



FACET-II | Facility for Advanced
Accelerator Experimental Tests

Spectrometer electron diagnostics and expected performance

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May 3, 2022



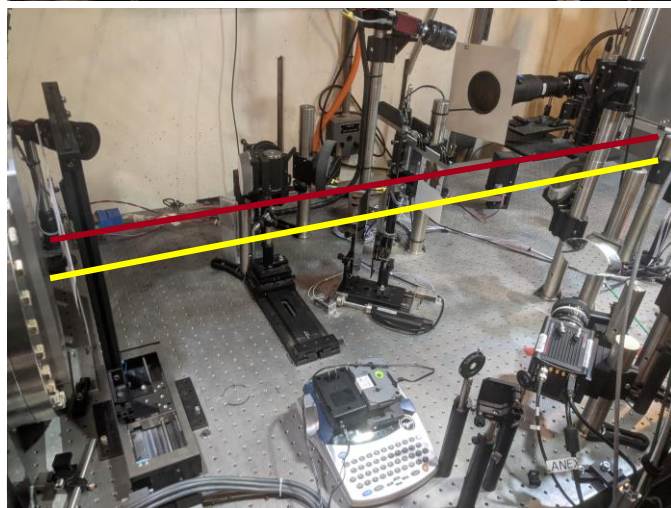
U.S. DEPARTMENT OF
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Current state of the Dump Table



Electron devices (*covered in this talk*):

- DTOTR1 and DTOTR2 – YAG and OTR
- LFOV – DRZ-FINE + Phosphor
- CHER spectrometer
- PRDMP – mainly used by ops

Gamma screens (*covered by Pablo in next talk*):

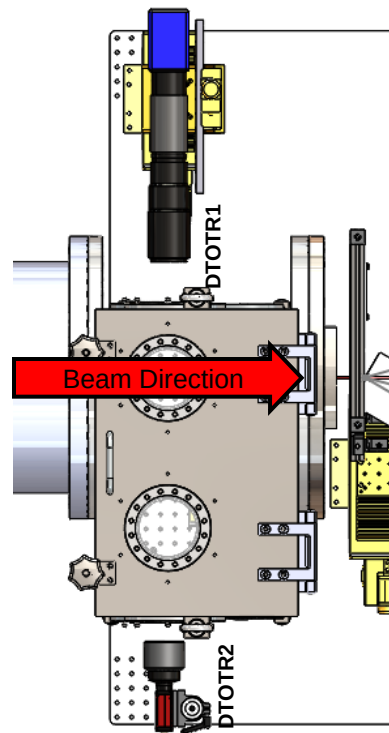
- GAMMA1 – DRZ + CsI array
- GAMMA2/3 – with camembert filter + DRZ fine

DTOTR1

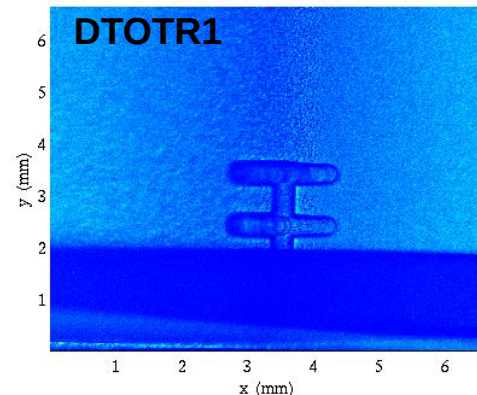
- High resolution in-vacuum profile monitor
- Used for TCAV measurements, butterfly emittance, etc
 - FOV = 7x7 mm
 - Resolution $4.5\text{ }\mu\text{m} \rightarrow 0.01\%$ energy resolution

DTOTR2

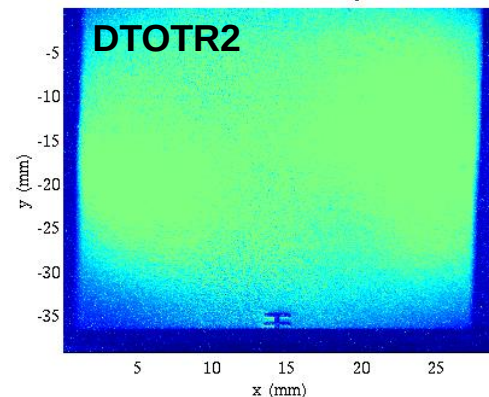
- Larger field of view option as DTOTR1 (for alignment, etc)
- 40mm Ø YAG disk, 30 μm pixel size
 - FOV = 40x25 mm
- Can view YAG simultaneously with DTOTR1



Profile Monitor CMOS:LI20:3505 27-Apr-2022 12:57:58

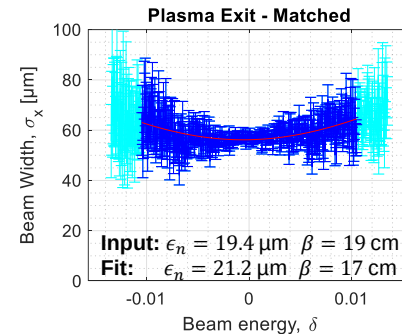
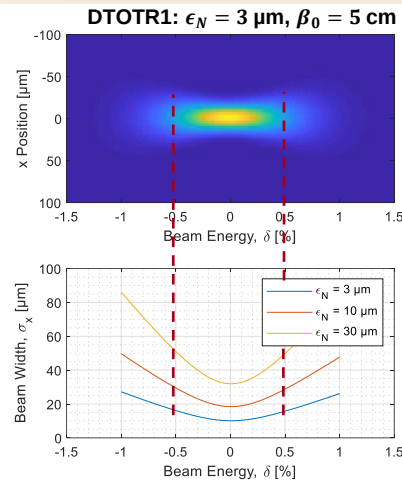


Profile Monitor CAMR:LI20:107 27-Apr-2022 14:11:35

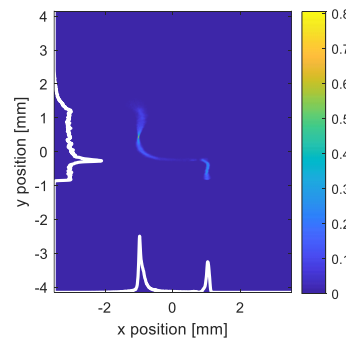


DTOTR Expected Performance

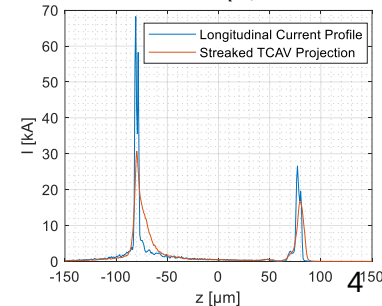
- Single shot emittance measurement
 - Expected Resolution: <5% emittance resolution for measuring matched beams at plasma exit
 - Limitations: Phase mismatch and existing correlations
- Dispersive quad scan emittance measurement
 - Provides energy dependency of emittance and measurement of low energy spread beams
 - Limitations: requires multi-shot stability
- 2-D longitudinal phase space
 - Will be used with M.L. techniques to train a virtual diagnostic to provide a non-invasive estimate of the LPS for every shot (C. Emma)



DTOTR1 – 2 Bunch w. XTCAV



$I_{\text{meas}} = 26 \text{ kA}$, $I_{\text{pk,Drive}} = 65 \text{ kA}$
 $I_{\text{meas}} = 17 \text{ kA}$, $I_{\text{pk,Wit.}} = 31 \text{ kA}$



DTOTR Initial Performance

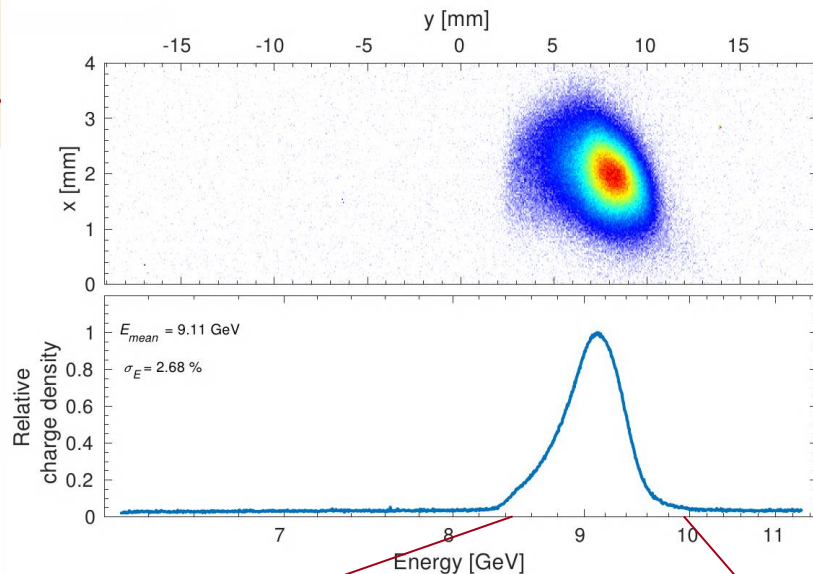
Dump table beam diagnostics beam commissioning shifts in August, December 2021

Plots show analysis from data collected on DTOTR2 in Aug 2021 run

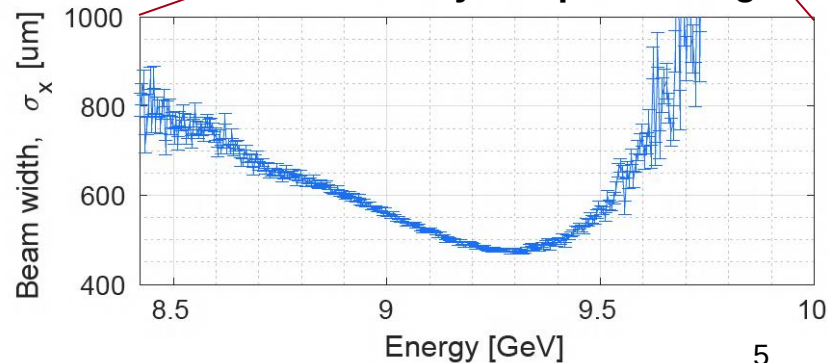
- Calibration of energy axis on dump diagnostics
- Measurement of energy spectrum
- Butterfly image captured, however in non-ideal beam and optics configuration

Shift plans written up to redo these and other measurements within next 2 weeks

Energy Spectrum Measurement



Butterfly Pre-processing



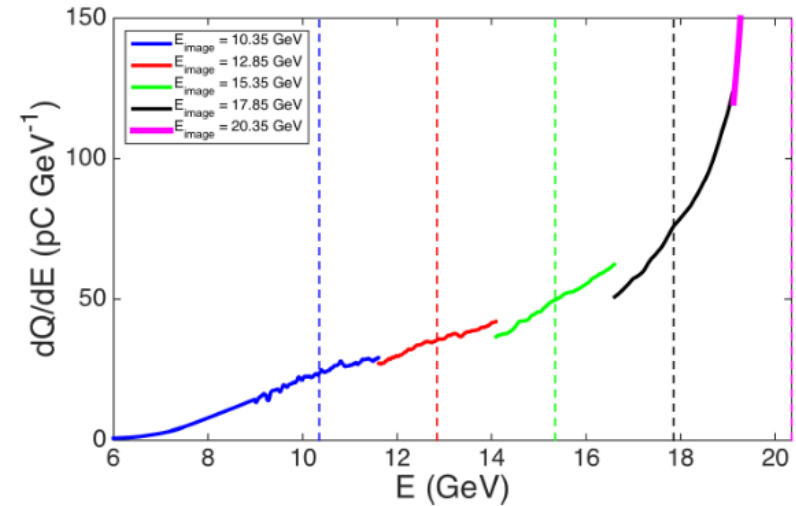
CHER Spectrometer

Specifications:

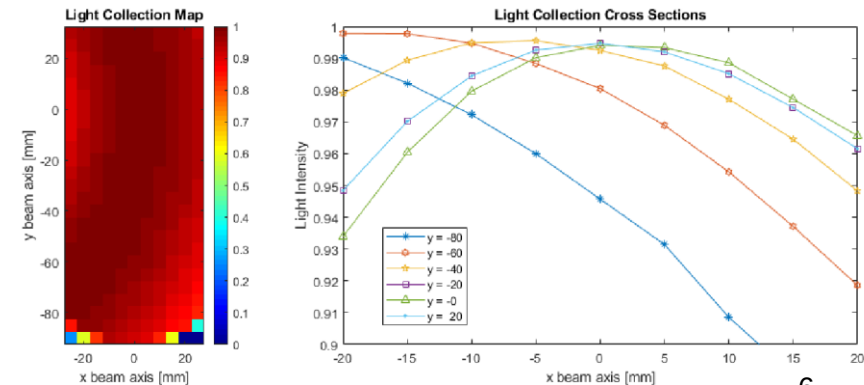
- Images the cherenkov radiation emitted within a gap between 2 silicon wafers
- FOV = 4.5 x 12cm
- Imaging resolution = $\sim 230 \mu\text{m} \rightarrow 0.4\%$ energy res.

The large FOV makes CHER the main electron energy spectrometer

- This will be key to showing Chan's first goal of energy depletion of the drive bunch.
- Online, but requires calibration, and characterization of the light collection efficiency across the field of view

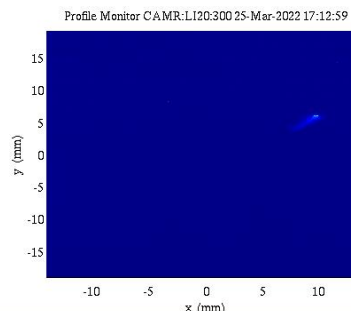
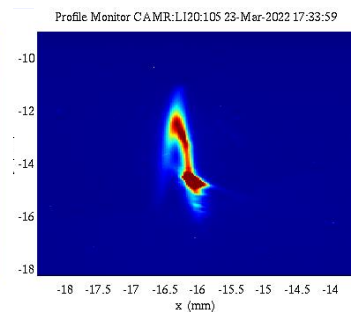
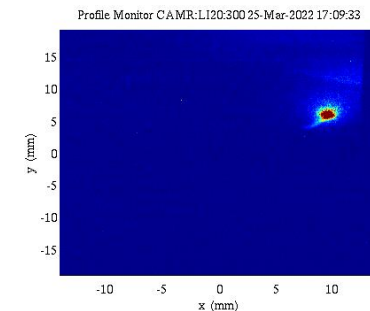
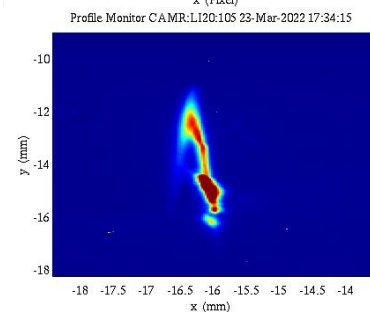
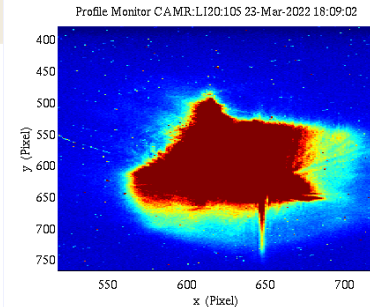
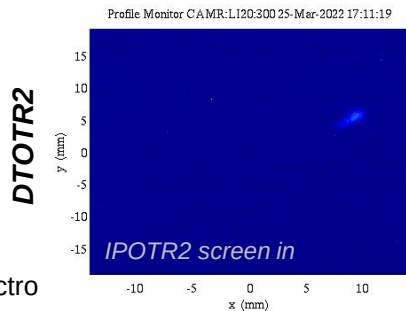
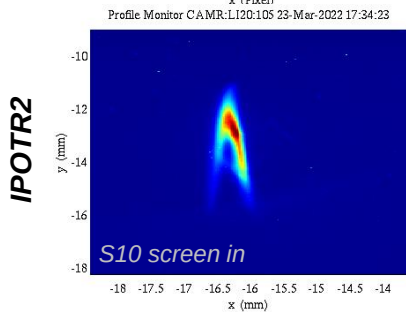
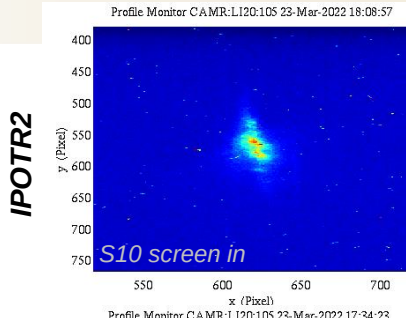
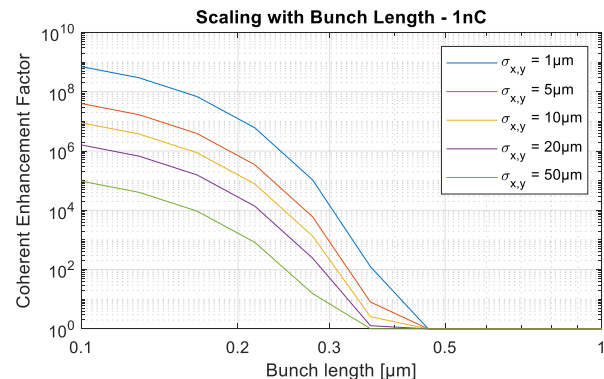


CHER Optical Characterization



COTR observations on the dump and IP cameras

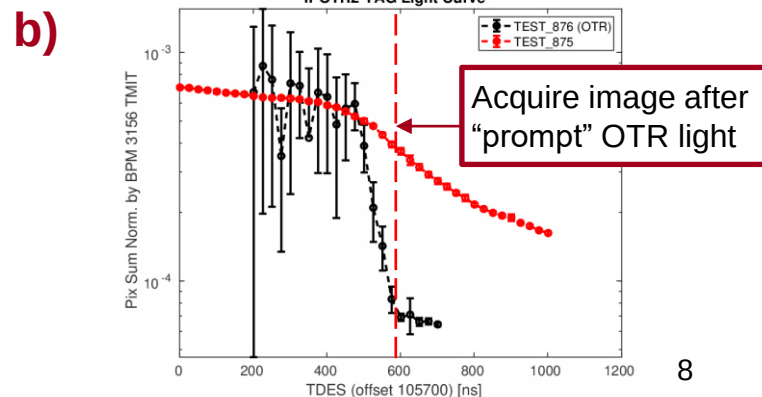
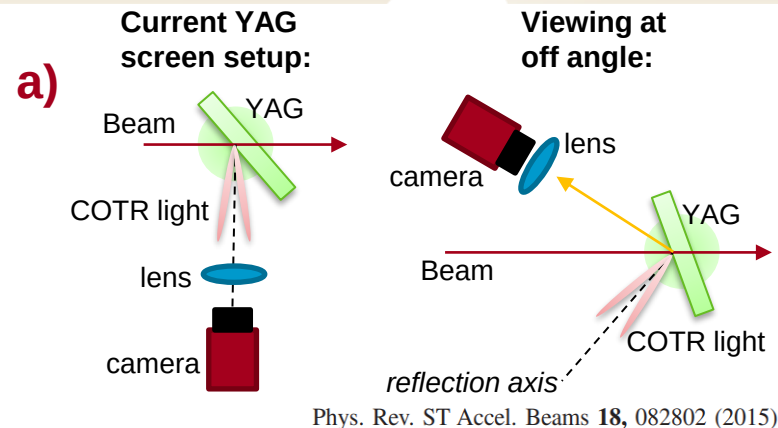
- Intermittent flashes of OTR light seen on various S20 screens
- Not correlated with charge measurements
- Flashes can be suppressed by inserting an earlier screen
- IPOTR2 and DTOTR2 shown here, but seen on almost all IP and dump OTR cameras
- From scaling studies below – COTR can emit orders of magnitude more light than incoherent OTR, so even a small charge spike can overwhelm the normal OTR signal



No other screens in

COTR mitigation

1. Laser heater – as Claudio covered
 - Will inhibit COTR from microbunching altogether
2. Using blue pass filters on cameras
 - Will block longer wavelengths of light that start emitting coherently first
 - *Filters installed on IPOTR2 camera to test at next opportunity*
3. Color camera
 - Can get cool color images so we can see the color content of COTR
 - *Have the camera, but requires some additional hardware. Will replace USOTR with color camera*
4. OTR rejection techniques:
 - a) Off axis scintillator imaging
 - b) Time delayed scintillator imaging



Summary and next steps

Summary

- Dump table now fully outfitted with first iteration of diagnostics
- Experience has been gained over a few shifts, but more dedicated beam commissioning required to test out emittance and LPS measurements
- COTR starting to appear → more sophisticated suppressions required

Commissioning procedures prepared for upcoming beam commissioning shifts:

- Dump table e- diagnostics:
 - <https://docs.google.com/document/d/1A3RfoVOopjoxTbNDSk-5PemZUKAwEaoEGOnkJzoszs/edit?usp=sharing>
- Gamma diagnostics: *Pablo is currently preparing*
- XTCAV 2D LPS:
 - https://docs.google.com/document/d/1jKNhruicX-gDcYP08y_O7JgQAJ5cplsF7GNMh3K3Jt0/edit?usp=sharing