Mass testing of the Large PMT electronics

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for the Padova group

JUNO-EU

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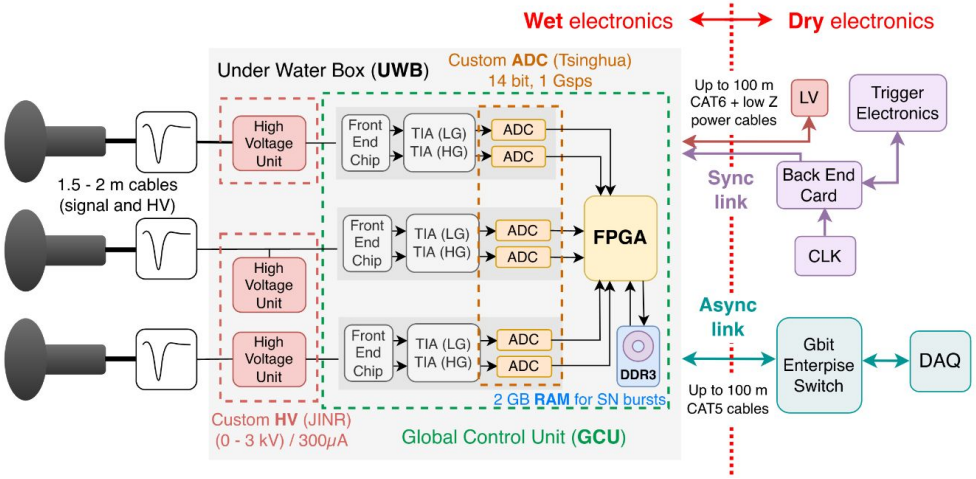
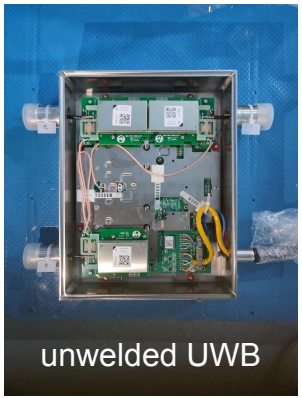
Ministry of Foreign Affairs
and International Cooperation

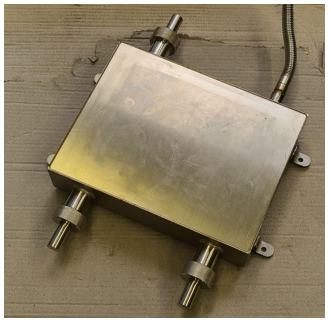
Reminder

- 20.021 LPMTs in JUNO: signal read-out and operation is managed by Underwater Boxes
- each UWB has 3 channels GCU + HV
  - digitization of waveforms close to voltage divider
  - HV operation
- UWB production is completed

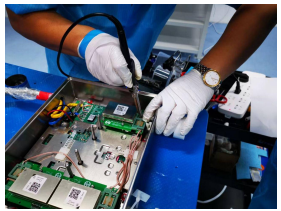




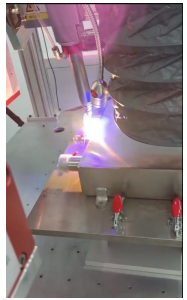
laser welded UWB



Mass production @ 昆山 Kunshan

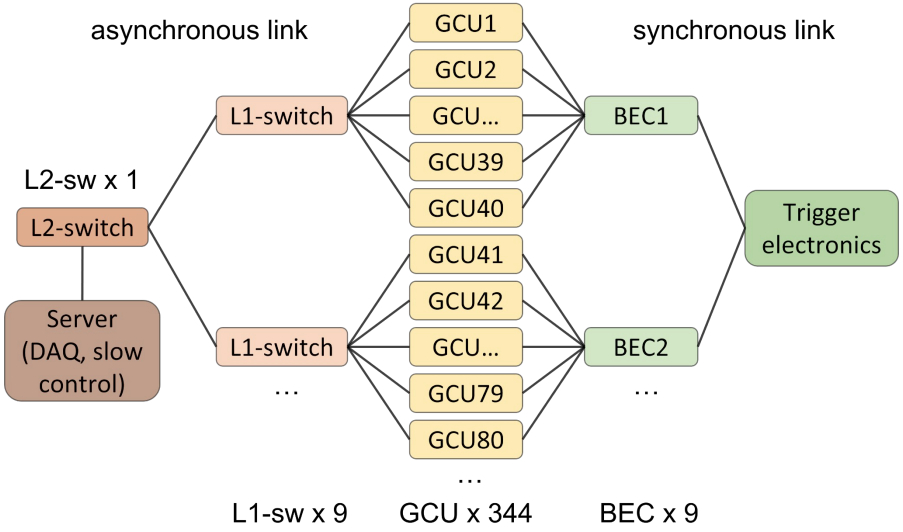


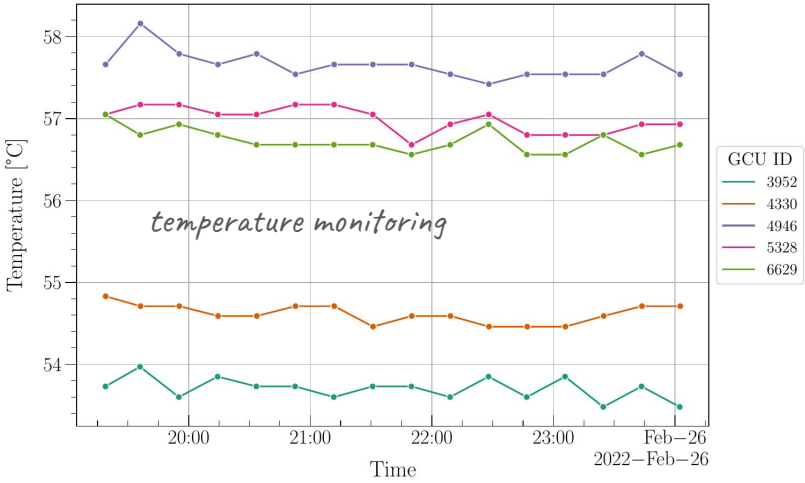
Box, bellows cables → welding leakage → threading label → assemble → aging test → laser welding leakage → packing → delivery → JUNO



昆山 Kunshan - test setup

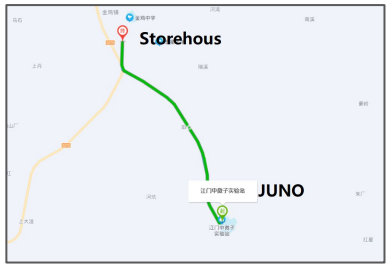
- test up to 344 GCUs in parallel with the test setup in Kunshan (~5% JUNO)





Mass production summary

- 6903 boxes assembled (6900 required)
- total yield: 99.22%
- Kunshan test setup (280 GCUs) operative until end of the month for further tests
- all UWBs arrived at storage near JUNO site



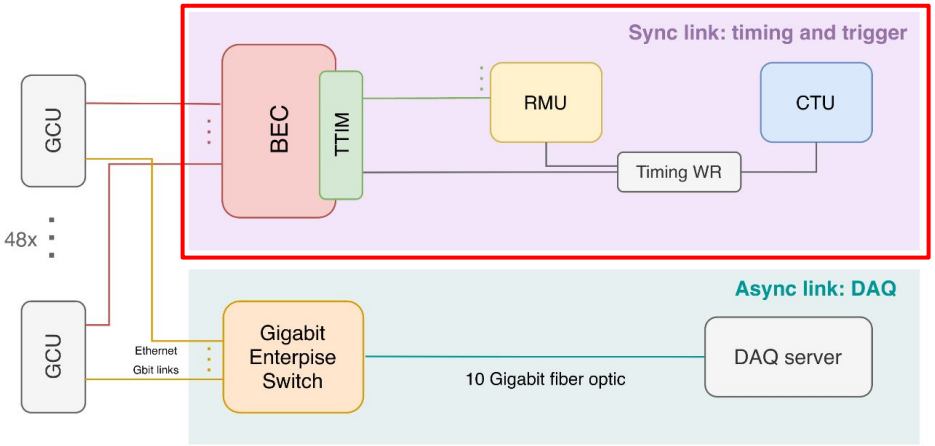
	Total Number	Q&A passed	Yield
Splitter	7100	7037 (single) 7030 (dual)	99.1 / 99.0
GCU board	7050	7001	99.3
GCU mod.	6957	6903 + 48	99.9
Full assembled	6903	6837	99.0

Failure Reason	#
Front-end issue: ADC chips	166
Ethernet readout issue: can't read back anything	33
HV readback value overrange	19
cable soldering	12
backend test	40
others	58
total	328

ca. 230 repaired for VETO

Trigger electronics

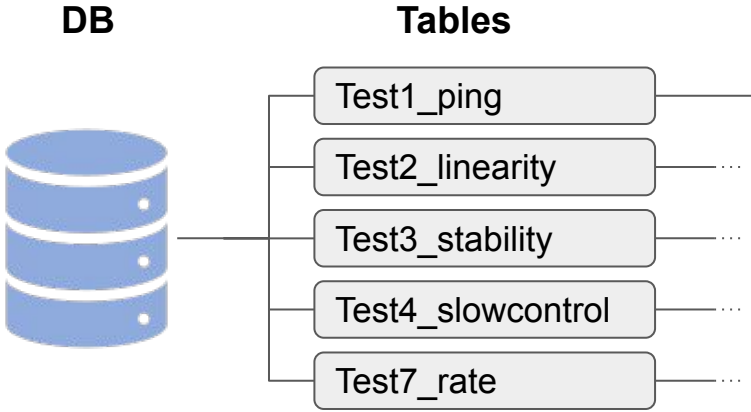
- 176 BEC aged (6 repaired mainly by reflashing the firmware)
- BECs sent to JUNO site
- 10 RMUs shipped to JUNO site
- CTU ready to use



➔ *see talk: Barbara Clerbaux - Monday*

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.



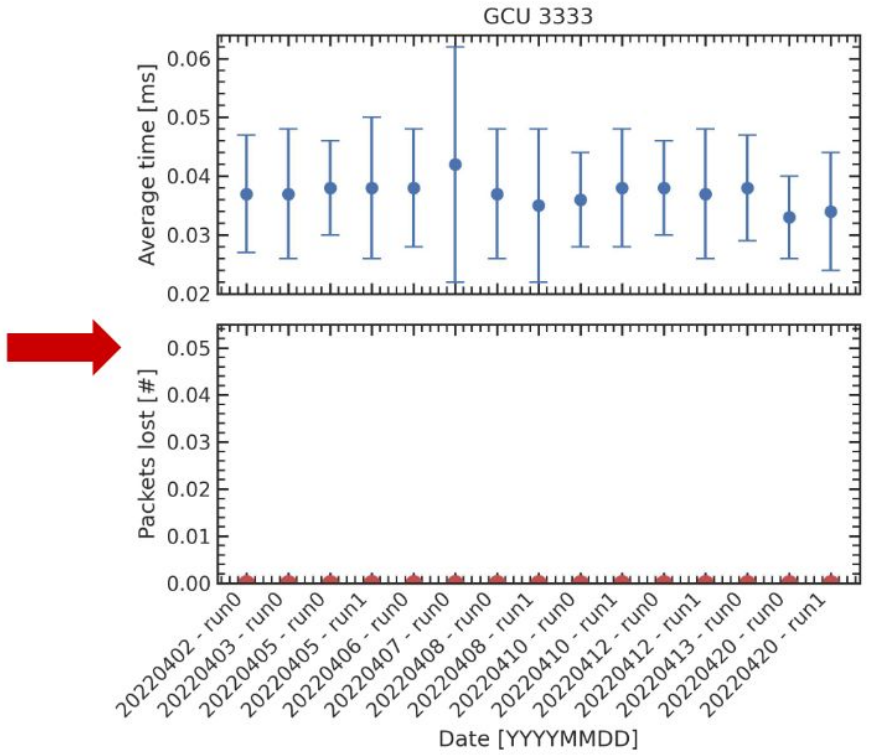
Indexes

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
…	…	…	…	…	…	…

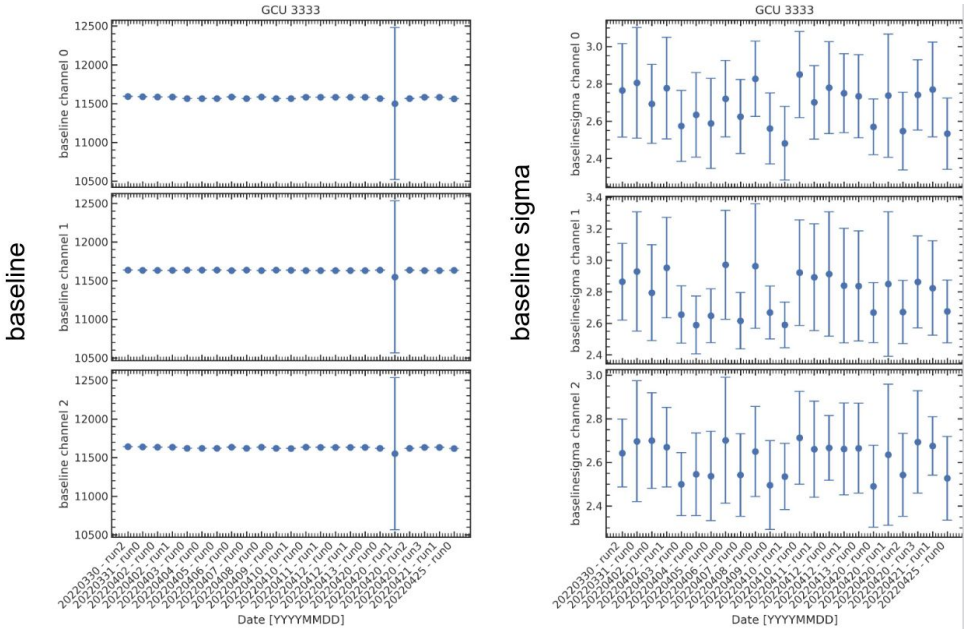
Querying the DB to investigate GCUs' properties

SELECT * FROM Test1 WHERE gcu_id =3333;

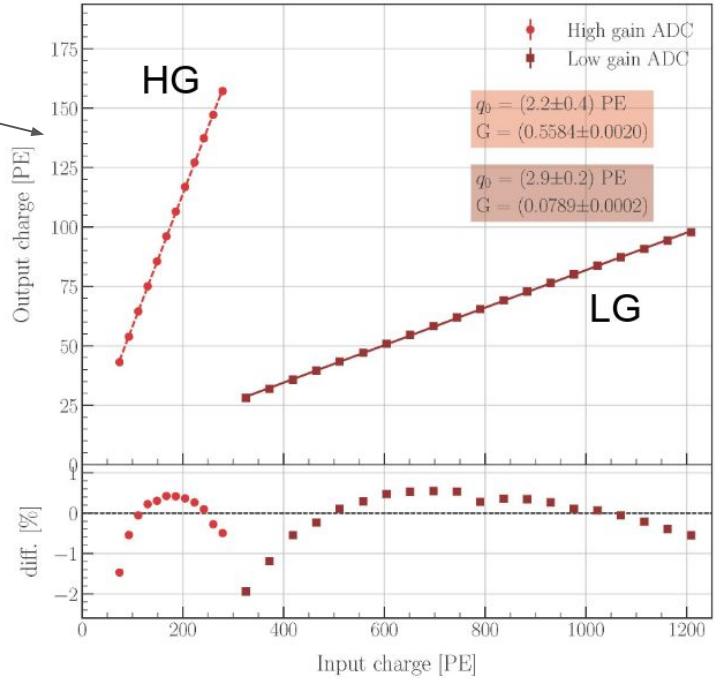
gcu_num	gcu_id	pkt_loss	avrg_time	avrg_time_dev	run	date
125	3333	0	0.037	0.01	run0	20220402
125	3333	0	0.037	0.011	run0	20220403
125	3333	0	0.038	0.008	run0	20220405
125	3333	0	0.038	0.012	run1	20220405
125	3333	0	0.038	0.01	run0	20220406
125	3333	0	0.042	0.02	run0	20220407
125	3333	0	0.037	0.011	run0	20220408
125	3333	0	0.035	0.013	run1	20220408
125	3333	0	0.036	0.008	run0	20220410
125	3333	0	0.038	0.01	run1	20220410
125	3333	0	0.038	0.008	run0	20220412
125	3333	0	0.037	0.011	run1	20220412
125	3333	0	0.038	0.009	run0	20220413
125	3333	0	0.033	0.007	run0	20220420
125	3333	0	0.034	0.01	run1	20220420



Test result



example linearity test results



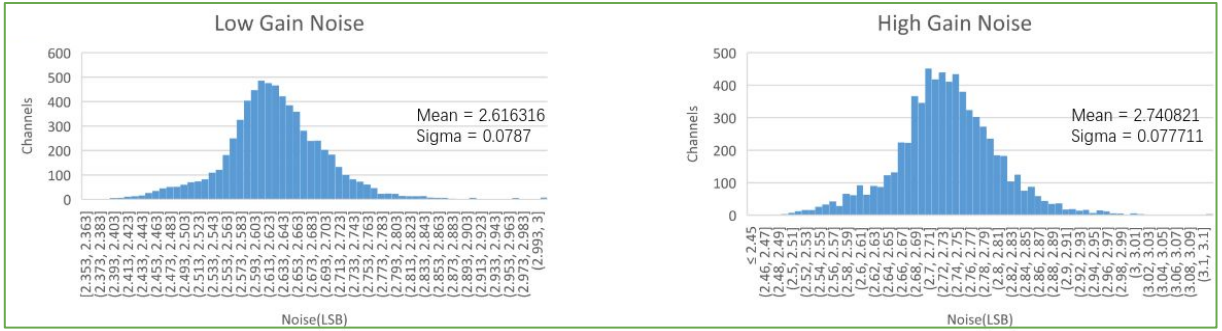
points: [4000,5000,...,24000] DAC counts
~ 75 - 450 PE

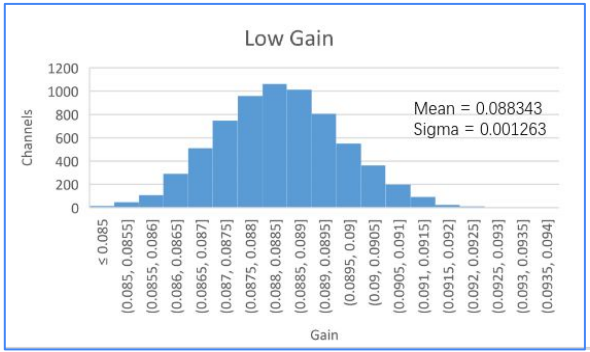
- results can be queried from database
- test results within requirements
- non-linearity < 1%

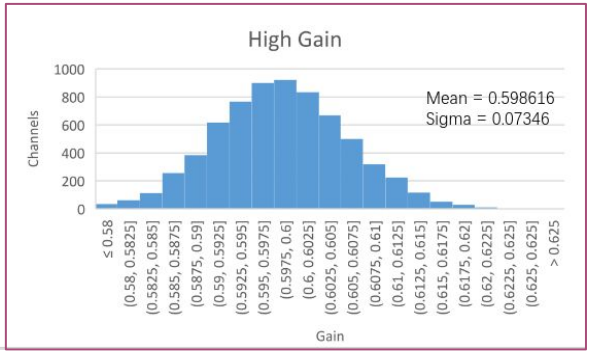
Test results - gain distribution

- results well within requirements

Parameter	Acceptance range
baseline	11000 - 12000 ADC counts
noise	2 - 4.5 ADC counts
high-stream gain	0.5 - 0.65
low-stream gain	0.05 - 0.095







JUNO site - SAB (surface assembly building)

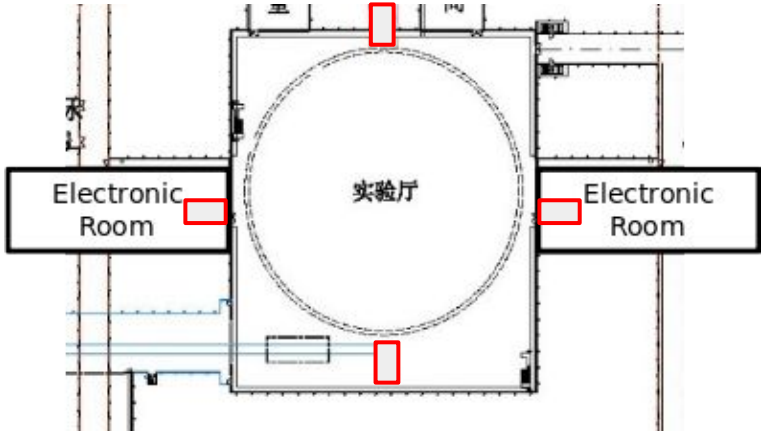
above ground

- transport GCUs to SAB for testing
- there is a clean room and a dark room
- GCUs will be tested with proper PMTs attached
- test full chain with 20 boxes at once

- test 40 GCUs / day and 120 PMTs
- test protocol TBD

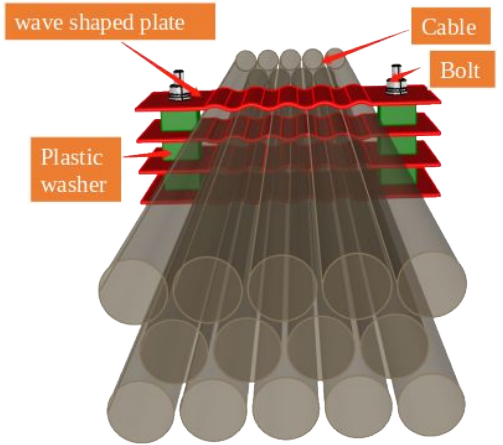
JUNO site - Installation underground

4 corrugated pipe straighteners



underground

- transport the LPMT electronic boxes on top of the pool
- straighten corrugated pipe and transport electronics box to installation area
- fix electronics box to steel structure
- arrange cables and fix with wave shaped plate
- problematic components can be exchanged on the spot



credit: Fan Lei

Installation procedure - channel matching

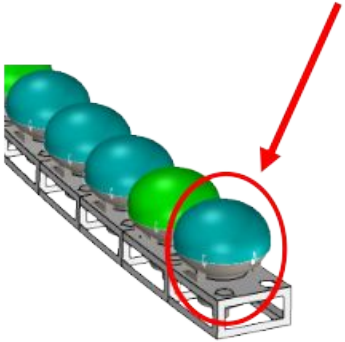
Module_Label

CID: P2

MID: GJ-N33-01 (1/5)

PID: N-33-114-WW-N

ElecCH: N-33-113-WW-N (2)



ElectronicBox_Label

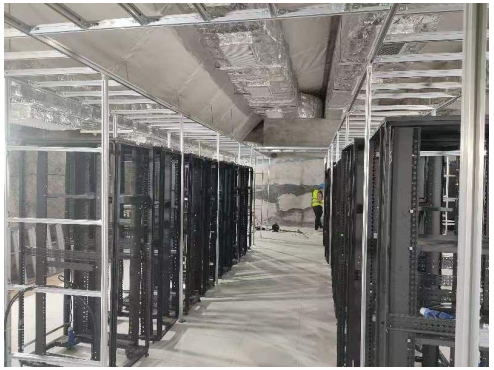
InsID: ?

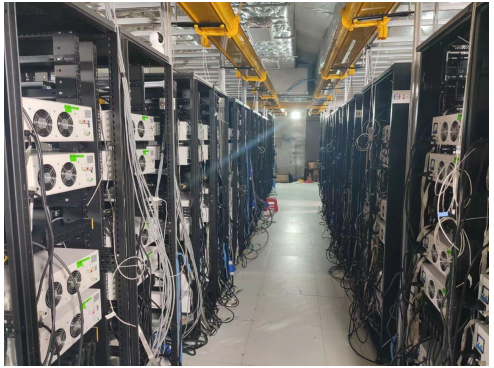
ElecCH: N-33-113-WW-N

BC:20

JUNO site - electronics room

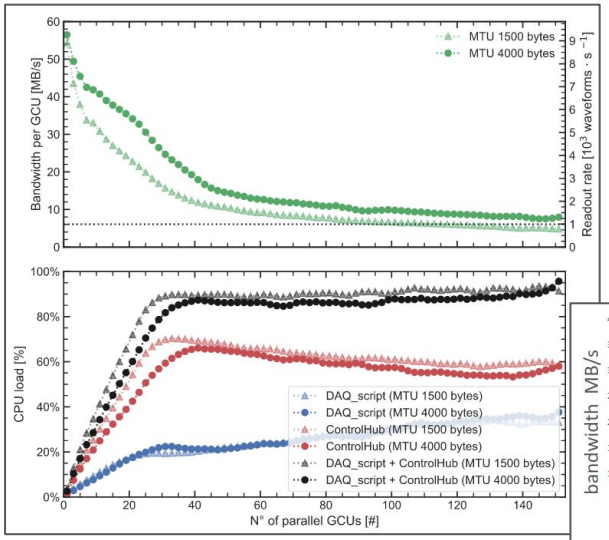
- electronics room ready
- all racks (from Daya Bay) installed
- clean ground issue resolved with installation of White Rabbit
- network is set up
- DAQ and DCS can be connected to remotely through ihep





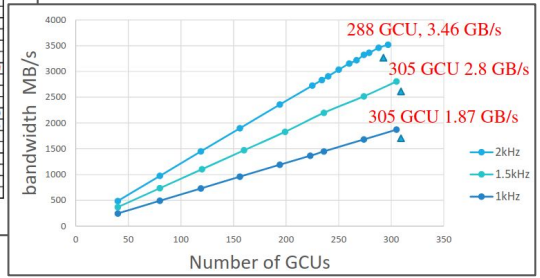

GCU firmware review

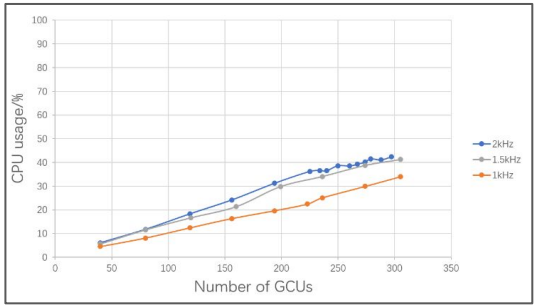
- Two firmware builds available
  - IPbus based: development since 2016
  - TCP/IP based: development since January
- Equivalent technical capabilities
- Different in used resources management and maturity
- decision postponed to next collaboration board



IPBus based

TCP/IP based

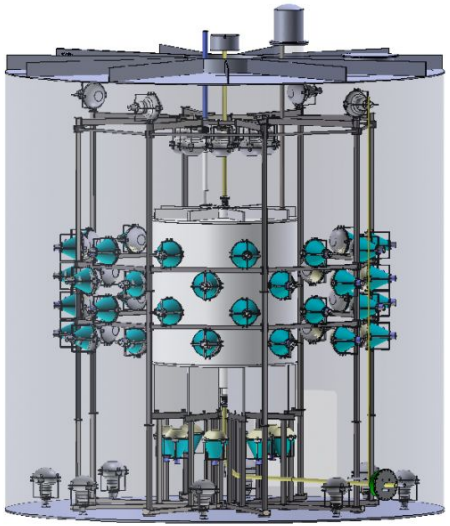




LPMT spares for Osiris

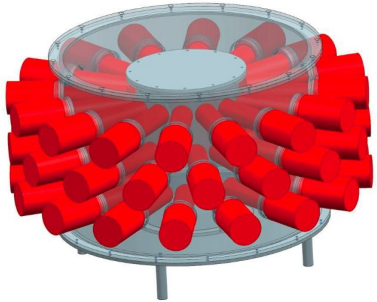
- OSIRIS PMTs not usable
- JUNO electronics + PMT spares:
  75 PMTs / 25 GCUs + 1 BEC
  will be used for OSIRIS
- Software development to be conducted with the Legnaro Mini-JUNO setup
  (48 channels - 16 GCUs)

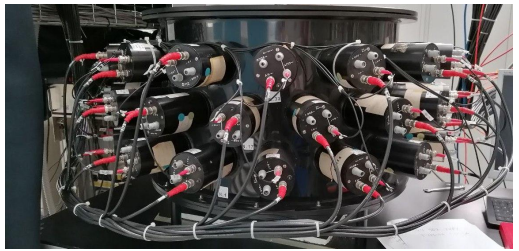
➔ *see talk: Kai Loo - Monday*



OSIRIS

Legnaro Mini-JUNO





Papers - 3 subgroup articles

Validation and integration tests of the JUNO 20-inch PMTs readout electronics

Vanessa Cerrone[a], Katharina von Sturm[a,b,*], Marco Bellato[b], Antonio Bergnoli[b], Riccardo Brugnera[a,b], Chao Chen[c], Barbara Clerbaux[d], Alberto Coppi[a], Flavio dal Corso[b], Daniele Corti[b], Jianmeng Dong[e], Wei Dou[e], Lei Fan[c], Alberto Garfagnini[a,b], Guanghua Gong[e], Marco Grassi[a,b], Cong He[c], Jun Hu[c], Roberto Isocrate[b], Beatrice Jel… Zehong Liang[c], Ivano Lippi[b], Hongb… Filippo Marini[a,b], Zhe Ning[c], Mariia Redchuk[b], Andrea Serafini[a,b], Yangfu Wang[c], Yusheng Wan… Xiaochuan Xie[c], Benda Xu[c], Chuan…

Implementation and performances of the IPbus protocol for the JUNO Large-PMT readout electronics

Riccardo Triozzi[a], Andrea Serafini[a,b,*], Marco Bellato[b], Antonio Bergnoli[b], Matteo Bolognesi[a,b], Riccardo Brugnera[a,b], Vanessa Cerrone[a], Chao Chen[c], Barbara Clerbaux[d], Alberto Coppi[a], Flavio dal Corso[b], Daniele Corti[b], Jianmeng Dong[e], Wei Dou[e], Lei Fan[c], Alberto Garfagnini[a,b], Guanghua Gong[e], Marco Grassi[a,b], Cong He[c], Jun Hu[c], Roberto Isocrate[b], Beatrice Jelmini[a,b], Xiaolu Ji[c], Xiaoshan Jiang[c], Fei Li[c], Zeho… Shenghui Liu[c], Xuewei Liu[c], Daibin Luo[c], Ronghua Luo[f], Fil… Pierre-Alexandre Petitjean[d], Alberto Pitacco[b], Mengyao Qi[c], L… Mariia Redchuk[b], Yunhua Sun[c], Andrea Triossi[a,b], Fabio Verones… Yusheng Wang[c], Yuyi Wang[e], Zheng Wang[c], Ping Wei[f], Jun Weng… Donglian Xu[g,h], Hai Xu[f], Xiongbo Yan[c,i], Ziyue Yan[c], Fengfan …

Mass testing of the JUNO experiment 20-inch PMTs readout electronics

Alberto Coppi[a], Beatrice Jelmini[a,b,*], Marco Bellato[b], Antonio Bergnoli[b], Matteo Bolognesi[a,b], Riccardo Brugnera[a,b], Vanessa Cerrone[a], Chao Chen[c], Barbara Clerbaux[d], Daniele Corti[b], Flavio dal Corso[b], Jianmeng Dong[e], Wei Dou[e], Lei Fan[c], Alberto Garfagnini[a,b], Guanghua Gong[e], Marco Grassi[a,b], Cong He[c], Jun Hu[c], Roberto Isocrate[b], Xiaolu Ji[c], Xiaoshan Jiang[c], Fei Li[c], Zehong Liang[c], Ivano Lippi[b], Hongbang Liu[f], Hongbin Liu[c], Shenghui Liu[c], Xuewei Liu[e], Daibin Luo[c], Ronghua Luo[f], Filippo Marini[a,b], Daniele Mazzaro[b], Luciano Modenese[b], Zhe Ning[c], Yu Peng[c], Pierre-Alexandre Petitjean[d], Alberto Pitacco[b], Mengyao Qi[c], Loris Ramina[b],

➔ subgroup articles about LPMT electronics tests at Legnaro and Kunshan

will be sent out shortly for internal review

Conclusion

- Mass production of LPMT electronics boxes concluded
  - excellent yield of 99.22%
- UWBs and other electronics transferred to storage near JUNO site
- Preparation for installation on-going (start end of this year?)
- Electronics room, SAB, dark room ready for pre-installation tests
- GCU firmware under review
- Spare electronics + PMTs to be installed in OSIRIS
- 3 subgroup papers regarding LPMT electronics tests in Legnaro and Kunshan almost ready to be distributed for review