Report from NSF

Ken Hicks

- NSF Nuclear Physics Program Scope
- Announcements
  - New Solicitation
- Budget
- Physics Division Personnel

Nuclear Physics @ NSF

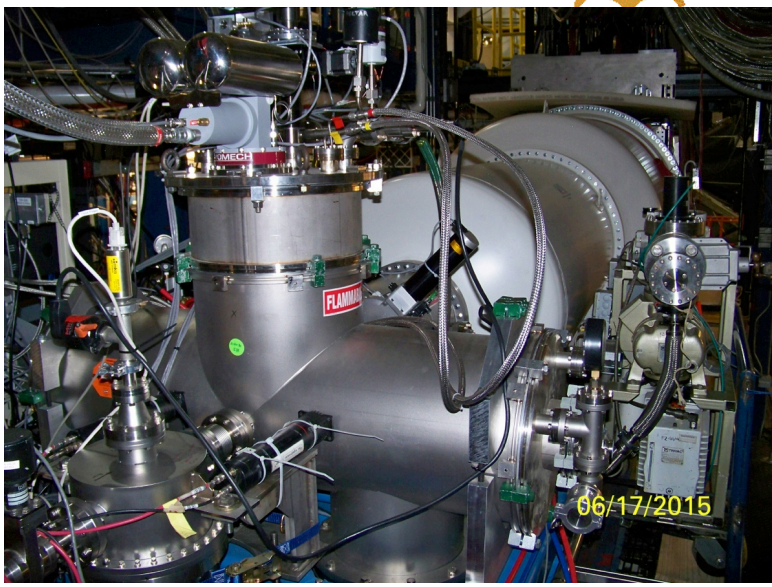
- **Nucleon and Hadron QCD** – properties and behavior of nucleons and nuclear matter under extreme conditions, confinement, hadron spectra, nuclear equation of state
- **Nuclear Reactions and Structure** – structure of many-body nuclei and reactions of relevance to structure
- **Nuclear Astrophysics** – 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

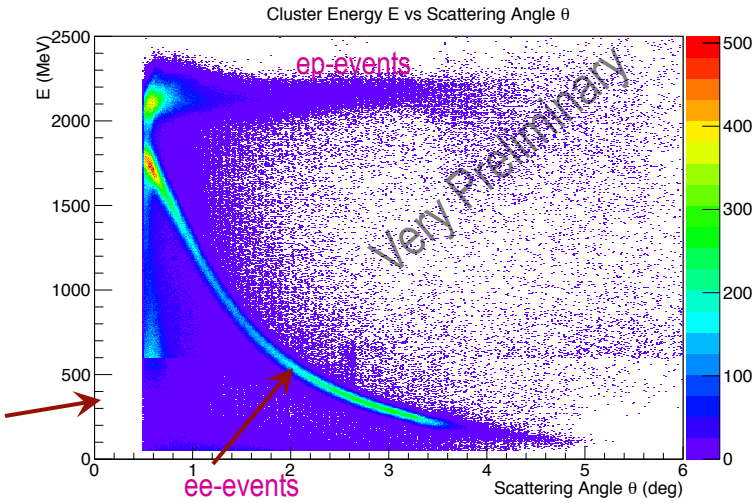
Highlights

- A few selected results shown here:
  - Results from some selected NSF PI's.
  - NSF experimental nuclear physics funds a broad range of experiments, and only a few results are highlighted.
  - I apologize if your NSF-funded results are not shown here.

Prad Experiment (Hall B)

- PRad is designed to address the *"Proton Radius Puzzle"*.
  - ✓ novel hydrogen gas flow windowless target (**funded by NSF MRI award: PHY-1229153**);
  - ✓ HyCal calorimeter refurbished and tested;
  - ✓ GEM large-size detectors constructed and tested
  - ✓ integrated high-speed DAQ system developed and tested;
- PRad is taking data from May 13 to June 21, 2016.
  - ✓ data taking for 1.1 GeV energy is completed;
  - ✓ data taking for 2.2 GeV is in progress;
- Major accomplishments so far:
  - ✓ $2x10^{+18}$ (H atoms/cm^2) areal density in hydrogen gas flow target achieved;
  - ✓ lowest Q^2 data set (~10^{-4} GeV/C^2) have been collected for the first time in ep-scattering experiments;
  - ✓ separation of Moller and ep-events at very low scattering angles demonstrated.
- On-line data analysis is in progress.





Qweak – Expect Analysis Completion in 2016

International Collaboration: 23 institutions, 95 Collaborators (23 grad students,10 postdocs)

Parity-violating e-p analyzing power with high precision at $Q^2 \sim 0.025$ (GeV/c)^2.

Determine: Q^p_W - proton's weak charge
Extract: C_{1u}, C_{1d}, $\sin^2\theta_W$

Any deviation from SM prediction would be indication of new physics.

+ Numerous ancillary measurements to be published separately.

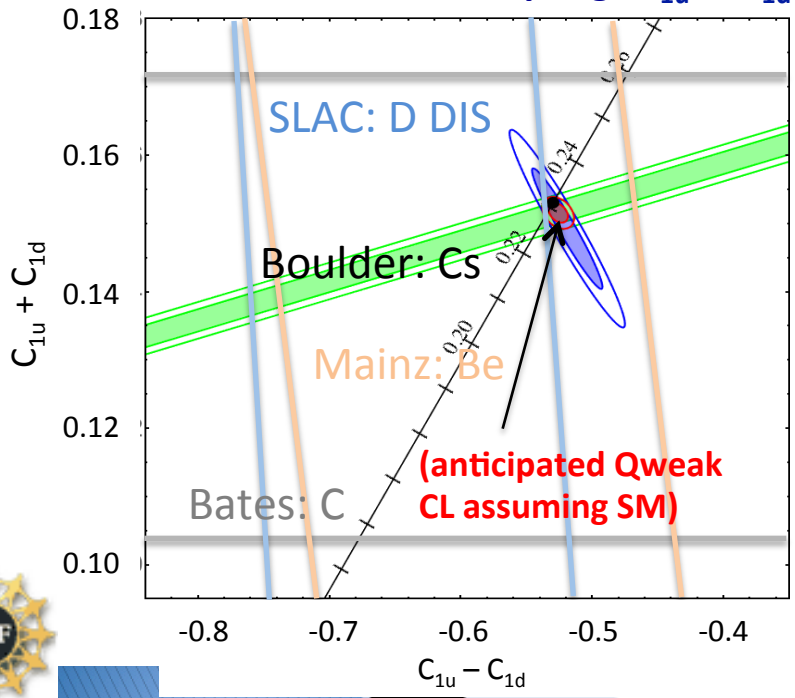
"Statistical analysis" of all data done.

The measurement has 25 systematic corrections with their associated uncertainties.

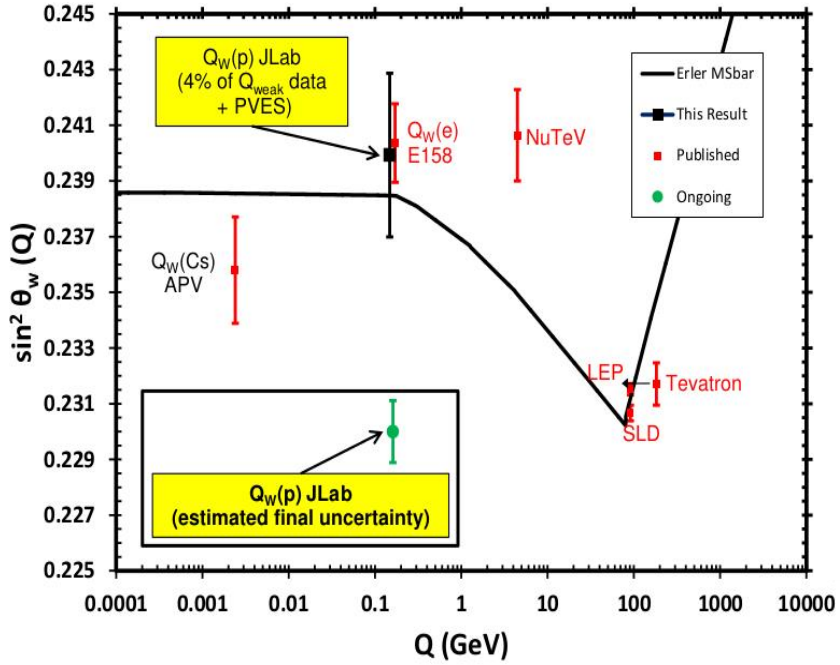
Finalizing the last significant correction.

Final result expected to yield most precise low energy weak mixing angle and significantly improved quark couplings.

Sensitive to Vector Couplings C_{1u} & C_{1d}



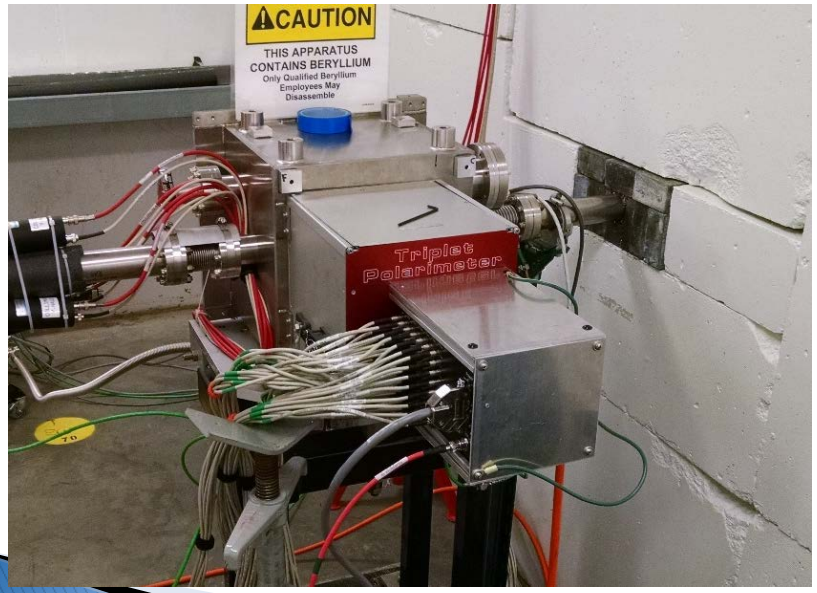
Running Plot of Weak Mixing Angle

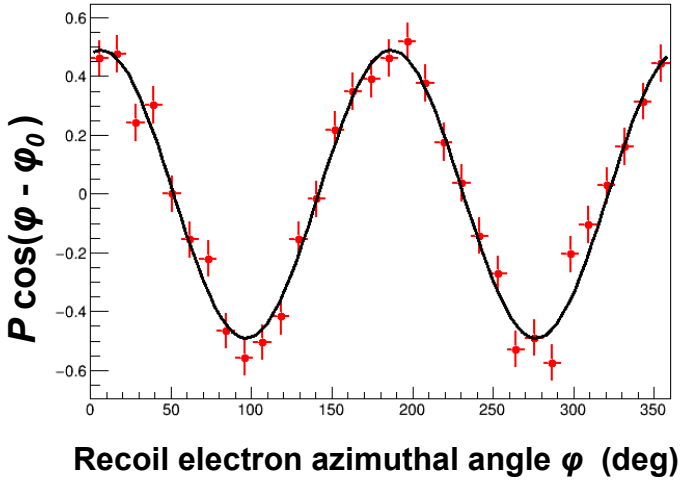


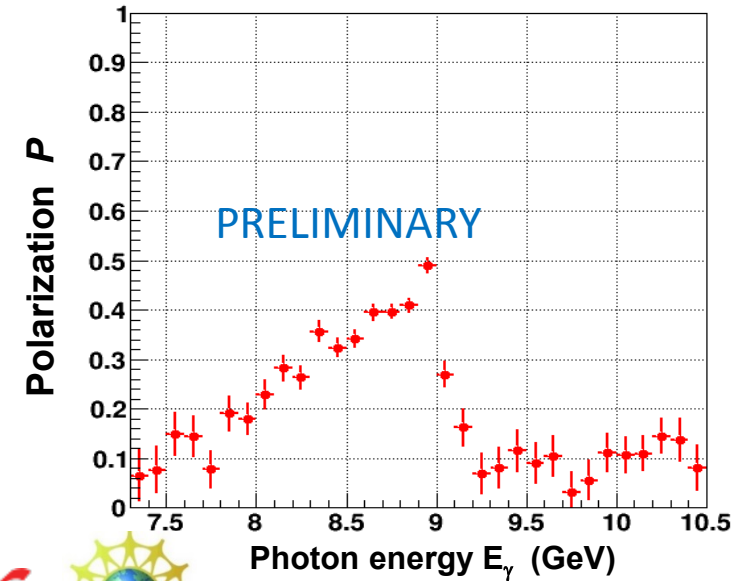
NSF collaborators: GWU, La. Tech, Ohio U. ,Virginia Tech, William and Mary; MRI for Qweak Tracking System

Hall D Triplet Polarimeter

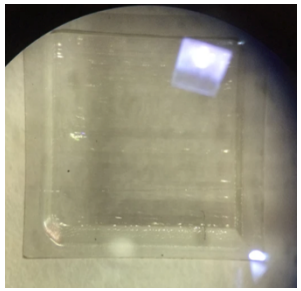
- Uses triplet photoproduction process to measure photon beam polarization
  - Triplet production: pair production on an atomic electron
  - Polarization in photon beam yields asymmetry in recoil atomic electron distribution
- Double-sided silicon strip detector, vacuum housing, beryllium target, and custom electronics

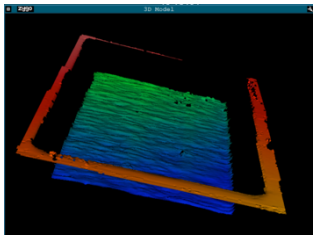






Cutting a thin window in a diamond plate using UV laser ablation

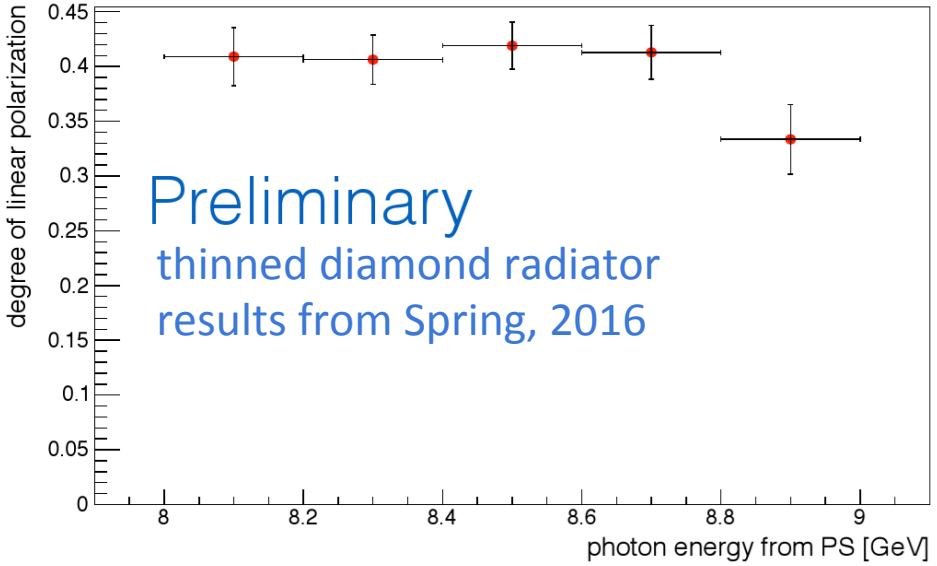




the GlueX polarized photon source

The Hall D tagger microscope (U. Conn.)

- 40% polarization over range 8-9 GeV
- 8 MeV energy bins
- 200 ps time resolution
- 10^8 γ/s rate capability



CLAS12

Forward Tagger

FT designed to detect electrons and photons at small angles

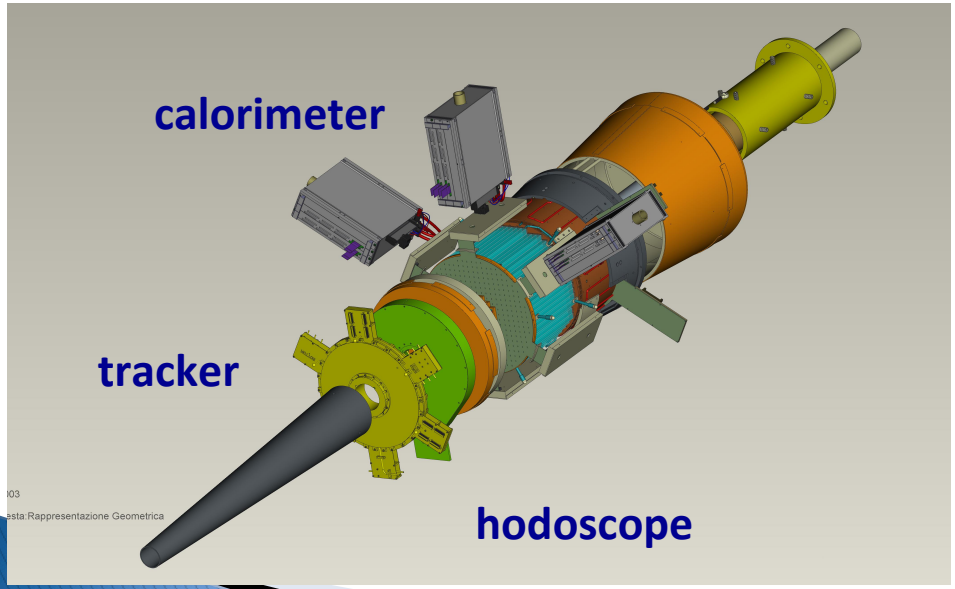
FT-Cal: calorimeter to measure electron energy/momentum

FT-Hodo: scintillation hodoscope to veto photons & backsplash

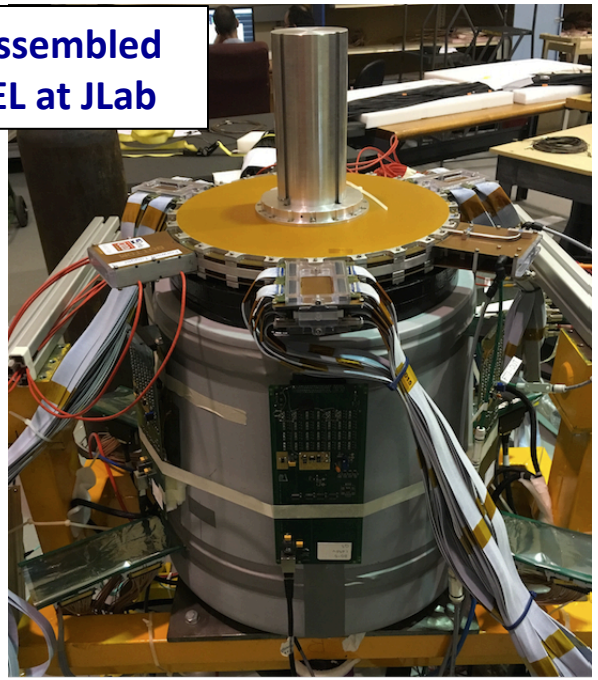
FT-Trk: micro-mega detector to measure electron angles, polarization plane

$$\theta = 2.5^\circ \rightarrow 4.5^\circ$$

$$\frac{\sigma(E)}{E} \leq \frac{0.02}{\sqrt{E\ (\mathrm{GeV})}} + 0.01$$



FT assembled in EEL at JLab



Schedule: Installation in CLAS12 - 11/2016

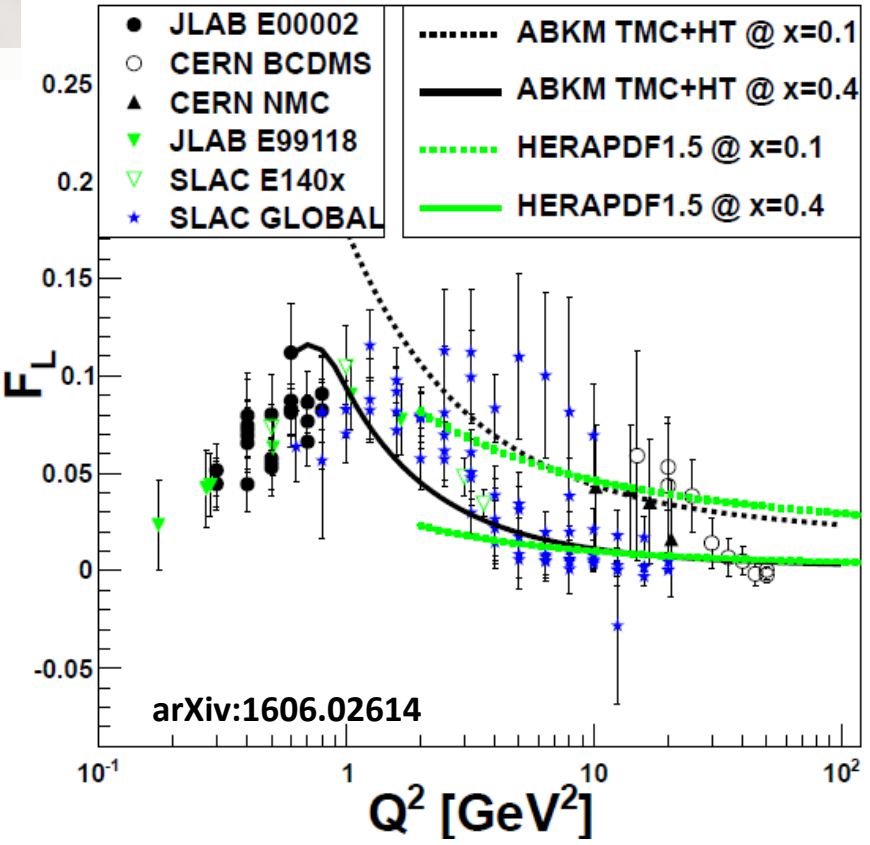
Jlab/Hall C
SHMS Hodoscope
NSF MRI 0722965

- Scintillator hodoscope designed, built, tested, and installed in Hall C by JMU-PNP group

Precision measurements of the F_2 structure function at large x in the resonance region and beyond (E12-10-002, S. Malace, M. Christy, C. Keppel, I. Niculescu spokespersons)

- Scheduled to run in Hall C in March 2017 as a commissioning experiment

Results on Longitudinal Structure Function for the Proton
(E00-002, I. Niculescu, C. Keppel spokespersons)

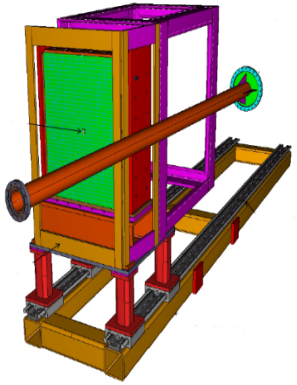


Neutral Particle Spectrometer (NPS)

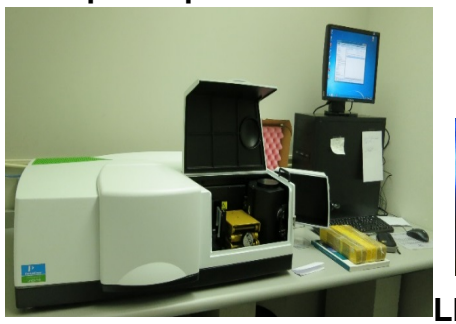
Supported by
NSF-MRI 1530874

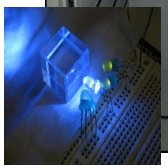
- Highly segmented $PbWO_4$-based EM calorimeter preceded by a sweeping magnet
  - Brings precision coincidence with neutral-particle detection
  - Required for five approved experiments in Hall C
- MRI provides for detector infrastructure and magnet assuming existing crystals
  - Steel for sweeping magnet on-site, design nearly final
  - Detector frame design concept completed, ready for detailed design
  - High voltage divider linearity optimization to begin
  - Significant efforts related to $PbWO_4$ crystals due to large variations that affect resolution performance requirements
    - In collaboration with EIC-related detector R&D
    - 45 SICCAS crystals being evaluated at CUA in collaboration with IPN-Orsay and Giessen University

X-ray machine for radiation hardness characterization



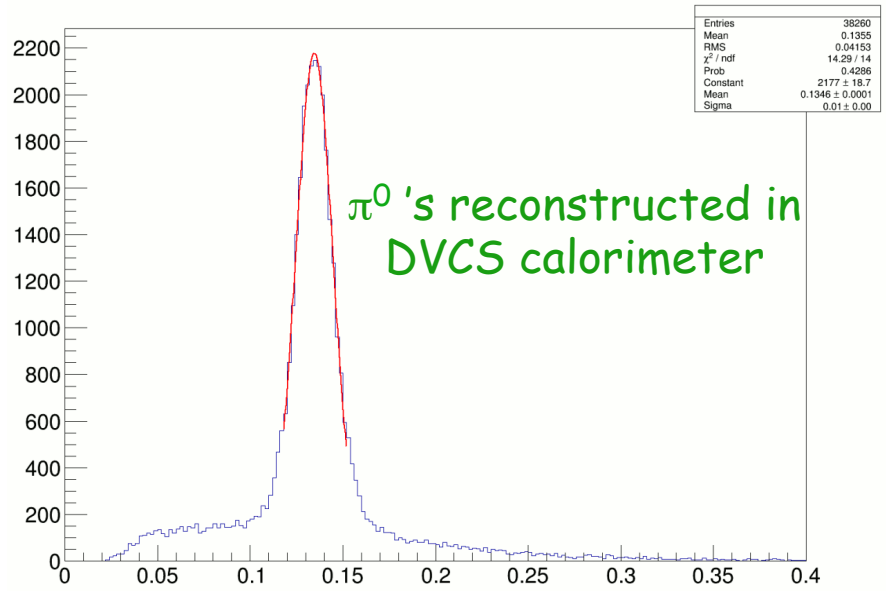
Light transmittance of the crystals with spectrophotometer



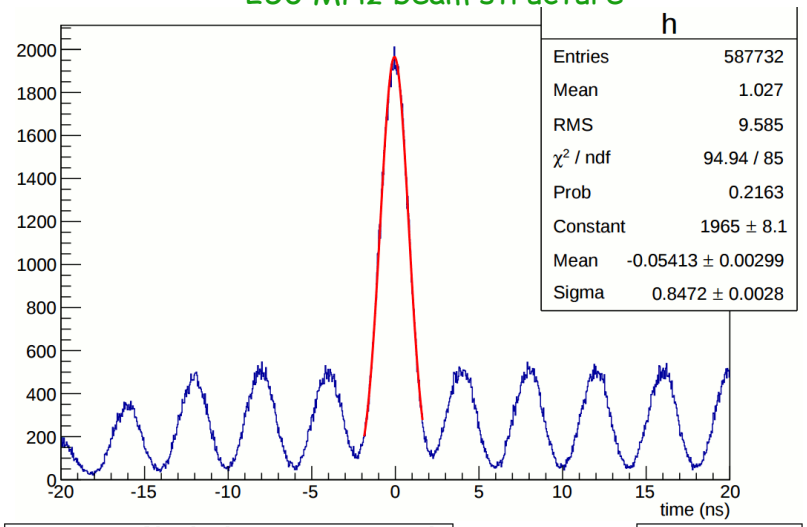


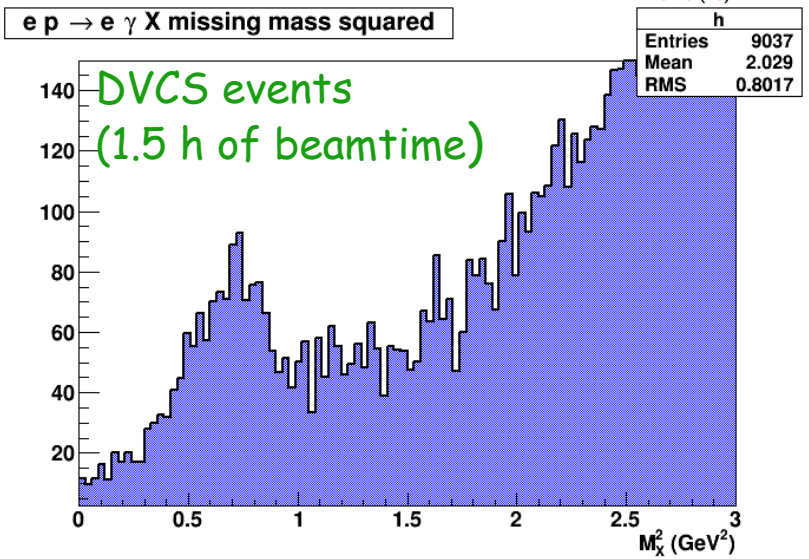
LED annealing

E12-06-114 DVCS/Hall A experiment at 11 GeV



Excellent coincident time resolution: 250 MHz beam structure





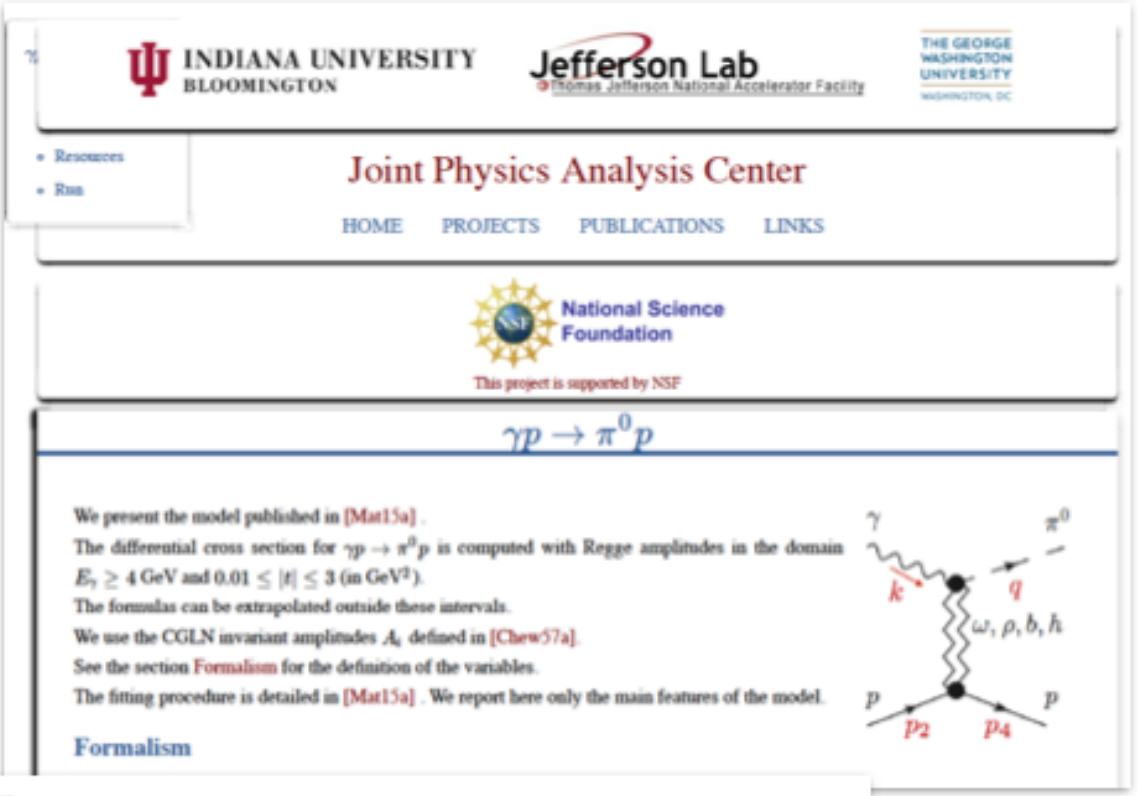
- **High impact experiment for nucleon 3D imaging program**
- High precision scaling tests of the DVCS cross section at constant x_B
- CEBAF12 will allow to explore for the first time the high x_B region
- 16% of experiment completed in 2014-2016

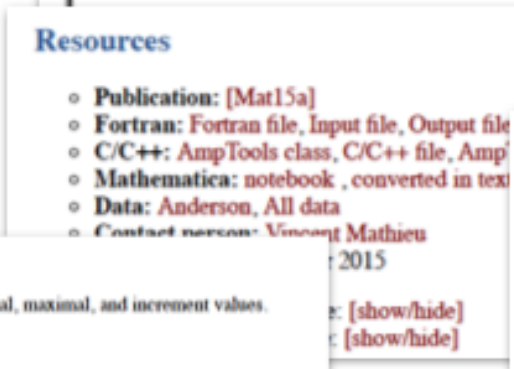
NSF funded groups: Roche/King (Ohio University), Christy (Hampton U, GMP experiment)

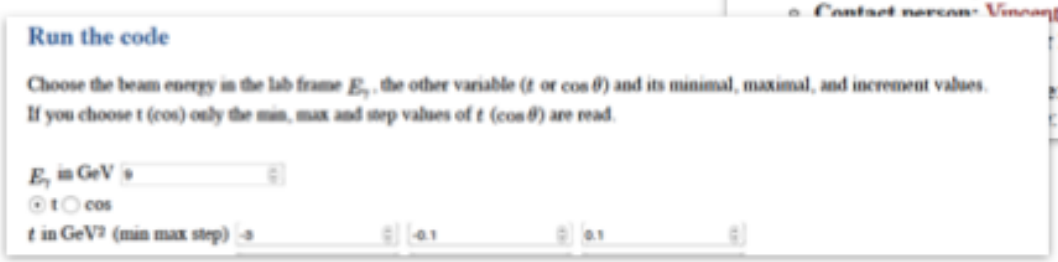
Particle Physics on the Cloud

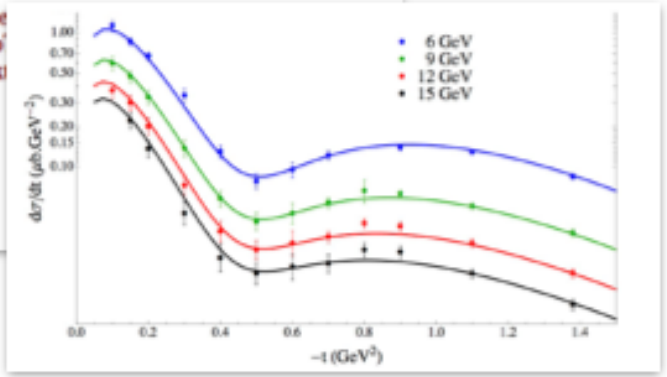
Example : π^0 photo production (eg. for GlueX/CLAS)

- Interactive portal for analysis of hadron reaction data.
- Collects both new and old theoretical reaction models.
- Includes description of individual reactions, formalism, references, theory, etc.
- Contains source codes and analysis tools. Codes run on/off-line, with variable parameters, display results on-line.
- Ready for MC and data analysis.
- List of reactions constantly updated.



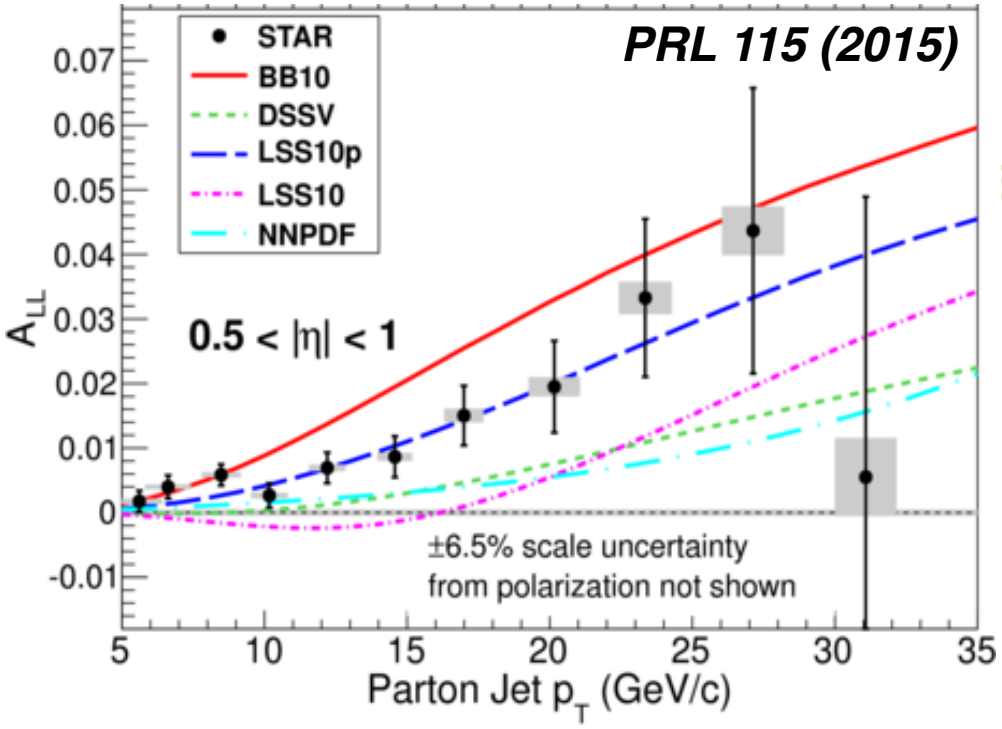


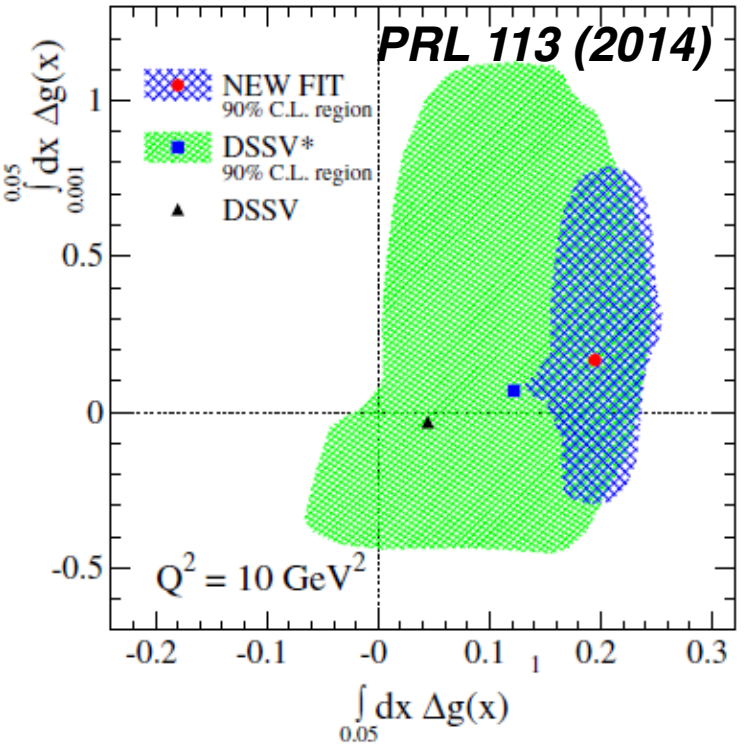




STAR results: IU site visit (S. Wissink)

Inclusive jets: Asymmetry results from 2009 data

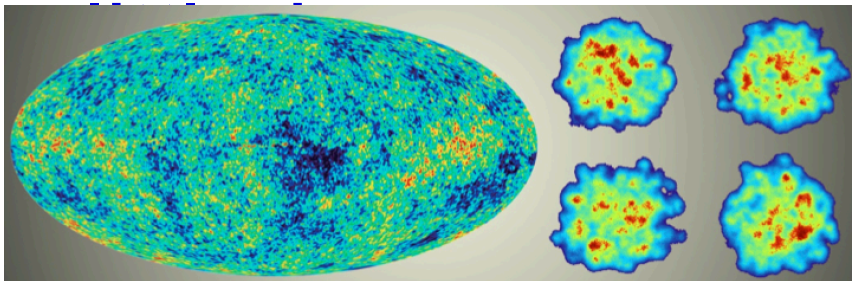




First strong evidence for non-zero gluon polarization in proton!

- Exploit greatly improved RHIC performance in luminosity, polarization
- Higher EMC trigger thresholds → increased focus on high-p_T region
- Combination of above → factor of 3-4 in stat. precision at high p_T

Image of the QGP harmonic flow

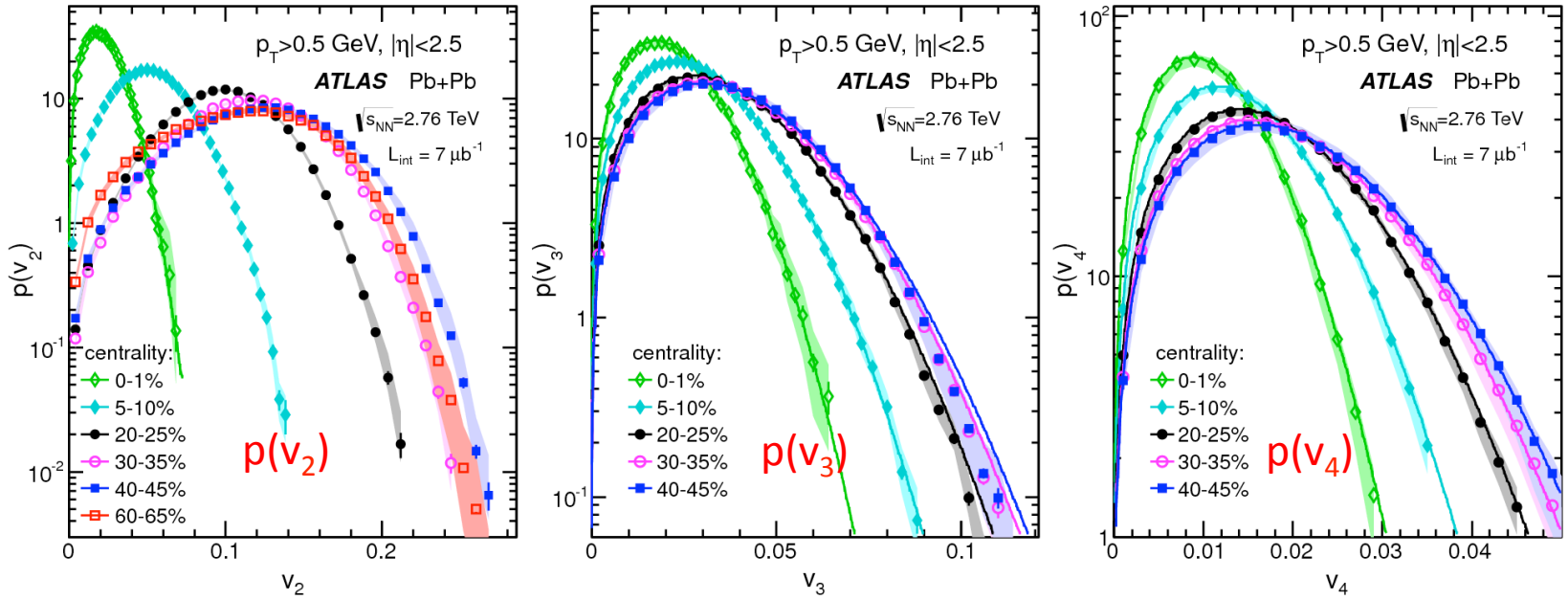


$$\frac{dN}{d\phi} \propto 1 + 2v_2 \cos 2(\phi - \Psi_2) + 2v_3 \cos 3(\phi - \Psi_3) + 2v_4 \cos 4(\phi - \Psi_4) + \ldots$$

First measurements of $p(v_n)$, $p(v_n,v_m)$, $p(\Psi_n,\Psi_m)$, $p(\Psi_n,\Psi_m,\Psi_k)$

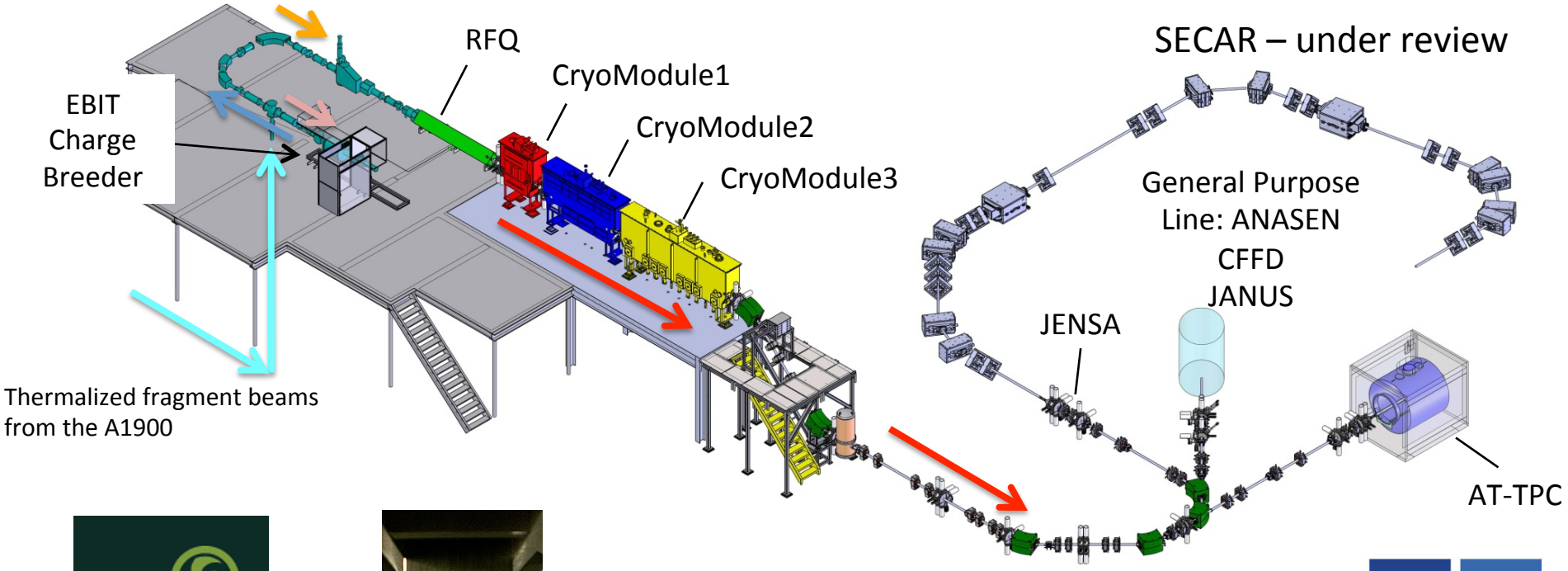
J. Jia: three papers published over 2012-2015:

JHEP11(2013)183, PRC90,024905 (2014), PRC92,034903(2015)



Re-Accelerator Facility at NSCL – Now Running!

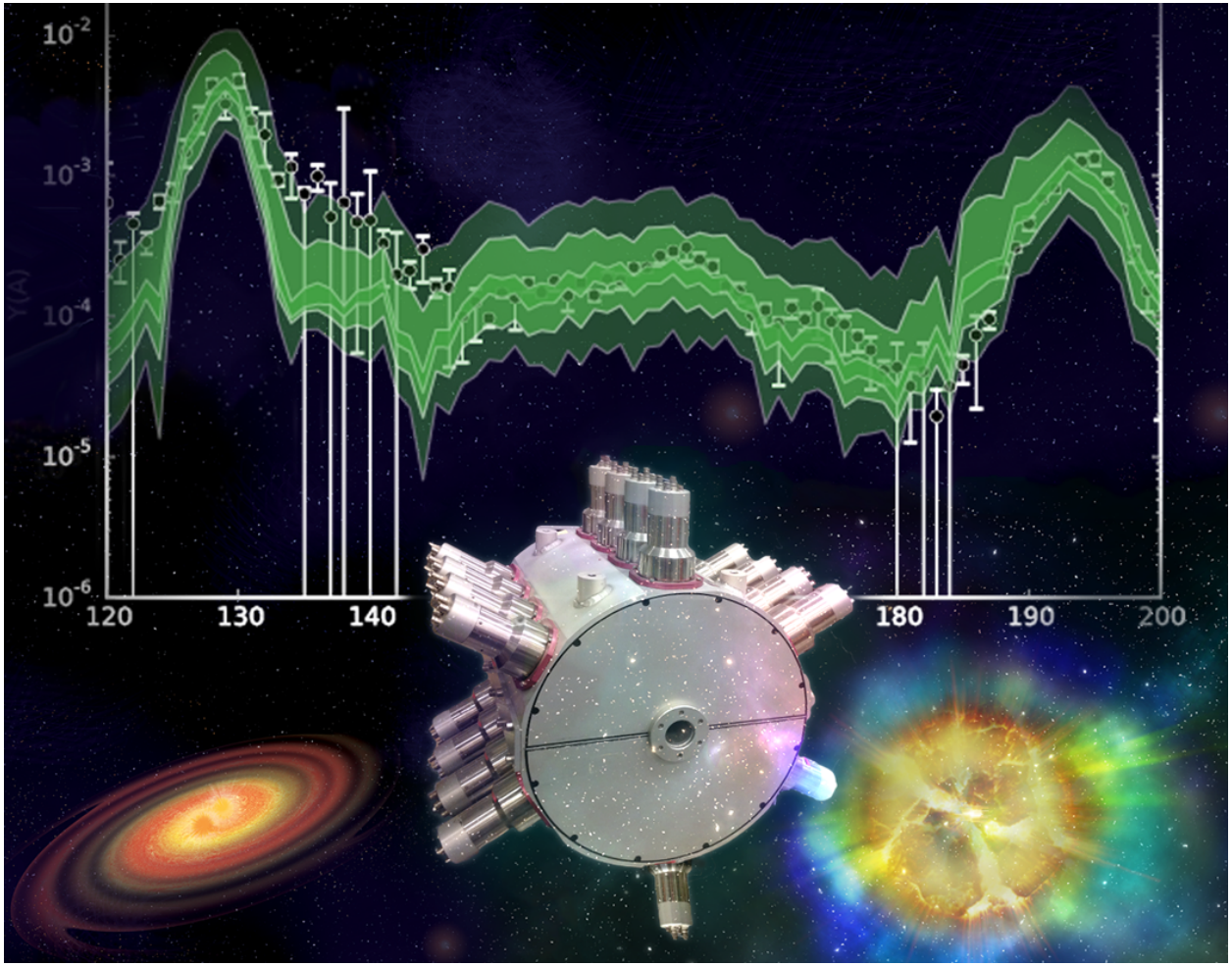
- First re-accelerator coupled to an in-flight rare isotope production facility



Nozzle of JENSA gas-jet target
(Colorado School of Mines, ORNL, JINA – funded by DOE Office of Science and NSF)

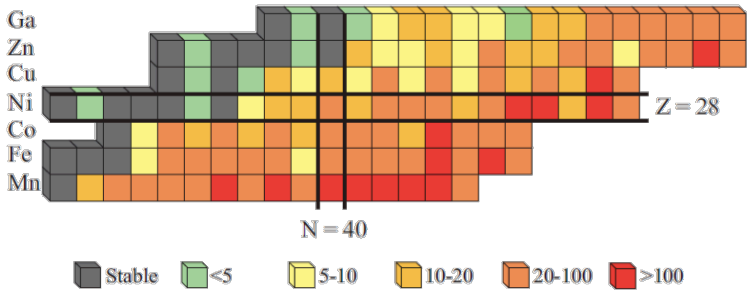
JINA–CEE

Connecting astrophysics and low-energy nuclear physics

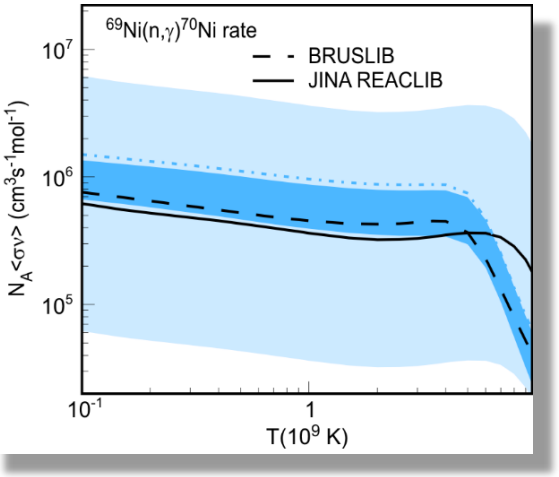


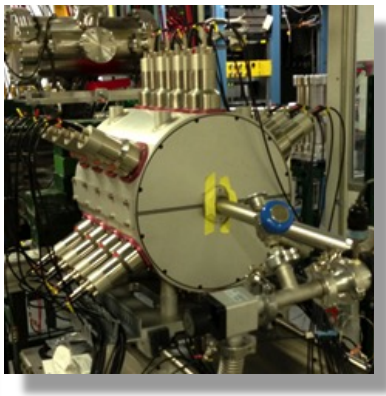
New work at NSCL probes elusive nuclear reactions key to modeling stellar explosions

- The abundance pattern resulting from stellar events encodes the underlying physics.
- Nuclear reaction rates must be known to allow r-process models to be tested against observations
- Color indicates the uncertainty of neutron-capture rates. Most key reactions are far from stability where rates are uncertain

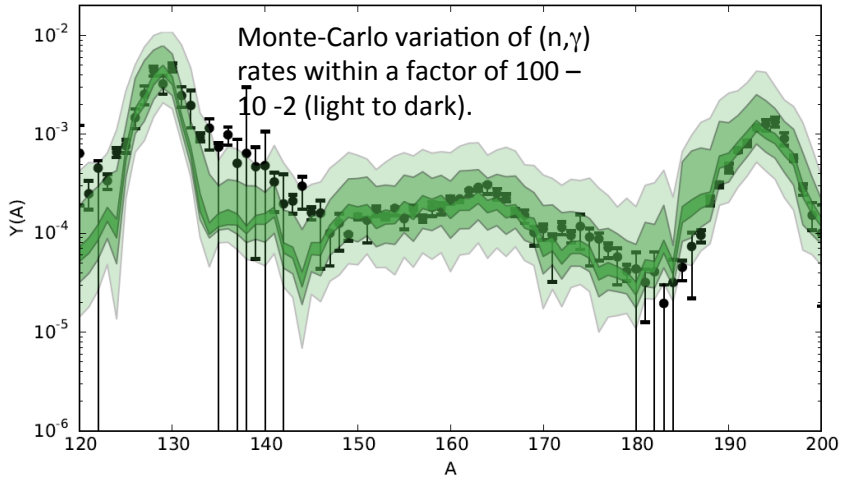


- New indirect technique using γ-ray calorimetery developed by MSU and University of Oslo using SuN detector at NSCL was applied to extract $^{69}Ni(n,\gamma)^{70}Ni$.
- Uncertainty is now approximately 2-3 (dark blue band) – achievable for rare isotopes far from stable
- Accurate rates allow model comparisons. With error of 2-3 dark green band is possible





SuN detector at NSCL



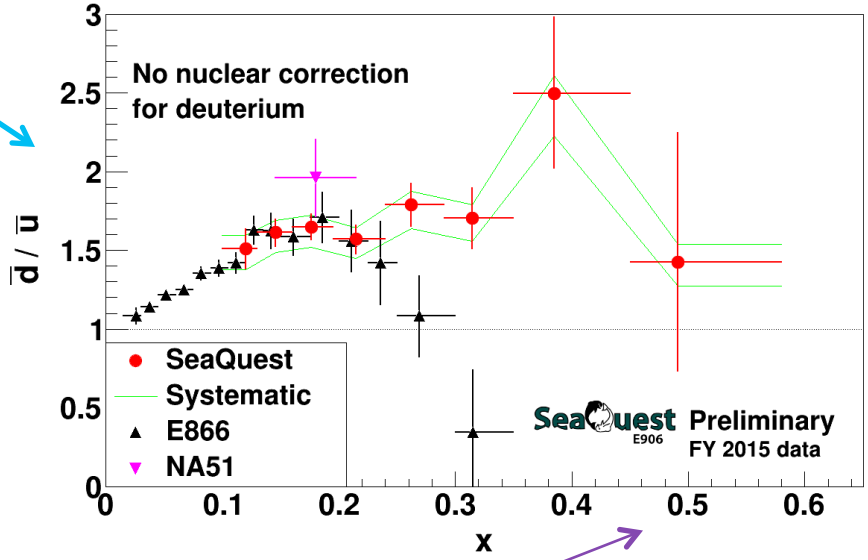
S.N. Liddick, A. Spyrou et al., Phys. Rev. Lett 116, 242502 (2016)

Physics Synopsis:
http://physics.aps.org/synopsis-for/10.1103/PhysRevLett.116.242502

E906 SeaQuest at Fermilab

- **First physics result**
  anti-quark distribution in nucleon sea

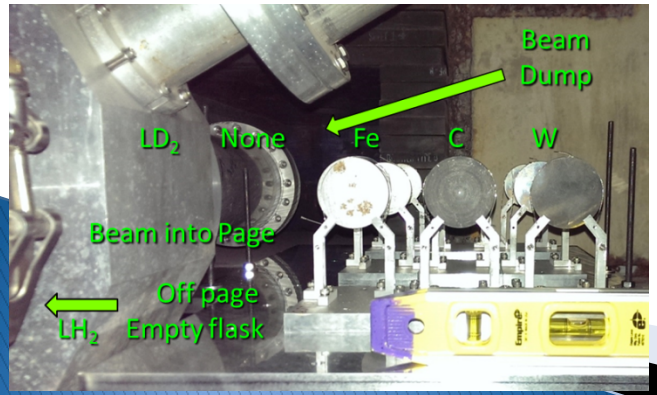
- **Physics Program**
  dbar/ubar
  Sea quark EMC effect
  Absolute Drell-Yan cross sections
  Partonic Energy Loss in cold nucl matter
  J/ψ Nuclear Dependence
  TMDS: Bohr-Mulders function
  Dark Photon search



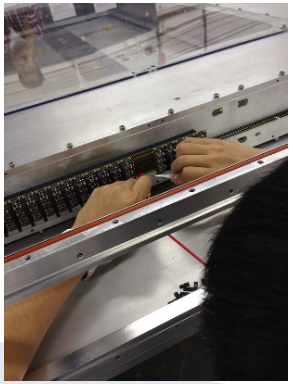
new D1 wire chamber:
access to large x

Dark Photon Search

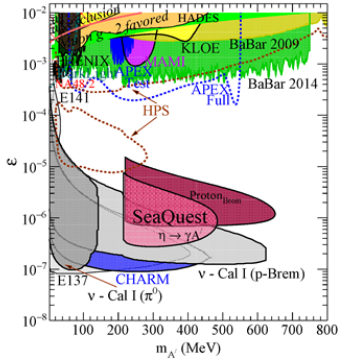
- **Main Responsibilities (LD_2 & LH_2)**
  C. Aidala & W. Lorenzon (Michigan)



E. Kinney (Colorado)



R. Gilman (Rutgers)



Announcements: New solicitation for NSF Physics Division Investigator-Initiated Research Projects 16-566

All proposals submitted to the Division of Physics programs must go through this solicitation.

- Deadlines:
  - **N*ovember 11, 2016 for Experimental Nuclear Physics & Theoretical Nuclear Physics***
  - December 1, 2016 Computational Physics
  - February 1, 2017 for Accelerator Science
- Follow Grant Proposal Guide checklist
- Other requests (conf. support, supplements, etc.)
  - Talk with us first (email or phone)
  - Submit at the same due date as above
  - Priority goes to summer schools and CEU

REU Supplements

- Available to NSF grantees to fund an undergraduate student (US citizen or permanent resident) for the summer.
  - Typically about 5 requests per year.
- Usually $5,000 (awarded as a *supplement*)
- Submit in Fastlane as a supplement to current grant. Must contact program director before submitting request – funds may not be available.

Career Awards

- Must include excellent research program as well as excellent educational plan
- There are eligibility requirements: e.g., must be assistant professor, untenured
- 5 year awards, $400,000 minimum
- Full proposal deadline: July 22, 2016 (for MPS)
- Contact program director for information/advice ahead of time (budget, scope)
- Solicitation: 15-555
- PECASE nominees are chosen from eligible CAREER winners

Major Research Instrumentation (MRI)

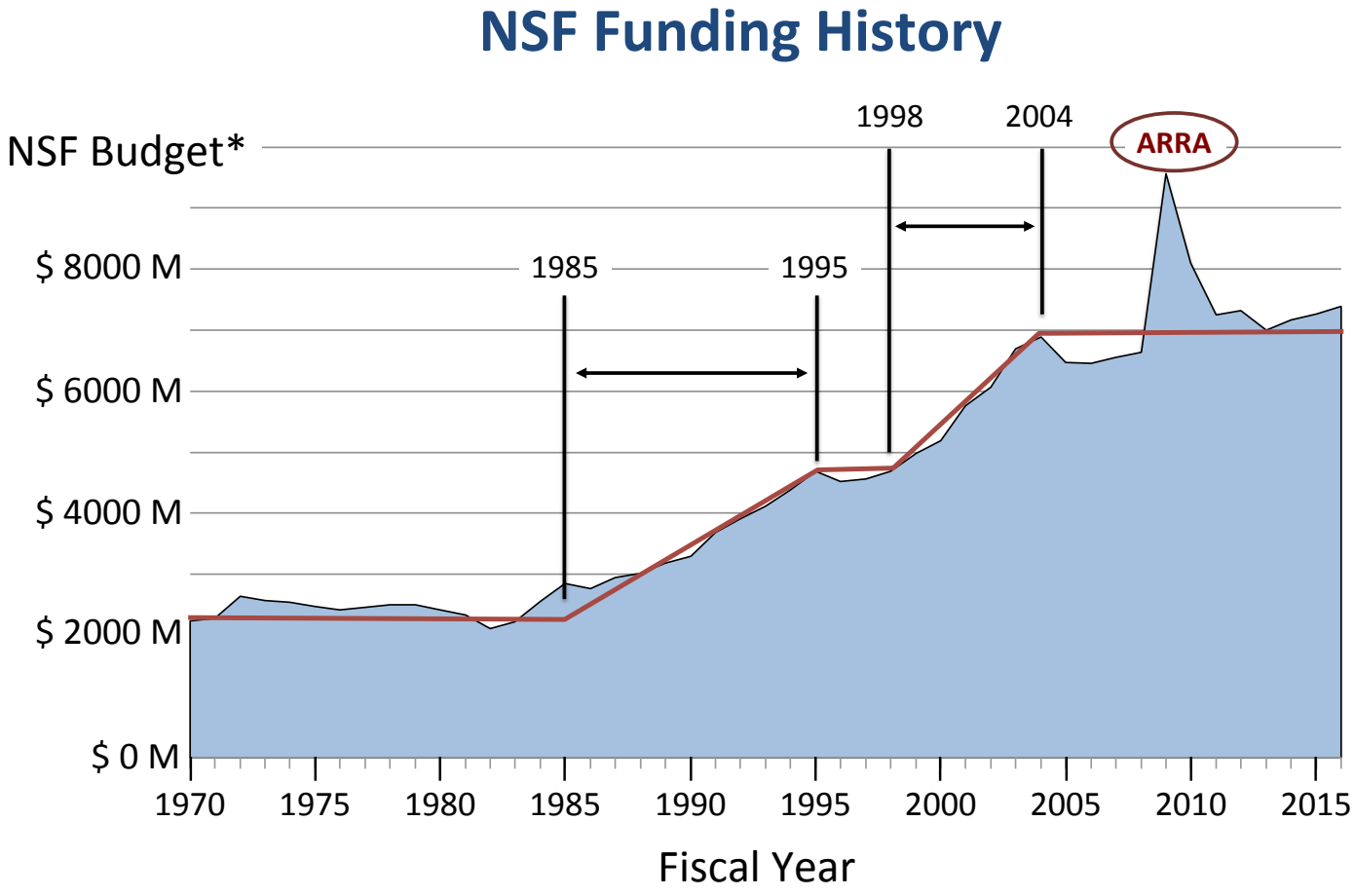
- Two types of awards: development and acquisition
- Contact program directors well ahead of submission to discuss (avoid pitfalls)
- Limited submissions from each university
- Maximum award is $4M; awards above $1M compete across the entire Foundation
- ***FY16: Physics received ~35 proposals, NP received 10 proposals***
  - Currently being reviewed; highly competitive
- Next deadline: Jan. 11, 2017

Mid-Scale Instrumentation

- The Physics Division has established a mid-scale instrumentation fund. The intention is to fund projects above $4 million (the MRI limit).
- This funding is NOT available for “operations” so program funds are used to run the experiment.
- Contact us for more information. PIs cannot apply to mid-scale directly; all proposals must go through the program. See solicitation 16-566.
- A priority of the division (and the directorate) is to increase the resources available for mid-scale.

Budget Information

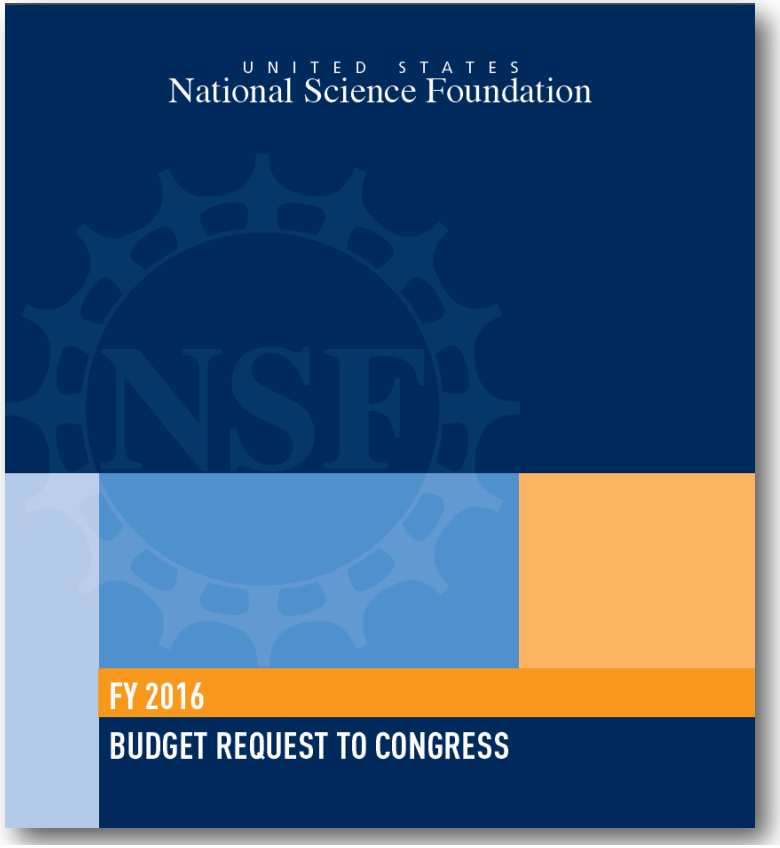
NSF overall trends



*Constant 2014$

FY16 as requested

FY 2016 Omnibus Bill

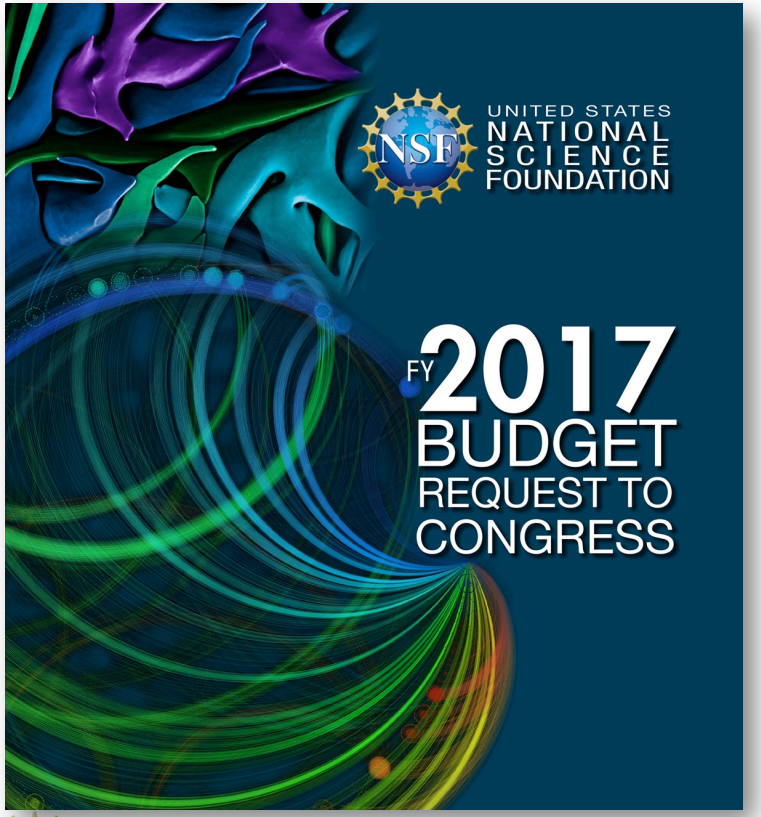


	FY 2015	FY 2016 (request)	
NSF	$ 7344 M	$ 7724 M	5.2%
R&RA	$ 5934 M	$ 6186 M	4.2%

	FY 2016 (estimate)	
NSF	$ 7463 M	1.6%
R&RA	$ 6034 M	1.7%

New FY17 request

The President's Request to Congress



	FY 2016 (Estimate)	FY 2017 (Total Request)	
NSF	$ 7463 M	$ 7964 M	6.7%
R&RA	$ 6034 M	$ 6425 M	6.5%

Two Components to R&RA

Discretionary	$ 6034 M	$ 6079 M	0.8%
Mandatory*	--	$ 346 M	--
Total	$ 6034 M	$ 6425 M	6.5%

*Direct spending (not subject to discretionary caps)
One-year duration

NSF PHY FY15 Estimate & FY16 Request

Physics (PHY) Funding

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, PHY	**$267.09**	**$274.99**	**$277.37**	**$2.38**	**0.9%**
Research	**163.82**	**176.05**	**176.19**	**0.14**	**0.1%**
CAREER	8.57	7.44	7.45	0.01	0.1%
Centers Funding (total)	0.02	0.02	-	-0.02	-
Nanoscale Science & Engineering Centers	0.02	0.02	-	-0.02	-
Education	**5.38**	**5.56**	**5.32**	**-0.24**	**-4.3%**
Infrastructure	**97.89**	**93.38**	**95.86**	**2.48**	**2.7%**
IceCube Neutrino Observatory	3.45	3.45	3.45	-	-
Large Hadron Collider (LHC)	17.37	18.00	18.00	-	-
Laser Interferometer Grav. Wave Obs. (LIGO)	36.43	39.43	39.43	-	-
National Superconducting Cyclotron Laboratory (NSCL)	22.50	23.00	24.00	-	-
Research Resources	11.56	-	-	-	N/A
Mid-scale Research Infrastructure	6.58	10.00	12.48	2.48	24.8%

Totals may not add due to rounding.

Budget Trends – NSF Nuclear Physics

~ 25% = Research
~ 75% = Operations

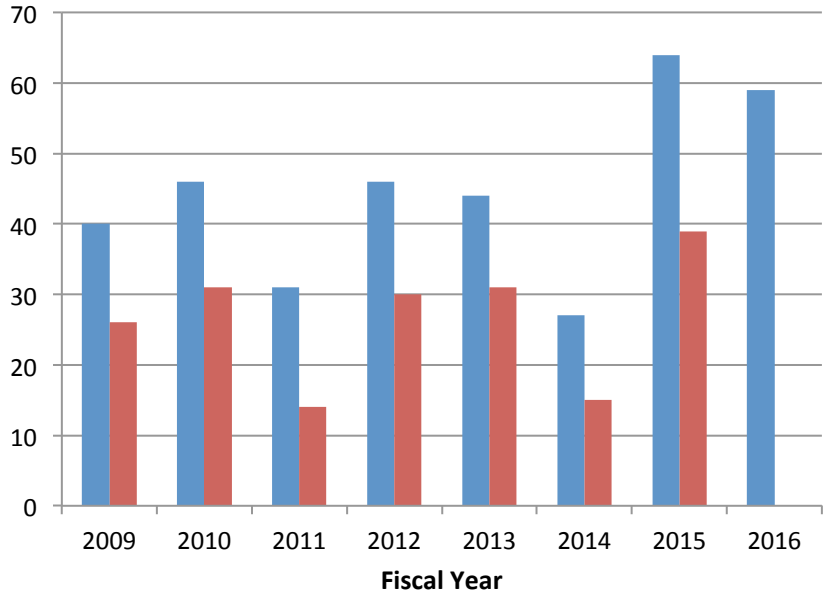
FY	Hadrons & Light Nuclei (k$)	Structure & Heavy Ions (k$)	Fund. Sym. (k$)	Nucl. Astro. (k$)	Theory (k$)	Program Total (k$)	NSCL (k$)	JINA JINA -CEE (k$)	MRI (K$)	Mid-Scale (K$)	Total Nuclear Physics (k$)
2009	7,663	4,734	5,572	N/A	5,825	23,794	22,500	2,000	8,058	9,524	65,877
2010	6,421	6,863	5,532	1,078	3,855	22,672	21,000	2,150	1,134		46,956
2011	5,349	6,485	5,336	1,994	3,719	22,883	21,500	2,150	729		47,262
2012	7,657	3,375	5,855	1,610	3,829	22,326	21,500	2,150	2,744		48,720
2013	5,218	4,259	5,304	1,754	3,474	20,008	21,500	2,150	2,996	490	47,144
2014	5,275	4,215	5,250	2,475	3,514	20,728	22,500	2,280	1,038	1,188	47,733
2015	5,941	3,722	6,818	2,245	4,183	22,908	23,000	2,280	1,801	1,367	51,357

FY15 Fundamental Symmetries: includes $1.32M for $0\nu\beta\beta$
MRI: competes each year; supplemental one-time acquisition/development funds
Mid-scale: ad hoc competition; supplemental construction funds

Experimental Nuclear Physics Program

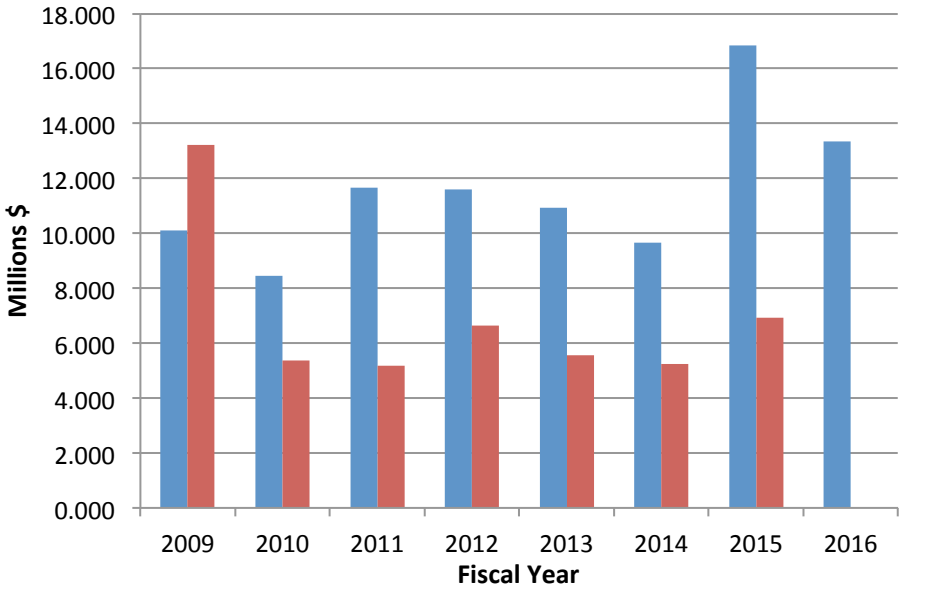
ENP Proposal Trends

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



ENP Funding Trends

New awards only



NSF/MPS/Physics Personnel

- France Cordova – Director
- Fleming Crim – Associate Director for MPS
- Denise Caldwell – Physics Division Director
- Brad Keister – Deputy Division Director
- Bogdan Mihaila – Nuclear Theory Program Director
- ~~Ken Hicks – Expt'l Nuclear Physics Program Director~~
- Allena Opper – Expt'l Nuclear Physics Program Director

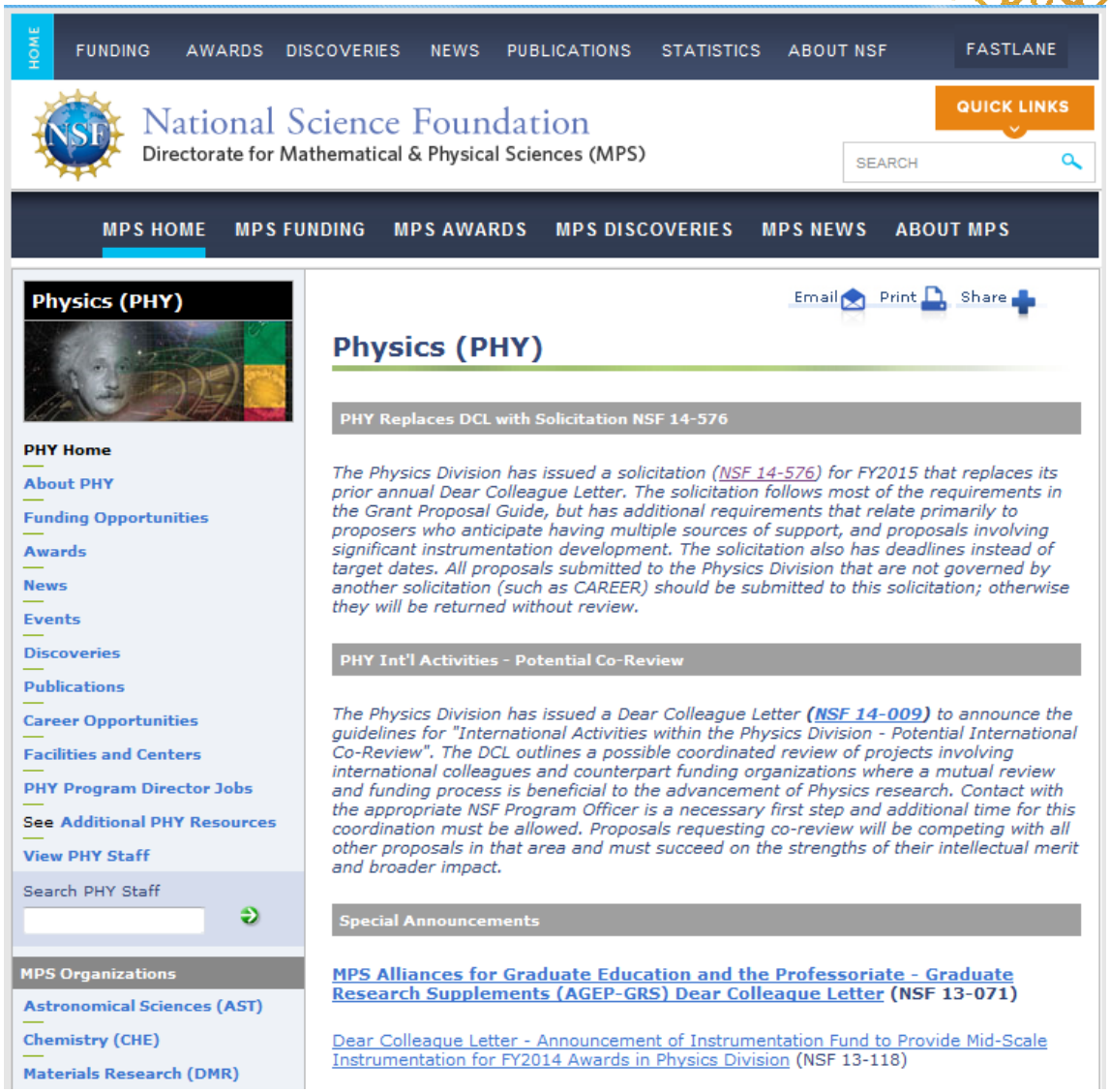
Search for a "rotator" Program Director in
Experimental Nuclear Physics nearly complete!
New person will likely start soon after September 2016
http://www.nsf.gov/pubs/2015/phy15001/phy15001.jsp?org=PHY
http://www.nsf.gov/careers/rotator/index.jsp

For the latest updates, check out

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

Contact us:

- bmihaila@nsf.gov
  or call (703)292-8235
- khicks@nsf.gov
  or call (703)292-8095
- aopper@nsf.gov
  or call (703)292-8958



Backup Slides

Tips on how NOT to get funded

- Who needs broader impacts??
  - Referees never pay any attention to this, right? RWR
- What is a postdoc mentoring plan?
  - My postdoc doesn't listen to my advice anyhow… RWR
- Cram as much as possible into the text.
  - The longer I make it, the more reviewers love it!
- Don't put your work in context.
  - I don't care what the PAC says, my research is brilliant.
- Don't proofread or spell check your text.
  - Any respectable reviewer doesn't care about grammar…

Accelerator Science

- The Physics Division program in Accelerator Science has significant interest from NP community. Over 60 proposals were received for consideration in FY15 (12 proposals in FY14)
- Next target date is February 3, 2016.
- Intended to fund accelerator science, not R&D for specific projects. Collaboration with a national lab (e.g., prototyping) is OK.

Computational Physics (CP)

- MPS, ENG, and OCI have established a cross-directorate program in Computational and Data-Enabled Science and Engineering (CDS&E: PD 15-7244).
- In Physics this program is implemented in the Computational Physics program under the PHY Solicitation. It focuses on cyber-infrastructure for the disciplines supported by the Physics Division.
  - » Deadline = December 1, 2016
  - » Bogdan Mihaila bmihaila@nsf.gov

NSF FY16 Request Summary

National Science Foundation
Summary Table
FY 2016 Request to Congress
(Dollars in Millions)

NSF by Account	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	FY 2016 Request over: FY 2014 Actual Amount	FY 2014 Actual Percent	FY 2015 Estimate Amount	FY 2015 Estimate Percent
BIO	$720.84	$731.03	$747.92	$27.08	3.8%	$16.89	2.3%
CISE	892.60	921.73	954.41	61.81	6.9%	32.68	3.5%
ENG	833.12	892.31	949.22	116.10	13.9%	56.91	6.4%
Eng Programs	*673.13*	*715.20*	*754.86*	*81.73*	*12.1%*	*39.66*	*5.5%*
SBIR/STTR	*159.99*	*177.11*	*194.36*	*34.37*	*21.5%*	*17.25*	*9.7%*
GEO	1,321.32	1,304.39	1,365.41	44.09	3.3%	61.02	4.7%
MPS	1,267.86	1,336.72	1,366.23	98.37	7.8%	29.51	2.2%
SBE	256.84	272.20	291.46	34.62	13.5%	19.26	7.1%
OISE[1]	48.31	48.52	51.02	2.71	5.6%	2.50	5.2%
IA[1]	433.12	425.34	459.15	26.03	6.0%	33.81	7.9%
U.S. Arctic Research Commission	1.30	1.41	1.48	0.18	13.5%	0.07	5.0%
Research & Related Activities	**$5,775.32**	**$5,933.65**	**$6,186.30**	**$410.98**	**7.1%**	**$252.66**	**4.3%**
Education & Human Resources	**$832.02**	**$866.00**	**$962.57**	**$130.55**	**15.7%**	**$96.57**	**11.2%**
Major Research Equipment and Facilities Construction	**$200.00**	**$200.76**	**$200.31**	**$0.31**	**0.2%**	**-$0.45**	**-0.2%**
Agency Operations and Award Management	**$305.95**	**$325.00**	**$354.84**	**$48.89**	**16.0%**	**$29.84**	**9.2%**
National Science Board	**$4.25**	**$4.37**	**$4.37**	**$0.12**	**2.8%**	**-**	**-**
Office of Inspector General	**$13.84**	**$14.43**	**$15.16**	**$1.32**	**9.5%**	**$0.73**	**5.1%**
Total, NSF	**$7,131.39**	**$7,344.21**	**$7,723.55**	**$592.16**	**8.3%**	**$379.34**	**5.2%**

Totals may not add due to rounding.

[1] This table reflects the realignment, expected in FY 2015, of the Office of International Science and Engineering (OISE) and Integrative Activities (IA) as separate budget activities. All data are presented in the FY 2015 structure for comparability.