UK Community meeting on plan B for ESPP

Sarah Williams, on behalf of the drafting coordination team (Jim Clarke, Ruben Saakyan, Mark Williams, Sarah Williams and Davide Costanzo)

Introduction

Introduction

- Thank you for everyone for their engagement with the process so far.
- The UK's input to the process so far can be found here: https://indico.cern.ch/event/1439855/contributions/6461578/
  - v1 ahead of 31st March deadline -> statement of support for FCC infrastructure as "plan A", full exploitation of LHC, maintain CERN as global leader in collider physics and avoid a long gap post-LHC, whilst supporting diversity in the field.
  - v2 following 28th April meeting -> reorganised discussion on risk mitigation/possible alternatives but no prioritization.
- The aim for today is to try and converge on prioritised plan B(s) in the specific scenarios that FCC is either not feasible or not competitive.
- **We should aim (if possible) to make clear statements in order to influence upcoming strategy discussions.**

Today

We are aiming to provide answers to the following questions (requested by the strategy secretariat), which will be submitted as a 1-2 page addendum to our existing input*

1. What is the preferred large-scale post-LHC accelerator for CERN?
2. What is the preferred alternative, if the preferred option is not feasible?
3. What is the preferred alternative, if the preferred option would not be competitive?

- We think (1) is already answered however we plan a short discussion to re-affirm our position and to discuss any possible strengthening of our previous statement.
- Most of today's discussion is then devoted to (2) and (3).

* ideally we would like to avoid updating the previous input

What do we mean by not feasible vs not competitive?

- Not feasible= cannot be delivered in reasonable time-frame due to cost/ resources/ technical developments.
- Not competitive= CEPC (or another e+e-) is delivered elsewhere on a shorter timescale.

This should be delineated from discussions on risk mitigation/adjustments WITHIN plan A (which were already discussed as part of our support for the FCC infrastructure).

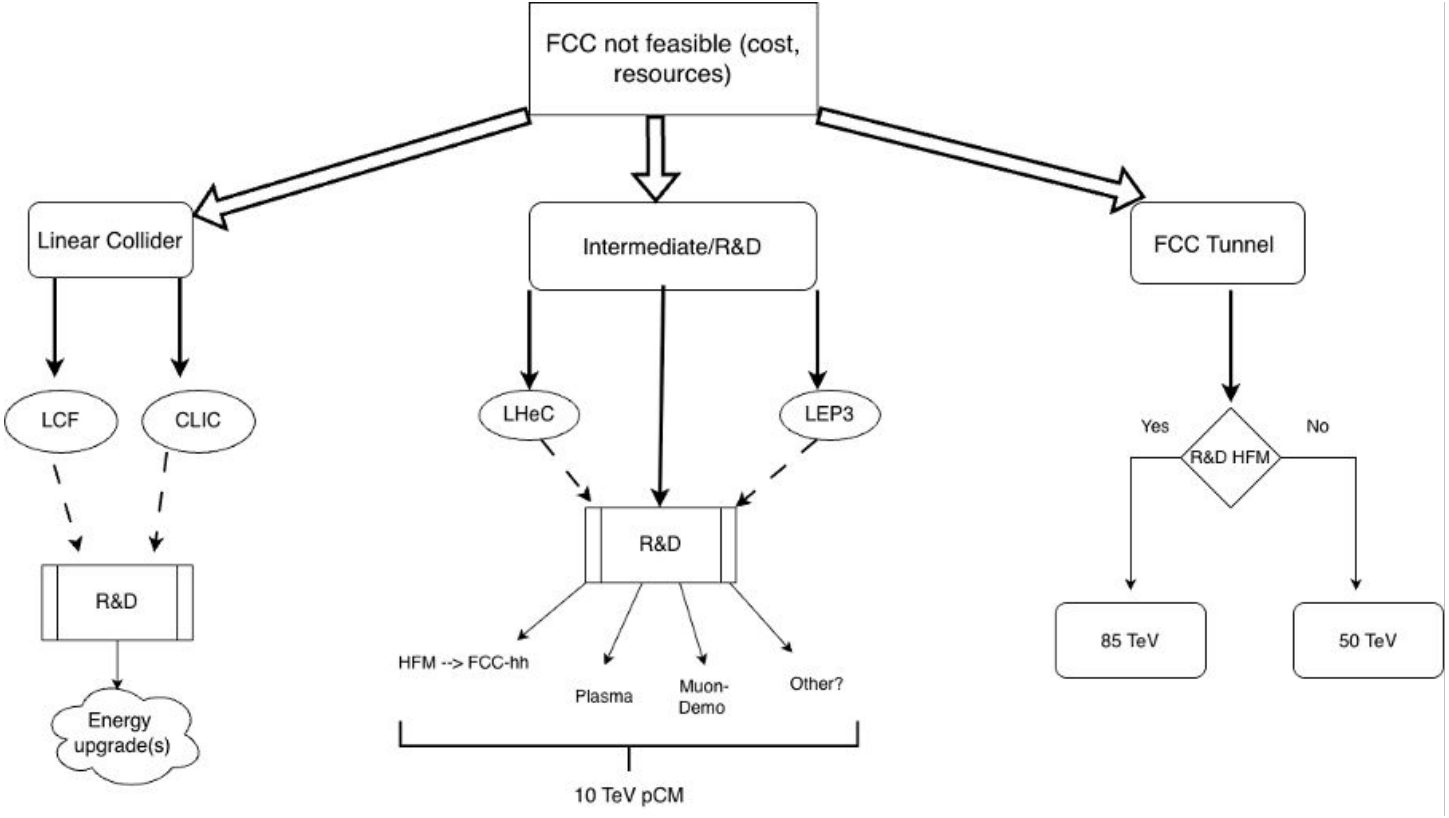
Input to this discussion

1. Inputs circulated to the community along with the survey:
   a. https://indico.in2p3.fr/event/33627/contributions/156477/
   b. Summary table put together by Mark Lancaster.
2. The physics briefing book (released at the end of september): https://cds.cern.ch/record/2944678?ln=en
3. ESG project comparison report.
4. Results of the community survey (which is NOT a vote).

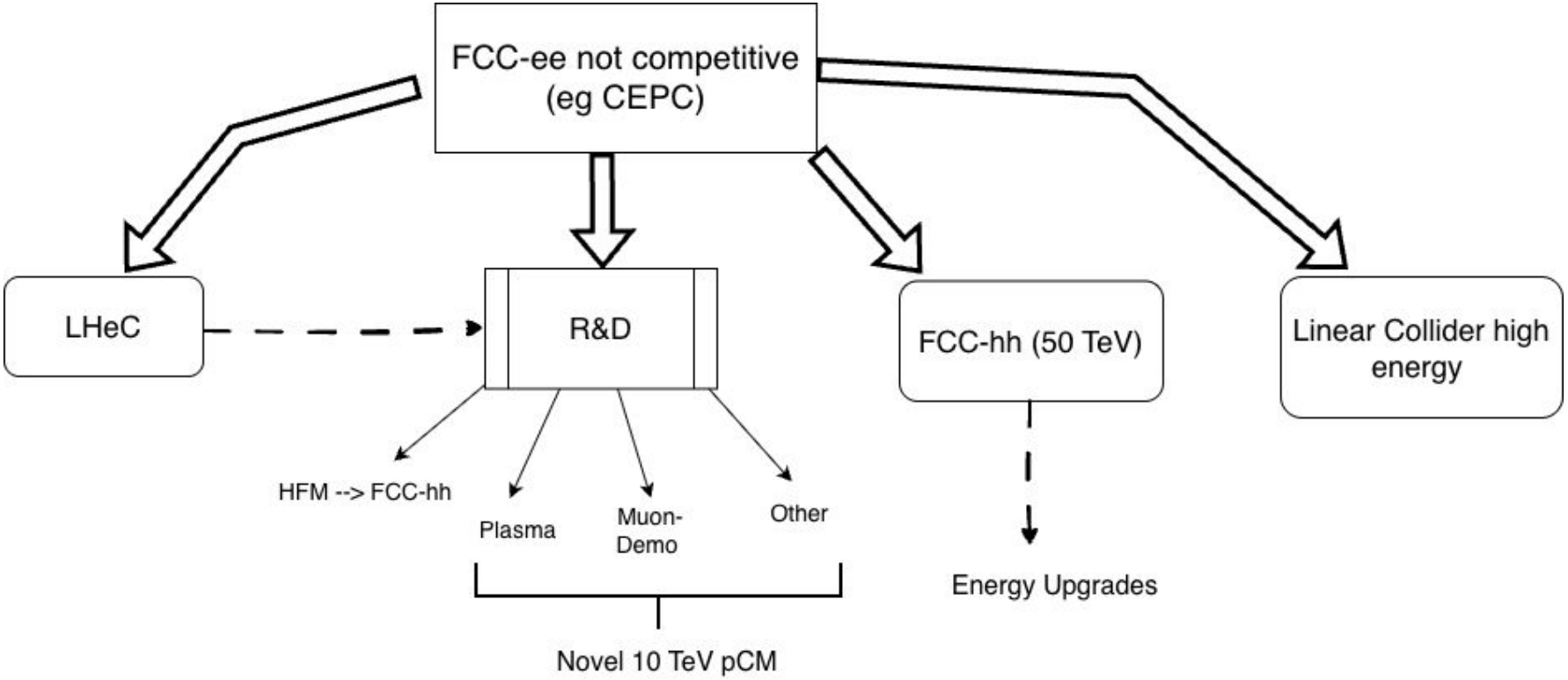
We plan to briefly summarise/signpost information from 2-4 before beginning our discussion.

Key point: in order to converge on some definite statements (most impact) we have sketched out some ‘decision-trees’ to guide the discussion…

Framing the discussion- FCC not feasible



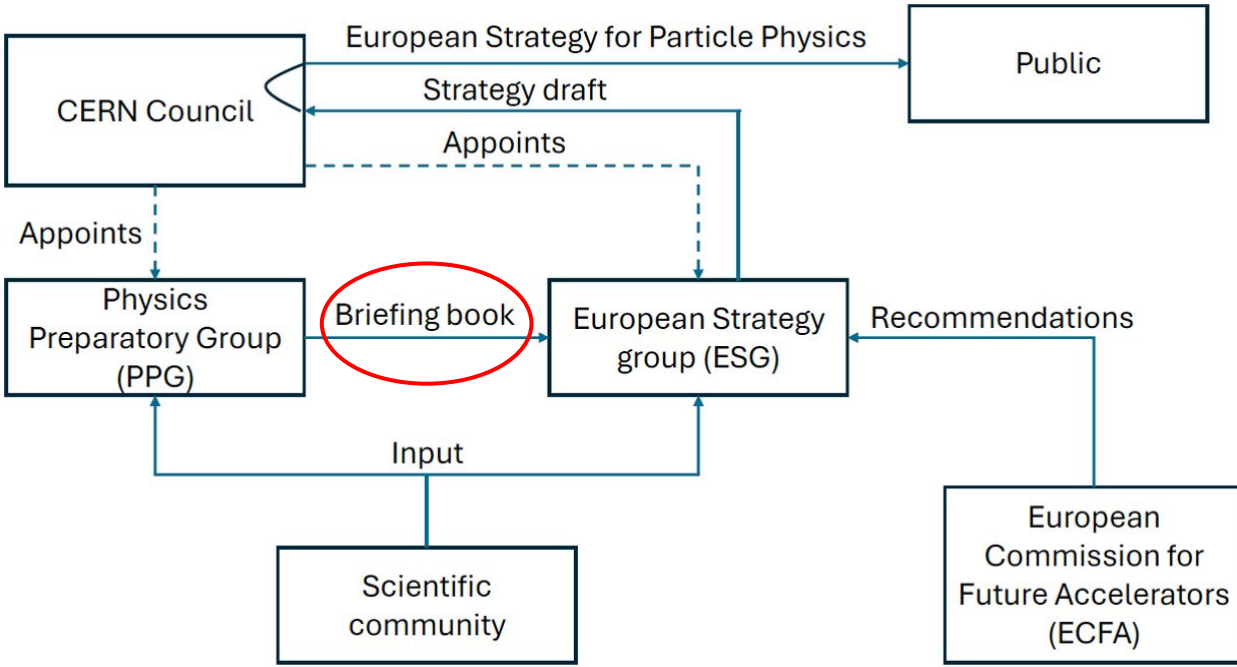
Framing the discussion- FCC not competitive



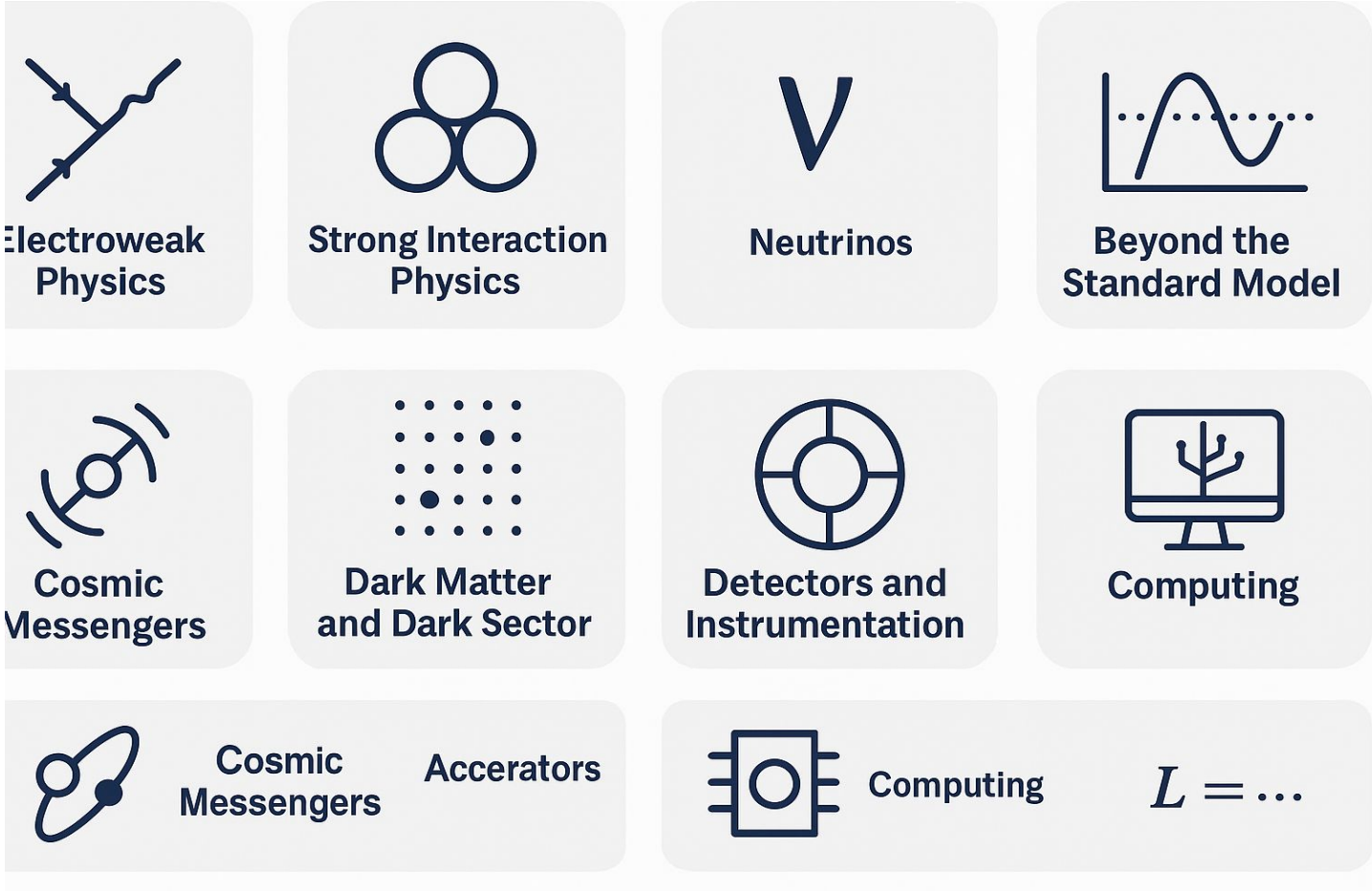
Overview of briefing book (slides prepared by Ruben)

Briefing Book and Plan B

- 300-page community summary underpinning the ESPP 2026 update.
- Provides scientific and R&D context for all frontier projects.
- Forms evidence base for strategic choices, not a prioritisation document.
- Relevant to Plan B because it identifies viable collider alternatives and the breadth of the field to preserve.

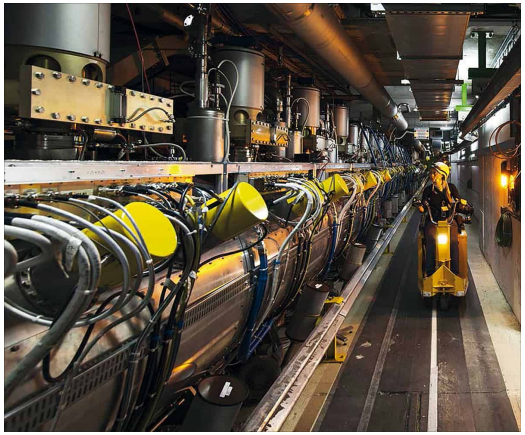


Main Physics and R&D areas



Alternatives to FCC

- **Linear Collider (ILC-type, CLIC):** mature R&D, precision Higgs/top, extendable to ~TeV. Potential CERN-based Higgs factory.
- **Intermediate projects (LHeC, LEP3):** lower-cost, compelling programme, reusing existing infrastructure. Bridge to FCC-hh.



Either path maintains CERN leadership in collider physics. But will have different implications on programme diversity and future of CERN

Pursuing R&D for FCC-hh or novel 10 TeV pCM is another strategic path. But could widen post-HL-LHC gap.

Ambition vs Resources: physics reach is cost driven

- Precision $\propto$ luminosity → power → cost.
- Energy $\propto$ size × magnet field → cost.
- Higher energy/precision → rise in complexity, infrastructure, timescale.
- *To first order: physics scales with money.* More nuanced for intermediate projects

Collider	Type	Main Operating Energies (√s)	Notes
LEP3	Circular e^+e^-	≈ 91 GeV (Z-pole)≈ 160 GeV (WW threshold)≈ 230 GeV (Higgs-strahlung peak)	Reuses existing LHC/LEP tunnel; two IPs.Focus on precision EW (Z, W) and Higgs factory at 230 GeV.
FCC-ee	Circular e^+e^-	91 GeV (Z-pole)160 GeV (WW threshold)240 GeV (Higgs-strahlung peak)365 GeV (top-pair threshold)	Four IPs; very high luminosity.Can also run at > 365 GeV for top EW couplings; basis for Tera-Z (6×10^{12} Z).
LCF (ILC-like)	Linear e^+e^-	91 GeV (Z-pole)250 GeV (Higgs factory)550 GeV (top threshold + di-Higgs)1 TeV (upgrade)	Polarised beams (e^-, e^+).Baseline: 250 GeV → 550 GeV → 1 TeV staged run plan.
CLIC	Linear e^+e^-	380 GeV (initial stage)1.5 TeV (intermediate)3 TeV (ultimate)	High-gradient two-beam acceleration; strong Higgs & top reach at > 550 GeV.
LHeC	Electron–proton (ep)**	50 GeV e^- × 7 TeV p → $\sqrt{s} \approx 1.2$ TeV	Energy-recovery linac for 50 GeV electrons; single IP in LHC ring.
FCC-hh	Proton–proton	85 TeV (√s)	Second-stage hadron collider in same tunnel; paired with FCC-ee in integrated programme.

Highlights: Physics reach and complementarity of alternatives

Observable	LEP3	FCC-ee	Linear Collider (LCF/CLIC)
Z sample	2×10^{12}	6×10^{12}	5×10^{9} (polarised)
mZ precision	7.5 keV (stat)	4 keV	200 keV
sin²θW precision	0.75×10^{-6}	0.4×10^{-6}	2.7×10^{-6}
mW precision	430 keV	180 keV	500 keV
Higgs mass precision	10 MeV	4 MeV	12 MeV
λ_3 (self-coupling)	No improvement	15–20%	7–11%
Invisible H width (95% CL)	0.20%	0.055%	0.12%
Top mass precision	–	7 MeV	20 MeV
Distinct features	Compact, lower cost	Ultimate precision (EW & Higgs)	Higher energy reach (top, λ_3)

FCC → detailed feasibility;

Linear Collider → established design;

LHeC/LEP3 → concept-level studies.

LHeC

Physics Area	Key Observable / Process	Expected Reach / Precision	Comments
Higgs sector	$H \to c\bar{c}$	*First direct measurement*	Unique probe of 2nd-generation Yukawa couplings.
	Charged-current Higgs production ($e^-p \to \nu H X$)	Precise HWW coupling	Clean EW environment; complements e^+e^- factories.
EW & PDFs	W-boson mass	± 3 MeV (combined with HL-LHC)	Among world-best; theory-driven via precise PDFs.
	sin²θW (running)	High-precision at 10–100 GeV Q^2	Tests weak mixing angle scale dependence.
	$\alpha s(mZ^2)$	≈ 0.1 %	One of the most precise determinations worldwide.
	Proton PDFs	≤ 1 % across broad x range	Critical input for FCC-hh / HL-LHC cross-sections.
Top quark	Wtb vertex	Clean single-top access	Isolates electroweak couplings with minimal QCD background.
BSM / EFT	Top-FCNC & EW operators	Sensitivity between HL-LHC and e^+e^- machines	Adds independent constraints on dimension-6 operators.

Take-Away

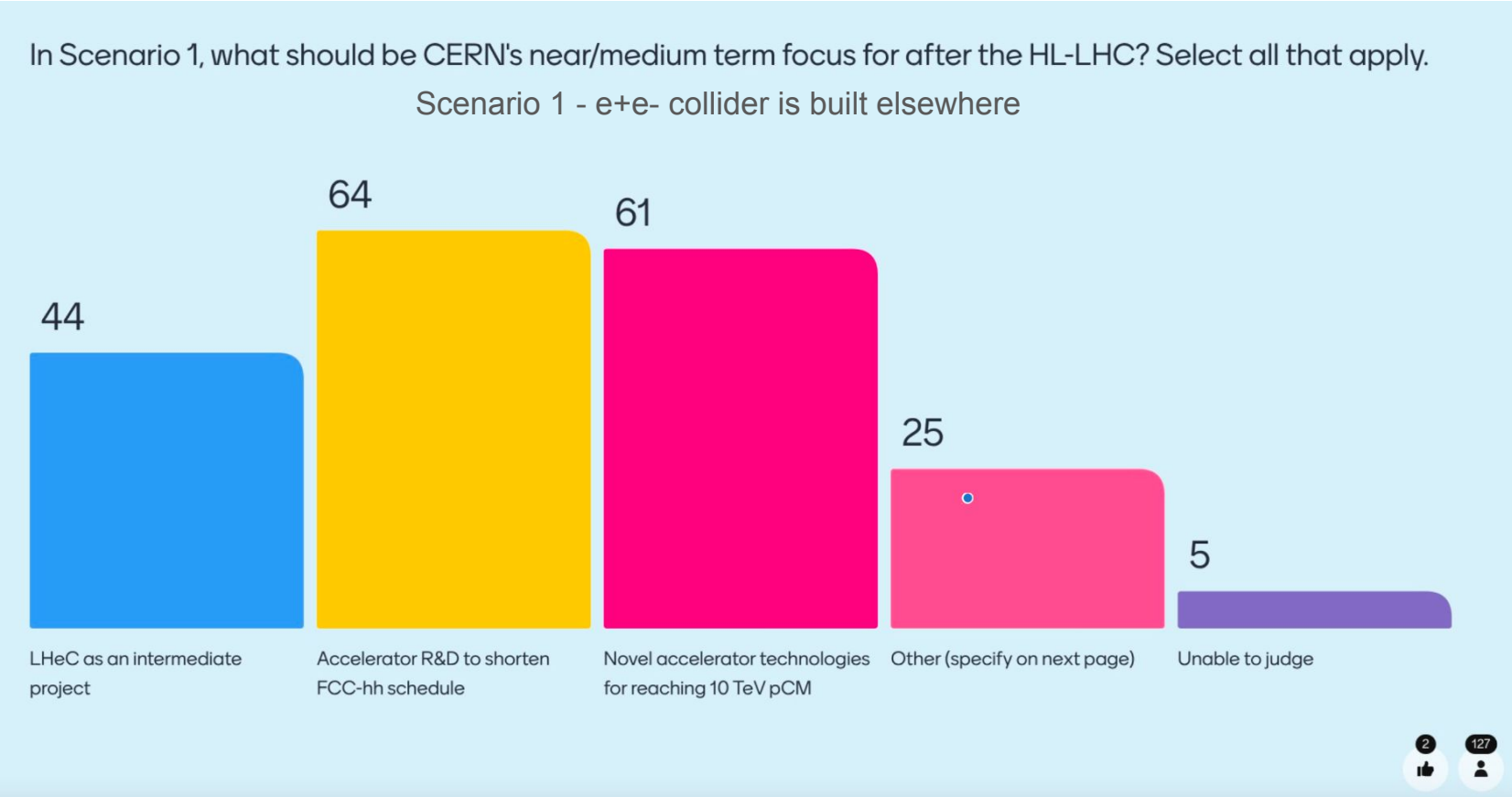
- Europe needs vision and flexibility
  - No single facility can cover full physics landscape
  - Combine flagship collider with sustained, diverse programmes and strong R&D
- Physics reach scales with investment but not linearly. Intermediate projects can sustain high physics value and CERN leadership under tighter budgets
- Main alternatives have different implications on programme diversity, R&D and future of CERN
  - Linear Collider
  - Intermediate projects (LHeC/LEP3)
  - R&D for 10 TeV pcM
- R&D effort must be maintained under all scenarios

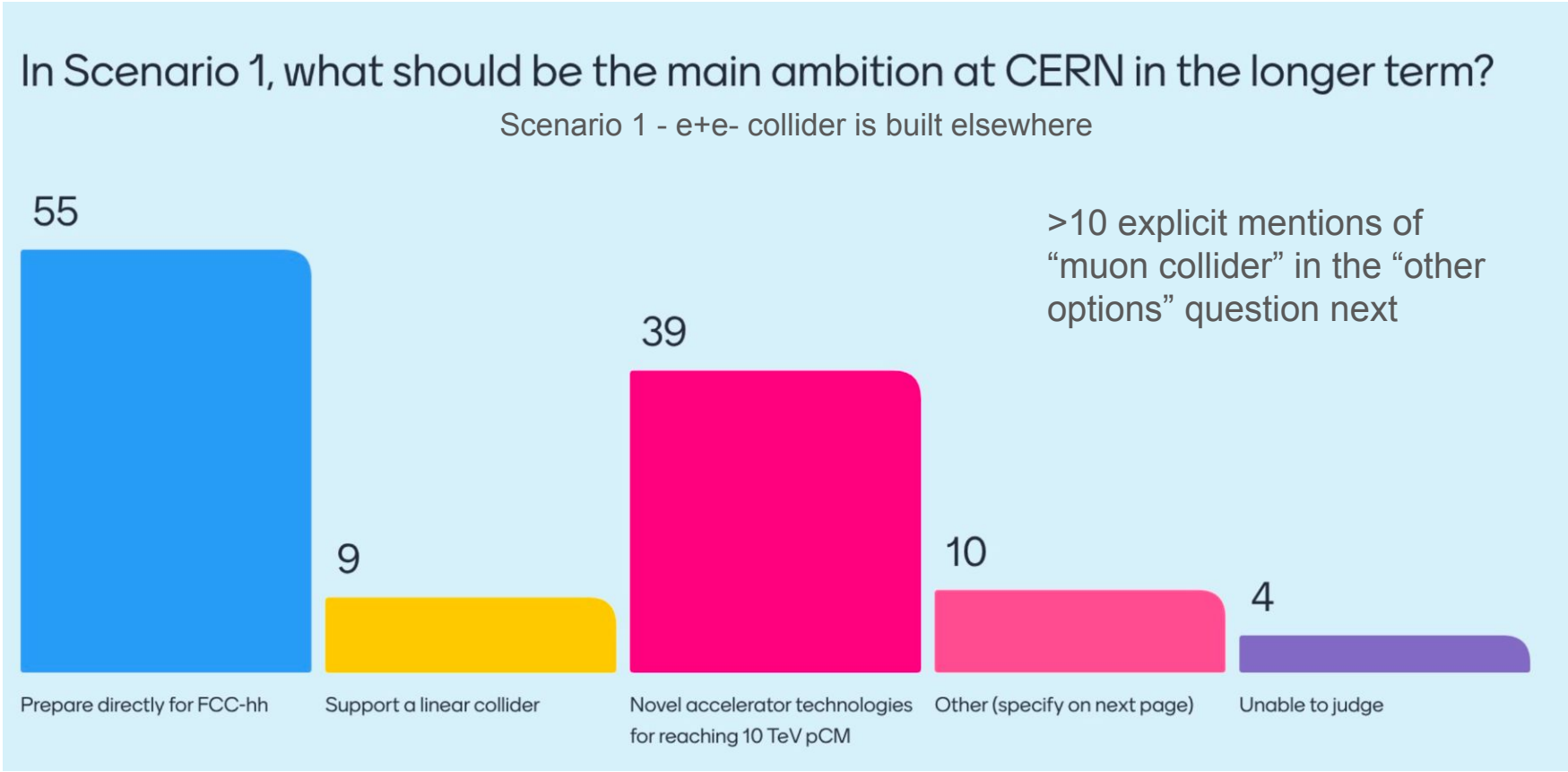
Considerations/perspectives from CERN (To be summarised by Mark Lancaster)

Summary of survey results

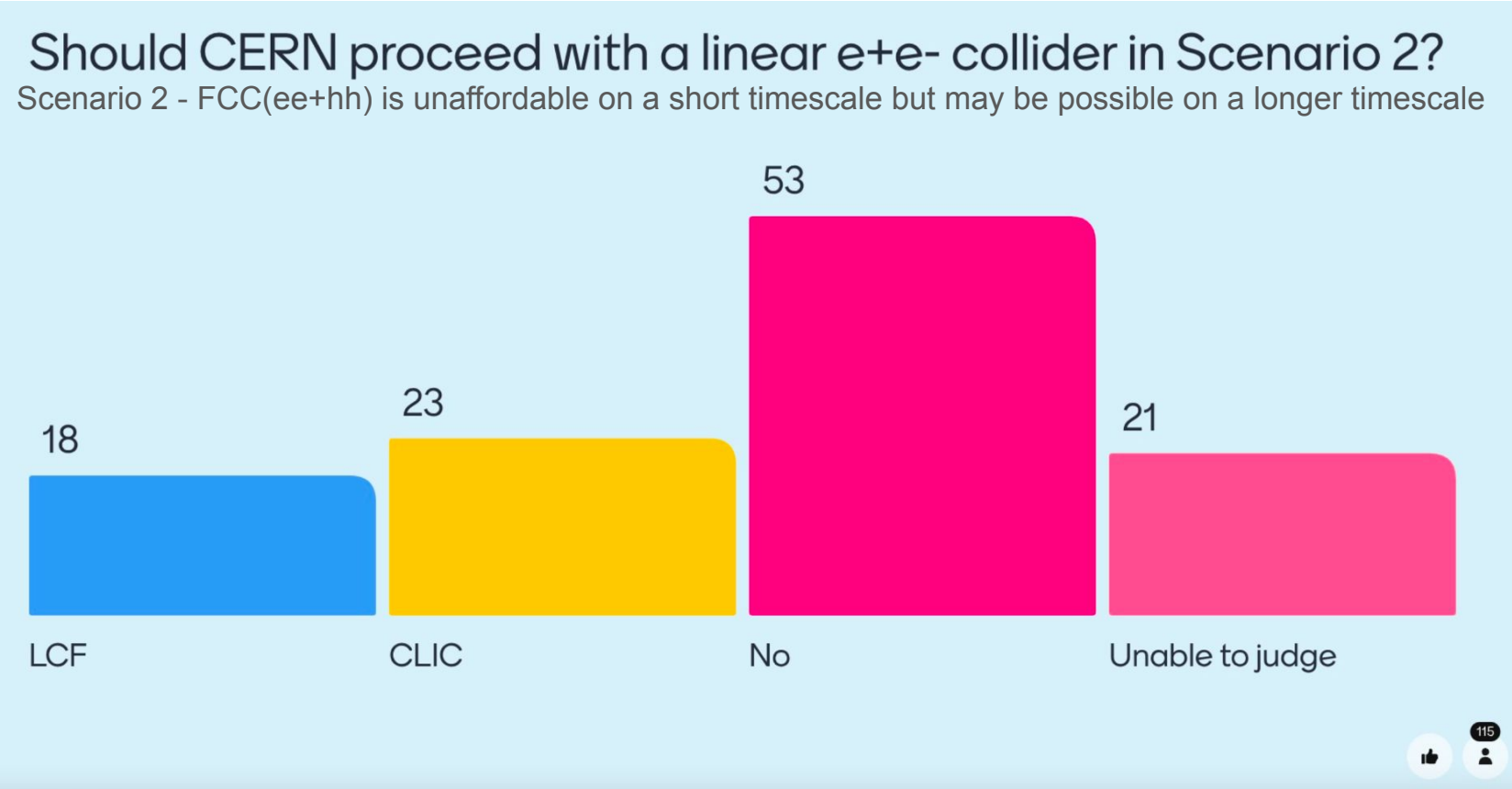
Scenarios considered

1. An e+e- collider is built elsewhere (e.g. CEPC in China, ILC in Japan)
2. FCC(ee+hh) is unaffordable on a short timescale but may be possible on a longer timescale
3. FCC(ee+hh) is unaffordable


In Scenario 1, what should be CERN's near/medium term focus for after the HL-LHC? Select all that apply.
Scenario 1 - e+e- collider is built elsewhere
44
64
61
25
5
LHeC as an intermediate project
Accelerator R&D to shorten FCC-hh schedule
Novel accelerator technologies for reaching 10 TeV pCM
Other (specify on next page)
Unable to judge
2
127

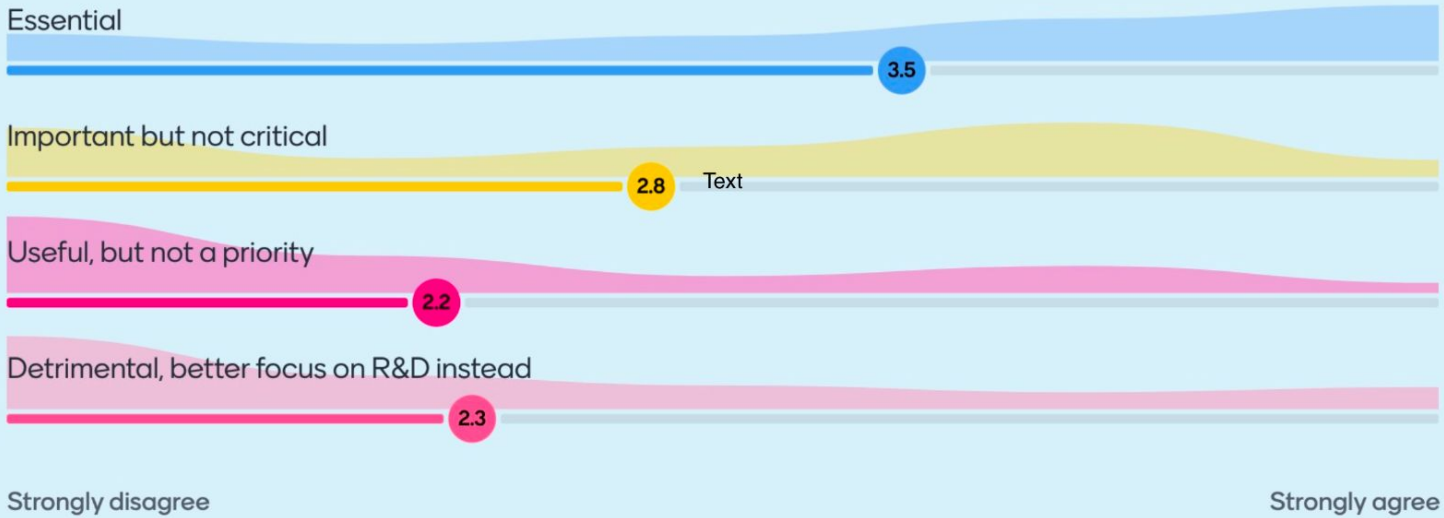

In Scenario 1, what should be the main ambition at CERN in the longer term?
Scenario 1 - e+e- collider is built elsewhere
55
9
39
10
4
>10 explicit mentions of “muon collider” in the “other options” question next
Prepare directly for FCC-hh
Support a linear collider
Novel accelerator technologies for reaching 10 TeV pCM
Other (specify on next page)
Unable to judge

Note- each participant only selected ONE answer for this question



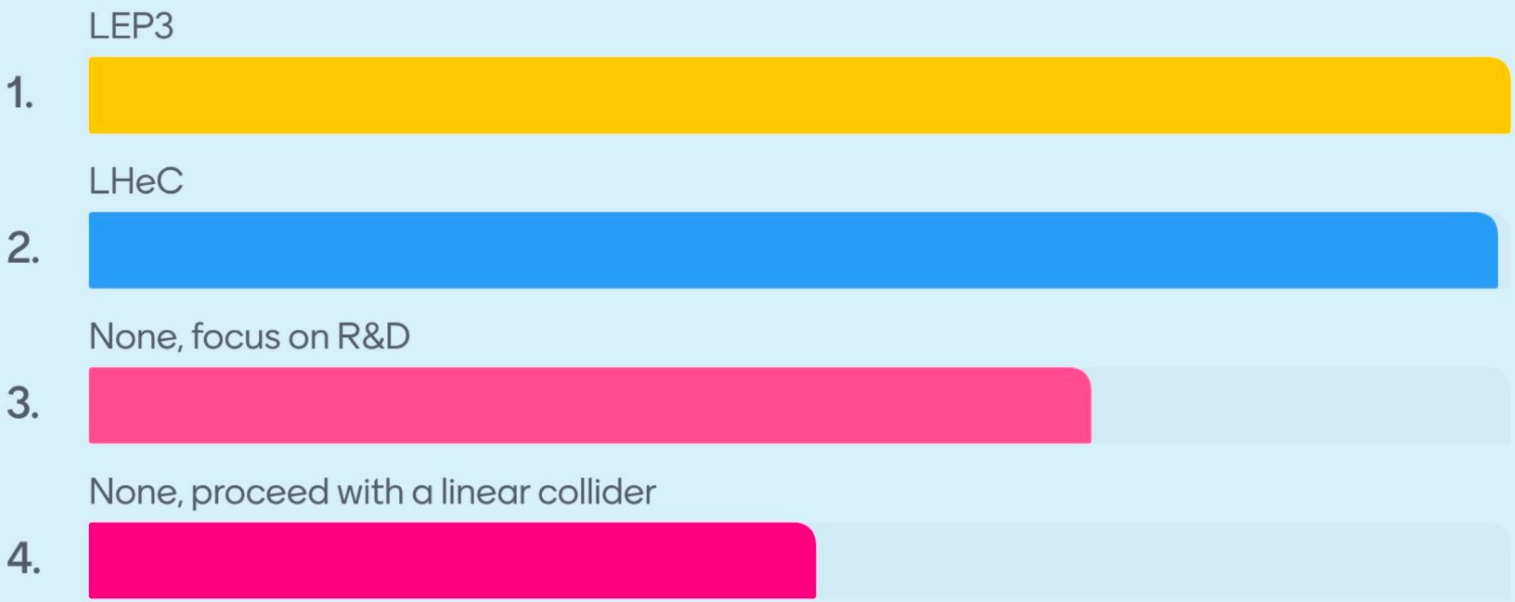
How important is it to have an intermediate project at CERN (e.g. LHeC, LEP3) in Scenario 2? Press skip if unsure.

Scenario 2 - FCC(ee+hh) is unaffordable on a short timescale but may be possible on a longer timescale



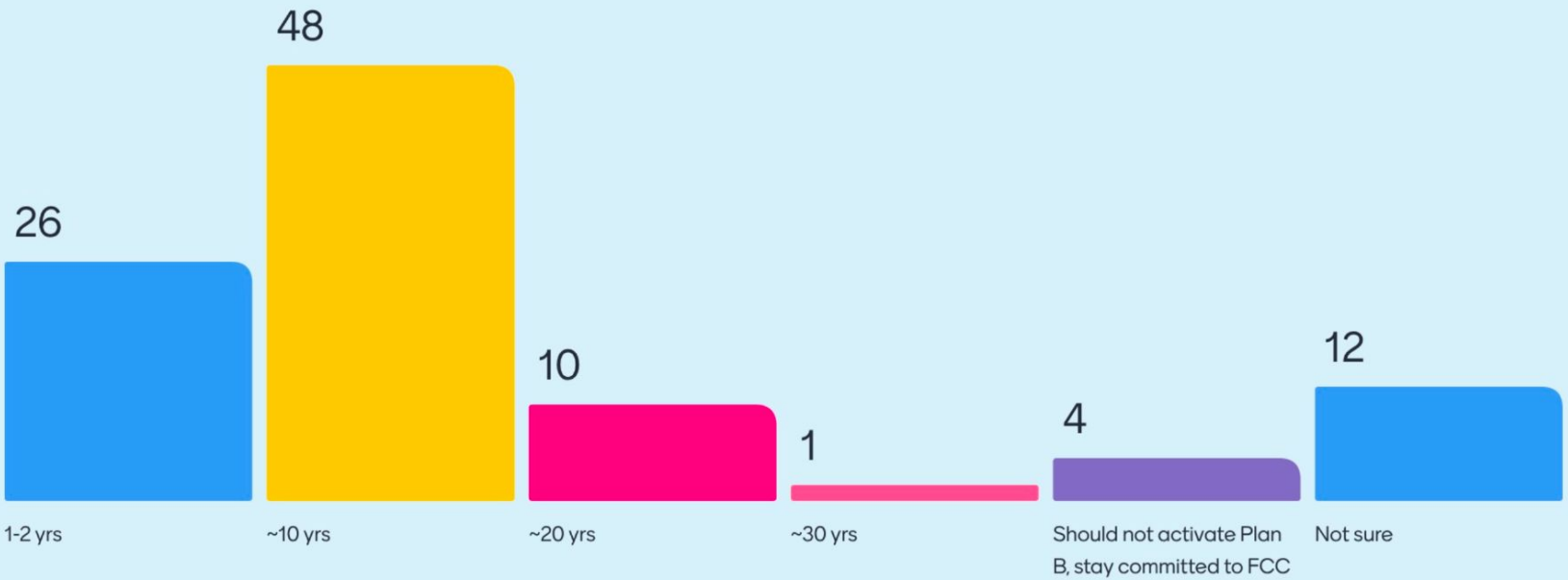
107

Which intermediate project should be prioritised? To skip press **Submit** without selecting.



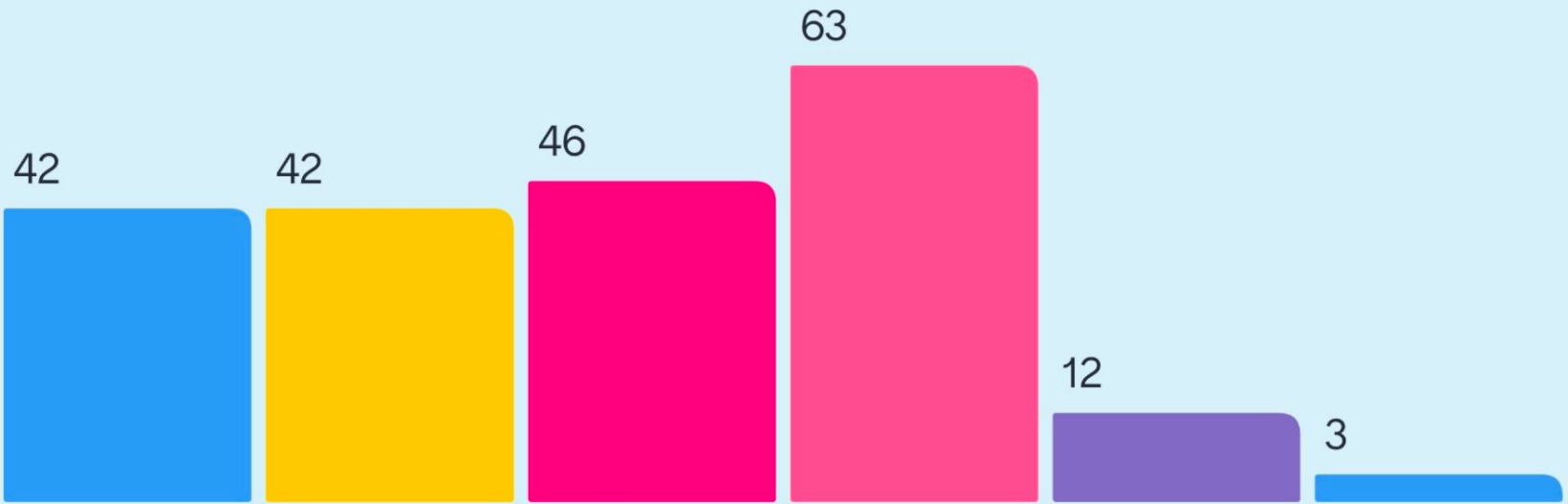
In Scenario 2, what is the maximum acceptable gap between the end of HL-LHC and the start of FCC before activating Plan B?

Scenario 2 - FCC(ee+hh) is unaffordable on a short timescale but may be possible on a longer timescale



If FCC is off the table, which option should be CERN's and Europe's strategy? Select all that apply.

Scenario 3- FCC (ee+hh) is unaffordable



Cross-cutting themes

Points for consideration throughout the discussions

There are some nuances/details we might want to consider that weren't fully captured in the survey (though some were mentioned in comments):

- Details on staging of LC- differentiate between "low-energy" and "high-energy" LC (only partially captured through LCF vs CLIC).
- Lower-energy hadron collider either in LHC or FCC tunnel?

Plus more you may want to raise?

Using the survey as input to the meeting

- Aim of the survey is to guide discussions today and not provide a vote!
- Proposal for questions (2) and (3): Identify possible statements from the results of the survey that *could* have consensus within the community and discuss whether they do match the consensus of the community and/or need to be rephrased.
- **Key point:** none of these statements are taken as a given, but we want to establish whether there would/wouldn’t be support for such statements and/or identify additional statements based on community discussions today.

ESG comparison of projects (presented by Phil Burrows)

Discussion session I- consensus on “plan A”

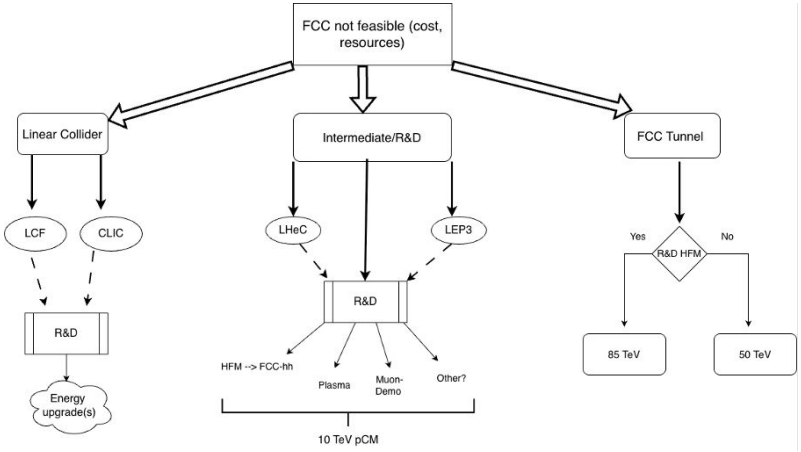
Discussion session I

Discussion session II-
What is the plan B alternative, if plan A isn’t feasible?

(2) what is the preferred alternative, if the preferred option is not feasible?

Possible statements based on survey (relevant to scenarios 2 and 3):

- If FCC **delayed**, we see a period of ~10 years as the maximum acceptable gap between the end of the HL-LHC and the start of FCC; if it will be greater than this a plan B should be pursued.
- If **not possible at all**, strong support for increased resources for accelerator R+D.



Suggested points for further discussion:

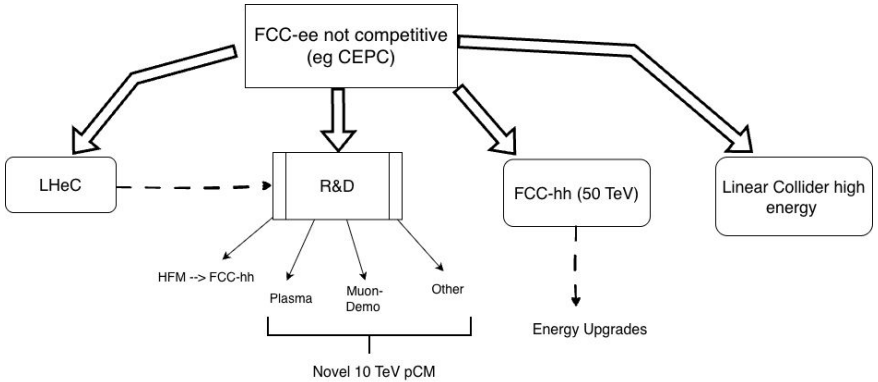
- Survey suggests no ‘strong’ consensus for/against LC in our scenario 2 (only marginally more against than in support of any LC facility than the sum of CLIC+LCF) - need to discuss interplay between medium and longer term priorities.
- In our ‘scenario 2’, for bridging projects saw roughly equal levels of support for LEP3 and LHeC- can we discriminate based on how they feed into the longer term programme or is further study needed?
- Implications of medium-term plans for **diversity** in the field.
- In cross-cutting themes section, strong support was indicated for high-field magnets, R+D towards a muon demonstrator, sustainable accelerators and plasma-based acceleration - are we prepared to try to prioritise these based on the route ahead?

Discussion session III-
What is the plan B alternative, if plan A isn’t competitive?

(3) what is the preferred alternative, if the preferred option would not be competitive?

Suggested sentiments based on survey (relevant to scenario 1):

- The (top) priority should be R+D to reach the 10 TeV pCM scale as soon as possible.
    - Accelerator R+D to shorten the timescale for FCC-hh would be compatible with our support for investing in FCC infrastructure and going to the highest energies.
- R+D towards muon demonstrator also highlighted in additional comments (but not our ‘top choice’ compared to hadrons?)



Points for further discussion:

- Survey suggests less support for LC if e+e- machine built elsewhere- does this assume ‘nominal’ staging- what about high-energy LC? (see diagram).
- Possible need for intermediate plan if this plan B would give a gap at CERN (as discussed previously).
- As on slide 33- strong support was accelerator R+D for high-field magnets, muon demonstrator, sustainable accelerators and plasma-based acceleration - are we prepared to try to prioritise these based on the route ahead?

Close-out