Effect of the Residual B-field on the CMS ECAL Monitoring Lasers and the Proposed Solution

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Residual B-field at the Laser Barrack

Measurement done on November 14

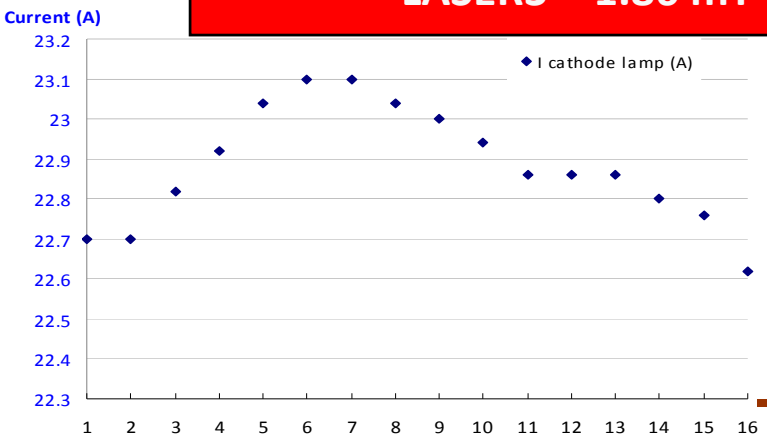
(S.Lusin and P.P.Trapani)

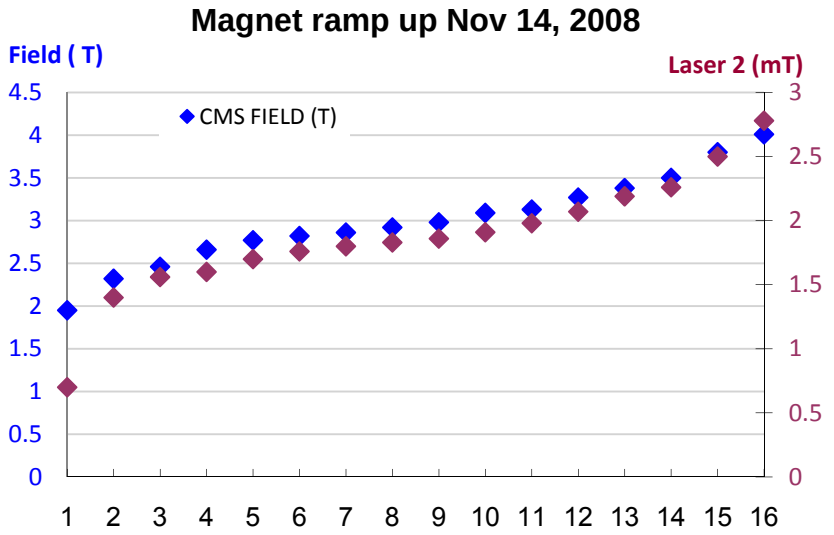
LASER 2 ON during ramping up and down the 14 Nov
→ NO FAILURE

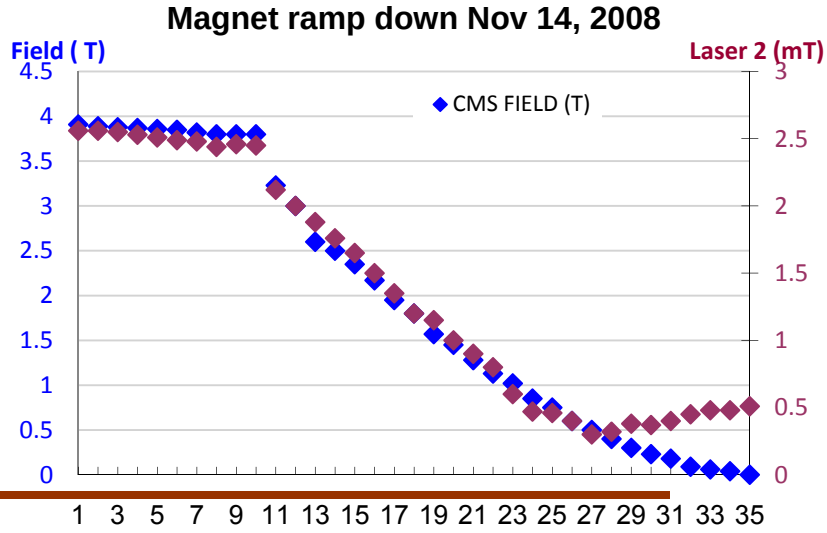
Current measured on the main 3 phases transformer:
1A variation during ramping

Current measured on the lamp cathode:
Some variation (22.6 to 23.1 A) observed for working point at 23A.

At 3.8T : LASER1 = 3.40 mT
LASER2 = 2.74 mT
LASER3 = 1.86 mT







Main Effects of the residual B-field in the laser system

In order of priority:

1) None of the two Newport power meters and detectors worked. This means that the power of both YLF and Ti:S lasers can not be measured in the B-field, preventing laser tuning.

2) The two IR viewers didn't work, preventing laser alignment, fine tuning and safety check.

3) The displays of the 3 Agilent digital scopes were significantly deformed in the B-field.

4) The AC control unit stopped working, and thus the laser room temperature was out of control.

5) The DC Krypton lamp of Nd:YLF laser broken three times at the cathode end at the time coincident with the B-field ramp down.

Power Meter: Feedback from Newport

Its power meter system does not work in B-field !

I have received confirmation that Newport power meters and detectors are not designed to work in magnetic fields (the electronic circuit was not designed to be immune to magnetic fields). 20 Gauss is significant for the power meter-detector system.

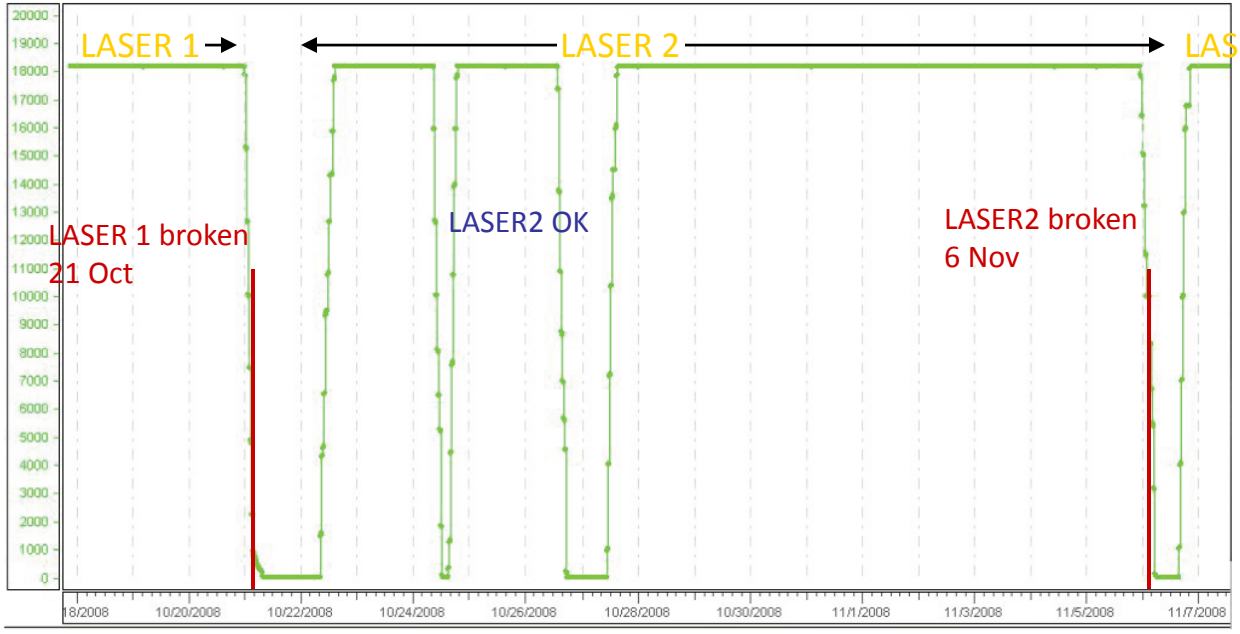
If the magnetic field is variable there will be large stray currents induced in the power meter traces and wires. If the magnetic field is static it might saturate the inductors in the power meter. In any case the power meter is not expected to work accurately.

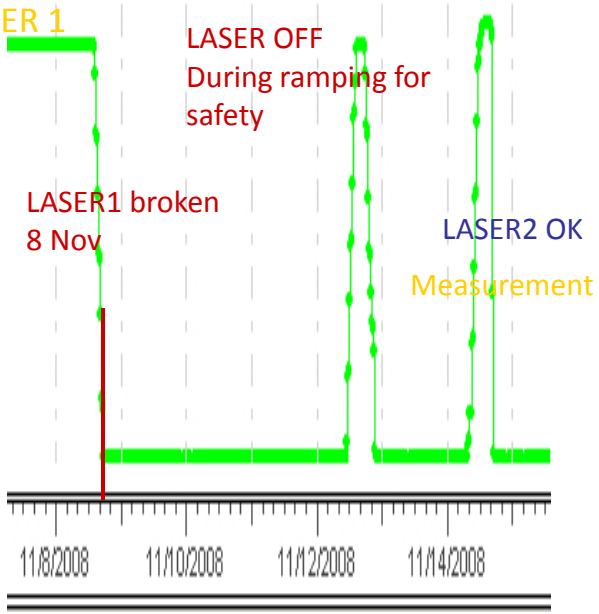
You need to shield the power meter-detector system from magnetic fields. You could use Mu-metal magnetic shield to screen static or variable magnetic fields. Since you cannot cover the front panel or the detector you have to be careful with the magnetic field orientation so that it does not enter the unshielded areas. We have not performed such experiments so you will need to determine the right material and shielding geometry for your power meter.

Laser pumping lamp and B-field ramping

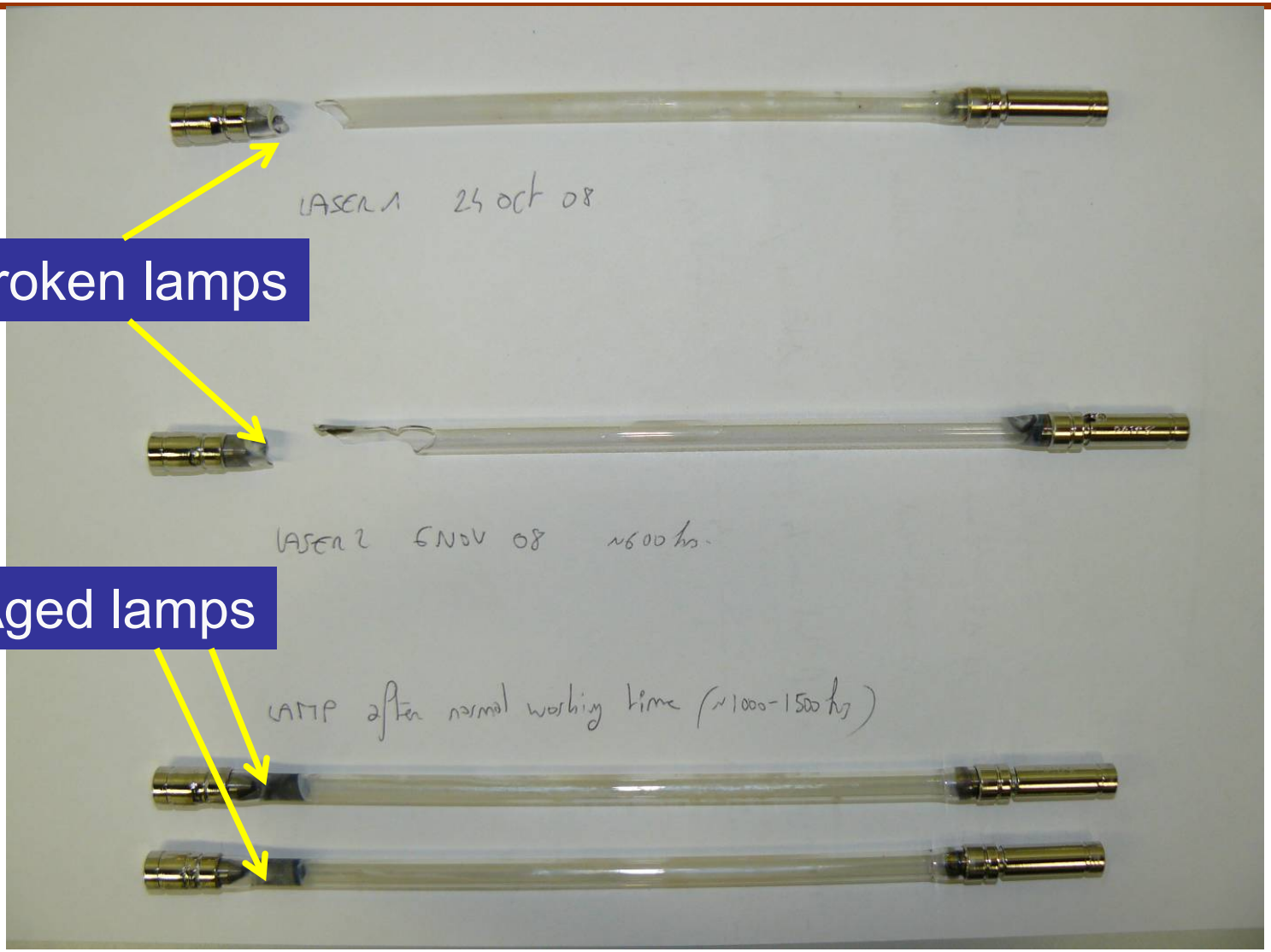
- 21 Oct : Lamp LASER 1 broken. Discovered on the 22Oct.
- 6 Nov: Lamp LASER 2 broken (380 hrs). Plateau 10kA at 1:50 hrs then fast dump. Laser went off at 1:52 *(run 69536)*
- 8 Nov: Lamp LASER 1 broken (<48hrs). Magnet shut down at 14:00, slow then fast dump. Laser went off since ~ 16:20.
- 10Nov: LASER 2 online.
- 14Nov: LASER 2 Lamp ON during ramping up and fast discharge → LAMP OK.

6 ramping down → 3 failures: 50% probability





Broken lamps during B-field ramping



Lamp: Feedback from Manufacturer

The manufacturer believes that its lamp would survive our B-field and the ramp-down.

"After speaking with other engineers within the company regarding possible effects of a changing B-field on the krypton lamp in question, we could not expect the 20G B-field to have any substantial effect on the lamp integrity. Even if the arc was temporarily deflected to the envelope wall, the lamp envelope should be capable of tolerating the increased wall loading for a limited period. Unfortunately, we have not performed any testing of arc-lamps in a magnetic field, so we have no specific data to support this conclusion."

Understanding the lamp breaking

- A unstable and constantly moving arc, particularly at the cathode, could result in continuing damage to the tube.
- The B-field induced mechanic force might hurt the lamp because of ferromagnetic electrodes.
- This issue will be resolved by introducing an interlock to turn off and on lasers automatically. Code should be developed in the ECAL laser supervisor.

Proposed Solutions

Option-I: reduce the residual B field by overall shielding.

- It may be OK if the residual field is greatly reduced as indicated in Austin's open talk on December 8.

Option-II: addressing each problem individually.

- Need to buy B immune equipments. There might also be other hidden problems.

Power Metter: First-try for Option II

Shielding test on November 12:

- MU metal all around power meter :

No effect

- Moving MU metal close to device measurement:

No effect

- Try with 5mm steel plate:

No effect

But shielding with MU metal seems useless : steel are used inside UXC and shielding OK.

It looks that more sophisticated shielding design and/or B immune equipments are needed.

Proposal for Option-II

1.) Power meter and detector

Based on a market survey, we propose to try product of Scientism, Inc, which is expected to survive a static B-field up to 100 Gauss. This company focuses on power meter system only and its product has been widely used in LIGO at Caltech.

2.) IR viewer

Commercially available IR viewers would not work in B-field because of electrons in these viewers are emitted from the photocathode to the luminescent screen. A solid state IR camera may work in B field.

Proposal for Option-II (cont.)

3.) DSO display

Given that the LCD PC monitor works in the B-field, the easiest approach is to replace our three DSOs by the late model with LCD screen.

4.) AC control unit

Shielding is needed for the AC controller

Cost Estimate for the Option-II

No	Issues	Next try		Final implementation	
		Company (model)	Unit Price	Quantity	Total price
1	Power meter	Scientech Inc. (S310 series)	$3,000	2	$6,000
2	IR viewer	to be decided, (IR camera)	$1,000	2	$2,000
3	Digital scope	Agilent Inc. (DSO6052A)	$9,000	3	$27,000
4	AC controller	to be decided	$1,000	3	$3,000
5	Mu material		$2.000	?	$2,000
	Total cost				$40,000