Application of the source terms distribution to fuel spray CFD simulations

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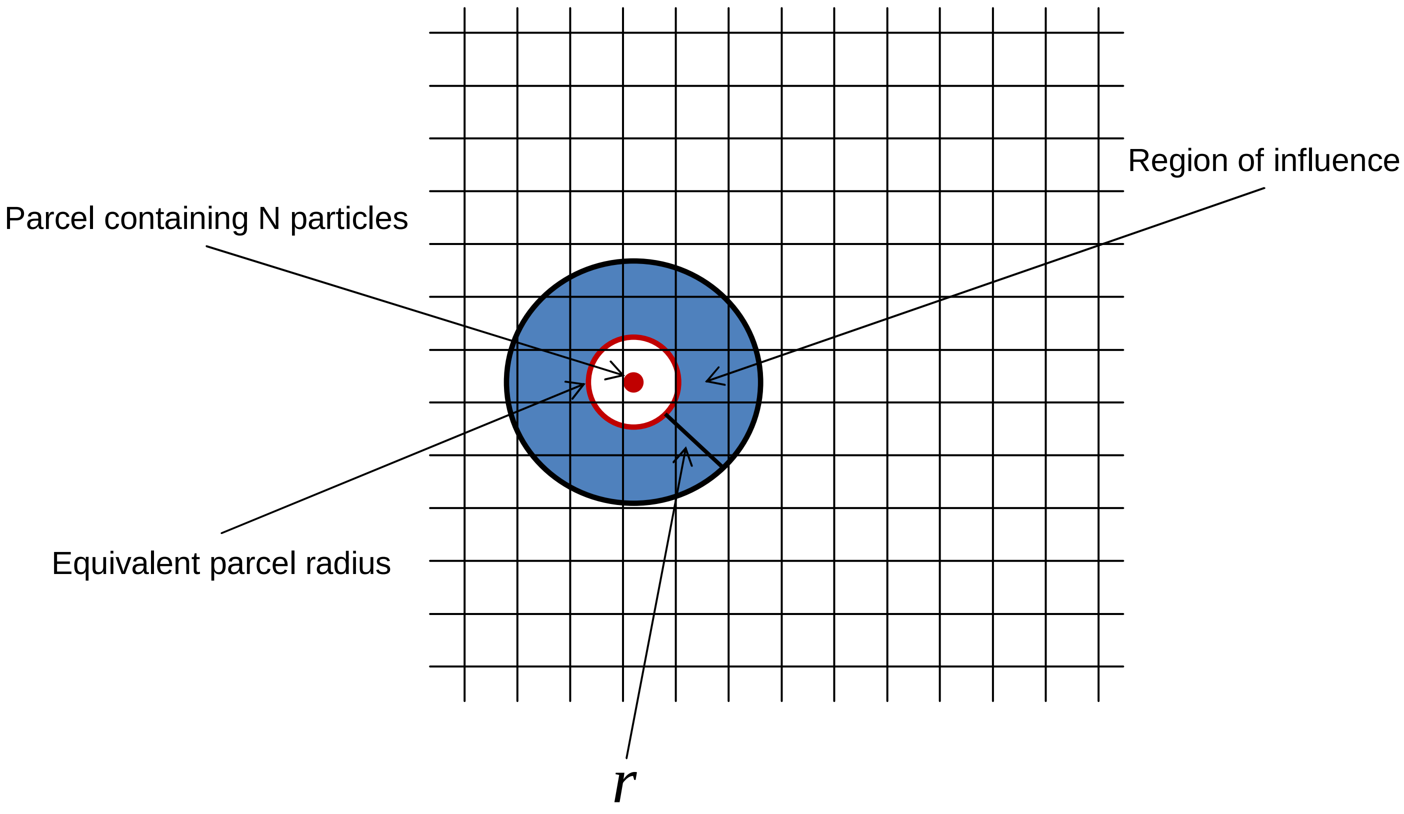
Aims of the work

- Following the work proposed in *S. Tonini, M. Gavaises , A. Theodorakakos, "Modelling of high-pressure dense diesel sprays...", International Journal of Heat and Fluid Flow 29 (2008) 427–448*
- Apply the source terms distribution methodology in a commercial CFD package (FLUENT®) using User Defined Functions (UDF)
- Apply the methodology to an accelerating diesel spray
- Compare computational results with LIF experiments

Source terms distribution process

- Standard Lagrangian methodology: source terms are added to the cell containing the parcel
- Source terms distribution methodology: source terms exchanged by the discrete parcel P and continuous phase is distributed among neighbouring cells within a certain distance
  - Identification of the cells in the region of influence
  - Weighting factors function of parcel to cell distance, cell volume and cell internal energy

Cells identification in the region of influence



Weighting factors

$$w_i = \frac{V_{C_i}}{\sum_i V_{C_i}}$$

$$w_i = \frac{1/\left(\gamma \cdot dist_i / r + 1\right)}{\sum_i 1/\left(\gamma \cdot dist_i / r + 1\right)}$$

$$w_i = \frac{V_{C_i} / \left(\gamma \cdot dist_i / r + 1\right)}{\sum_i V_{C_i} / \left(\gamma \cdot dist_i / r + 1\right)}$$

$$w_i = \frac{V_{C_i} \cdot \rho_{C_i} \cdot C_{PC_i} \cdot T_{C_i} / \left(\gamma \cdot dist_i / r + 1\right)}{\sum_i V_{C_i} \cdot \rho_{C_i} \cdot C_{PC_i} \cdot T_{C_i} / \left(\gamma \cdot dist_i / r + 1\right)}$$

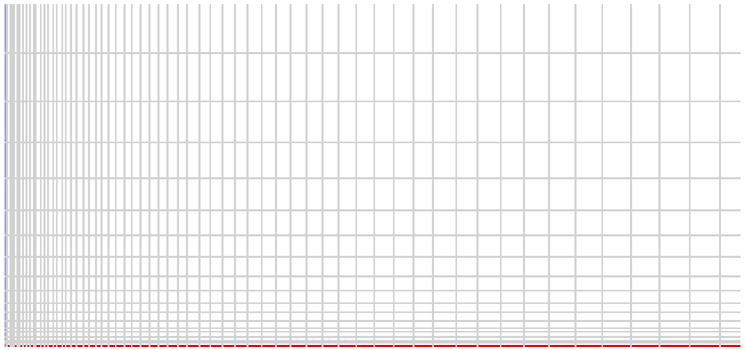
$$i = 1, N_C$$

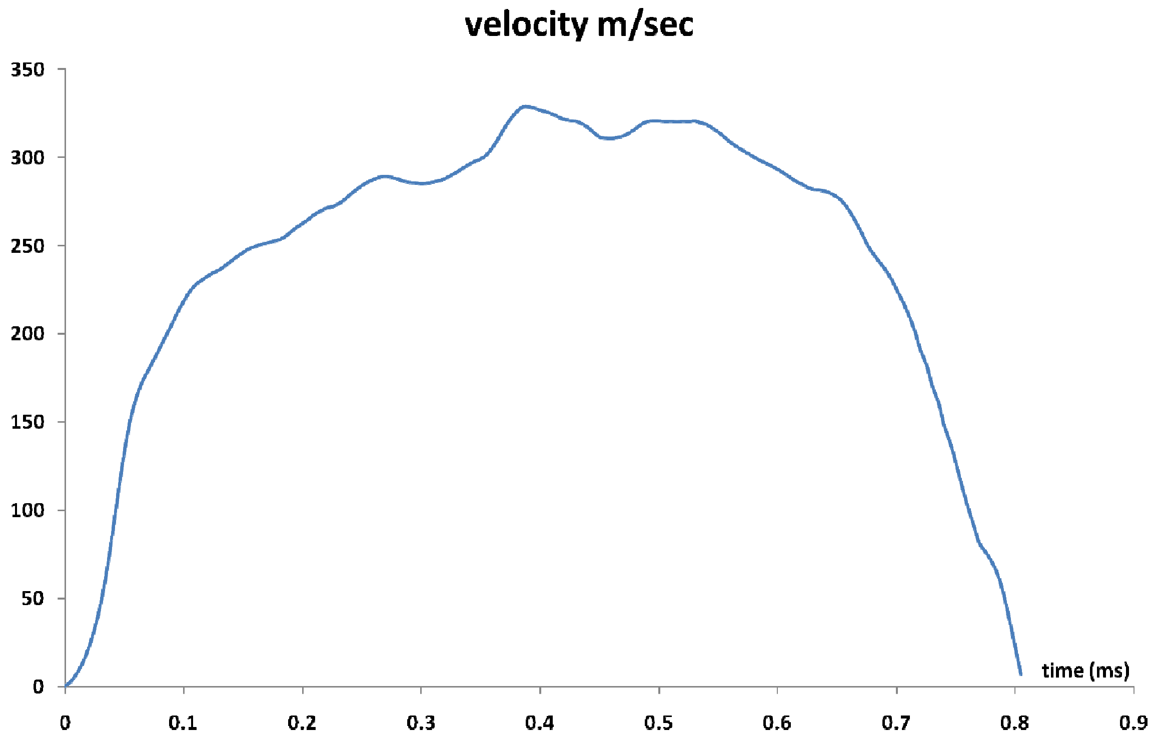
$$\gamma$$

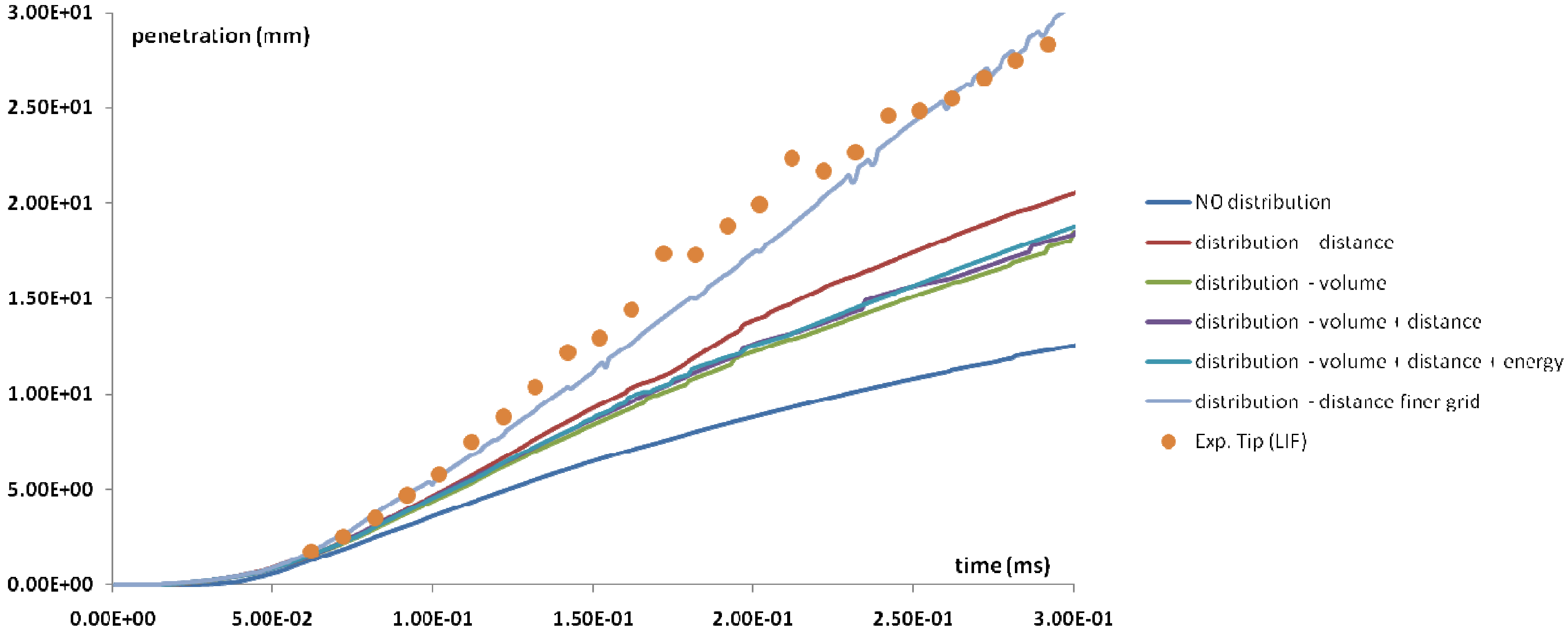
$$dist_i = | x_{C_i} - x_P |$$

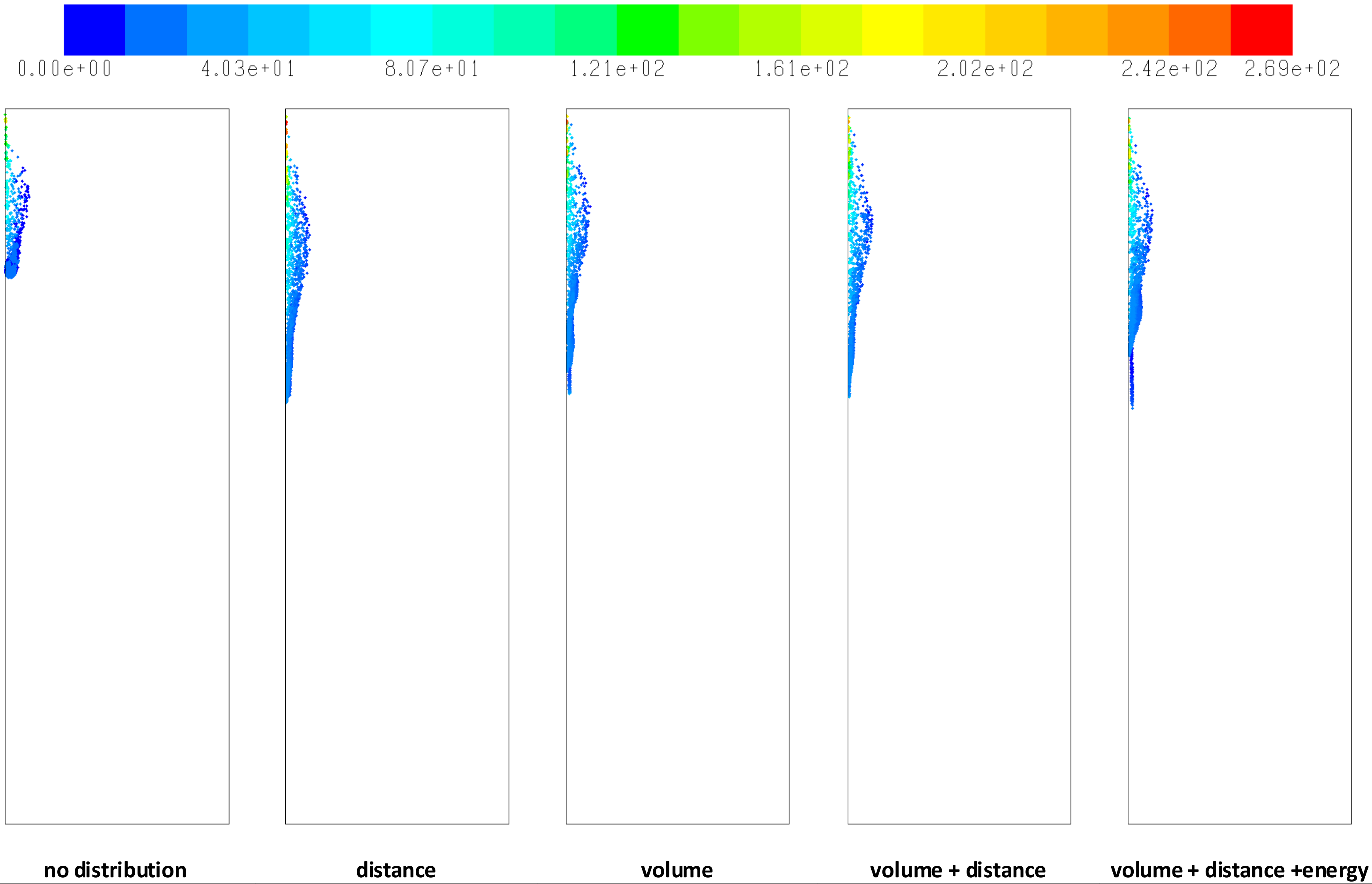
Experimental Condition Considered (PROTEUS Engine)

Injection Pressure = 100 MPa
Fuel Temp = 355 K
Air pressure = 2 MPa
Air Temperature = 350 K

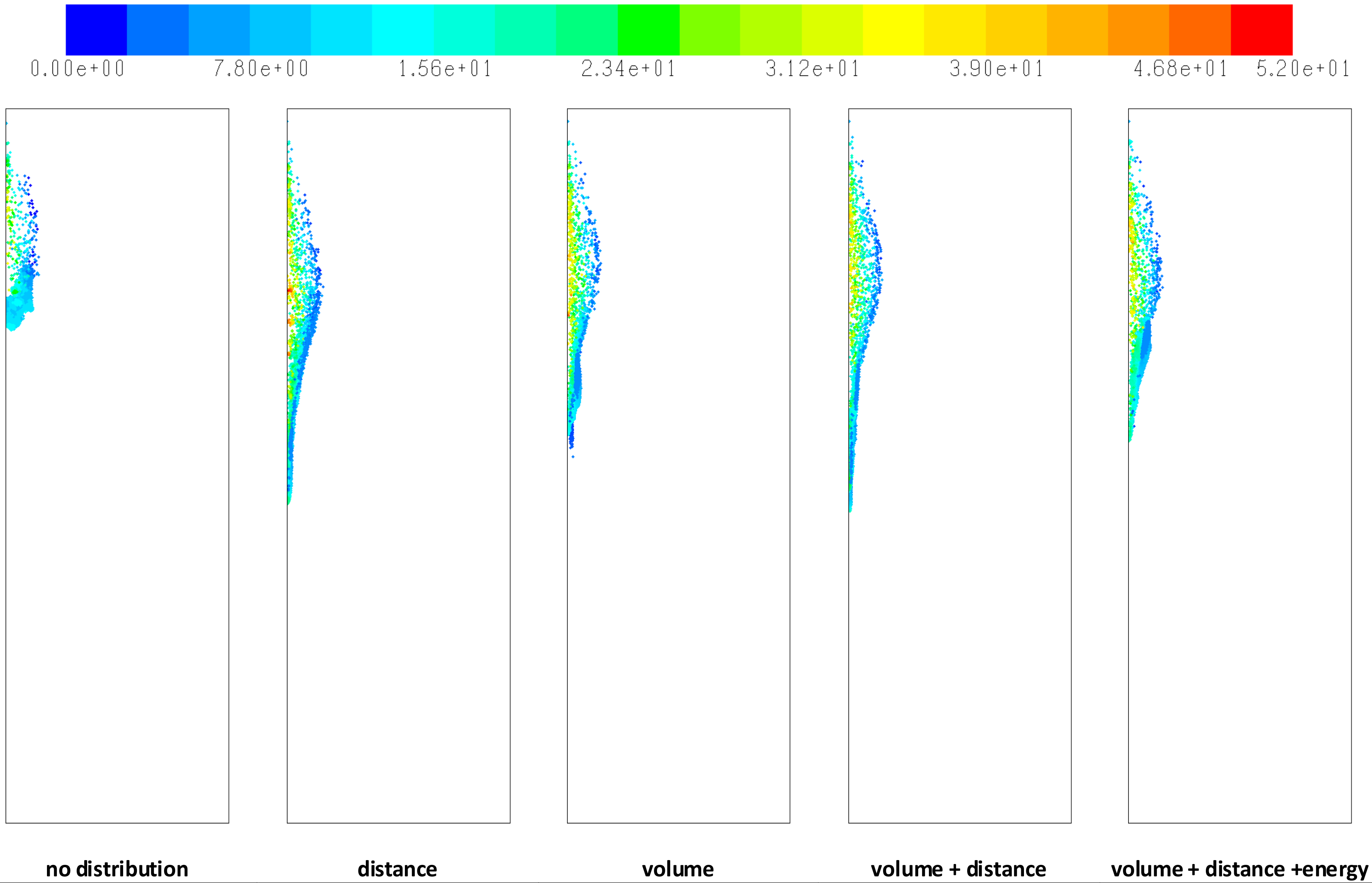





penetration (mm)
3.00E+01
2.50E+01
2.00E+01
1.50E+01
1.00E+01
5.00E+00
0.00E+00
time (ms)
0.00E+00
5.00E-02
1.00E-01
1.50E-01
2.00E-01
2.50E-01
3.00E-01
NO distribution
distribution - distance
distribution - volume
distribution - volume + distance
distribution - volume + distance + energy
distribution - distance finer grid
Exp. Tip (LIF)



Spray structure after 0.6 ms (particle coloured by velocity magnitude m/s)



Spray structure after 1.0 ms (particle coloured by velocity magnitude m/s)

Conclusions

- Possibility of adopting the source terms distribution in a “closed” CFD package
- Improvement of the results obtained with the standard Lagrangian methodology
- Possibility of refine the grid violating the restriction on the Parcel volume (typically less of 10-12% of the cell–containing volume) of the Eulerian–Lagrangian approch

Thank You for your attention

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