When the Chips Are Down....

Christopher Frost
ISIS Facility
A problem has been detected and Windows has been shut down to prevent damage to your computer.

The problem seems to be caused by the following file: SPCMDCON.SYS

PAGE_FAULT_IN_NONPAGED_AREA

If this is the first time you've seen this Stop error screen, restart your computer. If this screen appears again, follow these steps:

Check to make sure any new hardware or software is properly installed. If this is a new installation, ask your hardware or software manufacturer for any Windows updates you might need.

If problems continue, disable or remove any newly installed hardware or software. Disable BIOS memory options such as caching or shadowing. If you need to use Safe Mode to remove or disable components, restart your computer, press F8 to select Advanced Startup Options, and then select Safe Mode.

Technical information:

*** STOP: 0x00000050 (0xFD3094C2,0x00000001,0xFBFE7617,0x00000000)

*** SPCMDCON.SYS - Address FBFE7617 base at FBFE5000, DateStamp 3d6dd67c
Schaerbeek, Belgium: May 18th 2003, 22:30

4096 (2^{12}) votes added to an electronic voting machine

“worried about the influence of Martians on these elections.... unless the cosmic rays affect our lists in a positive way!”
SUN Microsystems - 2000
- Flagship Enterprise systems had problem in ‘cache’ memory

Cisco Systems - 2003
- High end 12000 series router line cards suffered failures

Cypress Semiconductor Corporation - 2001
- $1bn factory ground to halt every month due to single bit-flip in network


Images courtesy of Shutterstock and Cisco Systems
Neutron Radiation from Cosmic Rays

~ once a minute

Neutron Radiation from Cosmic Rays

~ 300 a minute

More neutrons at 35,000 feet

Neutron Radiation from Cosmic Rays

~ 300 a minute
More neutrons at 35,000 feet

The dominant reliability issue in aircraft avionics

Becoming a dominant reliability issue in all advanced electronics

A Single Event Effect (SEE) is when a highly energetic particle present in the environment, strikes sensitive regions of an electronic device disrupting its correct operation.
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‘Real-world Incident’

7th October 2008 at 04:40:26
Flight Qantas QF72 – Singapore to Perth
Blackpool Rollercoaster has a 213 ft drop
“It identified a number of specific lessons for the manufacturers of new, complex, safety-critical systems...”

The Chief Commissioner of the ATSB, Mr Martin Dolan
Media Report 19 December 2011
There were significant logistical difficulties in obtaining access to appropriate test facilities and developing test software and procedures.....
Martin Cooper invented the mobile phone and made the first call in 1973.

Functionality

Scale
Kilobyte: 1,000 bytes

Megabyte: 1,000,000 bytes

Gigabyte: 1,000,000,000 bytes

Terabyte: 1,000,000,000,000 bytes

Petabyte: 1,000,000,000,000,000 bytes

Exabyte: 1,000,000,000,000,000,000 bytes

Zettabyte: 1,000,000,000,000,000,000,000 bytes

Capacity of 3.5” Disk

Capacity of DVD

Capacity of human being’s functional memory

Amount of digitally stored information in the world (2010)

Source: Cisco
Functionality

Scale

Reproduced from data in ITRS Roadmap 2011
ISIS Neutron Source

Rutherford Appleton Lab
Basic Principle

Use fast neutron flux from ISIS source in two stage process:

- Harden spectrum from Target/Moderator/Reflection
- Illuminate scatterer in shutter to produce beams

Atmospheric Fast Neutron Beams: Pencil & Flood

Target

Proton Beam (800MeV)
**Primary Beam Specification**

<table>
<thead>
<tr>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>An energy bandwidth of 0-800MeV</td>
</tr>
<tr>
<td>The fast neutron flux (&gt;1MeV) should match the QinetiQ QARM model for the</td>
</tr>
<tr>
<td>atmospheric neutron spectrum</td>
</tr>
<tr>
<td>The integrated flux above (10MeV) should be of the order of 1×10^6 n/cm^2/s</td>
</tr>
<tr>
<td>The thermal neutron flux should be of the same order 1×10^6 n/cm^2/s and</td>
</tr>
<tr>
<td>removable via filters</td>
</tr>
<tr>
<td>A highly collimated beam up to as large area beam as possible (currently of</td>
</tr>
<tr>
<td>order 25cm×25cm)</td>
</tr>
<tr>
<td>The gamma-ray flux be less than 1krad/day, but ISIS should aim for &lt;1krad/</td>
</tr>
<tr>
<td>week</td>
</tr>
<tr>
<td>Variable collimation below a certain size (25cm×25cm) to down to a size of</td>
</tr>
<tr>
<td>~2×2cm^2</td>
</tr>
<tr>
<td>A ‘flood’ beam with 2-3 sizes up to a maximum of 100cm×100cm with flux of the</td>
</tr>
<tr>
<td>order of 1×10^4 n/cm^2/s</td>
</tr>
<tr>
<td>Ability to change to flux by two orders of magnitude (ideally 10^5 – 10^7</td>
</tr>
<tr>
<td>n/cm^2/s integrated flux above 10MeV for the collimated beam and 10^3 – 10^5</td>
</tr>
<tr>
<td>n/cm^2/s for the flood room)</td>
</tr>
</tbody>
</table>
ISIS Second Target Station: Fast Neutrons

Target

Be reflector
ISIS Second Target Station: Fast Neutrons

- ChipIr is more sensitive to target/moderator/reflect changes

New design

which increases cooling on front face

Water flow across front face

Tantalum end cap and water flow guide
ISIS Second Target Station: Fast Neutrons

- Target/moderator/reflector illuminated shutter/insert/front end
- Flux and spectrum optimised using Comblayer (Stuart Ansell) [MCNPX]
Shutter and Front End are illuminated by the fast neutrons
Facility | Integrated Flux >10MeV (n/cm²/s)
---|---
ISIS TS1 | 5.8×10⁴
ChipIr | 2.3×10⁶

<table>
<thead>
<tr>
<th>Beam</th>
<th>Size</th>
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</table>
| Collimated | Continuously variable  
250mm×250mm  
to 1mm×1mm |
| Flood | Fixed sizes  
1000m×1000mm  
500mm×500mm |
ISIS Second Target Station: Fast Neutrons

- Filters allow modification of the beam
<table>
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<td>Collimated</td>
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</tr>
<tr>
<td>Flood</td>
<td>Fixed sizes 1000m×1000mm, 500mm×500mm</td>
</tr>
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</table>
17cm by 25cm beam
17cm by 12cm beam
ISIS Second Target Station: Fast Neutrons

- Beamstop aims to reduce background in the blockhouse
ISIS Second Target Station: Fast Neutrons

- Blockhouse: Low background in Hall
ISIS Second Target Station: Fast Neutrons

- Blockhouse: DUT positions/Collimator/Beamstop
Under Construction

December 2013
“There are also efforts to improve radiation testing; for example, a facility to simulate effects of neutrons on aircraft systems has recently been developed as part of the ISIS facility for neutron science at the STFC Rutherford Appleton Laboratory”

- RAL Space and Lloyds of London
"The micro-electronics industry is on the verge of architectural shift as devices get to below 20 nm. It was predicted in 1979 that there will be a watershed moment when such devices become susceptible to muon ionisation, and we believe current technologies are approaching this threshold."

- Prof. Bhuva from Vanderbilt University