Laser Refurbishment
Results from the ECAL Laser Task Force
W.Z.

Members: Brad Cox, Marc Dejardin, Roger Rusack, Wolfram Zeuner, Ren-Yuan Zhu

Recall of problems and motivation for calling the Task Force

The optical switch

The blue laser

Installation and Schedule

Summary

Problems and Motivation I

Primary motivation to call the Task Force:

Talk by Ren-Yuan Zhu in Dec. 2010 made ECAL community aware that the laser system will not be produced any more in its current configuration
The production of DC Kr lamp pumped Nd:YLF laser has been stopped in 2005
The production of parts has been stopped in 2009, some consumables are not longer available.

The blue laser system is a key component for the performance of ECAL
Must run 24/7 during LHC beam operation – data go directly into calibration and energy resolution of ECAL. Extremely important for some top priority analyses of CMS

Objective for the Task Force:
- Review a possible refurbishment
- Try to propose a system that will be sustainable for >10 years
- Try to propose a new system that will reach the design performance
- Propose time line, installation schedule
- Consider costs
- Concentrate on the blue laser system for the moment

Problems and Motivation II

- The ECAL has not yet reached its design performance
  One problem: Steps in the APD/PN ratio
  Some correlated with maintenance – mainly on the pump laser
  Stability of operation seems to be a key feature to improve
  Technical details see e.g. talk by Ren-Yuan Zhu from Sept.27

- The current system requires very much maintenance
  Residual magnetic field aggravate operation of the laser and peripheral installations
  Typically once a week an intervention is necessary – situation far from being optimal

- Satisfactory level of spare parts for all essential components has to be guaranteed to be able to sustain 24/7 operation over years.

➔Task force scrutinized the entire blue laser system

The Optical Switch

The system needs a 1 to 88 optical switch to distribute the laser signal
There is a 1 to 100 switch in use since the beginning – never had problems
There is no spare – single point failure with potentially long down-time

Solutions:

1. Purchase a second 1 to 100 switch – offer exists ~70k$
2. Split signals on the output to reduce the number of channels to <80
   Use an existing 1 to 80 switch
   Illuminate two areas at once – readout one a time for band width reasons
   Advantage – “only” ~35k$ investment
   BUT requires change of sequence, steering software etc
   must be done now and must be thoroughly tested with both switches.

The Blue Laser I

Replacing only the pump laser is the cheapest solution (70k$/piece)
Problem: the blue laser itself shows signs of aging and first failures
- the current blue laser is custom made
- the knowledge about the system at the producer is fading away
- sustainability might become an issue
- continuous upgrade might hamper stability and delay reaching ultimate performance

Alternative: integrated solution
A diode pumped YLF pumping laser together with blue Ti:Sapphire laser

Specifications revised – some discussion still ongoing
Pulse FWHM < 30ns to match ECAL readout
Pulse jitter < 3ns for synchronization with LHC
Pulse rate up to 100 Hz – full scan in ~20min
Pulse intensity instability < 3%
Pulse energy 1mJ/pulse at 440nm, equivalent to 1.3 TeV dynamic range
Pulse delay from ext. trigger < 90µs for monitoring trigger to stay in one LHC cycle

The Blue Laser II

12 Companies have been contacted for quotes
3 quotes received, 2 of them fulfill the specs.

Under discussion

- Relaxing the stability of laser intensity – all systems fulfill it anyway – nothing to safe
- Laser pulse width - smaller pulse width reduces correction for different linearity of APD and PN.
  Depending on how the smaller pulse width is realized one has to pay in $, jitter and/or delay time from external trigger

$\Rightarrow$ Current parameters seem to be a good compromise
$\Rightarrow$ Discussion will end soon.

Installation and Schedule

A new blue laser should be phased in parallel to the operation of the old system
After delivery the system has to be commissioned for 8 weeks at Caltech
After shipping to CERN it will take 2 weeks to make it operational at PT5
A place can be found in one of the laser barracks in USC55

The aim should be to operate the new laser already in 2012

The CMS expert on magnetic field calculations will consulted now to discuss possible shielding in case the residual magnetic field will lead to problems. Shielding should be easier for the new system as it is much more compact

As fall back the barrack might be re-located to the surface during LS1

It is important to keep the old system operational throughout the entire running period of LHC in 2012 in case there are unexpected problems with the new system

Summary and Recommendations

For both the optical switch and the blue laser system there are now several options how to refurbish them.
With all discussed possibilities it will be possible to make/keep the monitoring operational

For the choice between the options one has to balance
Investment cost vs work to commission and effort to operate

For the optical switch the cheaper solution with splitters requires a serious change of the system with risk to encounter unexpected problems – the signal will be different, the attenuation has to be readjusted etc.

For the laser system the situation is similar – one can change only the pump laser now and leave the blue laser for the future. The risk of this option is to compromise the stability of the system which seems to be a key ingredient to reach the ultimate performance

Therefore in my view the recommendations from June 18 are still valid

Summary and Recommendations

Recommendatios

1. Procure now a large (1:100) optical switch
2. Procure now an integrated blue laser – blue Ti:Sapphire laser pumped by a diode pumped Nd:YLF laser
3. The energy of 1mJ is an advantage in case the laser barrack has to go to the surface
4. The specifications of the current system are sufficient and should not be changed
5. The new laser should be operated in parallel with the current system

A word of warning – on the long term getting a backup system for the blue laser will be unavoidable…
The red laser, though not essential for the data taking, faces similar problems as the blue one. Nothing to worry for the moment but on long term decisions have to be made

References for technical details

ECAL-LAS 2011 by Tommaso Tabarelli de Fatis

Talk by Ren-Yuan Zhu from Sept 27 2011 – Indico???