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The Estimation of potential Consequences from the Sabotage of Nuclear Material Transports

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- Examples for Sabotage
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Transportation Threat Examples

Unauthorized Removal

Sabotage

Motivation

- Likelihood of terrorist sabotage attack against transports of nuclear material
- Sabotage attack could generate a particulate radioactive matter from the inventory of the cask
- Airborne release to the environment
- Potential Radiological consequences?!

Motivation

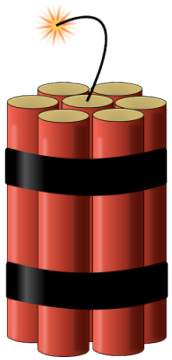
Nuclear Security Series Publications, INFCIRC 225, Rev. 5:

- Radioactive material has to be protected against unauthorized removal since it could have significant consequences if dispersed or used otherwise for a malicious
- …the State should define protection requirements that correspond to the level of potential radiological consequences.

Assessing radiological consequences important for graded approach!

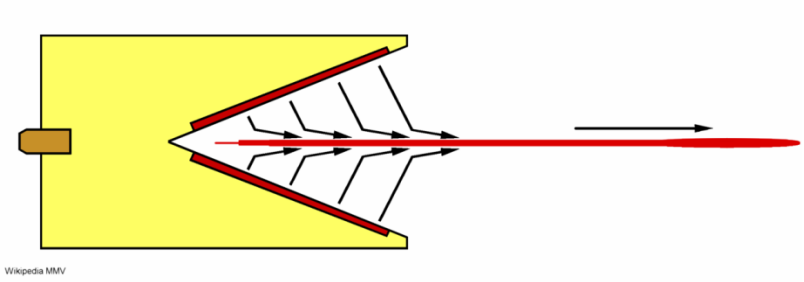
Examples for Sabotage

- Explosives
  - Directly put on the transport configuration
  - On a vehicle next to the conveyence
- Conical Shaped Charges (CSC)
- Explosively Formed Projectiles (EFP)



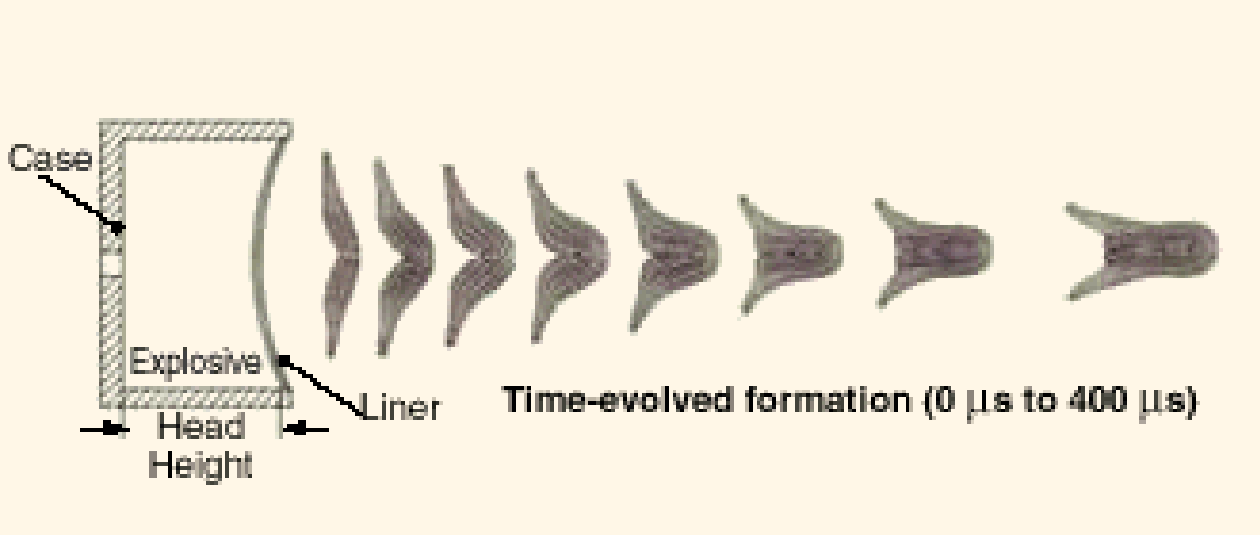
Conical Shapes Charge

- Highly sophisticated weapon
- Can be shot from a high distance
- High penetration depth



Explosively Formed Projectile (EFP)

- Not very sophisticated
- Standoff distance: Few meters to hundreds of meters
- Penetrates armour: 0.4 - 0.8 times the diameter



Examples for EFP´s

Different sizes:

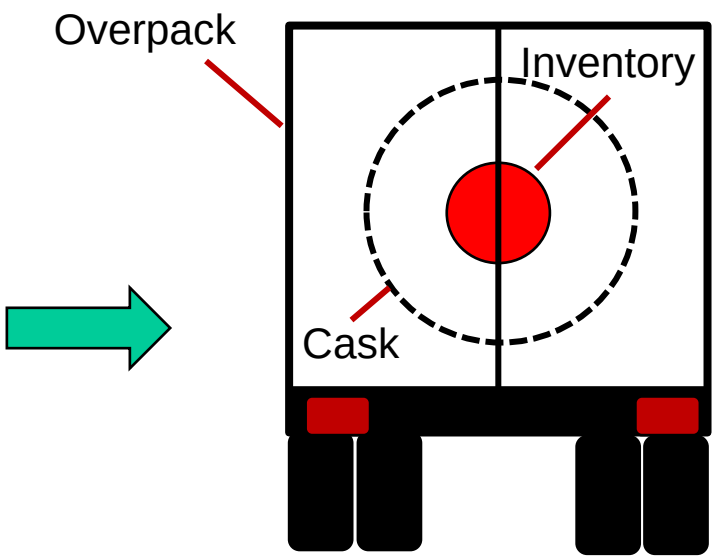
- Roadside Bomb
- Pocket – EFP
- …

EFP´s are built easily:

- Explosive
- Pipe (like drainpipe, …)
- Layer (copper, …)

From Sabotage to potential Consequences

Weapon



Transport Configuration

From Sabotage to potential Consequences

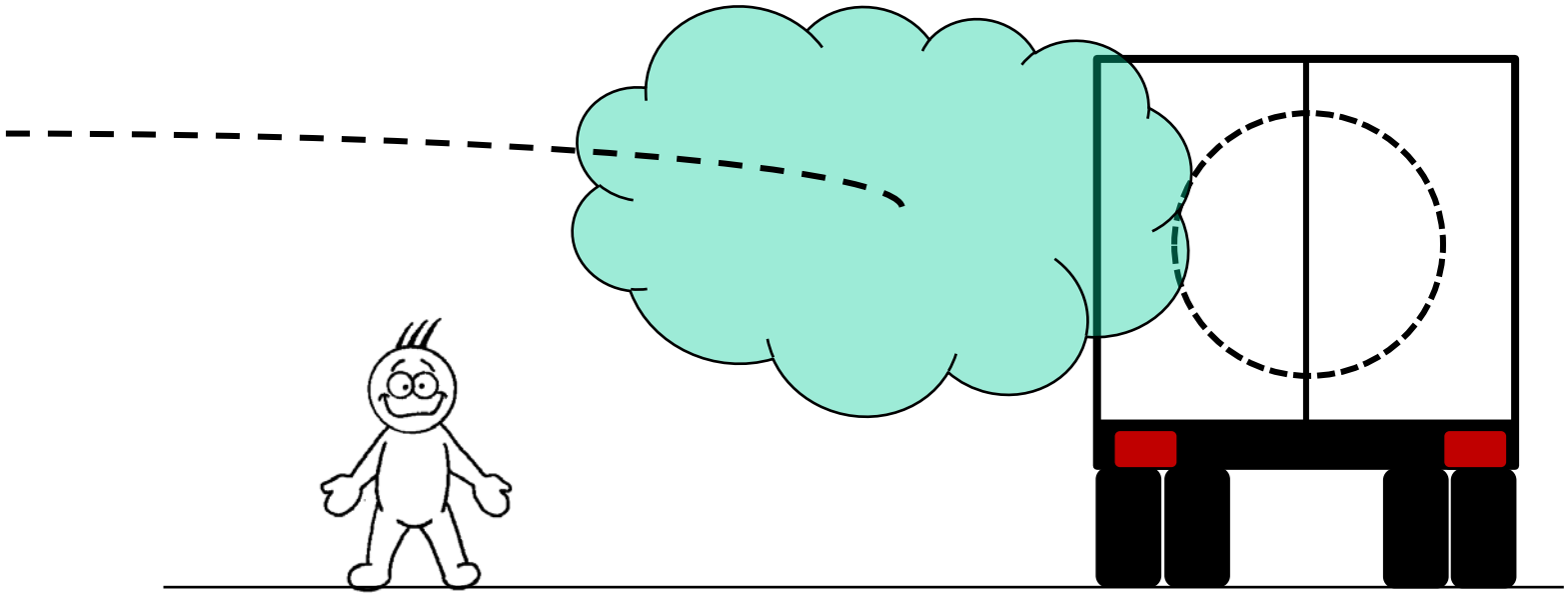
First step:

- Damage Pattern of:
  - Cask
  - Inventory
- Airborne Release Fraction (ARF) of inventory (respirable aerosols)
- Aerosol transport process from the inside of the cask to the environment

From Sabotage to potential Consequences

Second step:

- Determination of dispersion of respirable particles
- Dose calculation



Research Projects

Performing experiments to:

- Understand the mechanisms of different sabotage attacks on transport casks

  ⇨ Obtain empirical correlations of kind of sabotage and ARF

- Verify numerical simulations

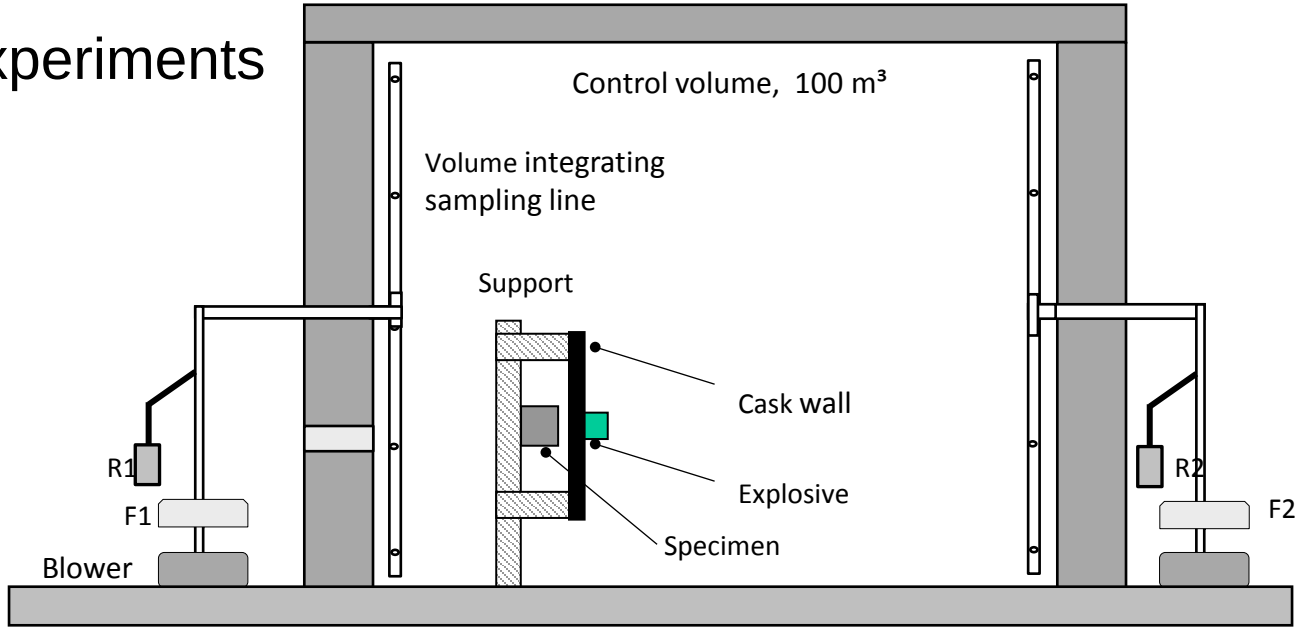
Create a predictive model to assess radiological consequences of sabotage attacks on various transport configurations

Research Projects of GRS

- Conical Shaped Charge: Different research projects of GRS in collaboration with Fraunhofer-Gesellschaft, IRSN and Sandia National Laboratories
- Explosives: Actual research project in collaboration with FhG ITEM and FhG EMI, funded by BMUB
- Explosively Formed Projectile: Actual research project in collaboration with FhG ITEM and FhG EMI, funded by BMUB

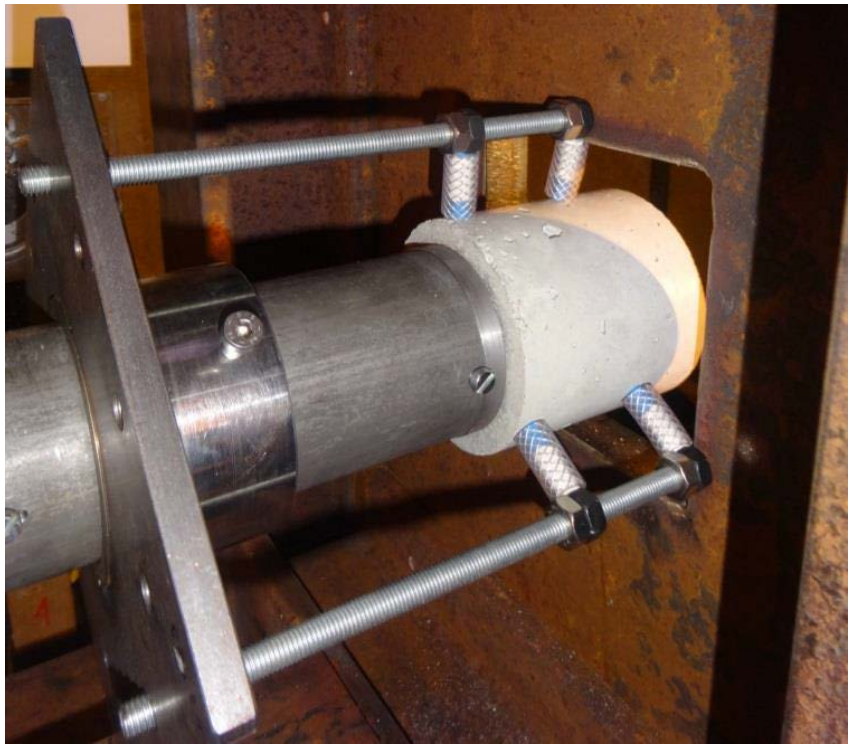
Explosives: Experimental Setup

Small-Scale experiments



- Experiments were performed at Fraunhofer EMI, Germany
- Experimental Setup was designed and installed by Fraunhofer ITEM, Germany

Targets

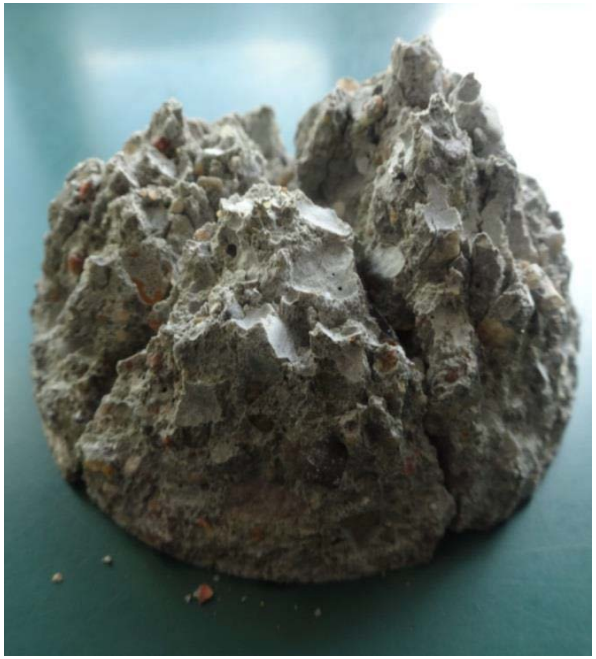


What was measured?

- Concentration of respirable fraction inside the cask
- Temperature
- Pressure

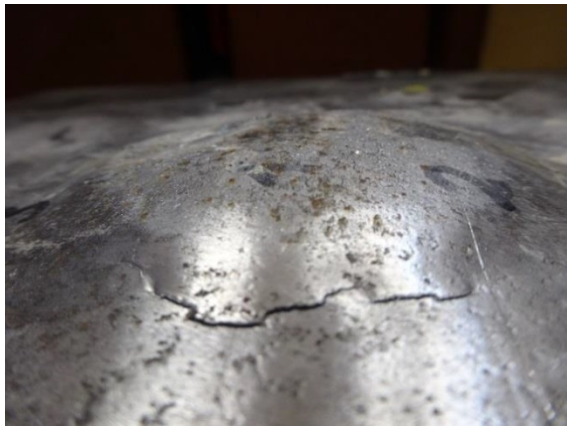
Helping to model the potential outflow of gases

Qualitative Results



Qualitative Results

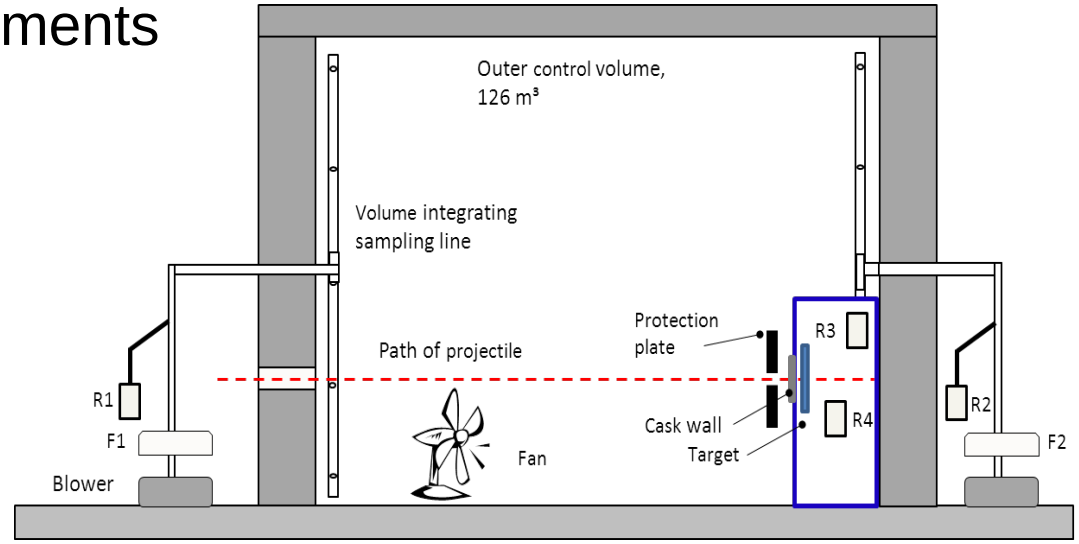
Smaller charge:



Bigger charge:

EFP: Experimental Setup

Small-Scale experiments



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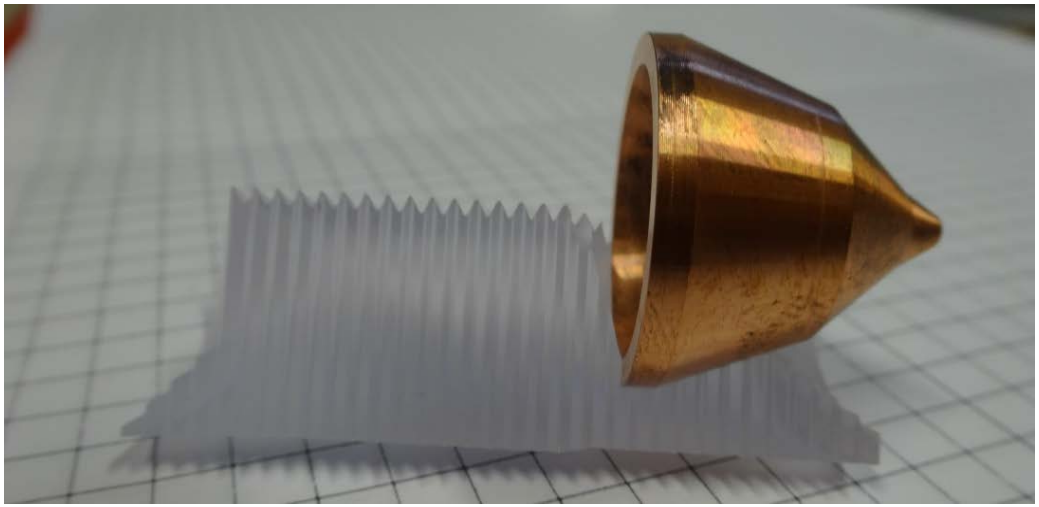
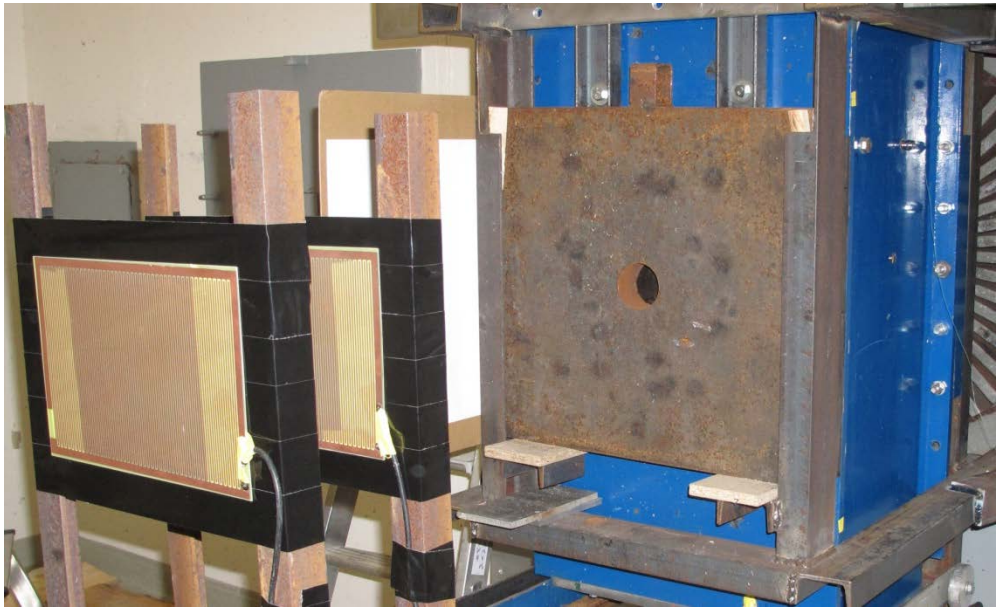
Projectile

- Bell-shaped flyer plates embedded in a sabot
- Shot with a powder gun



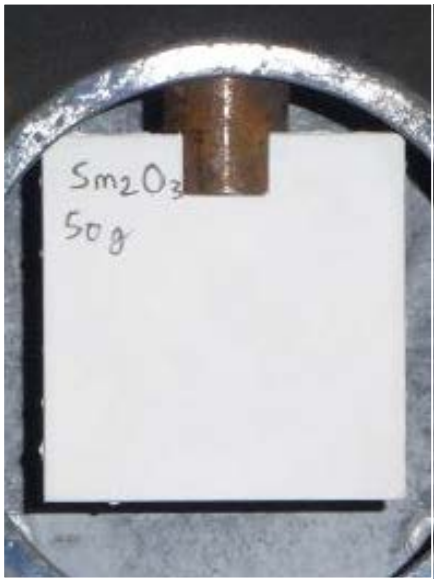
Cask Mock-Up

- Closed box
- Stainless-steel wall segments of variable thickness



Targets

Three differents kinds of targets were used:



What was measured?

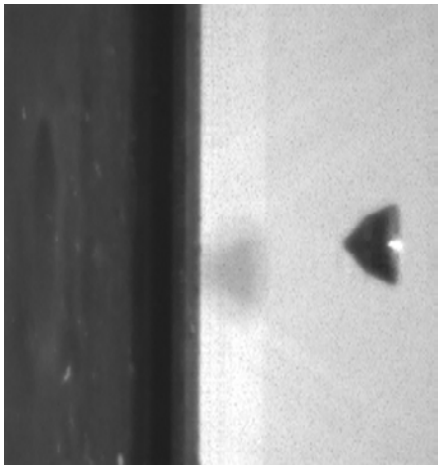
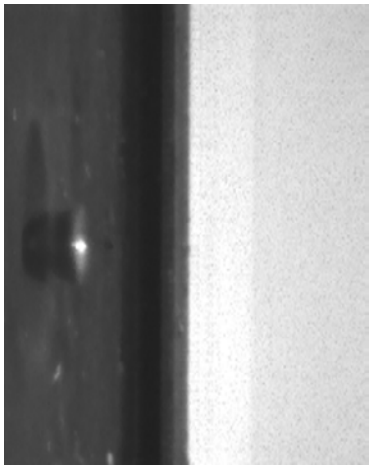
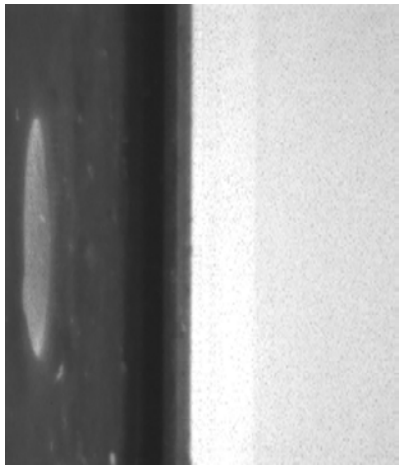
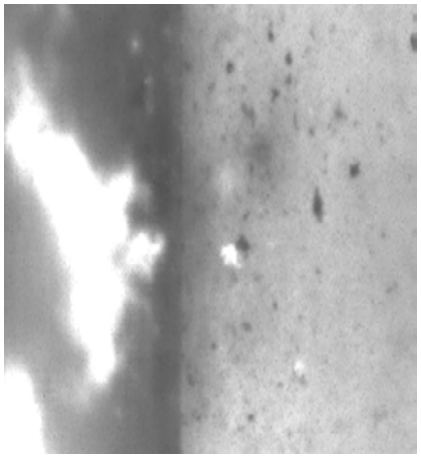
- Actual impact velocity of EFP directly in front of cask
- Concentration of respirable fraction inside and outside the cask
- Temperature inside the cask
- Pressure inside the cask

Helping to model the potential outflow of gases

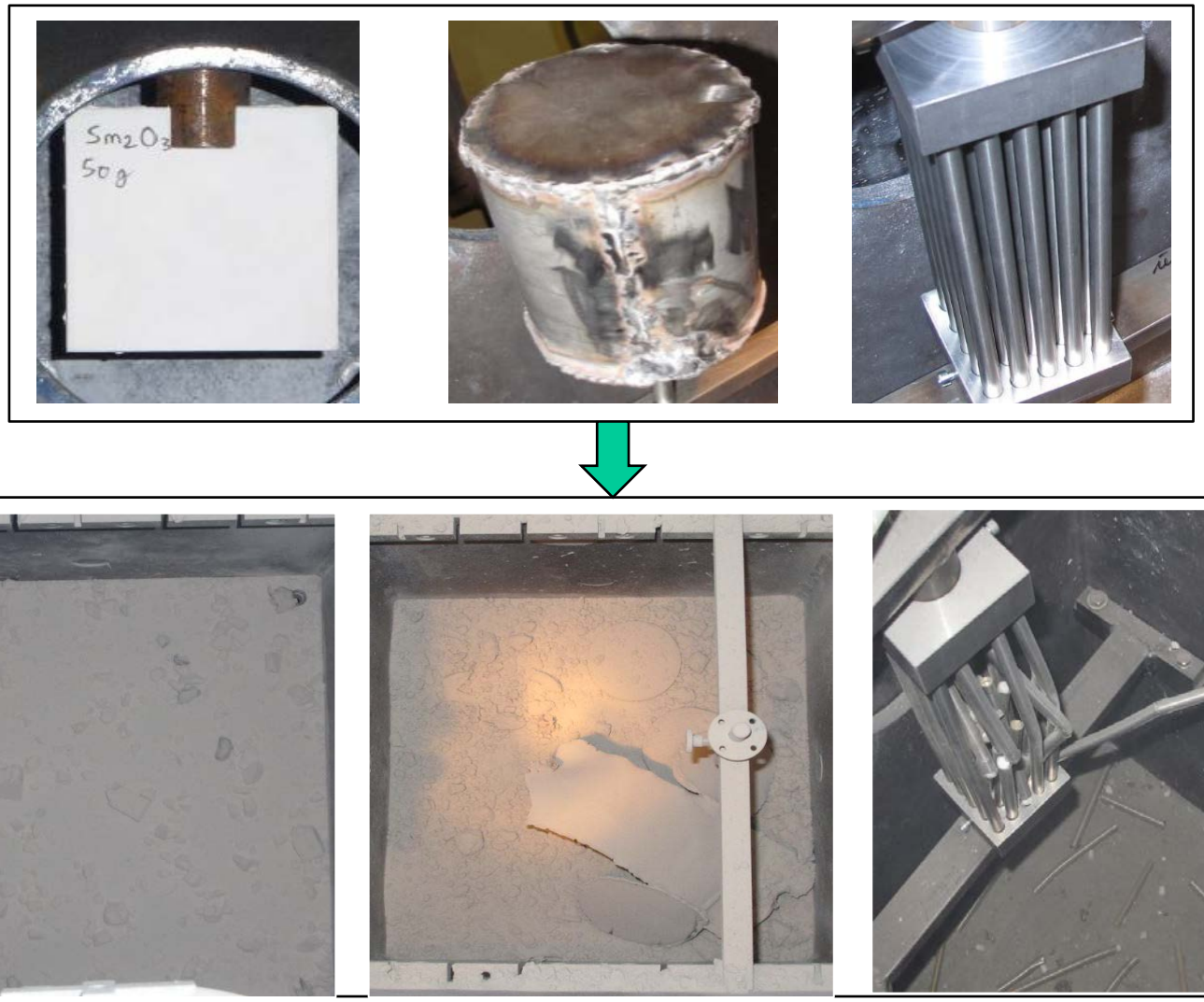
Qualitative Results

Pictures of the high speed camera:

- Projectile flying towards the cask mock-up with the stainless-steel wall segment

Qualitative Results



Prospects

- Working on models to quantify the pattern of damage of:
  - Cask
  - Inventory
- With this: Determination of the source term, i.e. release fraction defined as the fraction of the inventory released as (respirable) aerosols

Thanks for your attention!