bluetifuel

COMBUSTION BAY ONE

Ideas Engineering Solutions

An innovative Concept for the complete and low-NOx Combustion of non-carbon Eco-fuels using a thermo-acoustically-driven, hydrogen-powered Pilot Stage

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Combustion Bay One e.U., advanced combustion management

Graz, Austria

CfP 17. Symposium Energieinnovation
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COMBUSTION BAY ONE

FH JOANNEUM
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Blue flames for low-emission combustion using non-carbon eco-fuels

FFG Forschung wirkt.

klima+ energie fonds

Bundesministerium
Klimaschutz, Umwelt,
Energie, Mobilität,
Innovation und Technologie

Bundesministerium
Bildung, Wissenschaft
und Forschung

Content

- Project Bluetifuel
- Siren E
- CFD Simulation
- Combustion Experiments
- Conclusion & Perspectives

Content

- **Project Bluetifuel**
  - **Vision and Strategy**
- Siren E
- CFD Simulation
- Combustion Experiments
- Conclusion & Perspectives

Project Bluetifuel

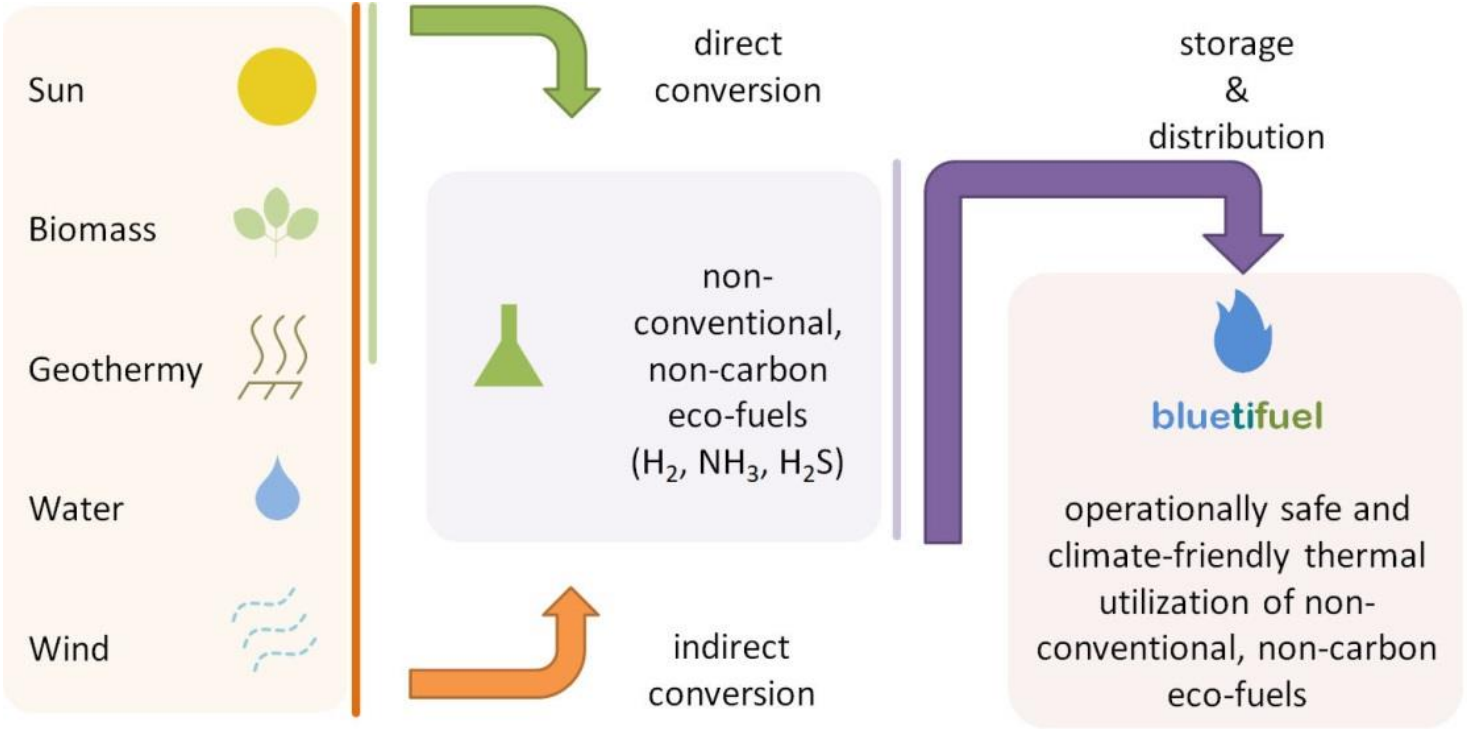
bluetifuel

Blue flames
for low-emission combustion
using non-carbon eco-fuels

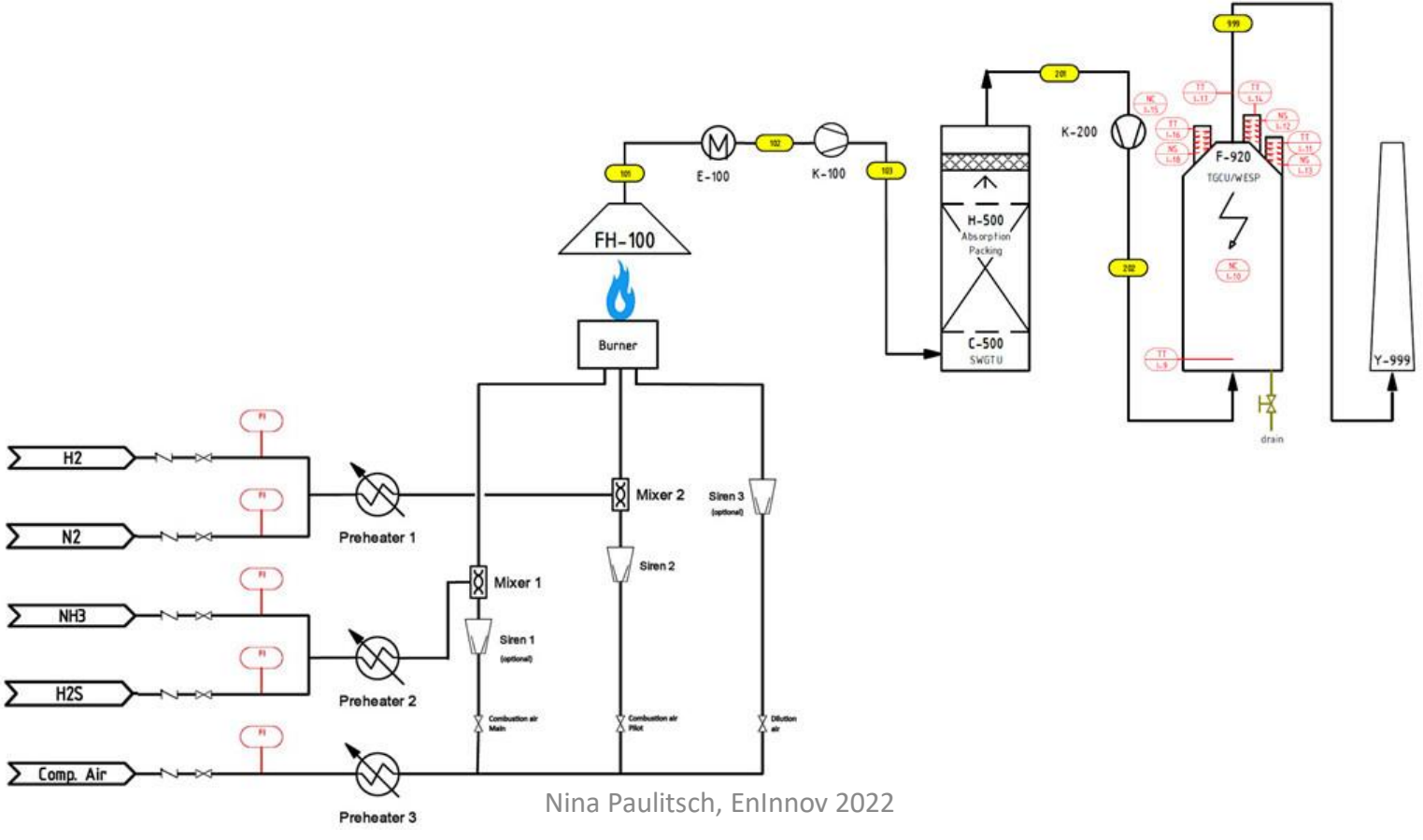
Idea:
Combine the benefits of an ultra-lean combustion in terms of NO_x-performance with precisely controlled, forced flame pulsation

Aim:
A safe and highly digitalised combustion technology for the complete and low-NO_x combustion of H_2, NH_3 and H_2S

Project Bluetifuel - Vision



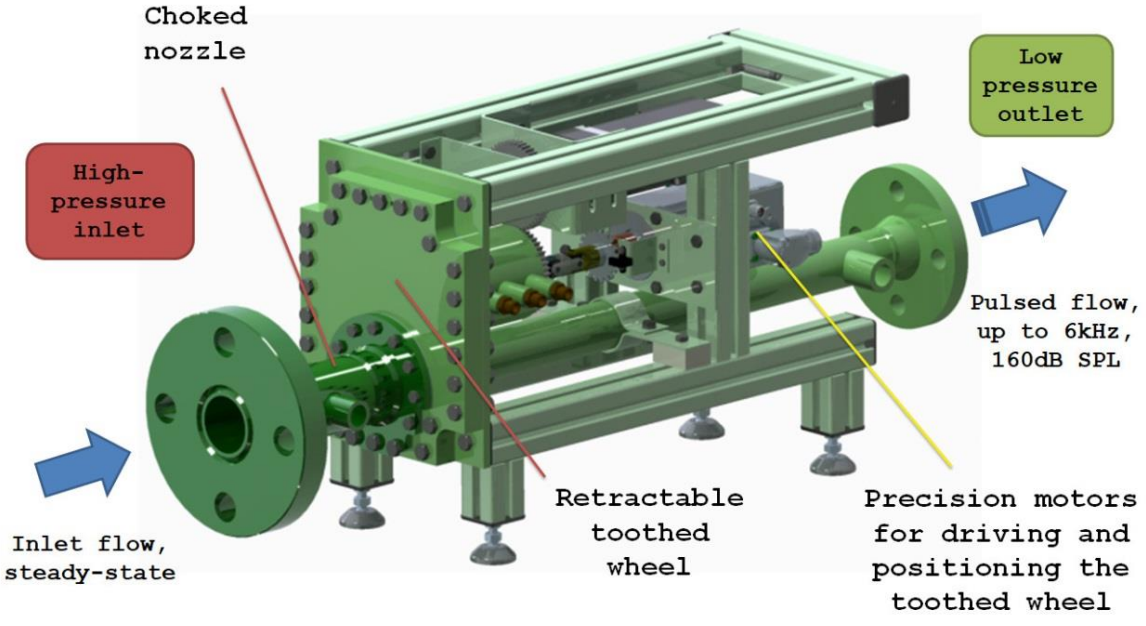
Project Bluetifuel - Strategy



Content

- Project Bluetifuel
- **Siren E**
  - **Specifications, Principle, Application**
  - **Method for detecting Eigenfrequencies of the Flame**
- CFD Simulation
- Combustion Experiments
- Conclusion & Perspectives

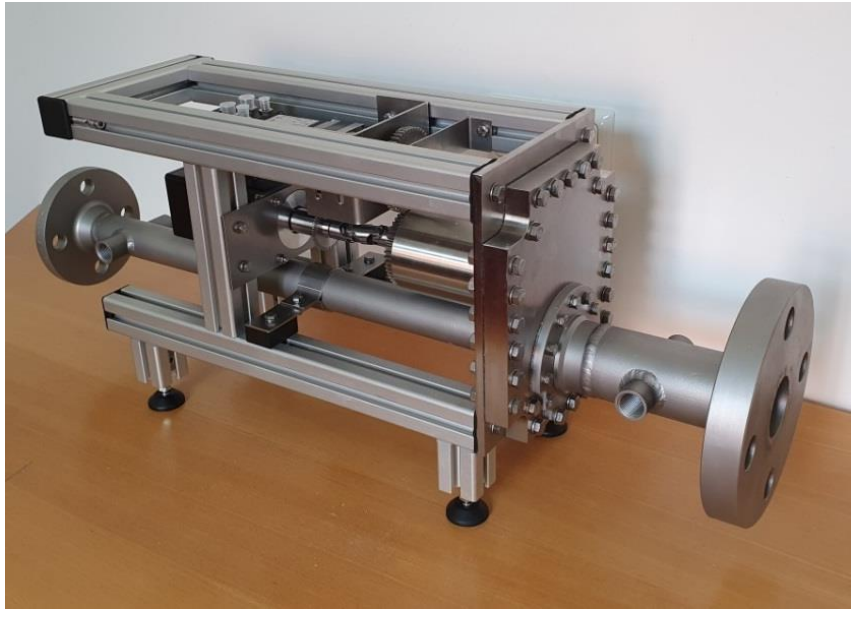
Siren E - Specifications



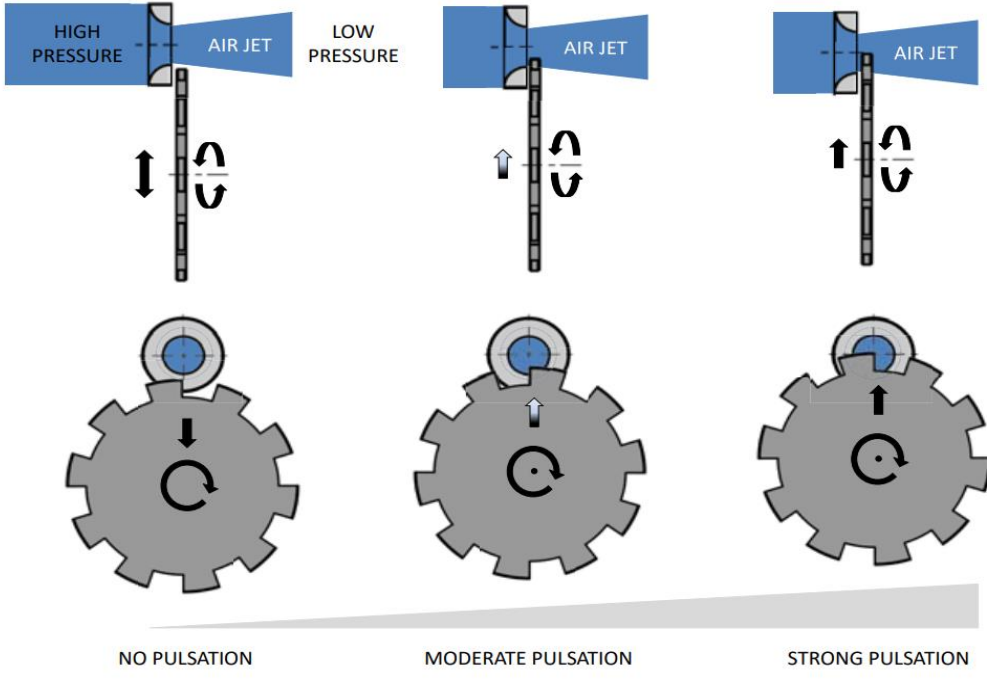
- High pressure side up to **80bar**
- Low pressure side up to **40bar**
- Pulsation frequency up to **6000Hz**

Siren E - Specification

- Air mass flow rate up to **3kg/s** under maximum pressure drop and 30% pulsation
- Noise levels up to **160 dB SPL**

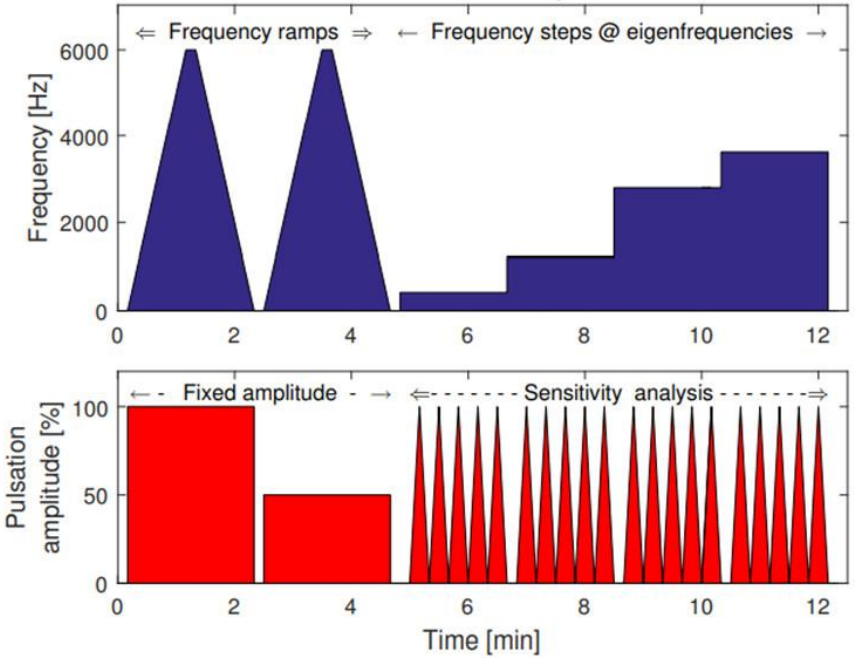


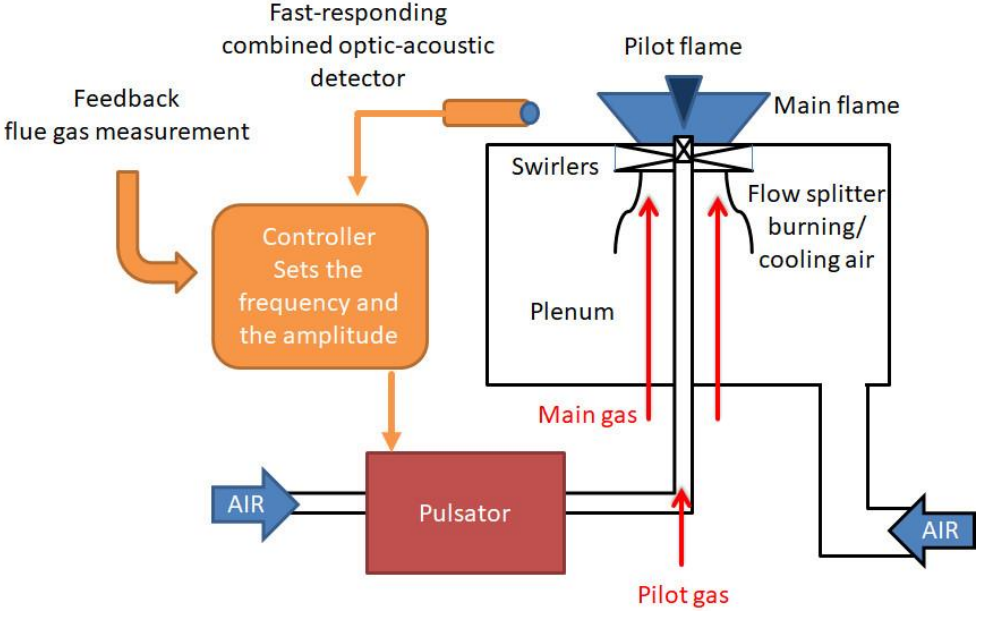
Siren E - Principle & Application



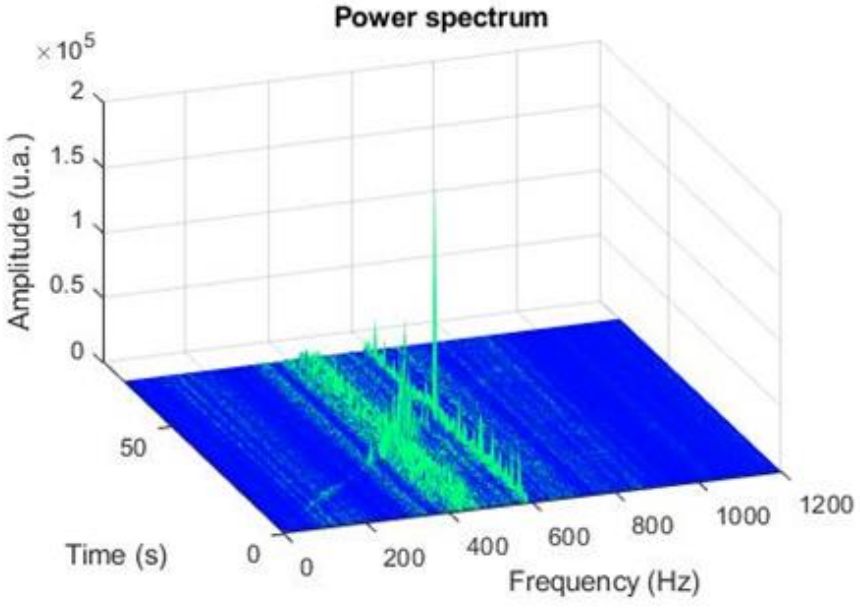
- Calibration of dynamic pressure transducers
- Acoustic characterisation of a combustor assembly
- Flow control and flame forcing

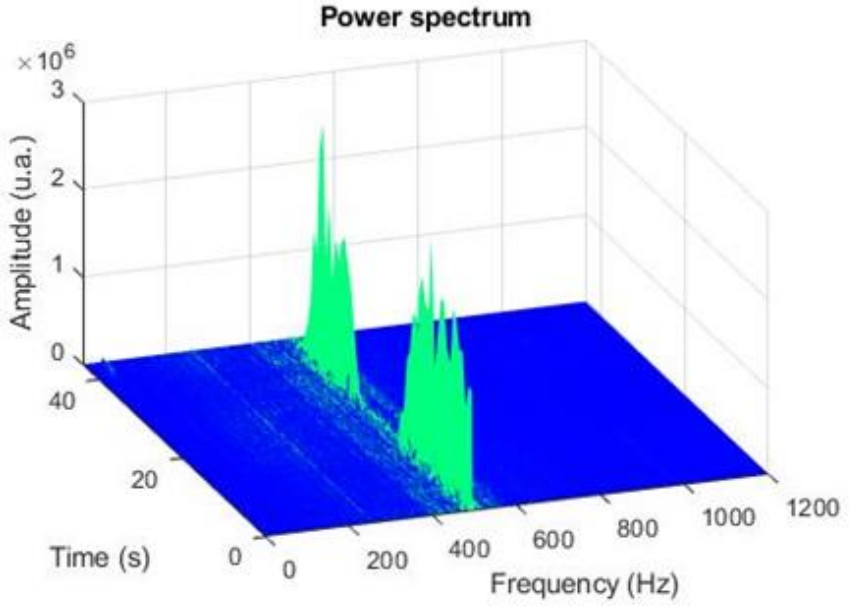
Siren E - Method for detecting Eigenfrequencies





Siren E - Method for detecting Eigenfrequencies

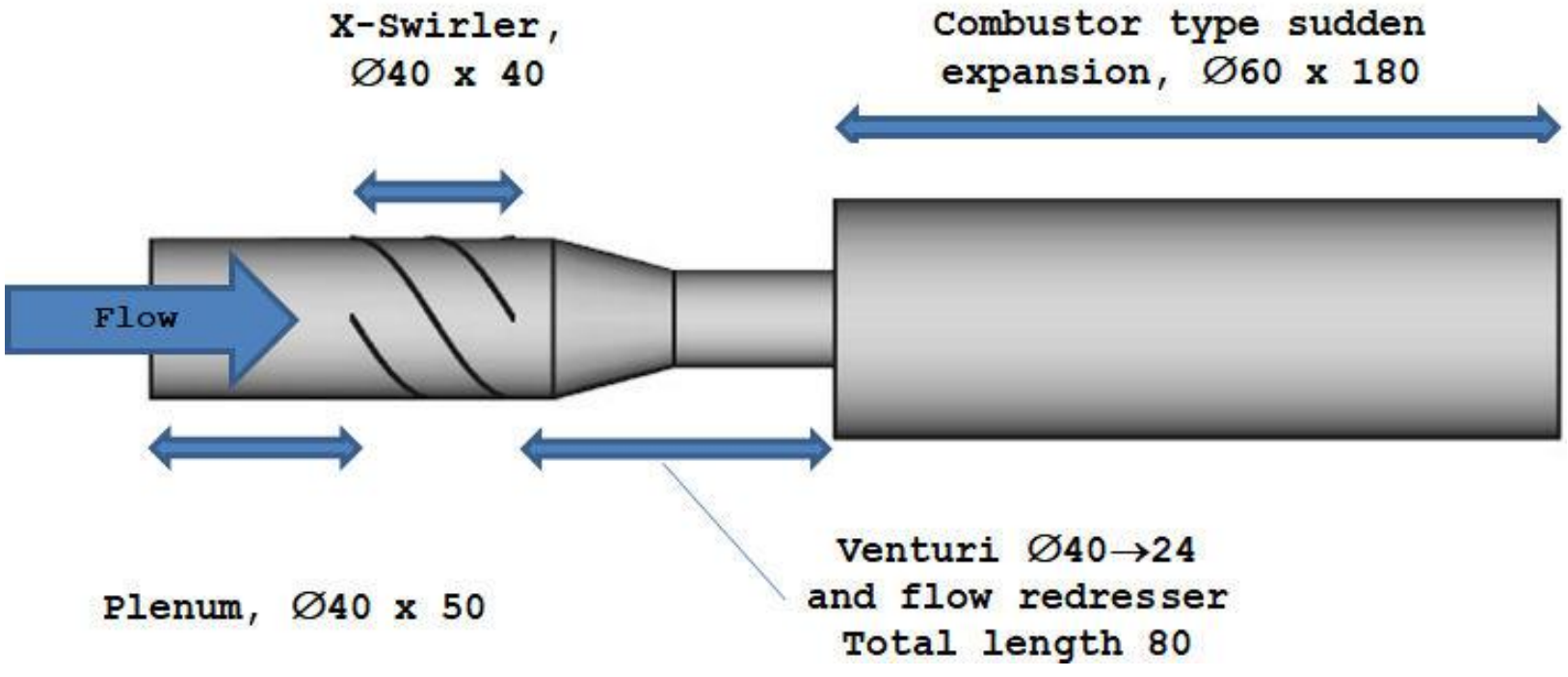




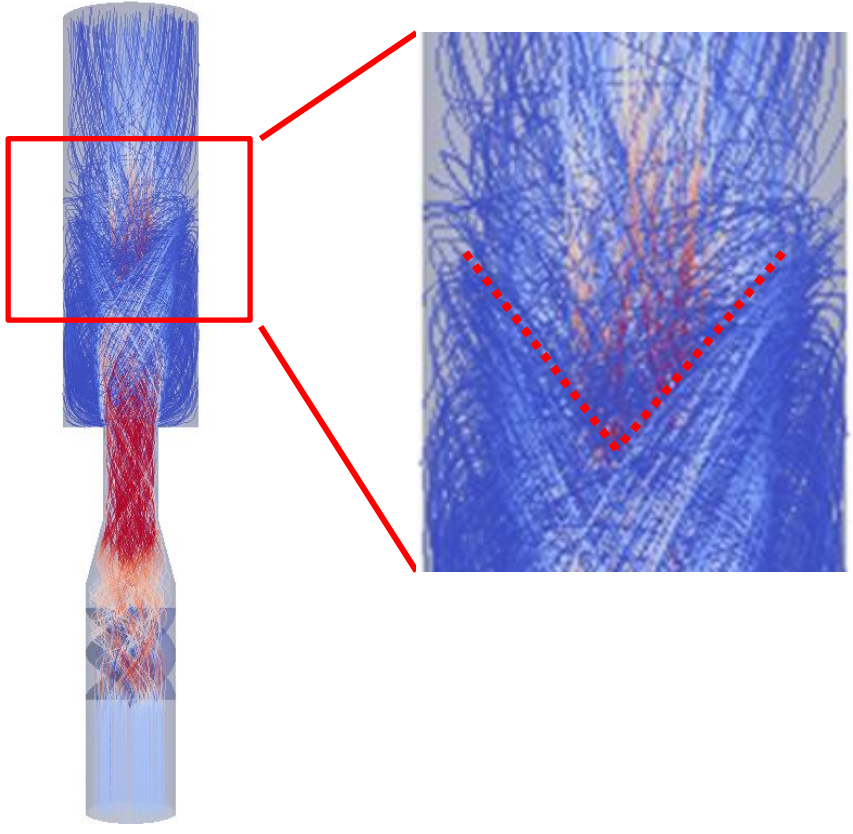
Content

- Project Bluetifuel
- Siren E
- **CFD Simulation**
  - **The Model**
  - **Aerodynamic Study of the Pilot Stage**
  - **Stability and Flashback Study**
- Combustion Experiments
- Conclusion & Perspectives

CFD Simulation – The Model



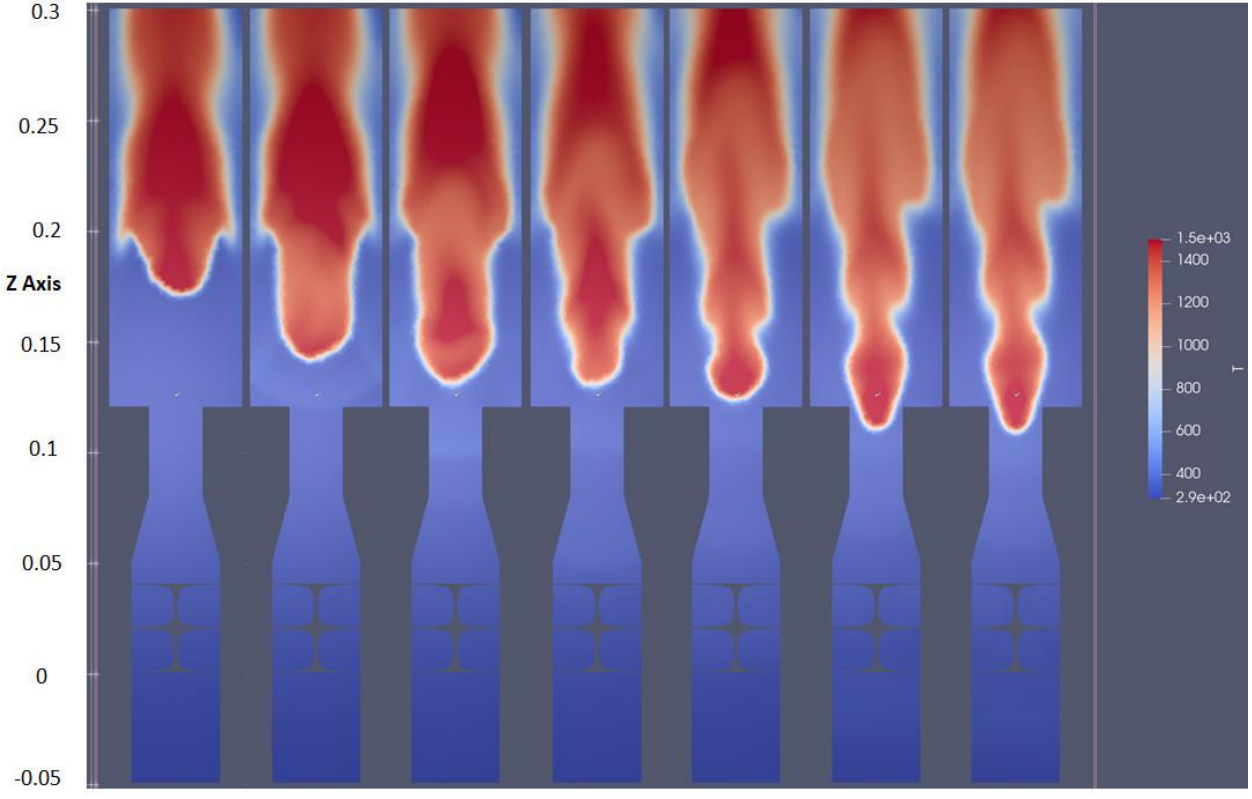
CFD Simulation – Aerodynamic Study



- Solver: PisoFoam
- Fluid Air
  - Quantity adapted to a fictitious thermal power of 5 kW and equivalence ratio of 0.5
  - Density and Viscosity adapted to fictitious hydrogen content

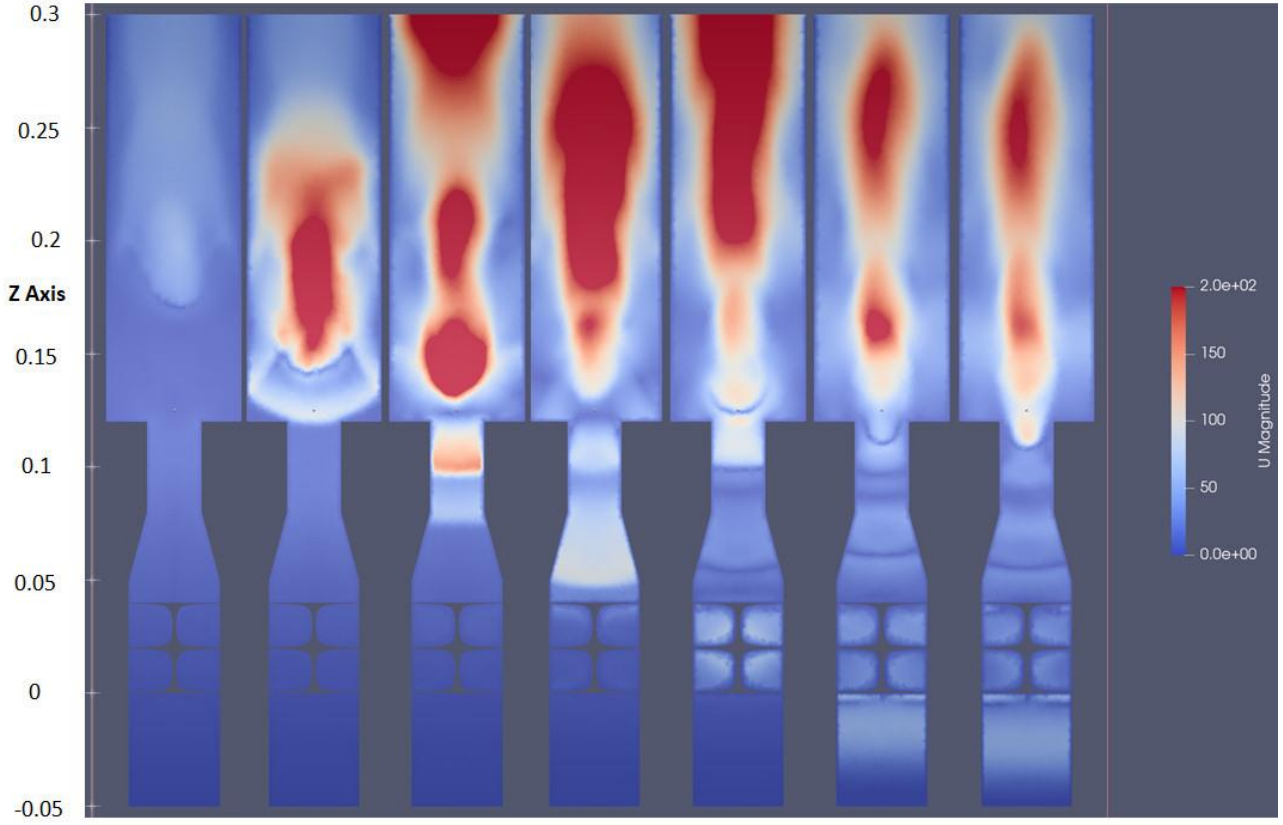
- Strong recirculation zone
- Assumed flame position at reattachment point

CFD Simulation – Stability and Flashback Study



- Solver: XiFoam
- Premixed H_2
- P = 5 kW
- Phi = 0.5
- Temperature field

CFD Simulation – Stability and Flashback Study



- Velocity field
- Bubbles of hydrogen
  - Elevated flame speed

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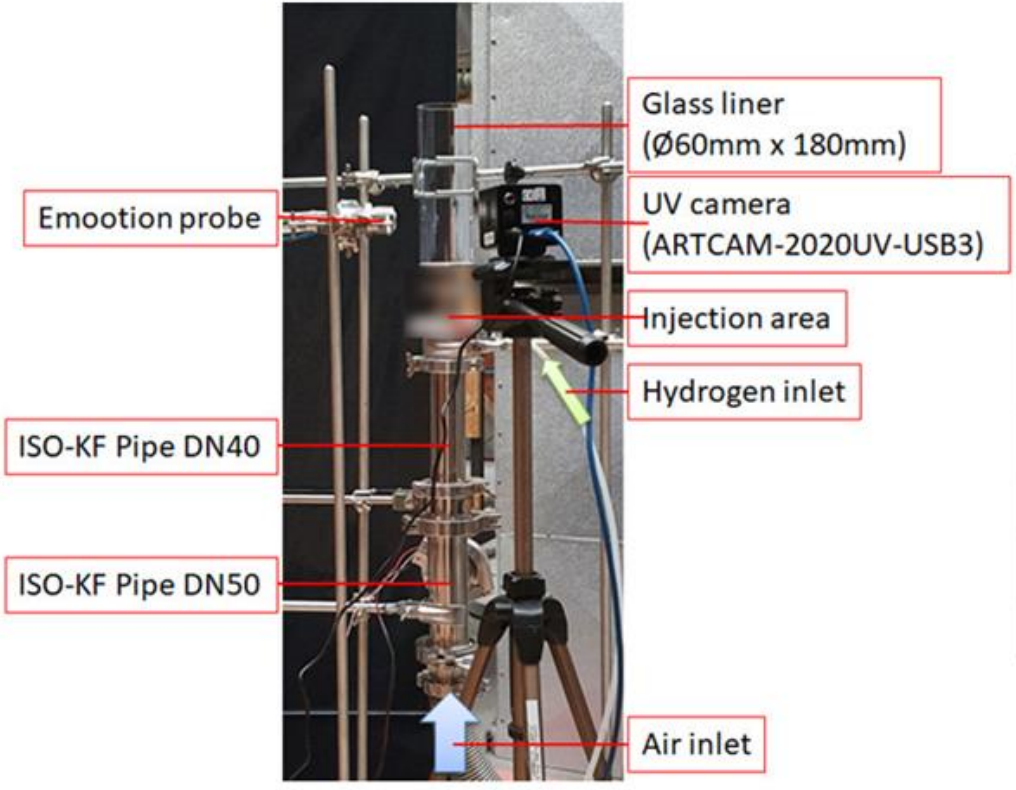
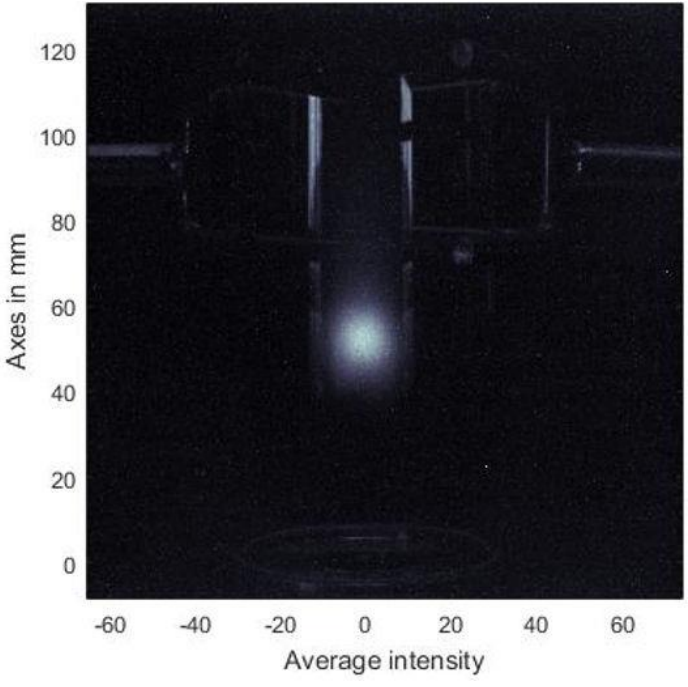
- **Combustion Experiments**
  - **Test Setup**
  - **Results**
- Conclusion & Perspectives

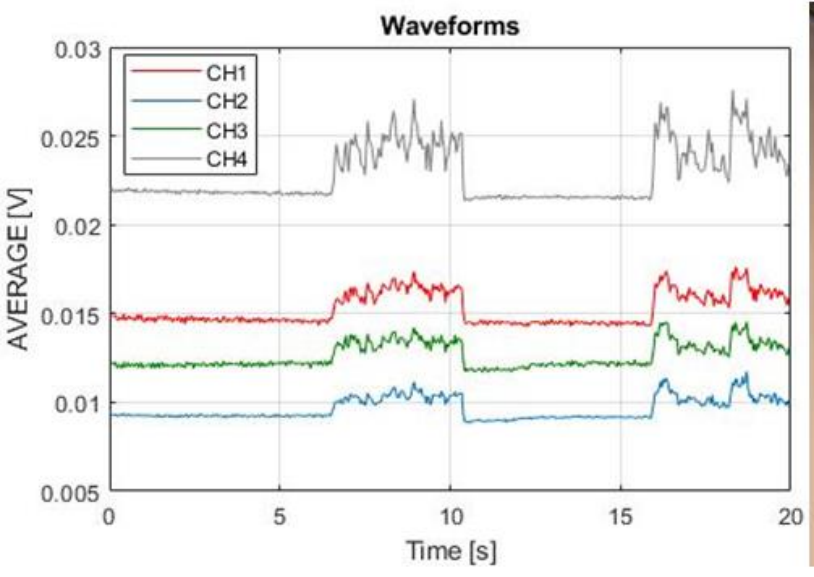
Combustion Experiments – Test Setup



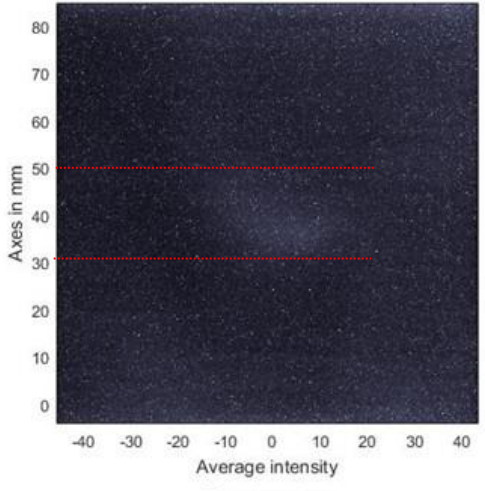
DESIGNATION	UNIT	VALUE
Thermal power range	[kW]	1.3 - 7.5
Equivalence ratio range	[-]	0.07 - 0.5
Air mass flow range	[g/s]	3 - 6.6
Hydrogen mass flow range	[g/s]	0.011 - 0.06
Standard operating point - air	[g/s]	4.46
Standard operating point - hydrogen	[g/s]	0.0266
Standard equivalence ratio	[-]	0.2

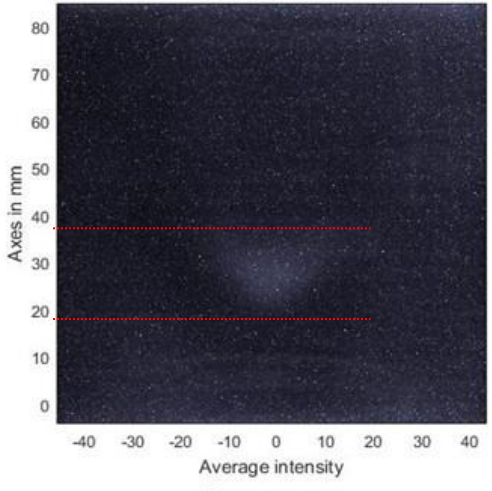
Combustion Experiments – Results

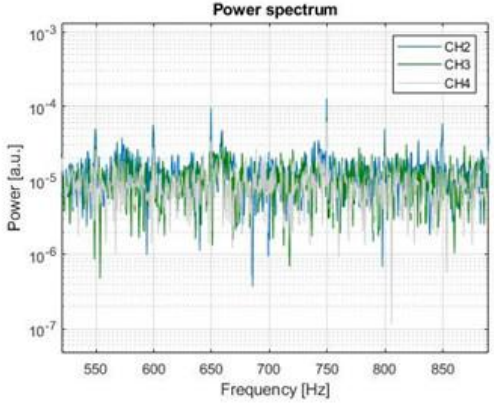


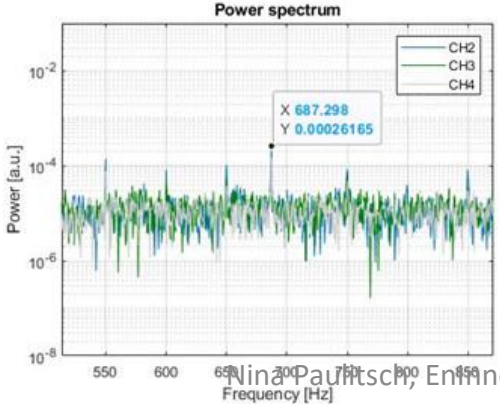


Combustion Experiments – Results









Operating Point:

- H2 = 0.0266 g/s
- Air = 4.46 g/s
- ϕ = 0.2

Left: no pulsation

Right: pulsation with 687Hz

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Conclusion & Perspectives

- Pilot Stage
  - Operates safely under ultra-lean conditions ($\phi \leq 0.5$)
  - Provides the desired auto-ignition temperature of the eco-fuels
  - Pulsation showed a significant effect on a detached, swirl-stabilised hydrogen flame
- Next step is to investigate in more detail what effect pulsation has on combustion stability and combustion quality
- Correlation between pulsation and combustion temperature, NO_x formation and combustion range extension

Conclusion & Perspectives

- Emootion Probe
  - Actually designed for the use with conventional fuels
  - Good response to the hydrogen flame in open area
  - Response of the probe needs to be investigated in more detail, as results can be distorted by thermal radiation from the combustor walls

- Next step is the characterisation of the probe for a hydrogen flame in combustor
- Adaption to the UV range, if necessary

Perspectives

- Further numerical computations will be performed with reacting flows including hydrogen and ammonia
- Initial combustion tests performed with premixed ammonia and hydrogen-powered pilot stage

Thank you for your attention!
Danke für Ihre Aufmerksamkeit!

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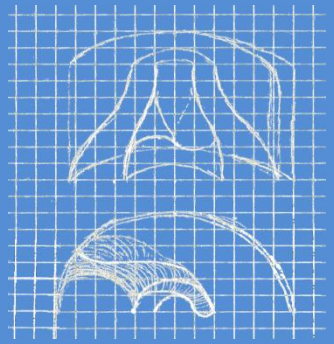

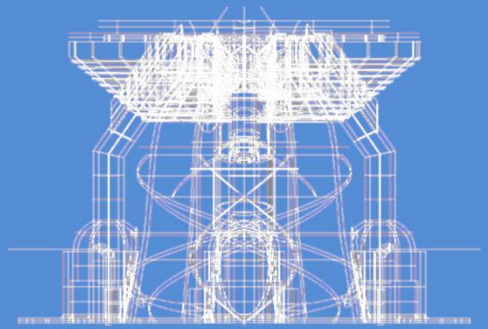

Ideas **Engineering** **Solutions**

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