PARIS - IN2P3
APC - PCC/Collège de France
Proposition

- Study of focal surface mechanics
  Phase a : produce an explicit document with the requirements and how to obtain solutions. (Part of Instrument Specification) - 2 Spatial Engineers
  Phase b : Calculations of focal surface mechanics - [CETIM, X, Supelec ..]
  - - - - > Industry ....
- Simulations : to be seen at Eric Plagnol presentation
- Tests of focal surface / macrocells
  Make a matrix of light sources (UV LEDs ...) with same number than pixels (1296 = 81 x 16) driven by amplifiers linked to a pattern generator (τ = 10 us).

  Phase a : small model (16 to 64) in a few m³ black box - 3 physicists + one engineer (+ students, post-docs ...)
  Phase b : big model with small EUSO Fresnel lenses.

Focal plane surface S = 5.26 10^6 mm^2
On ground, at 400 km, with 30°, 1.26 10^5 km^2

M64, base line

Gain 3.105, needs preamps.
Glass thickness 0.8 mm
(0.2 mm @ 30°)
3204 PMT : 205000 pixels

Pixel surface
a) 100% efficient: 1.5 mm^2:
total anode surface: 3.08 10^5 mm^2
5.9% of S if no Winston cones

NO GOOD

b) down to 50% efficient
(total efficiency per pixel 80%):
4 mm^2:
total anode surface: 8.20 10^5 mm^2
15.6% of S if no Winston cones

NO GOOD

h=0mm

0.3	1.4	0.4
0.8	100	1.2
0.2	1.1	0.3

Light Source: SCSF78(1.0mm)
Applied Voltage: 800(V)

h=0.5mm

0.4	2.6	0.6
1.5	100	1.9
0.3	1.8	0.4

Light Source: SCSF78(1.0mm)
Applied Voltage: 800(V)

Figure 8: The cross-talk in accordance with the height of the fiber (h=0 mm and h=0.5 mm)

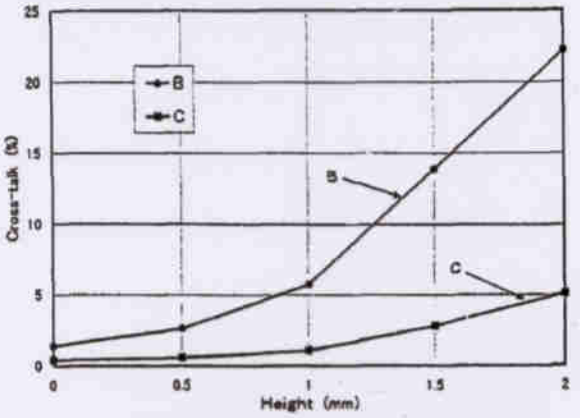


Figure 9: The cross-talk of pixel B and C in accordance with the height of the fiber

the cross-talk data at the heights of 0 mm and 0.5 mm. In this data, each square corresponds to each pixel and the numbers in the squares show relative values of anode output signal. Figure 9 shows cross-talk data of pixels B and C at the height from 0 mm to 2.0 mm. The symbols B and C correspond to pixels which are shown in Figure 5. It was confirmed that the height should be less than 0.5 mm if the cross-talk would be kept within 3 %.

B. Anode Uniformity

Anode uniformity is one of the important characteristics of multi anode PMTs. Uniform response in all of pixels is desired. However, R5900-00-M64 has common dynodes for 64 pixels, even though photocathode response is quite uniform, the gain variation between pixels is occurred. It's due to a difference of the secondary emission yield in accordance with the position of the dynode. As an example, the anode uniformity of R5900-00-M64 for all of pixels is shown in Figure 10. In this uniformity test, W (tungsten) lamp was used as uniform DC light source. All of useful area of the cathode was illuminated, and anode signal from each pixel was measured. It's shown as a height of a pole in this figure. The variation between pixel to pixel is within factor 3 in this data. This is typical variation at present.

Figure 11 shows an anode uniformity of one pixel. In this

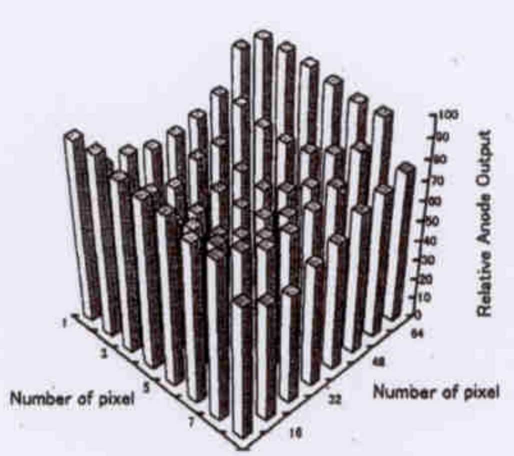


Figure 10: Anode uniformity for all of pixels

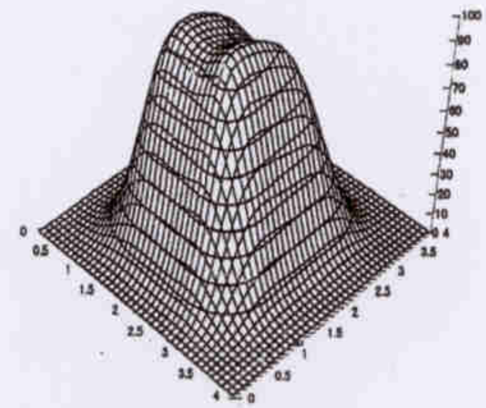


Figure 11: Anode uniformity of one pixel

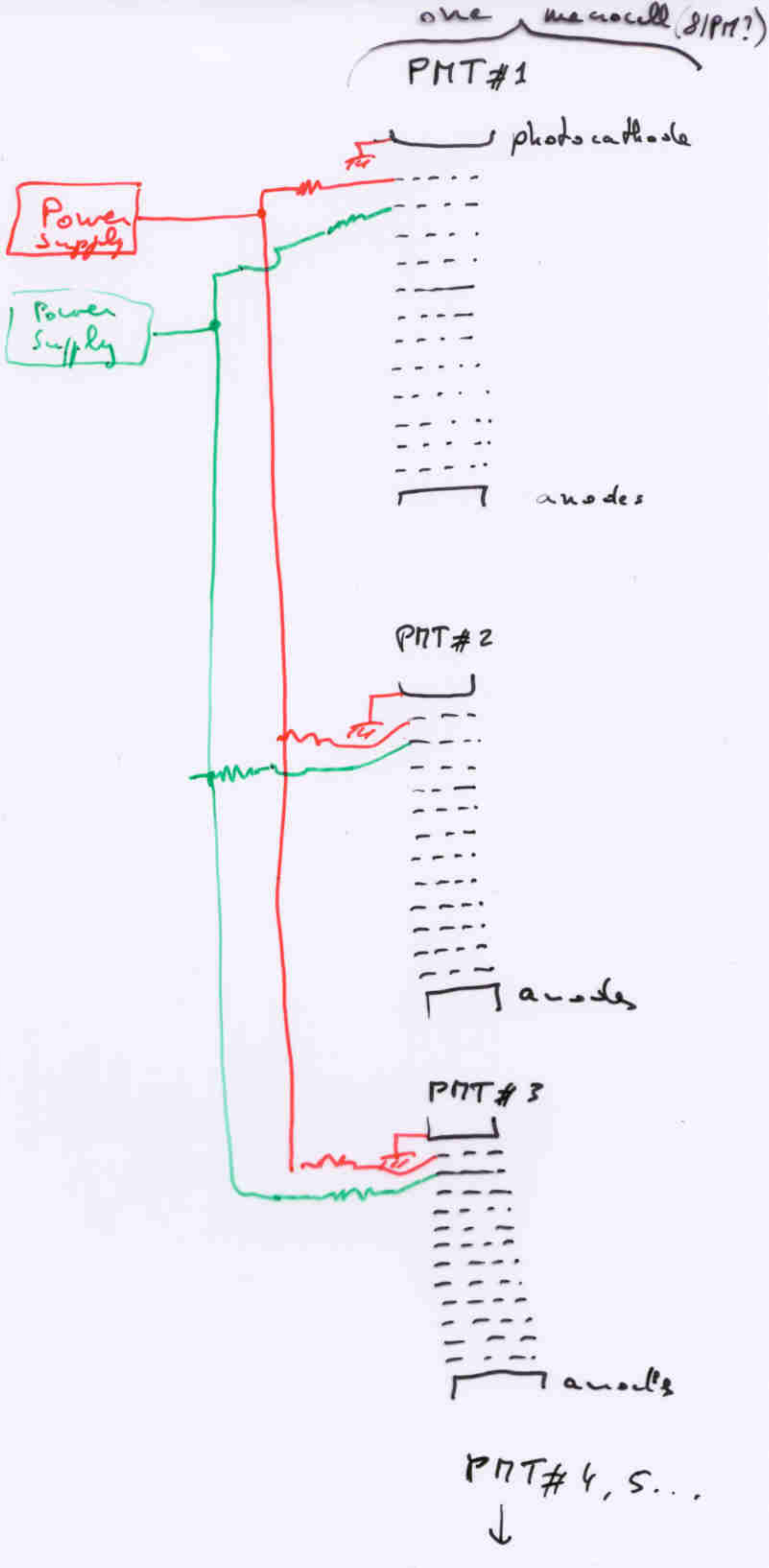
test, the SCSF78 was also used as DC spot light source. It was moved with 0.1 mm step around the pixel and the anode signal was measured at each position. The two peaks correspond to two channels of metal channel dynode in one pixel.

C. Pulse Height Distribution with Single p.e.

In general, light yield of a scintillating fiber read out in a tracking detector is around several photoelectron (p.e.) s, good pulse height distribution (PHD) with single p.e. is also important to set its lower level discrimination with high detection efficiency. As an example, PHD of 4 pixels with single p.e. is shown in Figure 12. It was confirmed that the single p.e. peak can be seen with reasonable peak to valley ratio.

D. Pulse Linearity

A scintillating fiber in a tracking detector usually produces few photoelectrons as its signal. The pulse linearity, which corresponds to dynamic range of a multi anode PMT, isn't so important in this application. However, it's necessary to study


one macrocell (8 PM?)
PMT#1
photocathode
Power supply
Power Supply
anodes
PMT#2
anodes
PMT#3
anodes
PMT#4, 5...

Focal plane surface S = 5.26 10^6 mm^2
On ground, at 400 km, with 30°, 1.26 10^5 km^2

M64, base line

Gain 3.105, needs preamps.
Glass thickness 0.8 mm
(0.2 mm @ 30°)
3204 PMT : 205000 pixels

Now, WINSTON CONES

Squares of 5 mm side to reduce to squres of 2 mm side
Angular efficiency 44%, surface efficiency: 19%

Total efficiency: 80% times 19% = 15%

NO GOOD

Focal plane surface S = 5.26 10^6 mm^2
On ground, at 400 km, with 30°, 1.26 10^5 km^2

M64, base line

Gain 3.105, needs preamps.
Glass thickness 0.8 mm
(0.2 mm @ 30°)
3204 PMT : 205000 pixels

HEMISPHERICAL LENSES

Does not work: needs 2 magnifying powers together

Focal plane surface S = 5.26 10^6 mm^2
On ground, at 400 km, with 30°, 1.26 10^5 km^2

M64, base line

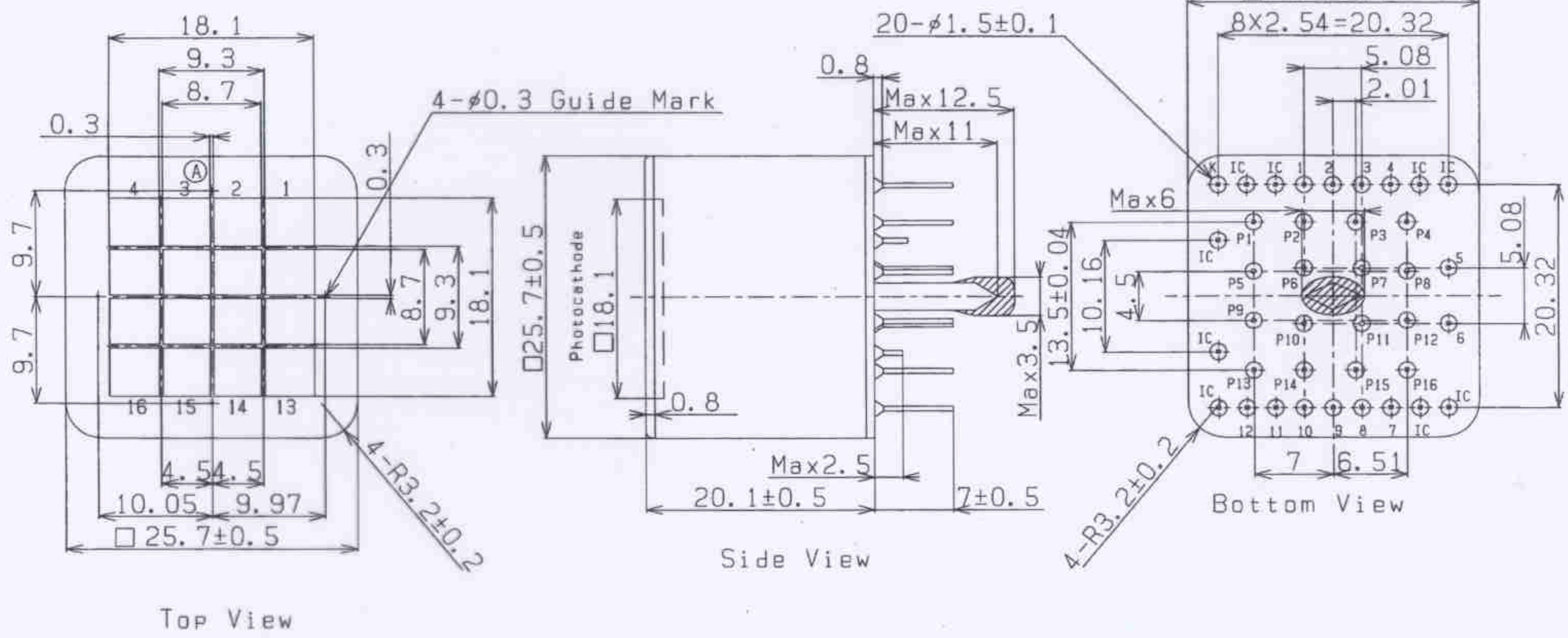
Gain 3.10^5, needs preamps.
Glass thickness 0.8 mm
(0.2 mm @ 30°)

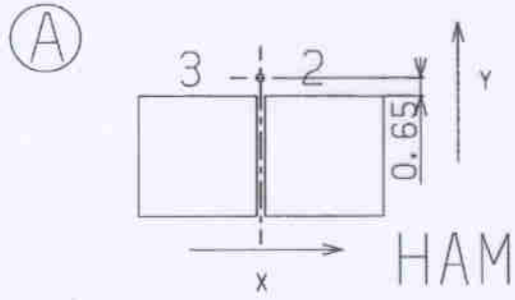
Focal plane filled
6855 PMT : 439000 pixels
on ground, squares of 0.54 km side

Now, Winston cones fully efficient,
but

Do we need it?
Watts go up

R7600-00-M16 Dimensional Outline





Voltage Distribution Ratio

K:Photocathode, Dy:Dynode(Dy1-Dy12), P:Anode(P1-P16)

Electrode	K	1	2	3	4	5	6	7	8	9	10	11	12	P
Distribution Ratio	2.4	2.4	2.4	1	1	1	1	1	1	1	1	1.2	2.4	

Date:Oct. 31. 2000

HAMAMATSU PHOTONICS K.K

Focal plane surface S = 5.26 10^6 mm^2
On ground, at 400 km, with 30°, 1.26 10^5 km^2

M16 classical

Gain 3.10^6, no preamps.
Glass thickness 0.8 mm
(0.2 mm @ 30°)
efficiency of a pixel (4 by 4 mm) = 90%

Focal plane filled
7970 PMT : 127500 pixels
on ground, squares of 0.99 km side

Now, Winston cones:
angular efficiency 75%
surface efficiency 56%

Total efficiency 50-60%

Better, but still not very good

Subject: **info M16**
Date: Wed, 26 Sep 2001 11:47:57 +0100
From: "Veronique PUILL" <vpuill@hamamatsu.fr>
To: philippe.gorodetzky@cern.ch

Bonjour,

Dernières nouvelles du Japon :

We will prepare the drawing. Please wait for few days.

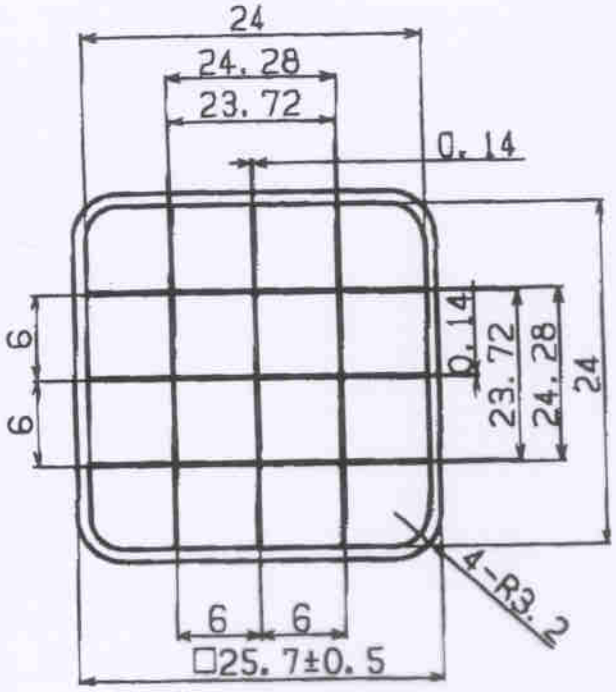
Regarding the detailed information about the R8520MOD-M16F, please kindly advise Dr.Thomas Patzak and Dr.Philippe Gorodetzky to contact with Dr.Shimizu/Riken/Japan.

Je vous enverrai le schéma par fax dès réception, j'envoi le devis par fax aujourd'hui.

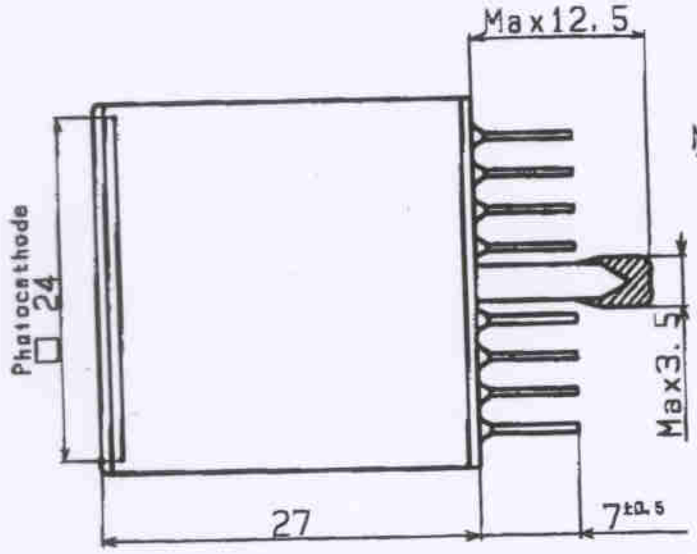
Cordialement

V. PUILL

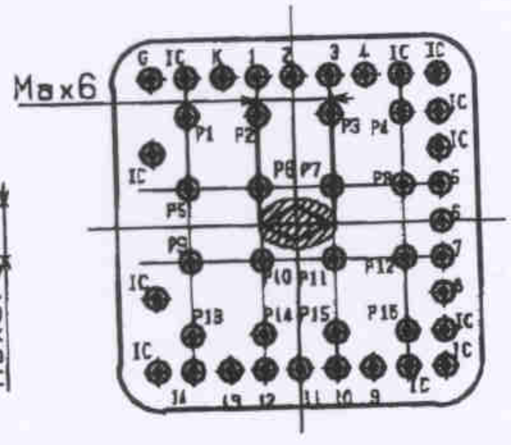
R8520MOD-03-M16F Dimensional Outline



Top View



Side View



Bottom View

Voltage Distribution Ratio

K:Photocathode, Dy:Dynode(Dy1-Dy14), P:Anode(P1-P16)

Electrode	K	G	1	2	3	4	5	6	7	8	9	10	11	12	13	14	P
Distribution Ratio	0.5	1.5	2	1	1	1	1	1	1	1	1	1	1	1	1	1	

Date:Sep. 26. 2001

HAMAMATSU

Focal plane surface S = 5.26 10^6 mm^2
On ground, at 400 km, with 30°, 1.26 10^5 km^2

M16 new

Gain 3.10^6, no preamps.
Glass thickness 0.8 mm
(0.2 mm @ 30°)

Total cathode surface 547 mm^2
Total surface used by PMT: 25.7^2 = 660 mm^2

Focal plane filled
7970 PMT : 127500 pixels
on ground, squares of 0.99 km side

No Winston cones:
Total efficiency 83%

MUCH BETTER, our choice!

PREAMPS

a) If output pulse is 100 mV, probably
quiecent current is 500 μA.
Power supply 3V

1.5 mW per pixel

b) CERN Icon chip 1 mW

200-300 W for 200000 pixels (M64)

0 W for M16

High Voltage

a) Resistor chain

Hamamatsu recommends 2.2 MΩ, 800 V
0.3 W per PMT

M64, 3200 PMT, 930 W too much
M16, 8000 PMT, 1800 W, Way too much

b) We propose one set of power supplies (PS) per macrocell

Each set has 14 (in case of 14 dynodes) switching PS.
1st: 80 V
2nd 160 V
3rd 240 V
.....

All first dynodes are together
(some decoupling, but no power loss)
All second dynodes are together
Etc.

Very efficient: only uses power during pulses.
Guess: 10 times less: 180 W.
If one macrocell dies, we lose 1%.

Focal plane surface $S = 5.26\ 10^6\ mm^2$
On ground, at 400 km, with 30°, $1.26\ 10^5\ km^2$

FLAT PANEL

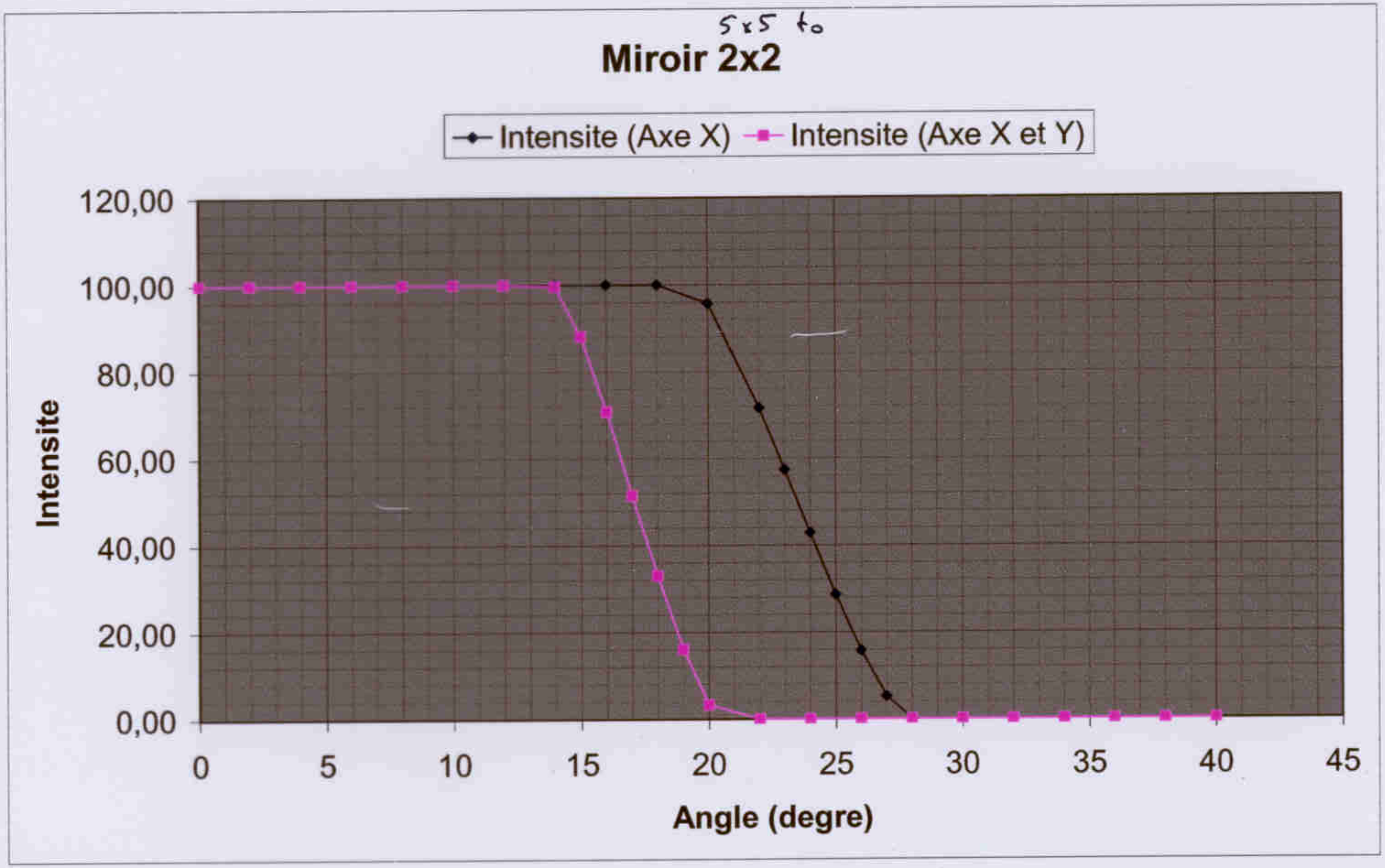
Gain 3.10^5, needs preamps.
Glass thickness 2.5 mm
(0.7 mm @ 30°)

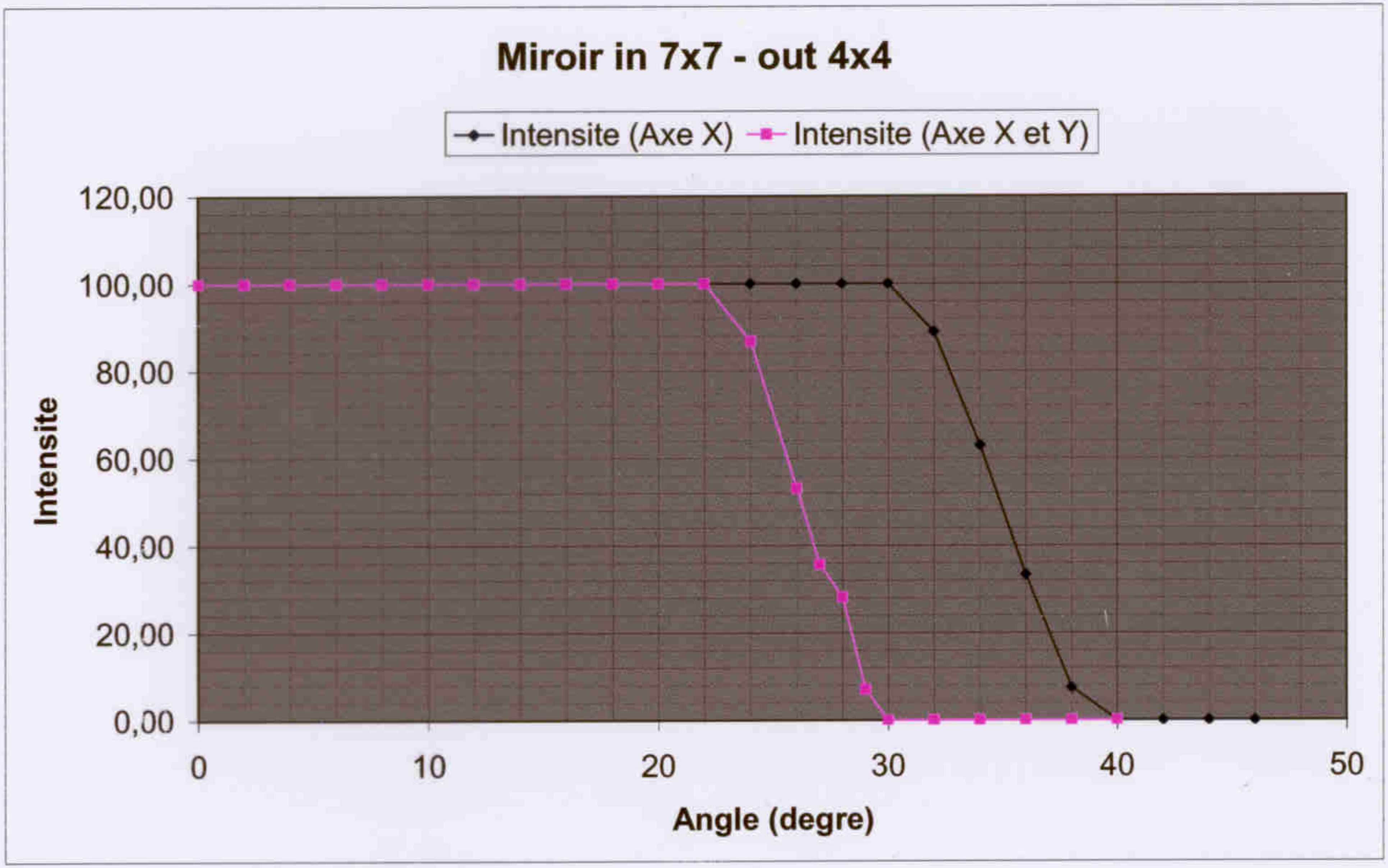
Focal plane filled

No Winston cones:

Total efficiency 90%

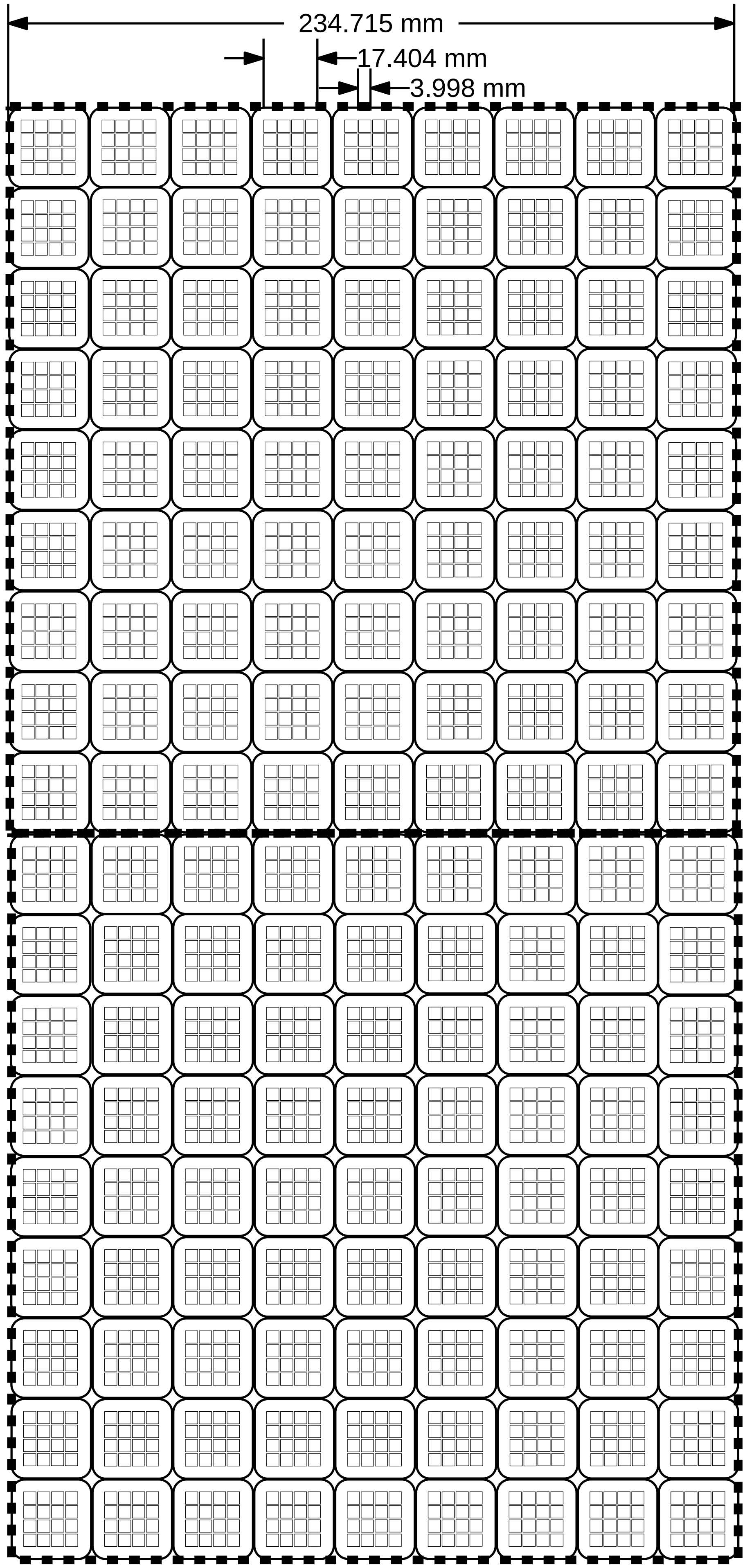
MUCH Better, but preamps


5x5 to
Miroir 2x2
Intensite (Axe X)
Intensite (Axe X et Y)
Intensite
120,00
100,00
80,00
60,00
40,00
20,00
0,00
0
5
10
15
20
25
30
35
40
45
Angle (degre)


Miroir in 7x7 - out 4x4
Intensite (Axe X)
Intensite (Axe X et Y)
Intensite
120,00
100,00
80,00
60,00
40,00
20,00
0,00
0
10
20
30
40
50
Angle (degre)

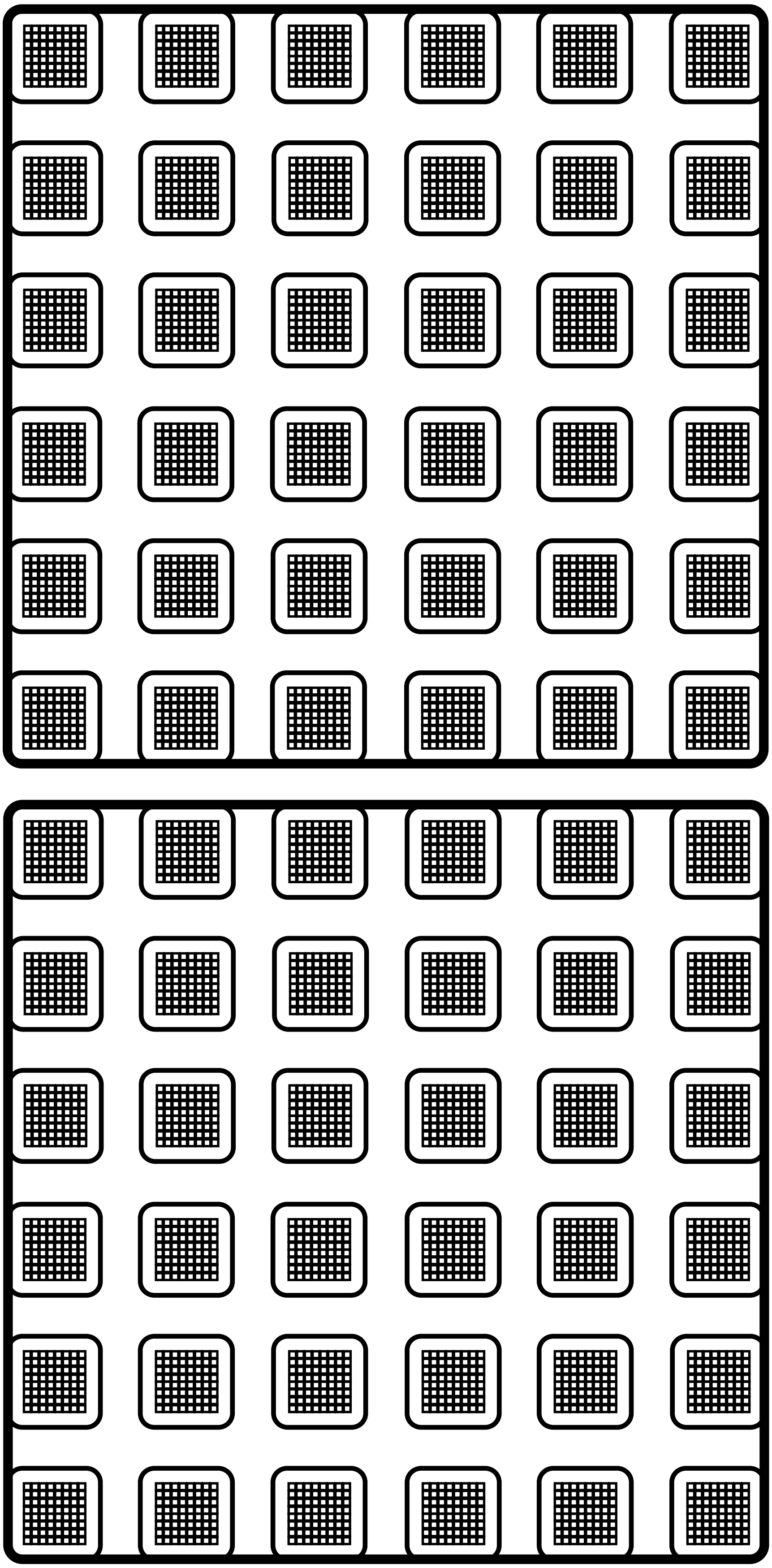
EUSO

2 macrocells shown with PM 16 anodes, evenly spaced (0.4 mm between PM)

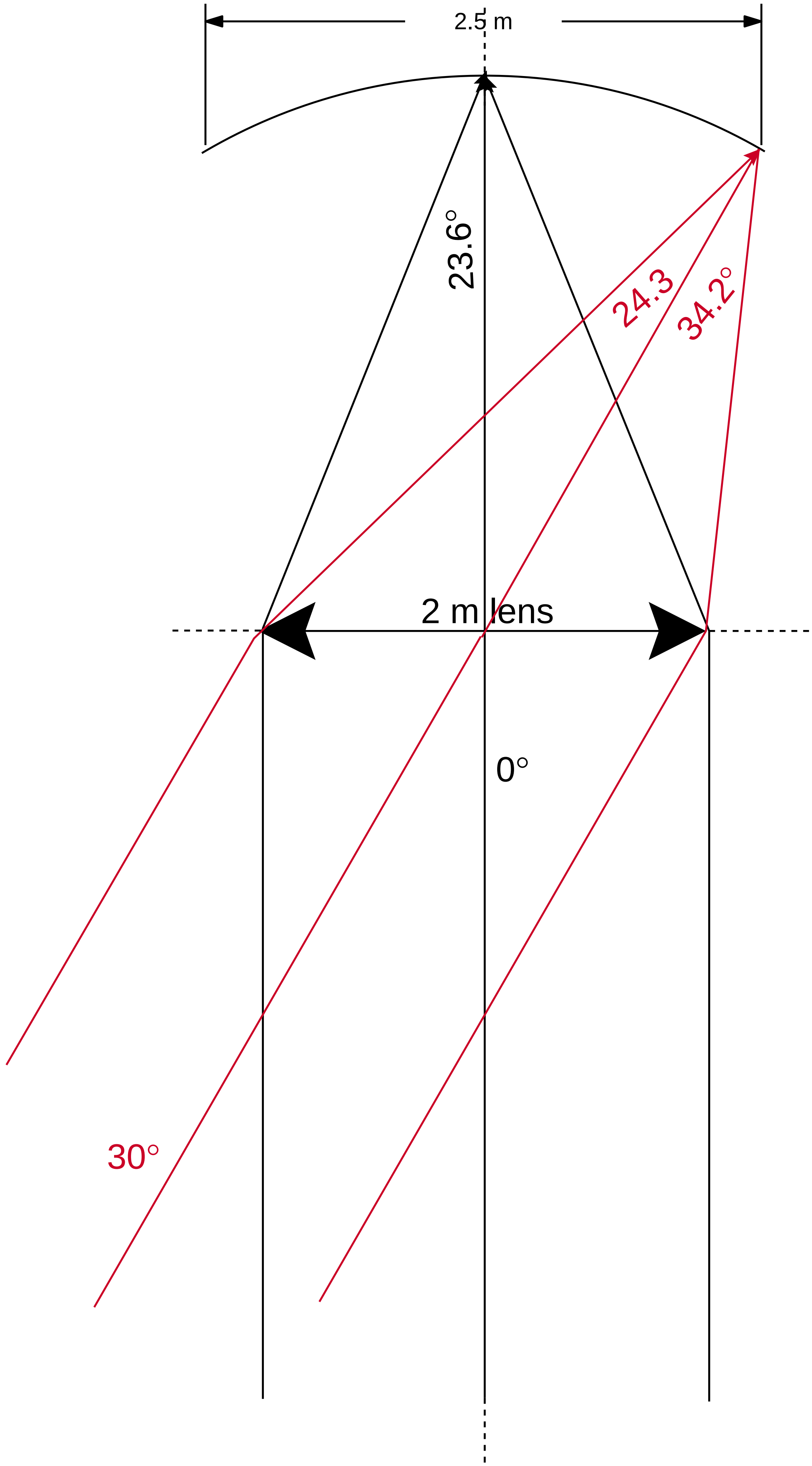


EUSO

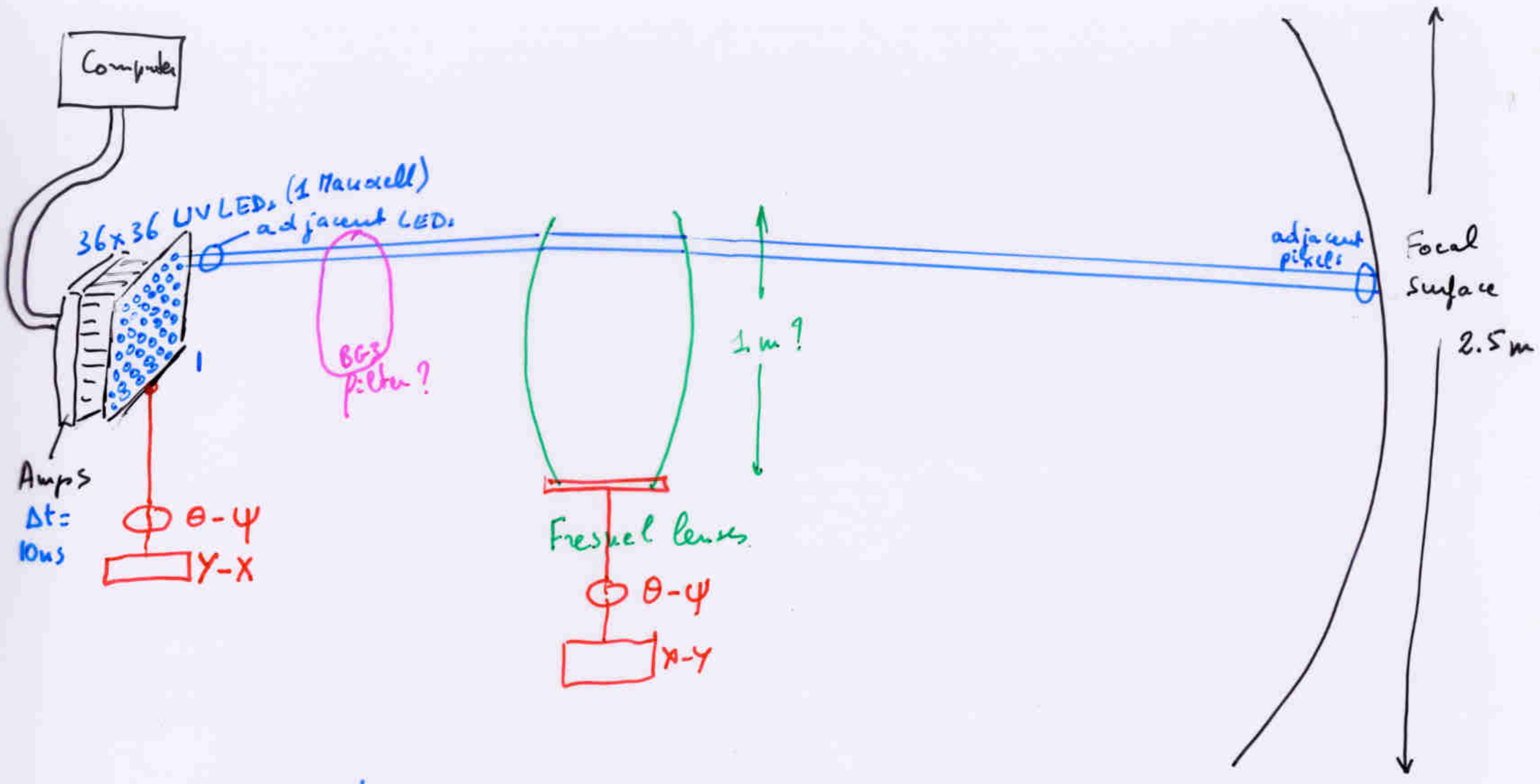
2 macrocells shown with PM 64 anodes, evenly spaced (11.44 mm between PM



scale = 1/2



2.5 m
23.6°
24.3
34.2°
2 m lens
0°
30°



⇒ can test individually each pixel in X-Y-θ

can send patterns of showers given by simulations