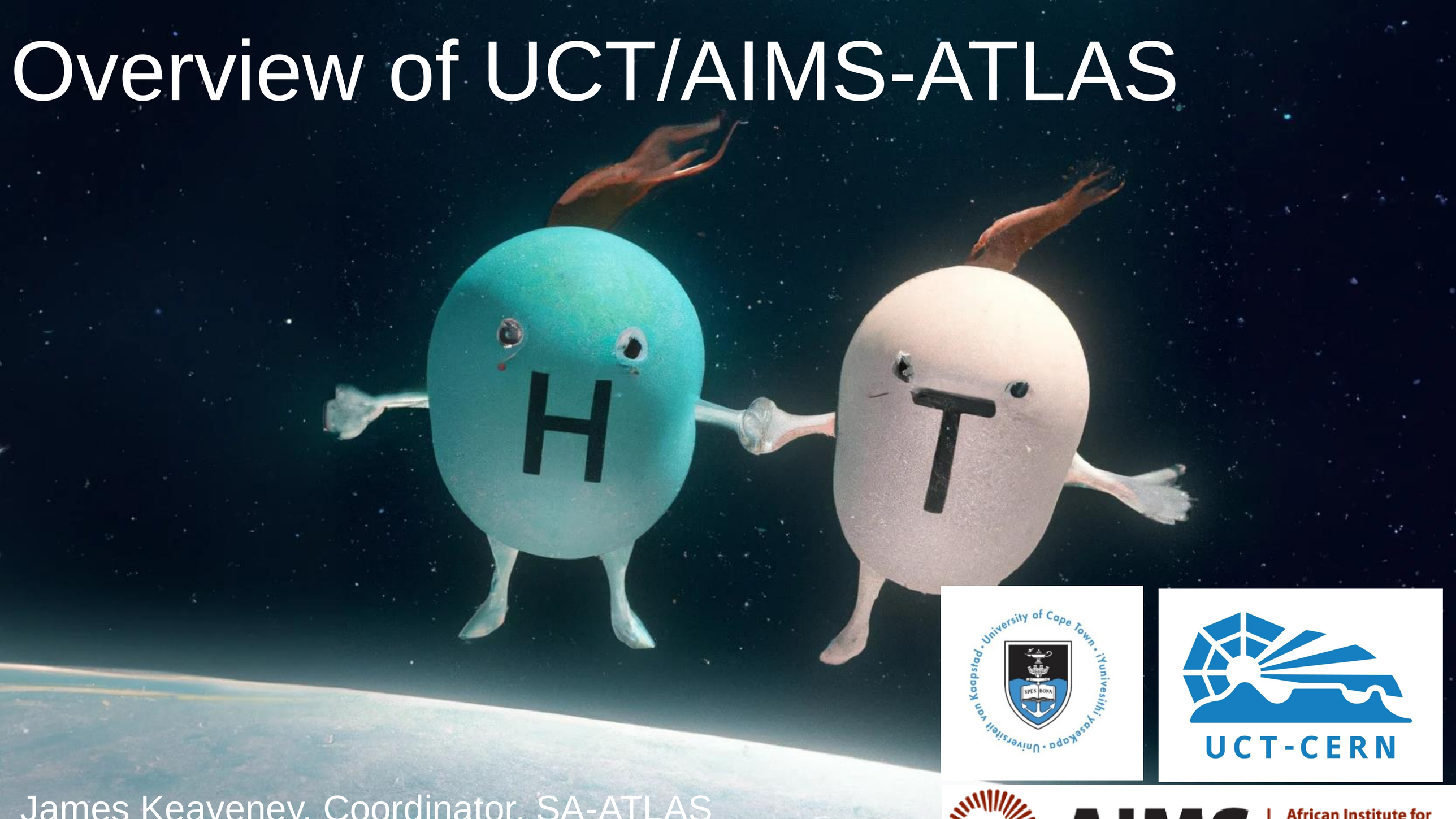
Overview of UCT/AIMS-ATLAS



James Keaveney, Coordinator, SA-ATLAS

UCT-ATLAS Size & Shape

1 Academic Physics PI (James Keaveney)
3 Engineering Faculty – Prof. Ed. Boje, Dr. Reuben Govender, Prof. Amit Mishra

2 Physics PhD Students:

- Ryan Atkin – *VH Cross Section and ITk simulation*
- Cameron Garvey – *Top Yukawa, ITk EoS QC and Jet calibrations*

Physics Masters students:

- James Mitchell – *tWZ search Run II*
- Thobani Sangweni – *tWZ search Run III*
- Jemma Bagg – *Anomaly Detection Triggers*
- Aminul Hossain – *Modelling Toponium*

Engineering Masters students:

- Amandla Mvimbi – *Evaporating cooling*
- Thomas Stern – *Algorithms for Anomaly Detection Triggers*
- Alex Ross – *Outer Barrell moderator design and installation*
- Lloyd Ross – *Evaporating cooling*

Around 4 3rd/4th year undergrad projects per year

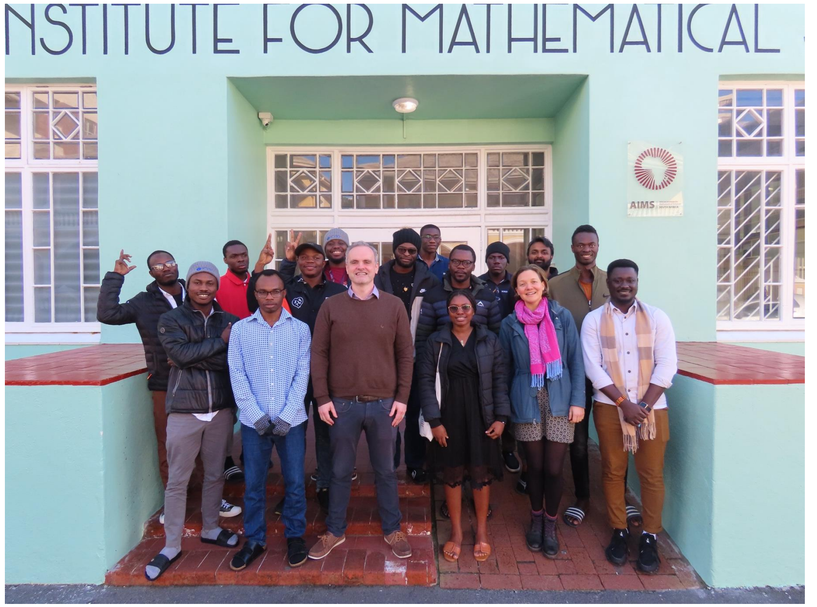
Around 30 3rd year lab projects with ATLAS OpenData

Growing UCT/AIMS-ATLAS

1 New Academic Physics PI from Feb 1st 2025 (Dr. Kevin Barends)
1 Honorary Academic post (Dr. Claire David) since 2024
1 New Postdoc shared between UCT and AIMS from Feb 6th 2025

Expansion of research programme in AIMS MSc *AI for Science:*

- 3 Week taught module on “Data Science of Particle Physics” taught with Dr. Julia Gonski (ATLAS, SLAC)
- Msc short project on Anomaly Detection in the trigger



UCT, SA-ATLAS & AIMS

Dr. David Francis, CERN, ATLAS Resources Coordinator

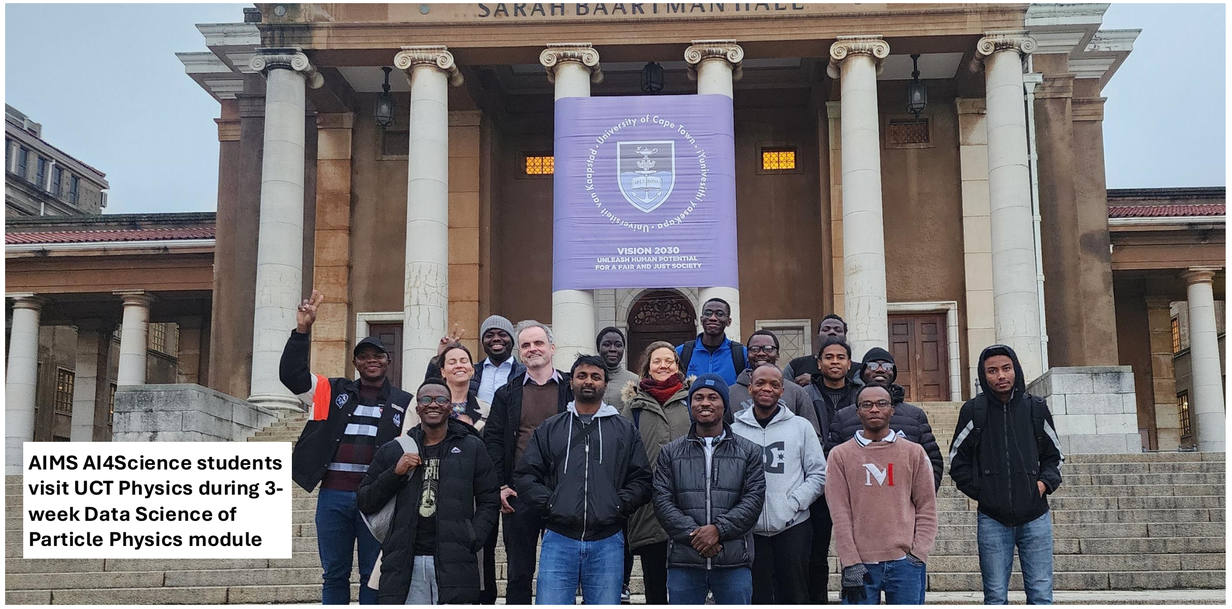
Dr. Ulrich Paquet, AIMS Director, Google DeepMind

Dr. Benedetto Gorini, CERN, ATLAS

Dr. Andreas Höcker, CERN, ATLAS Spokesperson

Dr. Claire David, AIMS Academic Director, UCT ATLAS

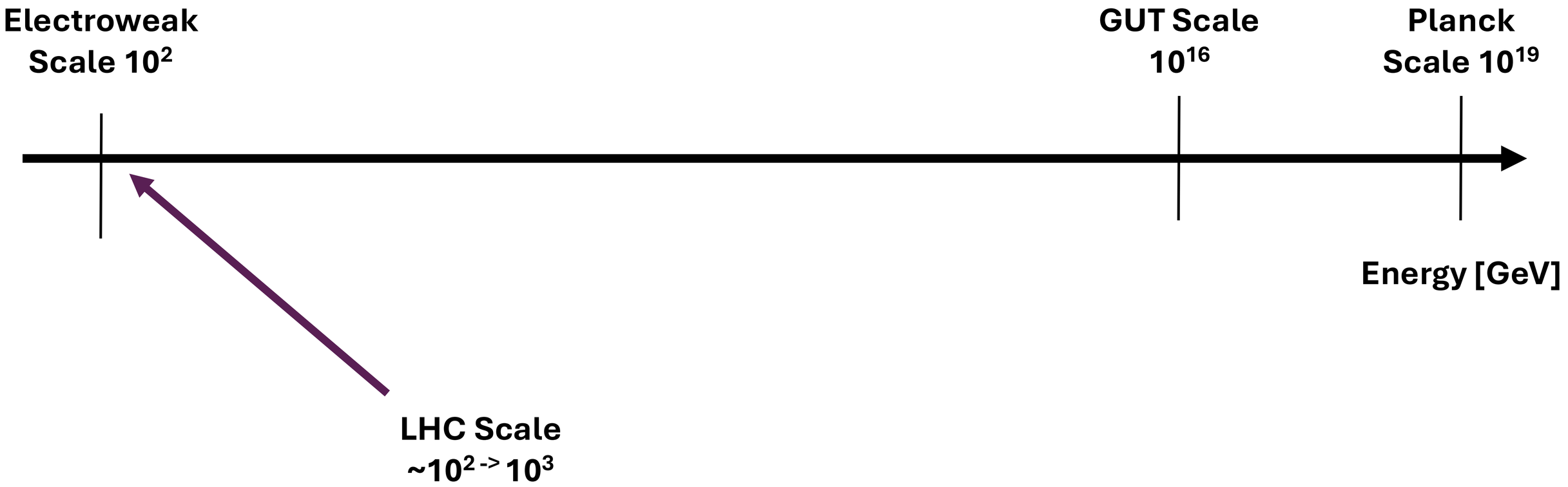
UCT-CERN Seminar of Real-Time Artificial Intelligence in ATLAS experiment from Dr. Julia Gonski (SLAC/Stanford)



AIMS AI4Science students visit UCT Physics during 3-week Data Science of Particle Physics module

April 2024 - UCT-CERN Seminar “Free Energy is all you need” from world-renowned AI expert Dr. Max Welling (Uni Amsterdam)

LHC energies - in context



Physics. Top quarks and Anomalies.

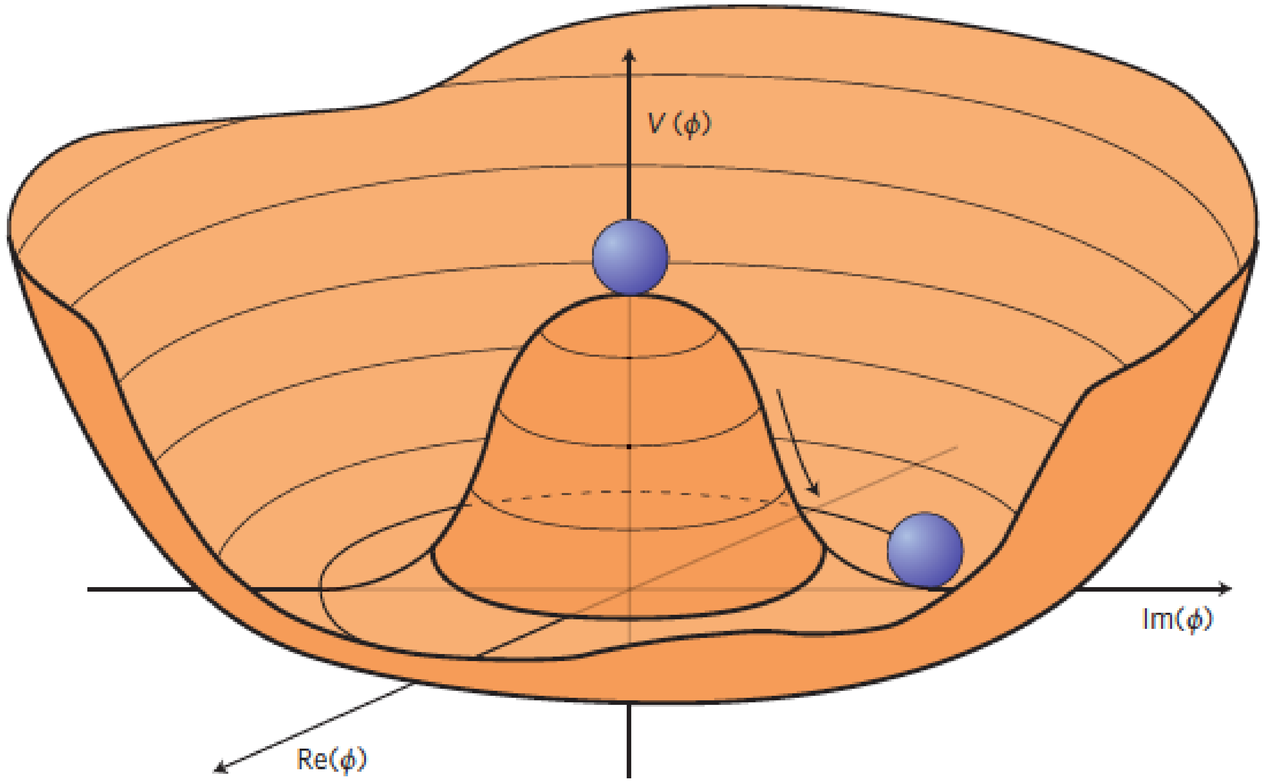
ATLAS and Education - OpenData.

Upgrade – ITk Polymoderator and EoS cards.

Fermion masses in the Standard Model

- Explicit particle mass terms, i.e., $m_f(\overline{\Psi_f}\Psi_f)$ break gauge invariance
- Introduce a complex scalar field ϕ with self-interaction terms $-\mu^2(\phi^\dagger\phi)$ and $\lambda(\phi^\dagger\phi)^2$

- **Invariant Lagrangian, but non-invariant vacuum**



$$\mathcal{L} = \frac{y_f}{\sqrt{2}}v(\overline{\Psi_f}\Psi_f) + \cdots$$

$$m_f = \frac{y_f}{\sqrt{2}}v$$

$$y_f = \sqrt{2}\frac{m_f}{v}$$

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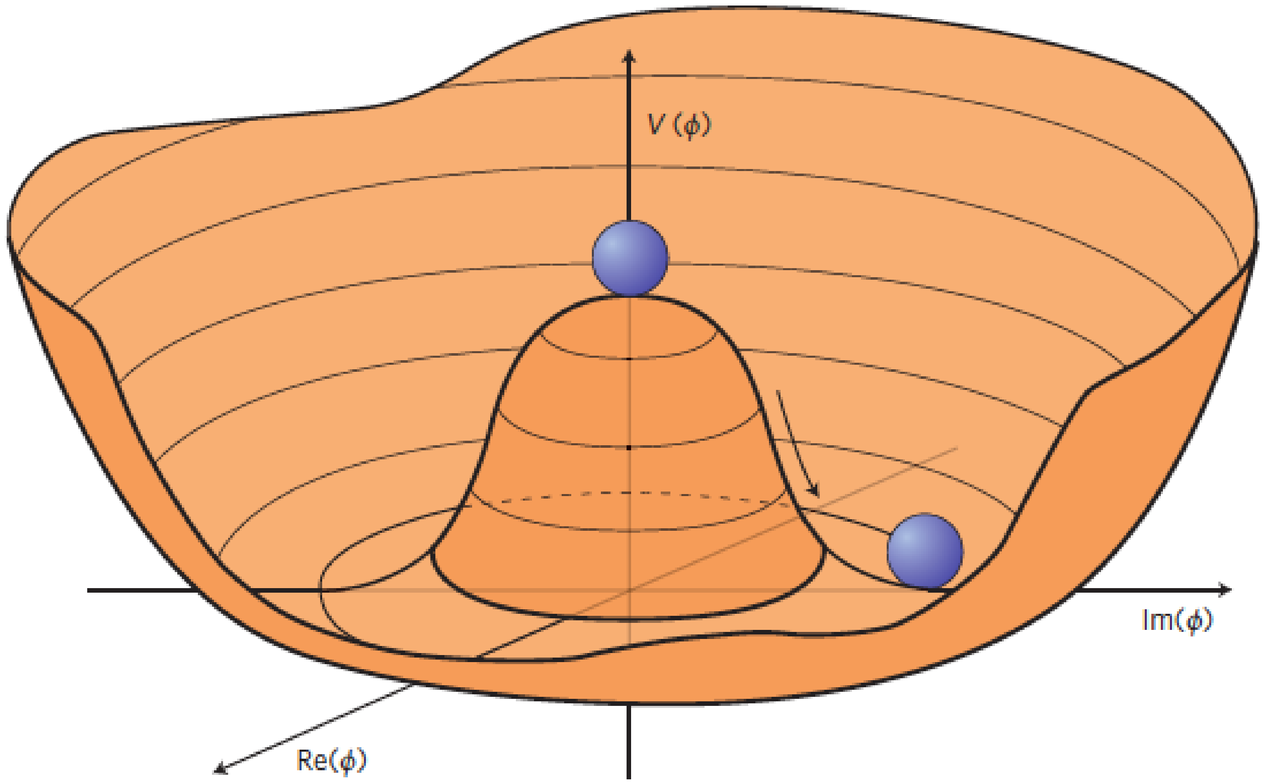

$$\mathcal{L} = \frac{y_f}{\sqrt{2}}v(\overline{\Psi_f}\Psi_f) + \cdots$$

$$m_t \approx 172.5GeV$$

$$v = \left(\frac{1}{\sqrt{2}G_v}\right) \approx 246GeV$$

$$y_t = \sqrt{2}\frac{m_t}{v} \approx 0.9899 \approx 1$$

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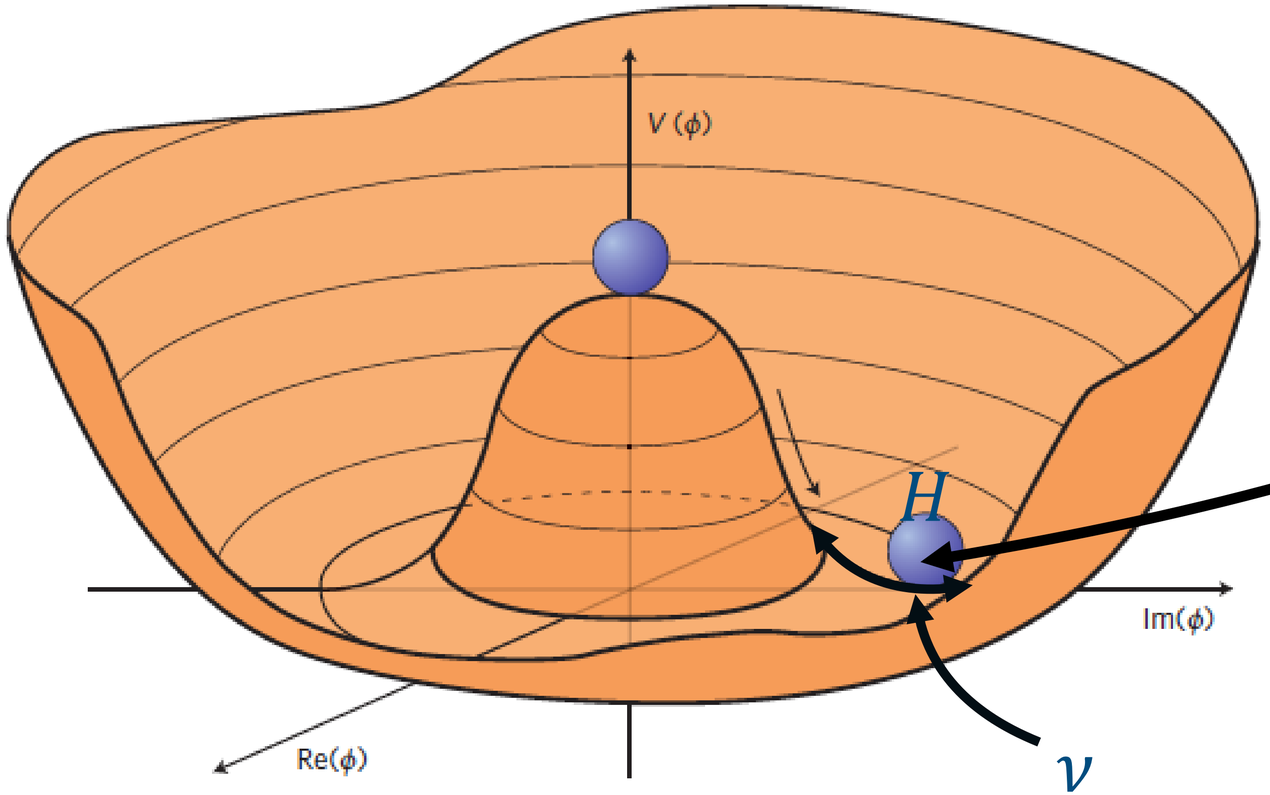
$$\mathcal{L} = \frac{y_f}{\sqrt{2}}(v + H)(\overline{\Psi_f}\Psi_f) + \cdots$$



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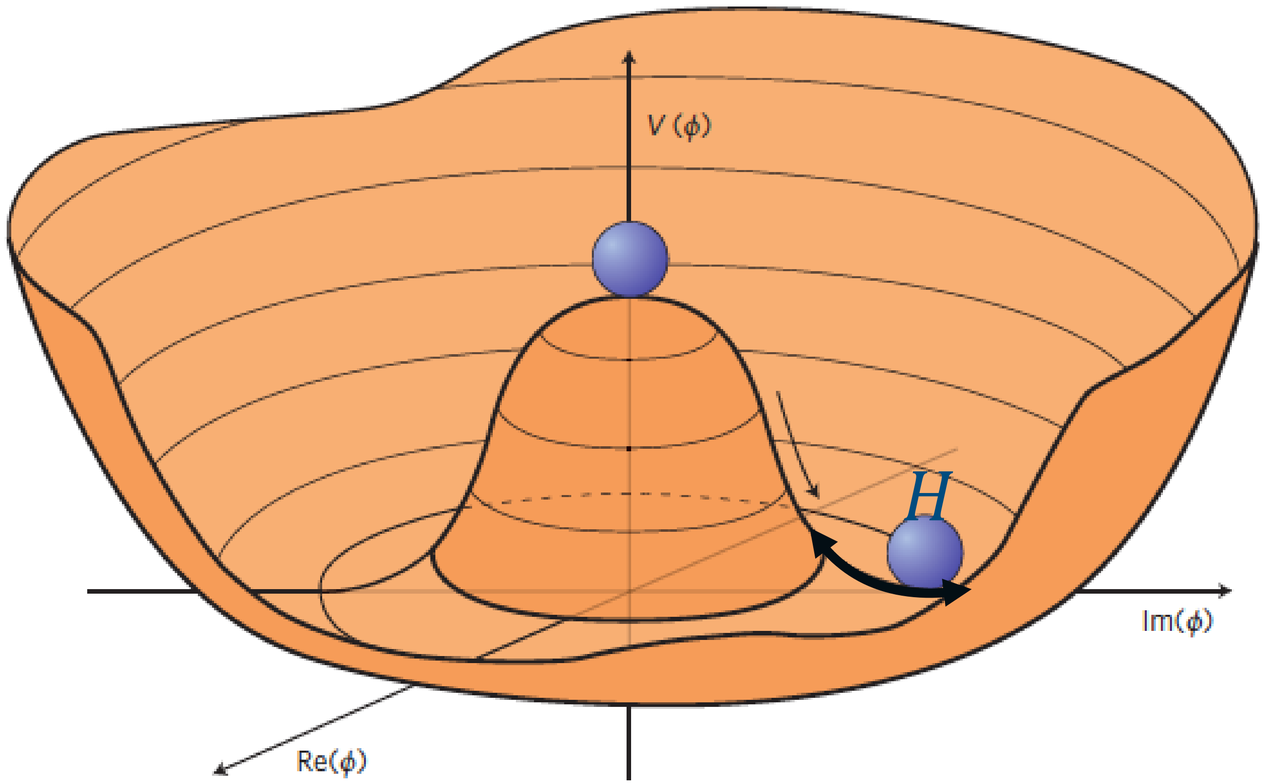

$$\mathcal{L} = \frac{y_f}{\sqrt{2}}v(\overline{\Psi_f}\Psi_f) + \frac{y_f}{\sqrt{2}}H(\overline{\Psi_f}\Psi_f) + \cdots$$

$$= m_f(\overline{\Psi_f}\Psi_f) + \frac{y_f}{\sqrt{2}}H(\overline{\Psi_f}\Psi_f) + \cdots$$

Fermion masses in the Standard Model

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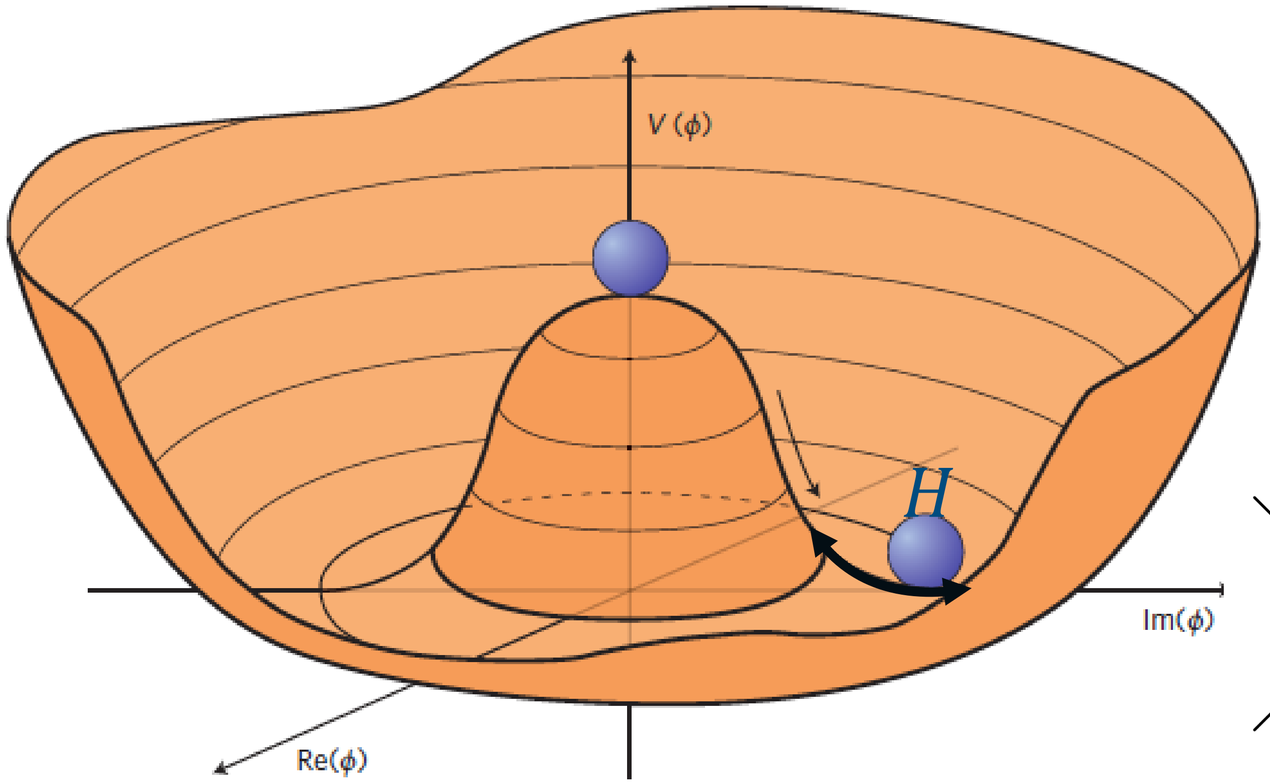
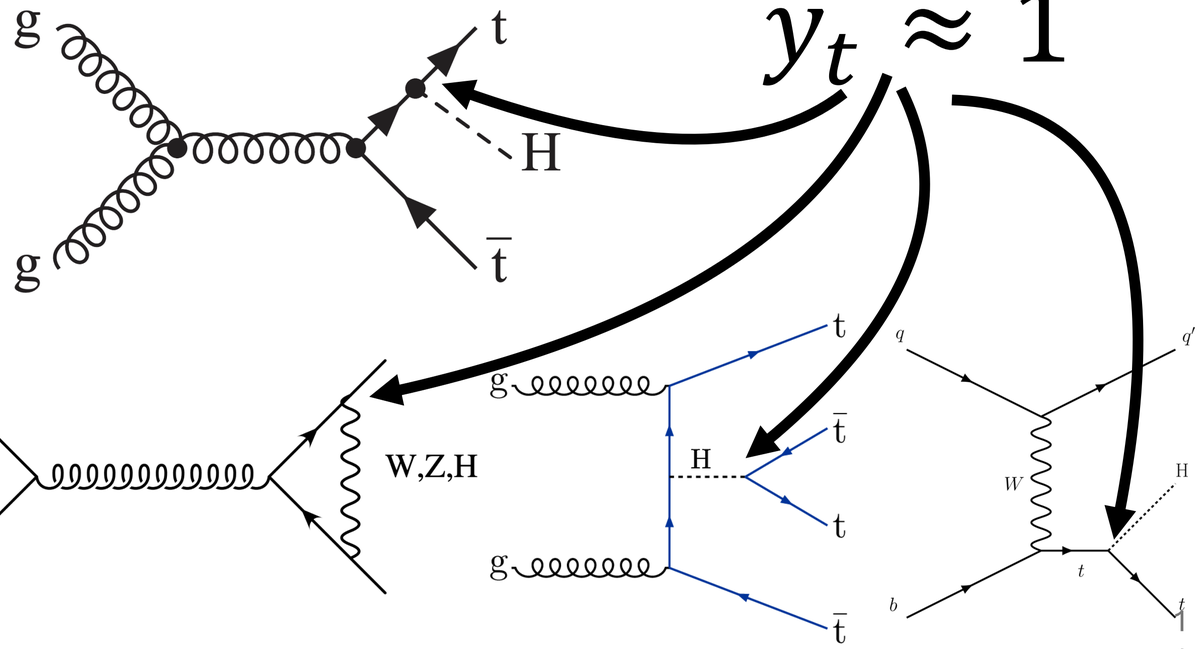
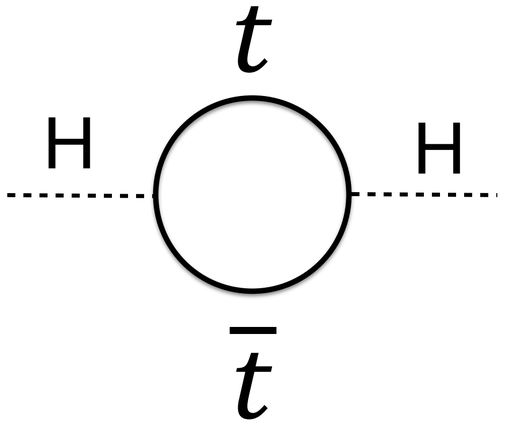


$y_t \approx 1$



The Top quark and the Higgs boson

$y_t \approx 1$ results in huge corrections to effective Higgs parameters below a cut off scale Λ_{cutoff}

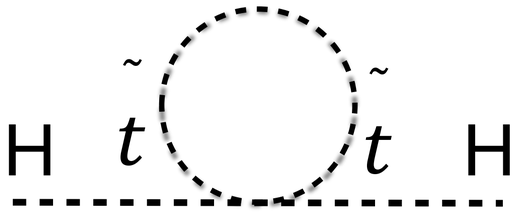


- if Λ_{cutoff} ~ quantum gravity scale → correction is 10^{32} times observed value!
- need extremely *fine-tuned* cancellation of "bare" parameters and corrections to give $m_H \approx 125GeV$

$$\Delta(\mu^2) \approx y_t^2 \Lambda_{cutoff}$$

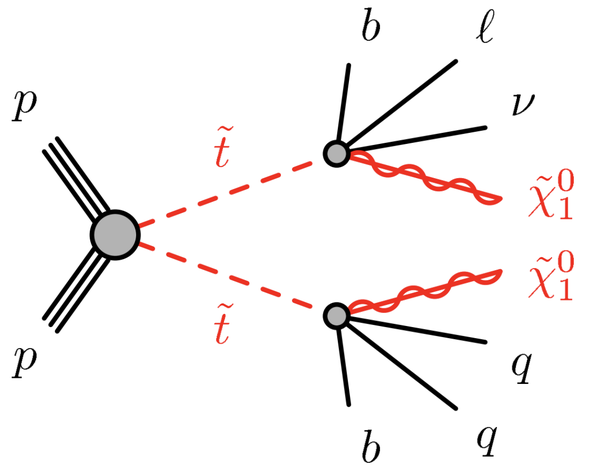
  - Is fine-tuning "just fine"?
  - If not, we have a (Hierarchy) problem…

- new physics could provide the cancellation (and lower Λ_{cutoff})
  - **e.g, supersymmetric top partners $\tilde{t}$**

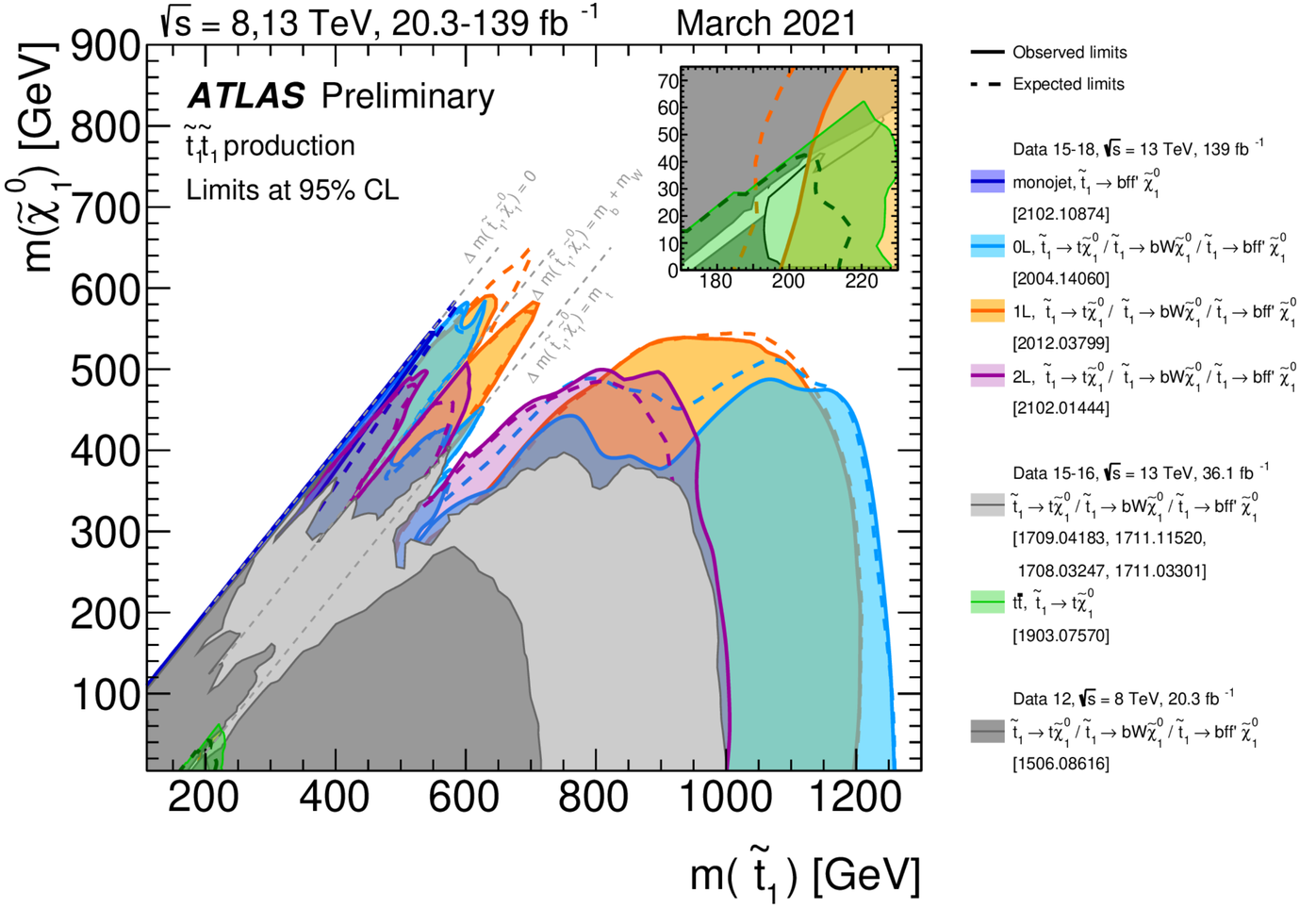


What we see.

New physics to resolve the Hierarchy Problem
- The SuSy example

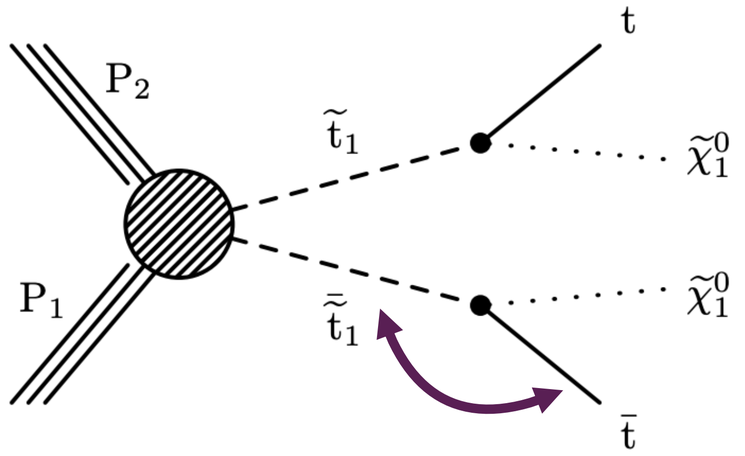


- supersymmetric top partners $\tilde{t}$ with $m_{\tilde{t}} = ??$
  - clear experimental prediction
- What do we see in the LHC data?
- No hint whatsoever of *natural* top partners

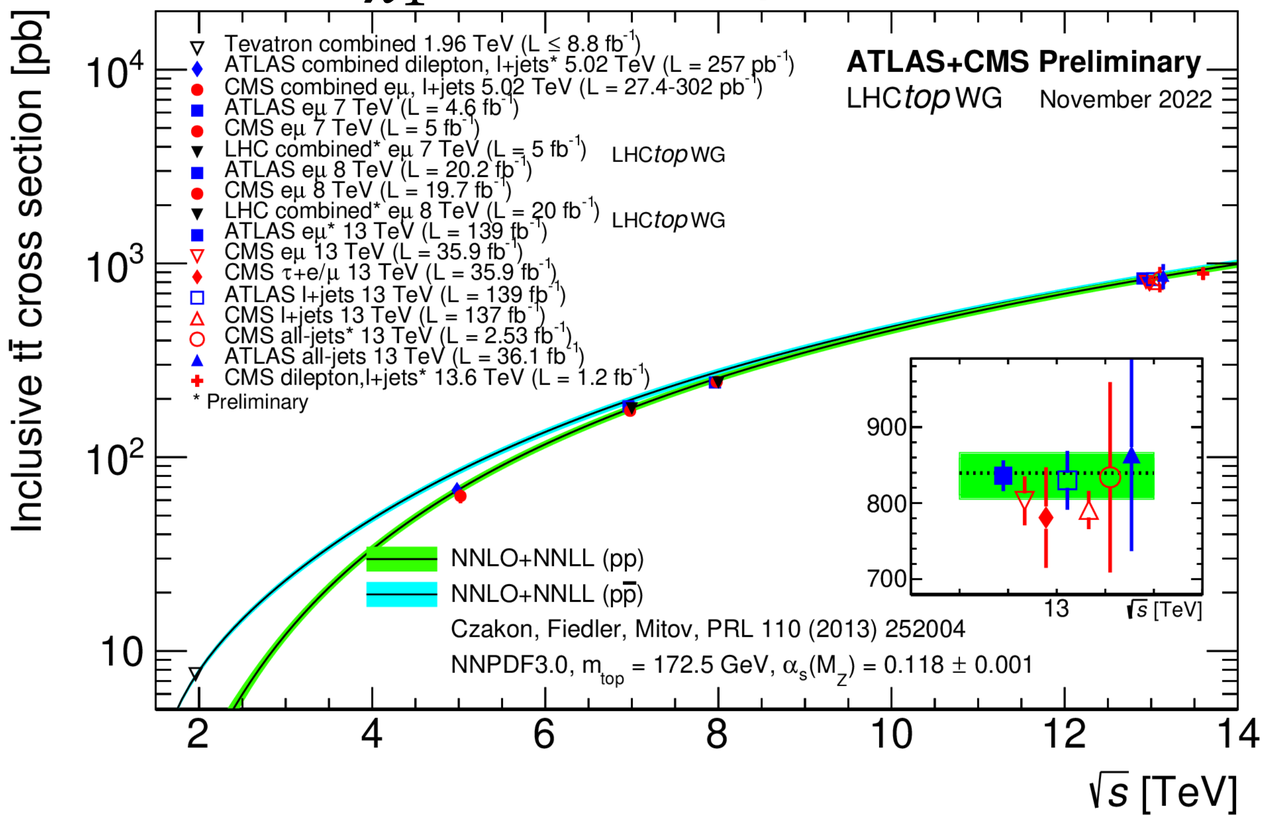


Seeking new physics with tops

- supersymmetric top partners $\tilde{t}$ with $m_{\tilde{t}} \approx m_t$
- clear experimental prediction
- As $m_{\tilde{t}} \to m_t$ signal would be manifested as an increased $\sigma_{t\bar{t}}$ w.r.t $\sigma_{t\bar{t}}^{SM}$
- What do we see in the LHC data?
  - %-level agreement with $\sigma_{t\bar{t}}^{SM}$
- No hint whatsoever of natural top partners



$$E_{\tilde{\chi}_1^0} \to 0 \text{ as } m_{\tilde{t}} \to m_t$$



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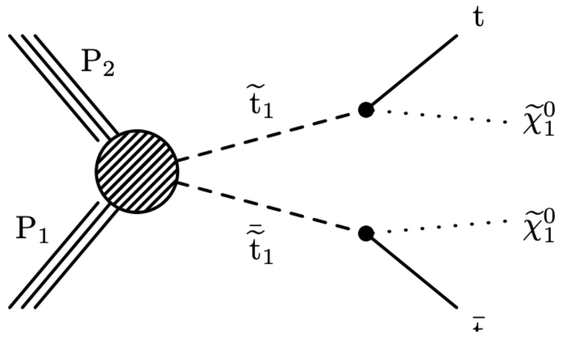
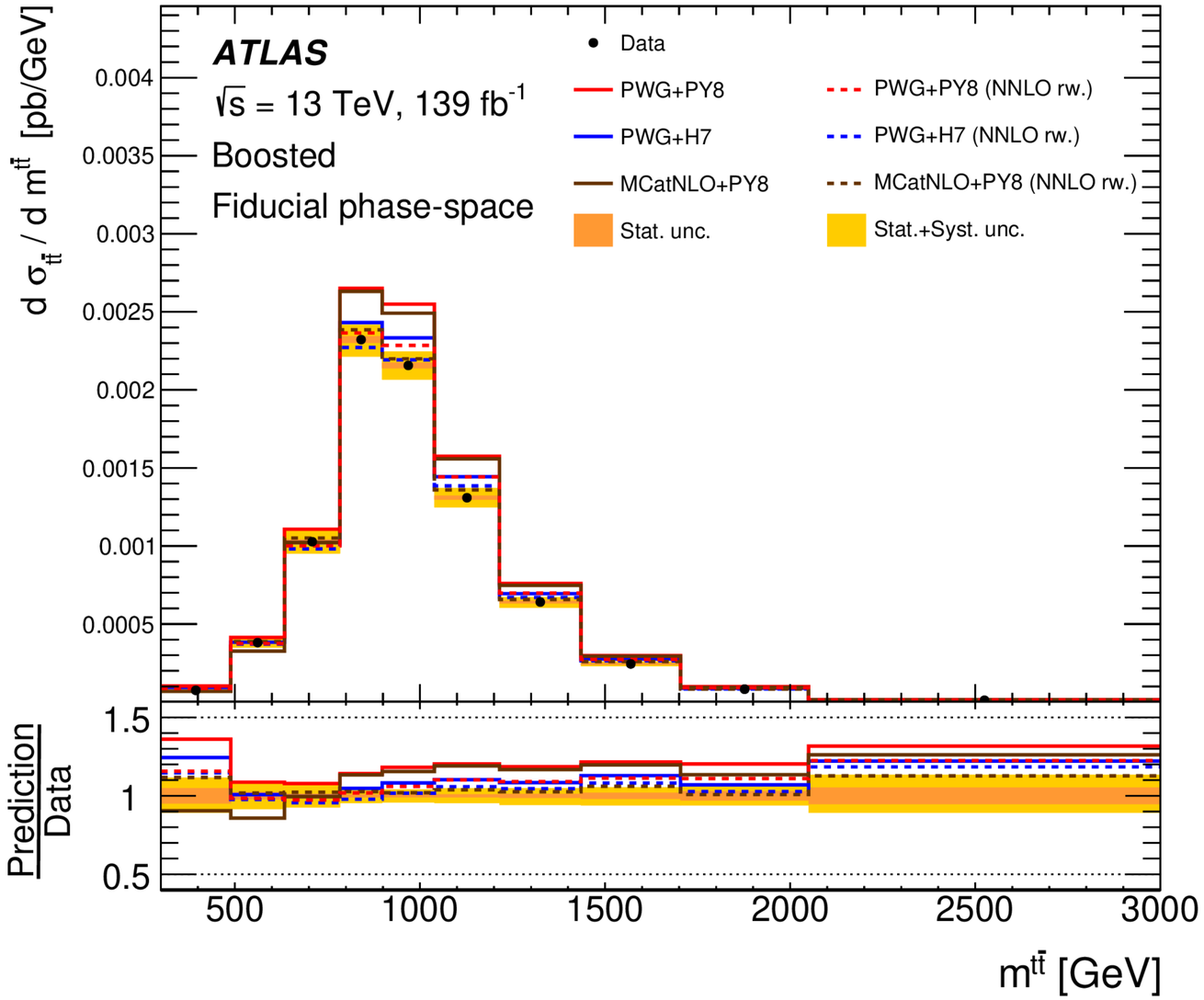
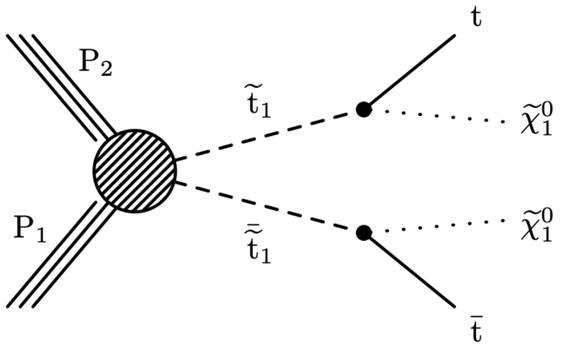
- As $m_{\tilde{t}} >> m_t$ more efficient to select *boosted* **top**ologies

- What do we see in the LHC data?
  - Mild slope in $\frac{d\sigma_{t\bar{t}}}{dm_{t\bar{t}}}$ spectrum for boosted topologies





Seeking new physics with tops



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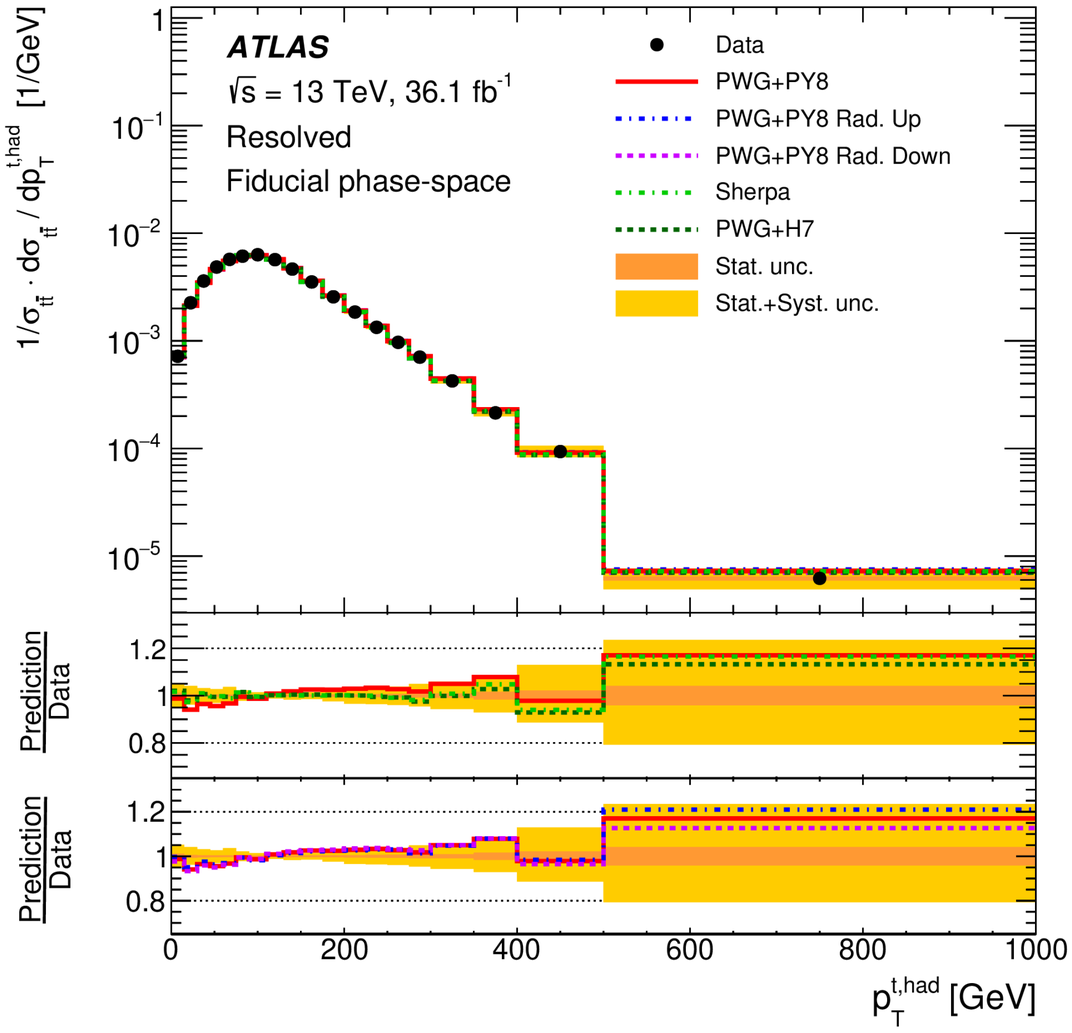
- What do we see in the LHC data?
  - Persistent slope in top pt spectrum
  - Also observed at 8 TeV and in CMS



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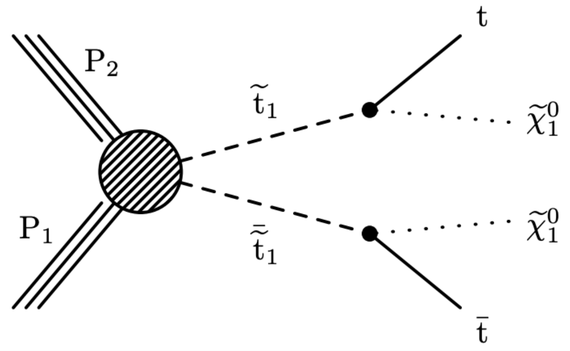
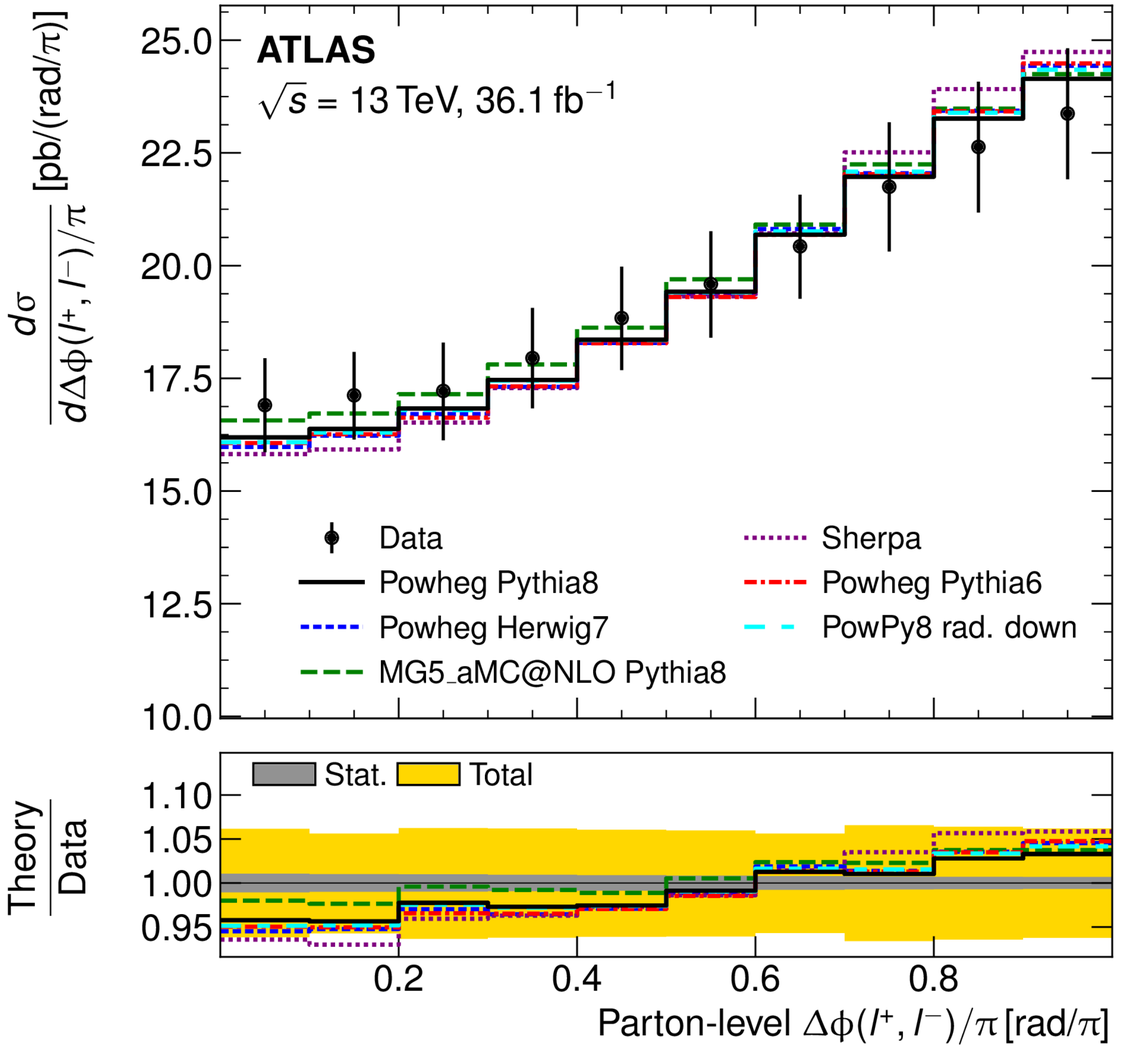
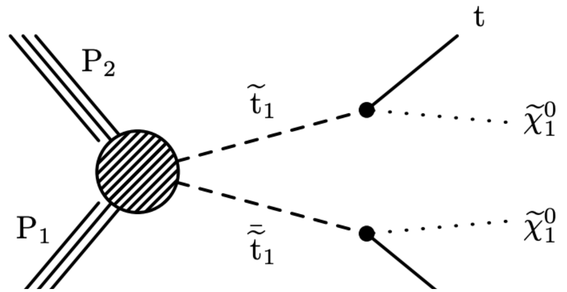
- What do we see in the LHC data?
  - **stronger spin correlations?!**





Seeking new physics with tops



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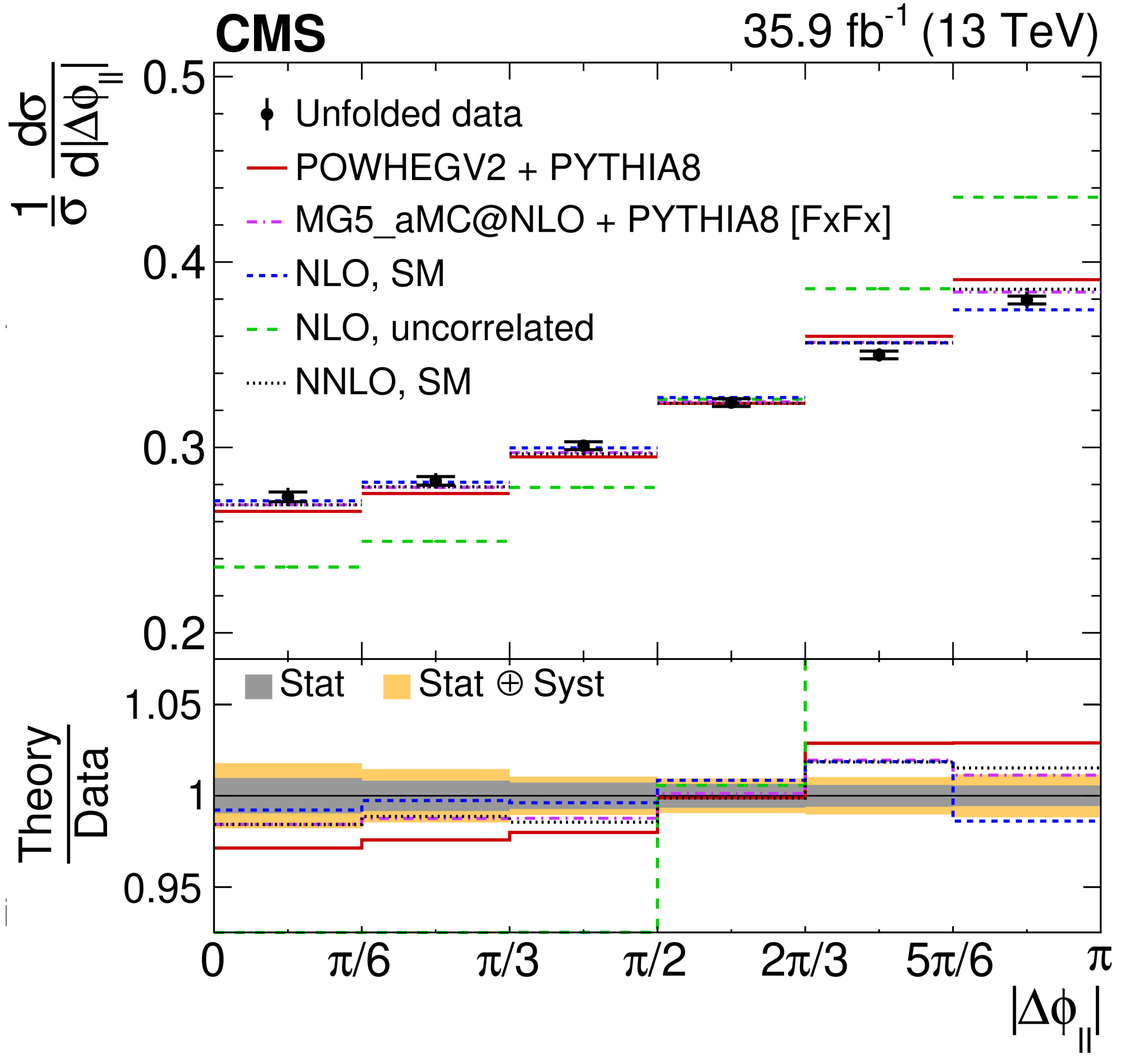

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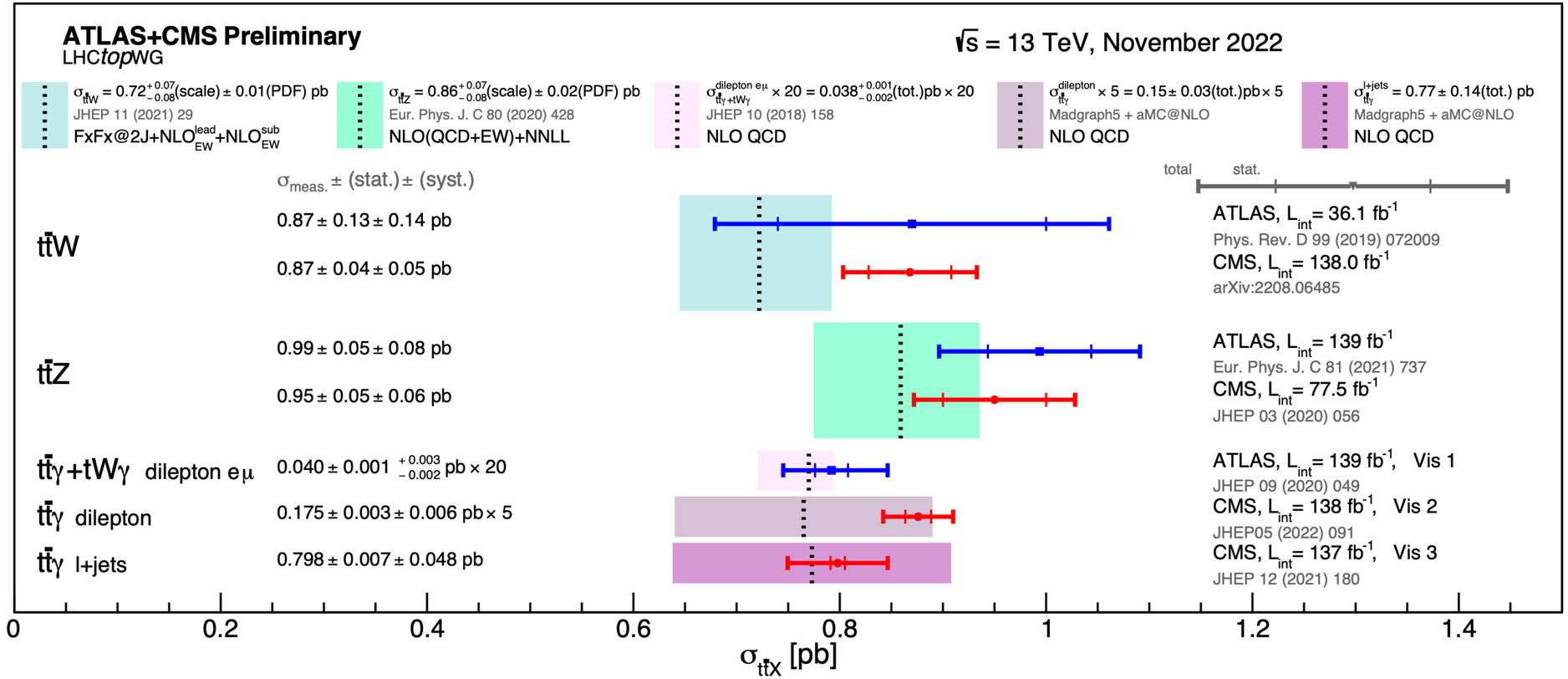


- What do we see in the LHC data?
  - Consistent excesses with respect to $\sigma^{SM}_{t\bar{t}W/Z/\gamma}$ in both ATLAS and CMS

Seeking new physics with tops - summary

- What do we see in the LHC data?
- *No smoking gun* of light new physics
  - Numerous mild but interesting tensions with the SM expectation

Can we tell the difference between a meaningful pattern of subtle new physics and less interesting set of unrelated mis-modelling and fluctuations?

Why we should look closer.

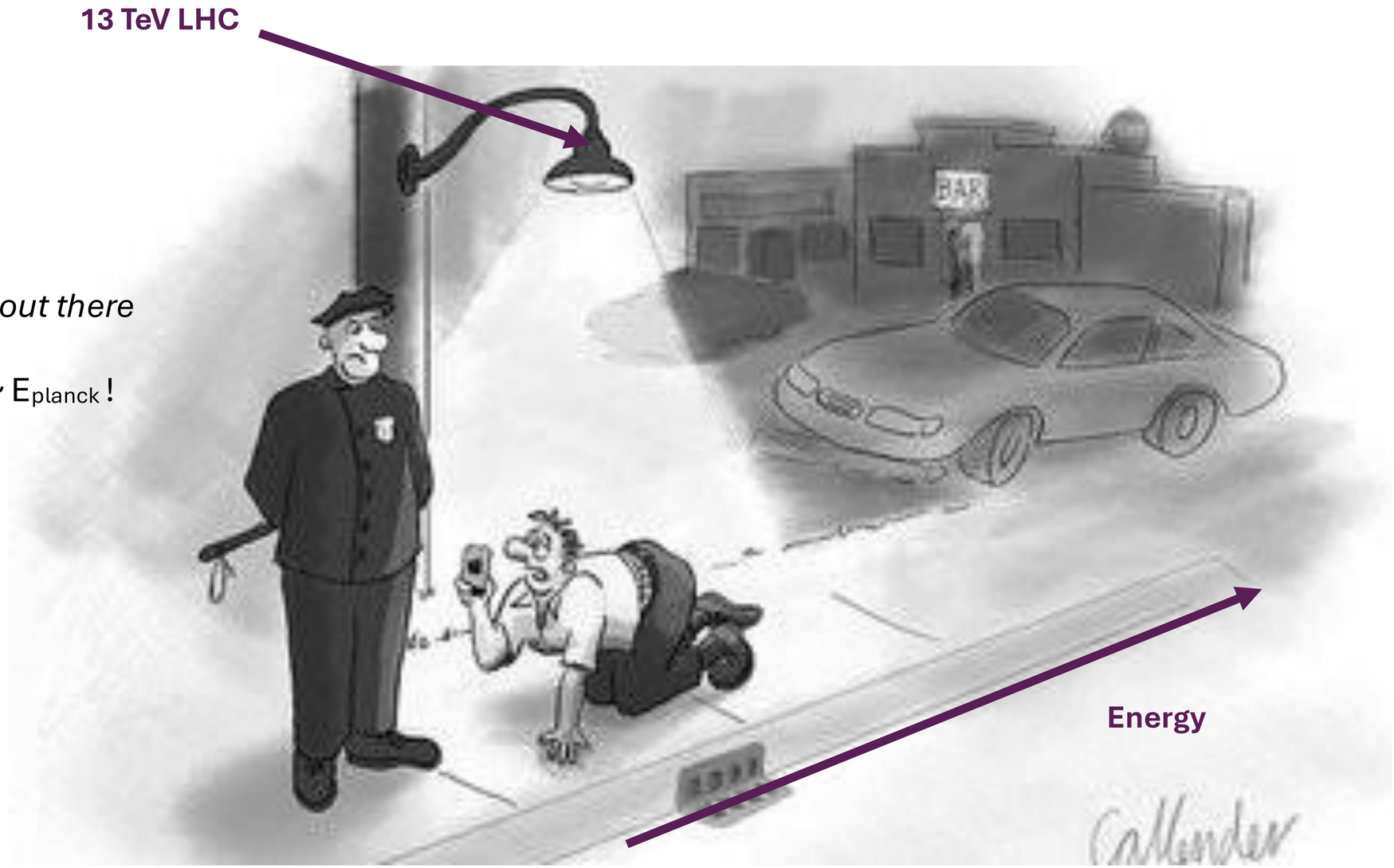
The *Drunkard's Search (*aka The LHC physics programme*)*

The *Drunkard's Search (*aka The LHC physics programme*)*

we are confident that there is new physics *out there*

- don't know its energy scale…could be ~ E_{planck} !

- we look at ~ E_{EW}—> few TeV
  - the energies we can directly access
  - **"This is where the light is"**



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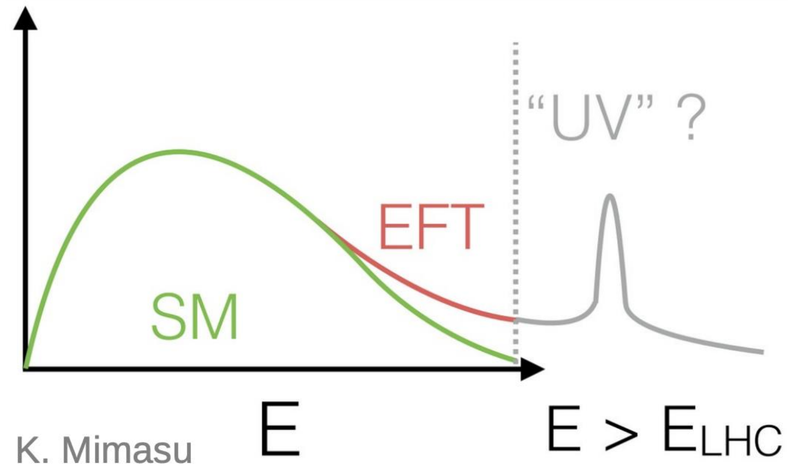
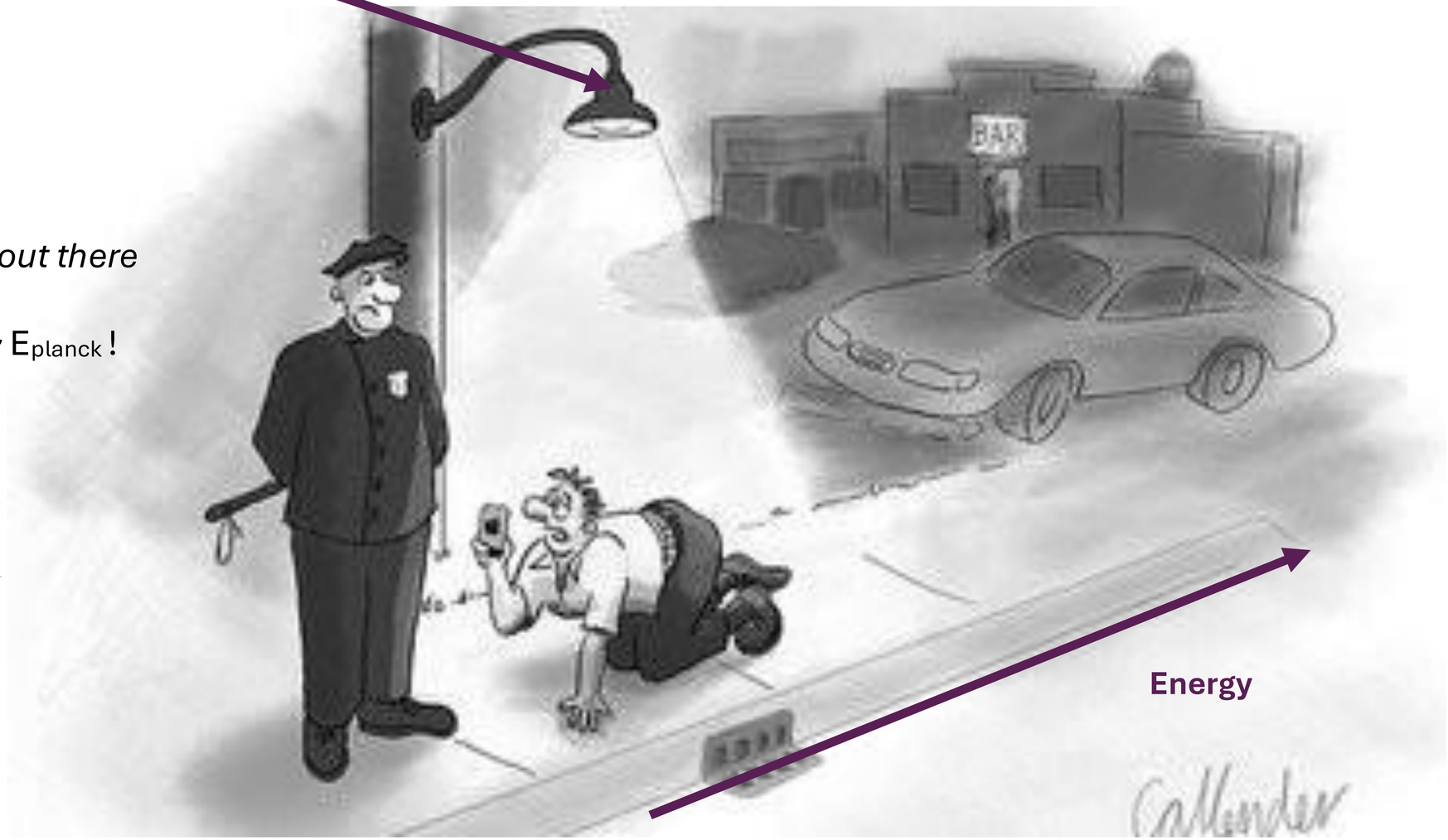


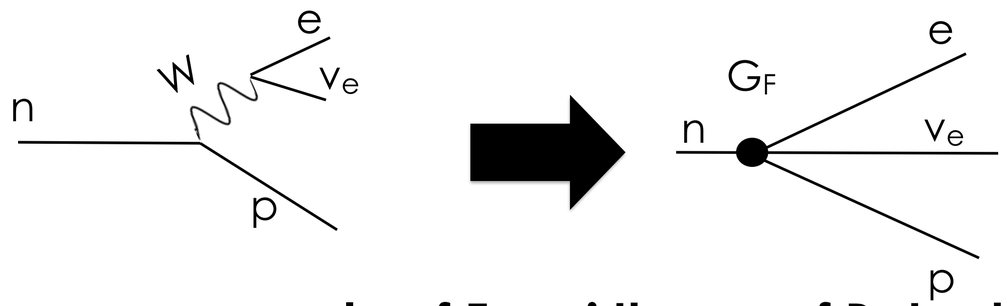


The *Drunkard's Search* has failed

- No light new physics observed in the LHC data

- **Why?**
  - is the NP scale (Λ_{NP}) far larger than the LHC scale?

- **Effective Field Theory** tells the effect of high-scale NP on low energy observables
- Integrate out heavy particles…replace with new operators and effective couplings
- Specific details of new particles invisible at low energy



famous example of Fermi theory of Beta decay

The SM as an EFT: SMEFT

- **Assume**:
  - $\Lambda_{NP} >>$ LHC scale
  - SM symmetries are respected at the LHC scale

- **Don't Assume**:
  - Any particular UV completion over Λ_{NP}

$$\mathcal{L}_{SM}^{(6)} = \mathcal{L}_{SM}^{(4)} + \sum_i \frac{c_i}{\Lambda^2}\mathcal{O}_i + \dots$$

– extend the SM Lagrangian with higher-order operators

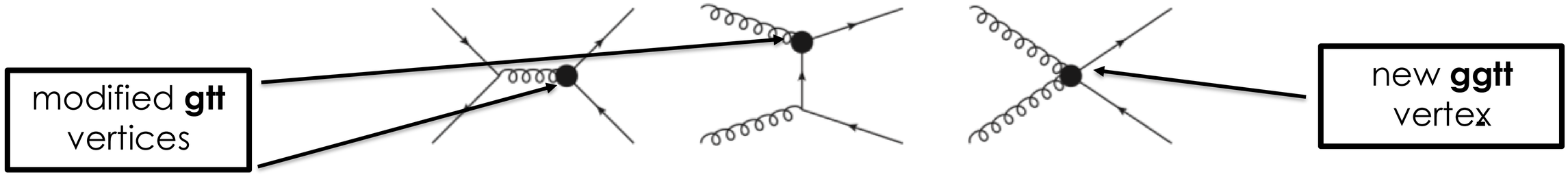
– usually the most important operators are dimension 6

The SM as an EFT: SMEFT

d-6 operators cause subtle effects in rates and kinematics of processes

$$\mathcal{O}_{tG} = ig_s(\overline{Q}\tau^{\mu\nu}T_A t)\tilde{\phi}G^A_{\mu\nu}$$

LHC example – O_{tG} affecting **rate and kinematics** of $t\bar{t}$ production



arXiv:1505.08841

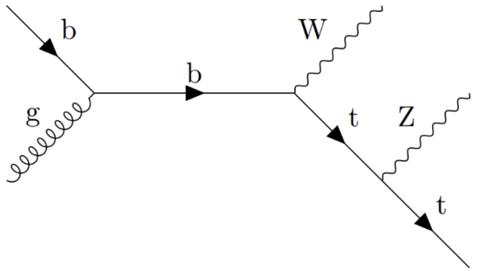
searching for new particles ➔ searching for new interactions

bump-hunting ➔ determining c_i

UCT-ATLAS

Diverse, high-profile analyses

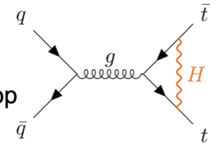
- **Top quark physics**
  - ttW charge asymmetry - constraining electroweak couplings and subtle new physics JHEP 07 (2023) 033
  - novel top mass measurements using J/Psi ANA-TOPQ-2018-19
  - ongoing - search for rare tWZ process **ANA-TOPQ-2019-29**



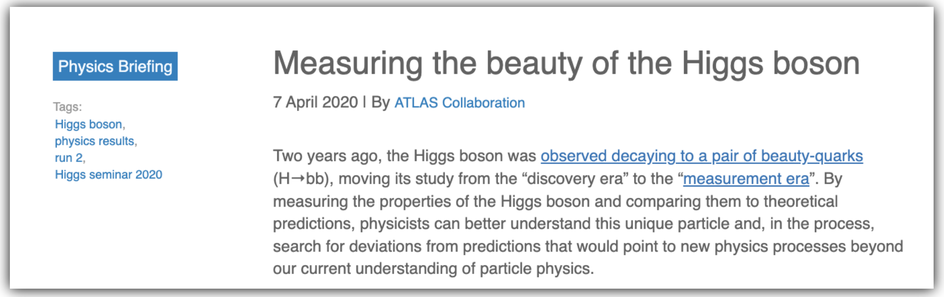
  - ongoing – constraining Top Yukawa from tt threshold **ANA-TOPQ-2023-33**

Indirect:

Processes where virtual Higgs exchanged e.g. 4 top & tt cross-section

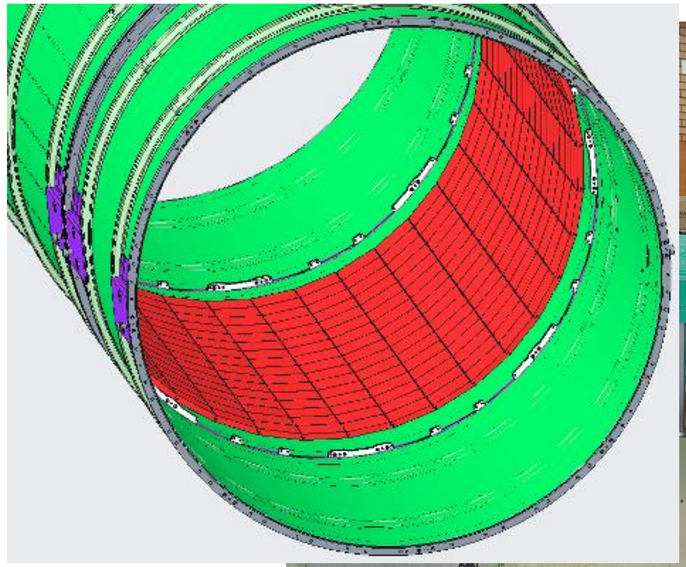


- **Higgs (VH(H->bb)) STXS optimisation**
  - ANA-HIGG-2020-20 Eur. Phys. J. C 81 (2021) 178

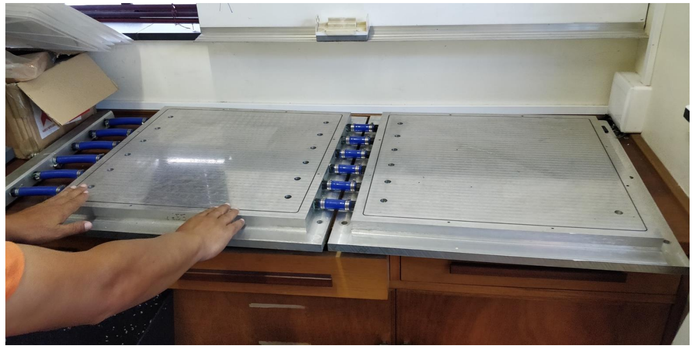


ITk Polymoderator

- UCT producing 3 polymoderators (central & outer barrel and endcaps) to shield the ITk from damaging neutron flux in the HL-LHC
- All raw materials (HDPE) procured and delivered to SAAO Cape Town for fabrication
- Central Barrel completed and delivered to CERN
  - Endcap fabrication commencing this quarter
- Outer barrell design M.Eng project of Alex Ross (superv. Dr. Reuben Govender)



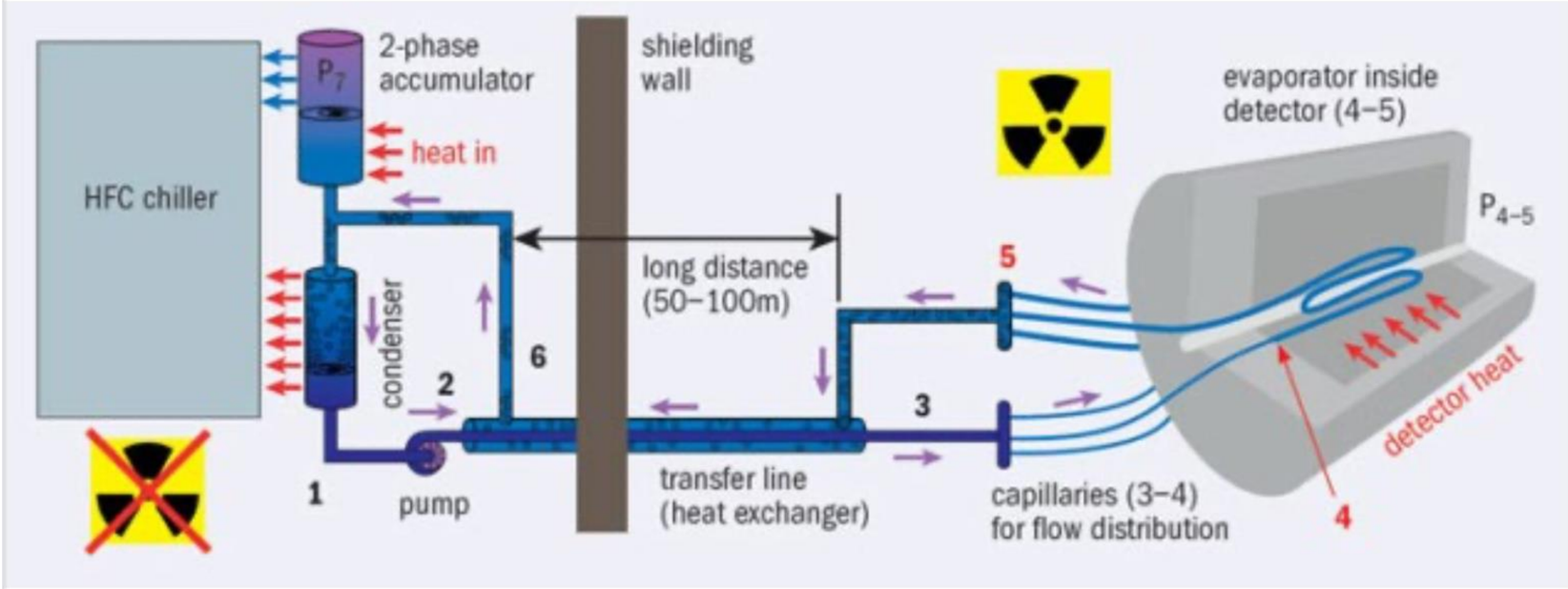
CERN Dec 2022



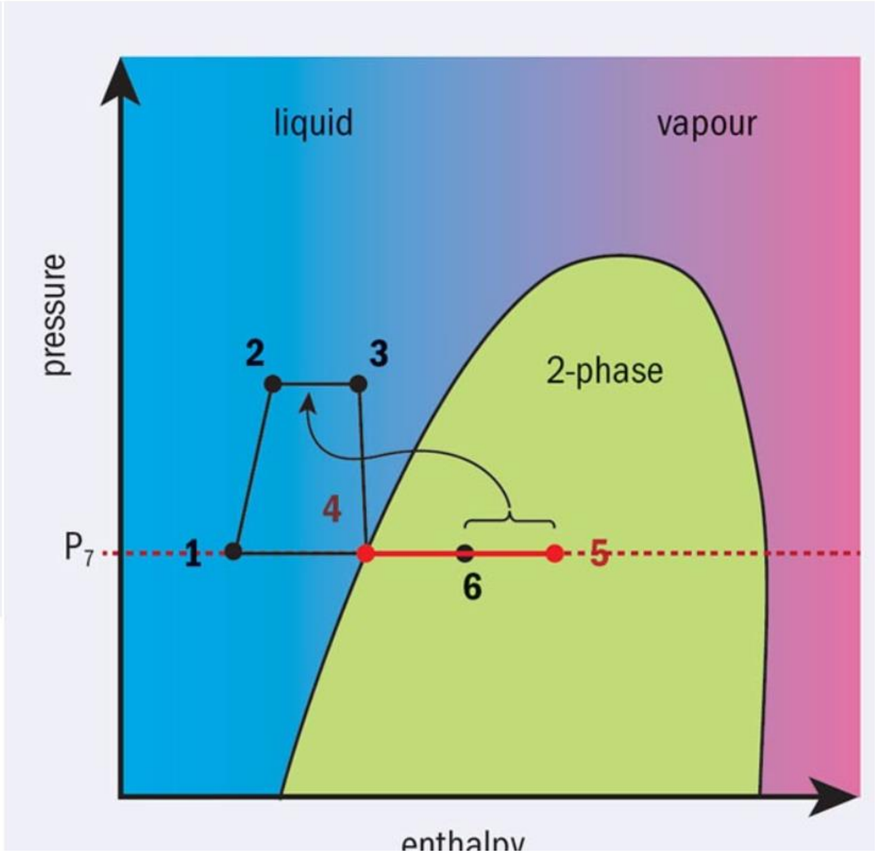
Precision, large area milling on hard HPDE required R&D and innovate approach in Mechanical Engineering

ITk Upgrade.

ITk Cooling

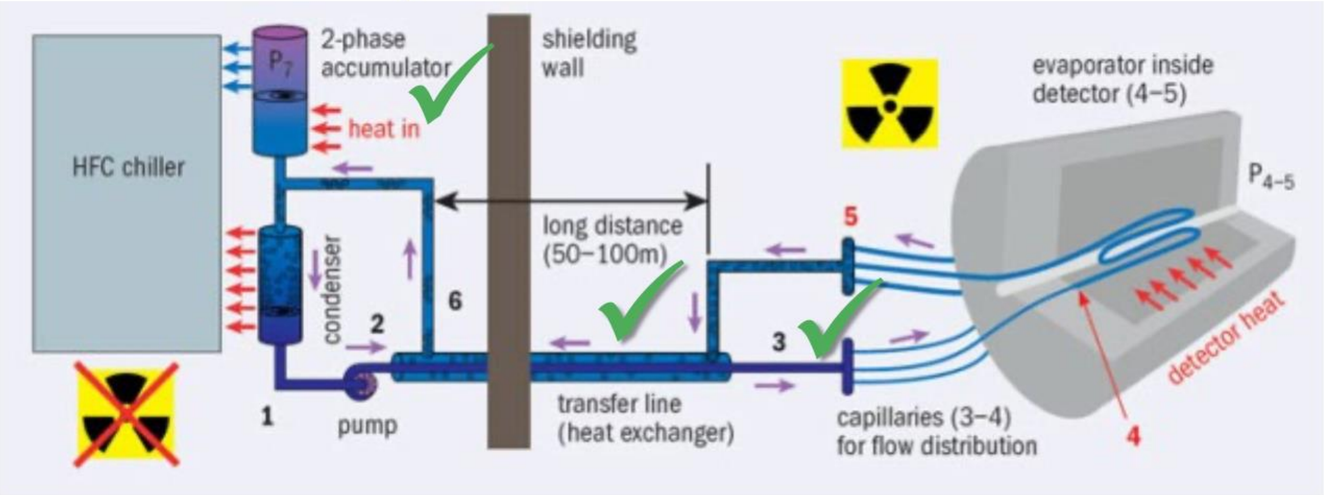


https://cerncourier.com/a/co2-cooling-is-getting-hot-in-high-energy-physics//



ITk Cooling

Model for detector, transfer lines and accumulator

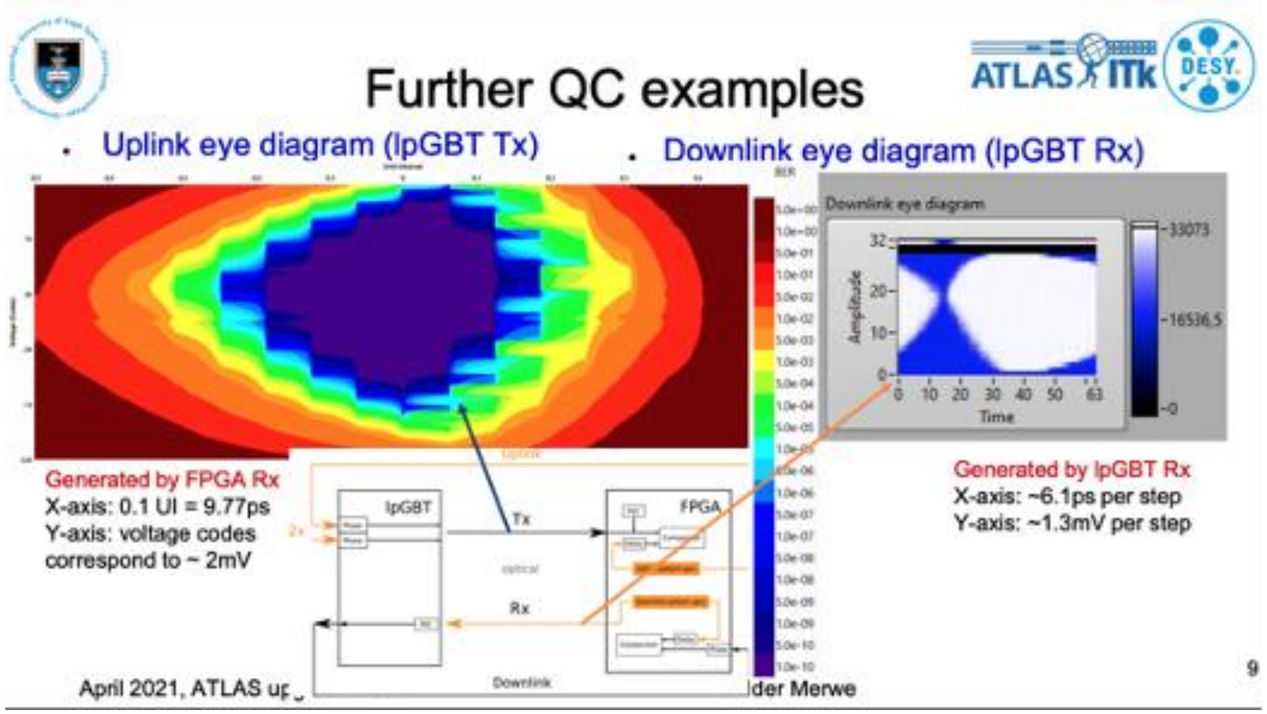


- **Measurements:**
- dP in two phase transfer line
- P_d, P_a Pressure at start and end of transfer line return
- T_{1a}, T_{1d} Temperatures in single-phase transfer line supply
- L = Accumulator level
- F = mass flow rate in the single-phase transfer line supply

- **State variables**
- Detector specific enthalpy (h, or $x, x_{\dot{m}}, \rho$)
- Specific enthalpy in n segments along the transfer line two-phase return, h_i
- Accumulator mass

ITk EoS Cards

UCT group in collaboration with **DESY** developed firmware and test procedures for EoS electronics card production campaign



automated generation of statistical uplink eye diagram tests of high-speed links developed entirely at UCT -> UCT firmware now in heavy usage in EoS production @ DESY

Outreach!

Phenomenal Physics event at UCT for 200+ High School Learners

Visit of ATLAS experiment Management Team to SA-ATLAS, Nov 2023

Relaunched UCT CERN Research Centre to host public lecture

10 NOVEMBER 2023 | **STORY** THANDILE XESI. **PHOTO** ISTOCK. **Read time** 1 min.

Titled "Journey to the Origin of Matter and Universe", the lecture will centre around particle physics, with a special focus on the Large Hadron Collider.

The New Lecture Theatre (NLT) will host the relaunch of the University of Cape Town's (UCT) CERN Research Centre on 24 November. The event will be marked by a public lecture.

Titled "Journey to the Origin of Matter and Universe", the lecture will centre around particle physics, with a special focus on the Large Hadron Collider.

The event features guest speaker, Dr Andreas Hoecker, the spokesperson of the A Toroidal LHC ApparatuS (ATLAS) experiment at CERN, who brings a wealth of knowledge and expertise in elementary particle physics. With a background in physics and a PhD from Orsay, France, Dr Hoecker has been a key member of CERN since 2005.

The research at CERN explores the theory of the Quark–Gluon Plasma, a unique state of matter that existed moments after the Big Bang. It also delves into the properties of the Quark/Higgs boson using the ATLAS experiment.

UCT News survey

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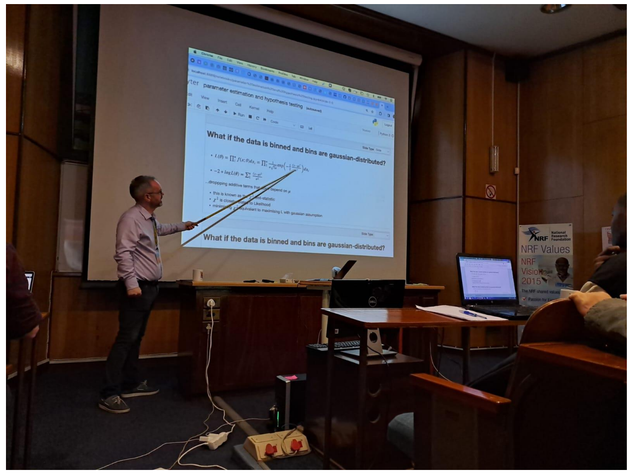
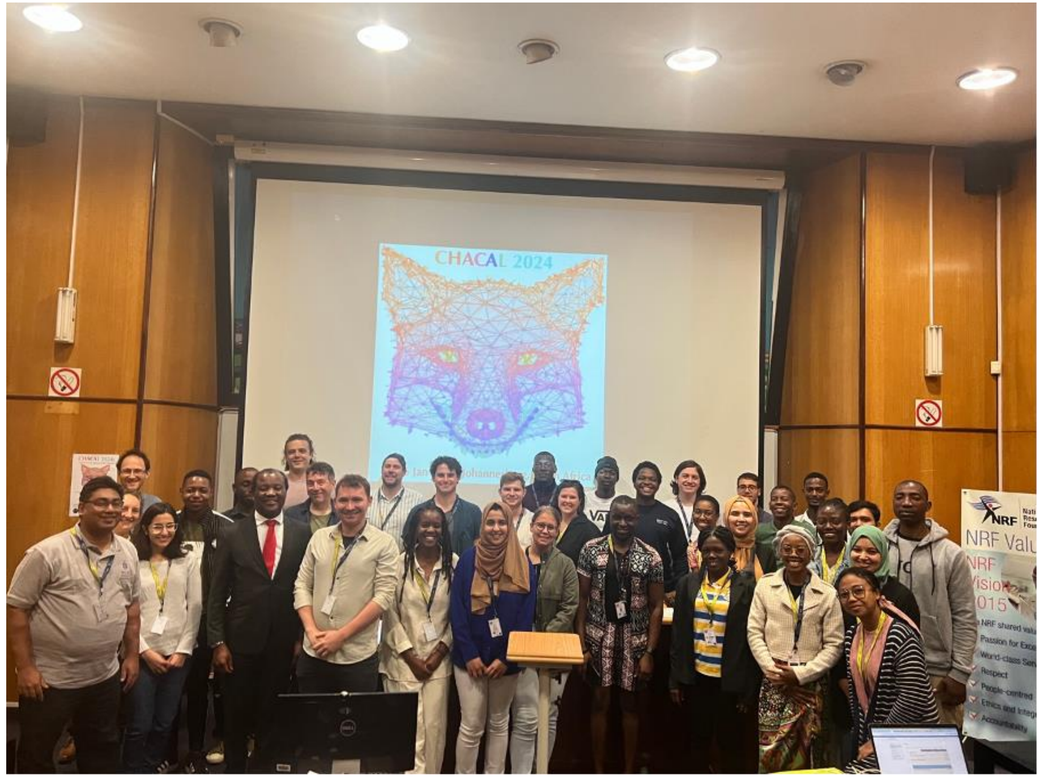
SUBMIT

Most read

- **Nobel Laureate Professor Abhijit Banerjee delivers open lecture** 09:30, 5 March 2024
- **DSA to host Welcome Festival** 16:40, 5 February 2024
- **Summer School serves up a feast during annual festival of…** 11:21, 17 January 2024
- **2024 First-Year Campus Reception** 15:40, 16 January 2024
- **Opera UCT, Cape Town Opera to stage reimagined 'La Traviata'** 13:00, 20 October 2023

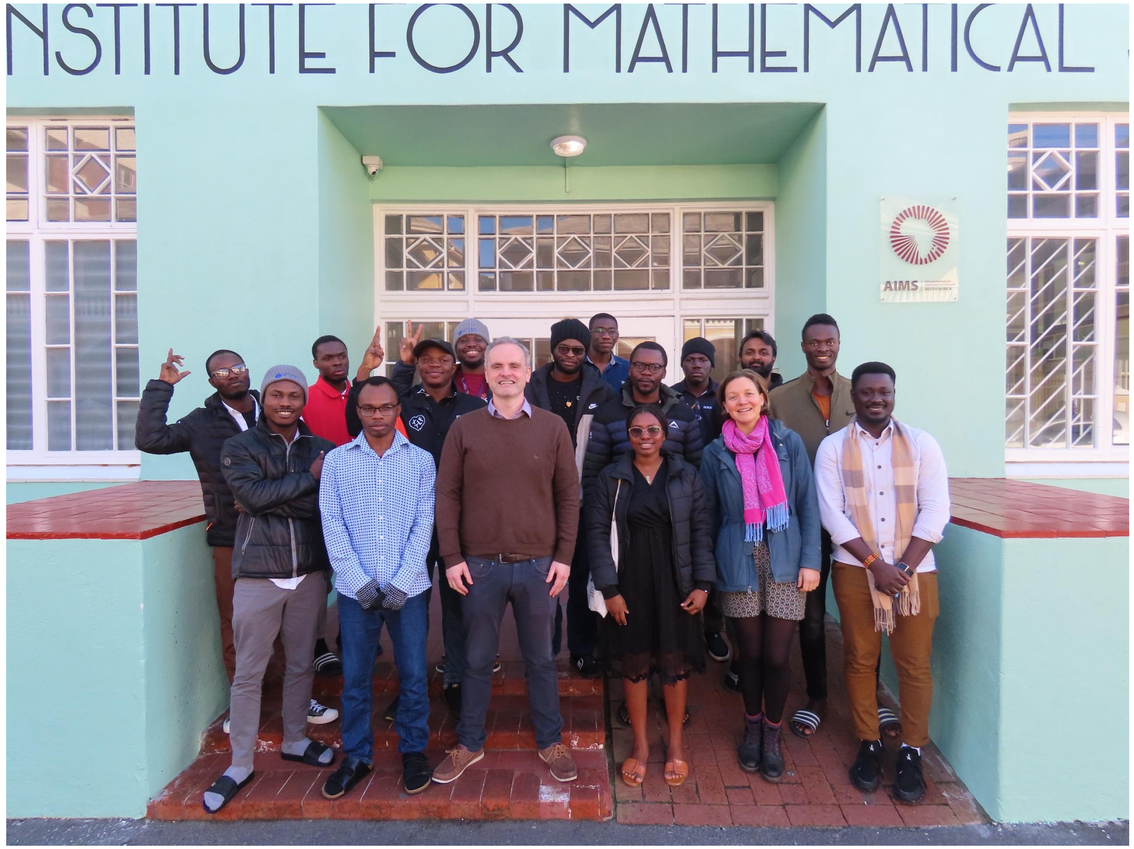




CHACAL 2024 School at Wits, co-funded by CNRS, France

Outreach!

Public talk at UCT from Andreas Hoecker Nov 2023



Dr. James Keaveney & Dr. Julia Gonski (SLAC/Stanford) teaching 3-week module on data science and Real-time AI to the cream of young African AI Talent

ATLAS *open data* at UCT

public access to data, simulation, and software to for education

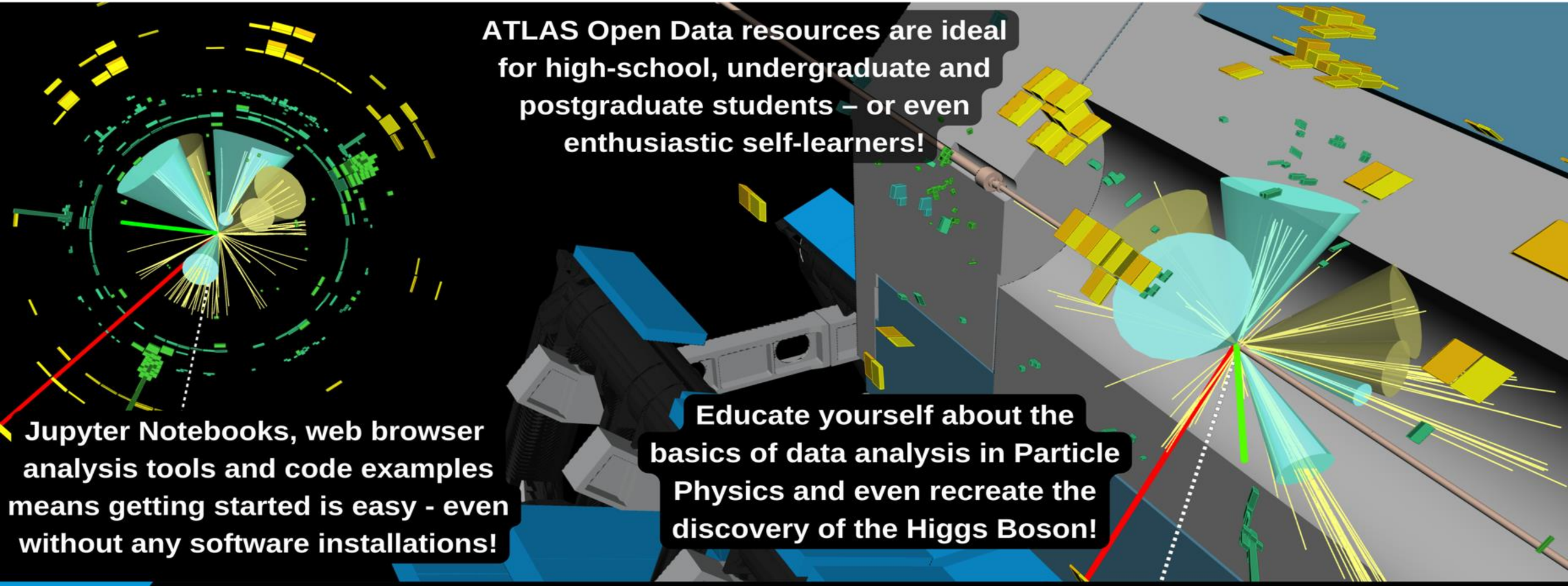
open data ATLAS

atlas.cern/Resources/Opendata

DEPARTMENT OF PHYSICS
UNIVERSITY OF CAPE TOWN

UCT-CERN

At UCT, we use ATLAS *open data* to deepen students' understanding of data analysis in particle physics



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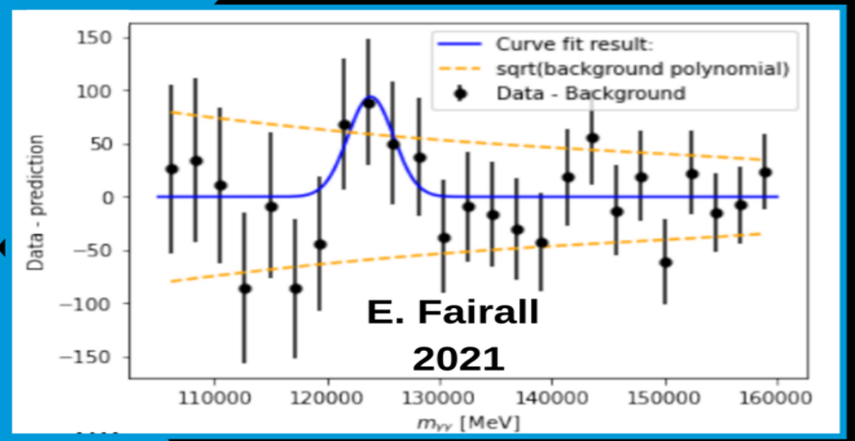
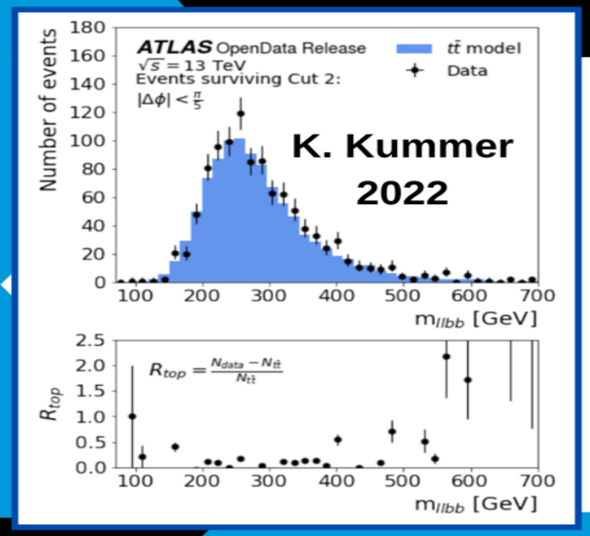
Educate yourself about the basics of data analysis in Particle Physics and even recreate the discovery of the Higgs Boson!



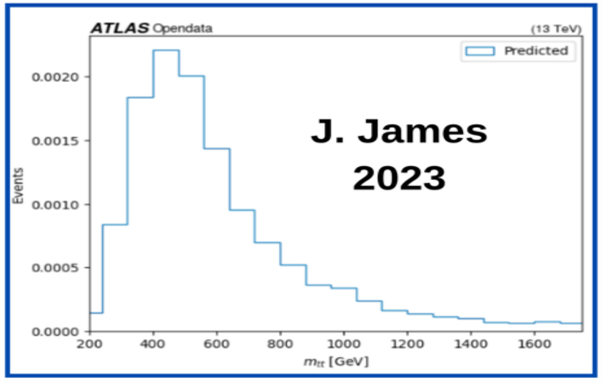
ATLAS OPEN DATA IN UCT 3RD YEAR LABS

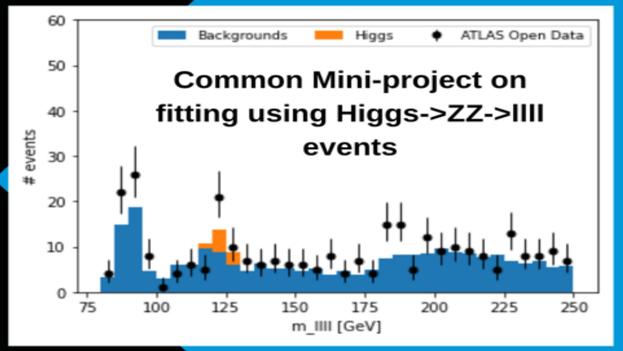
- ***Rediscover the Higgs Boson***
  - Step-by-step guided analysis of diphoton events
  - Skeleton analysis code provided in via user-friendly Jupyter Notebook
  - Fit of signal + background model
  - Calculate significance of Higgs signal
  - **Is the evidence sufficent to rediscover the Higgs boson?**



ATLAS OPEN DATA IN UCT 3RD YEAR PROJECTS

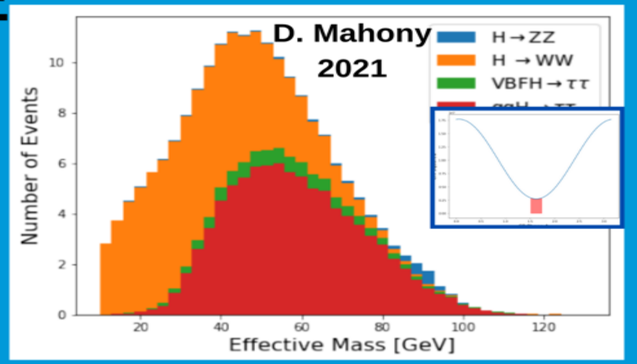
- Searches for *Toponium* in top quark pair production
- **2022 -** Interpret Data vs. Standard Model in tt threshold region as potential Toponium signal - apply cuts to maximise Toponium signal
- **2023 -** Reconstruct the top quarks to better isolate the threshold region
  - Analytic solution to kinematic equations of the *tt* system to deduce undetected neutrino kinematic and isolate threshold region





ATLAS OPEN DATA IN UCT DATA SCIENCE MODULE

- Honours/Msc. module focuses on Data Science Techniques: statistical analysis, machine learning, data visualisation, computing **as applied in particle physics**
- Students encouraged to use ATLAS OpenData for final project.
- Major open-ended independent project, e.g. extraction of CP violating phase from Higgs production



Conclusion

UCT-AIMS-ATLAS focuses on:

- ***discovering subtle hints of BSM physics in the top sector and ultimately via Anomaly Detection***
- ***making crucial contributions to the ITk construction***
- ***reaching out to potential new ATLAS physicists & engineers in SA via Outreach and Education***

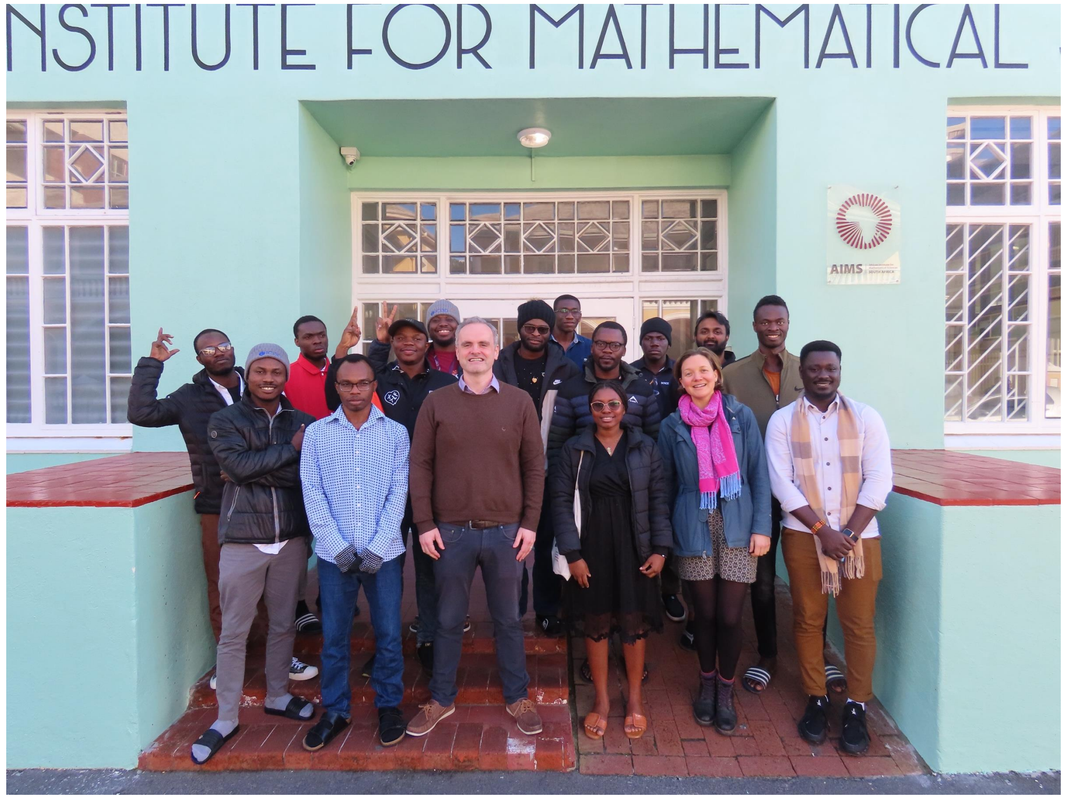
JOIN US!

Backup

UCT, SA-ATLAS & AIMS

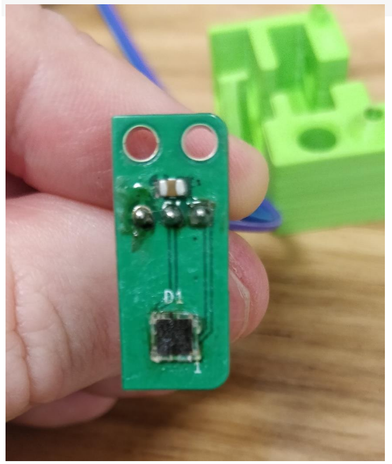
UCT ATLAS Research Programme of J. Keaveney & C. David on Real-Time Artificial Intelligence in the ATLAS Trigger

- Integrated into AIMS new AI4Science MSc programme funded by **$4.5 Million** from Google DeepMind
- Dr. Claire David (AIMS Academic Director) now Honorary Research Associate at UCT
- Dr. James Keaveney & Dr. Julia Gonski (SLAC/Stanford) teaching 3-week module on data science and Real-time AI to the cream of young African AI Talent



muCT – muon tomography for South Africa

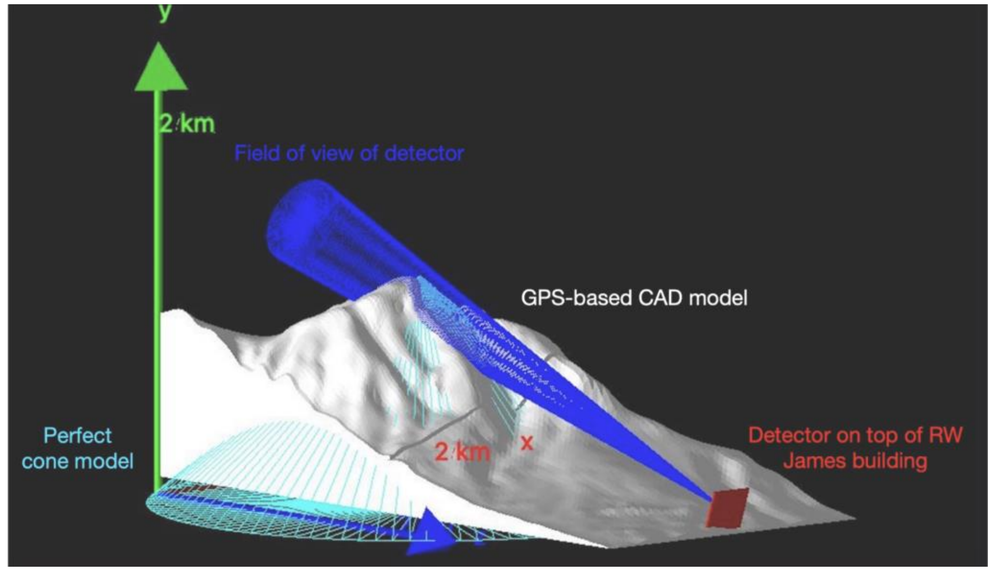
***muCT* - project to take particle physics detector technology and create real-world, commercialisable concepts.**



1.1 M ZAR awarded to J. Keaveney from UCT URC for ATLAS EoS project
500k ZAR awarded to J.Keaveney from UCT Innovation Builder Fund
260k ZAR from UCT to fund MSc student

Novel detector concept for Muon Tomography using plastic scintillators

- technology from the LHC with a real-world application
- Huge commercial potential in SA, IP creation
- collaboration spawned from on ATLAS EoS card for ITk

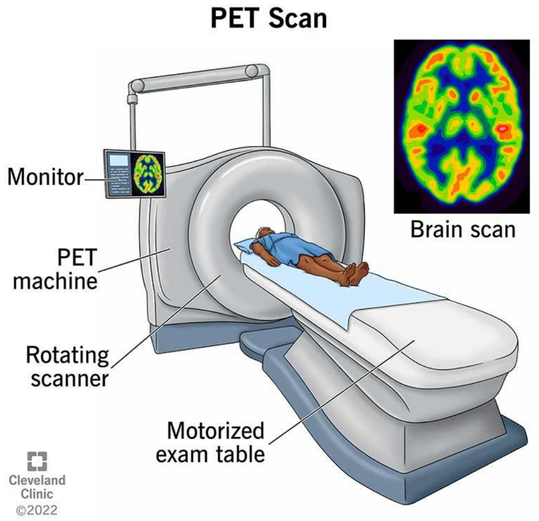


SA-CERN Tech. Transfer in action!

Bringing Fundamental Physics into the Real World

- Inaugural New Frontiers Research Award
- 5 year, 7.5M grant to apply particle physics technology

  to low-cost PET cancer imaging for South Africa



Basic Scientific Research the fertile ground for **innovation**

DAILY MAVERICK

OPINIONISTA

Taking science into the real world using particle physics in cancer and TB treatment

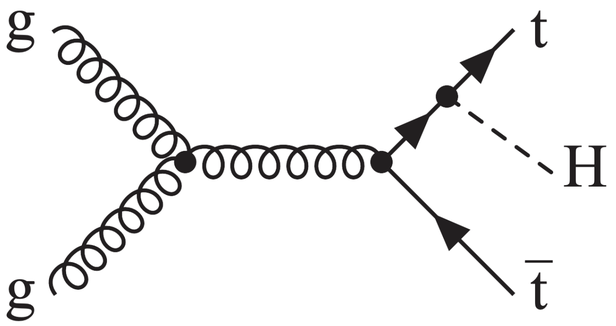
By James Keaveney Follow 04 Jul 2024 0

Dr James Keaveney is a particle physicist at the University of Cape Town and the inaugural recipient of the Oppenheimer Memorial Trust New Frontiers Research Award.

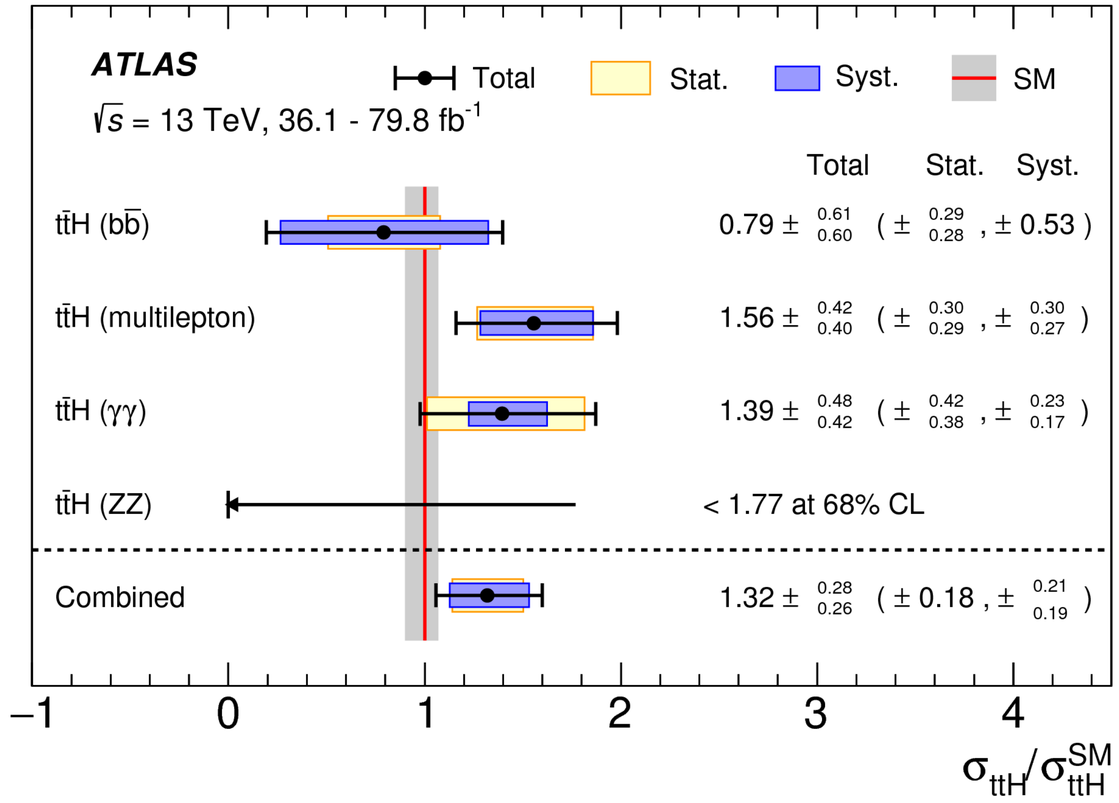
With the R7.5-million Oppenheimer Memorial Trust New Frontiers Research Award, I aim to follow UCT Nobel laureate Allan Cormack's example to make cutting-edge, life-saving and life-changing medical imaging cheaper, safer, more precise and available to all.

A **Huge Thank You** to the DSI/NRF/SA-CERN for providing the scientific platform for this opportunity!

Seeking new physics with tops



- What do we see in the LHC data?
  - Mild excesses with respect to $\sigma_{t\bar{t}H}^{SM}$ in ATLAS



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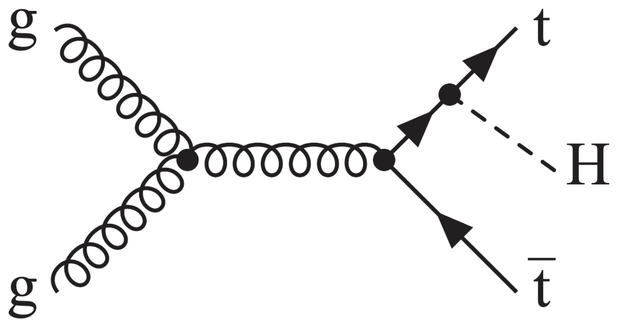
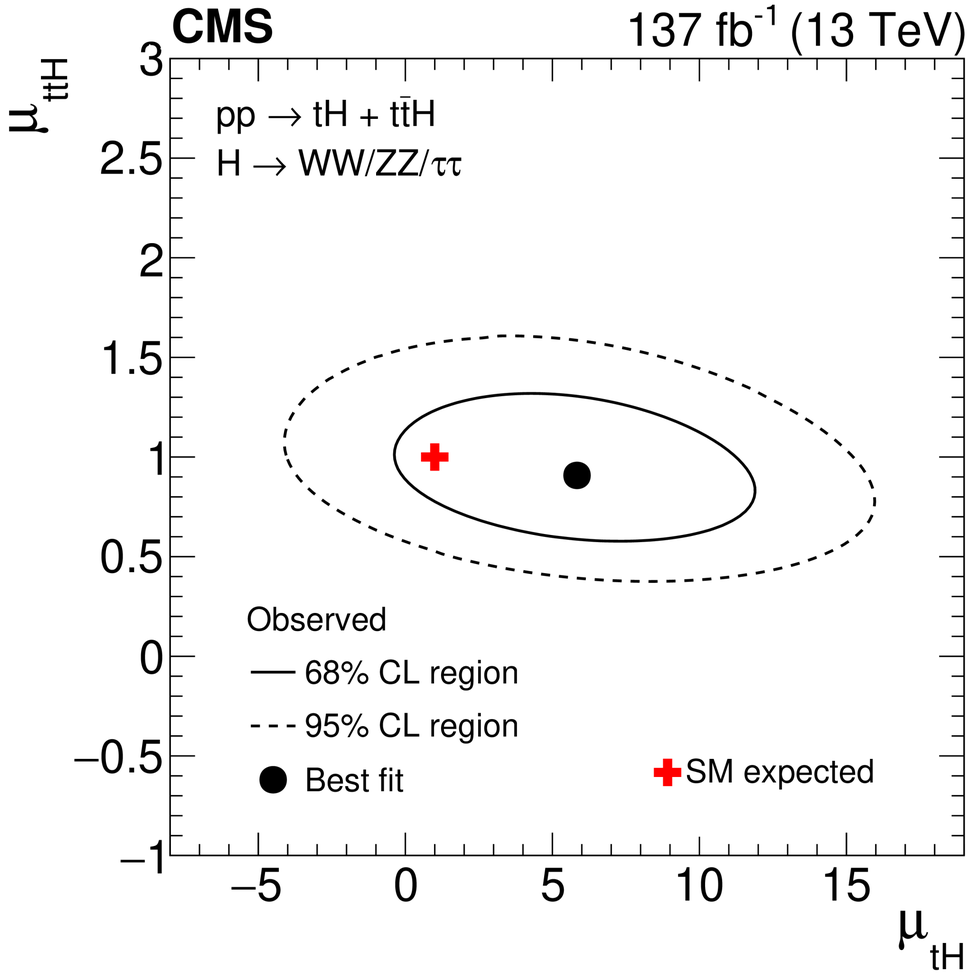


- What do we see in the LHC data?
  - Mild excesses with respect to $\sigma_{t\bar{t}H}^{SM}$ in ATLAS
  - CMS finds excellent agreement with SM



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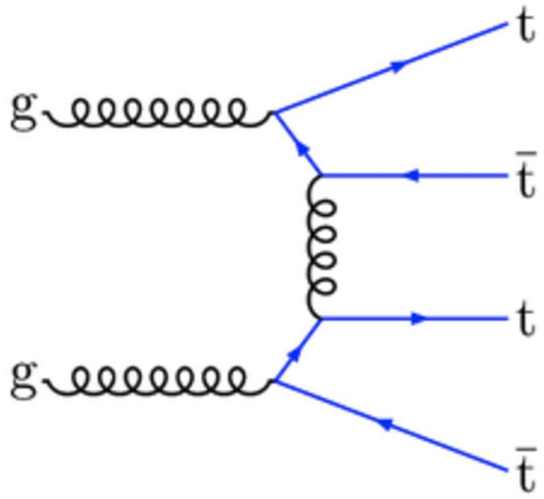
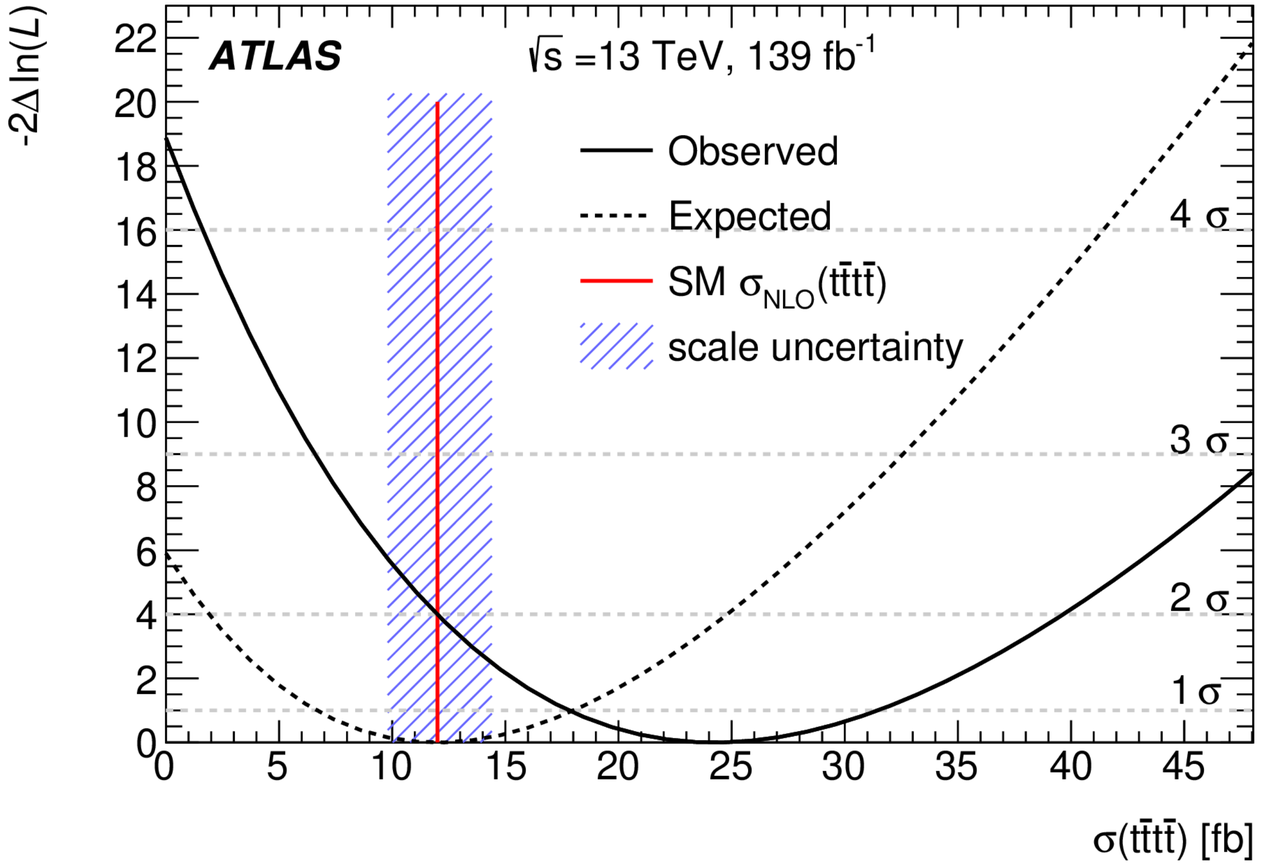
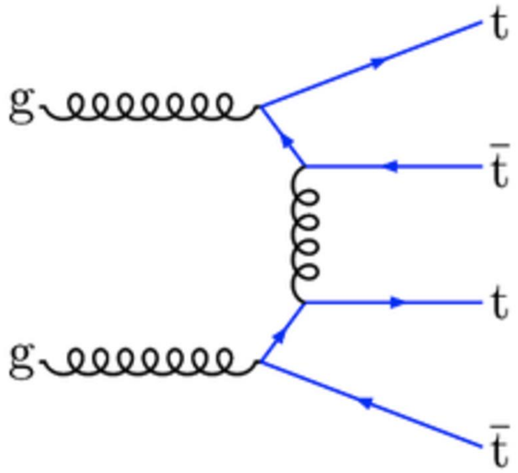


- Very heavy top-philic new physics could disrupt four top quark production rate

- What do we see in the LHC data?
  - **ATLAS: Mild excess with respect to $\sigma_{t\bar{t}t\bar{t}}^{SM}$**
  - **CMS: Mild excess with respect to $\sigma_{t\bar{t}t\bar{t}}^{SM}$**



Seeking new physics with tops



- supersymmetric top partners $\tilde{t}$ with $m_{\tilde{t}} \approx m_t$
- clear experimental prediction

- Very heavy top-philic new physics could disrupt four top quark production rate

- What do we see in the LHC data?
  - **ATLAS: Mild excess with respect to $\sigma_{t\bar{t}t\bar{t}}^{SM}$**
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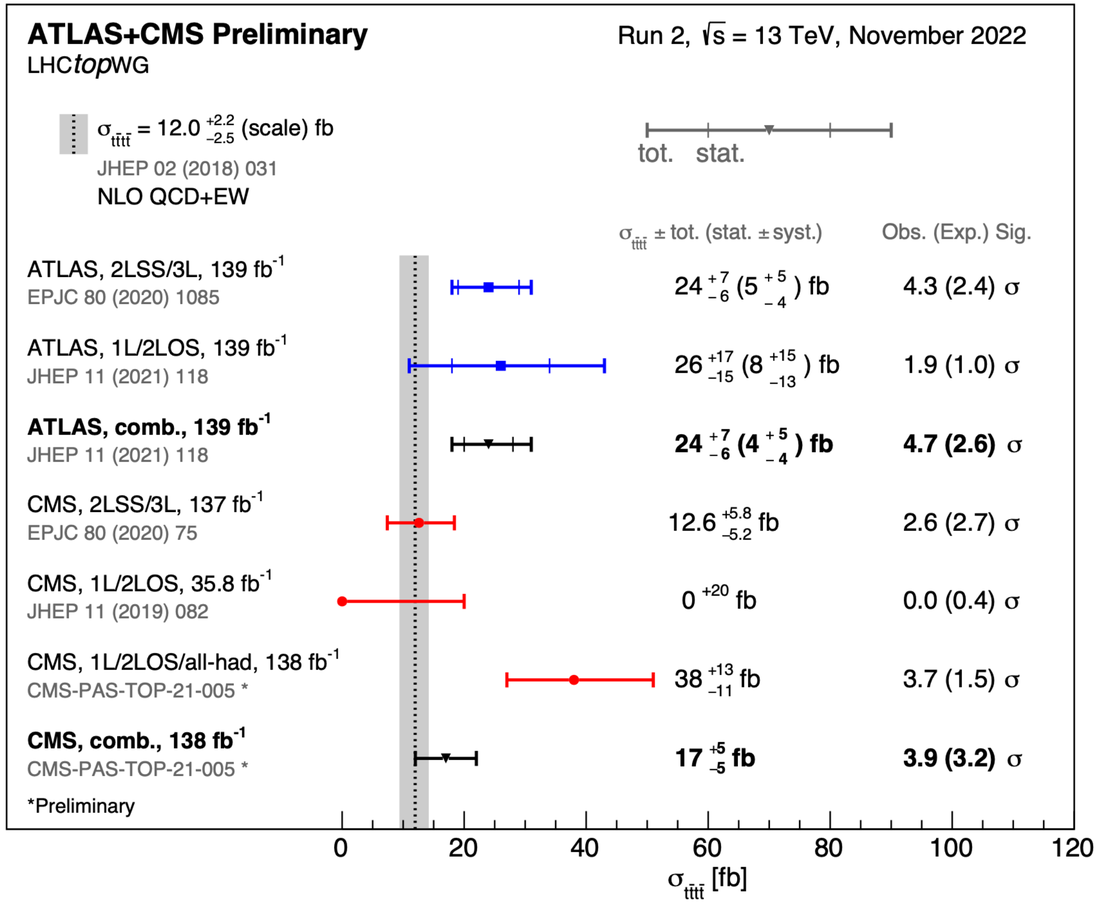
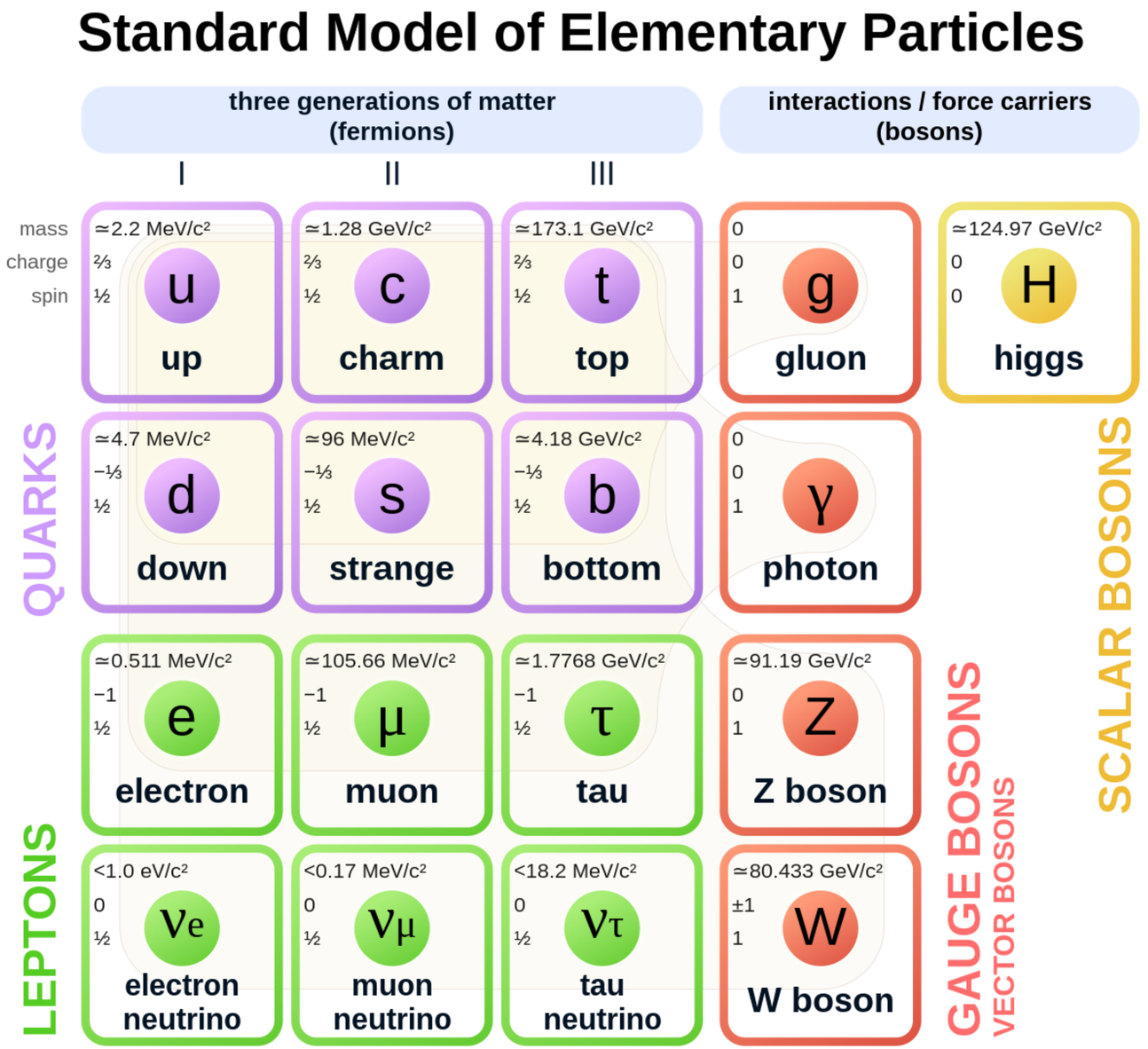
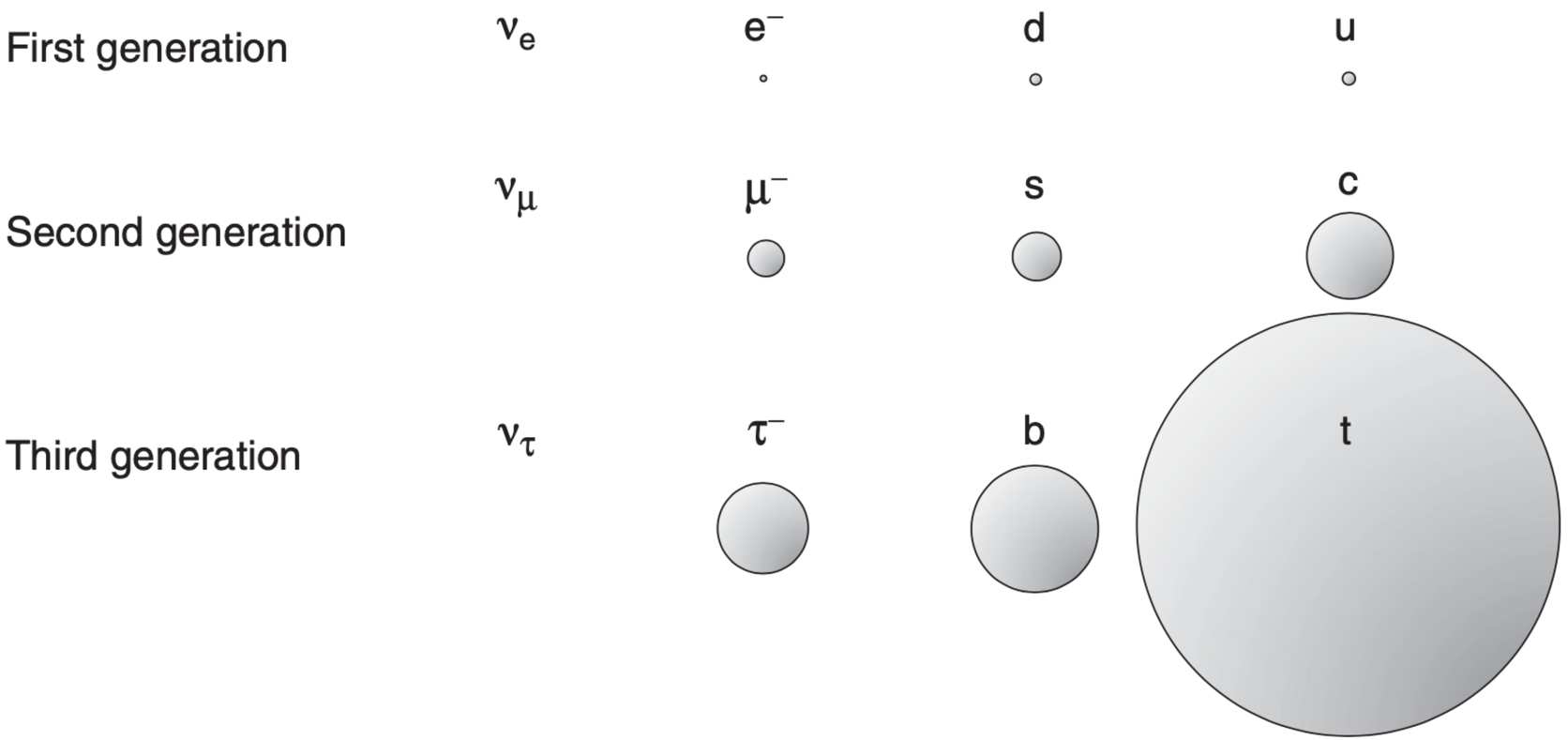


first things first - the Standard Model



Fermion masses in the Standard Model



Why three generations?
Why apparently random masses if these particles are fundamental?

$m_{top} \approx m_{Auatom}$!!

Outreach

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public access to data, simulation, and software to for education

open data ATLAS

atlas.cern/Resources/Opendata

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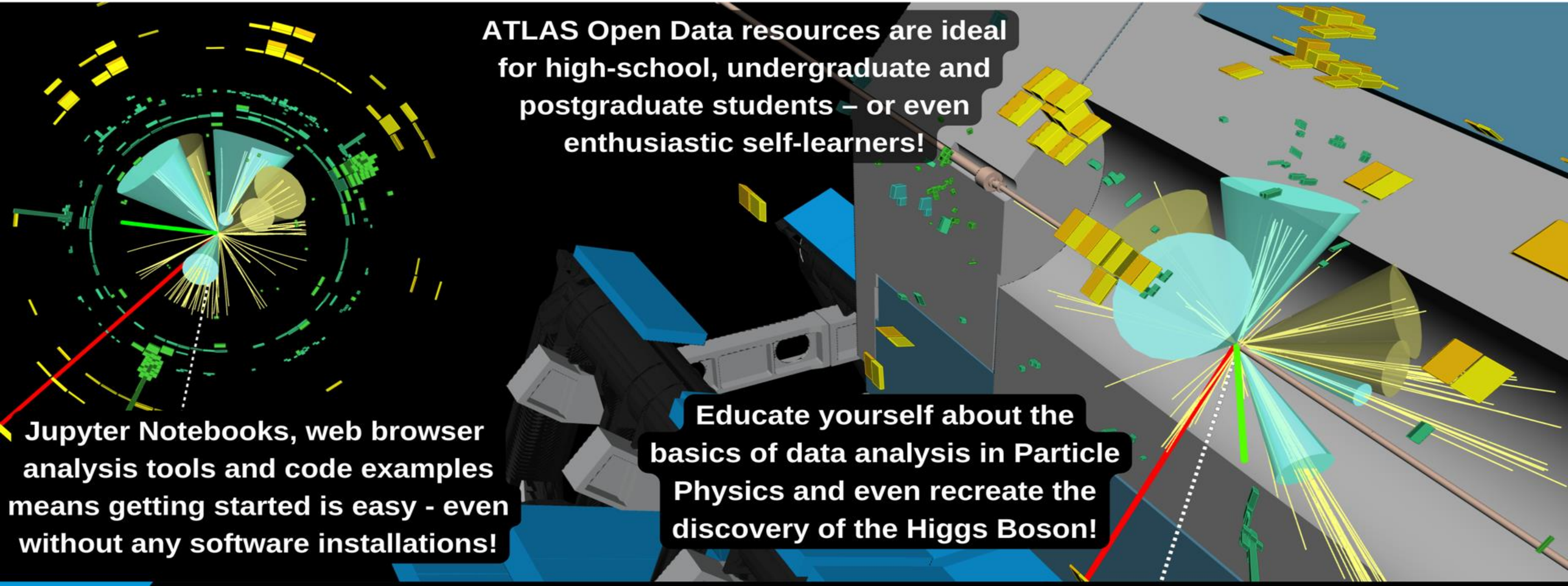

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Tech transfer: MinPET - Now acquiring R100M for the CDR

Accelerators, Detectors, High-throughput electronics, Big Data, Simulation (Geant4), Data quantitative visualization (ROOT), High Performance Computing, AI

MINPET DIAMONDS I SORTED

4IR Technology to "see" diamond enclosed in kimberlite. Other related technologies in medicine, mining, waste, homeland security

National Science and Technology Forum (NSTF)
2022 - Innovation Award: Corporate Organization

UNIVERSITY OF JOHANNESBURG

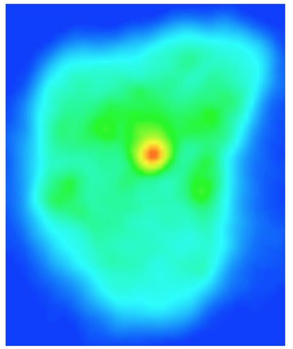
UJ DMES Research Team
UJInvnt
UJ Tech Transfer Office

2 Patents Granted in 2022
Innovation beyond MinPET

- **XRT on Steriods**: Method of Multiple Source and Detector Gamma Ray Tomographic Radiography
- **Poly-PET**: Materials Analysis Method and System

95mm kimberlite

0.91 ct



GEM DIAMONDS

UJ takes leadership in Innovation and Commercialization

Begins de-risking spend with work packages for the International Technology Partners and building the UJ Research Team

research instruments

NeT instruments

COSYLAB

STARK

Fibre Optic Sensors (FOS)… Keep ATLAS Dry !

UJ @ CERN: Fibre Optic Lab

A brief history of SA-CERN

- SA-CERN launched in December **2008**, celebrating **15** years in December 2023
- South African involvement in CERN, experiments (ATLAS, ALICE, ISOLDE) through a cluster approach
  - With THEORY and TECH TRANSFER making up the 5 *pillars* of SA-CERN
- SA-CERN Coordination Committee manages the programme on behalf of the Department of Science and Innovation, as a National Strategic programme, hosted at iThemba LABS (natural home)
- Programme managed by the Deputy CEO of NRF and resource allocation and administration managed at iThemba LABS

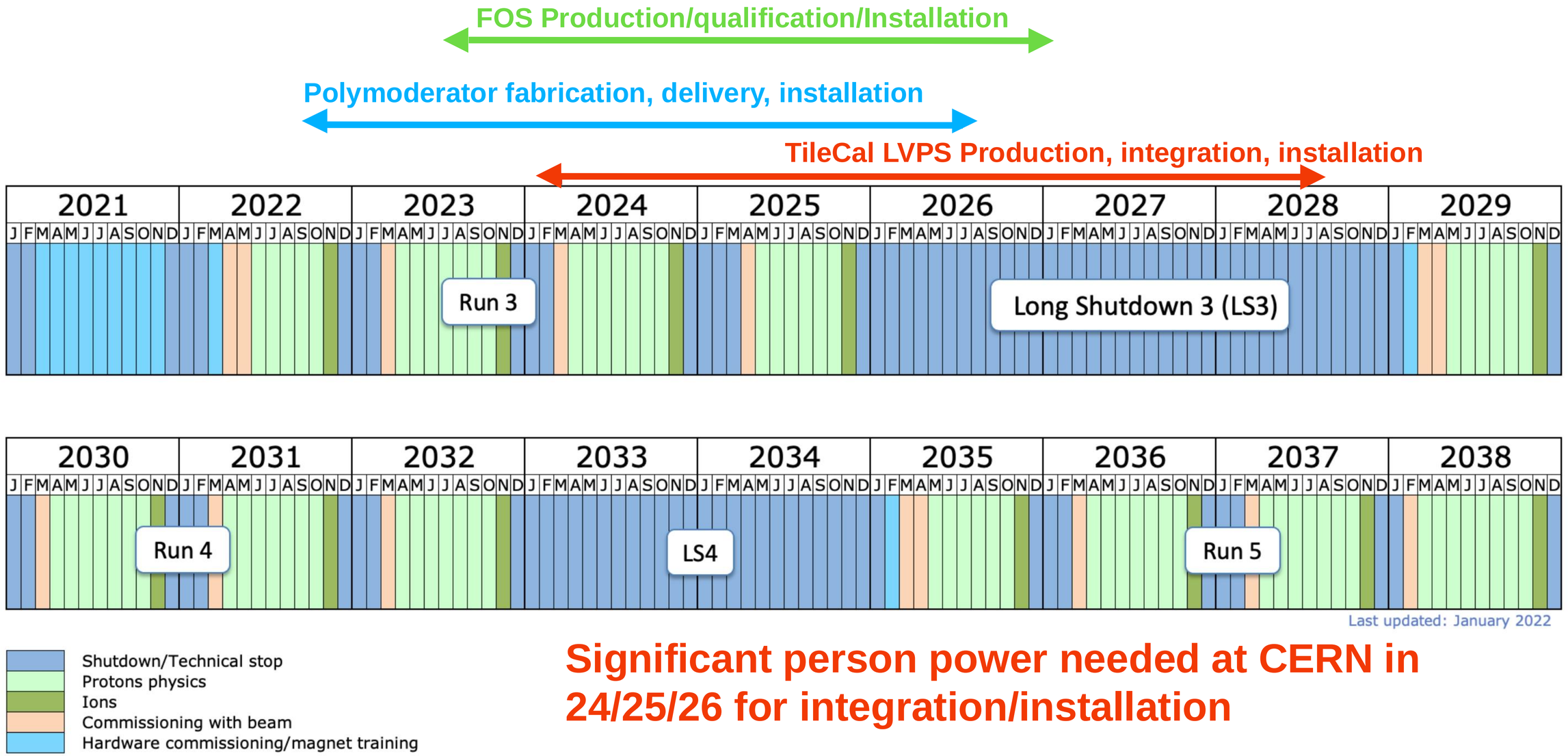
A brief history of SA-CERN

- Objectives:
  - Increase opportunities for the South African community to establish a solid presence at CERN
  - Use the SA-CERN and CERN platforms to grow the **human capacity development** through the number of researchers, post doc and students partaking in the physics research at CERN
  - Increase opportunities for SA researchers to contribute to major scientific output and discoveries from
  - Participate in major research equipment and instrumentation upgrades at CERN
  - Establishment of local infrastructure for CERN-related research
  - Technology transfer from training and expertise development via involvement in technical activities at

- Annual budget of R4m (CHF200k) in 2008 increasing to R30m (CHF1.5m) in 2023

- SA-CERN participated in Phase 1 upgrades as a cash contributor, and graduated to largely in-kind co
  - **Positive for local impact and tech transfer**

SA-ATLAS Phase II Upgrade Commitments



Significant person power needed at CERN in 24/25/26 for integration/installation

Status of SA-ATLAS upgrade commitments

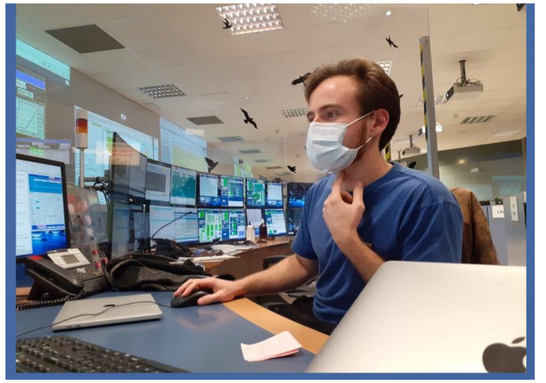
Detector Operations

- 100s of Physicists and Engineers oversee the daily operation of the ATLAS experiment
- **SA-ATLAS** plays a key role in operations with a **strong international reputation**.
  - **Maintenance** activities in **radiation-controlled** environments.
  - **Experts** on-call for **high- speed electronics** and **detector control systems**.
- Invaluable **leadership skills in an international environment**

SA-ATLAS punches well above its weight in leadership in the day to day running of ATLAS

TileCal Run coordinator 2022

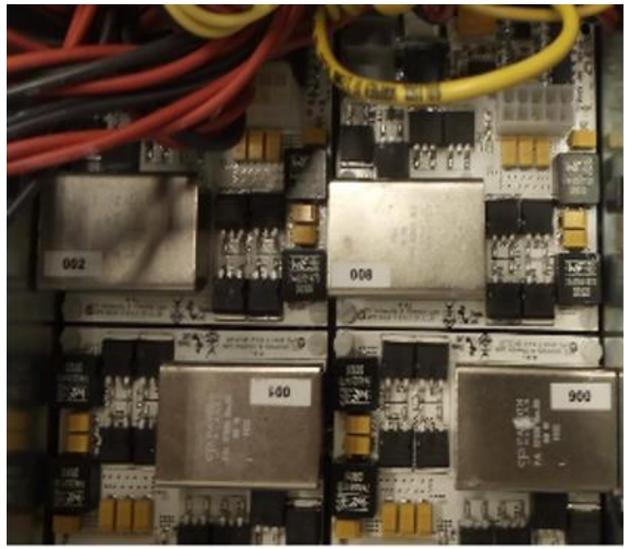
Run control 2022



TileCal Run coordinator 2023

TileCal LVPS & PPr

- Wits producing and qualifying significant fraction of LVPS & PPr for TileCal
- 1 SA-CERN postdoc to be engaged on this project at 90% level
- Status:
  - about to pass the Final Design Review (FDR) focusing on radiation hardness
- Status
  - LVPS Pre-production (10% of the total) (Q1-Q2 ’23)
  - LVPS Production Readiness Review, (Q3-Q4 ’23)
  - LVPS Full Production will take place end of 2023 in to 2024.
  - PPr FDR Q2 2023. Pre-production in 2023, production in 2024.



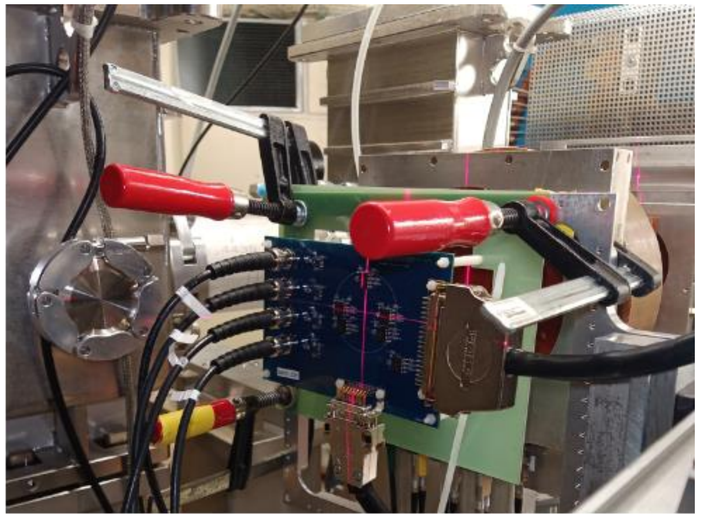
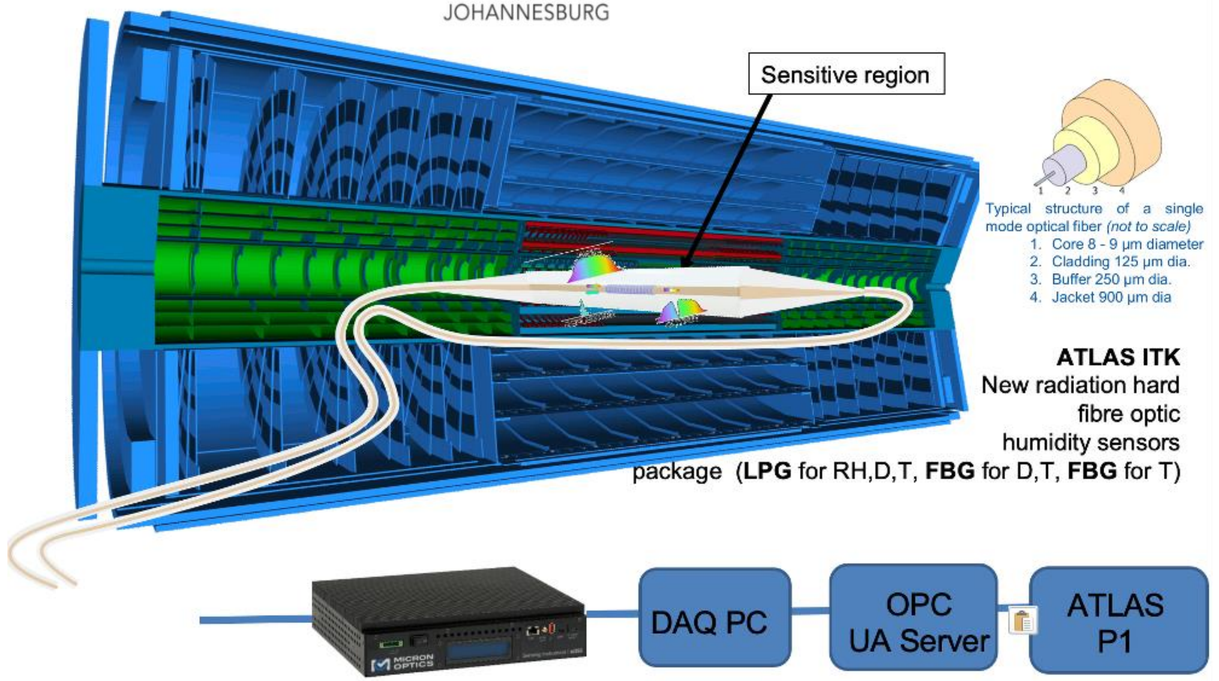


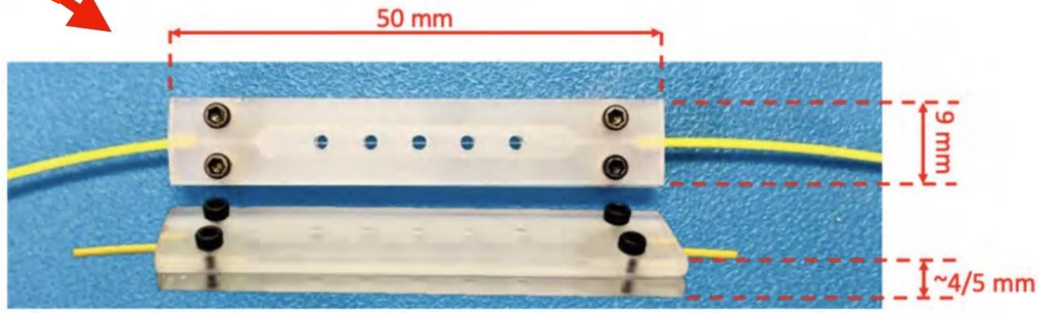
Figure: The most recent LVPS Box prepared for vertical slice tests in Building 175 at CERN. Eight WITS Low Voltage power supplies were installed to power the Phase-II Upgrade module electronics (right).
In February 2023, the AMC1300 chips underwent radiation testing at PSI with a flux of 2E8 p/cm2/s. With a constant input voltage of 0.2V, and an output of 1.64V was expected for all chips.

ITk Fibre Optic Sensors (FOS)

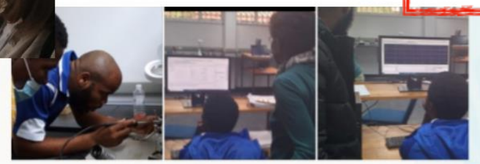
UNIVERSITY OF JOHANNESBURG

- UJ committed to in-kind contribution of production & qualification of radiation-hard FOS for humidity sensing
- Sensor based on industry-standard fibres with signification fabrication and qualification requirements, e.g. precision ceramic packages
- Development, testing production and characterisation to happened at CERN & UJ
- Role for local industry to machine ceramic straining mounts





SA-ATLAS Today



Programme

VIRTUAL INAUGURATION OF ELECTRONICS RESEARCH LABORATORY AT UNIZULU

Date: 30th June 2021
Time: 11H00 am (SA time)
LIVE WEBINAR
Venue: Zoom (Link)
Meeting ID: 635 1094 1511 Passcode: 400672

Master of Ceremony:
Prof Unathi Kolanisi

UNIZULU INTRODUCTION: (5 min)
Professor S Seepe: DVC

Welcome from UNIZULU Management: (10 min)
Professor X. Mtose –Vice-Chancellor

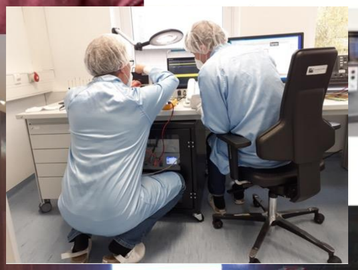
A note form Faculty (Dean): (10 min)
Prof Khoboso Lehloenya

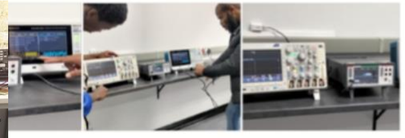
NRF/DSI/SA-CERN: (10 min)
Dr Faical Azaiez (Chair SA-CERN)

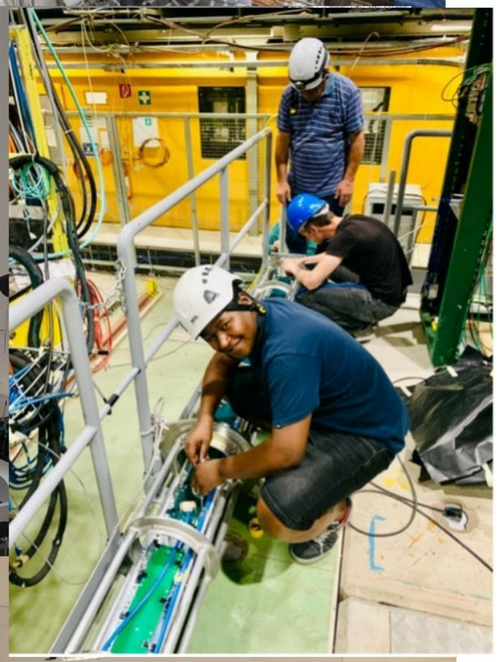
CERN: (10 min)
Dr Oleg Solovyanov (Project Leader of TileCal)

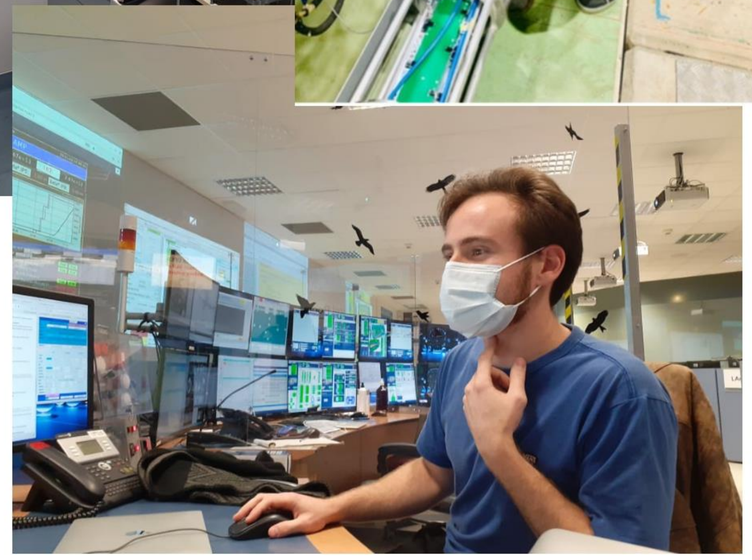
Lab Streaming (Department): (10 min)
Dr B Kibirige

Vote of Thanks: (5 min)
Dr TP Jili (HoD Physics)

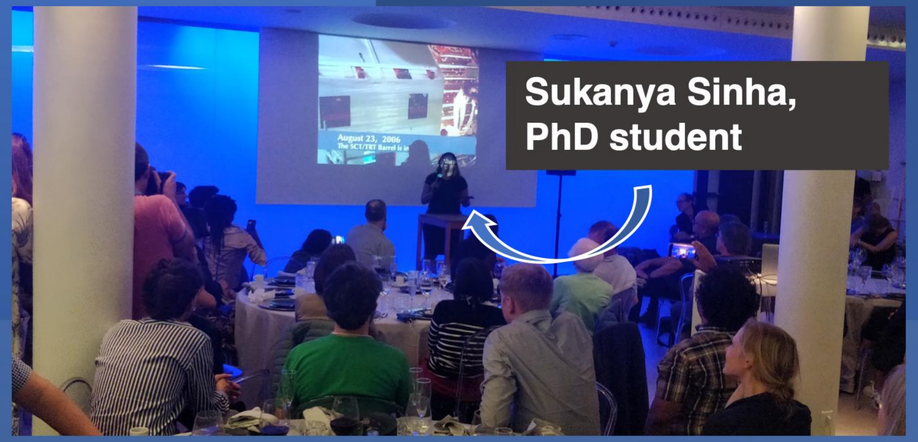




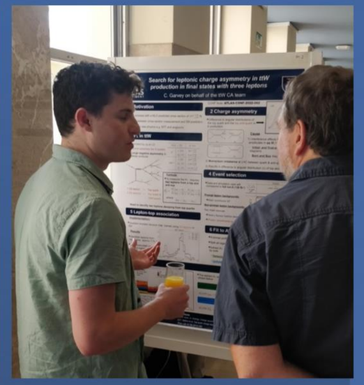


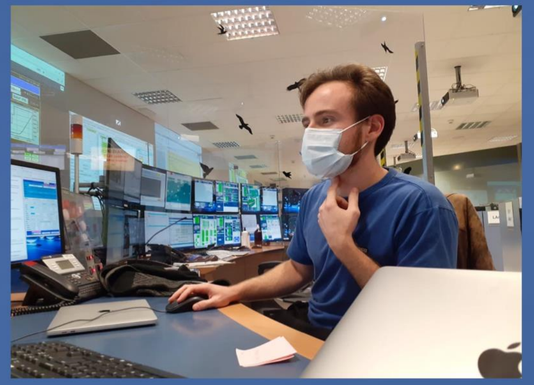



ATLAS Control Room


Sukanya Sinha,
PhD student


Cameron Garvey,
PhD student






A Search for tWZ production

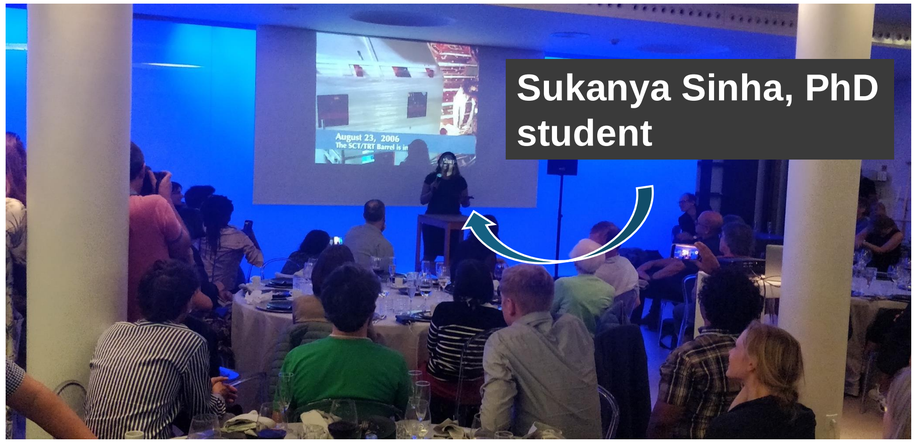
Tech transfer: Air Quality Monitoring via AI & IoT

SACAQM is an international consortium that was founded with the goal of bringing together government institutions, research institutions, and the private sector into a mutually beneficial ecosystem to deliver an industry-disrupting AI-powered IoT air quality monitoring and prediction system

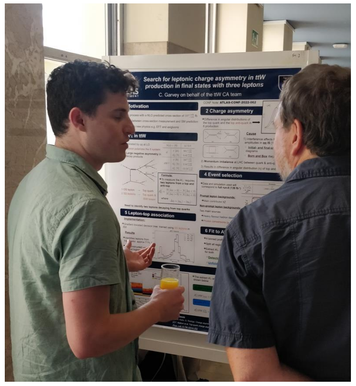
Synergy with monitoring of ATLAS detector with IoT technologies

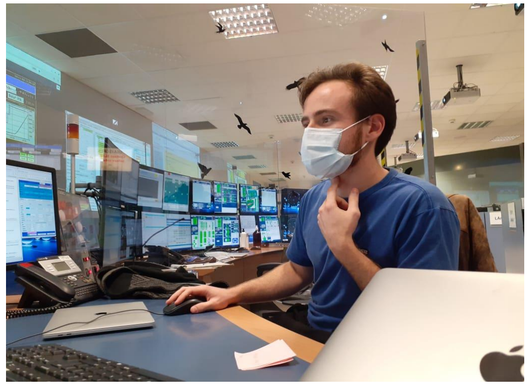
Backup

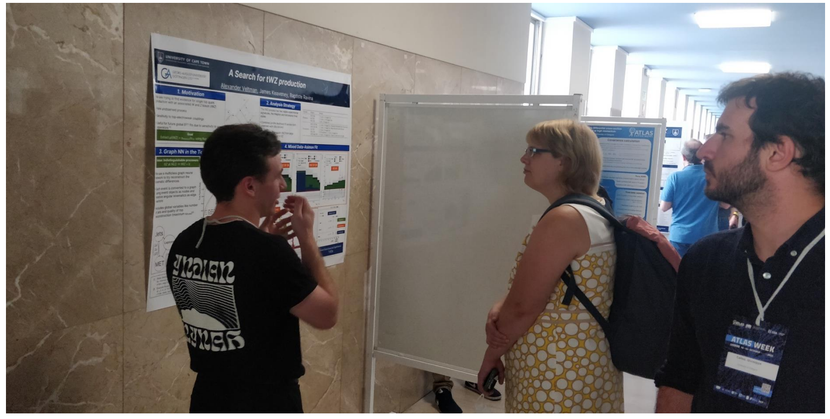

ATLAS Control Room

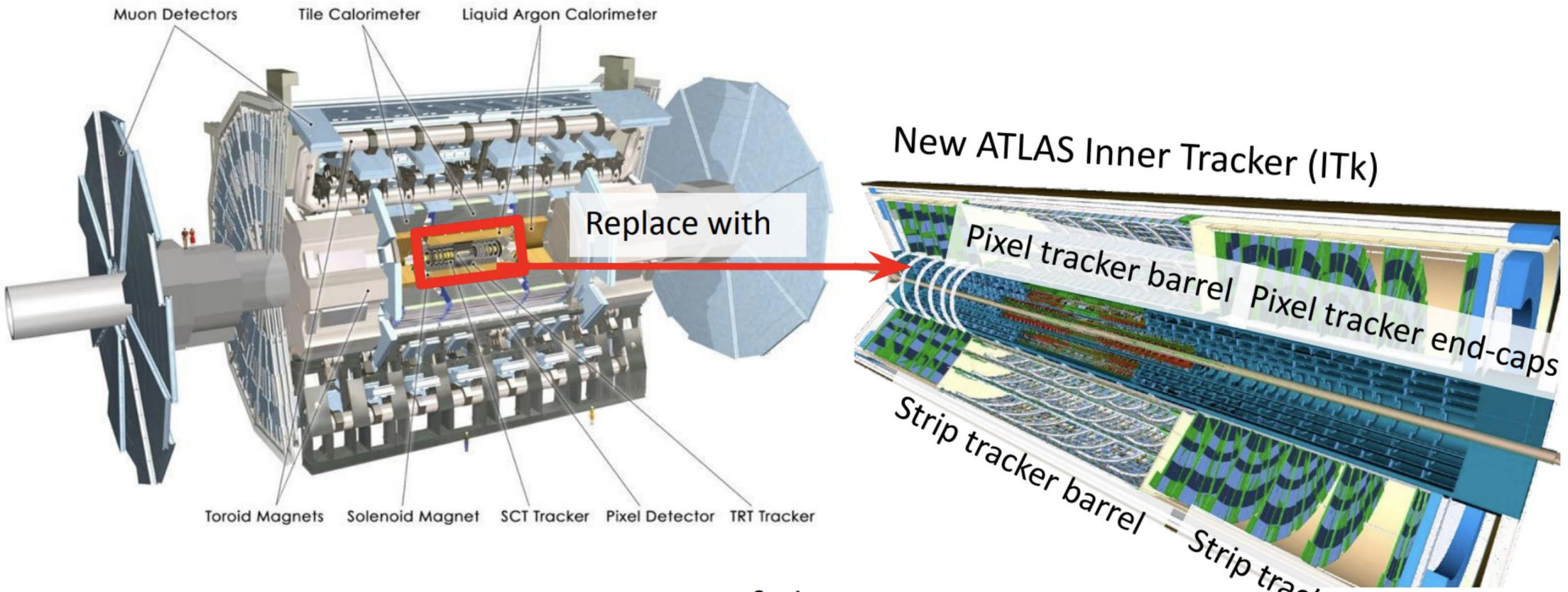

Sukanya Sinha, PhD student
August 23, 2006


Cameron Garvey, PhD student


Search for leptonic charge asymmetry in ttW production in final states with three leptons
C. Garvey on behalf of the ttW CA team



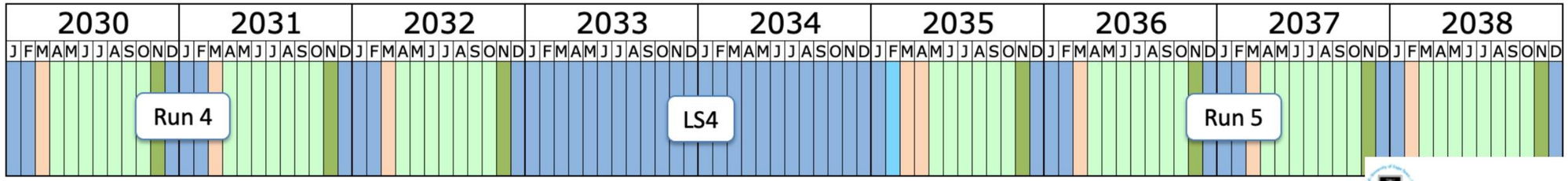

A Search for tWZ production



- HL-LHC peak luminosity: 5-7 x 10^{34} $cm^{-2}s^{-1}$
  - higher occupancy due to increased luminosity and pile-up
- Required radiation tolerance: factor 20 increase
- Higher granularity: 5000 million channels (ID: 100 million)
- Larger solid angle coverage: 180 m^2 area of silicon
- Minimised multiple scattering: require < 1% X/X0

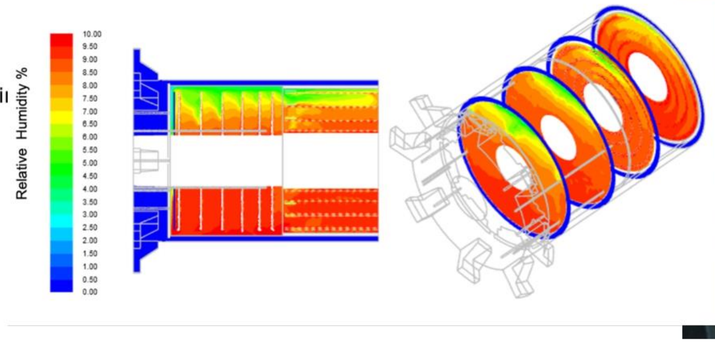
ATLAS Phase II Upgrade

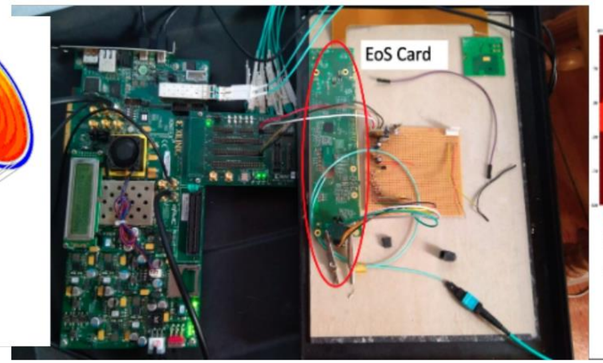
SA-ATLAS detector upgrade core commitments

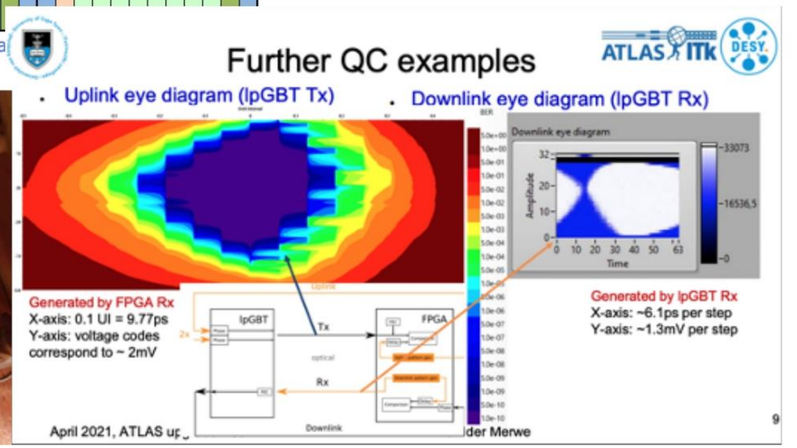


Shutdown/Technical stop
Protons physics
Ions
Commissioning with beam
Hardware commissioning/magnet trai

extra contributions







Priorities in SA-ATLAS

- Human capacity development & transformation
- Upgrade projects
  - ITk Polymoderator
  - TileCal Low Voltage Power supplies
  - ITk Fibre Optic Sensors
- Roadmap to 2027 and beyond

Human capacity development & transformation

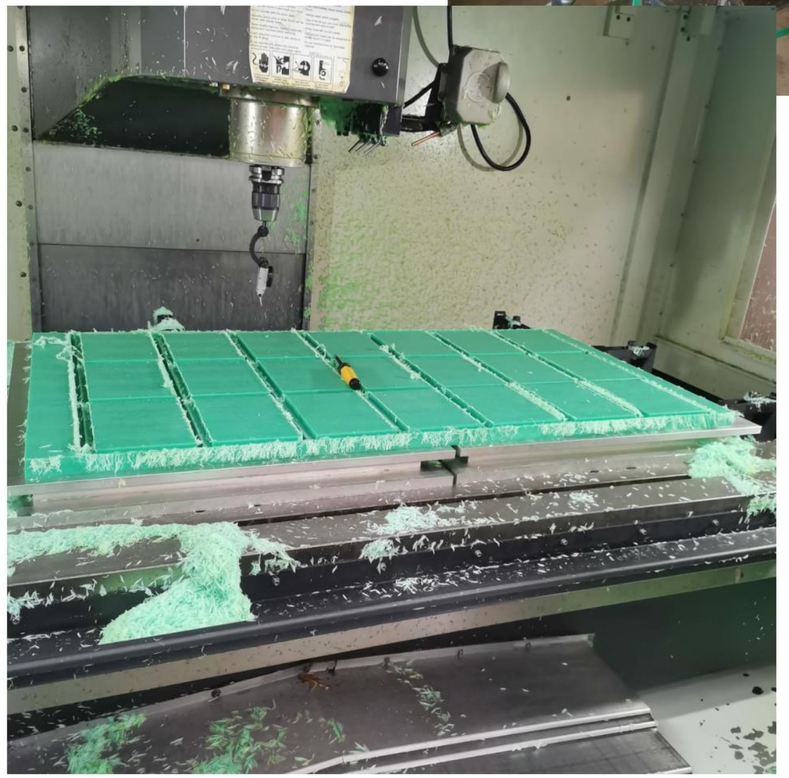
- **7 Principal Investigators**

  - **4** @ Wits/iTL
    - X. Ruan resignation 2022, replacement process ongoing
  - **2** @ UJ & UNISA & UWC
  - **1** @ UCT
    - S. Yacoob resignation 2022, replacement process ongoing -> ad posted for 2 positions

- PI numbers directly limit HCD with a severe need for postdoc person power
- Should be back up to 10 PIs within ~ 12 month with corresponding increase in student numbers

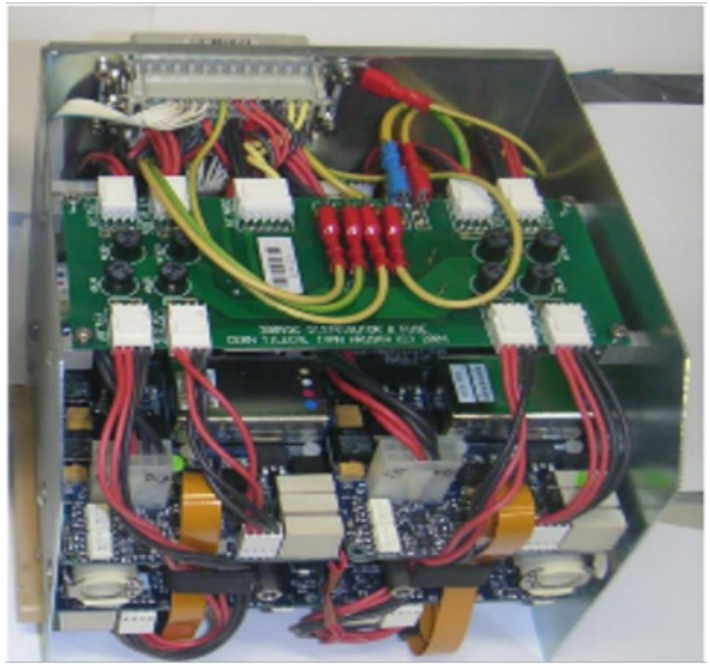
ITk Polymoderator

- UCT committed to producing 3 polymoderators (central & outer barrel and endcaps) that shield the ITk from damaging neutron flux in the HL-LHC
- Status:
  - Central Barrel design complete
  - **All** raw materials procured and delivered to Cape Town in sheet form
  - Precision machining and fabrication of tiles for Central Barrel ongoing at SAAO, Cape Town -> **ready for delivery to CERN Dec 2022**
  - Outer barrel and Endcap designs almost complete
  - Designs for outer barrel Al spark shields & bracket/ rail supports not yet defined, (role for SA-ATLAS postdoc)



TileCal LVPS & PPr

- Wits producing and qualifying significant fraction of LVPS & PPr for TileCal
- 1 SA-CERN postdoc to be engaged on this project at 90% level
- Status:
  - about to pass the Final Design Review (FDR) focusing on radiation hardness
- Near-term
  - LVPS Pre-production (10% of the total) (Q1-Q2 ’23)
  - LVPS Production Readiness Review, (Q3-Q4 ’23)
  - LVPS Full Production will take place end of 2023 in to 2024.
  - PPr FDR Q2 2023. Pre-production in 2023, production in 2024.



ITk Fibre Optic Sensors (FOS) I

- UJ committed to in-kind contribution of production & qualification of radiation-hard FOS for humidity sensing in ITk
- Sensor based on industry-standard fibres with signification fabrication and qualification requirements, e.g. precision ceramic packages
- E ff orts towards local production via SA companies has not been successful e.g. funds of order **200K** ZAR needed to test SA industry capacity via prototypes
- Local sensor development requires Interrogator unit
  - ~ **775K** ZAR
- Significant tech-transfer in place: MoUs NECSA, ESKOM to develop sensors for nuclear reactors

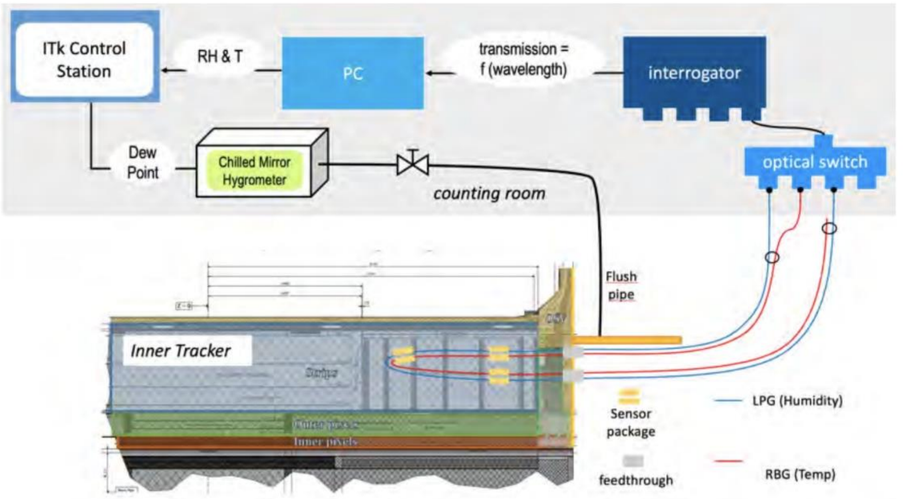
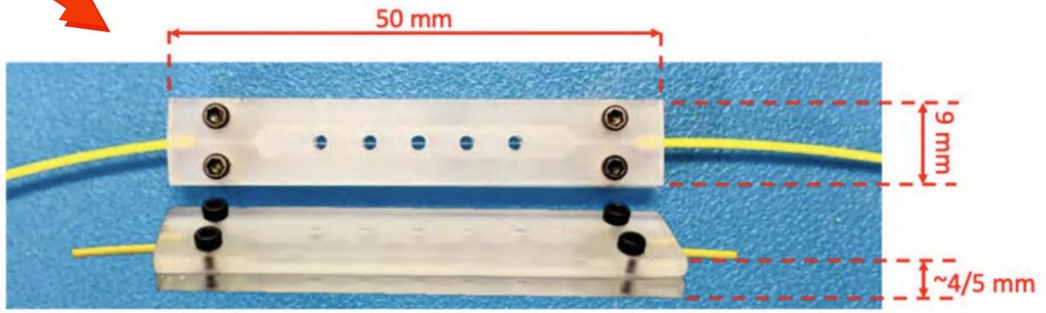


Figure 3.1: Overview of the whole readout chain. The sensor placement and fibre routing is conceptual. This detail is considered more carefully below.



ITk Fibre Optic Sensors (FOS) II

- Status
  - UJ & SA-ATLAS have not yet set up local development of FOS
    - e ff orts to procure interrogator/develop **local** package fabrication over 2020/21 have stalled
  - ITk project management expresses concerns about production readiness and SA commitments
  - UJ & ITk proposed that production happens at CERN with SA person power
  - significant change of plans and reduction in in-kind contribution

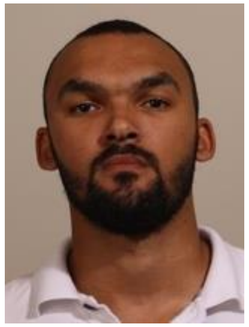
ITk Fibre Optic Sensors (FOS) III

- Rather urgently need a firm directive on next step
- Options:
  - **A)** We go with the UJ/ITk plan: production happens at CERN with SA person power
  - **B)** We find a compromised plan that maximises SA in-kind contribution but keeps project on schedule, e.g.
    - ceramic packages made by SA industry
    - sensors produced and fully qualified in UJ lab -> requires procurement of interrogator unit ~ 775K ZAR.

Beyond the next 5 years

- **Strengthening the academic pipeline**
  - Significant difficulties across all fields in retaining the best students in academia with lucrative o ff ers from industry
  - How is this being addressed nationally?
    - nGAP (new generation of academics) programme from DHET
    - structured, fast-tracked programme to take exceptional students/postdocs to junior faculty level with clear equity considerations
    - Funding partnership between DHET and host university
    - A similar scheme within SA-CERN would have enormous potential

Human Capacity Development - degrees awarded



Dr. Kevin Barends, PhD awarded Feb 2023

A measurement of the Top Quark Mass using events containing a J/Psi meson with the ATLAS experiment

- Immediately hired in Data Science consultancy position in Cape Town

Senzo Msutwana, MSc awarded March 2023

Development of a Data-Quality Early-Warning system for ATLAS using Machine-Learning

Max van der Merwe, M.Eng. awarded Dec 2022

Investigating the Optical Link Performance of the End-of-Substructure Card of the ATLAS ITk and its Susceptibility to SEUs

- Immediately hired in Data Science position with Tripco in Cape Town

Human Capacity Development - degrees awarded

Hannah van der Schyf, MSc awarded March 2023

Searches for Dark Matter using semi-visible jets with ATLAS

- Continuing on to PhD at Wits with Deepak Kar
- Hannah and Deepak's CERN summer project was picked in the first round, they will supervise a summer student.

Chris Lee, M.Phil

Fast Operational Context Switching for Very Large Scale High Performance Computing Systems

Xola Mapekula, MSc.

Search for a heavier Higgs like boson and a dark force boson using the ATLAS experiment

- Continuing with PhD at UJ

Human Capacity Development - theses submitted

Joshua Choma PhD thesis submitted

The application of weakly supervised learning in the search for heavy resonances at the LHC

Humphry Tlou, PhD thesis submitted

Implementation of the DAQ software for the ALTI module in the ATLAS TileCal and the search for new physics in the four lepton final state

Finn Stevenson

Leveraging Machine Learning in the Search for New Bosons at the LHC and Other Resulting Applications.

Nkosiphendule Njara

The development of a burn-in test station at Wits for the Phase-II upgrade of the Tile Calorimeter of the ATLAS experiment.

Thuso Mathaha

The use of Machine Learning in search for new physics at the ATLAS and applications to model COVID-19

Human Capacity Development

Wandile Nzuza

Completed her honours including ATLAS project with the best marks in the class

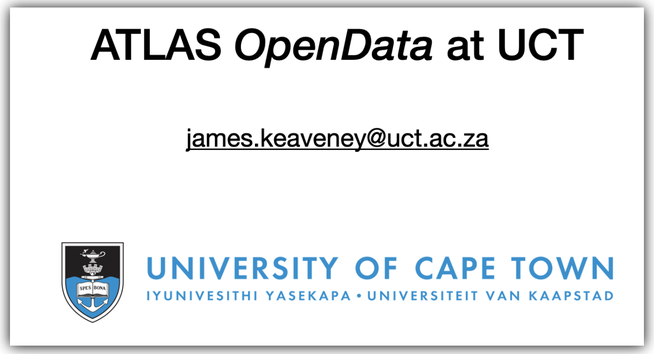
- started masters at Wits with Deepak Kar

Dillon Lewis

Completed his honours including ATLAS project with the best marks in the class

- Accepted to PhD at Cambridge, UK with full funding

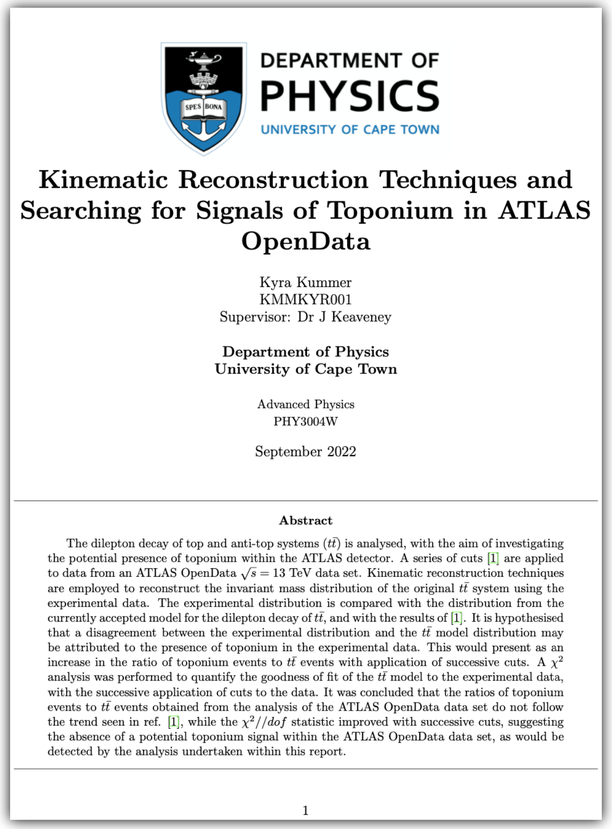
Human Capacity Development


ATLAS *OpenData* at UCT

james.keaveney@uct.ac.za

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

- Presentation by JK to the ATLAS Outreach group on usage of ATLAS OpenData in the undergraduate lab
- UCT is the leader within ATLAS
- Fantastic opportunity to reach out to next gen. of postgrad students... we should expand to other SA institutes!


DEPARTMENT OF PHYSICS
UNIVERSITY OF CAPE TOWN

Kinematic Reconstruction Techniques and Searching for Signals of Toponium in ATLAS OpenData

Kyra Kummer
KMMKYR001
Supervisor: Dr J Keaveney

Department of Physics
University of Cape Town

Advanced Physics
PHY3004W

September 2022

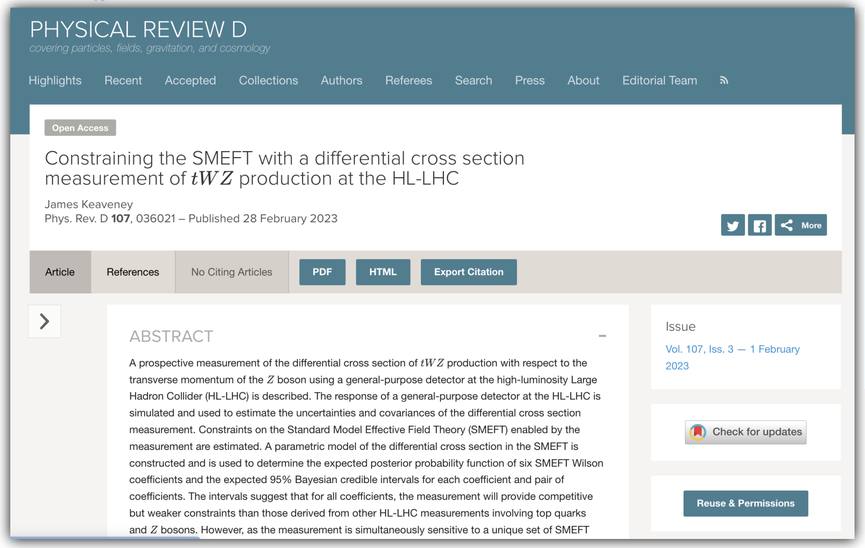
Abstract

The dilepton decay of top and anti-top systems ($t\bar{t}$) is analysed, with the aim of investigating the potential presence of toponium within the ATLAS detector. A series of cuts [1] are applied to data from an ATLAS OpenData $\sqrt{s} = 13$ TeV data set. Kinematic reconstruction techniques are employed to reconstruct the invariant mass distribution of the original $t\bar{t}$ system using the experimental data. The experimental distribution is compared with the distribution from the currently accepted model for the dilepton decay of $t\bar{t}$, and with the results of [1]. It is hypothesised that a disagreement between the experimental distribution and the $t\bar{t}$ model distribution may be attributed to the presence of toponium in the experimental data. This would present as an increase in the ratio of toponium events to $t\bar{t}$ events with application of successive cuts. A χ^2 analysis was performed to quantify the goodness of fit of the $t\bar{t}$ model to the experimental data, with the successive application of cuts to the data. It was concluded that the ratios of toponium events to $t\bar{t}$ events obtained from the analysis of the ATLAS OpenData data set do not follow the trend seen in ref. [1], while the $\chi^2//dof$ statistic improved with successive cuts, suggesting the absence of a potential toponium signal within the ATLAS OpenData data set, as would be detected by the analysis undertaken within this report.

1

- Cultivating the next generation of SA-postgrads with projects at the third-year and Honours level
- Exploring the possibility of running this lab internationally with Uni Manchester, UK.

Scientific outputs



PHYSICAL REVIEW D

covering particles, fields, gravitation, and cosmology

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Open Access

Constraining the SMEFT with a differential cross section measurement of tWZ production at the HL-LHC

James Keaveney

Phys. Rev. D **107**, 036021 – Published 28 February 2023

More

Article References No Citing Articles PDF HTML Export Citation

ABSTRACT

A prospective measurement of the differential cross section of tWZ production with respect to the transverse momentum of the Z boson using a general-purpose detector at the high-luminosity Large Hadron Collider (HL-LHC) is described. The response of a general-purpose detector at the HL-LHC is simulated and used to estimate the uncertainties and covariances of the differential cross section measurement. Constraints on the Standard Model Effective Field Theory (SMEFT) enabled by the measurement are estimated. A parametric model of the differential cross section in the SMEFT is constructed and is used to determine the expected posterior probability function of six SMEFT Wilson coefficients and the expected 95% Bayesian credible intervals for each coefficient and pair of coefficients. The intervals suggest that for all coefficients, the measurement will provide competitive but weaker constraints than those derived from other HL-LHC measurements involving top quarks and Z bosons. However, as the measurement is simultaneously sensitive to a unique set of SMEFT

Issue

Vol. 107, Iss. 3 — 1 February 2023

Check for updates

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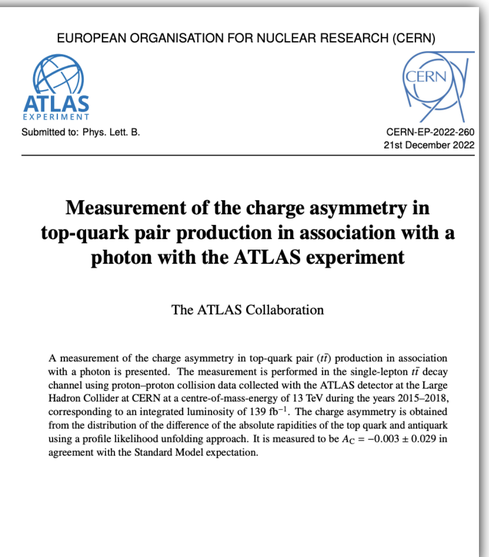
Single-author (J. Keaveney) paper on prospects for tWZ production as a fertile ground for new physics searches at the High-Luminosity LHC **Published in Physical Review D Feb 2023**



EUROPEAN ORGANISATION FOR NUCLEAR RESEARCH (CERN)

ATLAS EXPERIMENT

Submitted to: Phys. Lett. B.

CERN

CERN-EP-2022-260

21st December 2022

Measurement of the charge asymmetry in top-quark pair production in association with a photon with the ATLAS experiment

The ATLAS Collaboration

A measurement of the charge asymmetry in top-quark pair ($t\bar{t}$) production in association with a photon is presented. The measurement is performed in the single-lepton $t\bar{t}$ decay channel using proton–proton collision data collected with the ATLAS detector at the Large Hadron Collider at CERN at a centre-of-mass-energy of 13 TeV during the years 2015–2018, corresponding to an integrated luminosity of 139 fb^{-1}. The charge asymmetry is obtained from the distribution of the difference of the absolute rapidities of the top quark and antiquark using a profile likelihood unfolding approach. It is measured to be $A_C = -0.003 \pm 0.029$ in agreement with the Standard Model expectation.

UCT-led ATLAS analysis on charge asymmetries in ttW production submitted to JHEP Feb 2023.

JK invited to give seminar at CIEMAT, Madrid on search for subtle signs of new physics in the top quark - Higgs boson interaction

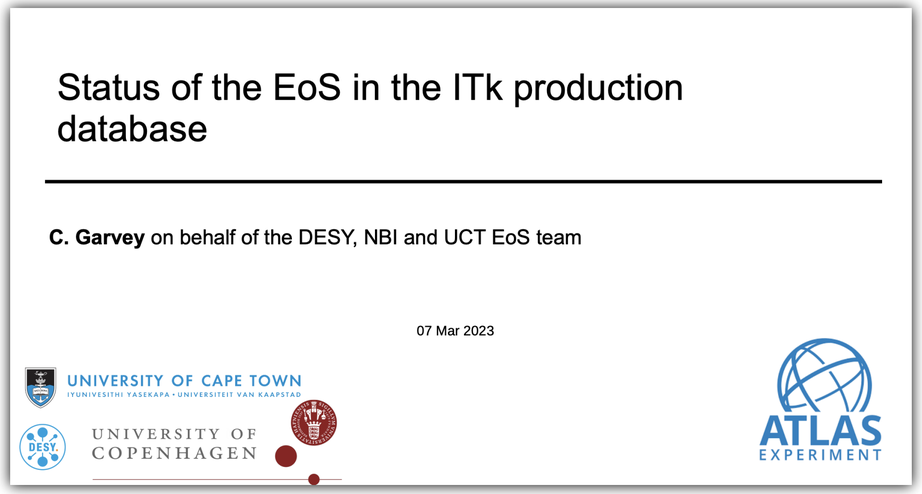
Scientific outputs

Deepak Kar presented a seminar *Novel probes for dark matter at the LHC* at Uni. Edinburgh on 17th February 2023

B. Mellado invited to give a plenary talk at the Zurich Phenomenology Workshop 2023, Zurich, Jan 11th 2023.

B. Mellado invited to give a plenary talk at the IAS Program High Energy Physics, Institute of Advanced Studies, the Hong Kong University of Science and Technology, February 2023.

Student achievements



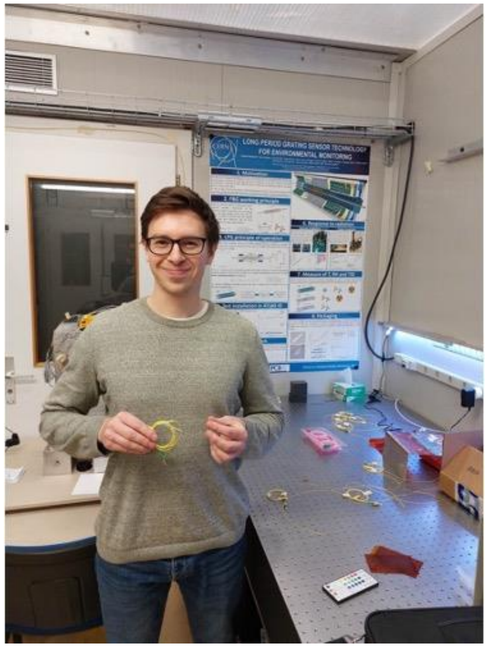
Cameron Garvey leading QC data management for ITk EoS card production.

- Invited for extended stay at DESY (**partially at DESY's expense**) to lead QC campaign for EoS card production in August 2023
- Presented status of complete EoS data analysis structure to close out his ATLAS Qualification Task at recent ITk week

PhD student, Ryan McKenzie appointed Run Coordinator of the Tile Calorimeter Jan 2023.

Ryan gave a plenary on behalf of the TileCal community at the ATLAS Collaboration week on February 14th.

Student achievements



Matt Connell: began working the EP-DT Lab at CERN on Fibre Optic Sensors for humidity monitoring in the ITk.

- Trained in cutting and splicing of fibres.
- Illustration of different fibre optic layers (core, cladding, buffer, sleeve), demonstration of mechanical properties e.g. flexibility and strength, size, length.
- Crucial for development of **local** activities at UJ

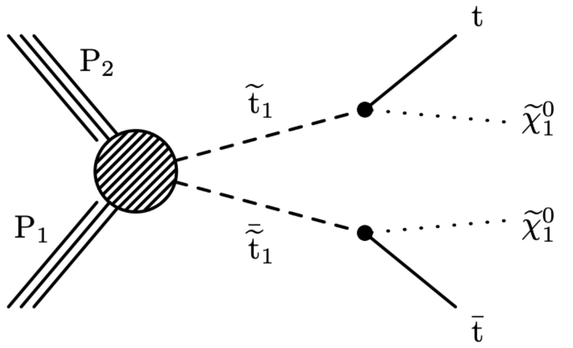
Deepak and Hannah's CERN summer project was picked in the first round, they will supervise a summer student in 2023

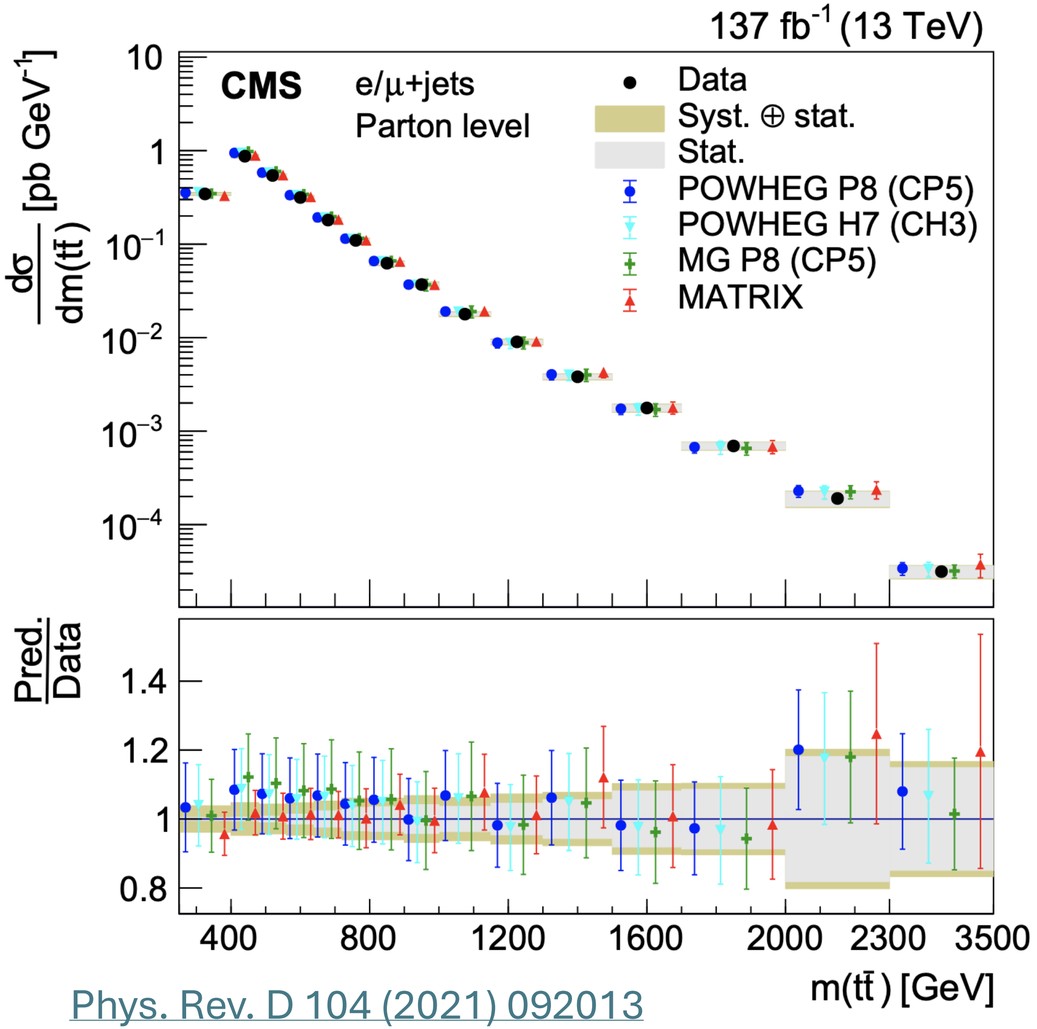
Seeking new physics with tops

- supersymmetric top partners $\tilde{t}$ with $m_{\tilde{t}} \approx m_t$
- clear experimental prediction

- As $m_{\tilde{t}} >> m_t$ signal would be manifested as a disrupted $\frac{d\sigma_{t\bar{t}}}{dX}$ e.g. upper tail of $\frac{d\sigma_{t\bar{t}}}{dm_{t\bar{t}}}$

- What do we see in the LHC data?





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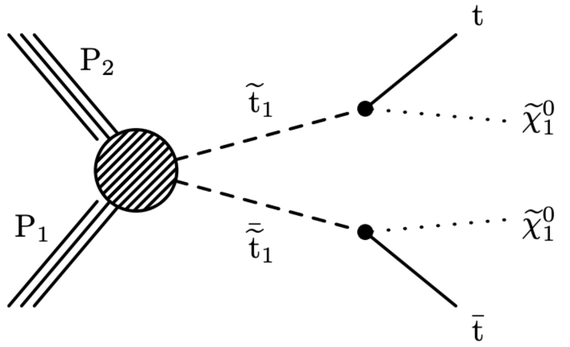
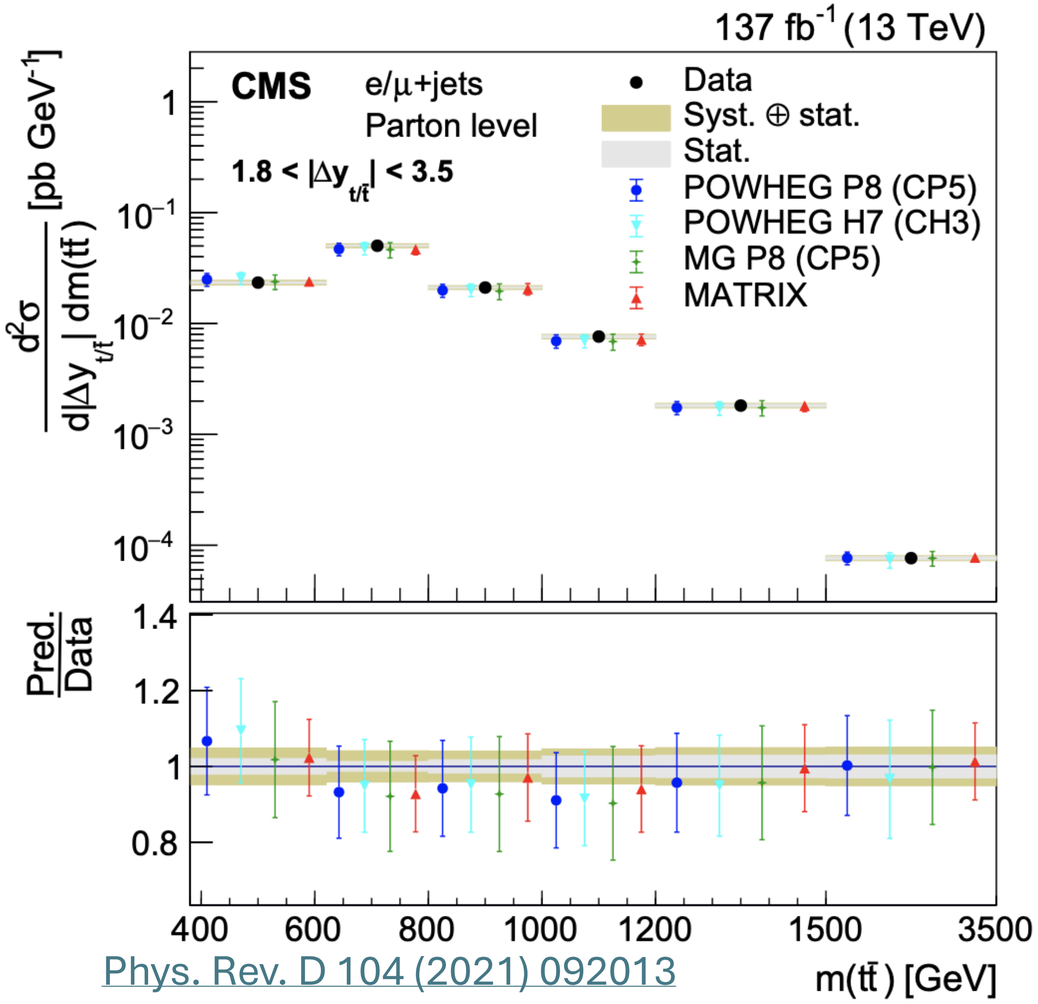


- As $m_t^{\sim} \rightarrow m_t$ signal would be manifested as an increased $\sigma_{t\bar{t}}$ w.r.t $\sigma_{t\bar{t}}^{SM}$
- As $m_t^{\sim} >> m_t$ signal would be manifested as a disrupted $\frac{d\sigma_{t\bar{t}}}{dX}$ e.g. upper tail of $\frac{d\sigma_{t\bar{t}}}{dm_{t\bar{t}}}$
- What do we see in the LHC data?



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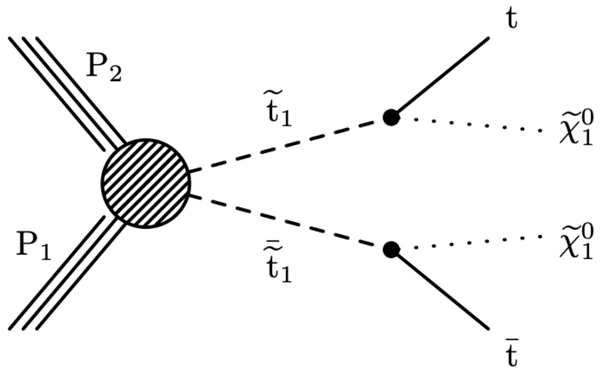
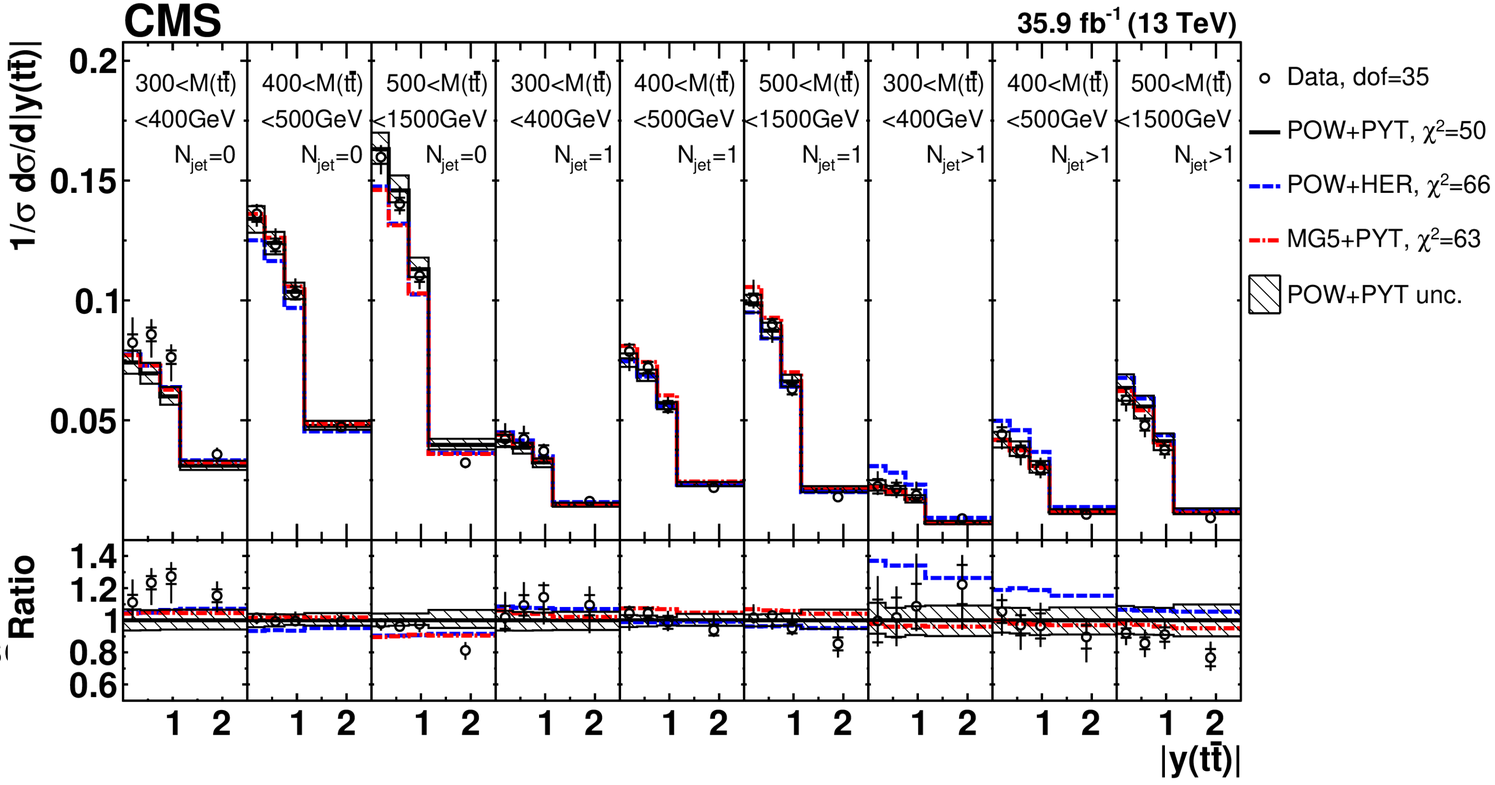


- As $m_{\tilde{t}} \to m_t$ signal would be manifested as an increased $\sigma_{t\bar{t}}$ w.r.t $\sigma_{t\bar{t}}^{SM}$
- As $m_{\tilde{t}} > m_t$ signal would be manifested as a disrupted $\frac{d\sigma_{t\bar{t}}}{dX}$ e.g. upper tail of $\frac{d\sigma_{t\bar{t}}}{dm_{t\bar{t}}}$
- What do we see in the LHC data?
  - Reasonable agreement across the entire phas space
  - Mild tensions in some bins



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