

Commission of CSR in Lanzhou

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Institute of Modern Physics, CAS



核素图

兰州重离子加速器国家实验室
HIRFL
江泽民

• Introduction

• Improvement of Injection Beam

• CSRm Commission

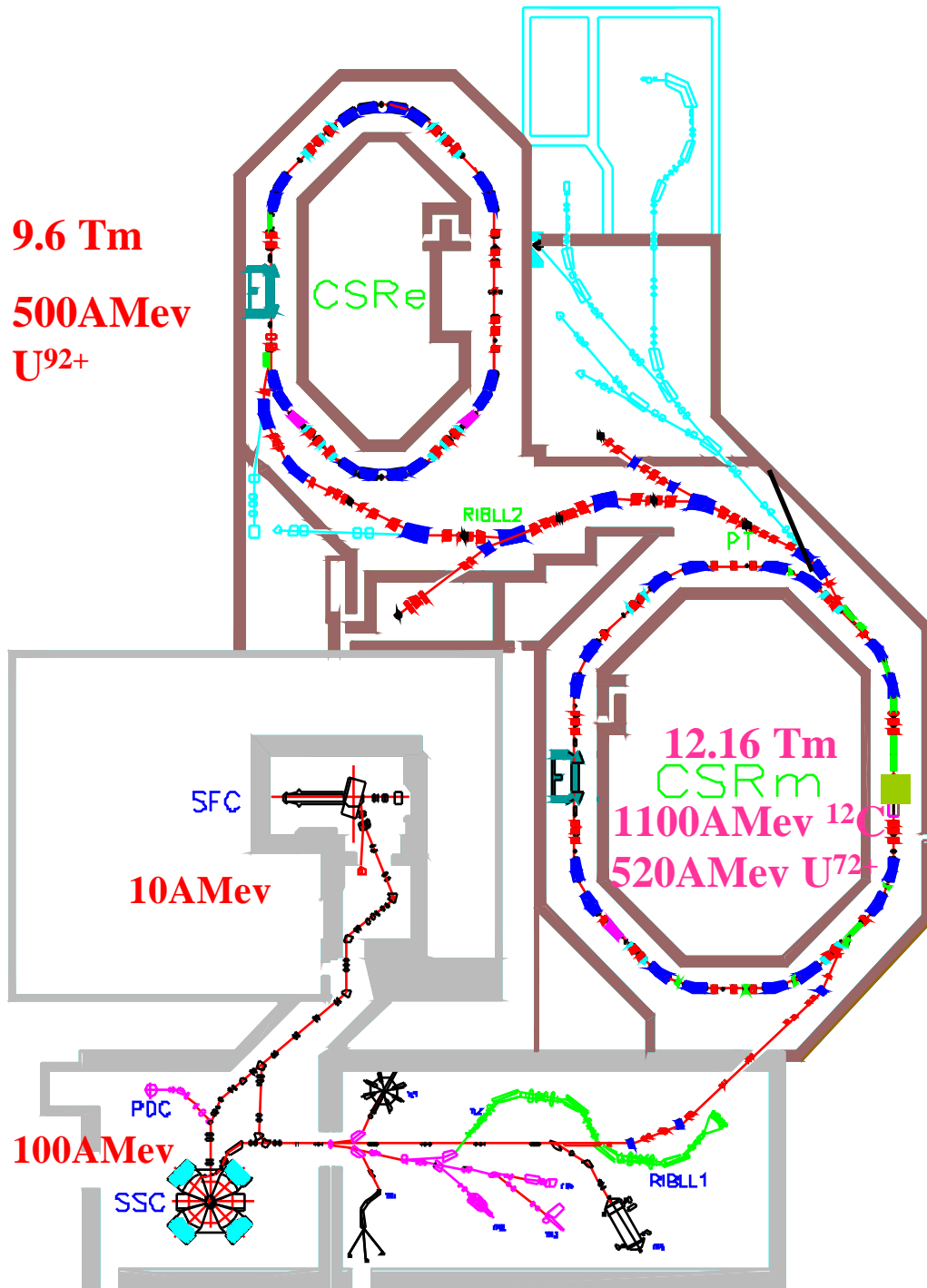
• RIBLL2 & CSRe Commission

• Conclusion

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Oct. 3

HIRFL Layout



- ECR Ion Source
- SFC K~70--10 AMeV
- SSC K=450 –100 AMeV
- CSRm cooler synchrotron
- CSRe: Accel. & Deccel. And High Sensitive & Accuracy ($\sim 10^{-6}$) Spectrometer

HIRFL Main Performances

	SFC	SSC	CSRm	CSRe
Species	Proton, HI	Proton, HI	Proton, HI, RIB?	Proton, HI, RIB, HCI
E(MeV)	K=70	K=450	P=2880	P=2000
C(MeV/u)	>10	~100	1100	760
U(MeV/u)	0.8(Q=26)	11(Q=40)	520(Q=72)	500(Q>90)
DP/P	$\sim 10^{-2}$	$\sim 10^{-3}$	$\sim 10^{-4}$	$\sim 10^{-5}$
dP/P (%) (entrance)			± 0.15	$\pm 0.25 \sim 0.5$
Emittance (mm-mrad)	>50p	~20 p	•5 p	•1 p

Main Physics Goals at HIRFL-CSR

Ø Nuclear Structure (RIB)

Ø EOS of Nuclear Matter

Ø Hadrons-Nucleon Physics in $E < 1.1 \text{ AGeV HI}$
 $\& < 2.88 \text{ GeV (3.7 GeV/c) Proton}$

Ø High Charge State of Atomic Physics

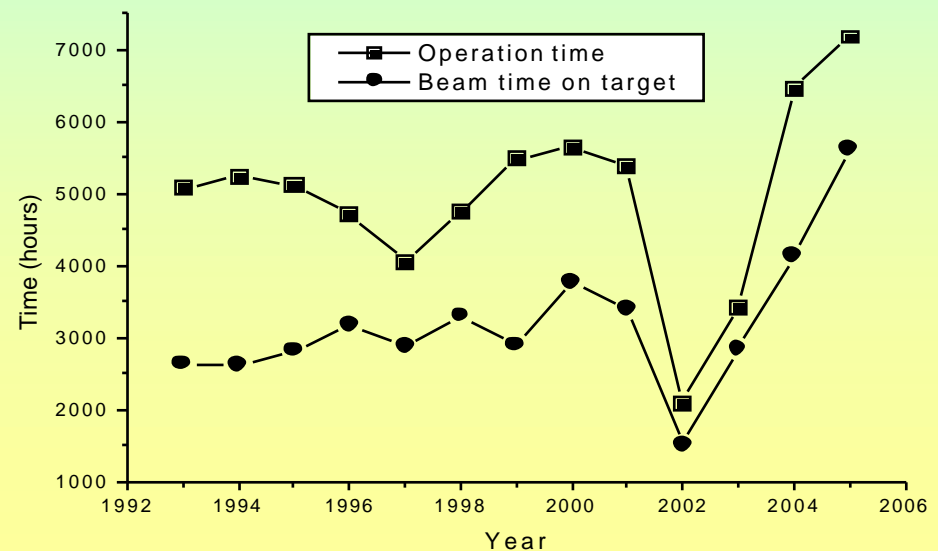
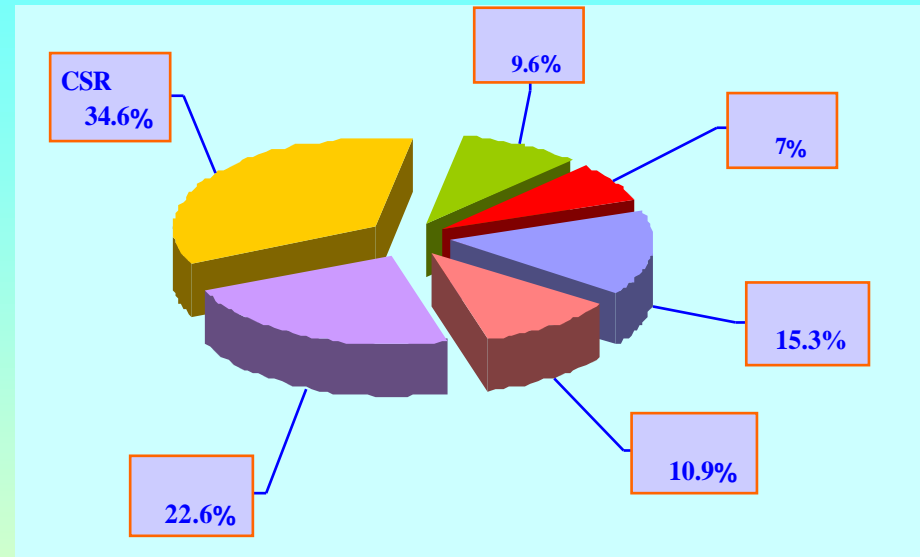
Ø High Energy Density Physics

Ø Astrophysics (Key Point)

Ø Applications: Irradiative Material, Biology
(Cancer Therapy)

SFC+SSC Operation Status 2006

- Total Operation Time :
~7000hr
- Acc. Using: ~2370hr
 - ~770h tuning;
 - ~500hr Acc. R&D;
 - ~1100hr faults
- Useful beam time :
5200hr
 - CSR:~2470hr;
 - EXP:~1610hr;
 - Cancer Therapy: ~690hr



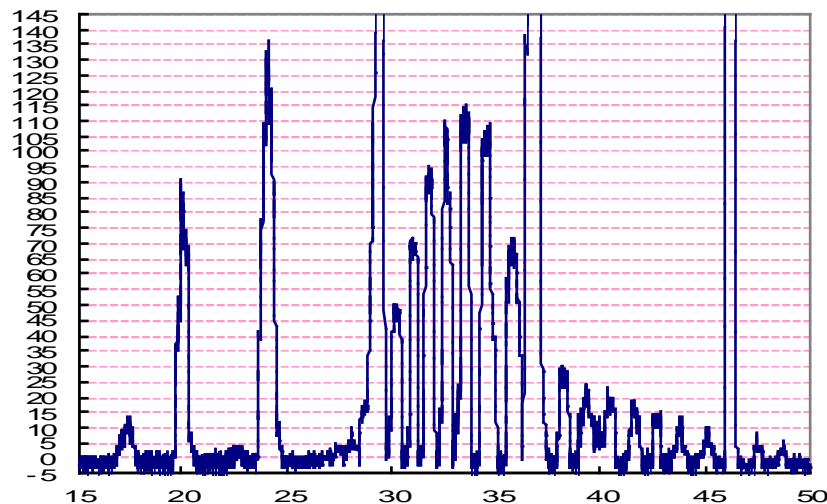
Superconductor ECR ion source



- High Intensity & Charge State for Acc.
- 18~28GHz design with compact, high eff.

Ions	SECRAL 18GHz 2.5-3 kW
$^{16}\text{O}^{6+}$	2.3 mA
$^{16}\text{O}^{7+}$	810 μA
$^{40}\text{Ar}^{11+}$	800 μA
$^{129}\text{Xe}^{20+}$	505 μA
$^{129}\text{Xe}^{27+}$	300 μA
$^{129}\text{Xe}^{34+}$	20 μA
$^{129}\text{Xe}^{36+}$	6.5 μA

Pw=2.05kW, HV=25kV, Pr=22W, $I_0=2.9\text{eA}$,
 $^{129}\text{Xe}+Q$, IX $e^{31+}=50\text{e}\mu\text{A}$, 2006-01-17, 21:40



H.W.Zhao Et al

Comparison of SFC+SSC Operation Time

Years	2004	2007	Before 2004
Operation time (h)	6500	7100	5500
Provide beam time (h)	4000	5200	3700

Comparison of SFC Maximum Beam Intensity

	C 6-8 Mev/u	O 6-8 Mev/u	Ne 6-8 Mev/u	Ar 2-3 MeV/u	Xe 2-3 MeV/u
I (before 2003)	5 eμA	5.5 eμA	3.7 eμA	3.2 eμA	0.54 eμA
I (After 2004)	12 eμA	13 eμA	14 eμA	15 eμA	5.5 eμA

Comparison of SSC Maximum Beam Intensity

	C 80 MeV/u	Ne 70 Mev/u	Ar 22 25MeV/u	Xe 15 20 MeV/u
I (before 2003)	0.2 eμA	0.15 eμA	0.15 eμA	0.01eμA
I (After 2004)	0.5 eμA	0.46 eμA	3.5 eμA	0.7 eμA

CSRm



CSRm C

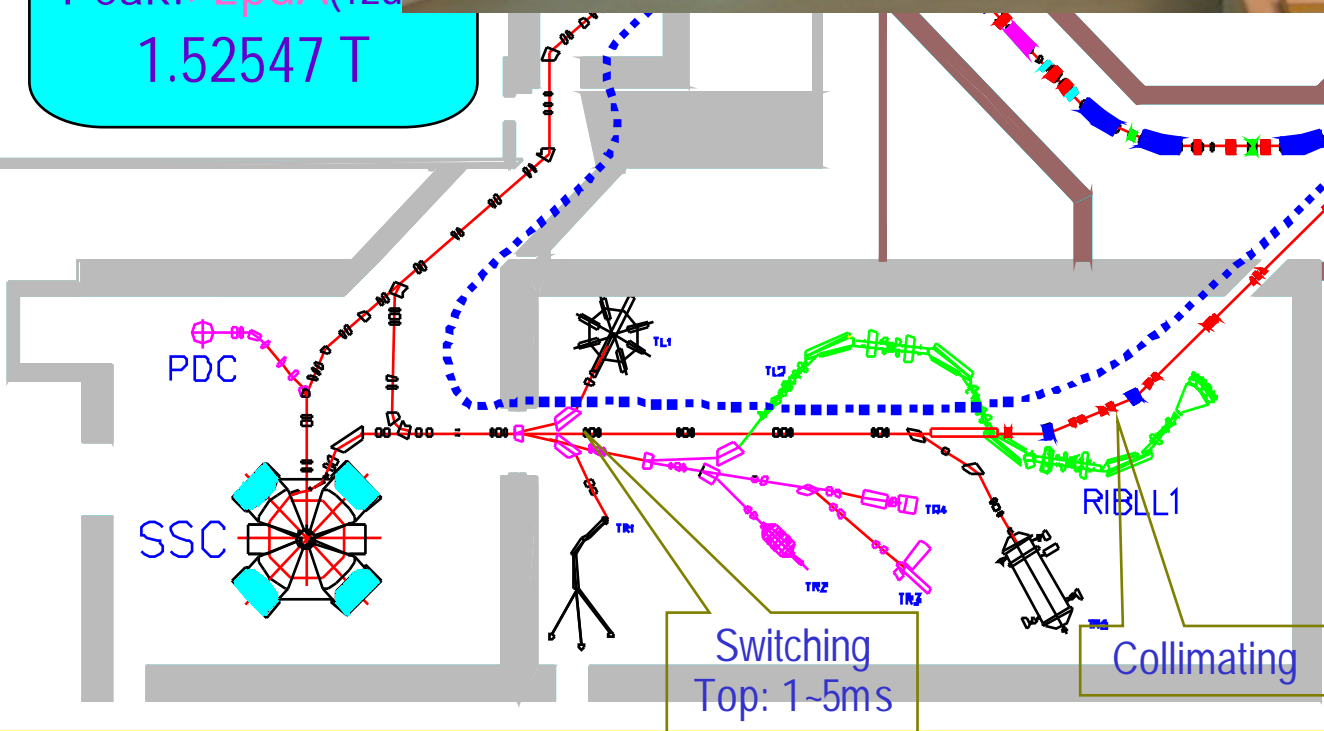


Chopping
Top: $1\mu\text{s}\sim 5\text{ms}$

SFC

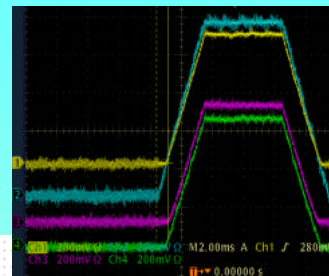
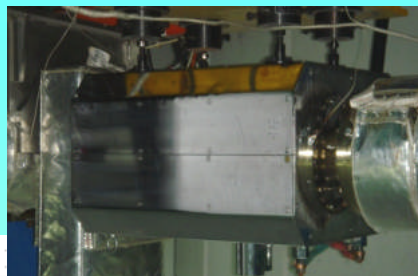
C^{4+} - 7 MeV/u
Peak: $>2\mu\text{A}$ (12u)
1.52547 T

0.10050 T



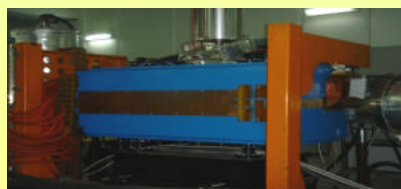
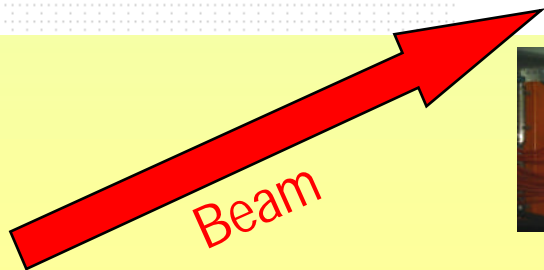
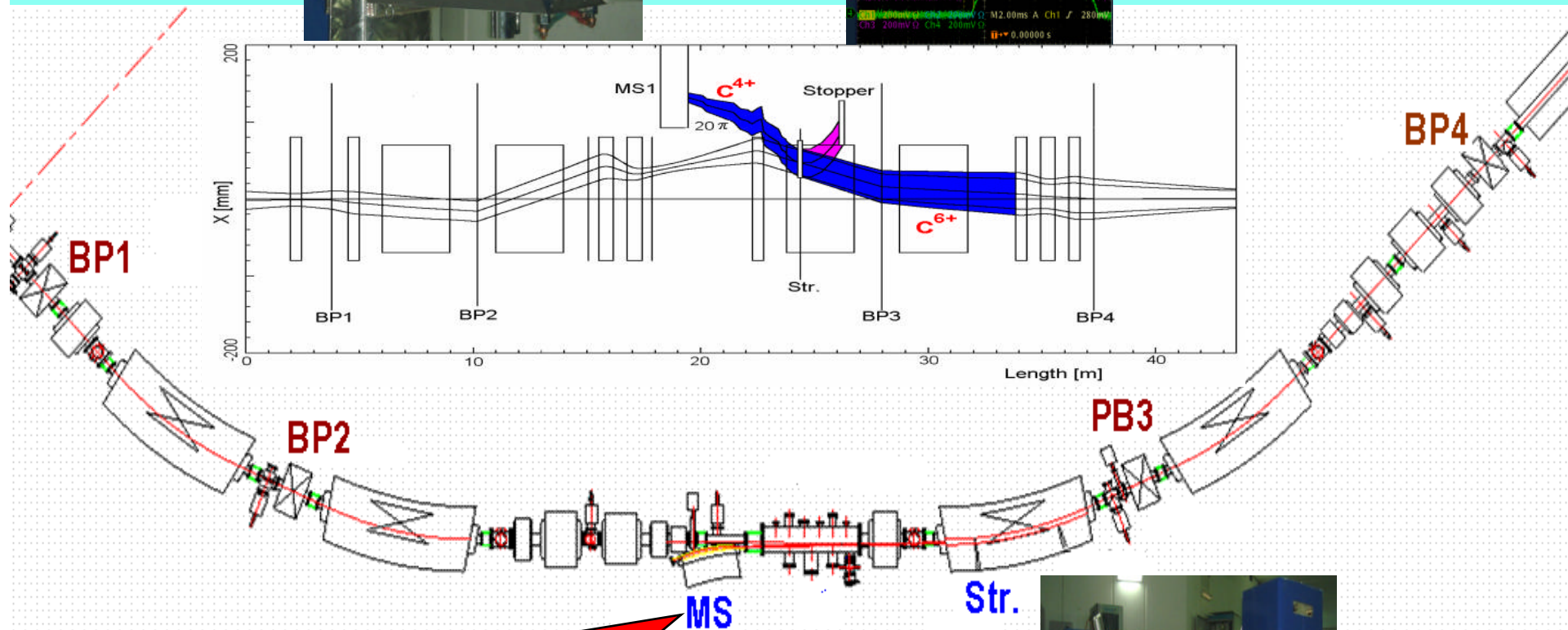
Stripping injection
 C^{4+} --- 7 MeV/u,
Peak: $>1\mu\text{A}$
20p mm-mrad
• P/P $< \pm 0.15\%$

Stripping Injection at CSRm



Bump-
PS

20~400ms
3200A
1600V



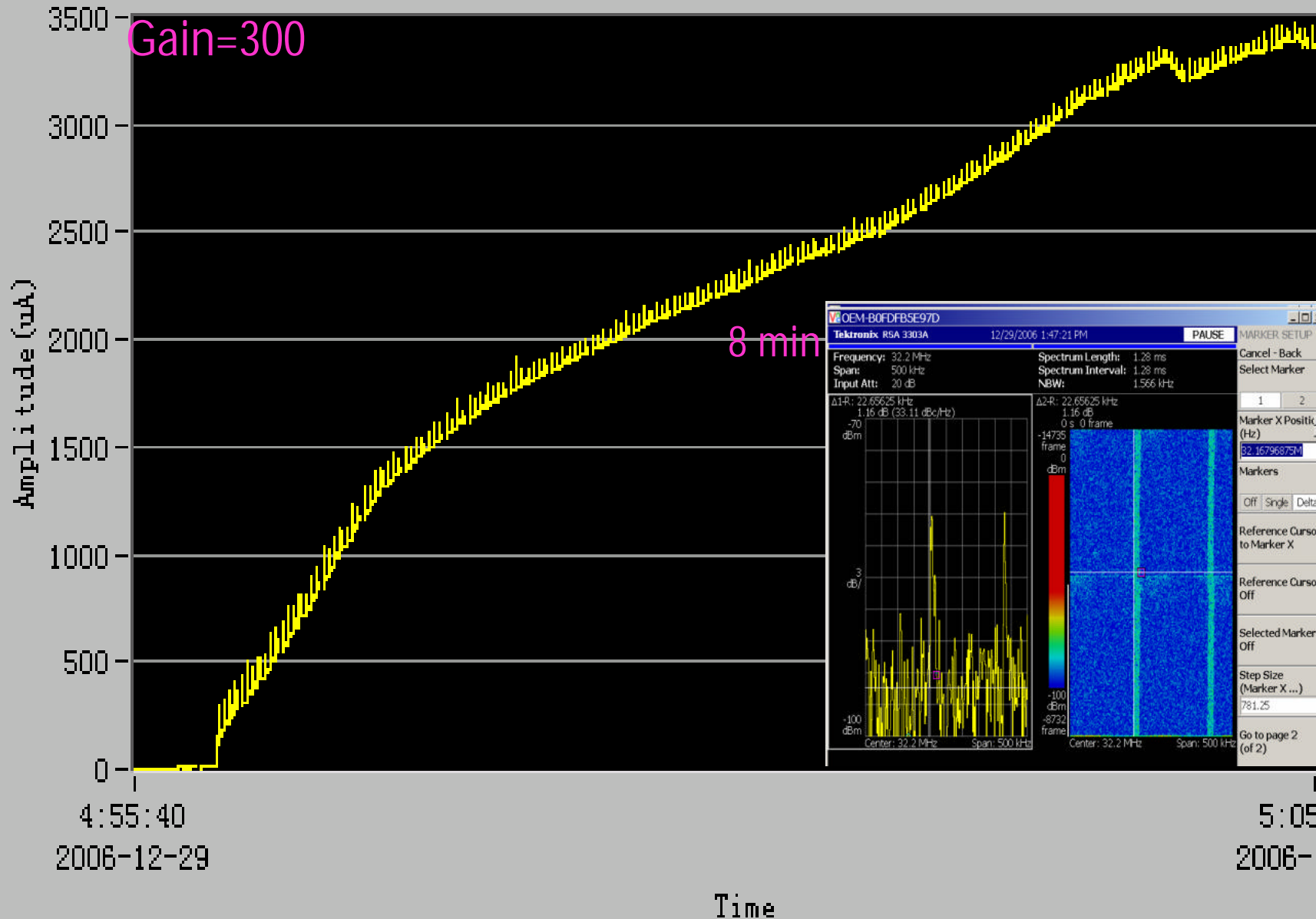
2900A, 8600G



Beam Accumulation with e-cooling in CSRm

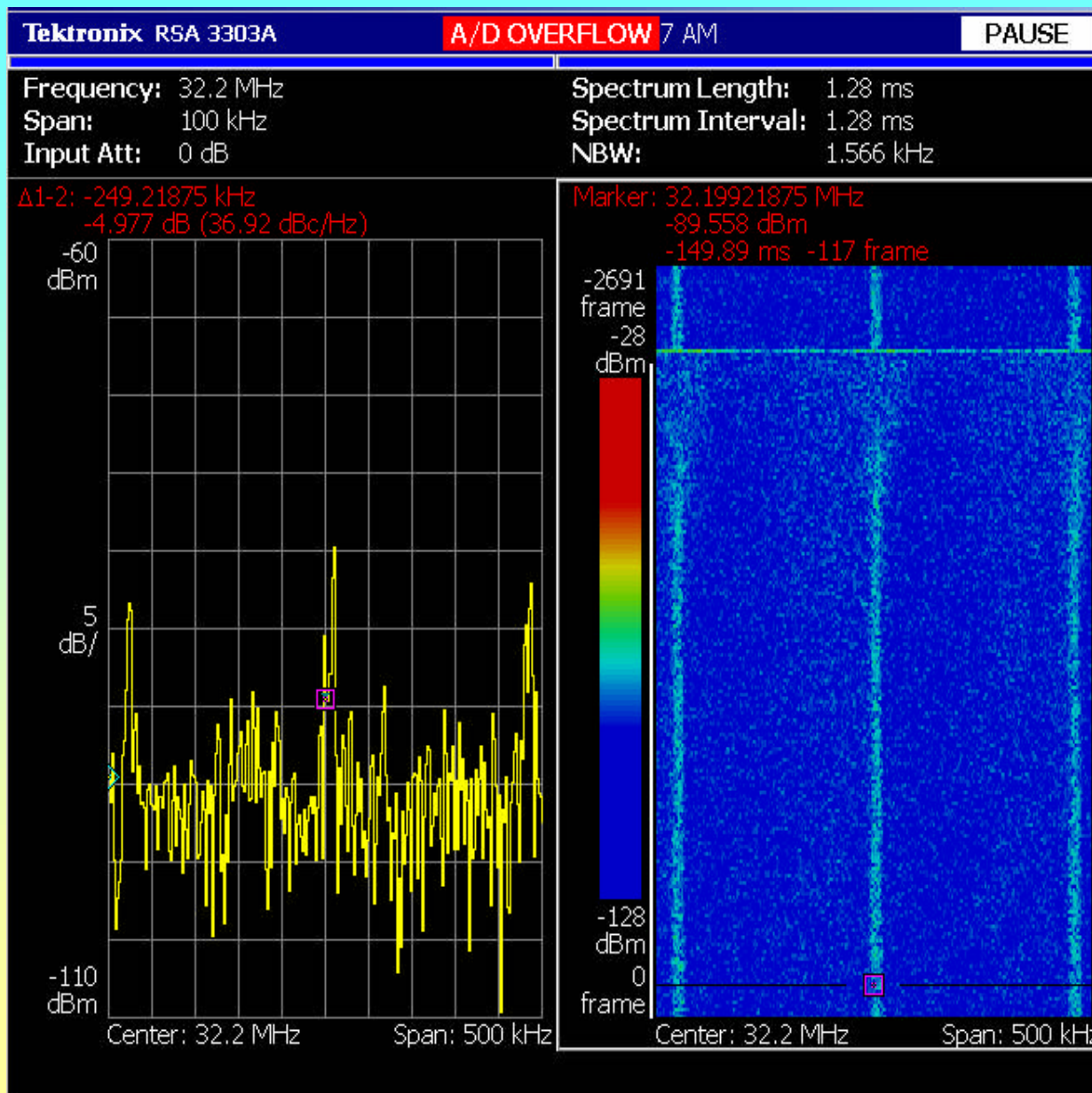
$I_{inj}=10.2\text{mA}$, Beam current: $3200\text{ }\mu\text{A}$, 1.6×10^{10} , 8min.,

06/12/29 5:00



E-cooling for C⁶⁺-beam at 7MeV/A

06/12/27 08:15



• P/P

$4 \cdot 10^{-3}$

-

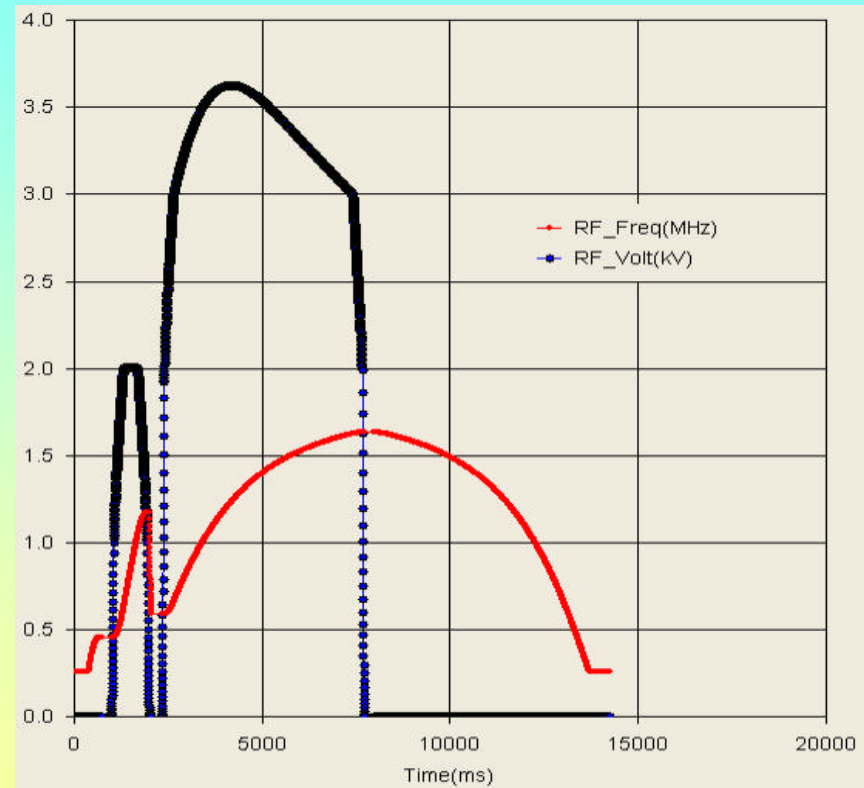
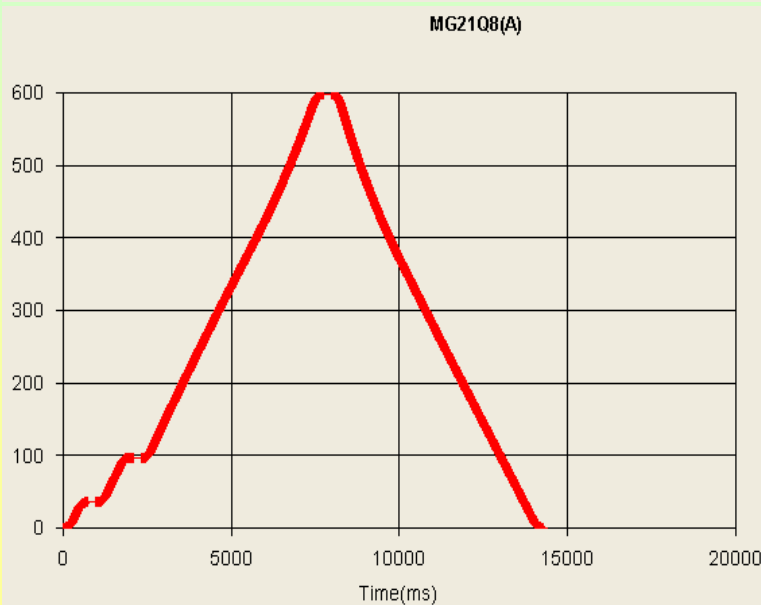
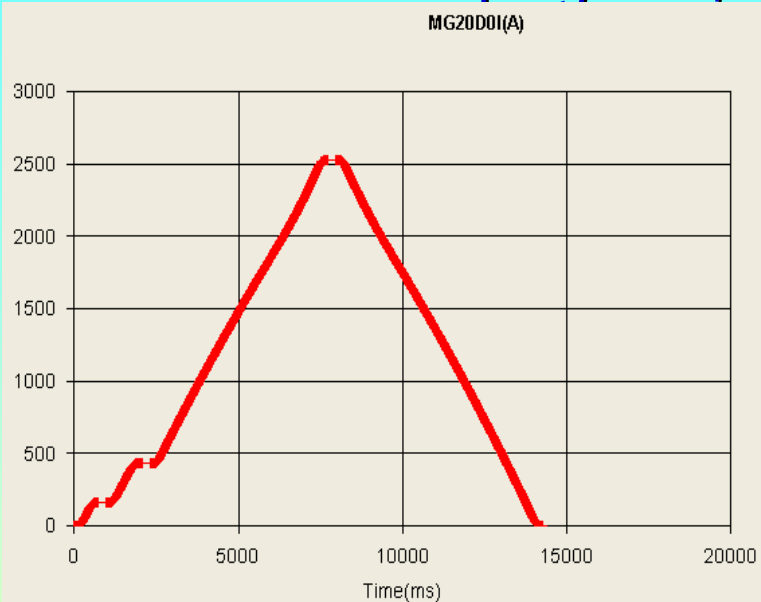
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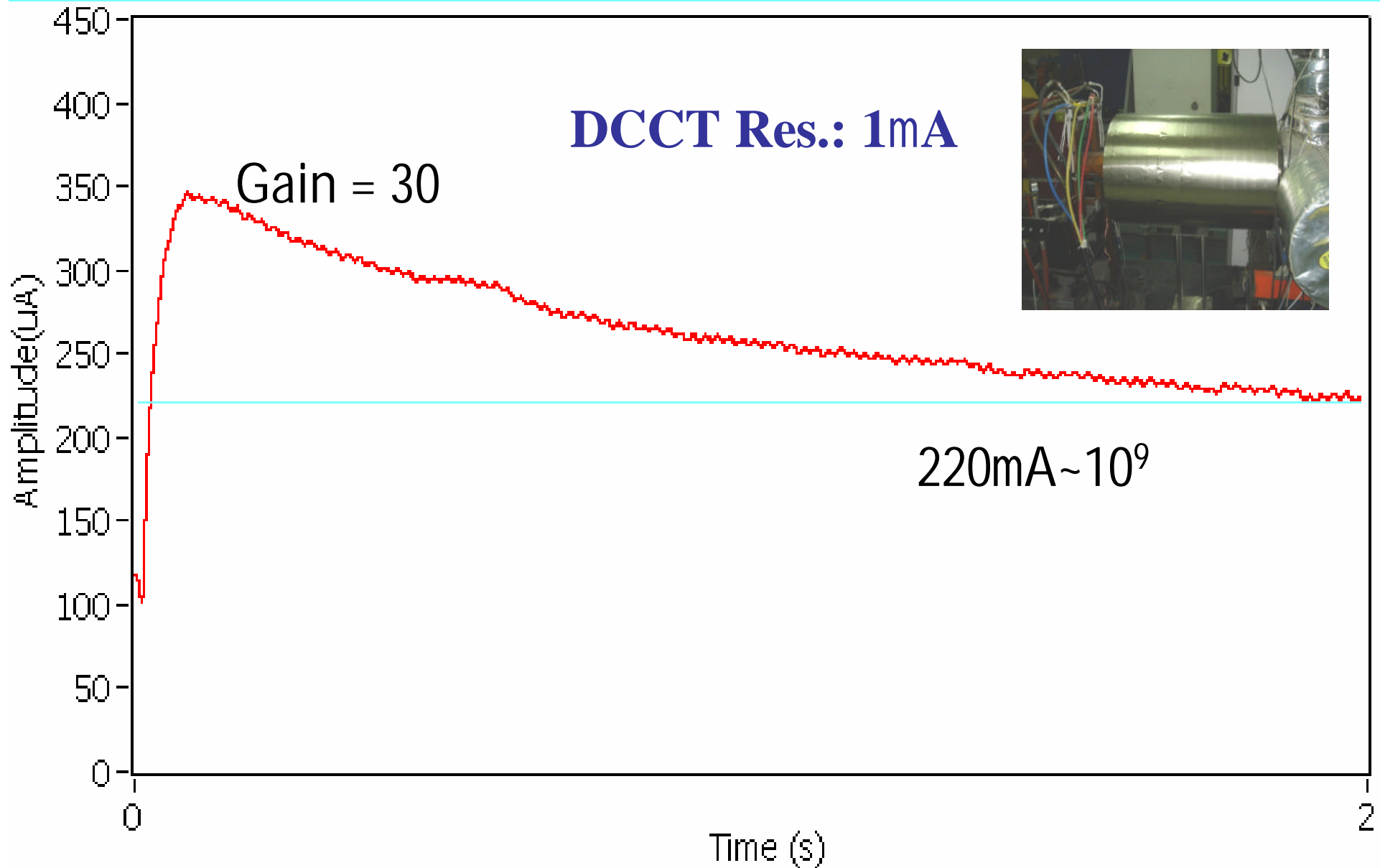
$2 \cdot 10^{-4}$

PS & RF Ramping

7• 1000MeV/u Ramping Test, $H = 2(4) \cdot 1$, $f_{rf} = 0.45 \cdot 1.63\text{MHz}$



A Bunch C⁶⁺ Beam Accumulation at CSRm



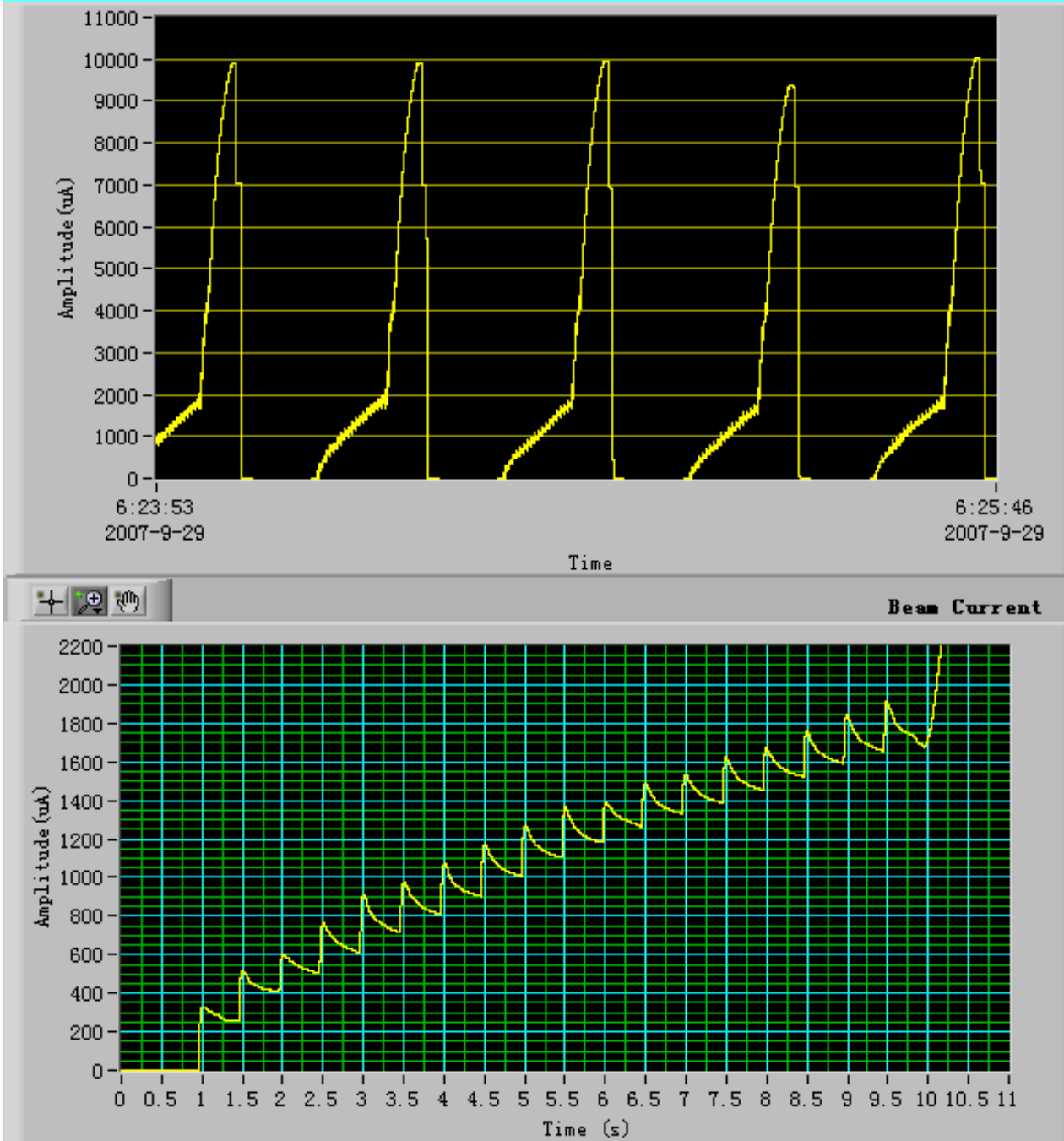
Stripping+ E_Cooling- Accumulation + Acceleration at CSRm

$^{12}\text{C} \sim 7 \cdot 10^9$ ppp,
& 600MeV/u

18 time Injection

for 0.5Sec.

Cooling/bunch

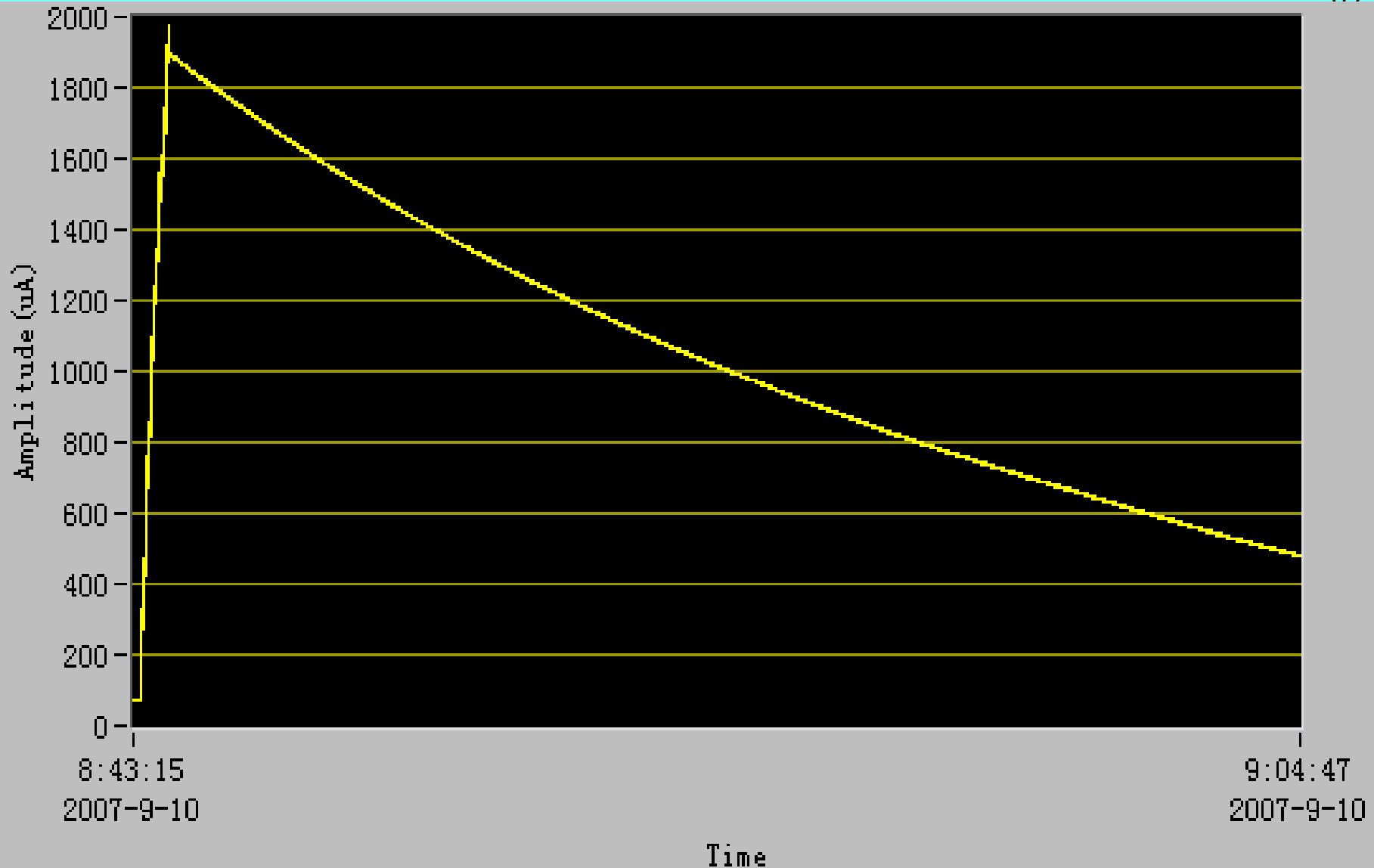


Lifetime of C^{6+} beam in CSRm with e-cooling

SFC- $^{12}C^{4+}$ -7MeV/u, STI, 1/e Life-time = 1088s

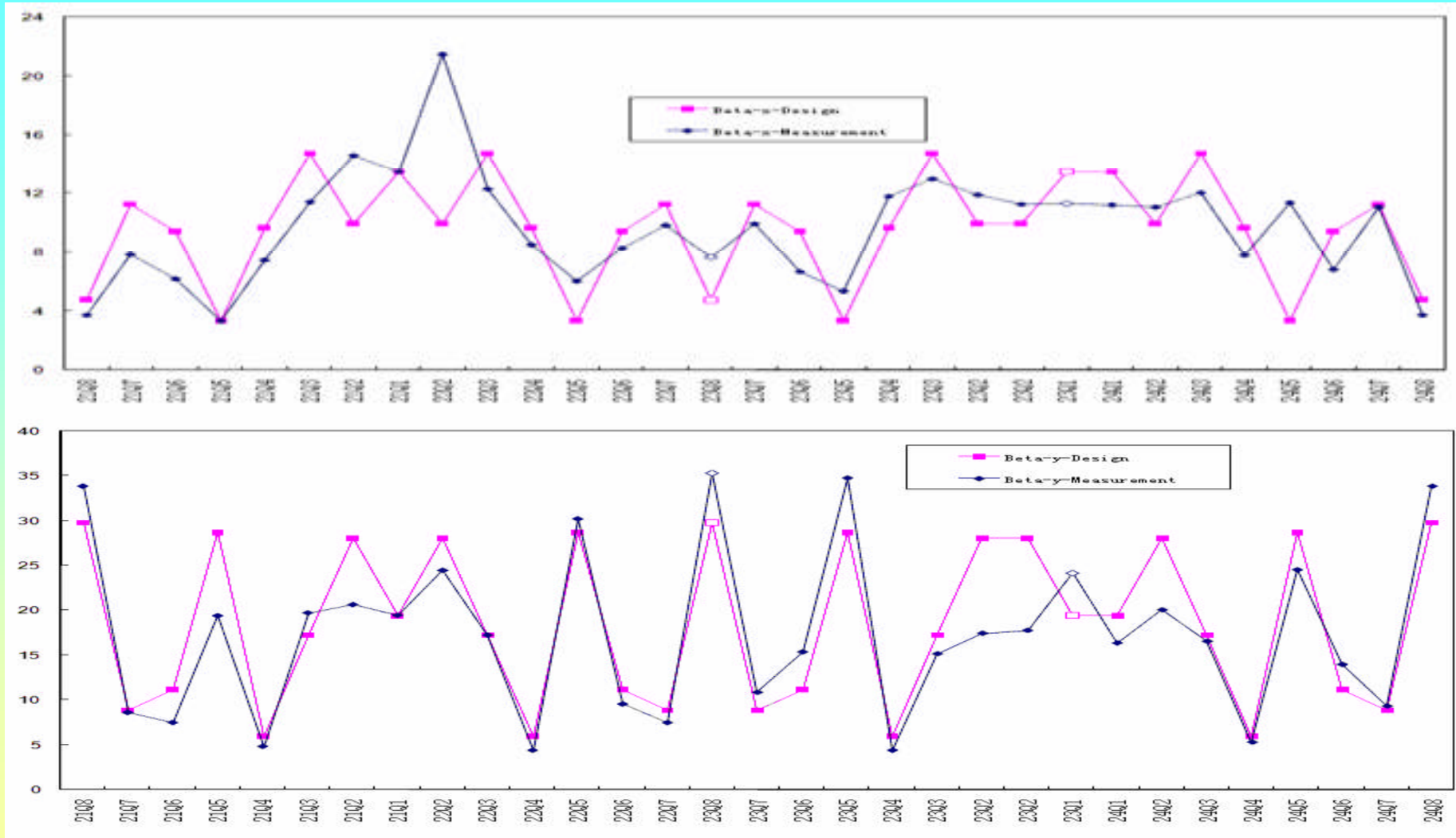
07/09/10

09:04



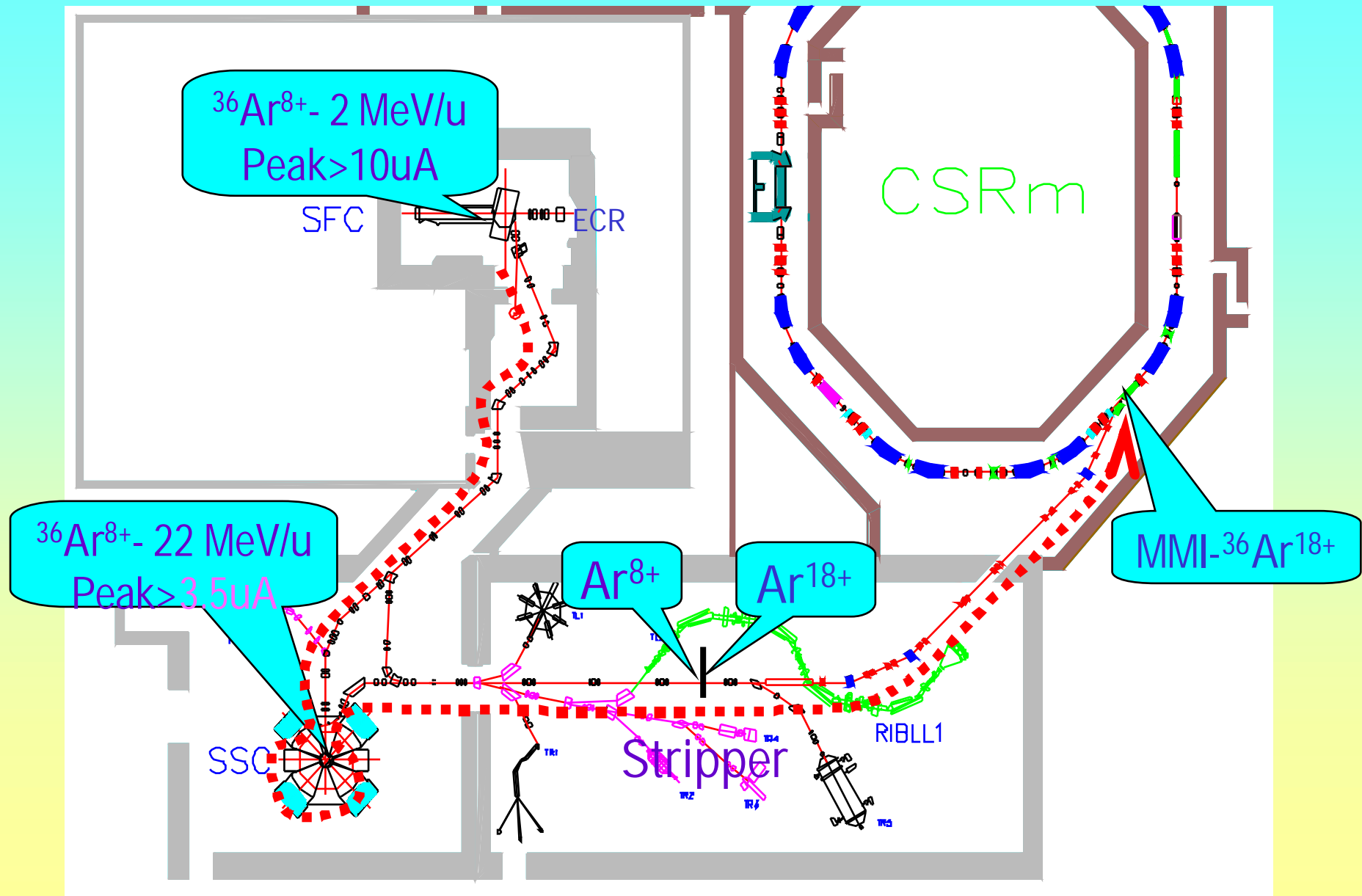
CSRm b & • Measurement

07/09/11-12



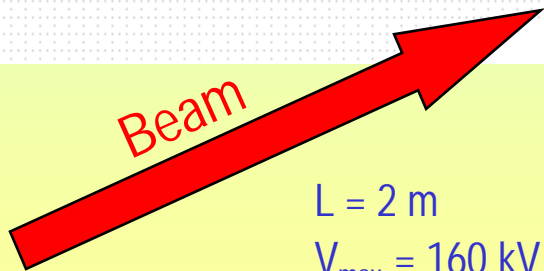
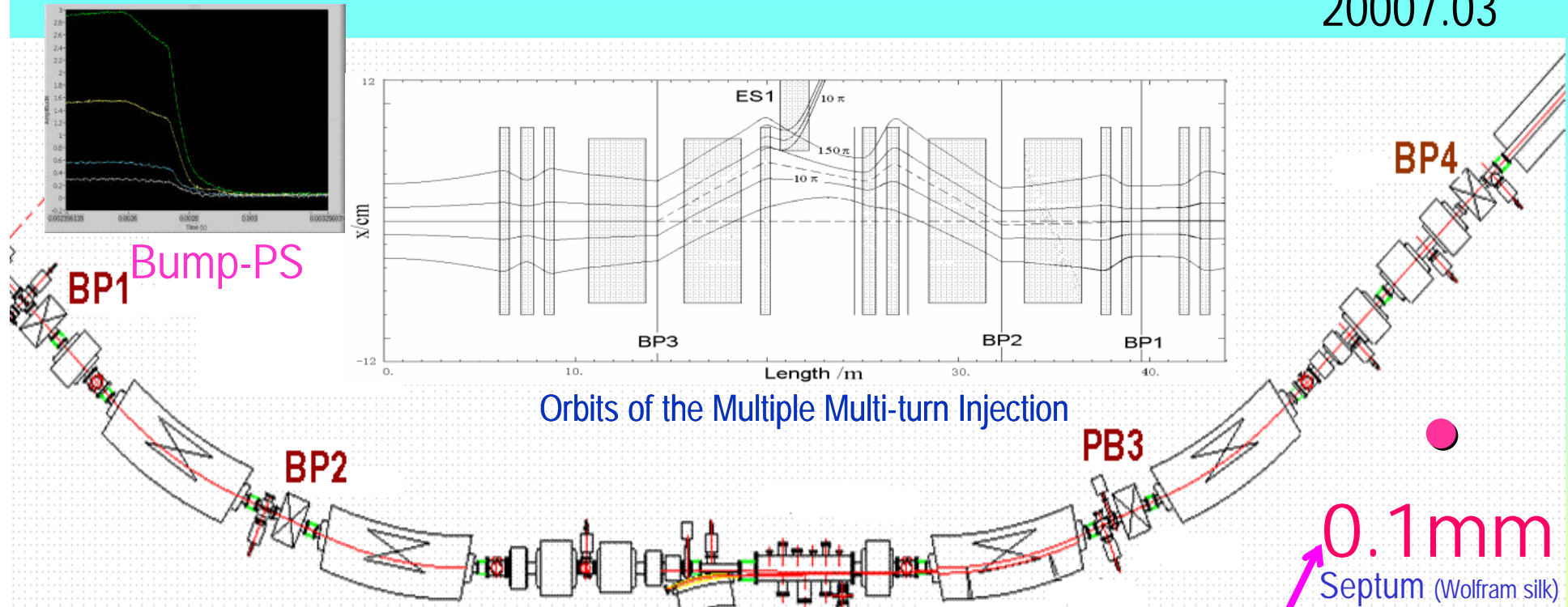
Emittance: $E_x(5\sigma)_n$ $E_y(5\sigma)_n$
1.6• mm.mrad **1• mm.mrad**

Scheme of MMI of Ar Test at CSRm

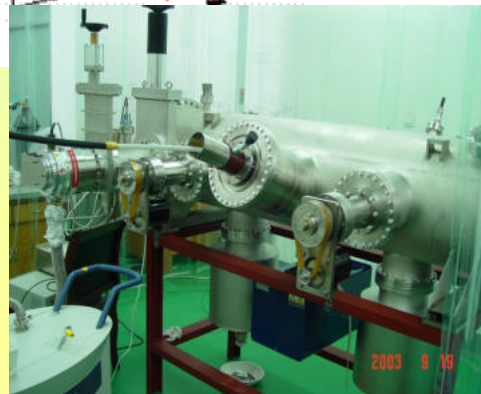


MMI Injection at CSRm

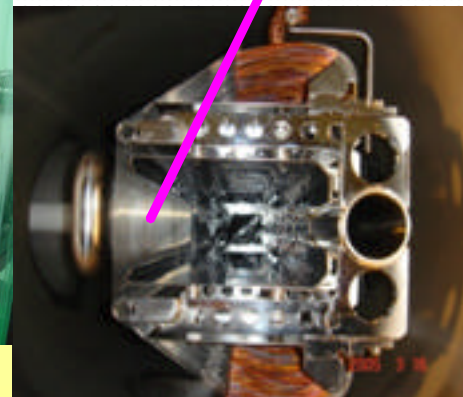
20007.03



$L = 2\text{ m}$
 $V_{\text{max}} = 160\text{ kV}$
Gap = 23mm



Static-electric septum

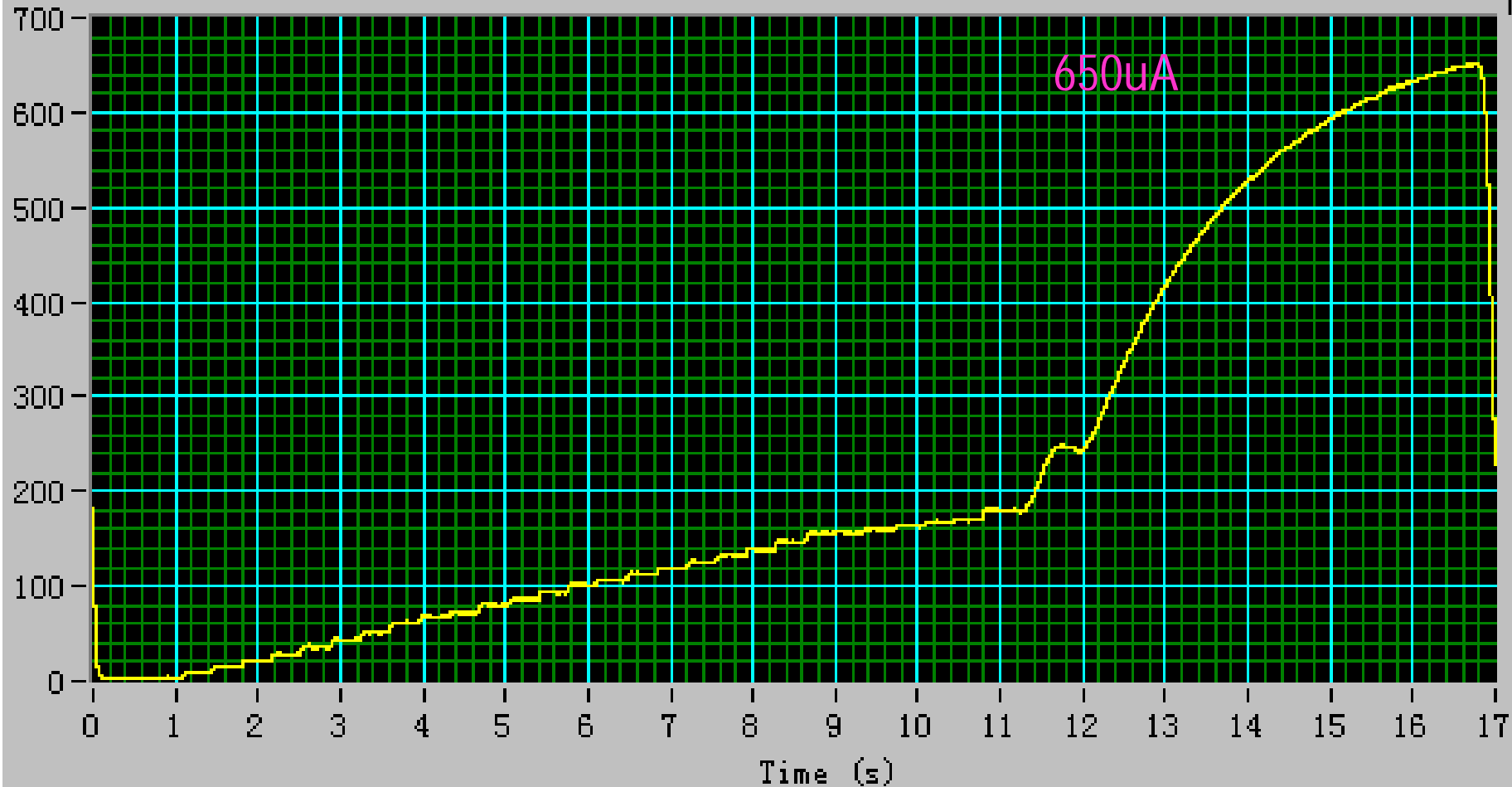


0.1mm
Septum (Wolfram silk)

CSRm MMI ($^{36}\text{Ar}^{18+}$ --22~1000MeV/u)

07/04/29

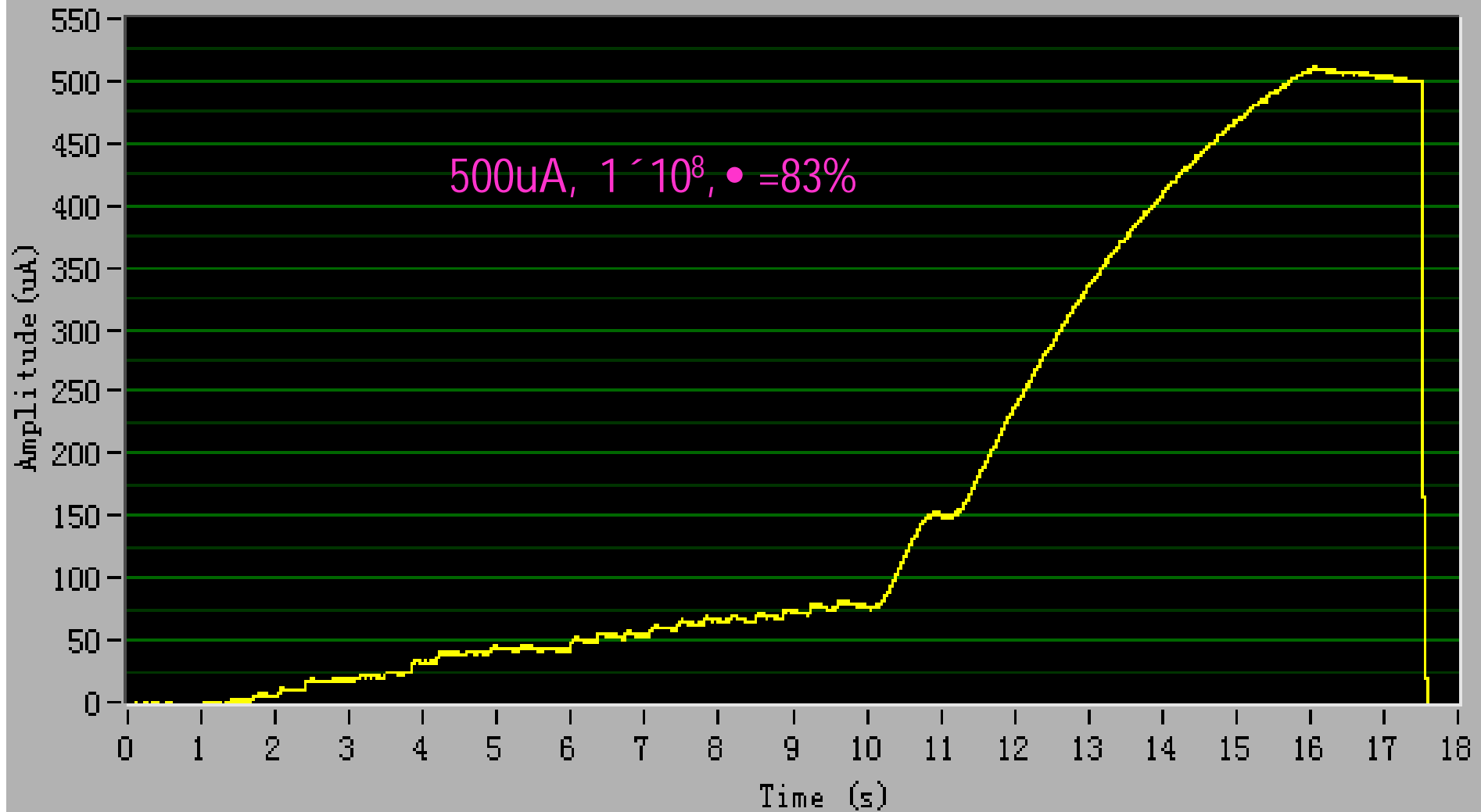
16:00



MMI+E_Cool+Acc.

$^{36}\text{Ar} \sim 1.4 \cdot 10^8$ ppp & 1000MeV/u 0.35 /Cooling

MMI+Acc. ($^{129}\text{Xe}^{27+}$ 2.9-235MeV/u) 07/06/25



$^{129}\text{Xe}^{27+}$ 2.86 à 235MeV/u & $>1 \cdot 10^8$ ppp
SECRAL à SFC à CSRm(MMI+E_Cool+Acc.) Extract

RIBLL- II



**External
Target II**



Primary Target

CSRe Side View



300kV Electron Cooler



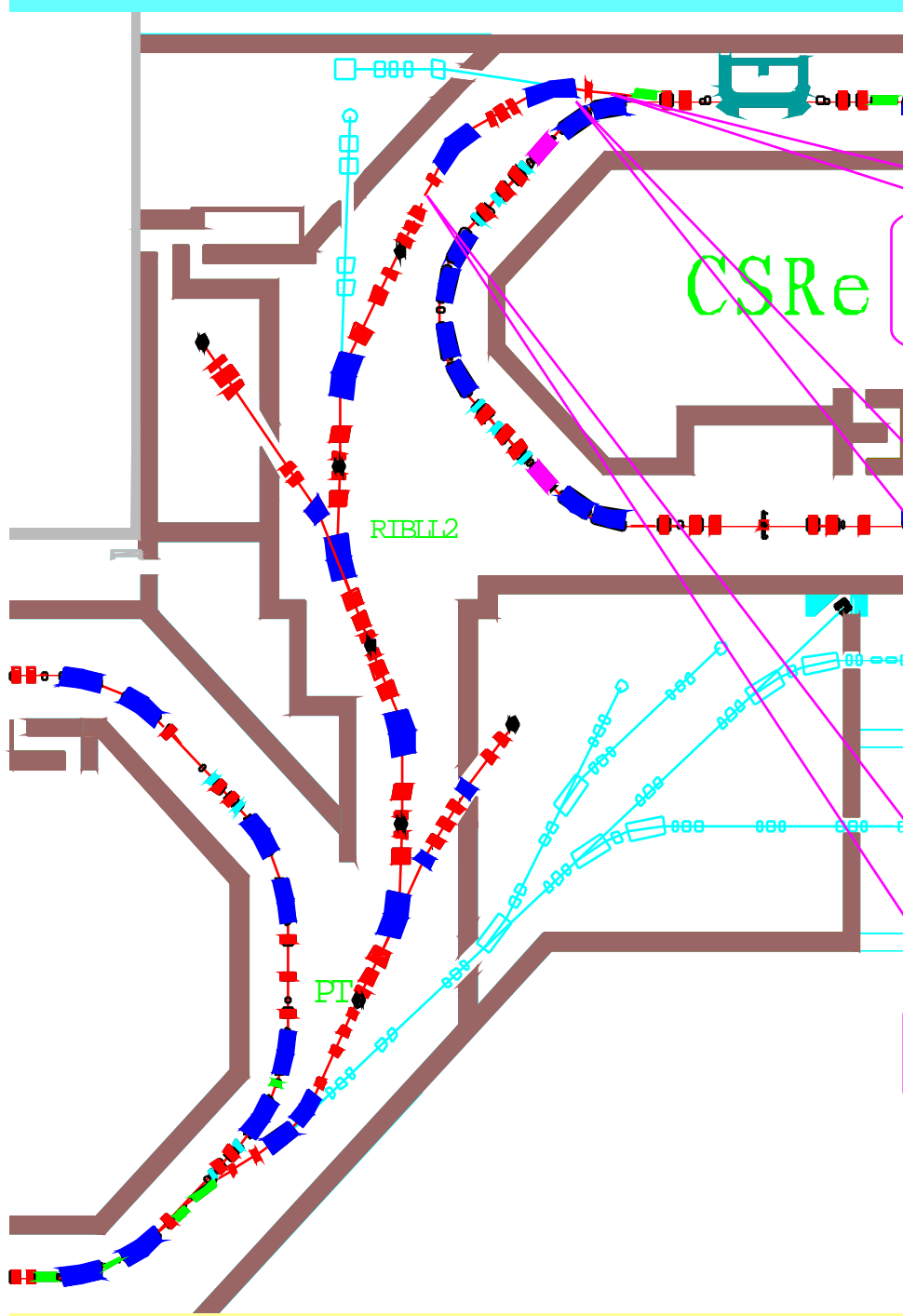
Gas Jet Target

H₂ >1 × 10¹³/cm²

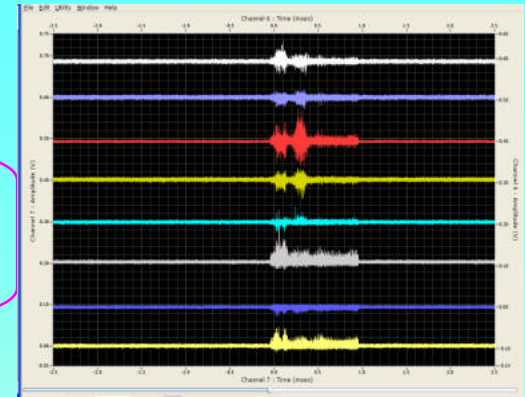
N₂ 2 × 10¹³/cm²

Ne ~2 × 10¹³/cm²

Ar 7 × 10¹³/cm²



07/08/30
07:00

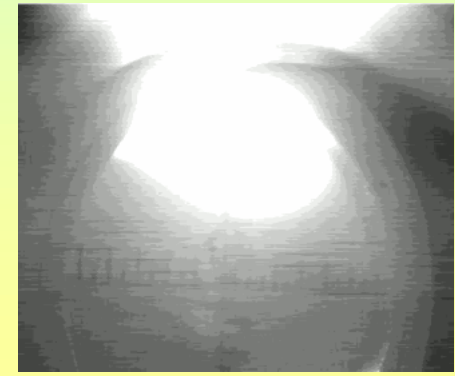


30BPM4

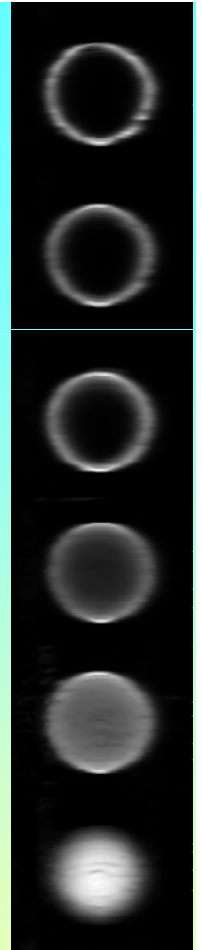
30FC4

30VS4

DevSn	BD30FC04
Beam	855.97



Features of CSR



- 1, new Generation E_Cooler:halo E-beam → high Accum.
- 2, RIB reaction Exp. at CSRe
- 3, 10^{-12} mbar UHV
- 4, Web+Internet+DB Control
- 5, Flexible Lattice by control Q_{ps} individually

Summary

- **SECRAL provide higher intensity of HCI online**
- **Injection beam intensity**
 - **SFC: $10^{12}\sim 10^{13}$ pps;**
 - **SSC: $10^{11}\sim 10^{12}$ pps for $A < 130$**
- **Accumulation beam**
 - **$\sim 10^9\sim 10^{10}$ ppp by Stripping Inj.**
 - **$\sim 10^8$ ppp by MMI**
- **Maximum Cooling Beam Lifetime ~ 1000 s at CSRm**
- **$^{12}\text{C}^{6+}$, $^{36}\text{Ar}^{18+}$ were accelerated to 1.0GeV/u, $^{129}\text{Xe}^{27+}$ was accelerated to 235MeV/u at CSR**
- **Dp/p : $4 \times 10^{-3} \rightarrow 2 \times 10^{-4}$ by E_Cooling in 7MeV/u
 $4 \times 10^{-3} \rightarrow 4 \times 10^{-4}$ in 1GeV/u without cooling**
- **RIBLL2 has commissioned successfully**
- **CSRe is commissioning and finishing end of 2007**

Thank You !

Welcome to IMP



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