5TH INTERNATIONAL SOCIETY FOR SAMPLE ENVIRONMENT (ISSE) TRAINING SCHOOL

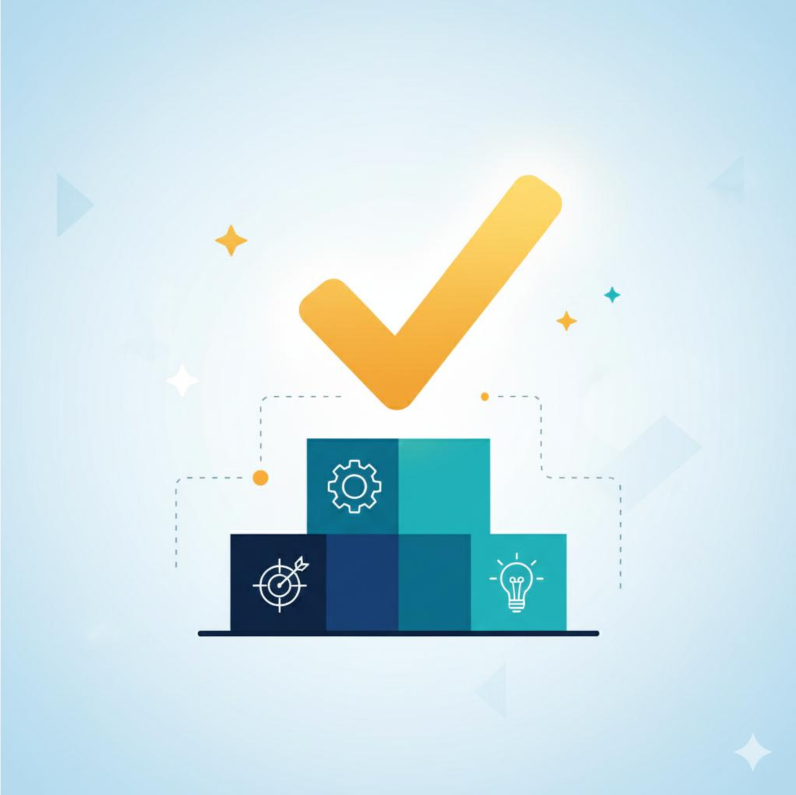
Safety in Experimental Sample Environments

From Paper Risk Assessments to Experimental Reality

Marcin Bielawski, Head of Safety, MAX IV, Lund, Sweden

Learning Objectives

- Understand what *Experimental Safety* really means at user facilities
- Recognize why declared setups often differ from real setups
- Identify common failure modes in Sample Environment (SE) experiments
- Apply practical strategies to reduce safety gaps
- Know your role and responsibility as SE staff



Why Experimental Safety is Special

Experimental safety different from:

- Occupational safety
- Radiation protection
- (Machine and Laser Safety)

Because experiments are:

- Temporary
- User-driven
- Modified late
- Often one-of a kind
- Operated under time pressure

➢ This makes Experimental safety **dynamic,** not static

Experimental Safety ≠ Compliance

Experimental safety ≠ compliance

- **Compliance:** rules, forms, approvals
- **Safety:** control of real hazards during operation

A fully approved experiment can still be unsafe!

You can *have* compliance:

- Approved proposal
- Approved risk assessment
- Approved equipment
- Approved ….

And still run an **unsafe** experiment due to:

- Late changes
- Incorrect assumptions
- Poor communication
- User behaviour

Where Safety Is Supposed to Happen

Experimental Safety Workflow @ MAX IV

1. Proposal phase including equipment and sample declaration
2. Beamline technical feasibility check (uncertainties are to be discussed with EST here)
3. Science case approved
4. Experiment preliminary hazard classification level (Green, Yellow, Red) by EST / Beamline Staff
5. ESRA submission by User (2-8 weeks prior to scheduled experiment)
6. ESRA evaluation by Experimental Safety Team (EST)
7. Approval and final experiment hazard classification level by EST
8. *Safety training orientation*
9. *On-site SE installations by users // Check-in by EST*
10. *Gatekeeping Floor coordinators – Green light to start*
11. *Operation – Executing the experiment*
12. *Wrapping up / de-installation*

SE – Sample Environment
ESRA – Experimental Safety Risk Assessment
EST – Experimental Safety Team

The Reality Gap

What is declared from the proposal stage vs. what appears in the final ESRA

“Minor gas use”	→	Multiple gas type and hazards request
“Benign samples”	→	Hazardous samples
“Room temperature”	→	Cryogenic cooling added or heating furnaces requests
“Closed system”	→	Vent lines improvised
“Standard setup”	→	Custom modifications, new hardware developed

Why Setups Change

Common drivers of late changes

- Long time between proposal submission to actual beamtime
- Beamtime pressure
- Samples not behaving as expected
- Equipment incompatibility or failing
- Novel setups not tested enough
- Knowledge gaps (especially early-career users)
- Home facilities lack formal technical safety reviews in the development of new SE

Typical High-Risk SE Domains

Some Sample Environment domains with elevated risk

- When Cryogenics is involved
- High pressure (gas & mechanical)
- Reactive or flammable gases – Toxic, Corrosive, Flammable, Oxidizing – Electrical eq in ATEX zones
- Electrochemistry
- Vacuum systems
- Energy-storing systems (batteries, capacitators)
- In-operando experiments (active battery charging, cycling, heating)
- Magnets
- Furnaces
- Sonic levitators
- Robotics (moving parts)

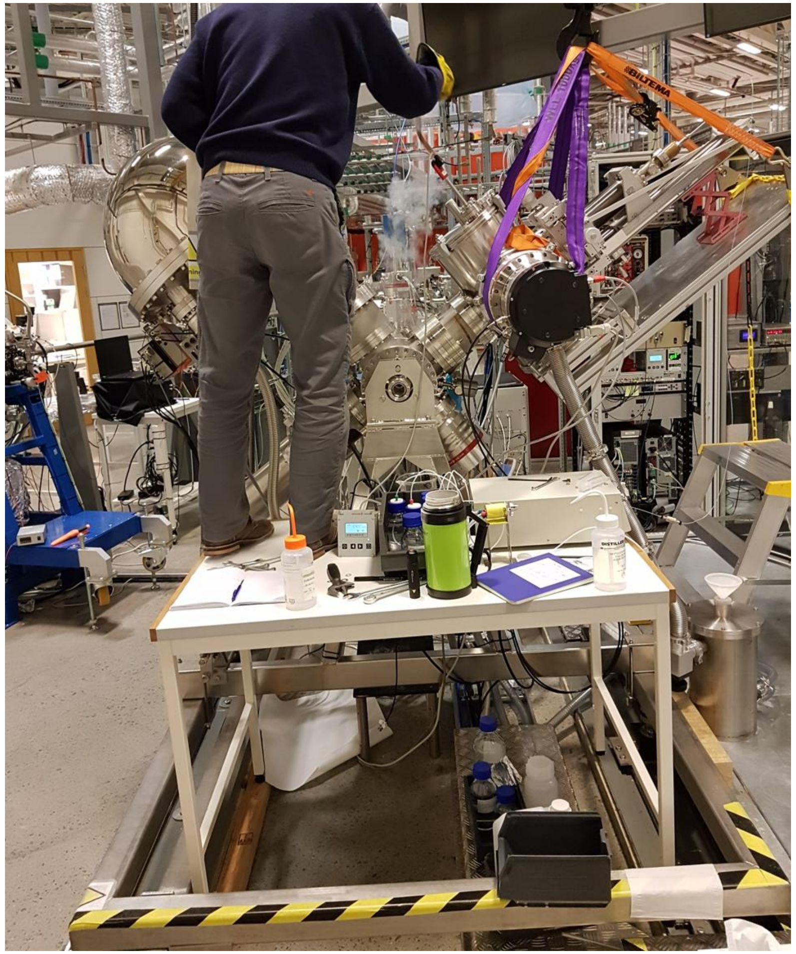
SE – Sample Environment
ATEX: Derived from the French "ATmosphères EXplosibles," this term is used for compliance, regulation, and classification within the EU.

MAX IV

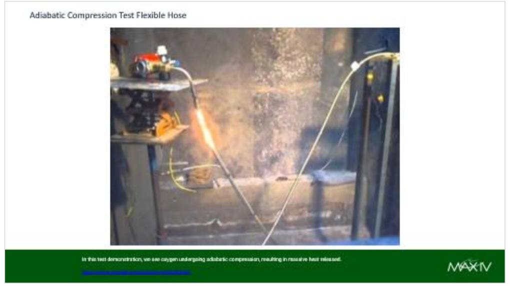
Cryogenics – Where Things Go Wrong

Common cryogenic hazards

- Oxygen deficiency (ODH)
- Cold burns and frostbite
- Ice blocking vents
- Brittle fracture of materials
- Improvised insulation



High Pressure – Small Volume, Big Energy



High-pressure misconceptions

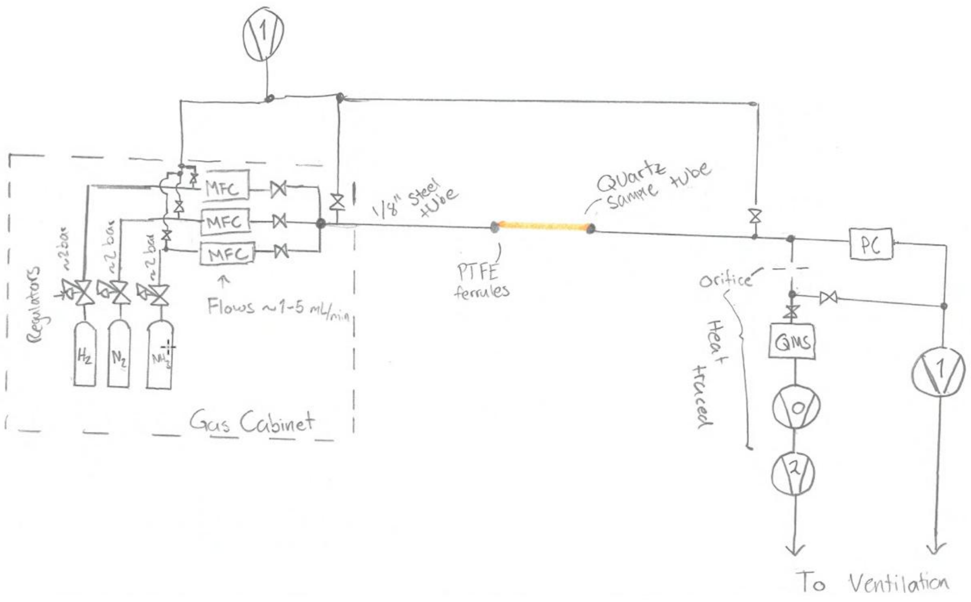
- “It’s only a small cell or capillary”
- “The pressure is low compared to industry”
- “We’ve used it before”

Reality: Stored energy scales fast

A useful way to think about pressure is that it is energy that has been **stored and compressed**, waiting for a way to escape. The gas or fluid inside the system is not dangerous because it is hot or reactive - it is dangerous because it is under **tension**. If containment fails, that energy is released extremely fast.

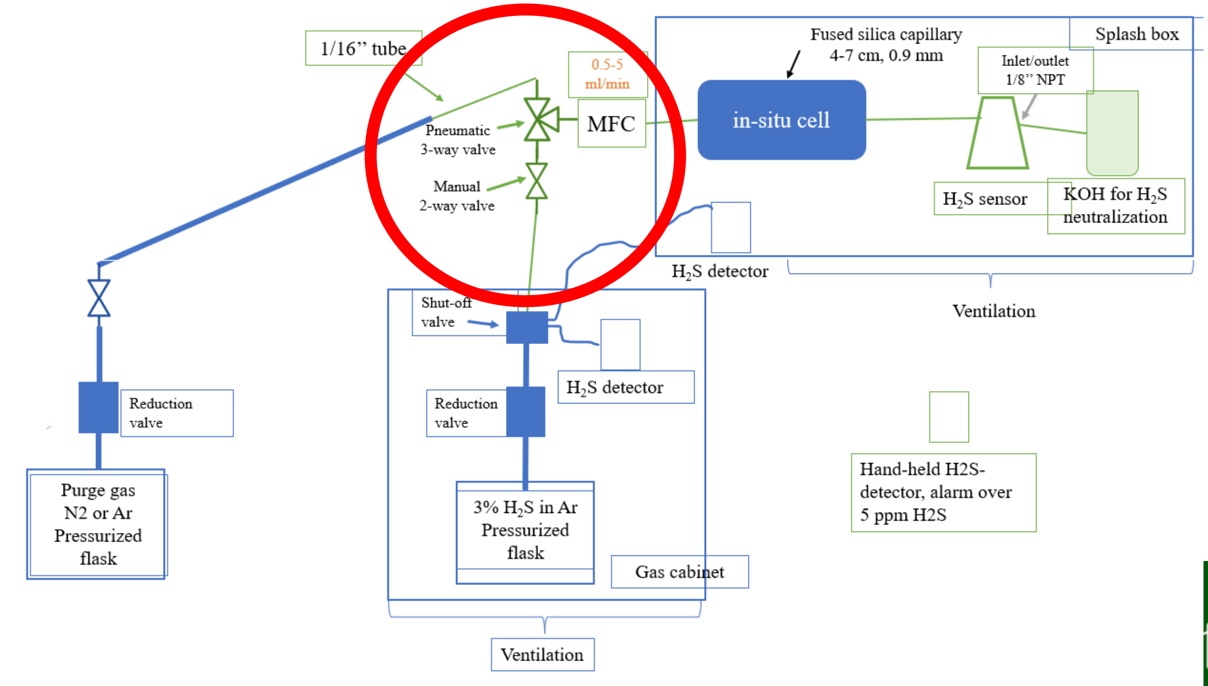
Spring analogy

Gas Handling – The Invisible Hazard



Typical gas-related failures

- Wrong gas connected
- Incompatible materials
- Imperial to metric fittings
- Leaks in temporary tubing
- Inadequate ventilation assumptions
- No clear ownership of gas system
- Lack of/or wrong gas detectors // built in or not



Electrochemistry – Often Underestimated

Electrochemistry risks

- Gas generation (H_2, O_2) or other – often slow – does not feel dangerous – over time it can accumulates
- Often strongly corrosive electrolytes
- Unexpected heating
- Electrical hazards in wet environments – conductive liq metal components and electricity in close proximity – shorts etc if system leaks

Ask yourself: What secondary hazards does this electrochemistry introduce into the surrounding environment, and how are they controlled over time?

Combination Effects

Examples of dangerous setups combine:

- Cryogenics + gas
- Pressure + temperature
- Electrochemistry + vacuum
- Unexpected heating
- Custom hardware + beamline constraints

When reviewing a setup, it is not enough to ask what hazards are present. The more important question is:

Ask yourself: How do these hazards interact, especially during changes, start-up, and failure?

Ownership and Responsibility

Who is responsible for safety in experiments?

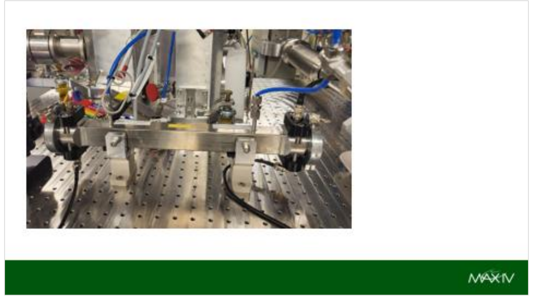
- Users?
- Beamline Staff / Manager?
- SE engineers?
- Safety Team?

Correct answer: All of the above, at different times

Role of SE Staff

SE staff are safety multipliers

- First to see deviations – often during setup and before safety come by for a visit
- Closest to real hardware
- Trusted by users – as you are often reasonable experts within the chaos
- Able to intervene early



Practical Red Flags

Red flags during installation/operation

- "It's only temporary"
- "We always do it this way"
- Unlabelled lines or flasks
- It seems that the users are not really preparing for what was declared
- Last-minute hardware from their brought experimental boxes

How to Intervene Effectively

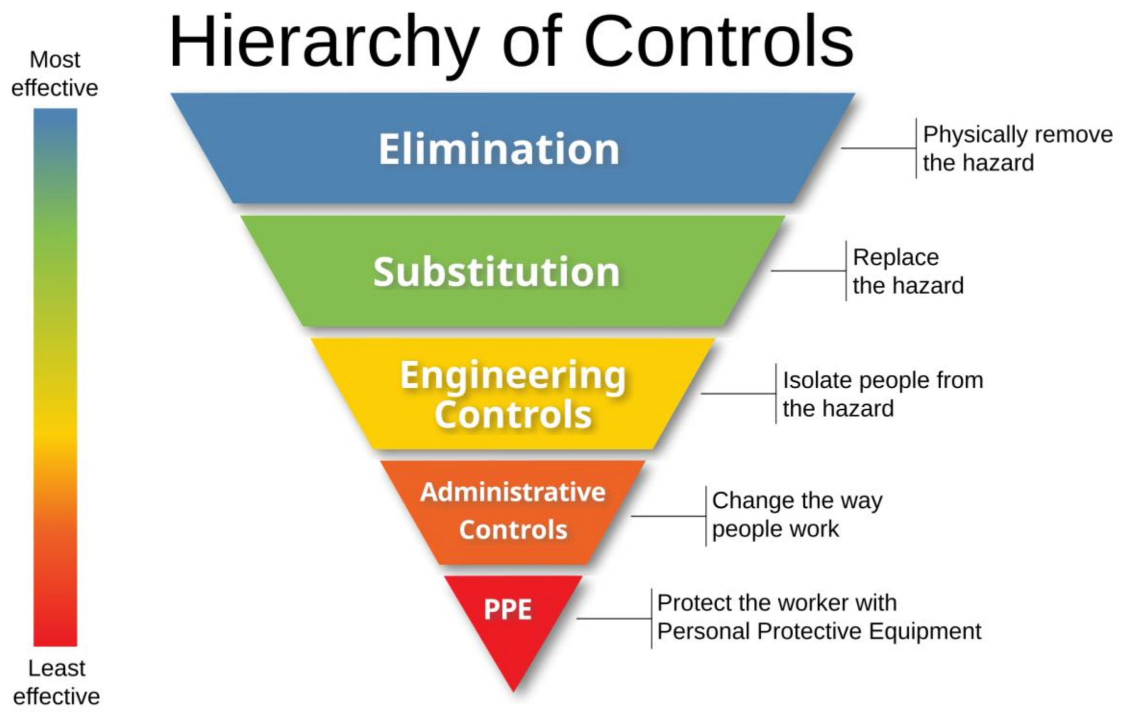
Many early-career staff hesitate to speak up – don't be!

- Ask "what changed?"
- Focus on hazards, not blame
- Use curiosity, not authority
- Escalate early, not late – remember – EST is not there to stop experiments either – solve problems together

Designing for Change

Good experimental safety systems:

- Prepare, prepare prepare…
- Expect deviation
- Make changes visible – inform relevant people
- Require re-check points – better to call it out sooner than later
- Encourage reporting – building trust is key
- Requires that you have an EST on stand-by during experimental start-up days



How Would You Act?

You arrive at the beamline and see a setup that differs from the approved risk assessment

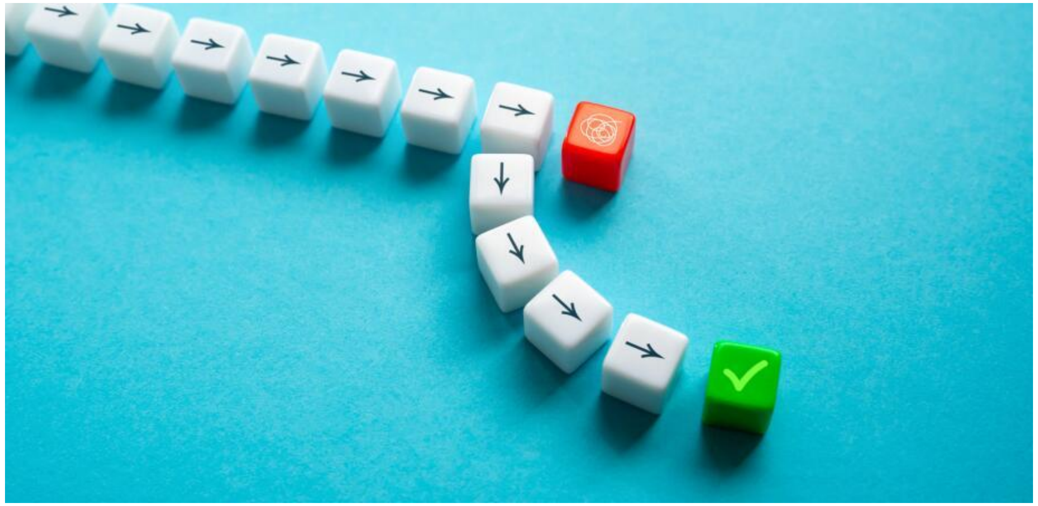
What do you do first?

- Stop the experiment immediately
- Ask the user to update documents
- Ask users what changed and why
- Call EST or the FCs ASAP

What Success Looks Like

Successful experimental safety means:

- No surprises during operation
- Deviations detected early
- Users feel supported, not blocked
- Science proceeds safely



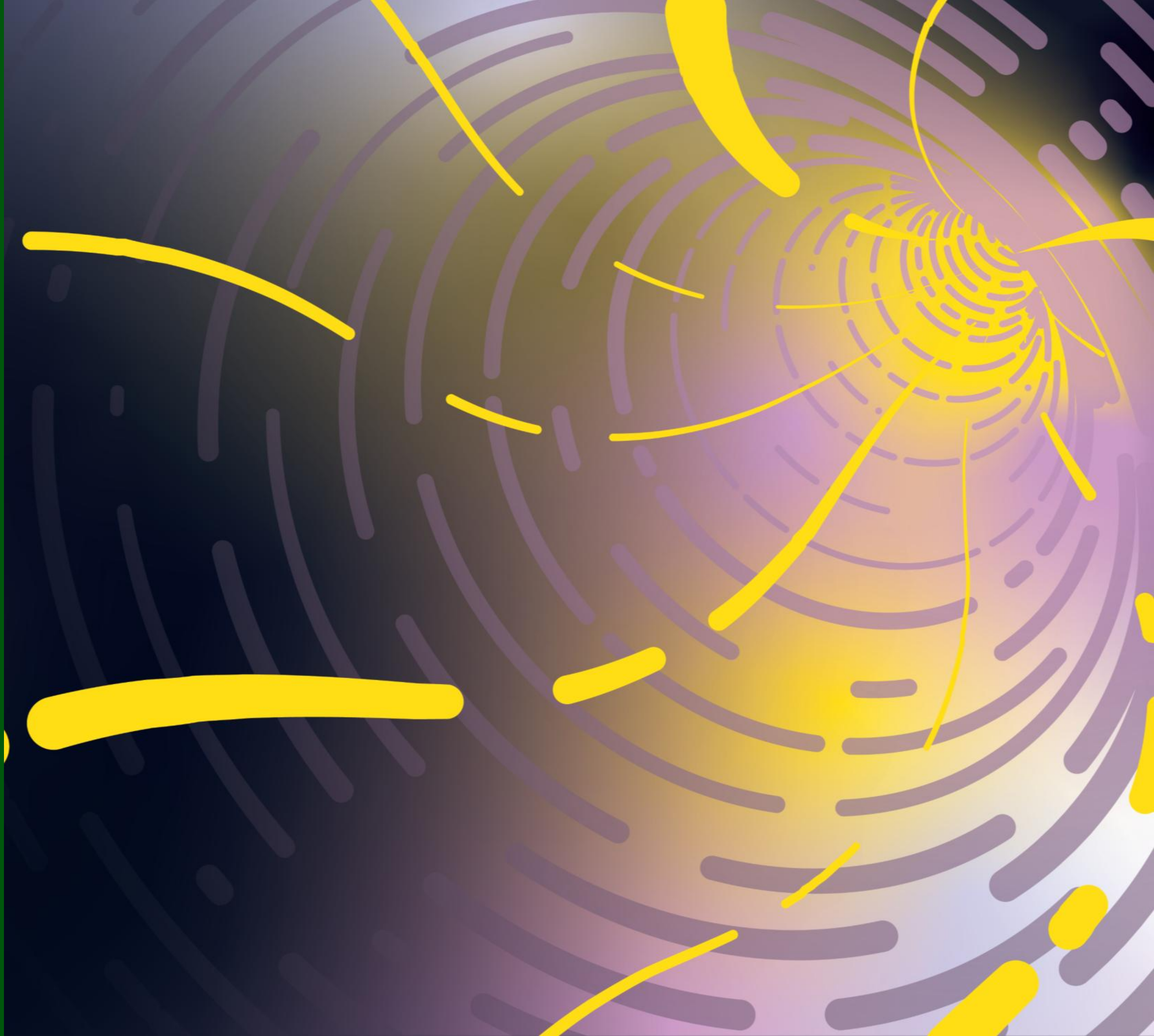
Safety is not the enemy of experiments, it enables them.

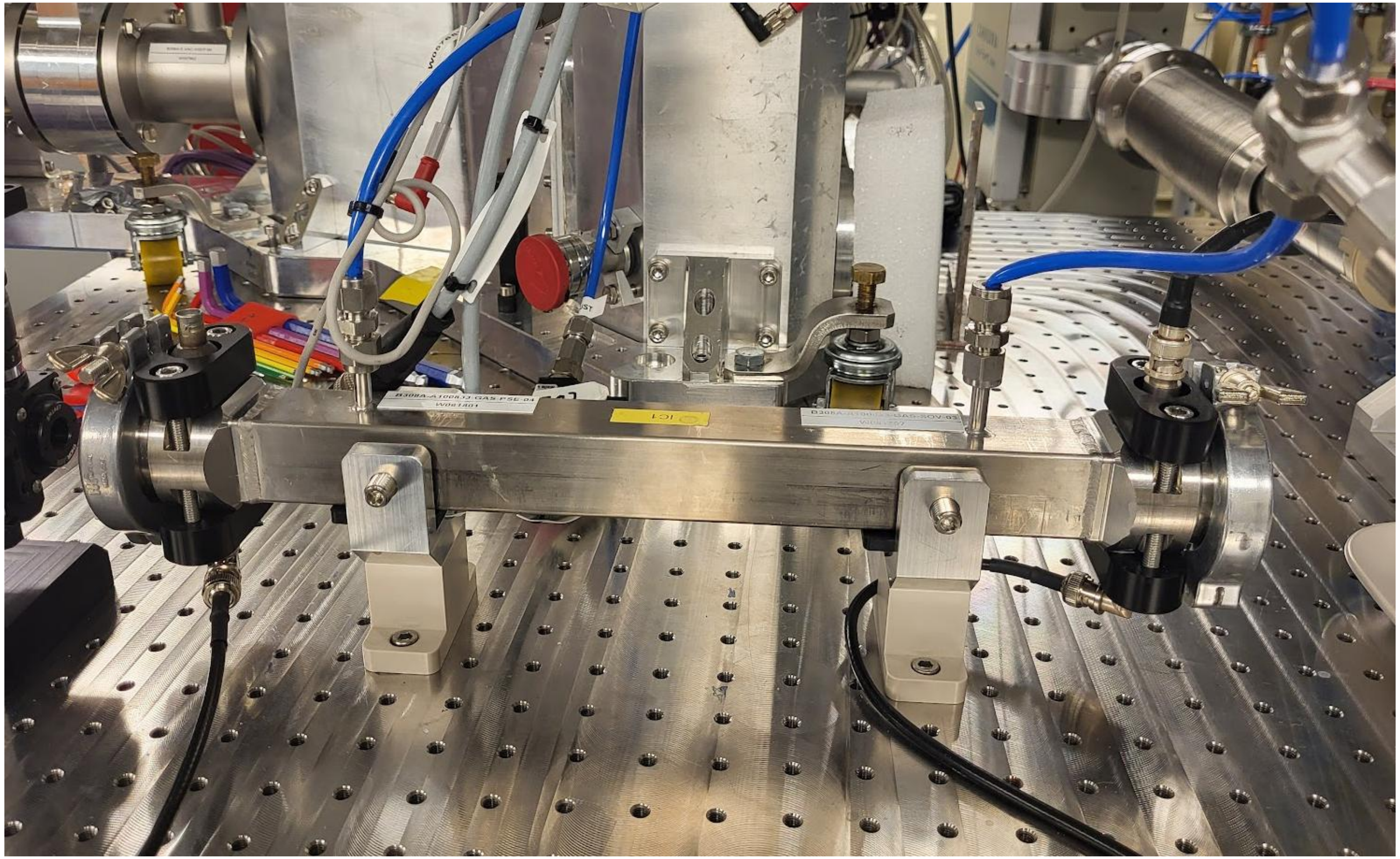
Key Take-Home Messages

- Experiments evolve; safety solutions must follow – BUT it requires a lot from the organization and staff
- Compliance is not the same as safety
- Combination hazards matter most
- SE staff/BL staff play a critical role
- Speaking up early prevents incidents

Good experimental safety practice does not block science.
It enables safe, successful experiments in the real world.

Thank you for your attention!

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Adiabatic Compression Test Flexible Hose

In this test demonstration, we see oxygen undergoing adiabatic compression, resulting in massive heat released.

https://www.youtube.com/watch?v=sMVuZR2Isb8

Hydrogen-Air Mixture Explosion Test Demonstration

In this test demonstration, a cylinder was filled with a dangerous combustible mixture of hydrogen and air. Once sufficient thermal or electrical energy is supplied, the mixture ignites, causing rapid combustion and the catastrophic failure of the cylinder.
https://www.youtube.com/watch?v=K9gW6A8yj54