III. **EDUCATION**

Educational Objectives

The overall educational objectives remain unchanged since initially defined in the Center's strategic plan. The Center's educational objectives are to:

a. Create a better-trained, diverse workforce in the area of materials and devices for information technology, and to improve the diversity of that work force through proactive recruiting and innovative web-based cooperative learning;
b. Create new opportunities for providing interdisciplinary, hands-on education by facilitating exchange of students amongst groups with diverse research capabilities and interests;
c. Design, implement, and assess new educational approaches that provide more flexible and accessible career pathways for students; and,
d. Provide ethics training through lectures given at each university to all incoming members; topics will include scientific integrity, the concept of inventorship, accurate record keeping, and the requirement to share credit.

The Center has made a great deal of progress toward these objectives in the design and implementation of a variety of Center activities. For example, an upcoming *ACS-PRF Workshop on the Chemistry of Information Technology* hosted by the Center will provide an inter-disciplinary, hands-on educational experience for a variety of participants from across the country; the design of web modules for the teaching of concepts central to information technology ultimately will lead to innovative web opportunities and provide new educational approaches for a diverse audience; and the Center's growing partnership with the Alliance for Non-Linear Optics will foster the development of a diverse workforce. In addition, a significant number of Center participants, including many undergraduates, have presented their research findings at professional conferences and workshops in K-12 and business arenas. Combined with ethics training in the form of seminars, courses, and guidelines for accurate record-keeping, these presentations have helped to convey an understanding of inventorship within the Center and its surrounding communities. It is expected that the educational efforts of the Center will be even more robust in the next reporting period. Now that the Center's management infrastructure has been established, including the newly hired Education Director, the Center's management will refine and clarify the existing objectives to better align with existing resources of organizations belonging to the Center, the needs of the communities surrounding the Center, and expertise and resources from within the Center. The refinement of objectives will enable the development of more clearly defined measurable goals, outcomes and related activities. This work will be informed by the expertise of an external advisory committee.

Performance and Management Indicators

This report will address goals identified in the Center's strategic plan which relate directly to those educational objectives mentioned above (see 1a.). The goals are:

(i) To recruit and track, proactively, individuals from under-represented groups into the Center, through seminar programs, internships, fellowships, and strategic interactions with the Alliance for Nonlinear Optics, Northern Arizona University, Norfolk State University, and California State University Los Angeles; and,

(ii) To create cross-disciplinary curricula and educational resource materials that are directly tied to the research function and expertise of this Center, and to evaluate their impact.

In an effort to measure our progress toward these goals, we have laid the groundwork for long-term information gathering. Specifically, we have recently constructed a Center-wide database for tracking the demographics and activities of all Center Participants and Affiliates. This dynamic database will be further expanded to track the graduation and future plans of Center students as well as the involvement of external participants in Center activities. It will be accessible through the internal portion of the Center's website and available to Center participants and staff.

The Center has also initiated a partnership with the University of Washington's Office of Educational Assessment (OEA) by providing the salary of Tamara Walser a program evaluator hired to work with the Center. The OEA will work closely with the Center's management in the refinement of goals and objectives, and correspondingly the Center management will work closely with OEA to develop and implement the evaluation plan.

To describe our progress thus far, each educational activity described below will reference the goals and objectives addressed.

Problems Encountered

The Center has encountered initial challenges toward the establishment of the education management team. The late hiring of the education management team was a direct result of delayed Center funding and staff turnover/reorganization (specifically, Gretchen Kalonji withdrew from the Center to pursue other interests). In the interim, Bruce Robinson and Natia Frank were pressed into service as coordinators of the Center's education efforts. While this slowed the rapid development of widespread Center activities, the newly hired education staff has tremendous potential. The Director of Education, Dr. Jasmine Bryant, has a PhD in inorganic chemistry, and a Master's Degree in Teaching. She is a former fellow in the NSF's GK-12 program and has experience in public and private K-12 education and outreach programs. The Center is also pursuing negotiations for a partnership with the University of Washington's K-12 Institute for Science and Mathematics Education. This Institute, established by the university's central administration, supports the university's mission to partner with and support Washington state's K-12 community. The work of the Institute fosters collaborative, systemic efforts for reform in science and mathematics education. These ties will be especially useful in harnessing the existing educational resources in the Center communities as well as rapidly defining effective plans for future Center efforts.

Initial efforts at UA to recruit teachers to be involved with Center activities has proven difficult. Specifically, the involvement of teachers in the design of web modules will require greater effort, as the web modules are the most advanced activity. It is perceived that depressed budgets of local school systems and lack of release time have contributed to this situation. The hiring of Rachel Morgan (as a post-doctoral fellow in Vicente Talanquer's science education research group) at UA is expected to improve the interface with the K-12 community significantly over the next year.

Internal Educational Activities

A number of activities have taken place that address the educational objectives and goals of the Center. These have taken the form of workshops, conferences, web module development, presentations, lab experiences and coursework. For each of the activities we have provided a narrative description. To the descriptions below, we have added information specifying the goals and objectives addressed by each activity. The impacts of these activities will become visible in the next reporting period as the education management team and all Center participants will work with the Office of Educational Assessment to develop and implement measurement strategies.

Activity Name	ACS-PRF Workshop on The Chemistry of Information Technology
Led by	Natia Frank, Bruce Robinson, Jasmine Bryant
Intended Audience	Undergraduates, graduate students, post-docs, new faculty, community college educators, industry scientists
Approx Number of Attendees (if appl.)	40 participants, 15 speakers, other 20-30 attendees
Objectives/Goals Addressed	Objectives a, b Goals: i, ii

The *ACS-PRF Workshop on the Chemistry of Information Technology* (funded by a grant from the Petroleum Research Fund) will take place on the University of Washington campus from June 18-25, 2003. It consists of a four-day workshop facilitated by Center faculty including laboratory experiences, tutorials, and education and reflective sessions. The workshop is followed by a three-day symposium composed of 36 talks given by leaders in the field of information technology. Workshop sessions will be recorded by UW TV and posted on the web. The symposium presentations will be published in a special, dedicated issue of the Journal of Physical Chemistry. The goals of this workshop are to educate and inform a diverse workforce as well as to integrate research and education. An initial assessment of the workshop will be organized by OEA. This will include a reflective session at the conclusion of the workshop in which participants will be able to provide feedback as well as discuss ways in which they will be able to use this information within the context of their organization – particularly how it relates to their educational practices. This session will provide a basis for designing future workshops. Secondary-level teachers will be included in the workshop (see External Activities, below).

Activity Name	Web modules
Led by	Neal Armstrong
Intended Audience	Undergraduates (initially), K-12 through post-graduate
Approx Number of Attendees (if appl.)	
Objectives/Goals Addressed	Objectives: a, b, c Goals: ii

One of the central activities of the educational efforts of the Center is the development of a web-based curriculum, in optics and optical materials, which ultimately will be vertically (K-12 through postgraduate) and horizontally (cross-disciplinary) integrated. The design of the initial web module is being approached as a pilot research activity around the delivery of web-based content and will provide the basis for the development of further modules. Specifically, the process will address the best way to implement web-based education activities, identification of the audience, how best to access the information, an assessment of user understanding at several levels, and how teachers might use the modules. The first six months of activity have been dedicated to the following tasks: a) hiring the appropriate staff in the Department of

Chemistry (Mike Bruck) at Arizona to work effectively with the UW group, b) beginning the creation of the web-page format for this curriculum, c) purchasing the necessary equipment to support this effort, d) beginning the design of the curriculum modules with staff from Faculty Instructional Services at Arizona (most particularly, Jennifer Franklin), e) initiating the first educational module on Refraction and f) the hiring of Rachel Morgan to assist in the interaction with local schools.

Masud Mansuripur has outlined content for the initial module. The topic of refraction has been chosen for this pilot module because it is closely aligned with the Center and is the area most advanced in Center research. The development of the interface for the module navigation is being led by Jennifer Franklin. Mike Bruck is leading the development of the module navigation system which includes a Concept Map interface and User History/Tracking system. Examples of the activities to be used in the first/pilot module can be found at:

http://www.ece.arizona.edu/~chandanp/work/Physics1/
http://www.ece.arizona.edu/~chandanp/work/Physics2/

Activity Name	ANLO Partnerships
Led by	Natia Frank, Seth Marder
Intended Audience	Undergraduates and faculty of partnership schools
Approx Number of Attendees (if appl.)	
Objectives/Goals Addressed	Objectives a, b Goals: i, ii

As part of our effort to reach more diverse populations, we have pursued a strong outreach program to traditionally Hispanic, Black and western-USA Native American colleges. Specifically, we have initiated collaborations with the Alliance for Nonlinear Optics (ANLO, Dr. Tatiana Timofeeva of New Mexico Highlands University, Director). Most ANLO investigators are from minority and historically black colleges and universities (U. Texas, El Paso; New Mexico Highlands U.; Spelman College; U. Puerto Rico at Mayaguez; Grambling State U.; U. Alabama at Huntsville; and Alabama A&M U.). ANLO concentrates on collaborative research projects in optical materials while reducing isolation between minority and historically black colleges and university-funded projects -- it cuts across racial, ethnic, regional, and educational boundaries. To these ends, several personal contacts have been established between STC and minority institutions: a) Perry (UA) has provided assistance in reviewing a project and provided a letter of support to Sarkisov (AA&MU). b) Brédas (UA) will be admitting an undergraduate from Cardelino's group (Spelman) for undergraduate research. c) Robinson and Eichinger (UW) have provided assistance to Timofeeva (NMHU) in the acquisition and operation of a molecular modeling program (Cerius2) and plans for a collaborative computational project are under way. In addition, an undergraduate from the Timofeeva group will be joining the Robinson group for summer undergraduate research. d) Marder (UA) and Timofeeva (NMHU) have collaborated in the preparation of a short structural/synthetic manuscript. e) Dalton (UW) has provided assistance to NMHU by reviewing a NASA grant proposal and providing a letter of support.

Furthermore, we intend to pursue relationships with additional colleges and universities. For example, Larry Dalton is a member of the advisory board and helped to secure funding for the Center for Research and Education on Advanced Materials at Norfolk State University (NSU), an historically black college. Furthermore, four students and one faculty member from NSU will be participating in our *ACS-PRF Workshop on the Chemistry of Information Technology*.

Activity Name	Undergraduate Opportunities
Led by	Individual Faculty/Jasmine Bryant
Intended Audience	Graduate Students, undergraduates, and faculty
Approx Number of Attendees (if appl.)	
Objectives/Goals Addressed	Objectives a, b Goals: i, ii

We have provided a number of undergraduate students with opportunities to perform research in Center laboratories. Across Center sites, there are currently 37 undergraduates taking on responsibilities for individual and joint research projects. These undergraduates attend group meetings, including joint, inter-disciplinary meetings of Center researchers. These research experiences generally last from three months to several years – providing students with authentic, hands-on experiences in the field of information technology. The research findings of these students have been presented at a variety of local and national conferences, including campus undergraduate research conferences, the Northwest section meeting of the American Chemical Society (ACS), and the ACS national meeting. Furthermore, plans are in place for undergraduates from ANLO partner schools to partake in summer research with Center faculty.

Activity Name	Faculty/graduate student presentations
Led by	Individual Faculty/Jasmine Bryant
Intended Audience	Undergraduates, graduate students, faculty
Approx Number of Attendees (if appl.)	
Objectives/Goals Addressed	Objectives a, b Goals: i

Over 80 talks have been given by Center participants at scientific conferences, workshops, and community engagements (see Section VIII. Center-Wide Outputs and Issues). These presentations assist the Center in its efforts to transfer the research of the Center to an educational format. For example, Masud Mansuripur's lecture "How do CD- and DVD- Players Work?" has been made available as a streaming video at:

(http://www.vala.arizona.edu/vss-bin/vss_SR/torpey/search)

Also, Larry Dalton has given two talks for the University of Washington Science Forum. The response was enthusiastic and UW TV recorded the presentation and will make this available as part of continuing education and outreach.

Activity Name	High-Tech Entrepreneurship Speaker Series
Led by	The Center for Technology Entrepreneurship
Intended Audience	Students from Science, Engineering, and Business; Faculty; and individuals from Industry and the Business Community
Approx Number of Attendees (if appl.)	150
Objectives/Goals Addressed	Objectives a, b Goals: i

The Center-related goal of participating in this program was the introduction of students, non-STC faculty, and the business community to key technologies being pursued in the Center. The anticipated output was an increased interest on the part of students, faculty, and the community in Center research. In the short term, an enthusiastic response occurred with a half dozen

students expressing interest in opportunities such as the certificate program involving combined business and science/engineering education. There was an enthusiastic response from the Business sector. Coupled with the very favorable responses received from the Technology Alliance, Washington Community Development Roundtable, Science Forum, and other community related lectures (see section 2b below), a group of business leaders (including those of the Technology Alliance) met with members of the Washington State Legislature to campaign for State funding of a Center for Strategic Advantage to be coupled with the Center. Several Seattle-based companies have approached the Office of Intellectual Property and Technology Transfer at the University of Washington to pursue licensing of technology produced within the Center. We will continue to develop these relationships, but it is still too soon to assess the longer-term impact of such a speaker series.

Activity Name	Frontiers in Nanotechology, BIOENG 599
Led by	The Center for Nanotechnology
Intended Audience	Graduate Students from Science and Engineering
Approx Number of Attendees (if appl.)	> 20
Objectives/Goals Addressed	Objectives a, b Goals: ii

Center faculty teach significant components of this course including those related to nanophotonics, nanoelectronics, sensors, MEMS, etc. This course is an important component of the Nanotechnology PhD program. The anticipated outcome of participation in the teaching of this course was improved interdisciplinary education of graduate students and advanced undergraduate students as well as the opportunity to build bridges to related technology programs. This course has been very successful in training students within the Center in topics related to nanoscience and nanotechnology. A significant fraction, if not a majority, of students taking this course are now pursuing research within the Center.

External Educational Activities

Activity Name	ACS-PRF Workshop on the Chemistry of Information Technology
Led by	Natia Frank, Bruce Robinson, Jasmine Bryant, Neal Armstrong
Intended Audience	Pre-college science teachers
Approx Number of Attendees (if appl.)	5
Objectives/Goals Addressed	Objectives: a, b, c Goals: ii

As part of the *ACS-PRF Workshop on The Chemistry of Information Technology* (described above), we have invited pre-college science teachers with strong backgrounds in chemistry to increase their knowledge in the field of Information Technology. Afternoon sessions will allow teachers to explore ways in which to incorporate workshop information into their classroom. We will also provide supplemental information and additional activities for K-12 teachers, including the opportunity for teachers to review and pilot web module activities.

Activity Name	Faculty/graduate student presentations
Led by	Individual Faculty/Jasmine Bryant

Intended Audience	K-12 students and teachers, general public
Approx Number of Attendees (if appl.)	
Objectives/Goals Addressed	Objectives: a, b, c Goals: ii

Many Center participants have realized the importance of communicating their research to the K-12 community. As a result, Center participants have been involved in a variety of activities. These include science fair judging and assistance, presentations at teacher workshops, lectures given in the business community, the mentoring of high school students, and classroom science demonstrations. For example, Greg Phelan, a Center graduate student and a NSF GK-12 Fellow, has given presentations at teacher workshops at The Villa Academy, Emerson Schools, and the African American Academy. Center graduate students Leo Fifield and Rhys Lawson have given presentations about Nanotechnology to 4th, 5th and 6th graders at Cathcart Elementary School. Larry Dalton, the Center Director, is currently mentoring 3 high school students: helping Adrian Lee of Beaver Lake Middle School on a science project; assisting Rafi Kuttner of Mercer Island High School with a project on information technology carried out in laboratories at UW; and advising Emma Mullen of Newport High School on her science project (conducted in UW laboratories) for the Intel Science Fair Competition.

Activity Name	Technology Alliance Lecture Series
Led by	Seattle Technology Alliance
Intended Audience	High Technology Business Community
Approx Number of Attendees (if appl.)	> 300
Objectives/Goals Addressed	Objectives: a, b, c Goals: i

The goal of participation in this activity was to strengthen Center interactions with the Seattle high technology business community. The lectures have been enthusiastically received and the Technology Alliance has become a lobby group for the Center with the Washington State Legislature and with other community business groups. The Technology Alliance supports an Education and Outreach program that in many ways dovetails with that of the Center. In this regard, the Technology Alliance has become an active promoter of our education efforts. Dr. Lynn Nixon of Agilent has played an invaluable role in coordinating the interaction of Center efforts with local, State, and industrial K-12 efforts and with the WASL testing program. While meaningful assessment can be accomplished only after more time has transpired, the initial prognosis is very positive. The Technology Alliance has elected Center Director Larry Dalton to membership, which further facilitates coordination of Center and Technology Alliance activities.

Activity Name	Washington Community Roundtable Luncheon Lecture Series
Led by	Seattle Chamber of Commerce
Intended Audience	Community Leaders
Approx Number of Attendees (if appl.)	> 100
Objectives/Goals Addressed	Objectives: a, b Goals: i

Participation in this lecture series was aimed at the facilitation of knowledge transfer to the business community as well as the building of a working relationship that would advance education, outreach, and knowledge transfer efforts. An enthusiastic response has been

received. Meetings with Seattle Mayor Nickels, members of the Gates Foundation, and Paul Allen have resulted. The law firm Preston Gates has provided release time for partner Marty Smith to work with the Center to coordinate education efforts with those of the Gates Foundation.

Professional Development Activities

Center participants have taken part in a variety of professional development activities including: conferences and workshops, an ethics course and/or presentation, coursework and lecture series, and joint, inter-disciplinary group meetings. The above mentioned *ACS-PRF Workshop on the Chemistry of Information Technology* provides a forum for the exchange of knowledge amongst a diverse group of participants. Undergraduates, graduate students, post-docs and faculty participated in both attending and presenting at a variety of conferences – over 80 presentations by Center faculty alone (see Section VIII. Center-Wide Outputs and Issues). Furthermore, in an effort to provide ethics training to Center participants, we have scheduled an ethics and intellectual property seminar to be attended by UW Center staff. We have further encouraged Center students at the UW to participate in an ethics course involving weekly discussions of: authorship of papers and responsibility for their contents, intellectual property and copyright, protection of oneself and one's colleagues from the publishing of bad work, the process of checking that other people have not done the work earlier, how a research group should be run and what the responsibilities of its leader and other members are, how and why good records are kept, and the balance between secretiveness and openness. All Center participants have received information regarding proper notebook maintenance and record-keeping. These efforts speak specifically to educational objective d. above. Many Center students also participate in weekly inter-disciplinary group meetings in order to exchange information and knowledge within the Center.

Integration of Research and Education

The Center strives to create a program and a culture that fosters the integration of teaching and research. Concepts central to each of the research thrusts will be reflected in the content of the web-based curricular resources, undergraduate research experiences, inter-disciplinary lectures, talks that are presented by our Center graduate students and faculty, weekly inter-disciplinary group meetings, our PRF summer workshop as well as our partnership with the Center for Technology Entrepreneurship (at UW). The summer workshop offers opportunities for Center faculty to provide exposure to high level research, as well as the fundamental underlying concepts central to Center research activities, to a broad audience – the K-12 teaching community, undergraduate and graduate, as well as the professional community (industry, post-doc, faculty) in the form of tutorials and laboratory experiences. It also provides instructors (K-Gray) the opportunity to hear inter-disciplinary lectures and to reflect on ways to incorporate this information into their educational practices. The creation of web modules takes advantage of content experts already on board at UA to provide design leadership.

The Center for Technology Entrepreneurship promotes the integration of research and education in a number of ways while serving as a contact point for science, engineering, business, and law. Most specifically, research, education, knowledge transfer, and technology transfer are facilitated through (1) the New Venture Creation Laboratory where students from science and engineering work together with students from the School of Business (and Law) to evaluate the commercial potential of research being pursued in the Center, (2) the High-Tech Entrepreneurship Speaker Series of the CTE whereby scientists (from the Center) and successful entrepreneurs from the community share their experiences and research advances,

(3) through a new certificate program designed to provide graduate students in science and engineering with an introduction to entrepreneurial thinking from a business perspective, and (4) a business plan competition which provides students experience in writing business plans. A Workshop with participation of Center scientists and engineers together with faculty from the UW School of Business will focus on providing students with a concentrated experience in topics ranging from ethics to entrepreneurship. This Workshop will ultimately be coordinated with the Annual Meeting of the Center and will involve a day focused on review of potential for technology transfer of specific STC research activities.

Future Plans

Despite the delay in establishing the education segment of the Center's management team, progress in the field of education has been made. Our plans for the upcoming year primarily center on a concerted effort to refine and clarify our educational objectives and goals, roles and responsibilities, and to refine and expand the scale and effectiveness of current activities. To this end, we have an active process in place. A working team of education-focused participants (Neal Armstrong, Vicente Talanquer, Jenny Franklin, Michael Bruck (all at UA), Jasmine Bryant, Natia Frank, Bruce Robinson, (UW Center Personnel), Laura Collins and Tamara Walser (UW Office of Educational Assessment) meets bi-weekly via videoconferencing for activity planning. We will more clearly define Center and faculty interactions as well as increase our active solicitation of funds to promote and expand educational activities.

APPENDIX IIIa

"*Half Hockey Puck*" Refraction Experiment

Storyboard for Video Recording
3/27/2002 – mab/jf

Video 1. Single Red laser - Refraction

Set up instructions:

1. accurately align and orient polarization of beam
2. accurately align center sample on rotating stage

Recording instructions:

3. **long-view** – record while rotating 360º
4. **zoom** – record while zooming to close-up
5. **close-up** – record while rotating 360º

Post-production instructions

6. combine 3-4-5 into single QTVR with center click on long-view and close-up activating a zoom to the other
7. create roll-over labels for all components of experiment
8. create caption to point out and identify Total Internal Reflectance for appropriate frames of rotating long-view and close-up

Video 2. Single Red laser – Brewster's Angle

Set up (#1) instructions:

1. accurately align and orient polarization of beam
2. accurately align center sample on rotating stage
3. determine method to simultaneously visualize refracted beam passing through sample and intensity and position of reflected beam on outer graduated ring
   a. single camera setup at appropriate angle to view sample and ring
   b. dual cameras setup to view sample and ring separately, synchronize videos in post-production with PIP (picture-in-picture) simultaneous views

Recording instructions:

4. rotate sample through Brewster's angle and record sample and reflected beam position and intensity (illustrate total loss of intensity)

Set up (#2) instructions:

5. re-align polarization of beam by 90º

Recording instructions:

6. rotate sample through Brewster's angle and record sample and reflected beam position and intensity (illustrate no loss of intensity)

Video 3. Dual Lasers, Red and (Green or Blue) – Refraction with Dispersion

Set up instructions:

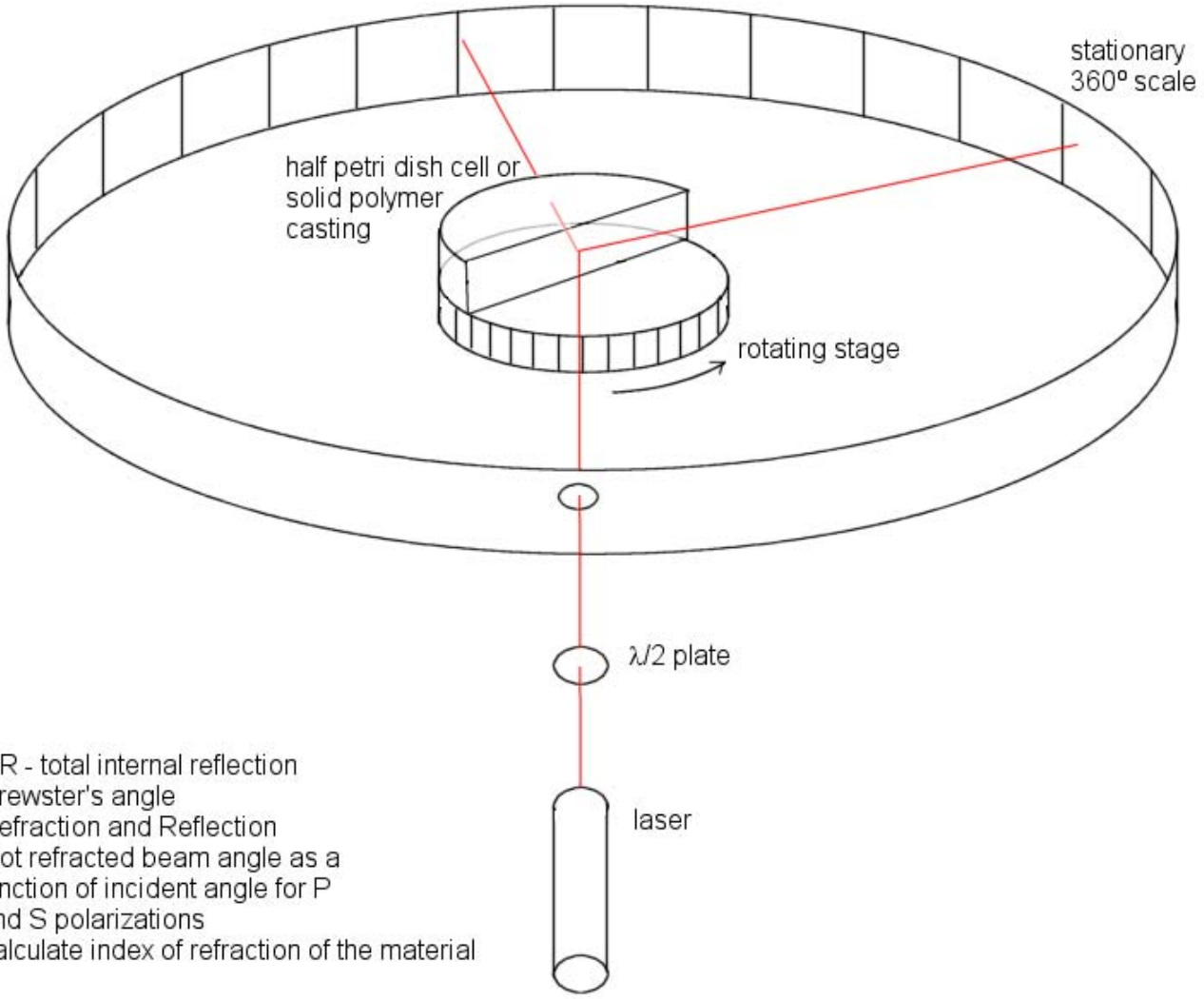
1. accurately align and orient polarization of beam
2. accurately align center sample on rotating stage

Recording instructions:

3. **long-view** – record while rotating 360º
4. **zoom** – record while zooming to close-up
5. **close-up** – record while rotating 360º

Post-production instructions

6. combine 3-4-5 into single QTVR with center click on long-view and close-up activating a zoom to the other
7. create roll-over labels for all components of experiment
8. create pop-up label to identify Total Internal Reflectance for appropriate frames of rotating long-view and close-up



1. TIR - total internal reflection
2. Brewster's angle
3. Refraction and Reflection
4. plot refracted beam angle as a function of incident angle for P and S polarizations
5. calculate index of refraction of the material