The SA-CERN Tech Transfer Pillar

Bruce Mellado

Wits and iThemba LABS

INSTITUTE FOR COLLIDER PARTICLE PHYSICS
UNIVERSITY OF THE WITWATERSRAND

NRF National Research Foundation | iThemba LABS Laboratory for Accelerator Based Sciences

SA-CERN 15th Anniversary

iThemba LABS, 21/01/25

Research - Innovate - Deploy

Tribute to late Prof. Danny Adams

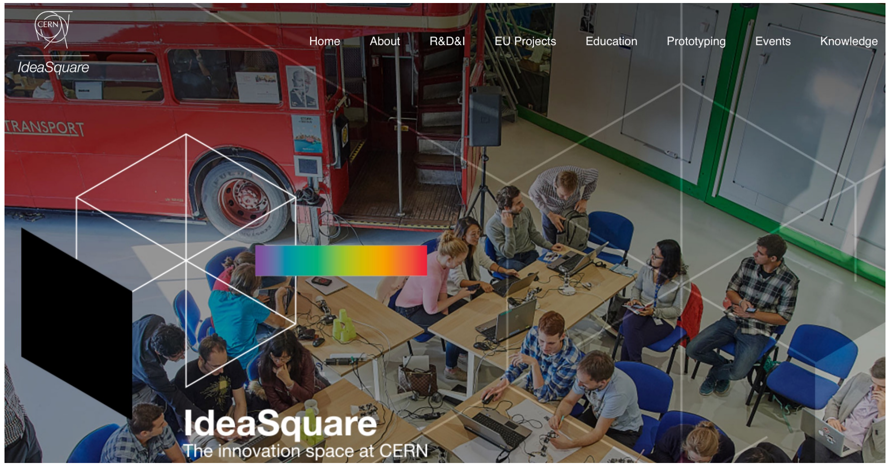
Special thanks to DSI’s DDG Imraan Patel and Director Glaudina Loots

The three-pronged mission is to ***research, innovate*** and ***deploy***– to develop accessible, affordable and equitable AI solutions and also bring breakthrough advances in AI and medicine to patients in Africa.

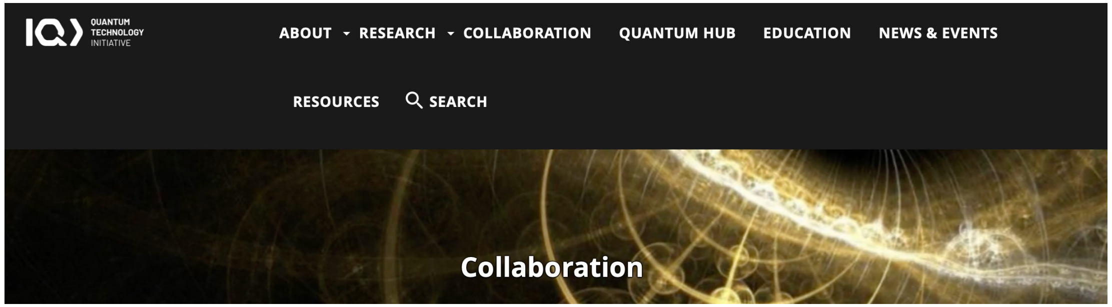
CERN's Tech Transfer Ecosystem

The Knowledge Transfer office
https://kt.cern

IdeaSquare, the innovation space
https://ideasquare.cern



The Quantum Technology Initiative
https://quantum.cern/collaboration



Scope of SA-CERN's TT Pillar

Transfer of knowledge from CERN research environment to other research environments

Include, accelerator physics, medical physics, FCC, etc… and CERN's Quantum initiative and cooperation with SA-QuTi

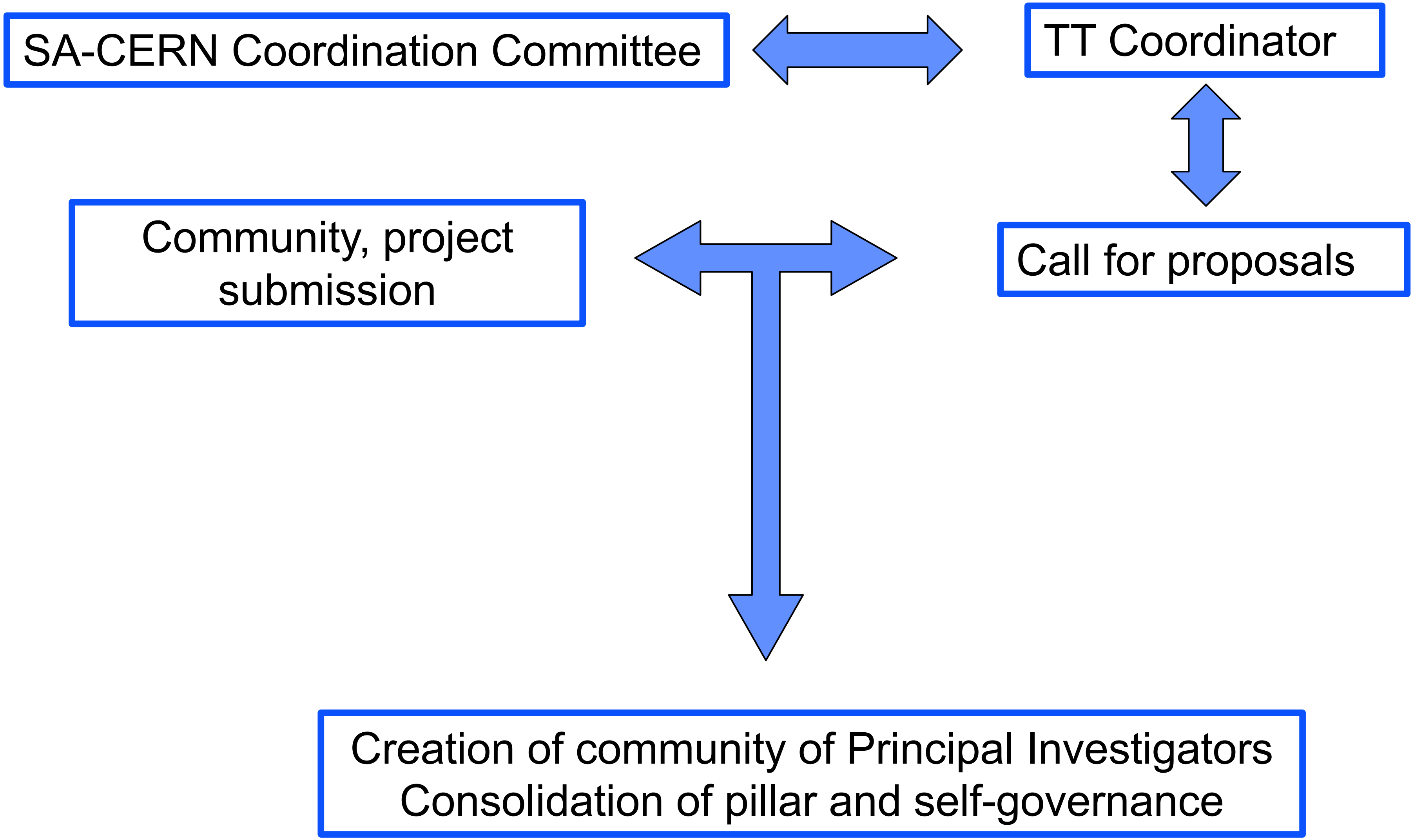
Tech and knowledge transfer to SA industry

Projects with SA industry based on niche areas of expertise

Facilitation of incubation efforts

Relations with TIA, and incubation centres (TuksNovation, Tshimologong Precint, Propella, LaunchLab, Solution Space, Invotech, etc…)

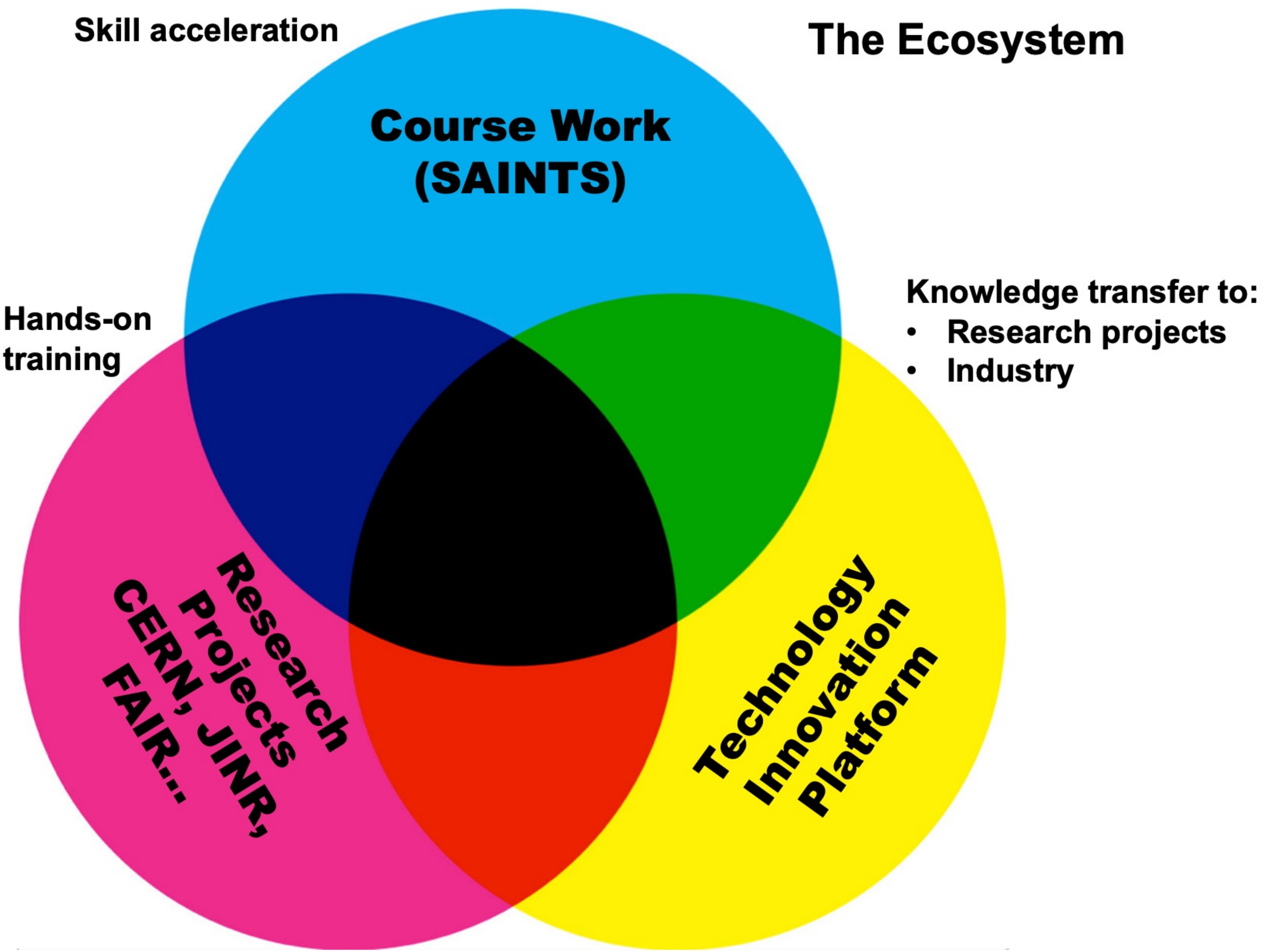
Initial Governance



The SA-CERN technology transfer pillar concerns itself with CERN-related activities in a wide range of disciplines that include, <u>but are not limited to:</u>

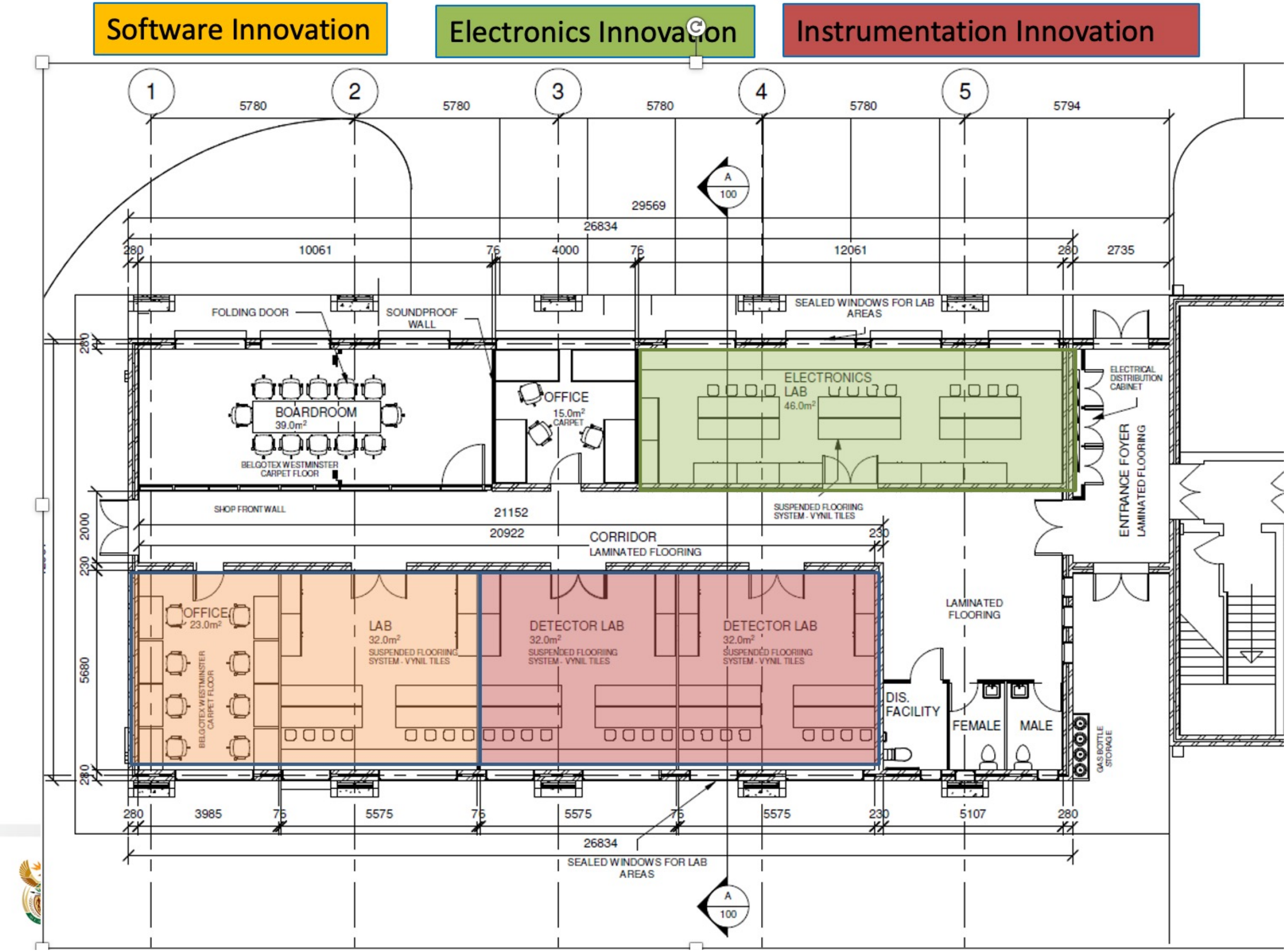
- Data Science, Big Data and Artificial Intelligence
- Electrical Engineering
- Accelerator Physics
- Medical Physics
- Quantum Computing

The Technology Innovation Platform

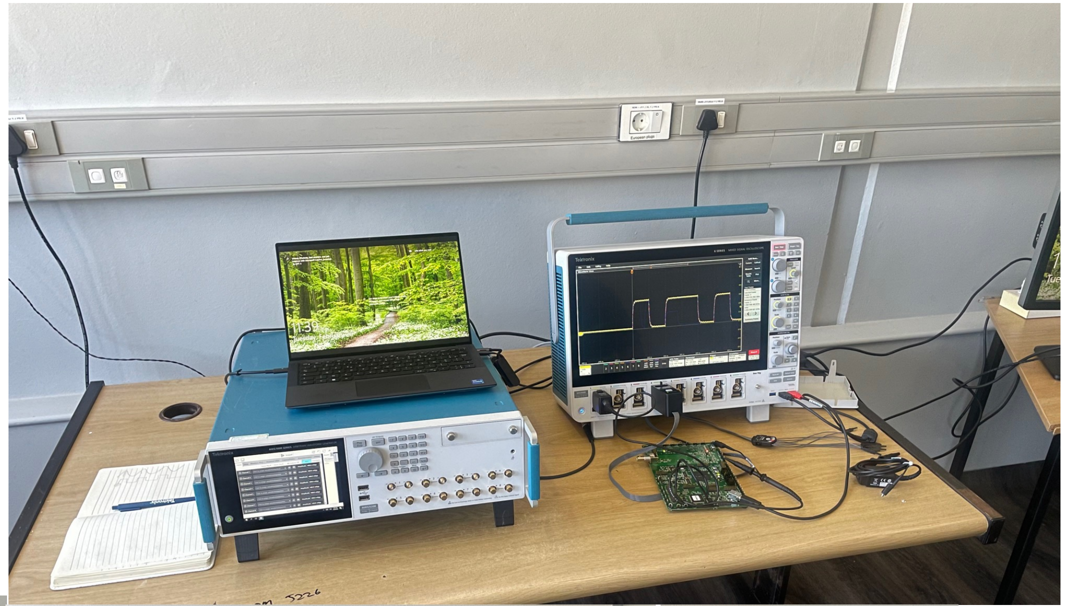

Skill acceleration
The Ecosystem
Course Work (SAINTS)
Hands-on training
Knowledge transfer to:
• Research projects
• Industry
Research Projects CERN, JINR, FAIR…
Technology Innovation Platform

Technology and Innovation Platform

- Developing innovative technology skills and know-how
- Sharing of technology with other facilities and universities
- Transfer of technology to industry

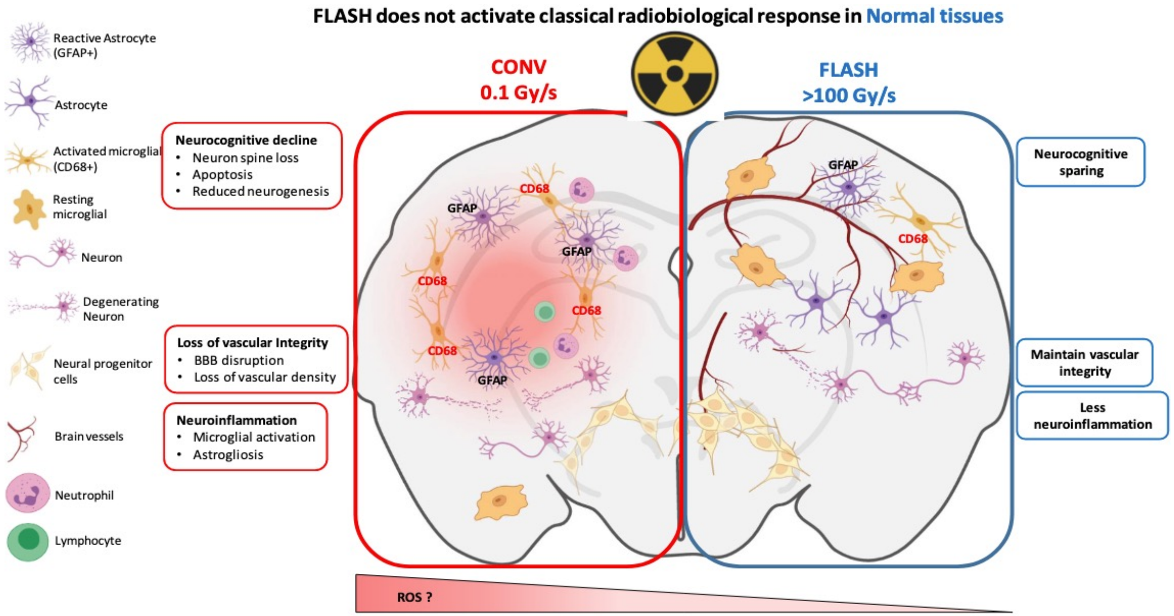


Software Innovation
Electronics Innovation
Instrumentation Innovation
FOLDING DOOR
SOUNDPROOF WALL
SEALED WINDOWS FOR LAB AREAS
BOARDROOM 39.0m²
BELGOTEX WESTMINSTER CARPET FLOOR
OFFICE 15.0m² CARPET
ELECTRONICS LAB 46.0m²
ELECTRICAL DISTRIBUTION CABINET
ENTRANCE FOYER LAMINATED FLOORING
SHOP FRONT WALL
SUSPENDED FLOORING SYSTEM - VYNIL TILES
CORRIDOR
LAMINATED FLOORING
OFFICE 23.0m²
BELGOTEX WESTMINSTER CARPET FLOOR
LAB 32.0m²
SUSPENDED FLOORING SYSTEM - VYNIL TILES
DETECTOR LAB 32.0m²
SUSPENDED FLOORIING SYSTEM - VYNIL TILES
DETECTOR LAB 32.0m²
SUSPENDED FLOORIING SYSTEM - VYNIL TILES
LAMINATED FLOORING
DIS. FACILITY
FEMALE
MALE
GAS BOTTLE STORAGE
SEALED WINDOWS FOR LAB AREAS
A 100



The Ecosystem of Projects

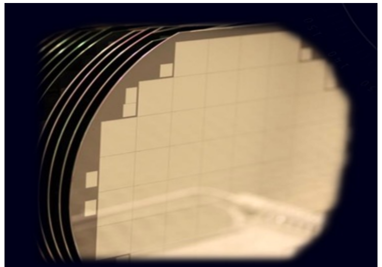
Application of LGADs in Flash Radiotherapy



- New trend in tumors treatments. Shows promising results with minimal side effects.
- **Requires Fast beam monitors to perform feedback on beam position and fluence**

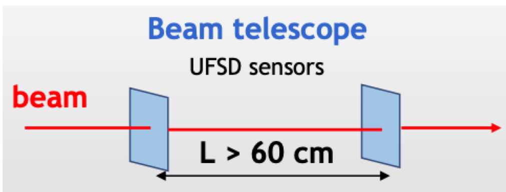
LGAD sensors (ns)

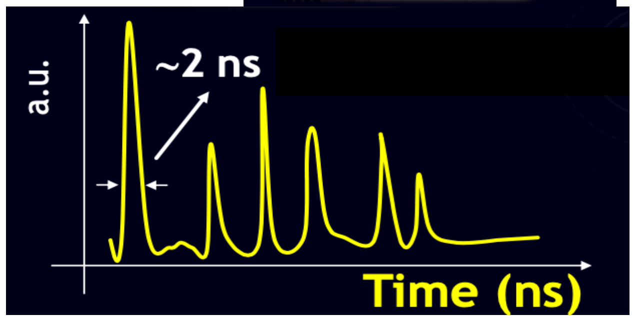
- Several R&D projects for LGAD-based beam monitors for particles counting and energy measurement, hadron radiotherapy (CERN/CH, USA, EU)



LGAD-BASED ONLINE

- Particle counter as beam fluence monitor
- Beam energy monitor based on Time of Flight



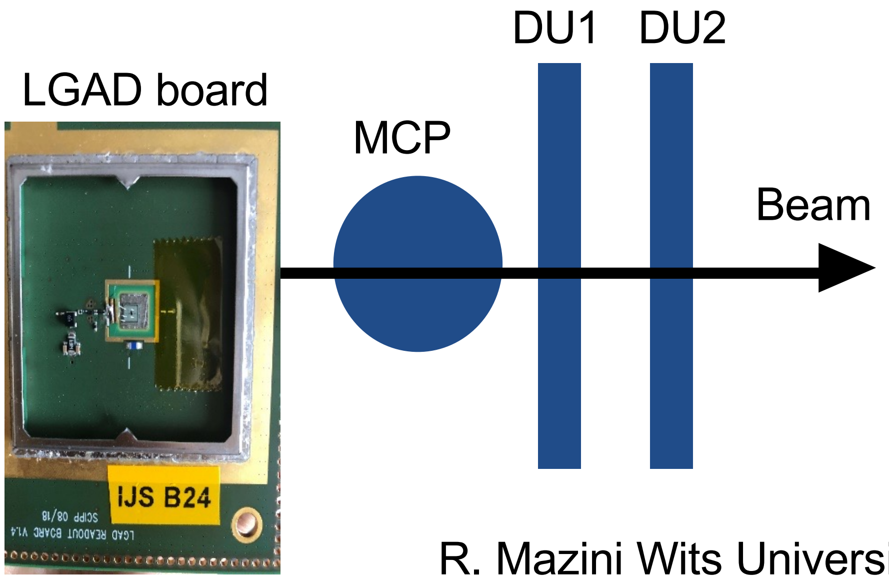


Beam Monitoring R&D at Wits

- Setting-up a bench test for LGAD use in beam monitoring
- Using IThemba lab accelerator system (Tandem and AMS)

- **Different ions beam with 6-200 MeV energy and size from few μm to mm**
- **Suitable for beam position scanning, time resolution and energy measurement**

- LGAD protypes from ATLAS HGTD project (single and multipad sensors)
- Other LGAD sensors from IHEP sensitive to low-energy γ's. Application in PET and imaging.
- Plan to manufacture PCB cards locally with the help of Wits/iThemba technical support.



R. Mazini Wits University

Positron Emission Tomography

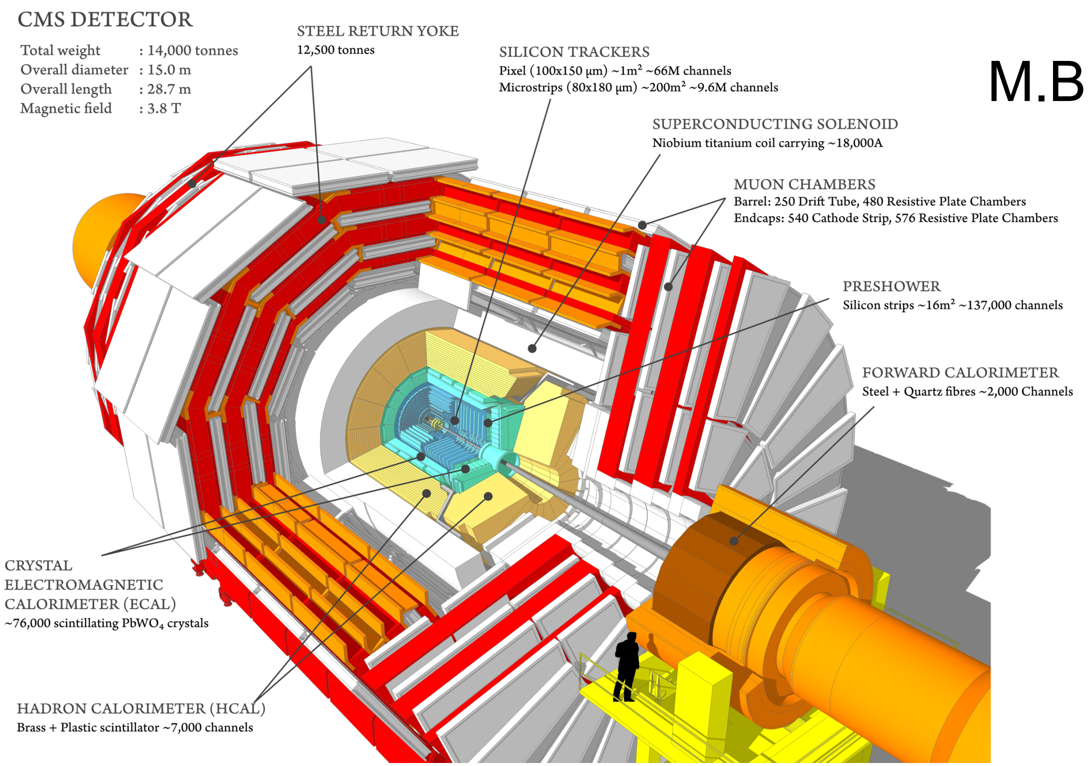
How it works

1. **A gamma ray interacts with a scintillation crystal.**
2. **The interaction excites electrons in the crystal, causing them to transition to the conduction band.**
3. **The excited electrons decay, emitting photons of a specific wavelength.**
4. **The photons are collected by a photodetector.**
5. **The photodetector converts the light into an electrical signal.**
6. **The electrical signal is processed to create the PET image.**

https://www.youtube.com/watch?v=oySvkmezdo0

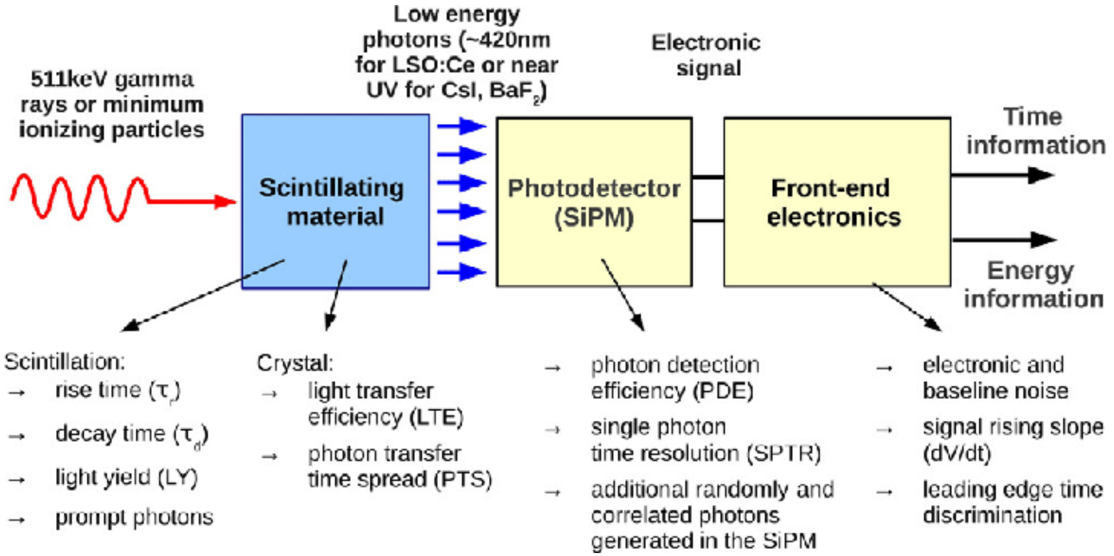
Crystal property	Purpose
High density	High γ-ray detection efficiency
High atomic number	High γ-ray detection efficiency
Short decay time	Good coincidence timing
High light output	Allows large number of crystal elements per photodetector
Good energy resolution	Clear identification of full energy events
Emission wavelength near 400 nm	Good match to photomultiplier tube response
Transparent at emission wavelength	Allows light to travel unimpeded to photomultiplier tube
Index of refraction near 1.5	Good transmission of light from crystal to photomultiplier tube
Radiation hard	Stable crystal performance
Nonhygroscopic	Simplifies packaging
Rugged	Allows fabrication of smaller crystal elements
Economic growth process	Reasonable cost

M.Blumenthal



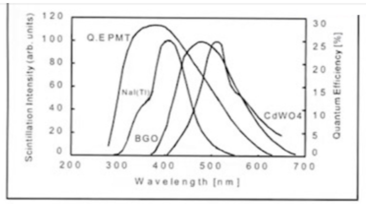
Scintillator Detector

M.Blumenthal

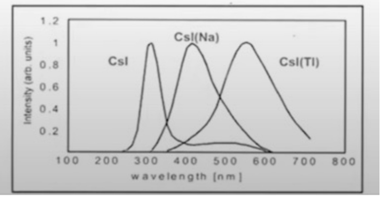


Light Output & Decay Time

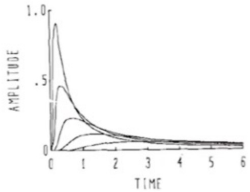
- Since photoelectron statistics plays a key role in the accurate determination of the energy of the radiation, the use of scintillation materials with a high light output is preferred.
- The scintillator emission wavelength should be matched to the sensitivity of the light detection device that is used (PMT or photodiode).



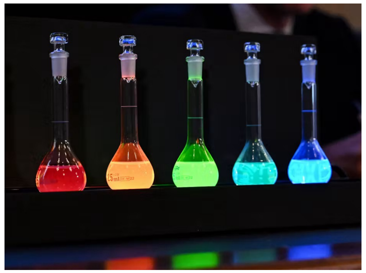
Emission spectra of NaI(Tl), BGO and $CdWO_4$ scaled on maximum emission intensity.



- Scintillation light pulses (flashes) are usually characterized by a fast increase of the intensity in time (pulse rise time) followed by an exponential decrease (decay time).
- Fast rise time is important for narrow coincidence timing window:
  - Reduced random coincidences ('randoms')
  - Enabling time of flight (TOF)
- Fast decay time (defined by the time after which the intensity of the light pulse has returned to 1/e of its maximum value), is important for:
  - Reduced deadtime



Quantum Dots



nature communications

Article

https://doi.org/10.1038/s41467-024-48351-9

Bright and durable scintillation from colloidal quantum shells

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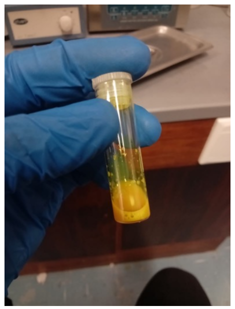
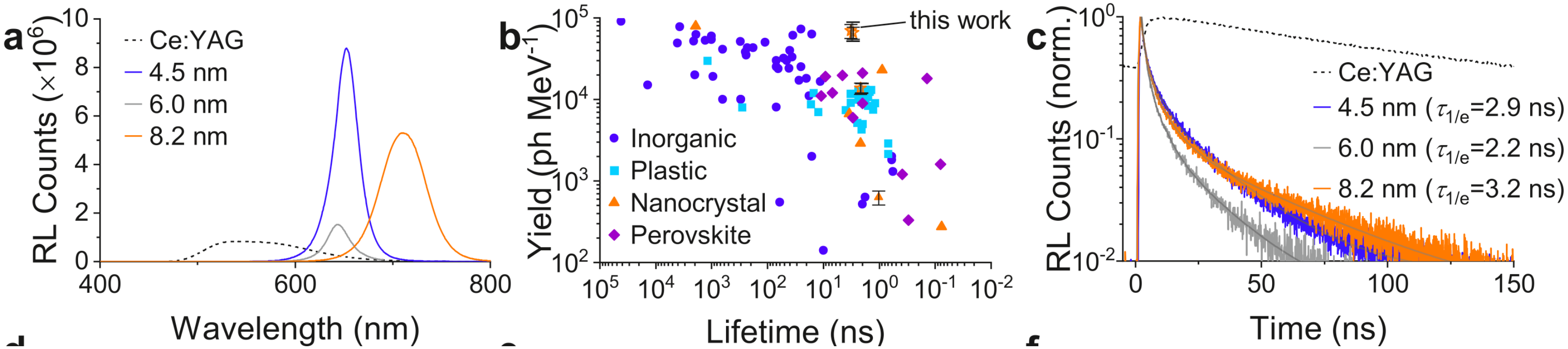
Burak Guzelturk[1], Benjamin T. Diroll[2], James P. Cassidy[3], Dulanjan Harankahage[3], Muchuan Hua[2], Xiao-Min Lin[2], Vasudevan Iyer[4], Richard D. Schaller[2,5], Benjamin J. Lawrie[4,6] & Mikhail Zamkov[3]



Cds



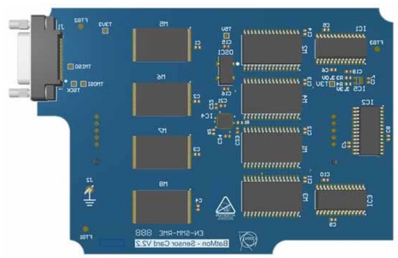
Radiation-Tolerant Multi-Application Wireless IoT Platform - System design prototype

- IoT in a particle accelerator is not a new concept: i.e ATLAS CERN control system
- The control system is missing **wireless** capabilities

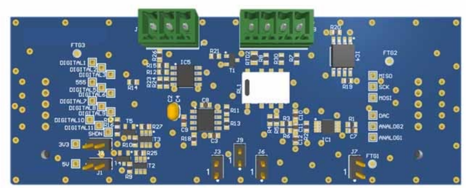
- Modular design supports multiple sensor configurations.
- Low-power system with standardised interfaces (I2C, SPI, USART).
- Reliable operation in high-radiation environments.

Functions Available
5 V, 3.3 V
I2C
USART
2 ADC
DAC or + 1 ADC
7 GPIOs Configurable (EXTI, PWM)
SPI

Sensor Board

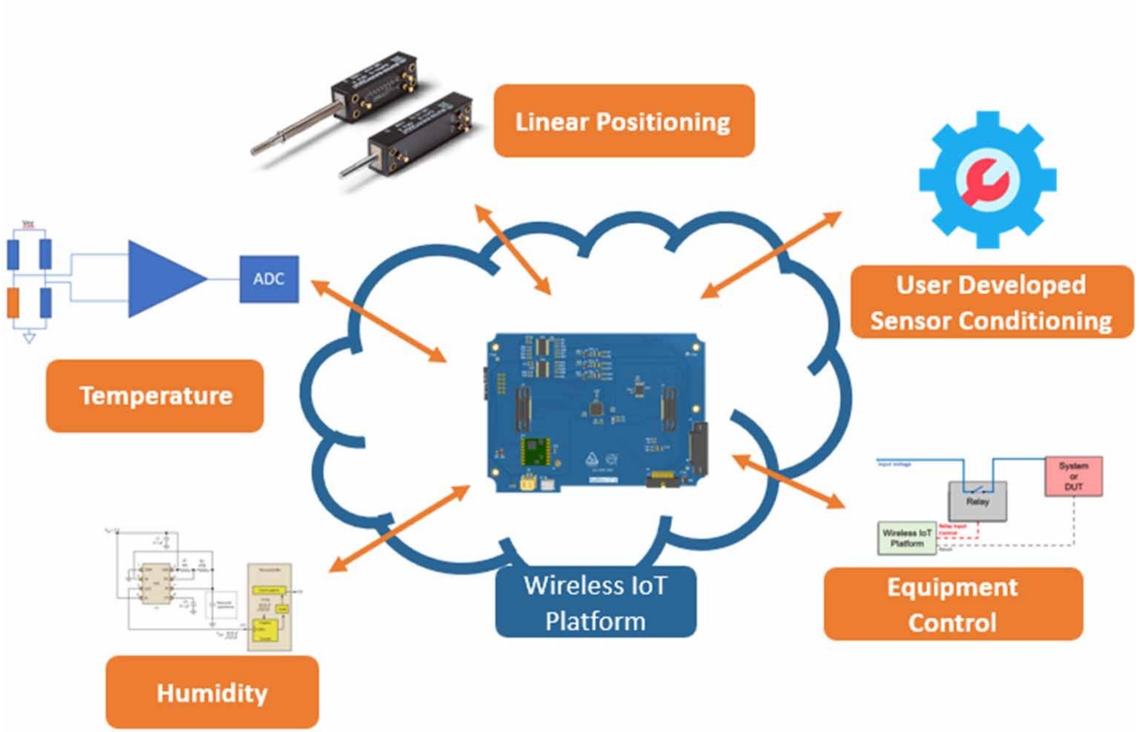


Sensor Board



Applications Examples

- The platform will be application independent
- Allow any user to develop its own sensor board:
  1. Interface any sensor with the IoT platform
  2. Send data via LoRa
- Use cases:
  - Radiation Monitoring
  - Temperature and Humidity sensor card
  - Position Sensor
  - Equipment Control

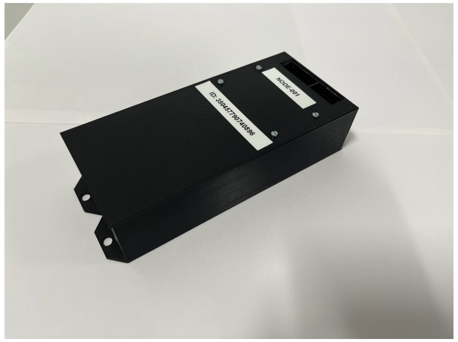


E.Nkadimeng

High-Performance Research Data Management Systems
PI: Mattia Vaccari (UCT/IDIA) - Co-PI: James Keaveney

- CERN has long been the big data international science centre par excellence
- South Africa must develop HPC and RDM expertise to make the most of the SKA
- (South) Africa can build on the SKA to better support other science disciplines
- This UCT-led project aims to leverage CERN's experience in developing, deploying and supporting advanced Research Data Management Software Systems for Big Science
- We will focus on the Rucio and InvenioRDM tools developed at CERN and specifically:

1) Establish a working relationship with the CERN Rucio and Invenio teams through virtual meetings and virtual collaboration platforms for remote collaboration/development
2) Define minimum viable products for Rucio deployment at UCT eResearch and IDIA and Invenio deployment at UCT eResearch, project requirements and project schedules
3) Deploy Rucio and Invenio in sandbox environments
4) Work with CERN Rucio and Invenio teams during visits to CERN to debug and optimise their deployment in sandbox environments
5) Move Rucio and Invenio to production institution-wide (UCT) and consortium-wide (IDIA)
6) Present our experience to and share expertise with other SA-CERN members



AI_r: An African Solution for AI Health

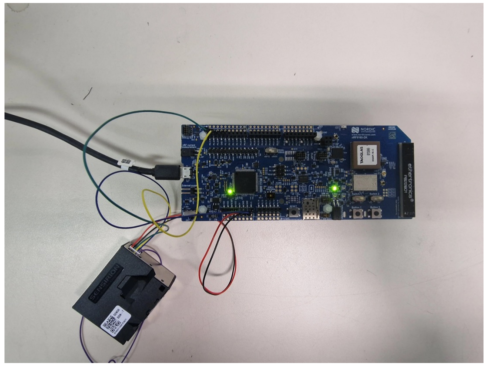
https://www.sacaqm.org

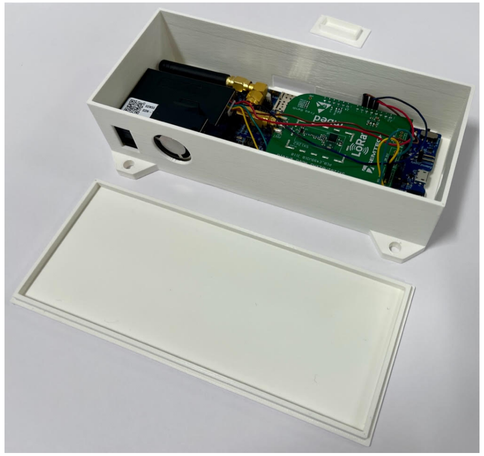
AI_r is an integrated system

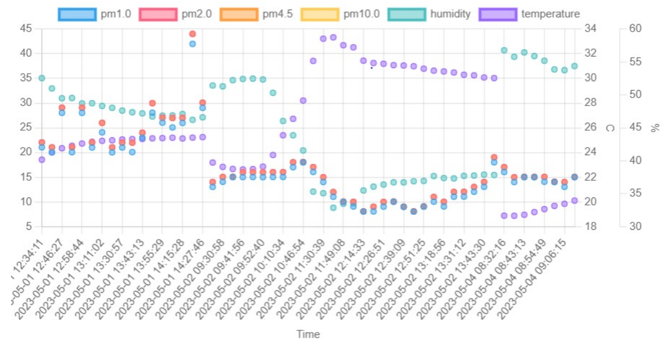
M.Kumar

Air Quality Sensor → IoT Communication through 4G + LoRa → Dashboard + AI modelling

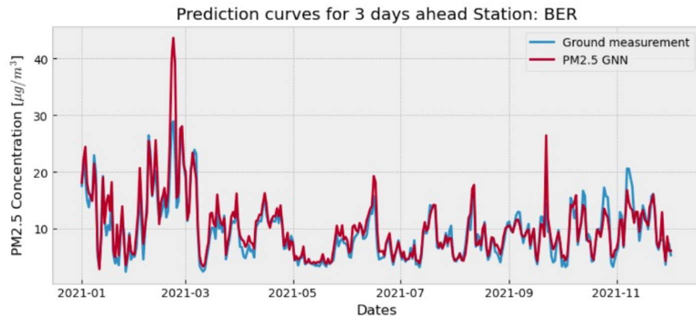
GC-0036







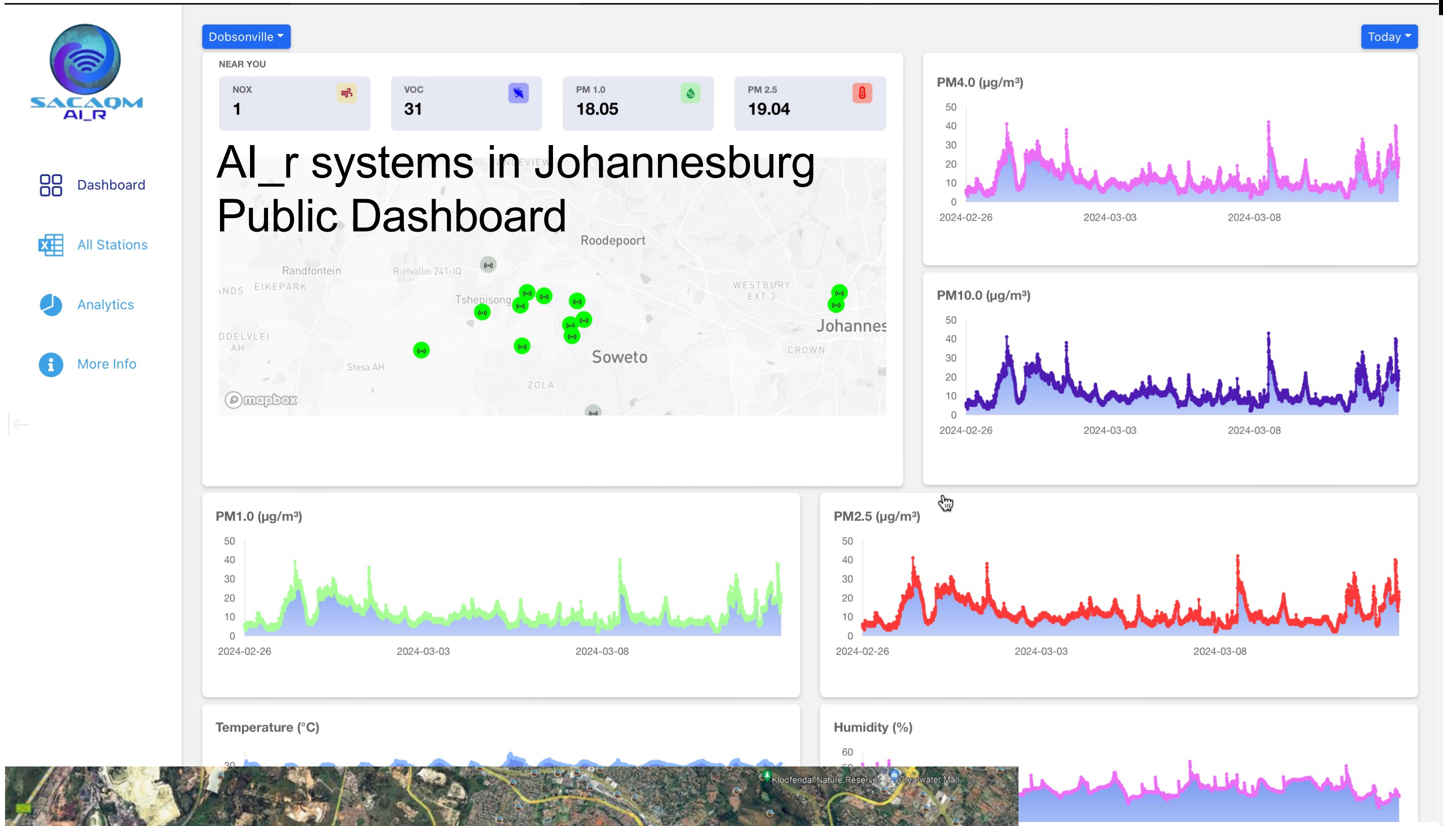
Predictive Deep Learning



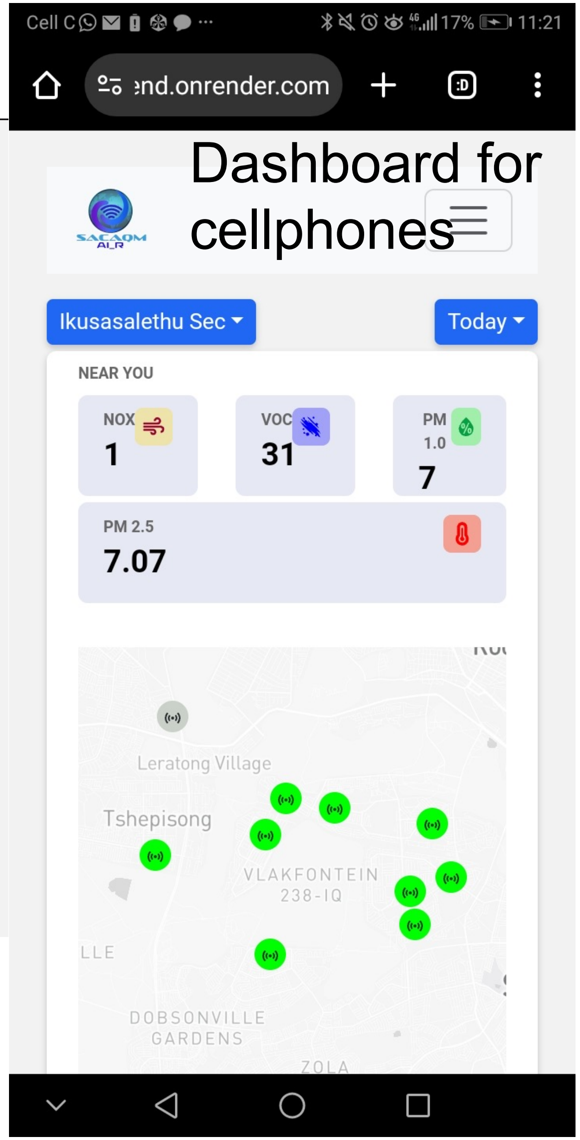
Cost of hardware is at least 2.5 times cheaper than competitors in the market.
No offerings in the market provide integrated AI-modelling.

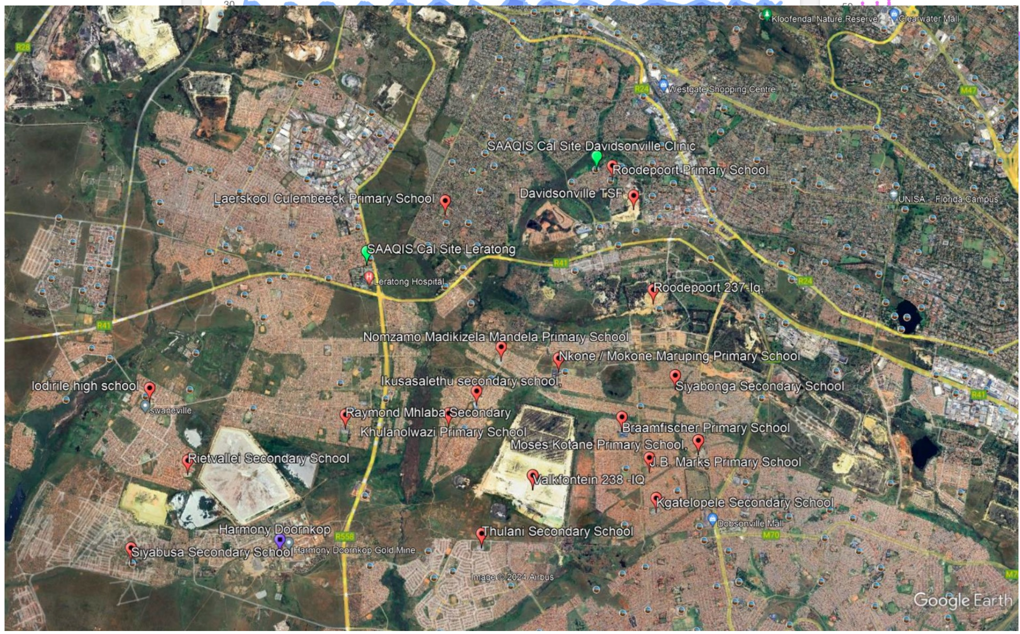
Towards large-scale deployment or AI_r

AI_r systems in Johannesburg Public Dashboard



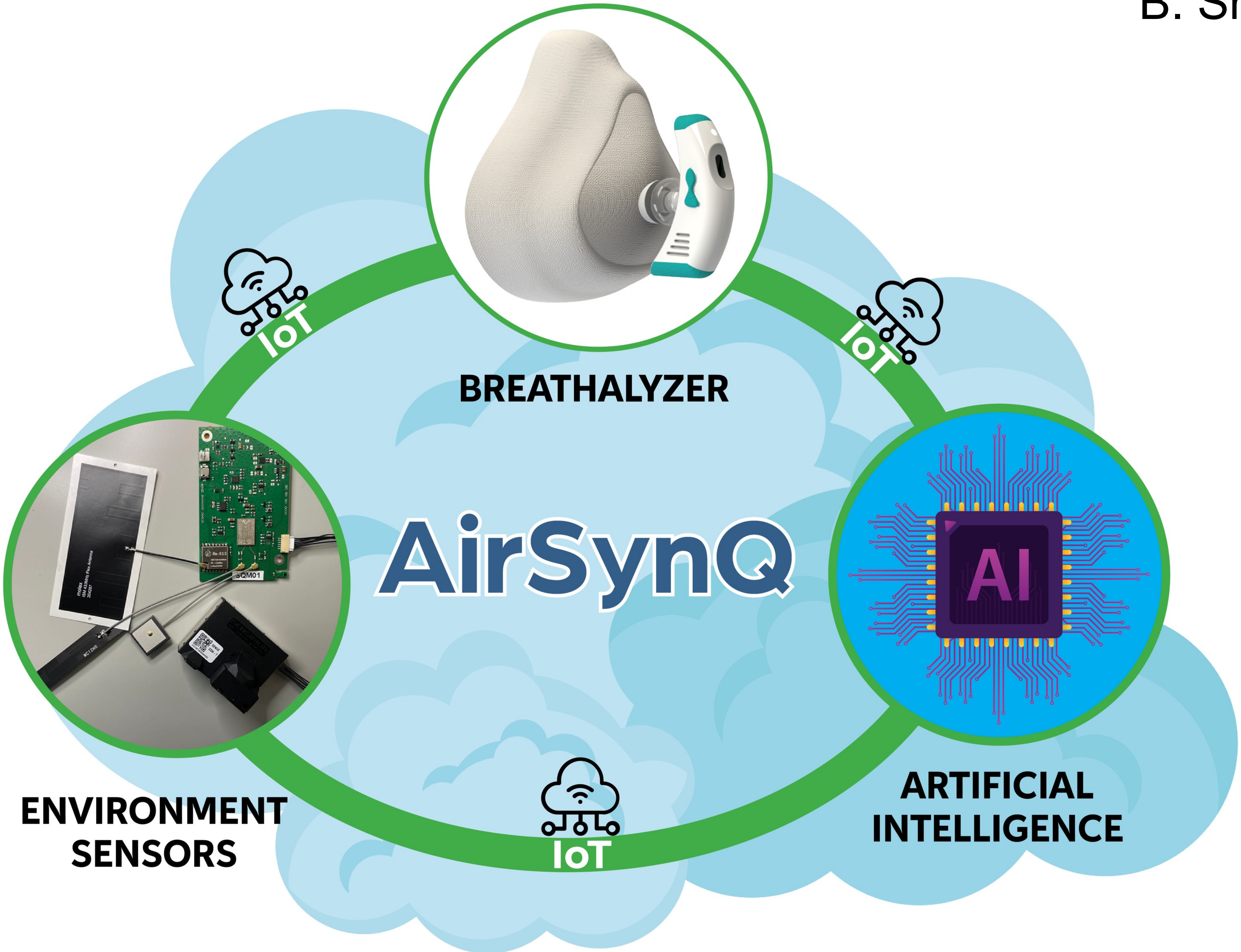
Dashboard for cellphones





Partnered with the Government and the private sector to deploy 300 AI_r systems in South Africa. This would be the largest network of air quality monitoring in Africa

B. Smith


BREATHALYZER
IoT
IoT
AirSynQ
ENVIRONMENT
SENSORS
ARTIFICIAL
INTELLIGENCE
IoT

Climate Change:
Poor air quality and climate change are interlinked: climate change worsens pollution through events like wildfires, while pollution contributes to climate change by emitting greenhouse gases. Addressing both is crucial for public health and environmental protection.

Clinic Application:
AIrSynQ breath monitoring device utilized in clinics for real-time health assessment. Doctors review results on iPad interface for personalized patient insights.

School Implementation:
AIrSynQ sensors installed in schools to monitor air quality and student health. Enhances student safety and well-being by detecting potential health risks early.

AirSynQ

Monitoring Health, Monitoring Air with AI and IoT

Occupational Health:
AIrSynQ sensors seamlessly integrate into workplace environments, promoting employee health and productivity.