# PROJECT DESCRIPTION

## Project name: "Polarimetry at LC"

### Personnel and Institution requesting funding

University of Iowa, Department of Physics and Astronomy:
Yasar Onel (professor), E. Norbeck (professor), J.P. Merlo, A. Mestvirisvili, U. Akgun, (post-docs), E. Albayrak, F. Duru, (grad.students), I. Schmidt (mechanical engineer), M. Miller (electronics engineer), M. Smalley, J. Wetzel (undergrad. scholar)

### Collaborators

Fairfield University, Department of Physics:
Dave Winn (professor), V. Podrasky (engineer), C. Sanzeni (programmer)

Iowa State University, Department of Physics:
Walter Anderson (professor)

Forschungszentrum Karlsruhe, Germany:
Robert Rossmanith (professor)

Bogazici University, Department of Physics, Istanbul, Turkey:
Erhan Gülmez (professor)

Cukurova University, Department of Physics, Adana, Turkey:
Gulsen Onengut (professor)

METU, Department of Physics, Ankara, Turkey:
Ramazan Sever (professor)

INFN-Trieste and University of Trieste, Department of Physics, Italy:
Aldo Penzo (professor)

### Project Leader

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### Classification (accelerator: subsystem)

IPBI / Accelerator

**Project Overview**
A high (~80%) and precisely known electron beam polarization is considered as a key feature at LC to detect and unambiguously interpret new physics signals [1]. Accurate measurements of beam polarization will be needed. The goal for the precision polarimetry is 0.25% as explained in [2]. Primary polarimeter is currently envisioned to be similar to SLD polarimeter, measuring the asymmetry of Compton-scattered electrons near the kinematic edge using a threshold gas Cherenkov counter. Our goal for this proposal is to investigate alternate polarimeter schemes.

i) use of a quartz fiber calorimeter (or counter) for either the Compton-scattered gammas or electrons
ii) W-pair asymmetry using forward W-pairs; determining forward detector requirements to do this.

Following the remarkable success of Compton backscattering polarimeters [3] at SLC and LEP, this method is a prime choice also at LC [4].

**Detection schemes**
The performance of electron polarimeters in the challenging environment at LC will crucially depend on the detection schemes for scattered electrons or photons. Quartz Fiber Calorimeters [5] have been proposed for a number of applications in extreme experimental conditions of very severe radiation levels both at hadron and lepton machines. Extensive studies have been carried out for the design of large detectors and realistic beam tests on full scale prototypes [6] have been performed recently. In particular, the Iowa group has been leading an effort aimed at building a very forward QFC (HF) for the CMS experiment at LHC [7] since 1994. The available information and know-how collected give evidence that such a type of detector would respond ideally to the highest level of requirements for a LC polarimeter, as already demonstrated at SLC [8]. QFC are radiation hard at the level of more than 2 Grad. The 0.2 MeV Cerenkov threshold makes the detector insensitive to a large fraction of soft radiation. With high-Z absorber material (for instance tungsten), the showers corresponding to high energy electrons or photons are completely contained in a compact device. Their transverse size is so small to provide an excellent position resolution and angle determination. The flexibility in the QF arrangement and in the PM readout can be matched to the required granularity for space resolution and density for energy resolution. The basic formalism for Compton polarimeter is given in Ref [9].

**R&D Program**
Our R&D study of a QFC designed for a LC polarimeter will largely benefit from our experience on the QF technology and the calorimetry properties of such devices. We gained this experience in the design and tests of the prototypes for the HF calorimeter of CMS. This extensive work background means substantial savings of time, efforts and costs in case of a specific project for a LC polarimeter detector. We will begin our R&D effort with studies and simulations to determine requirements for a QFC polarimeter and investigate its systematics. We will compare single and multi-Compton operation, and compare electron and gamma measurements. We intend to design and build a prototype QFC module of sub-millimetric granularity using multi-anode PMT (16 or 64 channels) for the QF readout. The prototype will be tested over a broad energy range relevant for scattered electrons and backward scattered photons.

We propose to perform detailed simulation and engineering studies during the first year, to investigate the role of this calorimeter for the electron detection and electron energy resolution and photon detection.

We hope to finalize the conceptual design of the polarimeter towards the end of the first year, and during the second year, to start design-studies for W-pair asymmetry and we will completer Compton polarimeter studies, hardware and beam test in the third year.

**Conclusions**

A QFC with optimized granularity and energy resolution for high energy EM Showers appears to be an essential component of an electron beam polarimeter at LC. Its advantages are radiation hardness, soft background rejection, good localization, and directional precision as well as energy resolution. Our group has ample experience with this type of detector, as well as with the use of multi-anode PMT [10]. Such accrued competence gives us complete confidence in our ability to design, build and test a prototype in order to demonstrate its suitability for polarimetry at LC in a timely and cost-effective fashion.

**Relevant Experience**

- Project leaders Y. Onel and A. Penzo have worked in the field of Experimental HEP Spin Physics and polarization for many years. They invented the “Spin Splitter” concept to polarize anti-matter in a storage ring with Robert Rossmanith. R. Rossmanith has also developed and designed the LEP polarimeter.
- Y. Onel and A. Penzo were co-spokesmen for the proposal on Nucleon Spin Studies with polarized proton and anti-proton beams at FNAL (E863). Onel/Penzo have edited two books in the field of spin/polarization physics, namely Spin and Polarization Dynamic in Nucleon and Particle Physics (World Scientific, 1990) and Trends in Collider Spin Physics (World Scientific, 1997).
- Y. Onel and A. Penzo were also involved in the Ultrafast Readout with multi-anode PMT development RD17 at CERN.
- Y. Onel and D. Winn have jointly proposed the quartz fiber calorimetry for the CMS forward Calorimeter (HF) in January 1994 after prototyping the quartz fiber calorimetry using SSC GEM closeout finds. There are now 6 U.S. and 9 international institutions (15 in total) in the CMS-HF group.

- The U.S. CMS HF group at Iowa was responsible for:

1- HF detector prototypes
   a. Engineering design of prototypes and preproduction prototypes and manufacturing the modules and components (in the machine shop at University of Iowa.)
   b. Engineering design and manufacturing of the Readout box for the preproduction modules (in the machine shop at University of Iowa.)
   c. Engineering design and manufacturing of the optical system for the preproduction modules.
   d. Engineering design of the HF calibration system (LASER and LED) and development of source calibration systems for the preproduction modules.
   e. Production and engineering design of the HCAL LED drivers (HB, HE, HO and HF) and manufacture of prototypes in the electronic shop at the University of Iowa.

2- Selection and purchase of US quartz fibers in addition to the responsibilities of procurement procedures, contracts, insurance, quality control at manufacturer (CMS IN 2002/028) and delivery schedules and final delivery.
3- Fiber radiation damage tests and studies at Iowa LIL/CERN facilities
4- Selection and purchase of Photomultiplier Tubes (PMT's) in addition to the responsibilities of procurement procedures, contracts, insurance, delivery schedules and final delivery.
5- Construction of the CMS-HF IOWA PMT test station facility.
6- Test and quality control of the HF PMT's and maintenance of a web-based database.
7- Design and construction of the HF light guides for the first two wedges (2 of 36) in the University of Iowa machine shop. Procurement of the light guide material for the remaining 34 wedges.
8- Design and construction of the source distribution mechanics, including source tubing couplers and coupler pins in the (University of Iowa machine shop.)

**Broader Impact**

The Iowa QuarkNet and other programs that bring high school teachers and their students into the U of I laboratory allows these people to experience the excitement of frontier scientific research. For the US to retain a lead in science and technology it is essential that talented young people become motivated to make a career in physics and related fields.

A major part of the pp program at the ILC is the search for Higgs and SUSY particles, the SUperSYmmetric analogs of the currently known elementary particles. Their production in heavy-ion collisions will provide additional information about these objects. SUSY particles are expected to decay to the lightest SUSY particle, which would be stable and a candidate for the "dark matter" that astronomers claim accounts for most of the mass of the universe.

A massive computer grid is being established to allow individual researchers access to the huge amount of data that will become available when the ILC turns on. In preparation, the U of I is developing grid-computing infrastructure. As a result of these developments a number of U of I faculty in other fields are now using grid computing. This process will be accelerated when real ILC data becomes available.

The study of known, or expected, nuclear phenomena at a much higher energy is good science and will provide a valuable increase our understanding of nature, but there is also the possibility of something totally new. Much of what makes us comfortable today is the result of physics discoveries that were not even conceivable at the time of Isaac Newton.

**Facilities, Equipment and Other Resources**

IOWA HEP Labs, IOWA HawkGrid, Physics machine shop, IOWA Hospitals radiation facility, Fermi National lab, Fermilab test beam facility, Iowa radiation damage measurement facility at CERN PS, CERN test beam facility SPS, Argonne National Lab - radiation facilities.

**Project Activities and Deliverables**

We will concentrate on the Monte Carlo simulations in FY06. We will produce a Report/Research Document showing the results and the details of our Monte Carlo simulations for the specific geometries and configurations as shown in our proposal to design a Cherenkov Calorimeter for LC.

We will initially focus on the simulations/study necessary for developing the detector requirements and estimating systematic errors. If we are successful in 06, we propose to continue with our R&D by constructing a prototype in 07. We will be collaborating with the group of Dr. M. Woods/SLAC and Eric Torrence/U. Oregon on this research.

## References

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[3] L. Piemontese (SLD Collaboration) in Proc. Adriatico Research Conf. on Trends in Collider Spin Physics; Ed. **Y. Onel**, N. Paver and **A. Penzo**; World Scientific Publ. (1997) 129 (and references therein); M.Placidi and R. Rossmanith: in Proc. 8th HEP SPIN Symp. MN; AIP 187 (1988) 1395; also NIM A274 ( 1988) 64

[4] M. Woods, Compton Polarimetry at a 1 TeV Collider, SLAC - PUB - 7744 (1998)

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[6] N. Akchurin, **Y. Onel**, et al., NIM A400 (1997) 267

[7] The CMS Collaboration, CERN/LHCC 97-31 (1997)

[8] S. C. Berridge et al., Proc. 13th Int. Symp. On High Energy Spin Physics (Protvino) (1998); Ed. N. E. Tyurin et al.; World Scientific Publ. (1999) 534

[9] M. Preger in Proc. San Miniato Topical Seminar on New Pespectives and Methods for High Energy Spin Physics; Ed. P.Pelfer and **A. Penzo**; Printed by Servizio Riproduzione INFN Trieste (1983) 227.

[10] RD-17 (FAROS Collaboration: CERN, INFN-Trieste, IHEP-Protvino, LAPP-IN2P3, Kyoto-Sangyo University, **University of Iowa**): Fast Readout of Scintillating Fibres using Position-Sensitive Photomultipliers; see also: V. Agoritsas, **Y. Onel, A. Penzo**, et al. NIM A357 (1995) 78.

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[12] The TESLA Compton polarimeter. V. Gharibyan, N. Meyners, P. Schuler, LC-DET-2001-047, February 2001. Compton polarimetry at a 1-TeV collider. M. Woods, Int. J. Mod. Phys. A 13, 2517 (1998), e-print hep-ex/9802009. Polarimetry at a future linear collider: How precise?. M. Woods, Int. J. Mod. Phys. A 15, 2529 (2000), e-print hep-ex/0004004.

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[14] Status of Linear Collider Beam Instrumentation Design. D. Cinabro, E. Torrence and M. Woods (2003), http://www.slac.stanford.edu/xorg/lcd/ipbi/notes/white.pdf ALCPG-03-0001 (2003).

**Two-year budget**

**Institution:** University of Iowa

| Item | FY06 | FY07 | Total |
|---|---|---|---|
| Other Professionals | - | - | - |
| Graduate Students | $5.3K | $5.3 | $10.6K |
| Undergraduate Students | - | - | - |
| Total Salaries and Wages | $5.3K | $5.3 | $10.6K |
| Fringe Benefits | $.7K | $.8K | $1.5K |
| Total Salaries, Wages and Fringe Benefits | $6.0K | $6.1K | $12.1K |
| Equipment | - | - | - |
| Travel | $4.0K | $12.0K | $16.0K |
| Materials and Supplies | $18.5K | - | $18.5K |
| Other Direct Costs | $.6K | $.8K | $1.4K |
| Total Direct Costs | $29.1K | $18.9K | $48.0K |
| Indirect Costs @ 26% | $7.4K | $4.7K | $12.1K |
| Total Direct and Indirect Costs | $36.5K | $23.6K | $60.1K |

Available equipment: FERA ADC 160 channels, discriminators, DAQ equipment, 1 16-channel H6568 PMTs, and calibration electronics and equipment to test QF Calorimeter (LED systems, Laser systems, PIN diodes systems, and radioactive source calibration)

**THE UNIVERSITY OF IOWA**
**"Polarimetry at LC"**
**(Y. Onel)**

**BUDGET JUSTIFICATION / DETAILED BUDGET**

| | Year 1 | Year 2 | | Year 1 | Year 2 | Total |
|---|---|---|---|---|---|---|
| **SALARIES** | | | | | | |
| Principal Investigator, Y. Onel | | | | | | |
| Professor, summer support | | | | | | |
| months/year: | 0.00 | 0.00 | | | | |
| rate/month: | 10,014 | 10,314 | | $0 | $0 | $0 |
| Postdoctoral Research Associate | | | | | | |
| months/year: | 0.00 | 0.00 | | | | |
| rate/month: | 3,433 | 3,536 | | 0 | 0 | 0 |
| Graduate Research Assistant, 50% time | | | | | | |
| graduates | 1 | 1 | | | | |
| months/year: | 2.53 | 2.48 | | | | |
| rate/month: | 2,083 | 2,123 | | 5,270 | 5,265 | 10,535 |
| Undergraduate Research Assistant | | | | | | |
| hours/year: | 0.00 | 0.00 | | | | |
| rate/hour: | 10 | 10 | | 0 | 0 | 0 |
| Total Salaries | | | | 5,270 | 5,265 | 10,535 |
| **STAFF BENEFITS** | | | | | | |
| Faculty | 27.2% | 28.0% | | 0 | 0 | 0 |
| Postdoc | 14.0% | 16.0% | | 0 | 0 | 0 |
| Grad Res Asst | 14.0% | 16.0% | | 738 | 842 | 1,580 |
| Hourly | 3.3% | 3.3% | | 0 | 0 | 0 |
| Total Staff Benefits | | | | 738 | 842 | 1,580 |
| **EQUIPMENT** | | | | 0 | 0 | 0 |
| **TRAVEL (Domestic)** | | | | | | |
| Participation in scientific conference | | | | | | |
| Trips | 2 | 6 | | | | |
| Persons | 1 | 1 | | | | |
| Days | 5 | 5 | | | | |
| Airfare | 800 | 800 | /trip | 1,600 | 4,800 | 6,400 |
| Hotel&PerDiem | 190 | 190 | /day | 1,900 | 5,700 | 7,600 |
| Car Rental | 50 | 50 | /day | 500 | 1,500 | 2,000 |
| Total Travel | | | | 4,000 | 12,000 | 16,000 |
| **MATERIALS** | | | | | | |
| Quartz Fiber | | | | 5,000 | 0 | 5,000 |
| Copper Absorber | | | | 4,500 | 0 | 4,500 |
| PMT | | | | 9,000 | 0 | 9,000 |
| Total Materials | | | | 18,500 | 0 | 18,500 |

| | Year 1 | Year 2 | Year 1 | Year 2 | Total |
|---|---|---|---|---|---|
| **OTHER DIRECT COSTS** | | | | | |
| Tuition | | | | | |
| graduates | 1 | 1 | | | |
| cost/grad | 2,250 | 3,000 | 633 | 827 | 1,460 |
| Total Other Direct Costs | | | 633 | 827 | 1,460 |
| **TOTAL DIRECT COSTS** | | | 29,141 | 18,934 | 48,075 |
| **FACILITIES & ADMINISTRATIVE (F&A) COSTS** | | | | | |
| Off-campus rate, 26%, applied to Modified Total Direct Cost (MTDC) | | | | | |
| Total Direct Costs | 29,141 | 18,934 | | | |
| Less Exclusions: | | | | | |
| Tuition | 633 | 827 | | | |
| Equipment | 0 | 0 | | | |
| Subs >25,000 | 0 | 0 | | | |
| MTDC by year | 28,508 | 18,107 | | | |
| F&A rate | 26.0% | 26.0% | | | |
| F&A cost | | | 7,412 | 4,708 | 12,120 |
| **TOTAL ESTIMATED COST** | | | $36,553 | $23,642 | $60,195 |