

**- 30 Years of LS
- 25 Years DGFS
Cooperation with
Franz Schönhofer†**

- in memoriam -

*Presented at
DGFS 2021 Annual Meeting
by Siegmund Möbius*





The Liquid Scintillation Counting LSC series conferences started in 1957 in Chicago (USA) and was organized in more recently by Franz Schönhofer in September 1992 in Laxenburg/Vienna

LSC1992: Tiana Möbius presenting „Extractive Liquid Scintillation“ for natural radionuclides

Determination of Ra, Rn, Pb and Po in Water Using Extractive Liquid Scintillation

Objective
Development of simple and rapid procedures for separation and measurement of natural radionuclides (Ra, Rn, Po, Pb, Th, U) in environmental samples.

Method
Radium and its decay products are separated by selective extraction into Diisopropylketone DPK (Po), Trioctylamine TOA (Pb), Dicyclohexano-21-crown-7 DC21C7 (Ra) or just toluene.

The use of "Extractive Scintillation" enables to measure the organic phases directly by Liquid Scintillation Counting LSC.

Interferences are eliminated by window setting and/or Pulse Shape Discrimination PSD.

*** U and Th can be quantified with an additional extraction into Trioctylphosphineoxide TOPO.

Procedures
Radium and Polonium after Preconcentration

Aqueous Feed (Water)
Ra, Rn, Pb, Po (U, Th)

Dewet 50 W X 8
Ba-133 Tracer
(EDTA pH 3)

Cation Exchange

Elution with 3 M HNO₃
Evaporation

Extraction

org. Ph.
Ra
LSC

Aqueous Feed (Water)
Ra, Rn, Pb, Po (U, Th)

Evaporation

0.1 M HBr
+ DPK*

Extraction

org. Ph.
Pb
LSC

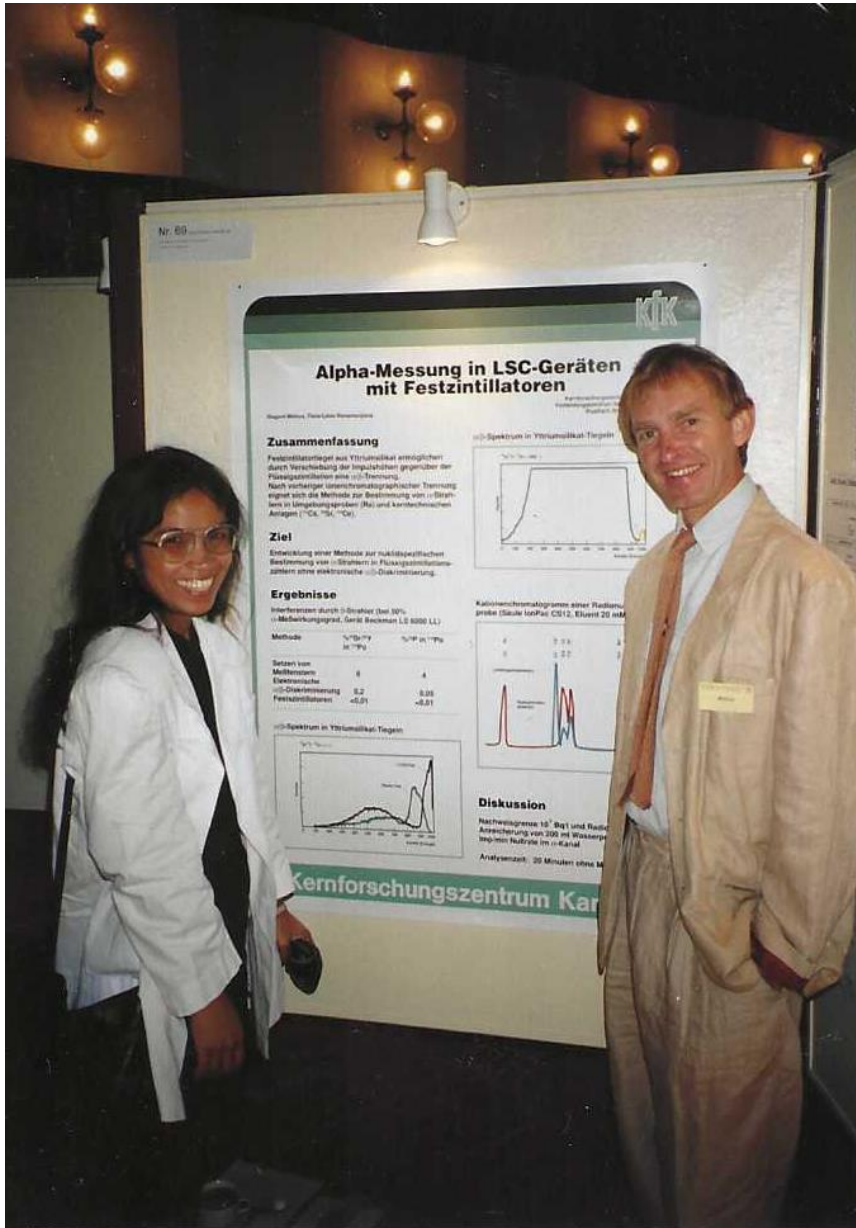
Radium and Daughter Products in Aqueous Samples

* Extractive Scintillator containing 1,1-diphenylpropanol (DPPH)

Results:

Counting efficiency:	~ 100 % for LSC
Recovery:	> 90 %
Overall time (excluding measurement):	1 hour
Interferences (from β- and γ):	< 0.01 % with 10 ⁻⁸ Bq/ml c solution ea
Sensitivity:	

ernforschungszentrum Karlsruhe



The follow-up Conference LSC1994 took place in Glasgow. Our investigations on „Solid Scintillator Caps“ were presented successfully.

Further Milestones of LSC:

- PERALS System with α -LS Spectrometry commercially available
- Numerous papers on Rn and Ra analysis by LSC published by Schönhofer
- Foundation of HIDEX by Jukka Haaslahti (1993)
- „Triathler“ as first mobile LS instrument with α/β PSD available

LSC2001 Initiation Meeting 1998
organized by HIDEX in Turku surroundings
from left: Mike N., Siegurd M. , Jukka H., Eberhard
Frenzel, Ville H., Franz Schönhofer



Conference Secretariat

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M. Neary, USA
J. Noakes, USA
C.-T. Peng, USA
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Organising Committee

S. Möbius (Chairman)
E. Frenzel
H. Geckeis
T. Möbius-Ramamonjisoa

With Financial Support from

Beckman Instruments, Inc.
EICHROM Industries
HIDEX
Packard Instruments Co.
Wallac Oy
Zinsser



Forschungszentrum Karlsruhe
Technik und Umwelt

LSC 2001

Advances in Liquid
Scintillation Spectrometry



May 7 - 11, 2001
Karlsruhe, Germany

First Announcement
and Call for Papers



2000: First
Announcement
of **LSC2001**



Inauguration of the German Society for Liquid Scintillation Spectrometry (DGFS). Sitting from left to right: Treasurer Eberhard Frenzel, President Siegmund Möbius



Inauguration of the
German Society for
Liquid Scintillation
DGFS in front of
KFK sculpture
„Einstein meets
Leonardo da Vinci“

Sitting from left:

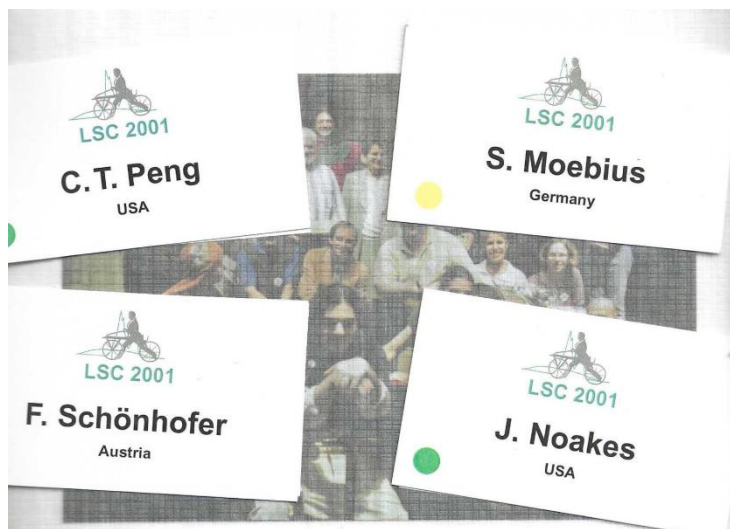
Treasurer Eberhard Frenzel,
President Siegmund Möbius

Standing:

Secretary Stephan Erat,
Franz Schönhofer

- LSC2001 was organized and directed by Siegurd Möbius with the assistance of Franz Schönhofer and his experiences.
- DGFS was founded primarily for handling Credit Card Payments and Conference Proceedings.
- This was in analogy to the Austrian Society for LS founded by Franz Schönhofer at the occasion of LSC1992.

Thus our history as DGFS is closely linked to Franz Schönhofer



Participants LSC2001 Karlsruhe



Conference Dinner at Historical Hambach Castle



Legende: Scientific and Organizing Committee Members (*from left*)

standing: Tiana Möbius, Joan Noakes, Chin-Tzu Peng, **Franz Schönhofer**, Laina Salonen, Mike Neary, Philippe Cassette (organizer LSC2010), Horst Geckeis, Annemarie Letsch

sitting middle: Siegurd Möbius, Stan Chalupnik (organizer LSC2005), Laura Hernandez

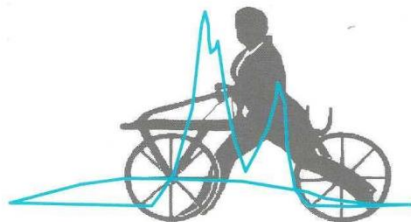


DGFS



International Conference on
ADVANCES IN
LIQUID SCINTILLATION SPECTROMETRY
2001

LSC 2001



Karlsruhe, Germany
7-11 May 2001

Siegurd Möbius

John E. Noakes

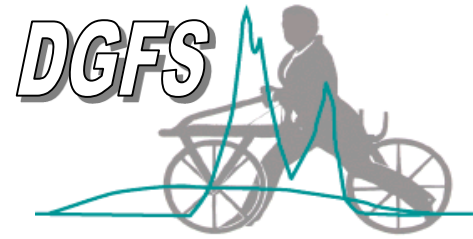
Franz Schönhofer



**Proceedings
LSC 2001:
Eds. Möbius, Noakes,
Schönhofer**

1st DGFS Publication

DGFS Contributions in LSC2001



S. Möbius: Fast Methods for Field Analysis of Natural Radionuclides
- New Approaches

T.-L. Möbius et al.: In-Situ Determination of Rn in Air after Enrichment

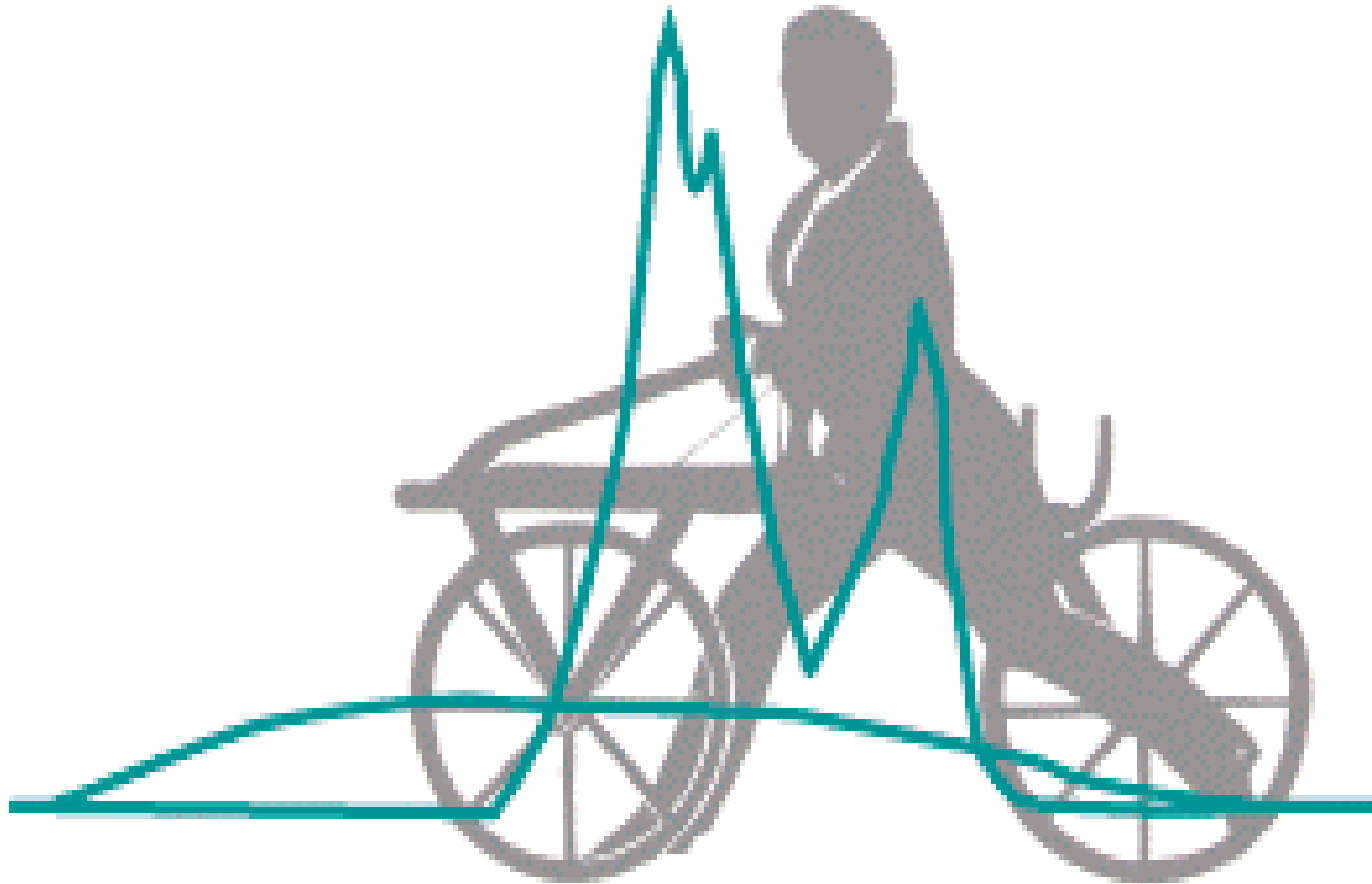
S. Möbius et al.: Investigations on Instrumental Ra Analysis by α/β -LSS

S. Möbius et al.: Extractive Methods for Fast Radium Analysis

E. Frenzel et al.: Localization of Depleted Uranium Contamination

S. Möbius et al.: Pilot Intercomparison and Workshop for Rn and Ra in Water

Logo LSC2001 = Logo DGFS



Karl Drais from Karlsruhe on his Running Machine („Laufrad“) with α/β PSD Rn in Water Spectrum as background

Drais went into history as the inventor of the bicycle

Recent International LSC Conferences



LSC 1992: Vienna (Austria)

LSC 1994: Glasgow (Scotland)

LSC 2001: Karlsruhe (Germany)

LSC 2005: Katowice (Poland)

LSC 2008: Davos (Switzerland)

LSC 2010: Paris (France)

LSC 2013: Barcelona (Spain)

LSC2017: Copenhagen (Danmark)

LSC 2020 (scheduled): Chengdu/online (China)

18-20 October, 2021

F. Schönhofe

G. Scott

S. Möbius

S. Chalupnik

J. Eikenberg

P. Cassette

J. Garcia, A. Tarancon

H. Xiaolin

Leifeng Cao



LSC2008:
Davos /
Jost Eikenberg†

NORM Materials
came into focus

Novel LS Methods for Radionuclides in the Oil and Gas Industries

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(2) FTU, Forschungszentrum Karlsruhe, D-76021 Karlsruhe, Germany

Scope and Objectives

Natural radionuclides of Radium, Lead and Polonium are trapped along with crude oil and gas and accumulate in vessels, piping, filters or pumps. Problems are caused by residues and sludge (^{226}Ra , ^{228}Ra) where NORM often becomes concentrated during the process of extraction (inlet lines, tubing), transport (pipelines) and storage (ponds and tanks) of crude oil. The applicability of LSC has been studied for the analysis of NORM products in the petroleum industry.

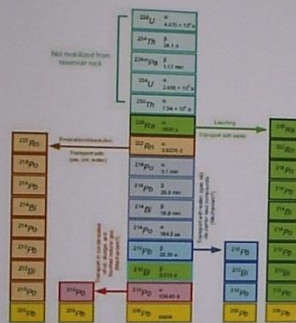


Figure 1: Mobilisation of ^{226}U -Decay Products (from IAEA Safety Series No.34)

Summary and Outlook

- α/β -LS is effective and simple for analysis of NORM in oil and gas industries.
- Rn in mineral oil by LS is sensitive (1 to 40 Bq/l for crude oil).
- Ra isotopes in scale may be quantified
 - ^{226}Ra in CaCO_3 after dissolution and Rn emanation
 - ^{226}Ra after dissolution and Rad Disk filtration
 - ^{226}Ra in BaSO_4 by Rn emanation.
- Rn emanation yield was found to 20% in average, however depend on physical characteristics of ore and scale.
- ^{210}Pb and ^{226}Ra in Produced Water are extracted as 2M HNO_3 solution by Rad Disk and determined by LS α/β -PSD after elution with DHC and EDTA.

Experimental and Results

Rn in Mineral Oil

Various amounts of different oil samples were dissolved in organic cocktails and measured by α/β PSD.

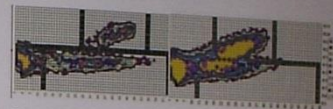


Figure 2: 3-D- α/β -Plot for 1% Mineral Oil (Divinol 10/40) (left) and 7% Mineral Oil (right, corresponds to 1 ml oil and 15 ml cocktail), Triathler HIDEX

Ra in Ore (Scale)

Ore (Pitchblende) was grinded and sieved into different grain size fractions. Defined amounts (100 to 200 mg) were contacted with Betaplate organic LS cocktail, stored for 20 days and aliquots measured after Rn extraction.

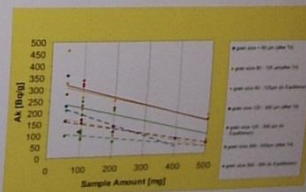


Figure 3: Emanation Data vs Grain Size and Sample Amount

Rn in Production Water

Water samples were analysed using Rad Disk filtration and DHC / EDTA elution and measured with OptiPhase HiSafe 3 cocktail.

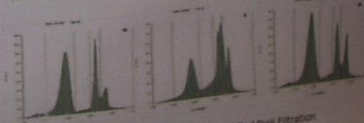
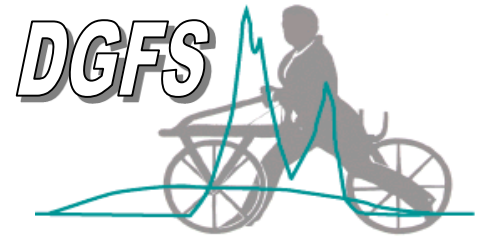


Figure 4: Dissolved Water Samples (Ore) after Rad Disk Filtration
a) First fraction of EDTA: ^{210}Pb is eluted preferentially
b) EDTA fraction directly after filtration
c) EDTA fraction after storage (1 week)

**LSC2008:
Social Event uphill of Davos**

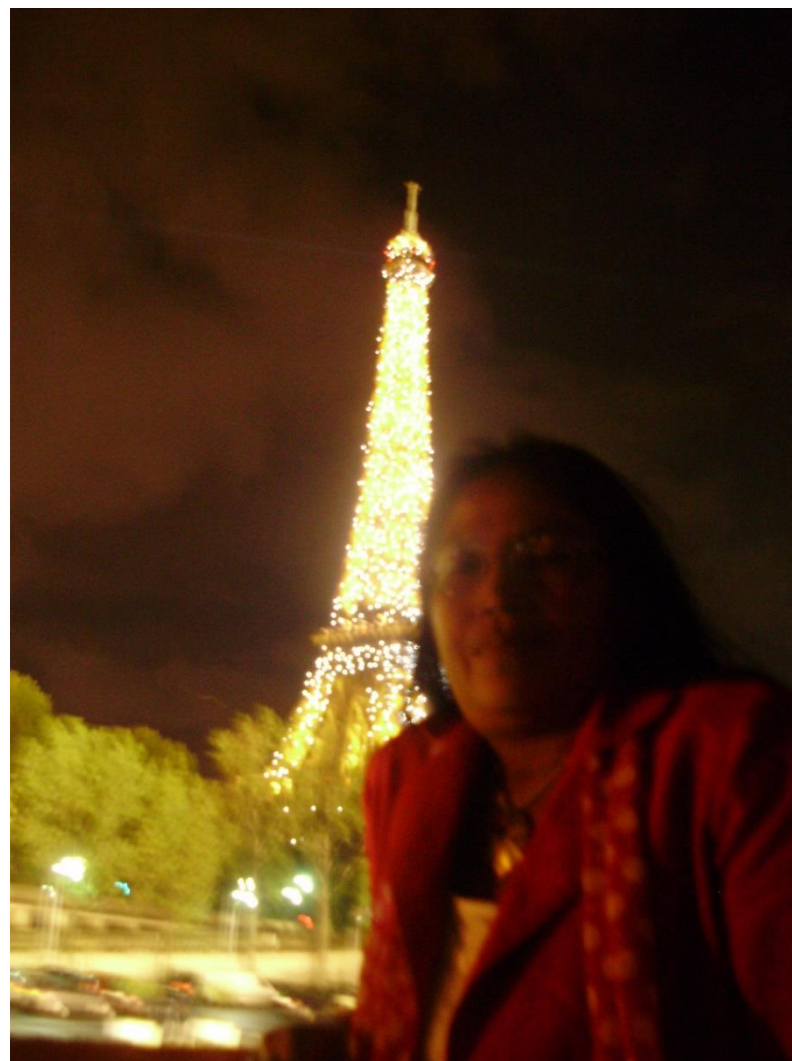


International Conference on
**ADVANCES IN LIQUID
SCINTILLATION
SPECTROMETRY**

Philippe Cassette, editor



PARIS, FRANCE
SEPT. 6-10, 2010



Even the Tour Eiffel scintillates!

Further Milestones of LSC :

- „Triple to Double Coincidence Ratio“ TDCR as Quenching Parameter is rediscovered and extensively discussed in LS Conferences and User Meetings
- New LS Equipment Lode Star LS300 with three PMT's for TDCR and low level counting available
- „Messenleitungen“ for LS Spectrometry published by Siegurd and Tiana Möbius as „Loseblattsammlung“
- DGFS organizes LS user meetings and international LS Training Courses/Expertises worldwide (Rio de Janeiro, Bangkok, Brisbane, Colombo)
- „Handbook on Liquid Scintillation – Present State and Recent Advances“ published by DGFS in 2015 and 2018 as 2nd ed.



LSC2013: Barcelona



Jose (Director) and Luz
from LSC2013 organizing committee



Franz Schönhofer: First row middle



Franz Schönhofer as Scientific Committee Member *(right)*

President Siegmund Möbius
presented DGFS as
Committee Member and
Chairperson in all more
Recent LS Conferences

LSC2013 Barcelona

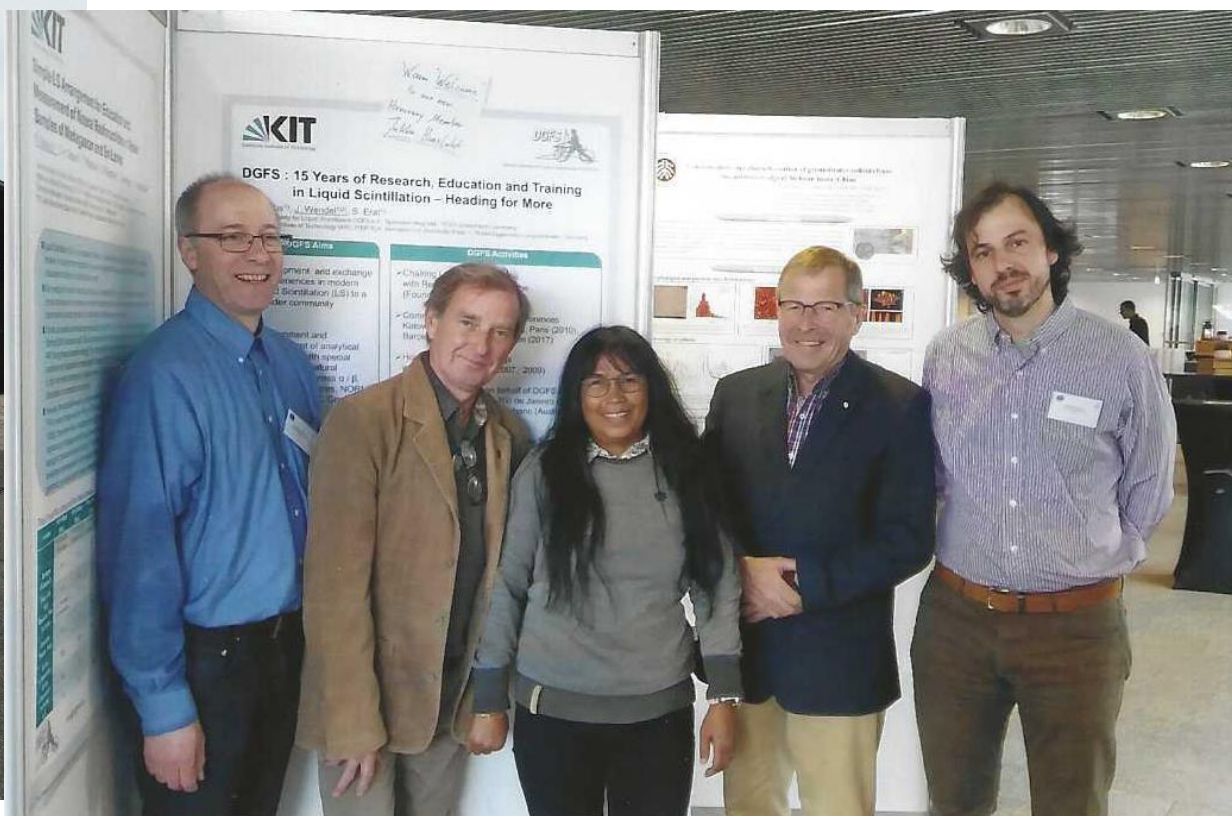




LSC2017: Copenhagen

DGFS Crew with Member of Honour

Jürgen Wendel, Siegurd and Tiana Möbius, **Jukka Haaslahti**, Alex Tarancon (*from left*)



DGFS : 15 Years of Research, Education and Training in Liquid Scintillation – Heading for More

S. Möbius¹⁾, J. Wendel¹⁾²⁾, S. Erat¹⁾

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²⁾Karlsruhe Institute of Technology (KIT), ITEP-TLK, Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen, Germany

DGFS Aims

- Development and exchange of experiences in modern Liquid Scintillation (LS) to a broader community
- Development and improvement of analytical procedures with special emphasis on natural radionuclides, gross α / β , Ra and Rn isotopes, NORM (see various LSC Conference Proceedings)
- Academical education and training in Liquid Scintillation

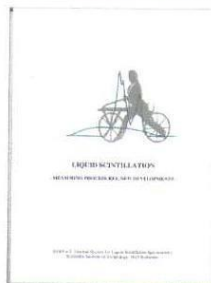
DGFS Activities

- Chairing LSC 2001 Karlsruhe with Research Centre Karlsruhe (Foundation of DGFS)
- Committee Member of LSC Conferences Katowice (2005), Davos (2008), Paris (2010), Barcelona (2013), Copenhagen (2017)
- Hosting LSC User Meetings in Karlsruhe, Germany (2007, 2009)
- LS Training Courses on behalf of DGFS and IAEA in Karlsruhe (Germany), Rio de Janeiro (Brazil), Bangkok (Thailand) and Brisbane (Australia)
- Heading for more:
 - Spreading Measuring Handbooks for University Education
 - Providing simple self made LS arrangements for training from widely available equipment

Recent DGFS Publications

- Handbook on Liquid Scintillation (2015) Measuring Procedures, New Developments (DGFS e.V.) ISBN 978-3-923704-87-3
- Handbook on Liquid Scintillation Spectrometry (2012) ISBN 978-3-923704-78-1
- Several publications in Conference Proceedings

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Simple LS Arrangement for Education and Measurement of Natural Radionuclides in Water Samples of Madagascar and Sri Lanka

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²⁾Karlsruhe Institute of Technology (KIT), ITEP-TLK, Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen, Germany
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⁴⁾Sri Lanka Atomic Energy Board, 60460, Baseline Road, Orugodawatte, Welisariya, Sri Lanka

- Liquid Scintillation (LS) is a universal and efficient, but nevertheless a simple measuring method. However, it lacks from the availability of low cost equipment with respect to the limited budget of educational institutions in developing countries.
- Our investigations aim at compiling a simple LS arrangement from widely available materials. It cannot substitute a more sensitive commercial equipment with automatic sample changer and α/β discrimination, but can promote LS in education to a broader group of users.
- The set up consists of a recycled photomultiplier tube (PMT) and a widely used nuclear analyzer (Berthold 2040) as central unit. The crucial step arises from the necessity of total light shielding of the PMT during manual sample changing. The instrumentation was adjusted for optimum counting conditions and calibrated for measurement. It turned out that the arrangement is suitable to quantify α , high and medium energetic β radiation down to 0.2 MeV maximum energy with efficiencies comparable to commercial instruments.
- However, the sensitivities without α/β discrimination are limited due to the high β background. For ^{222}Rn in water directly and for ^{226}Ra via ^{222}Rn extraction after storage a detection limit of around 150 Bq/L have been found. A customized mobile equipment was compiled at the University of Antsirana in Madagascar and was successfully applied for LS measurement within a radioecology training for graduate science students. Rn measurements in water samples both in Madagascar in the Northern territories and in the monazite bearing mountain area of Sri Lanka have been performed, as well as control measurements from the Black Forest and data are reported.

Table: Rn and Ra in Spring and Well Water Samples

Location	Rn in Water (Bq/L)	Ra in Water (Bq/L)	Ra in Water (Bq/L)
	Rn Extraction PMT tube	Ra Extraction Together w. PSD	Ra Extraction Together w. PSD
Montagne D'Ambre 2x	n.d.	n.d.	n.d.
Diego (City Well)	n.d.	16	n.d.
Monazite Area Sri Lanka	n.d. indication for β -emitters	n.d.	n.d.
Caracalla-Therne (raw)	n.d.	65	967
Spring « Blawald »	905	859	1000
Spring « Blawald »	554	541	1000
3m bottom LLD	157	0.3	205



- Materials and Equipment
 - Scintillation cocktail (e.g. Ultima Gold)
 - PMT (recycled e.g. from a Geiger counter)
 - Nuclear analyzer (Berthold 2040) with LS module and light shield
 - Sample vials (e.g. 20 mL) and sample holder
 - Large volume container (e.g. 20 L) for light shielding
 - Chemicals (e.g. NaOH, HCl, H₂O₂)
 - Glassware (e.g. 1 L and 20 mL)

info@dgfs-ev.eu

LSC 2020

International Conference on Advances in Liquid Scintillation Spectrometry

<http://lsc2020.swust.edu.cn>

October 18-20, 2021

Deadline for abstract submission: September 5, 2021

The Conference

LSC2020, an international conference on Advances in Liquid Scintillation Spectrometry is the next of a series of conferences on Liquid Scintillation Counting (LSC). The LSC series conferences started in 1957 in Chicago (USA), and have in more recent years taken place at Karlsruhe (Germany) 2001, Katowice (Poland) 2005, Davos (Switzerland) 2008, Paris (France) 2010, Barcelona (Spain) 2013, and Copenhagen (Denmark) 2017. The LSC2020 is the 24th edition of the LSC conferences; it will continue this series of conferences to provide a forum for discussing the latest developments in the instrumentation and methodology as well as applications of LSC in all aspects. Specialists and users of LSC are encouraged to attend and contribute with their experience.

Organization

Organized by: Laser Fusion Research Center

Science and Technology on Plasma Physics Laboratory

Co-organizer: Southwest University of Science and Technology

Conference form: a combination of online and offline

Online conference system: ZOOM

Offline conference: Chengdu or Shenzhen (Venue to be determined)

Scientific Committee



- Xiaolin Hou (Director)
Technical University of Denmark, Denmark
- Karsten Kossert
Physikalisch-Technische Bundesanstalt, Germany
- Philippe Cassette
Laboratoire National Henri Becquerel, France
- Jose F. Garcia
University of Barcelona, Spain
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- Mun Ja Kang
Korea Atomic Energy Research Institute, Korea
- Denis Bergeron
National Institute of Standards and Technology, USA
- Alex Tarancon
University of Barcelona, Spain
- Feng Wang
Laser fusion research center, CAEP, China
- Leifeng Cao
Shenzhen Technology University, China

Main Topics

- New development on LSC instrumentation, methodology and scintillators
- Radionuclide Metrology Using LSC
- Calibration, standardization, and quality assurance
- Data evaluation and spectrum analysis
- Applications in environmental radioactivity
- LSC in nuclear chemistry (decommissioning, waste processing, nuclear materials)
- Applications in bioscience, medicine, and drug studies
- Applications in natural radionuclides measurement, chronology and geology
- LSC in neutrino and neutron detection
- Plastic scintillator and application
- Application in tritium studies
- Applications based on alpha/beta spectrometry and other topics
- Application in high energy density physics
- Application in laser nuclear physics
- Nuclear electronics in LSC applications

Invited Speakers



Alex Tarancon
Department of Chemical Engineering and Analytical Chemistry, University of Barcelona, Spain
Title: Progress in new plastic scintillation microspheres



Jose F. Garcia
Departament d'Enginyeria Química i Química Analítica, Facultat de Químiques, Universitat de Barcelona, Spain
Title: Scintillation for future in a changing world



Philippe Cassette
Laboratoire National Henri Becquerel, France
Title: New developments in miniature TDCR counters



Steffen Happel
TrisKem International
Title: On the development of new extraction chromatographic materials for the separation of difficult to measure radionuclides

More will join us!

Contacts

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Website: <http://lsc2020.swust.edu.cn>

WeChat group: LSC2020 International Conference



QR code of the conference website



LSC 2020: Most recent Announcement

LSC“2020”: DGFS Contribution (admitted)

20 Years DGFS Society for Liquid Scintillation – New Developments

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The Society for Liquid Scintillation DGFS (<https://DGFS-ev.eu>) as non-profit society was founded along the LSC2001 Conference in Karlsruhe with the aim of development and transfer of modern Liquid Scintillation (LS) to a broader community. Selected analytical procedures have been compiled recently in the 2nd extended edition of the Handbook on New LS Measuring Procedures 2018 (1).

Besides the academic education and training in LS as key object, DGFS heads to develop new procedures and optimize existing ones in liquid scintillation spectrometry. Besides for artificial radionuclides e.g. in the nuclear fuel cycle LS enables a comprehensive survey of natural key nuclides in water processing (see (1) pp55). In combination with RAD Disks for Ra and Pb enrichment a simple and fast method in drinking water has been developed recently (see (1) pp46). Liquid Scintillation presents a key analytical skill for Tritium in the present KATRIN neutrino mass detection experiment at KIT, where its energy spectrum is examined. Various procedures were adapted for its detection in pipes after oxidation and for radiation protection purposes. For the detection of ²¹⁰Pb Black Powder deposits in the newly built Northstream Pipeline as suggested recently see procedure pp119 in (1). The ability of luminescence counting as tool for analysis of photon induced DNA/RNA labelling in future cancer and serum research is under investigation. A summary of new analytical developments as described in (1) is provided in this presentation.

In order to further spread this modern, universal and future prospective methodology, DGFS heads to transfer LS into the academical education of developing countries by applying simple LS arrangements (see (1) pp22). For successful developing future programs worldwide, you may help by active participation in our Society.

1. Moebius S., Erat S., Mayer K., Moebius R., Moebius T., Santiago L., Tarancon A., Wendel J., Wisser, S.
Liquid Scintillation – Measuring Procedures, New Developments - 2nd extended edition 2018,
DGFS e.V. German Society for Liquid Scintillation Spectrometry and KIT Karlsruhe Institute of Technology, 2018 Karlsruhe

**Franz,
we will never forget you as partner and friend!**

