Future Vehicle Evolution and Automotive Functional Safety

Reliability and Functional Safety

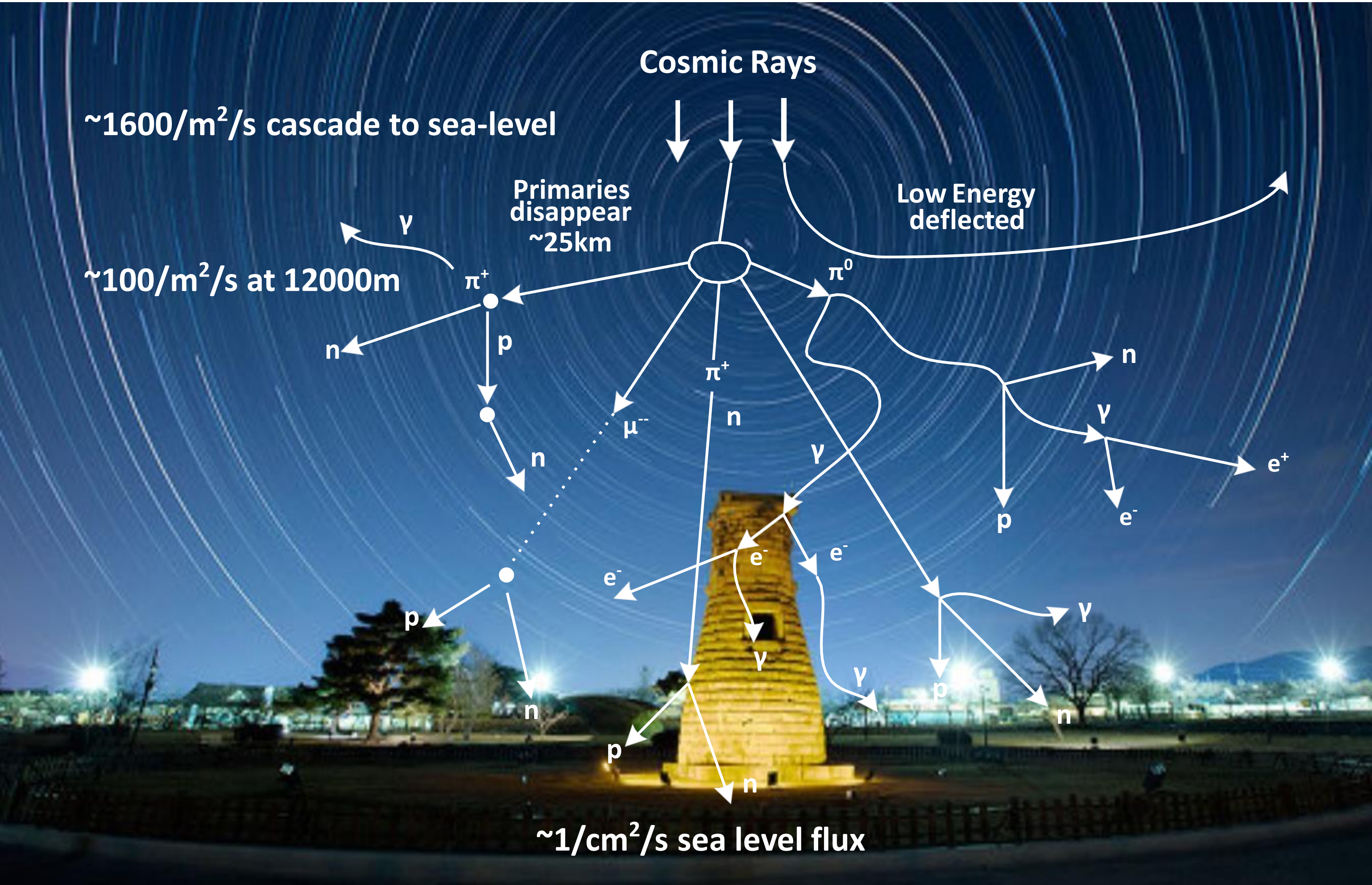
The 6th IEVE 2019

May 9-10, 2019, ICC JEJU Korea

Sung S. Chung | CTO QRT Inc.

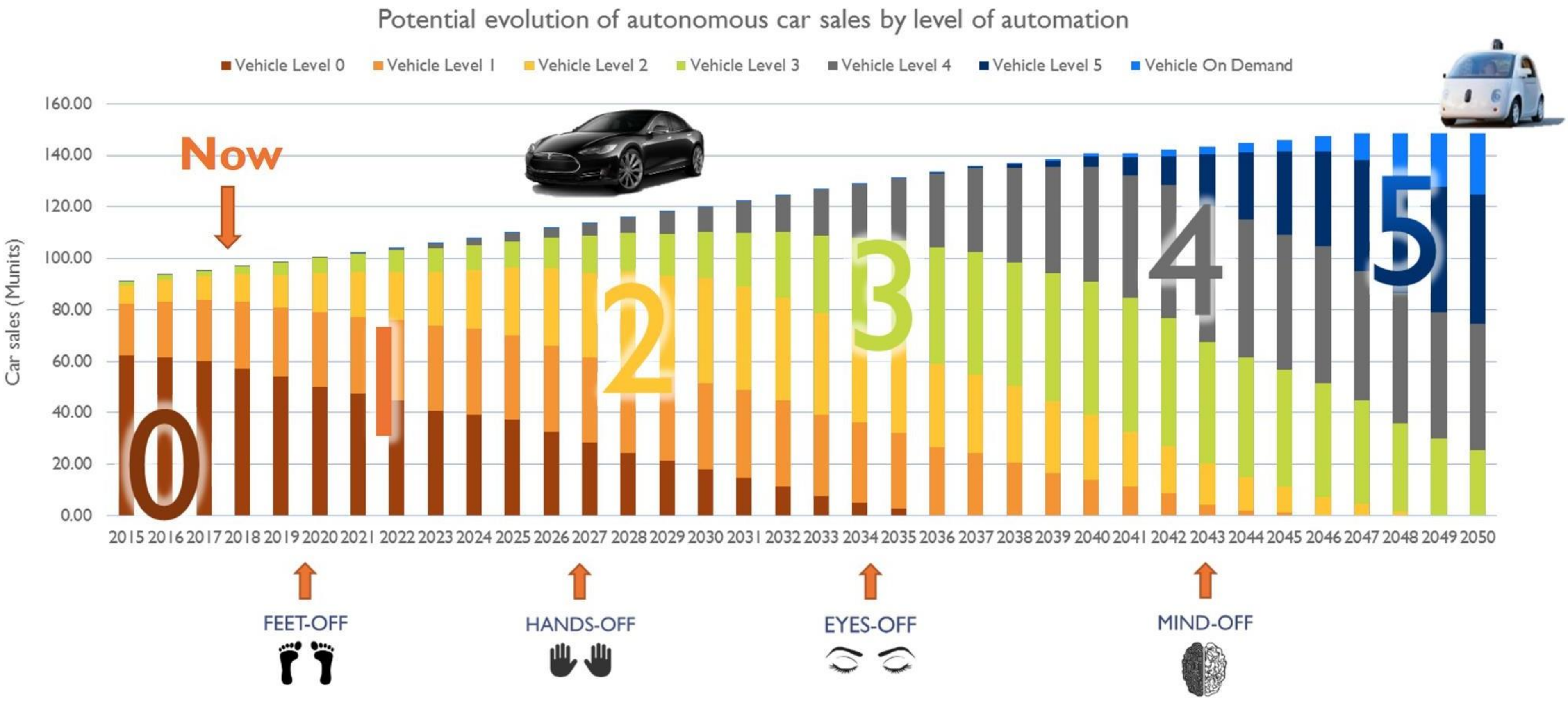
00 Opening Remark

Can't live without Neutron



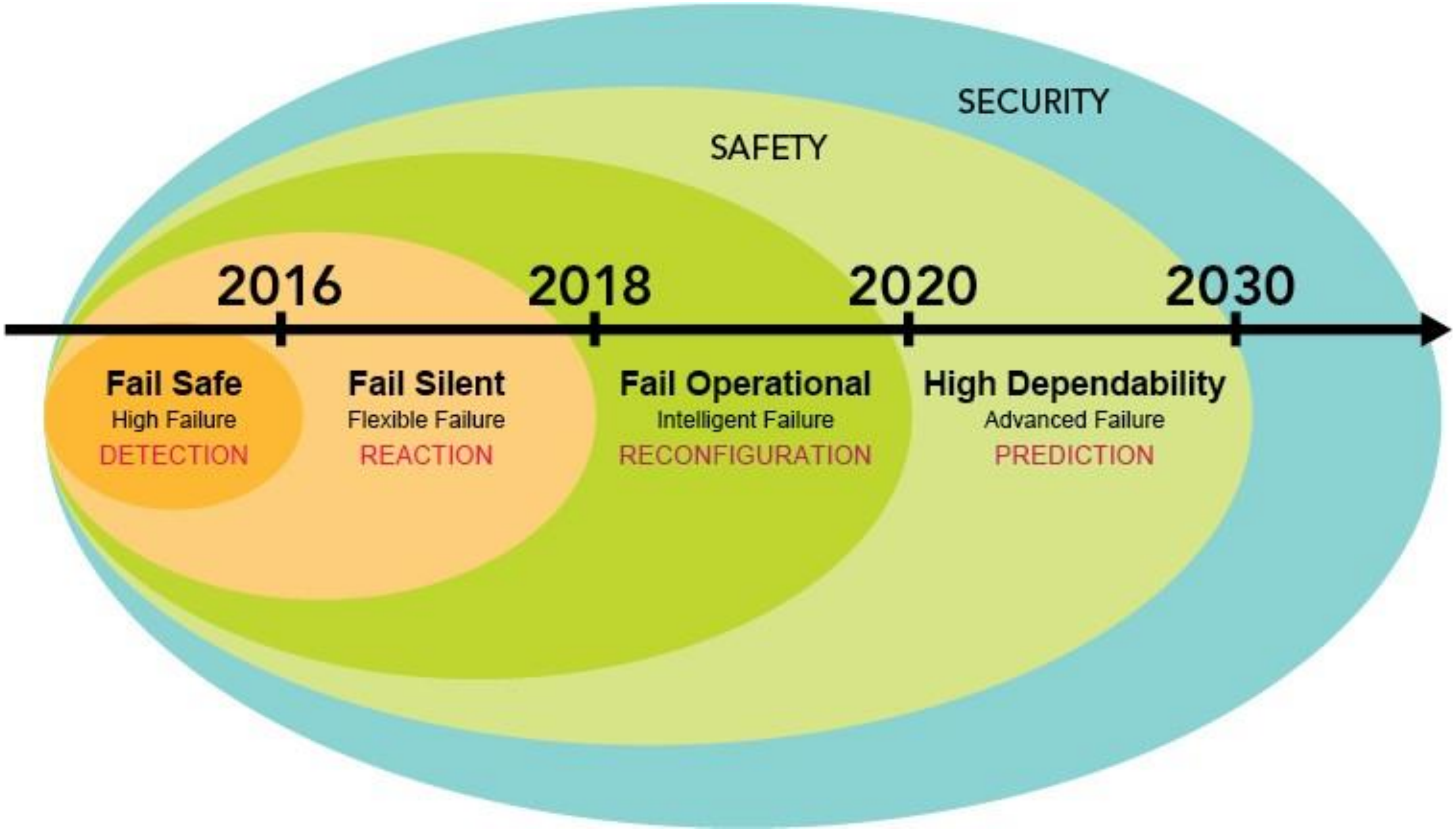
01 Advancement of Automotive System

Toward Fully Autonomous Vehicle



Source: Smart Automotive – Latest Trends in LiDAR and Sensors – SEMICON Dec 2017

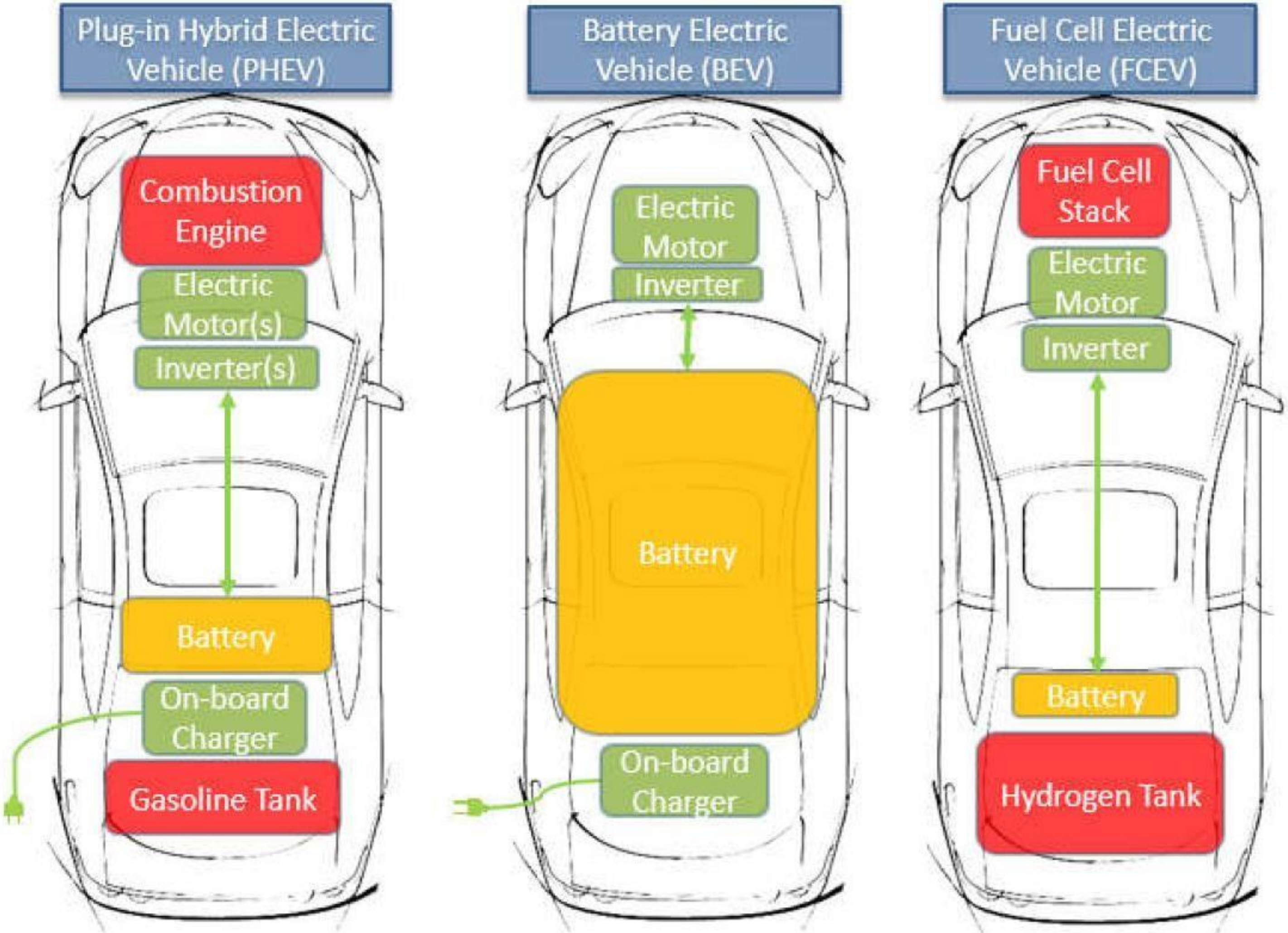
From Fail Safe to High Dependability



ISO 26262, SOTIF and C-ITS drive highly dependabile vehicle

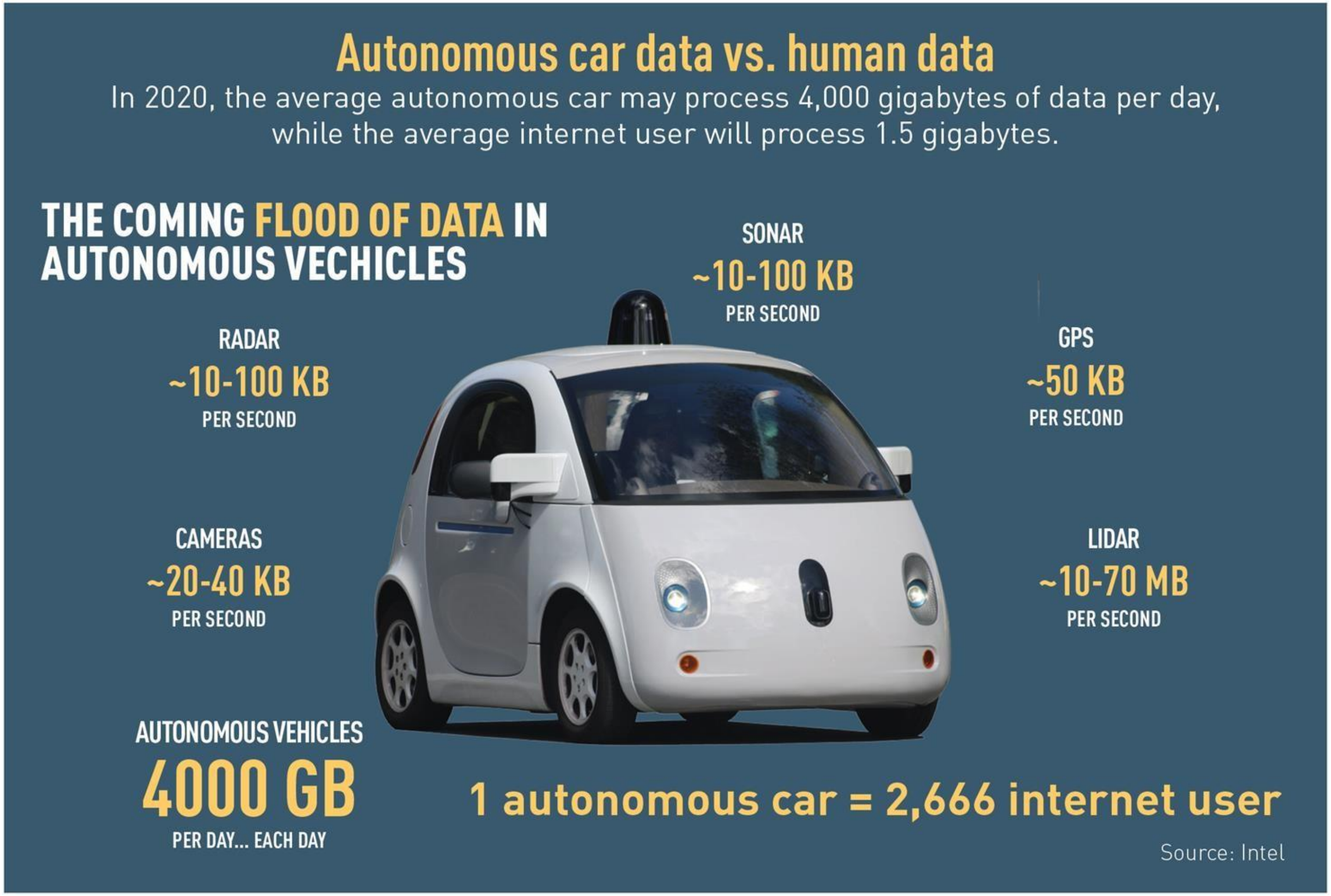
02 Full Electric and Connected Vehicle

Full Electric Drive Vehicle System Layouts



Source: U.S. DRIVE (Driving Research and Innovation for Vehicle efficiency and Energy sustainability), "Electrical and Electronics Tech Team Roadmap"

Future Vehicle Data Requirement



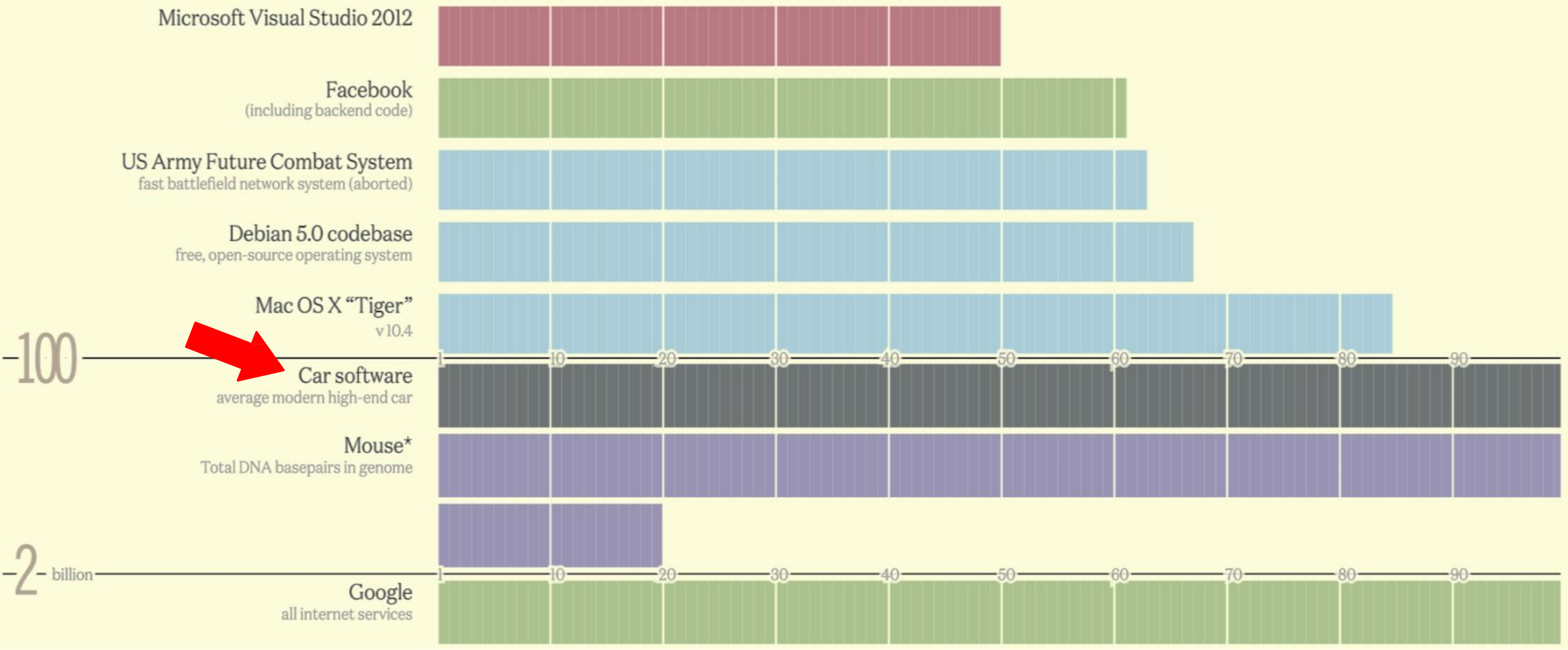
Evolution of Megacities: Key Smart Cities: 2009 -2025

Source: Sarwant Singh Partner, Frost & Sullivan, "360 Degree Perspective of the Global Electric Vehicle Market Opportunities and New Business Models"

152 million connected cars by 2020

Automotive industry needs to be prepared for 4 TB of data being generated by every car every day

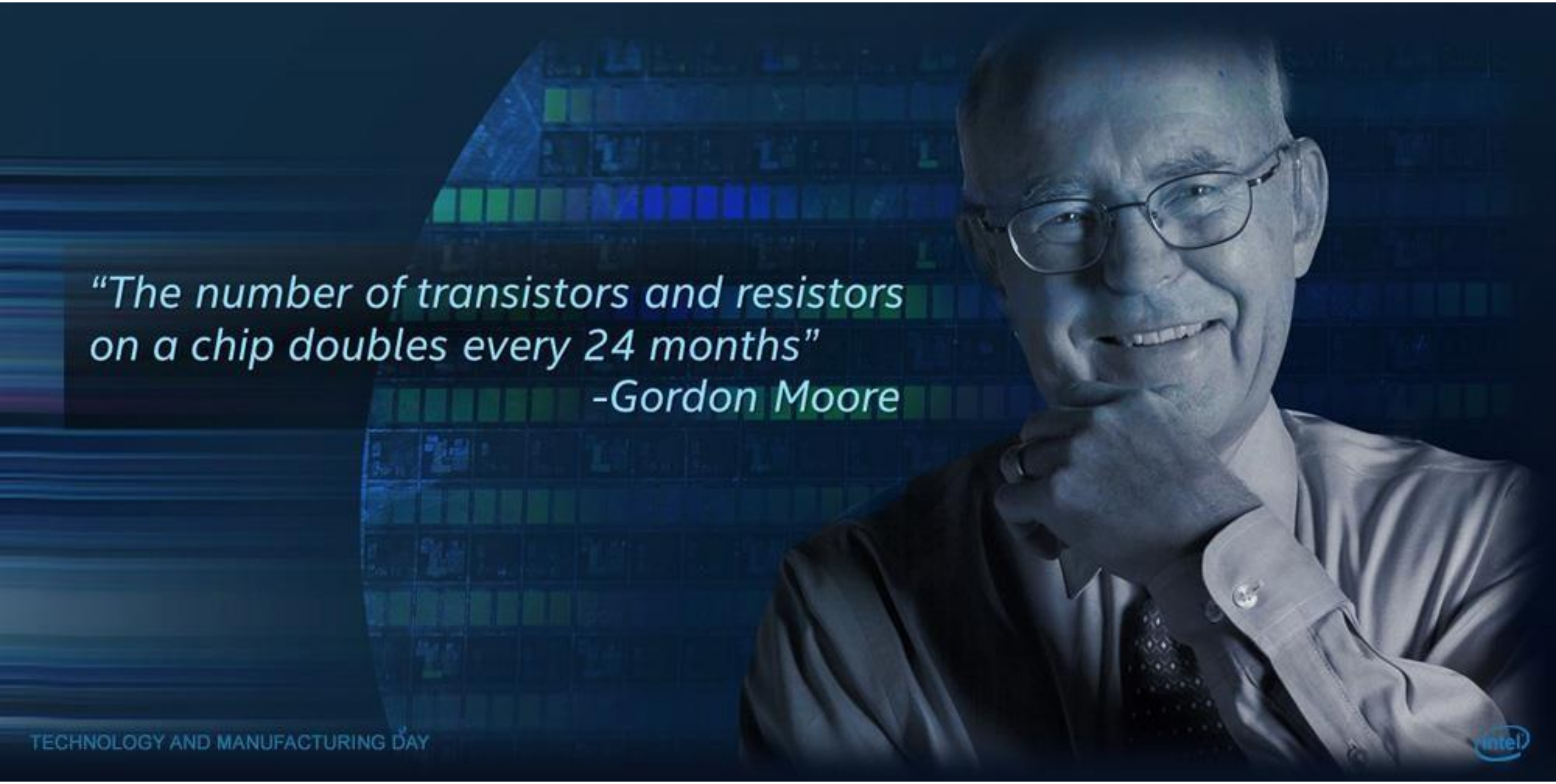
Brian Krzanich, CEO of Intel Corporation



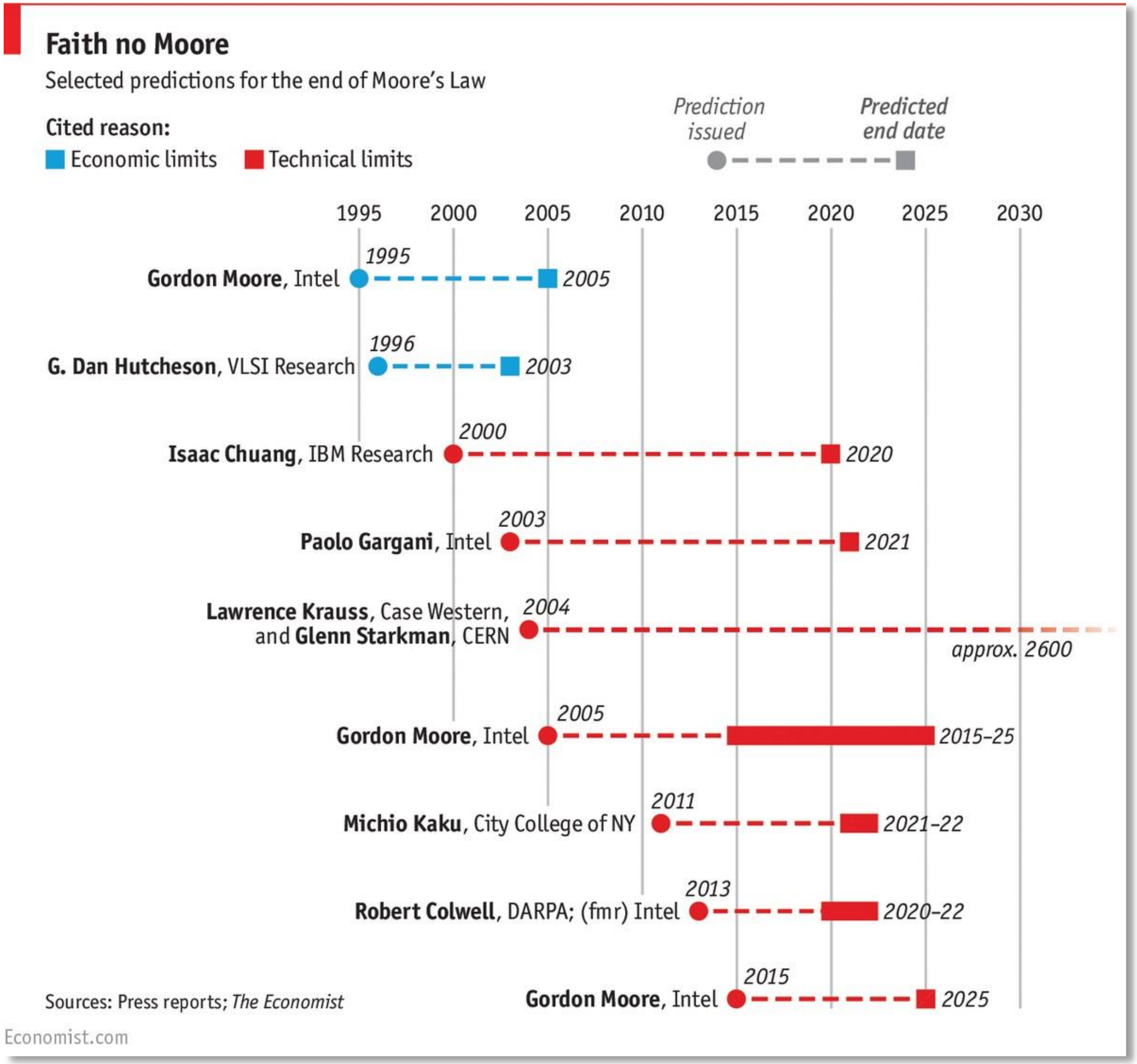
Source: https://informationisbeautiful.net/visualizations/million-lines-of-code//

03 Advancement of Device Technology

Moore's Law


"The number of transistors and resistors
on a chip doubles every 24 months"
-Gordon Moore
TECHNOLOGY AND MANUFACTURING DAY
intel

Faith No Moore



Intel: EUV-Enabled 7nm Process

EUV estimated demand per fab by market

Range of layers and corresponding systems per fab[1]

ASML
Public
Slide 9
8 November 2018

Market	Fab Capacity (kwspm[2])	EUV layers	EUV systems/fab
Logic (7nm – 5nm)	45	10 – 20	10 – 20
DRAM (16nm -1Anm)	100	1 - 6	2 - 10

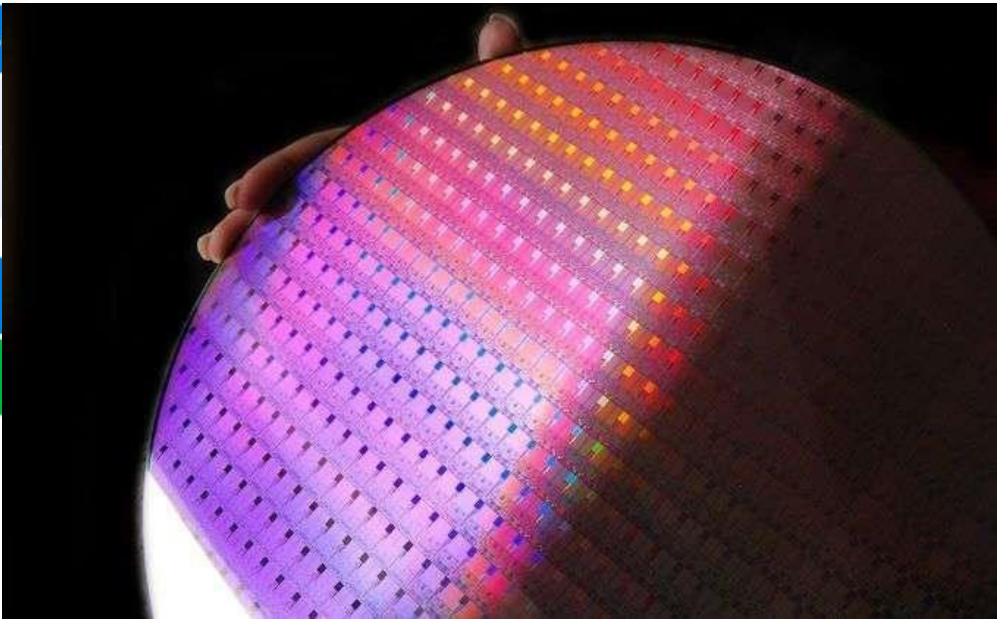
Logic EUV capacity:
1 EUV layer requires 1 EUV system for every 45k wafer starts per month

DRAM EUV capacity:
1 EUV layer requires 1.5 to 2 EUV systems for every 100k wafer starts per month

[1] "Typical" process and system conditions in the 2018-2022 timeframe, not specific customer condition
[2] kwspm: x1000 wafer starts per month

Extreme Ultraviolet Lithography (EUVL) Demand

Dec. 6, 2018



We are quite pleased with our progress on 7 nm. In fact, very pleased with our progress on 7 nm.

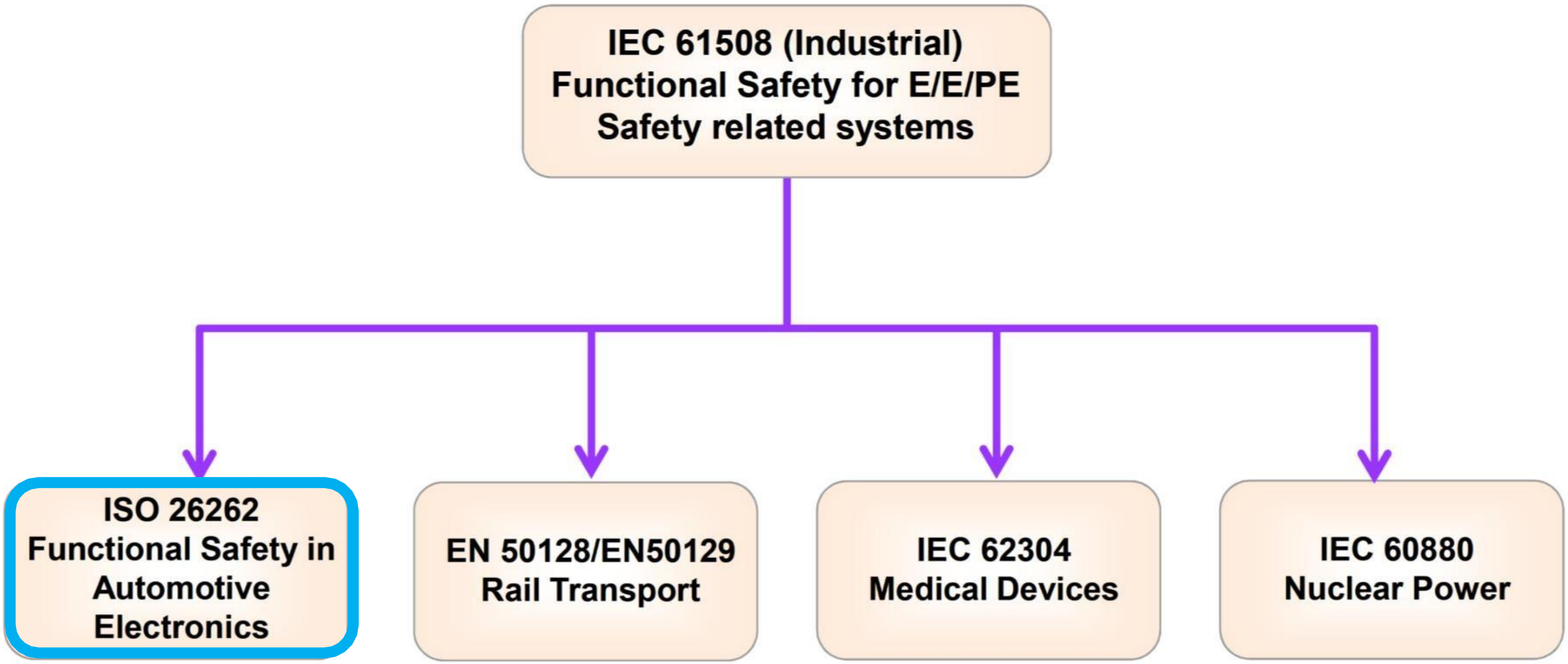
Murthy Renduchintala, chief engineering officer & president of technology

https://www.anandtech.com/show/13683/intel-euvenabled-7nm-process-tech-is-on-track

04 ISO 26262 Overview

ISO 26262 Genealogy

ISO 26262 is an adaptation of IEC 61508 for the automotive industry

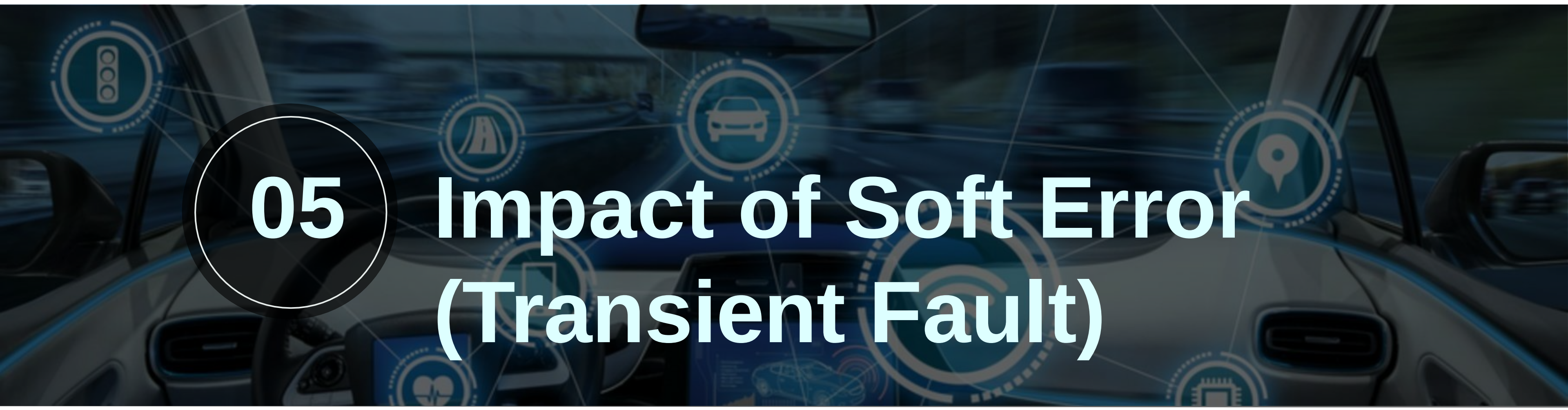


IEC 61508, ISO/PAS 19451 and ISO 26262

IEC 61508	ISO 26262
Part 1: General requirements	Part 1: Vocabulary
Part 2: Requirements for electrical/electronic/ programmable electronic safety-related systems	Part 2: Management of functional safety Part
Part 3: Software requirements	Part 3: Concept phase
Part 4: Definitions and abbreviations	Part 4: Product Development: System Level
Part 5: Examples of methods for the determination of safety integrity levels	Part 5: Product Development: Hardware Level
Part 6: Guidelines on the application of parts 2 and 3	Part 6: Product Development: Software Level
Part 7: Overview of techniques and measures	Part 7: Production and Operation
	Part 8: Supporting Processes
	Part 9: ASIL-orientated & safety-oriented analysis
	Part 10: Guideline
ISO/PAS 19451	Part 11: Guideline for semiconductors

Comparison of each revision

Chapter	Revision 1	Revision 2	FDIS 02-26-2018	Final Version Dec 2018
Ch 1	23	46	47	33
Ch 2	26	55	51	45
Ch 3	25	34	36	28
Ch 4	36	43	42	34
Ch 5	76	92	93	90
Ch 6	40	68	71	57
Ch 7	11	18	20	14
Ch 8	48	66	66	60
Ch 9	16	37	38	29
Ch 10	89	80	85	79
Ch 11		182	179	179
Ch 12				42
Total Pages	390	769	728	690 pages

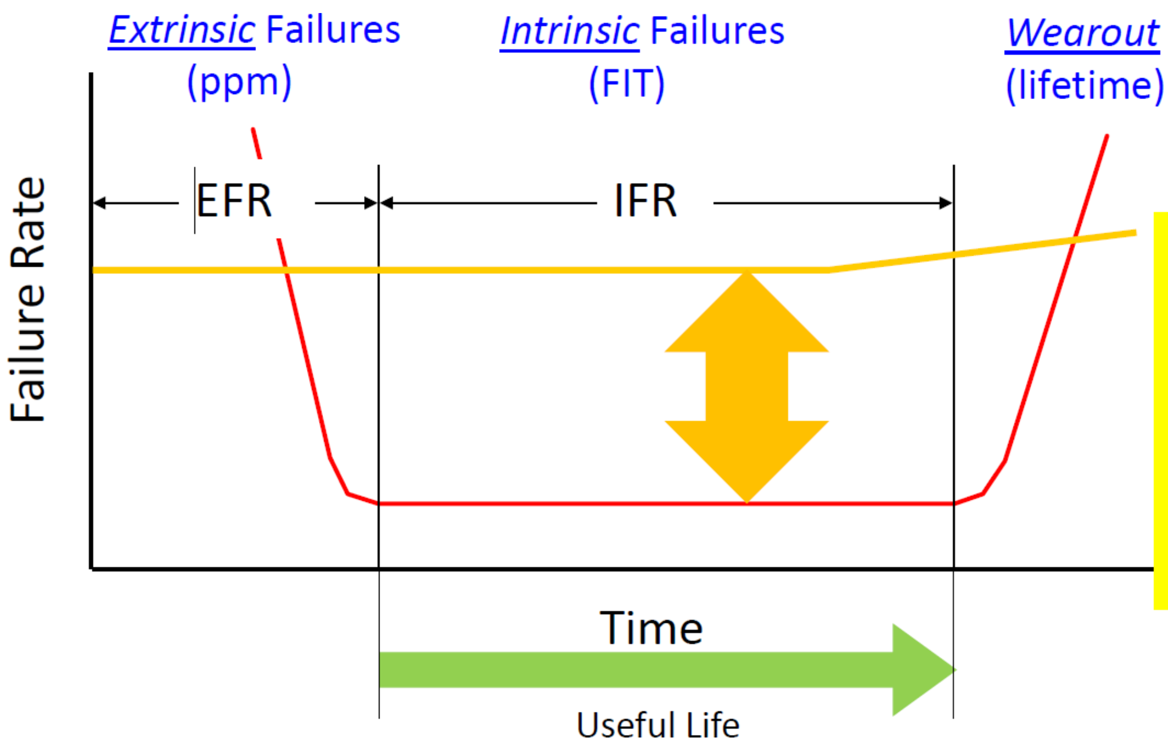


05 Impact of Soft Error (Transient Fault)

Soft error rate in modern devices

"Soft errors induce the **highest failure rate of all other** reliability mechanisms combined." Baumann, Robert.

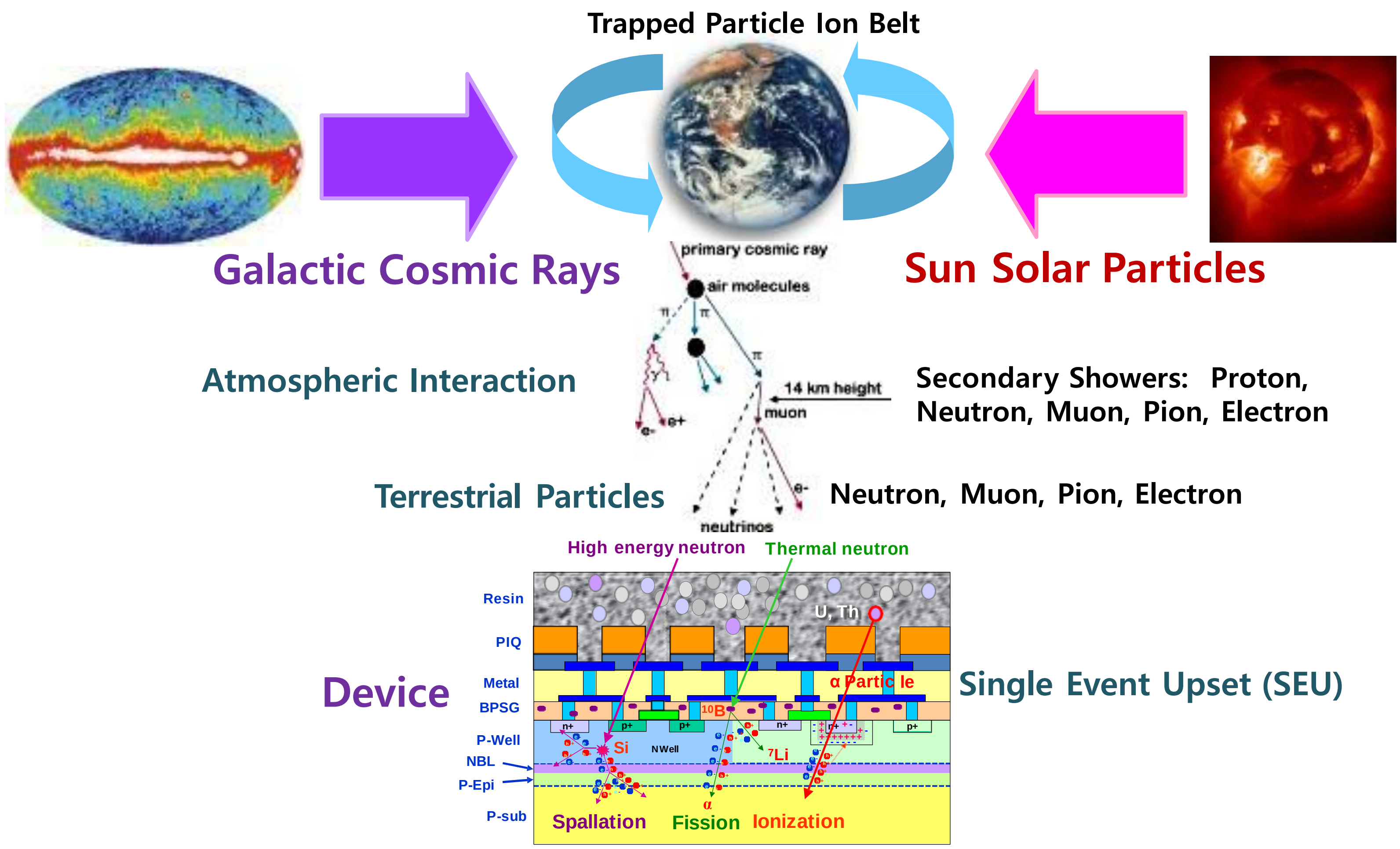
"Thus, one could postulate that there will be a cross-over point where **SET induced error rates will exceed the traditional SEU error-rates**" Kenneth La Bel



SEE is typically 1000x – 10,000x higher than all the hard failure mechanisms combined

After Robert C. Baumann, "LANDMARKS IN TERRESTRIAL SINGLE-EVENT EFFECTS" IEEE 50th *2013 NSREC Short-Course*

How Does Soft Error Happen



06 ISO26262 Language and Transient Fault

Definition: Error

- 3.46 **Error**: discrepancy between a computed observed or measured value or condition, and the true, specified or theoretically correct value or condition
  - Note An error can arise as a result of a fault (3.54) within the system (3.163) or component (3,21) being considered
- 3.50 **Failure**: termination of an intended behavior of an element (3.41) or an item (3.84) due to a fault (3.54) activation
- 3.109 **Permanent Fault**: fault (3,54) that occurs and stays until removed or repaired
- 3.173 **Transient Fault**: fault (3.54) that occurs once and subsequently disappears
  - Note: Transient fault can appear due to electromagnetic interference, which can lead to bit-flips. Soft errors such as Single Event Upset (SEU) of Single Event Transient (SET) are Transient faults.

Transient Fault Types

- **Single Event Transient (SET):** A momentary voltage excursion (e.g. a voltage spike) at a node in an integrated circuit caused by the passage of a single energetic particle
- **Single Event Upset (SEU):** A soft error caused by the signal induced by the passage of a single energetic particle
- **Single Bit Upset (SBU):** A single storage location upset from a single event
- **Multiple Cell Upset (MCU):** A single event that induces several bits in an IC to fail at the same time. The error bits are usually, but not always, physically adjacent
- **Multiple Bit Upset (MBU):** Two or more single-event-induced bit errors occurring in the same nibble, byte, or word. An MBU could be not corrected by a simple ECC (e.g. a single-bit error correction)

1. **SET, SEU, SBU, MCU** and **MBU** are typically indicated as "soft errors".
2. **Transition faults** and similar timing related phenomena are considered when relevant for the specific.
3. **Some fault models** can have the same effect as other fault models and therefore can be detected by the same safety mechanism. (**masking, derating**) An appropriate justification is provided to show that correspondence.

07 Summary

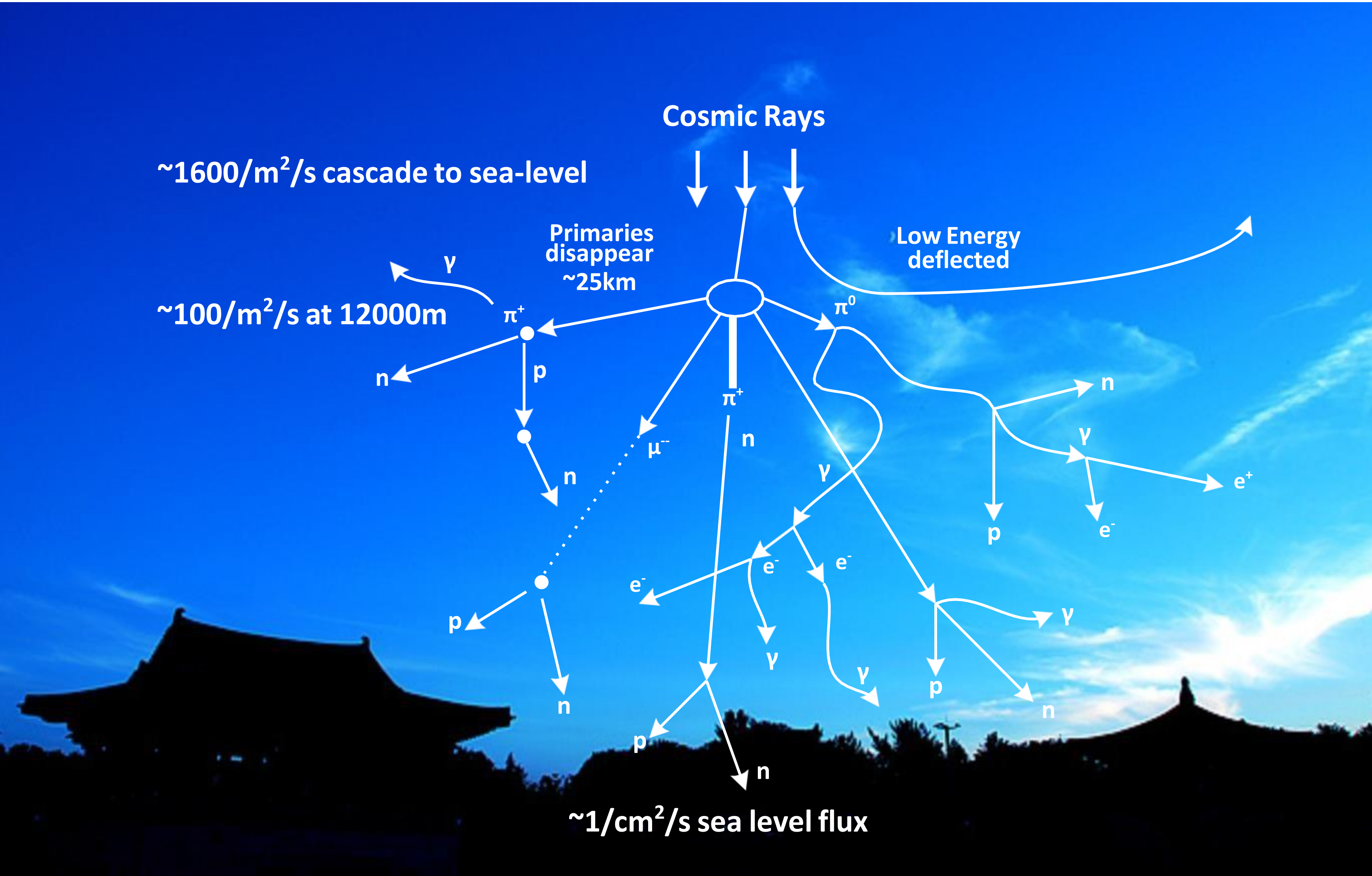
ISO26262 is here for functionally safe vehicle design

Soft Error Rate Evaluation becomes a **Normative Requirement** of ISO26262

So What's the problem for Future Safer Cars

- All current & future components must be **tested for SER**
  - Test facilities & services will be **over loaded** as the industry start to implement ISO 26262 compliance for E/E parts
- Auto industry will face very steep **SEE Learning Curve**
  - The standard defines SEU induced soft error as the **Transient Fault**
  - Many believes **Intrinsic Error Rate >> Extrinsic Error Rate**
  - Majority of automotive component suppliers don't believe that the neutron can impact automotive safety
  - Alpha impacts shall be quantified and minimized for future nodes
- Following terms need more clarification in the Standard
  - **SER Derating & Masking** Method
  - **Architectural Vulnerability Factor** analysis & respective derating
- We all wants **Safer Car** but the workers are few
  - We need more talent pool
  - We need more focus group to work on reliability and functional safety

Q & A


Cosmic Rays
~1600/m²/s cascade to sea-level
Primaries disappear ~25km
Low Energy deflected
~100/m²/s at 12000m
γ
π+
π0
n
p
n
μ--
π+
n
γ
n
γ
e+
e-
p
e-
e-
e-
p
n
γ
γ
γ
p
n
p
n
~1/cm²/s sea level flux