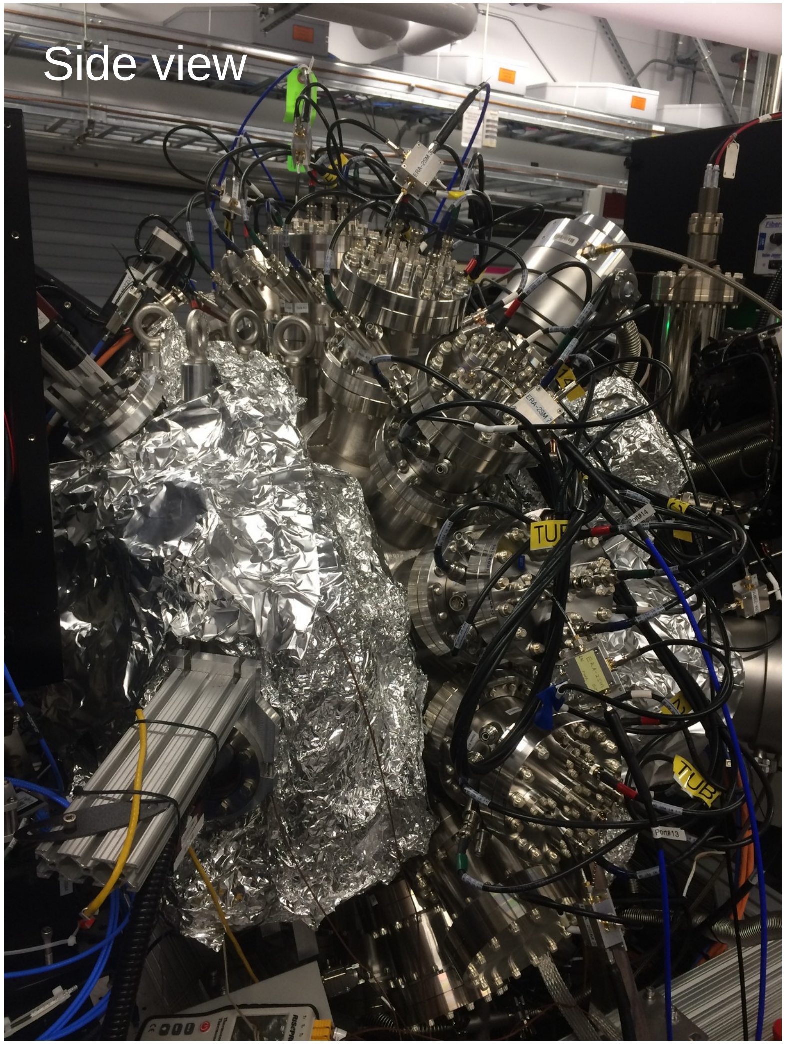
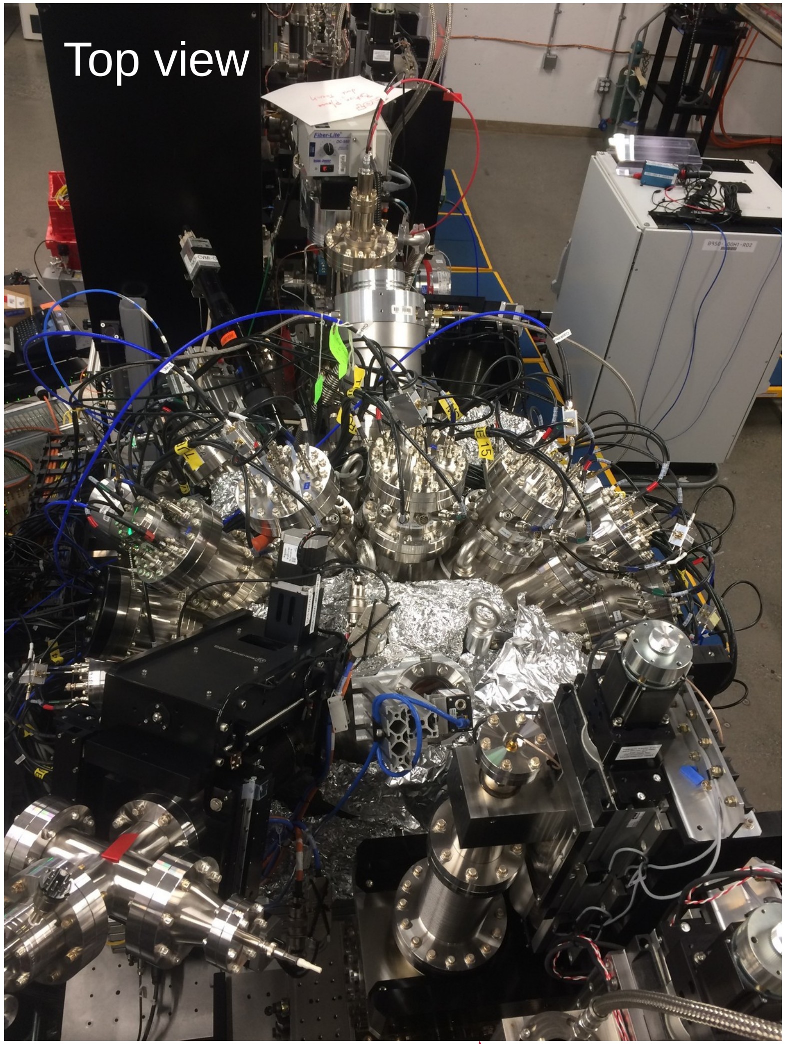
Installed system



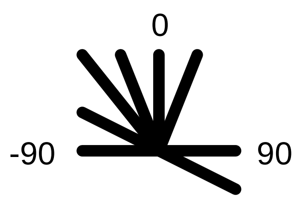


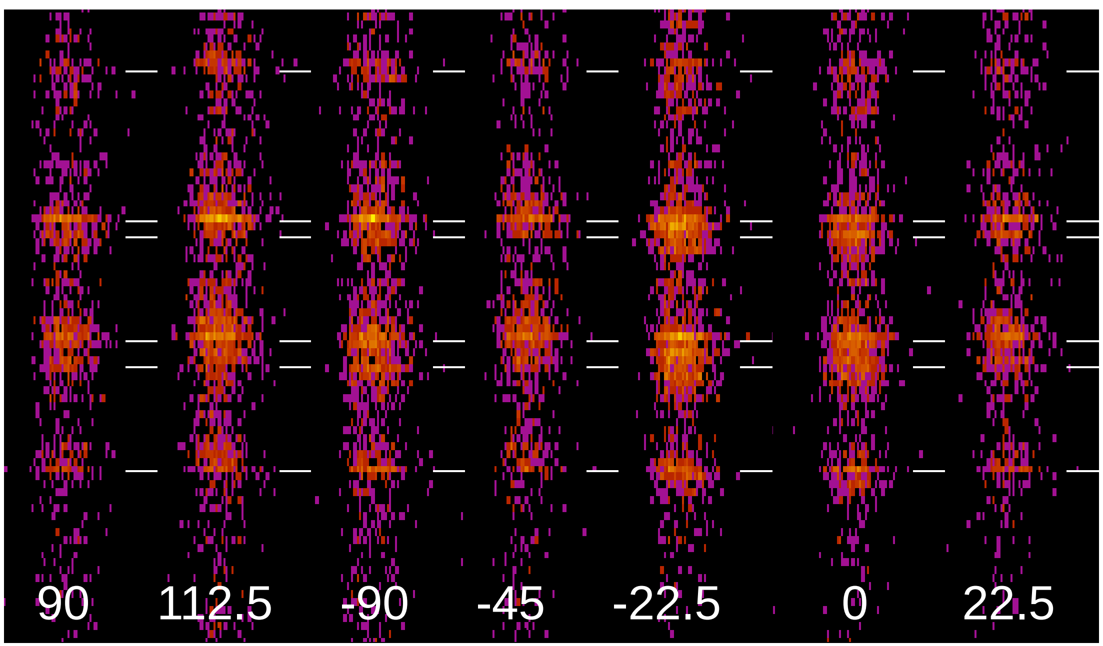
Inside the chamber

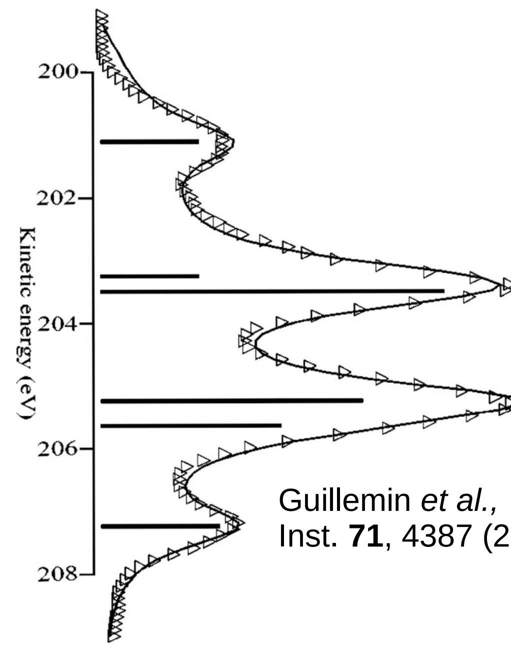
- 8 ToFs installed, 2 bare MCPs for “Current mode” resilience testing
- Positioning paddle, Gas needle, 4 pumps

Resolution measurements with Argon *LMM*

- 201, 203, 205, 207 eV spectral features with 100 V retardation
- Preliminarily ½ eV resolution at 100eV pass energy (maybe ¼ eV)





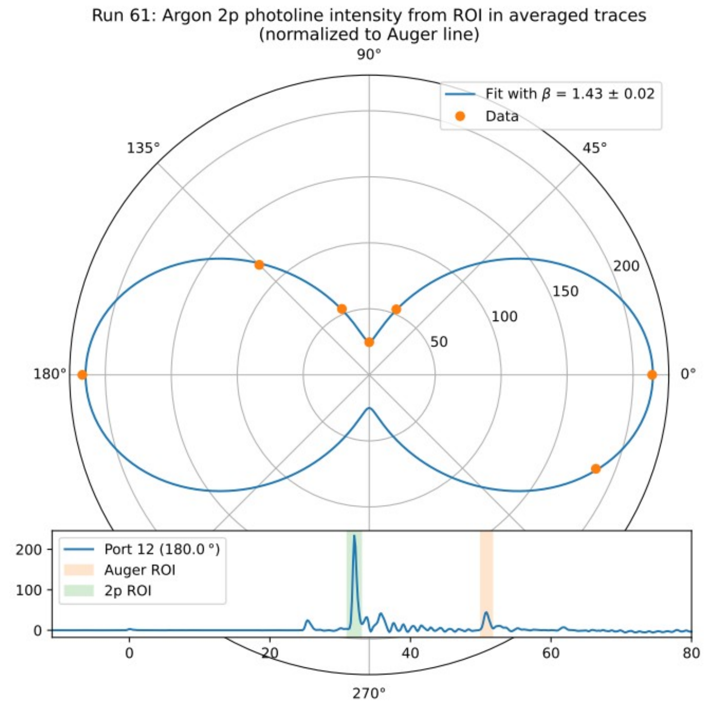


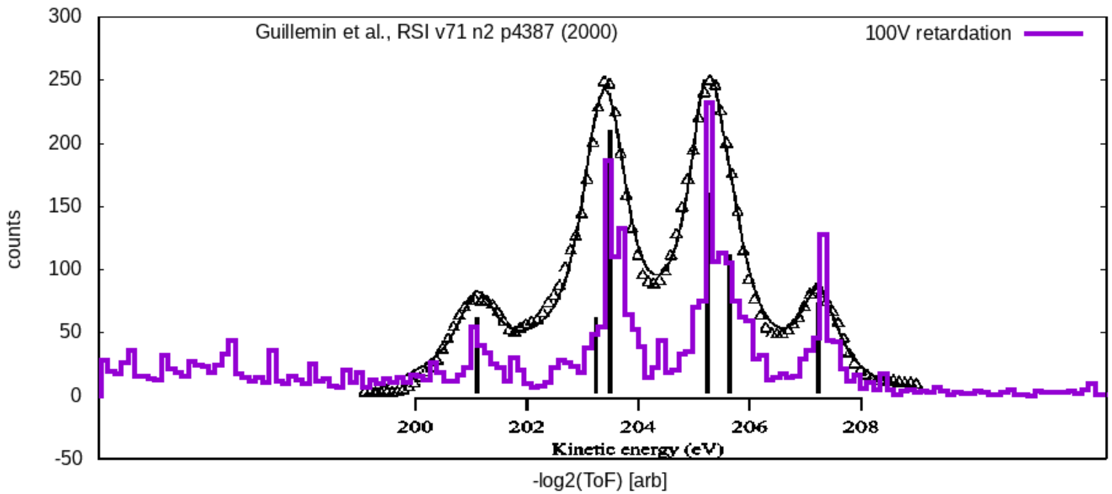
Guillemin *et al.*, Rev. Sci. Inst. **71**, 4387 (2000)

Argon *LMM* Auger resolution and 2p angular resolution

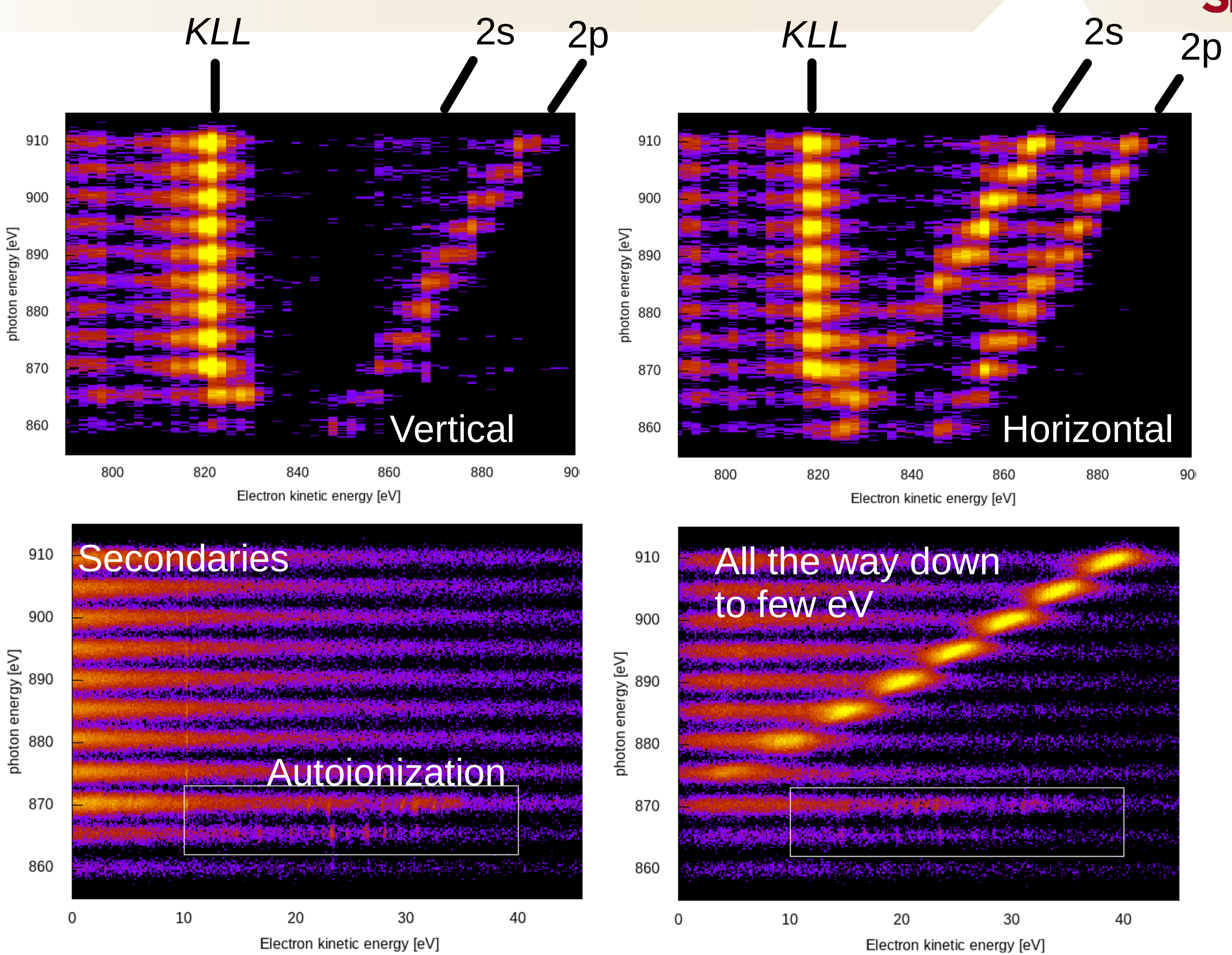
Courtesy Lars Funke

- Looks like simulation
- Measured 1.43 *vs* 1.465… validates use as polarimeter
-
- Potentially ½ or ¼ eV resolution at 100eV pass energy



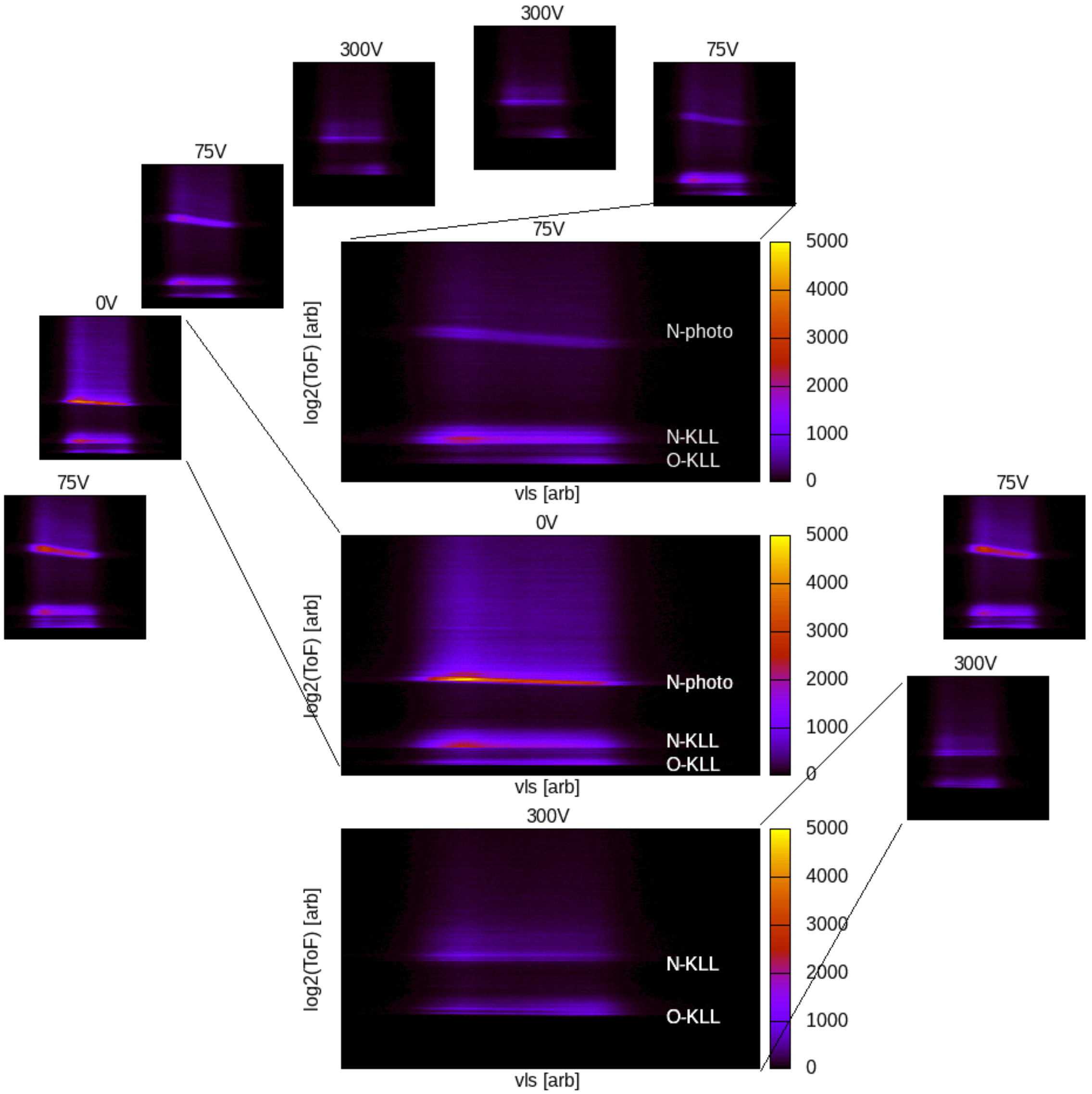


Neon Augers, Photos and Autoionizing $1s^2\,2s^1\,2p^4\,3p$
E/dE > 200 for single 0 eV -- 1 keV spectral window

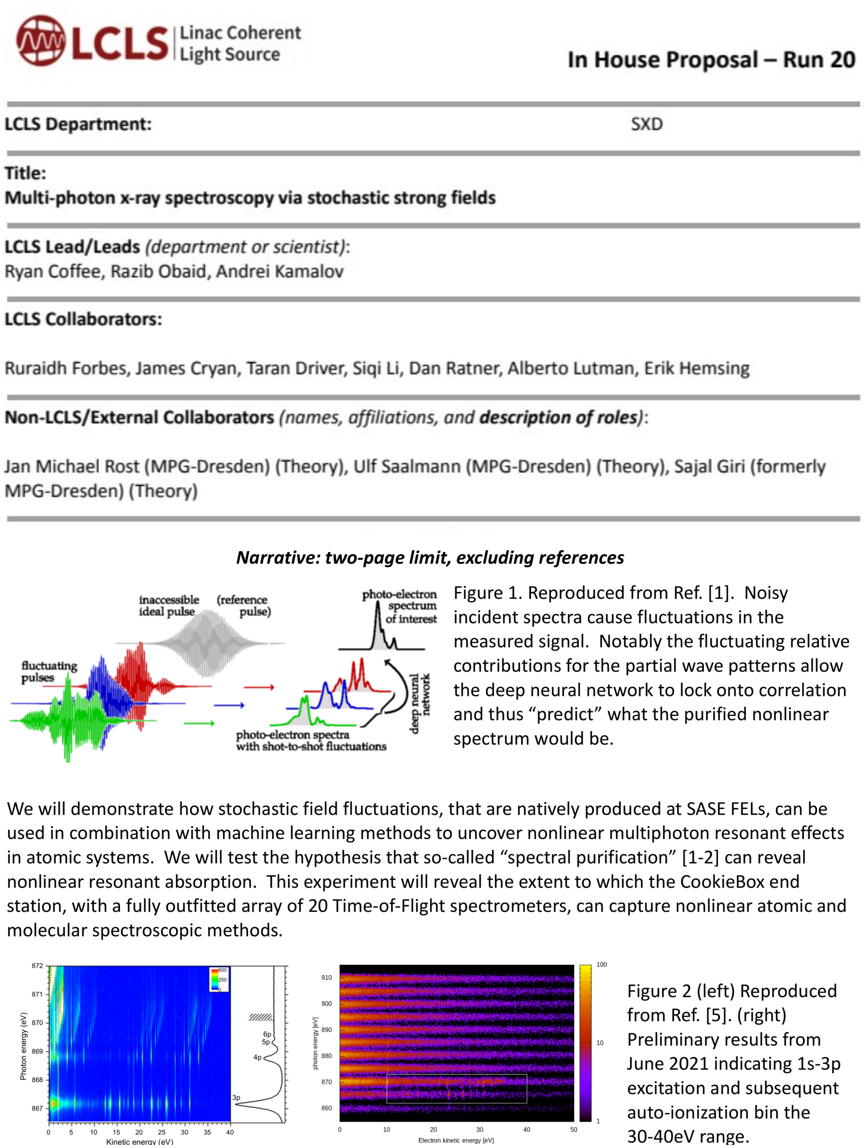


Multi-edge resolution

- N_2O Resonant Auger
- N 1s photoelectrons (75V)
- N KLL and O KLL Auger electrons (300V)
- Haven't yet pushed resolution here yet
- Surrogate demonstration for multi-color measurements



Autoionizing features motivates multi-path interference



LCLS Linac Coherent Light Source

In House Proposal – Run 20

LCLS Department: SXD

Title:
Multi-photon x-ray spectroscopy via stochastic strong fields

LCLS Lead/Leads *(department or scientist)*:
Ryan Coffee, Razib Obaid, Andrei Kamalov

LCLS Collaborators:

Ruraidh Forbes, James Cryan, Taran Driver, Siqi Li, Dan Ratner, Alberto Lutman, Erik Hemsing

Non-LCLS/External Collaborators *(names, affiliations, and* ***description of roles****)*:

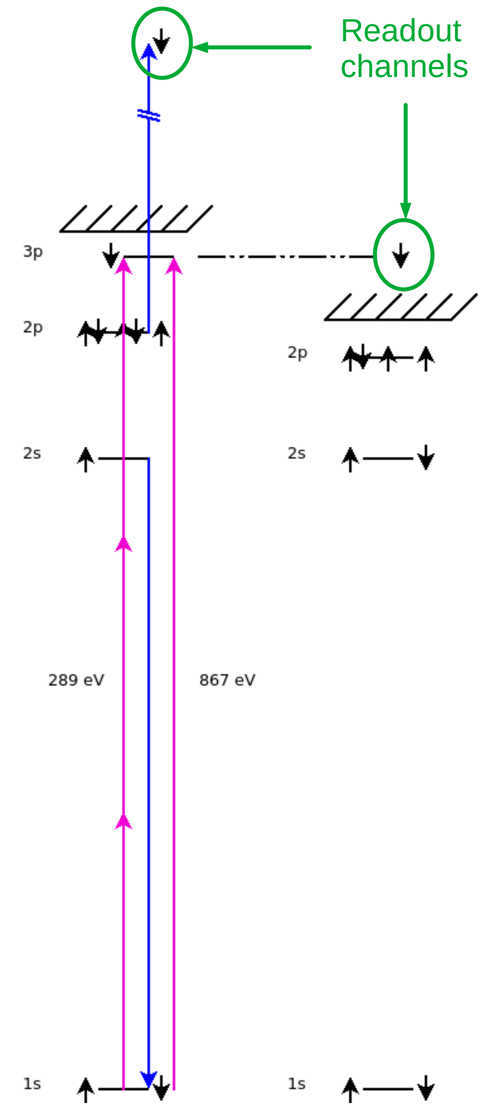
Jan Michael Rost (MPG-Dresden) (Theory), Ulf Saalmann (MPG-Dresden) (Theory), Sajal Giri (formerly MPG-Dresden) (Theory)

Narrative: two-page limit, excluding references

Figure 1. Reproduced from Ref. [1]. Noisy incident spectra cause fluctuations in the measured signal. Notably the fluctuating relative contributions for the partial wave patterns allow the deep neural network to lock onto correlation and thus "predict" what the purified nonlinear spectrum would be.

We will demonstrate how stochastic field fluctuations, that are natively produced at SASE FELs, can be used in combination with machine learning methods to uncover nonlinear multiphoton resonant effects in atomic systems. We will test the hypothesis that so-called "spectral purification" [1-2] can reveal nonlinear resonant absorption. This experiment will reveal the extent to which the CookieBox end station, with a fully outfitted array of 20 Time-of-Flight spectrometers, can capture nonlinear atomic and molecular spectroscopic methods.

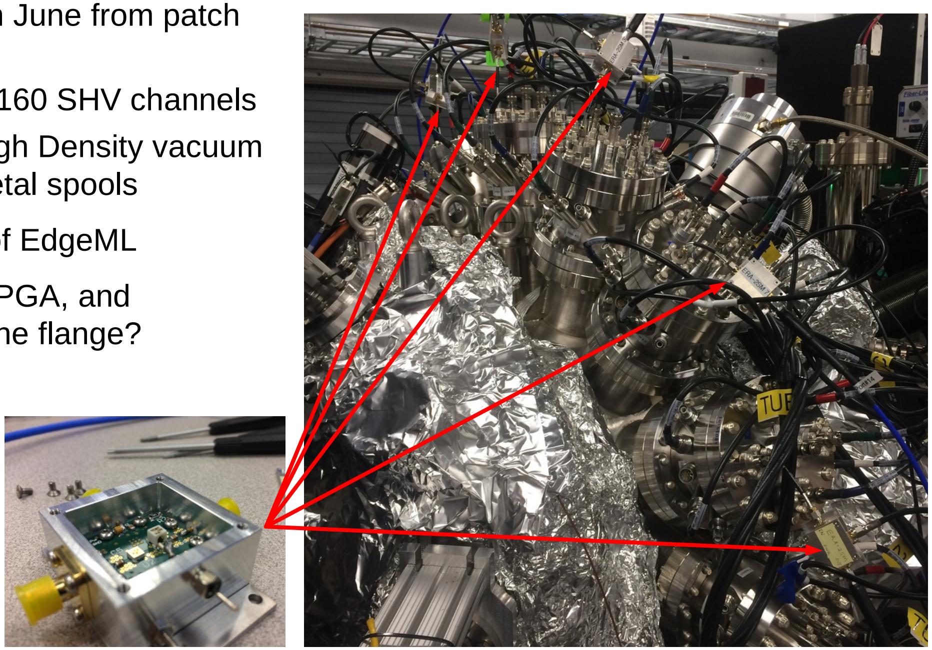
Figure 2 (left) Reproduced from Ref. [5]. (right) Preliminary results from June 2021 indicating 1s-3p excitation and subsequent auto-ionization bin the 30-40eV range.



High Density HV, High Density Data

- From 70 SHV cables in June from patch panel...

  … to a full build out of 160 SHV channels
- Ideally MDC can do High Density vacuum feedthroughs in mu-metal spools
- Very “sensor” frontier of EdgeML
- Can we put an ADC, FPGA, and EdgeTPU actually on the flange?



Bridge Data Center AI Systems with Edge Computing for Actionable Information Retrieval

A Preprint

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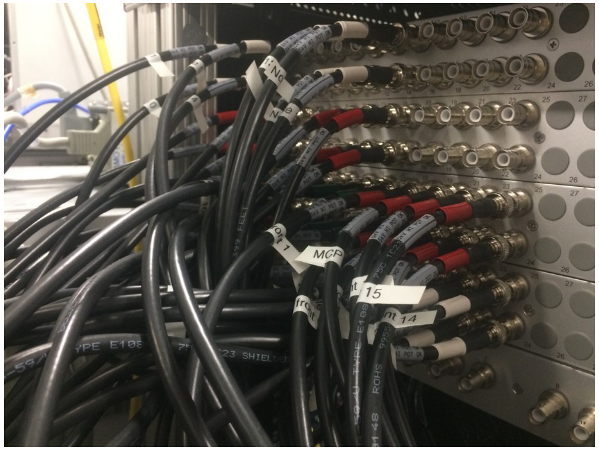

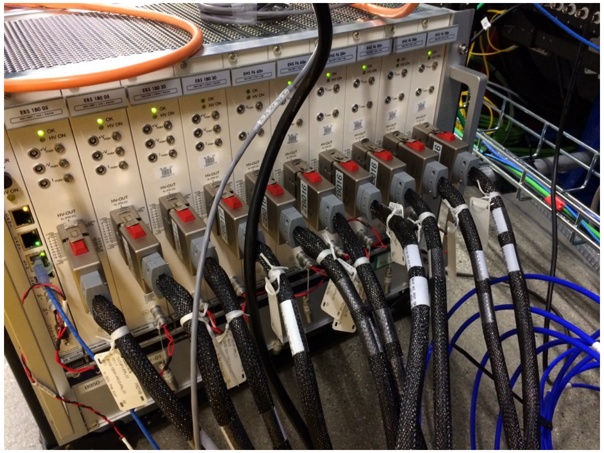

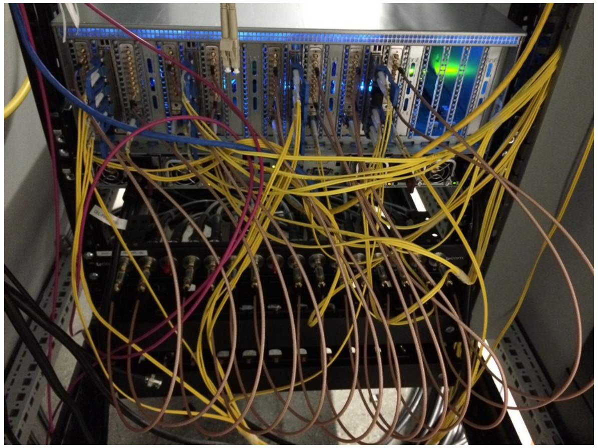

Enabling Strategic Developments – EdgeAI

Actionable Information from Sensor to Data Center

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Ryan Coffee, SLAC
Chun Hong Yoon, SLAC
Ryan Herbst, SLAC
Ian Foster, Argonne
Peter Kenesei, Argonne
Zhengchun Liu, Argonne
Antonino Miceli, Argonne
Nicholas Schwarz, Argonne

May 1, 2020

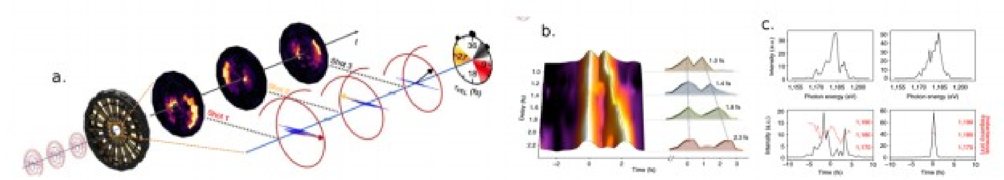

Figure 1: From Ref. [1]. a) CookieBox detector used for attosecond streaking. b) Individual events: pulse reconstruction identifies double x-ray pulses. c) Pulse retrieval for individual shots.

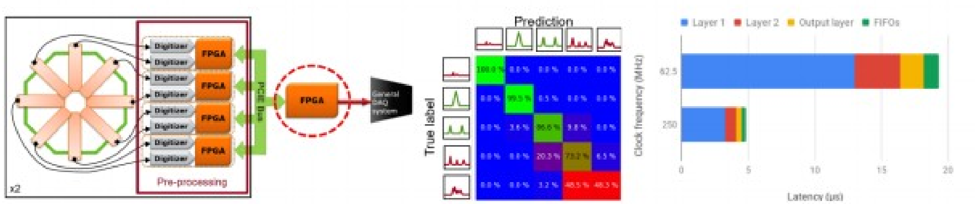

Figure 2: **L**: Schematic of preprocessing in digitizer FPGAs [6]; pre-processed results are collated into deeper fully connected neural network layers, circled in red. **C**: Confusion matrix for predicting number of sub-spikes in a SASE x-ray FEL pulse. **R**: Inference latency for network implementation in FPGA, Xilinx model XCKU115.

Red Hat

The Enterprise Neurosystem

The connective intelligence of Enterprise AI

Community Vision & Overview

Corbeil Therrien *et al.*, "Machine Learning at the Edge for Ultra High Rate Detectors" NSS-MIC, 1-4, (2019) doi: 10.1109/NSS/MIC42101.2019.9059671

The CookieBox → MRCO Team

- Omar Quijano (TID-AIR Staff)
  - EdgeML system admin
- Matt Feldman (EE/CS PhD Student) – Samba Nova
  - Spatial-lang for FPGA
- Audrey Corbeil-Therrein (Banting Post-Doc Fellow) – Faculty @ U. Sherbrooke
  - FPGA developer and ASIC design
- Andrei Kamalov (TMO Post-Doc)
  - Laser lab testing and demonstration, CookieBox design and assembly, beamtime co-lead
- Razib Obaid (TMO Project Scientist)
  - Detector R&D, CookieBox assembly, beamtime collaborator
- Averell Gatton (TMO Post-Doc) – (Clostra, Inc.)
  - Simulations and model training, CookieBox design, beamtime author
- Debadri Das (Applied Physics PhD Student)
  - Signal processing and algorithms
- Jack Hirschman (Applied Physics PhD and CS Student)
  - RF electronics, FPGA, ASIC, and source control
- Naoufal Layad (Institute for Computational and Mathematical Engineering Masters Student)
  - Surrogate modeling, Ensemble methods and Bayesian Networks
- Coffee (CookieBox lead), Walter (TMO/MRCO lead), Dragone (ASICs/Detectors), Herbst (FPGAs), Cryan (AMO)

Enabling Accelerator R&D and nonlinear x-ray methods

- Attoclocking in the FEE
  - Bigest question was THz in the FEE
  - Zhirong Huang, Alan Fisher, and Matthias Hoffman have **beam-based THz** development project that could **directly feed the CookieBox in the FEE with long wavelength light at rate!**
- LCLS-II developments CookieBox detector will support
  - Ago’s double XLEAP
  - Erik’s polarization shaping
  - Alberto’s **Fresh Slice methods… actually how we ran June beamtime**
  - Claudio’s Double Bunch and Harmonic Lasing
  - … anything **FEL shaping related and multi-bunch, e.g. in-line beam-based THz**
- Scientific methods it will enable
  - **X-ray multi-photon signals enhanced by SASE,** In-house proposal submitted last Friday
  - “Spooktroscopy” and attoclock ptychography as super-resolution methods in the time-energy domain … **Daniel Ratner engaged, Alberto Lutman mode used in beamtime**
  - Dynamic Chirality by fs-scale time-dependent polarization shaping, needs DELTA undulator

FY22 Technical R&D Topics

- Immediate CookieBox design adaptations
  - Alternative to Zn/Ni/Au coating of ToF parts (although Aluminum worked well so far)
  - High density HV feedtroughs to interface to solderless block
  - Incorporate **TIXEL area detector** versus bucket detector MCP
- Direct signal processing for inference
  - John Fox regarding custom MCP assembly for better RF signal decoupling
  - Razib Obaid and Bernhard Adams regarding glass embedded amplifier circuit with larger area MCP
  - Jack Hirschman's idea to put ADC and FPGAs on the air side of the detector flange, e.g. **featureize at the MCP.**
- High density HV supply for auto-tuning of compound electrostatic lens: **Self-aware CookieBox**