# Beam Loss Monitoring of ADS and HIRFL

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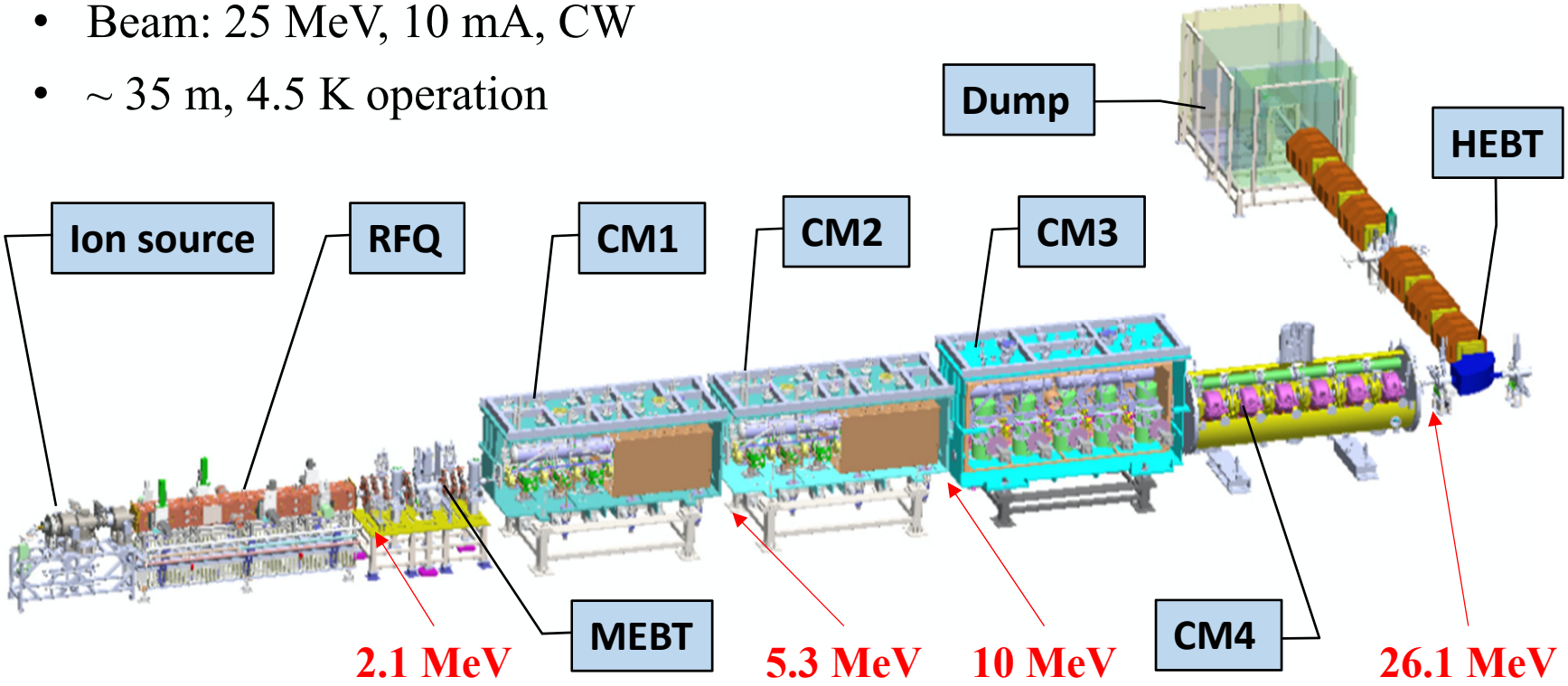
# Outline

- The purpose of beam loss monitoring
- Testing of ADS Proton LINAC
- Testing of HIRFL-RIBLL2
- Summary

# The purpose of beam loss monitoring

**China-ADS**

- A superconducting proton LINAC
- Beam: 25 MeV, 10 mA, CW
- ~ 35 m, 4.5 K operation

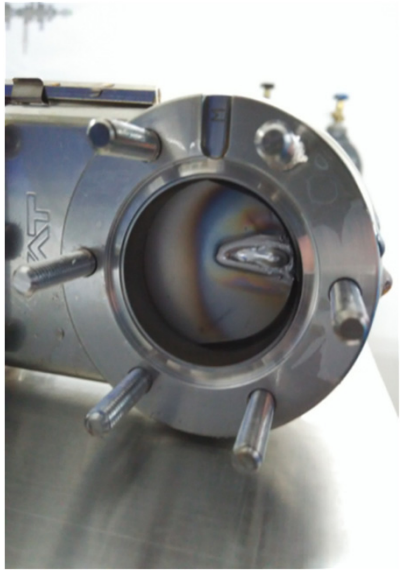



- *To demonstrate the technology of 10 mA CW beam of superconducting LINAC at the front-end*

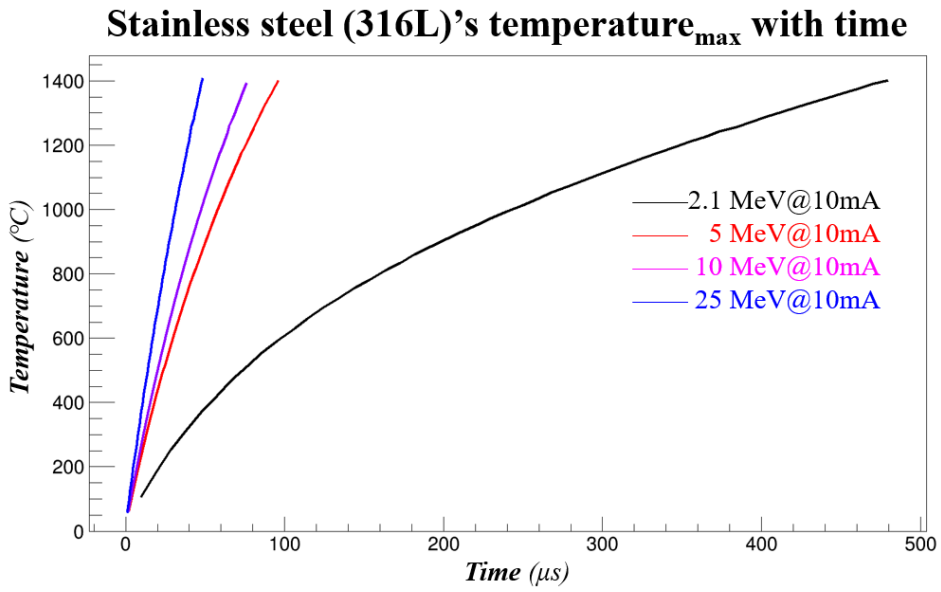
# The purpose of beam loss monitoring

***Effects of CW proton beams on machines***

- *Damage to the machine is very large, although beam energy is in the low energy region.*
- *If the energy of CW beam is up to 25 MeV, it takes only tens of microseconds to melt the stainless steel (1375℃).*
- *Fast beam loss monitoring is very important.*



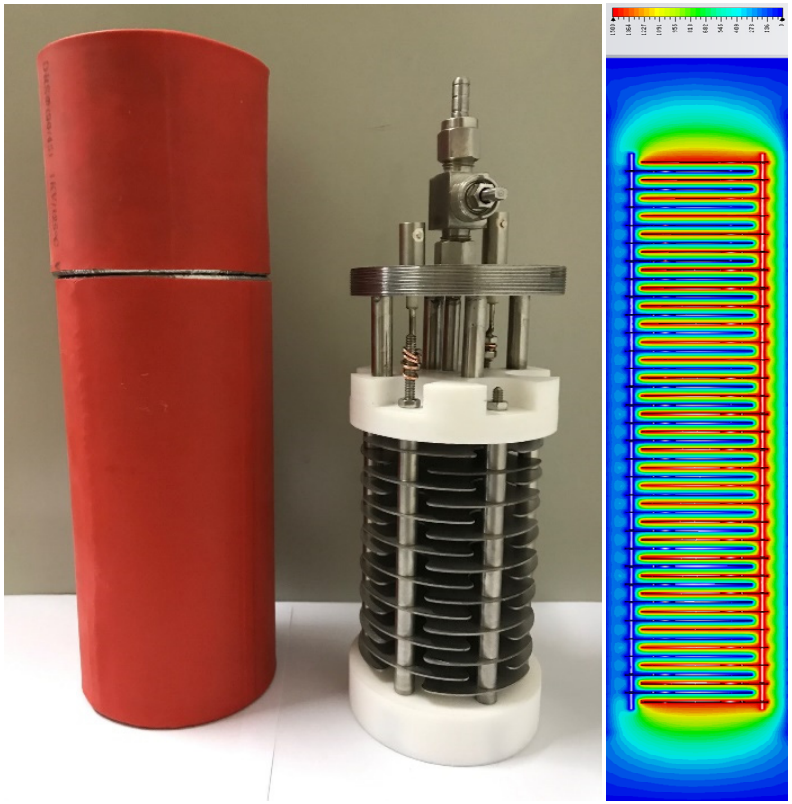
vacuum valve
2.7mA@2.5MeV, CW, 5s



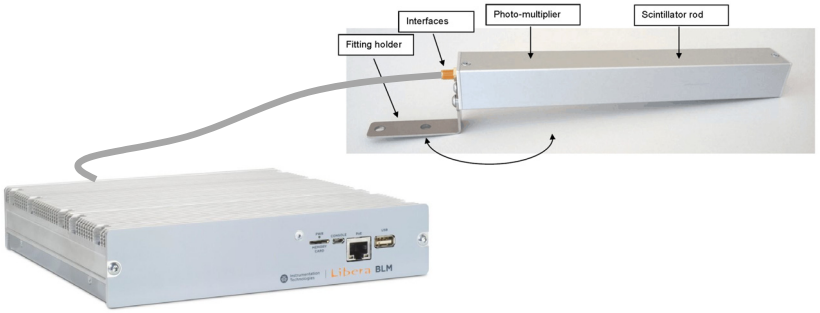

vacuum pipe of bending magnet
2.7mA@2.5MeV, CW, 1min

# Beam Loss Detectors

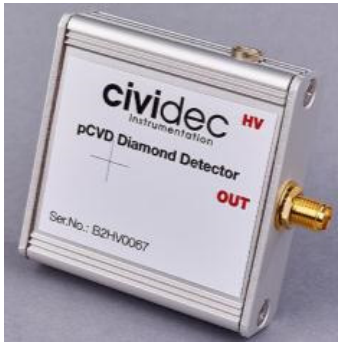
➢ **Choose the most common detectors for testing.**



Ionization Chamber
(similar to CERN's, $N^2$, 2 bar)




Libera-BLM
(plastic scintillator, 3 mm lead shield)




Diamond detector
(10×10 $mm^2$, 500 μm)

Silicon detector
(PIN, 10×10 $mm^2$, 300 μm)

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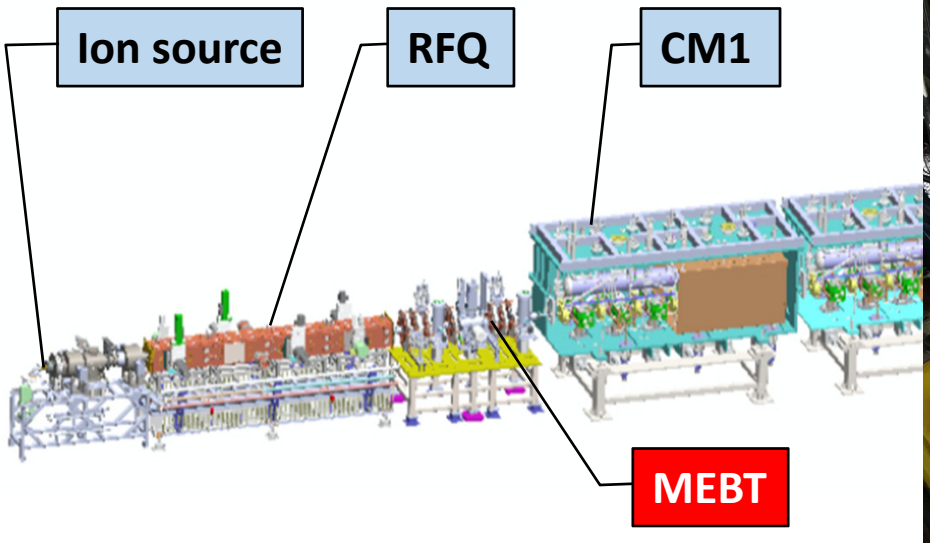
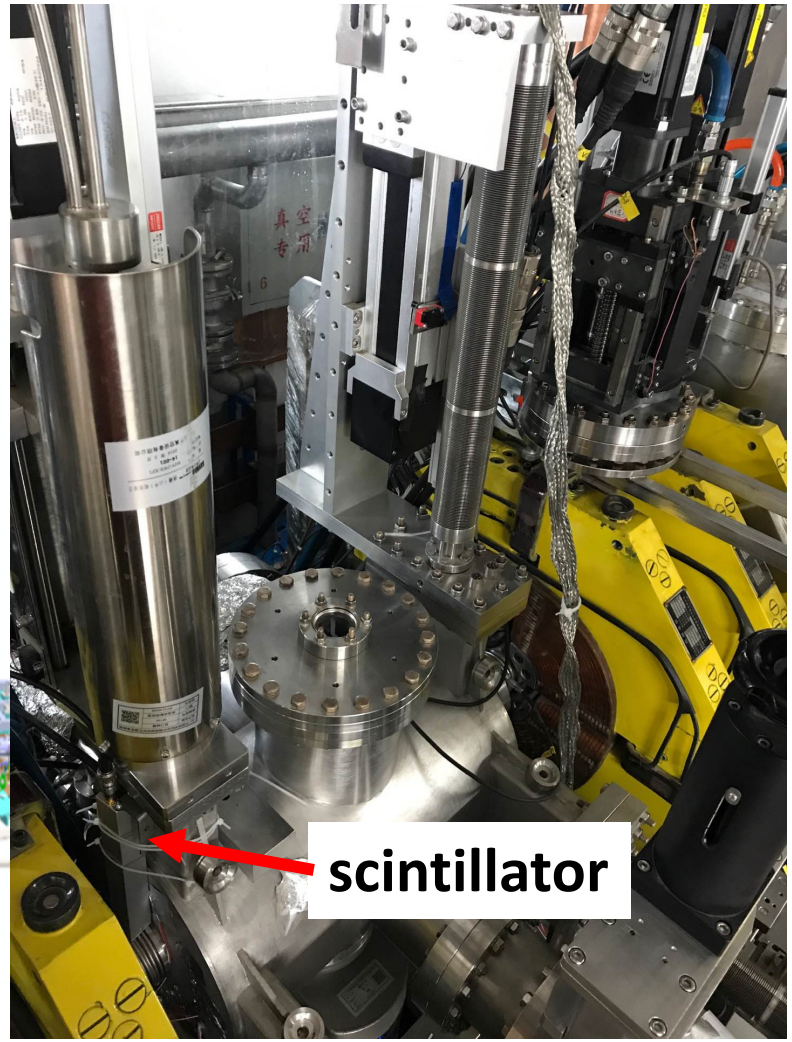
# Testing of ADS Proton LINAC

**First test——MEBT**

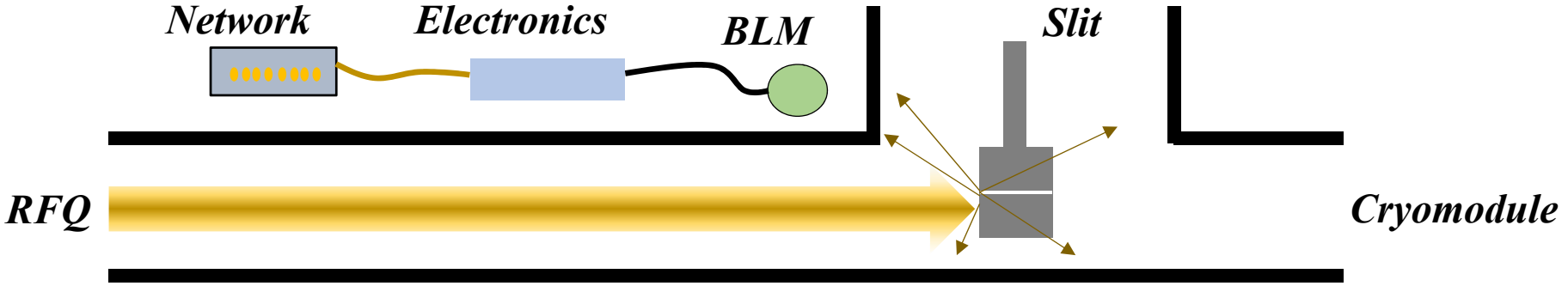
- Beam: proton (pulse)
- Energy: 2.1 MeV@ 7 mA
- Pulse Length: 30 μs@ 5 Hz
- Detector: Libera-BLD(scintillator)

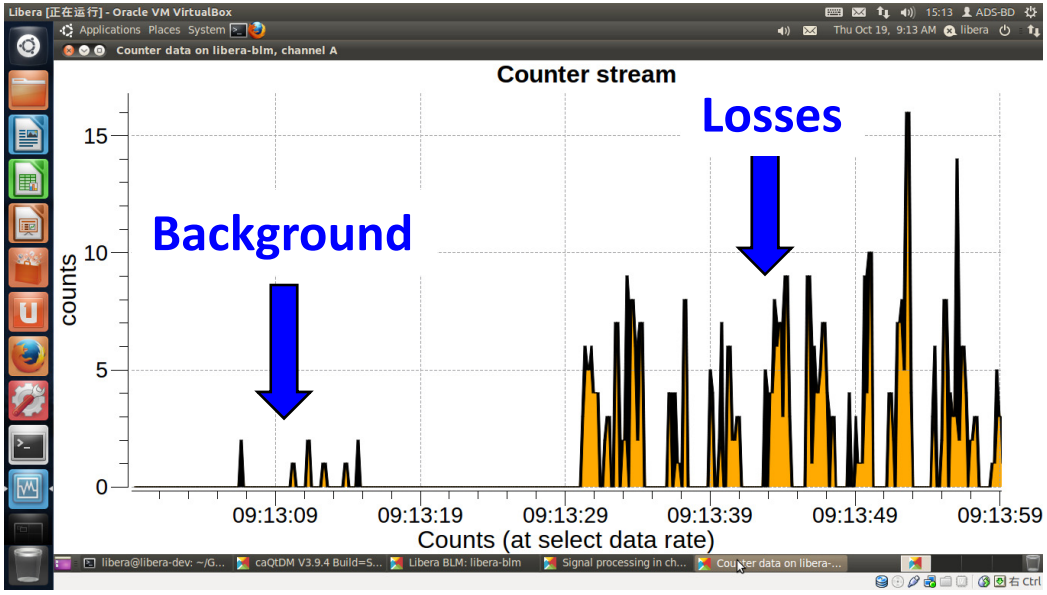


# Testing of ADS Proton LINAC

➢ **The beam loss processes was made by adjusting a slit (movable device).**



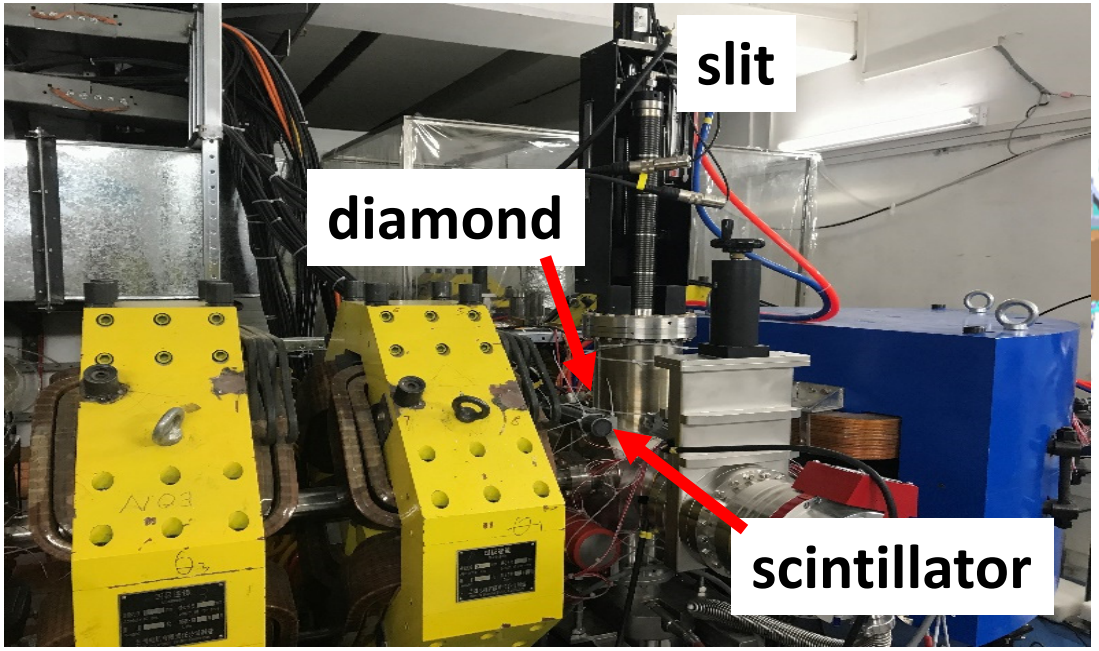



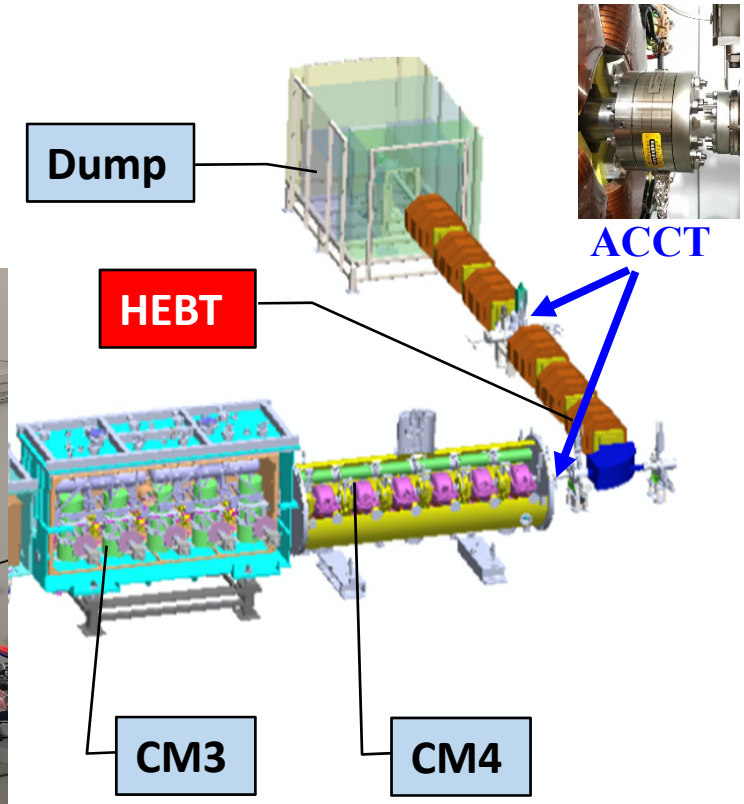

- *BLM (scintillator) can be used to monitor beam loss in the low energy region !*

# Testing of ADS Proton LINAC

**Second test——HEBT**

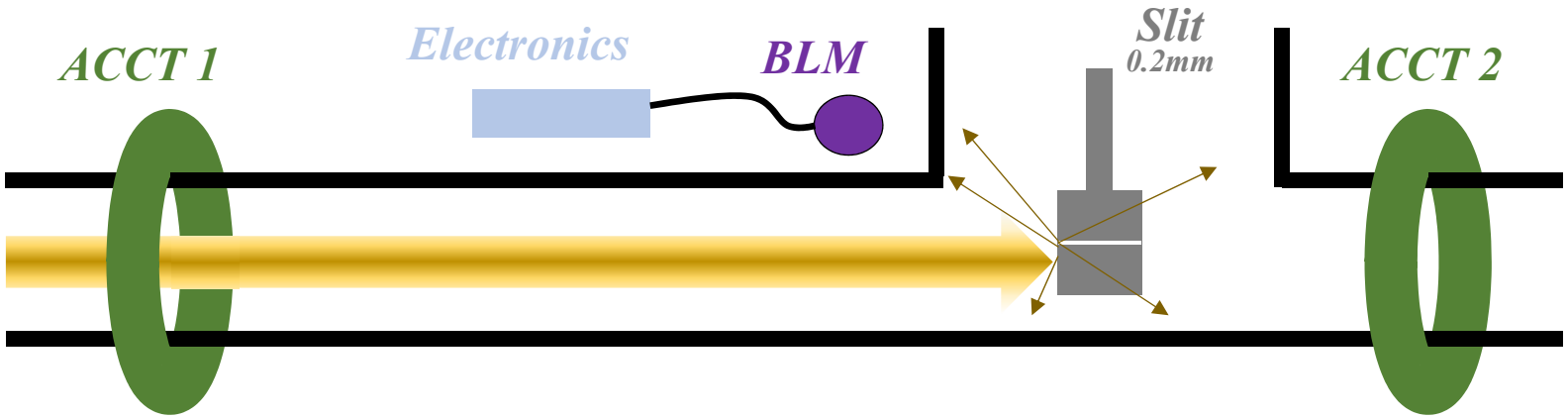
- Beam: proton (pulse)
- Energy: 18.3 MeV@ 1 mA
- Pulse Length: 10 μs@ 1 Hz
- Detector: scintillator and diamond
- Comparison with difference of ACCTs

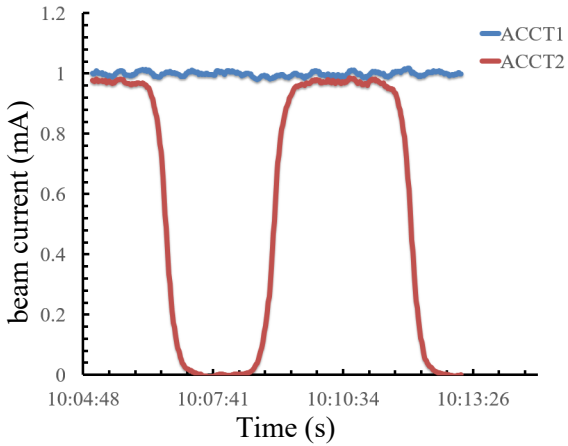


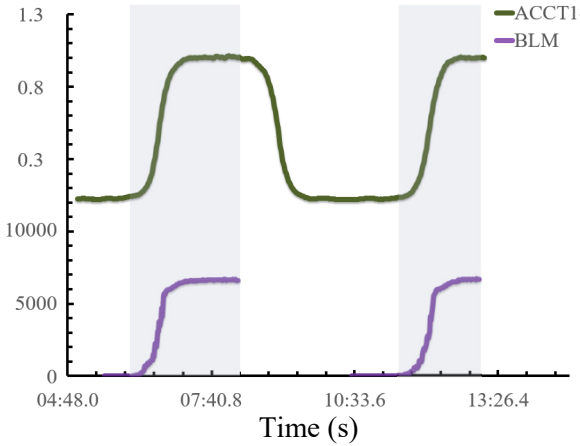



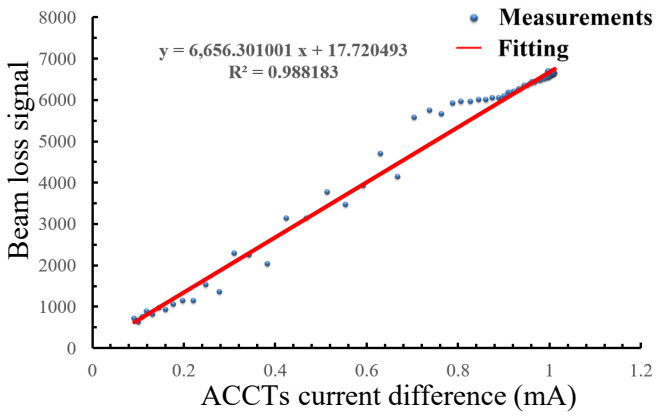
# Testing of ADS Proton LINAC

➢ **The beam loss processes was made by adjusting a slit (movable device).**



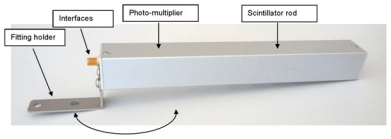




- *The reduced beam current was measured through two ACCTs.*
- *The beam loss detector was plastic scintillator.*
- *There is a linear relationship between BLM's signal and reduced beam current.*

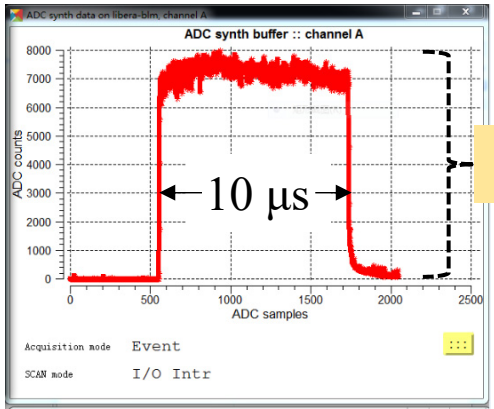
# Testing of ADS Proton LINAC

➢ One shot raw data

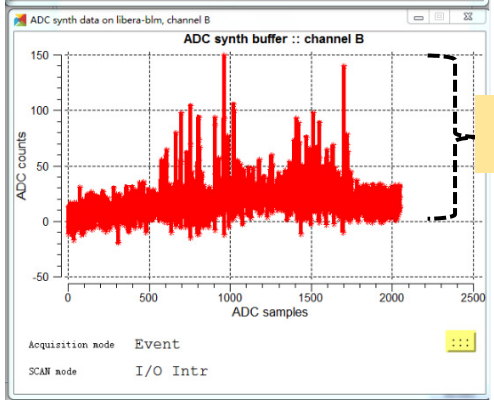



BLD-**scintillator**


BLD-**diamond**

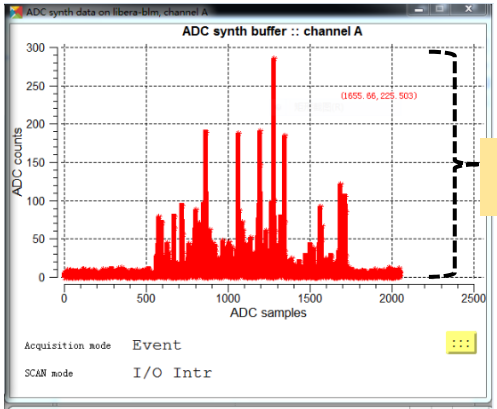



8000

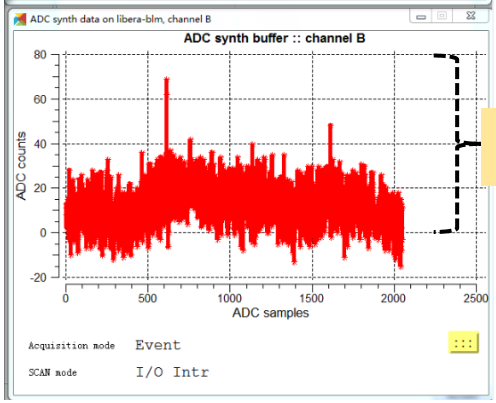



150

Slit inserted




300




80

Slit outside

- *The signal of scintillator is much larger than diamond's because the volume of the scintillator can be very large.*
- *When no make loss the BLD still had signal from beam halo.*

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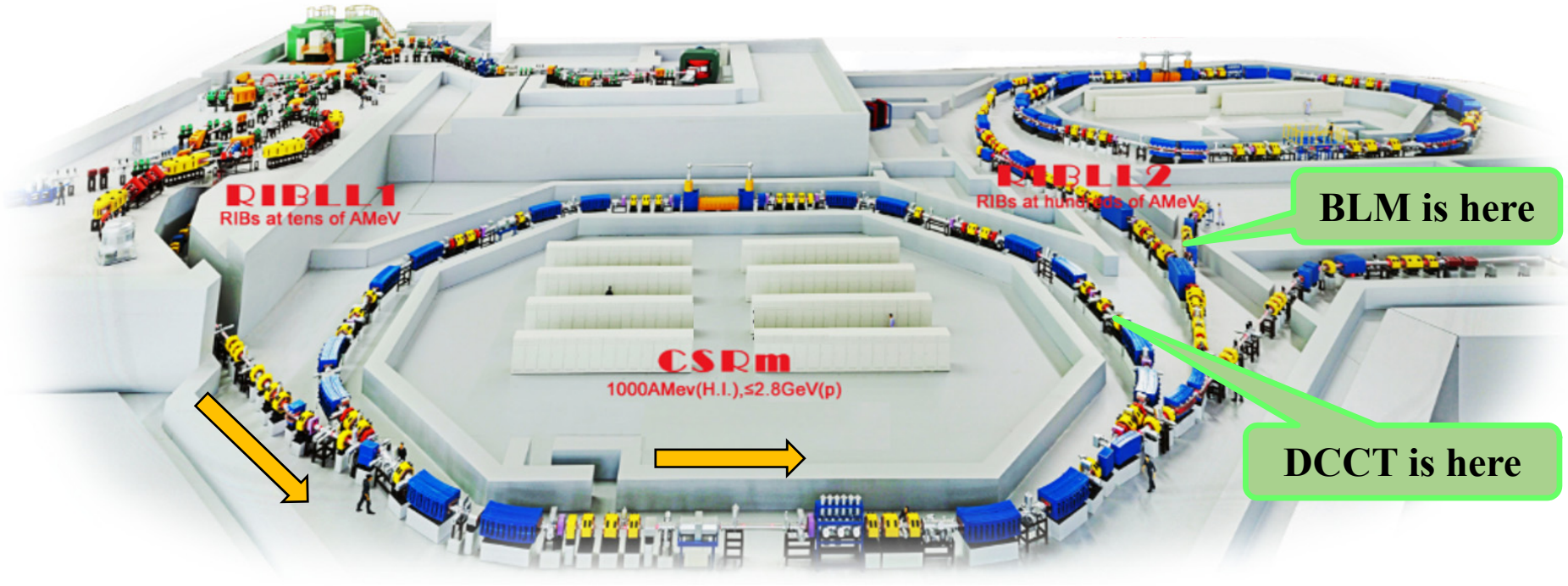
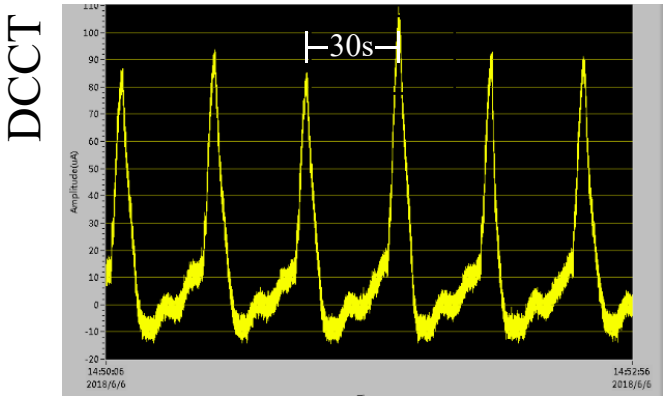
# Testing of HIRFL-RIBLL2

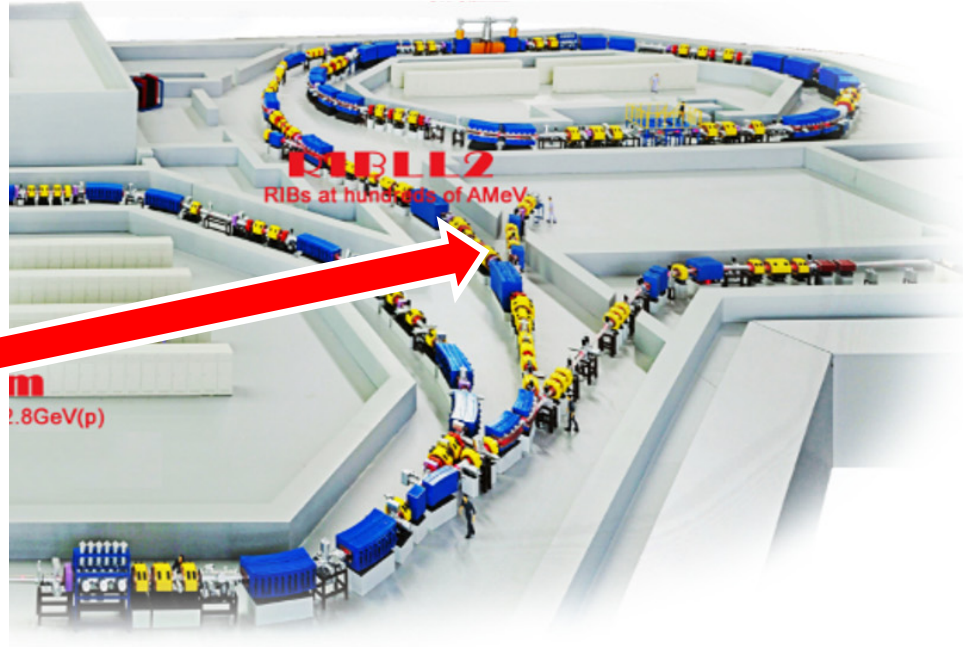



**Heavy Ion Research Facility of Lanzhou (HIRFL)**

- Beam: $^{18}O^{8+}$
- Energy: 280 MeV/u
- Operation mode: slow extraction (about 30s per period)
- Intensity of this test: 50 ~ 290 eμA



# Testing of HIRFL-RIBLL2

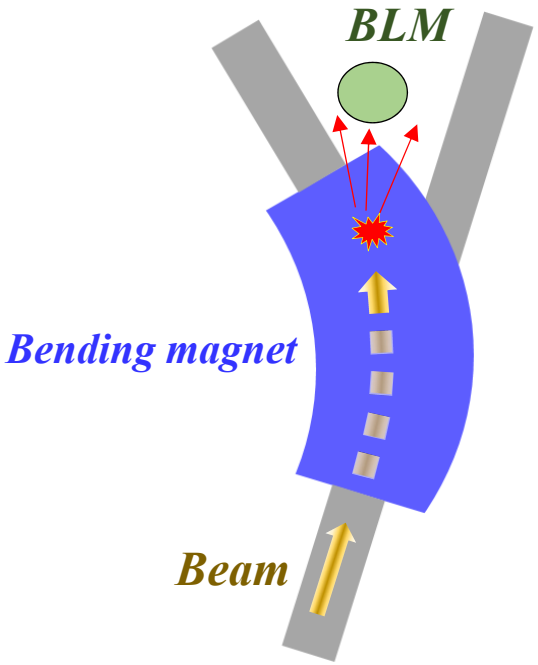



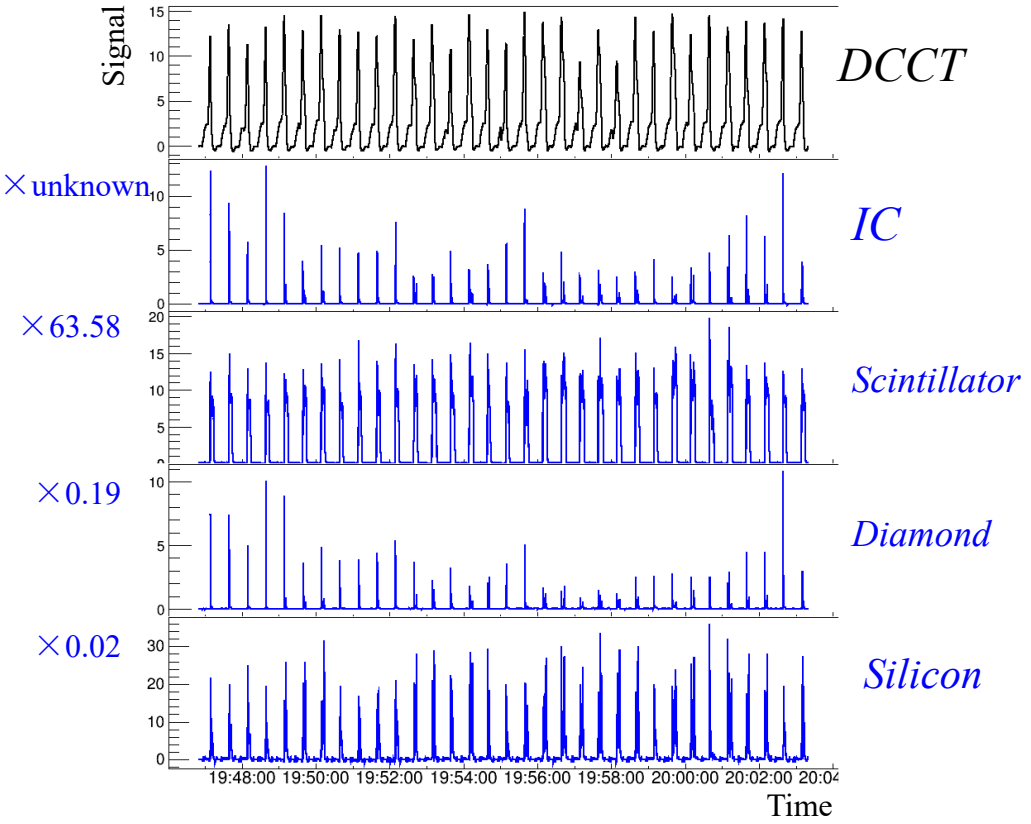

**Type of BLMs:**

- Ionization Chamber
- Libera-BLD(scintillator)
- Diamond detector
- Silicon detector

# Testing of HIRFL-RIBLL2

- **The beam loss processes was made by adjusting magnet strength.**

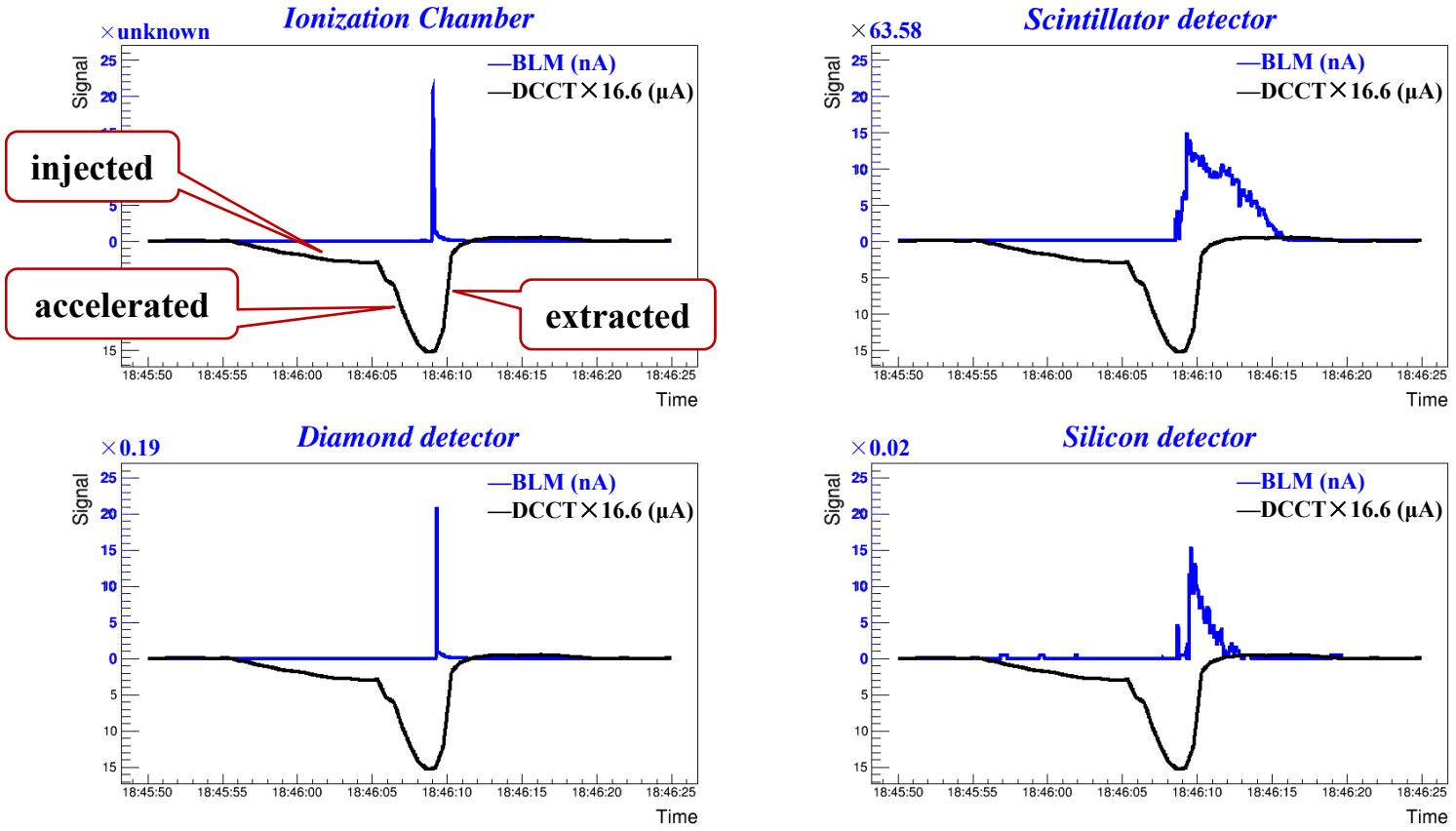



- *DCCT's value is the beam intensity in the upstream storage ring (CSRm).*
- *DCCT's peak value is equivalent to the sum of the extracted beam in each period.*
- *IC's signal is so weak, the electronics is an integrator (IC101).*

# Testing of HIRFL-RIBLL2

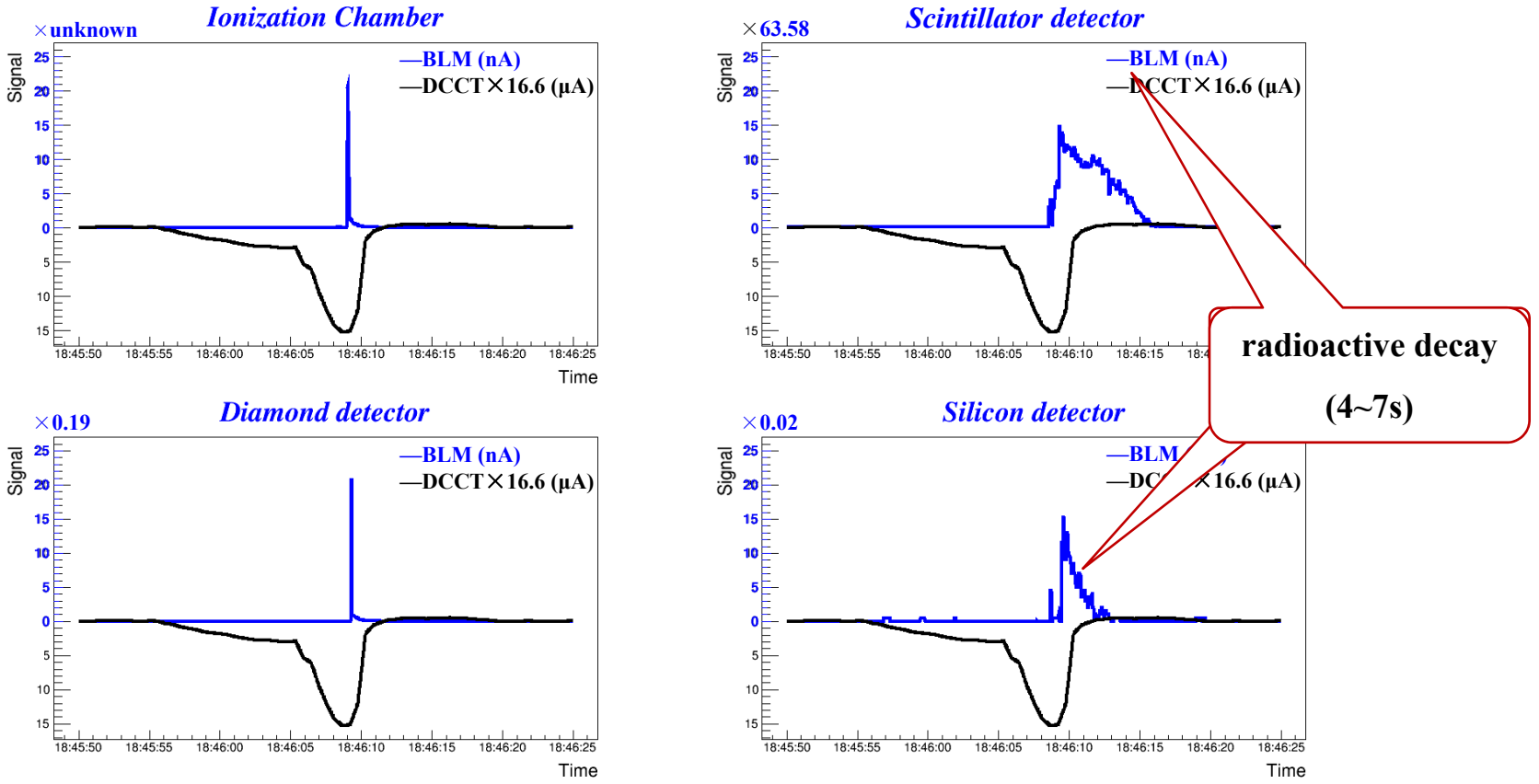
- One set of data per period




- *The beam was injected into CSRm to accelerate and then slowly extracted (~2s).*
- *When the beam was extracted, the value of DCCT decreased and the beam loss signal increased.*

# Testing of HIRFL-RIBLL2

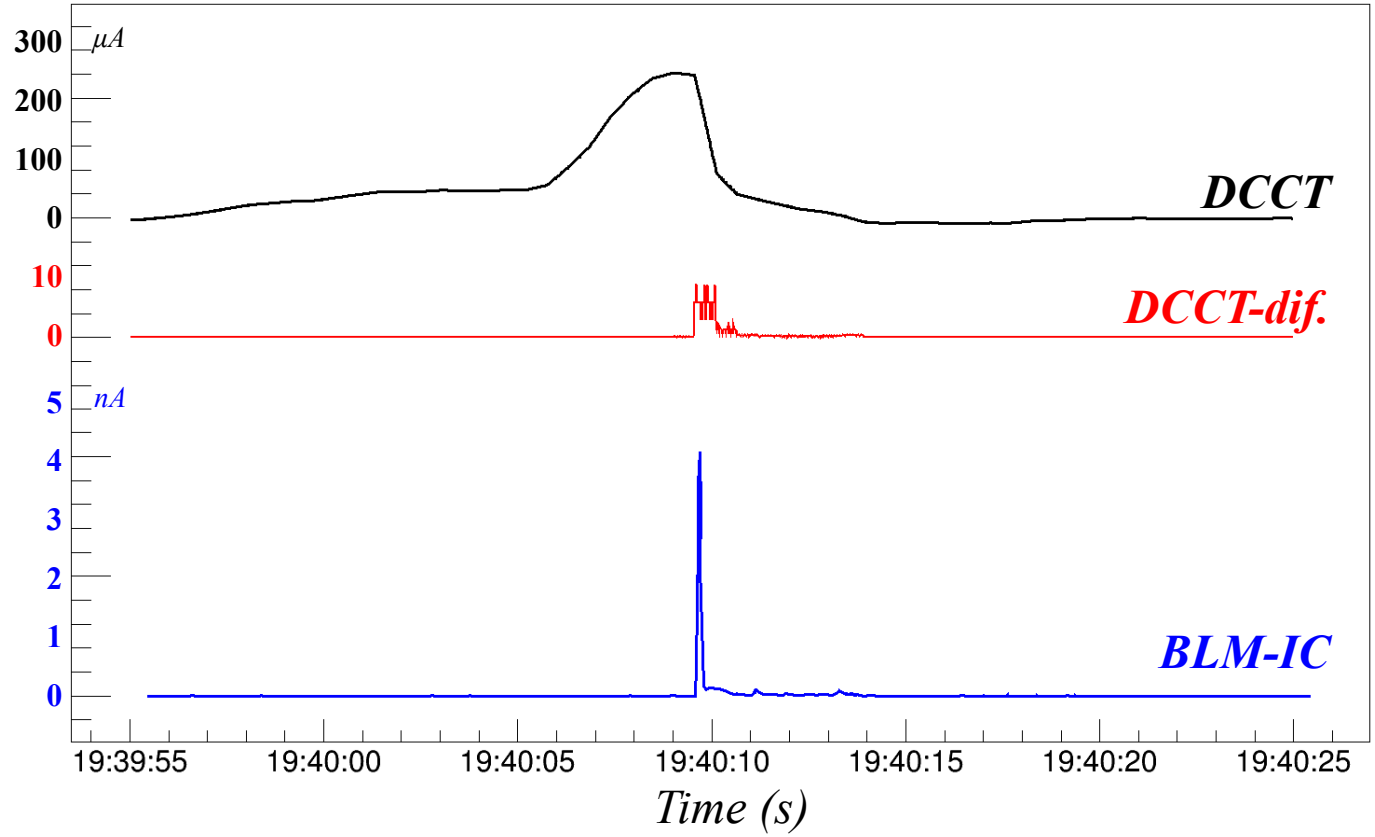
➢ One set of data




- *The signals of Ionization Chamber and Diamond are very clear.*
- *The signals of Scintillator and Silicon may be a superposition of the radioactive decay particles and lost beam.*

# Testing of HIRFL-RIBLL2

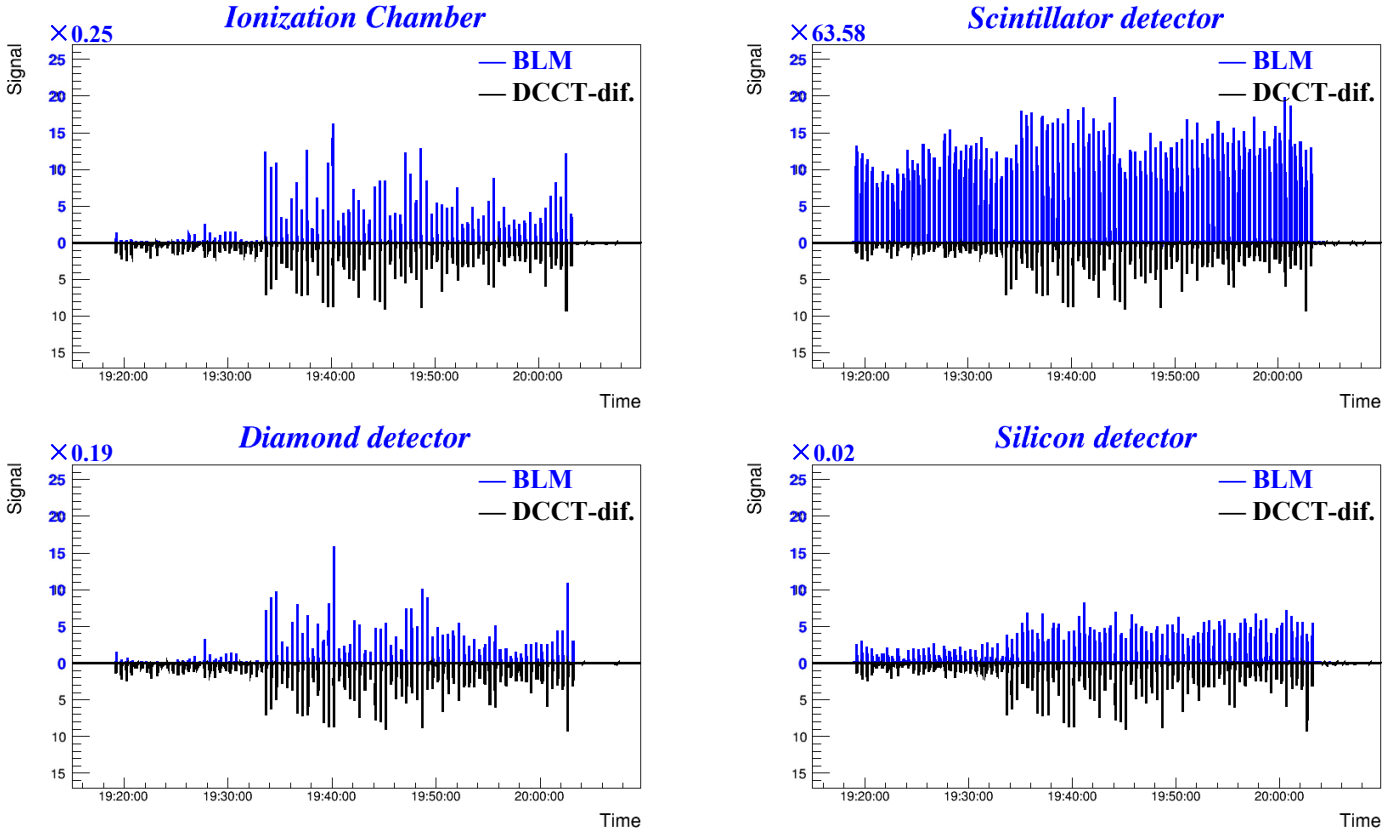
- One set of data comparing the BLM (Ionization Chamber) and DCCT.




- *The **DCCT-dif.** means the differential value of DCCT, which is equivalent to the reduced beam current near the magnet.*
- *We want to find a linear relationship between DCCT-dif. and BLM.*

# Testing of HIRFL-RIBLL2

- Comparison of different beam loss monitors for all raw data




- *Ionization chamber & diamond have a linear relationship with DCCT's difference.*
- *The scintillator & silicon are not good, which are affected by decay particles.*
- *Indeed, this beam loss reference is not very well!*

# Summary

- Beam loss monitors were tested at the ADS and HIRFL, including
  - ionization chamber,
  - plastic scintillator,
  - diamond and
  - silicon.
- For proton beam, **plastic scintillator** seems to have the best sensitivity and be good choice for the beam loss diagnostics in the low energy region.
- For heavy ion beam, the choice of BLM's shielding material is very important.
  - Plastic scintillator is covered with a layer of 3 mm lead for shielding low-energy rays, but it may produce some decay particles.
  - Diamond is good but relatively more expensive.
  - Silicon’s signal is so weak and need to improve that.
  - **Ionization chamber** similar to CERN’s design shows good properties, especially for beam loss monitoring in the high energy region.


*Thank you for your attention !*