A New Target Area for Relativistic Laser–Plasma Experiments Using The Multi-Terawatt Optical Parametric Amplifier Line (MTW-OPAL) Laser System at the Laboratory for Laser Energetics

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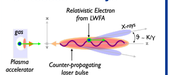
The goal is to perform experiments in the ultra-relativistic regime and to motivate development of EP-OPAL: a planned kJ/fs laser at LLE

Dephasingless Wakefield Acceleration

An ultrashort, high-intensity laser pulse is spatio-temporally structured to overcome dephasing by propagating at any velocity over any distance.

https://doi.org/10.1103/PhysRevLett.124.134802

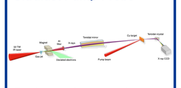
Counter-Propagation for Femtosecond Xrays



A laser-plasma accelerated electron beam is injected in a counterpropagating laser pulse. Electrons emit x rays or γ rays due to this motion.

https://doi.org/10.1103/RevModPhys.85.1

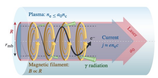
Ultrafast Pump-Probe



Femtosecond x-ray spectroscopy and radiography will aid understanding of warm dense matter and fast shock dynamics.

https://doi.org/10.1038/s41467-018-05791-4

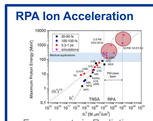
Microchannel Target Radiation Sources



Development of ultra-high flux gamma-ray sources for for use in a wide range of laser-driven strong-field QED studies.

https://doi.org/10.1088/1367-2630/ac22e7

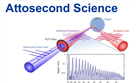
RPA Ion Acceleration



Experiments in Radiation Pressure Acceleration will pave the way for GeV ions using EP-OPAL.

https://doi.org/10.1063/1.4946025

Attosecond Science



Harmonic generation enables short-wavelength coherent light with attosecond duration.

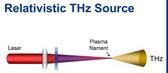
https://doi.org/10.1038%2Fs41598-020-61255-0

Neutron Beam Production

Short pulse duration neutron sources will offer a unique methodology to measure ion behavior in dense plasmas.

https://doi.org/10.3390/instruments5040038

Relativistic THz Source

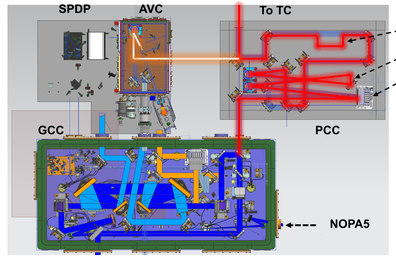


Femtosecond laser filamentation will enable THz imaging and novel relativistic science.

https://doi.org/10.1038/srep03880

A Pulse Conditioning Chamber (PCC) will prepare the beam for experiments

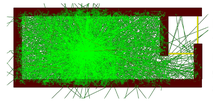
- **The PCC connects the existing GCC with**
  - The new anticipated Target Chamber (**TC**)
  - The Under Dense Plasma (**UDP**) chamber
- **The PCC provides a platform for innovation**
  - Wavefront control with a deformable mirror (**DM**)
  - Improved contrast with Double Plasma Mirror (**DPM**)
  - Circularly polarized beam using Reflective Phase Retarder (**RPR**)
  - Focus and pulse characterization with a diagnostic path to **AVC** and **SPDP** table



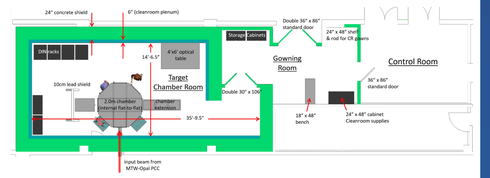
Radiation safety scheme is being validated for highest-dose experiments

Shielded Annual Dose Kept < ¼ MPAD (25 mrem/year)

- **Will allow thousands of shots/yr for highest ionizing dose producing interactions:**
  - High-Z, mm-scale targets
  - $\mathcal{O}(10^{-3}$ mrem/shot)
- **In practice, none of the campaigns under consideration are expected to produce doses this high**
- **With this design and for campaigns under consideration, shielding strategy will not limit shot rate**

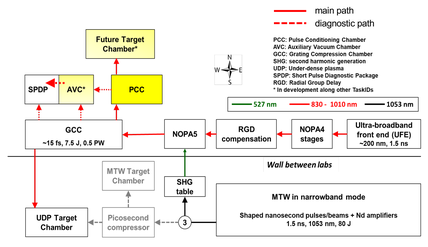


Monte Carlo particle tracking simulations performed with g4Beamline are aiding the shielding assessment



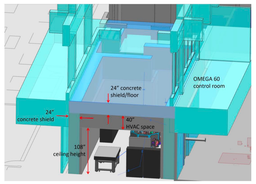
MTW-OPAL is an all-OPCPA system for ultra-intense laser development

- **MTW-OPAL has the following performance goals:**
  - 15 fs, 7.5 J on target (0.5 PW, 10^{21} W/cm^2)
  - High contrast (>10^{-10} w/ plasma mirrors)
  - High focusability (Strehl > 0.8 w/ deformable mirror)
  - High pointing stability (< 15 μrad rms)
- **The system is fundamentally sound and undergoing optimization/tuning**
  - 7.3 J after compression
  - Compression to 20 fs (plans to reduce to 15 fs)

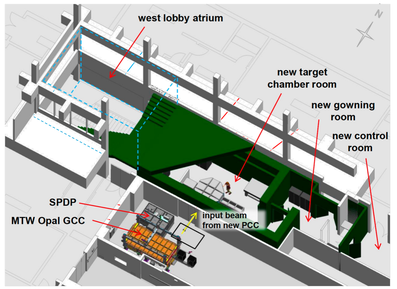


The notional target area will fit into the West Lobby

- **Lab to occupy part of existing west lobby**
  – Approx. 20' x 40' footprint
- **24" thick concrete envelope designed for all campaigns**
  – Shielded dose/year < ¼ MPAD for public directly outside walls
- **Cleanroom plenum compatible with LTD Annex**

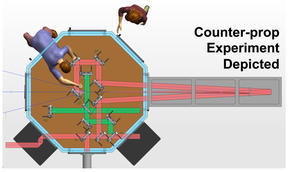


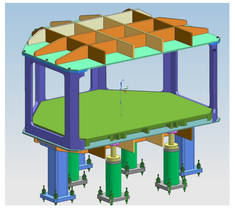
Working Concept (Starting Point for Architects)

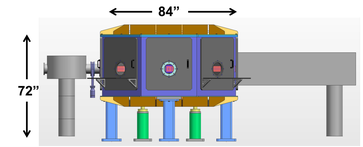


A new target chamber will be designed to accommodate a wide range of experimental campaigns

- **A new target chamber will enable a high degree of experimental flexibility, via:**
  – Swappable panels for unique port geometries
  – A vacuum extension for long f/# optics (max f/40)
  – Large internal diameter (2-2.5 m)







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