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# Plan for Resumption of APA Testing at CERN

# Cold Testing Aims

- To use the cold box in the NP04 clean room at CERN to cold-cycle 10% of the Daresbury factory output – 14 APAs.
  - Requires repeat transport between Daresbury and CERN.
- Validate that the APAs produced by the factory procedures don’t break at cryogenic temperatures.

# Part I: Short Term

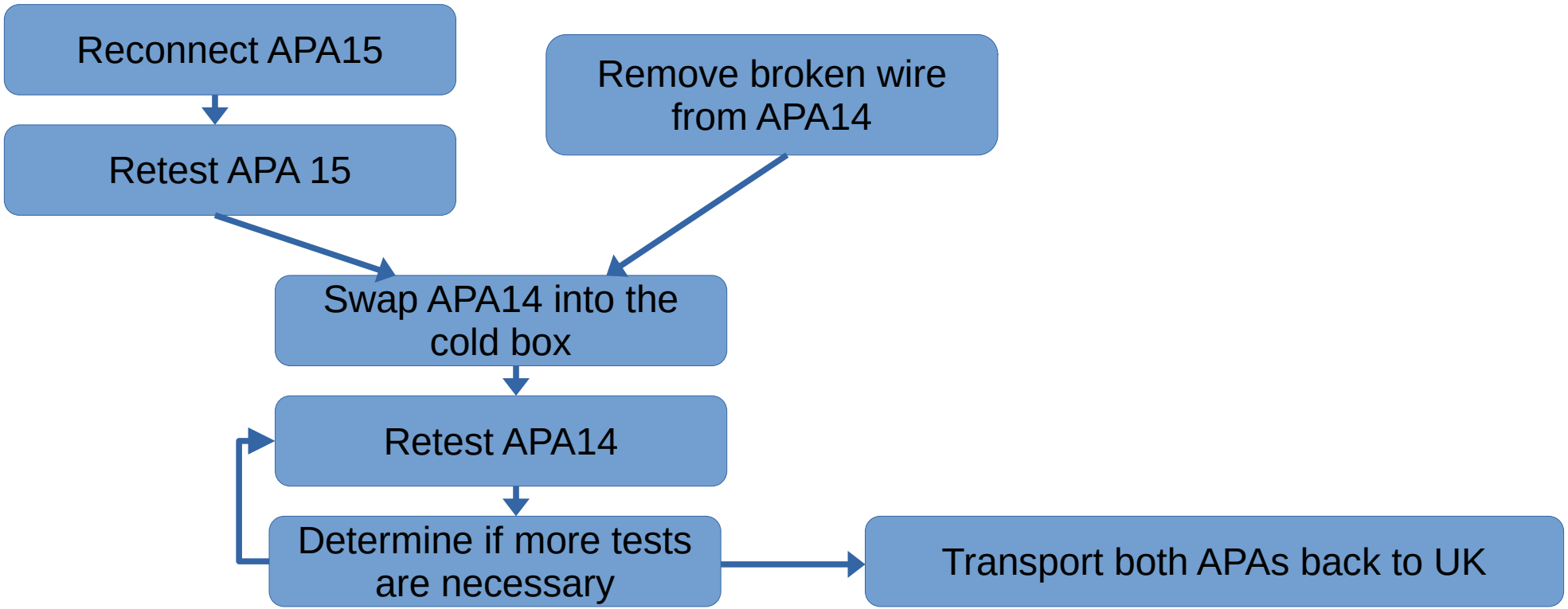
# 2024 Recap

- We shipped 2 APAs to CERN to start this test schedule at the end of September 2024: Daresbury APAs 14 and 15.
- Over ~6 weeks we cold-cycled both APAs.
- APA14 lost 1 wire during warmup.
- APA15 showed no signs of damage during the cold cycle, but through human error we lost connection to one FEMB before cooldown ⇒ were not able to read out 100% of channels.
- **This means both APAs should be put through a second cold cycle.**
  - APA14 once the broken wire has been removed.
  - APA15 once the connection has been fixed.

# Current Status

- Both APAs are still in the clean room.
- APA15 is still in the (inactive) cold box.
- APA14 is hanging from the clean room rail, with its protection panels installed.

# Short Term Plan



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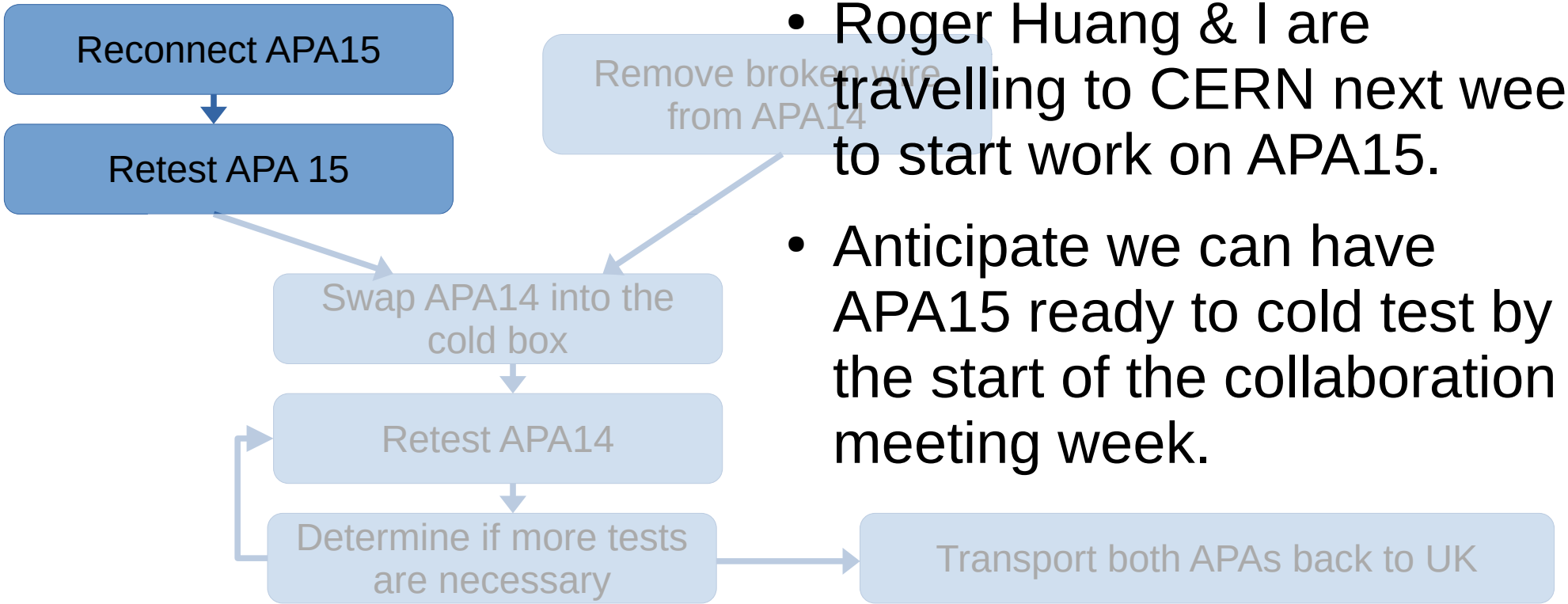


- Roger Huang & I are travelling to CERN next week to start work on APA15.
- Anticipate we can have APA15 ready to cold test by the start of the collaboration meeting week.

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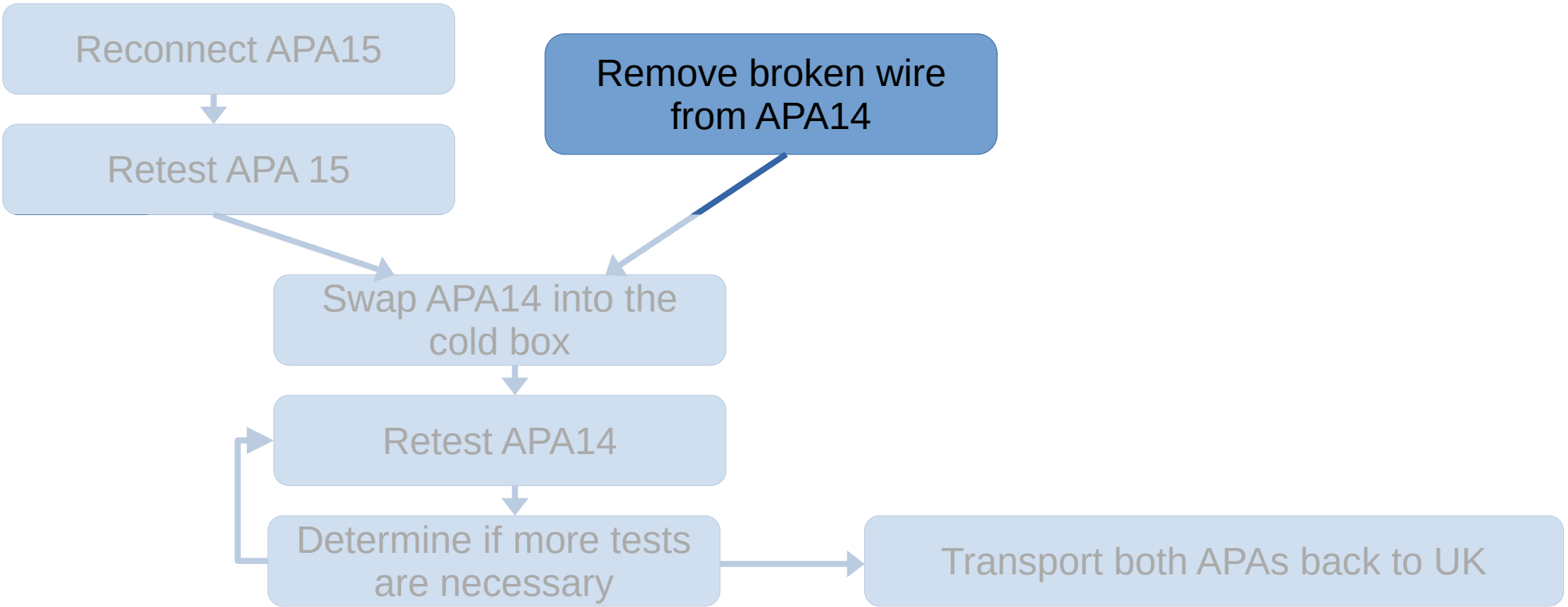
# Short Term Plan



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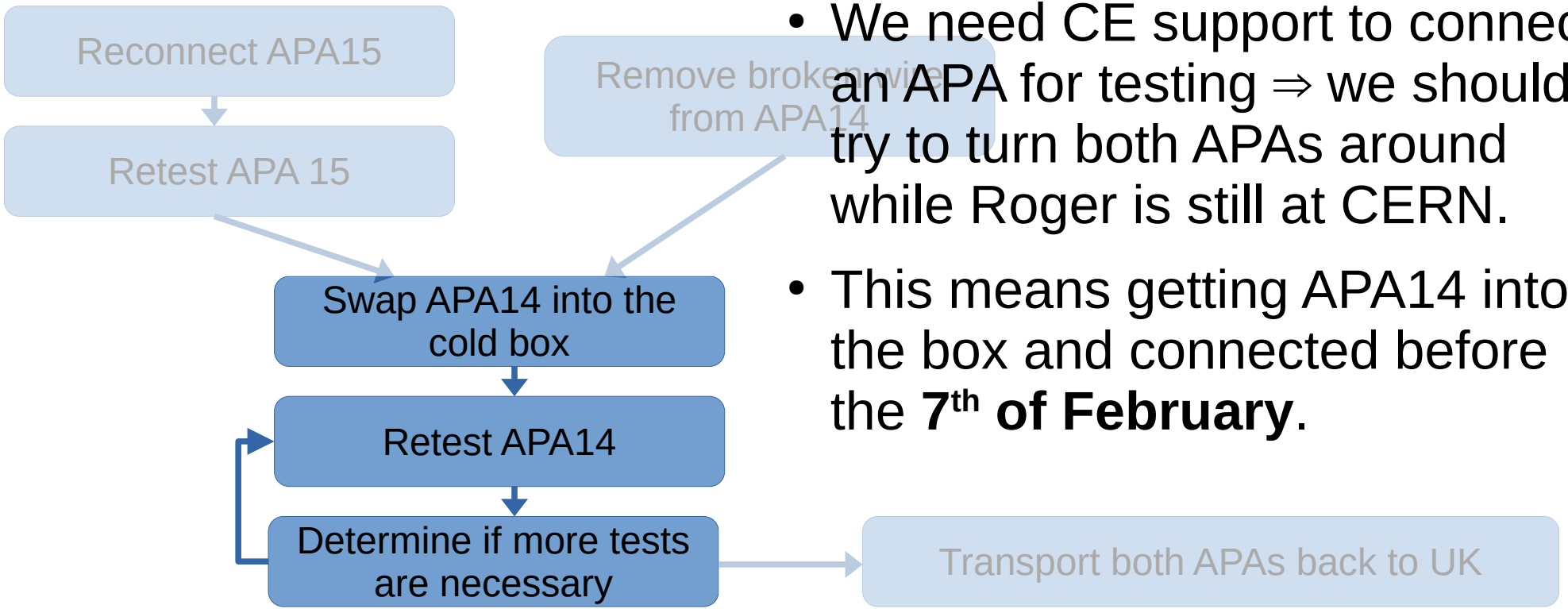
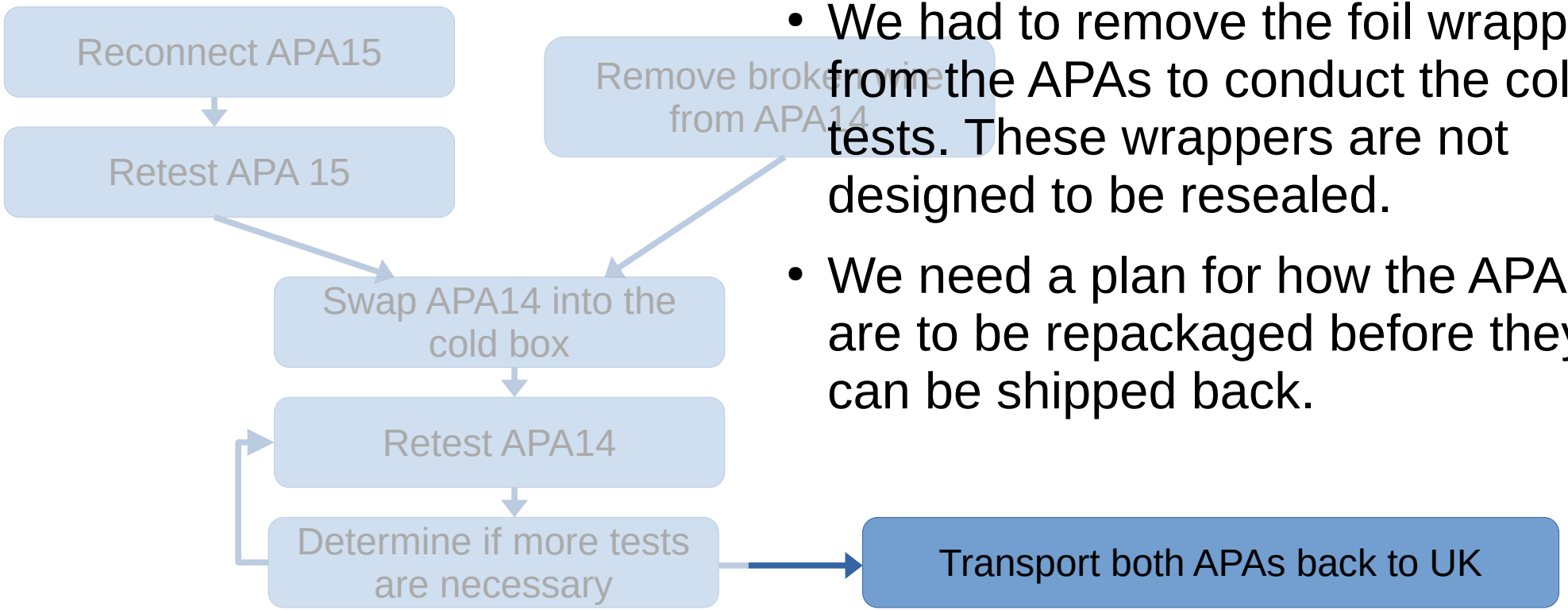



- We need CE support to connect an APA for testing ⇒ we should try to turn both APAs around while Roger is still at CERN.
- This means getting APA14 into the box and connected before the **7th of February**.

# Short Term Plan




- We had to remove the foil wrapper from the APAs to conduct the cold tests. These wrappers are not designed to be resealed.
- We need a plan for how the APAs are to be repackaged before they can be shipped back.

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# Foil Wrapper



# Short Term Schedule



| Week of | APA14 | APA15 |
|---|---|---|
| 20th January | • Fix broken wire | • Extract from cold box<br>• Reconnect + test connections<br>• Replace in cold box |
| 27th January | | • Cooldown |
| 3rd February | • Install in cold box | • Extract from cold box |
| 10th February | • Cooldown | |

After this: assess if further retesting is necessary/desired, have plan for repackaging and transport back to UK.

# Part II: Long Term

# Long Term Schedule

- In planning the 2024 test, I projected 7 weeks for a complete test cycle of 2 APAs.
- In practice, we stayed pretty much on track – work took 6 weeks, but did not include the last week of extracting the APAs back to the ASF.
- This means that to fulfil the original mission of testing 10% of the Daresbury output, we need a further 6 cycles x 7 weeks = **42 working weeks of testing at CERN**.
- It will already be (at least) calendar week 8 when Cycle 1 is complete ⇒ even assuming Cycle 2 started right away, the end of our test schedule is already nosing up to the start of 2026, not accounting for:
  - Turnaround time in getting APA pairs to CERN
  - Periods of restricted access/support at CERN
  - Periods of expert unavailability (holidays, illness, other collaboration duties)
- We can reasonably assume that since the first test found something, we should account for future tests also prompting further investigation beyond the 7-week turnaround.
- **The later we finish, the more APAs have already been produced without the feedback of the tests.**

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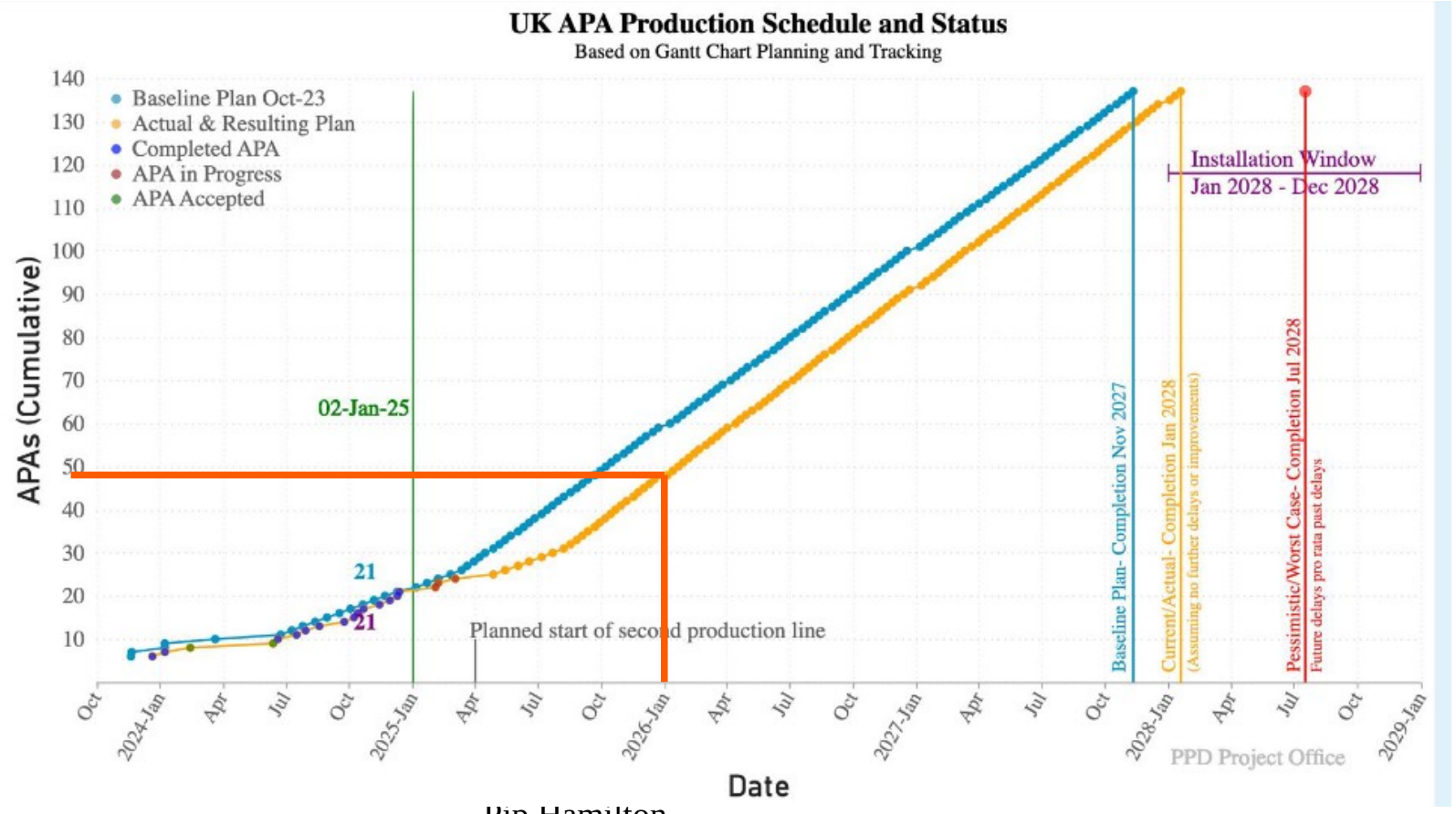
# Long Term Schedule

**End of 2025 = 50 APAs already produced**



# Long Term Resources

- To finish even by the end of 2025 requires non-stop work at EHN1.
- These tests require a lot of effort, and most of our experts are not based at CERN ⇒ cannot be present year-round.

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# Test Cycle 1 Personnel

| | | |
|---|---|---|
| COORDINATION | Pip Hamilton (Imperial) |  |
| DWA | Matt Wright (Manchester) |  |
| APA MANIPULATION | Tom Wieber (FNAL) |  |
| | Matt Brown (Liverpool) |  |
| | Hamza Naseer (Manchester) |  |
| C/R BOARDS | Anthony Ezeribe (Sheffield) |  |
| CE SUPPORT | Manhong Zhao (LBL) |  |
| | Roger Huang (LBL) |  |

24 person-weeks (not counting trainees who did not work + those already present at CERN)

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| APA MANIPULATION | Tom Wieber (FNAL) | Can be done by EHN1 techs? |
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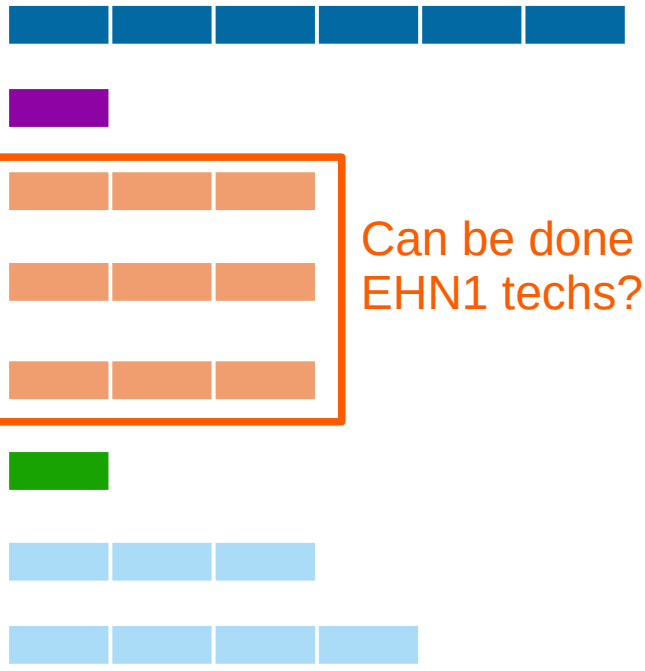

24 person-weeks (not counting trainees who did not work + those already present at CERN)

Lift driver
DWA operator
Board tester
Panel remover
etc...

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# Test Cycle 1 Personnel

~~COORDINATION~~ **Pip Hamilton (Imperial)**

DWA
APA
MANIPULATION
C/R BOARDS
CE SUPPORT

**Even with these contributions, we were running with a skeleton crew at many points!**

**Difficult to see how we sustain this effort continuously through 2025.**

24 person-weeks (not counting trainees who did not work + those already present at CERN)

# Cost

- We have to be mindful of how much it costs the project to bring experts out to CERN for this work.
  - Cold electronics support can only come from US ⇒ racking up the transatlantic flights
  - Geneva's not a cheap place to live!
- Shorter, targeted expert interventions can reduce costs, if we can depend on EHN1 staff to manage intervening tasks.
  - Would need agreement to allow EHN1 staff to manage some tasks unsupervised by the consortium.

# Resources vs. Schedule

We have 3 problems that are in tension with one another.

1. There is a need to deliver these tests faster than we currently can.

2. The tests are understaffed.

3. The tests need to cost less – fewer person-hours, less travel + accommodation.

Something's got to give!

**We need a long-term cold test schedule that addresses these issues, and gives our experts adequate notice of test periods.**

We should consider whether the 10% plan is well-motivated, and whether there are strategies we could adopt that could give us confidence in the APA performance with a more efficient use of resources (e.g. repeat cycling of APAs?).

# Pass/Fail Planning

To build contingency into our long-term schedule, we need to know:

- What defines an APA passing or failing its cold test?
- What do we do with an individual APA that fails?
  - Can imagine different failure modes motivating different answers, e.g. clear-cut wire breakage vs. something observed only by the cold electronics or DWA.
- Do we need to test 14 APAs or do we need to **pass** 14 APAs?
  - With only 14 tests, 1 failure is significant.
  - What is our statistical motivation, and does the current plan fulfil it?
  - Potential for significant extension of schedule.

# DWA Testing

- Integrating DWA measurements into the cold tests is crucial for the cold test results to be useful.
  - Only way to detect tension changes short of wire breakage.
- Easiest place to take the measurement is in the ASF – **requires transform function** to translate to tensions at Daresbury (in the process cart) and vertical (in the cold box).
- Currently there is only one operational DWA, which must be transported to CERN every time it is used there.
  - Risk of damage in transport.
  - Prevents parallel DWA work at Daresbury.
- **It is essential for the testing program to have a dedicated, tested DWA unit at CERN as soon as possible** (and ideally a spare unit/spare parts in case of breakdown).

# Long-Term Summary

- There is a strong need to complete the cold testing before too many more APAs are completed.
- An aggressive schedule on the current model will take all of 2025.
- It’s not clear that such an aggressive schedule is sustainable or affordable.
- We should consider whether the testing plan can be modified to address these issues.
- We **must** define at what point/with what results the tests are complete.
  - We must ensure that the tools to deliver those results are provided, e.g. DWA.
- We must do this **now,** so that we can build a schedule that gives participants more than 1-2 weeks’ notice of when they are needed.