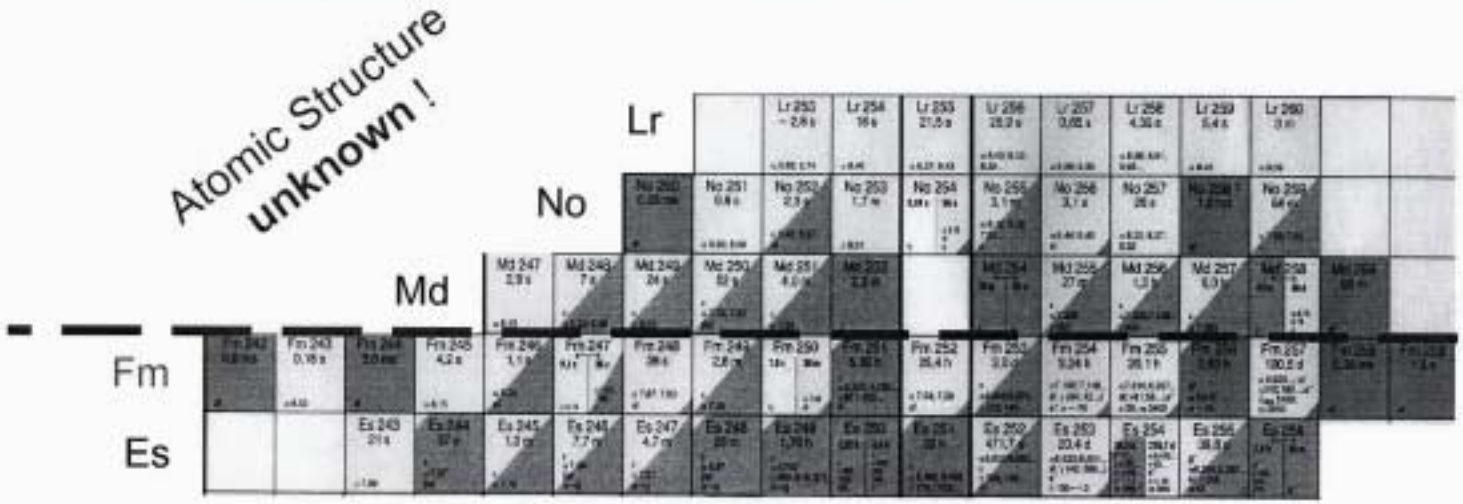
Ion Mobility Measurements in the Region of Super Heavy Elements with Z ≥ 100



Production :

Breeding in High Flux Reactors
$N_{Fm} < 10^{12}$; ^{255}Fm; $t_{1/2} = 20.1$ h

Nuclear Fusion Reactions at Heavy Ion Accelerators
$\dot{N}_{Fm} < 10^{4}$ / s

Resonance Ionization Spectroscopy (RIS) in a Buffer Gas Cell

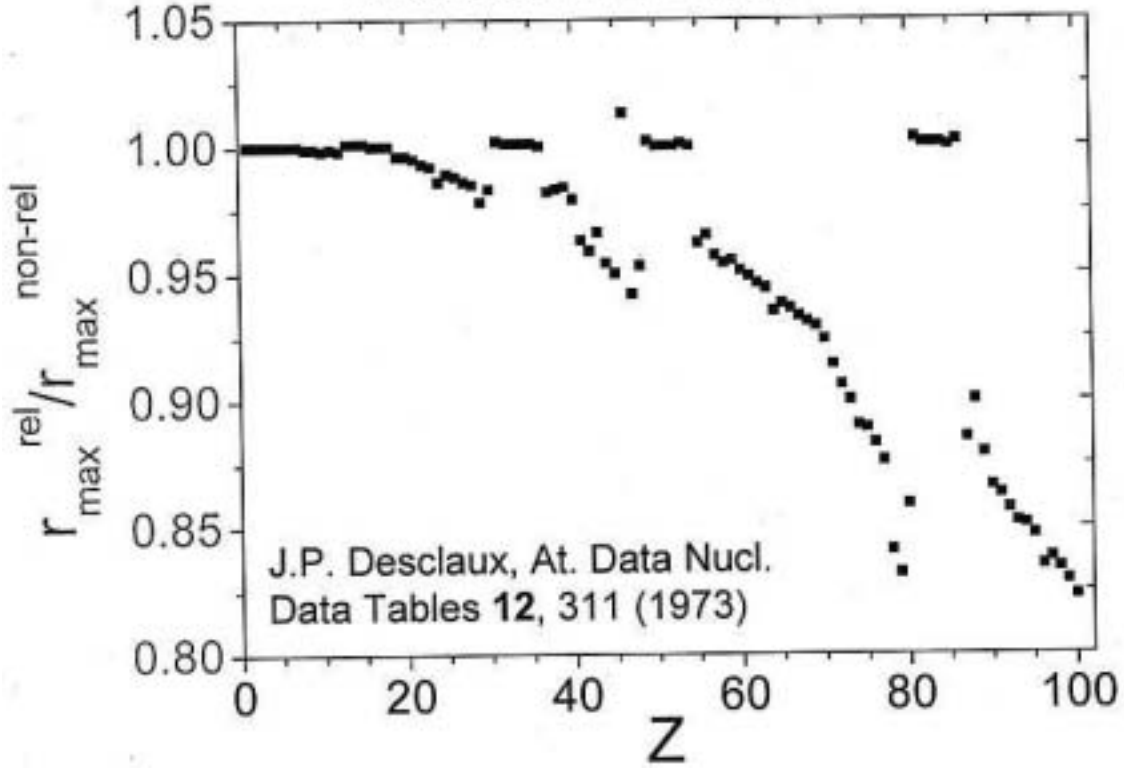
Long Half-Lifes:
~ h

Direct, Mass Selective Ion Detection

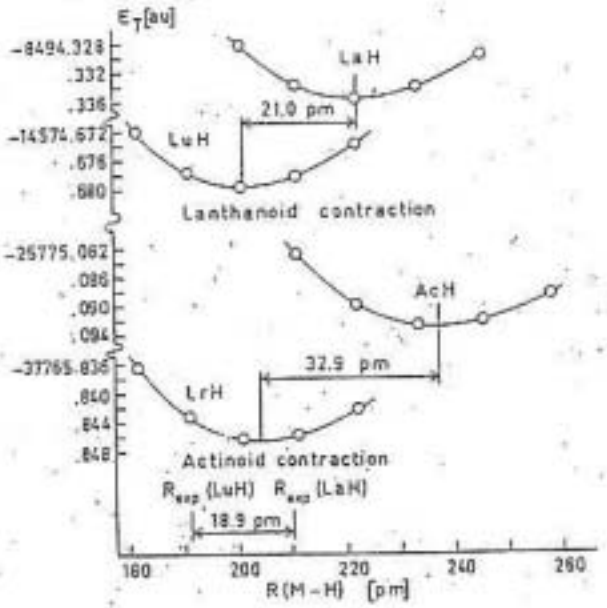
Relativistic Contraction

Atomic Properties

r_{max} : Principal Maximum of the Wave Function of the Outermost Orbital

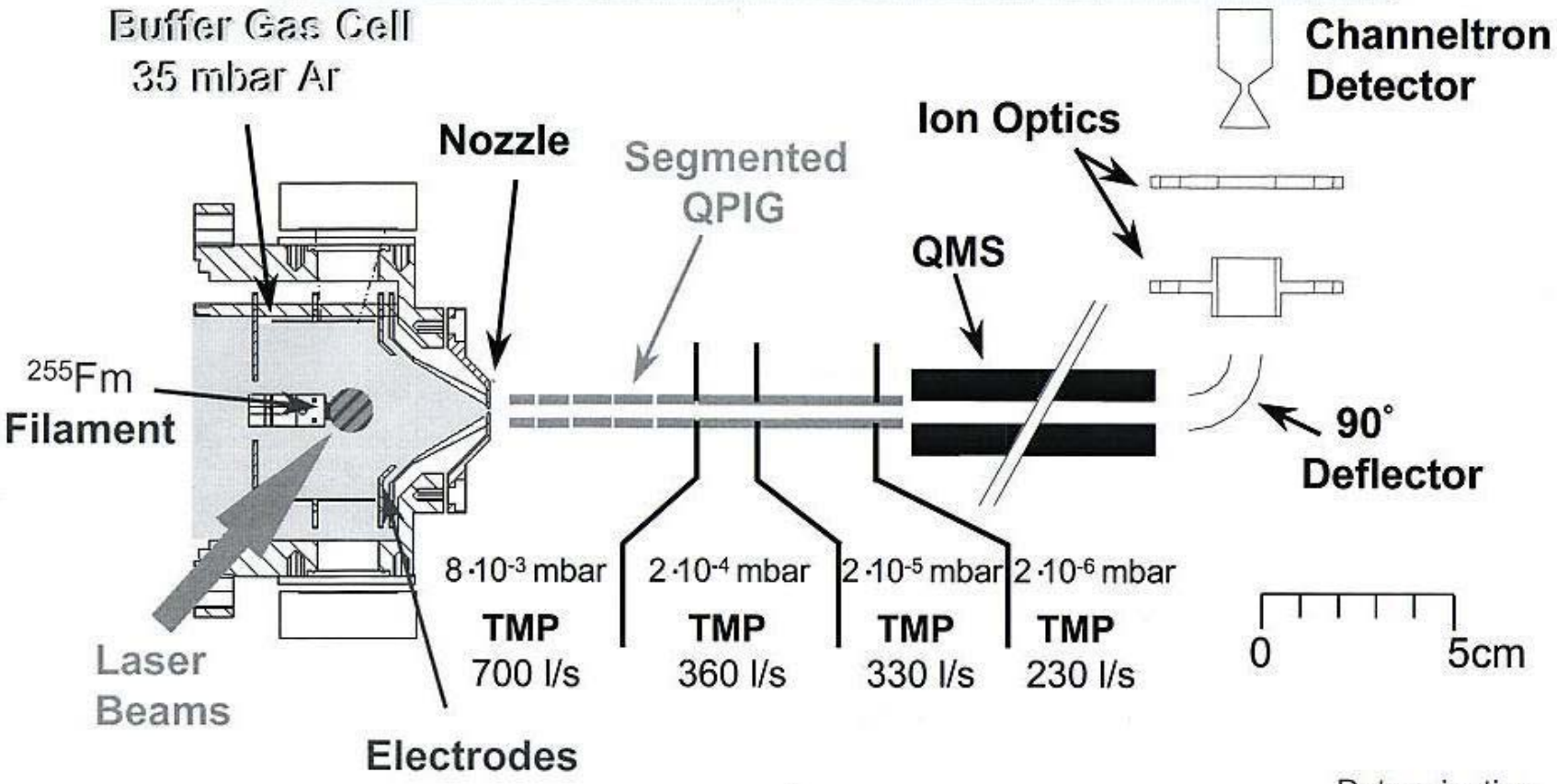


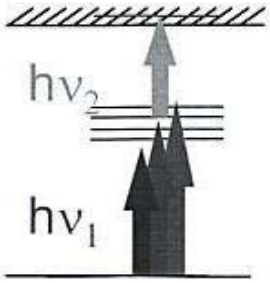
Molecular Properties

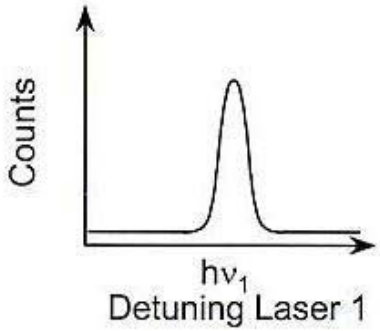


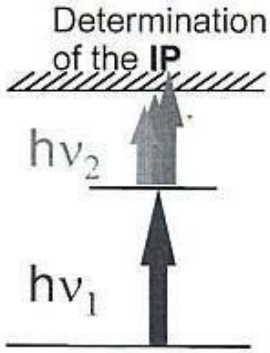
P. Pyykkö, Phys. Scr. **20**, 647 (1979)

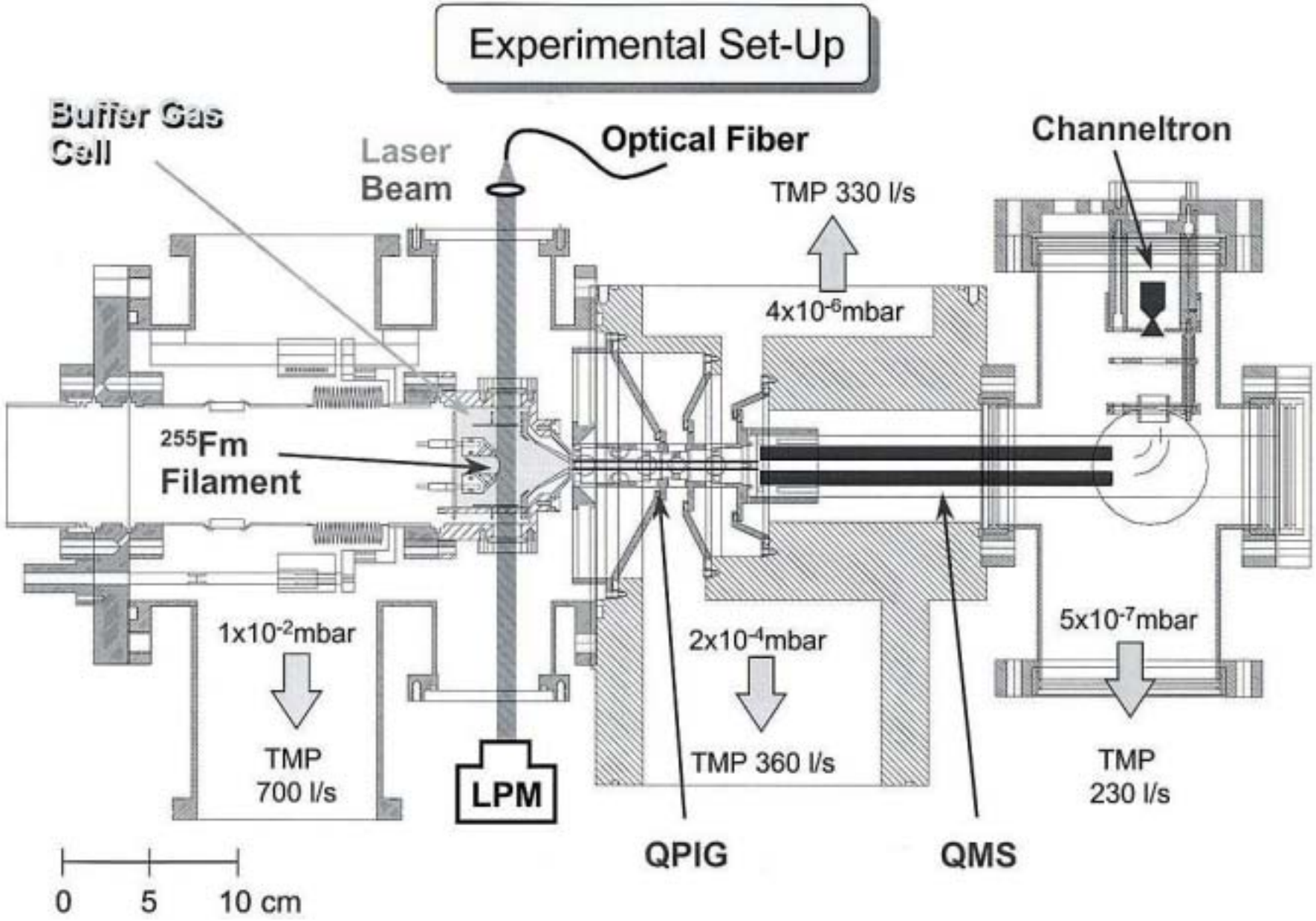
Resonance Ionization Spectroscopy (RIS) with Direct Mass Selective Ion Detection



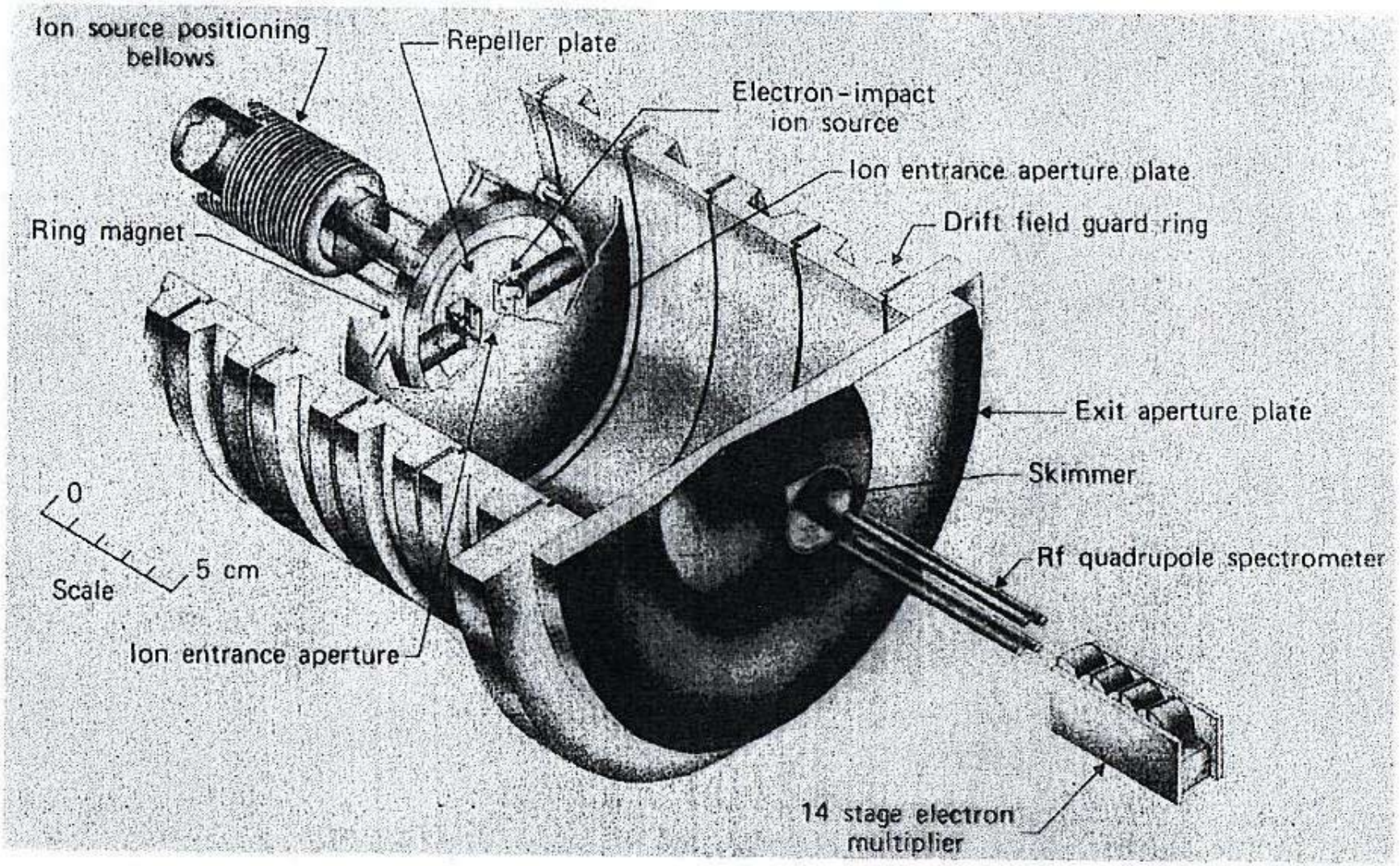






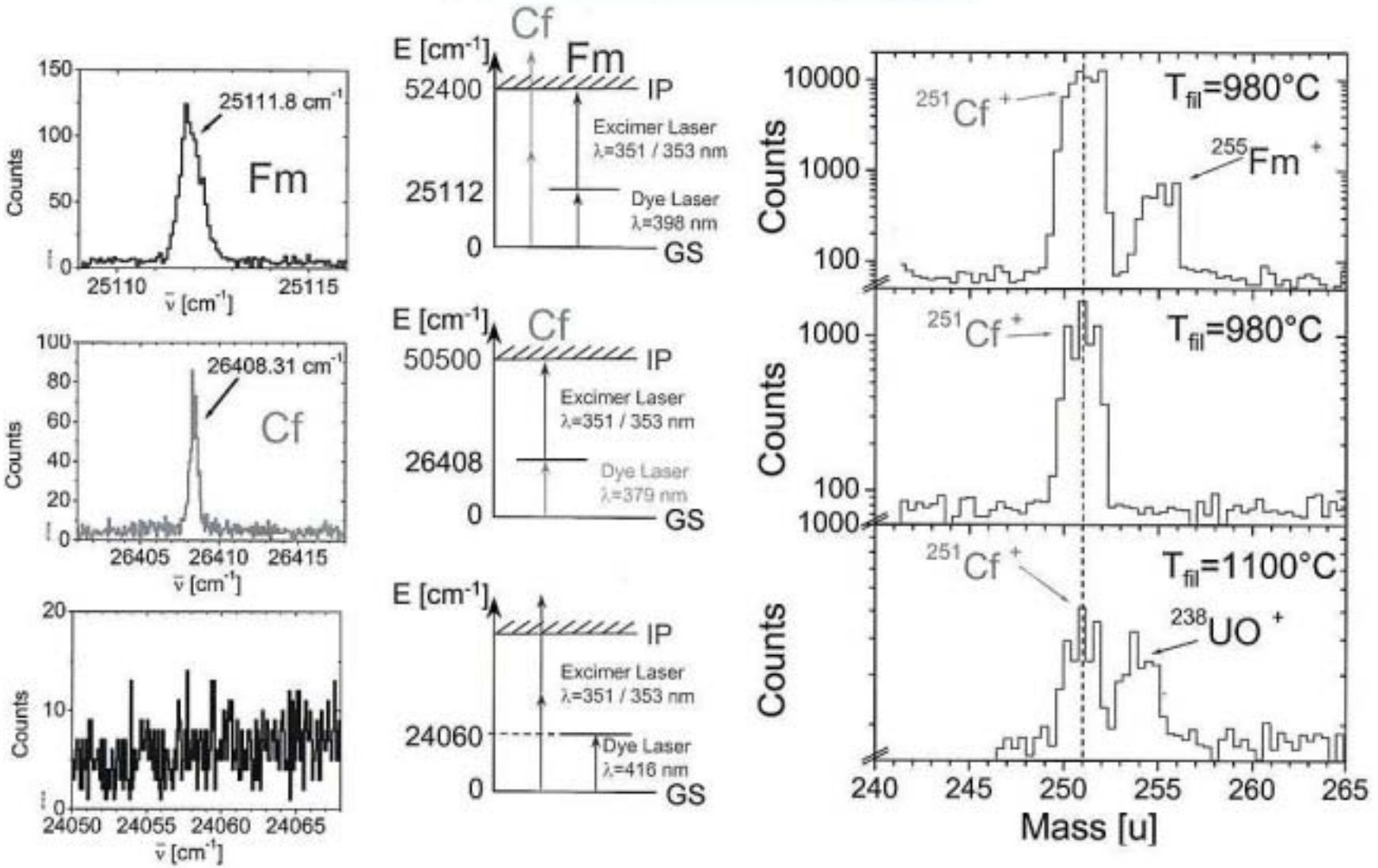

Experimental Set-Up
Buffer Gas Cell
Laser Beam
Optical Fiber
Channeltron
TMP 330 l/s
4x10-6mbar
255Fm Filament
1x10-2mbar
TMP 700 l/s
LPM
2x10-4mbar
TMP 360 l/s
5x10-7mbar
TMP 230 l/s
QPIG
QMS
0 5 10 cm

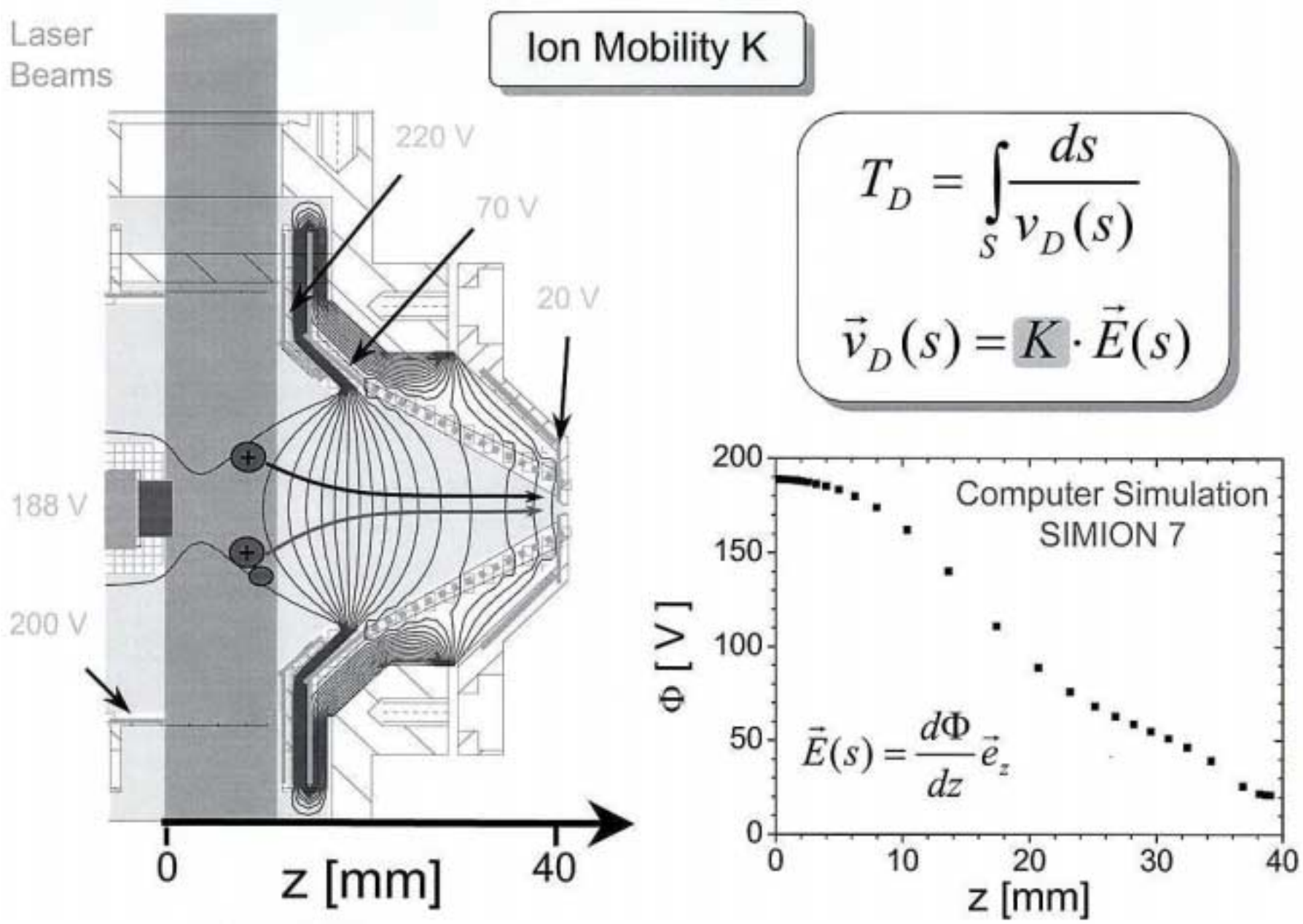
Measurement of Drift Velocities



Isometric view of the drift tube, ion source, and ion sampling apparatus. The electron multiplier has been replaced by one of the capillary type, located off-axis (McDaniel et al., 1970).

Identification of the Ions




Laser
Beams
220 V
70 V
20 V
188 V
200 V
0
z [mm]
40
Ion Mobility K
$T_D = \int_S \frac{ds}{v_D(s)}$
$\vec{v}_D(s) = K \cdot \vec{E}(s)$
Computer Simulation
SIMION 7
$\vec{E}(s) = \frac{d\Phi}{dz}\vec{e}_z$
Φ [V]
200
150
100
50
0
0
10
20
30
40
z [mm]

Ionic Radii from Ion Mobility

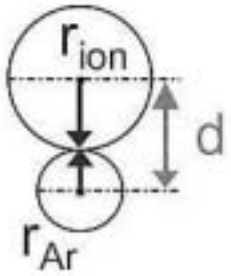
Ion Mobility K :

$$K = \frac{3}{16}\frac{e}{N}\sqrt{\frac{2\pi}{\mu k_B T_{eff}}}\frac{1+\alpha}{\overline{\Omega}_{1,1}(T_{eff})}$$

e : Charge
N : Number Density of Buffer Gas Atoms
μ : Reduced Mass
k_B : Boltzmann Constant
T_{eff} : Effective Temperature
$\overline{\Omega}_{1,1}(T_{eff})$: Collision Cross Section
α : Higher Order Corrections

Rigid Sphere Model :

$$\overline{\Omega}_{1,1}(T_{eff}) = \pi d^2 = \pi(r_{Ar} + r_{ion})^2$$



$$\delta\vec{E}(s) \Rightarrow \delta r_{ion} \approx 1\,\text{Å}$$

Relative Measurements :

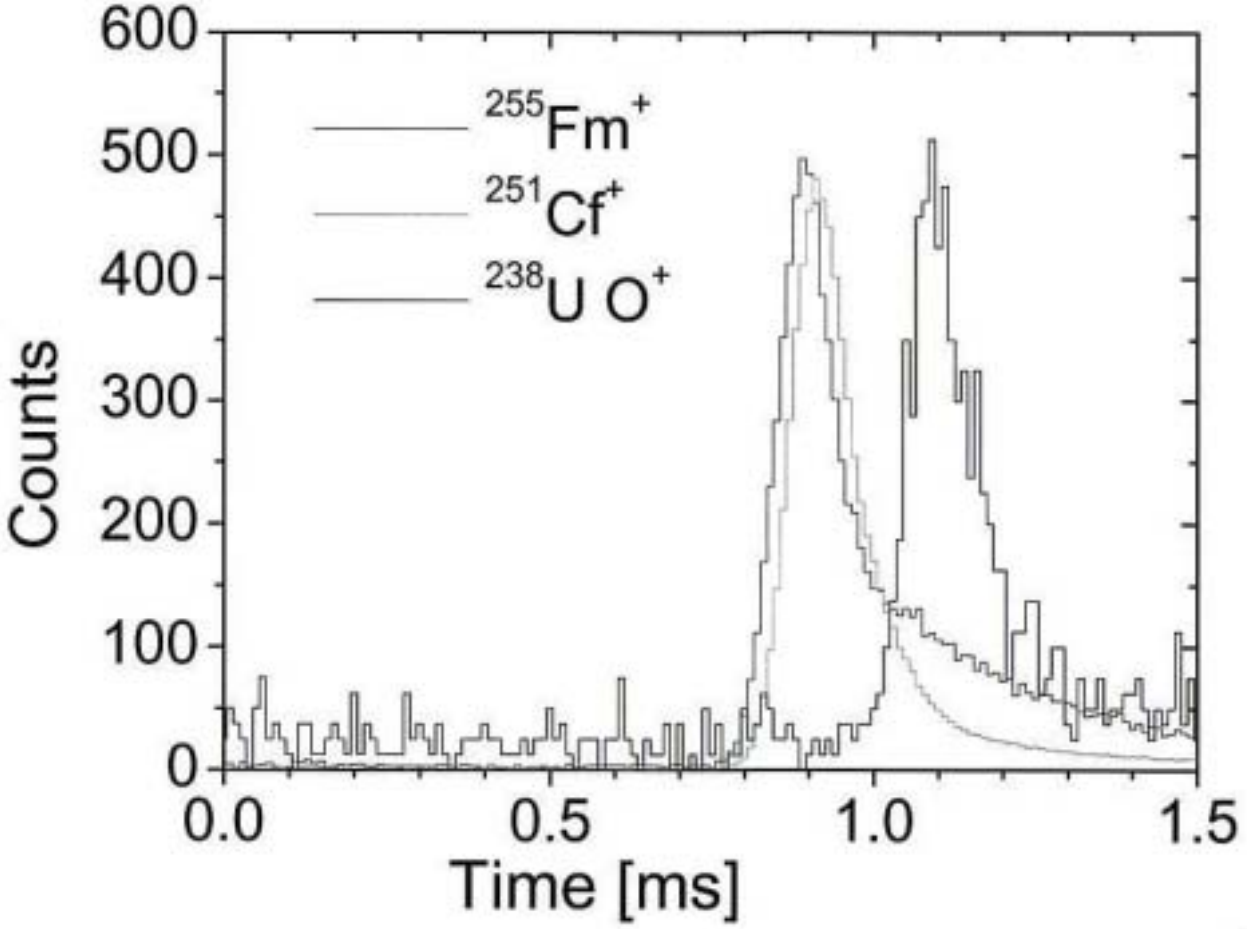
$$\frac{\Delta r^{1,2}{}_{ion}}{r^2{}_{ion}} \approx \frac{1}{2}\frac{\Delta T^{1,2}{}_D}{T^2{}_D}\left(1+\frac{r_{Ar}}{r^2{}_{ion}}\right)$$

$$\Delta r^{1,2}{}_{ion} = r^1{}_{ion} - r^2{}_{ion}$$

$$\Delta T^{1,2}{}_D = T^1{}_D - T^2{}_D$$

T_D : Drift Time

Results



$T^{Fm^+}_D = 0.89(1)$ ms

$T^{Cf^+}_D = 0.91(1)$ ms

$T^{UO^+}_D = 1.09(1)$ ms

$$\frac{\Delta r^{UO^+,Cf^+}{}_{ion}}{r^{Cf^+}{}_{ion}} = 20\%$$

$$\frac{\Delta r^{Fm^+,Cf^+}{}_{ion}}{r^{Cf^+}{}_{ion}} = -2\%$$

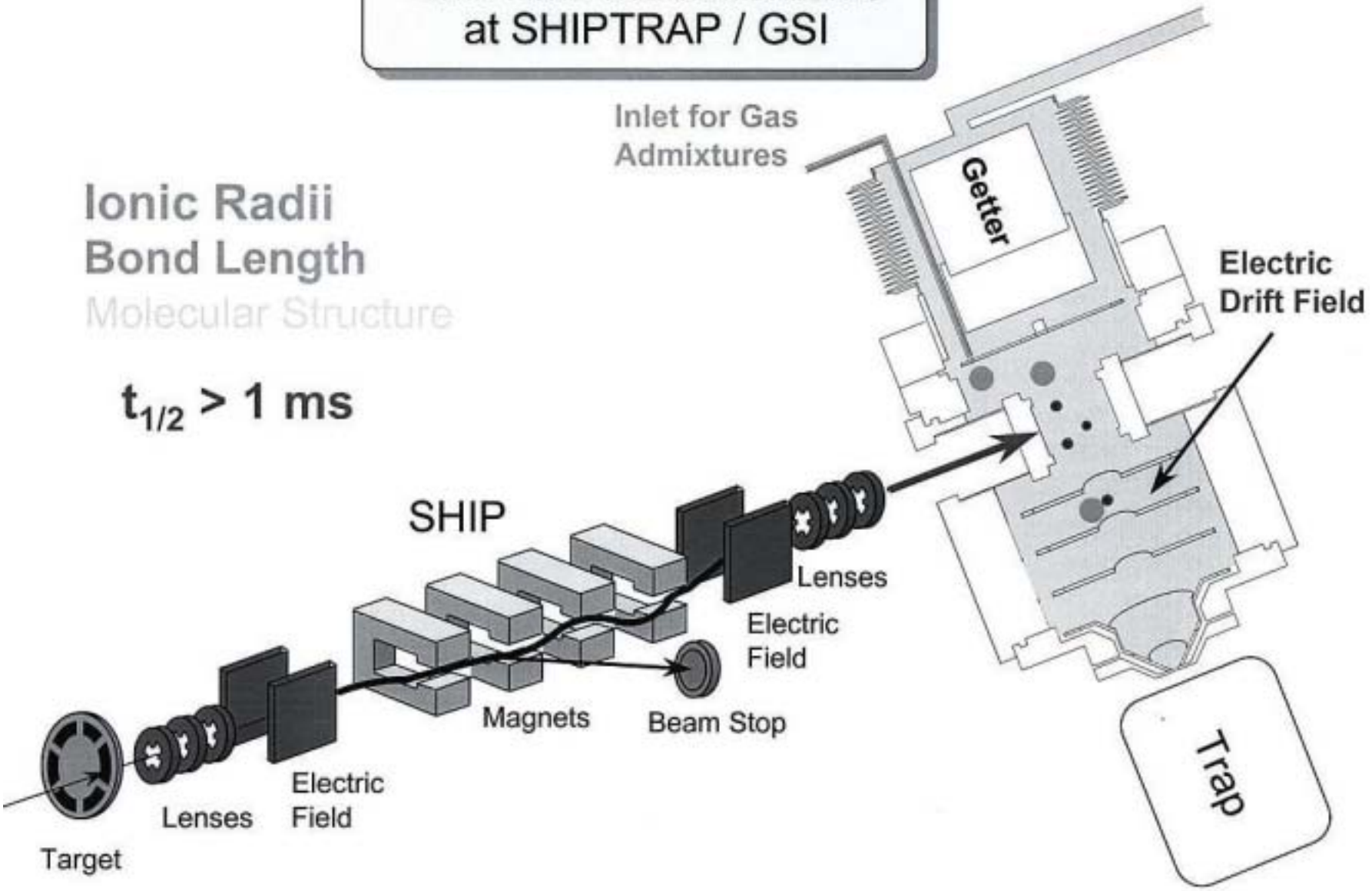
Ab Initio Theorie :
J.P. Desclaux

$$\frac{\Delta r^{Fm,Cf}{}_{\max}}{r^{Cf}{}_{\max}} = -3\%$$

Drift Time Measurements at SHIPTRAP / GSI

Ionic Radii
Bond Length
Molecular Structure

$t_{1/2} > 1$ ms



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