Overview of NDCX-II capabilities: the target station

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Two stages of NDCX-II seen from HEDLP perspective

	STAGE-I 27 period/12 active-cell	**STAGE-II** 37period/21 active-cell
Focal spot diameter	~1 mm	~1mm (0.2 mm)
Target thickness, *d* (5% uniformity)	2 μm	**4.5 μm**
Pulse duration (FWHM), τ	0.9 ns	**0.25 ns**
Hydro time, d/v_c	0.3 ns	0.7 ns
Pulse energy	60 mJ (13 J/cm^2)	150 mJ (20 J/cm^2)
Peak temperature estim.	1eV	**3eV** (10 eV)
Peak pressure	0.05 -0.2 Mbar	**0.2-0.8 Mbar** (1-2 Gbar)

STAGE-I: Isochoric heating of matter at under-solid density (foam targets, cryo target)
STAGE-II Isochoric heating of solid density matter (macroscopic volumes, $T_e=T_{ion}$)

Machine specs determine physics parameters (i.e. P, T, ρ, Δt), hence diagnostics

Hardware we have now and can field for near term experiments

- ✓ Multi-channel pyrometer; polarization pyrometer (T~0.1 eV-1 eV, 0.2 ns)
- ✓ 1 optical streak camera: can be transformed into streak optical pyrometer or FDI
- ✓ VISAR
- ✓ Basic interferometers
- ✓ 2 fast gated cameras
- ✓ 2 excimer lasers (300 mJ@ 266 nm, 10 ns)
- ✓ 2 NdYag (~100 mJ@ 1000nm, 1 ns)
- ✓ Dye laser (~10 mJ, 1 ns)
- ✓ Existing NDCX-I target chamber

- This equipment is sufficient for most stage-I experiments
- The NDCX-I chamber is small and will allow fielding of **ONE** diagnostic at a time

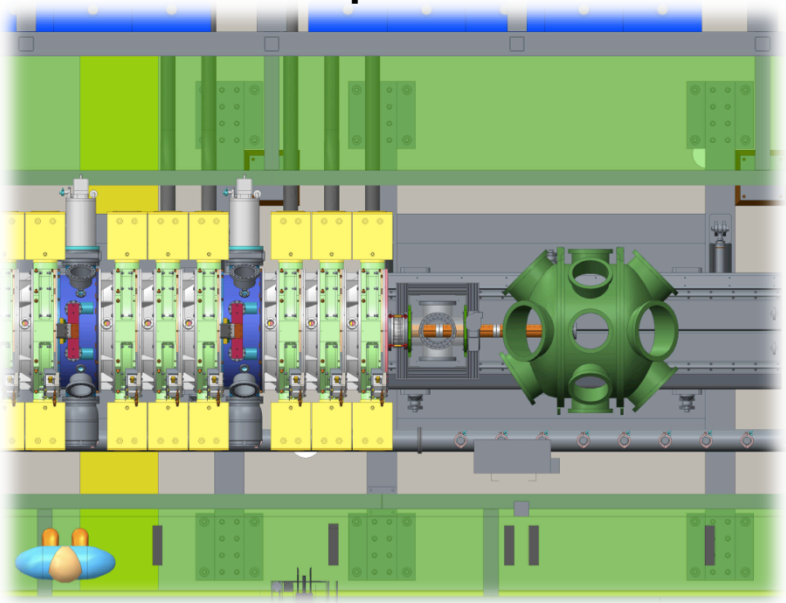
Additional diagnostics in the near term with moderate R&D funds

- **White light polarimetry**
  → broad band AC conductivity measurements
- **X-pinch as in x-ray source**
  → Density radiography
  →Thomson scattering
  →Crystallography
- **Cryogenics**
- →Can make isochoric heating of pure noble gas crystals
- **Frequency domain interferometer** (FDI)
  →Spatially/time resolved sample expansion
- **Energy analyzer/Thomson parabola**
  →dE/dx,
  → defect dynamics
- **High speed framing camera**
  →Droplet formations
  →Shock formation, instabilities, etc.
- **JLF "Calisto" chamber**

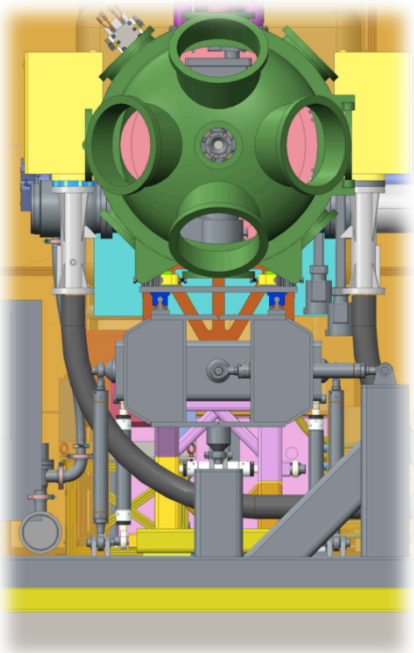
- This equipment will enable a greater variety of Stage-I experiments
- Can be done with lower costs through established relations/collaboration: e.g. students from D.Hoffmann, H. Yoneda, F.Beg, M. Roth, etc.

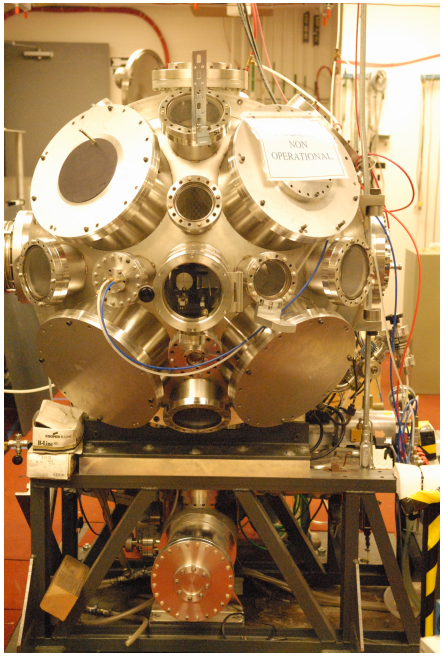
JLF Callisto chamber: a primary near-term candidate for NDCX-II, STAGE-I

Top view:



Frontal view:

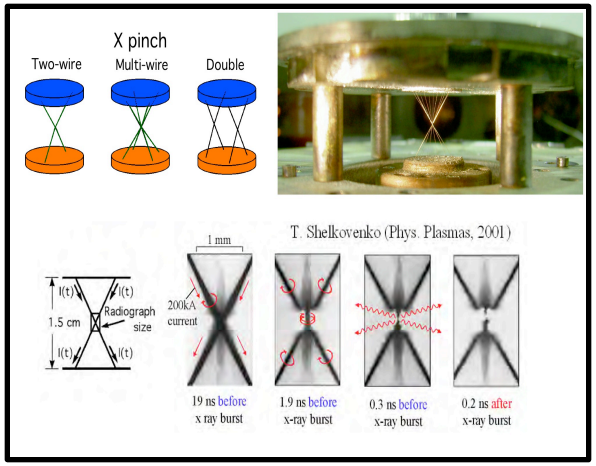




- Approx. 2x larger than NDCX-I chamber
- Initial engineering analysis showed no major mounting conflicts
- Major engineering costs: integration of plasma neutralization and solenoid components

An X-pinch – a "poor man's" x-ray source for radiography and Thomson scattering

- X-ray source is critical diagnostic for HEDLP
- Need high power laser ($2M)← prohibitive!
- X-pinches are well studied and cheap
- When optimized x-pinches, e.g can provide up to 10^8-10^{10} photons at at Ti He-α(4.75 keV) ← this line is sometimes used for Thomson scattering in laser experiments.



Major problem: large~10 ns ignition jitter.

- Initial studies (by W. Waldron) show the jitter can be reduced to 0.5 ns by using laser-triggered spark gap.
- 0.5 ns jitter is still bad for Stage-II but is tolerable for Stage-I.
- Requires R&D to develop such a pulser; the rest is straightforward

Benefits of adding an x-pinch:

- Density measurements
- X-ray refraction for crystallographic studies
- Thomson scattering? The number of photons is not high (10^{12} is needed for laser driven) but NDCX-II environment is also not as noisy as that in a laser experiment, so this might be OK.

Thinking big: Stage-II + Titan chamber+ high power laser system

Stage-II Fundamental difference: true isochoric heating of solid-state macroscopic samples →new class ("premier league") of experiments!

Following hardware is needed:

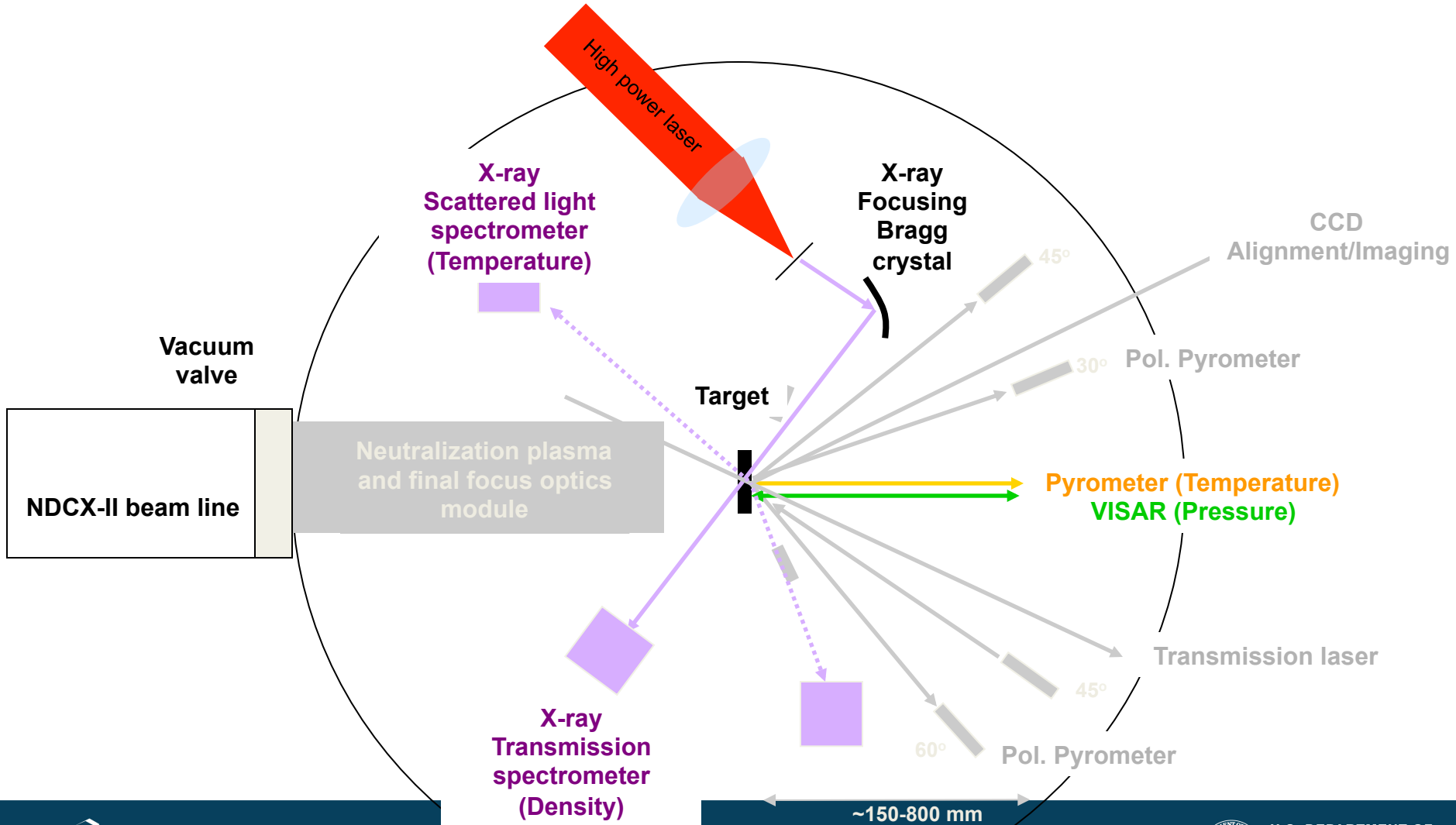
1. Larger ("Titan"-like) target chamber
2. High power laser system (at least 5 J-10 J, 500 fs-2 ns)
3. Improved final focusing system (2-3 times spot reduction)

These capabilities will certainly attract a larger range of users!

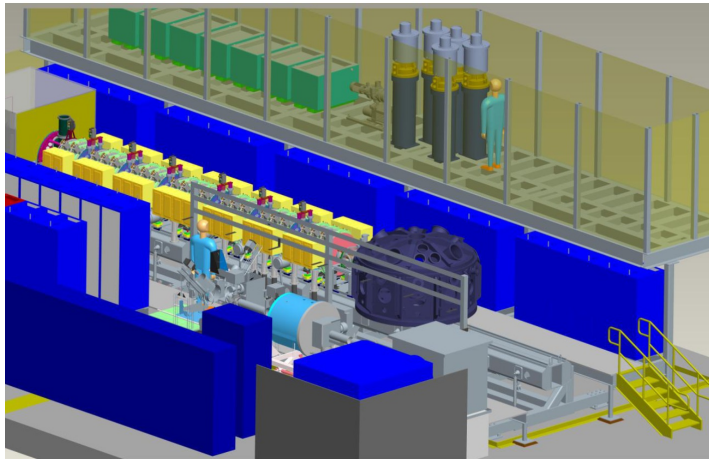
Possible experiments include:

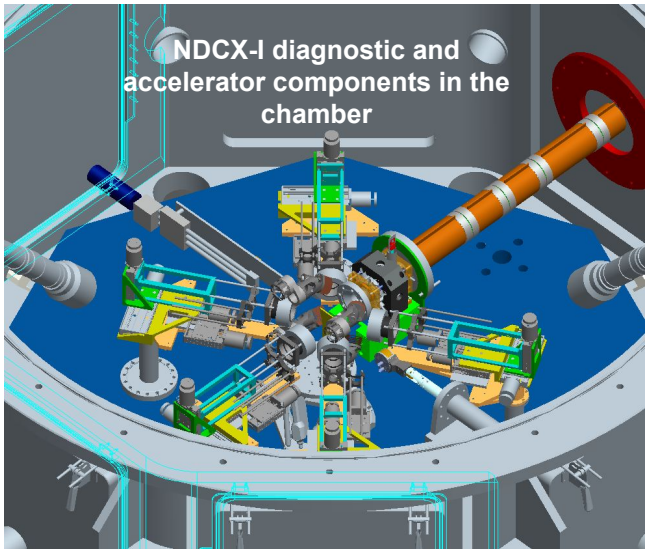
- Complete EOS measurements (T, P, rho)
- Thomson scattering of isochorically heated matter at 3 eV-10 eV
- Heavy ion driven shocks
- Hydro Instabilities relevant to ICF
- Proton/neutron radiography using TNSA protons
- dE/dx stopping in high density plasma
- …and of course unique ideas from users!

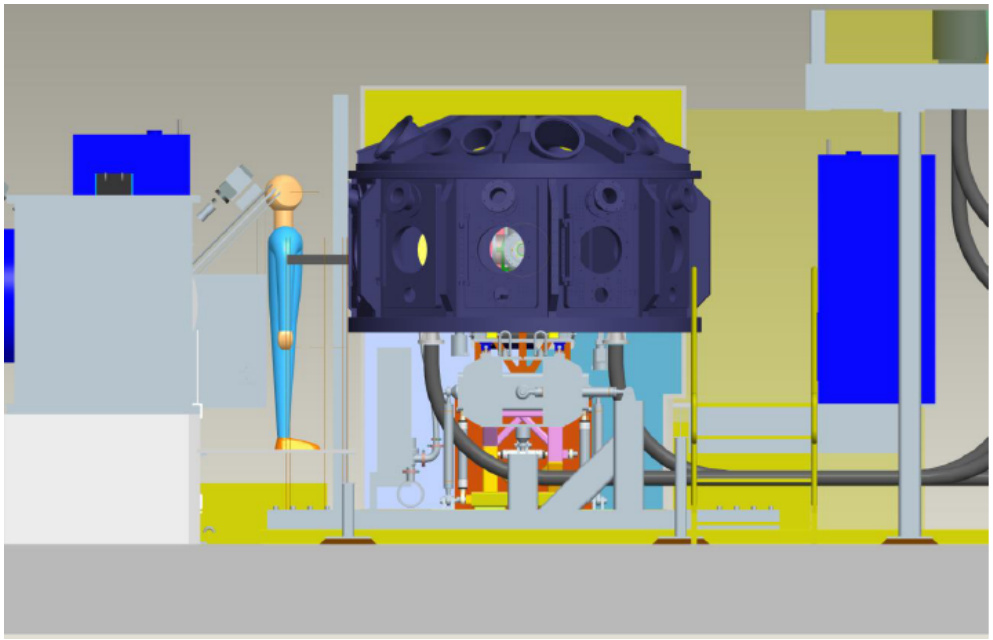
Example: experimental layout for EOS studies (i.e. simultaneous measurements of T, P, rho)



Titan chamber: the best chamber option for the NDCX-II user facility







- Gathered operation experience from LCSL and LLNL
- Performed an extensive engineering study
- Prepared procurement docs and finalized vendors
- Cost of chamber as of end of 2011 is ~ $500K

Possible diagnostic and technology sharing between Bay area HEDLP facilities

Theme suggested earlier by Andrew Ng: ..it is important to cross-check AC conductivity of WDM generated with all possible drivers, i.e. with x-rays, ions and laser…there can be important surprises!

JLF can provide expertise in

- High power lasers
- Thomson scattering
- Shock experiments

LBNL/ALS can provide expertise in

- low temperature WDM,
- x-ray absorption spectroscopy diagnostics,
- x-ray streak camera
- fs-laser

LCLS can provide expertise in

- FDI
- Titan chamber user experience
- X-ray streak cameras

Initially, LBNL can contribute with:

- Charged particles diagnostics
- Test bed for diagnostics to be used at partner facilites
- Pyrometry

Summary

- We have a range of exciting experiments to do with Stage-I and available diagnostics.
- NDCX-II is a unique ion-driven HEDLP facility and can make a major impact in HEDLP science.
- Pushing limits of STAGE-II will promote development of unique target diagnostic and accelerator technology.
- There are opportunities to share existing diagnostics and to carry out coordinated experimental campaigns.