BCAL R&D

George Lolos, Zisis Papandreou

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Work Report...

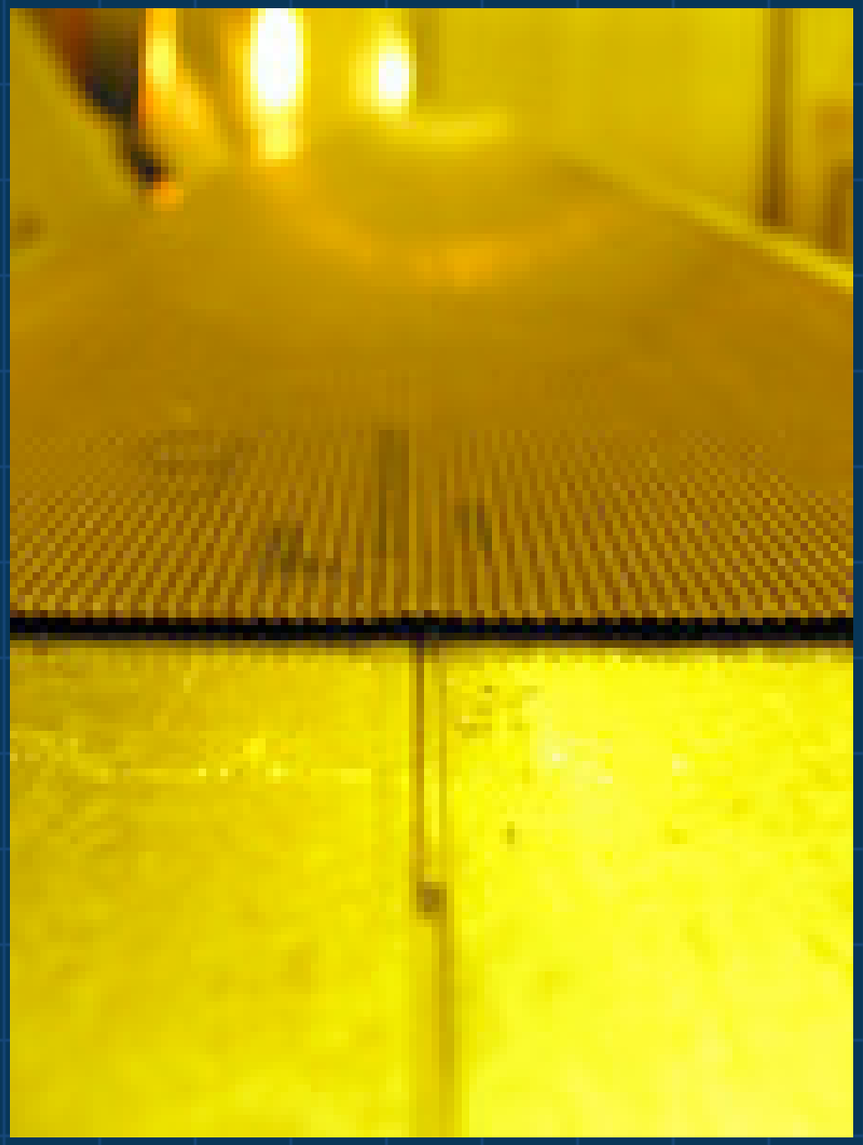
- Module-1 construction completed
  - Length is 400 cm after machining and polishing
  - Height is 23.3 cm of Pb/SciFi/Epoxy matrix
  - Used almost 80 km of SciFi's
  - Took 5-6 persons a month to complete
  - Used five gallons of BICRON 600 epoxy
  - All construction and machining was done at CSR
- Cosmic ray tests will be done at the UofR
- SiPM readout progress and in-beam tests

Some Pictures Now

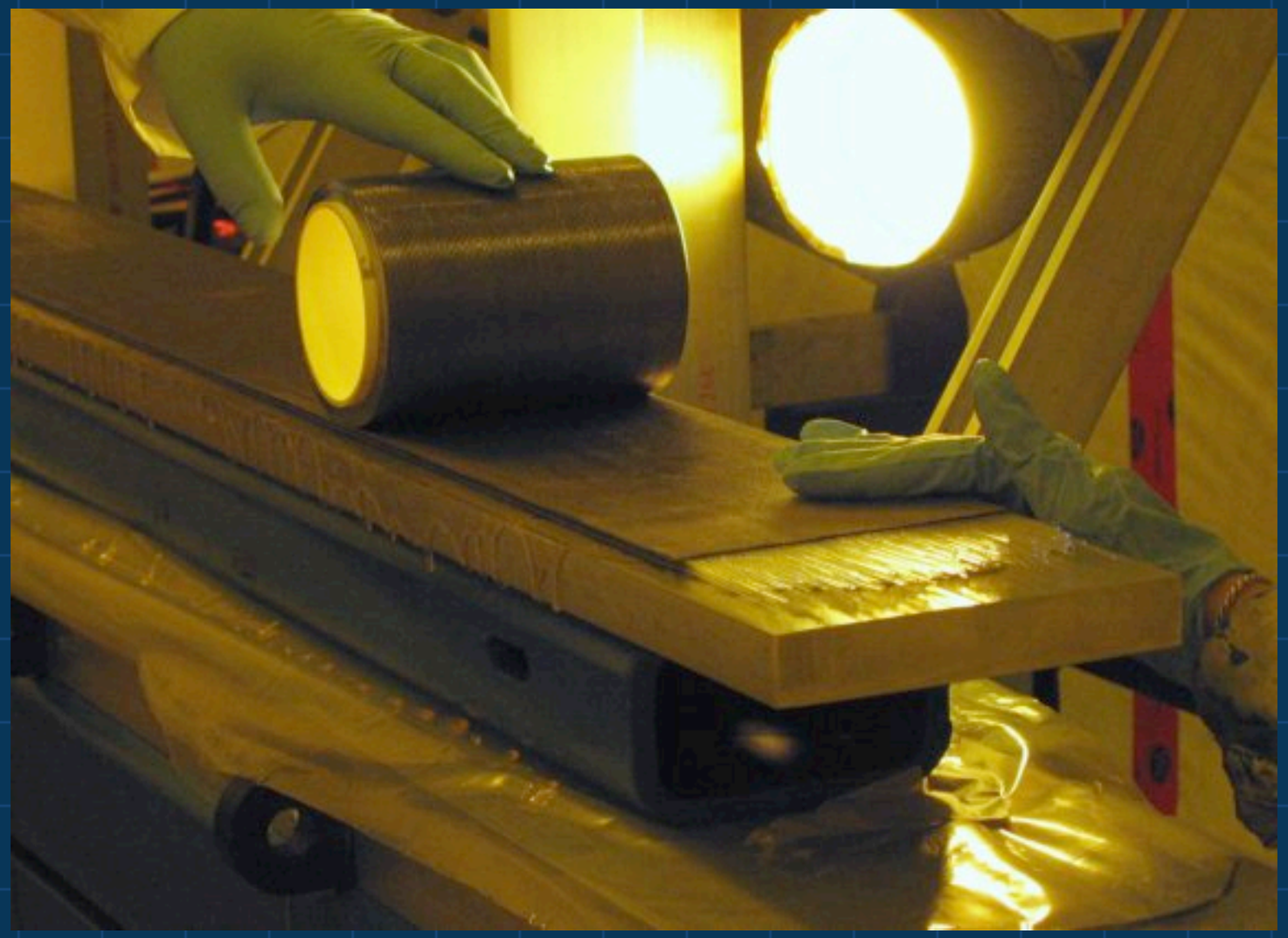
Details will be shown in the training video

In the Beginning....

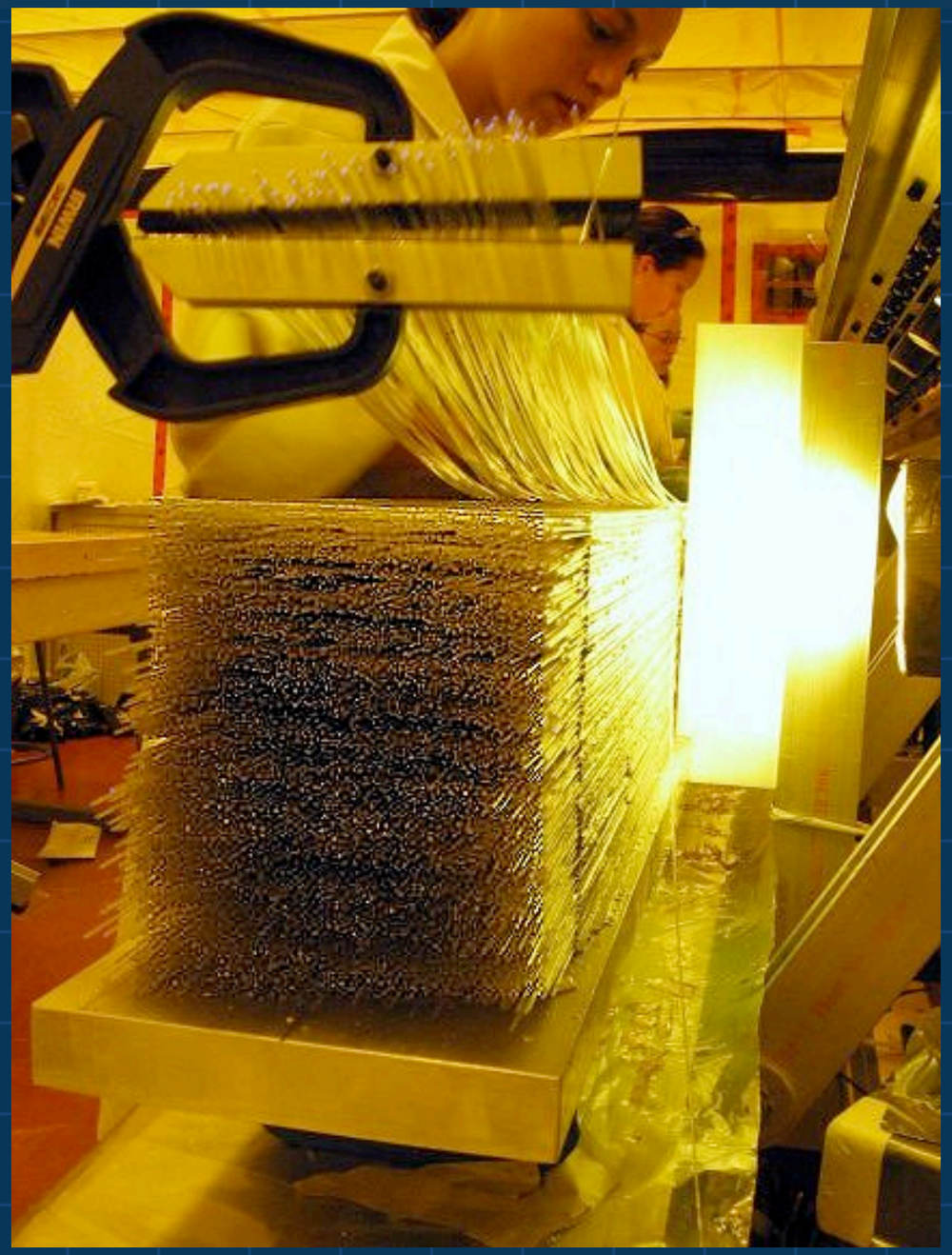
A Critical Operation



Let the Lead Roll



Placing the SciFi's, 96 at a time

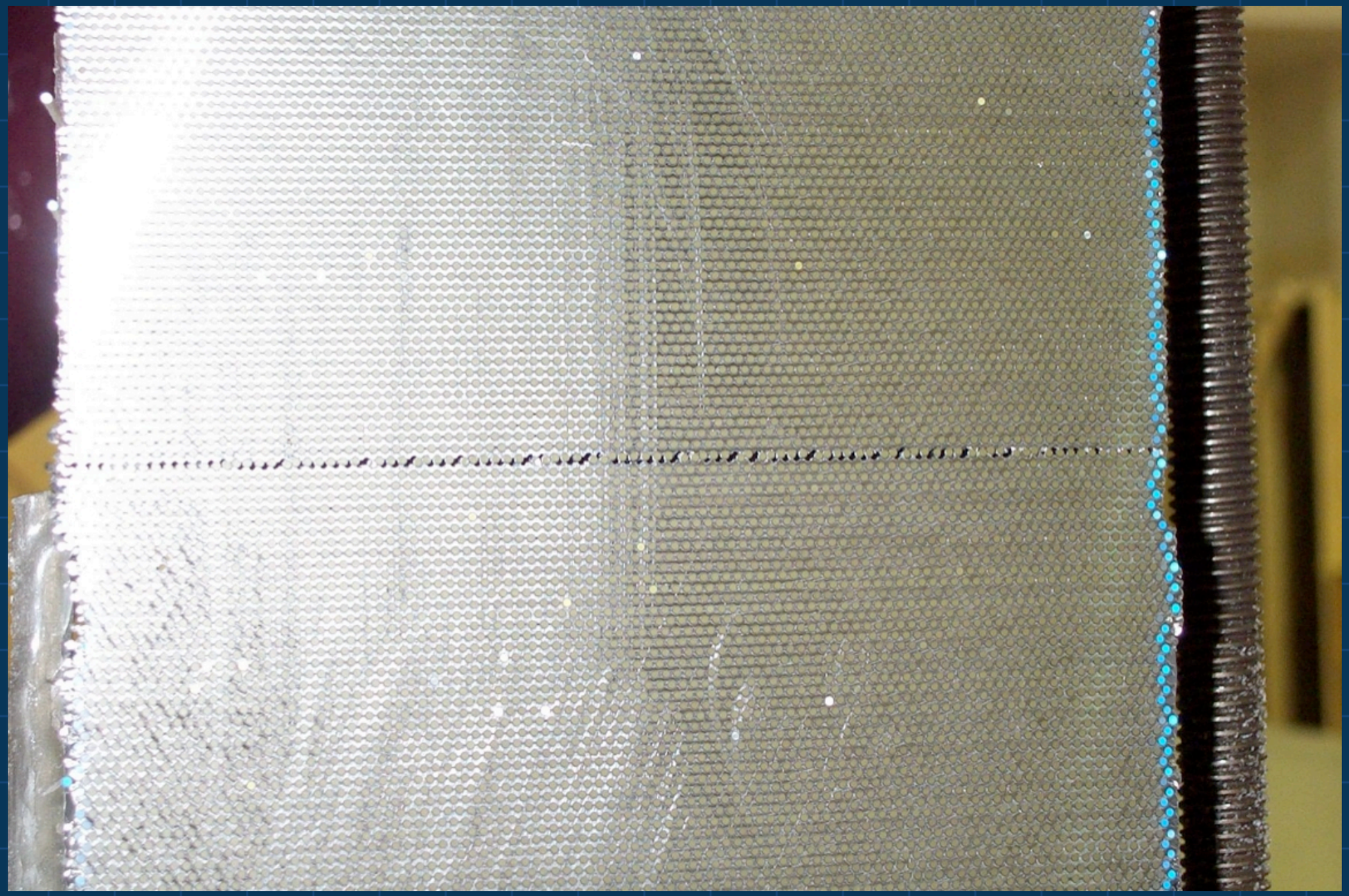


Module 1 Fully Grown @23.3 cm

Module 1 (a.k.a. Moly) leaves its incubator

Moly's first haircut before machining and polishing

Face Machined (first pass) and Oops!



Moly is coming home in a box

BCAL

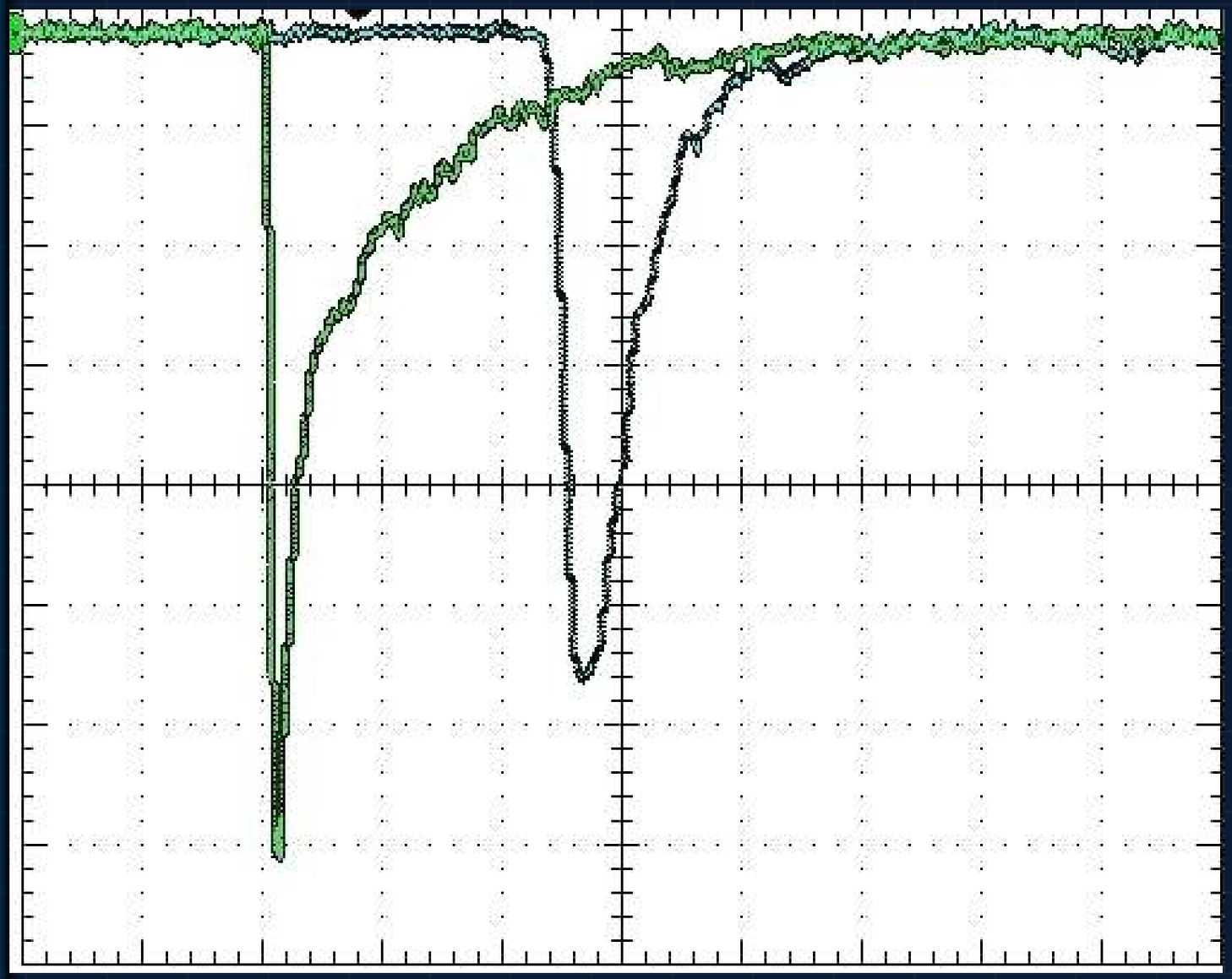
- **Performance Objectives**
  - **Energy resolution $\Delta E/E \approx (0.05 + 0.05/\sqrt{E})$ with E in GeV**
    - Depends on SciFi/Pb sampling ratio
    - Depends on Radiation Length
    - Depends on #P.E.'s and intrinsic PMT resolution
  - **Timing Resolution $\sigma \approx 200$ ps**
    - Depends on #P.E.'s (number of SciFi's read out per PMT that have recorded "hits")
    - Depends on intrinsic PMT resolution

Read-Out R&D

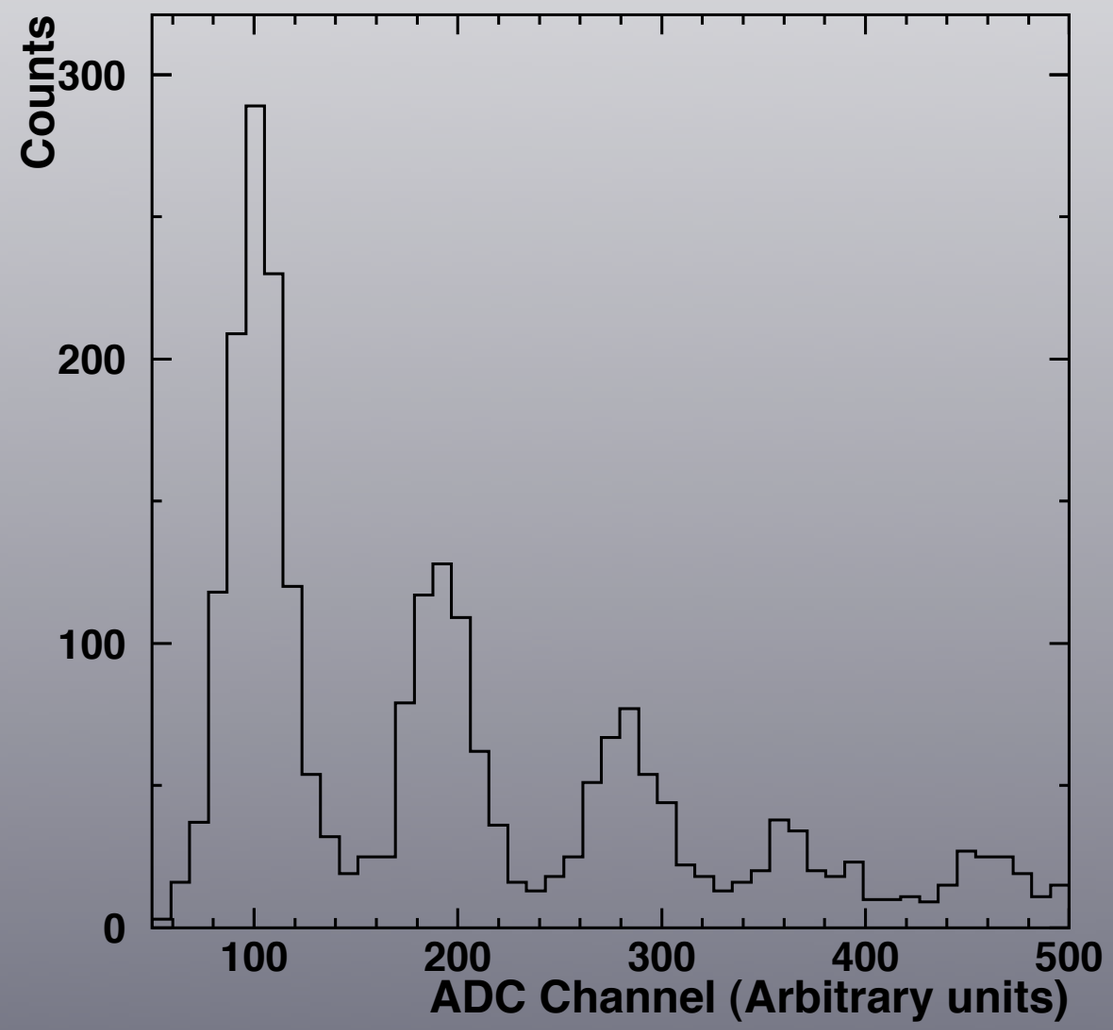
- 60 SiPM's have been obtained from CPTA
- All results so far have been very promising
- Significant R&D is required to determine the optimum SiPM-to-SciFi coupling to obtain the required timing and energy resolutions with the minimum number of SiPM's
- Pulse rise time and energy resolution are excellent and gain is almost as good as vacuum PMT's

SiPM vs. Burle 8575

- Green trace is for SiPM flashed with Optitron NR-1A
- Black trace is for BURLE 8575 under identical conditions and at 2,000 V
- 50 mV/unit and 20 ns/unit



SiPM and SciFi with source



SiPM's and dark rates

- SiPM's are more noisy than vacuum PMT's
- "Effective" noise levels depend on noise amplitude. Most vacuum PMT's have very high dark rates at the 1-5 mV levels, also known as electronic noise (well below 1 P.E. levels)
- Some brands of SiPM's have much higher noise rates and currents than others

CPTA with SciFi and LED

What does it all mean?

- The “noise” rate is shown to be less than 100 kHz, since the LED was triggered at that rate
- The noise amplitude is below the one P.E. level
- Each SiPM - in a matrix of 10-20 coupled devices viewing the same BCAL area - will be discriminated at that level to prevent noise triggering the TDC’s and causing amplitude resolution effects

Matching SiPM's to SciFi's

- "Standard" SiPM's have higher Q.E. in the $\lambda \approx 500-600$ nm range (Y-G)
- "Standard" (blue) SciFi's have peak emission in the $\lambda \approx 410-450$ nm. However, for lengths longer than 50 cm, the light surviving is in the Y-G region
- We need to model and test with beam and/or cosmic rays the optimum way to collect the light onto the SiPM's

Scintillating light wave shifting in SciFi

- Source: Ocean Optics 280 nm LED
- SciFi: PoliHiTech double-clad 1 mm ∅
- Transmission spectra have been obtained as a function of fiber length
- Blue ➡ Yellow–Green

Cost Projections (Materials) per Module (I)

- SciFi (80 km @ $0.65/m): $52,000
- BICRON 600 epoxy (5 gallons @ $600/gal) $3,000
- Lead: $2,000
- Consumables (industrial epoxy, gloves, brushes, paper and cloth wipes, alcohol, etc., etc.): $1,500
- Al plate and steel support channel: $2,500 (includes labour)

Cost Projections (Materials) per Module (II)

- 11 sets of 15 coupled (matrices) of SiPM's ($80 per SiPM): $13,200
- Electronics (bases + discriminator chips) for above: $12,000 (includes labour)
- 11 sets of SciFi-to-SiPM (matrix) light guides and Winston cones + 15 light collection fibers per set: $6,000 (includes labour)
- Shipping crate: $1,000 (includes labour)

Cost Projections (Equipment)

- New swaging machine: **$20,000** (includes labour)
- Second press-frame: **$15,000** (includes labour)
- Fiber handling and sorting table with Cu (grounded) table top cover: **$1,500**
- "Clean room" to house two presses and one main SciFi table with A/C (filtered) and temperature and humidity controls. Estimated cost: **$20,000** (includes labour)

Cost Projections for BCAL (Materials + Equipment)

☛ All these numbers are preliminary ☚

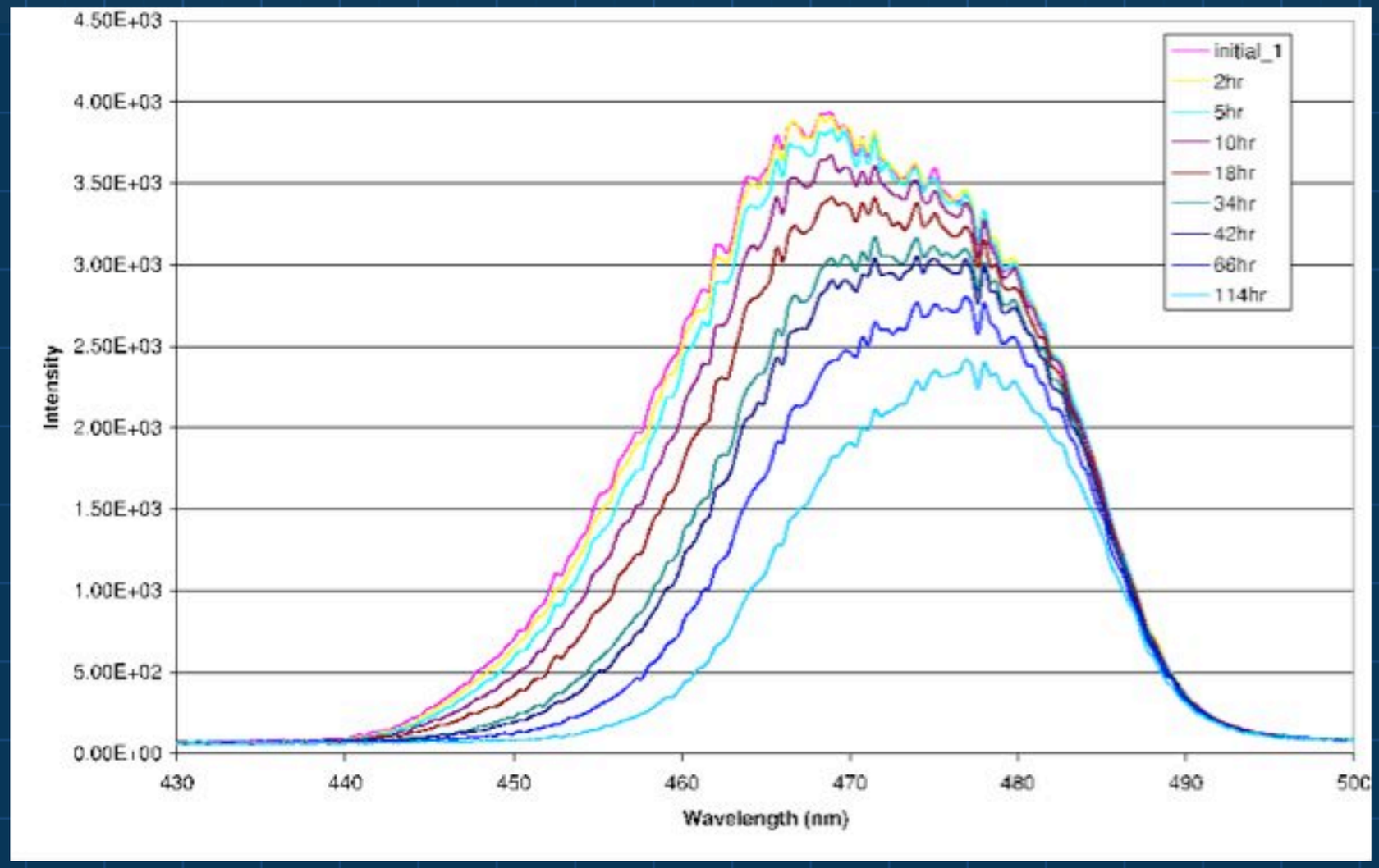
- **Total Materials Cost: $4,473,600**
- **Total Equipment Cost: $56,500**
- **Sub-Total Materials+Equipment (includes some labour, as indicated): $4,530,100**

Labour Cost Estimates

- Each module requires 5 man-months to complete - assuming eight hours per day (unskilled labour, e.g. students)
- Cutting and swaging ≈200 sheets require approximately 20 man-hours per module (unskilled labour, e.g. students)
- Labour and milling machine charges for machining each module to final dimensions are approximately $2,800 (machinist rates)
- More specific estimates will be provided for the detector review and the CDR.

It’s not cheap !

And UV tests of fibers…



Controlled exposure to fluorescent lighting; LED 480nm, transmission spectrum