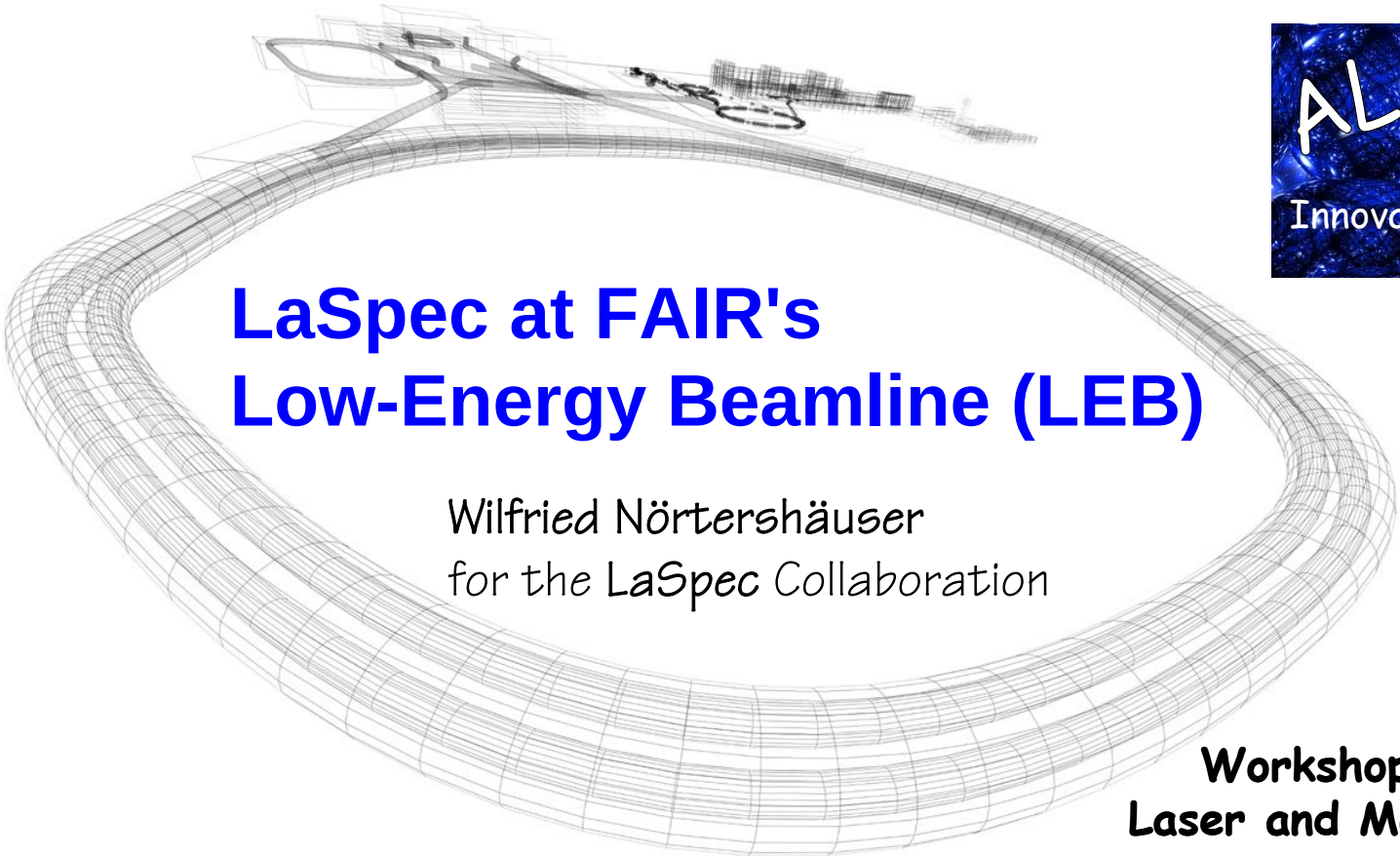
FAIR Facility for Antiproton and Ion Research



ALMAS-1
Innovative Physics Ideas

LaSpec at FAIR's Low-Energy Beamline (LEB)

Wilfried Nörtershäuser
for the LaSpec Collaboration

Workshop on Advanced Laser and Mass Spectroscopy

ILIMA

October 19th to 20th 2006
GSI, Darmstadt, Germany

LASPEC

MATS

The Collaboration

Leuven
Jyväskylä
Orsay
GSI
Munich
Mainz
Heidelberg
Manchester
CERN
Livermore
Pacific Northwest

"... combines a large part of the European expertise in the field."

NuStar PACs Report

Currently registered Members

Juha Äystö, Jonathan Billowes, Klaus Blaum, Bruce A. Bushaw, **Paul Campbell**, José R. Crespo López-Urrutia, Andreas Dax, Kieran T. Flanagan, Christopher Geppert, Dietrich Habs, Gerhard Huber, Mark Huyse, Ari Jokinen, Thomas Kessler, Iouri Koudriavtsev, Magdalena Kowalska, Thomas Kühl, Francois Le Blanc, David Lunney, Iain Moore, Gerda Neyens, Wilfried Nörtershäuser, Kari Perajarvi, Christoph Scheidenberger, Dieter Schneider, Maxim Seliverstov, Michael Sewtz, Jerzy Szerypo, Peter G. Thirolf, Marco Tomaselli, Joachim Ullrich, Piet Van Duppen, Klaus Wendt, Claus Zimmermann

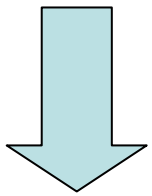
34 Members from 11 Institutes in 7 Countries

Spokesperson: Paul Campbell, Co-Spokesperson: Wilfried Nörtershäuser

http://www.uni-mainz.de/FB/Chemie/AK-Noertershaeuser/experiments/laspec
or http://www.kernchemie.uni-mainz.de/laser

Nuclear Ground State Properties

Isotope Shift (IS)

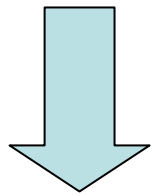


Mean Square Charge Radius

$$\delta\left\langle r^2 \right\rangle^{AA'}$$

Deformation β

Hyperfine Structure (HFS)

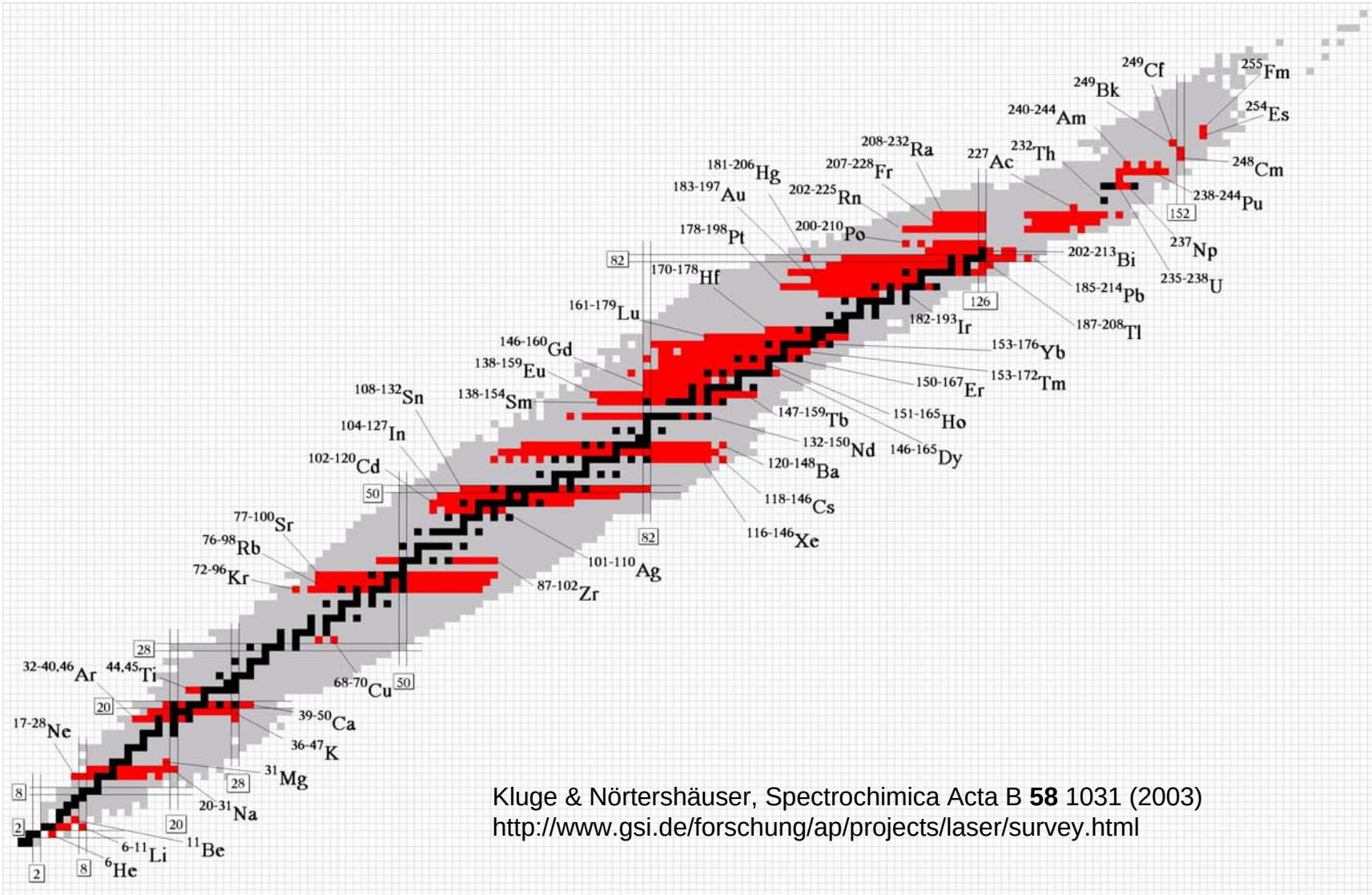


Nuclear Spin I

Magnetic Dipole Moment μ_I

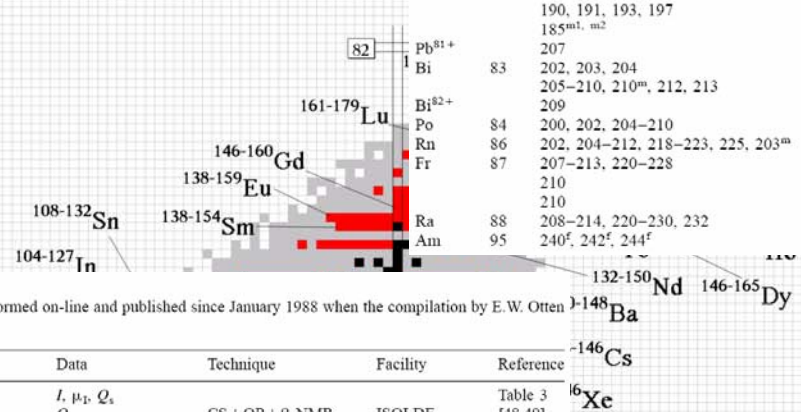
Electric Quadrupole Moment Q_s

On-Line Laser Spectroscopy – A Successful Story



Kluge & Nörtershäuser, Spectrochimica Acta B **58** 1031 (2003)
http://www.gsi.de/forschung/ap/projects/laser/survey.html

On-Line Laser Spectroscopy – A Successful Story



Au	79	185–197, 189^{m}	I, μ_I, (Q_s), $\delta\langle r^2\rangle$			Table 25
		186, 187, 190, 192, 194, 195–199	μ_I, $\delta\langle r^2\rangle$	RIMS	ISOLDE	[113]
		183–197	μ_I, Q_s, $\delta\langle r^2\rangle$	RIMS	ISOLDE	[114]
		191–194	μ_I, Q_s, $\delta\langle r^2\rangle$	RIMS	ISOLDE	[115]
		184, 184^{m}	μ_I, Q_s, $\delta\langle r^2\rangle$	RIMS	ISOLDE	[116]
		184, 184^{m}, 191, 193, 195	μ_I, Q_s, $\delta\langle r^2\rangle$	RIMS	ISOLDE	[112]
Hg	80	181–206, 185^{m}, 187^{m}, 189^{m}, 191^{m}, 193^{m}, 195^{m}, 197^{m}, 199^{m}	I, μ_I, Q_s, $\delta\langle r^2\rangle$			Table 26
Tl	81	193–205, 207, 189^{m}, 191^{m}, 193^{m}, 198^{m}	I, μ_I, (Q_s), $\delta\langle r^2\rangle$			Table 27
		188^{m}, 190^{g,m}–192^{g,m}, 194^{g,m}, 196^{g,m}	μ_I, Q_s, $\delta\langle r^2\rangle$	CS	GSI	[117]
		208	μ_I, $\delta\langle r^2\rangle$	RADRIS		[118]
		187, 188	μ_I, Q_s	CS	Oak Ridge	[119]
Pb	82	190–192, 194, 196–212, 214, 193^{m}, 195^{m}, 197^{m}, 202^{m}	I, μ_I, Q_s, $\delta\langle r^2\rangle$			Table 28
		190, 191, 193, 197	μ_I, Q_s, $\delta\langle r^2\rangle$	CS	GSI	[120]
		185$^{m1,\ m2}$	I, μ_I	Spectroscopy in LIS	ISOLDE	[121]
		207	Hfs anomaly	Storage ring	GSI	[44]
Bi	83	202, 203, 204	$\delta\langle r^2\rangle$, μ_I, Q_s	GCS	Stony Brook	[122]
		205–210, 210^{m}, 212, 213	$\delta\langle r^2\rangle$, μ_I, Q_s	GCS/ABS	ISOLDE	[123,124]
		209	Hfs anomaly	Storage ring	GSI	[69]
Po	84	200, 202, 204–210	μ_I, Q_s, $\delta\langle r^2\rangle$	LIF	FZ Karlsruhe	[125]
Rn	86	202, 204–212, 218–223, 225, 203^{m}	I, μ_I, Q_s, $\delta\langle r^2\rangle$			Table 29
Fr	87	207–213, 220–228	I, μ_I, Q_s, $\delta\langle r^2\rangle$			Table 30
		210	Hfs anomaly	Neutral atom trap	Stony Brook	[126]
		210	Hfs	Neutral atom trap	Stony Brook	[127]
Ra	88	208–214, 220–230, 232	I, μ_I, Q_s, $\delta\langle r^2\rangle$			Table 31
Am	95	240^{f}, 242^{f}, 244^{f}	Q_s, $\delta\langle r^2\rangle$	RADRIS	Heidelberg	[35,60]

Table 2
Optical spectroscopy experiments on radionuclides performed on-line and published since January 1988 when the compilation by E.W. Otten [43] was closed for additional data

	Z	A	Data	Technique	Facility	Reference
Li	3	6–9, 11	I, μ_I, Q_s			Table 3
		11	Q_s	CS + OP + β-NMR	ISOLDE	[48,49]
Be	4	11	μ_I	LIS + CS + β-NMR	ISOLDE	[55]
Ne	10	17–26, 28	I, μ_I, Q_s, $\delta\langle r^2\rangle$	CS + SSCI + β	ISOLDE	[56]
Na	11	20–31	I, μ_I, Q_s, $\delta\langle r^2\rangle$			Table 4
		21	$\Delta\nu_{hfs}$	Neutral atom trap	Berkeley	[15]
		26–29	Q_s	CS + β-NMR	ISOLDE	[58]
		27–31	μ_I			
		31	I			
Ar	18	32–40, 46	μ_I, Q_s, $\delta\langle r^2\rangle$	CS + SSCI + β	ISOLDE	[72]
K	19	36–47	I, μ_I, Q_s, $\delta\langle r^2\rangle$			Table 5
Ca	20	39–48	I, μ_I, Q_s, $\delta\langle r^2\rangle$			Table 6
		40-48	$\delta\langle r^2\rangle$	CS + SSN	ISOLDE	[73]
		50	$\delta\langle r^2\rangle$	CS + SSN + β	ISOLDE	[74]
		39	$\delta\langle r^2\rangle$	CS + SSN + β	ISOLDE	[75]
Ti	22	44, 45	$\delta\langle r^2\rangle$	Cooler RFQ + CS	Jyväskylä	[76]
Cu	29	68^{g,m}, 70^{g,m1,m2}	μ_I	Spectroscopy in LIS	ISOLDE	[77]
Kr	36	88, 90	$\delta\langle r^2\rangle$	CS	TRISTAN	[78]
		72, 74–96, 79^{m}, 81^{m}, 83^{m}, 85^{m}	I, μ_I, Q_s, $\delta\langle r^2\rangle$	CS + SSCI	ISOLDE	[79]
		72, 74–96, 79^{m}, 81^{m}, 83^{m}, 85^{m}	$\delta\langle r^2\rangle$	CS + SSCI	ISOLDE	[80]
Rb	37	76–98, 78^{m}, 81^{m}, 82^{m}, 84^{m}, 86^{m}, 90^{m}	I, μ_I, Q_s, $\delta\langle r^2\rangle$			Table 7
		82	Hfs	Neutral atom trap	Los Alamos	[16]
Sr	38	78–98, 100, 83^{m}, 85^{m}, 87^{m}	I, μ_I, Q_s, $\delta\langle r^2\rangle$			Table 8

pectrochimica Acta B **58** 1031 (2003)
ng/ap/projects/laser/survey.html

On-line Laser Spectroscopy

General techniques are well established in many variants.

LS implies many detection techniques with different applicabilities:

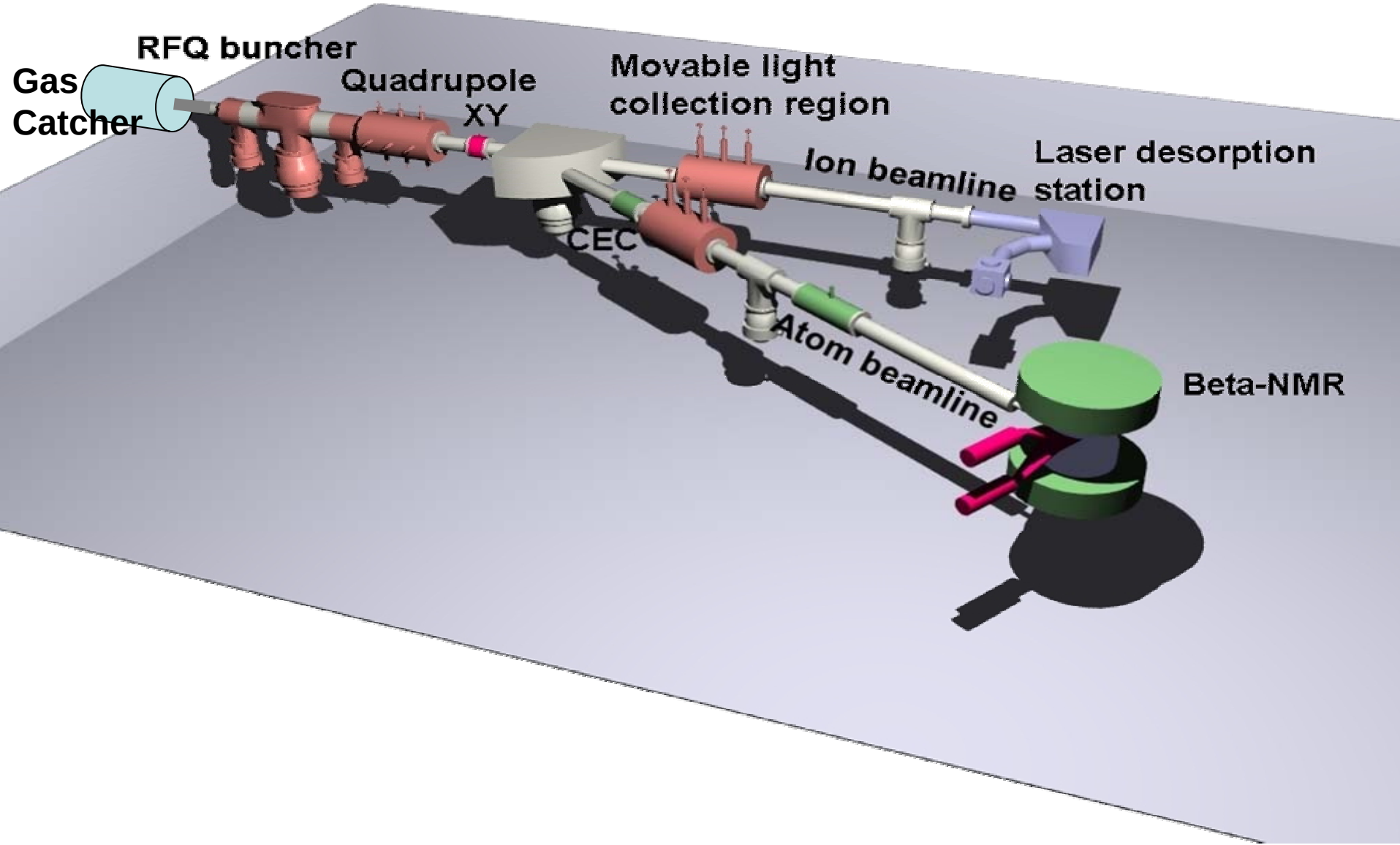
- optical photon detection (e.g. fluorescence),
- radiation detection (e.g. ß-NMR)
- particle detection (e.g. resonance ionization)

The **LaSpec Collaboration Technical Proposal** highlights

Six Principal LS Techniques

- applied on **two** beamlines,
- using a **variety** of lasers (2 general classes: cw [HR] & PL),

Laser Spectroscopy at the LEB



LaSpec's Sub-Projects

1. Collinear Laser Spectroscopy on Ions (Manchester)
2. Optical Pumping and Collinear Laser Spectroscopy on Atoms (Mainz)
3. β - Nuclear Magnetic Resonance (Leuven)
4. Resonance Ionization Laser Ion Source (Jyväskylä, Mainz)
5. Laser-Desorption Resonance Ionization (Orsay, Mainz)
6. Spectroscopy in an Electron Beam Ion Trap (Optional, MPIK Heidelberg)

We wish you an interesting, inspiring and productive workshop.

Enjoy...

... and thanks for your attention !