

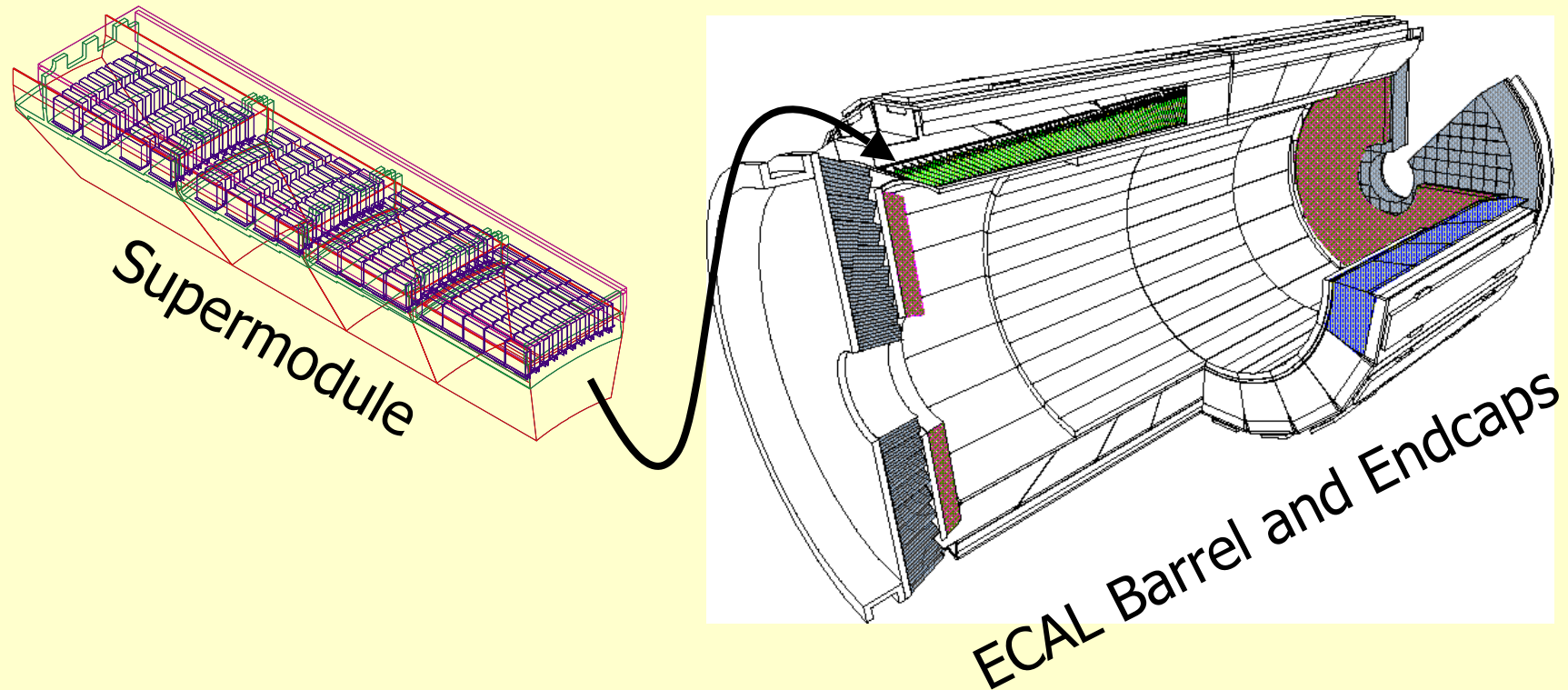
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# *PWO Crystal ECAL*

**Ren-yuan Zhu**  
**California Institute of Technology**  
**May 19<sup>th</sup> 2001**

# *The Calorimeter*

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**36 supermodules in barrel, 4 Dees in endcaps.**

**1700 crystals/supermodule, 4000 crystals/Dee**

**2 APD's/crystal in barrel, 1 VPT/crystal in endcaps**

**High resolution electronics, light to light readout.**

**1 monitoring fiber/crystal for in situ intercalibration.**

# V31 Schedule

VEILLET Lucien / EP

General planning V31(in work)

**Install EB+  
Jul-Dec, 2004**

5/8/01

ID	Task Name	2004														
		N	J	M	M	J	S	N	J	M	M	J	S	N	J	M
207	Close of Vacuum Tank by weld, Inst. transfer lines (SX5 PHASE 26)	3														
211	Vacuum tests of Vacuum Tank and lines and testing of control elements (SX5 PHASE 27)		2/4/04													
212	Trial inst. of HCAL Barrels HB+1,HB-1 Inside Vacuum Tank (SX5 PHASE 27)			2/9/04												
215	Test Assembly of ECAL Super Module EB on HB inside Vacuum Tank (SX5 PHASE 28)				2/23/04											
216	Start Cool-down of Coil (SX5 PHASE 28)		4/04													
217	Close Yoke, test magnet & commissioning (SX5 PHASE 29)					3/17/04										
218	INSTALL SUPER MODULE ECAL EB+															
219	ASSEMBLE FORWARD CALORIMETERS HF+1 IN SX5 (SX5 PHASE 29)															
220	ASSEMBLE FORWARD CALORIMETERS HF-1 IN SX5 (SX5 PHASE 29)															
221	Dismantle 80 tons crane & install in SDX5 (PHASE 33)															
238	<b>OCCUPANCY PX56 and UXC55 01/04/2004</b>															
287	CONNECT AND TEST HCAL HB-1 (UXC55 PHASE 19)															
288	CONNECT AND TEST HCAL HB-1 (UXC55 PHASE 23)															
289	CONNECTING, TESTING AND DEBUGGING OF ECAL EB+ (UXC55 PHASE 23)															
290	LOWER CRADLE HB-1 FOR ECAL SUPER MODULE															
291	INSTALL SUPER MODULES ECAL EB- (UXC55 PHASE 23)															
292	CONNECTING, TESTING AND DEBUGGING OF ECAL EB-															

**Install EB-  
Jan-Jun, 2005**

# **Critical Schedule Driver: Calibration**

**7 month run in 2006 at low luminosity.  
Goal: probe the Higgs to 2 photons.**

- **At low luminosity physics for calibration is limited by rates.**
- **Plan to start with crystals calibrated to 1%.**
- **Calibrate every crystal in beam thus is mandatory before installation.**

# *Test Beam Calibration Schedule*

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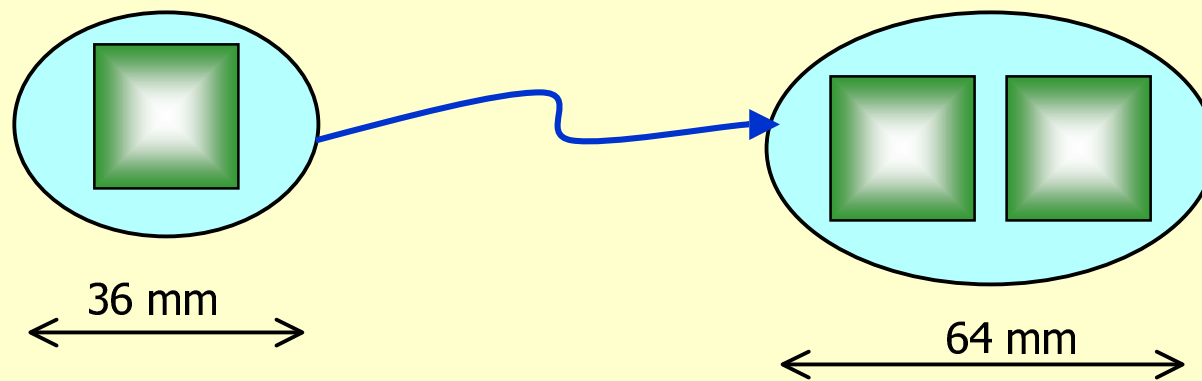
- **Test module 0 in Oct – Nov, 2001, to debug whole calibration process.**
- **Supermodule calibrations:**
  - SM1 3.5 months in 2002.
  - SM2 to SM11 2002.
  - SM12 to SM24 and DEE1 2003
  - SM25 to SM36 and DEE2 2004
- **Sufficient to remeasure ~10 SM's.**
- **Fits V31 plan:**
  - EB+ (SM1 – SM18) in SX5, Jul - Dec, 2004.
  - EB- (SM19 – SM36) in UX5, Jan – Jun, 2005.
  - EE+ (Dee1 – Dee2) in SX5, Jul – Nov, 2005.
  - EE- (Dee3 – Dee4) in UX5, Dec – Apr, 2006.

# *PWO Crystals*

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**Improvements to the crystal growth increased rate of production.**

- **New method: 2-crystals per boule.**

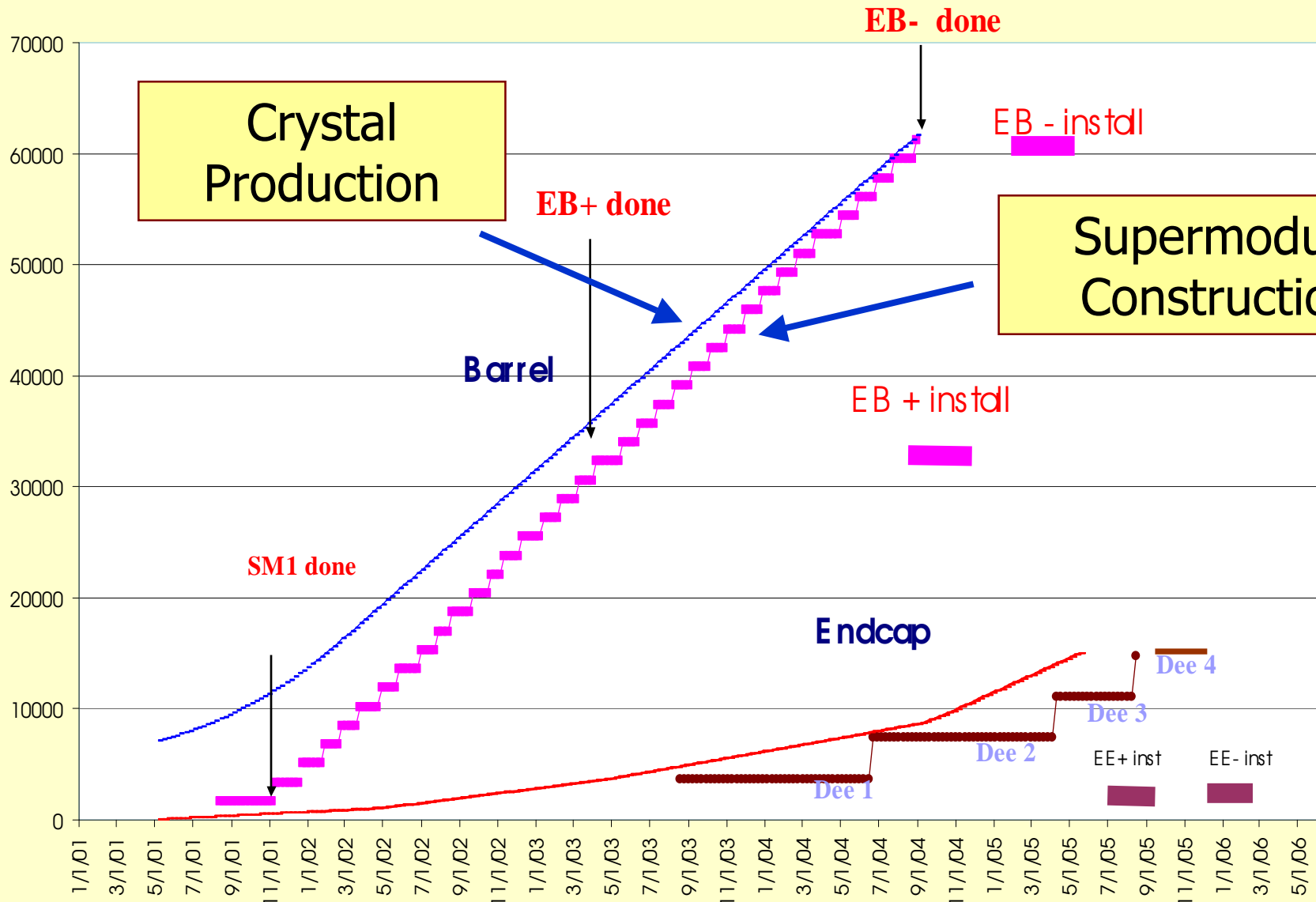


- **All Russian crystals to be grown this way.**





# Crystal Production

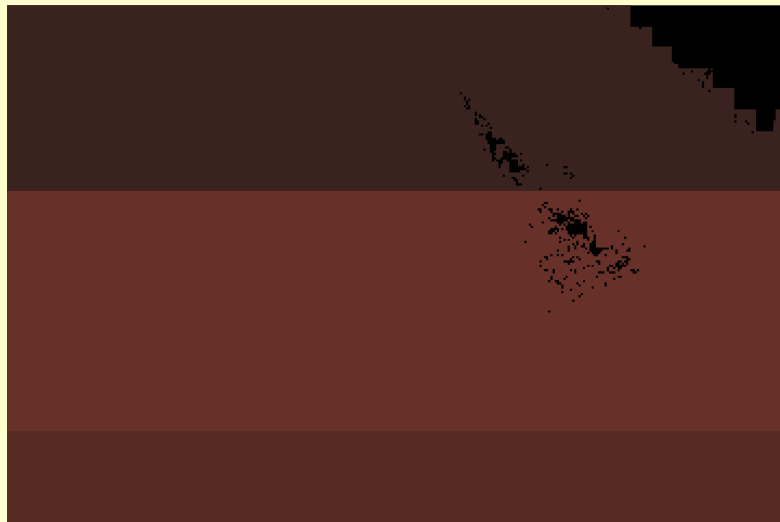




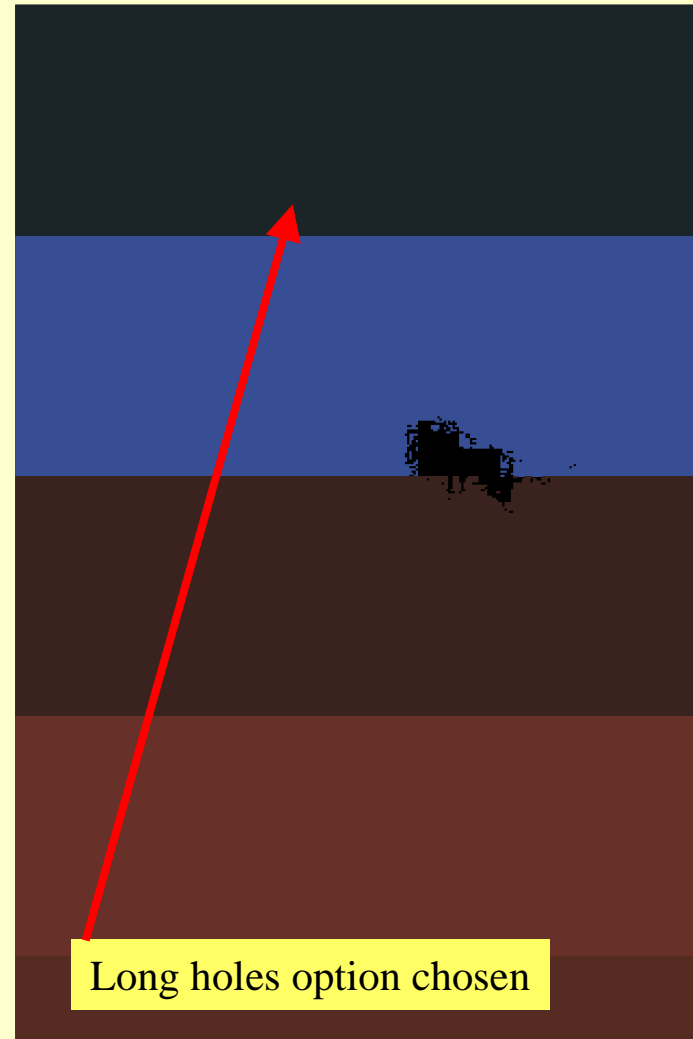
# *Barrel Mechanics*

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## **GRID TYPE-2 Machining in CECOM Jan-2001**



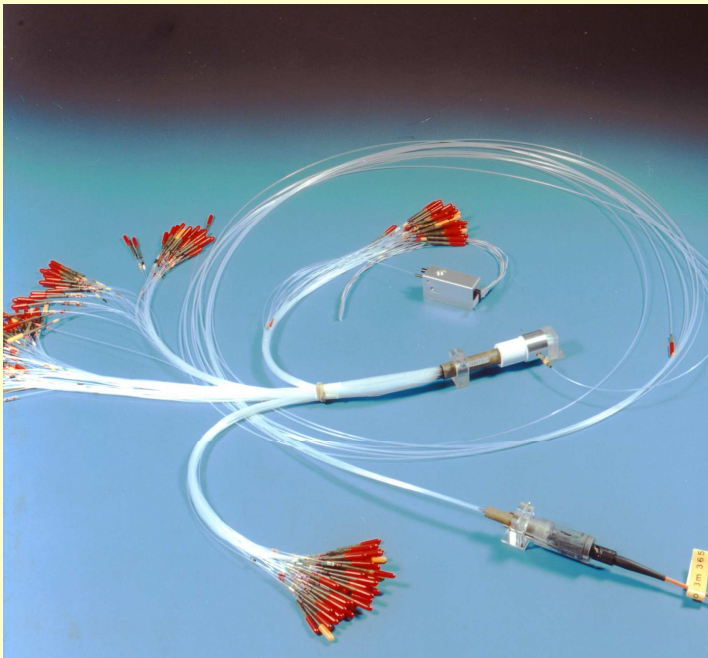
From INFN-ROME



Long holes option chosen

# *Monitor Low Level distribution*

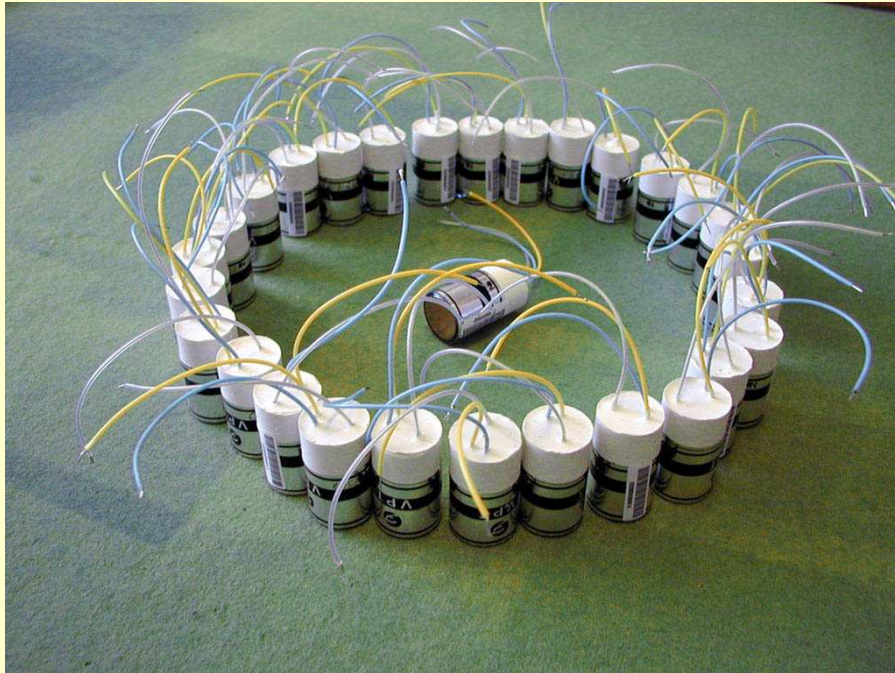
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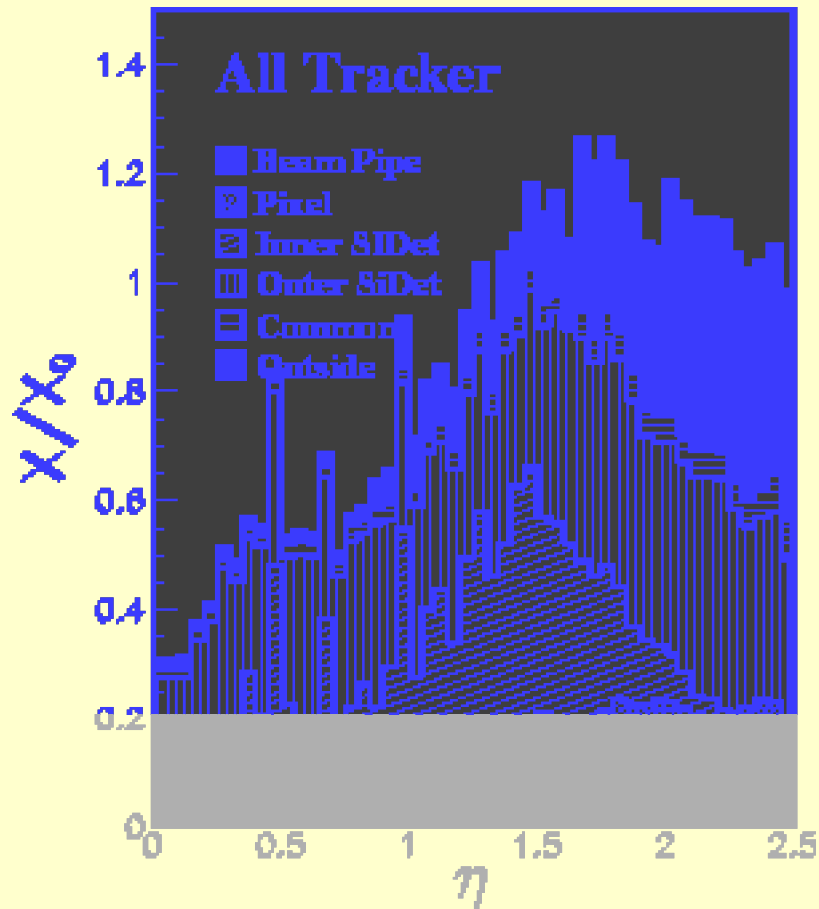
# ***VPT for Endcaps Readout***

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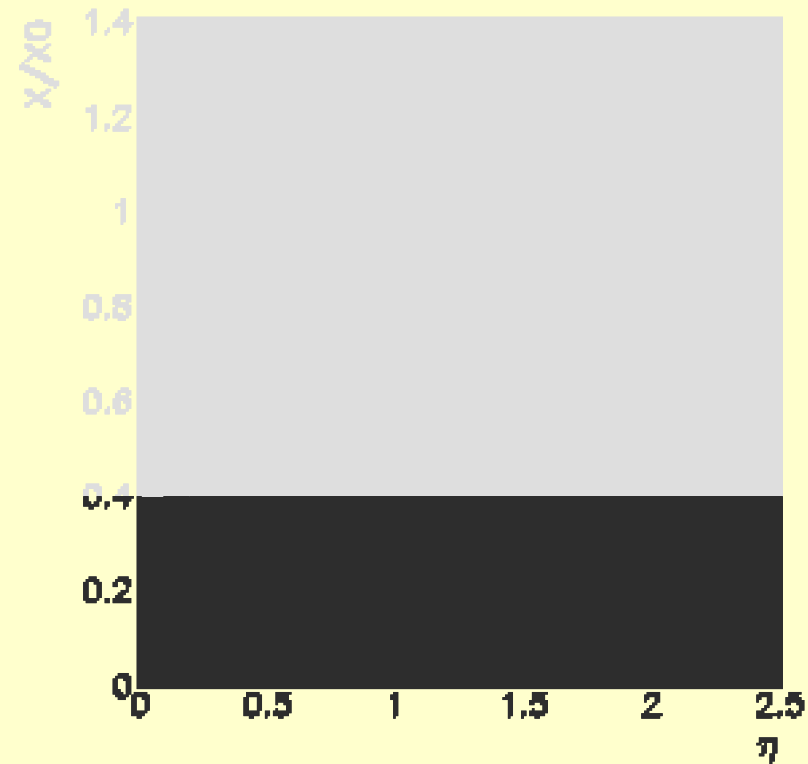
VPTs 500 preproduction delivery



# Issue of Concern: Tracker Material



Tracker Fractional Radiation Length



From A.Caner

Tracker material budget is large with 85% in services

# ***US Construction Responsibilities***

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## **APD: Northeastern and Minnesota**

- **30% procurement & 50% calibration**

## **Barrel Electronics: LBL (Princeton)**

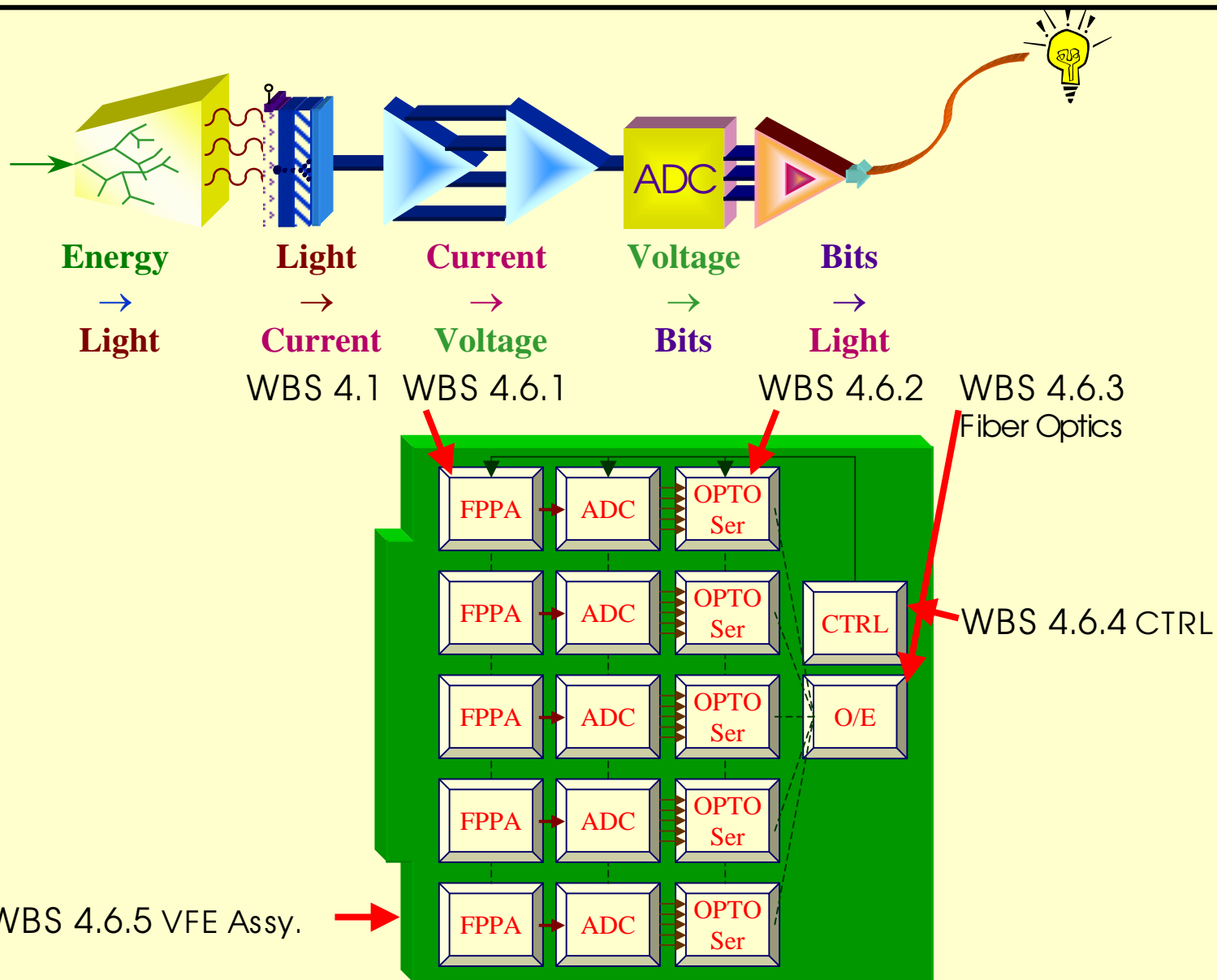
- **FPPA, Bit-Serializer, Optical interconnect, Control chip.**

## **Monitor Light Source: Caltech**

- **Laser light source and high level distribution for the monitoring and calibration of the calorimeter.**



# Light to Light Readout Electronics





# *Status of Front End Electronics*

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## **Bit-Serializer:**

- Drop Honeywell after 3 strikes.
- Switch to CERN solution deep sub micron technology.

## **Optical Components:**

- Use both Methode and Spinner.

## **FPPA:**

- Preamplifier noise too high.
- All other function OK.

## **ADC:**

- Ready for final mass production.

# Bit-Serializer

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Last year two failed runs at Honeywell and then 3" 'safe' mode run failed.

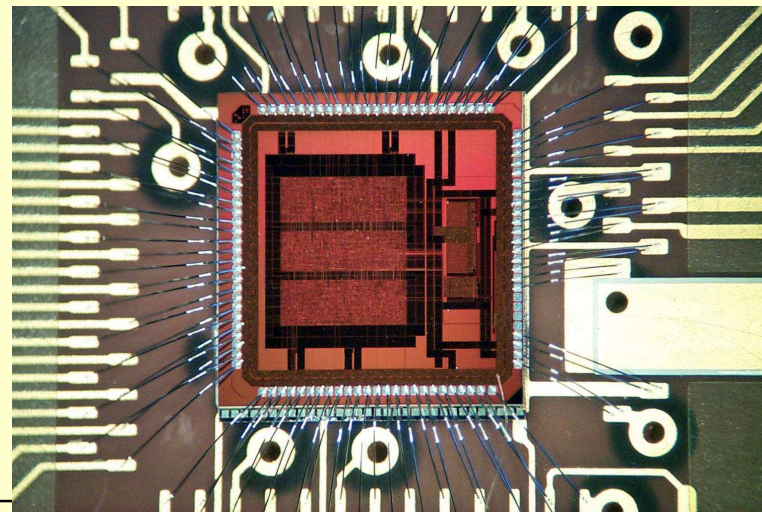
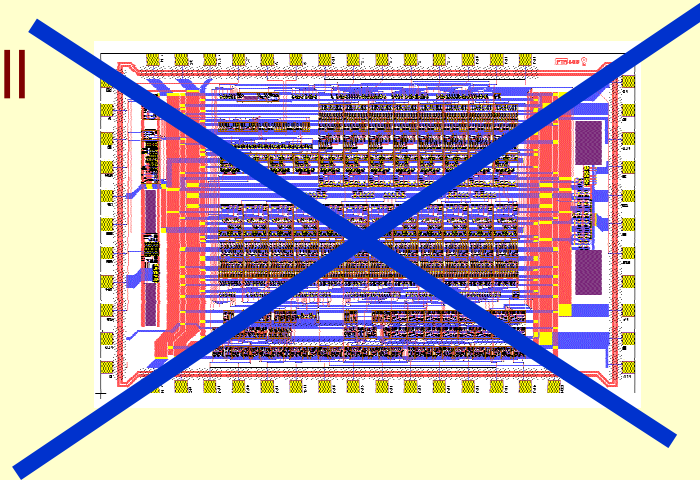
Three strikes and...

Switched to CERN solution:  
Giga-optical link. Made in  $0.25\ \mu$  process.

*Cheaper...*

Bit error rate test in the 800Mbit/s G-Link mode: 20 hours error free transmission

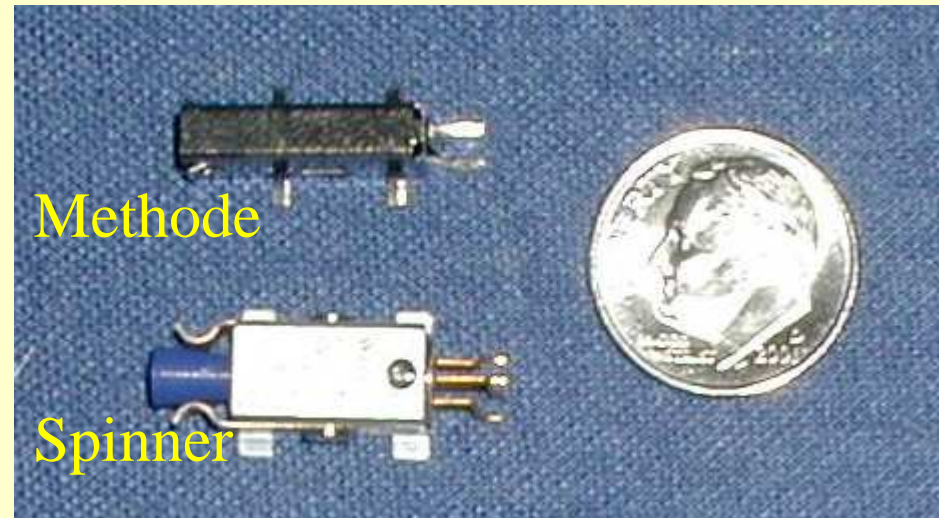
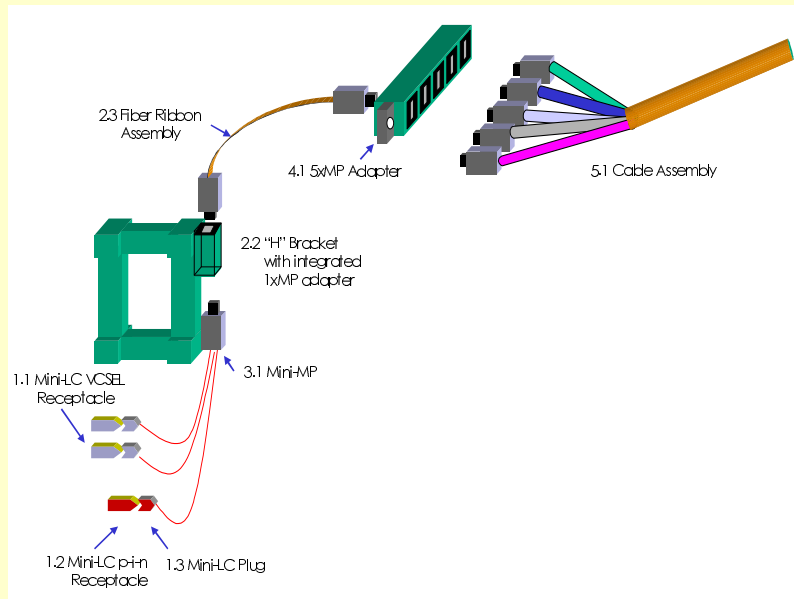
Problems with VCSEL driver  
Mods for ECAL. Submission May 2001  
Will not be ready for Module 0'



# *Electro-Optics*

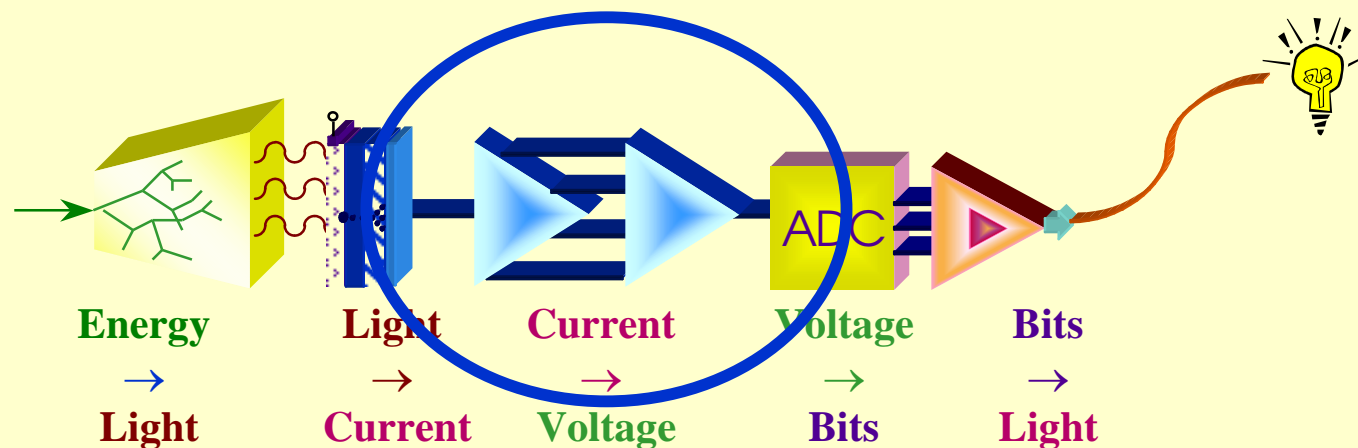
**These components are needed in the final form for the 2001 calibration test.**

- **Send output of serializer to upper level readout.**
- **Delivery from Methode is slow.**
- **Second vendor Spinner is identified.**



# *Intersil FPPA (UHF1x)*

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40 MHz Multi-ranging sample-and-hold  
Intersil UHF-1X process  
Joint Lyon-Princeton (LBL) design

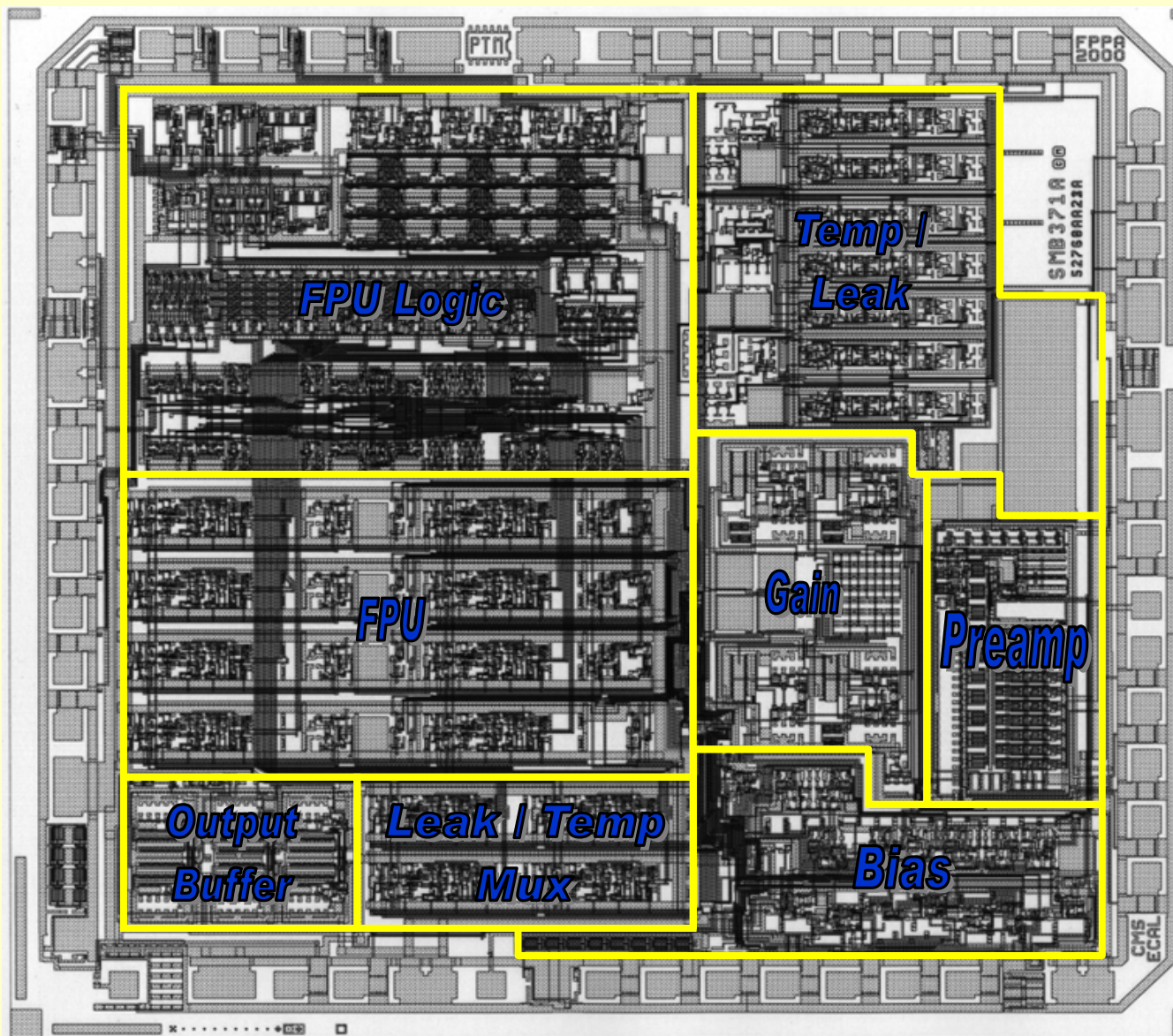
1000 parts made. Circuit functions as designed.

**Noise is 4 times higher than designed.**

Need 2<sup>nd</sup> engineering run, add few months to SM1.



# *Intersil FPPA Layout*



# *Status of Avalanche Photodiode*

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Procurement held after receiving 6,000 APD because of radiation damage problem.

- Failure goal 0.1%, 5% observed in PSI proton beam.
- $2 \times 10^{13}$  n/cm<sup>2</sup> and 1 Mrad expected over 10 years.
- PSI proton beam delivers full dose in 2 hours.

## Corrections

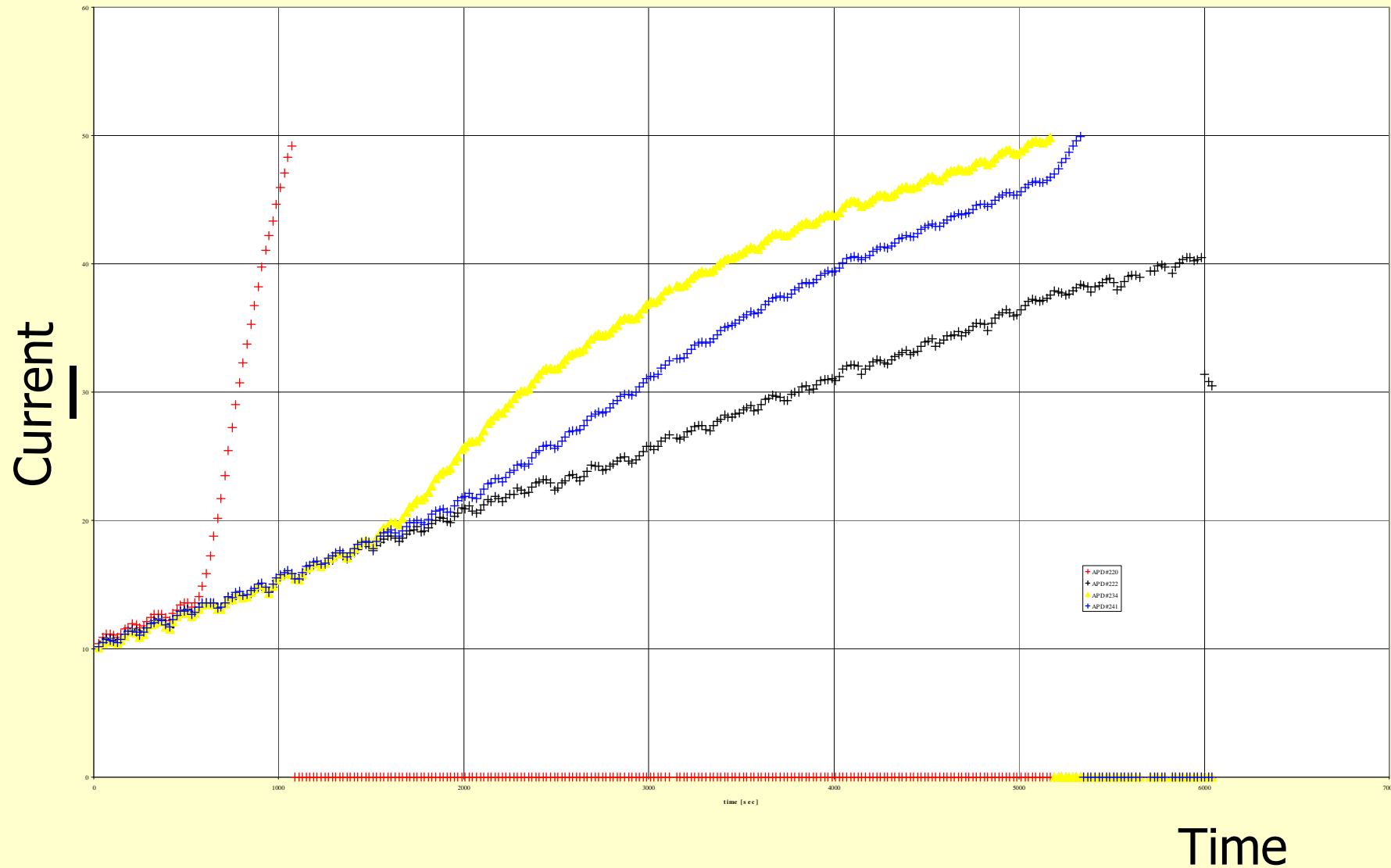
- Irradiate 250+135 APD with neutrons: 100% survival.
- Irradiate 1648 APD with Co-60: 32 (<2%) changes (dVb>10V).
- Irradiate 156 APD with 70 MeV protons: 2 died in surface.
- Improve APD design in collaboration with Hamamatsu.

## Current Status

- Define APD screening with Co-60. All 62 survive 1 Mrad.
- Delivery starts 4/15/01 at 1000/ 2 weeks and 7/1 at 1000/week.
- APD produced before lot 28 will be replaced by Hamamatsu.

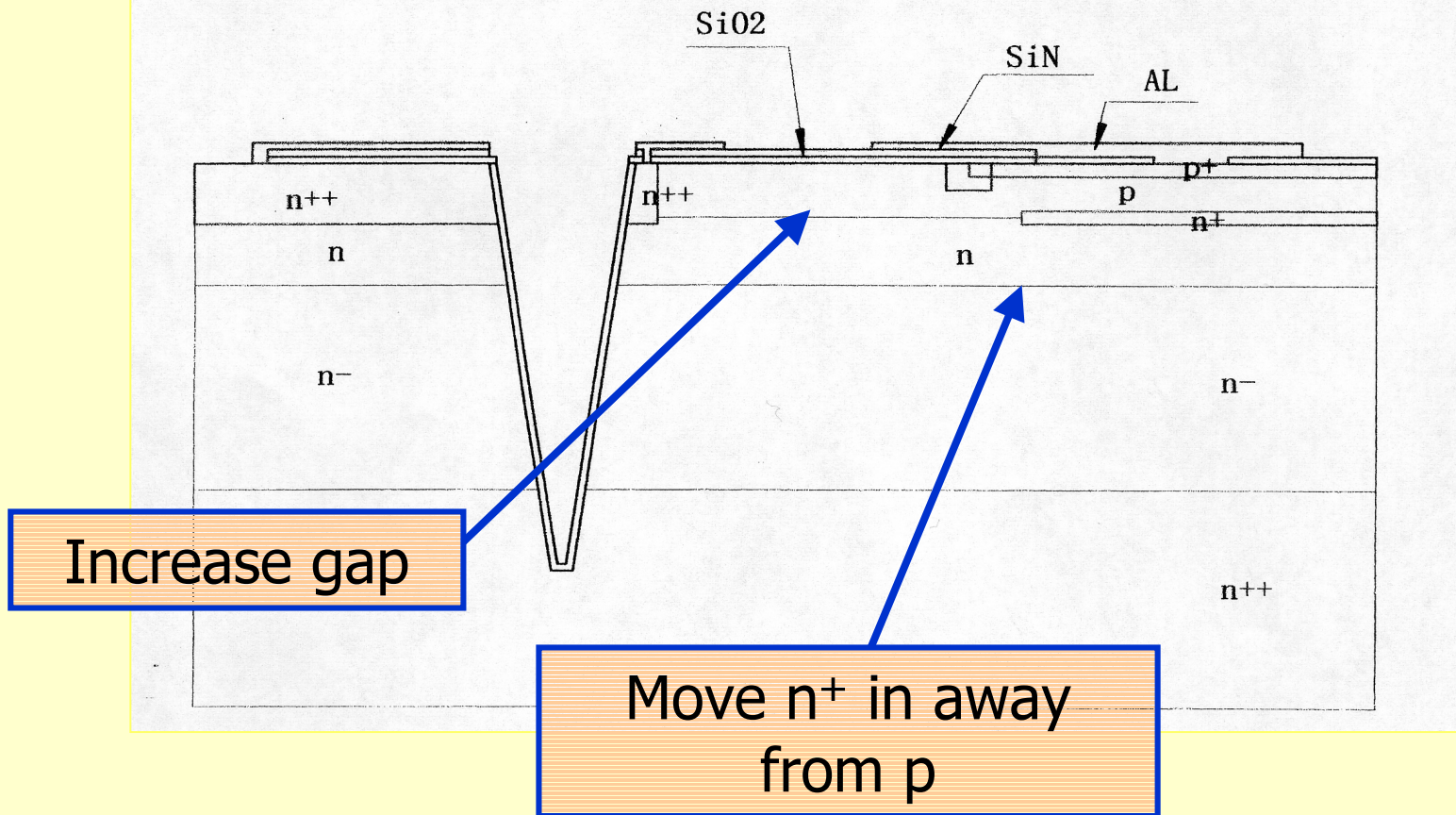


# Radiation Damage to APD's



# Modifications in APD Design

NV-ND-1: Revised corner, Guard ring







# ***Status of Monitoring Light Source***

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**Completed monitoring test bench,  
determined monitoring wavelength  
at 440 nm.**

**Laser light source construction is on  
schedule and cost.**

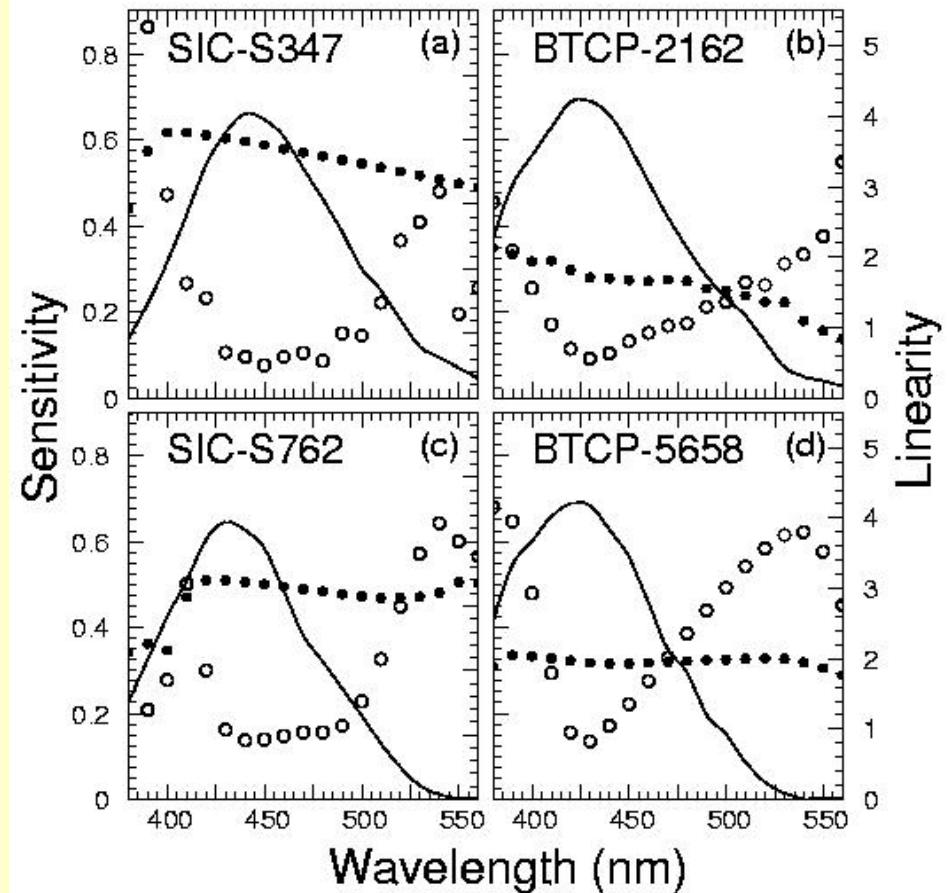
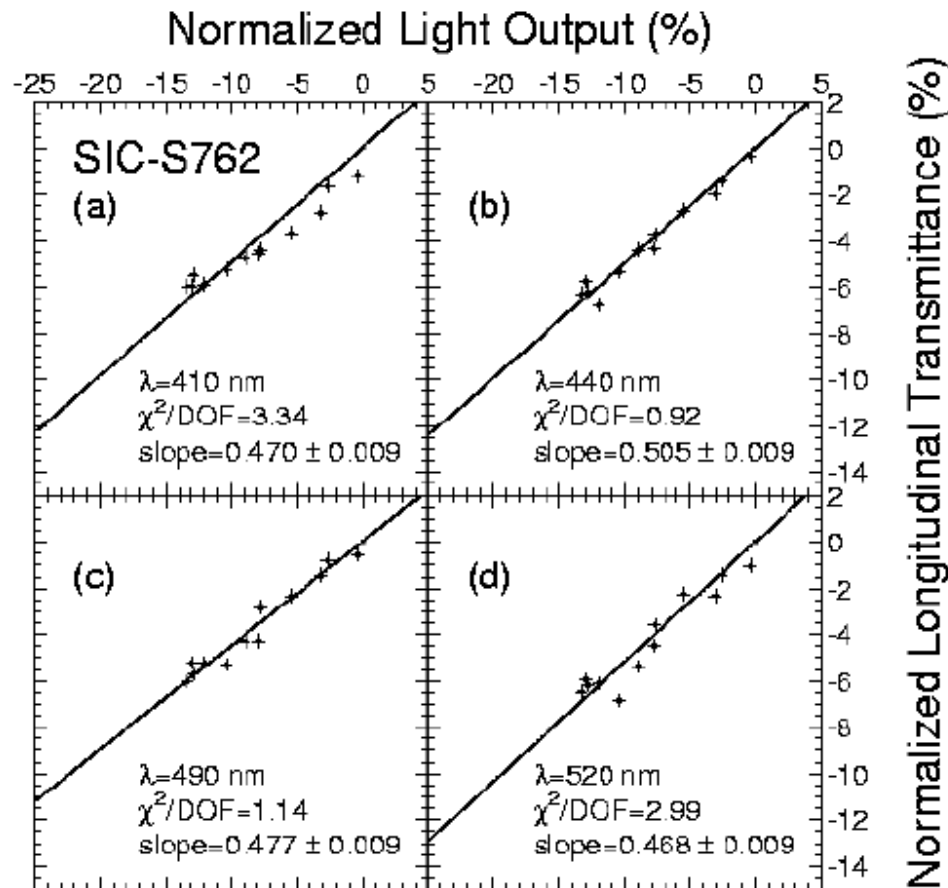
- **Quantronix corrected design errors.**
- **1<sup>st</sup> laser characterized in 240 h stability test.**
- **Control software is under development.**
- **1<sup>st</sup> laser will be installed at CERN in August.**

**A laser at long wavelength (red) is  
under consideration to be added to  
the system.**

# Monitoring Wavelength Determination

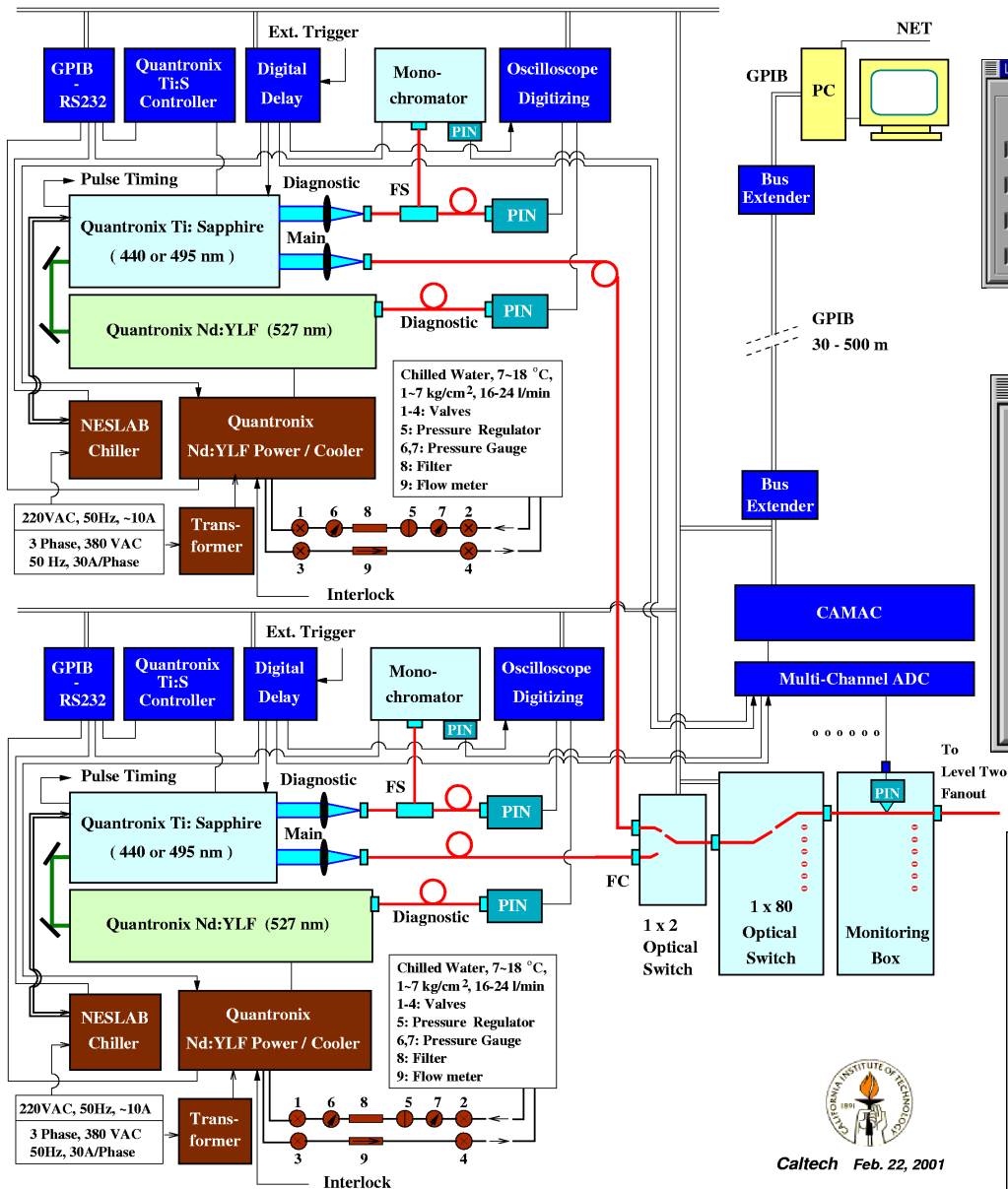
d(T) versus d(LY)

Sensitivity & Linearity

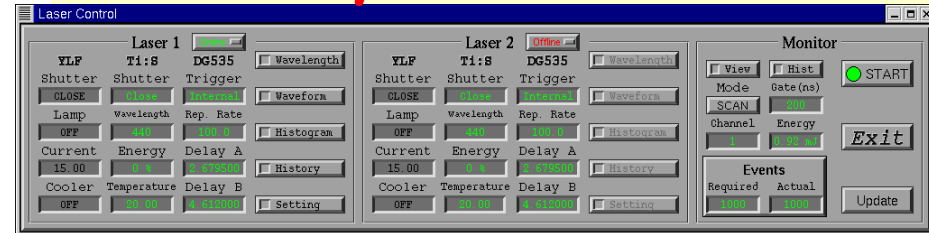




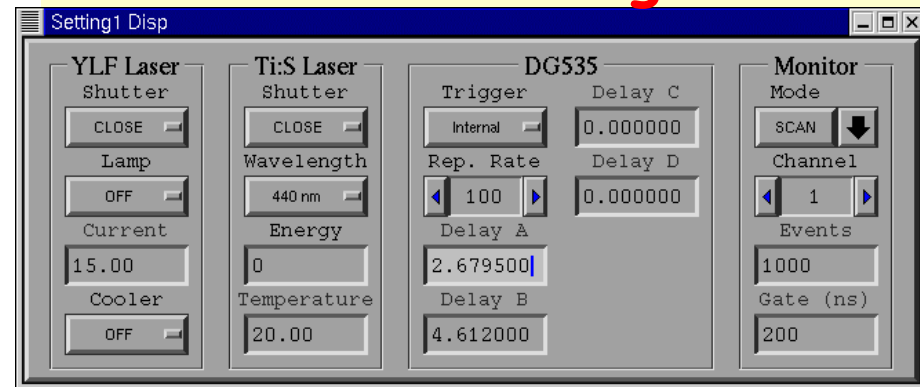
# Design of Monitoring Light Source



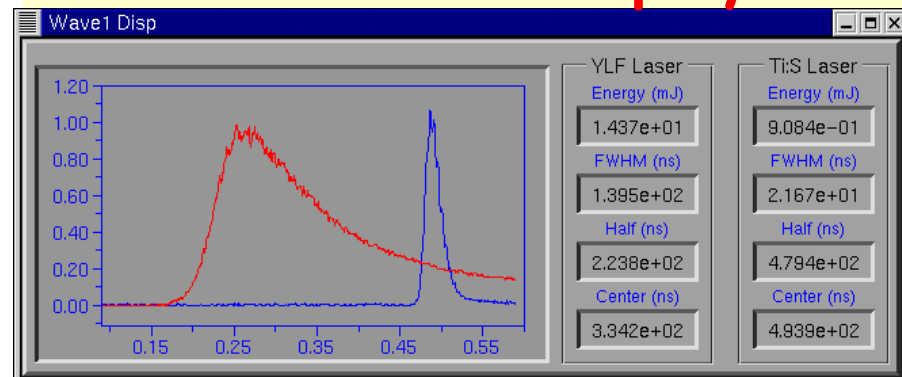
## Laser System Control



## Laser Settings



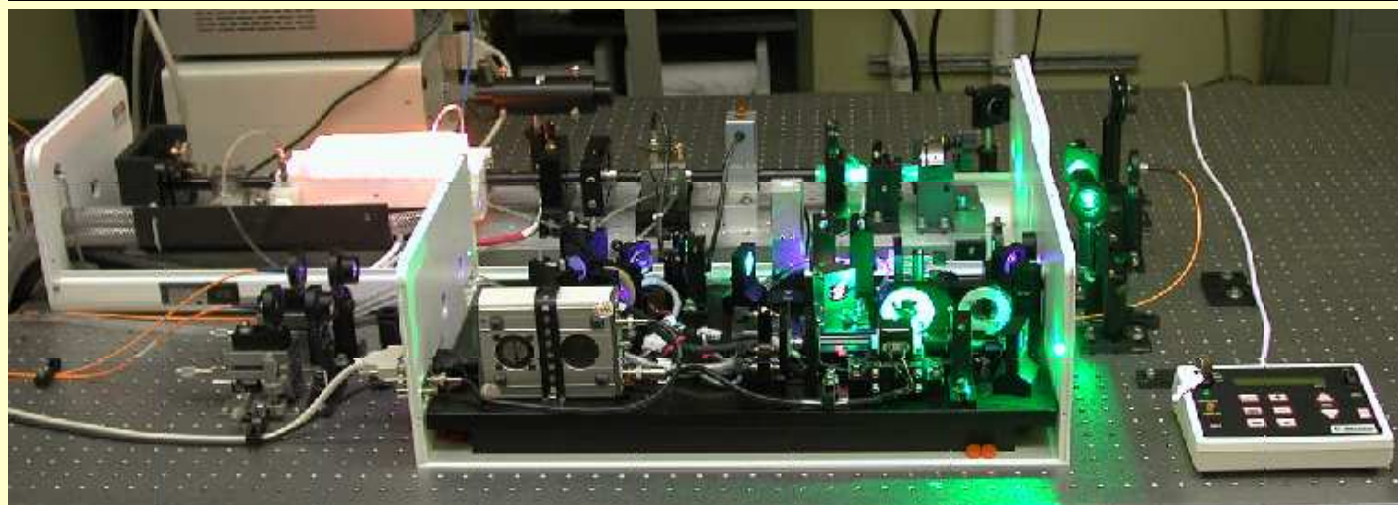
## Waveform Display



Caltech Feb. 22, 2001



# Monitoring Lasers



**System Ready to ship to CERN**

# ***ECAL Construction Schedule***

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## **Three major phases:**

- **First supermodule: late 2001.**
  - Needs electronics and APD for 1700 crystals.
- **Supermodule Production: 2002 to 2003**
  - Production quantities of electronics
- **Last supermodules and Dees: 2004 to 2005**
  - Limited by crystal production rate.

**The pace of the first two phases is set by electronics production.**

# ***US Deliverables for 1st Supermodule***

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## **The US groups need to deliver:**

- **2000 Serializers, in collaboration with CERN.**
- **2000 FPPA chips, in collaboration with Lyon.**
- **Optical Interconnect, in collaboration with ETH.**
- **200 Control Chips, in collaboration with ETH.**
- **4000 APD's, in collaboration with PSI.**
- **Monitor System, in collaboration with Saclay.**

**All are production items**

**Supermodule 1 will go into the detector.**

# ***Schedule of the 1<sup>st</sup> Supermodule***

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- 1. All crystals are in hand now.**
- 2. APD's are being delivered.**
- 3. Assemble modules is progressing.**
- 4. Assemble into supermodules.**
- 5. Install electronics in December, 2001.**
- 6. Lab test will follow.**
- 7. Calibrate all crystals on test beam.**

**All parts of VFE card are required for (5).**

# *Summary*

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**PWO crystal ECAL promises precision photon and electron physics at LHC.**

**The overall ECAL V31 schedule is tight but allows calibration of all crystals before installation.**

**US takes significant responsibility in ECAL construction. Monitoring and APD are on schedule.**

**Electronics is in critical path. Any delay will hurt the possibility of calibrating all crystals before installation.**

**In long term crystal production will be in critical path.**

**Urgent issue: resolve FPPA noise problem.**