# *Long(er)* Summary of PPAP Community Survey

PPAN Roadmap discussion, PPAP Community Meeting

Birmingham 25-26 June 2024

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**PPAP**

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# Introductory Remarks

- We were asked to provide a more detailed summary of the survey results related to the PPAN roadmapping.
- Reminder of useful links: Full survey summary document and meeting/post-meeting comments
- This presentation will provide an overview of some of the themes that arose in the qualitative analysis

# Results presentation/methodology

- 2 PPAP members from different science areas read and summarised each survey response.
- We tried to capture general themes repeated by two or more respondents
- When relevant, group responses were disjoined from individual responses

Obvious comment: qualitative analysis is HARD and not something we do often in particle physics. Need to be mindful of ‘selection bias’ when trying to extract community views from a dataset that includes many individual opinions

# Reminder of PPAN roadmapping questions

1. Have there been any **significant changes** or **developments** that would cause the panel to alter the recommendations in their **current roadmap**?
2. Have there been any **major scientific developments** within the field since the roadmap was last updated that should affect STFC's consideration of future support of relevant UK research?
3. Where applicable, have there been any significant updates to relevant **international roadmaps**?
4. Have any significant **new opportunities or risks** emerged for the health of discipline that are not included in the current roadmap, or that need to be expanded upon in more detail?
5. Do any of the **recommendations** in the roadmap require a significant update or revision?
6. What do you consider to be your **key skills gaps** that need addressing?
7. Are there **any trends** across skills needs (for example, regional, career stage) that are notable within your particular area?
8. What do you anticipate will be the **future skills** needs?
9. What are the key **strengths, weaknesses, opportunities and threats** for your science area currently, and looking across the next 10 years?

## What are the top scientific challenges (in order of priority with highest first) in particle physics that the UK community needs to be involved in solving in the next 10-20 years?

**Trends that emerged:**

- Neutrino physics: mixing patterns,mass hierarchy, CP violation, absolute mass, nature (neutrino-less double beta decay). 90 mentions
- Dark matter searches with the wide range of masses (and thus the need for a range of complementary approaches) also noted 51 mentions
- Higgs characterisation, including measurements of the Higgs potential. 39 mentions
- Flavour physics (anomalies, the flavour problem, CPV in lepton/quark sectors, EDMs). 36 mentions
- Gravitational waves for probing BSM/quantum gravity. 26 mentions
- Improving theoretical predictions 21 mentions
- Precision measurements (including top physics) 17 mentions
- Understand mechanism of baryogenesis. 13 mentions
- Accelerator and detector R+D. 13 mentions
- Dark energy and inflationary dynamics. 10 mentions

**Additional drivers:**

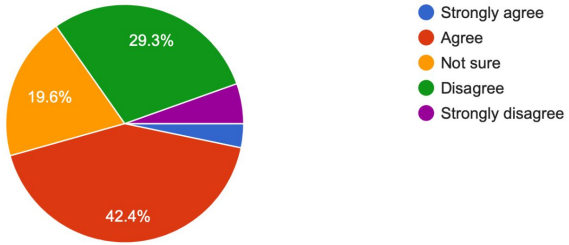
- ECR job security
- Sustainability/climate change
- Public engagement, outreach, D+I
- Advances in AI

**Additional points from non-individual submissions**

- Stability of the UK QTFP programme (ECR retention).

# Balance of programme between science areas?

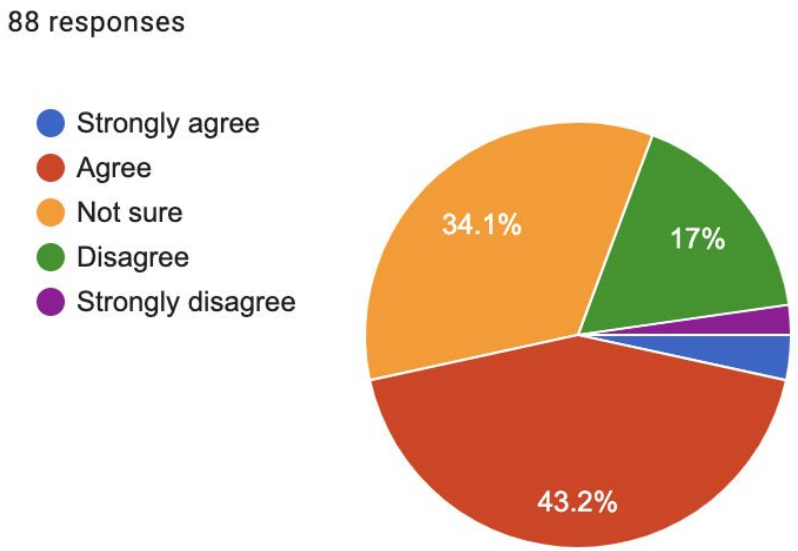
Do you consider the current Particle Physics programme well balanced between science areas ("Energy Frontier", "Flavour Physics", "Neutrino Phys...", "Detector R&D", "Accelerator Technologies" )?
92 responses




Details of comments divided by respondents based on "(strongly) agree","not sure" and "(strongly) disagree" provided in the doc.

- **Headline message:** need to devote more resources to detector (and accelerator) R+D. 30 responses mentioned R&D)
- The "science areas" overlap, and some are technically facility types rather than science drivers, so **care should be taken interpreting results**.
- **Conflicting views** included:
  - level of emphasis on energy-frontier,
  - emphasis between larger and smaller projects need to allow headroom for new opportunities whilst meeting existing commitments and fully exploiting current strengths.
  - Scale (level of involvement) and balance (LHCb vs kaon) of quark-flavour physics within UK
- More support needed for **theory**.
- Breadth of dark matter/sector searches should be supported.

# Is the UK particle physics theory well positioned to guide the experimental programme?



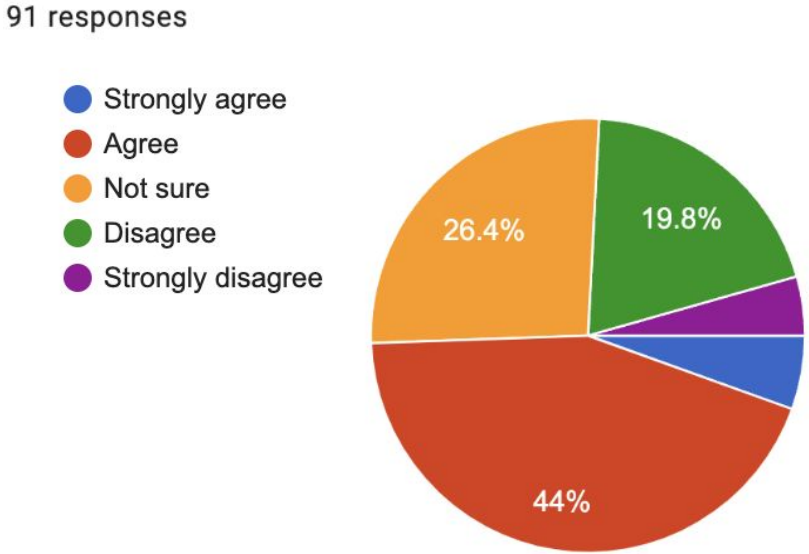

**Headline messages:**

- **Funding for theory is too little**, small groups that cannot make big impact, efforts are mostly centralised at IPPP. Hardly any FEC support for theorists, with consequences on their status and duties at their home institutions
- Better connection between theory and experiment needed, what role could IPPP play in this respect?

**Science Areas:**

- Gravitational waves, as well as theory for QFTP should be more supported
- Uplift of funding on the lattice, given its crucial role in the intensity frontier
- Well positioned for LHC, less for other experiments
- Neutrino interaction theory needed
- There is a need for BSM phenomenologists, able to provide visionary guide to experiments
- Theory for MC and event generators is strong and we should continue to support it

# Does the UK computing infrastructure and existing investment in computing skills adequately support the current and future needs of the field?

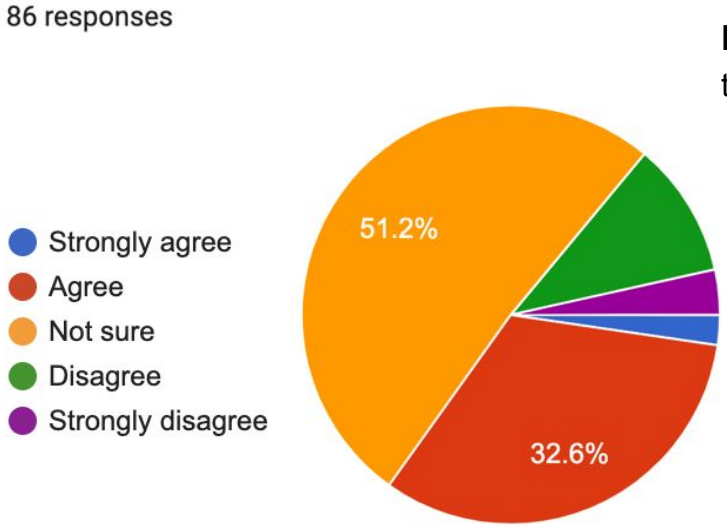



**Headline messages:**

- evident lack of support for RSE and need for attractive career pathways across the PP programme. An expansion of the SWIFT-HEP project was recognised as a way to achieve this
- we need to invest in skills and development to ensure our software and computing projects are sustainable
- current computing resources are adequate with a challenging future ahead
- Develop capabilities for AI and heterogeneous computing

Interestingly computing skills & ML/AI technology rank high in the list of underpinning future techs (Q23)

# Is the UK investment in the accelerator R&D programme commensurate with its current research portfolio and future aspirations?

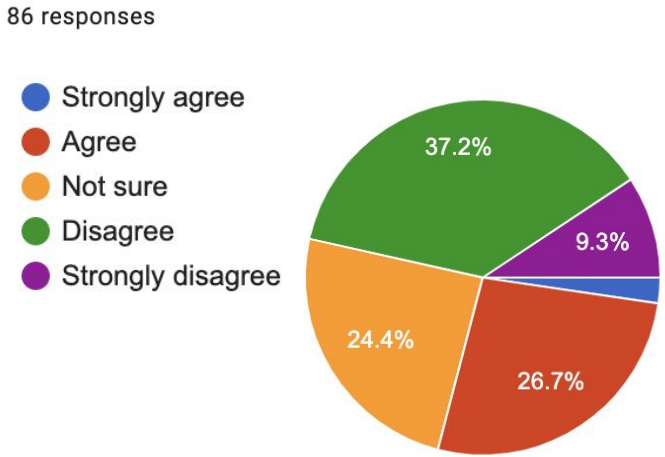



Significant number of “non-expert” feedback, approximately 30%

**Headline messages:** Lack of a strategic plan that is actually followed through.

- Significant underinvestment in accelerator R&D inconsistent with the STFC statement strategy to increase return on investment from CERN and other labs and with high-priority initiatives stated in last ESPUU.
- Future physics reach in many cases depends more on developments in accelerator.
- UK expertise is in many cases world-leading and innovative but is significantly under-utilised.
- Carbon footprint and environmental sustainability of future accelerators must be a central element of R&D.
- Need for “small-scale” UK based accelerator facilities for test beams and “quick-return” physics (e.g. 10 GeV e-beam at Daresbury for photon structure, dark matter, QED )
- If a future collider is built, the UK should play a leading role in accelerator development
- There is significant interest in muon collider and muon beams

# Is the UK investment in the detector R&D programme commensurate with its current research portfolio and future aspirations?




**Headline message:** R&D is severely underfunded → dangerous for the health of the field. *Funding considerations:*

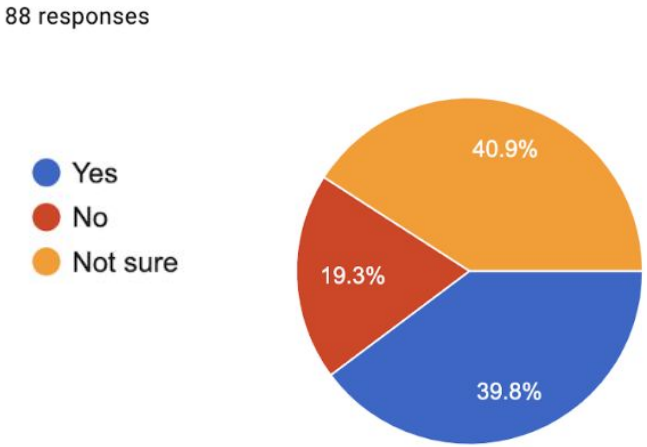
- Need to increase/ring-fence R&D spending to 10-15% of research budget to have impact.
- Fund DRD
- Drop in CG core funding makes blue-skies R&D semi-impossible. No other mechanism.
- Provide funded access to specialist facilities
- Crucial for ECR opportunities.

**DRDs:** DRD programme widely recognised as needing significant long-term funding, but directions/focus are frequently criticised (fear of top-down, CERN-led direction). DRD partly addresses **lack of R&D strategy** for strategic/mid TRL R&D.

Lack of PRD-like schemes is especially a problem for ECRs for whom it had been an obvious entry route for career progression. **Difficult in recruitment.**

Need investment in novel technologies (e.g. quantum). QTFP is a good example but questions re the sustainability of the programme.

# Have there been significant developments in the UK particle physics programme that are not captured in Roadmap-2021?




**Science updates:**

- HIKE was dropped by CERN, what is the future for the Kaon community?
- SHIP is now supported by CERN
- UK dark matter experimental landscape has evolved significantly: establishment of a plan to build a large international experiment at Boulby (XLZD).
- QTFP has grown since the 2021 document
- Electron Ion Collider (EIC), if in scope of PPAP, should be included
- Revise the role of muon and EDM precision experiments
- Revision of current experiments (e.g. HL-LHC), plans for future colliders and participation to R&D
- Better connection between experiment and theory, role of the theory in guiding experiments and role of IPPP in providing the connection.
- Neutrino cross sections and short baseline neutrino experiments missing. What about neutrino astronomy?
- Gravitational waves and interplay with particle physics needs to be included

**Additional drivers:**

- It would be useful to have scenario planning
- Sustainability & impact on the wider society needs to be an important consideration in PPAP planning
- Recruitment and support for international PhD students needs to be considered

# What are the key infrastructure requirements for the UK particle physics programme in the short (5 yrs), medium (5-15 yrs) and long- (15-30 years) terms?

Three main themes:

1) Boulby lab development and expansion to host dark matter and other low background searches (particle- and wave-like DM, 0vbb)
2) Computing support and resources for data intensive experiments including corresponding software development
3) Strategic programme and increased support for detector R&D (DRD) for futures experiments (collider and non-collider), shared R&D facilities and support for facilities at RAL & Daresbury

Other desirable infrastructure requirements:

- Test beams for detector R&D (proton, electron, muon)
- Accelerator research and development, including magnets and RF sources
- Radiation facilities

# What are the key infrastructure requirements for the UK particle physics programme in the short (5 yrs), medium (5-15 yrs) and long- (15-30 years) terms?

**Short term**

1) Development of Boulby lab,
2) computing and software investment,
3) detector R&D investment

**Medium term**

1) Detector R&D: facilities that can support major construction activities, accelerator development (proton & muon),
2) extension of Boulby to host several small scale experiments,
3) computing & software with sustained RSE support

**Long term**

1) Boulby: ability to host major international experiment (e.g. XLZD, AION, etc.)
2) Develop detector and accelerator capabilities, also with view towards future colliders

Throughout, **theory** should be supported so it can underpin all of the above activities.
All infrastructure investments should be carried out with **sustainability** in mind.

# What are the critical underpinning technologies and skills that will be essential to support the field in the next 10 years?

**Technologies:**

- A dominant theme in terms of underpinning technologies is the use of **AI/ML in a number of areas**, from reconstruction to triggering but also in experiment design.
- fast, efficient reconstruction **algorithms** and simulation tools with an eye on energy efficiency
- high performance and high throughput **computing**;
- software & **firmware** development and associated **hardware** (GPUs, FPGAs, ASICs, etc.)
- **detector R&D**: semiconductors (silicon), noble elements, light sensors, tracking detectors, radiopure materials, low background
- fast DAQ and Trigger, and detector readout electronics
- **Quantum** Sensors and Computing
- Accelerator R&D: high power proton targets

**Additional drivers:**

**technical skills retention**

→ difficulties in funding core staff and engineers/technicians with the current funding schemes (8).

Support for the following skills was expressed: **software/computing engineering** (10), electronic engineering (6), mechanical engineering (3), thermal engineering(3), quantum engineering (2), hardware and detectors (2), large project management (2), critical thinking (1)

# Additional comments

**Recurring themes**

- Roadmap process:
  - Fact checking is required (x3)
  - The process is onerous and not always consequential (x2)
  - Better communication needed (x2)
  - The roadmap should be streamlined and have fewer recommendations
- People:
  - ECR career paths need to be considered as part of the roadmap (x4)
  - Training the next generation (x2)
- Implementation:
  - A transparent and robust way to prioritise the programme is needed (x3)
  - Better oversight and monitoring of projects is needed (x2)
  - The strategy should adapt to changing circumstances

# Discussion points arising from google doc

- The ECFA meeting in Durham in September should include a discussion on computing and software R&D (recent recommendations for R&D and lot of ongoing work within the JENAS framework)