Production Readiness Review

Irradiation tests
Louvain La Neuve

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Introduction

- Apart from the ASIC, 9 other components have been irradiated
  - Drivers, OA, buffers, and the ADC we want to use on the FEB
    - 1 - OPA4350EA
    - 2 – BFR92A
    - 3 – FDV305N
    - 4 – IDT8SLVD1204
    - 5 – SN74AVC4T774PW
    - 6 – MMBT3094
    - 7 – NB6L11S
    - 8 – HC14
    - 9 - AD9238
- Irradiation done with protons as for the ASIC
  - Energy = 62MeV
  - Diameter of the beam ~ 8 cm
  - Roughly 50krad in 30minutes

Acquisition system

- Acquisition based on 2 NI6008 systems

  - All the components, but the ADC
    - 4 Current measurements/box
    - 2 boxes used
    - Vdrop on a 1Ω resistor
    - 8 components tested altogether
  - Check that there is no current variation (dose, SEL)

  - ADC : 1 single chip tested at a time / box and a single box read out
    - 2 current measurements / chip
    - Apply an analog signal at the input of the ADC (requires that a clock is sent to the ADC)
    - Read back the digital signal with the acquisition box
  - Current gives any sensitivity to dose, SEL
  - Check the proper functionning of the ADC

Beam conditions and results

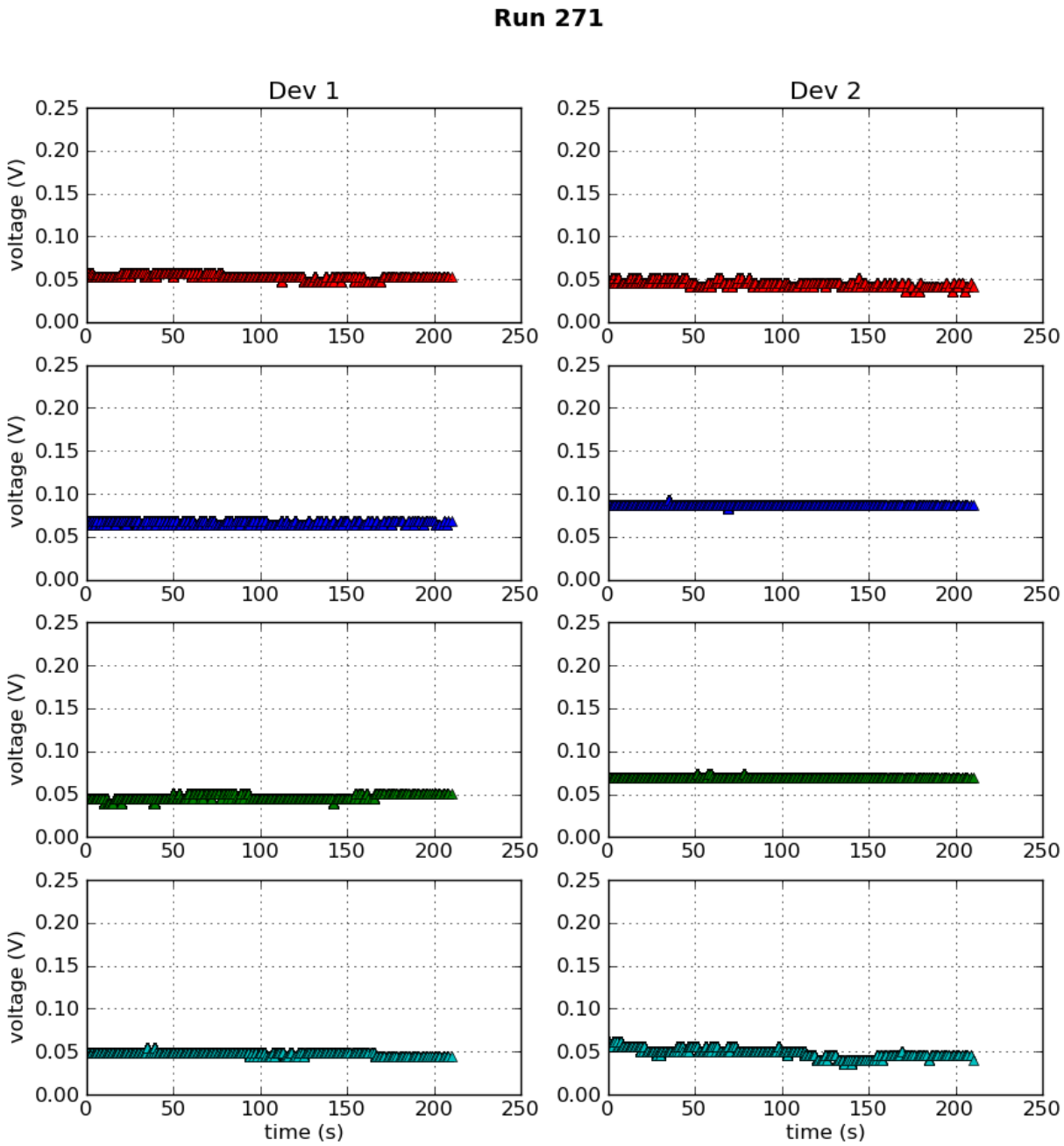
Degrador Combination mm	Energy MeV	LET MeV/mg/cm2	RangeSi mm	Dose rad/s
0	62	8,39E-03	17.86	26,89
2	59,9	8,61E-03	16.80	27,60
4.2	57,5	8,89E-03	15.62	28,49
2 + 4.2	55,2	9,18E-03	14.53	29,42
8.2	52,9	9,49E-03	13.47	30,42
2 + 8.2	50,5	9,82E-03	12.40	31,47
4.2 + 8.2	47,7	1,03E-02	11.20	33,01
2 + 4.2 + 8.2	45	1,07E-02	10.10	34,29
16	42,8	1,12E-02	9.24	35,90
2 + 16	40,1	1,17E-02	8.22	37,50
4.2 + 16	36,9	1,25E-02	7.09	40,06
2 + 4.2 + 16	33	1,37E-02	5.81	43,91
8.2 + 16	29,4	1,50E-02	4.73	48,08
2 + 8.2 + 16	25,9	1,66E-02	3.78	53,21
4.2 + 8.2 + 16	20,9	1,96E-02	2.59	62,82
2 + 4.2 + 8.2 + 16	14,4	2,63E-02	1.34	84,29

1 rad	62400,0	MeV/mg
Si density	2,2	g/cm3
Flux	2,00E+08	proton/cm^2/s

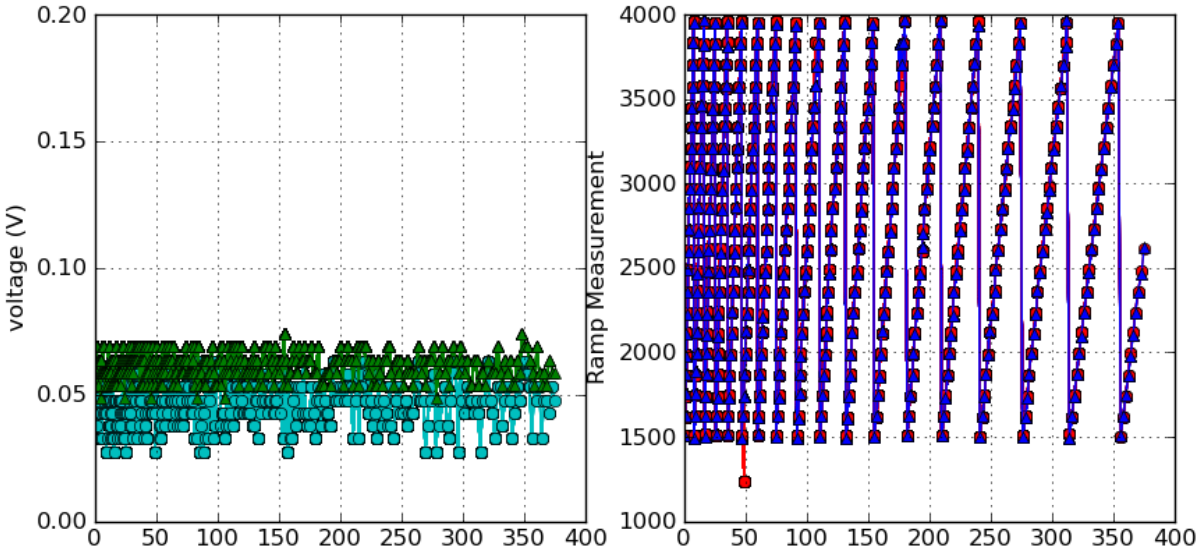
Dose max 50 krad

- No SEL was observed on any of the 9 componants tested
  - No need to perform any reset of the power supply to clear an upset
- No evolution of the current towards larger consumption in spite of
  - The large dose reached
  - The large flux used (no annealing)

Example of the OA OPA4350EA

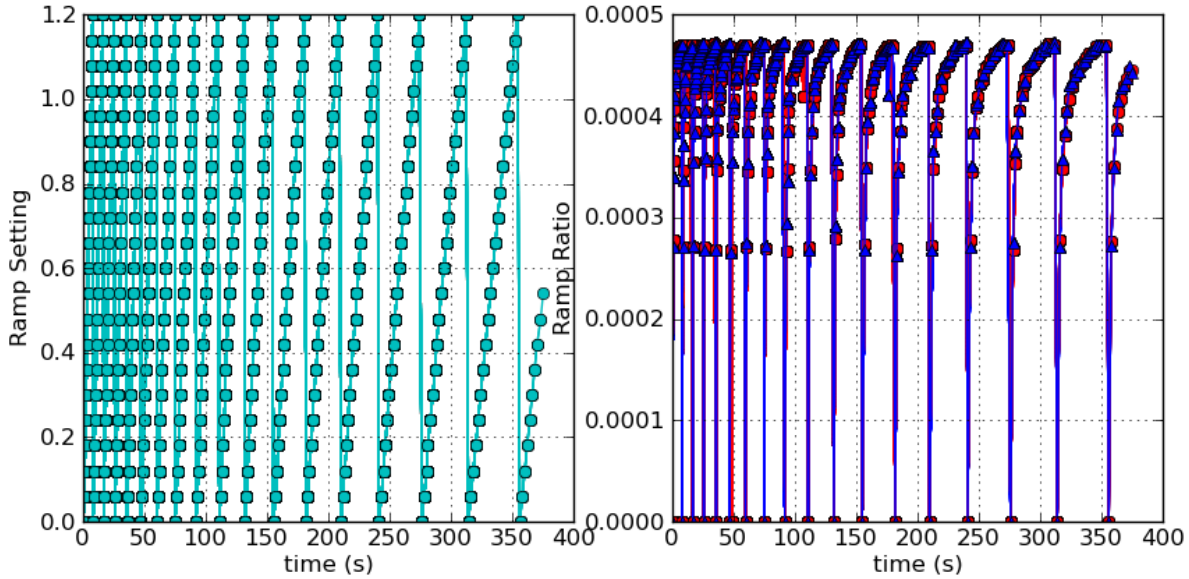


Current measurements



Decoding of the digital output of the ADC

Analog signal imposed



What is expected in the cavern: dose

- From the previous studies (calorimeter TDR)
  - we should expect ~100 rad/fb^{-1}
  - Nice to get a confirmation from the passive dosimeter readout
- Supposing 50fb-1 integrated at the end of the upgrade
  - 5krad should be tolerated by the electronics
- Adding safety factors, test the electronics up to 50krad and beyond

Dose reached

Component	#1	#2	#3	#4	#5	#6	#7	#8
OPA4350EA	70	70	70	70	70	70	70	70
BFR92A	50	50	50	50	50	50	50	50
FDV305N	50	50	50	50				
IDT8SLVD1204	50	50	50	50				
SN74AVC4T774PW	50	50	50	50				
MMBT3094	50	50	50	50				
NB6L11S	50	50	50	50				
HC14	50	50	50	50				
AD 9238	50	100						

No time to test those components

What is expected in the cavern: SEL

- Estimation with protons

  Suppose that:
  - Maximum Linear Energy Transfer that can be reached in the cavern :
    - 15 MeV.mg^{-1}.cm^{2}
    - 10^{6} p needed to break a Si with a fragment able to trigger a SEL

- From simulations (TDR calorimeter)
  - 420 particles per second at L=5x10^{32}cm^{-2}.s-1
  - 1680 particles per second at 2x10^{33}cm^{-2}.s^{-1} (upgrade max inst. L) mostly neutrons
  - 50 fb^{-1} would be reached in 2.5x10^{7} s
  - Total fluence of 4.2x10^{10} particles per cm^{2}

Approx. limit on the number of SEL

- From the previous numbers, it is possible to extract an estimate of the limits corresponding to the irradiation test performed with protons at Louvain-La Neuve

Component	Fluence	/50fb^{-1}	#	1MeV eq n	# SEL (Limit)
OPA4350EA	4.2x10^{12}	100	~5x250	8.2x10^{12}	12.5
BFR92A	3.0x10^{12}	71.4	~5x250	5.9x10^{12}	17.5
FDV305N	1.5x10^{12}	35.7	~5x250	2.9x10^{12}	35
IDT8SLVD1204	1.5x10^{12}	35.7	~5x250	2.9x10^{12}	35
SN74AVC4T774PW	1.5x10^{12}	35.7	~5x250	2.9x10^{12}	35
MMBT3094	1.5x10^{12}	35.7	~5x250	2.9x10^{12}	35
NB6L11S	1.5x10^{12}	35.7	~5x250	2.9x10^{12}	35
HC14	1.5x10^{12}	35.7	~5x250	2.9x10^{12}	35
AD 9238	1.1x10^{12}	26.2	16x250	2.2x10^{12}	150

- Proton to neutron conversion factor is 1.96 (thank you Yuri)
- 1MeV n eq : 3.6x10^{10} for 50fb^{-1}, determined from
  - 91.05mb (σ total), 50 fb^{-1}, 4x10^{-4} 1MeV neq /collision/cm^2

Conclusion

- The test at Louvain-La-Neuve was very satisfactory
  - No SEL observed
  - No increase of the current on any of the 9 components tested
- All the components of the FEB/Control board should be fine
- Test with protons
  - Perfect for the dose
  - The limit on the number of SEL for the full upgrade period and the full calorimeter reaches from 10 to 100 SEL
- We use a current protection (MAX component) on our boards which should prevent any SEL to be destructive