THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

BOARD OF TRUSTEES
COMMERCIALIZATION & ECONOMIC DEVELOPMENT COMMITTEE
MAY 18, 2016, 2:30PM
CHANCELLOR'S BALLROOM EAST, CAROLINA INN

OPEN SESSION

FOR INFORMATION ONLY
(No formal action is requested at this time)

1. Introduction and Chair's Remarks
   Lowry Caudill, UNC Board of Trustees

2. Translational Disciplines: (Attachment A)
   - Applied Physical Sciences
     Ed Samulski, Chair, Department of Applied Physical Sciences

*Some of the business to be conducted is authorized by the N.C. Open Meetings Law to be conducted in closed session.

COMMITTEE MEMBERS
W. Lowry Caudill, Chair
Julia Sprunt Grumbles, Vice Chair
Jefferson W. Brown
Haywood D. Cochrane, Jr.
Donald Williams Curtis
Hari H. Nath
Administrative Liaison:
Judith Cone, Vice Chancellor for Commercialization and Economic Development

A Brief History of Applied Physical Science and Up-fit of Murray Hall

Ed Samulski

May 18, 2016

THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

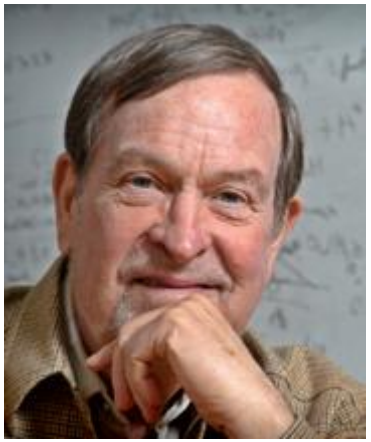
APPLIED PHYSICAL SCIENCES

A brief history of APS @ Carolina

- *1900's Charles Hughes Herty, Dean of APS (1908-1912)*
- *1930's President F. P. Graham moved Engineering to "State College"*
- *1980's Microelectronic Center (MCNC) allocated positions to Carolina and NCSU*
  - *Curriculum in APS launched*
  - *ETS recruited to start polymer pgm in Chemistry*

APPLIED PHYSICAL SCIENCES

A brief history of APS @ Carolina



- *1990's PhD pgm Mat. Sci. (TJ Meyer)*
  - *Curriculum in Applied Mat Sci (CAMS)*
  - *Concept of "Science Complex" born*
- *2000's National Center Grants awarded*
  - *NSF (JMD)* - *$17MM* → Micelle & Liquidia Tech.
  - *ONR (OZ)* - *$5.5MM* → Xintek Inc.
  - *NASA (ETS)* - *$3.4 MM* → Allotropica Tech.
- *2004 Inst. Adv. Mat. (IAM) and CHANL launched*
  - *CAMS → CASE (BME and Mat Sci)*

APPLIED PHYSICAL SCIENCES

A brief history of APS @ Carolina

A Strategic Roadmap
for
Applied Physical Sciences
in
The College of Arts & Sciences
The University of North Carolina
Chapel Hill

Submitted to Dean Karen Gil
The Applied Sciences Task Force
July 2012

Applied Sciences Task Force

Edward Samulski, ASTF Chair, *Chemistry*

Nancy Allbritton, *Chair of Biomedical Engineering*

Lowry Caudill, *Chair of the Innovation Circle, Board of Trustees (Facilitator)*

Arthur Champagne, *Chair of Physics & Astronomy*

Michael Crimmins, *Sr. Assoc. Dean* (ex officio)

Joseph DeSimone, *Director of Institute for Advanced Materials*

Anselmo Lastra, *Chair of Computer Science*

Thomas Meyer, *Director of Energy Frontier Research Center*

Peter Mucha, *Chair of Mathematics*

Richard Superfine, *Physics & Astronomy*

- ***2011 APS Roadmap (Lowry Caudill & ETS)***
- ***2012 Dean Gil accepted recommendation to launch APS dept***

APPLIED
PHYSICAL SCIENCES

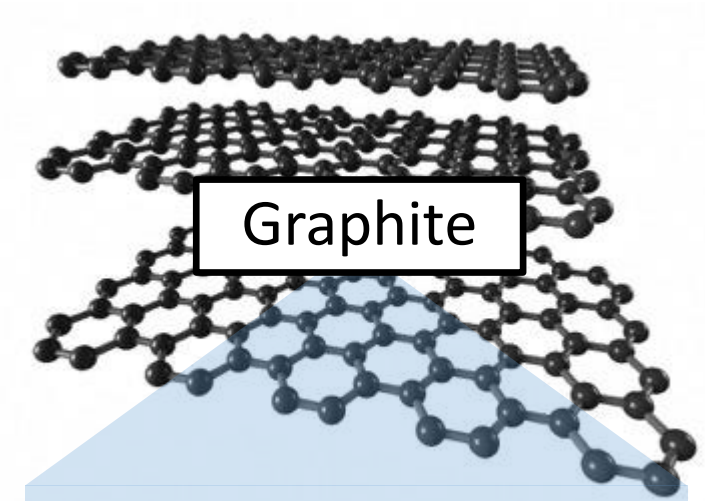
A brief history of APS @ Carolina

- ***2013** Strategic Plan for APS (P. Mucha & P. Friga)*

  - *1st hire **Scott Warren (2-D materials for energy sciences)***

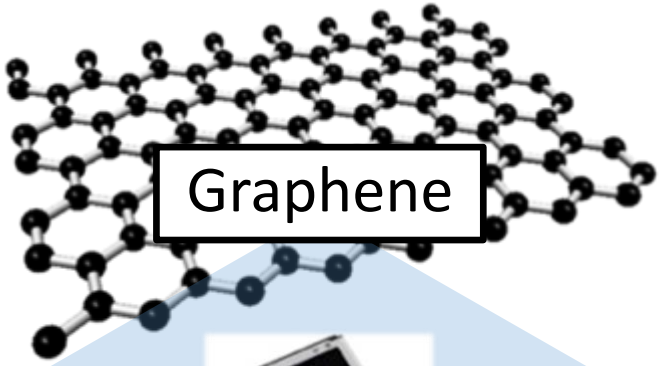
APPLIED PHYSICAL SCIENCES

The Warren Lab: from basic research to new products



carbon brushes

composites



battery coatings

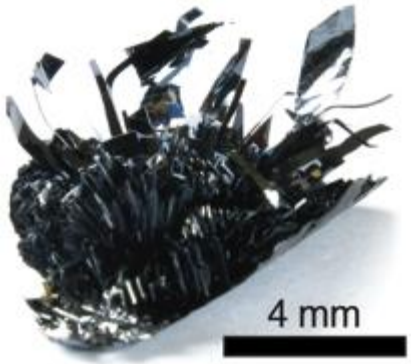
flexible/wearable electronics

APPLIED PHYSICAL SCIENCES

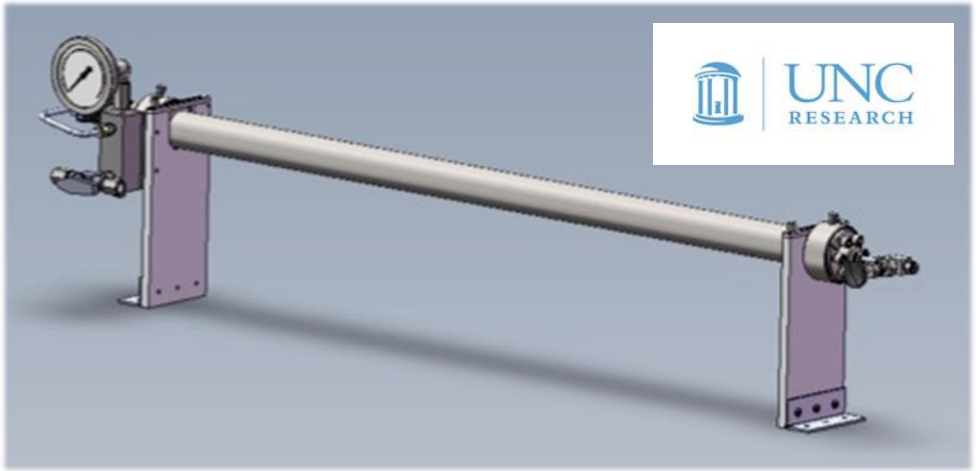
Black phosphorus: scale-up for industry

red phosphorus
$0.50 per gram

High temperature and pressure



black phosphorus
$570 per gram



high pressure system for synthesis
UNC Office of Technology Development

Academic labs require black phosphorus for fundamental scientific studies, while industry requires large quantities for testing and optimization.

APPLIED PHYSICAL SCIENCES

Phosphorene: scale-up & commercialization

Liquid exfoliation:
Solution-processing of phosphorene at the 10-gram scale.

Patent Pending:
"Two dimensional materials produced by the liquid exfoliation of black phosphorus." 2/031, 184, **2014**.
Warren, S. C.; Woomer, A. H.; Wells, R. A.; Farnsworth, T. W.

Major commercial interests:
Alfa Aesar (Thermo Scientific), Sigma-Aldrich (Millipore Sigma), and others.

APPLIED PHYSICAL SCIENCES

Early-stage partnership with industry

A major automotive company is funding exploratory research in our lab.

Electric vehicles with extended range.

APPLIED PHYSICAL SCIENCES

Our values

To enhance the value of scientific research.

To create jobs.

To inspire & educate students.

To solve society's most important problems.

APPLIED PHYSICAL SCIENCES

APS @ Carolina Today

Dec 18

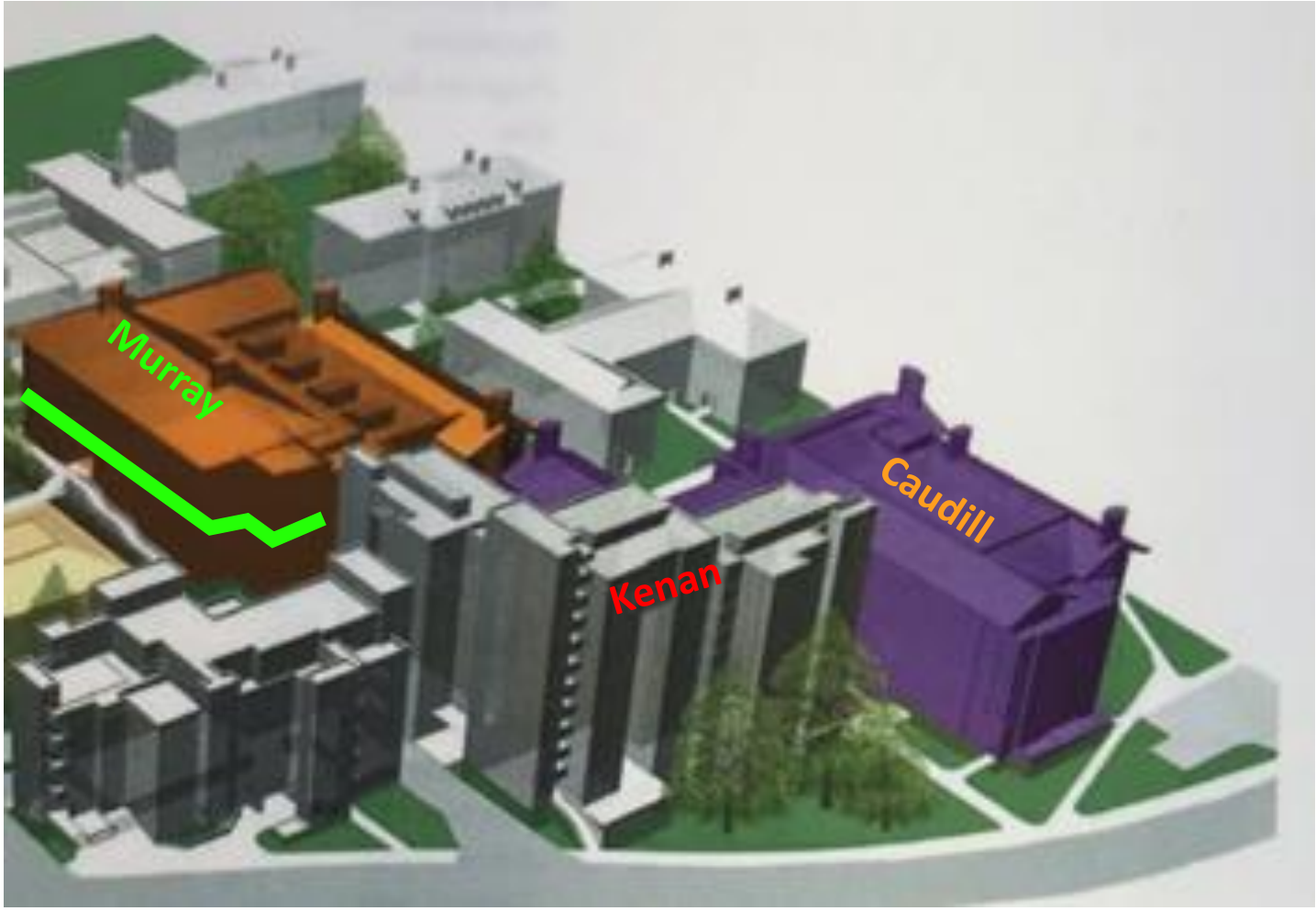
CLUSTER HIRES

The new department seeks to hire faculty with experience in applying their scientific discoveries to real-world problems, either through start-up companies or partnerships with government and industry. The initial research emphasis will be on Soft Matter and Energy and the founding cluster hires will be expected to build upon existing strengths at Carolina, but outstanding candidates from any field will be considered. To launch the initial clusters, Applied Physical Sciences will target six (6) hires in 2016 with emphasis on both outstanding junior and established senior faculty who are conducting research at the interface between the physical and life sciences, and in energy storage and membrane technologies. Interested faculty candidates should exhibit potential for multidisciplinary collaborations in an established institution. Ultimately APS will have 20 new hires by 2020, including new clusters.

- ***2015-16** hiring, interviewing, and renovations*
  - *2nd hire **Daphne Klotsa***
  - *3rd hire **Theo Dingemans***
- *Today APS is located in Murray Hall (and Kenan)*

APPLIED PHYSICAL SCIENCES

APS home in Murray Hall



APPLIED PHYSICAL SCIENCES

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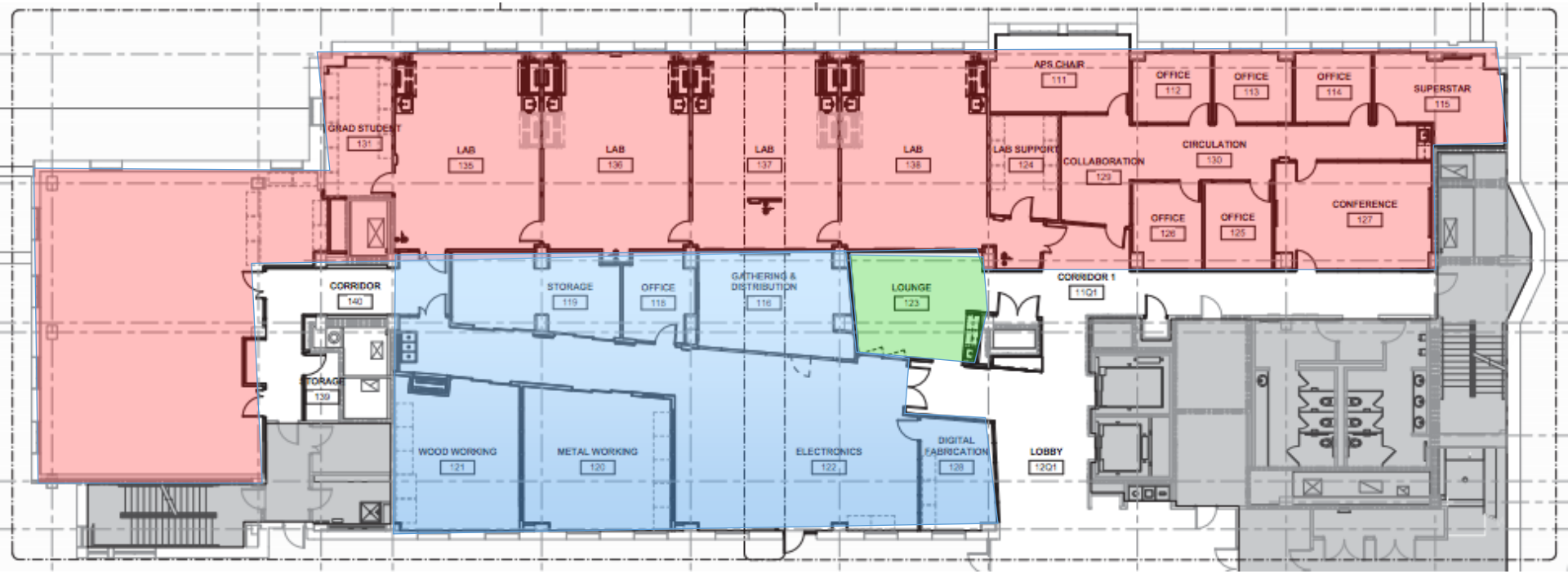
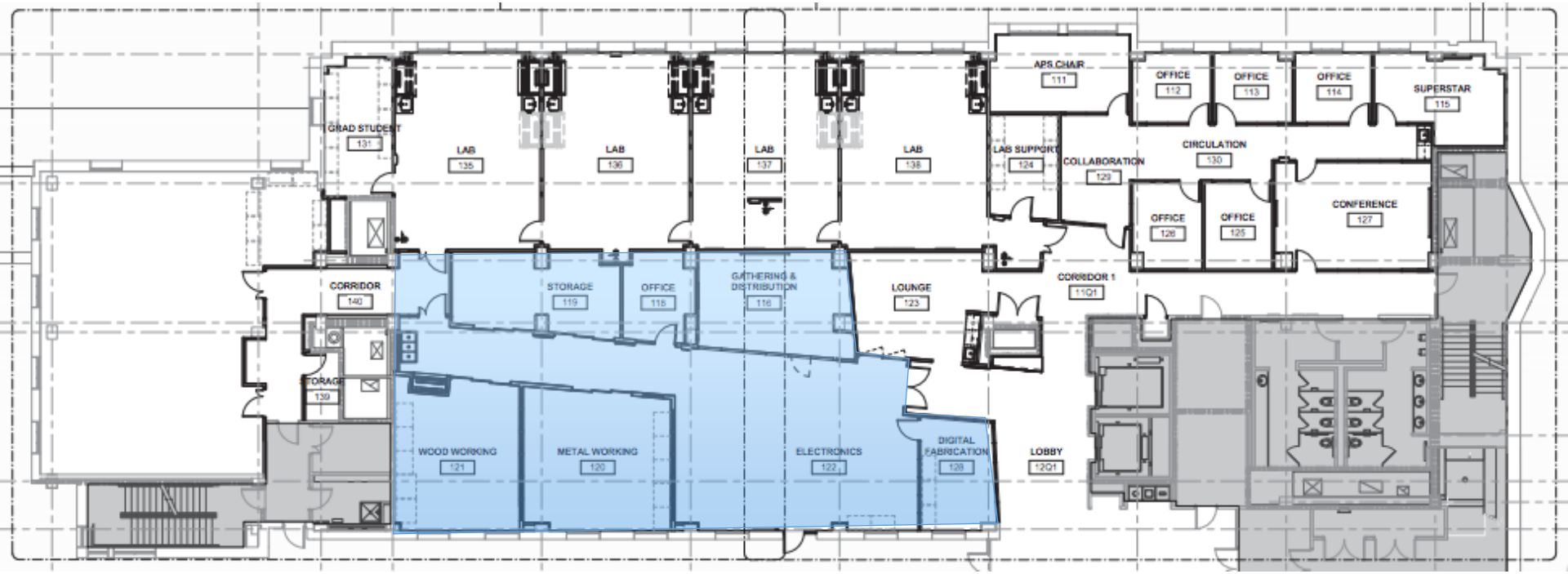


Applied Sciences Labs Total ...4660 sf
Makers Space Shop Total .....3090 sf
Seminar Room .....560 sf
Office Suite Total .....1110 sf
Lounge .....350 sf

APPLIED PHYSICAL SCIENCES

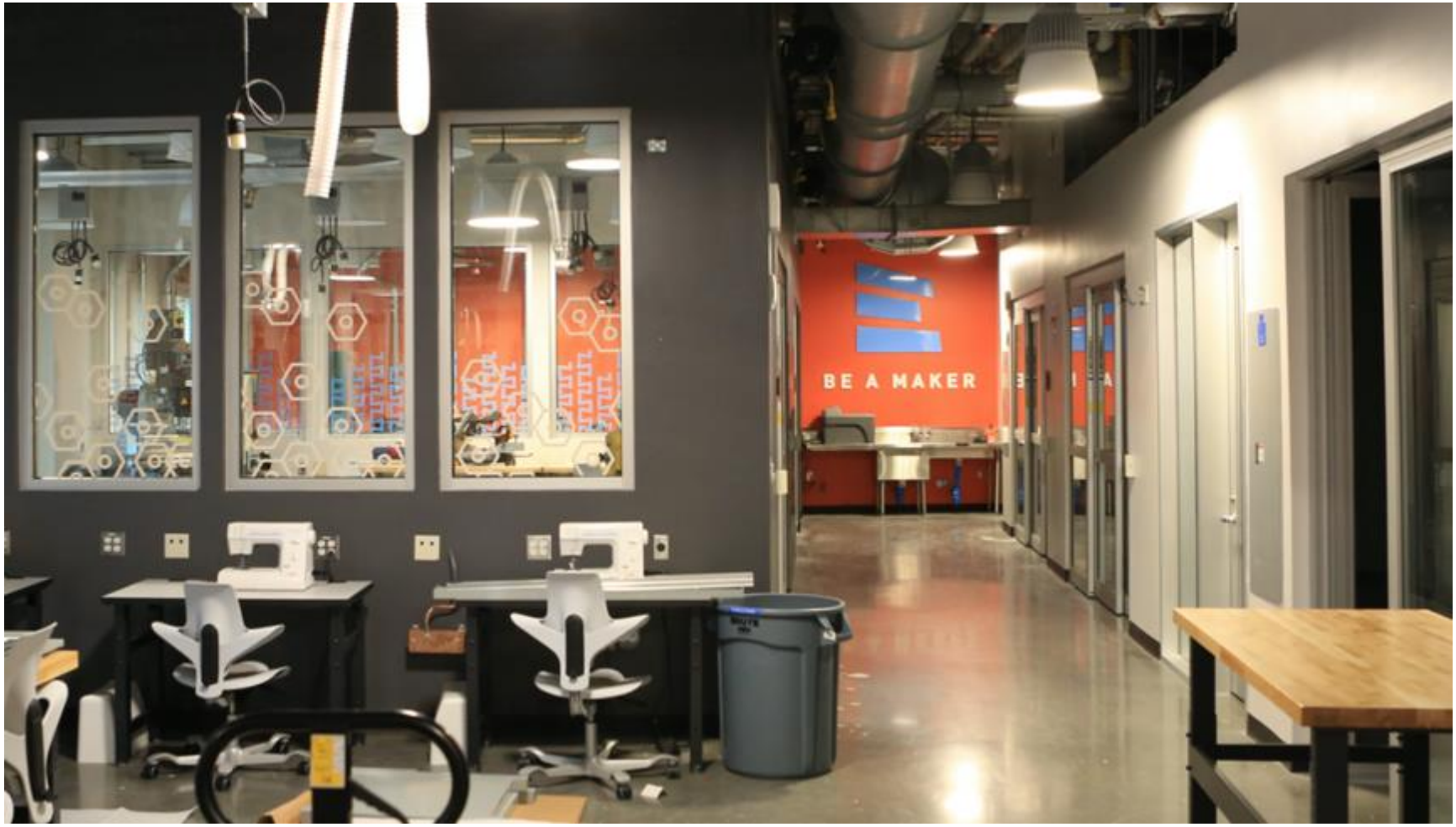
Maker Space in Murray Hall



BE A MAKER

APPLIED PHYSICAL SCIENCES

Maker Space in Murray Hall



BEAM
BE A MAKER

APPLIED
PHYSICAL SCIENCES

Maker Space in Murray Hall

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APPLIED PHYSICAL SCIENCES

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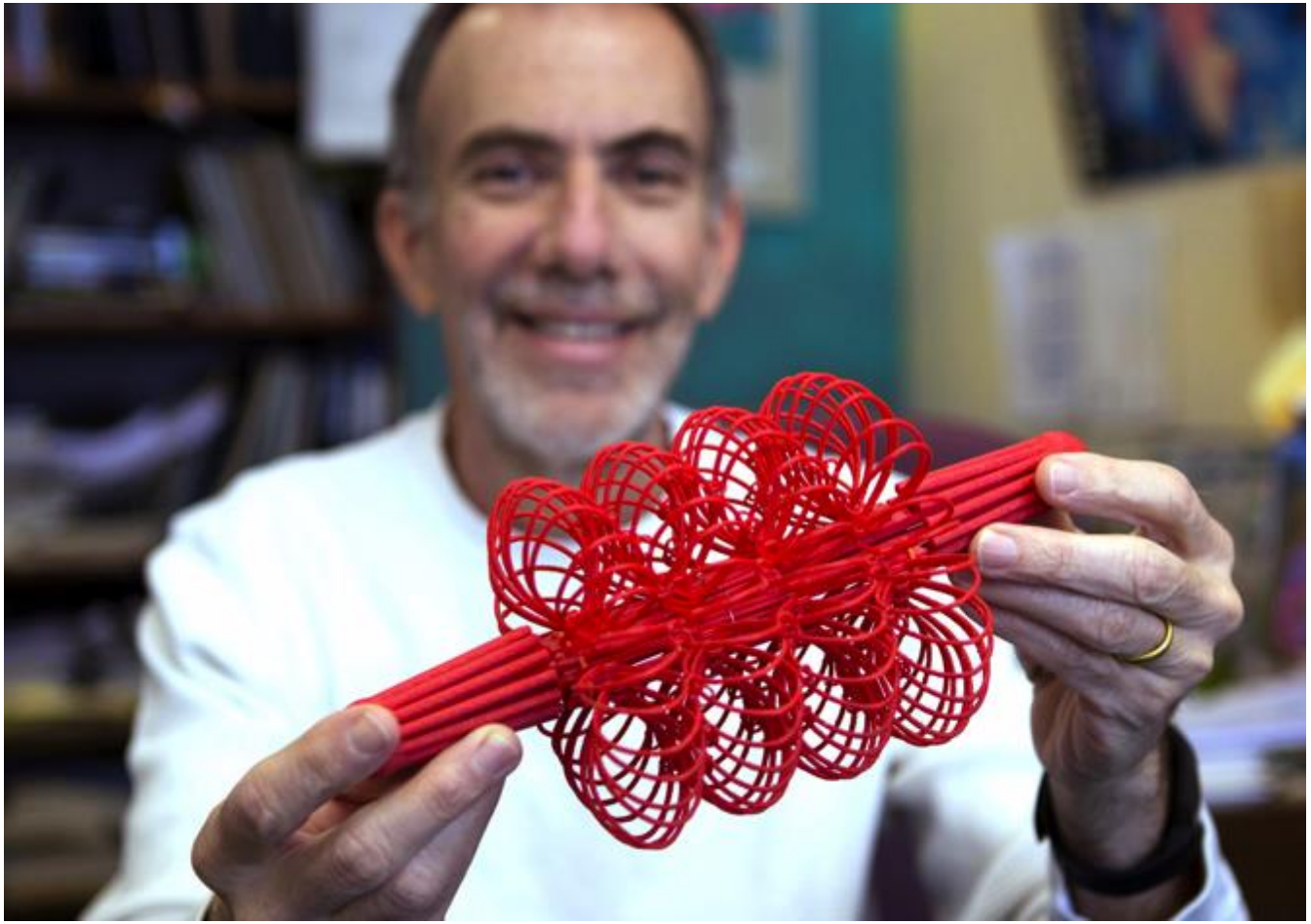
APPLIED
PHYSICAL SCIENCES

Maker Space in Murray Hall



BEAM
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PHYSICAL SCIENCES

APS home in Murray Hall

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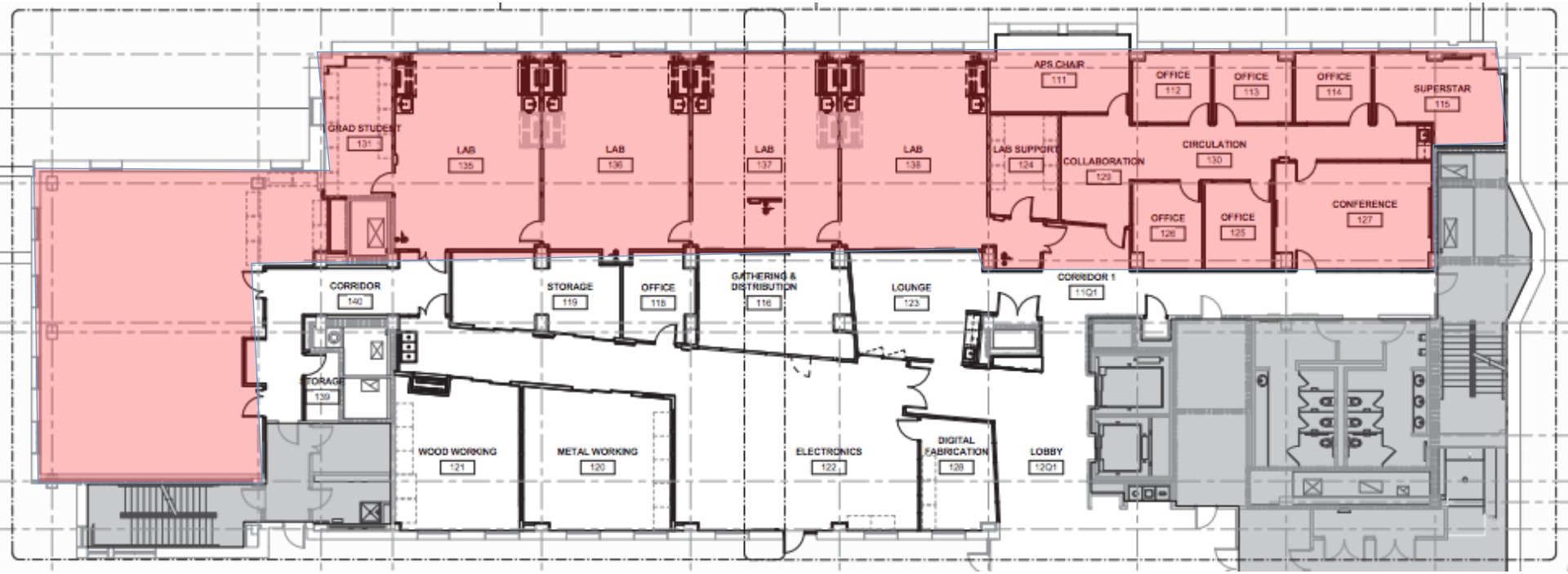


APPLIED PHYSICAL SCIENCES

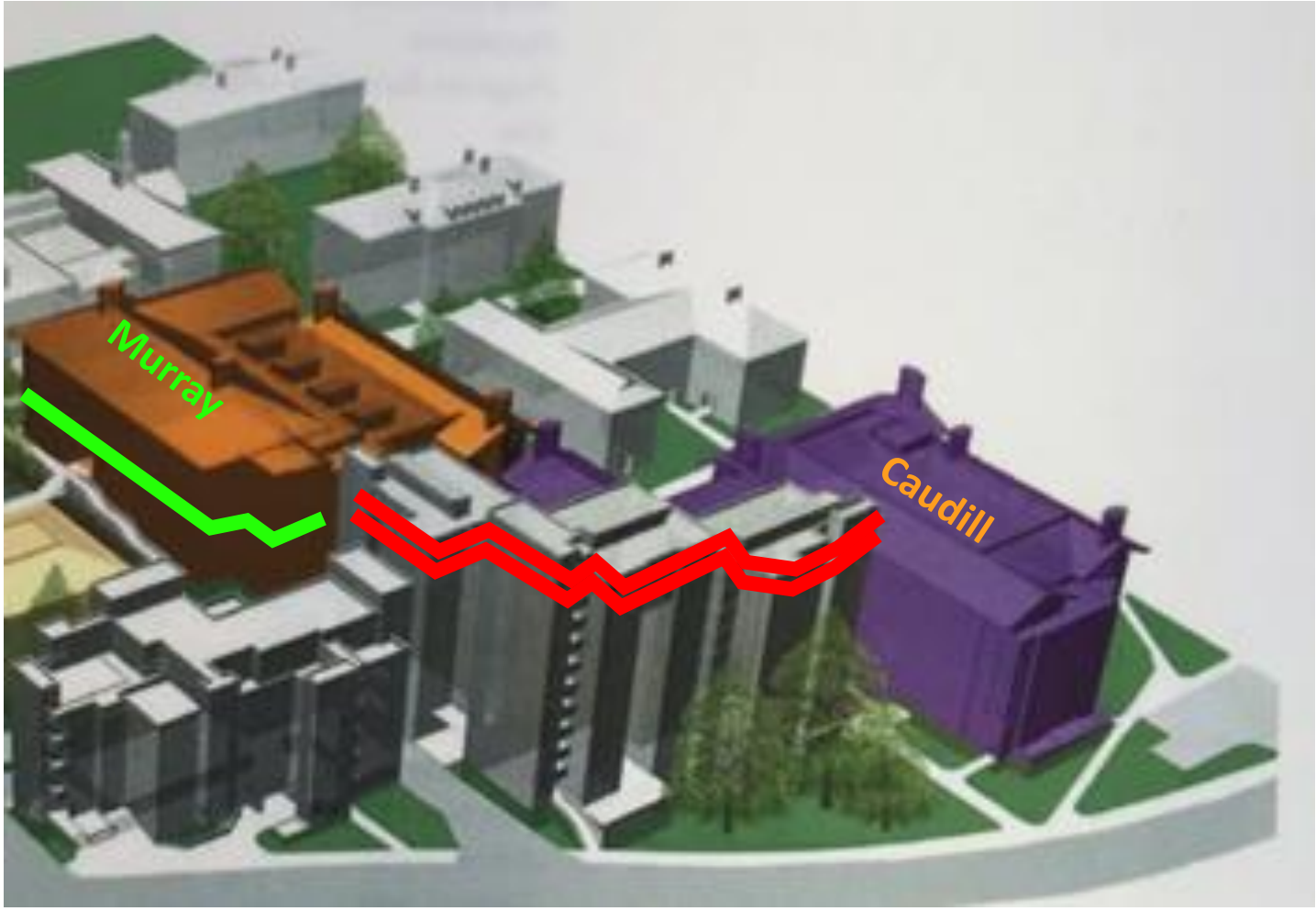
APS home in Murray Hall

APPLIED
PHYSICAL SCIENCES

APS home in Murray Hall

APPLIED PHYSICAL SCIENCES

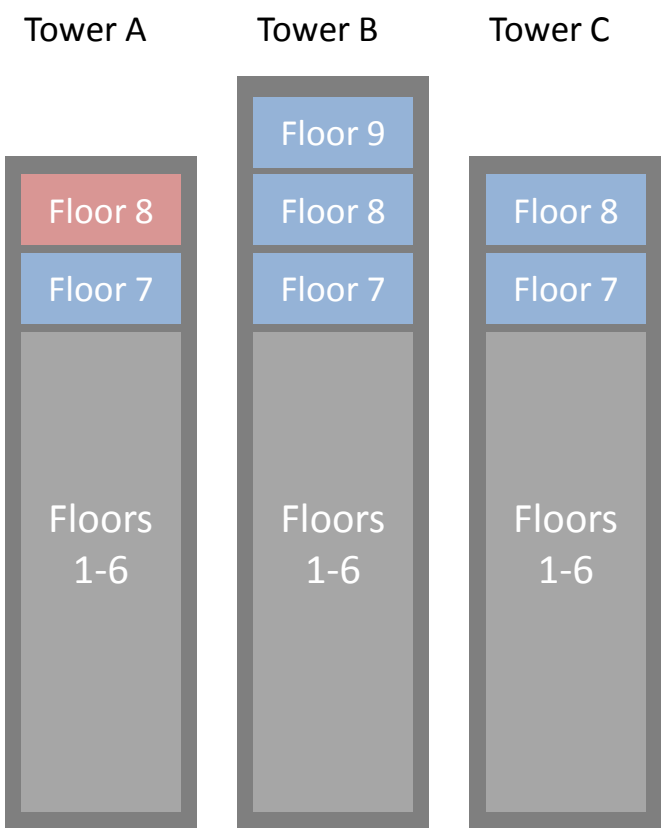
APS renovations in Kenan (7, 8 & 9)



APPLIED PHYSICAL SCIENCES

The existing space allocated to APSc is sufficient for at most 6-8 new hires into the department

Allotted Space (Kenan Labs)



Legend

- Scott Warren*
- Available
- Chemistry

Floors

Floor 7
- 1 Large Lab per Tower
- 5-6 Smaller Rooms

Floor 8
- 1 Large Lab per Tower
- 5-6 Smaller Rooms

Floor 9
- 1 Large Lab
- A few offices

*Approx. 90% occupied

Current sq.ft. Space Allocation

Total	18,600
Scott Warren	~2,500
Remaining 16,100	

This only leaves space for at most 6-8 New Hires

The Department projects to run out of space near the end of the 1st cluster hires in 2017

The department will need ~100k sq ft of new space by 2019

The existing space allocated to APSc is sufficient for at most 6-8 new hires into the department

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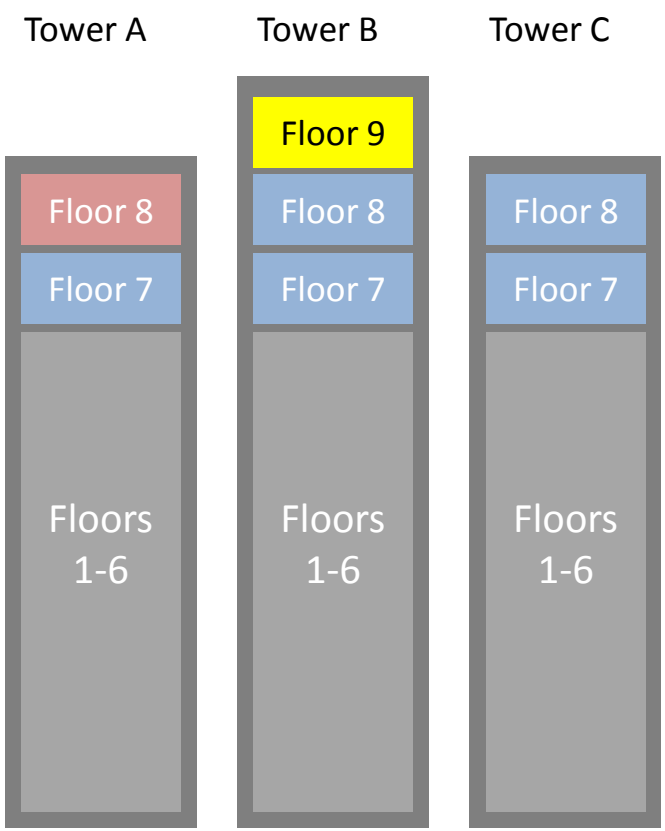

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Floor 9
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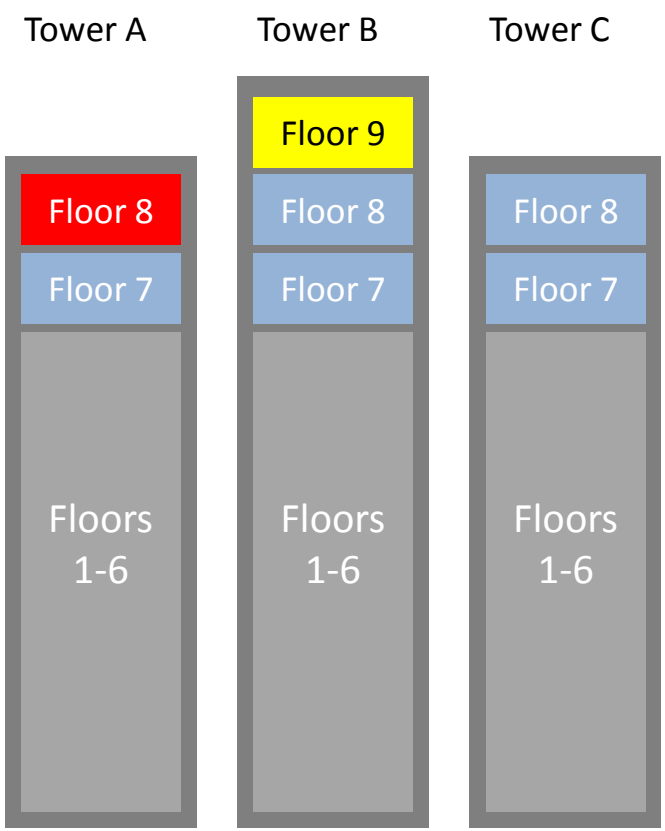

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Antiquated HVAC in Kenan doubles renovation estimate

Allotted Space (Kenan Labs)

Tower A | Tower B | Tower C

Floor 8

Floor 7

Floors 1-6

Legend

Scott Warren*

Available

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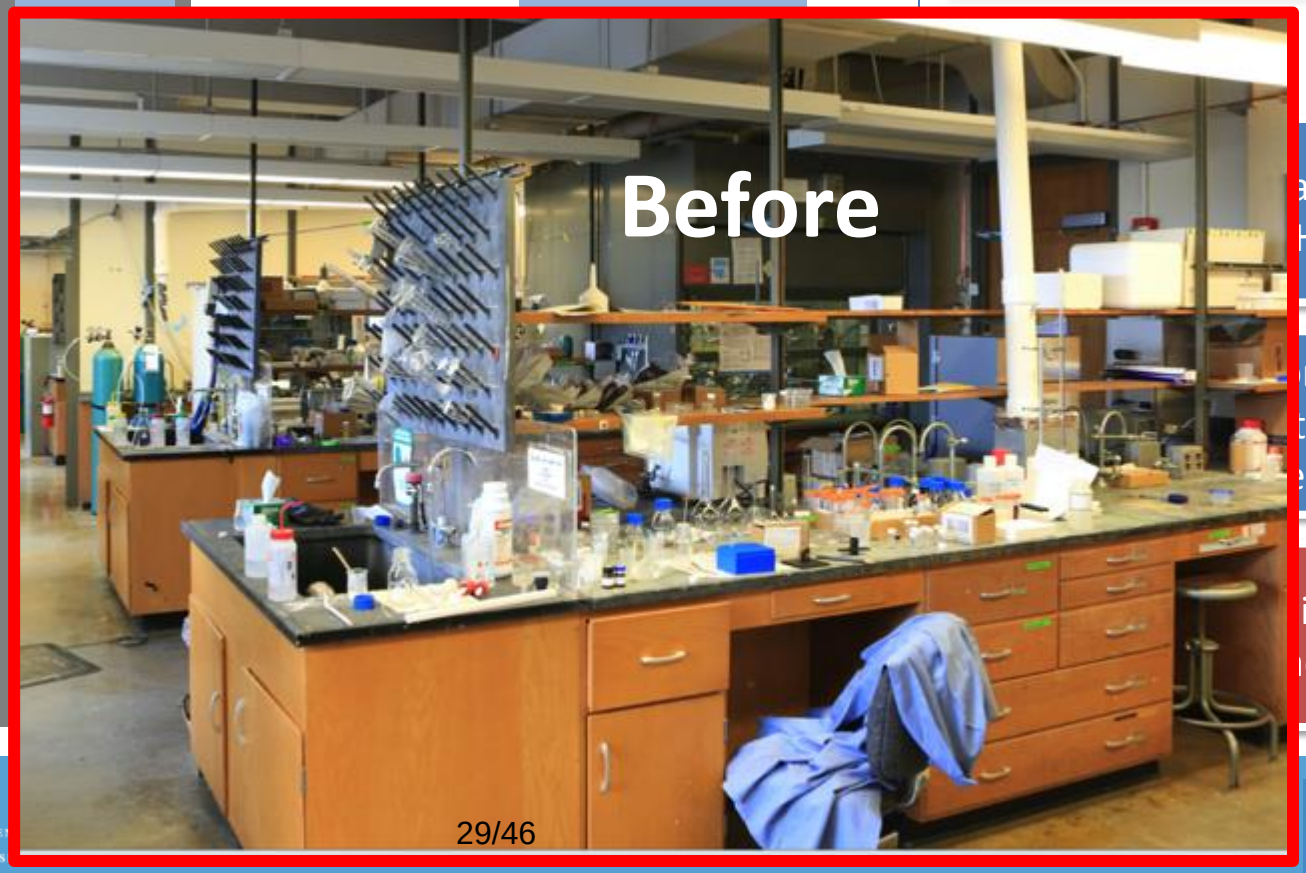

ace for at most
Hires

rojects to run
the end of the
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Allotted Space (Kenan Labs)

Tower A | Tower B | Tower C

Floor 8
Floor 7
Floors 1-6

Legend

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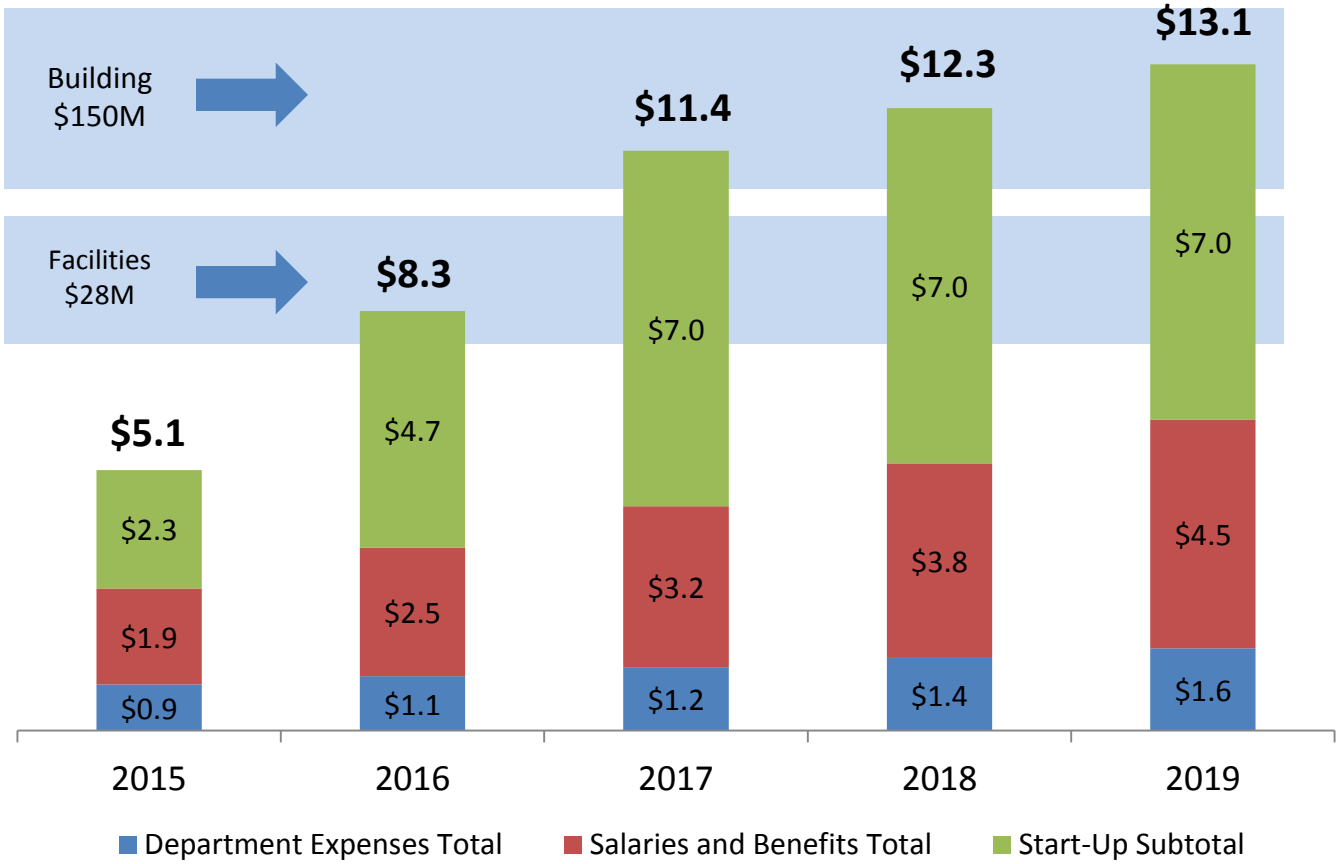
Our ambitious ramp up plan will require significant faculty start up and salary expenses

Select Non-building Expense Totals ($M)



The 5 year (2015-2019) ask for non-building expenses is: $50.2M

The addition of:

- ISB Building (**$150M**)
- Design (**$15M**)
- **Renovations ($3M)**
- Facilities (**$28M**)

Brings the 5yr ask to: $250.2M

*F&A returns cover $1.5M

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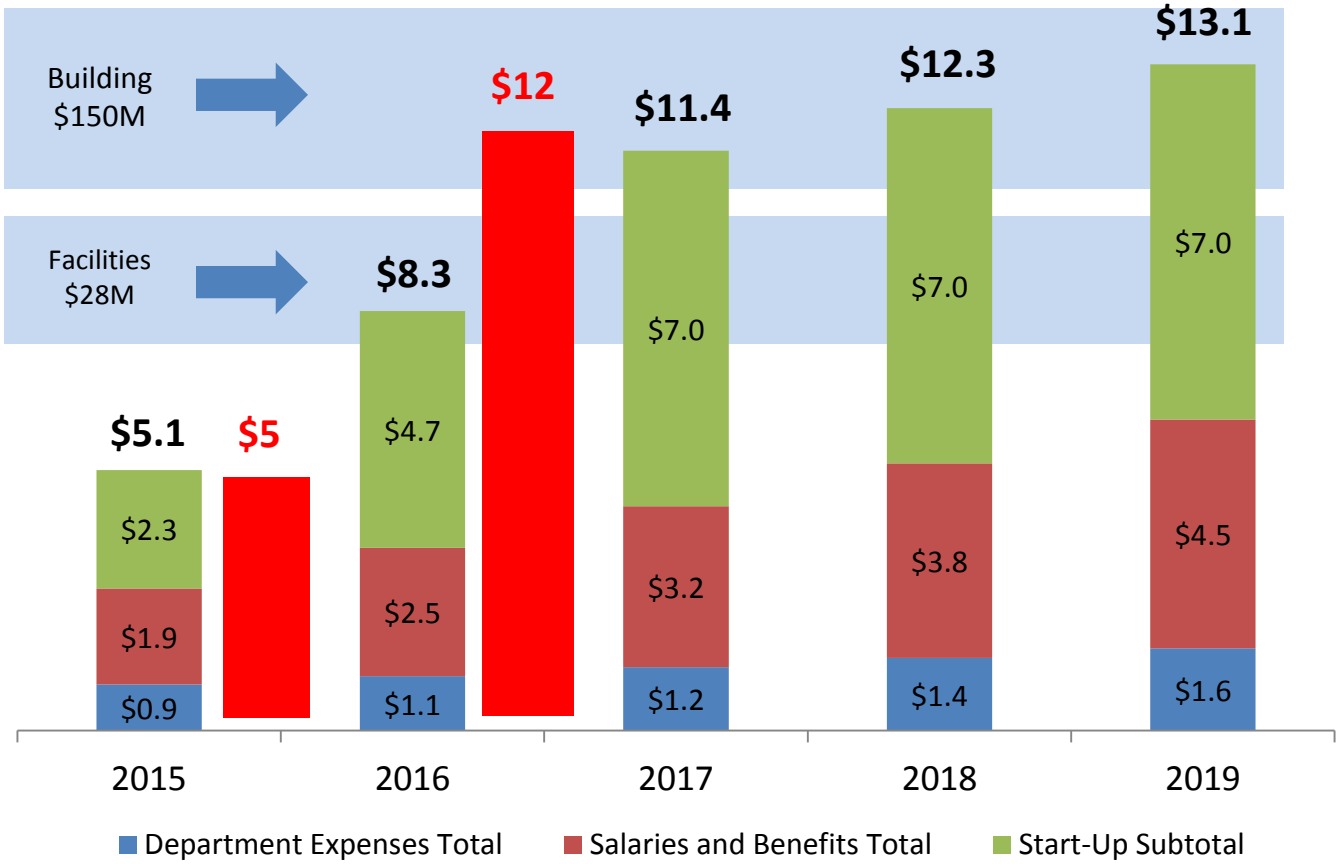

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UNC APSc: Strategic Planning Project

Executive Summary

September 12, 2013

The combined draft strategy statements for the UNC Department of Applied Physical Sciences

Mission Statement

Our mission is to solve the world's most challenging problems through applied physical sciences.

Vision Statement

Our vision is to create and translate scientific research into practical application to improve the lives of the people of North Carolina and the nation.

Slogan: "Ideas to Impact"

Values Statement

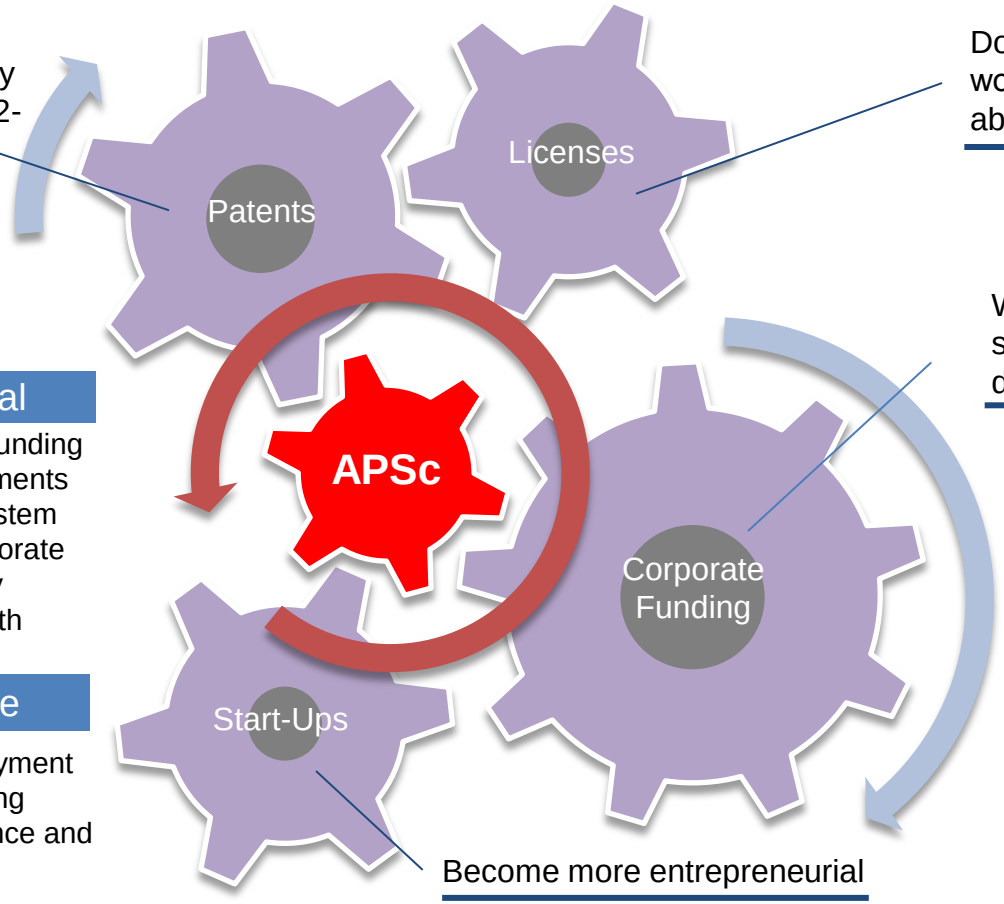
Our values embrace an interdisciplinary approach, team-based science, and an entrepreneurial mindset.

APSc could act as a catalyst for productivity, not only within the department, but also unlocking stranded potential across UNC

"Unlocking the full potential of the $800M machine"

What if patent productivity across campus became 2-3x more efficient?
200 Patents/Year

Doubling the number of licenses would move UNC's productivity above the average for its peers



What if corporate research sponsorship across campus doubled or tripled?

Unrealized Potential

- Top 10 federal research funding
- Dozens of ranked departments
- Highly ranked hospital system
- 10 miles from top 20 corporate R&D center in the country
- #2 region poised for growth

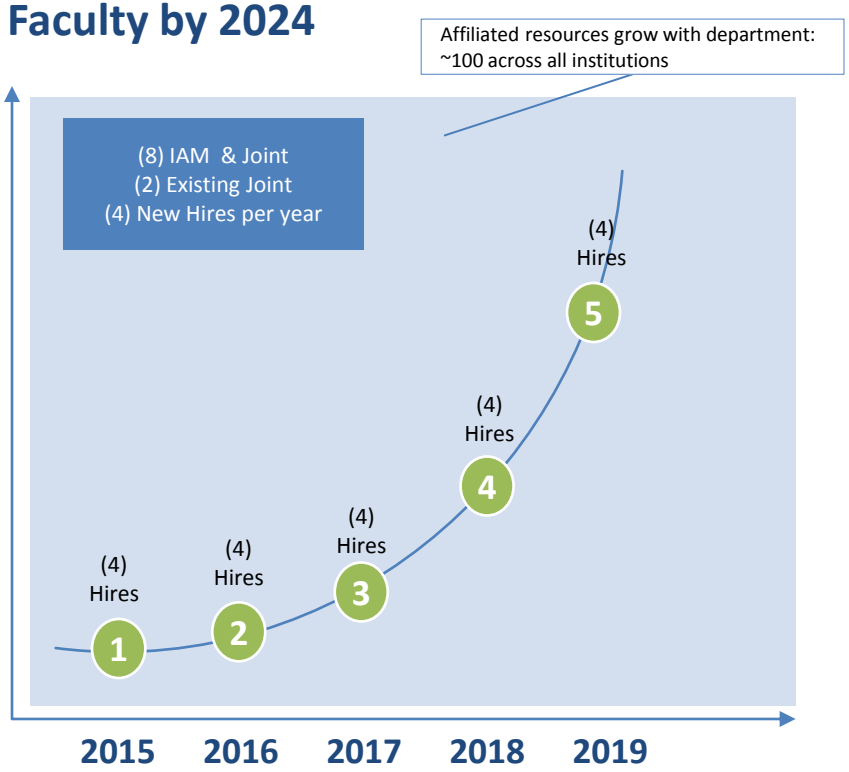
Demand in the state

- 5th nationally in unemployment
- Below average VC funding
- Dropped 8 spots in Science and Technology ranking

Become more entrepreneurial

The Department will seek to hire 20 new faculty in 5 years to grow upon existing joint appointments and affiliates

Faculty by 2024



30	New Hires (Joint and Full) Joint appointments from existing resources
100+	Affiliated resources across Internal Units and External Partners

Faculty Hiring Detail

1

IAM Joint Appointments – Potential APSc Faculty:
- Nancy Allbritton (Chemistry/BME), Rene Lopez (Physics), Tom Meyer (Chemistry), Peter Mucha (Mathematics), Mike Ramsey (Chemistry), Wei You (Chemistry)

- **Other APSc joint appointments:**
  - Potential: Rich Superfine (Physics)
  - Hired Spring 2013: Scott Warren (Chemistry)
- **New Hires** as joint as possible, hired in clusters in materials applications

2

- **Joint:** Additional joint appointments from existing faculty (~2)
- **New Hires:** Joint where possible but ready to hire full-in-APSc
  - Improve incentives to collaborate across units
  - Need to be able to hire "unique" faculty resources of a type that have been difficult to hire in the past at UNC

3-5

- **Affiliated Faculty:** Help them and their departments, not "part" of the departments (approx. 100 over 10 years)
- **Final New Hires:** Hire 20 new faculty in 5 years, as many joint as possible (e.g., 10 new full-in-APSc and 10 new joint faculty)

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The new department can bring $73M to North Carolina over the next 5 years (2015 – 2019)

Investment

Faculty

- New Faculty: 20
- 5yr Cost: **$43.9M**

Department

- Business Dev. 2
- Administrative 5
- Students 20
- 5yr Cost: **$6.3M**

Space

- Facilities: **$30M**
- Renovation: **$3M**
- ISB: **$165M**

Returns

Research Funding

	Federal	Corporate
2019 Funding:	$15M	$5M

- 5yr Brought to NC: **$45M**

Students

- Graduate: 20/yr.
- 5yr Return to NC: **$2.1M**

Patents

	Applied	Granted	Licensed
Patents :	25	6	3

- 5yr Return to UNC: **$4.2M**

Start-Ups

- Start-Ups: 5
- 5yr Return to NC: **$23M**

- 5 yr Cost: **$250M**
- 5 yr Cost (less ISB) **$50M**

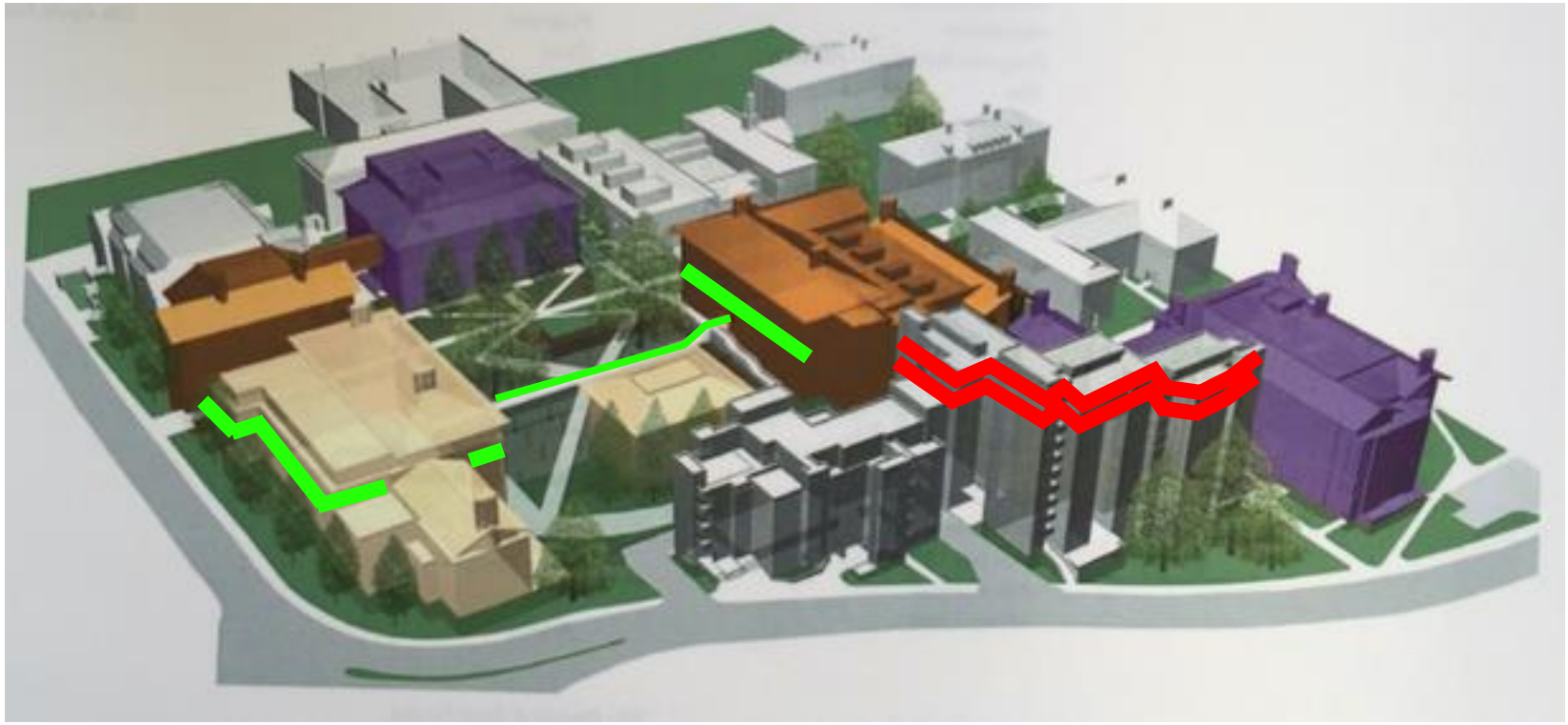
ROI →

- New Jobs in NC **600 – 1,000**
- 5 yr. Return to NC: **$73M**

Tangible return on investments

- Scott Warren (NSF grant)
- Theo Dingemans, Daphne Klotsa, Peter Mucha, Greg Forest (ARO grant)
- Joe DeSimone (Nat'l Medal Innovation & Tech)
- Theo Dingemans (GA ROI grant)

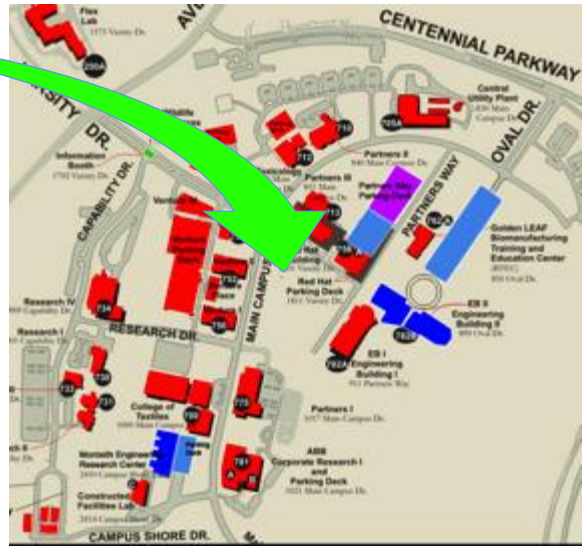
APS in 3rd Phase of Science Complex



APPLIED PHYSICAL SCIENCES

APS @ Carolina - a natural bridge to NCSU

Carolina



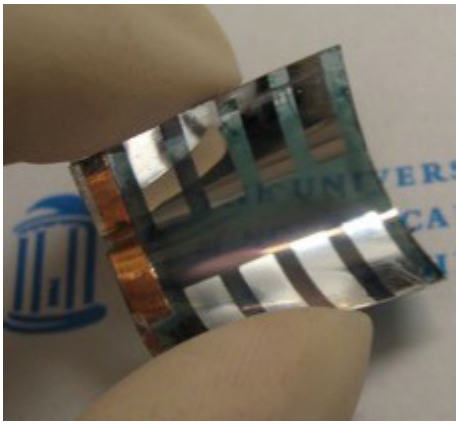
NCSU

APPLIED PHYSICAL SCIENCES

Applied Physical Sciences: Faculty Highlights

Wei You

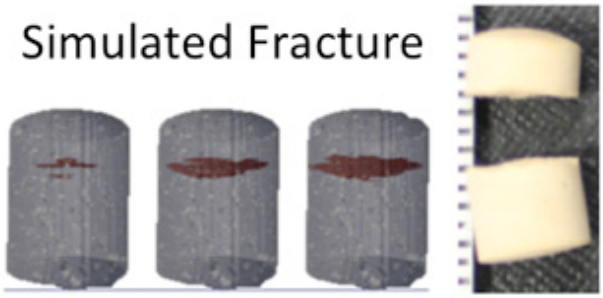
Associate Professor, Assistant Department Chair
Department of Chemistry



Wei You works with Carolina chemists and physicists to develop flexible plastic solar cells in conjunction with collaborators at Duke and NCSU as well as solar cell companies.

Sorin Mitran

Professor
Department of Mathematics



Sorin Mitran simulates the destructive power of high frequency sound waves for disintegrating kidney stones in collaboration with Carolina physicians, computational modelers, and engineers.

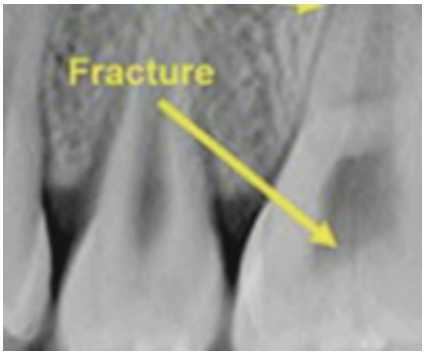
Michael Rubinstein

Distinguished Professor
Department of Chemistry

Michael Rubinstein develops theoretical models and uses computer simulations of soft matter and contrasts with experimental findings of collaborate at the UNC Cystic Fibrosis Center to advance effective treatments of airway diseases.

Otto Zhou

Distinguished Professor
Department of Physics and Astronomy

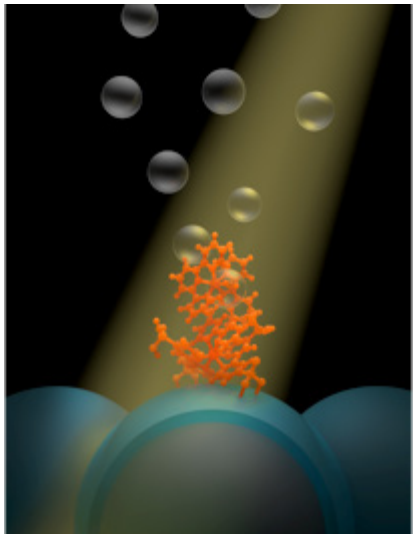


Otto Zhou uses carbon nanotubes to generate high resolution X-ray pictures used by physicians from UNC Radiology, Radiation Oncology, the Cancer Center and the School of Dentistry.

Tom Meyer

Distinguished Professor

Department of Chemistry

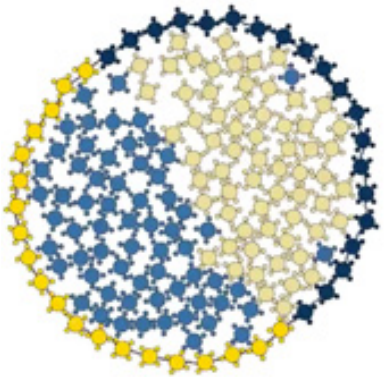


Tom Meyer leads a group of researchers in UNC's Departments of Chemistry and Physics as well as groups at the University of Florida, Georgia Institute of Technology, and the University of Colorado – Boulder in the DOE-funded University of North Carolina Energy Frontier Research Center for Solar Fuels Artificial Photosynthesis to design and build an artificial leaf.

Daphne Klosta

Assistant Professor

Department of Applied Physical Sciences

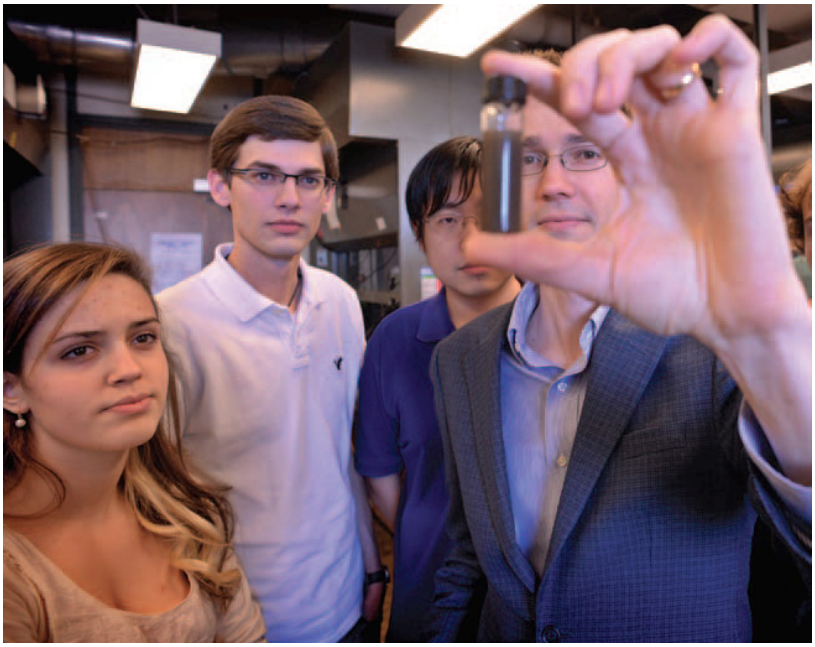


Daphne Klotsa explores emergent collective properties—emergent "intelligence"—to enable cooperative nanoparticles in drug delivery, swarms of robots for deep-ocean exploration, and synthetic smart materials that adapt, self-heal, and regenerate.

Scott Warren

Assistant Professor

Department of Chemistry

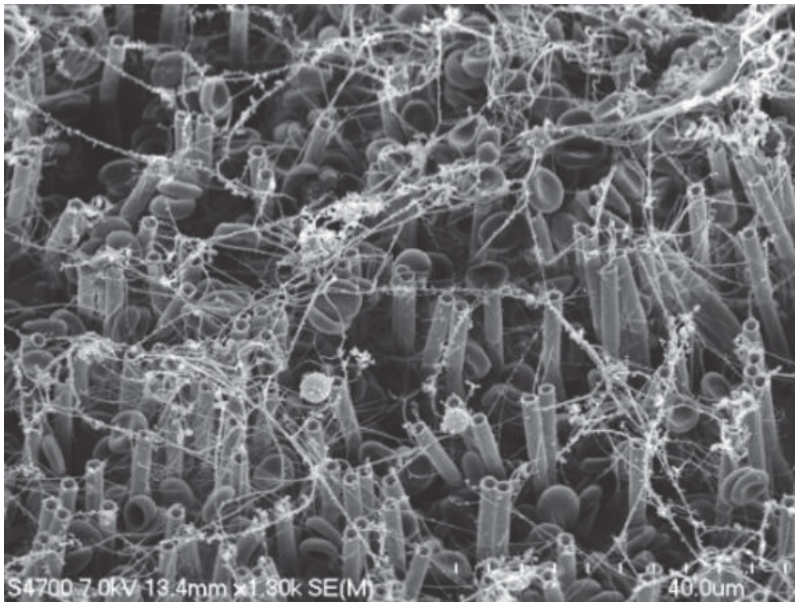


Scott Warren is exploring 1-atom thick new 2D materials for improved solar cells, batteries, and window coatings.

Richard Superfine

Taylor-Williams Distinguished Professor
Department of Physics and Astronomy

Richard Superfine leads an NIH center that studies the biological physics of forces in single molecules, cells and physiological phenomena including cancer, blood clotting and mucus clearance in the lung. Superfine has pioneered Carolina's Maker Space—BeAM (Be a Maker) and wants all students — creative types and technocrats and science geeks — to use the spaces.



Greg Forest

Distinguished Professor
Department of Mathematics
Department of Biomedical Engineering

Greg Forest and colleagues saw the opportunity to formulate many open questions from applied mathematics and materials science in one remarkable biological system – lung transport of mucus.

Advanced Manufacturing Targeted by Applied Physical Sciences

The state of North Carolina is primed to create advanced manufacturing jobs in the aerospace/transport sector. The Southeast is increasingly attractive to those industries: *Honda Jet* and *Spirit AeroSystems* have relocated to North Caroina, and Boeing is aggressively building capacity in Charleston, SC.

Carolina has an opportunity to leverage this trend to benefit the state and the university system, building on intrinsic strengths:

- UNC-Chapel Hill has an internationally-recognized polymer program, housed in a nationally-ranked chemistry department.
- UNC-CH is building a new department of Applied Physical Sciences with the express intention of establishing expertise in the lucrative area of advanced materials and manufacturing.
- NCSU has high visibility in polymer composites, in both Aerospace and Mechanical Engineering, and in the School of Textiles.

One of the biggest barriers to entry into the aerospace/transport composites industry for Carolina is the difficulty of attracting researchers with both excellent academic credentials and expertise in industrial research, which requires access to companies and manufacturing facilities.

APS has successfully hired a senior faculty member, Theo Dingemans, PhD, Distinguished Professor of Aerospace Engineering at the Technical University of Delft (start date, July 1, 2016). Dingemans' expertise straddles those at UNC's flagship institutions and his research will nucleate the kind of training that supports the attraction of advance manufacturing industries to NC with their associated high-value jobs.

Theo Dingemans, PhD

Theo Dingemans obtained his PhD at UNC-CH in 1998 under Ed Samulski, current chair of APS. He went on to NASA Langley, where he developed a new class of high performance polymer composites for use in the space shuttle. Dingemans brings a strong consulting relationship with *Boeing*, and many high-tech companies in the US and abroad have requested samples of his new class of composites—*Fokker, KLM, Airbus, SKF, Shell, Schlumberger*, etc. He is a superb scientist with excellent leadership skills, one who can bridge the science and engineering at our two flagship universities. In April 2016 his ROI proposal on water-based polymer composites was selected for the General Administration competition.

Will robots school like fish or flock like birds?

Daphne Klotsa's research centers on active matter physics. Active matter is defined as an active "agent" that uses energy to move or exert force. For example, schools of fish or flocks of birds are considered active matter, as are bacteria, robots or self-propelled particles.

What happens when a single bird suddenly becomes a swirling flock of birds? Why do they assemble in a particular shape? How do ants form bridges when their colony is flooded? Such examples of active self-assembly in the natural world hold potential clues for designing robots that could repair buildings constructed in water or under bridges.

The mechanics of swimming may seem obvious. Think about how Olympic swimmers propel their arms and legs, fish undulate their bodies or bacteria spin their flagella. But what is the simplest method of swimming, and how do things transition from being in a stationary position to actively swimming? That information has the potential to transform the design of microscopic and macroscopic robots in medicine and engineering.

Klotsa and colleagues published a report in the journal *Physical Review Letters* this spring that describes experiments that demonstrate how fluid dynamics influence swimming. They broke down the mechanics of swimming to its simplest form by using robots made of two spheres to show that swimming can only occur once a critical change in fluid flow has taken place. Their report can help scientists understand the fundamental nature of motion.

"This finding can facilitate advances in robotics and potential applications of robotic swimmers for drug delivery in the body or exploration of the deep seas," Klotsa explained. She conducted the research with colleagues at the University of Nottingham while she was based at Cambridge University, and then finished the work at UNC-Chapel Hill.

Daphne Klosta, PhD

Daphne Klotsa joined APS July 1, 2015, as an assistant professor. She said she is delighted to join the faculty of the applied physical sciences department in the College of Arts and Sciences. "It's the perfect recipe: picking extraordinary scientists, people with a similar vision for interdisciplinary work and translation of science into real-world solutions, and putting them together to make a new department," she said. She is reaching out to fellow UNC scientists in applied mathematics, biology, and the Cystic Fibrosis Center, and hopes to establish collaborations across campus and beyond.

See more at: http://college.unc.edu/2016/03/22/klotsa/#sthash.wAw6GLnh.dpuf