Smart ideas for large PMTs

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Photonis, Brive, France

VLVnT workshop

NIKHEF 2003-10-05

- PHOTONIS
- Traditional PMTs
- Smart PMTs
- Wild cards

Brive


UNITED KINGDOM
BELGIUM
LUXEMBOURG
GERMANY
SPAIN
ANDORRA
ATLANTIC OCEAN
BAY OF BISCAY
MEDITERRANEAN SEA
PARIS
BRIVE-LA-GAILLARDE

PHOTONIS

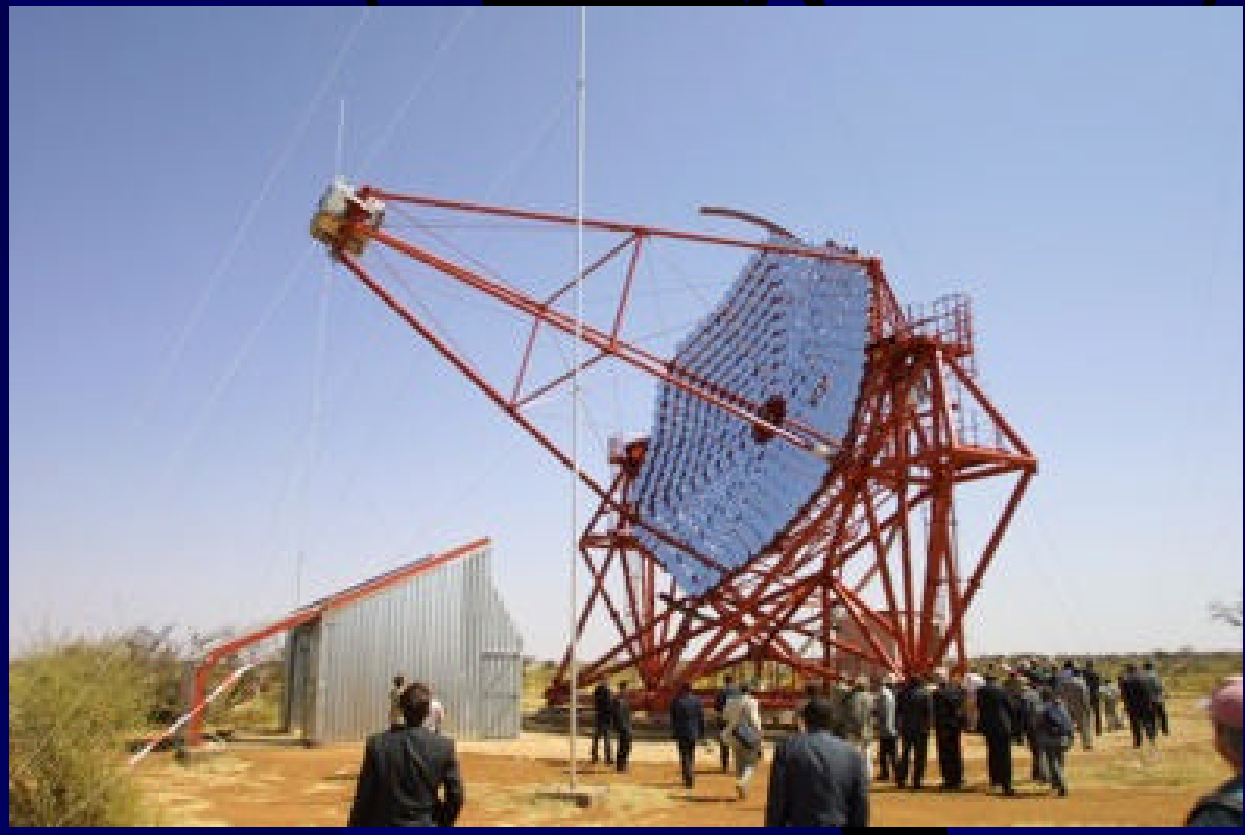
- ***Photomultipliers***
- ***Image intensifiers***

- **Streak tubes**
- **Microchannel plates**
- **Single channel electron multipliers**
- **Neutron detectors**

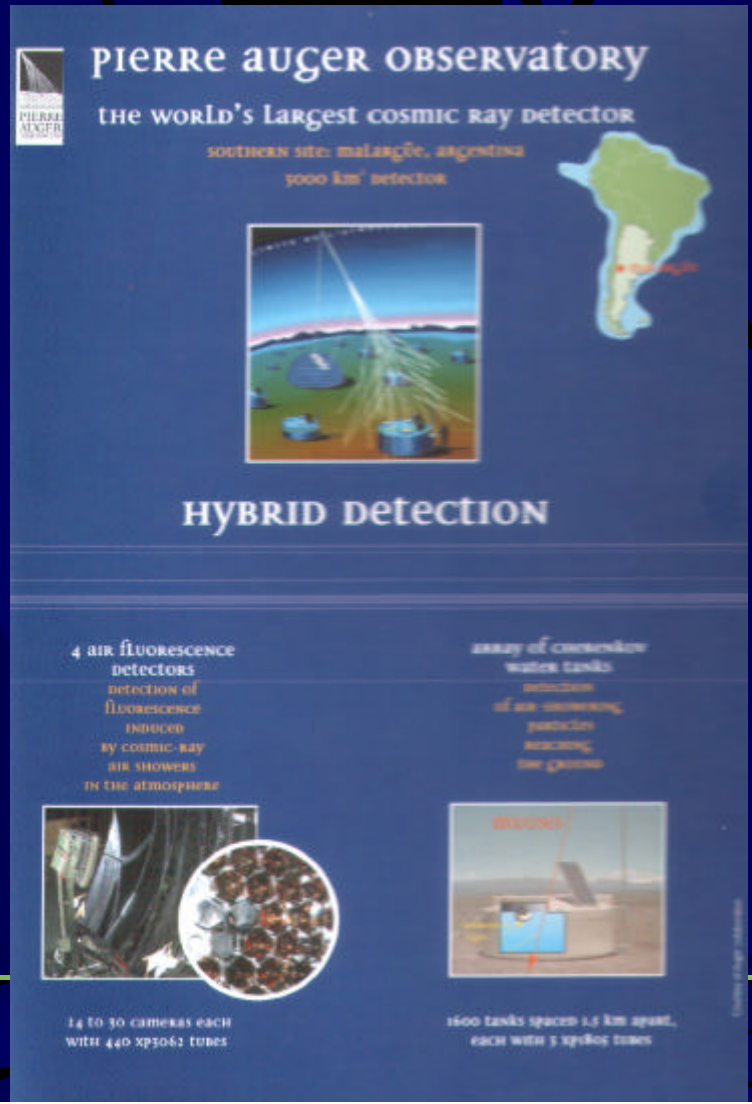
PMTs

- Nuclear medicine (~80%)
  - gamma cameras
  - PET scanners
- Analytics/industrial (~10%)
- Physics (~10%)

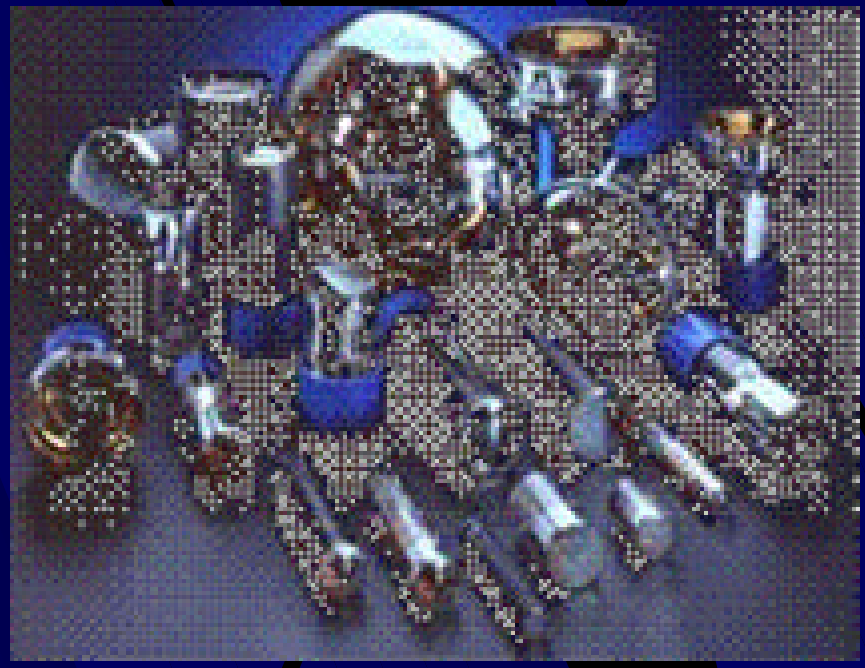
H.E.S.S. in Namibia



Auger in Argentina



Traditional PMT´s



8“, 9“, 10.6“, 12“

„Smart“ PMTs ?

- ***Detector concept!!***
  - Embedded
  - Sensitivity
  - Timing
  - Pulse-height resolution
  - Directionality?

Embedded...

- Single independent OMs?
- Clustered OMs?
- „Local“ coincidences?

Sensitivity...

- OM ⇔ PMT size?
- Light collection!
- Quantum efficiency!
- Electron collection!
- Imaging?

Timing...

- !!!

Pulse height resolution..

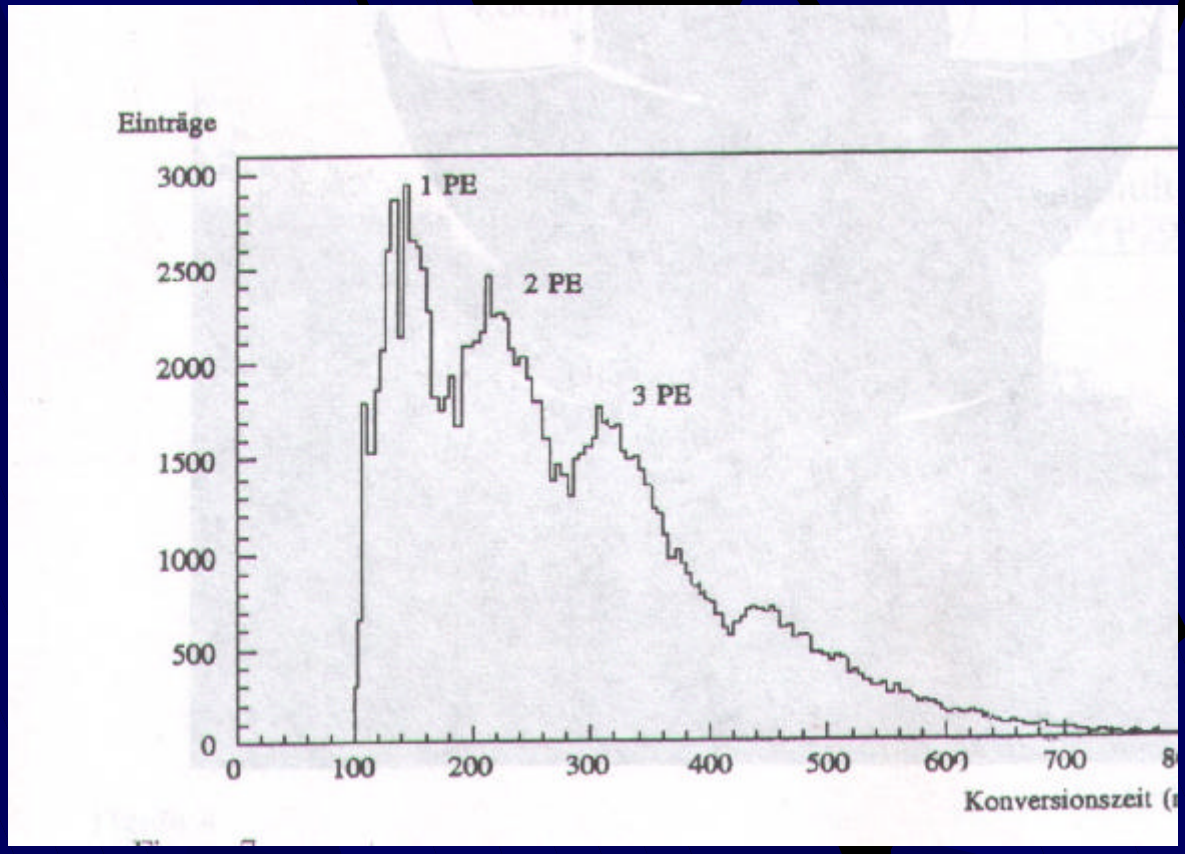
- Noise suppression
  - Thermal photoelctrons (=single PEs!)
  - ^{40}K (glass, ocean)

Single/multielectron noise

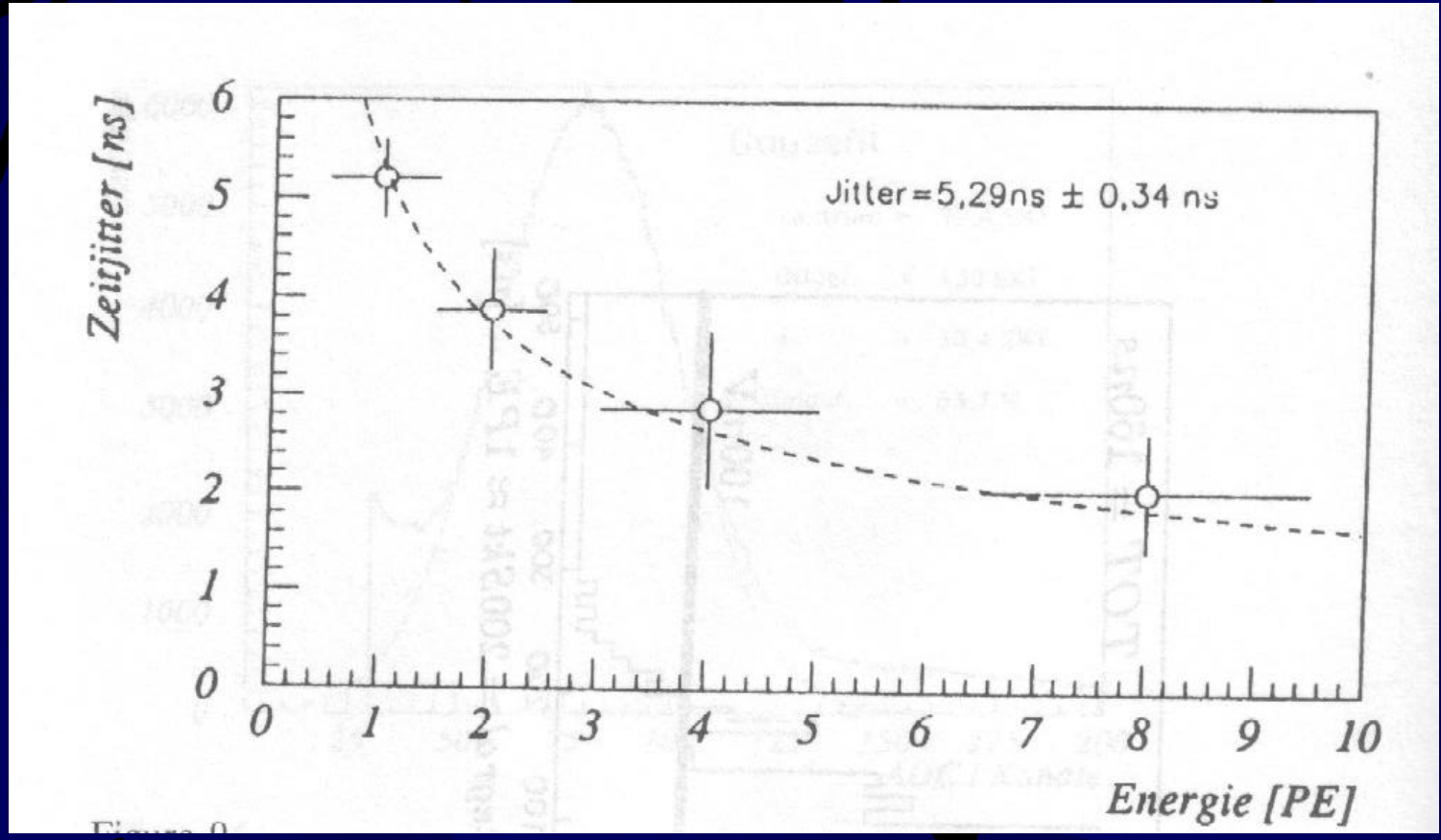
TUBE	SE noise > 0.5 PE [cps]	ME noise >2.5 PE [cps]	ME noise >4 PE [cps]	Gain	S_k [μA/lmF]
B008	23,500	NM	275	35	NM
B014	38,000	2100	NM	31	9.0
B015	30,000	2000	1300	36	10.5
B016	10,000	910	690	40	9.5
B019	11,700	200	95	35	9.1

Legend: SE = Single electron noise, threshold >0.5 PE
ME = Multi-electron noise, threshold >2.5 PE & >4 PE
S_k = Photocathode sensitivity for blue light with a filter Corning CS 5-58, half stock thickness expressed in μA/lmF , F= filtered.
NM = Not measured.

Energy resolution



Time resolution

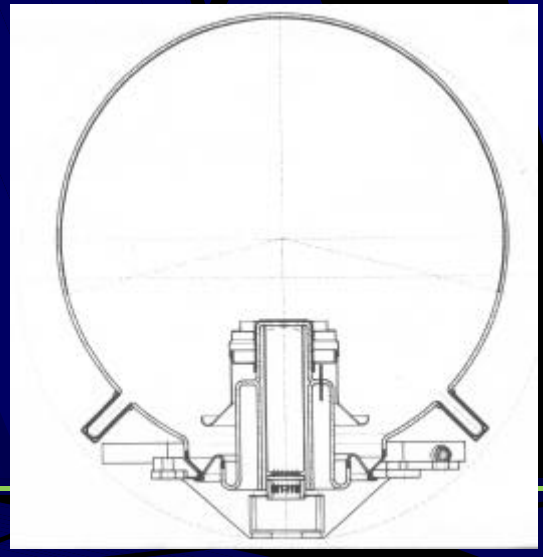


Directionality...

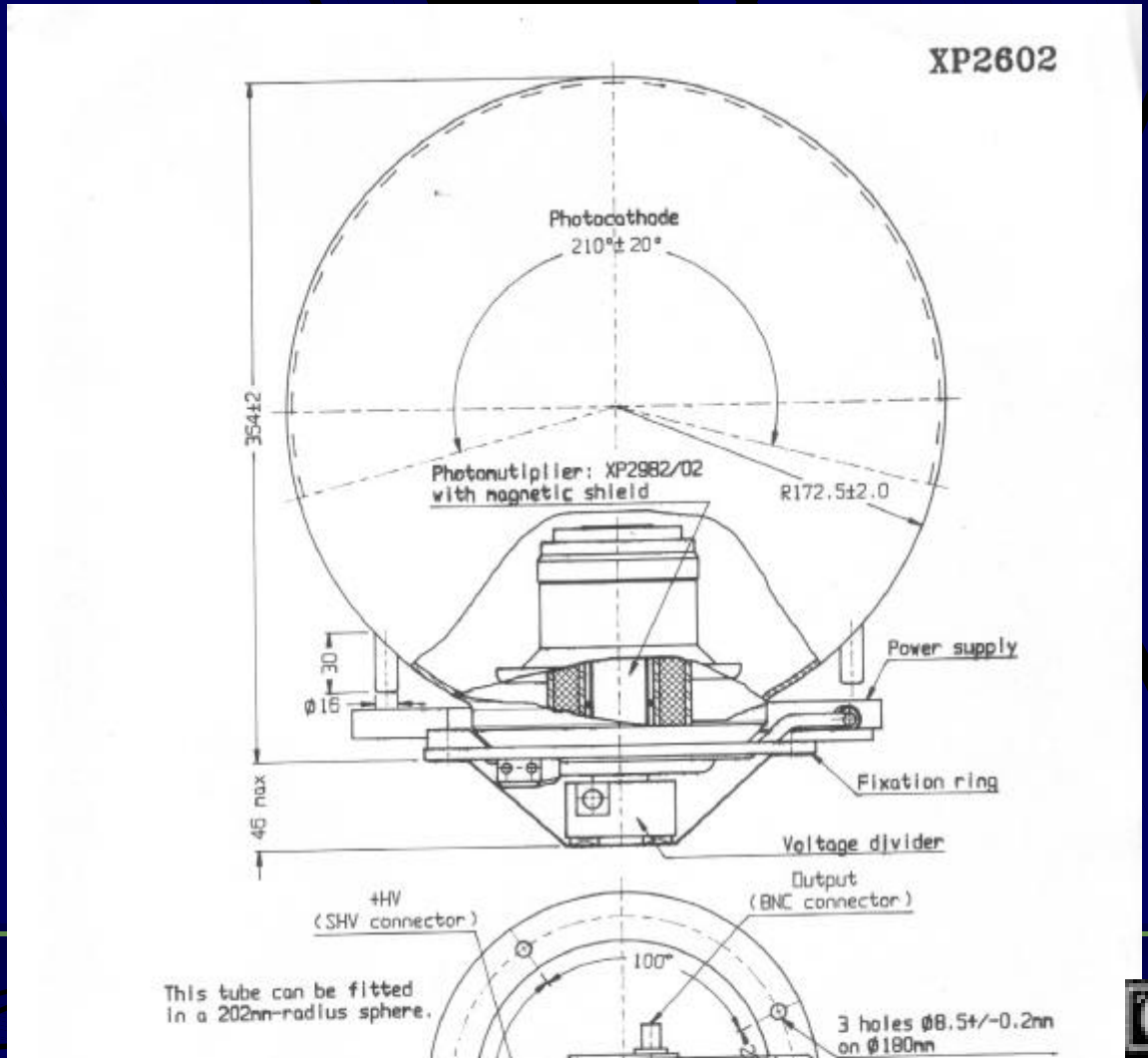
- ??
- Image-forming element?
- Collimator á la INFN Genoa?

„Smart“ PMTs so far

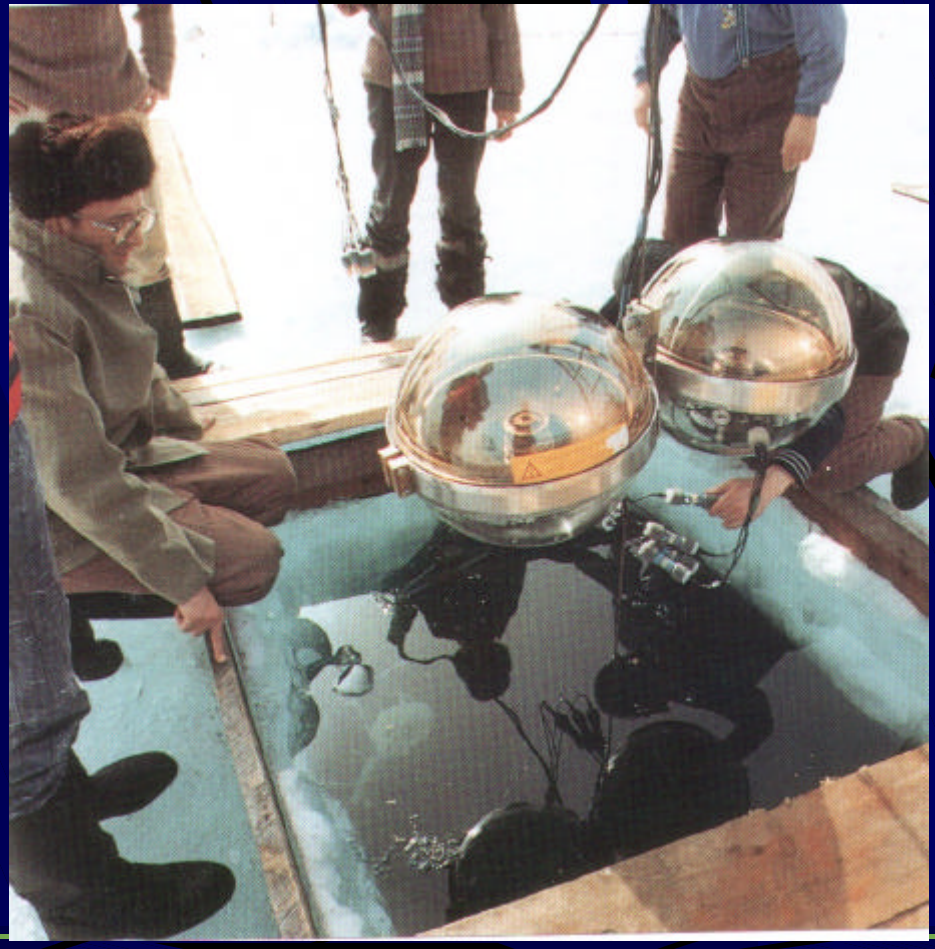
- => PHR (elimination of single PEs)
- Patented by Philips (Photonis)
- Copied (and improved) by INR



Details...


XP2602
Photocathode
210°± 20°
354±2
Photomultiplier: XP2982/02
with magnetic shield
R172.5±2.0
Power supply
30
ø16
Fixation ring
46 max
Voltage divider
Output
(BNC connector)
+HV
(SHV connector)
100°
This tube can be fitted
in a 202mm-radius sphere.
3 holes ø8.5+/-0.2mm
on ø180mm

Prototypes 8 & 10



Status „smart“ PMTs

- Philips made ~ 30; invested 1 M$!
- 200 Quasars in Lake Baikal!!!
- No ongoing production

Future „smart“ PMTs

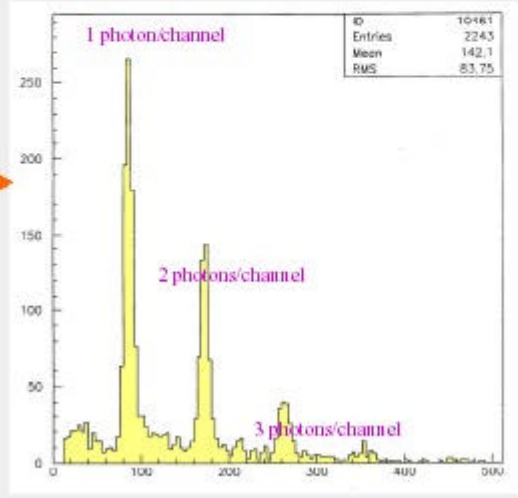
- Reproduce and improve former tubes
- Redesign (target)
  - Better scintillator (LSO, ZnO:Ga, ...)
  - Si diode/Si diode array
  - APD/APD array
  - Multianode multiplier
  - Quadrant PMT (inside/outside)
  - ??

„Double-smart“ HPD

The HPD tube

HPD combines single photon sensitivity of PMT with spatial and energy resolution of silicon sensor.

Performance



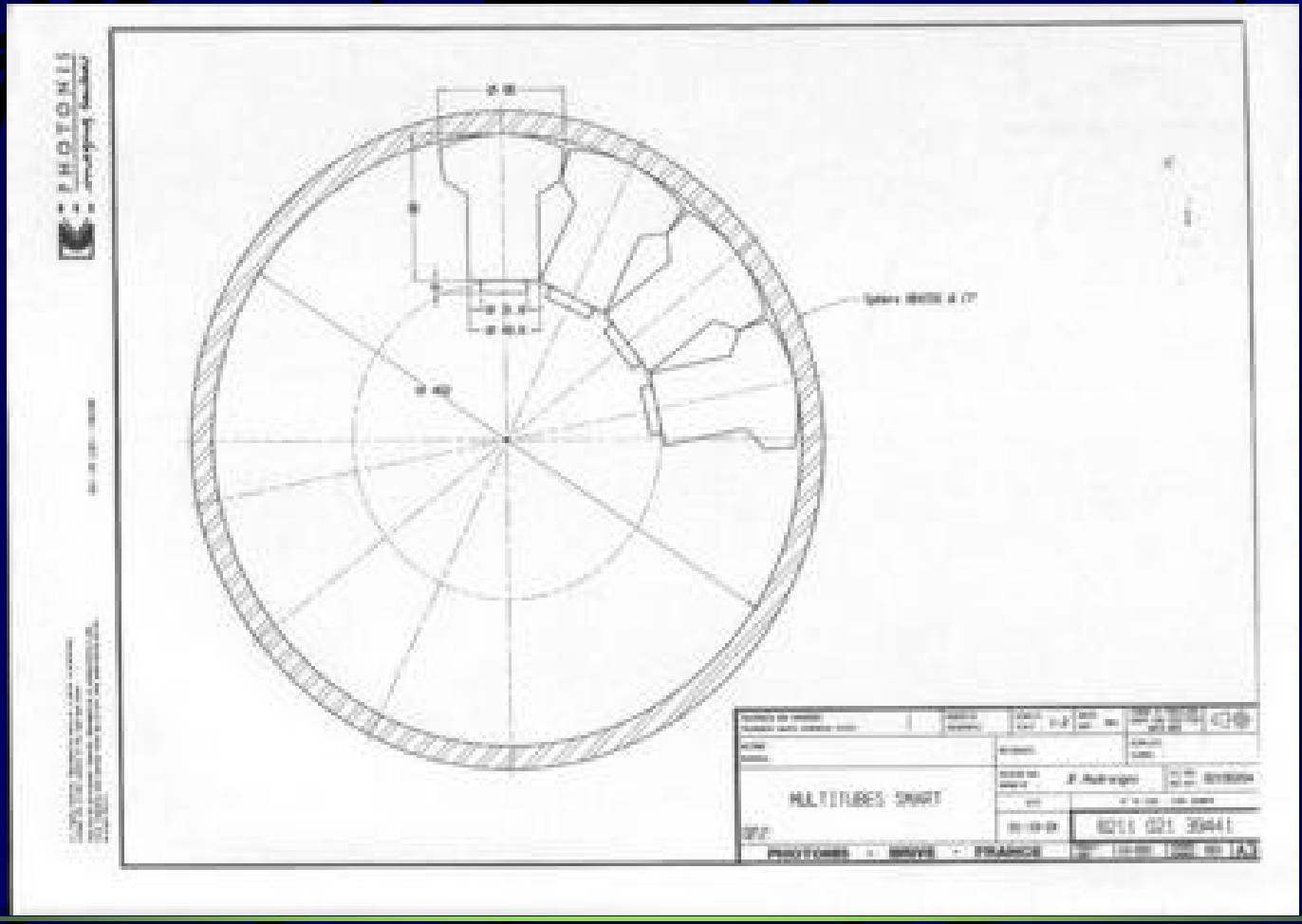
HPD tube manufactured at CERN: 2048 channel P.M.

(courtesy of P.Weilhammer/CERN)

Wild Cards

- Multiple small (inexpensive) PMTs/OM
- The „BLOB“

Multiple PMTs/OM



Features

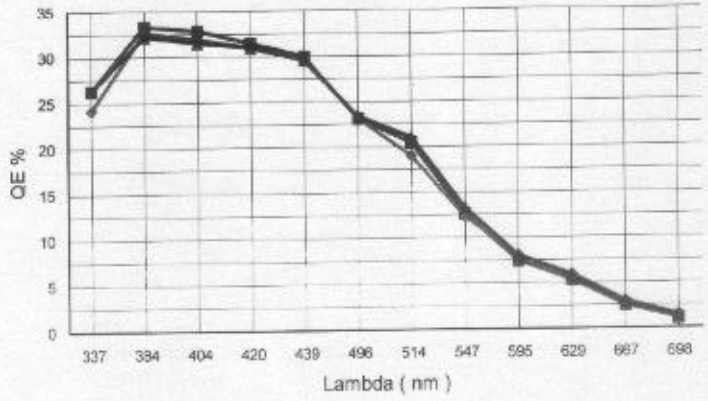
- Low-noise tubes!
- Quantum efficiency/tube higher =>
- Effective cathode area similar (~70%)
- High design flexibility
- Similar cost
- Ready for production; unlimited capacity!

High QE

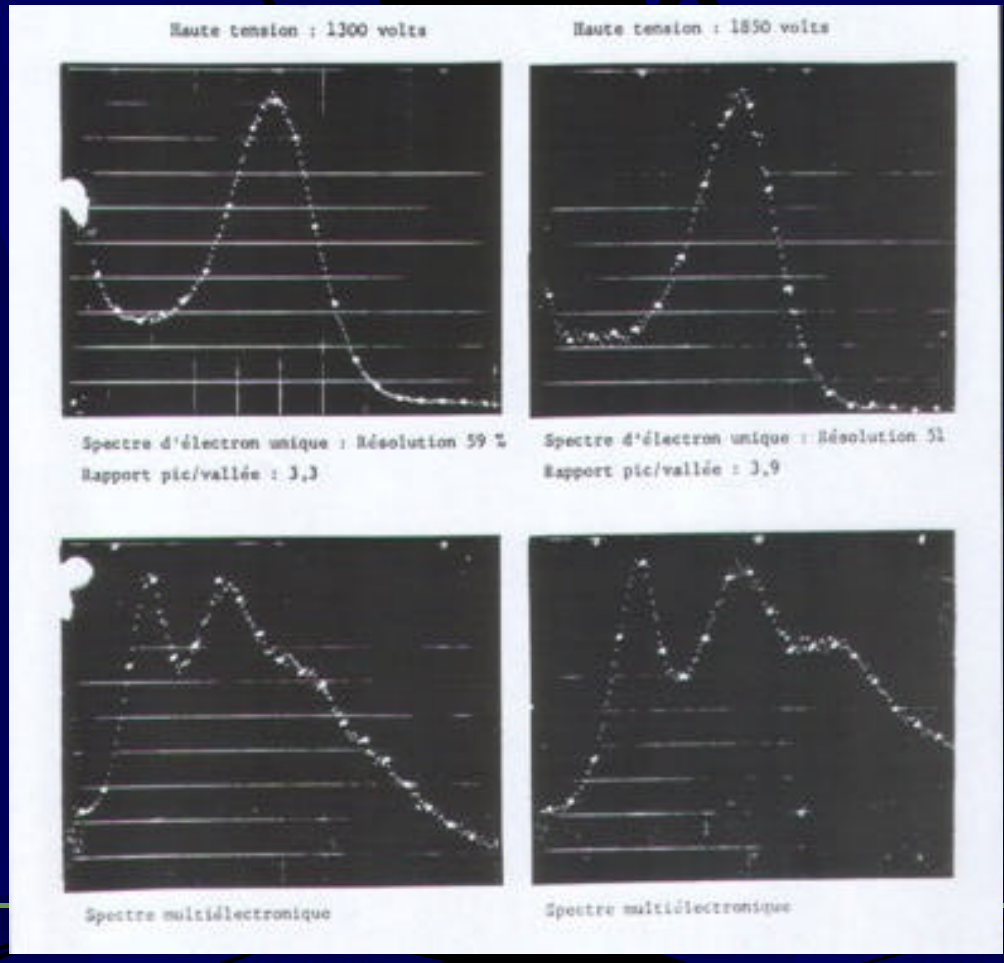
lambda	QE		
en nm	n° 93599	n° 93600	n°93601
337	26	24	26
384	33	33	32
404	33	32	31
420	31	31	31
439	30	30	30
496	23	23	23
514	20	19	21
547	13	12	13
595	7	8	8
629	5	6	6
667	3	3	3
698	1	1	1
blanc	164	165	165
bleu	13.4	13.6	13.1

Q.E.on 3 XP5382 3" tube

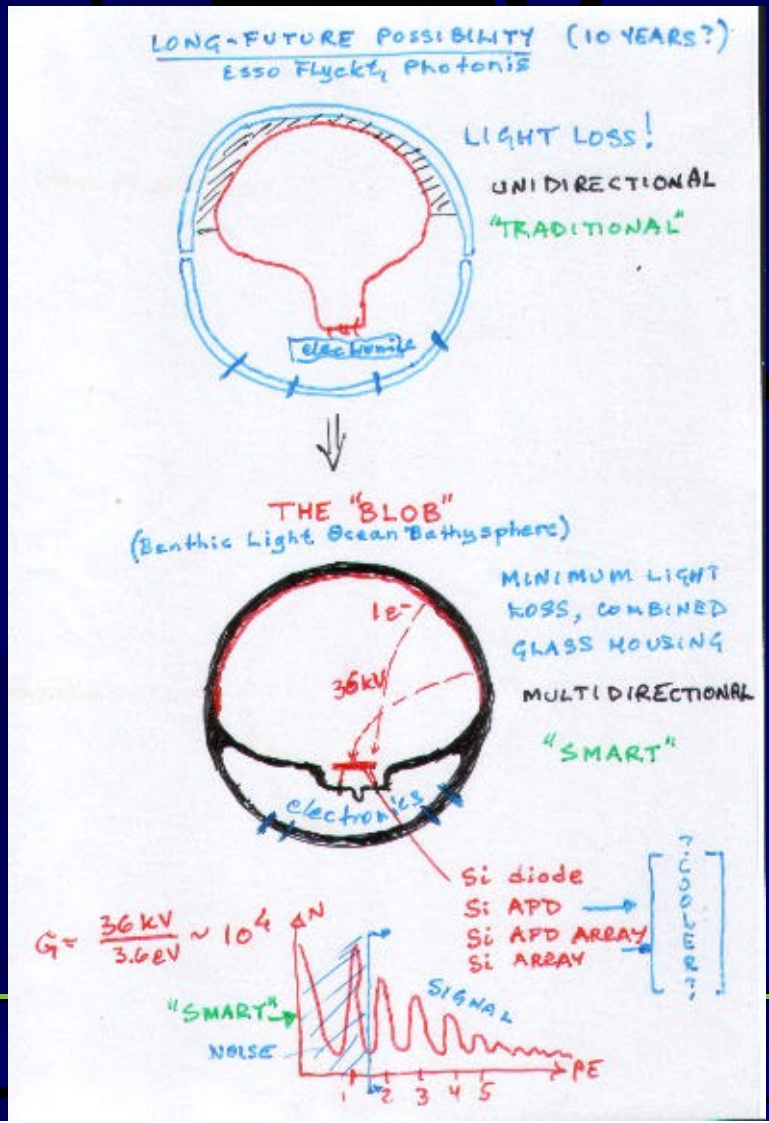
Soda lime window thickness = 3mm



High-gain first dynode



The BLOB


LONG-FUTURE POSSIBILITY (10 YEARS?)
Esso Flycky Photonis
LIGHT LOSS!
UNIDIRECTIONAL
"TRADITIONAL"
electronics
THE "BLOB"
(Benthic Light Ocean Bathysphere)
MINIMUM LIGHT LOSS, COMBINED GLASS HOUSING
MULTIDIRECTIONAL
"SMART"
1e⁻
36kV
electronics
Si diode
Si APD
Si APD ARRAY
Si ARRAY
COOLER?
G= 36kV / 3.6eV ~ 10⁴
N
"SMART"
NOISE
SIGNAL
PE
1 2 3 4 5

Discussion

- Local noise suppression ⇔ upload all
- Smartness needed?
- Local coincidences?
- Causal suppression?

- Total OM cost!?!

Outlook

- Many „smart“ PMT ideas exist
- Which ones to explore ⇔ concept
- Development (and funding) is needed