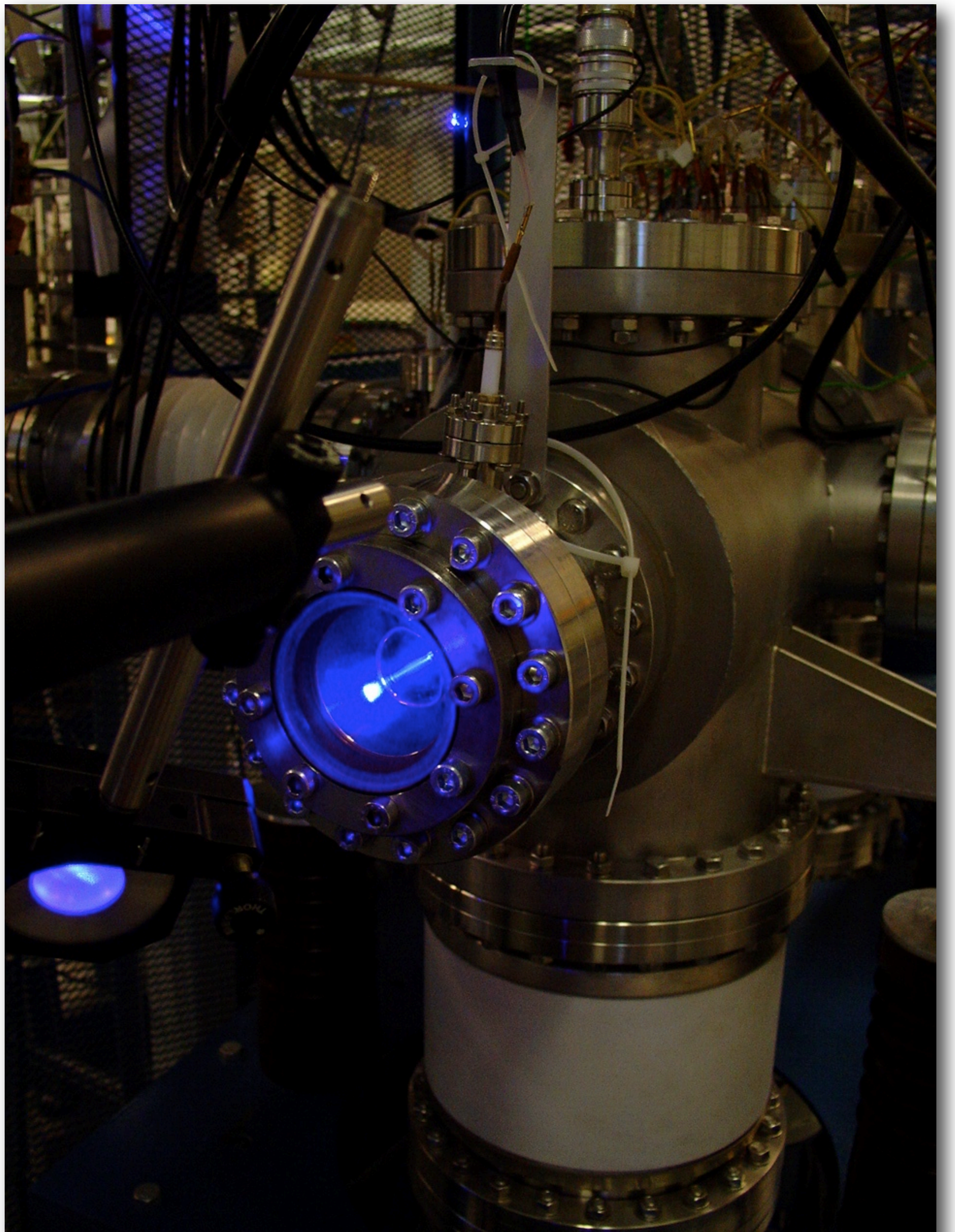
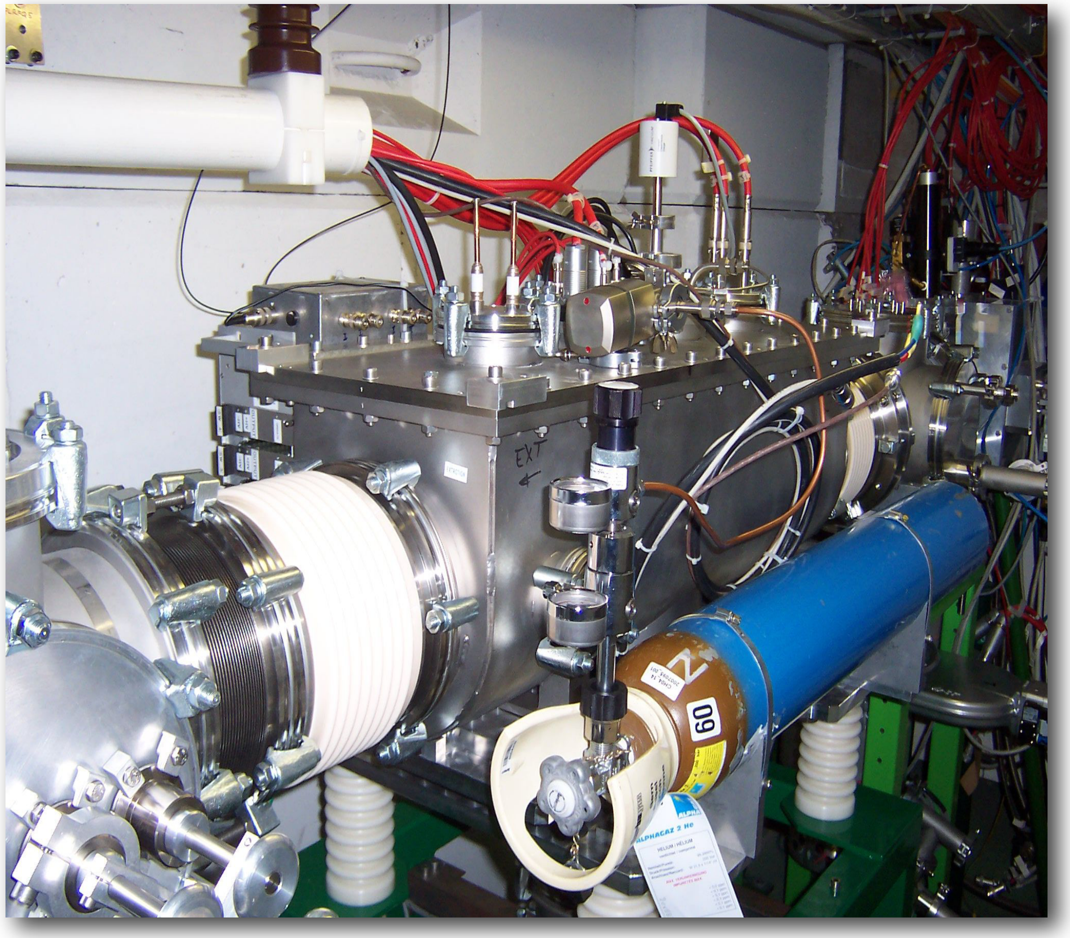
MANCHESTER
1824

The University of Manchester

Ultra sensitive laser spectroscopy of pure beams





MANCHESTER 1824

The University of Manchester

Outline of talk

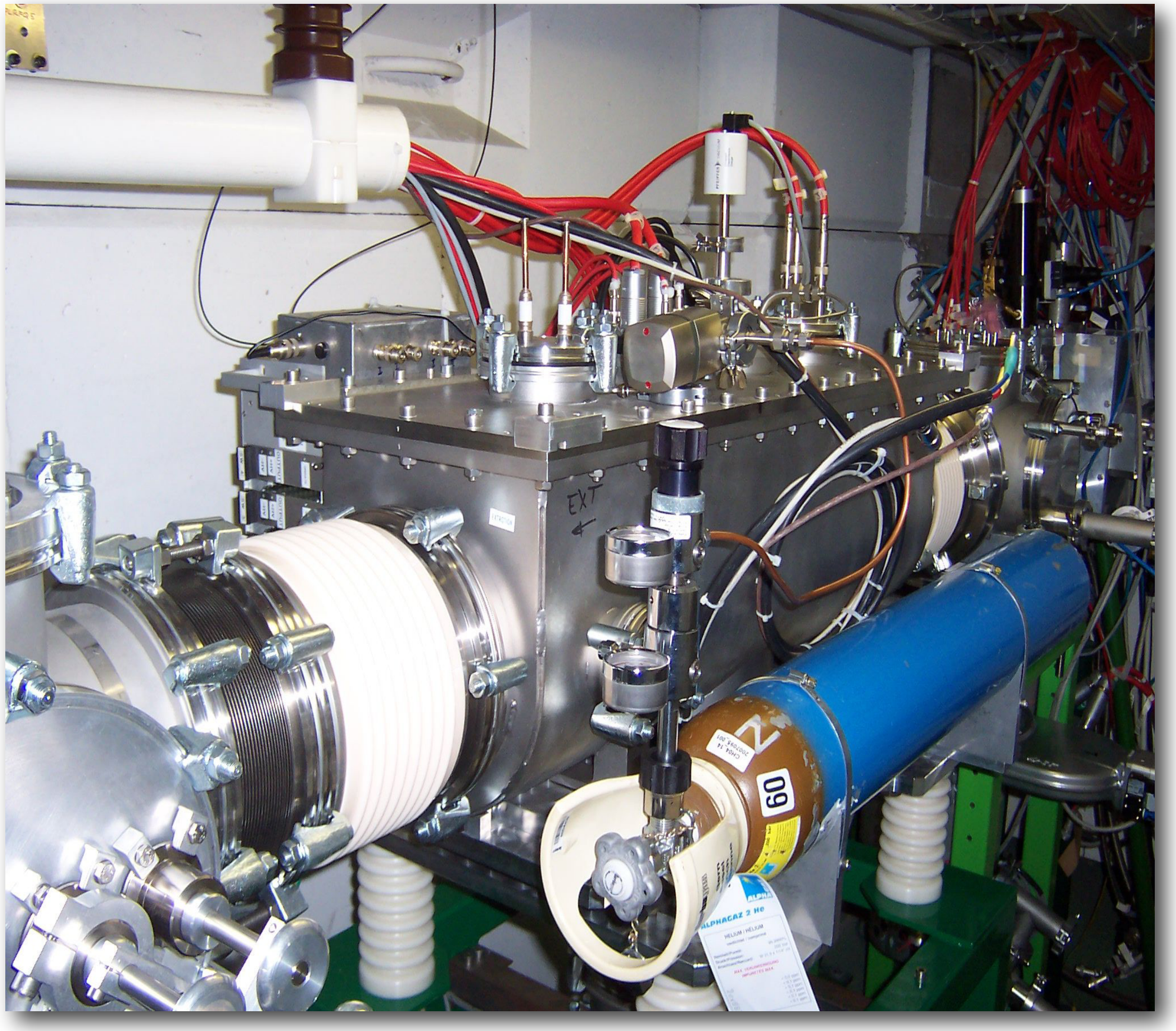
- Sources of photon background
  (fluorescence detection, bunching technique)

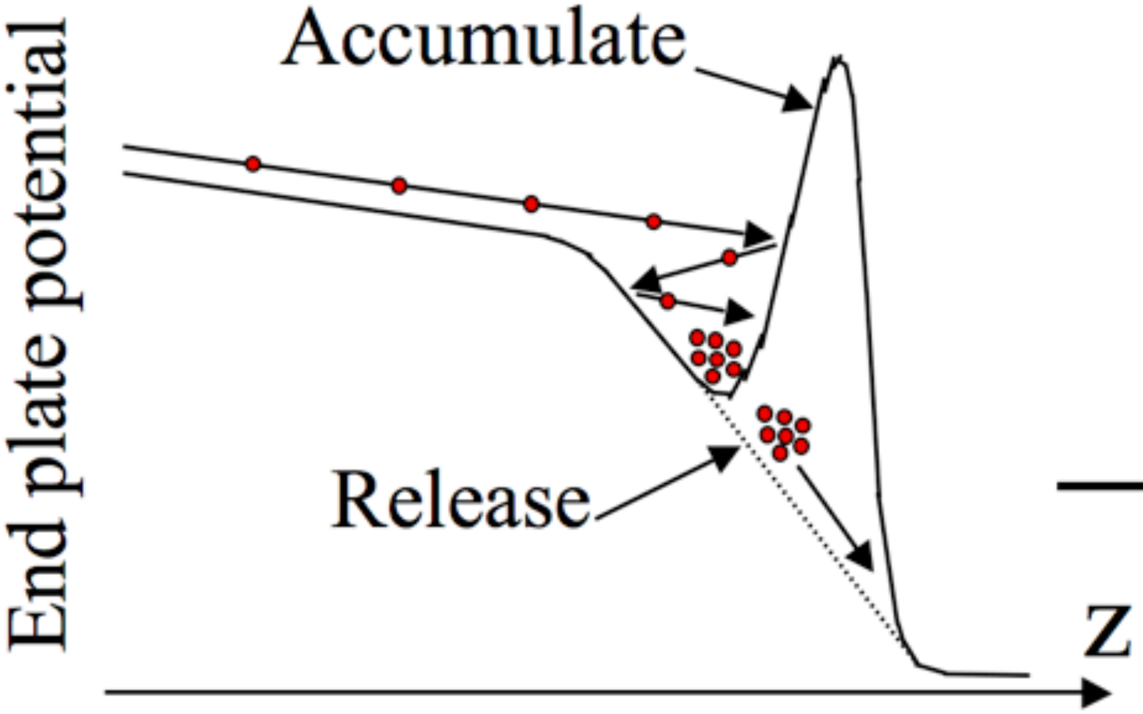
- The need for pure beams
  (and how to obtain them...)

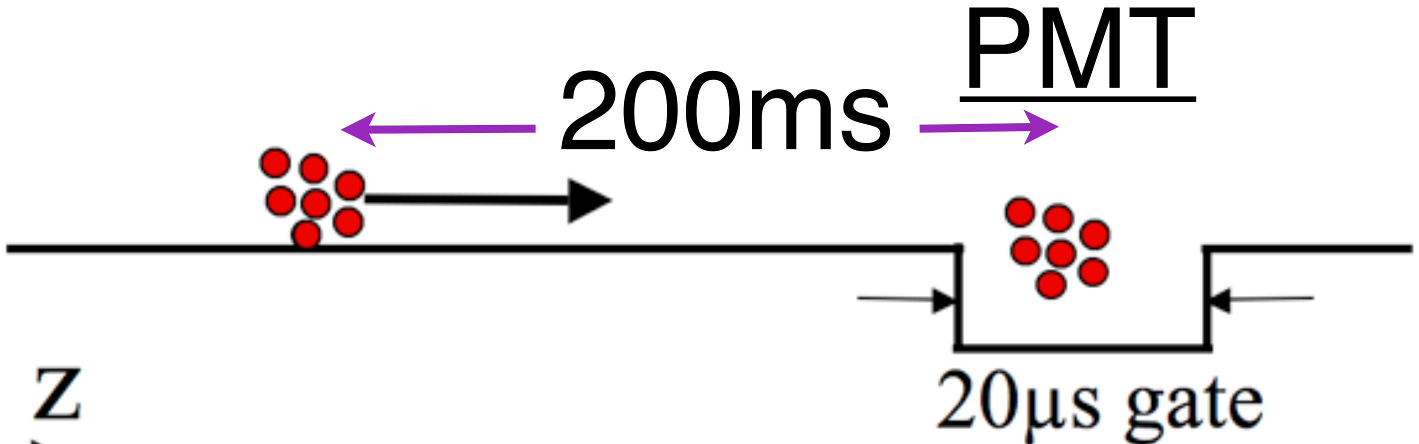
- Photon-Ion coincidence detection
  (and its resurrection)

Bunching for laser spectroscopy

Photon background dominated by continuous laser scatter



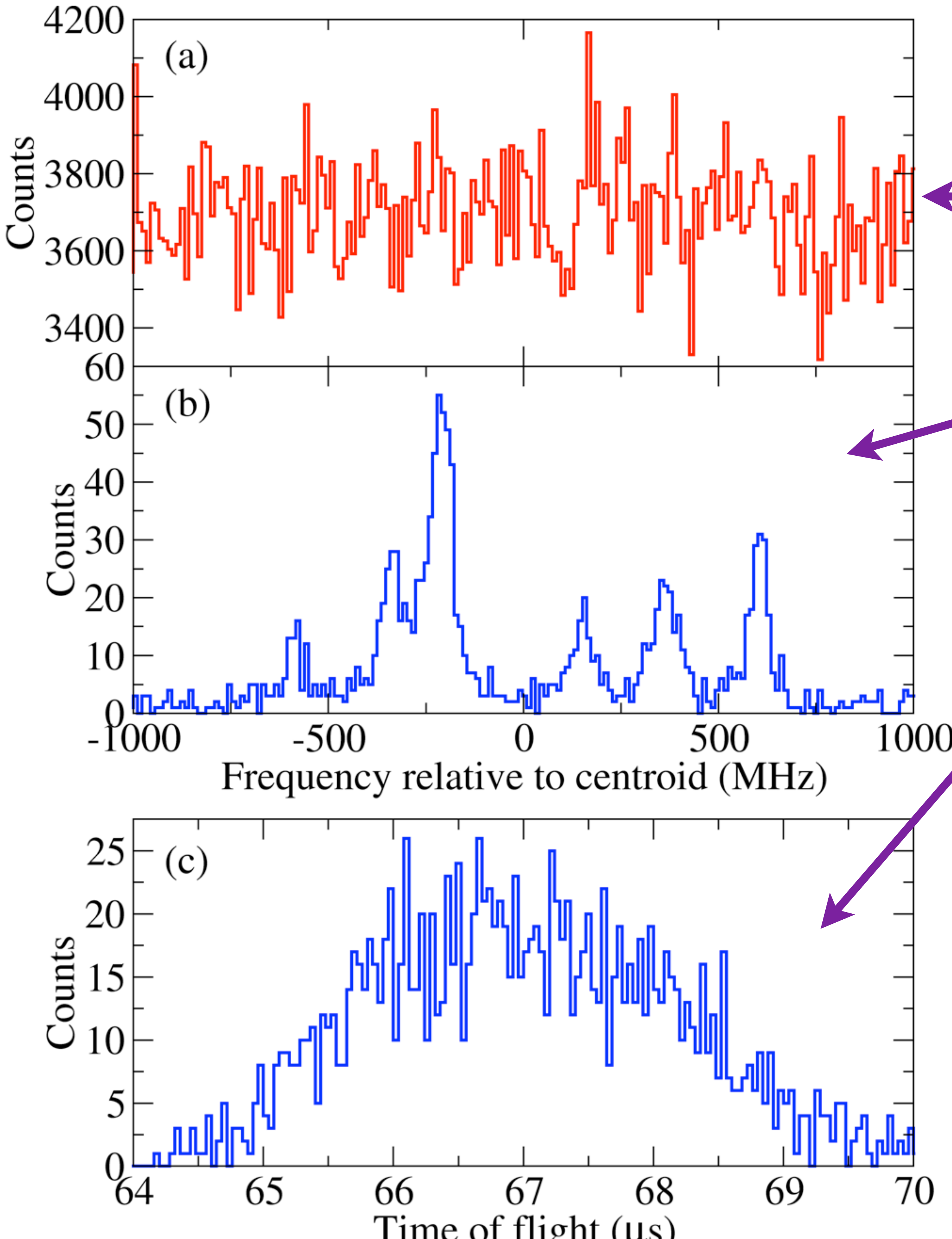




MANCHESTER 1824

The University of Manchester

Bunched spectra (ISCOOL '09)



Ungated

Gated (64μs - 70μs)

Time of flight (50ms accumulation)

<u>Background suppression</u>

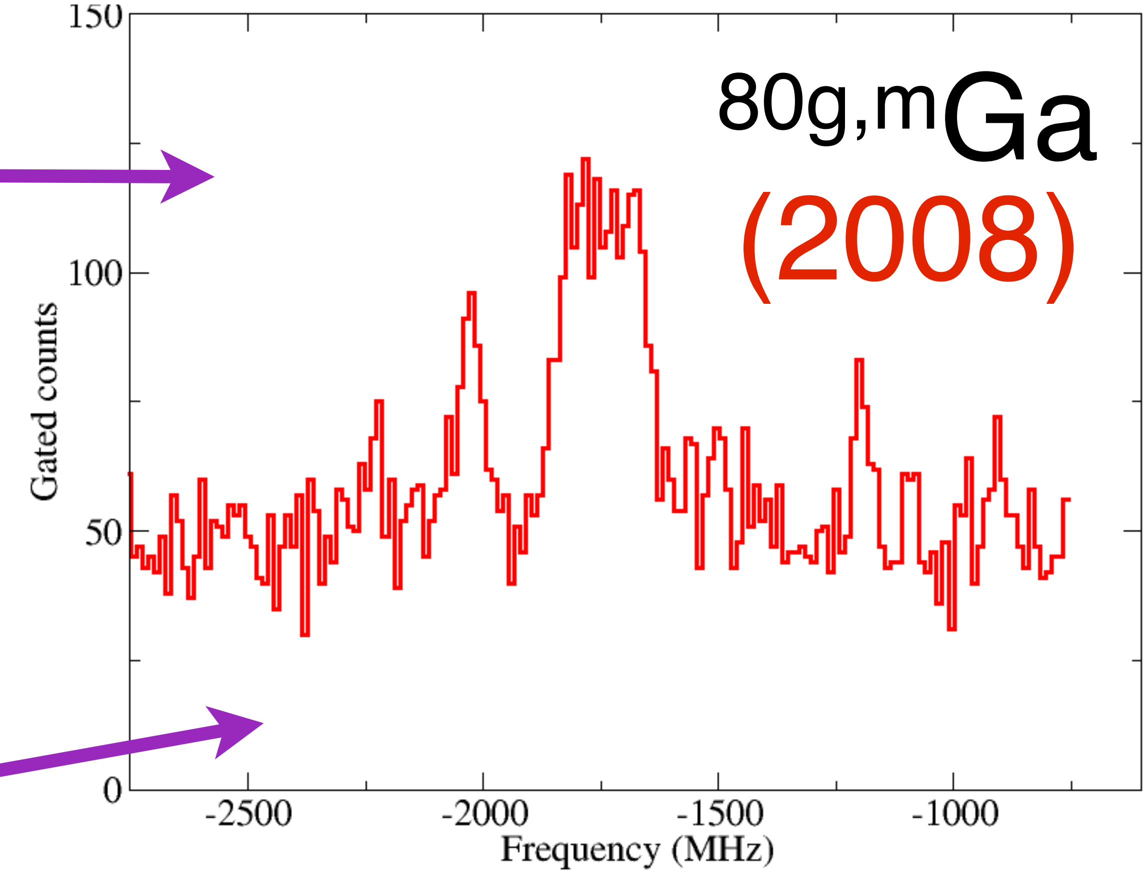
50ms / 6μs = ~10^4

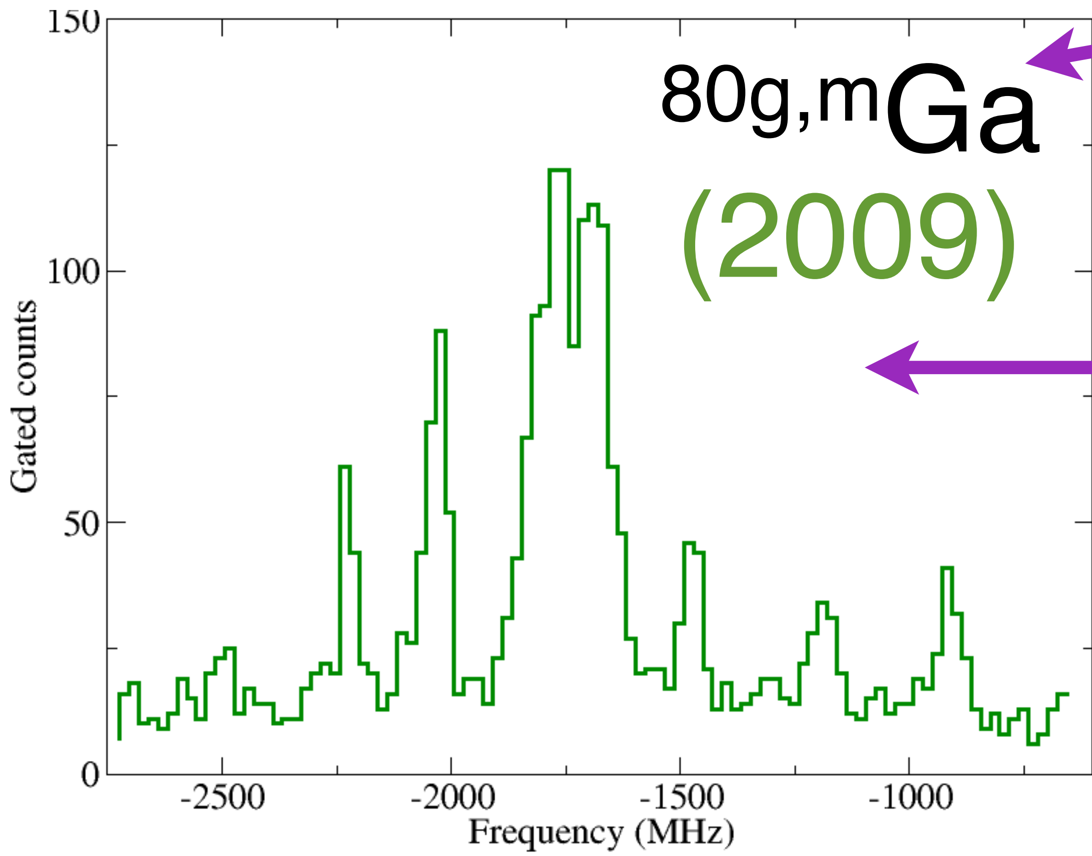
MANCHESTER 1824

The University of Manchester

But complications arise...

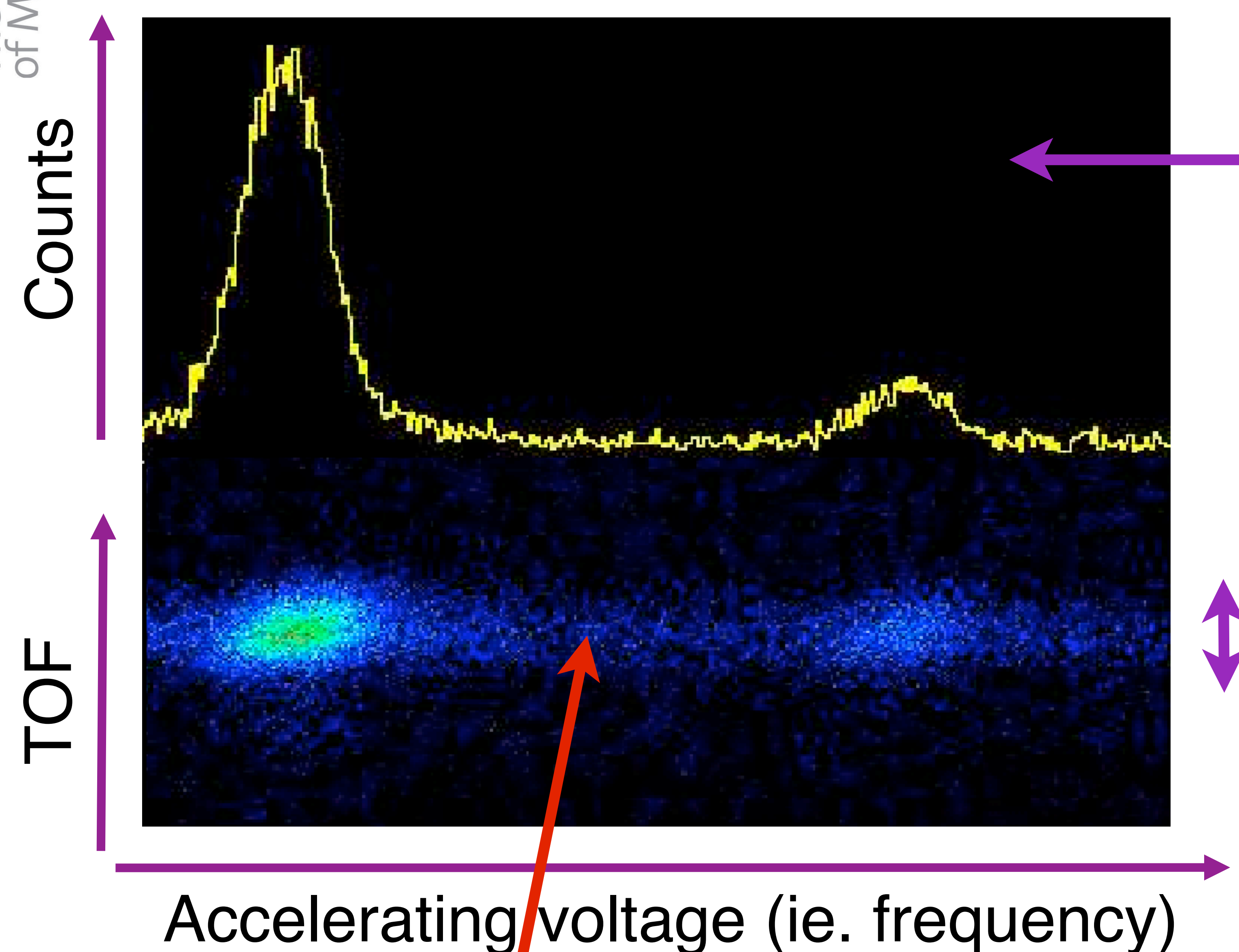
Large Rb isobar
➔ Trap saturation
➔ Photon background





Suppression of Rb isobar
with neutron converter

Ions also cause background



Optical spectrum projected

Gate applied

(eg. 10µs of 100ms cycle)

Isobaric contaminants have same TOF (m/q dep.)

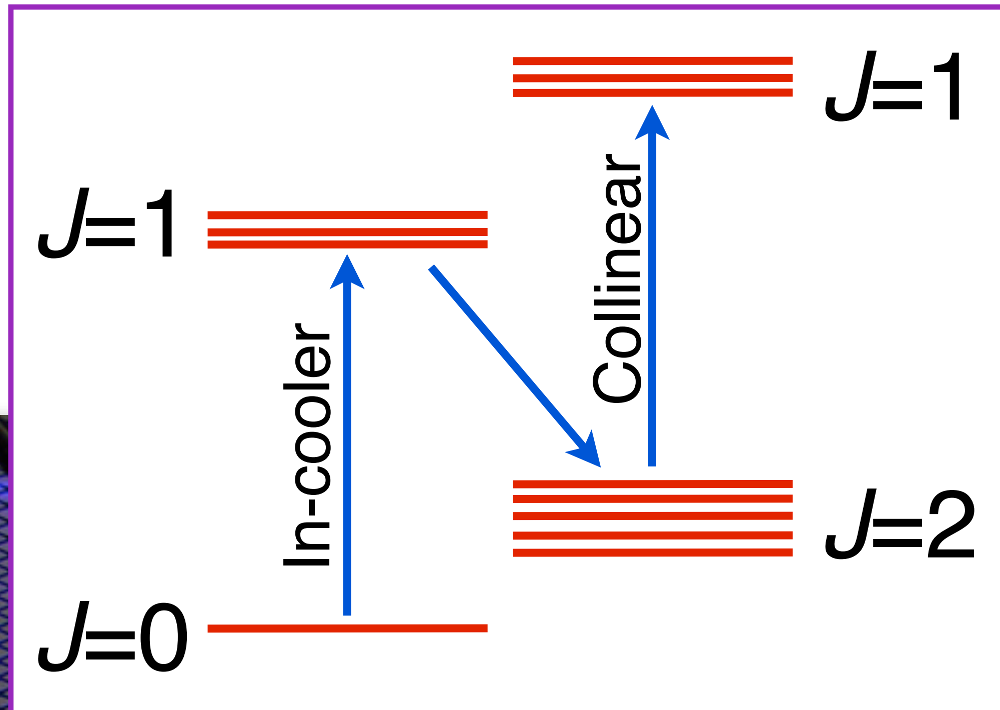
➔ Bunching doesn't help here

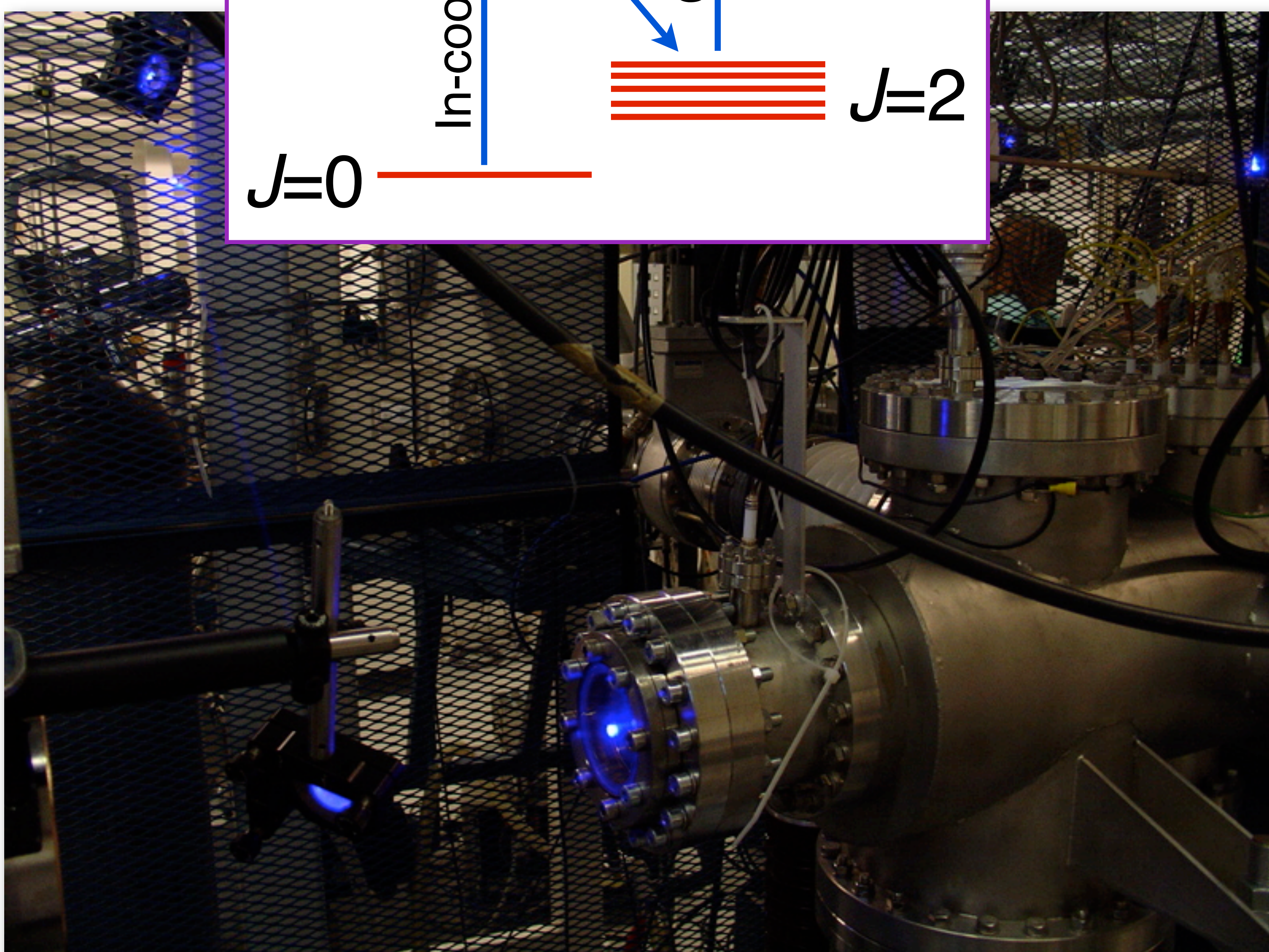
➔ Need *Z*-selectivity to separate

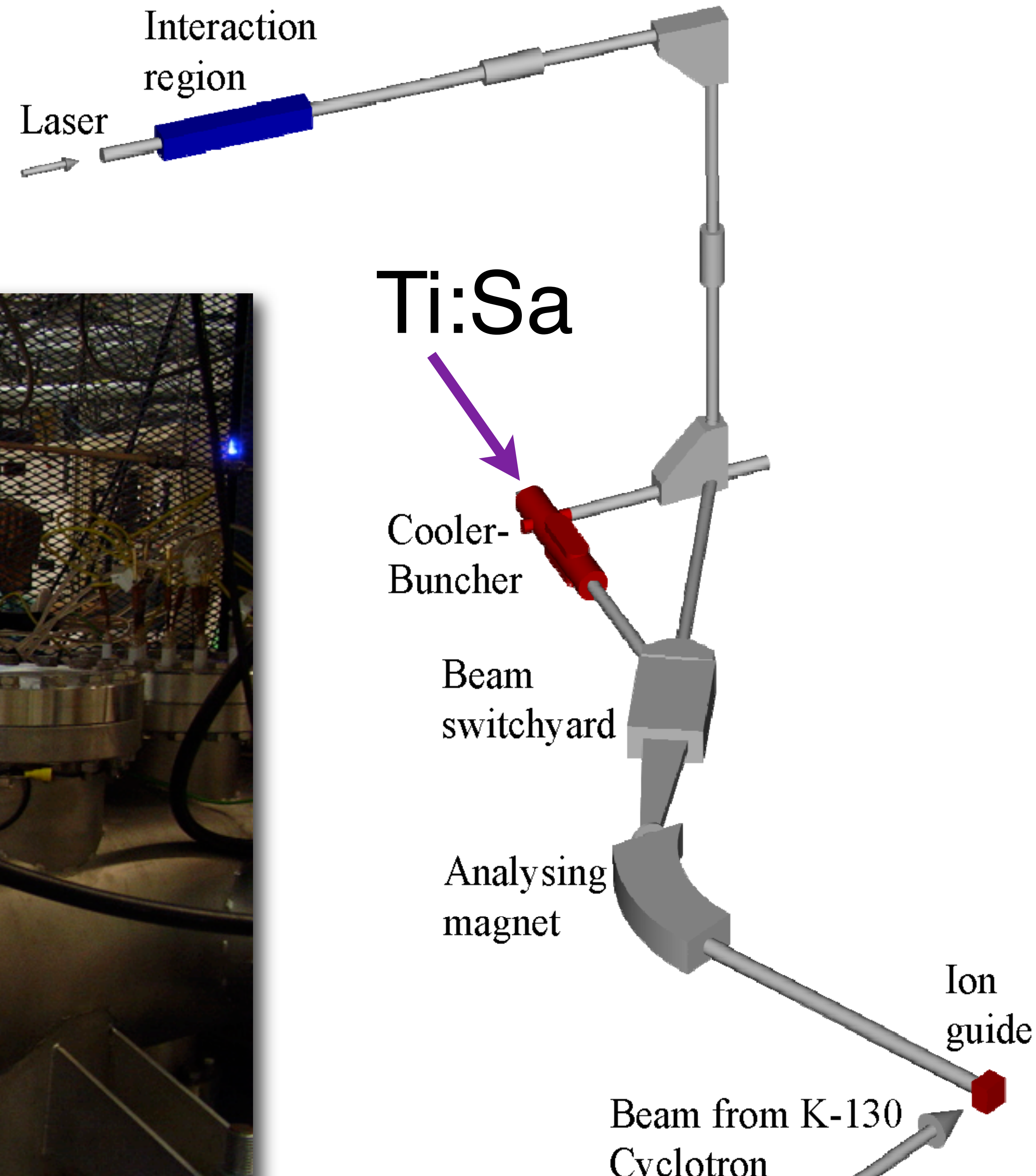
MANCHESTER 1824

The University of Manchester

Optical pumping in the cooler

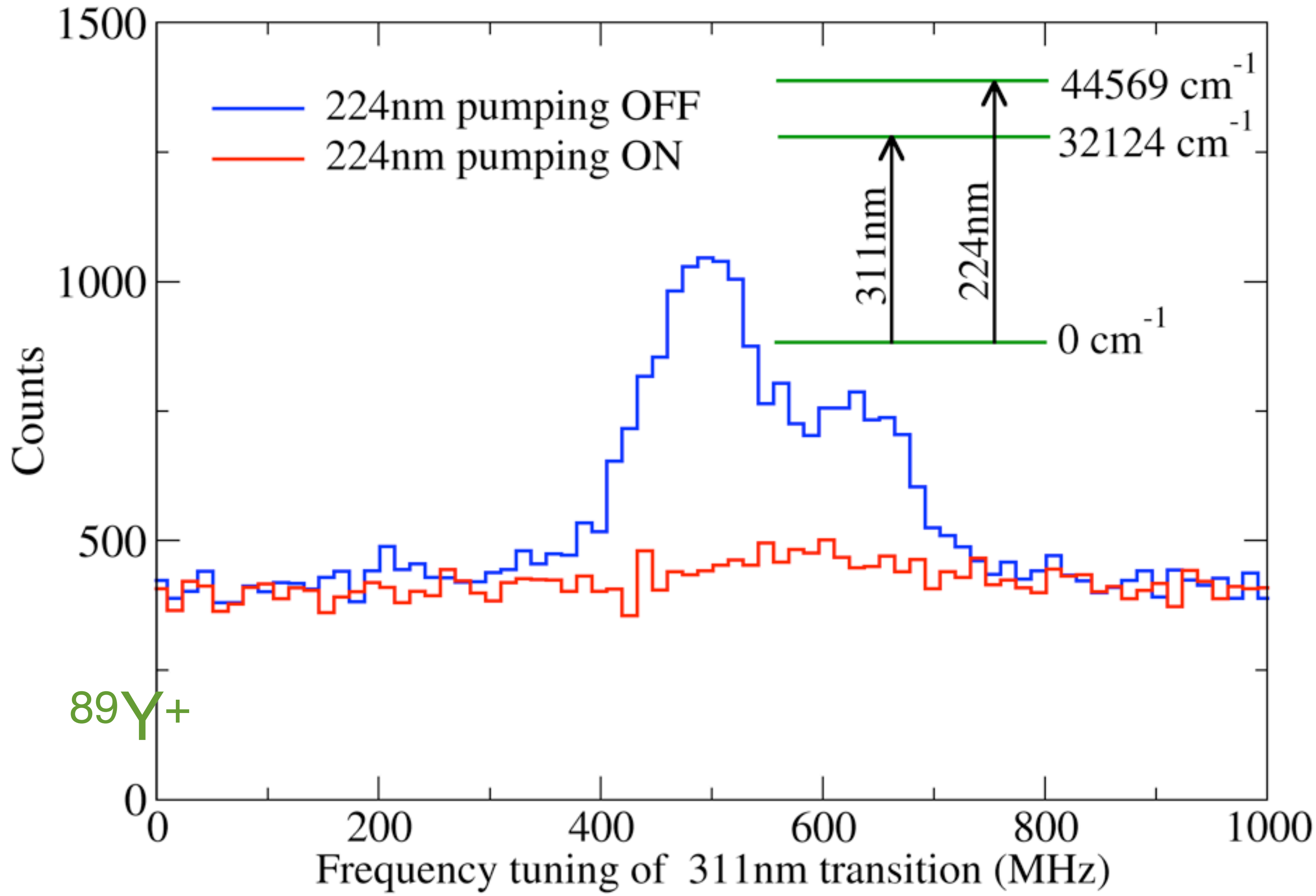






sub-ms (1^+), refractory

Why in the cooler? (efficiency)



B.Cheal PRL 102, 222501 (2009)

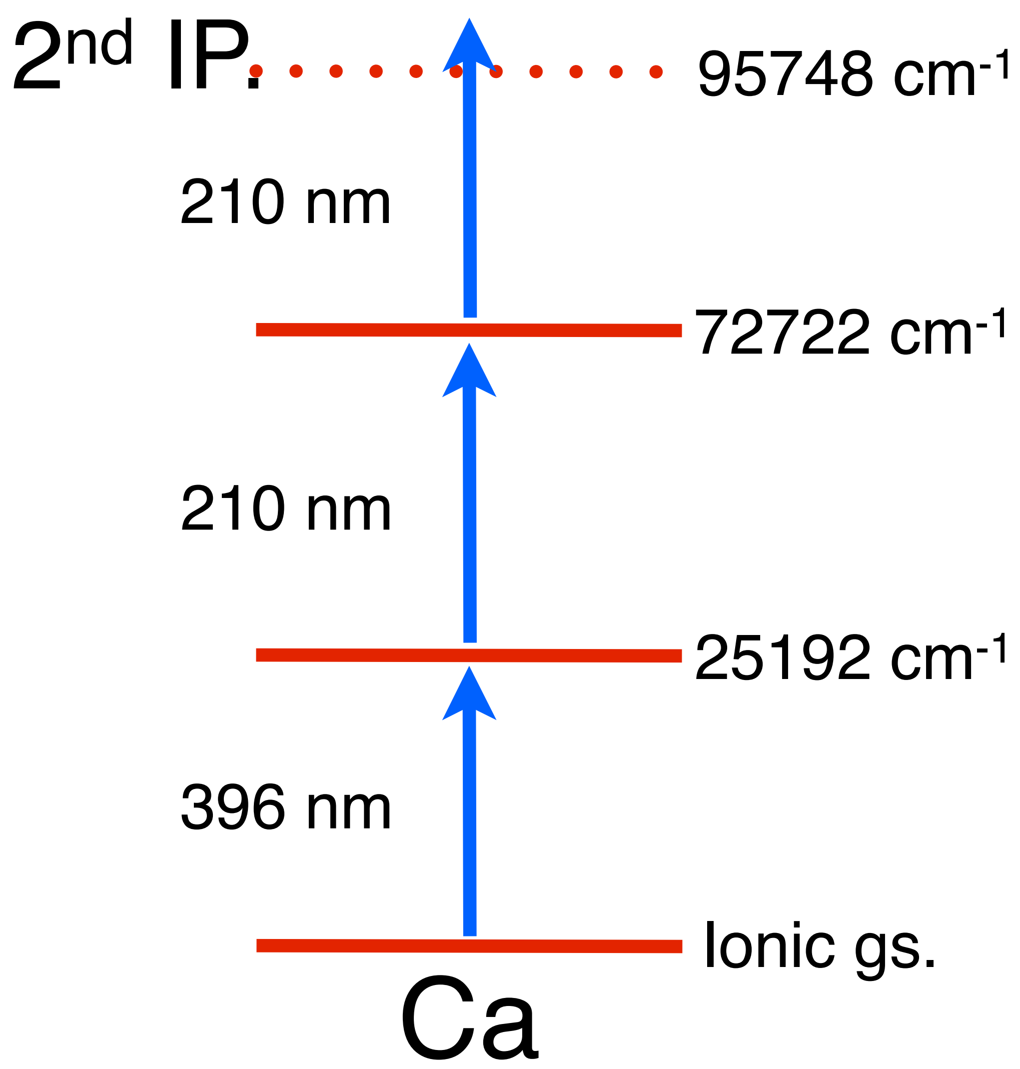
- Focal point of slowly travelling ions ➜ efficient
- Can use broadband/pulsed lasers ➜ large λ range

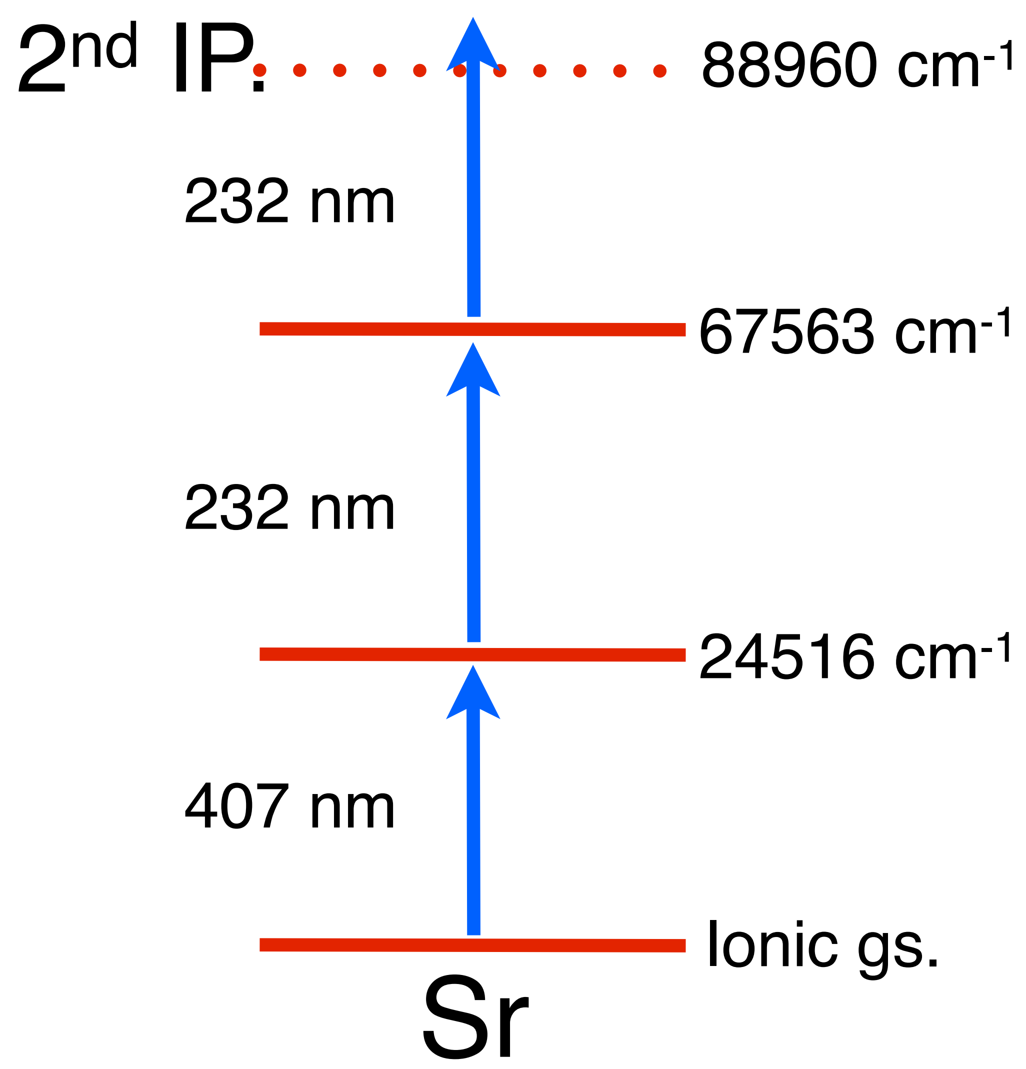
The University of Manchester

In-cooler *ion* resonance ionisation

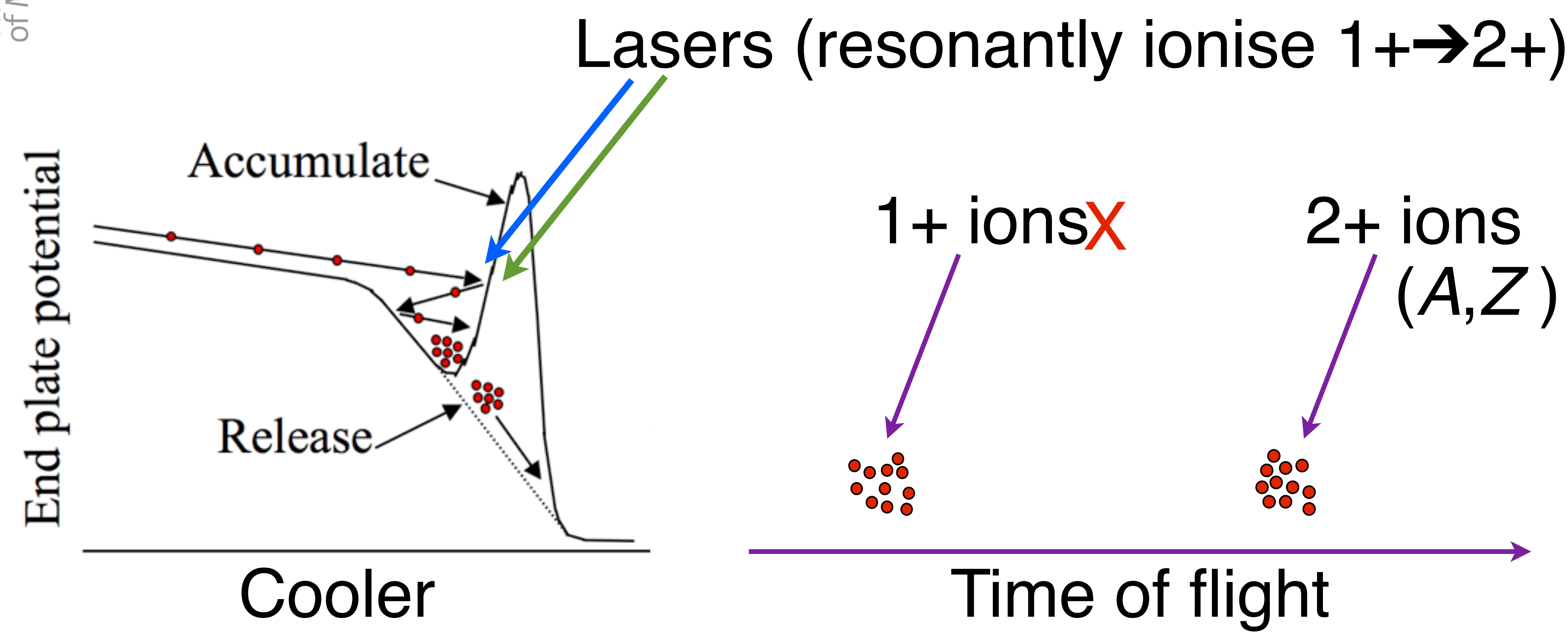
Ionise 1+ ions to 2+ state

Simplest test cases first, eg:-





How does that help?



➡ Pure beam of single *A* **and *Z***

➡ No contaminant will have *m*/*q* selected by magnet **and** *m*/(2*q*) selected by TOF (or other device)

Photon background suppression

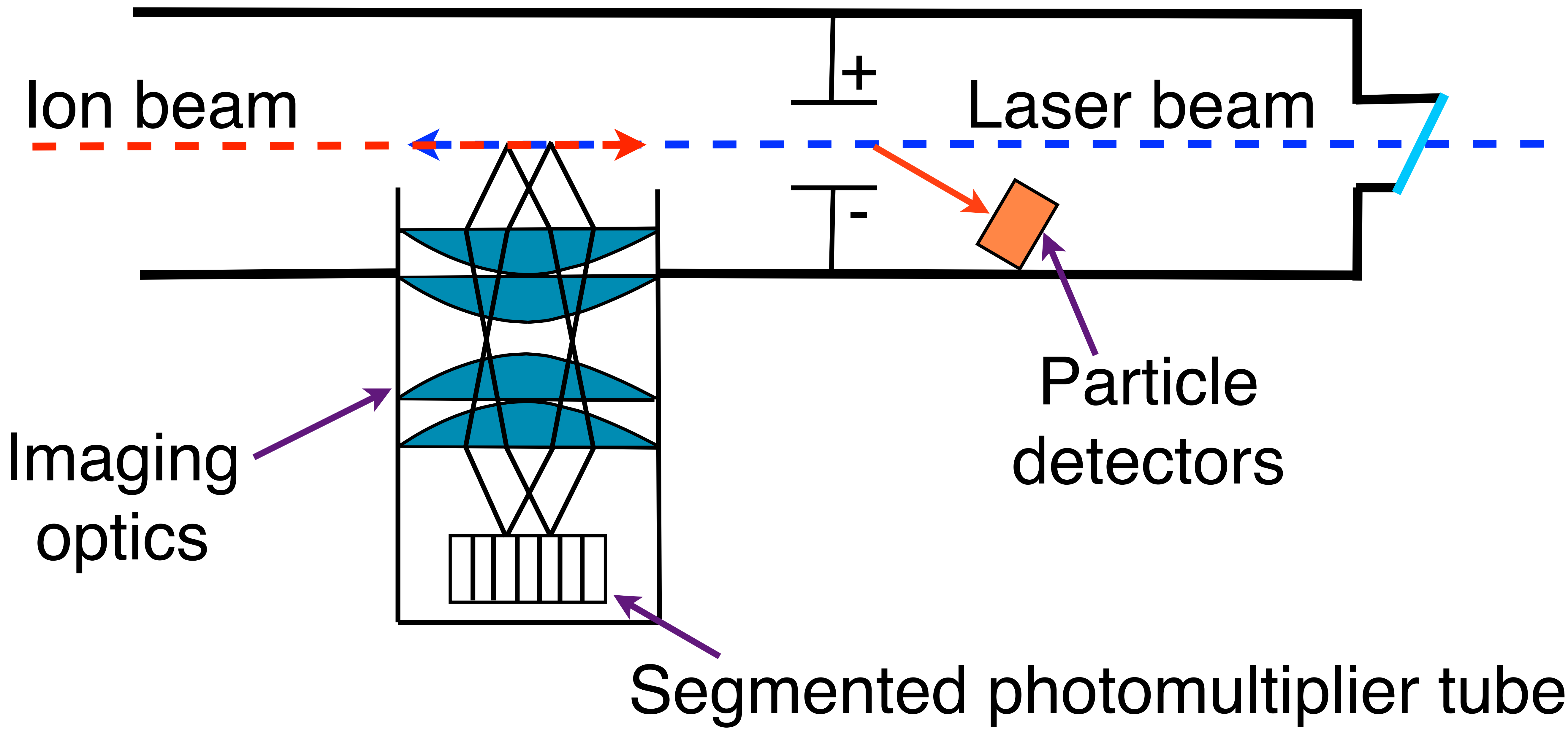
- Background from laser ➔ bunching ✔
- Background from ions ➔ pure beams ✔

Immediately applicable...

...but can we improve upon bunching technique?

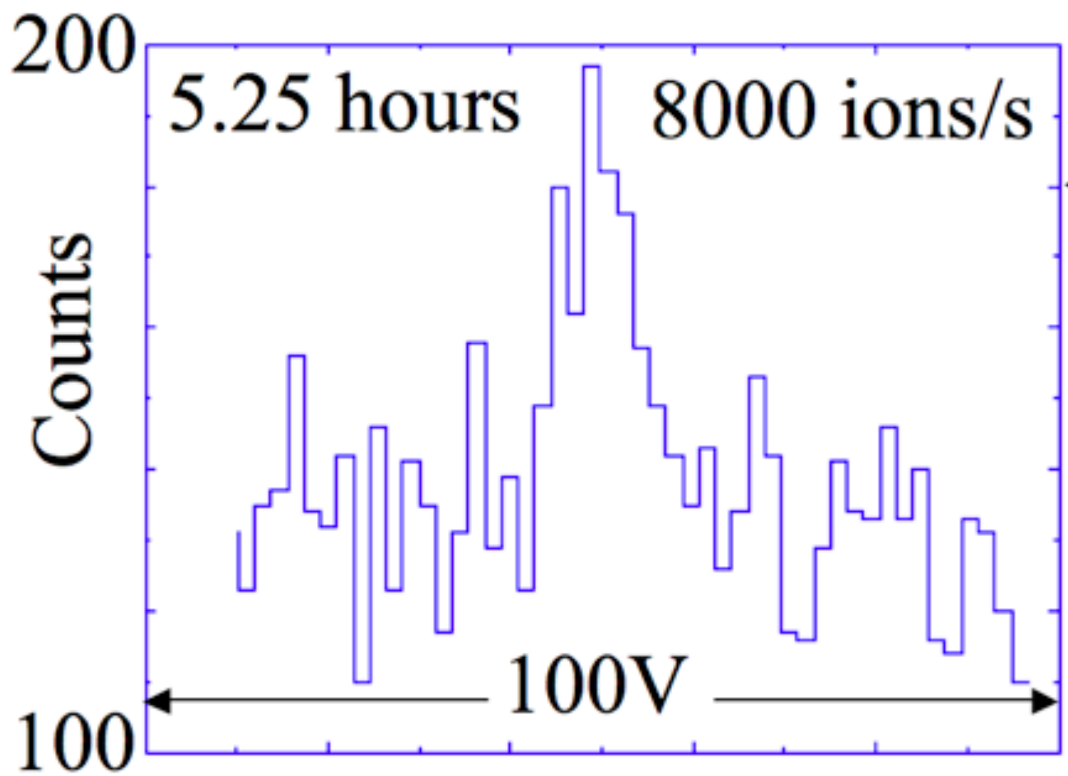
(gates $> 5\mu s$)

Single photon-ion coincidence

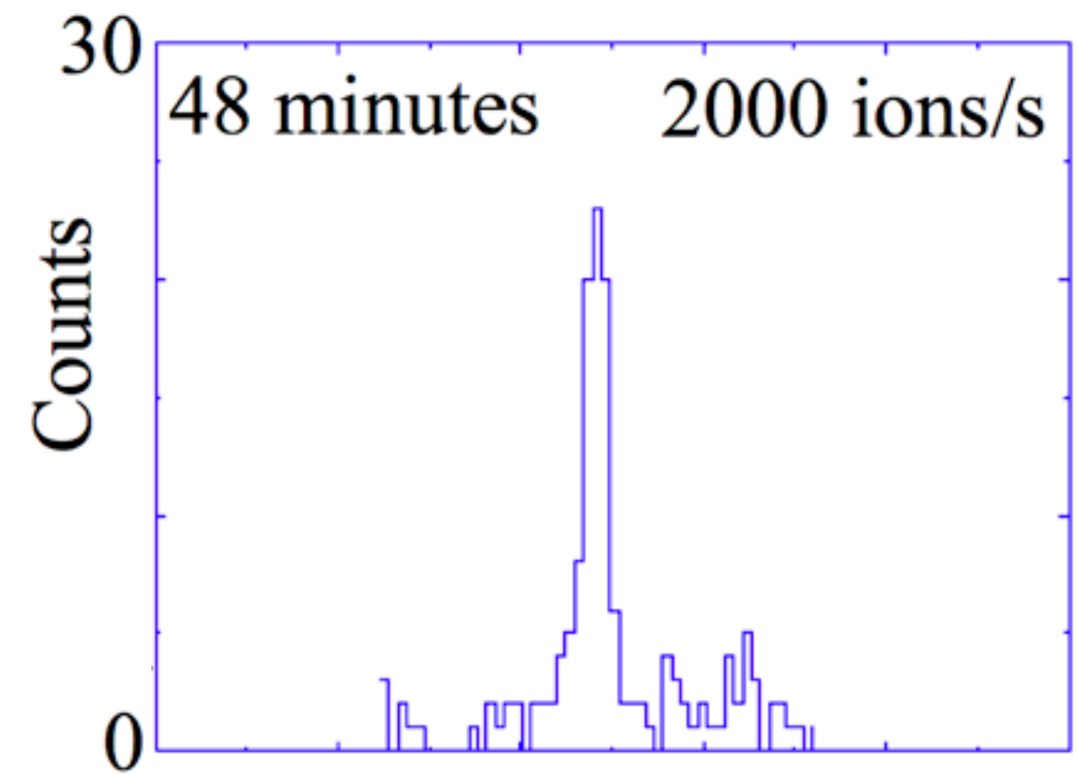


Events with ~20ns timing resolution

So why do we bunch instead?



Single photon-ion coincidence

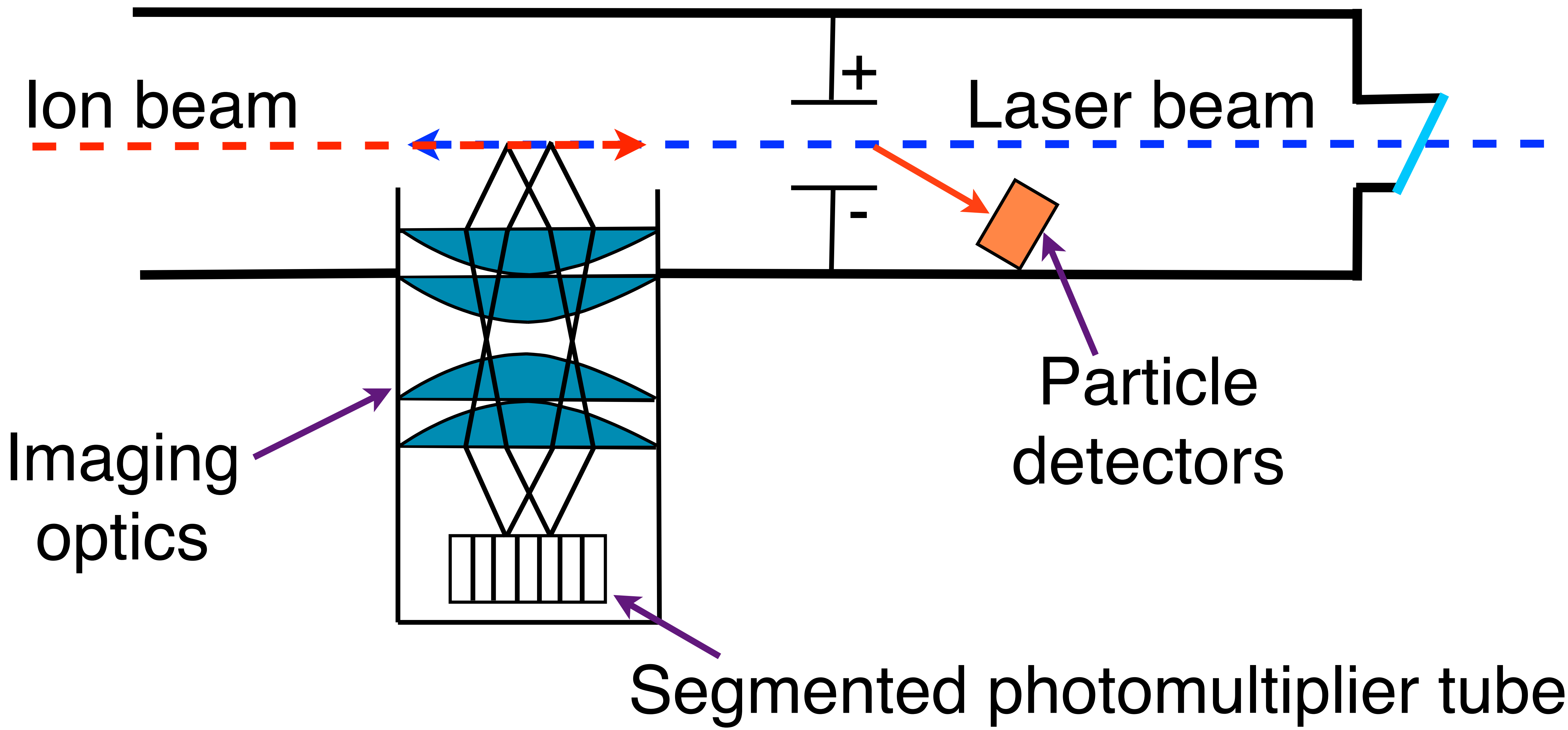


Ion-bunch gating (using cooler)

Isobaric contamination causes

“false” coincidences

Using pure beams

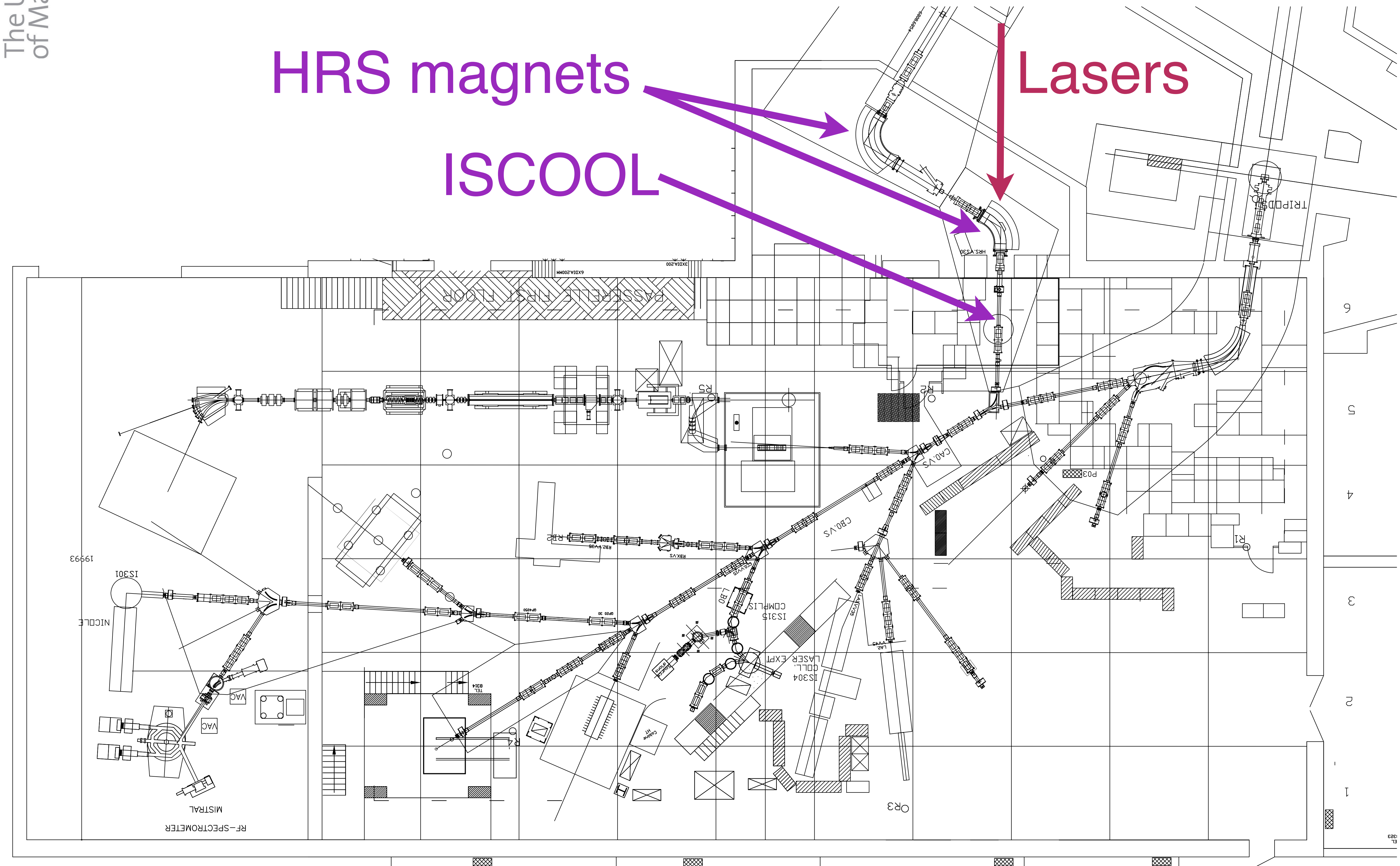


Cooled beams ➔ ~5 ns resolution ➔ few atoms/s

MANCHESTER
1824

The University
of Manchester

Optical pumping at ISOLDE



MANCHESTER
1824

The University
of Manchester

Summary

- In-cooler ion resonance ionisation can be used to produce a pure beam of single (*A*,*Z*) ... isomeric purity?

- Pure beams reduce the photon background, increasing the sensitivity of HR laser fluorescence spectroscopy

- In the absence of isobaric contamination, single photon-ion coincidence will provide greatest sensitivity

- Propose tests in JYFL and ISOLDE.

MANCHESTER
1824

The University of Manchester

Acknowledgements

The University of Manchester, UK

J. Billowes
P. Campbell
F. Charlwood
B. Cheal
K. Flanagan
D. Johnson
T. Procter

Others...

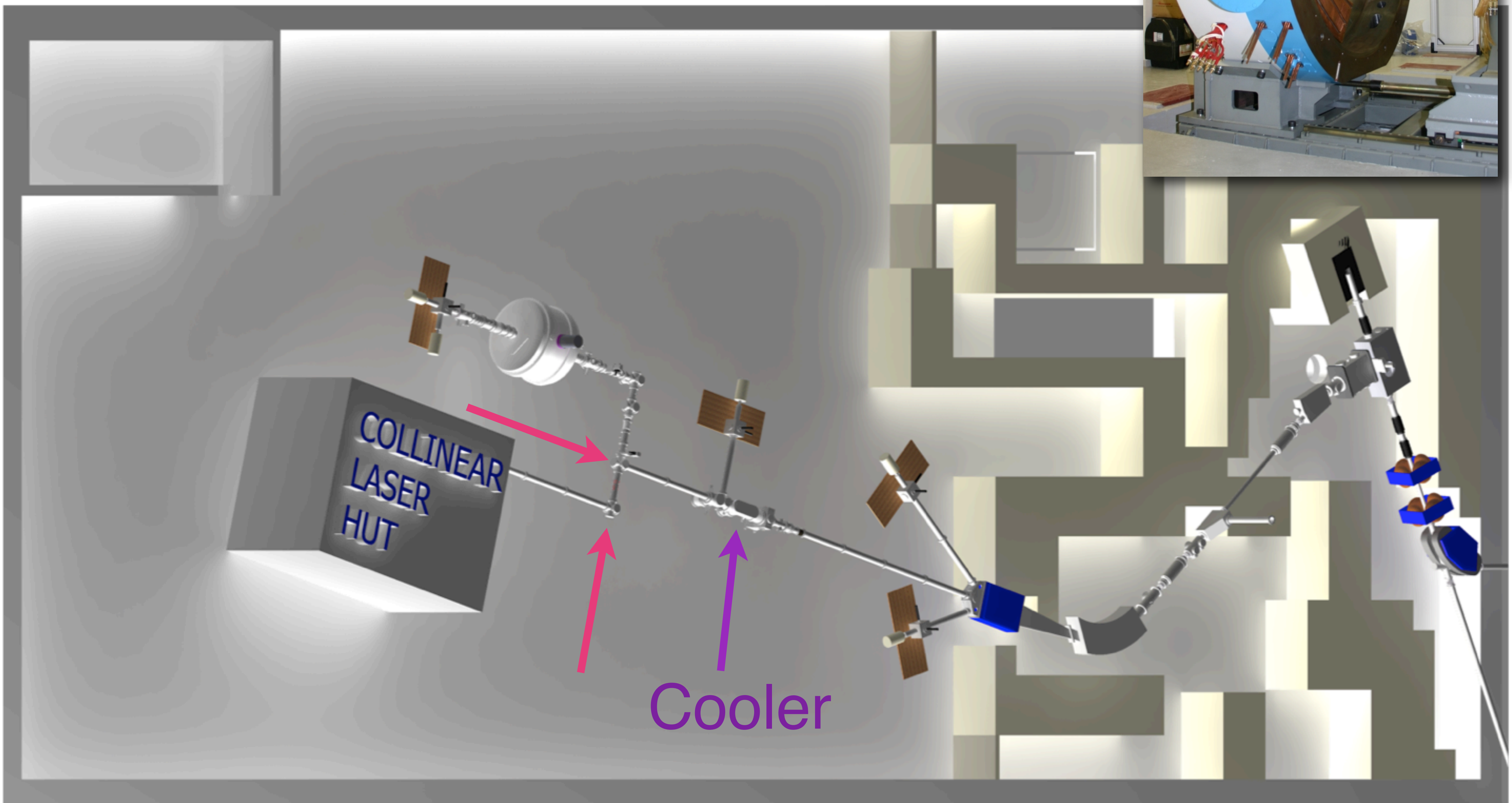
Data from:-
Birmingham/Jyväskylä/Manchester (optical pumping)
IS457 Collaboration (gallium)

The University of Manchester

MANCHESTER 1824

New laboratory at JYFL

Sub-ms, refractory elements...



Bunching for laser spectroscopy