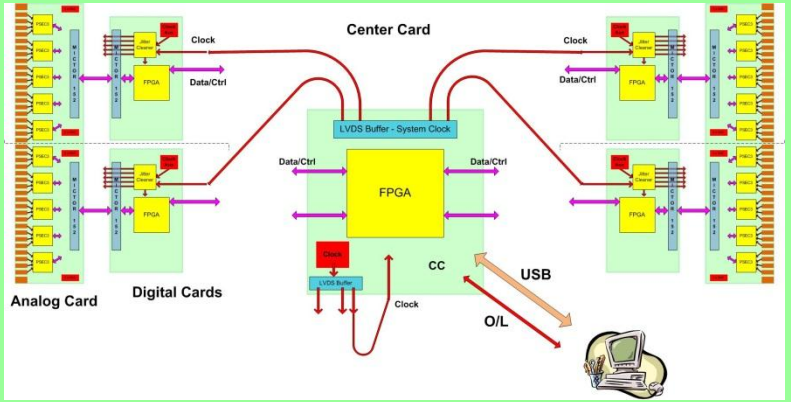
Progress in developing large-area high resolution photo-detectors (LAPPD)

Henry Frisch
Enrico Fermi Institute, Univ. of Chicago
and HEPD, Argonne National Laboratory

The 4 `Divisions' of LAPPD

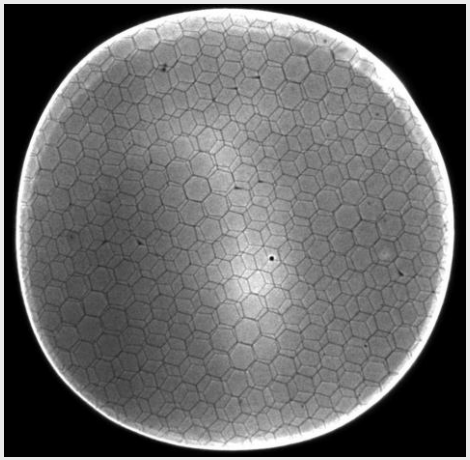
Hermetic Packaging

Electronics/Integration

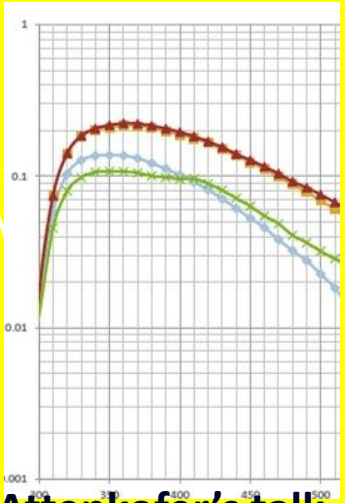


See (hear) Eric Oberla's talk

MicroChannel Plates



Photocathodes



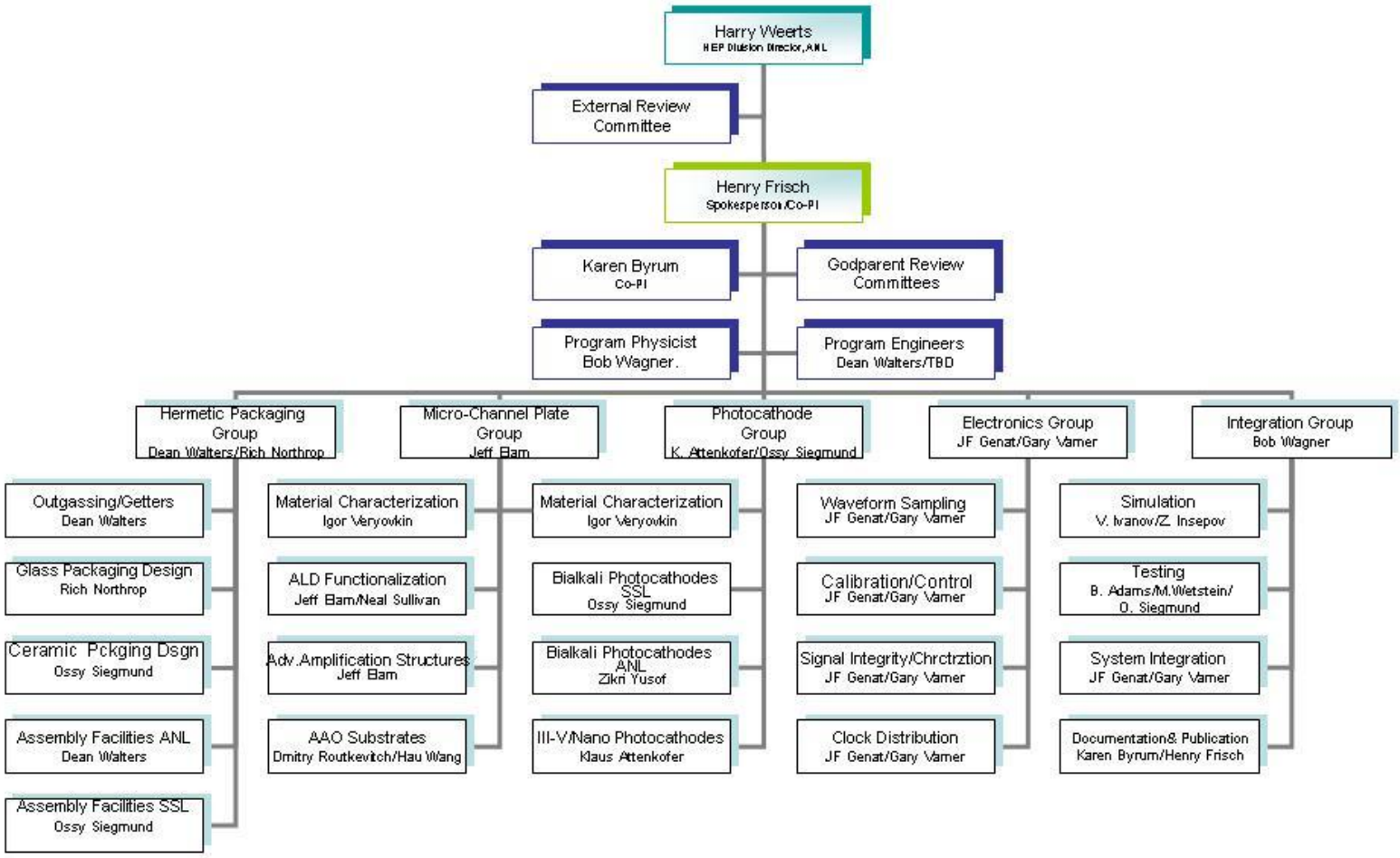
See (hear) Klaus Attenkofer's talk

The Large-Area Psec Photo-Detector Collaboration

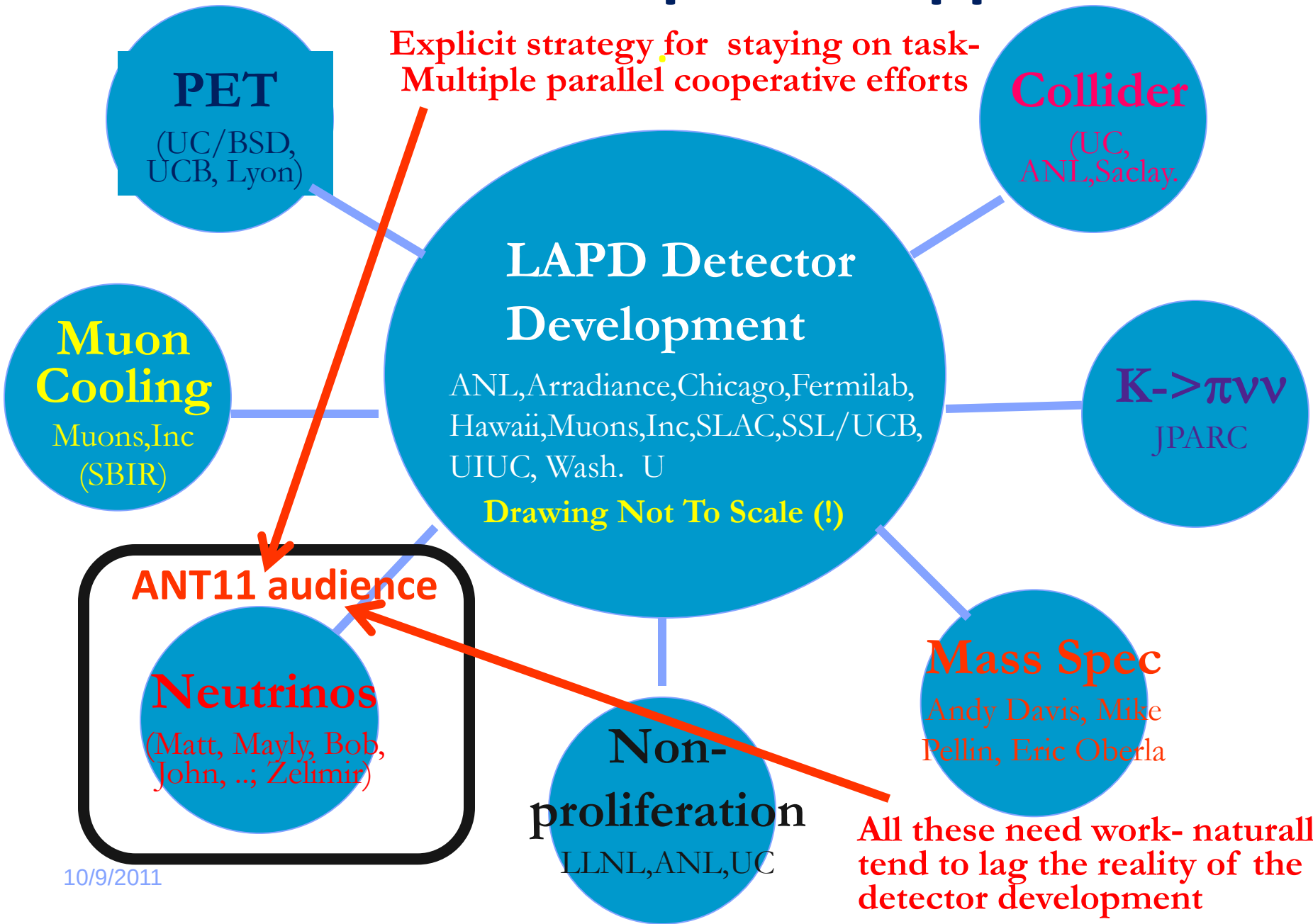
Version 2.0
Feb. 9, 2010

Organization Chart

R&D Program for the Development of Large-Area Fast Photodetectors

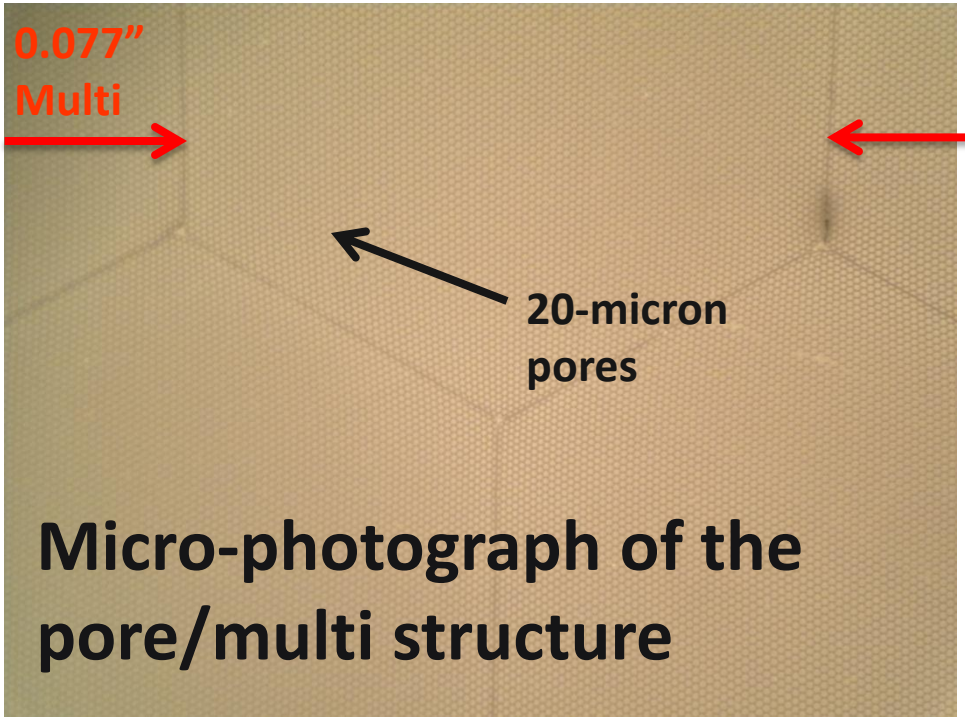


Parallel Efforts on Specific Applications

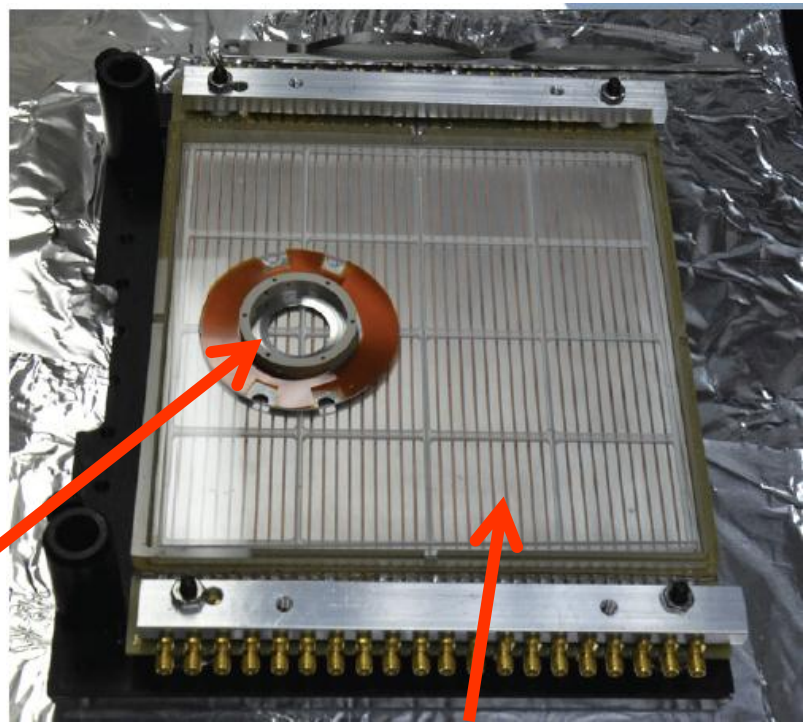


Microchannel Plates-1

- Incom Glass Substrates- Hard (untreated) glass



2 working formats:

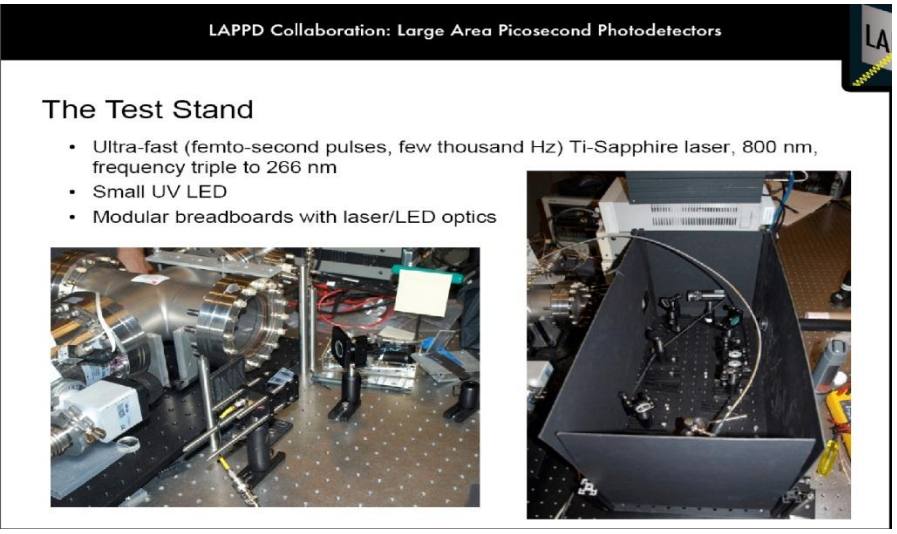


33mm Disc
(Development)

8”-square (the `Tile’)

Microchannel Plates-2

- **Argonne ALD and test Facilities**



- **In situ measurements of R (Anil)**
- **Femto-second laser time/position measurements (Matt, Bernhard, Razib, Sasha)**
- **33 mm development program**
- **8” anode injection measurements**

Anil Mani and Bob Wagner

Razib Obaid and Matt Wetstein

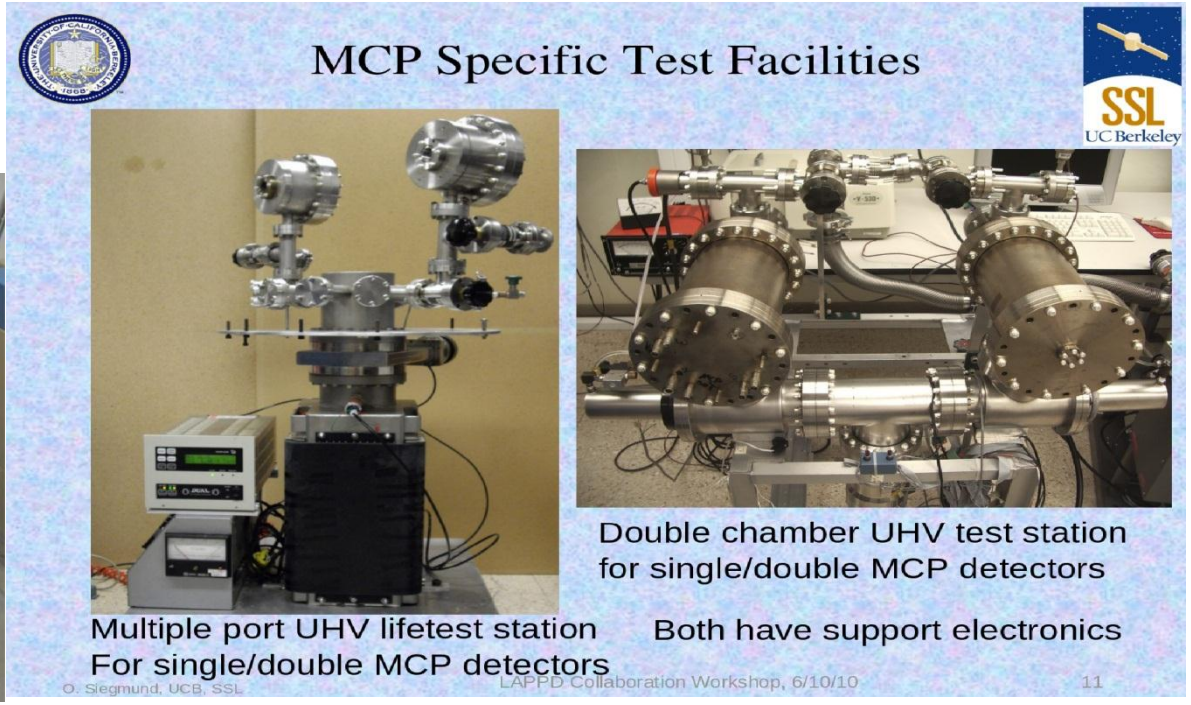
Microchannel Plates-3

- **SSL (Berkeley) Test/Fab Facilities**

Ossy Siegmund, Jason McPhate, Sharon Jelenski, and Anton Tremsin-

Decades of experience

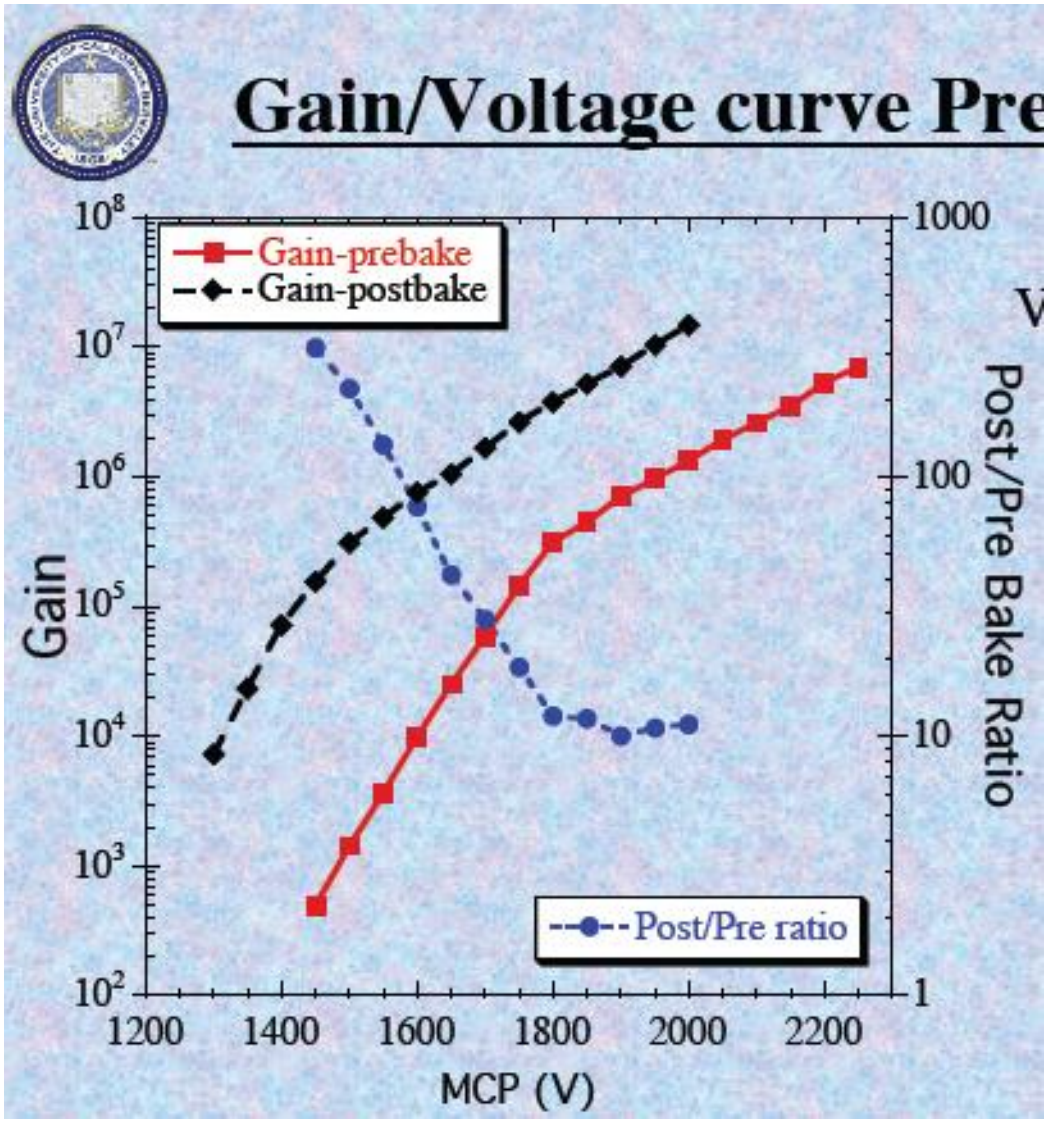
(some of us have decades of inexperience?)



Microchannel Plates-4a

Performance: First, the gain. We see gains > 10^7 in a chevron-pair; > 10^5 in a single plate (attractive possibility for cost/simplicity)

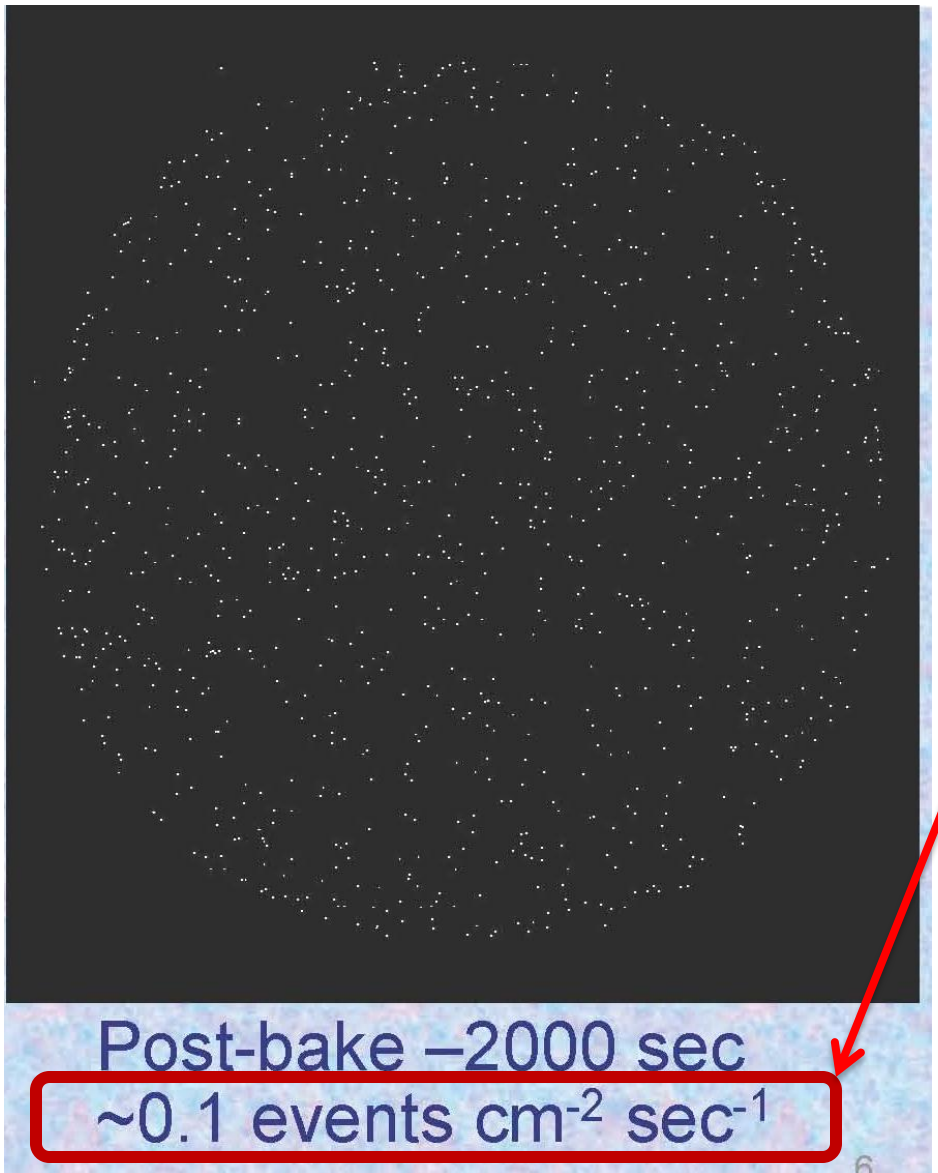
Ossy Siegmund, Jason McPhate, Sharon Jelinsky, SSL/UCB



Microchannel Plates-4b

Performance:

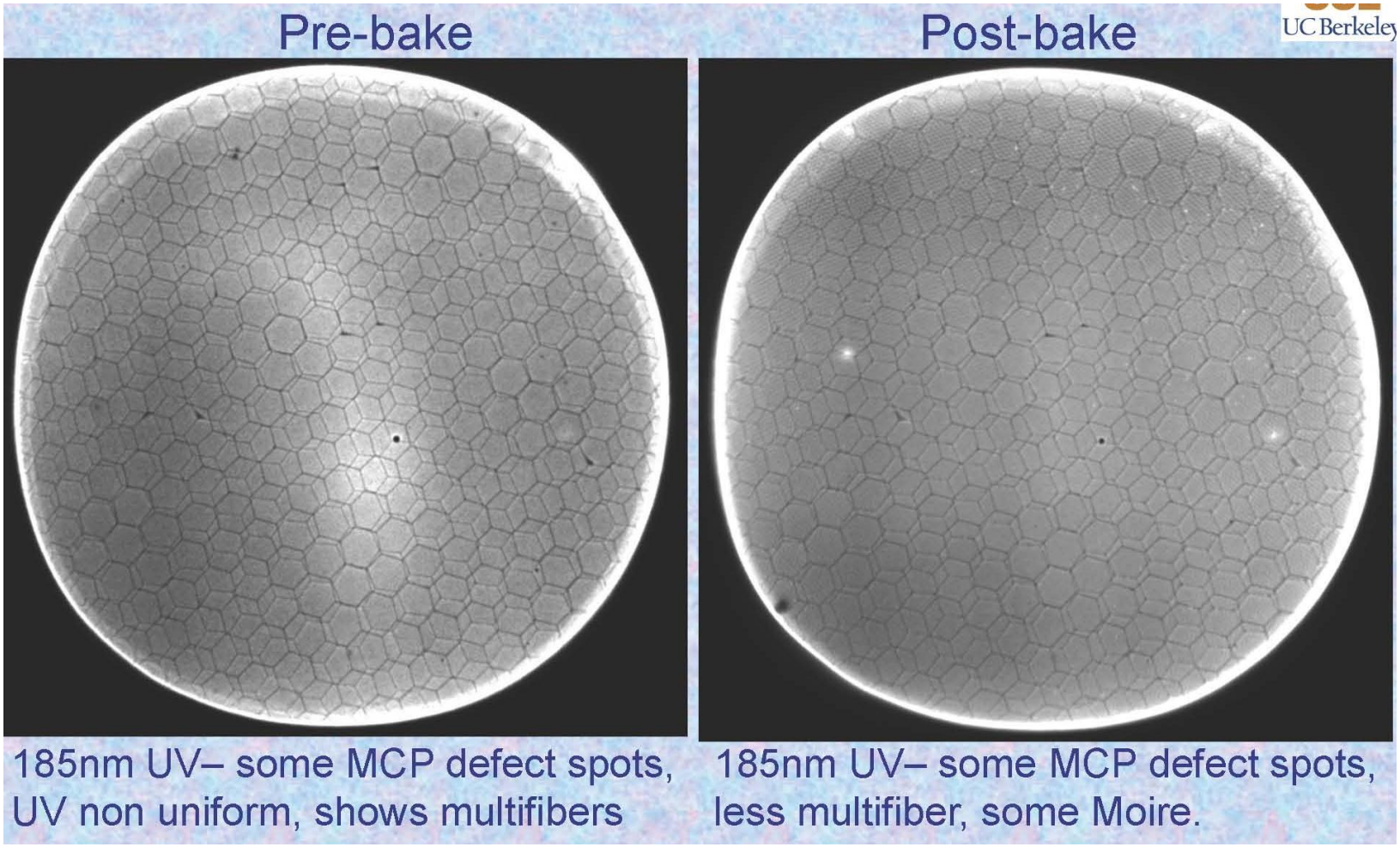
Ossy Siegmund, Jason McPhate, Sharon Jelinsky, SSL/UCB



Noise (bkgd rate). <=0.1 counts/cm^2/sec; factors of few > cosmics (!)

Microchannel Plates-4c

Performance: Image quality, spatial resolution, uniformity:
Good uniformity; can resolve the multi boundaries in top plate (20microns)

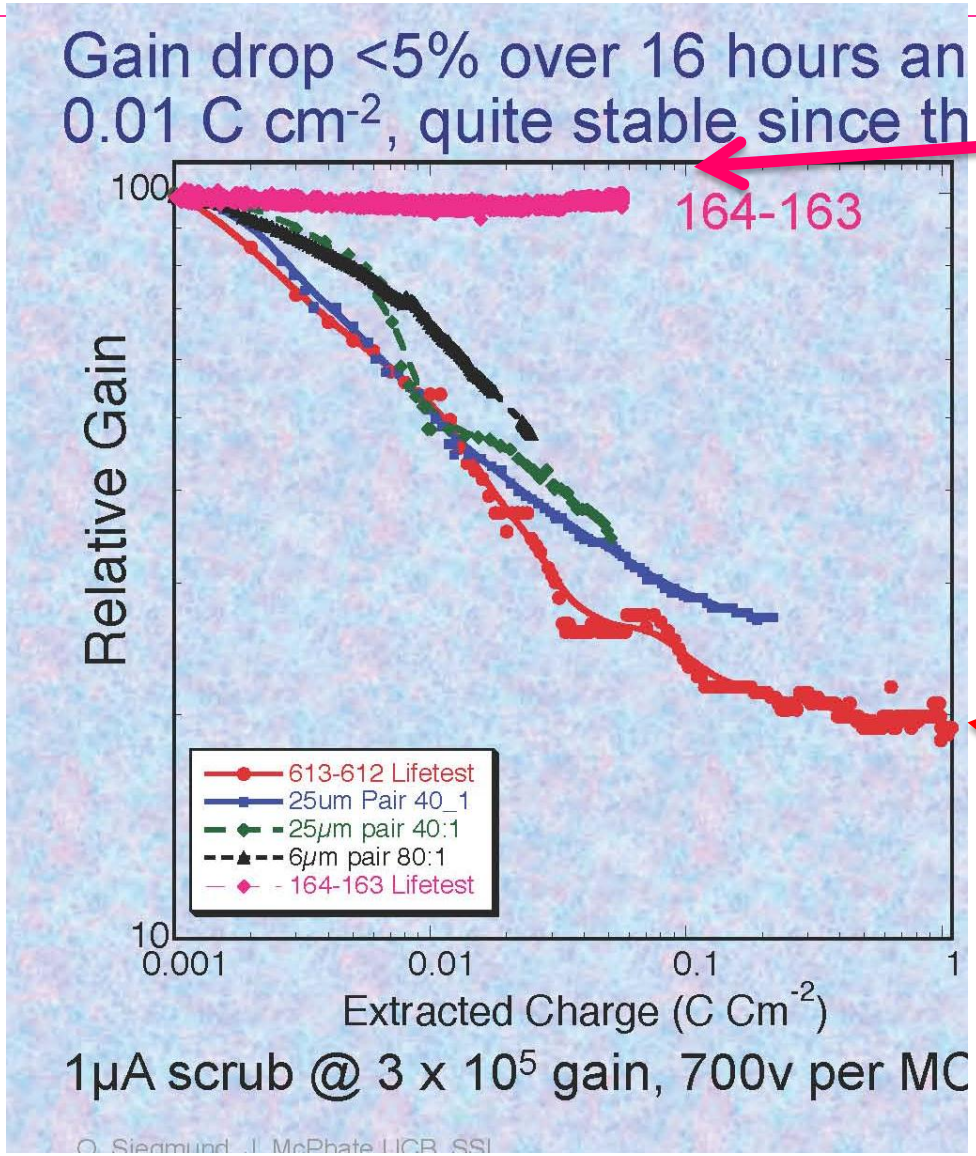


Ossy Siegmund, Jason McPhate, Sharon Jelinsky, SSL/UCB

Microchannel Plates-4d

Performance: burn-in (aka `scrub')

Measurements by Ossy Siegmund, Jason McPhate, Sharon Jelinsky, SSL/UCB

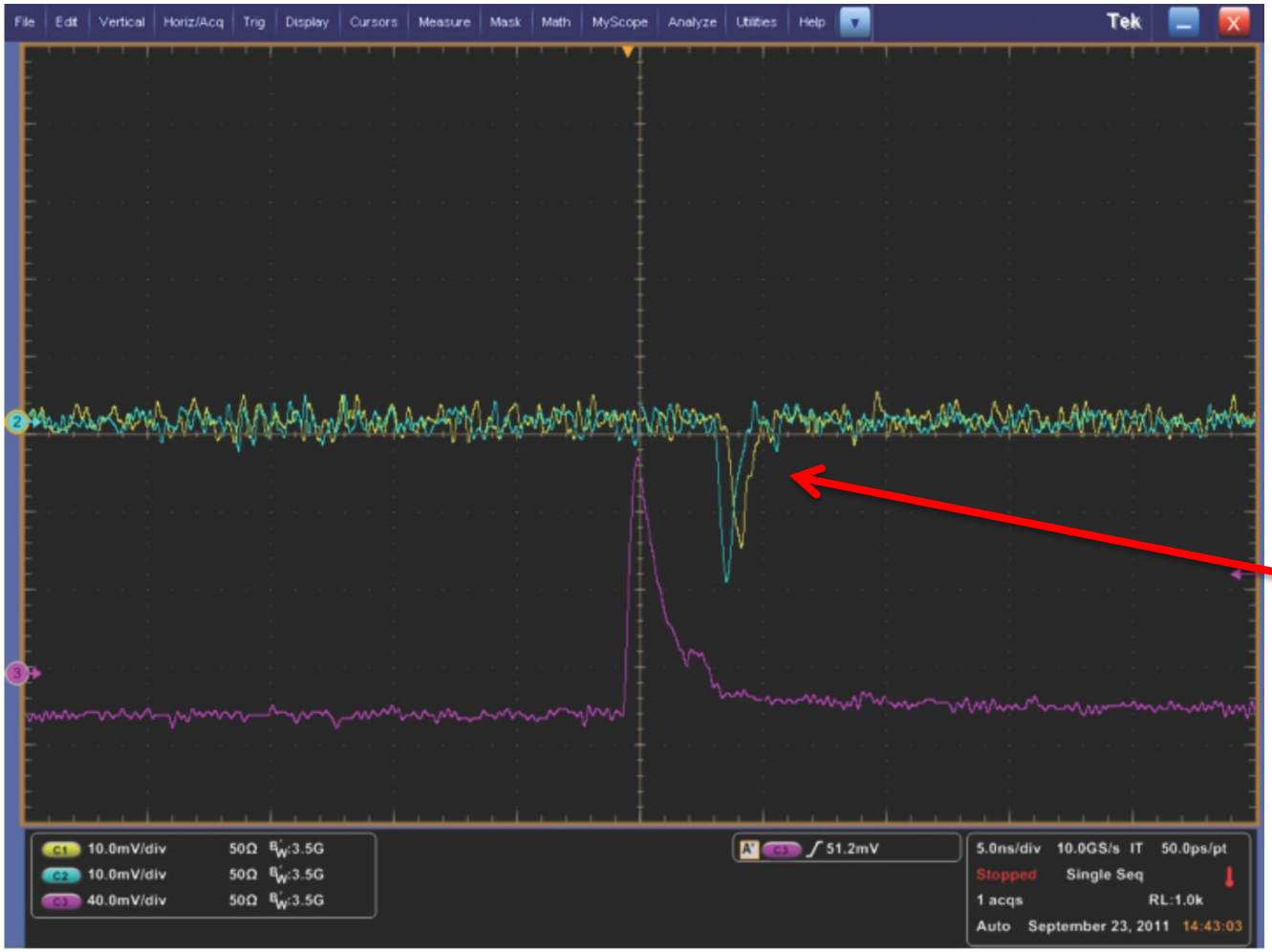


Measured ANL ALD-MCP behavior

(ALD by Anil Mane, Jeff Elam, ANL)

Typical MCP behavior- long scrub-times

First Pulses From an 8” MCP (!)



Caveats- this is the first time… TDIITDs- don’t over analyze this

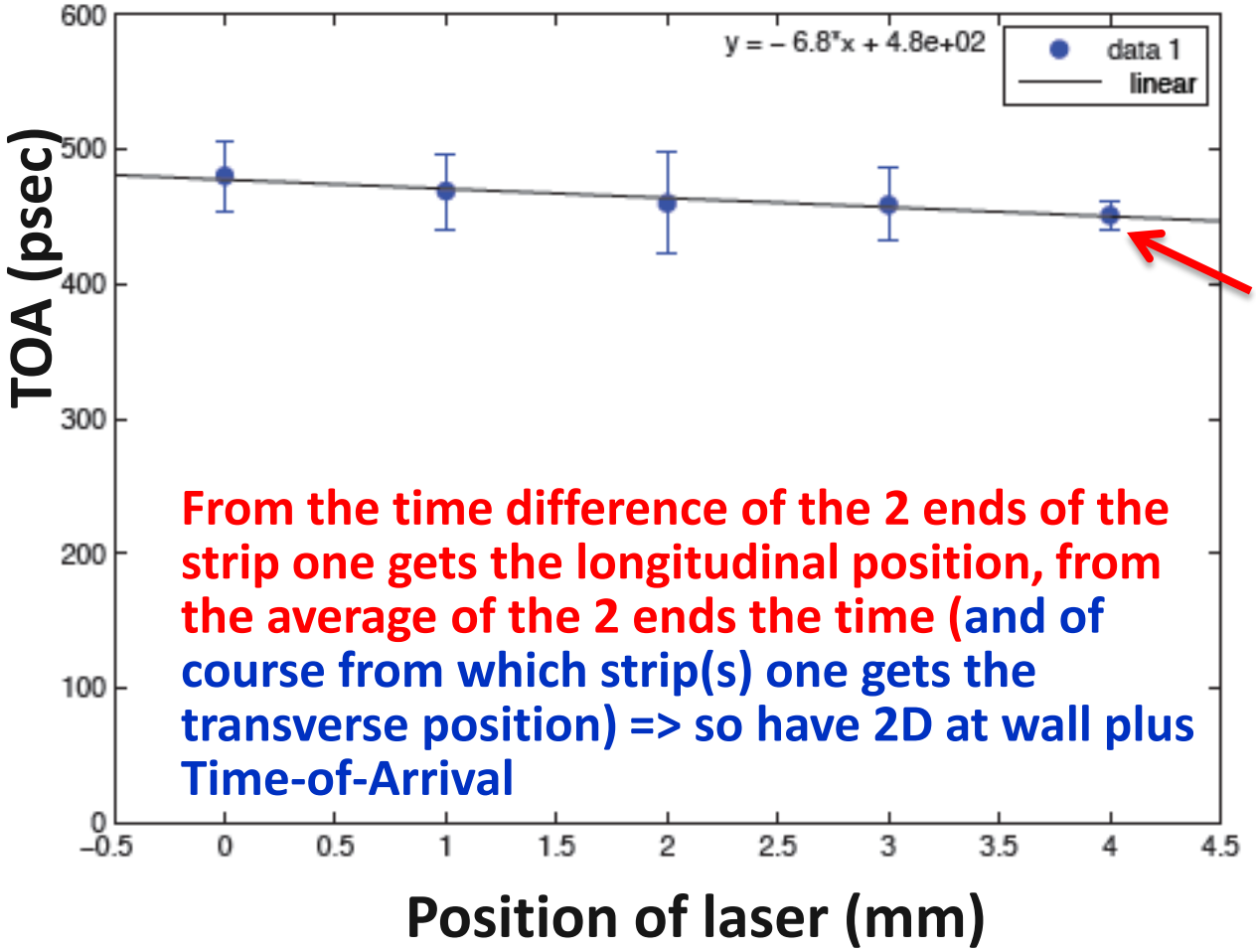
Pulses from the 2 ends of an 8” anode strip

Matt Wetstein, Bernhard Adams, Razib Obaid, Sasha Vostrikov (ANL and UC)

First Pulses From an 8” MCP

Matt Wetstein, Bernhard Adams, Razib Obaid, Sasha Vostrikov (ANL and UC)

average arrival time (picoseconds) versus position (mm)



TrueError bar prob.
like this
(ask Matt)

Note
c= 0.3mm/ps
1/c=3.3 psec/mm

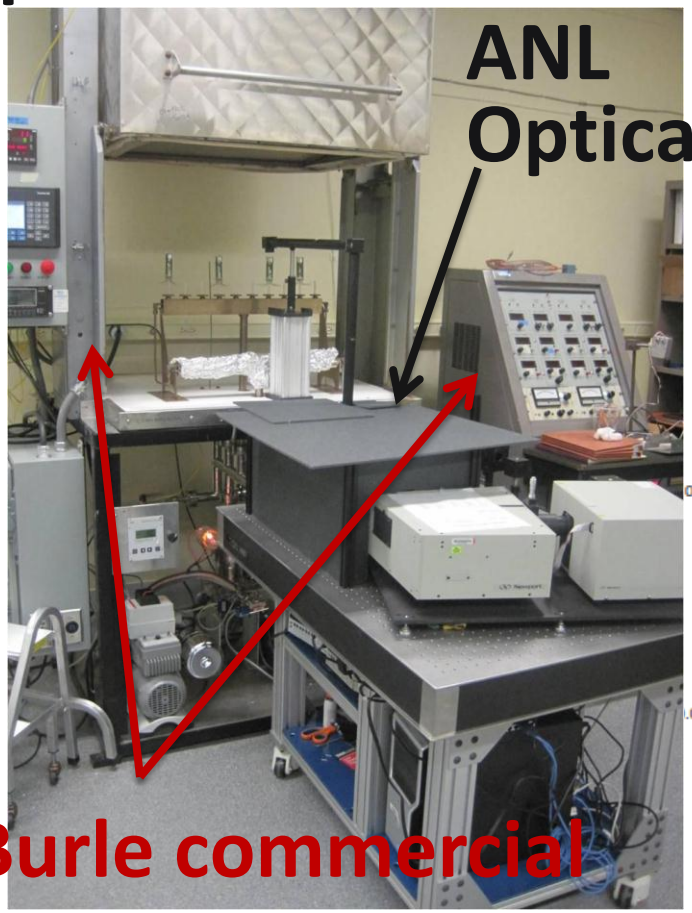
MCP Prognosis

- Incom has made great strides in making substrates- the 3-pt joint of the multis seems solved; some cleaning issues remain and are being worked on
- Strong UHV test facilities have been constructed at SSL and ANL (this was a big effort- UHV isn't fast or easy- requires real infrastructure)
- ALD development has a 1st-generation baseline that shows high gain, low noise, and short burn-in (ALD: Anil Mane and Jeff Elam, ANL)
- Transferring knowledge gained from hundreds of 33mm plates to 8" plates and Beneq machine now (Anil Mane and Jeff Elam, ANL)
- Fast turn-around electroding has turned out to be an issue- we have attacked now on parallel fronts (this was a surprise)
- We have started a program with Incom to produce more blocks to get enough 8" plates for a first-round of users in the field (see slide 4 for the customers)

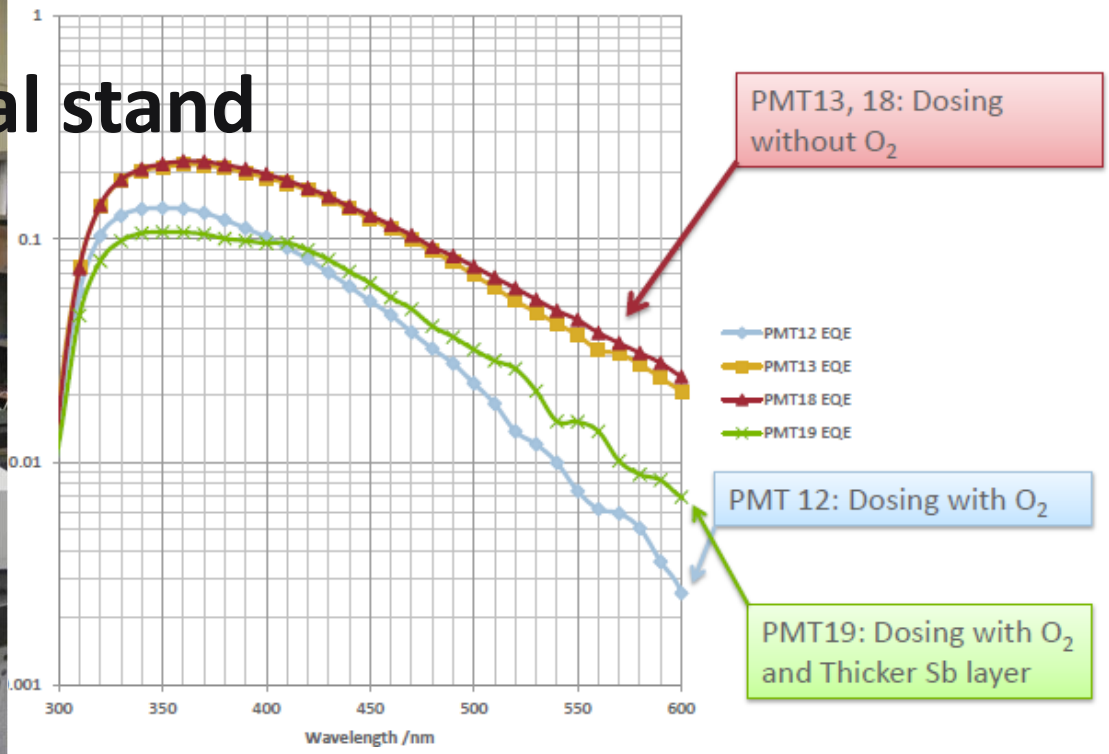
Photocathodes

Subject of next talk by Klaus- touch on here only briefly

LAPPD goal- 20-25% QE, 8”-square
2 parallel efforts: SSL (knows how), and ANL (learning)



Burle commercial equipment



First cathodes made at ANL

Photocathodes- 2

Subject of next talk by Klaus

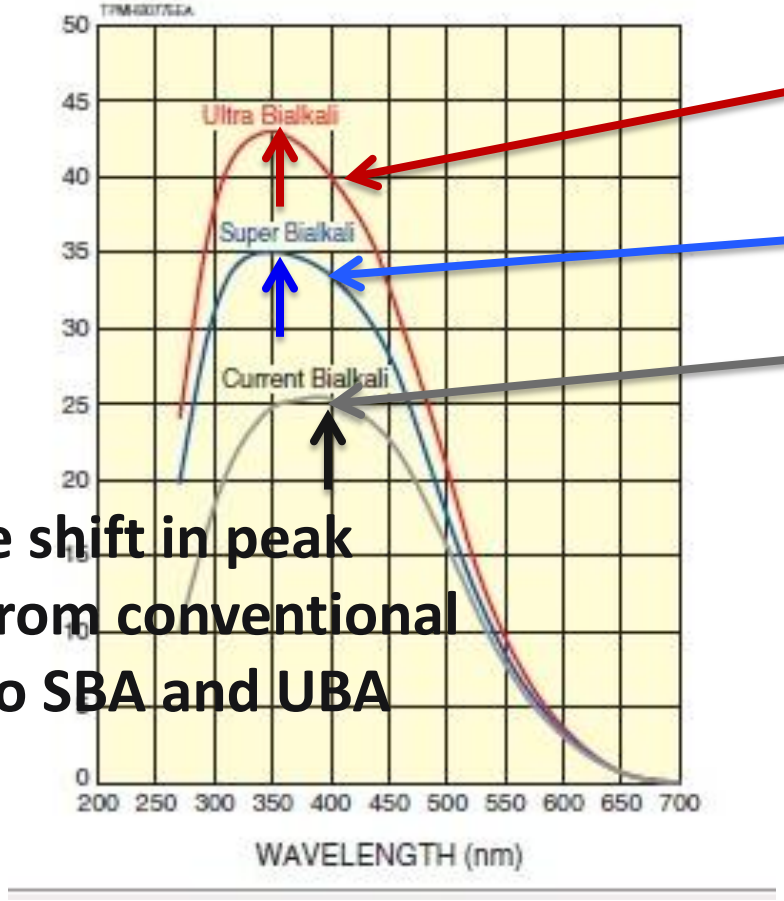
SSL has years of experience making bialkali photocathodes-
They are our treasury bonds (Swiss francs?) in the LAPPD `portfolio of risk'

8" Photocathode Chamber

Photocathodes

But longer-term, we have started a broadly collaborative program outside of LAPPD on high QE (goal: > 50% QE) cathodes and tuning spectral response (LDRD funds now- ideal flagship for a (the) Natl. Detector Center

Hamamatsu bialkalis



Ultra (UBA)-40%@400nb

Super(SBA)-34%@400nb

Conv. BA-25%@400nb

Q

Note shift in peak QE from conventional BA to SBA and UBA

Photocathodes

An obvious question to this audience is:

What are the economics of QE vs PMT area at constant bang-for-buck in a) CPV, and b) ~~proton~~?

For example, going from 25%QE to 50%QE would allow going from a 7” tube to a 5” tube at constant photons*

Q

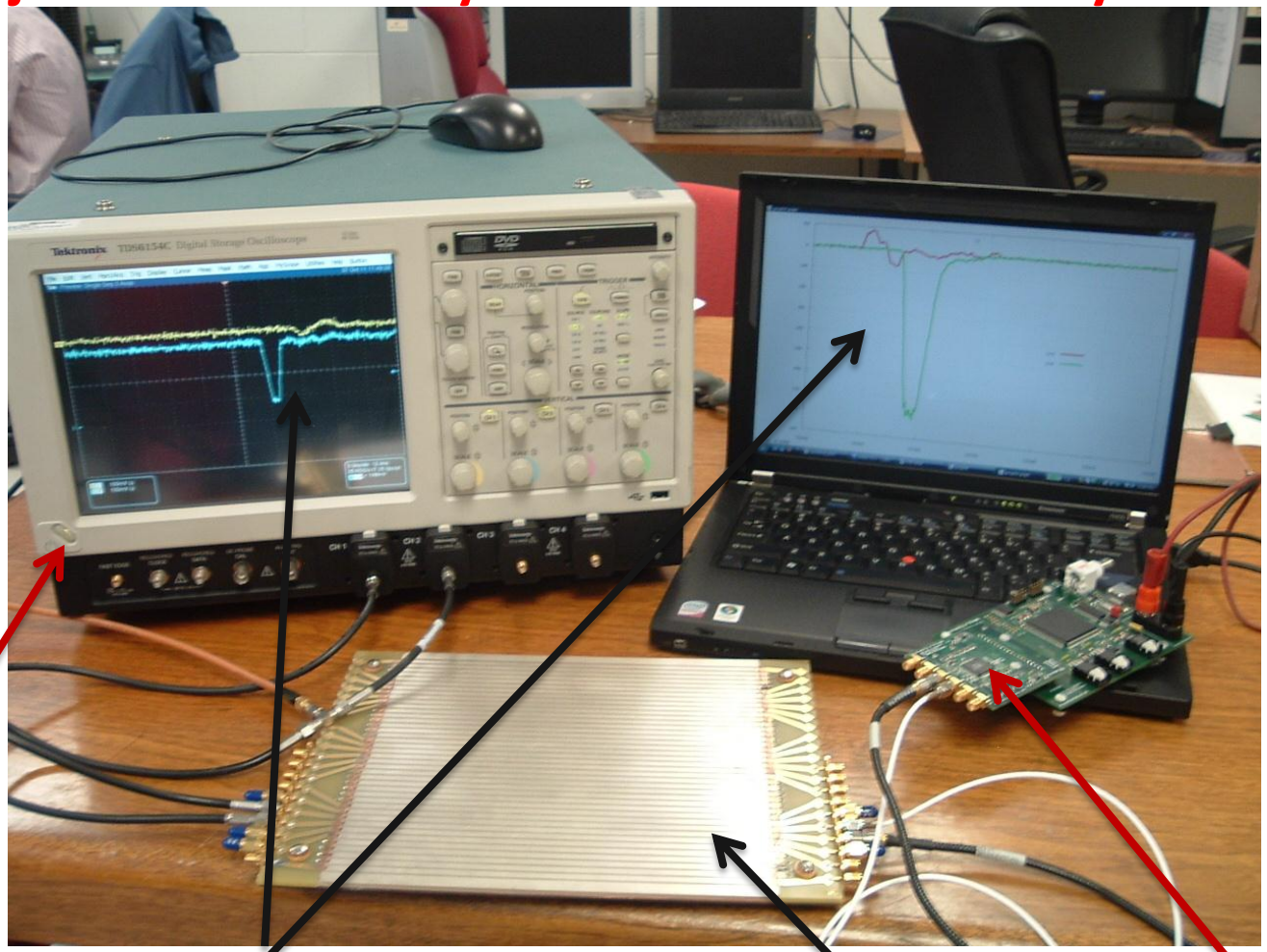
Alzo, a Winston cone for a 5” tube is easier and smaller than one for a 7” tube (tho not for a wavelength-shifting plate?)

Crudely, put, “what’s QE worth to you in $?”

* **Note `constant photons ‘doesn’t apply to time-position-sensitive detectors like LAPPD**

Electronics and Integration

Subject of next talk by Eric - touch on here only briefly



Real digitized traces from anode

20 GS/scope
4-channels (142K$)

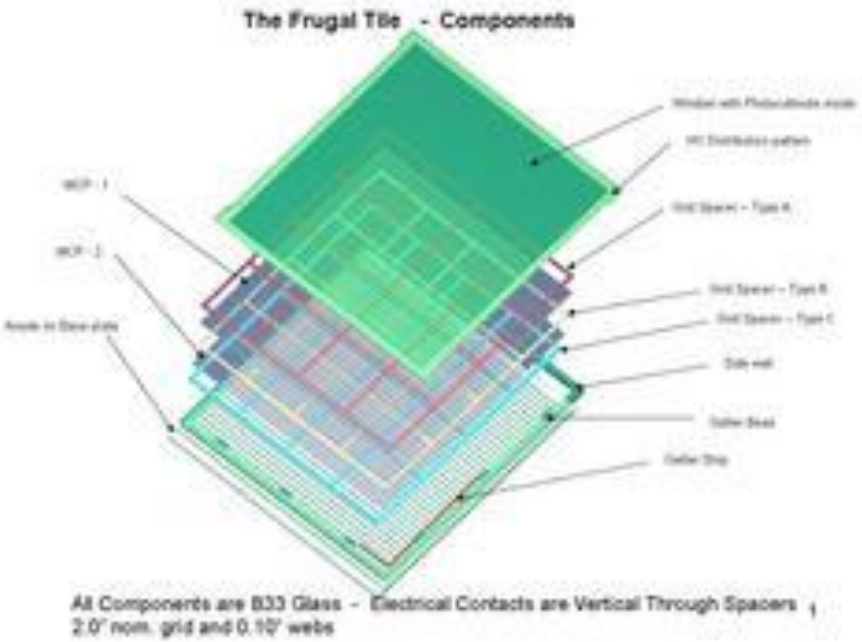
17 GS/PSEC-4 chip
6-channels ($130 ?!)

Hermetic Packaging

- Have moved to a tile/tray design: tray has all the electronics; only connections to tiles are HV and ground
- Tiles are glued with spray glue to tray
- HV divider chain is made with ALD
- No pins through glass
- Tile is plate glass
- Anode strips connect
- Modular; simple
- Top seal is cold (ANL) Hot (SSL)

Hermetic Packaging

- **ANL/UC Glass Package**



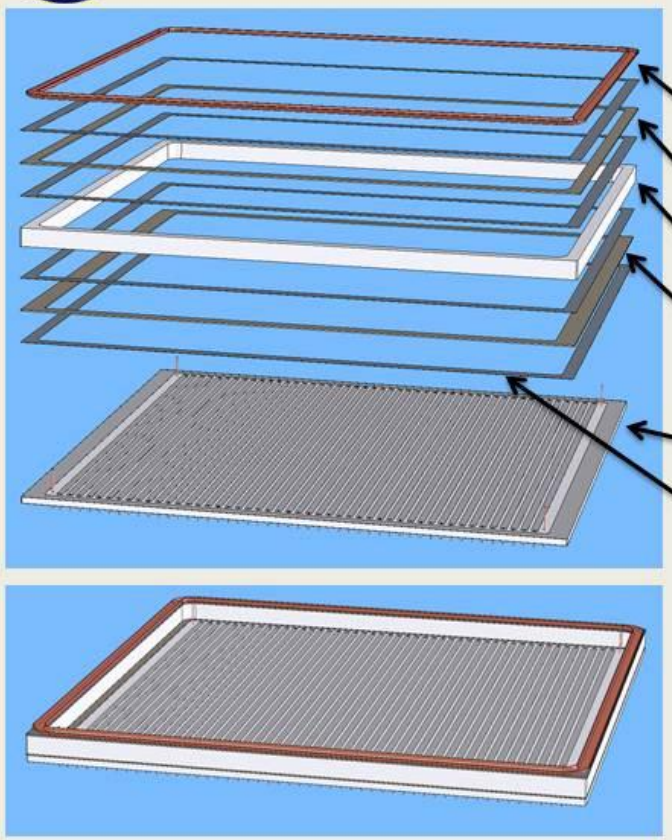
Glass package showing ALD-coated 8” MCP, grid spacer, bottom seal

(apologies for blurriness)

Hermetic Packaging

SSL Ceramic Package (2 parallel paths)

Brazed Body Assembly

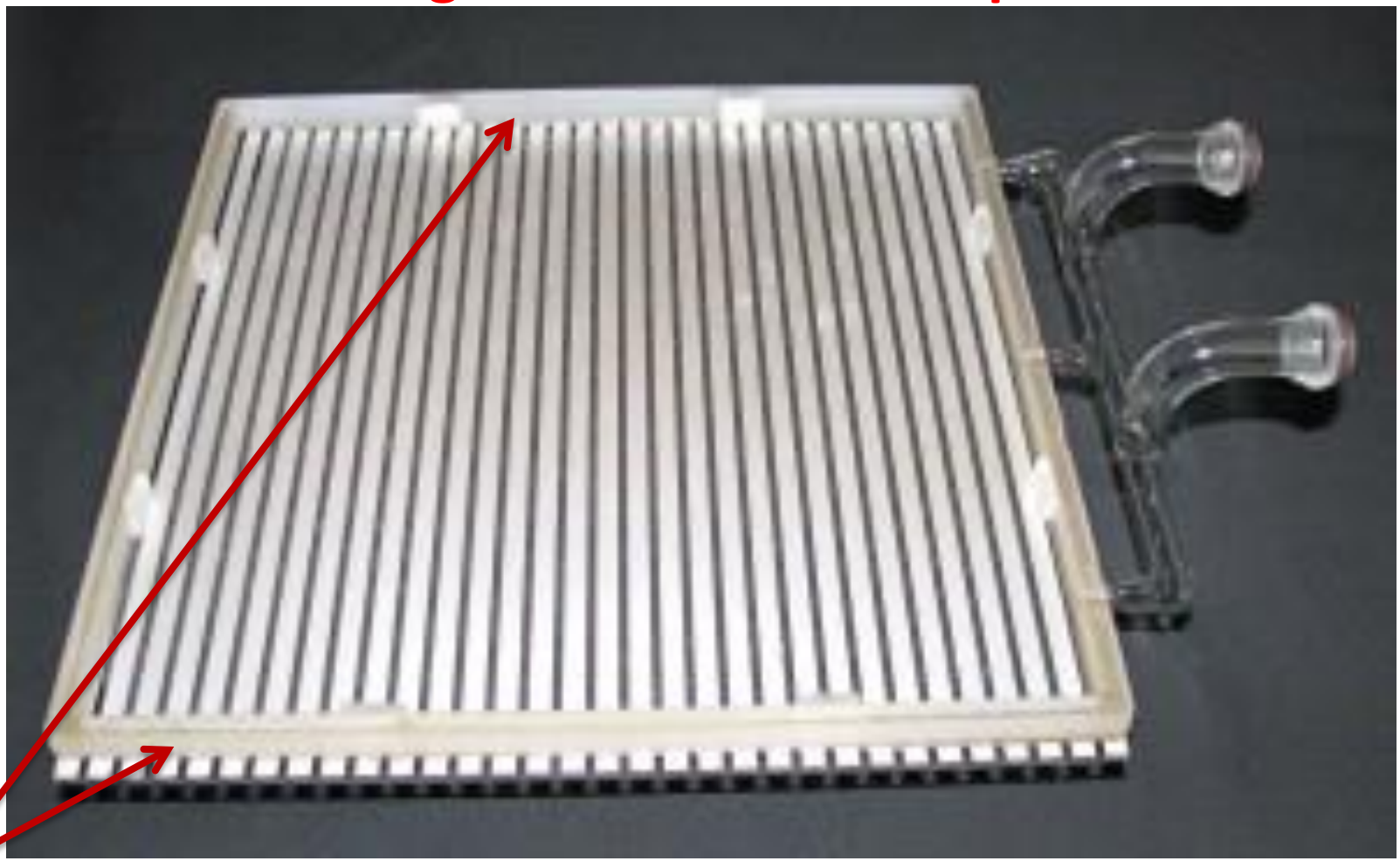


- Single step braze
  - Stamped OFHC Cu or Kovar indium well
  - Kovar intermediary flange
  - Alumina wall
  - Kovar getter flange
  - HiTemp, CuSil brazed anode
- InCuSil braze alloy (750°C braze)
  - Avoids remelt of anode CuSil
- Four braze joints in final assembly

26 April 2011 J. McPhate – LAPP Hermetic Packaging Godparent Review 12

Hermetic Packaging

We have solved sealing over the anode strips

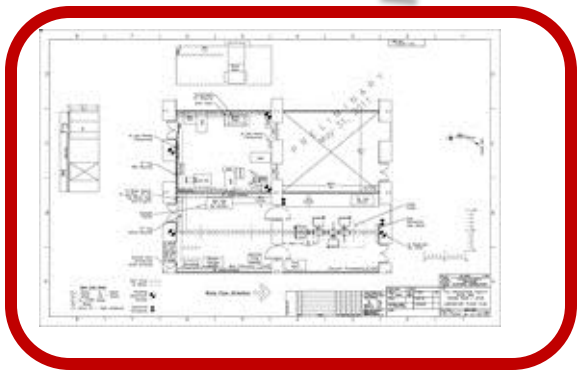


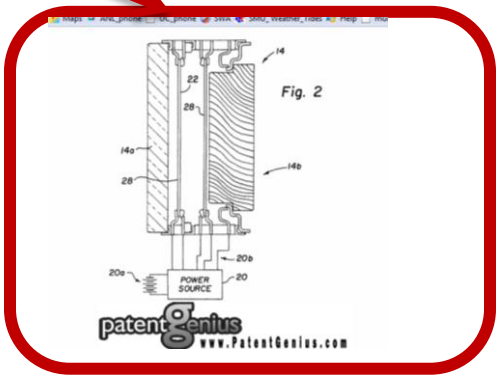
Bottom seal by Joe Gregar, ANL master glass-blower with help from Michael Minot (Minotech, Incom) and Ferro Corp

Hermetic Packaging

- **Top Seal and Photocathode- this year's priority**

3 parallel paths





Tile Development Facility at ANL

Production Facility at SSL/UCB

Commercial RFI for 100 tiles
(Have had one proposal for 7K-21K tiles/yr)

Some Neutrino specific aspects

The ALICE TPC: Drift electrons onto wires that measure *where* and *when* for *each* electron.

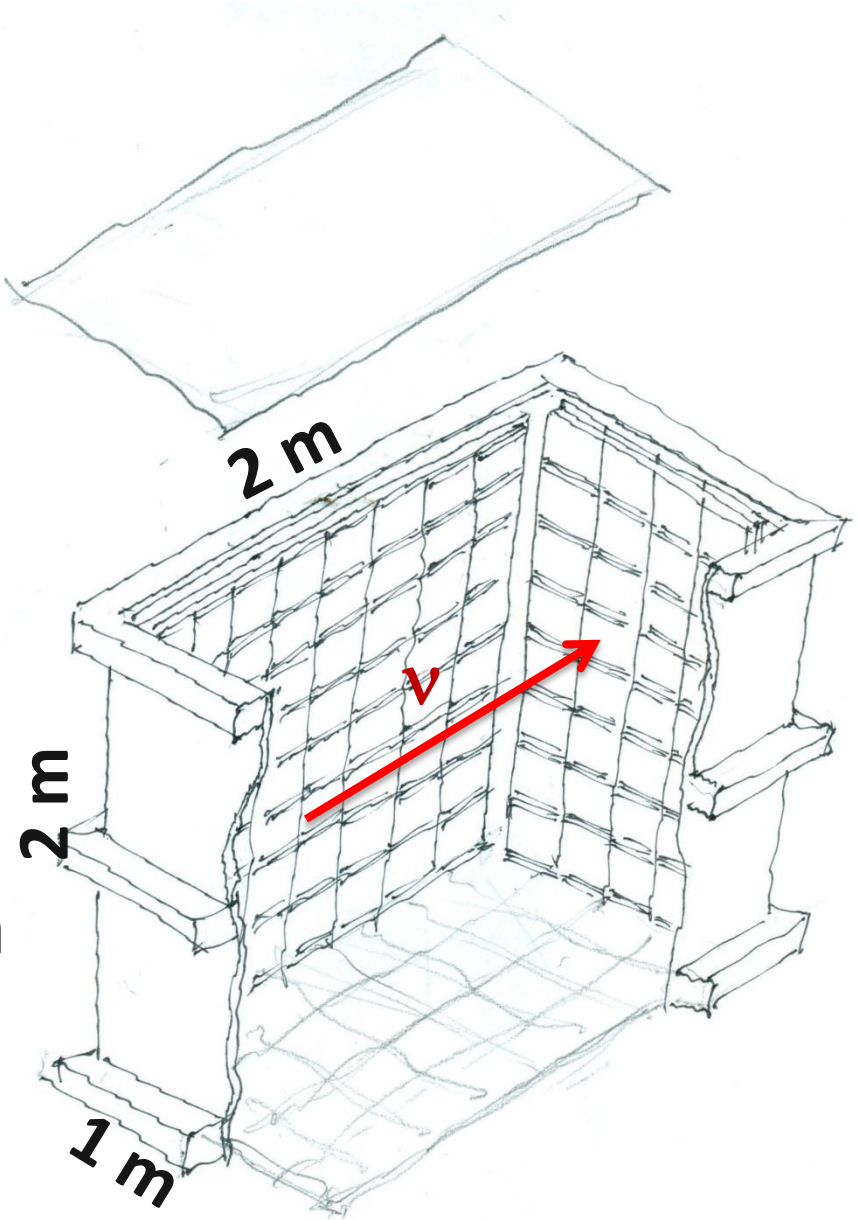
We drift photons- good time resolution would buy nothing if one integrated over a whole (blue) TPC sector- ie didn't correlate *when* and *where*

Same holds with water cherenkov-see matt's talk

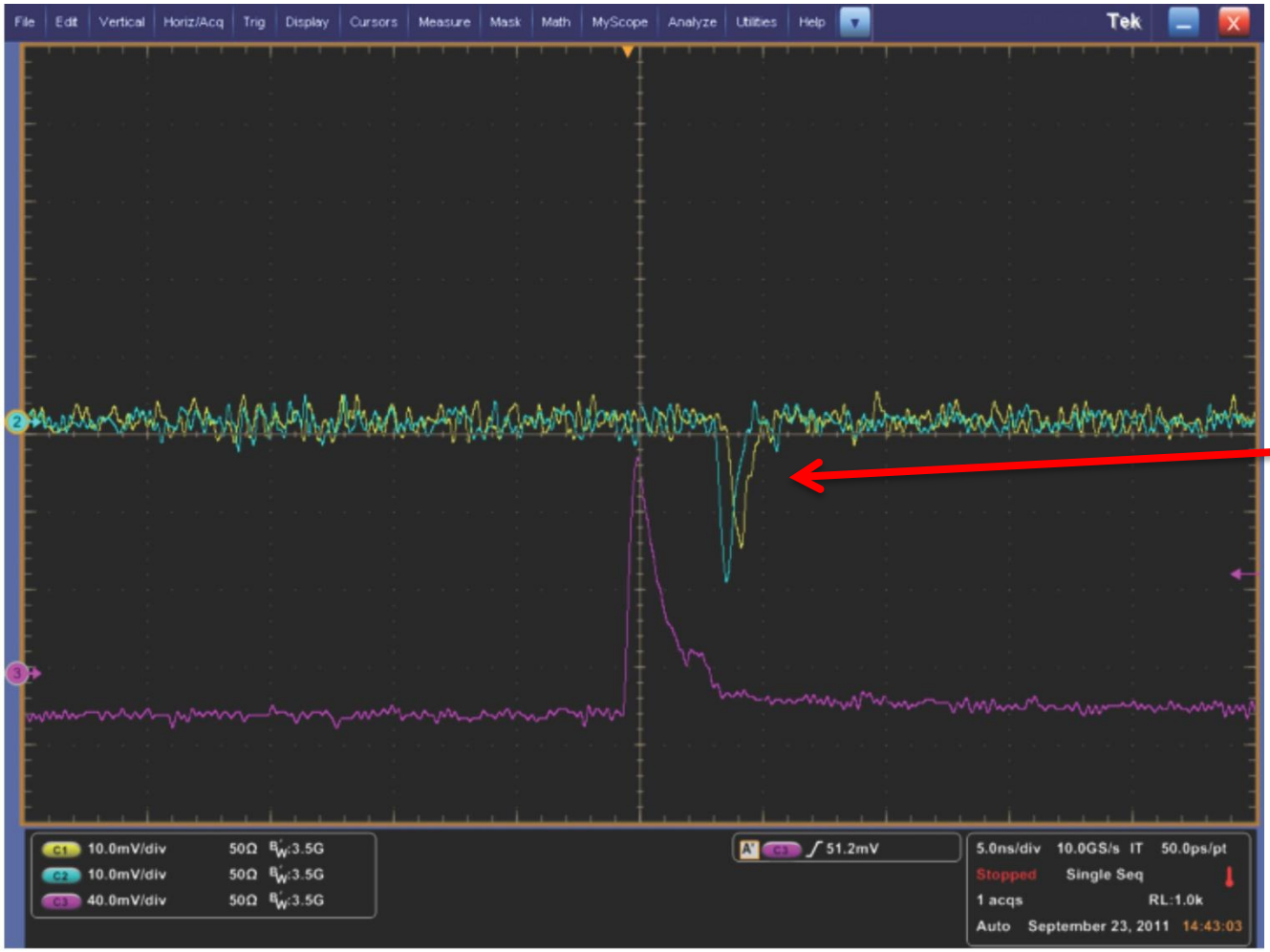
Daniel Boone

- **Proposal (LDRD) to build a little proto-type to test photon-TPC ideas and as a simulation testbed**
- **`Book-on-end' geometry- long, higher than wide**
- **Close to 100% coverage so bigger Fid/Tot volume**
- **$\Delta x, \Delta y << 1$ cm**
- **$\Delta t < 100$ psec**
- **Idea: to reconstruct vertices, tracks, events as in a TPC (or, as in LiA).**

See Matt's talk tomorrow



The End



Pulses from the 2 ends of an 8" anode strip

BACKUP SLIDES