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SIMULATION OF GAS INJECTION INTO LIQUID WITH SIMMER

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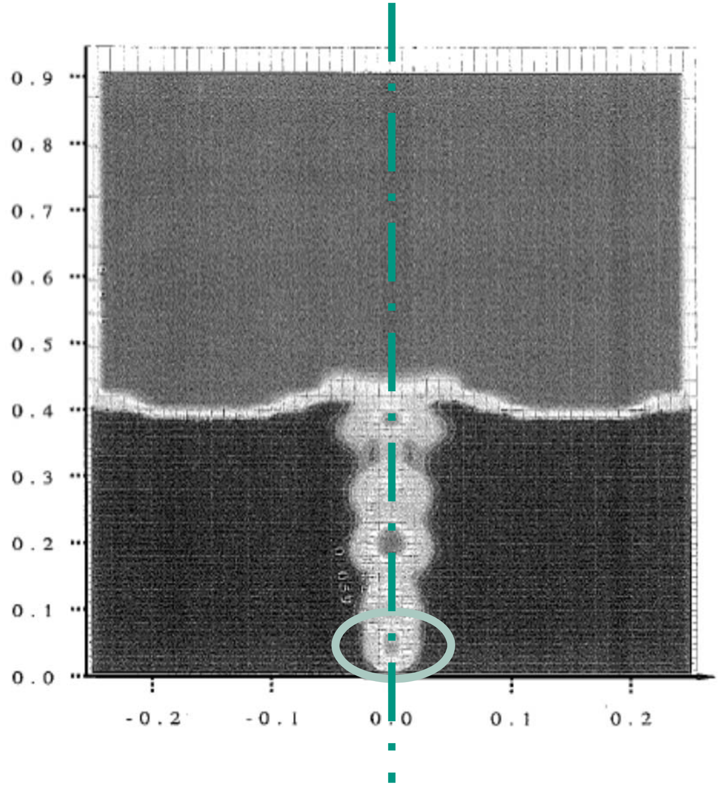
❑ Introduction

SAMOSAFER

- Euratom Project: SAMOSAFER since 2018
- Molten Salt Reactor (MSR)
- Severe Accident Modeling and Safety Assessment
- Gas Bubbling in Molten Salt Reactor
- SIMMER Application and Validation by Experiment of Gas Injection into Water

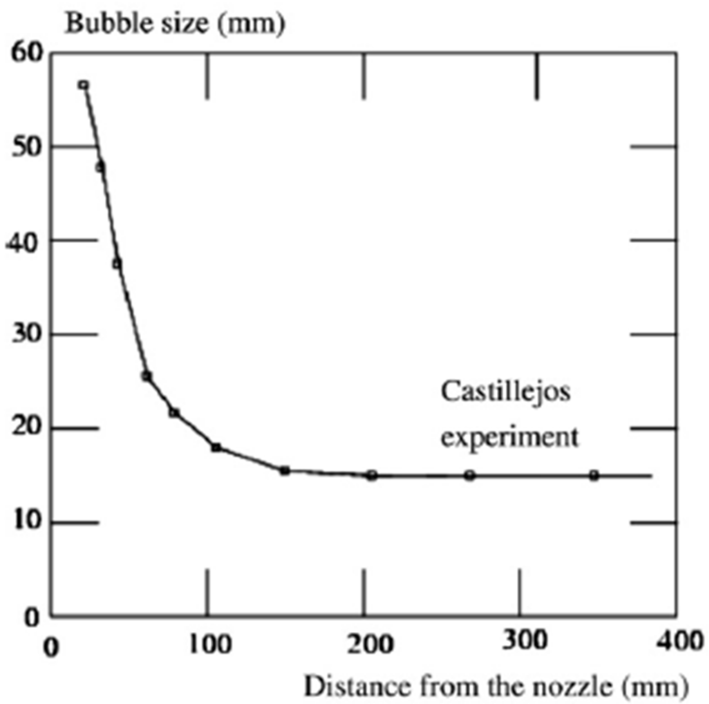
❑ Introduction

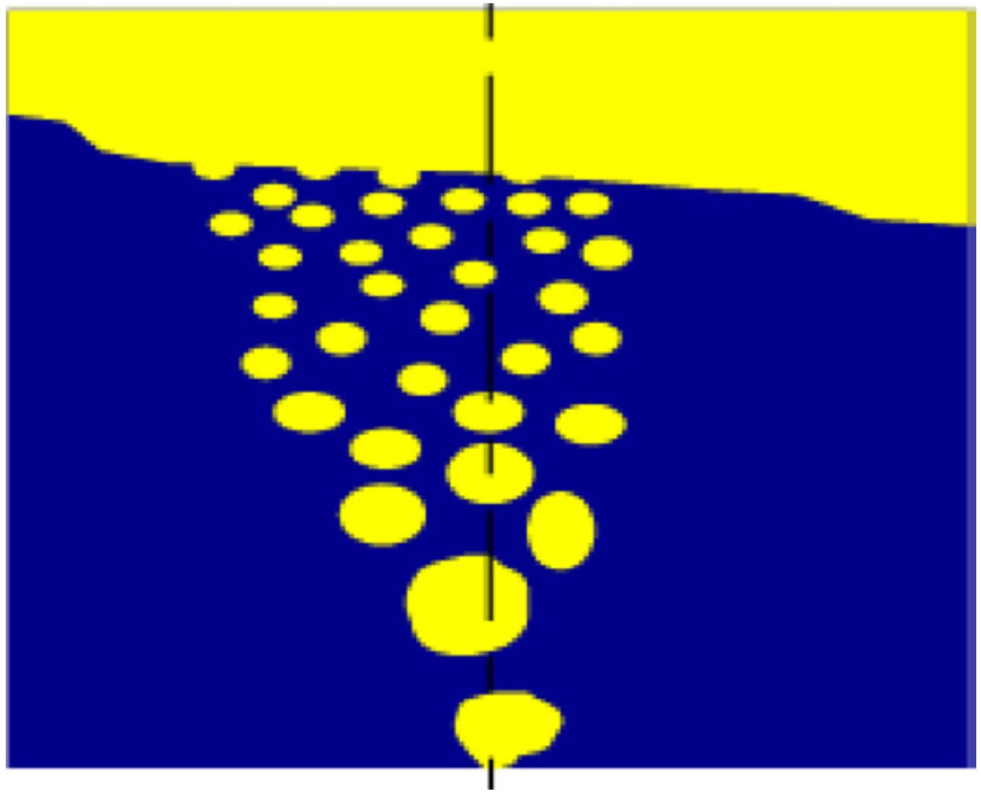
- Castillejos experiment
  - One of SIMMER validation experiments
  - References: Pigny (2010, 2011)
- Air injected in a water-filled cylindrical tank
  - Water depth 40 cm
  - Tank diameter 50 cm
  - Injection diameter 0.635 cm
- Inlet gas flow rate:
  - Q = 371, 876 cm^3/s
  - Vav = 11.71, 27.66 m/s



❑ Introduction

- According to experimental observation
  - The gas plume spreads out
  - The bubbles break up and splitt into smaller ones





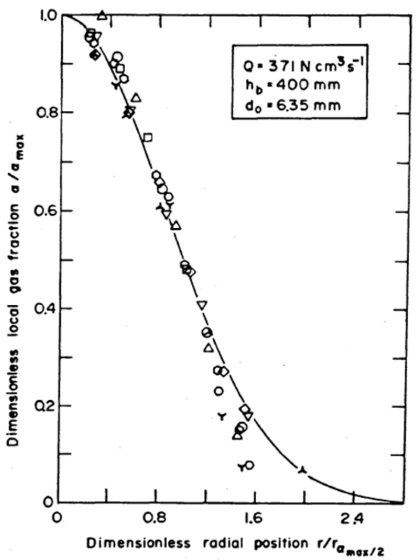
❑ Introduction

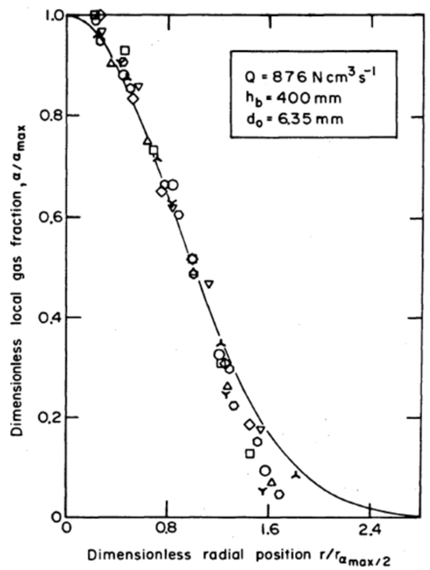
Void Fraction Correlation of Experimental Results

- Experimental void fraction (gas volume fraction) distributions have been summarized by correlations
- The radial distribution: Gaus Bell Function

$$\frac{\alpha}{\alpha_{max}} = \exp\left(-0.7\left(\frac{r}{r_{\alpha\,max/2}}\right)^2\right)$$

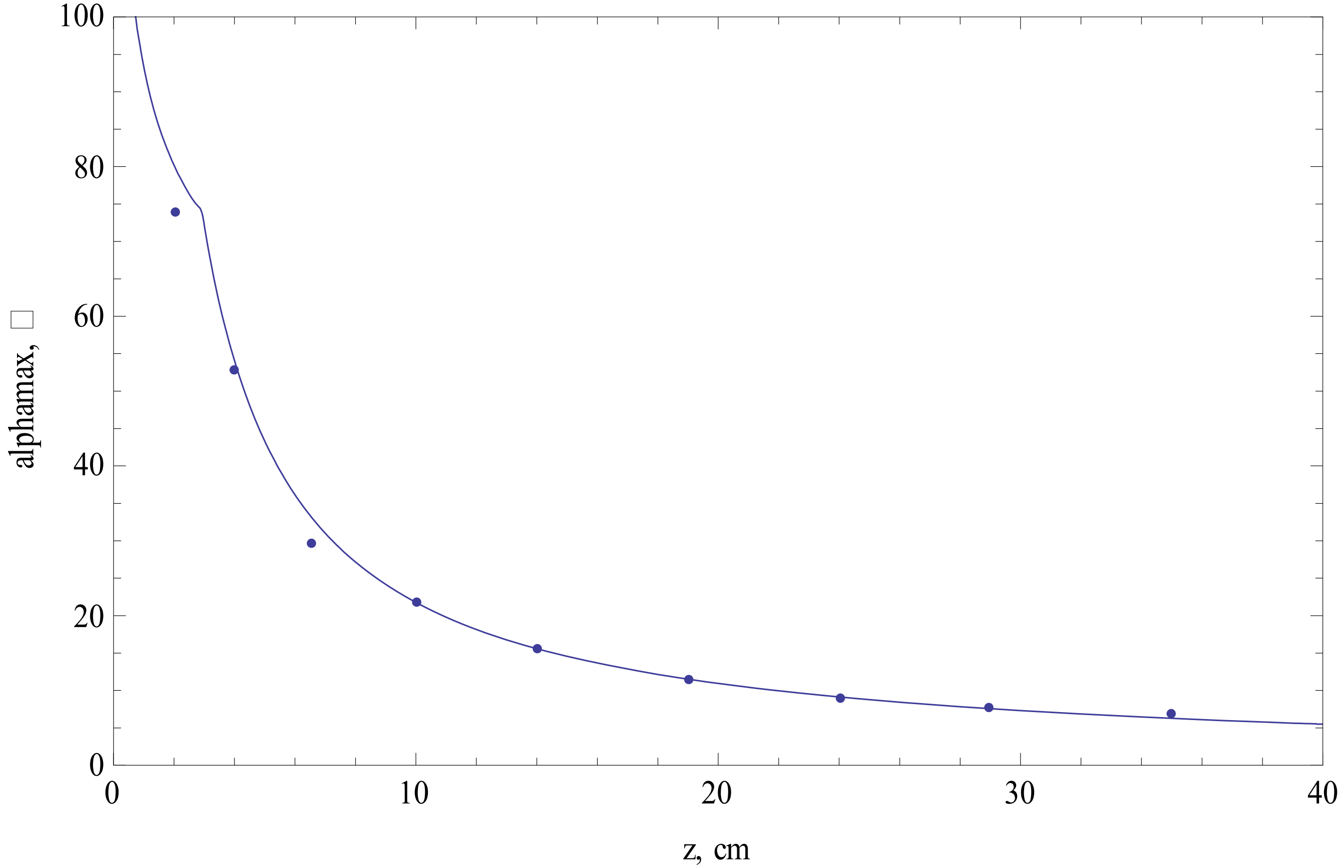
- The half-value radius and the maximal void fraction as function of z (the height over the injection point)
- Radial distribution for different z positions





Void Fraction Correlation of Experimental Results

- Axial maximal void fraction: Q=371 cm^3/s



❑ SIMMER Gas Injection Modeling

- SIMMER Code: 2-D and 3-D advanced fluid-dynamics of multiphase-flow and neutronics models
- SIMMER-III v3F version (2-D) and meshes
  - Mesh refinement: 25x50=>50x100
  - One injection cell => two injection cells
  - Radial mesh adjustment, finer in the central plume region
- SIMMER other options
  - Turbulence-diffusion effect on the viscous drag term taken into account
  - Modification of bubble drag coefficient, interpolated between ellipsoidal bubbles and cap bubble's (Suzuki 2003)
  - Large interface simulation (LIS) model (Coste 2013, Pigny 2011)

References:

T. Suzuki, et al. Nuclear Engineering and Design 220 (2003) 207–223

P. Coste, NED 255 (2013) 38-50

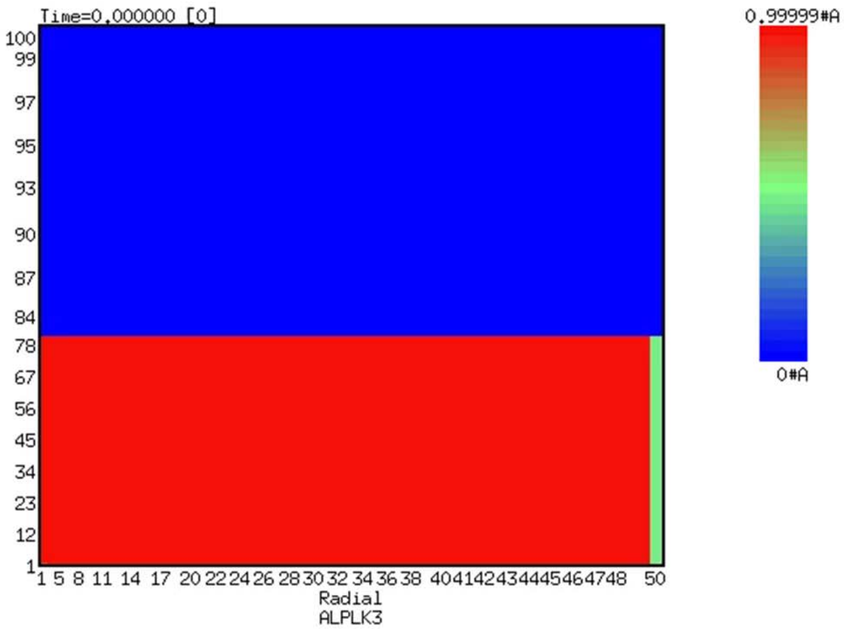
S. L. Pigny, NED 241 (2011) 874-887

❑ SIMMER Gas Injection Modeling and Results

Original Meshes 25x50; New Meshes 50X100

Q = 371 cm^3/s, Vin = 11.71 m/s

chen@inr-lvm-14:~/1-Castillejos/3-V143-NEW-DHINP/3-V143-MXF95-DH50-CCD4



Q = 876 cm^3/s, Vin = 27.66 m/s

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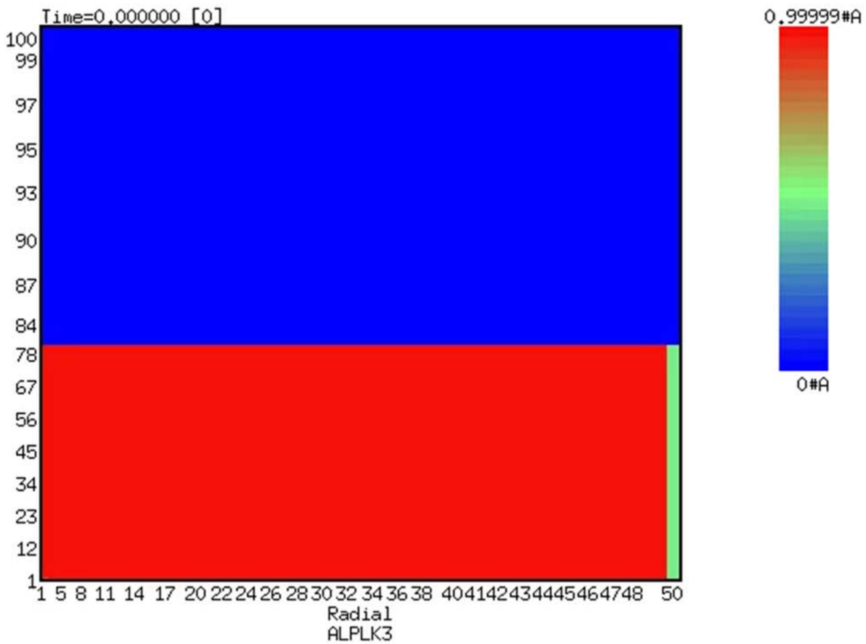
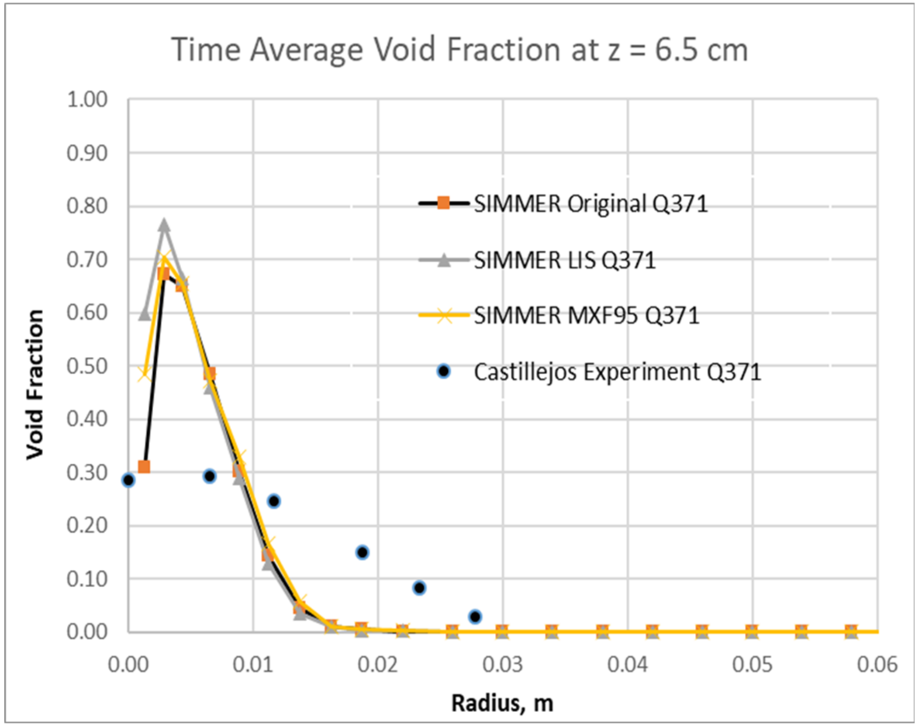
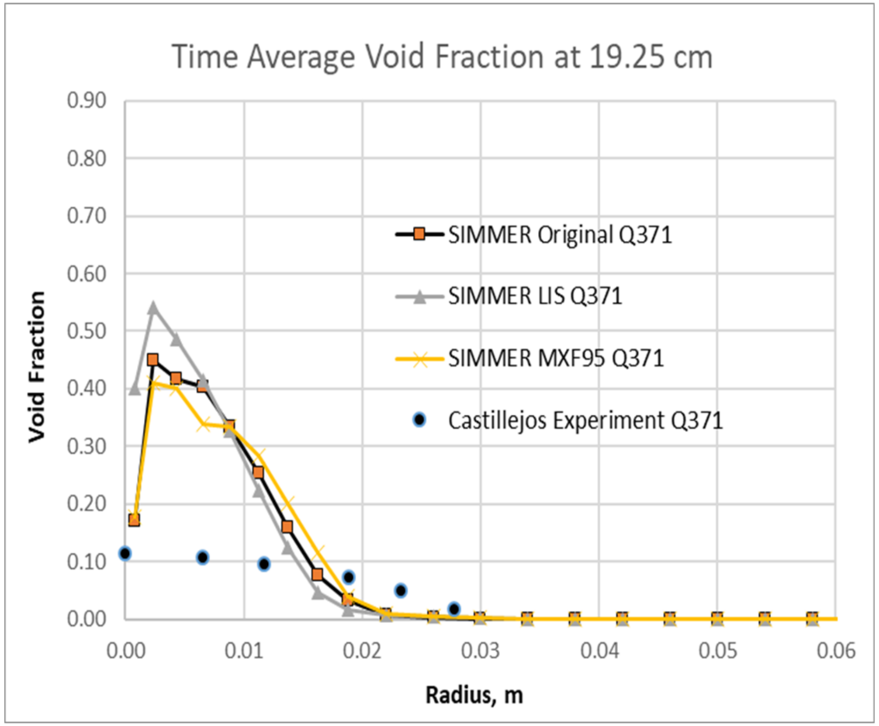


SIMMER Simulation Results

Two-cell injection, radial and axial modified meshes FM (50x100) Q371
Two gas velocities: 14.30 and 7.12 m/s, average 11.71 m/s





❑ SIMMER Simulation Results

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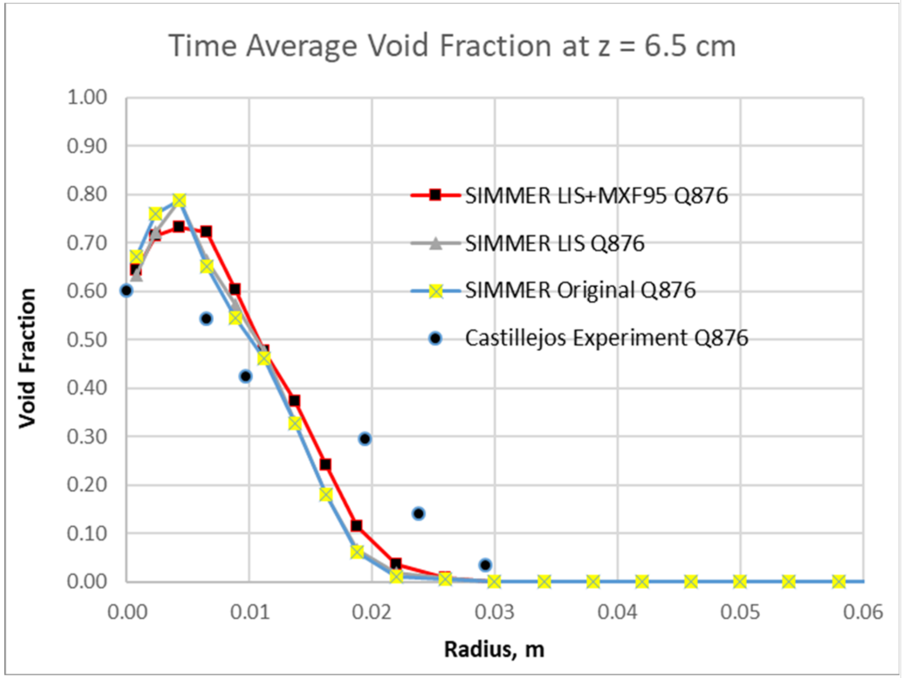
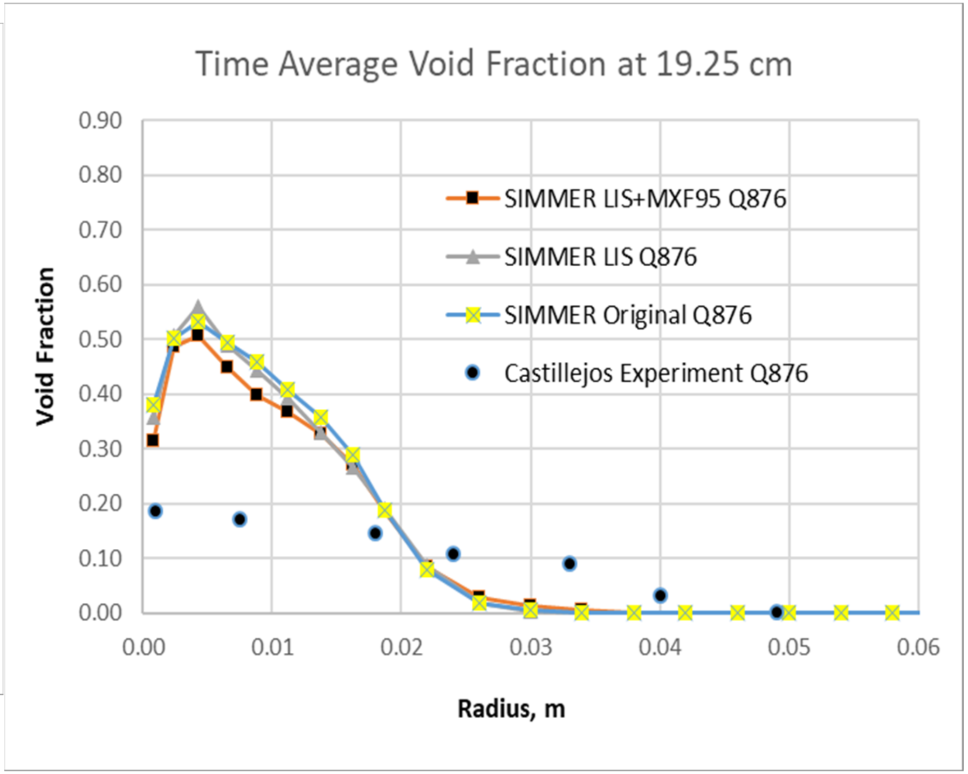
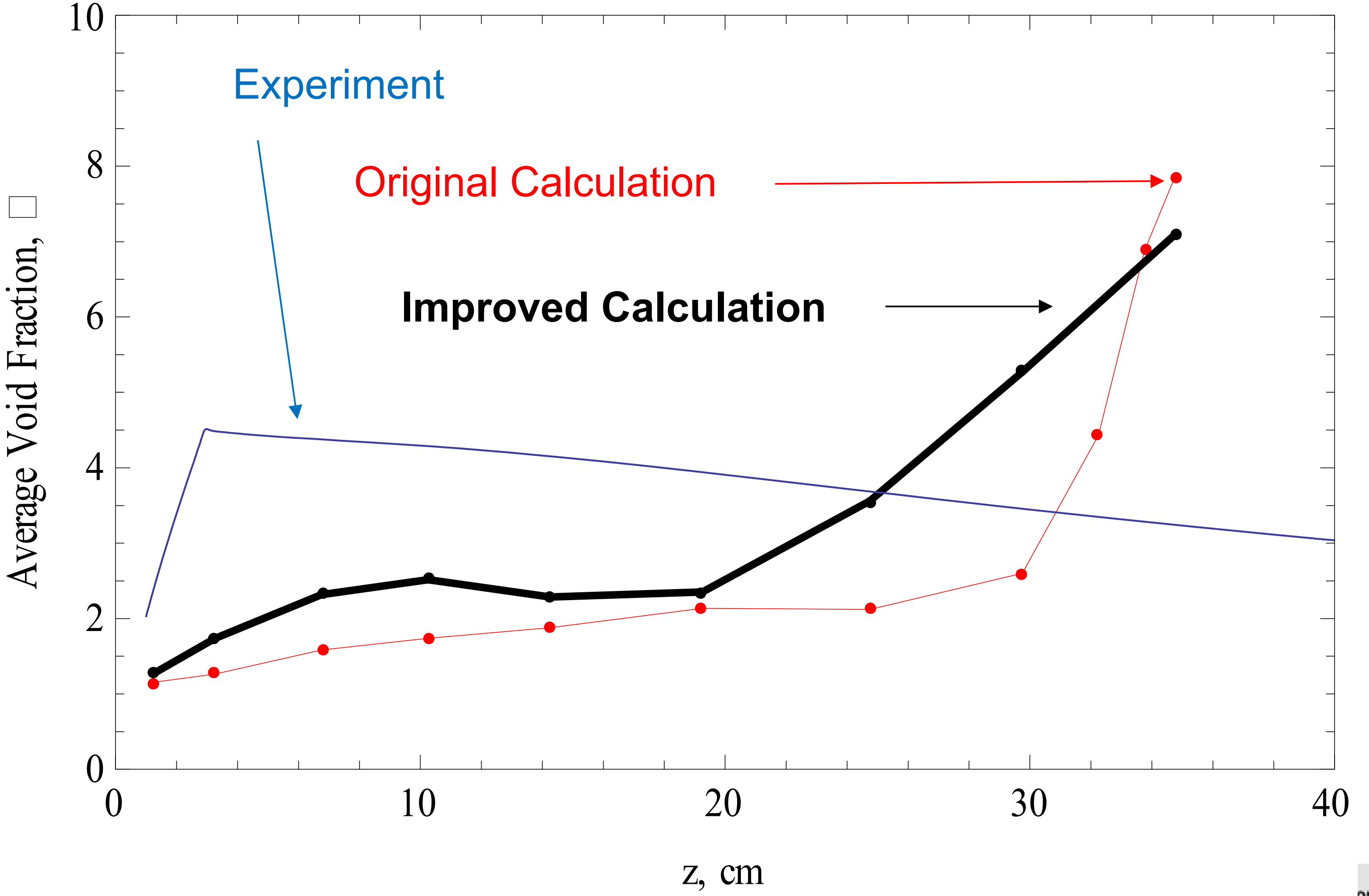
Two-cell injection, radial and axial modified meshes FM (50x100) Q876
Two gas velocities: 34.66 and 25.41 m/s, average 27.66 m/s





❑ SIMMER Simulation Results

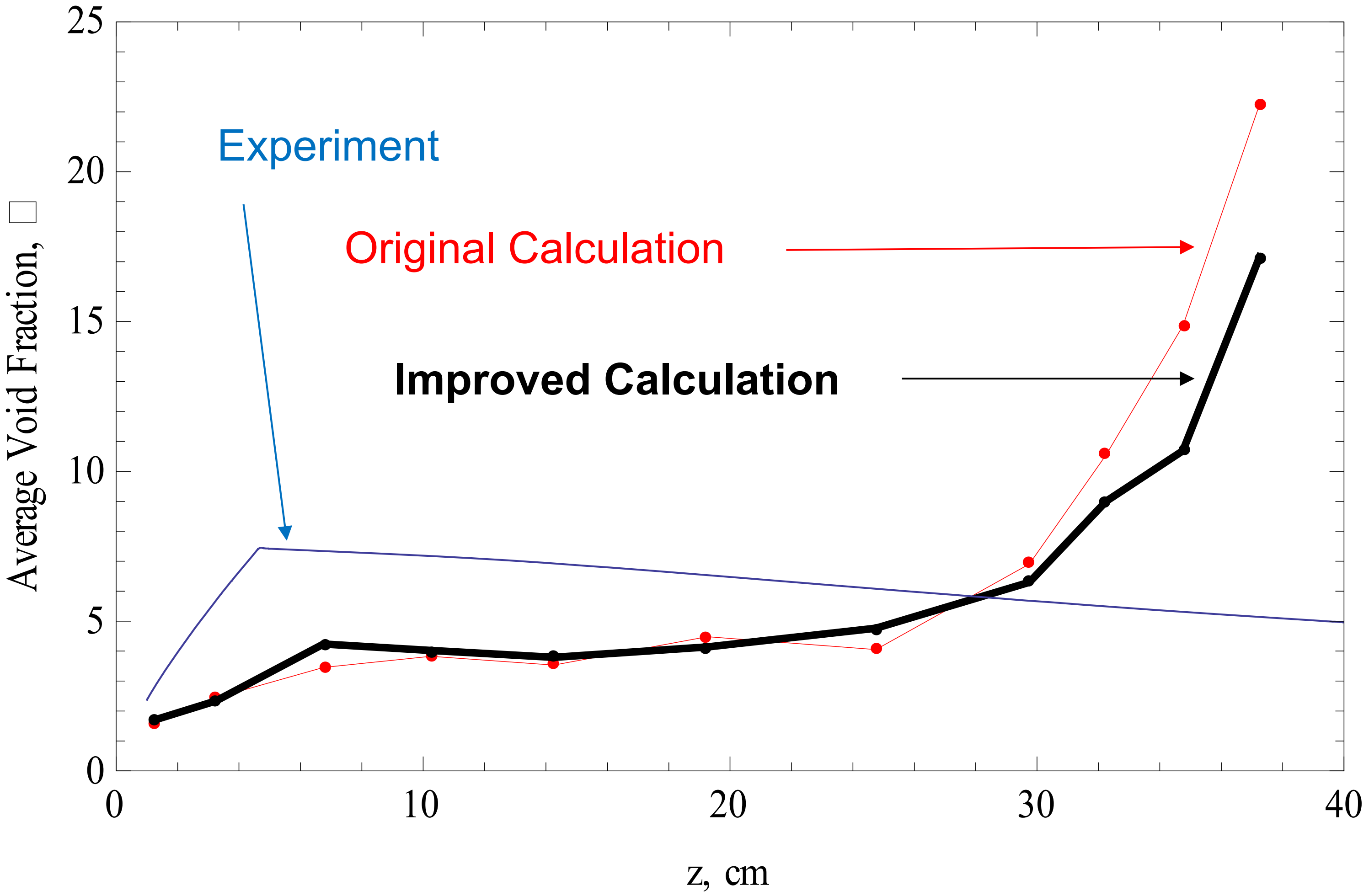
FM (50x100) Q371, Cross-sectional area averaged void fraction vs z



❑ SIMMER Simulation Results

FM (50x100) Q876, Cross-sectional area averaged void fraction vs z

R = 6.0 cm



❑ SIMMER Simulation Results

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Total volume averaged void fraction

Case	Q371	Q876
Experiment, %	**3.90**	**6.33**
SIMMER Original	2.24	4.69
SIMMER Improved	**3.17**	**4.56**

❑ Conclusions

- The fine meshes lead to better results, but even finer meshes cause the numerical instablility.
- The LIS option does not have significant improvement effects.
- Momentum exchange option (Suzuki, MXF95) has effects in improvement.
- In general SIMMER gives narrower plume as the experiment.
- A good volume averaged void fraction can be achieved by SIMMER, although its radial and axial distributions are not so good in agreement with the experiment.

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