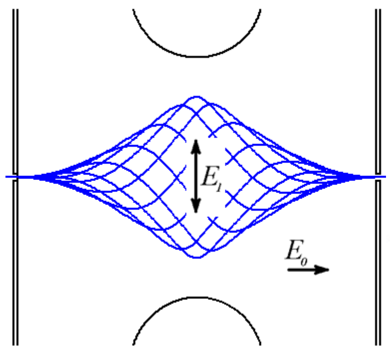
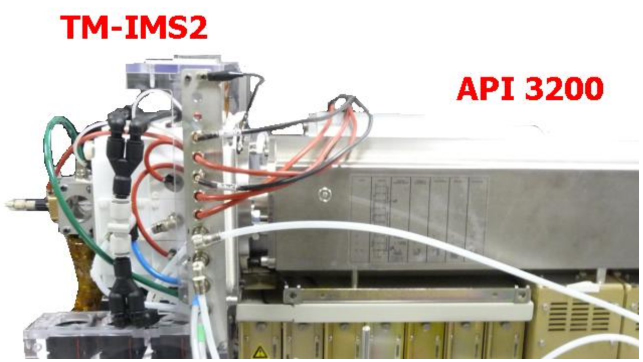
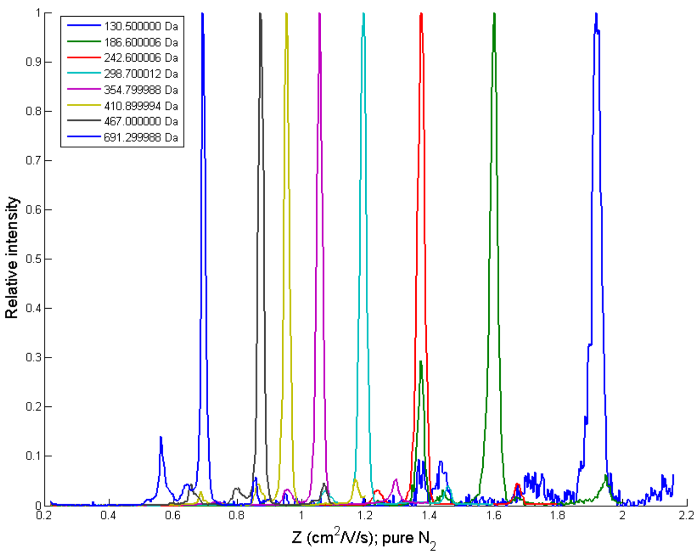
Transversal Modulation IMS. (TMIMS)

“Ion Mobility MS: New Instrumentation & Enabling Technologies”







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Summary

- Principle of operation:
- Demonstrator 1: TMIMS1:
  - Proof of concept: Resolving power & Robustness.
- Demonstrator 2: TMIMS2-MS:
  - Architecture.
  - IMS & IMS^2 modes.
  - Orthogonality.
- Numerical simulations.
- Conclusions.
- Challenges.

TMIMS. Principle of operation.

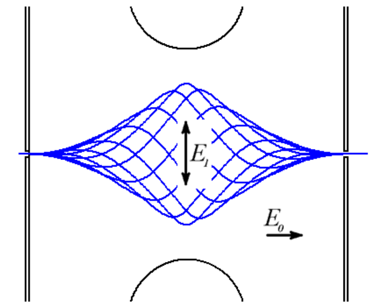
- Uniform electric fields:
  - Velocity → trajectories:

$u = KE_0$

$v = KE_1 \sin(\Omega t)$

$$x = KE_0 (t - t_0)$$

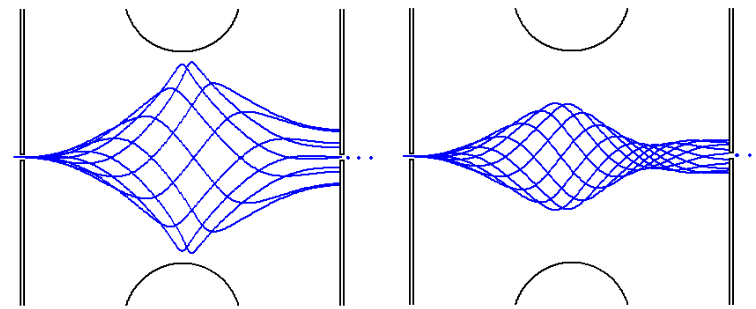
$$y = 2\frac{KE_1}{\Omega}\sin\left(\frac{\Omega}{2}(t - t_0)\right)\sin\left(\frac{\Omega}{2}(t + t_0)\right)$$



  - Distance to the outlet slit

$$Y = 2\frac{KE_1}{\Omega}\sin\left(\frac{\Omega l}{2KE_0}\right)\sin\left(\Omega t - \frac{\Omega l}{2KE_0}\right)$$

$= 0$

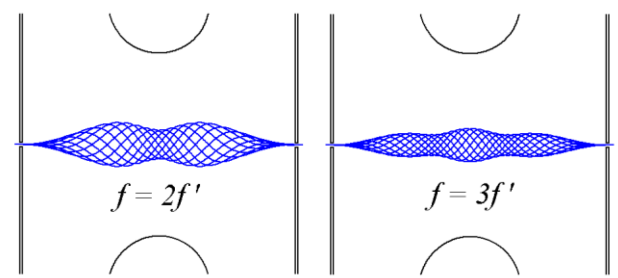


  - Selection criterion:

$$K = \frac{\Omega l}{2\pi E_0}$$

  - Higher resonances

$$K_n = \frac{\Omega l}{2n\pi E_0}$$



TMIMS. Principle of operation.

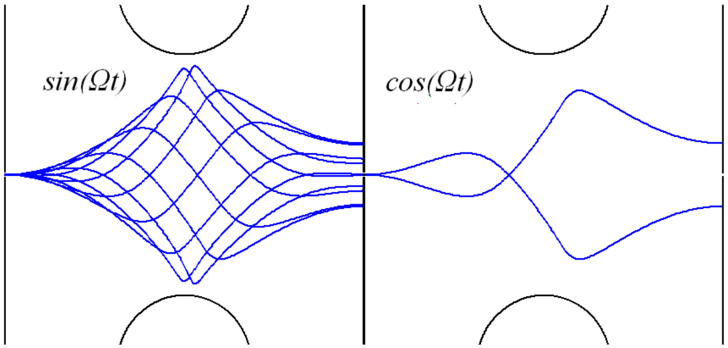
Two stages

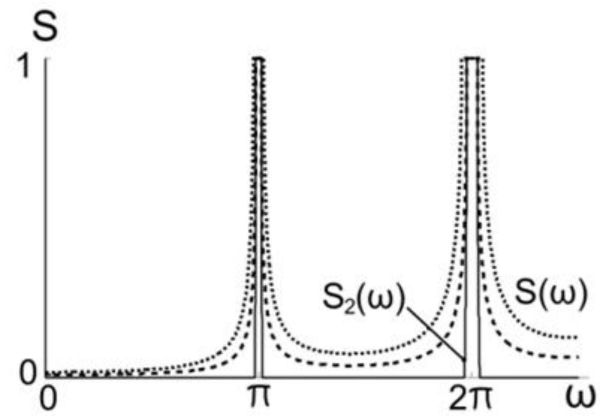
- One stage produces a pulsed output:

$$Y = 2\frac{KE_1}{\Omega}\sin\left(\frac{\Omega l}{2KE_0}\right)\sin\left(\Omega t - \frac{\Omega l}{2KE_0}\right)$$

= 0

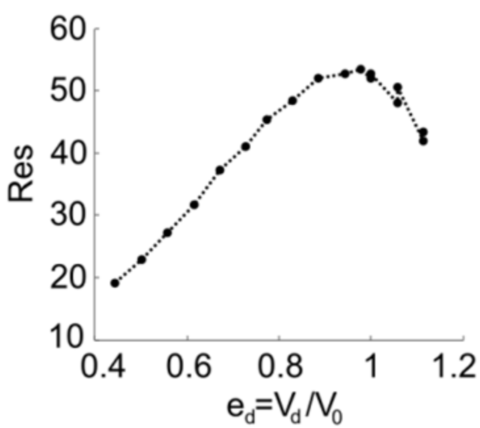
- Two stages operated in quadrature (same frequency) eliminate the pulsed output.
- Each stage can be operated with a different gas and a different voltage
    - **IMS-IMS** analysis.

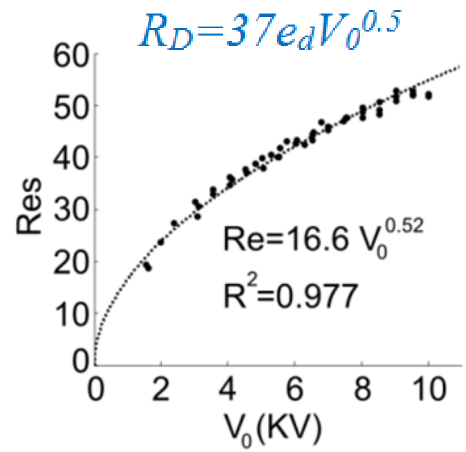


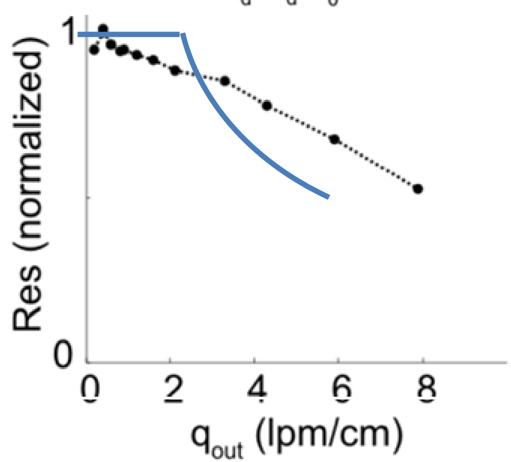


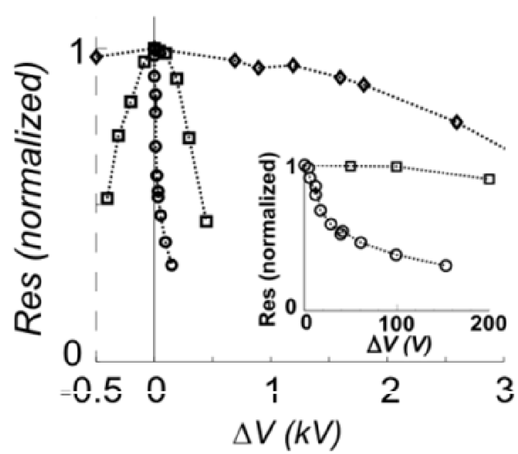
TMIMS1. Proof of concept.

Resolving power & Robustness



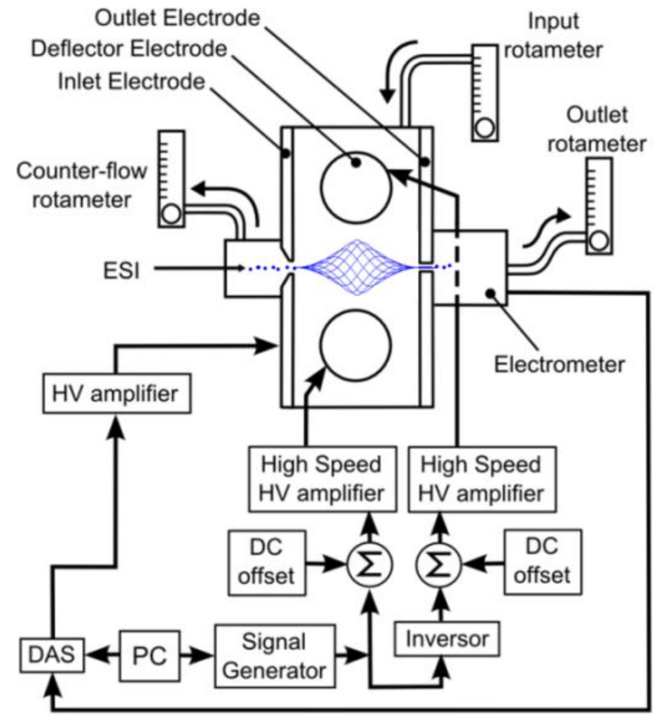


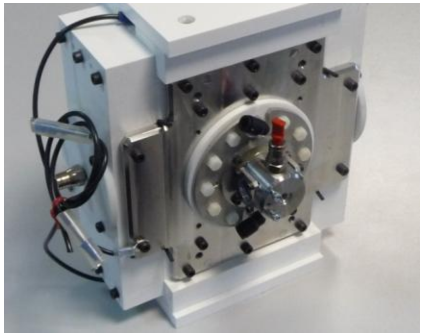




-Transversal voltage: circles; Longitudinal voltage: squares; Different wave amplitude voltages: diamonds

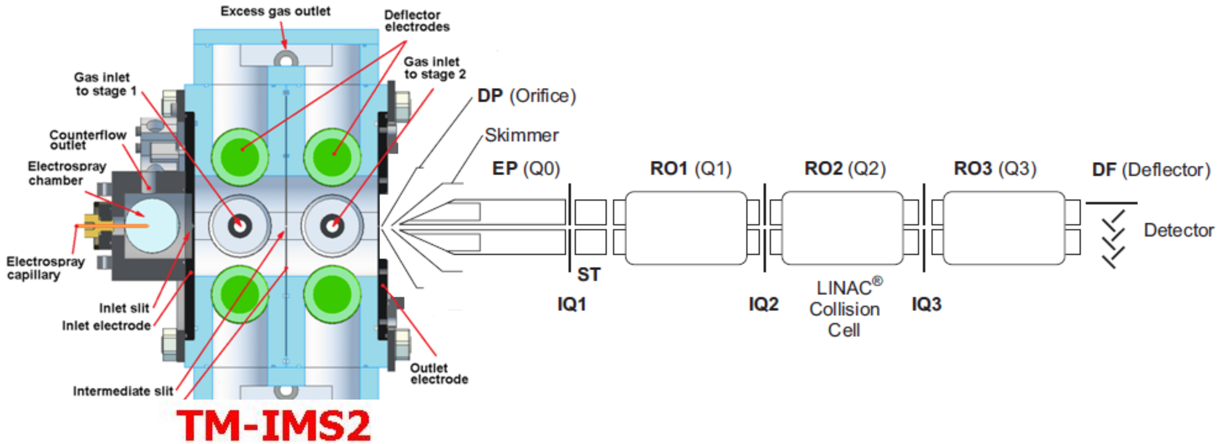
•One TMIMS stage; Nano-ESI; Electrometer.

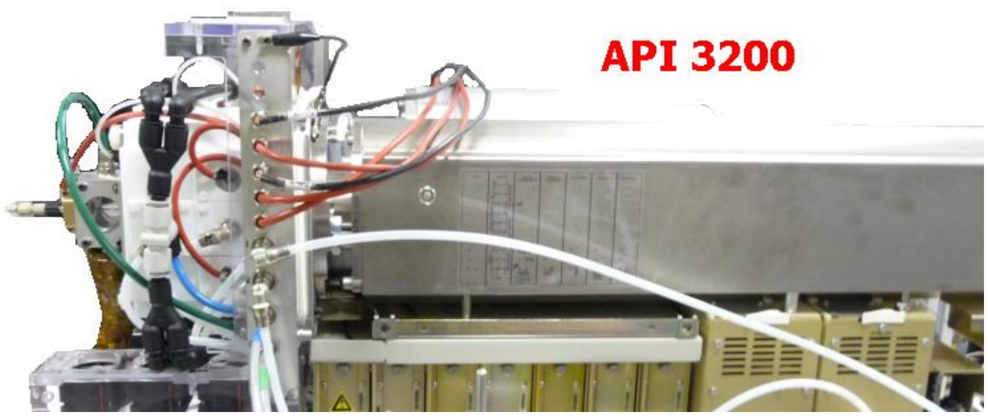




TMIMS2-MS, Architecture.

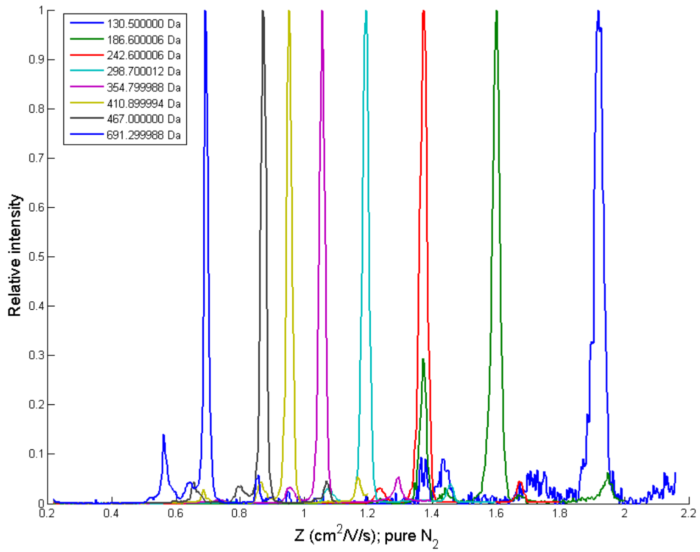
– IMS-MS selection with a continuous output.
– TM-IMS^2 enhances peak capacity.

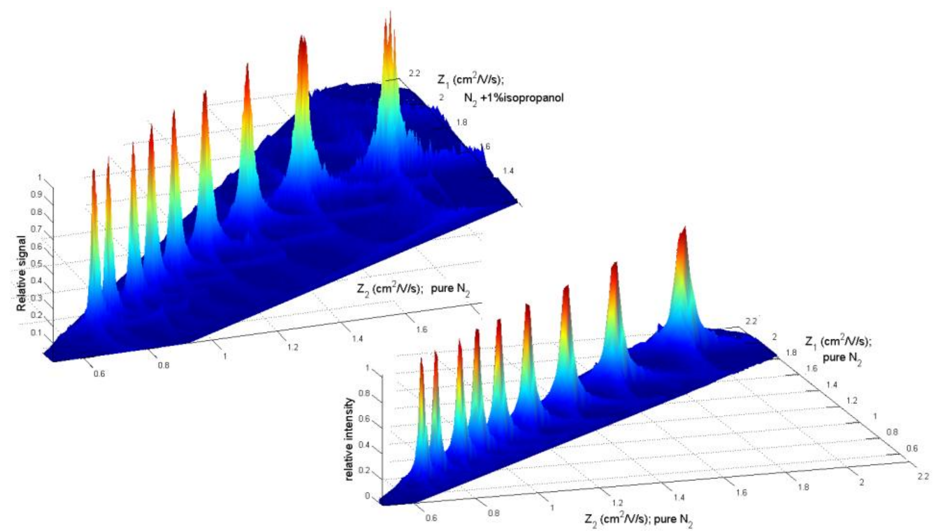




TMIMS2-MS: IMS & IMS^2 modes

- Tetra alkyl ammonium ions. (Ethyl -Dodethyl).

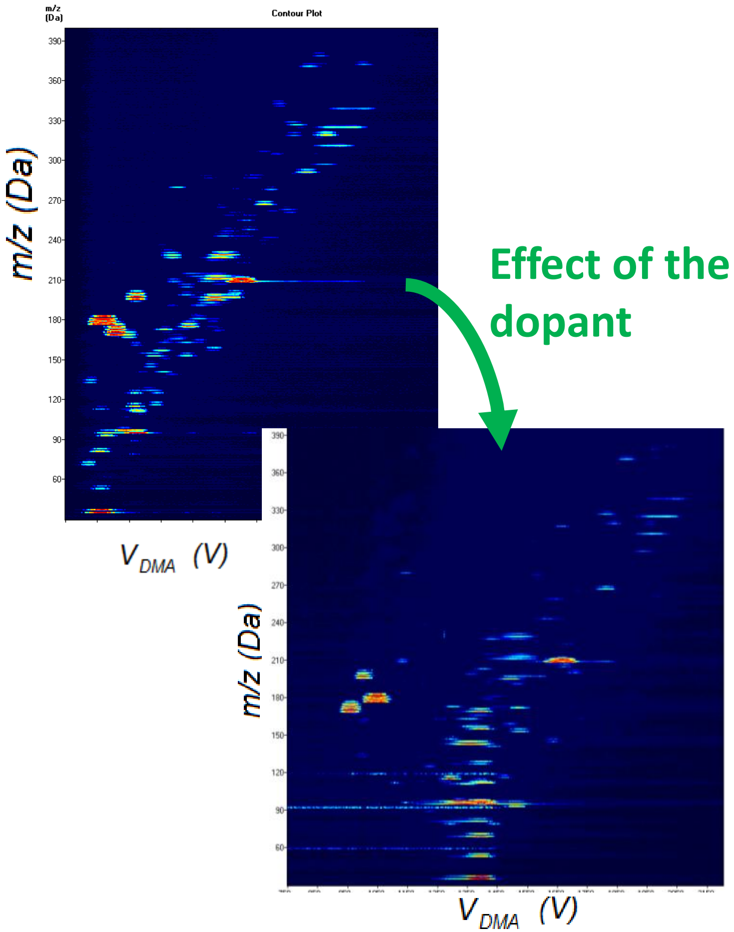


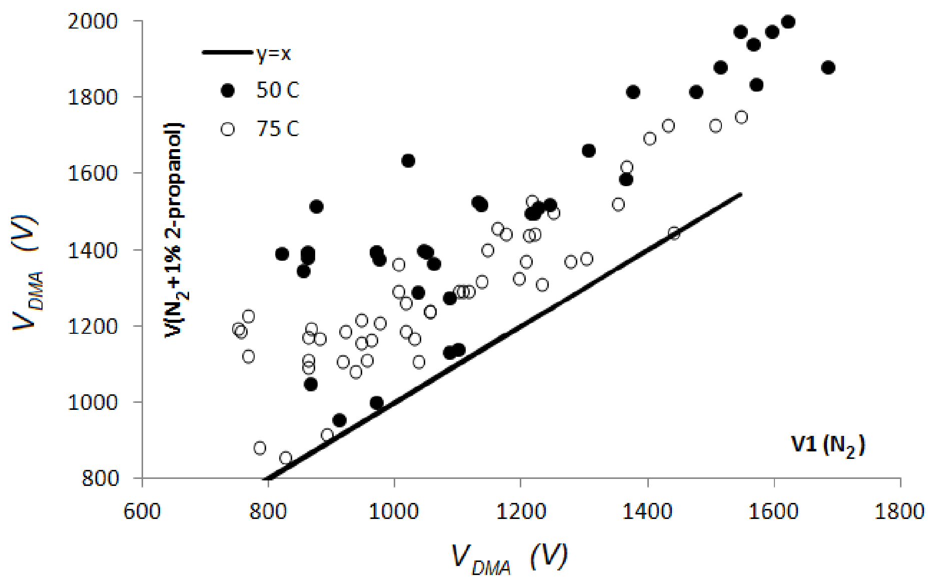


- And transparent mode too.
  - Peak search strategies enable IMS^2 operation with moderate operational time.

IMS^2 Orthogonality

- Dry N_2 vs N_2 doped with 1% 2-propanol
- DMSO-Octanol-HCl nano-ESI; DMA-MS spectra.



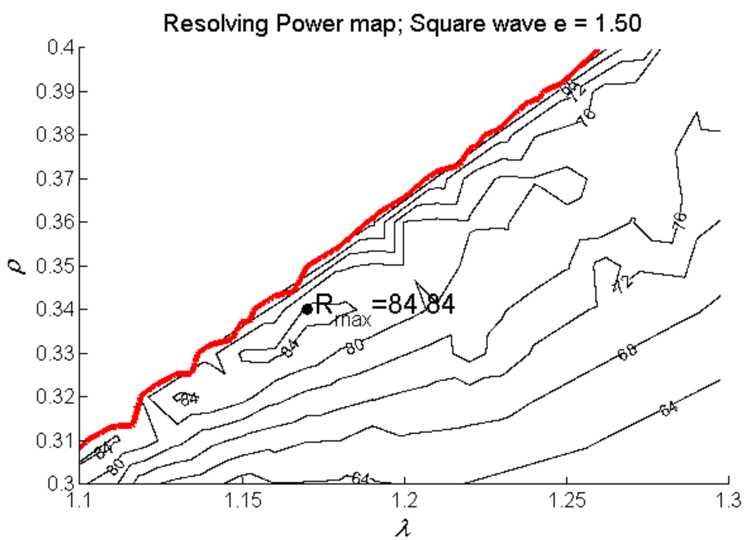


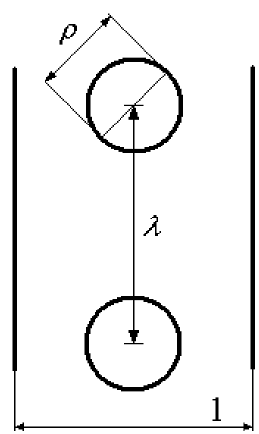
•2-propanol affects each species differently.

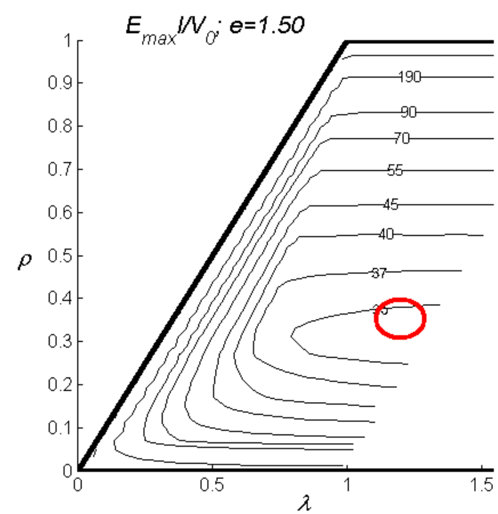
•It is a promising result, but orthogonality still needs to be characterized for the samples of interest.

Numerical simulations

- Allow us to simulate real geometries.
  - Electric fields: Boundary Element Method.
  - Ideal convective trajectories: Runge-Kutta.
  - Diffusive model: Transversal diffusion
- Validated with TMIMS-1 and TMIMS-2.
- Used to determine optimum geometries







Conclusions

- Current prototypes demonstrate:
  - IMS-IMS and IMS pre-filtration, with interesting IMS-IMS orthogonality.
  - Resolving power of 60 in IMS mode.
  - Resolving power of 40 in each stage IMS-IMS mode.
  - Estimated separation capacity: 40·(1+40·20%)=360.
  - Robustness, atmospheric pressure operation continuous output and :
    - facilitate coupling with most pre-existing MS.
- Numerical simulations show:
  - Optimized geometries would reach R=80.
  - Separation capacity would be 80·(1+80·20%)=1360

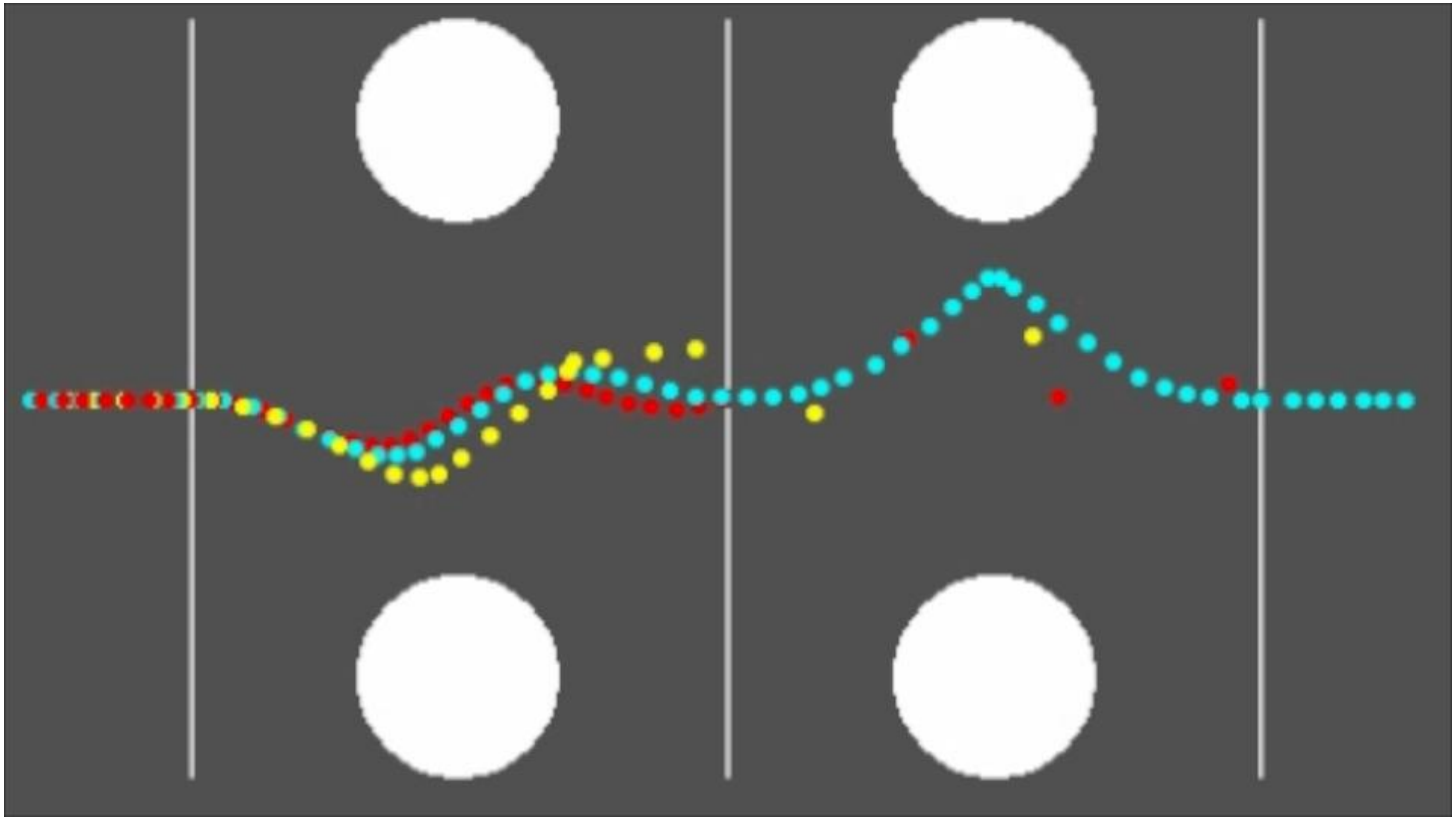
TMIMS Challenges

- Couple with commercial ion sources.
- Improve transmission.
- Reduce size and cost of the High Voltage system.

  …

- **Bring the tool to life by using it!**

Thanks for your attention!



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