Advanced Detectors for Better Awareness of Neutrons and Gamma Rays in Environment AD-BANG

Czech-Norwegian Research Programme CZ09

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on behalf of AD-BANG collaboration
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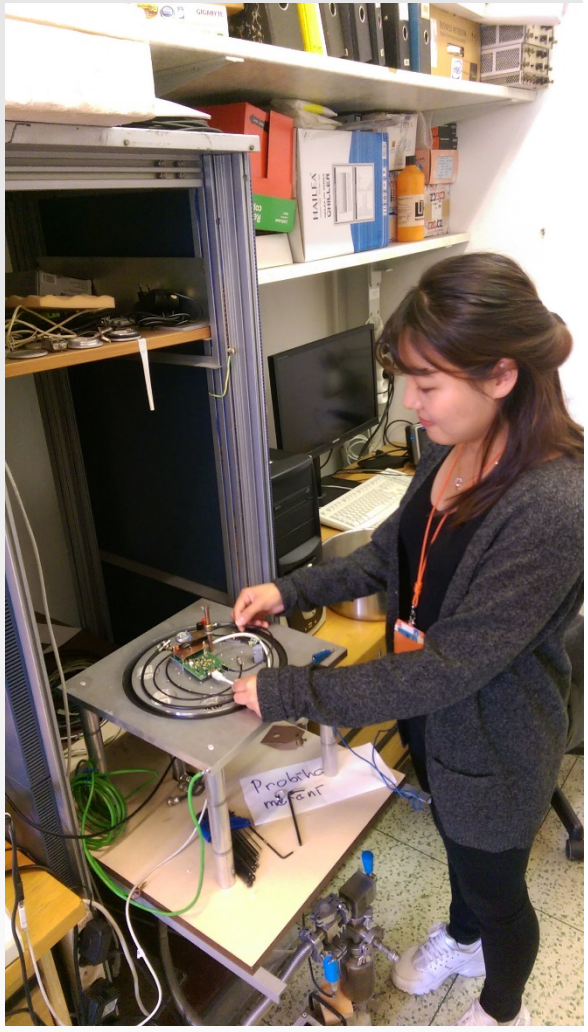
Prague

Project consortium

- Project Promoter:
  - Czech Technical University in Prague represented by Institute of Experimental and Applied Physics
    - Hardware and software design, development and testing.
- Partners
  - Czech:
    - National Radiation Protection Institute
      - Dosimetry and end-user requirements advisor
    - Department of Dosimetry and Application of Ionizing Radiation, Faculty of Nuclear Sciences and Physical Engineering, CTU
      - Monte Carlo simulations and dosimetry.
  - Norwegian:
    - Stiftelsen SINTEF
      - Silicon sensor development and production.
    - Integrated Detector Electronics AS
      - Application Specific Integrated Circuit (ASIC) design and production.
- Consortium was built on solid foundation based on previous long-term cooperation between institutes. CZ09 allowed to grow from ideas developed during internal research activities to proper research project where all technological capabilities and knowledge could be employed and this cooperation will continue further after the CZ09 programme.

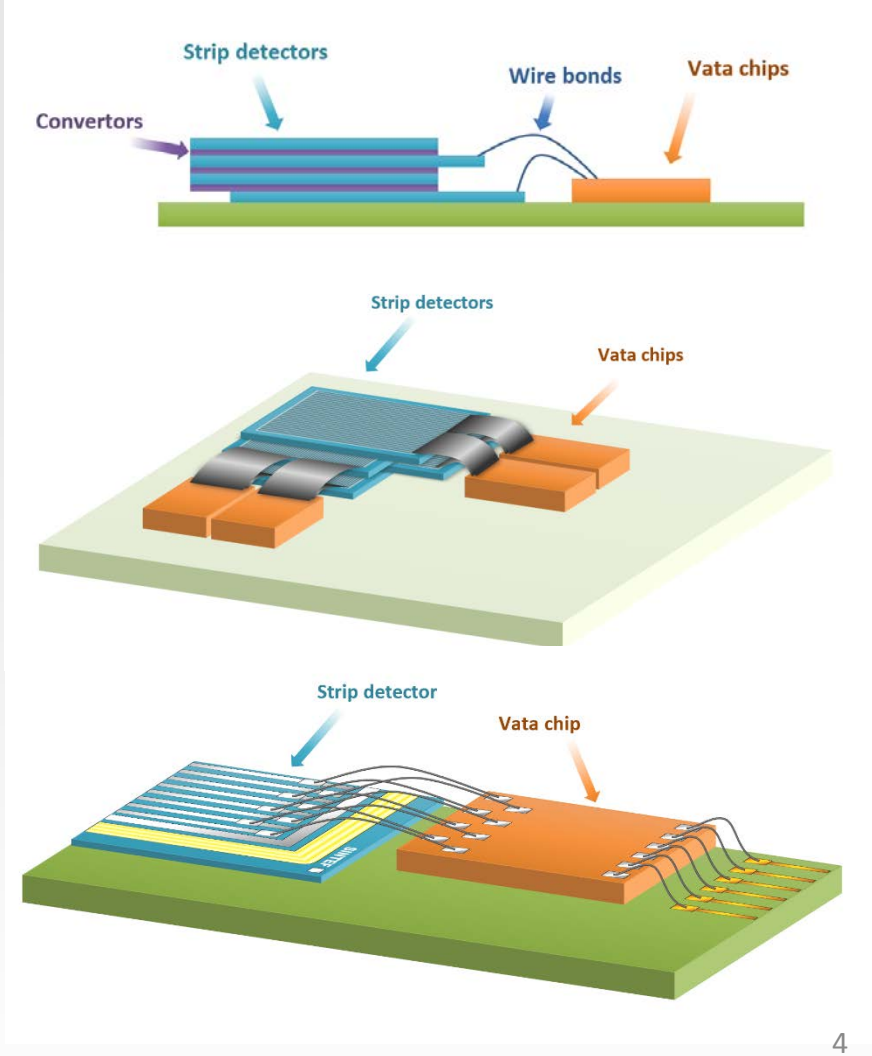
Why is project needed?

- The project was proposed to leap forward in cooperation between Czech and Norwegian partners.
- Norwegian partners retain advance technologies for sensor development and read-out electronics design which are not available in Czechia while Czech partners had several ideas how to employ this technologies.
- The programme allows the ideas to become reality.
- Ideas are generated and realized mostly by young people (students, PhD and post-docs, 75% of the project members are under age 35).



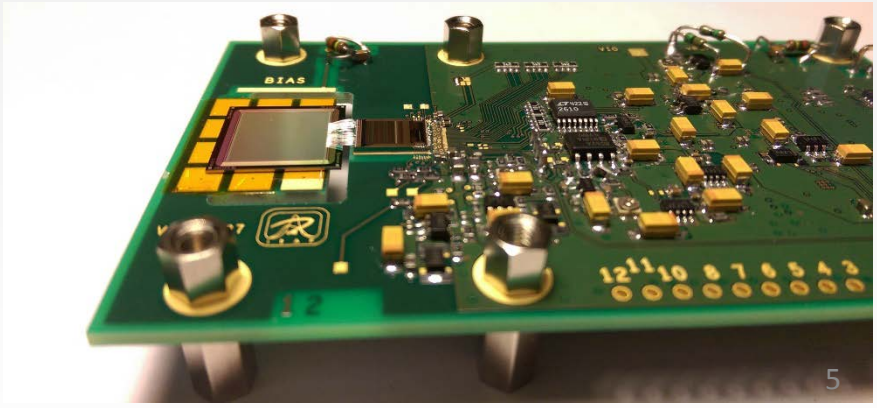
What are the project‘s objectives?

- To develop integrated detection system for the measurement of neutrons in mixed radiation fields.
  - Detection and monitoring of neutrons is in general a problem everywhere where methods of subatomic physics are employed.
  - The proposed system improve our understanding of radiation protection of human health and environment via accurate measurement of radiation whether from natural decay, solar activities or environment.
  - Radiation has also become one of the most powerful diagnostic and treatment tool in healthcare where monitoring of radiation exposure is an important part of the quality assurance for both patients and healthcare personnel.



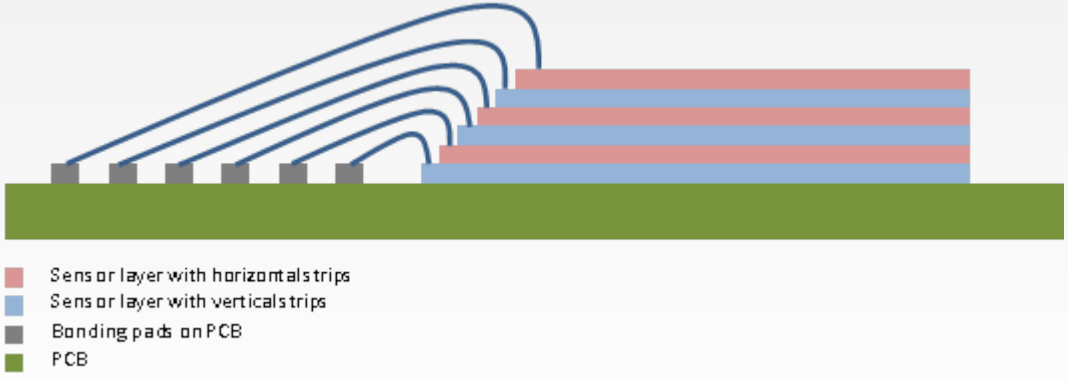
What is the project expected to achieve?

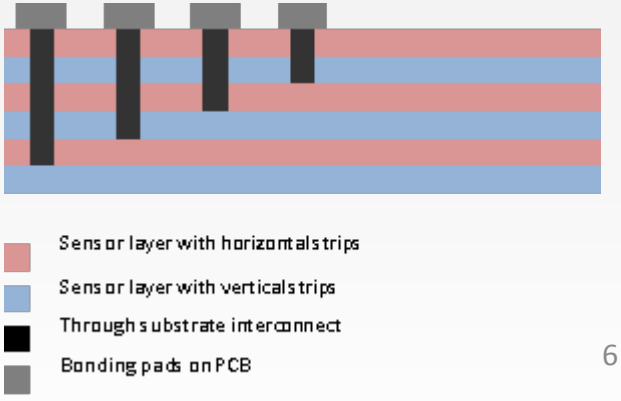
- The key task of this project is to deliver a demonstrator of a new sensor unit based on novel micromachining assembled with custom readout electronics and to fully demonstrate how this sensor unit improves the current state-of-the-art dosimeter and camera system for measurements in mixed radiation fields
- Thanks to wide group of project partners from different fields of research and development we expect imminent start of knowledge transfer. The high technological quality research provides a solid basis for learning and education of doctoral students and post-doctoral employees. Partners cover rather different areas of expertise, students gain knowledge of sensor fabrication technology and adaptation of microelectronics in Norway and, conversely, gain experience in instrumentation and sensor characterization in Czechia.
- Knowledge transfer won't be only within the project partners or within the community related to field of research but we expect impacts also e.g. in fields of fundamental biology research or microelectronics.



How are you going to address these challenges?

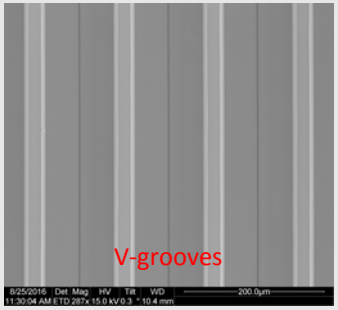
- Stacked sensor unit
  - Our approach is to stack multiple layers of conventional silicon strip sensors to increase the total sensitive volume for a wider range of radiation detection. Each single layer provides a 1D geometric location of the particle interaction point. The stacked layers with a cross strip arrangement can then provide information in 3D as well as angular and directional information of incoming particles.
  - For detection of neutrons, strip sensors are interlaced by a selected neutron converter based on either ^{6}Li or ^{10}B or a hydrogen rich material such as polyethylene.
  - Two different approaches are employed in this project to stack and bias the sensors and to readout signal from them; either conventional wire-bonding or through silicon via interconnect technology (TSV).
- Introduction of 3-dimensional micro-structures
  - Neutron detection efficiency is improved by introducing 3D micro-structure to increase the surface area of the back side of the sensor where the neutron converter will be deposited.
- Signal readout
  - Sensor developed during this project is a complex structure with more than hundred readout channels. Readout of analogue information simultaneously from all channels and transformation of the information into digital form is a very challenging task. For our application we use analog multiplexer ASIC which will forward signals into analog to digital (A/D) converter.

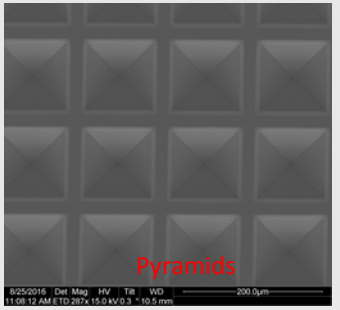




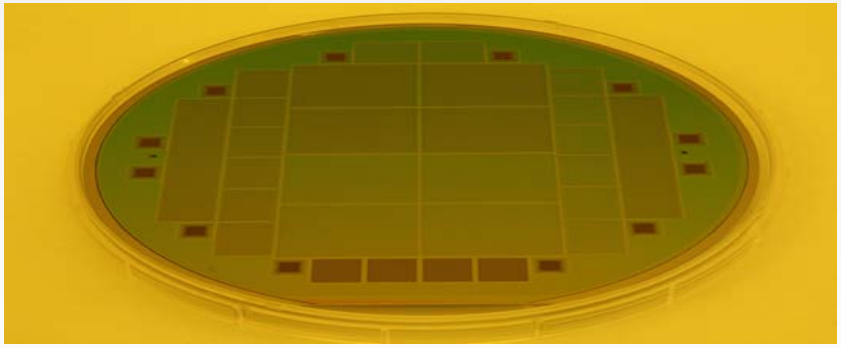
How are you going to address these challenges?

- Silicon sensor R&D
  - The larger surface area needed to improve the neutron detection efficiency is achieved by employing wet chemical silicon etch methods available at SINTEF MiNaLab to configure the backside surface of the sensor into 3-dimensional structures such as V-grooves and pyramids
  - SINTEF MiNaLab's unique expertise in Deep Reactive Ion Etching (DRIE) – which facilitates "drilling" of high aspect ratio holes through silicon sensors – provides an ideal solution for stacking multiple silicon sensors with vertical electrical connection through these holes (silicon via interconnect technology -TSV)





SINTEF MiNaLab



6 inch silicon wafer with AD-BANG strip sensors under processing in MiNaLab

Who is going to benefit from the project?

- Project outcomes will form a part of knowledge platform in understanding of how silicon technology can be exploited to improve the current status of dosimeter and camera using mixed radiations.
- Project results are disseminated to experts in many different fields. These includes fabrication; semiconductor packaging; instrumentation; radiation measurement; readout electronics; radiation protection; cosmology; healthcare and other possible applications.
- Even though R&D in scope of the project isn't very popular between women most of the project partners (3 out of 5) succeeded to integrate at least one female into their research and demonstrate their interest in gender equality.
- Most of the technical work on the project is carried out by PhDs or post-docs (8 within the consortium) with support and guidance of experienced researchers.

Thank you very much! Tusen takk!

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