

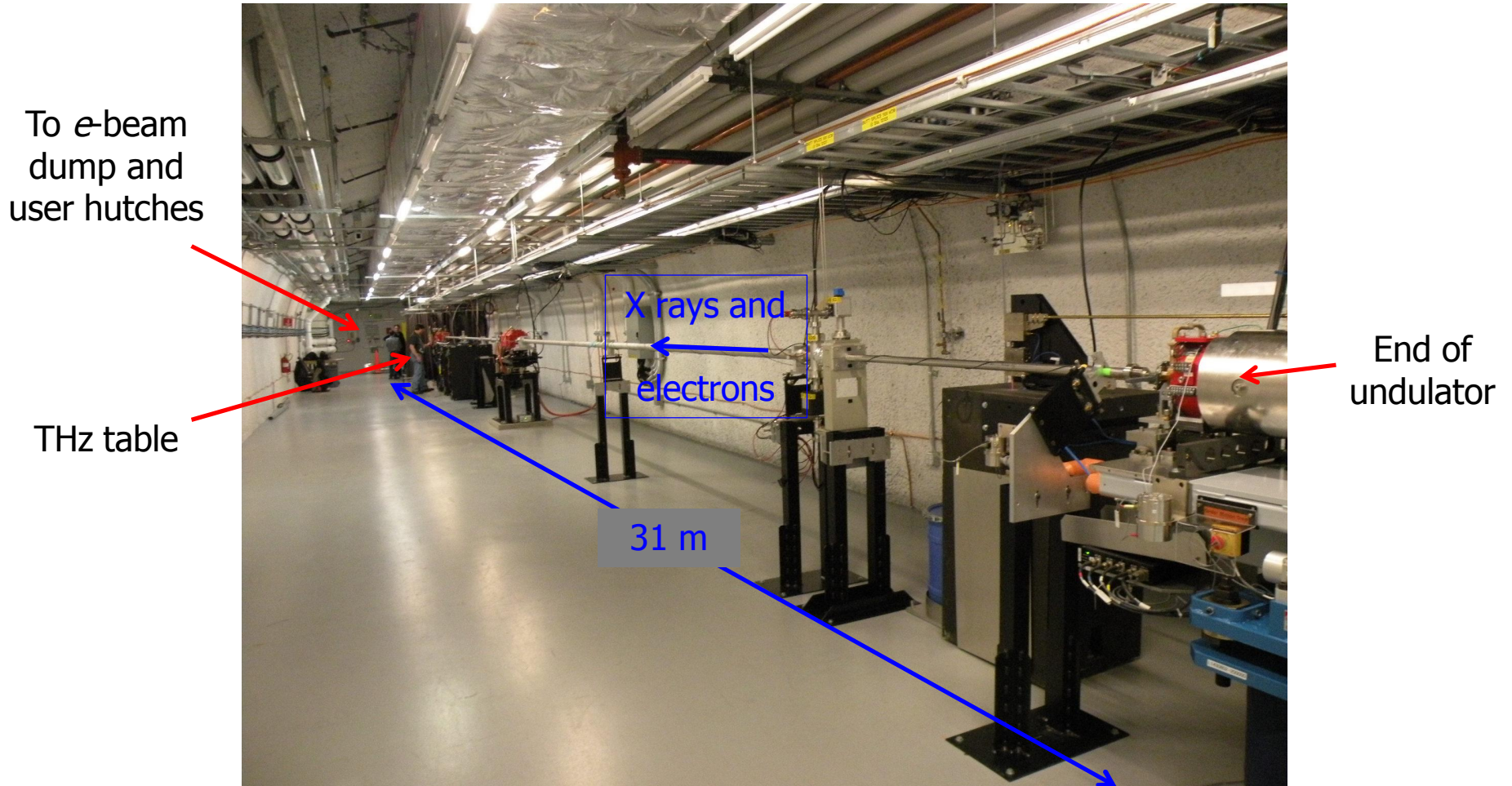
Planning Terahertz Pump and X-Ray Probe at LCLS

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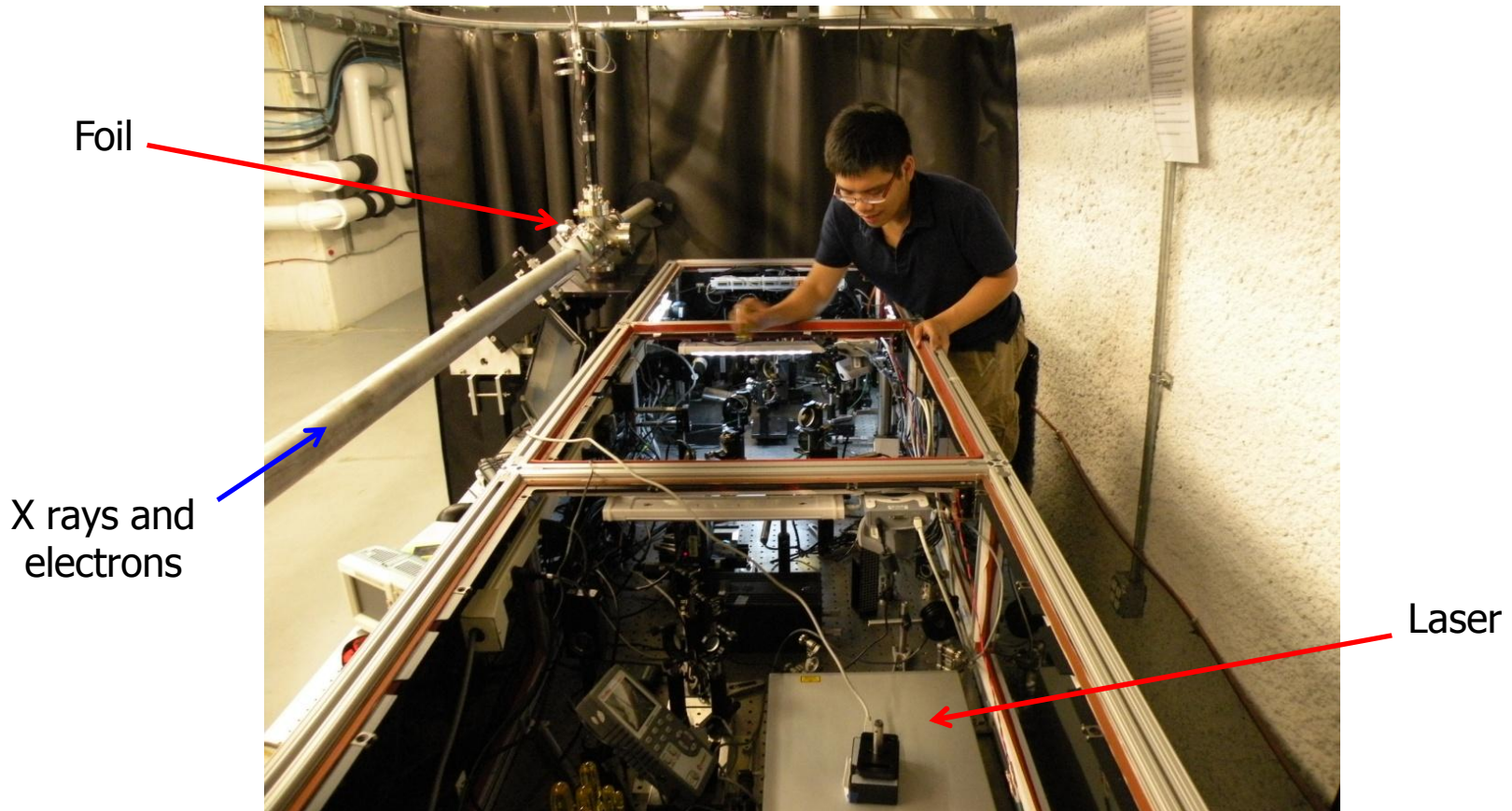


- THz generated by coherent transition radiation in a 10- μm Be foil
- Between undulator and beam dump: Electrons and x-rays pass through foil

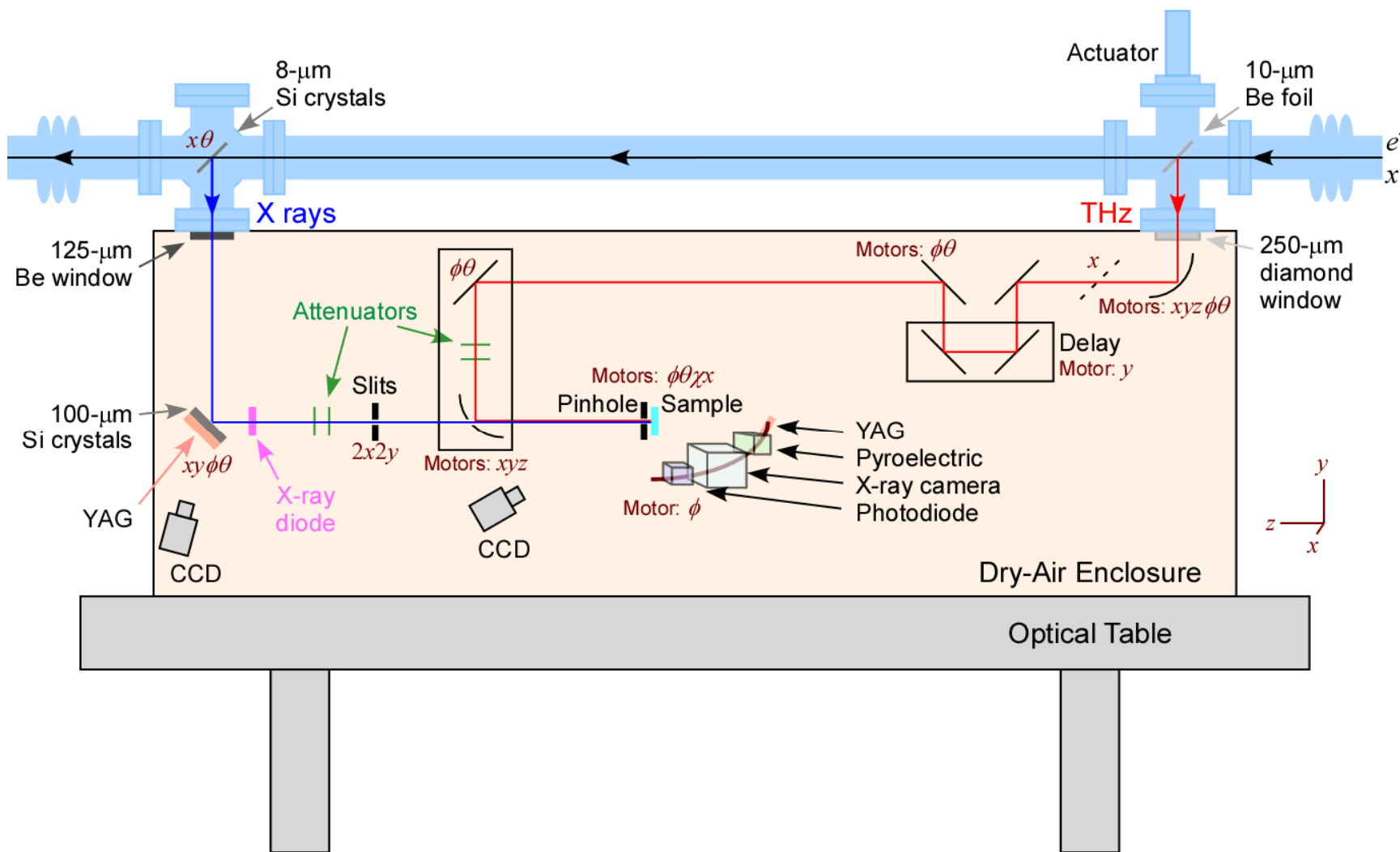


- To reach users in the Near Experimental Hall (NEH):
 - THz needs a ~ 100 -m transport line, with reimaging mirrors
 - Diffraction: Large (~ 200 mm) and frequent (every ~ 10 m) mirrors
 - Optical path for THz is longer: Arrives *after* x rays
 - Add a second electron bunch, ~ 100 ns later: THz, then x rays
 - With 2 bunches, both make x-rays, and one arrives *before* THz
 - Can we kill the FEL gain of first bunch?
- Consider these transport issues later
- First we'd like to demonstrate pump/probe with a simpler arrangement that uses only one bunch and fits on one table.

- Enclosure purged with dry air also provides a laser-safety housing
- Ti:sapphire laser for THz pump and optical probe
- Space below beampipe is available for THz pump and x-ray probe



Demonstrating THz Pump & X-Ray Probe



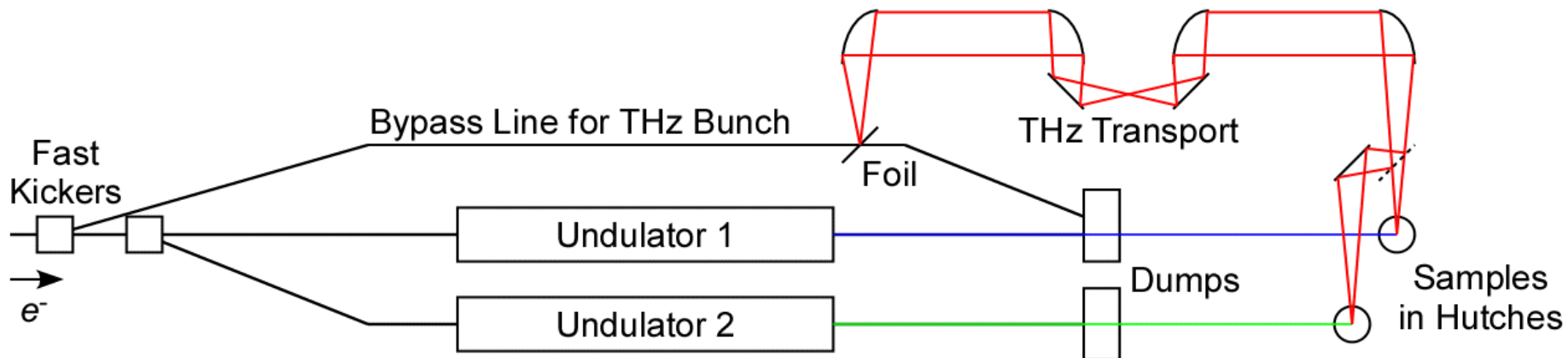
- Initial approval from management
- But first suitable thin Bragg crystals are needed
- Thin crystals are being developed to split an LCLS x-ray pulse
 - Large-Offset Monochromator will allow two hutches to share a pulse
 - Split and delay scheme will send two x-ray pulses to a user with fully adjustable delay
 - Both have trouble with acoustic vibrations in the crystal driven by heat deposited by the pulse
 - High Q makes vibration linger, disrupting diffraction of the next pulse
 - Operation at 1 Hz is workable
 - Testing various concepts to increase damping
 - Have been using silicon, and will soon test diamond

- Problem: Soft x rays are *absorbed* by the foil
- Remedy: **Separate electrons from x rays**
 - Move foil a bit to one side and bend the electron beam
 - X rays miss the foil

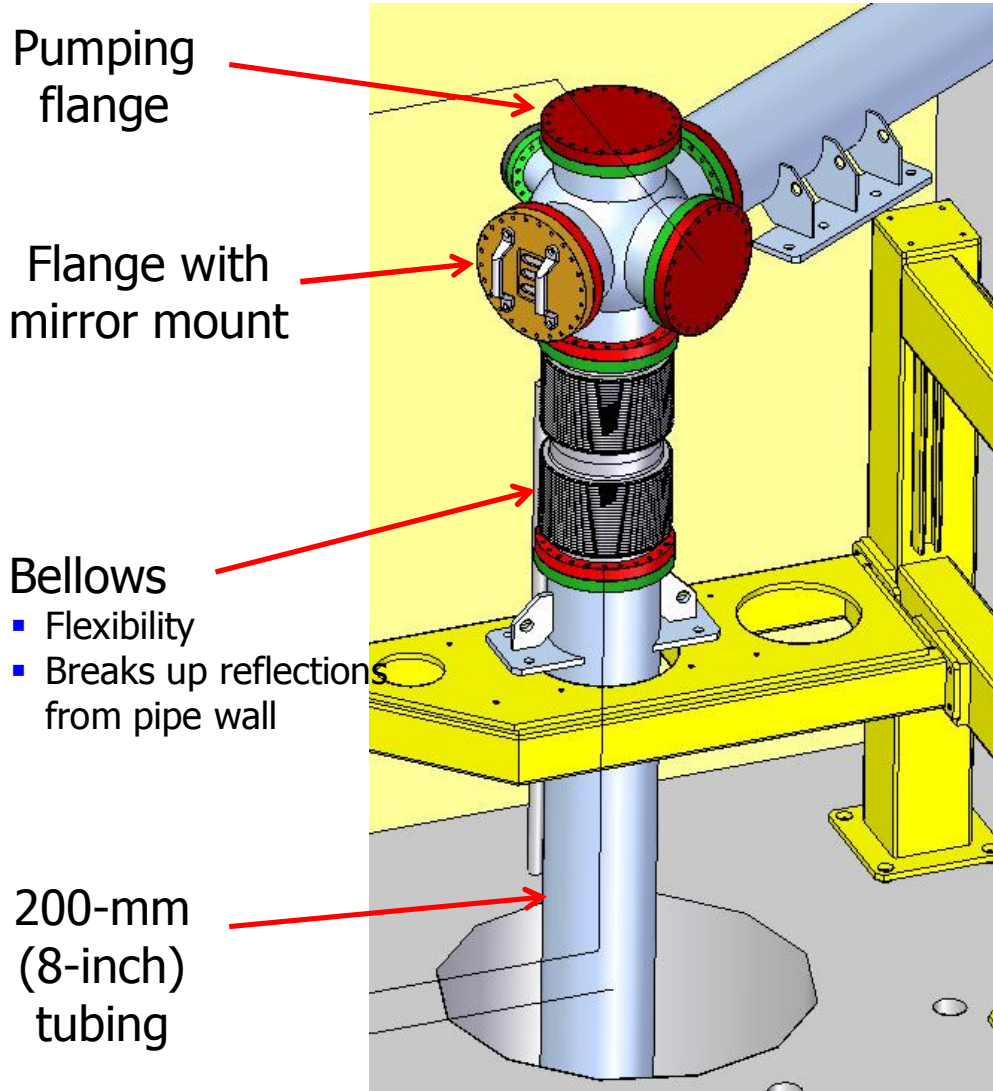
- Problem: Longer path: THz arrives ~ 100 ns *after* x rays
 - Probe/pump instead of pump/probe
- Remedy: **Two electron bunches**
 - First bunch is optimized for THz
 - High bunch charge and peak compression
 - Second bunch makes x rays in the FEL
 - Bunch charge and compression set to user's preference
 - Pump/probe spacing set by an integer number of RF buckets plus an “optical trombone” delay
- LCLS has briefly tested two-bunch operation
- Two bunches are planned for LCLS-II
 - Intended to drive two undulators, but adaptable to THz

- Each bunch emits both x rays and THz
 - Arrival order: *X ray 1*, *THz 1*, *X ray 2*, *THz 2*
 - Early x-ray pulse interferes with pump-probe measurements
 - Also, final THz pulse—after pump-probe—might be a problem
- Remedy: Suppress lasing by the first bunch
 - High charge and full compression spoil gain
 - Can also use high laser-heater energy for first bunch
 - Kicker to make beam oscillate in the undulator
- But the first bunch emits *spontaneous* in the undulator
 - Could interfere with *some* experiments

- Add a **fast kicker** before the undulator, sending electrons into a **bypass beamline**
 - 1st bunch goes through bypass, parallel to undulator
 - Put THz foil in the bypass
 - Bunch makes THz but no x rays
 - 2nd bunch goes through the FEL
 - Bunch makes x rays but no THz
 - No trailing THz pulse after pump/probe
 - Also, soft x rays are not absorbed by foil

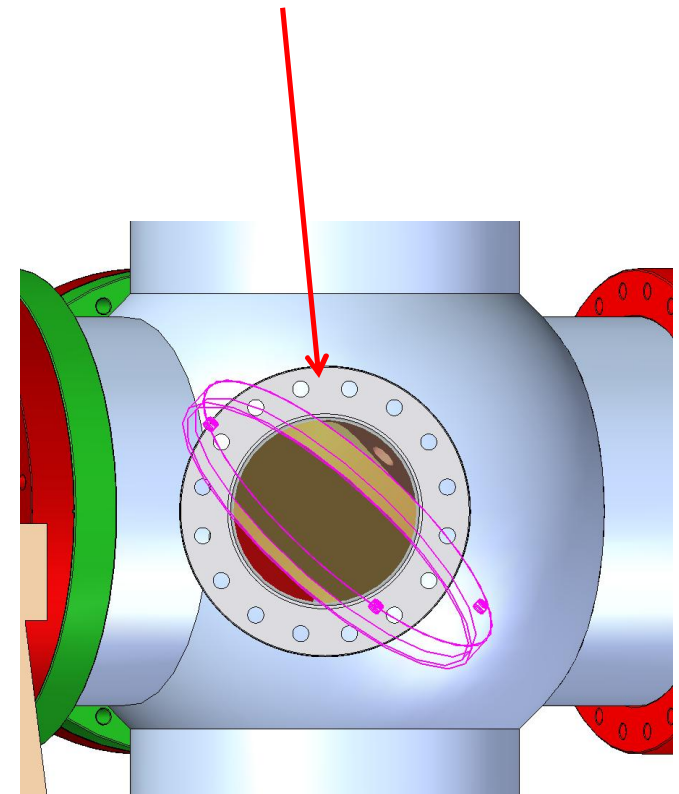


- Two bunches in each 120-Hz pulse
- Two ways to share:
 - Bunch 1 to Undulator 1, Bunch 2 to Undulator 2
 - Each user gets 120-Hz x rays, without THz
 - Bunch 1 to bypass, Bunch 2 alternates between undulators
 - Each user gets THz and x rays at 60 Hz



Alignment viewport

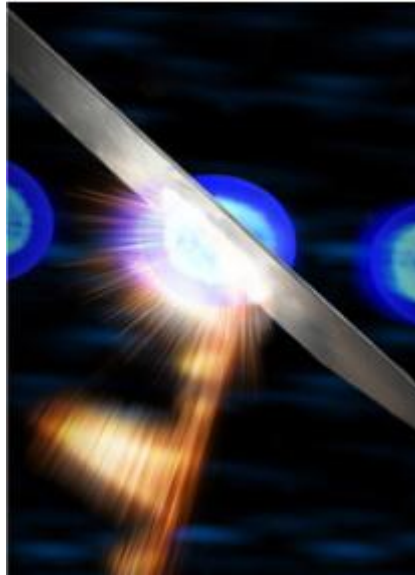
- View HeNe alignment beam directly or with a camera



- A layout for THz pump and x-ray probe, on a single table and with a single bunch, has received initial approval
- For final approval:
 - Development of suitable thin crystals and mounts that damp vibrations
- Successful THz experiments on this test table may be followed by a transport line to the hutches
 - Requires two-bunch operation
- In deciding on the future role for THz at SLAC, management will be guided by this workshop and by an upcoming one at SLAC...

Frontiers of THz Science

5-6 September, 2012,
SLAC National Accelerator Laboratory



This workshop is focused on exploring and defining scientific opportunities associated with THz radiation in a wide range of scientific fields.

https://slacportal.slac.stanford.edu/sites/conf_public/THz_2012_09/Pages/default.aspx