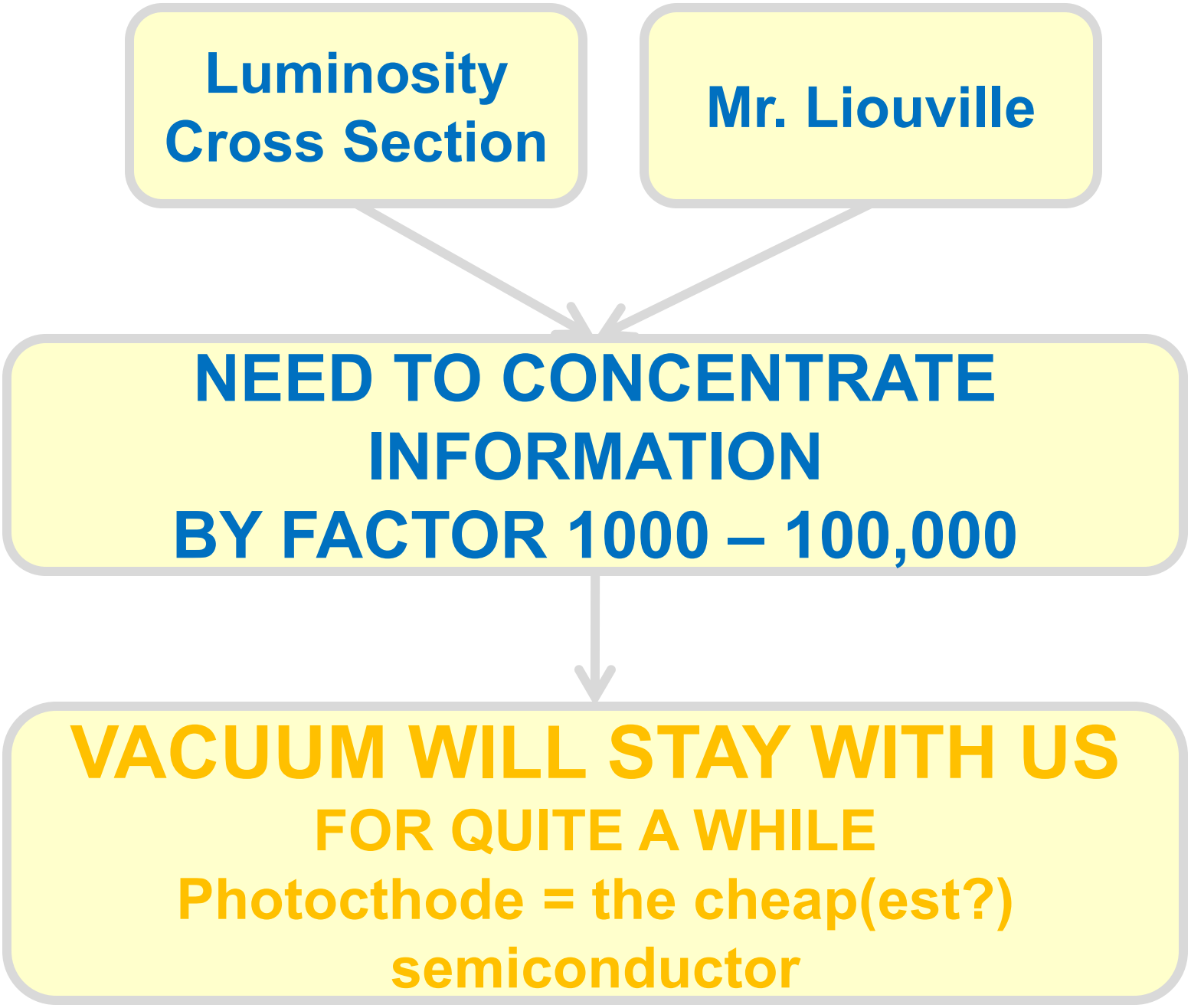
- Motivation
- A glimpse of the (long) History of ABALONE
- Prototyping:
  FACTORY PROTOTYPE
  vs.
  PROTOTYPE FACTORY

  NOW:
  our factory prototype = prototype factory
- First Prototype Assembly

Collaborators

- Eckart Lorenz
- UC Davis: D. Ferenc, A. Chang, D. Johnson, J. Thomson
  (simulations, overall design, assembly, components, patent protection)
- U Wisconsin (since March 2011):: T. Montaruli. M. Duvernois, I. Wischer, K. Jero
  (GEANT, readout, components)
- U. of Split and Rijeka: D. Ferenc, D. Dominis, I. Puljak, N. Godinovic
  (transport system design and manufacture, simulations, readout)


Luminosity
Cross Section
Mr. Liouville
NEED TO CONCENTRATE
INFORMATION
BY FACTOR 1000 – 100,000
VACUUM WILL STAY WITH US
FOR QUITE A WHILE
Photocthode = the cheap(est?)
semiconductor

ABALONE

NOVEL MASS-PRODUCTION TECHNOLOGY

and a novel design that allows full implementation of that technology

→PATENT PENDING

& LOTS OF KNOW-HOW

Will reveal all secrets !

ABALONE

NOVEL MASS-PRODUCTION TECHNOLOGY

and a novel design that allows full implementation of that technology

→PATENT PENDING
& LOTS OF KNOW-HOW

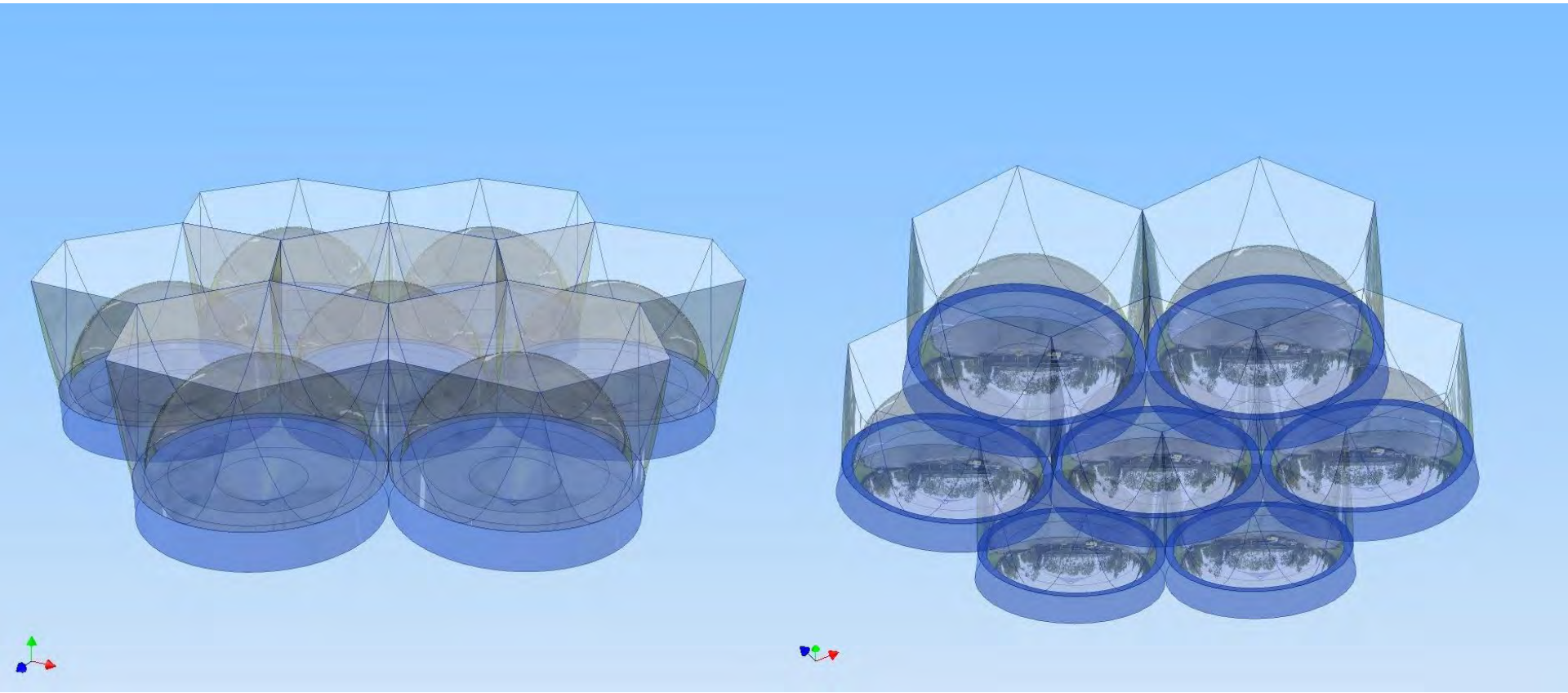
Will reveal all secrets !

The day after other companies do so.

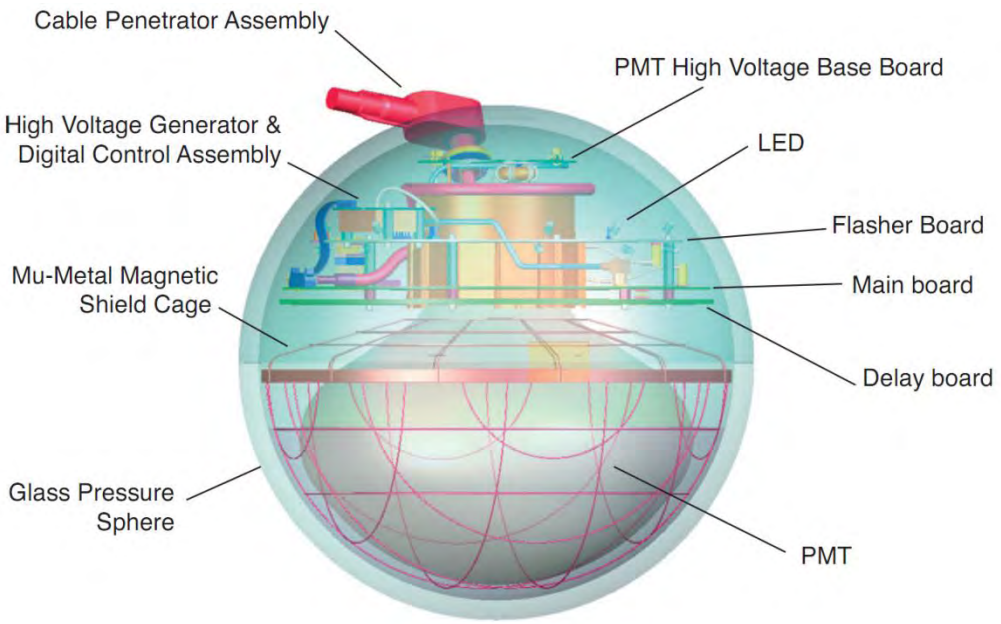
ABALONE

as a
FLAT PANEL PHOTOSENSOR WITHOUT DEAD AREA

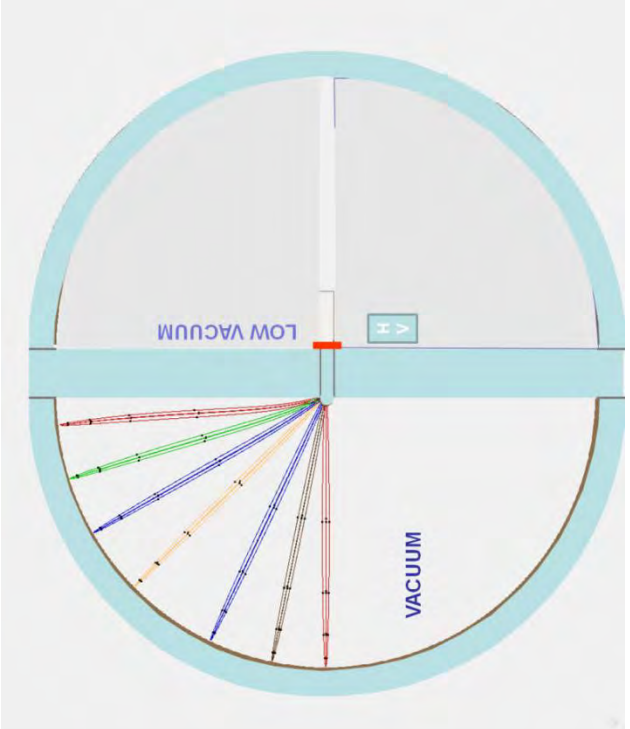
ARRAYS OF
“hex-paraboloid-hemispheres”



IceCube OPTICAL MODULE



ABALONE

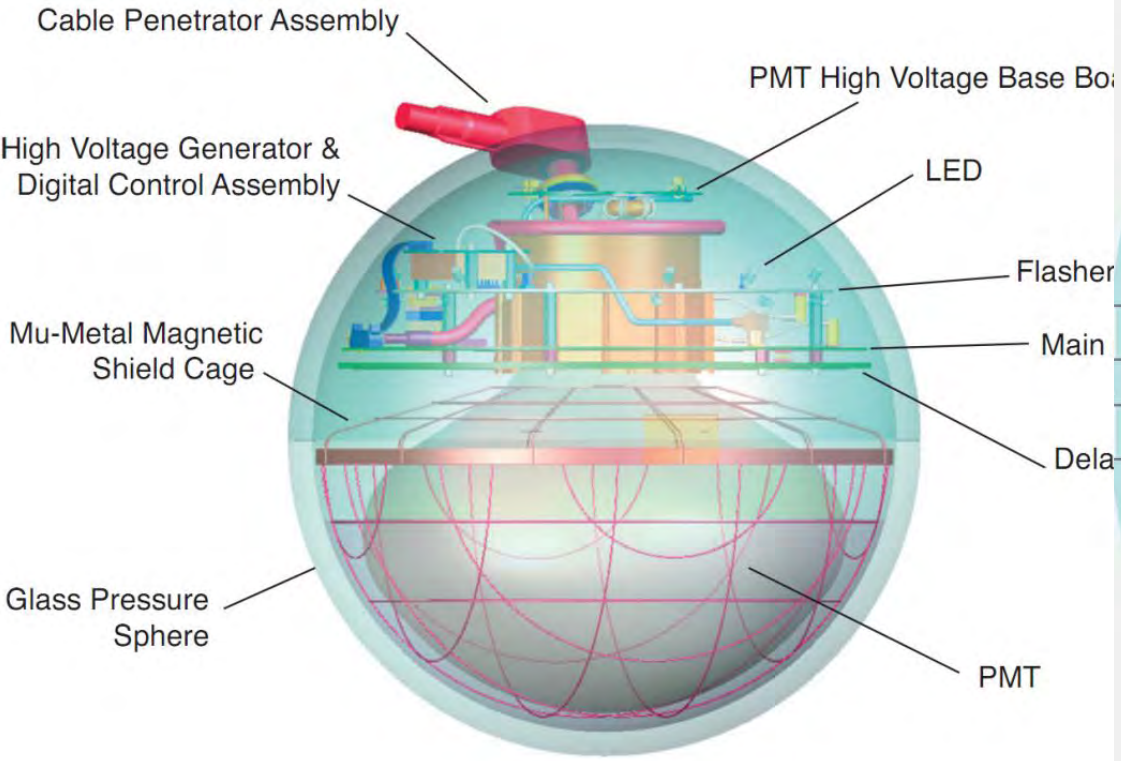


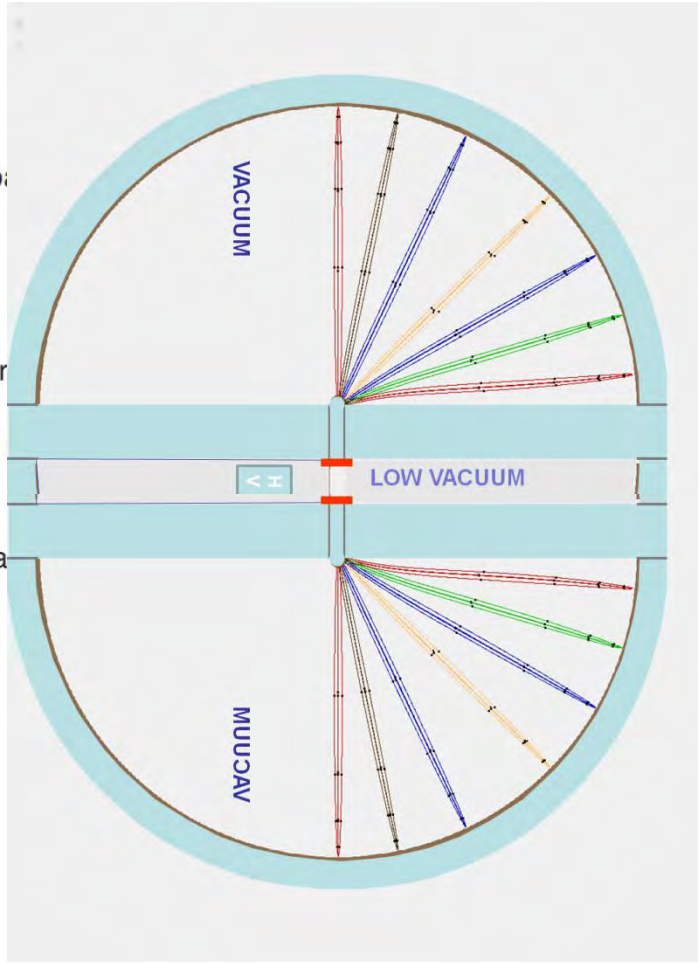
NO PMT !!!

NO DYNODES
NO VOLTAGE DIVIDER
NO ELECTRODES
NO uMETAL
~NO *MANU*-FACTURE
MASS-PRODUCTION, SCALLABLE
EXTREME ROBUSTNESS (mech, el.)
~100% COLLECTION EFFICIENCY
etc.

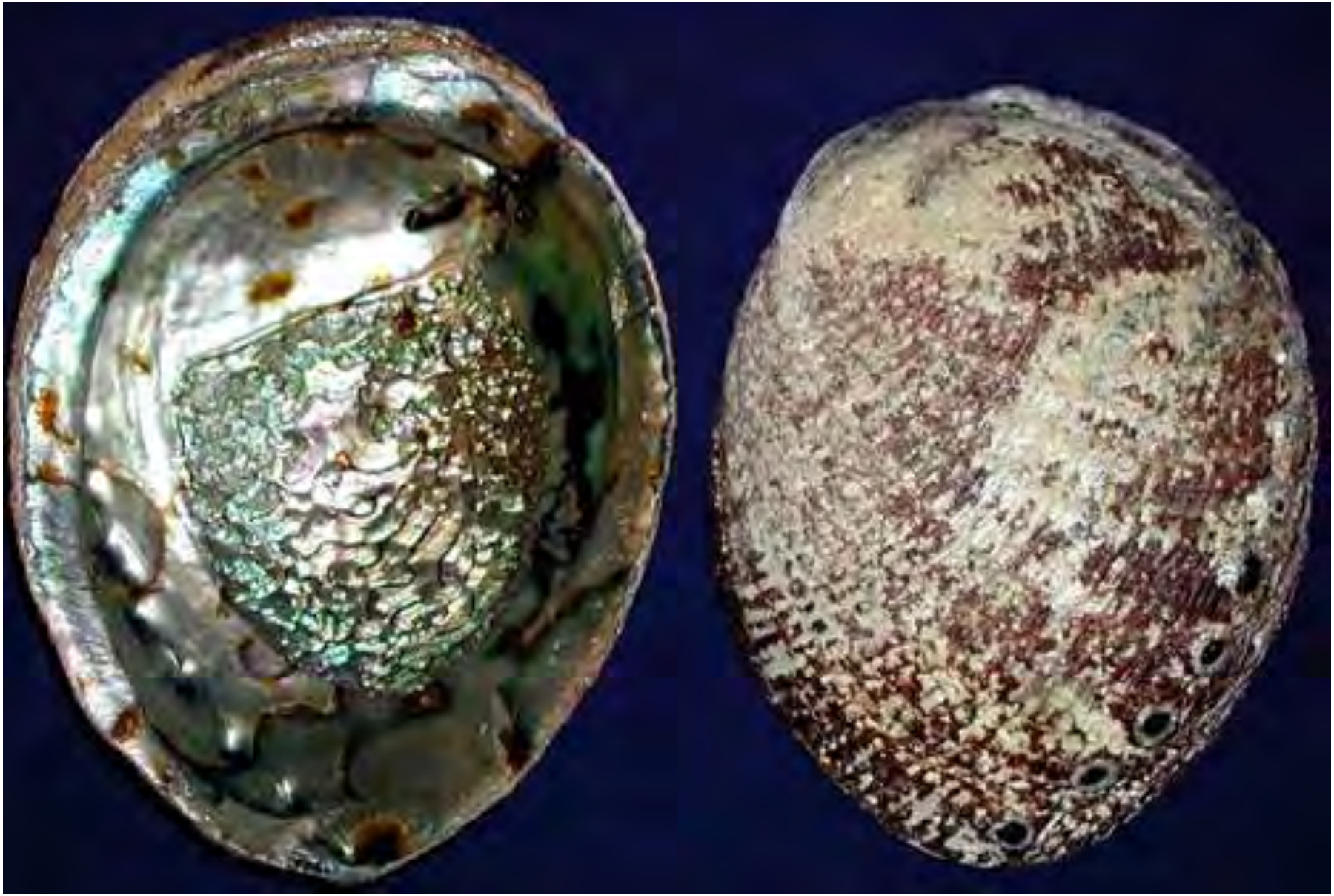
IceCube OPTICAL MODULE

The 4-PI ABALONE IceCube DREAM





ABALONE

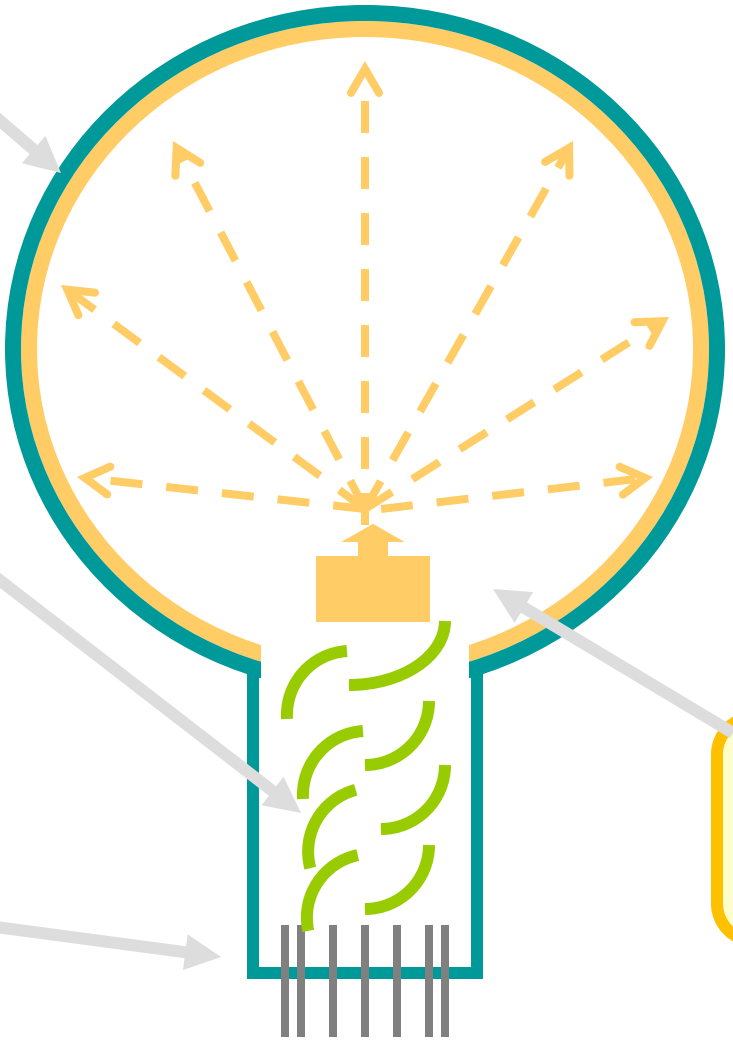


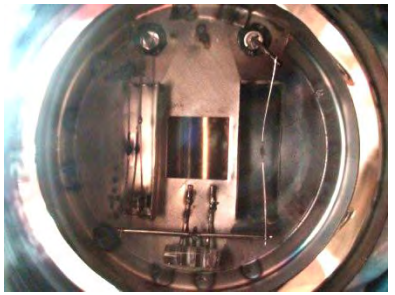
PMTs – 1960's Technology

Bulb
~handmade

Dynodes
~handmade

Feedthroughs
= 'ugly'





Cs, K, Na, Sb

WITH A FINE TOUCH OF A GENIUS

Development of Other Vacuum Devices

~1960

~2000

Production Cost '11 < $300/m^2

ENCLOSURE:
FLAT-PANEL TV

MAJOR MODIFICATIONS

LOOKING FORWARD FOR IMPROVEMENTS
But not critical

3 existing
mass-production technologies

PHOTON→ELECTRON CONVERSION:
CLASSICAL PHOTOCATHODE ALREADY VERY GOOD

ELECTRON DETECTION:
SEMICONDUCTOR
Scintillator + Geiger-MODE AVALANCHE DIODE
'Light Amplifier'

INFORMATION CONCENTRATOR

TOM YPSILANTIS et al.,
AQUARICH CONCEPT (also development for LHCb)

~1997

VERY FAR FROM BEING „MNIMALISTIC"

D.F., Imaging Hybrid Photon Detectors with Minimized Dead Area and Protection Against Positive Ion Feedback. Nuclear Instruments and Methods in Physics Research A431(1999)460-

ELSEVIER

Nuclear Instruments and Methods in Physics Research A 431 (1999) 460–475

NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH Section A

www.elsevier.nl/locate/nima

Imaging hybrid photon detectors with minimized dead area and protection against positive ion feedback

Daniel Ferenc*

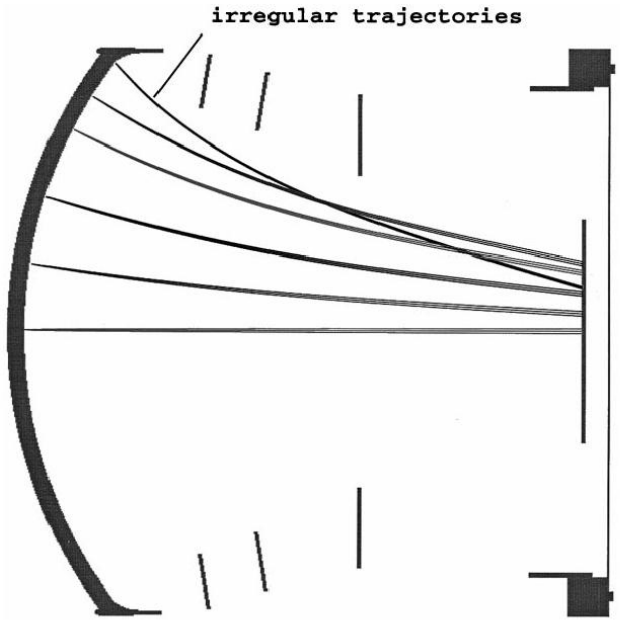
Div. PPE, CERN, 1211-Geneva, 23 Switzerland

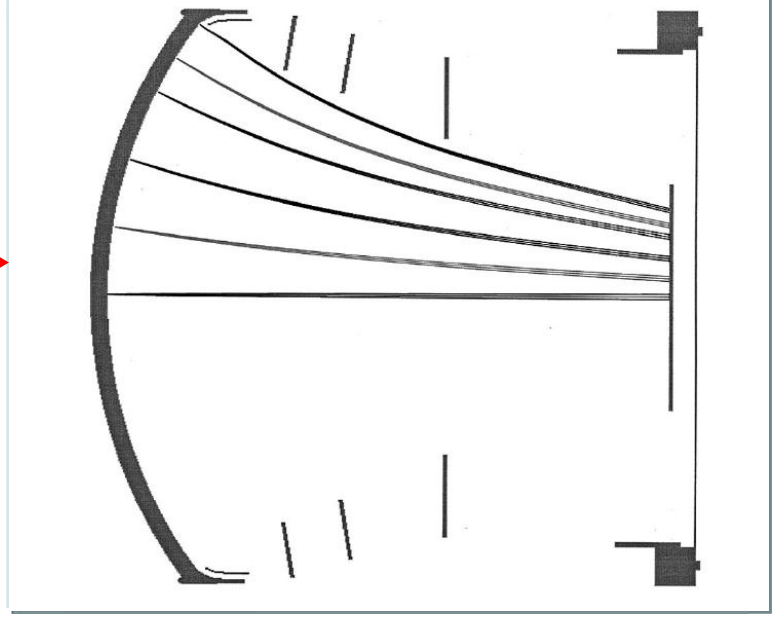
Received 15 December 1998

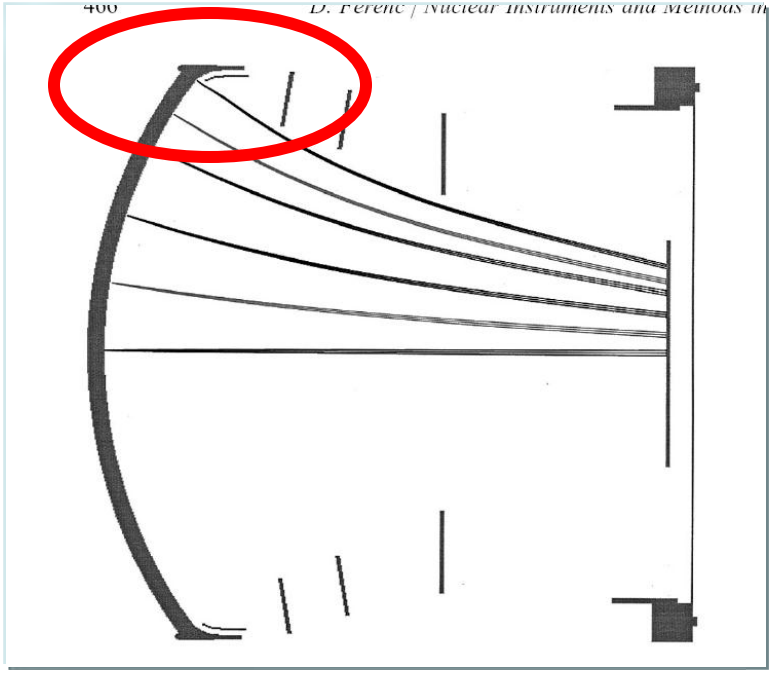
Abstract

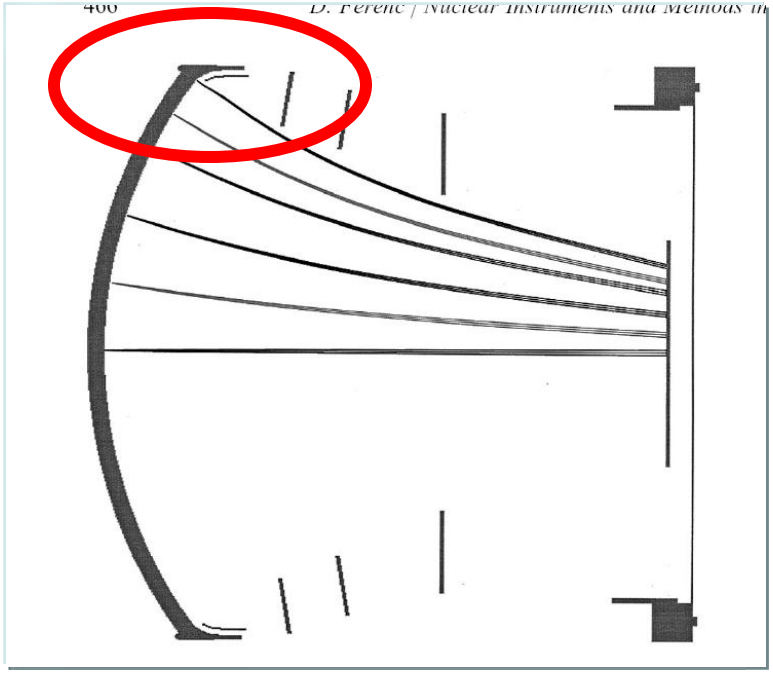
Imaging Hybrid Photon Detectors (HPD) have been developed for integration in large area Cherenkov detectors for high-energy physics and astrophysics. The presented designs – developed particularly for the experiments MAGIC, LHCb and AQUA-RICH – comprise very good imaging properties, protection against positive ion feedback and(or) minimum dead area. The underlying innovations are discussed in some detail.

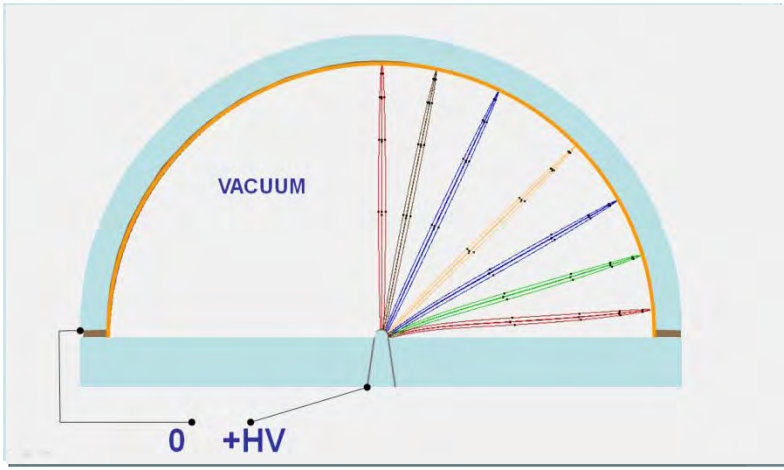
Keywords: Ion feedback; Dead area; RICH detectors; Atmospheric Cherenkov telescopes; Photon detectors; Gamma ray astronomy; High-energy physics

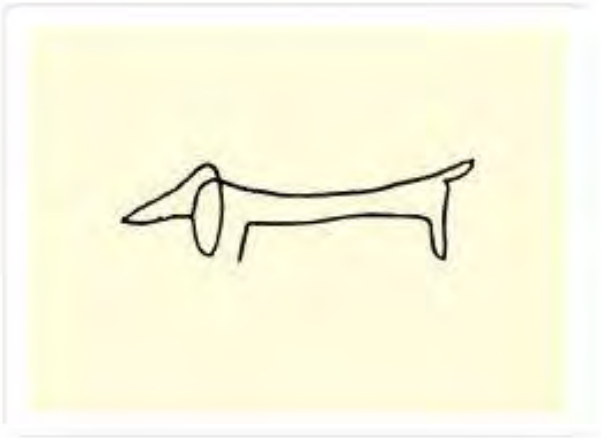


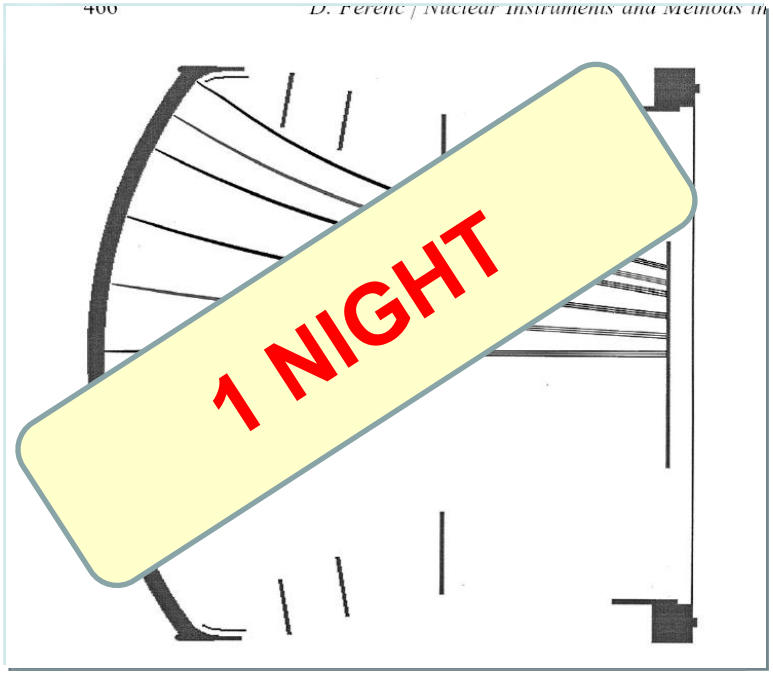


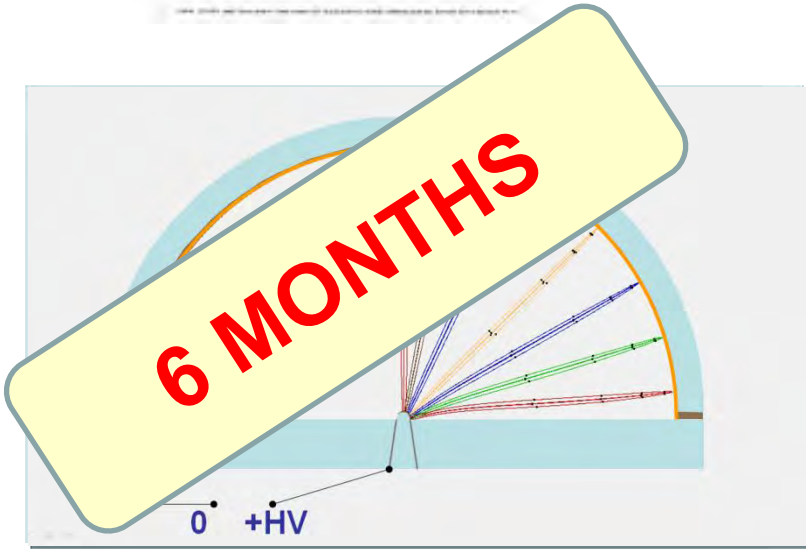


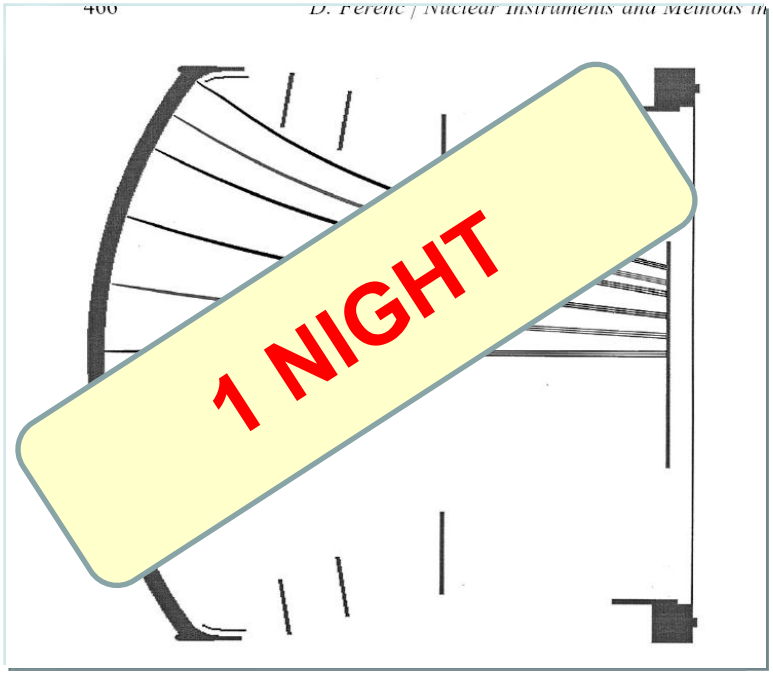



VACUUM
0
+HV



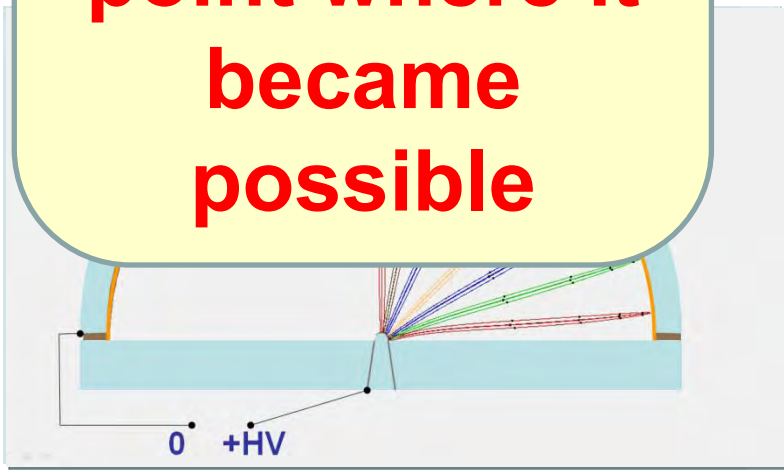

1 NIGHT


6 MONTHS
0
+HV



6 MONTHS

+10 years it took us to reach the technological point where it became possible

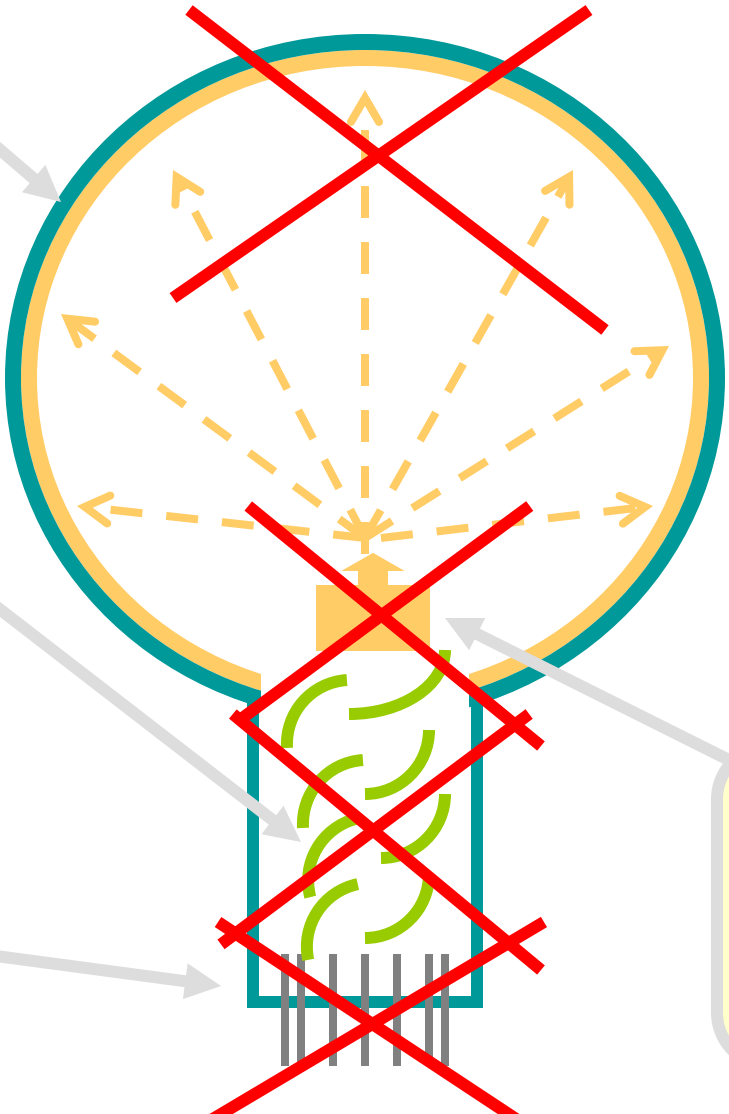


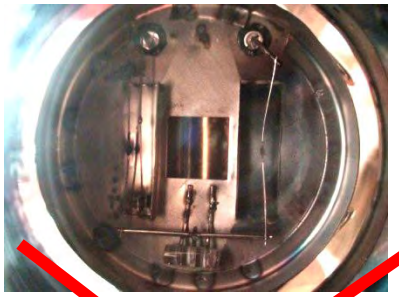
MASS-PRODUCTION TECHNOLOGY

Bulb
~handmade

Dynodes
~handmade

Feedthroughs





Cs, K, Na, Sb
Remain inside
the PMT

MASS-PRODUCTION TECHNOLOGY

The KEY:

VACUUM PROCESSING

- MINIMUM # OF MASS-PRODUCED (MOLDED) GLASS ELEMENTS (3)
- ASSEMBLY
  - CONTINUOUS VACUUM PRODUCTION LINE
  - SUPER-SIMPLE
  - SUPER-FAST
  - SUPER-CHEAP (FACTOR 20 less than PMT)

➔ NO METAL ELEMENTS ←

➔ NO CERAMICS←

→ ABALONE

MASS-PRODUCTION TECHNOLOGY

The KEY:

VACUUM PROC

- MINIMUM # OF MASS-PRO)
  GLASS ELEMENTS (3)
- ASSEMBLY
  - CONTINUOU UCTION LINE
  - SUPER-S
  - SUPE
  - SU TOR 20 less than PMT)

L ELEMENTS ←

O CERAMICS←

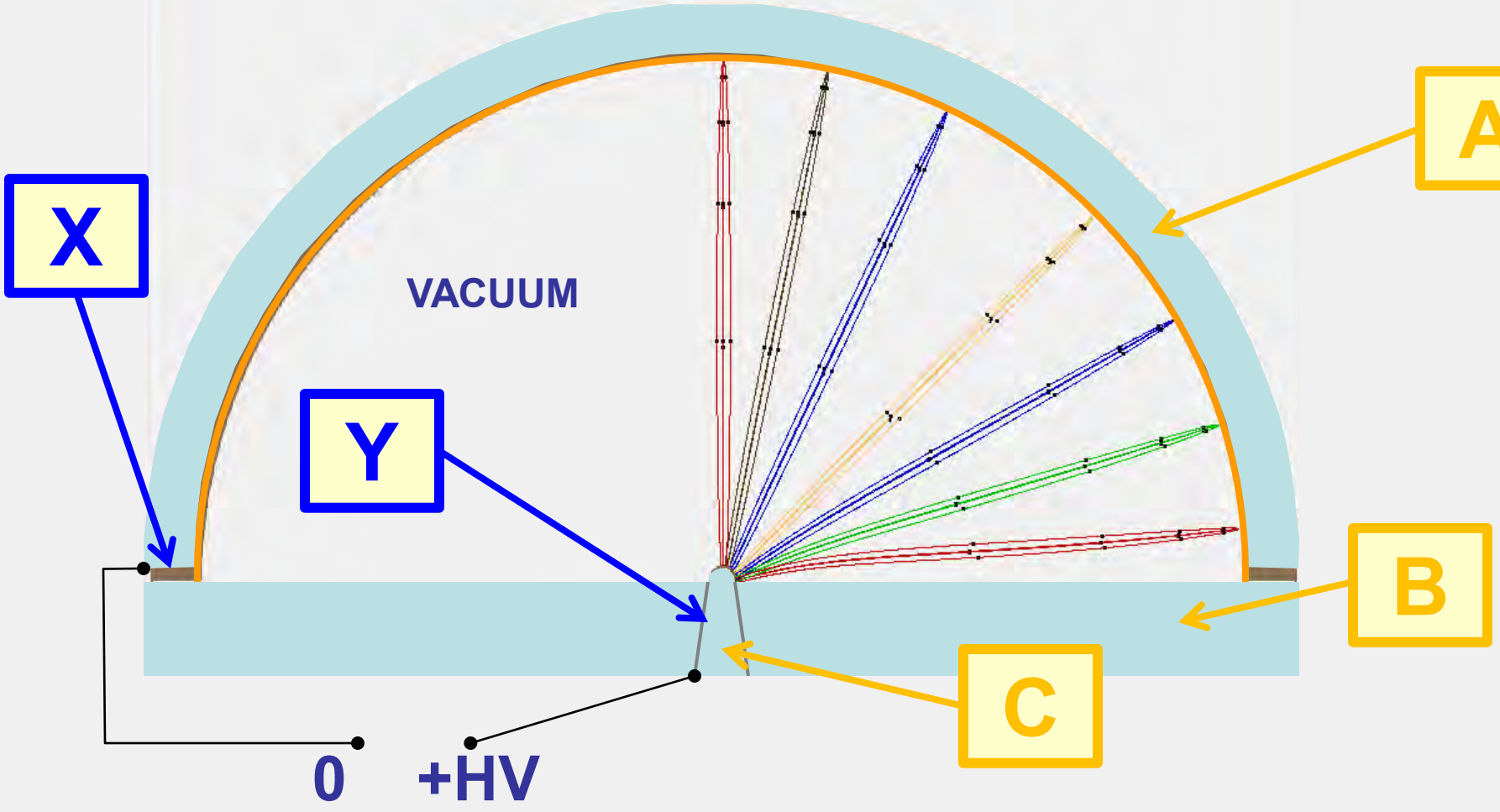
HOW IS THAT POSSIBLE ?

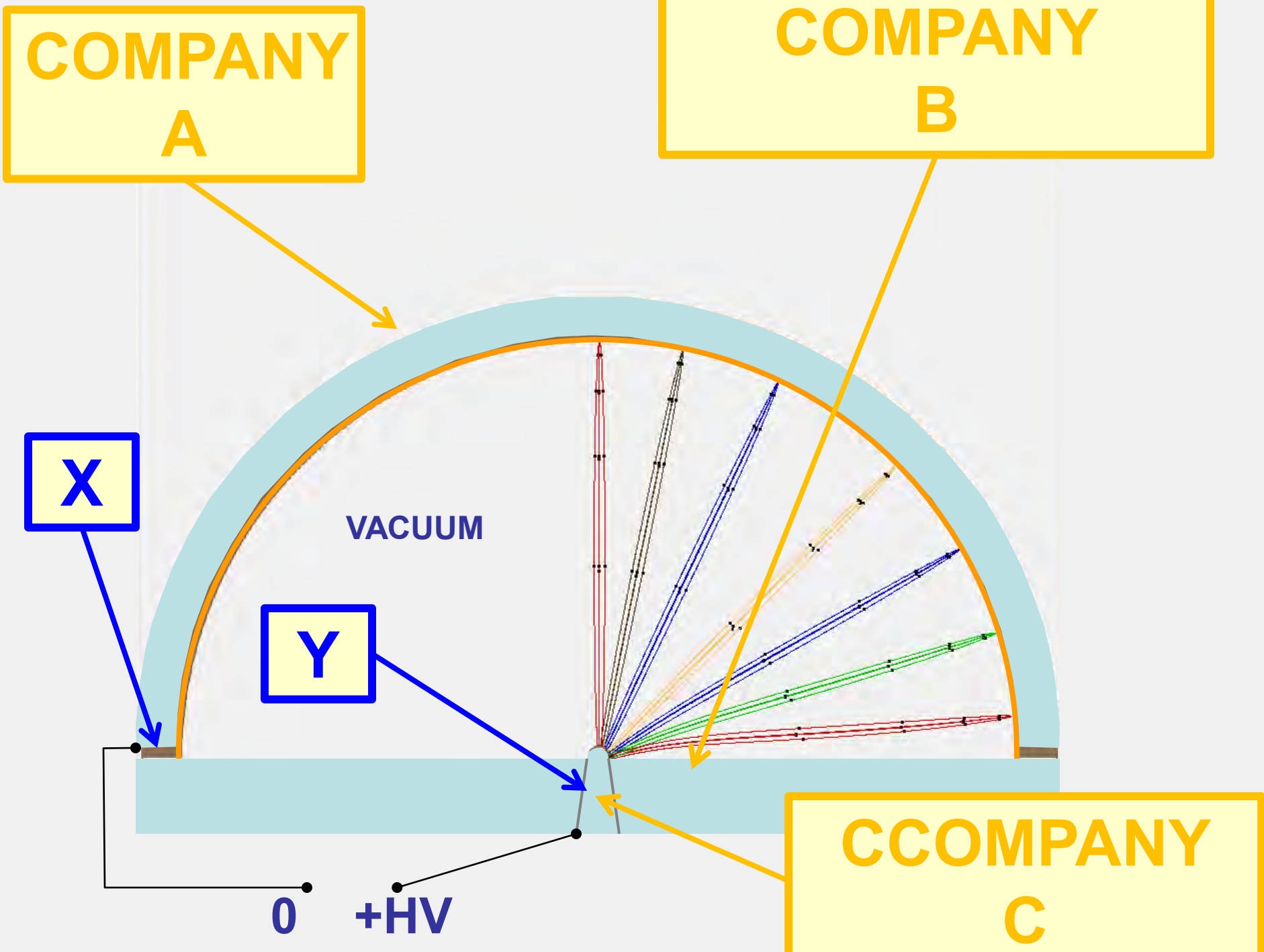
→ ABALONE

THE ABALONE VACUUM ASSEMBLY

1. **ONLY 3** MOLDED GLASS ELEMENTS: A, B, C
2. SEALED TOGETHER AT ONCE, DIRECTLY → GLASS-TO-GLASS WITH OUR OXIDE-FREE METHOD

   → **ONLY 2** ULTRATHIN SEALING SURFACES: X, Y
3. X & Y = **THE ONLY 2** ELECRICAL CONNECTIONS (GND and HV)



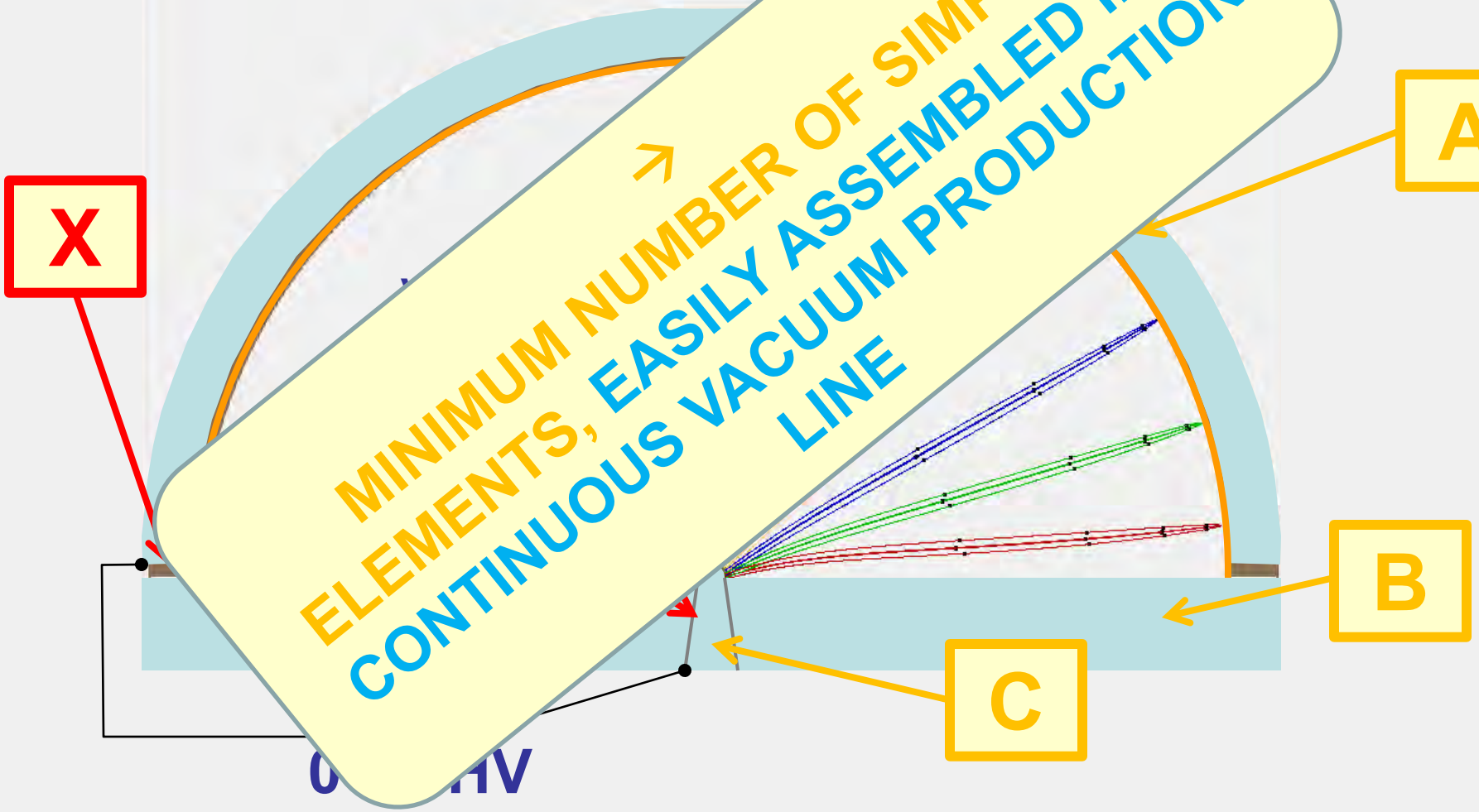

COMPANY
A
COMPANY
B
X
VACUUM
Y
0
+HV
CCOMPANY
C

THE ABALONE VACUUM ASSEMBLY

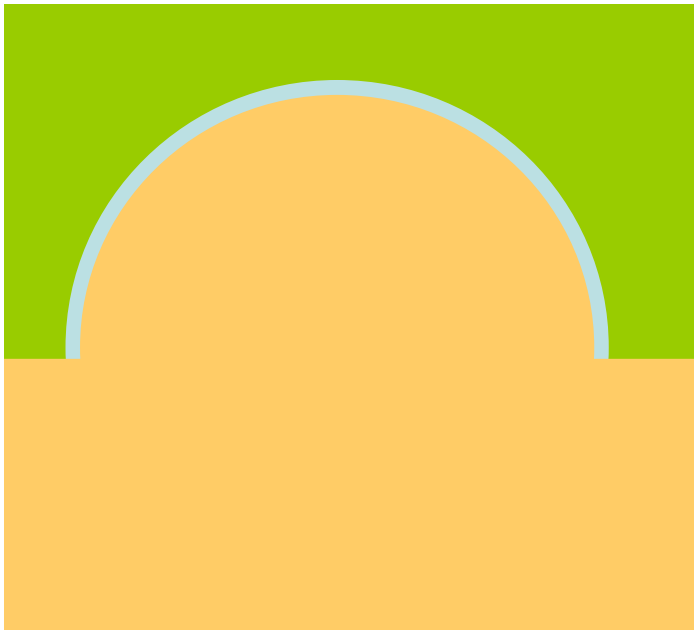
1. ONLY 3 MOLDED GLASS ELEMENTS: A, B, C
2. SEALED TOGETHER AT ONCE, DIRECTLY → GLASS-TO SS WITH OUR OXIDE-FREE METHOD

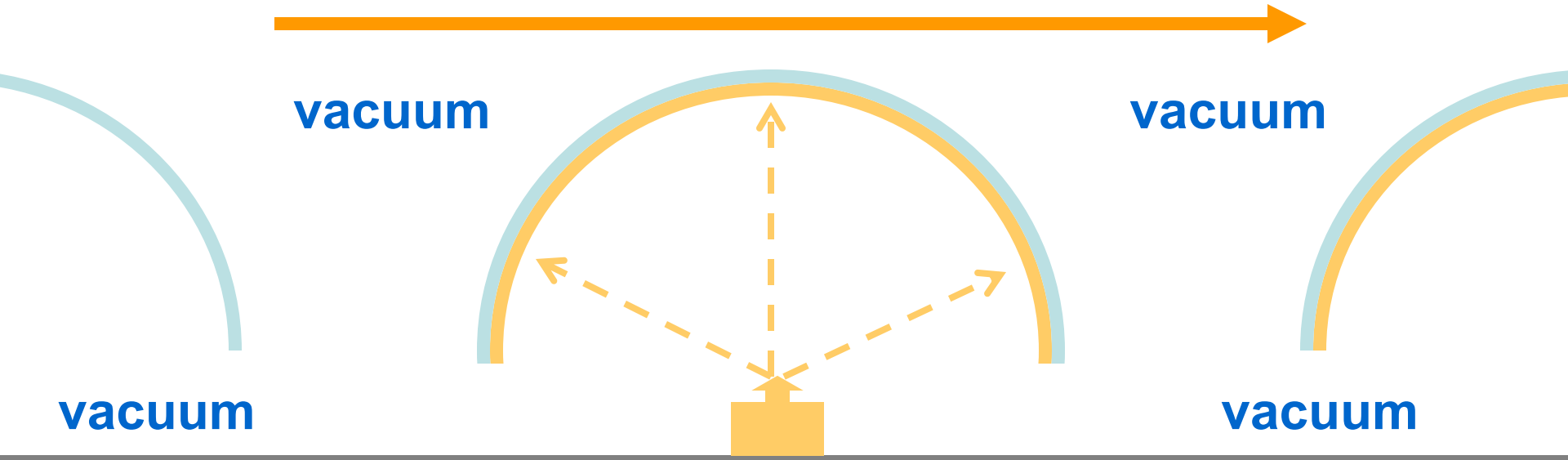
   → ONLY 2 ULTRATHIN SEALING SURFACES
3. X & Y = THE ONLY 2 ELECRICAL HV)

→ MINIMUM NUMBER OF SIMPLE ELEMENTS, EASILY ASSEMBLED IN A CONTINUOUS VACUUM PRODUCTION LINE



MASS-PRODUCTION - 1
COMPRESSION MOLDING





MASS-PRODUCTION - 2

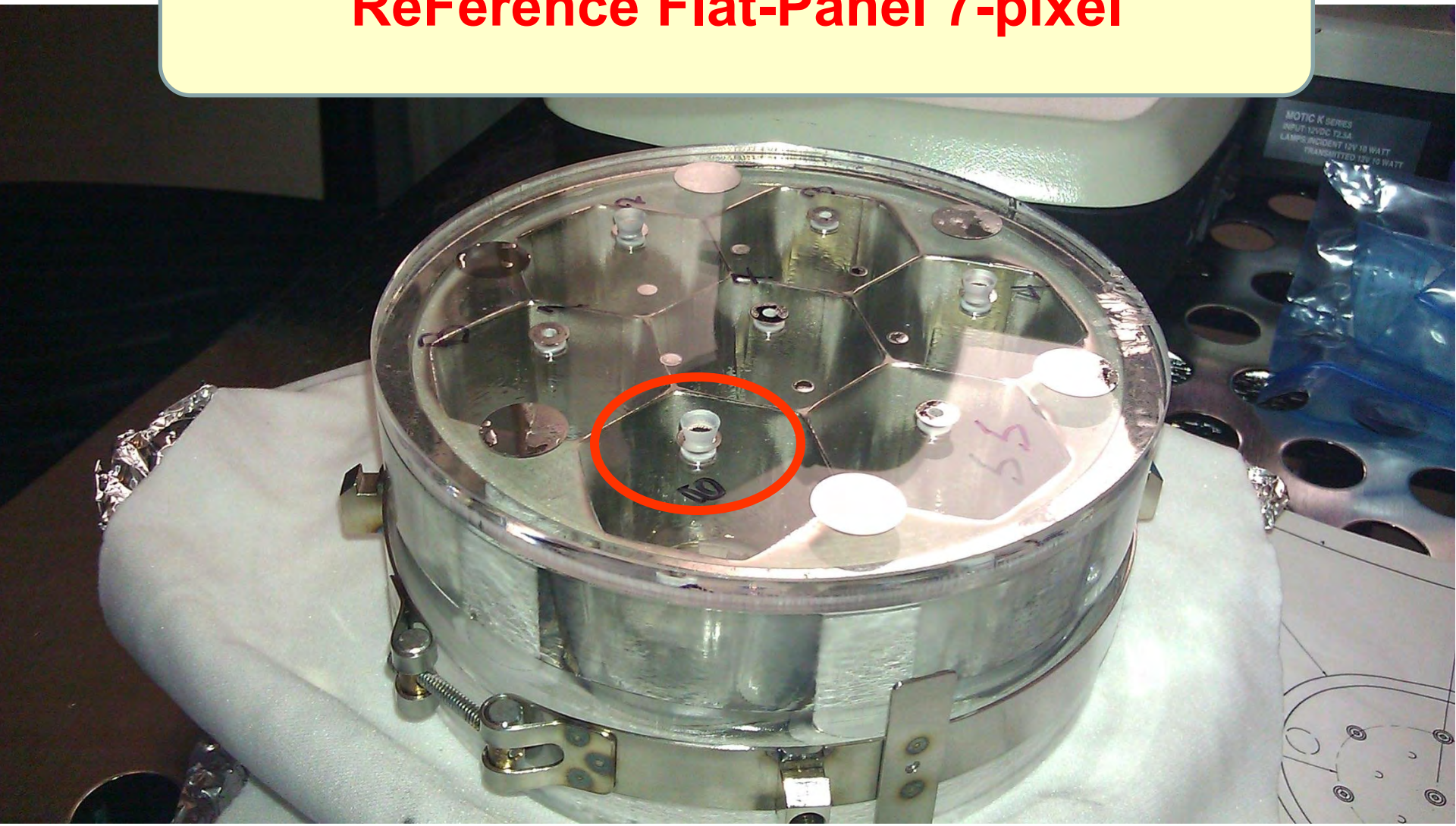
CONTINUOUS VACUUM PRODUCTION LINE – MINI-PROTOTYPE FACTORY EXISTS @ UCD !!!

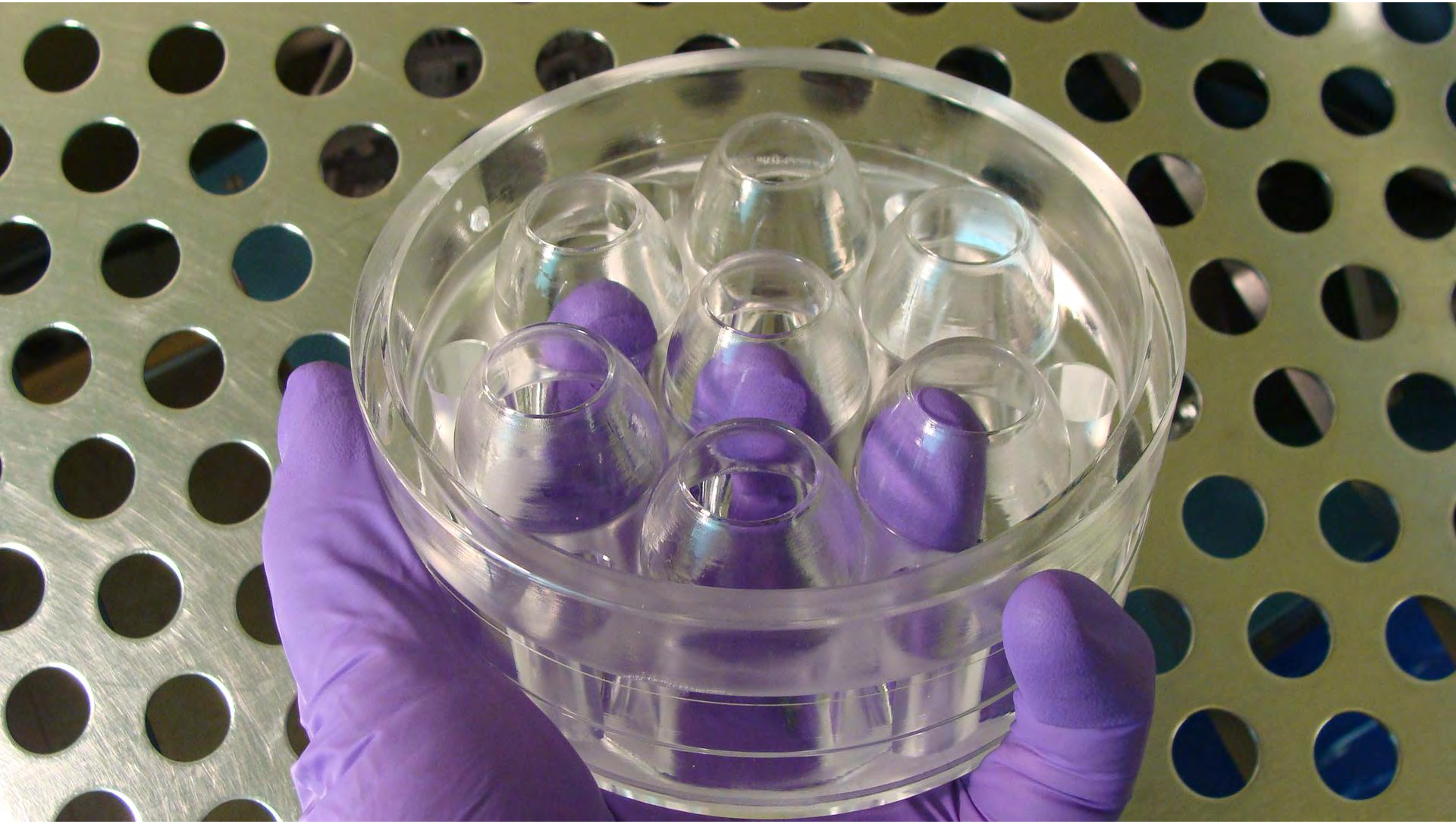
ULTRAFAST, FULLY CONTROLLED :

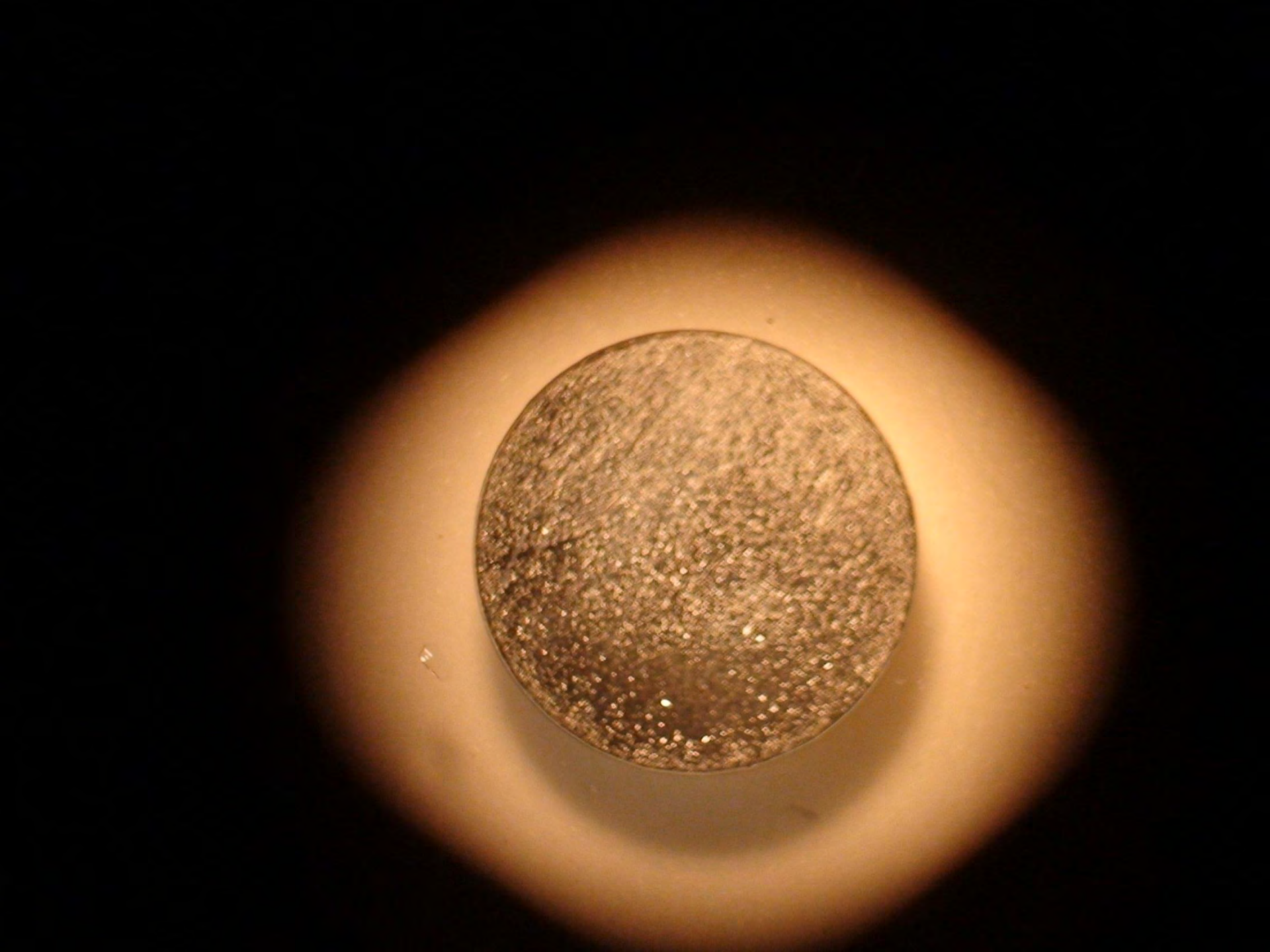
THIN-FILM MATERIAL DEPOSITION

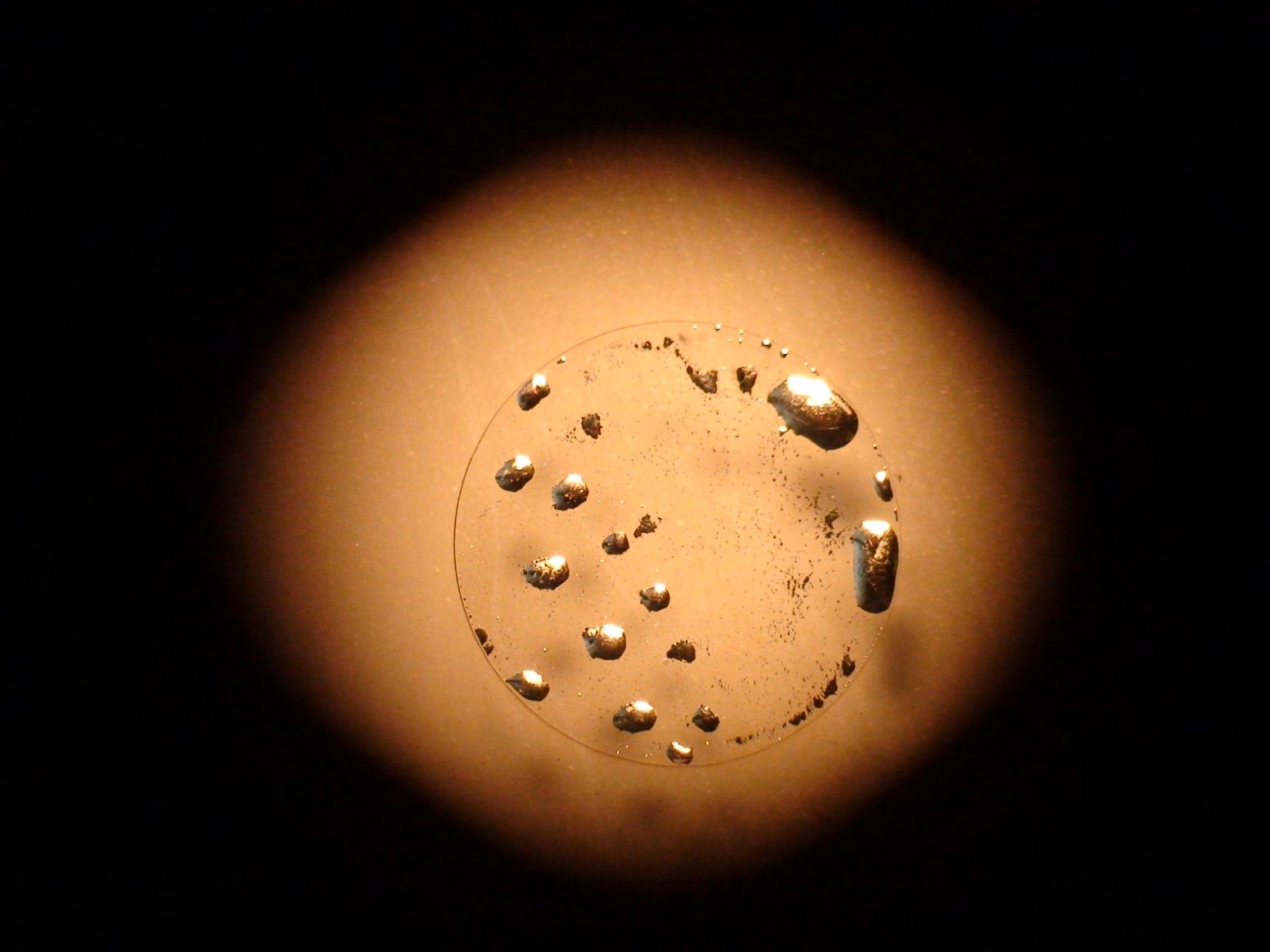
INCLUDING PHOTOCATHODE !!!!

ReFerence Flat-Panel 7-pixel









EXTREMELY IMPORTANT

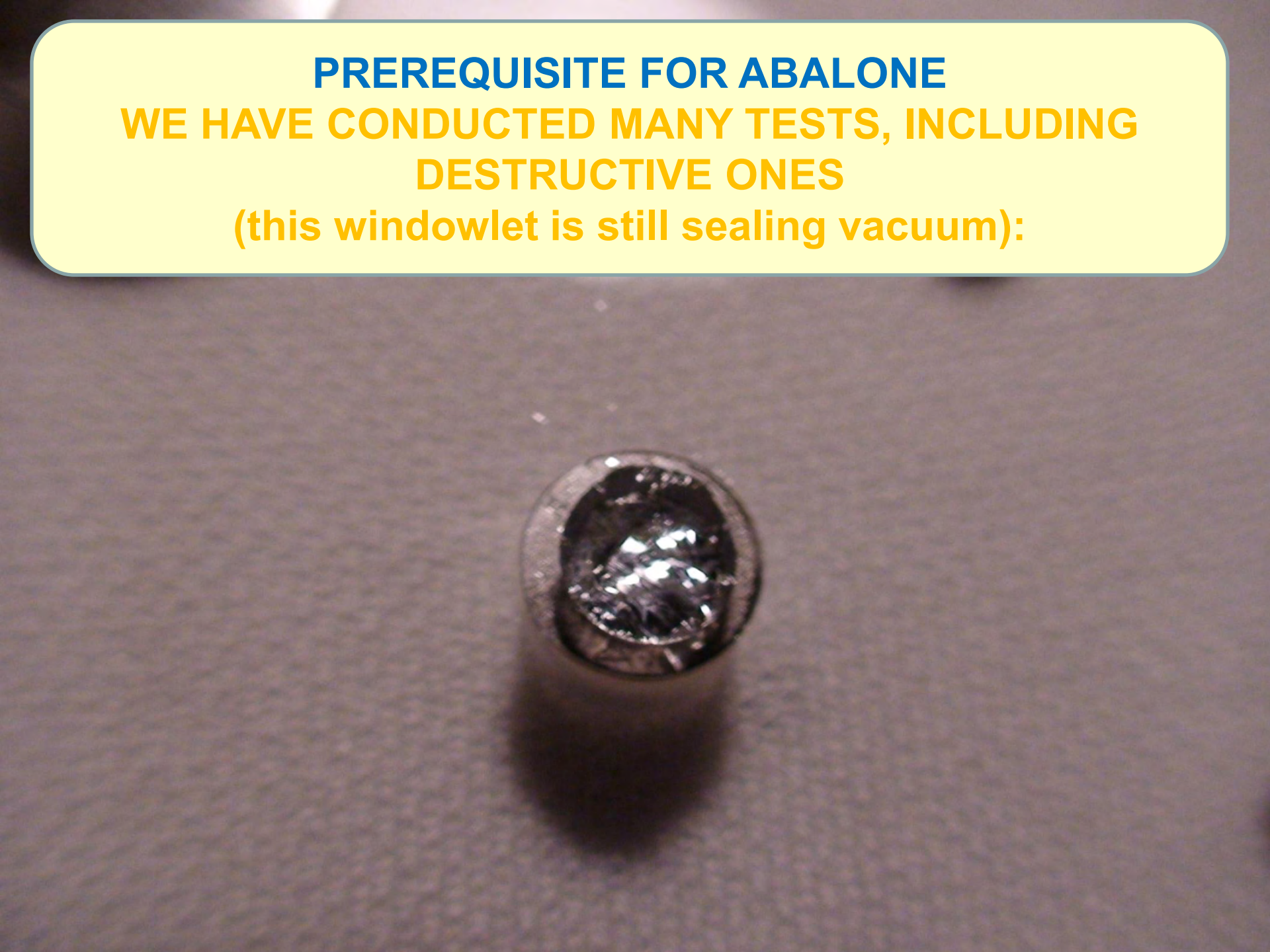
WE HAVE MASTERED THE OXIDE-FREE GLASS-TO-GLASS SEALING TECHNIQUE

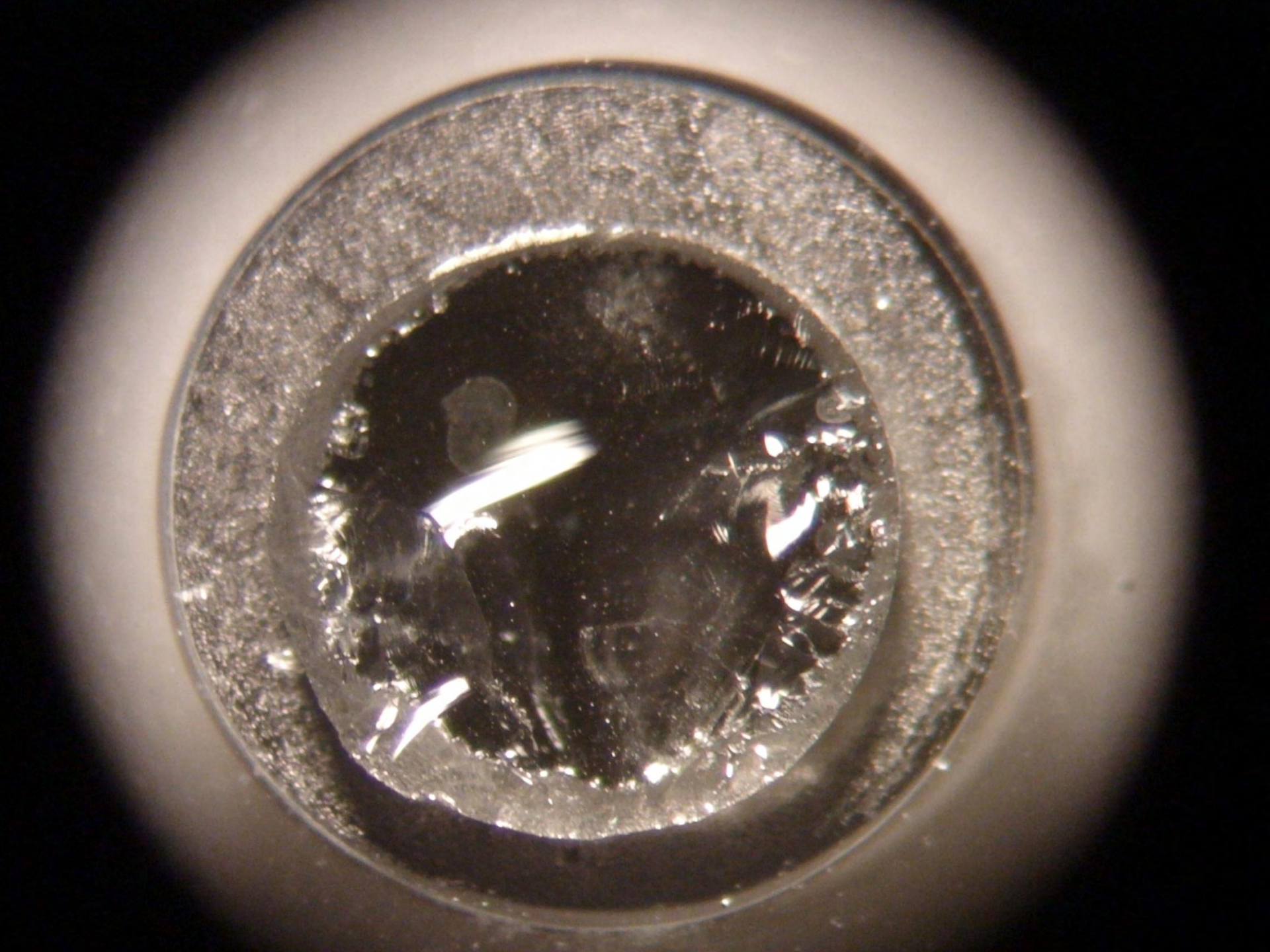
AND ON SMALL SURFACES (~2 mm)

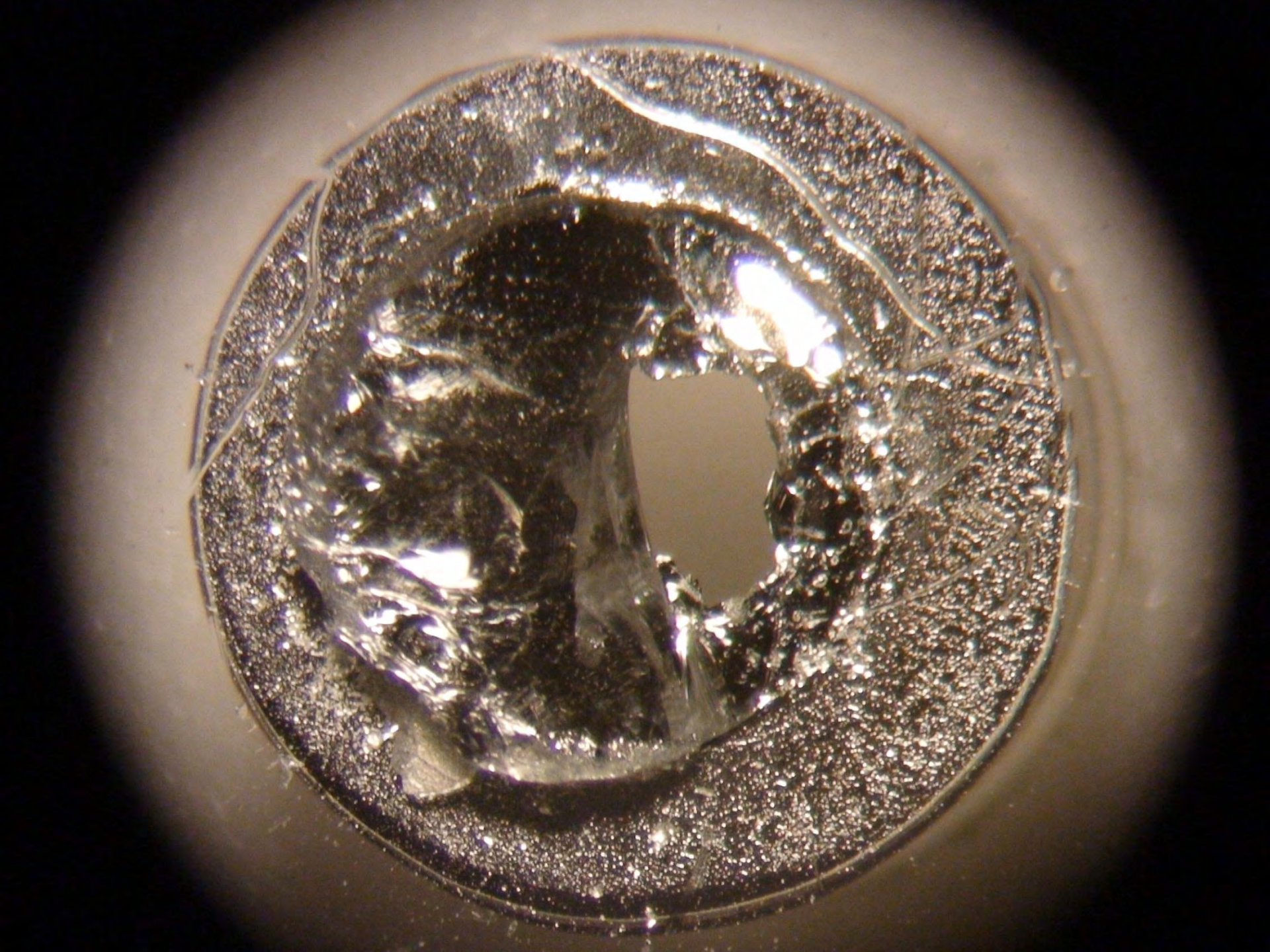
PREREQUISITE FOR ABALONE

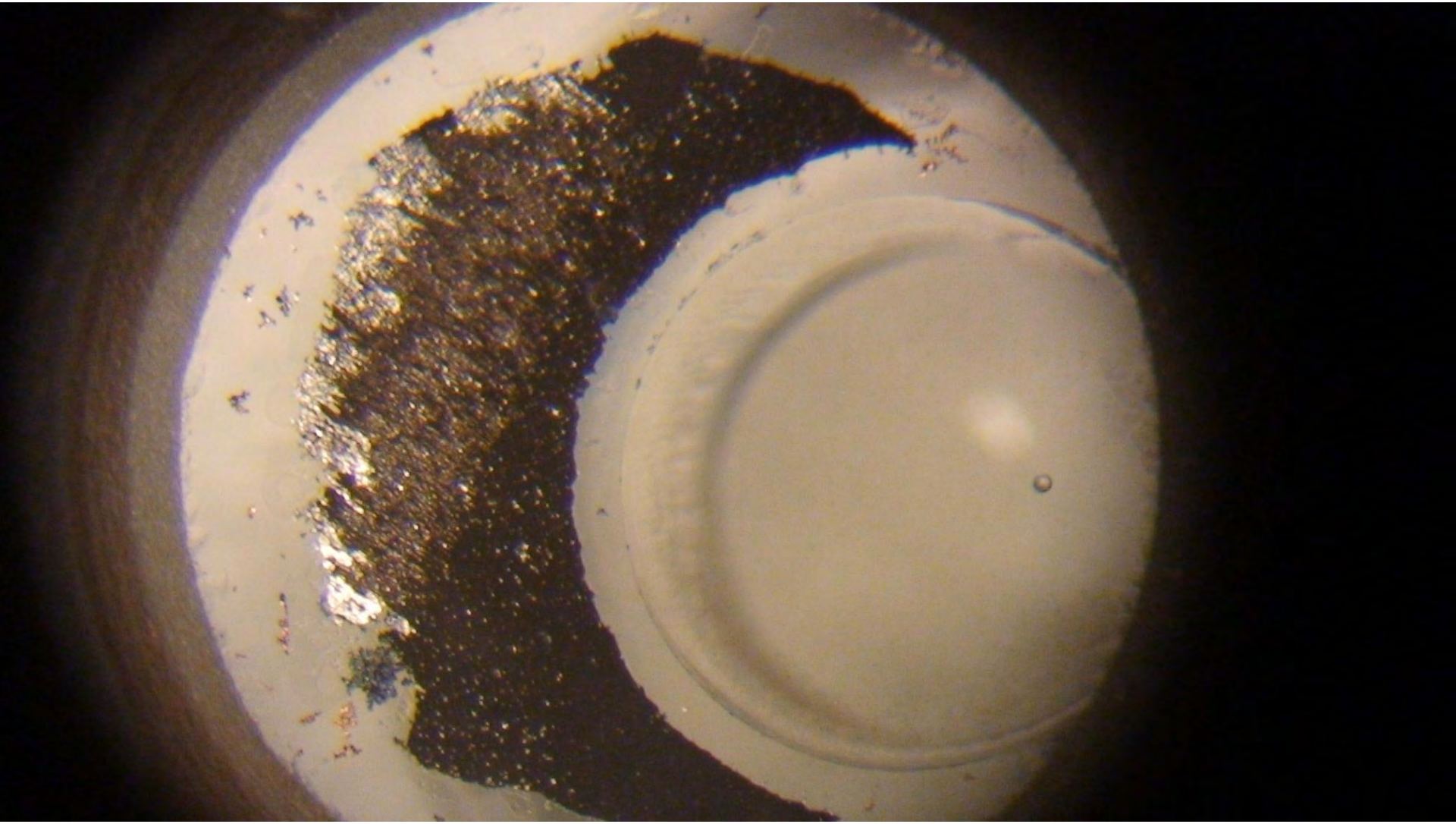
WE HAVE CONDUCTED MANY TESTS, INCLUDING DESTRUCTIVE ONES

(this windowlet is still sealing vacuum):









HAMAMATSU

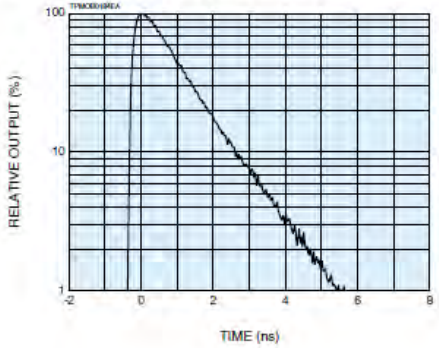
FAST DECAY PHOSPHOR J9758

For Electron Beam Detection, High Speed and Long Life Phosphor

FEATURES

- **High Speed Decay (Decay Time: 2.3 ns)**
- **Long Life**
- **High Brightness Efficiency**

Figure 1: Phosphor Decay Characteristics



APPLICATIONS

- **Semiconductor Inspection Instrument**
- **SEM (Scanning Electron Microscopy)**
- **Mass Spectrometry**
- **General Electron Detection**

SPECIFICATIONS

GENERAL

Parameter	Description/Value	Unit
Dimensional Outline Ⓐ	φ9.0 mm × 0.5 mm	—
Detection Energy Range (Electron beam)	5 to 12	keV
Decay time (90 % to 10 %) Typ.	2.3	ns
Peak Emission Wavelength	400	nm
Electrode Thickness (Aluminum)	50	nm
Operating Temperature Range	+5 to +45	°C

Ⓐ Applicable maximum size is φ50 mm.

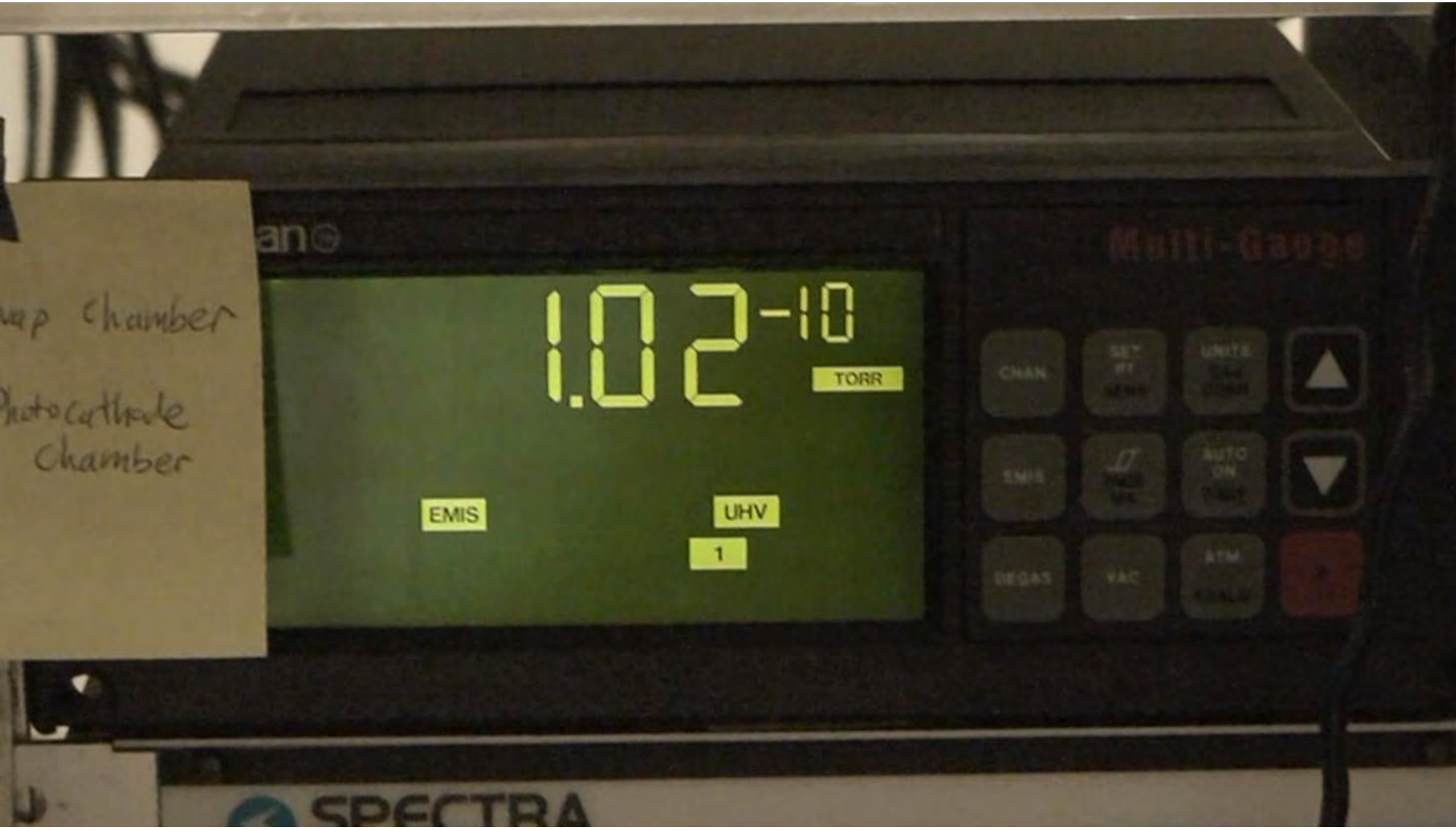
NOTE: Custom assembly of light guide or vacuum flange is available upon request.

COMPARISON OF OTHER PHOSPHOR

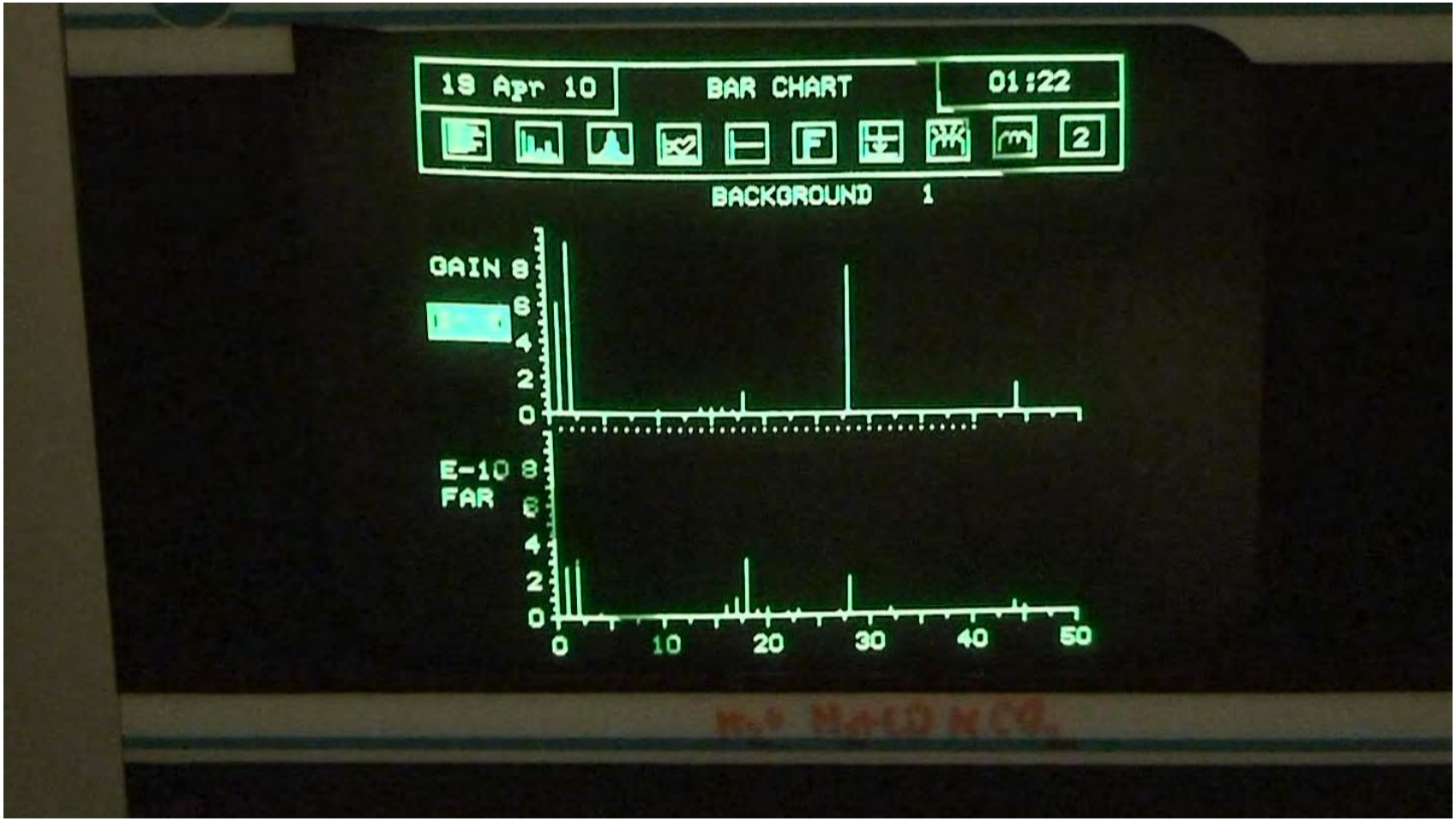
Phosphor	Decay Time (90 % to 10 %)	Relative Intensity Ⓑ (DC)	Life
Fast Decay Phosphor J9758	2.3 ns	100	Good
P47 Phosphor	100 ns	160	Good
YAP	30 ns	30	Good
Plastic Scintillator	5 ns	25	No good

Ⓑ Relative value with output from Fast Decay Phosphor J9758 set as 100, measured by HAMAMATSU Si Photodiode (S1337-BQ).

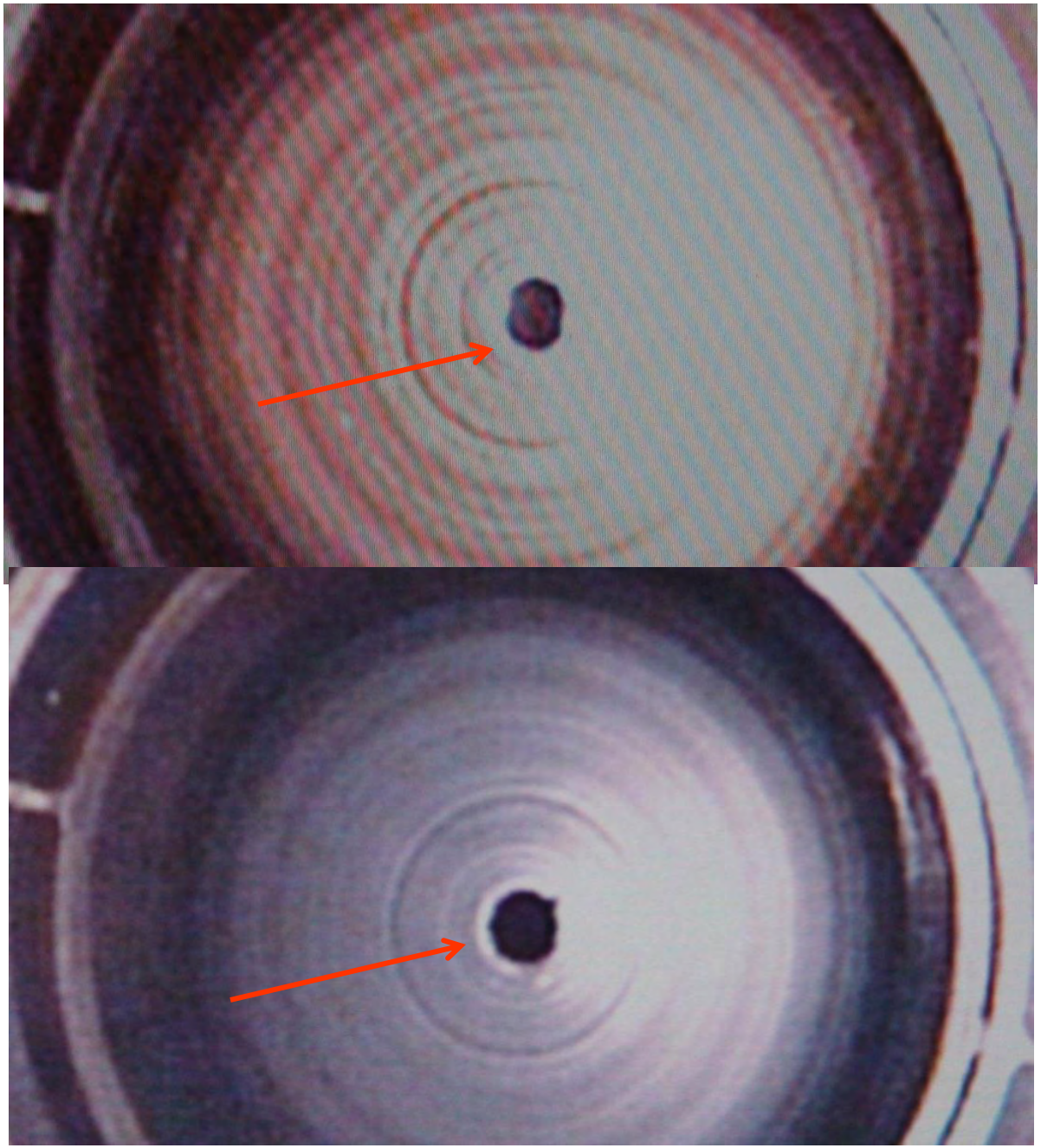
SIGNIFICANTLY UPGRADED FACTORY
SUPERB VACUUM
IN 5 UHV CHAMBERS



SUPERB CONTROL – e.g. MASS SPECTROMETERS ON EACH CHAMBER



FIRST SPINOFF



THE FUTURE OF ABALONE

- OUR COMMUNITY SHOULD RECOGNIZE THE POTENTIAL OF ABALONE AND SUPPORT IT ON ALL LEVELS

- THE ABALONE TECHNOLOGY IS
  - VERY SIMILAR TO MODERN SEMICONDUCTOR AND TV-PANEL TECHNOLOGY
  - VERY DIFFERENT FROM PMT TECHNOLOGY

- PATENT PENDING (GUARANTEE FOR INVESTORS)

- STARTUP COMPANY FORMATION UNDER WAY