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Smart Environment Panel on New ITU standards to address soft error measures affecting communication devices

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December 18, 2018

New ITU standards to prevent soft errors caused by cosmic rays

By ITU News

New ITU standards provide guidelines to protect telecommunication equipment from 'soft errors' caused by particle radiation stemming from cosmic rays.

Particle radiation of neutrons generated by cosmic rays and alpha particles generated by minute quantities of radioisotopes found in semiconductor devices can create soft errors, a phenomenon where bits within the data on the device have their values reversed. This can affect the performance telecommunication equipment in such a way that adversely affects quality of service.

https://news.itu.int/new-itu-standards-to-prevent-soft-errors-caused-by-cosmic-rays/

Agenda

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1. Introduction
2. Process of Standardization
3. Overview of standardization
4. Soft error mechanisms
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6. Soft error mitigation measures
7. Soft error testing using particle accelerator
8. Reliability requirements
9. Quality estimation

※After my talk, Mr. Mitsuo Hattori will introduce example of soft error test.

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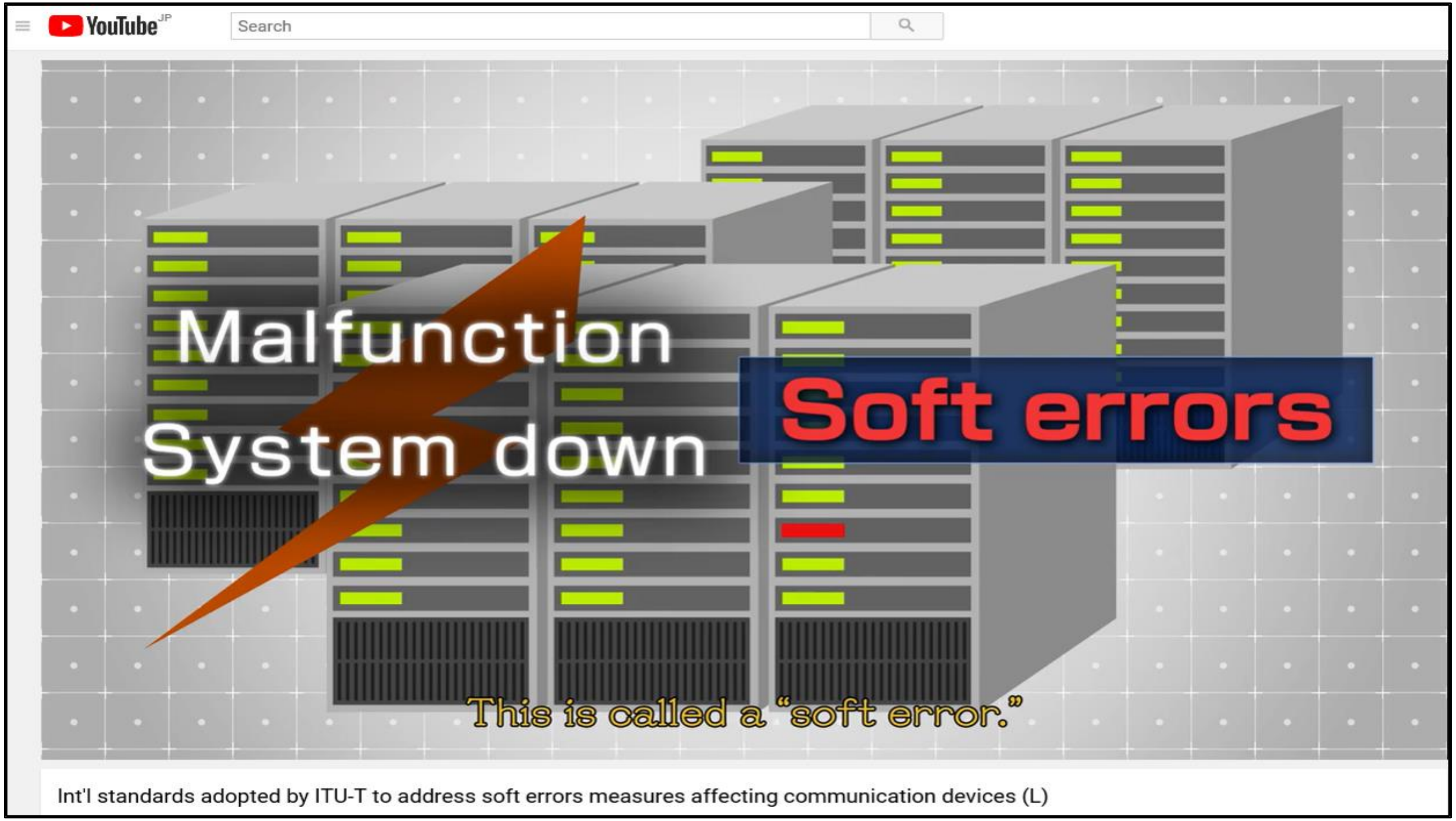
1. Introduction
Video



https://youtu.be/LKirDhW6yiA?start=10

2. Process of Standardization (1/2)

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TTC※(The Telecommunication Technology Committee)

The Ad Hoc Committee on Soft Error Testing(SOET Adhoc) member companies worked together and wrote Contributions.

Member of SOET Adhoc (As of Dec. 2018)

NTT Fujitsu Hitachi NEC Oki Xilinx

Upstream

International Telecommunication Union

2. Process of Standardization (2/2)

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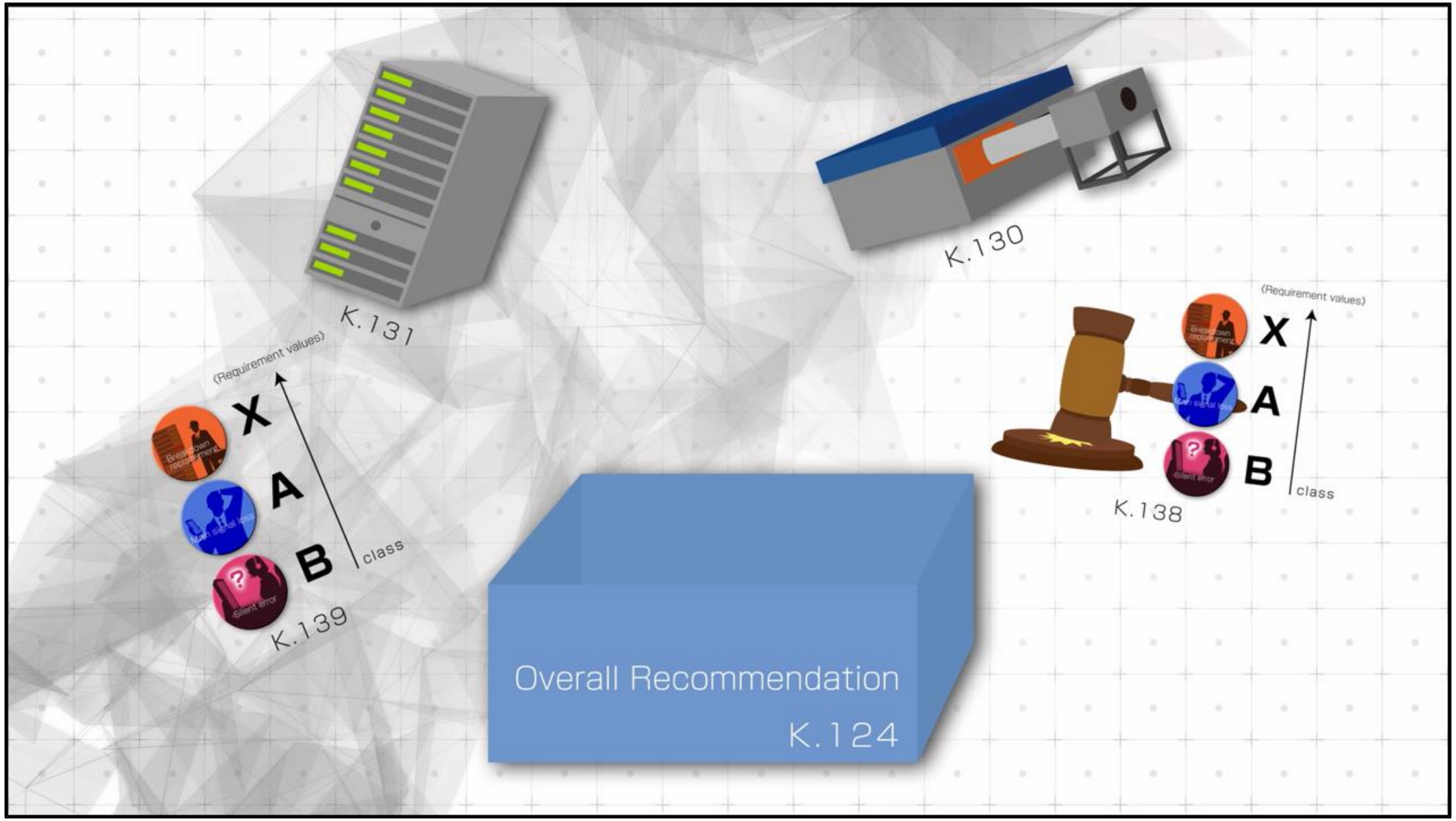
Soft errors are discussed in WP1/5 Q5/5.

Acronym		Title
PLEN	Q8/5	Guides and terminology on environment and climate change
WP1/5 EMC, lightning protection, EMF	Q1/5	Protection of information and communication technology (ICT) infrastructure from electromagnetic surges
	Q2/5	Equipment resistibility and protective components
	Q3/5	Human exposure to electromagnetic fields (EMFs) from information and communication technologies (ICTs)
	Q4/5	Electromagnetic compatibility (EMC) issues arising in the telecommunication environment
	Q5/5	Security and reliability of information and communication technology (ICT) systems from electromagnetic and **particle radiations**
WP2/5 Environment, Energy Efficiency and the Circular Economy	Q6/5	Achieving energy efficiency and smart energy
	Q7/5	Circular economy including e-waste
	Q9/5	Climate change and assessment of information and communication technology (ICT) in the framework of the Sustainable Development Goals (SDGs)

3. Overview of standardization Video



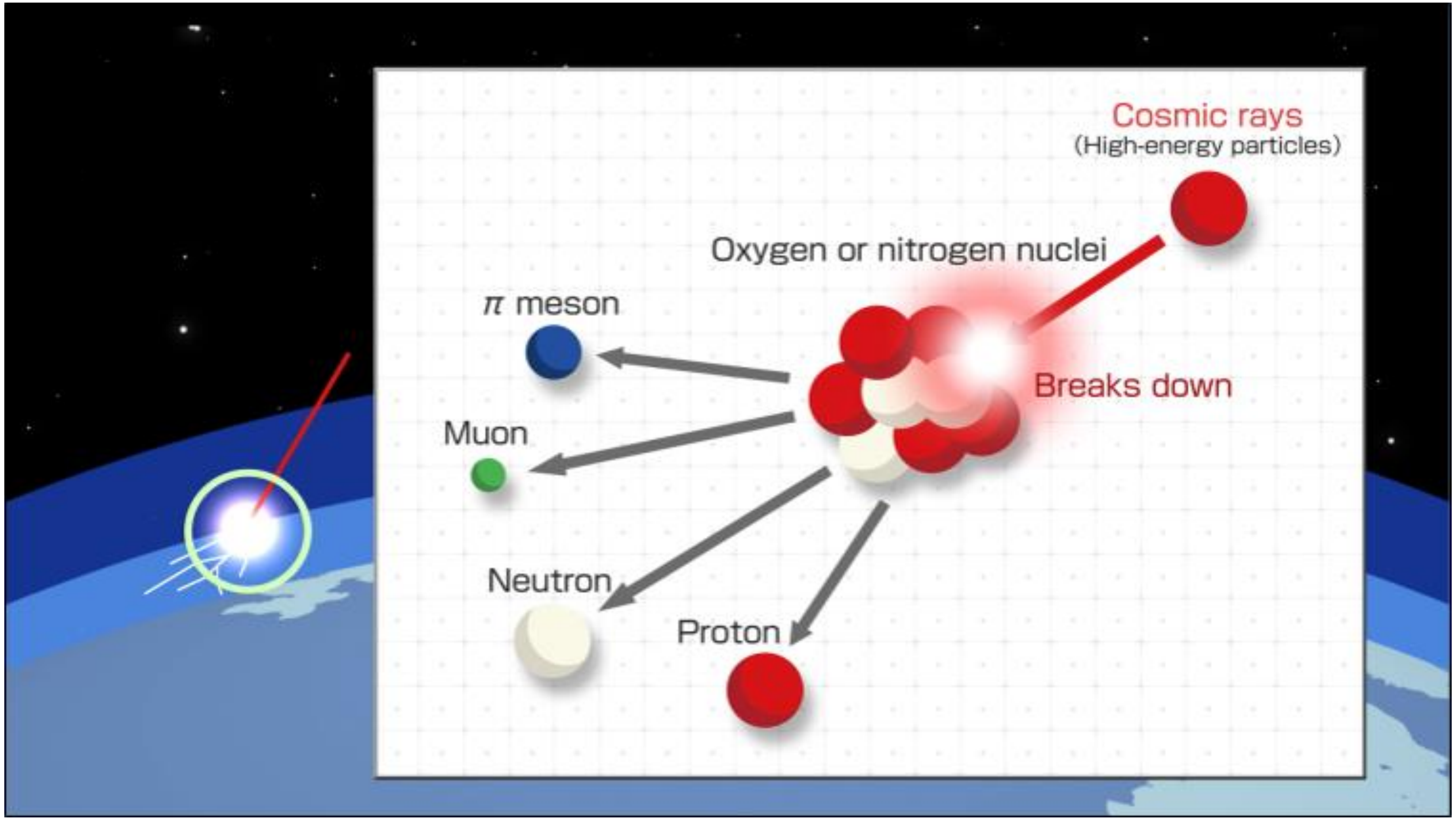
https://youtu.be/zZoDaYlJZPw?t=2m45s

3. Overview of standardization
List of soft error Recommendations

Number	Subject	Title
K.124	Overview	Overview of particle radiation effects on telecommunication systems
K.130	Test	Neutron irradiation test methods for telecommunication equipment
K.131	Design	Design methodologies for telecommunication systems applying soft error measures
K.Suppl 11	Supplement	Supplement to K.131 – Soft error measures for FPGAs
K.139	Requirements	Reliability requirements for telecommunication systems affected by particle radiation
K.138	Quality estimation	Quality estimation methods and application guidelines for mitigation measures based on particle radiation tests

2015	2016	2017	2018
▲August TTC SOET Adhoc was opened. ▲October New work item proposal was approved in ITU-T SG5 meeting.	▲December K.124(Approval)		▲January K.130, K.131 (Approval) ▲November K.138, K.139 (Approval)

4. Soft error mechanisms
Video



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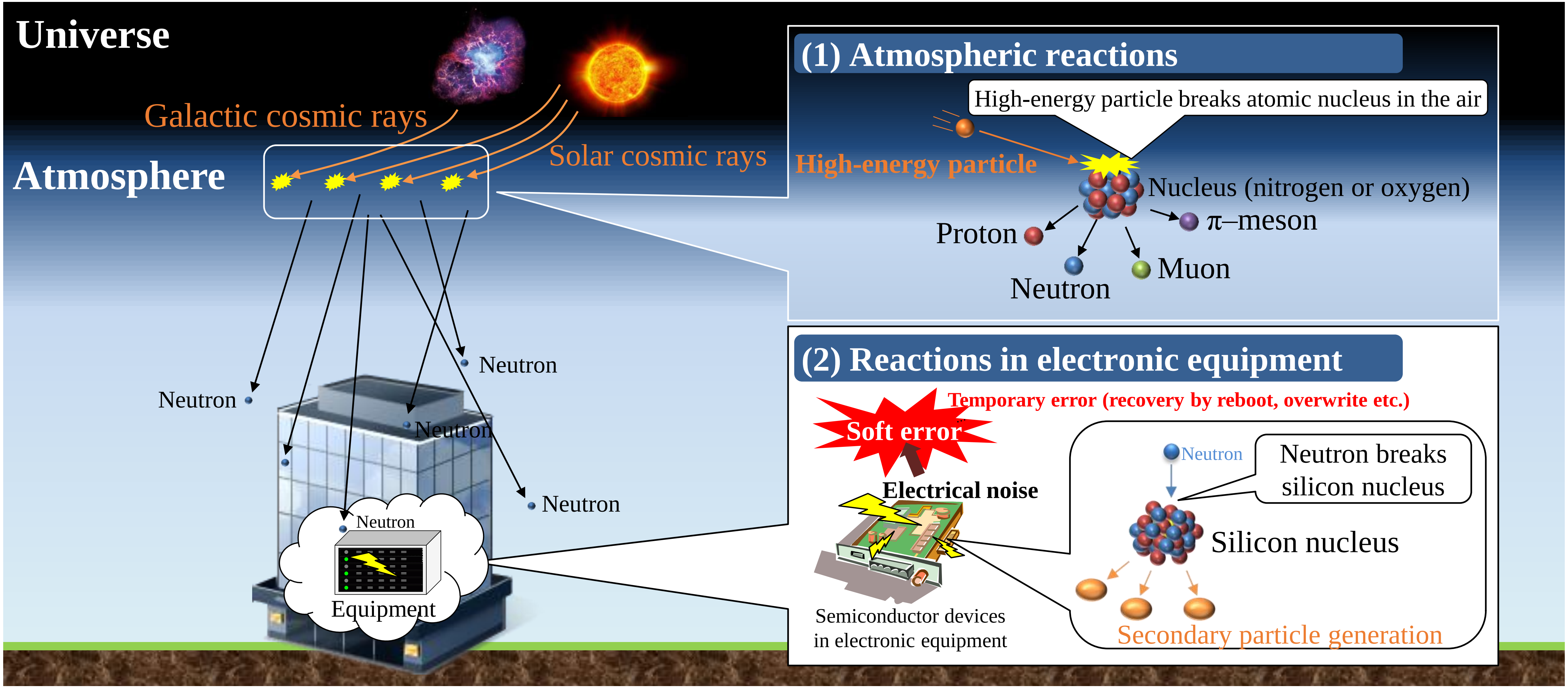
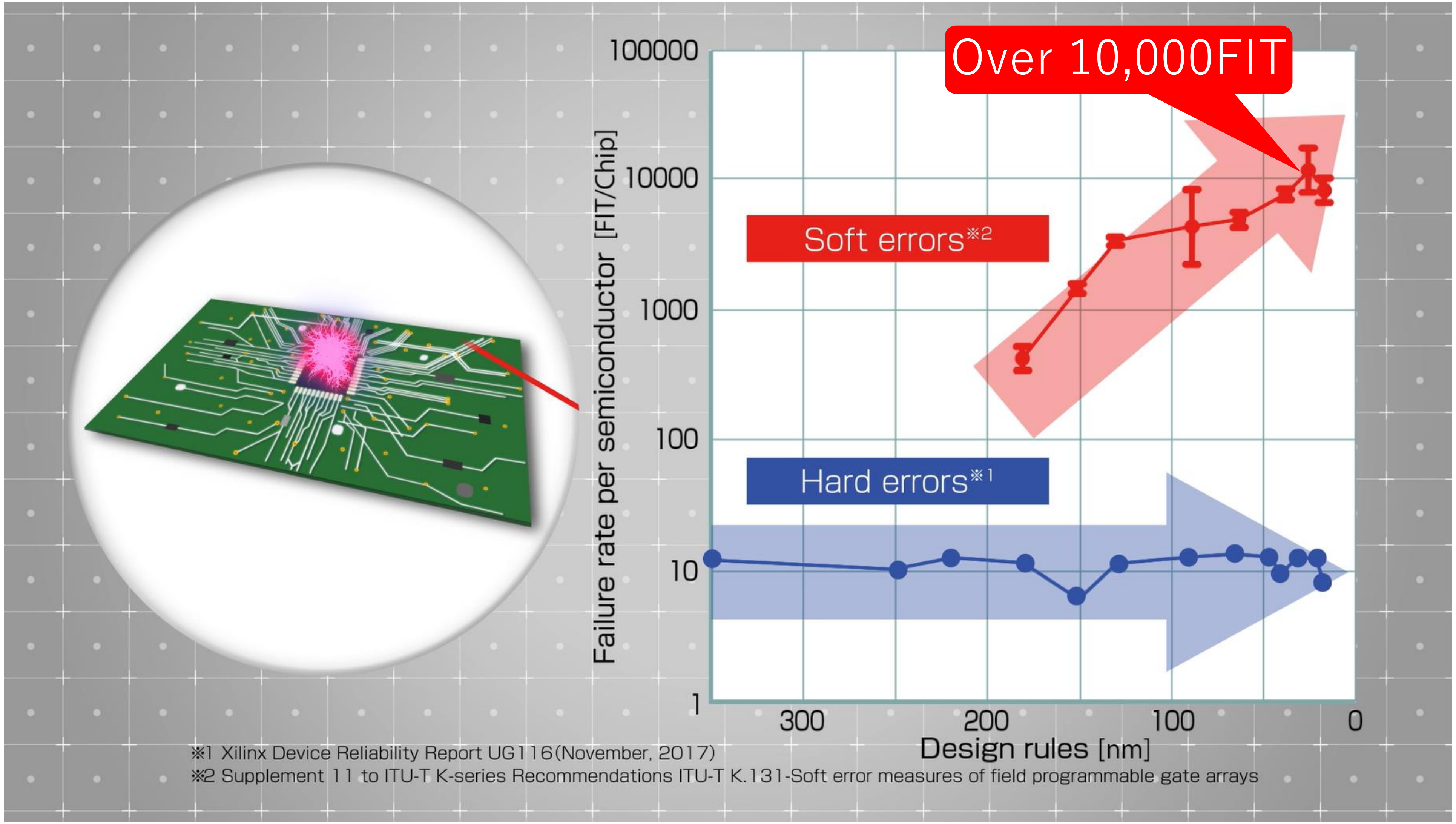
4. Soft error mechanisms



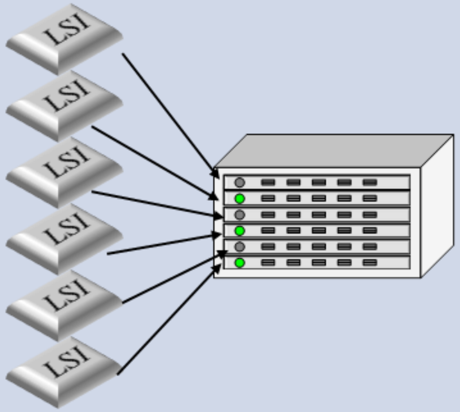
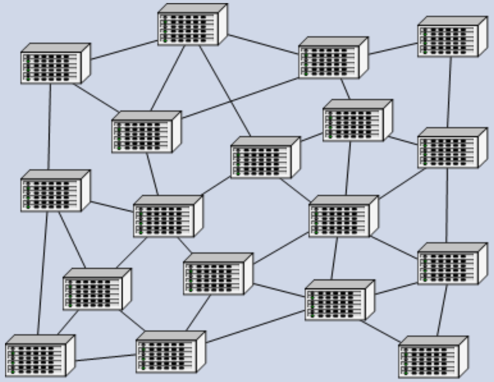
5. Impacts of soft errors
The increase of soft errors



5. Impact of soft errors
Impact of 10,000FIT/Chip

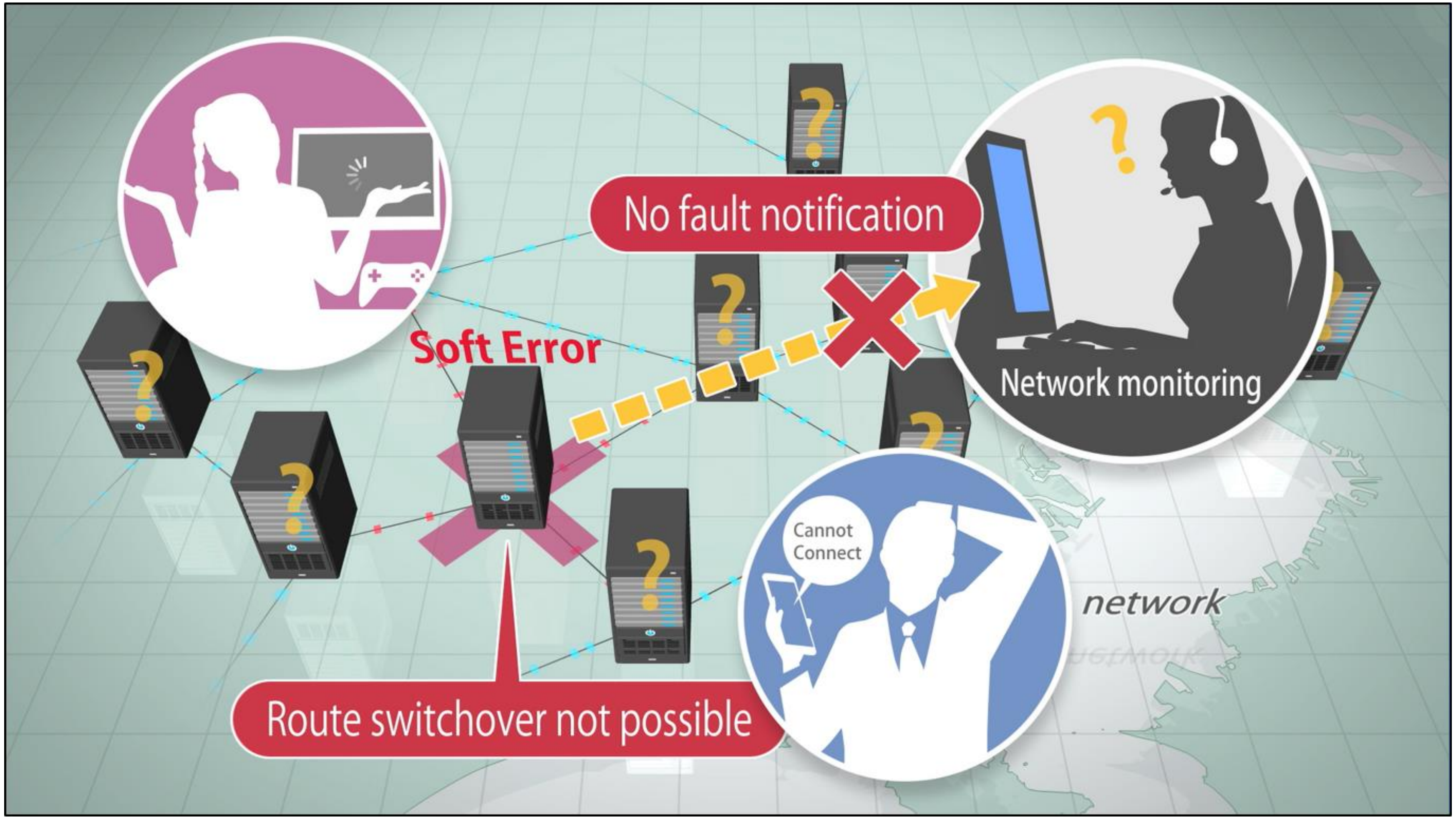
10,000 FIT※/Chip is a very high failure rate.

Soft errors occur several times a day in whole network.

	Per LSI	Per equipment	Per network
Condition	10,000 FIT 	6 LSIs per equipment 	5,000 Units 
FIT	10,000 FIT	60,000 FIT	300,000,000 FIT
MTBF	100,000 hours (11.4 years)	16,667 hours (1.9 years)	3.3 hours
Number of Soft errors	0.09 errors / year	0.5 errors / year	7.2 errors / day 2628 errors / year

※FIT: Failures in time; the number of failures per 10^9 device-hours

5. Impact of soft errors
Impact in telecommunications network (Video)



https://youtu.be/ZDxj4iX7n7w?t=1m30s

6. Soft error mitigation measures
Overview

There are three principles of soft error measures:

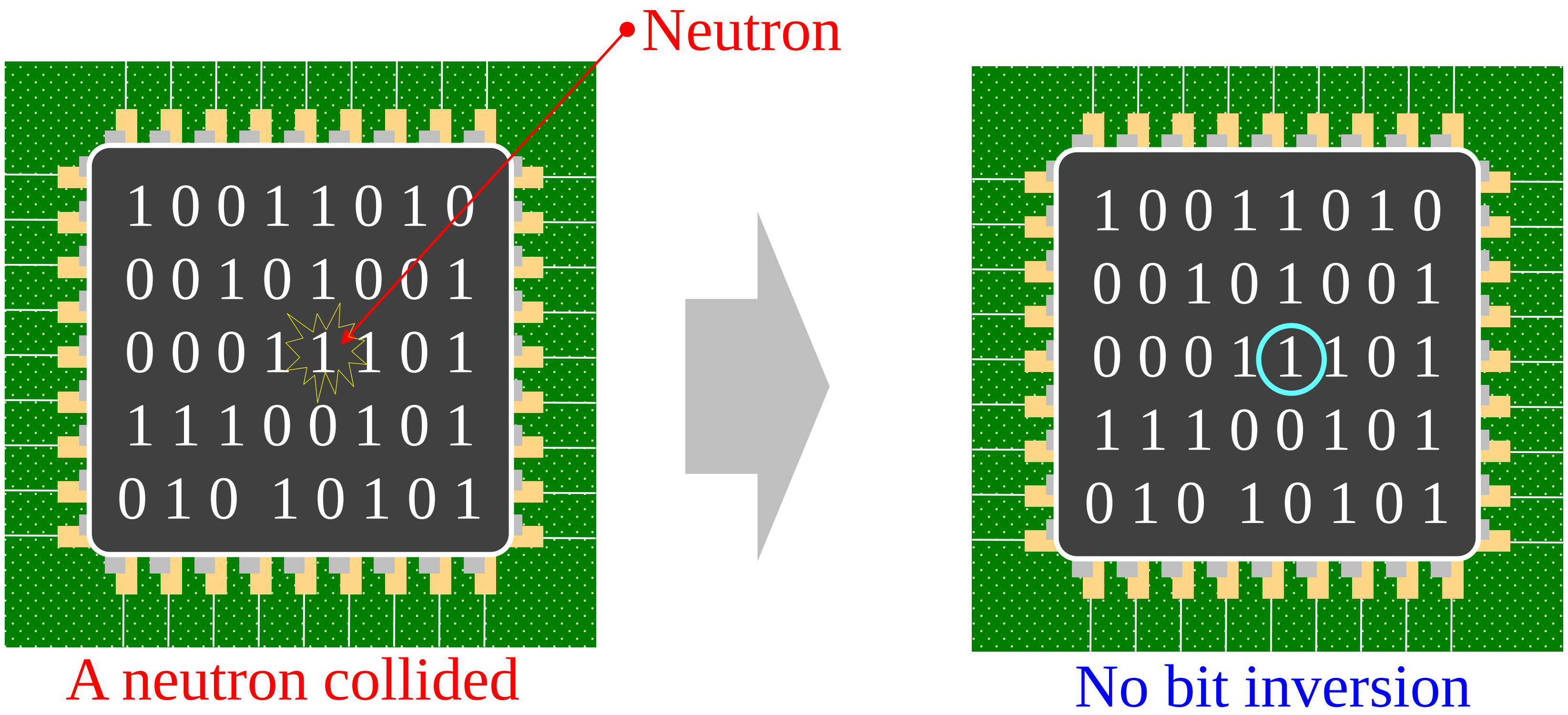
(1) reduction, (2) isolation and (3) correction.

Principles	Mitigation techniques		Examples
(1) Reduction	A	Change in materials	➢ Magnetoresistive Random Access Memory(MRAM) ➢ Ultra-low alpha (ULA) package materials
	B	Work on physical structure	➢ 3D transistor structure (FinFET, etc.) ➢ Reinforcing Charge Collection (RCC) technology for logical circuits
	C	Reduction in areas where soft errors occur	➢ Elimination of CRAM by use of ASIC instead of FPGA
(2) Isolation	A	Work on circuit configuration	➢ Triple modular redundancy (TMR) ➢ Memory bit interleaving configuration
	B	Identification of parts with and without substantial function	➢ Remove monitoring of areas where RAM in unused ➢ Remove parts that are not active in CRAM of FPGA from monitoring target
(3) Correction	A	Automatic correction in hardware	➢ ECC correction, or corrected data overwriting ➢ Dual Interlocked storage CEll (DICE) structure logic circuit
	B	Automatic correction in the equipment control program	➢ Setting data overwriting ➢ Reinitialization
	C	Correction in accordance with maintenance personnel operation	➢ Reset by remote control

K.131 Table 9-1 Principles of soft error measures

6. Soft error mitigation measures
(1) Reduction

Physical measures to reduce the occurrence of actual soft errors in a device.



Ex1. Change in materials
Ex2. Work on physical structure
Ex3. Reduction in areas where soft error occur

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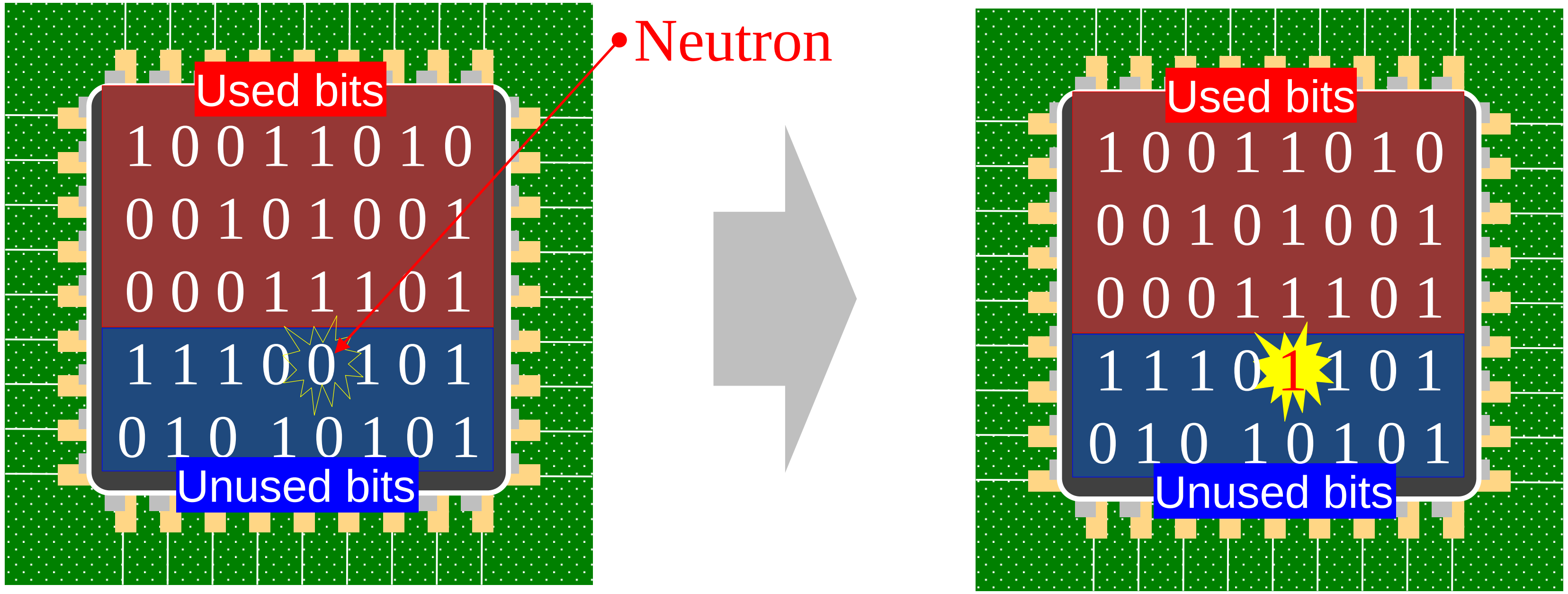
6. Soft error mitigation measures
(2) Isolation

Isolation means that the system doesn't check or make alarm on the soft errors occurred in unused bits.



A neutron collided with unused bit

Bit inversion occurred
→ Don't determine as an error

Ex1. Identification of parts with and without substantial function
Ex2. Work on circuit configuration

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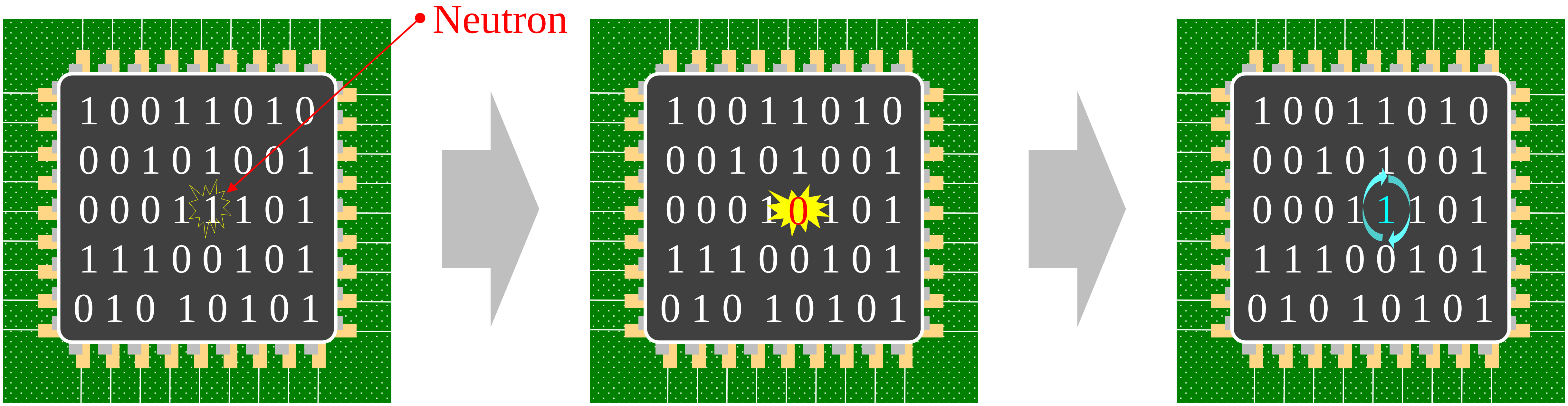
6. Soft error mitigation measures
(3) Correction

The correction principle means automatic correction of the data such as ECC, overwriting error data with the correct one or reinitializing the whole data to restore a normal state.



A neutron collided — Bit inversion occurred — Bit corrected

Ex1. Automatic correction in hardware
Ex2. Automatic correction in the equipment control program
Ex3. Correction in accordance with maintenance personnel operation

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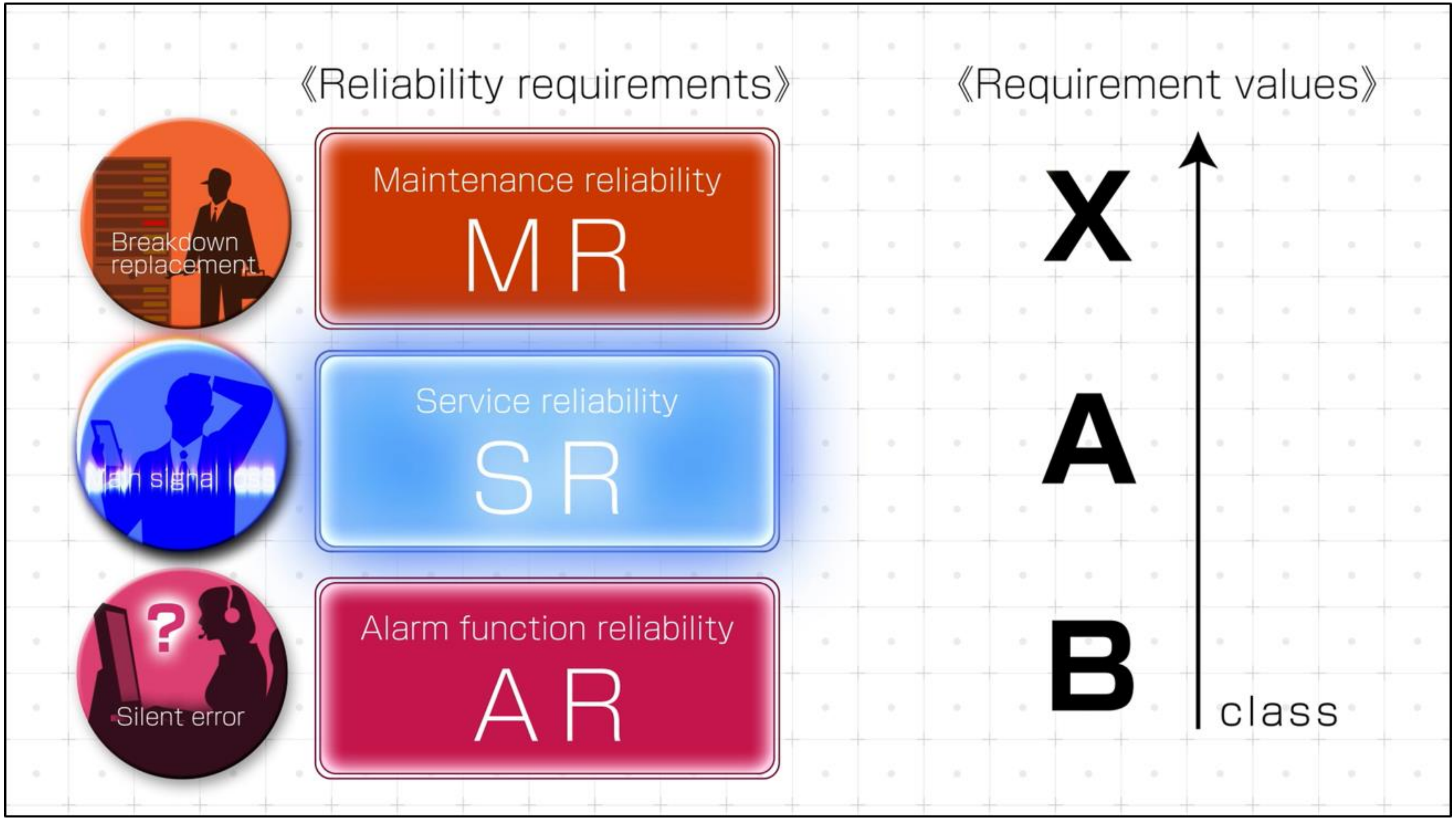
7. Soft error testing using particle accelerator
Necessity

- Currently, there is no useful physical measures to prevent the occurrence of soft errors.
- Therefore, it is necessary for the telecommunication equipment to appropriately recover the generated soft errors.
- A soft error test using an accelerator-driven neutron source is most useful to reproduce the soft errors of telecommunication equipment and to confirm the effectiveness of the soft error mitigation measures.

※After my talk, Mr. Mitsuo Hattori will introduce example of soft error test.

8. Reliability requirements
Video



https://youtu.be/zZoDaYlJZPw?t=3m45s

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8. Reliability requirements

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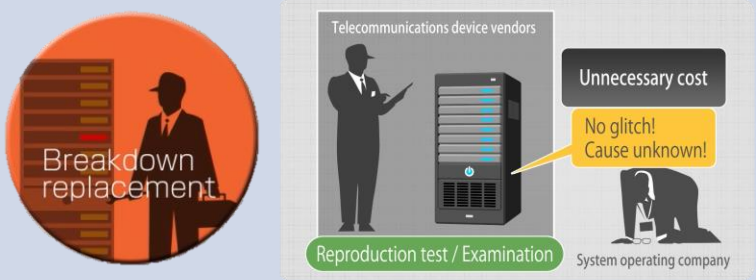
Reliability requirements	Class

Maintenance reliability MR

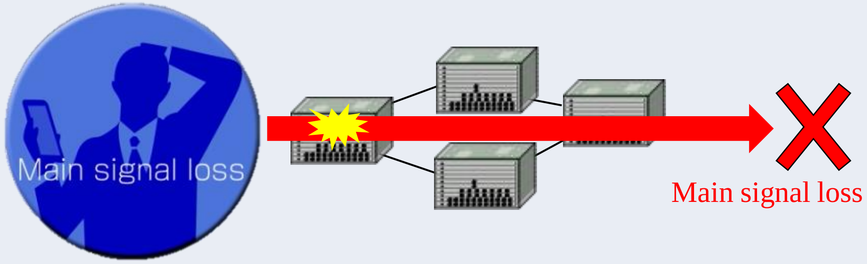
Reduce the equipment maintenance



MR class	Failure occurrence rate
X	Determined by negotiation between carrier and manufacturer
A	< 2,000 FIT/equipment
B	< 5,000 FIT

Service reliability SR

Reduce the service provision



SR class	Failure occurrence rate	
	(M) Momentary interruption (0.2～1.0s)	(C) Continuous interruption (> 1.0s)
X	Determined by negotiation between carrier and manufacturer	
A	< 2,000 FIT	< 200 FIT
B	< 10,000 FIT	< 1,000 FIT

Alarm function reliability AR

Prevent the silent errors

AR class	No-silent failure-period evaluated from the test
X	Determined by negotiation between carrier and manufacturer
A	> 10,000 years/equipment
B	> 2,000 years/equipment

Class X : For networks for which particularly high operational reliability
Class A : A standard level of reliability is required in a carrier network
Class B : For carrier network for which a lower level of reliability is acceptable in relation to service and operation condition

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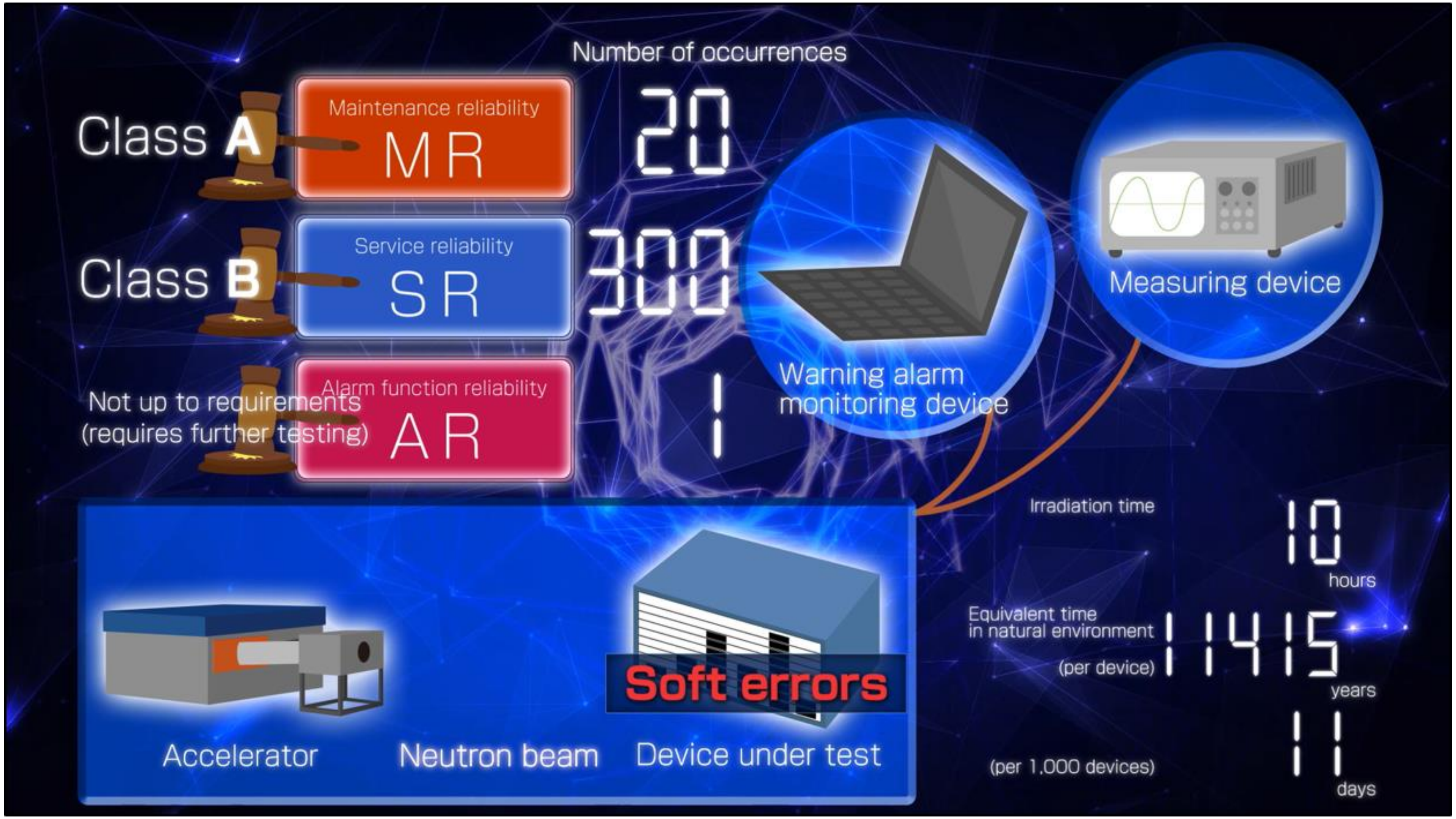
9. Quality estimation
Video



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9. Quality estimation
Overview of quality estimation by neutron irradiation test

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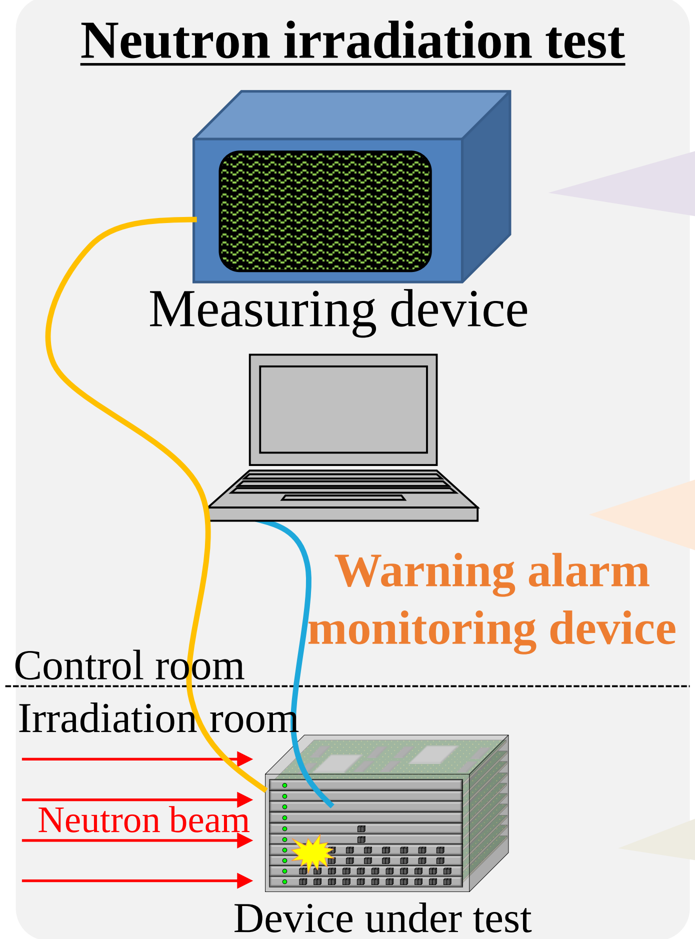
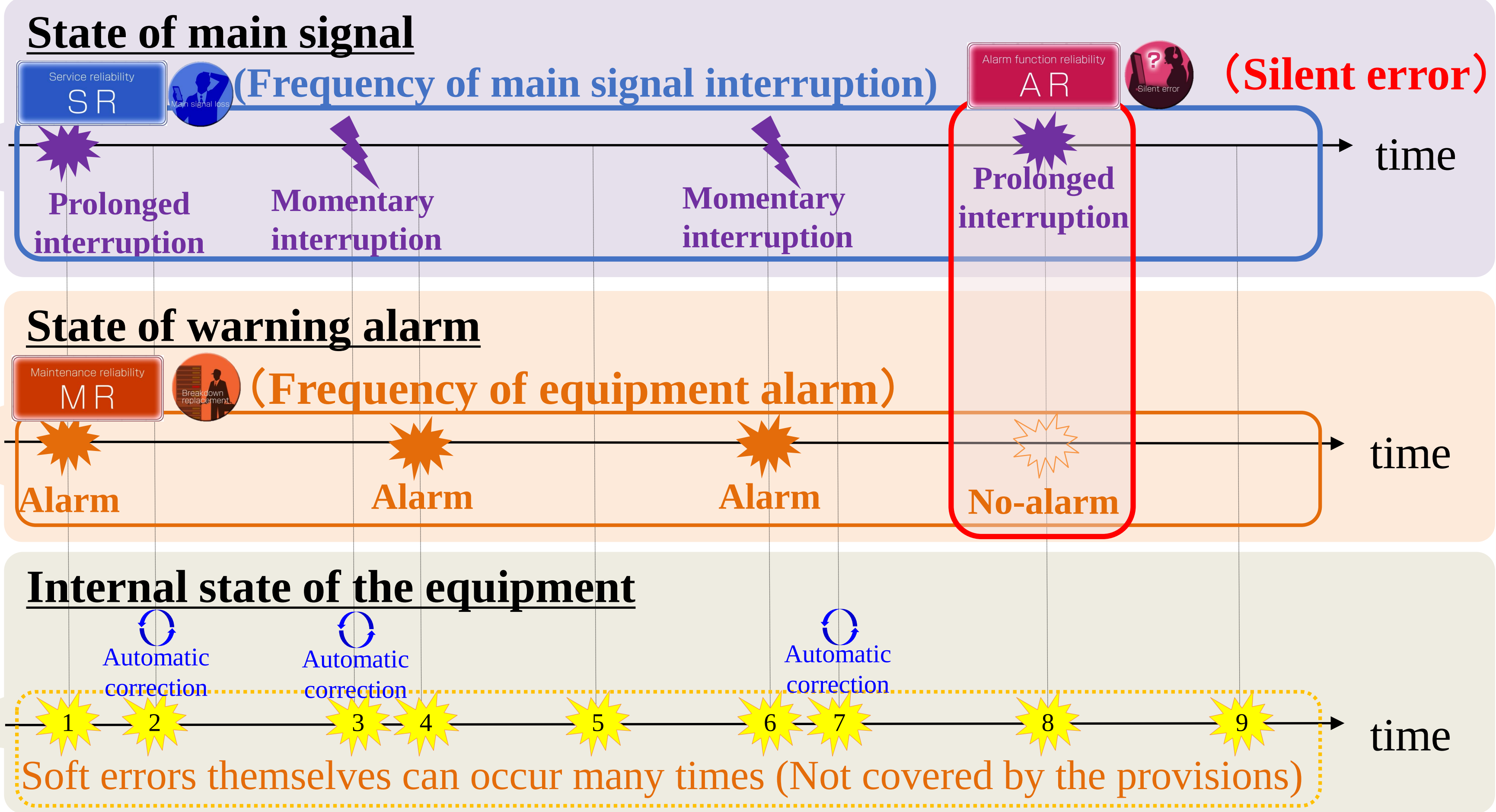
The impact of soft errors is classified into three reliability requirement (MR,SR, AR).





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9. Quality estimation Classification example

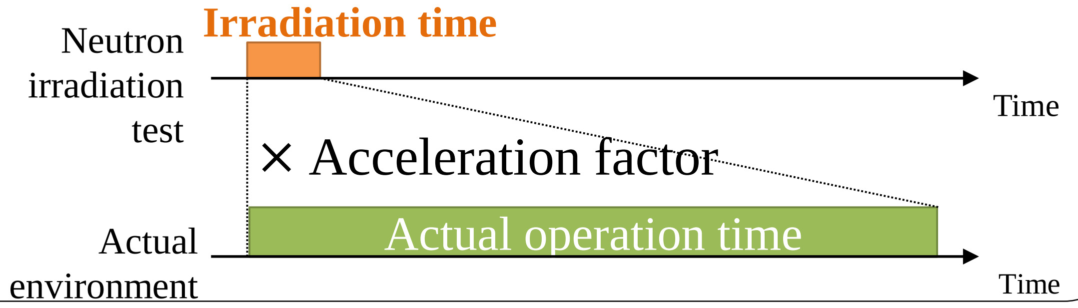
Analyze the results obtained from the neutron irradiation test, and determine the class (from requirement for X, A and B) based on the FIT number obtained.

Reliability requirement		Ex. Results of soft error test: 1. Number of failure	Ex. Results of soft error test: 2. Actual-operation time	Analysis: 3.MTBF[h]	Analysis: 4. FIT	Class		Classification
Maintenance reliability MR (Breakdown replacement)		20	10^8[h] (11,415years)	5.0×10^6	200 (±22%)	Class A Class B	< 2,000FIT < 5,000FIT	Class A
Service reliability SR (Main signal loss)	Interruption (0.2s〜1s)	300		3.3×10^5	3000 (±6%)	Class A Class B	< 2,000FIT <10,000FIT	Class B
	Interruption (> 1.0s)	3		3.3×10^7	30 (±57%)	Class A Class B	< 200FIT < 1,000FIT	
Alarm function reliability AR (Silent error)		1		1.0×10^8	10 (±100%)	Class A Class B	10,000 years 2,000 years	Not up to requirements

Calculation method of actual-operation time

Ex） Acceleration factor：Irradiation at 10 million times for 10 hours

$$Actual\ operation\ time[h] = Irradiation\ time[h] \times Acceleration\ Factor$$
$$= 10[h] \times 10^7 = 10^8[h]\ (11415years)$$



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Thank you for your attention

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