Recap: HIFS-VNL driver options for near term warm dense matter (from last PAC 8-9-06) *

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Context for the charge

Charge (1): Taking into account recent progress in experiments and modeling, please review the several alternative strategies to be presented to carry-out first VNL heavy-ion beam-driven warm dense matter (WDM) experiments before the end of FY08, and recommend priorities in the pursuit of the various options prior to a decision point mid 2007: what are the technical risks, cost-benefits and programmatic trade-offs to resolve?

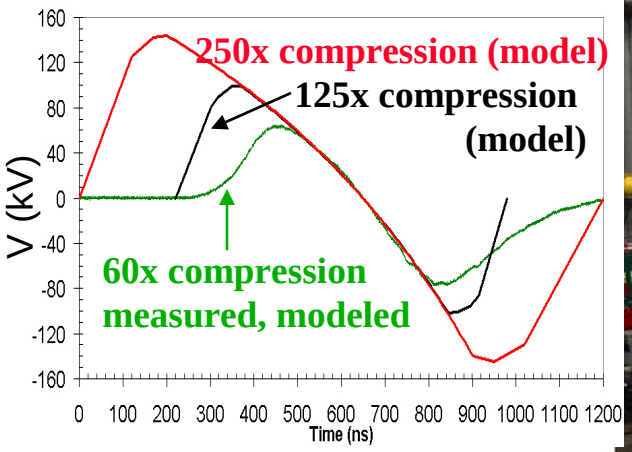
Background to Charge (1):

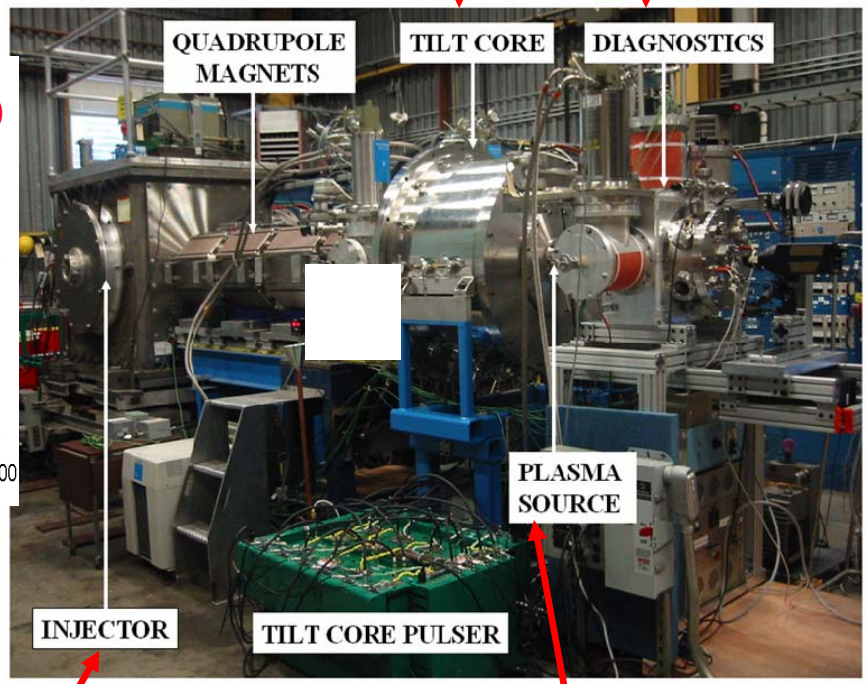
The HIFS-VNL plan to achieve 1 eV in heavy-ion-beam-driven targets has not changed for the last three years: NDCX-I is to be upgraded to NDCX-II assuming $5 M hardware in incremental funding. OFES granted Mission Need (CD-0) on 12-1-05 for the Integrated Beam-High Energy Density Physics Experiment, a future $50M-class heavy-ion beam HEDP user facility, in which NDCX-II is a stated prerequisite. However, as NDCX-II funding may continue to be delayed, we are evaluating alternative options to begin initial target experiments below 1 eV.

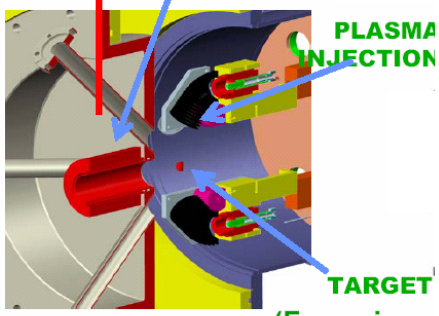
We have to decide our path forward before next month's OFES budget meeting →based on present information

Approach # 1: Enhance present 400 keV NDCX-1 to increase target intensity

Induction core impresses head-to-tail velocity ramp ("tilt") on few 100-ns slices of injected 400 keV K^+ ion beam, compressing the slices to few ns at a target







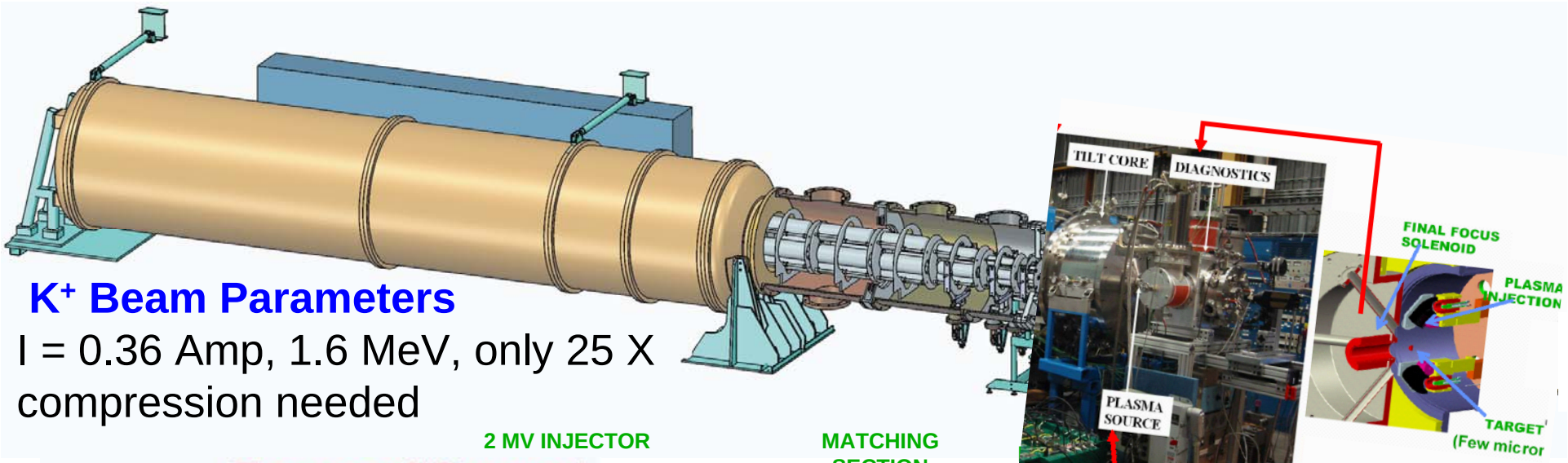
Improve/add volt-sec to induction waveform

Add high field focusing solenoid (first 5 then 15 T)

Same injector as the current NDCX experiment except 80 mA @ 400 keV

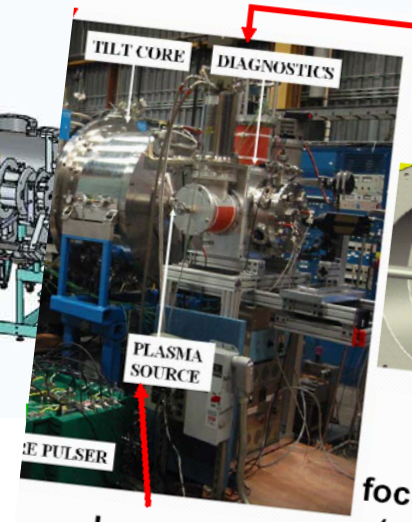
Longer 2.9 m NDC compression, higher plasma density

Approach # 2 Convert HCX into a 1.6 MeV WDM target shooter with NDC



K^+ Beam Parameters

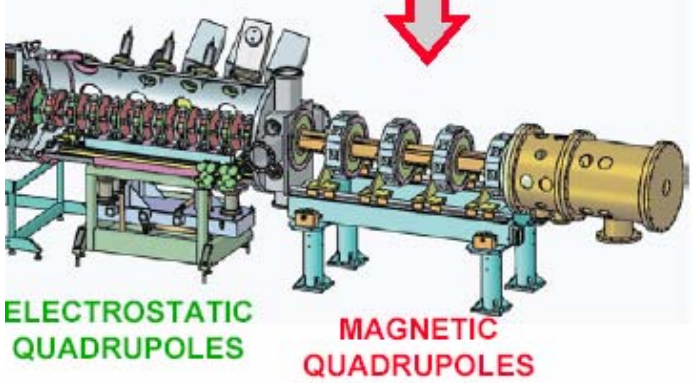
I = 0.36 Amp, 1.6 MeV, only 25 X compression needed



Longer 2.9 m NDC compression, higher plasma density

Add high field focusing solenoid (up to 10 to 15 T)

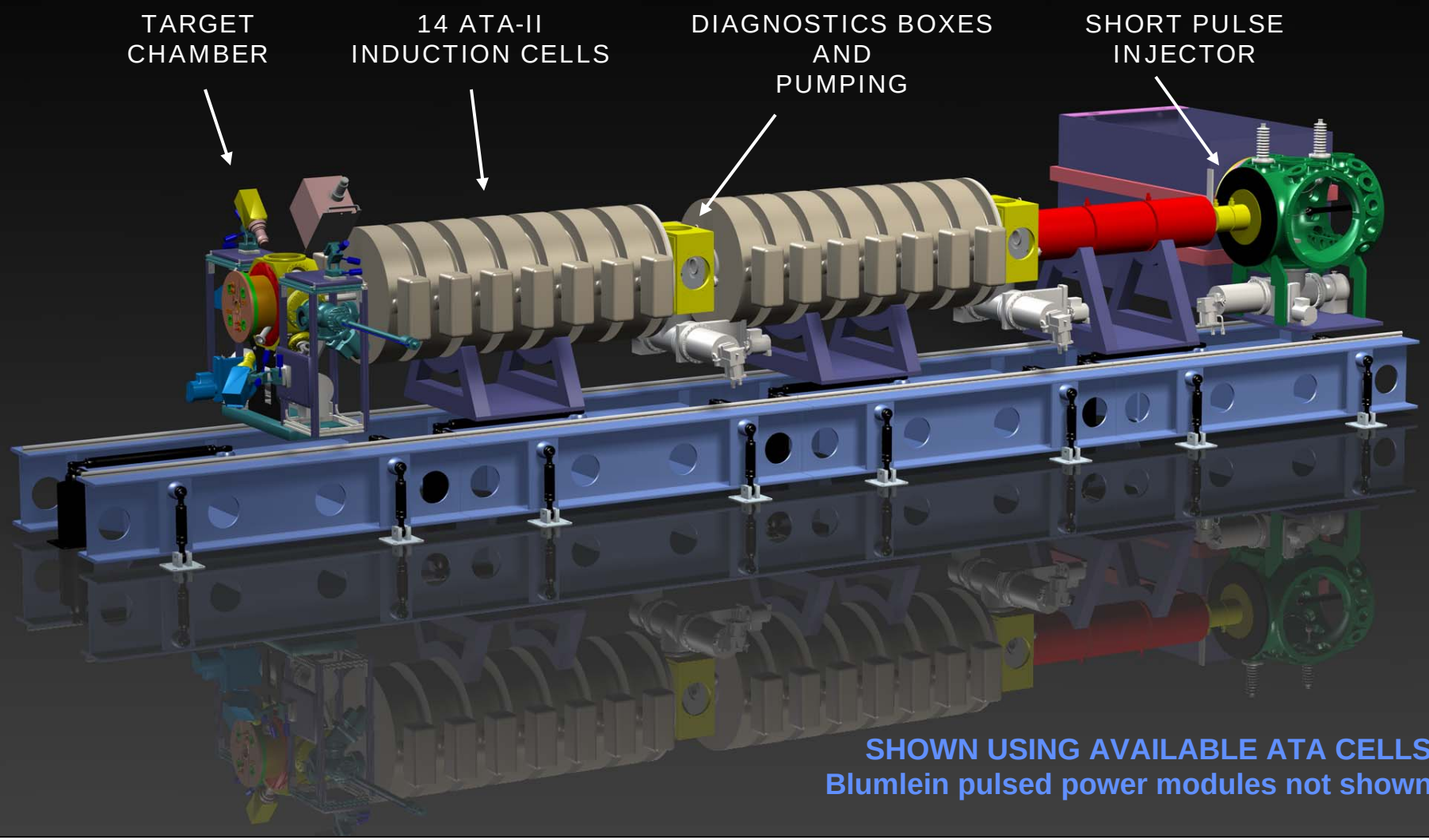
Focus of Current Gas/Electron Experiments



Swap-out current HCX quadrupole transport sections, replace with NDCX tilt core, NDC plasma source, final focus solenoid & target chamber

Approach #3: 2.8 MeV Lithium WDM driver (LLF)

Thanks to LLNL Beam Research Program, we have enough parts for 6 MeV of acceleration.
Our main cost item would be to replace solenoids to 1.5 to 2 T (6 m x 100K/m ~ $600K)



SHOWN USING AVAILABLE ATA CELLS.
Blumlein pulsed power modules not shown.

Backup slides

Comparing three "near-term" WDM driver options vs NDCX-II

Case	I_b (A) source	E_b MeV	Init. Pulse (ns)	Comp-ression ratio	Final Pulse (hydro) (ns)	dE/dx In Al (MeV/ mg/ cm^2)	ε_{nx} mm-mrad	T_b (eV) Long. beam temp	NDC Length (m)	T_{target} (eV)*** (Barnard model) *no hydro*
(1) NDCX-1	0.08	0.4	100	50	2.0 (τ_{hyd}~ 0.4)**	4.1 (K)	0.17	1.1	0.69	0.48
(2) HCX-NDC	0.36	1.6	50	25	2.0 (τ_{hyd}~ 1.1)**	6.4 (K)	0.53	1.7	2.16	1.7
(3) LLF	0.10	2.8*	300	60 (33) eff	1.0 (τ_{hyd}~ 6.1)**	2.05 (Li)	0.68	3.1	2.60	2.5
NDCX-II	0.56 @ 1 MeV	24*	177	20	1.0 (τ_{hyd}~ 10.8)**	10 (Na)	2.3	25	5.3	3.6

*ion K.E. > Bragg peak for uniform heating ** hydro time in 10% aluminum ***hydro lowers T_e some

PROS and CONS of the three approaches

	PROS	CONS
(1) NDCX-1	Fastest to implement for WDM diagnostic development and testing	▪Low Te < 0.5 eV likely ▪ $T_{ion} << T_{Bragg\ Peak}$ (uniformity) ▪ $\tau_{pulse} > \tau_{hydro}$ (uniformity) ▪ probable preheat effects*
(2) HCX-NDC	~10 X more peak beam power than NDCX-1, →Te ~ 1 eV possible	▪ several months down time ▪ $T_{ion} << T_{Bragg\ Peak}$ (uniformity) ▪ $\tau_{pulse} > \tau_{hydro}$ (uniformity) ▪ probable preheat effects* ▪ interrupts quadrupole transport experiments on HCX
(3) Lithium Linac and Focus (LLF)	~10 X more peak beam power than NDCX-1, →Te > 1 eV, $\tau_{pulse} < \tau_{hydro}$ @Bragg Peak (uniform) → prototype of NDCX-II	Most hardware cost and assembly time (my guess is 500K/yr x two years-not yet vetted) . Likely earliest target shots in FY09

*Possible to mitigate with time-dependent focusing

Remaining issues to assess for the three options

- **More detailed cost and schedule estimates**
- **Evaluate an ATA cell for 1.5 to 3 T solenoid upgrade**
- **More common-basis target-hydro simulations of actual target designs, including preheat, and assessment of EOS measurement accuracy with calculated non-uniformities and diagnostic resolutions.**
- **Assessment and plan for time-dependent focusing**
- **Development of 1.5 inch diameter, 10 mA/cm^2 Lithium source, and self-consistent injector modeling.**
- **Simulations of longitudinal heating by discrete gap acceleration**