LIGO-G960202-00-D

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VIRGO Photodetector

- Aim : measure the output interferometer light

- Specifications :
  - about 10 MHz frequency bandwidth
  - high quantum efficiency
  - incident power of 1 W (if 1-C= 10^{-4}) without characteristic modifications

- Available commercial photodetectors

at λ=1.064 μm : η = 10% for silicon
η = 50% for doped silicon
η = 70-80% for germanium
η = 85-90% for InGaAs

$\Rightarrow$ Photodiode InGaAs

1 mm diameter InGaAs photodiode

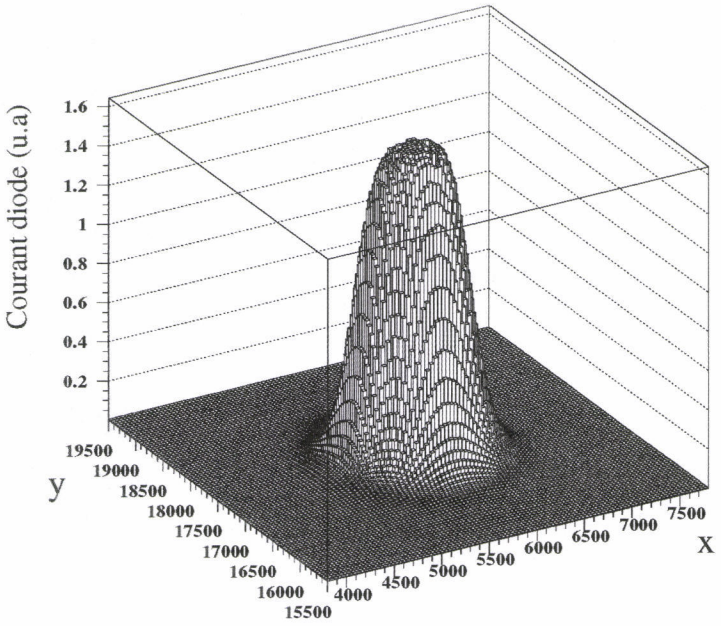
	Reference	Capacity (pF)	Breakdown voltage (at 10 μA)	Dark current (at 10 V)
Telcom (U.S.A)	35PD1M	38	75 V	2.5 nA
Fermionics (U.S.A)	FD1000-WX	25.3	"mou"	-
E.G.G (Canada)	C30641	18.2	60 V	2 nA
Epitaxx (U.S.A)	ETX-1000T	-	-	-
E.O.S (U.S.A)	IGA010	-	-	-
E.O.M (Great Britain)	InGaAs-1mm	26.5	"mou"	150 μA
Hamamatsu (Japan)	G3476-10	25	70 V	2 nA

3 mm diameter InGaAs photodiode

	Reference	Capacity (pF)	Breakdown voltage (at 10 μA)	Dark current (at 10 V)
E.O.S	IGA030	253	85 V	1 nA
Epitaxx	ETX-3000T5	330	30 V	11.5 nA
Hamamatsu	G5114-03	-	80 V	1.6 nA
E.G.G	C30665E	144	"mou"	1 μA
E.O.M	InGaAs-3mm	125	"mou"	150 μA

Uniformity of the diode response

- Uniformity measurement example

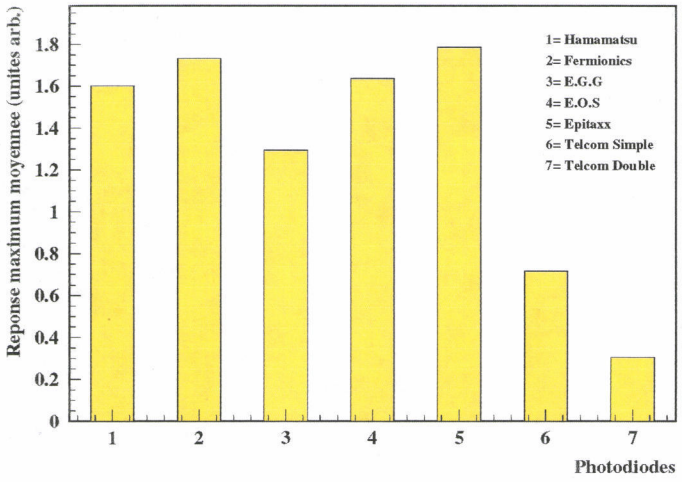


photodiode Hamamatsu
diameter 1 mm

beam : diameter 350 μm

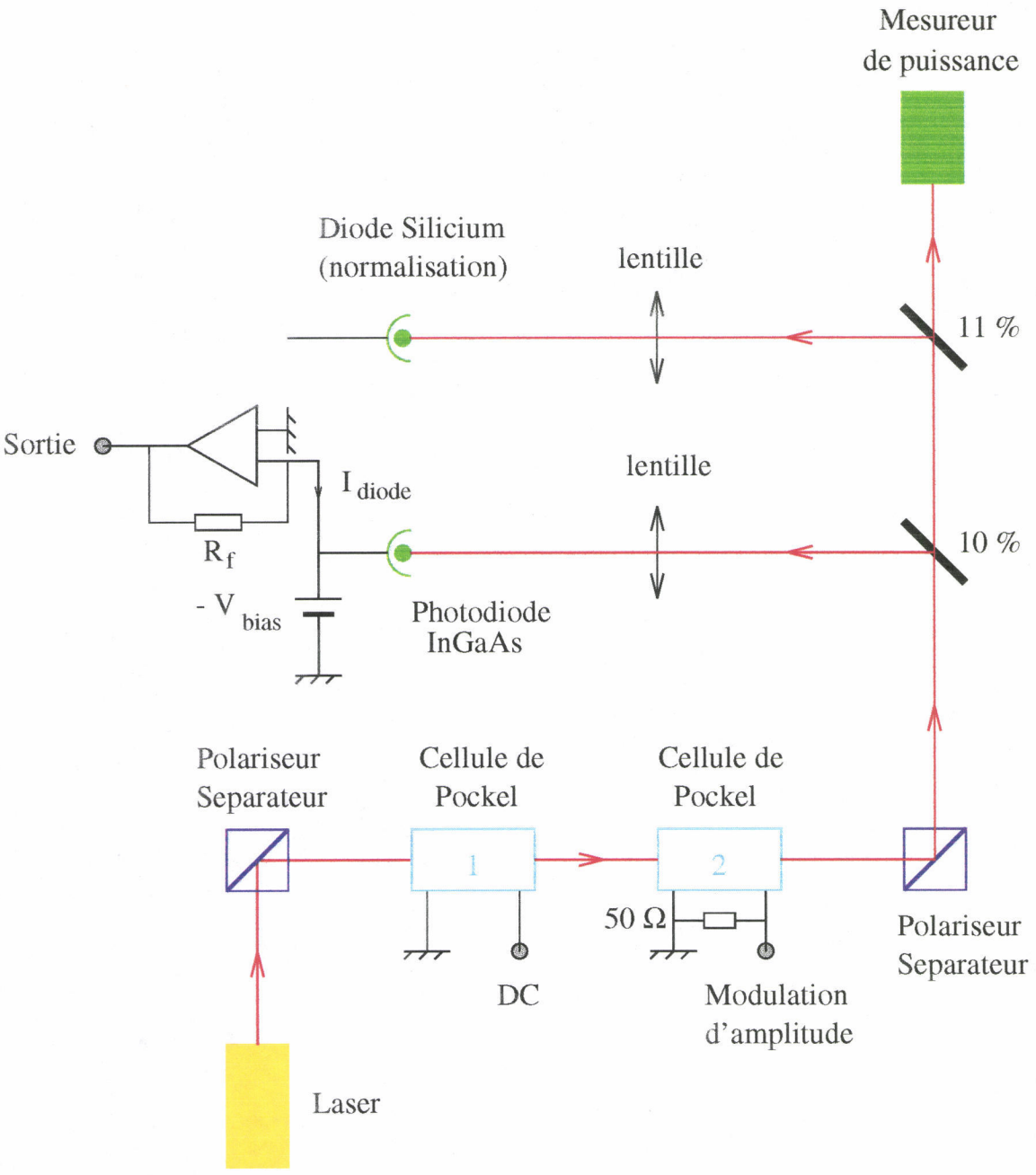
$\Rightarrow$ UNIFORMITY OK

- Photodiodes comparison

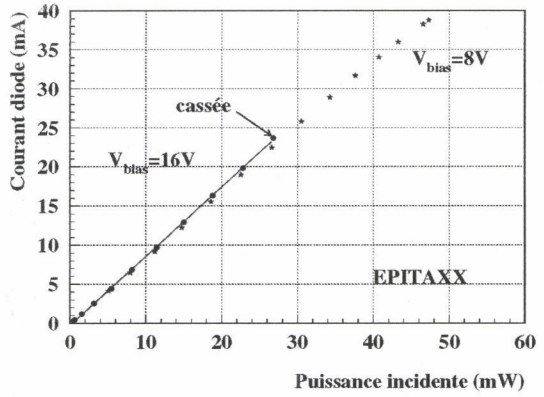


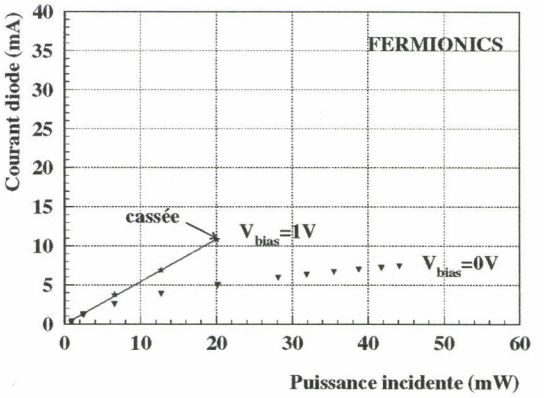
$\Rightarrow$ SELECTION

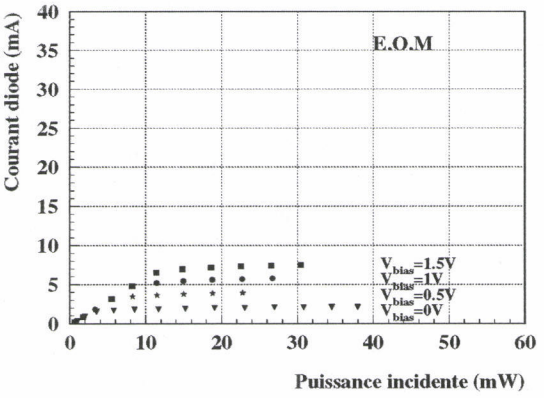
Photodiode test setup

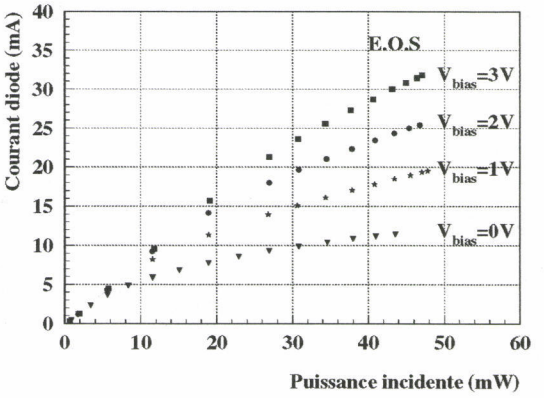


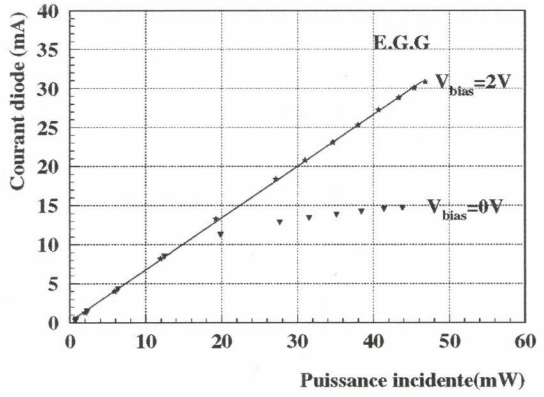
DC response linearity

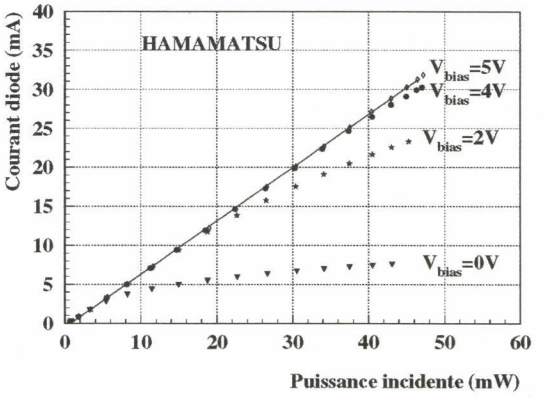








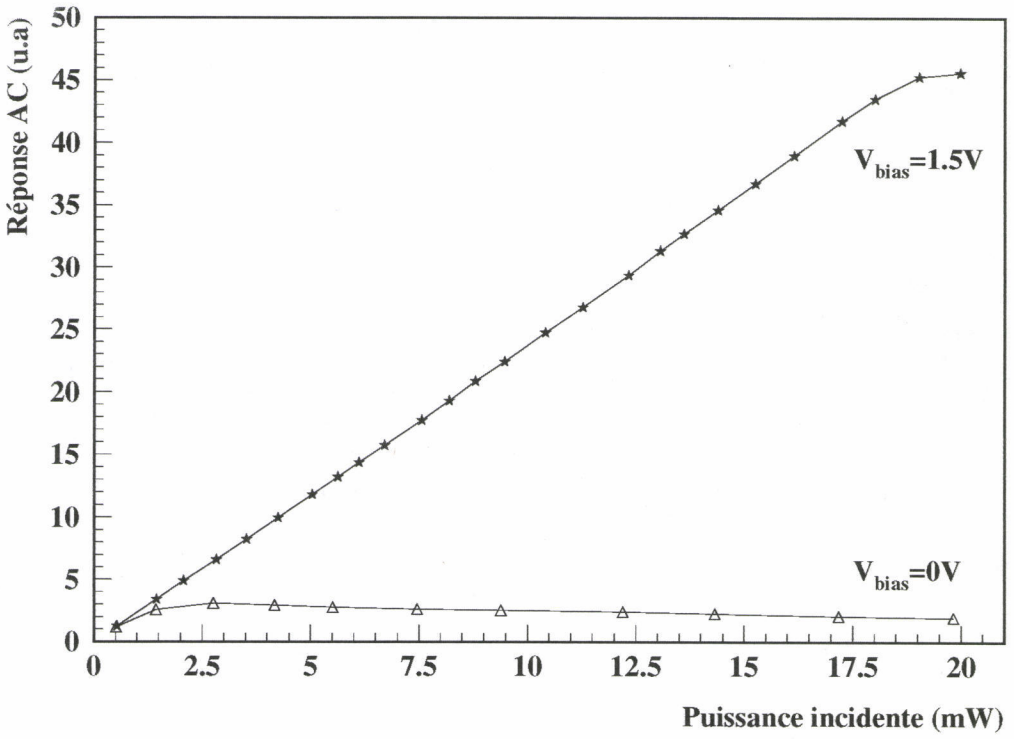




$\Rightarrow$ Linearity increases when V_{bias} increases

10 MHz response linearity

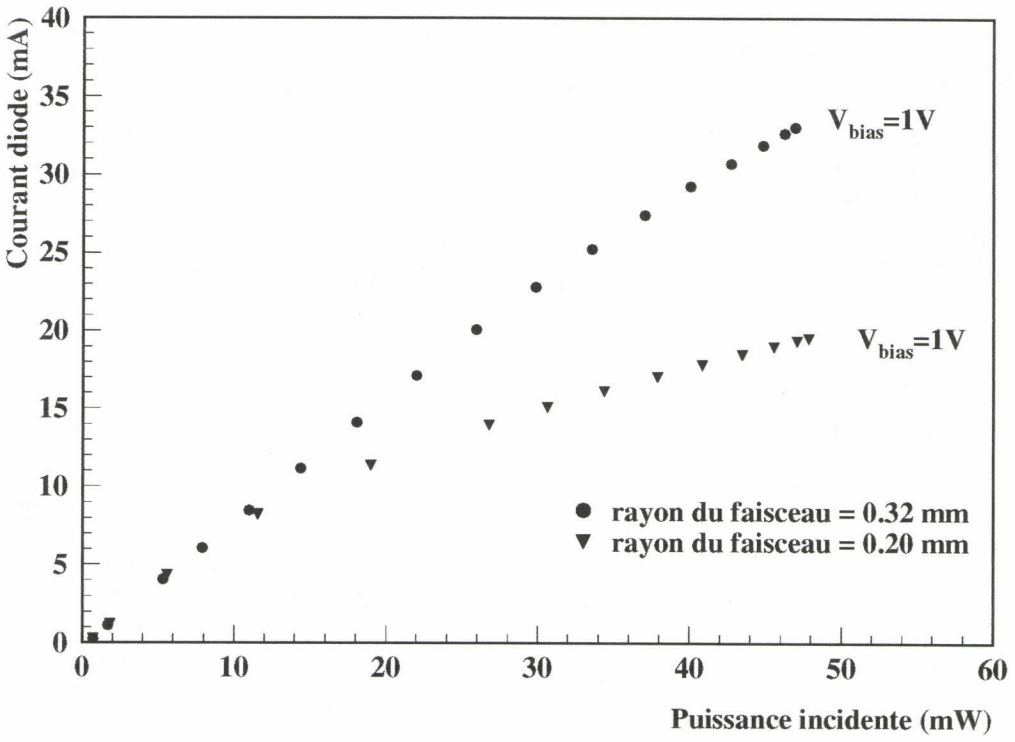
modulation depth = 7 % of incident light power



Photodiode E.O.S
diameter 1 mm

$\Rightarrow$ Inverse tension V_{bias} needed

Density effect

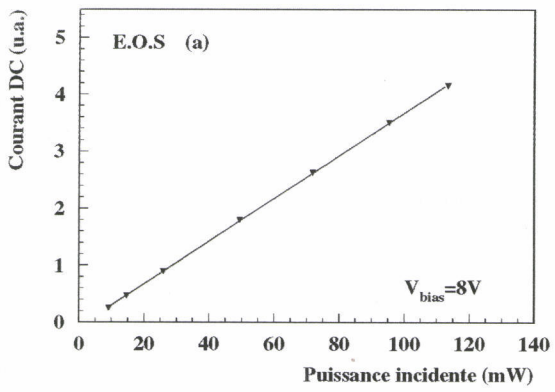


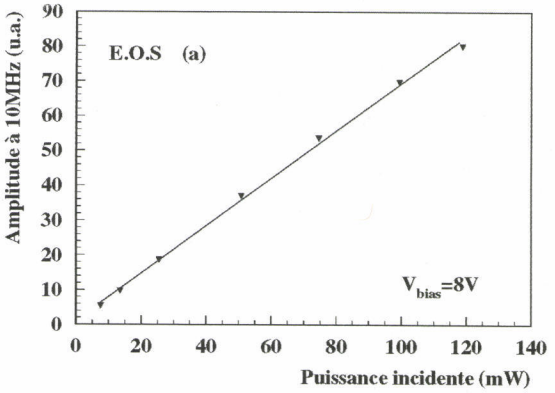
Photodiode E.O.S
diameter 1 mm

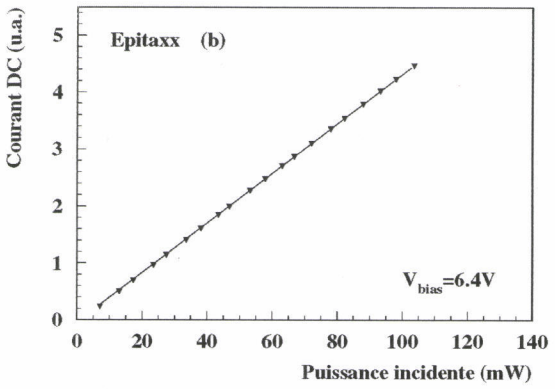
$\Rightarrow$ Increase of the photodetector surface area

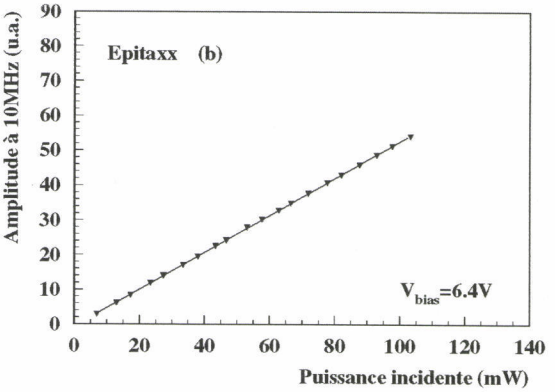
3 mm diameter photodiode

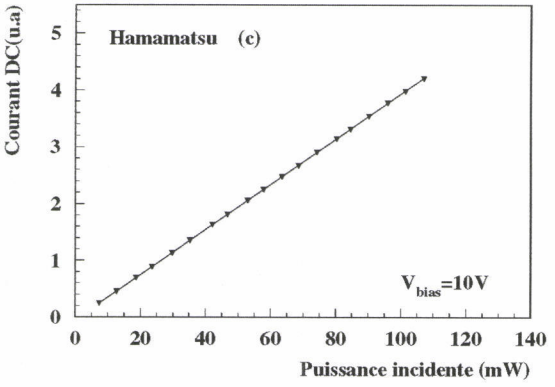
3 mm diameter photodiode linearity

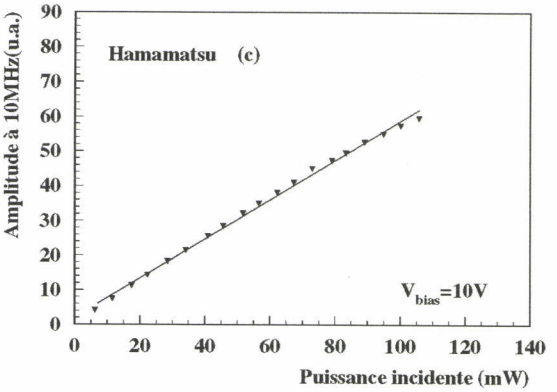












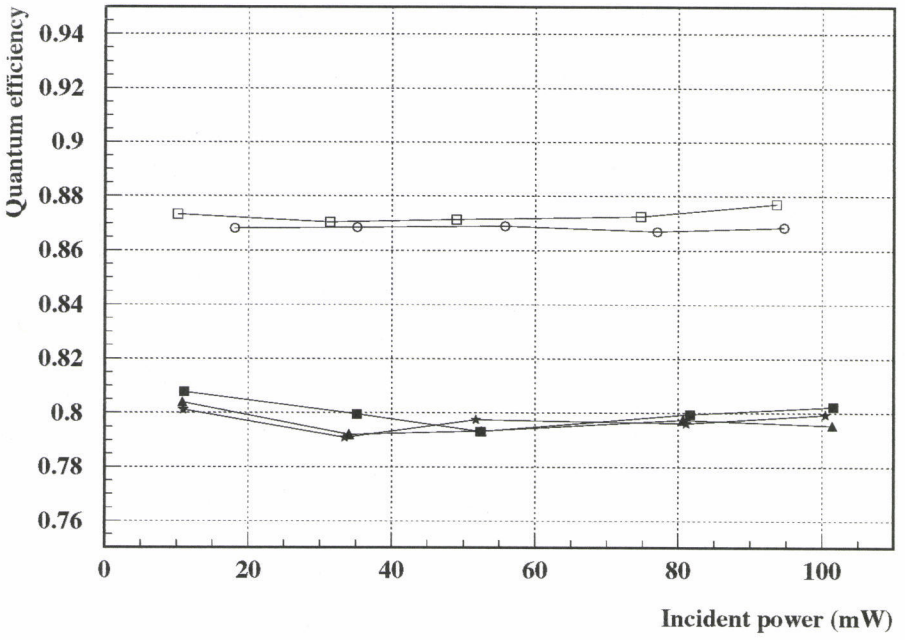
DC response

10 MHZ response

Photodiode choice

$\Rightarrow$ "Hamamatsu" photodiode

fulfils : 100 mW incident power
at 10 MHz
and a good uniformity
with a high quantum efficiency



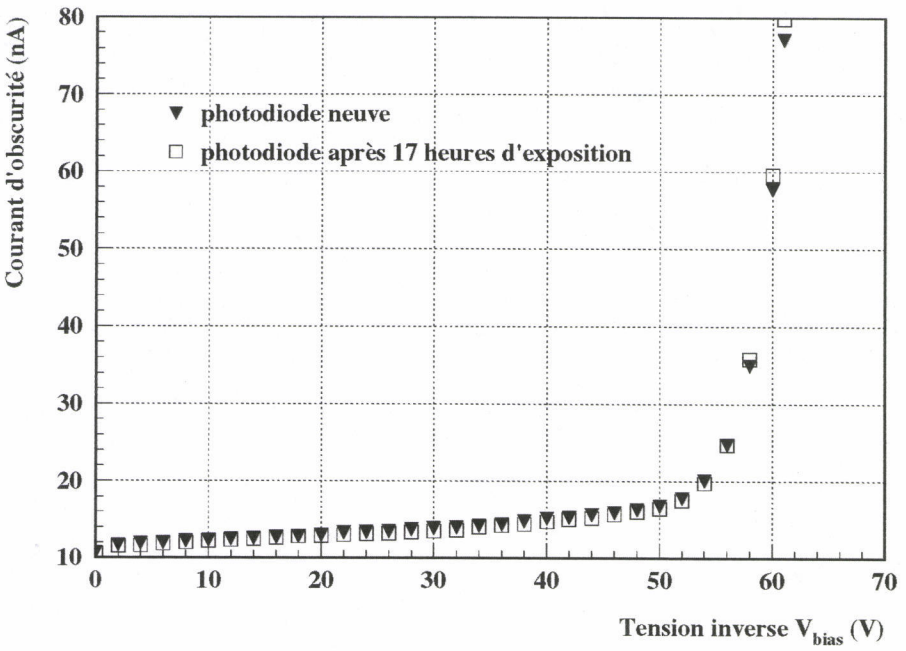
$\rightarrow$ anti-reflection coating on the window
$\rightarrow$ anti-reflection coating on the photodiode

$\Rightarrow$ quantum efficiency = 86 % (0.74 A/W)

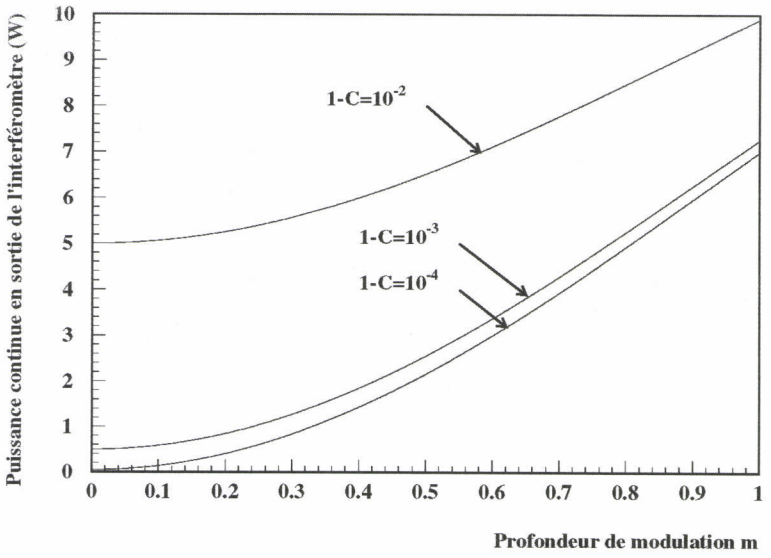
"Hamamatsu" photodiode

Other measurements :

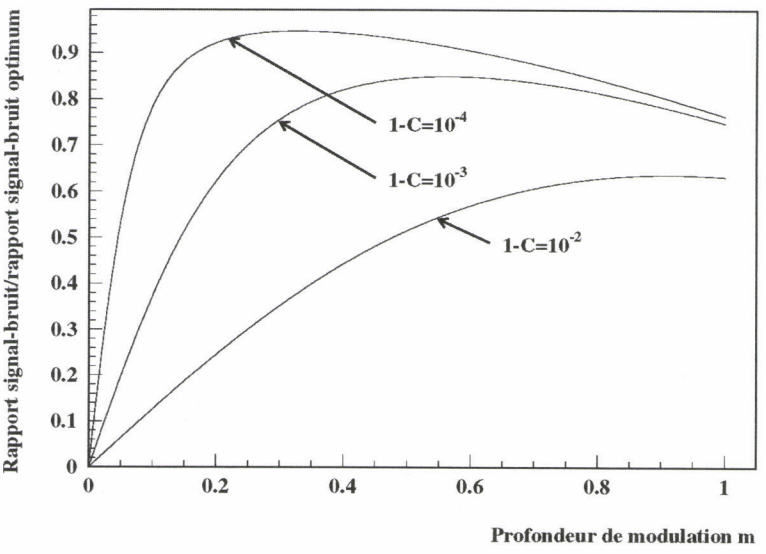
- noise measurement
- resistance to temperature increase
  $\rightarrow$ measurement of $E_g = 0.841 \pm 0.003$ eV
- long time power exposition (100 mW)



Contrast and signal-to-noise ratio



Better contrast $\Rightarrow$ decrease of incident light power on photodetectors

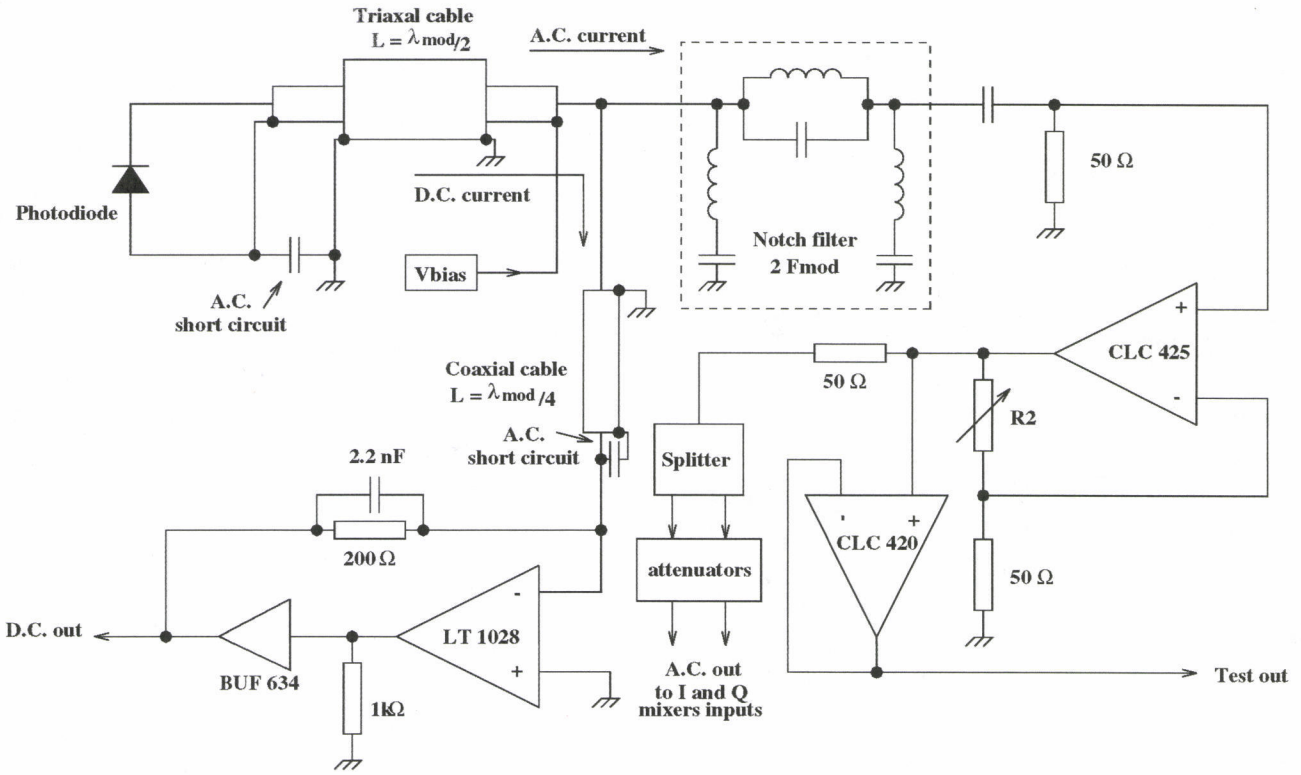


Better contrast $\Rightarrow$ better signal-to-noise ratio

Photodiode electronic

- Incident light power = 1W $\Rightarrow$ 16 photodiodes

- One photodiode electronic channel



VIRGO detection bench setup - 13