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Outline

NINO | **MoGr** | **MMS** | **RaDoM**

- Description of the Technology
- Intellectual Property
- Technical Specifications / Features
- Exploitation
- Licences

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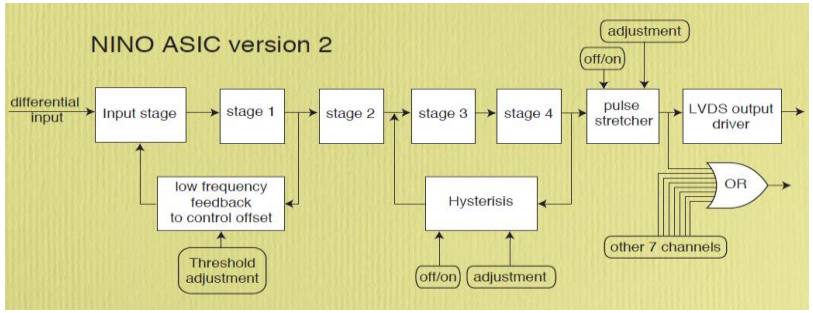
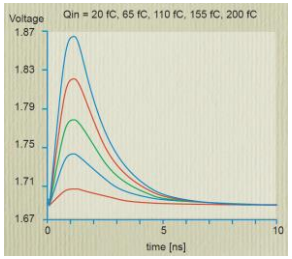
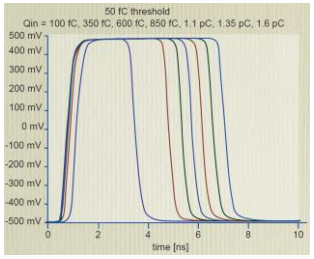
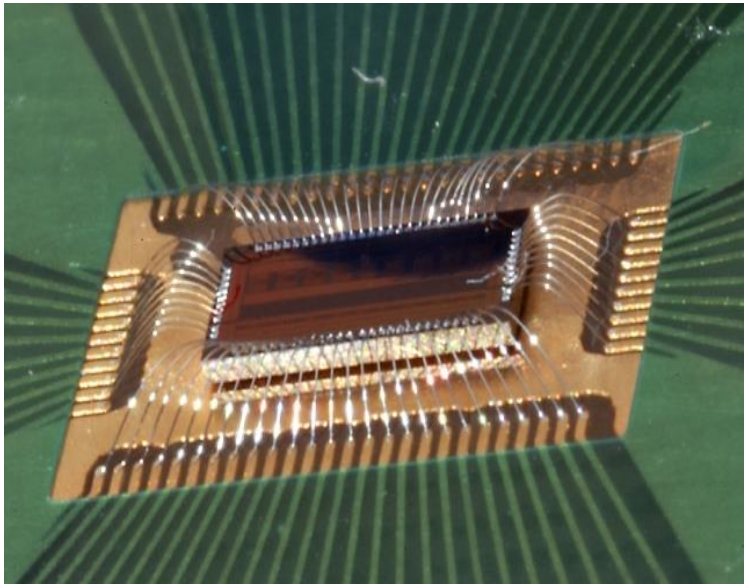
NINO Description of the Technology

An ultra-fast differential amplifier-discriminator









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NINO Intellectual Property

- Developed at CERN under LAA project
  - LAA collaborative R&D activity to study new detection techniques for the next generation of hadron-colliders that would reach the scale of TeVs (1986). The project had a huge impact in the LHC electronics.
- Front-end electronics ALICE TOF detector
  - Used for time-of-flight measurements for particle vertex reconstruction in the ALICE experiment of the LHC collider.
- NINO32 channels version, NINO board
- CERN owns 100% the intellectual property
  - In recognition of the LAA financial contribution that enabled the development of NINO, the net income from exploitation of the NINO chips is shared between CERN and a University member of the LAA project.
- Protected by Know-how

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NINO Innovative Features

- Low noise-large bandwidth input stage;
- Adjustable discriminator threshold;
- Adjustable input impedance;
- Low delay in the amplification and high slew rate;
- Small hysteresis on the threshold;

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NINO Technical Specifications

- 0.25um CMOS technology
- Size: 2 x 4 mm^2
- # channels: 8
- Power supply: 2.5 V
- Peaking time: 1 ns
- Input signal range: [100fC, 2pC]
- Noise: < 5000 e- rms
- Threshold: [10fC, 100fC]
- Front edge time jitter: < 25ps rms
- Power consumption: 30mW/channel
- Differential input impedance: [40Ω, 75 Ω]
- Rate: > 10 MHz

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NINO Exploitation

- Applications:
  - Life Sciences
  - Medical imaging
  - Material research
- R&D licenses in Germany, UK, Spain, Portugal, Slovakia, Romania, China, …

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NINO Licences

2014

- Beijing Normal University (2014)
- University of Glasgow (2014)
- University of Physics SAS, Slovakia (2014)
- IFINHH (Horia Hulubei National Institute of Physics and Nuclear Engineering) Romania (2014)

2015

- LIP, Portugal (2015)
- Universitat Politecnica Catalunya (2015)
- INFN (Instituto Nazionale di Fisica Nucleare), Italy, 2015
- LPCCAEN , France (2015)
- VECC (Variable Energy Cyclotron) India (2015)
- University of Delhi, India (2015)

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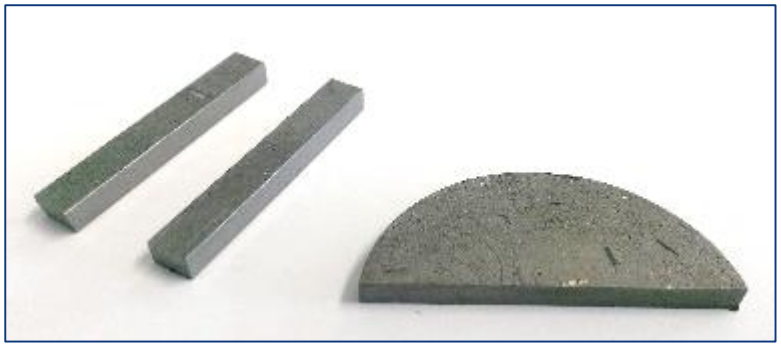
MoGr Description of the technology

Molybdenum – Graphite (MoGr) is a new generation of **metal and ceramic matrix composites.**

Several materials were tested: MoGr is showing promising results, in particular **Copper-Diamond** and **Molybdenum Carbide – Graphite.**



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MoGr Why we need it?

- Particle beams have reached **unprecedented energy** and **energy density.** This trend is set to continue for future accelerators (**690 MJ** for **HL-LHC).**
- Beam-induced accidents, beam losses and beam stability are amongst the most relevant issues for high power particle accelerators!
- Beam Intercepting Devices (such as collimators) are inherently exposed to such events!

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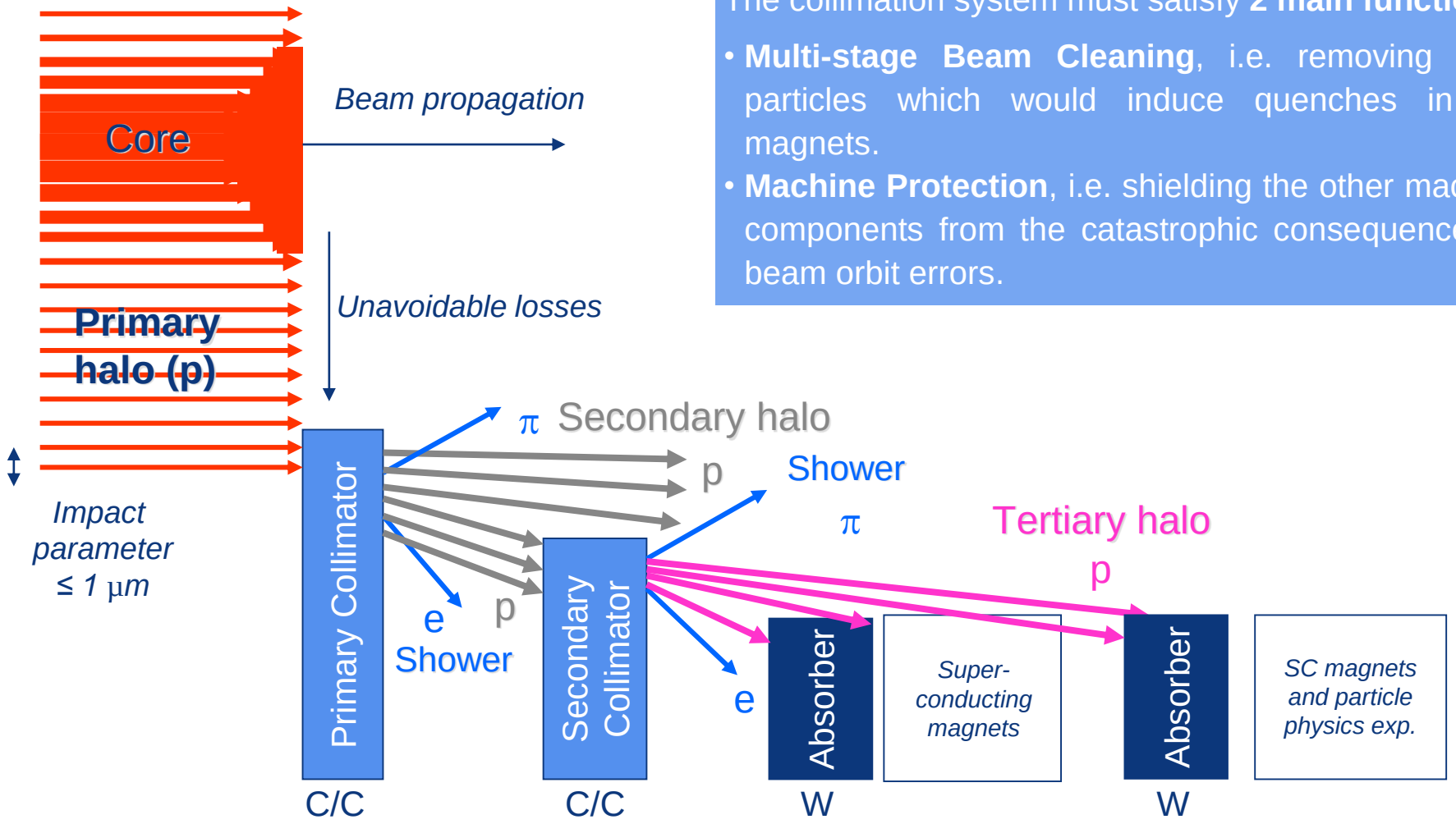
MoGr Why we need it?

The collimation system must satisfy **2 main functions**:

- **Multi-stage Beam Cleaning**, i.e. removing stray particles which would induce quenches in SC magnets.
- **Machine Protection**, i.e. shielding the other machine components from the catastrophic consequences of beam orbit errors.



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MoGr Technical Specifications

- **Thermal Conductivity:** Maximize it, to maintain geometrical stability under steady-state losses.
- **Coefficient of Thermal Expansion:** Minimize it, to increase resistance to thermal shock induced by accidental beam impact.
- **Melting/Degradation Temperature:** Maximize it, to withstand high temperatures reached in case of accidents.
- **Specific Heat:** Maximize it, to improve thermal shock resistance (lowers temperature increase).
- **Ultimate Strength:** Maximize it, to improve thermal shock resistance.
- **Radiation-induced Degradation:** Minimize it, to improve component lifetime under long term particle irradiation.
- **Outgassing Rate:** Minimize it, to ensure compatibility with UHV environment.

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MoGr Technical Specifications

Material	C-C	Mo	Glidcop ®	Cu-CD	Ag-CD	Mo-Gr
Density [g/cm³]	1.65	10.22	8.90	~5.4	~6.10	2.8
Atomic Number (Z)	6	42	29	~11.4	~13.9	8.3
T_m [°C]	3650	2623	1083	~1083	~840	~2520
SSNI [kWm²/kg]	24	2.6	2.5	13.1÷15.3	11.1÷15.4	83*
TSNI [kJ/kg]	793	55	35	44÷51	60÷92	195*
Electrical Conductivity [MS/m]	0.14	19.2	53.8	~12.6	~11.8	1÷18**

Worse — Better

* Estimated values

** γ = 18 MS/m with Mo surface coating

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MoGr Intellectual Property

- Developed under collaboration between CERN and an Italian company
- CERN has filed the patent application and the company is a co-applicant of the patent
- Both CERN and the company share the patent management costs and benefits related

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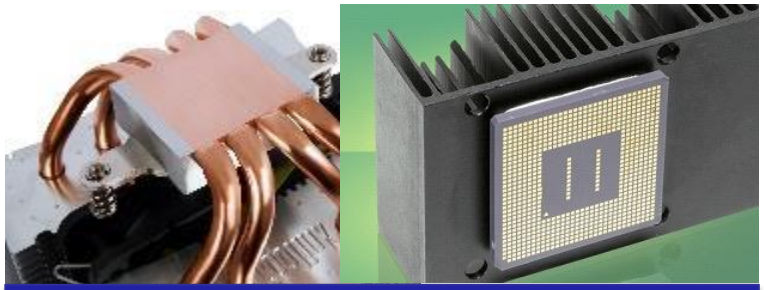
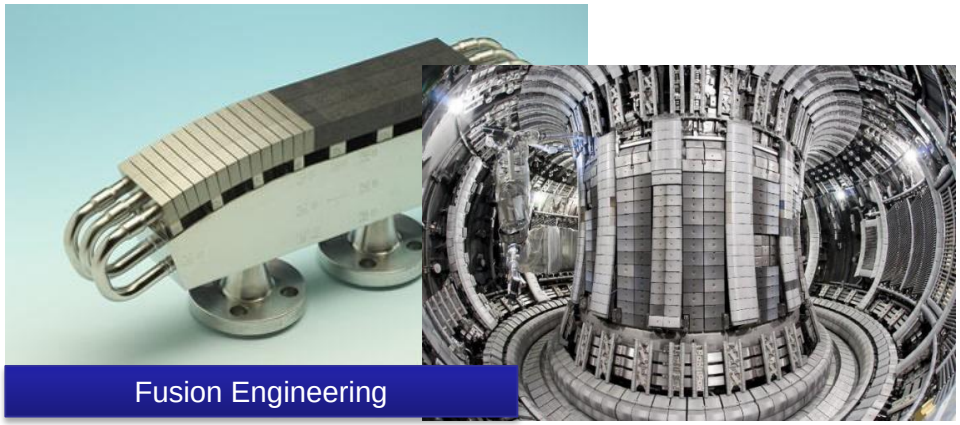
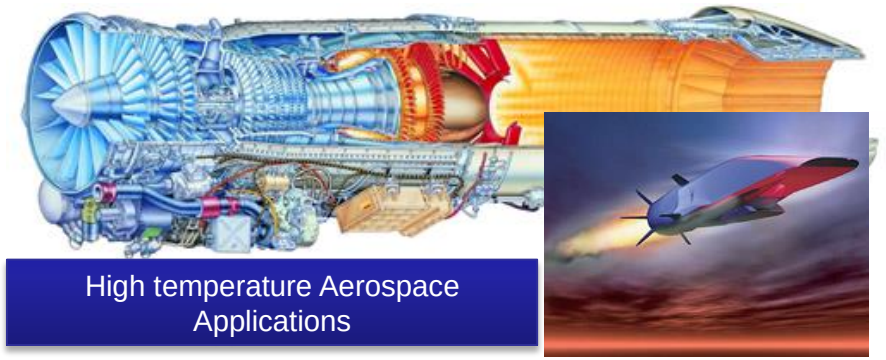
MoGr Exploitation



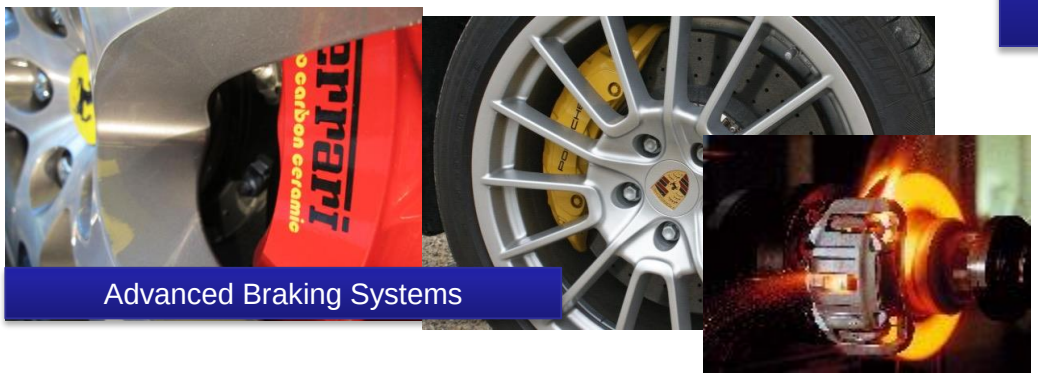
Thermal Management for High Power Electronics



Fusion Engineering



High temperature Aerospace Applications



Advanced Braking Systems

Solar Energy Applications

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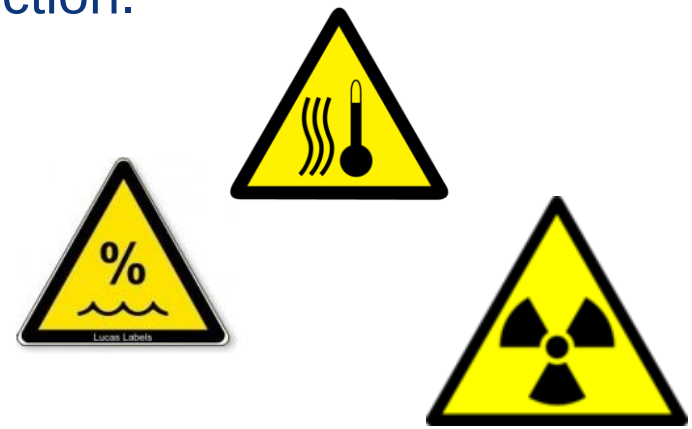
MMS Description of the technology

MMS: Automatic Memory Management System

Programmable devices store configurations and/or the main application code in non-volatile memory. Harsh conditions, such as extreme temperatures or ionising radiation, can corrupt the configuration, leading to a system malfunction.



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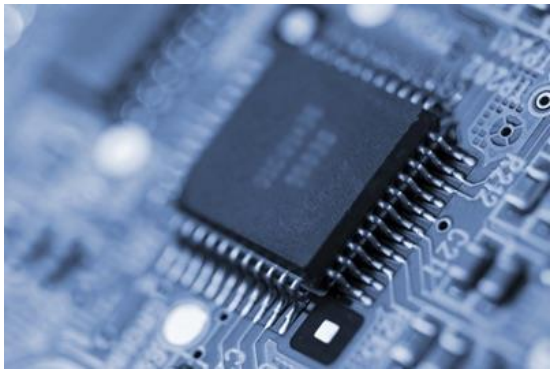
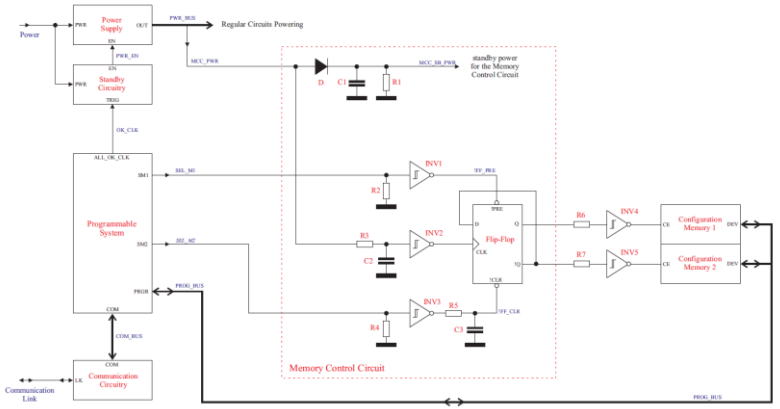
MMS Technical Specifications

CERN developed a new multiple memory configuration circuit, which solves this problem and increases the reliability of a programmable system located in harsh environments. The new system can identify and bypass a corrupted memory, ensuring continuous access to the information stored.

- **Automatic System recovery:** Once the programmable system starts successfully, the content of the good configuration memory can be copied to the corrupted one.
- **System update:** The set-up can be used for a fail-safe change of the programmable system functionality, for example a system upgrade.
- **Damage mode triggering:** The same setup can be used to adapt the system to the changes of the harsh environment.





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MMS Intellectual Property

- We‘ve identified several technologies with implementations of similar concepts.
- However, the disclosures do not explicitly define a second, **physically separate memory** chip but in most cases appear to utilise redundant memory bits of the same memory.
- The simplicity of the solution makes it difficult to protect it via industrial secret, in a potential transfer. Implementing the technology in an ASIC could be an option.

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MMS Exploitation

FPGA manufacturers:

Xilinx / Altera

Critical applications Motherboards manufacturers:

Acer / ACube Systems / AMAX Information Technologies / Aopen / ASRock / Asus / Biostar / Chassis Plans / DFI (industrial motherboards) / ECS (Elitegroup Computer Systems) / EPoX / EVGA Corporation / First International Computer / Foxconn / Gigabyte Technology / Gumstix / IBM / Intel / Lanner Inc / Leadtek / LiteOn / Magic-Pro / MSI (Micro-Star International) / PNY Technologies / Powercolor / Sapphire Technology / Shuttle Inc. / Simmtronics / Supermicro / Trenton Technology / Tyan / VIA Technologies / XFX / Xi Computer Corp. / Zotac

Chipsets for motherboards

Nvidia / ServerWorks / Silicon Integrated Systems / VIA Technologies

Central processing units (CPUs)

AMD / ARM Holdings / Broadcom / Cyrix / Freescale / Fujitsu / HiSilicon/ Imagination Technologies / Marvell / MediaTek / NexGen / Nvidia Tegra / Ockel Products / Oracle (previously Sun Microsystems) / Qualcomm / Rise Technology / Rockchip / Samsung / SigmaTel / Texas Instruments / Tilera / Transmeta / Via (formerly Centaur Technology division) / WinChip

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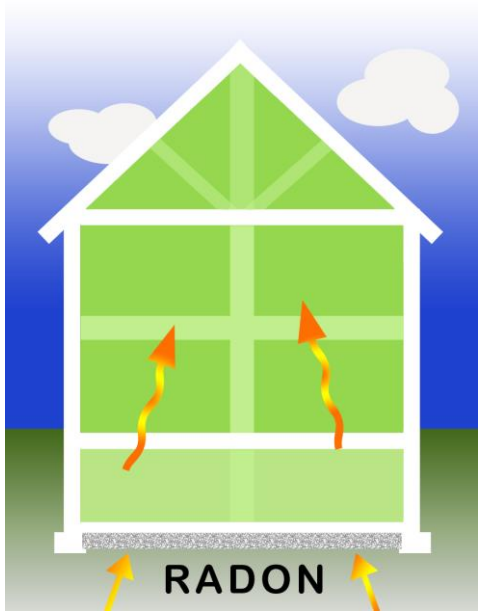
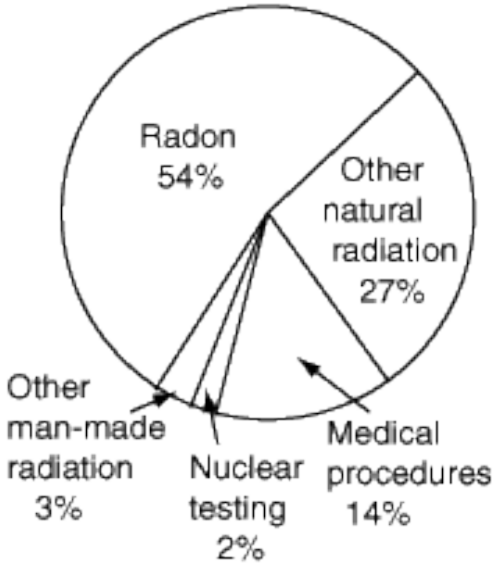
RaDoM Description of the technology





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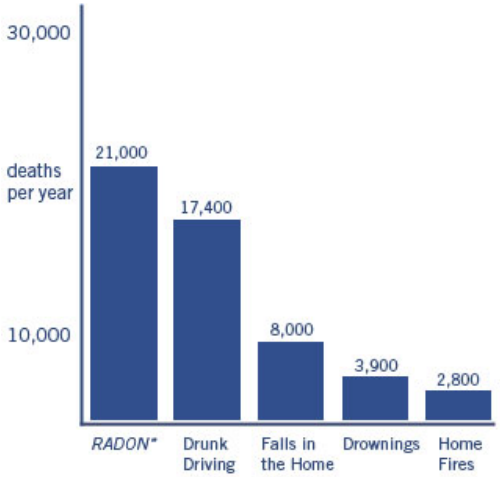
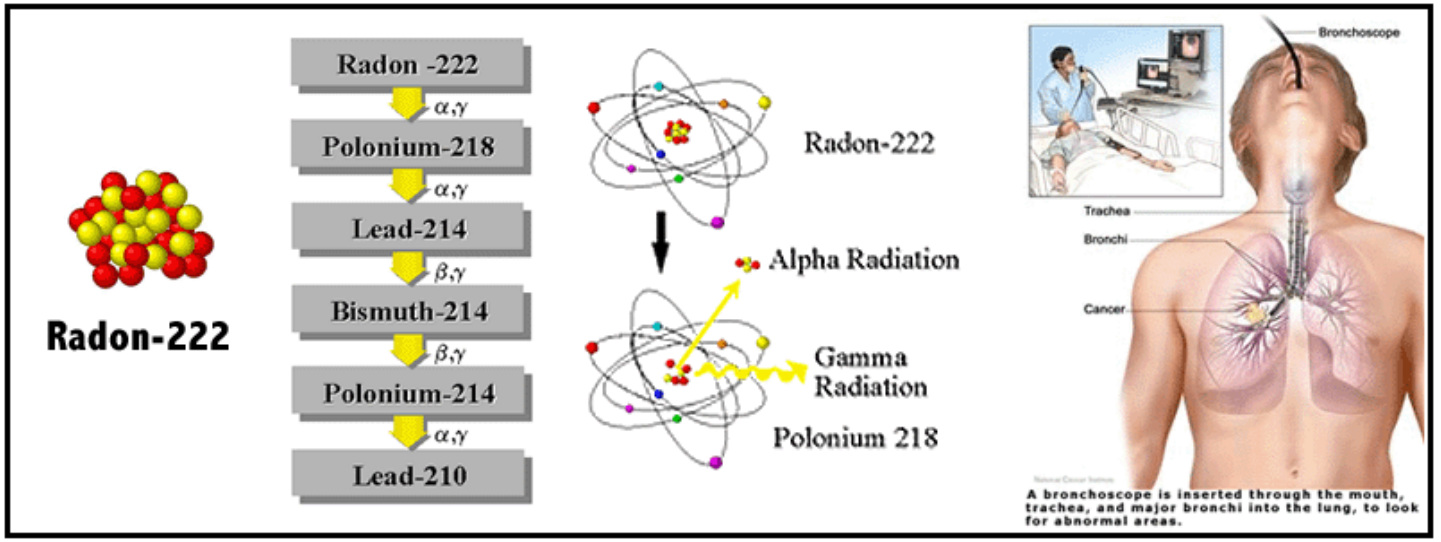
RaDoM Description of the technology





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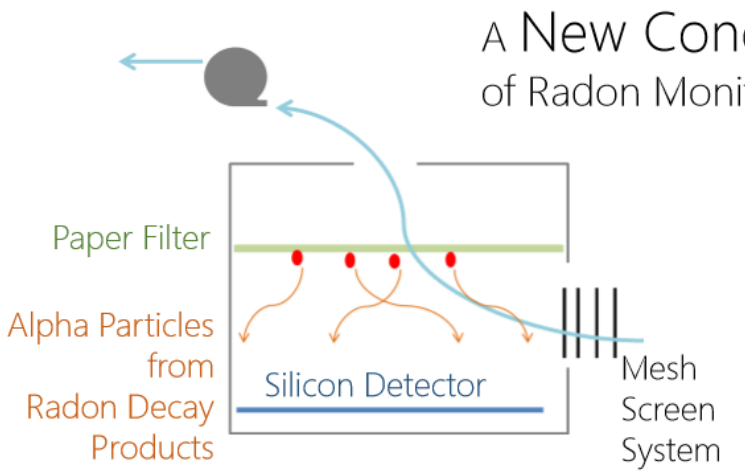
RaDoM Features



Small and Lightweight

3D Printed

Arduino as a Microcontroller

Portable and Affordable Devices

Battery Powered

Computer Independent

Embedded Devices

Smart

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RaDoM Intellectual Property

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Questions

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Molybdenum - Graphite

The inventors found that a molybdenum carbide / carbon composite comprising carbon fibers allows to combine the desirable properties of metals (such as large electrical conductivity and high fracture toughness) with high thermal conductivity, low density, and low coefficient of thermal expansion. This combination of properties makes the new family of materials ideally suited for applications in beam intercepting devices, such as beam jaws in collimators, but also for a large number of other applications with similar requirements, such as for thermal management applications for microelectronics, braking discs for high-end sport cars, or materials for plasma-facing components in nuclear fusion reactors. The composite material may be a metal matrix composite and/or ceramic matrix composite. The molybdenum carbide may comprise Mo_2C and/or other molybdenum carbide phases.

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NINO

Licences and scope: additional info

- Beijing Normal University (2014) - development of readout electronics for arrays of silicon photomultipliers to be used in time-resolved fluorescence spectroscopy
- LIP, Portugal (2015) – CMS TOTEM
- Universitat Politecnica Catalunya (2015) – development of a LIDAR camera for 3D imaging through TOF technique
- University of Glasgow (2014) – new focal plane hodoscope
- University of Physics SAS, Slovakia (2014) – position sensitive scintillator

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