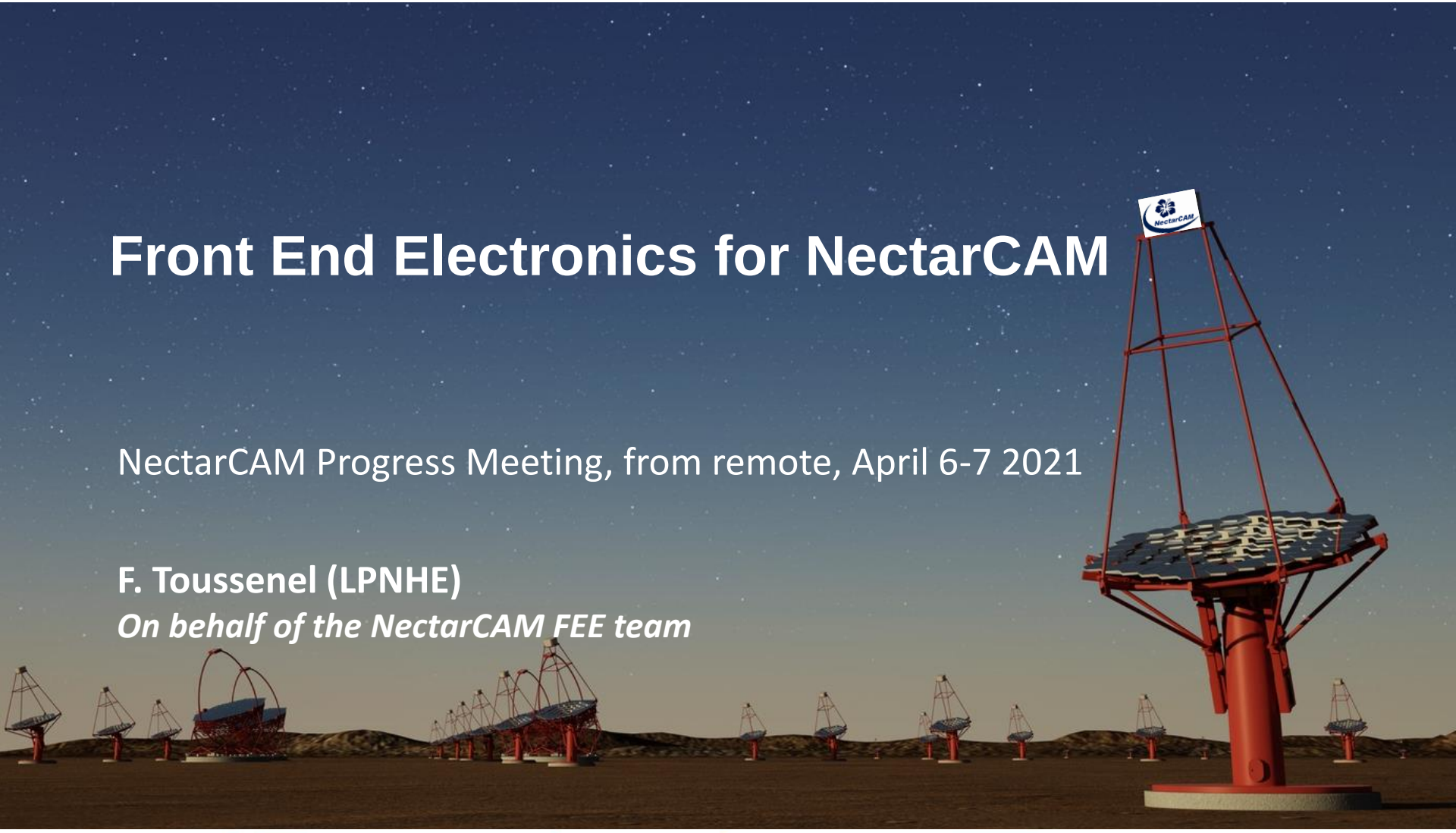
Front End Electronics for NectarCAM



NectarCAM Progress Meeting, from remote, April 6-7 2021

F. Toussenel (LPNHE)

On behalf of the NectarCAM FEE team

cherenkov telescope array

NectarCAM

FEB2 V5.1

ASICs

FEB2 V6

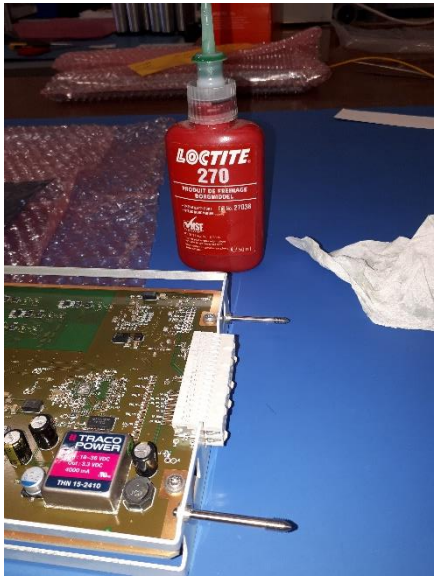
CDMR

Next Steps

FEB2 V5.1 for qualification model (camera 1)

Boards available:

- **313** (315 produced, 2 rejected) => All identical
- Mechanical assembly performed at IRFU on Jan 2020
- New pin added for FEB centering/fixing => in progress => see picture =>
  - ~200 boards done on March 30-31
  - Upgrade requested after Berlin test (hard to unlock some modules)
- FEBs almost ready for integration in the QM => planned this month



Current firmware

- NECTARCAM_V5.6_20200302

Remote FEB firmware upload

- Upgraded to reduce the memory need during upload => pending for validation

CDMR documentation data package (available on the NCAM wiki)

- Version 5.1 was the one presented to the CDMR panel as FEB2 V6 performances were not already availabe
- Most of the verifications are now done for FEB2 V6 or in progress showing no major issues so far .

ASICs for NectarCAM => could be on the critical path

Nectar2:

ASIC was initially planned to be produced in Q1 2020 => luckyly, was not the case

- First: some delay due to the covid19 pandemic
- Second: Improvement brought to the chip following similutations (ADC issue)
- Third: Wait for FEB2 V6 tests results (July 2020 –Feb 2021) => just in case …
  - Several issues found during the test : most of them corrected by firmware adjustment and mainly one due to the nectarchip and finally corrected (more details in next slides)
- Nectar2 (+ ACTA with in pulser) submitted to CMP in March 2021=> to be transfered to AMS soon
  - **Last minute!** design correction ongoing (peak in the HG when a trig occured during readout)
- Chips to be packaged by Aptasic (Switzerland)
  - we might have some unexpected delay due to the current situation regarding ASIC's market in the world.

Production of PACTA, ACTA, TL0, TL1 ASICs

- Order sent to IMEC Dec 12 2019
- Total cost: ~188 k€ (as expected)
- Delivery Initially expected by the end of 2020
  - Wafers delivered to IMEC in September 2020
  - Then sent to ASE
  - Side effect of Covid Crisis => huge delay for ASIC Dicing and packaging
    - Biweekly follow up with IMEC
    - Some information about the CTA project context sent to IMEC 2 weeks ago in order to push for delivery
    - **Last update (March 30)**:
      - PACTA should be delivered by the end of April but no firm date so far.
      - No SODs (ship out dates) for the following ones L0, ACTA and L1.

FEB2 V6

Reminder => changes requested and consequences

- New Nectar chip with reduced dead time (ping pong mode) => /10
  - Firmware updated accordingly
  - Reduced memory depth => /2 => 512 cells => 512 ns @ 1 GS/s
- New Nectar Package : QFN 100 instead of QFP 128
  - New FEB layout
  - Single version of the Nectar chip (top)
  - Simplified layout with all 7 Nectar chips on the top side of the PCB (cheaper)
- New clock system => Choice with hard switch between internal and external 66MHz clock
- No more delay lines on the FEB, only L0 ASIC is used, delays adjusted in the DTBP
- No more L1 ASIC required => digital trigger use

Intial plan (presented in Barcelona) / reality

Prototype production x 3-5 => early 2020 => March / PCB delivered in May, board delivered end of June 2020
Test and validation => Spring 2020 / July 2020 to February 2021
Small production, 50-60 boards => expected fall 2020 / Pre serial in summer 2021 ?

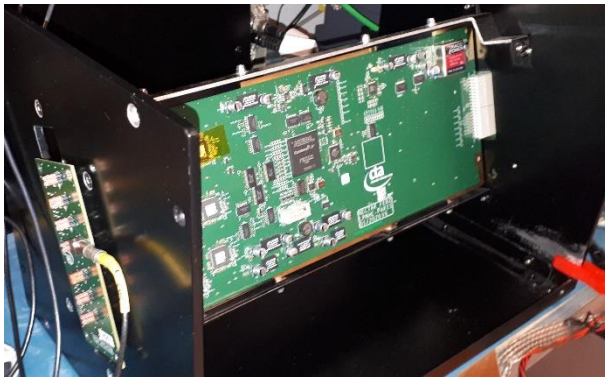
Software and firmware to be updated (new Nectar, use of ACTA in pulser, reset of IB µController …)

New firmware available for the Nectar2 chip => current version is :
Software updated accordingly,
Production test software updated for FEB2 V6

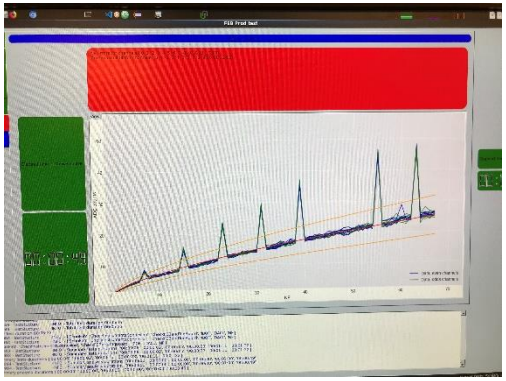
New ACTA chip being produced now, test of in pulser functionality delayed, fw and sw to be updated …

FEB2 V6 ping pong (PP) mode debug phase

As usual logbook available on the NectarCAM wiki:
FEB2 V5: https://forge.in2p3.fr/projects/nectarcam/wiki/FEB_V5_docs_and_logbook
FEB2 V6: https://forge.in2p3.fr/projects/nectarcam/wiki/FEB_V6_docs_and_logbook



A big thank to all the teams involved who helped during this important phase with a "mention spéciale" to Jean-Luc, Patrick and Eric who worked hard to understand and fix encountered issues.



Main issues encountered during the debugging phase:

Peak in the NF scan => Read clk is now running permanently => issue fixed

Acquisition getting stuck with permanent busy

- border effect at specific DT between 2 consecutive trigger
- Firmware improved => issue fixed

LG affected when a trigger occured during readout (only possible in PP mode)

- Nectar chip feature => corrected in the design => issue fixed

Bad synchro event =>

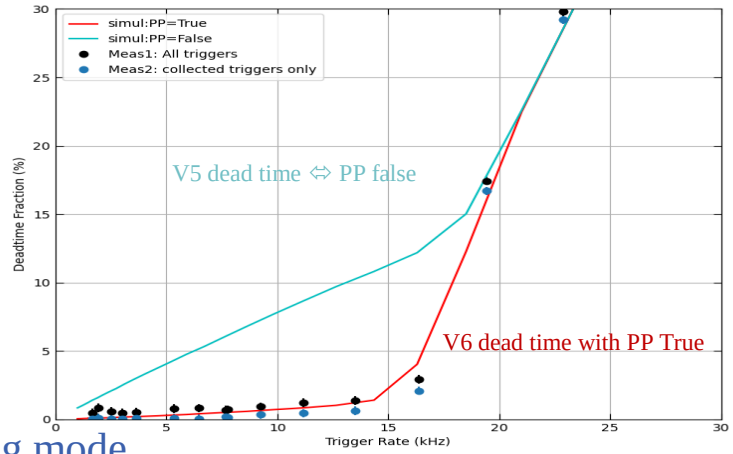
- improve synchronization process in the firmware => issue fixed

FEB2 V6 tests summary

Stages

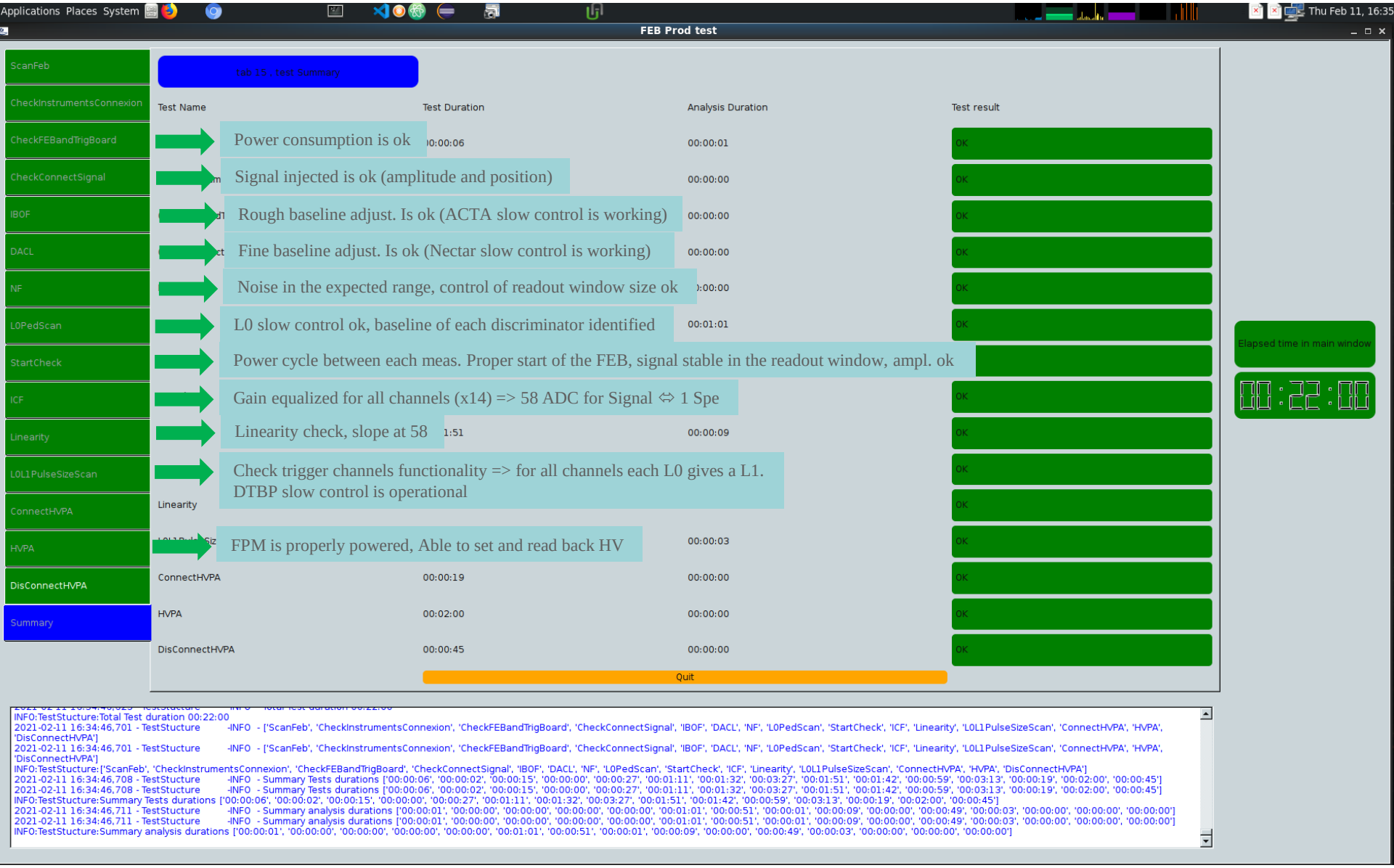
- July 2019: New Nectar validated on FEB2 V5 (QFP) with new FW.
- July 2020: FEB2 V6 (with Nectar2 in QFP package) operated in V5 mode => prod test passed (V5 like)
- Fall 2020: Start debug of the ping-pong mode
- Dec 23 2020: FEB V6 firmware stable for PP mode operation
  - With expected performances ⇔ FEB2 V5 perfs
- Jan 2021: prod. test bench upgraded for V6: all tests ok
- Jan 27 2021: Deadtime measurement at IRFU with FPM ➔
  - DT < 2,5% up to 16kHz
- FEB 11 2021
  - Production test ok for FEB2 V6 (x2) operated in ping pong mode

60 samples readout window – random trigger source



- NEXT STEPS : April 2021
  - Validate remaining requirements => ongoing (run taken in March, being analysed)
  - Update documents and data package for FEB2 V6
- *and still to be done (asap)*
  - Test of distributed clock configuration (not a requirement)

FEB2 V6 test summary FEB2 V6 ping pong mode



CDMR => concerns regarding FEE

Mainly one concern

Provide evidence of design verification for FEB V6.

- Already done for most of the FEE requirements (as mentioned during the review)
  - Production tests passed in both mode.
- For the 3 remaining reqs (see below) => Specific runs taken at IRFU in March (ongoing analysis, see analysis session)

So far, FEB2 V6 is performing as expected and is compliant with FEE requirements

C-MST-CAM-NC-0152 => Event rate: Digitization dead time
Dead time of digitization and read-out will be < 5% for the nominal CTA trigger
=> Corresponding note : MST-CAM-TN-0331-IRFU : Maximum event rate of NectarCAM
Preliminary measurements give a dead time < 2,5% up to 16 kHz of trigger (random) => Compliant

C-MST-CAM-NC-0147 dynamic range. The dynamic range of the readout is from 0.5 to 2000 p.e
and
C-MST-CAM-NC-0325 non-linearity. The charge non-linearity will be <5% between 0.5 and 2000 p.e.
=> Corresponding note: MST-CAM-TN-0368-IRFU : Linearity of NectarCAM (Crosstalk and B-TEL-1390)

B-TEL-1380: Systematic Pixel Timing Uncertainty: The rms uncertainty on the mean relative reconstructed arrival time in every Camera pixel for uniform simultaneous pulsed illumination (<5 ns FWHM) must not exceed 1 ns for amplitudes in the range 20 to 2000 photons per pixel
=> Corresponding note: MST-CAM-TN-0340-IRFU : Timing resolution of NectarCAM

CDMR => others concerns regarding FEE

Nothing critical

42561	DD034 Ch 11.3. Serial Devices in troubleshoot	Toussenel Francois	RAMS

42399	DD027-NectarCAM module controller ICD	Toussenel Francois	Front End Electronics
42454	Comments on DD035_NectarCAM NMC Users manual.pdf	Toussenel Francois	Front End Electronics
42533	DD029_ECR_FEB_V5-1toV6: This ECR from the QM to production version has not been implemented in the documents	Toussenel Francois	Front End Electronics
42606	DD026_LMST-CAM-ICD-0238-LPNHE_FE_BP_interface_v10-2.pdf	Toussenel Francois	Front End Electronics
42609	DD028_I_NCam_Mechanics_FEB_ICD.pdf	Toussenel Francois	Front End Electronics
42761	DD033 FEB V5.1 performance verification - 7. Firmware / 8. Software	Toussenel Francois	Front End Electronics
42763	DD034 NectarCAM Front End Board User Manual	Toussenel Francois	Front End Electronics
42764	DD034 NectarCAM Front End Board User Manual - 4. Readout System	Toussenel Francois	Front End Electronics
42766	DD034 NectarCAM Front End Board User Manual - 8. FEB Initialization	Toussenel Francois	Front End Electronics
42767	DD034 NectarCAM Front End Board User Manual - 9. FEB user guide	Toussenel Francois	Front End Electronics
42768	DD034 NectarCAM Front End Board User Manual - 11 Annexe 2	Toussenel Francois	Front End Electronics

42924	ICD drawing	Toussenel Francois	Mechanics and Cooling

Documents will be updated along production and test

Tentative time schedule for the next steps and production

- April 2021: Finalize FEB2 V6 verification according to CDMR request.
- April 2021: FEB2 V6 launch call for offer
  - Pre-serial of 25 boards, serial of 1400 boards, option for 1120 boards
- April 2021: Delivery of ASICs by IMEC (PACTA, ACTA, L0, L1)
  - Currently worrying : PACTA expected in April, no firm date. No date for other ASICs
- April – October 2021 : Quality control of the ASICs at ICC-UB
- June 2021: place order for pre serial of 25 boards
  - Enough L0 ASICs (100), and current ACTA (no pulser) available
  - Pending for Nectar and new ACTA delivery => July 2021 ?
- July – September 2021: delivery of Nectar and ACTA + Quality control of the ASICs
- October 2021: test and validation of pre serial boards in Tower 66
  - Includes new ACTA test and validation => Select ACTA version for production
  - Pending on ASICs delivery on time
- November 2021: place order for large production of 1400 boards
  - Expected rate of 140 boards /month => ~ 1 year prod. => ~ 2 months for 1 camera (280 boards)
  - Pending for ASICs delivery => produced (IMEC, CMP) and tested (IRFU, ICC-UB)
- December 2022 : End of production

Thanks !

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