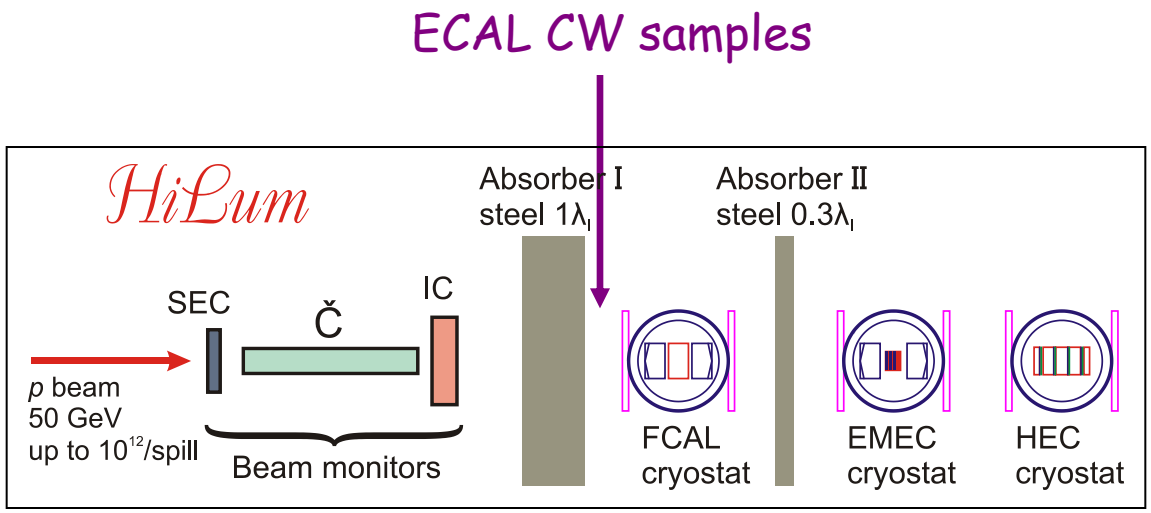
PMT/CW Irradiation tests-2010

CW irradiation tests, Nov 2008 (Yu. Gilitsky)

The test was conducted 12-18 Nov 2008 at the HiLum facility (IHEP, Protvino) constructed for the irradiation tests of the ATLAS LAr: 50 GeV proton beam (extracted using bent crystal technique), up to 10^{12} *p*/spill (9 sec interval, 1.7 sec duration).

Four ECAL CW samples were places behind Absorber I ($1\lambda_I$ steel) and irradiated to the doses of ~ 0.5, 0.7, 0.8 and 0.9 Mrad. It was shown that the "inner" CWs remain operational at such doses. For details, see presentation from the CALO meeting 04.02.2009:

http://indico.cern.ch/getFile.py/access?contribId=18&resId=0&materialId=slides&confId=51076



PM/CW irradiation tests-2010

Many thanks to many people:

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G. Britvich (IHEP, RP div)

V. Rykalin (IHEP EP div)

P. Semenov, Yu. Melnik, V. Mochalov (IHEP, PANDA group)

The irradiation was performed 13-15 April 2010, again at the ATLAS LAr irradiation facility (HiLum) at IHEP, Protvino

Irradiated were:

- 3 CW samples of "inner" type, to determine their rad. hardness limit (in 2008 it was not reached, only found that it is > 0.9 Mrad)
- a xCAL PMT (broken one), to study the degradation of its window glass
- for the comparison, a "usual" PMT with "usual" glass (FEU-85)

A non irradiated sample of each PMT type was available for comparison

U_{CTRL} of the CWs was fixed to ~2.2 V, the output HV was monitored (initially ~900V), irradiation stopped when output HV in 2 out of 3 CWs dropped

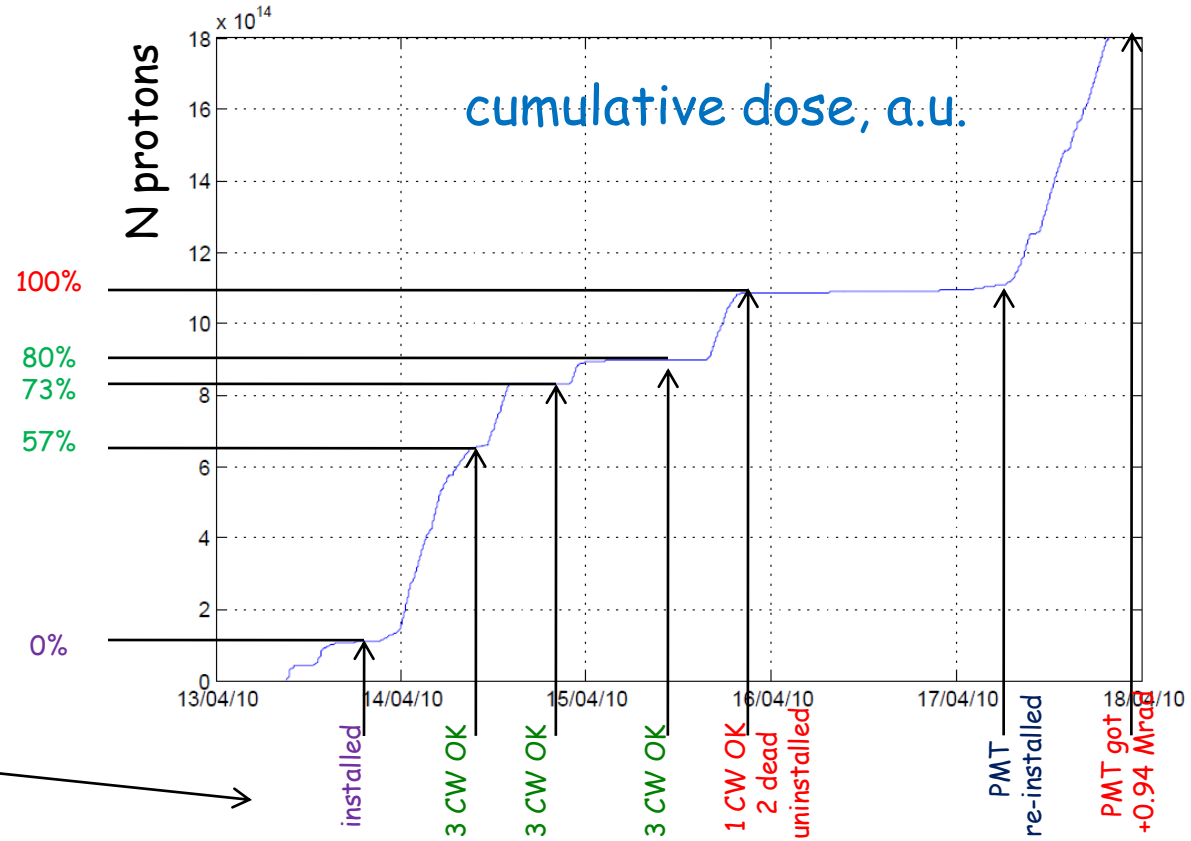
At this point, the HAMAMATSU PMT sample got 0.97 Mrad. It was then re-installed into the irradiation zone and got +0.94 Mrad (total of 1.91 Mrad). Then the transmittance of all 4 glasses was measured with a spectrophotometer.

The dose rate was quite high (up to 2 Mrad per 2 days), the results can be only considered as indicative! (hopefully as a lower limit)

Results, in brief:

- "inner" CWs died between ~1.4 and ~1.7 Mrad
- the HAMAMATSU PMT window loses only few % in transmittance after 1.9 Mrad; in "ordinary" PMT it loses ~70% after ~1 Mrad
- the induced radiation level was measured till 11 days after irradiation, it decays significantly in ~1 week after the end of the irradiation.

CW bases



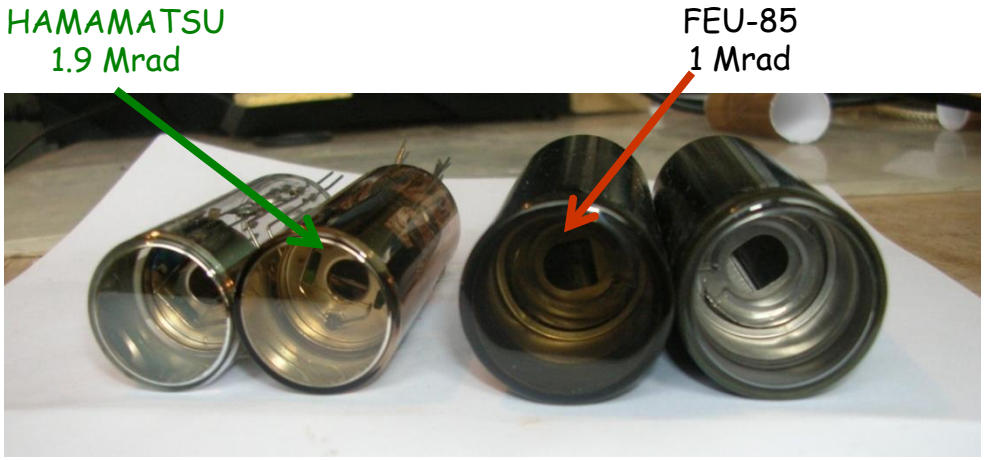
The state of CWs was checked at these points

CW	Dose, Mrad 15.04 11:30	Dose, Mrad 15.04 22:20	HV out, V 15.04 22:20	comment	HV max, V 27.04 10:30
#1	0.78	0.97	920	not damaged	1320
#2	1.36	1.71	550	damaged	880
#3	1.41	1.76	**0**	damaged; 0==oscillator problem?	**450** ! oscillator recovered?

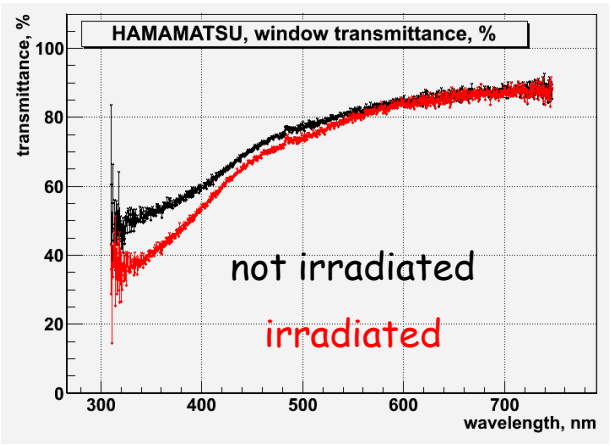
CWs die between ~1.4 and ~1.7 Mrad ➔ seems at least 1 Mrad guaranteed

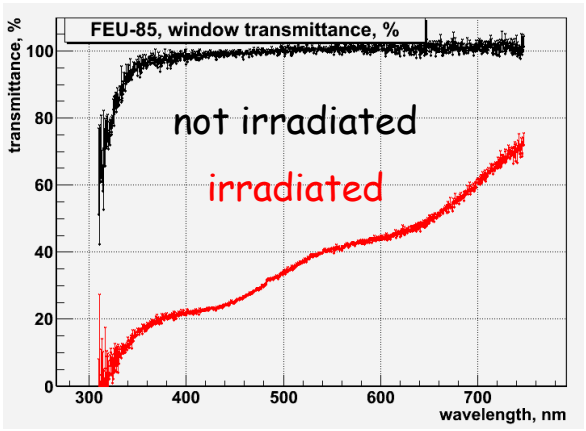
PMTs

Doses in PMTs: FEU-85 – 0.97 Mrad, HAMAMATSU – 1.91 Mrad (0.97 on 13-15 April and other 0.94 Mrad on 16 April). Both irradiated samples got dark, HAMAMATSU less than FEU-85. The PM windows were then cut away and studied with a spectrophotometer (11 days after the irradiation).



The irradiated and non irradiated samples are easily distinguishable. One can see that the HAMAMATSU glass @1.9 Mrad degraded by several %, which is significantly less than FEU-85 @1 Mrad. Generally, the glass degradation in our PMTs does not seem to be a problem.





Not checked: PMT gain degradation at several hundred Coulomb

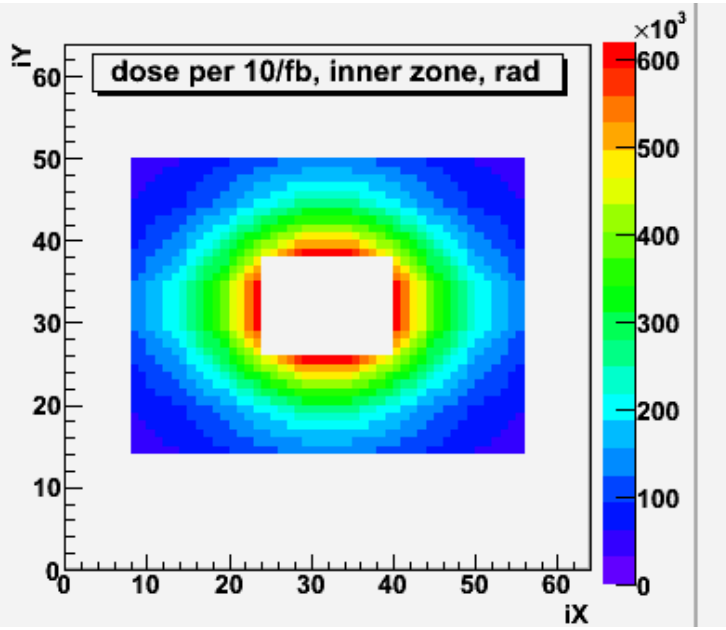
Induced radiation

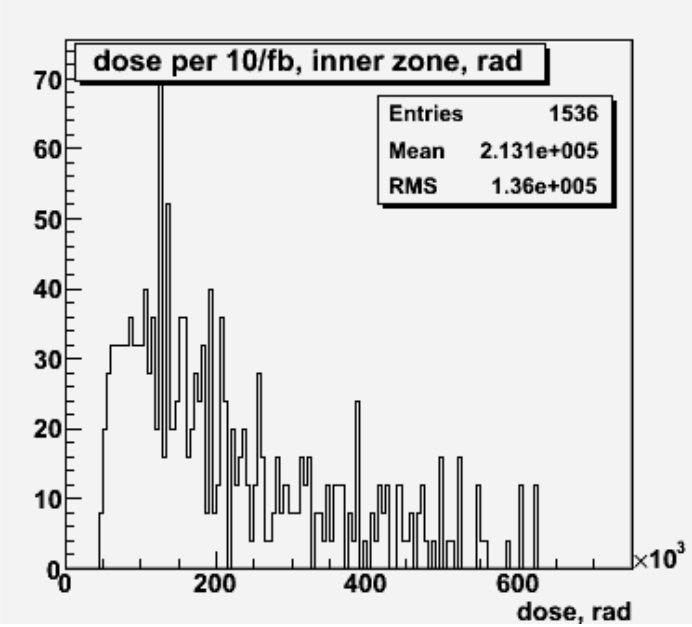
Measurements of induced radiation done with a dosimeter from CERN RP div. The readings of this device are given in μSv/hour, on surface of the object (and 10cm apart). ***NB*** points 0 and 1 are not given for the reason of overflow of the dosimeter.

days	2	3	4	5	7	8	9	11
CW #1	55(2)	28(1.3)	20(0.9)	18(1.0)	13(0.7)	11(0.5)	8.5(0.4)	8(0.5)
CW #2	160(10)	68(4)	42(3.2)	43(3.2)	28(2)	24(1.4)	23(1.3)	21(1.3)
CW #3	150(10)	75(4)	54(2.9)	42(3.0)	30(2.2)	31(1.7)	26(1.1)	20(0.9)
HAMA	100(10)	+irrad.	90(6.3)	75(4.0)	45(3.0)	42(2.6)		
FEU-85	50(4)	38(3.6)	29(2.0)	23(1.7)	18(1.2)	11(0.5)		

Additional info: an electronic board which got ~3 Mrad 5 month ago, now shows ~1 μSv/hour on surface.

Expected doses in PMTs of the inner zone of ECAL per 10 fb^{-1}. Derived from data at the LHCb "Radiation, background and Beam pipe" page.





Dose, krad	#PM
250…333	176
333…500	228
>500	72

Assuming 4 years of operation at 10 /fb /year, we will have to perform replacement of irradiated CWs. Replacement of CW board on PM: an easy procedure taking ~ 10 minutes/board or less.

The exact intervention schedule will depend on actual situation, as well as on strategy (dose limit, rotation etc).

Example: 1 Mrad dose limit, no rotation

	What to replace	#
1	>500 krad/yr	72
2	>500 +333…500 krad/yr	72+228
3	>500 +250…333 krad/year	72+176
total		660

Preliminary: we may need to produce additional ~500 CW bases, (NB ~300 of them will be spent to equip existing spare PMTs)

Conclusion

It seems that we are safe in what concerns ECAL PMT/CWs, but

- (may) need to produce spare CWs
- the PMT gain degradation at high (several hundred Coulomb) integrated anode current not yet checked (to be done?)