Accident physics – Gas phase
Premixed combustion

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Outline

- Motivation
- Fundamental challenges
- Practical challenges
  - Realistic geometries and scales
  - Validation and predictive capabilities
  - Structural response
- Acknowledgements

Motivation

- We need reliable engineering tools for estimating the consequences of accidental explosions.
- There are still knowledge gaps with respect to relevant fundamental physical phenomena.
- It is not realistic to construct practical engineering tools from first principles by a purely axiomatic approach.
- Experiments are often performed in idealized and downscaled geometries – extrapolation to actual industrial geometries is not straightforward.
- Blind-prediction studies represents an attractive way to evaluate consequence models and drive development.

Geometry with medium level of congestion and low degree of confinement

Fundamental challenges

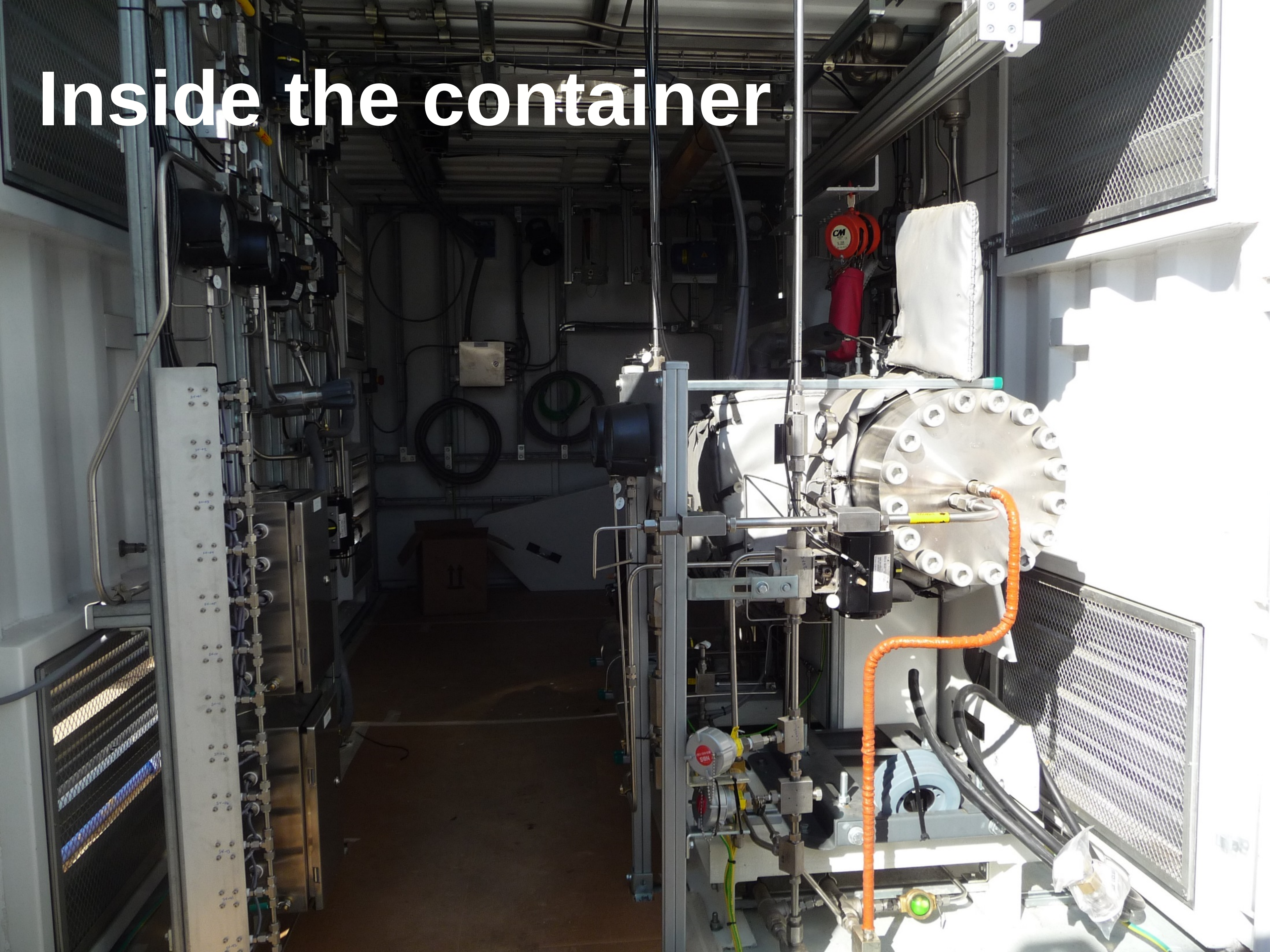
- Correlations for turbulent burning velocity
  - Laminar burning velocity for entire combustible range?
  - Markstein numbers/lengths for entire combustible range?
  - Markstein numbers for mixtures of hydrogen and other fuels?
  - The relative effect of other flame instabilities (than turbulence) on flame acceleration in complex geometries?
  - Reliable measurements of turbulence length scales (or spectrum)?
  - Effect of turbulence length scale on combustion?
- Deflagration-to-detonation transition (DDT)
  - Effect of spatial scale on DDT in congested geometries?

Practical challenges

- Realistic geometries
  - Effect of obstacles on flame acceleration
  - Effect of spatial scale on flame propagation
- Structural response and projectiles
  - Structural response is an inherent part of many accident scenarios
  - Projectiles may extend the safety distance beyond estimates based on flame length and decay of blast waves
- Modelling capabilities
  - Realistic representation of complex geometries
  - Blind-prediction studies for realistic systems

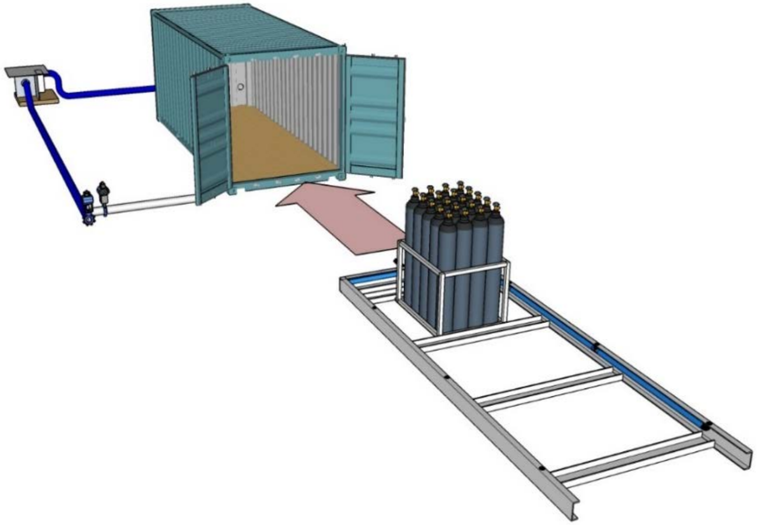
Compressor in ISO container

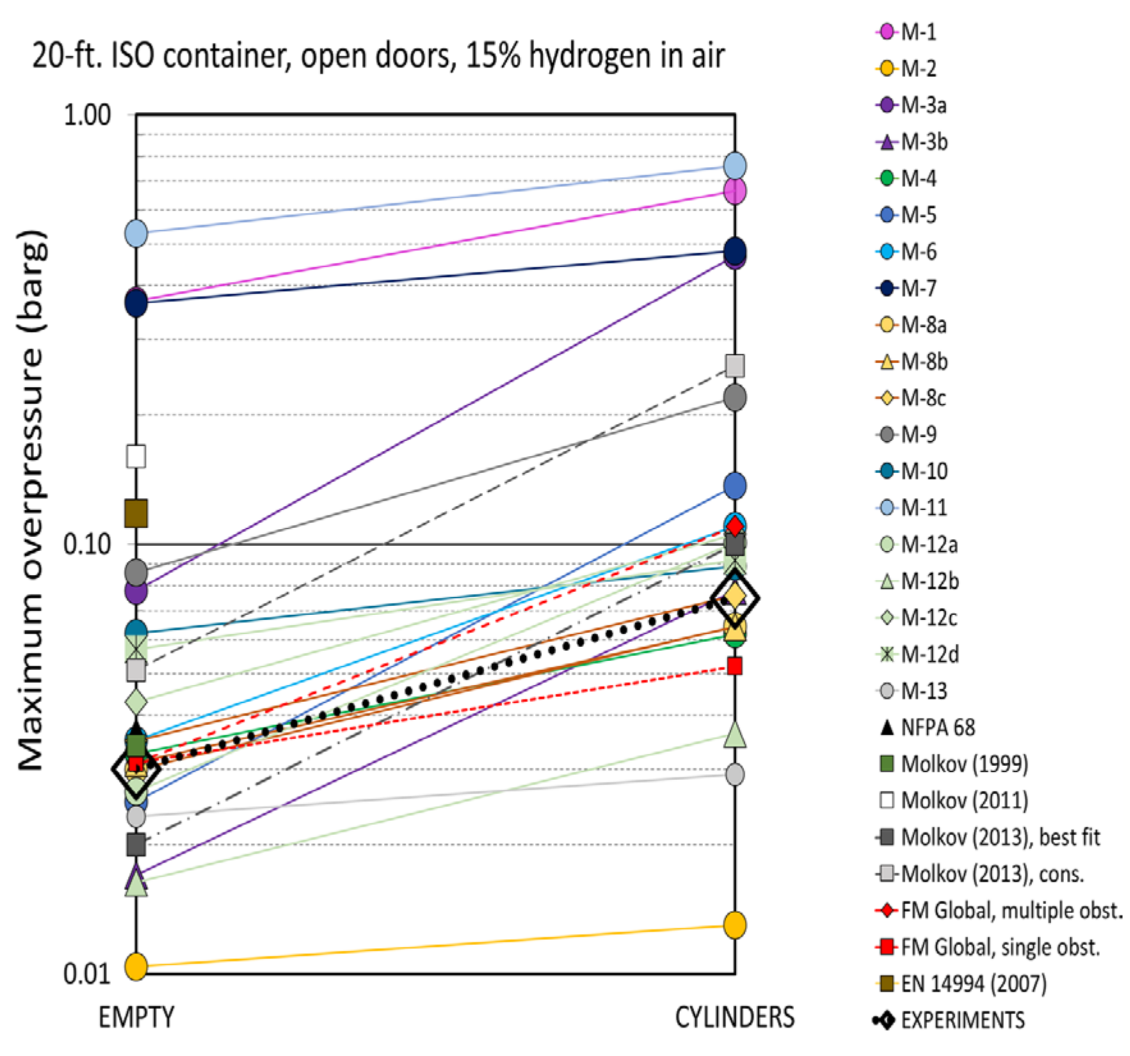
Inside the container



First HySEA blind-prediction

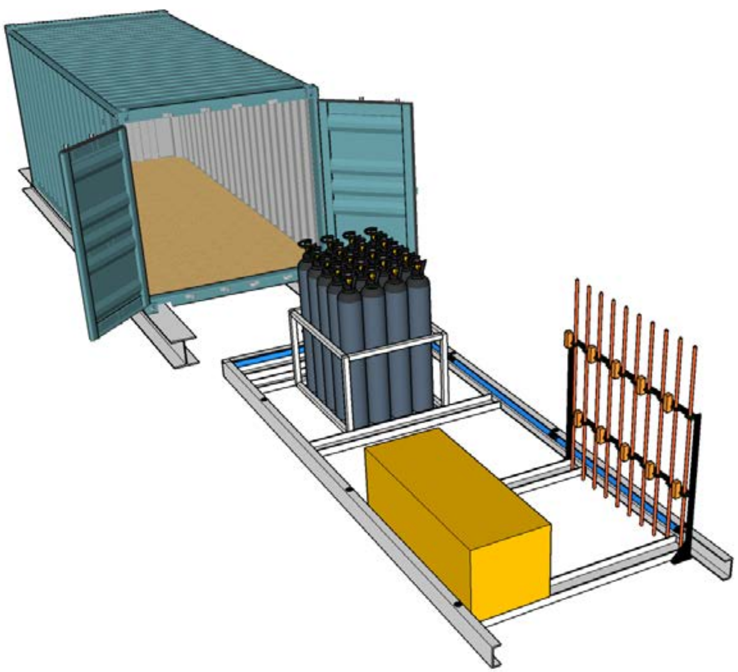
- ► Systematic validation must be an integrated part of model development
- ► Blind-prediction studies can be used to challenge consequence models

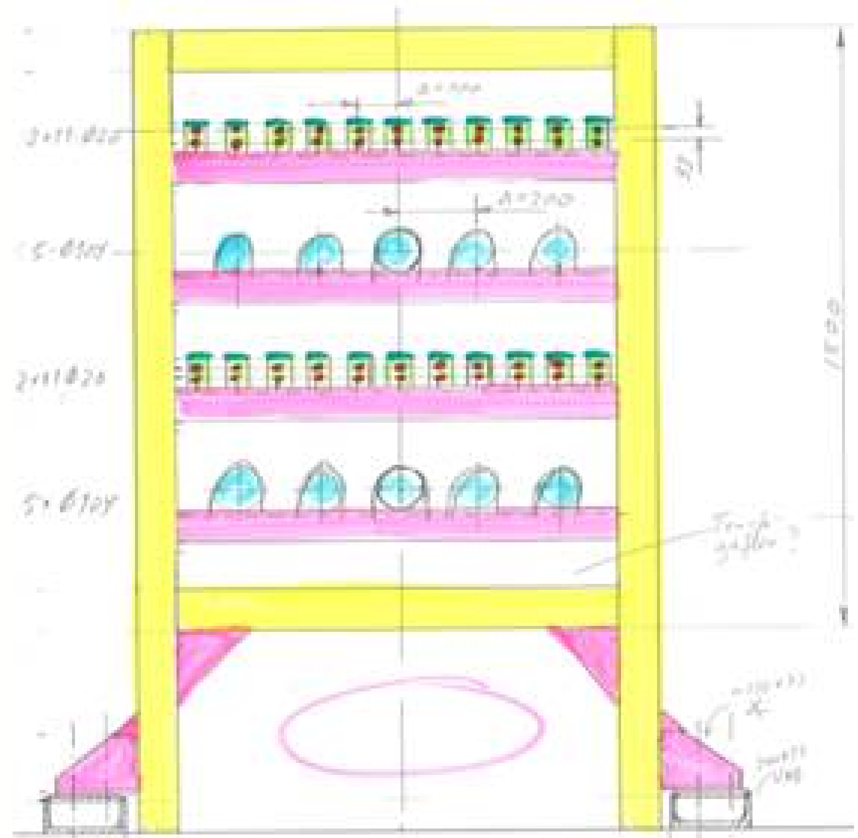




HySEA experiments

- Other obstacles and obstacle configurations
- Commercial vent panels on the roof
- Phase 2: Non-homogeneous clouds





Structural response

Open doors

vs.

Doors closed

Both test performed with 24% H_2 in air, homogeneous mixtures, and closed-end ignition.

www.hysea.eu

Prospects

- White-paper on fire and explosion for the Combustion Institute (on-going and related)
- Risk analysis: design, operation or compliance?

- Hydrogen can be implemented safely, but …
- It is essential to consider safety in early design!
- Do not blindly use/trust standards or guidelines!
  - Verify application range!
  - Consult experts!
  - Manage risk!

Acknowledgements

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Questions (or) **Videos?**

See also: http://syslagronn.no/2016/09/16/syslagronn/her-far-hydrogen-og-luft-kontaineren-til-eksplodere_153864/