FINAL REPORT

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High Energy Collider Physics

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Department of Physics, We have no objection from a patent
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I. Introduction

With the demise of the Superconducting Supercollider (SSC) Project, there was great concern that the technological developments for that accelerator and its associated detectors might well be lost in the aftermath. In the case of scintillating fiber tracking, such has not been the case.

During the period 1990 - 1993, several tracking technologies were under development for SDC, including Scintillating Fiber Tracking, Straw-tubes, and Microstrip Gas Chambers. In summer 1990, several members of the Fiber Tracking Group (FTG) proposed the use of Scintillating Fiber Tracking to the DØ experiment at Fermilab. This proposal was accepted, and DØ now is building a 75,000 fiber channel tracking detector with readout via Visible Light Photon Counters (VLPC) which were devices pioneered by the SDC Fiber Tracking Group. In addition, all the preshower detectors for DØ also make use of fiber readout (in this case waveshifting fibers) and VLPC for photosensing.

In February 1993, a full 7 months prior to cancellation of the SSC project by Congress, the SDC experiment rejected scintillating fiber tracking for further development. Fortunately for all concerned, the DØ experiment had already embraced this technology, so this important detector concept could be further developed, refined, and utilized for physics experimentation. In early 2000, data will be taken with the DØ fiber tracker to study Top Quarks, Beauty Particles, Electroweak Physics, QCD phenomena, and to search for new phenomena.

The University of Notre Dame has played a fundamental and seminal role in the development and implementation of this detector technology. R. Ruchti has served as co-spokesman of the Fiber Tracking Group since its inception in 1989, and has been a pioneer of fiber tracking technology since 1980.

In addition, at least one other experiment at Fermilab, E835, has utilized scintillating fibers with VLPC readout to study Charmonium in proton-antiproton collisions using a gas-jet target in the Tevatron antiproton accumulator ring. This fiber detector has been operated successfully for over 1 year of actual beam conditions.

II. Program Accomplishments

At the outset of the DOE funded program, scintillating fiber tracking technology for fixed-target experiments was a reality, but for high-rate, colliding beam experiments the

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technology was a dream awaiting proof of principle. The SDC fiber tracking group (R. Ruchti of Notre Dame was co-spokesman along with D. Koltick of Purdue University and M. Atac of UCLA) undertook critical device developments for scintillating fibers including the development of the visible light photon counters (VLPC), solid state phototransducers capable of high gain (~20,000), high rate operation (> 10 MHz), and high quantum efficiency (60-80%); and multicladd scintillating and waveguide fibers which afforded improved light collection (by a factor 1.7) and improved light transmission over conventional, single-clad fibers (20-25% improvement in attenuation length). The Conceptual Design Report for Scintillating Fiber Tracking for the SDC experiment is included in this summary packet. [1]

These major advances allowed the detected mean photoelectron level from scintillating fibers of 3m length and 830 μ m diameter optically coupled to clear fiber waveguides of 8m length and 960 μ m diameter and read out with VLPC to rise from 1.5 photoelectrons to at least 6 photoelectrons with the fiber ends unmirrored, and to 10 photoelectrons mirrored. These results were first obtained at Notre Dame in May 1993 using a lab-bench test set up of 16 fibers and VLPCs. The VLPC version was called "HISTE-IV". This established "proof of principle". The publication based on this work is attached here. [2]

More recently, in the 1994-1996 period, the DØ experiment fiber tracking group (of which Notre Dame is a member and Notre Dame Professor Mitchell Wayne is co-project leader with Alan Bross of Fermilab), confirmed the 1993 Notre Dame measurements but with a system of 3000 fiber channels with VLPC readout. This system was operated in two versions for a period of 15 months, and established "proof of practicality" - that the technique could be operated successfully and stably for long periods of time - suitable for scientific experimentation. [3] Papers on this work were also included in a conference organized and held at Notre Dame in 1993 called "SCIFI93".[4] This book is an important reference work for the field.

A previous meeting "SCIFI88" was organized by R. Ruchti and held at Fermilab in 1988, prior to the beginnings of this grant period, but SCIFI88 served as a starting point for fiber tracking technology in the SSC era, bringing together key players who later would form the SDC and DØ fiber tracking groups.

Recently, in November 1997, the third of these meetings was held, again at Notre Dame. Entitled "SCIFI97", this meeting brought together researchers from around the world in such areas as particle physics, nuclear physics, space and astrophysics, medical physics, and over a dozen commercial companies with interests in optical imaging and photosensing. The proceedings are to be published by the American Institute of Physics and should appear later in calendar year 1998, once the editorial process is completed.

In 1996, R. Ruchti was invited to write several summary articles on fiber tracking, one entitled: "The Use of Scintillating Fibers for Charged-Particle Tracking" which was published in The Annual Reviews of Nuclear and Particle Science, Volume 46, pp 281-319 (1996).[5,6] These papers are included in this packet.

III. Epilogue

Scintillating Fiber Tracking technology is now firmly established as one of the important tools for experimentation in science. Pioneered for particle physics experimentation, it now finds application in many scientific and medical disciplines for particle detection and sensing. This research grant from the Department of Energy played an important role in the development, advancement, acceptance and application of this

important research technique. Notre Dame is internationally recognized for its pioneering role in the development and advancement of this field, thanks to the support from the US DOE, the US NSF, The Texas National Laboratory Research Commission, the University of Notre Dame, Fermilab, and US DOE/SBIR, over the nearly two decades span of this research and development program.

IV. Selected Bibliography

For further and more detailed references, the reader is referred to the extensive bibliography contained in reference 6.

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- [1] "Conceptual Design: Scintillating Fiber Outer Tracker", R. Ruchti et al, eds, SDC-92-174, January 1992.
- [2] B. Baumbaugh, et al, "Performance of multiclاد scintillating and clear waveguide fibers read out with visible light photon counters", Nucl Instr. and Methods A 345 (1994) p 271.
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- [4] "SCIFI93: Workshop on Scintillating Fiber Detectors", A. D. Bross, R. C. Ruchti, and M. R. Wayne, eds, World Scientific (1995).
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- [5] R. Ruchti, "Tracking with Scintillating Fibers", Nuclear Physics B (Proc Suppl) 44 (1995) p 308.
- [6] R. Ruchti, "The Use of Scintillating Fibers for Charged-Particle Tracking", Annu. Rev. Nucl. Part. Sci., Vol 46, (1996), p.281.