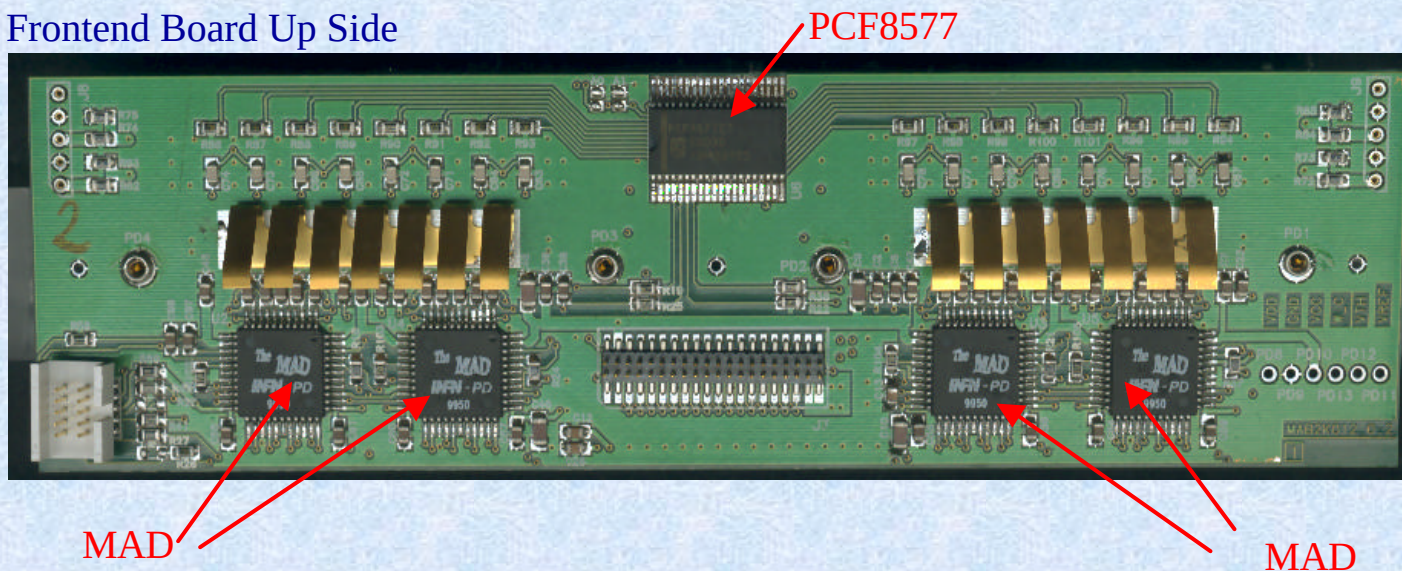


RADIATION TESTS

CMS Muon Barrel Frontend Electronics

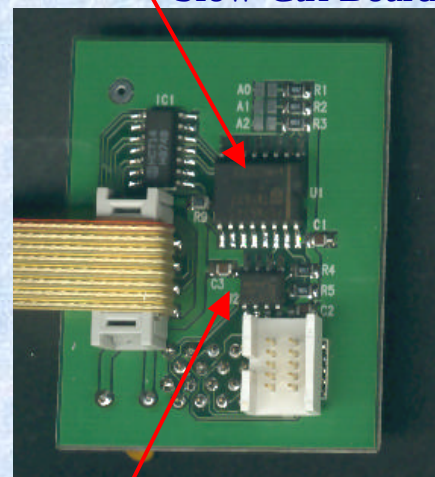
Frontend Board Up Side



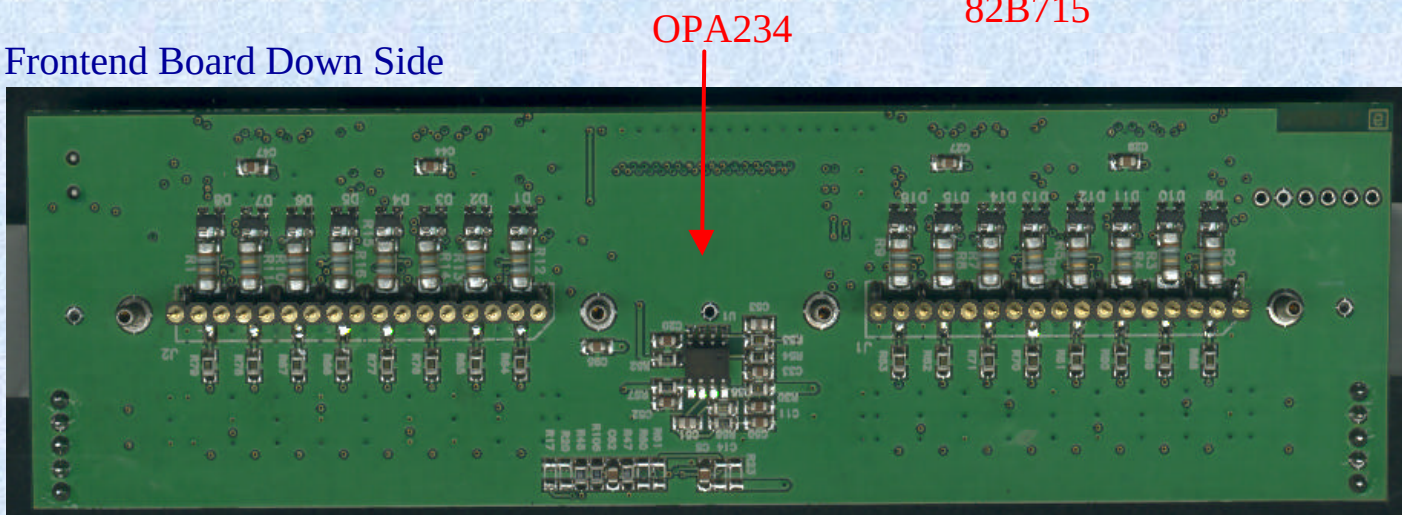
**All frontend electronics ASIC and COTS
have been tested against
radiation to check
LHC environment compatibility:**

- MAD frontend ASIC (Frontend board)
- Philips PCF8577 (Frontend board)
- Burr-Brown OPA234 (Frontend board)
- Philips PCF8574 (Slow-Ctrl board)
- Philips 82B715 (Slow-Ctrl board)

PCF8574 Slow-Ctrl Board



Frontend Board Down Side

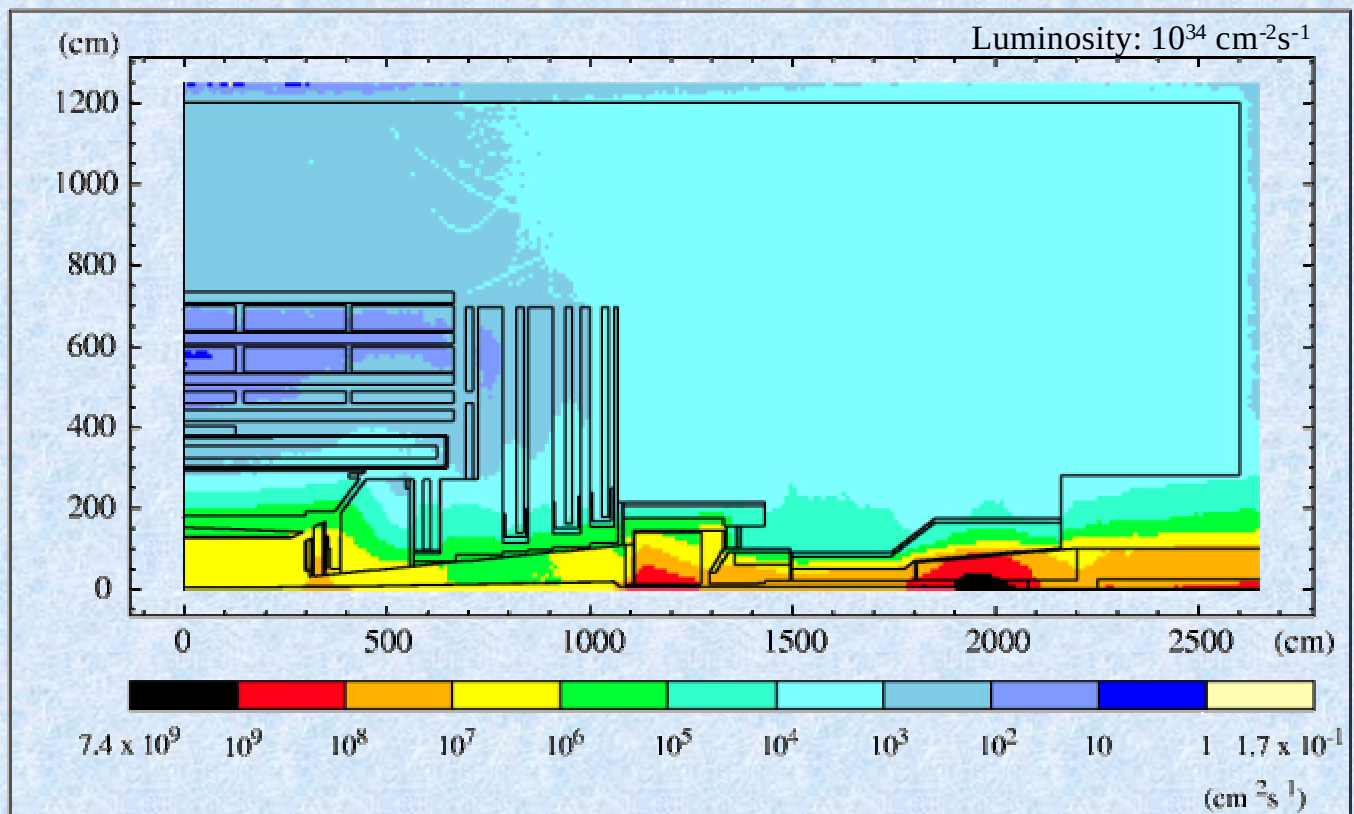


RADIATION TESTS

Heavy Ions and Neutrons Irradiation

In CMS barrel irradiation flux is very low,
only neutron flux can give problems by
Single Event Effects:

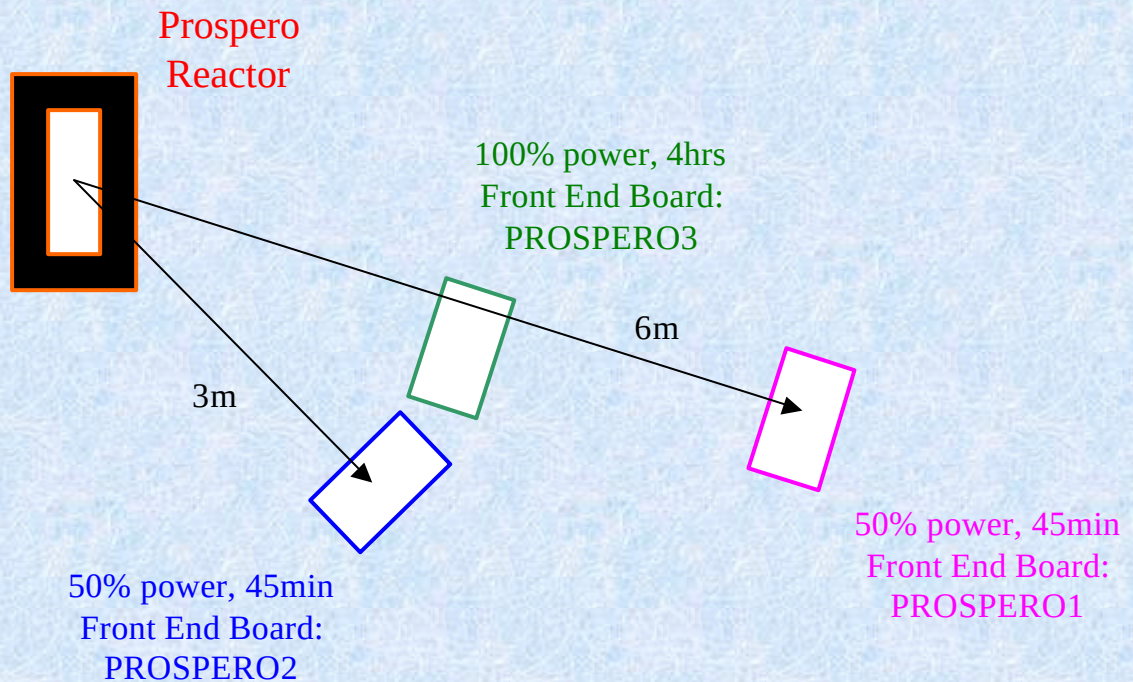
$5 \cdot 10^{10} \text{ n/cm}^2$ for 10y activity (10% thermal)



For best ASIC characterisation against SEL
heavy ions irradiation is tested too

RADIATION TESTS

Fast Neutrons at PROSPERO Facility

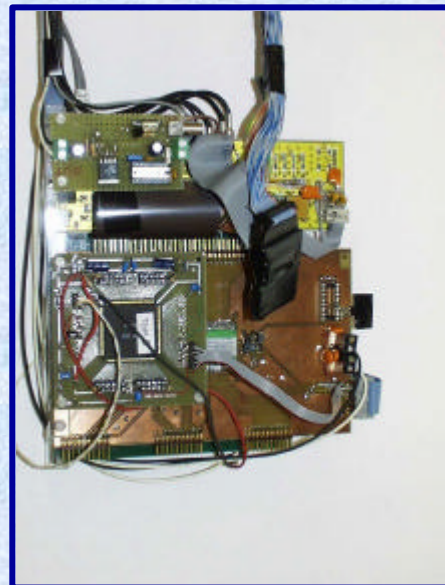
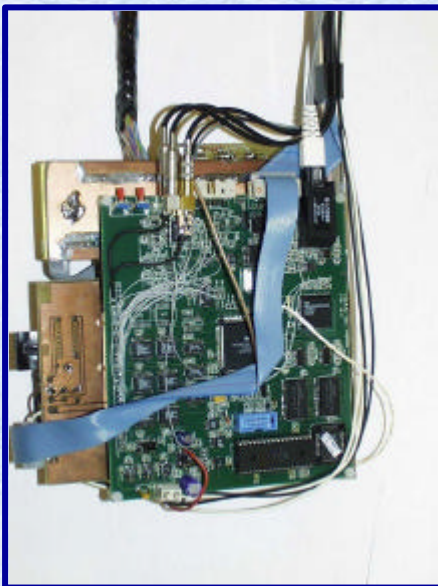
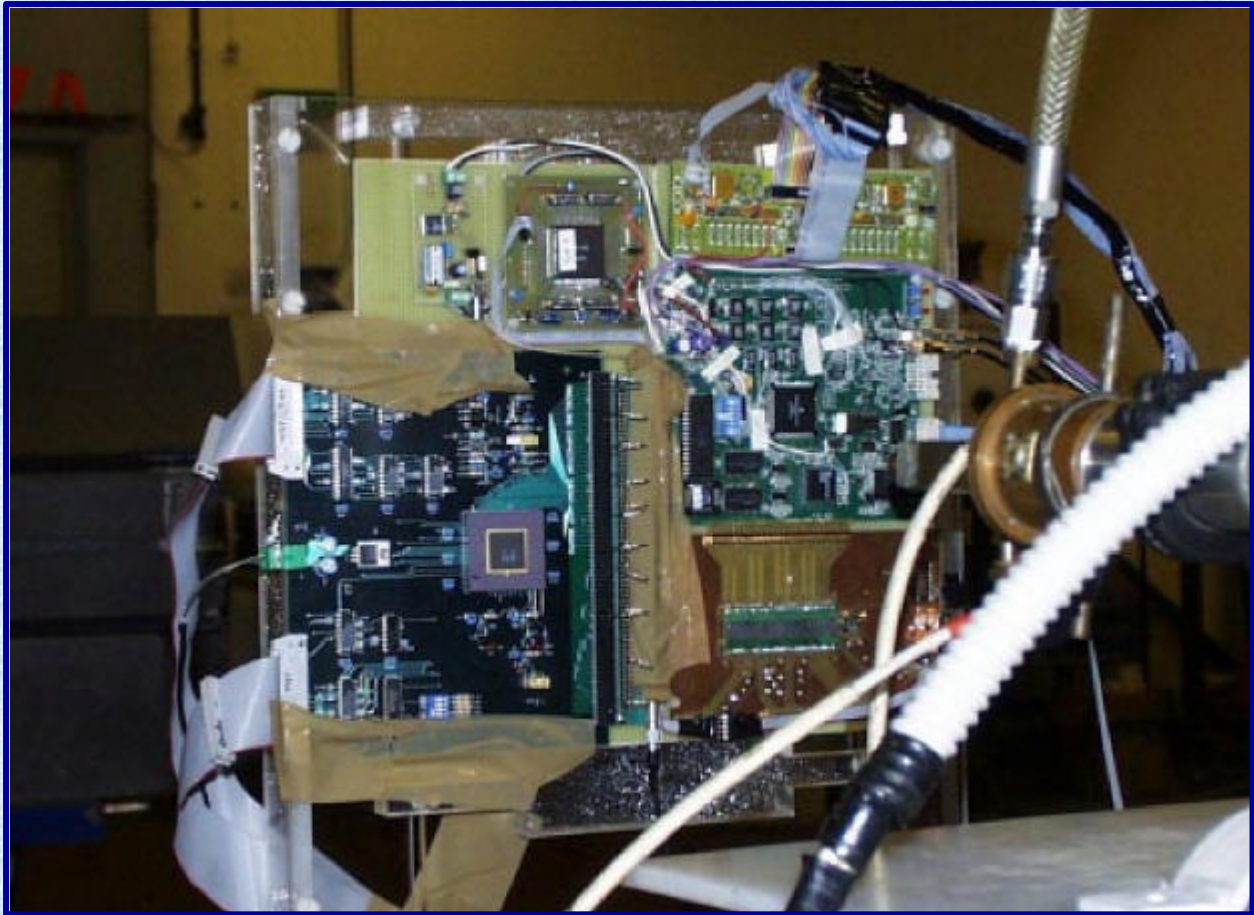


FRONT END BOARD	REACTOR DISTANCE	n/cm^2 EQ. 1MeV(SI)
PROSPERO1	6m	$4.85 \cdot 10^{10}$
PROSPERO2	3m	$1.53 \cdot 10^{11}$
PROSPERO3	3m	$1.72 \cdot 10^{12}$

NO dynamic or static changes measured!

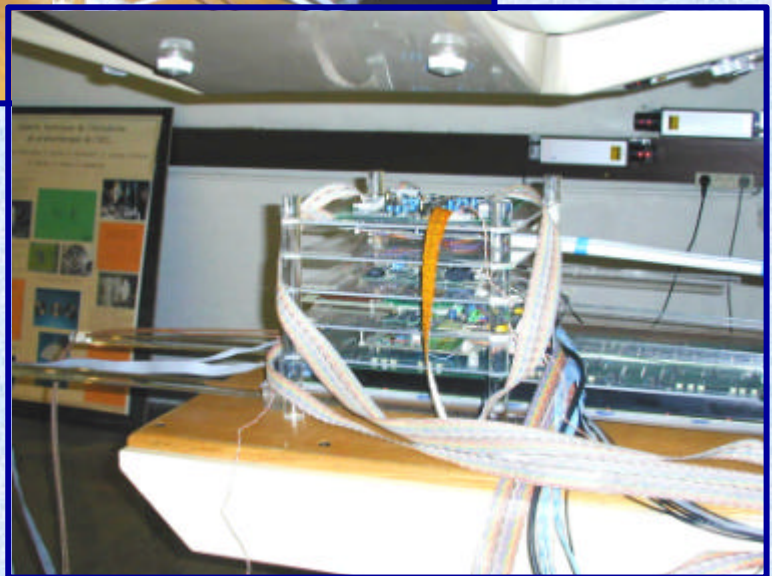
RADIATION TESTS

SE induced by Fast and Slow Neutrons at LNL



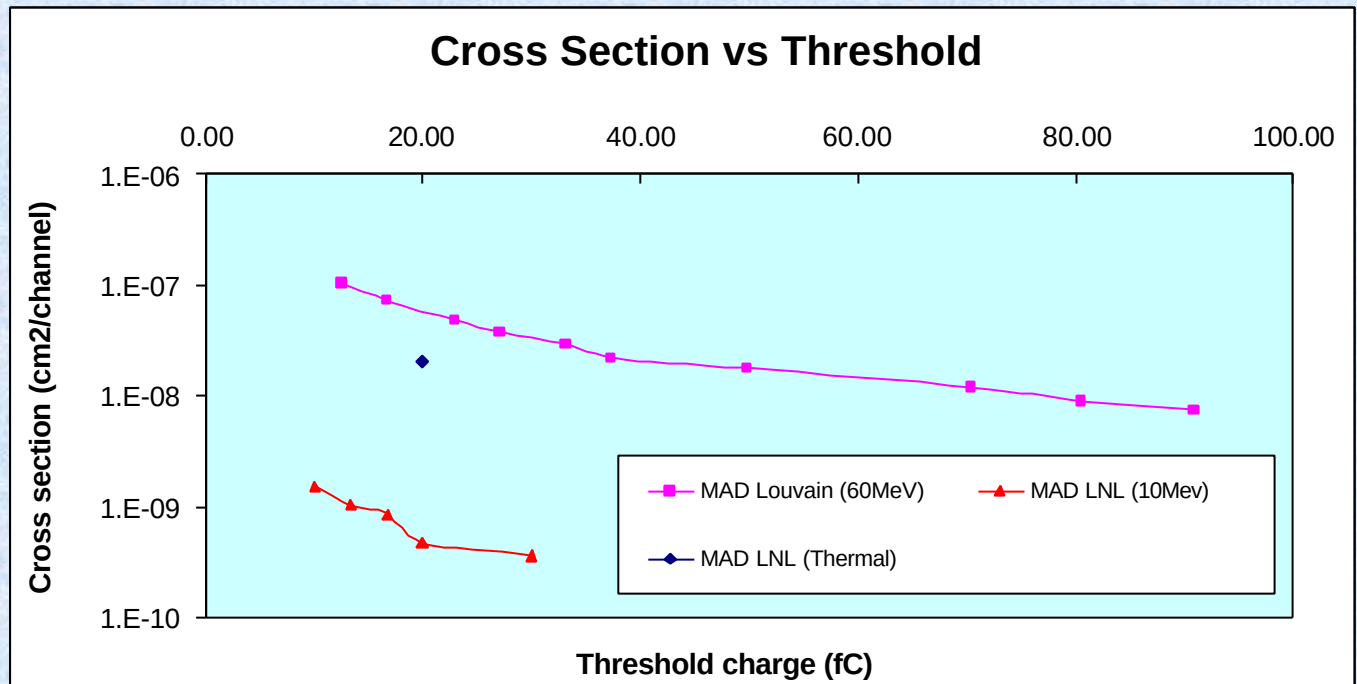
RADIATION TESTS

SE induced by Fast Neutrons at Louvain

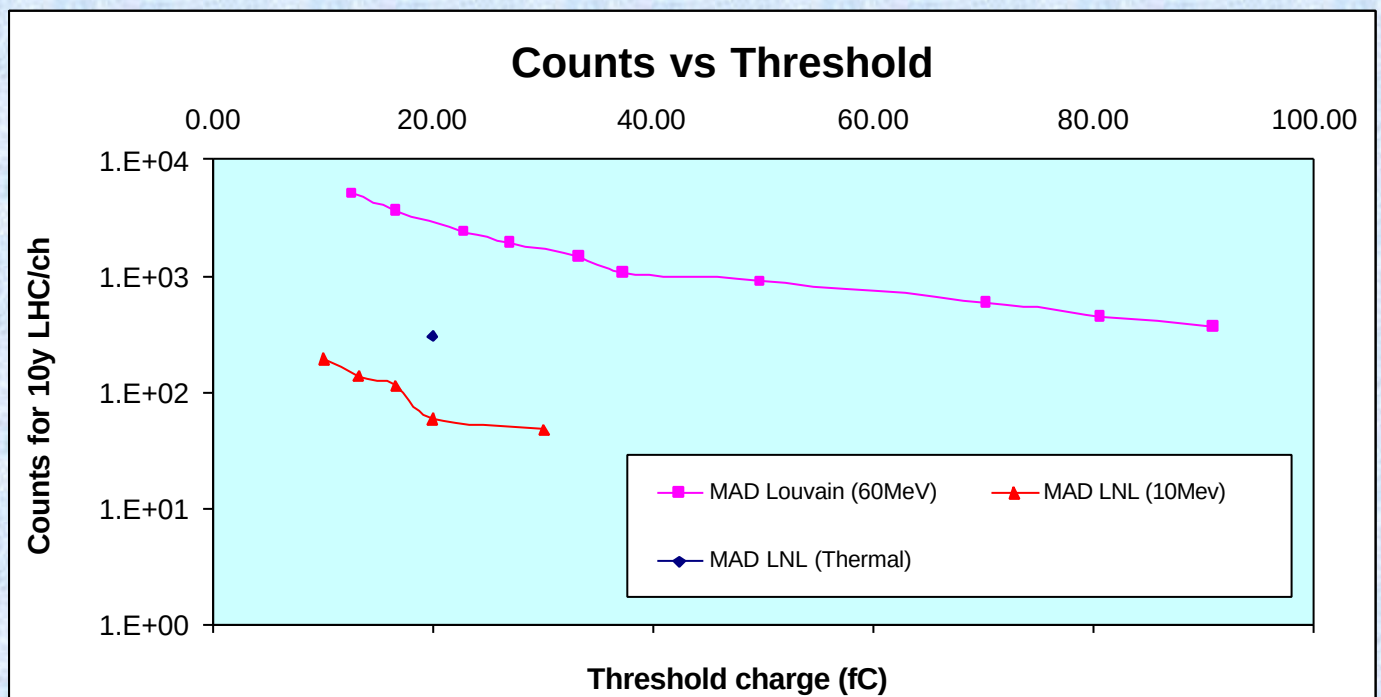


RADIATION TESTS

SEU induced by Fast and Thermal Neutrons

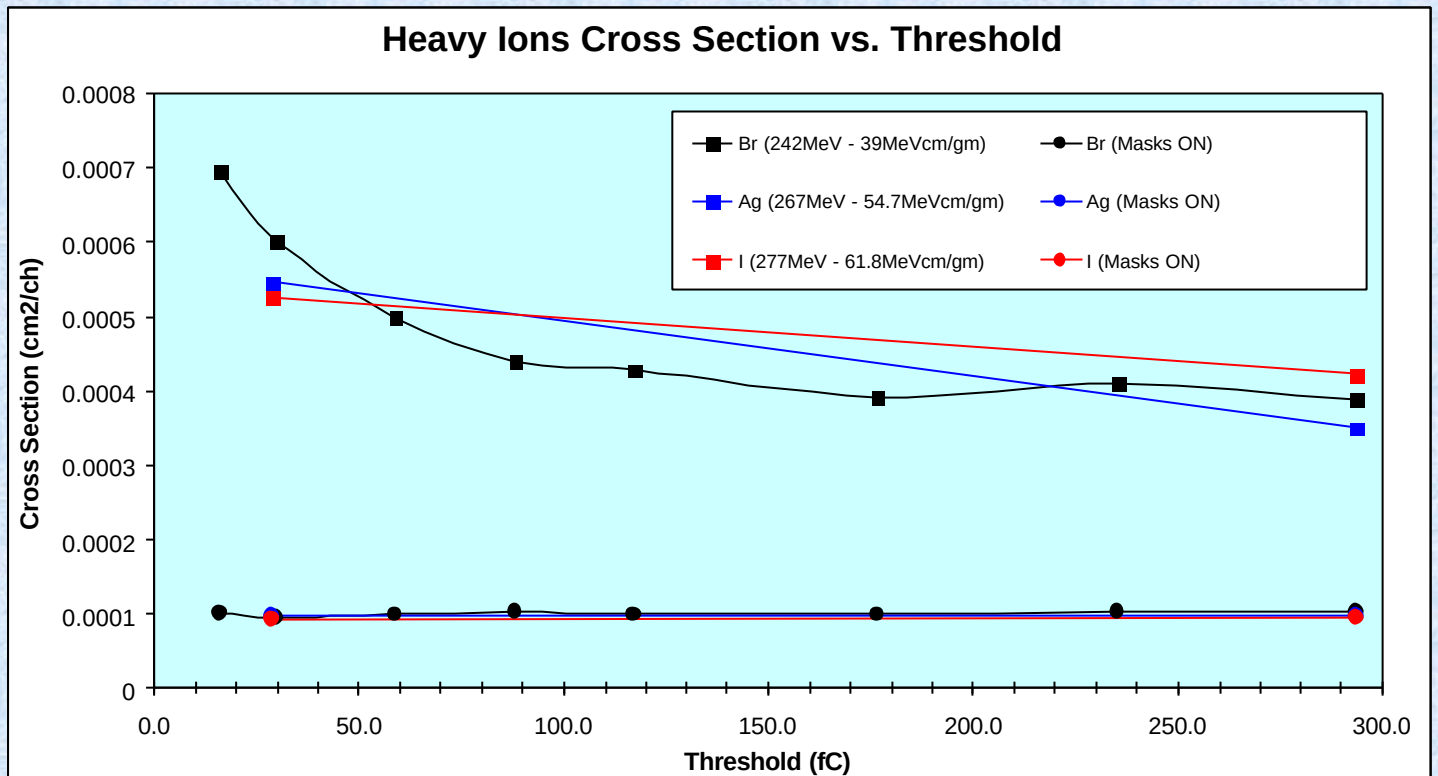


From these data we can estimate about few thousand counts for electronic channel for 10y LHC activity



RADIATION TESTS

SEU induced by Heavy Ions



The graph shows the cross section vs. threshold for heavy ions irradiation of a frontend ASIC in 2 cases: in the first input channels are enabled, in the second they are disabled at preamplifier stage (threshold independence) .

Ion	Energy (MeV)	LET (MeVcm/mg)
Bromine	242	39
Silver	267	54.7
Iodine	277	61.8

RADIATION TESTS

SE Upset and Latch-up induced by Neutrons

SEU							
		Threshold (fC)	Flux (n/cm2)	Counts (all channels)	Cross Section (cm2)	Cross Section/ch (cm2)	
	LOUVAIN 16 channels FEB	60MEV neutron	12.6	2.60E+10	42522	1.638E-06	1.024E-07
			16.7	2.60E+10	29932	1.153E-06	7.206E-08
			22.9	2.60E+10	20154	7.763E-07	4.852E-08
			27.1	2.67E+10	16321	6.108E-07	3.817E-08
			33.2	2.67E+10	12555	4.699E-07	2.937E-08
			37.4	2.67E+10	9319	3.488E-07	2.180E-08
			49.7	2.67E+10	7707	2.888E-07	1.805E-08
			70.3	2.67E+10	5057	1.895E-07	1.184E-08
80.6			2.49E+10	3607	1.451E-07	9.066E-09	
90.9	2.49E+10	2935	1.180E-07	7.377E-09			
LNL 3 channels MAD chip	10MeV neutron	10.0	1.27E+10	50	4.549E-09	1.516E-09	
		13.3	6.95E+09	19	3.091E-09	1.030E-09	
		16.7	8.10E+09	19	2.601E-09	8.670E-10	
		20.0	8.12E+09	10	1.395E-09	4.650E-10	
		30.0	7.79E+09	8	1.092E-09	3.640E-10	
	40.0	7.91E+09	4	4.820E-10	1.607E-10		
	Thermal neutron	20	9.14E+09	562	6.143E-08	2.048E-08	
SEL	No events for 10y LHC activity						

RADIATION TESTS

SE Upset and Latch-up induced by Heavy Ions

	Threshold (fC)	Flux (ions/cm2)	Counts (all channels)	Cross Section (cm2)	Cross Section/ch (cm2)	Masks (analog)	
SEU	Bromine 242MeV	15.9	2.14E+07	9419	4.40E-04	1.10E-04	ON
		15.9	4.51E+07	125387	2.78E-03	6.95E-04	OFF
		29.7	4.43E+07	106693	2.41E-03	6.01E-04	OFF
		29.7	2.89E+07	11704	4.05E-04	1.01E-04	ON
		58.5	5.74E+07	114609	2.00E-03	4.99E-04	OFF
		58.5	3.25E+07	12975	3.99E-04	9.98E-05	ON
		87.9	2.92E+07	51366	1.76E-03	4.40E-04	OFF
		87.9	2.82E+07	11630	4.12E-04	1.03E-04	ON
		117.1	2.88E+07	49322	1.71E-03	4.28E-04	OFF
		117.1	2.83E+07	11193	3.96E-04	9.90E-05	ON
		176.5	2.55E+07	39982	1.57E-03	3.93E-04	OFF
		176.5	2.26E+07	9055	4.01E-04	1.00E-04	ON
		235.0	3.88E+07	63509	1.64E-03	4.09E-04	OFF
		235.0	3.67E+07	15164	4.13E-04	1.03E-04	ON
		293.5	3.33E+07	51679	1.55E-03	3.88E-04	OFF
		293.5	3.40E+07	13973	4.11E-04	1.03E-04	ON
	Silver 267MeV	28.5	6.44E+07	140549	2.18E-03	5.45E-04	OFF
		293.5	6.06E+07	84890	1.40E-03	3.50E-04	OFF
		28.5	5.56E+07	21830	3.93E-04	9.82E-05	ON
		293.5	5.89E+07	22756	3.86E-04	9.66E-05	ON
	Iodine 277MeV	28.5	9.43E+07	198516	2.11E-03	5.26E-04	OFF
		293.5	7.82E+07	131693	1.68E-03	4.21E-04	OFF
		28.5	8.65E+07	32901	3.80E-04	9.51E-05	ON
		293.5	1.15E+08	43031	3.75E-04	9.36E-05	ON
SEL	No events found						

RADIATION TESTS

Conclusion

**All frontend electronics tested
no problems found.**

ASIC successfully tested on heavy ions.

**Few thousand counts/ch estimated for 10y
LHC activity.**

**In all radiation tests
No LATCH-UP events
detected.**

**Further work could be done for better
radiation characterization with proton beams
at fixed energy**