

Transactions of the Korean Nuclear Society Autumn Meeting
Online, December 16-18, 2020

Hydrogen Stratification Breakup model with modified Froude number

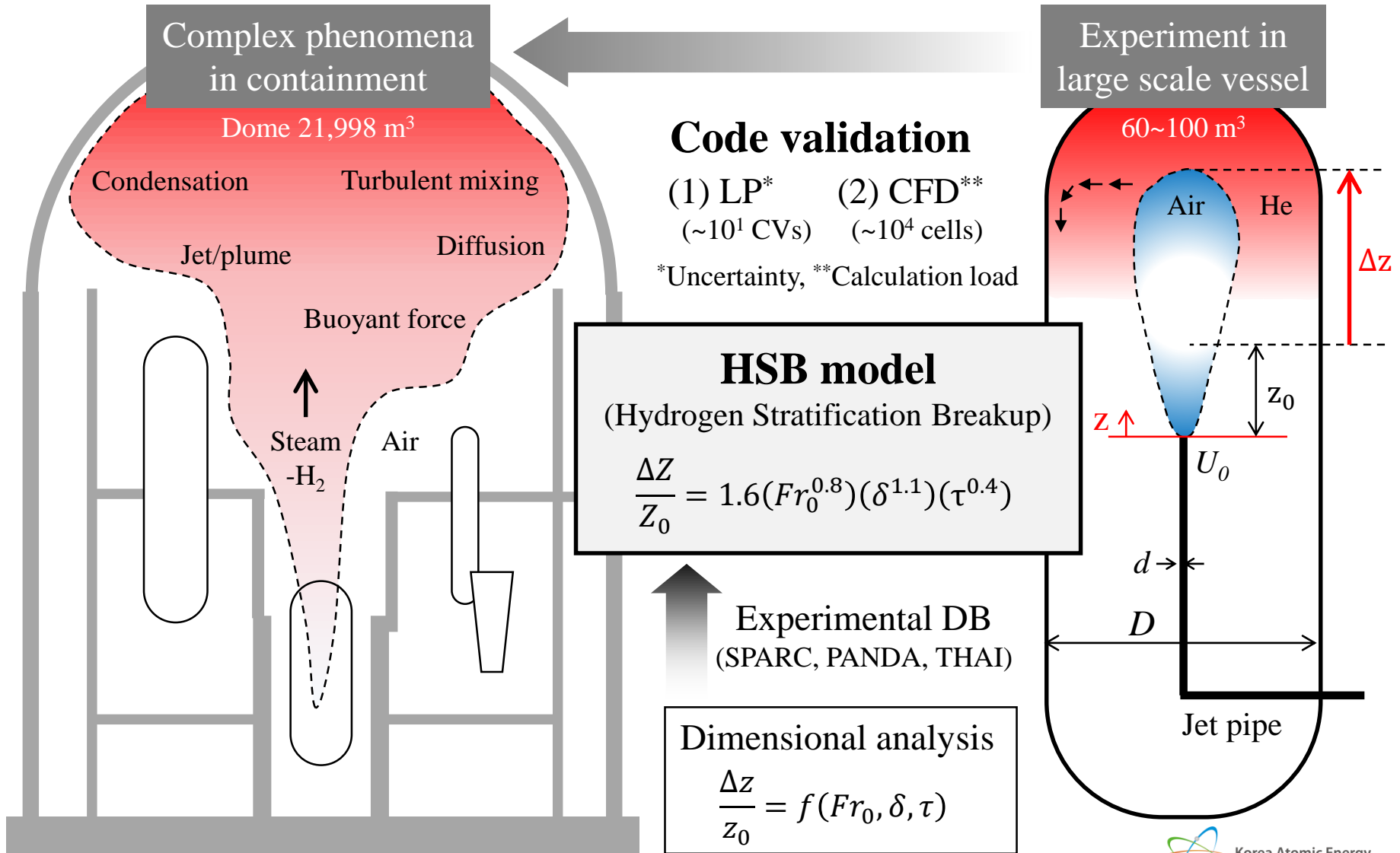
Apply HSB model to assessment of OPR1000 SBLOCA

Youngsu Na

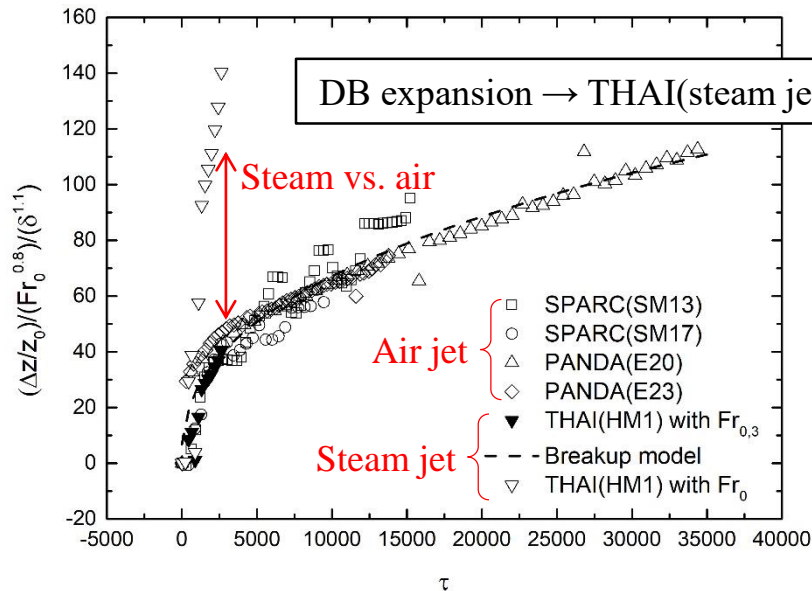
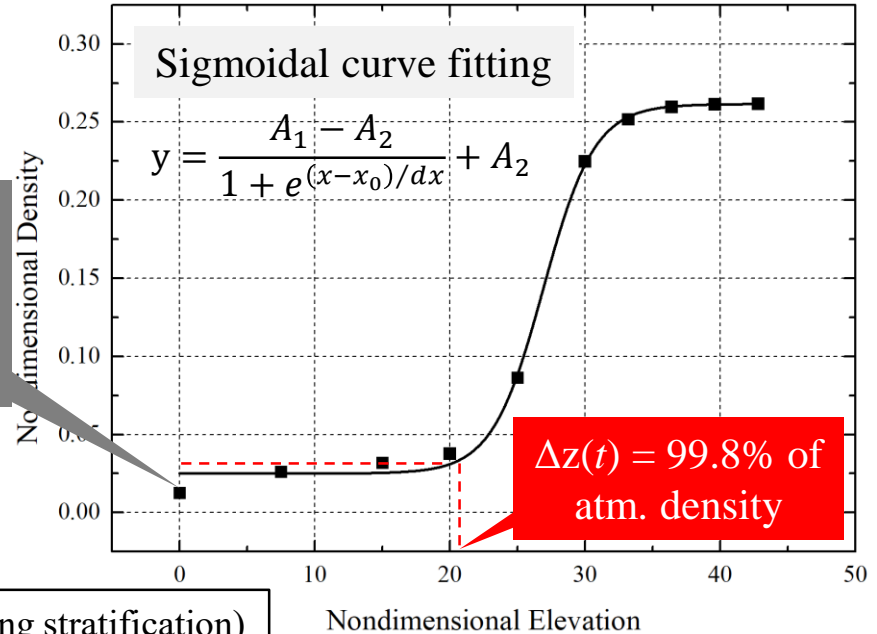
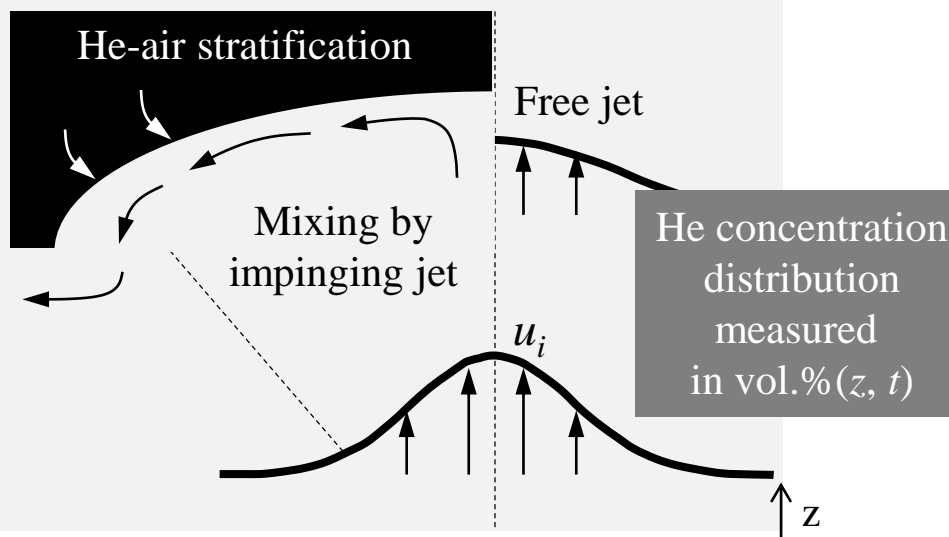
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Hydrogen stratified in containment



Stratification Breakup Model



$$Fr_0 = \sqrt{\frac{U_0^2 \rho_j}{\Delta \rho g z_0}}$$

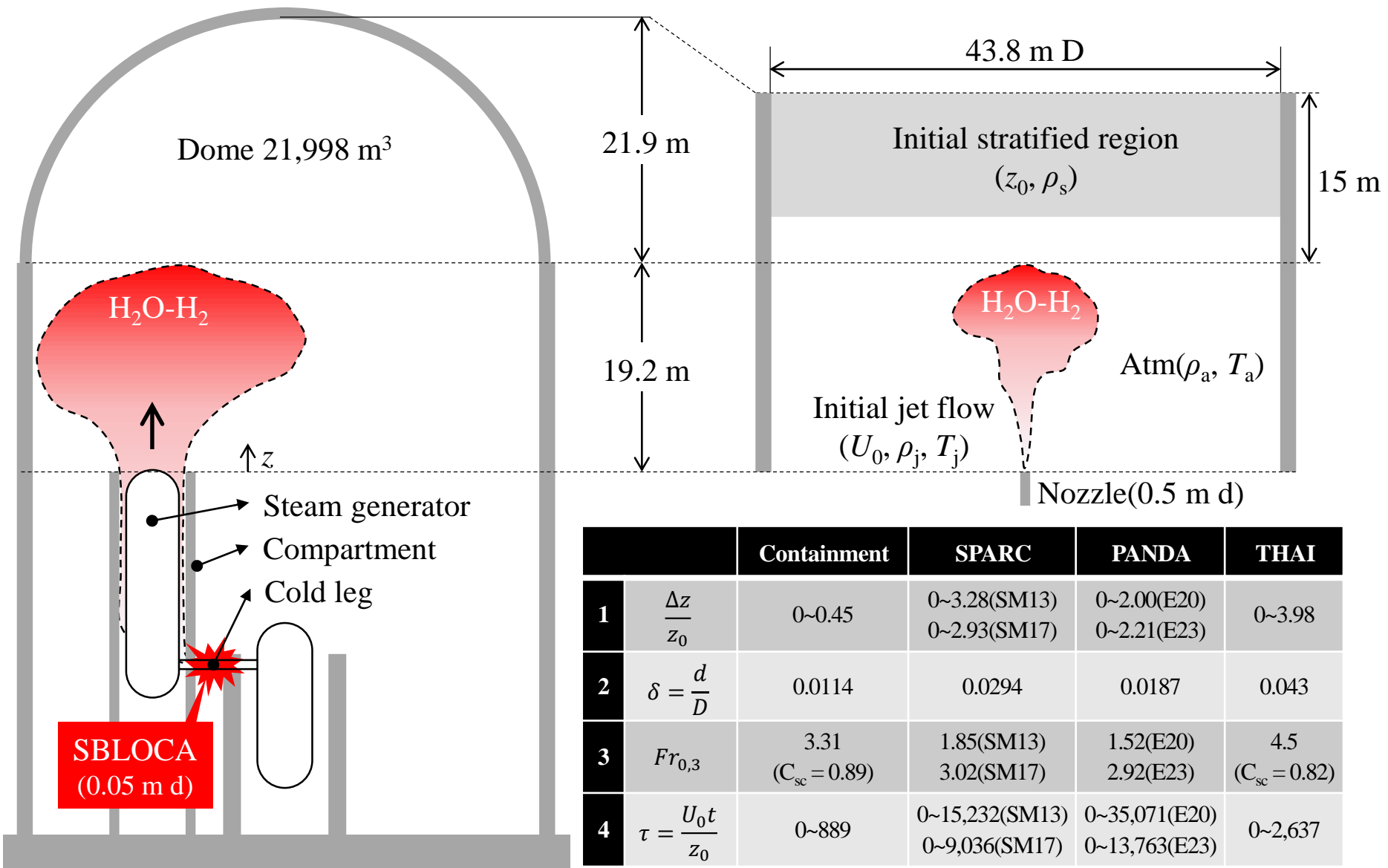
modified for buoyancy and condensation* of steam

$$Fr_{0,3} = \sqrt{\frac{C_{sc} (U_0^2 \rho_j + \Delta \rho_j g d_j)}{\Delta \rho g z_0}}$$

*Correction factor of density reduction

$$C_{sc} = \frac{T_a}{T_{j,0}}$$

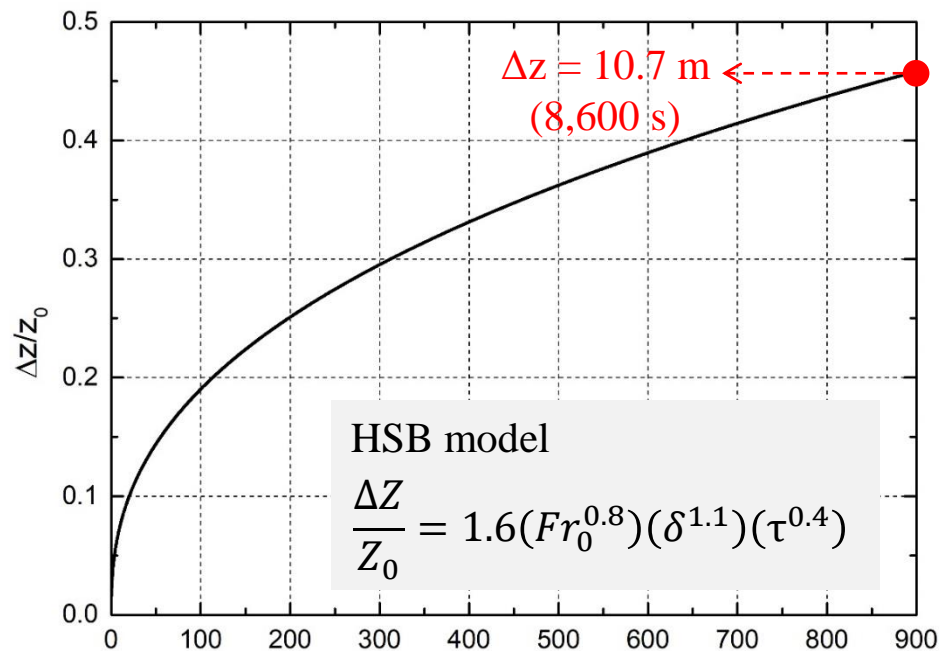
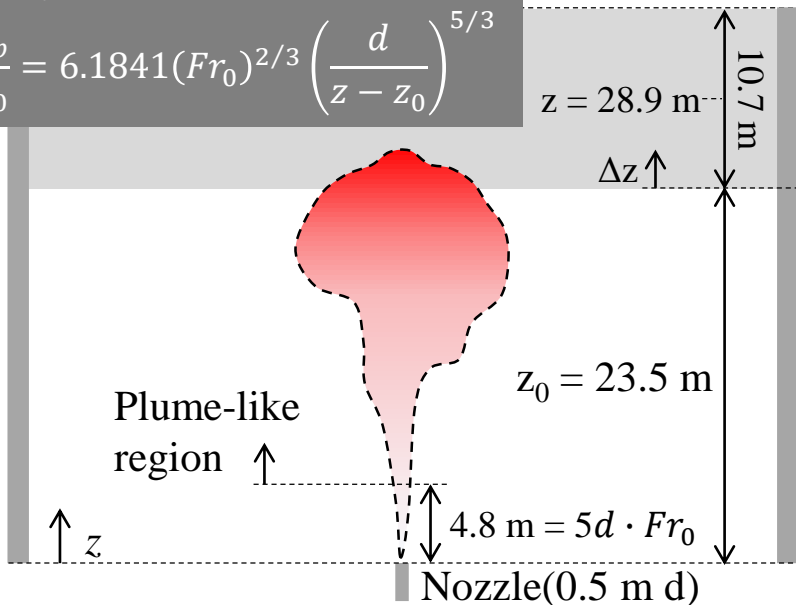
Apply HSB model to OPR1000 SBLOCA



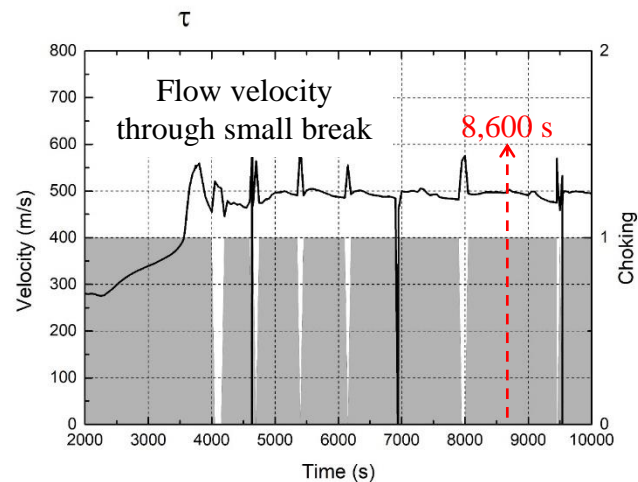
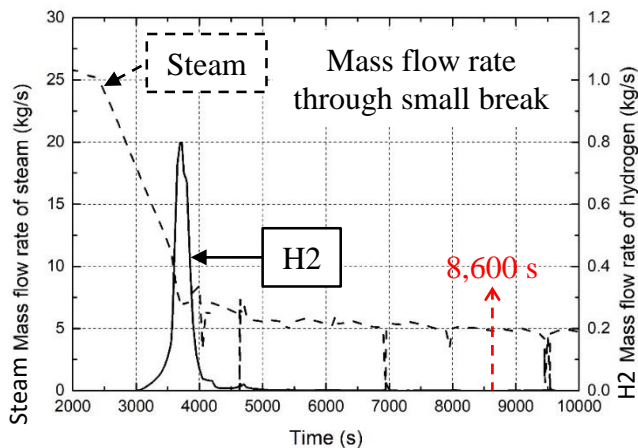
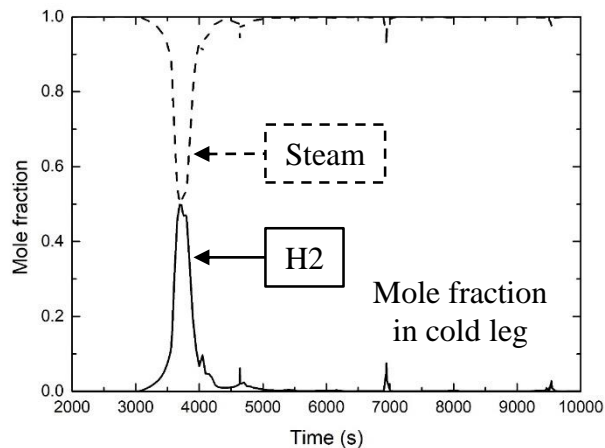
SBLOCA in OPR1000*

Decay rate of concentration

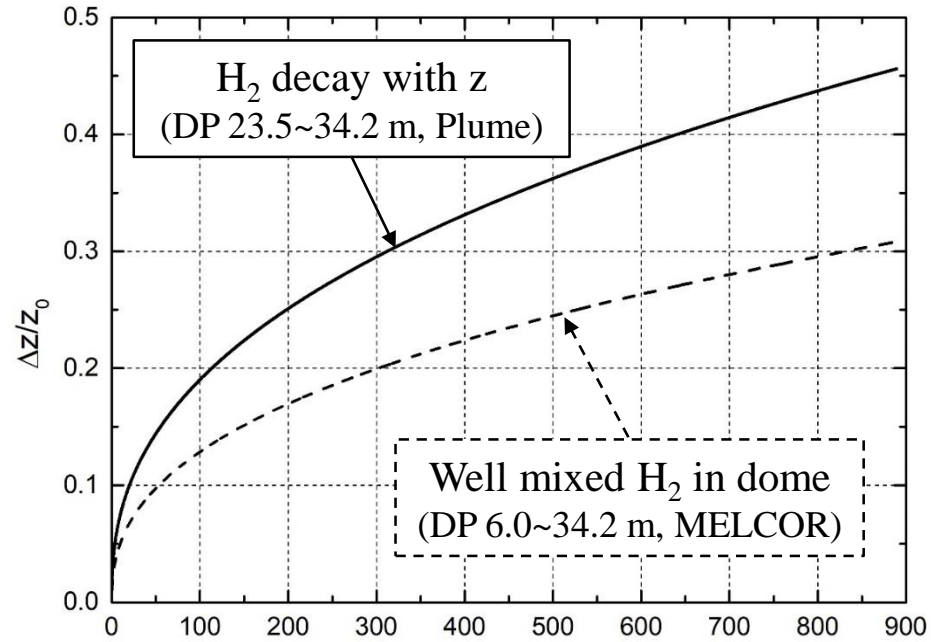
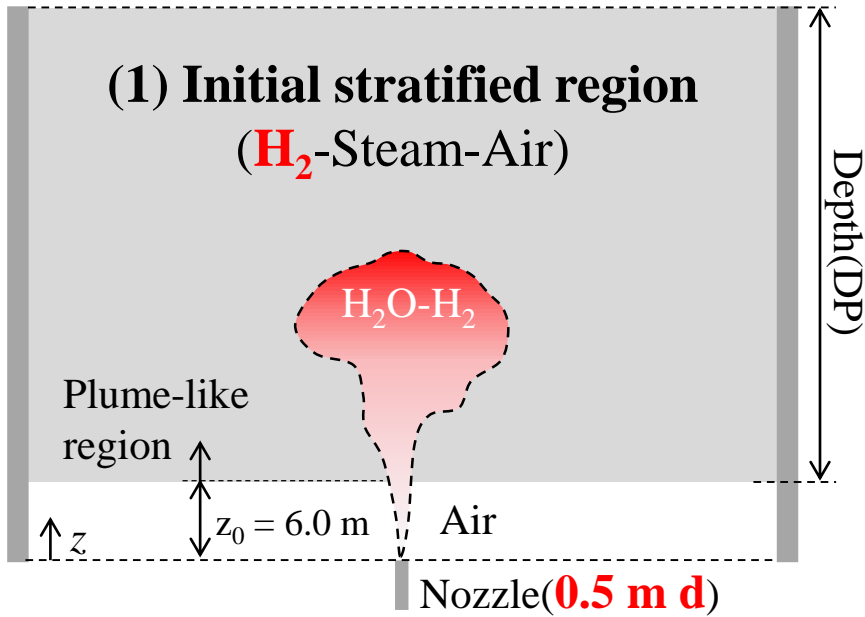
$$\frac{C_p}{C_0} = 6.1841(Fr_0)^{2/3} \left(\frac{d}{z - z_0} \right)^{5/3}$$



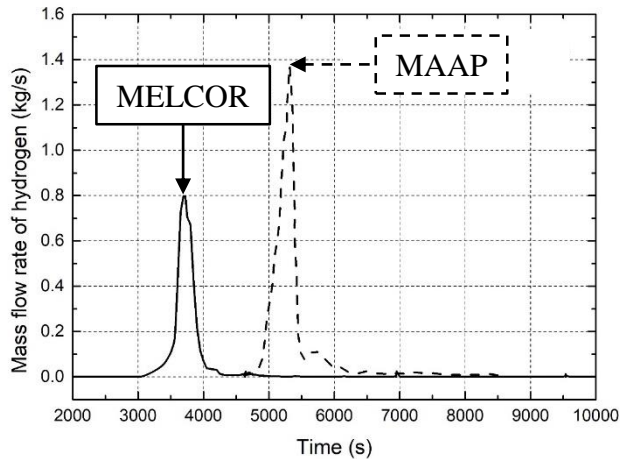
MELCOR calculation*



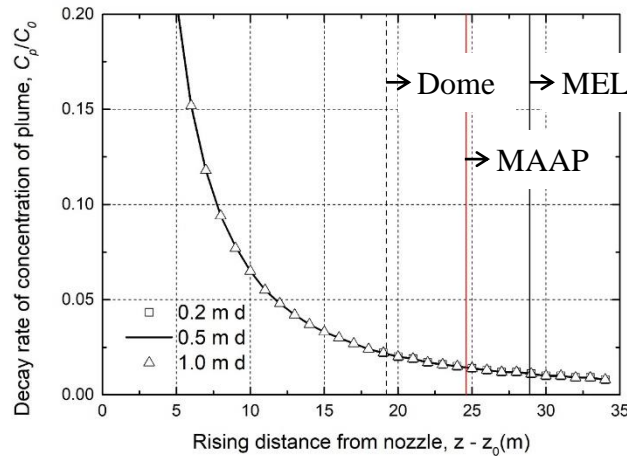
Uncertainty of stratification



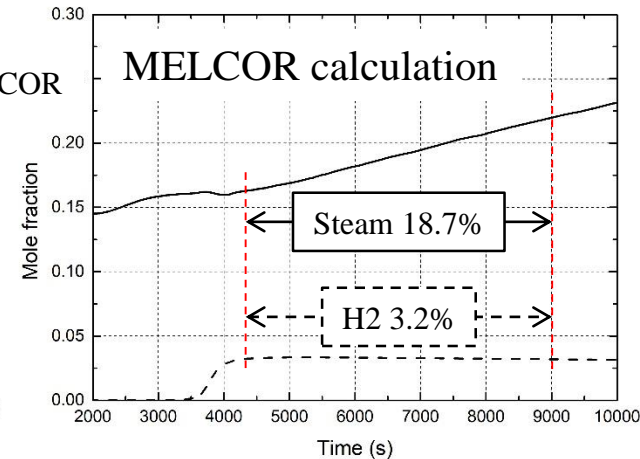
MELCOR vs. MAAP



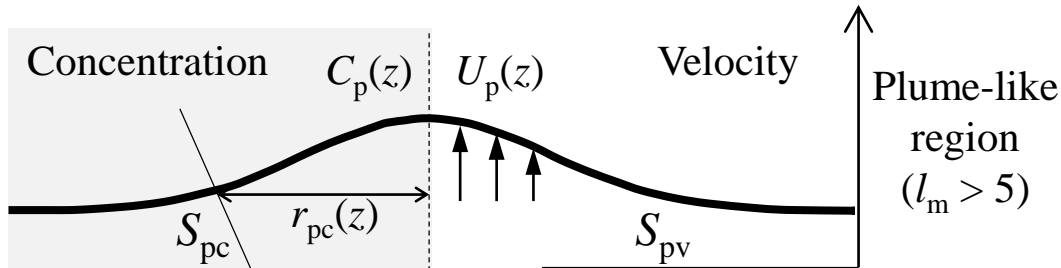
Plume correlation



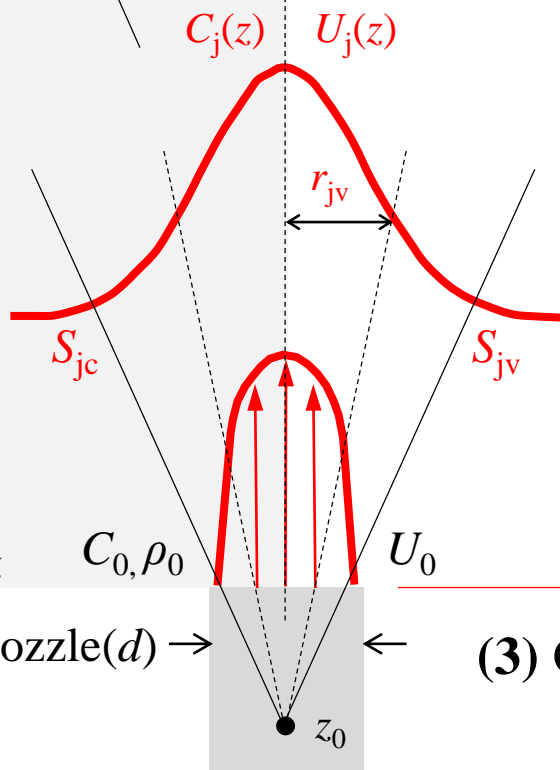
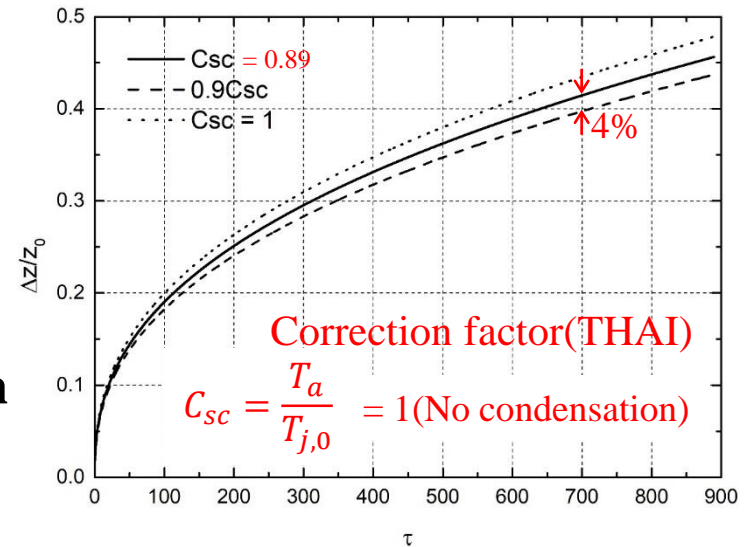
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Uncertainty of plume behavior



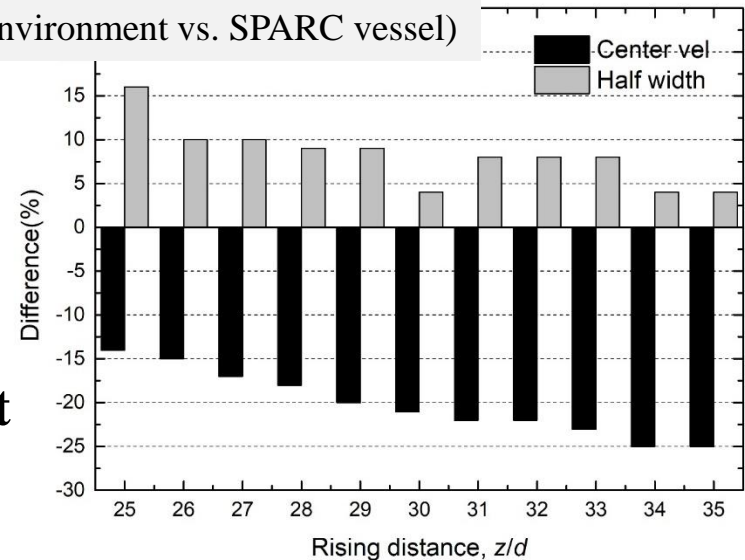
(2) Condensation (H₂-Steam-Air)



Free jet (Infinite environment vs. SPARC vessel)

Jet-like region ($l_m < 0.5$)

(3) Confinement effect (Plume C_p, U_p)



Conclusion and future work

“Development of dimensional analysis for hydrogen behavior in containment under severe accident”

2018(1_{st} year) Experimental database of stratified H₂ mixing by jet⁽¹⁾

2019(2_{nd} year) Dimensional analysis⁽²⁾ $\rightarrow \frac{\Delta Z}{Z_0} = f(Fr_0, \delta, \tau)$

2020(3_{rd} year) H₂ Stratification Breakup model $\rightarrow \frac{\Delta Z}{Z_0} = 1.6(Fr_0^{0.8})(\delta^{1.1})(\tau^{0.4})$

DB expansion \rightarrow Modified Froude number

Apply HSB model to SBLOCA in OPR1000

Uncertainty (1) H₂ stratified in dome, (2) Steam condensation
(3) Confinement effect \rightarrow Validation exp. required

(1)NSTAR-19NS22-13, (2)NSTAR-20NS22-10, Int. J. Heat Mass Trans. 141, 1159-1167(2019), Nucl. Technol. 206, 544-553(2020)

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