Notes on PPAP Flavour-changing physics + QCD Day: 13th July 2009

(1) Draft PPAP findings

NB: These notes do not represent a verbatim transcript of everything said on the day, but rather provide a brief summary of the main points which came up in the discussions. For details of the presentations please see the slides on the agenda page at

http://conference.ippp.dur.ac.uk/conferenceDisplay.py?confId=273 .

- Flavour-changing observables have a unique and powerful role to play in helping to characterise the new physics that the LHC is expected to discover. The experiments under discussion have the sensitivity to carry out this programme. The pedigree of the UK community in flavour physics is undisputed, and hence we are well placed to assume a leading role in this science.
- Flavour experiments are needed to probe the symmetry structure of physics beyond the Standard Model. High energy and high precision experiments are complementary – both will be needed to fully reconstruct the Lagrangian of the underlying theory.
- If new physics (NP) is at the TeV scale, we already know something about the structure since NP signals have not yet been seen in flavour. This can be accommodated in the minimal flavour violation (MFV) scenario (Standard Model (SM) Yukawa couplings are the only non-trivial flavour-breaking terms – ie. alignment between SM and NP), but this is not expected to be exact, and some flavour observables could still reveal large non-standard effects.
- There is no unique outstanding observable – and improvements are needed on several fronts (charged leptons, B, charm & K), concentrating on the cleanest modes. Among the most interesting channels (not listed here) some will not be theory- or systematics-limited by 2014, while improvements in lattice calculations will be beneficial for others. Future experiments on these clean channels are therefore well-motivated.
- There are two main possible future facilities for b physics (which also have charm and tau physics capabilities)
  - e+e-: KEKB upgrade or SuperB (aiming for instantaneous luminosities of O(10^36/cm2/s), and data samples of 50-100/ab). The main differences are that the current SuperB design offers the possibility for: 1) higher luminosity; 2) a beam polarisation option; 3) operation at charm threshold. There is UK interest in SuperB (QMUL, RAL, Cockcroft); current hardware interests are in the vertex detector and the accelerator.
  - pp: The LHCb upgrade (aiming to allow running at ~2 10^33/cm2/s, providing an increase of 10-20 in statistics w.r.t. baseline experiment, not contingent on any LHC upgrade) is being actively pursued by all UK LHCb institutes in the areas where responsibilities already exist, ie. vertexing and PID**.** Additional LHC potential - in dimuon B decay channels - will come from the GPDs, including their upgrades, with UK playing a leading role in B physics at ATLAS (Lancaster, RAL).
- The extremely high statistics which can be accumulated by the LHCb upgrade promise higher precision in B (and charm) decay studies involving exclusive charged particle final states. Time dependent B_s physics will only be possible at the LHC. On the other hand the next generation B-factories will be able to make truly inclusive measurements, exploit modes with neutral particles and missing energy (including critical modes such as $B_d \to K_S \pi^0$ and $B^+ \to \tau^+ \nu$), and provide better prospects in LFV tau decays. There is also overlap, for example in some measurements of time-dependent CP violation in the B_d system.
- Upgrades to the GPDs as required for SLHC may well allow for important contributions in certain specific, but important measurements, eg. $B_d \to \mu\mu / B_s \to \mu\mu$.
- In the next decade kaon physics will focus on the golden $K \to \pi \nu\bar{\nu}$ modes, mainly through experiments at CERN (NA62 – $K^+ \to \pi^+ \nu\bar{\nu}$) and J-PARC (KOTO – $K_L \to \pi^0 \nu\bar{\nu}$), though there may also be a programme at FNAL. There is UK interest in the former (Birmingham, Bristol, Glasgow and Liverpool). A SoI was submitted to PPAN in February 2009 outlining a case for £1.2M, with the focus on PID, trigger and computing.

- The first stages of both NA62 and KOTO should observe events at the SM level (many and several, respectively), but will not reach precision comparable with the theoretical uncertainty on the rates. Further upgrades of both could therefore potentially be interesting. The CERN programme would benefit from an upgrade to the SPS, in which case studies of the $K_L \to \pi^0 \nu\bar{\nu}$ mode could potentially also be possible.
- The UK plays a leading role in lattice QCD, responsible for many of the important developments in the field, and active in three different approaches (ETMC: twisted mass; HPQCD: staggered; RBC-UKQCD: domain wall) with a variety of research interests in flavour physics. Further improvements in lattice calculations are expected, and are necessary to keep pace with the expected developments in experiment.
- The search for charged lepton flavour violation is one of the most interesting routes to investigate physics beyond the Standard Model, with obvious connections to the neutrino sector. The MEG experiment (searching for $\mu \to e\gamma$) at PSI could find the first evidence within the next few years.
- $\mu \to e$ conversions provide the best route to explore further μ LFV. Two experiments (μ2e at FNAL and COMET at J-PARC) aim to improve the sensitivity of previous experiments by a factor 10000. There is UK interest in the latter (IC and UCL), which has just received stage 1 approval from the J-PARC PAC, and aims to begin data-taking around 2015.
- A second phase of the COMET experiment, called PRISM/PRIME, could use FFAGs to provide a further two orders of magnitude increase in sensitivity. UK interest in this project includes Cockcroft, John Adams, RAL, ASTeC, IC and UCL. A second phase of mu2e will benefit from ProjectX to obtain a similar improvement in sensitivity.
- There are a number of flavour-physics projects worldwide in which there is currently no expressed interest within the UK (these include KEKB upgrade, BESIII, a possible BINP tau-charm factory, KLOE upgrade, KOTO and other rare kaon decay experiments at J-PARC, possible kaon physics experiments as a part of Project X at FNAL, a next generation muon g-2 experiment).