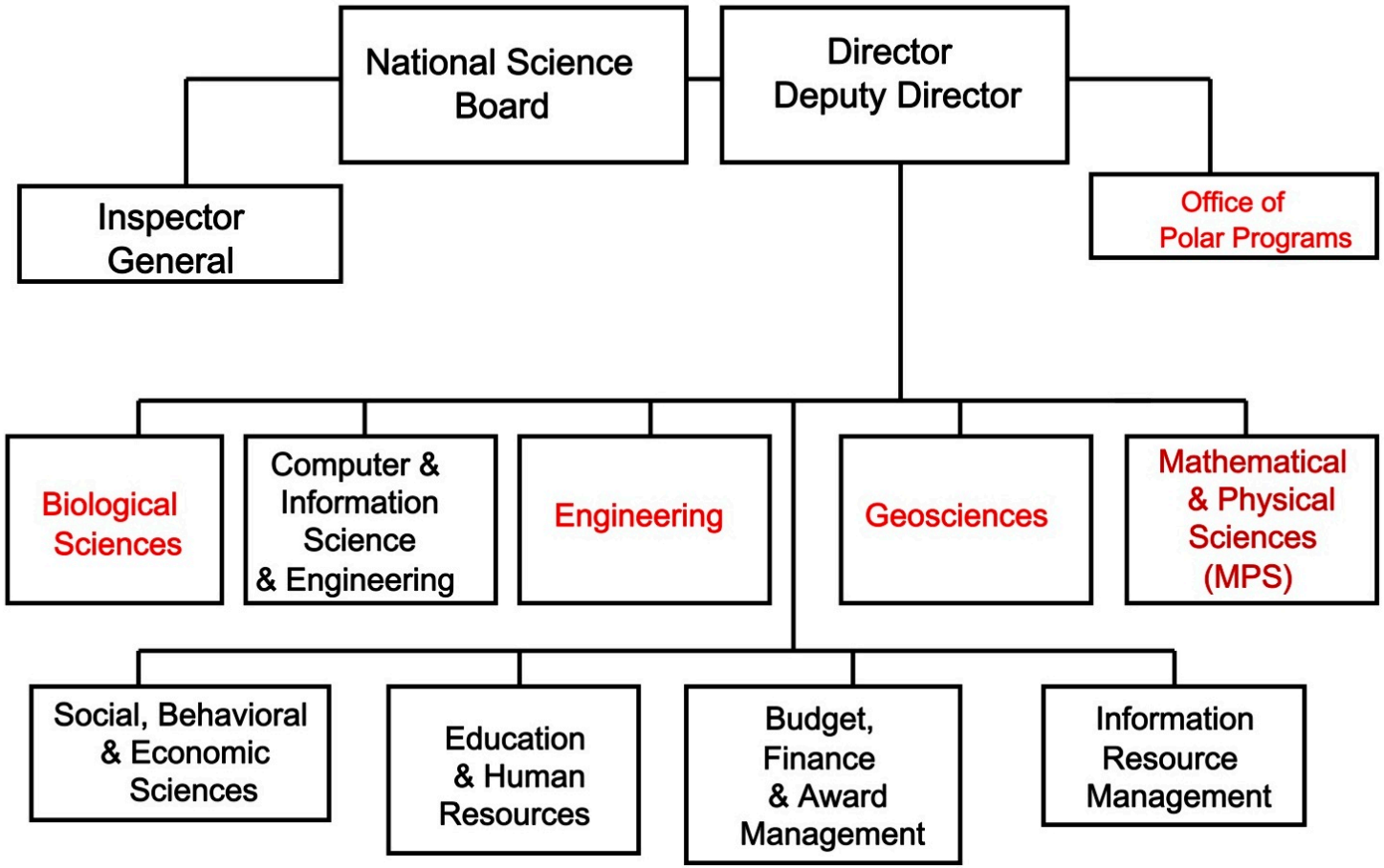
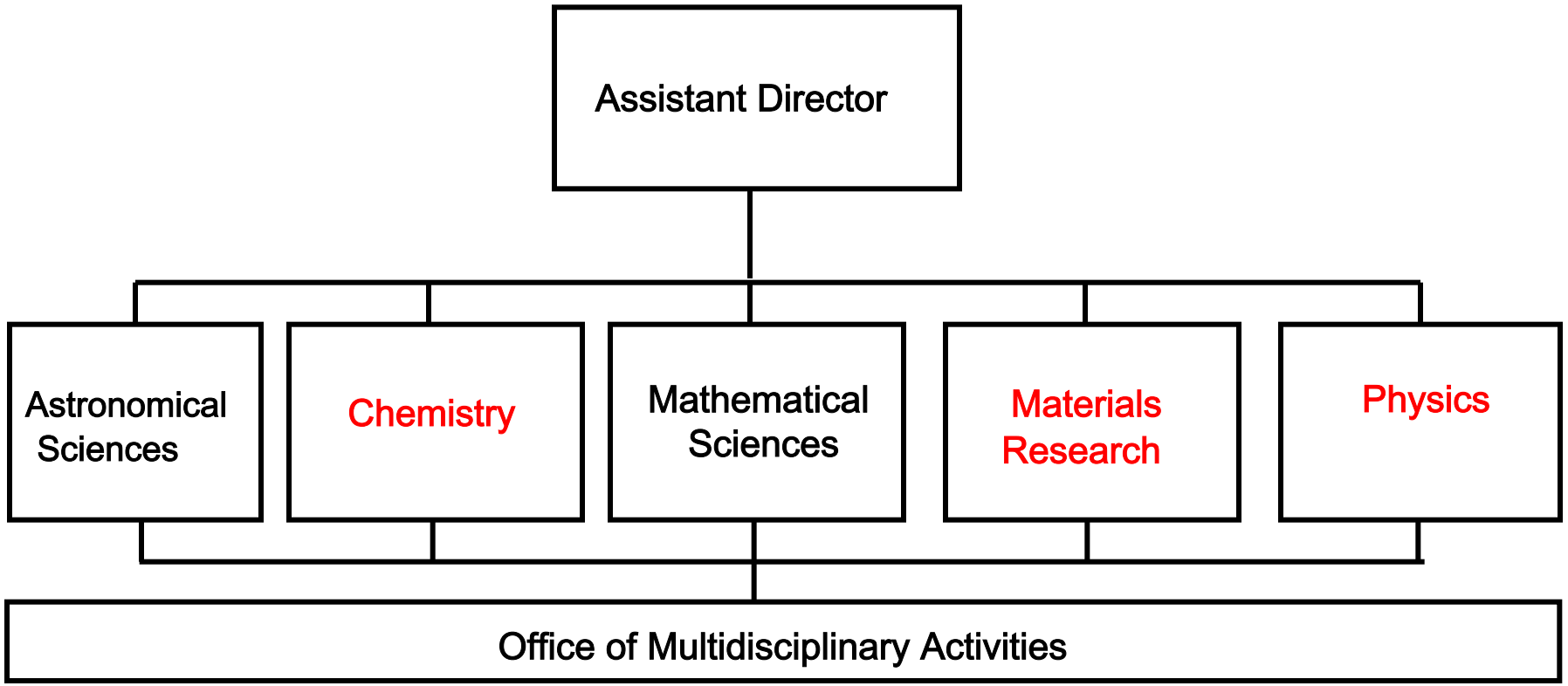
Isotope Needs for NSF-Supported Investigators

- Overview of NSF
- Feedback from 2008 Survey
- Update
- Summary

NSF Organization



Mathematical & Physical Sciences Directorate



NSF in National Context

- Supports most scientific disciplines, though not medicine
- Often larger mission agency budgets (NSF: $6B)
  - NIH (BIO)
  - NASA (AST)
  - DOE (NP, EPP)
- Primarily support of university research
  - No dedicated labs
  - 42,000+ senior scientists; 11,500 new awards each year
  - All information indirect via PIs

Look for cases where NSF research role is unique

- Response mixed!

Responses from 2008

User Facility: National Superconducting Cyclotron Laboratory (MSU)

- 310 employees, incl. 120 students, 30 faculty
- 700 users

Questions:

- Properties of extreme p/n nuclei ratios
  - Limits of existence, Structure
- Origin of the elements of the cosmos
  - Novae, supernovae, stellar burning
- Properties of neutron-rich nuclear matter
  - Structure and dynamics of neutron stars

Capabilities:

- Wide variety of unstable isotopes
- from tritium (A=3) to tellurium (A=134)
- Lifetimes as low as 1 msec

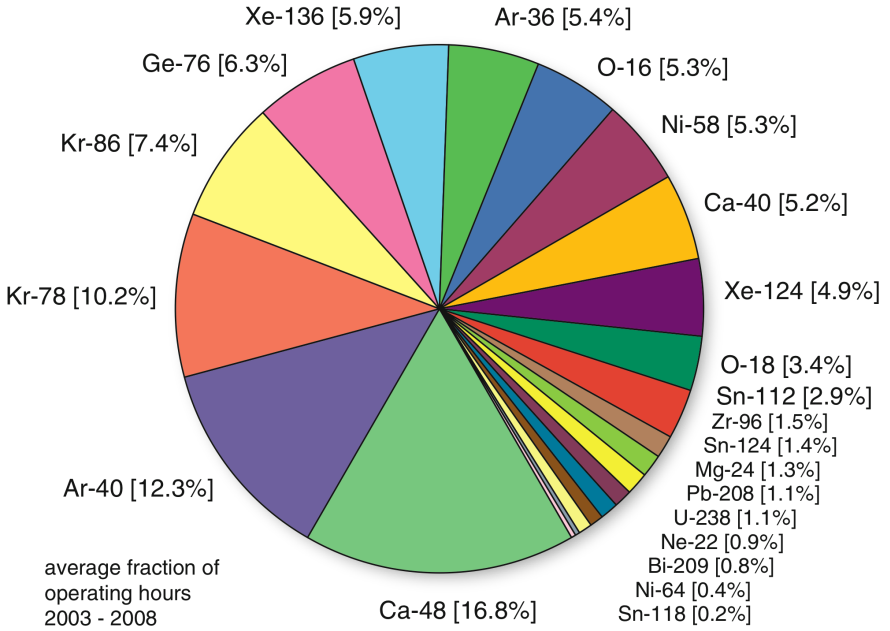
NSCL

NSCL Isotope Use

Average Isotope Consumption [in mg/year]

^{18}O	200
^{22}Ne	200
^{24}Mg	500
^{36}Ar	600
^{48}Ca	1100
^{58}Ni	900
^{76}Ge	1400
^{78}Kr	1300
^{86}Kr	1700
^{112}Sn	400
^{118}Sn	100
^{124}Sn	100
^{124}Xe	3000
^{136}Xe	1300
^{238}U	5000

CCF Primary Beam Isotope Statistics



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University of Notre Dame

- **Isotopes for Astrophysics, typically with 70-99% enrichment:**
- ^{17}O, $^{21,22}Ne$, $^{25,26}Mg$, $^{33,34}S$, ^{36}Ar
- Cd, Sn, and Te (These purchased in Ukraine by Russian collaborators)

- **Isotopes for Structure, typically with greater than 95% enrichment:**
- ^{208}Pb
- $^{144,148,154}Sm$
- $^{112,114,116,118,120,122,124}Sn$
- $^{106,108,110,112,114,116}Cd$
- $^{128,130}Te$
- $^{106,108,110}Pd$
- ^{100}Mo
- ^{72}Ge
- $^{35,37}Cl$
- $^{32,34,36}S$
- $^{28,29,30}Si$
- ^{18}O

...many purchased from Russian Sources (cheaper than ORNL)

Florida State University

- moderately enriched (say 50%) stable separated isotopes for use in the ion source, especially ^{26}Mg and ^{29}Si
- long-lived radioactive isotopes: ^{10}Be and tritium.
- targets: ^{14}C.
- neutron-rich beams: ^{48}Ca

Division of Materials Research

Stable isotopes, readily available:		
^{2}H	CMP: NMR and neutron scattering, ICR, Biochemistry	
^{7}Li	CMP: neutron scattering	
^{11}B	CMP: NMR	
^{13}C	CMP: NMR, Biochemistry NMR, Biochemistry ICR	
^{15}N	Biochemical NMR	
^{18}O	ICR	availability difficult in the past; extremely high cost
^{25}Mg	Biochemical NMR	
^{43}Ca	Biochemical NMR	
^{67}Zn	Biochemical NMR	
^{57}Fe	CMP: Mossbauer Spectroscopy	
^{57}Co	CMP: Mossbauer Spectroscopy	
^{63}Cu	CMP NMR	
Stable isotopes, not readily available:		
^{3}He	CMP: Cryogenics applications	Concerned about future availability, given helium shortage
^{17}O	CMP NMR, Biochemistry NMR	Availability has dropped dramatically
^{114}Cd	CMP: neutron scattering	
^{162}Dy	CMP: neutron scattering	
^{180}Hf	CMP: neutron scattering	
^{202}Pb	Geochemistry, High precision detection of lead cycling through the environment	Would like to have, but is not available
^{205}Pb	Geochemistry, High precision detection of lead cycling through the environment	Critically low inventory and is no longer produced.
CMP: Condensed Matter Physics		
ICR: Ion Cyclotron Resonance		

Division of Chemistry

Response 1:
Our grantees would make only occasional use of most isotopes. We believe that one occasional isotope, tritium, is missing in the workshop report.

The obvious and most important isotope for our division:

Deuterium present in deuterated solvents.

The workshop report indicates D is not produced in the US. As a rough estimate, about 150 funded programs in CHE make heavy use of deuterated solvents. *Thus, there is a need by our grantees for about 150 liters per year, mainly of water, chloroform, and dimethylsulfoxide.*

The workshop seems to under emphasize ^{15}N which along with ^{13}C has heavy use in biological NMR studies of proteins and nucleic acids. The workshop attendees did not reflect this relatively large group of investigators. In general such NMR studies are not performed by our grantees, but the results of such studies have a significant effect on the projects many of our grantees pursue.

Isotopes are widely used in bioanalytical assays. There has been a desire to replace them with fluorescent tags but derivatization chemistry is not always selective. Bioassays often use deuterium, phosphourus and iodine isotopes.

Division of Chemistry

Response 2:
In my program, the primary use for special isotopes is in spectroscopy. The NMR community uses specific. Example: S isotope that is only available from Russia.

Some positron-based research uses radioactive Na to produce e^+, but these would be minor users compared to the need for PET scans.

We also support research using isotopic substitution studies in kinetics, and isotope-editing to clean up peptide infrared spectra.

Most isotopic labeling in the physical chemistry community uses primarily deuterium and ^{13}C. This is the norm for us.

My impression is that the P-Chem PIs do not want to deal with the hassle of working with radioactive materials. We have had one recent CAREER proposal from someone to do spectroscopy with molecules containing heavy-metal radioactive isotopes, but this was to be done in collaboration with DOE laboratory staff at a DOE lab set up to handle these things.

Division of Chemistry

Response 3:
Isotopes are widely used in bioanalytical assays. There has been a desire to replace them with fluorescent tags but derivatization chemistry is not always selective. Bioassays often use deuterium, phosphourus and iodine isotopes.

Response 4:
- ^{18}O, ^{15}N, ^{13}C, ^{2}H: high-molecular weight protein NMR structural determinations
- ^{3}H, ^{14}C, ^{32}P: radioactive tracers in metabolic and biosynthesis studies

From Division Director:
You may remember the comments made by the GE representative at our 2006 workshop on innovation concerning the need for trained PhDs in radiochemistry, since he wanted to hire 50 such individuals and yet was unable to find any.

Directorate for Biosciences

Summary of responses:

- *Where isotope needs exist, they tend to overlap those of NIH, which would be far greater*
- *University researchers are moving away from radioisotopes because of the strict regulatory requirements for use*
- Biomolecular community uses a variety of isotopes for NMR:
  - Not represented in workshop, but
  - ^{13}N, ^{13}C most commonly used and abundant
  - No large increase in demand seen over next 5 years

Directorate for Engineering

Summary of responses:

•Isotope needs in general ‘not an issue’

ENG has partnered on 5-year initiative with DHS Domestic Nuclear Detection Office; best to refer relevant isotope needs to DHS

Division of Materials Research December 2011*

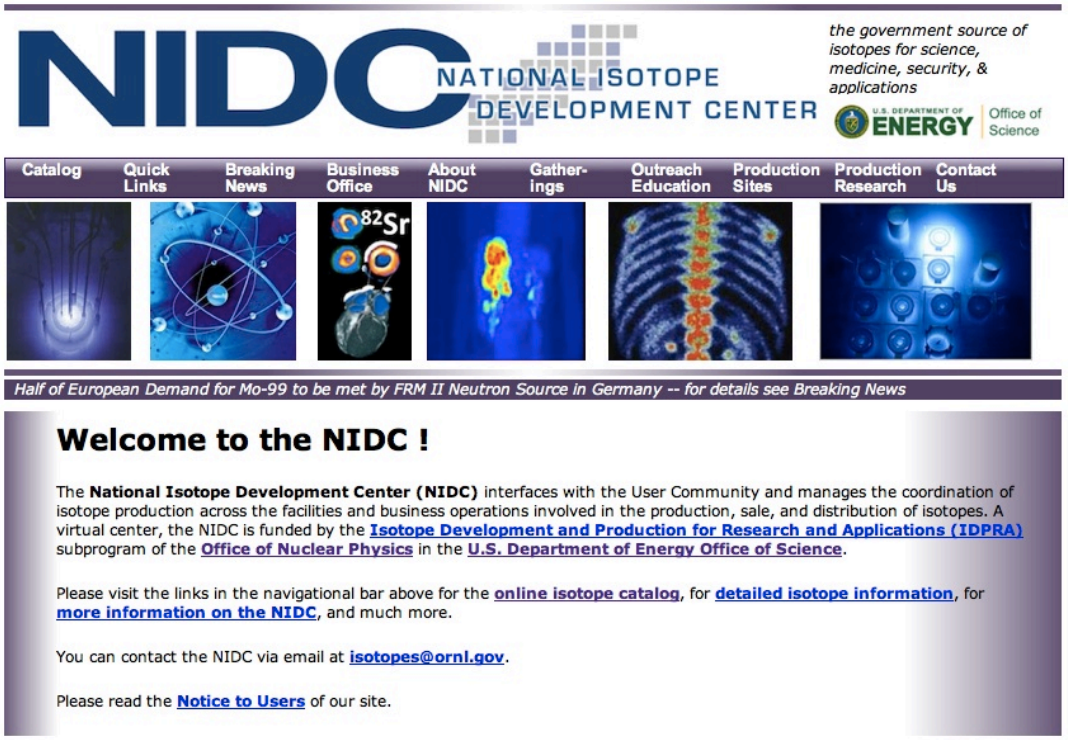
A	Institution	Intended Use	Purity	Physical Form	FY12	FY13	FY14	FY15	FY16
^{18}O	University A	Isotopic labeling	0.99	Gas	10 l				
^{15}N	University A	Isotopic labeling	0.99	Gas	10 l				
^{2}H	University A	Isotopic labeling	0.99	Gas	10 l				
^{238}U	University B	NMR measurements	0.999	Ingot	10 g	10 g	10 g	10 g	10 g
^{61}Ni	University B	NMR measurements	0.999	ingot	0.5 g	0.5 g	0.5 g	0.5 g	0.5 g
^{101}Ru	University B	NMR measurements	0.999	Ingot	1 g	1 g	1 g	1 g	1 g
^{99}Ru	University B	NMR measurements	0.999	Ingot	1 g	1 g	1 g	1 g	1 g
^{29}Si	University B	NMR measurements	0.999	Solid	1 g	1 g	1 g	1 g	1 g
^{13}C	University B	NMR measurements	0.999	Solid	1 g	1 g	1 g	1 g	1 g
^{17}O	University B	NMR measurements	0.999	Gas	1 g	1 g	1 g	1 g	1 g
^{14}C	University C	Environmental Transfer studies in Bacteria	C-14 Radio labeled CNT	Solid	1 mCi	1 mCi	1 mCi		

*D. Finotello

Summary

- NSF covers broad range of science
- Usually not the largest stakeholder for specific isotopes
- Specific research areas (NP, condensed matter) use broad range of isotopes
- Investigators typically do not contact NSF regarding their isotope requirements
- Investigators may be unaware of pending shortages

Best Practice for Individuals and Small Groups



- Investigators most likely to contact source directly
- imperative to make that source accessible and user friendly