# Comments on
## *Opportunities in Nuclear Science: A Long-Range Plan for the Next Decade April 2002 DOE/NSF Nuclear Science Advisory Committee (NSAC)*

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## 1 General Comments

**Page 1:**

> "Increase support for facility operations—especially our unique new facilities, RHIC, CEBAF and NSCL—which will greatly enhance the impact of the nation's nuclear science program."

*This statement is Priority 1, Bullet 1. The term 'especially' emphasizes the major nuclear physics research facilities, but this does not preclude support for other programs that impact the nation's nuclear science program.*

**Page 3:**

> "the development of QCD...has provided the theoretical foundation for understanding nuclear phenomena and is now central to much of contemporary nuclear research."

*QCD physics is really what the ESA spin structure function program and the real photon program are about.*

**Page 4:**

> "What is the structure of the nucleon?"

*This question is addressed in E161 by a measurement of the polarized gluon distribution, and in E159 by a measurement of the spin response of neutron and proton to high energy photoabsorption*

> "What is the structure of nucleonic matter?"

*This question is addressed in E160 by a measurement of charmonium interactions with nuclear matter.*

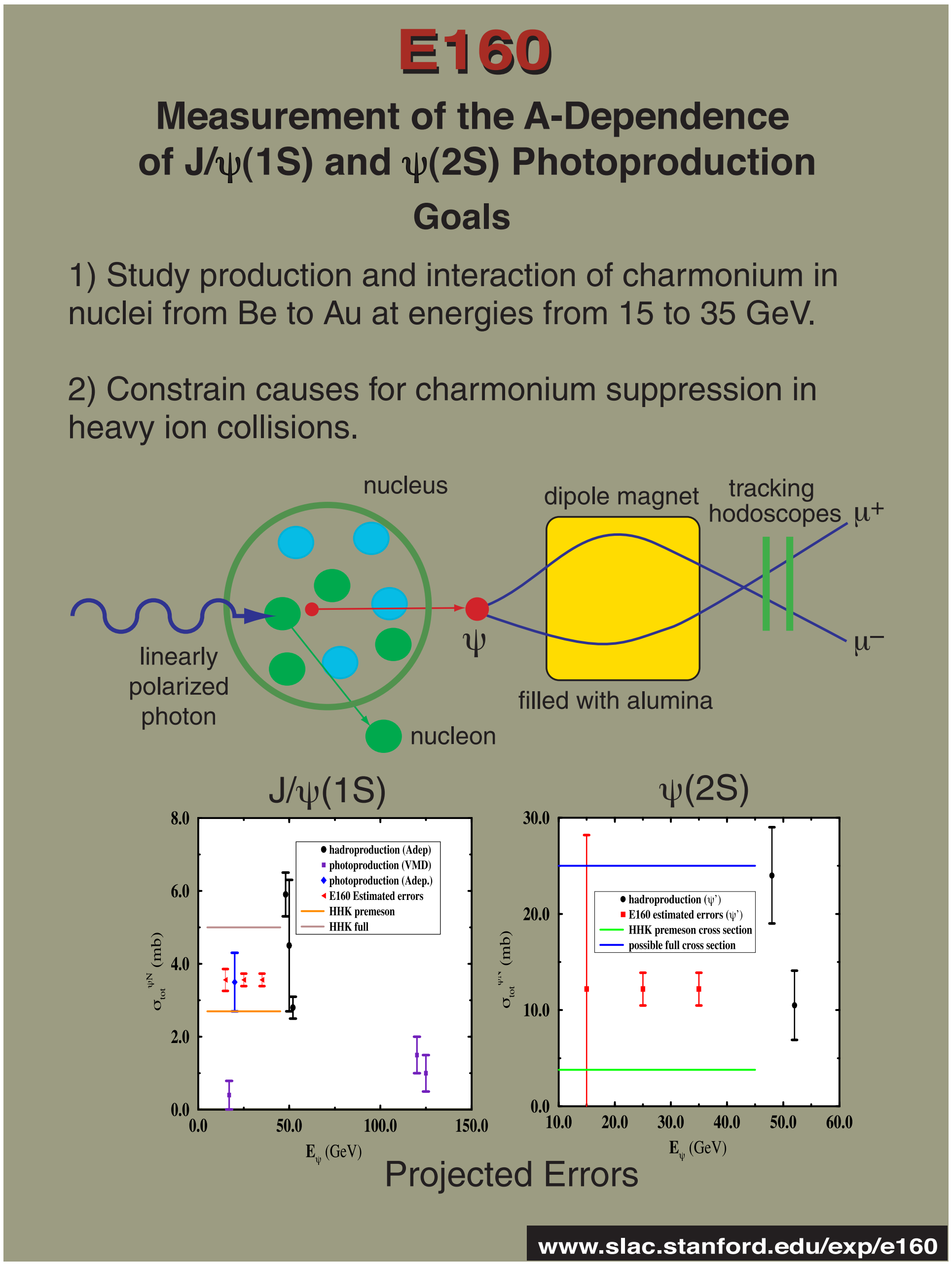


Figure 1: Summary of the E160 experiment.

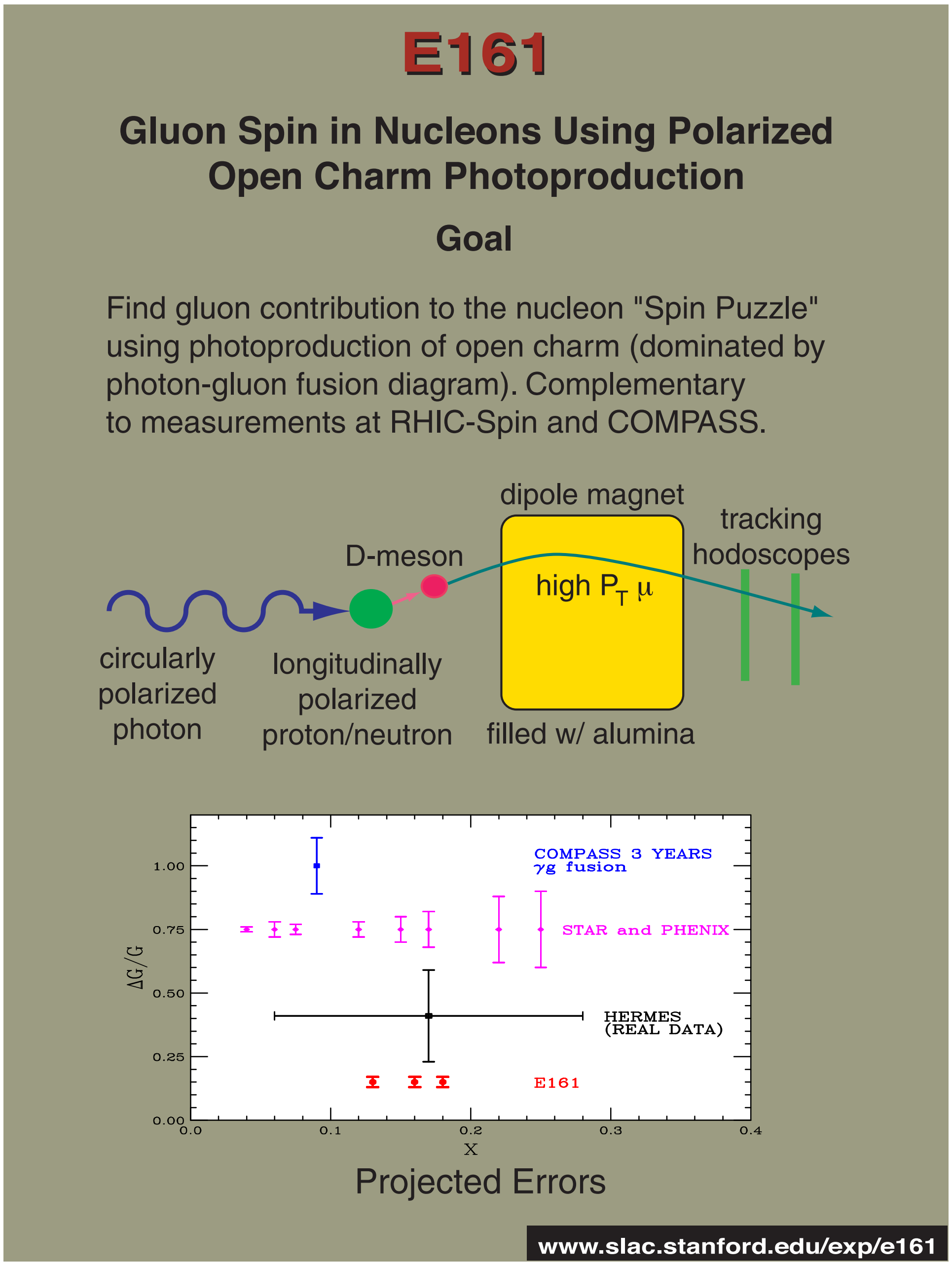


Figure 2: Summary of the E161 experiment.

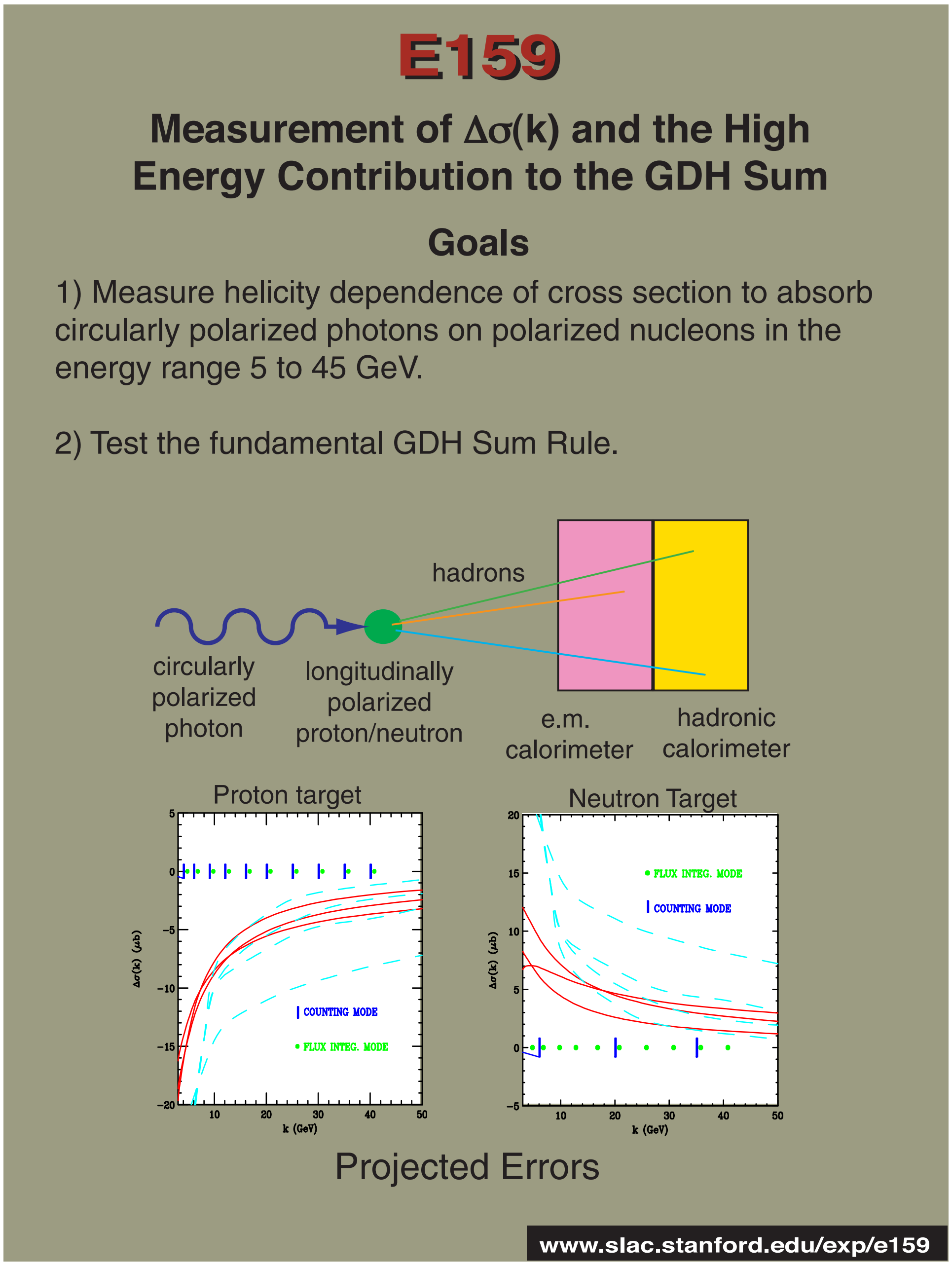


Figure 3: Summary of the E159 experiment.

"What are the properties of hot nuclear matter?"

*This question is indirectly addressed in E160 which provides the baseline for charmonium production and propagation in cold nuclear matter.*

*Clearly, the SLAC Real Photon Program impacts 3 of the 5 questions that drive nuclear science.*

**Page 4:**

"The importance of gluons has been emphasized by their rapidly growing density as the proton is probed with higher resolving power, and by the fact that quark spins alone account for only a fraction of the nucleon's overall spin."

*SLAC ESA figures prominently in one of 5 recent accomplishments.*

**Page 6:**

"Perhaps the most visible result of previous plans has been the construction of two major new facilities that remain unique in the world [Jlab and RHIC]".

*Although these are arguably the most visible, they are not the only results of previous plans, nor should they be for this one.*

**Page 7:**

"Investment in new facilities is equally important. Scientific goals continually change as we obtain new results and as new opportunities arise. If resources were directed toward operating our present facilities to the exclusion of pursuing new directions, our field would quickly stagnate."

**Page 9:**

"Even under the tightest budget constraints, a fraction of the nuclear physics budget must be set aside to provide the flexibility to fund smaller new initiatives."

*The SLAC real photon experiments were only just getting approved at the time of the deliberations for this long-range plan. As a consequence, they were not fully incorporated into the document.*

**Page 15:**

"A complete understanding of the fundamental structure of matter will require continued experiments over a broad range of energies and the continued development of new devices and capabilities."

**Page 15:**

"For the future, important new devices and capabilities are under development, including...intense polarized photon beams"

*In this section on 'A View to the Future' SLAC isn't mentioned, although this is exactly what the Real Photon Beam Line provides.*

**Page 15:**

> "The high-energy hard-scattering data [E142, E143, E154, E155, as well as CERN and HERMES] have shown that strange quarks and antiquarks ($s\bar{s}$) also play a role inside the nucleon, in particular by contributing to the spin of the proton and neutron."

**Page 17:**

> "A detailed mapping of the quark and gluon constituents of the nucleon has been undertaken through hard scattering of electron, muon, or neutrino beams from protons or neutrons within light nuclei."

**Page 20:**

*Figure 2.5 shows the world data on $g_1$, with SLAC providing the defining data in 4 experiments.*

**Page 21:**

> "Experiments planned at CERN, SLAC, and RHIC aim to determine the gluon contribution to the proton's spin...SLAC will study the photon-gluon fusion process with real photons."

*Figure 2.6 shows expected data on gluon polarization. Although the figure does not show SLAC expected errors, the text does mention SLAC.*

**Page 25:**

*Figure 2.10 shows SLAC ESA data for the deuteron form factors, together with more recent JLab data, motivated by the SLAC work.*

**Page 52:**

> "$J/\psi$ suppression is another well-known proposed signature of deconfinement. RHIC will be able to measure $J/\psi$ production in both the muon and electron channels. One of the crucial measurements that must accompany the measurement of the $J/\psi$ is that of open charm production...The $J/\psi$ is but one of the vector mesons in the charm family. The excited states of the $J/\psi$, as well as the upsilon family (bound states of the $b\bar{b}$), should exhibit some degree of suppression...each of these should melt at a different temperature."

*Understanding the dynamics of $J/\psi$ and $\psi'$ propagation through nuclei by E160 is a prerequisite for this.*

**Page 53:**

"The behavior of QCD at the high-energy frontier is not yet understood theoretically. The simplest and most fundamental questions are still unanswered: Why do hadron cross sections rise at high energies? How are particles produced? What is the wave function of a high-energy hadron?"

*These are all questions that E160 addresses.*

**Page 53:**

"Nuclear shadowing is another important process in understanding the initial stages of RHIC collisions...If the gluon and quark densities can saturate, this will affect the gluon distribution deep inside a heavy nucleus, as well as the dynamics of the early stage of a heavy-ion collision."

*Again, this is something that has been studied with deep-inelastic scattering and photon reactions on nuclei for quite some time at high-energy physics labs. E160 can shed light on the nuclear gluon distributions by the A-dependence of photoproduction on nuclei.*

**Page 53:**

"Gluon fusion processes dominate the production of charm and bottom quarks at energies attainable at RHIC."

*This is similar to the photoproduction of charm in E160.*

**Page 89:**

"The End Station A facility (ESA) at SLAC has carried out fixed-target electron-scattering experiments for more than 30 years. ESA operates with electron energies in the range 15-48 GeV, with between $1 \times 10^9$ and $5 \times 10^{11}$ electrons per pulse and 120 pulses per second. It remains a unique facility for probing QCD in the nucleon, especially when high beam polarization, coupled with a beam energy greater than 15 GeV, is needed. Experiments at ESA have produced some of the world's most precise data on the structure of the nucleon. The E158 experiment, which is now under way, will make the world's most precise measurement of the electroweak mixing angle at low $Q^2$ (see pages 74-75) via parity-violating Moller scattering. Upon completion of E158, a new program of polarized photon experiments will be commissioned that will study novel aspects of nuclei and nucleons that can only be probed with high-energy polarized photon beams."

*SLAC ESA is mentioned here under the caption 'Other Facilities'.*

**Page 107:**

"It is no exaggeration to say that the connections among these several facets of modern physics [particle physics, astrophysics and condensed-matter physics] are so strong that these fields most progress together. All of them are necessary if we are to obtain a complete picture of the role of the strong interaction in the universe."

"The study of the partonic structure of hadrons began with particle physics experiments at SLAC in the late 1960's. Recent studies of the partonic spin structure of the proton, carried out at CERN, SLAC, and DESY, and of the quark and antiquark sea, through muon-pair production at Fermilab, have been key experiments at high-energy laboratories, with much of the intellectual leadership and research effort provided by nuclear physicists...An outstanding fundamental issue will be addressed by new experiments focused on the gluonic contribution to the proton's spin, which began at RHIC in 2001. Finally, experiments are planned that would study elastic and diffractive scattering at RHIC with polarized protons: These experiments are likely to shed new light on the nature of the pomeron.

*E160 will study the pomeron via elastic $J/\psi$ production, and E161 will study the gluon distribution.*

**Page 121:**

"Investment in the future is equally important. Scientific goals change as new results are obtained, and the capabilities of our facilities must evolve to meet these new challenges if we are to ensure the continued vitality of the field. And finally, balance across the program comes into play because we wish to lay out a coordinated framework that will make progress possible in several subfields of nuclear science. While our community is fortunate to have two major new facilities, it should be remembered that a significant number of the scientific questions we wish to answer will not be addressed at either of them. Substantial progress in other subfields will rely on the funding of new initiatives."

**Page 122:**

*SLAC and FNAL are not mentioned in facility support because they are not considered nuclear physics labs.*

**Page 131:**

"The continuing vitality of nuclear science demands a constant flow of new ideas, both theoretical and experimental. Among such ideas are proposals tied to new facilities, new instrumentation, and significant upgrades to existing experiments. Even under the tightest budget constraints, a fraction of the nuclear physics budget must be set aside to provide the flexibility to pursue new initiatives.

**Page 140:**

*Current total funding for nuclear science (Figure 6.4) in 2002 is about \$400M. The ESA program costs the equivalent of only about a half percent of the nuclear science budget. Of the 10 figures in "Protons and Neutrons: Structure and Interactions", 2 have actual ESA data and one should have E161 error bars on it. The ESA program as noted by quotes above, has more than its share of significant results, all for a relatively tiny sum.*

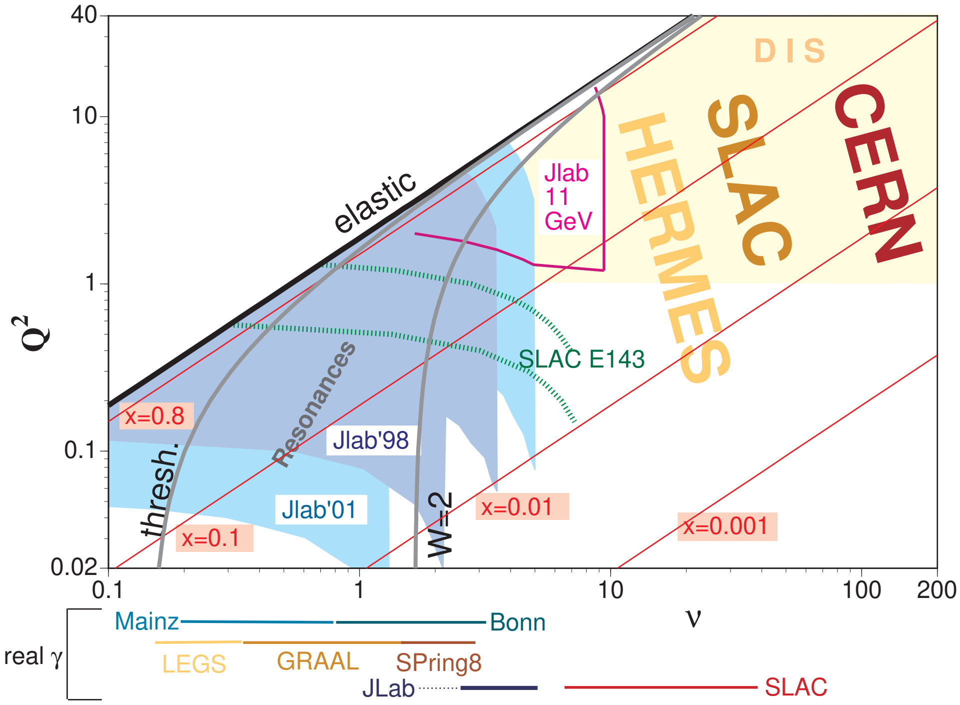


Figure 4: World kinematics for doubly-polarized lepton scattering and photoabsorption experiments on the nucleon. E159 at SLAC covers a wide range of real photon energies not accessible by any other labs in the world. These data are essential to determine the Gerasimov-Drell-Hearn sum.