Quick Introduction to the NHMFL
#NationalMagLab

NATIONAL MAGLAB

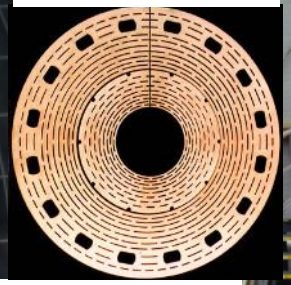
National High Magnetic Field Laboratory
Users Committee Meeting
September 18-20, 2018

National High Magnetic Field Laboratory

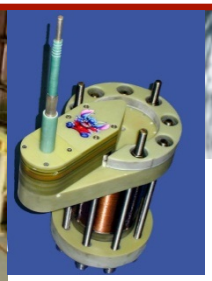
1.4 GW Generator

Florida State University

45T Hybrid
DC Magnet



Los Alamos National Laboratory

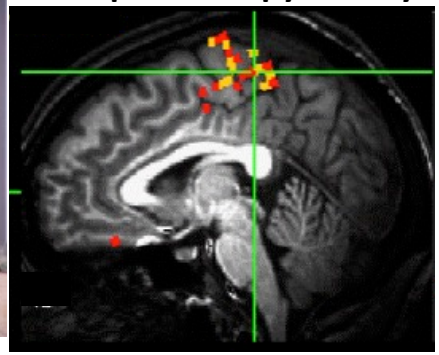


101T Pulse Magnet
10mm bore

11.4T MRI Magnet
400mm warm bore

University of Florida

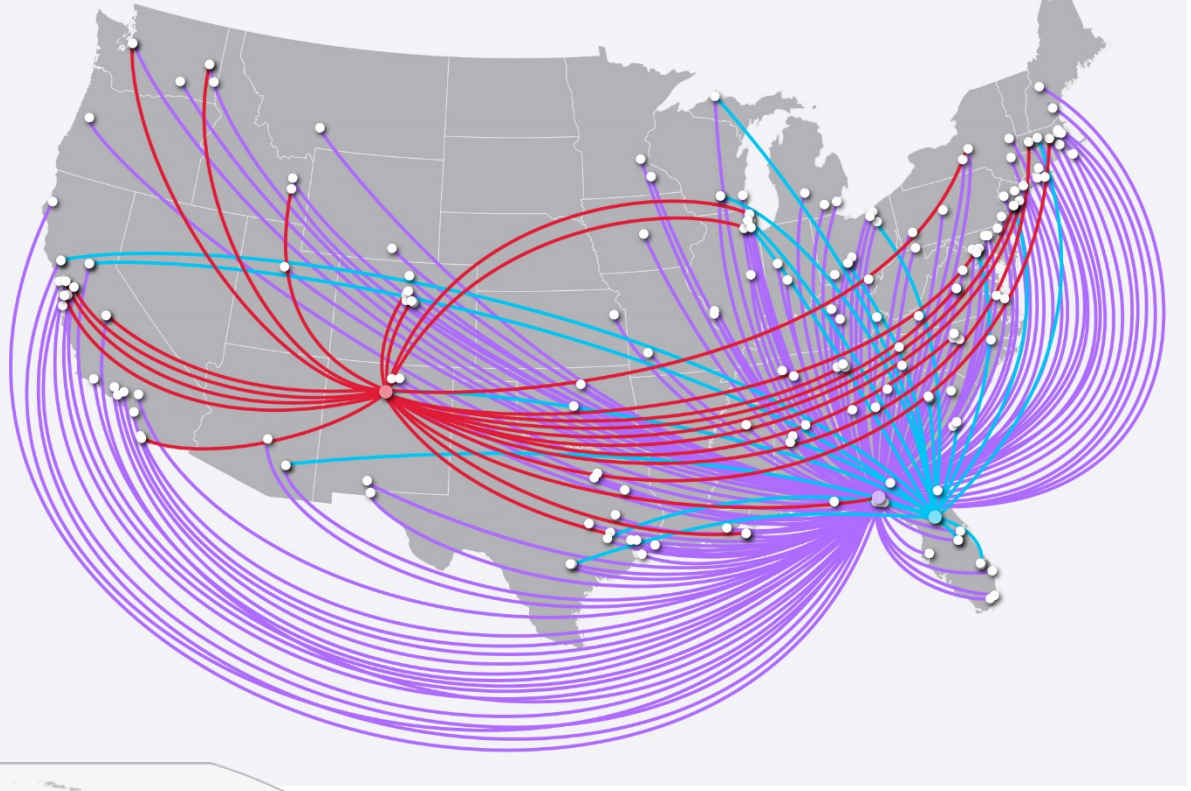
Advanced Magnetic
Resonance Imaging
and Spectroscopy Facility



High B/T Facility
17T, 6weeks at 1mK

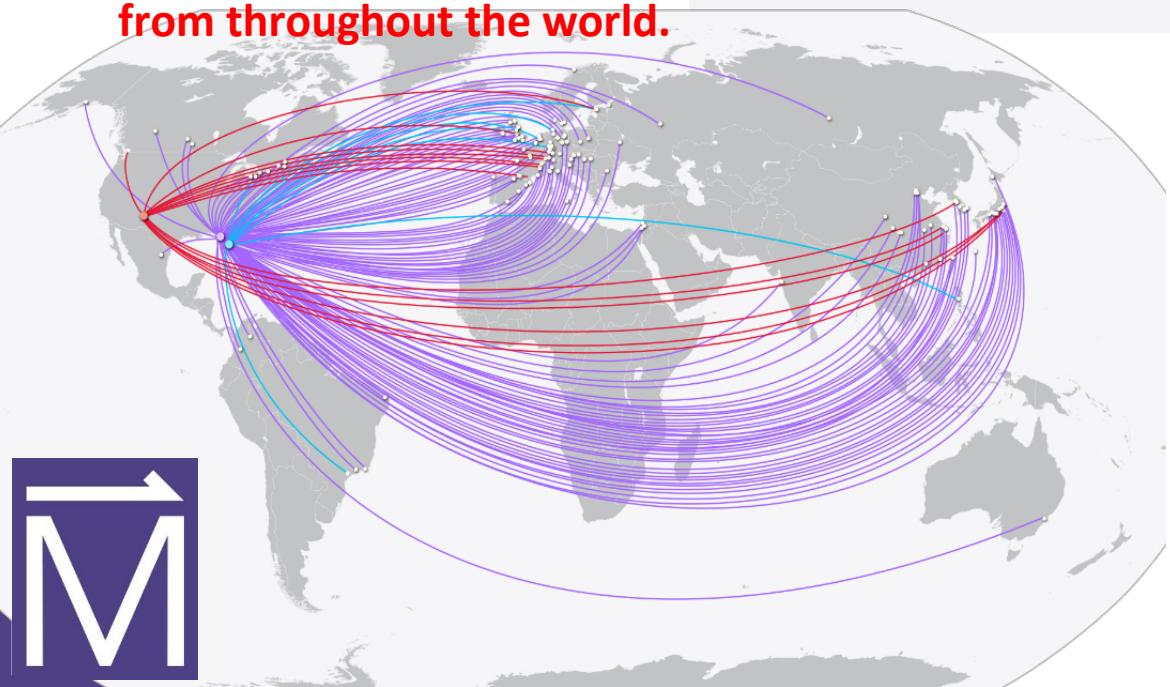
900MHz, 105mm bore
21T NMR/MRI Magnet

The MagLab attracts Researchers from Around The World



In 2017, the MagLab hosted experiments by more than 1800 users from 173 institutions across the United States…

…and a total of 324 institutions from throughout the world.



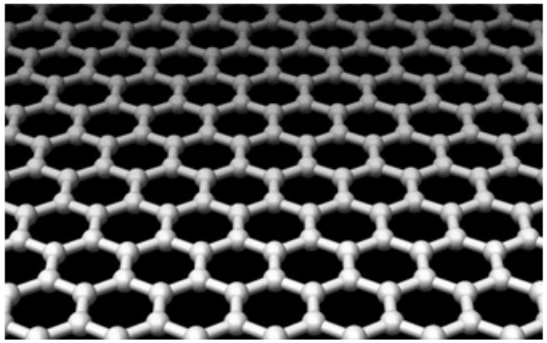
Every year…the MagLab User Program:
helps to train ~225 postdocs
and ~560 graduate students

and publishes ~450 refereed papers:

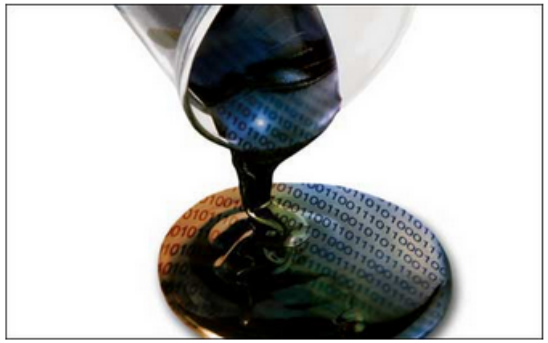
6	***Proc. Nat'l Acad. Sciences***
24	***Nature Journals***
20	***Physical Review Letters***
62	***Physical Review B***
9	***J American Chemical Society***

~ 25% of Principal Investigators are first-time-ever PI's at the MagLab

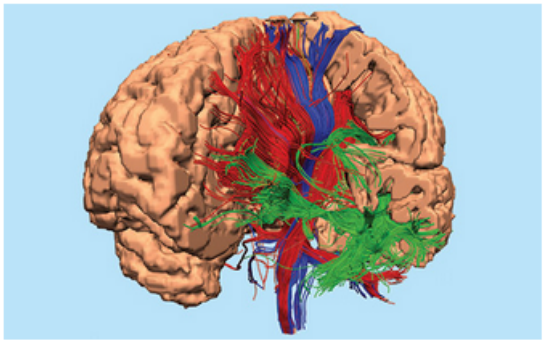
Three Major MagLab Research Themes



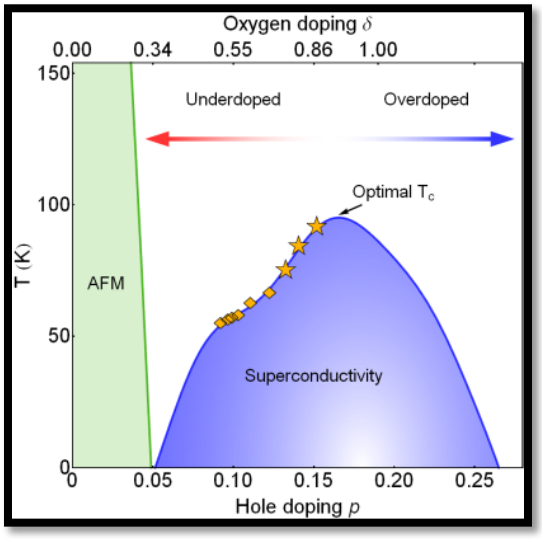
MATERIALS

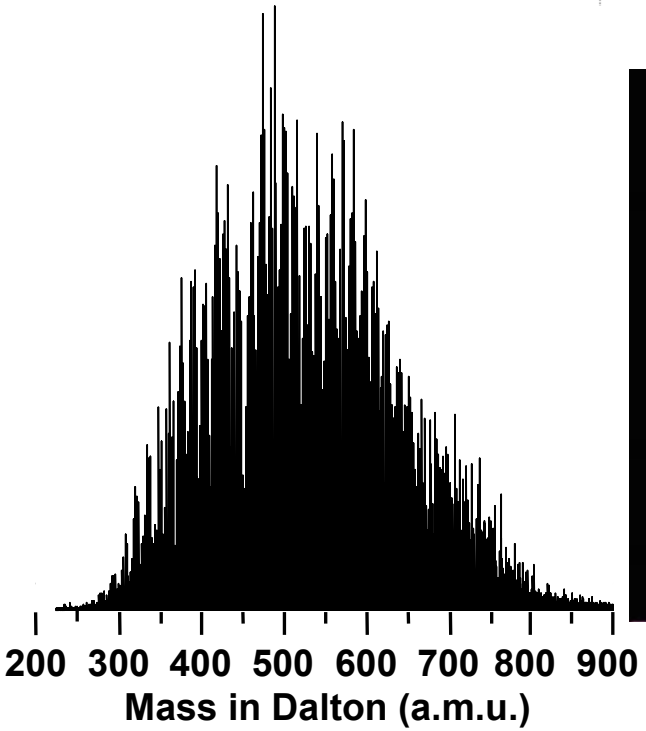


ENERGY



LIFE

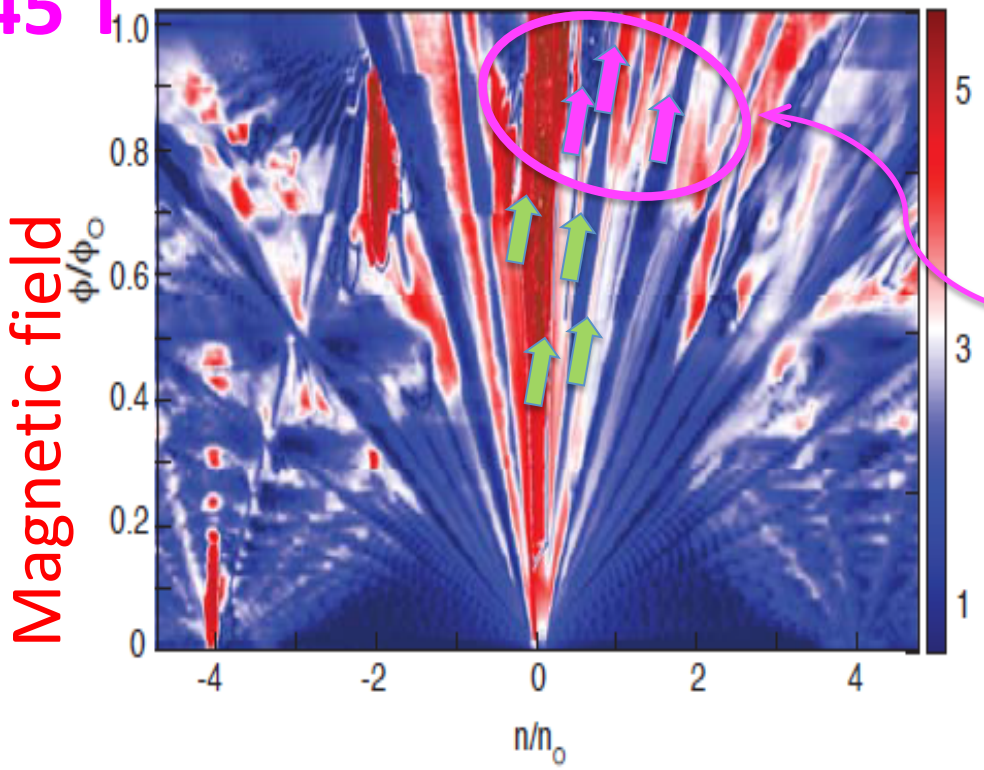




A Materials Example: Landau Levels in Graphene

Fractal and Fractional Quantum Hall Effect

45 T



- TWO simultaneous quantizations (space and magnetic field) produce ***fractal energy level structure.***
- ***FOUND @ 30-45 T:*** Unexplained ***fractional*** Landau levels associated with fractional quantization of each of the two topological numbers:
  t (magnetic field) and
  s (spatial periodic potential)

Landau Level filling factor (no periodic potential)

$$n/n_0 = \mathbf{t}\, f/f_0 + \mathbf{s}$$

Bloch band filling factor (from periodic potential)

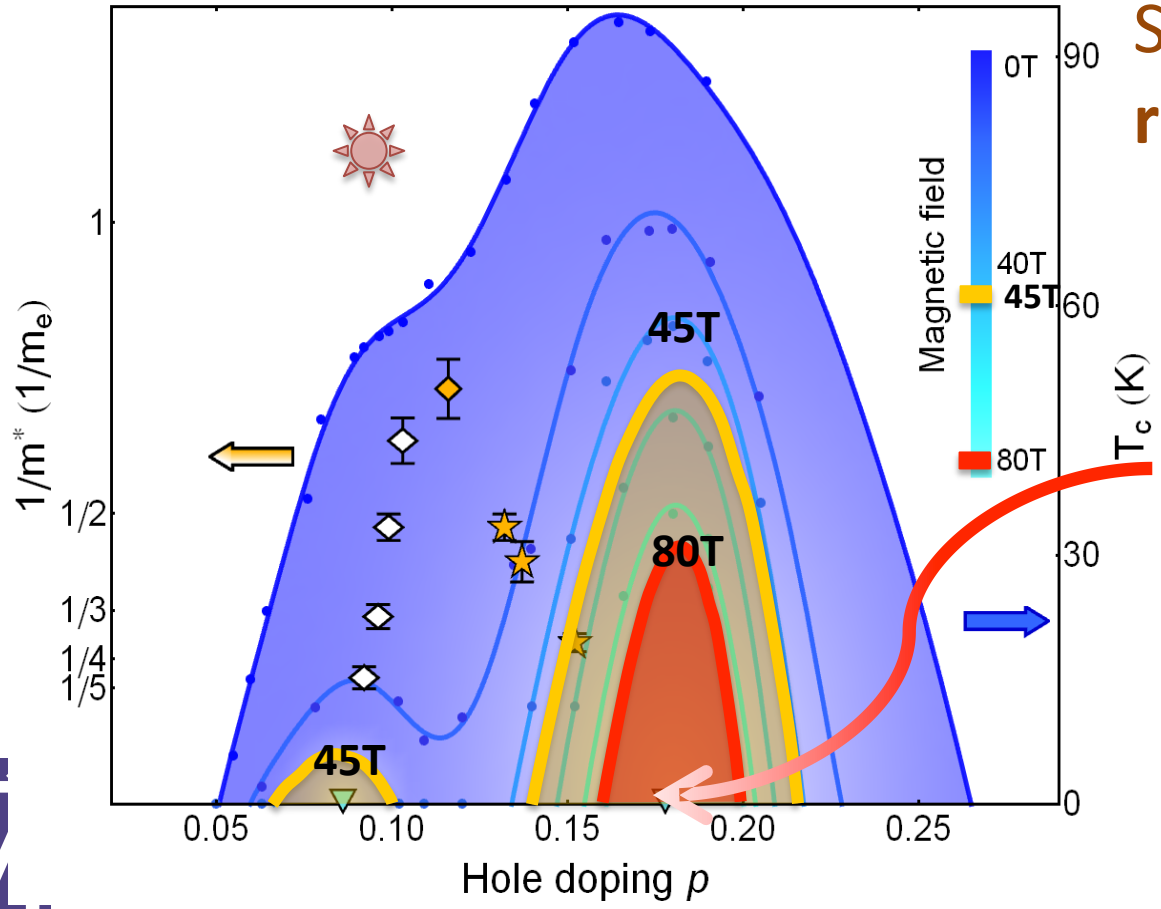
User: Cory Dean Group, Columbia

L. Wang et al, Science 350, 1231 (2015)

MagLab: What's Under the Dome?

MagLab fields (45T) suppress the SC to see this. Higher B needed to find nature of N-state under dome*

S.E. Sebastian *et al.,* PNAS (2010);
B.J. Ramshaw, *et al.,* Science (2015)

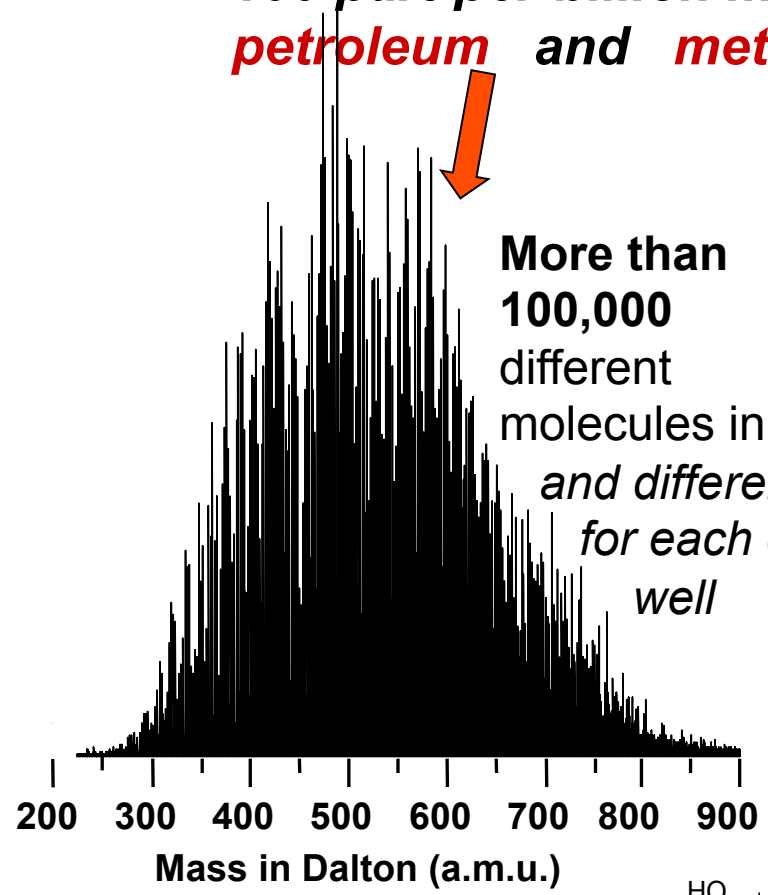


*High-Temp Superconductors **required** for very high B => **60 T**

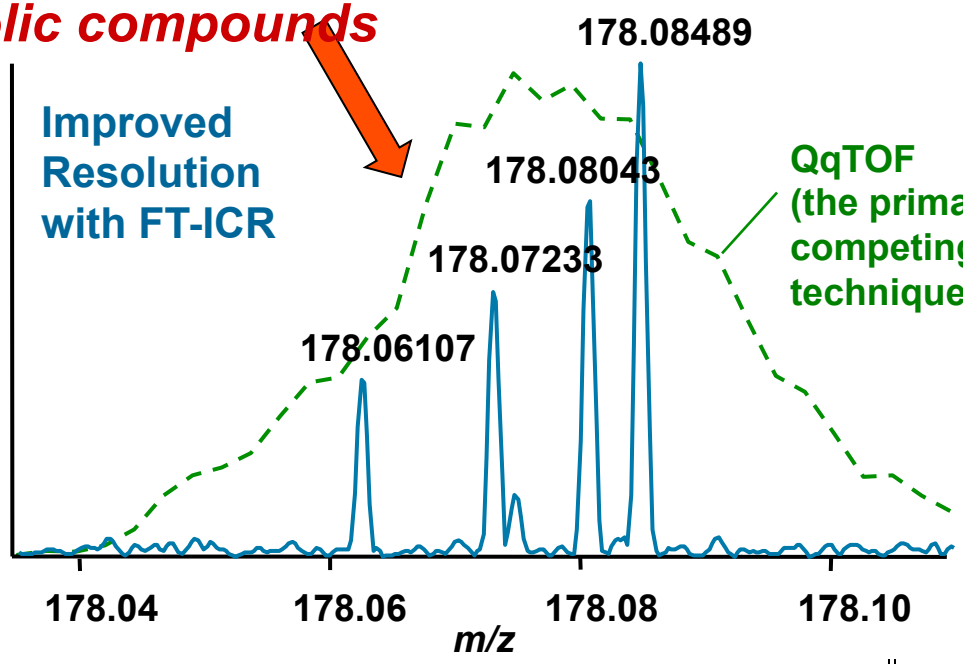
Why does HTS emerge out of these competing phases?

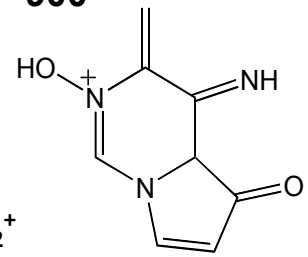
Energy Example: Ion Cyclotron Resonance

14 T high-homogeneity wide-bore magnet,
100 part-per-billion mass resolution
petroleum and metabolic compounds



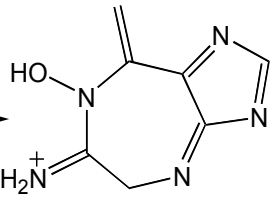
More than 100,000 different molecules in oil *and different for each oil well*



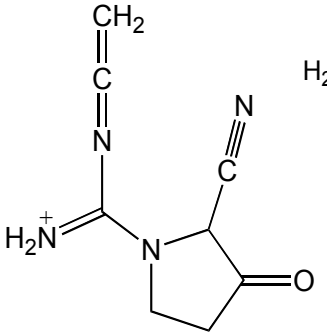


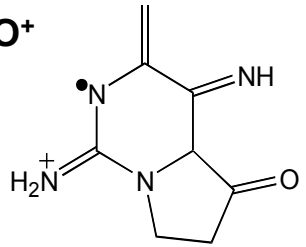
$C_8H_8N_3O_2^+$
m/z 178.06110

$C7H8N5O^+$
m/z 178.07234



$^{12}C7^{13}C1H9N4O^+$
m/z 178.08044





$C_8H_{10}N_4O^{+\bullet}$
m/z 178.08491

Energy Example: Ion Cyclotron Resonance

14 T high-homogeneity wide-bore magnet,
100 part-per-billion mass resolution
petroleum and metabolic compounds

Petroleomics:

- Did BP and Exxon strike the same well in the Gulf (drill cost ~ $1B/ea)
- Where did a spill originate? (Forensics)

Proteomics:

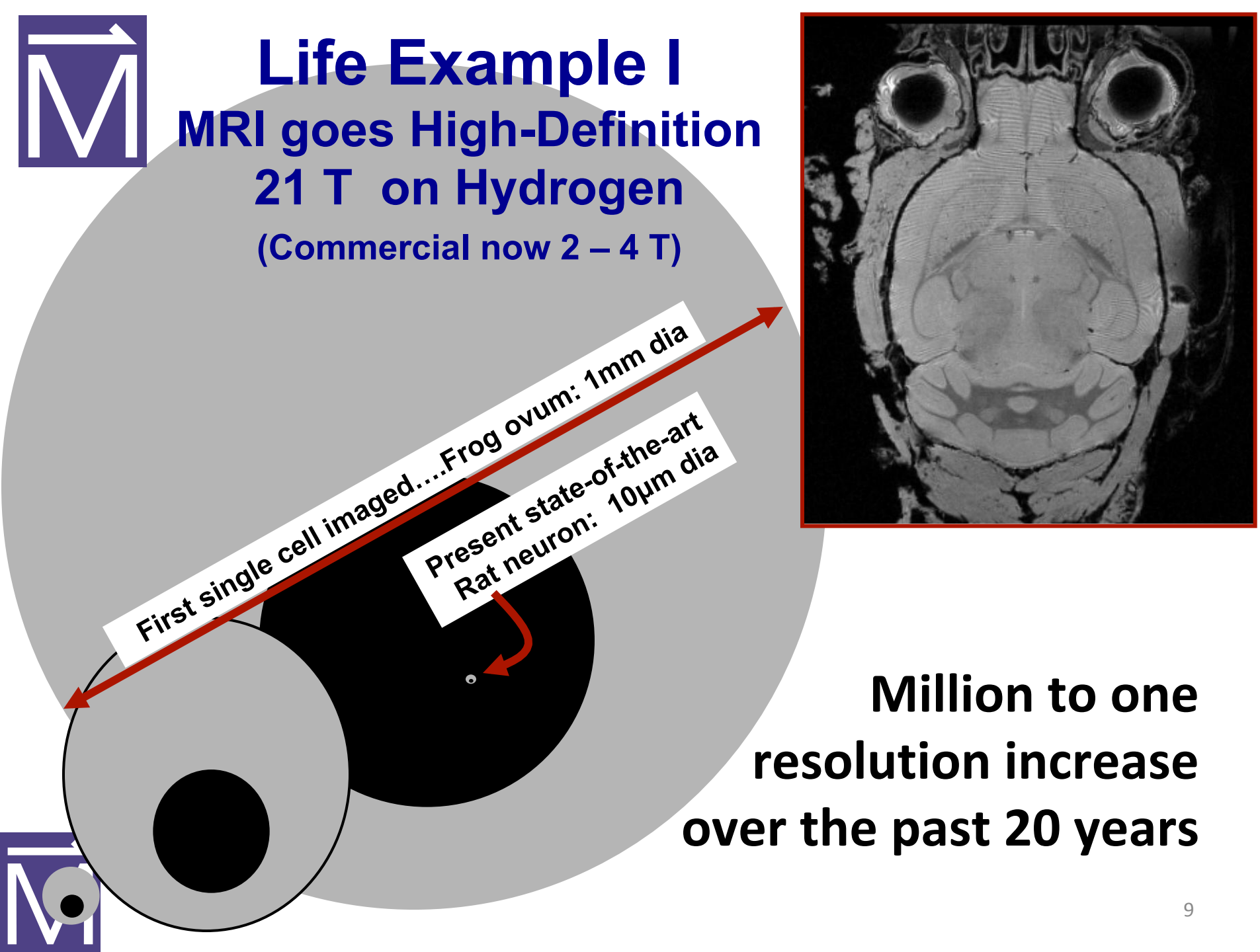
- Identify PROTEIN FOLDING through H-D exchange: Recently identified p53 registrations (to classify malignant/non-malignant)
- Protein makeups

Life Example I

MRI goes High-Definition

21 T on Hydrogen

(Commercial now 2 – 4 T)

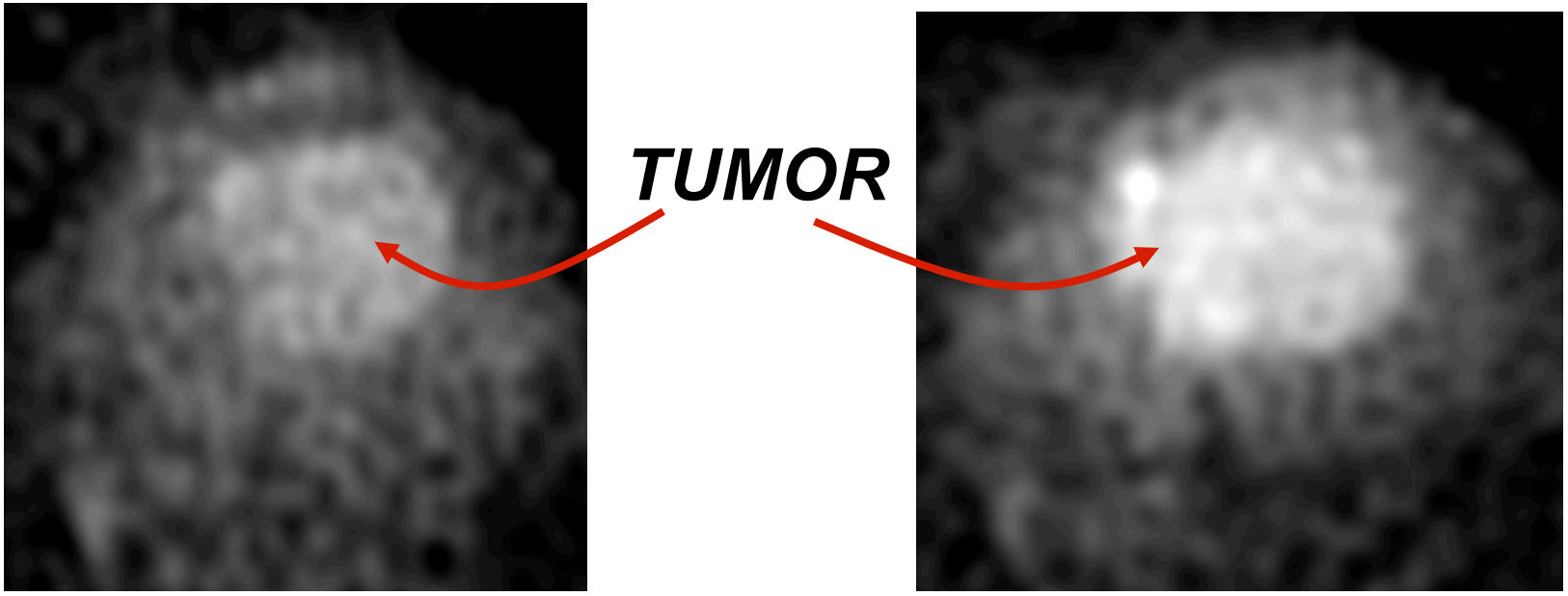


Million to one resolution increase over the past 20 years

Mag Lab Life Example II: MRI Across the Periodic Table

Imaging Sodium in Mouse Brain at *21 T*

Before Chemotherapy ***4 Days After***



The 'lighting up' of the tumor means the chemotherapy is working