Welcome to the Sixth HEPP Workshop

University of Venda, Jan 29th-31st 2020
SA-CERN celebrated its 10th anniversary this coming November 19th-21st

Presenting at the event plans for the next 10 years including continued expansion of the effort in the area of technology transfer and innovation.

iThemba LABS is the host of the SA-CERN program
The Large Hadron Collider

SA’s contribution
ALICE
ATLAS
ISOLDE
Theory
In the early stages of the Universe; Quarks and gluons were reaming freely.

As the universe cooled down, they got confined and have remained imprisoned ever since...
Heavy Ion Collisions with the ALICE Detector
A surprise: Observation of elliptic flow and other effects first seen in heavy-ion collisions also in pp and p-Pb collisions

- Puzzle: is QGP in small systems?
- But no jet quenching seen in small systems

- Ongoing discussion

Quest:
- study of particle production mechanisms in different collisions systems
  - Which mechanisms involved?
- Possible connection between hard and soft processes
  - Production at QGP freeze-out
  - Role of hadronic re-scattering phase
  - Hadronization at high-$p_T$
Are We happy with the SM?

- The SM as it is does not solve a number of fundamental questions/problems
  - Quadratic divergences of the Higgs mass
    - Higgs mass grows with scale of new physics
  - Does not explain the origin of the neutrino mass
  - Does not explain dark matter in the universe
  - Does not explain dark energy in the universe
    - The universe expanding at an accelerated rate
  - How about gravity?
  - Unification of fundamental interactions
  - Why three generations?
  - Etc...
Multi-lepton anomalies in p-p collisions
Implications for LHC and future colliders
Connection with anomalies in Astro-Physics?

$H \rightarrow Sh$

With simplified model
obtain $\sim 8\sigma$ significance

$H \rightarrow 4\ell, 2\mu$

New and predicted excess not included in the combination on the left.
Is the SM breaking down through the leptonic sector?

- Apparent violation of lepton flavor conservation in $B$-meson decays

- Anomalous magnetic moment of the muon (also electron?)

- Multi-lepton anomalies in $p$-$p$ collisions at the LHC (see above)

- Electron neutrino appearance at MiniBooNE/LSND

$$R_{D^{(*)}} = \frac{\mathcal{B}(\bar{B} \rightarrow D^{(*)}\tau\bar{\nu})}{\mathcal{B}(\bar{B} \rightarrow D^{(*)}\ell\bar{\nu})}$$

$$R_K = \frac{\mathcal{B}(B^+ \rightarrow K^+\mu^+\mu^-)}{\mathcal{B}(B^+ \rightarrow K^+e^+e^-)}$$

$$R_{K^*} = \frac{\mathcal{B}(B^0 \rightarrow K^{*0}\mu^+\mu^-)}{\mathcal{B}(B^0 \rightarrow K^{*0}e^+e^-)}$$

$$\tilde{\mu} = g \frac{e}{2m} \hat{s}$$

How about Astro-Physics?
Excesses in Astro-Physics consistent with DM annihilation into not so heavy mediators. Includes leptophilic excesses, such as position rise in PAMELA/AMS02. Consequences for MeerKat/SKA, KM3NeT.

\[ S \rightarrow b\bar{b} \]
Machine Learning

- (1a) Input Variables
  - (1b) De-correlated Input Variables
  - (1c) PCA-transformed Input Variables
  - (2a) Input Variable Correlations (scatter profiles)
  - (2b) De-correlated Input Variable Correlations (scatter profiles)
  - (2c) PCA-transformed Input Variable Correlations (scatter profiles)
  - (3) Input Variable Linear Correlation Coefficients
  - (4a) Classifier Output Distributions
  - (4b) Classifier Output Distributions for Training and Test Samples
  - (4c) Classifier Probability Distributions
  - (4d) Classifier Rarities Distributions
  - (5a) Classifier Cut Efficiencies
  - (5b) Classifier Background Rejection vs Signal Efficiency (ROC curve)
  - (6) Likelihood Reference Distributions
  - (7a) Network Architecture
  - (7b) Network Convergence Test
  - (8) Decision Trees
  - (9) PDFs of Classifiers
  - (10) Rule Ensemble Importance Plots
  - (11) GUI

- TMVA Plotting Macros

- Correlation Matrix (signal)

- Rank: Variable: Separation
  - 1: var4: 0.606
  - 2: var1+var2: 0.182
  - 3: var3: 0.173
  - 4: var1-var2: 0.014

- TMVA overtraining check for classifier: BDT

- Cut efficiencies and optimal cut value

- Average no. of nodes before/after pruning: 4193 / 968
Plans for next ten years include: contributing to the upgrade of the detectors, expanding the student body and our technology transfer and innovation efforts.

Phase-II upgrade has been postponed to 25-27
Tech Transfer and Relations with Industry

- Technology Innovation Platform
  - Presentation by Prof. Papka
- Application of Classroom Fundamentals in Industry
  - Presentation by Rinae Nnduvheni (Deloitte)
- Bridging the Gap between Industry and Academia
  - Presentation by Dingane Hlaluku (IBM)
Structure of the Workshop
Distinguished Foreign Lecturers

Prof. Kaoru Hagiwara

Prof. Benjamin Fuks
<table>
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<tr>
<th>Time</th>
<th>Session</th>
<th>Description</th>
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<tr>
<td>09:00</td>
<td>Session I (until 10:30)</td>
<td>Greetings from the DVC Academic - Prof. J.E. Crafford (University of Venda)</td>
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<tr>
<td>09:15</td>
<td>Session I (until 10:30)</td>
<td>Greetings from the Dean of the Faculty of Science - Prof. N. Pretorius (University of Venda)</td>
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<td>09:30</td>
<td>Session I (until 10:30)</td>
<td>Greetings from the Head of the School of Physics - Dr Eric Maluta (University of Venda)</td>
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<td>09:45</td>
<td>Session I (until 10:30)</td>
<td>Overview and goals of the workshop - Nan Sterkley Cornett (University of Johannesburg (ZA))</td>
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<tr>
<td>11:00</td>
<td>Session III (until 12:30)</td>
<td>Standard Model of Particle Physics III and IV - Prof. Kees Higlwaara (KEK)</td>
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<td>11:15</td>
<td>Session III (until 12:30)</td>
<td>Tea/Coffee</td>
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<td>New Physics Simulations at Colliders I - Benjamin Piek (Centre National de la Recherche Scientifique (FNAL))</td>
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<td>11:45</td>
<td>Session III (until 12:30)</td>
<td>Heavy Ion Physics I - William Alexander Hortzwitz (University of Cape Town (ZA))</td>
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<tr>
<td>11:00</td>
<td>Session IV (until 17:30)</td>
<td>DSM searches using SM measurements - Deepak Kar (University of the Witwatersrand (ZA))</td>
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<tr>
<td>11:15</td>
<td>Session IV (until 17:30)</td>
<td>Implementing a robust anti-QCD tagger with mass dis-correlated jet image data - Mr. Khoza Phatho (University of Venda (ZA))</td>
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<td>11:30</td>
<td>Session IV (until 17:30)</td>
<td>Application of a novel Machine Learning approach for the search of heavy bosons with topological features at the LHC - Rajesh K. Dahiya (University of the Witwatersrand (ZA))</td>
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<td>11:45</td>
<td>Session IV (until 17:30)</td>
<td>Testing the search for new resonances in the di-boson channel with topological requirements on the production of the Standard Model Higgs boson at the LHC - Mr. Nakumise Joshua Chomba (University of the Witwatersrand (ZA))</td>
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<tr>
<td>12:00</td>
<td>Lunch</td>
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<td>13:30</td>
<td>Session V (until 17:30)</td>
<td>Fluctuating open heavy flavour energy loss in a strongly coupled plasma with observable from RHIC and the LHC - Mr. Blessed Blessed Ngwenya (University of Cape Town (ZA))</td>
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<td>13:45</td>
<td>Session V (until 17:30)</td>
<td>A step-by-step analysis of the interpretation of hadron matter from the microscopic model - Mr. Tran Tolombe (University of Namibia (U))</td>
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<tr>
<td>14:00</td>
<td>Session V (until 17:30)</td>
<td>Computation of the effective potential in the gauge-Higgs unification models - Mr. Stanley Cornett (University of Johannesburg (ZA))</td>
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<td>14:15</td>
<td>Session V (until 17:30)</td>
<td>Searches for a ubiquitous U(1) pseudo-scalar at future lepton colliders - Ms. Laura Biason (University of Johannesburg (ZA))</td>
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<td>14:30</td>
<td>Session V (until 17:30)</td>
<td>Measuring the mass of the W boson with full Run-II ATLAS data - Benjamin William Warren (University of Cape Town (ZA))</td>
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<td>Session V (until 17:30)</td>
<td>An Alternative to Monte Carlo Generators with Deep Generative Models - Mr. Thabang Lobono (University of the Witwatersrand (ZA))</td>
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<td>15:00</td>
<td>Session V (until 17:30)</td>
<td>--- Tea/Coffee ---</td>
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<td>Session V (until 17:30)</td>
<td>Applications of Weakly-Supervised Machine Learning Techniques in the Search for New Bosons Focusing on Di-lepton Final States at the ATLAS Experiment - Mr. Benjamin Lieberman (University of the Witwatersrand (ZA))</td>
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<td>Session V (until 17:30)</td>
<td>Searching for heavy scalar resonances in the LHC Run 2 dataset in the ZP/gammaS final states using machine learning techniques - Mr. Helmut Schumacher (University of the Witwatersrand (ZA))</td>
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<td>16:00</td>
<td>Session V (until 17:30)</td>
<td>Application of Machine Learning to satellite data - Mr. Ayanda Thaiva (University of Eswatini)</td>
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<tr>
<td>16:15</td>
<td>Session V (until 17:30)</td>
<td>Search for a resonance decaying into two photons in association with Z-&gt;jets events - Mr. Ahmad Ameen (University of the Witwatersrand (ZA))</td>
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<td>16:30</td>
<td>Session V (until 17:30)</td>
<td>Background determination of the central region of the 7TeV LHC Data IV: The Higgs boson mass determination - Mr. Abdallaoue Idrissi (University of the Witwatersrand (ZA))</td>
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<td>16:45</td>
<td>Session V (until 17:30)</td>
<td>An exploration of the anomalous T' rate at the LHC - Mr. Stefan von Huldenbrock (University of the Witwatersrand (ZA))</td>
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Note: The schedule includes sessions on various topics related to particle physics and experimental searches at the LHC and RHIC. Each session includes a speaker and a duration, with breaks marked as "Tea/Coffee". The schedule also includes lunch breaks at 12:00 and 14:30.
Proceedings due **March 1\textsuperscript{st} 2020**

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The URL of your paper is

http://dx.doi.org/10.1088/1742-6596/645/1/012027
The book!

Particle physics book for beginners in the field, published by Institute of Physics, UK

Book launch held on 4th October