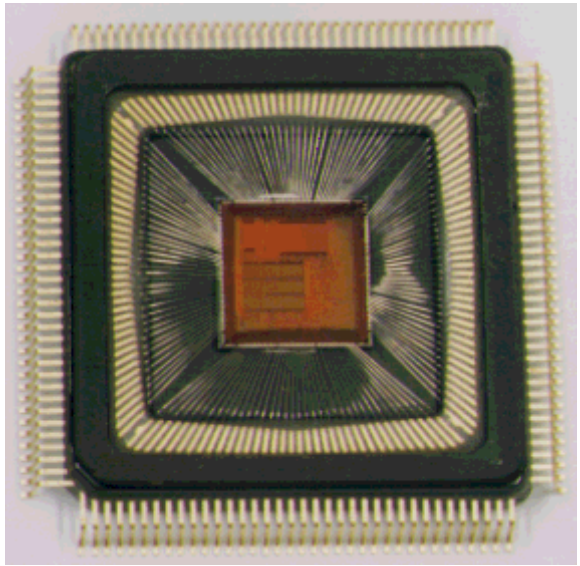
ATLAS

Production Readiness Review
ATLAS Muon TDC (AMT)

20 June 2002@CERN
Yasuo Arai (KEK)
yasuo.arai@kek.jp
http://atlas.kek.jp/tdc/PRR/

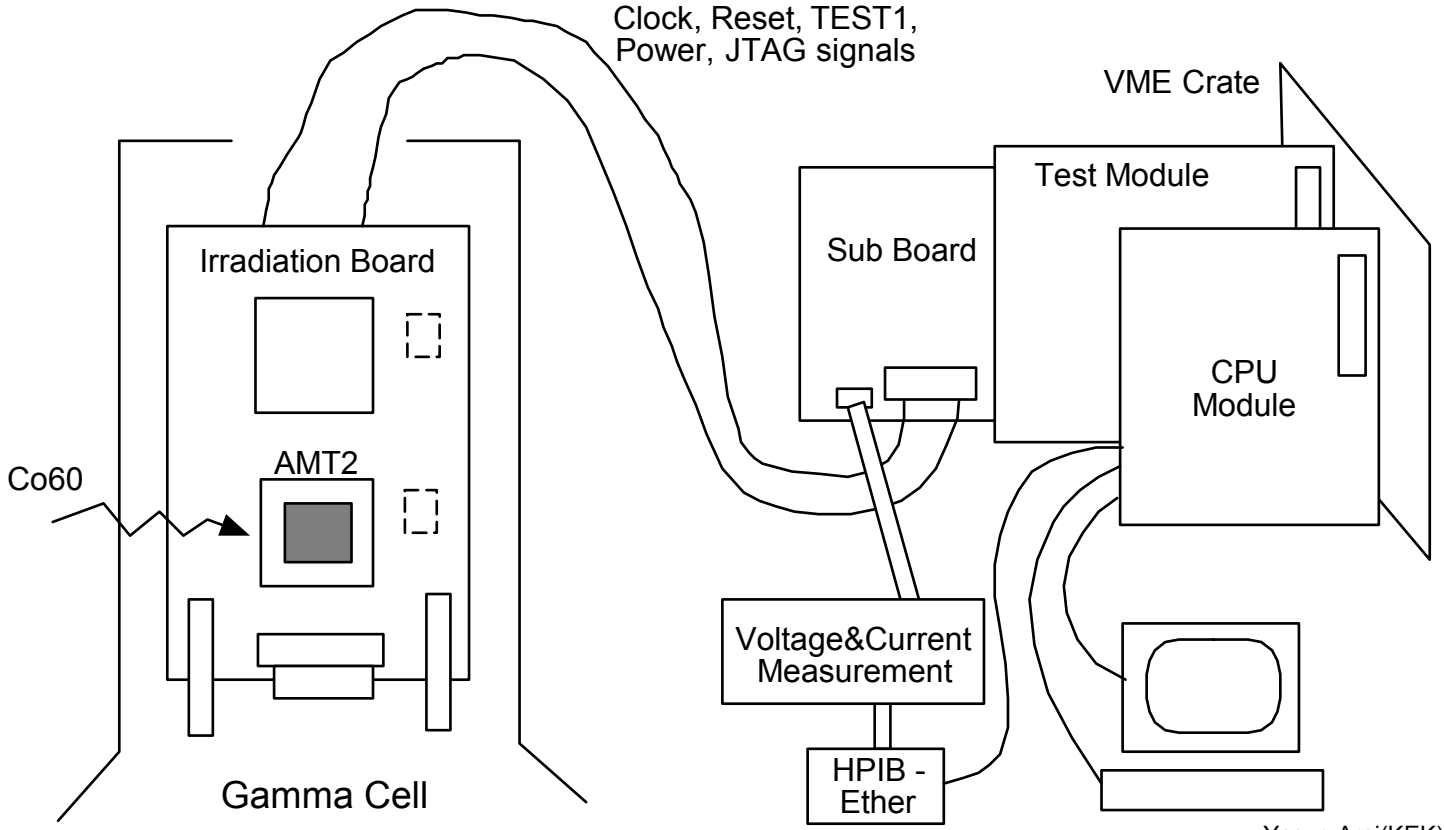
Radiation Test

- TID test
- SEE test
- Summary



TID Test

- Irradiated at Tokyo Metropolitan Univ.
- ^{60}Co (60 rad/sec) -> 20 krad (RTCtid max = 10.5 krad)
- 40 MHz Clock running, Power On.
- Dynamic <-> Static state change through JTAG
- Voltage & Current were measured at every 10 sec.



Gamma Cell

After Irradiation

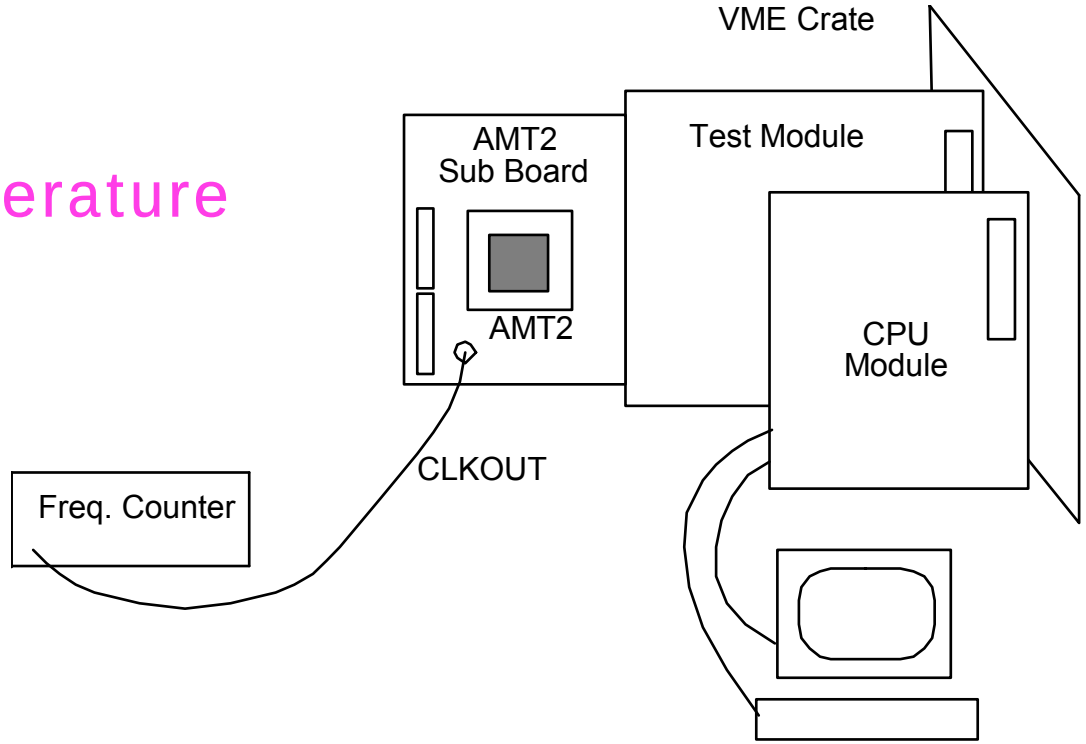
Measure :

- Time Resolution
- Oscillating Frequency of PLL
- CSR Read/Write
- BIST check

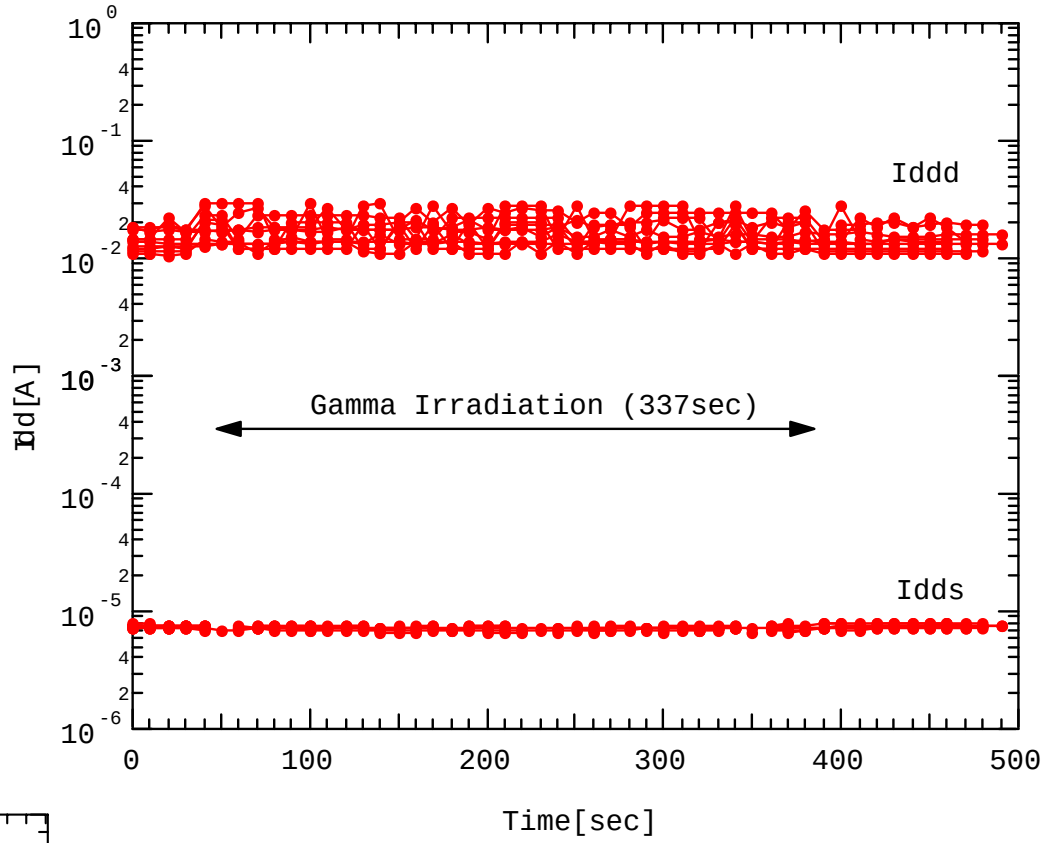
Annealing:

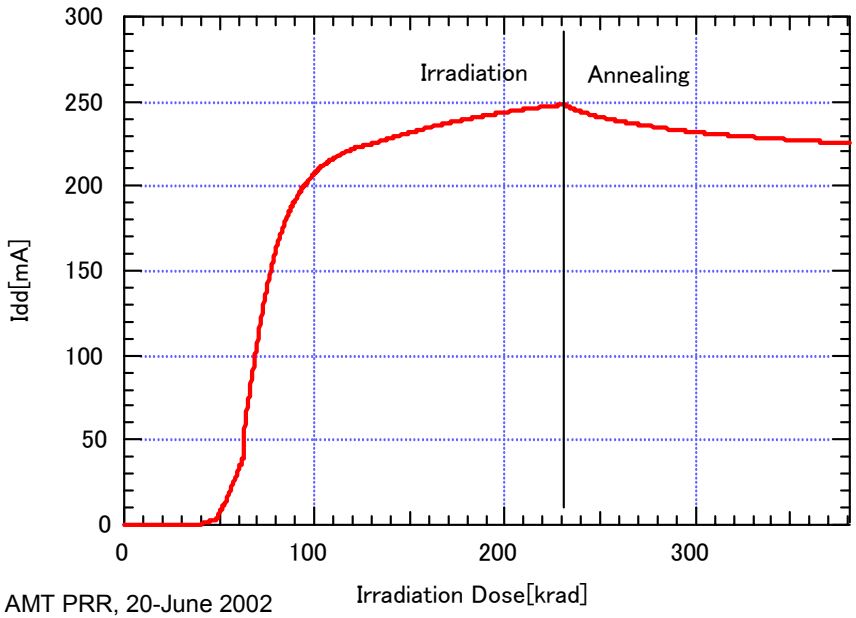
1 week at room temperature

1 week at 100 ˚C



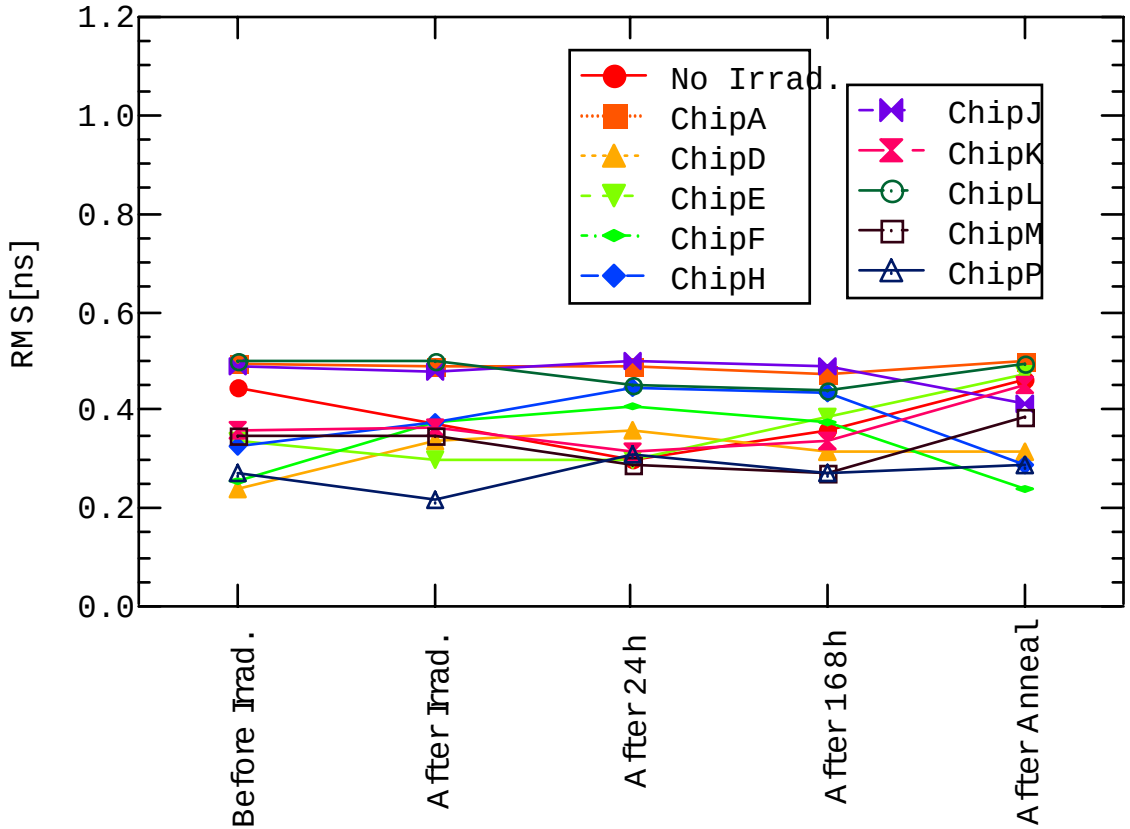
Leak Current



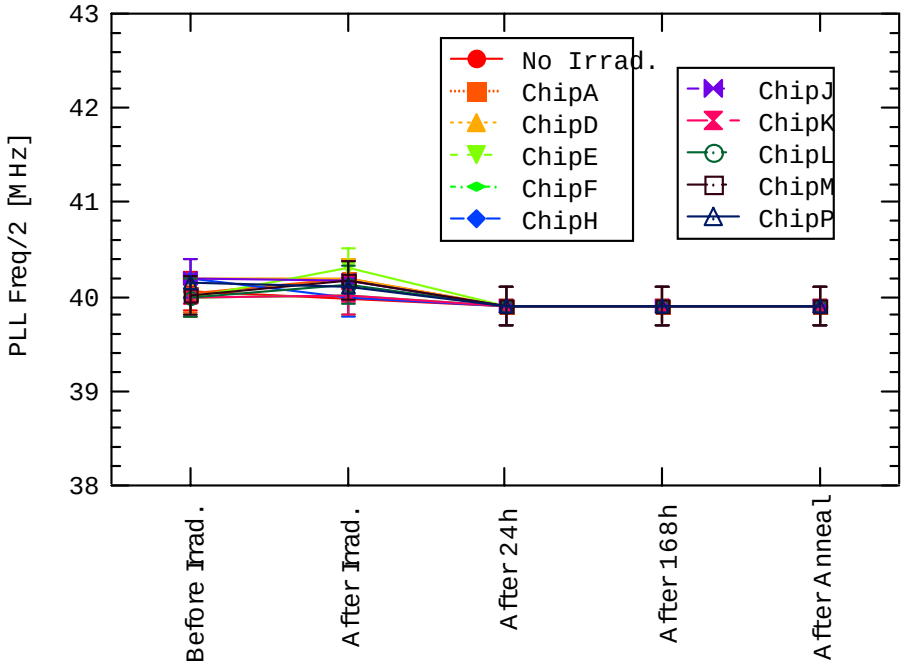


Time Resolution

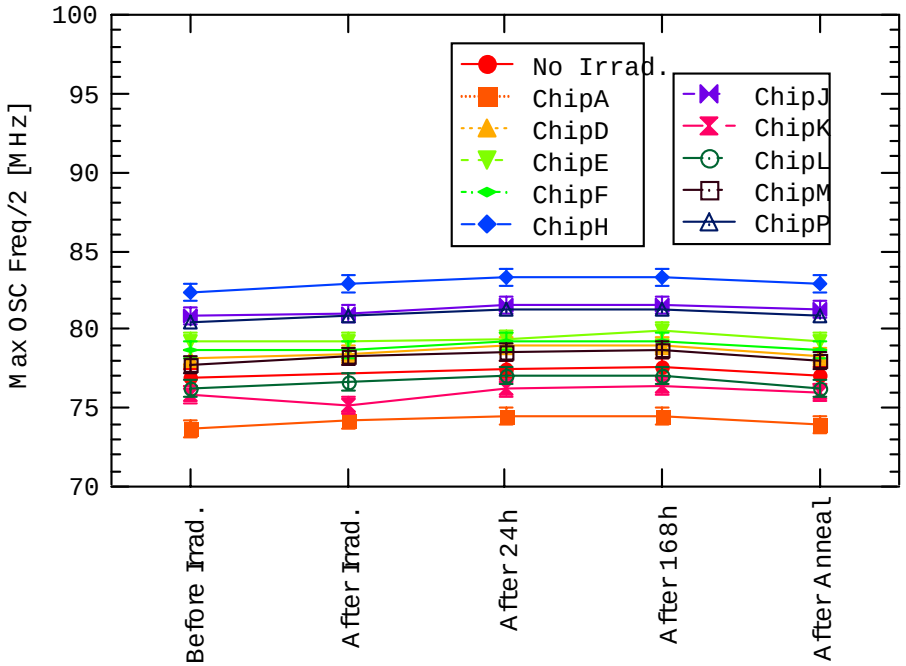
Simple measurement of two pulses generated from clock in CPLD.



Locked Frequency @40MHz

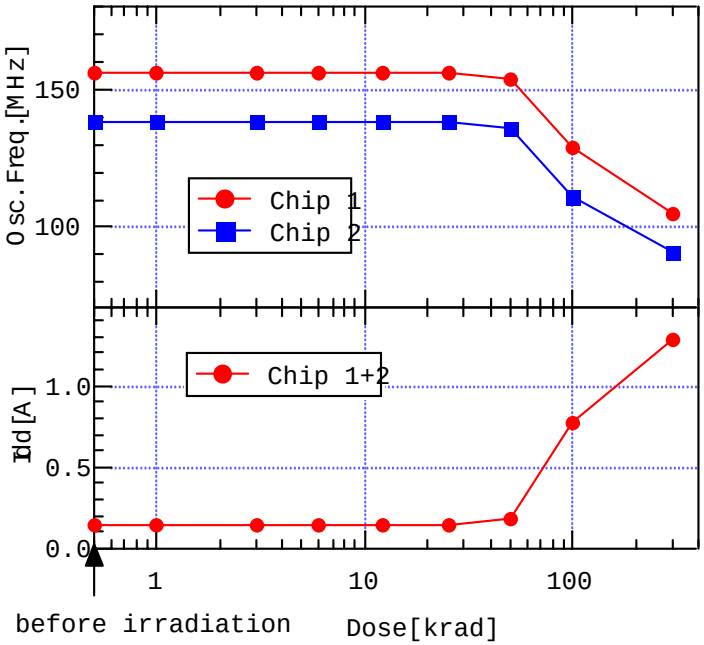


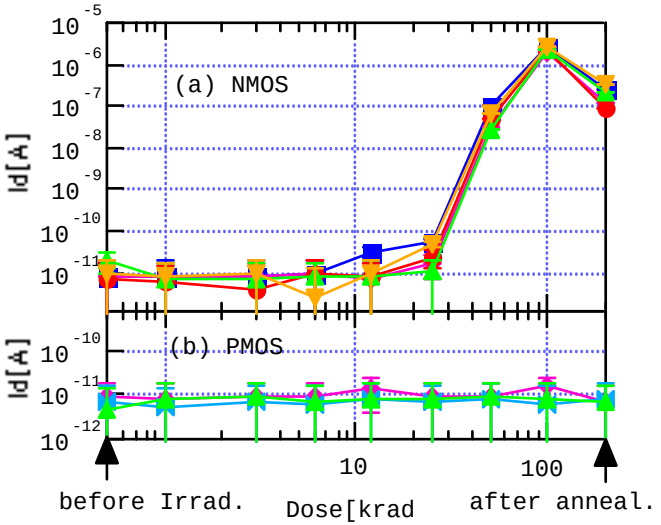
Max. Osc. Frequency

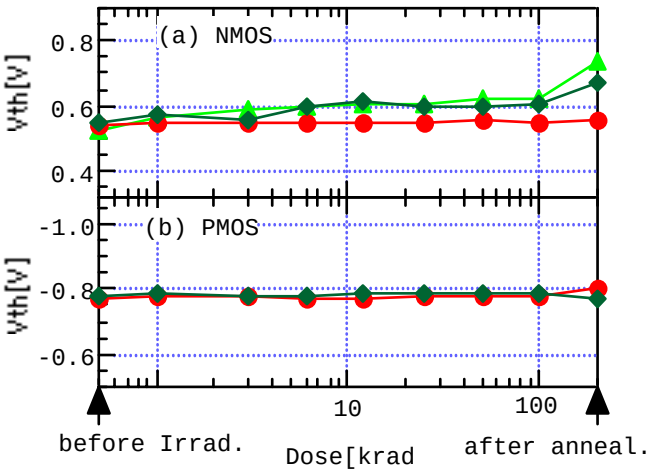


Other TID Test (Transistor Parameter)

- Source : ^{60}Co (~90 rad(Si)/sec)
- Biased in worst condition (PMOS short, NMOS ON)
- 1 week annealing at 100 ° C





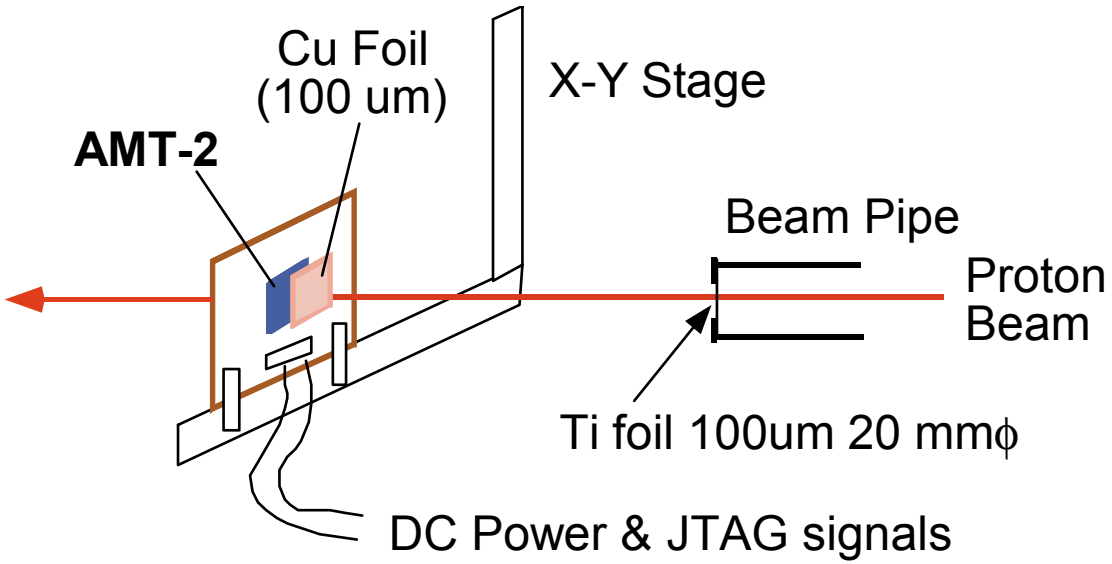


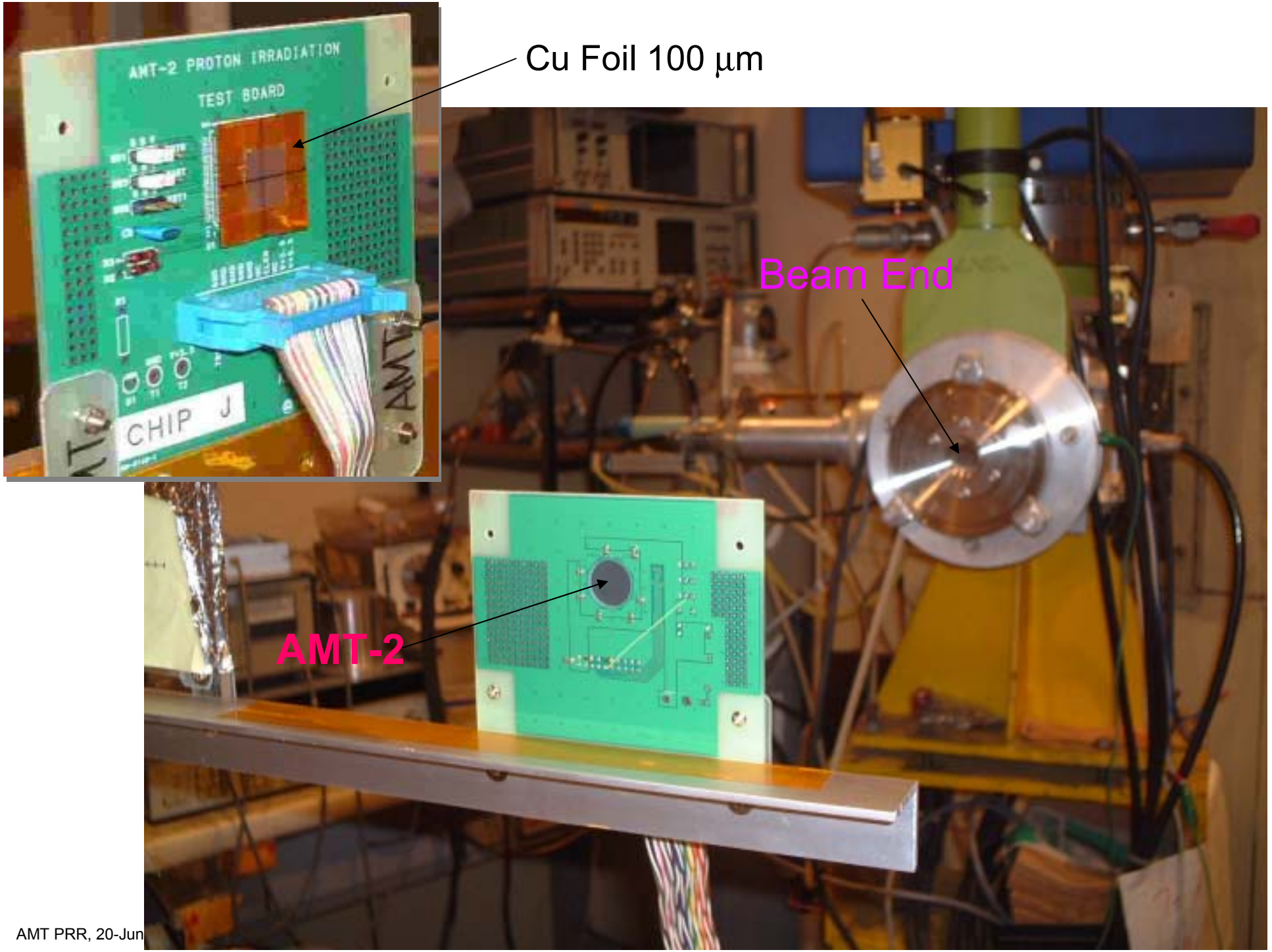
Summary of TID test

- We have irradiated 10 AMT-2 chip following ATLAS standard test method.
- The chips were annealed 1 week at room temperature, and then annealed another 1 week at 100°C.
- There was no change in leakage current, oscillating frequency and time resolution.
- There was no malfunction in CSR registers and JTAG logic.

SEE Test : Proton Beam

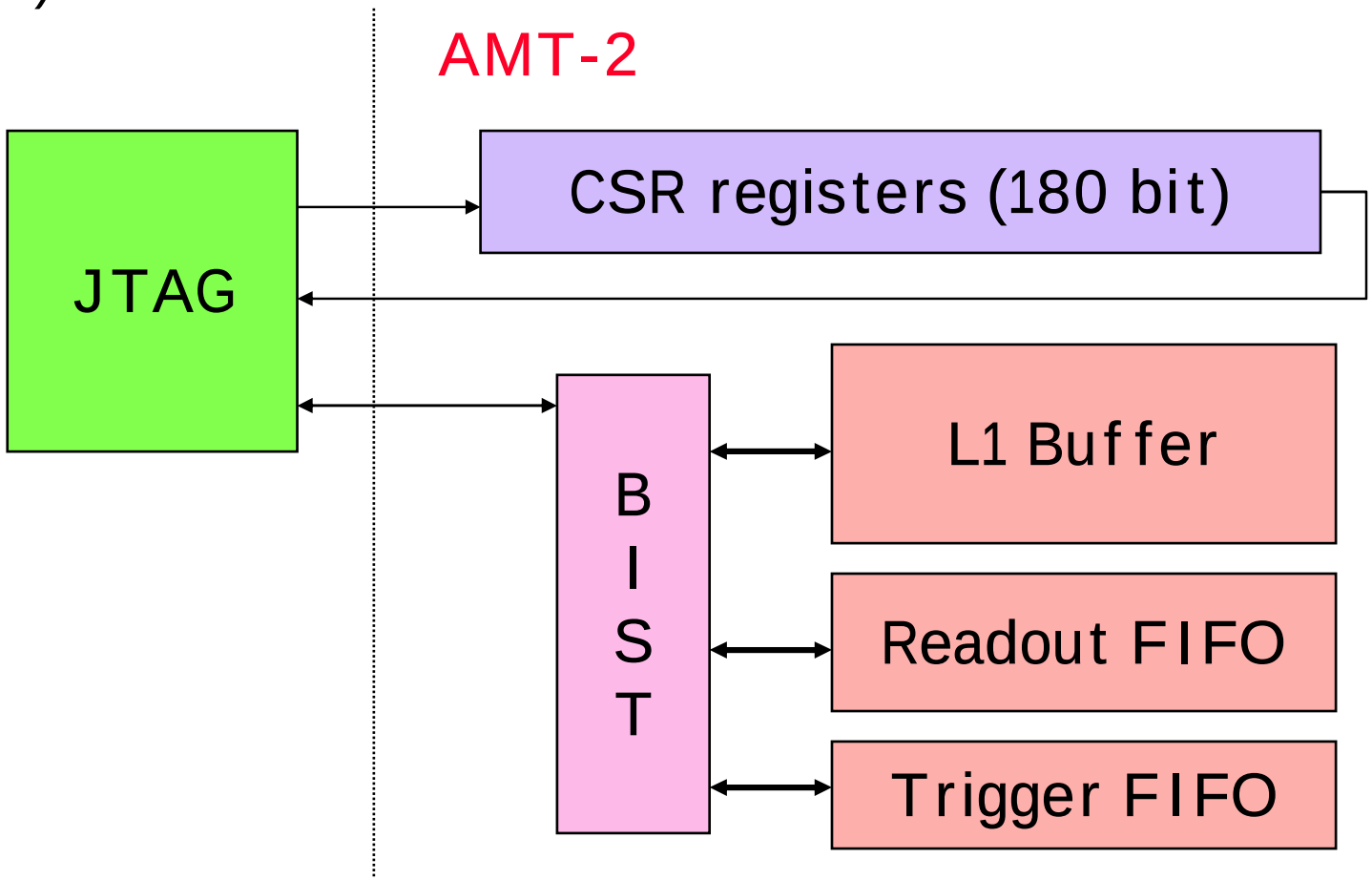
- Proton beam at AVF Cycrotron (CYRIC, Tohoku Univ. Japan)
- Irradiation were done with E(proton) = 70 MeV.
- 4 AMT-2 chips were irradiated.
- Beam intensity & profile are monitored with Dosimetry of Cu foil .



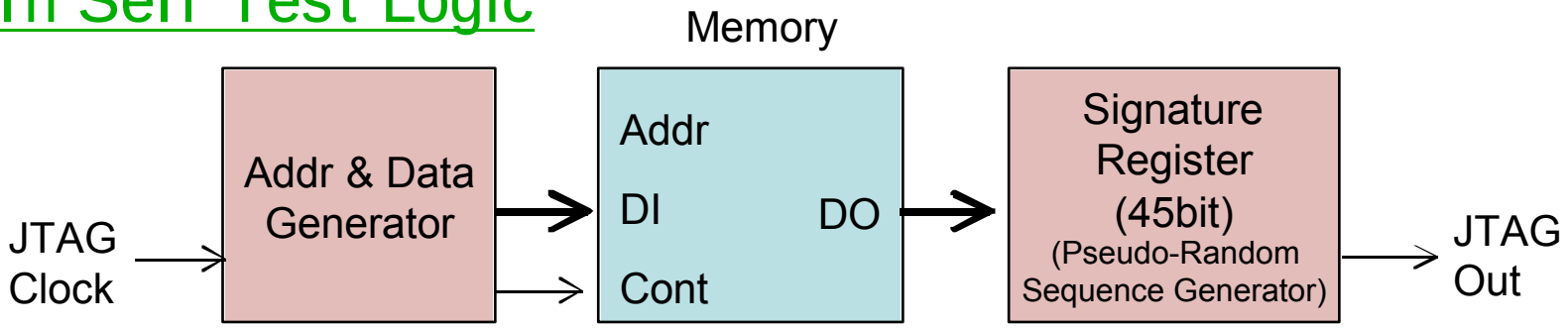

AMT-2 PROTON IRRADIATION
TEST BOARD
CHIP J
Cu Foil 100 μm
Beam End
AMT-2

Single Event Upset Test

- CSR registers (180 bits) are directly written/verified throgh JTAG.
- Data buffers (11,360 bits) are tested by using a Built-In Self-Test (BIST) circuit.



Built-In Self Test Logic



13N Marching Pattern ('10' & '11' Backgrounds)

Addr.	Initialize	1st Step	2nd Step	3rd Step	4th Step
0	W(1)	R(1)W(0)R(0)	R(0)W(1)R(1)	R(1)W(0)R(0)	R(0)W(1)R(1)
1	W(0)	R(0)W(1)R(1)	R(1)W(0)R(0)	R(0)W(1)R(1)	R(1)W(0)R(0)
2	W(1)	R(1)W(0)R(0)	R(0)W(1)R(1)	R(1)W(0)R(0)	R(0)W(0)R(1)
:	\	\	\	/	/
N-1	W(0)	R(0)W(1)R(1)	R(1)W(0)R(0)	R(0)W(1)R(1)	R(1)W(0)R(0)

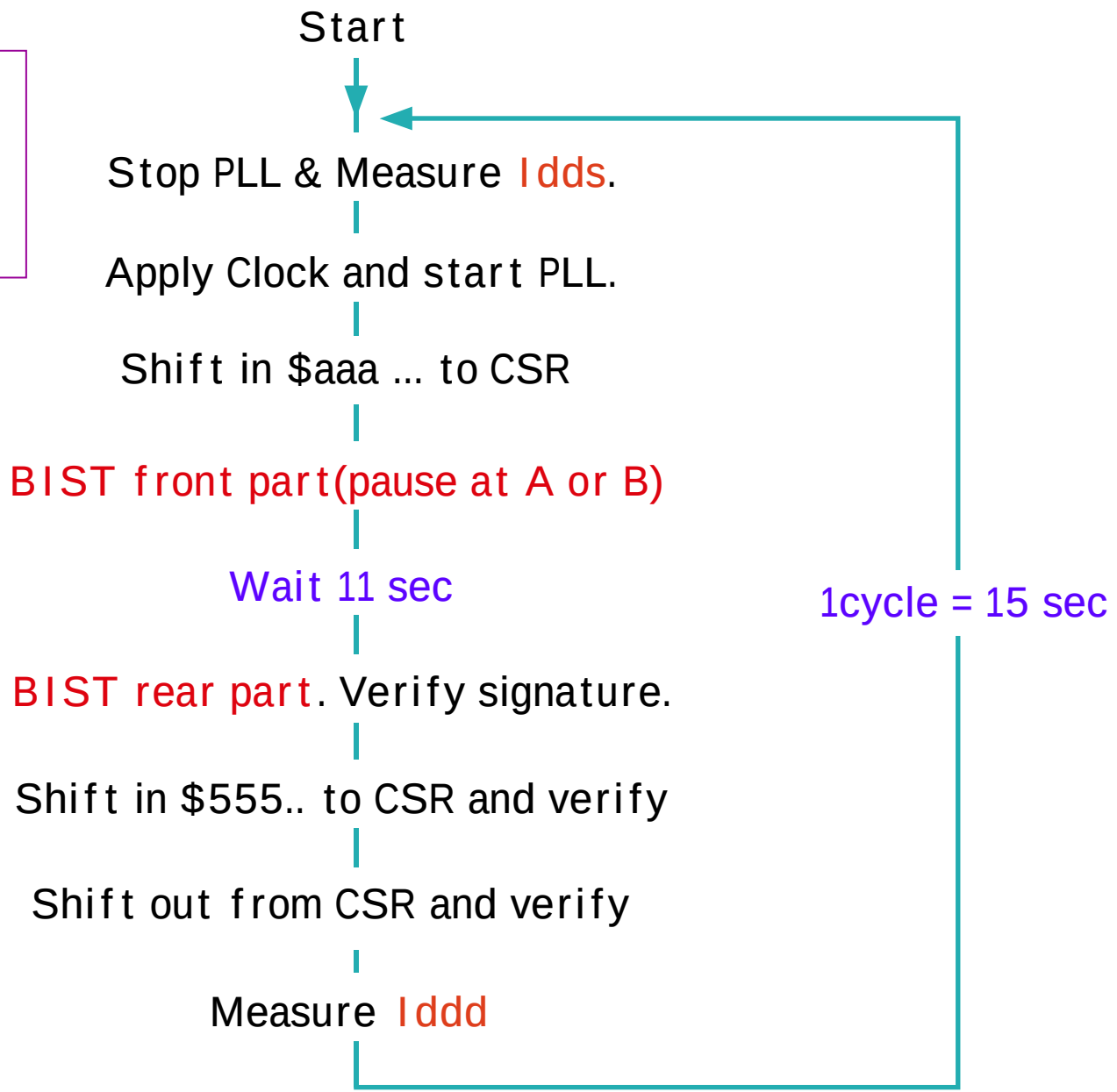
Pause A

Addr.	Initialize	1st Step	2nd Step	3rd Step	4th Step
0	W(1)	R(1)W(0)R(0)	R(0)W(1)R(1)	R(1)W(0)R(0)	R(0)W(1)R(1)
1	W(1)	R(1)W(0)R(0)	R(0)W(1)R(1)	R(1)W(0)R(0)	R(0)W(1)R(1)
2	W(1)	R(1)W(0)R(0)	R(0)W(1)R(1)	R(1)W(0)R(0)	R(0)W(1)R(1)
:	\	\	\	/	/
N-1	W(1)	R(1)W(0)R(0)	R(0)W(1)R(1)	R(1)W(0)R(0)	R(0)W(1)R(1)

Pause B

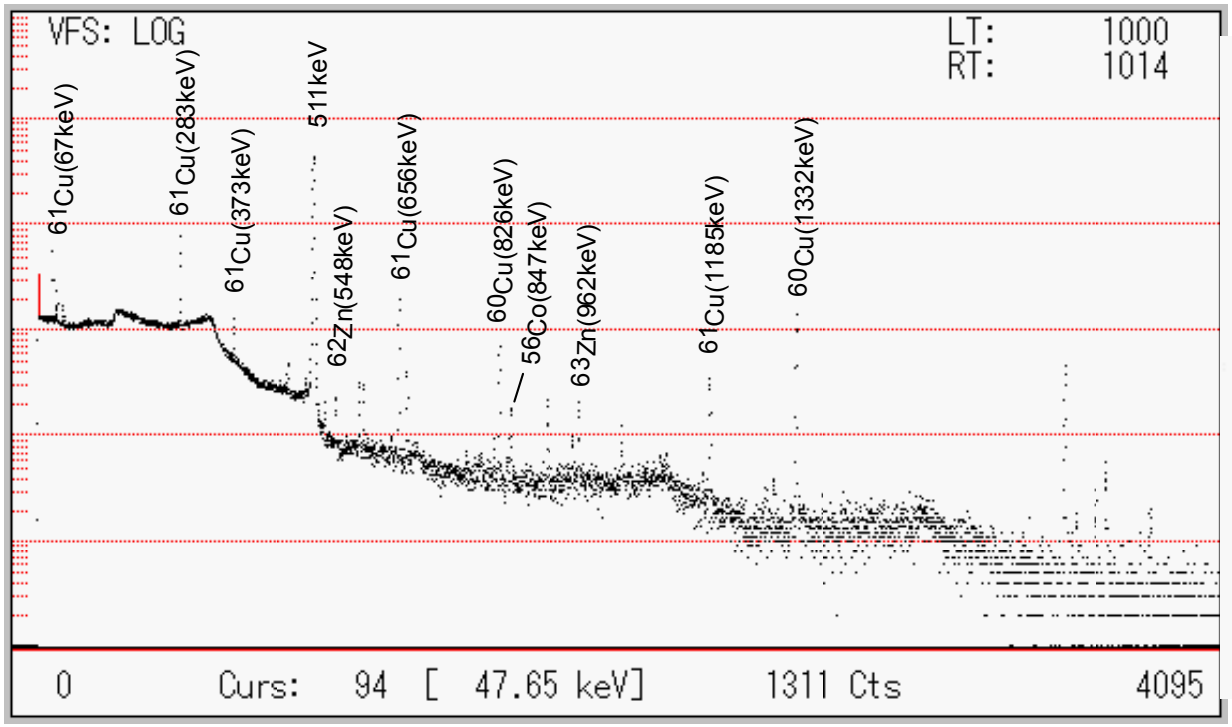
AMT-2 Test sequence

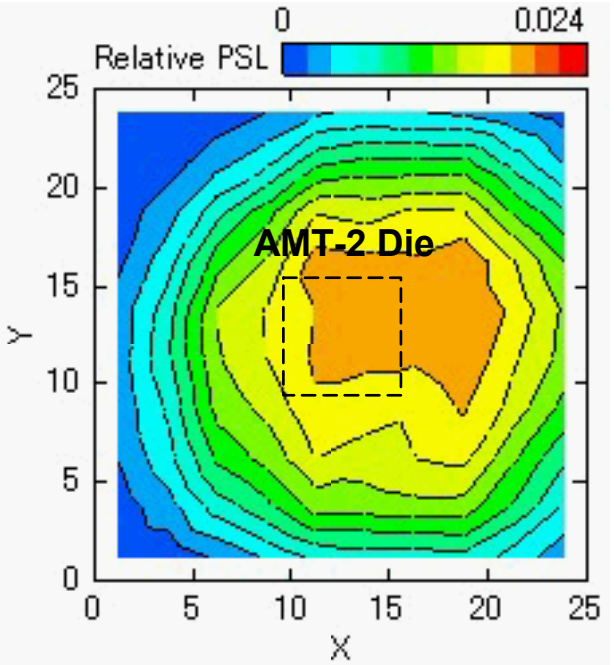
Read/Write through JTAG
Clock is always ON
Power is always ON
Continuous Beam



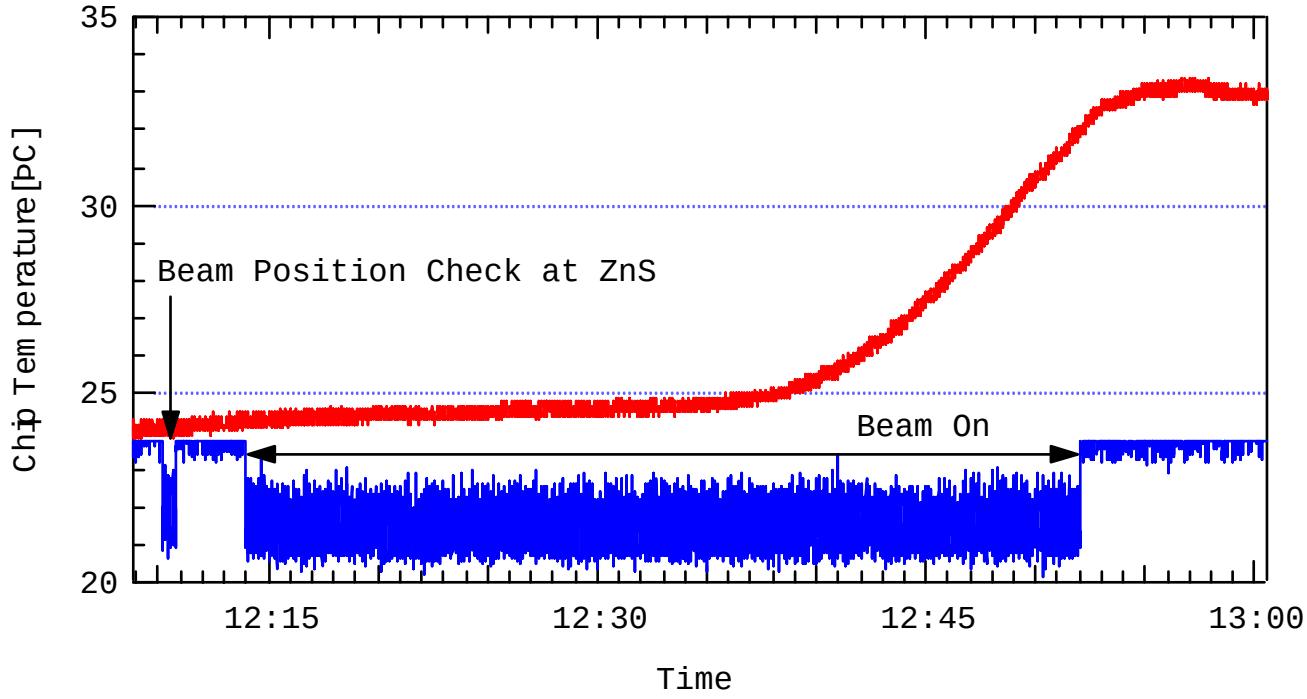
Proton Beam Flux and Profile

- 100 μm thick Cu Foil (25 mm x 25 mm) was placed in front of the AMT-2.
- γ Spectrum was measured with Ge detector (measure absolute intensity).
- Relative intensity of 5 mm x 5 mm pieces were measured with Imaging Plate.

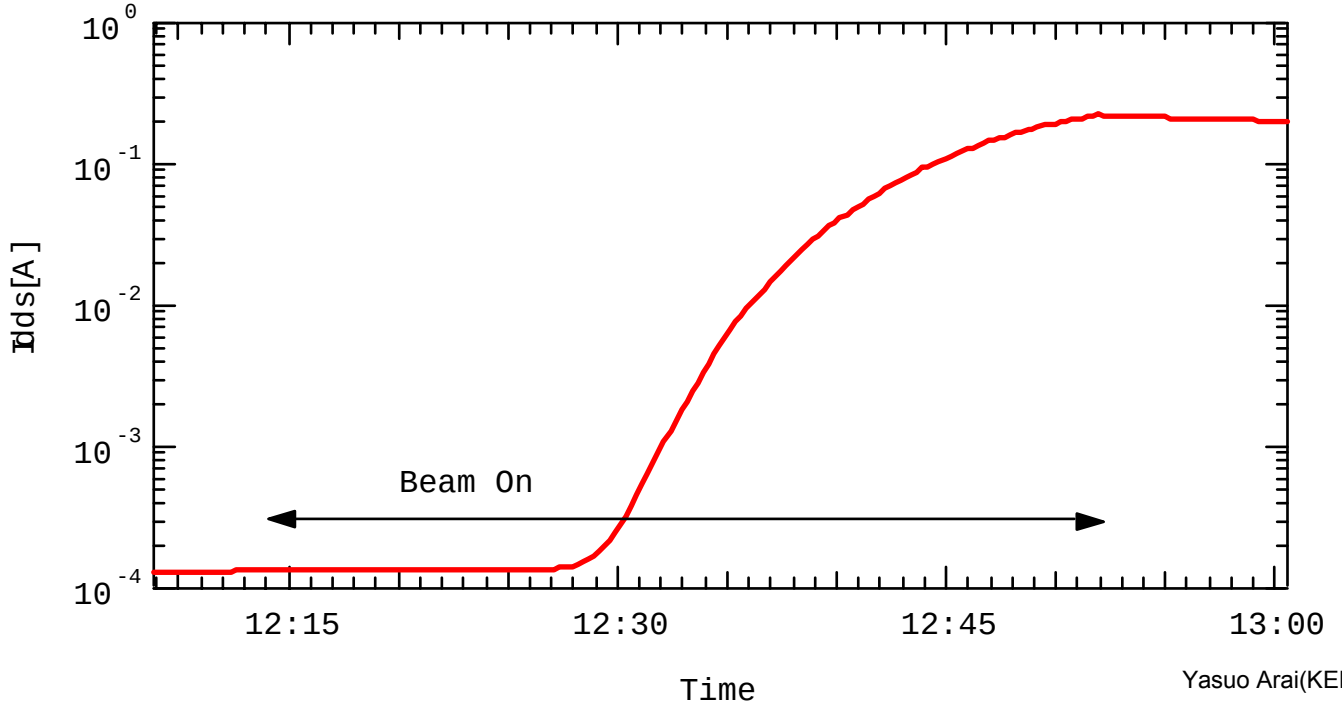




Temperature



Leak Current



SEE Test Summary

Chip	Proto fluence ($1/cm^2$)	Effective Fluence ($1/cm^2$)	Radiation Dose (krad)	Latch up	No. of SEU in Mem	σ_{SEU} (Mem) (cm^2/bit)	No. of SEU in CSR	σ_{SEU}(CSR) (cm^2/bit)
AA	8.10×10^{11}	5.94×10^{11}	130	None	0	$< 3.6 \times 10^{-16}$	0	$< 2.3 \times 10^{-14}$
CC	8.02×10^{11}	5.88×10^{11}	128	None	1	$< 6.5 \times 10^{-16}$	0	$< 2.3 \times 10^{-14}$
DD	8.03×10^{11}	5.89×10^{11}	128	None	0	$< 3.6 \times 10^{-16}$	0	$< 2.3 \times 10^{-14}$
FF	8.06×10^{11}	5.91×10^{11}	129	None	0	$< 3.6 \times 10^{-16}$	0	$< 2.3 \times 10^{-14}$
Total	3.22×10^{12}	2.36×10^{12}		None	1	$< 1.6 \times 10^{-16}$	0	$< 5.6 \times 10^{-15}$

- Soft SEU(foreseen) = 6.8×10^{-6} [upset/sec/MDT]
- Average value of the hadron flux is 2×10^9 $h/cm^2/y$,
  -> SEU < 55 (SEU/MDT system/year).
- No Latch up observed.

Summary for SEE Test

- We have done SEE test with 70 MeV proton.
- Only 1 upset for the 2.36×10^{12} irradiation
- Foreseen soft SEU rate is 6.8×10^{-6} [upset/sec/MDT]
- No Latch Up observed.