CHINA SPALLATION NEUTRON SOURCE

The Beam Diagnostics of CSNS

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CSNS BI system

CSNS CHINESE ACADEMY OF SCIENCES

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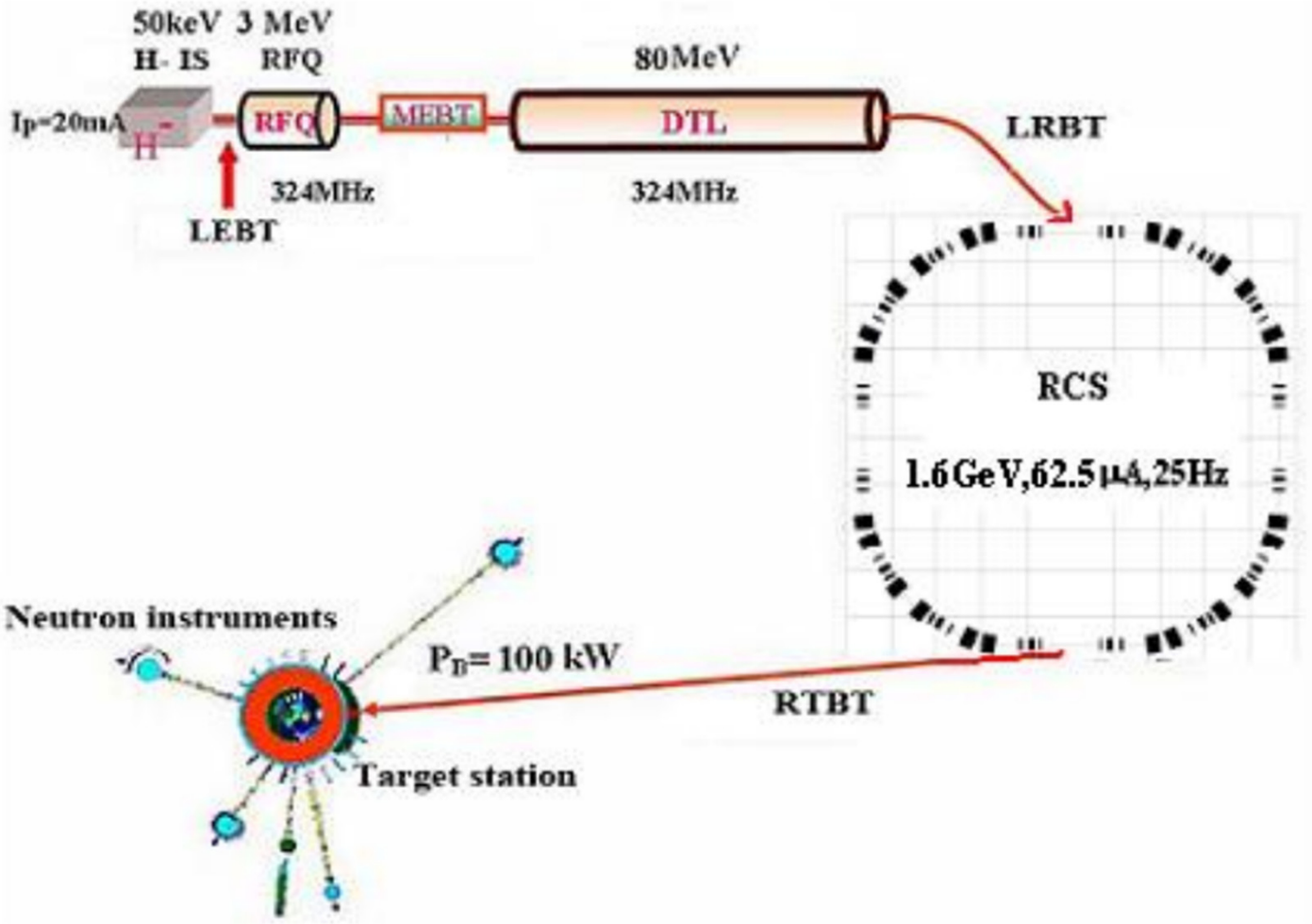
Introduction of CSNS



Introduction of CSNS

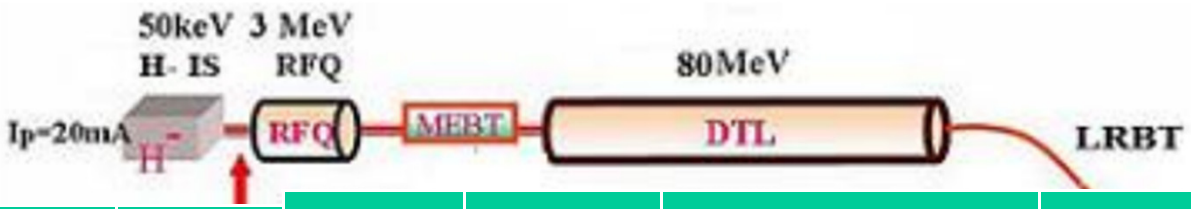
	linac+LRBT
Particle	H-
Beam energy (MeV)	0-80
Repitition rate (Hz)	25 (1)
Pulse current (mA)	15(5)
Macro pulse width (μs)	500(50)
Chopped pulse width (ns)	468
Chopped ratio	50%

	RCS+RTBT
Particle	proton
Beam energy (MeV)	80-1600(80)
Repetition rate (Hz)	25(single shot)
Bunch particles	7.80E+12
Harmonic	2
Bunch length(ns)	500-100
Injection turns	225
Revolution frequency(MHz)	0.535-1.232

Introduction of CSNS beam diagnostics

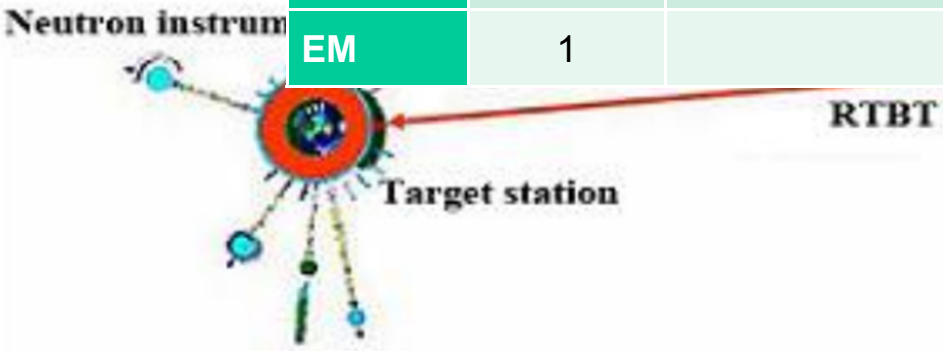
- **Information about BI system**
  - The system is established several years
  - The members in the group are all freshman
- **Design philosophy**
  - Mature
  - Traditional
  - Task-oriented

Introduction of CSNS beam diagnostics



	LEBT	Full Scale
BCT	2	35mA
EM	1	

	MEBT	Full Scale	accuracy	resolution
BCT	2	35mA	0.35mA	0.2mA
BLM	3		0.2W/m	0.1W/m
BPM	8	±R/2	R*1%	R*0.5%
WS	4	±R	±0.5mm	0.3mm
Phase	5		±1°	0.5°
EM	1		±5%	



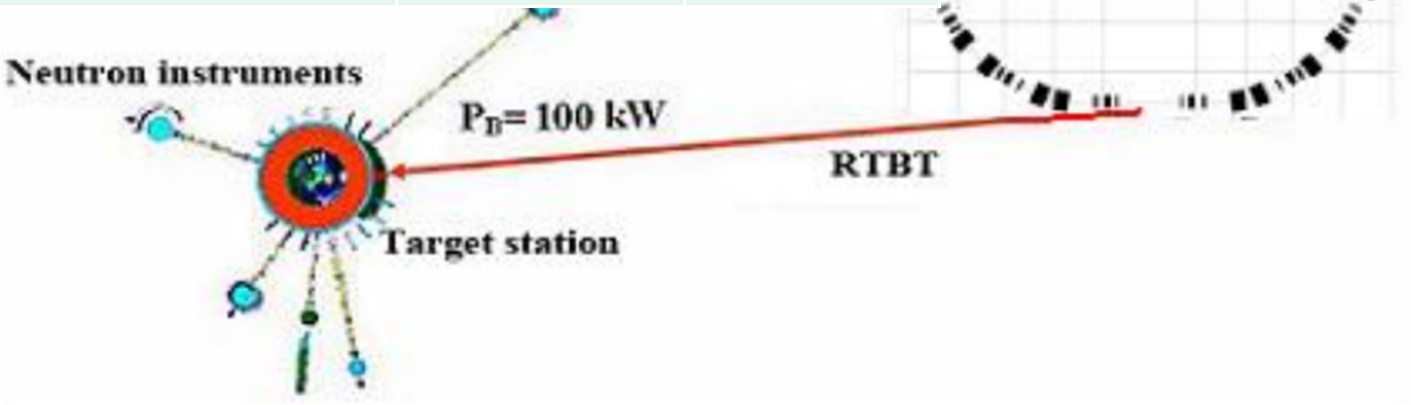
Introduction of CSNS beam diagnostics

	DTL	Full Scale	Accuracy	Resolution
BCT	3	35mA	0.35mA	0.2mA
BLM	12	40-80M		
FBLM	1	~ns respon		
Phase	3			

	LRBT	Full Scale	Accuracy	Resolution
BCT	4	35mA	0.35mA	0.2mA
BLM	28	40-80MeV	0.2W/m	0.1W/m
FBLM	3	~ns response time		
BPM	20	±R/2	R*1%	R*0.5%
WS	7	±R	±0.5mm	0.3mm
MWPM	6	±R	±1mm	0.5mm
Phase	5		±1degree	0.5°
WCM	3	0-10A		
Foil	1			

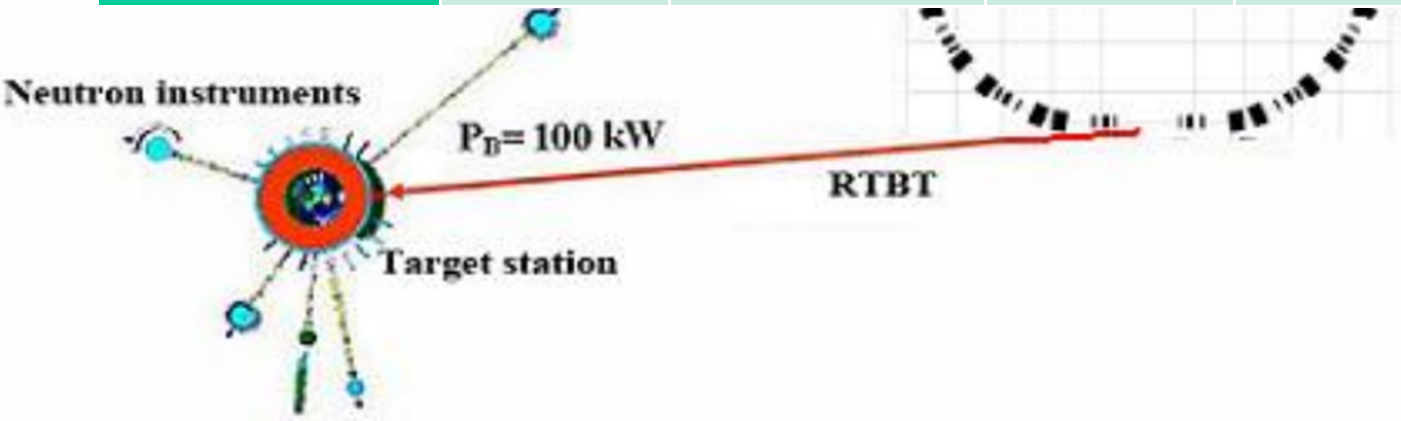
Introduction of CSNS beam diagnostics

	RCS	Full Scale	Accuracy	Resolution
BLM	72	80-1600MeV	0.1W/m	0.05W/m
FBLM	9	~ns response time		
BPM (Linear cut)	32	±R/2	R*1%	R*0.5%
S-BPM	3	±R/2	R*1%	R*0.5%
DCCT	1	0-20A	1%FS	0.5%FS
SCT	1	0-20A	1%FS	0.5%FS
MCT	1			
FCT	3	0-10A		
WCM	2	0-10A		
Tune	2		±0.1%	



Introduction of CSNS beam diagnostics

	RTBT	Full Scale	accuracy	resolution
BCT	4	35mA	.35mA	0.2mA
BLM	50	80-1600MeV	0.1W/m	0.05W/m
FBLM	2	~ns response time		
BPM	9	±R/2	R*1%	R*0.5%
S-BPM	24	±R/2	R*1%	R*0.5%
WS	8	±R	±0.5mm	0.3mm
MWPM	2	±R	±1mm	0.5mm

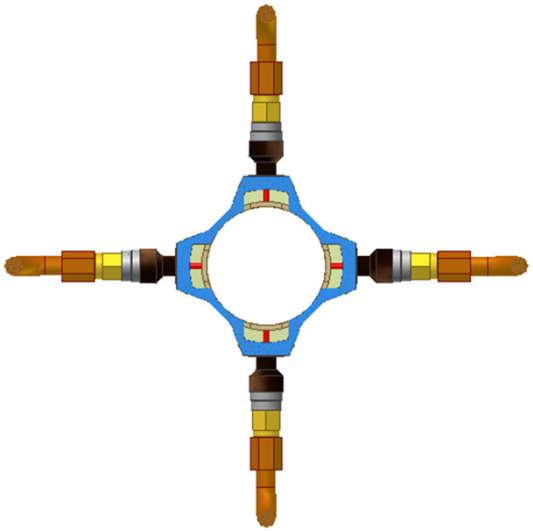


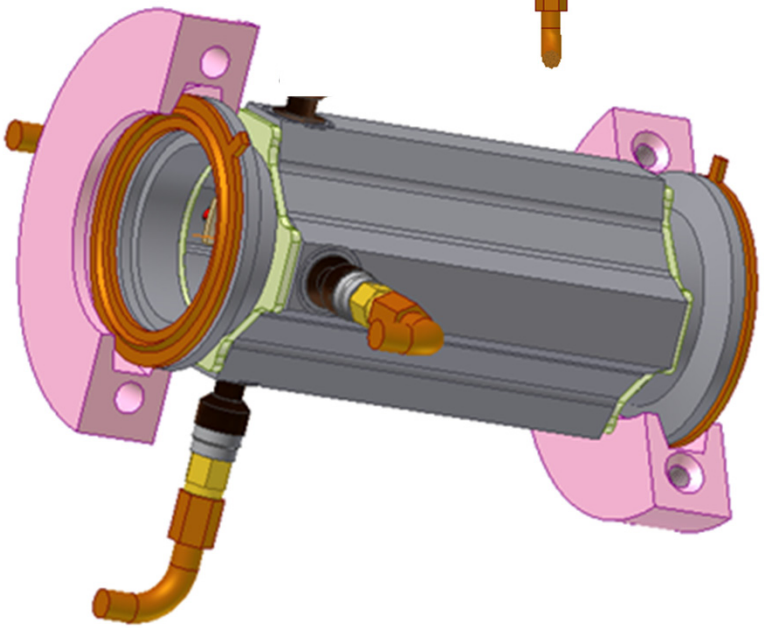
The progress of CSNS beam diagnostics

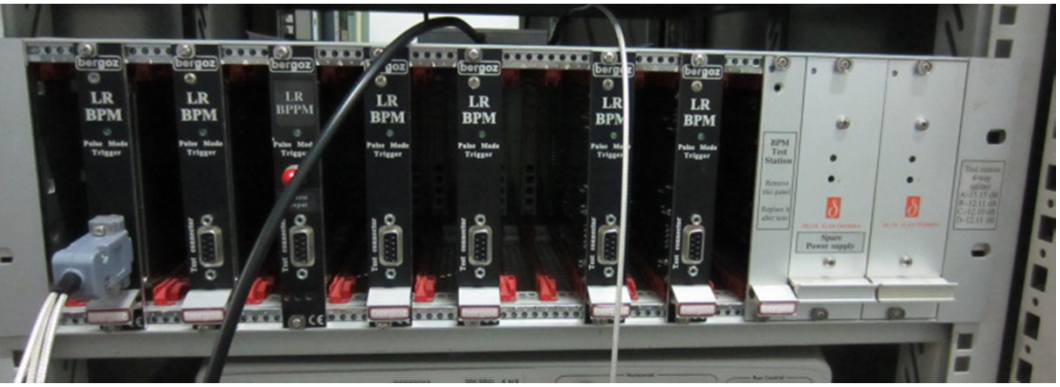
- **RFQ Beam test (a halo study beam line after RFQ is built)**
  - Strip line BPM
  - BCT
  - WS
  - BLM/FBLM
  - Phase measurement
- **Ion source beam test**
  - EM
- **WCM**
- **Readout system**

The progress of CSNS beam diagnostics (BPM)

- **Strip line BPM**
  - MEBT limited space
    - The BPM is installed in Q magnet.
  - Electronics
    - Bergoz LR-BPM
    - Combiner + Oscilloscope

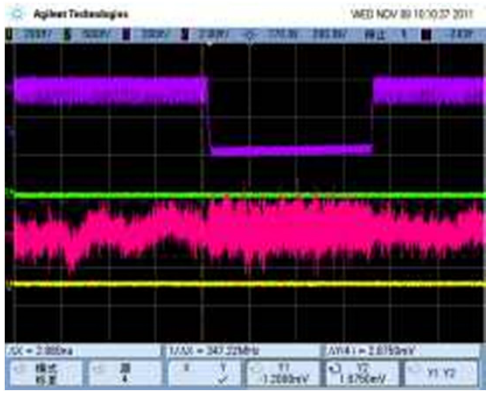




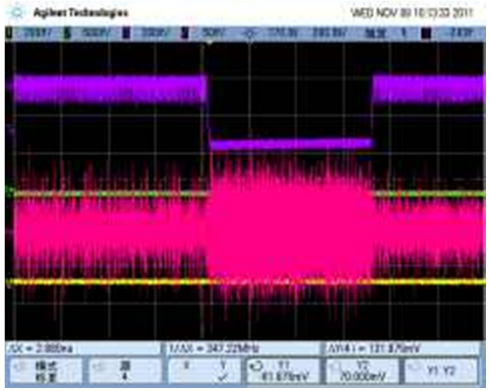


The progress of CSNS beam diagnostics (BPM)

- **beam test**
  - The RF noise also is observed.
  - Effective signal Vp-p~400mV`-> <1%
  - But we will improve the connection of each point.



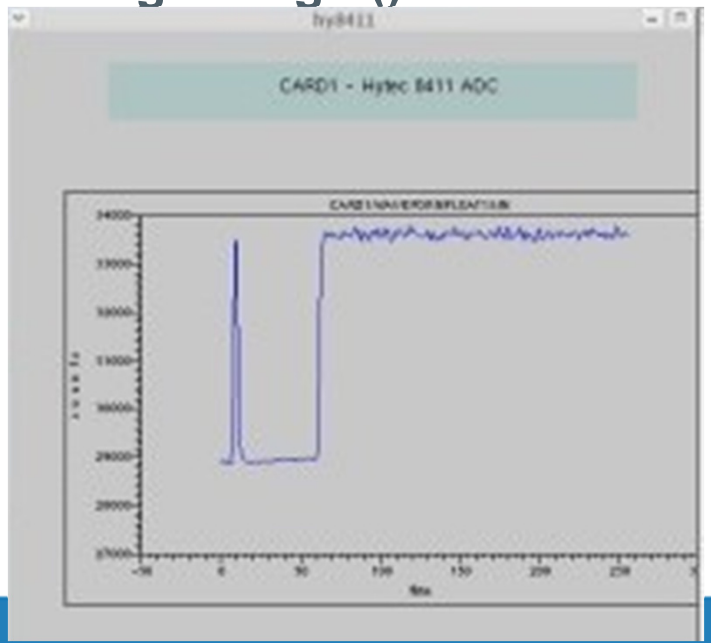
40dB amplify



Vp-p~ 140mV

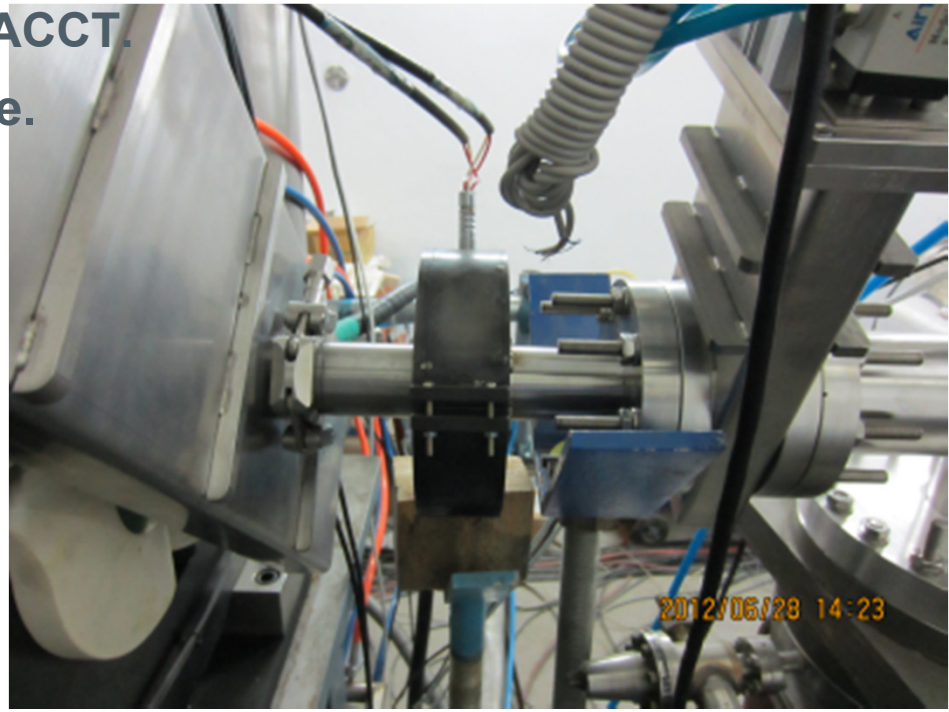
The progress of CSNS beam diagnostics (BPM)

- **Readout system of BPM**
  - Based on EPICS 3.14+Vxworks
  - Hytec 8411 16ch，16bit，100kSa/s/ch ADC, ±5V input signal
    - 100kSa/s/ch　Normal running, 500μs signal is ok; commissioning, 50μs, just 3-4 effective data
  - Other person can get the data through “caget()” mode



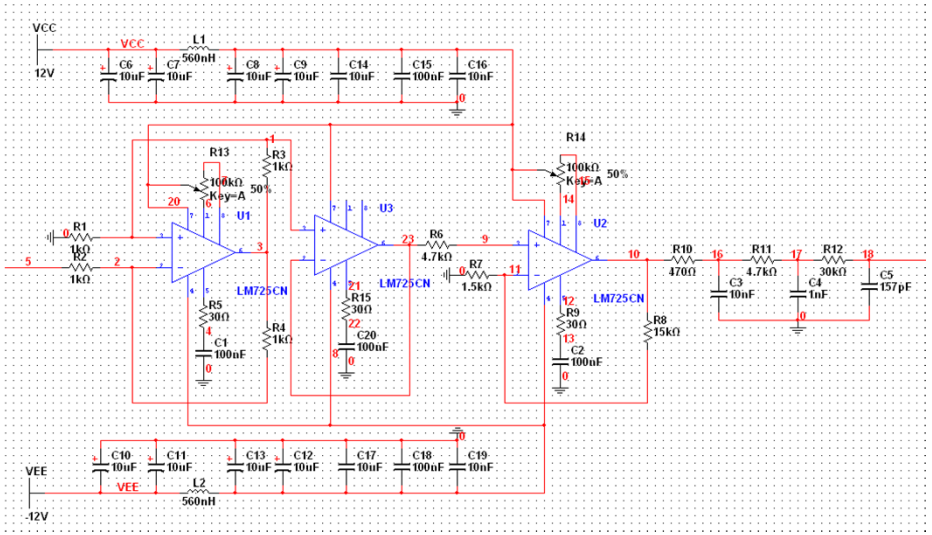
The progress of CSNS beam diagnostics (BCT)

- on RFQ beam line, two ACCTs are installed
  - One : bought from Bergoz Co.;
  - the other: made by ourselves
    - 150 turns of second coil, the inductance of self-made BCT is less than the 250 turns bergoz's ACCT.
  - Installed at end of the beam line.

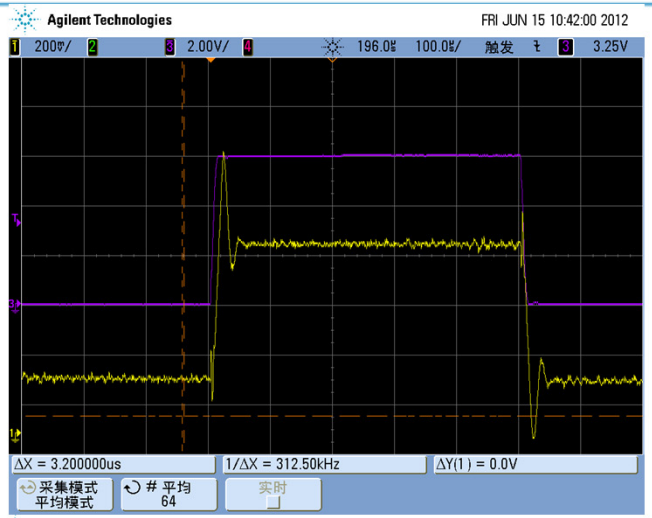


The progress of CSNS beam diagnostics (BCT)

- **The development of BCT electronics**
  - Based on two method:
    - The CT's load impedance is changed to zero from The Nuclear Science Research Facility, Institute for Chemical Research, Kyoto University
    - Fermilab 8GeV beam line CT used type.

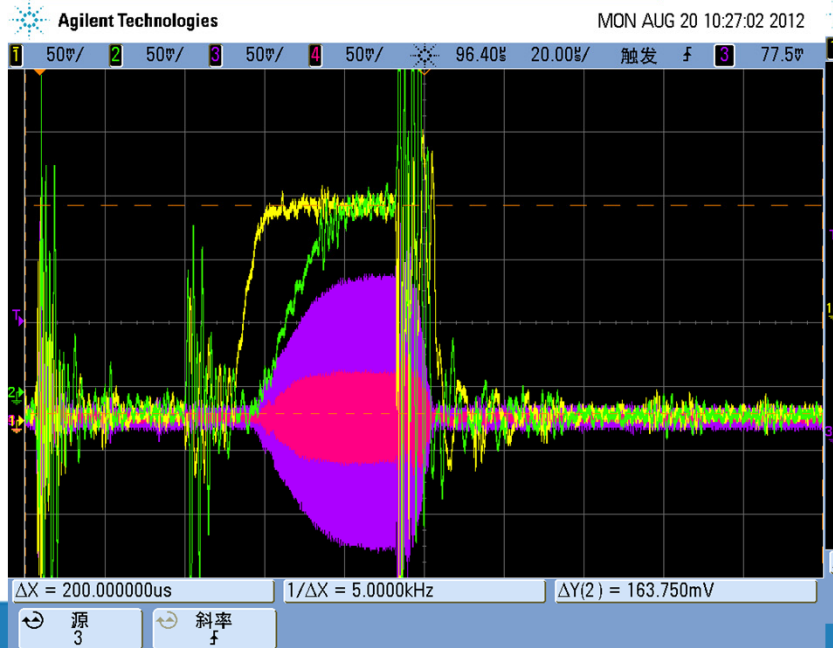


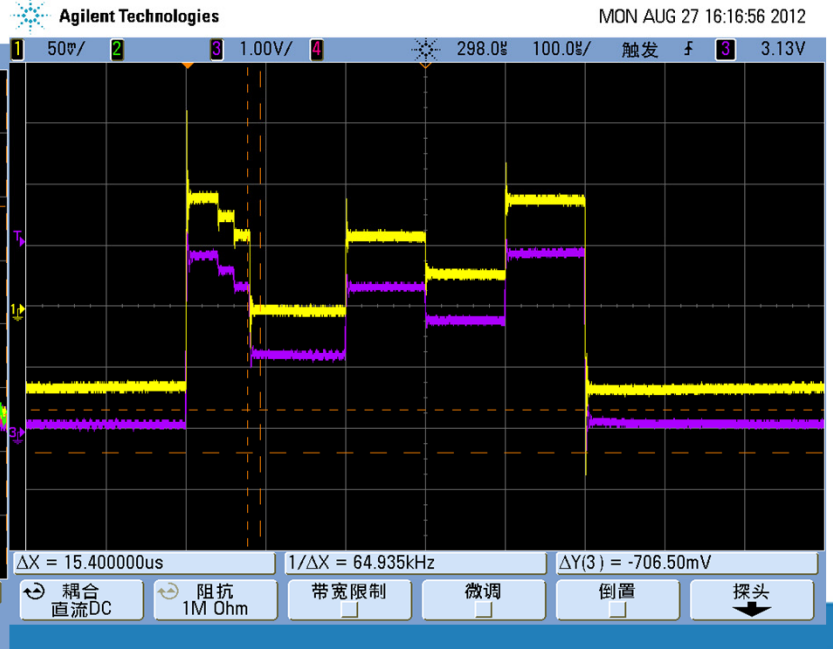
The progress of CSNS beam diagnostics (BCT)



The kyoto type is suit for long pulse, the sag of signal is very small.

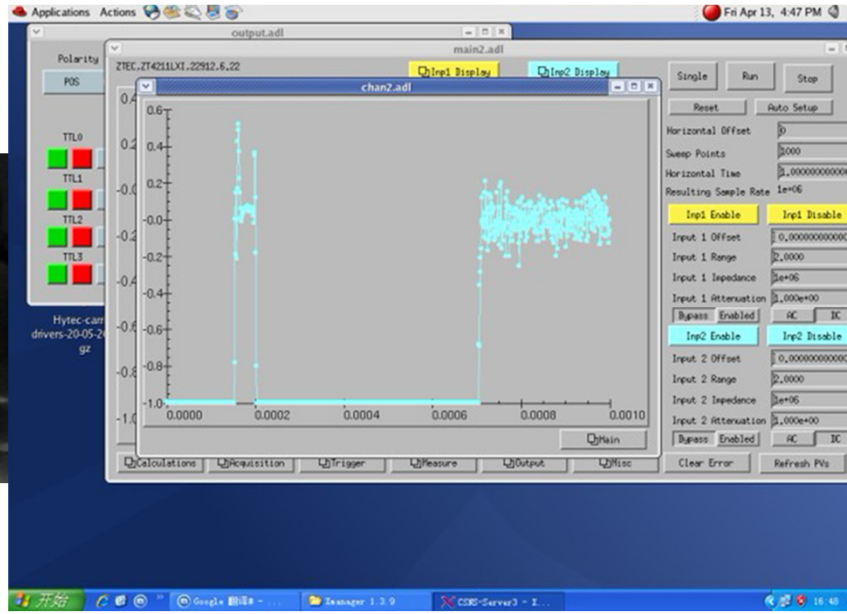
The fermilab type is suit for short pulse, such as 50μs.
The rise time is about 0.5~3μs according to the different amplification.





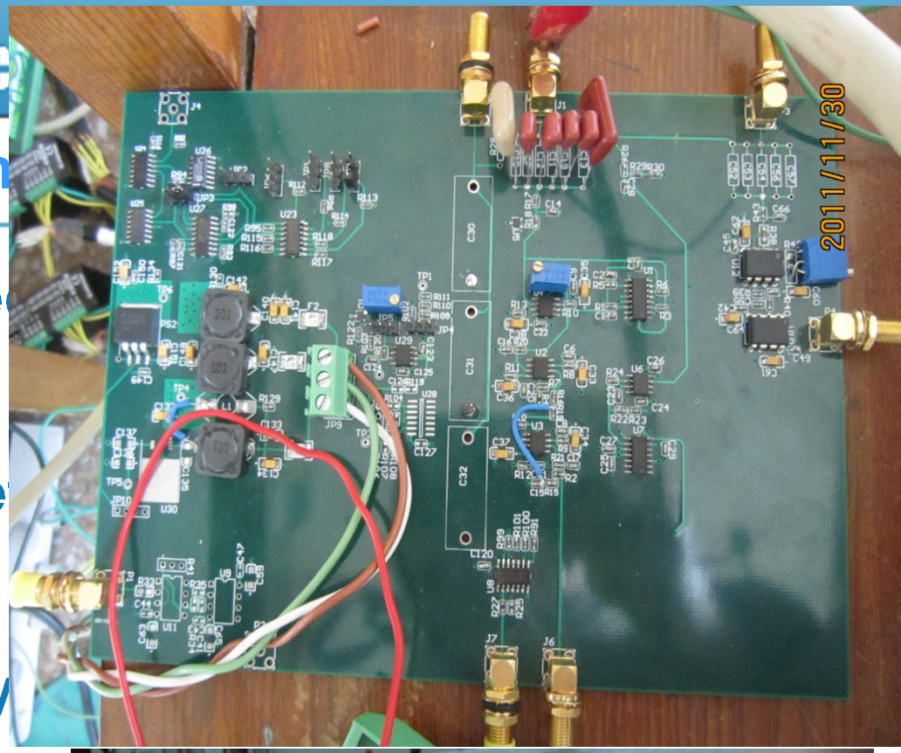
The progress of CSNS beam diagnostics (BCT)

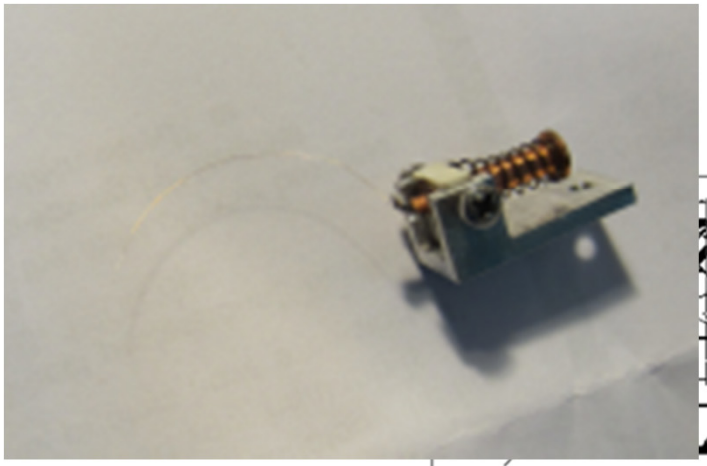
- **Readout system of BCT**
  - Two methods are chosen:
    - 1 using hytec ADC 8411, same with BPM's to get 500μs beam current data
    - 2 using ZTEC ZT4211-01E LXI 8bits 350MHz，2ch oscilloscope, which embedded EPICS 3.14 with multiplexer to monitor more beam current waveform.

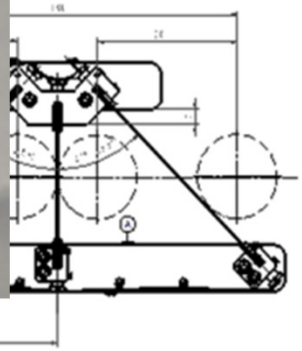


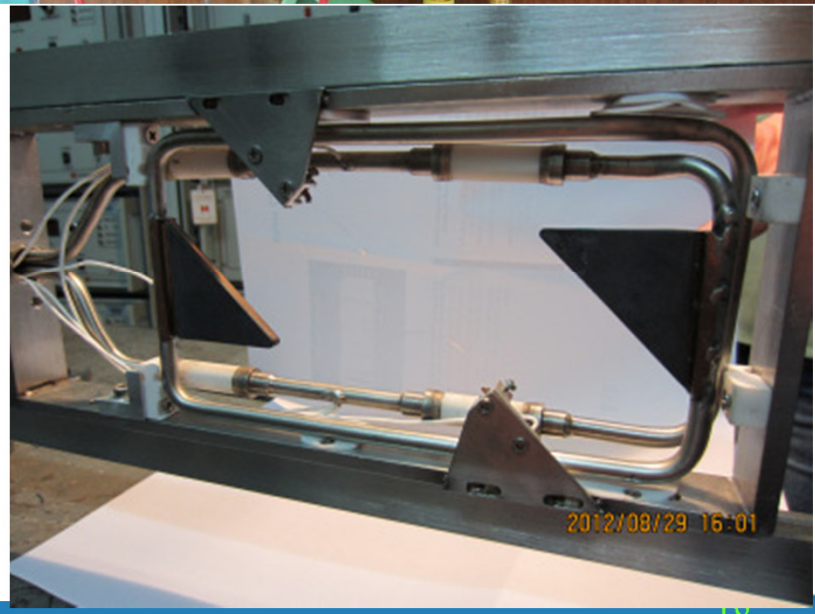
The progress of CSNS beam diagn

- The LANL type WS system is use
  the beam.
- During the test, the beam parame
  current is about 15-30mA, proton
- All the tungsten wire is broken by
  alive.



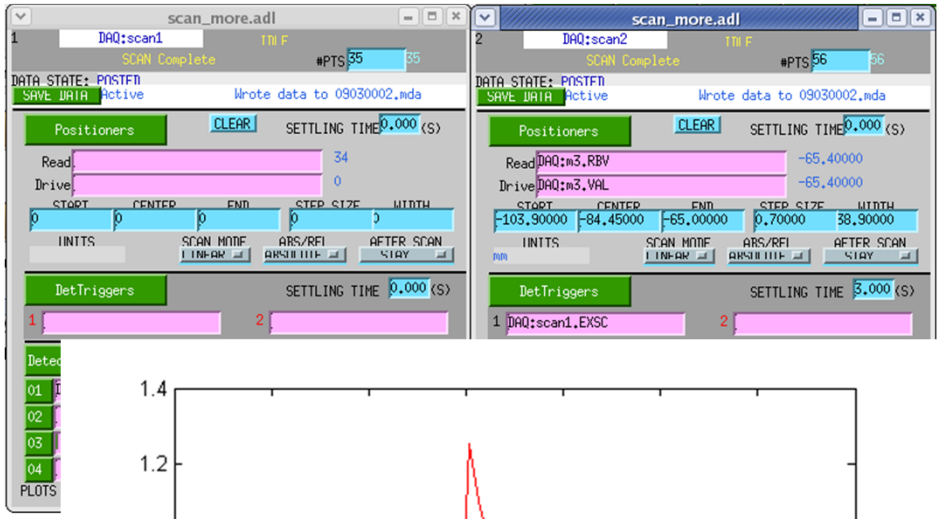


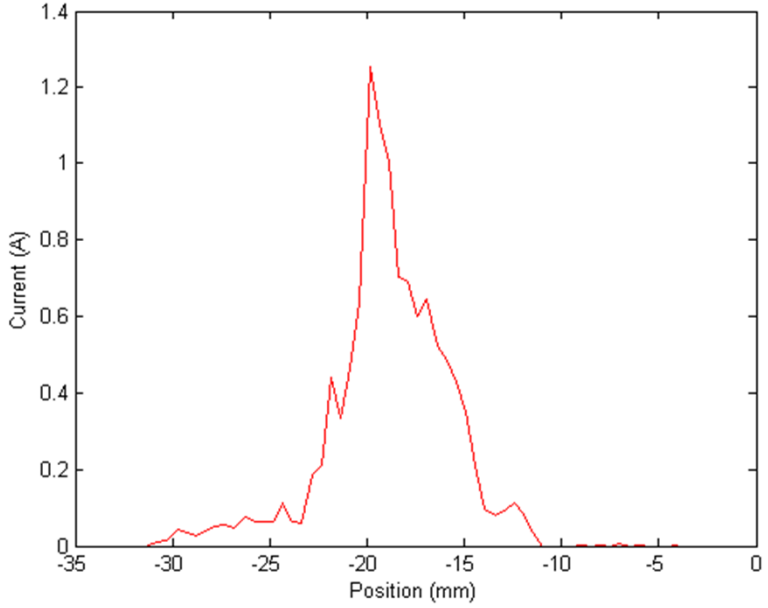




The progress of CSNS beam diagnostics (WS)

- **Readout system of WS**





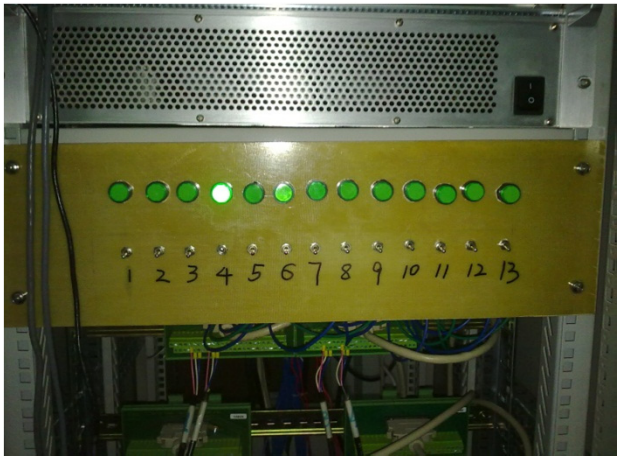
Using synAPPS SSCAN tools to sample the origin data, Using another code to draw the beam profile.

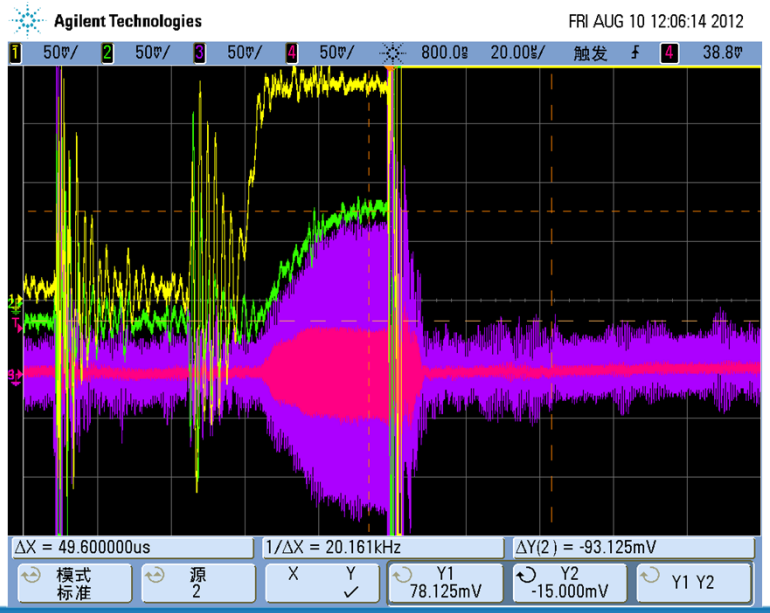
The progress of CSNS beam diagnostics (WS)

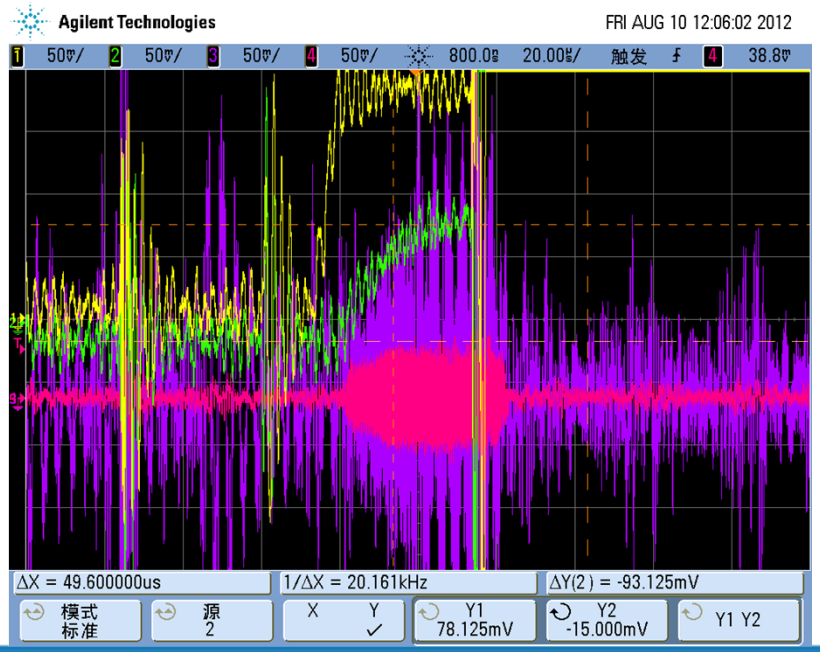
If all the driver of motor is powered, the brake current can influence the other system.

We build a control panel, just supply the power of using WS motor driver.

The interference is decreased.

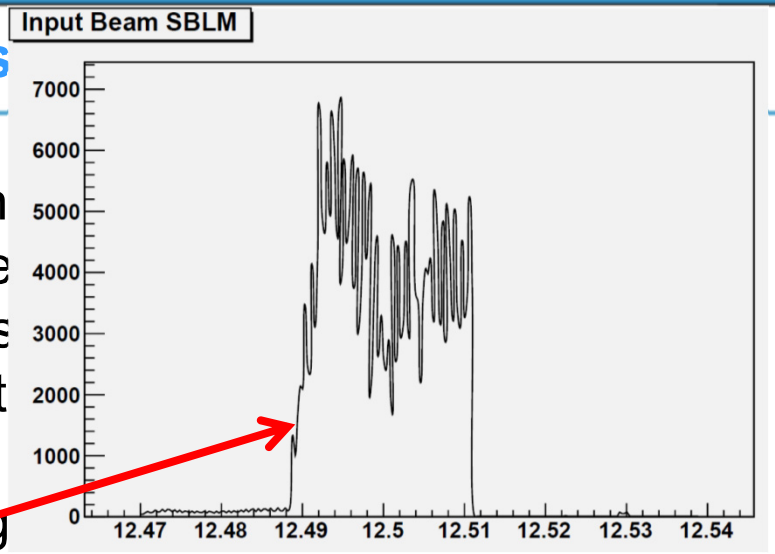


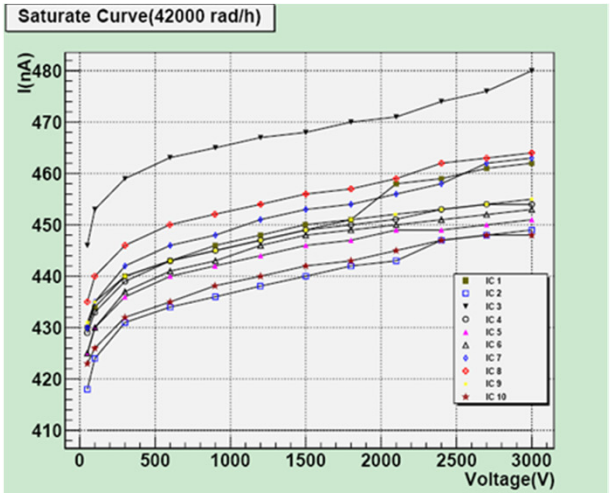


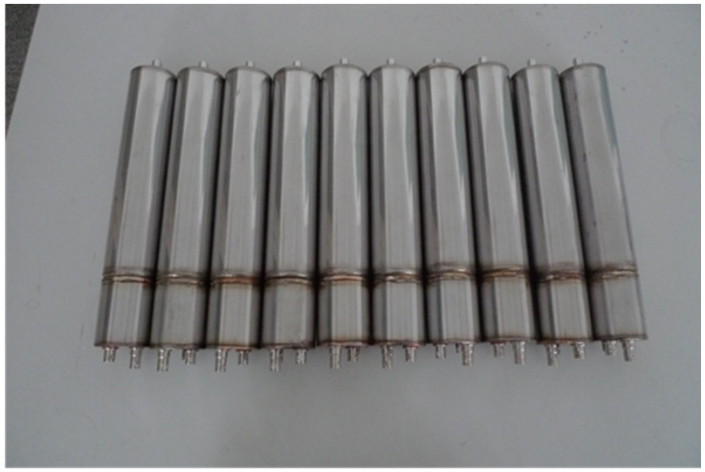


The progress of CSNS beam diagnos

- Following the SNS ion chamber design
- Filled with 70% Argon and 30% Nitroge
- The properties of them have good cons
- A BLM is installed at BII electron inject as readout instruments
- The beam loss can be observed during

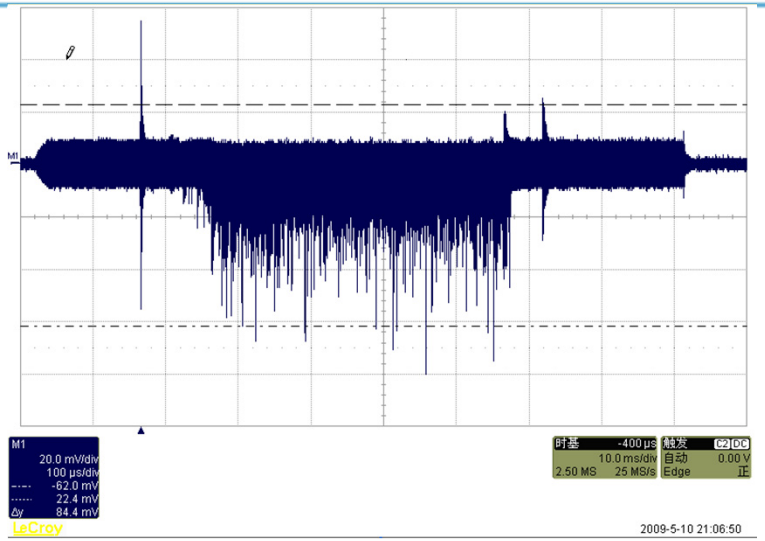


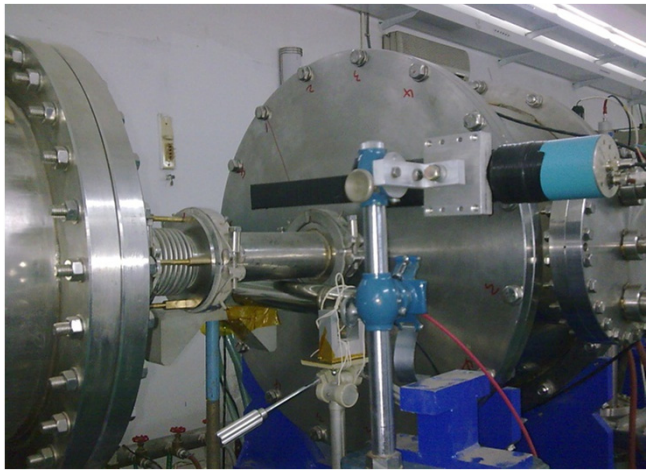


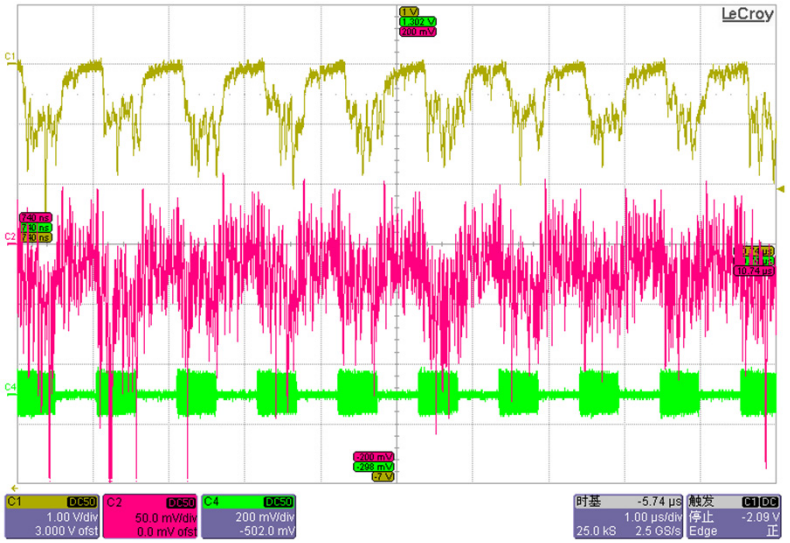


The progress of CSNS beam diagnostics (FBLM)

- A plastic scintillator NE102A + A PMT XP2020 has been finished.
- The signal is observed using an oscilloscope with 600 MHz bandwidth.

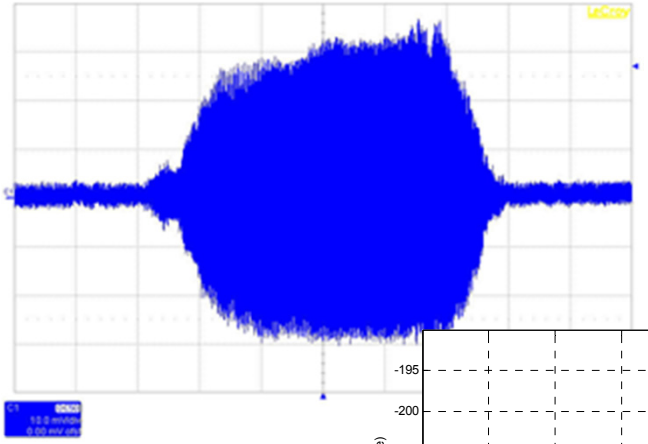




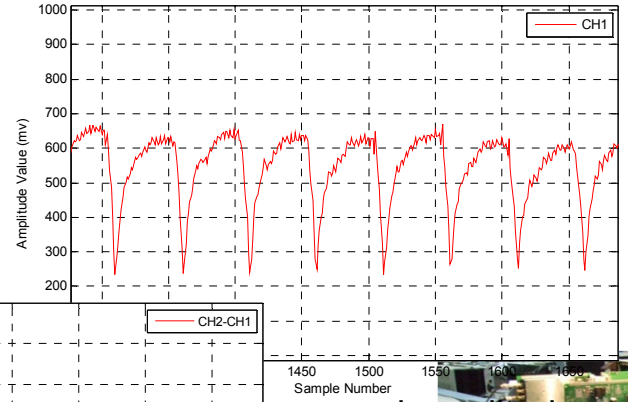


The progress of CSNS beam diagnostics (Phase)

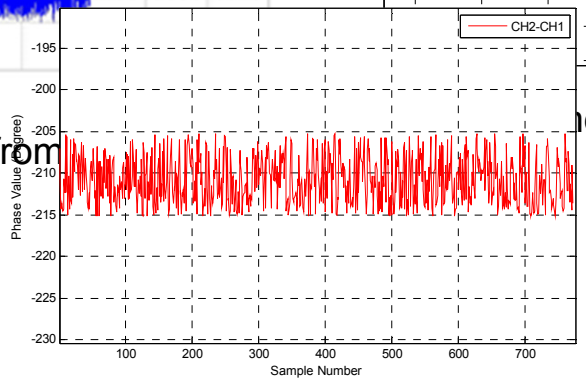
- The Bergoz's FCT is chosen as detector.
- The electronics prototype developed by the Key Laboratory of Physical Electronics, USTC and test with the real beam.



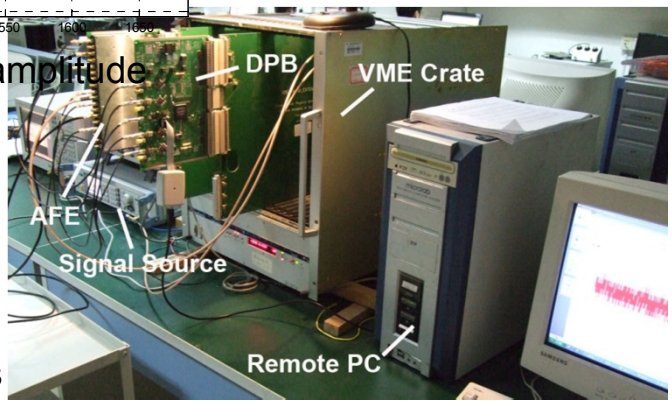
Origin signal output from



easured amplitude



The phase difference between two phase detectors

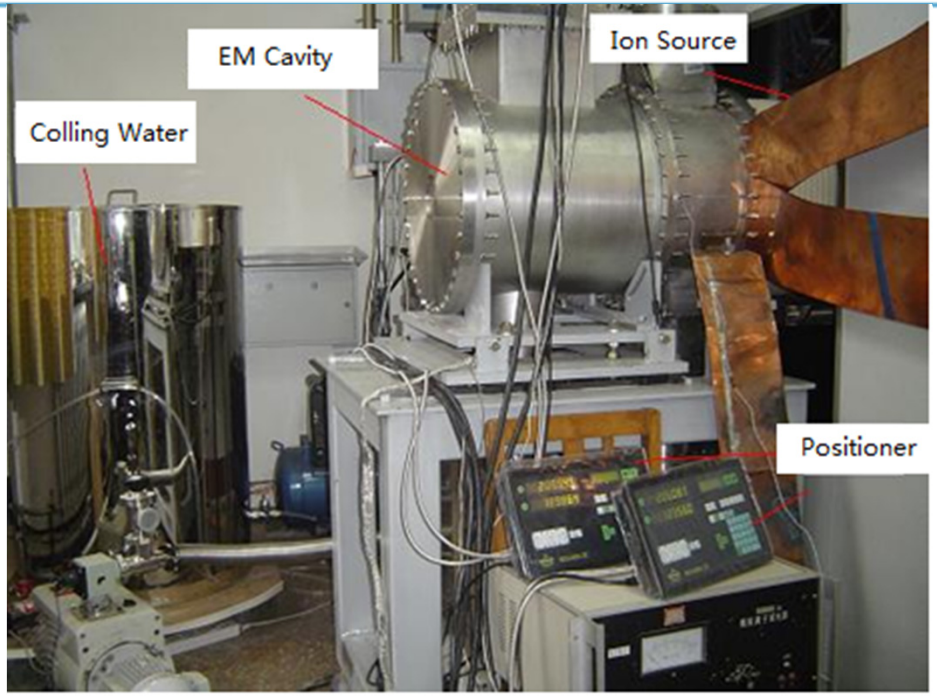


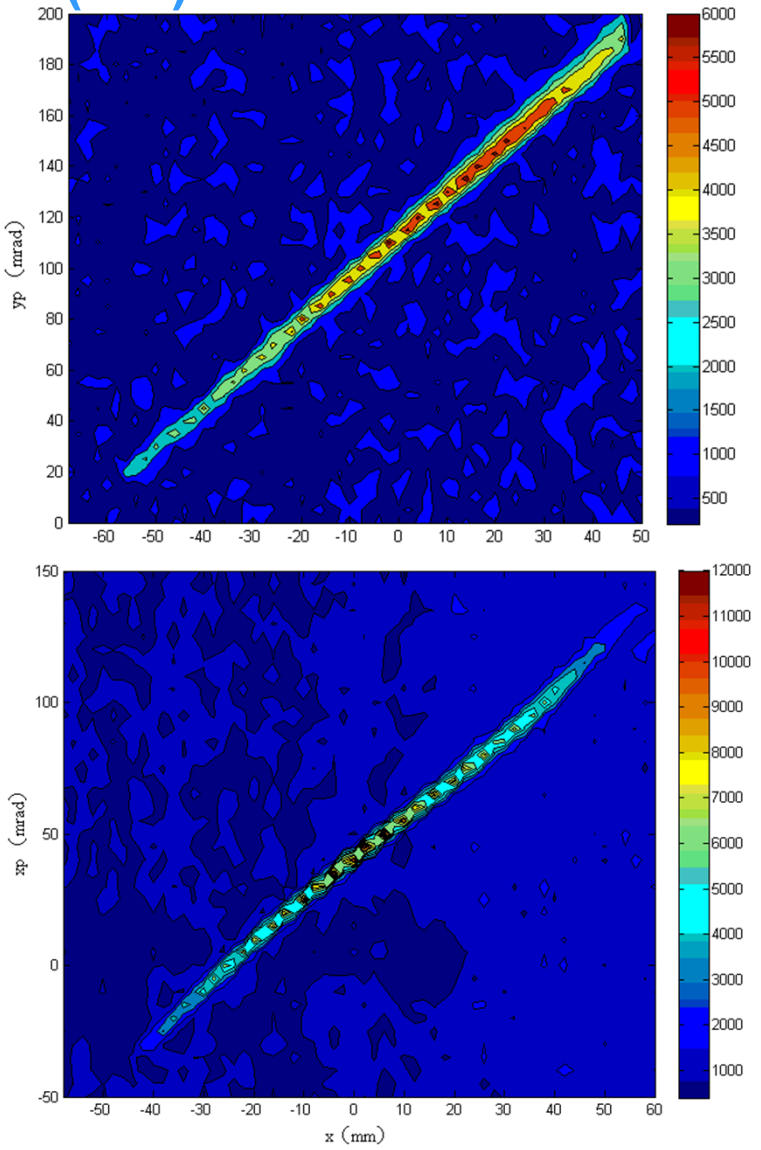
The progress of CSNS beam diagnostics (Phase)

- Base on LLRF data of SNS, through the beam phase measurement, the specification of reference signal of phase system is clear.
- Harmonic ≤-40dBc; spurious ≤-80dBc
- Phase noise: the datasheet of other frequency can be added 20*log(f1/f2).

SSB (dBc/Hz)							
f(MHz) \ Hz	1	10	100	1k	10k	100k	1M
11.74	-98	-128	-148	-163	-168	-168	-168
46.96	-85	-115	-135	-150	-155	-155	-155
340.46	-68	-98	-118	-133	-138	-138	-138
352.2	-68	-98	-118	-133	-138	-138	-138

The progress of CSNS beam diagnostics (EM)



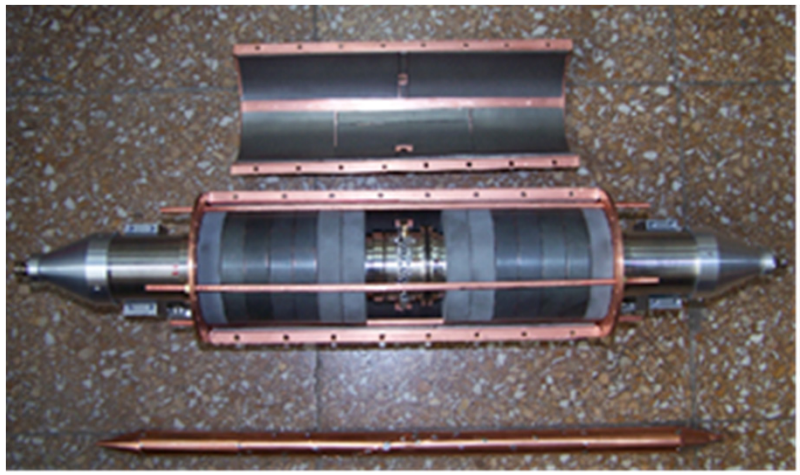


The ion source emittance is measured.

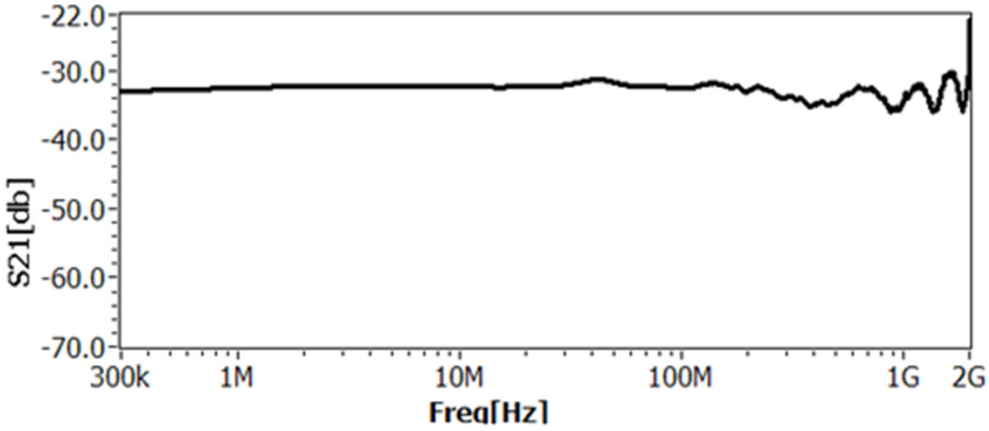
It need to do more measurement to improve the whole system.

The progress of CSNS beam diagnostics (WCM)

- Referred the Fermi type
- The prototype is made.

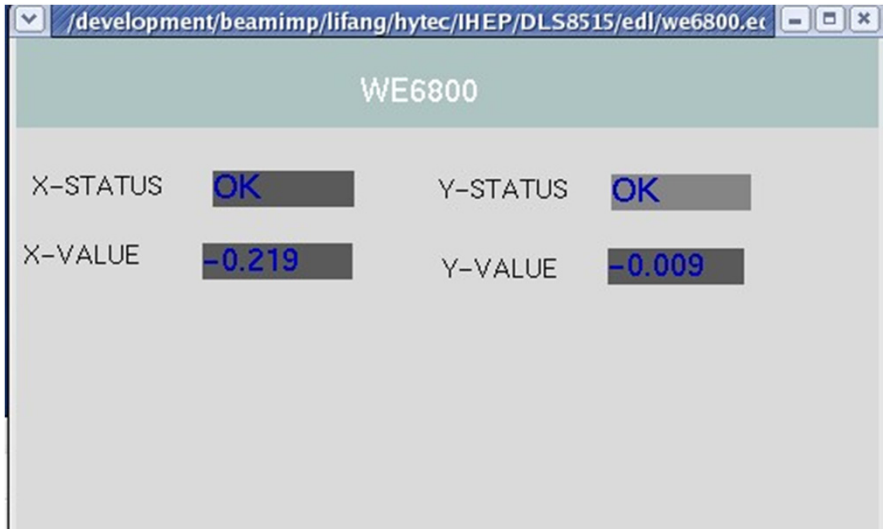


Wall current monitor and central conductor



The progress of CSNS beam diagnostics (Readout system)

- **Based on EPICS 3.14**
  - We can used the ADC, DAC, DIO, introduced in advance.
  - We will choose the hytec ADC 8424: 1MHz sampling rate, 14 bit for wire scanner.
  - Serial communication can be used for Optical Scale electronics.



The Next year's plan

- According to the CSNS CPM plan, at mid of the next year, the commissioning of CSNS FE will be started.
- All beam monitors in FE should be finished manufacturing, purchasing, assembling and pre-commissioning.

Acknowledgment

- Thanks for J-Parc experts help

  – on monitor design, layout of the beam diagnostics; exchange their experience on commissioning, manufacture and so on.

- Thanks for SNS experts help!
- http://neutrons.ornl.gov/diagnostics/documentation.html
- http://www.jacow.org/
- http://www.aps.anl.gov/epics/

Thank you for your attention!

SNS
CHINESE ACADEMY OF SCIENCES