# UK Particle Theory: Programme Overview

Simon Hands (co-chair STFC PPGP)

**R-ECFA** UK Visit
RAL, 7th November 2014

Most PPT activity in UK supported via funding from Science & Technology Facilities Council

Unique opportunity to bid every 3 years for *Consolidated Grant* support for theory groups in institutions - CG13 gives a "snapshot"

CG support covers a fraction of salary costs (FEC), PDRAs, travel, consumables and technical support - in last 2 rounds also covered HPC recurrent costs

PGR studentships and Fellowships awarded in a separate exercise (Tara Shears)

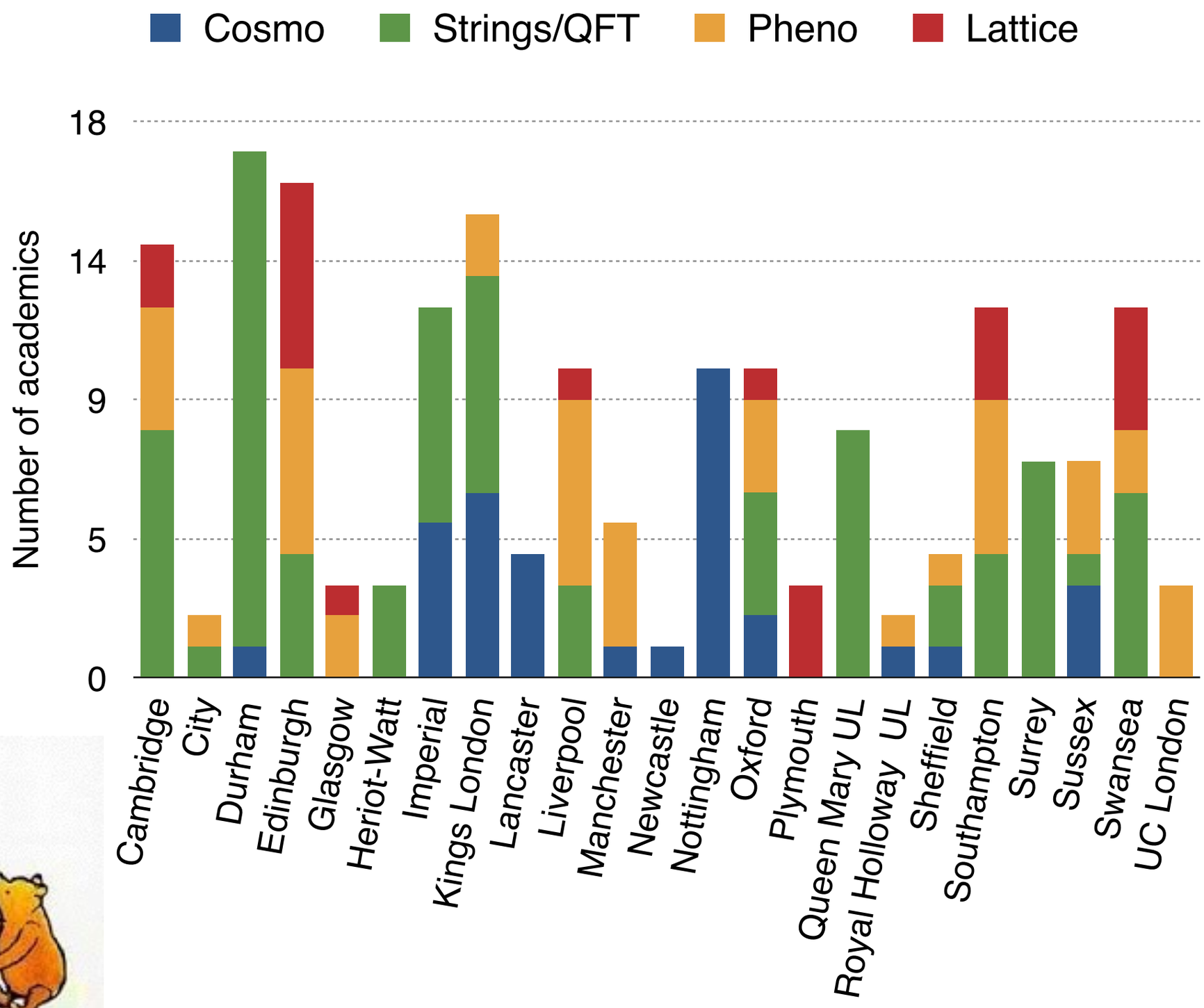
# STFC's view of PPT mission…

Science & Technology Facilities Council

**STFC supports theoretical research in particle physics, particle cosmology, theoretical astronomy and cosmology, and areas related or relevant to these. Its theoretical activity includes:**

- **theoretical insight into physical phenomena;**
- **development and study of theoretical frameworks;**
- **development of models and theories with the aim of further enhancing or unifying our understanding of the physical world;**
- **development of models and theories with the aim of further enhancing or unifying our understanding of the origin and development of the Universe;**
- **analysis and interpretation of data from experiments and observations; guidance for further experiments and observations;**
- **development of calculational and computational techniques enabling more precise comparison of theory with experiment.**

# What size/shape is the UK PPT Community?




~180 academics bid for support in CG13

# Recent Physics Highlights

## Phenomenology

### UK plays leading role in LHC analysis

- leads 2/3 general purpose event generators
- leads 2/3 PDF models
- expertise in collider, neutrino, flavor physics
- construction of BSM models

## String and Formal Field Theory

### UK has led since first days of field

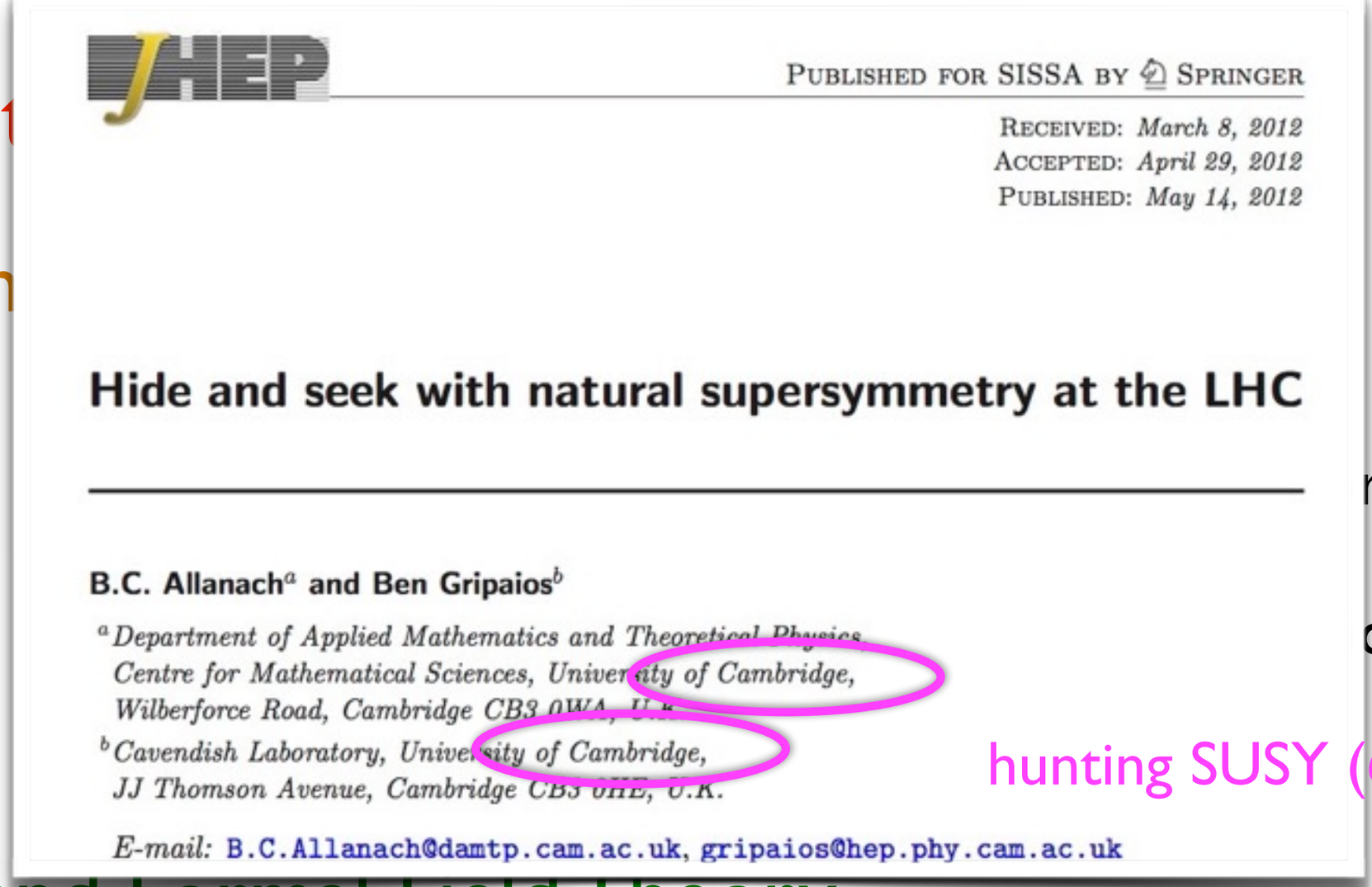
- M-theory, generalised geometry, integrability
- SUSY gauge theories, gauge-gravity duality
- applications to thermal/many-body systems
- advanced techniques for scattering amplitudes
- string-inspired phenomenology/cosmology

Recent

Phenom

rs

cs



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## Hide and seek with natural supersymmetry at the LHC

**B.C. Allanach**[a] **and Ben Gripaios**[b]

[a] *Department of Applied Mathematics and Theoretical Physics, Centre for Mathematical Sciences, University of Cambridge, Wilberforce Road, Cambridge CB3 0WA, U.K.*

[b] *Cavendish Laboratory, University of Cambridge, JJ Thomson Avenue, Cambridge CB3 0HE, U.K.*

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hunting SUSY (65 cites)

String and Formal Field Theory

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[a] *Department of Applied Mathematics and Theoretical Physics, Centre for Mathematical Sciences, University of Cambridge,*

PHYSICAL REVIEW D **77,** 065008 (2008)

## Gauge symmetry and supersymmetry of multiple M2-branes

Jonathan Bagger*

*Department of Physics and Astronomy, Johns Hopkins University, 3400 North Charles Street, Baltimore, Maryland 21218, USA*

Neil Lambert†

*Department of Mathematics, King's College London, The Strand, London WC2R 2LS, United Kingdom*
(Received 12 November 2007; published 7 March 2008)

In previous work we proposed a field theory model for multiple M2-branes based on an algebra with a totally antisymmetric triple product. In this paper we gauge a symmetry that arises from the algebra's triple product. We then construct a supersymmetric theory that is consistent with all the symmetries expected of a multiple M2-brane theory: 16 supersymmetries, conformal invariance, and an $SO(8)$ R-symmetry that acts on the eight transverse scalars. The gauge field is not dynamical. The result is a new type of maximally supersymmetric gauge theory in three dimensions.

DOI: 10.1103/PhysRevD.77.065008 PACS numbers: 04.65.+e, 04.50.−h, 11.25.Hf

brane field theory (734 cites)

# Lattice QCD

## World-class support via *DiRAC* HPC facility

- flavor physics (q/Q) to constrain CKM
- kaon physics and $\Delta I=\frac{1}{2}$
- (g-2) for muon
- hadron excitations/transport for $T>T_c$
- near-conformal dynamics for EWSB
- new methods for $n_{baryon}>0$ and nuclear matter

# Particle Astrophysics/Cosmology

## Onset of Planck era (also *DiRAC*)

- direct and indirect Dark Matter searches
- connecting inflation with particle physics
- phase transitions, baryogenesis
- theories of dark energy, modified gravity
- extra dimensions, brane inflation, cosmic strings

Lat

PRL 108, 141601 (2012) PHYSICAL REVIEW LETTERS week ending 6 APRIL 2012

# $K \to (\pi\pi)_{I=2}$ Decay Amplitude from Lattice QCD

T. Blum,[1] P. A. Boyle,[2] N. H. Christ,[3] N. Garron,[2] E. Goode,[4] T. Izubuchi,[5,6] C. Jung,[5] C. Kelly,[3] C. Lehner,[6] M. Lightman,[3,7] Q. Liu,[3] A. T. Lytle,[4] R. D. Mawhinney,[3] C. T. Sachrajda,[4] A. Soni,[5] and C. Sturm[8]

(RBC and UKQCD Collaborations)

[1]*Physics Department, University of Connecticut, Storrs, Connecticut 06269-3046, USA*
[2]*SUPA, School of Physics, The University of Edinburgh, Edinburgh EH9 3JZ, United Kingdom*
[3]*Physics Department, Columbia University, New York, New York 10027, USA*
[4]*School of Physics and Astronomy, University of Southampton, Southampton SO17 1BJ, United Kingdom*
[5]*Brookhaven National Laboratory, Upton, New York 11973, USA*
[6]*RIKEN-BNL Research Center, Brookhaven National Laboratory, Upton, New York 11973, USA*
[7]*Physics Department, Washington University, 1 Brookings Drive, St. Louis, Missouri 63130-4899, USA*
[8]*Max-Planck-Institut für Physik, Föhringer Ring 6, 80805 München, Germany*
(Received 8 November 2011; published 4 April 2012)

Baryon

2012 Ken Wilson Award (53 cites)

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[7]*Physics Department, Washington University, 1 Brookings Drive, St. Louis, Missouri 63130-4899, USA*

PRL 108, 051101 (2012) PHYSICAL REVIEW LETTERS week ending 3 FEBRUARY 2012

# General Second-Order Scalar-Tensor Theory and Self-Tuning

Christos Charmousis,[1,2] Edmund J. Copeland,[3] Antonio Padilla,[3] and Paul M. Saffin[3]

[1]*LPT, CNRS UMR 8627, Université Paris Sud-11, 91405 Orsay Cedex, France*
[2]*LMPT, CNRS UMR 6083, Université François Rabelais Tours, 37200, France*
[3]*School of Physics and Astronomy, University of Nottingham, Nottingham NG7 2RD, United Kingdom*
(Received 22 June 2011; published 30 January 2012)

Starting from the most general scalar-tensor theory with second-order field equations in four dimensions, we establish the unique action that will allow for the existence of a consistent self-tuning mechanism on Friedmann-Lemaître-Robertson-Walker backgrounds, and show how it can be understood as a combination of just four base Lagrangians with an intriguing geometric structure dependent on the Ricci scalar, the Einstein tensor, the double dual of the Riemann tensor, and the Gauss-Bonnet combination. Spacetime curvature can be screened from the net cosmological constant at any given moment because we allow the scalar field to break Poincaré invariance on the self-tuning vacua, thereby evading the Weinberg no-go theorem. We show how the four arbitrary functions of the scalar field combine in an elegant way opening up the possibility of obtaining nontrivial cosmological solutions.

DOI: 10.1103/PhysRevLett.108.051101 PACS numbers: 04.50.Kd, 98.80.Jk

the *Fab Four* (105 cites)

# Conduct of CG13

Peer review by a **standing panel** with range of subject expertise and geographical spread

## PPGP membership

Simon Hands (Swansea, chair) lattice
Silvia Pascoli (IPPP Durham, core) pheno
Luigi Del Debbio (Edinburgh) lattice
Mark Hindmarsh (Sussex) cosmo
Neil Lambert (KCL) strings
Apostolos Pilaftsis (Manchester) pheno/cosmo
Radu Tatar (Liverpool) strings
Robert Thorne (UCL) pheno
Joel Goldstein (Bristol, exp chair)
Matthew Wing (UCL, exp core)

appointment typically covers 2 CG cycles

105 referees (UK + international) used - average of 6 per bid.

Referees comment on particular scientific areas, not whole bid.

Comments sent to PIs, responses considered by PPGP

# Consolidated Grants 2013

17 applications from 23 institutions

(5 from consortia)

supporting 185 academics covering 48 "scientific areas"

1 new group (Surrey) bid in 2013

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Indicative Budget (GBP)

| | 14/15 | 15/16 | 16/17 | 17/18 |
|---|---|---|---|---|
| PPGP(T) post PR/SR | 5030 | 5030 | 5030 | 5030 |
| Committed | 2426 | 20 | - | - |
| Conferences/New Applicants | 23 | 25 | 25 | 25 |
| Isaac Newton Institute | 100 | 100 | 100 | 100 |
| Available | 2481 | 4885 | 4905 | 4905 |
| Requested | 8036 | 16242 | 15817 | 8097 |
| Δ | -5555 | -11357 | -10912 | -3192 |

# DiRAC

(Distributed Research utilising Advanced Computing)

STFC's HPC facility supports theoretical research in particle physics, astronomy and nuclear physics since 2009. The main **PPT** usage is at

## Cambridge Data Analytic Cluster

200Tflop/s, 9600x4GByte RAM, 0.75PByte storage

## Cambridge COSMOS Shared Memory Service

42Tflop/s 1856x8GByte RAM (globally shared), 146TByte storage

## Edinburgh BlueGene/Q

1.3Pflop/s

www.dirac.ac.uk

# DiRAC HPC recurrent costs

BIS/STFC capital investment in HPC not
initially matched by sustainable recurrent funding
(electricity, system support…)

DiRAC recurrent costs tensioned
against rest of PPT programme in CG11 and CG13

CG13: total bid £1.86M for 2014-17 (~11% of programme)
revised downwards to £1.19M in consultation with
DiRAC PMB, Project and Technical Directors

PPGP recommended award £893k over 3 years
(~5.3% of PPGP(T) programme)

Following the publication of the 2012/13 Programmatic Review report, a separate funding line has been set up for DiRAC from FY 2014/15 onwards.

# The Outcome

## Initial scan of bids yielded *optimal funding scenario*

| | PDRAs | students | core FTE | academic FTE |
|---|---|---|---|---|
| Fundable | 51.7 | 3 | 1.4 | 88.6 |
| Funded | 28 | 1 | 1→0 (DiRAC) | 23.7 |

## Projects recommended funding in three bands:

| | # projects | PDRAs | academic FTE | max FEC |
|---|---|---|---|---|
| leading | 20 | 23 | 11.7 | 20% |
| important | 15 | 5 | 9.3 | 15% |
| competitive | 12 | - | 2.7 | 10% |
| not funded | 1 | - | - | - |

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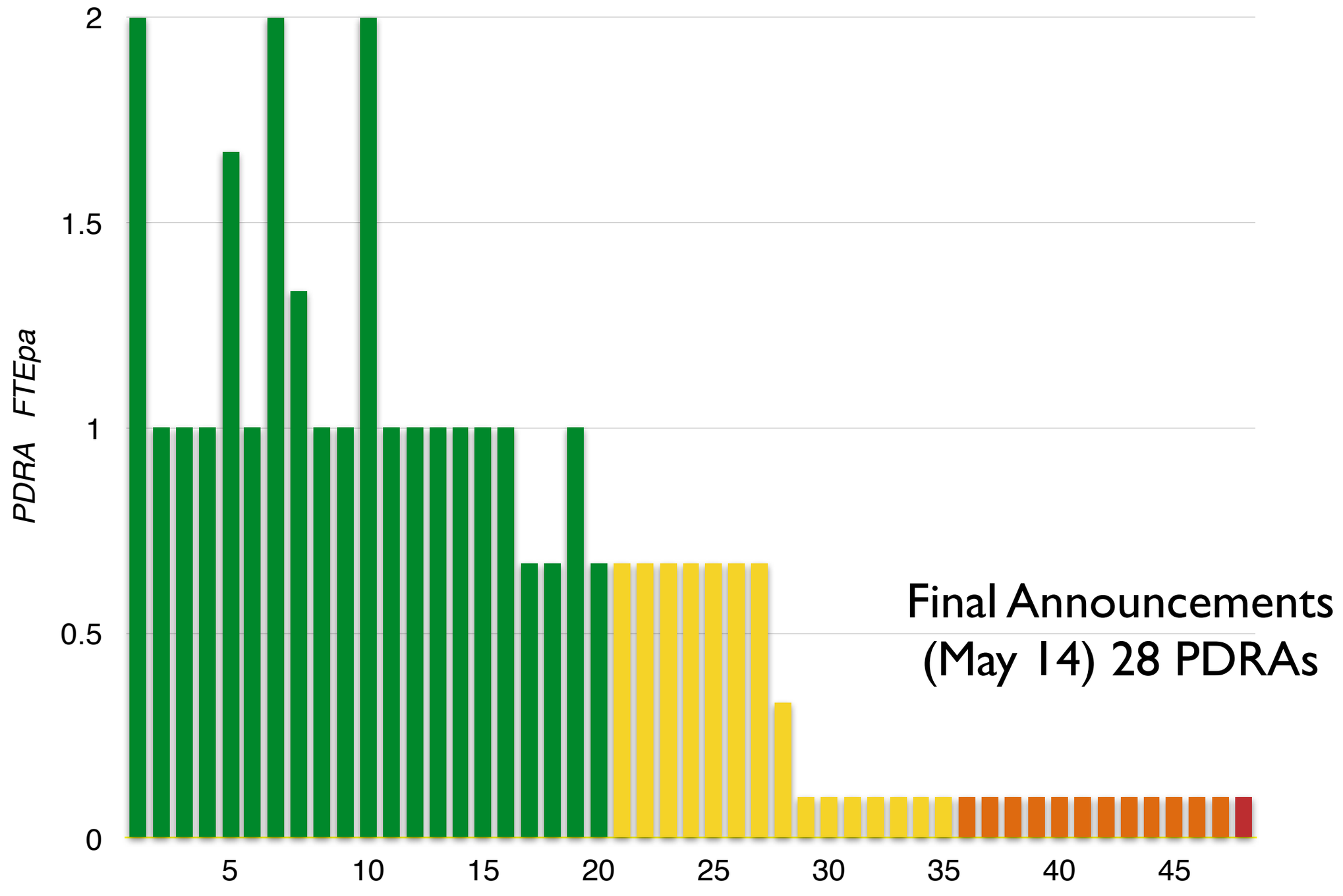
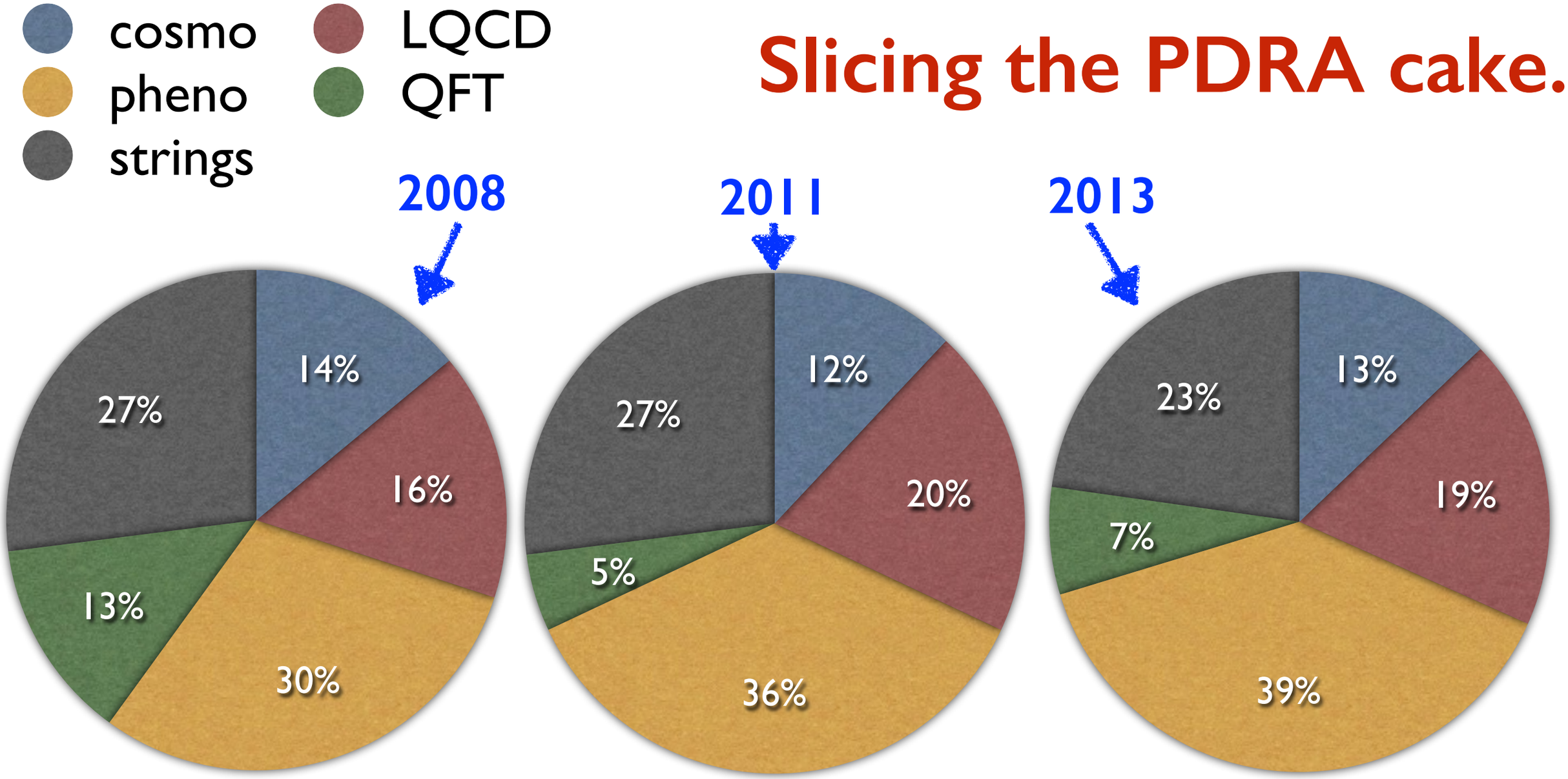
In the same CG13 snapshot PPT activity also supported by 7 **ERC** Grants (3 Advanced, 4 Starter) spread across 4 institutions

# PDRA distribution by band…



# Slicing the PDRA cake...




- steady growth of pheno - onset of LHC
- lattice stable - onset of DiRAC
- cosmo stable - onset of Planck
- decline in strings/QFT over time…

# Institute for Particle Physics Phenomenology

Joint support from STFC and Durham University

16 academics, 20 PDRAs

coordinates pheno activity (theo/exp) in the UK via

- Senior Fellowships
- Associateships
- Workshops

www.ippp.dur.ac.uk

# Isaac Newton Institute for Mathematical Sciences

Joint support from RCUK and Cambridge University

Visitor research programmes on selected themes in mathematics and mathematical sciences

£100k pa from STFC PPT funding line

www.newton.ac.uk

# Trends over time

| | 2005 | 2008 | 2011 | 2013 |
|---|---|---|---|---|
| # bidding academics | 122 | 155 | 163 | 185 |
| Budget (inc FEC) | - | £16.4M | £14.5M | £14.5M |
| maximum FEC | - | 28.5% | 20% | 20% |
| average FEC | - | 20% | 14% | 16% |
| PDRAs | 34 (+7 SPG) | 34.3 (+1SPG) | 29.3 | 28 |

# Summary

UK PPT continuing to deliver world class
science in an unfriendly funding environment

## Consolidated Grant mechanism:

- focuses on projects rather than groups
- favours clear timelines/deliverables
- able to exploit developments (LHC, DiRAC, Planck…)

Concern about decline in support for formal theory

Commitment to preserve funding,
in difficult times,
of leading science at expense of important
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**Questions?**