Laser Spectroscopy of Radioactive Atoms at the **L**ow **E**nergy **B**eamline

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Laser Spectroscopy at the LEB

Investigation of

- Hyperfine Structure
- Isotope Shifts
- Isomer Shifts

provides **model-independent** nuclear data…

Why OPTICAL??

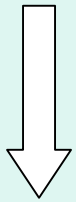
provides **high-sensitivity…**

Further Possibilities…

- in an EBIT (highly charged species; QED, relativistic effects)

Nuclear Ground State Properties

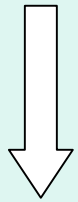
Isotope Shift (IS)



Mean Square Charge Radii

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

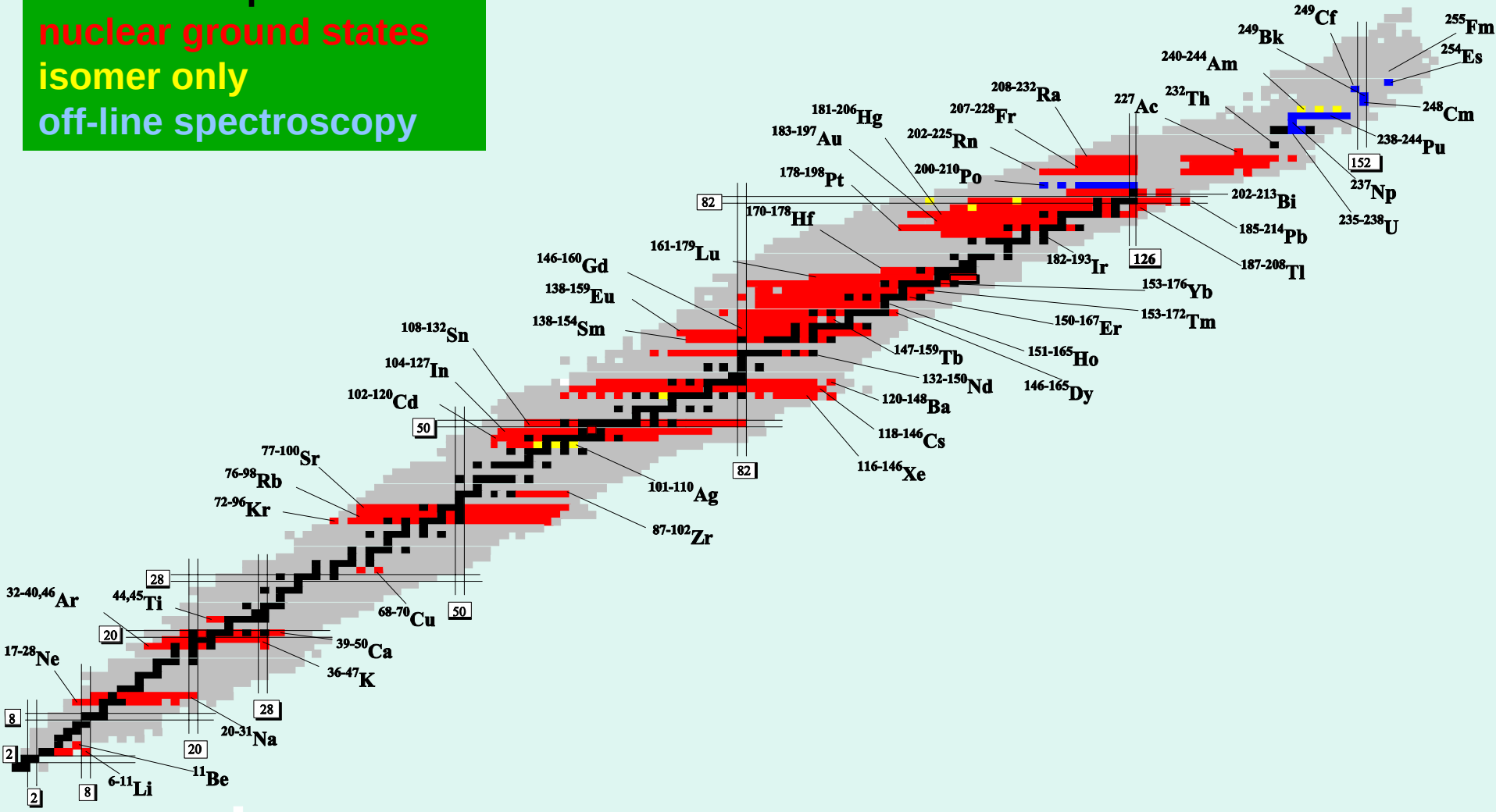
Hyperfine Structure (HFS)



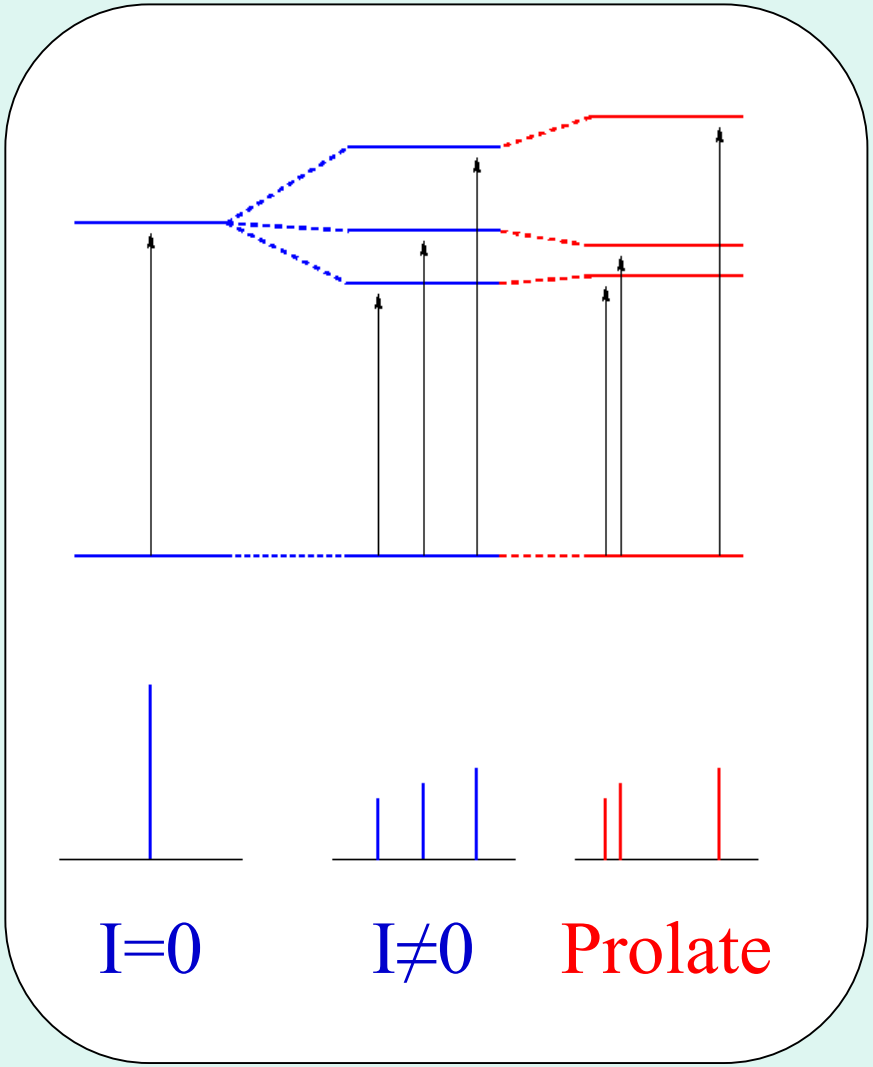
Nuclear Spin I
Magnetic Dipole Moment μ_I
Electric Quadrupole Moment Q_s
Hyperfine Anomaly

On-Line Laser Spectroscopy

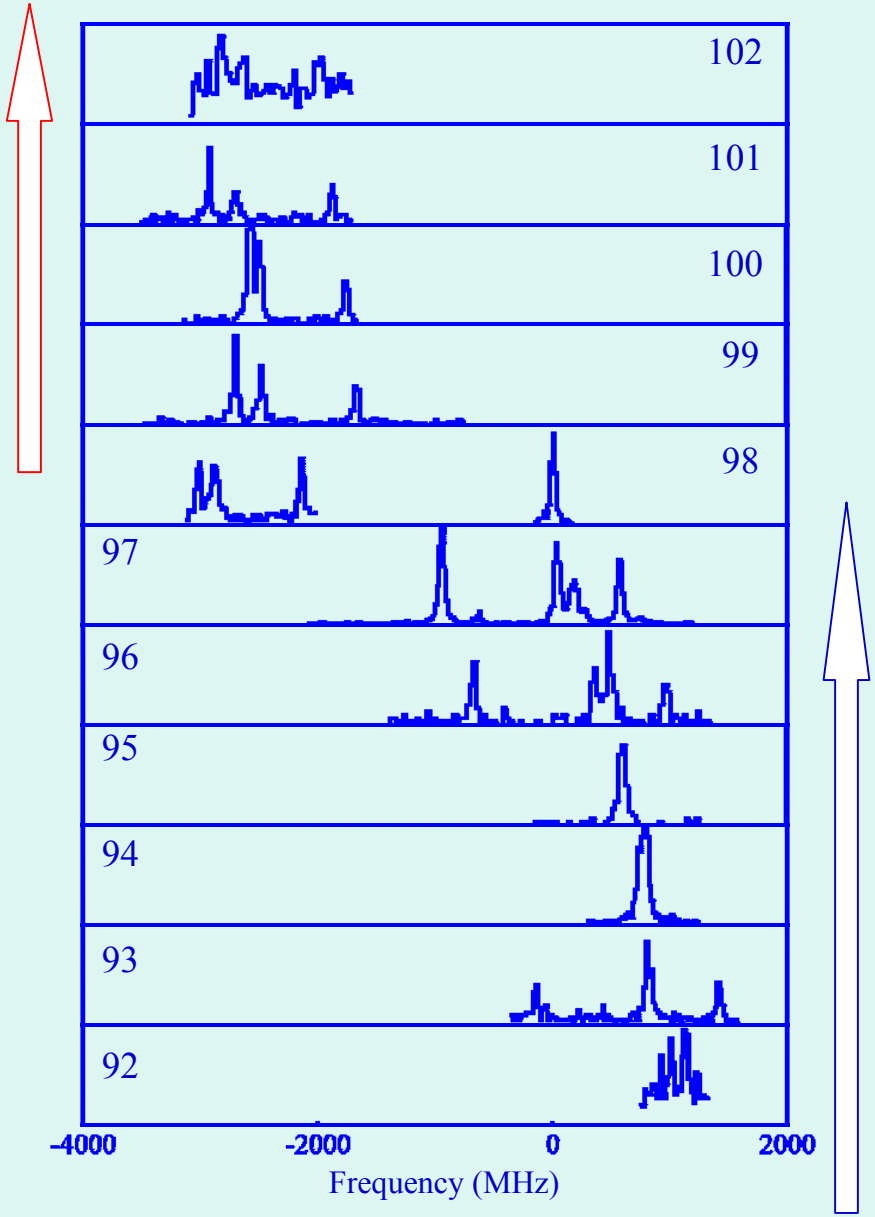
stable isotopes
nuclear ground states
isomer only
off-line spectroscopy



Yttrium J=0 – J'=1

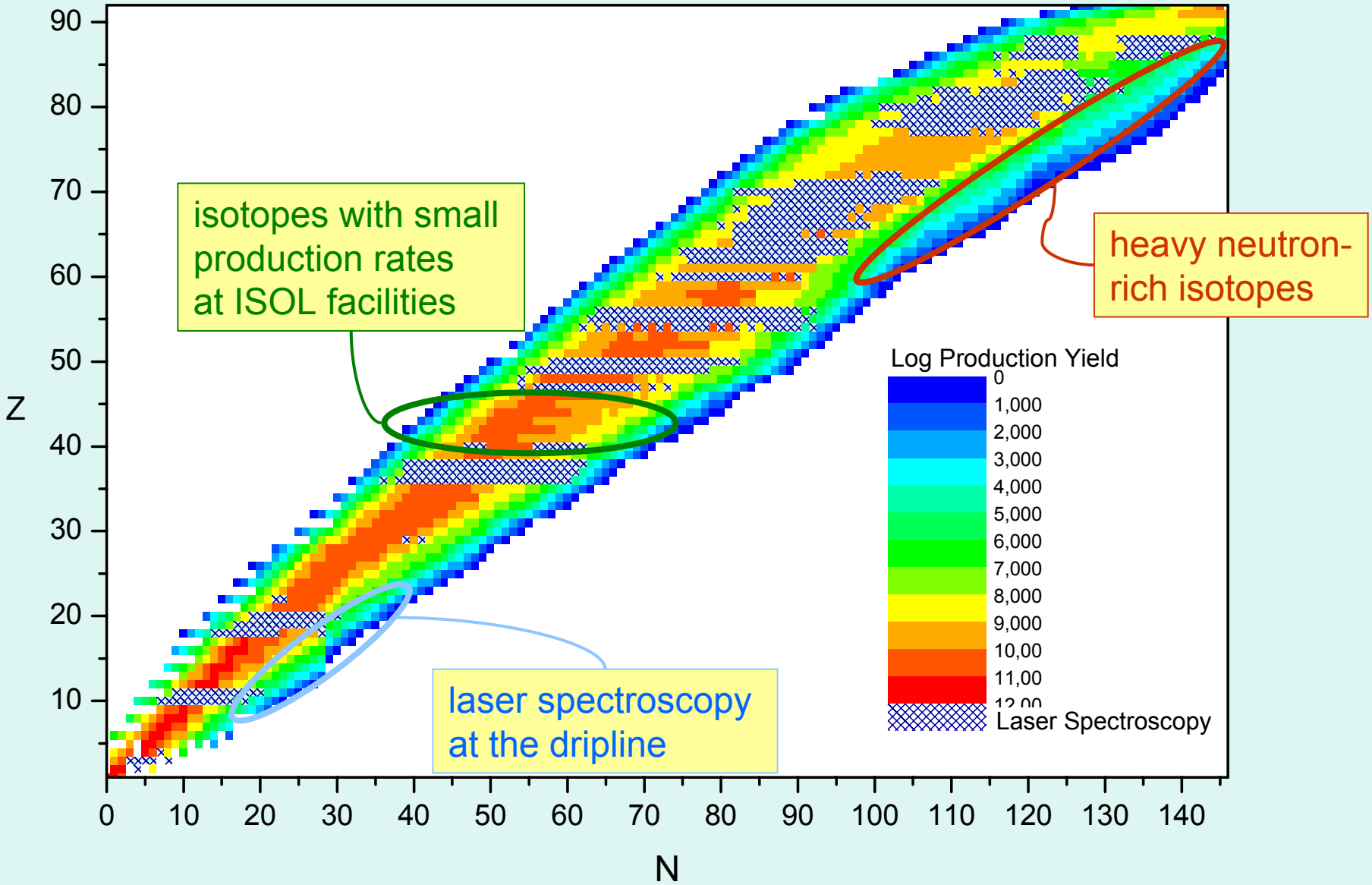


Decreasingly strong prolate



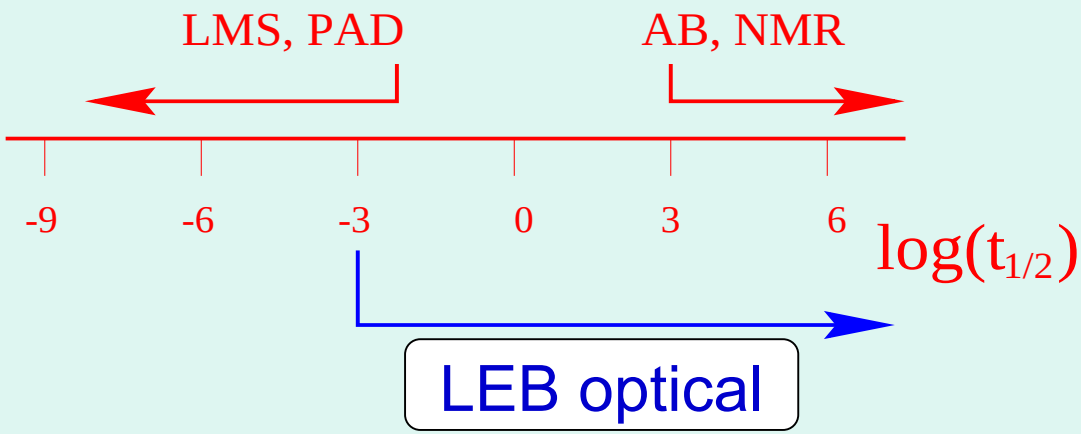
Increasingly oblate

New Opportunities at the LEB



New Opportunities at the LEB

- At the limits of halflife: high-K isomers, etc
- Bridge the gap to non-optical measurements



On-line Laser Spectroscopy

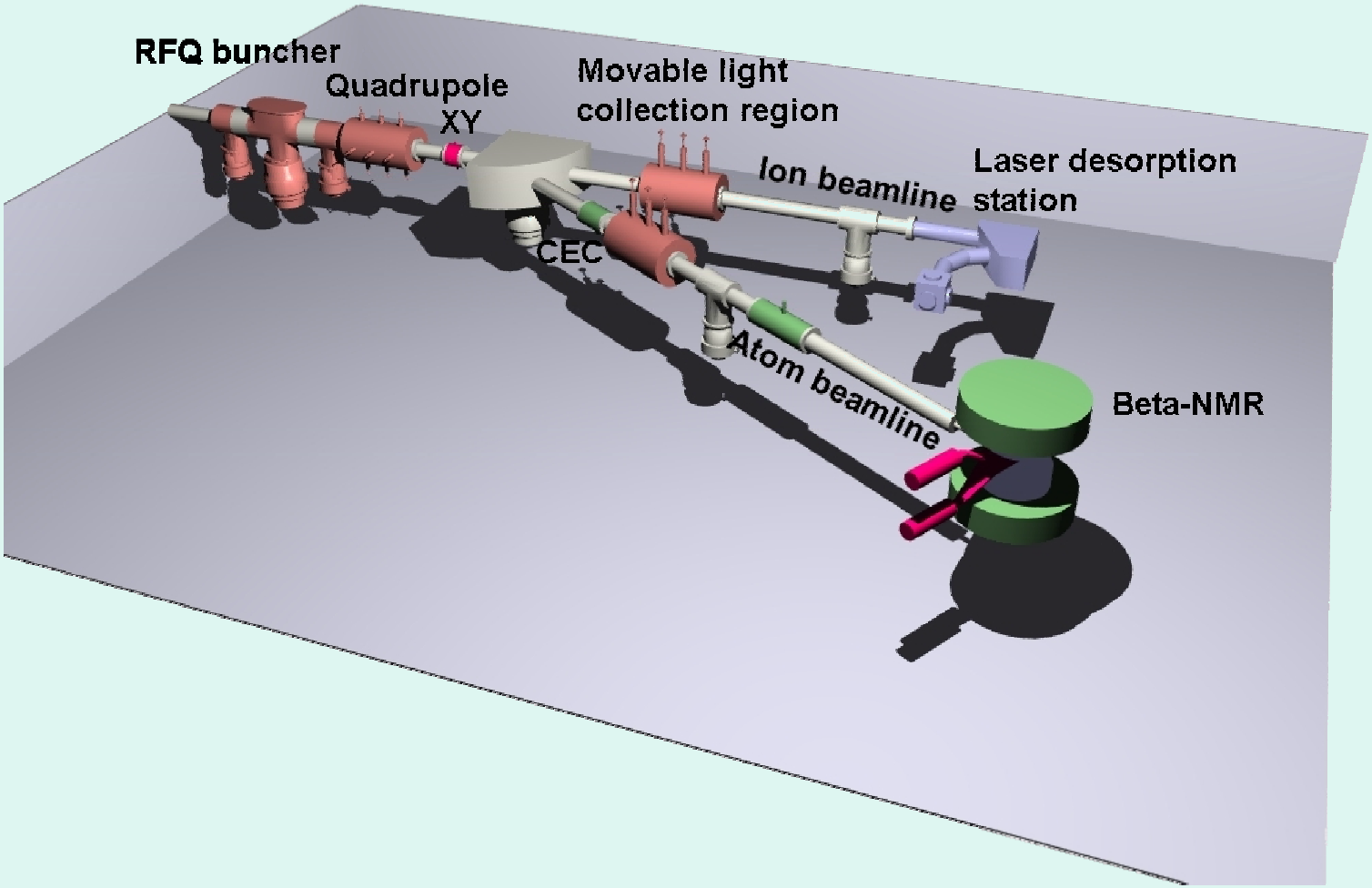
General technique and many variants are well established.

many detection techniques with different applicabilities,

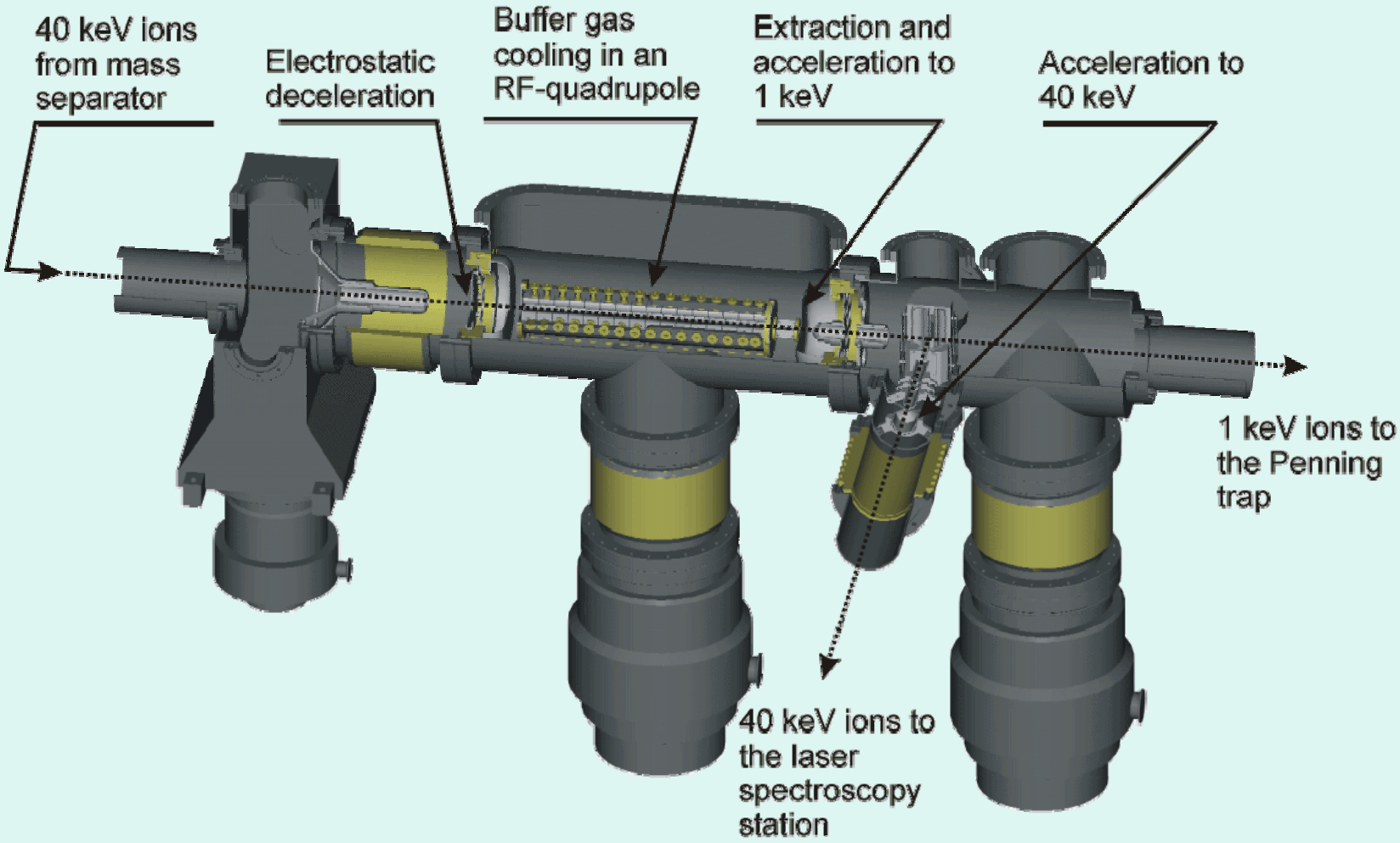
- fluorescence detection,
- ß-NMR,
- resonance ionization, etc

In the LaSpec collaboration's Technical Proposal we have highlighted 6 major techniques. These will be applied on two beamlines, use a variety of lasers and and will provide necessary and sufficient experimental capability for spectroscopy down to 1 - 10 ions per sec.

Laser Spectroscopy at the LEB



We will need to cool and bunch:



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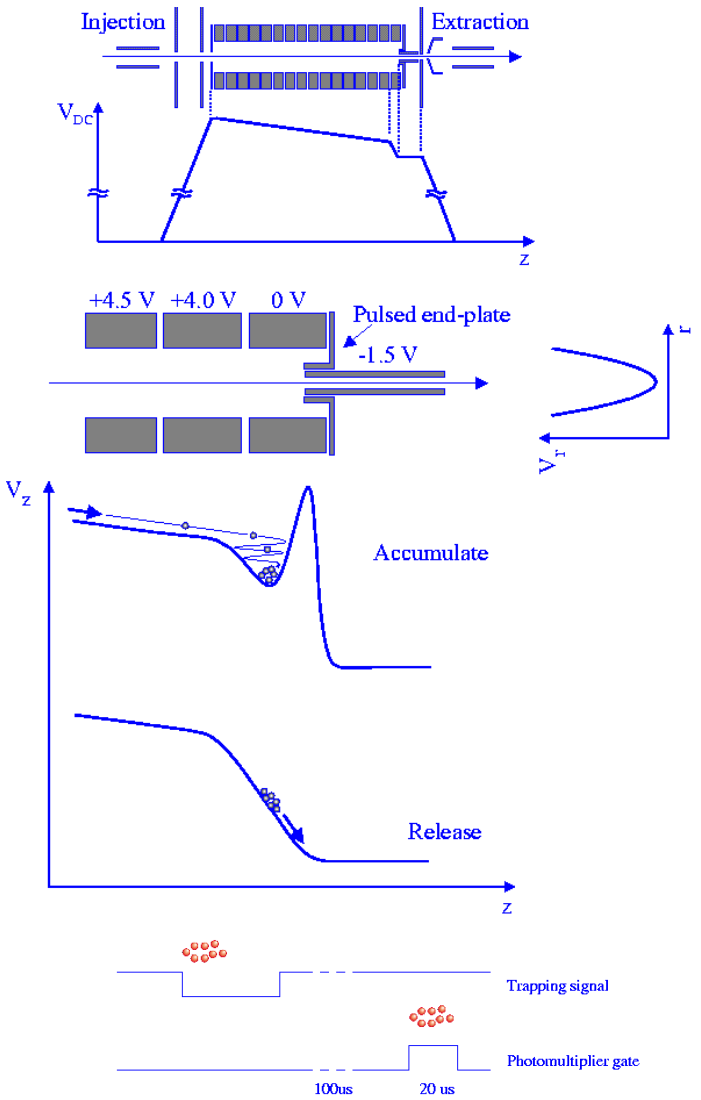
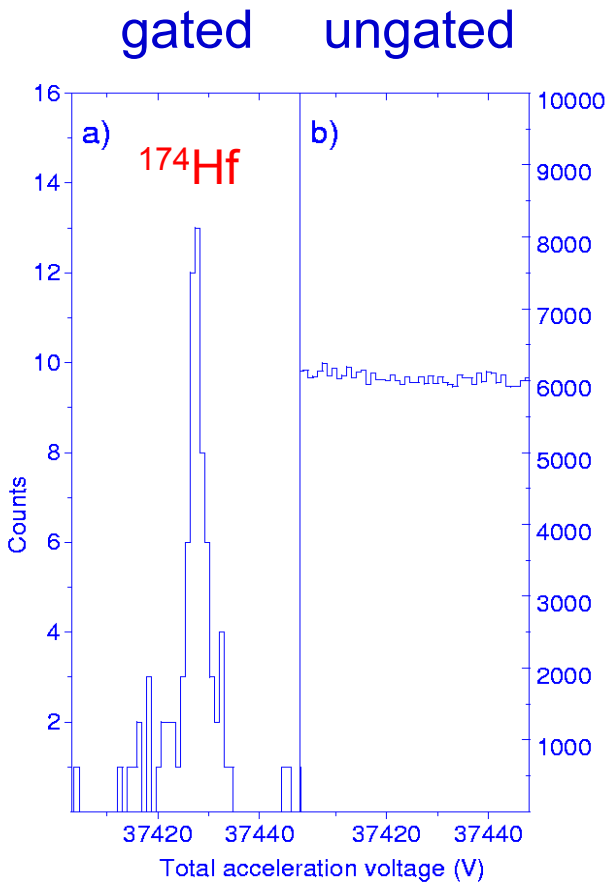
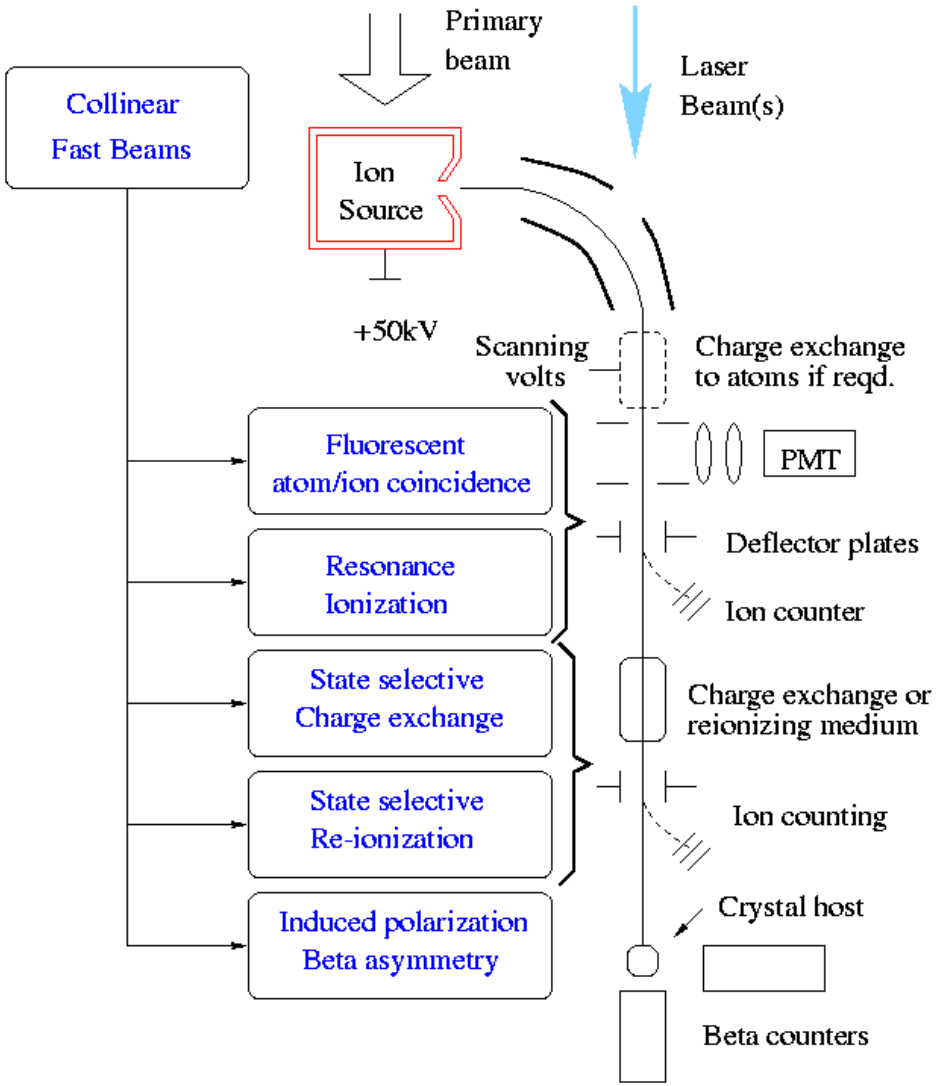




A. Nieminen *et al.*, PRL **88**, 094801 (2002)

The “collinear” approaches:



In LaSpec

Ion fluorescence
Atom fluorescence
Optical pumping
Collinear RIS
ß-NMR

Laser Spectroscopy at the LEB

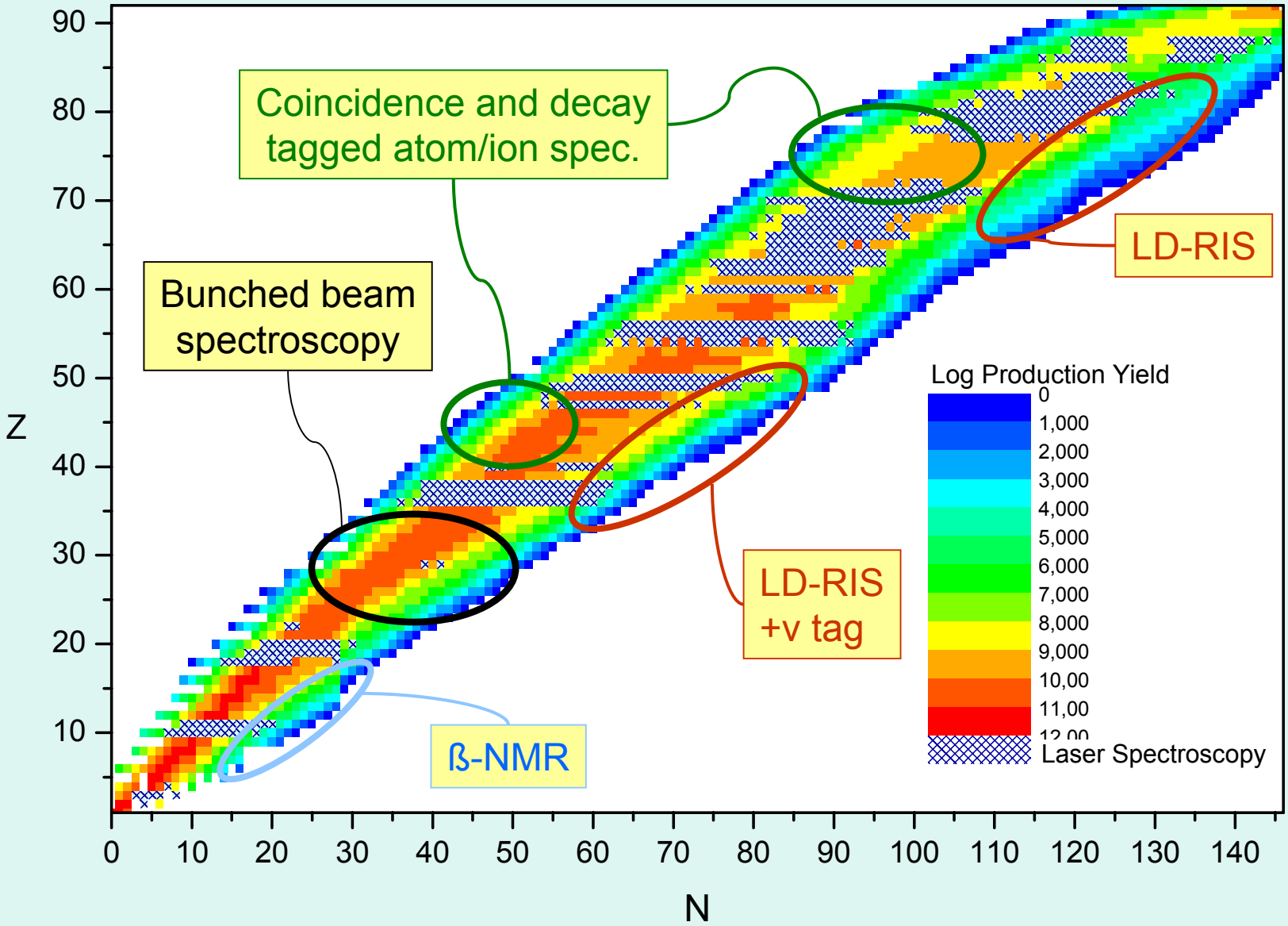
We want to study:

- Unhindered by chemistry
- At the proton drip line
- The heavy neutron-rich
- Low-Z isotopes
- The shortest-lived
- Against `high' background (isobaric contamination)

We have:

- Ionic and atomic spec.
- Bunched and coin. CLIS
- LD-RIS
- ß-NMR
- Decay tagging
- RILIS and non-optical detection

New Opportunities at the LEB



The Physics from LaSpec…

Limits of stability….

Diffuse proton structures
Neutron skins
Magicity

Limits of lifetime…

Pairing effects
Field calibration

Into the unknown….

New regions
of deformation

LaSpec

Birmingham
Manchester
GSI
Jyvaskyla
Leuven
Mainz
Orsay
Heidelberg
Munich
Tubingen
CERN
Livermore
Pacific Northwest