

Kjerne- og radiokjemi i Norge – hvor går veien videre?

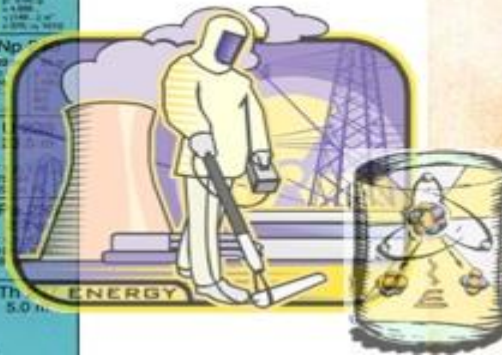
Jon Petter Omtvedt

Kjemisk institutt, UiO

NKS foredrag 30. november 2016



Pu 236 2.858 a α 5.760, 5.701, 4.96, 3.9 1.98E-08, 2.4E-08, 1.9E-08, 1.9E-08 λ 2.20E-07	Pu 237 45.2 d α 5.596, 5.596, 5.596, 5.596 1.9E-08, 1.9E-08, 1.9E-08, 1.9E-08 λ 2.20E-07	Pu 238 87.74 a α 5.596, 5.596, 5.596, 5.596 1.9E-08, 1.9E-08, 1.9E-08, 1.9E-08 λ 2.20E-07	Pu 239 2.41E+10 a α 5.596, 5.596, 5.596, 5.596 1.9E-08, 1.9E-08, 1.9E-08, 1.9E-08 λ 2.20E-07	Pu 240 6563 a α 5.596, 5.596, 5.596, 5.596 1.9E-08, 1.9E-08, 1.9E-08, 1.9E-08 λ 2.20E-07	Pu 241 14.35 a α 5.596, 5.596, 5.596, 5.596 1.9E-08, 1.9E-08, 1.9E-08, 1.9E-08 λ 2.20E-07
Np 235 396.1 d α 5.596, 5.596, 5.596, 5.596 1.9E-08, 1.9E-08, 1.9E-08, 1.9E-08 λ 2.20E-07	Np 236 1.14E+10 a α 5.596, 5.596, 5.596, 5.596 1.9E-08, 1.9E-08, 1.9E-08, 1.9E-08 λ 2.20E-07	Np 237 2.14E+10 a α 5.596, 5.596, 5.596, 5.596 1.9E-08, 1.9E-08, 1.9E-08, 1.9E-08 λ 2.20E-07	Np 238 2.117 d α 5.596, 5.596, 5.596, 5.596 1.9E-08, 1.9E-08, 1.9E-08, 1.9E-08 λ 2.20E-07	Np 239 2.355 d α 5.596, 5.596, 5.596, 5.596 1.9E-08, 1.9E-08, 1.9E-08, 1.9E-08 λ 2.20E-07	Np 240 1.14E+10 a α 5.596, 5.596, 5.596, 5.596 1.9E-08, 1.9E-08, 1.9E-08, 1.9E-08 λ 2.20E-07
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Outline

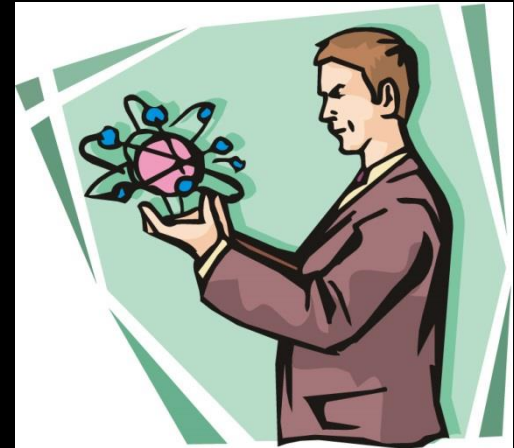


- What is **Nuclear and Radiochemistry** (NRC)?
- Short (?) **history** of NRC at UiO
- The **future**
 - exciting **research** opportunities
 - difficult **funding** situation
 - need for NRC **competence and knowledge**

What *is* Nuclear and Radiochemistry?

My definitions:

- **Nuclear chemistry** is *basic (nuclear) research about properties of nuclei* (borderline between Chemistry and Physics)
- **Radiochemistry** is *application of nuclear chemistry*



Nuclear and Radio*chemistry* Research?

- **Nuclear Energy**, in particular fabrication of fuel and treatment of spent nuclear fuel
- Synthesization of **radiolabeled compounds for medical** diagnostics and therapy
- Migration of radionuclei in nature (**radioecology**)
- **Radiation protection & nuclear forensics**
- **Fundamental properties** of nuclei
- **Radiotracers** used as tools in industry & research

Ellen Gleditsch – Norway's Marie Curie

- The young pharmacist Ellen Gleditsch was employed as assistant to prof. E. Bødtker in 1903.
- She soon showed her scientific qualities and was able to take her "PhD" in 1906, after much hard work.
- She then worked as associate professor until 1907.



Ellen Gleditsch, Student 1902

Ellen Gleditsch – Norway's Marie Curie

- The exciting developments in the Curies laboratory draw her to Paris.
- The French laboratories was crowded, but Bødker was able to convince M. Curie that his assistant was worthy and that she "was so small she would hardly occupy any laboratory space". Beside this, Curie needed a chemist.




Elen Gleditsch – further reading



https://www.muv.uio.no/uios-historie/mennesker/forskeren/realister/gleditsch-lykknes-250907.html Ellen Gleditsch: Professor, r...

Forsiden UiO > Museum for universitets- og vitenskapshistorie

For ansatte English website Søk

 **UiO : Museum for universitets- og vitenskapshistorie**

Forsiden MUV UiOs historie Tall og fakta Samlinger Publikumstjenester Om MUV

UiOs historie

Mennesker

Forskeren


- Humanister
- Jurister
- Pedagoger

Ellen Gleditsch: Professor, radiokjemiker og mentor

Ellen Gleditsch (1879-1968) studerte radioaktivitet hos Marie Curie i Paris og ble Norges første autoritet innen dette feltet.

Av Annette Lykknes

Som universitetsstipendiat (1912), dosent (1916) og professor (1929) startet hun den møysommelige prosessen med å bygge opp et undervisningstilbud



Relatert stoff

- Lydoptak (NRK): Ellen Gleditsch forteller om UiO under krigen
- Artikkel: Odd Hassel - Nobelprisvinner i kjemi
- Artikkel: Ingen "Mildare" behandling - Kjemikeren Milda Prytz
- Artikkel: Tre kjemikere i Professorboligen
- Reidar Aulies portrett av Gleditsch (UiOs kunstsamling)


Elen Gleditsch – further reading



https://www.muv.uio.no/uio-historie/mennesker/forskeren/gleditsch-lykknes-250907.html Ellen Gleditsch: Professor, r...

Forsiden UiO > Museum for universitets- og vitenskapshistorie

For ansatte Eng

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Torleiv Kronen * Alexis C. Pappas
ELLEN GLEDITSCH
Et liv i forskning og medmenneskelighet



Med et utvalg av hennes korrespondanse
med Madame Curie og andre forskere
Aventura

Elen Gleditsch – further reading



Ansatte



Annette Lykknes
Førsteamanuensis

Program for lærerutdanning

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Jonsvannsveien 82, PLU * B373



Forskningsområder: Kjemedidaktikk og kjemi/vitenskapshistorie

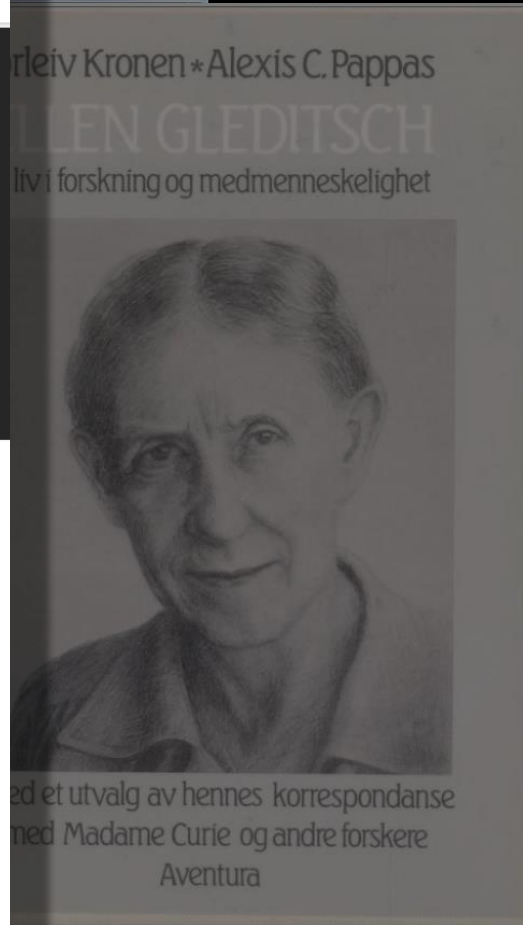
Interesseområder: Kjemiundervisning, lærebøker, skriving i naturfag/kjemi, kvinner i naturvitenskap og ingeniørfag, forskerpar, vitenskapelige instrumenter, ingeniørutdanning, kjemihistorie 20 årh.

Emner: [Kjemi fagdidaktikk](#) (PPU 4224/4727) - [Episoder i naturvitenskapenes historie](#) (RFEL 3093) - Selvalgt teori ([LPY3006](#) - Master i naturfagdidaktikk)

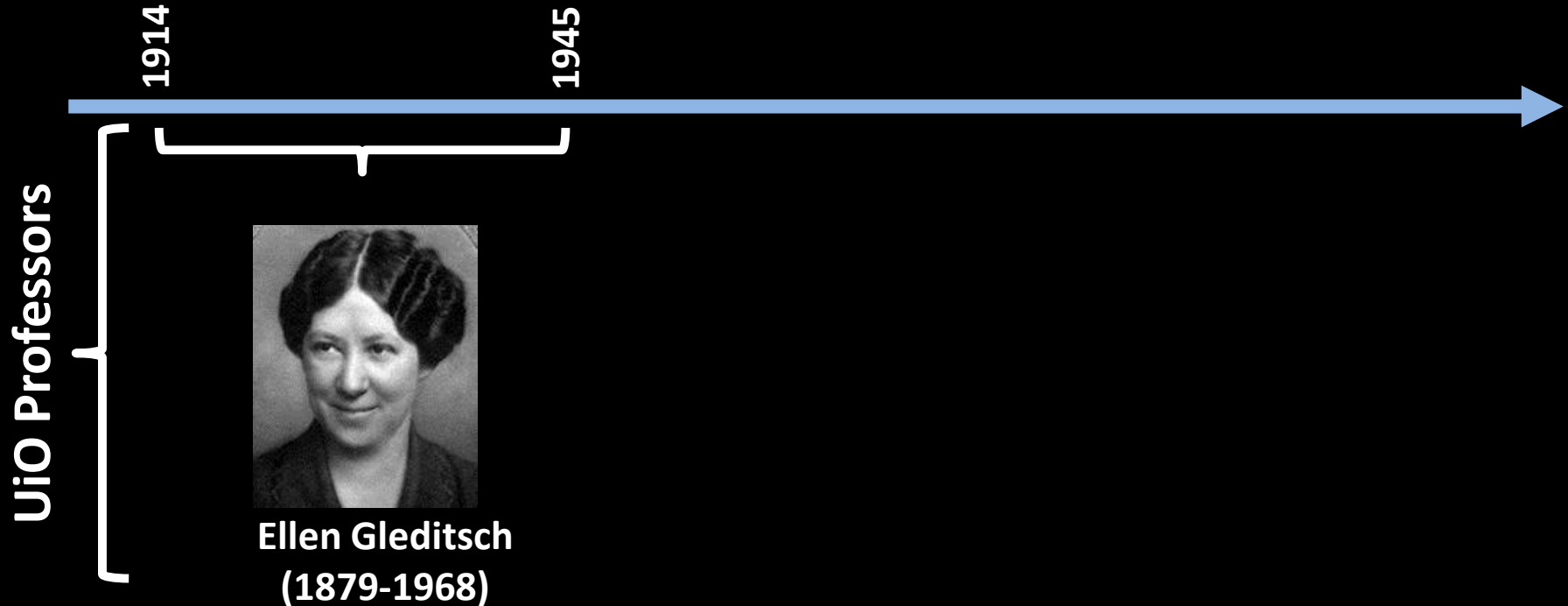
Vitenskapelig, faglig og kunstnerisk arbeid

Viser et utvalg av aktivitet. [Se alle publikasjoner i databasen](#)

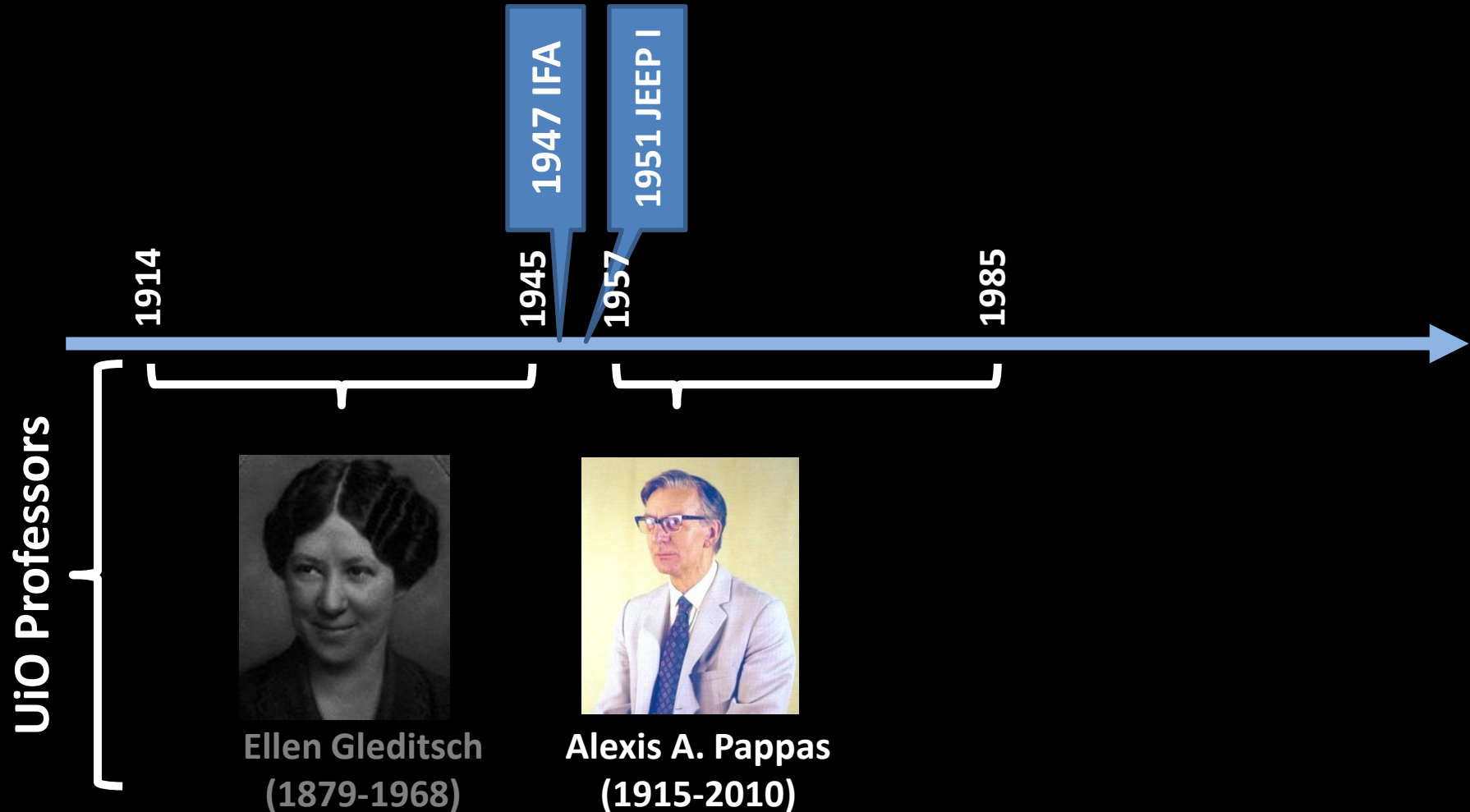
Tidsskriftspublikasjoner



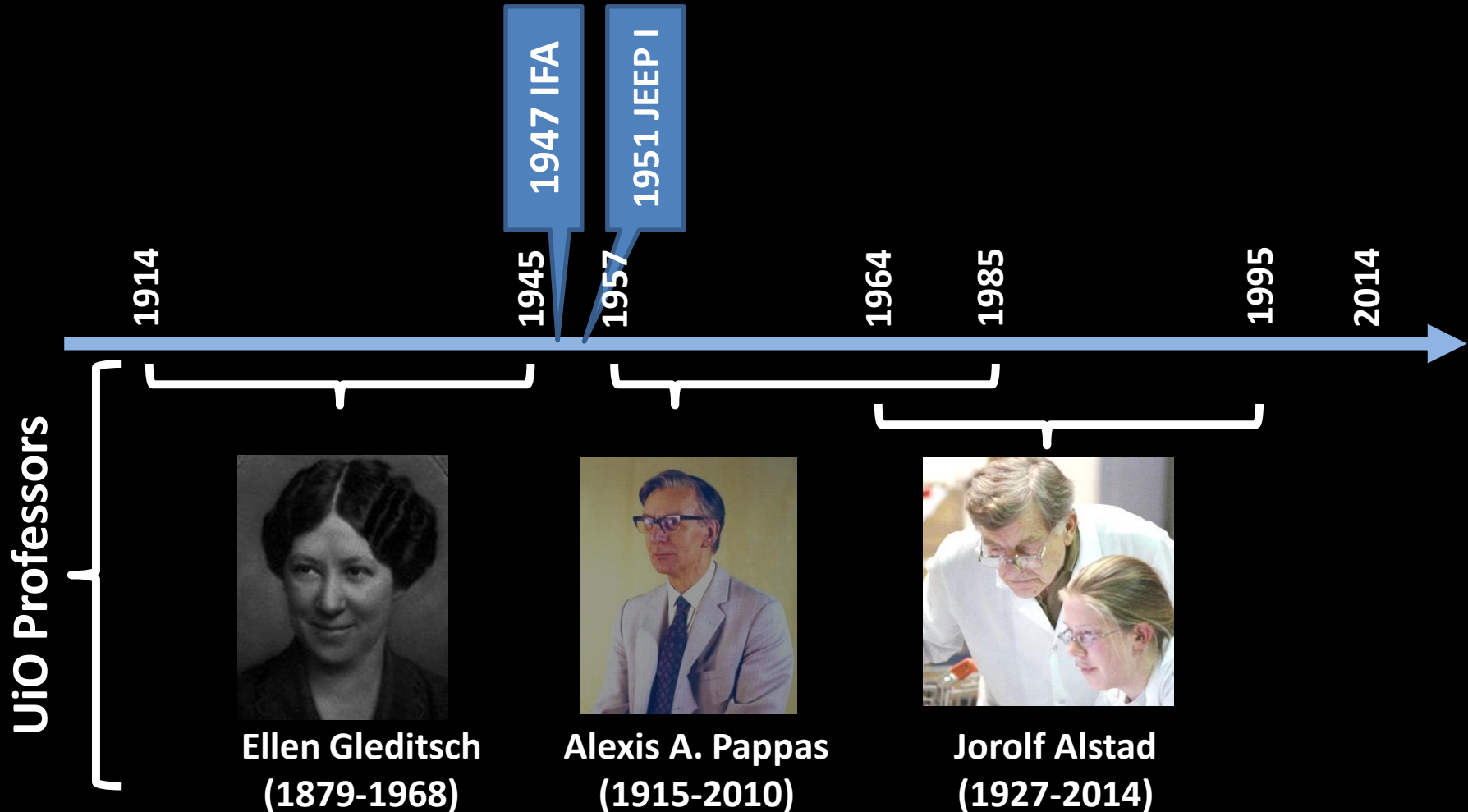
NRC in Norway - Timeline



NRC in Norway - Timeline



NRC in Norway - Timeline



NRC in Norway - Timeline

1914

1945

1947 IFA

1957

1951 JEEP I

1964

1969 - EKOFISK
Oil is discovered

1985

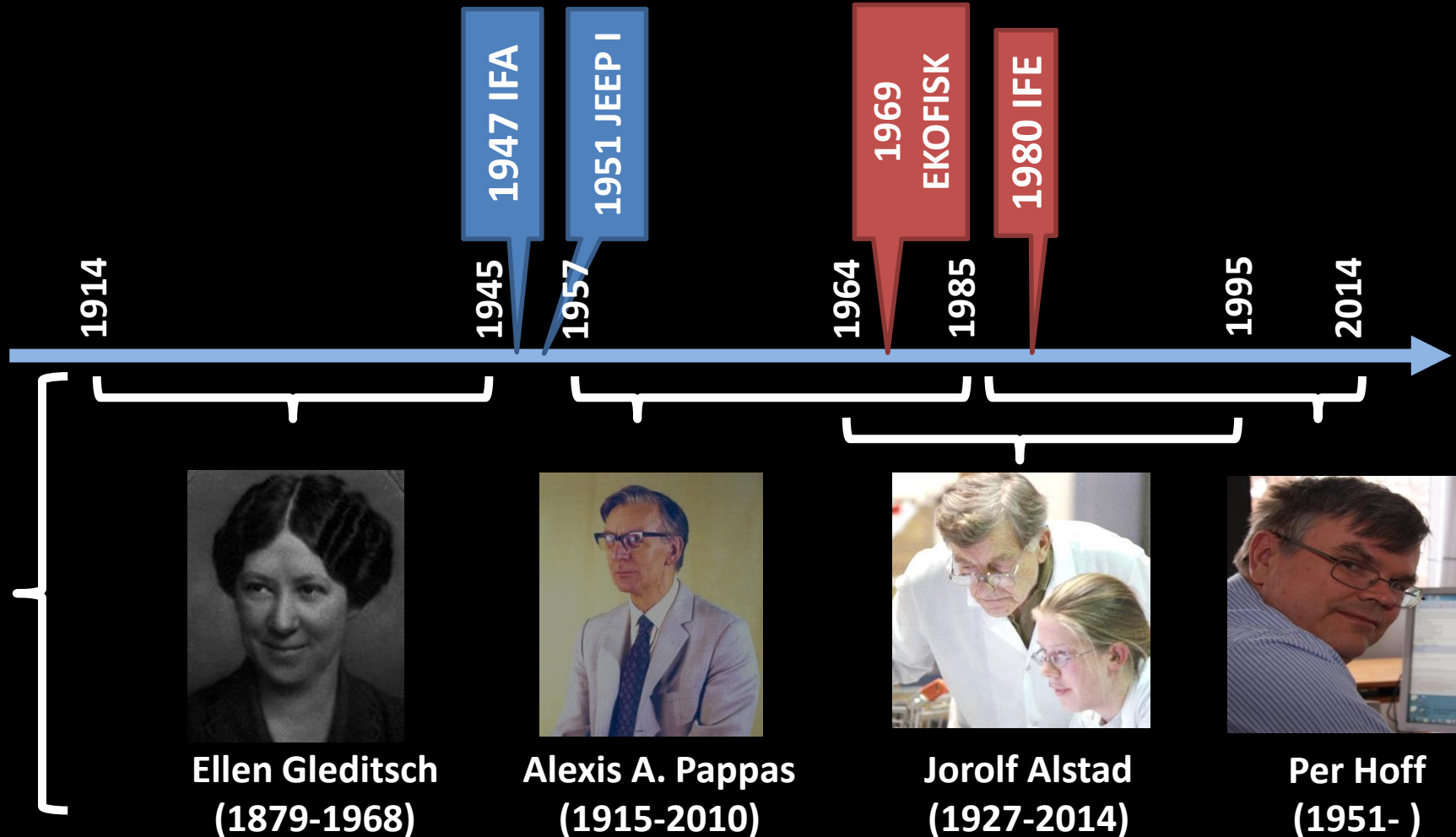
1995

2014



NRC in Norway - Timeline

UiO Professors



NRC in Norway - Timeline

IFA

IEEP I

69

FISK

1980 IFE

Britt Salbu builds up Radioecology at Ås



Lindis Skipperud & Britt Salbu



Centre for
Environmental
Radioactivity
(CERAD)



1985

1995

2014



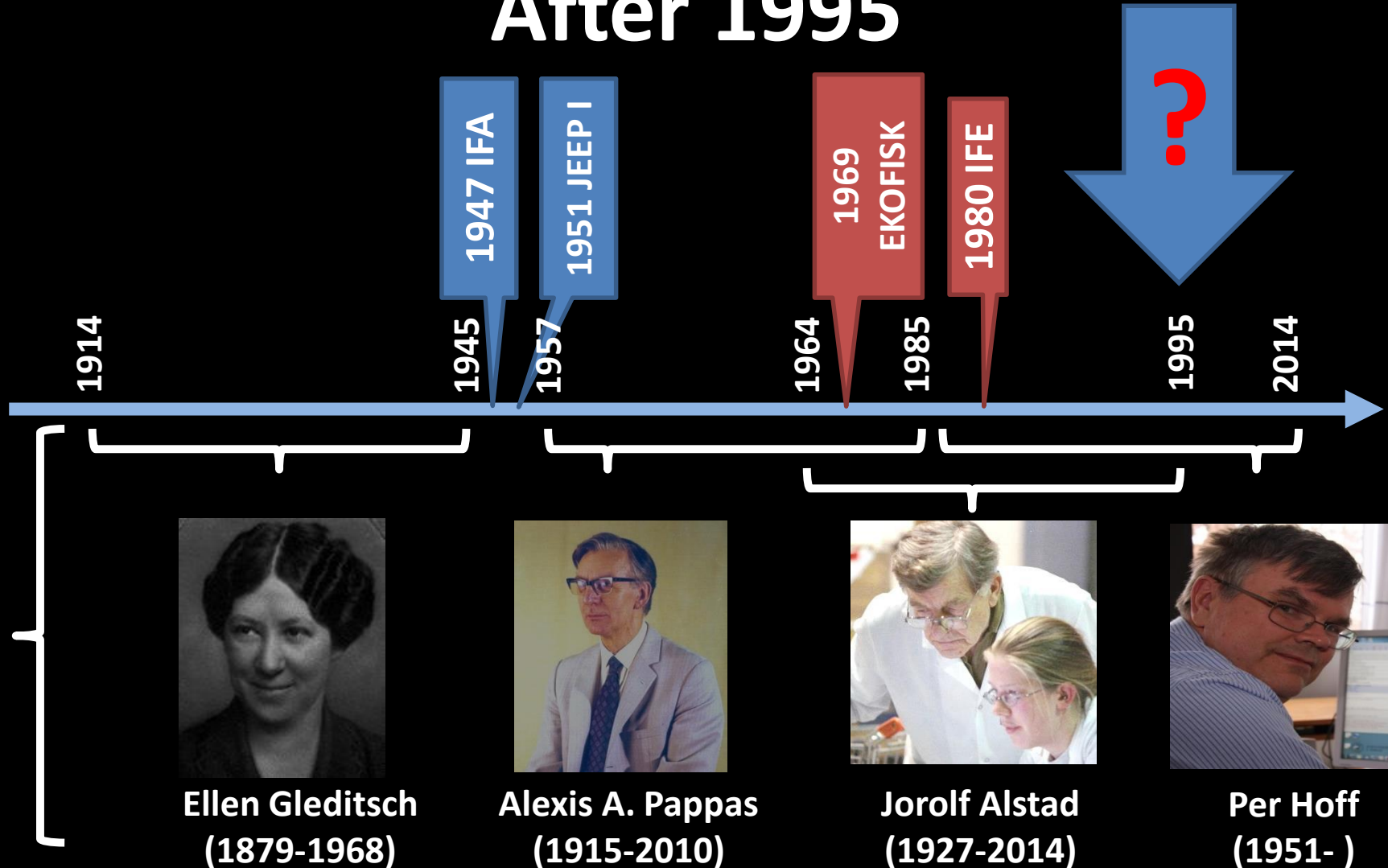
Rolf Alstad
(1927-2014)



Per Hoff
(1951-)

After 1995

UiO Professors



After 1995

UiO Professors

1914



Ellen G. ... is A. Pappas
(187... 1915-2010)

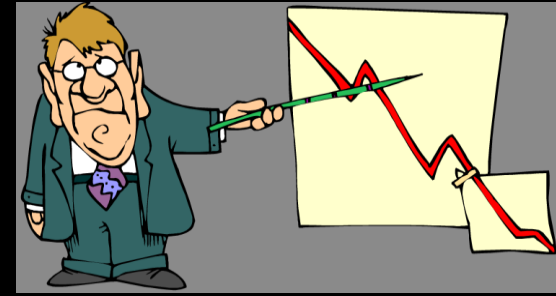
Jorolf Alstad
(1927-2014)

Per Hoff
(1951-)

1995 - 2010

Successes:

- Foundation for Algeta developed by Roy Larsen under supervision of Per Hoff and Jorolf Alstad in the 1990's

A screenshot of the Bayer Nordic website. The header includes the Bayer logo and the text 'Bayer: Science For A Better Life' and 'Bayer Nordic - Norge'. The navigation bar has links for 'Menu', 'Søg', and 'Kontakt'. The main content area is titled 'Algetas historikk' and contains the text 'Algeta - En norsk suksesshistorie'. The text describes the founding of Algeta in 1997 by Roy Larsen and Øyvind Bruland, and its growth over time, including its listing on the Oslo stock exchange in 2007.

Bayer: Science For A Better Life
Bayer Nordic - Norge

Menu Søg Kontakt

Hjem > Bayer Norge > Om Bayer i Norge > Om Algeta

Algetas historikk

Algeta - En norsk suksesshistorie

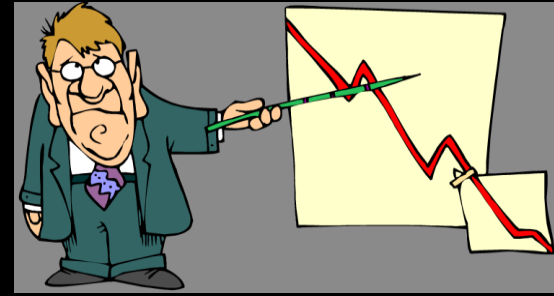
Begynnelsen

Algeta ble stiftet under navnet Anticancer Therapeutic Inventions AS (ATI) i 1997 av Roy Larsen, en nukleærkjemiker fra Universitetet i Oslo, og Øyvind Bruland, professor i onkologi ved Radiumhospitalet, basert på deres forskning på alfa-emitterende substanser brukt til kreftbehandling.

I 2001 ble Thomas Ramdahl ansatt som administrerende direktør – han kom da fra Pronova Biocare AS hvor han jobbet som Senior Vice President, Operations. I 2001 ble også den første dosen av et nytt legemiddel ferdigstilt, og kliniske forsøk startet. Institutt for Energiteknikk på Kjeller, og IFE har siden vært en god og viktig samarbeidspartner for Algeta.

I 2003 skiftet ATI navn til Algeta og 27. mars 2007 ble Algeta notert på Oslo børs. Ved børsnotering hentet selskapet inn 250 millioner kroner og kunne dermed øke staben ytterligere.

1995 - 2010

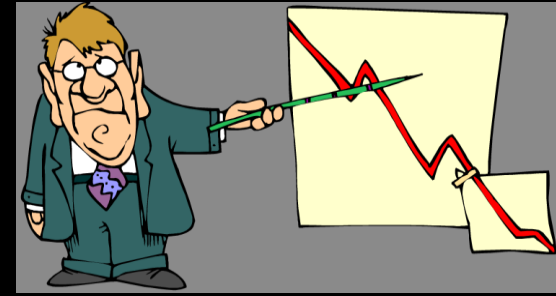


Successes:

- Foundation for Algeta developed by Roy Larsen under supervision of Per Hoff and Jorolf Alstad in the 1990's
- Research group for chemical and physical studies of Super-heavy Elements (SHEs) built up from 1995



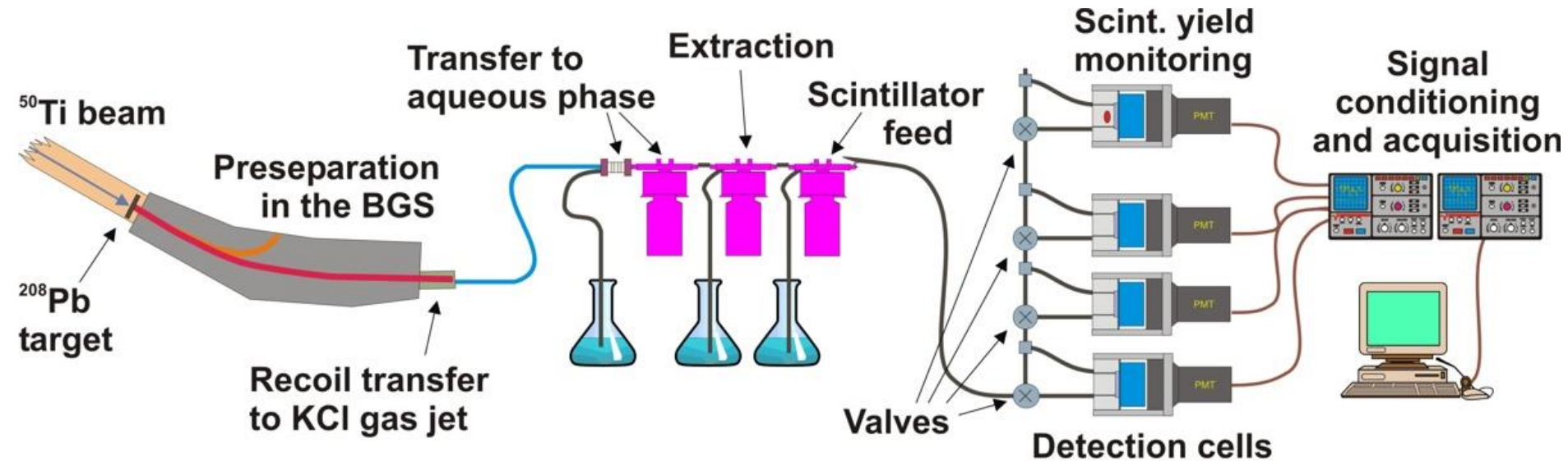
1995 - 2010



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J. P. Omtvedt *et al.*, J. Nucl. Radiochem. Sci. **3**, 121 (2002).



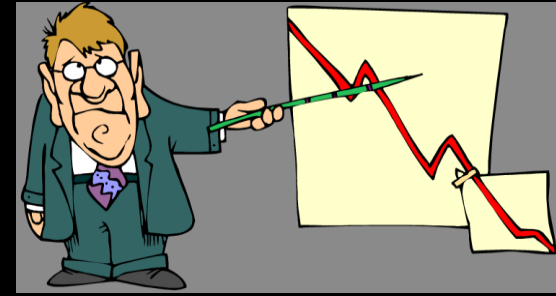
1995 - 2010

BGS + SISAK + Scintillation counting

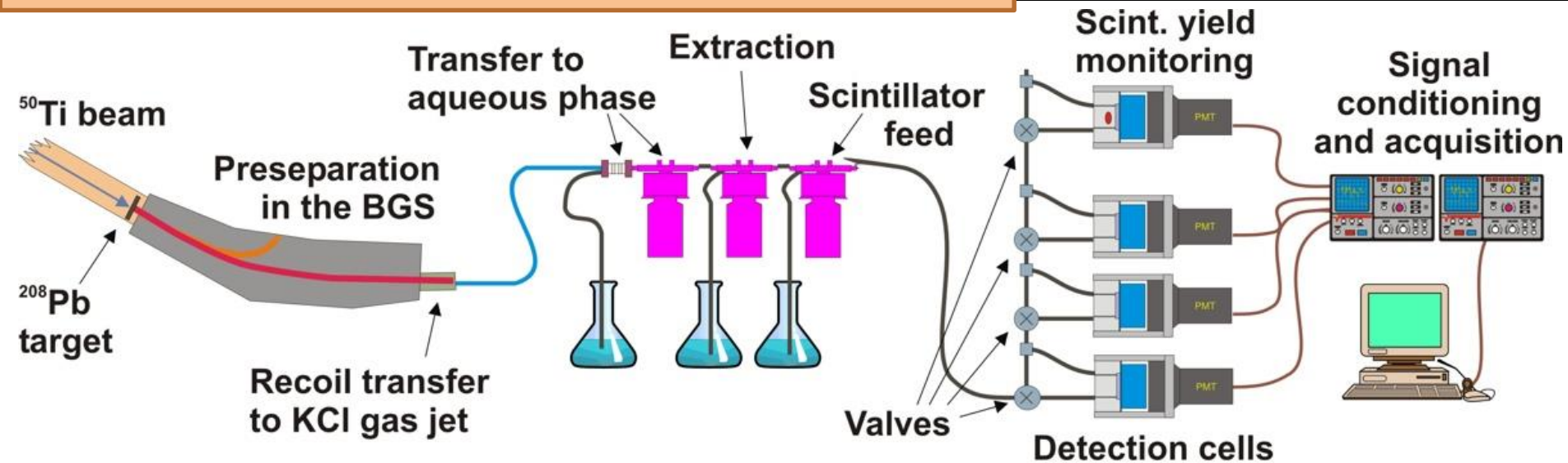
$^{208}\text{Pb}(^{50}\text{Ti}, n)^{257}\text{Rf}$ ($T_{1/2} = 4 \text{ s}$)

– **fastest liquid phase chemistry ever performed for SHE-research.**

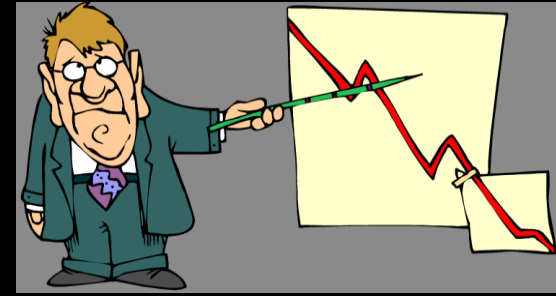
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1995 - 2010



Successes:

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- Research group for chemical and physical studies of Super-heavy Elements (SHEs) built up from 1995
- SAFE center created in 2005
 - Joint use of the Oslo Cyclotron Laboratory (OCL)
 - Major upgrade of OCL and radiochemistry laboratories
 - PET research started at Ki and is a major "satsningsområde" at UiO



2005 - 2015



Problem buildup:

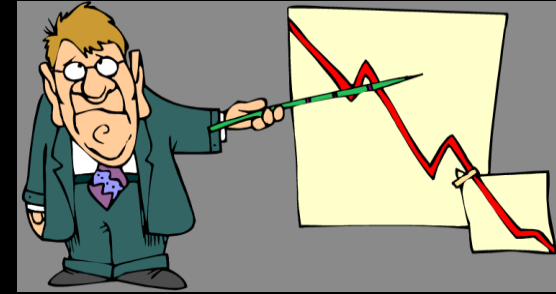
- Economic setback at Ki around 2004-2008 hits NuC hard
- Large fraction of staff ineffective due to illness or maternity leave in period from 2005-2015
- UiO radiation protection organization a total failure
- PET-chemistry PI quits in 2010
- Very few students



2005 - 2015

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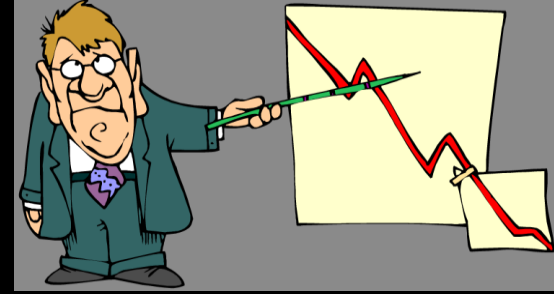
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 - PET-chemistry PI quits in 2010
 - Very few students
- OCL unsuitable for PET and SHE model experiments
 - SAFE discontinued in 2015
 - Foundation for PET vanishes



What went wrong with SAFE?

- Original ideas:
 - Should become strong enough to attract external funding
 - The Nuclear Physics Group and the Nuclear Chemistry Group should each be built up to 4 – four – PIs
- Reality:
 - All applications (>10) were turned down
 - Nuclear Chemistry Group downsized, not expanded
 - No administrative support, too little technical support
 - OCL not suitable for PET

2015 - 2016



New Life-Science Building

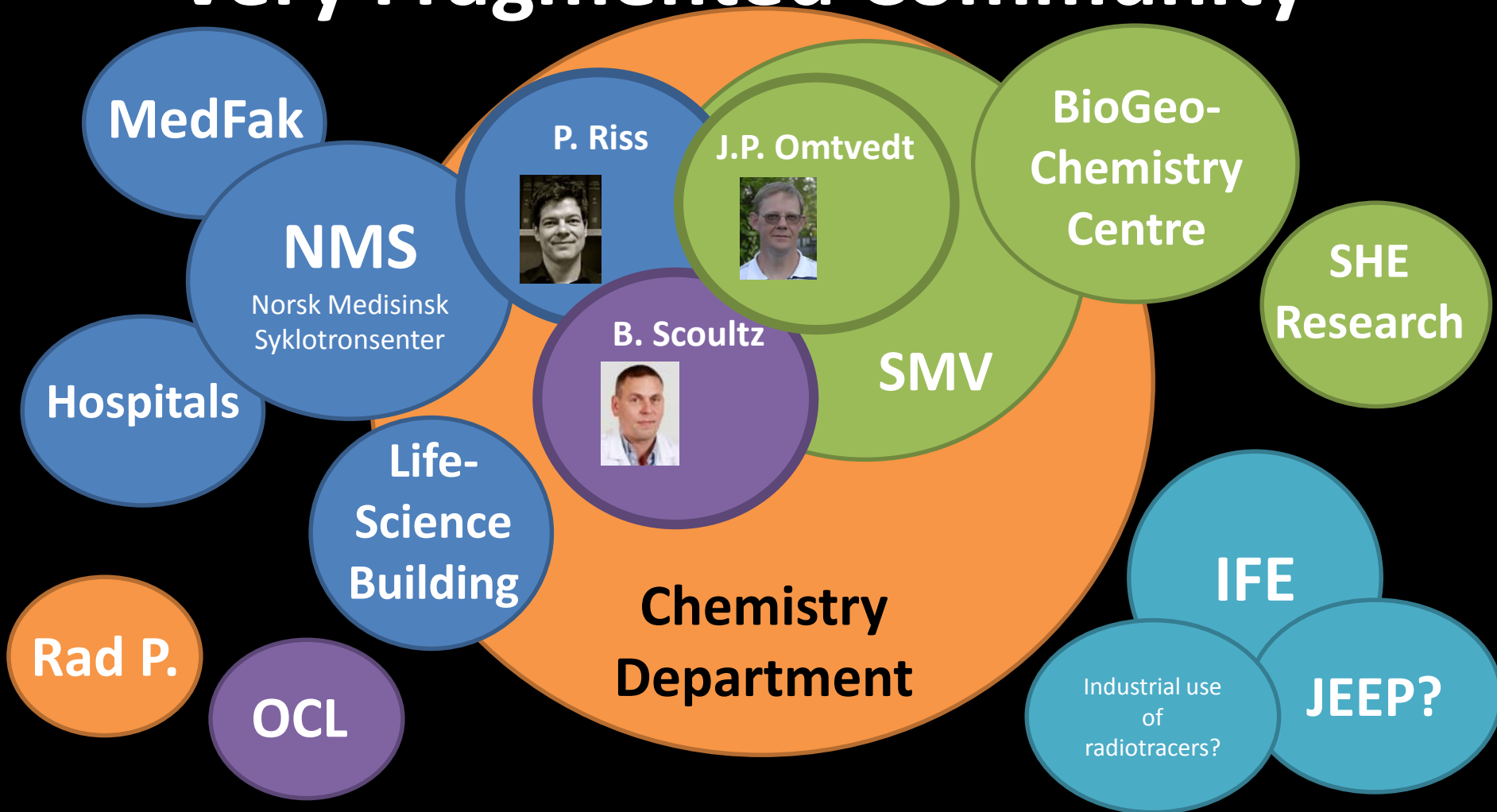
- No space or money for NRC facilities
- Whap will happen to NuC?



Summary as per 2016

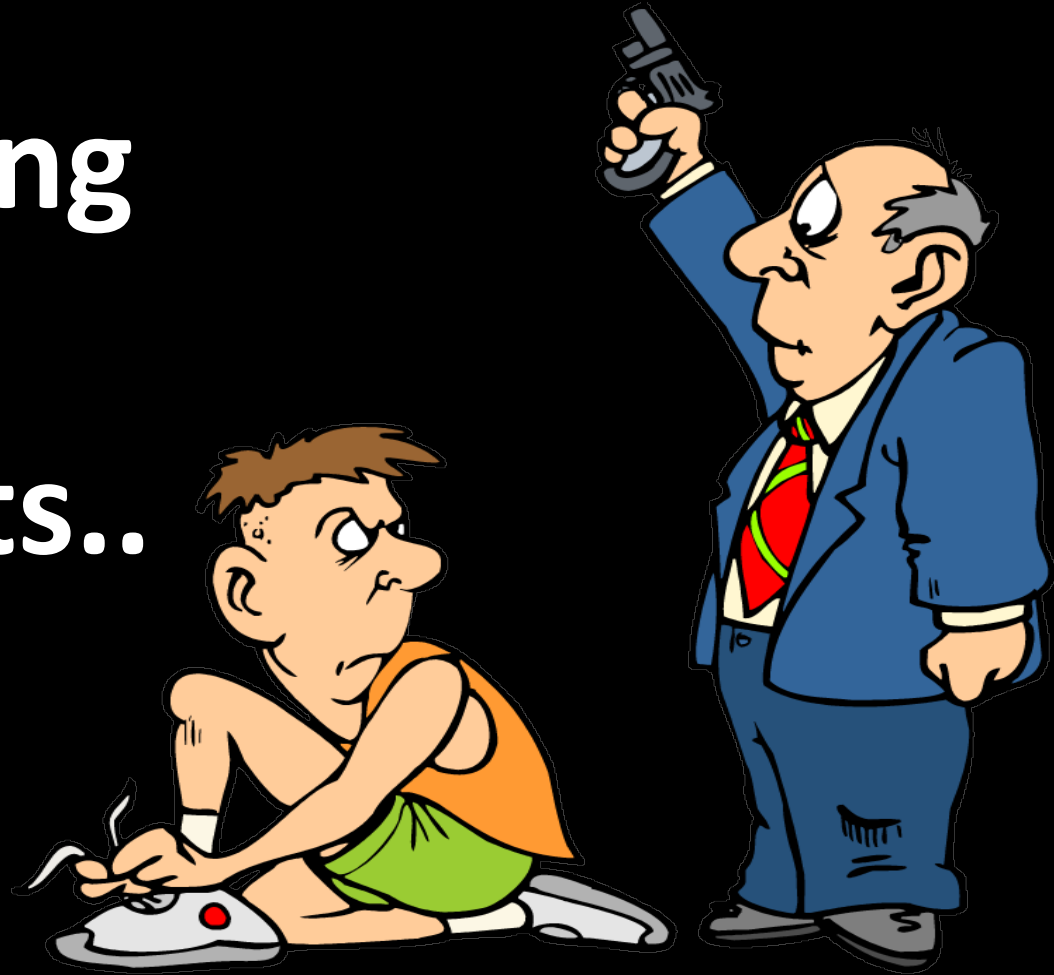
- **Nuclear Chemistry Group** (NuC) is formally part of **Center for Environmental Science** (SMV)
- Two PIs at NuC
 - **Patrick Riss** returns to full position in Oslo from 1. Dec
- **Bent Schoultz** is involved in building up ^{211}At research at OCL
- **Radiation Protection** "an open question"
- Good **laboratory facilities**
- No in-house **source for radionuclei**
- Old and run-down **detectors**

Very Fragmented Community



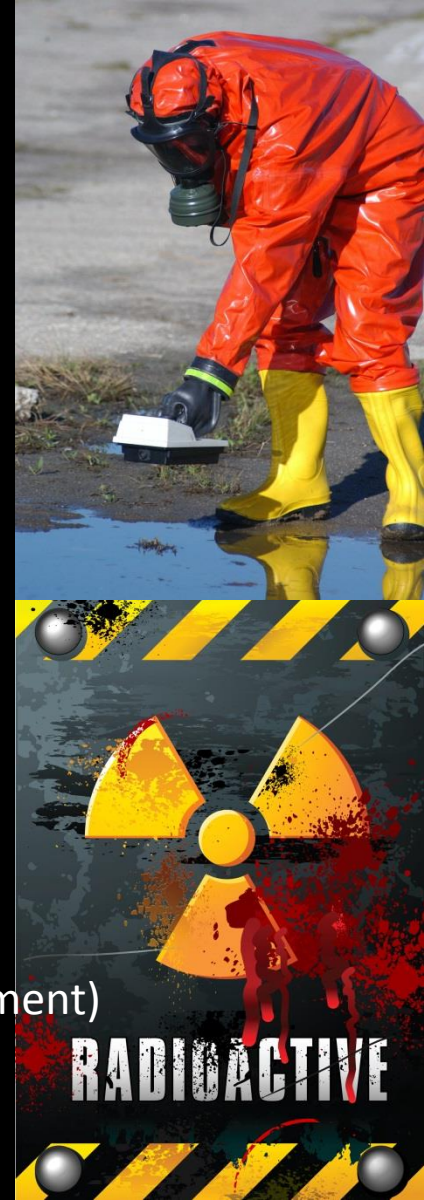
2017-2025

A good starting
point for
improvements..



Do Society *Need* NRC?

- Estimates in the US and EU indicate that future need for radiochemists is 5x larger than "production"
- Needed for
 - **Nuclear power industry:**
 - for buildup or,
 - if shut down (for decommissioning)
 - **Nuclear medicine** (diagnostic and therapy)
 - **Tracers** for industry and research
 - **Radiation protection** (industry, hospitals and government)
 - **Radioecology** and **nuclear forensics**



Do NRC belong in Academia?

Basic science is about pushing the limits and go where nobody has been before



**J. Irwin and D. Scott's Apollo 15
mission to the moon in 1971
(NASA)**



**J. Cameron took
DeepSea Challenger
down to the bottom of
the Mariana Trench on
26th March 2012**

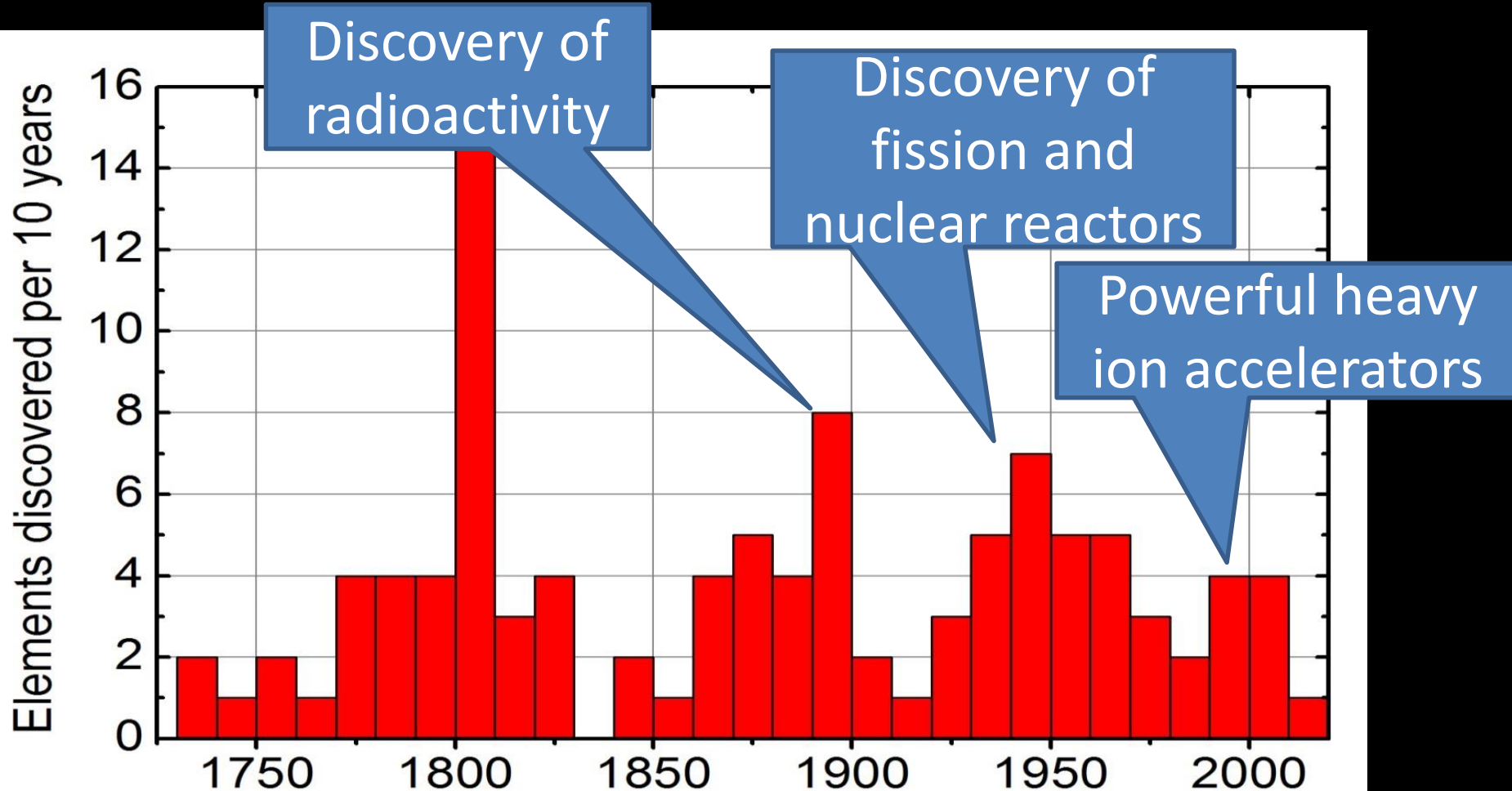
A photograph of an astronaut in a full space suit standing on the lunar surface. The astronaut is wearing a white helmet and a backpack, and is holding a tool. The background shows the dark, cratered surface of the Moon under a bright sky.

**J. Irwin
mission
(NASA)**

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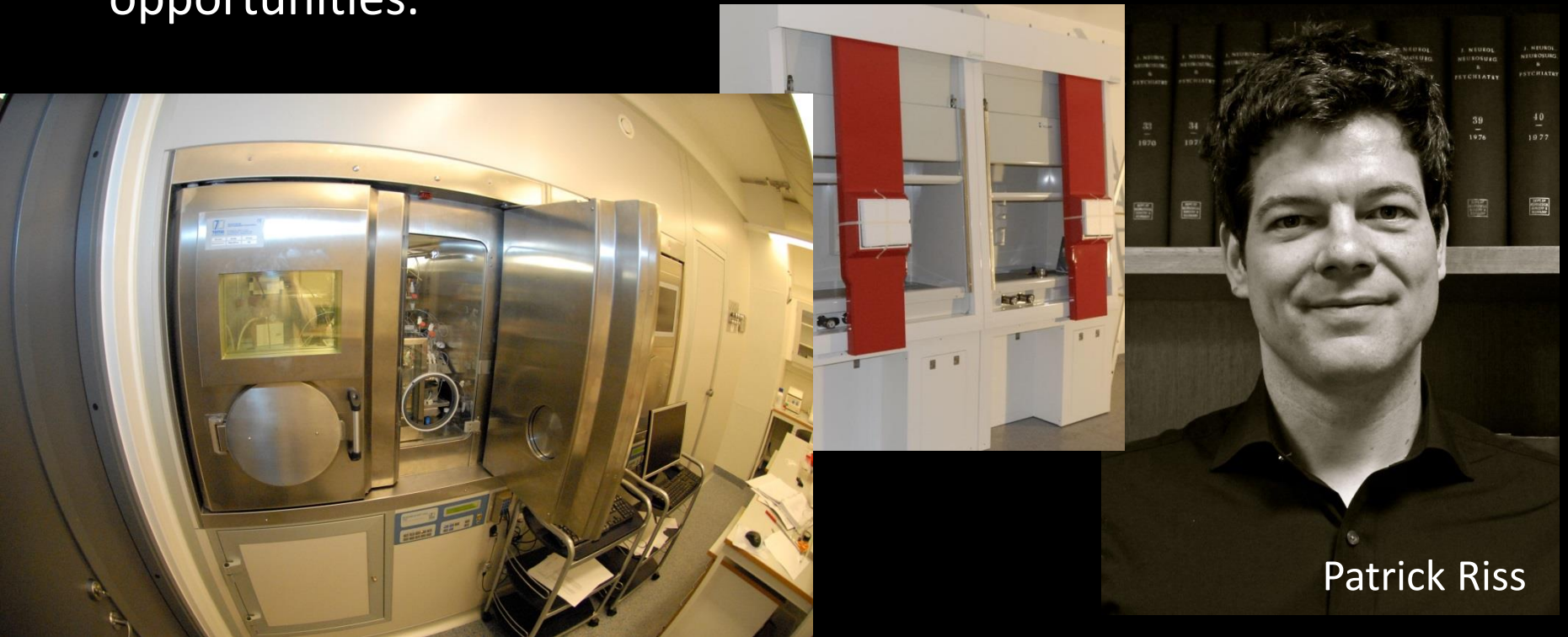


Element Discovery - Trend



Do NRC belong in Academia?

- Crafting new radiolabeled compounds for Nuclear Medicine is neither easy nor obvious – many challenging research opportunities.

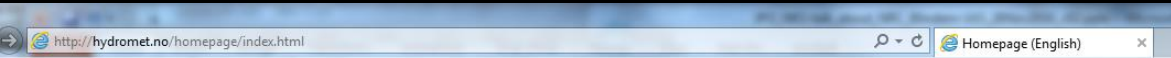


Patrick Riss

Do NRC belong in Academia?

- Crafting new radiolabeled compounds for Nuclear Medicine is neither easy nor obvious – many challenging research opportunities.
- Using radiotracers to understand and solve problems in applied research is important and challenging

Hydromet



Hydromet

A UiO-NTNU-Sintef-IFE Norwegian Research Council
hydrometallurgy competence-building project in collaboration with
Norwegian companies Yara, Boliden Odda og Glencore Nikkelverk



Startside

Kurs og utdannelse

Møter og seminarer

Partnere

Pekere

Internsider

Homepage
(English)

Protected pages

Hydrometallurgy
Course

Homepage (English)

The four-year Hydromet project aims at strengthening and developing hydrometallurgical research and education in Norway.

The project is a close collaboration between Norwegian process industry and
forefront Norwegian research institutions: The University of Oslo (UiO),
University of Trondheim (NTNU), and the research institutes SINTEF
Partners from the process industry are Yara International in Porsgrunn, Glencore
Nikkelverk in Kristiansand, and Boliden in Odda.

The Hydromet project has two main goals:

- To educate candidates highly skilled in hydrometallurgy and therefore



Kontaktpersoner

Jon Petter Omtvedt
(prosjektleder)

Dag Ø. Eriksen
(daglig prosjektleder)

post@hydromet.no

Få informasjon!

Ønsker du informasjon
om seminarer,
arrangement og andre
ting vedrørende

Do NRC belong in Academia?

- Crafting new radiolabeled compounds for Nuclear Medicine is neither easy nor obvious – many challenging research opportunities.
- Using radiotracers to understand and solve problems in applied research is important and challenging
- Countering threats from criminal and terrorist smuggling and using nuclear material is extremely challenging

Do NRC belong in Academia?

- Crafting new radiolabeled compounds for Nuclear Medicine is neither easy nor obvious – many challenging research opportunities.
- Using radiotracers to understand and solve problems in applied research is important and challenging
- Countering threats from criminal and terrorist smuggling and using nuclear material is extremely challenging
- Understanding how radionuclei behave environmentally is challenging and important.

Nuclear and Radiochemistry Research?

- **Nuclear Energy**, in particular fabrication of fuel and treatment of spent nuclear fuel
- Synthesis of **radiolabeled compounds** for **medical** diagnostics and therapy
- Migration of radionuclides in nature (**radioecology**)
- **Radiation protection & nuclear forensics**
- **Fundamental properties** of nuclei
- **Radiotracers** used as tools in industry & research









Politically
impossible

UiO priority

CeRAD and
NMBU (Ås)

UiO
opportunity

Sustainability

	PET	Hydro-metallurgy	SHE
Good Science			
Students			
Funding			

NuC@UiO should:


- Maintain NUC knowledge and competence
- Contribute to education in Radiation Protection
- Key areas:
 - Nuclear Medicine (i.e. radiopharmaceutical chemistry)
 - Super-heavy Elements research
 - Application of radiotracers in industry

Education

- We have participated in the CINCH EU-projects to promote and enhance NRC teaching in Europe
 - NRC EuroMaster label based on minimum requirements for NRC competence and knowledge
 - Developed e-learning tools (headed by UiO)
 - Free NRC Textbook written by Jukka Lehto (UH)
 - Access to courses across Europe for UiO students
- CINCH-III (application submitted)
 - UiO will head creation of a NRC MOOC



CINCH E-learning tools

NucWik  **Nuclear and Radiochemistry**
Teaching Material **Wiki** CINCH

CINCH  **Moodle Platform**

RoboLab  **Remote Operated RadLab**
for Teaching Radiochemistry CINCH

CSE exercises

Details?
Talk at NRC9:



Cooperation in Education and Training in
Nuclear- and Radiochemistry in Europe

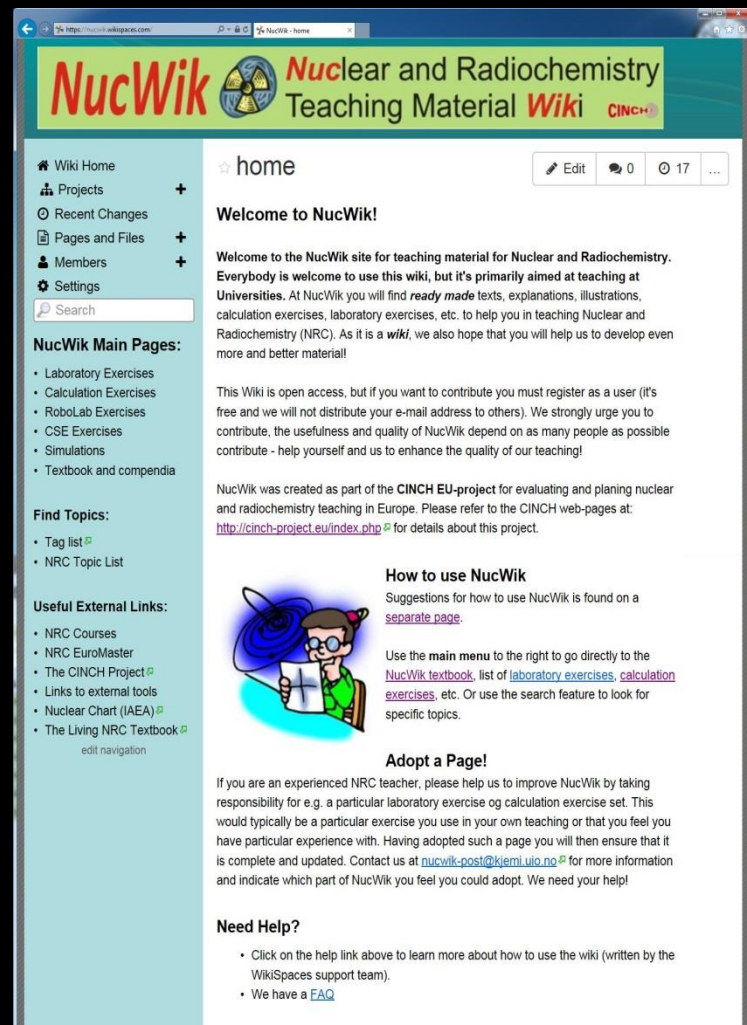
Site for Sharing *Teaching Material*

NucWik:

- No reading or downloading restrictions.
- Must register to upload material or edit content.
- It's free!

<http://nucwik.wikispaces.com/>

.. or just Google "NucWik"

A screenshot of the NucWik website interface. The header features the 'NucWik' logo with a radiation symbol and the text 'Nuclear and Radiochemistry Teaching Material Wiki CINCH+'. The left sidebar contains navigation links: Wiki Home, Projects, Recent Changes, Pages and Files, Members, Settings, and a search bar. Below these are 'NucWik Main Pages' (Laboratory Exercises, Calculation Exercises, RoboLab Exercises, CSE Exercises, Simulations, Textbook and compendia), 'Find Topics' (Tag list, NRC Topic List), and 'Useful External Links' (NRC Courses, NRC EuroMaster, The CINCH Project, Links to external tools, Nuclear Chart (IAEA), The Living NRC Textbook). The main content area welcomes users to the site, explaining its purpose for teaching nuclear and radiochemistry. It includes a 'How to use NucWik' section with a cartoon character and a 'Adopt a Page!' section encouraging experienced teachers to contribute. A 'Need Help?' section at the bottom provides contact information for the support team.

NucWik Nuclear and Radiochemistry Teaching Material Wiki CINCH+

home Edit 0 17

Welcome to NucWik!

Welcome to the NucWik site for teaching material for Nuclear and Radiochemistry. Everybody is welcome to use this wiki, but it's primarily aimed at teaching at Universities. At NucWik you will find *ready made* texts, explanations, illustrations, calculation exercises, laboratory exercises, etc. to help you in teaching Nuclear and Radiochemistry (NRC). As it is a *wiki*, we also hope that you will help us to develop even more and better material!

This Wiki is open access, but if you want to contribute you must register as a user (it's free and we will not distribute your e-mail address to others). We strongly urge you to contribute, the usefulness and quality of NucWik depend on as many people as possible contribute - help yourself and us to enhance the quality of our teaching!

NucWik was created as part of the CINCH EU-project for evaluating and planing nuclear and radiochemistry teaching in Europe. Please refer to the CINCH web-pages at: <http://cinch-project.eu/index.php> for details about this project.

How to use NucWik
Suggestions for how to use NucWik is found on a [separate page](#).

Use the **main menu** to the right to go directly to the [NucWik textbook](#), list of [laboratory exercises](#), [calculation exercises](#), etc. Or use the search feature to look for specific topics.

Adopt a Page!
If you are an experienced NRC teacher, please help us to improve NucWik by taking responsibility for e.g. a particular laboratory exercise or calculation exercise set. This would typically be a particular exercise you use in your own teaching or that you feel you have particular experience with. Having adopted such a page you will then ensure that it is complete and updated. Contact us at nucwik-post@hjemli.uio.no for more information and indicate which part of NucWik you feel you could adopt. We need your help!

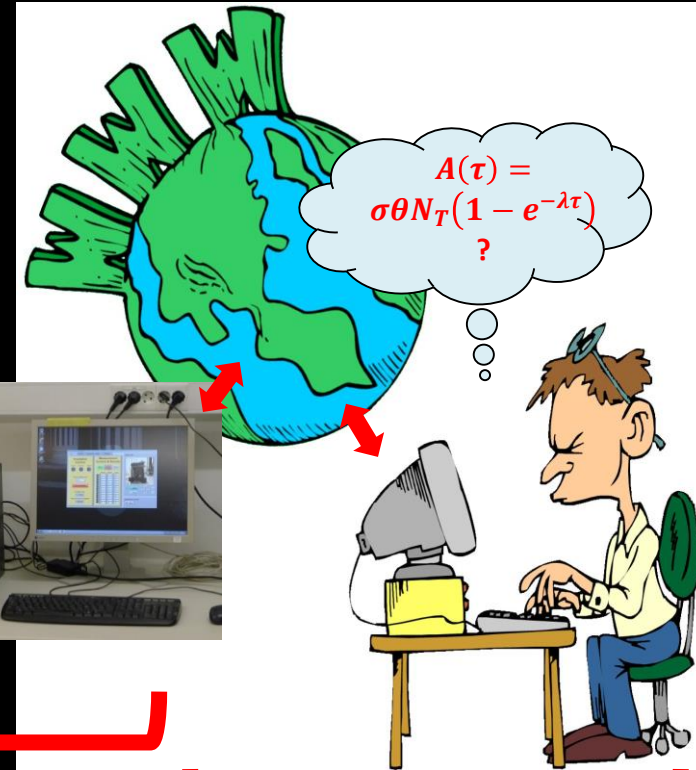
Need Help?

- Click on the help link above to learn more about how to use the wiki (written by the WikiSpaces support team).
- We have a [FAQ](#)

RoboLab Principle



**A real nuclear laboratory using
radioactive material**



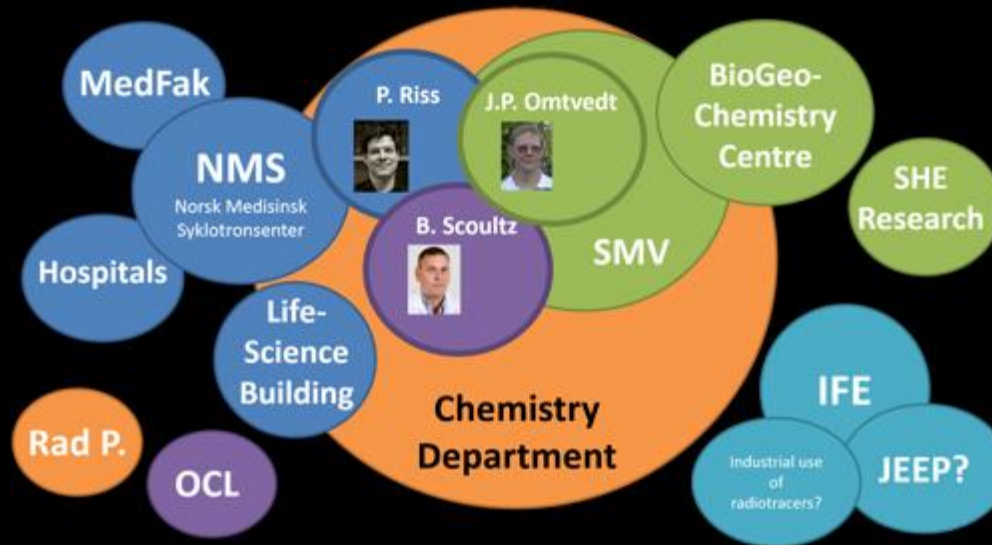
**Student using the lab
through his computer**

Challenges & Opportunities

- Will Kjeller reactor be shut down? Where should we make our radionuclides? Can we get our own n-generator (~5 MNOK)?
- PET-research
 - Can we get a used PET cyclotron?
 - New center for Nuclear Medicine at IFE?
- SHE and hydrometallurgy research
 - Hydrometallurgy and "urban mining" related research is fundable, wanted (by industry) and attract students
 - SHE must be based on travel (particle accelerators in Rez and RIKEN)

Conclusions

- Fragmentation of resources is a big problem



Conclusions

- Physical location must be decided
 - Where should NuC stay when Department moves to new building?
 - What relation should NuC have to possible new cyclotron center at IFE?
 - How should NuC relate to new BioGeoChemistry center?
 - What relation should NuC have to NMS?

Conclusions - For My Own Part

- Hydrometallurgy is fundable and have large overlap with SHE chemistry (LLX etc.)
 - SHE is first priority, this is what I do best
 - Hydrometallurgy (including environmental concerns, recycling of metals and urban mining) is second priority



Talk dedicated to memory of
Jorolf Alstad
(1927 – 2014)

Thanks for your Attention!

