

# Laser Spectroscopy of Radioactive Atoms at the Low Energy Beamline

**Paul Campbell**

University of Manchester

for the LaSpec Collaboration

# Laser Spectroscopy at the LEB

Investigation of

- Hyperfine Structure
- Isotope Shift
- Isomer Shifts

provides **model-independent** nuclear data...

Why **OPTICAL??**

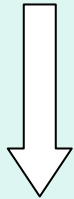
provides **high-sensitivity**...

Further Possibilities...

- in Atom Traps (e.g. **Weak Interaction Studies, PNC**)
- in an EBIT (simpler atomic structure, polarization)

# Nuclear Ground State Properties

Isotope Shift (IS)



Mean Square Charge Radii

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

Hyperfine Structure (HFS)



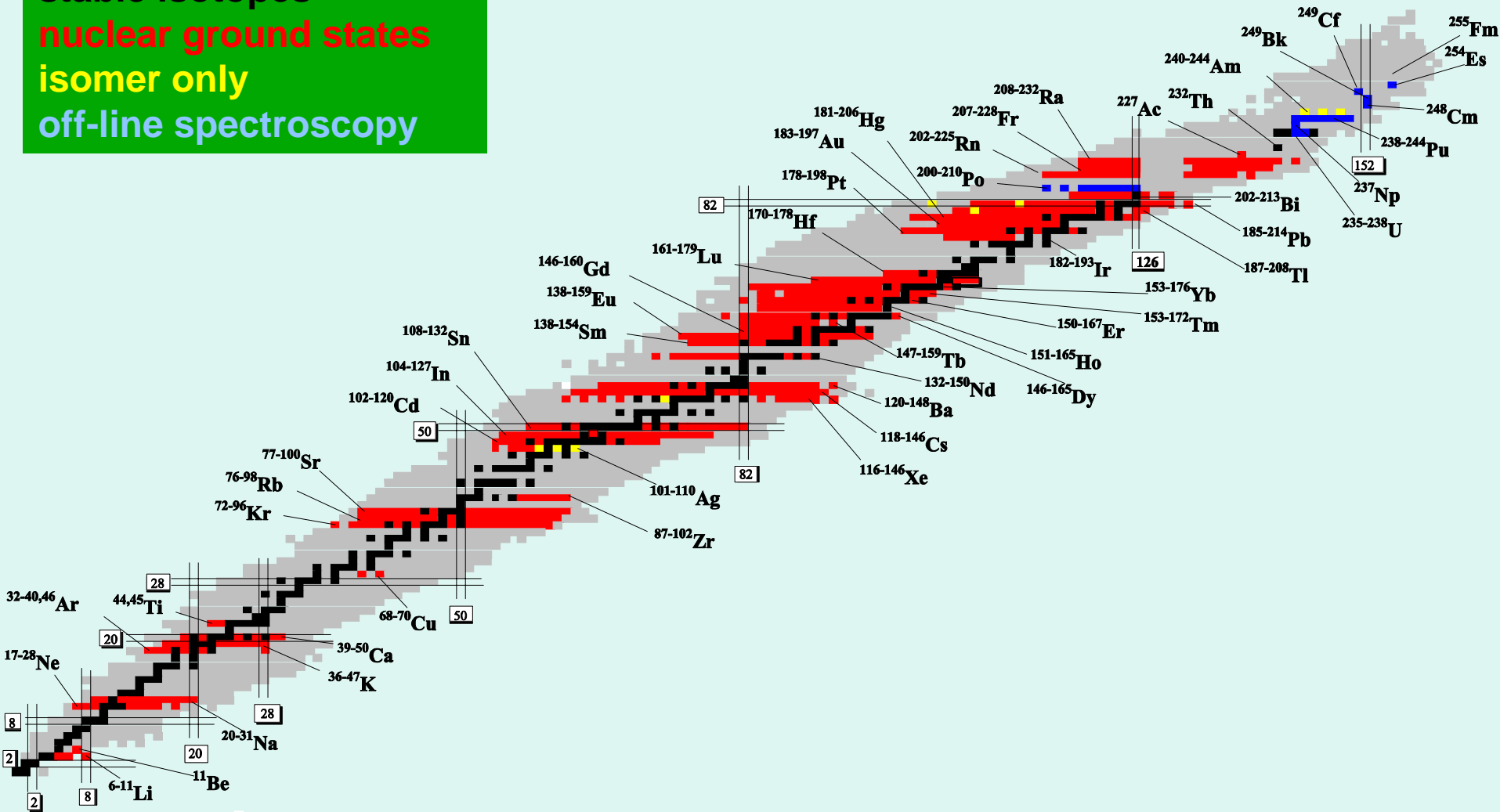
Nuclear Spin  $I$

Magnetic Dipole Moment  $\mu_I$   
Electric Quadrupole Moment  $Q_s$   
Hyperfine Anomaly

**if, and only if, the sample can be suitably prepared....**

# On-Line Laser Spectroscopy

stable isotopes  
nuclear ground states  
isomer only  
off-line spectroscopy

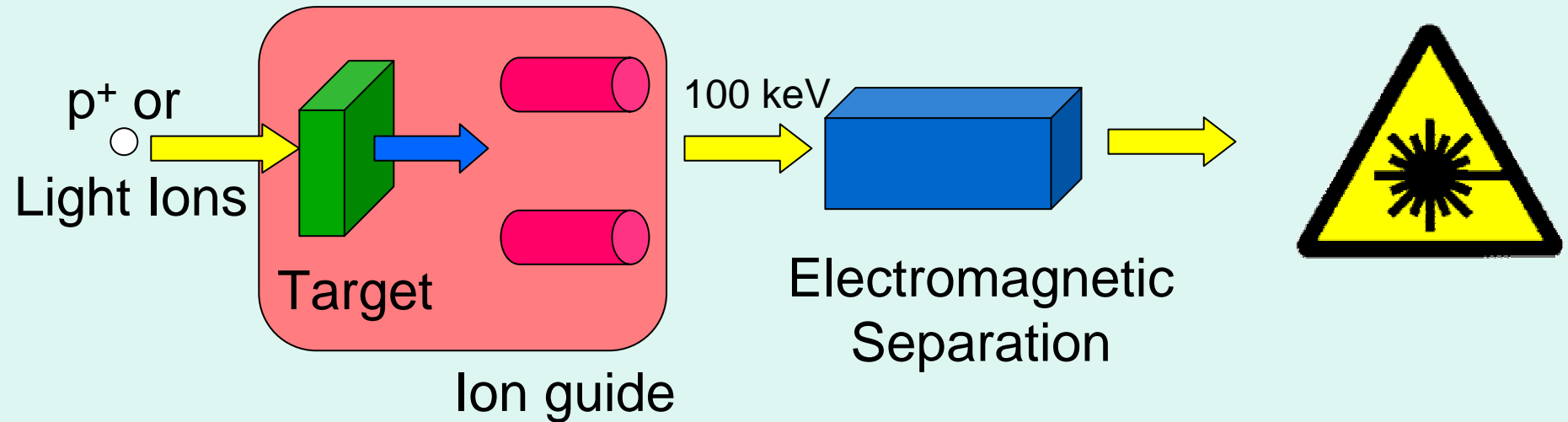


# ISOL

$T_{1/2} \sim 10$  ms  
no reactive elements  
no refractory elements

Good conditions for spectroscopy: highly successful and productive

Ion source

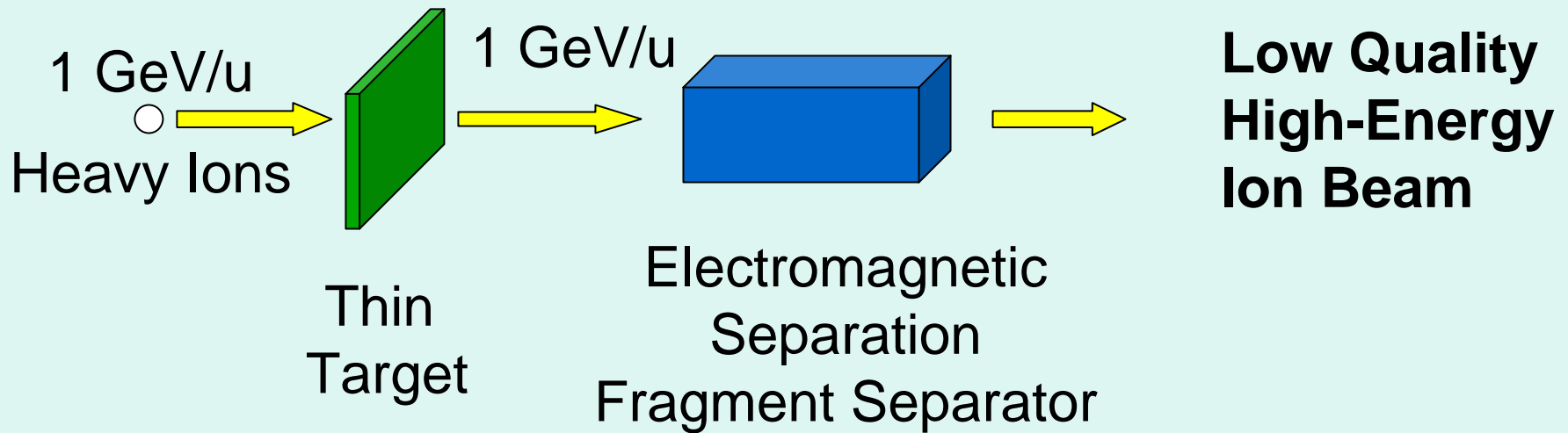


# IGISOL

$T_{1/2} \sim 1$  ms  
reactive elements  
refractory elements  
very modest yields

Good conditions for spectroscopy **only** if the beam is cooled

# In-Flight Fragmentation



**All Elements**  
**chemically non-selective**

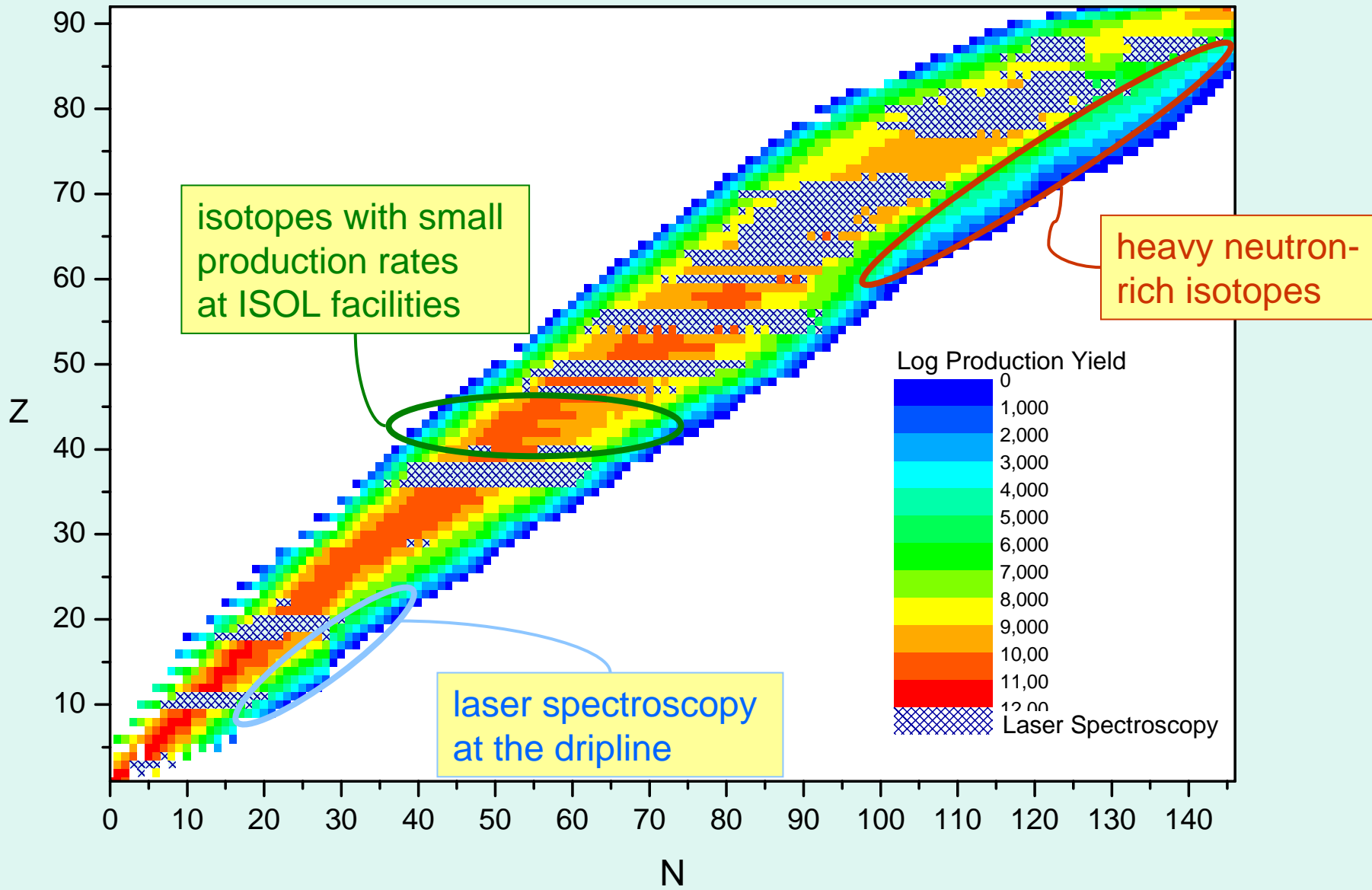
**$T_{1/2} \sim 1 \mu\text{s}$**

# LEB: The Best of All Worlds

## ISOL-Type Beams from an In-flight facility

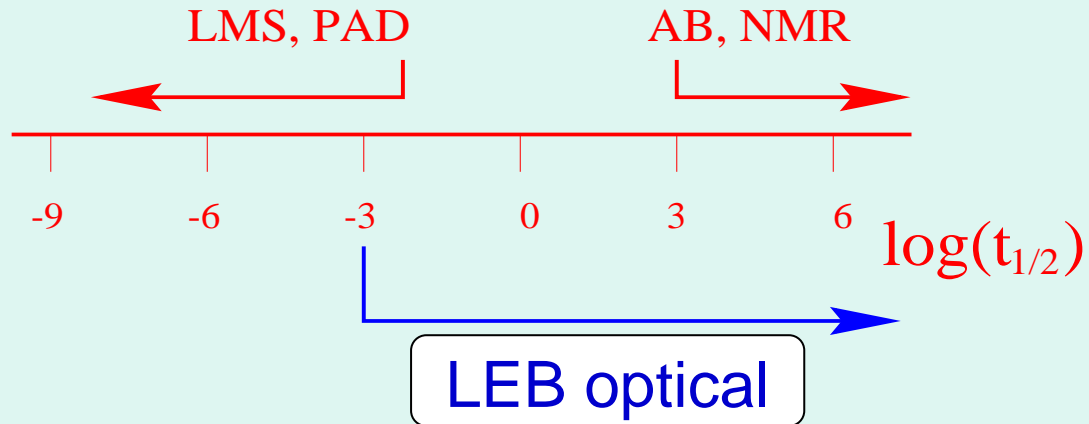
Laser spectroscopy at ISOL facilities is highly developed and has provided nuclear state properties for two decades. The LEB offers the only possibility to make these studies at the limits of stability and lifetime.

# 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



# Collinear Laser Spectroscopy

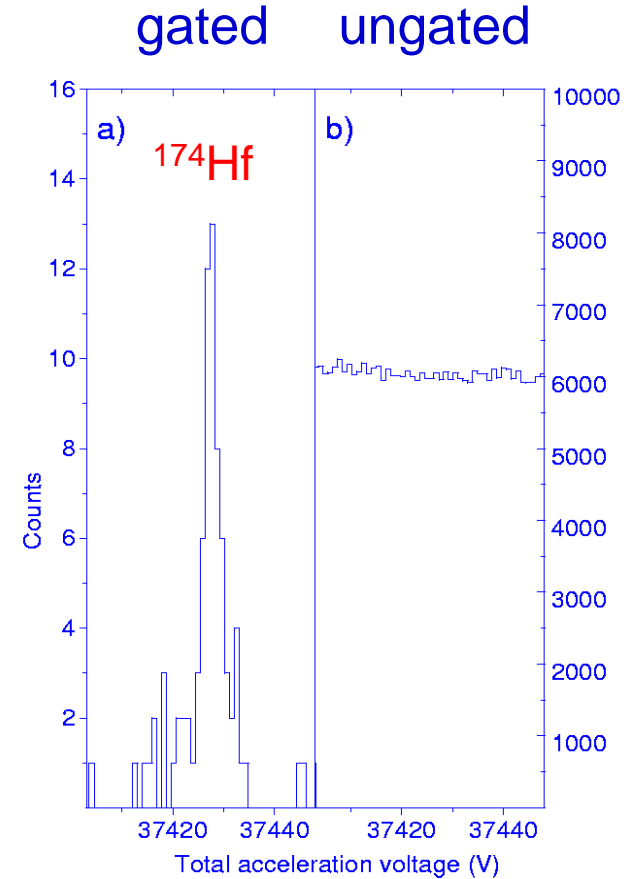
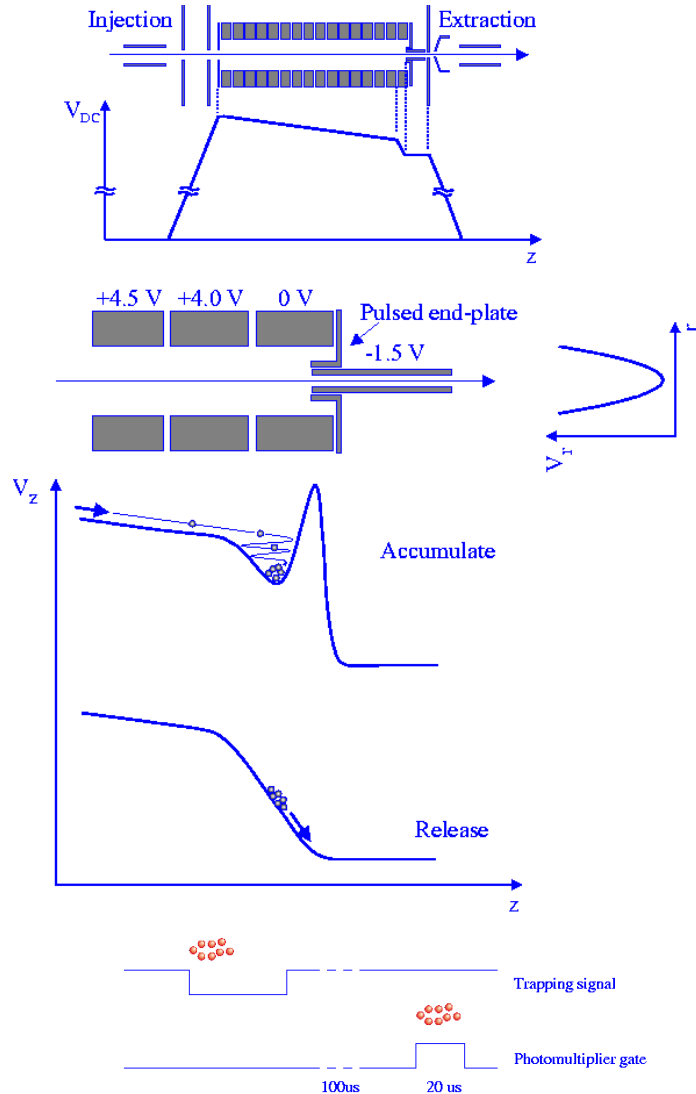
General technique and many variants are well established.

many detection techniques with different sensitivity and applicabilities, e.g.

- fluorescence detection
- state-selective ionization
- resonance ionization

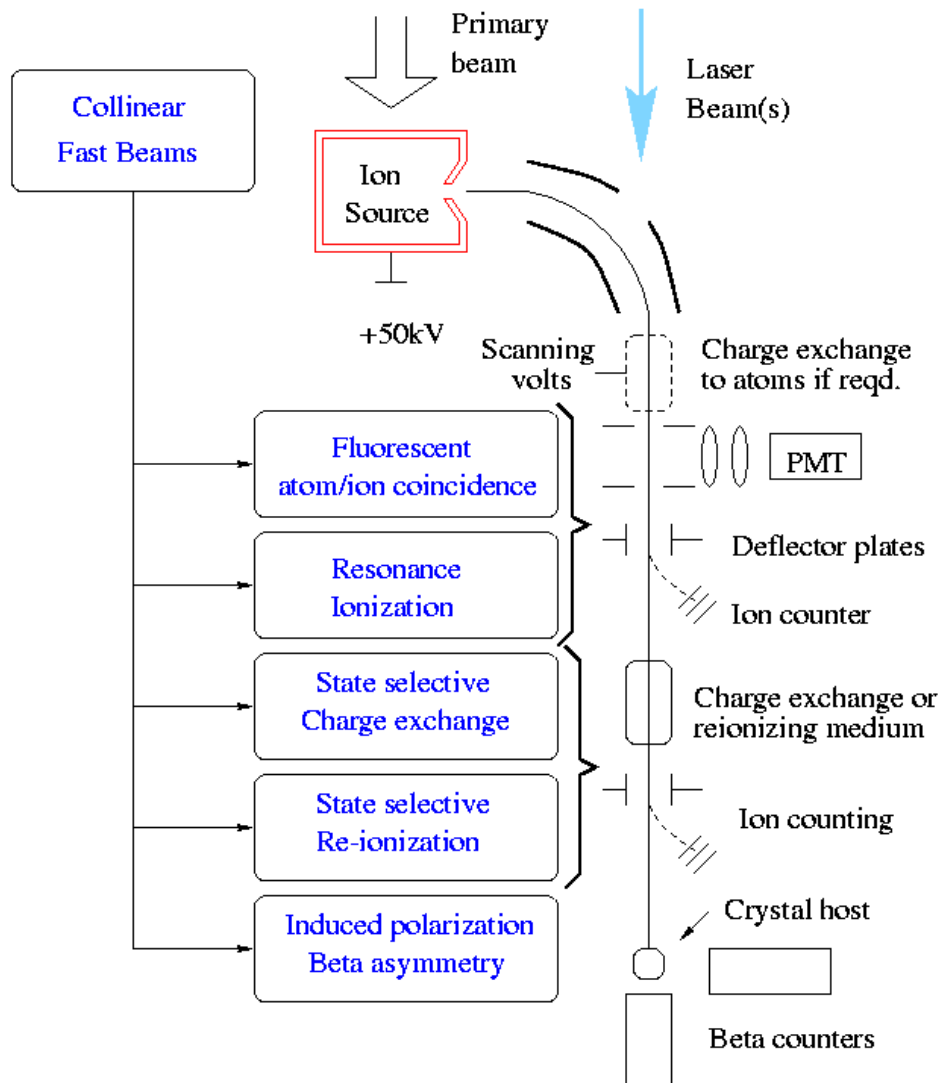
The LaSpec collaboration contains groups specialized in all of these fields. The collaborators have performed spectroscopy at rates as small as 10/s and on systems with lifetimes as short as 10ms...

# We will need to cool and bunch:



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

# ...and many other approaches:



On behalf of LaSpec

CERN  
GSI  
JYFL  
LLNL  
LMU  
Manchester  
MPI  
Orsay  
PNL  
Tubingen