

Particle Physics @ Sydney

Celine Boehm, Archil Kobakhidze, Kevin Varvell, Bruce Yabsley



THE UNIVERSITY OF
SYDNEY

Australian Meeting on Accelerator-Based Particle Physics

Monash U, 18 Feb 2019

Particle Physics Group members

Senior Academics:

Prof Celine Boehm – theory – Physics HoS

A/Prof Archil Kobakhidze – theory

Prof Kevin Varvell – experiment – Head of Group/CoEPP node director

A/Prof Bruce Yabsley – experiment

Postdocs:

Dr Chia-Ling Hsu – experiment, Belle II

Dr Frank Meier – experiment, Belle II

Honorary staff:

Dr Andrew Bakich – experiment – emeritus

Dr Robert Foot – theory – Senior Principal Research Fellow

A/Prof Lawrence Peak – experiment – emeritus

Dr Aldo Saavedra – experiment

Dr Juris Ulrichs – experiment – emeritus

Particle Physics Group members

Postgraduate Research Students:

Suntharan Arunasalam – PhD theory (Kobakhidze)

Shyam Balaji – PhD experiment, ATLAS (Varvell)

Yunho Kim – PhD theory (Kobakhidze)

Cyril Lager – PhD theory (Kobakhidze)

Zachary Picker – PhD theory (Boehm/Kobakhidze)

Carl Suster – PhD experiment, ATLAS (Varvell)

Matthew Talia – PhD theory (Kobakhidze), recently completed, moving to Poland as a postdoc

Nadia Toutounji – Masters experiment, Belle II (Varvell), recently completed.

Lachlan Vaughan-Taylor – Masters experiment, Belle II (Varvell)

Honours Students (2019):

Isabel Bunting – theory (Kobakhidze)

Priyanka Cheema – experiment (Yabsley)

Lawrence Cohen – theory (Kobakhidze)

Ethan Cross – experiment (Varvell)

Darcy O’Sullivan – theory (Kobakhidze)

Recent Alumni

In the last 5 years,

- 11 PhD graduates
- 1 MPhil graduate
- 16 Honours Students (most H1, 4 University Medal)

Dr Michael Schmidt – theory – faculty @ UNSW

Dr Kristian McDonald – theory

Dr Lei Wu – theory – faculty @ Nanjing Normal University

Dr Jin Wang – experiment – staff position @ IHEP Beijing

Dr Kevin Finelli – experiment – postdoc @ Boston University

Dr Tony Limosani – experiment – financial sector, Switzerland

Dr Anthony Morley – experiment – staff position at CERN

Dr Aldo Saavedra – experiment – health data scientist @ University of Sydney

Dr Alexei Sibidanov – experiment – postdoc @ University of Victoria, Canada

Dr Geng-Yuan Jeng – experiment – postdoc @ University of Maryland

Teaching/Training

Particle Physics (and related) courses:

- Senior Particle Physics (3rd Year, Varvell)
- Nuclear Physics (Honours, Yabsley; M.Med.Phys*., Yabsley)
- Quantum Field Theory (Honours, Kobakhidze)
- Physics of the Standard Model (Honours, Varvell)
- Particle Cosmology and Baryonic Astrophysics (Honours, Hamann, Schmidt, Kobakhidze)

Particle Physics Theory Journal Club (Joint with UNSW):

Selected advanced courses in theory and phenomenology of particle physics, gravity, astrophysics and cosmology (e.g., Path Integrals, Instantons and Quantum Anomalies, Supersymmetry, Gravitational waves, Collider Pheno, Dark Matter, CMB Physics,...)

CoEPP Summer Schools; Spring School in Particle Physics and Cosmology (Berengut, Kobakhidze, Hamann, Skands, Schmidt, Wong) – will be useful to revive

*Potential collaboration @ USyd: medical physics supports the p,C therapy accelerator proposal @ Westmead site

Research (Experiment)

Flavour physics at Belle/Belle II (Varvell)

- member of the “(Semi-)Leptonic and Missing Energy Decays WG” group
- Leptonic decays of B mesons, hadronic tagging (Full Event Interpretation) and KL calibration (DP170102389, with Leo Piilonen [Virginia Tech]. Students Nadia Toutounji, Lachlan Vaughan-Taylor
- Charmless semileptonic decays of B mesons, determination of $|V_{ub}|$
- Flavour anomalies in B physics

Top, Higgs physics and upgrade at ATLAS (Varvell)

- Single top production, differential distributions. Student Carl Suster. With Mark Kruse, Duke.
- Search for heavy resonances $A \rightarrow Zh$, non 125 GeV h. Student Shyam Balaji.
- Machine learning for improved calorimeter resolution. With Troels Petersen, NBI Copenhagen.
- ITk strips upgrade, DAQ. With Melbourne, Adelaide.

Research (Experiment)

Flavour and quarkonium physics at ATLAS (Bruce)

- Bruce is a member of the “B-physics and Light States” group and was co-convener of the Onia subgroup 2016-2018
- search for X_b (hidden-beauty analogue of $X(3872)$) and other exotic states
- select B-physics topics including $B_{(s)} \rightarrow mm$ and $B \rightarrow J/\psi f$
- quarkonium and B_c spectroscopy
- quarkonium production and associated production

Calorimeter reconstruction and analysis development for Belle II (Bruce)

- calibration of the calorimeter (and other subdetectors) for neutrons and anti-neutrons (DP170102204, with Alex Kuzmin [BINP], head of ECL group)
- track-driven reconstruction of the calorimeter, initial trial and development
- ultimate goals:
 - improved background rejection for rare decay analyses
 - improved missing-momentum reconstruction

Research (Theory)

Dark Matter Program (lead by Celine Boehm)

- Collider dark matter pheno (Boehm, Kobakhidze): simplified models, unitarized EFTs,...
- Alternative dark matter theories (Boehm, Kobakhidze): self-interacting dm; axion/dilaton; exotics
- Direct dark matter detection (Boehm): Sabre project; theoretical analysis/interpretation of data
- Indirect dark matter detection (Boehm)
- Dark matter and cosmology (Boehm)
- Dark matter & quantum technologies (Kobakhidze)

(Potential) collaborations @ USyd: SIFA (Joss Bland-Hawthorn, Geraint Lewis), Quantum Group (Stephen Bartlett, Andrew Doherty); @ UCL (Sougato Bose) and @ Adelaide, Melbourne, Monash and UNSW

Research (Theory)

Higgs Physics in the Standard Model and Beyond (lead by Archil Kobakhidze)

- EFT description of Higgs anomalous couplings and the related collider pheno
- Higgs Physics and cosmological electroweak phase transition and baryogenesis
- Higgs vacuum stability and the related cosmology
- Topological avatars of the Standard Model: EW monopoles, sphalerons, skyrmions,...
- Pheno of scale invariant models with light dilaton
- Cosmological implications: quark matter nuggets; gravitational waves; primordial black holes
- Gravitational Weyl anomaly vs diffeomorphism; quantum scale invariance

Gravity and fundamental physics (lead by Archil Kobakhidze)

- Exploring fundamental physics via gravitational waves
- Gravitational instantons and particle physics
- BMS symmetries, soft-hair and tensor networks

Potential collaborations @ USyd Quantum group (Stephen Bartlett, Andrew Doherty) and @ Adelaide, Melbourne, Monash, UNSW

Future Particle Physics @ Sydney

We would like to sustain and expand present level of scientific activities in particle and astroparticle physics in both theory and experiment

- Currently, we are at the edge of capacity to run research programs fully:
 - Increasing number of students vs permanent academic staff;
 - Post-CoEPP reduction of funding => fewer postdocs and visitors, less conference travel, summer schools for students, etc...;

Short-term solution: revitalize existing and create new collaborations within Australia, including exchange of expertise, shared supervision/training, joint grants, regular webinars and online journal clubs, effective use of common resources (e.g., AUSHEP);

ARC opportunities: We actively try to attract bright early and mid career researchers to apply for ARC FT and DECRA – challenge uncertainties with post-fellowship opportunities (Usyd Robinson Fellowships)

Strategic appointments by the University: seek for suitable candidates(?)

Future Particle Physics @ Sydney

The important mid term goal is to support new ARC CoEs related to particle/astroparticle physics

- Celine Boehm is a CI on the current Dark Matter CoE proposal;
- Support for a new accelerator-based CoE application for the next round (particle collider physics, accelerator physics, detector development, including medical and other applications);
- Support for a new astroparticle CoE

While we strongly support all the above CoEs, the limited resources, existing commitments (ATLAS, Belle II) and personal research preferences will necessarily involve some divergence of choices. It is our belief, that if we deal with the different opinions in a collegial, inclusive and supportive manner, the 'divergence' will be viewed as an opportunity to expand the field and community, rather than its disintegration.

Future Particle Physics @ Sydney

Strategic vision of Sydney particle physicists is to seek opportunities to institutionalize the support of the field. In this regard, we strongly support Australia's Associate Membership at CERN.