

# Designing Research Environments for a Quantum Future

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**Jeremy Barrette**

AEI / Principal

**Sean McGreal**

ZGF Architects / Principal



# Learning Objectives

## Learning Objective 1

Understand strategies for designing for quantum and optic lab requirements, while delivering an experiential building that's meaningfully integrated and connected to campus.

## Learning Objective 2

Learn about solutions for designing all-electric laboratories in harsh climates, including high-performance envelope strategies that reduce energy demands, harvest daylight into interior spaces, and create shading that enables year-round enjoyment of outdoor spaces.

## Learning Objective 3

How to develop a laboratory module that can flex from wet to damp to dry over the lifetime of the building, supporting evolving nature of grant-driven research focused on quantum science.

## Learning Objective 4

How engineering played an integral role during concept and programming in building systems decision making. This includes how metering existing spaces played a key role in driving cooling and electrical capacity design, how spare utilities were routed through a central linear equipment corridor for ease of future access, and how the makeup air and exhaust system was optimized for efficiency, safety, and growth.

# Meet the Team



**Jeremy Barrette** PE, HFDP, EDAC

Principal, Affiliated Engineers, Inc.

Lead MEP Engineer



**Sean McGreal** AIA

Principal, ZGF Architects

Lead Designer

# Grand Challenges Research Building

University of Arizona

**GRAND CHALLENGES CALL FOR GRAND SOLUTIONS.**

The Grand Challenges Research Building is designed to do just that: provide an interdisciplinary venue for developing quantitative solutions for the eight 'grand challenges' of the Fourth Industrial Revolution. This includes:



WATER



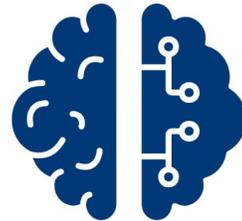
ENERGY



CLIMATE  
CHANGE



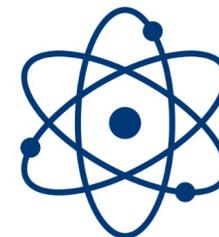
PRECISION  
MEDICINE



NEUROSCIENCE



SPACE  
EXPLORATION



QUANTUM  
INFORMATION

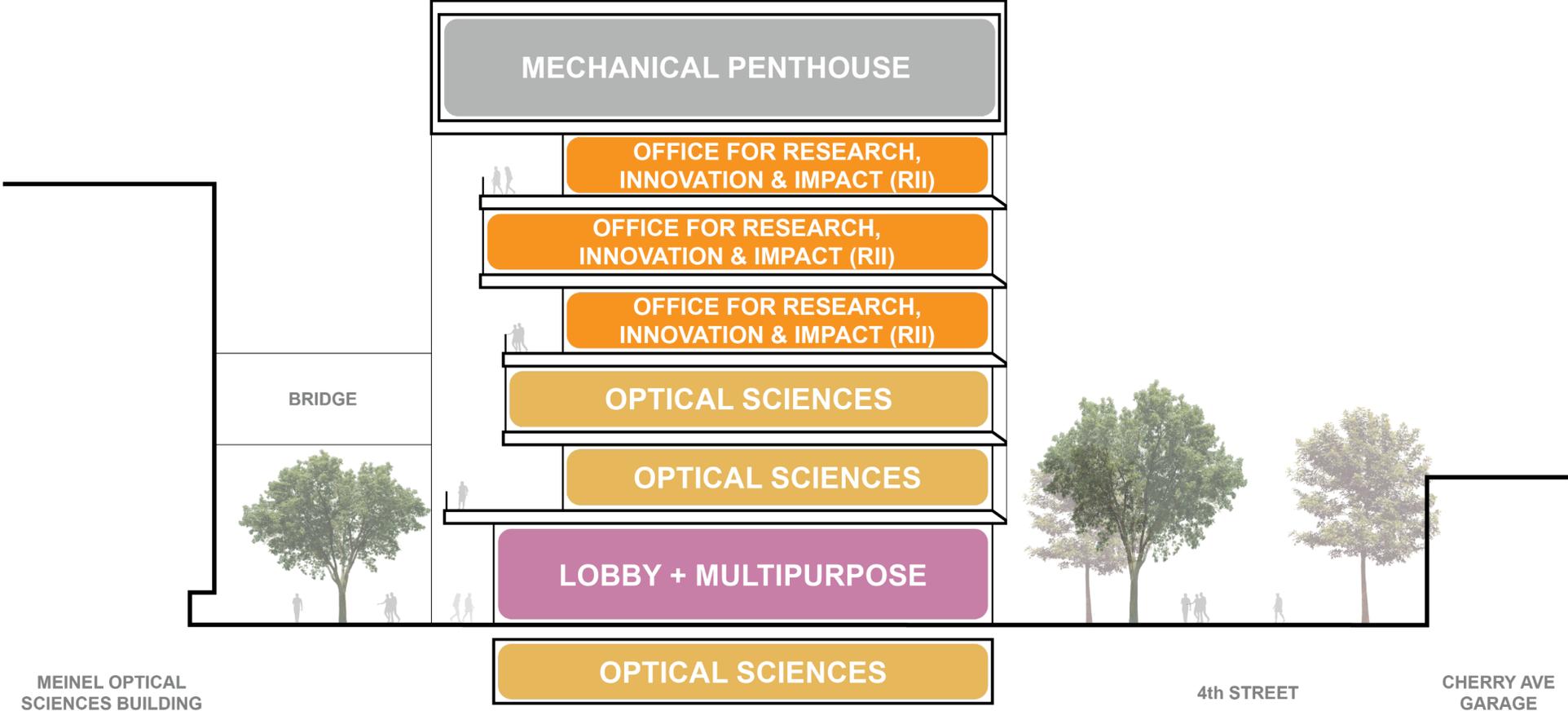


MATERIAL  
SCIENCE

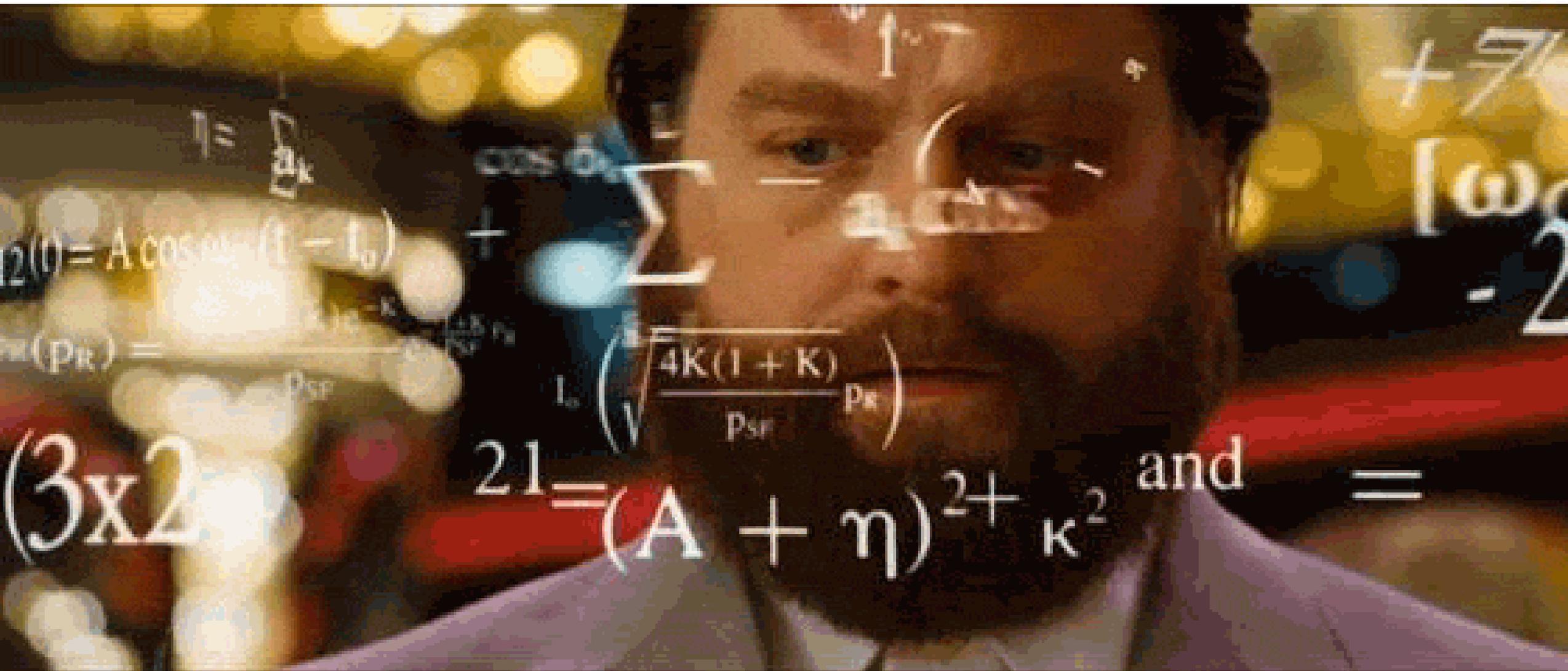
*....as it relates to advanced analytics, automation, and advanced-manufacturing technology.*

# Grand Challenges Research Building

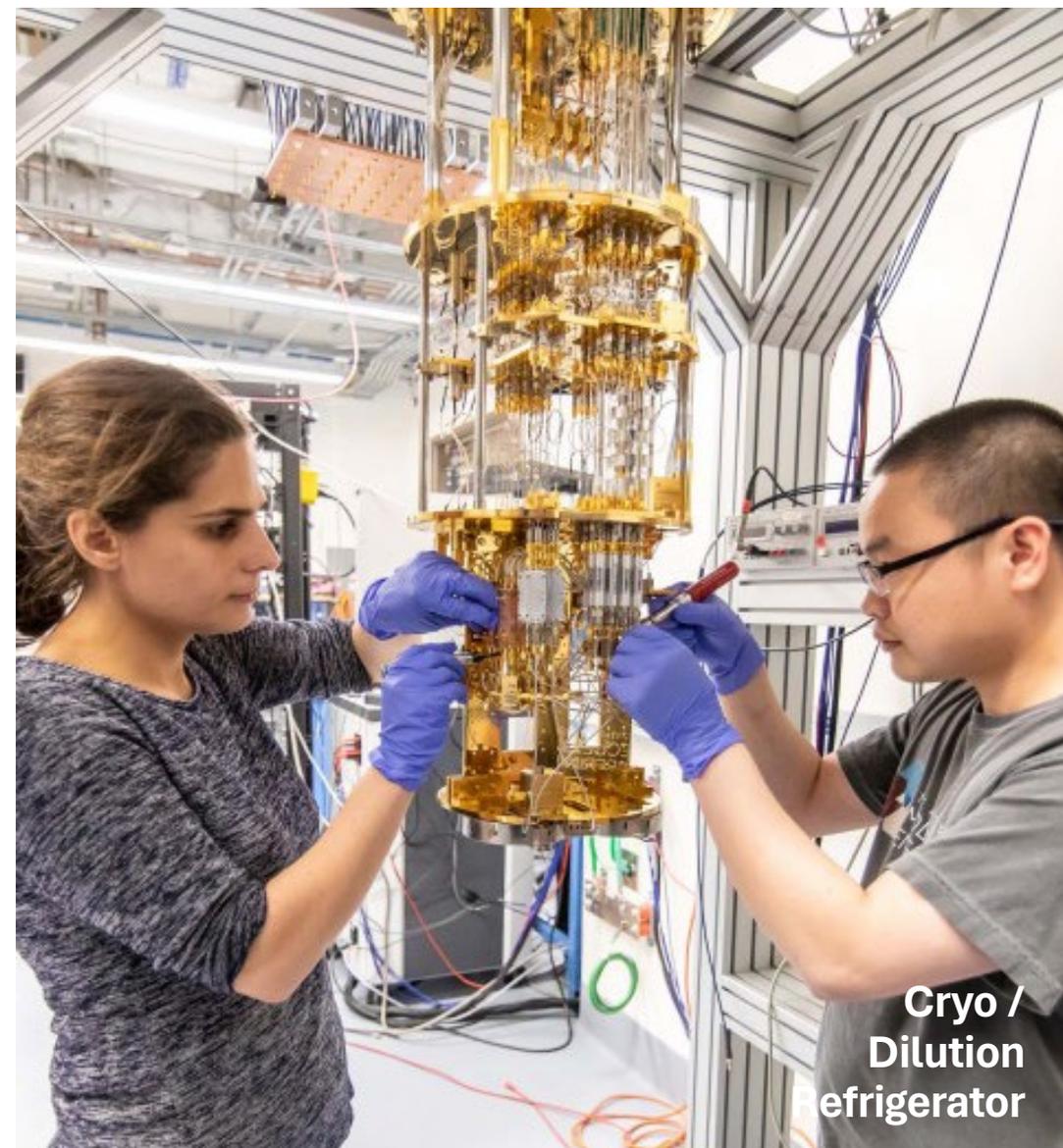
## Program Stacking Diagram



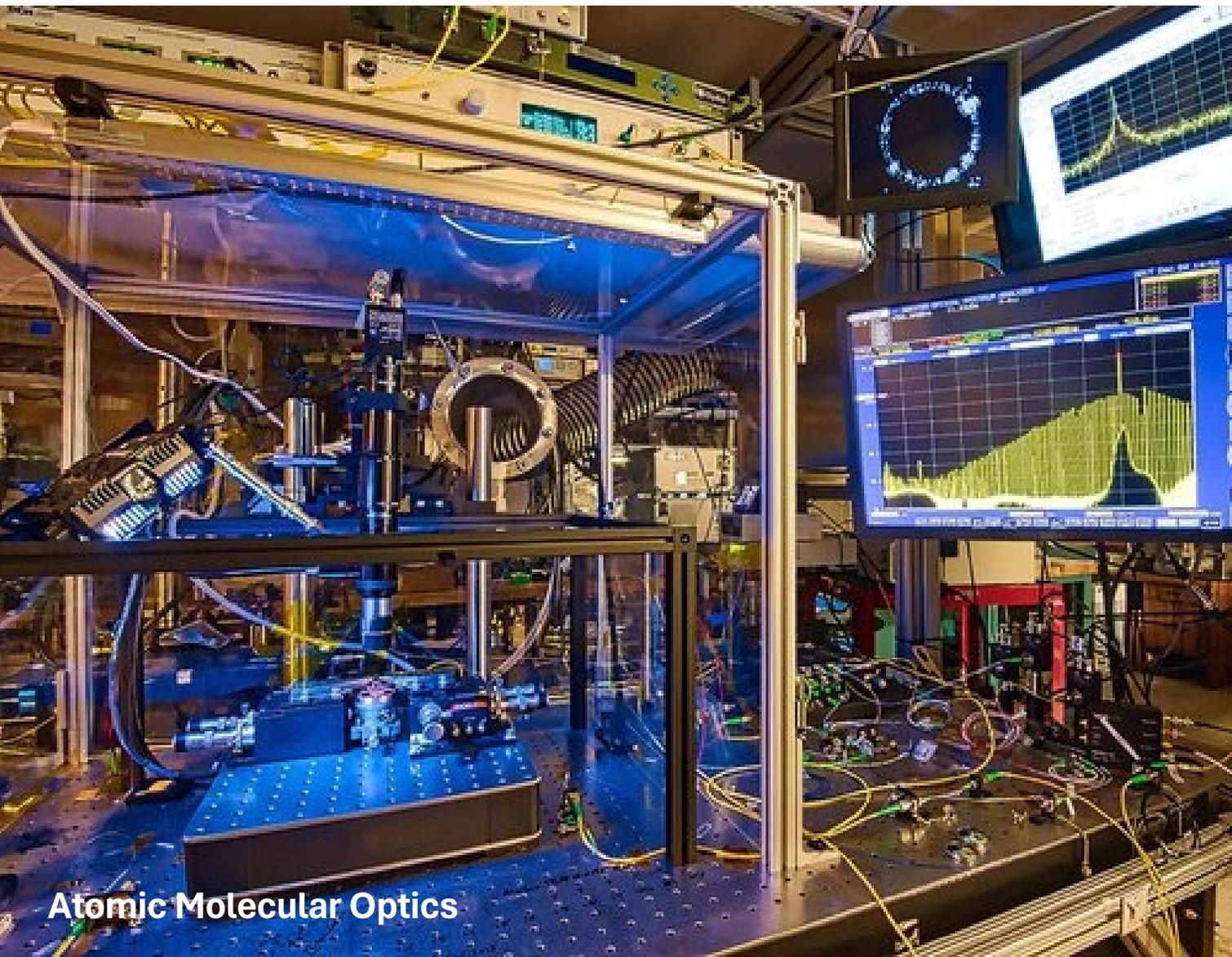
## What is Quantum Research?



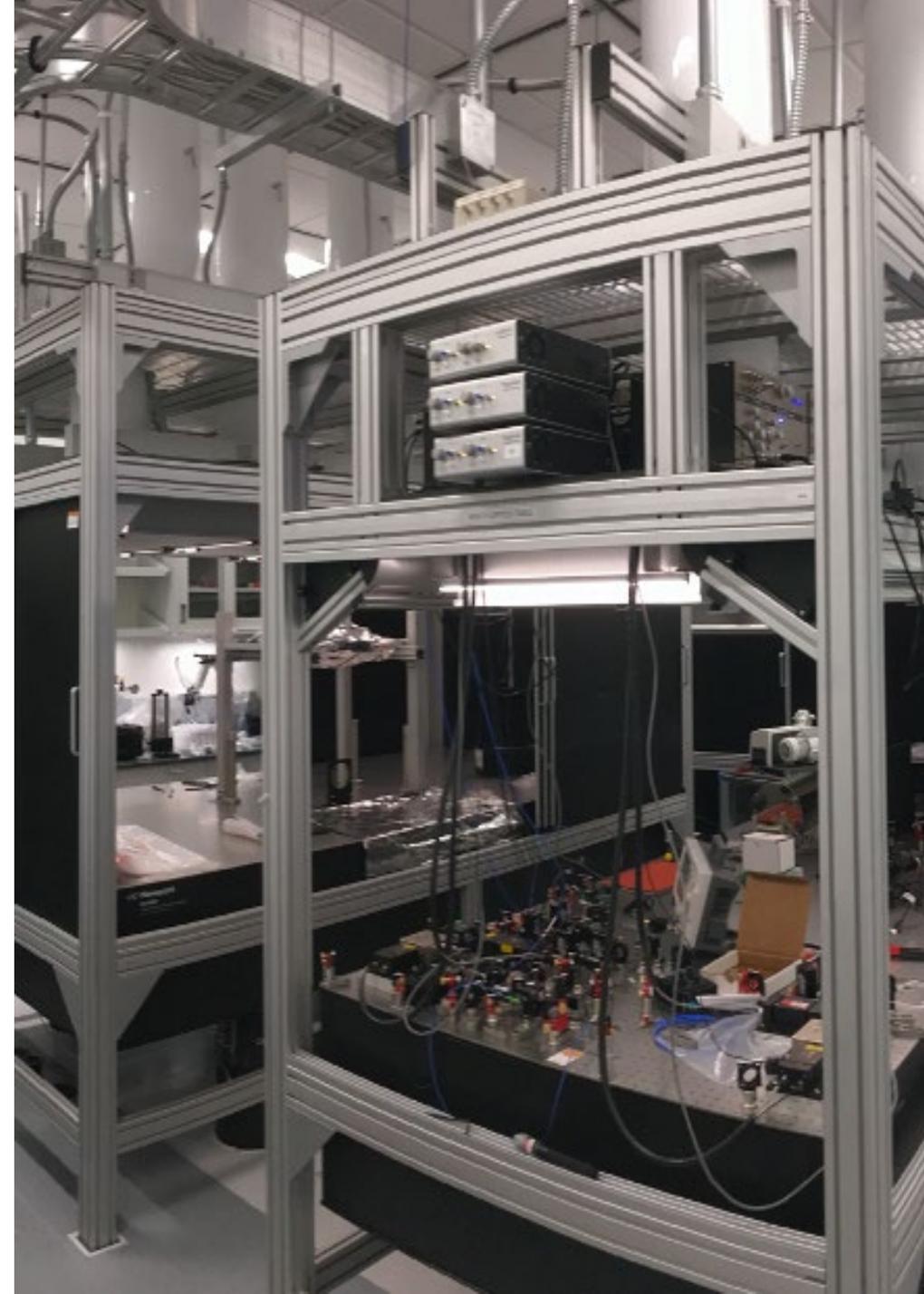
# What's So Special About Quantum Research?



# What's So Special About Quantum Research?



Atomic Molecular Optics





**Design Approach**

# Project Site



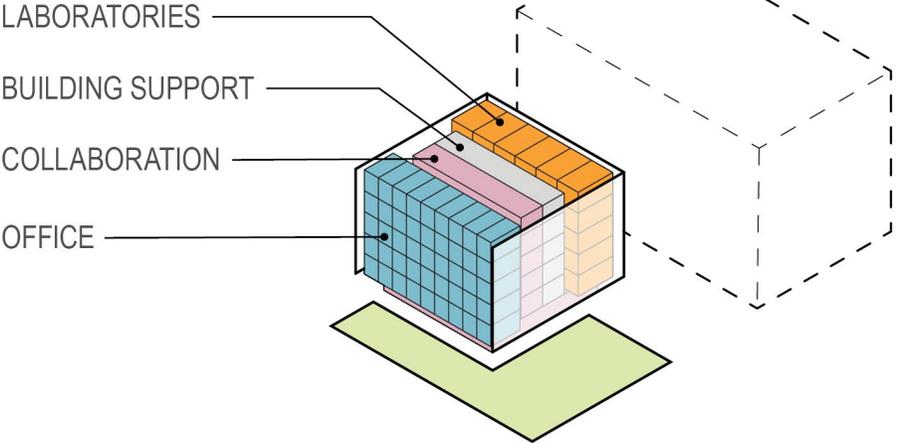
# Project Site

View from the South

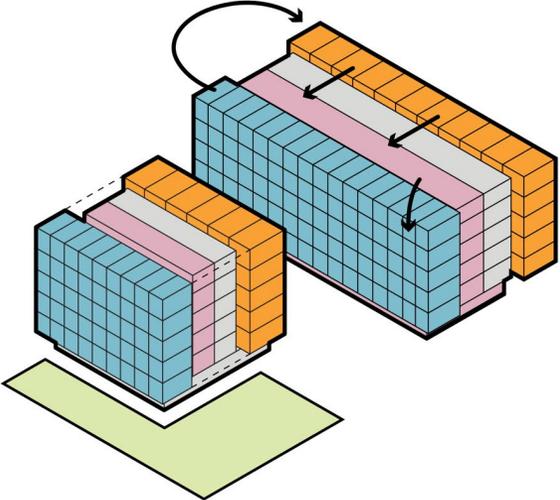
PROJECT SITE



# Conceptual Layout

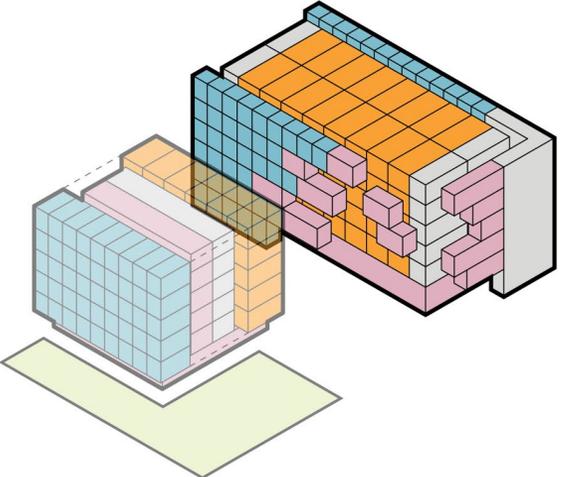


1. MEINEL WEST

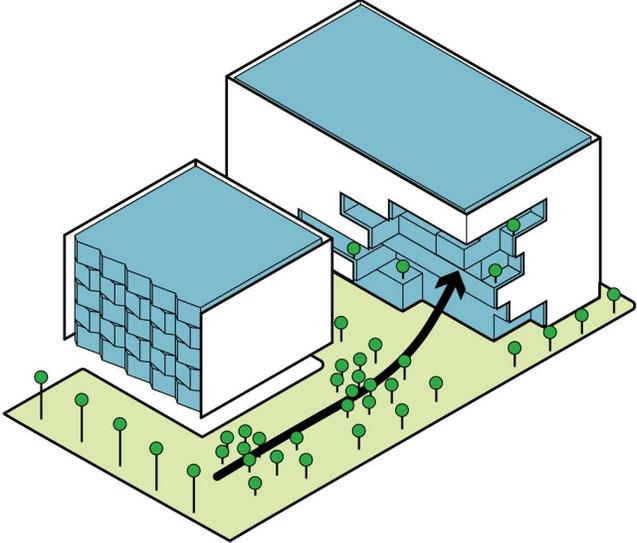


2. REARRANGE PROGRAM

- LEGEND**
- LABORATORIES
  - BUILDING SUPPORT
  - COLLABORATION
  - OFFICE



3. ADJUSTED PROGRAM,  
COLLABORATION ON DISPLAY



4. EXTENSION OF LANDSCAPE

# View from the University's Main Mall

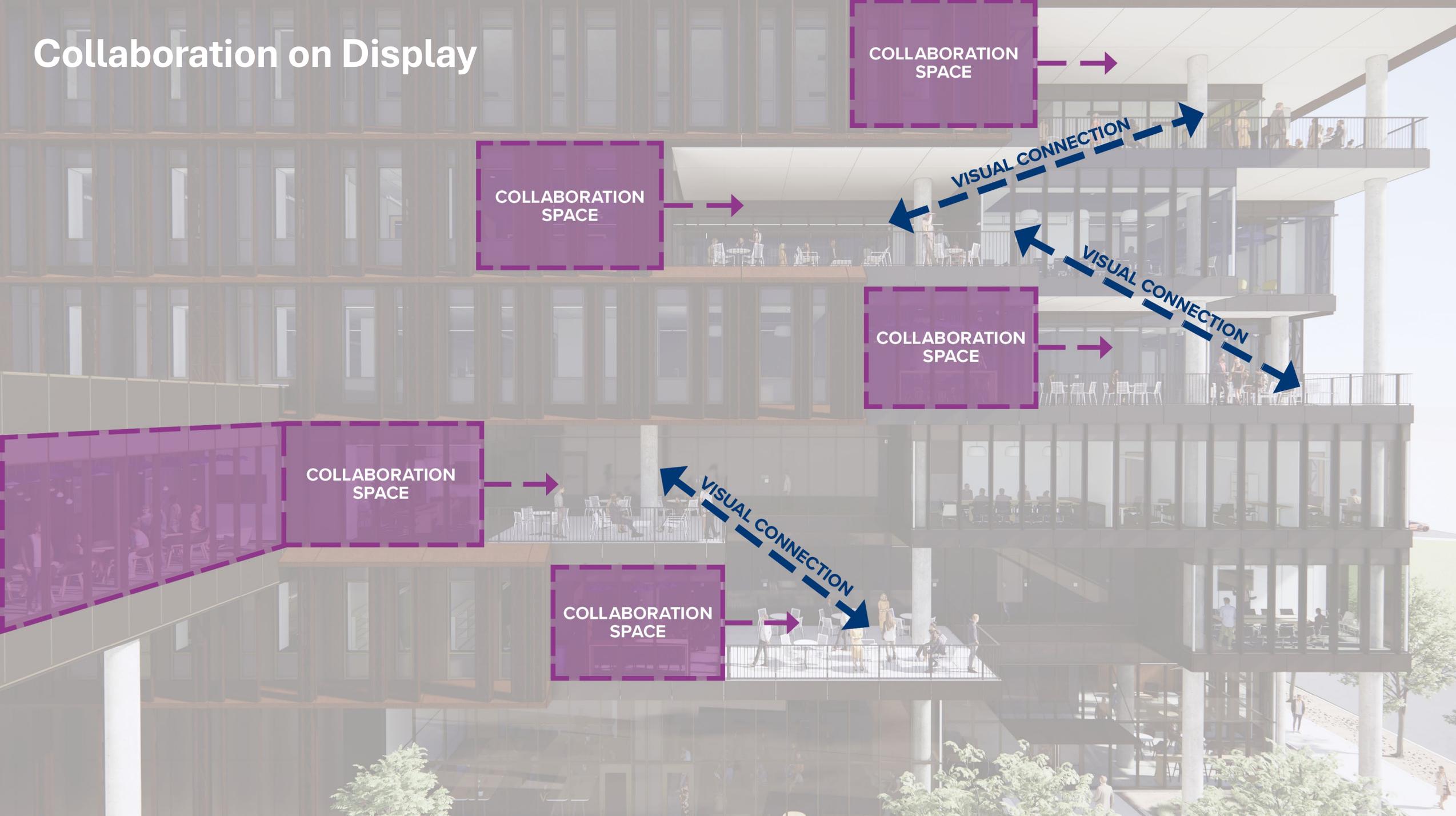


# Collaboration on Display

View from the North



# Collaboration on Display



COLLABORATION SPACE

COLLABORATION SPACE

COLLABORATION SPACE

COLLABORATION SPACE

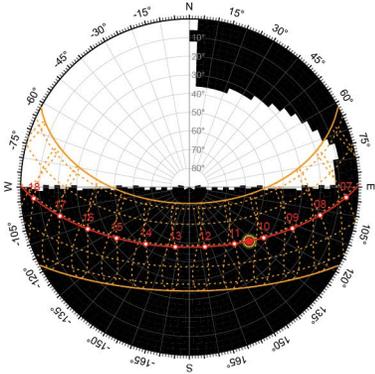
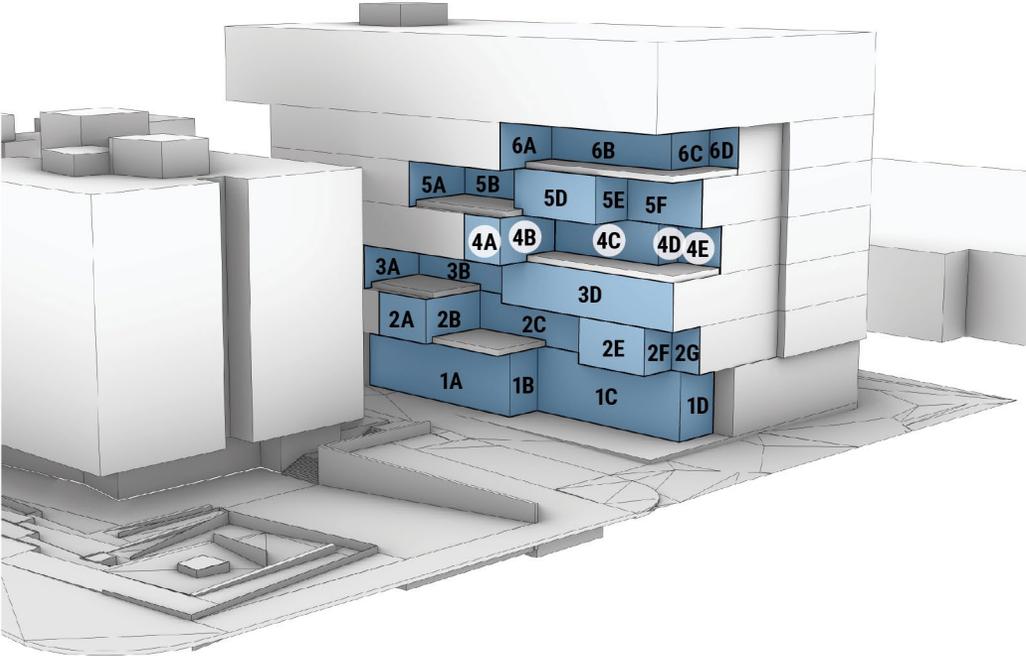
COLLABORATION SPACE

VISUAL CONNECTION

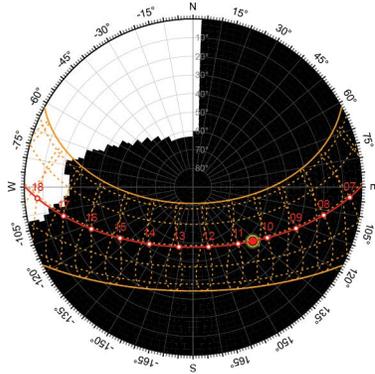
VISUAL CONNECTION

VISUAL CONNECTION

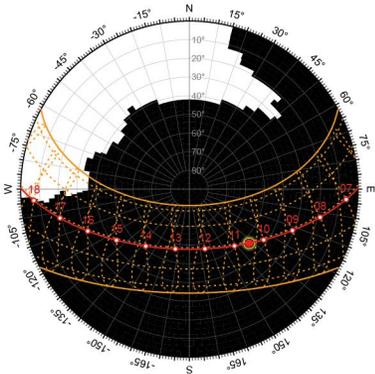
# Self-Shading Analysis



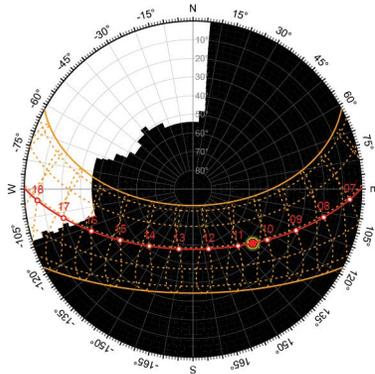
4A



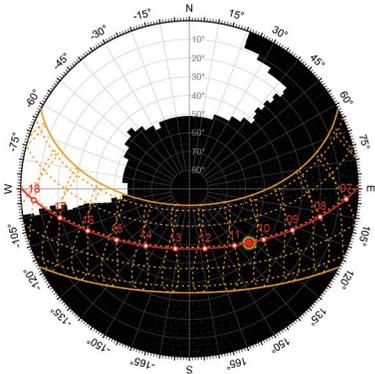
4B



4C

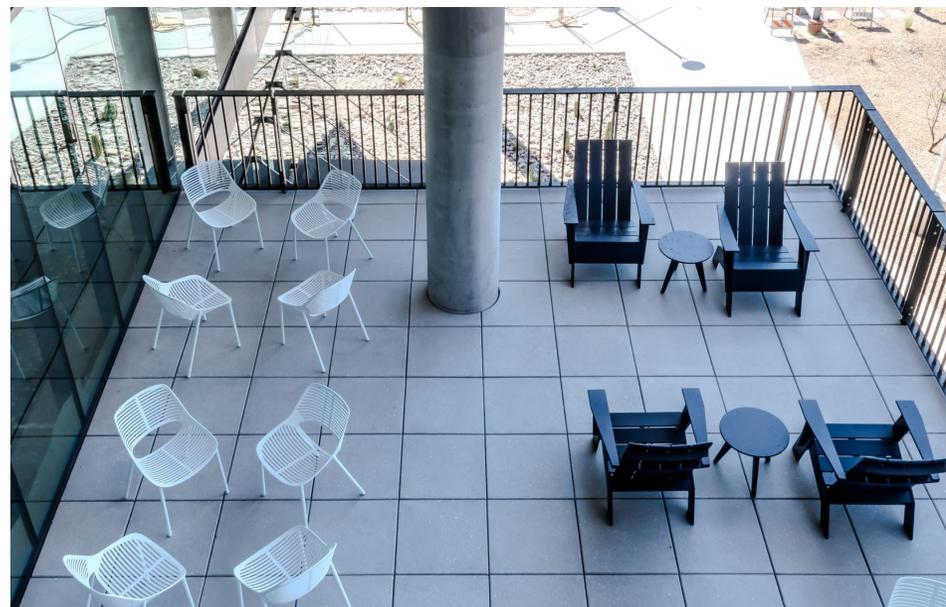


4D



4E

# Visual Connections + Self-Shading



# Visual Connections

View from the Bridge



# Sustainability Strategies



Cooling provided by campus district energy system (DES).



Net Zero Carbon: 100% of annual energy usage (56 Megawatts) is procured by off-site renewable energy (solar and wind power).



All electric building systems.



- 1 BIKE PARKING**  
Providing bike parking areas around the building promotes the use of alternate modes of transportation, conserving energy and reducing emissions, throughout the campus.
- 2 OUTDOOR WATER & LANDSCAPE**  
The native, drought-tolerant plant palette reduces water consumption by 50%.
- 3 DAYLIGHT**  
Placing balconies strategically offers self-shading and access to daylight, providing 40% spatial daylight autonomy in all regularly occupied spaces.
- 4 CHILLED BEAMS**  
Chilled beams provide highly energy-efficient air-conditioning in offices, as well as collaboration spaces.
- 5 DEDICATED OUTDOOR AIR SYSTEM**  
DOAS (Dedicated Outdoor Air System) with heat pipe energy recovery, resulting in a 60% reduction in space heating energy.
- 6 HIGH-PERFORMANCE ENVELOPE**  
A dual facade deliver a high-performance building envelope that helps reduce glare and solar heat gain, and is made of recyclable corten steel.
- 7 BIO HABITAT**  
Native vegetation in the bio-retention garden filters stormwater, infiltrates water into the aquifer, and creates a vibrant riparian habitat, mimicking those found in the Sonoran Desert of Tucson, Arizona. It filters 100% of stormwater, with a capacity of 17,700 gallons.



# Sustainability Strategies

## Bio-retention Garden



# Sustainability Strategies

## High Performance Facade



# Sustainability Strategies

## High-Performance Facade



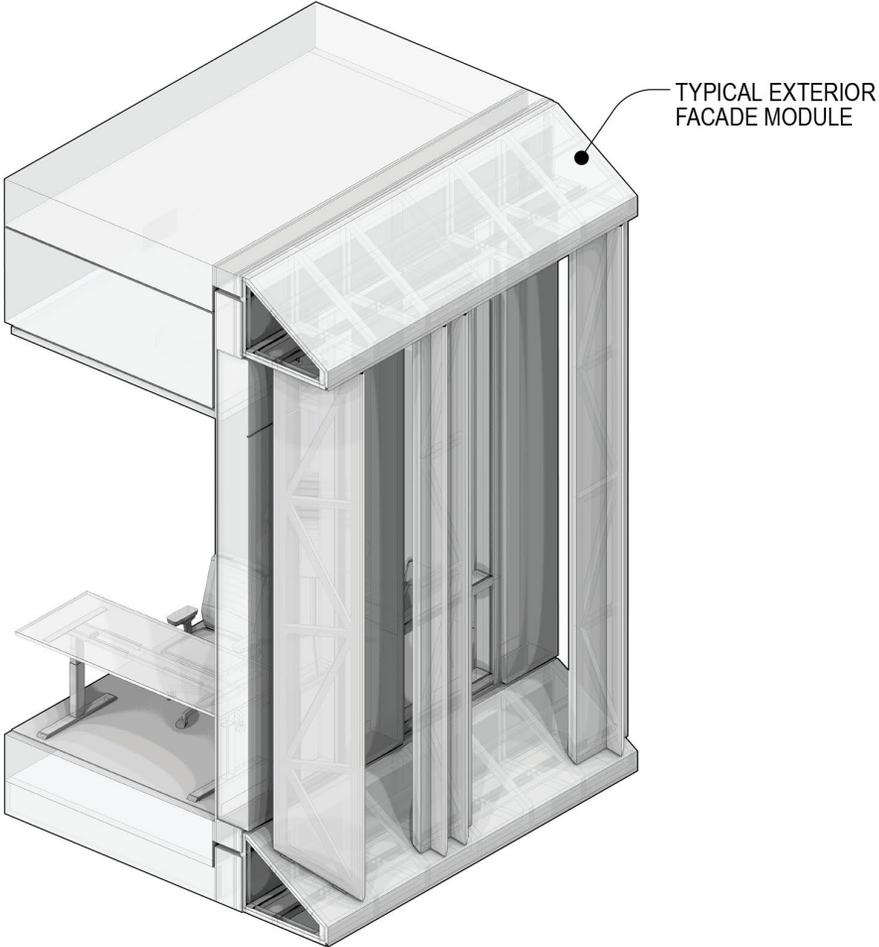
# Sustainability Strategies

High-Performance Facade

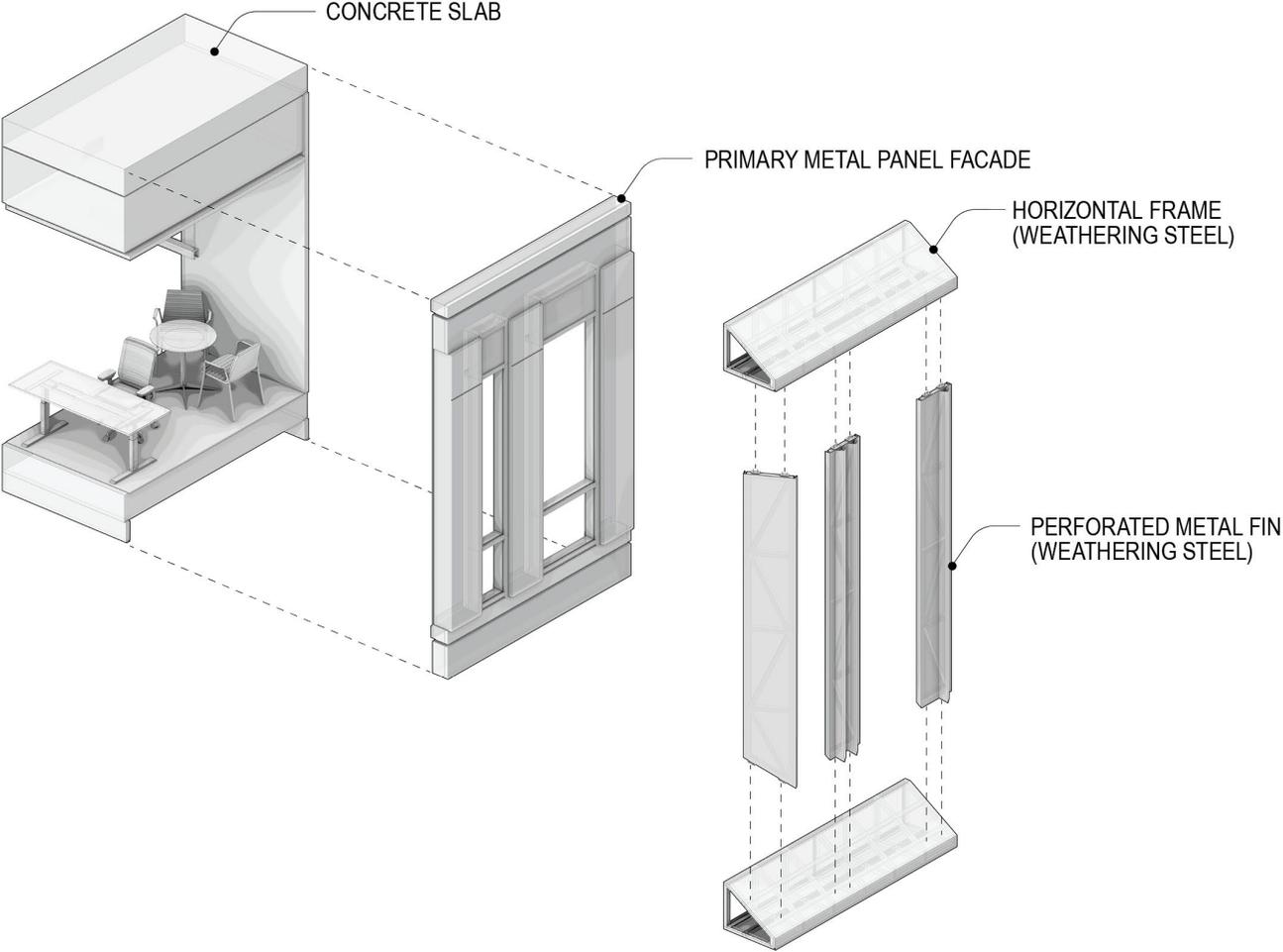


# Sustainability Strategies

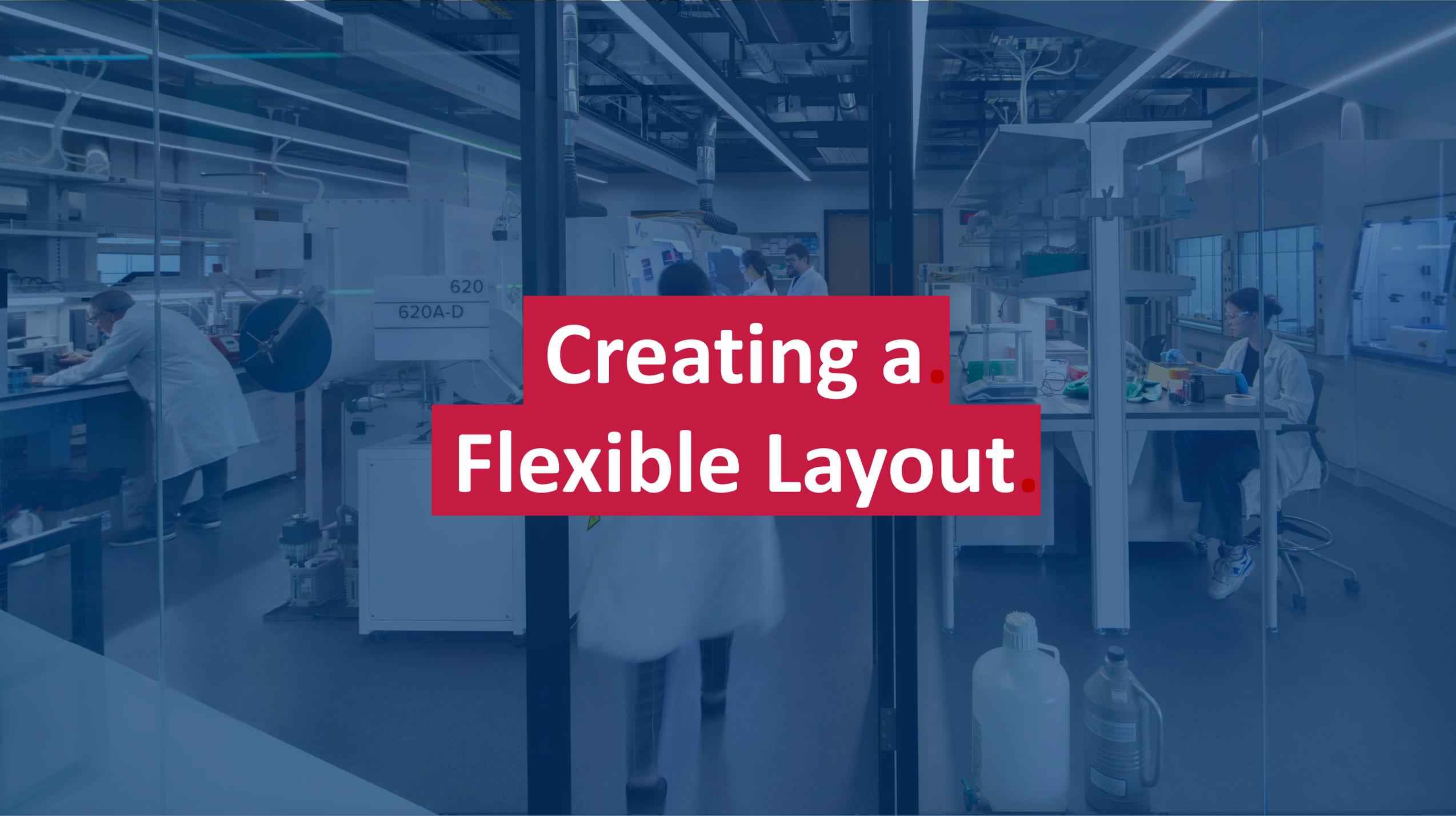
## High-Performance Facade



ASSEMBLED FACADE



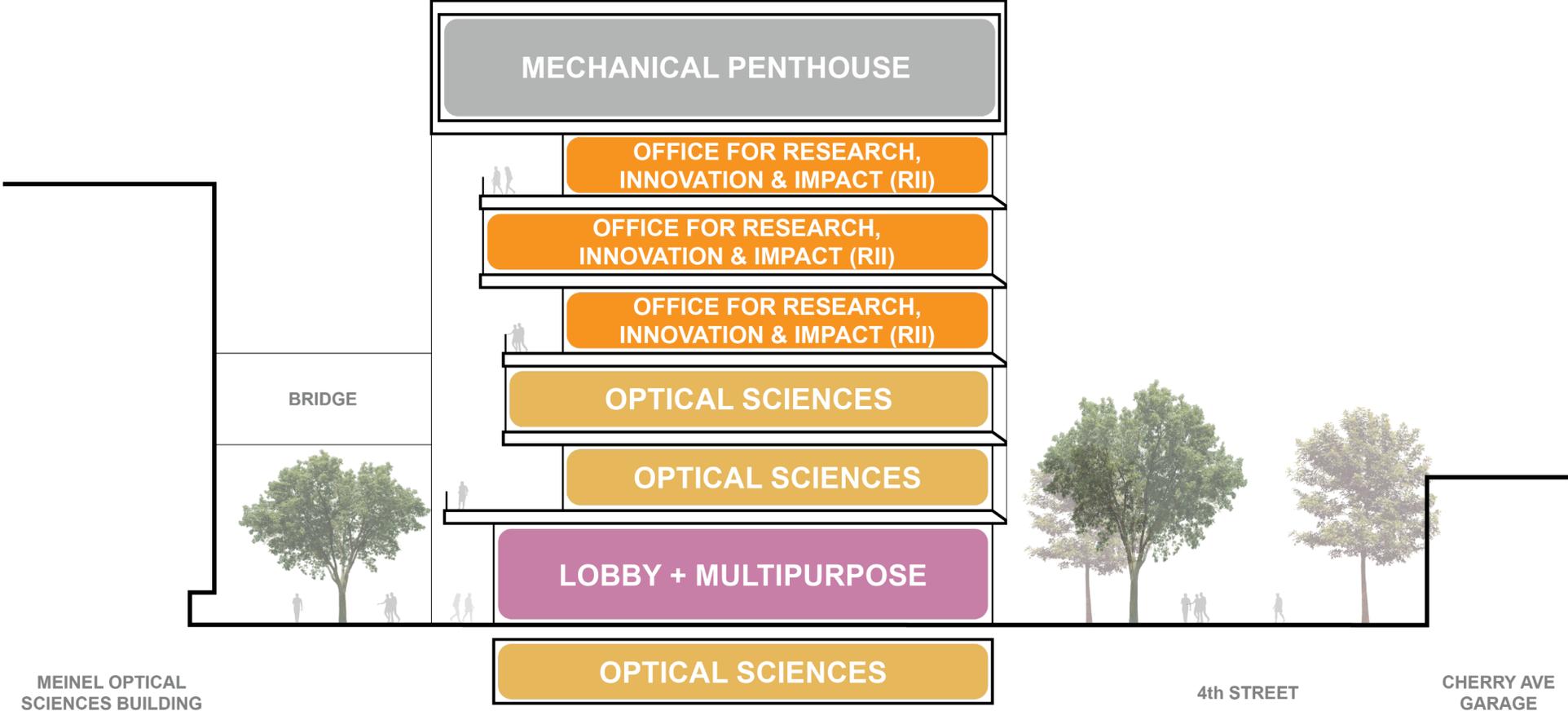
EXPLODED FACADE



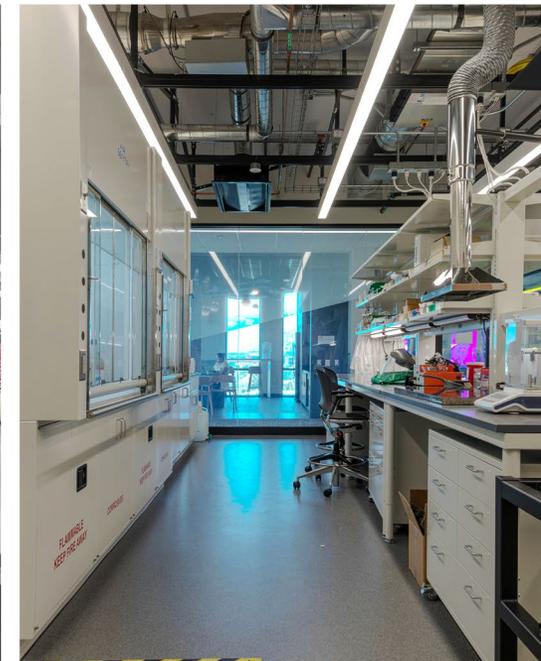
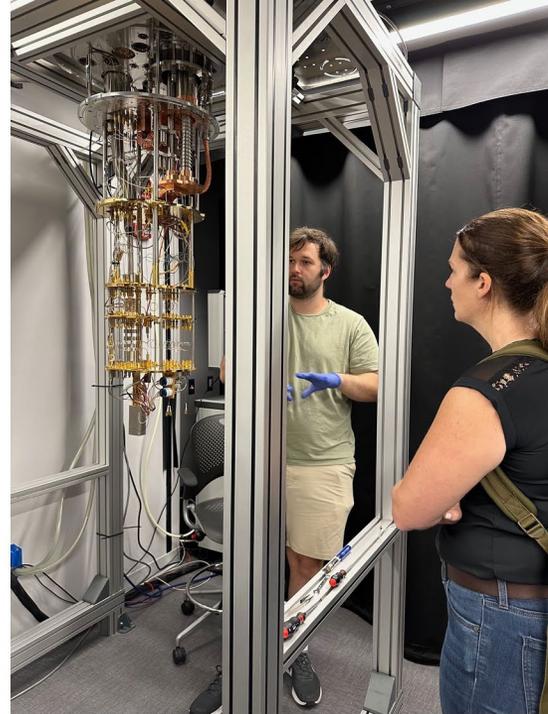
**Creating a  
Flexible Layout.**

# Program Strategies

## Stacking Diagram

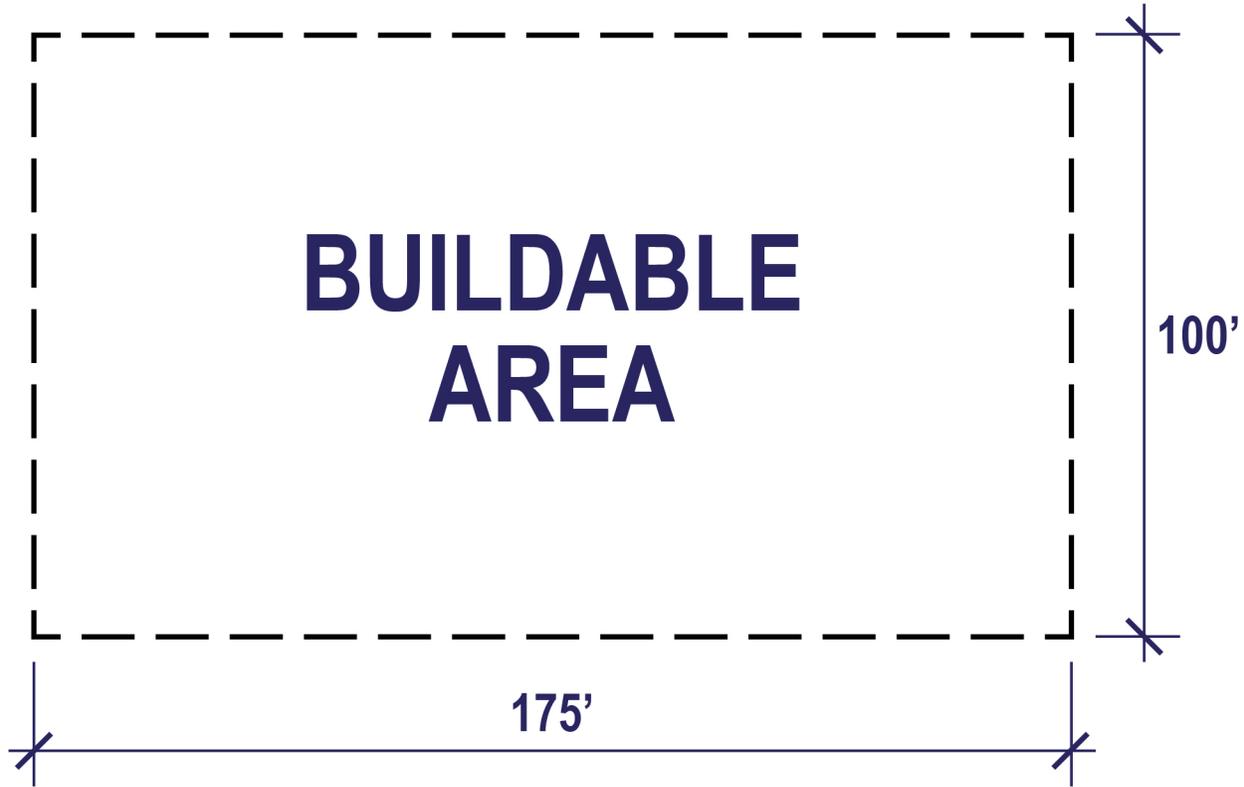


# Laboratory Typologies



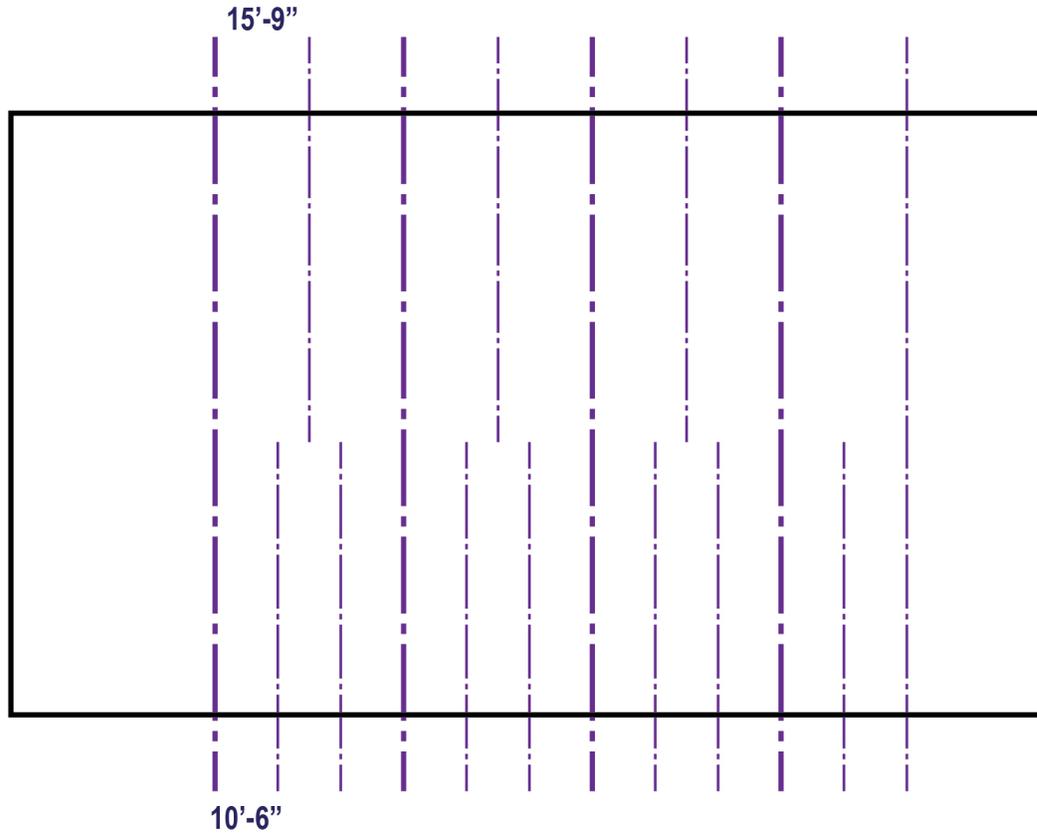
# Finding a Common Module

MEINEL  
OPTICAL  
SCIENCES



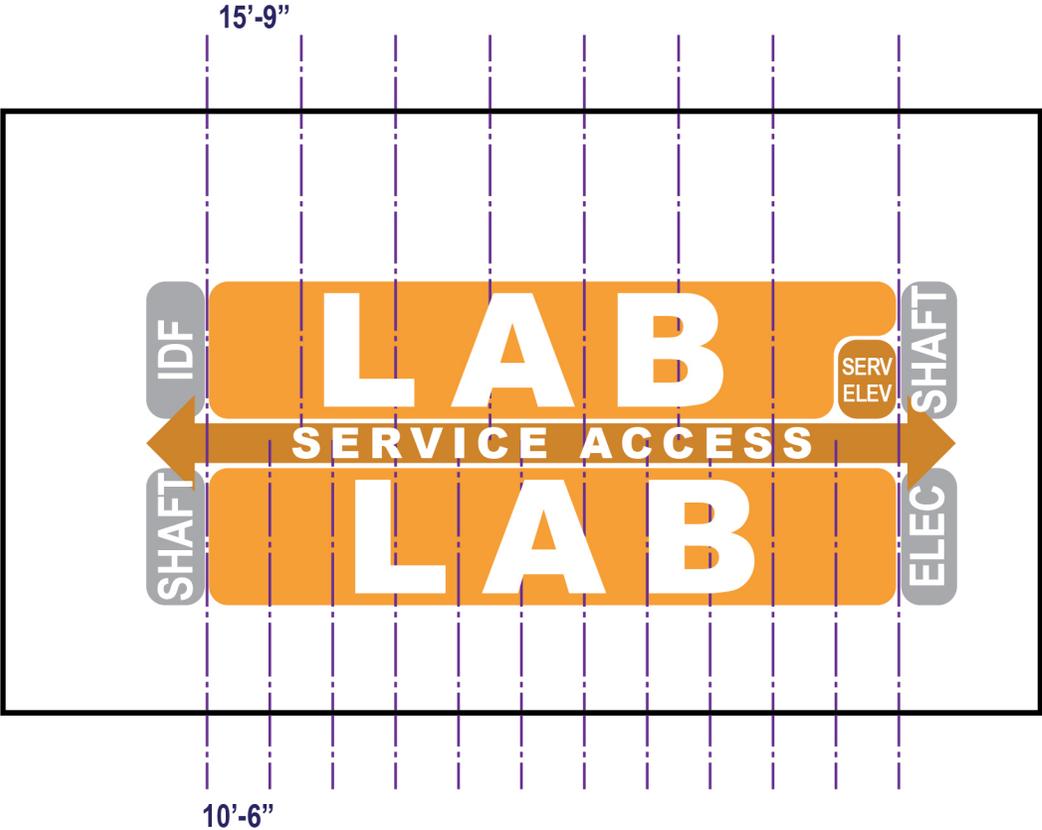
# Finding a Common Module

MEINEL  
OPTICAL  
SCIENCES



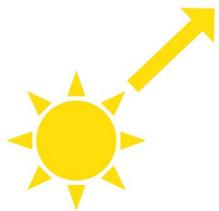
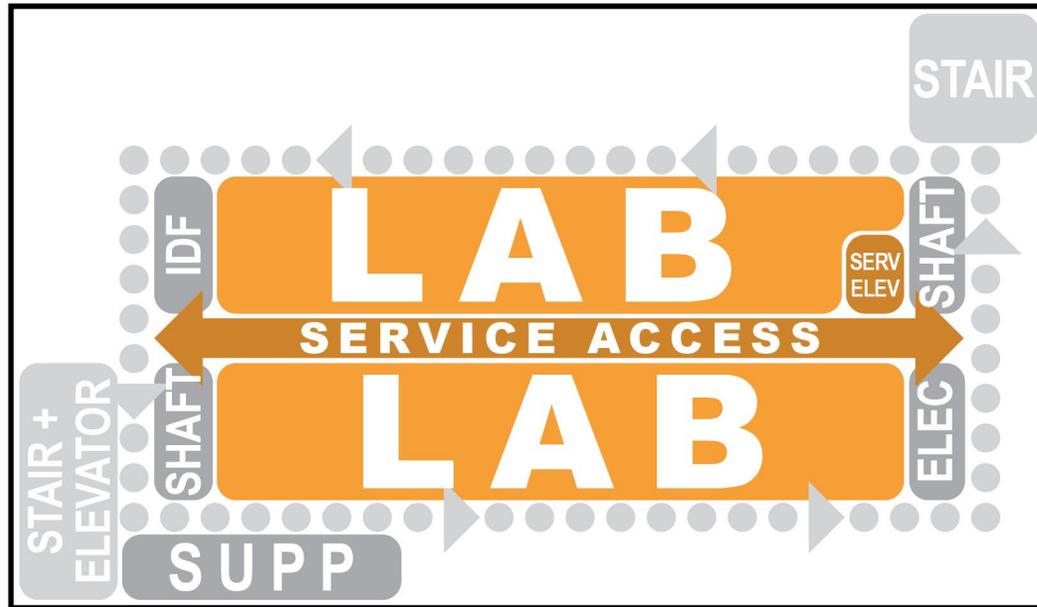
# Lab Layout

MEINEL  
OPTICAL  
SCIENCES



# Responding to Orientation

MEINEL  
OPTICAL  
SCIENCES



# Views In and Out

VIEWS FROM  
THE MAIN MALL



VIEWS TO THE MAIN MALL  
AND THE MOUNTAINS BEYOND



MEINEL  
OPTICAL  
SCIENCES



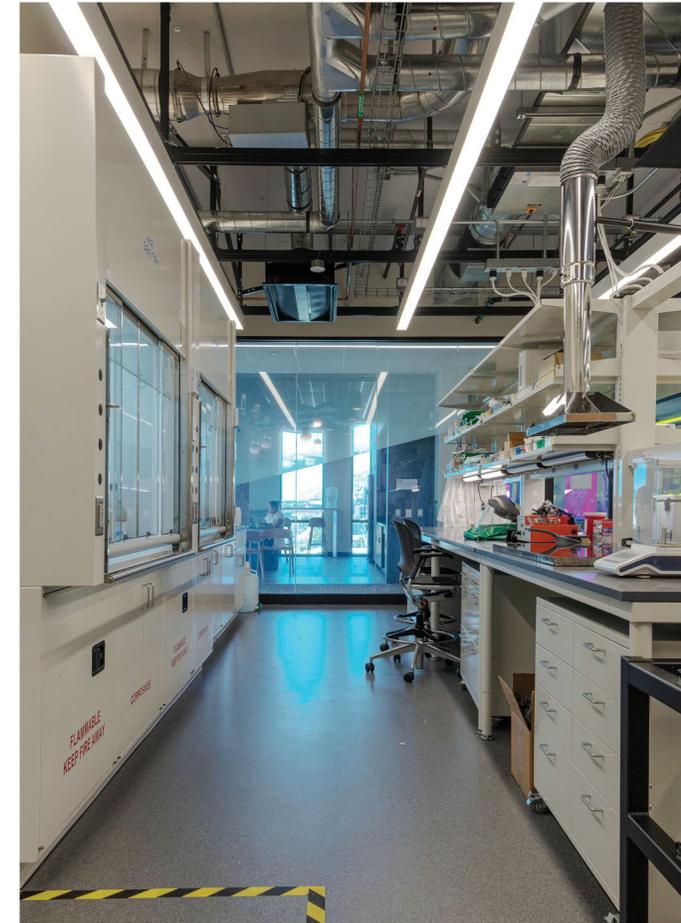
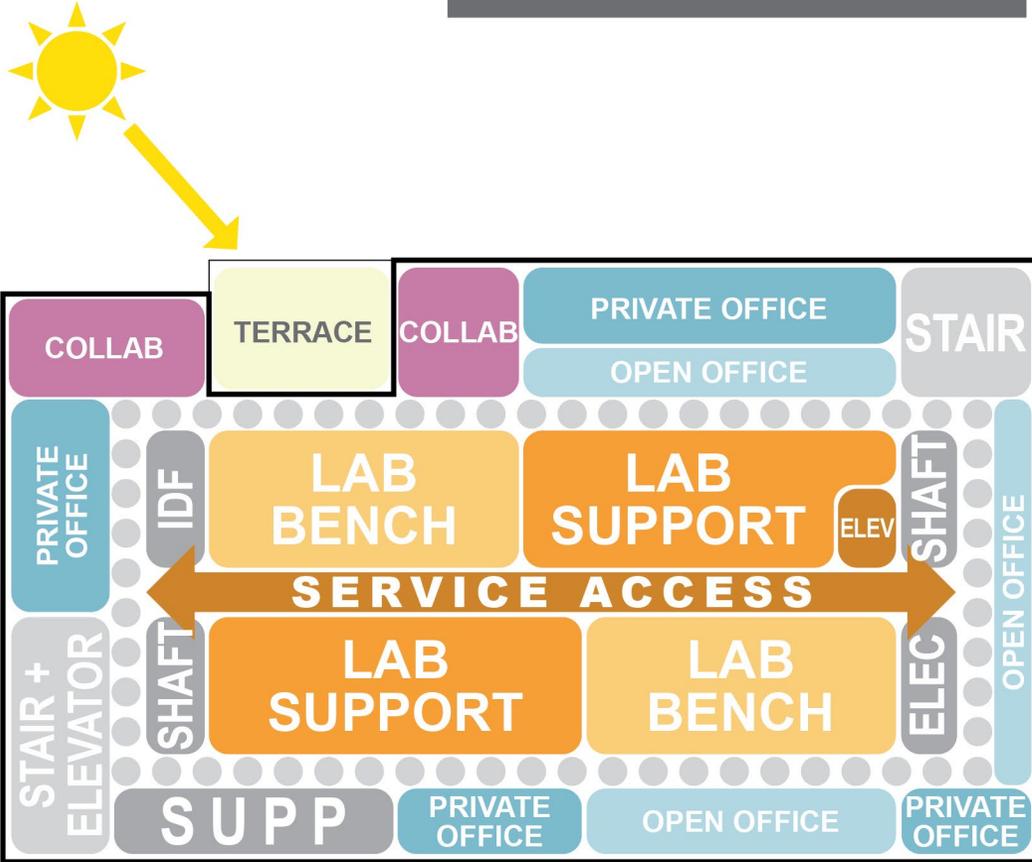
# View to the Mall



# Scenario Testing

Wet Bench Labs

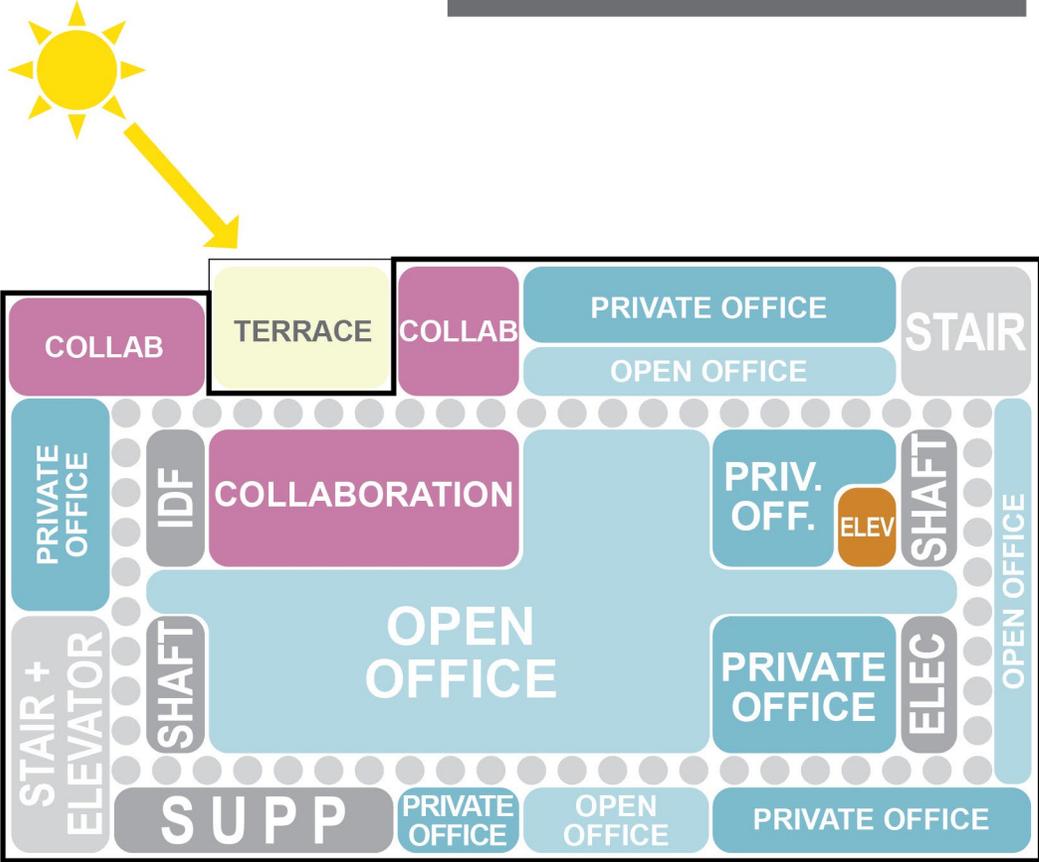
MEINEL  
OPTICAL  
SCIENCES



# Scenario Testing

Computational (Dry) Labs

MEINEL  
OPTICAL  
SCIENCES



# Daylight Penetration

Another valid solution can be obtained by conjugating and reversing the fields backward in time ( $t \rightarrow -t$ )

$a=0 \Rightarrow a(t) = a_0 e^{-i\omega t}$  with  $S_{\text{in}} = \sqrt{2\gamma} a$

$\frac{d}{dt} |a|^2 = 2\gamma |a|^2$ ,  $b^2 |S_{\text{in}}|^2 = \gamma |a|^2$

but  $\beta_1 S_{\text{in}} = -\gamma_1 a$  or  $\beta_1 |S_{\text{in}}|^2 = \gamma_1 |a|^2$

and  $|S_{\text{in}}|^2 = \gamma_1 |a|^2 \Rightarrow \beta_1 = \gamma_1$

$a = -i\omega_0 a_0 - \gamma a + \alpha_1 S_{\text{in}} = \frac{\alpha_1 a_0}{\omega_0 - \gamma + \alpha_1}$

$\Rightarrow 2\gamma a = \alpha_1 S_{\text{in}}$

but  $S_{\text{in}} = \gamma_1 a = \sqrt{2\gamma} a$

so  $2\gamma a = \alpha_1 \sqrt{2\gamma} a$

or  $\alpha_1 = \sqrt{2\gamma}$



# Layout Flexibility

## Final Floor Plans



LEVEL 04



LEVEL 06



LEVEL 03



LEVEL 05

- LEGEND**
- OPEN LAB
  - LAB SUPPORT
  - PRIVATE OFFICE
  - OPEN OFFICE
  - COLLABORATION
  - BUILDING SUPPORT

A modern laboratory with scientists working at benches and equipment. The image is overlaid with a blue tint and a red text box. The text box contains the following text: 

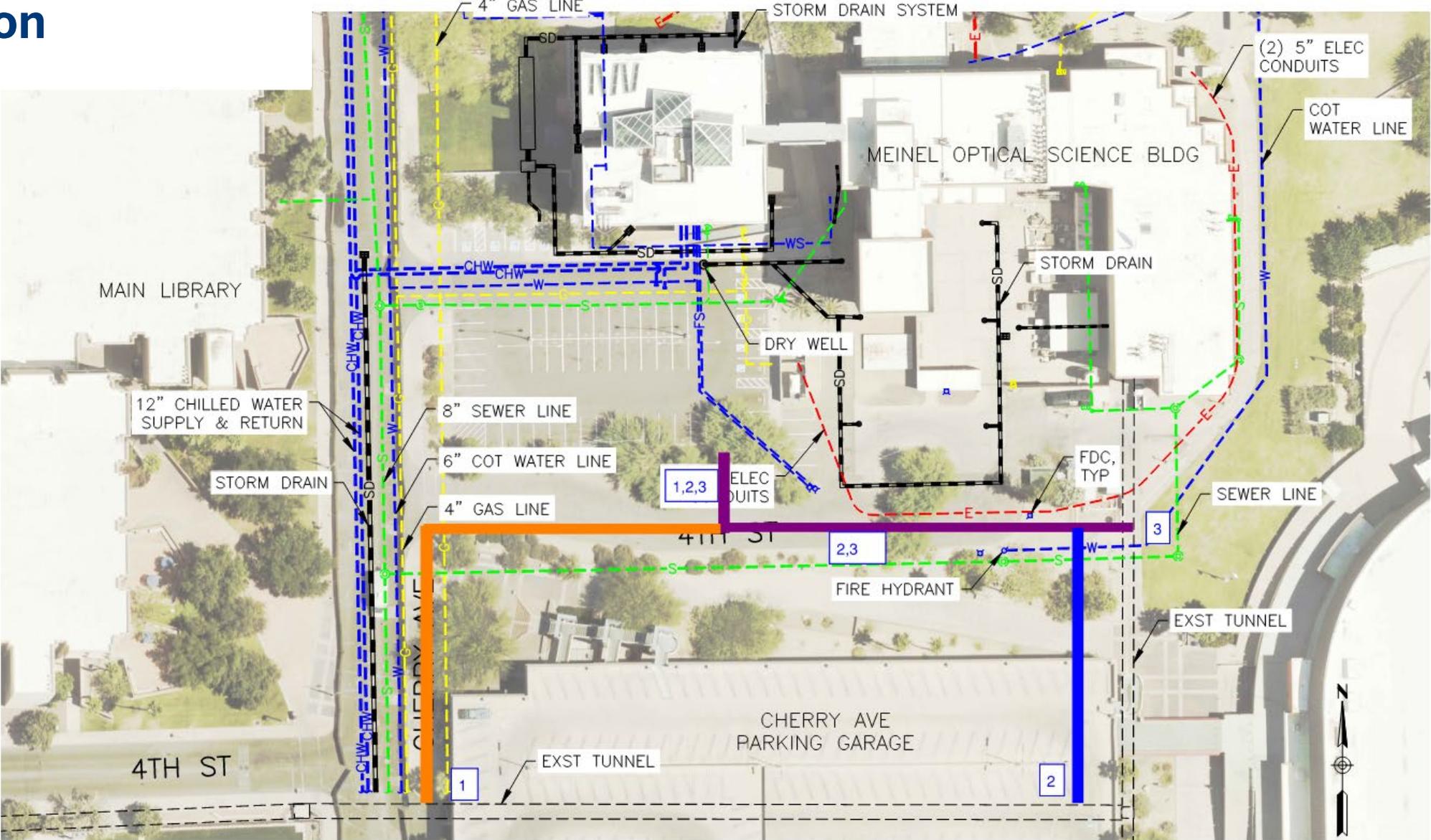
**Electrification,  
Right-Sizing,  
and Flexibility.**

## Right Sizing Cooling and Power

- Discussions with Optical Group during programming
- How to size power density and space cooling?
  - Range could be 4-20 W/sf
- Metered existing users labs
  - Results were 4-6 W/sf
- Proceeded 8 W/sf for flexibility

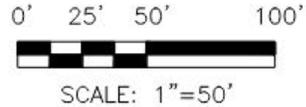


# Electrification



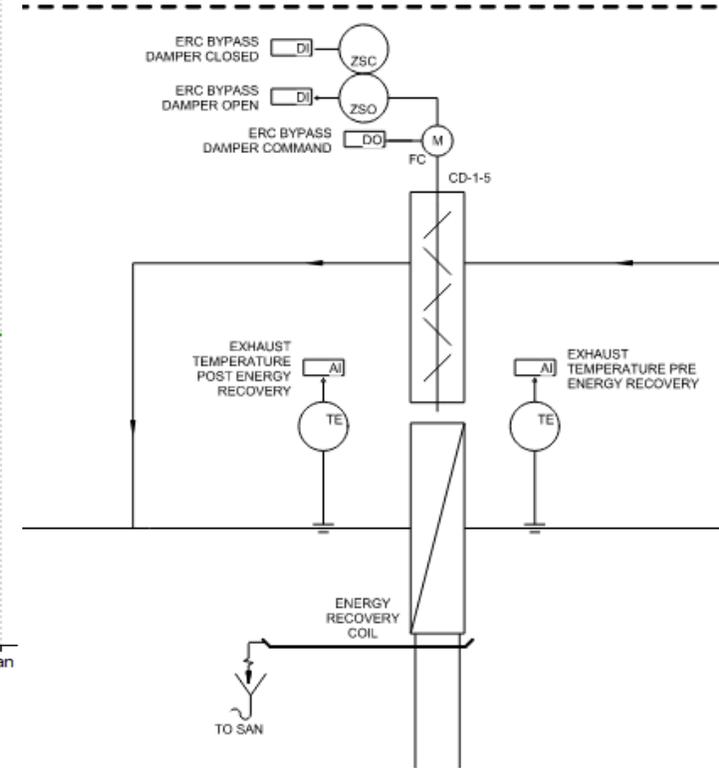
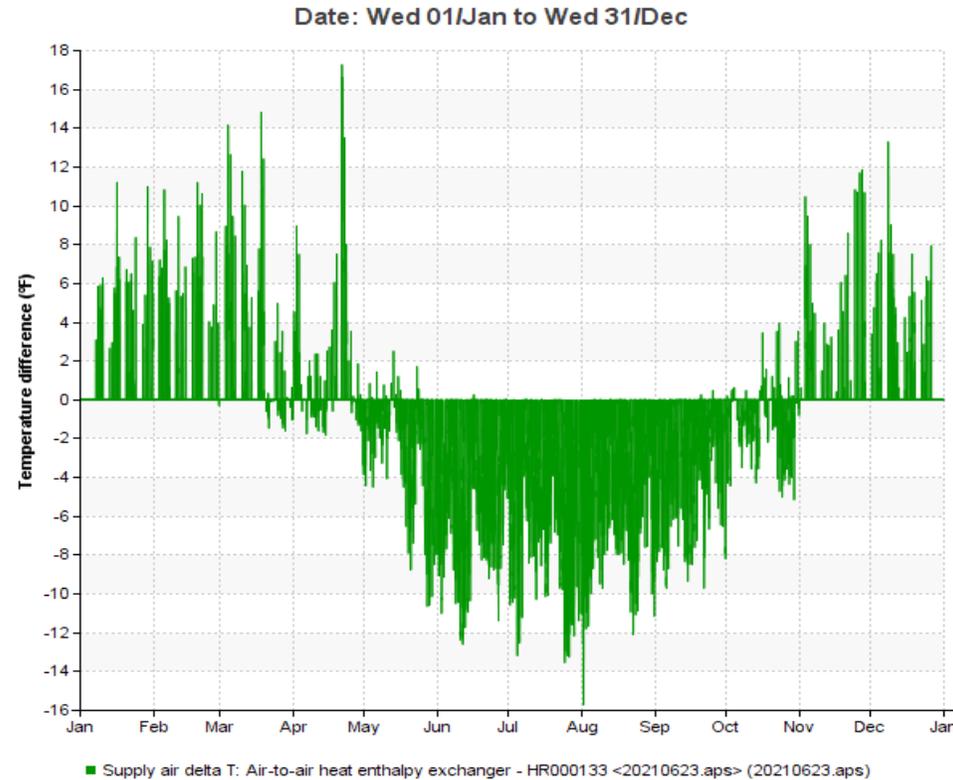
- EXST CHILLED WATER ---CHW---
- EXST WATER LINE ---W---
- EXST GAS LINE ---G---
- EXST SEWER LINE ---S---
- EXST ELECTRICAL LINE ---E---

- EXST STORM DRAIN ---SD---
- EXST TUNNEL ------

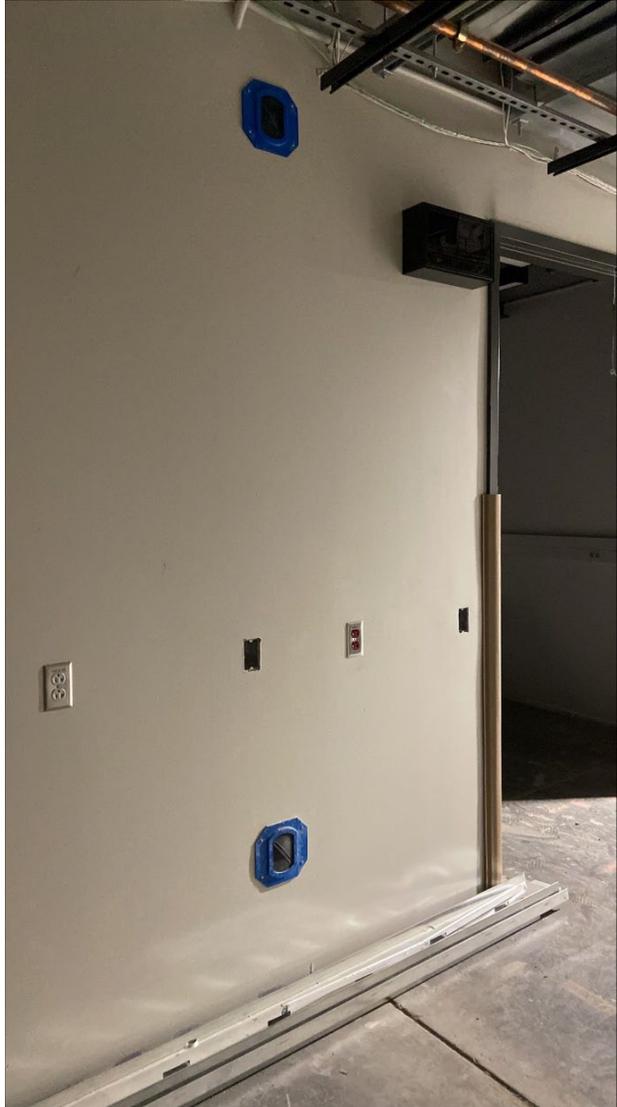
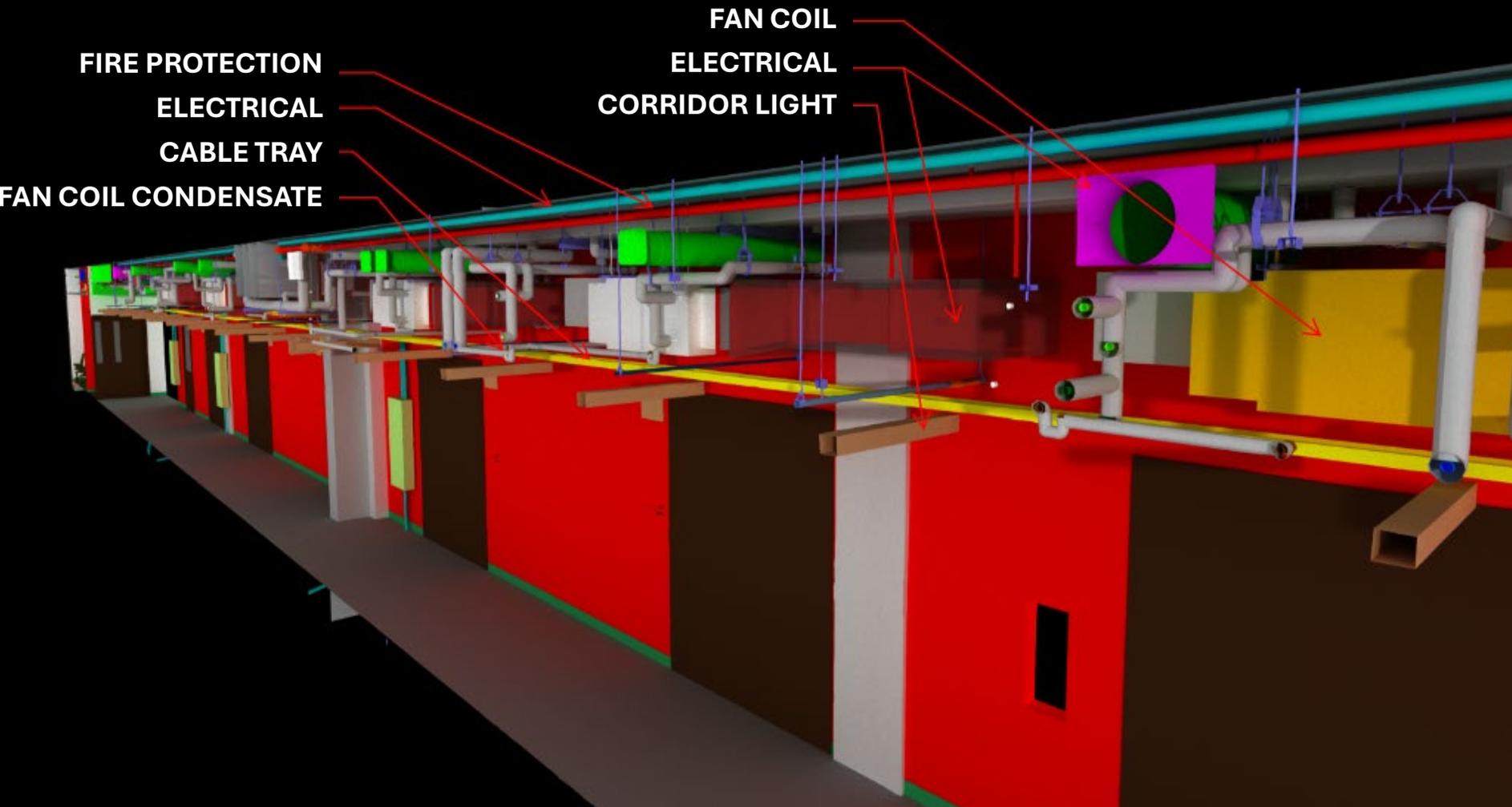


# Decoupled Ventilation and Cooling

- Base 6 ACH in lab
- Remainder of sensible cooling via FCUs or chilled beams
- Offices also on lab system for pressurization transfer air
- Heat pipe energy recovery with bypasses



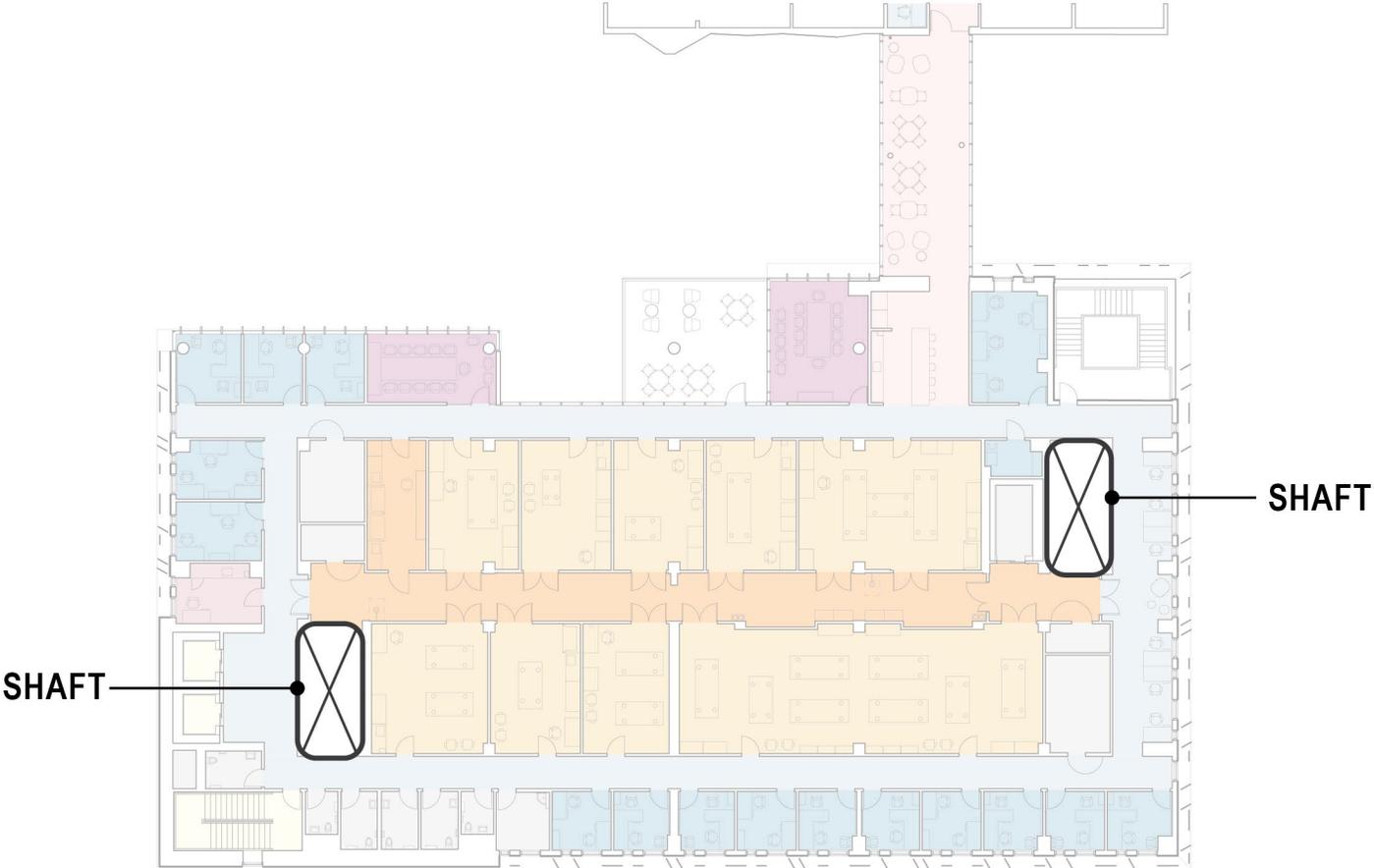
# Lab Service Corridor Utility Routing



# Flexible Utility Routing

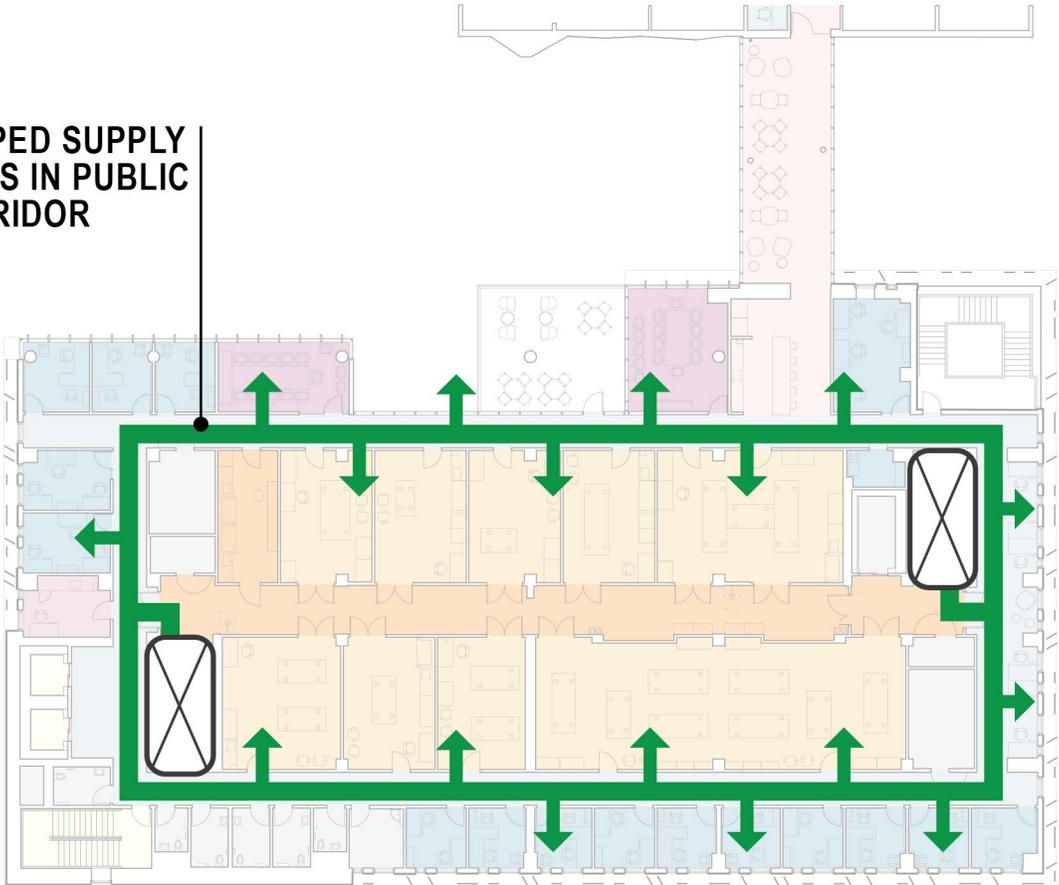


# Lab Service Corridor Utility Routing



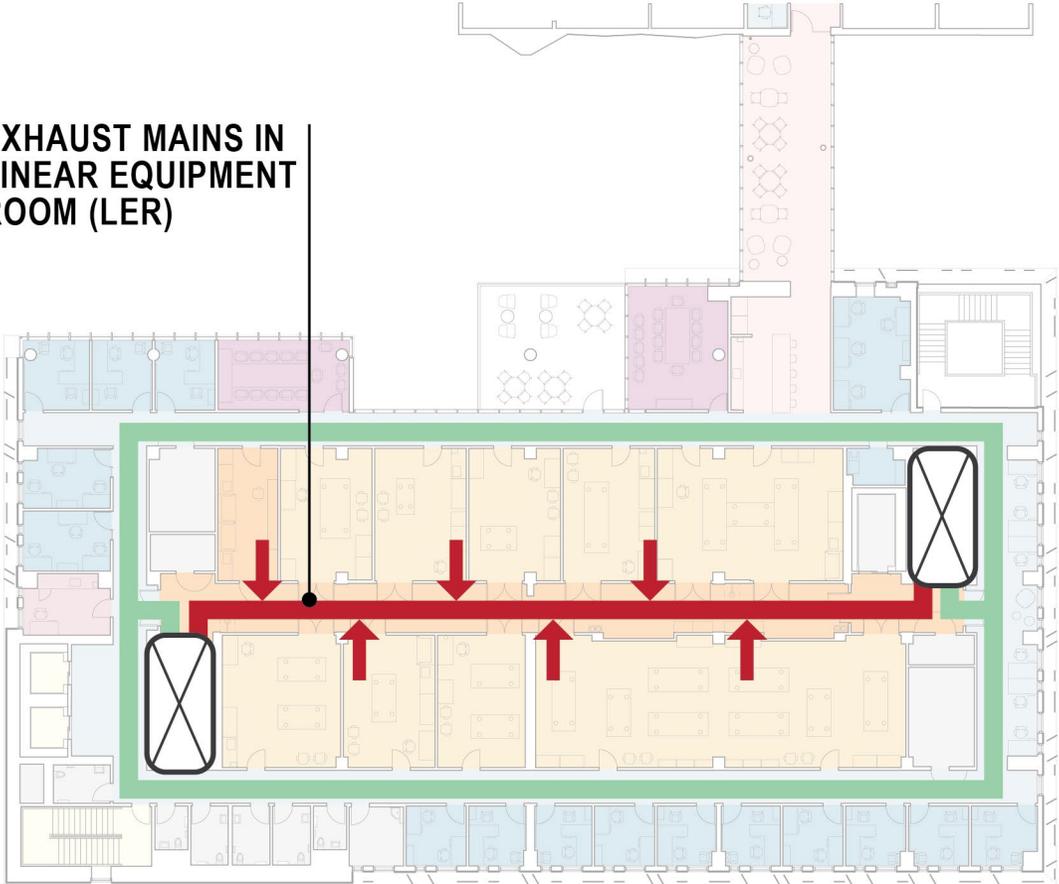
# Lab Service Corridor Utility Routing

LOOPED SUPPLY  
MAINS IN PUBLIC  
CORRIDOR



# Lab Service Corridor Utility Routing

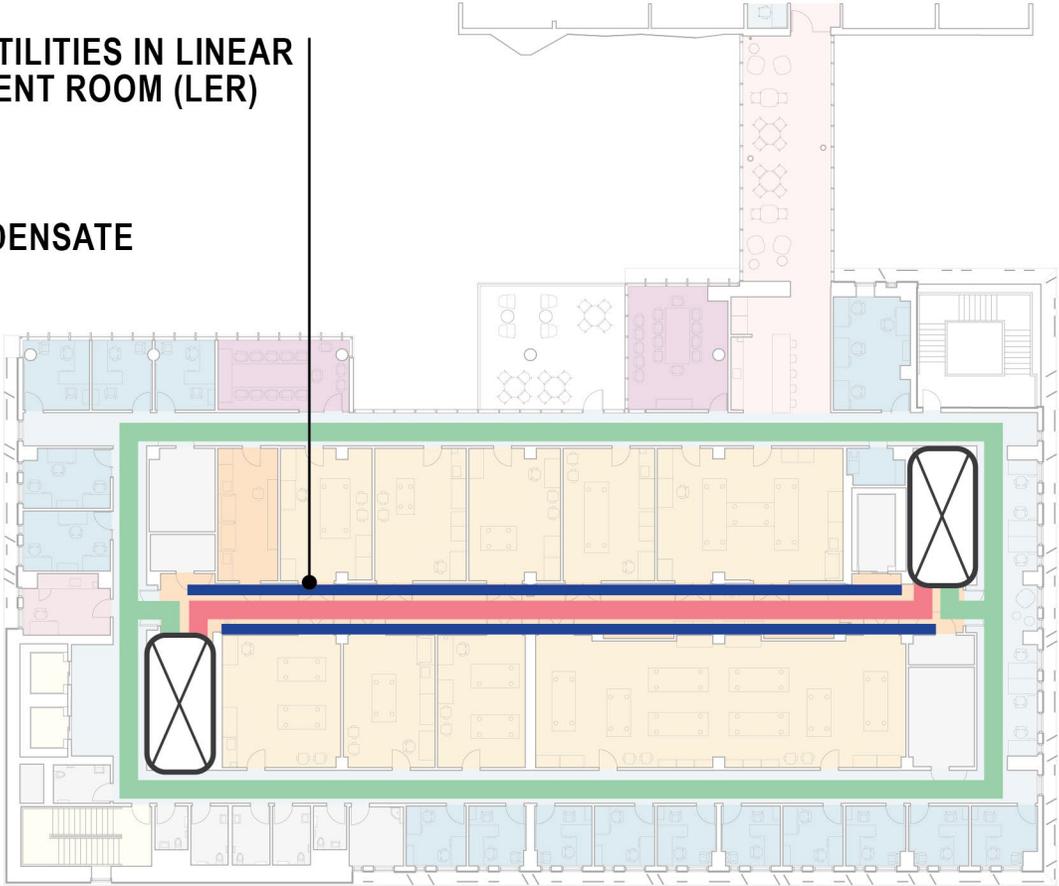
EXHAUST MAINS IN  
LINEAR EQUIPMENT  
ROOM (LER)



# Lab Service Corridor Utility Routing

**PIPED UTILITIES IN LINEAR EQUIPMENT ROOM (LER)**

- CDA
- PCW
- CHW
- CONDENSATE



A photograph of a modern, multi-story building with a prominent red overlay containing the text 'Questions?'. The building features a mix of dark, textured panels and large glass windows. The scene is set outdoors with trees and a clear sky. In the foreground, there are some people walking and a motorcycle on a road.

**Questions?**