alternatives to “missing” hardware capabilities
- Early ODA

LIMA features – Image control

- **Geometric image transformations**
 - **Reconstruction of discontinuous readout**
 - **Bin, Rol, Flip & Rotation**
 - **Stripe concatenation**
- **Basic image processing**
 - **Multi-Rol Statistics**
 - **Centroid (Beam Position Monitoring)**
 - **Rol \Rightarrow Spectrum**
 - **Background subtraction, Flat-field normalisation**
 - **Spatial distortion correction**
 - **Frame accumulation**
 - **Image Mask**

Internals – Process lib



Common interface for 2D image acquisition

- Starting, stopping, triggering, reading, saving

Common interface for 2D image manipulation

- Binning, flipping, ROIs, ROI collections, dark and flat subtraction, etc

160 detectors running with LIMA at the ESRF

- 14 Frelon
- 17 Maxipix (Single chip, 2x2, 5x1, Meta 2x (3x1))
- 15 Dectris Eiger2
- 10 Dectris Pilatus3
- 70 GigaE video camera: Basler, Prosilica, PointGrey, uEye
- 4 Andor I-Kon ccd, Zyla, Neo, Marana cmos
- 4 imXPAD
- 10 PCO Dimax & Edge, Edge HS, 2K, Camlink and USB
- 3 Perkin Elmer flat panel
- 2 Dexela flat panel
- 2 RoperScientific (aka Princeton)
- 3 Rayonix HS ccd
- 2 PSI Eiger 2M and 500K, 2 JungFrau 4M
- 1 FLI ccd
- 2 Advacam Minipix
- 2 Tucsen Dhyana cmos



2D Detector Data Deluge

Detector data throughput has been multiplied by more nearly 200 in 25 years, exceeding today 10GB/s
Today Lima foundation goals are still valid but the project has reached its limits.

For users to be able to use / analyze all these data:

- Absolute need for data reduction, [online|automatic] processing
- Need to parallelize handling and processing
- Scalability
- Detectors central to current data strategy

How Lima2 may address all these questions?

2024: 2D DETECTOR DEPLOYMENT PLAN

	2024 Q3	2024 Q4	2025 Q1	2025 Q2	2025 Q3	2025 Q4
PILATUS4 - lima2:						
ID15A – Pilatus4 XE 4M CdTe – October 2024	█					
ID31 – Pilatus XE 4M CdTe – Sept/2025					█	
ID30A – Pilatus4 X 4M Si – April/2025				█		
ID30B – Pilatus4 XE 4M CdTe – Sept/2025					█	
EIGER2 lima1/lima2:						
BM02 – Eiger2 X 4M CdTe – September 2024	█					
BM02 – Eiger2 X 4M Si – Q4 2025			█			
BM02 – Eiger2 X 1M-Wide Si – Q4 2025			█			
All BL - On-demand upgrade to lima2	█					
Others:						
BM18 - Fraunhofer – date ?? - lima2		█				
ID16A - Andor Balor 16.7M – NOW !! - lima1	█					
ID01 - XIMEA 37.7M – Q1/2025 - lima1			█			
ID27 - Advacam Widepix – September 2024		█				
ID10 - Rigaku – on-going – lima2			█			
ID24 - Pilatus3 100K – December 2024		█				
ID01 - Citius		█				
SMARTPIX – lima2:						
ID31 - Smartpix 1M CdTe or CZT - Q1/2025			█			
ID10 - Smartpix 1M CdTe or CZT – Q2/2025				█		
ID06 - Smartpix 1M CdTe or CZT - Q2/2025				█		
ID01 - Smartpix 1M Si - Q3/2025					█	
ID02 - Smartpix 1M Si - Q3/2025					█	
ID20 - Smartpix Octopix 6 x 65k pixels Si - Q3/2025					█	



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Welcome