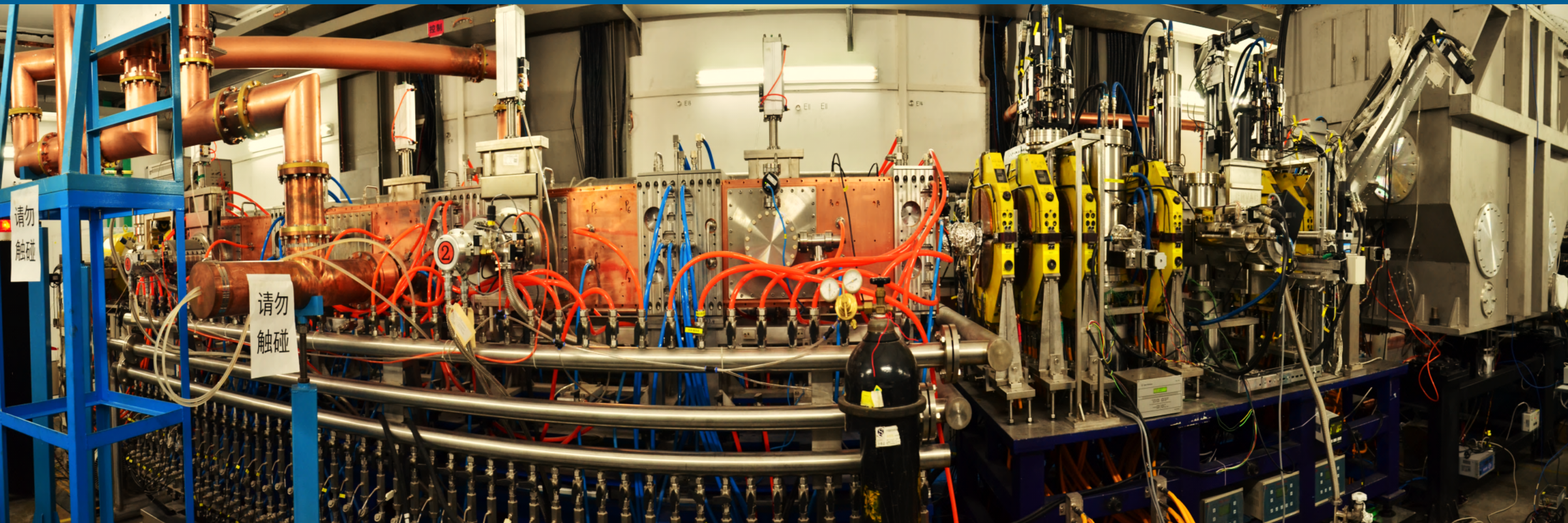
CADS
Chiniese Accel rator Driven
Sub-critical System

High Power Beam Commissioning Issues for the Prototype of C-ADS Injector



C-ADS Injector Demo Facility

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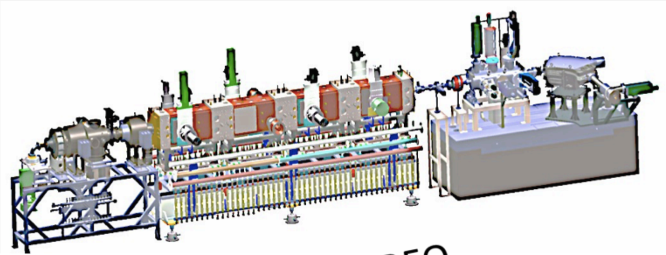
13th International Conference on Heavy Ion Accelerator Technology,
YOKOHAMA, JAPAN， September 7-11, 2015

Outline

- Brief introduction of the beam commissioning progress
- Commissioning Issues for the C-ADS injector
- Summary and outlook
- Acknowledge

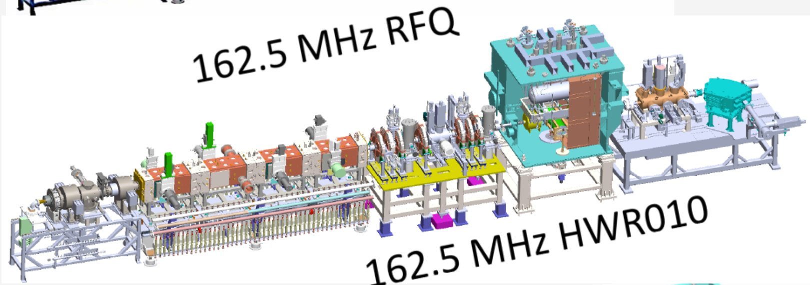
Commissioning Schedule of C-ADS injector

1



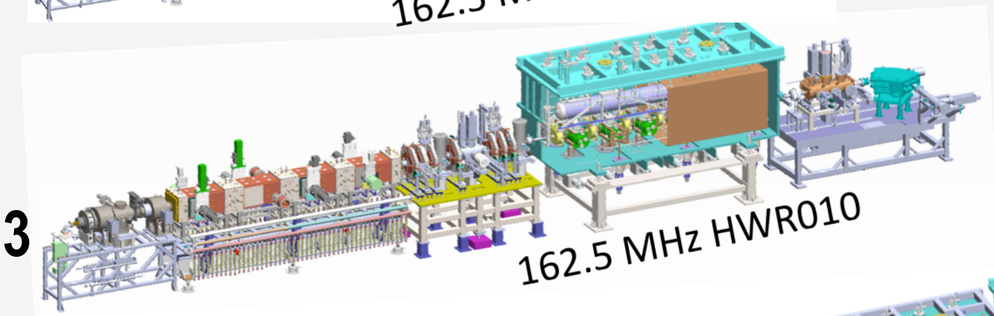
- At the beginning of June , RF CW achieved,2014
- June 6th, the first beam, energy is 2.15 MeV ,2014
- June 30th, 10 mA, CW beam, beam power 21.6 kW,2014

2



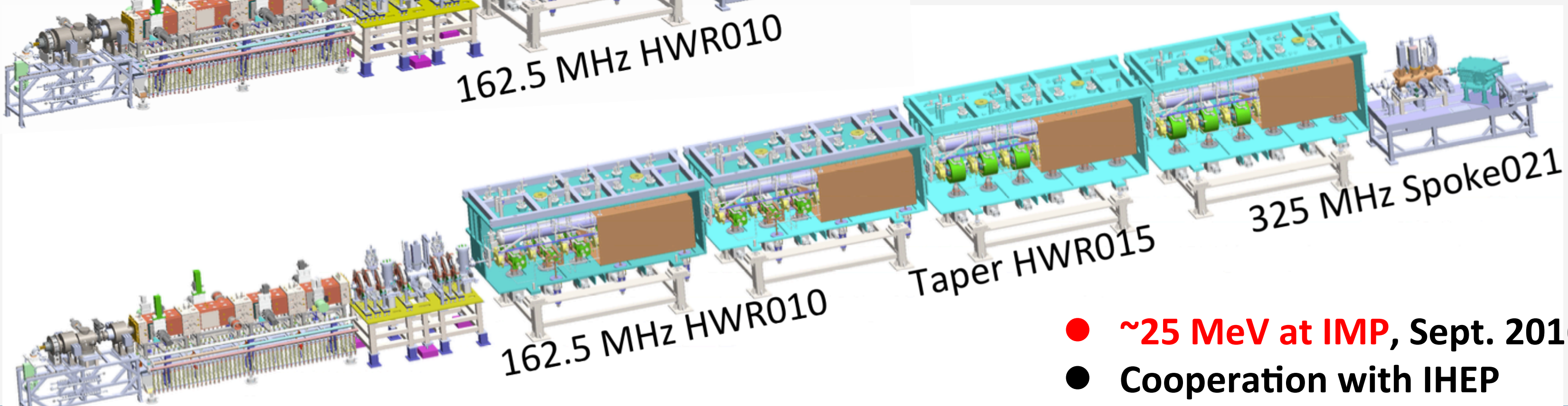
- ECRIS + LEBT + RFQ + MEBT + TCM, 2.5 MeV,2015
- RFQ commissioning, validate CM design.
- CW operation with 10 mA in Feb, 2015 successfully

3



- ECRIS+LEBT+RFQ+MEBT+CM6, 5 MeV
- 10.2mA,5.3MeV, pulsed beam at 6th Jun:2.7mA , 5.2 MeV ,CW at 24th Jun ,2015

4

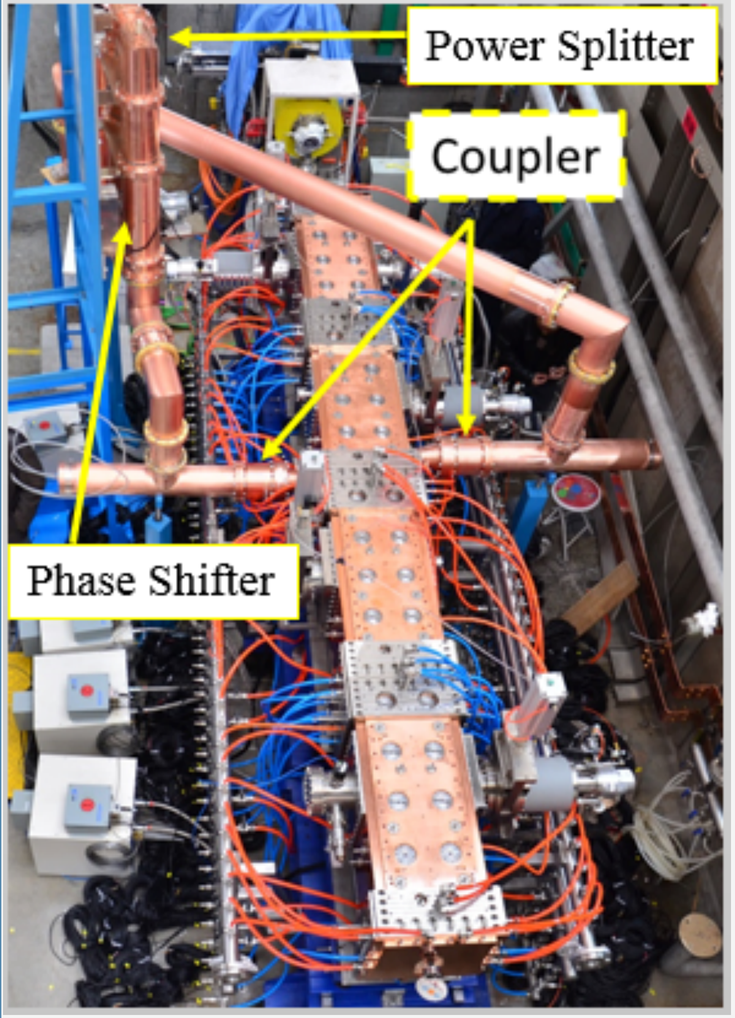


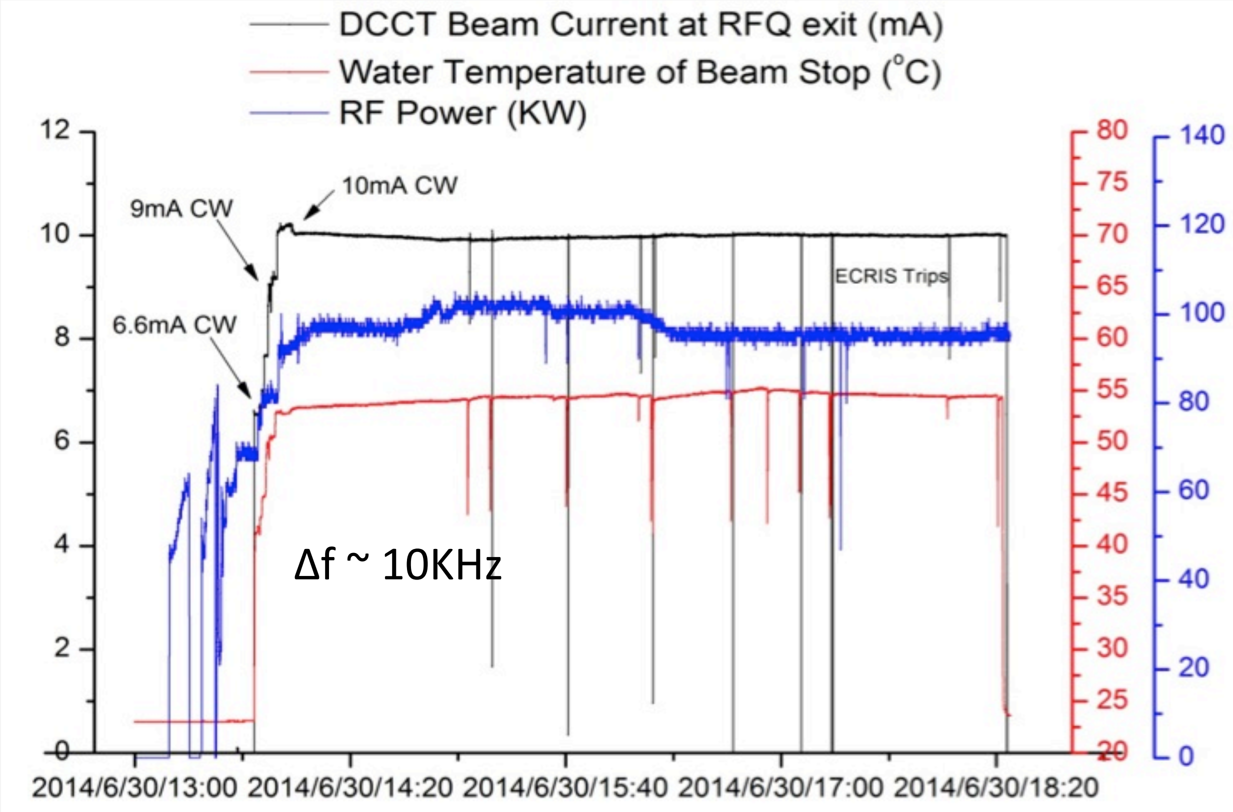
- ~25 MeV at IMP, Sept. 2016 – 2017
- Cooperation with IHEP

Beam commissioning Issues for the Prototype of C-ADS injector

- CW operated RFQ with 10 mA beam
- Benchmark between simulation and experiments
- Hydrogen gas transfer problem
- Beam loss control and detection
- Pulse beam to CW beam issue
- 6D-emittance measurements with no-interceptive BPMs

10 mA CW beam tuning of RFQ





The RF power amplifier is tuned to compensate the beam loading effect.

10 mA CW beam tuning of MEBT&TCM1

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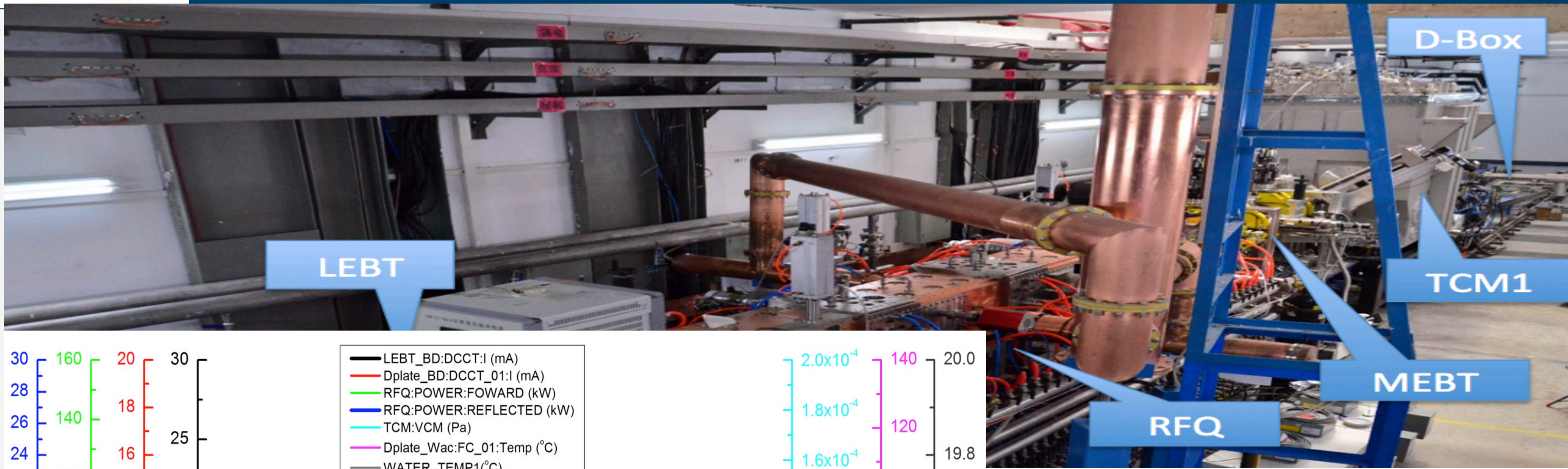
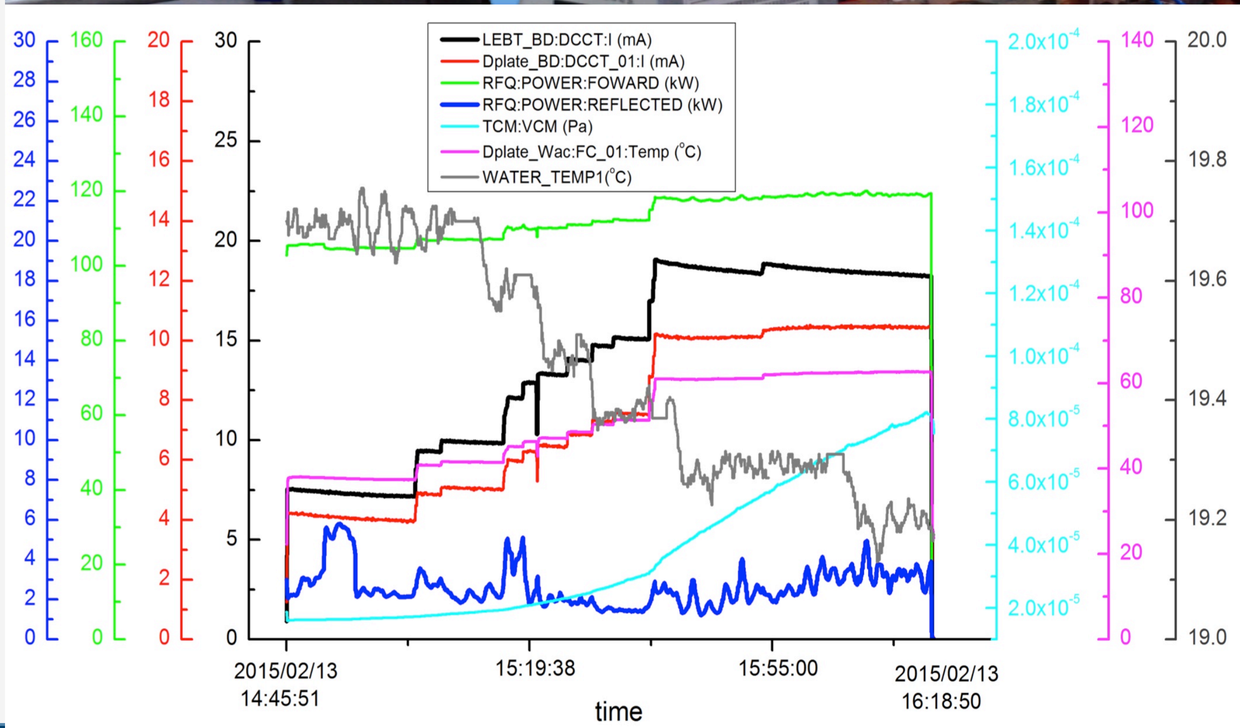
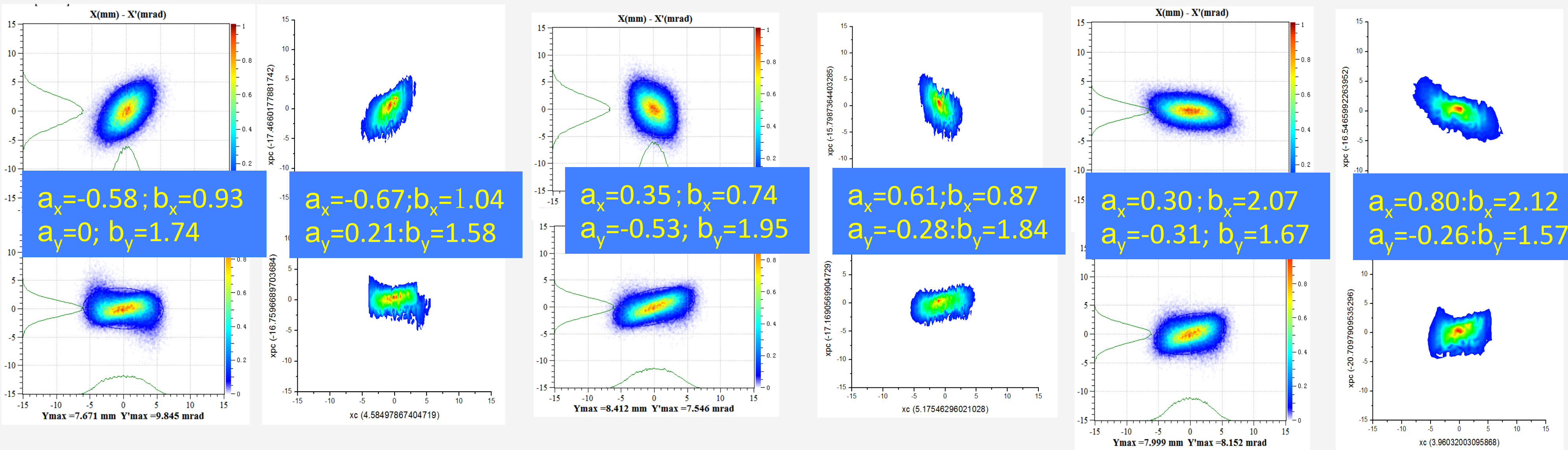




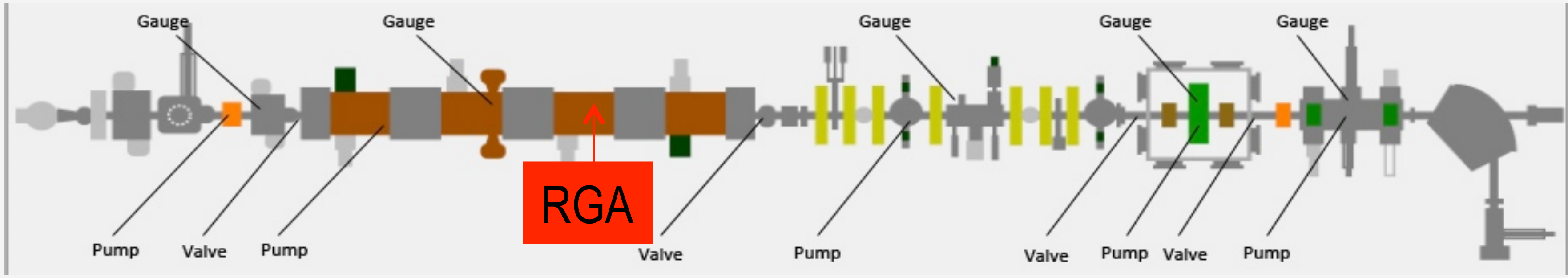
The temperature of RFQ cavity cooling water is tuned manually to decrease the reflection RF power caused by beam loading!

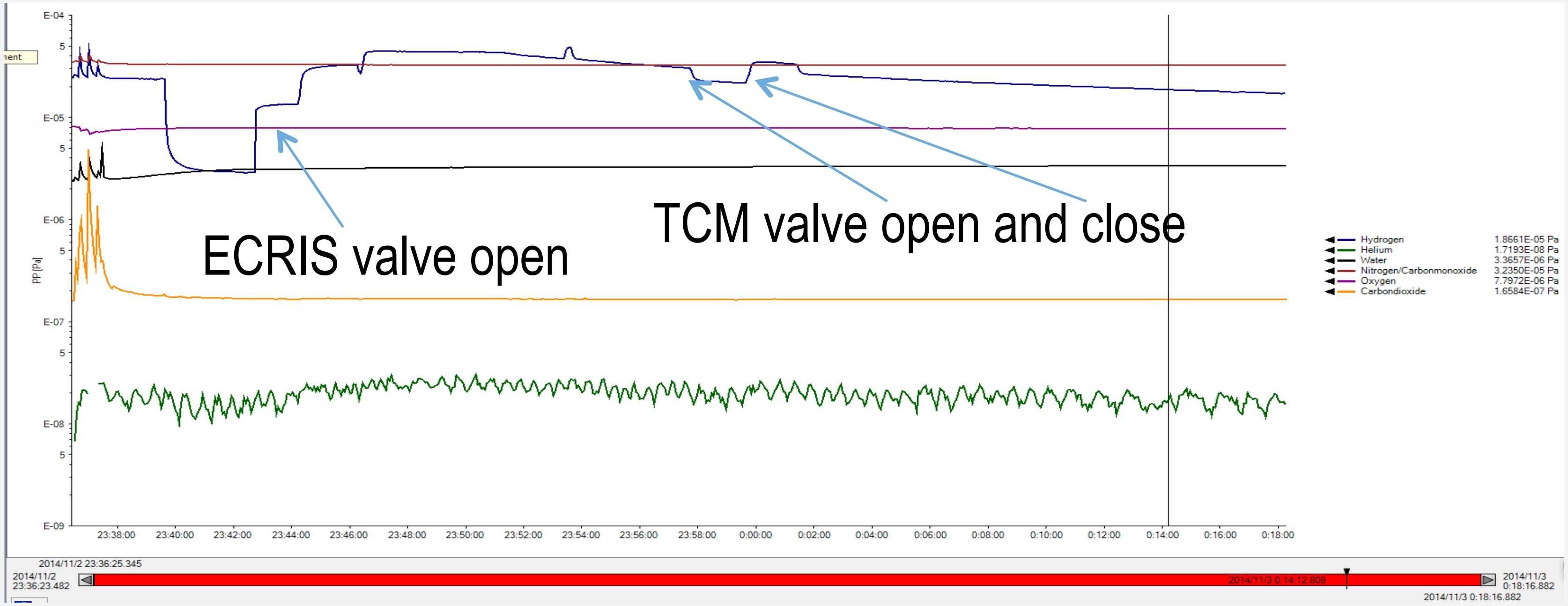
Benchmark between simulation and experiential results

	Alpha_x	Beta_x (m/rad)	Alpha_y	Beta_y (m/rad)
Exp	0.3	0.22	-0.11	0.12
Parmteq	0.46	0.27	-0.10	0.12
Totoutis	0.20	0.22	-0.18	0.11
Track	0.22	0.23	-0.31	0.11



Transfer of hydrogen at C-ADS





Issues of hydrogen transfer at SARAF

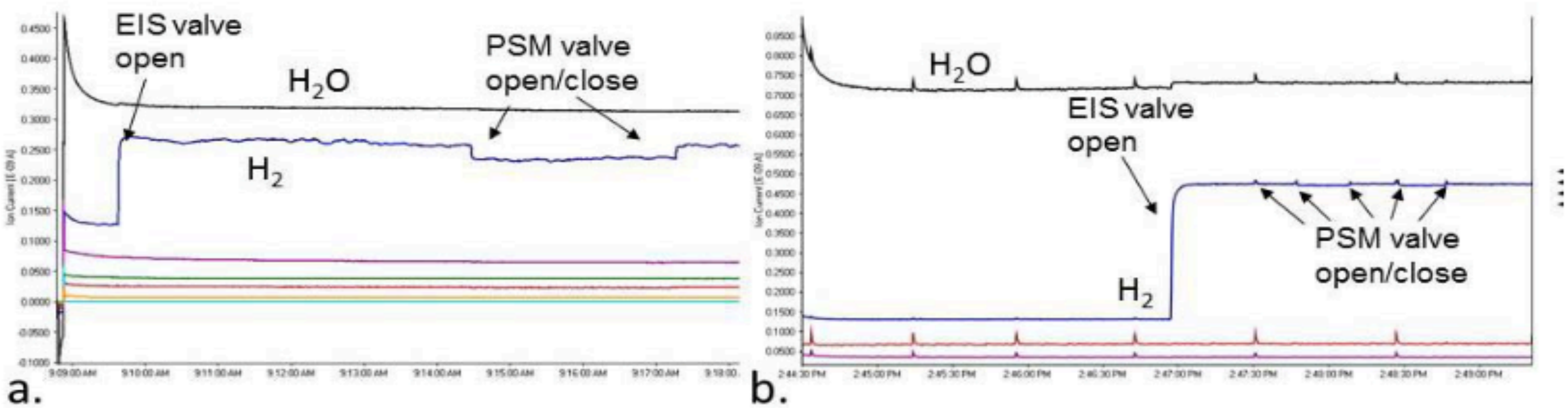


Fig. 13. Log of the RGA installed at the first MEBT chamber. Effect on hydrogen partial pressure at opening of the EIS and PSM valves are shown for the original configuration (a) and after replacement of the ion pump by a turbo pump (b).

The hydrogen and residual gas will frozen on the RF surface of sc cavity. It is contaminated again and causing multipacting.

The reason of sc cavity failure?

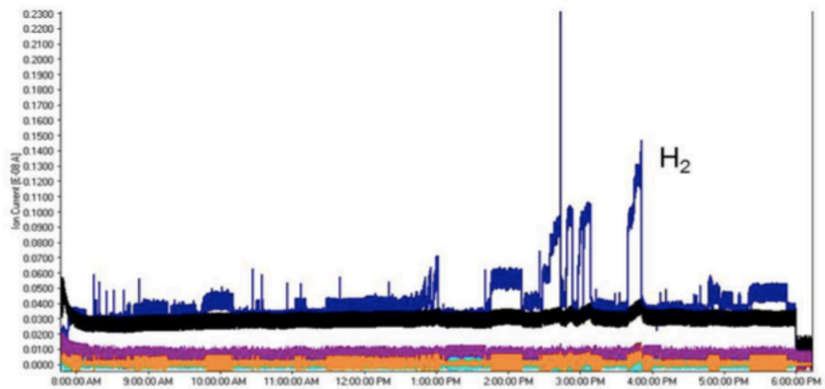
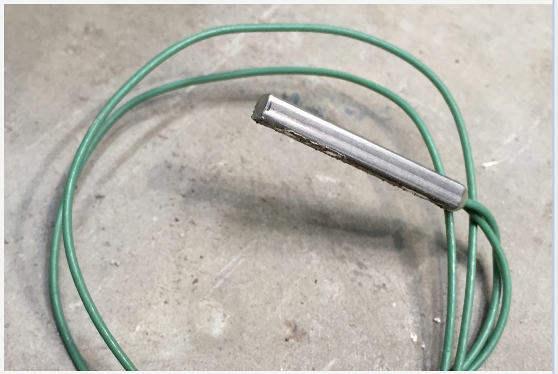
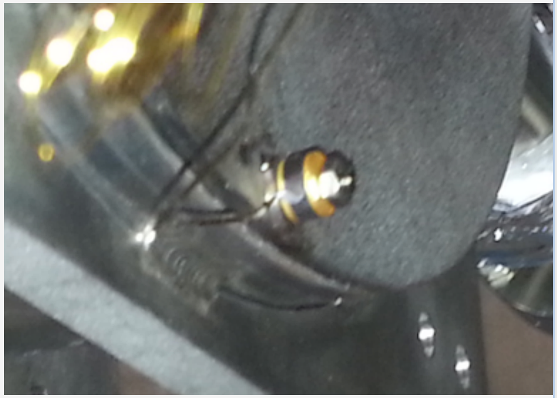


Fig.14. Increase of hydrogen pressure in the MEBT chamber during beam operation

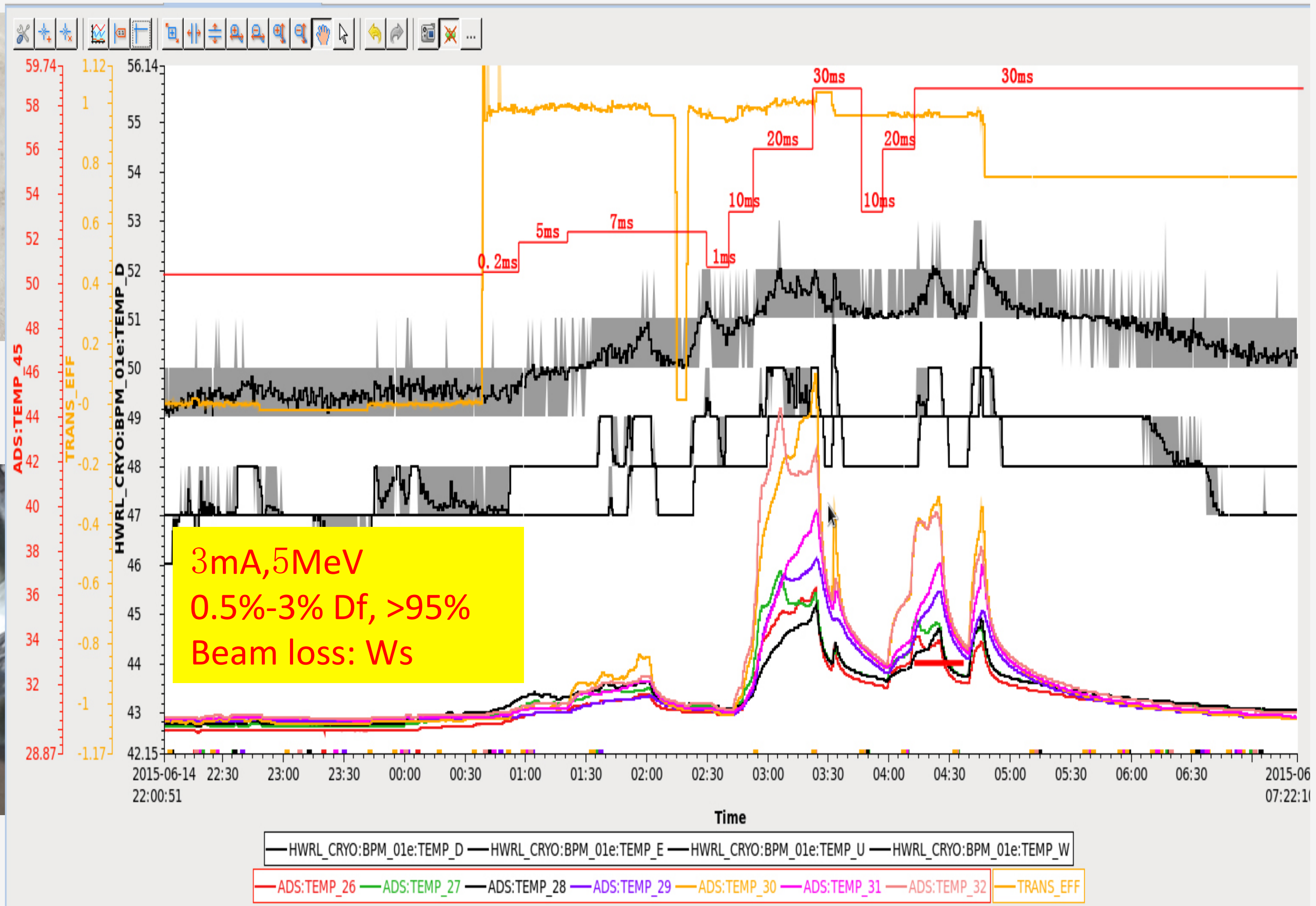
Beam loss detection



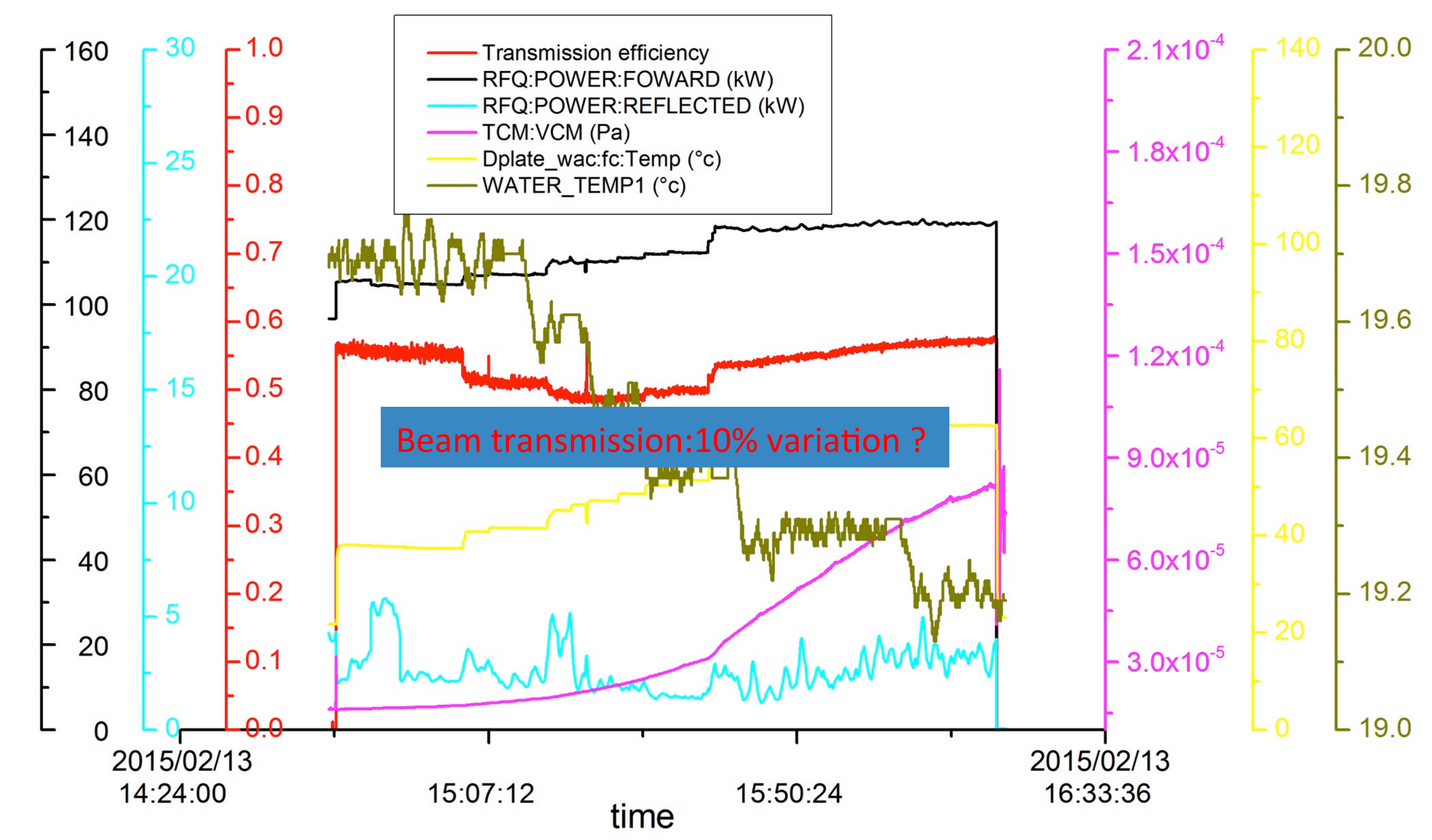
Type: PT100
Normal temperature



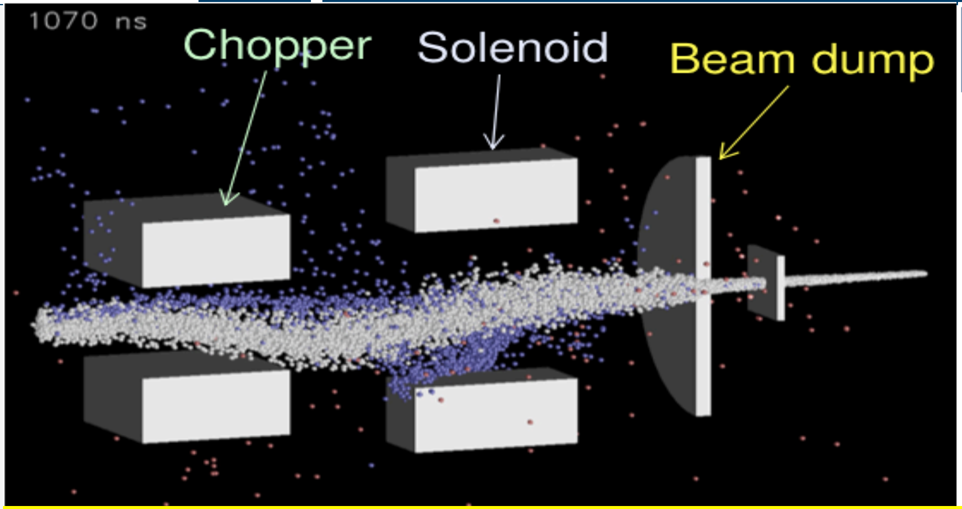
LAKE SHORE：DT-670B
2K-305K（±0.5K)

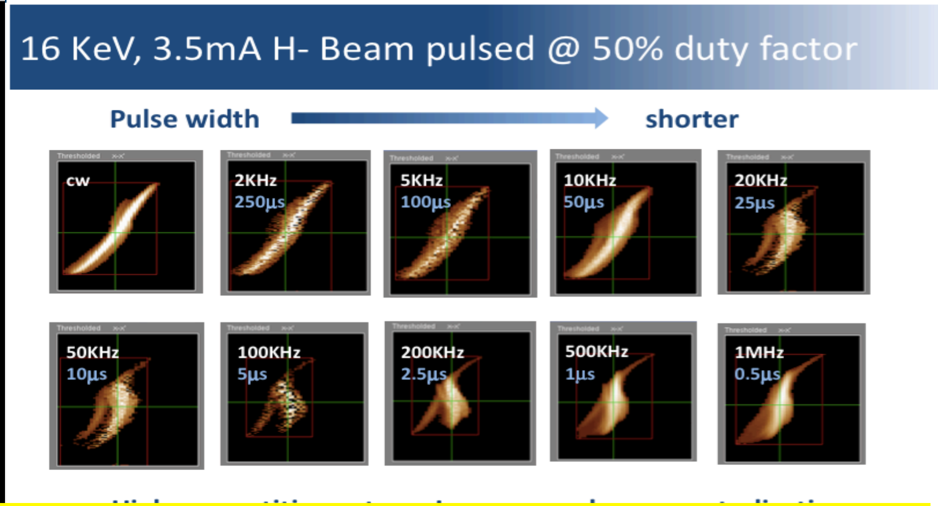


Operation from Pulse to CW beam



Operation from Pulse to CW beam





Operation mode transition from pulse mode to CW, beam maybe out of control.

Q. Ji *et al* Beam dynamics studies of H- beam chopping in a LEBT for project X 12/19

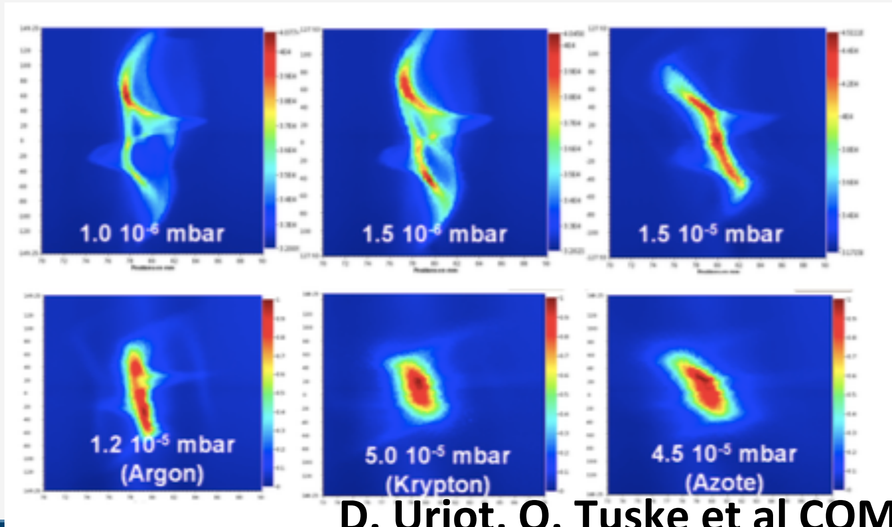
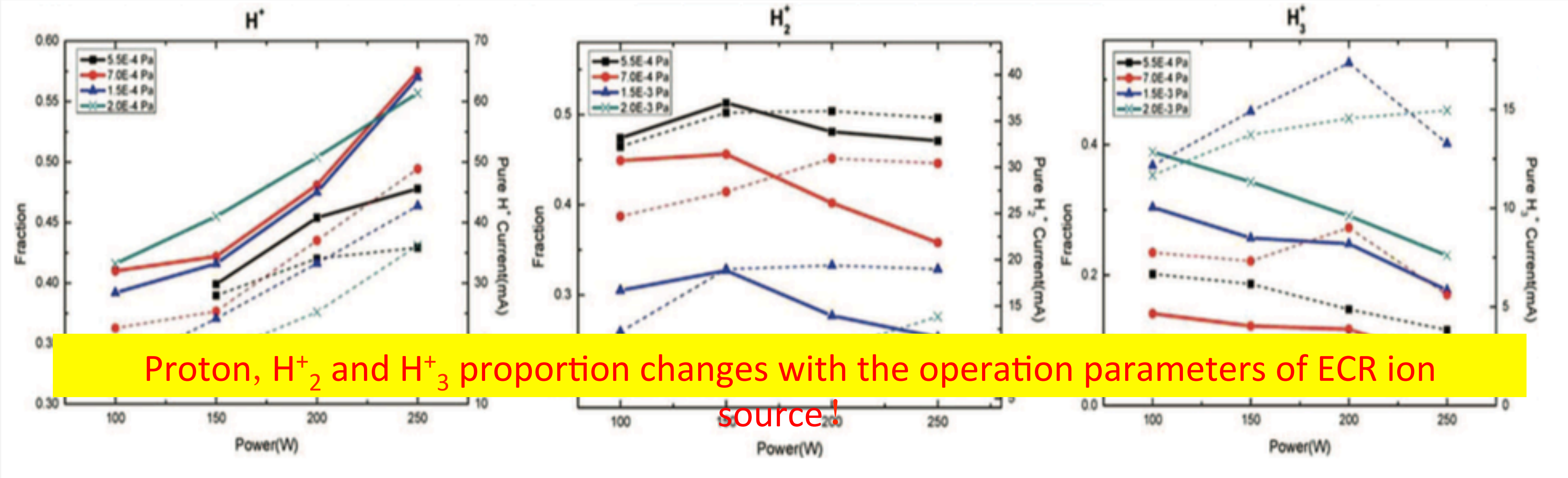


Table 2: Space-Charge Transient Time for Proton Beam

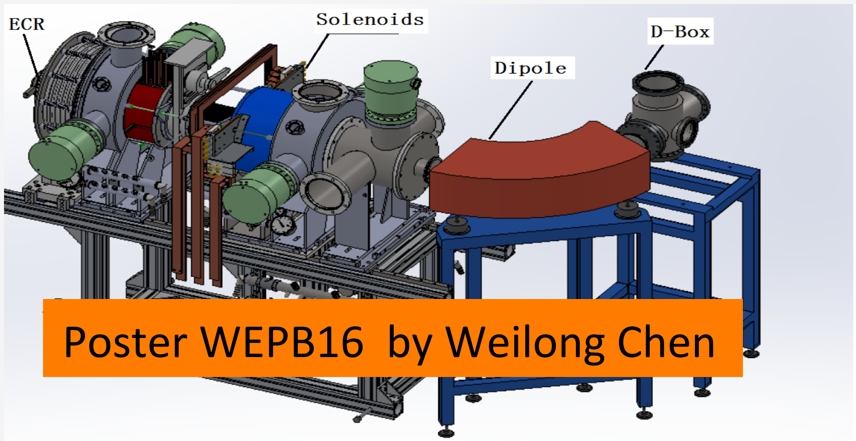
Pressure	SCC rise time
3.5 10^{-7} mbar	300 µs
7.5 10^{-7} mbar	150 µs
5.5 10^{-6} mbar	30 µs
1.2 10^{-5} mbar	15 µs

D. Uriot, O. Tuske et al COMMISSIONING OF THE SPIRAL2 DEUTERON INJECTOR

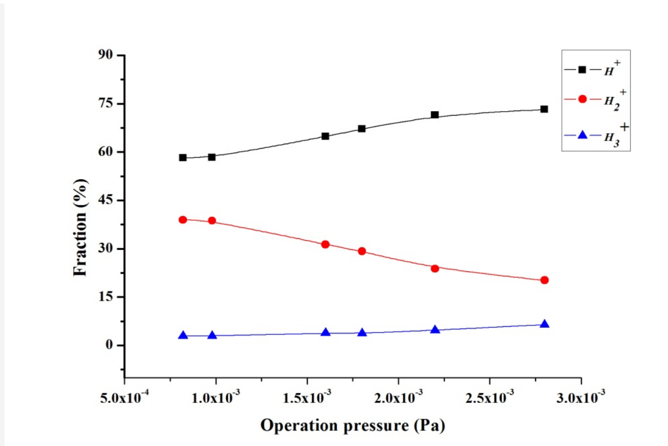
Operation from Pulse to CW beam



Proton, H^+_2 and H^+_3 proportion changes with the operation parameters of ECR ion source!

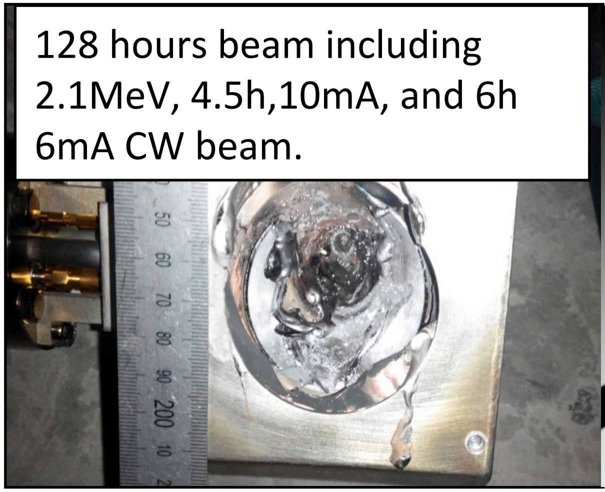


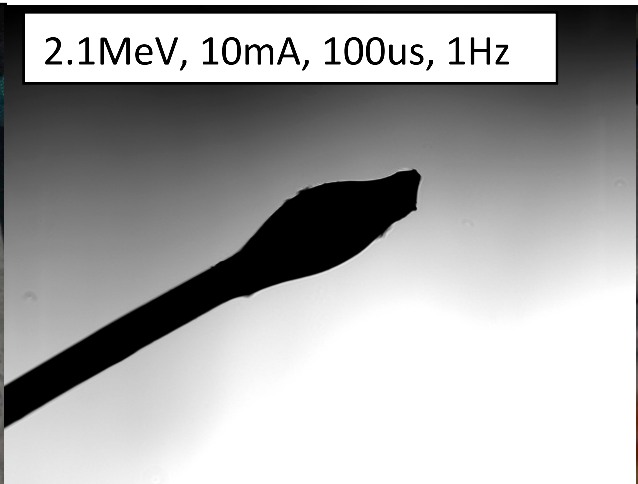
Poster WEPB16 by Weilong Chen

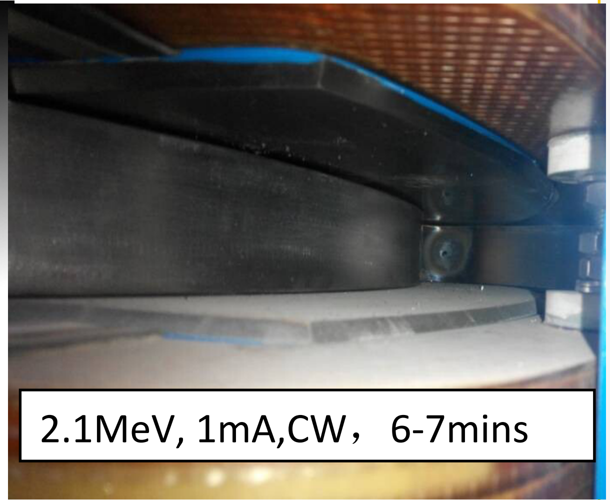


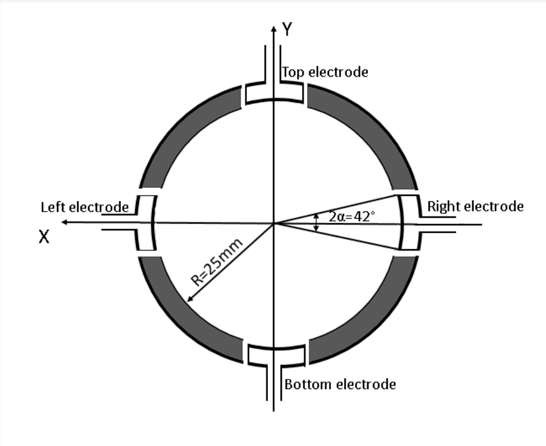
Yuan Xu, Shixiang Peng etal, High current H_2+ and H_3+ beam generation by pulsed 2.45 GHz electron cyclotron resonance ion source

No-interceptive diagnostics-BPMs









Transverse：

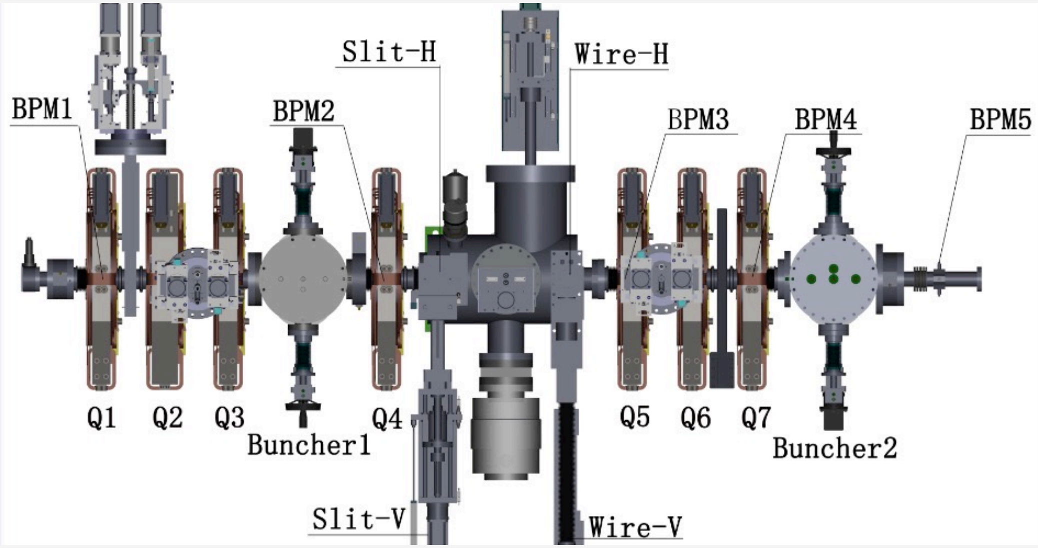
$$\langle x^2\rangle - \langle y^2\rangle + \bar{x}^2 - \bar{y}^2 = a^2 \frac{\alpha}{\sin 2\alpha} \frac{A_R + {}_L - A_T - A_B}{A_R + A_L + A_T + A_B}$$

Longitudinal：

$$Z_\varphi = \left(-\frac{360^{\circ 4}}{2\pi^2} \left(\frac{f_{RF}}{f_{BPM}} \right)^2 Ln\left(AMP_{bpm} \cdot I_{BPM}^{sum} \right) \right)^{-1/2}$$

The 6-D Twiss parameters can be calculated by scanning technology.

No-interceptive diagnostics-BPMs



- Multi-Q scanning
- Small beam size inside the BPM
- Benchmarked with silt + wire scanner method
- The longitudinal emittance is under study

$$\begin{pmatrix} <x_i^2> \\ <x_i x_i^{'}> \\ <x_i^{'2}> \\ <y_i^2> \\ <y_i y_i^{'}> \\ <y_i^{'2}> \end{pmatrix} = (A^T A)^{-1} A^T \begin{pmatrix} (<x_f^2> - <y_f^2>)^{(1)} \\ (<x_f^2> - <y_f^2>)^{(2)} \\ \dots \\ (<x_f^2> - <y_f^2>)^{(m)} \end{pmatrix}$$

	BPM	Wires	Δ(%)
α_x	0.146	0.302	52
β_x(m)	0.212	0.22	3.6
E_x(mmmrad)	0.294	0.286	2.8
α_y	-0.397	-0.102	289
β_y(m)	0.141	0.121	5.0
E_y(mmmrad)	0.306	0.297	3.0

Summary and outlooks

- RFQ with CW 10mA, stability still on the way.
  - Circulator has delivered and tested at IMP
  - The frequency stability control achieved
- Transverse emittance has been studied, longitudinal is the point next step.
- Hydrogen gas transfer has been investigated
  - New LEBT scheme has been proposed
- Beam loss control and detection, more detailed work needed
- 6D-emittance measurements with no-interceptive BPM
  - Multi-electrode has been proposed

Acknowledge

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Chiniese Accel rator Driven Sub-critical System

IHEP — Accelerator physics; High power sc coupler; SC cavity design & test

SINAP — SC cavity test & Chemical treatment

PKU — SC cavity test & Treatment

USTC — Beam loss detection

HIT — SC Cavities drawing & welding

USA LBNL — RFQ Design & Fabrication

USA MSU — SC cavities design; Beam dynamics

CAN TRIUMF — LLRF

USA JLAb — SC cavities test & operation

CADS
Chinese Accelerator driven
Sub –critical System

THANKS for your attention!