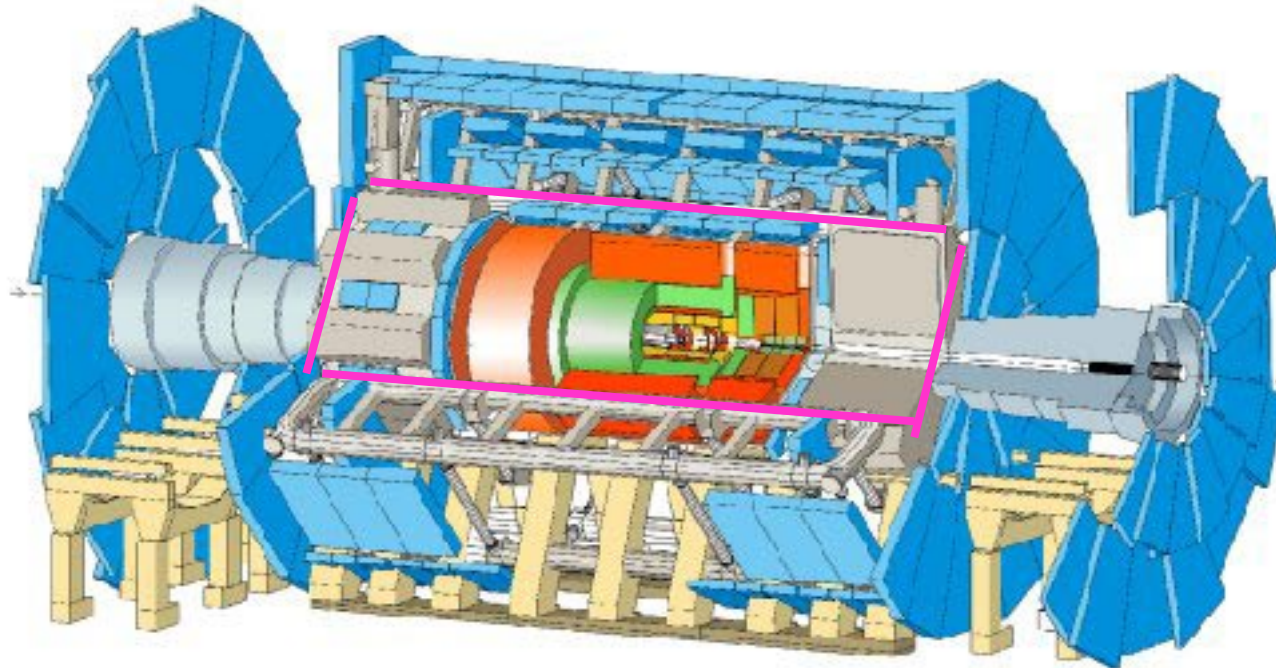




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CAN ELMB Module

NIKHEF and CERN



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B. Hallgren, H. Kvedalen, N.Roussel and F. Varela-Rodriguez



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Introduction

There is a need for a general-purpose
Detector Front-End I/O Control System
which can be **embedded** in the detectors.

- to monitor voltages, currents, temperatures, ..
- to control power supplies, cooling system, ...
- to read and write status bits
- to check in-system programmable devices via serial control e.g. JTAG and I2C



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Embedded Local Monitor Board (ELMB)

Radiation levels in ATLAS

- Total Ionising Dose TID 0.5 Gy/ year
- Non-Ionising Energy Loss NIEL 3×10^9 n/cm² per year (1 MeV Si)
- Single Even Effects SEE 5.7×10^9 hadrons /cm² >20 MeV

Magnetic Field (0.1T to 1.5T) **DC-DC converters**

Distributed I/O points over the whole detector volume <100m

Standardised connections to the software system SCADA

- Hardware: CANbus / LAN
- Software: CANopen, OPC

Low power consumption

- remote power supplies and cables

Low cost COTS

- in ATLAS ~5000 ELMBs will be needed ~ 2 EUR/ch

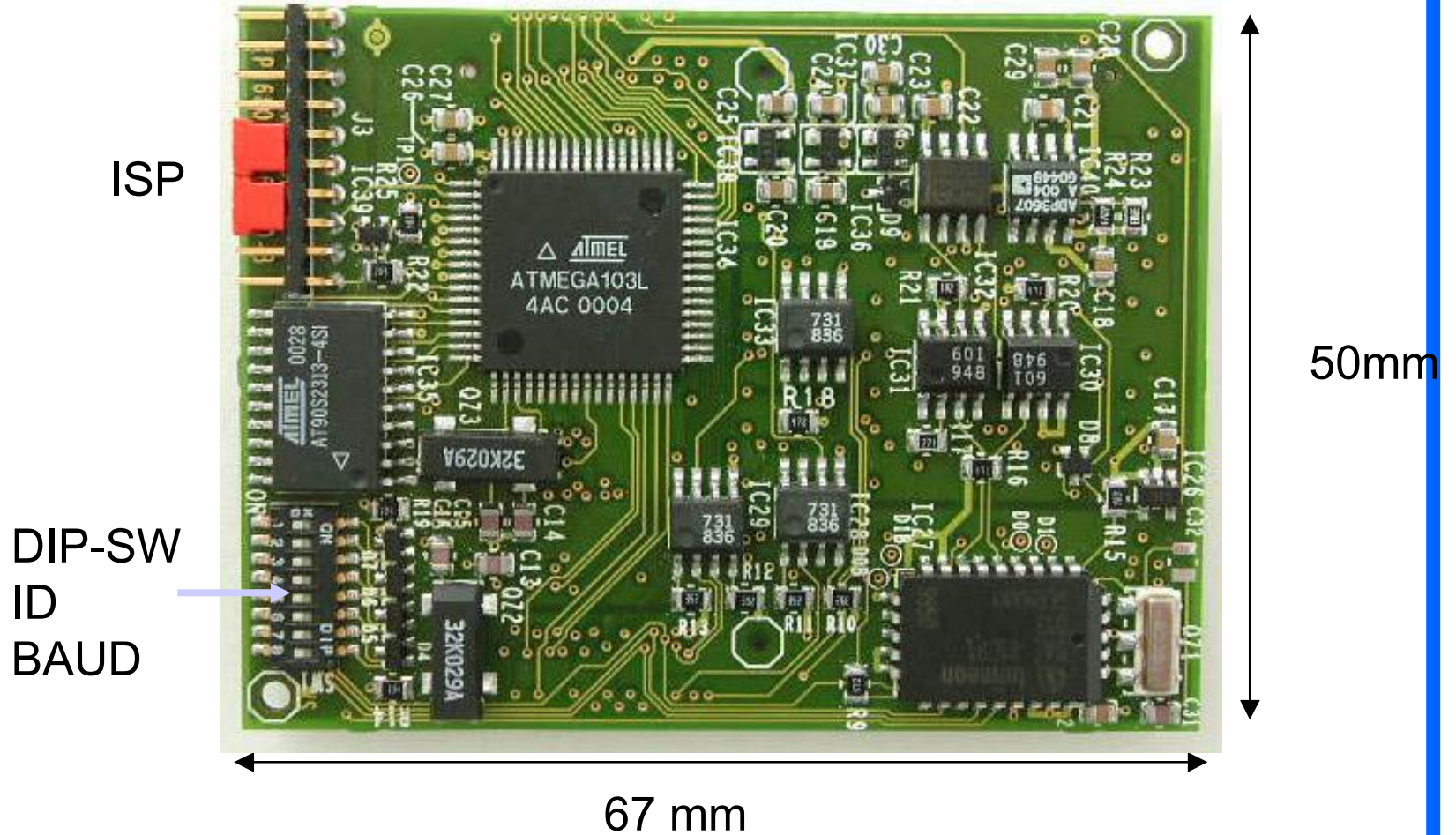
Common effort savings in manpower

- Several ATLAS subdetectors involved in HW and SW- CERN, NIKHEF.



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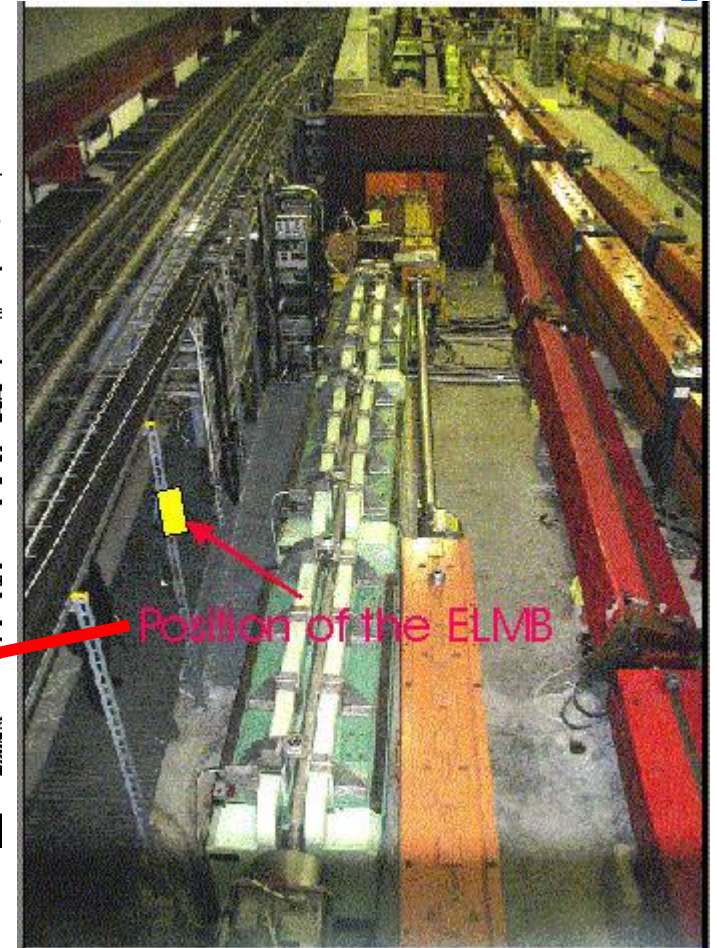
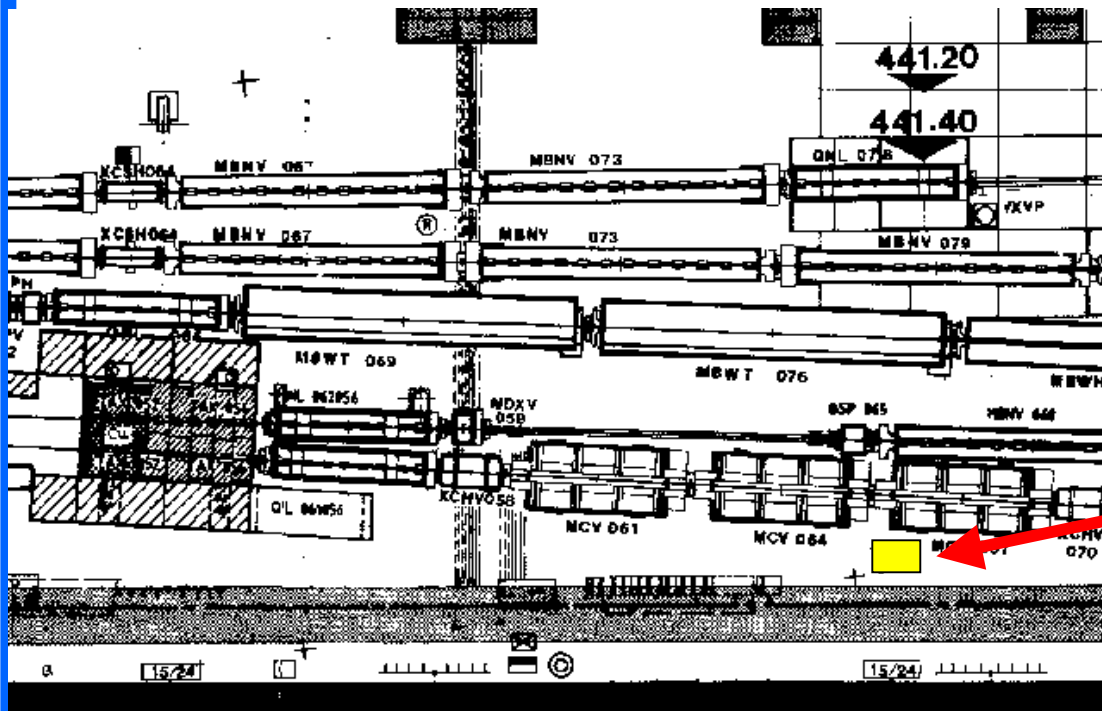
ELMB front side





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ELMB TCC2 Location



7/12 2001

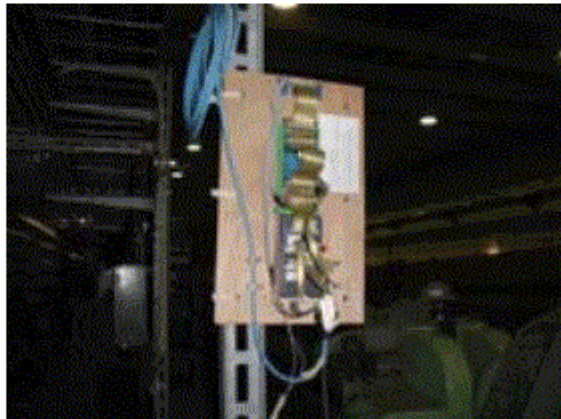
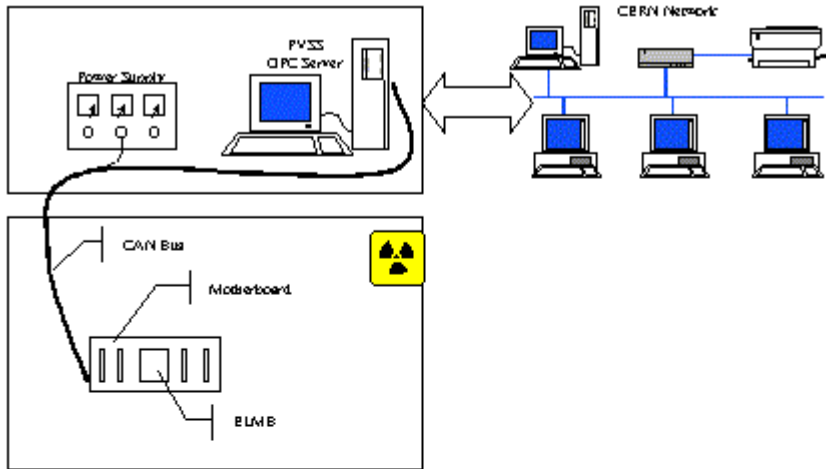
B. Hallgren ATLAS INTEGRATION
& MAGNET GROUP

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ELMB SEE setup



- **One PC in non-radiation area, with power supply**
- **One ELMB on Motherboard in radiation area**
- **Connected via 150 m of CAN bus**
- **Power via CAN bus**
- **ELMB measures own currents and voltage**



ATLAS

1200

No of SEE

1000

800

600

400

200

0

15/7

22/7

29/7

5/8

12/8

19/8

26/8

2/9

9/9

16/9

Date

Results: Total SEEs



Red - ELMB SEEs

Blue - Data lost for some other problem



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Results: **SEE** effects

WEB on line display

Over two months:

- 3 soft resets
- 3 hard resets
- 2 PVSS crashes
- 2 archive made disk full
- 1 fatal error
(openhost/NICAN card,
PVSS, ELMB current
consumption)
 - No recovery possible

TCC2 Radiation Testing

Below are the readings for the TCC2 test for the ELMB. The test was conducted at CERN, Preessin, using one ELMB undergoing the actual radiation testing which monitors its own current on channels 1-3. Channel 4 is used to monitor VDP.

The Current readings...

Section	Current (mA)	Date/Time Stamp
CAN	18.1768	08.10.2001 17.57.32
Analog	10.0926	08.10.2001 17.57.32
Digital	27.7784	08.10.2001 17.57.33

The Test results...

Test Type	Byte Read	Byte Exp.	Address	Num. of Errors	Last Update
RAM	161	165	2354	1	08.10.2001 17.55.34
EEPROM	0	0	0	0	27.09.2001 09.30.46
FLASH	0	0	0	0	27.09.2001 09.30.47
CAN	213	85	246	0	08.10.2001 11.27.47
ADC	168	85	0	0	08.10.2001 13.01.35

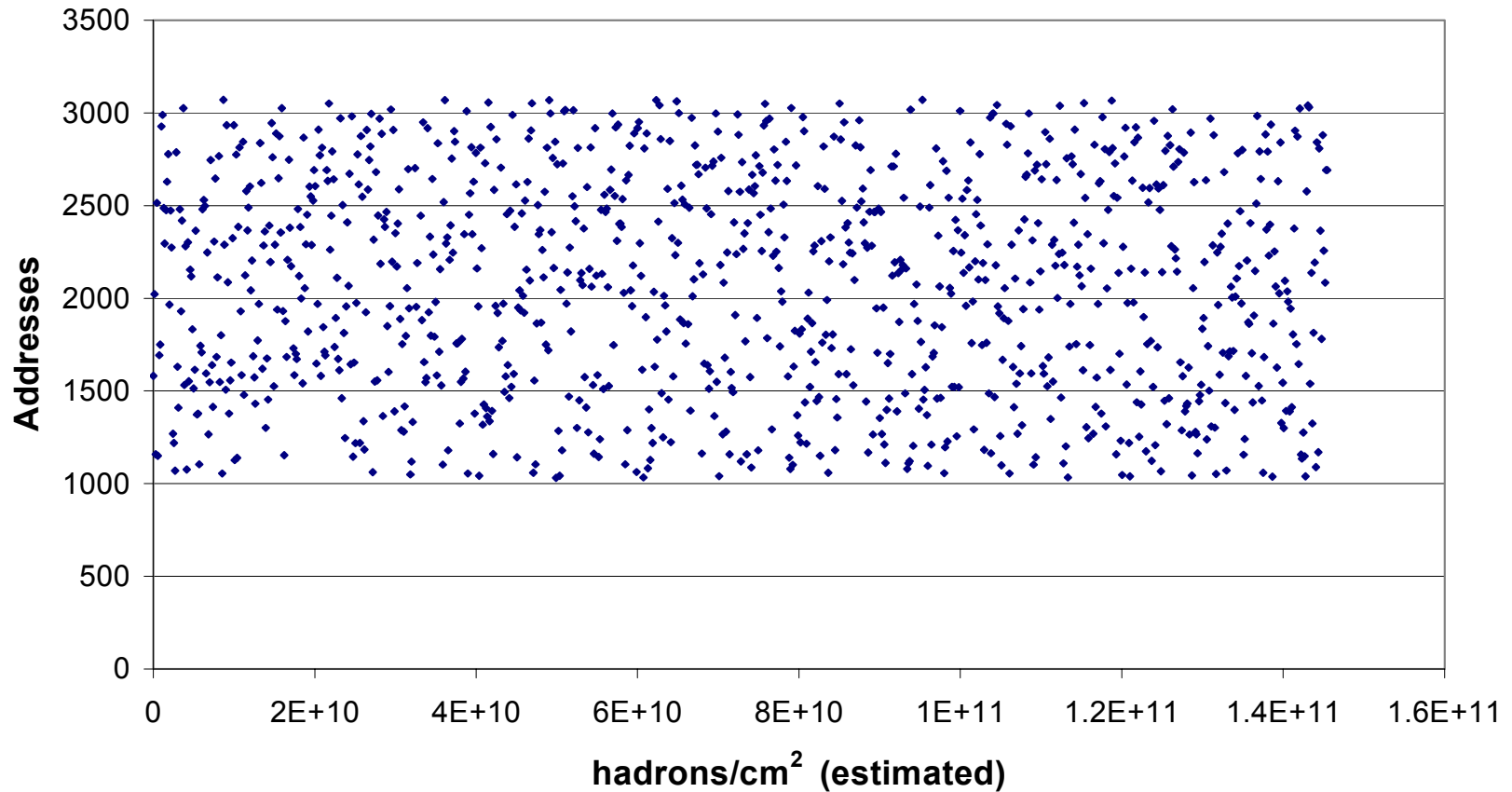
The Voltage readings



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Results: **SRAM Address Distribution**

TCC2 - 1 Distribution of SRAM addresses where SEE occurred

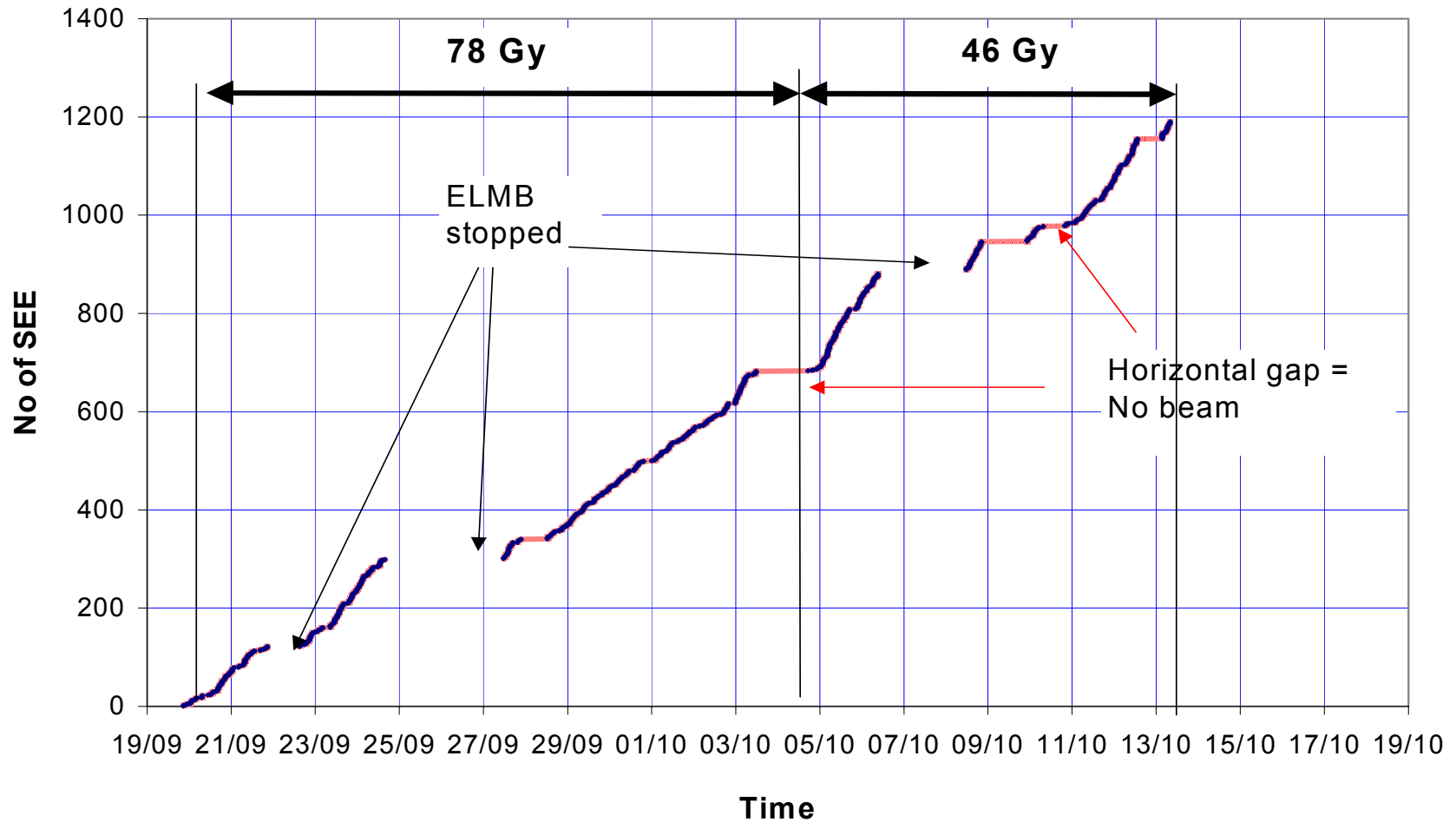




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Results: **Total SEEs**

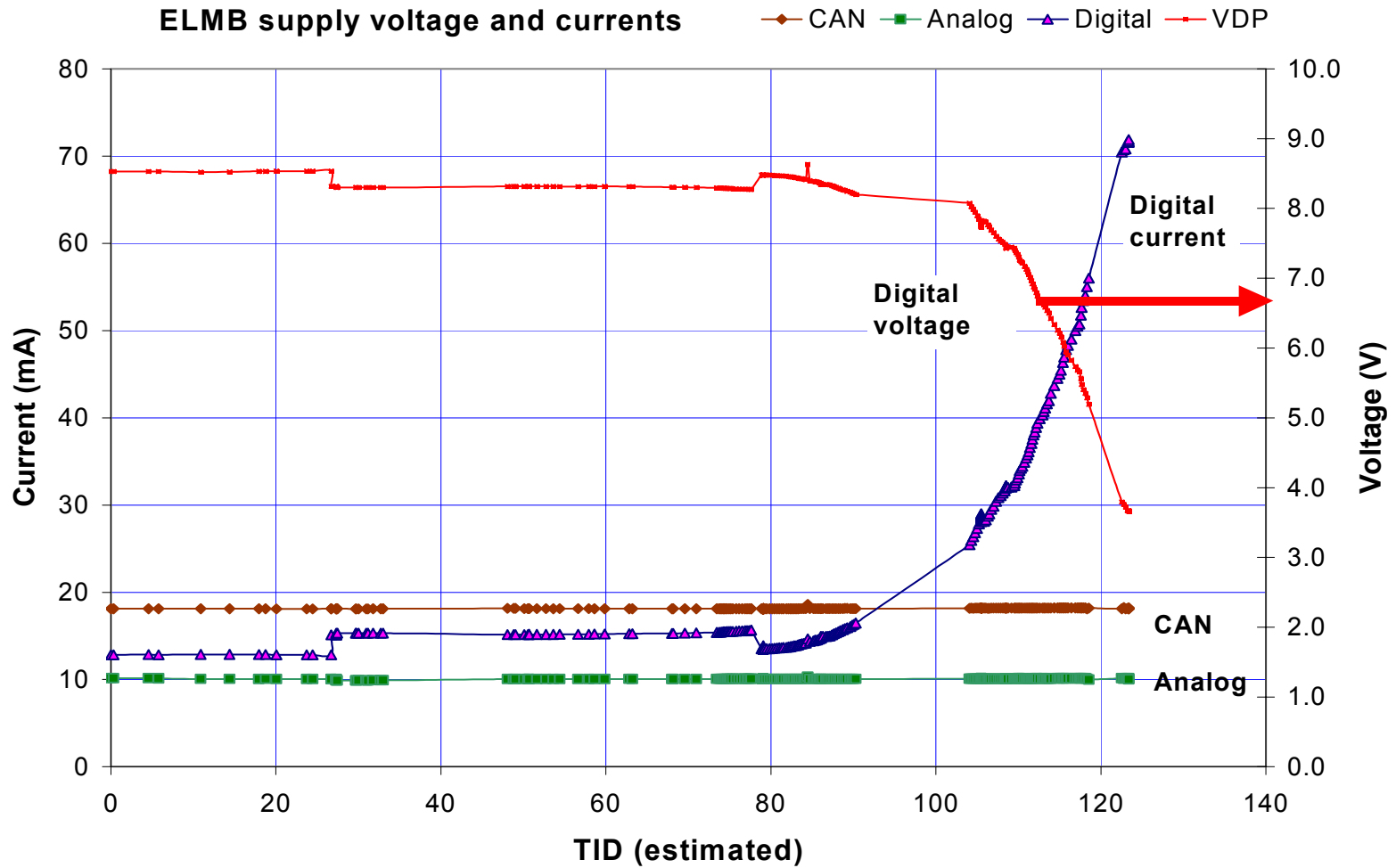
SEE in the ELMB SRAM TCC2 2nd period 2001





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Results: (TID effect)





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ELMB Summary

- **Over 8 weeks, 6 ELMB errors observed**
- **ATLAS MDT in 10 years: 5.7×10^9 hadrons /cm² >20 MeV**
- **TCC2 estimated from SRAM: 1.4×10^{11} h/cm²**
- **6 errors per ELMB in 240 years ATLAS Muon Detector!**
- **But there are 1200 ELMBs in the MDT!**
- **TID reached is about 90 Gy**
- **ATLAS MDT 0.5 Gy/year**
- **180 years of operation (other tests 80 years)**
- **NIEL (tested at PROSPERO) 3×10^{12} n /cm² equiv. 1 MeV in Si**
- **ATLAS MDT 3×10^9 n/cm² per year**
- **1000 years of operation**



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TCC2 in the year 2002

**TCC2 very realistic for a complete system -
SEE tests for long time no other places like
this!!**

- Complete system test hardware and software with a few more ELMBs at different places.
- Automatic detection and recovery of SEE (a few seconds)
- Wanted better radiation monitors and data from
- the beam line monitors