

E338 Outlook for FY26

FACET-II Long term planning meeting

SLAC National Accelerator Laboratory

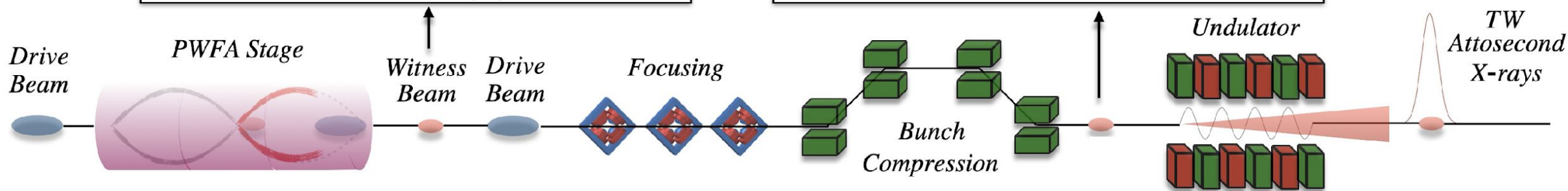
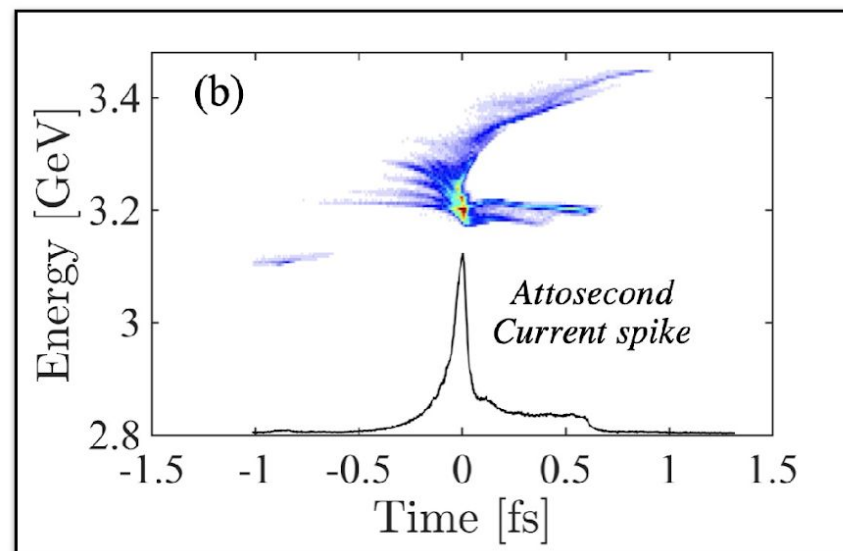
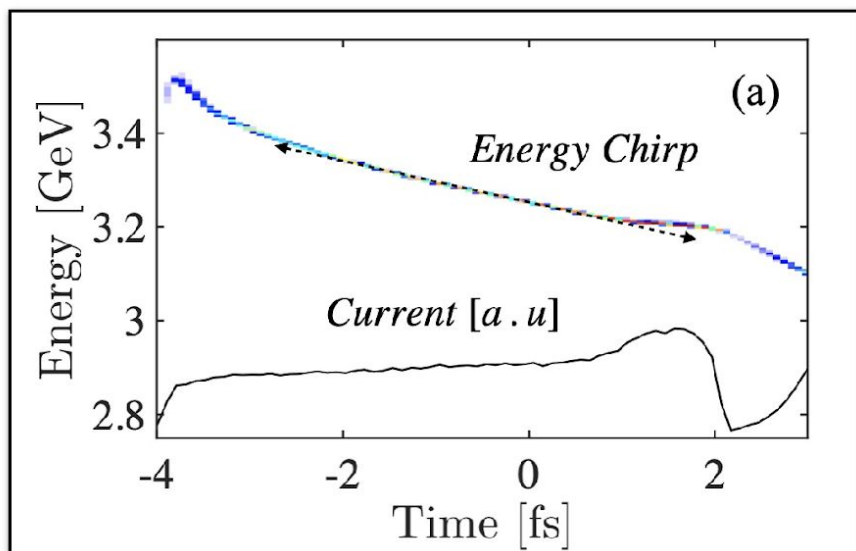
July 25th, 2025

PIs: Claudio Emma, Ago Marinelli



Overview, science goals, publication timeline

PAX concept: a Plasma-driven Attosecond X-ray Source



C. Emma et al., APL Photonics, 6, 076107 (2021)

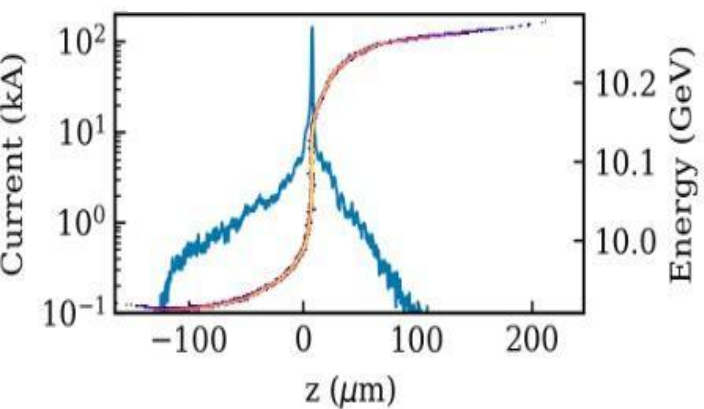
Concept for scaling to shorter wavelengths R. Hessami et al., PRAB (2024)

E338 Experimental goals at FACET-II

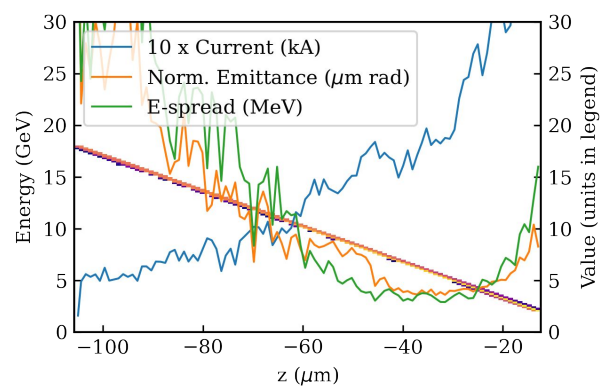
Science Goals

1. Demonstrate post-plasma sub-fs compression of e- beam
2. Measure + characterize XUV CSR for compressed e- beam down to 100 nm
3. Using plasma-injector, compress + measure coherent XUV down to 50 nm

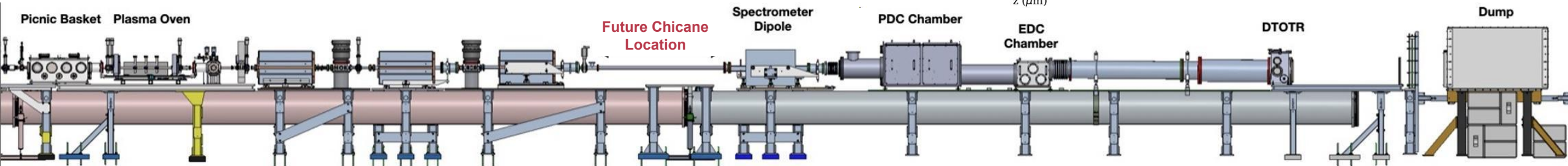
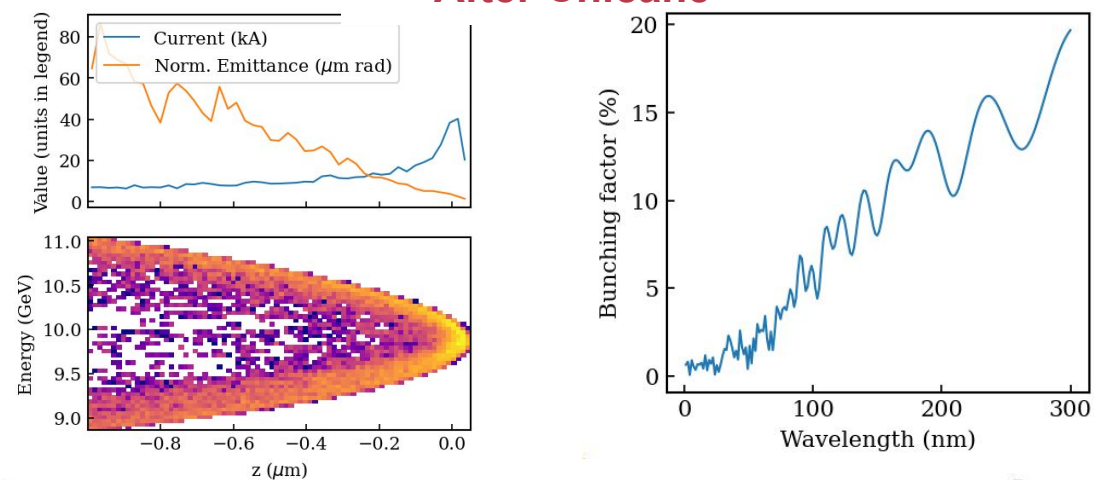
Before Plasma



After Plasma



After Chicane

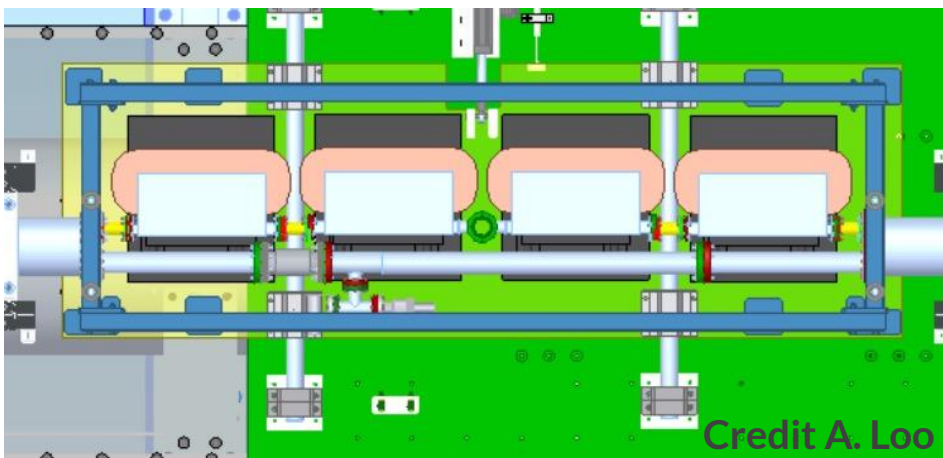


E338 Experimental setup and diagnostics

Plasma Sources

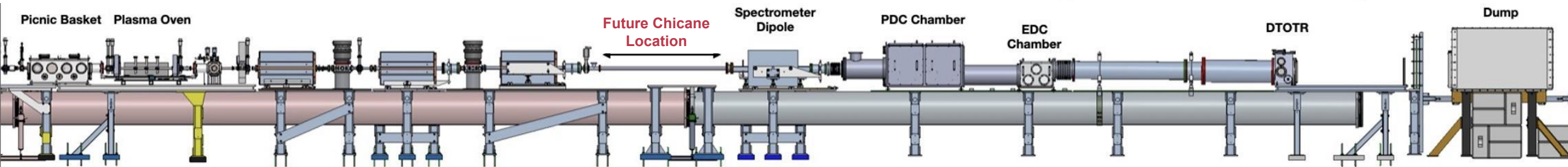
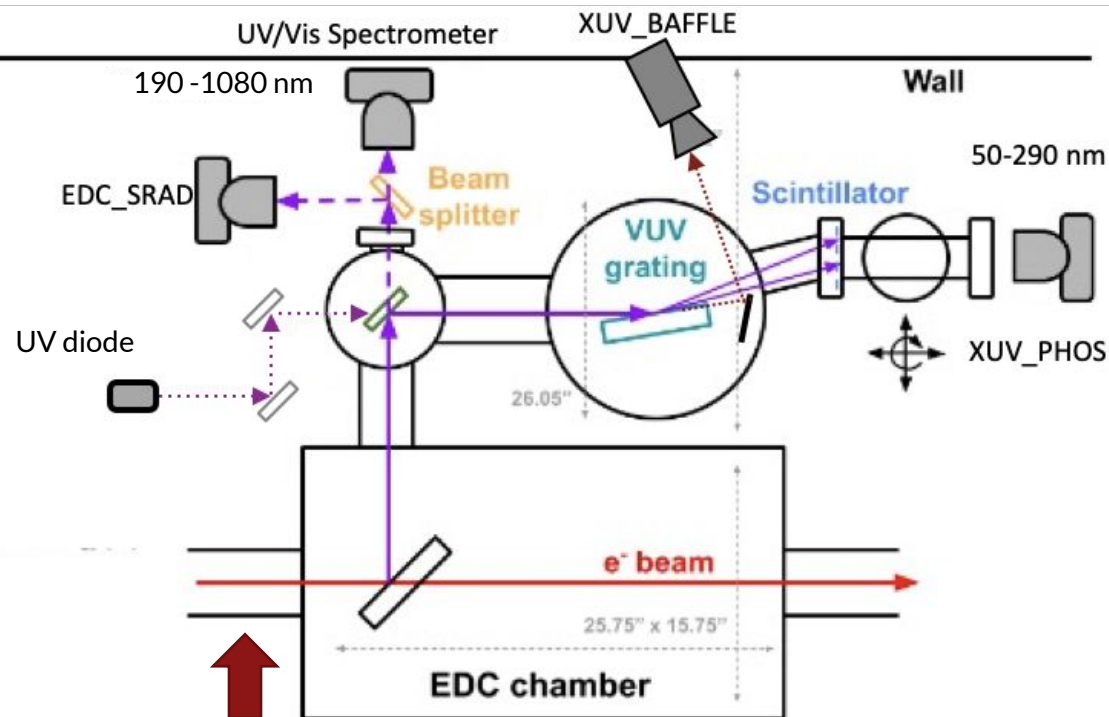
- Gas Jet
 $n_e = 10^{18} - 10^{20} \text{ cm}^{-3}$
- Li Oven
 $n_e = 10^{16} - 10^{17} \text{ cm}^{-3}$
- Static fill

Chicane + bypass line



Spectral Measurement Setup

[Confluence](#)



Radiation setup detects broadband spectral content to map bunching factor of fully-compressed e-beam

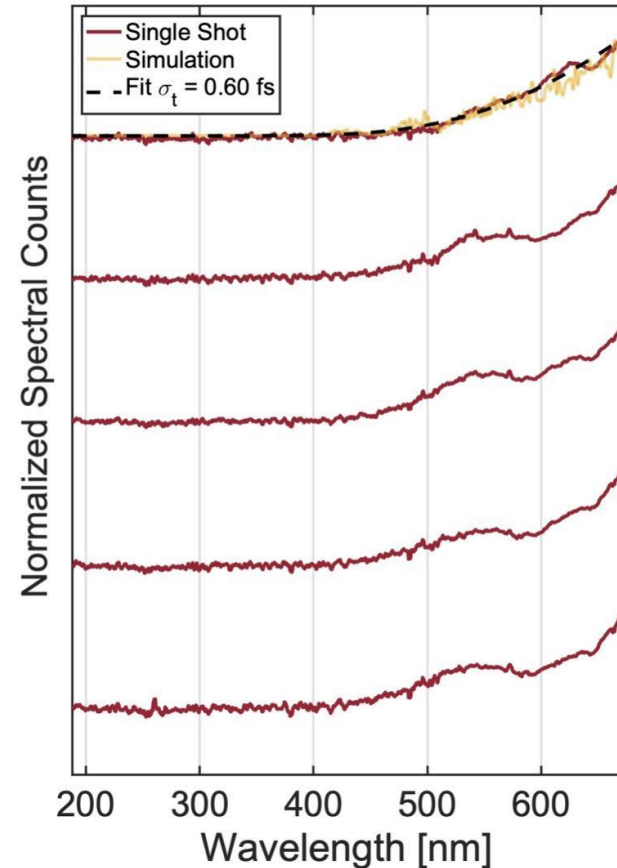
E338 Publications timeline

Experiment	Result	Journal	Timeline for getting data	Needs
E338/E300	Longitudinal wakefield mapping and strongly chirped beam generation	PRAB	Have some, maybe all we need?	
E338	Spectral diagnostics of beam-plasma interaction	PRAB	Have some, more in next run	
E338	Attosecond beams from post-plasma compression	Nat Photonics	Fall 2026	Chicane
E338	XUV Coherent undulator radiation from plasma-compressed beams	Nat Photonics	Fall 2027	Chicane + Und

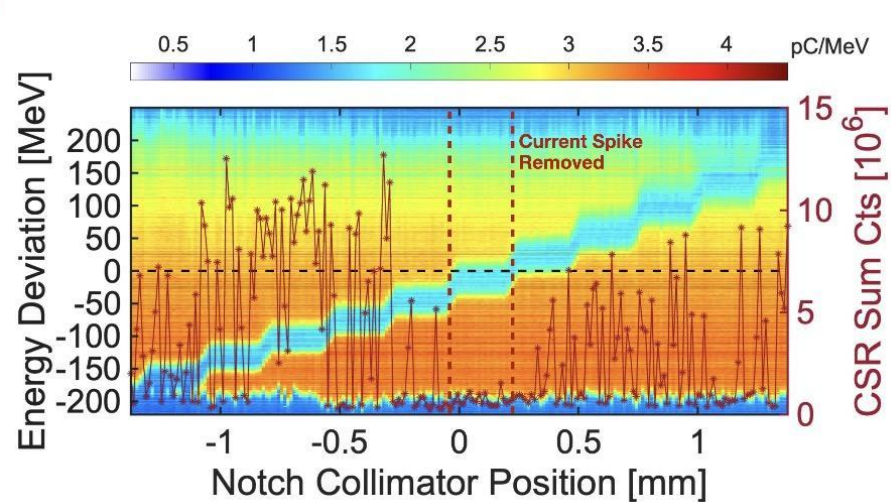
What we did in FY25 (1 dedicated shift, but...)

E338 Diagnostics - what worked

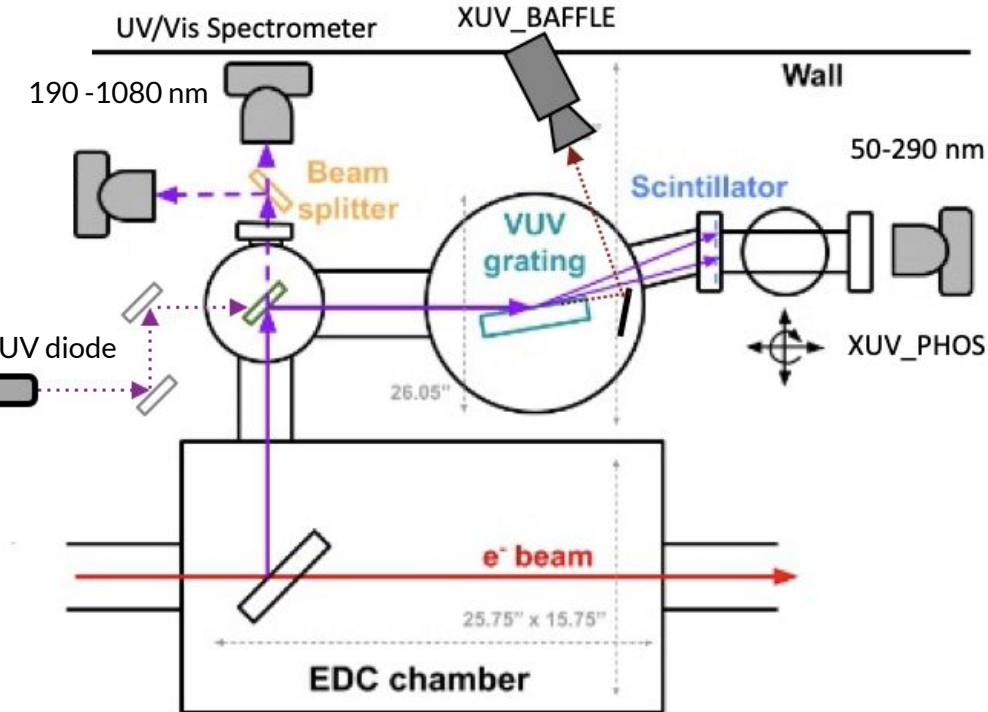
Heater on - Short Gaussian



CSR measurement during notch collimator scan



- Spectral diagnostics used to characterize laser heater shaped high current beams
- UV-Vis spectra measured in good agreement with simulated beam profiles

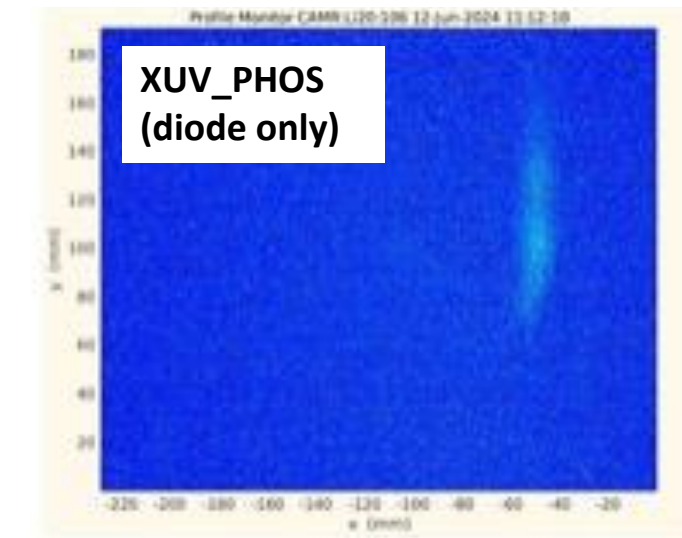
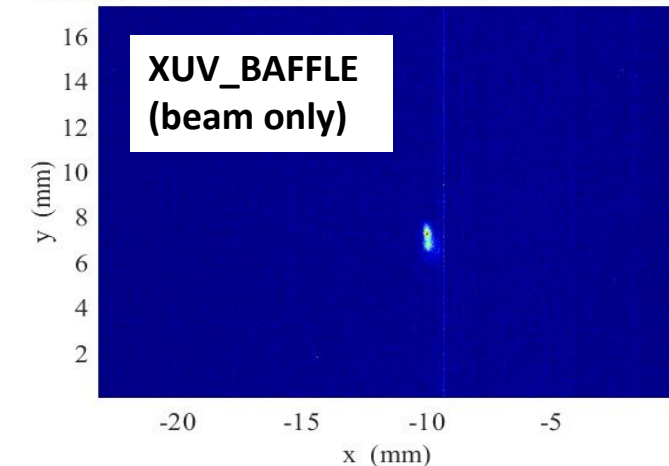


Radiation setup used to measure fs current spikes from laser heater shaping

E338 Diagnostics - what didn't work (yet)

- (1) XUV spectrometer calibrated, aligned and tested with UV diode
- (2) No signal from e-beam observed on XUV spectrometer yet, likely due to lack of e-beam bunching
- (3) Risk mitigation strategy: increase collection efficiency
 - From phosphor screen to camera (fiber optic windows, move camera directly in front of phosphor screen)
 - **Expect ~600x increase over current setup**
 - Direct XUV detection (Andor XUV/x-ray camera)
 - **Expect ~1200x increase over current setup**

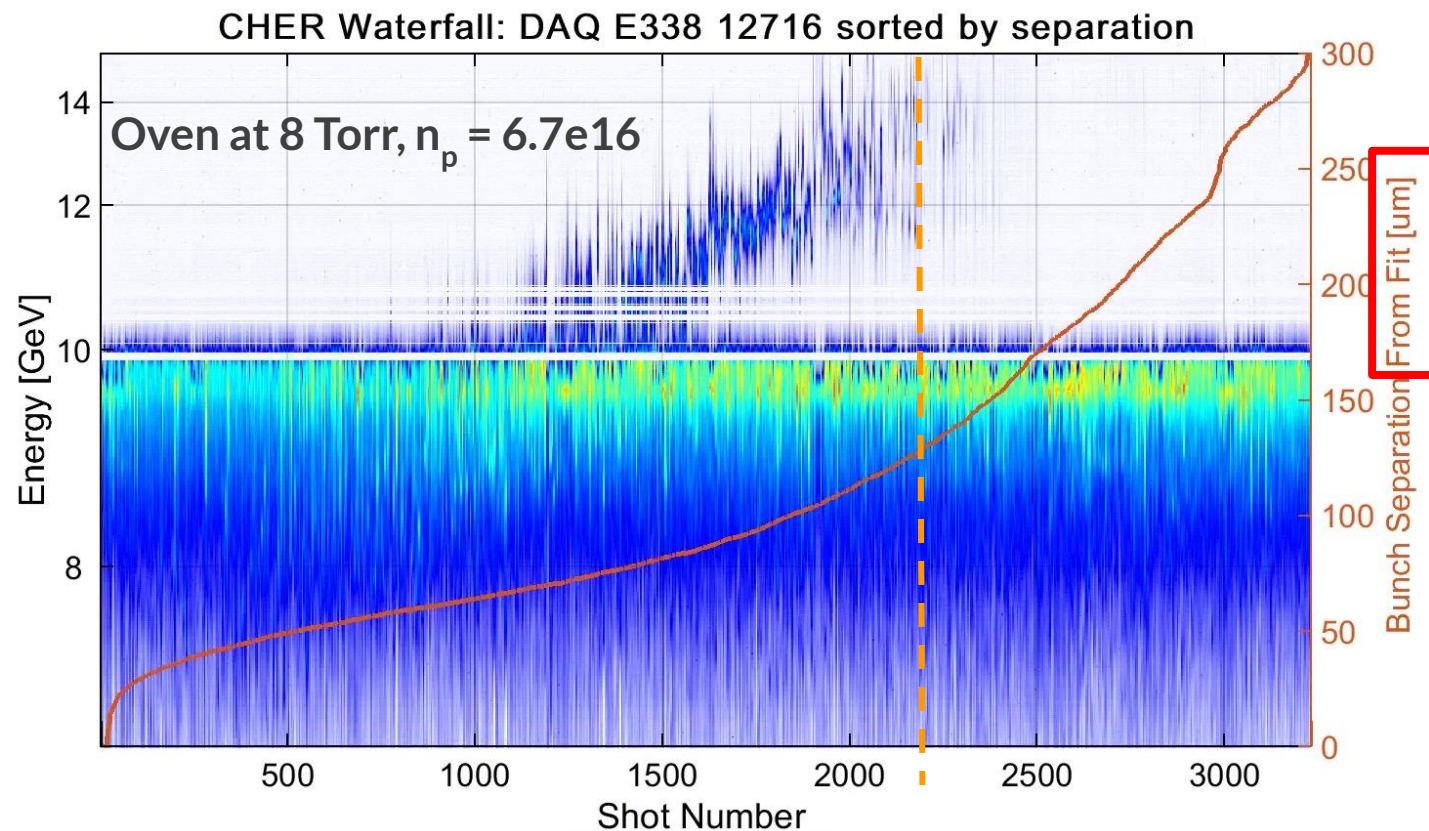
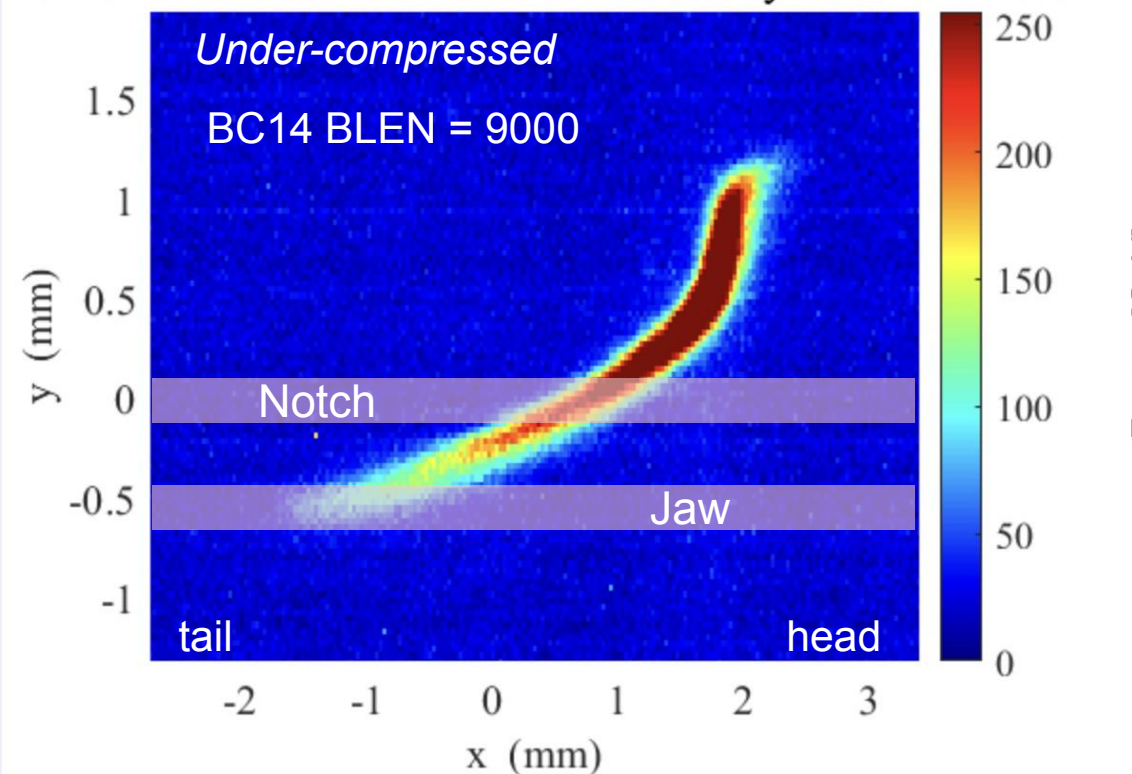
Profile Monitor CAMR:LI20:109 06-Jun-2024 18:31:47



Radiation setup being improved to measure shortest (sub 100 nm) bunches

E338 FY25 - Beam Configuration Commissioning

Profile Monitor CAMR:LI20:107 07-May-2025 22:22:37



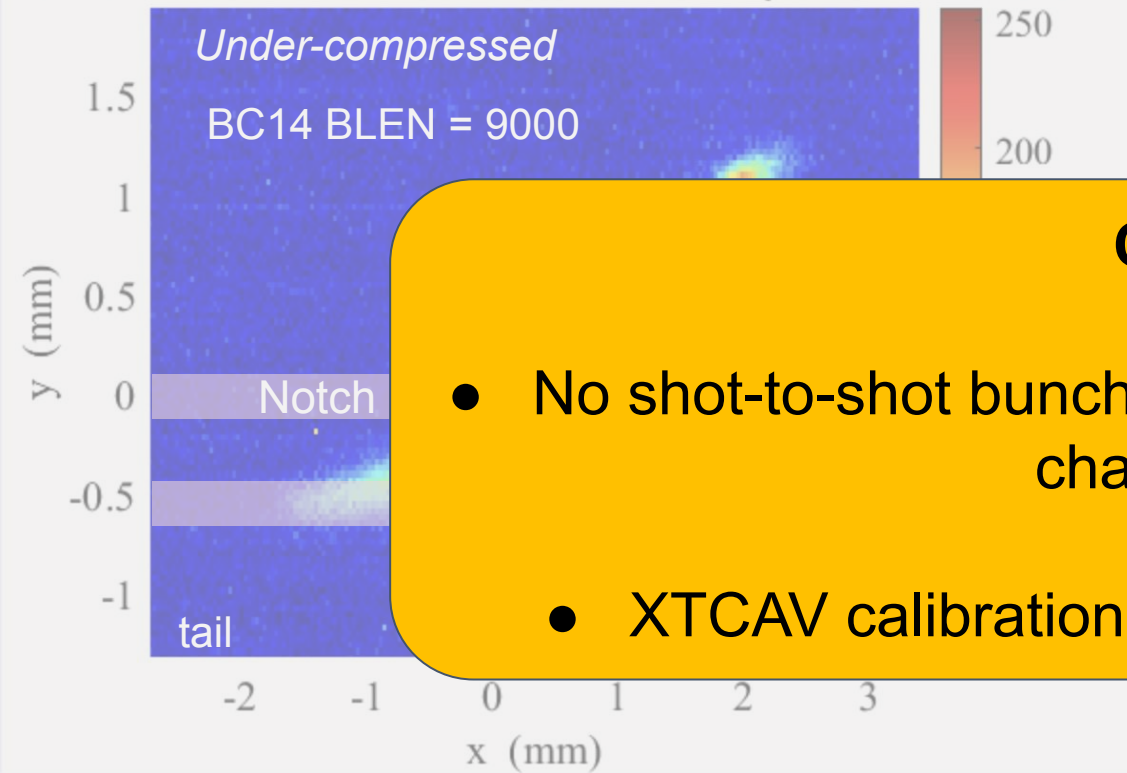
Plasma Wavelength

Chose under-compressed working point for wakefield mapping: longer tail, larger drive-witness current ratio, more stable machine.

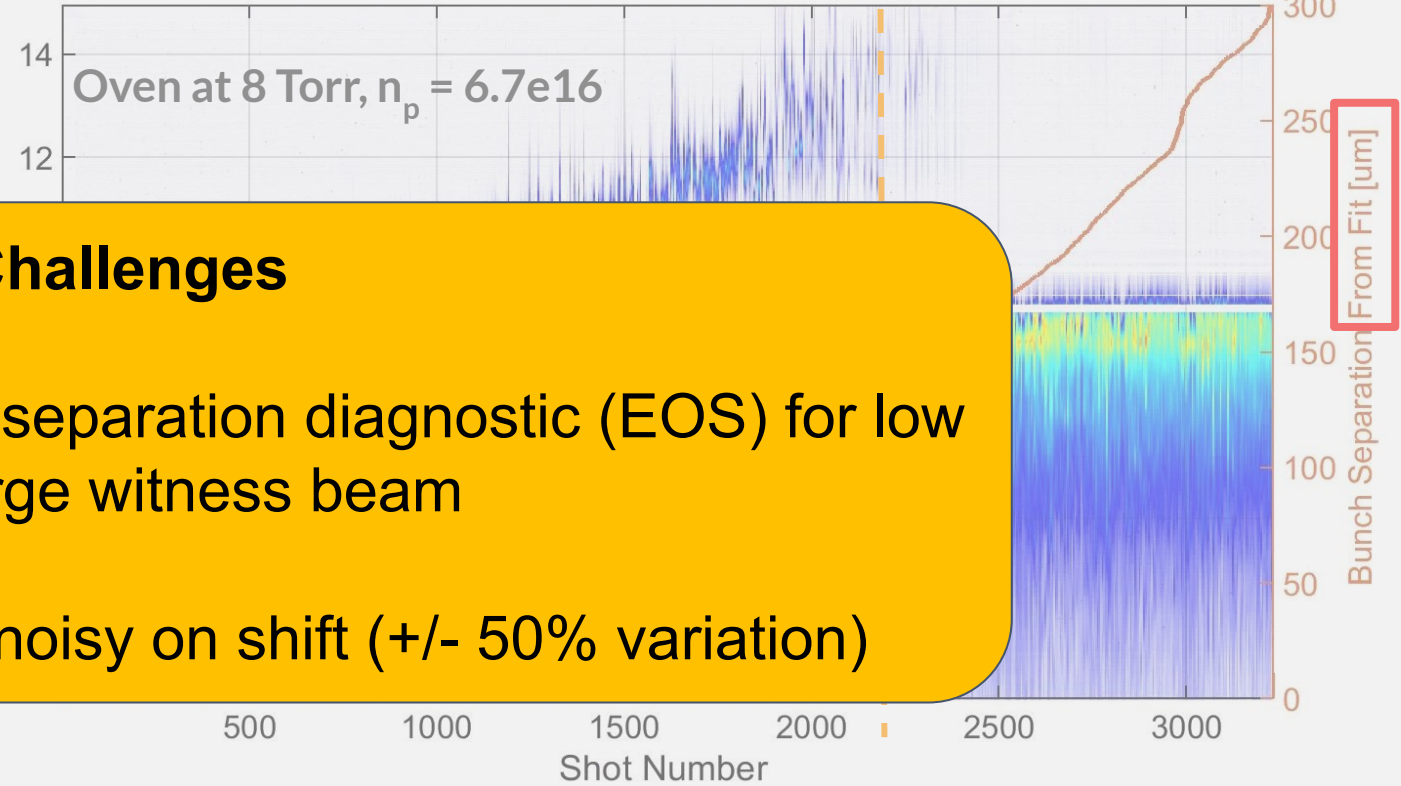
Notched two-bunch configuration used to map longitudinal wakefield of Li oven plasma

E338 FY25 - Beam Configuration Commissioning

Profile Monitor CAMR:LI20:107 07-May-2025 22:22:37



CHER Waterfall: DAQ E338 12716 sorted by separation



Challenges

- No shot-to-shot bunch separation diagnostic (EOS) for low charge witness beam
- XTCAV calibration noisy on shift (+/- 50% variation)

Plasma Wavelength

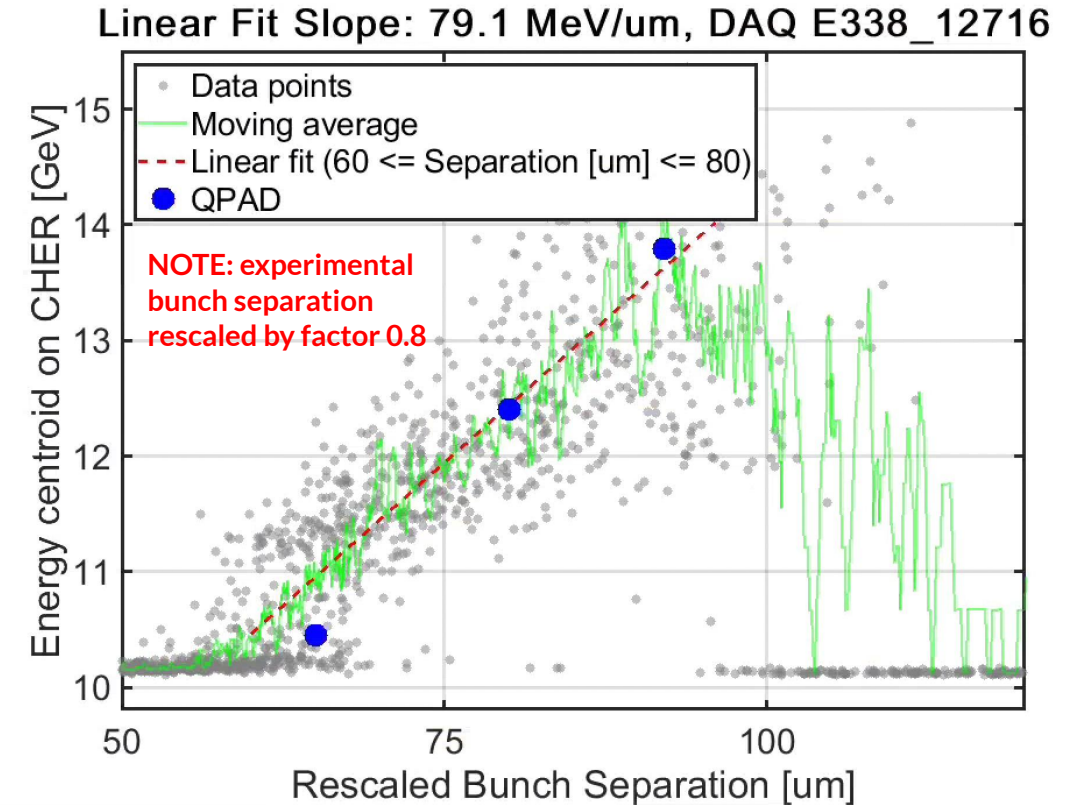
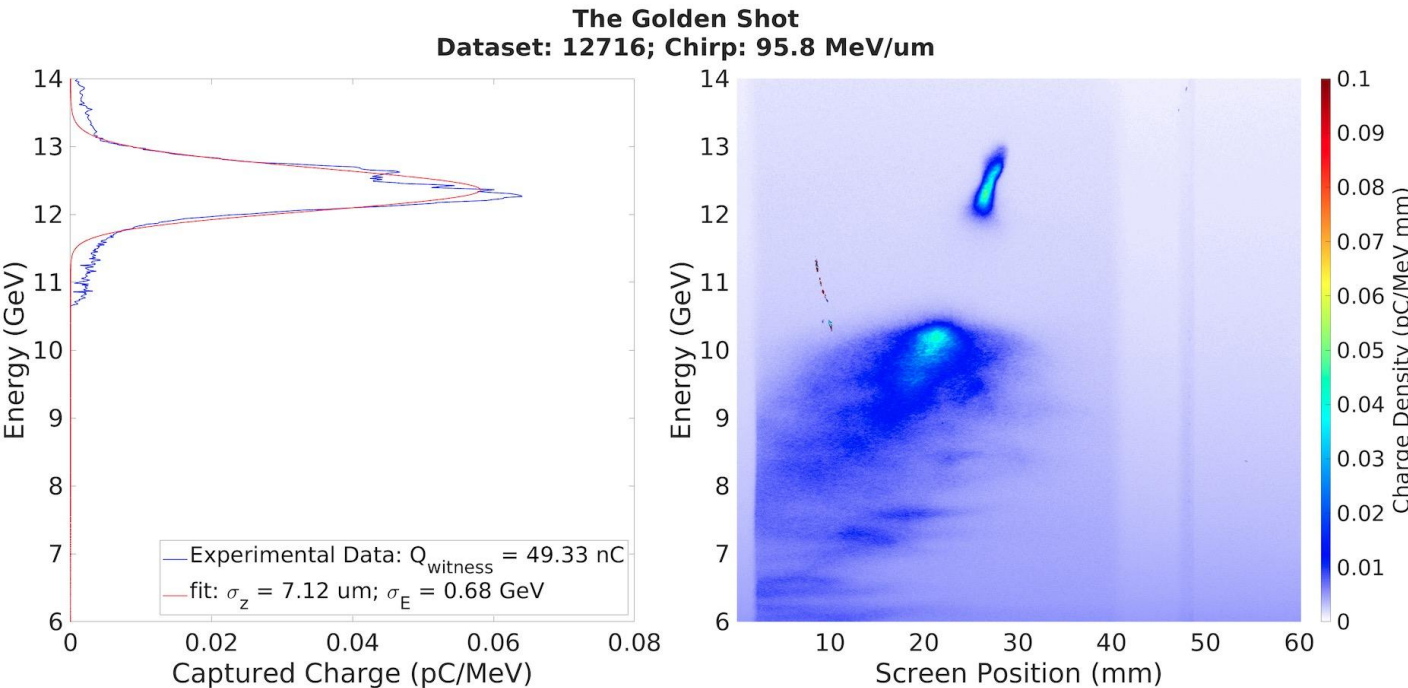
Chose under-compressed working point for wakefield mapping: longer tail, larger drive-witness current ratio, more stable machine.

Notched two-bunch configuration used to map longitudinal wakefield of Li oven plasma

Chirp calculation results

Oven at 8 Torr, $n_p = 6.7e16$

Plasma density (10^{16} cm^{-3})	Experimental chirp (MeV/um)	Simulation chirp (MeV/um)
3.5	47.8	43.8
6.7	79.1	87.0



- QPAD simulations in agreement with data for chirp and witness energy gain. Rescaling of experimental bunch separation due to uncertain TCAV calibration.

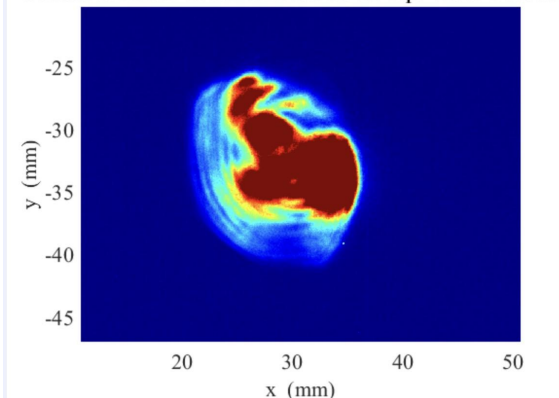
Chirped beams generated with Li oven sufficient for full compression of up to $\sim 11 \text{ GeV}$ energy

Measurements/analysis we wanted to do but haven't gotten to yet

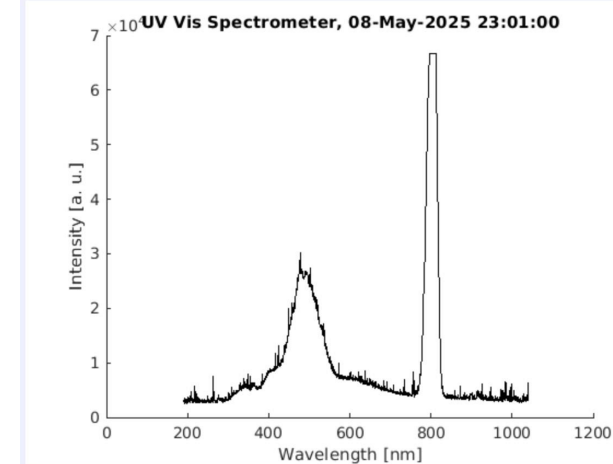
- Test alternative beam configurations with similar wakefield mapping measurements (two bunch and/or notched single bunch in Li oven and/or static fill). E.g. long ramps in H2 static fill a-la E301 may be better than Li oven for chirping/charge capture.
- Detailed analysis of spatial-spectral correlations in coherent radiation signal
 - Hyperspectral imaging of beam in Li oven looking at EDC_SRAD.
 - Can we learn something about the beam (e.g. drive-witness tilt) if we correlate which parts of the beam are emitting in what wavelength range?
- Correlate UV-Vis spectra sum counts with oscillations on CHER.
 - Can we learn something about beam matching in the plasma if we see correlations in CHER - spectral data?

NAME EDC_SRAD, X_ORIENT Positive, Y_ORIENT Positive, RESOLUTION 53
are those two distinct CSR blobs from drive+witness? if so, may be useful for alignment...

Profile Monitor CAMR:LI20:310 22-Apr-2025 14:04:24



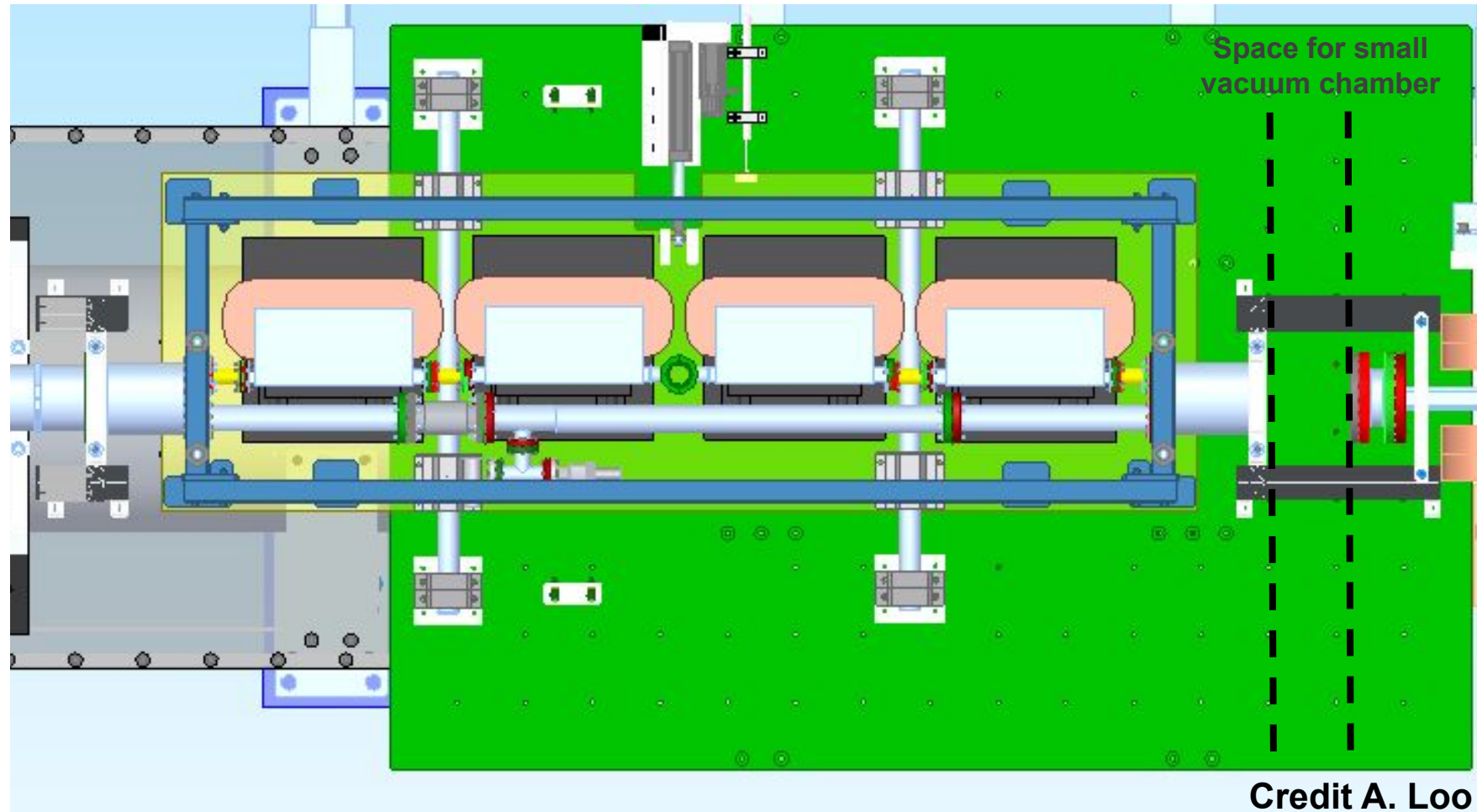
that peak at 500 nm is from the beam, not the laser



Plans for FY26

E338 Chicane + bypass line installation

- Chicane sits on a mover table remotely insertable in beamline
- Space for small interaction chamber downstream before dump dipole.
- Magnets + bypass line delivery behind schedule. Expected arrival 8/2025, staged installation 9/25 - 12/25



Chicane will (hopefully) be available for experiments starting Fall 2025

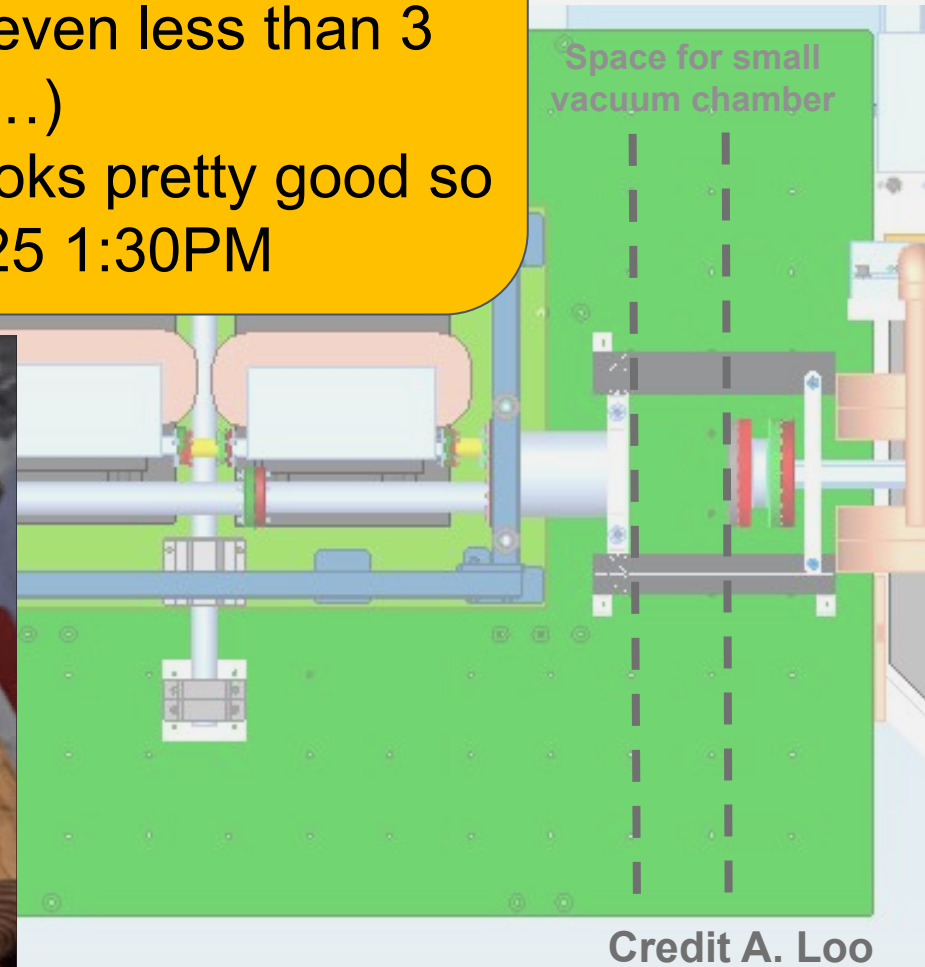
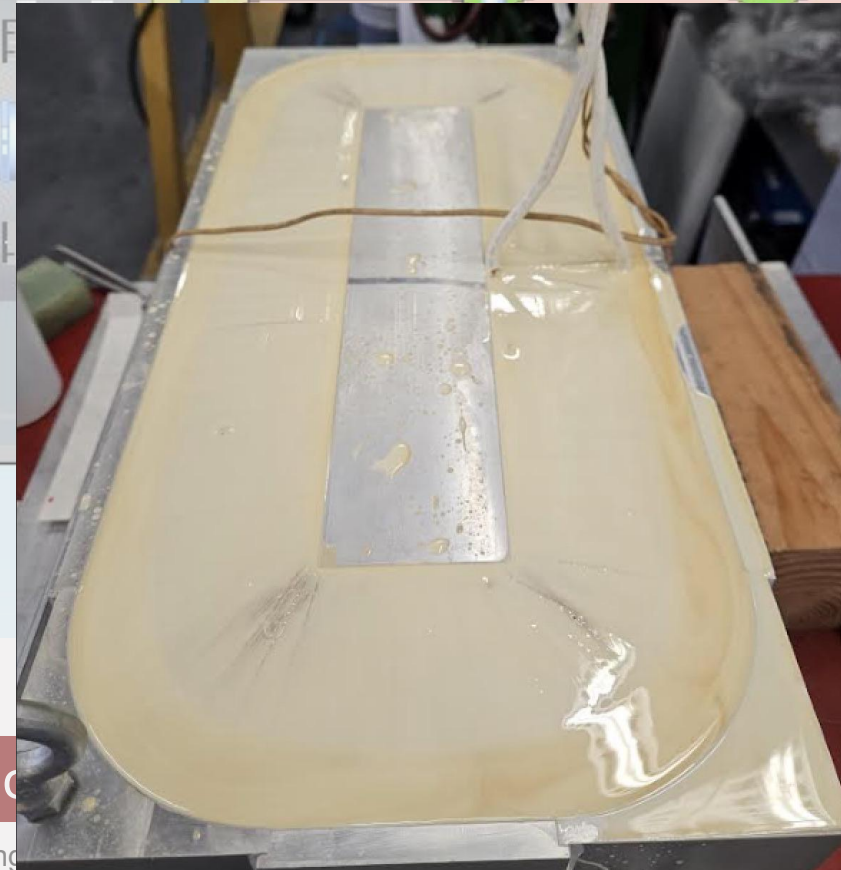
Challenge

- Getting magnets delivered on time (or even less than 3 months behind schedule...)
- “The coil was in the oven yesterday. It looks pretty good so far”, Stangenes Industries, 7/25/25 1:30PM

- Chicane sits table remote beamline

- Space for small interaction chamber downstream before dump dipole.

- Magnets + bypass line delivery behind schedule. Expected arrival 8/2025, staged installation 9/25 - 12/25

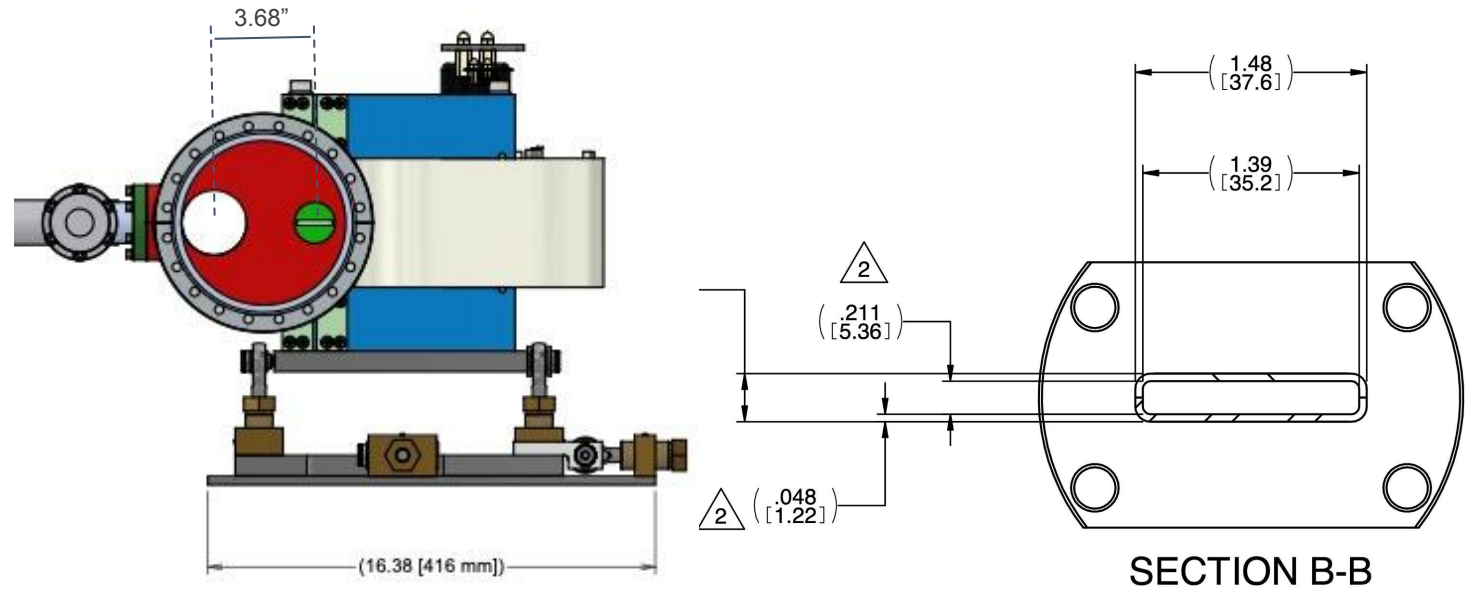


Chicane will (h

s starting Fall 2025

E338 Chicane parameters

Parameter	Value	Unit
Electron Beam Energy	10	GeV
Momentum Compaction R_{56}	100 (150)	um
Bend Length	33.2	cm
Drift Length between bends	18.9	cm
Total length (bellows-to-bellows)	2.6	m
Single bend integrated field strength	0.38 (0.46)	T.m
Peak Magnetic Field Strength	1.14 (1.39)	T
Max beam deflection	5.9 (7.10)	mm

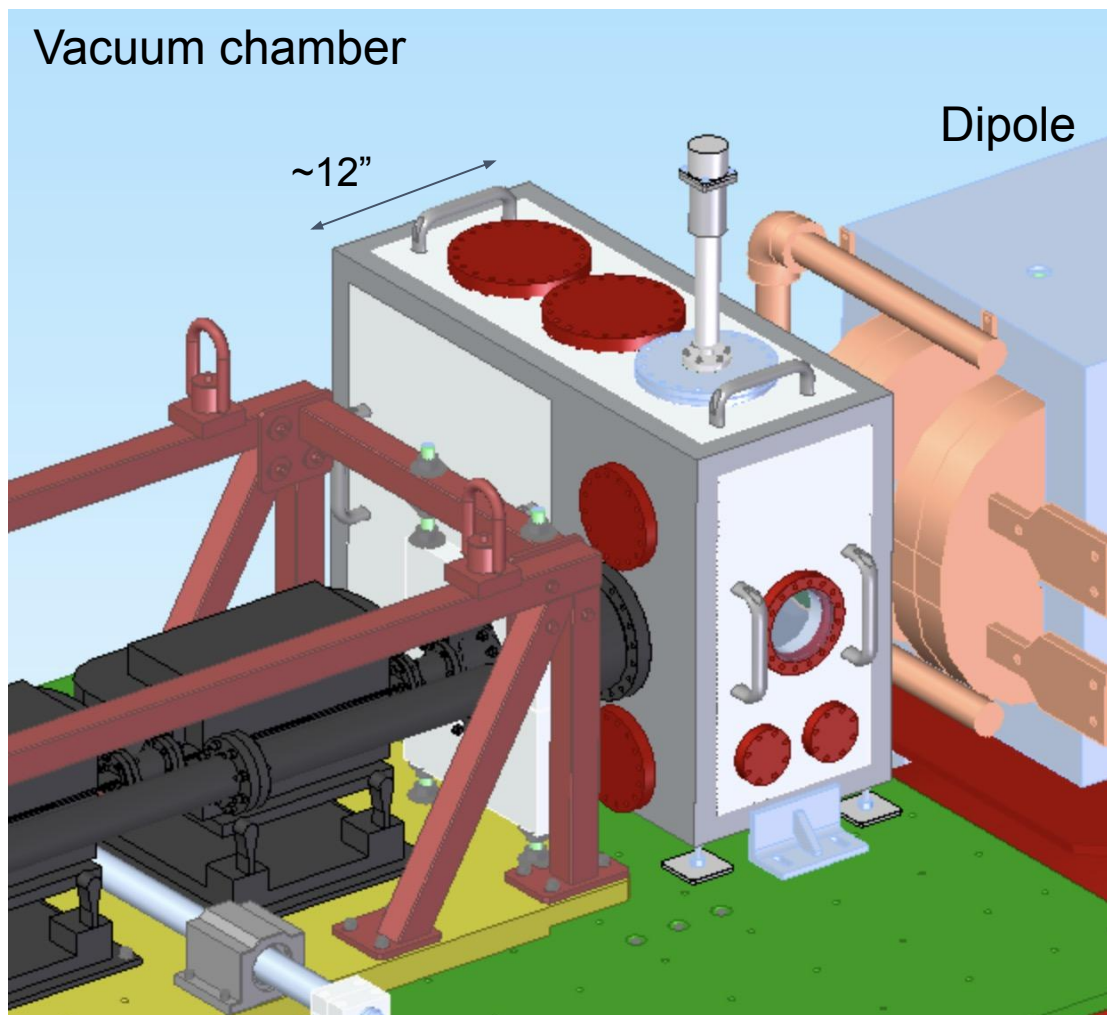


- Max horizontal deflection at 10 GeV is 7.1 mm
- Chicane vacuum chamber vertical aperture is 5.36 mm. Bypass line is 2.5" diameter pipe.
- Bypass line to chicane line translation = 3.68"
- Initial commissioning shifts will test deflection without plasma and beam optics setup.

Bypass line designed to avoid introducing a limiting aperture for upstream experiments

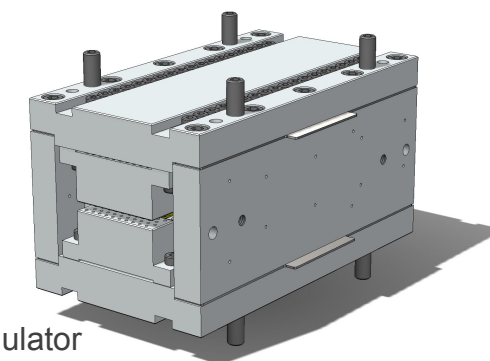
Post-chicane chamber

Design [details](#)



Chamber can support:

- Gas jets
- Solid targets
- OTR screens
- Undulators
- Others?



- Stakeholders consulted during design process.
- Cost: ~\$47k with bare panels
- Lead time: 12-14 weeks

Post-chicane chamber design iterated with group. Ideally would be available for experiments in Spring run.

Summary

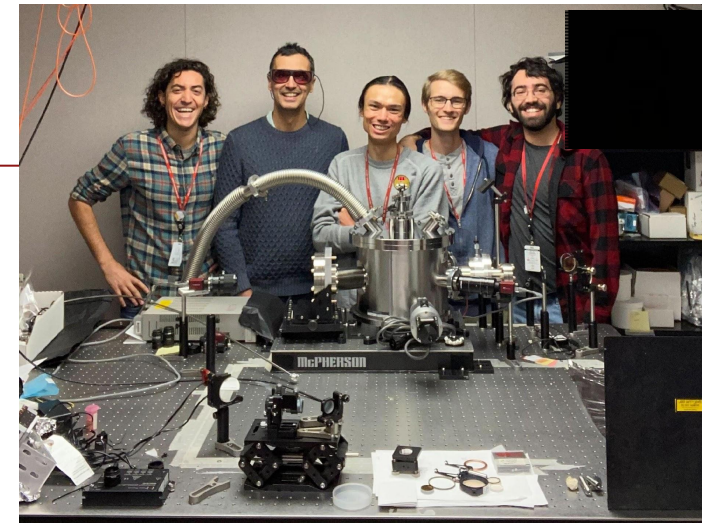
- **What are your high-level scientific goals?**
 - Plasma compression of FACET photoinjector e-beams ~ 100 nm bunching
 - Compression of plasma injected e-beams < 50 nm generating attosecond XUV pulses
- **What data do you have and what analysis has been done?**
 - Radiation diagnostics installed in tunnel and commissioned.
 - Chirped beams generated with Li oven. Sufficient for compression with chicane.
- **What went well?**
 - Commissioning of UV-Vis spec & CSR camera, integrated in DAQ with BSA
- **What could go better?**
 - Detection of beam-produced signal on XUV
 - XTCAV calibration fluctuations
 - Shot-to-shot bunch separation diagnostic for low charge witness
- **Outlook for next run?**
 - Start compression experiments with photoinjector and (later) plasma injected beams

E338 well positioned to meet its goals with successful commissioning of diagnostics and beam setup

Acknowledgments

Collaborators

- **SLAC:** R. Hessami, K. Larsen, R. Robles, K. Swanson, C. Emma, A. Marinelli, FACET-II AARD & Beam Physics groups
- **UCLA:** A. Fisher, P. Musumeci, C. Zhang, C. Joshi, K. Marsh
- **Experimental Collaborations with:** E-300, E-304, E310, ...
- ***Special thanks to:*** Doug for operating oven, Sebastien for operating laser and Sebastien + Sheldon for writing notch + jaw scan function, Nathan for sinusoidalizer/sextupole optimization tools we used during wakefield mapping shift



Thank you for your attention