HERE'S THE (IN)SITU-ATION:

Optimizing and Testing a Prototype for Beamline Helium-3 Polarization

NIST National Institute of Standards and Technology U.S. Department of Commerce

CHRNS NSF NIST CENTER FOR HIGH RESOLUTION NEUTRON SCATTERING

Joelle Baer

Hamilton

PRESENTATION OVERVIEW

What is ^{3}He used for at the NIST Center for Neutron Research (NCNR) ?

What is the In Situ Polarizer?

What are the steps in designing and optimizing such a device?

Findings from neutron beam testing.

NIST CENTER FOR NEUTRON RESEARCH

Home to a 20 MW reactor that provides neutrons for scientific research

250 days of operation per year

28 experiment stations for scientific research

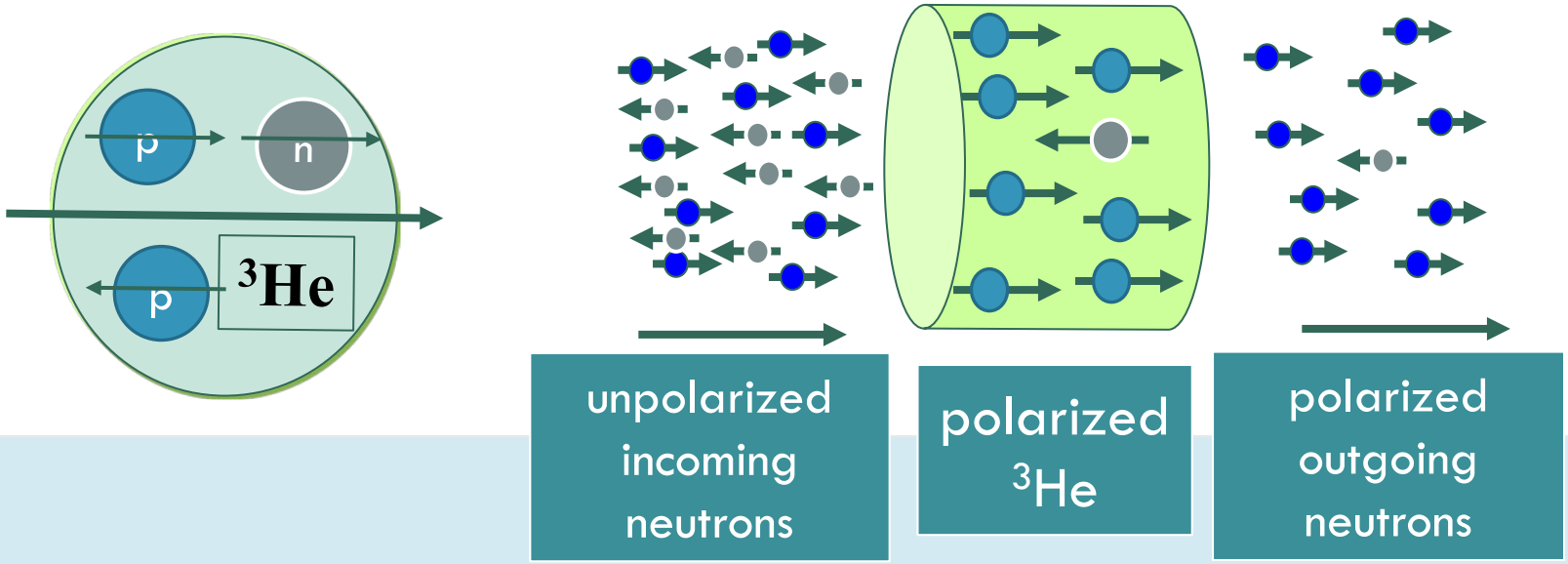
Over 2000 users from university, government, institution and industry

NIST National Institute of Standards and Technology U.S. Department of Commerce

CHRNS

Hamilton

What is a ^{3}He cell?



Spin dependent neutron absorption

K.P. Coulter et al, NIM A 288, 463 (1990)

WHAT IS A ^{3}HE CELL?

- Back-filled with ^{3}He and a small amount of N_2
- Combination of distilled Rb/K
- Different cell characteristics
- Single unit for Analyzer and Flipper

Cell for Typical Beam Experiments (Slider)

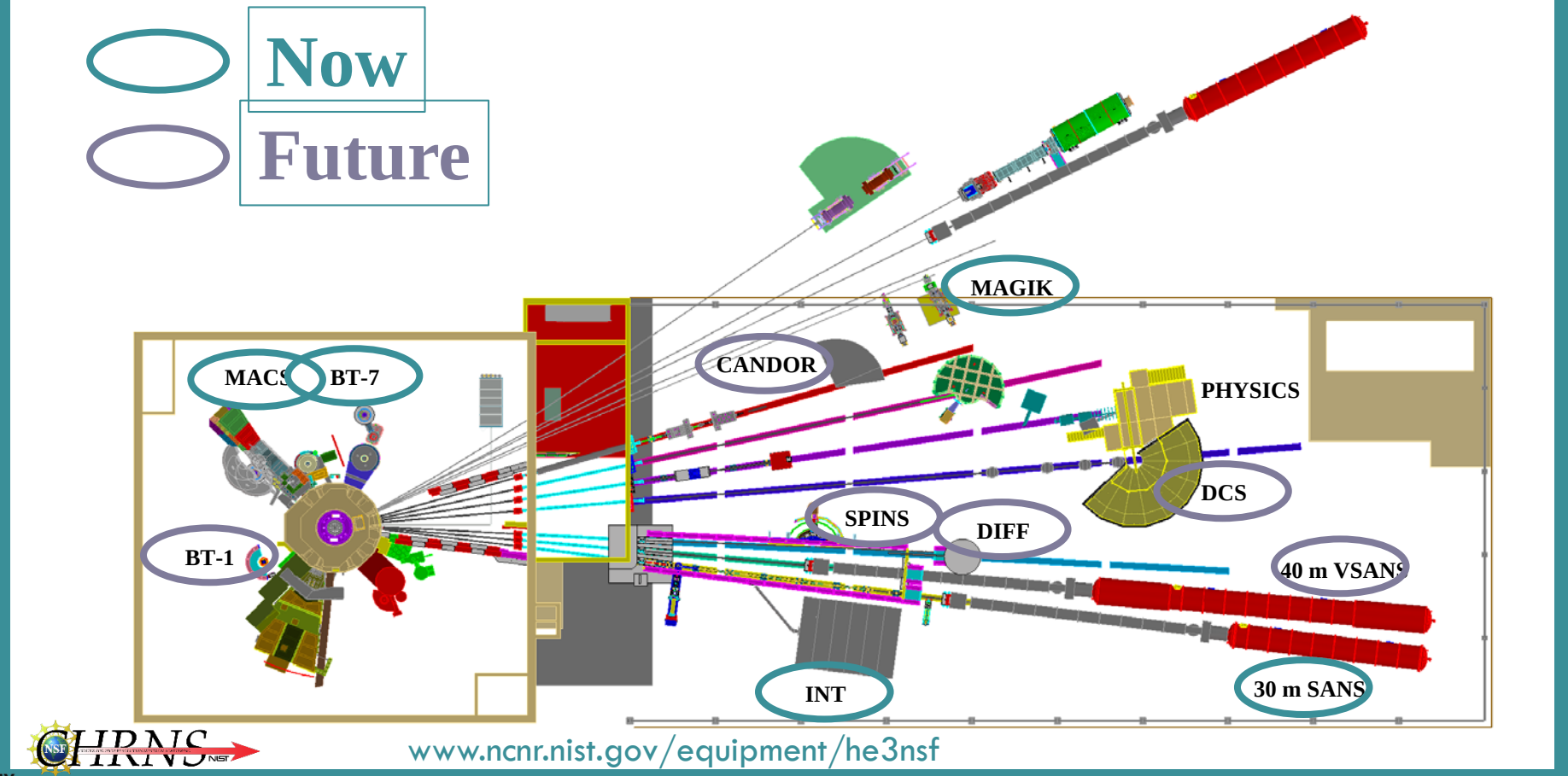
Wide Angle Cell (Reliance)

NIST National Institute of Standards and Technology U.S. Department of Commerce

CHRNS

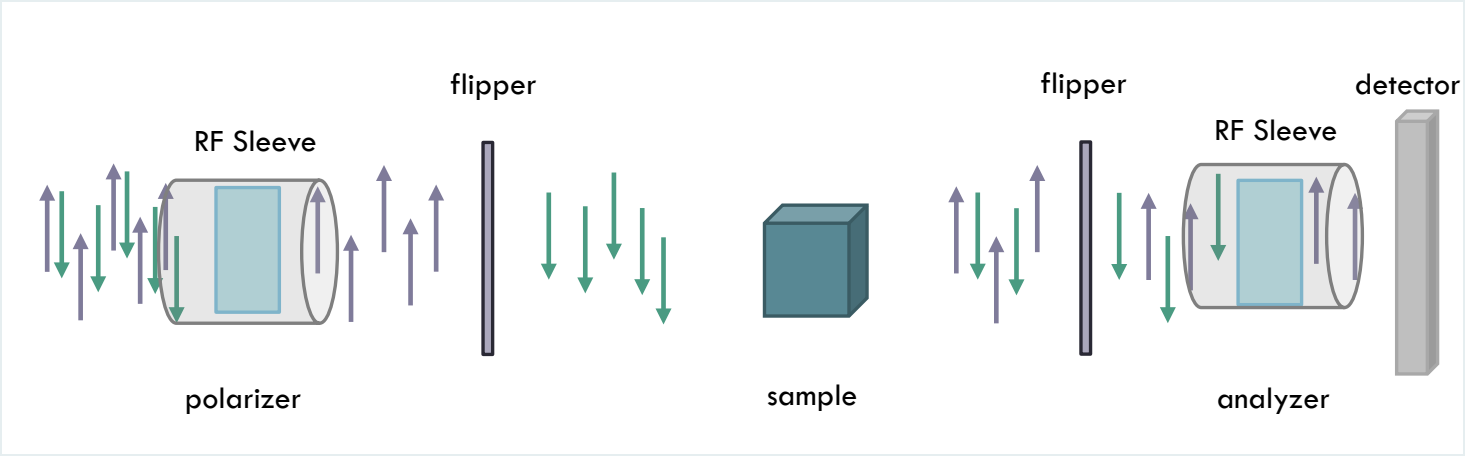
Hamilton

WHAT IS POLARIZED ^{3}HE USED FOR AT THE NCNR?



Polarization Analysis using ^{3}He

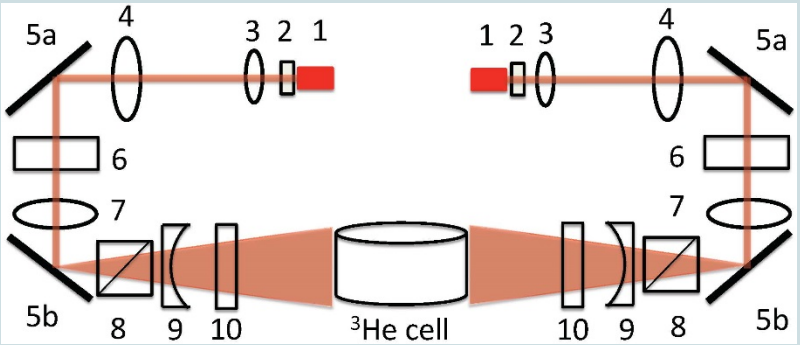
Cross Sections: ↑↑ ↓↓ ↑↓ ↓↑

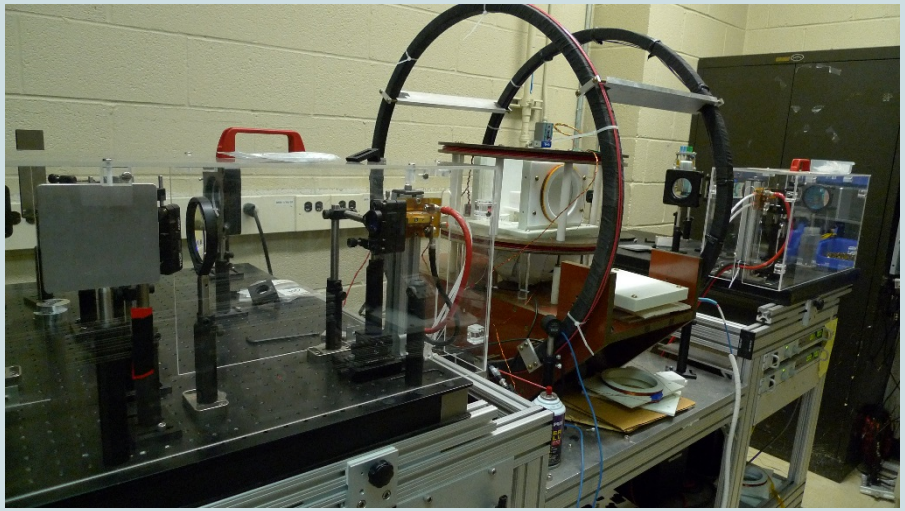


- Probe magnetic properties from a sample
- Measure four cross sections
- Example ↓↑

Polarizing the Cell

Spin Exchange Optical Pumping (SEOP)



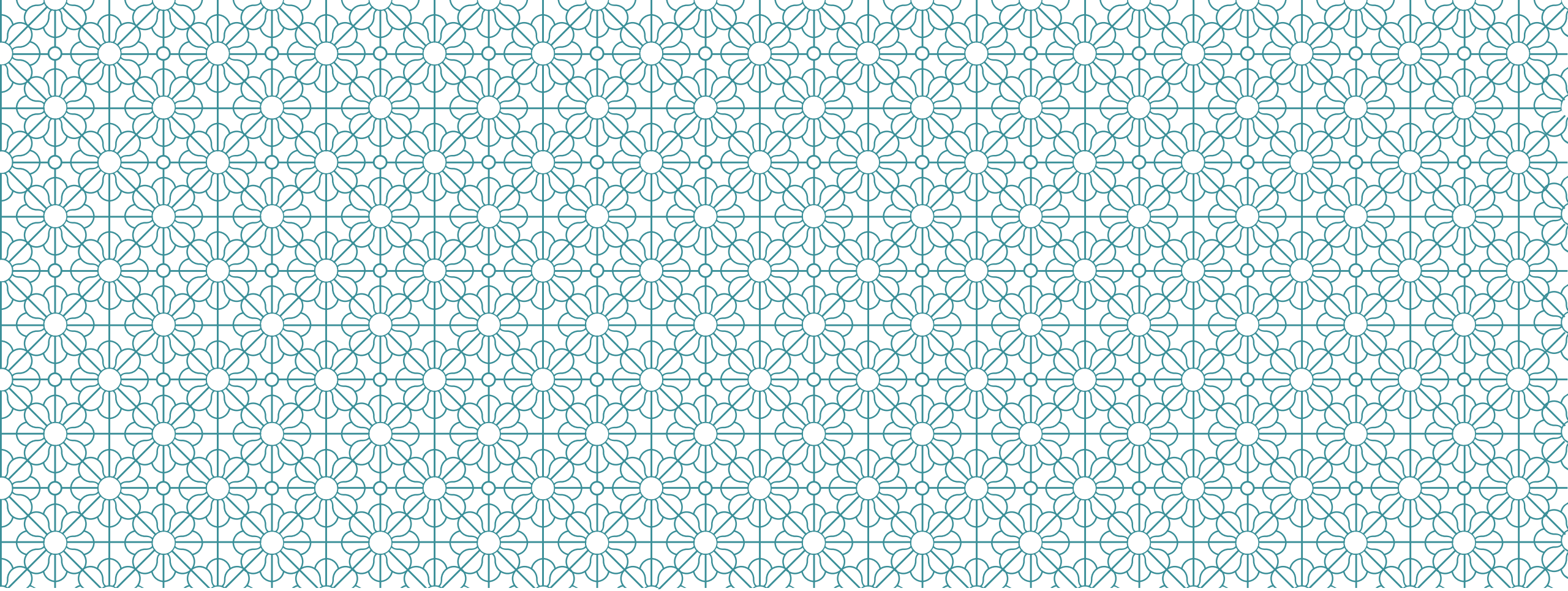


- Near infrared laser
- Electrons are polarized
- Spin exchange with ^{3}He
- Lengthy process

NIST National Institute of Standards and Technology U.S. Department of Commerce

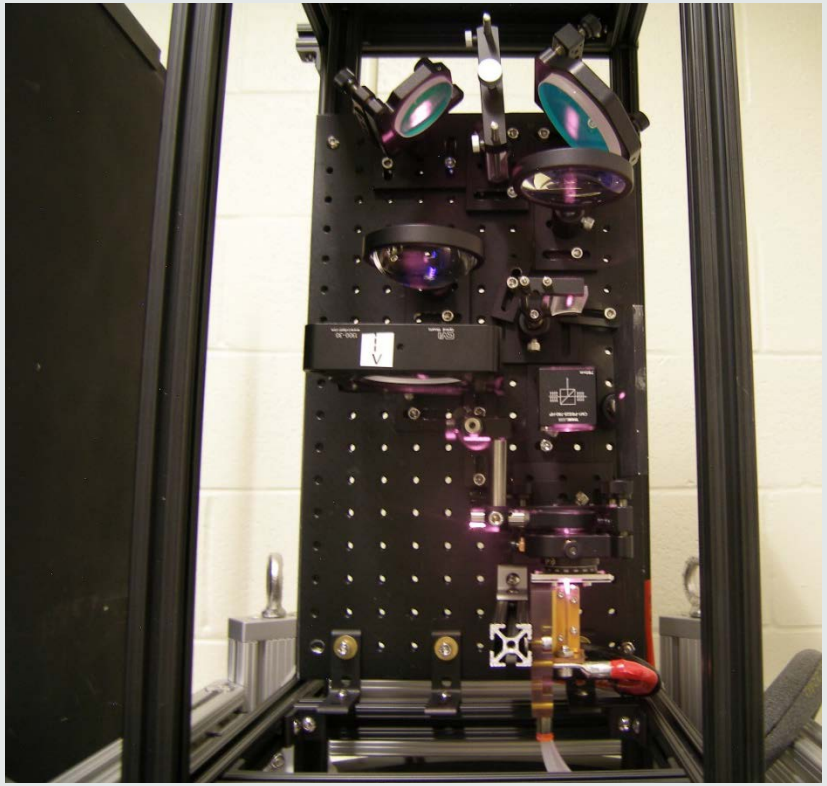
CHRNS

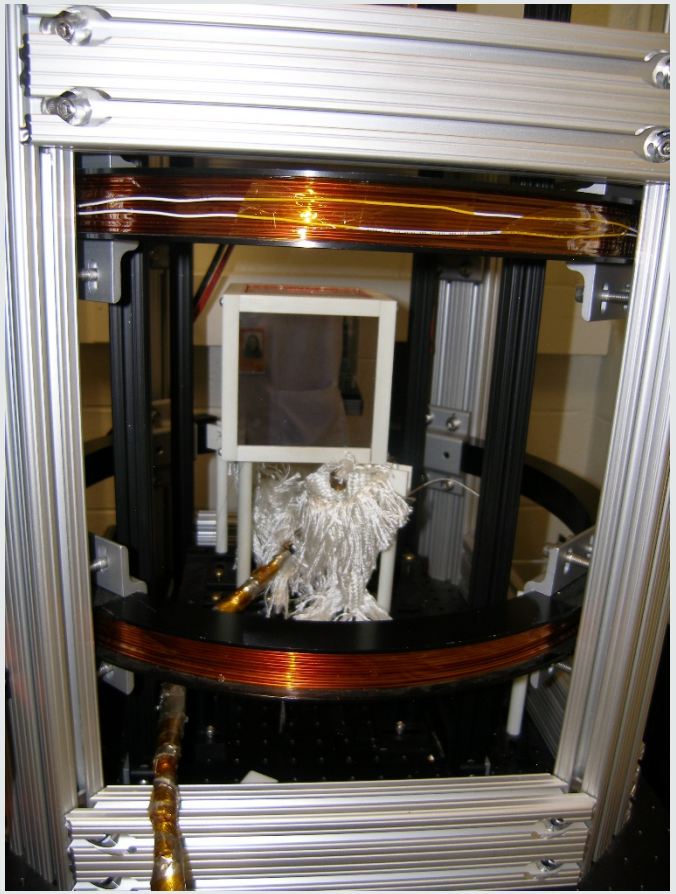
Hamilton



WHY DO WE NEED AN INSITU SYSTEM?

CREATING AN INSITU SYSTEM





System in early stages of configuration

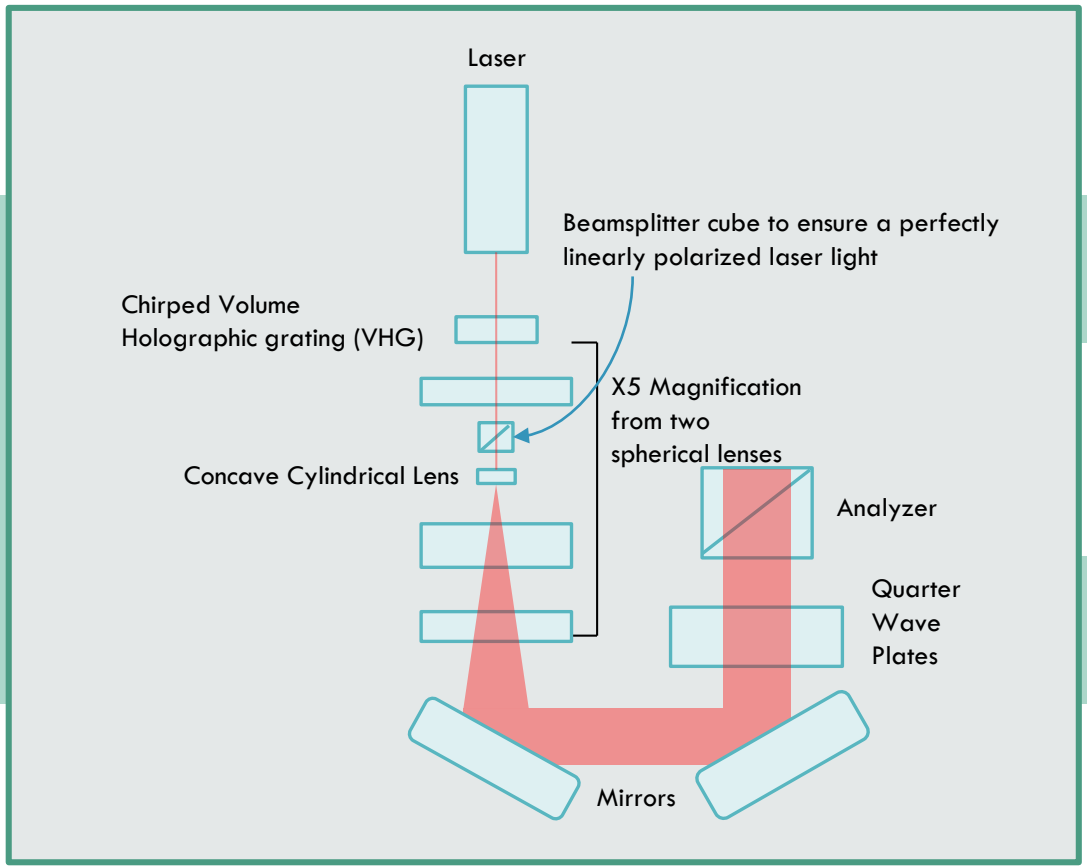
- Compress ~7 foot long apparatus into under 4 square feet of space
- Enclose the oven, RF coil and lasers in laser shielding
- Orient the equipment with both the laser and neutron beams
- Neutron beam and laser beam are orthogonal
- Allow access to the oven and lasers

NIST National Institute of Standards and Technology U.S. Department of Commerce

CHRNS

Hamilton

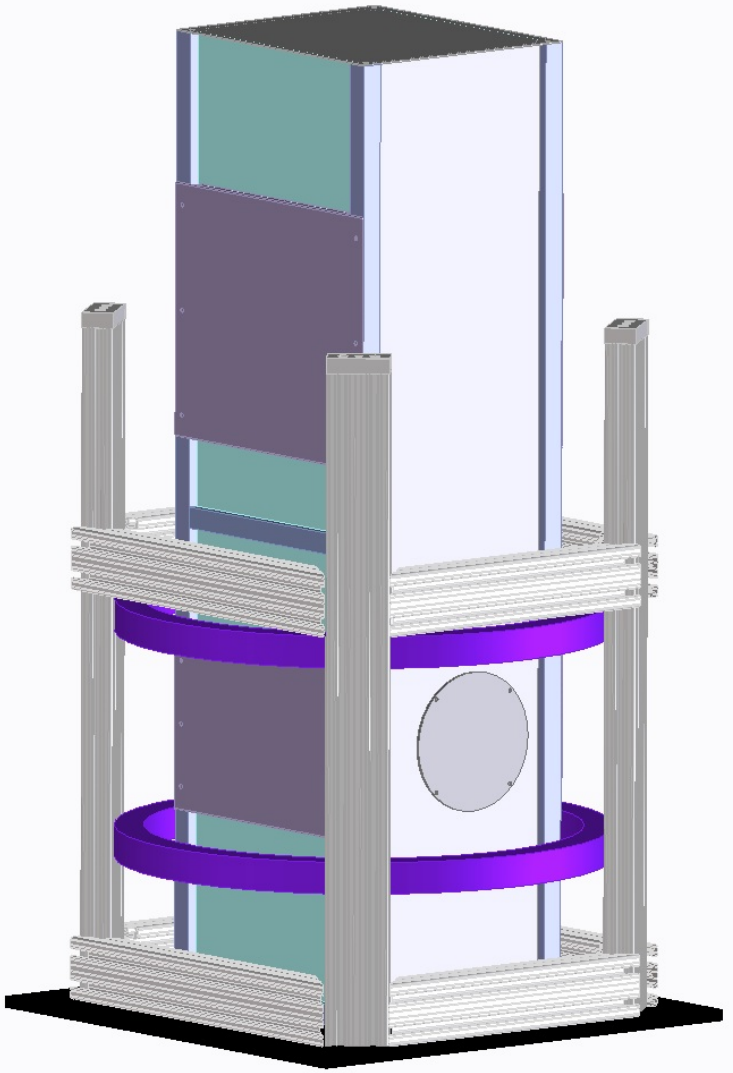
LASER PUMPING SET UP



- 100 W semiconductor single diode
- 795 nm wavelength with 2nm spectral linewidth
- Spectrally narrowed with Chirped VHG to 0.2nm spectral linewidth

DESIGNING THE LASER SHIELDING

- Necessary to prevent laser leakage
- Panels made of Black Oxidized Aluminum
- Doors for access to laser box and oven sections

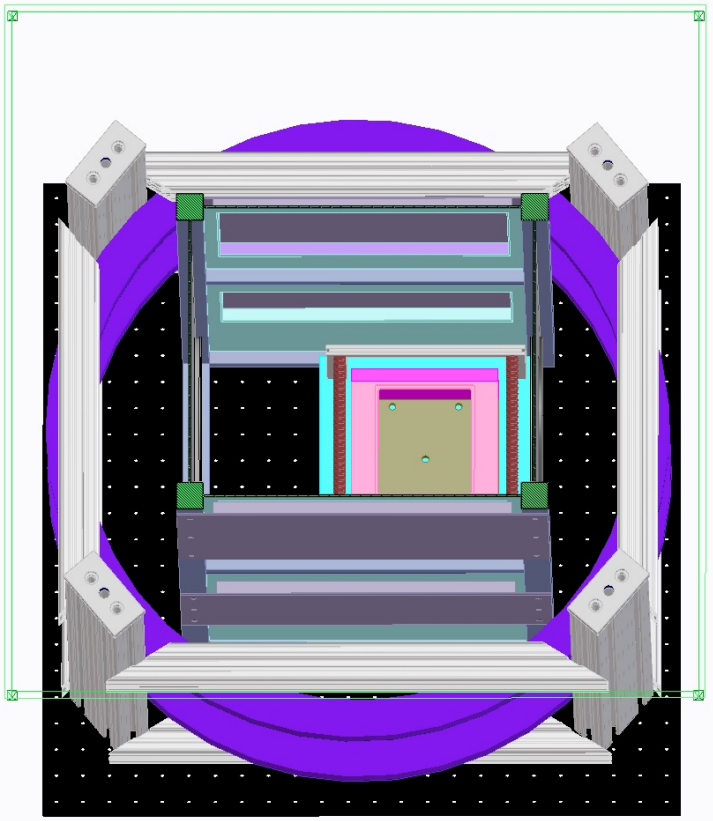


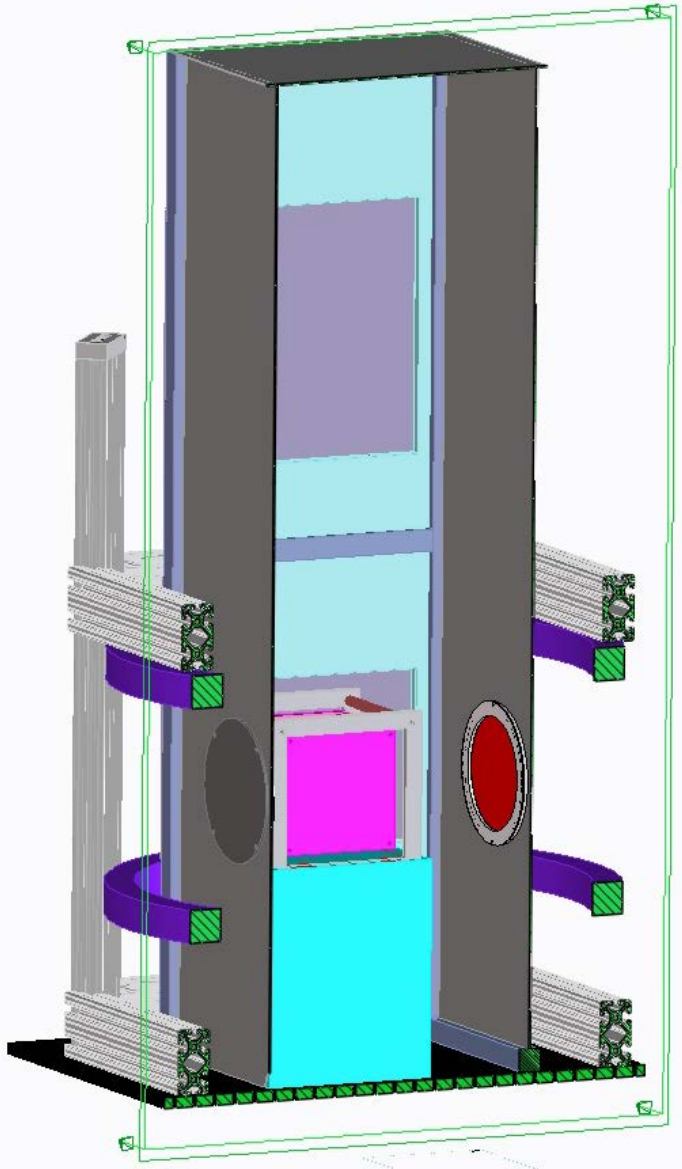
NIST National Institute of Standards and Technology U.S. Department of Commerce

CHRNS

Hamilton

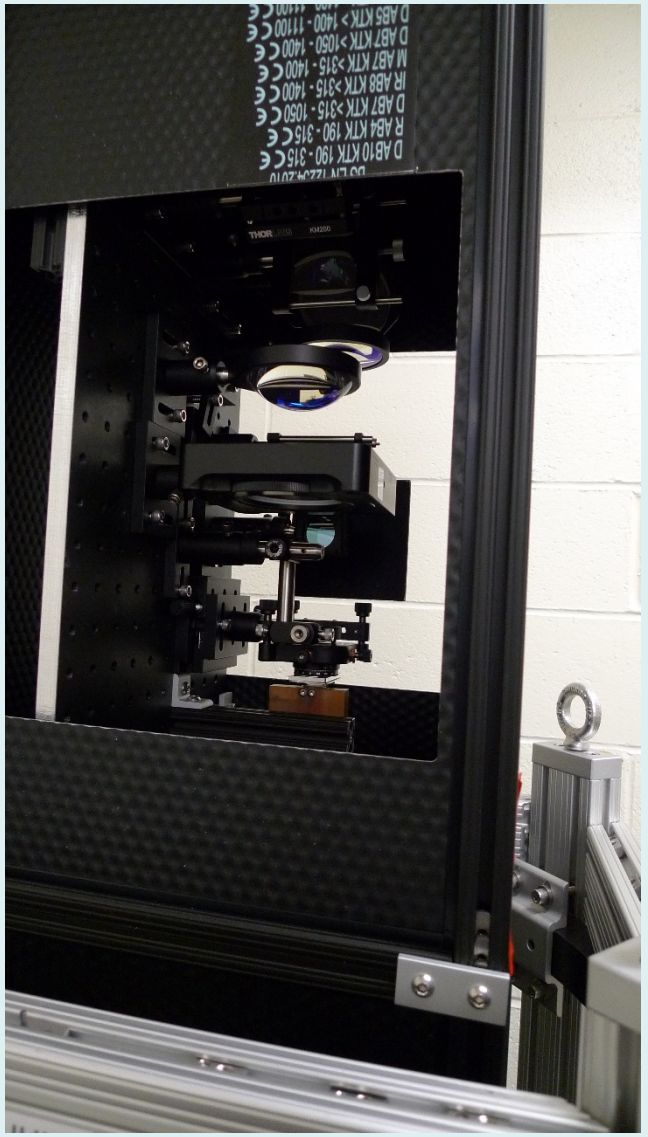
DESIGNING THE LASER SHIELDING





CONSTRUCTING THE LASER BOX

- Shielding crimped with Black Oxidized Al Edge trim
- Slide down the 80-20 extrusions
- Crimped with a punch and hammer
- Door covers bolt to the 80-20 extrusion
- Preliminary tests-
  - Oven heating
  - Polarization flipping efficiencies



NIST National Institute of Standards and Technology U.S. Department of Commerce

CHRNS

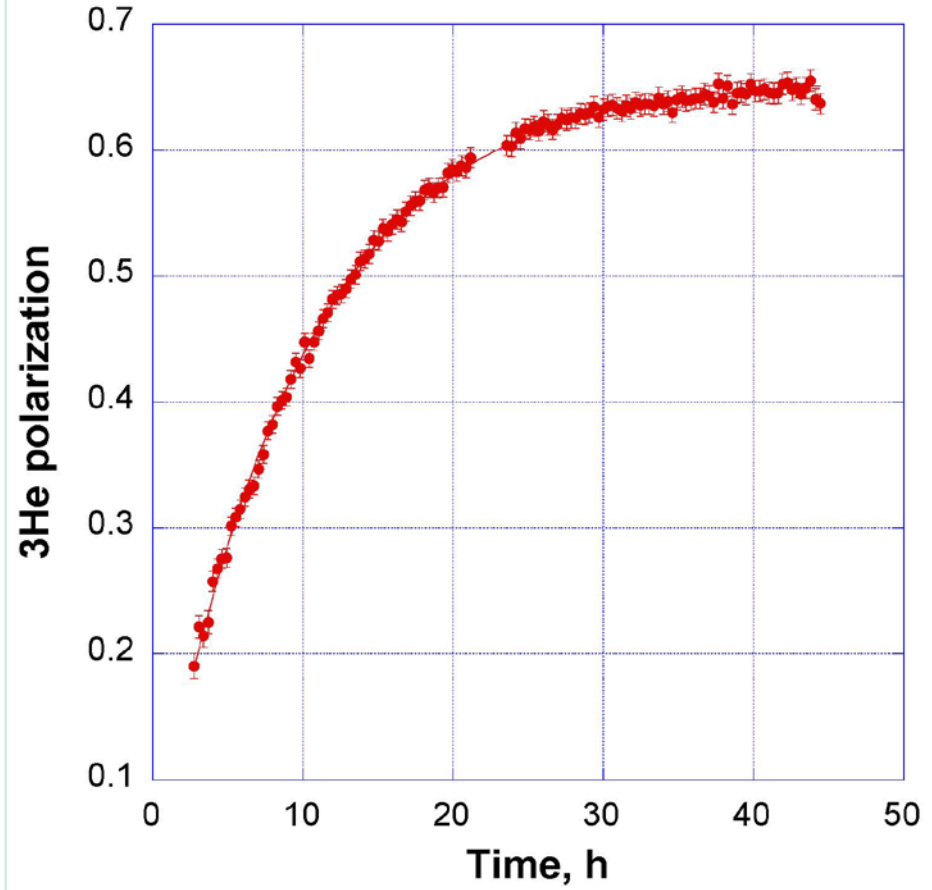
Hamilton

CONSTRUCTION DEVELOPMENT

- Design change for the walls of the box for ‘ease’ of construction
- Changing the compressed air tubing 3 times to optimize oven heating
- Replacing parts of the oven for better insulation
- Cutting and re-cutting the sides for various pass through notches (power, water, air)
- Not being able to get the system out of the lab hallway
- Having to create a cooling system because the box sealed too well that the lasers overheated
- Replaced a laser and 3 Silicone windows

TESTING AT PHADES

Polarized Helium-3 And Detector Experiment Station



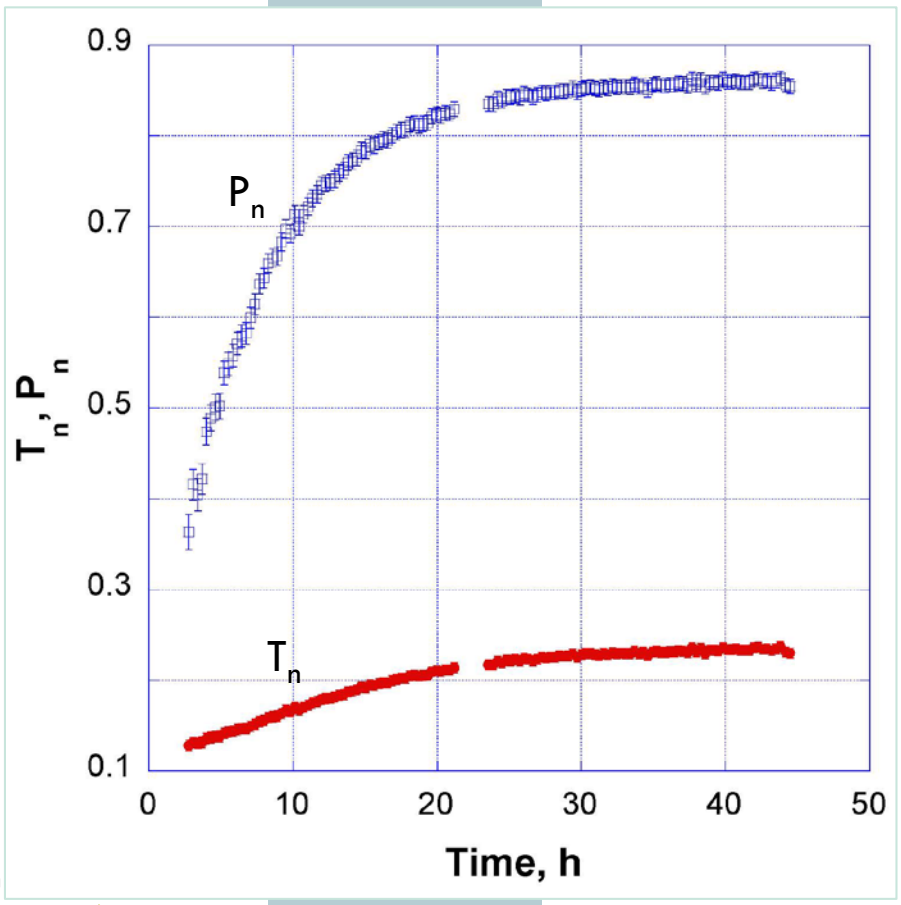
NIST National Institute of Standards and Technology U.S. Department of Commerce

CHRNS

Hamilton

TESTING AT PHADES

Neutron Polarization & Transmission



Neutron Polarization:

$$P_n = \frac{T_+ - T_-}{T_+ + T_-} = tanh\,(\sigma(\lambda) N_{He} l P_{He})$$

Neutron Transmission:

$$T_n = T_0 \cosh(\sigma(\lambda)\, N_{He} l P_{He})$$

- Initial testing:
  - Total neutron transmission
  - Total Helium-3 polarization
  - Total neutron polarization
  - Cell Lifetime
- First Insitu polarizer to perform with comparable efficiency

NEXT STEPS

- Testing:
  - Optimizing laser alignment
  - Determining magnetic hotspots
- Future Models:
  - Reconfigure Helmholtz coils to a vertical orientation
  - Adding more lasers
  - Adding sample environment capability
  - Manifold panel for quick disconnect
  - Dedicated instrument cabling
- My Work with the Helium-3 team:
  - Focus my senior thesis working with Gordon Jones on creating a *gradiometer*, a way to measure the field gradient in a polarized 3He cell using FID NMR

Acknowledgements

Many thanks to

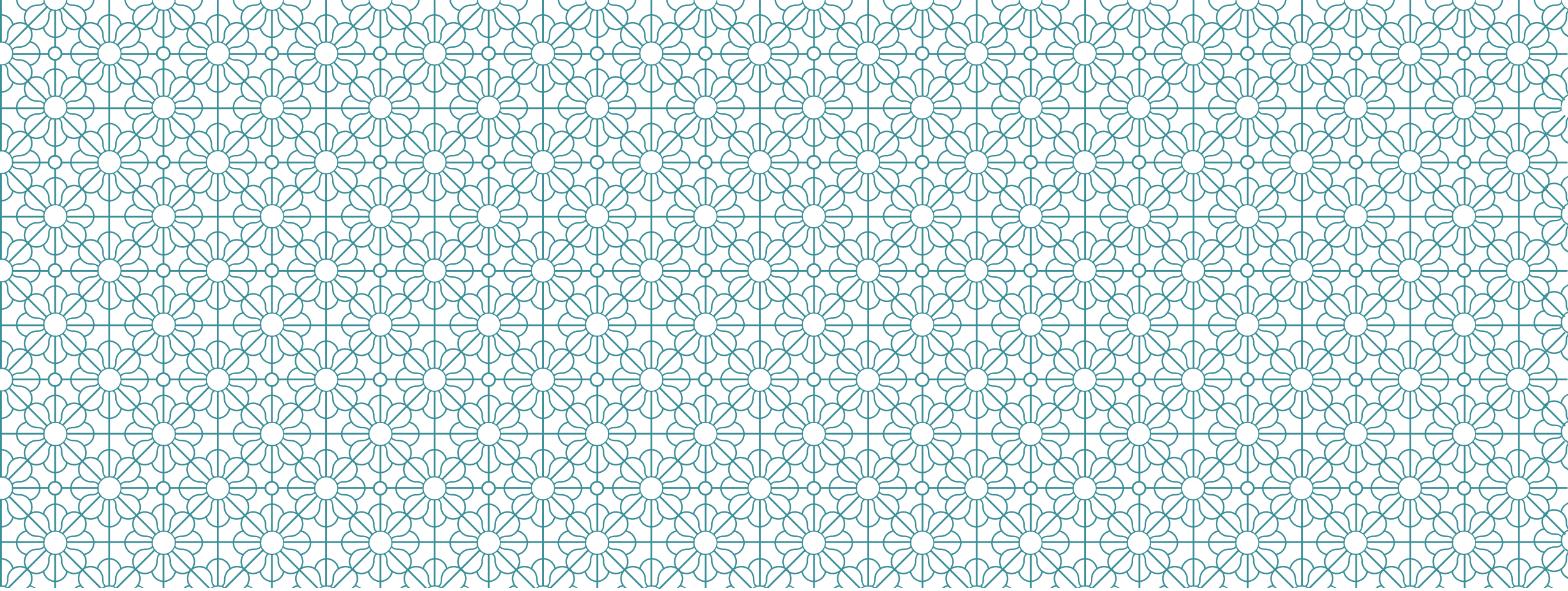
The SURF Program, the NSF, Wangchun Chen, Shannon Watson, Robert Dimeo, Dan Neumann, Julie Borchers, Tom Gentile and Gordon Jones

Special Thanks to the Mechanical Engineering Technicians for quick turn around on machining

NIST National Institute of Standards and Technology U.S. Department of Commerce

CHRNS

Hamilton



QUESTIONS?