The BMV project : axion search with a pulsed magnet

Status of the experiment

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The Biréfringence Magnétique du Vide project

Laboratoire des Collisions Agrégats et Réactivité, Toulouse :

B. Pinto da Souza (Ph-D student), C. Robilliard, J. Vigué, C. Rizzo.

Laboratoire National des Champs Magnétiques Pulsés, Toulouse :

S. Batut (Ph-D student), R. Battesti, O. Portugall, G. Rikken

Laboratoire des Matériaux Avancés -VIRGO, Lyon :

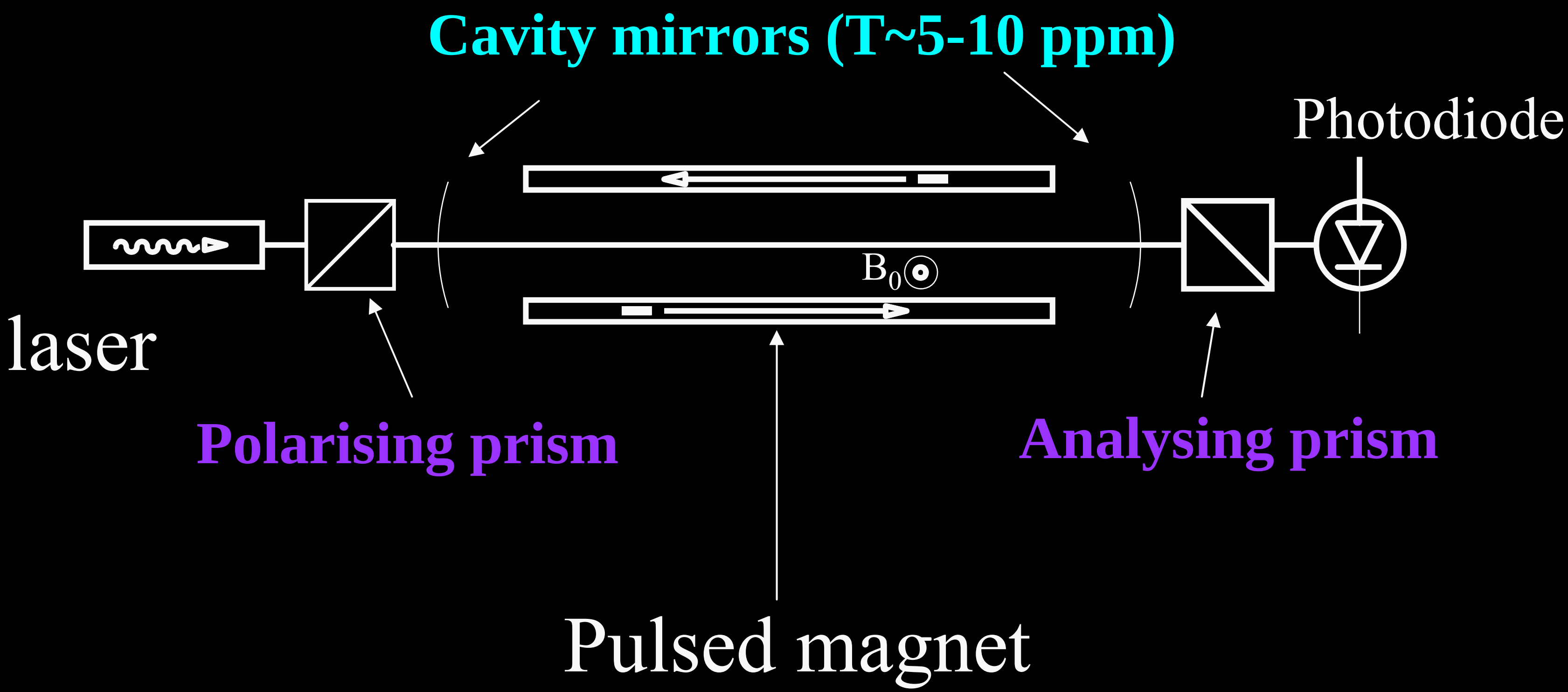
P. Ganau, A. Remillieux, C. Michel, L. Pinard, J-M. Mackowski.

Astrophysical consequences

Centre d'Etudes Spatiales du Rayonnement, Toulouse :

G.F. Bignami, JF Olive

Principle of the experiment



Experimental Challenge

QED Vacuum ellipticity :

$$\Psi_0 = 2F \frac{L}{\lambda} \Delta n \left(\frac{B}{1\,\mathrm{T}} \right)^2 \sin 2\theta \qquad \text{with } \theta = 45^\circ \text{ and}$$

$$\Delta n = 4 \times 10^{-24} \qquad \text{for } B = 1\,\mathrm{T}$$

Relevant parameters :
F = Finesse of the Optical Cavity
L = Length of the Magnet
λ= Laser Wavelength
B = Magnetic Field
and
Ψ_s = Sensitivity

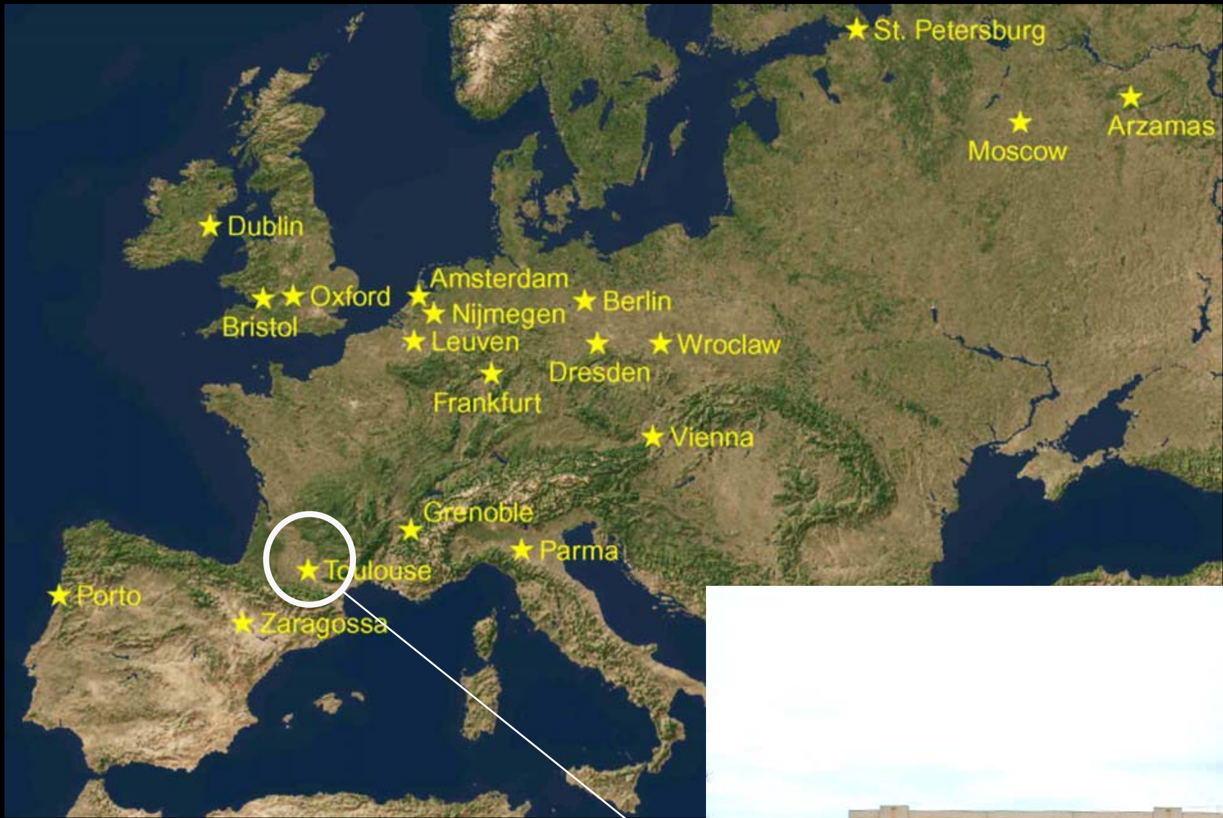
Reference experiment : PVLAS

(arXiv:hep-ex/0507107)

- $B^2L = 25\ T^2m$
- F = 70 000
- modulation frequency 0.6 Hz
- $\Psi s = 10^{-7}\ 1/Hz^{1/2}$

The pulsed magnet

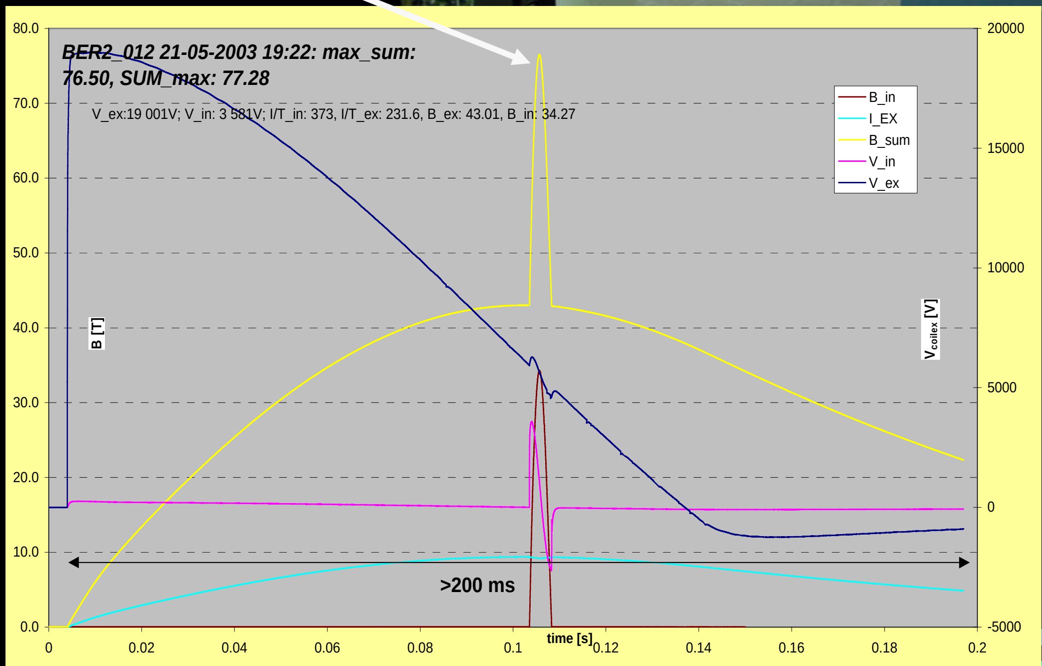
Magnetic field labs in Europe



One of the highest field in the world

Generator
24 kV,14 MJ
65 kA current limitation

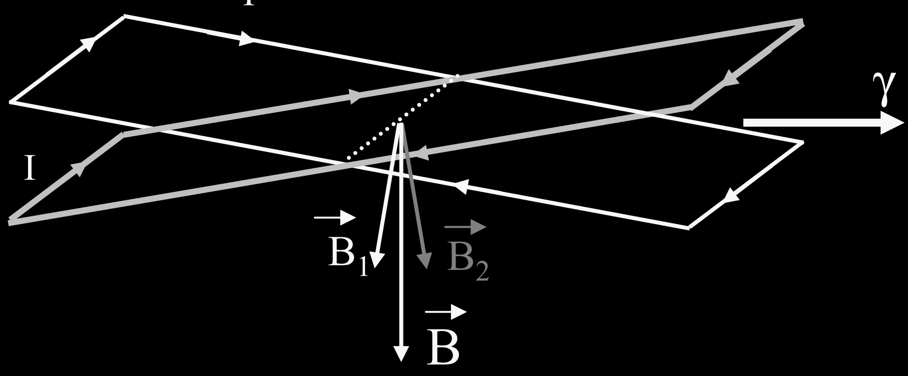
77,3 T



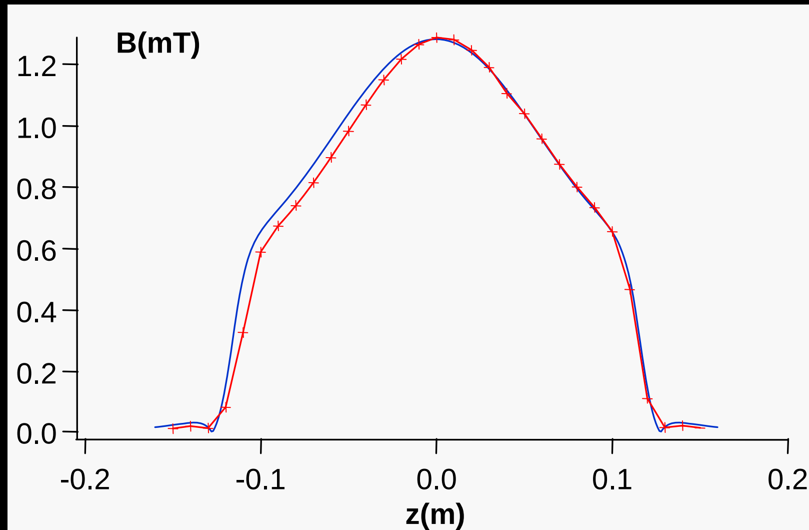
Design of the pulsed magnet : X-coil

Goal : → Transverse magnetic field
→ $B^2L > 30\ T^2m$

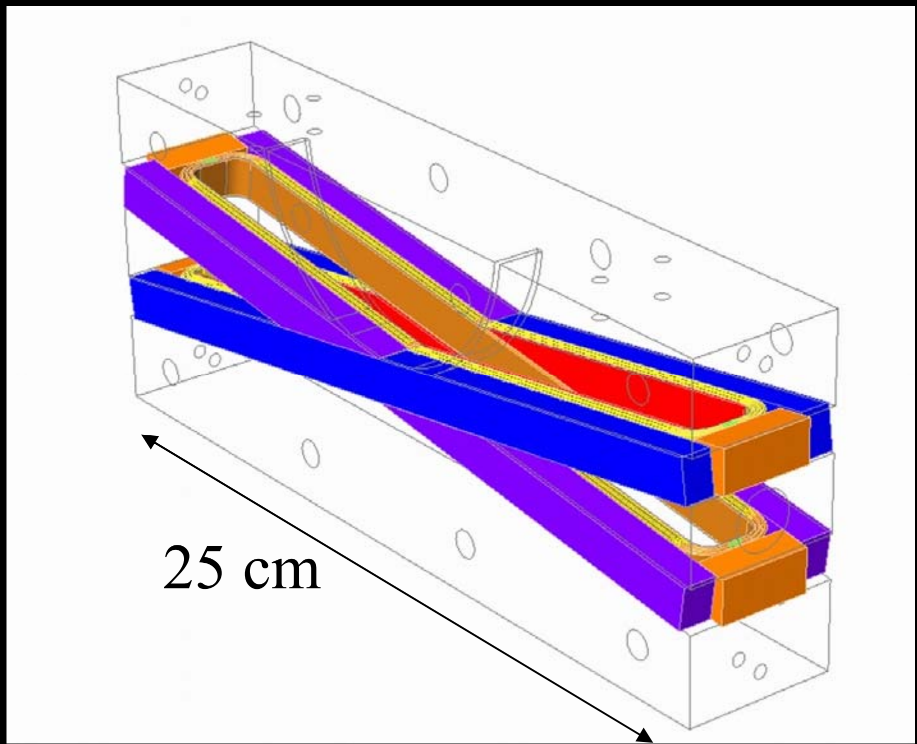
$B^2L/I^2 = 2{,}5\times10^{-7}\ T^2m/A^2$



X coil geometry

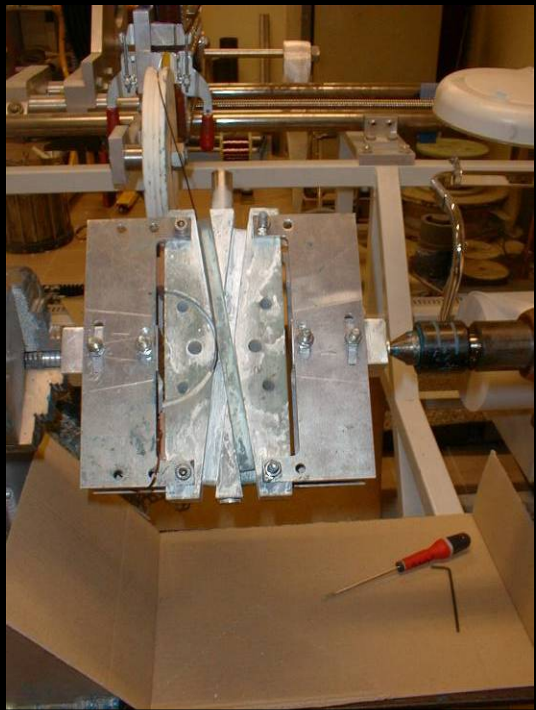


Magnet prototype



- copper wire
- cool at liquid nitrogen temperature
- cost ~ 1 000 €

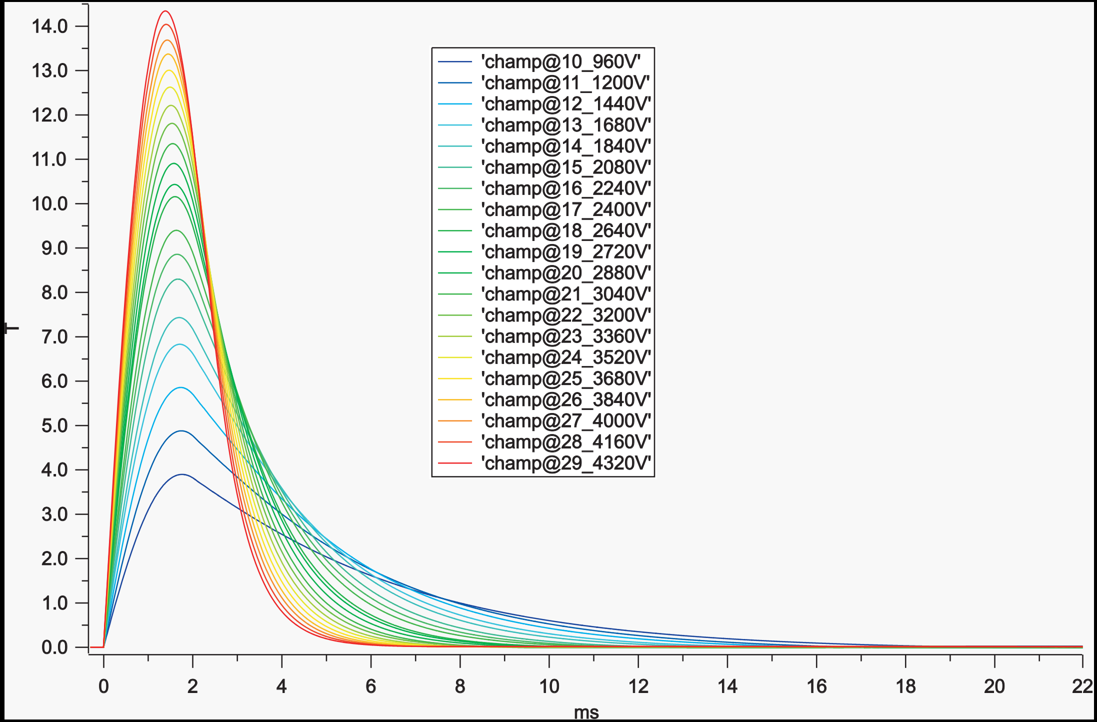
X coil



Winding
(5 hours)

Test at liquid
nitrogen temperature

Last results



Imax = 8 300 A

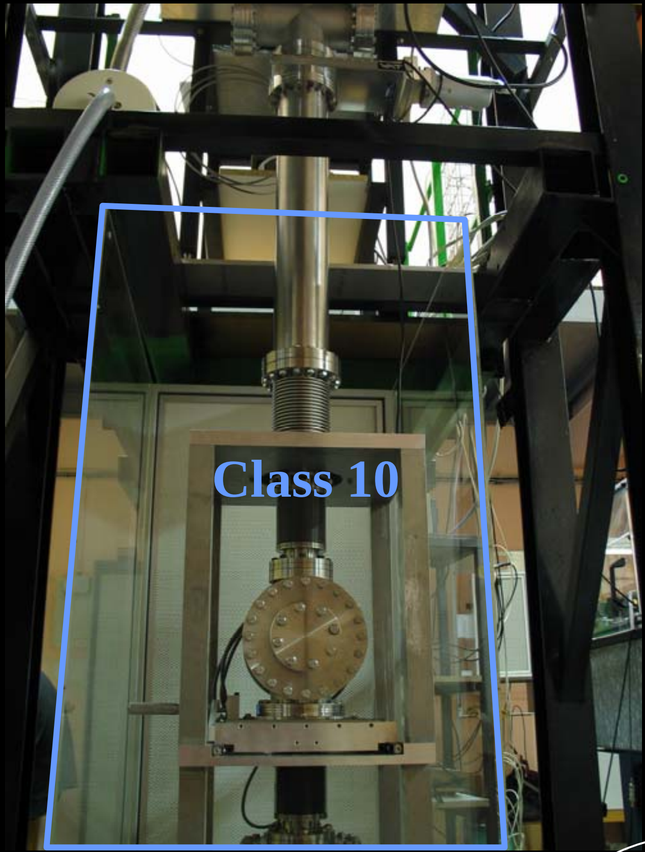
Vmax= 3 700 V

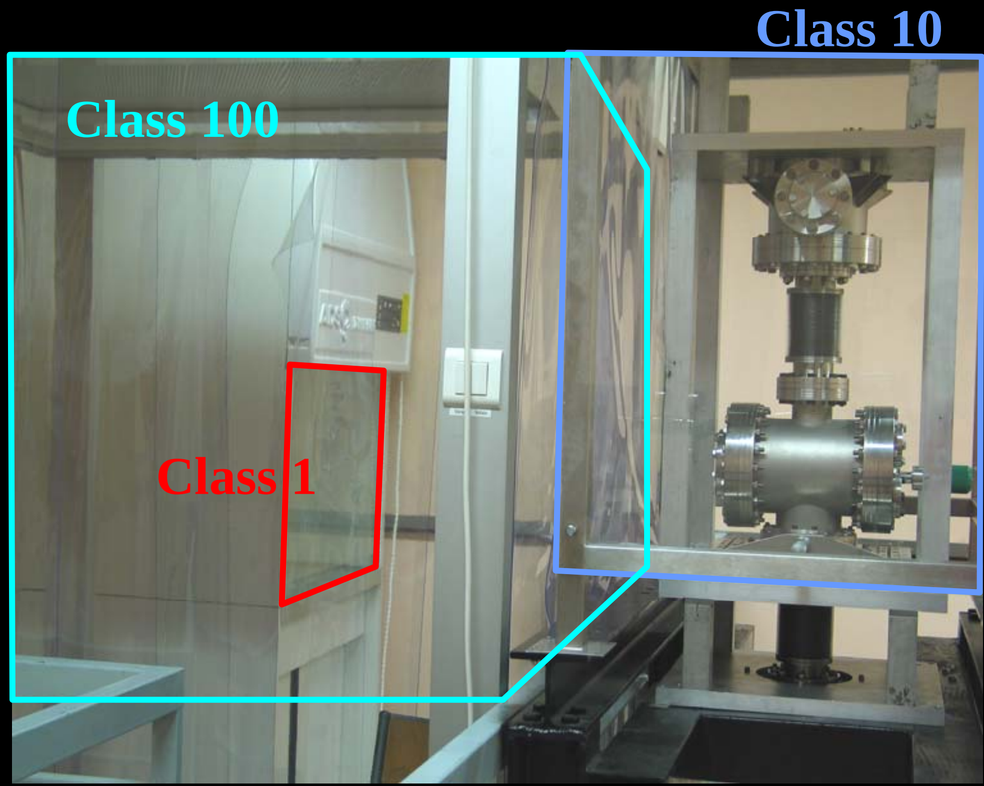
Bmax = 14,3 T

B^2Lmax = 28 T^2m

The cavity mirrors

Clean environments for our VIRGO mirrors





Class 1 → mounting the mirrors in barrels
(= 1 particle > 0.3 µm per ft^3)
Class 10 → inserting the mirror in the chamber

Class 100 → for the people to stand (fully equipped)

Miroirs après Montage et Démontage sur la cavité réalisé en Novembre 2005

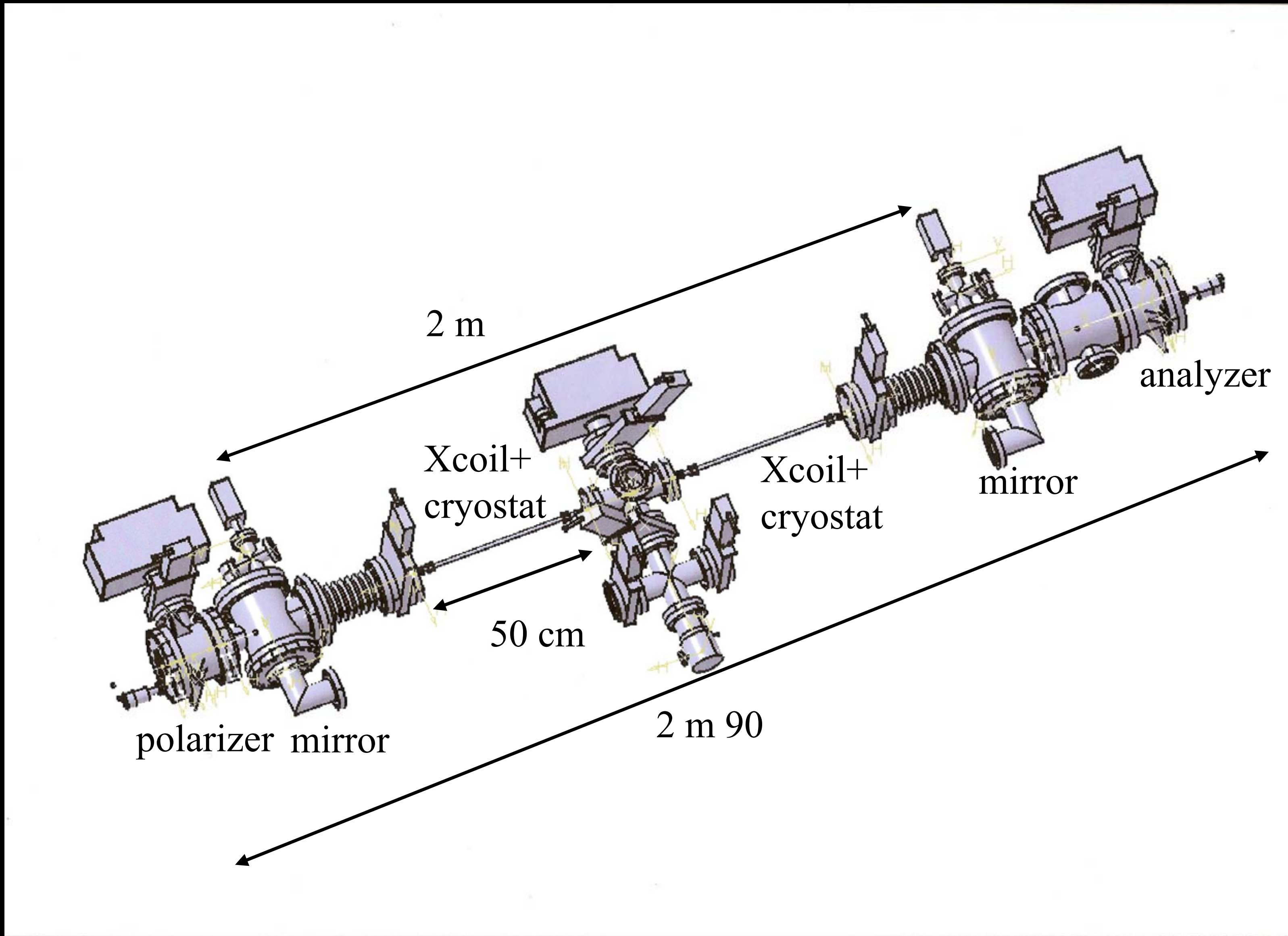
Référence	Original diffusion ∅ 12 mm (2002)	Diffusion after 1st manipulation ∅ 12 mm (2004)	Diffusion after cleaning ∅ 12 mm (2004)	Diffusion after last manipulation ∅ 12 mm (2005)
C02011/2 concave 8 m, incidence 0°, 1064 nm	**8 ppm**	**2500 ppm**	**69 ppm**	**67 ppm**
C02011/3 concave 8 m, incidence 0°,1064 nm	**25 ppm**	**3000 ppm**	**120 ppm**	**125 ppm**
C02011/5 concave 8 m, incidence 0°,1064 nm	**15 ppm**	**4200 ppm**	**2300 ppm**	**2100 ppm**
C02011/6 concave 8 m, incidence 0°,1064 nm	**30 ppm**	**4000 ppm**	**75 ppm**	**80 ppm**

great improvement !

Clean room at LNCMP

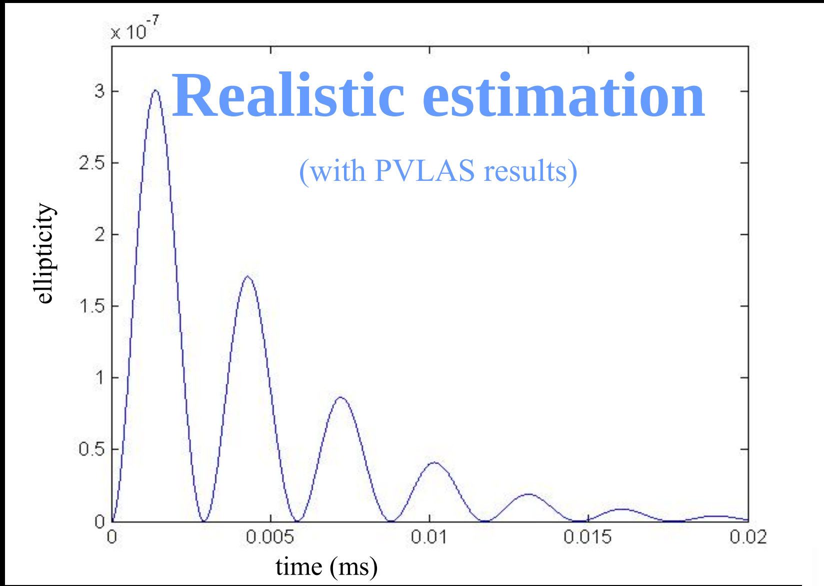
Set-up starting
February 06

Cavity set-up



Sensitivity

Ψ_S sensitivity



Ellipticity modulated at frequency

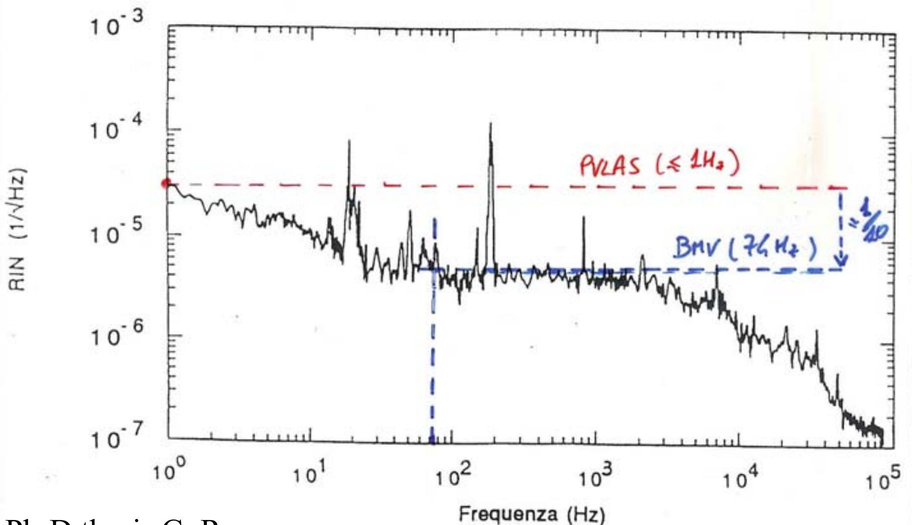
$2\nu_b > 100$ Hz

We can reasonably expect

$$\Psi_s \sim 10^{-8}\, 1/\sqrt{Hz}$$

Shot noise

$$\Psi_S \sim 10^{-9}\, 1/\sqrt{Hz}$$



Ph-D thesis G. Ruoso

Conclusion

Magnet is ready
Mirrors of the cavity have been tested
Our sensitivity is sufficient

Goal for 2006 :

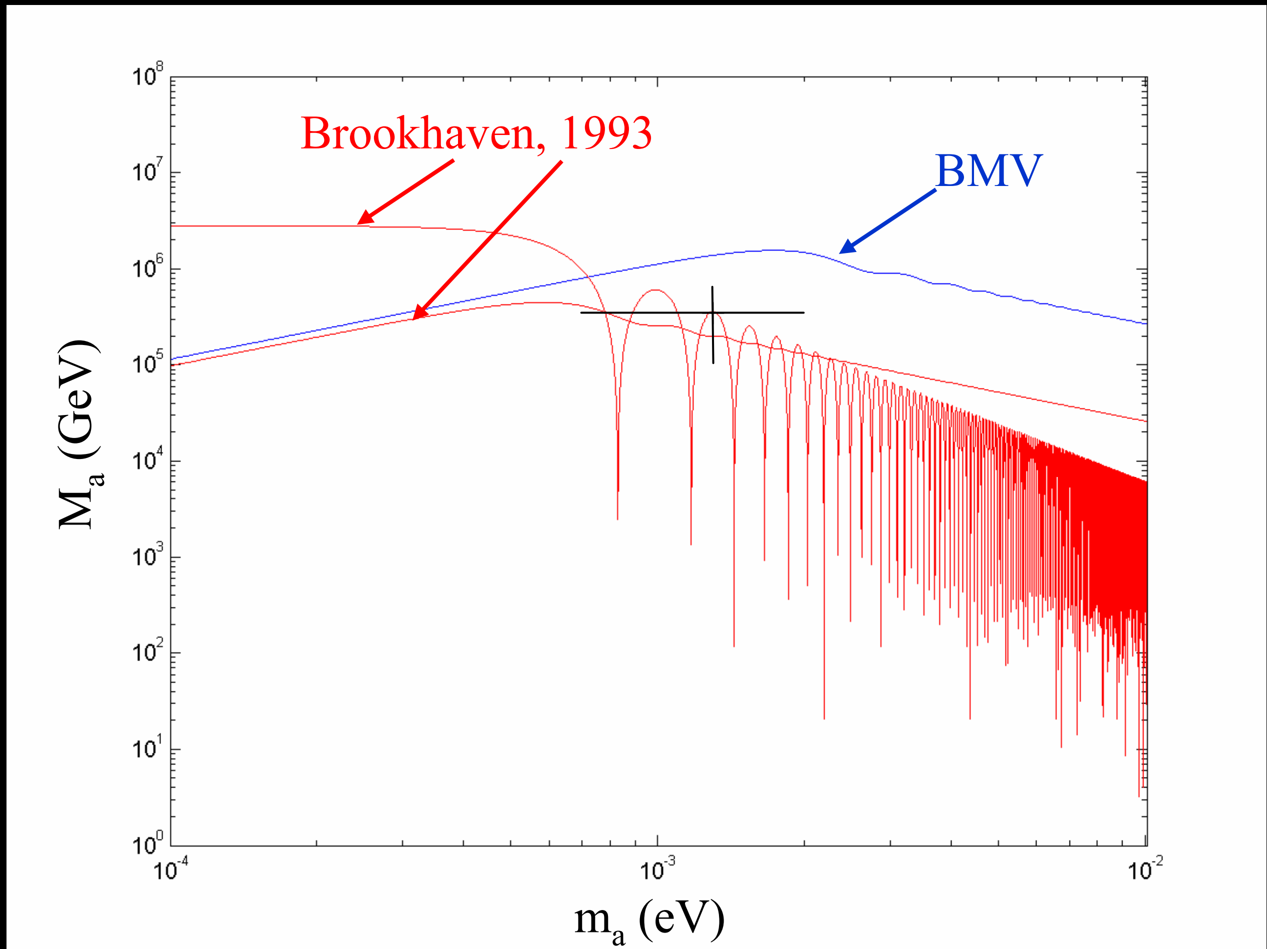
Build the experiment and take the first datas

Parameters :

- $B^2L = 30\ T^2m$
- finesse = 200 000
- $\Psi s = 10^{-8}\ /Hz^{1/2}$

Conclusion

Goal for 2007 :



Perspectives

- 25 T over 1.5 m
- 1 000 000 finesse

} QED effect

Feasability study for Mega Gauss generator at LNCMP

→ destructive coil : 300 T over 10 cm

→ photoregeneration experiment

Astrophysical observations : GLAST telescope 2007

PRL 94, 161101, 2005 and PRL 95, 211302,2005