AMMONIA BLENDED FUELS – ENERGY SOLUTIONS FOR A GREEN FUTURE

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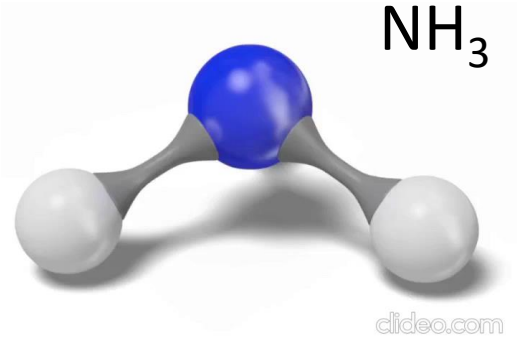
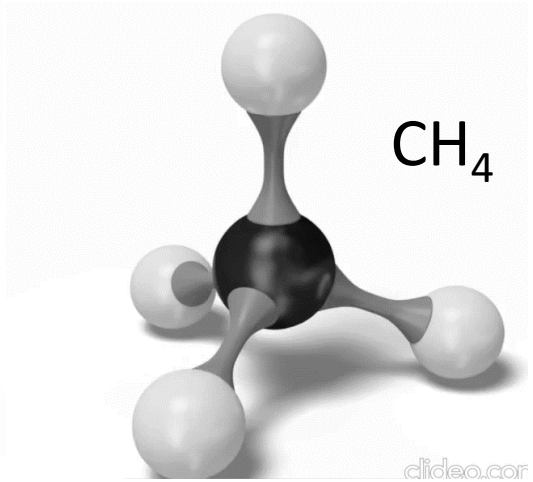
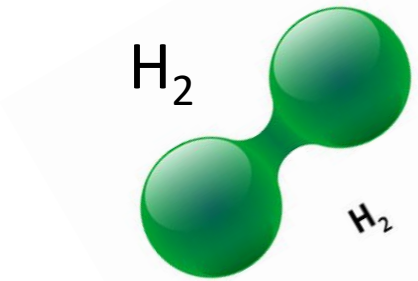
Introduction – Research Aim

- Ammonia (NH_3)
  - Carbon-free energy, H_2 vector
  - **Advantages**
  - **Combustion Challenges**

  <u>Research Aim</u>
  - Fundamental Understanding
  - Applied Challenges
  - Fuel Blending







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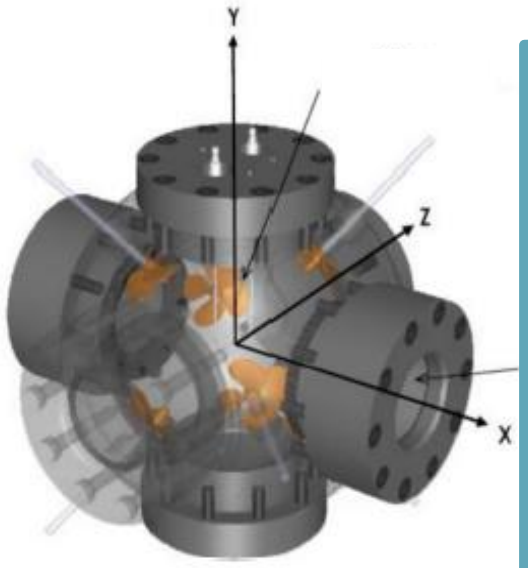
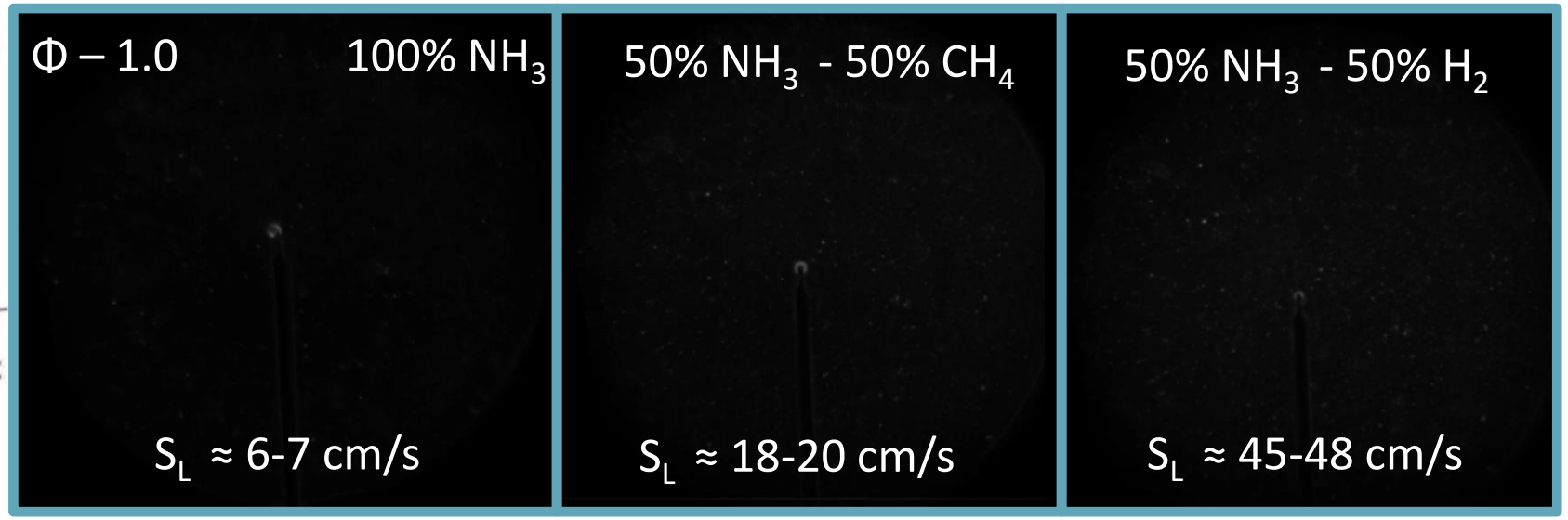
Part I – Fundamental Combustion Characteristics

- Laminar Burning Velocity (S_L)
  - Measurements of U_L – CH_4/NH_3 & H_2/NH_3 (60% vol.%) across Φ

  –Spherical Expanding Flames





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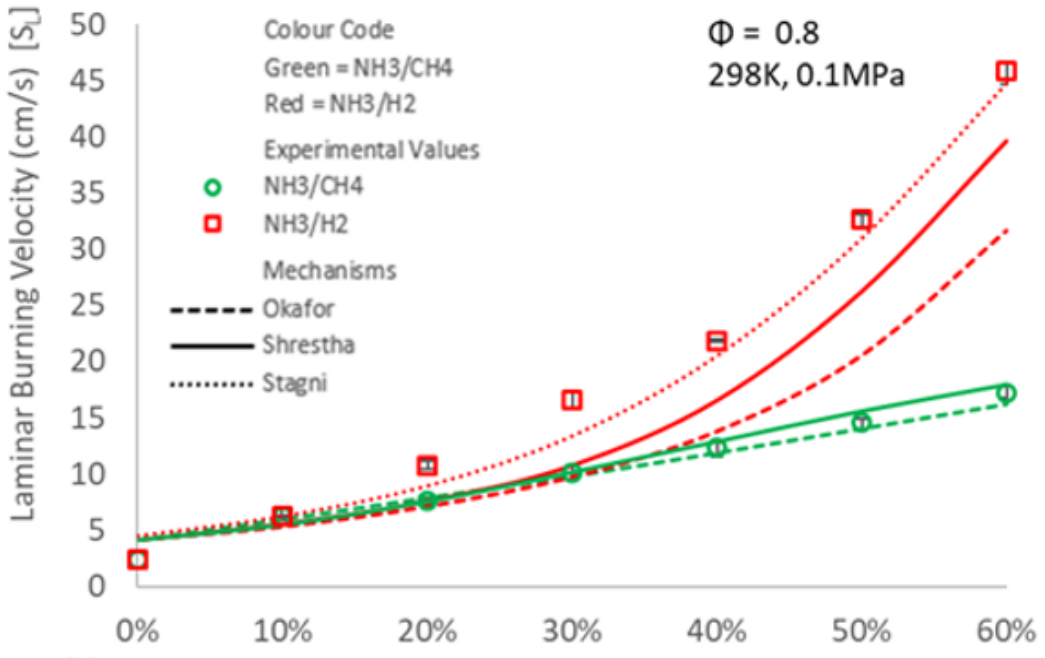
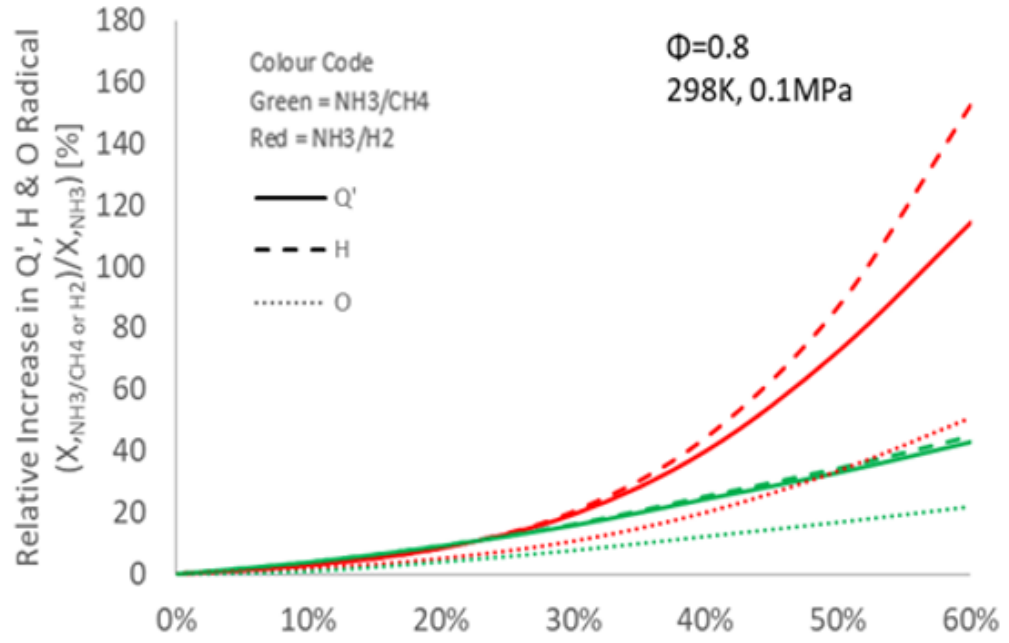
Part I – Fundamental Combustion Characteristics

- CH_4 to NH_3 = Linear enhancement of S_L
- H_2 to NH_3 = Exponential increase in S_L after > 20% H_2

- S_L highly correlated to burning intensity, O and H radical conc.(%), E_a





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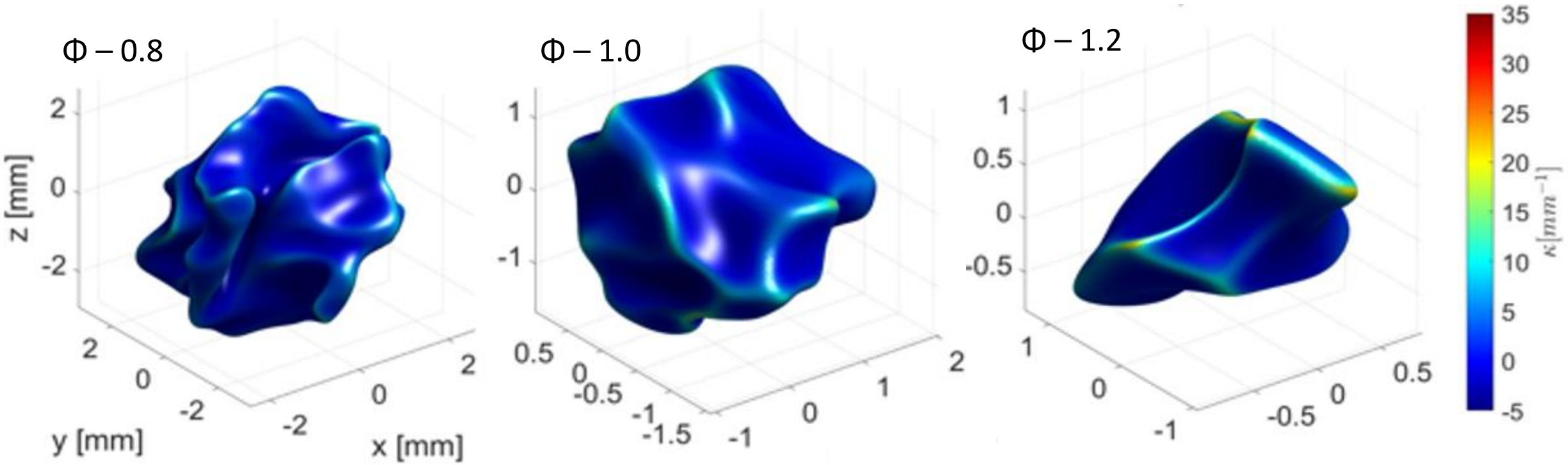
Part II – DNS Modelling of NH_3/H_2 FLAME KERNELS

- DNS Studies – Turbulent 3-D Flame kernels - 50% NH_3 50% H_2
  - Lean flame wrinkled on smaller scale
  - Smooth flame surface for rich case



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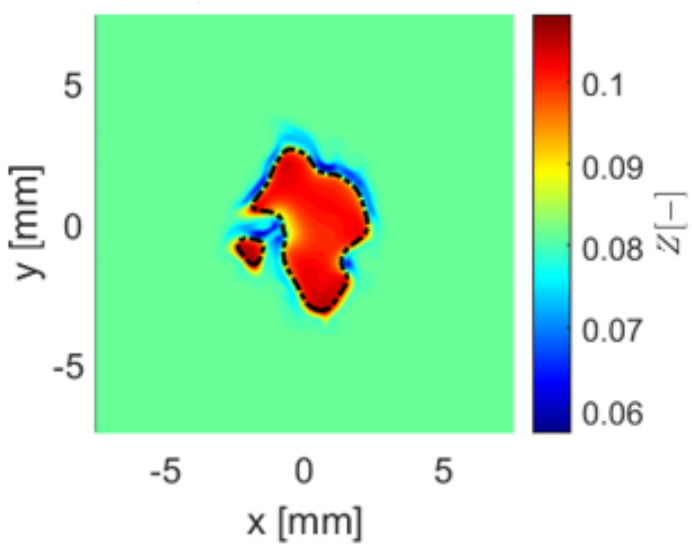
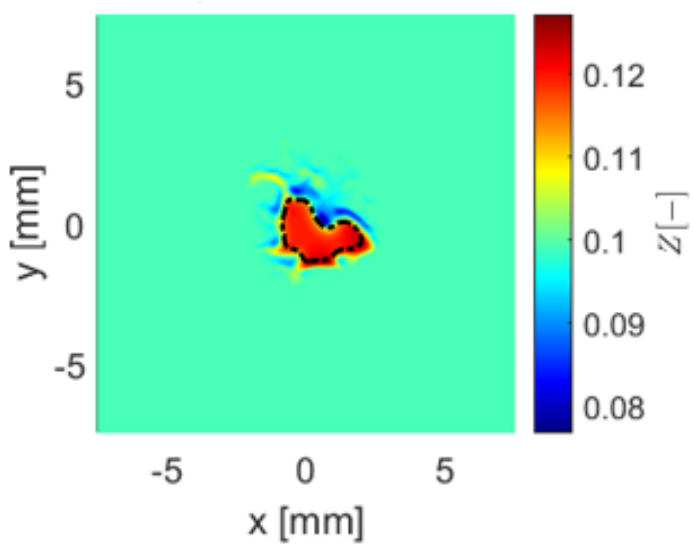
Part II – DNS Modelling of NH_3/H_2 FLAME KERNELS

- Snapshots of the flame at the mid-plane across z-axis
  - Turbulence affects mixture composition at flame front
  - Large disturbances in rich case

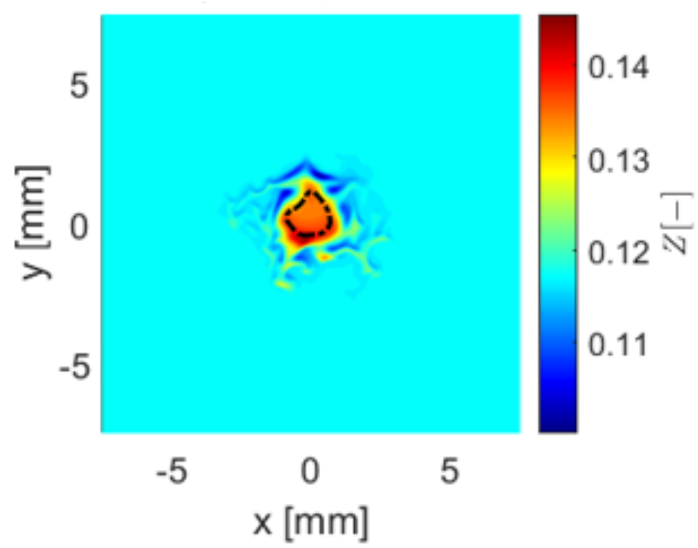
Φ = 0.8 t≈0.75τ



Φ = 1.0 t≈0.75τ



Φ = 1.2 t≈0.75τ



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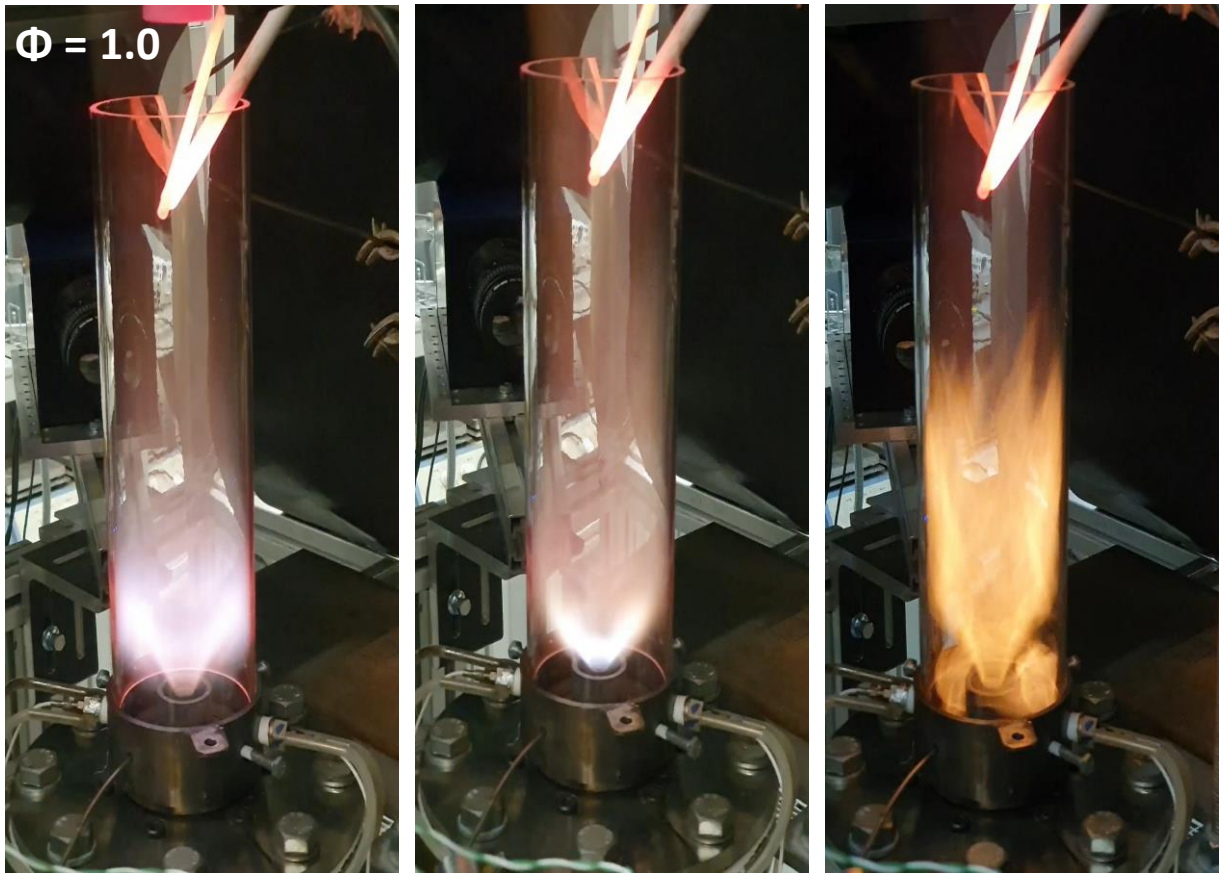
Part III – Tangential Swirl Burner

- Tangential Swirl Burner
  - 10 kW, S_g – 1.05
- $CH_4/NH_3/H_2$ blends, Φ-1.2
- Chemiluminescence
  - OH*, CH*, NH*, NH_2*
- Exhaust emissions
  - NO, NO_2,NH_3,N_2O



$50/50_{VOL\%}$ CH_4/NH_3 **$50/50_{VOL\%}$ H_2/NH_3** **$100_{VOL\%}$ NH_3**

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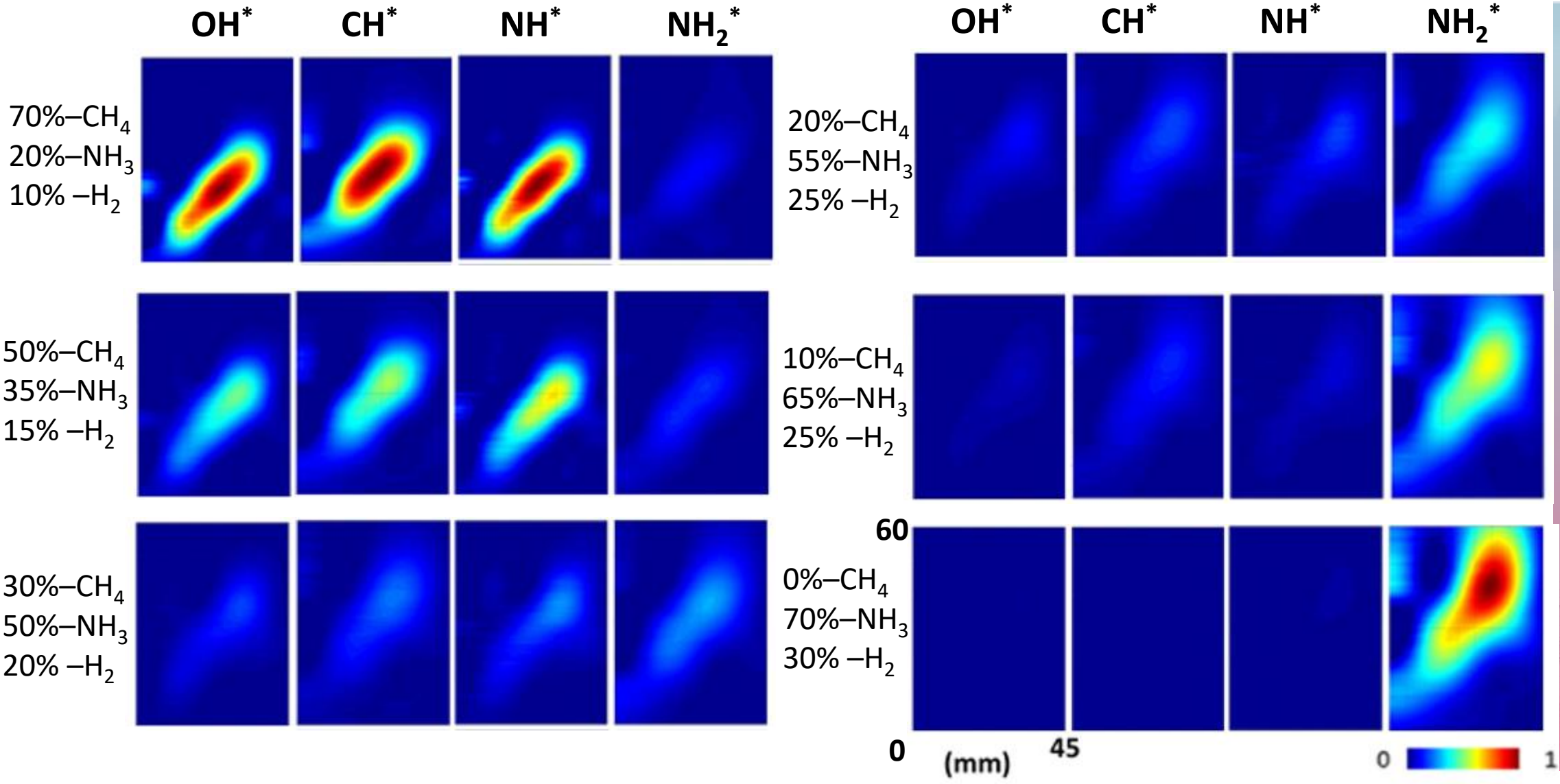
Part III – Tangential Swirl Burner



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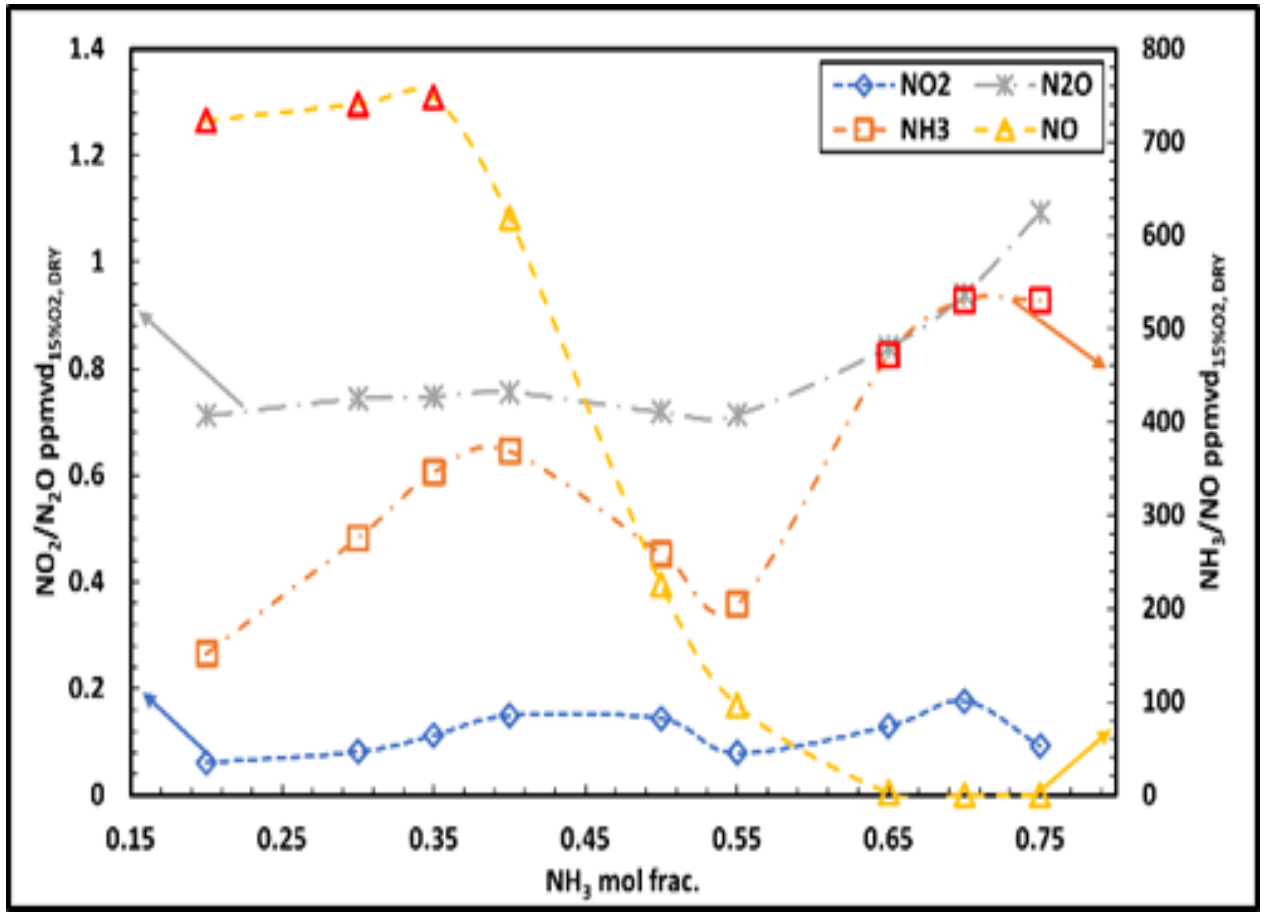
Part III – Tangential Swirl Burner

- NH_3 emissions
  - non-monotonic trend
- NO emissions decreases with increasing NH_3 content in the fuel
- N_2O & NO_2 relatively low



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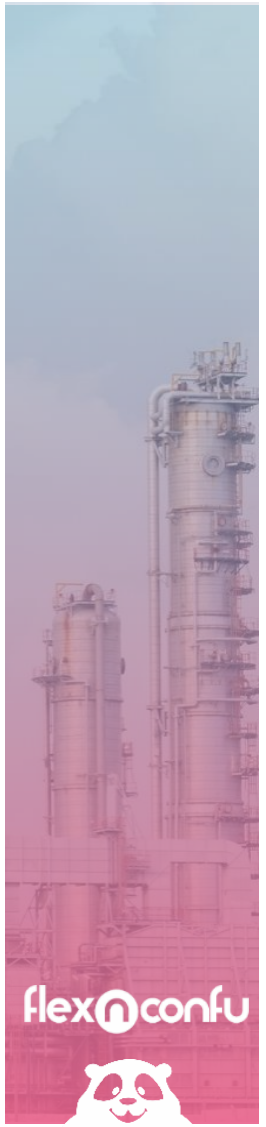
Conclusions & Future Work

- U_L of NH_3 increases linearly with CH_4 addition and exponentially with H_2 addition (>20%)
  - U_L, burning intensity, O & H radical highly correlated
- Modelled 50/50 NH_3/H_2 flames show enhanced small scale wrinkling under lean conditions, opposite for rich case
  - Preferential diffusion
- $CH_4/NH_3/H_2$ - H* important to minimise unburnt NH_3
  - NO decreases with increasing NH_3



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Acknowledgements & Questions

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Thank you for listening and please feel free to ask any questions!