FACET-II Long Term Planning Aug. 22, 2024

Sebastian Meuren (E-320)

Shifts in 2023 & 2024: we got very close to take great data

- **2023, Oct. 11**: unsuccessful, large accelerator drifts
- **2023, Oct. 13**: recovered collisions, but no non-linear interactions (pencil beam)

- **2023, Nov. 19**: unsuccessful, large drifts in horizontal e-beam position
- **2023, Nov. 22**: unsuccessful; not enough time (final shift of the run)

- **2024, Feb. 17-19**: collisions, new overlap procedure (pencil beam)

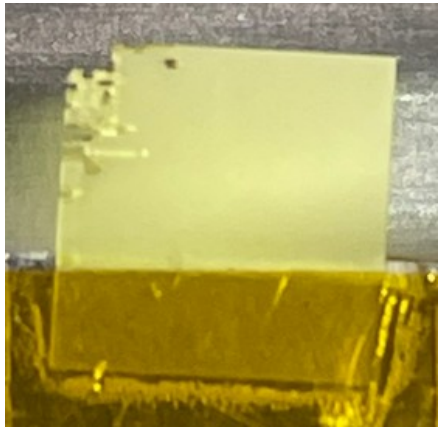
- **2024, Apr. 30**: collisions (compressed beam), but large beam-induced backgrounds
- **2024, May 1**: collisions with reduced e-beam background but weird beam vector

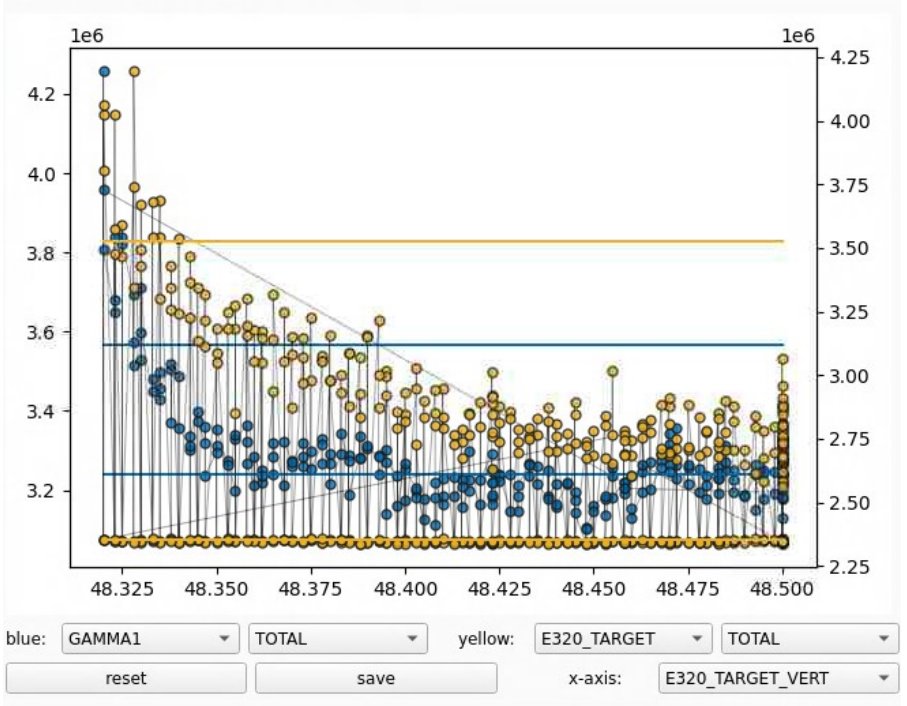
- **2024, May 20/21**: nice beam vector, little e-beam background but little accelerator up-time

- We used the high-quality dielectric OAP starting from April 24, 2024
- We took it out May 21/22 to minimize risk due to Lithium contamination by plasma oven

Main challenge in fall 2023: YAG damage

Old crystal

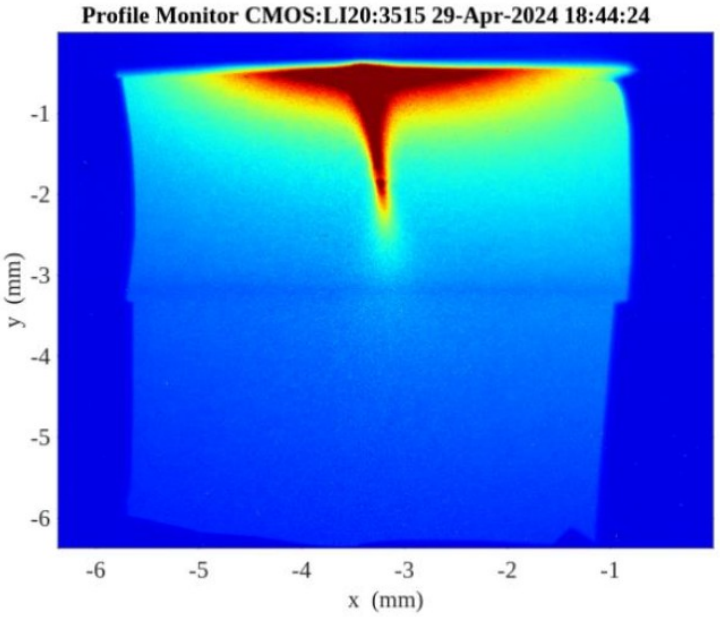




- Developed new software for fast camera readout and motor control ”python DAQ”
- Crystal movement is stopped once we observe x-ray/gamma radiation above background

New method for finding spatial overlap allows us to recover collisions quickly and reliably

Main challenge in spring 2024: beam-induced background



- Background looks like a Compton signal; renders experiment very difficult
- We need to “thread” the beam through a hole in the upstream Be window to reduce backgrounds
- Beam tuning takes very long and we can easily end up with a weird beam vector

Retractable upstream Be window is a very high priority for E-320

```
08:30 pm: there is still a low-energy electron tail even though Ops tried many things. Corrector
 Y3017, Y3057 correctors and sextupoles were talking to the tail and might have improved
 its intensity. The sextupoles could split the tail into two which led to the hypothesis
 that the two tails is maybe two parts of the beam that are scattered around the very
 small hole in the US Be window. When setting sextupoles to this 2-tail mode it was possible
 to move the separation between the tails with correctors.
Scattering on SYAG could be excluded
```

Time for recovering collisions has been significantly reduced

09:00 pm: Starting alignment to E320 setup
09:19 pm: Compressor window out now
09:45 pm: Focal scan before beam shaping
http://physics-elog.slac.stanford.edu/facetelog/show.jsp?dir=/2024/18/29.04&pos=2024-04-29T21:4
22:00 pm: Beam shaping with deformable mirror
Dataset after beam shaping
http://physics-elog.slac.stanford.edu/facetelog/show.jsp?dir=/2024/18/29.04&pos=2024-04-29T22:1

11:00 pm: vertical beam edge at 48.3175 mm http://physics-elog.slac.stanford.edu/facetelog/show

11:25 pm: drilled a hole accidentally: http://physics-elog.slac.stanford.edu/facetelog/show.jsp

11:30 pm: darkened YAG on the edge: http://physics-elog.slac.stanford.edu/facetelog/show.jsp?di

11:45 pm: found horizontal overlap: ht

01:00 am: found EOS timing (EOS 2) at

01:10 am: beam was at 5 Hz for a while
http://physics-elog.slac.sta

02:09 am: collisions! http://physics-
t0: 1255.2675
EOS delay stage: -19

1st day: 5-6 hours

2nd day: 4 hours

04/30/2024 23:59 Team E320 **E320 running log**

18:00 pm Laser in tunnel. EOS2 signal found. Moved compressor grating separation back to 26.6 and EOS delay back to -21, matching previous conditions for optimal pulse duration: http://physi

19:00 pm Focus recovered on MO_MAG, still looks nice: http://physics-elog.slac.stanford.edu/fac

20:20 pm beam intercepted with YAG in vertical direction at position 48.55 mm

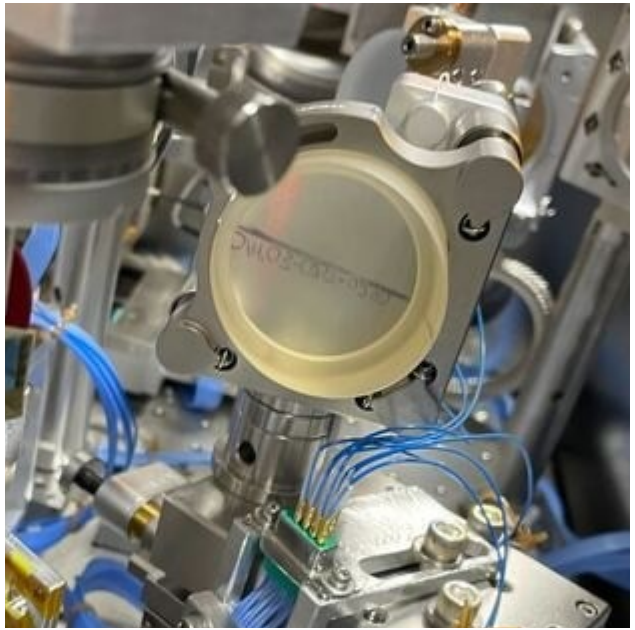
20:37 pm Laser vertically aligned

21:15 pm Laser spatially aligned, going for collisions

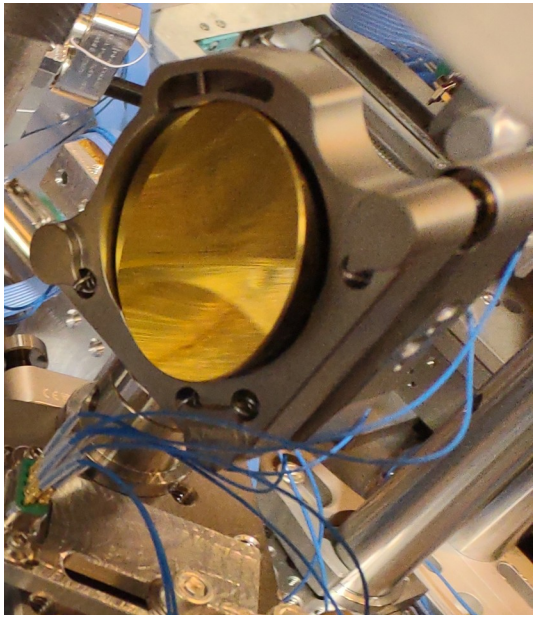
22:00 pm recovered collisions

- Importance of multi-day shifts: 2nd day was always much more productive
- Science program is getting too complicated for single-day shifts

Installation of dielectric λ/10 OAP (Alex & Junzhi, April 24, 2024)

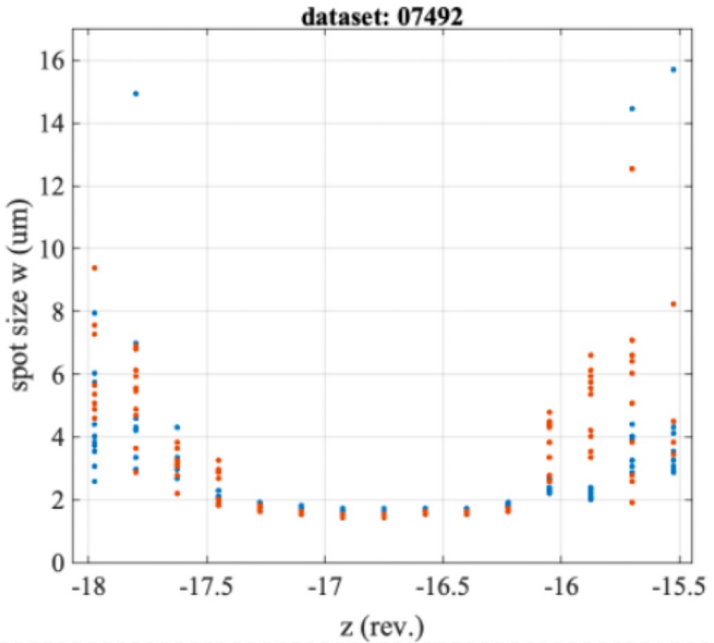


new, dielectric OAP, λ/10

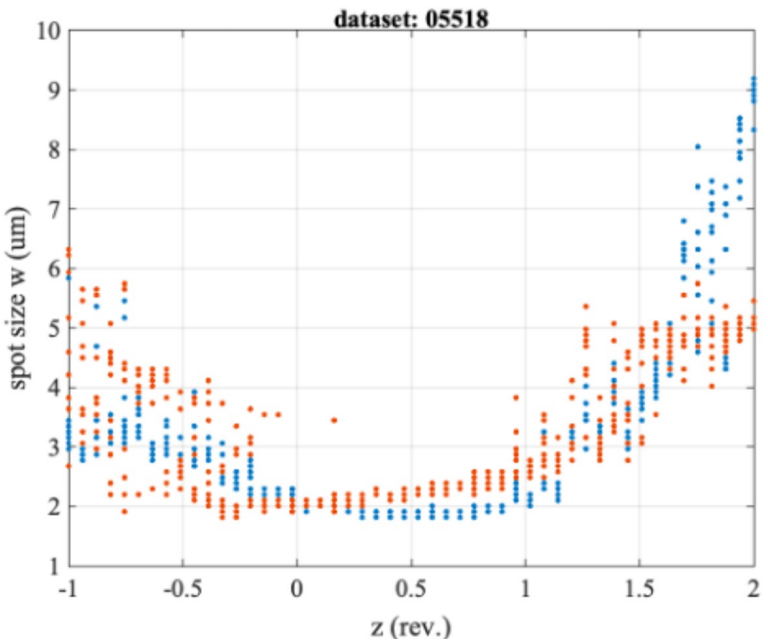


old, gold OAP, λ/4

Dielectric λ/10 OAP: improved focal quality



new, dielectric OAP, λ/10

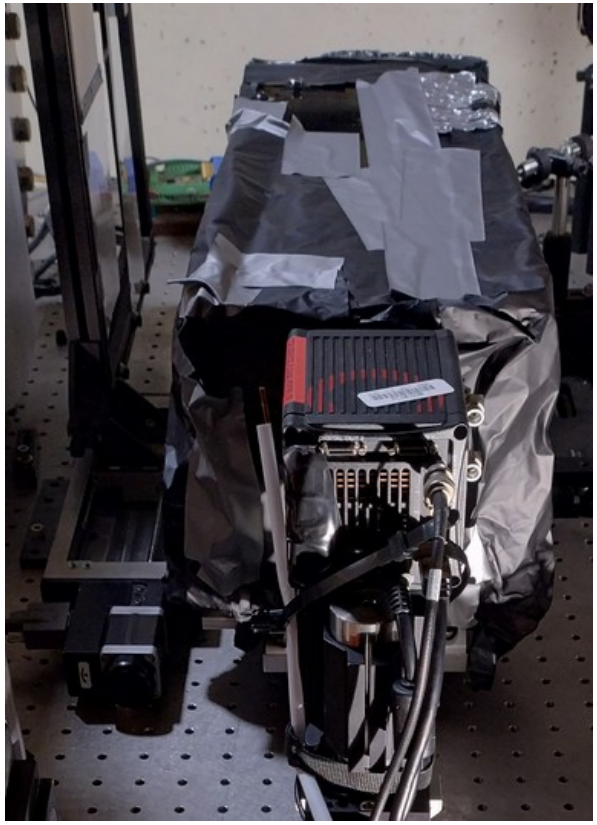


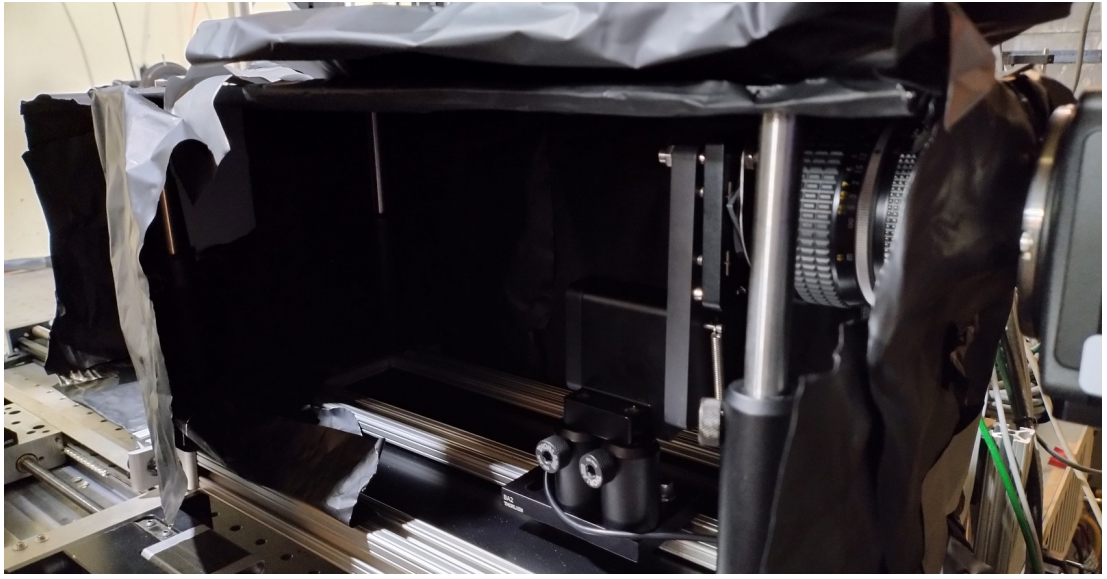
old, gold OAP, λ/4

Analysis & plots: Alex

Better spot quality, higher Strehl, much improved focal scans

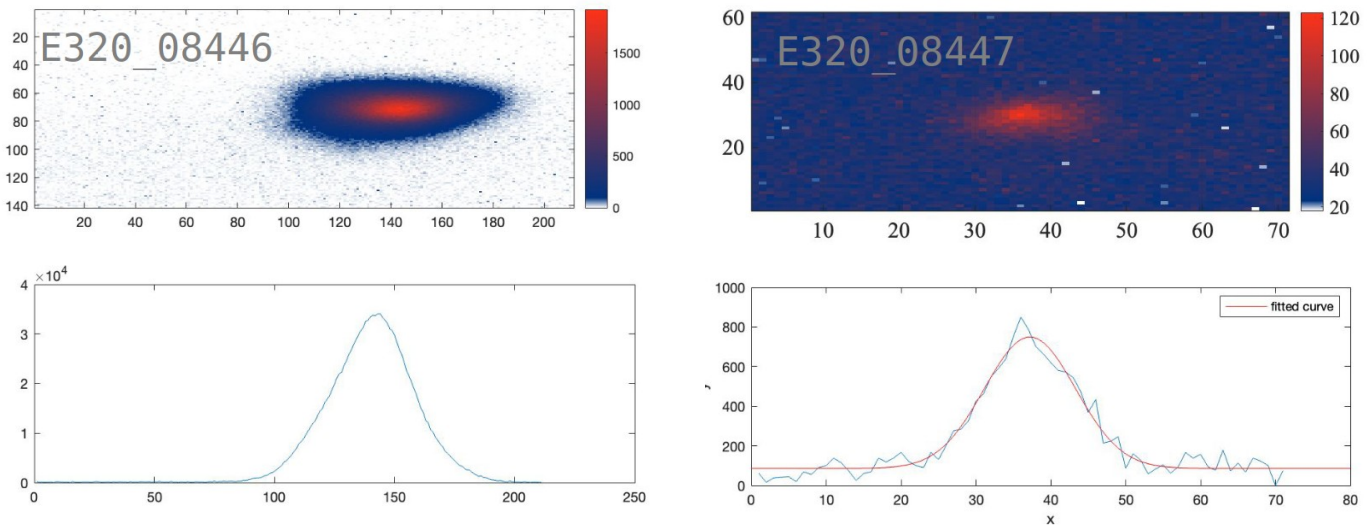
Low-Background LFOV (Alex & Me)





- ORCA FLASH 4.0 + Nikkor 50mm f/1.2 + DRZ fine
- Sees up to 24.4 cm over the table surface
- Allows us to detect low-energy scattered electrons
- Great “temporary” solution while ePix is not available

Low-Background LFOV: dark-current calibration



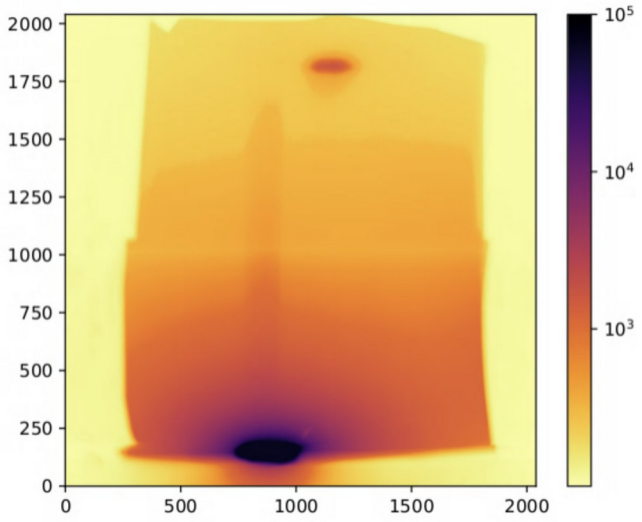
Analysis & plots: Alex

Significant higher sensitivity in comparison with respect to LFOV

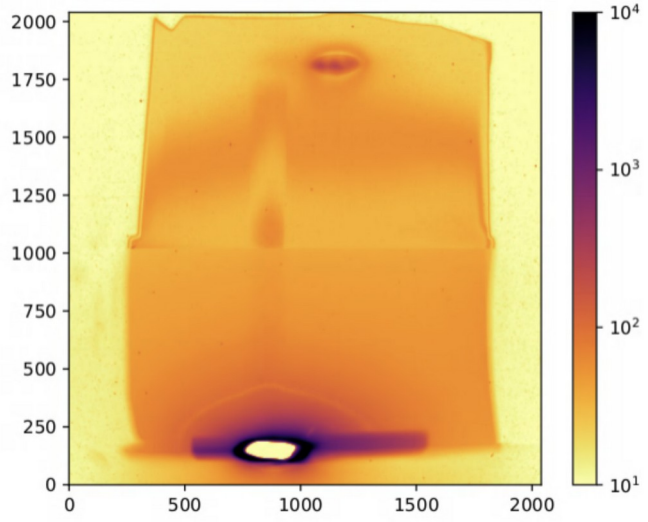
This downtime: LBG_LFOV v2

- have entire screen in focus, e.g., using Scheimpflug optics (thanks Doug)
- Improve flatness of screen, possibility to add filters for x-rays
- Improve the modularity (easy access, easy changes) and stability (change stage)

Goose trigger: crucial to remove “fictitious signals”



mean background image

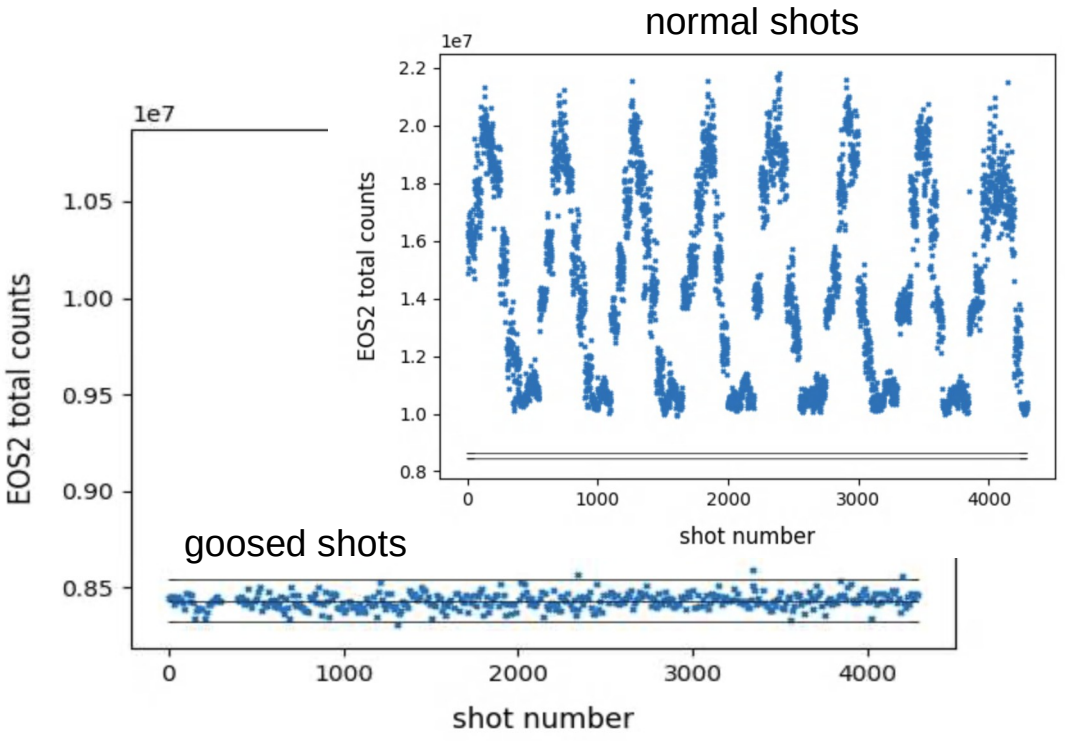


standard deviation

- Background subtraction important for high-quality data (high-frequency features in bg)
- We see large shot-to-shot fluctuations in the background; bias-free statistics is important
- Currently: regular goose pattern, aligned with power-line harmonics etc. (1-off, 9-on, etc.)

Pseudo-random goose trigger as for LCLS is crucial for high-quality data

Goose identification: EOS signal strength

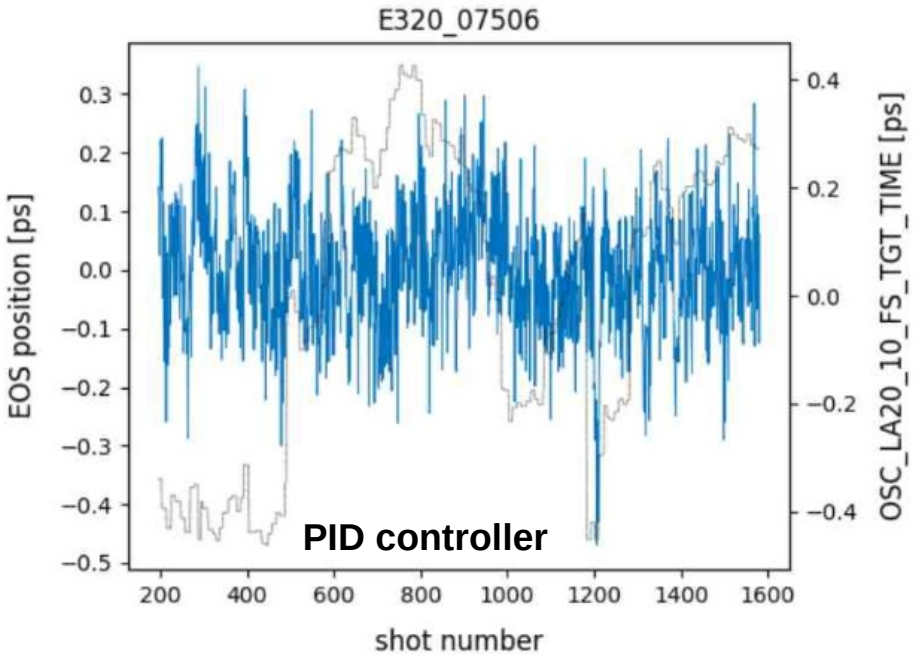


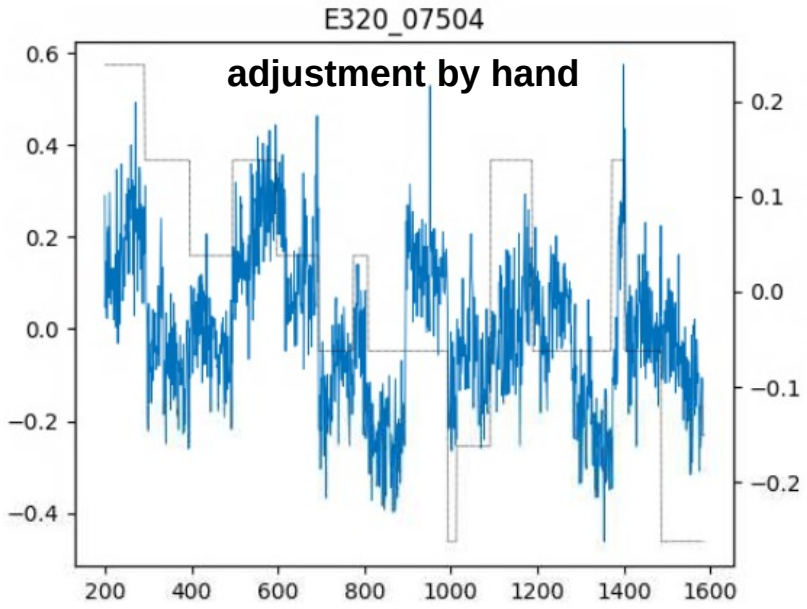
analysis & plots: Tania

- We can identify “goosed” shots using a clustering algorithm
- If we change laser intensity / timing the signal on EOS changes and for low intensities EOS is unusable

It would be convenient to have a PV that provides the status of the trigger

EOS-based timing stabilization (Alex)

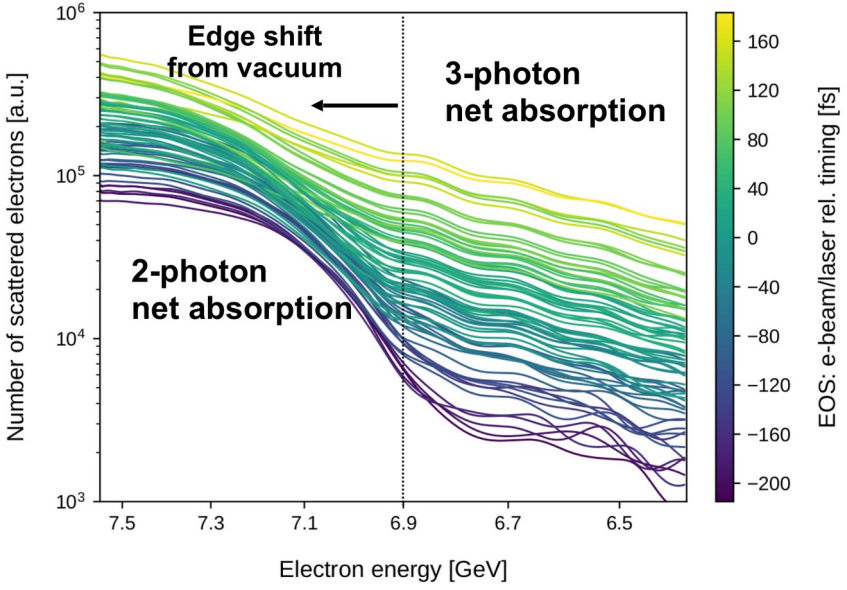




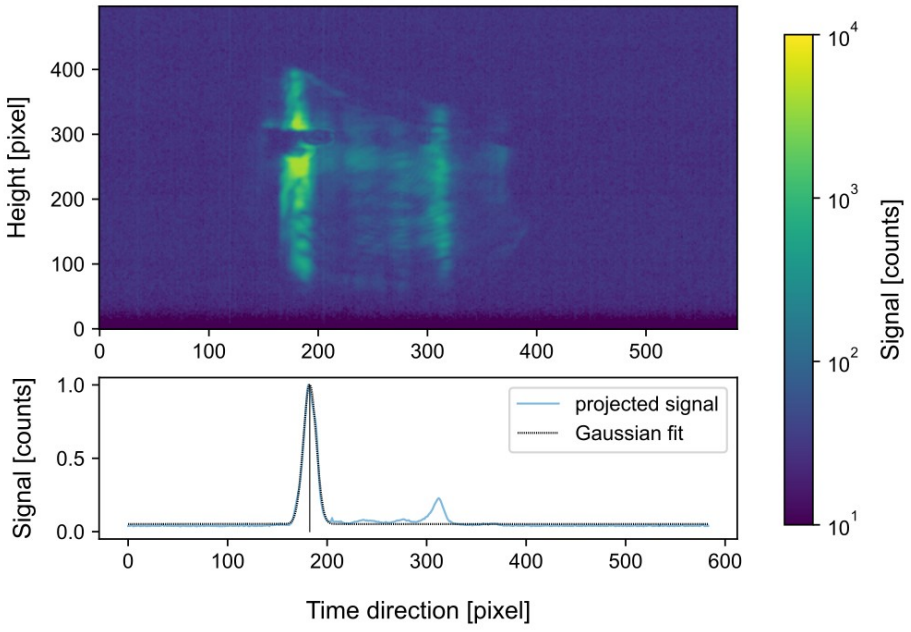
PID feedback helps to stabilize relative timing drifts between “requested” and “actual”

EOS: crucial for getting shot-to-shot timing information

Analysis & plots: Tania



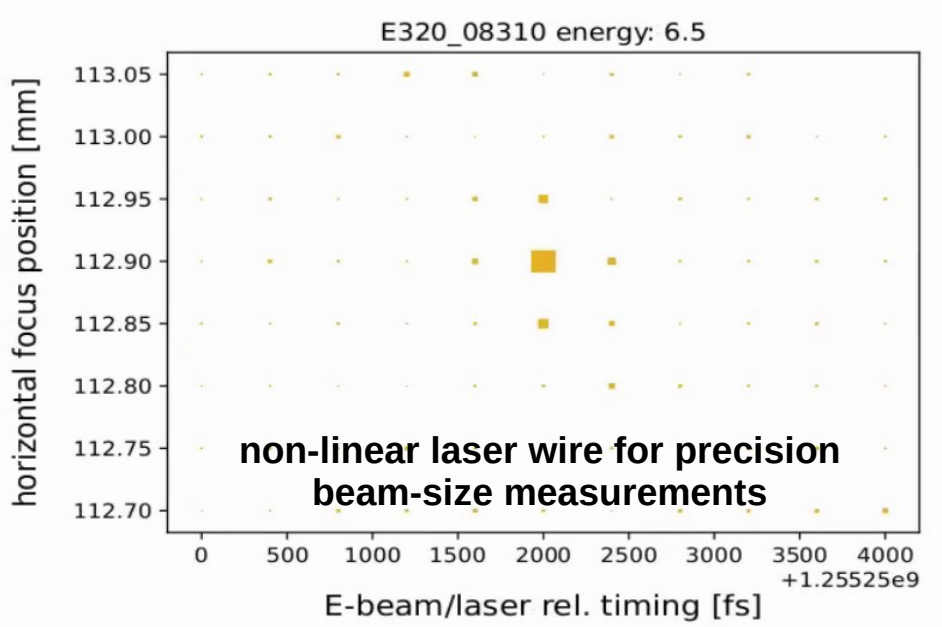
EOS camera image

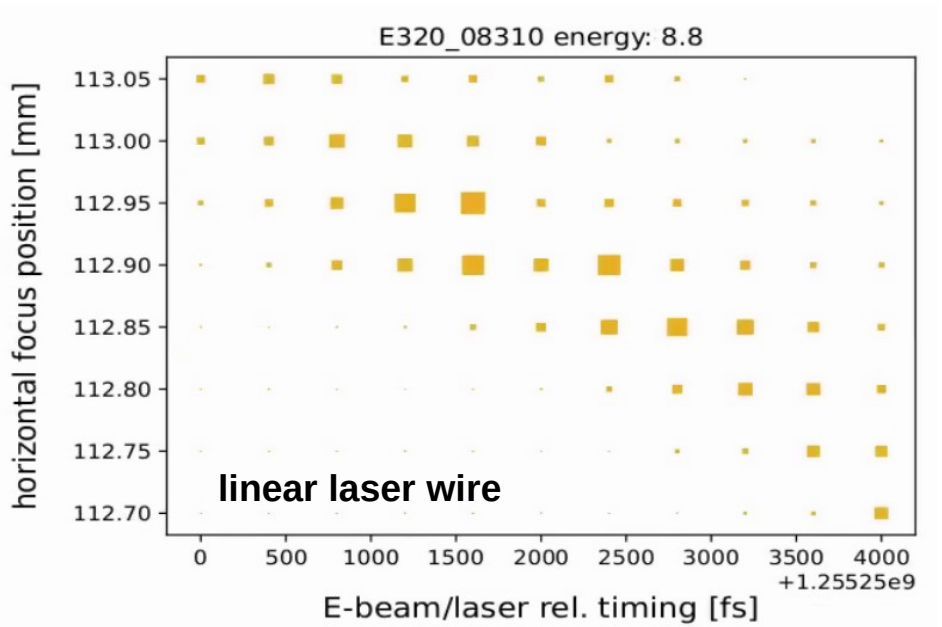


Transition from perturbative to non-perturbative spectrum is a Nature-scale paper

- The relative arrival time has a big impact on the effective collision geometry
- Suggestion: improve EOS resolution using Wollaston prisms (David)

Online analysis for fine-tuning collision parameters (Tania)



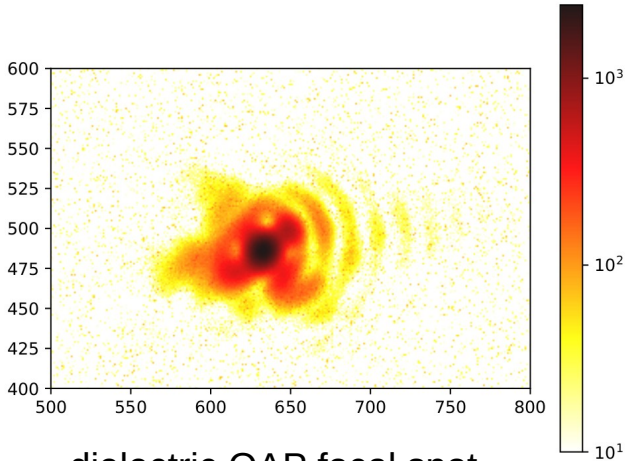


- We can determine the optimal beam overlap after ~10 minutes of data processing
- We couldn't take better measurements (our final shift had very little accelerator up-time)

Priority for Oct./Nov.: repeat this measurement with higher spatial resolution

Future improvements

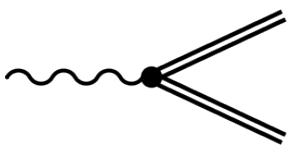
Increase the peak laser intensity



dielectric OAP focal spot
(E320_08307)

- Currently, we sent at most 0.6 J to the tunnel
  (when can we return to 0.8 J; is ≳ 1 J feasible?)
- Transport / compressor efficiency: 0.48
  (dynamic splitting between main & probe feasible?)
- Current best: 50 fs, 0.3 Joule on target: **a_0 ~ 5**

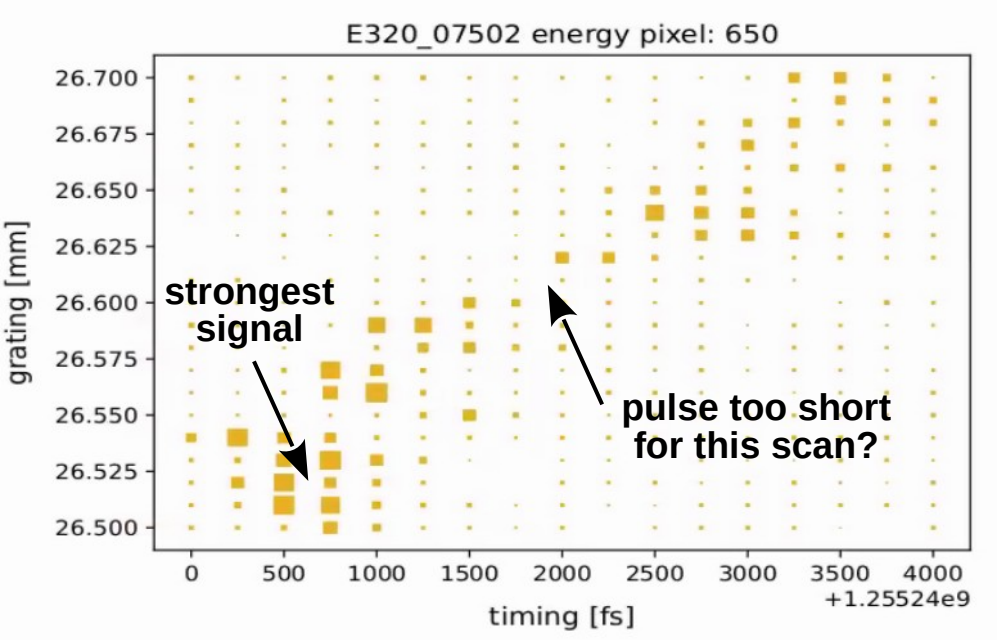
We need to increase to a_0 ≳ 7-8 to see positrons and to see multiple hard emissions

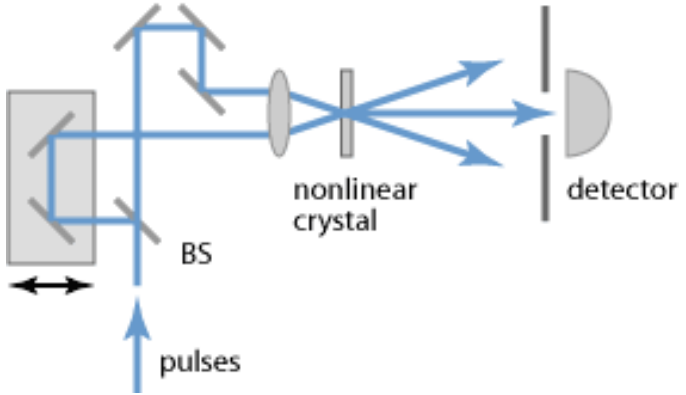


Tunneling electron-positron pair production (Nature-scale publication)

Clear dominance of higher-order emissions (potential Nature-scale publication, depending on what we can claim; requires more theory work)

Need to understand the laser pulse duration





https://www.rp-photonics.com/autocorrelators.html

Where do we have the shortest pulse duration?

Can we fit an autocorrelator into the compressor?

Measurement of the actual pulse duration during the experiment is highly desirable

DAQ: reliability with 5-10 cameras; flexible scan functions

Currently we are limiting ourselves to 3 cameras that are absolutely necessary:

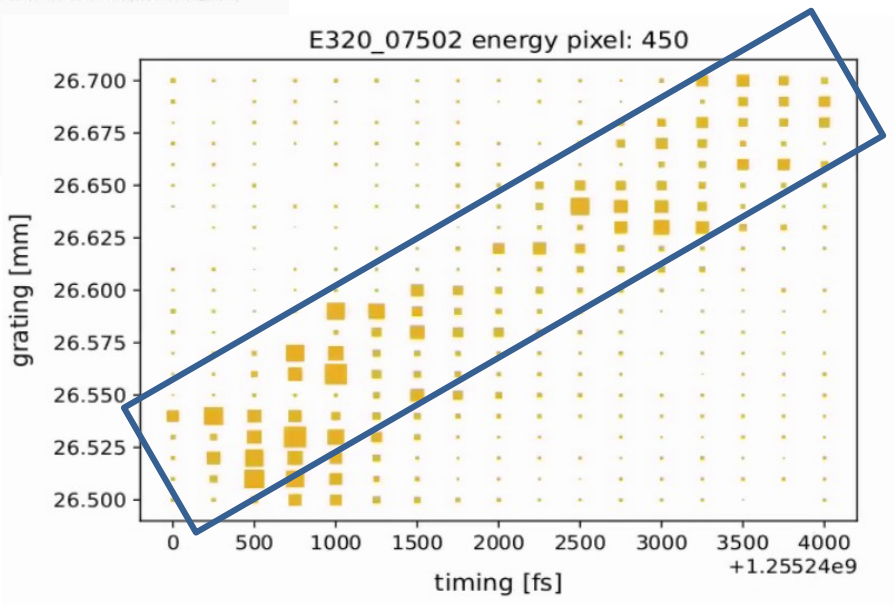
05/21/2024 04:52 E320 **E320_08314 DAQ**

x-t scan Goose on, timing feeedback off, laser 100EOS2, GAMMA1, LBG_LFOV,
FACET DAQ 08314 for **E320**.
30 shots per step and 4 steps.
Scan of E320_OAPAssembly_horizontal (PV XPS:LI20:MC10:M3) from 112.70 to 113.05 in 2 steps.
Scan of LASER_TIME_Scan (PV OSC:LA20:10:FS_TGT_TIME) from 1255.25 to 1255.25 in 2 steps.
Path: /nas/nas-li20-pm00/E320/2024/20240521/E320_08314

NAME	SAVE	REQ	MATCH
EOS2	120	120	120
GAMMA1	120	120	120
LBG_LFOV	120	120	120

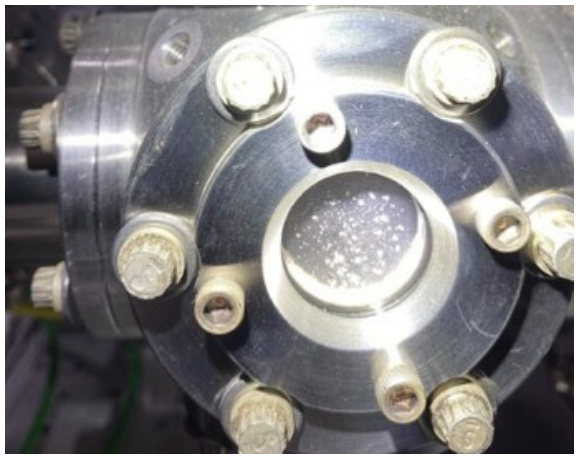
Future runs:

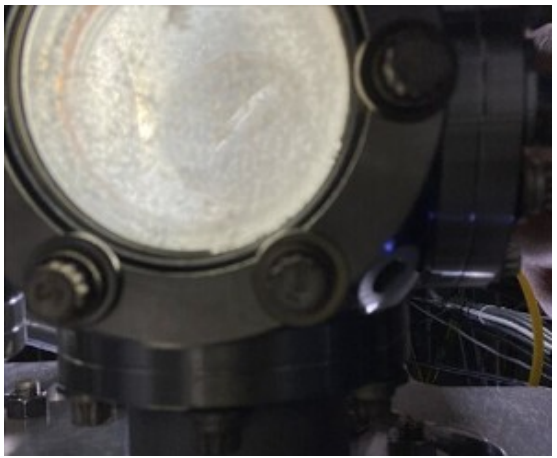
scattered electrons	LBG_LFOV + EDC
gamma radiation	GAMMA1 + 2
positrons	PDC_CAM
relative timing information +BPM:	EOS1 + 2
laser post-focus diagnostic:	PB_NEAR + FAR



flexible scan functions (e.g., diagonal)

Risk of Lithium contamination in the PB



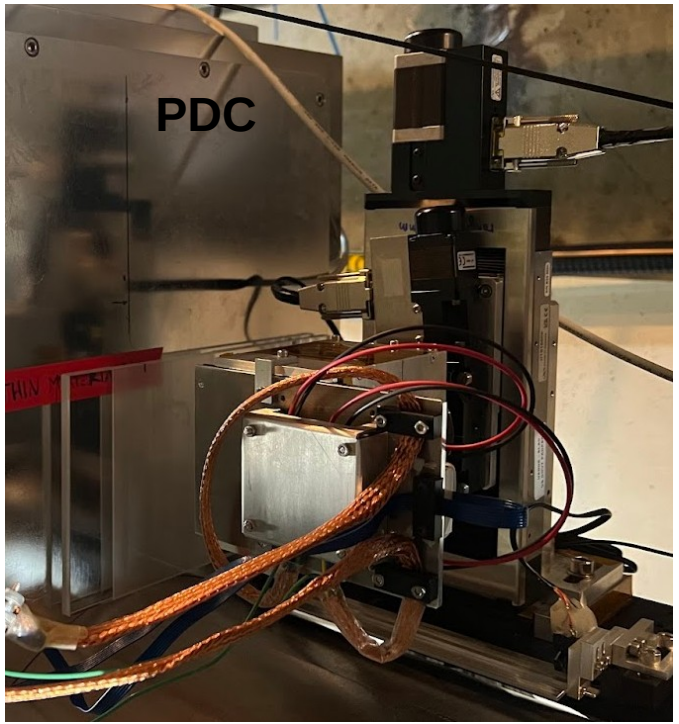


major concern for E-320

- We are worried about damage to our expensive optic (dielectric OAP)
- Other concerns: corrosion of, e.g., TRA motors (currently no spares)
- It is important to coordinate when the oven is running, such that we can take out the OAP
- Do we have a cleaning procedure in case there will be large-scale contamination?

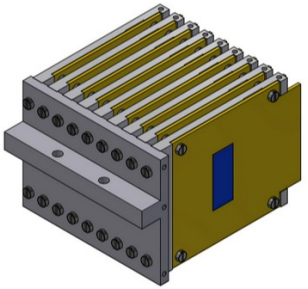
We are grateful for the help of the facility, e.g., spare OAP and risk mitigation

Positron tracker (Noam Tal Hod's group @ Weizmann, T-619)



- Thin monolithic active pixel sensors (MAPS), dubbed "ALPIDEs" (ALice PIxel Detector)
- Produced by TowerJazz for the upgrade of the ALICE experiment at the LHC
- Radiation hardness: technology was selected for HL-LHC heavy ion collisions

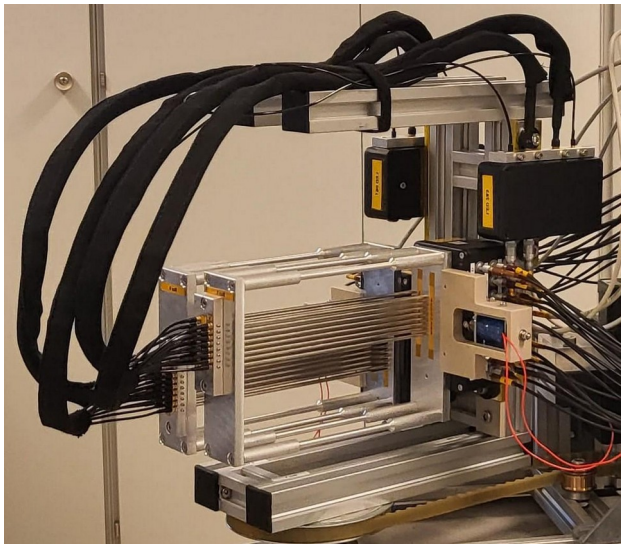
Details: LUXE TDR (https://arxiv.org/pdf/2308.00515.pdf)



Tracker is crucial for identifying laser-produced positrons and reducing backgrounds

LUXE Electron Detection System (DESY, T-618)

Installation at the FACET-II dump table



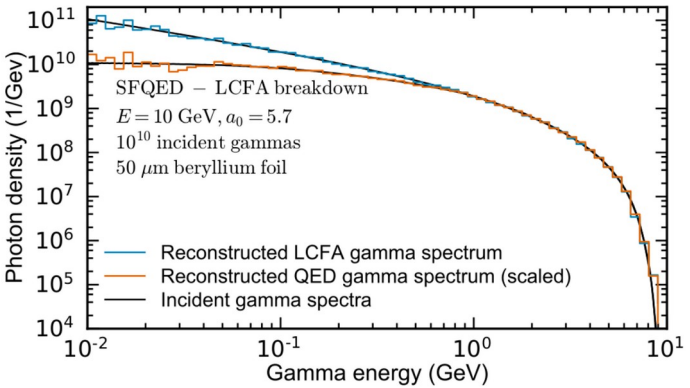
DESY team: A. Athanassiadis, L. Hendriks, L. Helary, R. M. Jacob, J. List, E. Ranken, I. Schulthess, M. Wing

LUXE TDR: https://arxiv.org/pdf/2308.00515.pdf
EPS talk: https://indico.desy.de/event/34916/

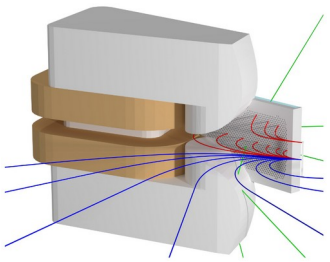
First tests have been successful; waiting for E-320 data taking in Oct./Nov.

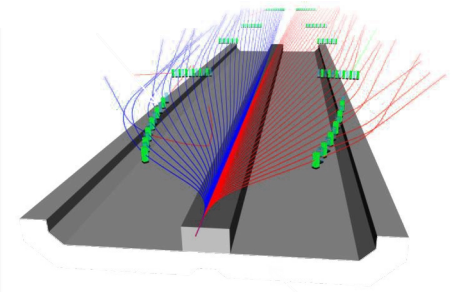
Gamma-ray spectrometer (UCLA)

Measure photon formation length



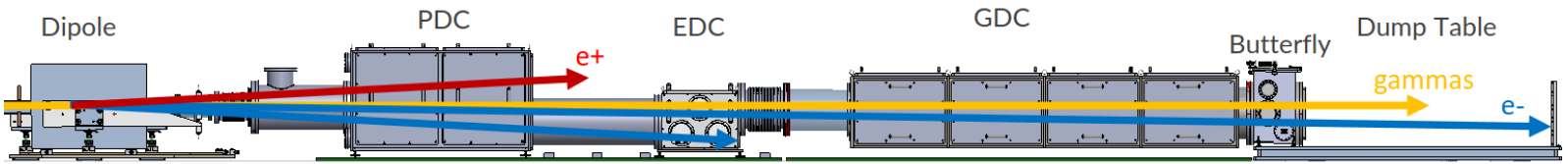
UCLA group





Compton (MeV) + gamma pair spectrometer (GeV)

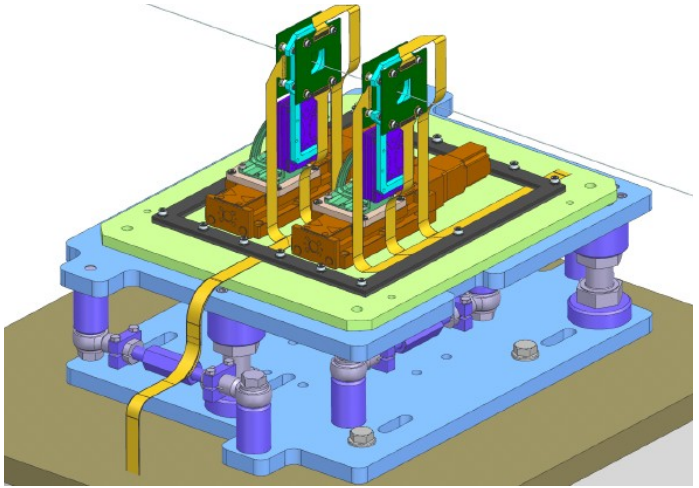
B. Naranjo et al., IPAC2021 THPAB269, THPAB270 (2021)



High priority: LCFA breakdown (nature-scale publication)

Gamma-ray profiler with high resolution

Sapphire-strip detector

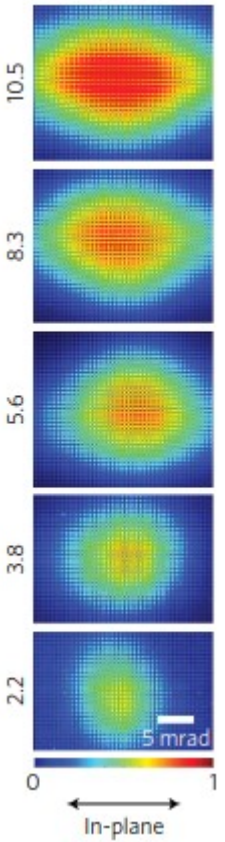


2x2cm^2 field of view, 5-10 μm resolution,
High radiation resistance (Sapphire)

The gamma-profile ellipticity is related to a_0 in the interaction region

High-order multiphoton Thomson scattering
Yan et al., Nature Photon. 11, 514 (2017)

Har-Shemesh & Di Piazza
Opt. Lett. 37, 1352–1354 (2012)



INFN, U. Bologna, & U. Padova: P. Grutta, M. Bruschi, M. Morandin, F. Lasagni, S. Vasiukov, U. Dossell
QUB: K. Fleck, N. Cavanagh, E. Gerstmayr, M. Streeter

Thank you all for your support of E-320

In particular Doug Storey, Ivan, Juan, & Doug McCormick