

# Solid-state detector R&D research activities and interests

**October 4, 2023**

**Dr. Jennifer Ott**

**on behalf of the UCSC- SCIPP Silicon Detectors and Ultrafast Timing research group**

# Research topics

## **LGADs in all varieties** → *RDC 11 Fast Timing*

- DC-LGAD: radiation hardness
- **AC-LGAD**
- **Deep-junction LGAD (with Cactus Materials Inc; FBK/RD50)**

## **Other semiconductor materials, with collaborators**

- Diamond
- InP
- (amorphous Se)
- (CZT)

## **Fast electronics** → *RDC 11 Fast Timing*

- Waveform digitization (with Nalu LLC)
- Fast, low-noise, low-power SiGe (with Anadyne Inc)
- Occasionally testing other ASICs, e.g. Torino FAST family

- **4D / 5D Tracking in future HEP and NP experiments**
- **Use of LGADs and Diamond for x-ray detection including synchrotron radiation; beam monitoring; high-rate applications**
- **3D integration: would like to move forward on this**

# Collaborations

## **ATLAS**

- HGTD development until Technical Proposal

**RD50** Radiation-hard semiconductor detectors for the HL-LHC → **ECFA/CERN DRD3**

## **EIC ePIC**

- eRD112 (AC-LGADs) and eRD109 (Electronics)
- TOF-PID: AC-LGADs, electronics; considering contribution to module assembly

**PIONEER** (precision measurements of pion decay branching ratio and pion beta decay)

- UCSC is leading the R&D for the Active TARget detector: 2x2 cm<sup>2</sup> area with 48 planes of AC-LGAD strips, thickness 120 μm, pitch ca. 200 μm. Ideally quasi-5D-tracking

## **Future Colliders**

- Have responded to surveys for FCC(-ee) and Muon Collider
- So far, not strongly leaning towards one or the other

# Research group

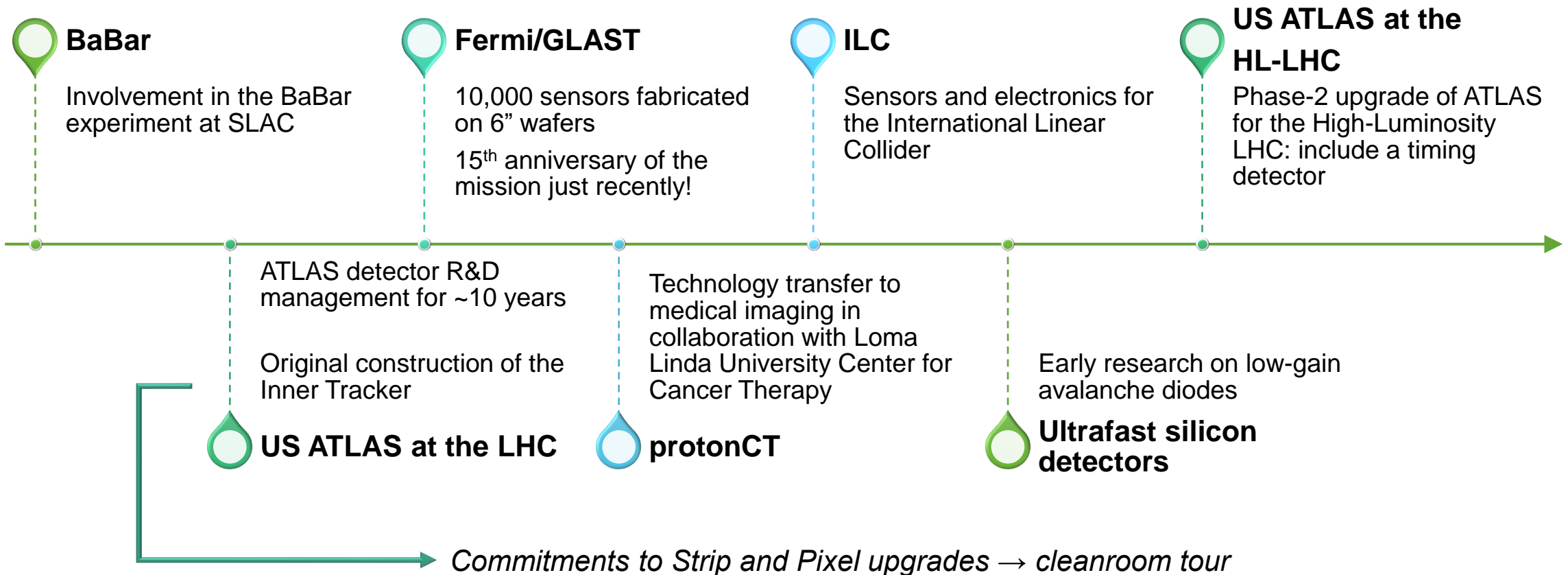
## The group:

- Prof. Bruce Schumm
  - Prof. emer. Abraham Seiden
  - Prof. emer. Hartmut Sadrozinski
  - Asst. Adj. Prof. Matthew Gignac
  - Asst. Project Scientist Simone Mazza
  - Postdoc Mohammad Nizam
  - Postdoc Jennifer Ott
  - Senior Specialist Taylor Shin
  - Junior Specialist Noah Nagel
  - (Senior Specialists Max Wilder, Forest Martinez-Mckinney)
  - Graduate student Yuzhan Zhao
  - Graduate student Rene Padilla
  - Graduate student Adam Molnar
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- Strong involvement of undergraduate students from UCSC's diverse student community
  - Graduate student program in Department of Physics
  - Contribution to HEP-CAT program, currently one graduate student funded - focusing mainly on instrumentation
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- Collaboration with other university departments, such as Engineering
  - Collaborating widely with FNAL, BNL, LANL who have all joined research on LGADs
  - Participation in DoE US-Japan program, research consortium for Development of AC-LGADs for 4D trackers
  - Successful collaboration with small companies in the DoE Small Business Research and Innovation grant environment
  - The group has been strongly supported through DoE R&D Base grants, including 2023-2026

# BACKUP



# Research background



# DoE-funded research on silicon sensors at SCIPP

**The group has been strongly supported through DoE Base grants**

- Base grant direction letters for Fall 2023 received just recently

**Successful collaboration with small companies in the DoE Small Business Research and Innovation grant environment:**

- SBIR Phase-1 (Cactus Materials, Inc; AZ): Deep-junction LGADs
- SBIR Phase-2 (Cactus Materials, Inc; AZ): Deep-junction LGADs
- SBIR Phase-1 (Nalu Scientific, LLC; HI): Fast waveform digitization ASIC
- SBIR Phase-1 (Anadyne, Inc; Santa Cruz, CA): Analog SiGe fast timing ASIC

**Participation in DoE US-Japan program, research consortium for Development of AC-LGADs for 4D trackers**

**Collaborating widely with FNAL, BNL, LANL who have all joined research on LGADs**

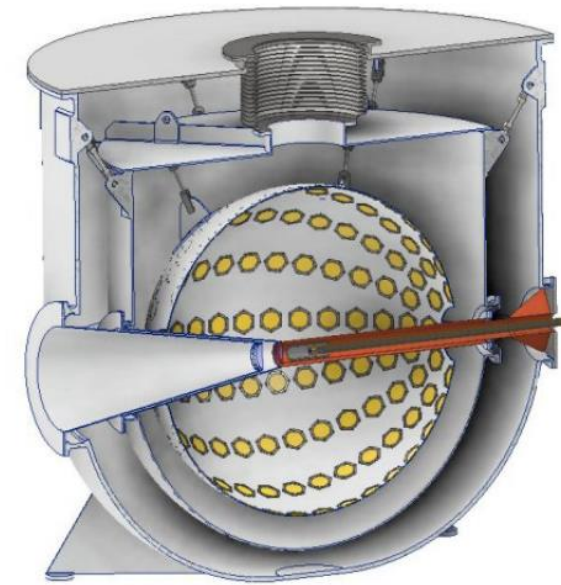
# Future experiments

## PIONEER: precision measurements of pion decay branching ratio and pion beta decay

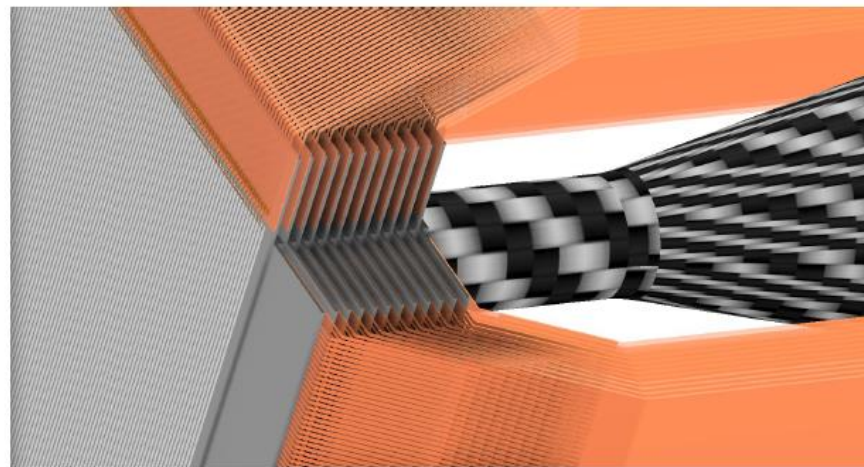
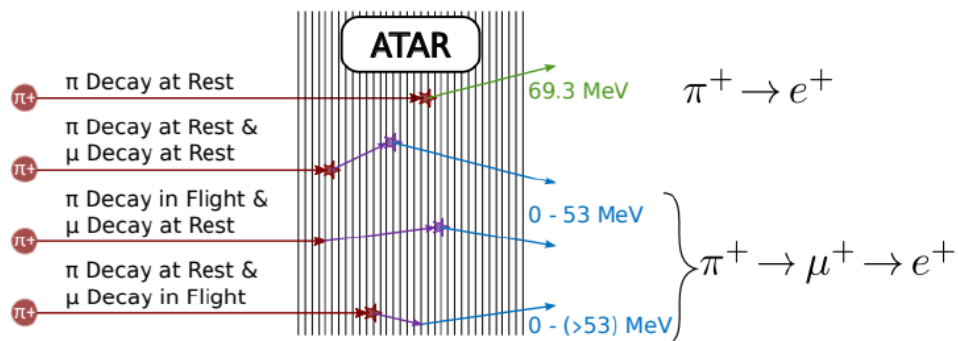
- New pion decay experiment approved at Paul Scherrer Institute, data taking to be started in 2028 - first beam time conducted in May 2022, next in December 2023

## UCSC is leading the R&D for the Active TARget detector

- 2x2 cm<sup>2</sup> area with 48 planes of AC-LGAD strips, thickness 120 μm, pitch ca. 200 μm



Layout of the PIONEER experiment



Simulated layout of the ATAR detector, close-up on stacked strip sensors

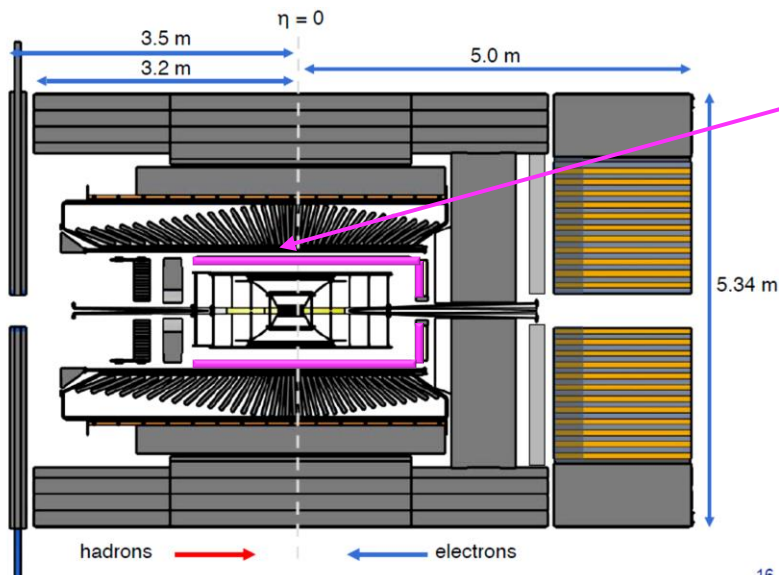
Intensity Frontier



# Future experiments

## Electron-Ion-Collider at Brookhaven National Laboratory

Detector 1: recommendation issued in 2022, now operating as ePIC Detector collaboration



- Design includes AC-LGADs for time-of-flight particle ID,  $t_0$  determination and timing, and serving as additional layer in Tracking
- Efforts organized in the TOF-PID subdetector system, and eRD consortia on LGAD sensors and readout electronics

*Nuclear physics*

Schematic cross-sectional view of the ePIC detector

