

# Wasserstofftechnik – Forschung für Sicherheit (und Transport)

1. Sicherheit von Wasserstoff
2. Integration / Koordination internationaler  
Sicherheitsforschung mit „HySafe“
3. Ausbildungsangebote

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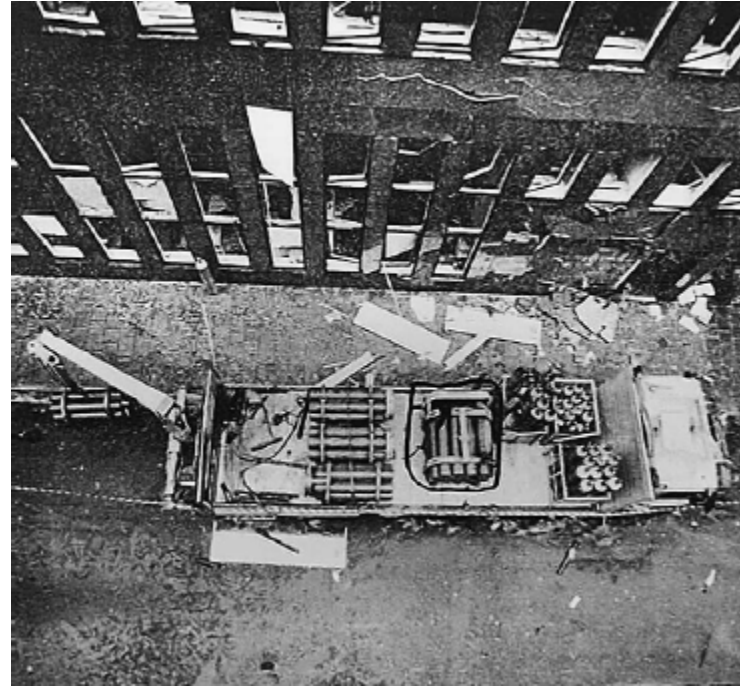
# UNFÄLLE MIT WASSERSTOFF

Norwegen 1984



Detonation von ~5 kg,  
2 Tote, Zerstörung  
des gesamten  
Industriegebäudes

Stockholm 1984



H<sub>2</sub>-Quelle 180 Nm<sup>3</sup>  
16 Verletzte, beschädigte  
Fahrzeuge u. Gebäude  
im Umkreis von 90 m

Köln 2005

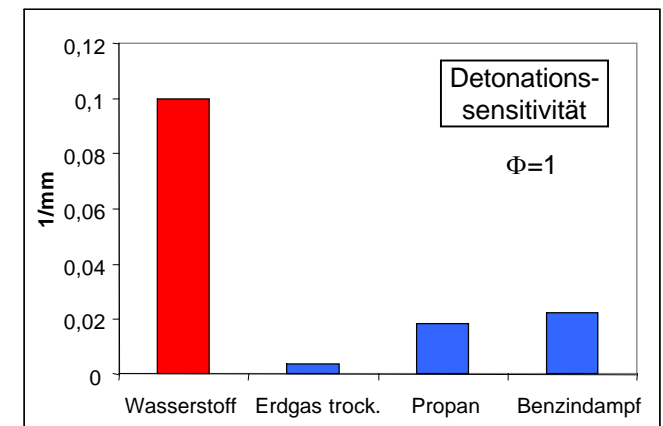
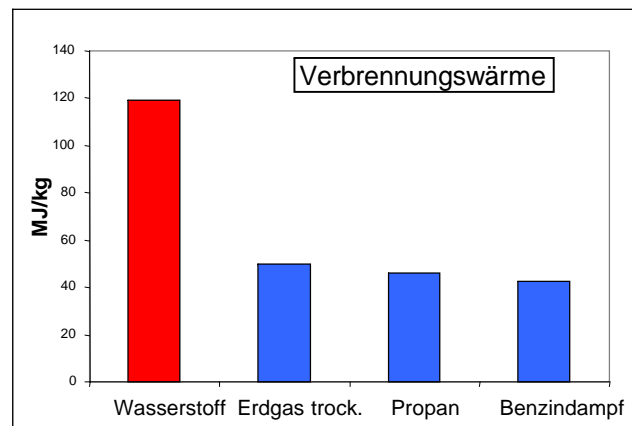
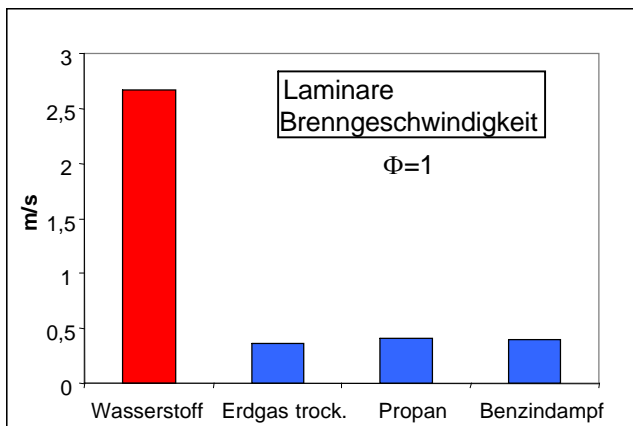
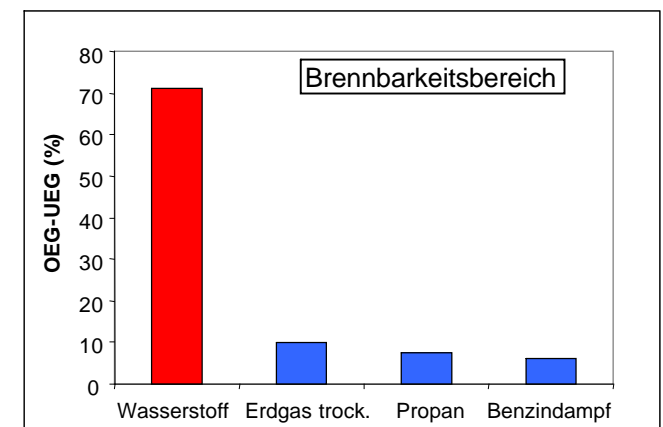
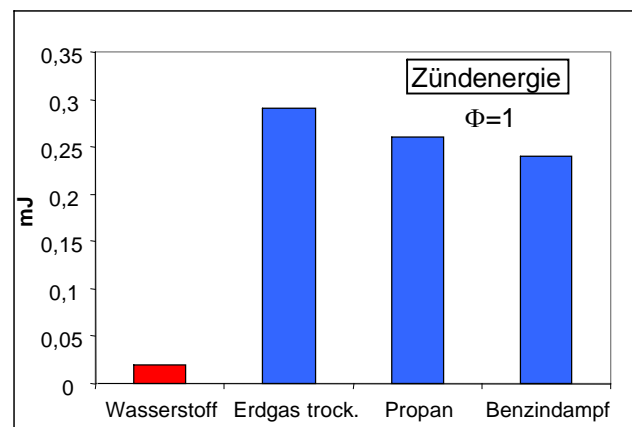
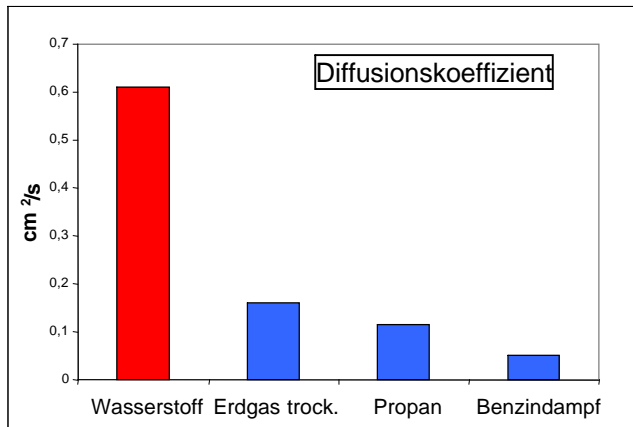
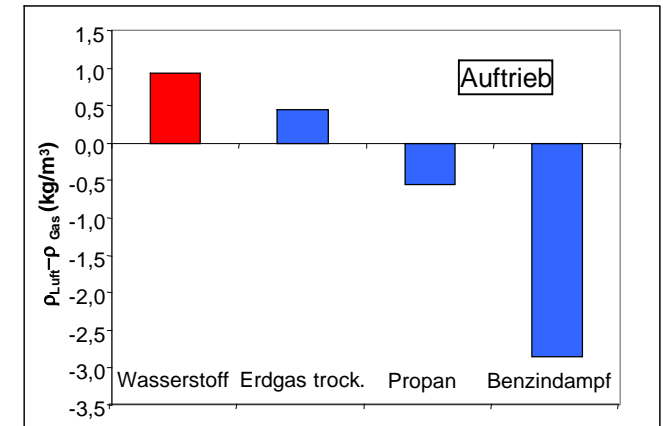
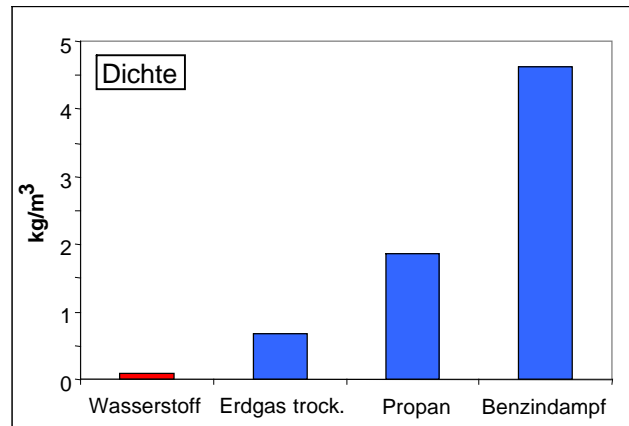


Was wäre wenn...?

# SICHERHEITSRELEVANTE EIGENSCHAFTEN GH<sub>2</sub>

## Sicherheitsrelevante Eigenschaften von

- Wasserstoff
- Erdgas trocken
- Propan
- Benzindampf



# SPEZIFISCHE GEFAHREN MIT LH<sub>2</sub>



- **-253°C** → Kaltverbrennungen, Erfrierungen,  
Materialdegeneration (Tiefkaltversprödung NDTT)
- **780 x Volumenzunahme** beim Verdampfen → Erstickung
- **Pool kann durch Kryopumpeneffekt LO<sub>2</sub> einlagern** →  
Spontanzündungen möglich

# Grösste Unfalldatenbank HySafe/HIAD

ie

Hydrogen Incidents & Accidents Database (HIAD)



> 170 H2 spezifische Fälle

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## HySafe - Hydrogen Incident and Accident Database (HIAD)

Welcome to the H.I.A.D. BETA version!!!!



Courtesy of Holmefjord:  
Livorno Hydrogen Refuelling Station



Courtesy of Gerd Petra Haugom:  
Beijing Hydrogen Refuelling Station



Courtesy of Gerd Petra Haugom:  
Beijing Hydrogen Refuelling Station

Over the last few months JRC and DNV have been working on HIAD application. As you know, the previous-version of the Data Entry Module (DEM) - onl Graphical User Interface (GUI) - was available for comments the last few months. The developed carried out has mainly been related to integrating a new

Done

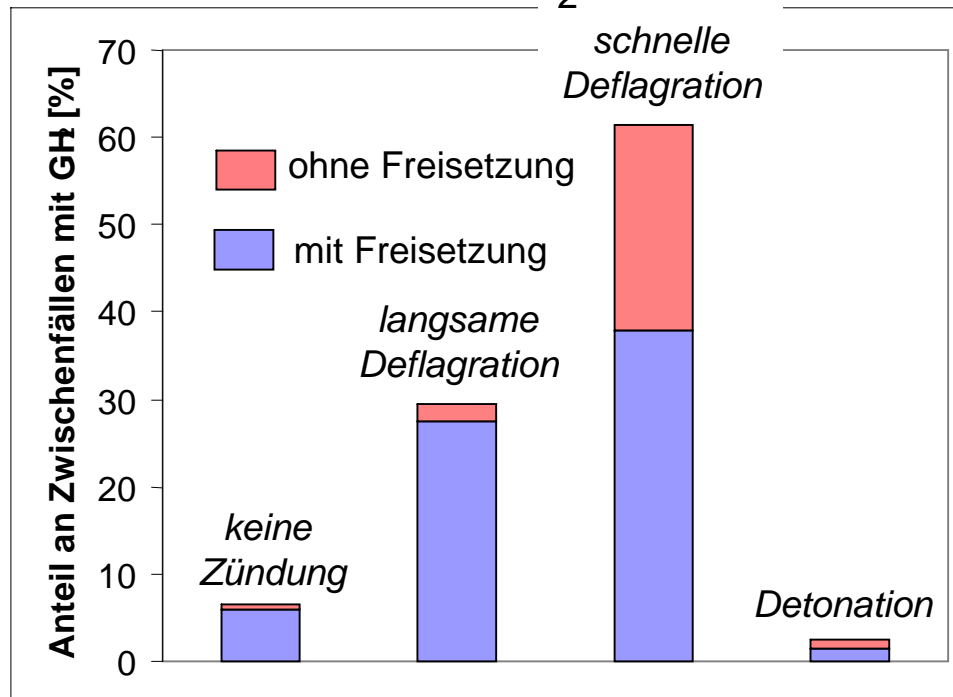
Internet

# ZWISCHENFÄLLE MIT WASSERSTOFF: FOLGEN

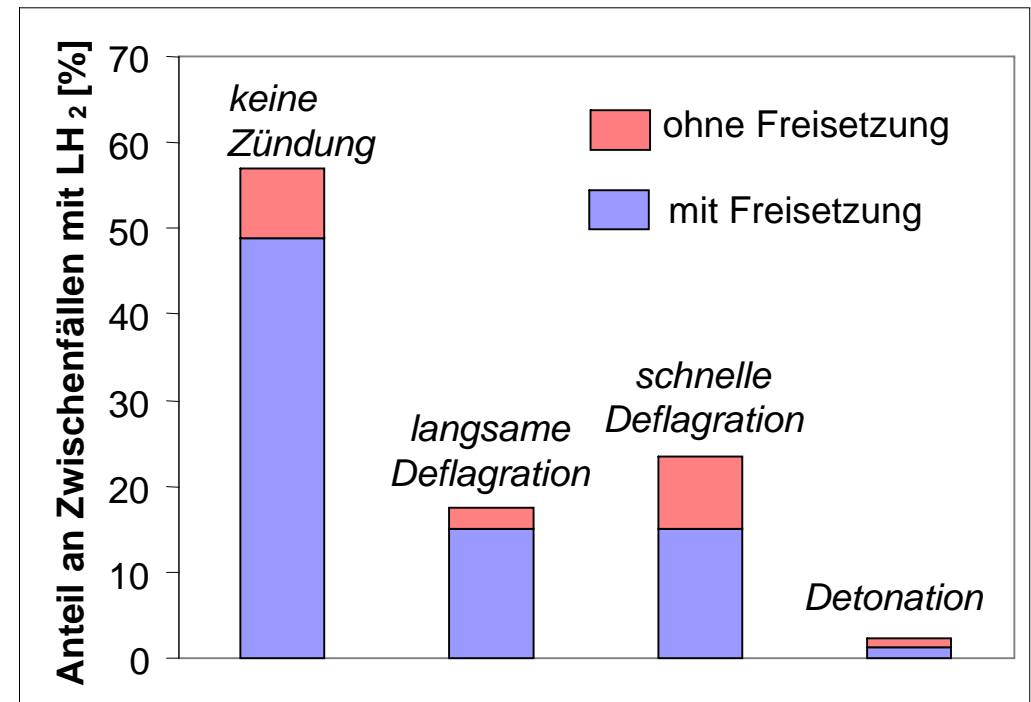
Störfällen werden unterschieden in:

- ohne Freisetzung (Wasserstoff verbleibt in Speicherbehälter oder Prozessanlage)
- mit Freisetzung, (Wasserstoff wird in Umgebung freigesetzt, oder in für Menschen zugängliche Räume)

$\text{GH}_2$

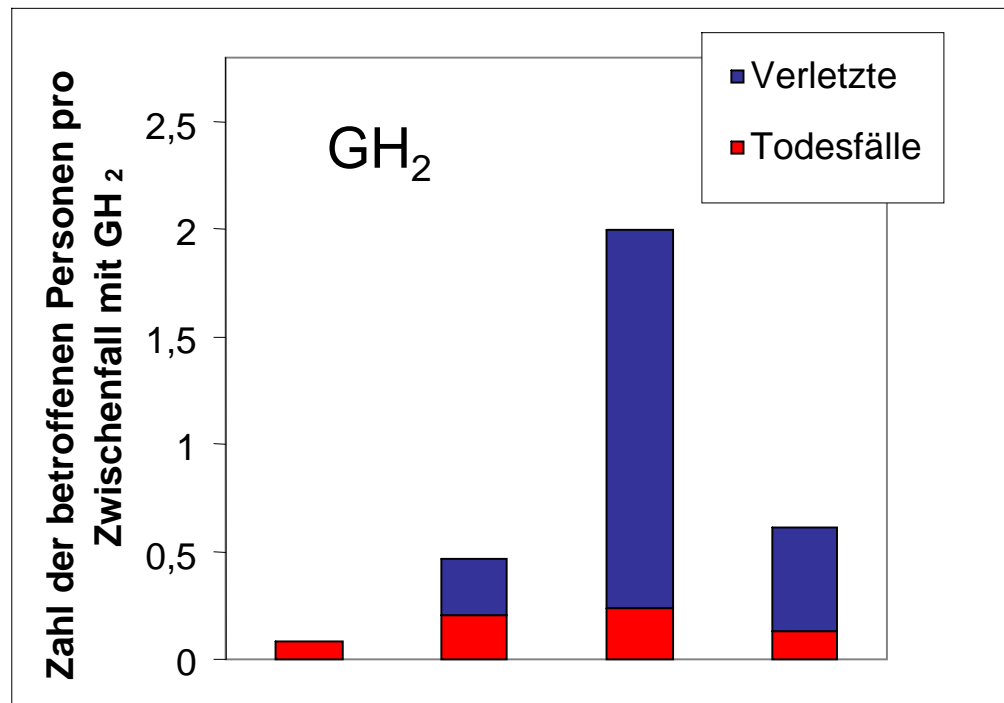


$\text{LH}_2$

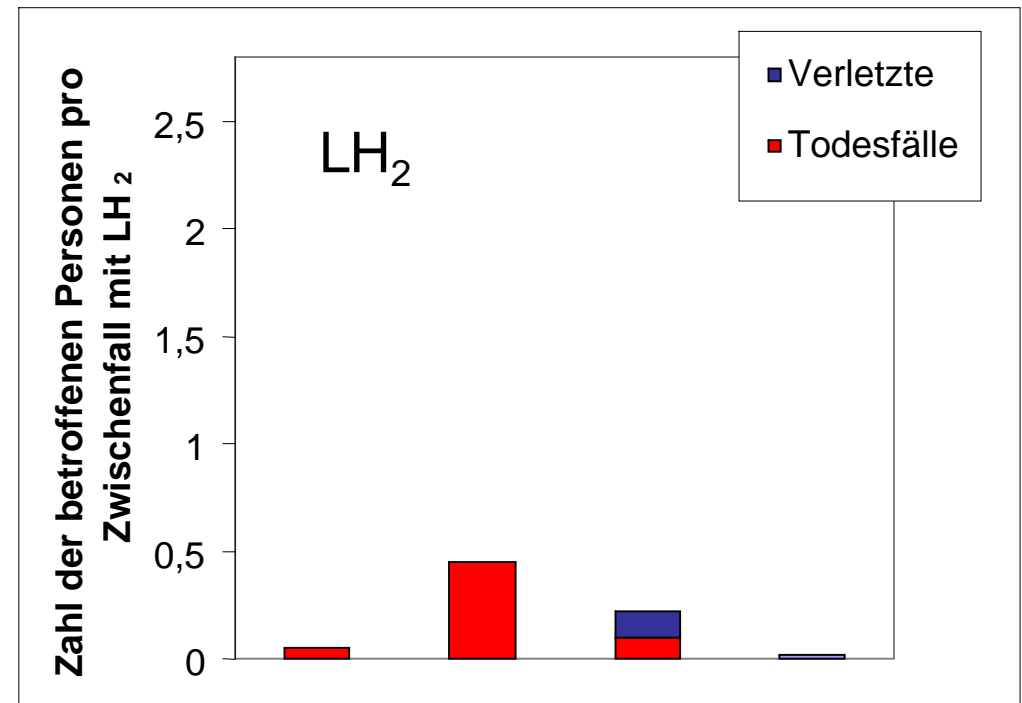


- Zwischenfälle mit  $\text{GH}_2$  führen überwiegend zur Zündung und schnellen Deflagrationen
- Zwischenfälle mit  $\text{LH}_2$  zünden wesentlich seltener als solche mit  $\text{GH}_2$  (Gemischbildung)

# ZWISCHENFÄLLE MIT WASSERSTOFF: PERSONENSCHÄDEN



Freisetzung ohne Zündung    Freisetzung und Feuer    Freisetzung und Explosion    Keine Freisetzung



Freisetzung ohne Zündung    Freisetzung und Feuer    Freisetzung und Explosion    Keine Freisetzung

- Wesentlich weniger Verletzte mit  $\text{LH}_2$  als mit  $\text{GH}_2$ , aber vergleichbare Anzahl an Todesopfern
- Fazit: Es treten alle Verbrennungsregimes auf, Konsequenzen hängen von vielen verschiedenen Einflussparametern ab, systematische Analyse notwendig

# Integration der EU Forschung über das NoE HySafe

## Consortium

- 24 partners from 12 European countries incl. Russia (Kurchatov Institute) and one Canadian partner (University of Calgary)
- 13 public research organisations, 7 industrial partners, 5 universities
- ~150 scientists involved



## Budget

Total > 13 M€ with a EC grant of max. 7 M€

## Time schedule

network/project start: 03/2004

subsidised max. duration: 5 years

→ 02/2009 activities transferred to the  
International Association “HySafe”

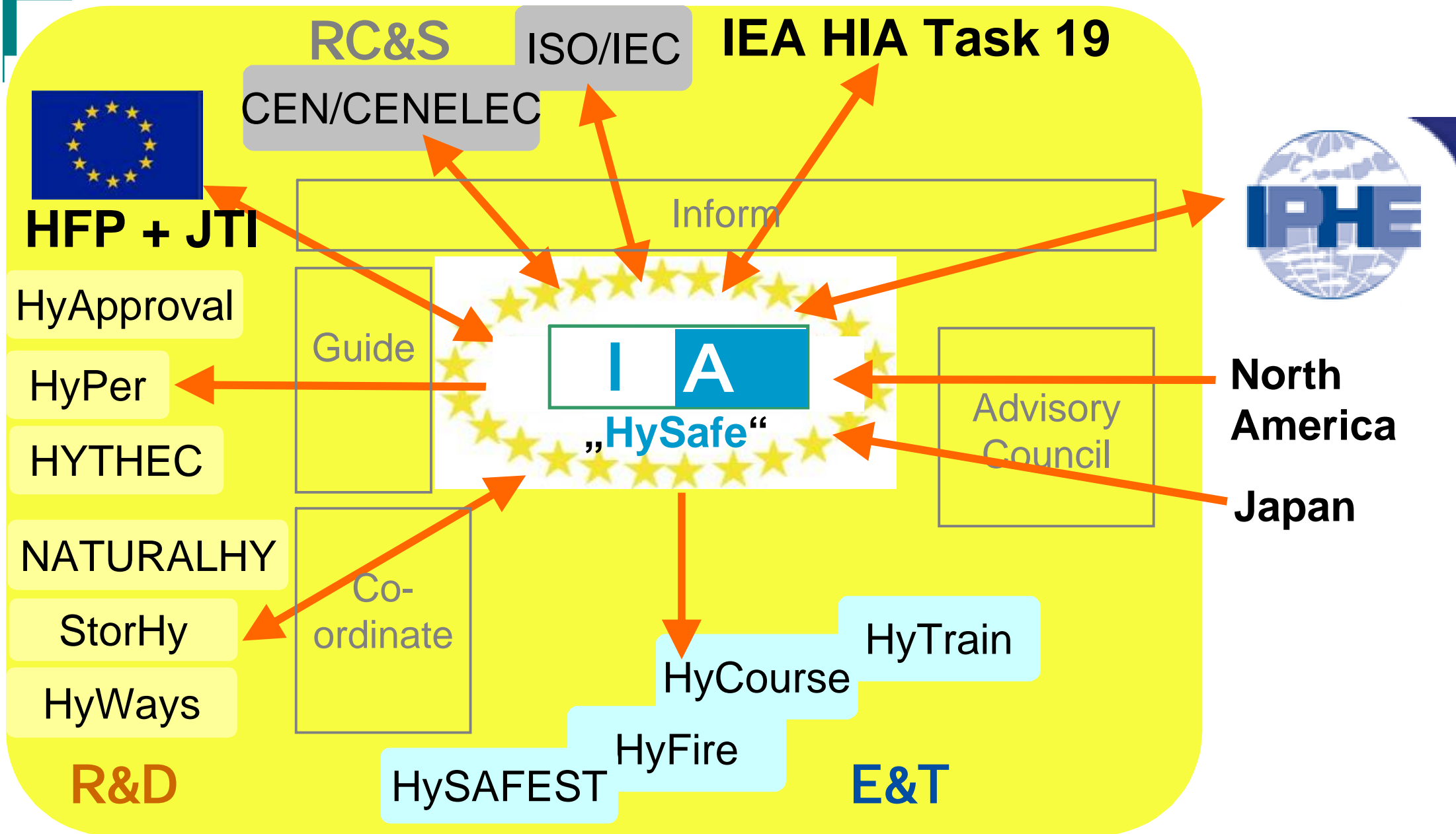


# HySafe Consortium



Forschungszentrum Karlsruhe GmbH	DE
L'Air Liquide	FR
Federal Inst for Materials Research and Testing	DE
BMW Forschung und Technik GmbH	DE
Building Research Establishment Ltd	UK
Commissariat à l'Energie Atomique	FR
Det Norske Veritas AS	NO
Fraunhofer-Gesellschaft ICT	DE
Forschungszentrum Jülich GmbH	DE
GexCon AS	NO
The UKs Health and Safety Laboratory	UK
Foundation INASMET	ES
Inst Nat de l'Environm industriel et des RISques	FR
European Commission - JRC - Inst for Energy	NL
National Center for Scientific Research Demokritos	EL
Norsk Hydro ASA	NO
Risø National Laboratory	DK
TNO	NL
University of Calgary	CA
University of Pisa	IT
Universidad Politécnica de Madrid	ES
University of Ulster	UK
VOLVO Technology Corporation	SE
Warsaw University of Technology	PL
Russian Research Centre Kurchatov Institute	RUS

# Internationale Einbettung von HySafe



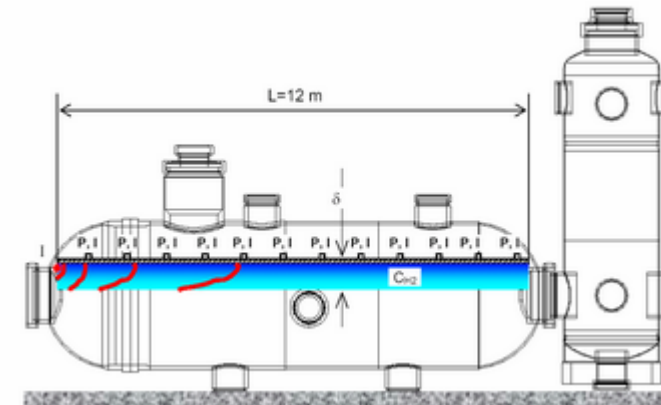
# Research Headlines

## ➤ (Partially) Confined Releases ➤ Mitigation

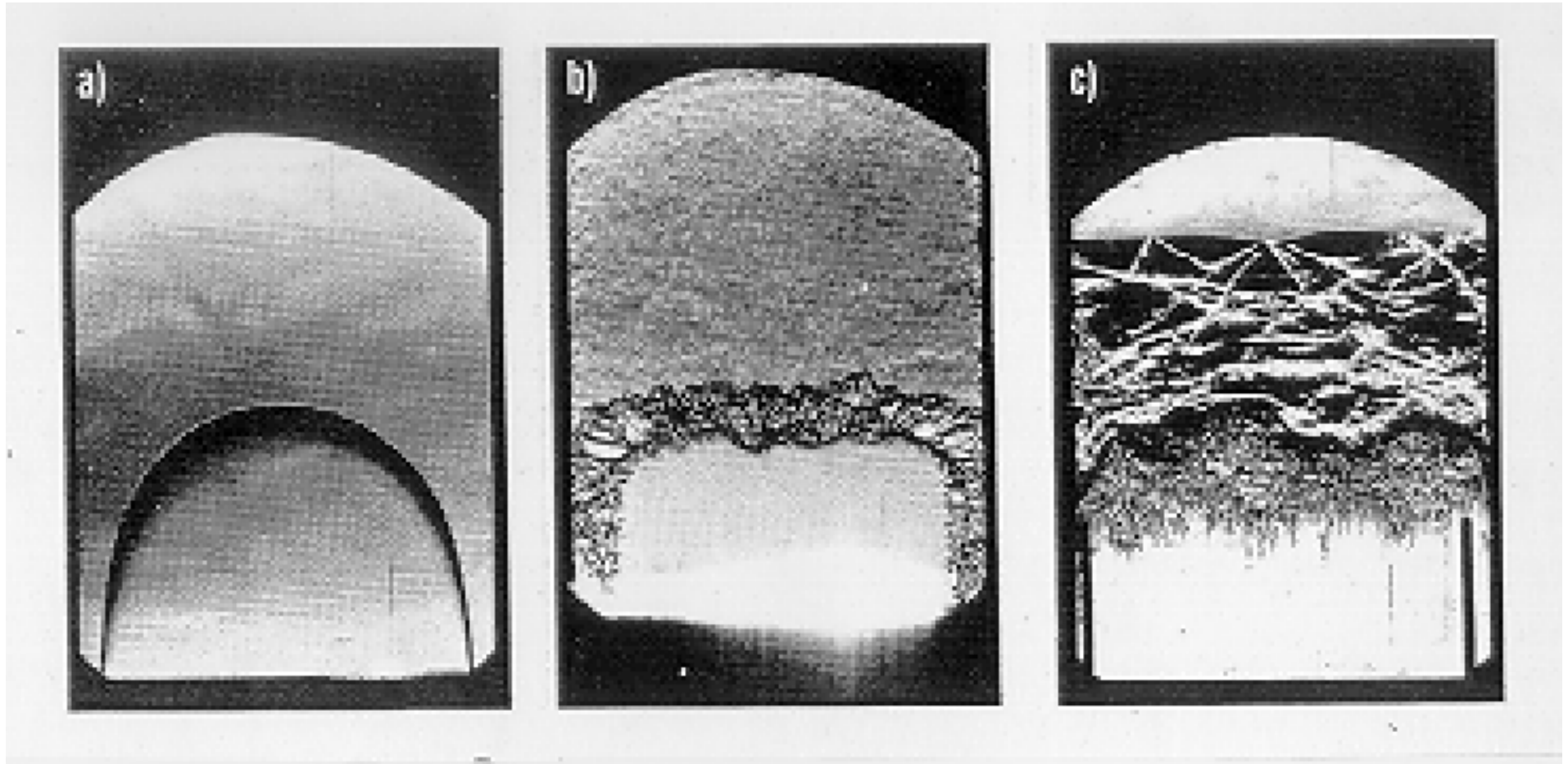
determined by

- initial PIRT study
- expert questionnaire
- state-of-the-art survey

**communicate** the network's working topics,  
**orientate** the work on intermediate time  
scale (proposals for experiments,  
benchmarking, Internal Projects ...)



# VERBRENNUNGSREGIMES VON H<sub>2</sub>-LUFT GEMISCHEN

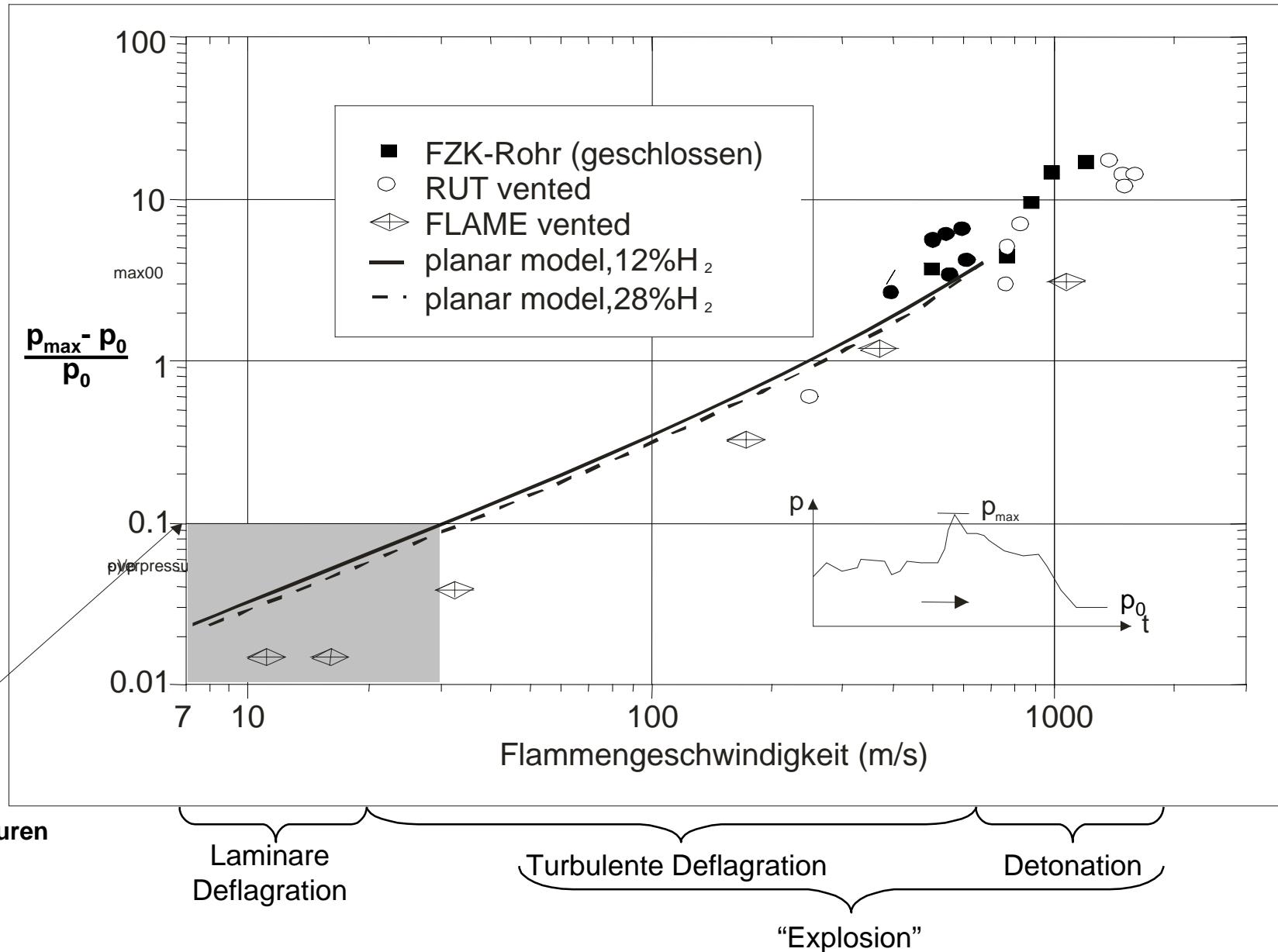


Laminare Flamme  
 $v \approx 1 \text{ m/s}$ ,  $Ma \ll 1$

Turbulente Flamme  
 $v \approx 300 \text{ m/s}$ ,  $Ma \approx 1$

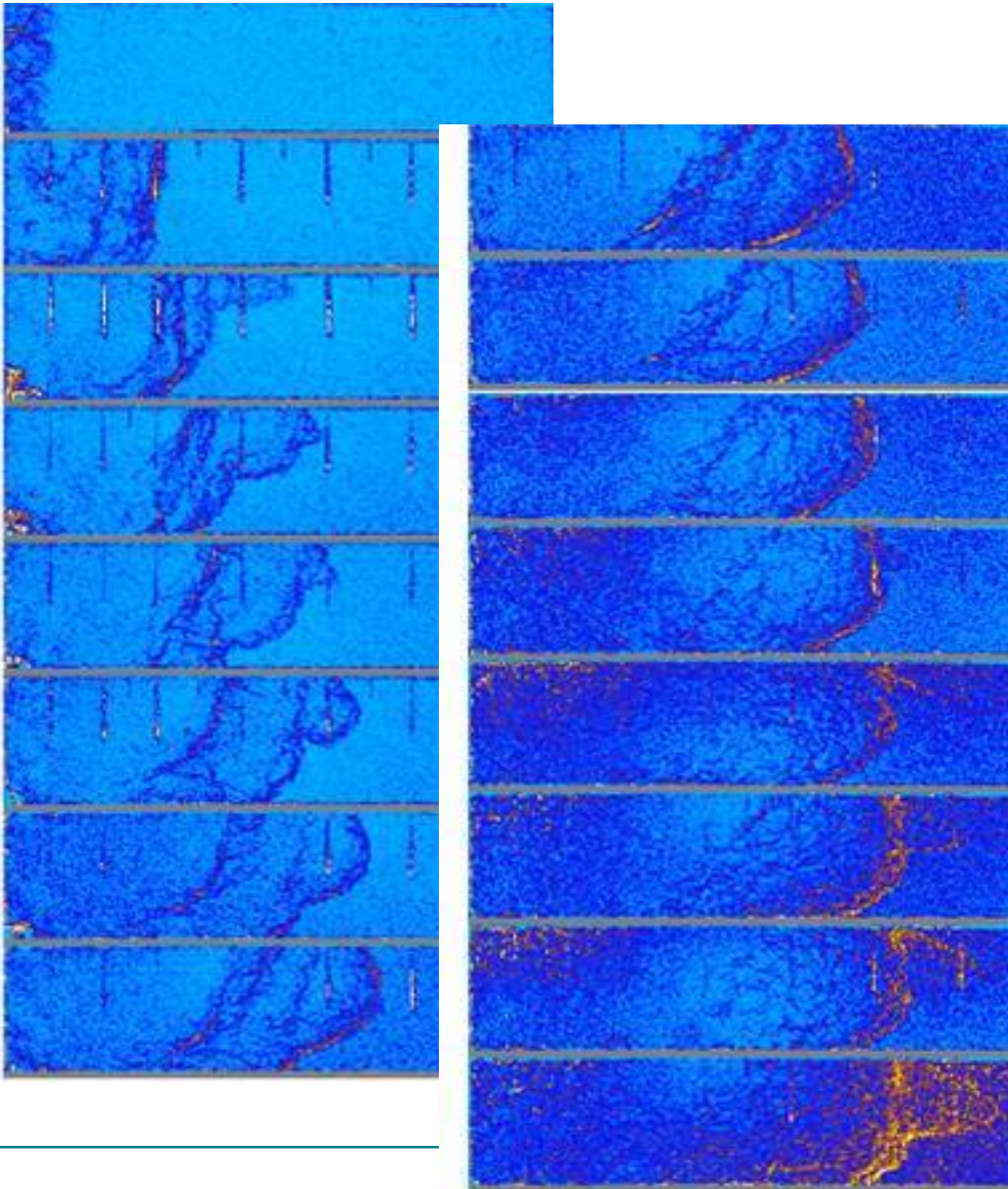
(Quasi-) Detonation  
 $v > 1000 \text{ m/s}$ ,  $Ma > 1$

# ÜBERDRÜCKE VON H<sub>2</sub> – LUFT - FLAMMEN

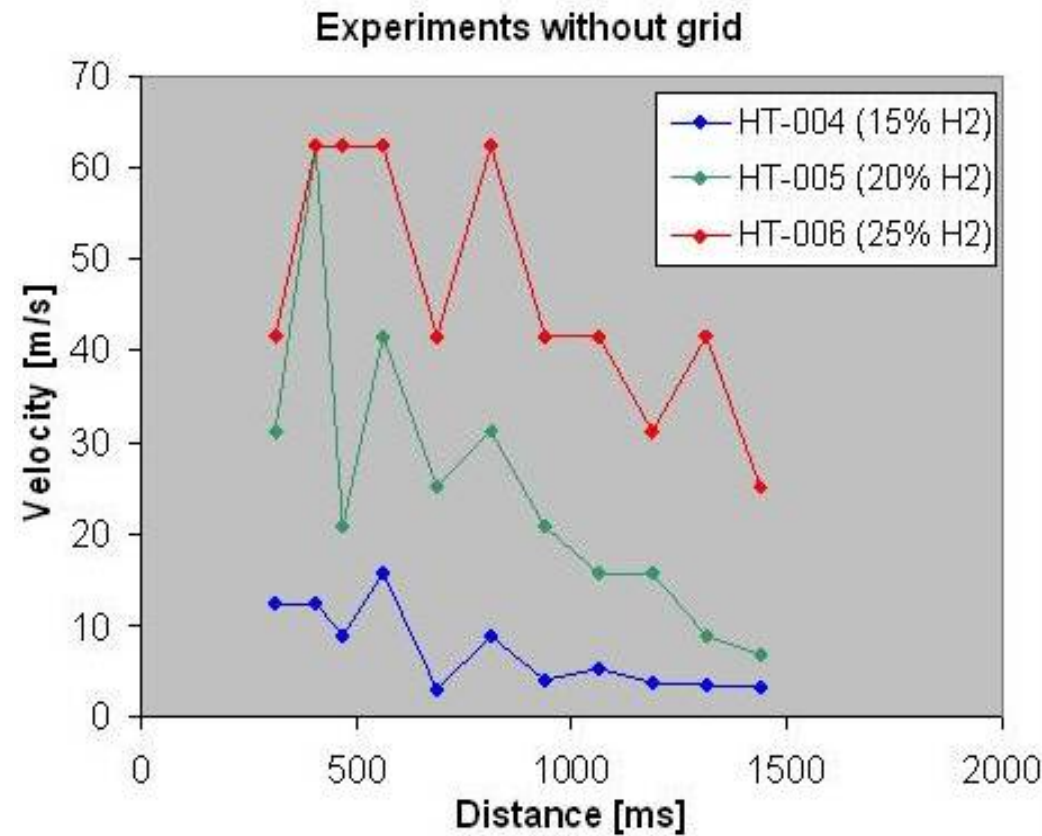


# “HyTunnel” – Pretests Results

BOS 15 % H<sub>2</sub>/air w/o obstacles



## Flame velocity vs. distance



# “HyTunnel” – Experimente

Large scale facility (5.7 x 1.6 x 0.6 m)

- effective venting ratio  $\alpha = 0.46$  (layer thickness  $\delta = 0.15$  m)

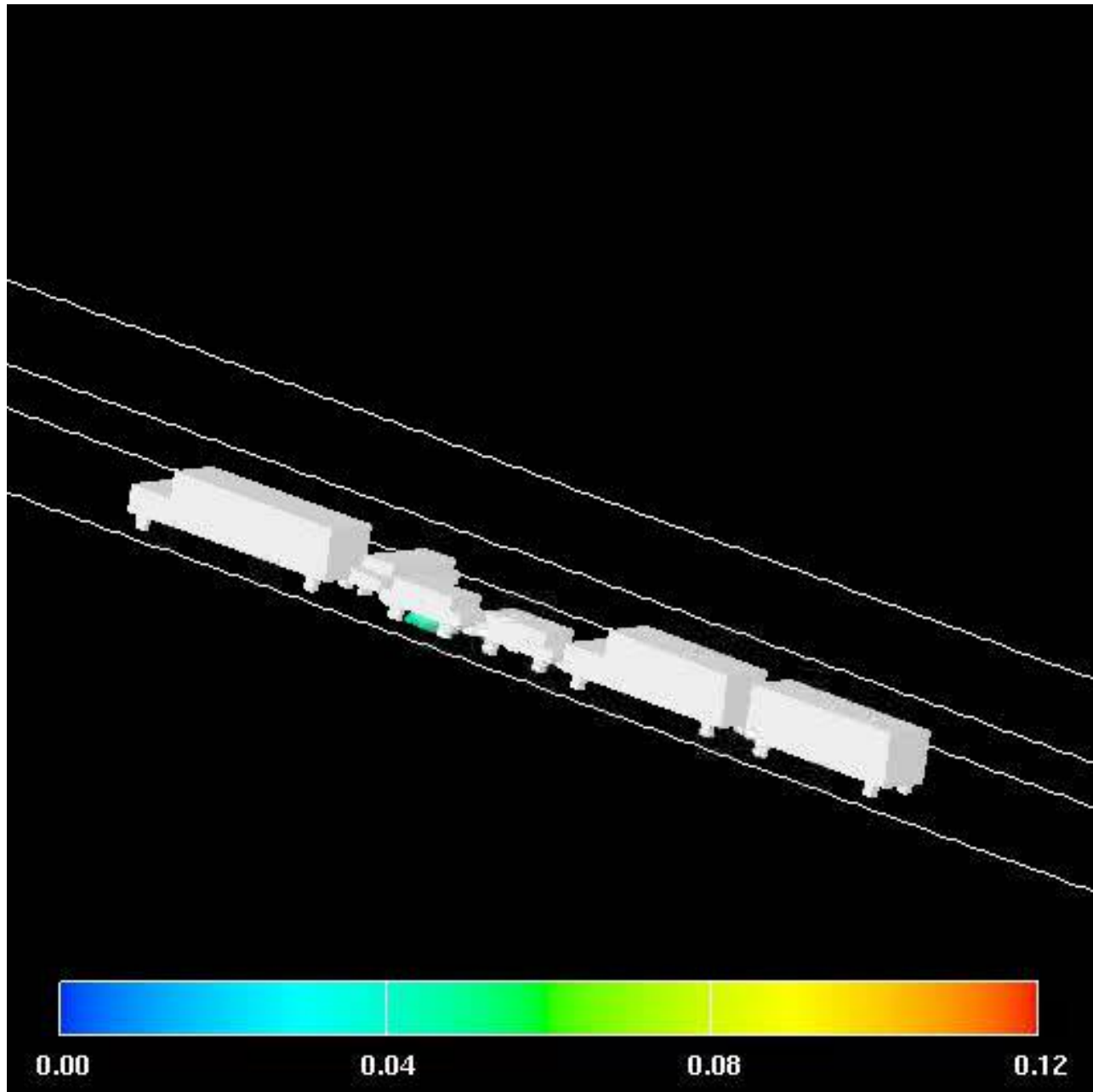
Diagonal view



Film opening



# Tunnel-Simulation



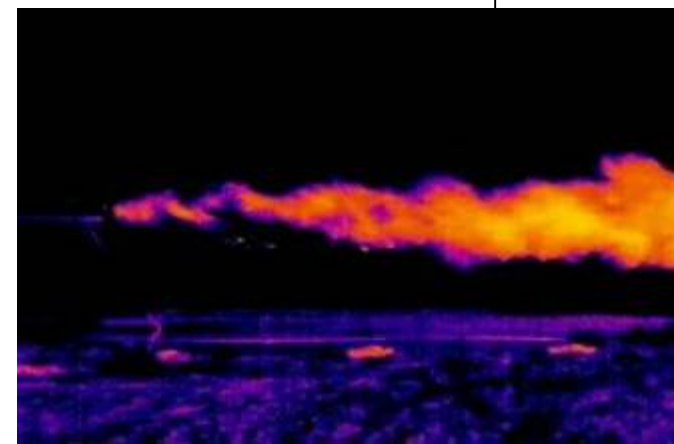
Zündfähige Wolke bei  
Freisetzung von 5 kg LH2



## WP18.4 “HyNano” – Zielsetzung

**Fundamental understanding the safety issues regarding nano-scaled solid-state hydrogen storage materials/systems through:**

- (i) development of standard testing techniques to quantitatively evaluate both materials and systems,**
- (ii) understand the fundamental science of environmental reactivity of hydrides and**
- (iii) develop methods and systems to mitigate the risks to acceptable levels.**



nano-structured alanate blown out of a heat exchanger tube at 10 bar and 120 °C (frames of a high speed video (left) and of a infrared video (right) at the same instant)

# Wasserstoff-Tankstellen

(Optionales Video)

A simulation contributions to the EC project HyApproval „Handbook for the safe installation/operation of a HRS“ (details on <http://www.hyapproval.org>)

# Schulungsmaterial

<http://www.ehammertraining.us/energy/hydrogen/controller.cfm>

Introduction to Hydrogen Safety for First Responders

U.S. Department of Energy  
Hydrogen Program  
www.hydrogen.energy.gov

COURSE MATERIALS LIBRARY EXIT

Hydrogen Basics Transport & Storage Hydrogen Vehicles Hydrogen Dispensing Stationary Facilities Codes & Standards Emergency Response Summary

### Hydrogen Storage for Transport

INCREASE YOUR H<sub>2</sub> IQ  
www.hydrogen.energy.gov

Tube trailers transport bulk quantities of hydrogen gas, while cargo tanks carry bulk liquid hydrogen. Placards and/or other markings are required on bulk shipments to help first responders recognize the material and respond appropriately in the event of an emergency. Information about those markings is included in the

**Liquid Cargo Tanks**  
Photo: Air Products and Chemicals, Inc.

**Tube Trailers**  
Photo: Praxair, Inc.

**Cylinders**  
Image: Airgas, Inc.


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University of ULSTER Progress in Hydrogen Safety  
International short course series

## Hydrogen and fuel cell technologies: Safety issues

29 September - 3 October 2008, Belfast, UK

Early booking recommended for all courses!



Further courses in 2008/2009 series

Hydrogen regulation, codes and standards  
January 2009

Safety of hydrogen fuelled vehicles  
April 2009

The hydrogen and fuel cell infrastructure  
June 2009

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in der Helmholtz-Gemeinschaft

# Invitation to the 3rd Int. Conf. on Hydrogen Safety September 16-18th, 2009 Ajaccio, Corse, France



Italian National Fire Corps



Contact: [ICHS@hysafe.org](mailto:ICHS@hysafe.org)

INTERNATIONAL CONFERENCE ON HYDROGEN SAFETY