The UJ–ATLAS and Associated Innovation Group + UNISA + UWC

- **Staff**
  - Simon Connell (Prof)
  - Muaaz Bhamjee (Sn Lect)
  - Nicolin Govender (Prof)
  - Loan Truong (Lecturer, Visiting Prof)
  - Francois Pieterse (Sn Lect)
- **Post Docs**
  - Bongani Maqabuka
  - Emmanuel Igumbor
  - Hasina Ralijaona
- **Students**
  - PhD: Phineas Ntsoele
  - PhD: Thendo Nemakhavhani
  - PhD: Matthew Connell
  - MSc: Xola Mapekula
  - MSc: Mr Mitchell Phiri
  - MSc: Gideon Bentum
  - MSc Chris Lee
- **Associate sub-institute**
  - Lerothodi Leeuw (Prof UWC)
  - Pedro Mafa (Dr UNISA)
  - Mantile Lekala (Prof UNISA)
- **Necsa Associates**
  - Dr Graham Daniels, Dr Dazmen Mavunda, Eric Chinaka, Linina Bedhesi
- **Research Associates**
  - Dr Martin Cook (SRA UJ),
  - Dr Sergio Ballestrero (SRA UJ)
  - Tim Brooks (SRA UJ)



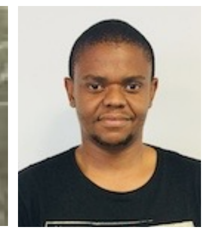
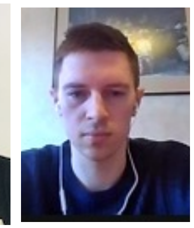




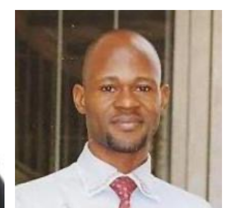

+ many colleagues from ATLAS
Prof Kétévi Assamagan
BNL







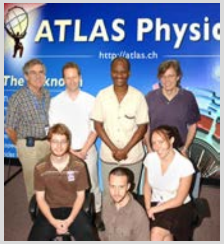







ATLAS
Innovation

UJ in ATLAS Timeline ….. Many 1st achievements



3 Students learn Grid Computing in USA

UJ organises 1st Grid School in SA

SA-CERN launched

UNISA partner with UJ in ATLAS Astro + HEP

1st Commercialization ?
Proposed partners
UJInvnt
Gem Diamonds
Letśeng Mine
NeT Instruments
Research Instruments
Cosylab

Dr C Lee 1st SA PhD in ATLAS

2005 — 2010 — 2015 — 2020

Physics + Outreach + Tech Transfer

MinPET + Reactor Physics + Grid Computing

Staff members in TDAQ HPC / Engineering

Extreme Sensors

Health

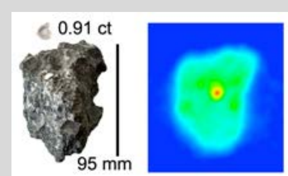
K Assamagan (BNL) visits SA to arrange entry into ATLAS

UJ 1st SA entity in ATLAS as a Sub-Institute of BNL

SA-ATLAS launched

Necsa partner with UJ in ATLAS

PET, PEPT, SPECT

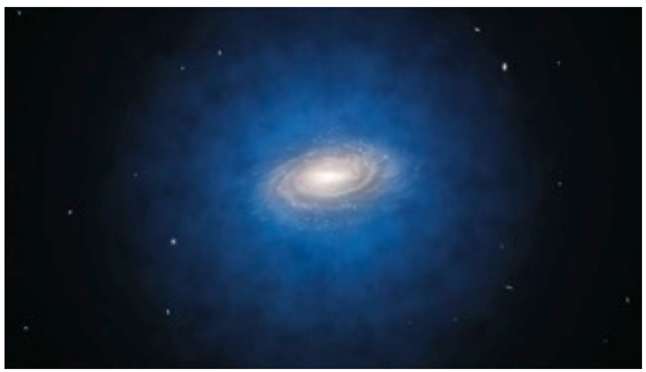


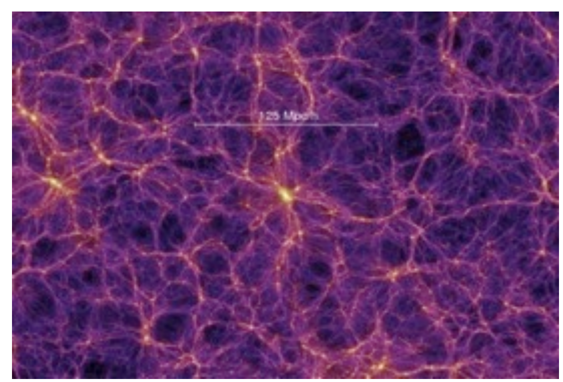
Necsa and ESKOM / Koeberg

Modelling and CFD in COVID-19

Analysis : Physics motivated by searches for Dark Matter

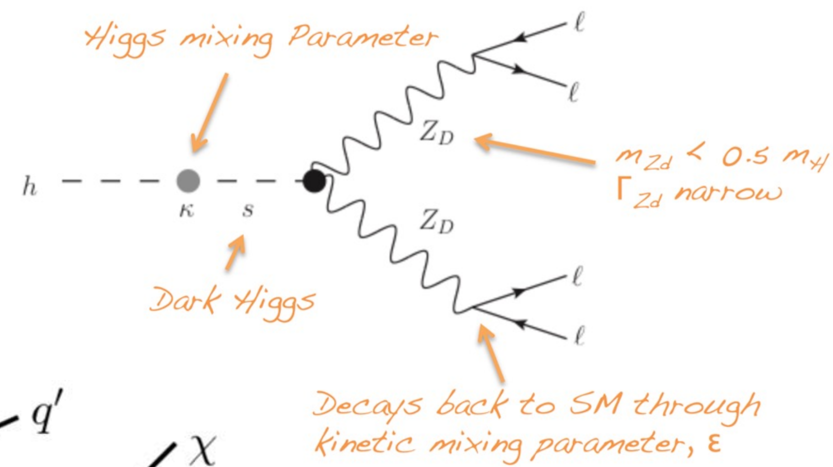
- Standard Model (SM) has deficiencies
  - Many free parameters, no DM or DE, (anti)matter paradox, hierarchy problem, strong CP problem, no gravity …
- Hidden (dark) sector states introduced with an additional $U(1)_d$ dark gauge symmetry appear in many extensions to the SM, the models are capable of
  - providing a candidate for the dark matter (DM) in the universe
  - explain astrophysical "observations" which may have DM interpretation
- This represents an alternative DM scenario to that of Super Symmetry



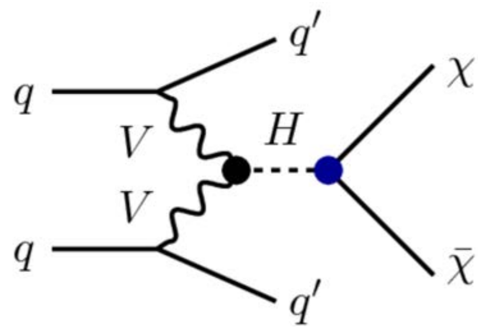



Higgs Portal Models for BSM DM

- J.D. Wells, arXiv:0803.1243, 2008
- S. Gopalakrishna, S. Jung and J.D Wells PRD, 78(5):055002, 2008
- Curtin et al, http://arxiv.org/abs/1312.4992



1. $H \rightarrow Z_d Z_d \rightarrow 4e, 4\mu, 2e2\mu,$
2. $H \rightarrow Z Z_d \rightarrow 4e, 4\mu, 2e2\mu$
3. $S \rightarrow Z_d Z_d \rightarrow 4e, 4\mu, 2e2\mu$
4. $S \rightarrow Z_d Z_d \rightarrow 4e, 4\mu, 2e2\mu + 2j$
5. $S \rightarrow Z_d Z_d \rightarrow 4e, 4\mu, 2e2\mu + \text{MET}$



6. $H \rightarrow$ invisible (VBF)

7. $H \rightarrow \gamma\gamma_d$

Analysis : The Higgs Portal to the Hidden sector with Z_d

UNIVERSITY OF JOHANNESBURG

Latest published result ….. Just gone on the arXiv

arXiv.org > hep-ex > arXiv:2110.13673

Search... All fields Search

Help | Advanced Search

High Energy Physics – Experiment

[Submitted on 26 Oct 2021]

Search for Higgs bosons decaying into new spin-0 or spin-1 particles in four-lepton final states with the ATLAS detector with 139 fb^{-1} of pp collision data at $\sqrt{s} = 13$ TeV

ATLAS Collaboration

Searches are conducted for new spin-0 or spin-1 bosons using events where a Higgs boson with mass 125 GeV decays into four leptons ($\ell = e,\mu$). This decay is presumed to occur via an intermediate state which contains two on-shell, promptly decaying bosons: $H \to XX/ZX \to 4\ell$, where the new boson X has a mass between 1 and 60 GeV. The search uses pp collision data collected with the ATLAS detector at the LHC with an integrated luminosity of 139 fb^{-1} at a centre-of-mass energy $\sqrt{s} = 13$ TeV. The data are found to be consistent with Standard Model expectations. Limits are set on fiducial cross sections and on the branching ratio of the Higgs boson to decay into XX/ZX, improving those from previous publications by a factor between two and four. Limits are also set on mixing parameters relevant in extensions of the Standard Model containing a dark sector where X is interpreted to be a dark boson.

Comments: 65 pages in total, author list starting page 49, 20 figures, 6 tables, submitted to JHEP. All figures including auxiliary figures are available at this http URL

Subjects: **High Energy Physics – Experiment (hep-ex)**

Report number: CERN-EP-2021-193

Cite as: arXiv:2110.13673 **[hep-ex]**

(or arXiv:2110.13673v1 **[hep-ex]** for this version)

Download:

- PDF
- Other formats

Current browse context:
hep-ex

< prev | next >

new | recent | 2110

References & Citations

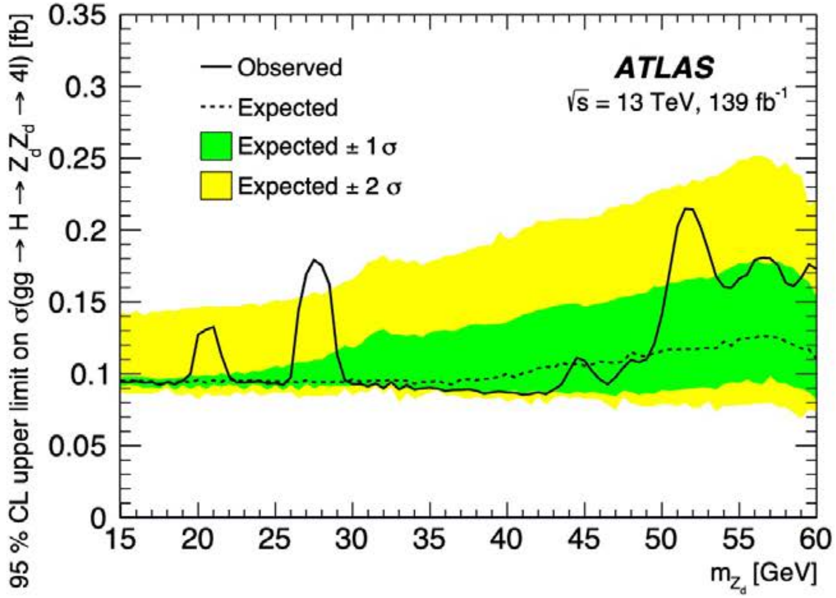
- INSPIRE HEP
- NASA ADS
- Google Scholar
- Semantic Scholar

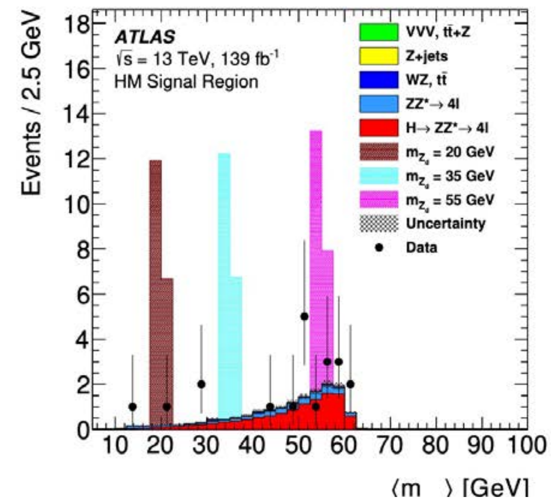
Export Bibtex Citation

Bookmark

Analysis : The Higgs Portal to the Hidden sector with Z_d

Latest published result ….. Just gone on the arXiv





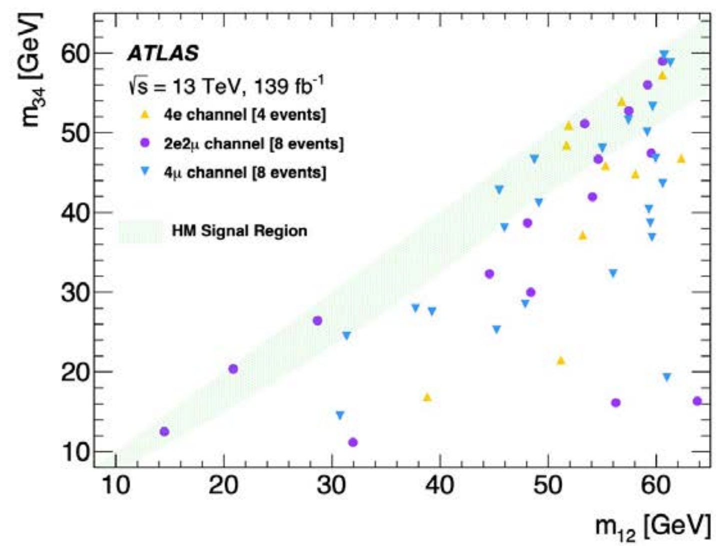
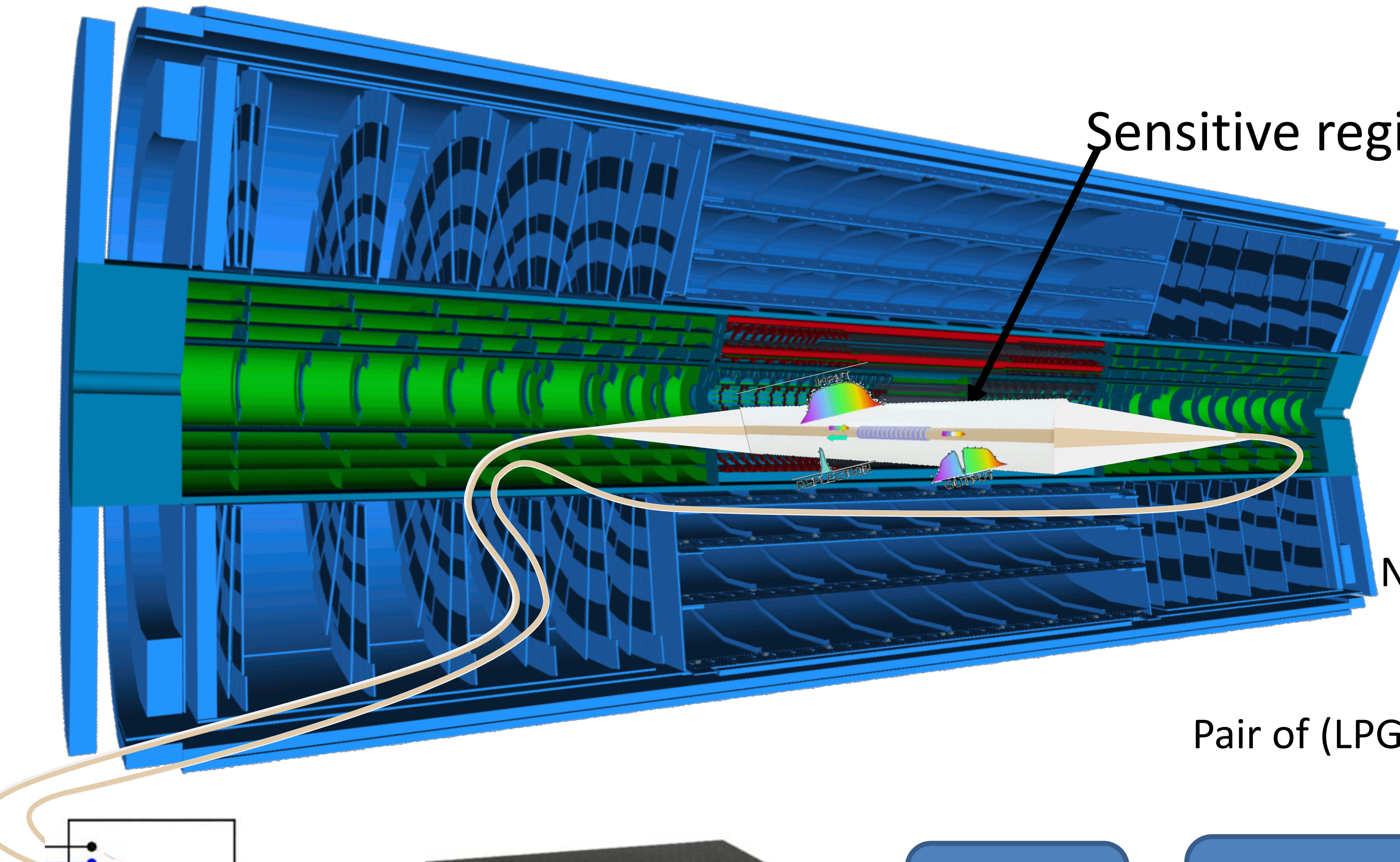
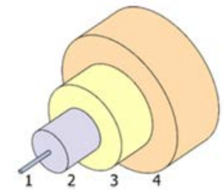


Figure 3: Distribution of (a) $\langle m_{\ell\ell}\rangle$ and (b) m_{34} vs m_{12}, for events selected in the HM $H \to XX \to 4\ell$ ($15\,\text{GeV} < m_X < 60\,\text{GeV}$) analysis. In the $\langle m_{\ell\ell}\rangle$ distribution (a), the (pre-fit) background expectations are also shown; the hatched band contains the statistical and systematic uncertainties. The expectations for the signal are also shown, for several masses. The signal histograms are stacked on top of the background histograms, and expected yields are normalized with $\sigma(pp \to H \to Z_d Z_d \to 4\ell) = \frac{1}{10}\sigma_{SM}(pp \to H \to ZZ^* \to 4\ell) = 0.60$ fb (ggF process only). The uncertainties of the plotted data are asymmetric and are calculated using Eqs. (40.76) of Ref. [156]. For the m_{34} vs m_{12} distribution (b), each marker corresponds to an event that passed the Higgs boson window requirement and Z boson veto. The markers (differentiated by channel) that fall inside the green shaded area correspond to the events of the signal region.

Upgrade: Keeping the ITk dry. (Humidity / Temperature)





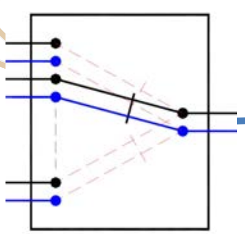
Typical structure of a single mode optical fiber *(not to scale)*

1. Core 8 - 9 μm diameter
2. Cladding 125 μm dia.
3. Buffer 250 μm dia.
4. Jacket 900 μm dia

ATLAS ITK

New radiation hard fibre optic humidity sensors

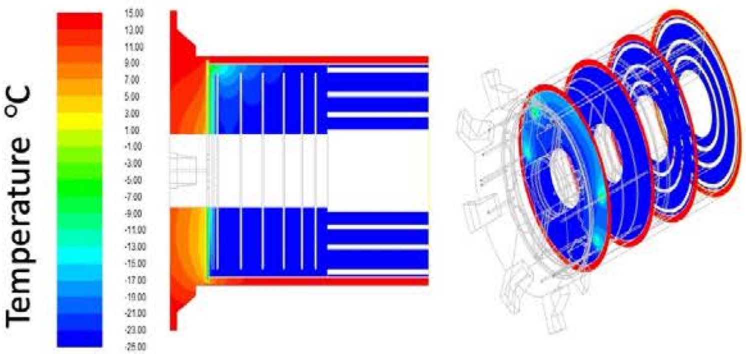
Pair of (LPG for RH, FBG for T)



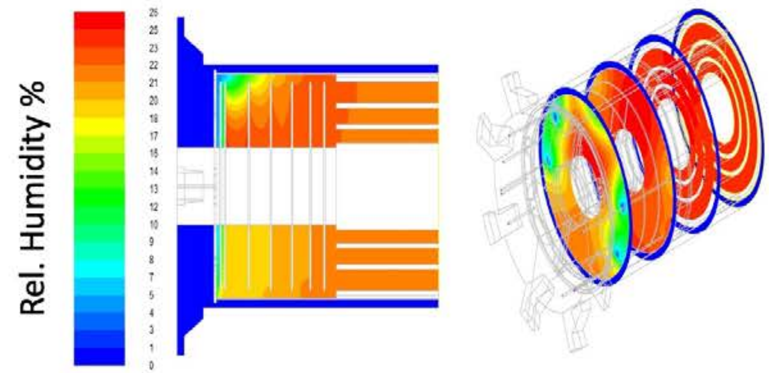
DAQ PC → OPC UA Server → ATLAS P1

CFD simulations for temperature and humidity distribution inside the detector volume … lead by Dr Muaaz Bhamjee

ATLAS ITK Upgrade – N_2 Purging and Humidity Simulations



+

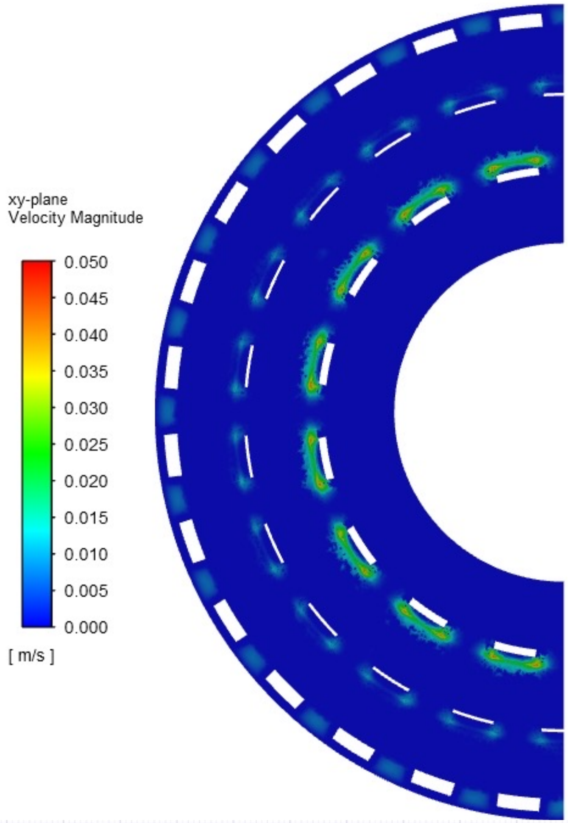


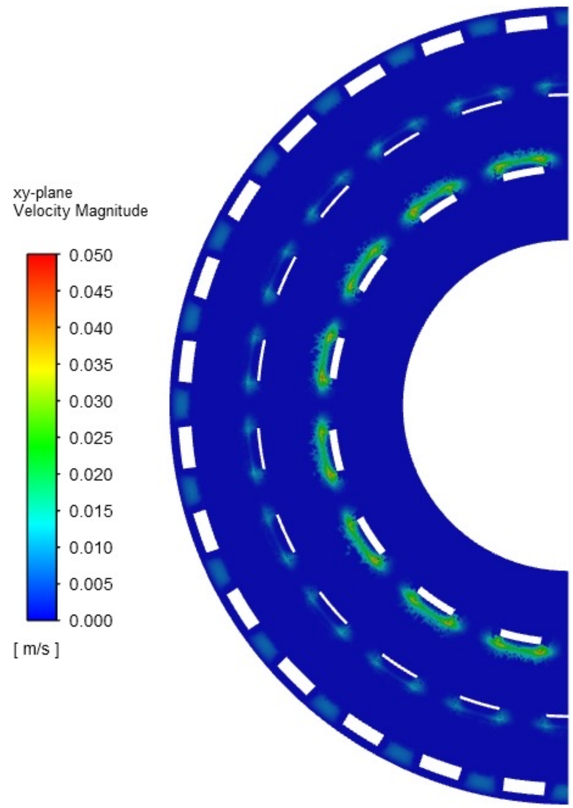
The Dew point was calculated using a the Bögel modification of the Magnus formula:

$$\gamma_m(T, RH) = ln\left(\frac{RH}{100} e^{\left(b - \frac{T}{d}\right)\left(\frac{T}{c+T}\right)}\right)$$

$$T_{dp} = \frac{c\gamma_m(T, RH)}{b - \gamma_m(T, RH)}$$

=

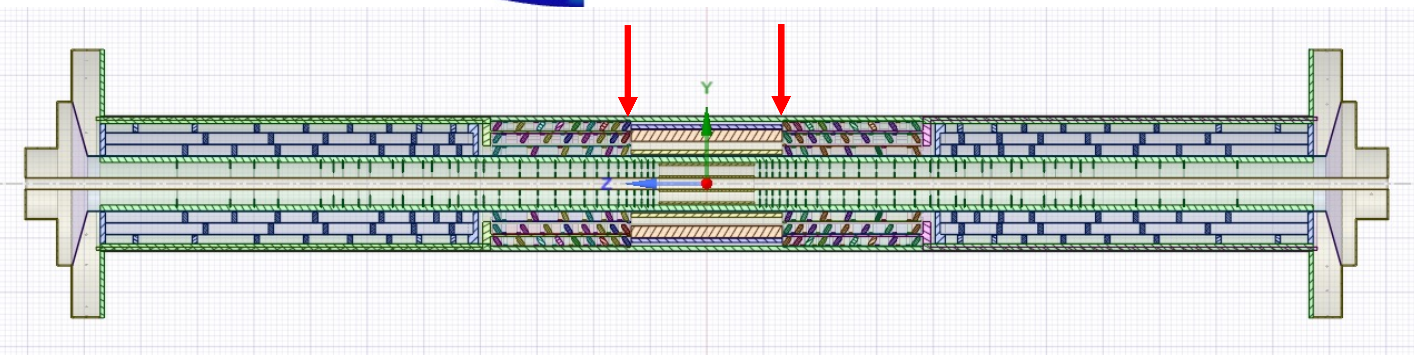




Outer Pixels
CFD simulations for temperature and humidity distribution inside the detector volume

<u>Z +-375mm:</u> 0.05 scale

- **Border between longerons and conical disc sections.**
- **Flow much faster towards the centre.**

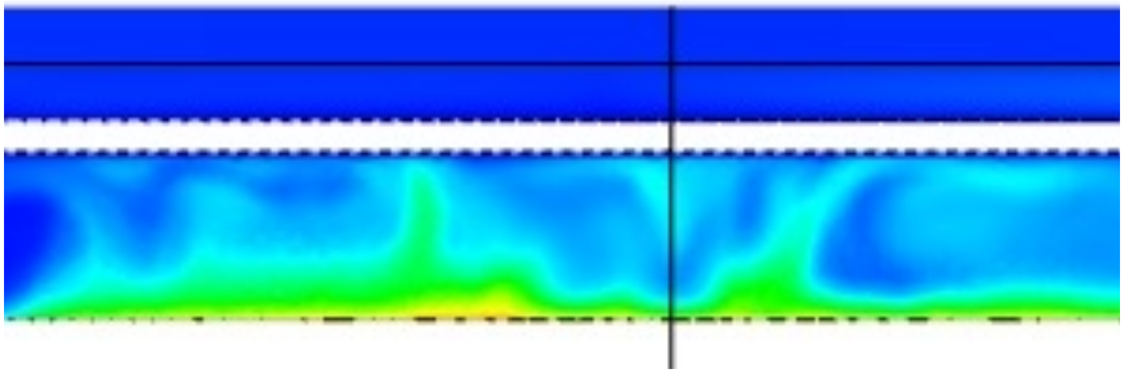


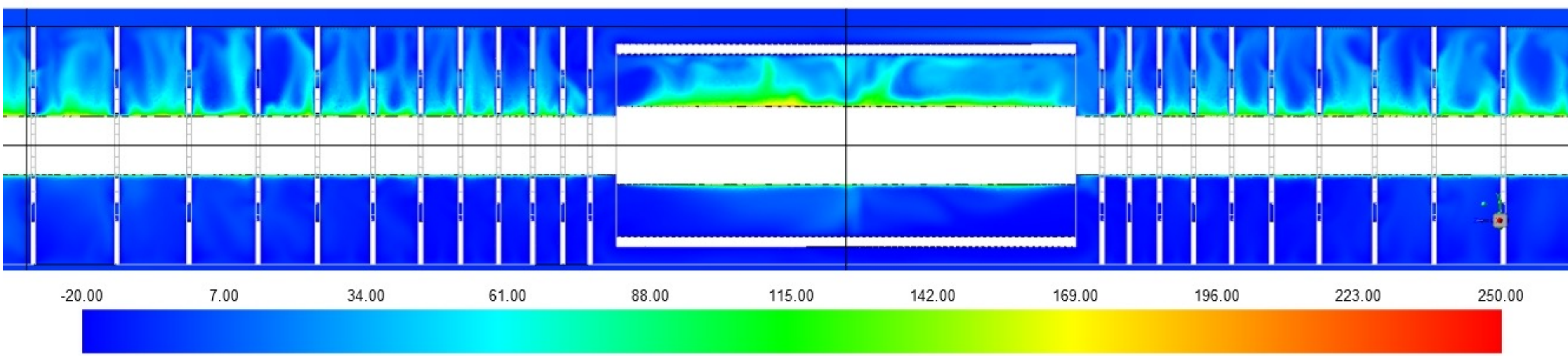
Upgrade: Keeping the ITk dry. (Humidity / Temperature)

Inner Pixels

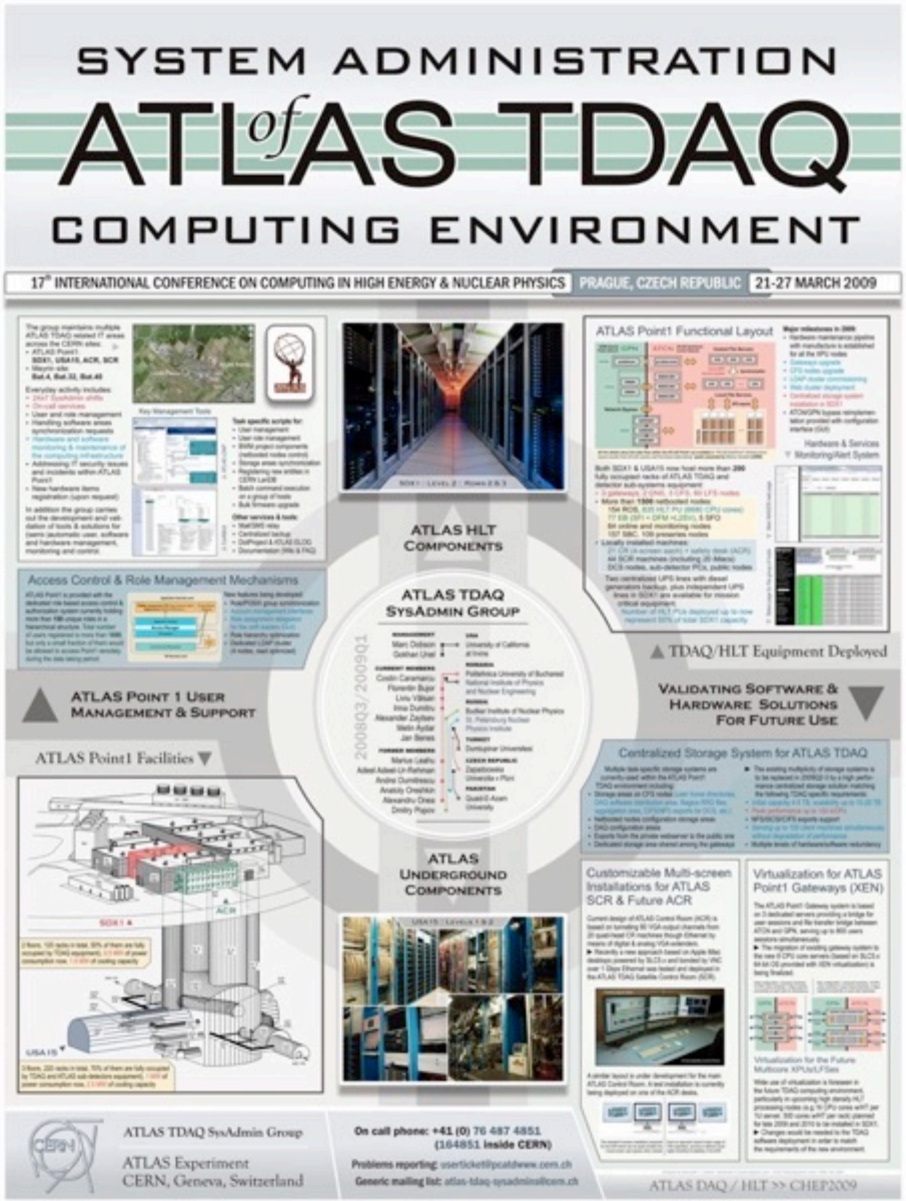
CFD simulations for temperature flow during bakeout …

This version, thermals w/o radiation. Homogeneity improves slightly with radiation





Temperature



- The TDAQ (trigger and data acquisition) has a System Administration Team with one UJ Staff member (Haydn du Plessis – left 31 Jan 2019).
- This section records the data direct from the ATLAS detector, does substantial online analysis, and stores the data.
- Haydn assisting as Sys Admin of the UJ Research cluster.
- Mitchell Phiri started 1 Feb 2019 in the Network section.

Sergio Ballestrero
2008-2012

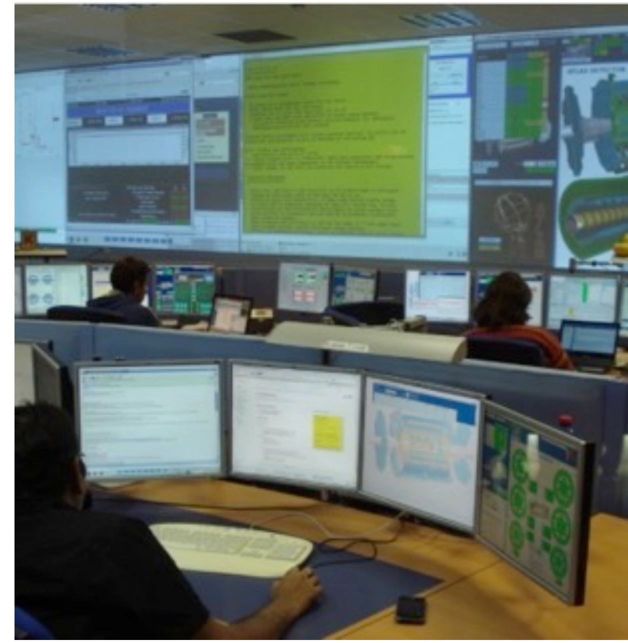
Chris Lee
2012-2015
2019-2021

Haydn du Plessis
2017-2019 Jan

Mitchell Phiri
2019-2020

Operations : Muon ConfigDB in the Control Room

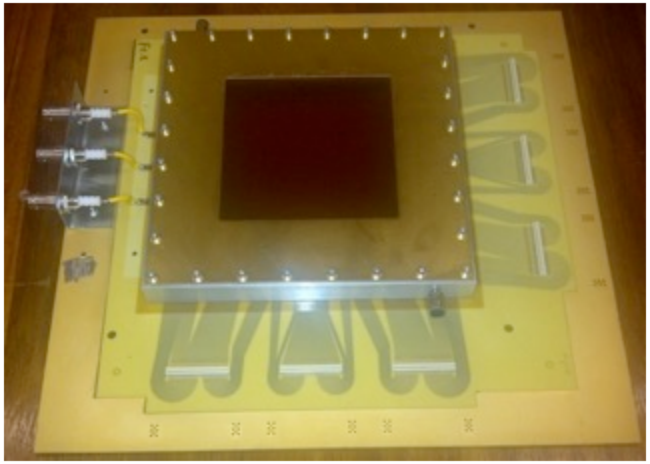
Muon ConfigDB schematic view

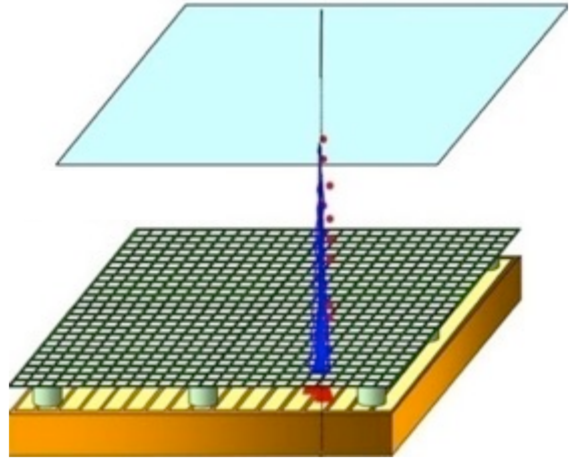


- Provide access in an intuitive way to the Muon Data Base
- Make finding problematic devices/parameters easier for experts
- Keep things simple enough for non-experts

- => Access to DB
- => Identification (user, privileges)
- => GUI

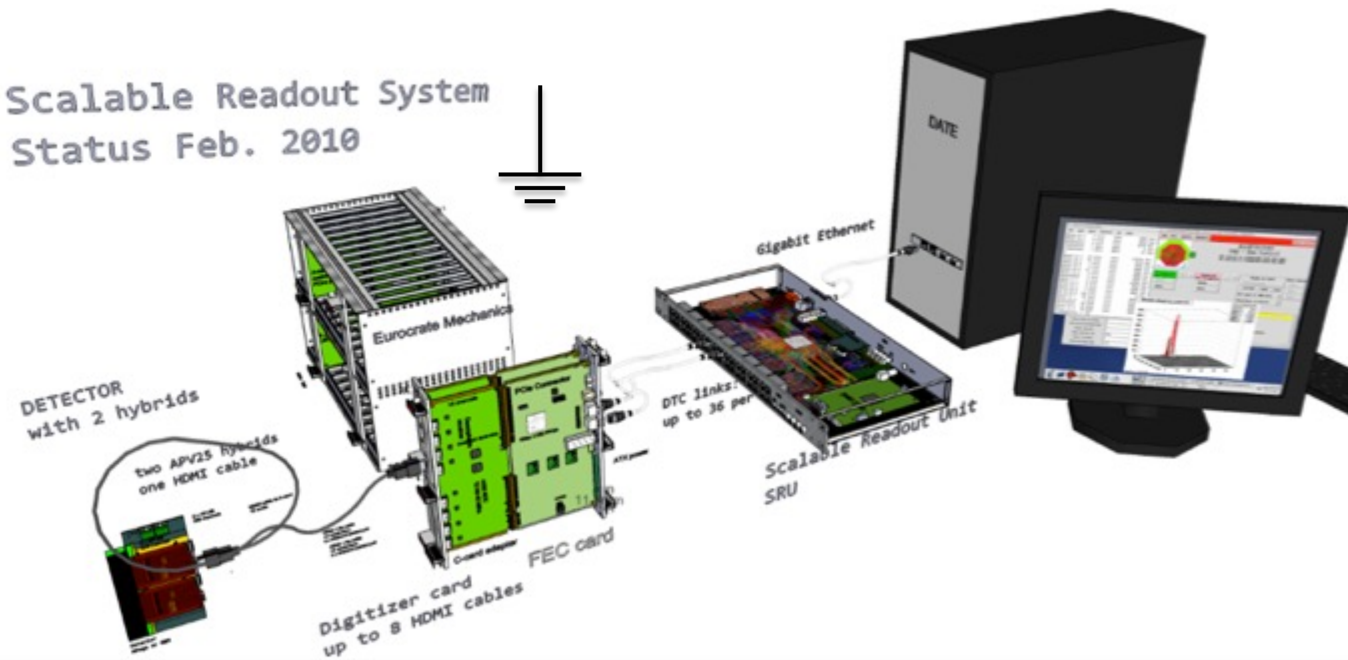
Operations : UJ-ATLAS Detector Lab – Micro-Megas NSW





The UJ and UCT local Lab

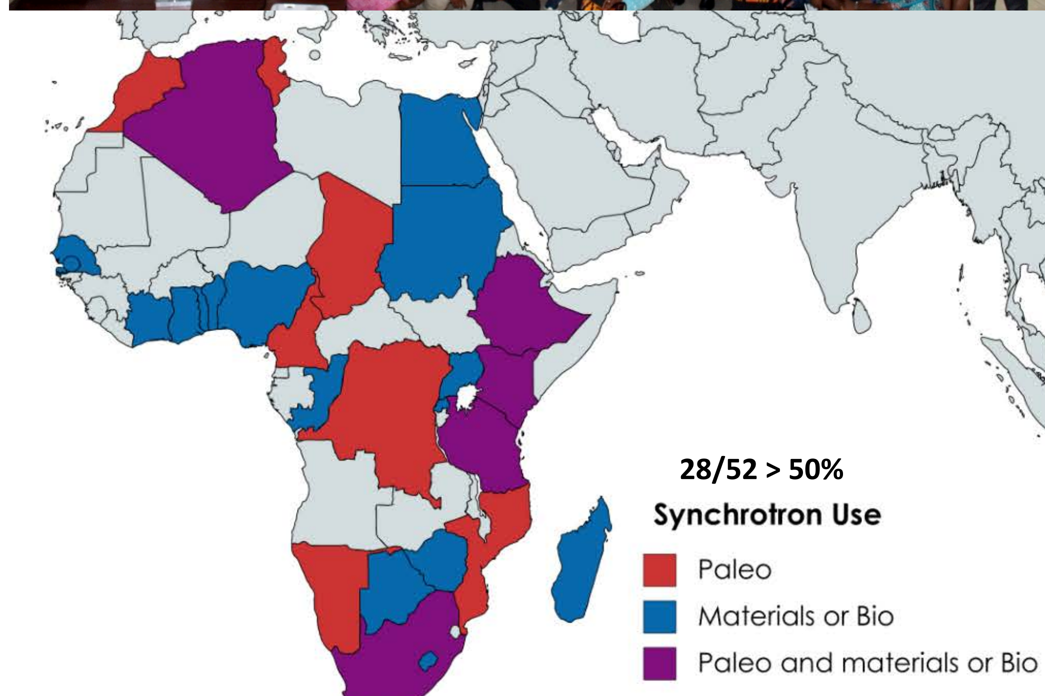
1. R2M NRF NEP / UJ procurement
2. Some procurement shown below



Outreach : Many … one eg. Accelerators for Africa

UNIVERSITY OF JOHANNESBURG

Capacity Building, Regional Infrastructure, African Governments, Pan African organisations.



PhD / Paper / Programme

Towards Innovation

UNIVERSITY OF JOHANNESBURG

Research at ATLAS

1. Physics Discovery searches
2. Upgrade
3. Operation
4. Detector Development

Knowledge Hub, Networking and then Technology Transfer

1. Modern, pre-commercial high-performance sensors (detectors)
2. High throughput electronics
3. Intelligent DAQ
4. Big data
5. Data visualisation, reconstruction
6. High Performance Computing, Multi-CPU, GPU, AI, ML
7. Full Physics Modelling
8. Full Dress Rehearsal Experiments and Simulation
9. Digital Twins
10. Innovation, IP Protection, Commercialisation
    (9 Patents filed in last 3 years)
    (Many patentable disclosures pending decision)

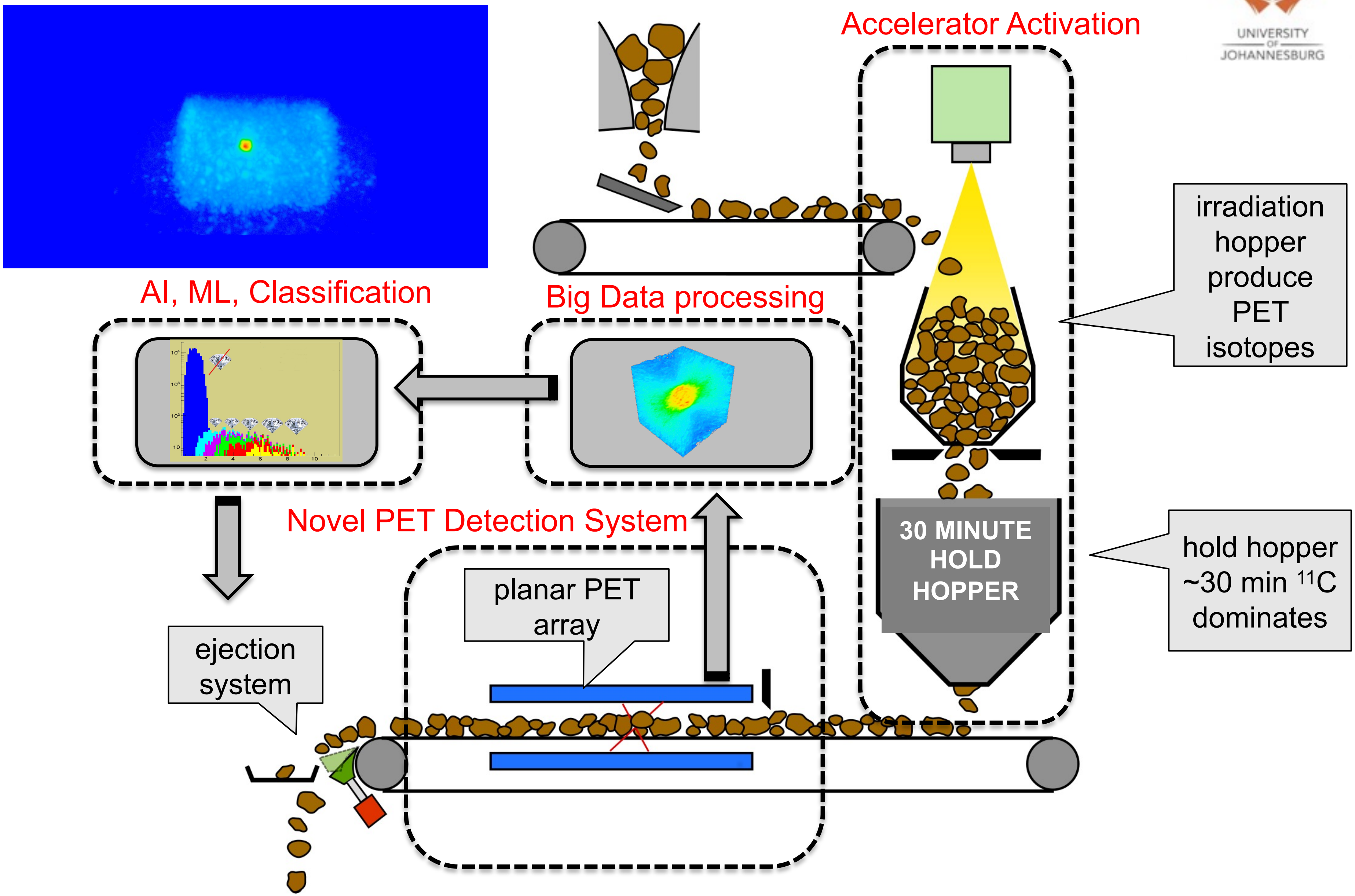
Commercial Programmes

1. MinPET (discovery of diamond in Kimberlite)
2. Medial PET, PEPT for Mining, Poly PET, SPECT for Security
3. FOS in reactors, real-time, on-line, in-core
4. Public Health - CFD, Wearables AI, Epidemiology
5. Blaze-DEM
6. Ubuntu Reactors (Geant4)

2. Patents

1. MinPET : Detection of Diamonds, 2005/03/14, SA Patent Application 2006/08025, ARIPO Patent Application AP/P/2006/003753 and AP 1986, Canadian Patent Application 2,559,516, Australian Patent Application 2005220403 Russia Patent Application 2006135960 and 2334974, China Patent application 200580011607.9, India Patent Application 5365/DELNP/2006 Patentscope
2. MGRT : Method of Multiple Source and Detector Gamma Ray Tomographic Radiography, 2018/10/19, PCT INTERNATIONAL APPLICATION (253LPS) PCT/IB2018/058162, Patentscope
3. MinPET 1 : Method and System for High Speed Detection of Diamonds, 2018/9/8, PCT INTERNATIONAL APPLICATION P82286PC00,Patentscope
4. MinPET 2 : Detector Arrangement, Detection System and Method of Processing Data from a Detector Arrangement for High Throughput Data Handling, 2019/11/12, PCT INTERNATIONAL APPLICATION P82287PC00m Patentscope
5. MinPET 3 : Method and System for Irradiating and Activating an Object, 2020/01/23, PCT INTERNATIONAL APPLICATION P82288PC00, Patentscope
6. MinPET 4 : Reducing Artefacts in Positron Emission Tomography Image Reconstruction, 2020/06/24, PCT INTERNATIONAL APPLICATION P82289ZP00, Patentscope
7. MinPET 5 : Detector Arrangement, Detection System and Method of Positioning a Detector Arrangement to Reduce Imaging Artefacts, 2020/07/30, PCT INTERNATIONAL APPLICATION P82290PC00, Patentscope

Towards Innovation



Low Hanging fruit for PET Innovation …. Diamond discovery

Note many clean recent breakage surfaces

A high quality 254 carat Type II white diamond, on 29 April 2021.

Clip from Letśeng movie

$CaCO_3$

^{40}Ca -> ^{38}K

^{16}O -> ^{15}O

^{12}C -> ^{11}C

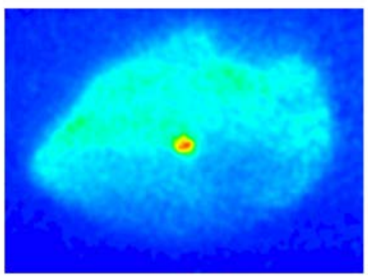
All three are PET isotopes

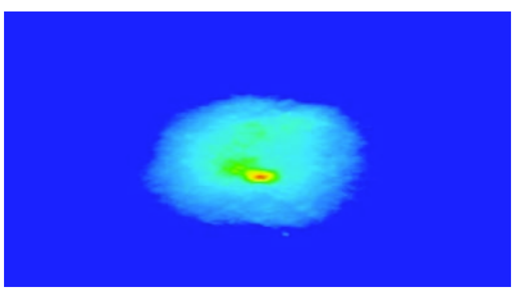
Worst case of "background"

10.3 ct diamond

Typical run of mine, 400 tons/per/hour … (MinPET: 700-1400 tph)

1.431 kg of Calcite
L = 15cm

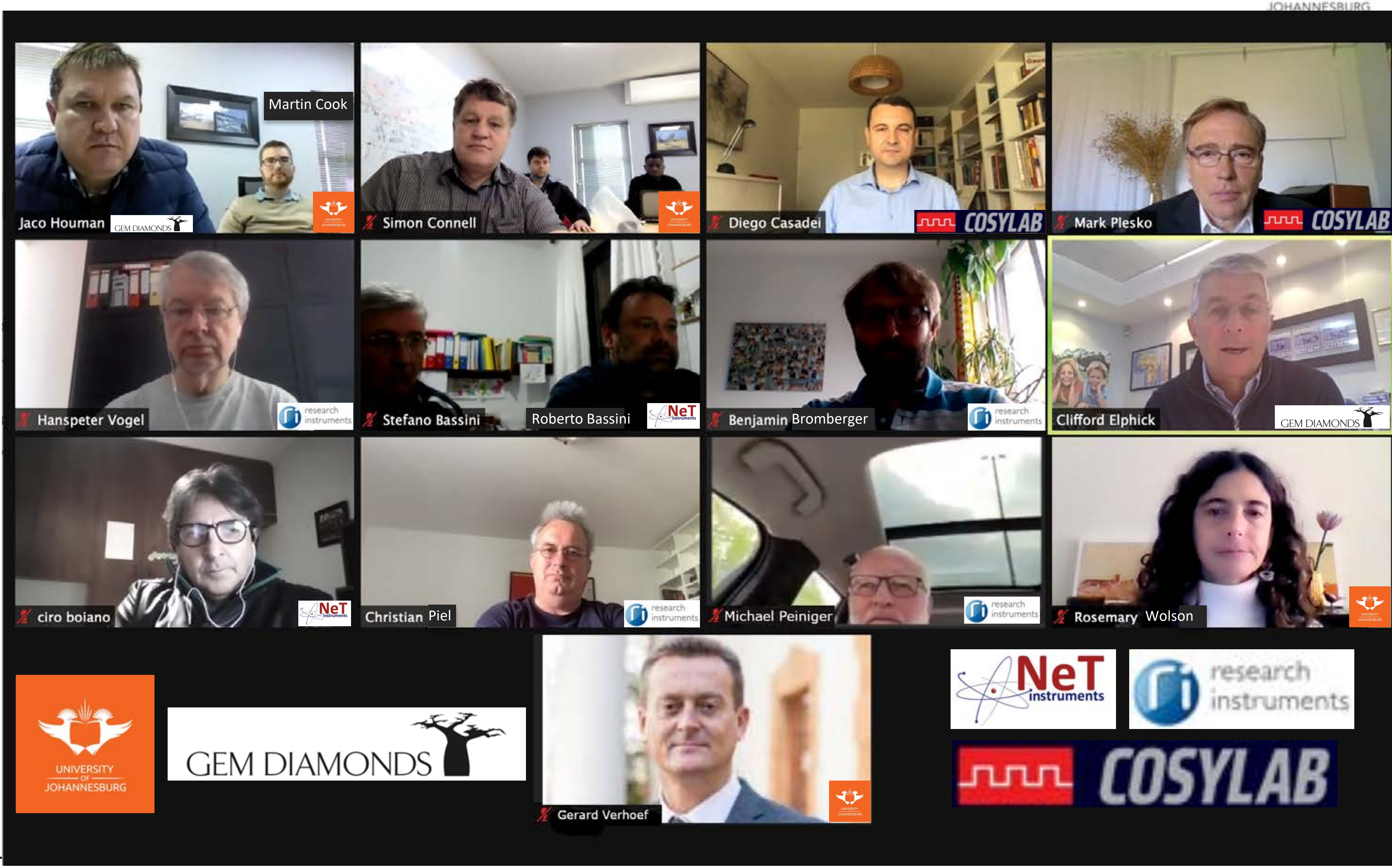




Low Hanging fruit for PET Innovation …. Diamond discovery

UNIVERSITY OF JOHANNESBURG

MinPET – proposed Technology Partners first Full Meet and Greet – Zoom 3.6.2021



UNIVERSITY OF JOHANNESBURG

Towards a Monte Carlo Simulation of a Pebble Bed Type High Temperature Gas Cooled Reactor using Geant4

A.C. Cilliers[a], S.H. Connell[b,*], J. Conradie[b], M.N.H. Cook[b], M. Laassiri[c,e], B.G. Maqabuka[b], R. Mudau[d], P. Naidoo[b], D. Nicholls[b]

[a]*Kairos Power, California, USA*
[b]*Department of Mechanical Engineering, University of Johannesburg, South Africa*
[c]*ESMaR, Mohammed V University, Morocco*
[d]*Necsa, Pelindaba, South Africa*
[e]*Brookhaven National Laboratory, Department of Physics, Upton, New York, 11983, USA*

Abstract

This paper introduces the stochastic Monte Carlo (MC) modelling of a nuclear reactor core using the Geant4 framework. The simulation is exercised in the context of a High Temperature Gas Cooled Reactor (HTGCR) that uses helium (a noble gas) as a coolant and graphite as a neutron moderator. The study presents the results from the implementation of basic neutronics, scalability, geometrical discretisation for studying the spatial variation of physical parameters, time slicing and adaptation of Geant4 for correct intra-slice persistence, a scheme of integration with thermal hydraulics by workflow scheduling, validation of the thermal macroscopic cross-section behaviour, the process of fission, burn, decay, and differential energy depositions for the various physics processes, validation of the Xenon effects on the neutronics, criticality and core follow over multiple time steps.

Keywords: Reactor physics, nuclear engineering, Monte Carlo

*Corresponding author
Email address: shconnell@uj.ac.za (S.H. Connell)

Preprint submitted to Annals of Nuclear Energy *November 17, 2021*

Green Sustainable Energy

1. Developing open-source Reactors Physics modelling.
2. Extensions to Geant4 enable Burn, Decay and Core follow
3. 29 page paper accepted in Annals of Nuclear Energy

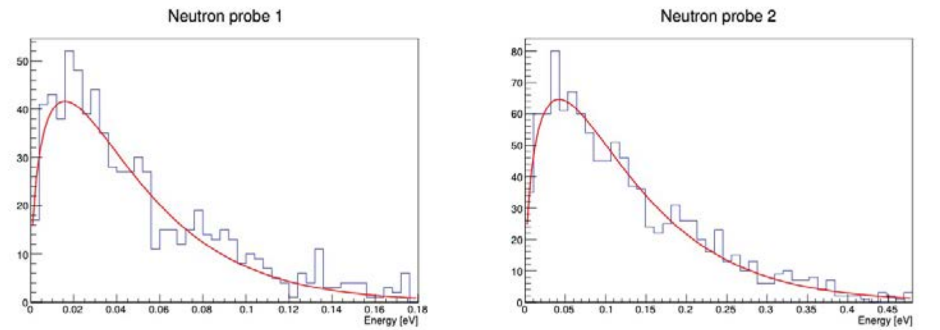


Figure 13: Maxwell-Boltzmann fit for the energy of neutrons incident on neutron flux probes.

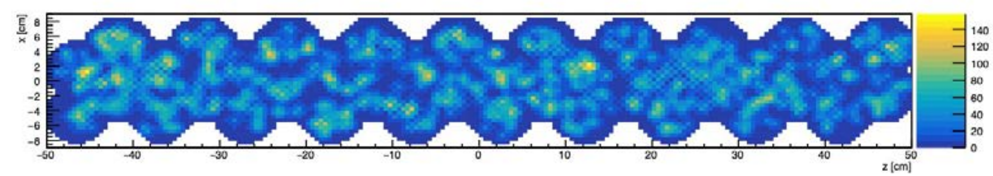
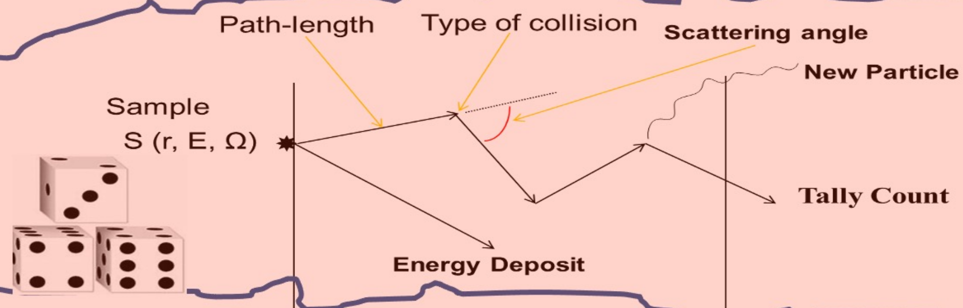


Figure 14: Energy deposits within pebbles [MeV], for 50k neutrons, shown in a x-z slice for $y = 0$.

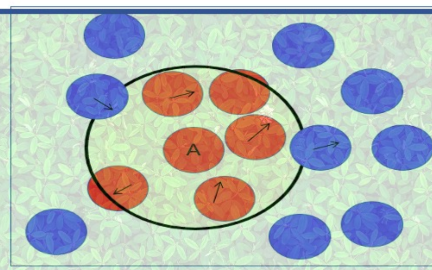
Prof Nicolin Govender

Event Based
(Monte Carlo)



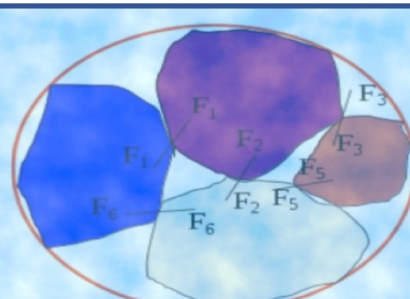
At particle level embarrassingly parallel. Instruction complexity some what divergent.

Proximity Based
(Molecular Dynamics)



At particle level embarrassingly parallel. Instruction complexity fairly similar.

Contact Based
(DEM, Impulse)



At particle level embarrassingly parallel. Instruction complexity is divergent for complex shape.

Granular Material

Second most manipulated substance on the planet after water !

Even exists in the cosmos

UNIVERSITY OF JOHANNESBURG

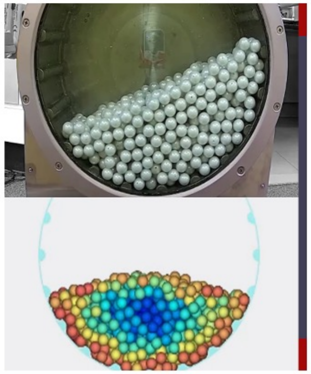
Particle simulations are computationally expensive

Most sites/offices will have a workstation

However, CPU based simulations are only feasible on large clusters

Possibly using more power than they would actually save

Particle Number: *Industrial devices contains hundreds of thousands to millions of particles, yet most simulations can only do tens of thousands in a feasible time.*



What we get

Digital twin in the mining industry: a grinding mill case study

ROCKY

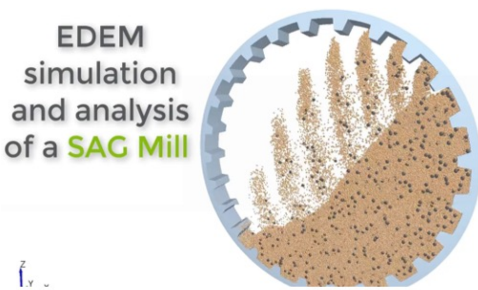
High Performance Computing, Blaze-DEM, GPU, AI, etc

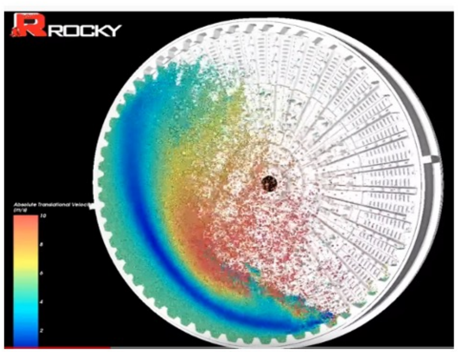
UNIVERSITY OF

NVIDIA
INCEPTION PROGRAM

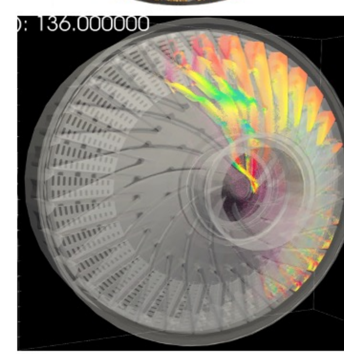
NVIDIA
CUDA RESEARCH CENTER

Blaze-DEM at least 15x faster than commercial solutions and more accurate.

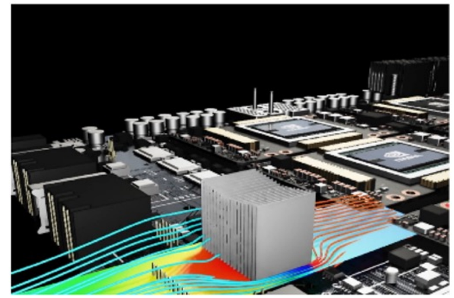


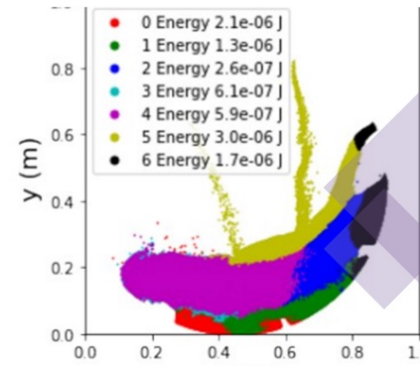


You go from slice simulations with spheres in "hours" to accurate full simulations with

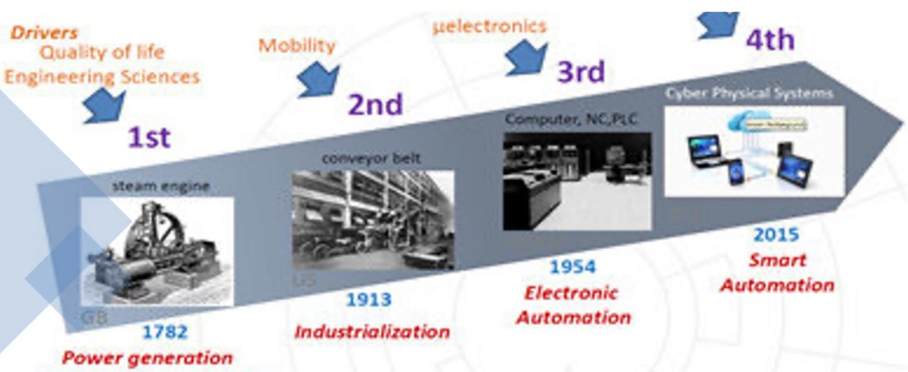


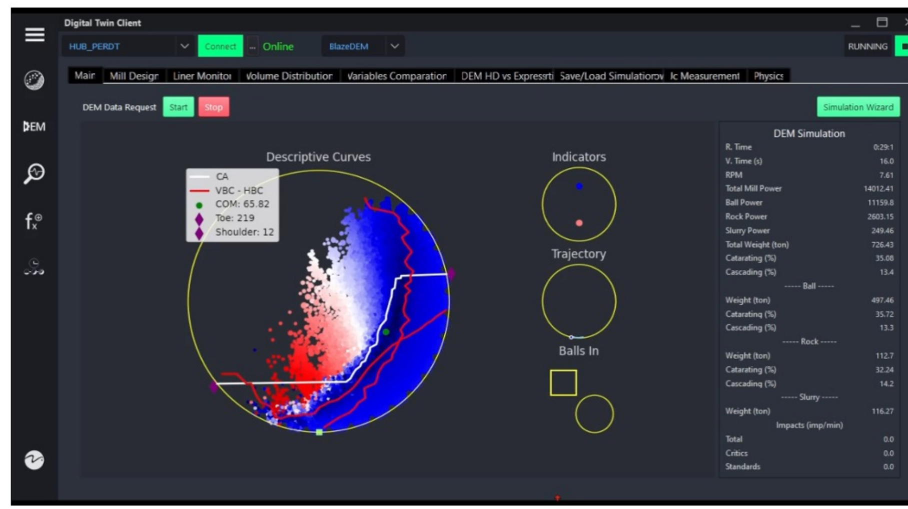
GPU computing with Blaze-DEM is enabling the 4IR





- Industrially relevant sizes of equipment can be simulated with increased fidelity.
- These in-turn drives the training of AI physics based predictive models.
- As well as physics-based automation.



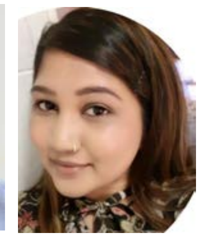


UNIVERSITY OF JOHANNESBURG

Nuclear Energy

Radiation Hard, Moderate Temperature (300° C - 400° C)

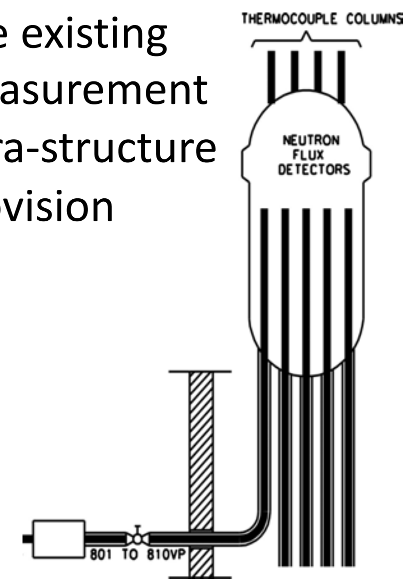
- Koeberg (ESKOM) : Monitoring of temperature, neutron flux (power)
- Sense Temp, Dose, Water-level etc – in-core, on-line, real-time
- Fiber survival beyond 1 x 10^{21} n/cm^2 (epi-thermal) in SAFARI tests.
- R&D in progress.



+ other colleagues

Tests so far equivalent to at least 2 G Gray, or two weeks in a 1GW PWR.

Use existing measurement infra-structure provision



Improved reactor efficiency and safety.

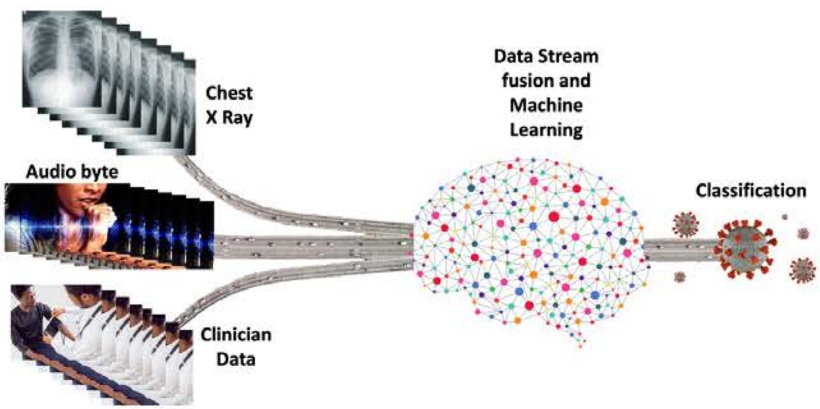
Some of our projects …..

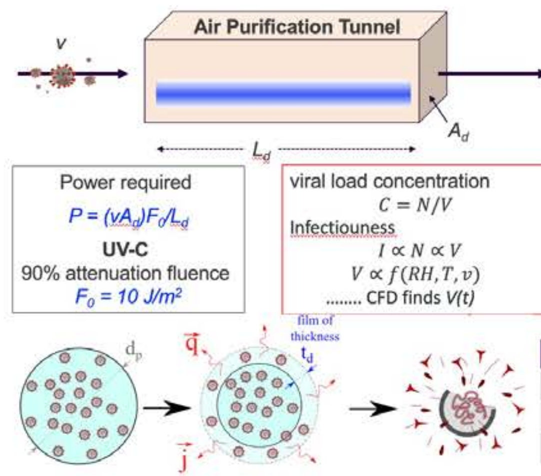
Preventing COVID-19 with Mathematical Modelling, Digital twins, AI and 4IR Engineered solutions

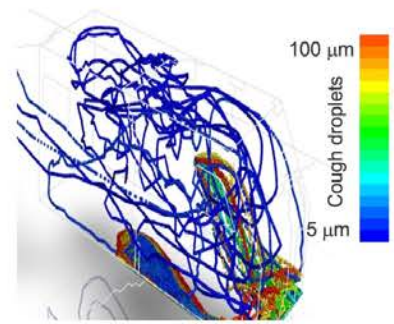
PI: Dr. Muaaz Bhamjee
Co-PIs: Prof. Charis Harley and Prof. Simon H. Connell
Faculty: Faculty of Engineering and the Built Environment

Project Description:

1. The use of mathematical modelling (CFD + algorithms),digital twins and optimising 4IR engineered solutions to make public spaces safer. Novel feature is augmentation of CFD with two droplet infectiousness models.
2. Public Health, Artificial Intelligence and Diagnosis based on Multiple Data Sources - Chest X-rays, Audio Bytes, Clinician data, data processing and data fusion, longitudinal studies, develop machine learning augmentation of clinician diagnoses.







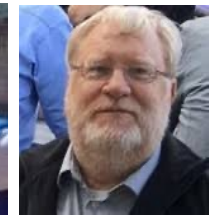
UV-C (nm)	Pathogen	F_0 (J/m²)
222	H1B1	15
254	MHV	6.6
254	RNA-DNA viruses	3 - 12

Timeline: Two years

The UJ –ATLAS and Associated Innovation Group + UNISA + UWC

- **Staff**
  - Simon Connell (Prof)
  - Muaaz Bhamjee (Sn Lect)
  - Nicolin Govender (Prof)
  - Loan Truong (Lecturer, Visiting Prof)
  - Francois Pieterse (Sn Lect)
- **Post Docs**
  - Bongani Maqabuka
  - Emmanuel Igumbor
  - Hasina Ralijaona
- **Students**
  - PhD: Phineas Ntsoele
  - PhD: Thendo Nemakhavhani
  - PhD: Matthew Connell
  - MSc: Xola Mapekula
  - MSc: Mr Mitchell Phiri
  - MSc: Gideon Bentum
  - MSc Chris Lee
- **Associate sub-institute**
  - Lerothodi Leeuw (Prof UWC)
  - Pedro Mafa (Dr UNISA)
  - Mantile Lekala (Prof UNISA)
- **Necsa Associates**
  - Dr Graham Daniels, Dr Dazmen Mavunda, Eric Chinaka, Linina Bedhesi
- **Research Associates**
  - Dr Martin Cook (SRA UJ),
  - Dr Sergio Ballestrero (SRA UJ)
  - Tim Brooks (SRA UJ)



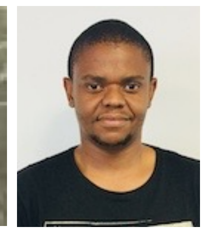
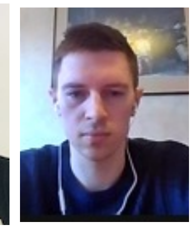





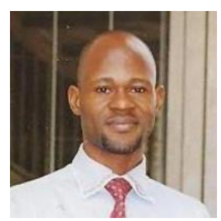
+ many colleagues from ATLAS
Prof Kétévi Assamagan
BNL












ATLAS
Innovation