THE UNIVERSITY of ADELAIDE

ARC Centre of Excellence in Precision Fundamental Physics

Paul Jackson

February 4th, 2021

Introduction

Welcome and thank you for attending this discussion on CE23 EOI

Your thoughts, ideas and input are ***very welcome and appreciated***

Fundamental Physics has gone through a revolution in the past decade.

Increased accuracy of many measurements challenge theory and technology.

The discovery of the Higgs Boson has completed the composition of the Standard Model of Particle Physics – but there are still many unsolved problems.

We are moving towards deeply scrutinizing various anomalous measurements that, when taken together, suggest that cracks are opening in the Standard Model.

Instead of a New Machine and New Experiments – we need Increased Precision!

This requires advances in theory and technology along with better experimental results

Better Calculations + Better Technology => Increased Precision.

CE23 team – interested parties

Adelaide: Paul Jackson, Derek Leinweber, Martin White, James Zanotti, Ross Young

ANU: John Close, Joe Hope, Cedric Simenel

Melbourne: Martin Sevior, Andrea Thamm, Ray Volkas, Nicole Bell, Phillip Urquijo, Matthew Dolan, Geoffrey Taylor

Monash: Csaba Balasz, Ulrik Egede, Jordan Nash, Peter Skands, German Valencia

UNSW: Michael Schmidt, Yvonne Wong

UQ: Jacinda Ginges, Pat Scott, Magdalena Zych

Sydney: Archil Kobakhidze, Kevin Varvell, Bruce Yabsley

Comments on composition:
Good spread of representation across the many nodes;
Currently ***too many people to all be CIs*** – we need to streamline the participants;
Seven of the Go8 Universities involved in the discussions;
15 (1) current/former ARC Future Fellows (DECRA Fellows) involved;
The gender/diversity balance is not good! We must address this directly prior to EOI stage (if possible) or by proactive ***hiring of female staff at all nodes*** as a result of the Centre award.
Overlap of personnel with other Centre's (notably CDMPP) and other CE23 bids – problem?

Topics spanning broad/focused range

- Precision flavour physics: LHCb, Belle II, COMET, ATLAS
  - Rare Penguin/Box diagrams and leptonic processes (B→Xll, b → sγ, B → lnu, B → D$\tau\nu$, $\mu \rightarrow e$ conversion, t → bW, maybe Higgs, plus others)
  - Precise determination of CKM matrix elements
- Quantum precision
  - Quantum limited and sub-quantum limited measurements of the gravitational field for beyond standard model physics and to test GR
- Precision in Nuclear experimentation
- Lattice inputs for precise SM measurements and better predictions
  - Form factors and matrix elements
- Global fitting of inputs to improve SM precision and constrain BSM theories
- Theory Calculations for all rare processes
  - Precision flavour, impact on neutrinos and the lepton sector more broadly
- Atomic parity-violation, P- or T-violating electric dipole moments
- g-2 muon calculation
- Generator improvements to create more precise tools and simulations
- Technological advancements in triggering and data acquisition
- Use of accelerators (i.e. GPUs) in nuclear/particle → vast speed increases in calculations

ARC Timeline

- While the timelines are tight, we are more than capable of bringing this together

- **ARC EOIs for CE23 open: 8th June 2021**
- **ARC EOIs for CE23 close: 28th July 2021**

- Rejoinders CLOSE: 14th October 2021

- Successful Applications Notified: November 2021

- ARC Full Proposals Open: 8th December 2021
- ARC Full Proposals Close: 2nd March 2022

- ARC Full Proposal Rejoinders: May 2022
- ARC Full Proposal Interviews: June/July 2022

These are the key dates for us to consider in the first instance.

We don't need all the answers today, but we can't wait too much longer before making some choices and pressing ahead

Summary

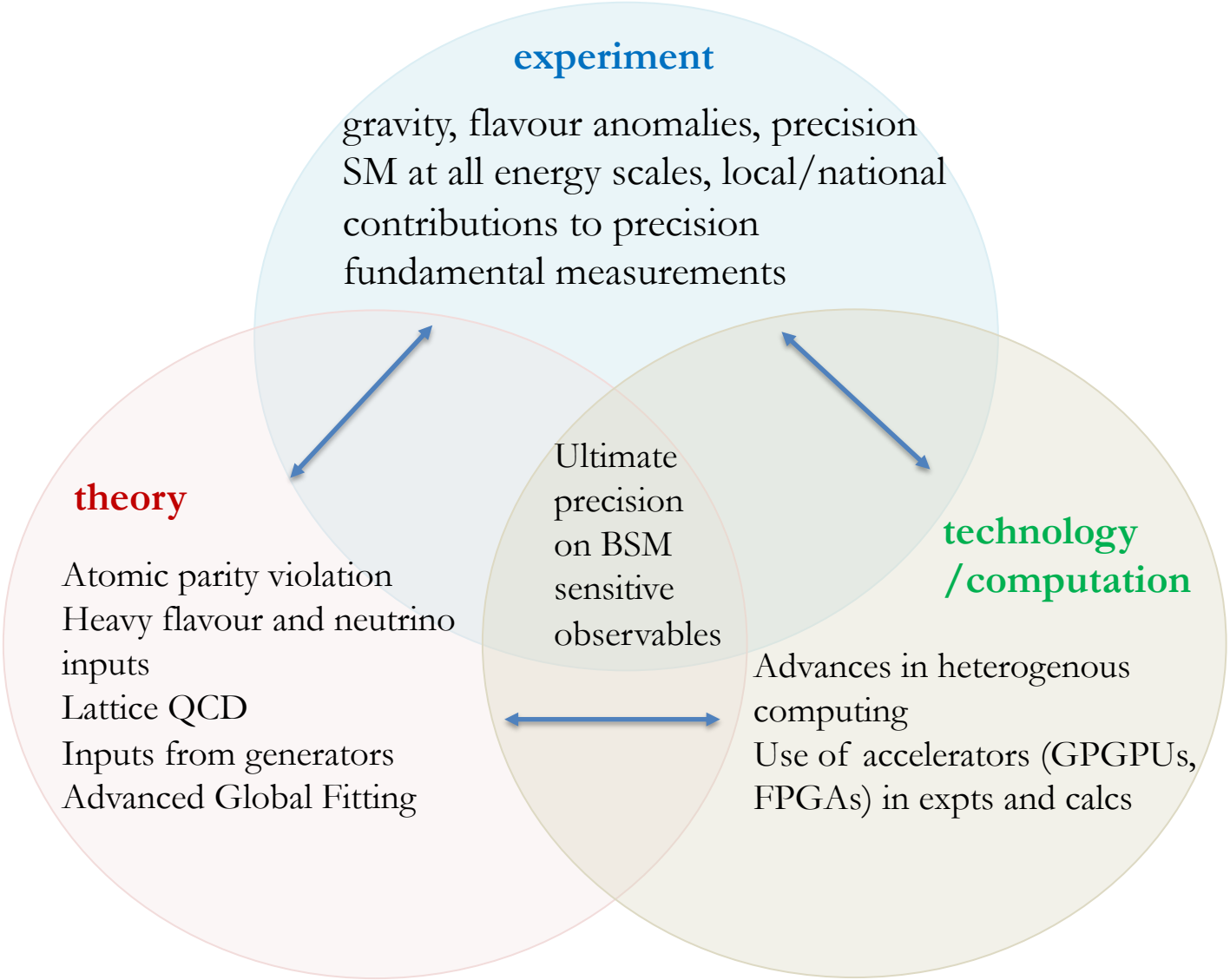
- The next big results in nuclear/particle/quantum physics will come as a result of precise measurement and calculation and improved sensitivity on fundamental parameters – not at this time requiring one brand new machine

- In Australia, are very well placed to make a telling contribution to this global effort

- Multiple anomalous results from various sources require deeper scrutiny in the coming decade – this physics spans many orders of magnitude – enticing!

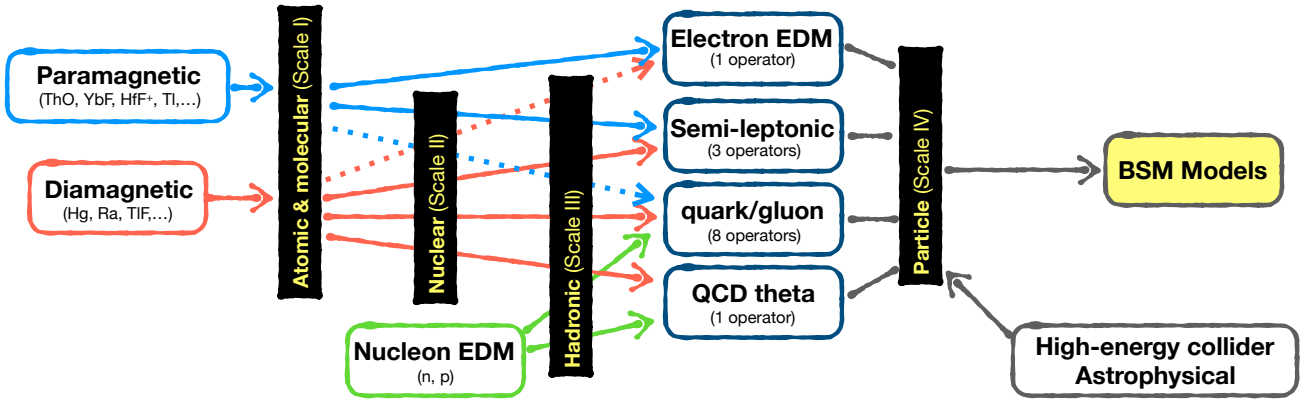
- We have the apparatus, technology, theoretical knowledge, personnel and interest to do this; how do we shift our thinking and pitch the best story?

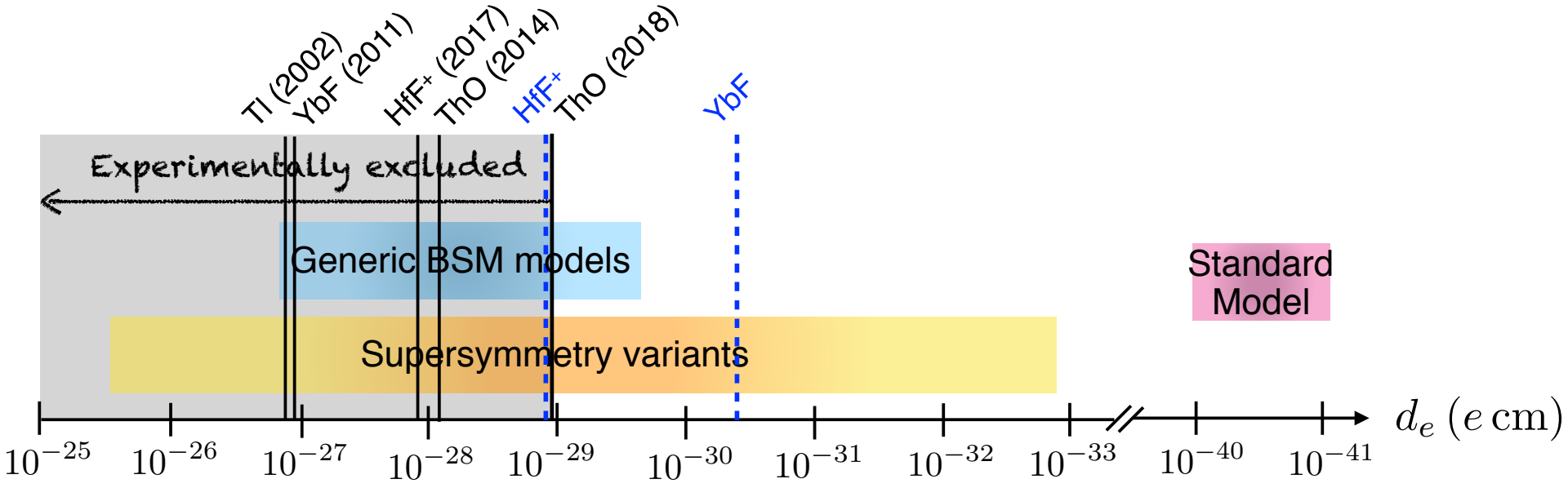
Synergies


experiment
gravity, flavour anomalies, precision SM at all energy scales, local/national contributions to precision fundamental measurements
theory
Atomic parity violation
Heavy flavour and neutrino inputs
Lattice QCD
Inputs from generators
Advanced Global Fitting
Ultimate precision on BSM sensitive observables
technology /computation
Advances in heterogenous computing
Use of accelerators (GPGPUs, FPGAs) in expts and calcs

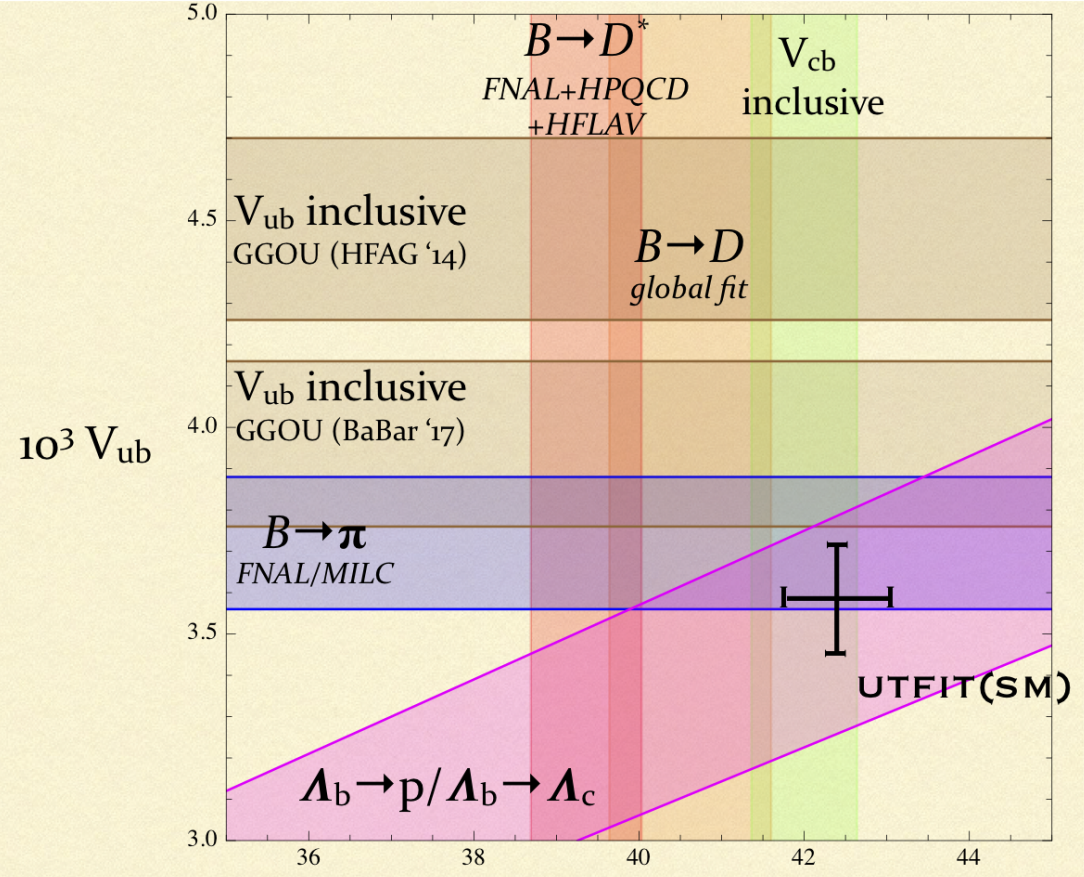
Additional Material

Input and scales from EDM





Input from lattice on V_{ub} vs V_{cb}



Current constraints on CKM matrix elements V_{ub} and V_{cb} (x10^3).
Clear tension exists between inclusive and exclusive determinations.
(Fig. credit: P.Gambino, Moriond 2018)