# Pre-BCP Presentation About (NSF) LAr FEB2 (and related DoE scope)

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# bPOL12V Challenge for LAr FEB2

- LAr FEB2 board provides 128-channels of readout, integrating many custom ASICs
  - 32 (DoE) ALFE PA/S, 32 (NSF) COLUTA ADC, 24 (NSF) lpGBT, 8 VTRx+
- Starting with Vin = 48V, FEB2 must deliver "clean" power to ASICs (mostly at 1.2V)
  - Given our large current requirements (~50A at 1.2V), power scheme implemented on each board includes 2 bPOL48V, followed by 20 bPOL12V, followed by ~50 LDOs
  - To limit in-rush current at power-on, FEB2 design (until now) enabled only 4 bPOL12V at power-on, and then used software to enable other 16 bPOL12V chips later
- The understanding of the recently discovered bPOL12V ASIC problem shows that having Vin present but the chip disabled provides what CERN calls "killer stress", and leads to device failure after some time, aggravated by TID and low-temp. operation
  - When the bPOL12V ASIC fails, Vout becomes ~Vin (~11 V in our case), which would kill all the downstream loads (ie. our LDOs and ASICs)
  - It is possible that, given the modest LAr FEB2 TID requirement (140 kRad) and room-T operation, we MIGHT not see bPOL12V failures
  - However, we need ~30.5k bPOL12V devices installed on the detector to equip the full LAr system – I do not see a realistic possibility of becoming sufficiently confident, without changing the power-on strategy, of achieving the reliability we need
  - We need to modify the FEB2 design and validate with a new FEB2 Prototype version (v2.8)

# v2.8 FEB2 Design

- The v2.8 FEB2 Prototype design will enable all 20 bPOL12V circuits directly from a voltage-divider connected to their Vin
  - This power-on scheme avoids the “killer stress” condition (apart from ~ms scale period during Vin = 48V ramp-up of the LVPS), and is therefore recommended by CERN to mitigate the bPOL12V reliability problem
  - This scheme is being adopted by ALL other systems at HL-LHC (incl. both ATLAS and CMS)
- A LAr challenge is that up to 28 FEB2 boards (ie. 560 bPOL12V) are connected to a single LVPS, requiring ~76A from 48V when fully configured
  - We need to be careful about the in-rush current at power-on, which can cause reliability problems for the LVPS, can cause transient over-voltage and/or over-current conditions at the FE crate (and blow fuses or cause other damage on the FEB2 boards), etc.
  - This concern is exacerbated by the long (up to 20 m) power cables connecting the LVPS to the FE crate
  - To limit the in-rush current at power-on, the v2.8 FEB2 design will implement software-control of the Enable signals of the downstream LDOs; ie. all 20 bPOL12V will power on immediately, but most of the LDOs will be disabled at power-on and switched on later
  - We estimate this approach will limit the 48V DC current required after power-on to ~0.3A per board (as opposed to ~0.2A per board in the previous design), ie. only ~10% of the total current
  - System-level simulations of the in-rush are being performed by INFN Milano, who are responsible for both the LVPS and the power cables

# NSF preBCP Proposal (BCP-1119)

- We need to add new tasks to finalize the design of the new (v2.8) version of the FEB2 Prototype, as well as to fabricate it and test/validate it for both functionality and performance
  - By acting quickly, we managed to limit the ("short-term") delay to ~2.5 months
- I say "short-term delay" since this BCP also includes further changes to mitigate this delay and actually create additional float
- The motivation to do so results from some important points to remember:
  - The LAr FEB2 is on the Critical Path
  - At the the time of the 07/25 NSF review, we had 113 days of float in the working schedule, while MC said we needed 155 days @ 90% CL
  - The NSF review committee recommended we proactively deal with this lack of adequate float
- Since the 07/25 review, we have suffered further delays in the working schedule, plus now this new 2.5 month delay in the baseline schedule
  - It is time to implement into the baseline plan, as part of this BCP, the "possible mitigation" strategy presented at the last review – namely, increase the rate of FEB2 QC testing and thereby reduce the duration of the QC testing phase (and move the end date earlier)

# NSF preBCP Proposal (BCP-1119)

- How to increase the rate (ie. throughput) of the FEB2 QC testing?
  1. Take advantage of the automation we have already achieved, which allows faster testing of a single board compared to my estimates from many years ago
  2. Operate 2 FEB2 QC teststands in parallel at Nevis
- Implications:
  1. We can decrease the calendar time required for FEB2 QC testing at Nevis
  2. To do so, we need more people – hire 2 additional postbacs by around this summer
  3. To translate this speed-up to a corresponding speed-up in FEB2 deliveries to CERN, we need to also speed up the (DoE) work at BNL, where final tests of 50% of the FEB2 boards are performed
- On the NSF side, the overall results are the following:
  - Cost impact - $316.1k cost increase (dominated by increased labor)
  - Schedule impact – end date moved EARLIER by 50 days
- Cost impact is beyond $250k threshold so this BCP will require NSF approval, so important to get it to them soon

# DoE preBCP Proposal (BCP-204)

- To translate the increase in FEB2 QC testing throughput at Nevis into advances in FEB2 deliveries to CERN, BNL needs to correspondingly increase their throughput
  - The required change corresponds roughly to increasing from 4 boards per day to about 5.3 boards per day
  - Profiting from the QC automation achieved at Nevis, which BNL can also partially benefit from, Hao estimates that he can achieve this increase with his current team – therefore, there is no request for increased manpower (or other) resources
- On the DoE side, the overall results are the following:
  - Cost impact – negligible ($529, due to tasks crossing FY boundaries)
  - Schedule impact – end date moved EARLIER by 50 days (aligned, by design given the inter-connections implemented long ago in P6, with NSF side)

# Schedule Impacts

- Due to the inter-connections implemented in P6, end-dates of FEB2 deliveries and acceptance tests at CERN are the same for NSF (6.4.2) and DoE (6.4.4)
  - 6.4.2 Task FEB21770 (Milestone: FEB2 Acceptance Tests at CERN - 100% Complete)
  - 6.4.4 Task SYS460420 (Milestone: FEB2 Prod Shipment to CERN Complete)

- Both completion milestone tasks are moved earlier to 27-Sep-27 (previously they were 09-Dec-27)
  - ie. both end dates are moved earlier by 50 days (2.5 months)
  - This change increases the float, which is measured between these end dates and the dates provided by ATLAS TC for FEB2 installation on the detector in the pit
    - The final installation phase starts on 02-Oct-28, so we now have ~1 year of float according to this new baseline schedule

# Cost Impacts

- The RLS changes for both 6.4.2 (NSF FEB2) and 6.4.4 (DOE Syst Integ) have been implemented in P6 by Carrie
  - The NSF summary cost diff. report from COBRA is shown below

| Sum of Value | Column Labels | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Row Labels | FY20 | FY21 | FY22 | FY23 | FY24 | FY25 | FY26 | FY27 | FY28 | Grand Total |
| ⊟ After | 583,577 | 1,769,672 | 1,461,538 | 2,669,137 | 3,724,085 | 3,497,035 | 4,239,357 | 7,448,038 | 63,793 | 25,456,230 |
| 6.04.01 FE Electronics | 330,882 | 1,215,392 | 827,546 | 1,253,331 | 1,803,839 | 1,448,618 | 457,018 | 39,802 | | 7,376,429 |
| 6.04.02 FEB2 | 123,501 | 230,517 | 287,102 | 853,851 | 858,075 | 1,300,033 | 2,298,332 | 3,877,126 | 63,793 | 9,892,331 |
| 6.04.03 BE Electronics | 129,194 | 323,763 | 346,889 | 561,954 | 1,062,170 | 748,383 | 1,484,007 | 3,531,110 | | 8,187,470 |
| ⊟ Before | 583,577 | 1,769,672 | 1,461,538 | 2,669,137 | 3,724,085 | 3,497,035 | 4,309,253 | 6,974,348 | 151,484 | 25,140,128 |
| 6.04.01 FE Electronics | 330,882 | 1,215,392 | 827,546 | 1,253,331 | 1,803,839 | 1,448,618 | 457,018 | 39,802 | | 7,376,429 |
| 6.04.02 FEB2 | 123,501 | 230,517 | 287,102 | 853,851 | 858,075 | 1,300,033 | 2,368,228 | 3,403,437 | 151,484 | 9,576,228 |
| 6.04.03 BE Electronics | 129,194 | 323,763 | 346,889 | 561,954 | 1,062,170 | 748,383 | 1,484,007 | 3,531,110 | | 8,187,470 |
| **Delta** | - | - | - | - | - | - | **(69,896)** | **473,689** | **(87,691)** | **316,102** |
| 6.04.01 FE Electronics | - | - | - | - | (0) | - | (0) | - | - | (0) |
| 6.04.02 FEB2 | - | - | - | - | - | - | (69,896) | 473,689 | (87,691) | 316,102 |
| 6.04.03 BE Electronics | - | - | - | - | - | - | 0 | - | - | 0 |

  - Total NSF cost increase is ~$316.1k (including $66.2k due to escalation)
    - Breakdown is ~286k (labor), ~26k (M&S), ~4k (travel)

  - Total DOE cost increase is only $592 (due to escalation)

# Risk Analysis

- On the NSF side, this BCP realizes the overall highest-ranked LAr risk
  - RN-06-04-02-001 (Delay in launch of FEB2 preproduction), with Rank 140
    - Cost impact range 50k-500k, Schedule impact range (1 – 7) mo.
- On the DoE side, this BCP realizes one of the highest-ranked DoE LAr risks
  - RD-06-04-04-001 (FE crate system integration delayed), with Rank 60
    - Cost impact range 60k-120k, Schedule impact range (3 - 6) mo.

(the fact that both of these risks are number 001 in their L3 list of risks is not a surprise, since these risks have been leading concerns since the beginning of the project)

- Until the validation of v2.8 as the final FEB2 Prototype is achieved and we pass the FEB2 FDR, we cannot retire these risks
  - According to the new plan, we should be able to retire both within the next few months
  - We propose to leave these risks as is for now

# Summary

- To deal with the recently discovered bPOL12V reliability issue, we need to modify the FEB2 design, and validate the changes by fabricating and testing a new (v2.8) FEB2 Prototype board
  - The additional tasks required introduce a short-term delay of about 2.5 months
- In the same BCP, we implement changes to speed up the FEB2 production QC steps in order to mitigate this delay and also address the recommendation from the last NSF review about the inadequate float (according to the MC)
  - Achieving the speed-up requires coherent changes to both 6.4.2 (NSF) and 6.4.4 (DoE)
- The overall changes are the following:
  - End of FEB2 delivery/acceptance at CERN is moved 50 days (~2.5 months) earlier, creating ~1 yr of baseline float
  - NSF cost increase is $316k, and DoE cost increase is $529
  - Highly ranked risks on both NSF and DoE sides are realized, but need to be maintained as currently specified in Risk Register for another few months until v2.8 is validated and FEB2 FDR is passed

# BACKUP