Workshop on Accelerator Driven High Energy Density Physics
LBNL October 26-29, 2004

Report from the working group on Single-Gap Pulsed Power

Craig Olson, Paul Ottinger, and Tim Renk

Introduction

A Pre-Workshop was held at SNL on October 19, 2004 to discuss the use of Single Gap Pulsed Power to produce ion beams for accelerator driven HEDP. Many who participated in this Pre-Workshop could not attend the main Workshop, so this was a valuable mechanism to get input from the "Single-Gap Pulsed Power" community. In the following, a summary of the results of this Pre-Workshop is given - including general comments on single-stage ion diodes, possible facilities for single-stage ion diode experiments, and an introduction to the Ionization Front Accelerator (IFA). Then, proposals are given for (1) possible single-stage ion diode experiments for HEDP, and (2) possible IFA experiments for HEDP.

Summary of the Pre-Workshop on Single-Gap Pulsed Power

The Pre-Workshop at SNL on October 19, 2004 included input from the following:

SNL	NRL	ATK-MRC	UNM	Cornell
Craig Olson	Paul Ottinger	Dave Rose	Stan Humphries	John Greenly
Tim Renk	Jess Neri	Dale Welch		(by telephone)
John Maenchen	Bruce Weber			
Steve Slutz	Frank Young			
Mike Desjarlais				

The purpose of the meeting was to review the HEDP requirements as per the HIF-VNL documents, and then assess the utility of various pulsed power, single-gap accelerators to reach the HEDP goals. Possible accelerators considered were:

(1) Gamble II at NRL
(2) Mercury facility at NRL
(3) RITS facility as SNL
(4) RHEPP/MAP facility at SNL
(5) High impedance ion diode with no requirement on efficiency
(6) IFA

(Note that Sabre at SNL and Cobra at Cornell were not considered because Sabre has been disassembled, and Cobra has been converted to a z-pinch driver.) Of course, any of these facilities might be used directly, or the accelerator concept could be developed into an accelerator that could be constructed at LBNL if desired.

First, it should be noted that pulsed power accelerators have been used for a long time for HEDP. In Table 1, a brief summary of HEDP examples from pulsed power facilities is given. With these approaches, matter has been heated up to temperatures exceeding 200 eV. More importantly, the pulsed power community has developed considerable expertise in diagnosing hot dense matter in a harsh environment. Some of this diagnostic expertise may be useful for the HIF-VNL in developing accelerator driven HEDP.

Table 1. HEDP examples with Pulsed Power facilities

electron beam - rod pinch on Gamble II	25 eV
ion beam (D): PRD on Gamble II	15 eV
ion beam (p): (diode on Sabre)	30 eV
ion beam (Li): (barrel diode on PBFA II)	60 eV
ion beam (p): (short focus on Kalif)	several 10’s eV
x-rays (double-pinch target on Z)	70 eV
x-rays (dynamic hohlraum on Z)	215 eV

Throughout our discussions, several questions arose concerning the charge to the group. Some of these questions were recurring, so we wanted to pose them to the entire group. These questions are:

1. If the first 1 ns of the ion pulse meets the requirements, can the actual ion pulse be longer? (i.e., is it acceptable to leave the beam on longer).
2. Why does it need to be repetitive? Why have multiple chambers? Aren't the HEDP experiments intrinsically single-shot experiments?
3. The neutralizing plasma near the target was listed as having a density requirement $\sim 10^{12}/cm^3$, but shouldn't it be much higher (since the ion beam density near the target will be $\sim 3x10^{14}/cm^3$)?
4. Why have only 5 m total length (since this will require a huge velocity tilt)?
5. Is enhanced ion stopping being considered (since it was not mentioned in the paper)?

Lastly, the desired nominal ion beam parameters that we considered were:

19 MeV Ne^{+1}, $N \sim 1.4x10^{13}$, $t \sim 1$ ns, $r_{spot} \sim 1$ mm.
energy/nucleon ~ 1 MeV, $I_{particle} \sim 2.2$ kA, $\beta \sim 0.05$,
ion pulse length = $\beta ct \sim 1.5$ cm, total ion bunch energy ~ 36 J

For the ion diodes used in the light ion fusion program, high diode voltages and small anode-cathode gaps (required to maximize the ion current density possible) meant that there would always be electron emission from the cathodes. Therefore, the pulsed power ion diodes used for light ion fusion were all designed to minimize the electron current to the anode to achieve high efficiency. This was accomplished by preventing the electrons from reaching the anode for as long as possible. This led to several diode types [reflexing-electron diode, magnetically-insulated diode (with external magnetic field coils), and pinched electron beam diode]. For the "barrel-diode" geometry used on PBFA, several schemes were devised, including the radial applied B diode, the AMPFION diode, the hybrid diode, and the pinch reflex diode. This culminated in the applied B, extractor diode used on PBFA that produced 50 kJ of Li ions. A comparison of the beam from this PBFA-X diode with the parameters needed for a high-yield (HY) fusion driver beam are summarized in Table 2. Note that the microdivergence required for the HY case was 6 mR (assuming ballistic transport) and 12 mR (assuming channel-like transport).

Table 2. Parameters achieved on PBFA-X, and parameters needed for a High-Yield Facility Li ion beam.

Parameter	PBFA-X	HY Li ion beam
Diode voltage	10 MV	30 MV
Ion current	0.3 MA	1 MA
Ion Power	3 TW	30 TW
Ion pulse length	15 ns	40 ns
Ion energy	50 kJ	1.2 MJ
Ion micro-divergence	22 mR	6-12 mR
Ion current density at source	0.6 kA/cm^2	1-2 kA/cm^2

The key issues that were uncovered in ion beam generation using high-power single-gap ion diodes in the light ion program were microdivergence, parasitic load, and impedance collapse. Microdivergence: if the transverse beam temperature associated with the microdivergence of 22 mR achieved with a passive ion source on PBFA-X held constant as the voltage increased from 10 MV to 30 MV, then the microdivergence would scale to 12 mR for a HY driver - exactly as needed. Therefore, it could be argued that the microdivergence was essentially within reach for a HY driver. Parasitic load: A more serious problem was that the desired Li beam was only the initial and small part of the total ion beam produced. Further work on creating a pure Li ion source was needed. Impedance collapse: The desired diode electrical behavior was to simultaneously have a rising voltage (for beam bunching) and a rising beam current. Typically, the current would rise (due to the parasitic load) and the voltage would drop - i.e., the impedance collapsed. It should be emphasized that all of these issues occurred for a magnetically-insulated ion diode in which a circulating electron cloud in the anode-cathode gap was present.

The voltage accuracy needed for ion bunching is a concern for all schemes that use drift compression of a voltage-ramped ion beam. The voltage accuracy needed, ε_{volt}, is given in Figure 1. Examples of the voltage accuracy needed for several relevant cases (IBX, HEDP, and an HIF driver) are given in Table 3.

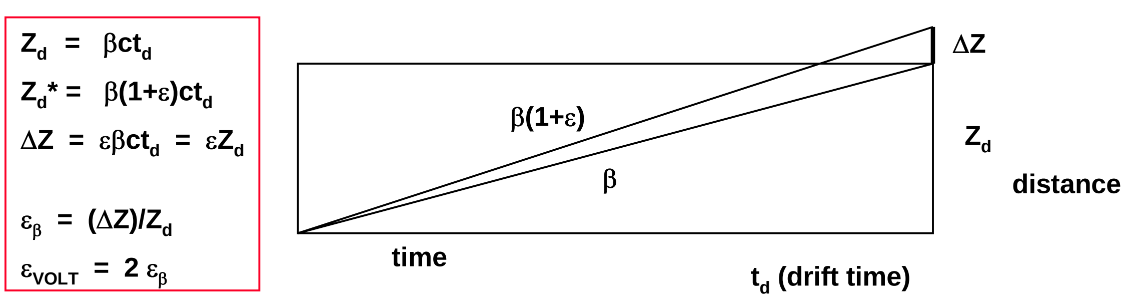

Figure 1. Voltage accuracy (ε_{volt}) needed for bunching.

Table 3. Examples of the voltage accuracy needed for bunching.

Examples:	IBX	HEDP	HIF Driver
	$\beta = 0.03$	$\beta = 0.05$	$\beta = 0.2$
"acceptance"	$\Delta t = 50$ ns	$\Delta t = 1$ ns	$\Delta t = 10$ ns
($\Delta Z = \beta c \Delta t$)	$\Delta Z = 45$ cm	$\Delta Z = 1.5$ cm	$\Delta Z = 60$ cm
	$Z_d = 30$ m	$Z_d = 5$m	$Z_d = 400$ m
	$\varepsilon_\beta = 45/3000 = 1.5\%$	$\varepsilon_\beta = 1.5/500 = 0.3\%$	$\varepsilon_\beta = 60/40000 = 0.15\%$
	$\varepsilon_{VOLT} = 3\%$	$\varepsilon_{VOLT} = 0.6\%$	$\varepsilon_{VOLT} = 0.3\%$

Note that the voltage accuracy needed for the HEDP case is getting close to that needed for the HIF driver case.

Based on discussions at the Pre-Workshop, several general comments were made concerning the utility of considering pulsed power single-gap ion diodes for accelerator driven HEDP. These comments were:

1. The shortest pulses in pulsed power accelerators are typically 10-20 ns (not 1 ns).
2. Ion beam transverse temperatures are sufficiently large so that for ballistic focusing, very short focal lengths are required to hit a small spot (e.g., 1 mm radius).
3. Therefore, for drift compression, the beam must be transported at a relatively large radius, and then focused radially near the target with a focusing cell.
4. The voltage accuracy needed for a single-stage, voltage-ramped, ion diode will typically limit the drift compression possible to factors much less than 100. (For the light ion program, bunching factors of only a few were needed, and the corresponding voltage accuracy needed was 20% - which could readily be achieved).
5. All past ion diode studied for fusion required high efficiency, whereas for HEDP, this is not a requirement. For example, the simple bi-polar diode offers the possibility of better beam quality.

Given these general comments on pulsed power ion diodes, the group then proceeded to consider several existing facilities as a possible facility for a single-stage ion diode for accelerator driven HEDP. The electrical parameters for these facilities are:

Gamble II at NRL: (1.5 MV, 1 MA, 50 ns)
Mercury at NRL: (6 MV, 350 kA, 50 ns, either + or - polarity: will be operational in FY05)
RITS at SNL: (Radiographic Integrated Test Stand accelerator, 5.5 MV, 150 kA, 60 ns, either + or - polarity: will be upgraded to 11 MV, 150 kA in FY05)
RHEPP/MAP at SNL: (0.5-0.75 MV, beams from H, He, N_2, O_2, Ne, Ar, Xe, etc.)
(Sabre at SNL has been disassembled)
(Cobra at Cornell has been made into a z-pinch driver)

Based on all of the above considerations, the group proposed three possible single-gap diode options for accelerator driven HEDP:

Single-gap ion diode OPTION 1:
(Near-term) PRD (Pinch Reflex Diode) on Gamble II at NRL at 1.5 MV

The purpose of this option is to get started doing accelerator driven HEDP as soon as possible. This experiment would use a PRD on Gamble II at ~ 1.5 MV, and focus a proton beam to obtain the highest ion current density possible at the focus (~ 250 kA/cm^2). Then, at the focus, a plate with a 1 mm radius hole would allow a 1 mm radius beamlet to pass. The beamlet current be ~ 7.5 kA. The beamlet energy per ns would be (7.5 kA)(1.5 MV)(1 ns) $\approx$ 10 J, which means 10 J/ns would go into a 1 mm radius spot.

The issues associated with this direct approach concern the pulse length. The ion beam pulse length is 50 ns, and the beam rise time is 25 ns. The question then is how to switch out a 1 ns portion of the beam at full power? For example, can the ion beam burn through a foil to steepen the pulse front? If steepened, can a pulse length longer than 1 ns be used?

The possible phases of this approach would be:

Phase 1. Set up an ion diode on Gamble II and create a 1 mm radius beamlet ASAP. This would take about 1-2 weeks on Gamble II at about $45k/week (includes experimenter). Total cost for this phase: ~ $100k.

Phase 2. Do experiments to steepen the pulse front (e.g., burn though a foil) and test HEDP diagnostics. Total cost for this phase: ~ $100k.

Phase 3. Add a z-discharge focus cell (λ/4 or λ/8) to obtain even higher deposition for HEDP. Total cost for this phase: ~ $150k.

The total cost for all phases would be ~ $350k, and the experiments could be done on a time scale of less than a year.

Single-gap ion diode OPTION 2:
(Medium-term) MAP He Applied-B Diode on Mercury at 6 MV

The purpose of this option is to combine (1) the He MAP active ion source developed on RHEPP that produces a pure He^{+1} beam, (2) the newly commissioned 6 MV Mercury voltage-adder accelerator at NRL that could be operated in positive polarity, and (3) applied-B ion diode expertise as developed at SNL during the light ion program:

(1) The He MAP source on RHEPP at 750 kV produces pure He^{+1}, as determined by TOF. Measurements are underway to confirm the ion composition with a Thompson Spectrometer. Faraday cup signals on RHEPP show an initial sharp rise, evidently due to voltage bunching. This maximizes energy delivery in the first part of the pulse. Although the beam emittance on RHEPP is not yet known, beam quality measurements on RHEPP are on-going. The ion beam in RHEPP tends to diverge, as if from a line source in the diode. This could be caused by either (a) lack of a fixed magnetic field topology due to the fact that the MAP source in RHEPP has evolving field lines, or (b) beam blow-up due to excessively high space charge in spite of the co-emitted and co-moving electrons. The Russian group at Tomsk operates a MAP diode with a screen on the anode in place of an open hole, as used at SNL. The Russian group will be making both shadow-box and Thompson spectrometer measurements of beam quality to compare with similar data on RHEPP at SNL.

(2) The Mercury accelerator at NRL will operate at 6 MV with 350 kA. This relatively high impedance is in the right direction for a large gap, high-insulating field beam, which should tend to maximize beam quality.

(3) Magnetically-insulated ion diodes have been studied at SNL for about two decades, and operated at voltages up to ~ 10 MV with the PBFA-X extractor ion diode. This expertise would be used to design an applied-B diode for Mercury.

Combining He MAP, Mercury, and applied-B ion diode expertise should produce a 6 MeV He^{+1} ion beam (1.5 MeV/nucleon). Assuming present estimates of beam brightness, a rough estimate of the beam power delivered to an HEDP target would be 2-10 J/cm^2 in the first 1 ns of the beam. In a 1 mm radius spot, this would be 0.06- 0.3 J in the first 1 ns (too small for HEDP). In a 2.5 mm radius spot, this would be 0.4-1.9 J in the first ns: radial focusing in a z-discharge cell might then be used to reduce the radius to 1 mm.

This single-gap diode option would require applied-B diode design and modeling, capacitor banks for the B field, subsystems for MAP, conversion of Mercury to positive polarity, machine time for bringing up hardware and optimizing the diode, etc. A rough estimate of the cost involved would be $1M - $2M, and the time scale would be 1-2 years.

Single-gap ion diode OPTION 3:

(Longer-term) High impedance ion diode with no requirement on efficiency

As mentioned earlier, all of the ion diodes developed for the light ion program use various means to prevent the electrons from crossing the anode-cathode gap and draining most of the power, i.e., the efficiency for ion production had to be high. The presence of the electrons in the diode led to instabilities that contributed to strong emittance growth of the ion beam. For HEDP, there is the possibility of developing a high impedance ion diode with no requirement on the efficiency - the ion beam so produced should show much better beam quality (lower emitance, etc.).

The simplest example of such a diode is the bi-polar diode in which both ions and electrons flow freely. A bi-polar diode might be investigated to see if such a diode would have a much improved ion beam emittance. For a planar bi-polar flow diode, the electron current must remain below the magnetic pinching limit. Paul Ottinger estimates that this means the diode impedance must be

$$Z(\text{Ohms}) > 30\,(\gamma^{1/2} - 0.8471)^2/(\gamma + 1)$$

(where γ is the usual relativistic factor for the electrons) to avoid pinching of the electron flow. For 1.5 MV, this is roughly 8 Ohms. The ratio of the ion current to the electron current for bi-polar flow is

$$I_i / I_e = (Zm_e/m_i)^{1/2}\,[(\gamma + 1)/2]^{1/2}$$

Therefore, at 1.5 MV for protons, $I_i \sim 7$ kA and $I_e \sim 190$ kA. At 4.5 MV for He^{+1}, the impedance must be greater than 15 Ohms, and $I_i \sim 8$ kA and $I_e \sim 300$ kA.

This option would need a high impedance driver and a bi-polar diode. If the ion beam emittance is significantly improved over that of magnetically-insulated ion diodes, then this approach may prove useful for HEDP. For initial tests to study the ion beam emittance for a 1.5 MV bi-polar, planar, proton diode on Gamble II, a rough funding estimate would be ~ $200k, and the time scale would be less than a year. Further experiments with a focusing diode would then be needed to assess the utility of this concept for HEDP. .

Ionization Front Accelerator OPTION:

Ion acceleration based on use of the collective fields of an intense, relativistic electron beam (IREB) were studied at length in the 1970's. A natural collective acceleration process that occurs when an IREB is injected into a low pressure neutral gas was demonstrated at many laboratories, and many theories were proposed to explain the effect. A theory developed by C. Olson showed that the mechanism was a space charge mechanism, and this theory was compared in great detail with all of the data that had accumulated. This understanding led to the concept of the Ionization Front Accelerator (IFA) which is a controlled collective ion accelerator that improves on the natural collective acceleration process to make a scalable high-gradient ion accelerator. A comprehensive summary of research in this field is in the book "Collective Ion Acceleration" by C. L. Olson (Collective Ion Acceleration with Linear Electron Beams) and U. Schmacher (Collective Ion Acceleration with Electron Rings), Springer Tracts in Modern Physics, Vol. 84, (Springer-Verlag, Berlin-Heidelberg-New York, 1979).

In the IFA, the ions are bunched radially and longitudinally into a compact ion bunch right at the start of the accelerator, and ion bunch pulse lengths less than 1 ns are typical. Two sets of experiments (IFA-1 and IFA-2) were successfully completed in the late 1970's and early 1980's. The IFE concept was scaled to an HIF driver (and for several other applications such as GeV protons, etc.). The IFE uses a pulsed power IREB and short-pulse high-power laser(s) to produce and control the motion of a strong potential well at the head of the beam that can trap and accelerate ions. What is new now is that high-power short-pulse laser technology, as well as pulsed power technology, has made great improvements over the last 20 years. This suggests that it is worth re-visiting the IFE concept, especially since the IFA may potentially be used for both HEDP and HIF.

The IFA concept is shown in Figure 2. An IREB with current typically above the space charge limiting current is injected into a drift tube that has "perfectly conducting walls." A special working gas at low pressure fills the tube. The pressure of the working gas is chosen to be low enough so that the IREB does not significantly ionize the gas on the time scale of interest. Then a swept photoionizing light source (a laser or lasers) is injected though the side of the drift tube. The gas is ionized by the light source to provide a fractional charge neutralization of $f_e = 1$ for the IREB (the background secondary electrons are quickly expelled radially). In this manner, the IREB will propagate though the $f_e = 1$ region, and then blow up just past the f_e front. In the front region, a deep electrostatic potential well is created that will synchronously follow the swept ionization front. Ions are trapped and accelerated in the deep potential well. Acceleration gradients of 100 MV/m and larger (above 1 GV/m) are possible.

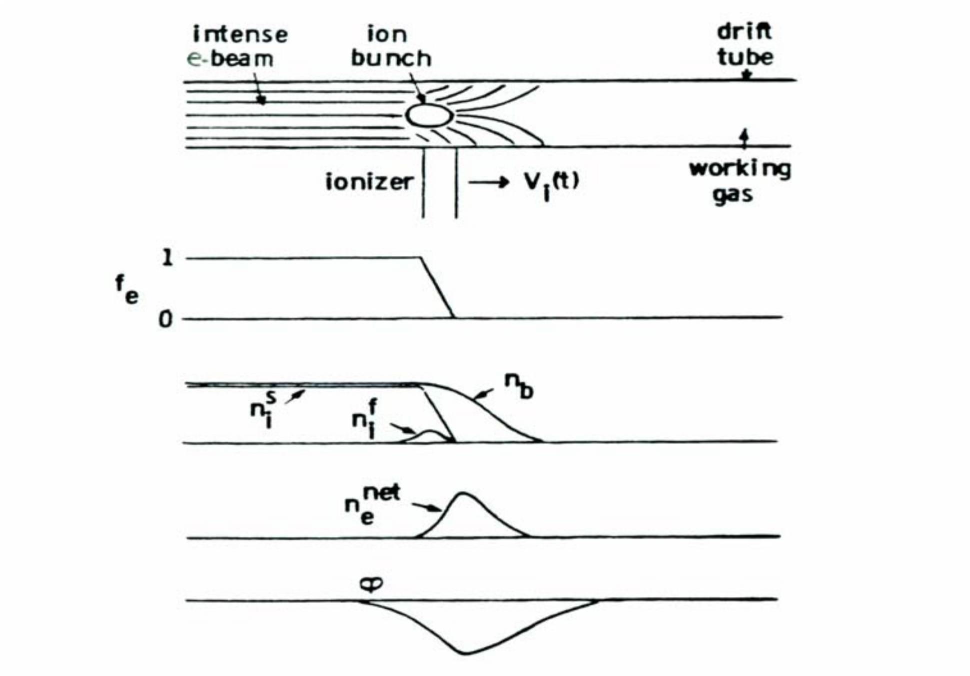

Figure 2. Ionization Front Accelerator (IFA).

The first set of experiments (IFA-1) used the configuration shown in Figure 3. The working gas was Cs at low pressure (30 mTorr). The ion source was a separate gas (such as hydrogen for protons) that was partially ionized by the IREB to provide some test ions. The ionization process was 2-step photoionization with a dye laser exciter (852.1 nm) that was swept by using a light pipe array. The "kicker" laser was a ruby laser frequency doubled. Self-breakdown oil switches on the IREB machine blumlein had a jitter of about 5 ns. The second set of experiments (IFA-2) used the configuration shown in Figure 4. The working gas was again Cs at low pressure (30 mTorr). The ion source was again a separate gas that was partially ionized by the IREB to provide some test ions. The ionization process was 2-step photoionization with a dye laser exciter (852.1 nm) that flooded the acceleration region, and a "kicker" laser that was a XeCl laser (308 nm) that was swept with a programmed fast electro-optic deflector. Laser-triggered switches were used on the ethylene glycol insulated blumlein to provide 1 ns jitter. Different sweep rates controlled the beam front velocity and test ion results showed that the ions were moving at the controlled beam front velocity [C.L. Olson, C.A. Frost. E.L. Patterson, J.P. Anthes, and J.W. Poukey, Phys. Rev. Lett. **56**, 2260 (1986)].

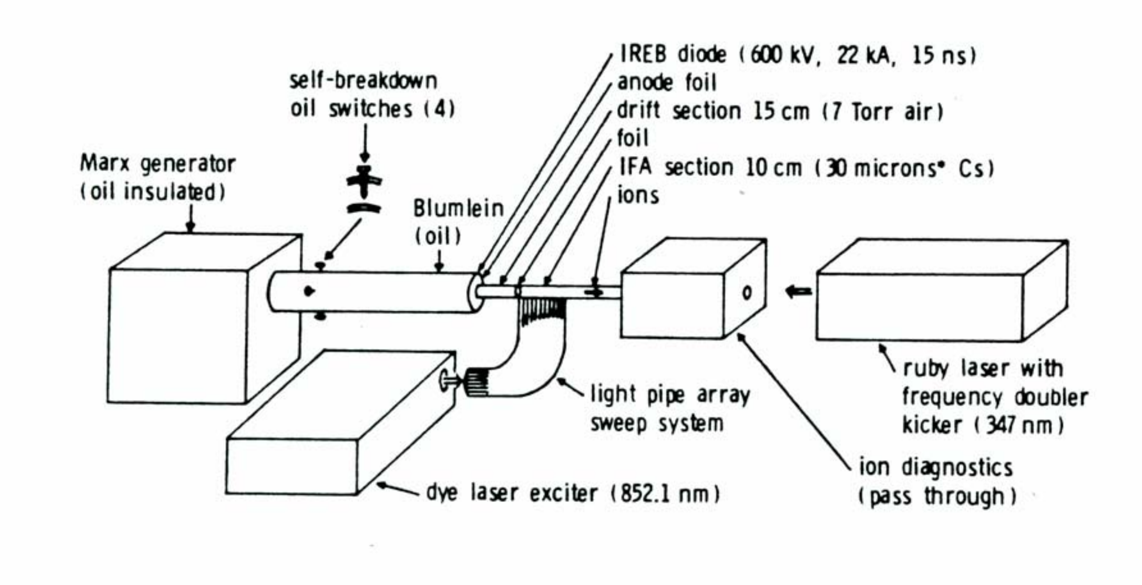

Figure 3. IFA-1.

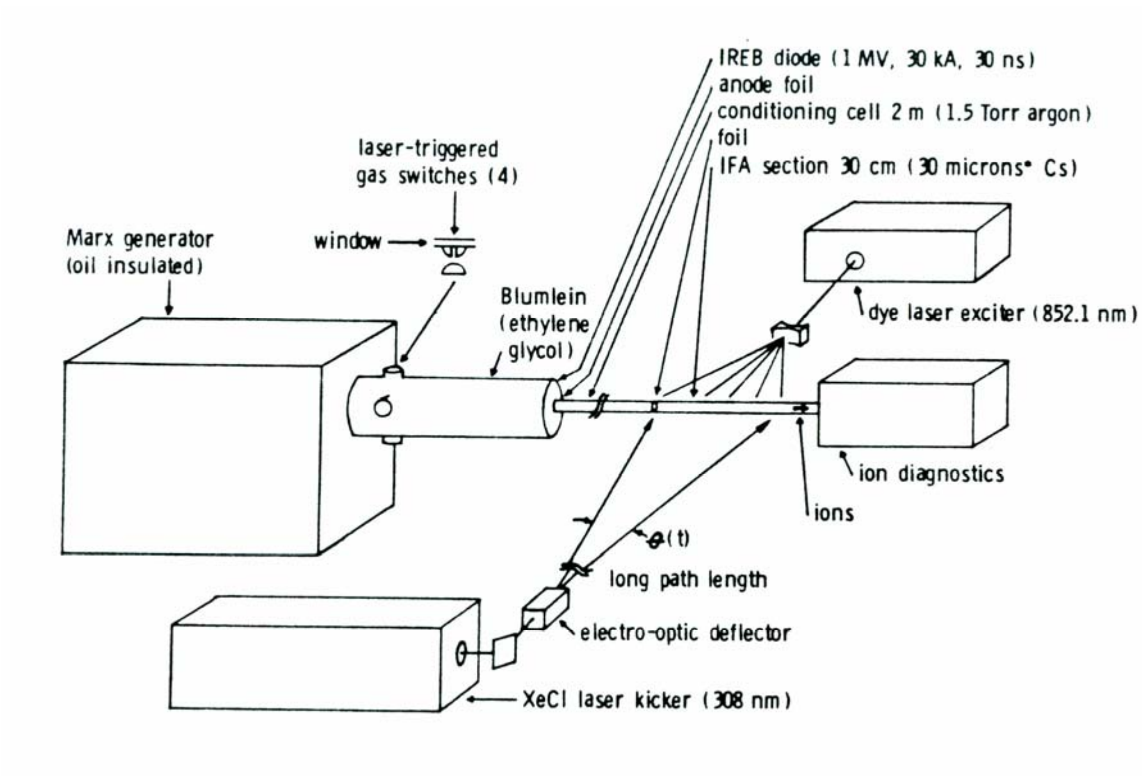

Figure 4. IFA-2.

The IFA intrinsically generates a sub-nanosecond ion pulse. Three examples of IFA parameters for 20 MeV p, 1 GeV p, and a 12 GeV U accelerators are given in Table 4. Note that the ion pulse lengths for the three cases are 100 ps, 30 ps, and 100 ps. All three cases also show the basic IFA scaling of (laser energy) < (ion energy) < (IREB energy). For HEDP, the ion energy for the third case would be reduced from 12 GeV to about 1.2 GeV, and the IFA accelerator length would be only 20 cm. The U ion source would be a laser-target ion source for this case.

Table 4. IFA examples for 20 MeV H, 1 GeV p, 12 GeV U

IFA Example: Feasibility (20 MeV Protons)

IREB	$\mathcal{E}_e$	600 keV
	I_o	20 kA
	τ	> 10 nsec
	r_b	0.5 cm
	$\mathcal{P}$	1.3×10^{10} W
	$\mathcal{E}_b$	>130 J
DRIFT	ℓ	20 cm
	E_o	10^6 V/cm
	p	0.003 Torr
	$\mathcal{E}_{IONIZE}$	6×10^{-5} J
LIGHT	$\mathcal{J}_1$	10^7 W
	τ_1	1 nsec
	$\mathcal{E}_1$	0.01 J
	$\mathcal{J}_2$	1.5×10^8 W
	τ_2	10 nsec
	$\mathcal{E}_2$	1.5 J
PROTONS	$\mathcal{E}_i$	20 MeV
	N	10^{12}
	$\mathcal{P}$	3×10^{10} W
	T	0.1 nsec
	$\mathcal{E}$	3 J

IFA Example: 1 GeV PROTON

IREB	$\mathcal{E}_e$	2 MeV
	I_o	30 kA
	τ	75 nsec
	r_b	1 cm
	$\mathcal{P}$	6×10^{10} W
	$\mathcal{E}_b$	4.5 kJ
DRIFT	ℓ	10 meters
	E_o	10^6 V/cm
	p	0.003 Torr
	$\mathcal{E}_{IONIZE}$	0.006 J
LIGHT	$\mathcal{J}_1$	10^9 W
	τ_1	1 nsec
	$\mathcal{E}_1$	1 J
	$\mathcal{J}_2$	1.5×10^8 W
	τ_2	75 nsec
	$\mathcal{E}_2$	11 J
PROTONS	$\mathcal{E}_i$	1 GeV
	N	3×10^{12}
	$\mathcal{P}$	10^{13} W
	T	0.03 nsec
	$\mathcal{E}$	500 J

IFA Example: 50 A MeV $^{238}_{92}U^{60+}$

IREB	$\mathcal{E}_e$	1 MeV
	I_o	30 kA
	τ	50 nsec
	r_b	1 cm
	$\mathcal{P}$	3×10^{10} W
	$\mathcal{E}_b$	1.5 kJ
DRIFT	ℓ	200 cm
	E_o	10^6 V/cm
	p	0.003 Torr
	$\mathcal{E}_{IONIZE}$	0.0012 J
LIGHT	$\mathcal{J}_1$	1.5×10^8 W
	τ_1	1 nsec
	$\mathcal{E}_1$	0.15 J
	$\mathcal{J}_2$	1.5×10^8 W
	τ_2	50 nsec
	$\mathcal{E}_2$	7.5 J
$^{238}_{92}U^{60+}$ IONS	$\mathcal{E}_i/A$	50 MeV
	$N\zeta$	3×10^{12}
	$\mathcal{P}$	10^{12} W
	T	0.1 nsec
	$\mathcal{E}$	100 J

The parameters for a first example of an IFA for accelerator driven HEDP are summarized in Table 5. A 300 ps pulse of 10 J of 1.2 GeV U ions would be in a spherical bunch of radius 5 mm. About 4 J of U ions would be contained within a 2.5 mm radius, and this radius could be reduced to 1 mm radius with a z-discharge focusing cell. These parameters are close enough to those desired for HEDP that the IFA should be considered as a possibility for HIF-HEDP.

Table 5. Possible parameters for an IFA for HIF HEDP

IREB: 1 MeV, 30 kA, 20 ns, radius 1 cm, $3\text{x}10^{10}$ W/cm^2, 600 J

Acceleration section: length 20 cm, acceleration gradient 10^6 V/cm,
sweep velocity $0 \rightarrow 0.1c$ in $\sim$ 16 ns

Ions: 1.2 GeV U^{60+}, 5 MeV/nucleon, $N\zeta = 3\text{x}10^{12}$, $N = 5\text{x}10^{10}$, power 30 MW,
pulse length 300 ps, energy 10 J, spherical bunch radius 5 mm

An IFA accelerator consists of an IREB machine, lasers, a heated cell with the working gas (presumably Cs), an ion source (presumably a laser/target source), and diagnostics (for the ions, IREB, lasers, Cs, etc.). Command firing with low jitter (~ 1 ns) is required to ensure proper synchronization of the lasers with the IREB.

The IREB parameters listed in Table 5 are very similar to those used for IFA-2. The IFA-2 experiments were funded at about $600k/year for several years in the late 1970s and early 1980s, and that did not include the costs of the major equipment (IREB machine, dye laser, XeCl laser, streak camera, etc.). A definitive IFA experiment today would require state-of-the-art equipment, dedicated laboratory space, and adequate funding. A very rough estimate for funding is $1M - $2M for equipment, and ~ $1M/year or more for 1-2 years for building, operating, and optimizing the IFA accelerator.