• 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)
  (GEANT, readout, components)
- U. of Split and Rijeka: D. Ferenc, D. Dominis, I. Puljak, N. Godinovic
  (transport system design and manufacture, simulations, readout)
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

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.
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/m²
3 existing mass-production technologies

ENCLOSURE: FLAT-PANEL TV

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

PHOTON→ELECTRON CONVERSION: CLASSICAL PHOTOCATHODE ALREADY VERY GOOD

LOOKING FORWARD FOR IMPROVEMENTS
But not critical

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

~1997


VERY FAR FROM BEING „MINIMALISTIC“
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. © 1999 Published by Elsevier Science B.V. All rights reserved.

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

Fig. 1. Proximity focusing 5 in.-diameter HPD. Photoelectron trajectories.
6 MONTHS
+10 years it took us to reach the technological point where it became possible
Cs, K, Na, Sb
Remain inside the PMT

Bulb
≈handmade

Dynodes
≈handmade

Feedthroughs

MASS-PRODUCTION TECHNOLOGY

MASS-PRODUCTION TECHNOLOGY
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:
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NO METAL ELEMENTS
NO CERAMICS

→ 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** ELECTRICAL CONNECTIONS (GND and HV)
THE ABALONE VACUUM ASSEMBLY

1. **ONLY** 3 MOLDED GLASS ELEMENTS: A, B, C
2. SEALED TOGETHER AT ONCE, DIRECTLY \( \Rightarrow \) GLASS-TO-GLASS WITH OUR OXIDE-FREE METHOD
\( \Rightarrow \) **ONLY** 2 ULTRATHIN SEALING SURFACES
3. X & Y = THE **ONLY** 2 ELECTRICAL CONNECTIONS (GND and 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

APPLICATIONS

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

Figure 1: Phosphor Decay Characteristics

<table>
<thead>
<tr>
<th>RELATIVE OUTPUT (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TIME (ns)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td>8</td>
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</table>

SPECIFICATIONS

GENERAL

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description/Value</th>
<th>Unit</th>
</tr>
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<tbody>
<tr>
<td>Dimensional Cutline(1)</td>
<td>49.0 mm × 0.5 mm</td>
<td></td>
</tr>
<tr>
<td>Detection Energy Range (Electron beam)</td>
<td>5.0 to 12</td>
<td>kV</td>
</tr>
<tr>
<td>Decay time (90% to 10% Typ.)</td>
<td>2.3 ns</td>
<td></td>
</tr>
<tr>
<td>Peak Emission Wavelength</td>
<td>400 nm</td>
<td></td>
</tr>
<tr>
<td>Electrode Thickness (Aluminum)</td>
<td>50 nm</td>
<td></td>
</tr>
<tr>
<td>Operating Temperature Range</td>
<td>+55 to +65°C</td>
<td></td>
</tr>
</tbody>
</table>

NOTE: Applicable maximum size is 460 mm.

COMPARISON OF OTHER PHOSPHOR

<table>
<thead>
<tr>
<th>Phosphor</th>
<th>Decay Time (90% to 10%)</th>
<th>Relative Intensity (DC)</th>
<th>Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>J9758</td>
<td>2.3 ns</td>
<td>100</td>
<td>Good</td>
</tr>
<tr>
<td>P47 Phosphor</td>
<td>150 ns</td>
<td>100</td>
<td>Good</td>
</tr>
<tr>
<td>VAP</td>
<td>59 ns</td>
<td>50</td>
<td>Good</td>
</tr>
<tr>
<td>Plastic Scintillator</td>
<td>5 ns</td>
<td>25</td>
<td>No good</td>
</tr>
</tbody>
</table>

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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