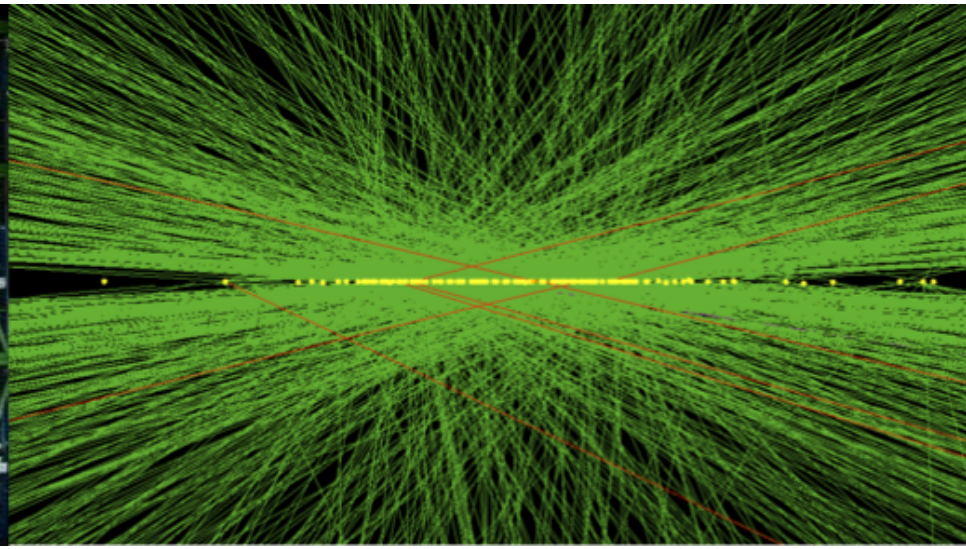
ELECTRONICS

Gilles DE LENTDECKER

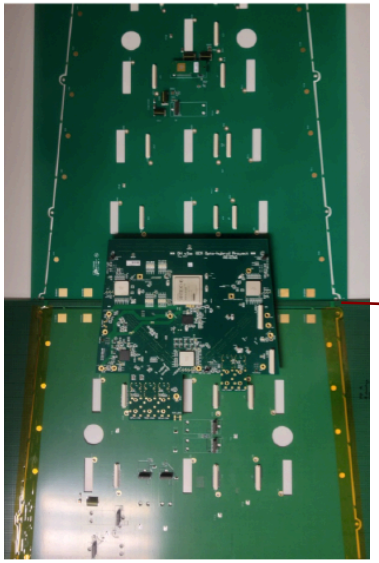
GE1/1 Electronics

September 30th, 2019

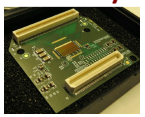


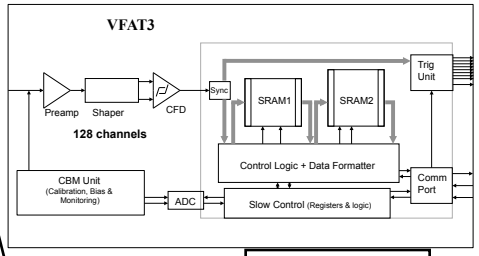
Electronics

2-pieces GEB v3 (1.2m)



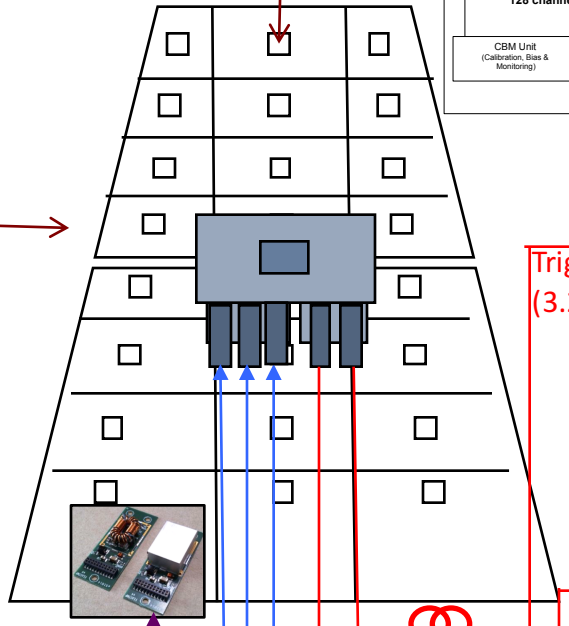
VFAT3 hybrid





VFAT3 chip on hybrid:

- Binary output, CFD
- 320 MHz
- L1 latency: up to 12 µs
- Slow control: ePort, GBT compatible
- Trigger data:
  1bit= OR of 2 strips
  (+DDR option)



CSC Trigger Mother Board (TMB)

Trigger data
(3.2 Gbps – 10b/8b)

/2
/2

Tracking data
3 x GBT – 4.8 Gbps

CMS AMC13

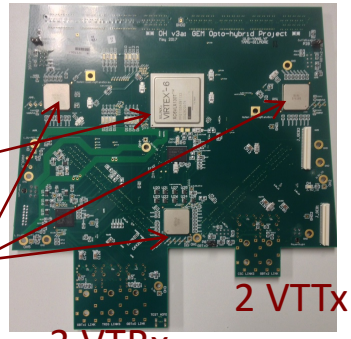
DAQ
TTC

MCH

µTCA

AMC = CTP7 from CMS Trigger upgrade

Opto-hybrid v3 (OH)



Virtex-6
+
3 GBTx

2 VTTx

3 VTRx

LV
VFAT3 & OH

Manufacturing

- VFAT3 hybrids
  - Needed for GE1/1: 3840
  - Assembled: 4574
  - QC passed: 3286
    - Average yield:89%
  - Still to be tested: 873
  - Still ~250 to be assembled
- GEBs
  - Needed for GE1/1: 72 of each type
  - 90 GEB-L manufactured
    - 45 fully qualified
  - 85 GEB-S manufactured
    - 57 fully qualified
- OH
  - Needed for GE1/1: 144
  - 160 PCB manufactured (30 more in production)
  - 120 OH assembled
  - 91 fully qualified

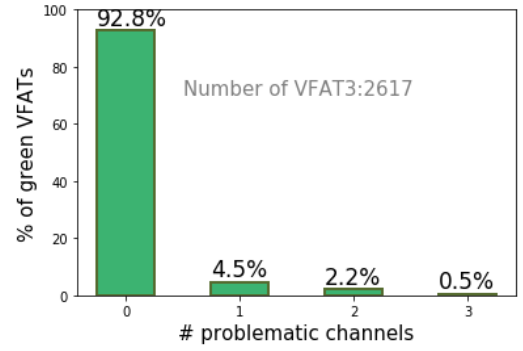
VFAT3 QC results

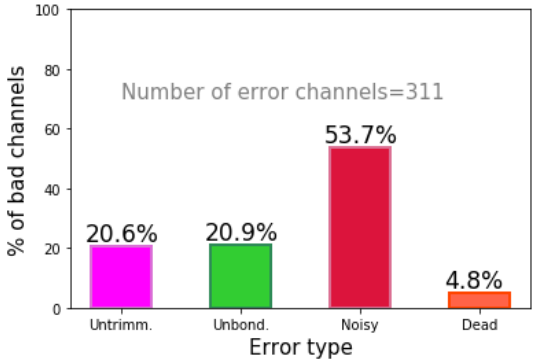
- Average QC yield: ~89 %

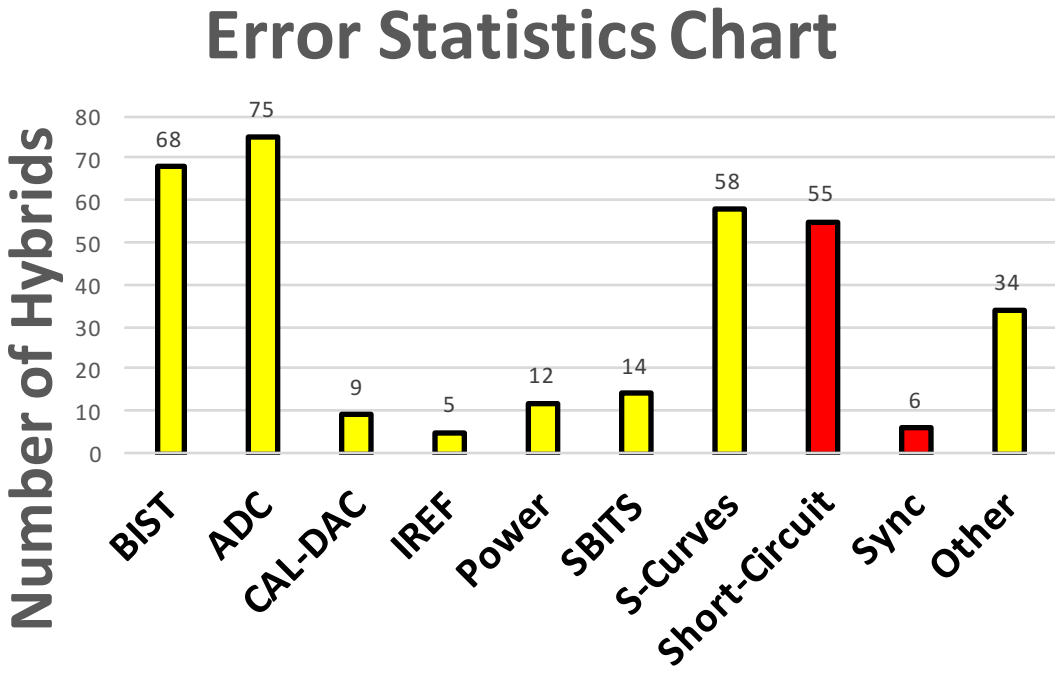
Assembled	Tested	QC passed
4574	3701	3286
Extrapolation:	4574	4061

  - + 241 hybrids still to be assembled

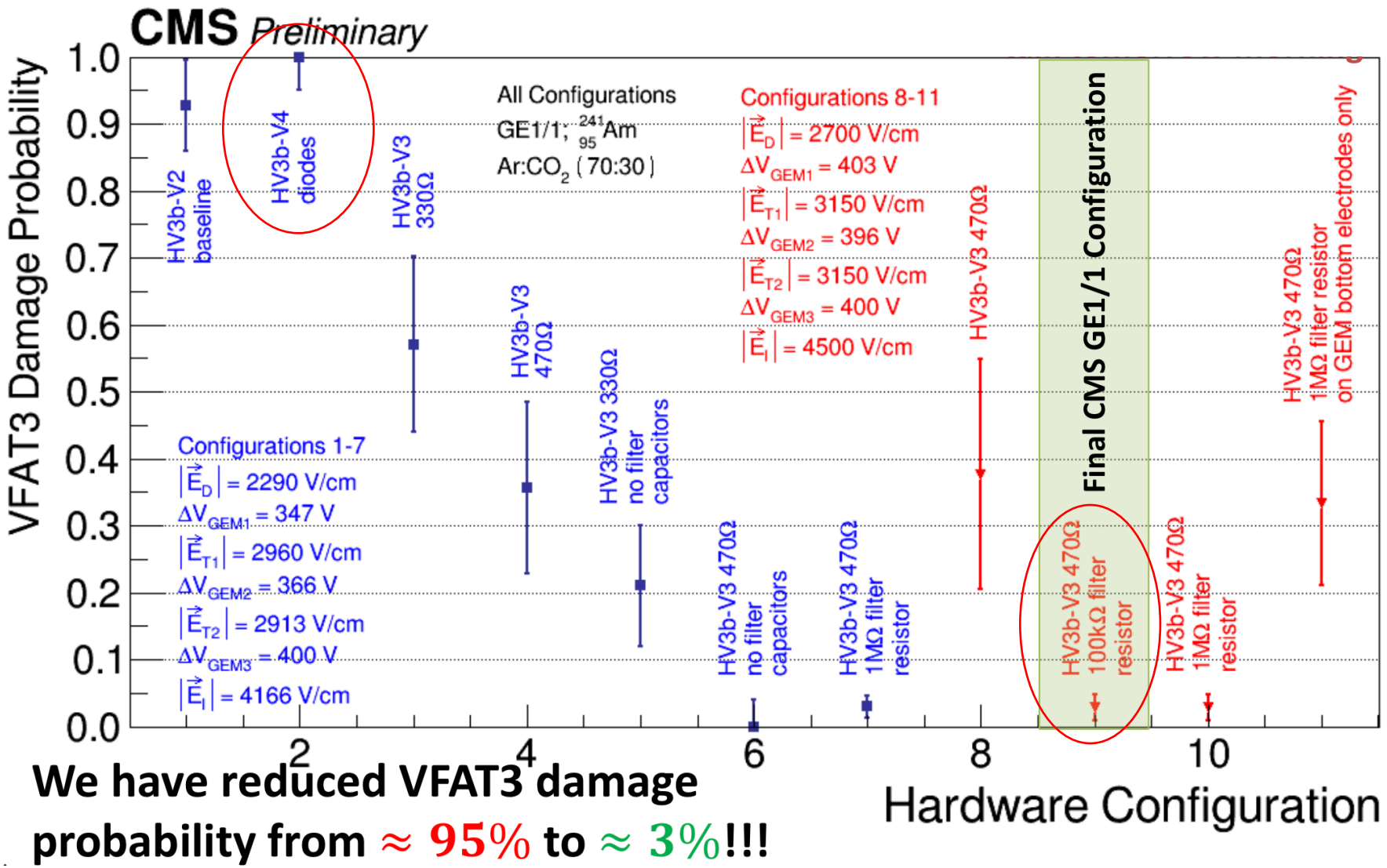
- QC Failures:







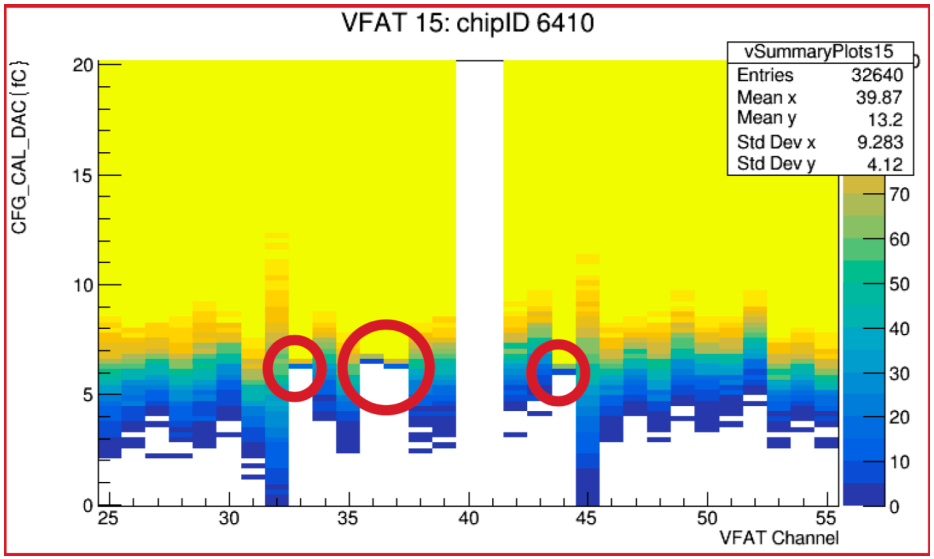
VFAT3 Hybrid protection



We have reduced VFAT3 damage probability from ≈ 95% to ≈ 3%!!!

Channel loss at QC8

- Monitored through daily s-curves



  - Detected through sharp s-curve (almost no noise)
- New QC6 procedure helps to reduce the trip rate
- Damaged VFAT3 hybrids replaced
- Confirm that damage probability in case of trip ~3%

More details in Federica's talk on Tuesday

GEB and OH QC

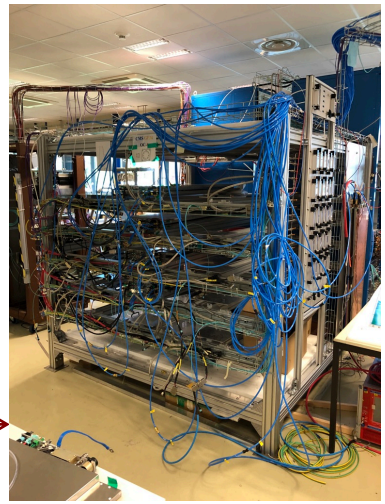
GEB QC
- QC0 by company: flying probes
- Assembly
- Visual inspection
- QC1 by PKU: connectivity test, Flatness, standoff torque

OH QC
- QC0 by company: flying probes
- Assembly
  - Visual inspection, X-ray,
  - Temperature cycles
- QC1 by ULB: connectivity test, GBT & FPGA functionality,

OH-GEB pairing @ ULB
- Check GEB flatness & soldering
- Power provided by FEASTs
- Communication with 24 VFATs
- GBT configuration & fusing
- GBT locking
- All 192 sbit lines are operational
- power cycles, overnight stability test
- etc.

Takes much longer than expected:
- Interconnect between OH-GEB-VFAT
- GEB Assembly issues
  - Poor soldering of standoffs
  - Cleanless of GEB boards at connectors

At CERN (QC7):
- Reception test (visual)
- Integration on ROB
- Readout test before adding cooling plate, etc.



QC8:cosmic stand

QC steps at ULB

Visual inspection (quality of the assembly, flateness)

↓

Consolidation of standoff soldering

↓

Check Standoff soldering by screwing every screw at defined torque

↓

Cleaning each connector with flux-remover + pressured air

↓

Check for power delivery (no short, no open lines)

↓

Assembly of OH, VFATs, FEASTs on GEB

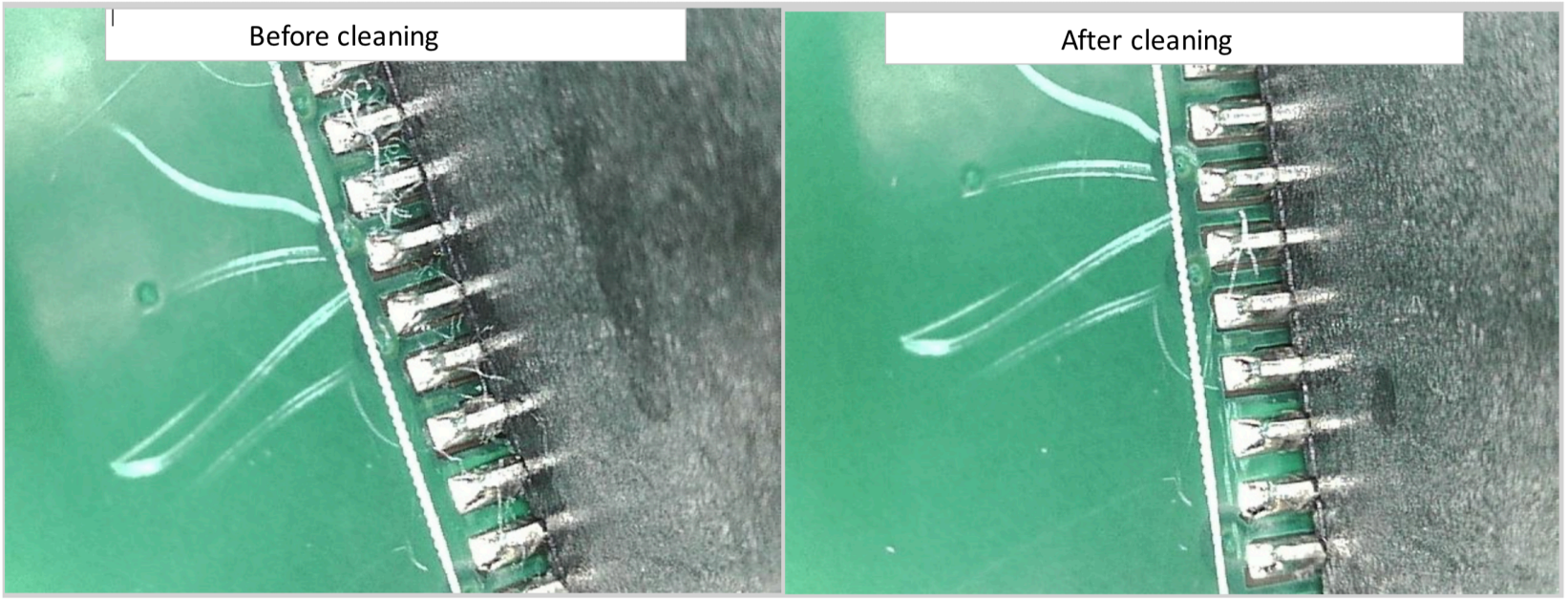
↓

Connectivity test like @ QC7 (including sbits)

↓

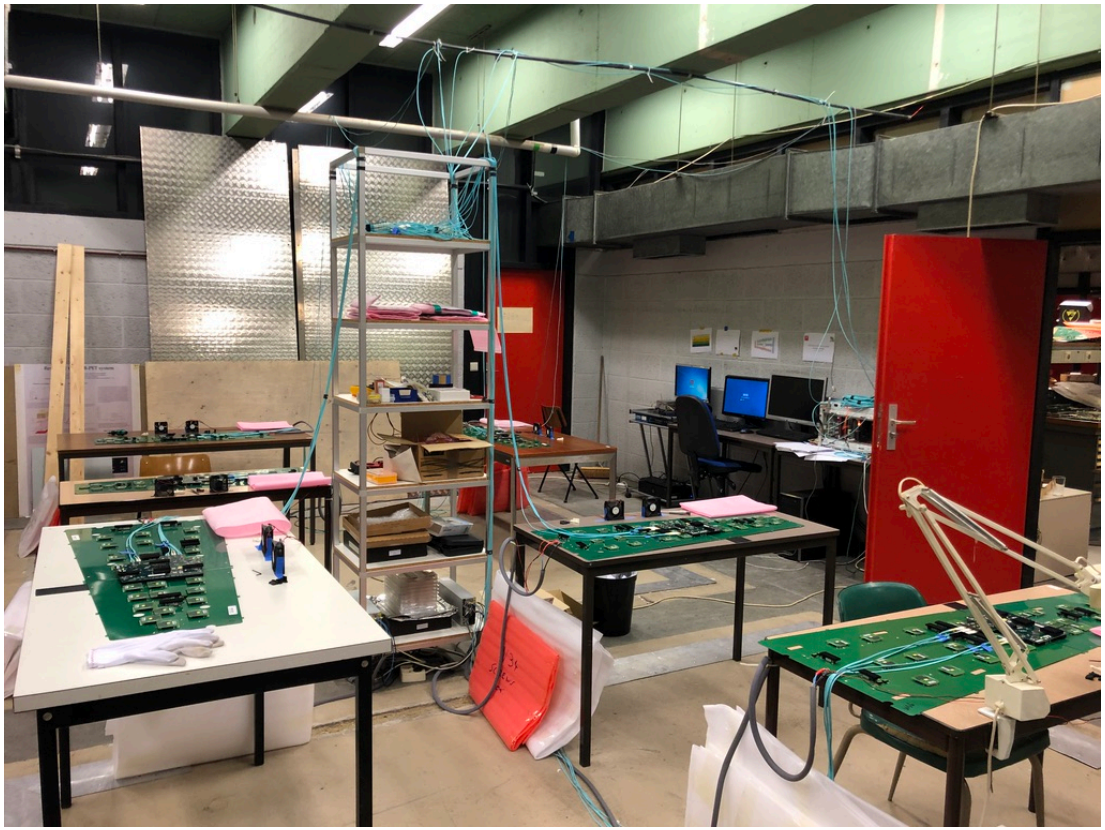
Overnight run (s-curve, stability (GBT unlocking/sync. Loss)

Example of cleaning



QC test @ ULB

- To increase the QC flow, we have installed 6 benches
  - 6 GEBs + OH tested in parallel
    - Including overnight run for long term stability



GEB & OH production

- 1st endcap components were delivered @ CERN on July 29th
- Testing of 2nd endcap electronics ongoing
  - To be delivered by mid-Nov.
  - In between, we took the time to improve our procedure and to investigate why many (12) OH's were returned from 904 (GBT not locking/ bad communication)
    - Now most of them returned to 904

  (more details in Laurent's talk on Wednesday afternoon)

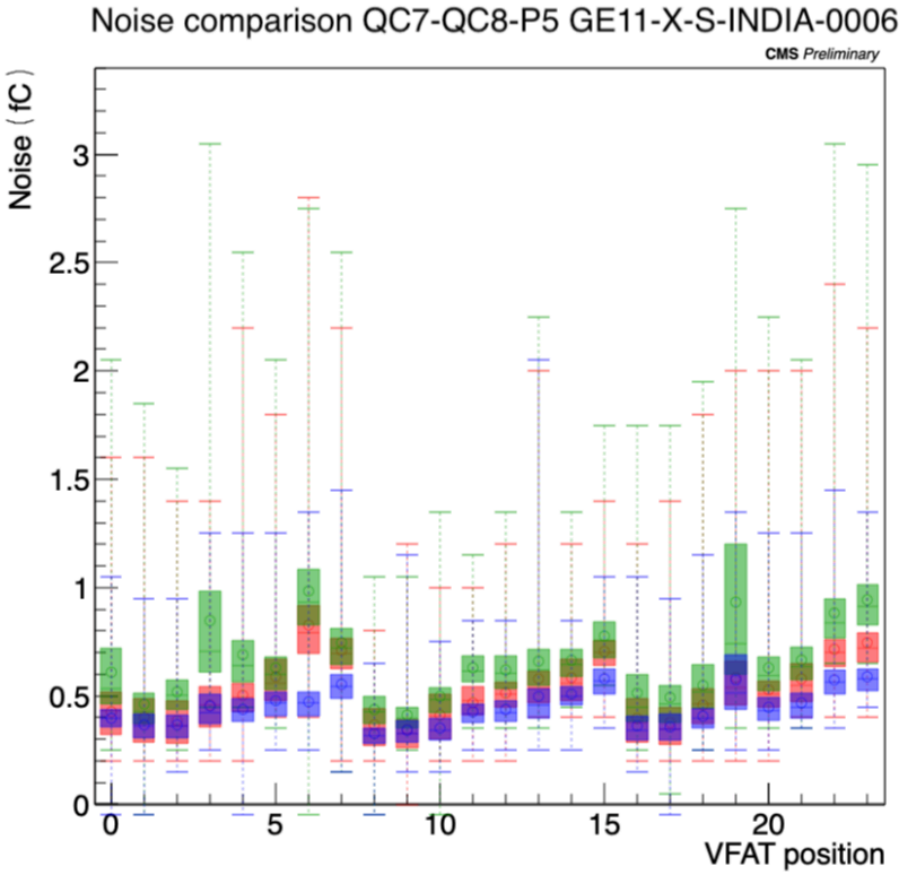
		Sept	Oct	Oct	Oct	Oct	Oct	Nov	Nov
	week	39	40	41	42	43	44	45	46
GEBv3c-S	Produced	85			115				
	Tested	60	65	70	75	80	85	85	85
	QC failed								
	QC passed	57							
	Returned to ULB	3							
	At 904	43	47	52	57	60	65	70	80
GEBv3c-L	Produced	90			110				
	Tested	49	50	55	60	65	70	75	85
	QC failed								
	QC passed	45							
	Returned to ULB								
	At 904	44	45	50	55	60	65	70	75
OHv3c	Produced	160							
	Assembled	120			160				
	QC failed	4							
	QC passed	91	100	110	120	130	140	150	160
	Returned to ULB	3							
	At 904	79	85	95	105	115	125	135	145
VFAT3b-Hv3	Produced	5000							
	Assembled	4574							
	QC passed	3286							
	delivered to 904								

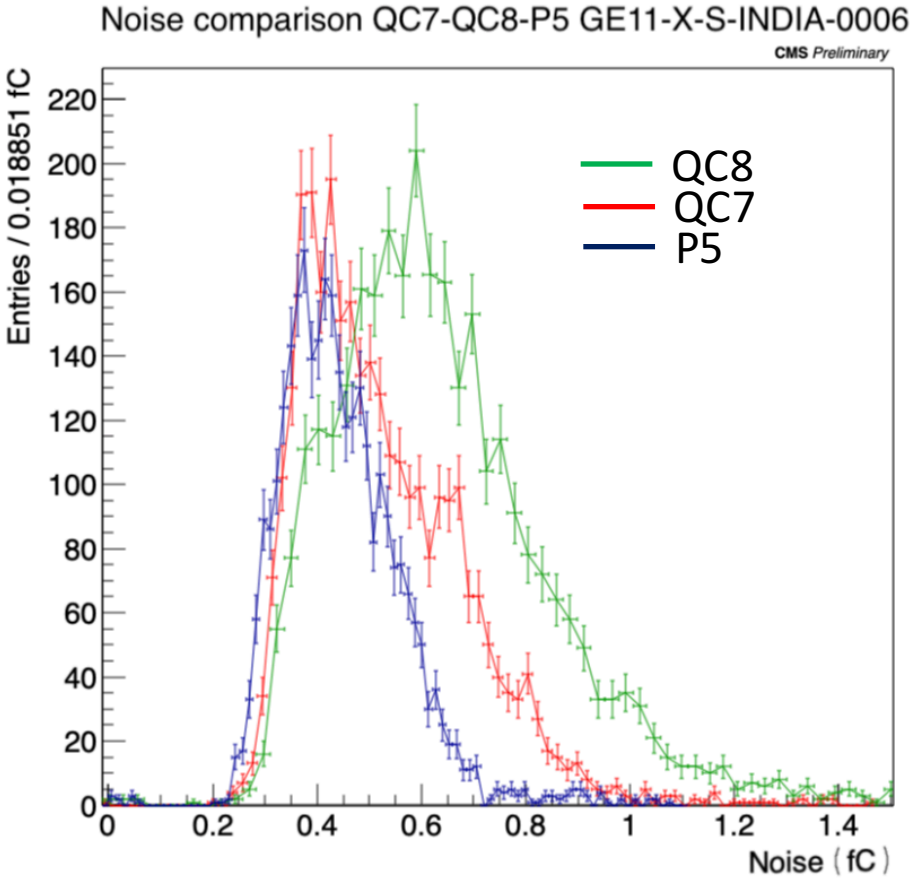
Issues noticed at GEB-OH QC

- GEB (out of 109 GEB tested)
  - Mechanical issue (repairable mis-alignment): 5
  - VFAT communication issue: 5
  - Sbit communication issue: 2
  - FEAST shorted: 1
  - Power Standoff broken: 4
- OH (out of 100 OH tested)
  - Sbit communication issues: 4
    - 3 b/c Samtec pins damaged during assembly
    - Will replace samtec connector
  - GBT not fusing: 1
    - Will replace the GBT
  - FPGA do not get clock: 1
  - FW issue: 1
- GBT unlocking seems to be due to VTRx dying

Noise measurements

- Preliminary noise measurements QC7->QC8->P5





More details in Francesco talk this morning, and follow-up discussion in Jared's talk

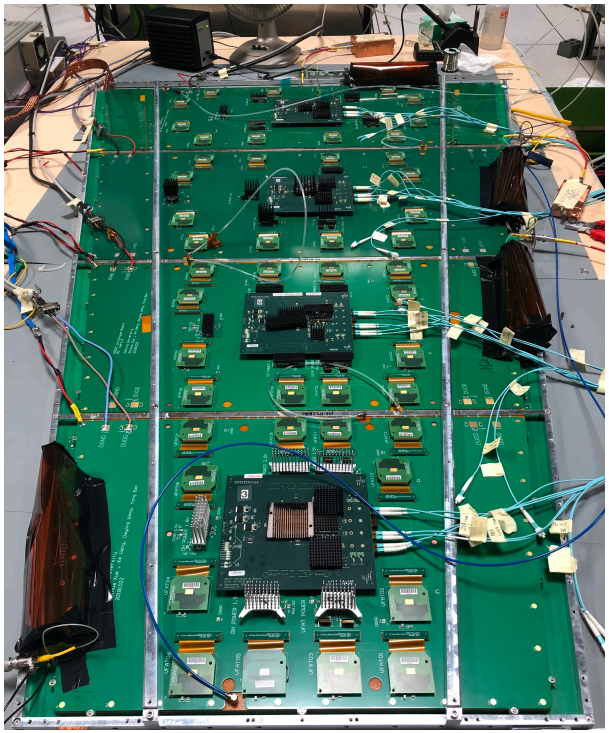
Backend electronics

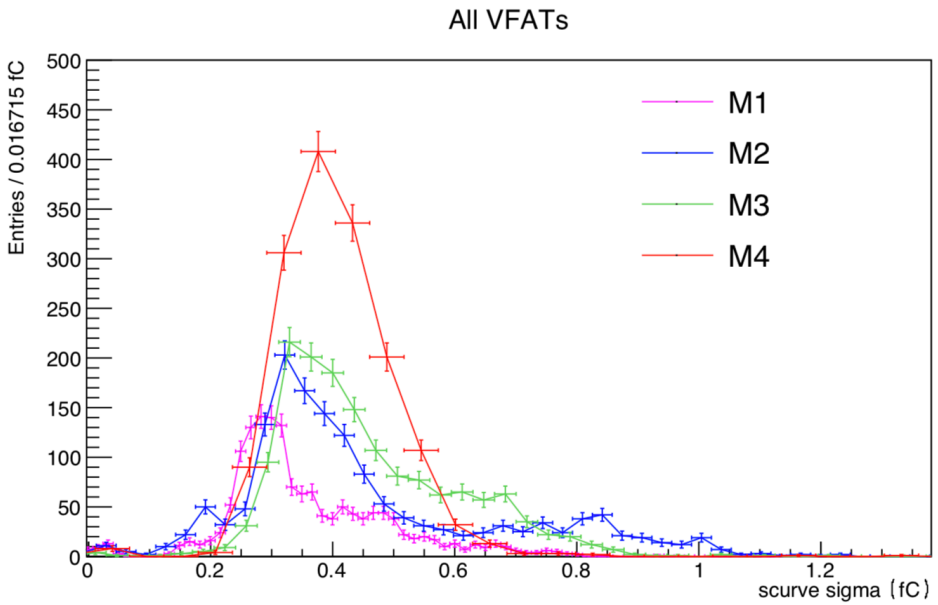
- 2 uTCA crates incl. AMC13 at P5
- CTP7 for P5
  - Needed: 12 + 2 spares needed for GE1/1
- Currently have 15 CTP7s (12 needed for P5 + 25%)
  - 6 boards at QC7/8 (one endcap worth of boards)
  - 2 at 904 integration stands (one for GE1/1, and one for GE2/1)
  - 1 at P5
  - 5 boards at university test stands (TAMU, UCLA, Rice, ULB)
  - 1 board used by CSC
  - We will acquire 2 more boards in Q2 next year

More details in Evaldas'talk (Wed or Thr.)

GE2/1 & ME0

- Some news:
  - End of August: GBT-based GE2/1 OH approved
  - VFAT3 package: design file of the substrate received from IMEC; will be reviewed in the coming days
  - G2/1 M1-M5 GEB prototypes in hand:

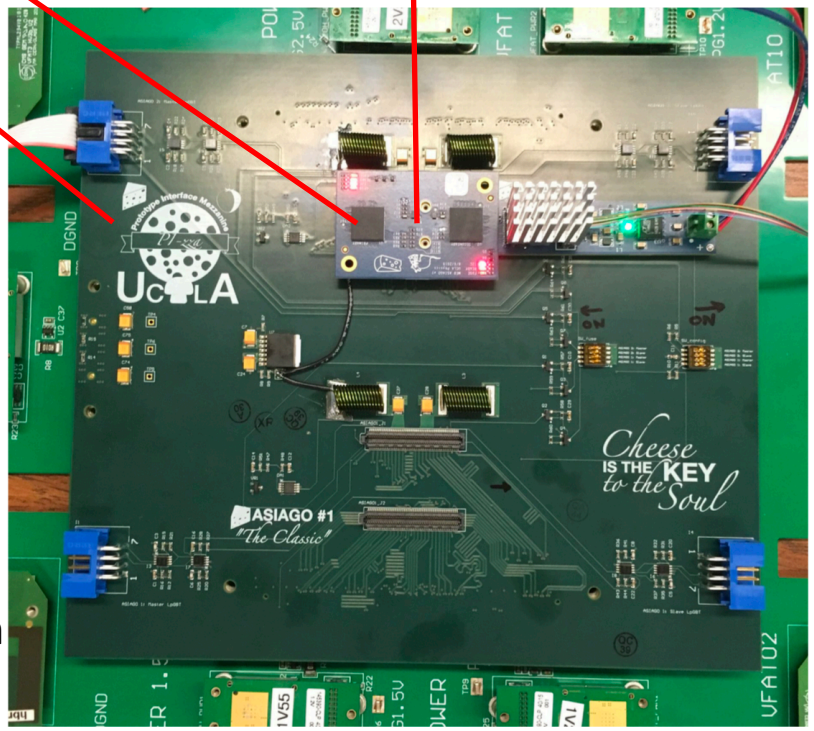




More details in Misha's talk on Friday

ME0

- 1st LpGBT board targeted for ME0: ASIAGO
- + Adapter (CACIO) to be able to use commercial SAMTEC Firefly instead of CERN VL+ (not yet available)
- + Adapter (PIZZA) to connect ASIAGO to GE2/1 GEB (ME0 GEB not existing yet)

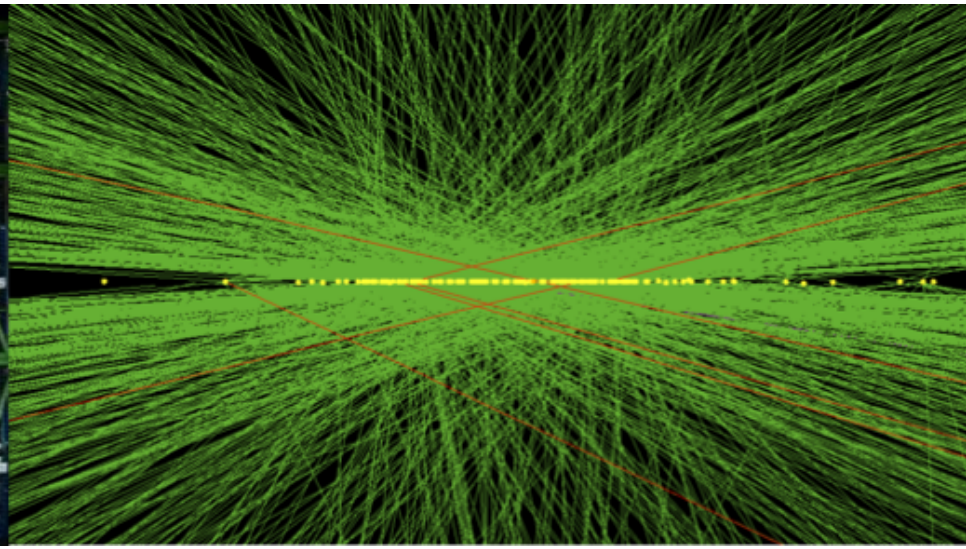


More details in Wednesday afternoon session

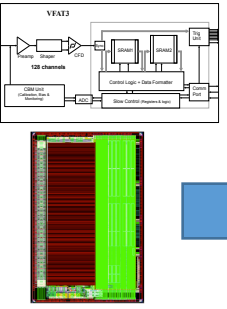
Conclusion

- Components for 1st endcap delivered to CERN by end of July
  - Many (12) OH's returned to ULB -> this led to a situation of lacking OHs at 904
  - Most of them are fine and returned to CERN
  - 3 had panasonic connector damaged during assembly
- Now qualifying at full speed components for 2nd endcap
  - To be delivered by mid-November
  - We have ordered more GEBs & OH to have more spares (>160)

backup

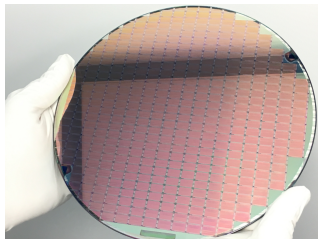


VFAT3 hybrid production flow

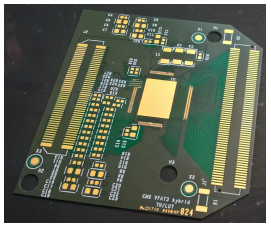


VFAT3 design

Fabrication



Wafer Processing



Hybrid PCB

Dense hybrid difficult to design. Extensive discussions with manufacturers to aid ease of manufacture.

Quality concerns during manufacturing

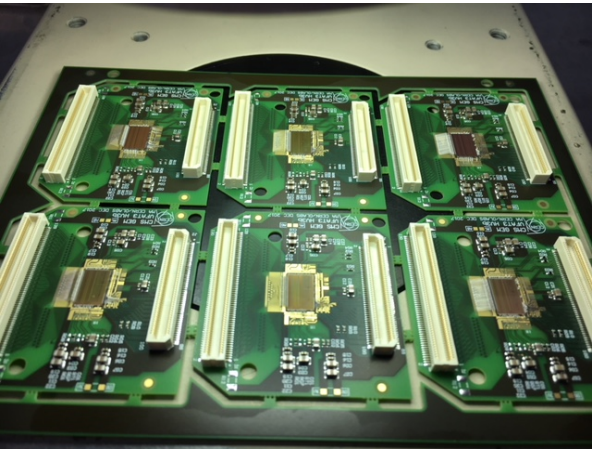
Prototypes done tried with 4 companies, 1 with success.

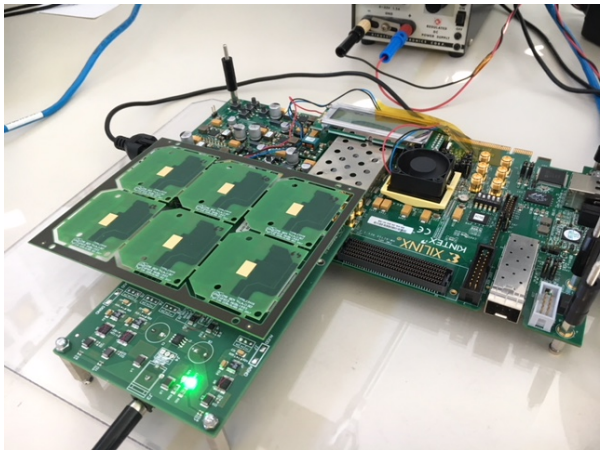
VFAT3 Hybrid Assembly

Dense bonds make assembly difficult.

Prototypes done tried with 3 companies, 1 with success.

Quality Control (after assembly)





Production test : Extensive procedure with logging in data base.

Production test bench
Custom designed Hardware & Firmware & Software.

Production test to be done by the assembly companies.

Test benches installed in the 2 assembly companies and staff trained in its use.

HV3b Production Tests

Tests in order of execution:
- Sync
- BIST
- Scan Chain
- Power Measurement
- Temperature Measurement
- Iref adjustment
- Write Chip ID
- Tests Registers
- Internal ADC calibration
- CAL_DAC conversion.
- Data Packet test
- Scan all DACs
- All channel S-curves.

Production test time < 2mins per hybrid

Results logged in data base

Traffic light acceptance result for operator:

- Bad
- Requires data inspection
- Good

From two first batches:
- *Assembly yield: 97%*
- *QC yield: 94%*
- *Total yield: 91%*

To be confirmed with latest batch

VFAT3 hybrids

- **Situation at the November MPR review:**

HV3b_v2

- Not sufficient input protection for the GE11 GEMs under present operating conditions
- 5000 hybrids in our hand since summer 2018 (800 assembled)

?

Baseline change

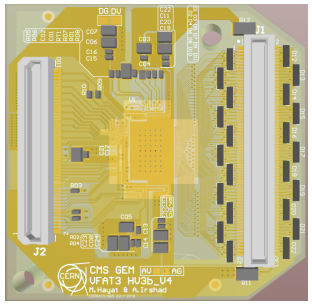
HV3b_v3 (with resistors)

- Discharge tests look positive but penalty is increased noise and cross-talk
- Prototypes completed and tested with 50x50 GEM detector. 500 discharges without a single channel loss.

?

HV3b_v4

- Discharge tests look positive, no pre-rad penalty of noise.
- Radiation tests with proton beam done, exposure done. All tests show negligible leakage current to a total of 10Mrad.



Choice to be confirmed on receipt of first prototypes and successful tests with GEM detectors.

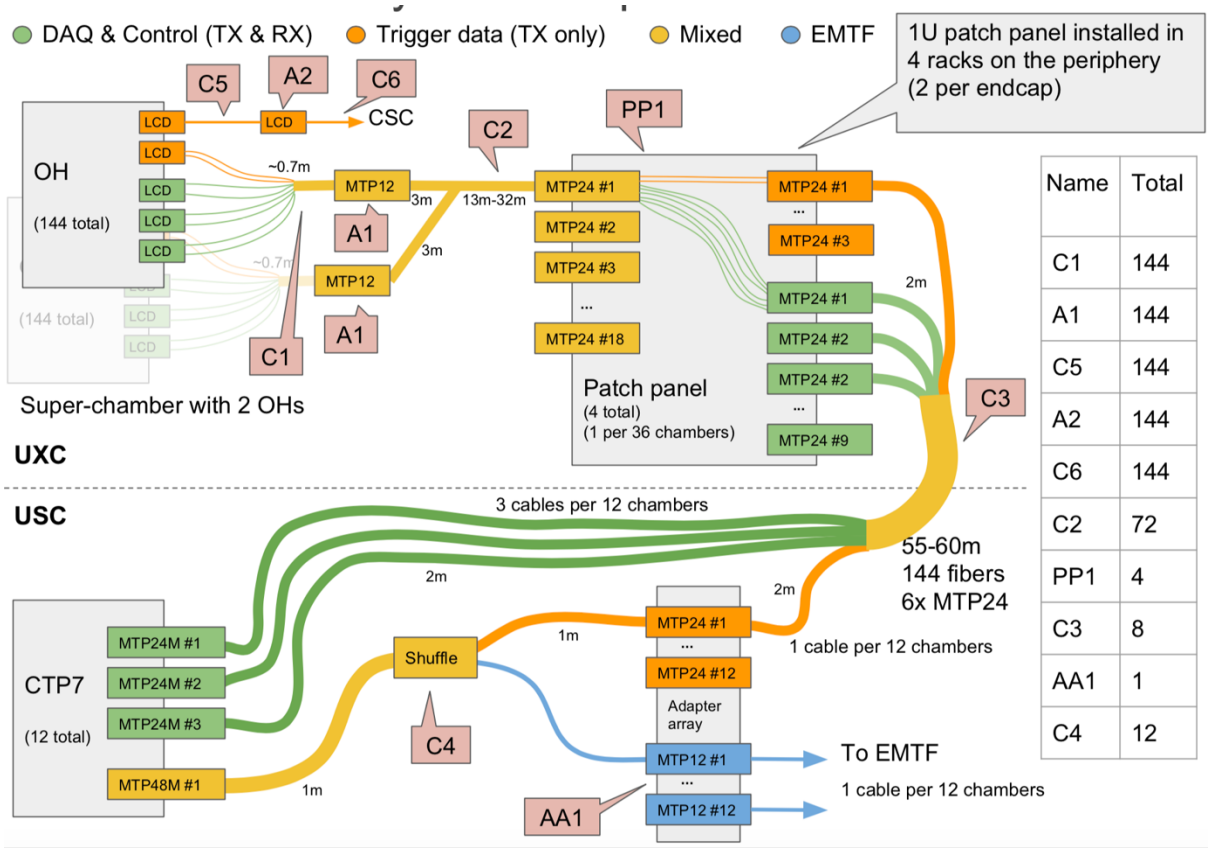
Status of HV3b_v3 production

- 31st of January ordered 500 PCBs to ASPOCOMP
  - At Hybrid S.A 1st days of March
    - Not the highest quality but bonding could be made on ~450 of them -> ordered 4500 more
- PO for 4500 pieces sent on March 26, expecting 400 PCBs on April 24 (then 1300 every 20 wd).
- 1st production batch
  - 111 pieces on April 25
  - 133 pieces on May 8
  - 300 pieces on May 20 -> ENIG problem at ASPOCOMP
- We visited ASPOCOMP on June 13
- Now ASPOCOMP uses a subcontractor for the ENIG
  - Production resumed
  - 1849 hybrids received at CERN on June 17, good quality according to Hybrid S.A. (HSA)

HV3b_v3 production planning

- 3840 hybrids needed for GE1/1
  - In hands ~900 assembled hybrids (489 under QC)
  - 2020 PCBs at HSA for assembly
    - Expected yield after assembly: 96% (to be confirmed with latest batch)
    - Expected final yield after QC: 94% (to be confirmed with latest batch)
  - Together this amounts to: ~2900 hybrids
    - 50% more than needed to complete 1 endcap
  - 1200 additional PCBs are expected to be shipped out by ASPOCOMP within one week
  - Assembly schedule:
    - 500 done by July 5 (week 27)
    - Then another 500 each following week

Fibres



Name	Total
C1	144
A1	144
C5	144
A2	144
C6	144
C2	72
PP1	4
C3	8
AA1	1
C4	12

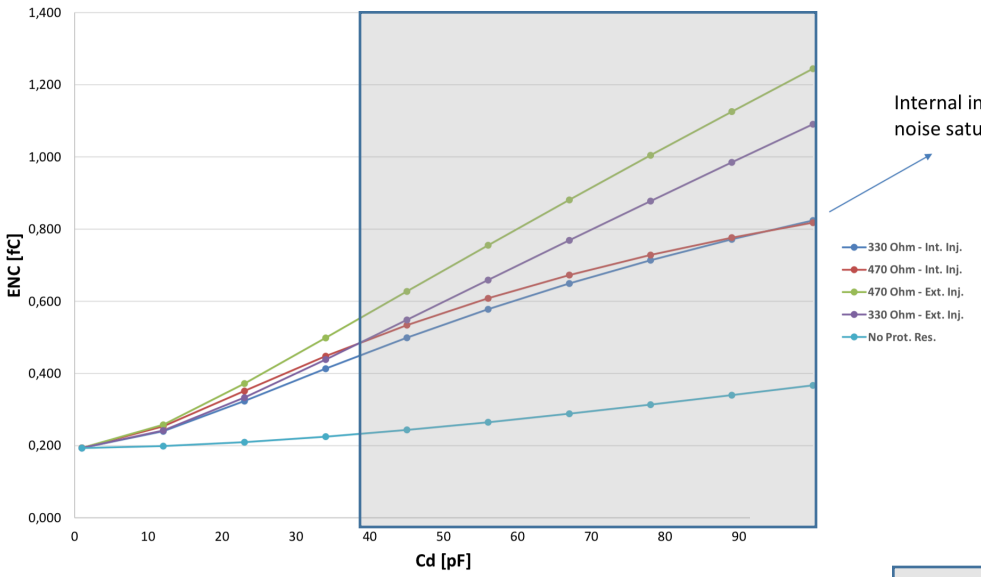
- All components received
- All C2, C4 & C6 tested & labelled
- C3 should be done by the end of the week
- All patch panels tested

Summary

- Several issues slowed down the production of the HV3b_v3
  - ~900 assembled hybrids available now and being used for chambers assembly
  - ASPOCOMP has found a solution to their ENIG issue, we got now more than 2000 new PCBs
    - We are confident to have enough in time for the 1st endcap.
- GEBs
  - 85 short and 90 long GEBs have been manufactured
    - 30 + 15 at 904 for chamber assembly
- OH
  - 120 have been manufactured
  - 55 fully qualified
  - 30 to be tested
  - 30 soon at assembly
- GEBs & OH integration
  - Slower at the beginning but now in cruising mode
    - Hick-ups at the beginning: rework of standoffs, SW/FW issues, …
    - Constantly improving the QC (along with QC7 and QC8)
      - Requires development of SW and FW
      - Adding test: burn-in, temperature cycles, overnight runs
- Next milestone: all components for 1st endcap qualified by end of July

VFAT3 with input protection

ENC vs Cd

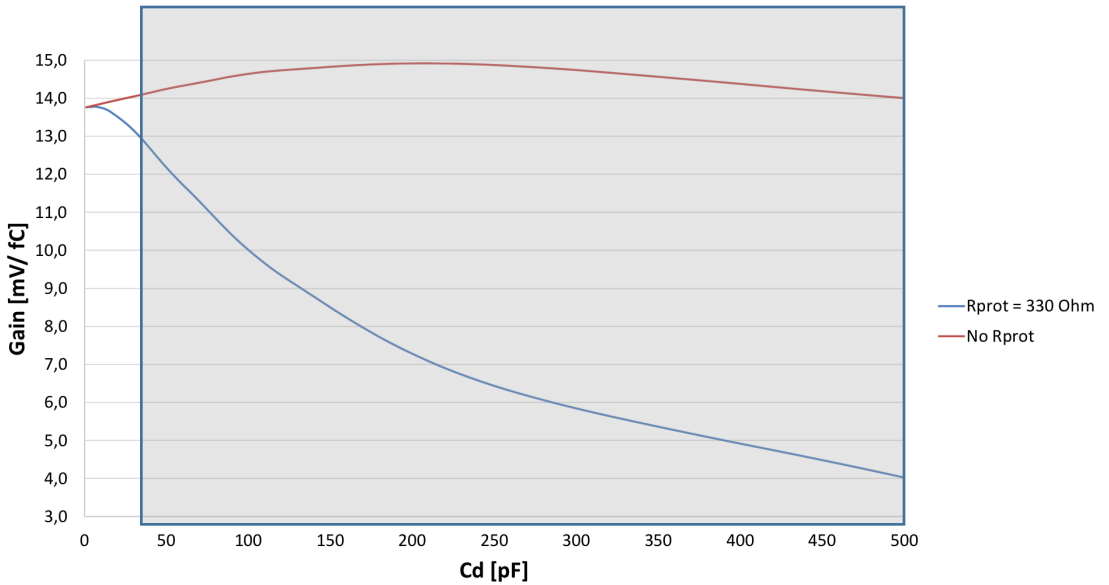


Internal injection: noise saturation

GE1/1 Cd < 30 pF

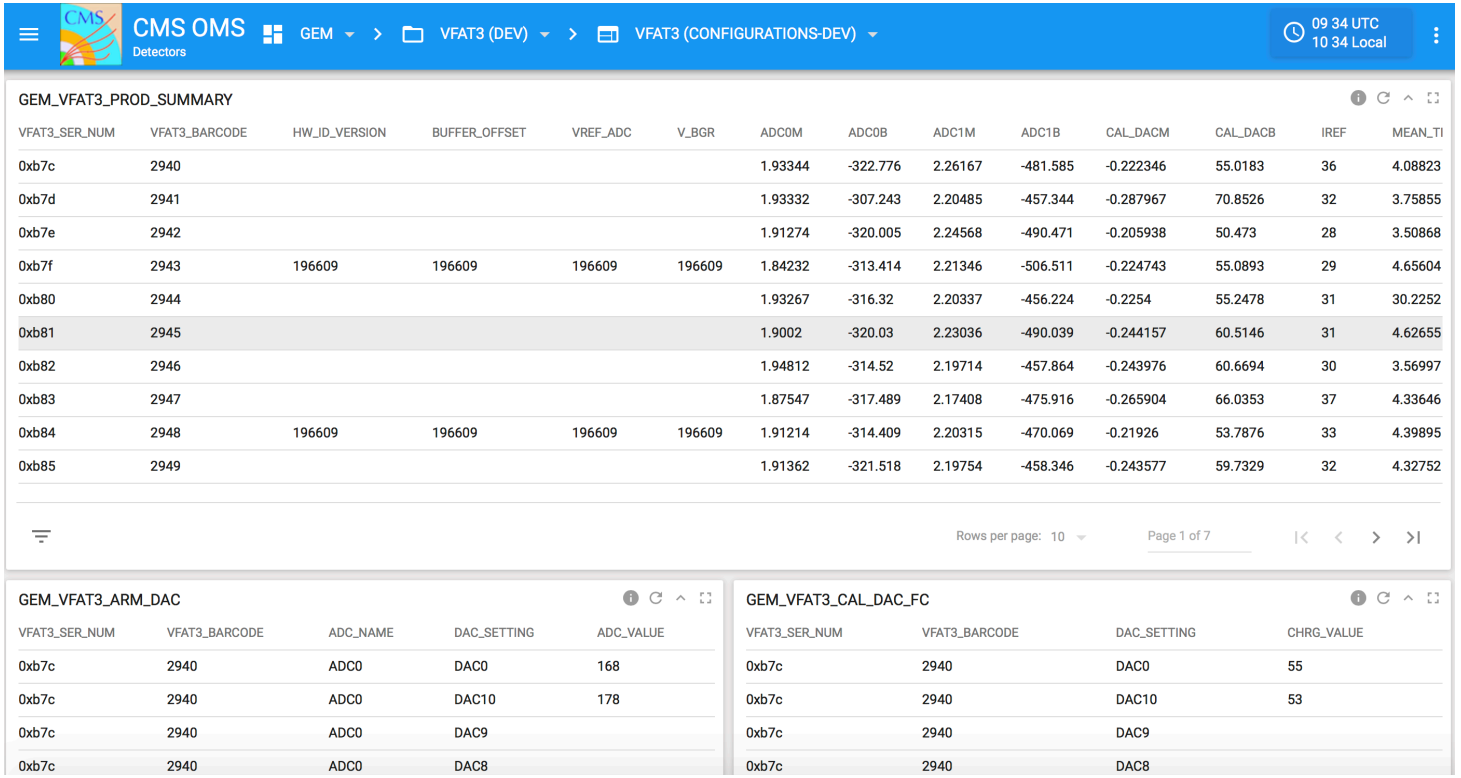
Gain vs Cd

Gain loss < 7%



Construction database

- VFAT3 tables fully functional:



- OH and GEB tables being implemented by DB experts
  - Use local database for the time being