A Comparative Study of the Identification of Heavy Carbon Clusters with Direct Recoil Spectroscopy (DRS) and ExB Velocity Spectrometer on PINSTECH Accelerator

By

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Outline

- Who Are We ?
  - PINSTECH Accelerator.
  - Accelerator Lab.
  - Carbon based Nanotechnology Lab.
- Sooting Sources.
  - Duoplasmatron.
  - Dual Hollow Cathode Discharge.
- Regenerative Sooting Discharge.
- Diagnostics:
  - Direct Recoil Spectroscopy.
  - ExB Velocity Spectrometer.
- Carbon Clusters.
- Future Work.

Who Are We ?

ASIA


Pakistan
International boundary
Province-level boundary
National capital
Province-level capital
Railroad
Expressway
Road
Azad Kashmir and the Northern Areas are administered by Pakistan but do not have provincial status.
0 100 200 Kilometers
0 100 200 Miles
Lambert Conformal Conic Projection, SP 23 15 N / 35 30 N
UZBEKISTAN
TURKM.
TAJIKISTAN
CHINA
AFGHANISTAN
IRAN
INDIA
PUNJAB
SINDH
BALOCHISTAN
NORTHERN AREAS
NORTH-WEST FRONTIER PROVINCE
FEDERALLY ADMINISTERED TRIBAL AREAS
ISLAMABAD CAPITAL TERRITORY
Dushanbe
Kabul
Islāmābād
New Delhi
Karāchi
Quetta
Peshāwar
Lahore
Hyderābād
Multān
Faisalābād
Rawalpindi
Kandahār
Jalālābād
Mazār-e Sharīf
Termiz
Qūrghonteppa
Kondoz
Baghlān
Feyzābād
Khorugh
Taxkorgan
Yecheng
Shache
Gilgit
Skardu
Srinagar
Jammu
Sialkot
Gujrānwāla
Pathānkot
Amritsar
Jalandhar
Ludhiāna
Chandigarh
Ambāla
Bhatinda
Pānīpat
Rohtak
Sargodha
Bannu
Zhob
Chaman
Sibi
Sukkur
Jacobābād
Lārkāna
Nawābshāh
Bahāwalpur
Rahimyār Khān
Jaisalmer
Bīkaner
Ratangarh
Jaipur
Ajmer
Jodhpur
Bārmer
Kota
Udaipur
Pālanpur
Turbat
Gwādar
Pasni
Jiwani
Panjgūr
Bela
Sūrāb
Dālbandin
Nok Kundi
Zāranj
Zābol
Farāh
Delārām
Lashkar Gāh
Ghazni
Gardīz
Sheberghān
Kholm
Pol-e Khomrī
Chārīkār
Khyber Pass
Pārachinār
Kohāt
Thal
Tānk
Dera Ismāīl Khān
Dera Ghāzi Khān
Jhang Sadr
Sāhīwal
Kasūr
Mardān
Muzaffarābād
Landī Kotal
Kargil
Mirpur Khās
Khost


N
Faisal Mosque
diplomatic district
Islamabad
Rawalpindi

US

PINSTECH Accelerator

- Development of Accelerator Started: 1988
- 100keV Accelerator Completed on: 1989
- Upgraded to 250keV on: 1994
- Direct Recoil Experiments: 1994-1997
- Regenerative soot Experiment: 1998-Continued
- Simultaneous Emission & ExB Mass Diagnostics: 2004
- It serves as a multi purpose and multi user heavy ion accelerator facility.

Accelerator Lab

Accelerator Tube

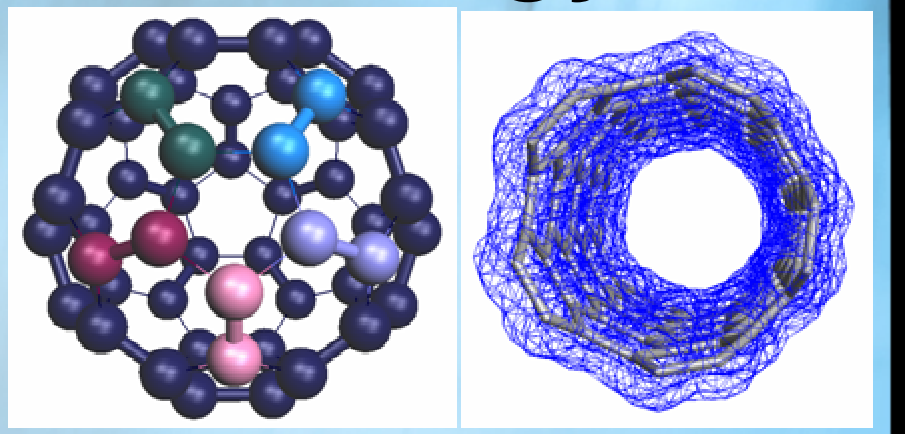
High Voltage Room

A bird's eye view of Accelerator Lab

- Direct Recoil Spectroscopy.
- ExB Velocity Filter based Diagnostics.
- Simultaneous Emission & Mass Diagnostics.
- Study of Carbon Cluster Formation by:
  - Duoplasmatron Ion Source
  - Cusp Hollow Cathode Ion Source.

Carbon based Nanotechnology Lab

- Carbon Cluster & Fullerene Synthesis Studies.
- C_{60} Fragmentation Studies.
- Atomic Resolution Microscopy.
- Computational & Theoretical Nanotechnology.

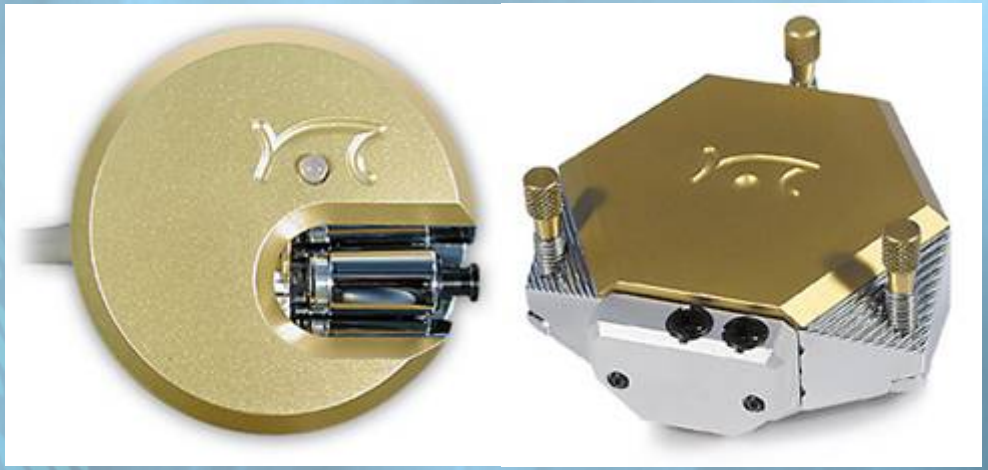


Diagnostics

ExB Velocity Spectrometer

Emission Spectroscopy

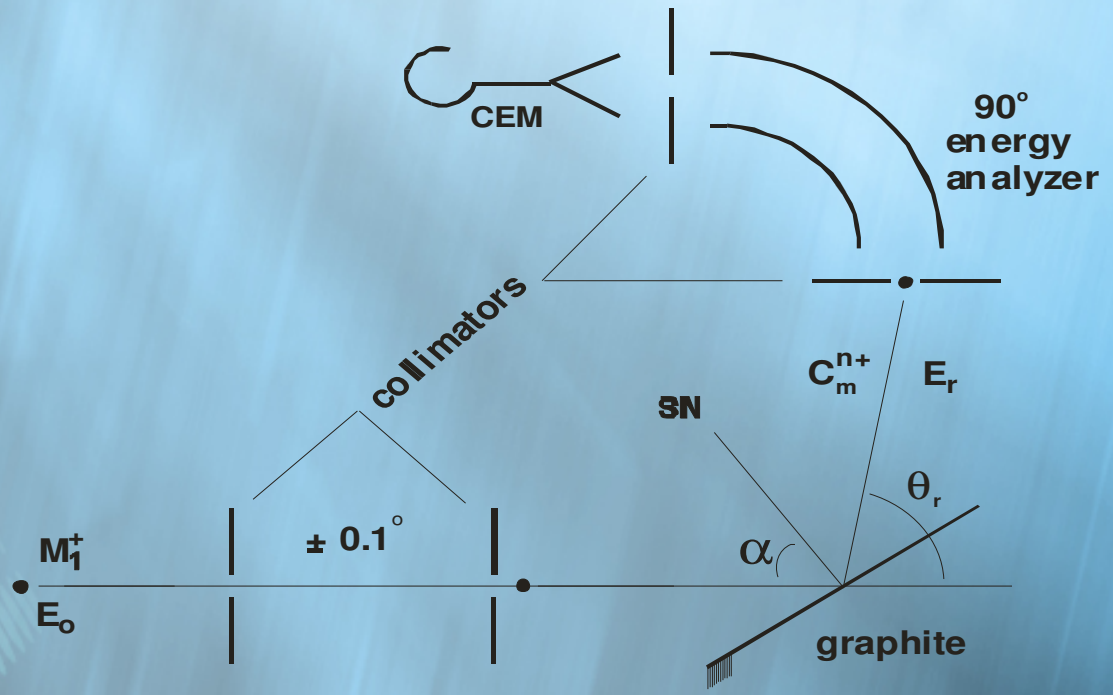
Direct Recoil Spectroscopy



Atomic Resolution Microscopy

$$E_{DR} = 4\frac{m_1 m_2}{(m_1 + m_2)^2} E_0 \cos^2 \theta_{DR}$$

Direct Recoil Spectroscopy



Direct Recoil Energy Spectra

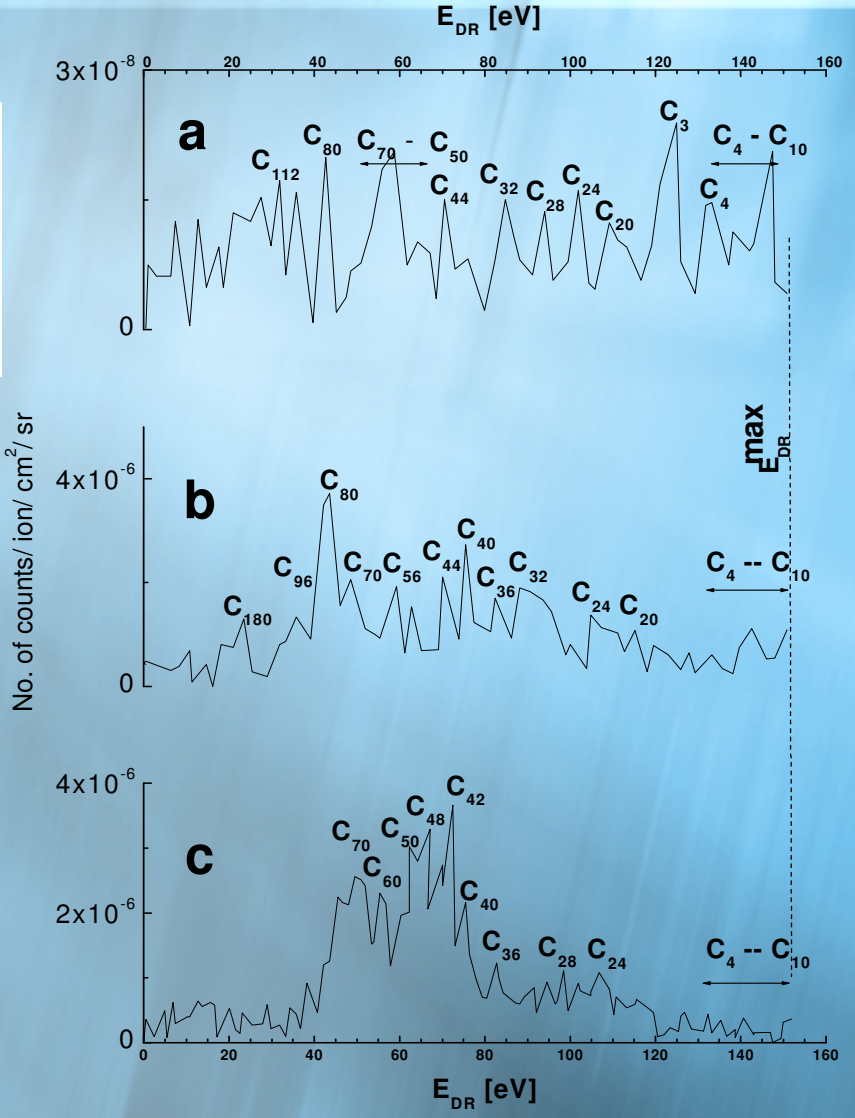
Eur. Phys. J. D **3**, 267–274 (1998)

THE EUROPEAN PHYSICAL JOURNAL D

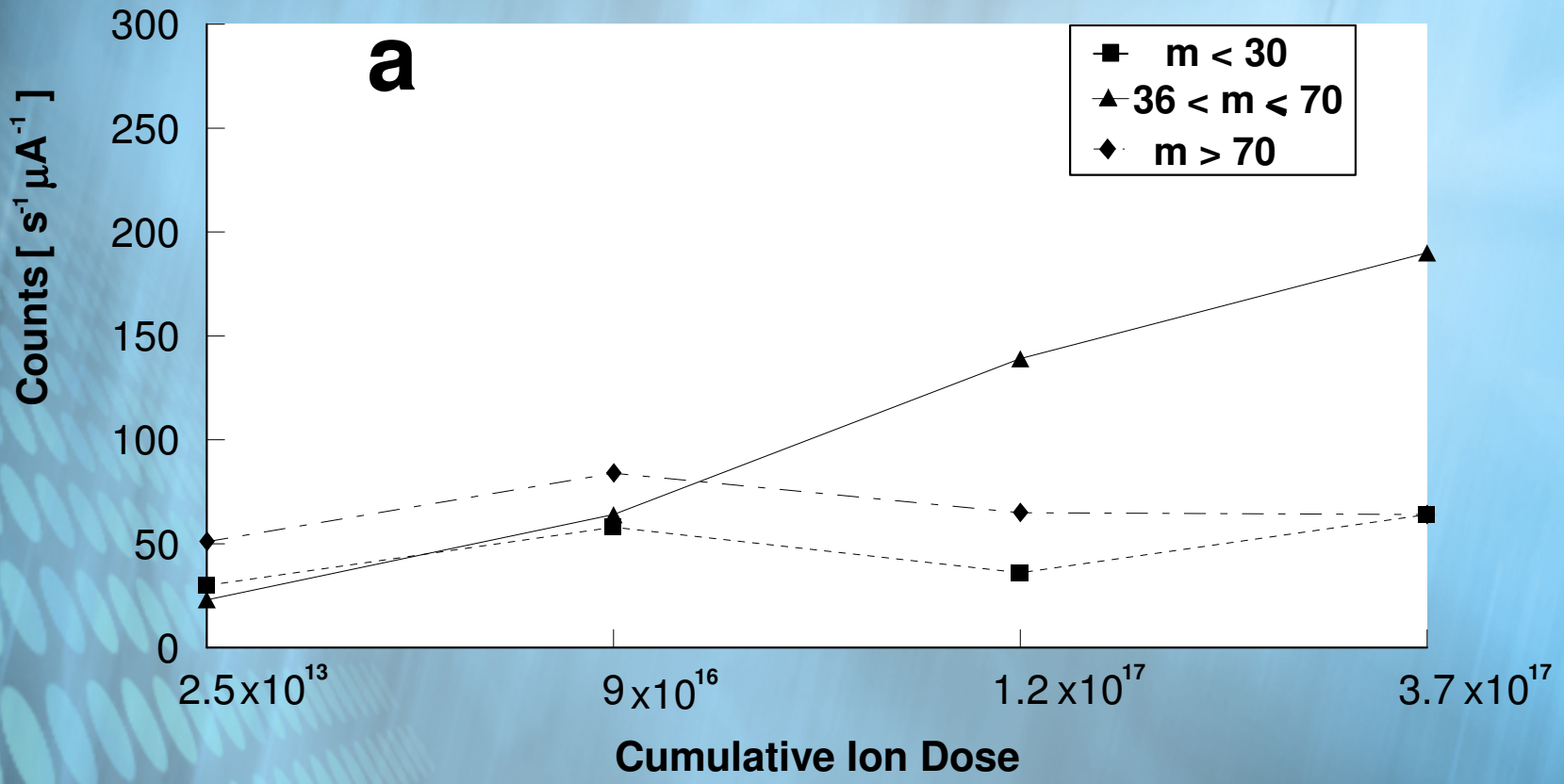
Heavy ion induced cluster formation and fragmentation phenomena in amorphous graphite

A. Qayyum, B. Ahmad, M.N. Akhtar, and S. Ahmad[a]

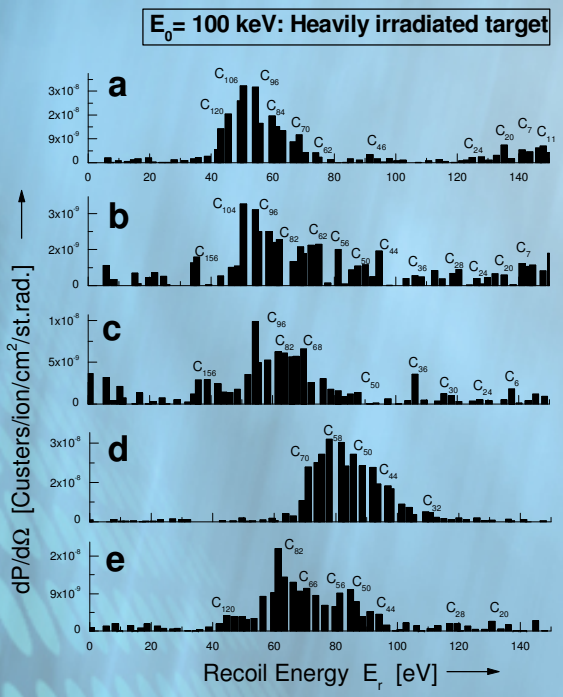
- Eur. Phys. D **3**, 267 (1998)
- Rad. Effects. Def. Solids **153**, 35 (2000)

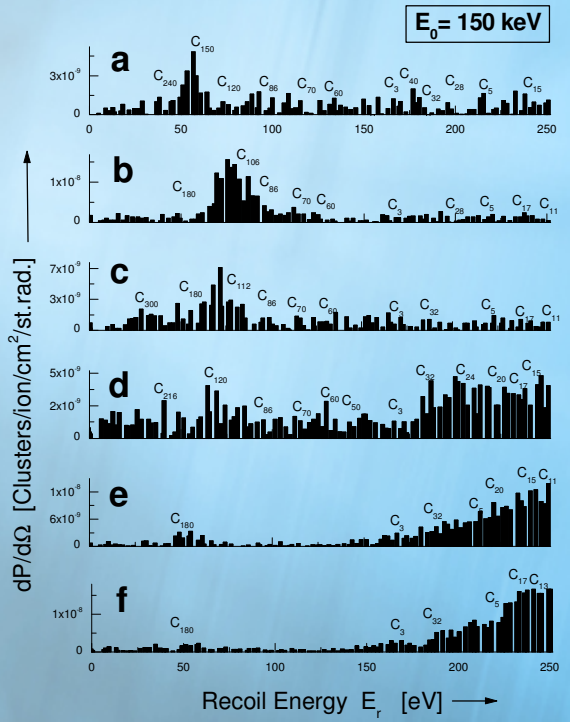


•Phys. Lett. A **234**, 367 (1997)

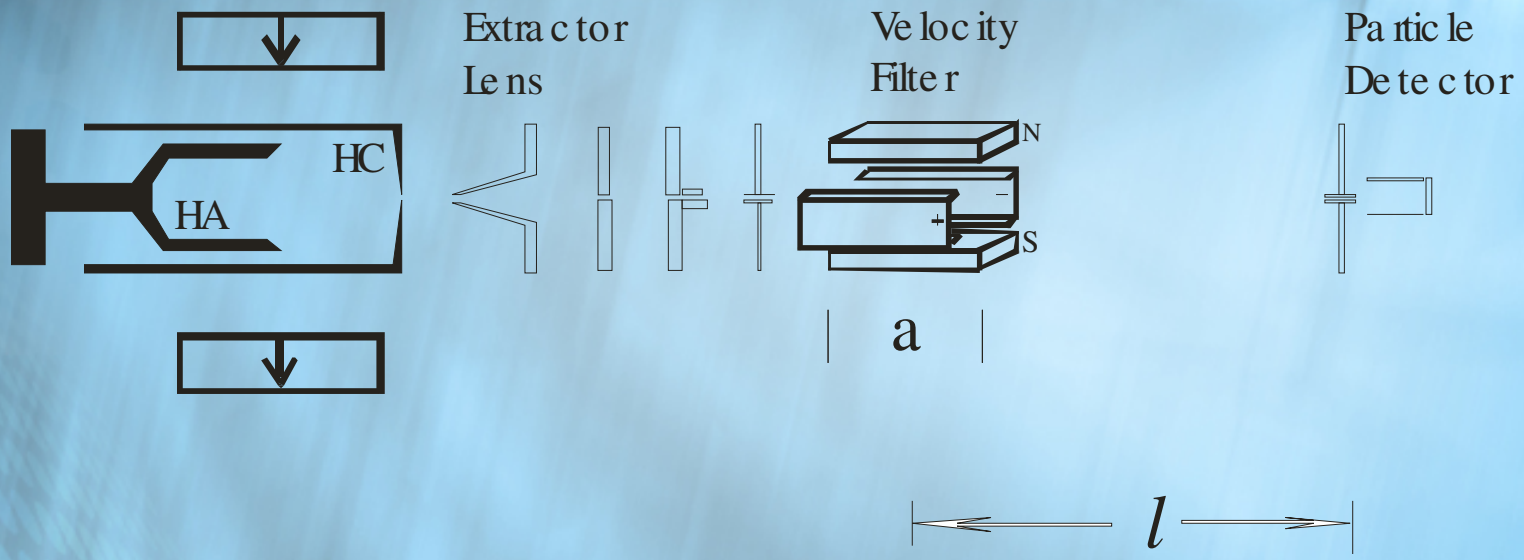


The dose effect on cluster formation and Fragmentation





ExB Velocity Spectrometery



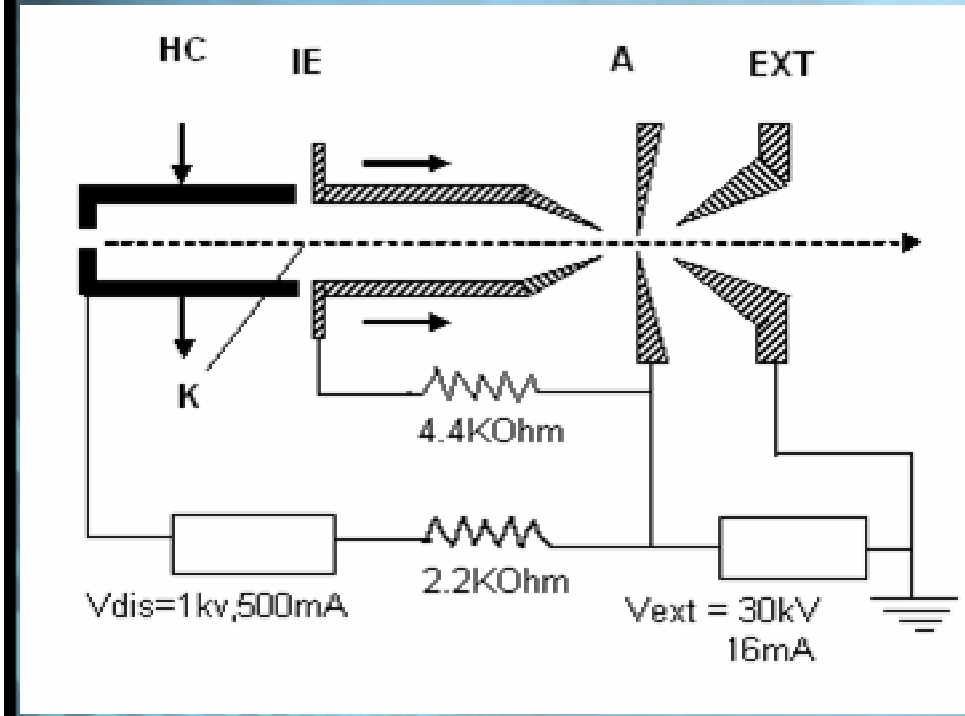
A compact, permanent-magnet-based $E \times B$ velocity filter for carbon cluster diagnostics

Shoaib Ahmad, Bashir Ahmad, A. Qayyum and M. N. Akhtar

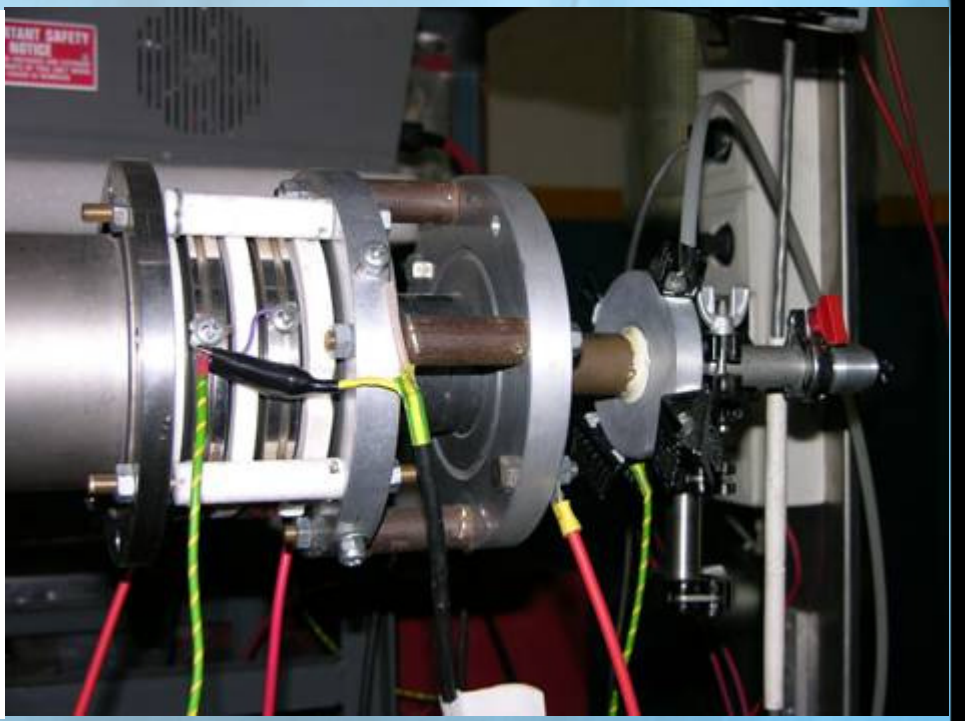
Accelerator Laboratory, PINSTECH, P.O. Nilore, Islamabad, Pakistan

Received 9 December 1999; revised 23 February 2000; accepted 16 March 2000. Available online 14 September 2000.

Duoplasmatron for Carbon Clusters



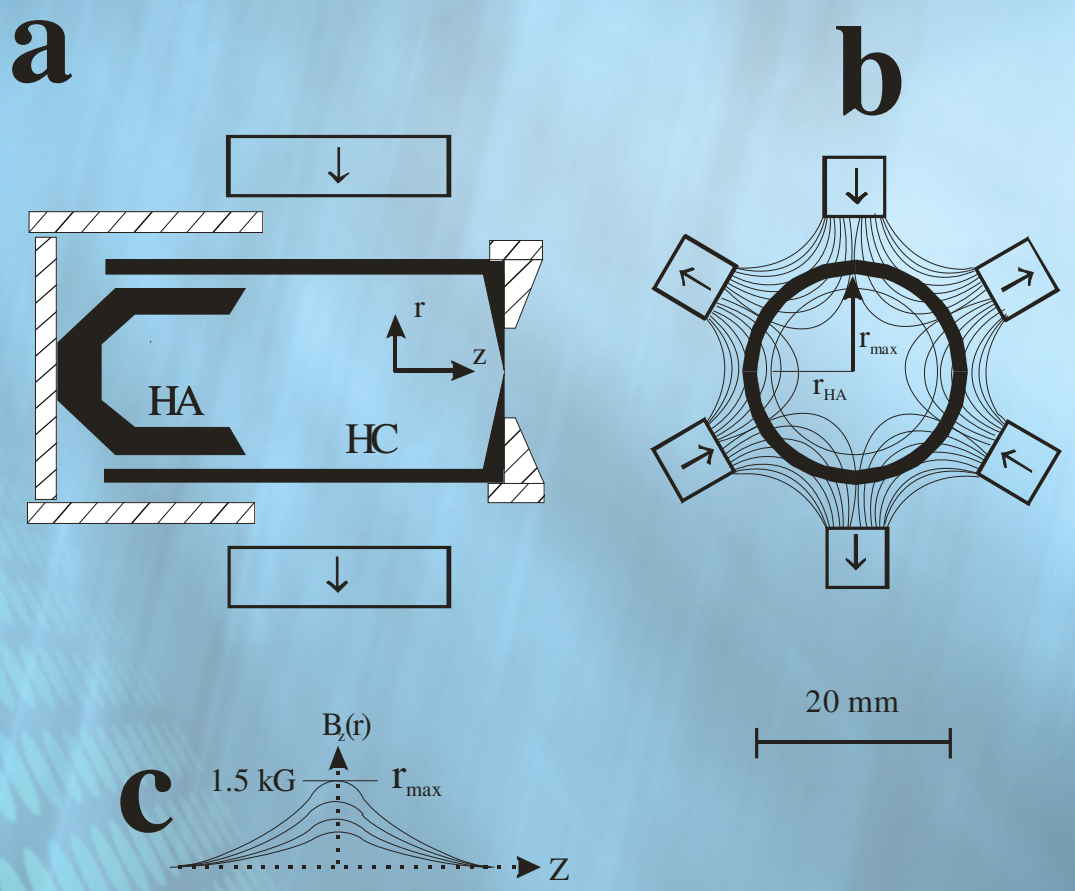
Electric Circuit of the Source



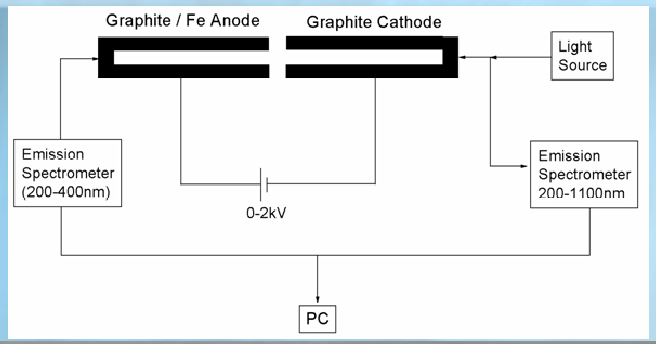
Cold Cathode Duoplasmatron Ion Source

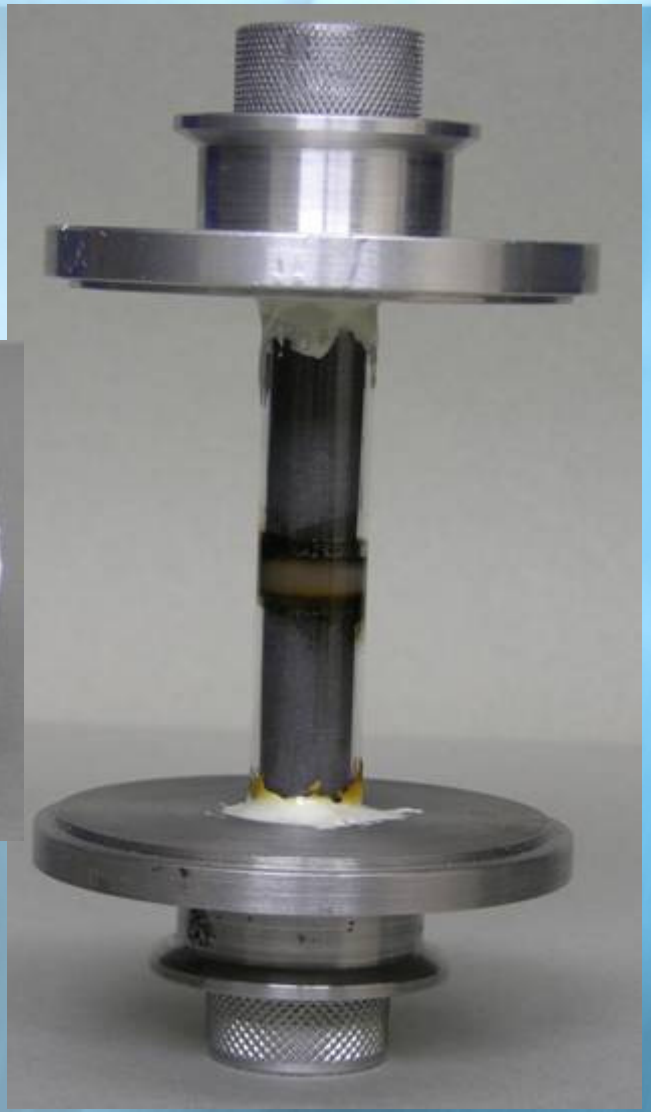
Regenerative Sooting Discharge Source

NIMB 152, 506 (1999)



Dual Hollow Cathode Discharge





INSTITUTE OF PHYSICS PUBLISHING JOURNAL OF PHYSICS D: APPLIED PHYSICS

J. Phys. D: Appl. Phys. 37 (2004) 1234–1240 PII: S0022-3727(04)62531-9

A study of population inversion of He I and Ne I in regenerative sooting discharges

Sajid Hussain[1], A Aleem[1], Rahila Khalid[1], S D Khan[1], A Ellahi[2], S A Janjua[1] and Shoaib Ahmad[1,2,3]

ELSEVIER

18 October 1999

PHYSICS LETTERS A

Physics Letters A 261 (1999) 327–331

www.elsevier.nl/locate/physleta

Carbon cluster formation in regenerative sooting plasmas

Shoaib Ahmad [1]

Eur. Phys. J. AP 5, 111–114 (1999)

THE EUROPEAN PHYSICAL JOURNAL APPLIED PHYSICS

Rapid Note

Emission of carbon clusters from sooting plasma

Shoaib Ahmad[a]

ELSEVIER

Nuclear Instruments and Methods in Physics Research B 000 (2000) 000–000

NIM B Beam Interactions with Materials & Atoms

www.elsevier.nl/locate/nimb

Sputtering and formation of C_1 and C_2 in the regenerative sooting discharge

Shoaib Ahmad *, A. Qayyum, M.N. Akhtar, T. Riffat

PHYSICAL REVIEW E, VOLUME 64, 026408

Transition from the C_3-dominated discharge to the sooting plasma

Shoaib Ahmad,* Bashir Ahmad, and Tasneem Riffat

Eur. Phys. J. D 15, 349–354 (2001)

THE EUROPEAN PHYSICAL JOURNAL D

EDP Sciences
Società Italiana di Fisica
Springer-Verlag 2001

The state of the carbon vapour in the regenerative sooting discharge

Shoaib Ahmad[a]

APPLIED PHYSICS LETTERS VOLUME 78, NUMBER 11 12 MARCH 2001

Role of the kinetic and potential sputtering in the regeneration of the soot

Shoaib Ahmad[a)] and M. N. Akhtar

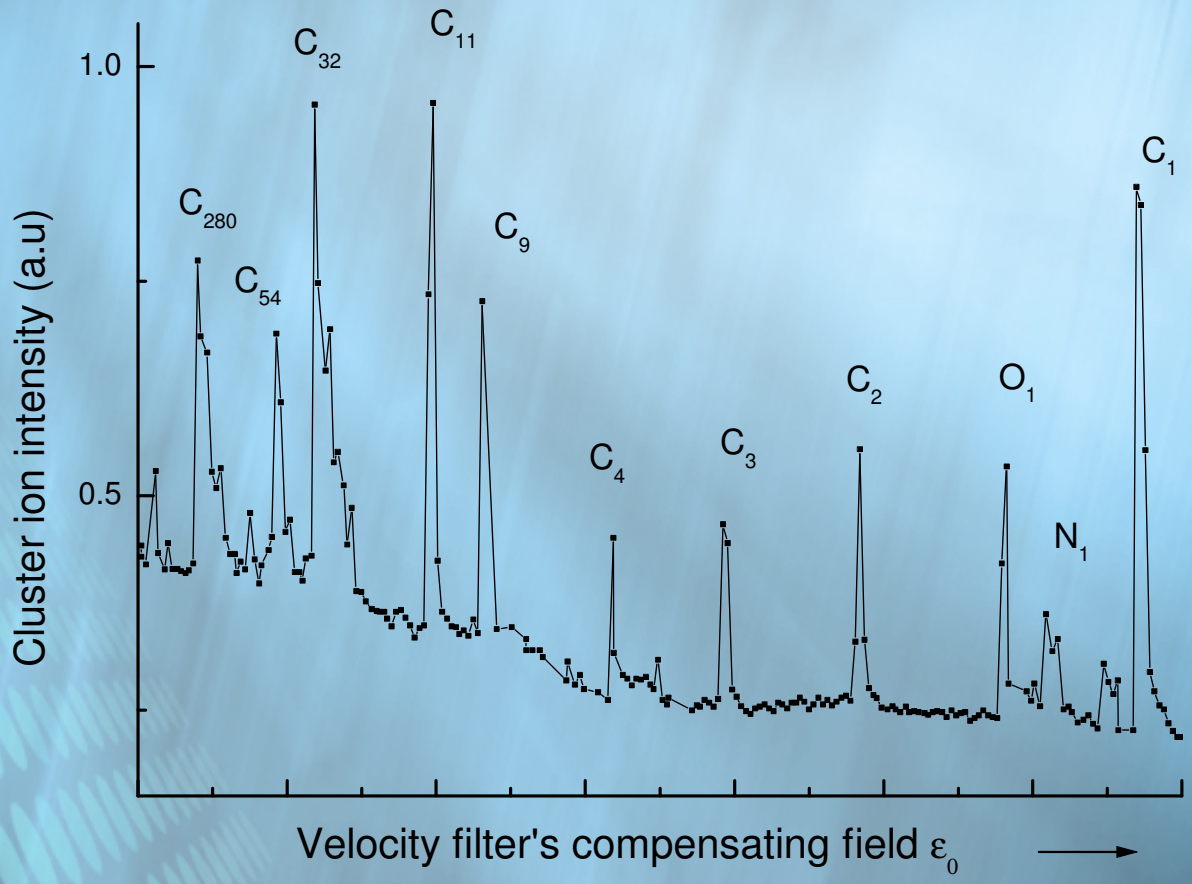
TE OF PHYSICS PUBLISHING JOURNAL OF PHYSICS D: APPLIED PHYSICS

D: Appl. Phys. 38 (2005) 1565–1570 doi:10.1088/0022-3727/38/10/011

Formation of CN in N_2 + He discharges in graphite hollow cathodes

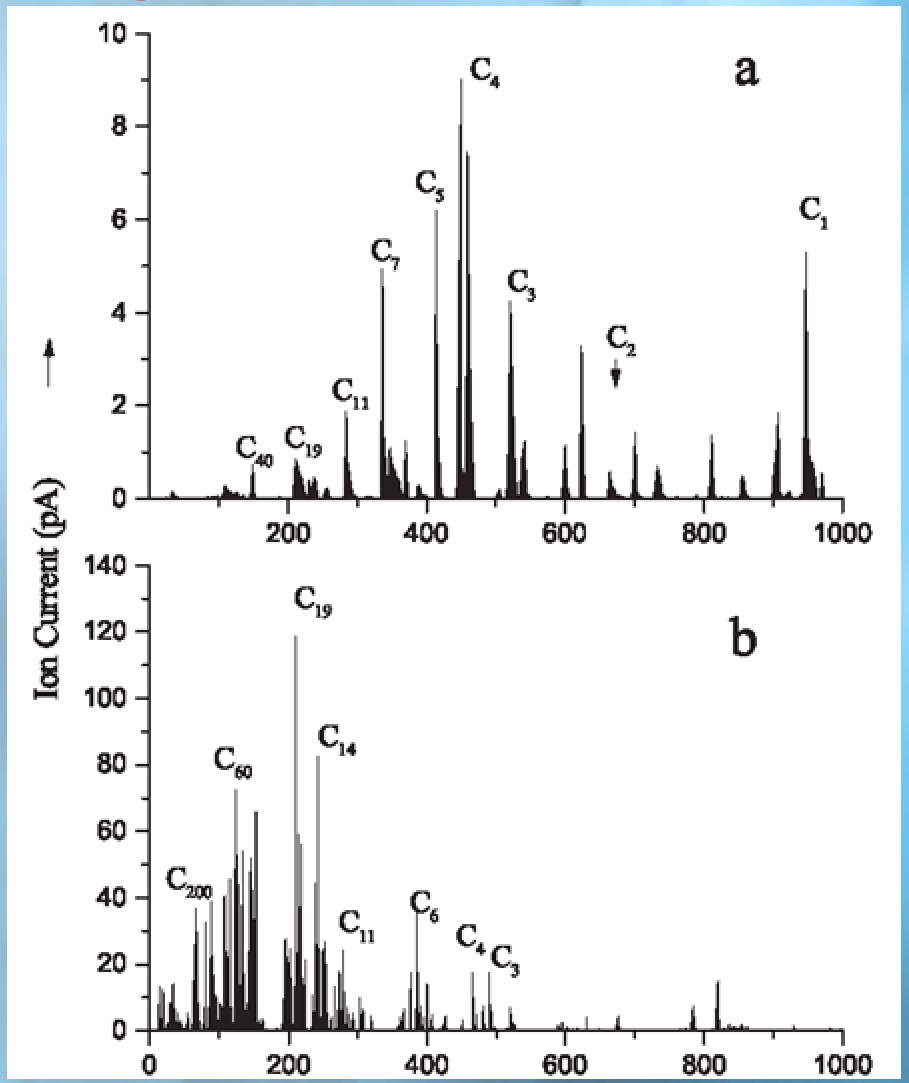
Anwaar Ellahi[1] and Shoaib Ahmad[2,3]

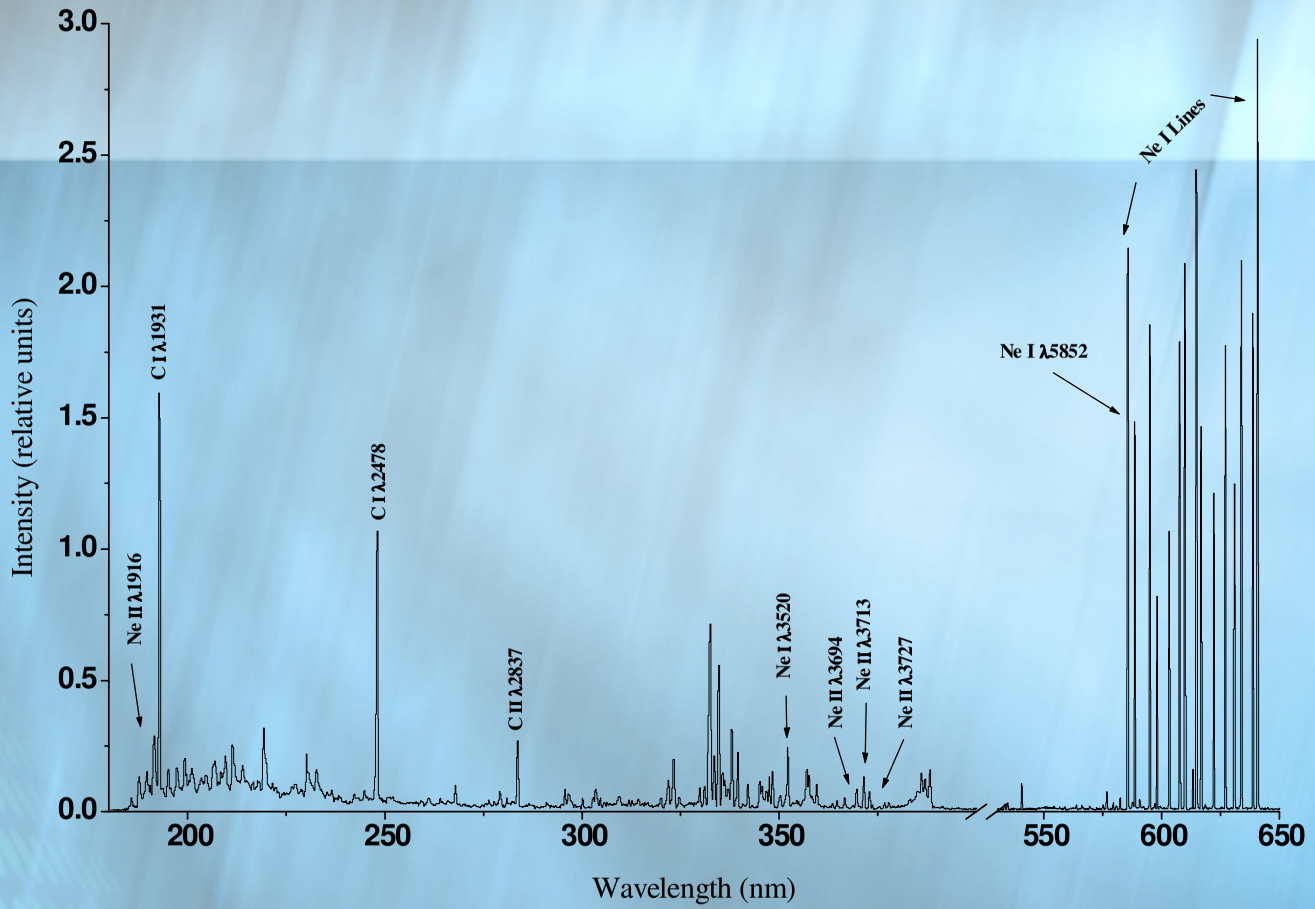
Velocity Spectrum



Transition from mild to well sooted discharge

- (a) A mildly sooting discharge
- (b) A well- sooted discharge





Eur. Phys. J. D **18**, 309–318 (2002)
DOI: 10.1140/epjd/e20020035

THE EUROPEAN PHYSICAL JOURNAL D
EDP Sciences

Spectroscopy of the regenerative soot

Shoaib Ahmad[a]

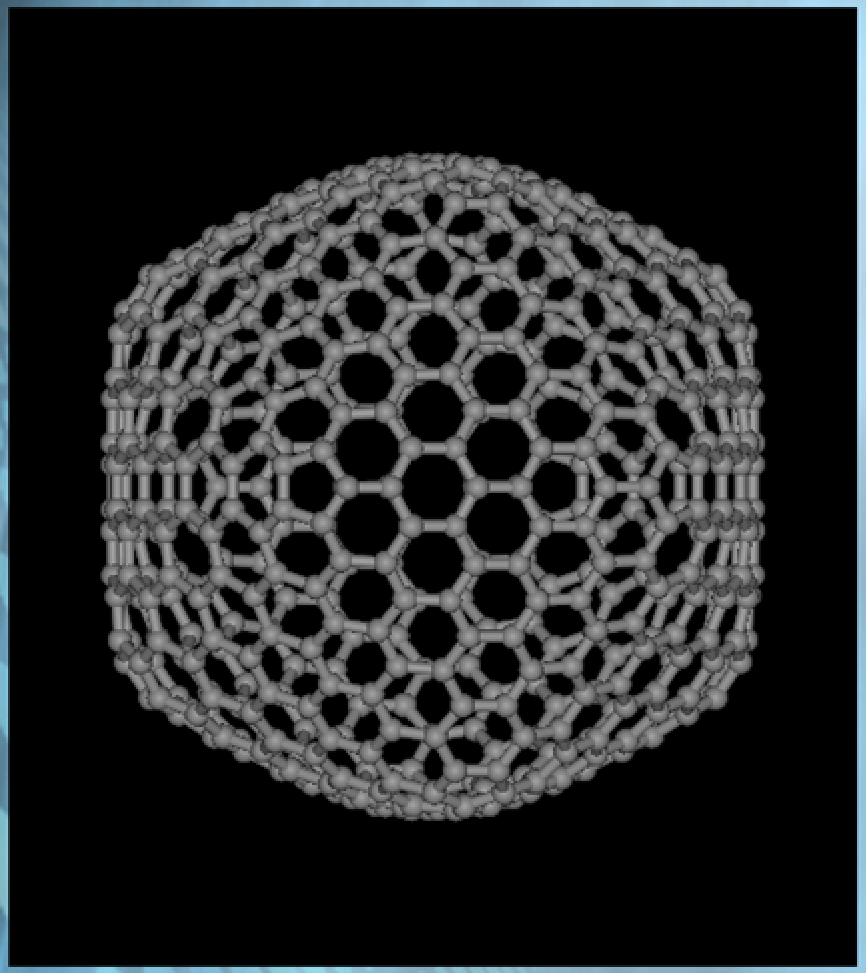
Comparison between DRS and Velocity Spectrometry

Direct Recoil Spectroscopy	Velocity Analysis
DRS provides recoiling clusters energy spectrum from which masses are deduced.	Cluster mass is directly available from the velocity spectra.
The mass identification depends on the resolution of energy spectrometer	Resolution can be improved by increasing the extraction energy or the drift length.
The evolution of clusters on the bombarded surface can be monitored as a function of time and ion dose.	The cluster evolution when monitored continually provides the parametric dependence of the regenerative soot.
The technique is limited to the heavy ion bombarded targets and has a limited utility as a general mass diagnostic tool.	It is a general technique and can be employed to masses varying from low to very heavy ones.

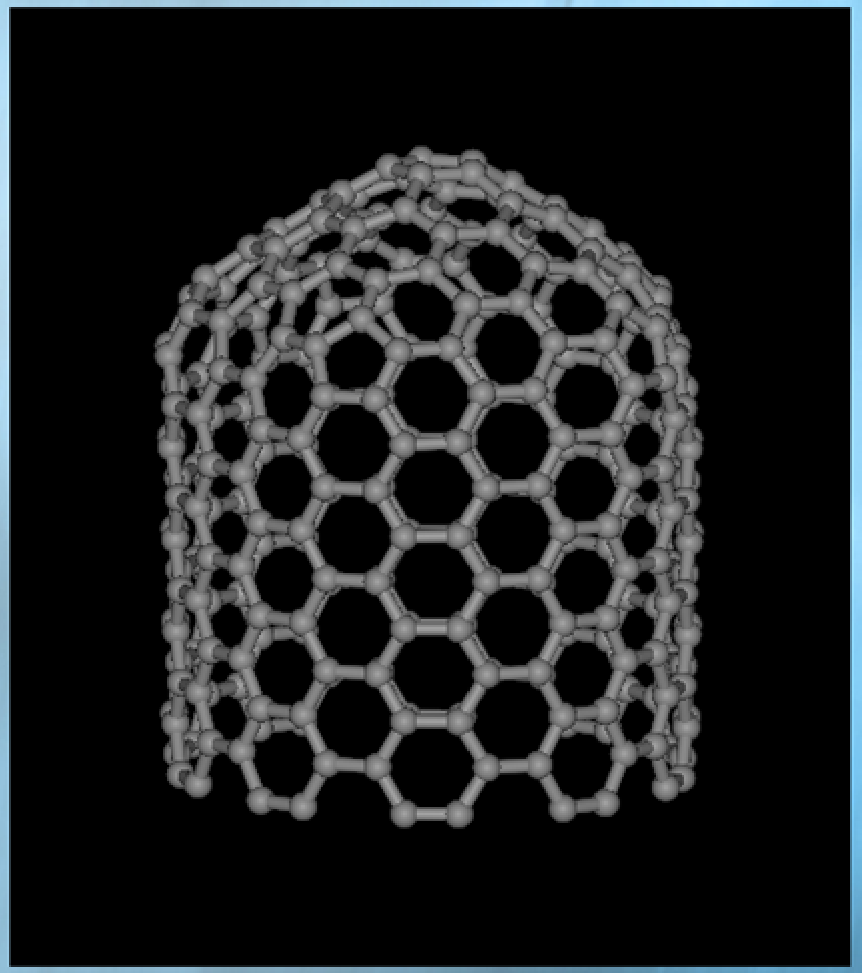
Future Work

- Development of Improved Resolution ExB Velocity Spectrometer.
- C_{60} Fragmentation Studies:
  - Sonoluminescence.
  - Microwave ECR Plasma Sources.
- RF Ion Sources.
- Time of Flight Mass Spectrometry.
- Thin Film Coating & Atomic Manipulation.
- Use of Synchrotron Radiation for Fullerene Research at SESAME.

Carbon Clusters



C_{540} Fullerene



14A Single Walled Nano Tube

JOURNAL OF CHEMICAL PHYSICS VOLUME 116, NUMBER 8 22 FEBRUARY 2002

Continuum elastic model of fullerenes and the sphericity of the carbon onion shells

Shoaib Ahmad[a)]