2002-2004 J-US Program Overview

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2002-2004 J-US Program

- **2002 US-J Workshop on Heavy Ion Fusion**
  - **Participants (K.Horioka, M.Ogawa, T.Katayama, S.Kawata, M.Murakami, T.Kikuchi, A.Sakumi)**
  - (2002 Mar, at Berkeley and LLNL)
  - J.Barnard, S.Lund
- Exchange Program; Japan>>US
- **Akira SAKUMI (RIKEN)**
  - Study of atomic Process in Beam-Plasma Interaction
  - 2003 Mar 12-25 Lawrence Berkeley Laboratory
  - LBNL Dr. John Barnard
- **Shigeo KAWATA (Utsunomiya University)**
  - Numerical Analysis of Final Beam Transport to Heavy Ion Fusion Reactor
  - 2003 Sep.1-14 UC Prof. P.Peterson, LLNL Dr. G.Logan
- **Masao WATANABE (RIKEN-JAERI)**
  - Waveform Control and Ferromagnetic Materials for Induction Accelerators
  - 2003 Sep.8-21, LBNL Dr.Grant Logan

2002-2004 J-US Program

- Fiscal Y 2004
- **Exchange Program; Japan >> US**
  - Dr.Takashi Kikuchi (Utsunomiya University)
  - Beam Dynamics of Final Beam Transport of Heavy Ion Fusion
  - LBNL; Dr.Grant Logan, Dr.Steven Lund
  - This exchange area covers the beam physics on transport of heavy-ion-fusion driver beams. He is going to discuss with US researchers on physics of bunching and focusing of intense space-charge dominated beams.

  - Prof.Yoshiyuki Oguri (Tokyo Institute of Technology)
  - Physics on interaction of Heavy Ions with High-density Plasma
  - Y.Oguri visits PPPL to discuss the physics of beam-plasma interaction for high-density, low-temperature plasma.
  - PPPL; Prof. Ronald Davidson

  - Prof. Kiyoshi Yatsui (Nagaoka University of Technology and Science)
  - (Substitute: Kazuhiko Horioka (Tokyo Institute of Technology))
  - This exchange aimed to improve the exiting pulse power technology and to develop a new area of pulse power application.
  - Pulse Power Induction Technology for Heavy Ion Drivers
  - SNL; Dr. Crag Olson

- **2004 US-J Workshop (PPPL) June 10-12**
  - (K.Horioka, S.Kawata, Y.Oguri, M.Murakami, M.Nakajima, J.Hasegawa, T. Kikuchi)

Title of Presentations for US-J Workshop from Japanese Side

- Ion Extraction from Expanding Plasma Laser Plasma
  - Mitsuo Nakajima (Tokyo Institute of Technology)
- Dynamics of Plasma Channel for Chamber Transport
  - Jun Hasegawa (Tokyo Institute of Technology)
- Beam Stopping Issues and HEDP
  - Yoshiyuki Oguri (Tokyo Institute of Technology)
- Final Beam Transport Issues
  - Shigeo Kawata (Ustunomiya University)
- Tolerance Change in HIB Pulse Duration
  - Takashi Kikuchi (Ustunomiya University)
- Uniformity in Fast Ignition : To Which Extent Should We Alter Our Conventional Beam-Target Design
  - Masakatsu Murakami (Osaka University)

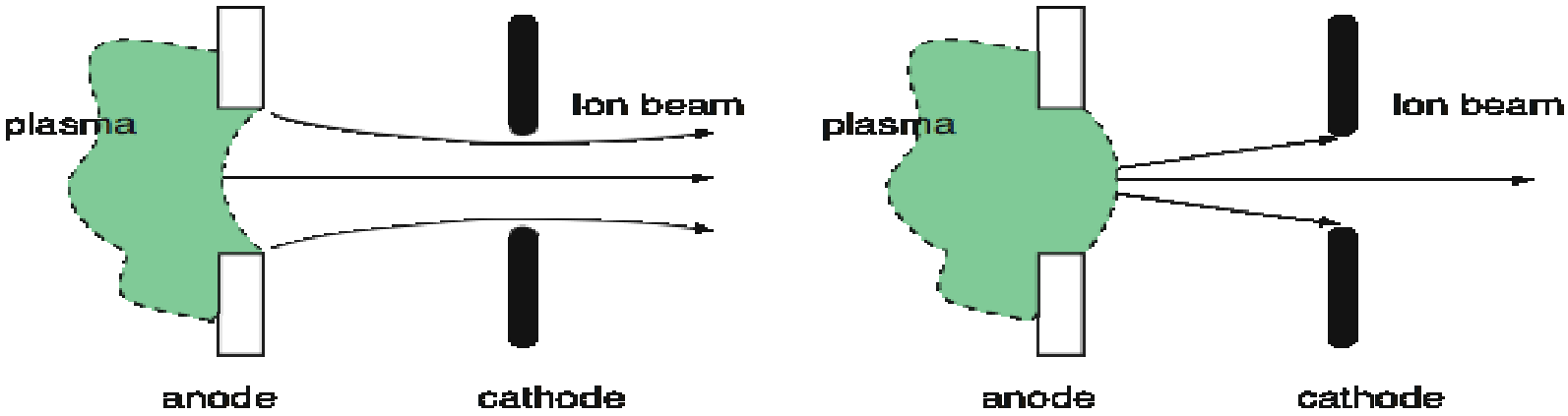
Ion Extraction from Moving Plasma

Ion Extraction from Expanding Plasma Laser Plasma

Mitsuo Nakajima (Tokyo Institute of Technology)

Behavior of Ion Emission Surface in Laser Ion Source

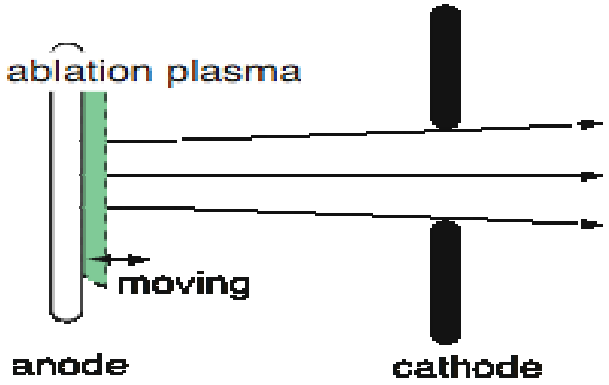
1) Plasma meniscus in a conventional ion extractor.



a) Supply current matched Child current

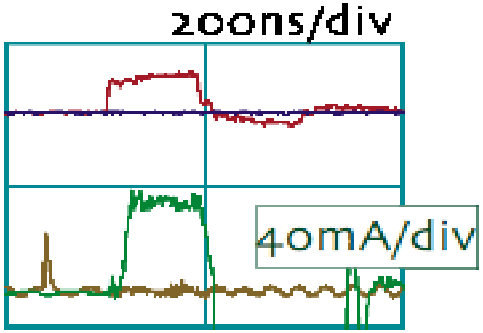
b) Excess plasma ion flux

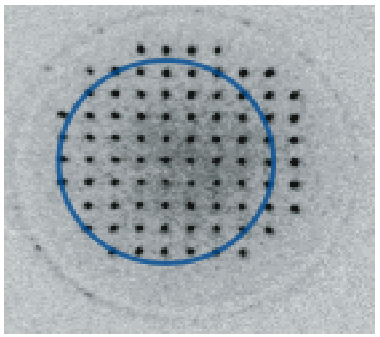
2) Direct Extraction from an ablated plasma by large area laser irrdiation

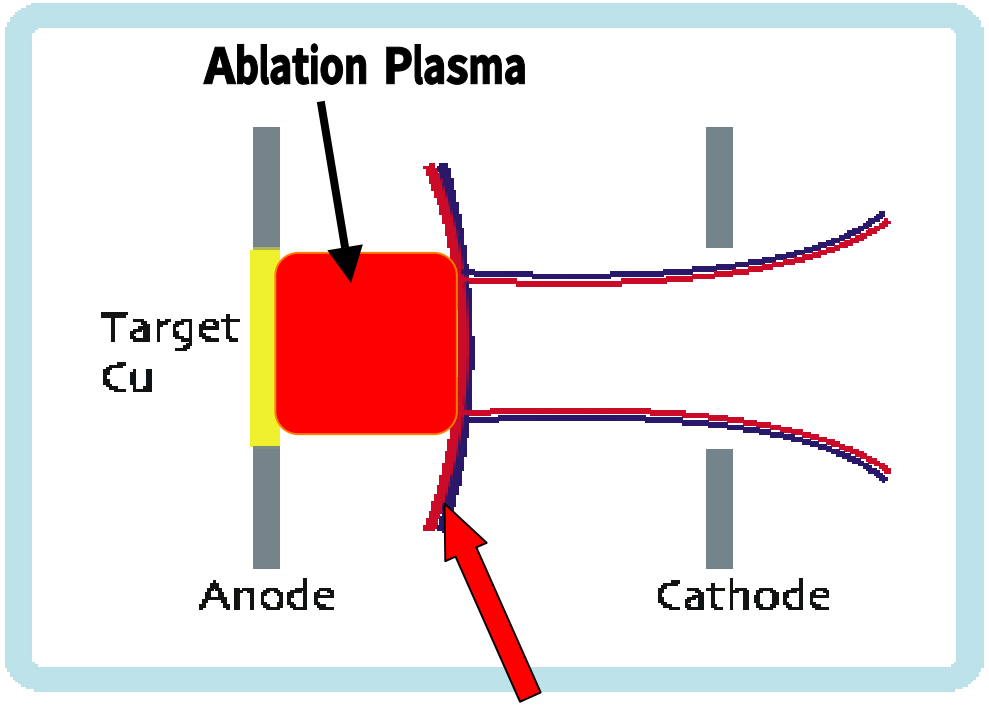


Quasi-Matching Condition was Observed

"Matching Condition"





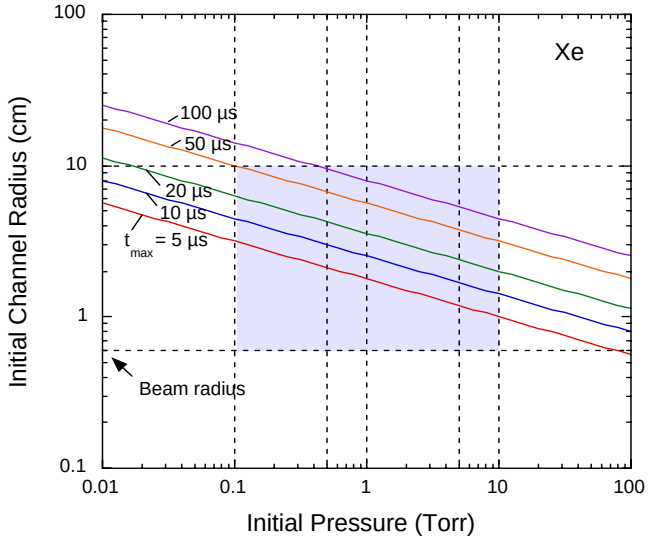


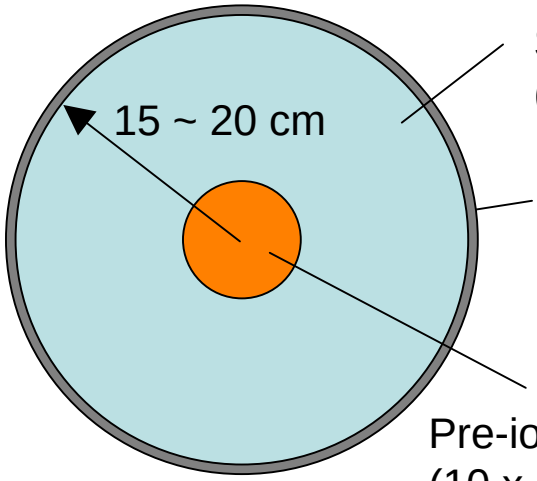
Dynamics of Plasma Channel for Chamber Transport

Dynamics of Plasma Channel for Chamber Transport

Jun Hasegawa (Tokyo Institute of Technology)

Plasma dynamics of transport channels was examined using 1D MHD simulations in a wide range of plasma parameters to find the optimum conditions for channel discharge and beam transport.

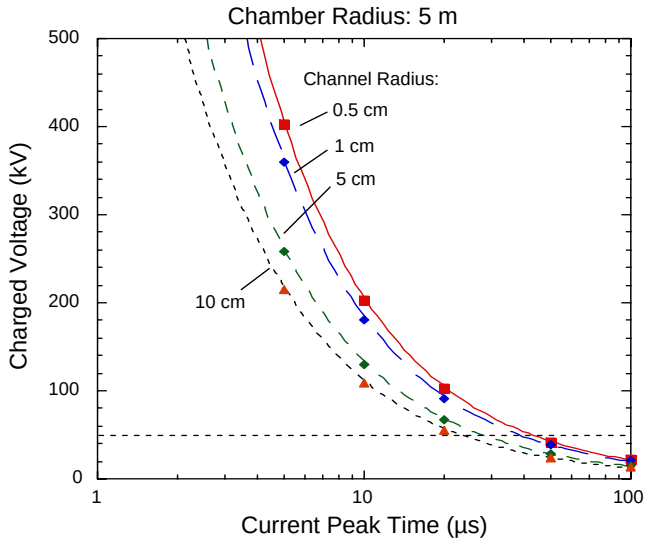


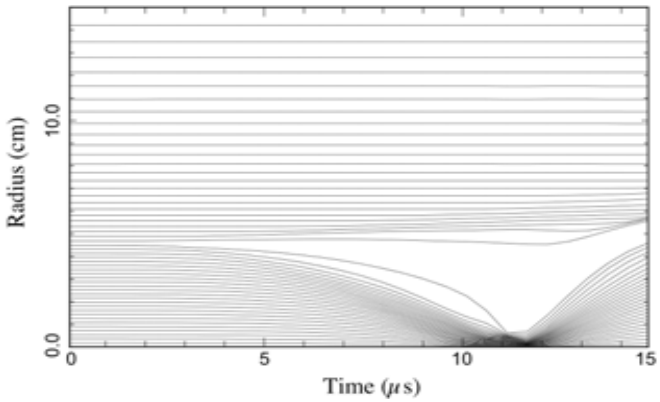


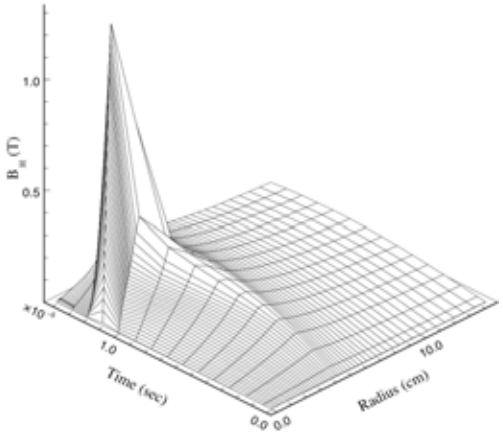
Surrounding cold gas
(room temperature ~ 293 K)

Rigid wall
(chamber wall)

Pre-ionized warm plasma channel
(10 x room temperature ~ 0.25 eV)







Beam Stopping Issues in HEDP

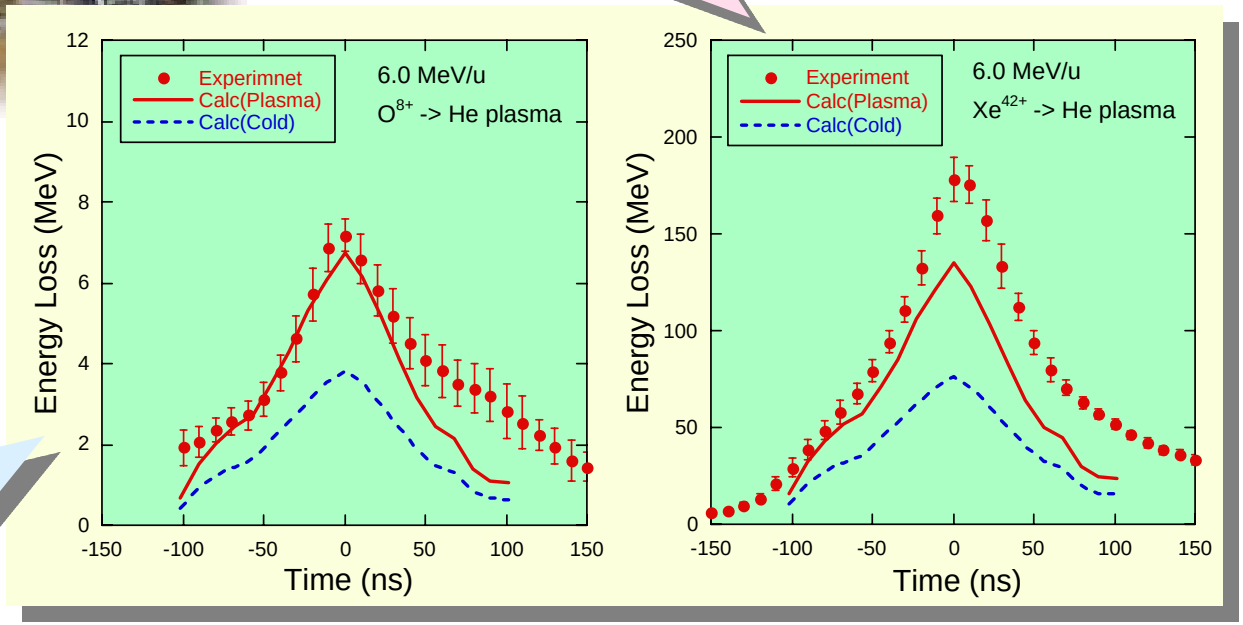
Beam Stopping Issues and HEDP

Yoshiyuki Oguri (Tokyo Institute of Technology)

Beam-plasma interaction experiments using a dense z-pinch plasma at Tokyo Tech.

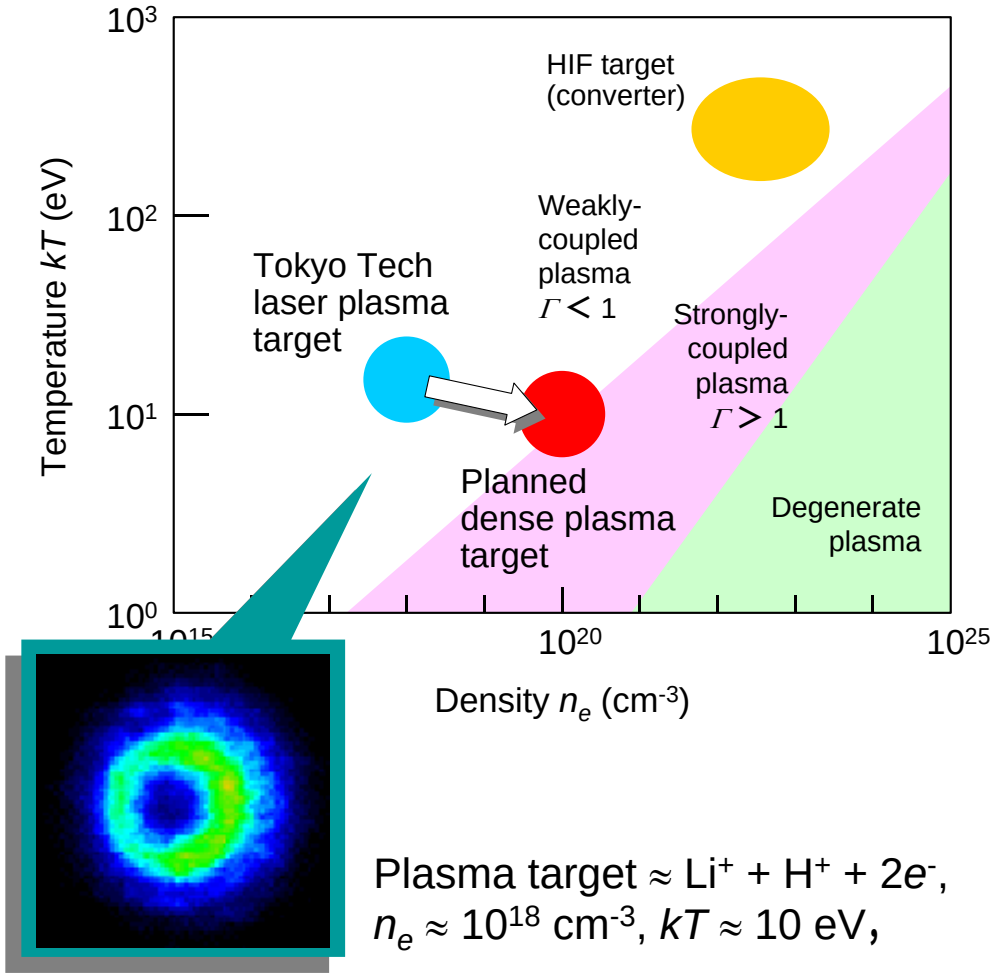
Large enhancement of energy losses of xenon ions was observed under target plasma densities above 10^{19} cm^{-3}, which was caused by an increase in projectile effective charge due to some density effects.

Energy loss of fully-stripped oxygen ions showed good agreement with theoretical predictions.



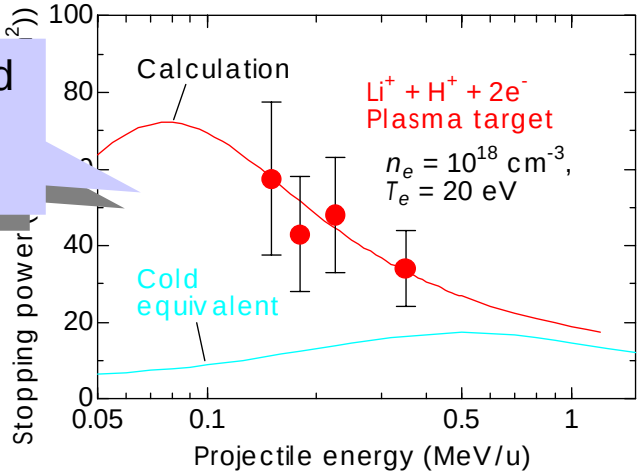
Beam-plasma interaction experiments with dense plasma targets are being planned at RLNR/Tokyo-Tech.

- Experiments performed so far using Tokyo-Tech 1.7 MV tandem accelerator:

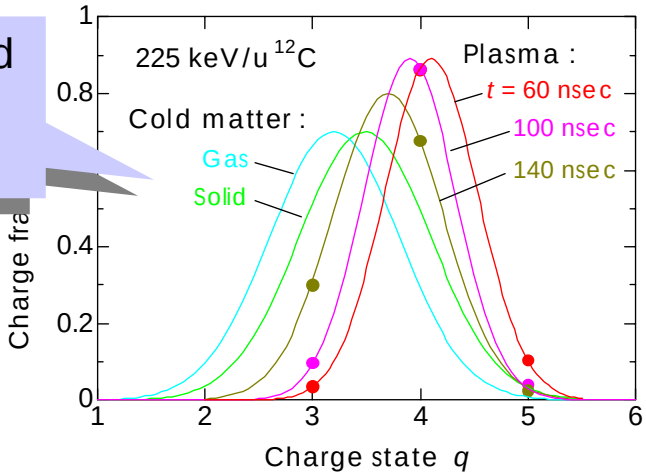


Plasma target ≈ $Li^+ + H^+ + 2e^-$,
$n_e \approx 10^{18}$ cm^{-3}, $kT \approx 10$ eV,

Enhanced *-dE/dx* in plasmas



Enhanced charge in plasmas



Final Beam Transport Issues and Target Irradiation Scheme

Final Beam Transport Issues
Shigeo Kawata (Ustunomiya University)

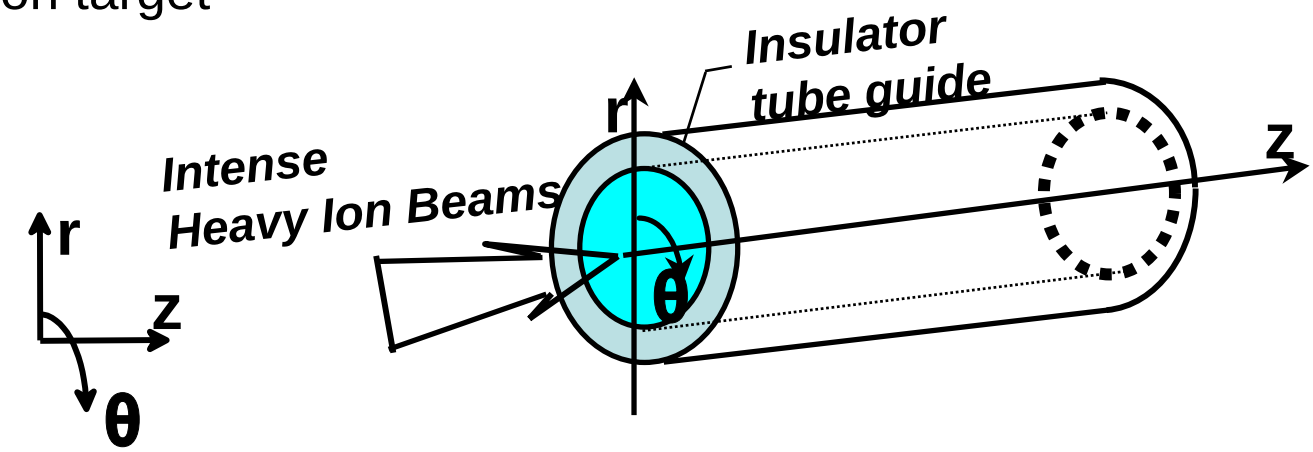
Tolerance Change in HIB Pulse Duration
Takashi Kikuchi (Ustunomiya University)

Uniformity in Fast Ignition : To Which Extent Should We Alter Our Conventional Beam-Target Design
Masakatsu Murakami (Osaka University)

Activities in HIF at Utsunomiya University

S.Kawata, T.Kikuchi, T.Someya, A.I. Ogoyski

/ Final HIB transport
/ HIB illumination on target
/ Implosion



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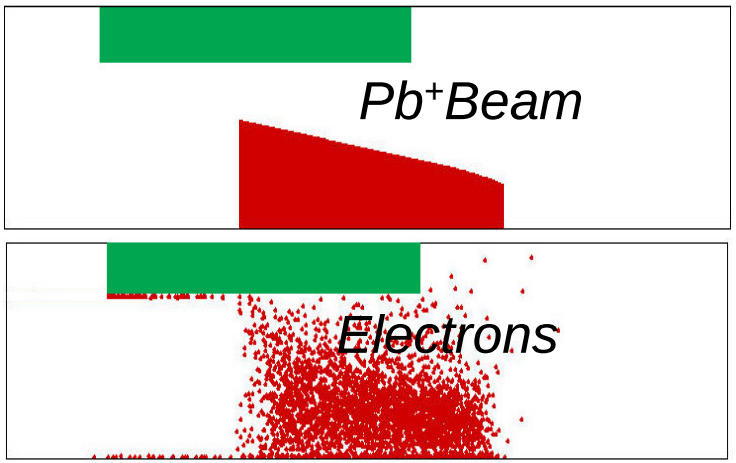
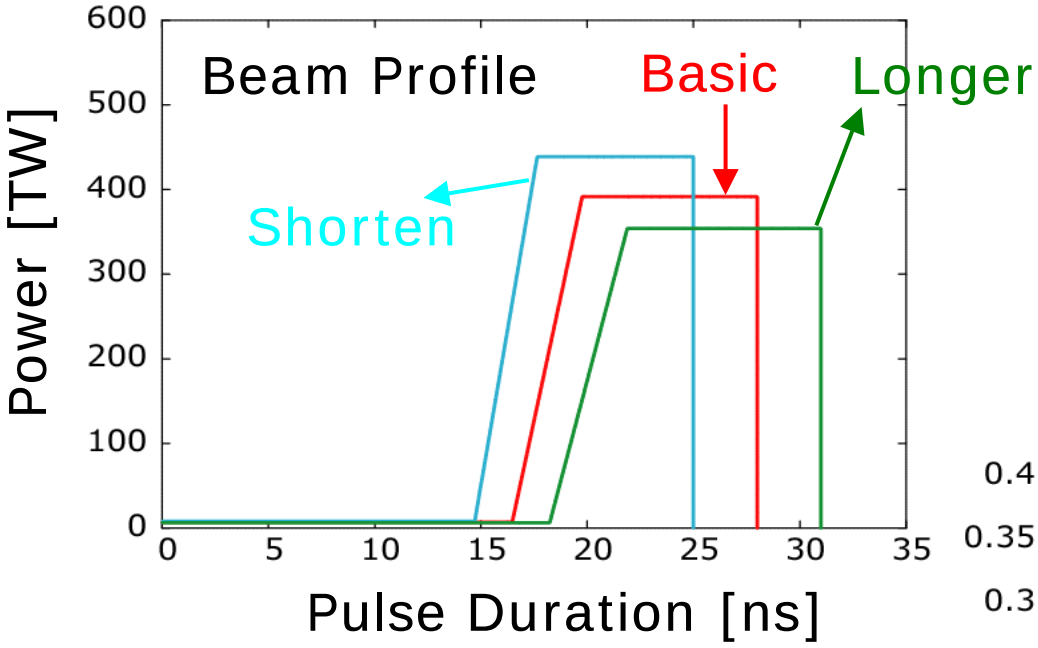


Insulator Guide supplies electrons.

Simple neutralization method

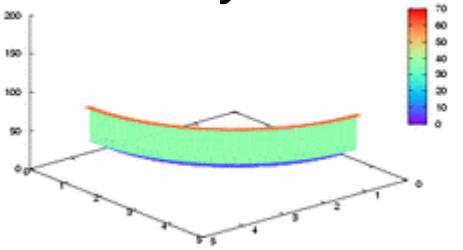
Pulse Duration Dependence on Implosion

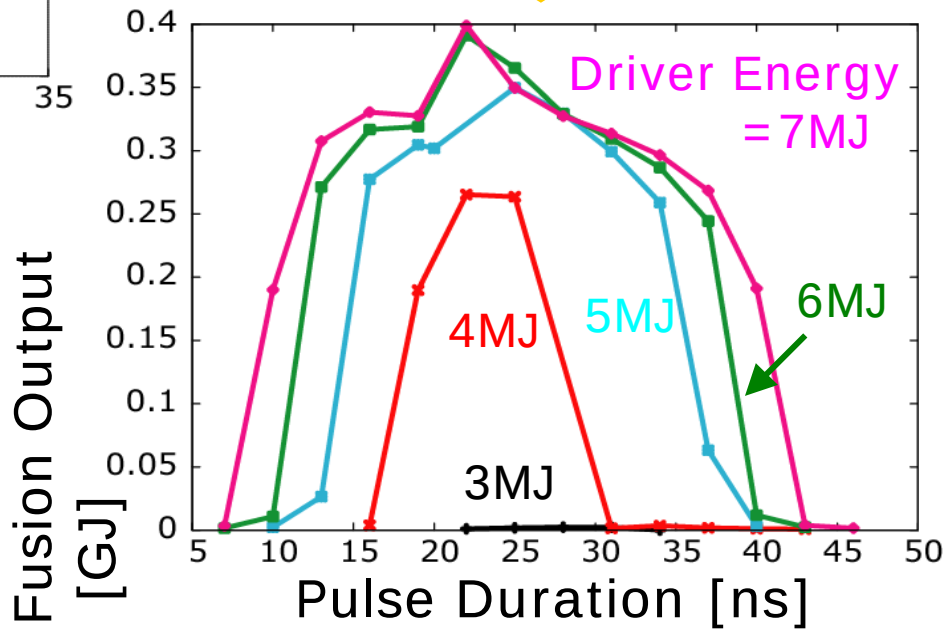
Study on tolerance of beam pulse duration for implosion



Larger Input Energy has
Larger Tolerance in Beam
Pulse Duration Error
for Fusion Output Energy.

Density Profile during
Implosion by 2D Simulation



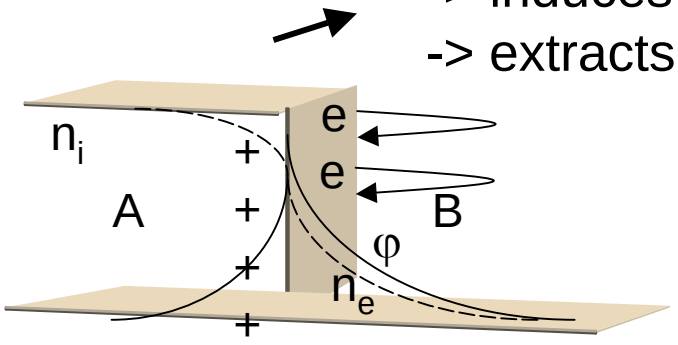


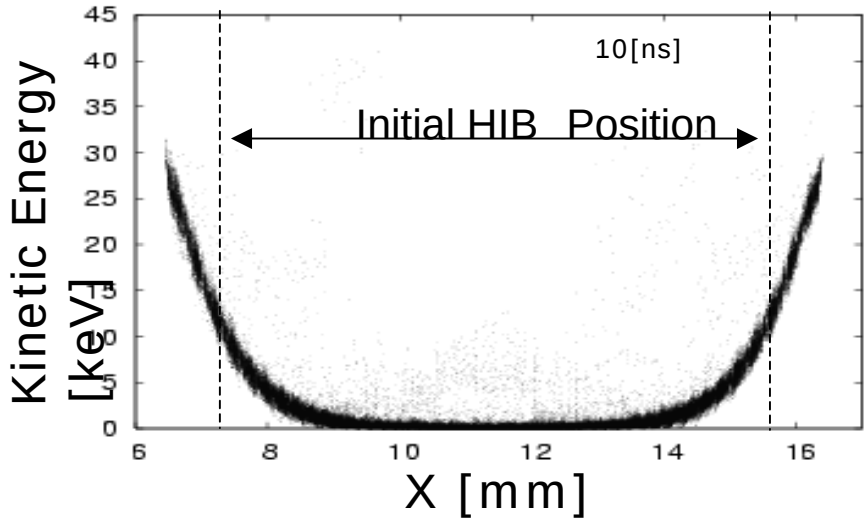
Ambipolar field HIB expansion

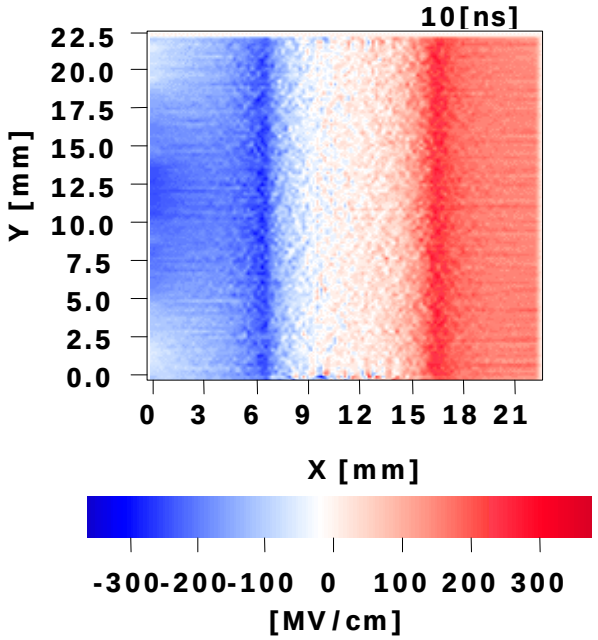
<- Neutralizing hot electrons induces charge separation at HIB surface

-> induces a strong electric field in radial

-> extracts HIB ions rdially







Wednesday, 09 June Morning "Final Beam Transport and Target Illumination"

Irradiation Uniformity :
in Fast Ignition Scheme
Allowable Level in Direct Driven Scheme

Uniformity in Fast Ignition : To Which Extent Should We Alter Our Conventional Beam-Target Design

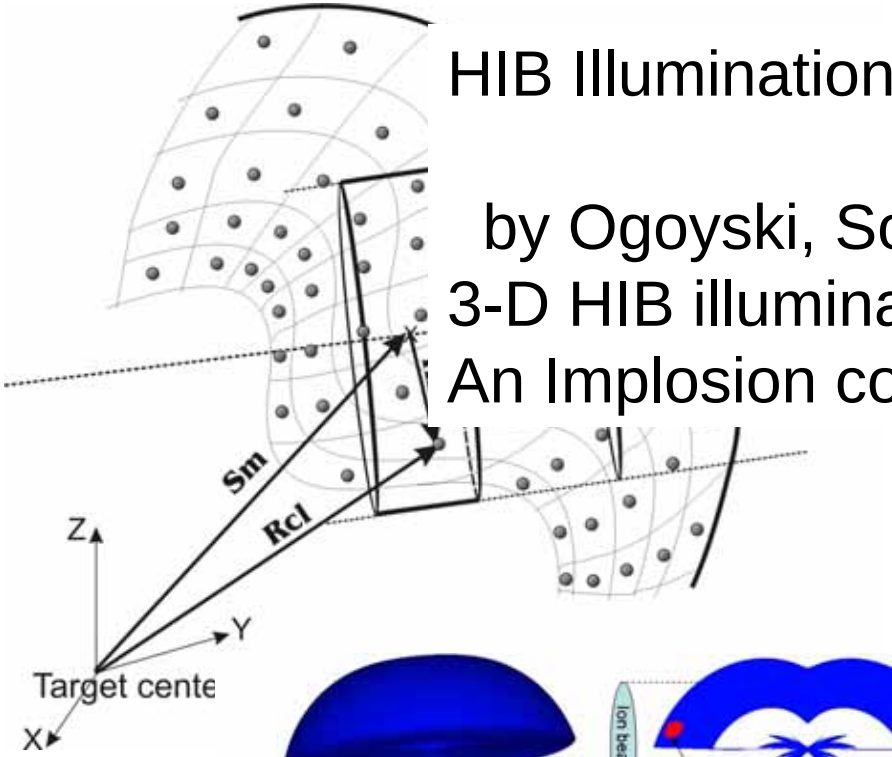
Masakatsu Murakami (Osaka University)

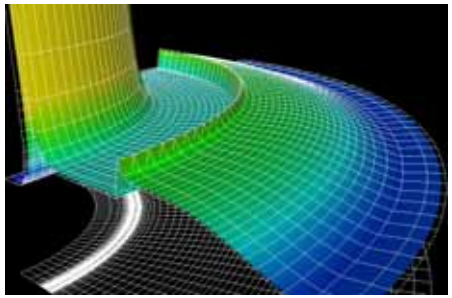
HIB Illumination 3-D Code is ready.

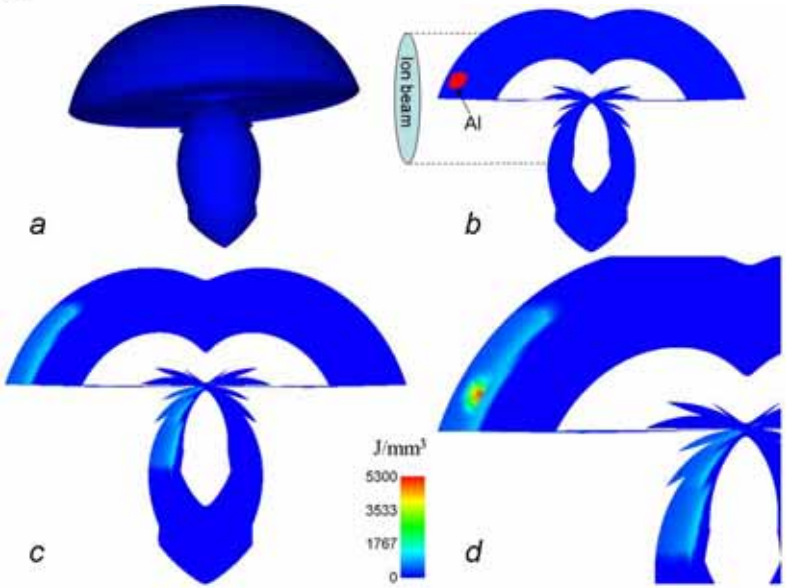
by Ogoyski, Someya, Kikuchi, Kawata

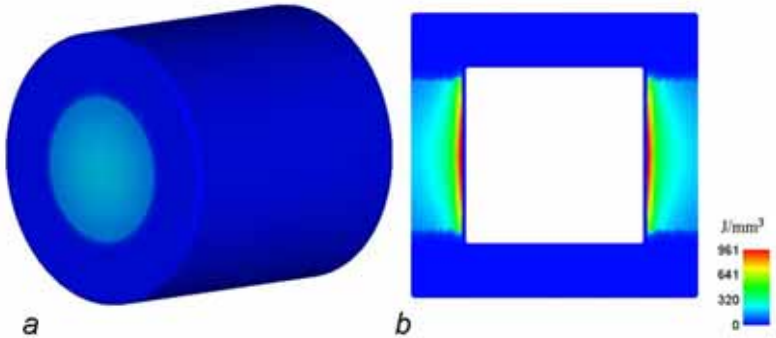
3-D HIB illumination code is ready

An Implosion code is now under construction





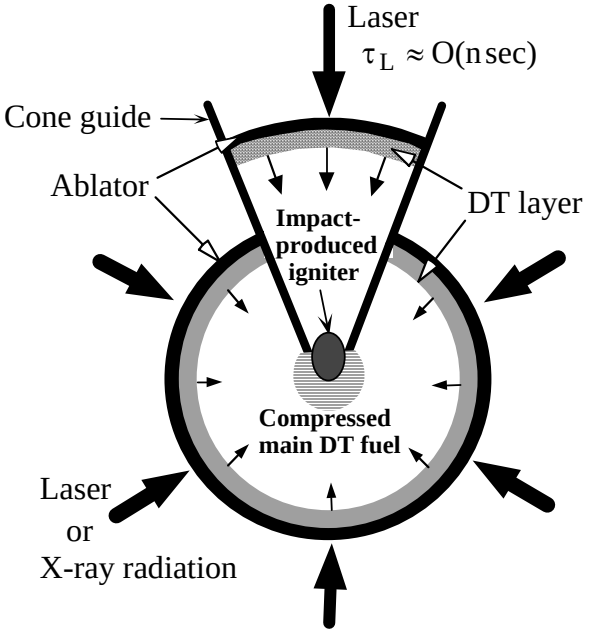


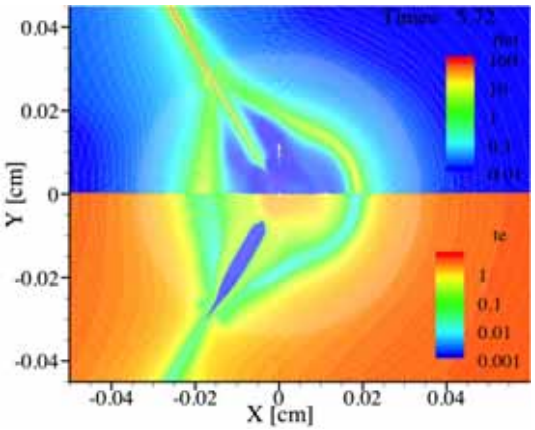


Wednesday Afternoon, June 9, T. Someya, et al., “HIB Illumination on a Target…”

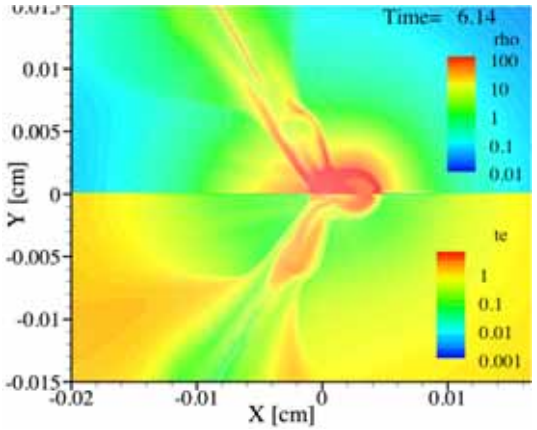
A New Twist to IFE - Impact Ignition -

- A totally new ignition scheme is proposed, in which the compressed DT main fuel is ignited by impact collision of another fraction of separately imploded DT fuel.





Isocontour map at a time shortly before the impact



Isocontour map at peak compression shortly after the impact

Advantages of Impact Ignition
(1) Simple Physics
(2) High Coupling Efficiency
(3) High Robustness
(4) High Gain
(5) Low Cost

Basic experiments are now being conducted under the operation of Gekko XII glass laser System at ILE, Osaka, Japan.

Summary

- High Flux Ion Injectors
  - Flux Level, Emittance
- Tolerance Level of ;
  - Final Buncher, Transport, Target Uniformity ?
- Neutralization Scheme & Optimum Beam Number ?
- Beam Stopping Power & Optimum Beam Energy ?
- Advantages & Disadvantages of Negative Ion Driver ?
- Optimum Accelerator System ?