Massimiliano Putignano

Development of a Beam Profile Monitor Based on a Supersonic Gas-Jet Curtain

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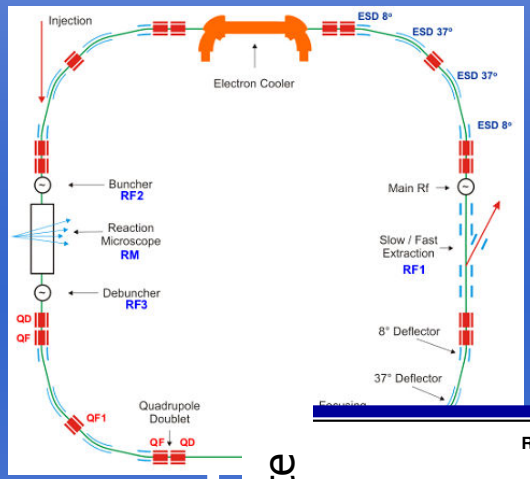
Why a Beam Profile Monitor using a Gas Jet?

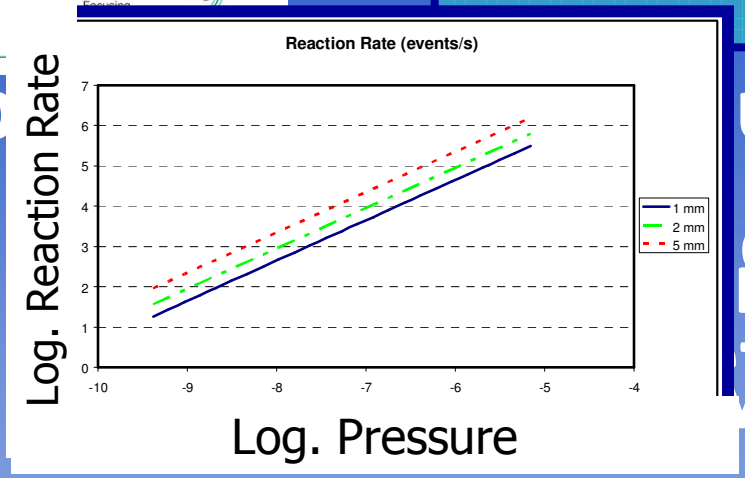
- **USR Project at FLAIR (FAIR facility, Darmstadt)**

A. Papash and C. P. Welsch, Physics of Particles and Nuclei Letters, Vol. 6, No. 3. (2009), pp. 216-226.



- **Ultra-low energy pbars (20-300 keV)**
- **Coasting/bunched beam**
- **Low pressure (10^{-11} mbar)**

- **Low perturb… unt rate**



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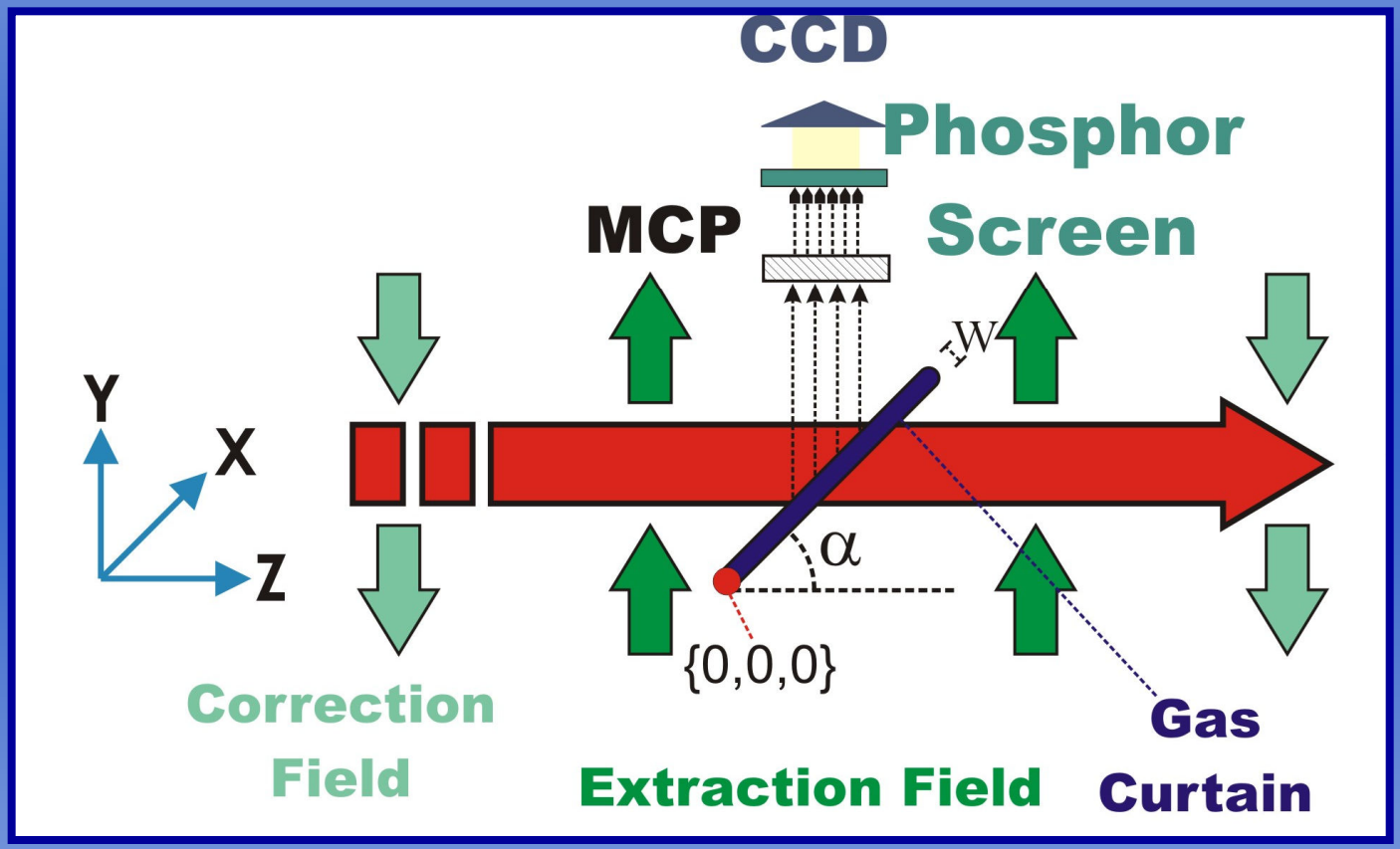
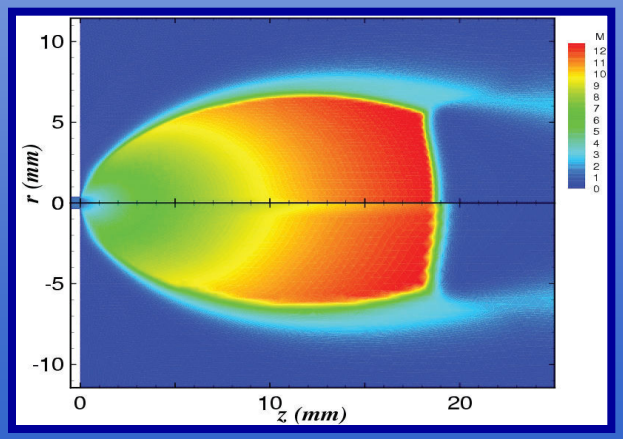
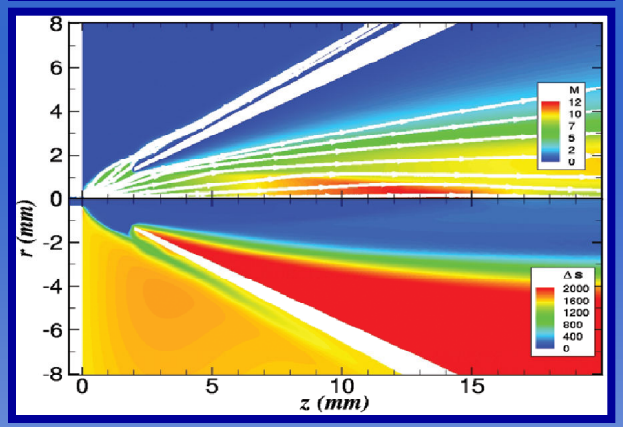
How does it work?



Where do we start?





M.Jugroot *et al*: Numerical investigation of interface region flows in mass spectrometers: neutral gas transport – J. Phys. D: Applied Physics, vol. 37 (2004) pp 1289.

State-of-the-art

- Detailed study of expansion structure
- Assessment of the impact on jet parameters
- Optimization of axis-symmetric jet for use as a target.

All optimization studies performed for an axis-symmetric jet.

- Identify parameters of interest to diagnostics.
- Propose a novel nozzle-skimmer system.
- Extend existing studies to planar jets.

- **Governing equations**
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  - **Mo**
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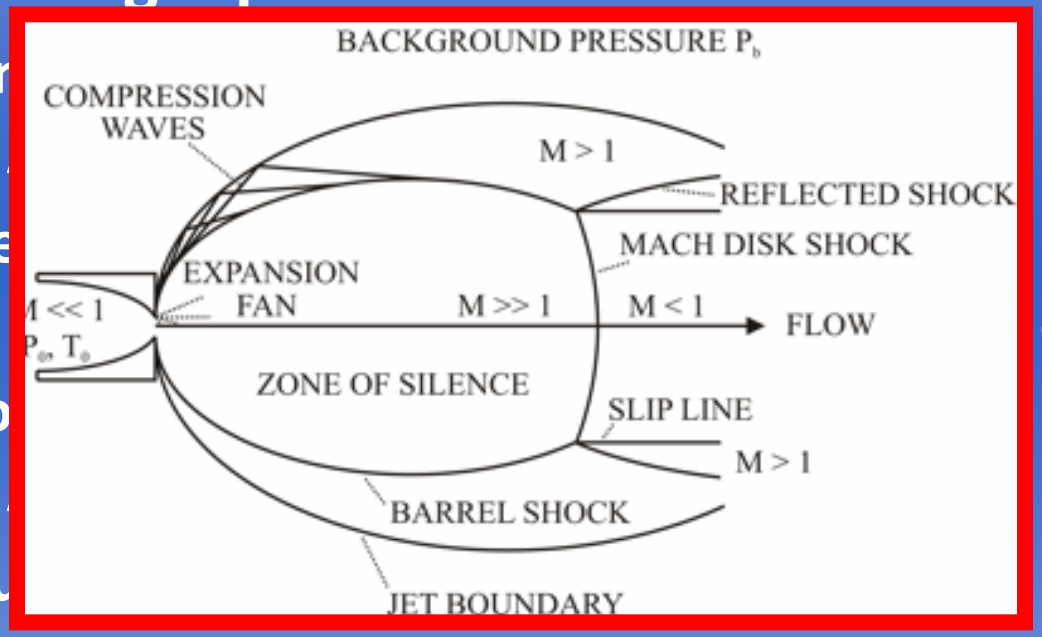
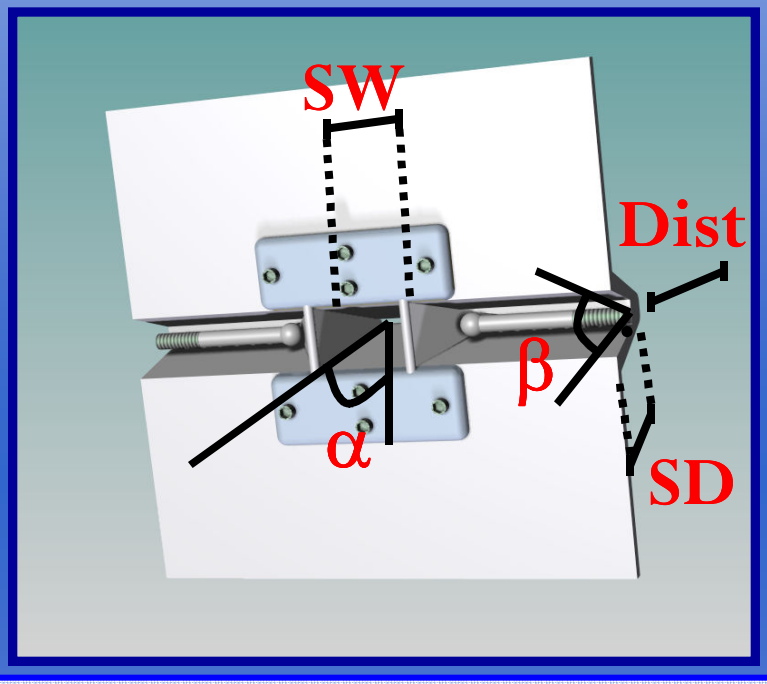
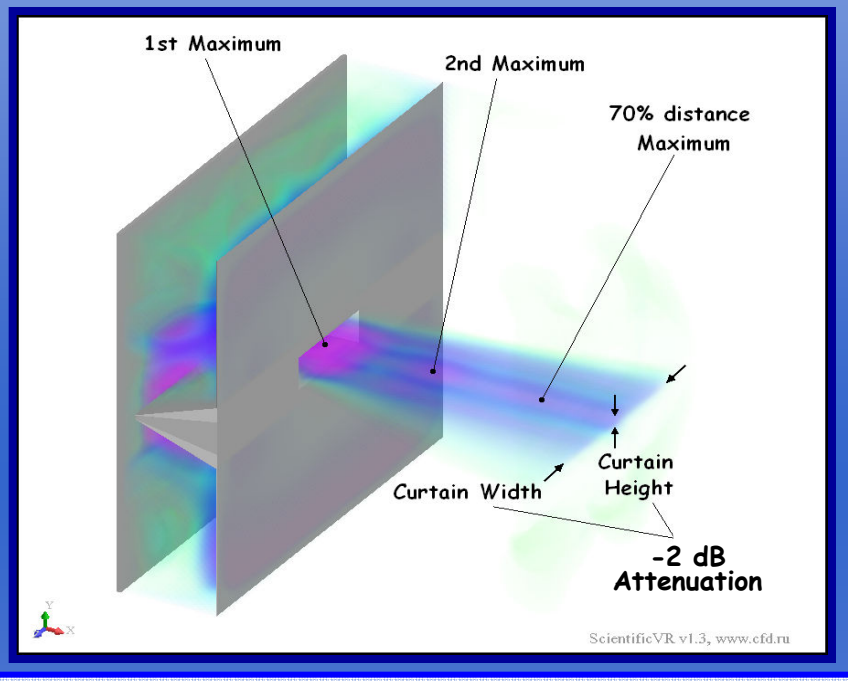
  - **Equ**
    - **Ideal gas equation of state (from kinetic theory)**
  - **Thermal Equation of state**
    - **Definition of int. energy and measurement of specific heat.**



Which variables and observables do we choose?





α – angle of skimmer aperture in the direction of curtain expansion;
β – angle of skimmer aperture in the direction perpendicular to curtain expansion
SW – skimmer slit width
SD – skimmer depth
Dist – nozzle-skimmer distance

M_{max} – Maximum Mach Number
CM_{max} – Coordinates maximum M
$M_{max70\%}$ - Maximum M at 70% simulation domain distance from nozzle
W – Curtain width (at -2 dB attenuation);
D – Curtain depth (at -2dB attenuation);

Curtain behavioral trends

	M_{max}	CM_{max}	M_{max} 70%	D	W
α	β, SD	β, SD	↘	↘	↗
β	α	α	↘	⌒	→
SW	↗	↗	↘	↘	↗
SD	α	α	α	⌒	⌒
Dist	↘	↗	↘	α, β	α, β

- System can be optimized through nozzle-skimmer geometry.
- Slit nozzle (instead of circular nozzle)
- Nozzle and skimmer slits have to be perpendicular
- ***Actual value of quality ratio: W/D.***

  Decreases of a factor of 2-3 m

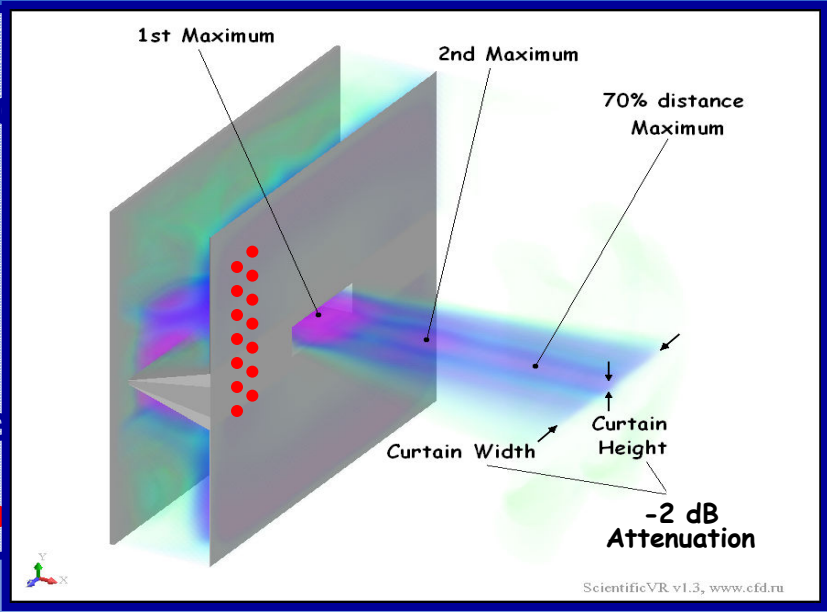
  Slit nozzle to Circular nozzle.

  Homogeneity of curtain: $\Delta\rho/\rho$ =

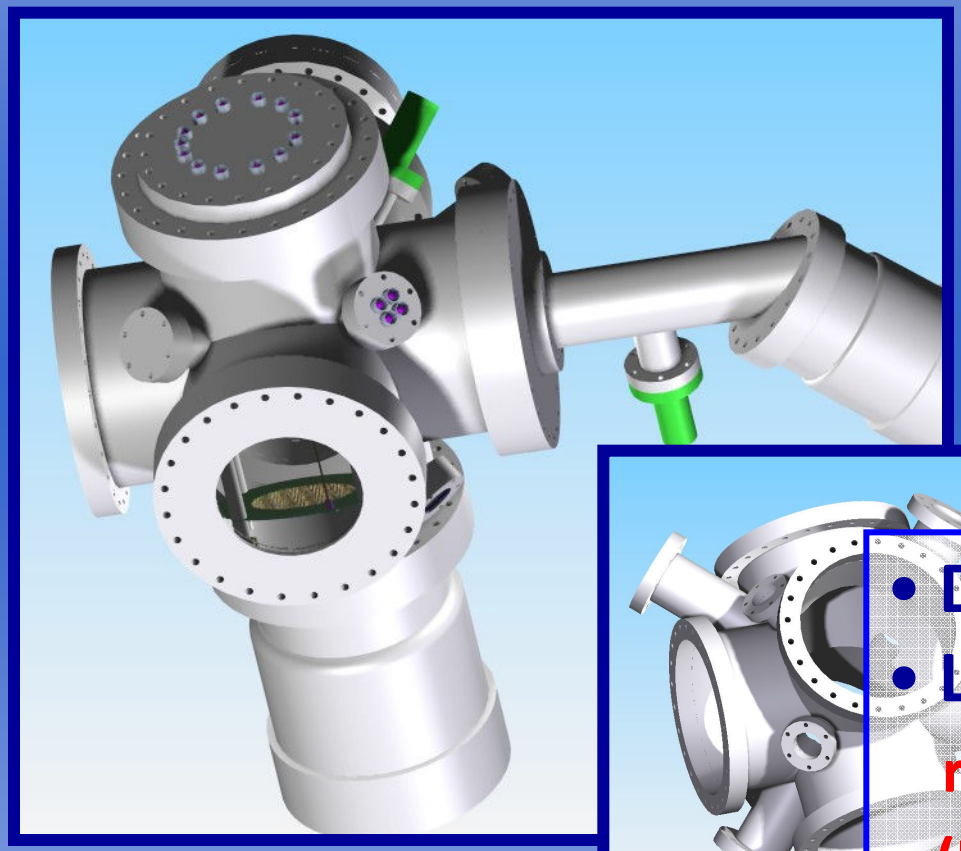
  Nozzle-Skimmer system:

  Perpendicular **Paralle**

  89% **68%**



Wow! and now?



- Differential Pumping
- Longitudinal (20 mm range) and angular (5° range) fine tuning.

- Acknowledgements:
  - Kai-Uwe Kühnel
  - Angela Intermite
  - Carsten P. Welsch

Thank you for your attention

- References:

1. M.Putignano *et al*: A Fast, Low Perturbation Ionization Beam Profile Monitor Based on a Gas-jet Curtain for the Ultra Low Energy Storage Ring - Hyperfine Interaction, accepted.
2. M.Putignano *et al*: Design of a nozzle-skimmer system for a low perturbation ionization beam profile monitor – DIPAC09 Proceedings.
3. M.Jugroot *et al*: Numerical investigation of interface region flows in mass spectrometers: neutral gas transport – J. Phys. D: Applied Physics, vol. 37 (2004) pp 1289.
4. Y. Hashimoto *et al*: Oxygen gas-sheet beam profile monitor for the synchrotron and storage ring - Nucl. Instr. Meth. Phys. Res. A 527 (2004) 289.