Peripheral Elements and Technology Associated with Pulsed Power Inertial Fusion：Part 2[1] Appendix 1

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[1] Supported by the Ministry of Education, Science, Culture and Sports in Japan, the Japan Society for the Promotion of Sciences, Tokyo Institute of Technology, Sandia National Laboratories, Institute of Optoelectronics, MUT, and Institute of Laser Engineering, Osaka University.

[2] Collaborations with A.Kasamatsu, Y.Kinoshita, T.Kamiya (TITech), T.Norimatsu, Y.Kozaki ,T.Yamanaka, S.Nakai (Osaka Univ.), T.Renk, C.Olson (SNL), W.Mroz, A.Prokopiuk (MUT).

Presented at the 2nd RCM of the IAEA CRP on "Elements of Power Plant Design for Inertial Fusion Energy", RC-845-F1.30.08, 21 May 2001, Vienna, Austria

Additional Topics for Second RCM , presented from Japan

1. Nuclear Fusion in Japan, Recent Decision
2. Typical Ions & Radiations Derived from Imploded Targets , Sample Calculation (Y.Kozaki, ILE, Osaka University)
3. Fundamental Research Results Concerning Heavy Ion IF (M.Ogawa, TITech-Tokyo)
4. Need to Discuss for the Future (Sadao Nakai)

Fusion Program in Japan

- ITER promotion

  authorized by Cabinet in May 2002

- To support ITER

  Tokamak, Upgrade of JT60

  Large Helical Device at NIFS

  Laser Fusion at ILE Osaka

  IFMIF(Neutron Source & Material)

Leading Fusion Facilities in Japan

Institute of Laser Engineering, Osaka University

Two Large Research Topics from 2002

(1) Laser Fusion (Fast Ignition etc.)

(2) Development of EUV Light Source for Lithography

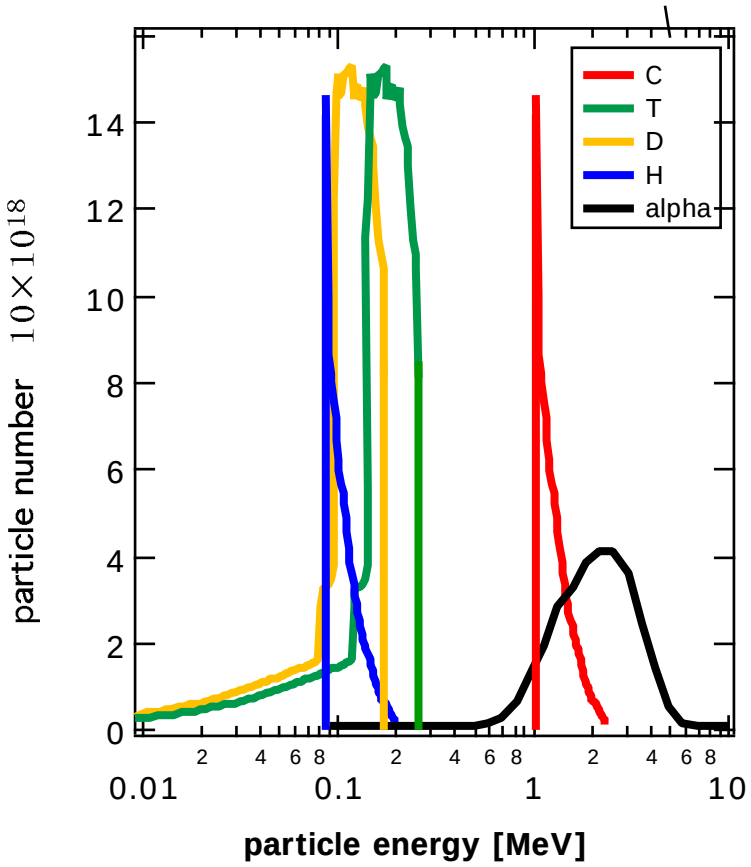
Followings results are samples of the minor groups which belong to the Japanese inertial fusion groups.

Yasuji Kozaki
(ILE, Osaka Univeristy)

Chamber Technology

Ion spectra of fusion output （400MJ targets）

ILE OSAKA



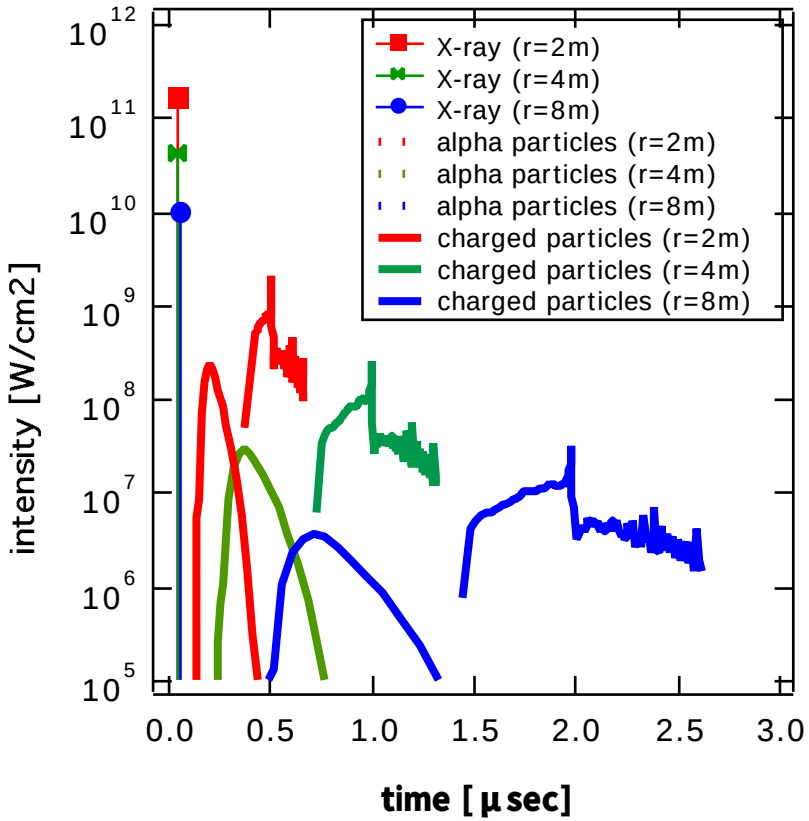
spectrum of fusion ions
(400MJ direct irradiation targets)

	energy MJ	average energies	%
X-rays	4	30 keV	1.0
α particles	10	3.5 MeV	2.5
charged particles	58	C: 1 MeV H,D,T: 200 keV	14.5
neutrons	328MJ	14.7 MeV	82.0
fusion output	400MJ	-	100

- X ray spectrum is much harder than indirect target
- α particles and fast ions energy are 1-4 MeV

Pulse heat loads on chamber walls（400MJtarget）

ILE OSAKA

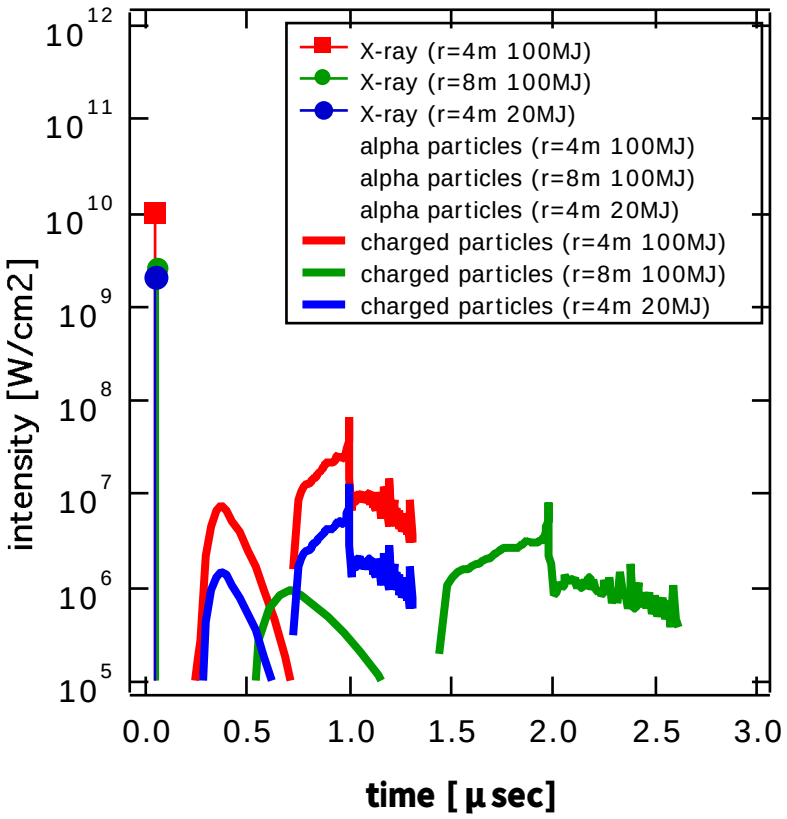


Thermal pulse power on first wall (400MJ targets) **radius 2m, 4m, 8m**

	r=2m	r=4m	r=8m
X-ray peak 10^{10} W/cm^2	16	4.0	1.0
α peak 10^8 W/cm^2	2.4	0.3	0.037
Ions peake 10^8 W/cm^2	19	2.4	0.3
α pulse width μsec	0.3	0.6	1.2
Ions pulse width μsec	0.4	0.8	1.6
Total pulse load J /cm^2	144	36	9
Average power 3Hz,W/cm^2	432	108	27
Neutron load 3Hz, MW/m^2	20	4.9	1.2

Pulse heat loads on chamber walls (fast ignition 20MJtarget)

ILE OSAKA



Thermal pulse power on first wall
(20MJ targets) radius 2m, 4m, 8m

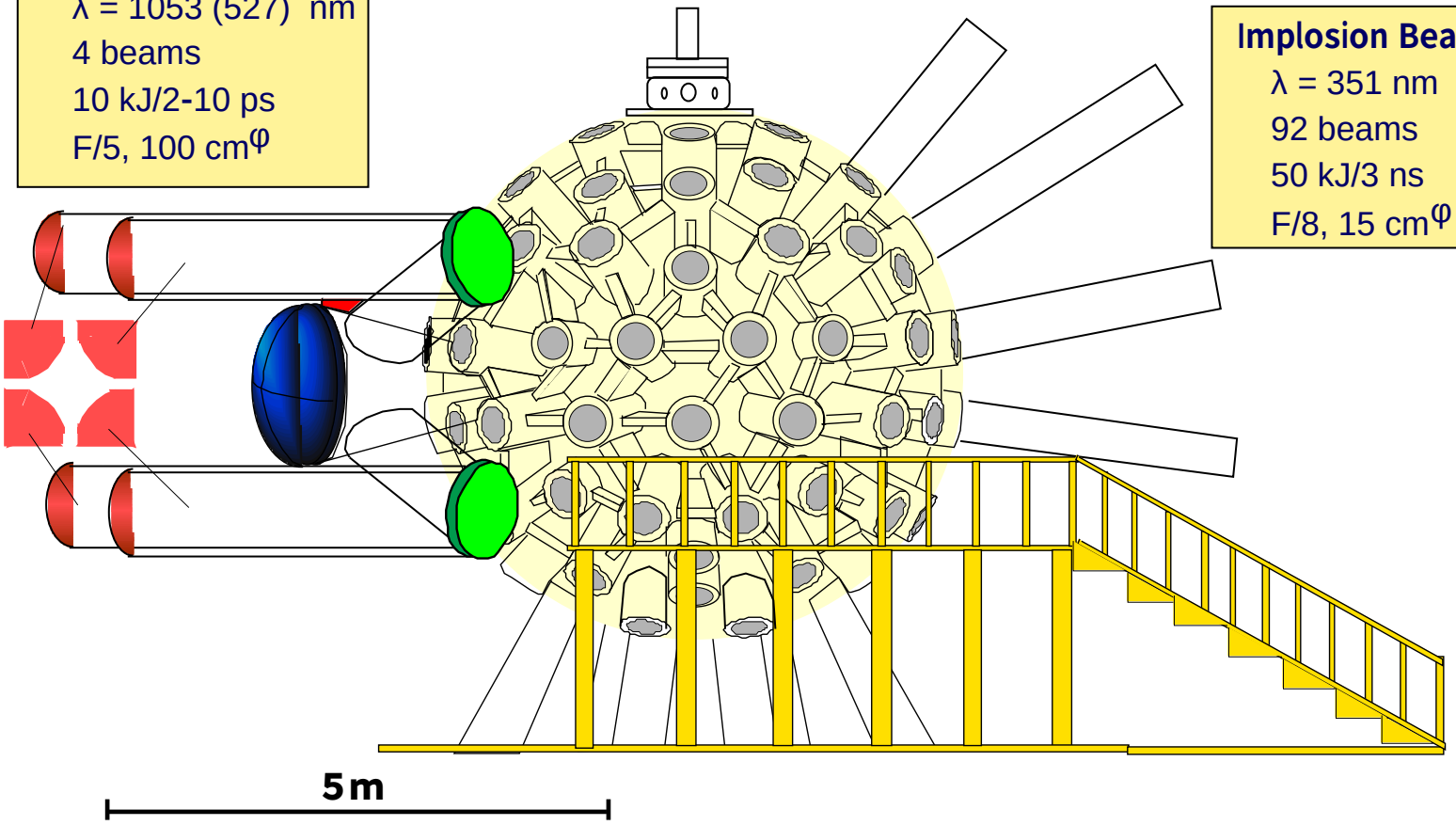
	20MJ r=4m	100MJ r=4m	100MJ r=8m
Laser energy kJ	200	500	500
Gain	100	200	200
X-ray peak 10^{10} W/cm^2	0.2	1.0	0.25
α peak 10^8 W/cm^2	0.015	0.075	0.009
Ions peak 10^8 W/cm^2	0.16	0.8	0.08
Total load J /cm^2	1.6	9.0	2.25
Average power 10Hz,W/cm^2	16	90	23
Neutron load 10Hz, MW/m^2	0.7	4.1	1.0

FIREX II Target Chamber System

ILE Osaka

Ignition Beam
- λ = 1053 (527) nm
- 4 beams
- 10 kJ/2-10 ps
- F/5, 100 cmφ

Implosion Beams
- λ = 351 nm
- 92 beams
- 50 kJ/3 ns
- F/8, 15 cmφ



Masao Ogawa, TITech at Tokyo

Heavy Ion Research Work at TITech

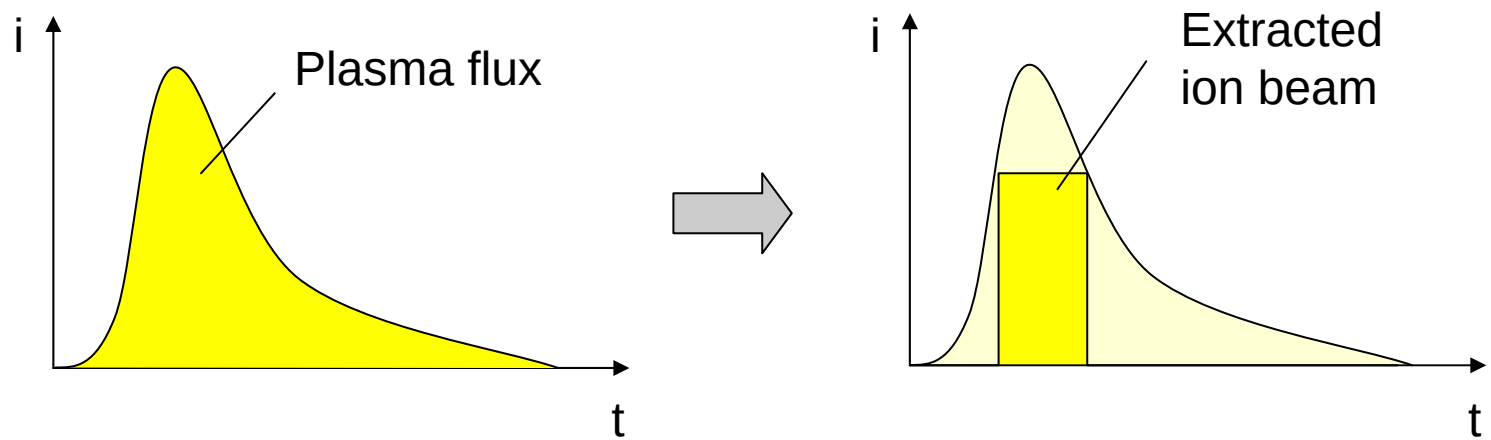
(1) Grid Control of Extracted Ions in the Case of Laser Produced Ion Source

(2) Energy Loss of Heavy Ion Beam in Dense He Plasma

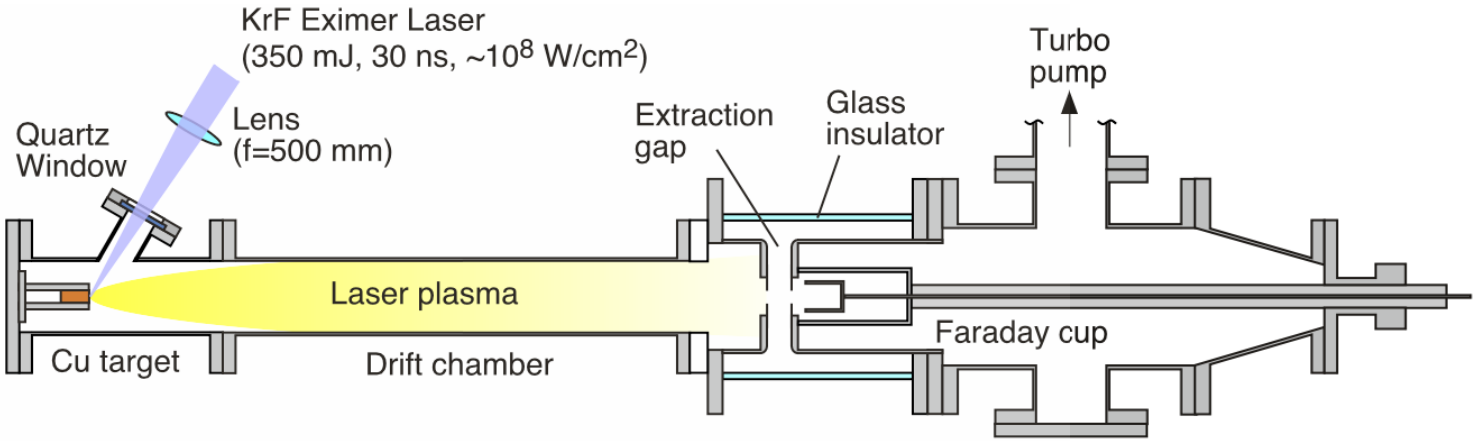
Problems of Laser Ion Source

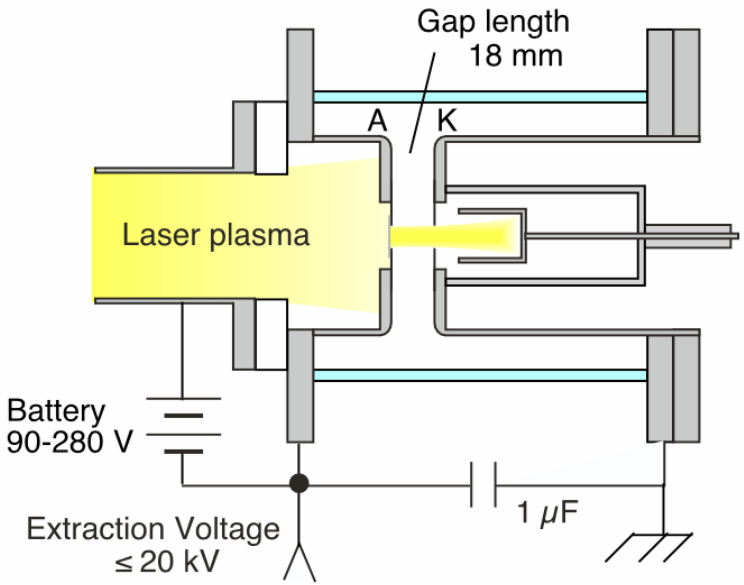
- Short Plasma Formation Time (ns ~ 10 ns)
- Large Fluctuation of Ion Supply
- Slow Rise Time

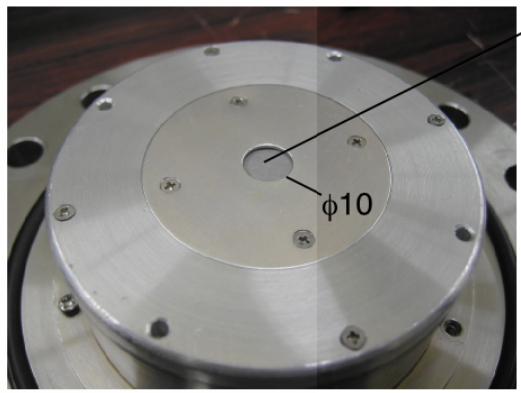
- Grid-Controlled Extraction



Grid Controlled Laser Ion Source

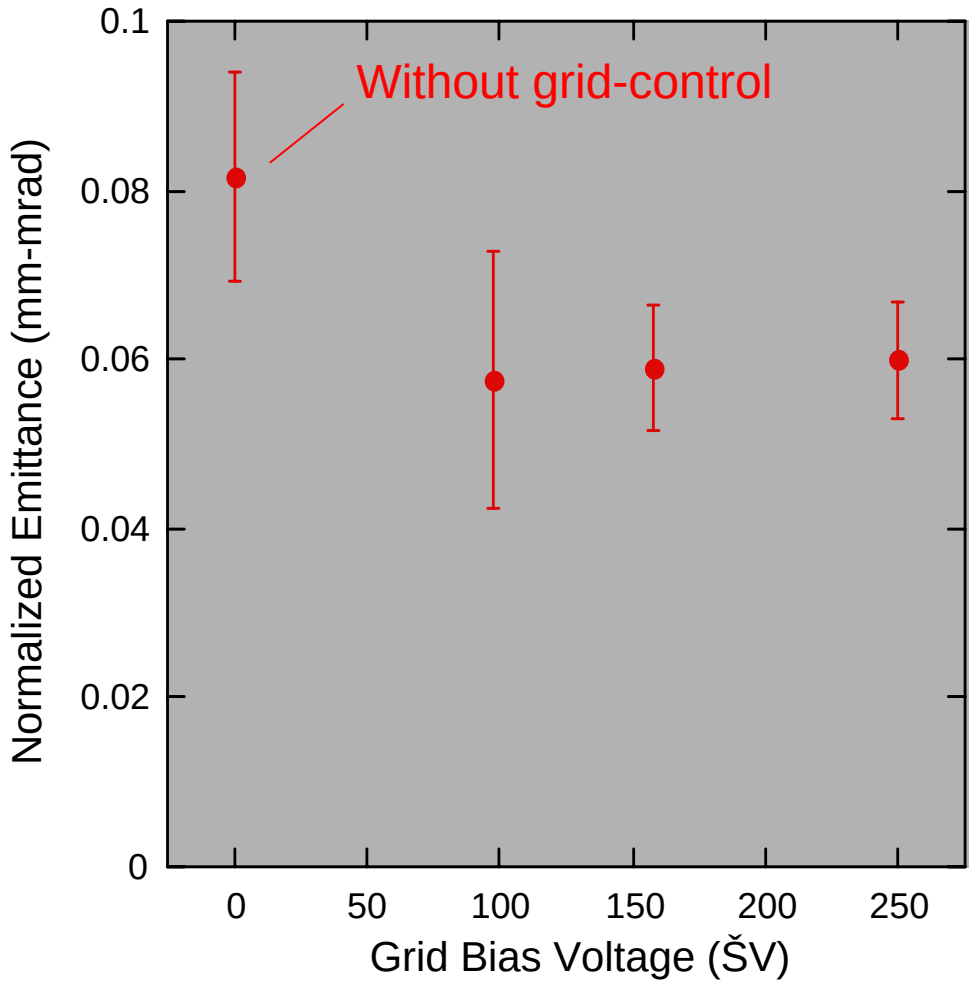






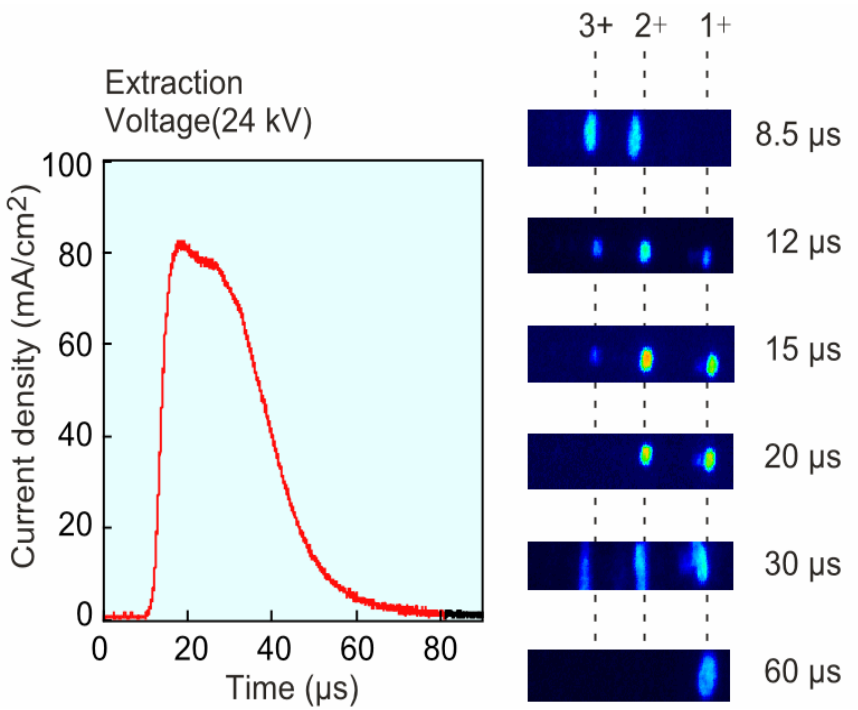
Extraction anode

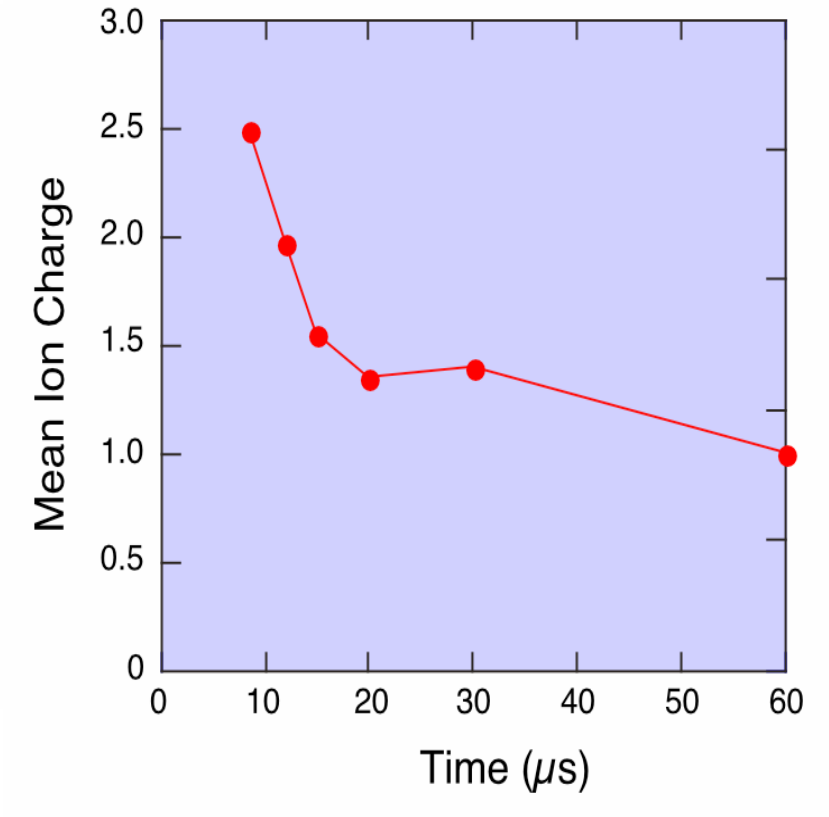
Emittance Depending on Grid Bias



Grid control improved emittance
Emittance was independent of grid bias

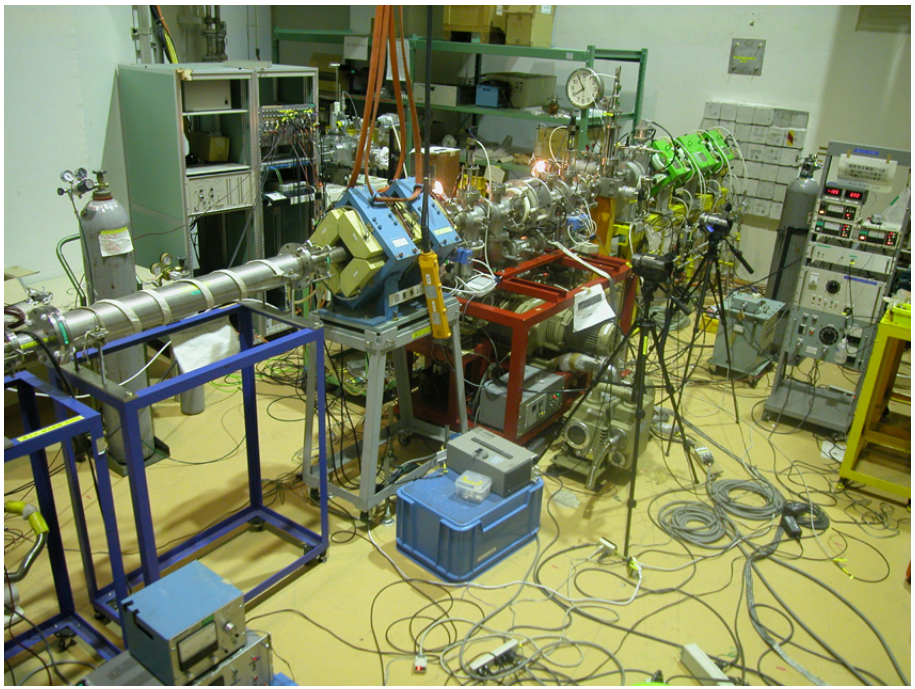
Ion Charge States

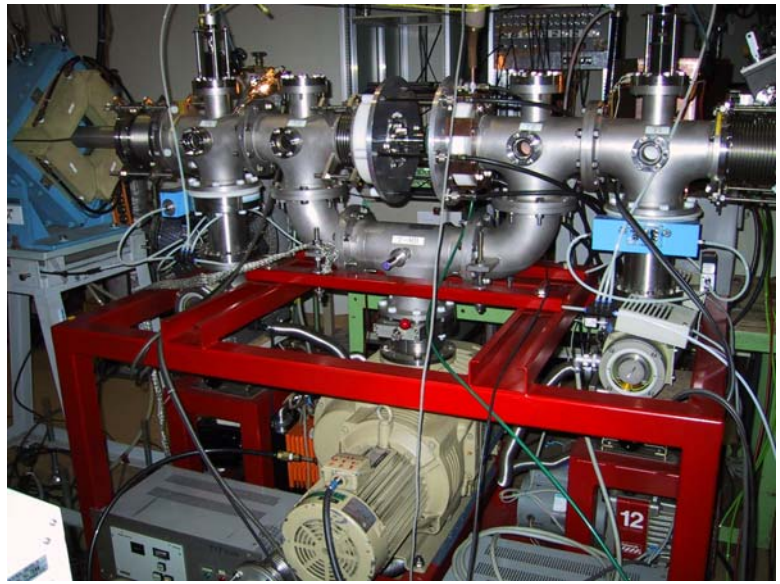


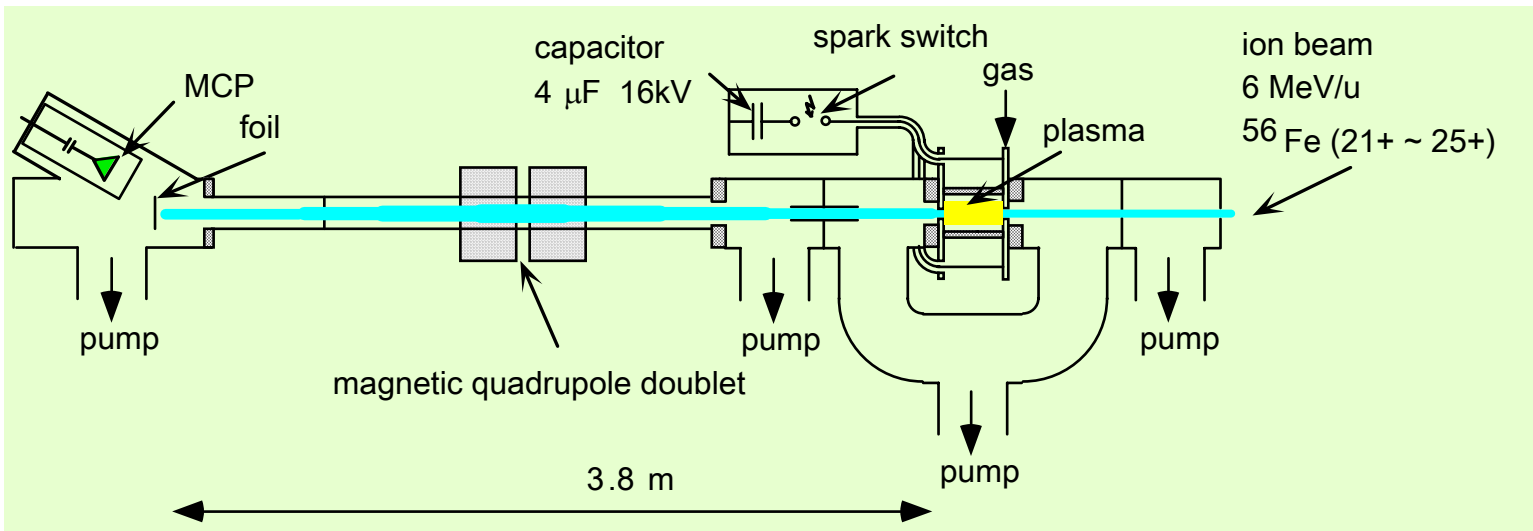


Energy Loss of Heavy Ion Beams in the Dense Plasma

Setup at HIMAC

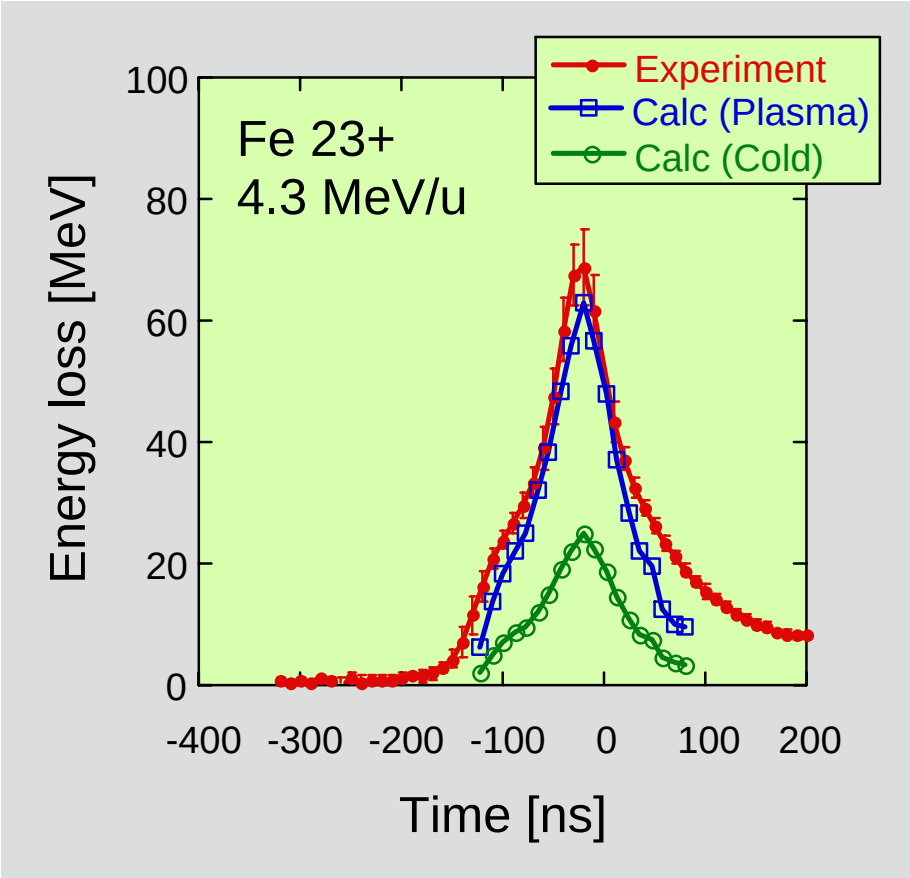


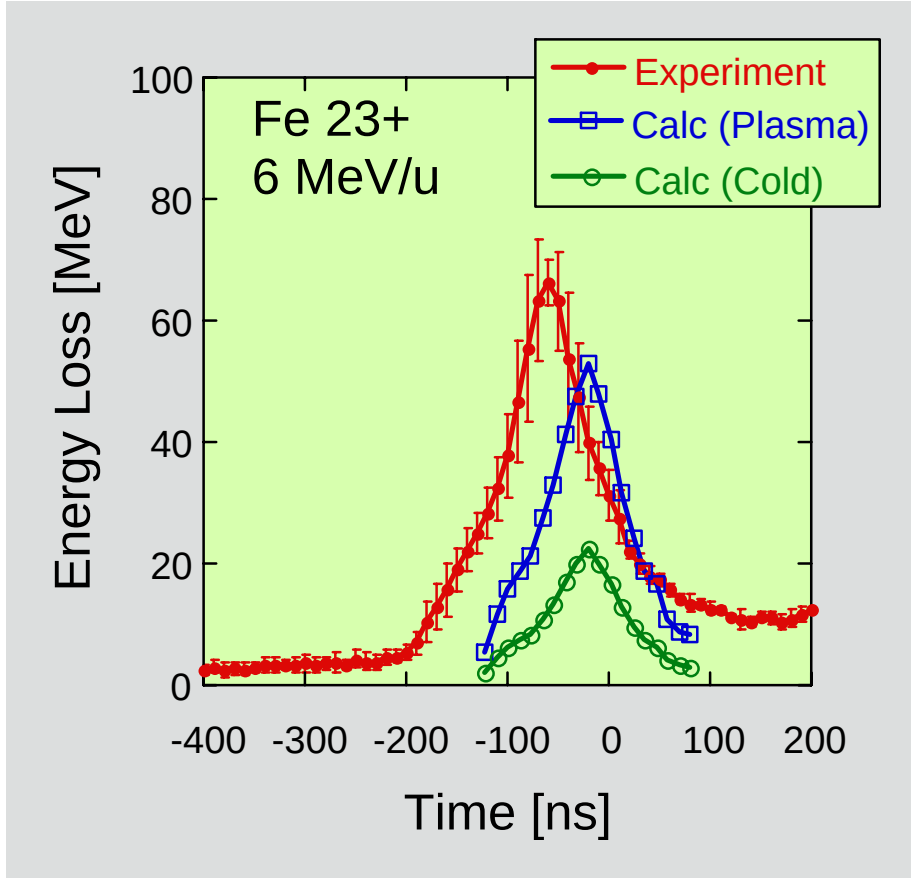




Energy Loss of ^{56}Fe Ions in He Plasma

He 300 Pa





Energy Loss and Charge States of Projectile Ions in He Plasma

Ion Species	Energy [MeV/u]	Energy Loss* (Exp) [MeV]	Energy Loss* (Calc) [MeV]	Z_{eff} (H)	Z_{eff} (O)	Z_{mean} (Calc)
H	6	0.20±0.04	0.12	N A	N A	N A
O	6	7.2±0.4	6.7	N A	N A	N A
	4.3	8.5±0.5	9.2	N A	N A	N A
Fe	6	66±4	53	18±2	24±1	23
	4.3	69±6	63	N A	23±1	21
Xe	6	178±11	127	30±3	40±2	36

*Energy Loss at Highest Plasma Density

Prof.S.Nakai wants to know the Followings to be discussed during this RCM (Vienna, Nov. 4-7, 2003):

1. Future schedule of this CRP,
   - 2000, Start
   - 2001, First RCM
   - 2002, TM, San Diego
   - 2003, Second RCM (Vienna)
   - 2004,
   - 2005,

2. Third RCM ?,
   Deadline of Final Reports ?
   Schedule for Final Reports,
   Schedule after the current CRP?

3. Nuclear Fusion Activity of IAEA in next year and the year after next,
   The big Conf.; France (Lyon), Portugal, (MFE and IFE),
   Other RCP,
   IAEA TM,
4. Deadline for New Proposal or Application,

Future Direction of this CRP; Power Plant Design?

5. Distribution of Information to all Members; Concerning this RCM including the agenda, all kinds of reports etc.,

   Access to the Websites of this CRP, for several years, at least?