Report from NSF

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Experimental Nuclear Physics
Mathematical and Physical Sciences
National Science Foundation

2017 Low Energy Community Meeting

3-4 August 2017 *Argonne National Laboratory*

Outline

- Nuclear Physics at NSF
- Budget
- Funding Opportunities and Highlights
- Final Notes

Nuclear Physics at NSF

- Nucleon and Hadron QCD – properties and behavior of nucleons and nuclear matter under extreme conditions, confinement, hadron spectra, nuclear equation of state

- Nuclear Reactions and Structure – structure of many-body nuclei and reactions of relevance to structure

  Nuclear Astrophysics – origin of the elements, properties of dense matter in a compact object, nuclear reactions that drive stars and stellar explosions

- Nuclear Precision Measurements and Fundamental Symmetries – tests of QCD and chiral perturbation theory, tests of the Standard Model in a strongly interacting environment

- Nuclear Theory – structure and reactions of nuclei and of hadrons in few-nucleon and nuclear environments, the quark/gluon substructure expressed by QCD

Goals of the Nuclear Physics Program

- Identify research opportunities and the most compelling physics through the peer review process
- Support as much of the above as possible while managing a balanced portfolio

Budget Trends – NSF Nuclear Physics

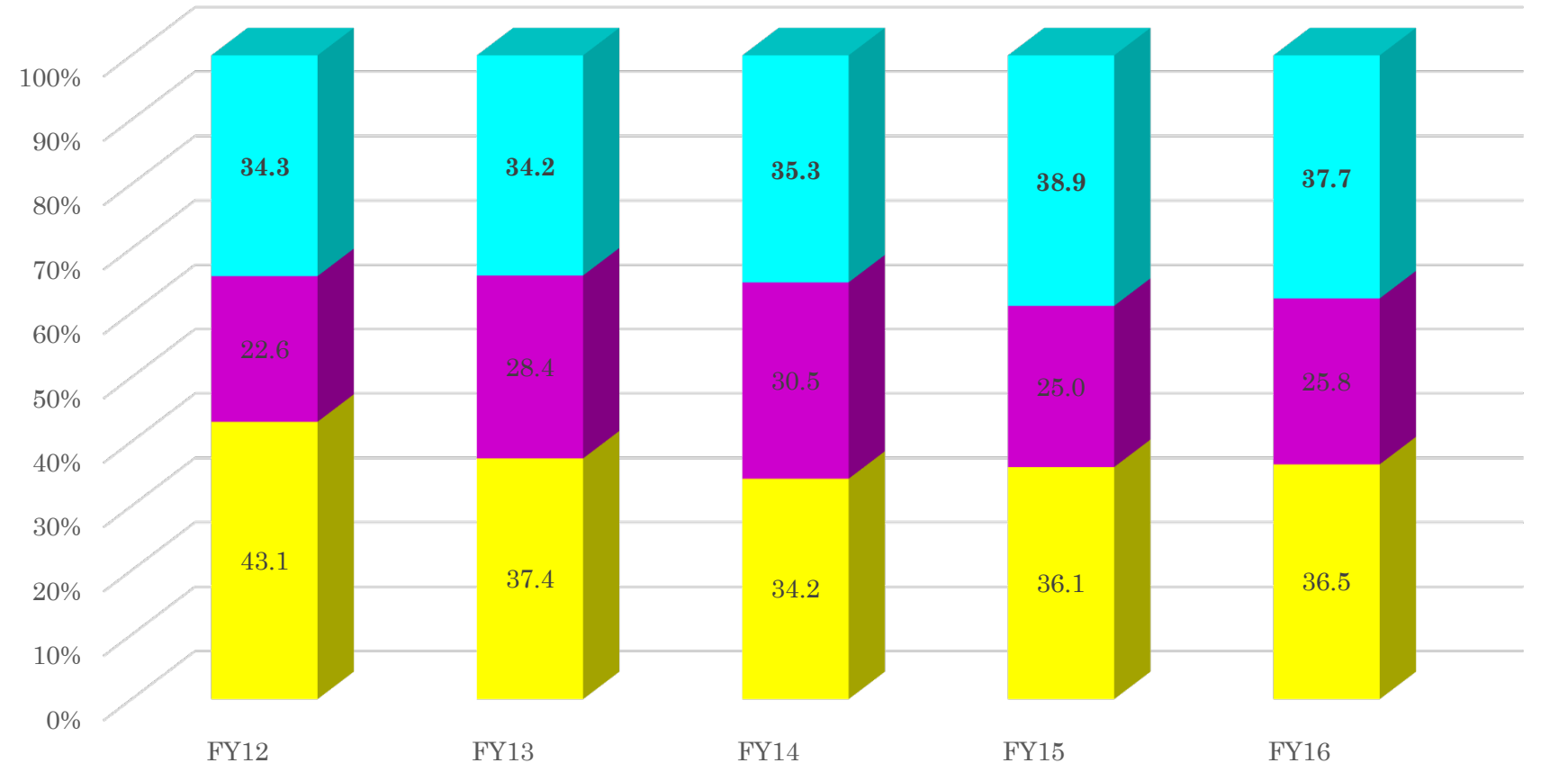
Includes co-funding and other leveraged funds

~ 25% = Research
~ 75% = Operations

FY	Nucleon & Hadron QCD (k$)	Nuclear Astroph, Reactions, Structure (k$)	Prec Meas'ts & Fund. Symm. (k$)	Total Exp't Nuclear Physics (k$)	Nuclear Theory (k$)	Nuclear Program Total (k$)	NSCL (k$)	JINA & JINA -CEE (k$)	MRI (K$)	Mid-Scale (K$)	Total Nuclear Physics (k$)
2011				19,164	3,719	22,883	21,500	2,150	729		47,262
2012	7,969	4,185	6,343	18,497	3,829	22,326	21,500	2,150	2,744		48,720
2013	6,183	4,693	5,653	16,509	3,474	20,008	21,500	2,150	2,996	490	47,144
2014	5,826	5,189	5,999	17,014	3,514	20,528	22,500	2,280	1,038	1,188	47,533
2015	6,769	4,702	7,304	18,774	4,183	22,957	23,000	2,280	1,801	1,367	51,406
2016	7,141	5,046	7,391	19,579	4,223	23,802	24,000	2,280	1,869	3,238	55,189
2017				17,800 +			24,000	2,280		2,990	

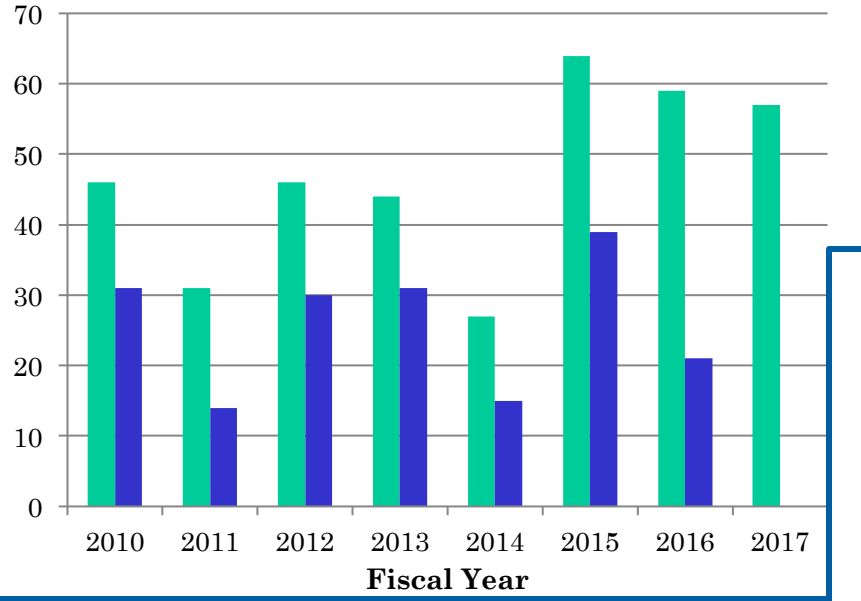
FY15 Fundamental Symmetries: + $1.32M for 0νββ
MRI: competes each year; one-time acquisition/development funds
Mid-scale: ad hoc competition; design and construction funds (nEDM & MUSE)

Budget Trends – NSF Nuclear Physics

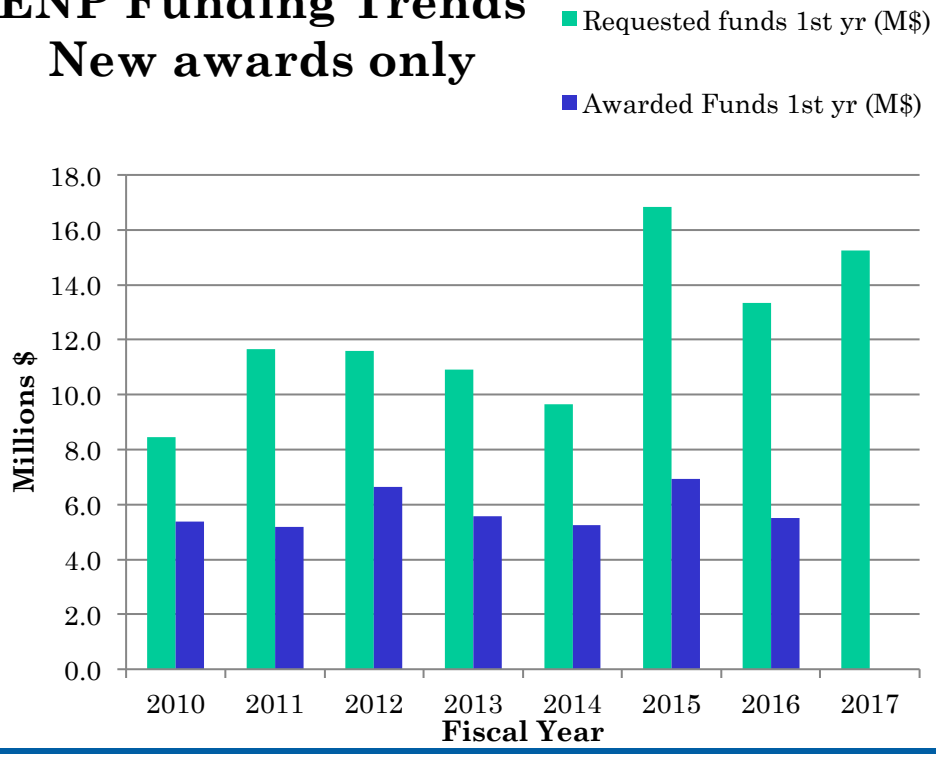


ENP Proposal Trends

*** 2015 includes 8 0vBB proposals**
2016 includes 7 0vBB proposals
2017 includes 8 0vBB proposals



ENP Funding Trends
New awards only



FY18 NSF Request $6,652.89 M

National Science Foundation
FY 2018 Budget Request to Congress
(Dollars in Millions)

NSF by Account	FY 2016 Actual	FY 2017 Annualized CR	FY 2018 Request	FY 2018 Request change over Amount	FY 2018 Request change over Percent
Research & Related Activities	$5,998.09	$6,022.18	$5,361.65	-$636.44	-10.6%
Education & Human Resources	$884.10	$878.33	$760.55	-$123.55	-14.0%
Major Research Equipment & Facilities Construction	$241.50	$199.93	$182.80	-$58.70	-24.3%
Agency Operations & Award Management	$351.11	$329.37	$328.51	-$22.60	-6.4%
National Science Board	$4.31	$4.36	$4.37	$0.06	1.5%
Office of Inspector General	$14.76	$15.13	$15.01	$0.25	1.7%
Total, NSF	$7,493.86	$7,449.30	$6,652.89	-$840.98	-11.2%

FY18 PHY $253.30M

- Approximately 2% for Operations
  - Panels, IPA Appointments and Travel, M&S
- Approximately 30% for M&O for Facilities
  - IceCube, LHC, LIGO, NSCL
- Approximately 8% for Physics Frontiers Centers
  - Currently 5 (one of which is JINA-CEE); near end of tri-annual competition
- Approximately 3% for Education and Broadening Participation
  - REU Sites, LIGO Education Center, …
- Approximately 57% ($152.09 M) for sevenmajor areas of Physics (AMO, PP, GP, NP, PA, Plasma, PoLS)
  - Experimental and Theoretical

FY18 PHY $253.30M

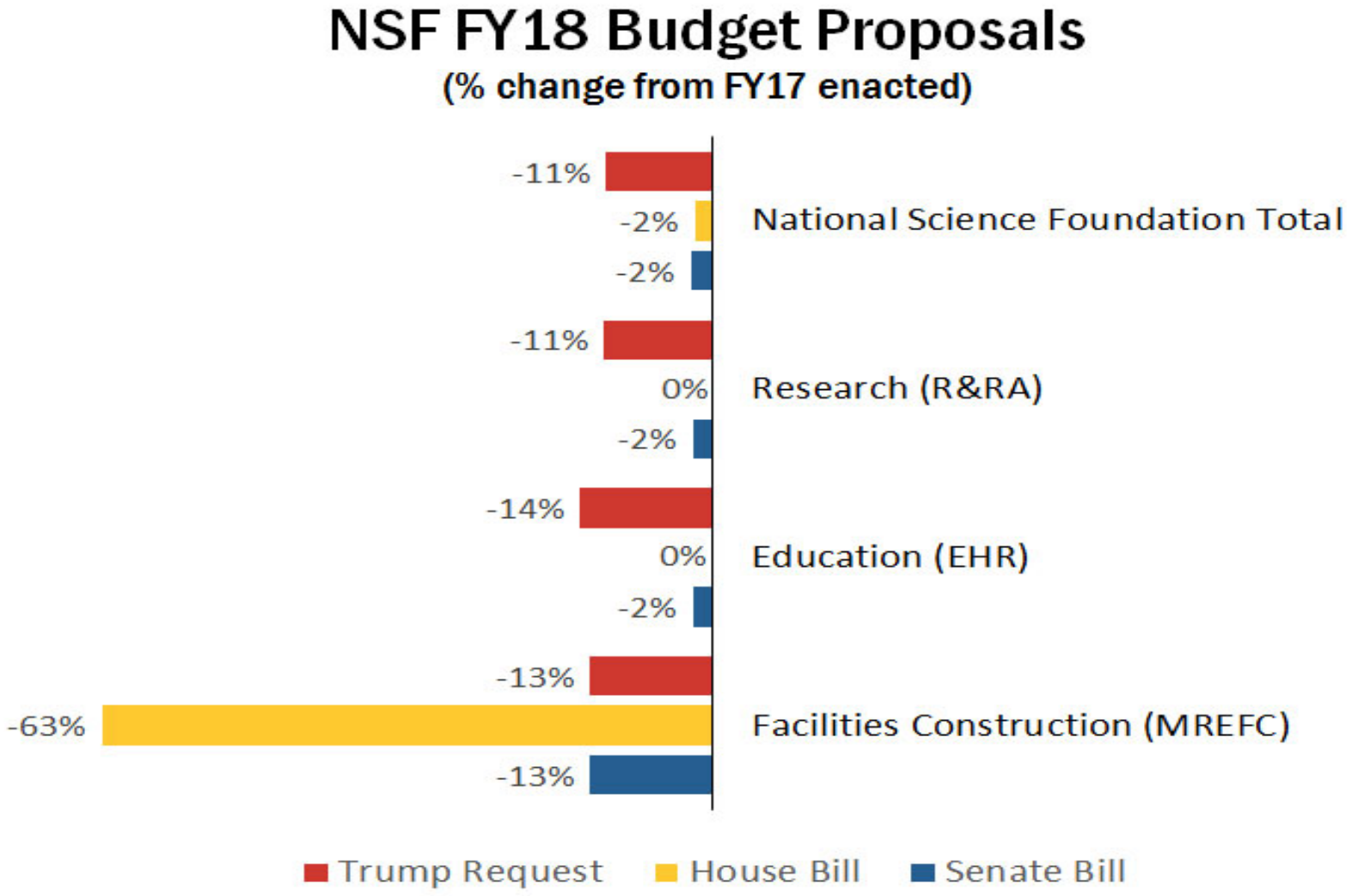
PHY Funding

(Dollars in Millions)

	FY 2016 Actual	FY 2017 (TBD)	FY 2018 Request	Change Over FY 2016 Actual Amount	Change Over FY 2016 Actual Percent
Total	**$276.91**	-	**$253.30**	**-$23.61**	**-8.5%**
Research	**174.12**	-	**152.09**	**-22.03**	**-12.7%**
CAREER	8.12	-	7.30	-0.82	-10.1%
STC: Center for Bright Beams (CBB)	-	-	5.00	5.00	N/A
Education	**5.40**	-	**4.80**	**-0.60**	**-11.1%**
Infrastructure	**97.39**	-	**96.41**	**-0.98**	**-1.0%**
IceCube	3.48	-	3.50	0.02	0.6%
Large Hadron Collider (LHC)	20.00	-	16.00	-4.00	-20.0%
Laser Interferometer Gravitational Wave Observatory (LIGO)	39.43	-	39.43	-	-
Nat'l Superconducting Cyclotron Lab. (NSCL)	24.00	-	23.00	-1.00	-4.2%
Midscale Research Infrastructure	10.48	-	8.18	-2.30	-21.9%
Pre-construction planning:	-	-	6.30	6.30	N/A
High-Luminosity LHC Upgrade Planning	-	-	6.30	6.30	N/A

Awards made in FY17 (ENP):
yr1 = $XXX yr2 = $(XXX)*0.9 yr3 = $(XXX)*0.9

Budget Update (August 2017)



Goals of the Nuclear Physics Program

- Identify research opportunities and the most compelling physics through the peer review process
- Support as much of the above as possible while managing a balanced portfolio

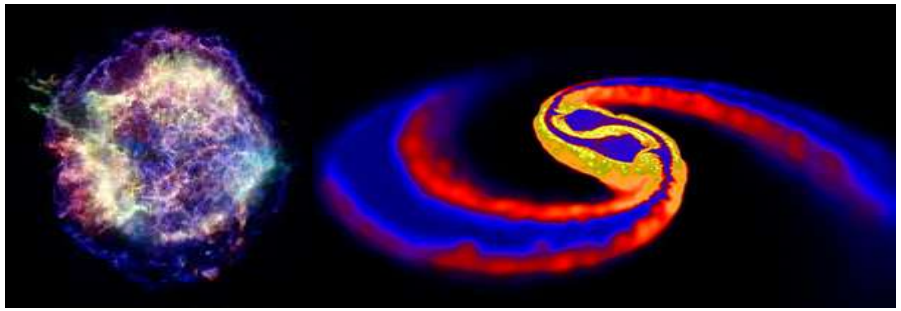
Our goals and actions remain the same – regardless of the budget

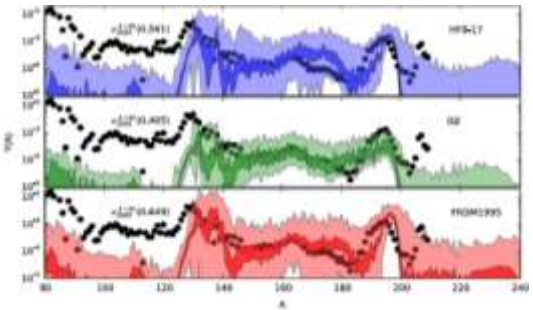
NSF Physics Division: Investigator-Initiated Research Projects (17-561)

- Most common type of proposals awarded in NSF for single PI or groups.
- Include proposals to the program for schools, workshops and conferences, must be submitted through this solicitation.
  - Priority will be given to schools.
  - Broad scope that serves a wide nuclear physics community
  - Involvement of under-represented groups
  - Contact us!

- However: Research at Undergraduate Institutions (RUI) proposals should be submitted through the RUI solicitation (14-579) by the deadlines in this PHY solicitation according to the closest disciplinary match.

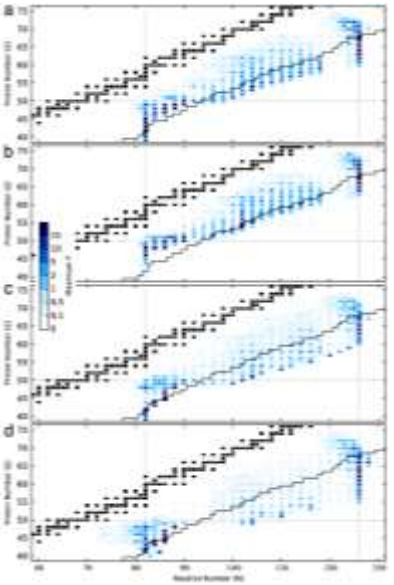
The impact of individual nuclear properties on r-process nucleosynthesis





Darker shaded band represents Monte Carlo simulation with mass model rms error reduced to 100 keV.

The r-process is thought to be the origin of 50% of all elements beyond Iron but the site for the r-process is unknown and remains one of the open challenges in all of physics today. This paper uses existing nuclear physics models and their implied properties for nuclei far from stability to determine the nuclei that have the greatest impact on a given astrophysical scenario.



Important β-decay half-lives in four astrophysical environments.

M.R. Mumpower, R. Surman, G.C. McLaughlin, A. Aprahamian
Progress in Particle and Nuclear Physics 86, 86-126 (2016)

UNIVERSITY OF NOTRE DAME

Career Program

- Solicitation: 17-537
- Must include excellent research proposal as well as excellent educational plan
- There are eligibility requirements: e.g., must be assistant professor, untenured
- 5 year awards, $400,000 minimum
- Proposal deadline: **July 21, 2017**
- PECASE nominees are chosen from CAREER winners
- Contact program officer for information/advice ahead of time (budget, scope)

FY17: 8 ENP proposals; 2 awarded

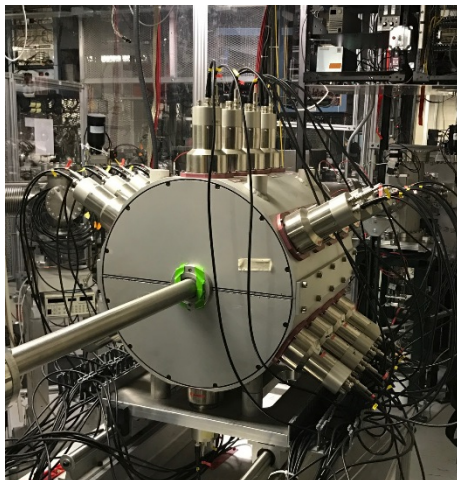
Jaideep Singh @ MSU & Liang Yang @ UIUC

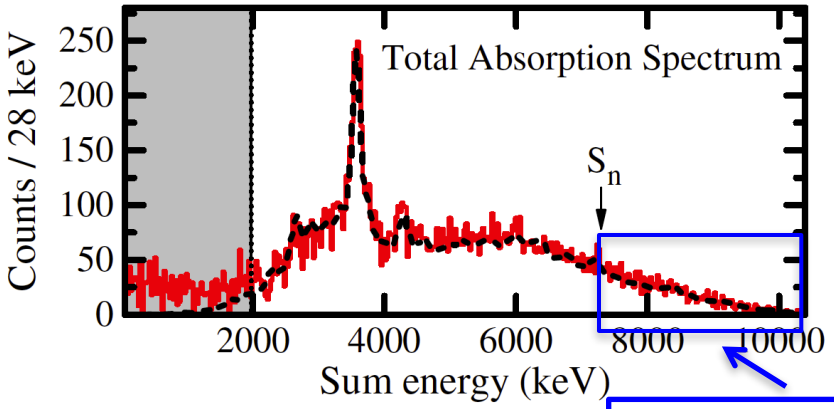
Beta-decay experiments to constrain astrophysical processes

Prof. Spyrou
award 1350234

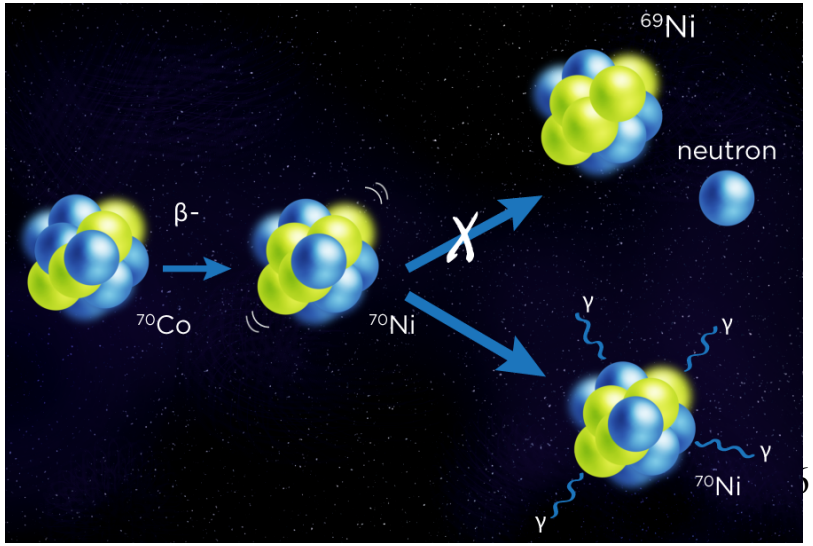
- β-delayed neutron emission is an important quantity for r-process nucleosynthesis.
- New NSCL experiment found that the expected neutron emission should be reduced in some nuclei due to nuclear structure effects.
- Strong γ-ray emission was observed above the neutron threshold.
- This behavior is rare and this particular case can only be explained based on shell model calculations and the mismatch between populated states in ^{70}Ni and the neutron daughter ^{69}Ni.

Experiment done at NSCL using the SuN detector





Unexpected γ-emission above the neutron threshold



Major Research Instrumentation (MRI) NSF 15-504

- Two types of awards: development and acquisition
- Contact program directors well ahead of submission to discuss (avoid pitfalls)
- Limited submissions from each university
- Maximum award is $4M; awards above $1M compete across the entire Foundation

FY17

- *Physics received 23 proposals, 10 in ENP*
  - *Review process complete*
  - *Funding recommendations soon*

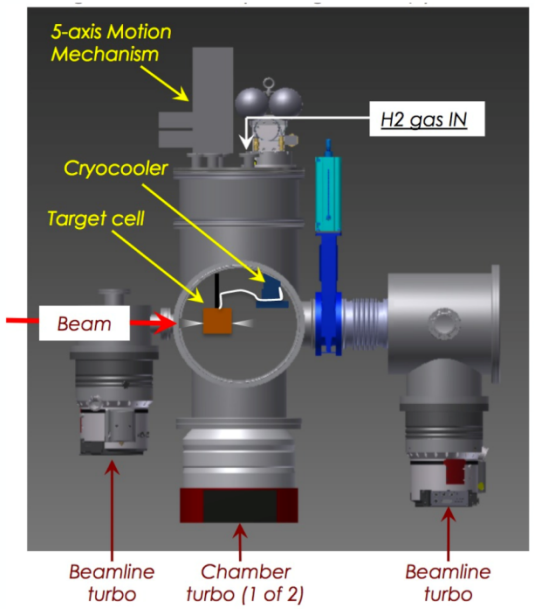
FY18

- **Likely to be a new solicitation**

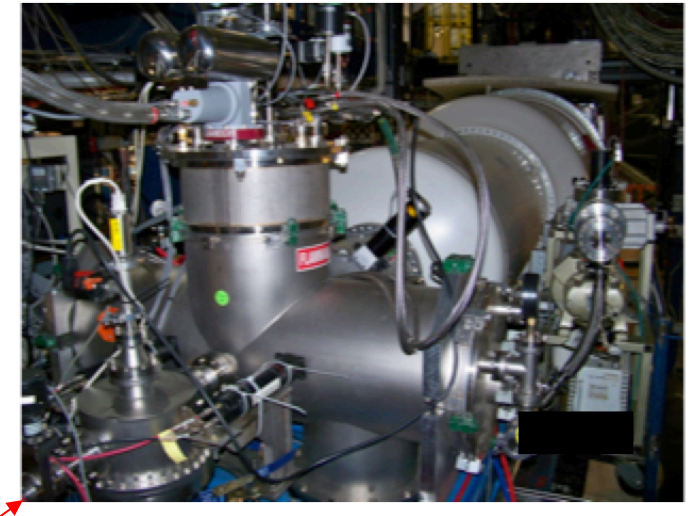
PRad (Proton Charge Radius Measurement at JLab)

- Experimental setup developed, constructed and tested for the past four years.
  - ✓ novel hydrogen gas flow windowless target (**funded by NSF MRI award: PHY-1229153**);

    Punjabi, Vina – NorfolkState University
  - ✓ HyCal (PrimEx) calorimeter refurbished and tested;
  - ✓ GEM large-size coordinate detectors constructed and tested (funded by DOE);
  - ✓ integrated high-speed DAQ system developed and tested.
- Experiment was performed in May/June of 2016,large statistics, high quality, rich data were collected:
  - ✓ lowest Q^2 data set (~10^{-4} GeV/C^2) has been collected for the first time in ep-scattering experiments;
  - ✓ simultaneous measurement of Moller and Mott scattering processes has been demonstrated to control systematic uncertainties.
- About half of 2.2 GeV beam energy data have been analyzed



Target schematic view



Target installed in Hall B beam line

Midscale Instrumentation

- Design and Construction *or* Acquisition of Instrumentation
  - R & early D, operations funded by research programs
- ~ $4M < TPC < ~ $15M; over multiple years
- Selection based on
  - merit review
  - exceptional opportunity
  - research community priorities.
- Currently 6 Midscale projects
- For more info, see PHY Solicitation 17-561

nEDM

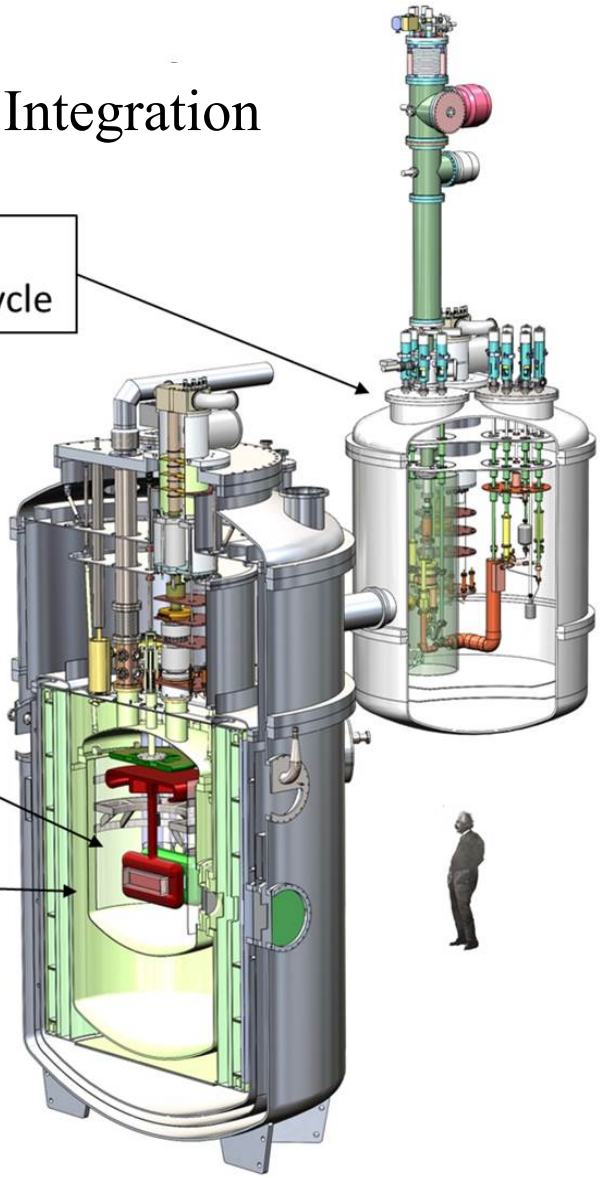
Experimental Nuclear Physics

Critical Component Design → Large Subsystem Integration

- Prepare polarized 3He
- Isotopically purify 4He each measurement cycle

- Generate electric field
- Store 3He, neutrons
- Monitor 3He, neutron precession frequencies

- Generate uniform B-field

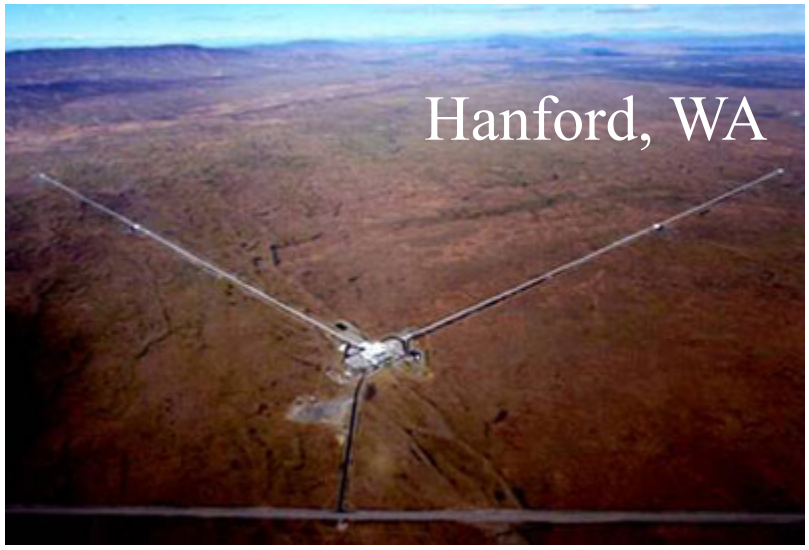


PIs: Brad Filippone (Caltech)
And Doug Beck (UIUC)

Major Research Equipment and Facilities Construction (MREFC)

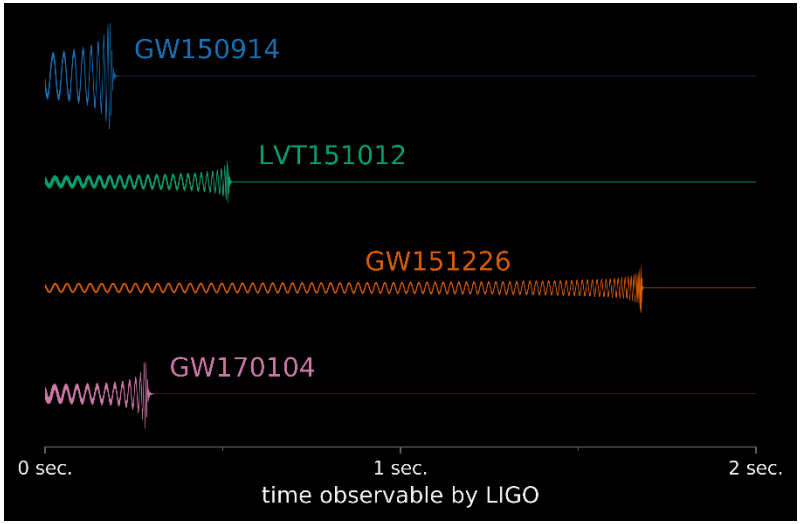
- The Major Research Equipment and Facilities Construction (MREFC) account supports the acquisition, construction, and commissioning of major research facilities and equipment that provide unique capabilities at the frontiers of science and engineering.
- Initial planning, design, and post-construction operations and maintenance are funded through the Research and Related Activities (R&RA) account.

Laser Interferometer Gravitational-Wave Observatory (LIGO)

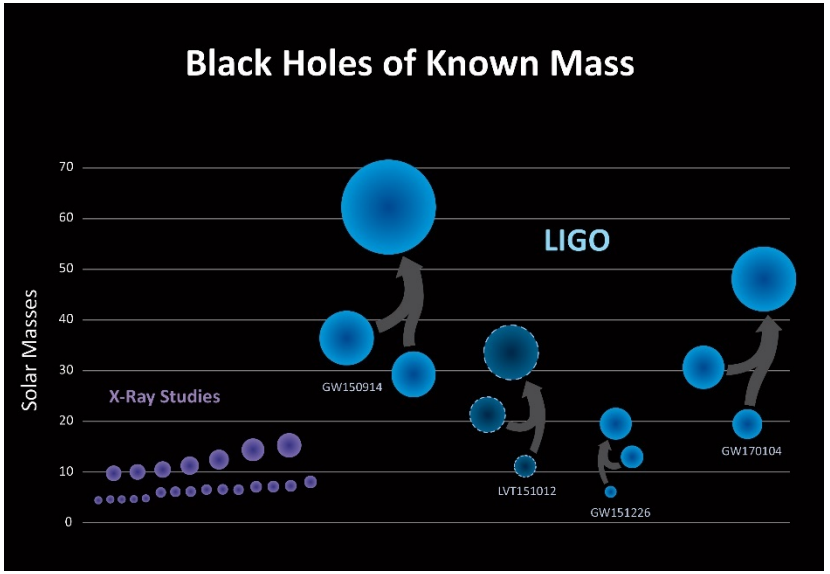


May 2017: Third Confirmed LIGO Detection GW170104

Likely that in this merger the BH spins were initially *counter* aligned with the orbital angular momentum, unlike previous two detections.



Images: LIGO.org



Original Black Holes Masses: 19 and 31 $M_\odot$.
Final Black Hole Mass: 49 $M_\odot$
Distance: 880 Mpc (z = 0.18).

Previously detected merged BH:
1st = 62 $M_\odot$ 2nd = 21 $M_\odot$

The farthest detection so far

For the latest updates, check out

http://www.nsf.gov/div/index.jsp?div=PHY

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