GCU mass production and LPMT full electronics chain tests @ 昆山 (Kunshan)

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Politecnico Milano 6th May, 2022

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Recap

- GCU mass production has started in September 2021

- We are doing the full-chain integration test during production:
  - To perform quality-control assurance and verify the performances before shipping them to the JUNO site for installation in the detector

➢ A great opportunity and challenge to perform a combined test of electronics, DAQ, Trigger and reconstruction software + event building
➢ Allows to debug the firmware with a large number of GCUs

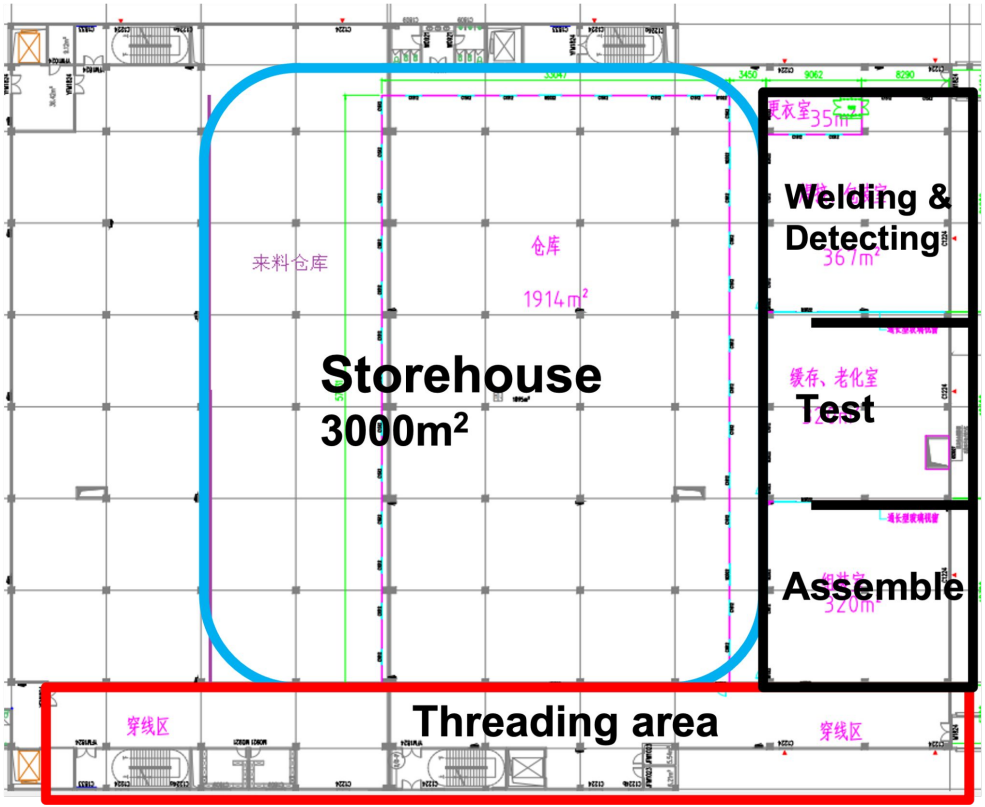
Electronics chain - some numbers

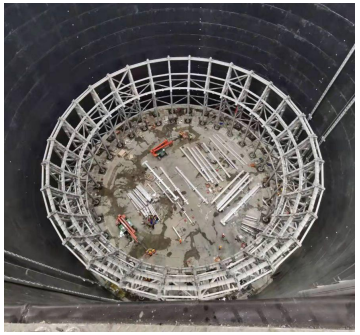
- all electronics components of the DAQ chain have to be tested
  - 7000 GCU
  - 176 BEC
  - 8 RMU
  - 1 CTU
  - 325 Power supply

full JUNO electronics chain

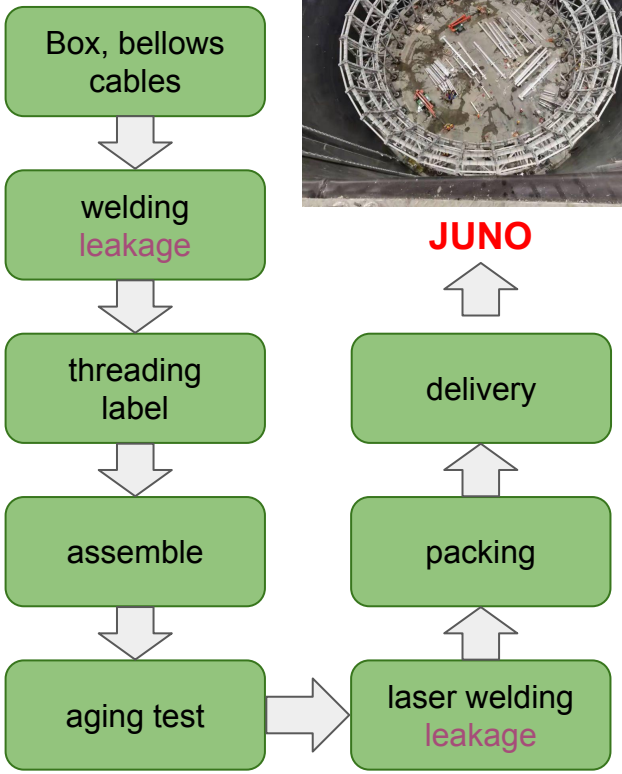
- full chain integration tests with now 344 GCUs in parallel on 9 shelves connected to 9 BEC, 1 RMU and 1 CTU
- 60 GCUs (1.5 shelves) exchanged per day in normal production

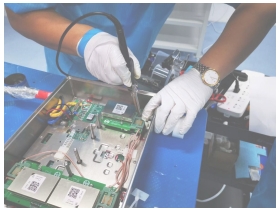
The assembly and test area

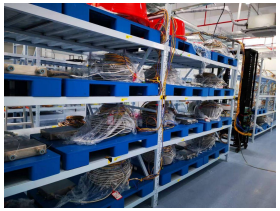




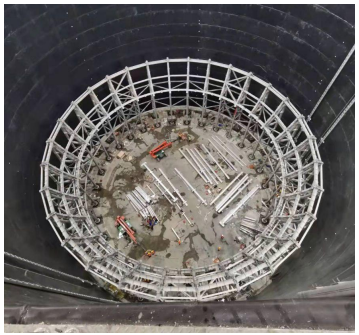
JUNO

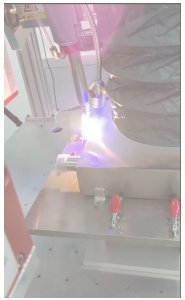






Box, bellows cables → welding leakage → threading label → assemble → aging test → laser welding leakage → packing → delivery → JUNO





The kunshan 昆山 test area

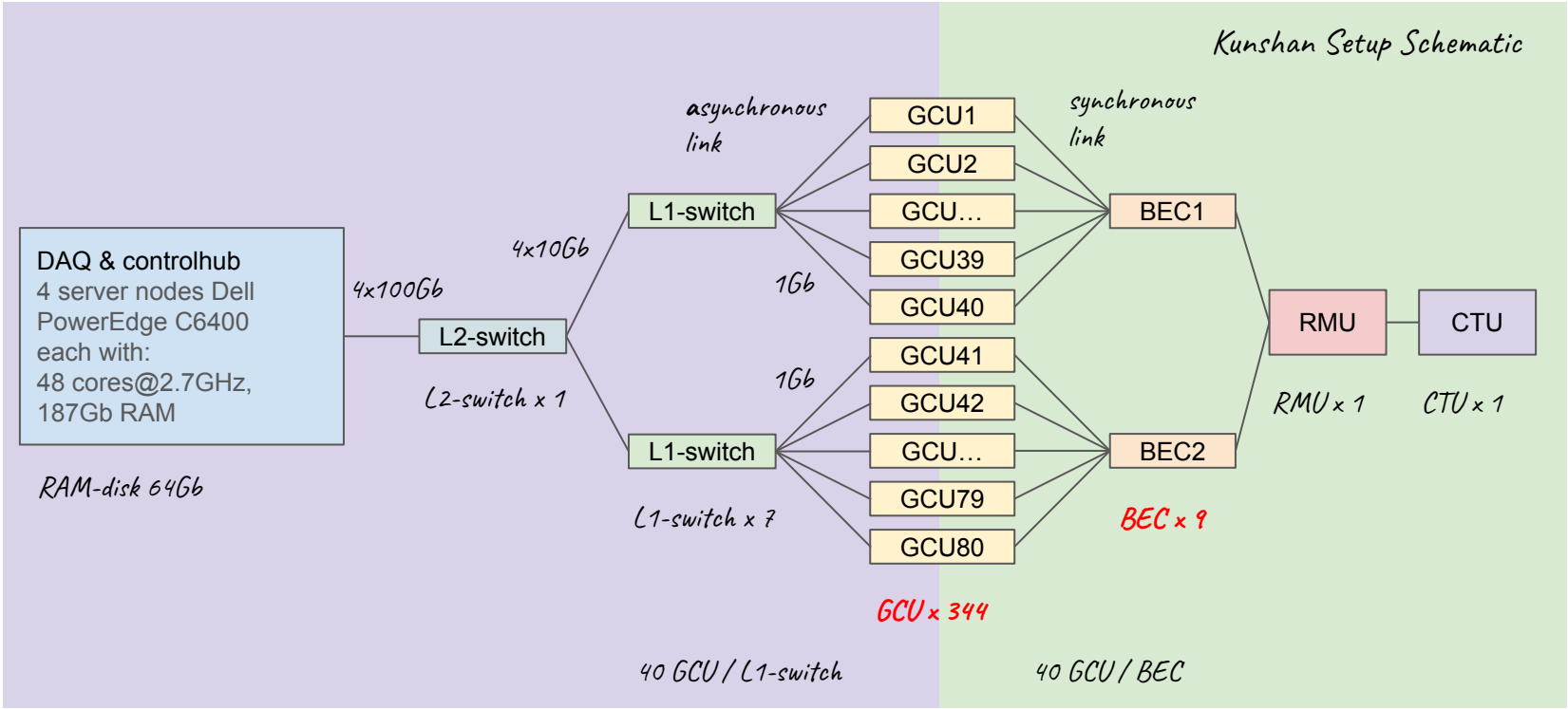
September 2021

The kunshan 昆山 test area - the shelves are filled now

Installation of GCUs in the Test room

- assembled GCUs are put on 9 shelves (344 max)
- Racks in between the shelves with
  - ethernet switches (async.)
  - white-rabbit switch
  - BECs (sync.)
  - RMU
  - CTU
- 60 GCUs exchanged per day in normal production
- Kintex7 firmware flushed for aging test

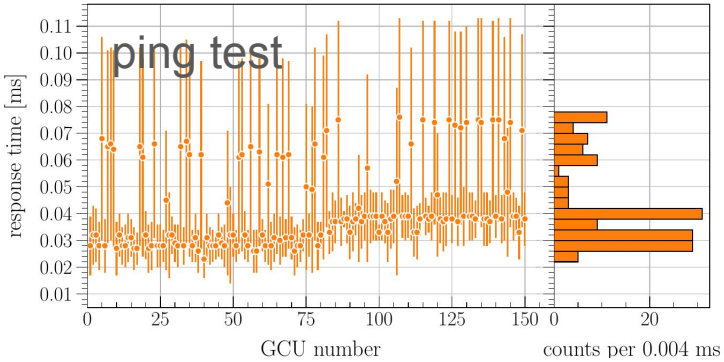
Electronics chain test @ Kunshan

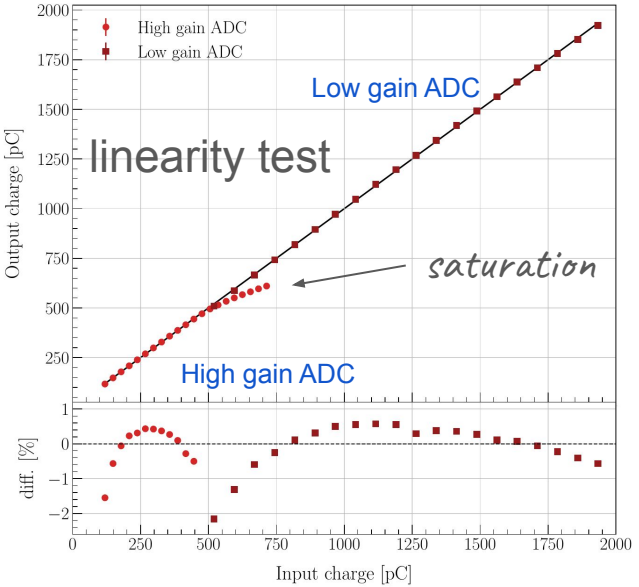


asynchronous

synchronous

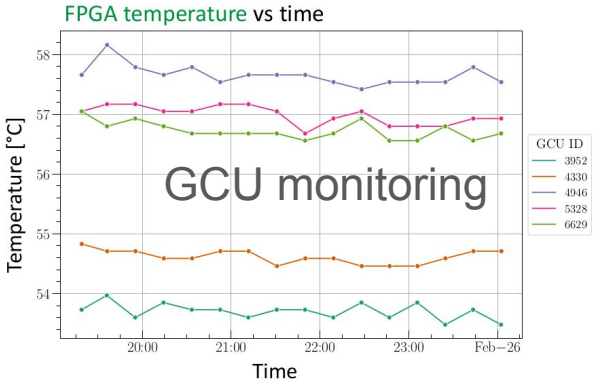
Test Protocol

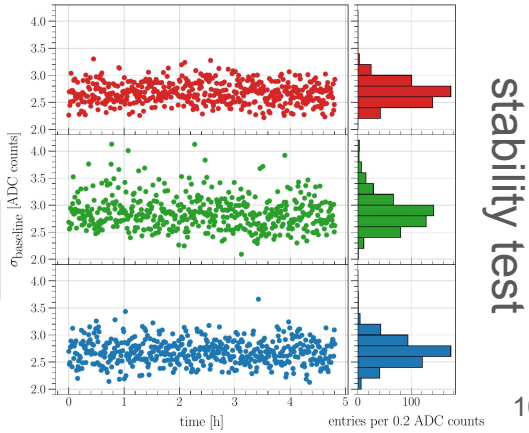




Daily shift

- Test1 - ping test
- Test2 - linearity test (see talk Beatrice Jelmini)
  - now with BEC error monitoring
- Test3 - stability test
  - now with BEC error monitoring
- Test4 - GCU monitoring





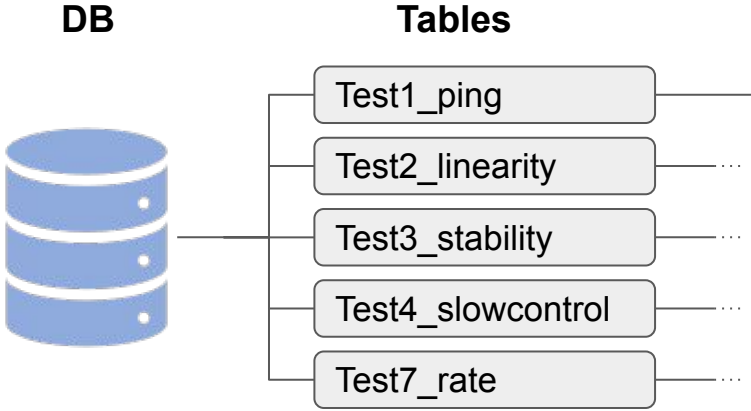
Special measurements

- Test6 - DDR3 test
- Test7 - rate test
  (see talk Andrea Serafini)

Andrea Serafini's work

Indexing tests results: an SQL database

- Results, setup and configuration information from Test 1, 2, 3, 4 and 7 are indexed and included in a SQL database (DB).
- GCUs and tests are uniquely identified by run number, date, time and GCU ID.
- The DB has a table for each Test type. Each table has an index for each information or plot available for that particular test.



Indexes

gcu_num	gcu_id	pkt_loss	avrg_time	avrg_time_dev	run	date
1	6959	0	0.065	0.037	run0	20211108
2	7443	0	0.033	0.009	run0	20211108
3	6957	0	0.031	0.007	run0	20211108
4	7235	0	0.027	0.006	run0	20211108
5	6990	0	0.055	0.033	run0	20211108
6	7155	0	0.053	0.034	run0	20211108
7	7422	0	0.028	0.007	run0	20211108
8	7319	0	0.031	0.004	run0	20211108
…	…	…	…	…	…	…

slide credits Beatrice Jelmini

Testing procedure

Daily shifts

- ✓ Shift at the end of production covered by Kunshan (6h)
- ✓ Evening/Night shifts covered by Padova (6h)
  - GCU setup
  - Test1 - ping test
  - Test2 - linearity + Test4 monitoring
  - Test3 - stability + Test4 monitoring
- ➢ alternating high and low gain ADC
- ➢ dedicated special measurements

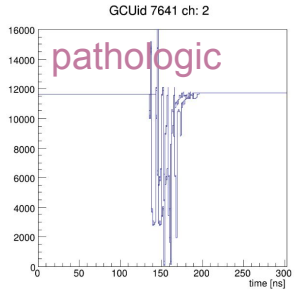
April

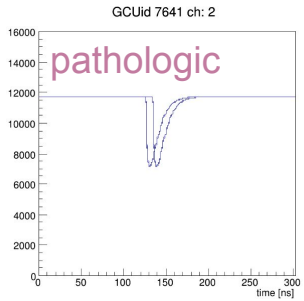
			Measurements						
			(Test1)	Linearity (Test2)		Stability (Test3)		(Test4)	External
	Time (BJ)	Shifter	Ping	High gain	Low gain	High gain	Low gain	Monitoring	disk
2	0 - 6 am	Andrea	run0	run2		run0 - 5h		run0 - 5h	10T
3	0 - 6 am	Andrea	run0		run1		run0 - 5h	run0 - 5h	10T
4	0 - 6 am	Alberto	-	-		-		-	
5	0 - 6 am	Andrea	run0		run0		X	X	10T
6	0 - 6 am	Alberto	run0	run0		run0 - 5h		run0 - 12h	10T
7	0 - 6 am	Beatrice	run0		run0		run0 - 3h	run0 - 3h	10T
8	0 - 6 am	Beatrice	run0	run0		run0 - 7h		run0 - 7h	10T
9	0 - 6 am	Andrea	run1		run2		run2 - 7h	run2 - 7h	10T
10	0 - 6 am	Beatrice	run0	run0		run0 - 7h		run0 - 7h	10T
11	0 - 6 am	Alberto	run1 [10.04]		run1 [10.04]		run1 [10.04] 9h	run1 [10.04] 10h	10T
12	0 - 6 am	Andrea	run0	run0		run0 - 7h		run0 - 7h	10T
13	0 - 6 am	Kate	run1		/	run1 - 72h (killed)		run1 - 72h	10T
14	0 - 6 am	Kate	run0	/		run0 - 6gg		run0 - 6gg	10T
15	0 - 6 am	Beatrice	/		/	864 running	/	OK (1032)	10T
16	0 - 6 am	Beatrice	/	/		864 running		OK (1032)	10T
17	0 - 6 am	Kate	/		/	858 running	/	OK (1032)	10T
18	0 - 6 am	Kate	/	/		858 running		OK (1032)	10T
19	0 - 6 am	Kate	/		/	837 running	/	OK (1032)	10T
20	0 - 6 am	Kate	run0		run0		run0 - 4h	run0 - 4h	10T
21	0 - 6 am	Andrea	run0	run0		run0 - 7h		run0 - 7h	10T

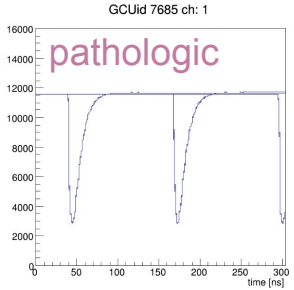
- GCU setup, all tests and analysis are automatized
- Alarm via WeChat if GCU temperature above threshold

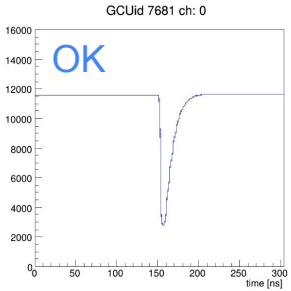
GCU firmware debugging and testing

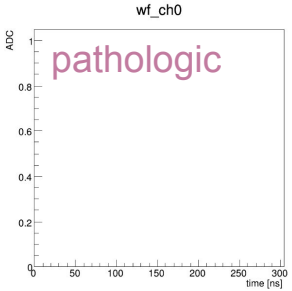
- Firmware at beginning of production with a lot of problems
  - Not aligned trigger
  - Bitflips
  - Empty files
  - Empty waveforms
  - Missing header/trailer
- After some debugging cycles
  - bugs resolved
- Test new features
  - IPbus switch high/low gain ADC
  - Global trigger from CTU
  - QT stream
  - Global trigger with test pulse

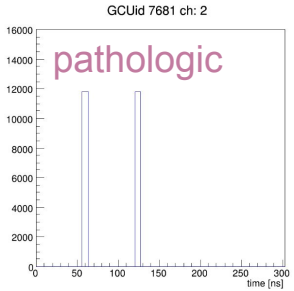


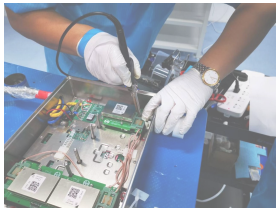












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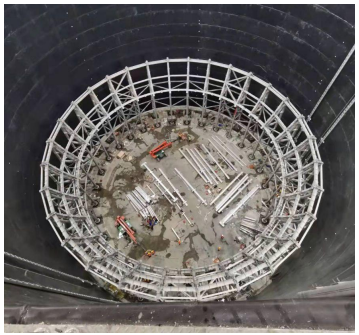
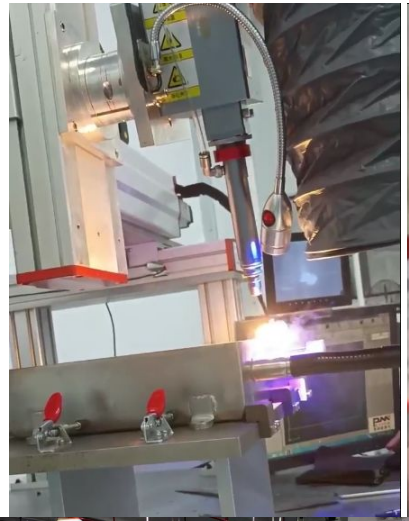
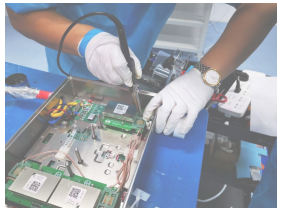


Laser welding + leak checking

- welding speed 20mm/s
- some GCUs had leakage after laser welding
- laser welding done twice now
- double welding procedure tested in pressure chamber at ihep
- leak check is the bottleneck of production (~30/day)
- leak check machine broke and needed repair (took a long time)
- leak check after welding had stopped for some time
- new machine ordered, still waiting for it





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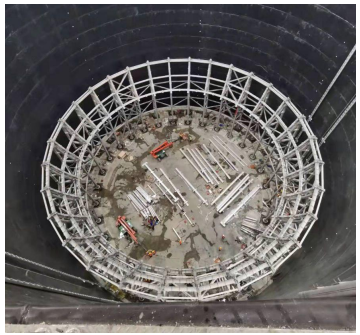

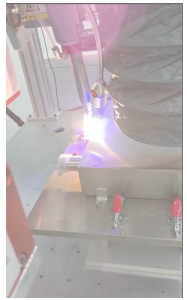

Packaging and delivery

- Packed GCUs ready for delivery: 2154
- GCUs will be stored close to JUNO in a dedicated storage site (2-3km)
- Easier to move GCUs to JUNO during production if roads should be blocked / new COVID lock down etc.
- Also production has different order than installation GCUs not ordered at Kunshan
- Delivery foreseen to start in August

Production numbers

- GCUs (out of 7000)
  - assembled: 4396
  - aged: 3992
  - welded: 3725
  - packed: 2154
- BEC aged: 64 out of 176
- Power supply aged: 220 out of 325
- RMUs still need to be shipped to ihep and then moved to Kunshan

- production started mid September 2021
- interrupted for COVID lockdown since 4th of April
- Leak check already restarted
- Few workers on site at the moment
- Normal production will restart next week

Conclusion

- Mass production of LPMT electronics and full chain tests started mid September @ Kunshan
- Weekly meetings on Tuesday morning 9am CEST / 3pm Beijing time
- Daily shifts with protocol for testing
- Due to COVID lockdown production has stopped on for one month now
- Production restarts next week
- End of production foreseen end of June
    - Leak check will take longer (bottleneck)
- Delivery starting in August to a storage house 2-3km from Juno site

Some impressions from production