



WORLD CHAMPIONS IN RAD-HARD ELECTRONICS AND SENSORS

SCK•CEN and MAGyICS - short presentation



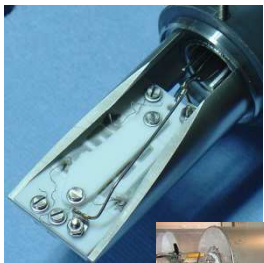
- SCK•CEN (also known as the nuclear research center in Mol) is a federal institute of public utility, with a lot of research capacities and large infrastructures (reactors, hot cells, hot chemical labs, etc), active since 1975 in the R&D for fusion technology.



- MAGyICS is a Spin-off in incubation phase within KU Leuven. The group conducts its research within the cooperation of the University of Leuven and SCK•CEN. Since its creation in 2008, the group has delivered many projects for SCK•CEN, fusion and fission industry.

SCK•CEN has a very long experience in fusion R&D

- SCK•CEN has been involved in R&D for fusion **technology** since 1975 with more focus on the following domains:



- Structural materials development and testing (RAFM steels, Tungsten, ...) and plasma facing components
- Diagnostics and instrumentation (development of FOCS; testing of radiation resistance of components)
- Robotics and remote handling (mostly the resistance to radiations of various components)
- Radioactive waste management and material recycling (incl. Tritium handling and detritiation)
- Socio-economic aspects of fusion development



SCK•CEN disposes of various irradiations facilities for qualifying components and systems



I. Cobalt-60

- BRIGITTE <20.0 kGy/h
- RITA * <1.3 kGy/h
- CAL <3.0 Gy/h (dry cell)

II. Spent Fuel (Cs-137)

- GEUSE II <2.0 kGy/h

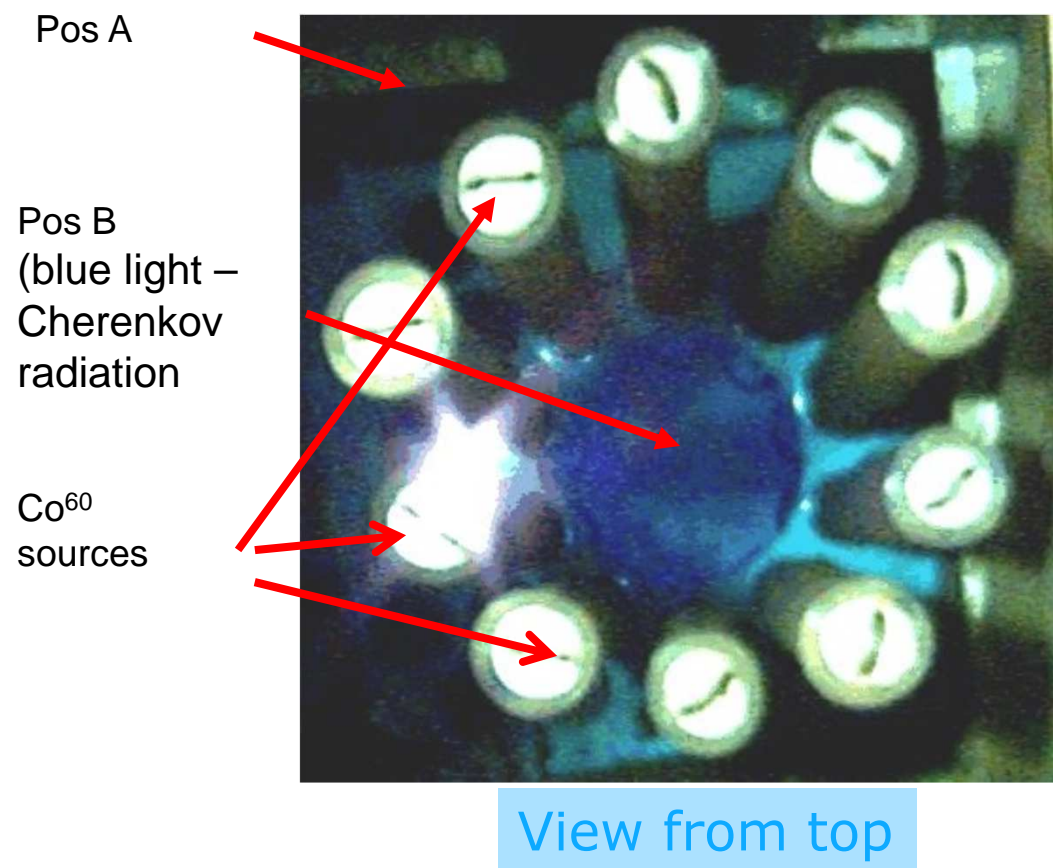
* The dose-rate is adjusted by changing the position and the number of of Co⁶⁰ sources

Detailed info on

http://science.sckcen.be/en/Services/Irradiations/Gamma_BR2



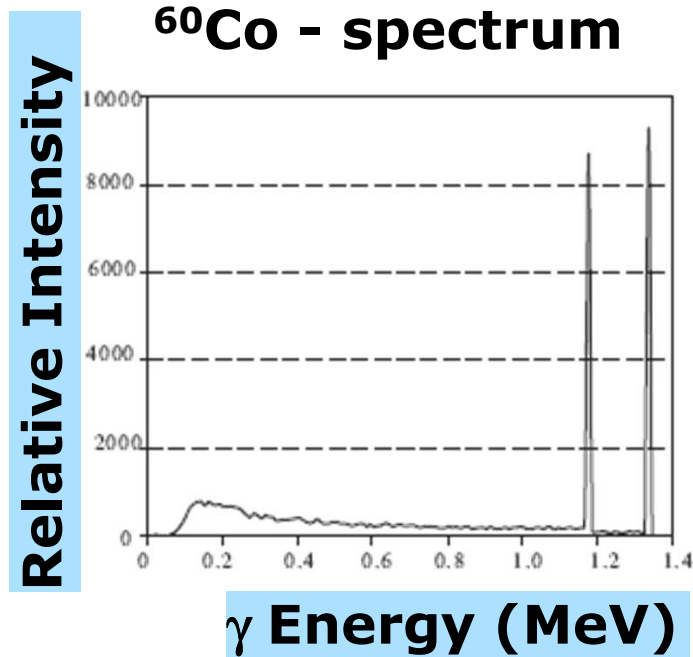
BRIGITTE: High Dose-Rate under water Irradiation Facility



Dose Rates

1 - 20 kGy/h

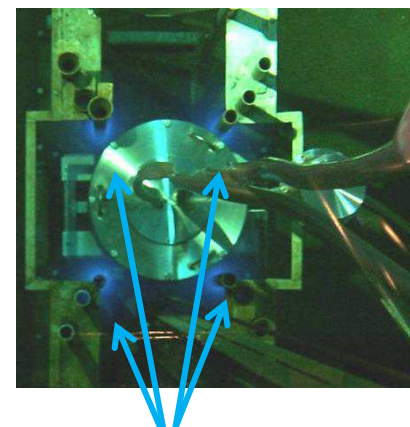
⁶⁰Co - spectrum



RITA: Co⁶⁰ under-water irradiation facility

Available volume (max):
Ø38 cm, h = 50 cm
Ambient temperature: 26-27°C
Temperatures up to **250 °C**
are possible with an oven
(slightly smaller volume)

Cylindrical Container for
irradiated samples



Container in the
irradiation position: Co⁶⁰
sources emit blue light –
Cherenkov radiation

Available dose-rates: **10 - 1300 Gy/h.**

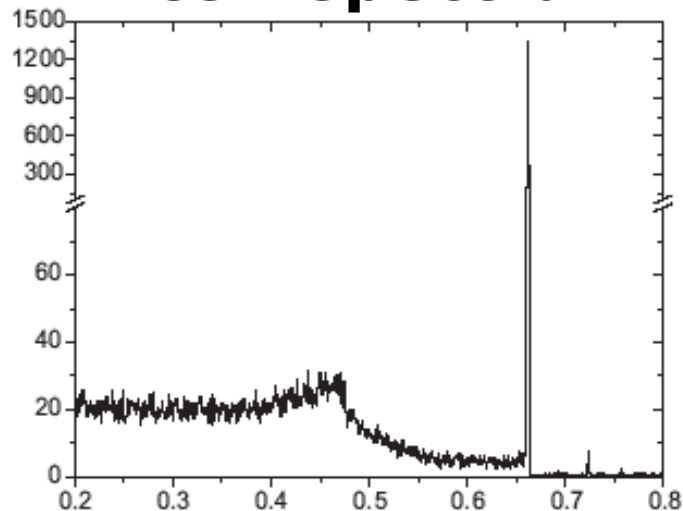
GEUSE II: Spent fuel

Dose Rate

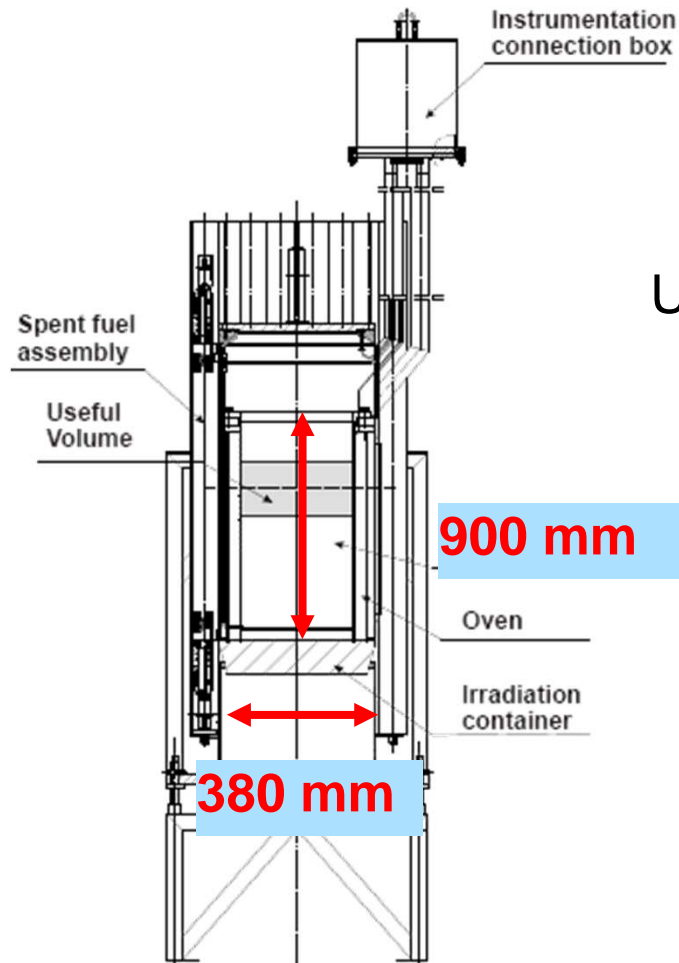
10 - 2000 Gy/h

^{137}Cs - spectrum

Relative Intensity



γ Energy (MeV)



Under water view



On-line instrumentation – see RITA

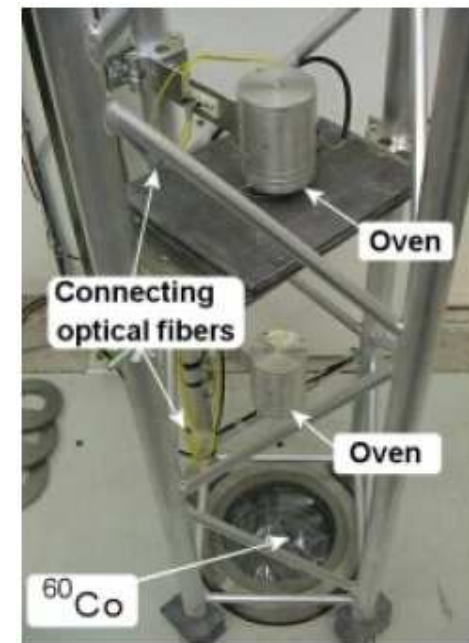
CAL Bunker Low dose-rate irradiation facility

Bunker Inside View



- Room temperature $\sim 21^{\circ}\text{C}$
- Atmosphere and humidity control

Output Source View



- Max Dose Rate: **3 Gy/h**

Some examples of qualifications of diagnostics/electronics devices



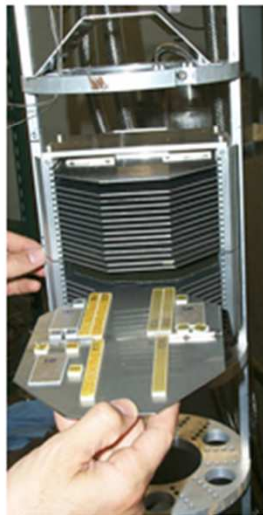
Opto-electronic components (on-line) in RITA and optical fibers (off-line) in BRIGITTE



Characteristics of components are measured under



Polymer irradiation Testing in Brigitte



Electronics in GEUSE: gamma-radiation testing of video-camera

Camera continuously transmits image of object; change of image quality is used to assess the effect of radiation on the camera operation



Fiber optics in RITA



DAQ is connected to fiber optics components using an optical fiber cable

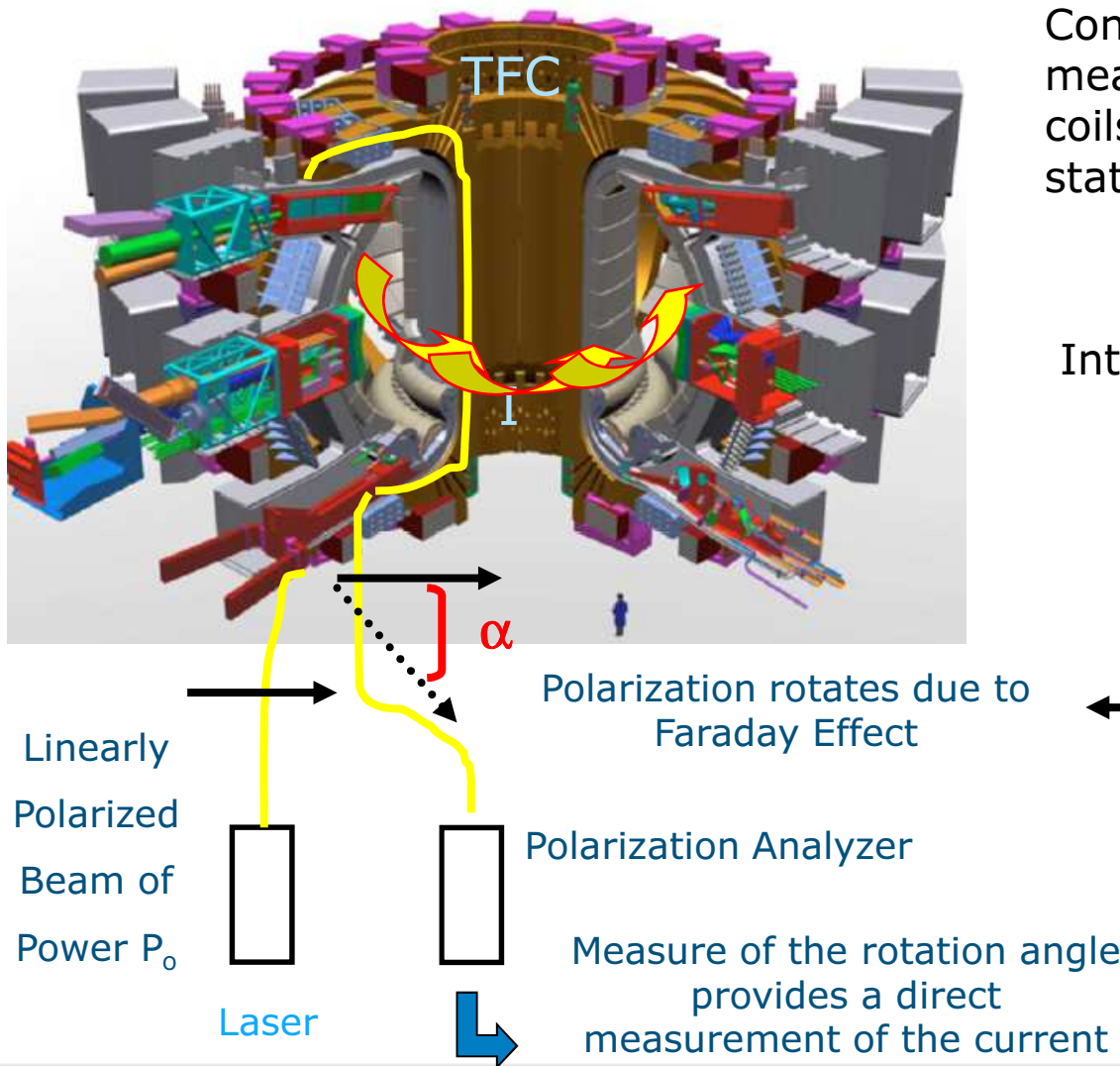


Development of a diagnostics for ITER: The Fiber Optics Current Sensor (FOCS)

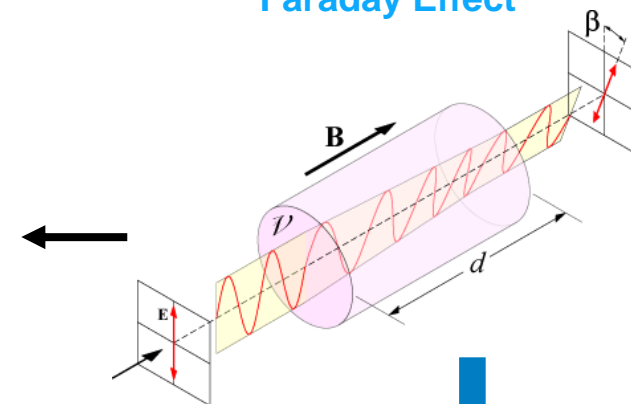
Conventional plasma current measurement system like Rogowski coils loses sensitivity in quasi steady state plasma



Interest for Fibre Current Sensor ?



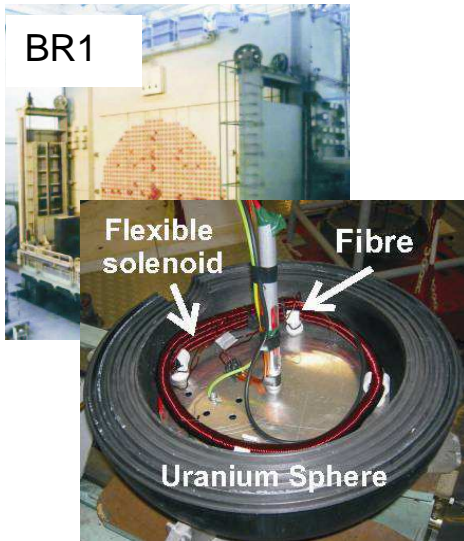
Faraday Effect



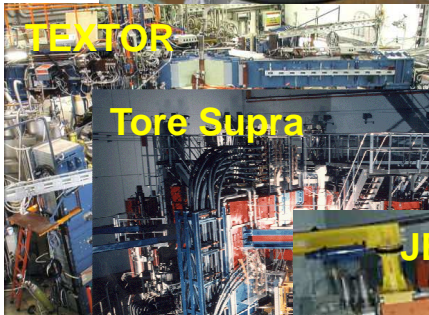
Need to assess the influence of **environmental effect** on the Verdet Constant



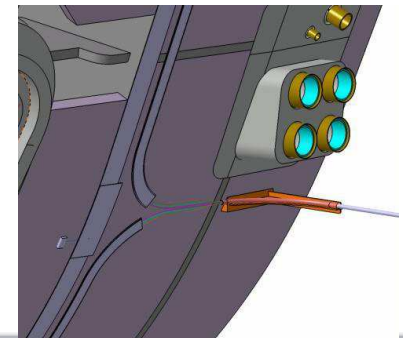
FOCS passed first critical design review (CDR) at ITER



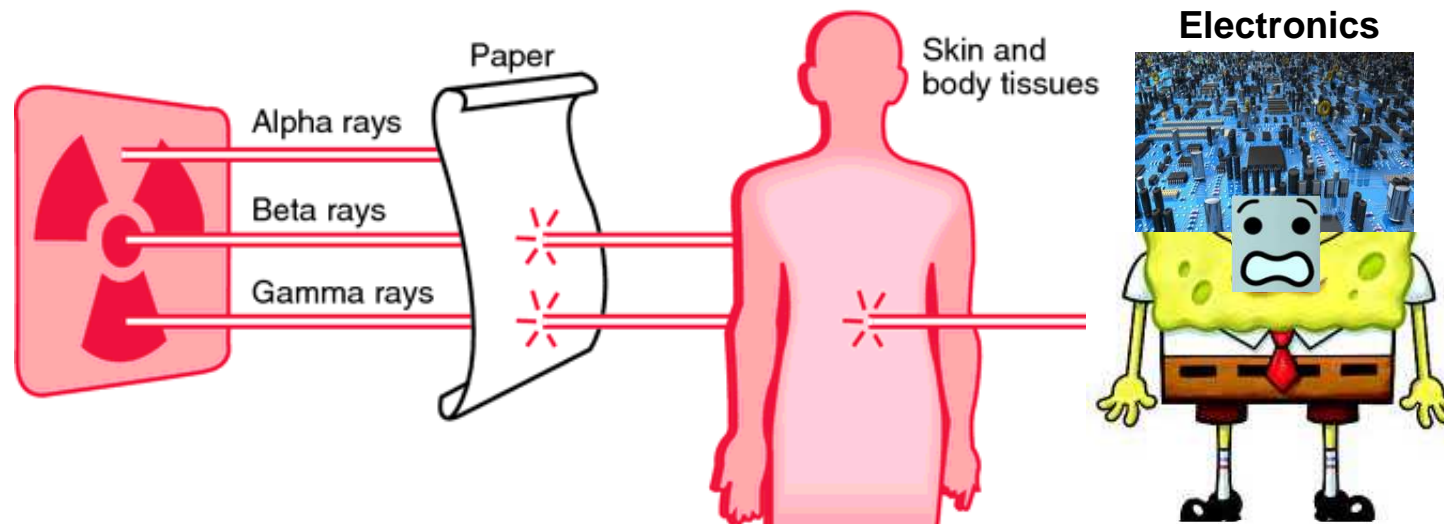
- Knowledge of the ITER processes and procedures
- Encouraging results of neutron irradiation of a FOCS sensor up to $3.5 \times 10^{13} \text{ n/cm}^2$ ($E > 0.1 \text{ MeV}$)
- Testing of FOCS response on several tokamaks: TEXTOR, Tore Supra, and preparation to test in JET
- Approach of ITER, F4E and partners for developing complex components for ITER



Tore Supra



Radiation and electronics are water and fire



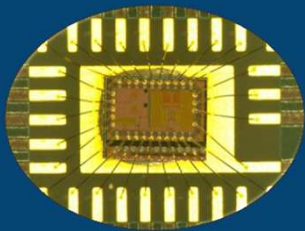
- ❖ Human annual exposure limit: **1mGy**
- ❖ Close to a nuclear reactor core: **50kGy/h**

FAILURE

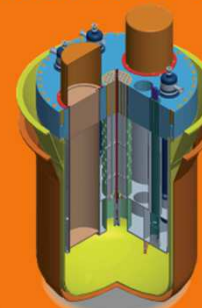
MAGyICS?



Semiconductor
Research



Nuclear
Research



Extreme radiation tolerant
electronic solutions!

The MAGyICS Team

Advisory board



Prof. Dr. Michiel Steyaert (MICAS)



Prof. Dr. Paul Leroux (AdvISe)



SCK-CEN

Radiation expertise
& facilities



Dr. Ying Cao

Expert radiation-tolerant
mixed-signal IC design.
Technology /production



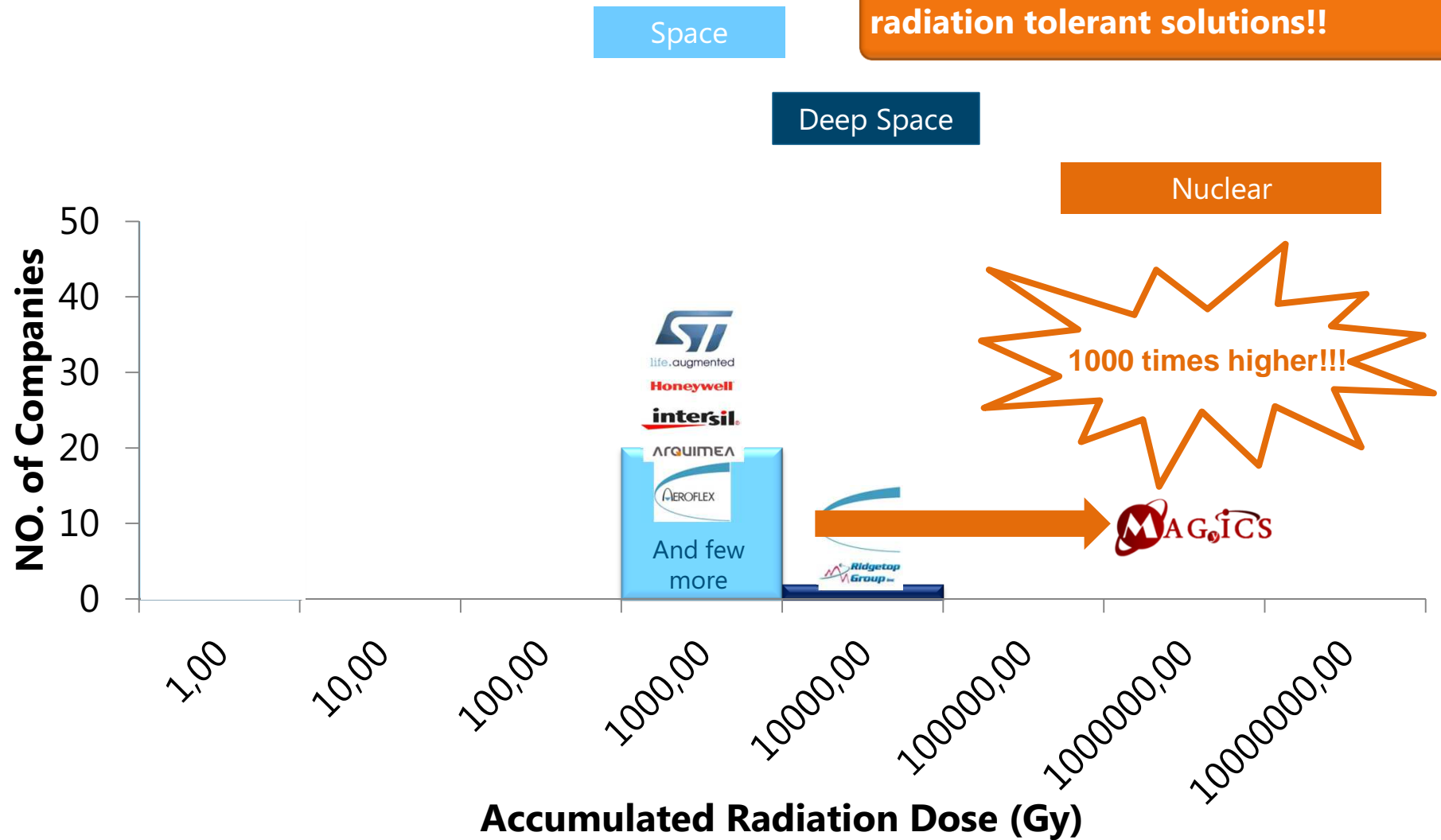
Ir. Jens Verbeeck

Radiation tolerant analog
IC design. Business/
relations / technology

- ✓ Hands-on experience (15+ years) in radiation hardened integrated circuits design for fusion and fission
- ✓ Hands-on experience (6+ years) in MGy-level radiation assessment for projects in both fusion and fission
- ✓ A passionate team with complementary skills, covering technology development, business development, project management, communication and strategic planning

MAGyICS: Game changer....

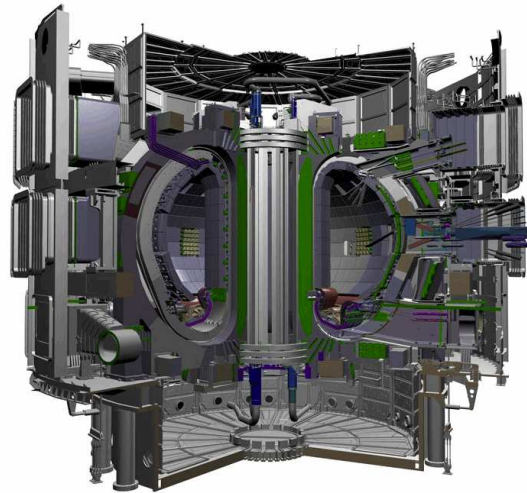
Your provider for the most extreme radiation tolerant solutions!!



ITER Challenge

*“International € 16 billion
Euro project”*

“7 ITER member states”



ITER tokamak

*“150 million °C = 10 times
temperature of the core of the
Sun!”*

We have:

- Remote handling
- Sensor instrumentation
- Cable multiplexers

Showstoppers:

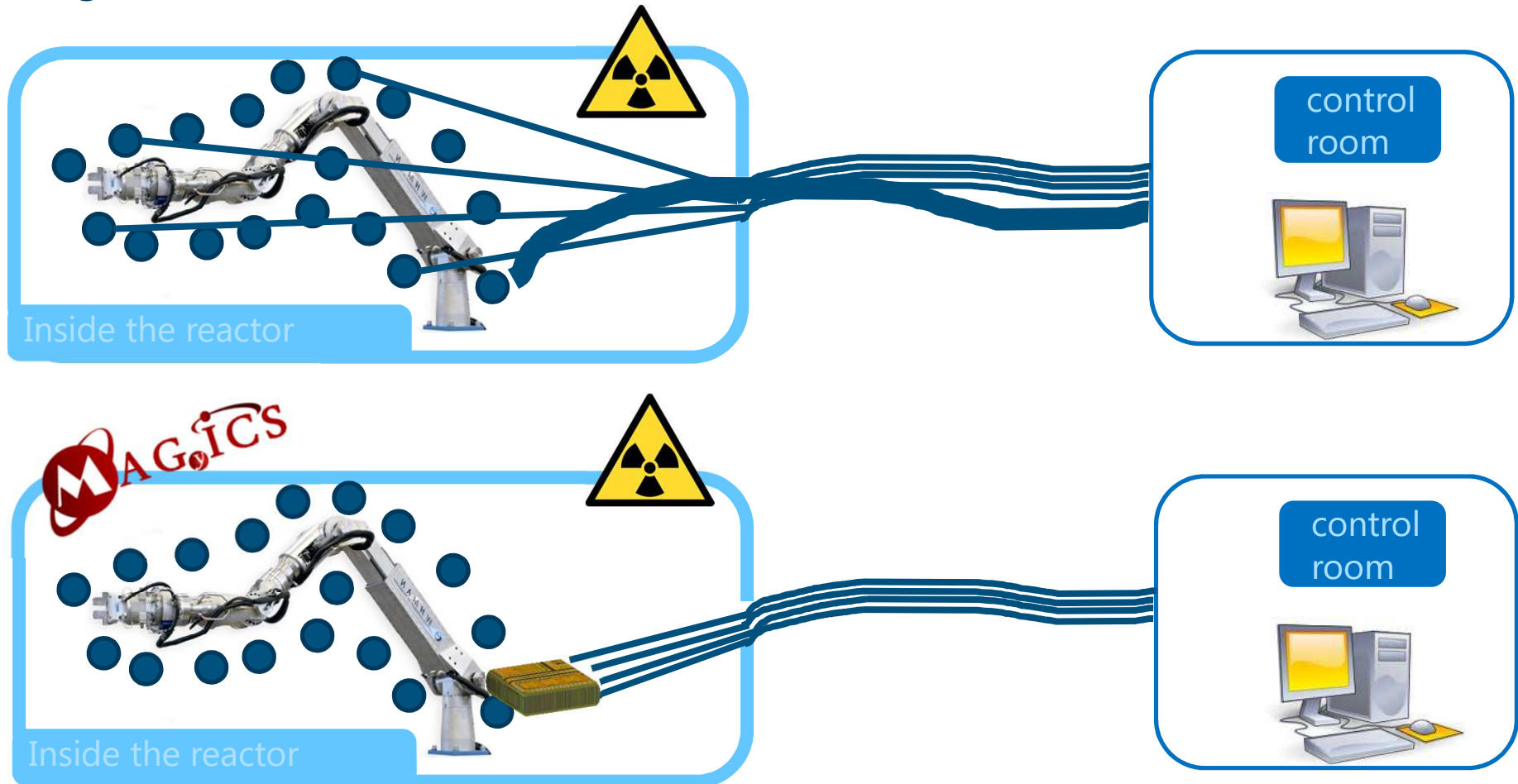
- MGy radiation levels
- Tight space
- Limited number of cables



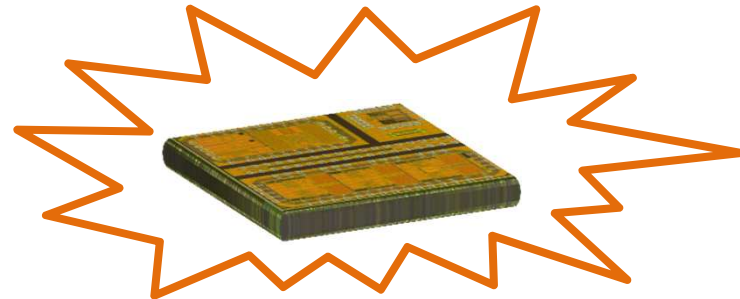
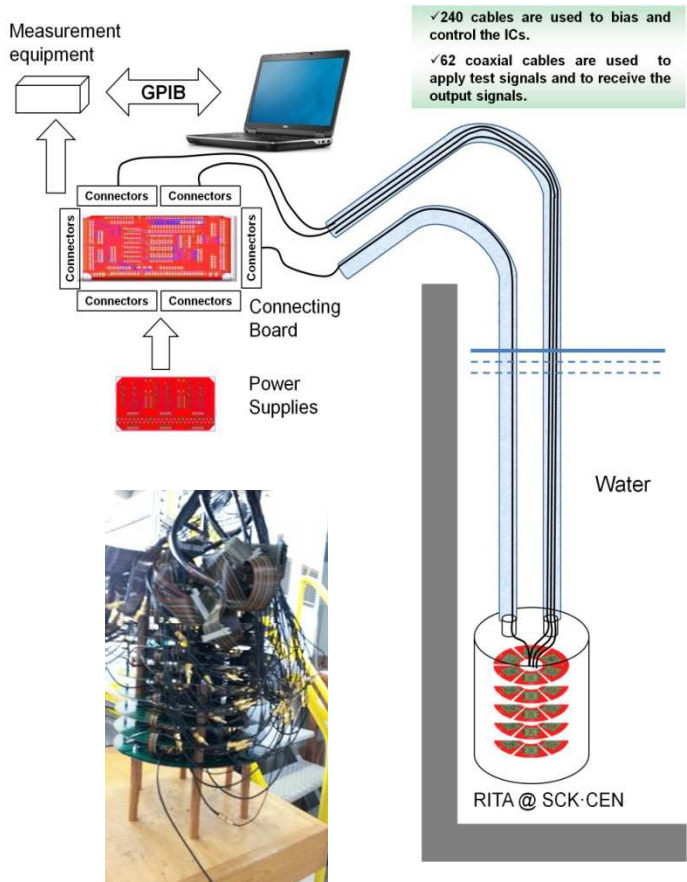


● = sensor

The show goes on for Fusion



MAGyICS in practice



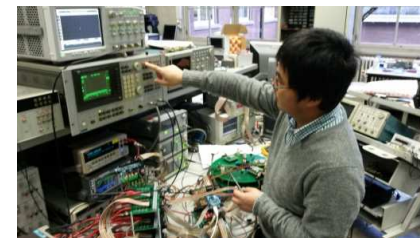
Ultra high dose custom IC design & standard sensor read-out modules.

Radiation qualification according to ITER/F4E policy and standards

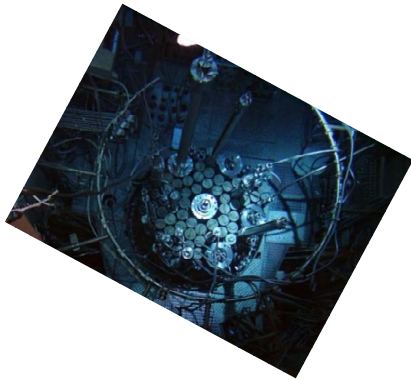
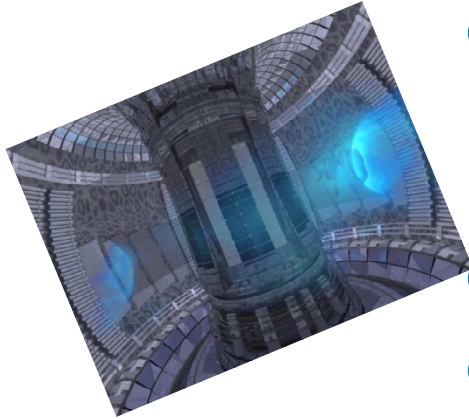
Temperature qualification and accelerated aging tests

Qualified measurement tools

And much more...

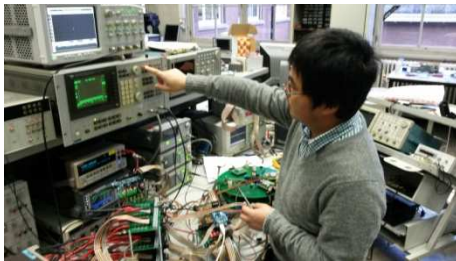
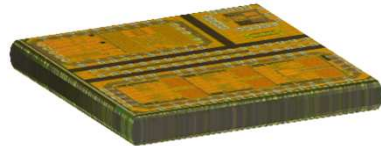


SCK•CEN can be **YOUR** partner for fusion components developments and qualification



- Knowledge of most of the technological fusion issues (and of the nuclear aspects of fusion developments)
- Knowledge of the ITER/F4E procedures
- Large network of people involved in fusion development and ITER construction
- Extended capacities of irradiation and qualification systems for fusion components and systems
- Know-how on nuclearization in general
- Good example of partnership with MAGyICS

MAGyICS can be your partner for electronic solutions and qualifications



- Has developed Megagray radiation tolerant electronics for F4E/ITER.
- Has set a bench mark for MGy radiation qualification tests.
- Has setup a qualification procedures with F4E for electronics.
- Has been involved in multiple tenders for F4E.
- Performed feasibility studies for ITER
- Network of people involved in fusion industry.
- Knowledge of ITER and F4E procedures.

Thank you for your attention

- And thanks to



for the nice organization

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SCK•CEN

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