The BMV Project

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Laboratories involved in the *Biréfringence Magnétique du Vide* project :

Laboratoire Collisions Agrégats Réactivité, Toulouse, France :

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Laboratoire National Champs Magnétiques Pulsés, Toulouse, France :

S.Batut (Ph-D), R.Battesti, S.George, B.Griffe, J.Mauchain, M.Nardone, O.Portugall, G.Rikken.

Laboratoire Matériaux Avancés - VIRGO, Lyon, France :

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

In collaboration with

F.Amiranoff, A-M.Sautivet, **LULI, Ecole Polytechnique, France.**

D.Bernard, **LLR, Ecole Polytechnique, France.**

G.F.Bignami, A.Dupays, M.Roncadelli, **INAF-IASF Milano and INFN Pavia, Italy**.

Campus of the Paul Sabatier University in Toulouse

LNCMP : 77,3 T

record européen de champ magnétique

Power supply
24 kV, 14 MJ, 65 kA

BMV Project :

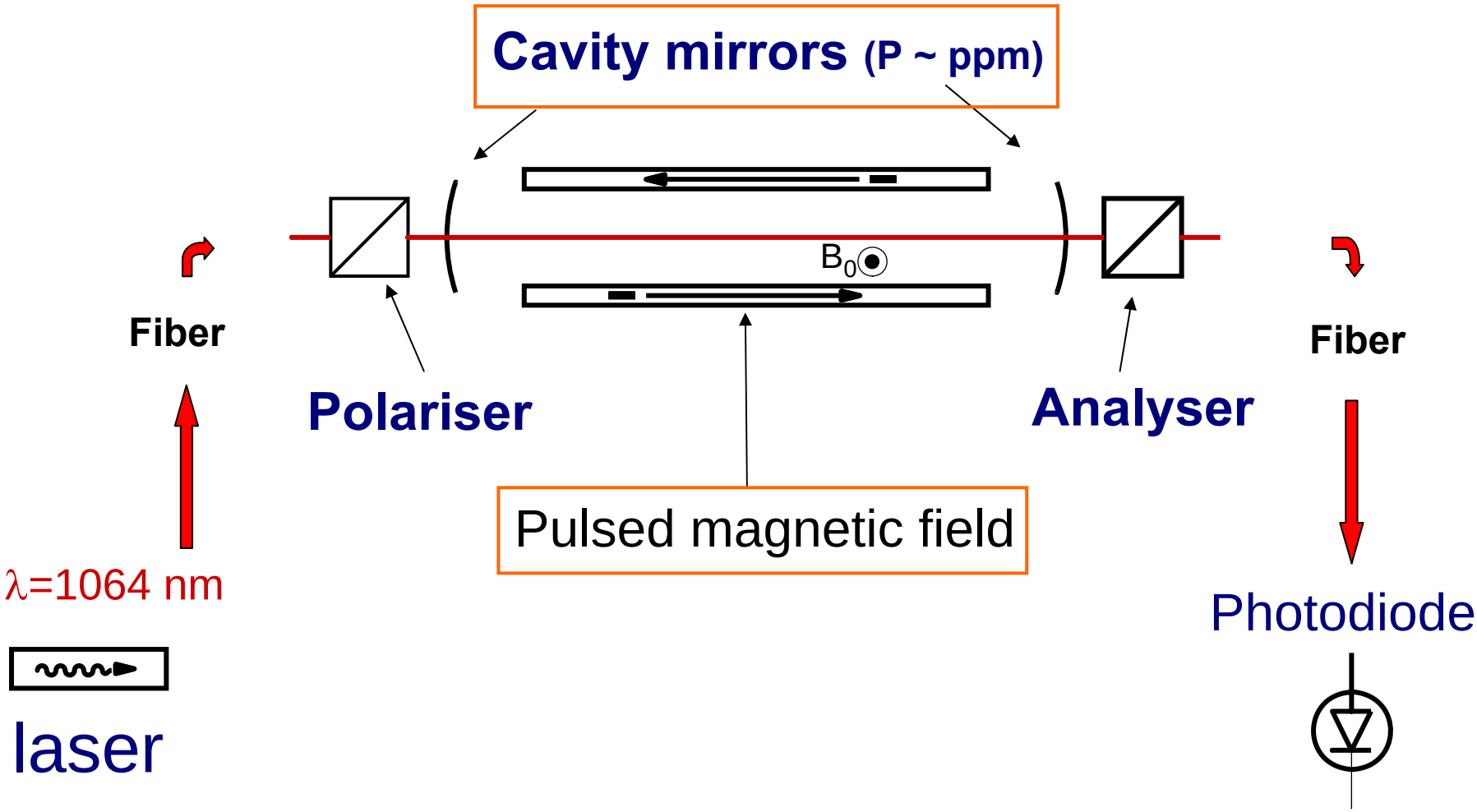
Laboratory tests — **BMV experiment at the LNCMP**

Funded since 2000
Motivated by QED

Photon Regeneration experiment at LULI

Astrophysical tests — **Quantum vacuum lensing**
&
Photon-Axion conversion

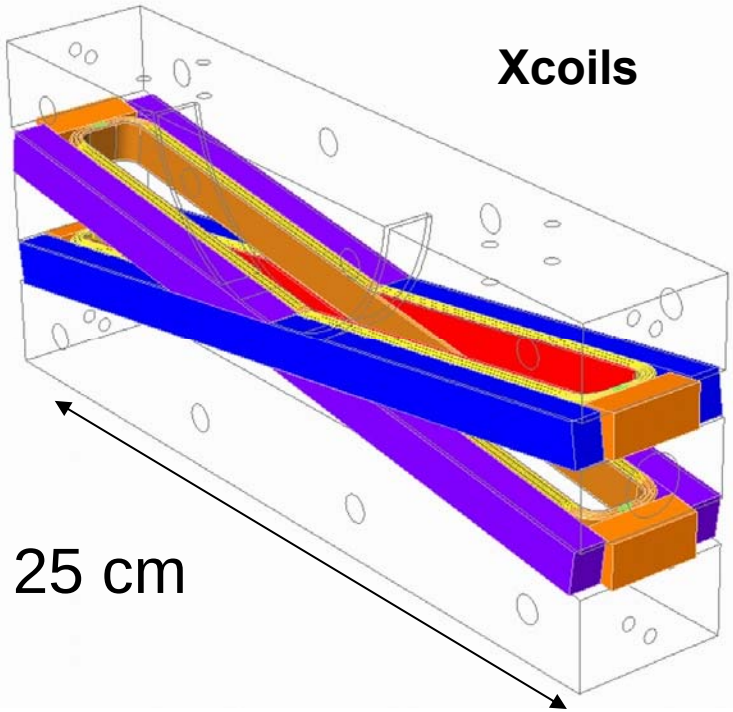
Experimental scheme : based on Iacopini and Zavattini's idea (1979)

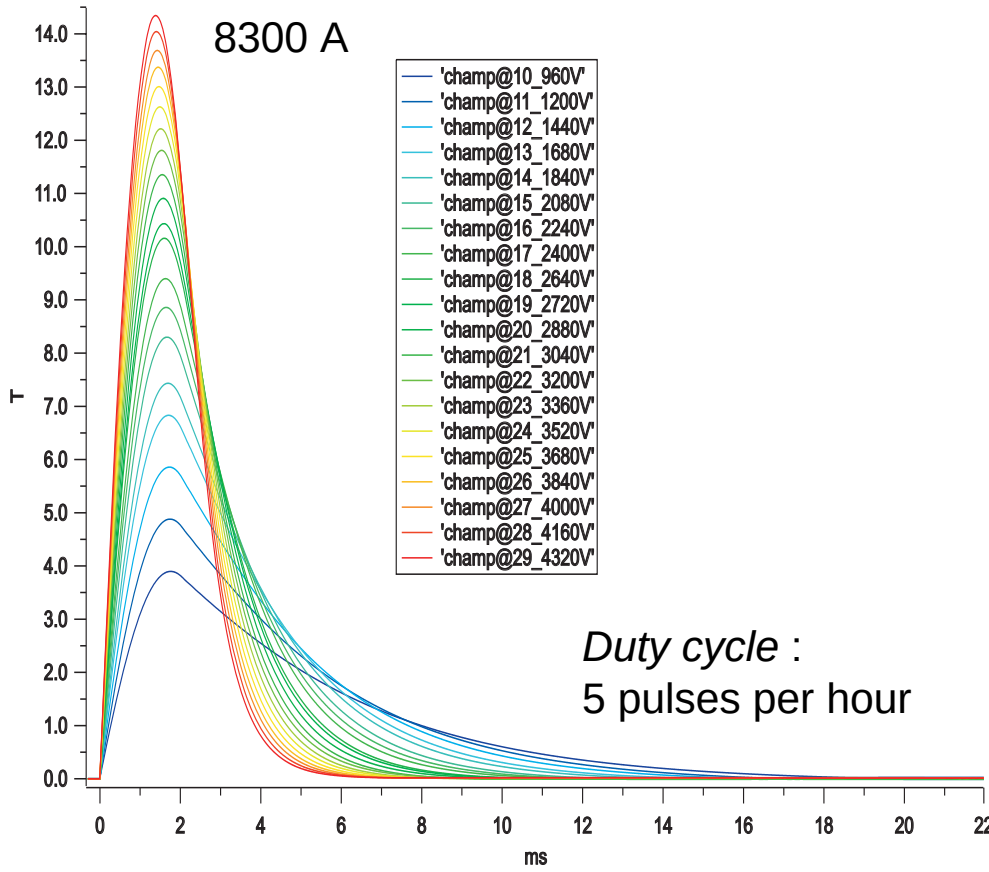


S.Askenazy, *et al*., CP564, *Quantum Electrodynamics and Physics of the Vacuum,* edited by G.Cantatore (2001) AIP

LNCMP

Xcoils





Duty cycle :
5 pulses per hour

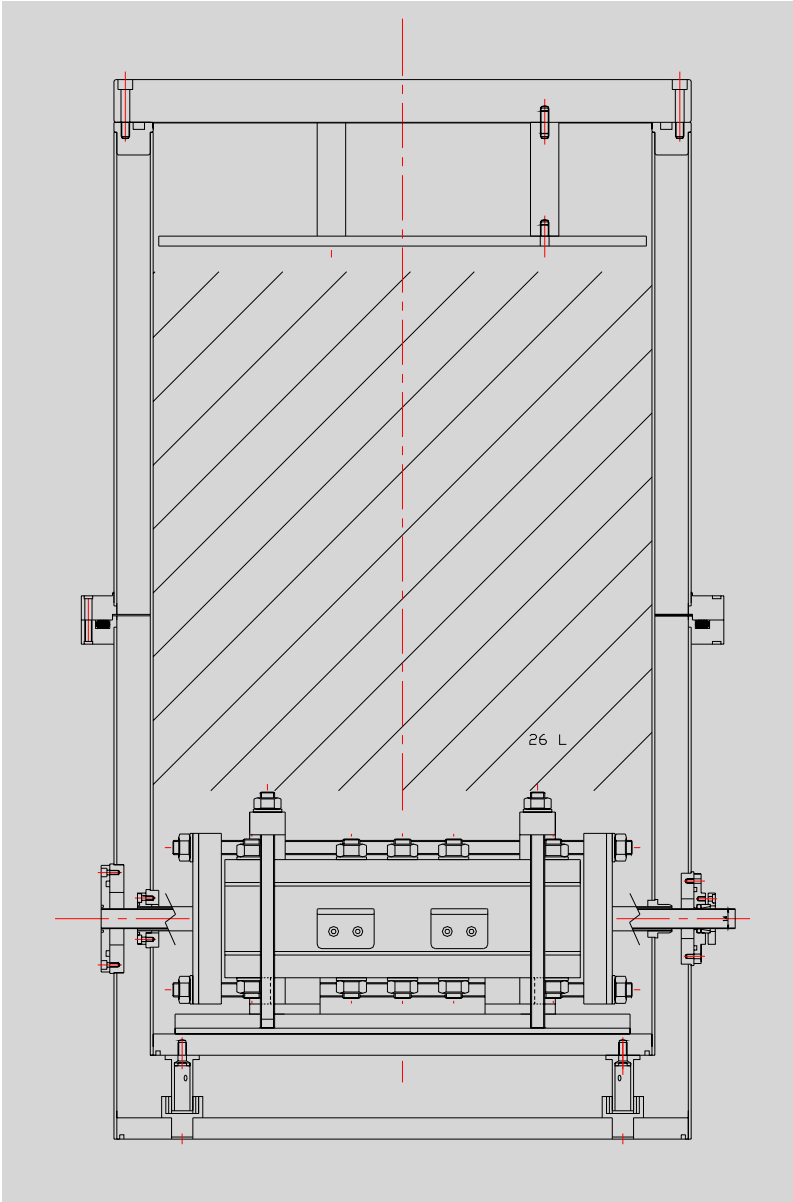
Coils have been aged :

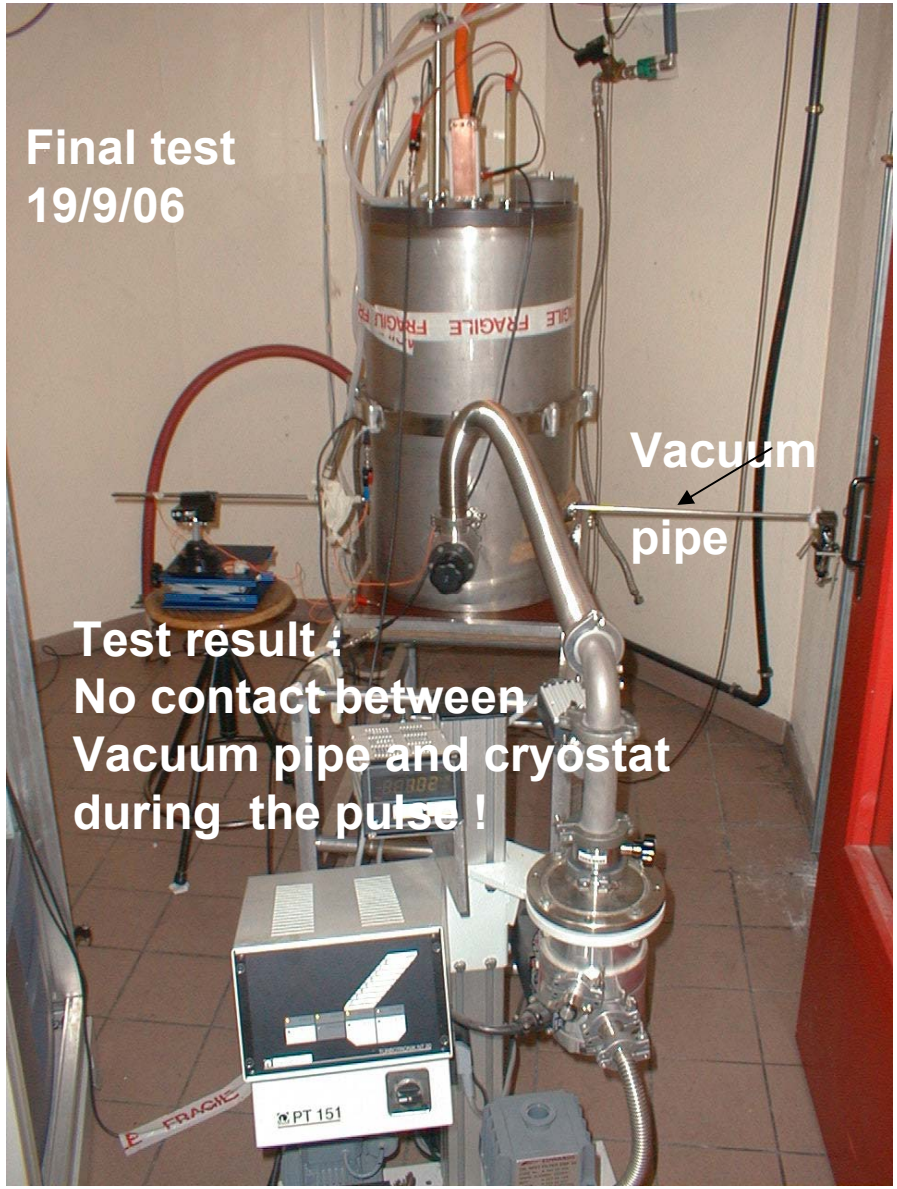
100 pulses at 11.5 T
100 pulses at 12.5 T

B = 14.3 T;

B^2L = 28 T²m; BL = 2.6 Tm

LN cryostat ready


26 L


Final test
19/9/06
Vacuum
pipe
Test result :
No contact between
Vacuum pipe and cryostat
during the pulse !
PT 151

Magnet R&D

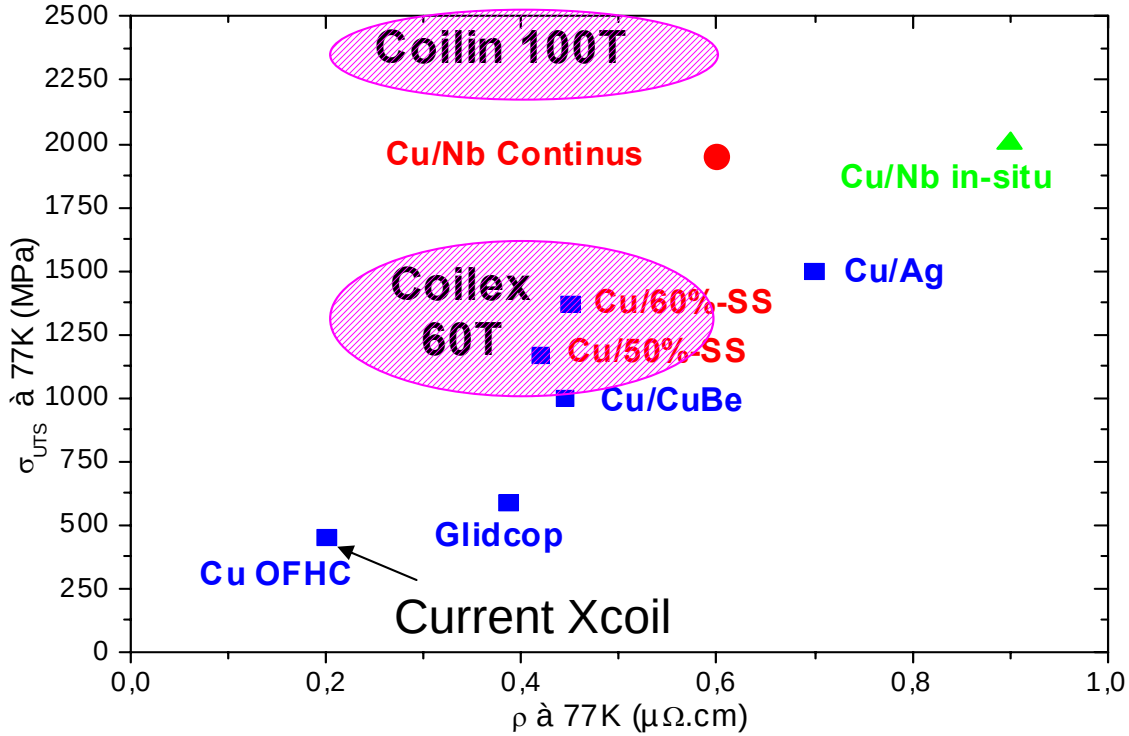
Next steps :

-Computer studies of forces and constraints

- New coils with stronger wire

Goal

25 T



Much stronger conductors available! Trade-off heating versus mechnical strength.

Fabry-Perot Mirrors : 4 ready in Toulouse

LABORATOIRE MATÉRIAUX AVANCÉS

Miroirs (HB)22 HBB haute réflectivité pour cavités BMV

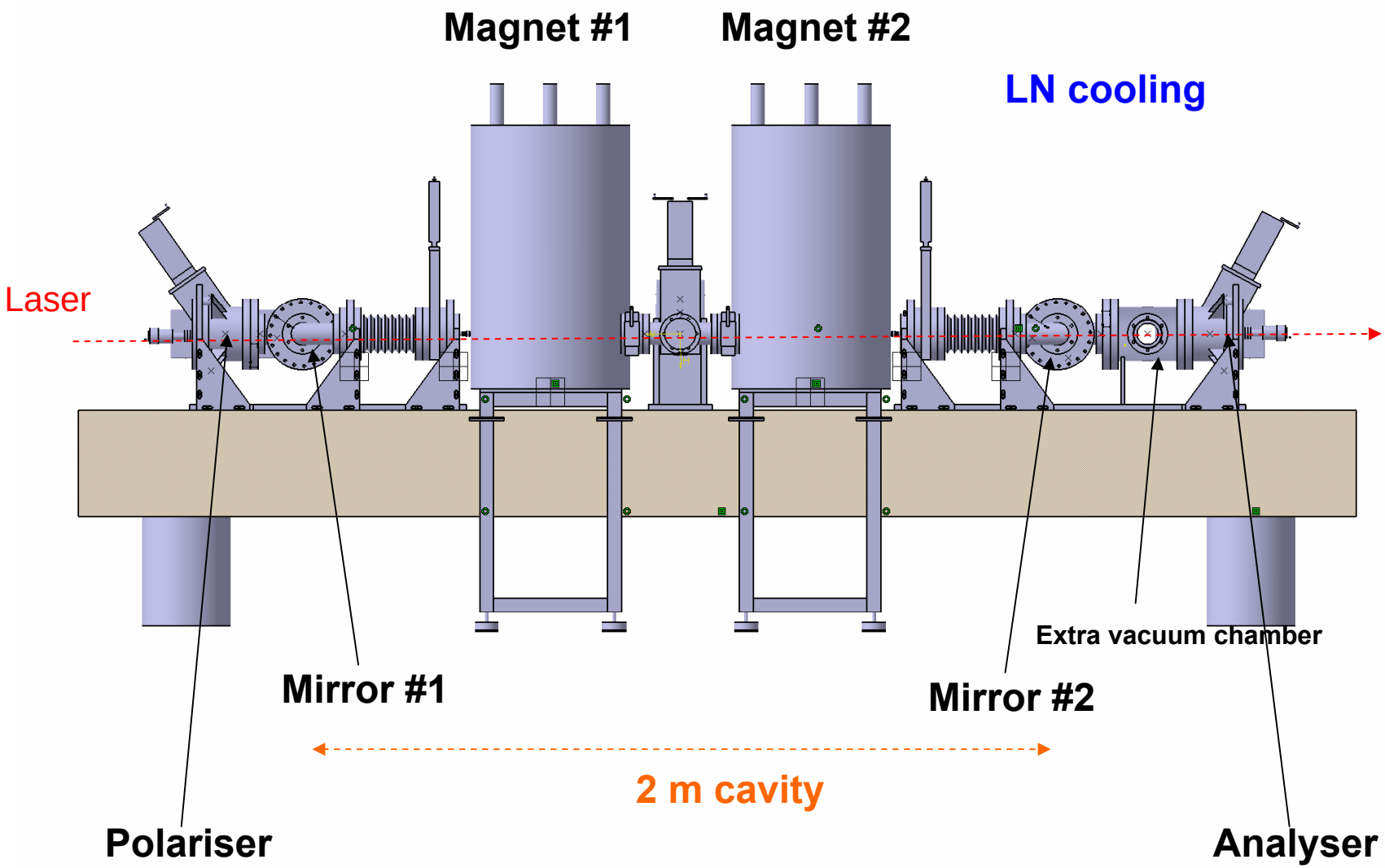
Référence	Diffusion (ppm) @ 1064 nm		Absorption @ 1064 nm (ppm)	Transmission @ 1064 nm (ppm)
	Sur ∅ 16 mm	Au centre		
		P_D	P_A	T
06033/11 concave 8 m, incidence 0°	9	2,4	0,8	**1,7** incidence 1°
06033/12 concave 8 m, incidence 0°	8	8	0,8	**1,9** incidence 1°
06033/13 concave 8 m, incidence 0°	9	7	0,8	**1,5** incidence 1°
06033/14 concave 8 m, incidence 0°	11	2,4	0,8	**1,6** incidence 1°

$$650\,000 \geq F = \frac{\pi}{T + P_D + P_A} \geq 290\,000$$

LMA
22, Bd Niels Bohr
69622 – Villeurbanne Cedex

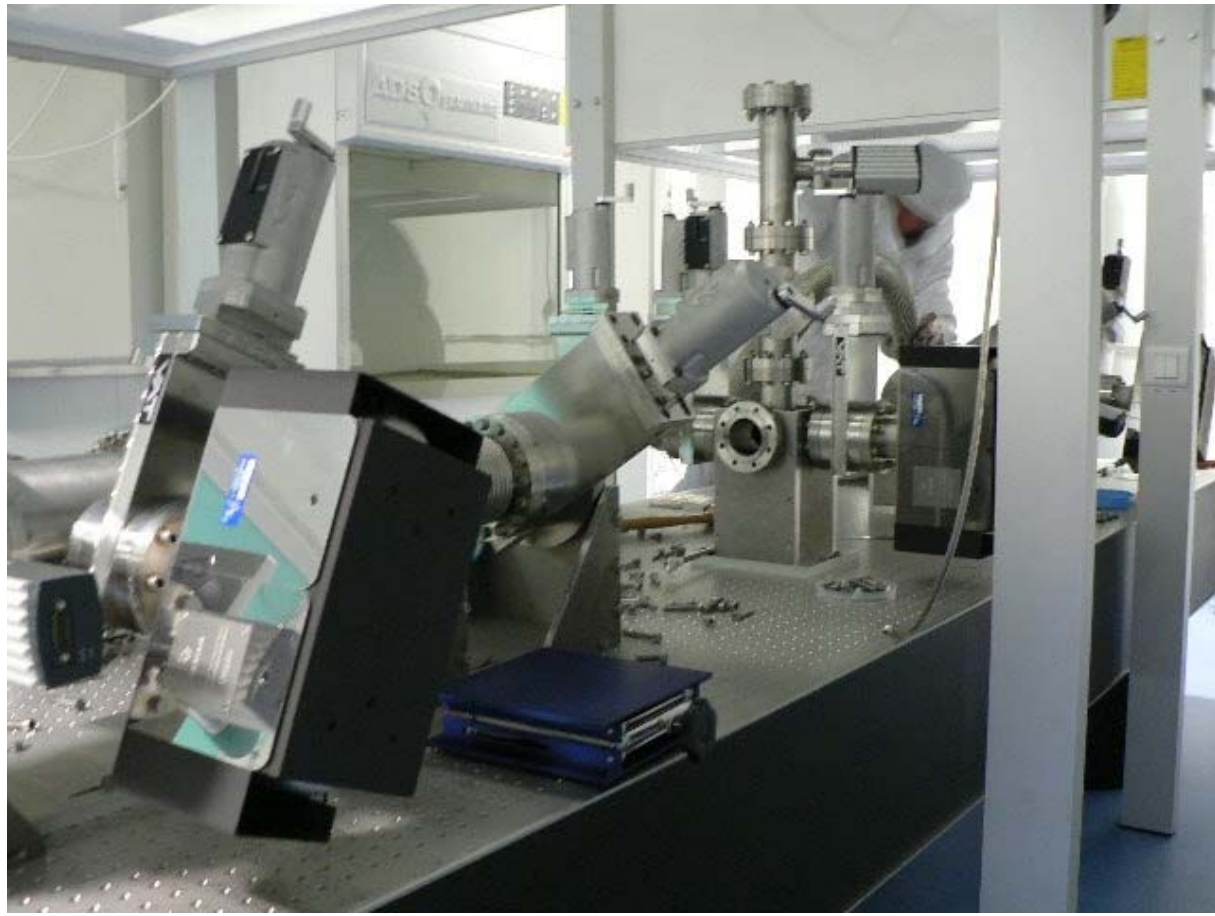
Mai 2006

ppm loss cavity mirrors need special care ⇒ **Experimental « clean room » at the LNCMP**



Experimental set up

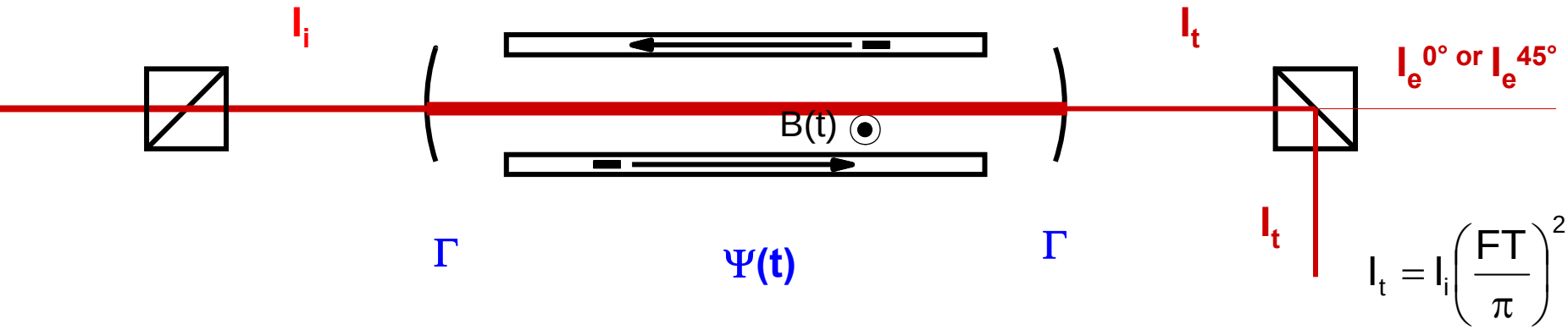
Optical set up completed july 2006



First data with low finesse cavity and magnetic field before end 06

BMV experimental scheme

0°, 45° Light polarisation with respect to B



$$I_t = I_i\left(\frac{FT}{\pi}\right)^2$$

Γ cavity birefringence
Ψ(t) ellipticity to be measured
σ^2 polarizers extinction

$$I_e^{0°}$$

$$I_e^{45°} = I_t\sigma^2 + I_t\left(\Gamma + \Psi(t)\right)^2 = I_t\left(\sigma^2 + \Gamma^2\right) + 2I_t\Gamma\Psi(t) + I_t\Psi(t)^2$$

We need

$$\Psi(t) = \frac{I_e^{45°} - I_e^{0°}}{2I_t\Gamma} \qquad \textbf{avec} \qquad \Gamma = \sqrt{\frac{I_e^{0°}}{I_t}}$$

$$I_t, I_e^{0°}, I_e^{45°}$$

And we can check that :
Without field = 0° polarisation

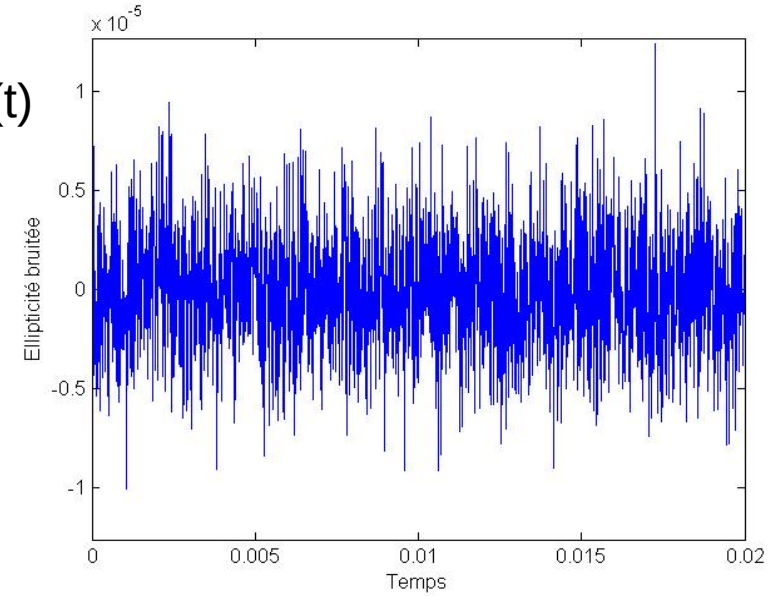
Basic signal analysis

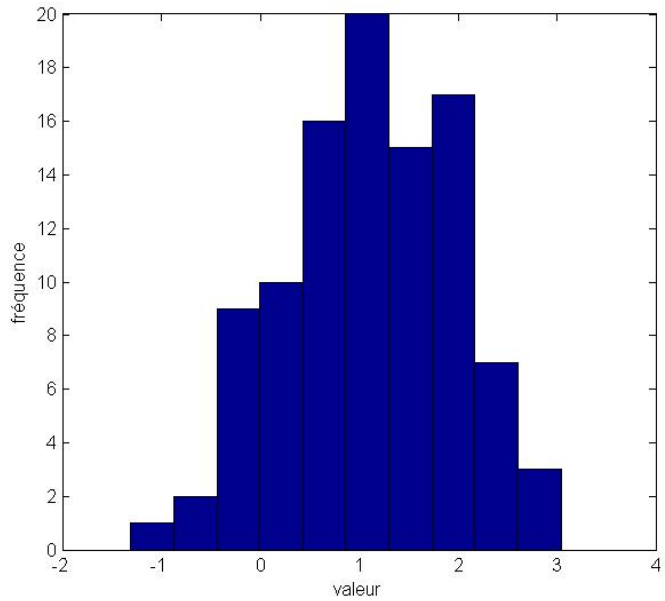
$$\Psi(t) = \alpha\, B(t)^2$$

$$\alpha = \frac{\int_0^T \Psi(t)\, B(t)^2 dt}{\int_0^T B(t)^4 dt}$$

Computer simulation : Ellipticity + noise

$\Psi(t)$





α

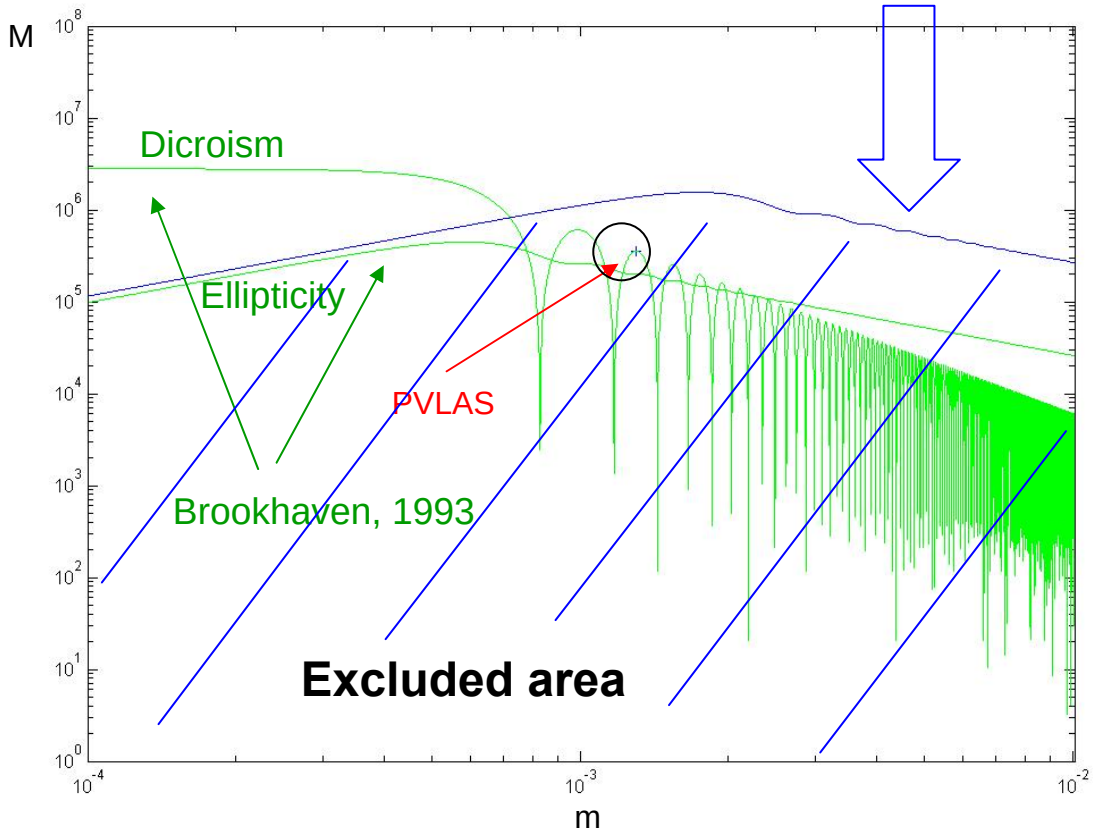
100 data

Expected :

- BL = (2x)2.3 Tm; B^2L = (2x)21 T²m
- finesse ≥ 200 000
- Sensitivity = $10^{-8}/Hz^{1/2}$

BMV, **30 pulses,** 1 day

Test of PVLAS results in 2007



BMV Project :

Laboratory tests	**BMV experiment at the LNCMP**	**First data end 06** **PVLAS test in 07**
	Photon Regeneration experiment at LULI	
Astrophysical tests	**Quantum vacuum lensing & Photon-Axion conversion**	

Photon Regeneration experiment at LULI

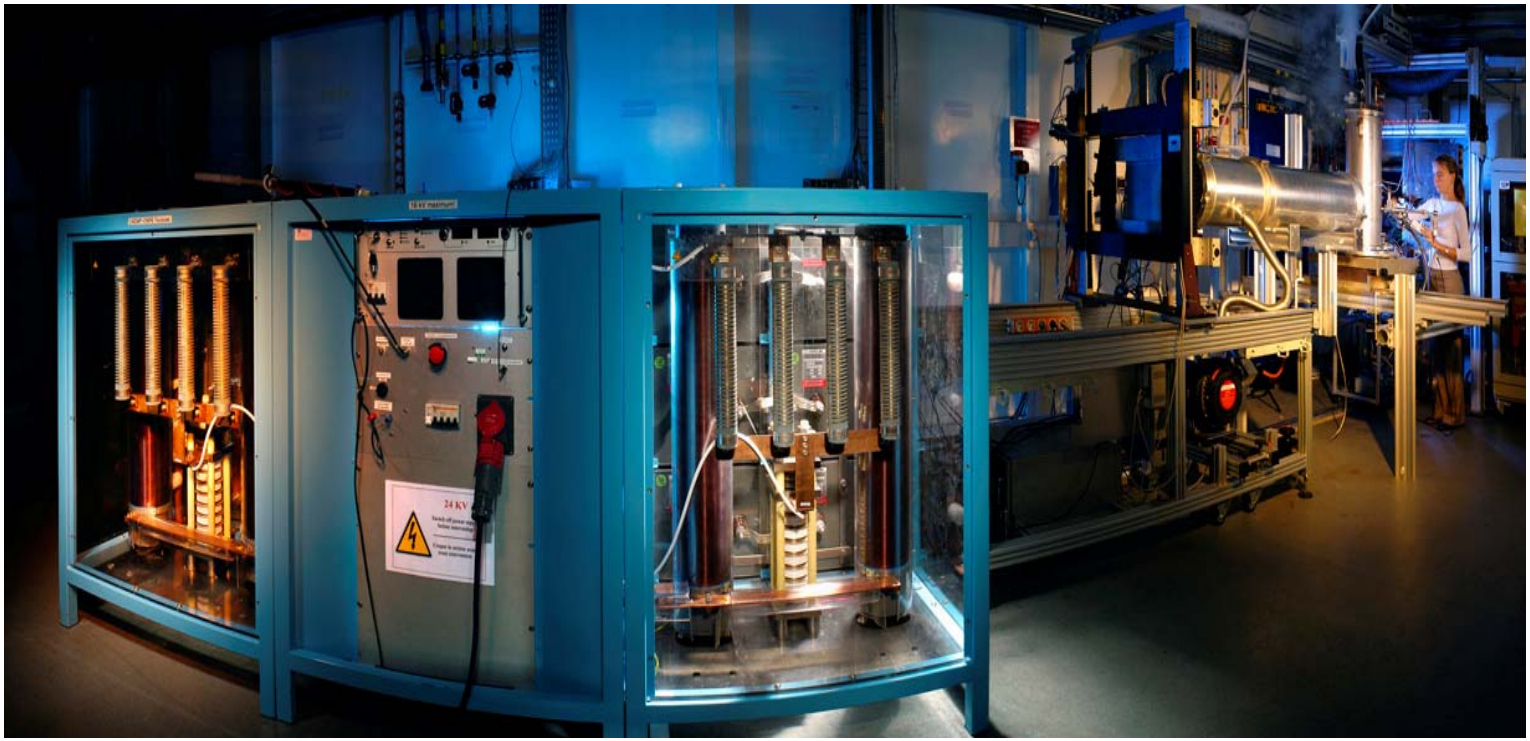
(***L**aboratoire pour l'**U**tilisation des **L**asers **I**ntenses*)

Campus of the

École Polytechnique

Outside Paris

thanks to BMV pulsed magnets



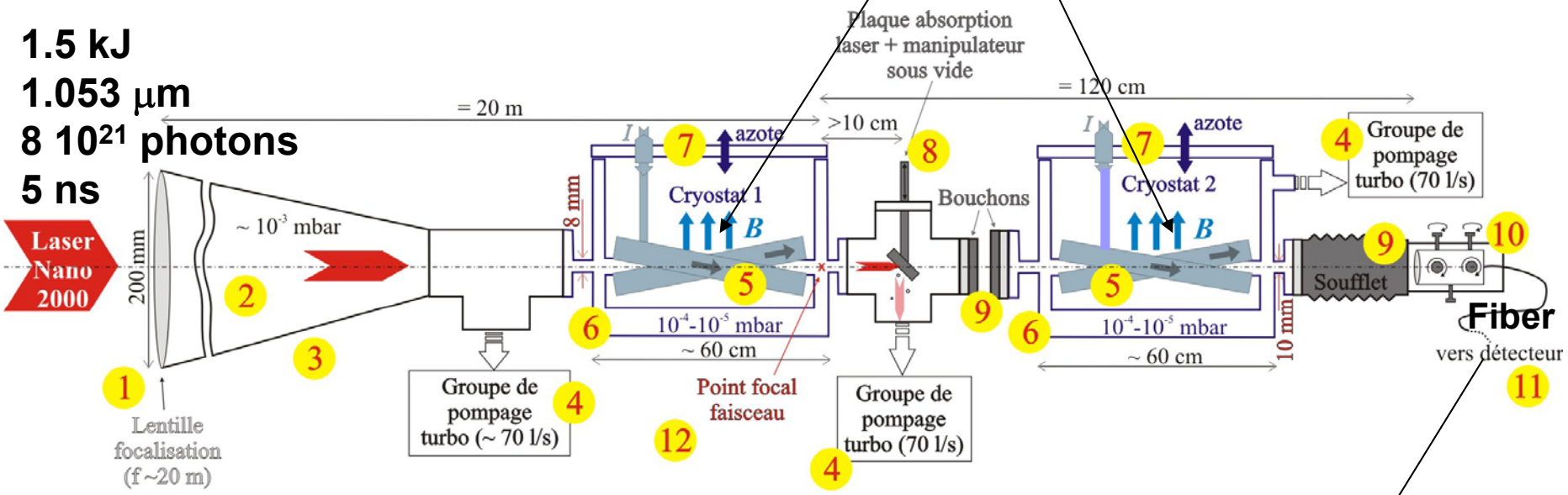
24 kV; 3x(1,2)^3 m^3

Pulsed magnet *portable* supply (here at the ESRF, Grenoble)

Experimental scheme

10 T over 0.4 m

1.5 kJ
1.053 μm
8 10^{21} photons
5 ns



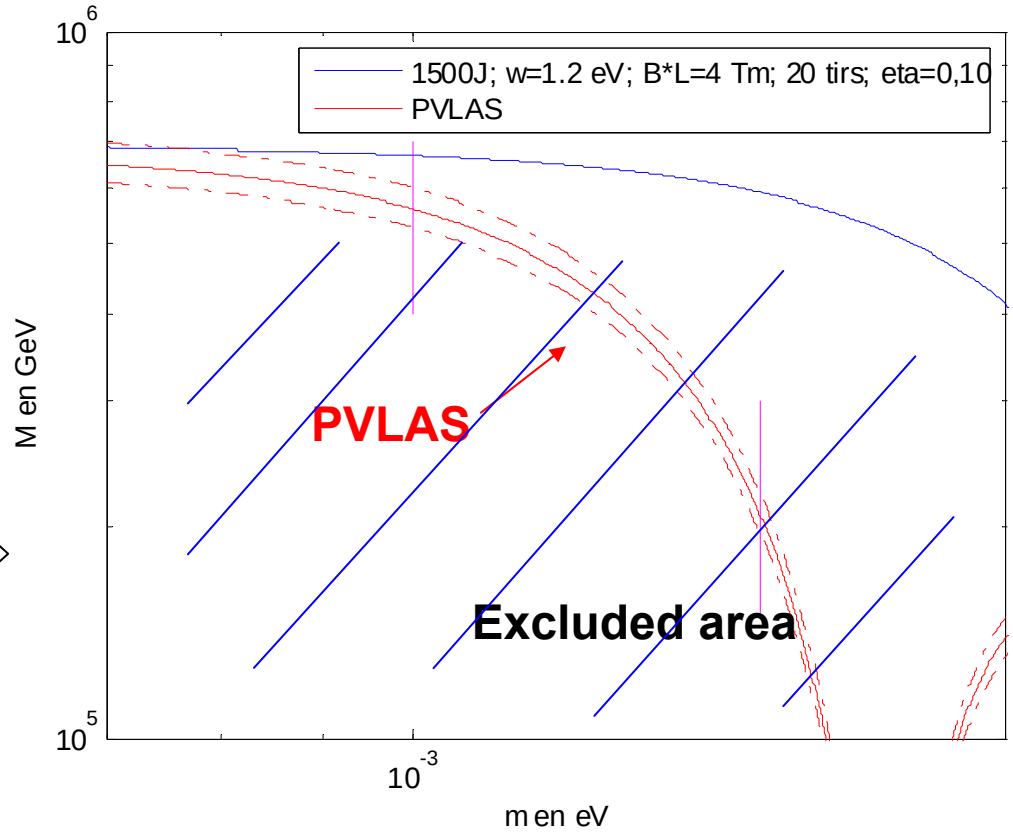
Commercially available single photon counter, 0.2 detection efficiency, 5 10^{-5} counts/ns noise

Laser room at LULI

Tight schedule : everything in place at LULI for march 2007 !

about 1 photon per pulse expected according to PVLAS

Limits after 20 pulses of 1500 J each (5 days)



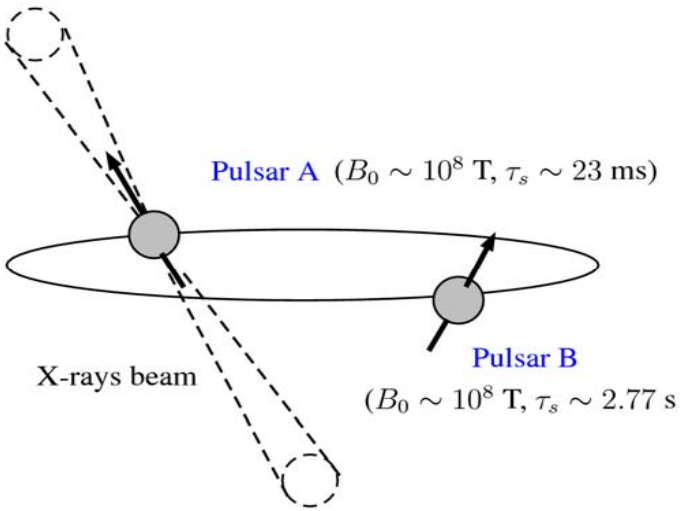
BMV Project :

Laboratory tests	BMV experiment at the LNCMP	First data end 06 PVLAS test in 07
	Photon Regeneration experiment At LULI	Ready at LULI 03/07 Beam time in 07

Astrophysical tests — **Quantum vacuum lensing**
&
Photon-Axion conversion

Very high magnetic fields in the cosmos ? Pulsars (10^7 T → 10^{11} T)

Neutron star Binary System J0737-3039



Discovered by M.Burgay et al. in 2003

Seen almost edge on !
Radio beam eclipse !

Revolution time : 2 h 45 min.

- **Quantum Vacuum Lensing**
  - Variation of the vacuum refraction index along the photon trajectory

ESA **XMM-Newton** ⇒ **Modulation of the photon flux**

- **Photon-axion Conversion**

NASA **GLAST**

⇓

Modulation of the photon flux

A. Dupays *et al.*, PRL **94**, 161101 (2005)

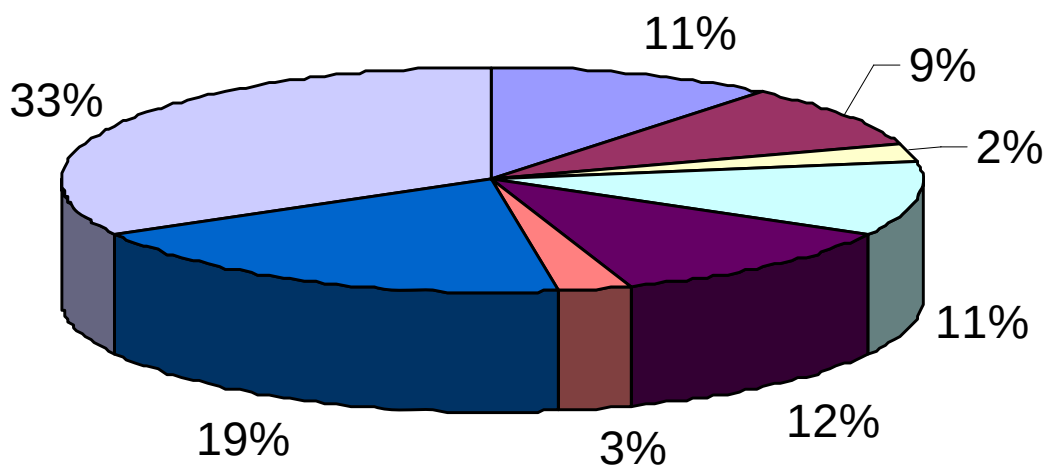
A. Dupays *et al.*, PRL **95**, 211302 (2005)

BMV Project :

Laboratory tests	**BMV experiment at the LNCMP**	**Operational Summer 2006 PVLAS test in 07**
	Photon Regeneration experiment At LULI	**Proposal to be submitted, juin 06 for runs in 07**
Astrophysical tests	**Quantum vacuum lensing**	**X_rays observation : XMM/Newton Scheduled in 07**
	Photon-Axion conversion	**γ_rays observation : GLAST, operational in 07 Approved**

Budget 2000-2008 (without salaries)

1 M€ project



CNRS SPM

Min. Edu. Nat. Rech. Tech.

Univ. PS & IRSAMC

LCAR

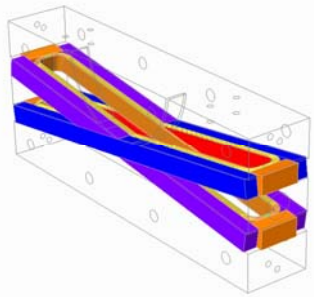
LNCMP

IN2P3

Agence Nat. Rech.

Requested to IN2P3

6 Physicists, 2 PhD Students, 15 Engineers and Technicians



The BMV Project

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