I. Introduction

A. Perspectives

We start from two different but complementary perspectives.

1. One is that of the University of Chicago (UofC). From this perspective, our long-term goal is building a center, the Center for the Presentation of Science (CPS), which will bring together graduate students and faculty from the University of Chicago to work and cooperate with nearby science museums and their scientific and technical staff. We hope to teach graduate students about public outreach and education. We shall bring the results of NSF-supported science to the museums and help them present this material. In bringing this CPS program together, we intend to provide an environment in which MPS scientists and their students can gain experience in presenting their research results, and also the basic stuff of their sciences, to a broad public.

2. The other perspective is that of the SciTech Hands-On Museum. We are a small science museum in Aurora, Illinois close to the Fermi National Accelerator Laboratory, the Argonne National Laboratory, and many technology-based industries. Our main activity is the presentation of science to an enthusiastic audience, mostly younger students and their parents. We are also a major regional, national and international center of exhibit-building for smaller science museums.

As a result of this program SciTech Hands On Museum hopes to:

a) build a working collaboration with talented interns and research scientists from the UofC and other institutions
b) implement exhibits that highlight current cutting edge research at UofC and elsewhere
c) develop educational programs that bring to the public current research
d) improve and expand SciTech's existing exhibits, labels, web pages
e) design and implement Virtual Reality environments highlighting current UofC research
e) train UofC graduate students about the presentation of science research to a broad audience, especially in and around science museums.

Both the UofC and SciTech are interested in the formation of a network of scientists and professionals who are knowledgeable both about science and about the presentation of science for a museum environment.

3. Time of Opportunity. There is a time of opportunity for building a program like this. The public looks to science museums as one of its major sources of information about science.[1] The number of museums continues to grow.[2] Science museums have considerable unmet need for good displays and other material, and are looking outward for help.

Students in the physical sciences are looking for new professional outlets for their talent. One of the PIs (LPK) has many years of experience helping Ph.D. students find careers outside the boundaries of the usual scientific professional disciplines.[3] At the same time, Museums and Planetaria are looking for new kinds of professionals who can help them build enthusiastic audiences.[4]

These opportunities are nationwide. But more specifically, the University of Chicago is ready for new directions in graduate education. In the last five years, the U of C put together several very successful Masters programs. The two most relevant for this

proposal are those in computer sciences[5] and social sciences.[6] The students in these programs, who often come back to school after successful years of working in industry or the public sector, have the right skills to complement those of the graduate students in the sciences. The latter provide a knowledge of up-to-date science. The social scientists provide experience in program evaluation, understanding the needs of non-scientific audiences, and in presentation technique, while the computer scientists provide specific skills sorely needed in present-day museums.

B. Long Term Goals

In building the Center for the Presentation of Science, the UofC is expressing its long-term interest in a program in which students from several different disciplines would collaborate and learn together. SciTech is interested in partnering in such programs. Below, we explain how we intend to meet our goals building a SciTech-UofC collaboration over the next three and one half years. The advantage of SciTech is that it is small and sophisticated with exhibits and floor space that are interesting, but not outrageously expensive. The advantage of Chicago is that is has world-class science and graduate students, along with the flexibility which makes interdisciplinary collaborations feasible. Of course, in the longer run, both the UofC and SciTech will seize upon whatever works right in our pilot effort and apply this to other groups of students, other exhibits, other collaborations, and other projects.

C. Goals of This Proposal

SciTech and the UofC propose a joint venture to develop techniques and forms of interaction specifically related to the exhibits on the floor at SciTech and in some measure focused upon computer techniques, which might work in this context.

The effort under this proposal would bring together

* Ph.D. students in the physical sciences with
* Masters and Ph.D. students in the Computational Sciences and
* Masters and Ph.D. students in the Social Sciences

to work intensively at the UofC and at SciTech. (In the longer run, we hope to involve students in the biological and medical sciences as well.)

The PI's include faculty from all these areas and a museum professional with a background in physics research. A board of scientific advisers drawn from MPS researchers at the UofC will provide additional input about the substantive science that should be shown at SciTech. Everyone involved will have to build their collaborative techniques and skills to bring the science into a form appropriate for its audience.

We shall employ two innovative models for our teaching/learning environments. One is a seminar-classroom environment including an interdisciplinary group of students and an equally interdisciplinary team of teachers. The other is model borrowed from the New Products Laboratory in our business school and MRSEC in which a small interdisciplinary team is sent our to do problem solving "on-site", under the direction of a professional/academic coach. In our case, the team would develop and implement programs and exhibits for SciTech and the coaching would likely be shared among the outreach directors for our multi-investigator laboratories.

D. Present Activities

We have begun to develop pieces of this program using our present resources. In the last year the UofC has assembled a team of students and faculty and begun the process of testing out the program. At the same time SciTech has formulated its programmatic goals and has assembled the resources it needs to make effective use of the UofC. So the last six months and the next five are a first trial run for the proposed NSF program.

II. Background

A. The Sponsoring Scientific Centers

1. SciTech. SciTech's mission[7] is to engage people in experiencing and learning science and technology in a fun and interactive way. In support of this mission the museum has established the following goals:

* To enhance the public understanding of science and demonstrate its relevance in everyday life.
* To make technology and science concepts accessible and exciting through exploration and discovery.
* To reach out to the populations that are under-represented in technology and science careers.
* To inspire young people to develop their talents in the fields of technology and science.
* To develop innovative exhibits and programs for a diverse population via local, national and international collaborations.
* To develop Centers of Excellence based on forefront topics. Topics for Excellence Centers include: Information Technology (Communications), Energy and Environment, Outdoor Science,[8,9] Young Discovery.

SciTech was established in 1988 by scientists from Fermi and Argonne National Accelerator Laboratories. An active corps of volunteers from the research facilities along the Illinois Research and Development Corridor was formed to create hands-on exhibits, giving students and adults direct experience with scientific exploration. An extensive exhibition plan was developed starting with physics, and adding biology and chemistry. Less than one third of SciTech's exhibits were purchased; the rest were built in-house by volunteers, SciTech Club for Girls and full-time exhibit developers. Of those, many are totally original, and the rest incorporate new technologies.

Through a collaboration with the Electronics Visualization Laboratory of the University of Illinois at Chicago, SciTech has implemented a room- sized Virtual Reality theater environment[10]. The immersive 3-D VR experience is operated by staff and visitors using a joystick. The VR environment provides simulations of an Ant, a Bee, Round Earth, the Solar System, the Wright Brothers Airplane, a Human Heart and Lungs, Virtual Harlem, and CrayoLand.

SciTech's Center For Learning offers both in house and extensive outreach educational programs. The Museum In a School program takes large exhibit sets to schools for one week of educational programming. As an expansion of the Museum in A School program, SciTech leads a collaboration of nine science museums in the Midwest that together have produced sets of traveling exhibits and educational programs on Wild Weather. Each museum sends the exhibits and programs to 15 schools every year, with the support of the National Science Foundation. This collaboration has been expanded to include science museums in Alaska and Texas. In this way SciTech exhibits are shared with up to 150,000 people per year. The consortium has been invited to submit a full proposal to NSF to expand the work of the collaborators in the development of a program on space exploration for use by small and medium-sized museums in a variety of informal science education settings.

SciTech is committed to Diversity. SciTech has a program for girl (and boy) scouts to design and build exhibits. Girls have built 52 full-size exhibits that are featured in the Museum. The posted admission fee is waived by staff members on duty at the door for anyone seeking to visit the Museum, but unable to pay. We have Spanish language

materials, an educational partnership with St. Rita School, a predominately Hispanic School; and a partnership with the Hispanic Society of Professional Engineers through Lucent's ASK program. We sponsor targeted programs for East Aurora where the most financially disadvantaged children in our community live. Our student Explainer staff includes 3 African Americans, 3 Hispanics, 1 American Indian and 10 Caucasians providing a diverse group of role models.

2. MRSEC. The Chicago NSF-funded Materials Research Science and Engineering Center addresses fundamental scientific problems of technological significance. The Center houses interdisciplinary collaborations between experimentalists, theorists, and computer simulators from six departments at the University of Chicago, including Chemistry, Computer Science, Mathematics, Molecular Genetics and Cell Biology, Physics, and Radiology. These departments are all ranked in the top ten in the country. It specializes in the continuous development and improvement of equipment-intensive facilities needed for this collaborative, interdisciplinary work. The outreach[11,12] for this center is led by Dr. Eileen Sheu who is also head coach for our present SciTech grad student team.

3. CfCP. The Center for Cosmological Physics is a Physics Frontier Center of the National Science Foundation, dedicated to pursuing and facilitating world-class research at the physics/astrophysics interface. Over the past two decades some of the most important discoveries both in physics and in astronomy have come at their boundary.

There are deep and profound connections between these fields: physics beyond the standard model is critical for understanding the birth and earliest evolution of the Universe, and the Universe itself provides a unique laboratory for studying the unification of the fundamental particles and forces. Our Center is devoted to exploiting the connections between physics at the smallest scale -- interactions of the quarks and leptons -- and at the largest scale -- the constitution and birth of the cosmos itself. The Center also strives to be an exemplar for a new way of approaching interdisciplinary problems.

The outreach[13,14] for this center is led by Mr. Randall Landsberg who will in part coach our proposed grad student team.

4. **HEP.** The High Energy Physics group at the University of Chicago include members of the Department of Physics who are active in several collider-based experiments designed to probe the fundamental constituents of matter at the highest achievable energy scales. This group is mainly supported by the NSF. Faculty also work in close collaboration with researchers at Fermi National Accelerator Laboratory and Argonne National Laboratory.

5. CI. The mission of the Computation Institute is to address the most challenging problems arising in the use of strategic computation and communications across a broad spectrum of intellectual activities. The CI sponsors activity in all the different parts of the University.

B. This Year's Activity

This is the warmup to the proposed NSF-sponsored project. It is sponsored and funded by the MRSEC, CfCP, the Master of Arts Program in the Social Sciences (MAPSS), SciTech, HEP, the CI, and the Physical Sciences Division of the UofC. Since this activity is intended to be a tryout for the MPS proposed activity, we shall describe it in detail under the section of proposed research. The faculty and professional people actually

working on the program this year are the same as the proposed workers for next year. The student team will "graduate" from the program this year, so that we propose that they be replaced by a new team of workers starting next year in January.

III. Results from Prior NSF Support

A. The Materials Laboratory

The PI, Leo P. Kadanoff has been supported through the Materials Laboratory program almost since its inception. In fact, the Materials Labs provided the main support which enabled the work which was honored by the National Medal of Science in 1999. Since he was twice director of the Chicago MRSEC 1981 - 1984 and 1994 - 1997 and since this grant is one of the basic sources of the work proposed here we list it in this section. The last completed grant was MRSEC/NSF DMR-0213745 with the title, "Materials Research Science and Engineering Center." The outreach components of this grant are most relevant to the present work.[15] These include:

1. Interactions with the Museum of Science and Industry[16] (MSI). The Physical Sciences Division and the MRSEC have in place a well-established partnership with the Museum of Science and Industry (MSI), situated 1 mile from campus. An MSI Outreach Coordinator (with salary supported jointly by the museum and MRSEC) facilitates projects in exhibit development, science demonstrations of advanced materials, and museum-based inner city science education programs. A focus of the planned next stage will be the joint development (together with Dr. Barry Aprison and his staff at the MSI) of new concepts and interactive science modules for the Grainger Hall of Science (14,000 square feet) at the MSI. This work will supplement the work proposed here, but it is not a part of this proposal.

2. Museum Conference. As the first step in building the program described here, the University of Chicago put together a conference with the title, "Images and Ideas: Exhibiting Science in Museums," on June 17 and 18, 2002. The conference,[17] which took place at the Adler Planetarium, the MSI, the Field Museum and the UofC, was intended to bring together academics and museums professionals and to help them plan joint programs. It has met its purpose.

3. Programs with schools. MRSEC faculty and postdocs have for several years now participated in the Young Scholars Program for Mathematically Talented High School Students, which teaches about 120 Chicago-area students each summer. One portion of this has traditionally been devoted to teaching about MRSEC and MPS' research on complexity to high school students. In addition the MRSEC has set up a partnership with the hugely successful Seminars for Elementary Specialists and Mathematics Educators (SESAME) program which provides math and science summer courses to Chicago public school teachers.

4. The Partners in Science Program. This program links faculty, postdocs, and graduate students at MRSEC with students at the Hartigan School, a Chicago Public School (K-8) located at the Robert Taylor Homes, a public housing project. In this program we display our commitment to helping with education for all, and especially for disadvantaged groups. We expect that these experiences will help us reach out to science museums and to the students and teachers that they serve.

5. The New Products Laboratory.[18] This course, a joint effort of the MRSEC and the Chicago business school, complements respectively their strong training in basic science and business theory by providing a problem-solving experience for a small but diverse group of students. The course accelerates the process by which

students learn to manage themselves and others when developing solutions to real-world business problems. It provides students with tools for solving complex problems and detailed feedback regarding their performance as managers, team players, and problem solvers. Students who complete this course report that they learn a great deal about their abilities as professionals and find themselves better prepared to manage complex analytical problems in the workplace. Guided by a faculty coach, who is an experienced business or scientific professional, each student group is challenged to solve a client problem as an effective team. In previous years Abbott Labs, Accenture, American Airlines, Ameritrade, Bank of America, Citicorp, Clorox, Dow Chemical, Eli Lilly, Frito-Lay, Johnson & Johnson, W.W. Grainger, Kraft, Lucent Technologies, Nabisco, Snap-on Tools, and Seagrams have sponsored real-world projects. Client-sponsors report that the business insights generated by our teams are comparable to those produced by top tier consulting firms.

B. Ronen Mir

His most recent NSF support was from grant NSF ISE 9815087, Midwestern Wild Weather Project. Midwestern Wild Weather is a traveling exhibit designed to reach audiences in small, rural communities and in science centers and museums in Illinois, Iowa, Indiana, and Michigan. The project represents a strong model for collaboration between museums, science centers and the formal educational system.[19] The main publication under this grant is a teachers' manual: R. Mir et al., Midwest Wild Weather Teacher Manual, Internal Report, 2001.

IV. The Proposed Program

The UofC has already put together the CPS team. It is split into three elements: the component for this proposed MPS grant will concentrate on SciTech and the SciTech Chicago Outreach Pilot Exploration (SCOPE), another element will focus upon a collaboration with the Adler Planetarium, and a third group will focus upon art and science and will serve both collaborations.

A. Our team of Interns

1. Composition of the team. The SCOPE team of graduate students will work together for the nine months or a little longer. This team will include two first year Ph.D. students in physics, two masters students in computer science, and four members of the master of arts program in the social sciences. One more physics student will form the liaison between the SCOPE team and the other team. The physics students are participating in the program as research assistants, while they take a half-time course load. The other students will be supported within their respective graduate programs. All students will be working side by side with essentially the same work requirements. They will begin work on January 1 and continue through September 1.

This SCOPE team is in place for this quarter and is being led by Dr. Eileen Sheu, chemist and outreach director for the MRSEC (Materials Research Science and Engineering Center) who will have the further assistance of Mr. Randall H. Landsberg, Education and Outreach Director of the CfCP. This team's work will be a pilot effort for the proposed NSF project. In addition, and slightly outside the NSF effort, there are two additional groups in the process of formation. One led by Mr. Landsberg which will concentrate upon the Adler Planetarium and Museum, and another group, intended to support both projects, which has an especial interest in artistic values of the scientific displays and how they interact with their educational impact.

The team's work will be supervised and directed by the PI's.

2. Recruitment of the team. The interns will be recruited from the pools of graduate students who are available in three programs:

* First and second year graduate students in the physical sciences,
* Graduate students (especially master's students) in computer science,
* Masters students in the closely related programs in the humanities and social sciences.

So every student must first be admitted to a standard UofC program. They will be advised about the possibilities of internship in our program before admission, and for many students this will be an attractive possibility. In particular, we expect that some students will be drawn to the University of Chicago by the possibility of this internship. All the graduate programs might be able to draw broader and more capable students, who in the long run might be able to fulfill some of the needs of museums.

After the students come to Chicago, early in the Fall Quarter, the PI's will pick the students who will participate, based their applications. This year we drew two applications from the physical sciences students, eleven applications from computer science, and six from the social sciences/humanities. The PI's will pick from a pool, which we might hope to be somewhat larger than this. Their choice will be based upon academic excellence, enthusiasm for this particular kind of activity, and upon the goal of having diversity in the intern-group. We have tried hard to put together a diverse group of interns during our present pre-pilot effort. Our present working group of twelve students includes one Afro-American male and five women. We have no Hispanics in our present cohort. We are certainly not satisfied with the diversity we now have, but we feel that we have begun moving in the right direction. In succeeding years, diversity will remain an important part of our goals.

Since each student will remain in our proposed program for only one year, the proposed student group will not overlap with the present team. Nonetheless, we give here a description of some of the members of our interns' team so that the reader might judge the qualities of the students available to us:

Ivan Watkins, MAPSS student; School of the Art Institute of Chicago, BFA 1990; artist extensive experience in community based programs; many grants, e.g., Louisiana Arts Council Grant awarded to develop African American Visual Arts Curriculum for grades K-12. Artistic adviser.

Joanne George, Masters Student in Humanities, University of Chicago; Barnard College, BA, 1999 - Anthropology Art History; The Metropolitan Museum of Art, New York, NY; 6/98-5/99 Intern for the Africas, Americas, and Oceanic Department. Artistic adviser.

James Munro, Ph. D. Student in Physics, Middlebury College A.B., Physics, May 2002; NIH-SURE Research Fellow 2001,2002; Conducted research on the binding properties of bacteriophage T4 protein and optical properties of semiconductor thin films.

Xinliang Xu, Ph. D. Student in Physics, BS, Tsinghua University. Beijing, 2002, major in physics, minor in English. Work experience, 2 years work as R.A..

Catherine Warner, MAPSS Student, BA William and Mary History and Economics 1999; Docent, Smithsonian National Museum of American History, 2000-2002; Intern, Colonial Williamsberg Outdoor Museum, 1998; The Advisory Board Company, analyst, 1999-2002.

Phoebe France, MAPSS student, BA St. John's College 2000, exhibits facilitator at Brookfield Zoo's Hamill Family Play Zoo. Field Museum Volunteer, summer 2002.

Danas Bagdonas, Master's student in Computer Sciences UofC; BS Mechanical Engineer Klaipeda University, Klaipeda, Lithuania (July 2000). Web Designer, Estancia El Corcel, Clinton, WI (June 01 - June 02); Marketing Director, Marketing / Advertising Agency "Vakarietiskas stilius," Lithuania (Oct. 98 - April 01).

Gurvirender Pal Singh Tejay, Master's student in Computer Sciences UofC; University of Wisconsin-Milwaukee, Masters of Art in Economics, 2002; Bachelor of Arts in Economics, December 2000; 09/99-12/99 Institute of Survey and Policy Research, UWM, Milwaukee, Wisconsin; Student Technical Assistant; 1995 Pilot Indian Air Force.

In addition there are four more students in Computer Sciences and Social Sciences associated with the Adler team.

B. The Students' Leaders

The "faculty" are the PI's who serve also as program directors: Leo P. Kadanoff, member, National Academy of Sciences, Emeritus Professor of Physics and Mathematics, University of Chicago; Dr. Ronen Mir, Executive Director, SciTech Hands on Museum, Aurora, Illinois; Prof. Leo Irakliotis, Associate Chair, Department of Computer Sciences, University of Chicago; Prof. Morris Fred, Professor Social Sciences, University of Chicago. On the University of Chicago side, the team is led by coaches who are presently Dr. Eileen Sheu, outreach coordinator MRSEC and Mr. Randall Landsberg, outreach Director CfCP.

The SciTech team: There is a strong team in place at SciTech. The overall direction will, of course, come from Dr. Mir, but the actual project leadership will be done by Ms. Carina Eizmendi, Curator, Exhibit Design and Development. Inputs from SciTech on the academic side will come from Dr. Mir who will be a guest lecturer on the Evolution of Science Museums in the Museums course and Ms. Eizmendi who will give a guest lecture at Chicago on Interactive Exhibit Design. The selection of suitable scientific materials for exhibits will be led by Ms. Eizmendi and by Ms. Libbie Randels, the Associate Director of SciTech. Mr. Ted De Jong, Senior Exhibit Developer, will play an important role in follow up and supervision of the team during the research, development and construction of exhibits. Finally the Evaluation Process will be led by Ms. Eizmendi and Ms. Randels.

C. The Year's Activities

1. Winter Quarter. The students start work in the winter quarter. On the academic side, they begin taking a course in the Anthropology of Museums, which has been taught for seven years by Prof. Morris Fred and Prof. Raymond Fogelson of the Anthropology Department. This course is intended as an introduction to museum functioning. It includes some of the academic and semi-popular literature on science museums. As part of the course, the students will visit museums and hear about museum-functioning from curators, trustees, architects, artists, and many other kinds of people. The course reaches well beyond the science museum to many different kinds of public displays of knowledge and culture including zoos and art exhibits and many other things.

We also intend to build another course especially designed for the program, one which teaches about computers as they function in and for museums.

In parallel, the SCOPE team will form up and begin its work. During this first quarter in SCOPE, the student's efforts will be mainly devoted to looking and preparing. Under

the direction of the coach, this quarter Dr. Sheu, the team will visit museums, first SciTech and then other scientific centers like the Adler. In this quarter, the team will begin to think about museum functioning, making use of its visits and what is has learned in the museum course. SciTech people will tell the group about their problems and opportunities and the group will struggle to define the nature, purpose, and audience of SciTech. Some technical opportunities will be explored via visits to centers of computer technology for museums, e.g. Argonne National Laboratory and the University of Illinois at Chicago. The team will finish the quarter by hearing a report from the Adler team and by reporting to that other group on what it thinks it might accomplish.

2. Spring Quarter. The museum course continues in the spring quarter with all the students in that course, not just ours, visiting and studying museums and reporting back. The SCOPE students have a bit of a head start, but a harder job in that their studies are more interdisciplinary. In this quarter (and the winter quarter) all the SCOPE students will continue their regular program which will enable them to do CS or SS or Physics or Chemistry or whatever.

In this quarter, the visiting process will intensify. Now the students will begin working with the museum professionals trying to construct particular projects.[20] They will aim to construct signage and parts of displays and exhibits for SciTech. Other trips will take place, particularly to museums with analogous functions to SciTech's to "see how the other guy does it." The students, as individuals, will construct reports on a museum, probably SciTech, for their museum course. At the same time, they will be constructing a group report and proposal for their SCOPE activity and project for the next quarter.

3. Summer Quarter.
The summer will begin with an international meeting related to this proposed MPS program.

No courses for the students will occur during the summer. The students will work at constructing and perfecting their museum project. The end will be a weekend in which families come and try out the new products. As this happens, the SciTech evaluation team will use questionnaires and observations to evaluate the projects, and everyone will see how the students' projects function in the SciTech environment. This will be followed by a weeklong period of writing a report, and then a meeting of the entire SCOPE project team with SciTech staff in which success and failures are exhibited and evaluated. In the evening the students will be feted and graduated from the program. The next day there is one more staff meeting in which academics, SciTech, and advisers evaluate THEIR successes and failures and plan to write their report, and to revise the program for the next year.

D. Projects
The crucial step is of course going from theory to practice. The students will, to some extent, choose their own directions. However, we have some solid ideas about directions and projects in which we might encourage them. Most of the ideas are based in part upon the research work being performed at Chicago. Below, we describe some possible projects. But before we do projects, the students and their leaders will have to ask. Who is our audience?

1. The Audience. At the moment, most of SciTech's audience is school children who come either in school groups, with their parents, or in other groups like Boy Scouts and Girl Scouts. Our first goal is to better serve these groups of appreciative and very interactive visitors. One part of this is helping to improve what is already in

SciTech. The students should ask how SciTech's hands on exhibits now do their job and then ask how these demonstrations might work better, more reliably, and more understandably. Small things, like better signage, are crucial and have to be done just right. Chicago people should learn how to make new displays that meet the expectations of the present audience. To do this, our students will be exposed to some of the science now being done at the UofC, pick the parts which can be best understood and displayed, and then design displays that are both informative and entertaining. In their designs, they will build upon the expectations already generated by the museum, and try to copy and expand upon what is already being done.

2. Signage with credits. The team should do new things to challenge the existing audience and to broaden the group of visitors. For example many of the children who come into SciTech do so together with adults. Some of the signage should be aimed at the adult audience to help them explain what is going on to the children. Perhaps some of the displays should have two explanatory placards, one placed lower for the children and one placed higher for the adult visitor which might then translate for and explain to the children. The adult placards should include some reference to who did the research being displayed, especially when that research is recent. This kind of reference to researcher and to sponsor might well help to draw scientists and other local technical people into the museum both as ordinary visitors and also as people who might hope to become involved in exhibiting their own science and technology.

Some displays should draw both adult and child equally. For example, displays which show local people both in their technical jobs and also in their homes with their children might be attractive. In this high-tech area of Illinois, oft-changing displays with titles like "My mother, the particle physicist" or "My brother the lab tech" or "my cousin the phlobotomist" might give an extra sense of the closeness of technical occupations, and might draw friends and relatives into the museum. Similarly, one might do well to exhibit the best of the year's Science Fair projects, including both pictures of the students who built them and also of the teachers and parents who inspired them.

3. Picking Projects. The projects will be mostly picked from among the very wide group of scientific studies conducted by the sponsoring multi-investigator laboratories. Here we list very briefly a few of the projects we shall first examine for possible implementation:

a. Strobed drops: Under the direction of Professor Sidney Nagel, the Chicago MRSEC has put together a strobed exhibit of dripping drops. The dripping process produces drops of a very wide variety of shapes and stability. We find it fascinating. Can it be made so for a younger audience? Our team will tell us, using the advice of the curators, and then, if given the go-ahead, produce a design of an exhibit aimed to work at SciTech.

b. Granular materials: Professor Heinrich Jaeger of the MRSEC has produced demonstrations of granular flow[22] using poppy seeds inside a device shaped like a wheel with transparent sides. Can this device be redesigned to serve the educational and fun needs of SciTech?

c. The Antarctic Environment: MPS supports ongoing research in Antarctica. Our Chicago Center for Antarctic Research has produced many different kinds of displays showing what it is like to do research in that environment. In a small-museum context, we can bring in Antarctic artifacts, instruments, and clothing and put them on display along with computerized pictures showing the adventure and fun of doing research in a difficult environment. From time to time, those displays can be supplemented by visits from Mr. Landsberg, or some of the graduate students who worked in the Antarctic, to talk about how its done.

d. Optical Tweezers: Professor Grier grabs very small objects with optical tweezers. A safe display can be built enabling museum visitors to do that too.

e. Virtual Reality: A major effort will be built around the virtual reality room at SciTech. For example, we shall take Professor Andrey Kravtsov's computer models of the formation of galactic clusters in the early universe and set them so one could use a joy-stick to fly through them. Parallel displays will compare distribution of dark matter with that of hot material to see how they follow one another.[23]

f. Sky Survey: An additional piece of work in that same direction would involve using the virtual reality environment to display the visualizations of the Sloan Digital Sky Survey data primarily done by Dr. Mark SubbaRao.[24] This raw material needs to be made understandable for the public (e.g., identify and convey the key concept), which requires work on the imagery and the content.

g. Electronic Profiles of Research and Researchers: If done properly these would also fit into the context of SciTech's VR room, Adler's Cyber Space, in smaller planetaria, and on the web. This would involve digital photography including 360-degree QTVR panoramas, graphics to illustrate the science, and possibly short video clips of researchers to explain key concepts or to illustrate that scientists are real people. The potential exists for creating interactive web experiences and travel logs especially for CfCP research in exotic locations e.g., Auger in Argentina and future telescopes in Antarctica.

It is too easy. Dozens of examples, drawn from MPS science, come to mind. (See also the examples in Dr. Mir's Weizmann exhibit.[25]) By putting together a committee of scientific advisers we can and will get many such examples. The interesting problem is not getting examples from the rich collection of MPS science being done on the UofC campus but seeing which ones can be best explained in a museum context. Our scientific panel, listed below, will feed possible ideas to us and then help us think about using them for SciTech and other environments. This board includes the following MPS scientists:

*Heinrich Jaeger (Granular Material in Motion)[26]
*David Grier (pulling with light)[27]
*Thomas Witten (hearing the shape of thunder.)[28]
*Sidney Nagel (Picturing Fluid Flow)[29]
*Wendy Zhang (Rainfall, Plants, and Splashing)[30]
*Andrey Kravtsov (Formation of Galaxies)[31]
* Steve Sibener (Nanoscale Dynamics of Interfaces)[32]
*David Oxtoby (Solidification)[33]
* Thomas Rosenbaum (little magnets do big jobs)[34]
*Bruce Winstein (the cosmos)[35]
*Jeff Harvey (what theorists do)[36]
*Juan I. Collar (Superheated Drops)[37]
*Melvyn Shochet (Fermilab research)[38]
*Michael Turner (The Universe and more.)[39]
*Jim Cronin (big storms from little particles)[40]
*Ka Yee Lee (breathing)[41]
*Todd Dupont (Coffee Stains)
*John Carlstrom (Early Times)[42]
*Robert Rosner (Storms on Stars)[43]
*Shankar C. Venkataramani (The crumple-chair)[44]

4. Evaluate and Extend the Virtual Reality environment. SciTech's virtual reality environment is now used to display exciting animals and the interior of the heart. It offers physical scientists a very rich range of possibilities for working in a cheap and controllable 3-d environment. We will learn what it takes to build new

displays in this context, build them, and then port the results to other museum contexts. Here we shall work with Mr. Sammy Landers, the SciTech specialist in the virtual reality environment, Ms. Carina Eizmendi, SciTech head of exhibits, and the group at the University of Illinois who were designers of the computer tools for the environments and exhibits, as well as the CI people at Chicago and the Argonne who are experts in computer display.

E. Conferences and Evaluations

1. Conferences. One major portion of the evaluation process involves bringing experts on science and science museums together to hear about a topic interesting to them, and also --not incidentally-- to hear about and criticize our progress. We shall put these conferences together with the aid of our advisory committee (see organization, below). The SCOPE program will support three two-day meetings. The first will be on The Relationship Between University Research and Science Museums, the second will have the title Museum Careers for Scientists, the third is tentatively picked to be Art and Science in Museum Settings. In each case, the student team from SCOPE will present their work and the overall planning of SCOPE, and CPS will be also presented for evaluation by advisory committee and conferees.

2. Evaluation. SciTech will be in charge of the evaluation process. They have had considerable experience in doing this with their earlier NSF program.

During each year, there will be three periods of intensive evaluation of the SCOPE effort. The first will be at the international conference that will take place during each June. At that meeting, the SCOPE team will describe their plans for exhibit construction intended to be realized during the summer to follow. Questionaires and evluation plans will also be presented by SciTech people. The conferees, including many members of the advisory committee will be asked to question the students, their coaches, faculty leaders, and museum leaders. They will also be asked to comment in private upon what they have heard, about exhibits, the educational level of the graduate students, and the leadership shown by UofC and SciTech, and especially about the further plans for evaluation. Their questions and conclusions will be written down and preserved for the NSF and for the program sponsors.

The second period of evaluation will occur as the projects are put up at SciTech. Using both questionnaires and observation, the evaluation team will see whether the elements actually function properly in the museum environment, and will assess the knowledge gained by the museum visitors and their degree of satisfaction with their experience. This process will culminate in the "big weekend" in which all the new exhibits will be tested at once.

The third period of evaluation will occur at the end of the summer in which the project staff will draw together all the other evaluations and provide a summary evaluation for NSF and sponsors.

Information about the exhibits and evaluation results will be available to the many museum collaborators SciTech works with. This information will also be shared through national and international conferences, other university collaborations, AAAS, and accessible through our web page.

V. Organization

This proposed MPS sponsored program, SCOPE, is a cooperation between SciTech and the UofC. SCOPE will be a part of the Center for the Presentation of Science, CPS. This center will have the responsibility for carrying the activity beyond the period of SCOPE. The SCOPE program is now sponsored by the Physical Sciences Division, the Master of Arts Program in the Social Sciences, the MRSEC, the Center for Cosmological Physics of the University of Chicago, The High Energy Physics group of the University of Chicago, the Computational Institute of the University of Chicago, and by the SciTech Hands on Museum, Aurora, Illinois.

The Program Directors are the PI's for the project. They supervise the Project Managers of SCOPE who are also the students coaches and are presently Dr. Eileen Sheu, outreach coordinator MRSEC, and Mr. Randall Landsberg, outreach Director CfCP.

The Program Directors report to the sponsors, specifically:

David Oxtoby, Dean Physical Sciences Division
Heinrich Jaeger, Director MRSEC
John MacAloon, Director MAPSS
Bruce Winstein, Director CfCP
Rick Stevens, Director Computational Institute
Melvyn Shochet, PI, HEP grant

They submit reports to and ask for advice from a CPS advisory committee which includes:

Nadia Abu El-Haj Assistant Professor of Anthropology, Columbia University.
Raymond Fogelson, Professor of Anthropology, University of Chicago.
Professor Leon Lederman, physicist, educator.
Ms. Michelle Nichols, Lead Educator for Informal Programs, Adler Planetarium & Astronomy Museum.
Robert L. Perlman, M.D., Ph.D, Professor, Departments of Pediatrics and Neurobiology, Pharmacology, & Physiology University of Chicago, Editor, Perspectives in Biology and Medicine.
Robert J. Richards, Professor of History, Philosophy, and Psychology, Director Fishbein Center for History of Science, University of Chicago.
James J. Sosnoski, Professor of Communication, University of Illinois at Chicago; Director of the ASCEND Network; President of Alternative Educational Environments; Coordinator of the Virtual Harlem Project Rick Stevens Professor of Computer Science, Director of Computation Institute, Argonne National Laboratory and the University of Chicago.
Dr. Karen Wilson, Director Oriental Institute Museum.

The program directors also report to and serve at the pleasure of Thomas Rosenbaum, Vice-President for Research, UofC.

VI. In the Long Run....

The MPS funding will encourage us to construct program elements not directly sponsored by this proposal. We hope to design courses specifically for the CPS program. It certainly needs a course in computer programming specifically aimed at the special mix of students in this project. Also needed is a third quarter of museum anthropology, specifically aimed at science museums.[45] Students should start the program with a course specifically aimed at issues in the presentation of science.[46,47] We will attempt to put these things in place.

This MPS proposal is for a pilot program, with a limited scope. Using the attraction of this proposed funding, we expect to get additional support to widen the program. We need to get additional funding to keep the Adler six-student team in action under the direction of Mr. Landsberg and to support a Science and Art team. We intend to widen the MPS range of the program by including input from Particle Physics and from the Indisciplinary Research Center for Biophysical Dynamics. This present proposal will support one student who will be responsible for liaison among the different teams and to help export the SCOPE work into additional museum centers. Mr. Landsberg's team will reach out to another group of museums, including the Adler Planetarium and Museum as well as smaller centers with astronomical interests.