Schedule and reliability

Xiaoshan Jiang

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FIT Value at 40 ℃ junction temperature

From Zhe Ning

	IHEP FIT (217)	Expected by Future Test	Prediction by Test	Germany (Manufacturer)	Germany (217)[1]	Germany (FIEDS)[2]	Russian (FIEDS)	Value（fit）
HV			5765		27	450	900	>27
Protection	?	?	?	?	?	?	?	~4.5
IHEP FEC		4.5						
Tsinghua ADC		4.5*2						
Vulcan	?	?	?	?	?	?	?	~4.5
GCU[3]	>44							>44
Power Board				39.8				39.8
Cable & Connector	?	?	?	?	?	?	?	~30
Total								>150

Note: 1. 217 is MIL-HDBK-217, Rev. F - Notice 2;
2. FIEDS is French aircraft standard;
3. The calculation of GCU without capacitors and resistors;

For 0.5% requirement, Need 95fit

Questions for the calculation

- 1 Some of the value is expected, such as Vulcan, cable and connector
- 2 HV reliability is very different from many calculation and testing
- 3 The calculation of the reliability of GCU not including all the resistance and capacitor

- Even with something uncertain, but from the expedition, the reliability can’t meet the requirement of physics
- Should we solve this problem?

The possible methods and schedule

- The possible methods
  - 1. lower temperature;
  - 2. Upgrade the reliability of the design itself;
  - 3. The upgraded structure and scheme;
  - 4. the lower requirements from physics;
- The possible schedule
  - the last time for us to make the decision is 2017.4.1, after this time, we almost have no chance to correct the problem if we want to finish on time

lower temperature

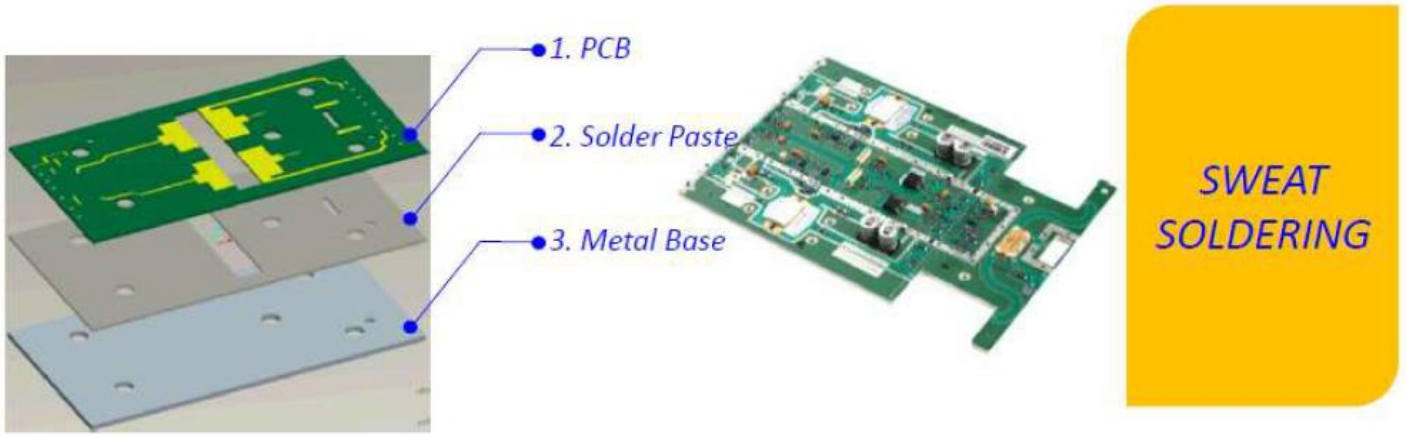
From Zhe Ning

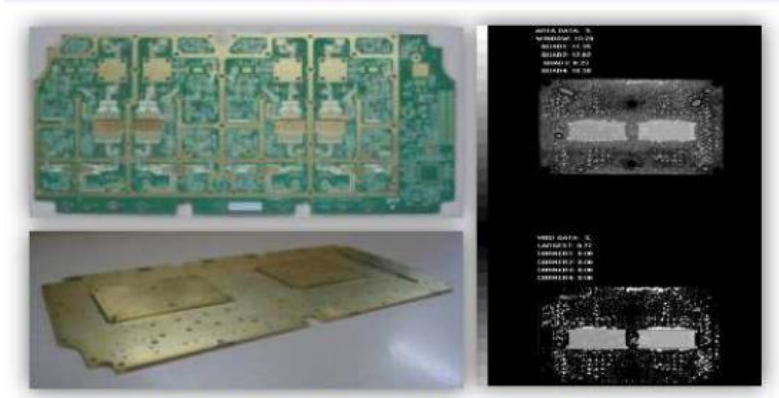
	30 ℃ junction temp.	40 ℃ junction temp.	55 ℃ junction temp.
HV	13	27	80
Protection Circuit	2	4.5	14.8
IHEP FEC	2	4.5	14.8
Tsinghua ADC	2*2	4.5*2	14.8*2
Vulcan	2	4.5	14.8
Main FPGA	1.5	3.4	11
GCU	19	44	114
Power Board	32	40	60
Cable & Connector	30	30	30
Total	81	150	313.6

1. Reliability is sensitive with temperature, we need to make the temperature lower
2. Because of the thermal resistance, it maybe difficult to make the junction temperature lower then 30 ℃

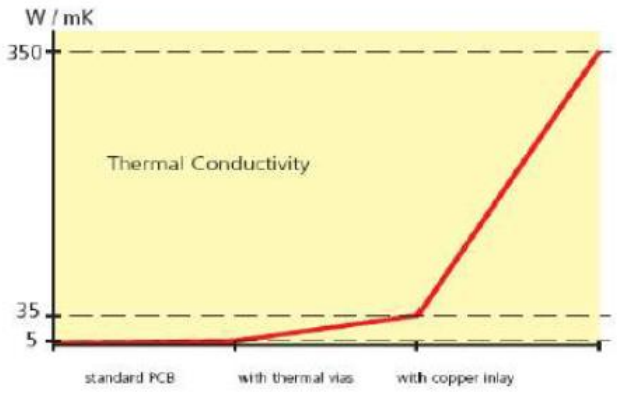
Efficient heat radiation method

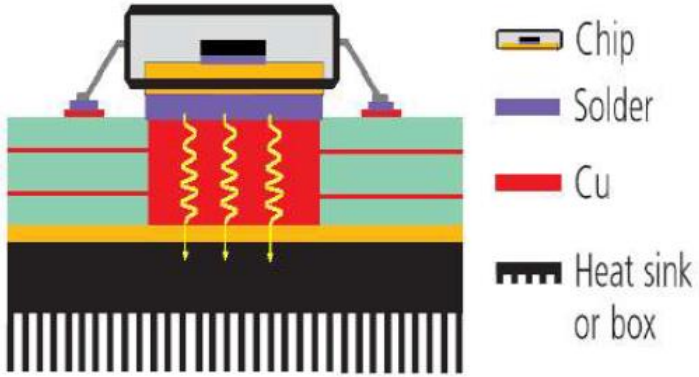
深圳中科系统集成技术有限公司
SHENZHEN ZSIPAK TECHNOLOGIES CO., LTD.





Partial Metal Base with Sweat-soldering

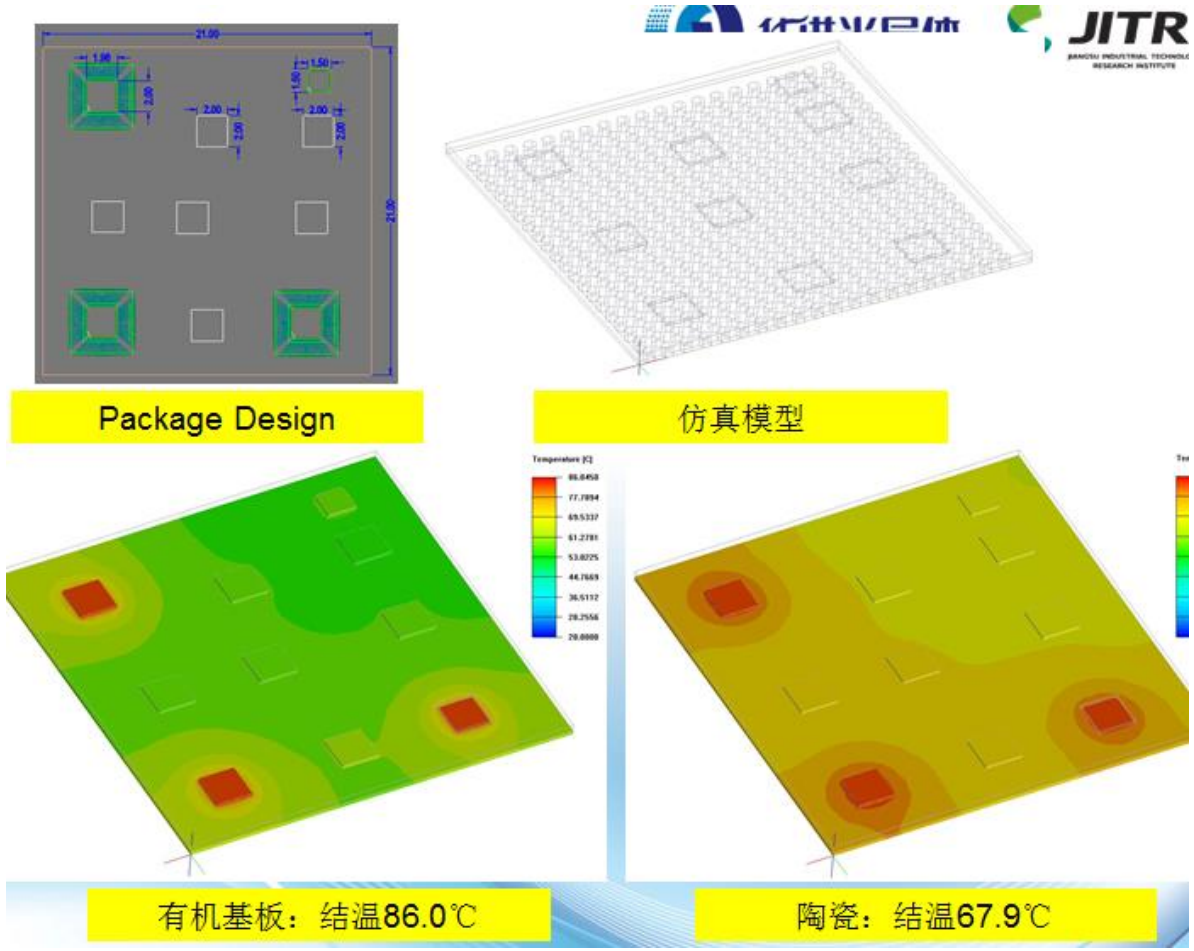




Copper & Aluminum Combined with Sweat-soldering

The junction temperature

- For the PCB is ok, but for the Chip is very difficult
- It’s hard to make the junction temperature below 55℃ of the power chips such as ADC and FPGA
- The picture is the simulation of the power consumption inside the package



Upgrade the reliability of the design itself

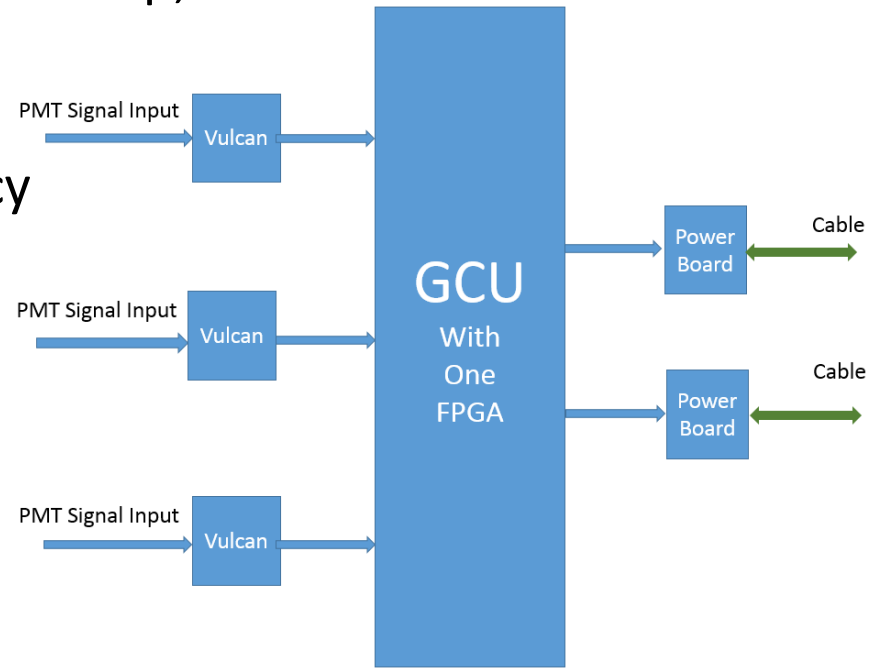
- 1 High quality components
- 2 Redundancy
- 3 Find and enhance the most unreliable part
- More advice…?

The upgraded structure and scheme

- The most difficult for us are:
  - 1 Can not be replaced
  - 2 Commercial components
  - 3 High reliability requirement
- And the easiest way is make it replaceable, if can’t be replaced, then make it redundancy
- How
  - 1 Change the structure, make most unreliable parts redundancy
  - 2 Cable out

Example : if one GCU for 3 PMTs?

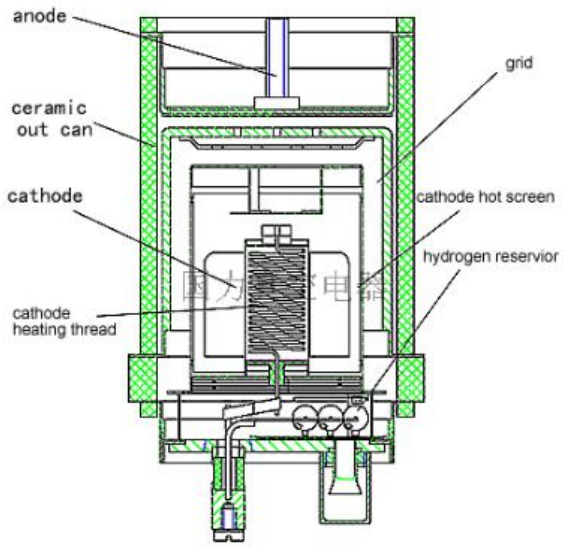
- One GCU for 3PMTs
  - Separate PMT and electronics box, to use one short coax between;
  - One electronics box with one GCU, two PBs and three Vulcans;
  - Using two CAT5+ cable for power and data transferring as backup;
  - Using connector for the CAT5+ connection
  - To design the GCU with redundancy except FPGA
  - Using one HV module for 3 PMTs and other for redundancy
  - Total system change
    - 0 -> 6000 boxes
    - 0 -> 18000 1m coax cable and potting
    - 18000 ->12000 Cat5+ cables and connector
    - 18000 -> 6000 GCUs(6000 FPGAs)
    - 18000 -> 1200 PBs
    - Power consumption should be lower
    - Redundancy design for most parts



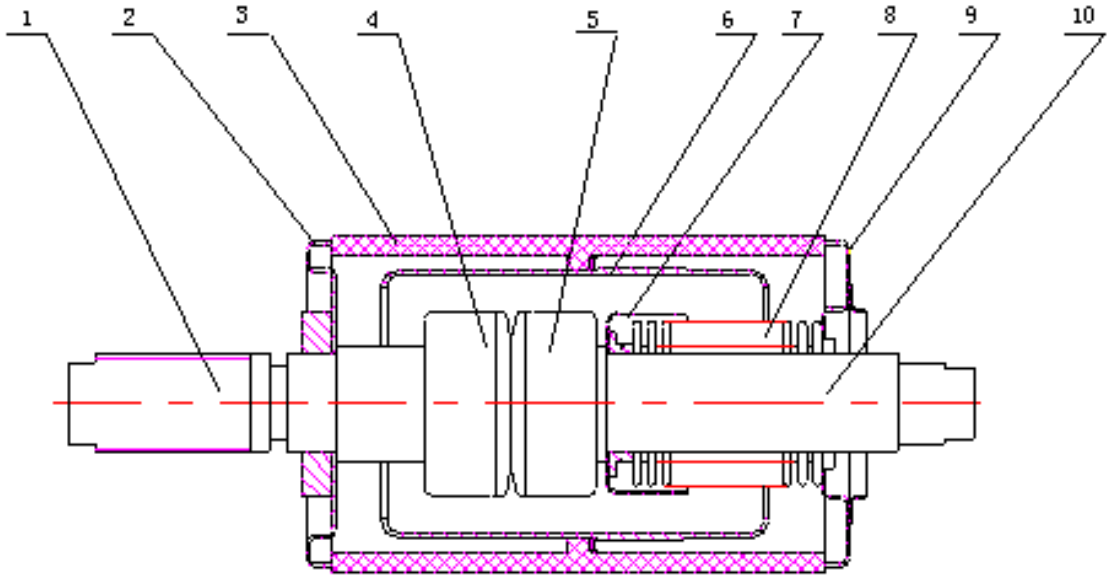
Electronics box

昆山国力真空电器有限公司
Kunshan GuoLi Vacuum Electric Co., Ltd

- To use vacuum technology for the electronics box to guarantee the reliability



Structure of Hydrogen Thyratron

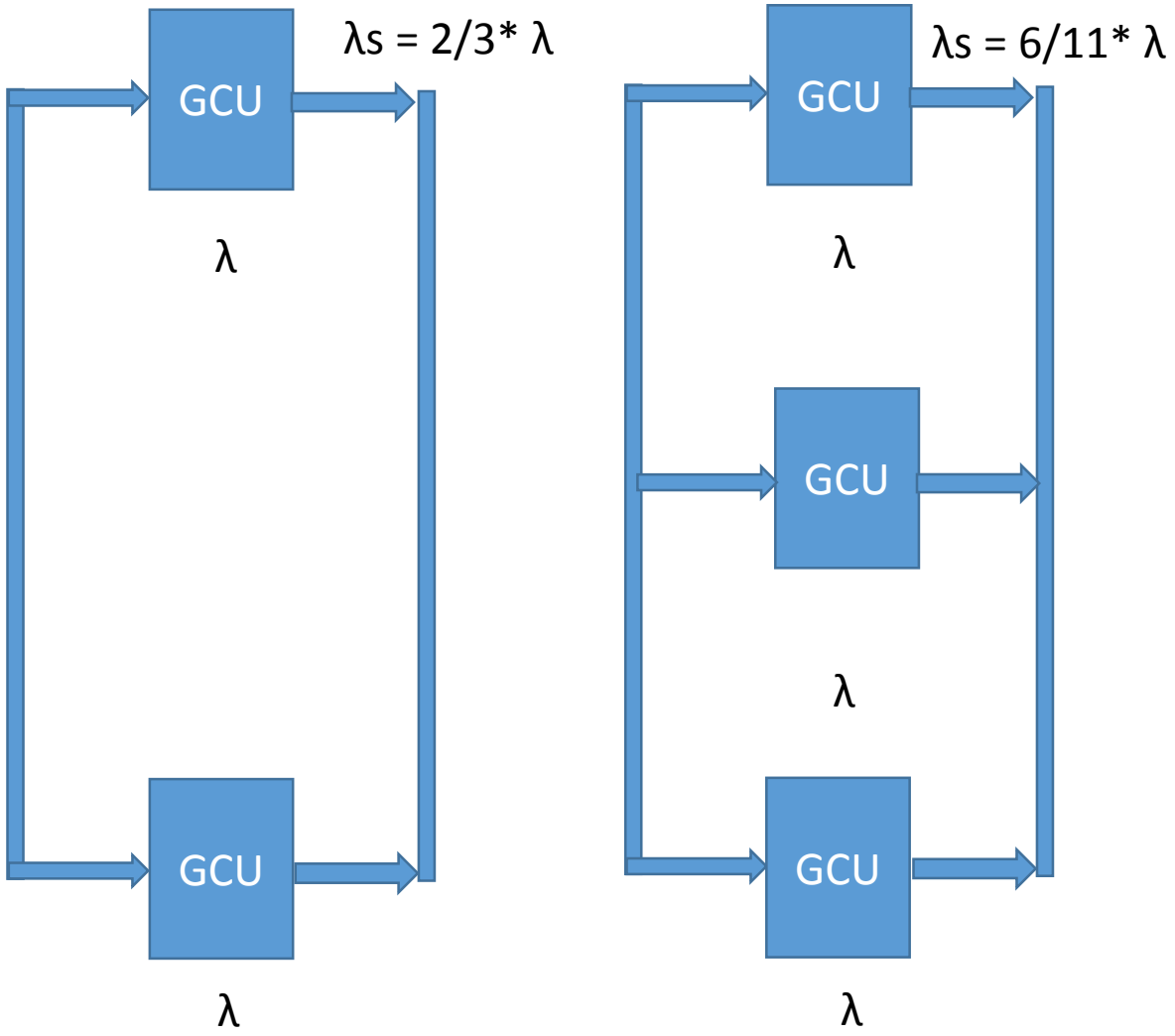


Basic structure of vacuum switch tube

1. Stationary conductive pole 2. Metal cover 3. Out can 4. Stationary contact head
5. Moveable contact head 6. Main shield 7. Bellow shield 8. Bellow 9. Metal cover 10. Moveable conductive pole

The reliability improved by redundancy

From Zhe Ning

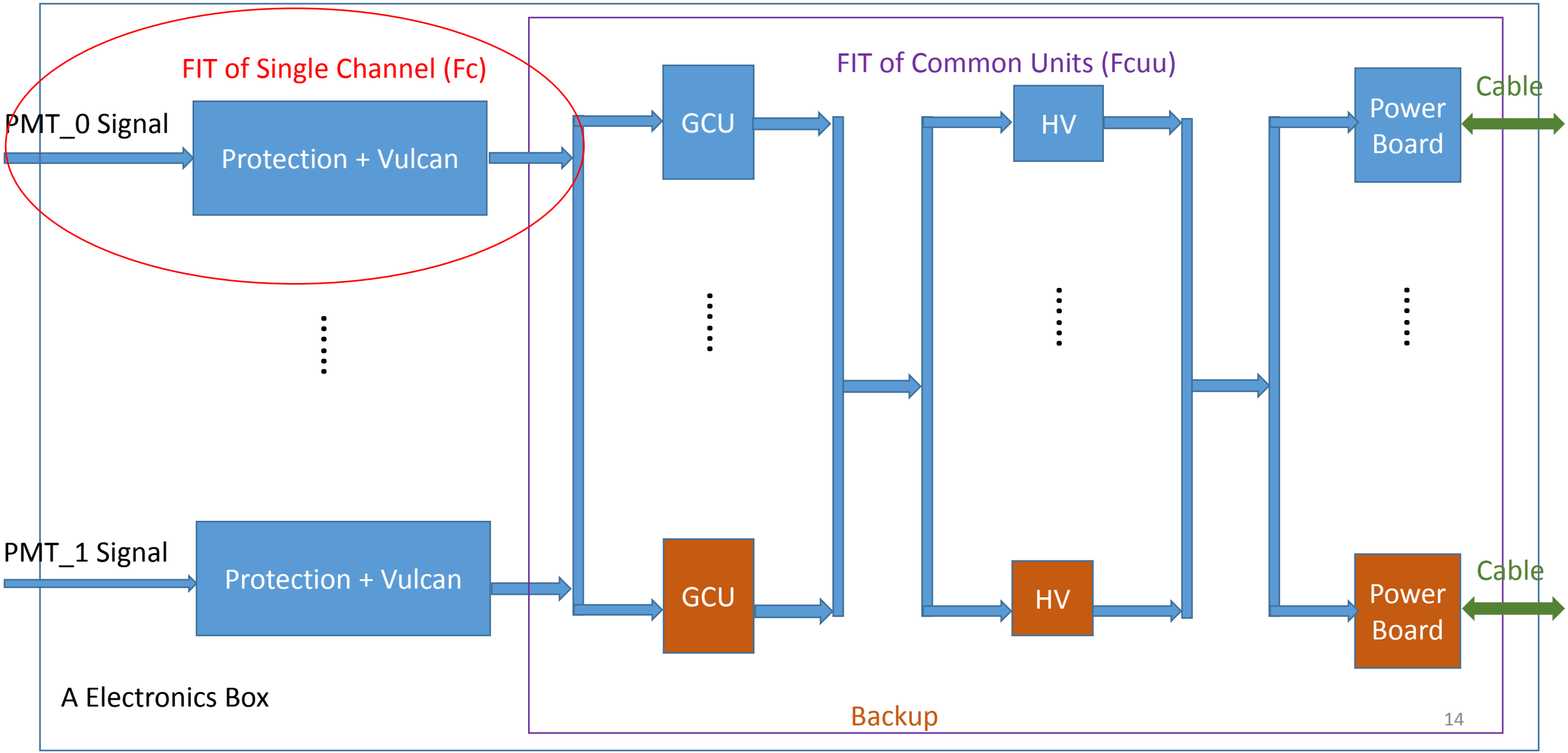


λ = failure rate of single GCU

Items	40 ℃ junction temp.	2 redundancy	3 redundancy
HV	27	18	14.7
Protection Circuit	4.5	3	2.45
IHEP FEC	4.5	3	2.45
Tsinghua ADC	4.5	3	2.45
Vulcan	4.5	3	2.45
Main FPGA	3.4	2.3	1.85
GCU	44	29	24
Power Board	39	26	21.3
Cable & Connector	30	20	16.4

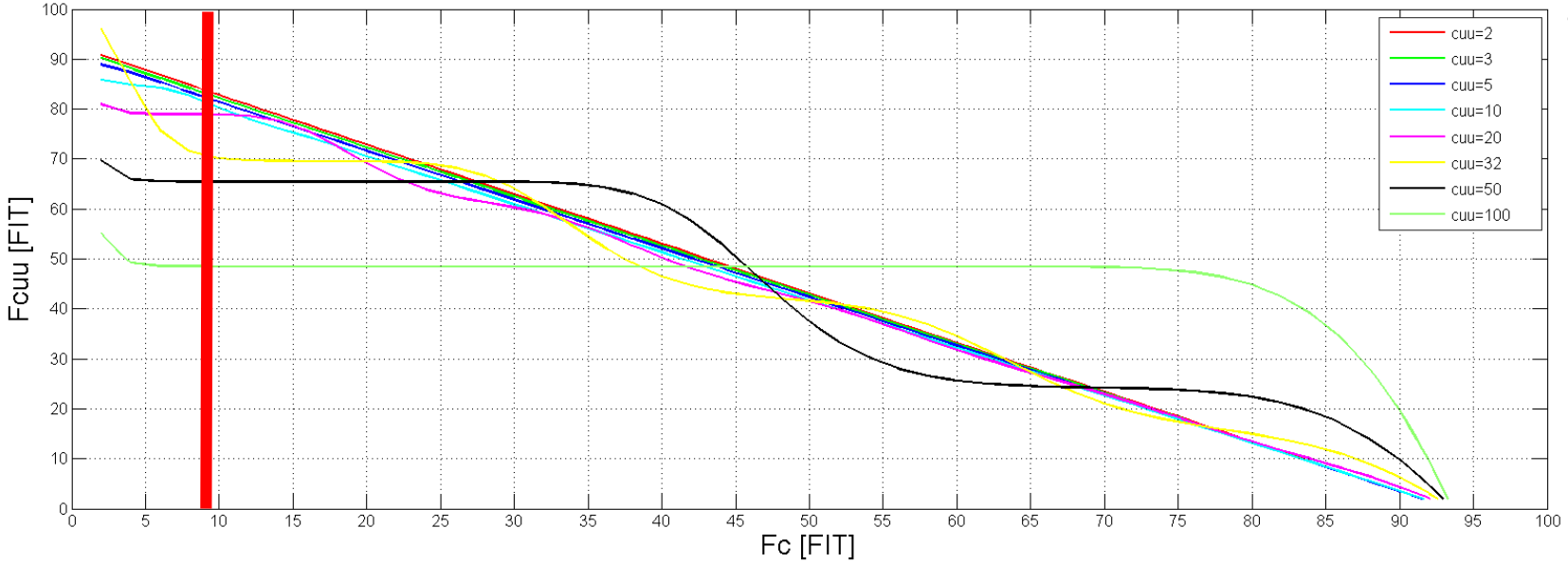
How about more PMT channels?

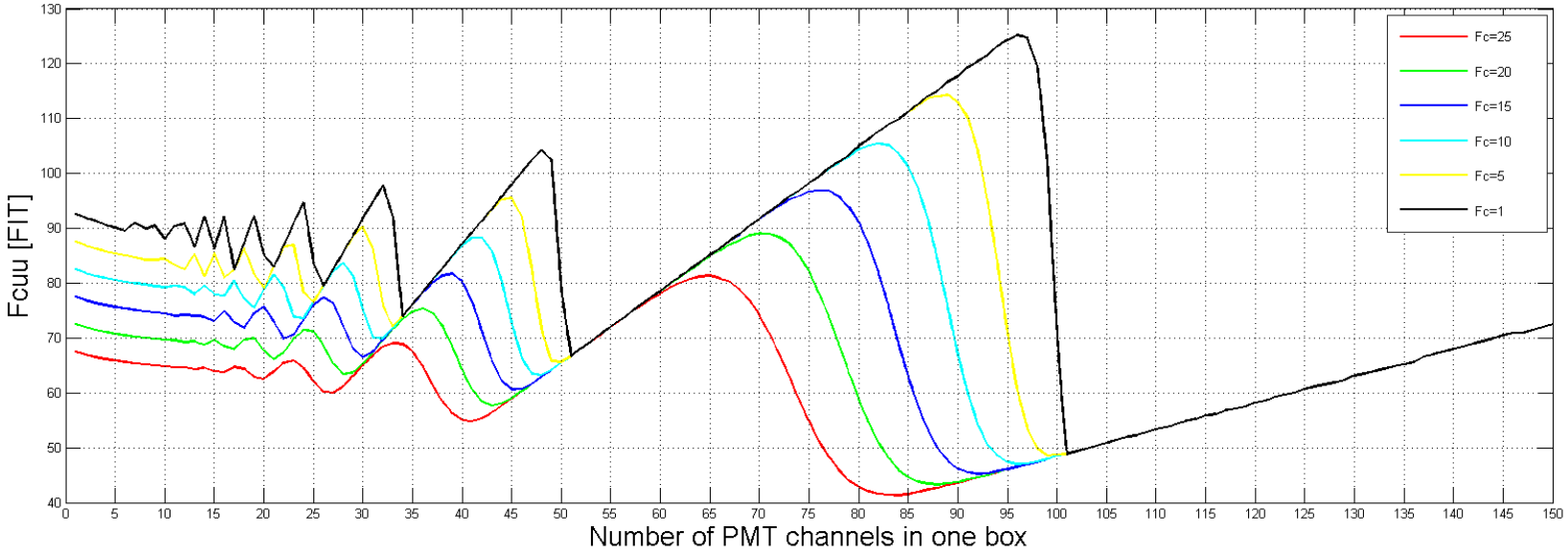
From Zhe Ning



Reliability calculation for more PMT channels

From Zhe Ning





The target is :

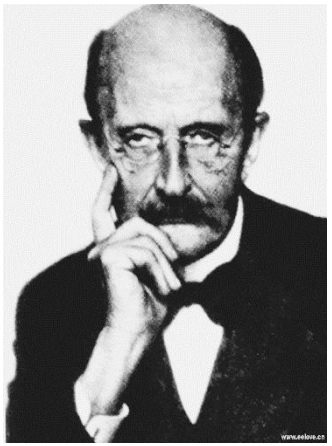
GROUP	Items	40 ℃ junction temp. Redundancy
Fc	Protection Circuit	4.5
	Vulcan	4.5
	Total	9
Fccu	HV	18
	GCU	21(?)
	Power Board	26(?)
	Cable & Connector	20
	Total	85

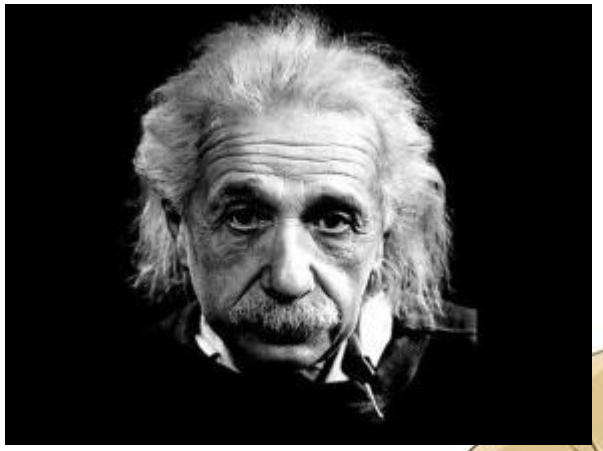
cuu= Number of PMT channels in one box

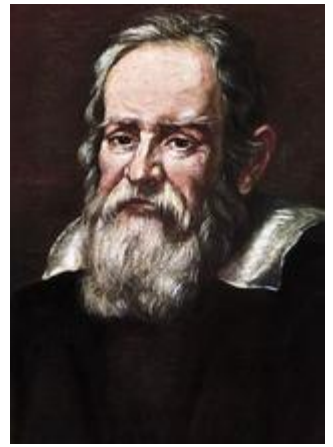
It’s not good to serve for too more PMTs.

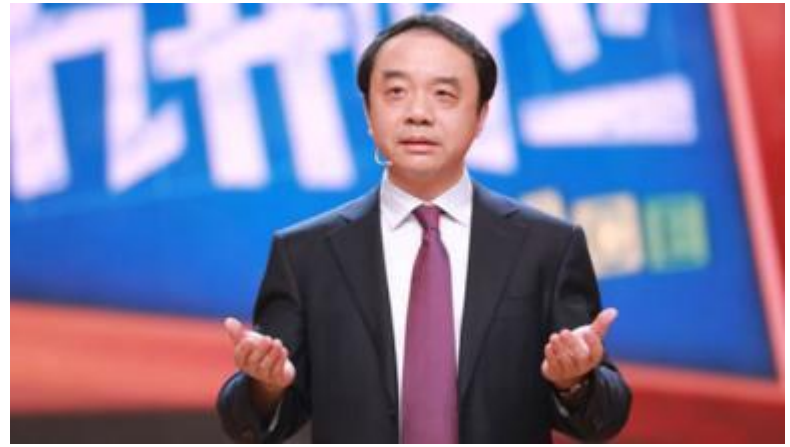
Study always Spiral rise

The lower requirements from physics

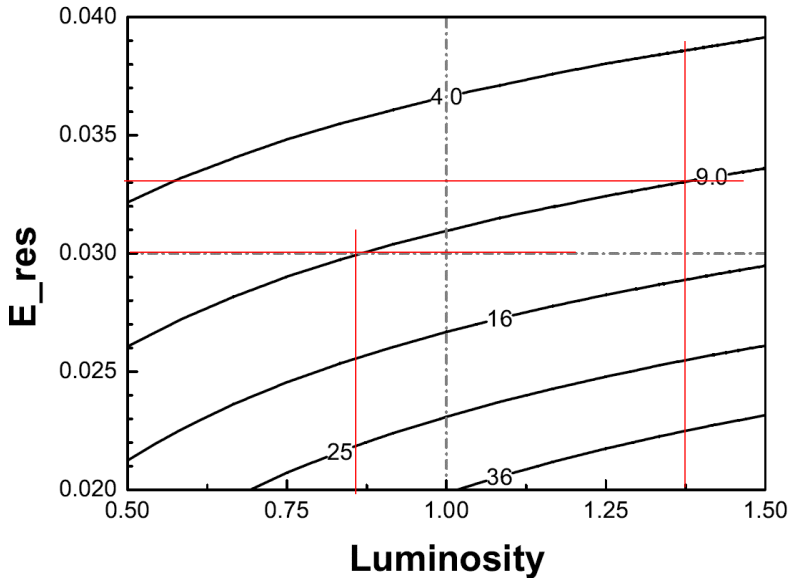


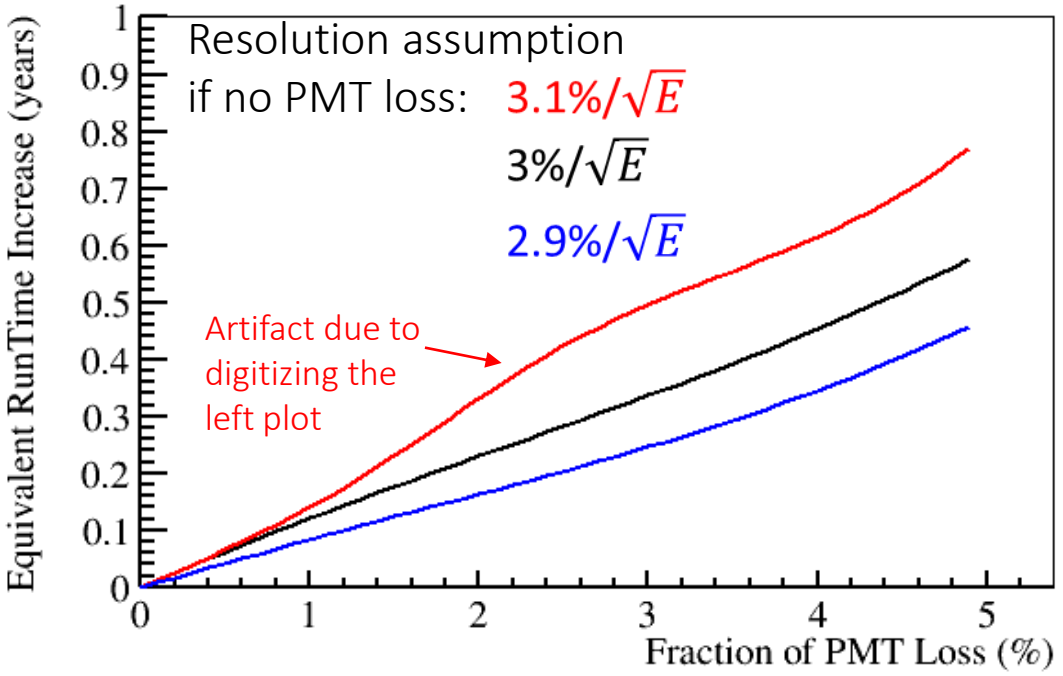






More data taking time and losing PMTs because of electronics, from liangjian Wen's slide





Simple assumption:
Fraction of PMT loss *X,* →
energy resolution *E_res*sqrt(1/(1-X))*

Right plot:
The degradation of energy resolution due to PMT loss → Increase run time to reach 3sigma sensitivity

Reliability and schedule

- Questions:
  - If we have done our best for the board design, but the final target of reliability still can’t achieve, what can we do?
  - If that time exist and come, had we the time for changing?
- Time we have:
  - Mass production will begin from 2018.1.1(main CPM)
    - 14 months for the finalization, from now
  - The final version development begin from 2017.5.1(after electronics review)
    - 7 months for the final version from the first version review
  - The first version can be tested – 2017.2.1
    - 11 months for the last version design
- Time we need:
  - The reliability verification need 5.6 months(50pics)
  - The second version of prototype(should be the final version) need 11 months

Summary

- We have the reliability problem and each groups need to put more attention and efforts to solve it.
- Suggestions:
  - 1 Let somebody to do study of the backup structure R&D in parallel, and this structure can absolutely meet the requirement
  - 2 Do reliability verification, not only calculation
  - 3 To make a deadline for schedule and red line for reliability, if the red line not meet at the deadline, change to backup structure or physics accept the truth
- Question:
  - When is the deadline?

Thanks!