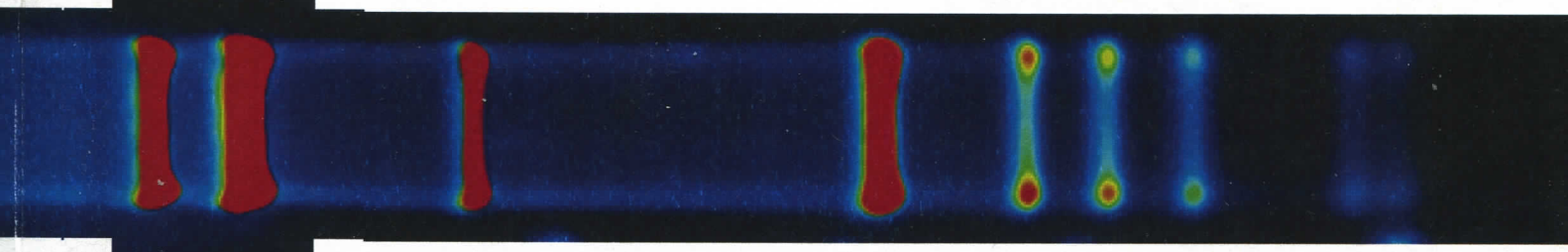

Book of Abstracts

1st Nano-IBCT Conference 2011

Radiation damage of biomolecular systems:
Nano-scale insights into Ion Beam Cancer Therapy

2nd-6th October 2011
Caen, France

organised in the framework of the COST ACTION MP1002 'NANO-IBCT'
http://fias.uni-frankfurt.de/nano-ibct/

cost CiMap FIAS Frankfurt Institute for Advanced Studies

Foreword

The 1st NanoIBCT Conference, entitled 'Radiation Damage of Biomolecular Systems: Nano-scale Insights into Ion Beam Cancer Therapy', is organized in Caen from October 2nd to October 6th. This conference is part of the COST Action MP1002 (Nano-IBCT) which has been launched in December 2010. We believe that this Action will be relevant for many communities (scientific, medical, technological, industrial) being interested in a detailed understanding of radiation interaction mechanisms at a molecular and nanoscopic scale. At present, twenty countries have joined the Action which is still open for other interested countries to join.

Ion beam therapy offers the possibility of excellent dose localization for treatment of malignant tumours, minimizing radiation damage in normal tissue, while maximizing cell-killing within the tumour. The first ion beam cancer therapy clinical centres are now opening in Europe. However, the full potential of such therapy can only be realised by better understanding the physical, chemical and biological mechanisms, that lead to cell death under ion irradiation. Considering a range of spatio-temporal scales, the proposed Action therefore aims to combine the unique experimental and theoretical expertise available within Europe to acquire greater insight at the nanoscopic and molecular level into radiation damage induced by ion impact. Success in this endeavour will be both an important scientific breakthrough and give great impetus to the practical improvement of this innovative therapeutic technique. Ion therapy provides potentially a significant advance in cancer therapy and the COST action MP1002 will be very significant in ensuring European leadership in this field, providing the science background, required data and mechanistic insight which is indispensable for the optimization of this new therapy.

We hope that this conference will create plenty of opportunities to exchange ideas on scientific and practical issues, to initiate new collaborations and to integrate in particular young researchers from the scientific as well as from the applied field in this wide community. In total, 118 participants from 28 countries will come together representing disciplines like physics, chemistry, biology, medicine as well as industrial partners and operators of hadron therapy projects and installations. Therefore, this meeting would provide an ideal forum for fruitful exchange and will help to progress in this biomedical endeavor. Please use these possibilities!

The Conference Chairs

Yann-Antoine Gauduel Bernd A. Huber Andrey V. Solov'yov

ABSOLUTE CROSS SECTIONS FOR ELECTRON INTERACTION WITH MOLECULES REPRESENTING SUB-UNITS OF BIOPOLYMERS

A. R. Milosavljević[(1)]*, F. Blanco[(2)], J. B. Maljković[(1)], G. García[(3)], and B. P. Marinković[(1)]

[(1)] *Institute of Physics, University of Belgrade, Pregrevica 118, 11080 Belgrade, Serbia*
[(2)] *Departamento de Física Atómica Molecular y Nuclear, Facultad de Ciencias Físicas, Universidad Complutense, Avda. Complutense s/n, E-28040 Madrid, Spain*
[(3)] *Instituto de Matemáticas y Física Fundamental, Consejo Superior de Investigaciones Científicas, Serrano 121, 28006 Madrid, Spain*

In recent years, we have reported both experimental and theoretical absolute differential cross sections (DCSs) for electron interaction with several different molecules representing building blocks of DNA [1]. Most recently this investigation has been also extended to the smallest molecular systems containing the peptide bond. Beside a fundamental interest to investigate electron/molecule interactions, the present work is also motivated by the research on radiation damage in biomolecular systems [2].

The present experimental procedure includes three independent measurements, namely: 1) relative DCSs measured as a function of scattering angle, 2) relative DCSs measured as a function of the incident electron energy and 3) absolute DCSs obtained at specific scattering angle and incident energy by applying relative flow technique. All these independent data sets are merged to form a consistent set of absolute DCSs for a specific target, which is finally compared to the theoretical results. The calculations of molecular cross sections are based on a corrected form of the independent-atom method, known as the SCAR (Screen Corrected Additivity Rule) procedure and using an improved quasifree absorption model. For all treated molecular targets, a very good agreement between the experimental and theoretical results has been obtained (see Figure 1).

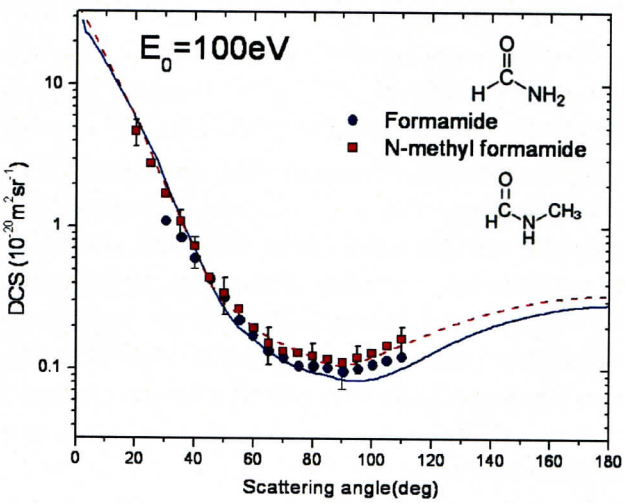

Fig. 1. Angular dependence of relative DCSs for elastic electron scattering from formamide (exp: circles; theory: full line) and N-methyl formamide (exp: squares; theory: dashed line) molecules.

References

[1] J. B. Maljković, A. R. Milosavljević, F. Blanco, D. Šević, G. García and B. P. Marinković, *Phys. Rev. A* **79**, 052706 (2009); A. R. Milosavljević, F. Blanco, J. B. Maljković, D. Šević, G. García and B. P. Marinković, *New Journal of Physics* **10**, 103005 (2008); A. R. Milosavljević, F. Blanco, D. Šević, G. García and B. P. Marinković, *Eur. Phys. J. D* **40**, 107 (2006).

[2] B. Boudaiffa, P. Cloutier, D. Hunting, M. A. Huels, and L. Sanche, *Science* **287**, 1658 (2000).

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Session/time	Speaker / chair person	Title
2.10.2011 Sunday		
18:00 – 22:30	**Reception/ Registration**	Café Mancel, Fine Arts Museum, Castle
3.10.2011 Monday		
8:00-9:00	**Registration / Coffee**	
9:00-9:15	Welcome	
Session I	Chair person:	Y. Gauduel
9:15-9:30	A. Solov'yov	Cost Action MP1002-NanoIBCT
9:30-10:00	J-L Habrand	Clinical benefit of particle beam therapies: nano-benefit ?
10:00-10:30	J. Ullrich	Research with advanced laser systems at MPIK
10:30-11:00	**Coffee break**	
Session II	Chair person:	B.A. Huber
11:00-11:10	B.A. Huber	WG1 activity
11:10-11:35	G. Garcia	Modeling charged particle tracks
11:35-12:00	R. Garcia-Molina	Depth-dose distribution of proton beams
12:00-12:25	A. Yakubovich	Nucleosome thermo-mechanical damage
12:30-14:30	**Lunch time**	
Session III	Chair person:	T. Schlathölter
14:30-14:40	T. Schlathölter	WG2/WG3 activities
14:40-15:05	A. Domaracka	Ion interaction & environmental effects
15:05-15:30	S. Bari	Peptide structure & fragmentation
15:30-15:55	M. Fuss	Transport of secondary species
16:00-16:30	**Coffee break**	
16:30-19:00	**Poster Session**	
4.10.2011 Tuesday		
Session IV	Chair person:	P. Limao-Vieira
9:00-9:30	E. Ilenberger	Electron induced reactions
9:30-10:00	M. Durante	Therapy for noncancer diseases
10:00-10:25	M. Dosanjh/ M. Durante	The ENLIGHT Project
10:30-11:00	**Coffee Break**	
Session V	Chair person:	A. Vibok
11:00-11:25	L. Feketeova	Electron interactions with biomolecular clusters
11:25-11:45	M.C. Bacchus-Montabonel	Actions of secondary ions / radiosensitization properties
11:45-12:05	B. Laster	Auger emission and telomerase inhibition
12:05-12:25	C. Champion	DNA/RNA components impacted by charged particles
12:30-14:30	**Lunch time**	
Session VI	Chair person:	M. Huels
14:30-14:55	M.A. Smialek-Telega	Ion induced radiation damage in plasmid DNA
14:55-15:20	E. Surdutovich	Calculation of clustered damage of DNA irradiated by ions
15:20-15:40	E. Suraud	Microscopic description of the irradiation of biomolecules
15:40-16:00	I. Rabadan	Aggregation effects in proton water collisions
16:00-16:30	**Coffee Break**	
Session VII	Chair person:	P. Bolognesi
16:30-16:40	G. Garcia	WG4 activity
16:40-17:05	E. Cauët	Calculations of ionization and charge transfer in DNA
17:05-17:30	S. Denifl	Low energy electron collisions with DNA building blocks
17:30-17:55	I. Baccarelli	Electron scattering calculations

Session/time	Speaker / chair person	Title
5.10.2011 Wednesday		
Session VIII	Chair person:	SVK Kumar
9:00-9:30	T. Haberer	The Heidelberg Ion Beam Therapy Center
9:30-10:00	H. Rabus	Dosimetry concepts for carbon ion therapy
10:00-10:25	N. Mason	VAMDC – The virtual Atomic and Molecular Data Center
10:30-11:00	**Coffee Break**	
Session IX	Chair person:	I. Abril
11:00-11:25	H. Whitlow	Anomalous dose and fluence behavior of PMMA
11:25-11:50	J. Kopyra	Electron driven reactions in DNA components
11:50-12:10	I. Bald	Strand breaks in DNA oligonucleotides
12:10-12:30	A. Stypczynska	Chemical modifications induced by X-rays
12:30-14:30	**Lunch time**	Meeting of the STPC
Session X	Chair person:	K. Prise
14:30-14:40	K. Prise	WG5 activity
14:40-15:05	M. Beuve	O2 and glutathione effects on water radiolysis
15:05-15:30	W.Friedland	Monte Carlo modeling of ion induced DNA damage
15:30-15:55	M. Falk	DNA double strand break repair and formation of chromosomal translocations
16:00-16:30	**Coffee Break**	
17:00-19:00	**Guided Town Tour**	
20:00-23:00	**Conference Dinner**	
6.10.2011 Thursday		
Session XI	Chair person:	N.J. Mason
9:00-9:30	A. Solov'yov	Multiscale approach to radiation damage by ions
9:30-9:55	V. Maeckel	Three-dimensional micro-irradiation of living cells
9:55-10:15	S. Lacombe	Nanomedicine and Hadrontherapy
10:15-10:45	**Coffee Break**	
Session XII	Chair person:	G. Garcia
10:45-11:10	Y. Gauduel	Femtosecond radiation chemistry and biology
11:10-11:35	G. Schettino	DNA damage induced by antiprotons in living cells
11:35-12:00	M. Krämer	Ion beams in radiotherapy: from tracks to treatment
12:00-12:25	K. Prise	Microbeams as experimental tools
12:25-12:40		Final remarks
End of the Conference		
12:40-14:30	**Lunch time**	
14:30-16:30	Meeting of the MC	
16:30-17:00	**Coffee Break**	
17:00-18:00	Meeting of the MC	

1st Nano-IBCT Conference 2011 – Radiation Damage of Biomolecular Systems: Nanoscale Insights into Ion Beam Cancer Therapy

2012 J. Phys.: Conf. Ser. 373 011001

(http://iopscience.iop.org/1742-6596/373/1/011001)

Preface

The 1st Nano-IBCT Conference entitled 'Radiation Damage in Biomolecular Systems: Nanoscale Insights into Ion Beam Cancer Therapy' was held in Caen, France, in October 2011. The Meeting was organised in the framework of the COST Action MP1002 (Nano-IBCT) which was launched in December 2010 (http://fias.uni-frankfurt.de/nano-ibct). This action aims to promote the understanding of mechanisms and processes underlying the radiation damage of biomolecular systems at the molecular and nanoscopic level and to use the findings to improve the strategy of Ion Beam Cancer Therapy. In the hope of achieving this, participants from different disciplines were invited to represent the fields of physics, biology, medicine and chemistry, and also included those from industry and the operators of hadron therapy centres.

Ion beam therapy offers the possibility of excellent dose localization for treatment of malignant tumours, minimizing radiation damage in normal healthy tissue, while maximizing cell killing within the tumour. Several ion beam cancer therapy clinical centres are now operating in Europe and elsewhere. However, the full potential of such therapy can only be exploited by better understanding the physical, chemical and biological mechanisms that lead to cell death under ion irradiation. Considering a range of spatio-temporal scales, the proposed action therefore aims to combine the unique experimental and theoretical expertise available within Europe to acquire greater insight at the nanoscopic and molecular level into radiation damage induced by ion impact. Success in this endeavour will be both an important scientific breakthrough and give great impetus to the practical improvement of this innovative therapeutic technique. Ion therapy potentially provides an important advance in cancer therapy and the COST action MP1002 will be very significant in ensuring Europe's leadership in this field, providing the scientific background, required data and mechanistic insight which are indispensable for the optimization of this new therapy.

The conference gathered 115 participants originating from 28 countries and addressed a large number of highly relevant aspects concerning ion propagation in biological matter, the production of secondary particles along the ion tracks as electrons, holes and radicals, and their propagation in the biomolecular medium. In particular, the attack of DNA molecules and proteins by electrons and free radicals, the relative importance of direct and indirect damage processes as well as the role of the environment were discussed. Not only were fundamental mechanisms and processes elucidated, but radiobiological scale effects, multi-scale approaches and recent advances in the theoretical description of the underlying complex phenomena were also presented. Aspects linked to the energy deposition (LET), the characteristics of the Bragg peak and new techniques of dosimetry and radiolysis were highlighted. Furthermore, methods for increasing the therapy efficiency by using radio sensitizers and the state-of-the-art of defining precise patient treatment plans, identifying the clinical benefits of this type of therapy, were also addressed.

We would like to thank all participants for the lively exchange of ideas and results, thus making this conference a very fruitful event. Furthermore, we appreciate the financial support of the sponsors of this conference, in particular of the COST Action MP1002 financed by ESF. We would also like to express our thanks to all authors of these proceedings, as well as to the reviewers for their time, efforts and recommendations made during the preparation of this volume. Finally, many thanks to U G Huber for a

careful proof-read of this manuscript.

We look forward to the 2nd Nano-IBCT Conference, which will be held in spring 2013.

Caen, 15 March 2012

Bernd A Huber, Christiane Malot, Alicja Domaracka and Andrey V Solov'yov

The Editors

Committees

The Conference has been organised in the framework of the COST Action MP1002 (Nano-IBCT: Nanoscale Insights into Ion Beam Cancer Therapy). Details can be found on the following website: http://fias.uni_frankfurt.de/nano-ibct

Co-chairs

Y Gauduel (ENSTA, Palaiseau, France)
B A Huber (CIMAP, Caen, France)
A V Solov'yov (FIAS, Frankfurt, Germany)

Local Organising Committee
(CIMAP, Caen, France)

L Adoui
A Domaracka
B A Huber
E Lattouf
S Maclot
C Malot
A Méry
J-C Poully
J Rangama
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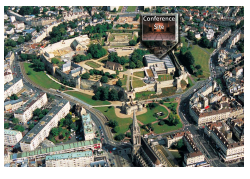
1st Nano-IBCT conference 2011

The 1st Nano-IBCT Conference is organized in the framework of the COST Action MP1002 (Nano-scale Insights into Ion Beam Cancer Therapy). It will take place in Caen (France) from October 2nd to October 6th, 2011.

This conference will bring together experts from different disciplines (physics, chemistry, biology, hadron-therapy centers, medical institutions) specialized in the radiation damage of biological matter.

In particular, the following subjects will be discussed:

- Ion propagation in matter
- Primary ionization in the medium, direct damage and production of secondary electrons and radicals
- Propagation of secondary electrons and radicals
- Electron attack on DNA and proteins
- Radiobiological scale effects
- Hadron therapy centers
- Related European projects



Important dates

- Abstract: deadline extended to **August 7th, 2011**
- Registration: deadline extended to **September 10th, 2011**
- Hotel reservation: recommended before **September 1st, 2011**

2nd announcement

The second announcement is available here.

Conference poster

The conference poster (first announcement) is available here.

Contact

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COST

EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

	List of poster presentations			
N°	**Name**		**Title**	**Affiliation**
1	Arndt	Alexander	Measurement of absolute cross sections for the fragmentation of biomolecules after ionization	PTB, Braunschweig, Germany
2	Baek	WoonYong	Total and elastic electron scattering cross sections of pyrimidine	PTB, Braunschweig, Germany
3	Bolognesi	Paola	Soft X-ray interaction with organic molecules of biological interest: The pyrimidine and halogenatedpyrimidine classes	CNR-IMIP, Roma, Italy
4	Boulanouar	Omar	Neutral products desorption from DNA thin films induced by low-energy electrons (0.5 - 10 eV)	Université Paris-Sud, Orsay, France
5	Boulanouar	Omar	Gold nanoparticles (GNP) and DNA Radiosensitization in solution: Impact of the DNA close-environment and the GNP-DNA interaction	Université Paris-Sud, Orsay, France
6	Bug	Marion	Secondary Electron emission from water after proton impact: investigating the accuracy of track structure simulations	PTB, Braunschweig, Germany
7	Champion	Christophe	Double ionization of oriented water molecules	Université Paul Verlaine-Metz, France
8	Champion	Christophe	Ion-induced ionization and capture in water: A multi-differential cross section study	Université Paul Verlaine-Metz, France
9	Champion	Christophe	Ion-induced ionization and capture cross sections for DNA nucleobases impacted by light ions	Université Paul Verlaine-Metz, France
10	Collauti	Paolo	Ionization-cluster distributions of light ions in nanometric volumes of propane	LNL-INFN, Legnaro, Italy
11	de Vera	Pablo	Simulated Bragg curves for high-energy proton beams in materials of interest in hadron therapy	Universitat d'Alacante, Spain
12	Dos Santos	Morgane	Analysis of double and simple strand breaks induced by protons within a detailed DNA geometrical target model using a Monte Carlo toolkit	IRSN, Fonteney aux Roses, France
13	Eden	Samuel	Contrasting UV multi-photon ionization pathways of adenine monomers and hydrated clusters	Open University, Milton Keynes, United Kingdom
14	Feketeova	Linda	On the quest to understand the repair mechanism of DNA damaged by UV radiation	University of Melbourne, Australia
15	Francis	Ziad	Nano-level linear energies using the Geant4 Monte-Carlo toolkit	Université Saint Joseph, Beirut, Lebanon
16	Francis	Ziad	Energy deposits clustering for heavy ions of the same LET using the DBSCAN algorithm	Université Saint Joseph, Beirut, Lebanon
17	Gonzalez-Magana	Omar	Ionization and fragmentation of free oligonucleotides by keV ions and soft X-ray photons	KVI, Groningen, The Netherlands

18	Gonzalez-Magana	Omar	Size effects in fragmentation of protonated peptides by energetic photons and keV ions	KVI, Groningen, The Netherlands
19	Ingolfsson	Oddur	Cisplatin as sensitizer for UVB irradiation - A study on the synergy effects of cis- and transplatin and UVB radiation	University of Iceland, Reykjavík, Iceland
20	Kumar	SVK	Fragmentation of pQE30 plasmid DNA by low energy electrons	Tata Institute, Mumbai, India
21	Lacombe	Sandrine	Nanoparticles and proton therapy to improve cancer treatments	Université Paris Sud, Orsay, France
22	Laster	Brenda	Hydrogen Peroxide: A major influence on the biological effects of radiation exposure	J J Cohen Radiobiology Laboratory, Beer Sheva, Israel
23	Limao-Vieira	Paulo	Degradation of glycine by electron transfer	FCT-Universidade Nova de Lisboa, 2829-516 Caparica, Portugal
24	Maclot	Sylvain	Interaction of multiply charged ions with nucleosides: case study of thymidine	CIMAP, Caen, France
25	Manil	Bruno	Experimental alternative to investigate the radiation induced radical chemistry at the molecular level	Université Paris 13, Villetaneuse, France
26	Méndez	Louis	Ionization electron capture and electron production in ion water collisions	Universidad Autonoma de Madrid, Spain
27	Metreveli	Nunu	UV radiation damages of collagen	Ilia State University, Tibilisi, Georgia
28	Milosavljevic	Alexandar	Absolute cross sections for electron interaction with molecules representing sub-units of biopolymers	University of Belgrade, Serbia
29	Milosavljevic	Alexandar	Ionization energies of protein ions	University of Belgrade, Serbia
30	Moreels	Marjan	Molecular and cellular changes in human endothelial cells in response to nickel ion irradiation	Radiobiology Unit, Mol, Belgium
31	Moretto Capelle	Patrick	Cationic emission of cis- and CARBO-platin following ionization by swift protons	Université Paul Sabatier, Toulouse, France
32	Papp	Peter	Resonance energies of simple biomolecules	Comenius University, Bratislava, Slovakia
33	Rabus	Hans	Activities at PTB in Metrology Development and Research for Ion Beam Therapy	PTB Braunschweig, Germany
34	Rothard	Hermann	Primary ionization and electron propagation in swift ion irradiation of condensed matter	CIMAP, Caen, France
35	Scifoni	Emanuele	The oxygen effect in ion beam cancer therapy: From modelling to implementation in treatment planning	GSI, Darmstadt, Germany

36	Smyth	Maeve	Excess electron localisation in solvated DNA components	Queen's University Belfast, United Kingdom
37	Suetens	Annelies	Biological effects induced by low-LET radiation in human prostate and colon carcinoma cell lines: experimental basis for future experiments with carbon ions.	Radiobiology Unit, Mol, Belgium
38	Testa	Etienne	Nanodosimetry as a tool to optimize ion beam therapy	Université Lyon I, Villeurbanne, France
39	Testard	Isabelle	A User Facility at GANIL for Radiobiology Research	CIMAP, Caen, France
40	Tribedi	Lokesch	Fast C-ion collisions with Uracil across Bragg peak : Electron emission in Ionization and fragmentation	Tata Institute, Mumbai, India
41	Veltcheva	Mina	Proton acceleration at kHz rate with a few cycle laser system	ENSTA-PARISTECH, Palaisceau, France
42	Vibok	Agnes	Conical intersections induced by light: applications for Na_2 and H_2^+ systems	University of Debrecen, Hungary
43	Villagrasa	Carmen	Analysis of DNA damage created by ^{60}Co irradiation using Monte Carlo track simulations and γH2AX immunofluorescence.	IRSN, Fontenay-aux-Roses, France
44	Waelzlein	Cathrin	Delta-electron emission in the presence of microscopic inhomogeneities	GSI, Darmstadt, Germany
45	Zychor	Izabella	Monte Carlo simulations for nanodosimetry	Andrzej Soltan Institute, Swierk, Poland

ABSOLUTE CROSS SECTIONS FOR ELECTRON INTERACTION WITH MOLECULES REPRESENTING SUB-UNITS OF BIOPOLYMERS

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[(2)] *Departamento de Física Atómica Molecular y Nuclear, Facultad de Ciencias Físicas, Universidad Complutense, Avda. Complutense s/n, E-28040 Madrid, Spain*
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In recent years, we have reported both experimental and theoretical absolute differential cross sections (DCSs) for electron interaction with several different molecules representing building blocks of DNA [1]. Most recently this investigation has been also extended to the smallest molecular systems containing the peptide bond. Beside a fundamental interest to investigate electron/molecule interactions, the present work is also motivated by the research on radiation damage in biomolecular systems [2].

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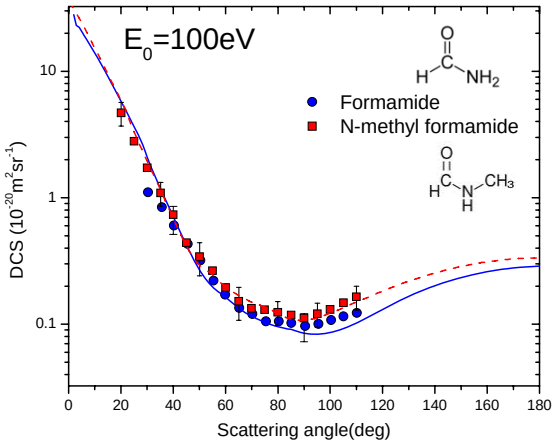

Figure 1: Angular dependence of relative DCSs for elastic electron scattering from formamide (exp: circles; theory: full line) and N-methyl formamide (exp: squares; theory: dashed line) molecules.

References

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COST Action MP 1002

1st Nano-IBCT Conference 2011

Radiation damage of biomolecular systems: Nano-scale insights into Ion Beam Cancer Therapy

2nd-6th October 2011
Auditorium du Musée des Beaux-Arts
Château de Caen, France

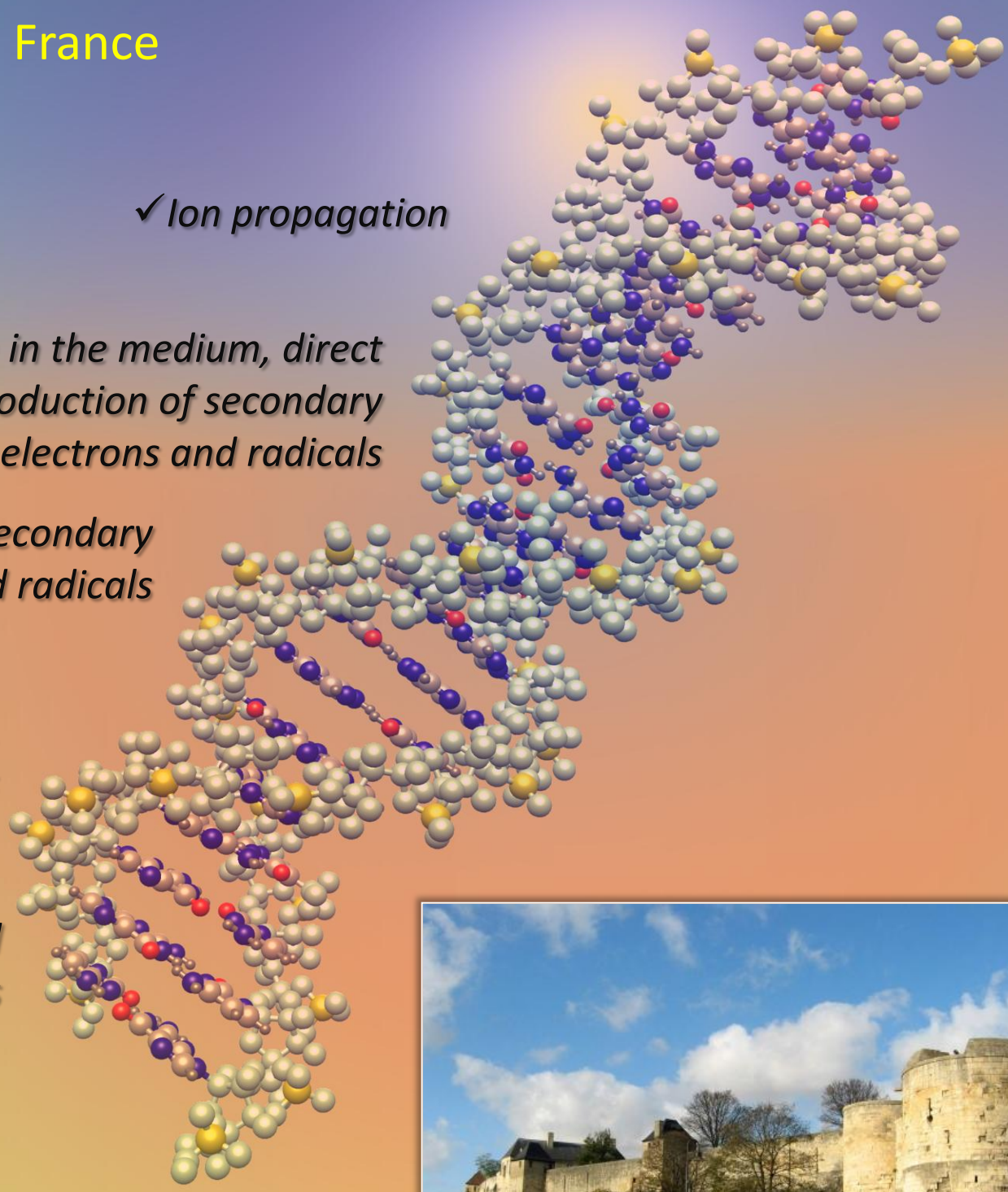
✓*Ion propagation*

✓*Primary ionization in the medium, direct damage and production of secondary electrons and radicals*

✓*Propagation of secondary electrons and radicals*

✓*Electron attack on DNA and proteins*

✓*Radiobiological scale effects*



Conference Chairs:
Y. Gauduel (INSERM, Ecole Polytechnique, ENSTA, Palaiseau)
B. A. Huber (CIMAP, Caen)
A. V. Solov'yov (FIAS, Frankfurt)

http://nano-ibct.sciencesconf.org
http://fias.uni-frankfurt.de/nano-ibct

Organisation and contact :
Christiane Malot
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Absolute Cross Sections for Electron Interaction with Molecules Representing Sub-units of Biopolymers

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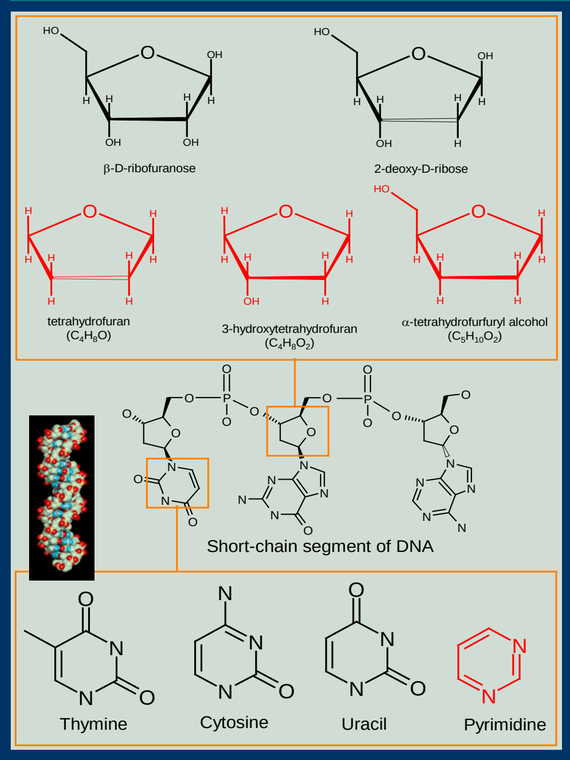
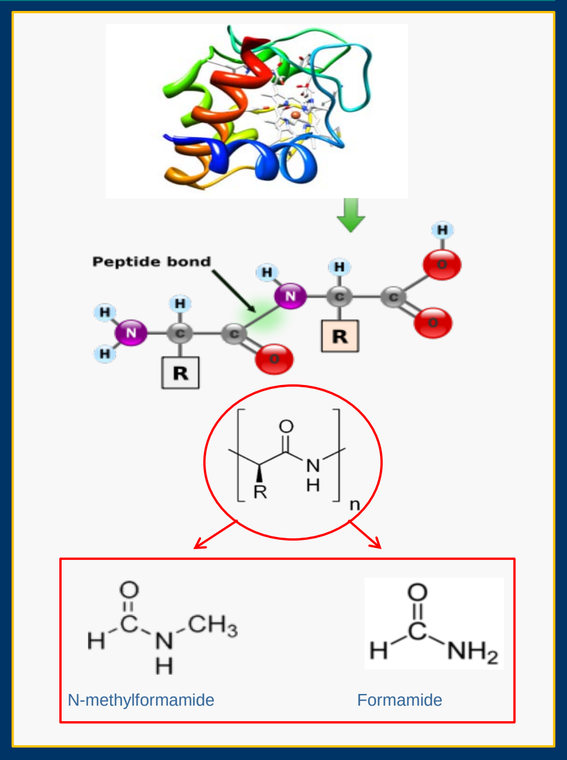
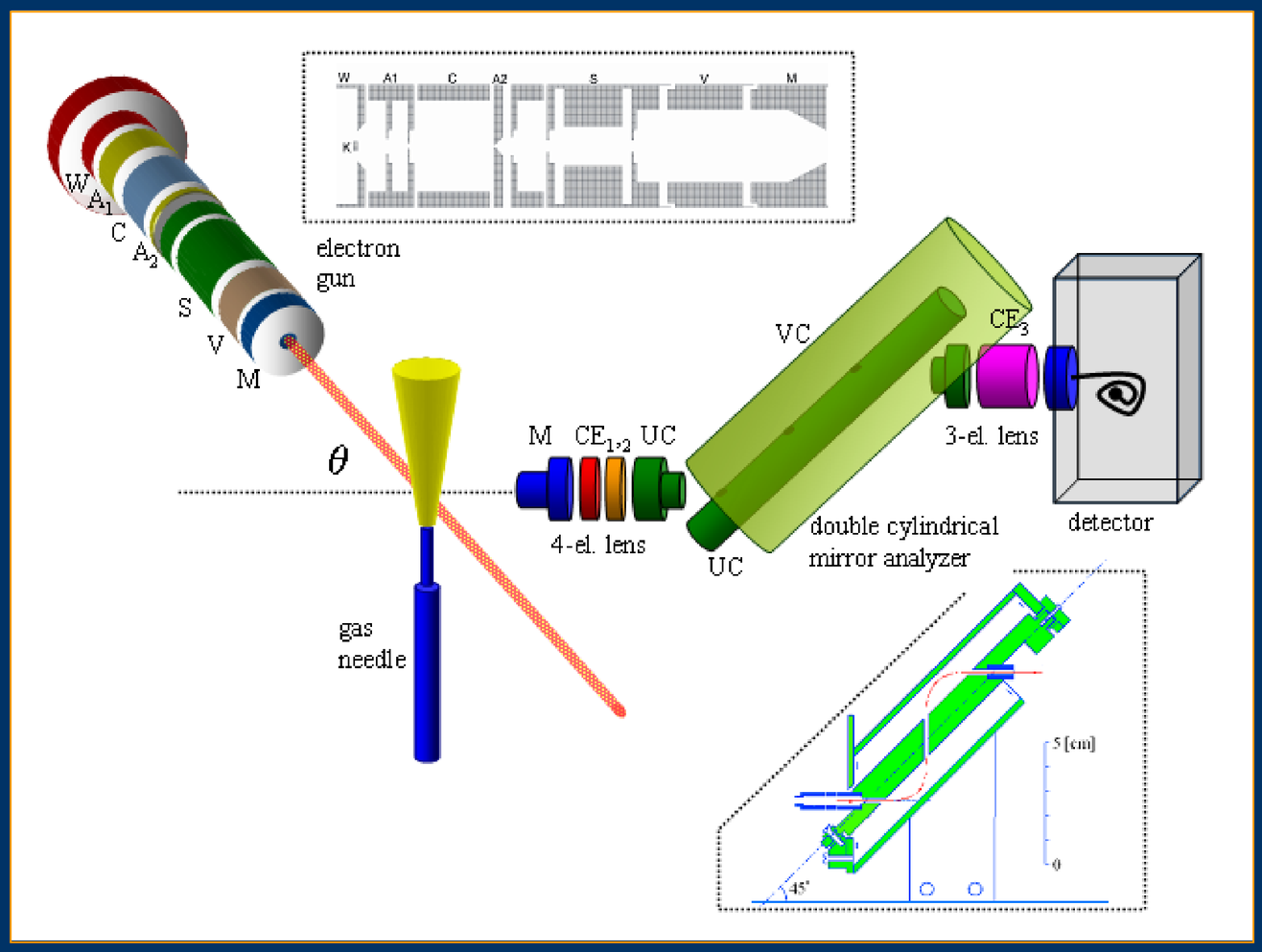
Abstract: In recent years, we have reported both experimental and theoretical absolute differential cross sections (DCSs) for electron interaction with several different molecules representing building blocks of DNA [1]. Most recently this investigation has been also extended to the smallest molecular systems containing the peptide bond. Beside a fundamental interest to investigate electron/molecule interactions, the present work is also motivated by the research on radiation damage in biomolecular systems [2].

The present experimental procedure includes three independent measurements, namely: **1)** relative DCSs measured as a function of scattering angle, **2)** relative DCSs measured as a function of the incident electron energy and **3)** absolute DCSs obtained at specific scattering angle and incident energy by applying relative flow technique. All these independent data sets are merged to form a consistent set of absolute DCSs for a specific target, which is finally compared to the theoretical results. The calculations of molecular cross sections are based on a corrected form of the independent-atom method, known as the SCAR (Screen Corrected Additivity Rule) procedure and using an improved quasifree absorption model.



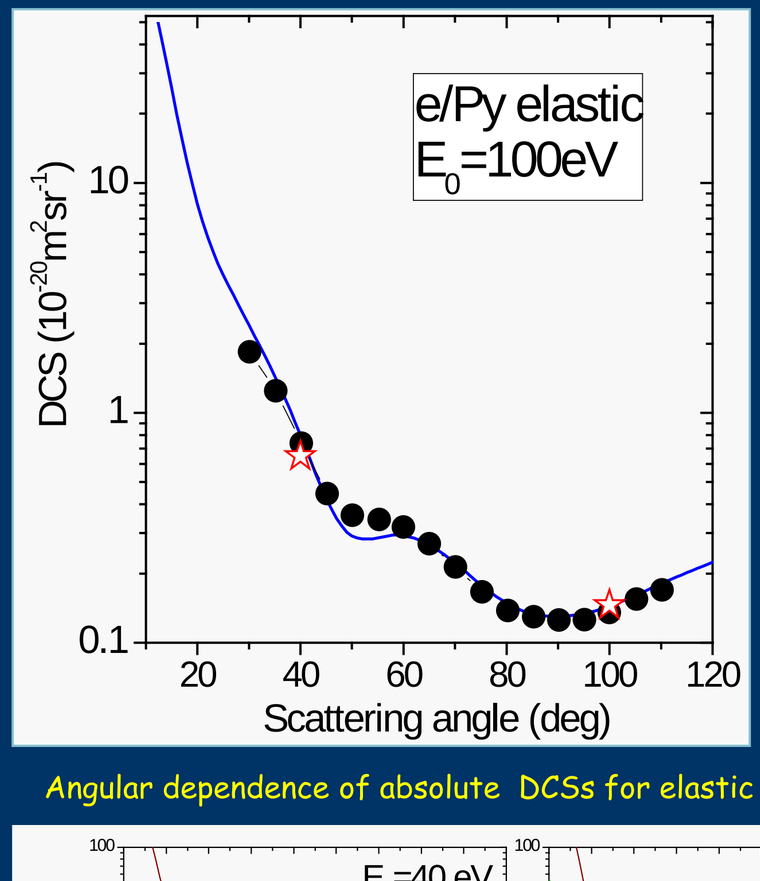


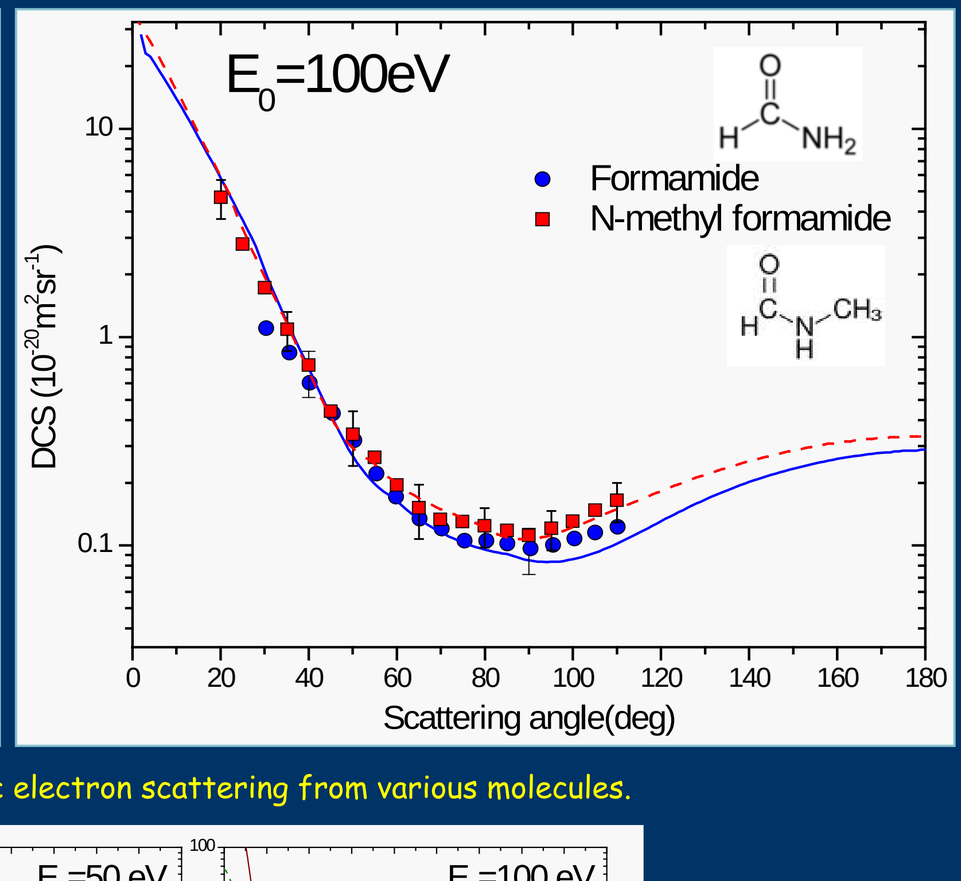
Experimental set-up



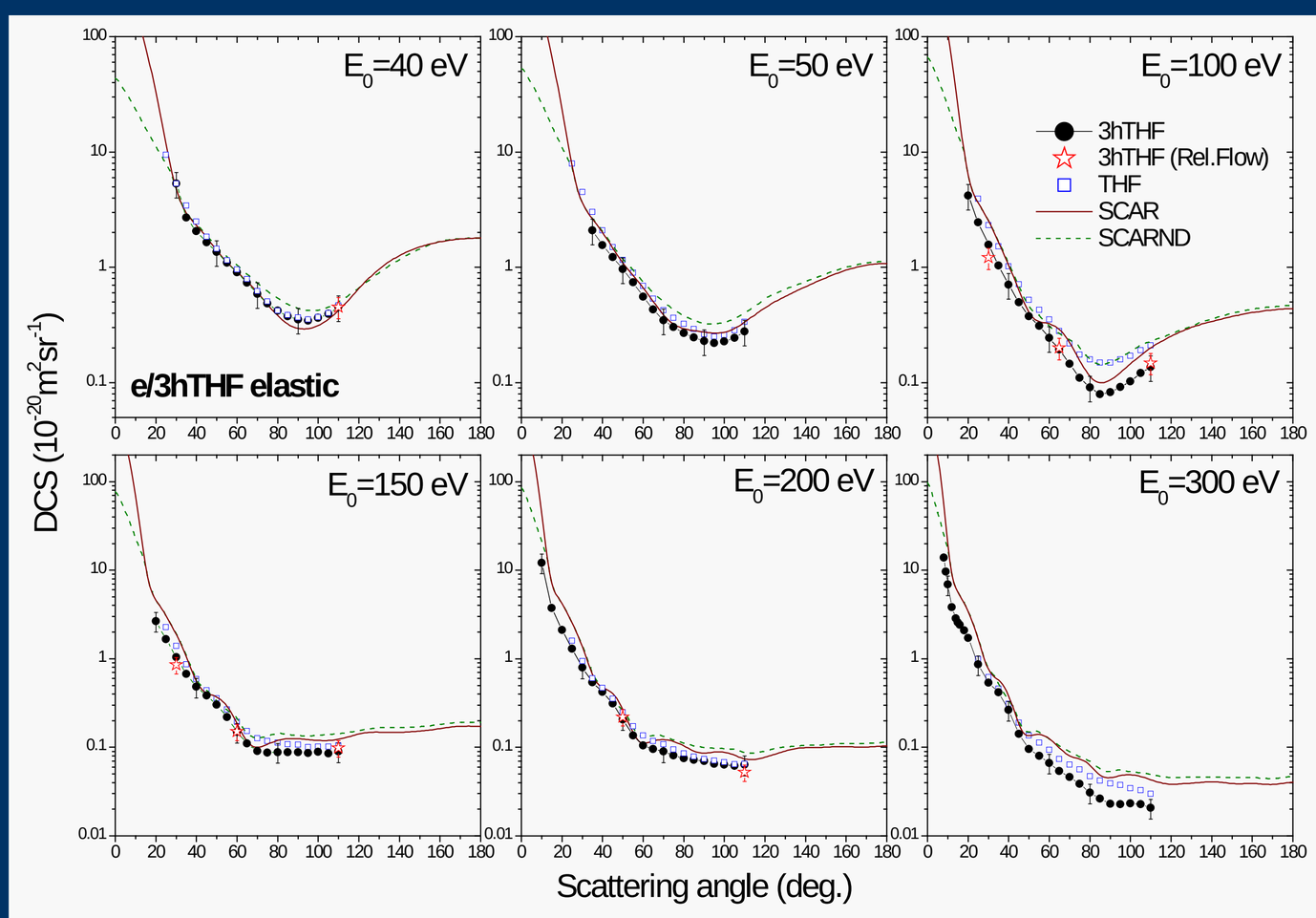
- The cross-beam experimental set-up has been performed using electron gun, a double cylindrical mirror energy analyzer and channel electron multiplier as a detector.
- The molecular beam has been obtained using stainless still needle connected to a heated container.
- Overall energy resolution: 0.6 eV. Angular range: -40° to 110°. Angular resolution: ±2°.
- The base pressure of about 5×10^{-7} mbar (turbo-molecular pump). The working pressure was usually less than 5×10^{-6} mbar and was recorded for each experimental point.

Results

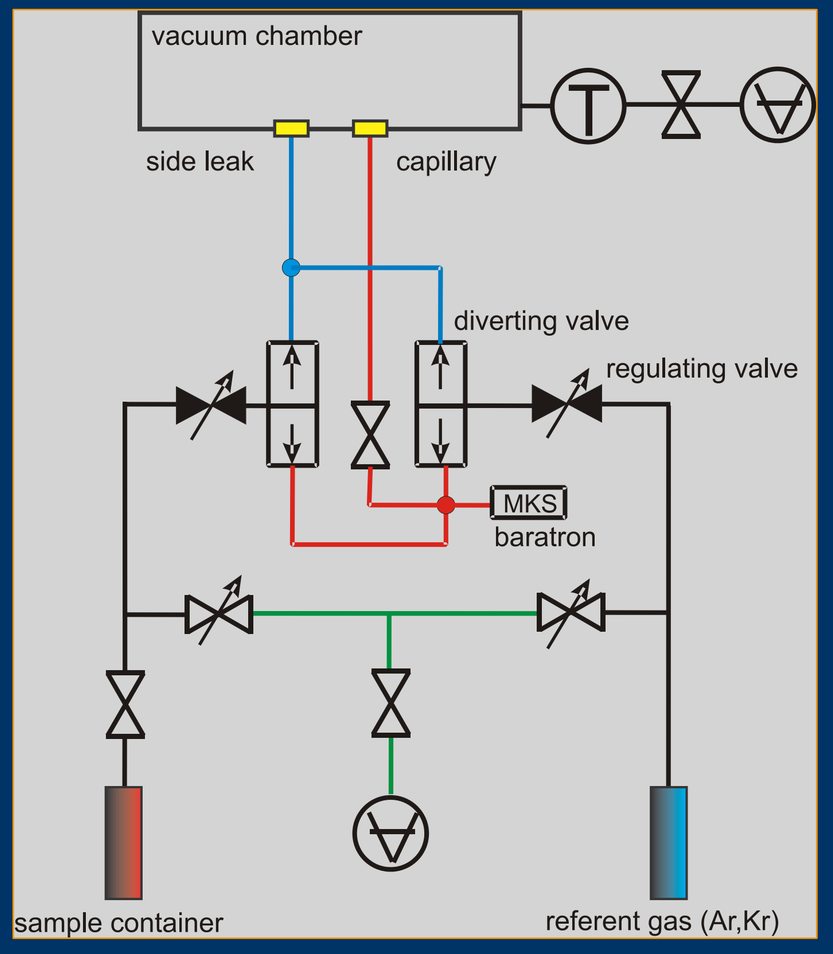




Angular dependence of absolute DCSs for elastic electron scattering from various molecules.



Relative flow method



- In the relative flow method, the DCSs for scattering of unknown gas is determined by comparing scattering signals from the standard target (here Ar) with its known differential cross sections, at a given incident electron energy and scattering angle under identical collision geometry conditions
- To obtain the same profiles for both gas beams, the gases must be operated at pressures behind the needle so that their mean free paths are the same.

$$DCSx(E,\theta) = DCSref(E,\theta)\frac{NxFref}{NrefFx}\sqrt{\frac{Mref}{Mx}}$$

References:

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[2] B. Boudaiffa, P. Cloutier, D. Hunting, M. A. Huels, and L. Sanche, Science **287**, 1658 (2000).

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