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The machine protection system design and lessons for C-ADS demo facility

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Outline

1. Introduction of C-ADS demo facility
2. MPS design conception
3. MPS design
4. Accidents
5. Summary

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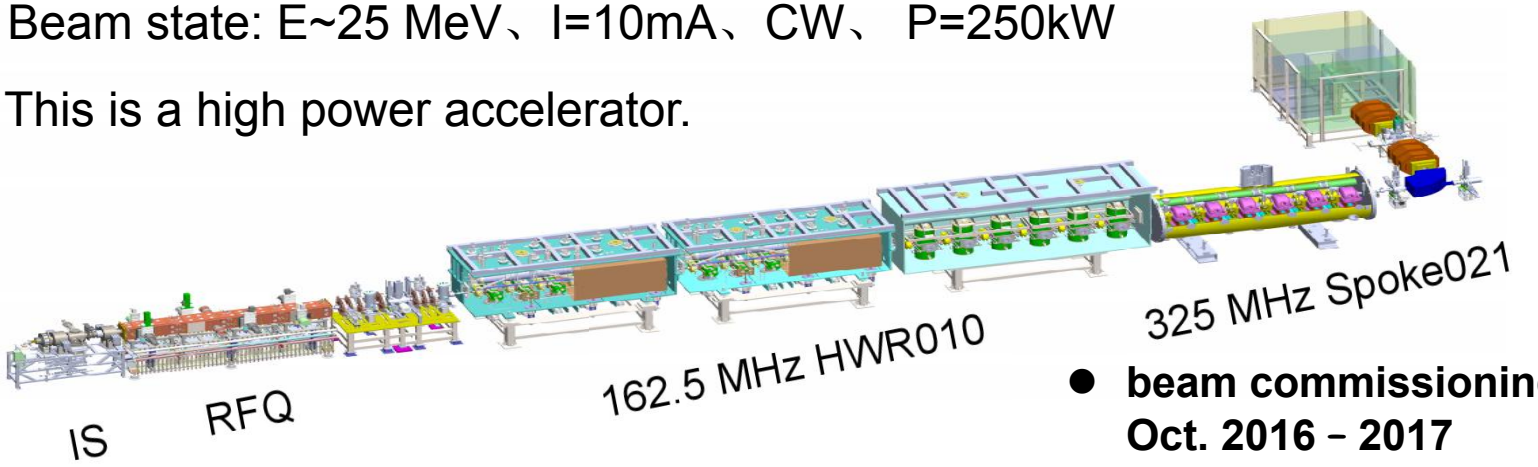
Introduction of C-ADS demo facifity

Beam state: E~25 MeV、I=10mA、CW、 P=250kW

This is a high power accelerator.



- **beam commissioning, Oct. 2016 – 2017**
- **Cooperation with IHEP**

The results of thermal shock analysis			
Materials	Tensile strength(MPa)	Beam state	Allowable time
OFHC	210	2.1MeV、10mA	20us
Niobium	400	10MeV、10mA	100us

Finally, we choose 20 us as the fast machine protection time.

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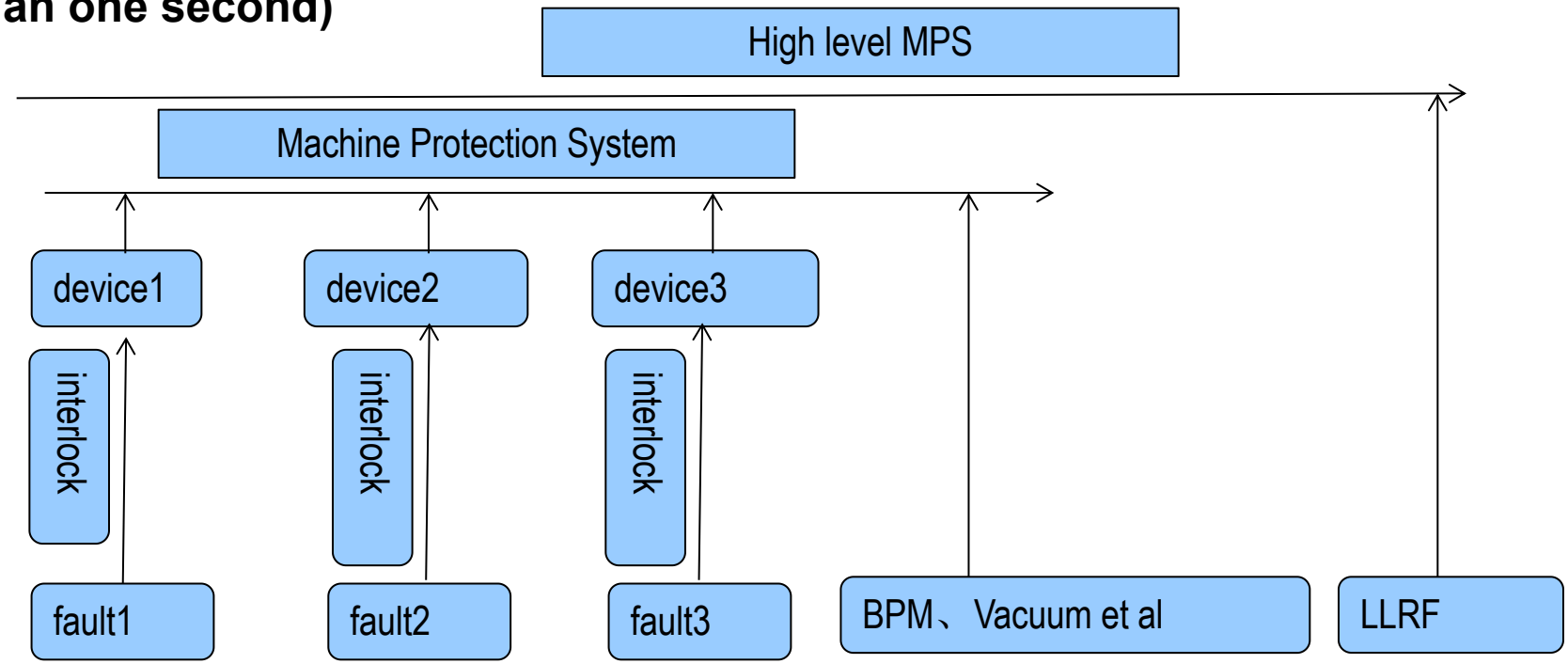
MPS design conception

- Layered protection

1. single device protection (interlock system)
2. accelerator protection (MPS)(Prevent the beam damaging the accelerator.)
3. **beam availability protection (high level MPS)(Recovery the beam for less than one second)**



The reliability and availability are nessary for MPS.(several independent roads to shutdown the beam and the bypass based device should be bulit)

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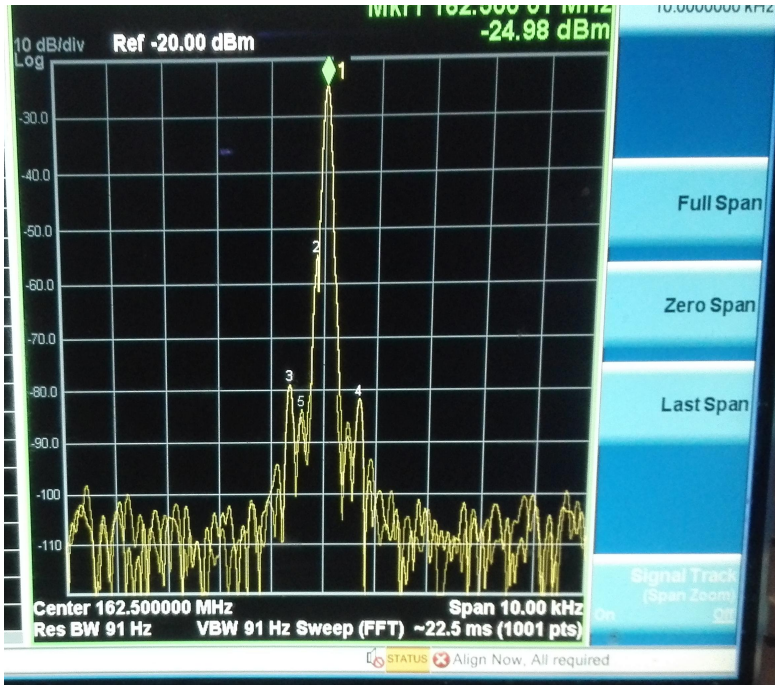
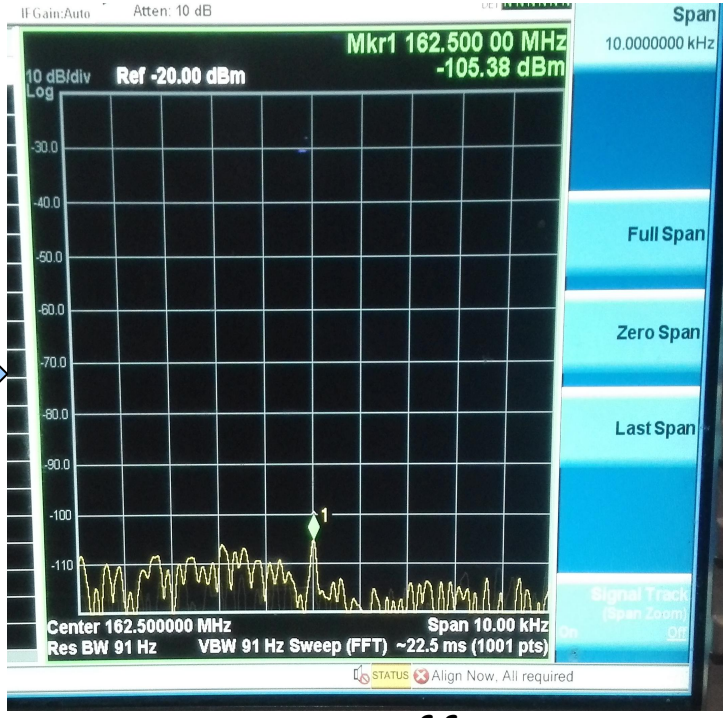
single device protection

- Interlock system



power loading

vacumm got worse



power off

The power of SC cavity was cut off by interlock system.

Accelerator protection

- Machine protection system

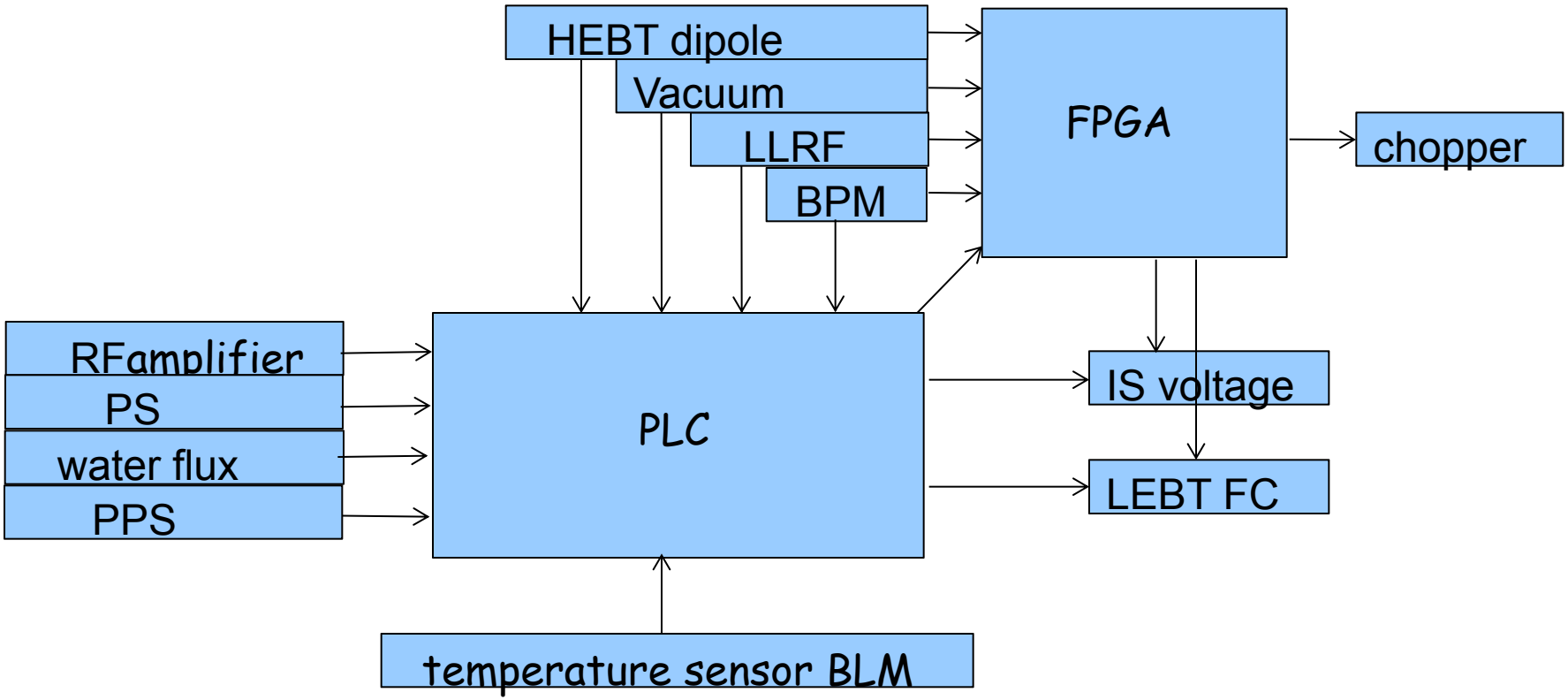
1. Hard wire system (protection system which is not sensitive to time)
2. Fast protection system (protection system which is sensitive to time and can cause the beam loss)
3. Run permit system(mode management)

system		inputs	shutdown
hard wire	PLC	temperature sensor BLM、PPS、water flux、vacumm、amplifier、 PS BPM、HEBT dipole	chopper、voltage、FC
fast ptotect	FPGA	BPM、LLRF、vacumm、amplifier、 PS、HEBT dipole	Chopper、valve、voltage、FC
run permit	EPICS	beam state intercepted element state	voltage、FC

Hard wire and fast protection system work as backups to protect the key system.

Accelerator protection

- Logic frame of MPS



The beam is shutdowned by MPS.

Accelerator protection

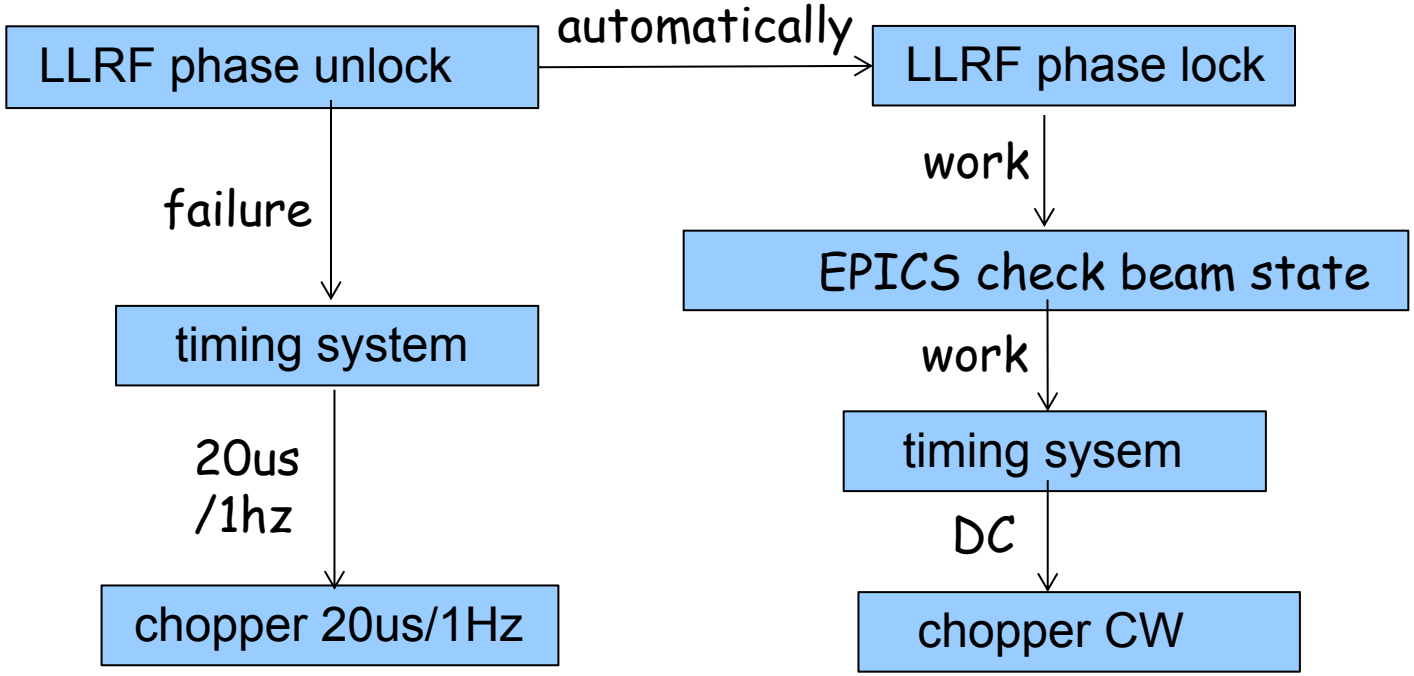
- Inputs signal count

Inputs signal count for 25MeV demo facifity					
amplifier	27	temperature sensor BLM	18	PPS	1
PS	111	BPM	23	dump water flux	4
vacumm	7	LLRF	26	HEBT dipole	1

Beam availability protection

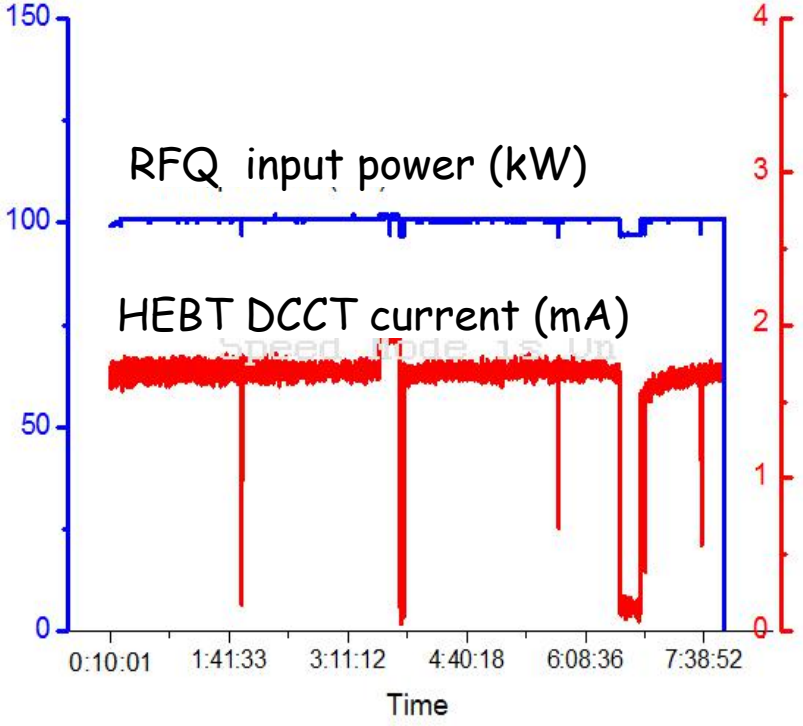
- High level MPS

for MPS: shutdwon the beam for LLRF phase unlock (it can not meet the demand for China ADS)
for high level MPS: recovery beam automatically to meet the demand for C- ADS

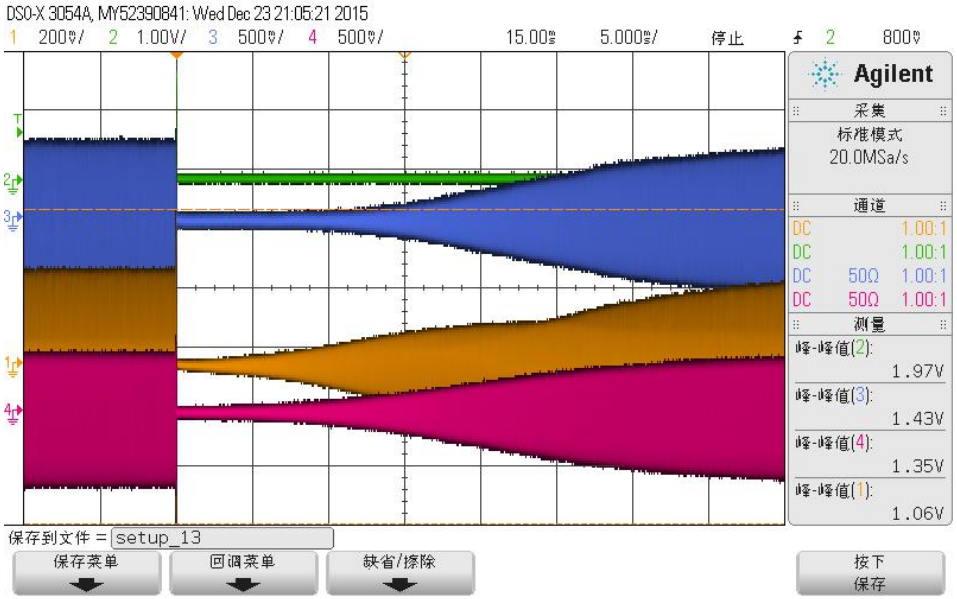


For LLRF phase unlock,the beam is not shutdowned at once, rather than recovered automatically.

Beam availability protection



CW beam record for seven hours

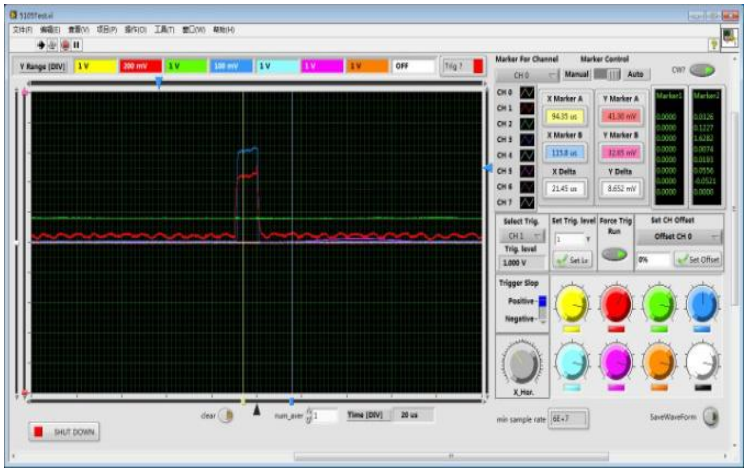


RFQ LLRF locked automatically

The beam can be recovered automatically for 40 ms.

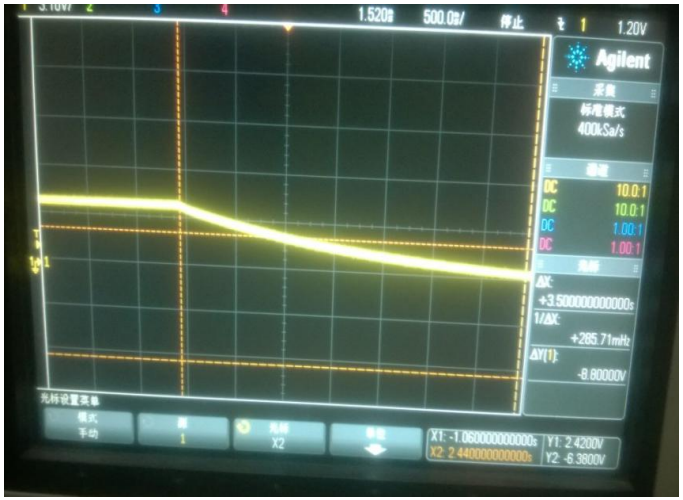
Response time

- Response time



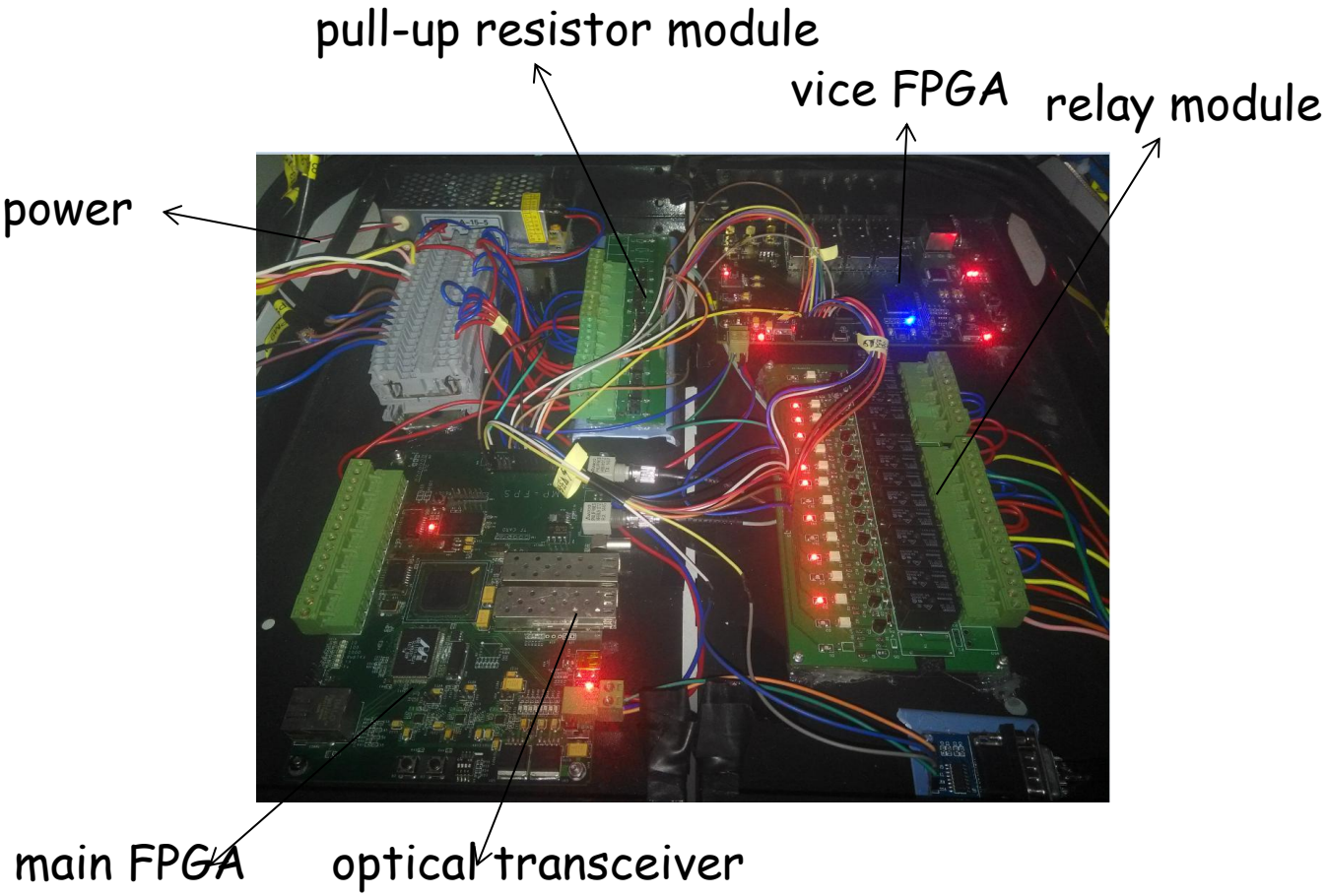
fast protection system ~10us

PLC ~17.1ms



ion source voltage ~3.5s

Fast protection board



CSS fault interface

CSS bypass interface

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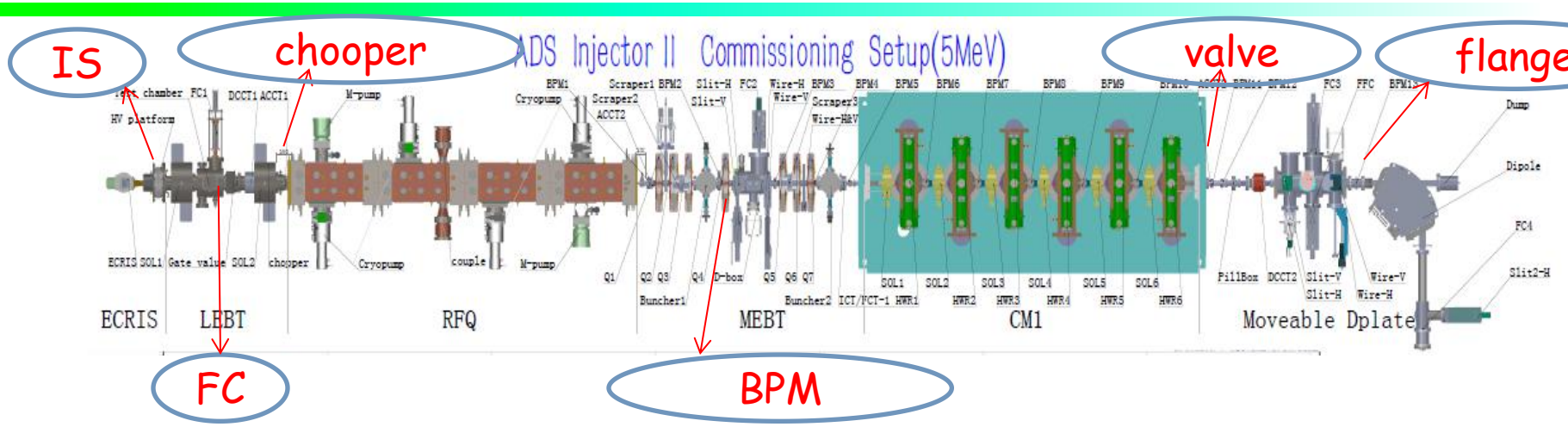
Accident 1



Date： June 29th 2015

Beam state：5.2MeV，2.7mA，CW，1 min

Result： The flange of dipole and the valve of CM exit was damaged. The CM vacuum leakage and the performance of SC cavity was worse.

Reason：

1、FPS response time is tested by trigger the BPM fault with CW beam from the ion sourse

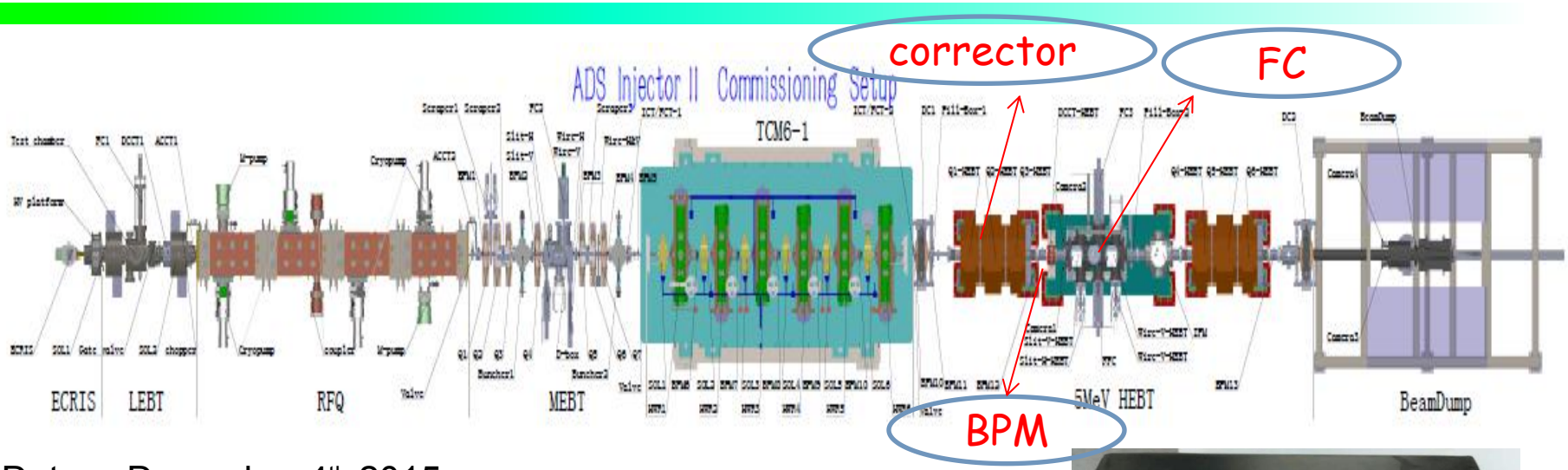
2、IS voltage and FC can not shutdown the beam beacuse of the relay for MPS died

3、the secondary accident because misjudgment of the valve damage

flange

valve

Accident 2

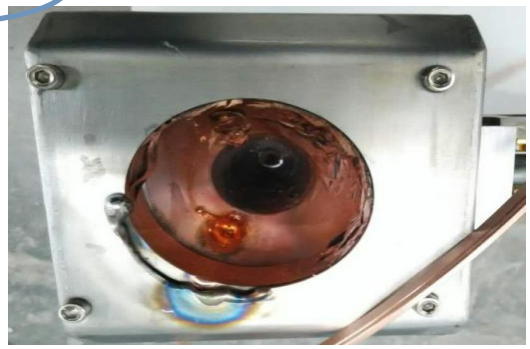


Date： December 4th 2015

Beam state：4.6MeV，3.9mA，CW ， 90s

Result：The cooling water pipe of HEBT FC is destroyed. The pump is filled with water and the steam is into CM.

water pipe



pump

Reason：

1、the curent of HEBT corrector is too lager to test the BPM signal and the current did not reduce to zero

2、the fault signal of BPM near the FC was bypassed.

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Summary

1. MPS is most important for high power accelerator, especially for supperconducting cavities.
2. Preliminary MPS system was built to meet demand for the demo facility, more factors need to be considered.
3. For CIADS project, beam availability i.e. SC cavity failure compensation need the higher level MPS.
4. Comments, suggestions, and helps are welcome.


2014. 11. 24凌晨5点30分


Thanks for your attention !