



**ORAU**

# 35 Years of Science & Technology Research and Leadership at ORNL and ORAU

May 9, 2023

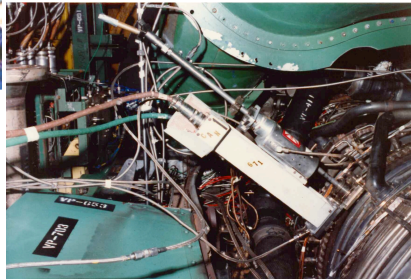
***Kenneth W. Tobin, Ph.D.***

*Chief Research and University  
Partnerships Officer*

# Began at ORNL doing a little bit of everything



Pratt & Whitney, thermo-phosphors



**1987**

Began my career at K-25 with a centrifuge physics group

Bureau of Engraving Printing



American Textile Partnership (AMTEX)



OIT Industries of the Future: Forest Products

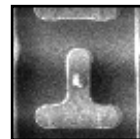
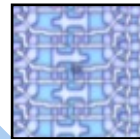
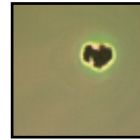
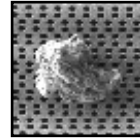
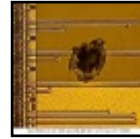


**1991**

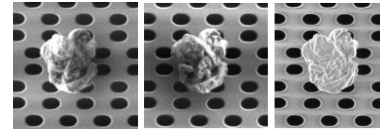
Became Image Science and Machine Vision group leader about the same time that CRADAs became fashionable (*National Competitiveness Technology Transfer Act of 1989*)

# Much of my tech transfer success began with the semiconductor industry around 1992

- Successful DOE-funded CRADA with KLA Instruments
- Began SPP with SEMATECH, Austin, TX
- Performed ADC benchmark and market survey
- ADC automates the tedious manual process of defect review and classification



*ADC Customization / Applied Materials DR SEM*



## **ADC**

**Base Technology:** Extensive monochrome and color feature analysis; pair-wise, multi-class, and fuzzy implementations of k-NN and radial basis function classifiers



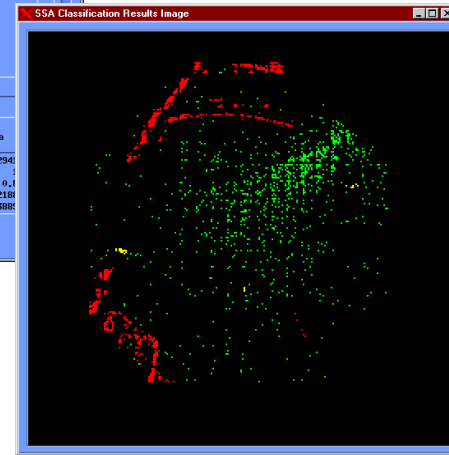
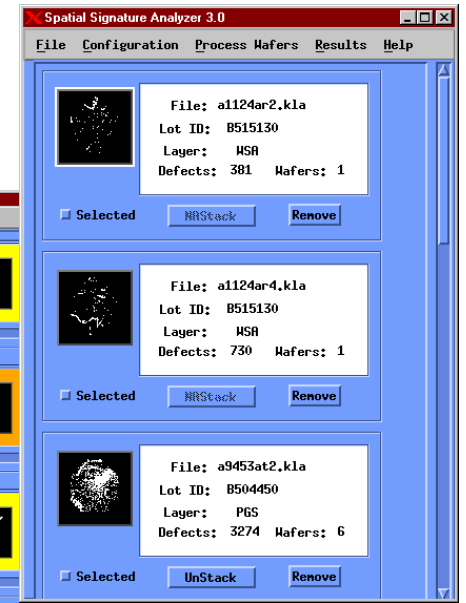
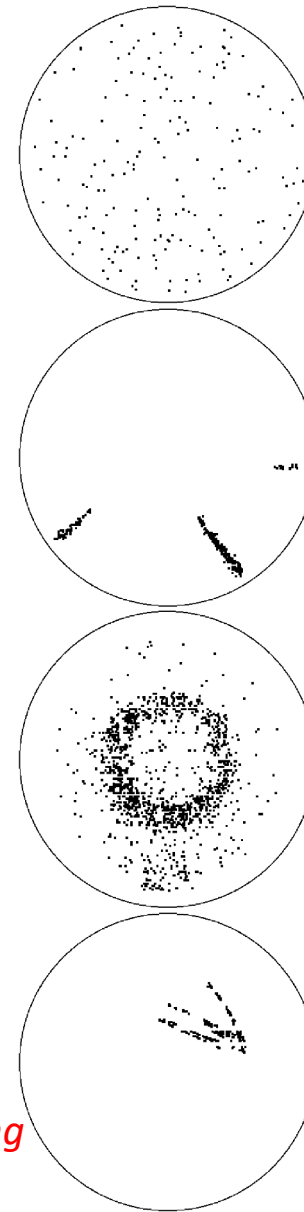
*Post fab wafer inspection / EGsoft QuickSilver IIIe*



*Tobin, K.W., Gleason, S.S., Jones, P.G., Bennett, M.H., "Automatic Defect Classification System Benchmark Results and Market Survey", Technology Transfer 95032760A-ENG, SEMATECH, Austin, TX, March 1995.*

# Opportunity to create

- Discovered new way to analyze wafer defect distributions looking at signatures
- Successful licensing
  - Advanced Micro Devices
  - Conexant (defunct in 2017)
  - Hewlett-Packard
  - IBM
  - Intel
  - Lucent Technologies (now Alcatel-Lucent)
  - Motorola,
  - Knights Technology



## SSA 7.1

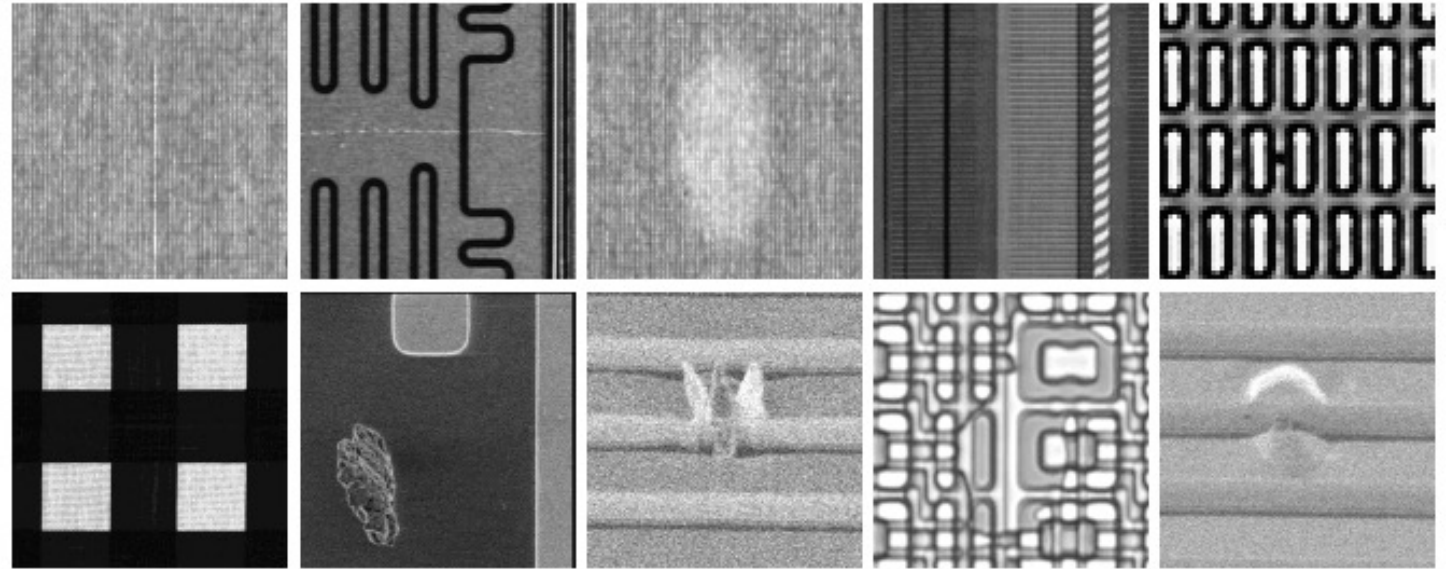
*Base Technology: Rule-based and morphological spatial clustering with trainable pair-wise fuzzy k-NN classifier*

*Tobin, K.W., Jr., Gleason, S.S., Karnowski, T.P., and Sari-Sarraf H., "Automated Defect Signature Analysis for Semiconductor Manufacturing Process Improvement", U.S. Patent No. 5,982,920, January 7, 1997.*

# LDRD: Manufacturing-specific, Content-based Image Retrieval (1998-1999, \$120K)

- Proposal to develop MS CBIR for image retrieval in the industrial environment
- Method incorporated an efficient  $O(\log_2(N))$  approximate nearest-neighbor indexing/search structure with operator feedback

*MS CBIR is an image-agnostic methodology for managing, sorting, and searching large image repositories*



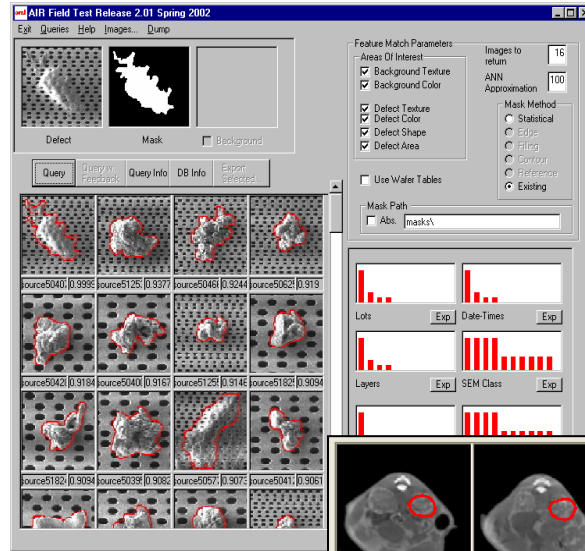
**Tobin, K.W., Karnowski, T.P., Ferrell, R.K.,** “Method for Indexing and Retrieving Manufacturing-Specific Digital Imagery Based on Image Content”, ERID No. 0668 / Q&B 6321-131, U.S. Patent No. 6,751,343, June 15, 2004.

**Tobin, K.W., Karnowski, T.P., Ferrell, R.K.,** “Method for Localizing and Isolating an Errant Process Step”, U.S. Patent No. 6,535,776, March 18, 2003.

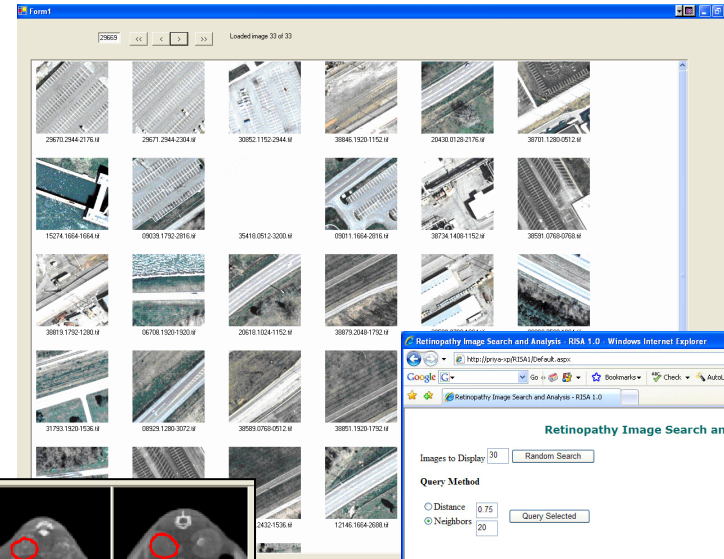
# CBIR led to many R&D opportunities

- This was an interesting application of a dynamic field of research at the time
- Led to funding by SEMATECH, NA-22, NIH, Applied Materials, ...

*Semiconductor yield learning*  
Learning about errant manufacturing processes using visually similar historical imagery



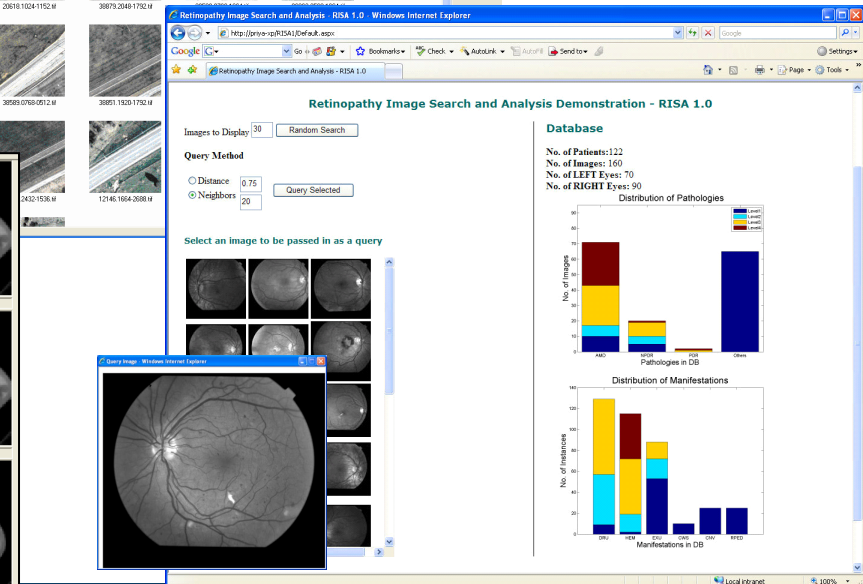
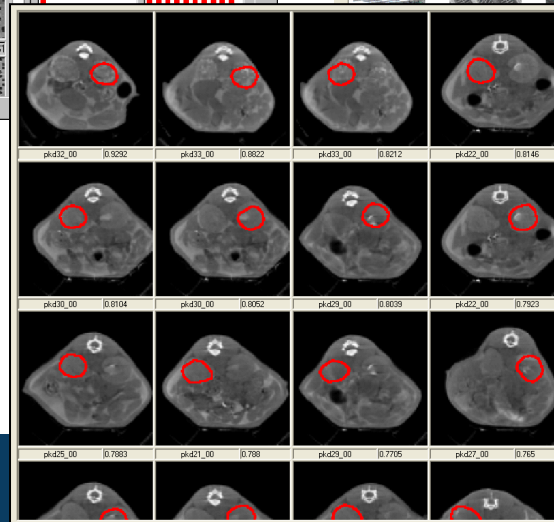
*Earth imagery search*  
Searching large geospatial databases to locate various manmade and natural structures



*Retinal Diagnostics*

Diagnosing retinal pathology in a telemedicine environment

*Small animal research*  
Searching small animal x-ray CT repository for genetic expressions

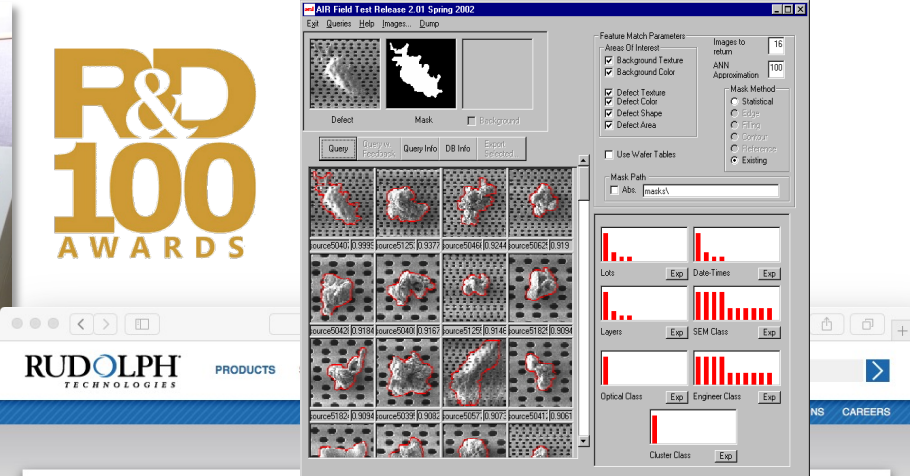


# Ranked No.9 - Semiconductor Image Retrieval, Top 10 ORNL Tech Transfer - Accounts for 48% of all Royalties

- Led to SEMATECH funded development project in 2000
- Automated image search engine that helps characterize semiconductor yield issues
- Originally licensed to Applied Materials (w/ \$3M SPP) until 9/11 (2001)
- Licensed to Rudolph Technologies in 2004 (TrueADC™)



R&D  
100  
AWARDS



HOME / PRODUCTS / DEFECT INSPECTION / TRUEADC ENTERPRISE

## TrueADC Enterprise

**DEFECT INSPECTION PRODUCTS**

Explorer  
EXPLORER PLATFORM  
F30  
NSX 330 SERIES  
E/B MODULE

NSX 220  
FIREFLY SERIES  
DRAGONFLY SYSTEM  
DISCOVER  
TRUEADC ENTERPRISE  
DISCOVER REVIEW

Unpatterned Wafer Inspection  
AWX

TrueADC® Enterprise software harnesses the power of a dynamic defect library method to overcome the limitations and frustrations of traditional ADC.

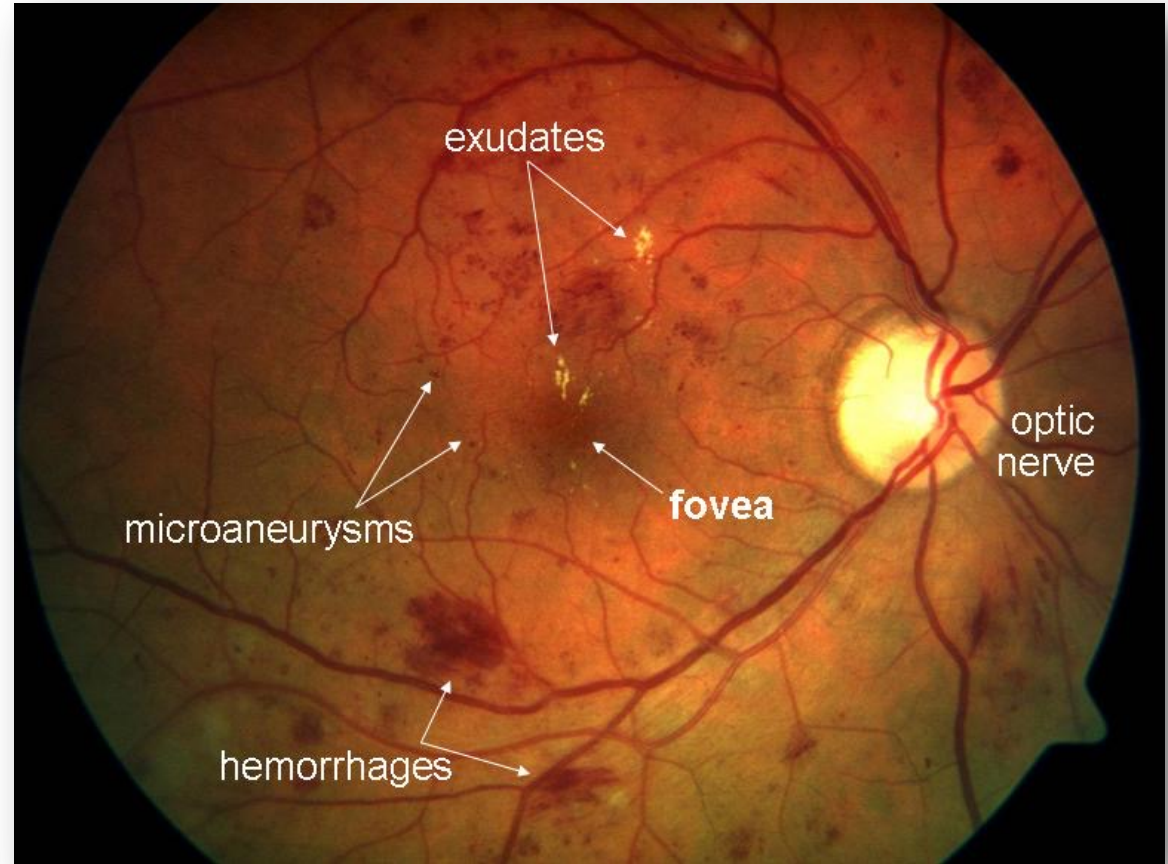
TrueADC Enterprise ensures database lookup, classification, and a response to the tool occur before the tool has captured the next image. To enable consistent performance, TrueADC Enterprise allows recipe sharing and engineering control of operator classifications before entering the database. TrueADC offers scalability, high speed classification, and a straightforward recipe creation process.

TrueADC Enterprise is designed to:

- Achieve the same high performance for standard TrueADC across your entire fab for SEM and optical review
- Improve the efficiency of an expensive SEM by enabling TrueADC on your optical review station
- Consolidate your multiple ADC packages into a single solution that serves your entire fab

# Automated Screening for Diabetic Retinopathy by Image Content (2006-2011, NIH \$3.8M)

- Hypothesis: retinal pathology can be identified and stratified from visually similar retinal images assembled from a large DR database
  - NIH NEI R01 EY017065-01, \$1.6M
- Renewal grant improved system performance to a level that permitted implementation as a fully automated patient care paradigm
  - NIH NEI R01 EY017065-02, \$2.2M

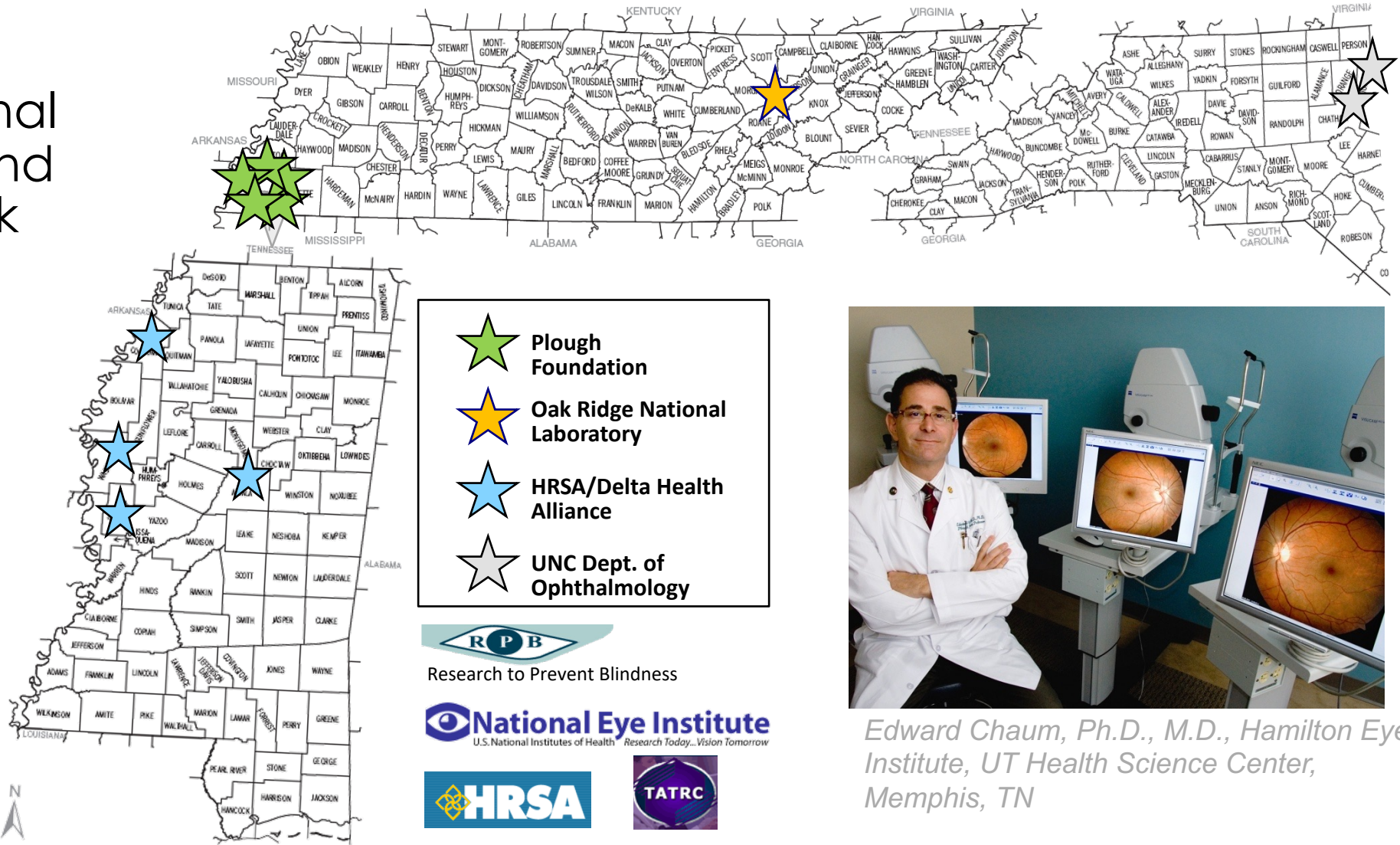


*Fundus image showing manifestations of non-proliferative diabetic retinopathy including exudates, hemorrhages, and microaneurysms.*

# TRIAD Network (9 sites in 3 states)

- Telemedical Retinal Image Analysis and Diagnosis network
- Led to start-up company in 2009

*Tobin, K.W., Karnowski, T.P., Chaum, E., "A Method for the Diagnosis of Blinding Eye Disease using Image Content and an Archive of Diagnosed Human Patient Data," UT-Battelle, LLC, Invention Disclosure No. 1596, DOE No. S-105,198, U.S. Patent No. 8,243,999, August 14, 2012.*



*Edward Chaum, Ph.D., M.D., Hamilton Eye Institute, UT Health Science Center, Memphis, TN*

# Hubble Telemedical, Inc. Sold in January 2015

- Hubble technology was licensed from UT-Battelle, LLC, (ORNL) in 2009
- Venture capital investment by Memphis Biomed Ventures in 2010
- Acquired by New York company, Welch Allyn, Inc., in January 2015
- Welch Allyn was acquired by Hill-Rom, Inc., in June 2015
- Agreement with CVS Minute Clinic in 2022



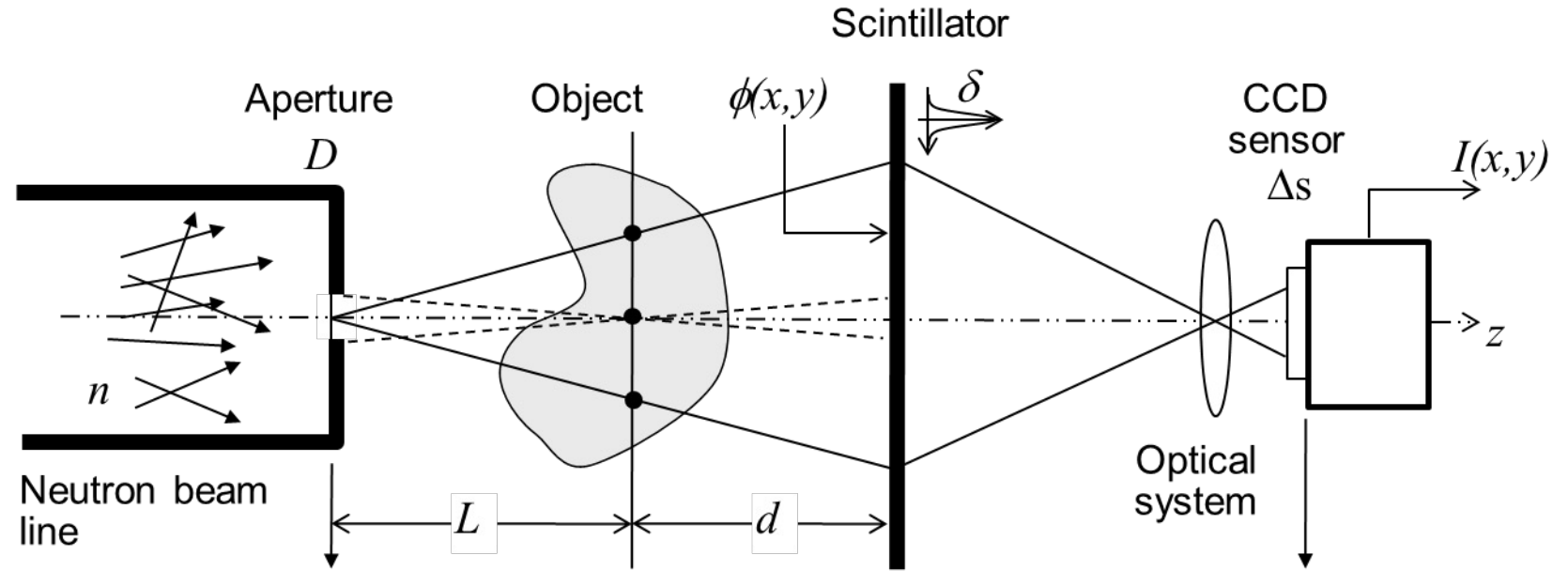
*From start-up to purchase in seven years. Is providing retinal health care to many thousands of patients nationwide, improving patient outcomes and reducing healthcare costs*



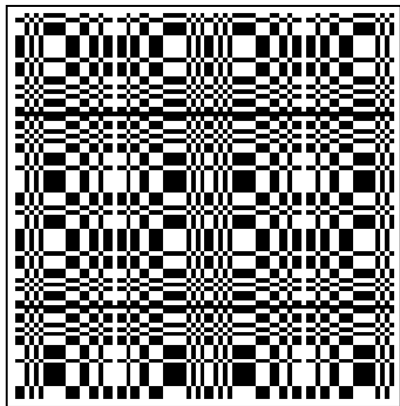
Skaneateles Falls, NY, January 20, 2015—[Welch Allyn, Inc.](#), a leading medical diagnostic device company that delivers practical innovation at the point of care, today announced the acquisition of Knoxville, TN-based [Hubble Telemedical, Inc.](#), a privately-held healthcare company that enables remote diabetic retinopathy screening and analysis in primary care and other convenient settings. Diabetic

# Neutron Microscopy with a Coded Source

- Novel extension of PhD dissertation topic from 1987



2-cycle 43x41 Uniformly Redundant Array



Coded aperture: A multiple pinhole neutron optic capable of achieving high resolution and high collection efficiency

$A(x'',y'')$

$O(x',y')$

$P(x,y)$

$$P(\mathbf{r}) = O(\mathbf{r}) * A(\mathbf{r}) \quad \text{Image formation}$$

$$\hat{O}(\mathbf{r}) = P(\mathbf{r}) * G(\mathbf{r}) \quad \text{Image reconstruction}$$

$$\hat{O}(\mathbf{r}) = O(\mathbf{r}) * (A(\mathbf{r}) * G(\mathbf{r})) \quad \text{Substitution}$$

$$\hat{O}(\mathbf{r}) \approx O(\mathbf{r}) \quad \text{iff} \quad A(\mathbf{r}) * G(\mathbf{r}) \approx \delta(\mathbf{r}) \quad \text{Aperture condition}$$

# Novel Enough for an LDRD and a Patent ...

## Novel Method to Achieve High-Resolution Neutron Microscopy

### A Proposal to the FY 2008 Seed Money Fund

P.R. Bingham,<sup>1</sup> H. Bilheux,<sup>2</sup> A.I. Hawari,<sup>3</sup> K.W. Tobin<sup>1</sup>

<sup>1</sup>Measurement Science and Systems Engineering Division

<sup>2</sup>Neutron Scattering Science Division

<sup>3</sup>Department of Nuclear Engineering, North Carolina State University, Raleigh, NC

### Principal Investigator and Point of Contact

P.R. Bingham ([binghampr@ornl.gov](mailto:binghampr@ornl.gov), 574-5680)

### Requested Budgets and Duration

FY 2008 Budget (5 months)	\$69,000
FY 2009 Budget (7 months)	\$106,000
Capital equipment	\$0.0
Total Budget (12 months)	\$175,000

**Invention Disclosures/Patents:** An invention disclosure on this concept is being filed with the Partnerships Office concurrent with this proposal submission.



US008304737B2

(12) **United States Patent**  
Tobin, Jr. et al.

(10) **Patent No.:** US 8,304,737 B2  
(45) **Date of Patent:** Nov. 6, 2012

(54) **APPARATUS AND METHOD TO ACHIEVE HIGH-RESOLUTION MICROSCOPY WITH NON-DIFFRACTING OR REFRACTING RADIATION**

(75) Inventors: **Kenneth W. Tobin, Jr.**, Harriman, TN (US); **Philip R. Bingham**, Knoxville, TN (US); **Ayman I. Hawari**, Cary, NC (US)

(73) Assignee: **UT-Battelle, LLC**, Oak Ridge, TN (US)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 403 days.

(21) Appl. No.: **12/572,536**

(22) Filed: **Oct. 2, 2009**

(65) **Prior Publication Data**  
US 2011/0079725 A1 Apr. 7, 2011

(51) **Int. Cl.** *G01T 1/16* (2006.01)  
(52) **U.S. Cl.** ..... **250/363.06**  
(58) **Field of Classification Search** ..... 250/363.06; 378/2  
See application file for complete search history.

(56) **References Cited**  
U.S. PATENT DOCUMENTS  
6,747,274 B2 \* 6/2004 Li ..... 250/288  
2004/0079890 A1 \* 4/2004 Fraser et al. .... 250/370.11  
2008/0095298 A1 \* 4/2008 Shefsky ..... 378/2

OTHER PUBLICATIONS  
Fenimore et al., "Coded aperture imaging with uniformly redundant arrays", Applied Optics, Feb. 1, 1978, pp. 337-347, vol. 17, No. 3.

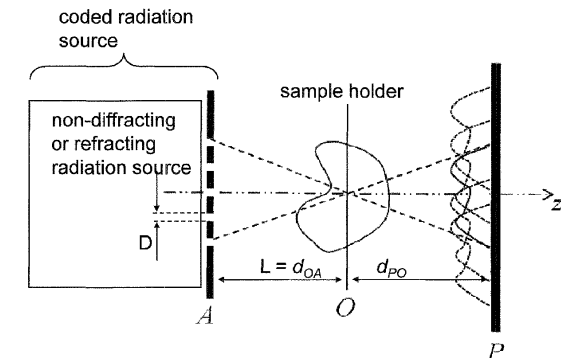
Fenimore et al., "Random array grid collimators", Rev. Sci. Instrum., Apr. 1980, pp. 445-453, 51(4).  
Fenimore et al., "Uniformly redundant arrays: digital reconstruction methods", Applied Optics, May 15, 1981, pp. 1858-1864, vol. 20, No. 10.  
Gaskill, "Linear Systems, Fourier Transforms, and Options", 1978, pp. 50-57.  
Grünauer, "Image deconvolution and coded masks in neutron radiography", Nuclear Instruments & Methods in Physics Research—Section A, 2005, pp. 342-352.  
Nadimi et al., "Flashing Tomosynthesis—A New Tomographic Method", Neuroradiology, 1980, pp. 113-117, 19.  
Vassilieva et al., "Method for reducing background artifacts from images in single-photon emission computed tomography with a uniformly redundant array coded aperture", Applied Optics, Mar. 1, 2002, pp. 1454-1461, vol. 41, No. 7.

\* cited by examiner

*Primary Examiner* — Mark R Gaworecki  
(74) *Attorney, Agent, or Firm* — Scully, Scott, Murphy & Presser, P.C.

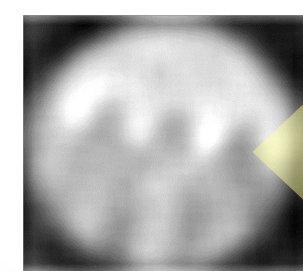
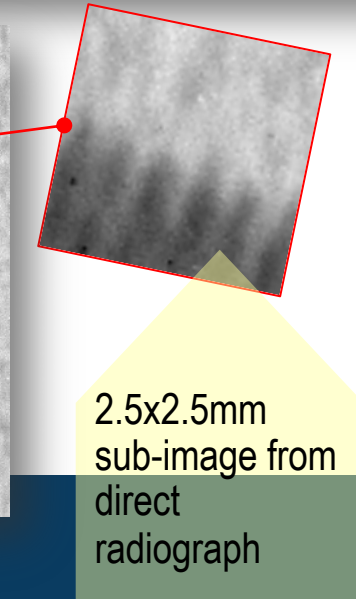
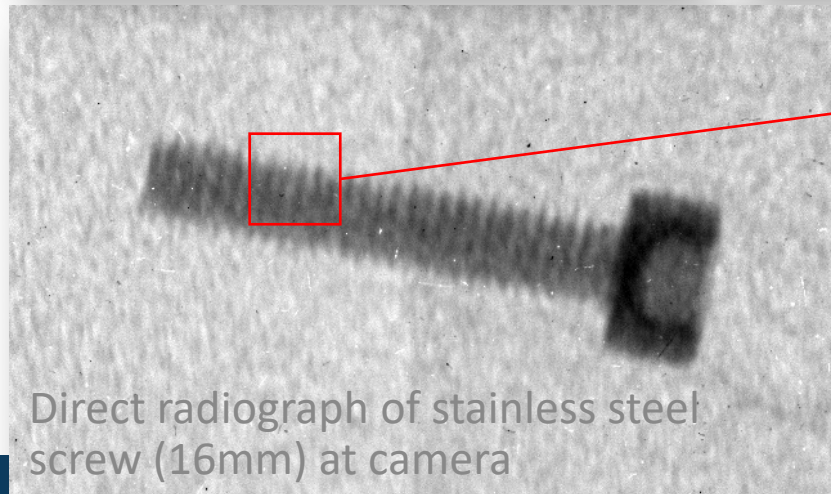
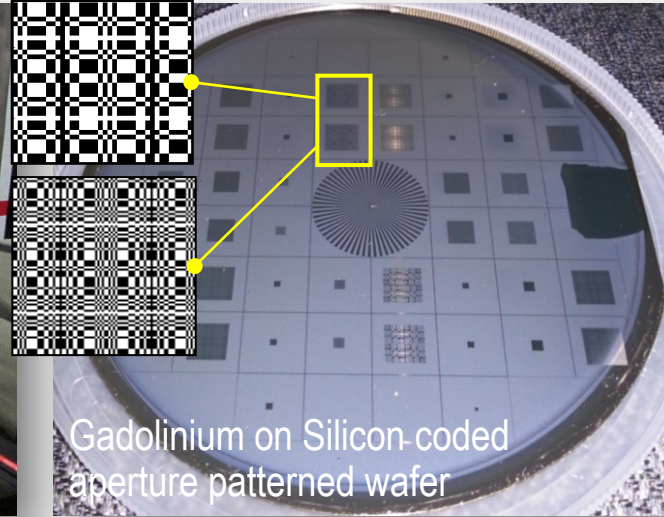
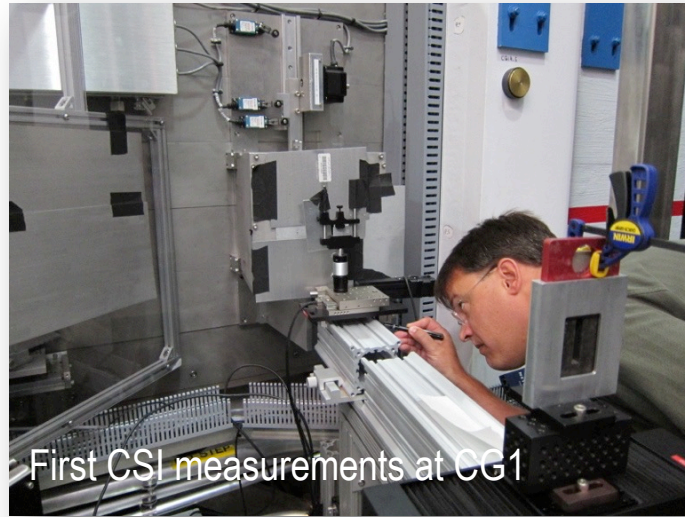
(57) **ABSTRACT**  
An imaging system employing a coded aperture mask having multiple pinholes is provided. The coded aperture mask is placed at a radiation source to pass the radiation through. The radiation impinges on, and passes through an object, which alters the radiation by absorption and/or scattering. Upon passing through the object, the radiation is detected at a detector plane to form an encoded image, which includes information on the absorption and/or scattering caused by the material and structural attributes of the object. The encoded image is decoded to provide a reconstructed image of the object. Because the coded aperture mask includes multiple pinholes, the radiation intensity is greater than a comparable system employing a single pinhole, thereby enabling a higher resolution. Further, the decoding of the encoded image can be performed to generate multiple images of the object at different distances from the detector plane. Methods and programs for operating the imaging system are also disclosed.

**34 Claims, 10 Drawing Sheets**

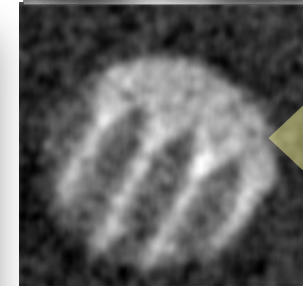


# Achieving unprecedented resolution with neutron microscopy using coded apertures

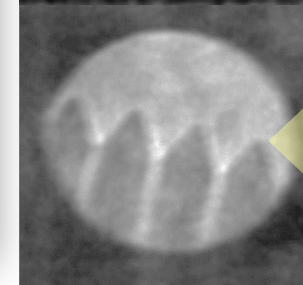
- DOE BES Early Career Award for Philip Bingham
- 5 years, \$5M



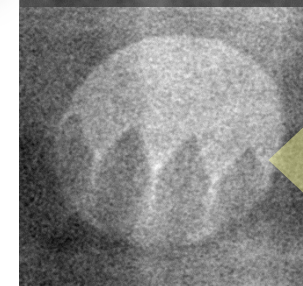
**200um** mask  
11x11 base  
5.5  $\mu$ m thick Gd  
Mag 18x



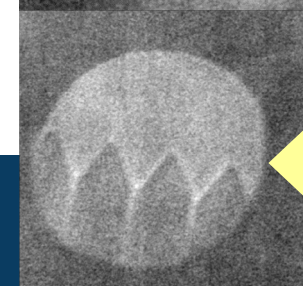
**100um** mask  
31x31 base  
5.5  $\mu$ m thick Gd  
Mag 16.6x



**50um** mask  
61x61 base  
5.5  $\mu$ m thick Gd  
Mag 20.5x

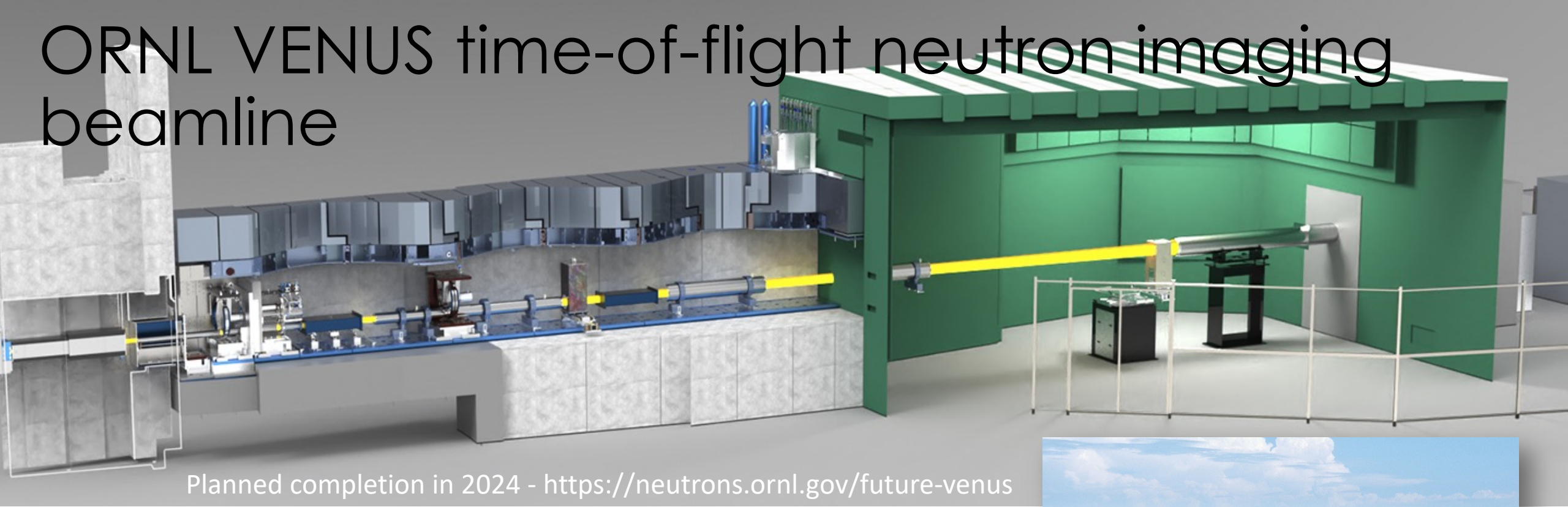


**20um** mask  
151x151 base  
9  $\mu$ m thick Gd  
Mag 24.3x



**10um** mask  
293x293 base  
9  $\mu$ m thick Gd  
Mag 24.3x

# ORNL VENUS time-of-flight neutron imaging beamline

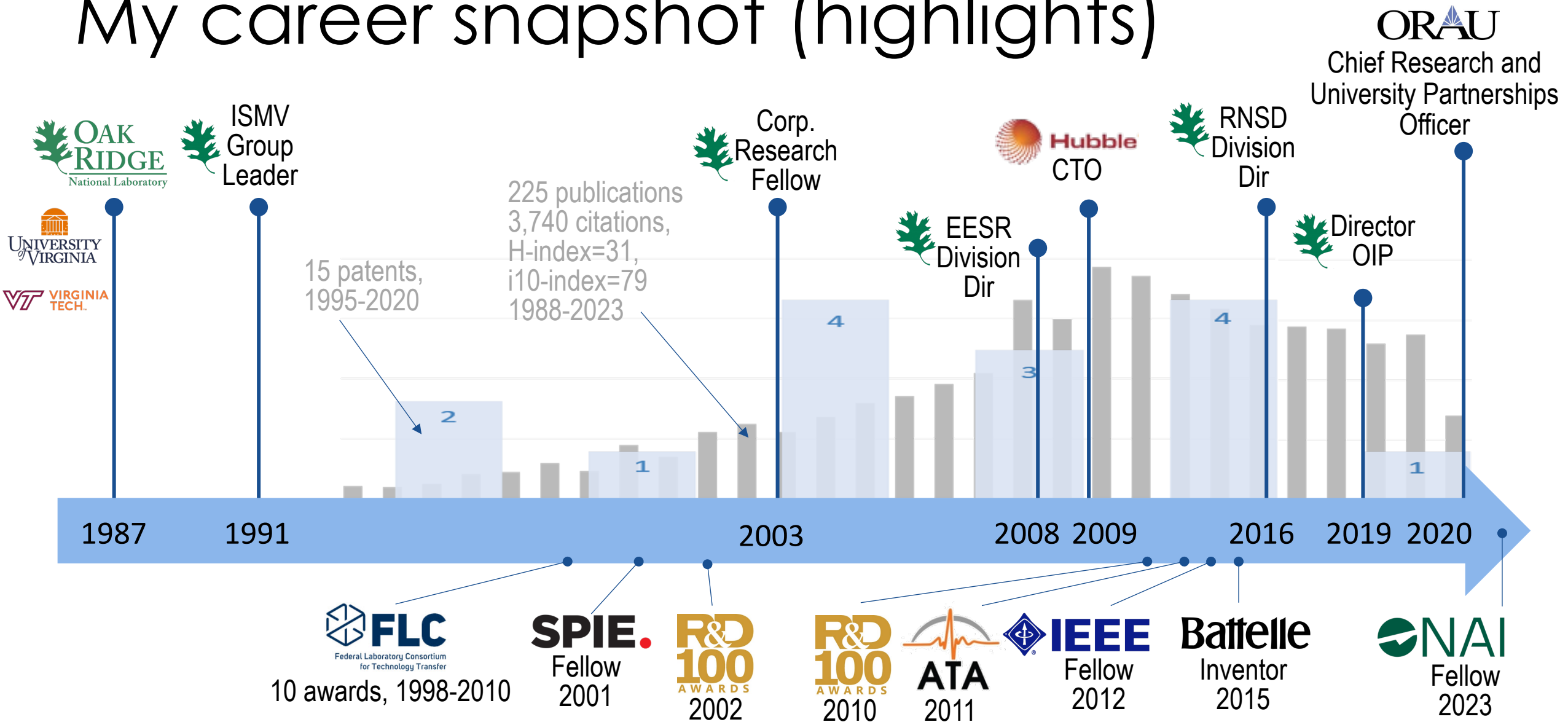


Planned completion in 2024 - <https://neutrons.ornl.gov/future-venus>

- Participated on team who defined and planned the first neutron imaging instrument for SNS
- VENUS is an engineering instrument for BES, EERE, and BER



# My career snapshot (highlights)



# ORAU by the numbers



Established in 1946  
as a 501(c)(3)

965+

Employees

\$409M

Annual Revenue

36+

State and Federal  
Customers

9,594

Annual  
Participants

75 years  
ORAU

Years in Business

25

Locations Nationally



Consortium of 153  
Universities

# Enduring Relationship with the DOE and Other Federal Agencies



Workforce  
Development



Peer Review



Scientific  
Assessment



Health &  
Environment

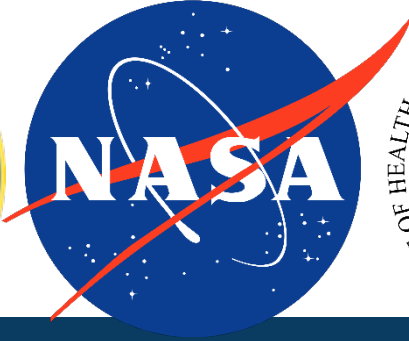


Preparedness &  
Response



## Research & University Partnerships

Creates and supports healthy and productive research culture at ORAU



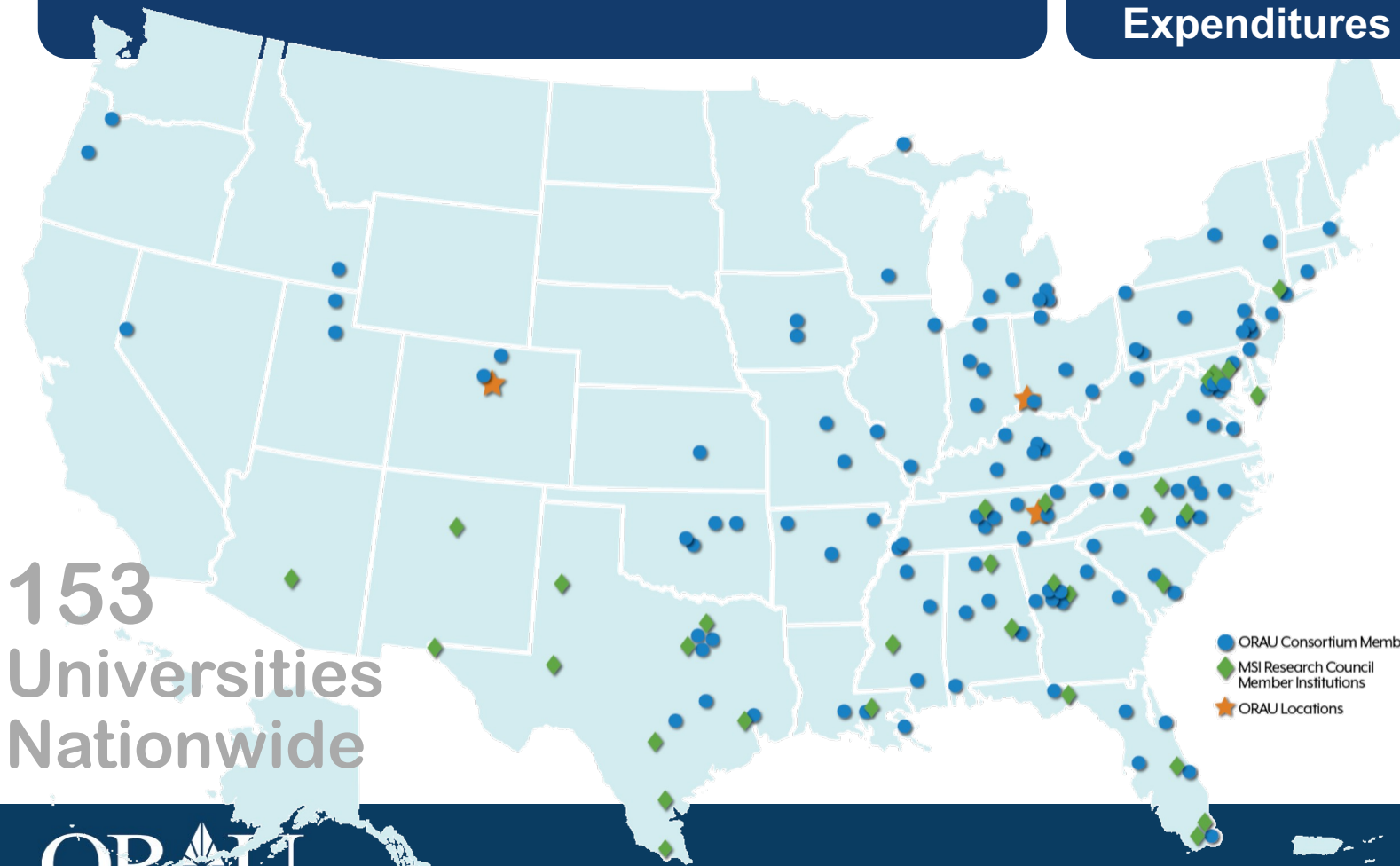
ORAU

Further. Together.

# ORAU Membership Spans the Country

128 Ph.D.-Granting Sponsoring Members  
and 25 Associate Members

Over 100 universities in the top 200 list of NSF  
Federally Financed Higher Education R&D  
Expenditures



## Our Staff



**Kenneth Tobin**  
Chief Research and University  
Partnerships Officer



**Cathy Fore**  
Senior Director of University  
Partnerships



# Providing Value to our Universities

**Advancing ORAU's research strengths through sustainable partnerships with ORAU's university consortium members**

## **ORAU Research Partnership Opportunities**

- Powe Junior Faculty Enhancement Program (*\$125K, 35 awards annually*)
- Innovation Partnership Grants (*\$80K, \$4K+\$1K awards*)
- ORAU-Directed Research & Development Program (*\$650K, 4-5 awards*)
- ORAU Summer Internships (*\$53K, 4-5 awards*)
- Annual Meetings of the Council of Sponsoring Institutions
- Virtual collaborations campus visits, and webinars
- Strategic partnerships with private industry and federal agencies
- Develop/provide unique tools and services

# Creating New Opportunities for Research Partnerships



- SAMHSA
- ORAU awarded lead in communications
- University of New Mexico
- Partnership with private industry awardees in technical assistance and training

## MITRE

- University engagement
- Waste Water Surveillance Webinar
- GEAR Center Webinar
- AI for Education
- Sara Alert™ hosting for universities



- Supports Y-12 on NNSA R&D
- University engagement on research
- Oak Ridge Enhanced Tech & Training Center



## BLUE WATER THINKING

- VHA
- Initiative to protect against veteran suicide
- 62 member schools performing R&D in this area
- 13 centers on veteran suicide prevention
- SME with,



- National Center for Birth Defects & Developmental Disabilities
- ORAU awarded lead
- 16 SMEs at 8 member universities

# Key Milestones in the ORNL-ORAU/ORISE Partnerships

1990

- Appalachian Region Commission High School Summer Math Program (ARC/ORNL)

1999

- Oak Ridge Sitewide Institutional Review Board (IRB)

2004

- Nuclear Engineering Science Laboratory Synthesis Program (NESLS)

2007

- DOE Science Undergraduate Internship Program (SULI)

2010

- Graduate Education for Minorities (GEM) Program

2014

- Launched ORISE online applicant management system (Zintellect)

2016

- Institute for Advanced Composite Manufacturing Innovation (IACMI)

2018

- Next Generation STEM Internship (NEXTGENS) Program



# Questions?

Ken W. Tobin, Ph.D.  
Chief Research and University  
Partnerships Officer  
[Ken.Tobin@orau.org](mailto:Ken.Tobin@orau.org)

