Preface

In today's Western world, sustainable employability is vital for the economy as well as employees themselves. Both employers and employees must cope with fluctuating demands regarding flexibility and changing job requirements both now and in the future. Sustainable employability includes an employee's capability to participate in present and future jobs while preserving good health and well-being. Its significance extends to retirement and the challenges and opportunities of aging.

Sustainable employability requires a supportive work environment in order to avoid accumulated stresses over time as well as maintaining a person-job fit. Monitoring the personalized accumulated stress structure (PASS) has been recently developed. It is based on modern health models and the implementation of new developments in preventive biomedicine and biophotonic technologies. It can now personalize a vitality profile facilitating subtyping plus differentiated advice.

The exciting and rapidly expanding field of interdisciplinary scientific research regarding biophotonics and biophotons is becoming the optical science and engineering for the twenty-first century. The field focuses to understand life processes by reading the language of the ultra-weak spontaneous emission from living cells, tissues, and man. It is the result of multi-disciplinary cooperation of chemists, physicists, biologists, engineers, medical doctors, and other healthcare professionals. It demonstrates our capacities to detect human stress offering great hope for the detection of early changes in the "health to disease" continuum.

This text is aimed to lead the reader (as painlessly as possible) into an understanding of what biophotons are, how they are generated, and how they are involved in life. Having established this basis, the text also covers recent developments both in systems biology and systems medicine (including the recent biophoton developments in health, stress, and disease). Such critical evaluations focus on the utilization of this knowledge to educate biomedical personnel and a new generation of researchers in the field of sustainable employability plus aging. Thus, it helps us to understand the philosophy of this preventive biomedicine as well as the background and non-invasive, scientifically valid technology to detect a person's stress structure.

We believe that this approach arrives at a good time when also large companies are moving to another type of interaction between companies and employees. For decades, companies practiced a rigid system of ranking employees. Formally known as the "vitality curve" (but more frequently called

"rank and yank"), the system hinged on the annual performance review boiling the employees' performance down to a number. Along with its rank and yank policy, most companies pushed people extremely hard. However, in recent years, large companies are positioned in the middle of a big shift opting for a less regimented system and more frequent feedback (e.g., via an app).

Often employees and employers who experience difficulties in their sustainable employability do not feel secure enough to discuss the issues (e.g., poor health, a decline in motivation, or difficulty in keeping up with their work) or may be insecure where the dividing line exists between private or business related problems. Such developments might be helped by beginning a dialogue between the employee, employer, or supervisor based on objective information. The rollout is going to be slow. However, it is important to initiate a company's cultural shift towards actively alienating employees based on a more critical understanding of human stress, energy structure, and motivation.

We, the authors, have tried to maintain a relaxed and conversational prose in the book without being excessively colloquial. This style makes it easier to convey to the reader our own excitement and enthusiasm for the intellectual challenge of the present technology. We hope that we have succeeded.

Before beginning, we like to offer a few words of advice:
—Be prepared to learn a multi-disciplinary vocabulary. The understanding of biophoton facts requires that you learn a little biological, biochemical, physics, photonics, and biomedical vocabulary. As with any new discipline, the more familiar you are with the vocabulary, the more easily you can learn and appreciate the discipline's potential.
—Each chapter begins with an introduction describing what a reader will discover. Each chapter ends with a take home message. The book emphasizes referencing. Specific referencing is more difficult than it seems because many of the statements made are distilled from several published papers and interpreted through the scientific experiences (or prejudices) of the authors. Each major statement in the text is now provided with some references placed at the end of each chapter. We hope that experts will forgive us if they find that their pet paper is not cited.

Acknowledgements
In order to author this text (a very broad range of very new topics), we received help from a large number of professors, associate-professors, and senior scientists. We owe a special debt of gratitude to: Rajendra P. Bajpai (North Eastern Hill University, Shilong India), Jan van de Greef (Leiden University, Leiden, The Netherlands), and Masaki Kobayashi (Tohoku

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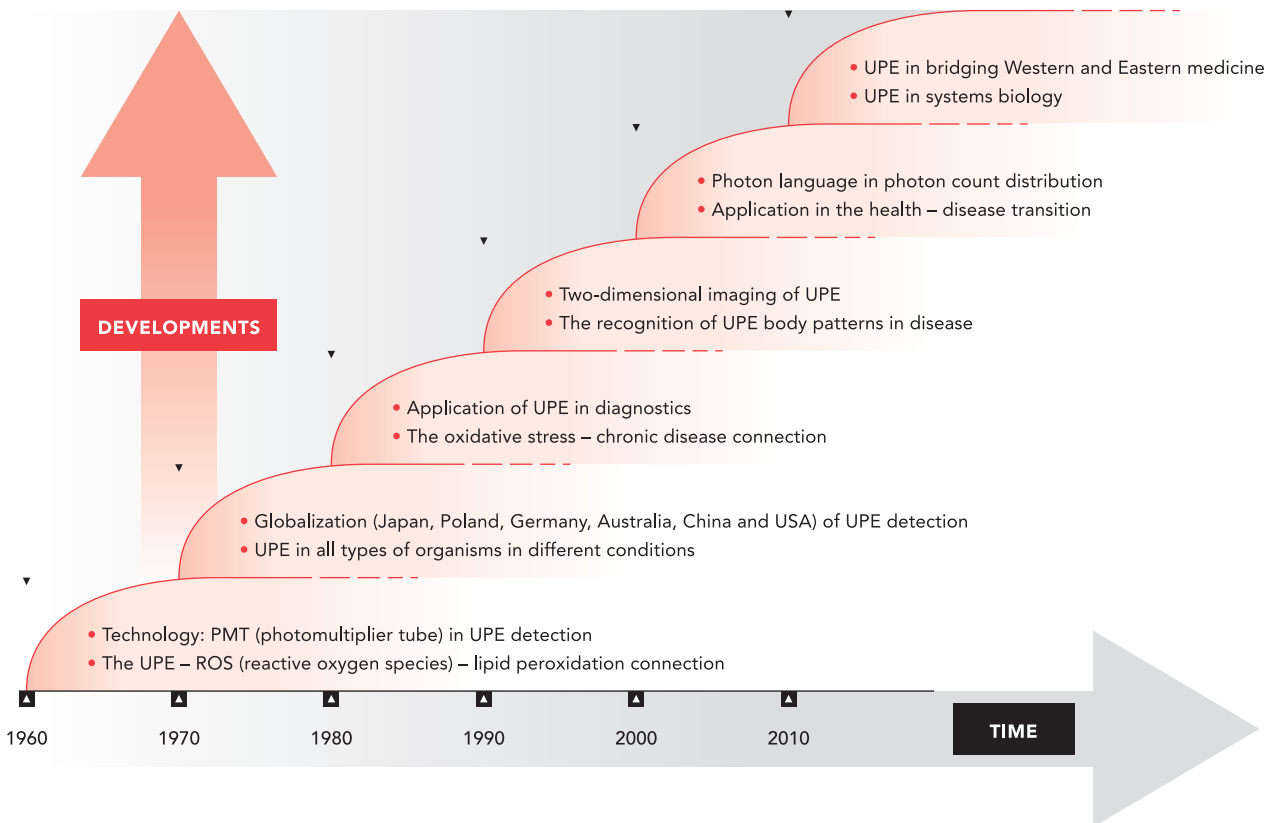
Contents

Prelude

This text addresses the present state of knowledge and technology that non-invasively assess and effectively utilize ultra-weak photon emission (UPE) in order to address a person's vital energy (vitality). Different scientific disciplines have contributed to the above beginning as early as 60 years ago.

The major developments over those six decades are displayed in Figure 1. Over time, research into ultra-weak photon emission within living organisms has developed a mature special detection methodology, and as such, it is now uniquely positioned to provide insight regarding the mechanisms of such phenomena. Detailed biochemical studies have demonstrated that ultra-weak photon emission is closely connected (in lipid metabolism) to both free radicals and their related reactive oxygen (and nitrogen) species. Physical studies demonstrated that photon emission from living organ-

Figure 1
Six decades of biophoton technology.



isms display fluctuations of a non-classical nature (which may represent the metabolic state from which they originate).

The above mixture of scientific knowledge has actually blocked the introduction of photon emission in general biology and medicine. However, this development has been the subject of many publications in international scientific journals. The reader interested in a more detailed background should be referred to a few references published since 2005 (Table 1).

This text addresses the possibility of diagnostic use of ultra-weak photon emission in humans. The potential diagnostic use of such emissions has been considered to reflect the complexity and dynamics of the biological system (as a whole) including its fields of metabolic substances and photon energies. The photon signal of such a system may contain certain features regarding human vitality. Such a photon signal property is important in order to discriminate states of fatigue, burnout, and other phenomena (wherein the organism is no longer capable to maneuver its energy).
The stepwise scientific development and validation of this human phenomena will be discussed utilizing "building blocks" of knowledge in order to erect a stable (evidence based) structure. Utilizing a temple as a metaphor, the strength and qualities of the foundation are important in order to conceptualize the types of pillars to erect. Pillars are constructed from building blocks positioned on top of each other (Figure 2).

Table 1
Recent books on biophotons and biophotonics.

Year	Title	Editors	Publisher
2005	*Optical Science and Engineering for the 21st Century*	X. Shen, R. Van Wijk	Springer, New York, USA
2007	*Biophotonics and Coherent Systems in Biology*	L.V. Beloussov, V.L. Voeikov, V.S. Martynyuk	Springer, New York, USA
2014	*Light in Shaping Life – Biophotons in Biology and Medicine*	R. Van Wijk	MeLuNa Research, Geldermalsen, The Netherlands
2015	*Fields of the Cell*	D. Fels, M. Cifra, F. Scholkmann	Research Signpost, India

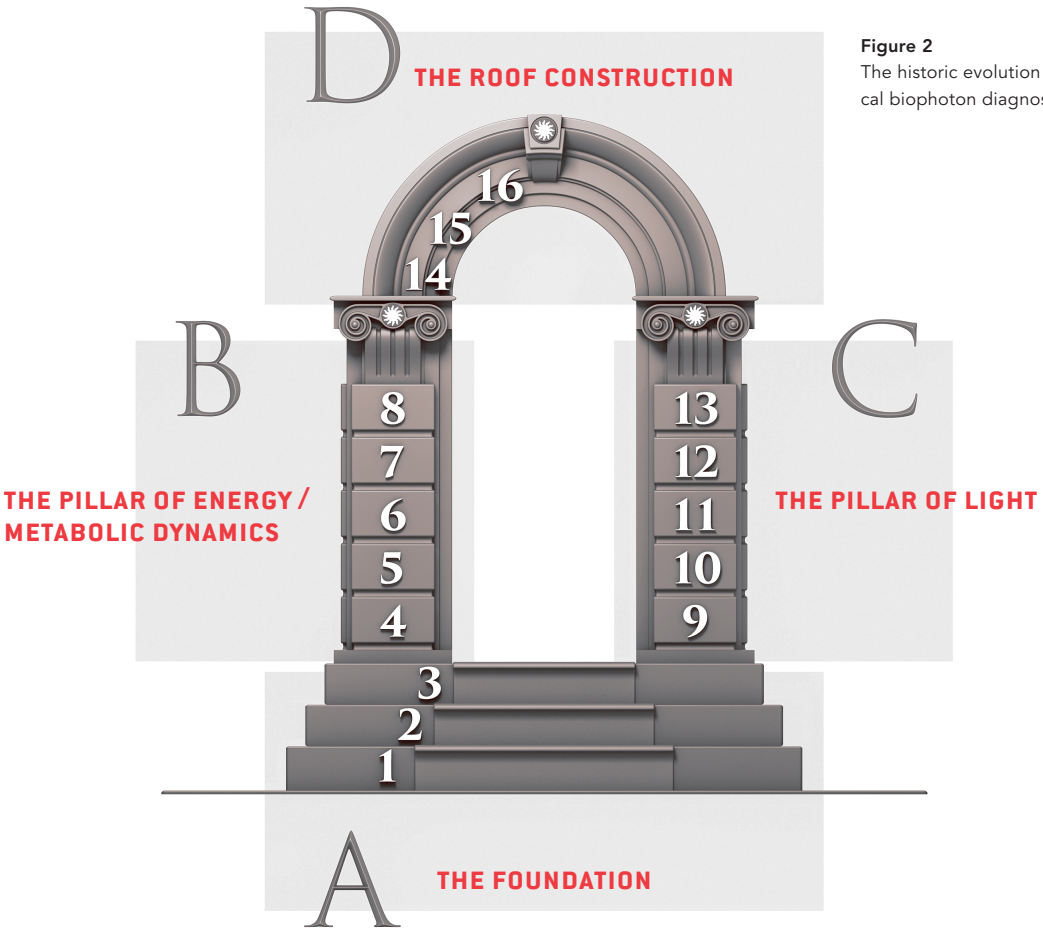


Figure 2
The historic evolution of a clinical biophoton diagnostics.

We will discuss two major pillars. One leads to our actual knowledge about an energy/metabolic dynamic state. By having reached the top of such a pillar, science then defined and clarified principles that currently direct our thinking about (a) human energy storage and mobilization plus (b) what is disturbed during stress resulting in a lower capacity to mobilize energy (i.e., fatigue and burnout).

The other pillar is light (known as the photon pillar). That pillar also has grown, stone by stone, vis-à-vis revised technologies (and experimental verifications). Both pillars support a roof that encloses the entire function for which it was built.

The objects of each part

Part A – The foundation

The research tool necessary to capture and then understand energy and the vitality diagnostics of human beings is biophoton technology. Only, if such

D

THE ROOF CONSTRUCTION

16 • An Elaborated Systems Biology Based Model of Vitality

15 • A Health Model including a Personalized Accumulated Stress Structure (PASS)

14 • Stress in Man: Living in a Loud, Bright, Fast, Tight, Chemical, and Scientifically Managed World

B

THE PILLAR OF ENERGY / METABOLIC DYNAMICS

8 • Oscillations at Large

7 • Life, Energy, and Coherence

6 • Dynamics of Metabolic and Information Networks

5 • Organization of Metabolism: A Hierarchical Network

4 • Metabolic Chart and Regulatory Principles

C

THE PILLAR OF LIGHT

13 • Human Photon Recording in Clinical Practice

12 • Study of the Human Photon Signal vis-à-vis Stress Reduction

11 • Advanced Protocol Regarding Human Emission Research and Photon Analysis

10 • Fano Factor in Human Photon Emission

9 • Human Photon Recording Technology in Stress

THE FOUNDATION

PART A

Introduction Part A

The research tool necessary to capture and then understand energy and the vitality diagnostics of human beings is biophoton technology. The technology focuses on the endogenous, spontaneous light emission from metabolism present in all living plants, animals, and human beings.
Part A has been limited to the core knowledge of classic biophoton science. It is the foundation that will be used to build the pillars of novel information regarding the metabolic state (pillar of energy/metabolic dynamics) and the photon technology (pillar of light).

Chapter 1 —reviews the early history of biophoton technology in relationship to stress focusing on cells, plants, and (small) animals. The history of photon research in biology began with the application of sensitive photomultiplier tools. It started, in the 1960's, in Russia, then spreading worldwide. Around 1980 it was concluded that all organisms emit photons. The intensity was related to stress and was derived from oxygen radicals.

To consolidate the initial fundament, two extra layers have been constructed in *Chapter 2* and *Chapter 3* before the fundament was considered to be scientifically sound for the erection of the pillars:

Chapter 2 —reviews the cell physiology as well as biochemistry of photon emission.

Chapter 3 —reviews the classic biochemistry of photon metabolism, including the processes of photon emission as well as photon absorption. Concluding *Part A*, we consider the possibility of using this fundamental knowledge to further construct an evidence-based science of vitality diagnostics.

1

Early History of Photon Research in Relationship to Stress

The first documentations of radiation emanating from living organisms utilizing photoelectric detectors was in the 1930's. The early data were not convincing and raised doubt about methodology. Although some researchers proved the existence of radiation, others were unable to find such an effect. The actual history of photon research in biology and medicine began when, in the early 1960's, several Russian groups utilized a sensitive photomultiplier tube to study the photon emission from biological organisms and tissues. It took until the early 1970's outside of the USSR for photomultiplier equipment to be in demand by research laboratories eager to study ultra-weak photon emission from biological organisms. The research finally began to provide experimental data from three groups spread over the world: Japan, Australia, and Poland. They were shortly followed by teams in Germany, USA, and China (Figure 1.1). Each research team was specialized in a particular field of biology. Photon technology was therefore applied in many disciplines of biology. Around 1980, it was concluded that all organisms (from bacteria to man) emit photons. For a full description of the history on photons in biology and medicine, the reader is referred to *Light in Shaping Life: Biophotons in Biology and Medicine* (2014).

Russian history of photon research in stress

The group headed by Tarusov focused on seedlings of plants. Their data demonstrated the extent to which the intensity of photon emission is dependent on the concentration of oxygen in the atmosphere. Regarding the influence of stress on ultra-weak photon emission, the Tarusov team evaluated the temperature dependence of photon emission. The seedlings were allowed to germinate at temperatures roughly between -8°C and 50°C. At each temperature between approximately 0°C and 40°C, the intensity of the seedlings remained in a steady state emitting photons at a constant level. This level rose with increasing temperature. However, there was an "upper critical temperature" beyond which no steady state could exist. At temperatures between 40°C and 45°C the intensity of emission began to fall. When temperatures rose further, another phenomenon appeared. Photon emission increased again between 45°C and 50°C. Thermal death of the seedlings occurred in the region of maximum radiation. A similar behavior was detected in the lower temperature range. The emission became minimal

2

Photon Emission Mechanisms

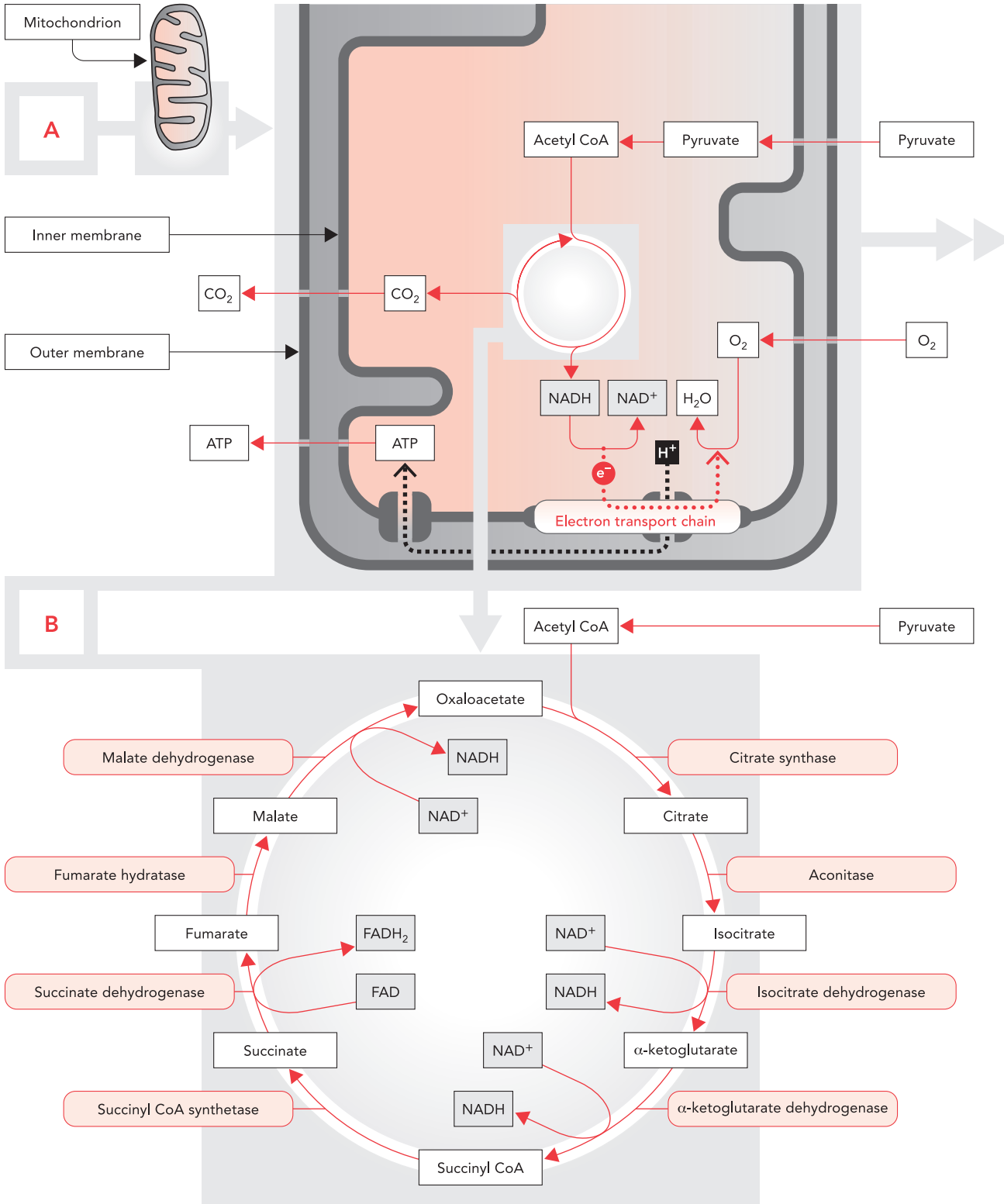
The emission of ultra-weak light is not limited to living organisms. In the field of chemistry, several reactions have been identified regarding photon production. It eventually resulted in the sub-discipline of chemiluminescence. Principally, the whole process of chemiluminescence begins with chemical reactants subsequently followed by the emerging chemical formation of an excited molecule which then shifts to its ground state emitting a photon. A more detailed description of the basic concepts of luminescence and terminology is presented in *More about 2.1.*

Mitochondria as sources of cellular photon emission

In searching for biological compounds that could produce chemiluminescence, Tarusov and Zhuravlev demonstrated (in the early 1960's) that up to 75% of the total emission (in the visible spectrum) from tissue homogenates was due to reactions associated with oxidation of lipids. The emission from lipids stretch from the blue part of the spectrum to the infrared. Some understanding of what causes such an emission slowly increased as the result of carefully controlled homogenization procedures that break up cells and tissues. Such procedures facilitated cell organelles to remain intact (depending on the protocol) and hence, facilitated the study of which cellular parts were responsible for the photon emission. Mitochondria seemed to be a main source of photon emission. According to Vladimirov and L'vova (1964), the luminescence of mitochondria is associated with oxidative phosphorylation. When ATP, oxidation substrates, or oxygen were excluded from the medium in which the mitochondria were incubated, a reduction (or disappearance) of emission was observed.

To better understand the mechanism of photon generation by mitochondrial oxidative phosphorylation requires a more detailed discussion of this organelle (Figure 2.1). The oxidative phosphorylation activity of each individual cell is distributed among many mitochondria. The number and shape of mitochondria in cells are not fixed. Human liver has ~2,500 mitochondria per cell and human nerve cells up to ~10,000. During the life cycle of a cell, mitochondria divide and fuse. They have a life time between 5 and 31 days depending on the cell type. Mitochondria contain two membranes (Figure 2.1.A). The outer membrane encloses the inner membrane which exhibits invaginations (cristae) arranged perpendicular to their long axis. The volume of these invaginations is proportional to their metabolic activities. Invaginations are thin within inactive mitochondria. However, in

Figure 2.1


Mitochondrion
A
Inner membrane
Outer membrane
Acetyl CoA
Pyruvate
Pyruvate
CO_2
CO_2
O_2
O_2
NADH
NAD^+
H_2O
ATP
ATP
H^+
e^-
Electron transport chain
B
Acetyl CoA
Pyruvate
Oxaloacetate
Malate dehydrogenase
NADH
Citrate synthase
Malate
NAD^+
Citrate
Fumarate hydratase
Aconitase
Fumarate
$FADH_2$
NAD^+
Isocitrate
Succinate dehydrogenase
FAD
NADH
Isocitrate dehydrogenase
Succinate
NAD^+
α-ketoglutarate
Succinyl CoA synthetase
NADH
α-ketoglutarate dehydrogenase
Succinyl CoA

MORE ABOUT...

BOX 2.2

■ TERMINOLOGY OF FREE RADICALS

In chemistry, a free radical is defined as an atom, group of atoms, or molecules containing one unpaired electron within an outer orbit. These unpaired electrons make free radicals highly and chemically reactive towards other substances (or even towards themselves). Their molecules will often spontaneously dimerize or polymerize if they come in contact with each other. A notable biological example of a free radical is superoxide ($O_2^{-\bullet}$). The sign • denotes an unpaired electron of a free radical species]. Other ones are the hydroxyl radical, ($HO^{\bullet}$) a molecule that has one unpaired electron on the oxygen atom and triplet oxygen which have two unpaired electrons. In contrast, the hydroxyl anion (HO^-) is not a radical since the unpaired electron is resolved by the addition of an electron.

In biology, the term has since been expanded to encompass oxidative damage from other reactive oxygen species such as H_2O_2 or singlet oxygen. The reactive oxygen species discovered in mitochondria are: (1) the superoxide anion radical ($O_2^{-\bullet}$), (2) the protonated form of the superoxide anion radical ($HO_2^{\bullet}$), (3) hydrogen peroxide (H_2O_2) plus hydro peroxide radicals ($ROO^{\bullet}$) [R denoting a residue of an organic molecule], and (4) the singlet oxygen molecule ($^1O_2^*$) [the sign * denotes an electron-excited state]. Singlet oxygen is, chemically speaking, not a radical as the two electrons are paired.

Formation of the free radical superoxide anion and other reactive oxygen species (ROS)

The complete strategy for the full reduction of O_2 is accomplished vis-à-vis the catalyst cytochrome c oxidase which does not release partly reduced intermediates by holding O_2 tightly between Fe and Cu ions. If this protection of O_2 is not present, an only partial reduction would be generated. The transfer of a single electron to O_2 results in a free radical, superoxide anion. The leakage of electrons is not limited to a proper functioning of Complex III. In essence, within the mitochondrial respiration chain, leakage of electrons at Complex I, Complex II, and Complex III may contribute to the generation of superoxide anions ($O_2^{-\bullet}$). The relative contribution of every complex to the overall $O_2^{-\bullet}$ production varies from organ to organ. Within the heart and lung Complex III of the respiratory chain appears to be responsible for most of the $O_2^{-\bullet}$ production. In the brain, complex I appears to be the primary source of $O_2^{-\bullet}$ (Figure 2.2).

Superoxide anions ($O_2^{-\bullet}$) appear on both sides of the inner mitochondrial membrane and hence are also in the matrix space. Within both compartments, enzymes are present that may specifically react with $O_2^{-\bullet}$. These are two different superoxide dismutase (SOD) enzymes, a manganese containing one (that is located at the matrix side), and a copper zinc containing enzyme (that is located at the intermembrane space). Both SOD's transform superoxide anions vis-à-vis the consumption of protons leading to hydrogen peroxide and excited oxygen in the triplet state (Figure 2.2):

$$2O_2^{-\bullet} + 2H^+ \rightarrow H_2O_2 + {}^3O_2^*$$

Hydrogen peroxide (H_2O_2) can also be rapidly formed by the spontaneous dismutation of superoxide. Consequently, the *in vivo* production of a free radical

Introduction Part C

This part reviews technological developments as well as experimental work regarding biophotons at the level of the human body. It increases knowledge regarding the light of the human body up to that height necessary for a functional diagnostic concept at the level of vital energy.

Chapter 9 —includes the technology (in a laboratory setting) in order to study human photon emission as well as the common human anatomical pattern of photon emission with its high symmetry of intensity (left/right, dorsal/ventral). This chapter also includes a pilot study regarding photon emission in relationship to stress reduction. The data suggests that more emphasis must be put on new procedures for the analysis of the photon signal.

Chapter 10 —continues on the photon signal analysis procedure that may picture the large scale metabolic organization in humans. The Fano factor time curve of human photon emission suggests that in daily life (stress), the photon emission is characterized by fractal properties and that relaxation procedures decrease such fractality.

Chapter 11 —reviews the new requirements to perform, at a larger scale, experimental studies on human photon emission in relation to stress reduction. These requirements comprise (a) a fewer number of body locations, and (b) improved analysis of photon count distribution. The chapter also includes a photon signal analysis procedure that assumes that the nonclassical properties of the photon signal reflect the remains of squeezed state properties of the light in the dense living matter.

Chapter 12 —reviews the contribution of Fano factor data and quantum parameters to establish the person's individual light (photon signal) properties as well as the specific signal property associated with stress reduction.

Chapter 13 —reviews the development and validation of the moveable "table top" photon device for in an ambient environment. The measurement has been limited to the hands without significant loss of information. This device was validated for its use in clinical offices under ambient light conditions.

9

Human Photon Recording Technology in Stress

In recent years, the increasing interest in human photon emission has fostered the development of a potential non-invasive diagnostic tool. In this context, stress was the major key word. All research groups studying ultra-weak photon emission had already demonstrated that photon emission intensity was influenced by stress. This was evident from the early Russian, Polish, and German studies with non-human organisms. The latter studies utilized concrete and observable sources of stress, both physical and chemical. Stepping up to human stress required a broadening of the stress concept. This chapter focuses on human photon recording technology as well as on its utilization in the field of human stress.

Human photon emission technology

It is little known that in 1989 Edwards and colleagues (in the United Kingdom) already published a study addressing human body photon emission. The protocol included a photomultiplier tube in a light-tight dark room. The tube was maintained at a constant low temperature of -23°C. The cooling improved the signal/noise ratio and facilitated the researchers to record a photon signal. The data were sufficient to conclude about some anatomical differences in emission intensity.

In Germany, Popp and co-workers began in 1993 with the design and building of a darkroom. In order to detect ultra-weak photon emission, this room needs a high light-tightness. To meet this requirement, several solutions were found and used in the construction which included: (a) the inside walls were all painted black to avoid light reflections; (b) the walls possessed double plates to avoid light penetration or light leakage; (c) the entry and exit of the ventilation system were built far from each other and connected with bent pipe to avoid light leakage through the ventilation system. The ventilation resulted in small fluctuations in room temperature but gave a negligible change in dark current (electronic noise) of the photon-counting device. The dark room had an inner size of 2 m x 1.5 m x 2 m and included a bed upon which subjects were comfortably recorded in lying or sitting position. Average temperature of the dark room was 20°C.

The photon detector system was hung on rails fixed on the ceiling and walls. It facilitated the photon detector head to move in 3-D and therefore to be able to scan over any surface areas of a subject (Figure 9.1). The initial version of photo multiplying system (PMS)-5 used an EMI 9558QA as a

sensor and a Peltier-cooled housing with an additional liquid cooler. Later on, the sensor was replaced by an EMI 9235QA. Compared to 9558QA with a broad sensitive spectrum (160-870 nm), the 9235QA had a more narrow spectrum (160-630 nm). This replacement brought two major advantages: (1) the 9235QA was more sensitive in the interesting spectral range for human skin measurement (470-570 nm), and (2) the 9235QA had less background noise than 9558QA because the insensitivity in far red and near infrared range made it immune to warmth-induced noise.

A spacer (a ring 7 cm high) at the front port of the photomultiplier tube facilitated the measurement of a 9 cm diameter anatomic area at a fixed distance. The PMS-5 was further improved beginning 2001. The Peltier-cooling housing for the sensor was replaced by a vacuum isolated housing

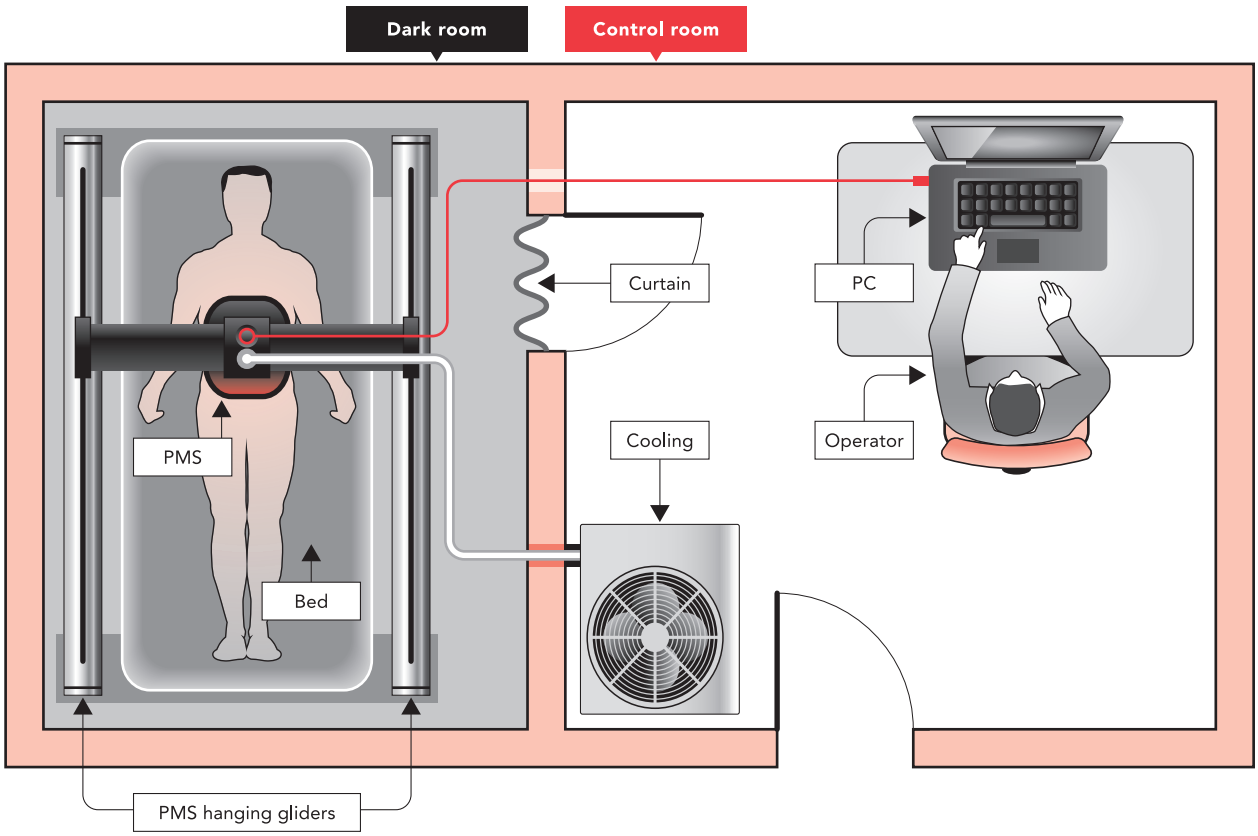


Figure 9.1
The special darkroom and moveable photomultiplier for multi-site recordings of spontaneous emission from the human body. PMS: Photomultiplier system. The computer controlled moveable PMS hung on runners. Subject in lying position on a bed below hanging runners.

11

Advanced Protocol Regarding Human Emission Research and Photon Analysis

To further validate anatomical photon emission characteristics regarding stress reduction, an additional study required a larger number of subjects plus changes to the measurement protocol. The researchers should focus on 12 selected anatomical locations that would be representative for the body emission pattern (instead of 29 locations shown in Figure 9.2). The reason to reduce the number of body locations was to limit the duration inside the dark room to less than 1 hour. For this validation study, the protocol for data analysis was also expanded in order to optimally utilize the rich structure in the fluctuations of the number of photons as might be presented in novel photon count distribution characteristics. This chapter focuses on the selection of the new photon emission pattern as well as on the advanced analysis of photon count distribution.

Revisiting the anatomical pattern utilizing CCD technology

The selection of body locations based on emission intensity gradient profiles required more spatial information on photon emission. To solve this question the researchers then looked for technologies that could image photon emission.

Imaging technology (historical development)

Beginning in 1991, Inaba and colleagues reported the imaging of ultraweak photon emission placing a skin lesion on the back of animals in the form of a circle. The intensity of emission over the lesion increased and reached its maximum between the third and the fifth day subsequent to the injury. Beginning with the sixth day, the emission intensity began to decrease. On the eighth day from the research (when the wound had completely healed), the image no longer revealed any clear pattern.

In Inaba's laboratory, a subsequent special research line was developed to create images of human emission. The sensitivity of their system was unique and made it possible to image light emission from human body surfaces (hands and fingers) when they were positioned close enough to the camera. A two-dimensional image exhibited a characteristic pattern of intensity with the highest levels in the region of the index and middle fingers and the lowest intensity in the middle of the palm regions. In 1994, Inaba's team demonstrated that they could use the measurements from the

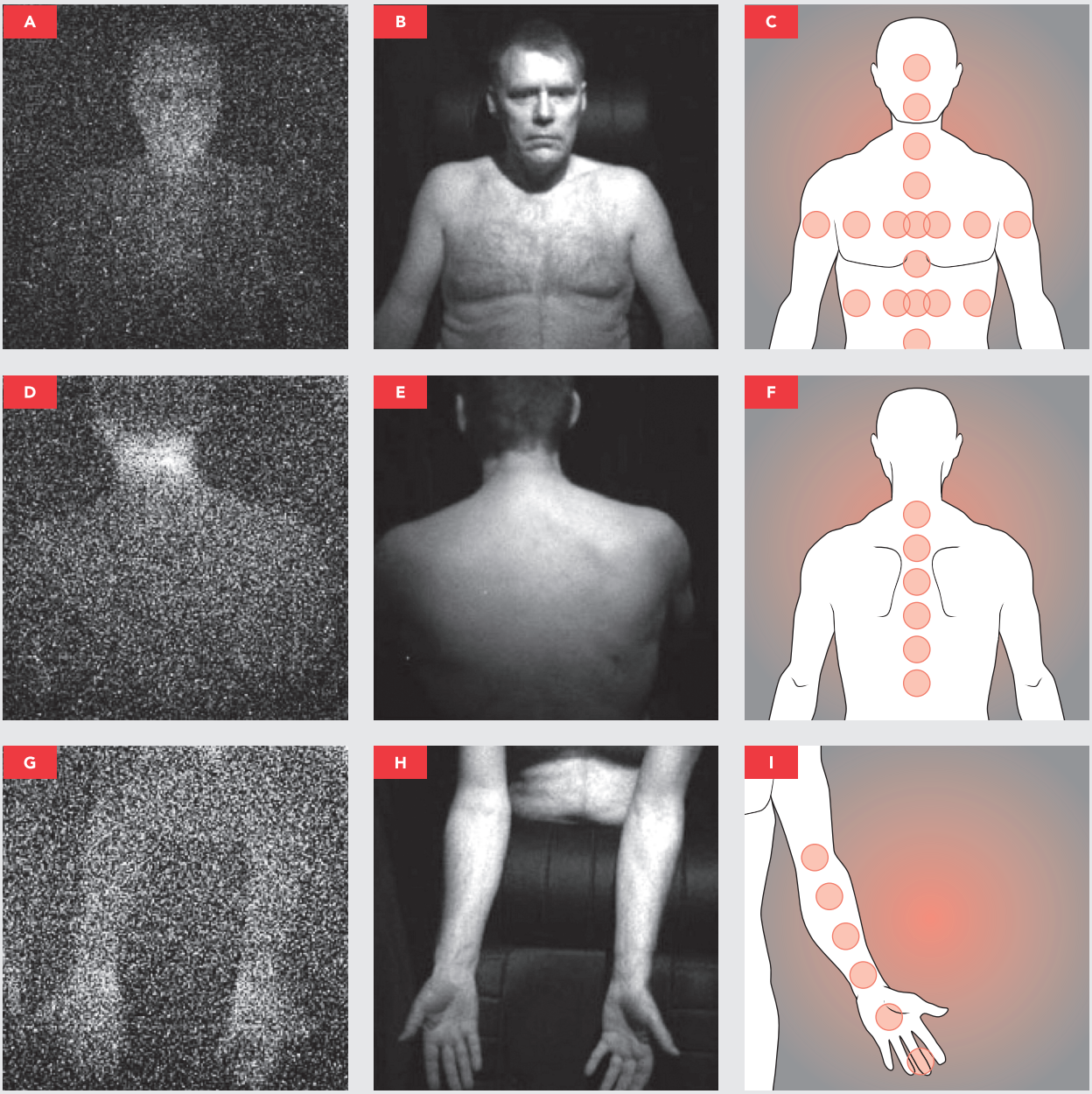


Figure 11.1
Ultra-weak photon emission of the ventral and dorsal torso and arms of a human subject. Photon emission image measured with the CCD imaging system: ventral torso (A), dorsal torso (D), and arms (G). Corresponding photographs taken under weak illumination: ventral torso (B), dorsal torso (E), and arms (H). Anatomic locations used for recording of ultra-weak photon emission using the moveable photomultiplier: ventral torso (C), dorsal torso (F), arms and palms (I).

Appendix – Technology to Measure the Personalized Accumulated Stress Structure

Software to evaluate the photon measurement data

The software package integrates measurement software, data analysis software, and database software in one program. The photon measurement procedure is controlled by the software. Each measurement includes a signal measurement and a background measurement. The measured data are directly visible on the screen. Both sets of measured data (signal plus background) are stored in a MySQL-database. The data can be analyzed directly after the measurement. The results of this analysis are shown on the screen and also automatically stored in the database.

Calculation procedure

The data analysis method is described in *Chapter 11* under the section "Advanced analysis of photon count distribution". Compared to the described calculation procedure by Bajpai, there are a few modifications (particularly, regarding techniques of quantum squeezed state estimation parameters). In the original calculation, the photon count distribution of each time series was utilized to estimate the parameters r, θ, φ by a fitting procedure minimizing the function $F(r, \theta, \varphi)$. The new calculation in the present software is done by a non-linear fitting to $P_{cal}(n)$ utilizing the Levenberg-Marquardt algorithm. This method provides a calculated curve that more accurately fits the measured data. This may be concluded from the lower residual value SSR, compared to the original calculation procedure. For this reason, the present calculation procedure results in slightly different values in case of θ, φ and SSI parameters compared to the original calculation. The values by $|\alpha|$ and r are the same as in the original calculation.

Main page

When the software starts, the *Main page* (Figure A.1) appears. Here the user can put in his "login name" and "password" for the MySQL database.

Overview page

After a successful login, the user will see the *Overview page* (Figure A.2). This page displays a table with all measured subjects. It allows the user to put in a name in "Search Person" and click "Find" to search an already measured subject. The results of this search are then displayed in the list. By clicking "Show All", all measured subjects are shown in the list. The user may click "Edit" to modify earlier information about a measured subject,

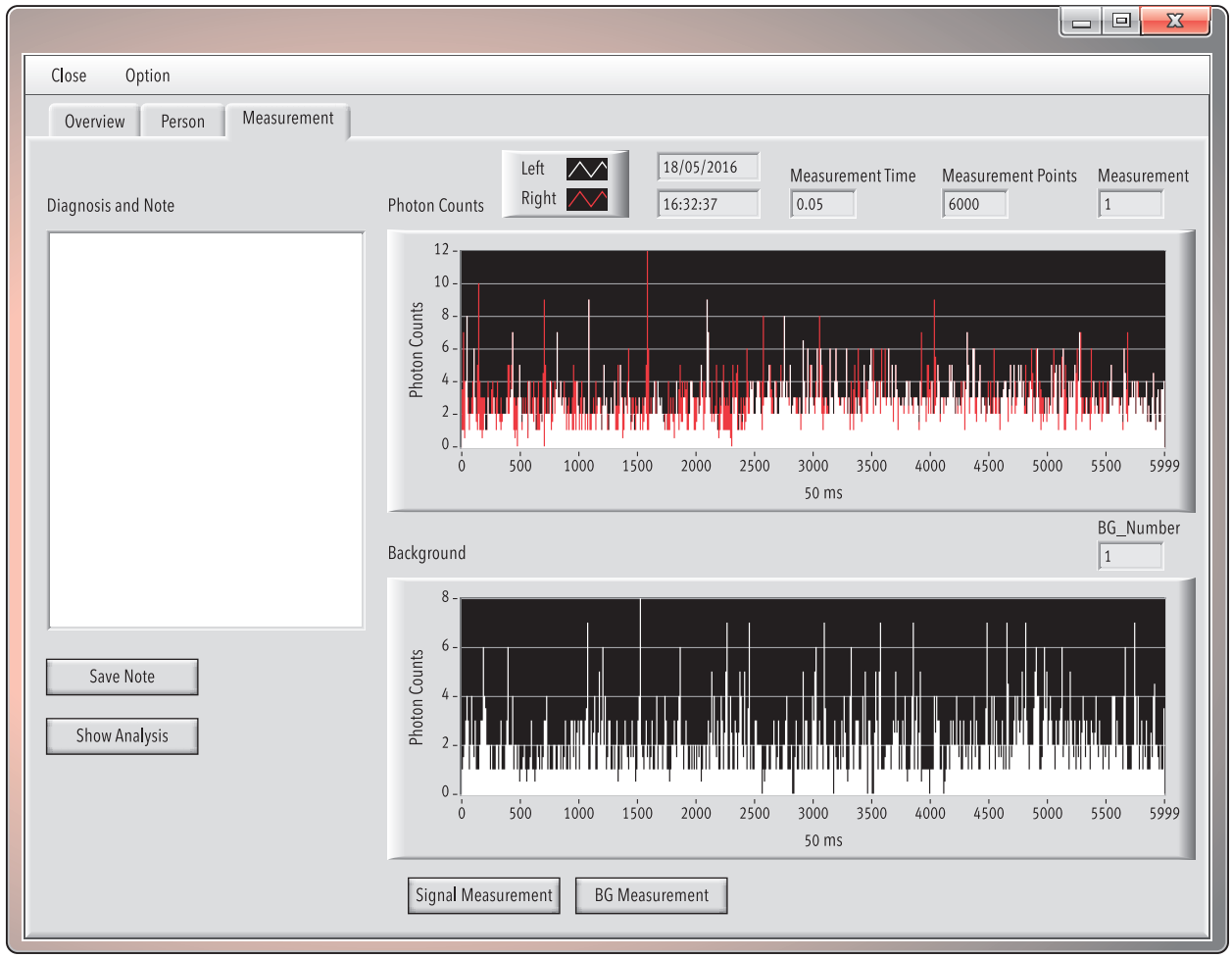


Figure A.4
Measurement page of the PCS-II-DH software.

list of subject's previous measurements is shown. In order to view a specific measurement, the user may click on "Show Measurement". The user can click on "New Measurement" to start a new measurement.
The "General Analysis" button will start an analysis using measurement data sets that were recorded at multiple points in time while repeating a fixed measurement protocol. The button "Recalculate All" allows the used to re-calculate all measurements shown in the list of the "List of Measurements".

Measurement page
After the user clicks "Show Measurement", the measurement information, signal and background are loaded from the database and shown in *Measurement page* (Figure A.4).
On the left, the user may view or modify the diagnosis and make notes for

Index