Silicon Drift Detectors:
A new technology for medical imaging

Introduction
Although breast cancer awareness was raised over the last two decades and breast cancer funding has risen strongly, the United States has one of the highest breast cancer rates in the world. Each year 180,000 women are diagnosed and 44,000 women will die of breast cancer. The even more alarming statistic is that about fifty years ago the probability for a woman to be diagnosed with breast cancer during her lifetime was one in fifty (0.2%), whereas today the probability is an alarming one in eight (12.5%). The situation is particularly critical for younger women because the cancer develops faster in younger tissue. The five-year survival rate for localized breast cancer (malignance size less than 15 mm) is over 95% after treatment, whereas the five year survival rate drops to less than 20% for metastatic cancer after treatment. The key is early detection when the malignancies are still sufficiently localized. Presently around 85% of all localized malignancies are detectable with x-ray mammography, and an optimized digital mammography device will be able to further reduce the minimum detectable malignance size. The use of digital radiographic equipment in the medical imaging field is becoming more and more relevant, simply because a digital device allows a lower and shorter exposure phase at similar or even superior resolutions than traditional film/screen devices. It also enables the physician to process and analyze the recorded digital information in a more efficient and computer guided way. Another strong advantage of digital mammography is that the achievable position resolutions (< 20 micron) allow us to measure microcalcifications very effectively. These small deposits of Calcium are the only indication of tumor formation in a large fraction of all cases. The deposits generally do not exceed a spread of more than 1 mm and thus a spatial resolution of better than 50 micron is required for good detection.

The main concern of a widespread application of x-ray mammography is the radiation dose that each patient receives per image. A preliminary study in Europe indicates that x-ray mammography is an effective prevention tool for women of age 50 and older, whereas in younger women the effect of the radiation (potential cell mutations) offsets the benefits of early detection. This cutoff age is obviously directly linked to the actual radiation dose per screening, which was set to 20 mGy/image for women of age 50 and older. In young women the breast tissue is generally denser which reduces the contrast to cancerous tissue and thus a successful mammography session requires higher exposure rates. One of the potential advantages of digital mammography over conventional x-ray mammography is the lower dose requirement.

Proposed Research
We propose to start a mammography device development project on the basis of a new semiconductor technology, Silicon Drift Detectors, which we, over the past decade, have developed for applications in High Energy Physics research. We propose to pair these detectors with a groundbreaking new digital single photon counting device, the Photon Counting Chip (PCC), which was developed over the last five years by the MEDIPIX collaboration in Europe.

The detectors are based on thin layers (250 micron) of high resistivity neutron transmutation doped (NTD) n-type Silicon material. This starting material is subjected to about 100 implantation steps in order to achieve the desired structures necessary for a Silicon drift detector. Over the past ten years these steps were developed by our group at WSU, in collaboration with Brookhaven National Laboratory (BNL) in Long Island, in order to design, construct and operate the Silicon Vertex Tracker (SVT) for the STAR experiment at the Relativistic Heavy Ion Collider (RHIC) at BNL. This Department of Energy funded project was initiated in 1992 as a R&D project, and converted to a construction project in 1996. The detector was completed and installed in early 2000, and since then is part of the very successful data-taking program of the STAR detector at RHIC. The funding for this project extended to 7 Million U.S. Dollars over the full period of eight years, which led to the first mass produced Silicon Drift Detector layout in history.

Our collaboration with a Norwegian semi-conductor vendor, SINTEF, ultimately yielded 250 good, large area (6.3 by 6.3 cm) wafers out of a starting batch of 350 bare wafers. The SVT itself consists of 216 wafers oriented in three concentric barrels around the interaction region in one of the RHIC halls. The SVT detectors are characterized by excellent position (< 20 micron in all three dimensions) and outstanding energy resolution (7% for minimum ionizing particles). All these features are achieved with a moderate coarse-grain (250 micron pitch) one-dimensional readout, which keeps the cost for the detector/electronics...
combination extremely low. In addition the quoted resolutions are for a detector operated at room temperature, which eases the use of such a device in a clinical environment. Many details of the STAR-SVT development can be found in a long series of NIM and IEEE articles [1-14].

Application of such detectors
A digital radiographic device based on silicon technology can be used for a variety of applications, some of which have been described in the recent literature [15]:

1.) the detector can be used for $\beta$-source measurements in 500-1000 keV range, which is the emission range for $^{32}$P, the main DNA marker, in DNA probe arrays.
2.) The detector can be used in nuclear medicine to measure the photon emission spectrum of radioactive markers, such as $^{241}$Am (60 keV photons) and $^{99m}$Tc (140 keV photons), which are most prominent in thyroid treatments.
3.) The detector can be used in dental x-ray tubes where the average photon energy is about 35 keV.
4.) The detector can be used for fast frame medical diagnostics
5.) The detector can be used for digital x-ray mammography with an average photon energy of around 20 keV.

Although all these applications are interesting and could potentially be performed with a single device, we will focus on the mammography application, because each different application requires a slight optimization of the Silicon device. The reviewers should keep in mind, though, that this device is very versatile and can be used in a variety of ways. Besides its immediate application, the mammography device is interesting in a fundamental sense because it tests the performance of any semiconductor device down to its lowest achievable photon energy (10-20 keV). The main argument for low energy photons is two fold: a.) the contrast-to-dose ratio peaks at low energies and b.) the signal-to-noise ratio decreases with photon energy.

Semiconductor for digital mammography
The main features of semi-conductor based digital mammography are:

1.) A wide dynamic range which allows the screening of low and high density tissue with equivalent resolution
2.) A linear response with x-ray exposure
3.) A reduced radiation dose compared to film devices, because the dose depends on the signal/noise ratio rather than the optical density of the film
4.) A reduced exposure (seconds) and analysis (minutes) time
5.) Better image processing due to digitized information

The main limitations of digital systems in the past were slightly worse spatial resolution (digital systems generally show spatial frequency measured in line-pairs per mm of less than 5 lp/mm) and an increased cost for the first few prototypes and their development compared to film based devices. Another initial problem was the lack of availability of large area active Silicon detectors. With the advent of the large drift detectors for STAR, though, we have proven that single wafers of 6 by 6 cm can be produced. The advancements of the semiconductor industry over the last two years indicate that we now should be able to produce 10 by 10 cm Silicon drift detectors. The advantage of drift detectors is that there is no intrinsic scalability limitation. With the existing drift detectors a device comparable in size to a standard x-ray film cassette (18 by 24 cm) could be constructed out of a 3 by 4 (=12) detector array. These detectors will also improve the limitations of spatial resolution, because their intrinsic position resolution of around 20 micron can be translated into a spatial frequency of 25 lp/mm, which is generally superior to the resolutions achievable with existing film devices.
Comparison of different semiconductor materials

The main shortcoming of Silicon for digital imaging is its intrinsically small detection quantum efficiency (DQE) in the relevant x-ray energy range. The DQE rises with the atomic mass of the semiconductor, so Silicon seems to be an especially poor candidate. In fact the quantum efficiency of a standard 300 micron thick silicon wafer is at best a few percent for 30 keV photons. Figure 1 shows a comparison of photon absorption efficiencies for different semiconductor materials. In recent years many groups explored heavier semiconductors, in particular GaAs. At this point, though, the improved DQE of GaAs (in excess of 50%) is offset by the difficulty to actually grow large GaAs wafers and to make them homogeneous. In addition the integration of the electronics is more difficult for GaAs. The vast industrial application palette of Silicon technology and the limited application of GaAs also helps to drive commercial developments based on Silicon rather than GaAs. In addition the latest tests with NTD n-type Silicon material, as used in Silicon Drift Detectors, show that a DQE of close to 25% can be reached for 20 keV photons. For a 1 mm thick detector the DQE should exceed 90%.

**Figure 1:** photon absorption efficiencies for different Z and different thickness semi-conductors

With respect to other Silicon technologies (strip, pixel, and CCD) the drift detector is more cost efficient compared to pixel detectors, radiation harder and faster compared to CCD’s, and has a better position resolution compared to strip detectors.

Pure semiconductor devices also compete with the latest commercial products which are largely based on a hybrid system consisting of a converter (scintillator (indirect) or heavy semiconductors (direct)) and an active detection matrix of amorphous Silicon (a-Si) which measures the visible photons from the scintillator or measures the active charge transfer from the heavy semiconductor. The latest commercial flat panel products use a-Si with phosphor (GE Sengraph 2000D), CsI (OPDIMA Siemens/Thomson CCD) or amorphous Selenium based converters (DIGITAL RADIOGRAPHY CORP. flat panel). In all these cases the hybrid concept constitutes a compromise. Although these detectors have digital output, the light conversion properties of the scintillator based detectors lead to signal degradations similar to the film based devices, and the charge transfer properties of the amorphous semi-conductor devices are inferior to a pure crystalline detector, and thus also lead to a poorer performance.

The major breakthrough in recent years for materials with small to moderate DQE was the development of electronics that allow the counting of single photons. Several years ago a consortium was formed in Europe, consisting of 15 research institutions (universities and National laboratories) from eight countries. This so-called MEDIPIX collaboration is centered at the European Nuclear Research Center (CERN) in Geneva. Its main purpose was to develop a digital medical imaging device based on Silicon pixel detectors and a new readout electronics technology. The first step in this project was the development of the MEDIPIX single photon counting chip (PCC). The chip has shown a remarkable single photon detection efficiency and a large signal to noise ratio when paired with either GaAs or Silicon pixel prototypes. Based on our long-standing collaboration with CERN in the field of relativistic heavy ion physics, the MEDIPIX
collaboration has agreed to collaborate on this proposal in order to combine their electronics with our drift detectors. First tests by MEDIPIX with a Silicon/PCC combination using a standardized phantom of the American College of Radiology (ACR-RMI 156), show superior results to film and even GaAs based detector prototypes under identical dose conditions [16]. Figure 2 shows results from the same test series obtained with a mammographic phantom, consisting of a 10 cm diameter and 4 cm thick Lucite cylinder with embedded Aluminum disks of 4 mm diameter in wax cylinders of 12 mm diameter. The imaging detectors were placed at a distance of about 20 cm behind the phantom and the images were taken, with varying image grid sizes, when the phantom was exposed for 1 sec at an exposure of 32 mAs, which corresponds to a dose of 6 mGy. Silicon, GaAs and film prototypes are being compared.

Figure 2: mammographic phantom image comparison between GaAs, Si, and film based x-ray devices. The images were taken under the same setup conditions and exposure rates.

Generally the x-ray attenuation properties of malignancies are very similar to normal tissue. Therefore, to maximize the radiological contrast, digital mammography is carried out with low energy spectra, which require a relatively high dose (2-20 mGy per image). Based on first calculations we believe that we can reduce the average dose required by a standard x-ray film by about a factor 4-5 without losing any spatial resolution, when using a Silicon drift detector with a 200 by 200 micron pixelation.

Details of proposal work plan

We propose to build an x-ray sensing element out of a Silicon drift detector diode, reversed biased, and coupled to an electronics readout system which allows to convert a charge signal from the detector to a digital pulse. The prototype readout system will be a PCC provided by the MEDIPIX collaboration. This chip is optimized for Silicon pixel detectors and thus part of our research will be to determine possible optimization of the electronics for drift detector applications. The first step of the proposal will be a proof of principle that a drift detector can be used for x-ray mammography. One of the potential problems in a drift detector is to process the two dimensional information (position and drift time) directly at the frontend chip. First tests in Europe, with a so-called controlled drift detector (CDD) have shown that this is a solvable problem, which would also allow us to use such a device for fast frame diagnostics [17]. As a second step will attempt to integrate the MEDIPIX chip in a fashion that allows two-dimensional readout in a short readout time. Third, we will investigate how an increase in the thickness of the silicon wafer, which will improve the detection quantum efficiency, affects the resolution and the dose requirements as well as the operating conditions. Fourth, we will run tests on the performance of our prototype devices in comparison to existing film based and a digital mammography detector.
References

[1] "Silicon Drift Detectors, present and future prospects"
J. Takahashi et al., Nucl. Instr. and Meth. A461 (2001) 139

[2] "Silicon Drift Detectors as tracking devices"

[3] "The STAR Silicon Vertex Tracker: a Large Area Silicon Drift Detector"

R. Bellwied et al., Nucl. Inst. and Meth. A439 (2000) 507

[5] "Silicon Drift Detectors for the STAR/SVT experiment at RHIC",

[6] "Radiation damage studies with STAR Silicon Drift Detectors"

[7] "The STAR Silicon Drift Vertex Detector",

[8] "Two Dimensional Studies of Dynamics of Electron Clouds in Silicon Drift Detectors.",

[9] "Studies of Ionizing Radiation Effects on STAR Silicon Drift Detectors"

[10] "Electron Injection in Semiconductor Drift Detectors"


[12] "Behavior of Silicon Drift Detectors in Large Magnetic Fields"

R. Bellwied et al., Nucl. Inst. and Meth. A400 (1997) 279

[14] "Development Of Large Linear Silicon Drift Detectors For The STAR Experiment At RHIC",

[15] Radiation Detectors in medical and biological applications

[16] Measurement with Si and GaAs pixel detectors bonded to photon counting readout chips
A. Schwarz et al., Nucl. Instr. And Meth. A 466 (2001) 87

A. Castoldi et al., Nucl. Instr. And Meth. A 461 (2001) 40
Biographical Sketch

<table>
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<tr>
<th>Name</th>
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<tr>
<td>Rene Bellwied</td>
<td>Professor of Physics</td>
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**Education/Training**

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<tr>
<td>Johannes Gutenberg University, Mainz, Germany</td>
<td>B.A. Chemistry</td>
<td>1984</td>
<td>Nuclear Chemistry</td>
</tr>
<tr>
<td>Johannes Gutenberg University, Mainz, Germany</td>
<td>Ph.D. Physics</td>
<td>1989</td>
<td>Nuclear Physics</td>
</tr>
<tr>
<td>SUNY Stony Brook, New York</td>
<td>Research Associate</td>
<td>1989-91</td>
<td>Nuclear Physics</td>
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**Research and Professional Experience.**

- 2002 – present  Professor of Physics (tenured), Physics Department, Wayne State University, Detroit, MI
- 1996 – 2002  Associate Professor (tenured), Physics Department, Wayne State University, Detroit, MI
- 1992 – 1996  Assistant Professor, Physics Department, Wayne State University, Detroit, MI
- 1991 – 1992  Research Associate, Physics Department, Wayne State University, Detroit, MI
- 1989 – 1991  Research Associate, Physics Department, SUNY Stony Brook, Stony Brook, NY

**Awards:**

- 1989 – 1991  Feodor Lynen Fellow of the Humboldt Foundation
- 1998  Career Development Chair of Wayne State University
- 2002  Teaching Award of Wayne State University

**Professional Publications.**

*Summary of number of published publications in recent years.*

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<th>Year</th>
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<td>1999</td>
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</table>

*Selected Publications of relevance to this project:*

- "A 240 channel Thick Film Multichip Module for Readout of Silicon Drift Detectors", D. Lynn et al., Nucl. Instr. and Meth. A439 (2000) 418


**Selected Physics publications (results obtained using the proposed detectors):**

- "First Results from the H0-Dibaryon Search and Hyperon Production Measurements by the AGS Experiment E896 ", H. Caines et.al., Nucl. Phys. A661 (1999) 170c

**Expertise Summary**

I have obtained my Ph.D. in Germany in 1989 on the topic of the search for superheavy elements. During my Ph.D. as well as in my time as a Research Associate at SUNY Stony Brook I developed an additional interest in detector development, in particular semi-conductor detectors that provide high precision position and energy information when traversed by charged particles or photons of a wide range of energies. From 1989 on I was heavily involved in the realization of the Relativistiv Heavy Ion Collider (RHIC) at Brookhaven National Laboratory (BNL) on Long Island. RHIC is the largest project the Nuclear Science division of the Department of Energy has ever funded. From its original conceptual design in 1989 it took a group of around 1000 scientists ten years to build the accelerator and the four detectors chosen to perform measurements at this facility. The main purpose of RHIC is to collide heavy ions traveling with close to the speed of light in order to recreate the Big Bang of the universe in the laboratory. The unique features of these heavy-ion collisions are the immediate production of a very large number of elementary particles (up to 5,000 particles can be measured from a single Gold ion on Gold ion collision) and the high collision probability, which requires the detectors to process the recorded information in the shortest possible time. The large number of particles requires very high precision in the position determination because the particles all originate from a single point in space and thus the particle separation after a very short flight path is on the order of only a few tens of microns.

Based on my expertise I was named the project leader for the Silicon Vertex Tracker (SVT) for one of the big experiments (STAR) at RHIC in 1992. The SVT was an eight year project with a $7 Million Budget, fully funded by the Department of Energy. The collaboration formed by me in order to realize this project consisted of 50 scientists, engineers, designers, and technicians from ten national and international institutions (Wayne State University, Ohio State University, Lawrence Berkeley Laboratory, Brookhaven National Laboratory, UT Austin, UW Seattle, University of Sao Paulo (Brazil), Warsaw Polytechnical University (Poland), Warsaw University (Poland), and SUBATECH Nantes (France)). The main technical goal of the project was to develop the first large area tracking and vertexing device based on Silicon Drift Detectors, a new technology, which was developed and prototyped by my group at Wayne in close collaboration with the Instrumentation Division at Brookhaven National Laboratory. The concept of drift detectors was first proposed by BNL engineers in the late 80’s and our group had developed prototypes which showed that this technology, if further developed, might be superior in performance to many widely used Silicon technologies, e.g. CCD’s, Silicon pixel detectors, Silicon strip detectors. I was the project leader of the SVT project until its successful completion in 2000. The detector is now part of the STAR experiment and had its first successful data run in 2001. The results show that these complex devices can now be mass-produced by a select group of companies in the world and that the detector performance indeed shows superior results to other semi-conductor devices. Part of my group is now operating and analyzing the SVT. The other part is looking for applications of this new and exciting technology. Over the years we were approached by several commercial companies, which are specializing in imaging devices. From these discussions as well as peer discussions at imaging conferences it seems obvious that this technology has a strong future in imaging applications.

**Specific expertise:**

a.) Head of Silicon testing facility at WSU Physics (includes clean room facility)
b.) Head of WSU silicon design group and detector simulation group
c.) Directed three Ph.D. and three masters students to successful theses on topics related to the proposed research
Biographical Sketch

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<tr>
<td>Claude A Pruneau</td>
<td>Associate Professor</td>
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Education/Training

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<td>Universite Laval</td>
<td>Ph.D.</td>
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<td>Nuclear Physics</td>
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- **Research and Professional Experience.**

**Positions:**
Wayne State University, Associate Professor (Tenured), 1999-
Wayne State University, Assistant Professor (Tenure Track), 1993-1999
Wayne State University, Assistant Professor (Research), 1992
McGill University (Montreal, Canada), Research Fellow, Sept 1989 – Aug 1992
Atomic Energy of Canada Limited, Chalk River Nuclear Laboratories, Chalk River, ON, Canada., Research Fellow, Sept 1987 – Aug 1989

**Awards:**
FCAR PhD Fellowship (Quebec), 1986.
PhD Fellowship from the Canadian National Sciences and Engineering Research Council, 1984-1986.

- **Professional Publications.**

**Summary of number of published publications in recent years.**

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**Publications of particular relevance for this project:**

- "Two Dimensional Studies of Dynamics of Electron Clouds in Silicon Drift Detectors."

Selected Recent Publications:


• Expertise Summary.


Directed three PhD and two M.Sc. students who have successfully completed their degree. Currently advising one M.Sc. student. Co-PI of an NSF Research Experience for Undergraduates (REU) and Teachers hosted at National Laboratories; 30 undergraduates and 12 teachers have so far been part of our program.
BIOGRAPHICAL SKETCH

NAME
Donald J. Peck

POSITION TITLE
Division Head, Physics and Engineering

EDUCATION/TRAINING (Begin with baccalaureate or other initial professional education, such as nursing, and include postdoctoral training.)

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<td>Oakland University, Rochester, Michigan</td>
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<td>Wayne State University, Detroit, Michigan</td>
<td>MS</td>
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<td>Radiological Physics</td>
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<tr>
<td>Oakland University, Rochester, Michigan</td>
<td>BS</td>
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</table>

Professional Experience

- Division Head, Physics and Engineering, Radiology, Henry Ford Health System, Detroit, MI, 1/99-present
- Radiation Safety Officer, Henry Ford Health System, Detroit, MI, 4/00-present
- Adjunct Instructor, Diagnostic Radiological Physics, Wayne State University, Detroit, MI, 8/94-present
- Medical Physicist, Radiology, Henry Ford Health System, Detroit, MI, 1/94-12/98
- Senior Research Assistant, Image enhancement and analysis, Henry Ford Hospital, Detroit, MI, 10/88-1/94

Publications


**Research Projects Ongoing or Completed During the Last Three Years**

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<td>M. Chopp</td>
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<td>06/31/00</td>
<td>NIH-NINDS: Center for Stroke Research – Core B</td>
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BIOGRAPHICAL SKETCH

NAME  
Michael J Flynn, Ph.D.

POSITION TITLE  
BioScience Professor

DOB  
4/6/45

RESEARCH AND/OR PROFESSIONAL EXPERIENCE:

Employment:
1974 - 1981 Sr. Radiological Physicist, The Mt. Sinai Medical Center of Cleveland
1981 - 1983 Assistant Prof. Dept. of Radiology, University of Michigan, Ann Arbor, MI
1983 - 1993 Head, Division of Radiologic Physics, Dept. of Radiology, Henry Ford Health Sys., Detroit, MI
1993 - present Director of Research, Department of Radiology, Henry Ford Health System, Detroit, MI

Teaching Appointments
1977 - 1980 Clinical Instructor, Radiology, Case Western Reserve University
1980 - 1982 Assistant Clinical Professor, Radiology, Case Western Reserve University
1981 - 1983 Asst. Prof. Of Radiology, University of Michigan, Ann Arbor, MI
1983 - present Professor (Adj.), Nuclear Engr. and Radiological Science, Univ. of Michigan, Ann Arbor, MI

HONORS:
Sigma Xi: 1967
Summa Cum Laude, Princeton University: 1967
Tau Beta Pi, Princeton Chapter 1971
National Science Foundation Trainee 1970, 1971

Other Active Support
R01-AR47994 (PI: Flynn) 9/01/2001 – 8/31/2004
NIH/NCRR Project: “Quantitative microTomography of Bone Trabeculae”,

Selected Publications


**Totals:** Publications (34), Scientific Exhibits (16), Patents (1), Proceedings (62), Abstracts (131)
Biographical Sketch

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<tr>
<td>Frank Van den Heuvel</td>
<td>Associate Professor</td>
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Education/Training

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<td>University of Antwerp - Belgium</td>
<td>M Sc</td>
<td>1980-1987</td>
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<tr>
<td>Free University of Brussels</td>
<td>PhD</td>
<td>1994-1995</td>
<td>Physics</td>
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Research and Professional Experience:

2002 - present  Associate Professor, Wayne State University, Radiation Oncology, Detroit, Michigan
2000 - present  Adjunct faculty, Institute for Scientific Computing, Wayne State University, Detroit, Michigan
1999 - present  Director of Informatics, Gershenson Radiation Oncology Center, Harper Hospital, Detroit, Michigan
1996 - present  Physicist, Gershenson Radiation Oncology Center, Harper Hospital, Detroit, Michigan
1999 - 2002     Assistant Professor, Wayne State University, Radiation Oncology, Detroit, Michigan
1996 - 99       Adjunct Assistant Professor, Wayne State University, Radiation Oncology, Detroit, Michigan
1990 - 95       Head of Physics Division, Department of Radiotherapy, Academic Hospital, Free University of Brussels
1989 - 90       Junior Physicist, Department of Radiotherapy, Academic Hospital, Free University of Brussels
1988 - 89       Programmer - Analyst, Seagha C.V. Software cooperation for the Port of Antwerp
1987 - 88       Teacher, Undergraduate level mathematics and physics, Royal Cadet School Lier (Belgium) (Compulsory Military Service)

Professional Publications:


Expertise Summary:

My current area of expertise is the application of novel technology in the field of radiation oncology, in particular imaging. The use of imaging in radiation oncology is important to accurately define the extent of the disease, to follow the progression of the disease under treatment and to help guide the treatment itself. The combination of these factors allows to treat patients to higher doses while maintaining the same or even lower levels of complications increasing the standard of life of the patient.
Biographical Sketch

Name  
Sadek A. Nehmeh

Position Title  
Post-Doctor Fellow

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| Memorial Sloan-Kettering Cancer Center  
New York, NY 10021 | Post-Doctor Fellow | 2000-Present | Nuclear Medicine/Radiation Therapy |
| Wayne State University  
Detroit, MI | Ph.D. | 1995-2000 | Nuclear Physics |
| Wayne State University  
Detroit, MI | Pursuing M.S. | 1998-2000 | Medical Physics |
| American University Of Beirut  
Beirut, Lebanon | B.S. | 1990-1993 | Physics |

Research and Professional Experience.

1995-2000  
Ph.D. Graduate Student, Wayne State University, Detroit, MI

2000-Present  
Post-Doctor Fellow/Resident, Nuclear Medicine/Radiation Therapy, Memorial Sloan-Kettering Cancer Center, New York, NY

Radiology:

- Specialty: PET
- QA: Combined PET/CT (GE-Discovery LS and CTI Biograph), PET (GE Advance), CT, SPECT

Radiation Therapy:

- Treatment Planning: 3DRT, IMRT, Stereotactic Radio-Surgery
- QA: 2100EX Linac, and Brachytherapy units.
- Brachytherapy: LDR Prostate, HDR Prostate, IORT, Sarcoma, eye plaque, seed calibration.

Radiation safety:

- Laboratory survey, radioactive material waste, and shielding calculations.

Teaching:

- Fall 2001: Basic Physics - Radiation therapy technical school - Memorial Sloan-Kettering Cancer Center.

1995 - 1997: Graduate Teaching Assistant - Wayne State University.

Other Experience:

- 1997 - 2000: Graduate Research Assistant at Wayne State University.

Awards

1. American Association of Physicists in Medicine (AAPM2001) Award for Young Investigator (3rd place).

2. Radiological and Medical Physics Society of New York (RAMPS2001); Young Investigator (3rd place).

Professional Publications.

1. Book Chapter: “Radiotherapy Treatment Planning with PET” in “Nuclear Medicine in Clinical Diagnosis and Treatment”, Erdi Y. and Nehmeh S., 3d edition, by Ell and Gambhir (work in progress)


Expertise Summary.

Currently, I am developing and investigating a new method to account for the internal motion artifacts in PET images of lung cancer. This is named the Respiratory Correlated Dynamic Acquisition (RCDA). This work is being integrated with a corresponding method developed by General Electric Medical Systems to achieve the same goal in CT imaging. The whole project is also in collaboration with Varian Medical Systems. Both methods are being implemented and investigated on the GE Discovery LS PET/CT scanner. The new method, i.e. RCDA, when compared to our previous developed method (Respiratory Gating) has the advantage of acquiring the PET data retrospectively, allowing drop irregular data from the final reconstructed image. This new method also would allow the use of the whole acquired data set, compared to just 10% in the old method, which allows a pronounced improvement in the signal-to-noise ratio. This is attained by using a new software, that I am currently developing, in order to reposition the disturbed events back to their proper positions, relative to a reference position, register the position-corrected data, and then reconstruct the full data image.

My work also involves Monte Carlo studies in PET imaging, which involve mainly the development of a new detector technology based PET scanner, aiming to improve the sensitivity and the resolution.

On another hand, my work also involves performing QA checks on both PET and CT of a CTI Biograph and a GE Discovery LS combined PET/CT scanners. I am also in charge of applying different clinical protocols, in particular application of PET images in Radiotherapy planning, image registration of different modalities, and respiratory gating. Moreover, I am involved in designing Radiotherapy plans in the Radiation Oncology department.

Prior to joining Memorial Sloan-Kettering Cancer Center, I was a graduate student within the Nuclear Physics group at Wayne State University, in Detroit, MI. As a graduate student, I was a member of the Experiment 896 collaboration. E896 is US department of energy experiment that took place at the AGS at Brookhaven National Laboratory in Long Island, New York. My Ph.D. work aimed to measure the transverse polarization of the Lambda hyperon in an 11.6 Gev/c Au+Au collision, using a novel technology, named the Silicon Drift Detector Array (SDDA). In this work I was involved in multiple hardware and software tasks, which include detector processing, and testing. I was also involved in developing multiple software packages for data analysis.