T. Albiol (IRSN) - L. Herranz (CIEMAT) - E. Riera (CSIC) - S. Guieu (EDF)
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New studies on passive and active systems towards enhanced severe accident source term mitigation – The PASSAM Project

PASSAM General Context (1/4)

- Proposal in answer to a call for tenders from the European Commission: dead-line for answer, March 27th.
- IRSN Coordinator.
- “Negotiation phase” since June 2012.
- Project starting date: January 1st, 2013.
- Duration: four years, up to December 31st, 2016.
- Project mainly experimental on PASSIVE and ACTIVE SYSTEMS on SEVERE ACCIDENT SOURCE TERM MITIGATION → Practically, on Filtered Containment Venting Systems (FCVS)

PASSAM General Context (2/4)

- 8 European partners

Participant N°	Participant organization name	Country
1 (Coordinator)	Institut de Radioprotection et de Sûreté Nucléaire (IRSN)	France
2	Centro de Investigaciones Energeticas Medio Ambientales y Tecnologicas (CIEMAT)	Spain
3	Agencia Estatal Consejo Superior de Investigaciones Cientificas (CSIC)	Spain
4	Electricité de France (EDF)	France
5	Paul Scherrer Institut (PSI)	Switzerland
6	Ricerca sul Sistema Energetico - RSE SpA (RSE)	Italy
7	VTT Technical Research Centre of Finland (VTT)	Finland
8	AREVA NP GmBH (AREVA)	Germany

- Total effort: 390 person.months
- Total cost: 5.1 millions Euros

PASSAM General Context (3/4)

- In case of a severe accident in a Nuclear Power Plant (NPP) fission products are released from the degraded fuel and may reach the environment if the containment building is damaged and/or bypassed. Given the high radio-toxicity of fission products for environment and population, it is absolutely necessary to avoid - or to drastically reduce - their release. This highlights the importance of relying on efficacious mitigation systems capable of reducing as much as possible any accidental release. This overall statement becomes even stronger after the accident of March 2011 at the Fukushima Daiichi NPP.

- Current NPPs are furnished with safeguards based on the Design Basis Accident and some extensions to cope with accidents beyond the design bases. So, there are a number of mitigation systems within a NPP, both to accommodate the energy release and to deplete most of potential radioactive emission to the environment. Sprays, suppression pools, particle filters (sand filters, pool scrubbers, …) are among those contributing to source term attenuation.

PASSAM General Context (4/4)

- The PASSAM project is of R&D experimental nature, aiming at:
  - Exploring potential enhancement of existing source term mitigation devices.
  - Demonstrating the ability of innovative systems to achieve larger source term attenuation.
- The project's outcomes will constitute a valuable database which may be strategic for helping the utilities on the decision of implementing and/or enhancing mitigation systems on their reactors and for improving severe accident management. Robustness features for each type of mitigation system studied will be evaluated to increase the reliability of operation and reduce the risk for environmental impact in case of a severe accident.
- The understanding gained from in-depth analysis of experimental results will make possible to produce simple models and/or correlations easy to be implemented in accident analysis codes. Then, the use of these codes will allow enhancing the capability of modelling Severe Accident Management scenarios and developing improved guidelines.

PASSAM Organisation: 5 Work-packages

WP N°	Work Package title (and short name)	N° - Lead participant	Person-months	Start month	End month
WP1	Project Management (MANAG)	1 - IRSN	**6**	**1**	**48**
WP2	State of the art and Modelling (THEOR)	2 - CIEMAT	**65**	**1**	**48**
WP2.1	*State of the art report (SOAR)*	*2 – CIEMAT*	*17*	*1*	*12*
WP2.2	*Development of simplified models/correlations (MODEL)*	*6 – RSE*	*48*	*18*	*46*
WP3	Existing Filtration Systems (EXIST)	5 - PSI	**134**	**6**	**42**
WP3.1	*Pool scrubbing systems (POOL)*	*5 - PSI*	*96*	*6*	*42*
WP3.2	*Sand bed filters plus metallic pre-filters (SAND)*	*1 - IRSN*	*38*	*6*	*42*
WP4	Innovative Filtration Systems (INNOV)	7 - VTT	**154**	**6**	**42**
WP4.1	*Acoustic agglomeration systems (ACOU)*	*2 – CIEMAT*	*44*	*6*	*42*
WP4.2	*Spray agglomeration systems (SPRAY)*	*6 – RSE*	*14*	*6*	*42*
WP4.3	*Electric filtration systems (ELEC)*	*7 - VTT*	*42*	*6*	*42*
WP4.4	*Improved zeolite filtration systems (ZEOL)*	*1 - IRSN*	*52*	*6*	*42*
WP4.5	*Combined filtration systems (COMB)*	*8 - AREVA*	*2*	*6*	*42*
WP5	Dissemination of Knowledge and Synthesis (DKS)	1 – IRSN	**31**	**1**	**48**
WP5.1	*Dissemination of knowledge (DISK)*	*1 – IRSN*	*10*	*1*	*48*
WP5.2	*Project synthesis (SYNTH)*	*1 – IRSN*	*21*	*36*	*48*
	TOTAL		390		

PASSAM Detail of Work-packages (1/4)

- WP2: (THEOR) STATE OF THE ART AND MODELLING (leader CIEMAT)
  - Two scientific parts of the project which are not directly experimental studies and which will be based on a real shared work between the partners.
  - WP2.1 (SOAR): State of the art report (leader CIEMAT)
  - The work will consist of performing a comprehensive literature survey and writing a state-of-the-art report on filtration systems used (pool scrubbing; sand filters plus metallic pre-filters), or potentially usable (agglomerators to be mounted upstream a filtration system; electrostatic precipitators; improved zeolites; combination of several systems…) for source term mitigation of severe accidents. This state-of-the-art report will allow highlighting both the existing knowledge and gaps in this field. From that step, the remaining needs will be identified and they will allow a precise definition of the experiments to be performed to improve the knowledge. For each type of filtration system the following questions will be answered:
    - What has been tested (aerosols, molecular iodine, organic iodine, other gaseous species)?
    - Under which conditions (more or less relevant as regards severe accident conditions)?
    - What filtration efficiency has been assessed?
    - What is the understanding of the trapping phenomena?
    - Are there models and/or correlation to pre-estimate the filtration efficiency of a specific system during an accident?
    - When considering the long term behaviour following an accident, will the trapped fission products remain in the filtration system or is there a significant risk that, due to the surrounding conditions (thermal-hydraulics, radioactivity), these fission products be released by re-entrainment or revaporisation or any other physical-chemical phenomenon?
  - Also, based on available literature and on other data coming from partners pre-existing knowledge, the ranges of major parameters determining FCVS operation will be included in the state-of-the-art report. This last point is of utmost importance to outline suitable test matrices within the PASSAM project. So, as a result of this work, tests to be performed will be clearly identified and test matrices will be defined for each type of system to be experimentally studied in WP3 and WP4.

PASSAM Detail of Work-packages (2/4)

- WP2.2 (MODEL): Development of simplified models/correlations (leader RSE)
- The partners will share the experimental results of the project and will proceed to a common detailed analysis of the experimental results obtained through WP3 and WP4 in order to understand the major phenomena which allow the trapping of the fission products and their long term behaviour under accident conditions. This analysis will allow deriving simplified models and/or correlations for each type of system studied, that will be easy to implement - but not included in the PASSAM project - in accident analysis codes, as ASTEC.

- WP3: (EXIST) EXPERIMENTAL STUDIES OF EXISTING FILTRATION SYSTEMS (leader PSI)
  - WP3.1 (POOL): Experimental studies of pool scrubbing systems (leader PSI).
  - Number of studies on pool scrubbing efficiency already exist but the results are still largely scattered and complementary tests remain relevant for validation purposes:
    - Tests with well controlled mono-disperse particles
    - Presence of additional structures in the pool; study of hydrodynamics in the pool under high jet flow velocities
    - Organic iodine retention (additives in the pool)
    - Long term stability of iodine compounds trapped in a pool scrubbing system under severe accident conditions
  - WP3.2 (SAND): Experimental studies of sand bed filters plus metallic pre-filters (leader IRSN).
  - Implemented on all French PWRs and tested in the late eighties and early nineties for aerosol retention. Complementary tests needed for:
    - Molecular and organic iodine retention
    - Long term stability of filtered fission products under severe accident conditions (temperature, flow-rate, pressure, humidity, irradiation)

PASSAM Detail of Work-packages (3/4)

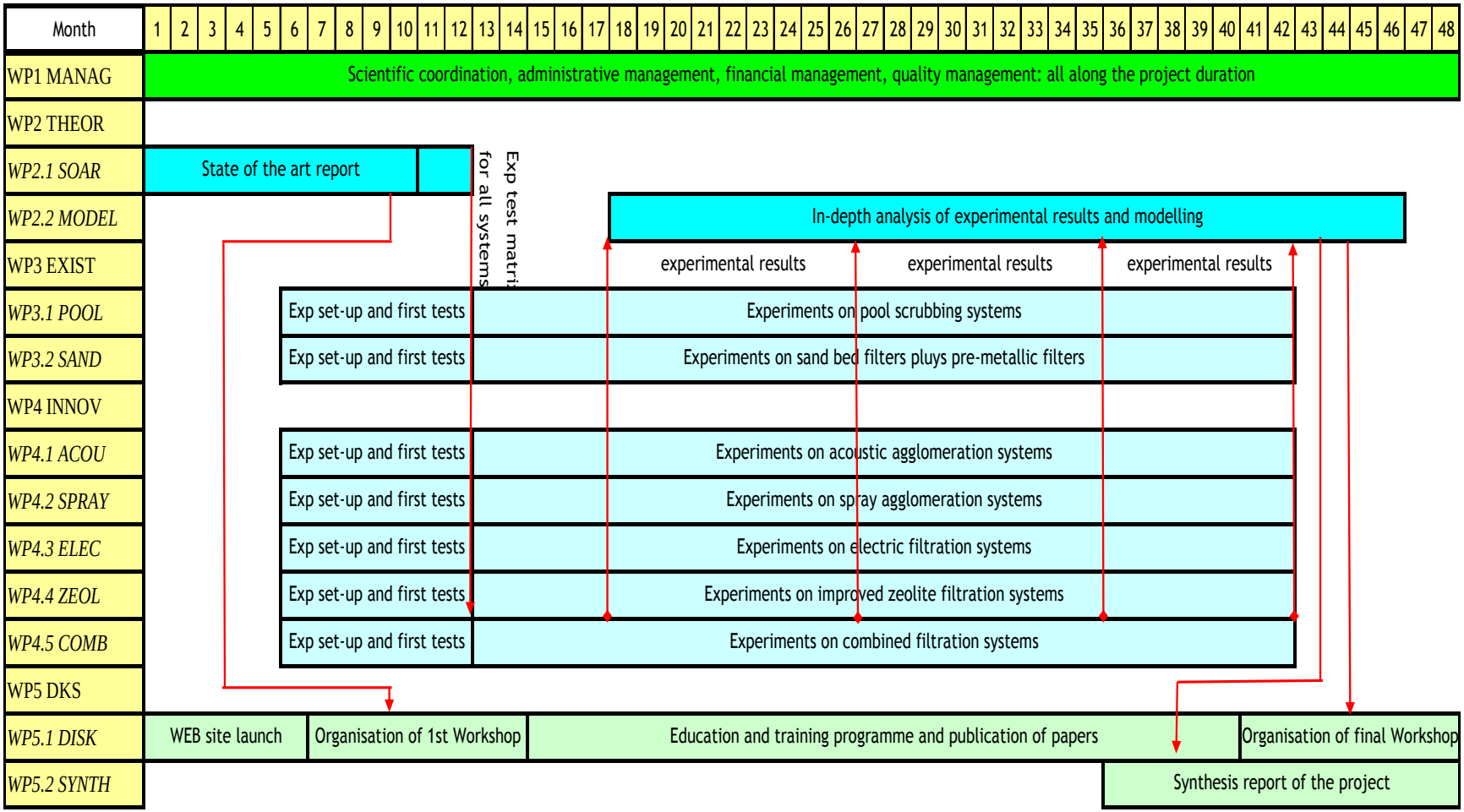
- WP4: (INNOV) EXPERIMENTAL STUDIES OF INNOVATIVE FILTRATION SYSTEMS (leader VTT)
  - WP4.1 (ACOU): Acoustic agglomeration systems (leader CIEMAT).
  - Objectives: Improving the retention efficiency of FCVS by agglomerating aerosol particles upstream of the filtration device (either in the containment building or in the venting line).
  - Means: Tests of acoustic agglomerator under severe accident conditions and optimization of its working conditions
  - WP4.2 (SPRAY): Spray agglomeration systems (leader RSE).
  - Objectives: Improving the retention efficiency of FCVS by agglomerating aerosol particles upstream of the filtration device (either in the containment building or in the venting line).
  - Means: Tests of different types of sprays; understanding of the associated mechanisms; tests of water additives and of water with electrical charging; tests of injection axis configurations.
  - WP4.3 (ELEC): Electric filtration systems (leader VTT).
  - Objectives: Use of existing industrial systems (with potential improvements) to severe accident conditions and determination of the best strategy (location of the filters).
  - Means: Tests of retention of gaseous (molecular and organic) iodine, of iodine aerosols and of mixture of them for wet and dry electric filtration systems under severe accident conditions.

PASSAM Detail of Work-packages (4/4)

- WP4.4 (ZEOL): Improved zeolite filtration systems (leader IRSN).
- Objectives: Develop innovative filtration systems based on zeolites (supposed high stability to dose rate).
- Means: Preliminary studies to identify the most suitable zeolites able to trap volatile iodine; Tests of retention efficiencies for molecular and organic iodine, including influence of humidity.
- WP4.5 (COMB): Combined Filtration Systems (Leader AREVA)
- Objectives: Investigate the combination of wet and dry filters as well as of adsorptive filters ; Assess the feasibility and the potential benefits.
- Means: First, theoretical work (taking into account severe accident conditions); then (depending on the results), large scale tests could be performed in representative conditions (retention efficiencies and system robustness).

- WP5: (DKS) DISSEMINATION OF KNOWLEDGE AND SYNTHESIS (leader IRSN)
  - WP5.1 (DISK): Dissemination of knowledge (leader IRSN).
  - Publication of several papers in scientific journals or conferences,
  - Organization of two open workshops mainly targeted to R&D organizations, National Safety Authorities and their Technical Support Organizations, to the utilities and to the vendors.
    - One workshop after writing the state-of-the-art report to present the outcomes of this report and the envisaged test programme,
    - One workshop at the end of the project to present the major outcomes of the project.
  - WP5.2 (SYNTH): Project synthesis (leader IRSN).
  - Final synthesis report of the project (open literature)

PASSAM Summary of Work-packages



CONCLUSIONS

- The PASSAM project is now ready to start for a 4 year duration
- It will involve 8 European partners bringing together their competencies and their various test facilities.
- The main technical outcomes will be documented in a final synthesis report and presented in a final workshop:
  - Extension of the current database on the existing or innovative mitigation systems:
    - Gaseous iodine retention (molecular and organic iodine),
    - Hydrodynamics for scrubbers,
    - Long term stability of trapped compounds.
  - Deeper understanding of the phenomena underlying their performance.
  - Models/correlations easy to implement in accident analysis codes, like ASTEC.
  - Advantages and drawbacks of all the systems studied (efficiencies, passive behaviour, robustness, long term retention, etc…).
  - Tentative extrapolation of developed models to accident conditions.
  - Estimation of orders of magnitude for source term reduction for each filtration system, including on the long term, in accident conditions.
  - Hints for improved filtration system.

- The authors thank the European Commission for showing a strong interest in the proposed PASSAM Project, and for being now on the way to propose a contract in order to fund it in the frame of the 7th framework programme for nuclear research and training activities

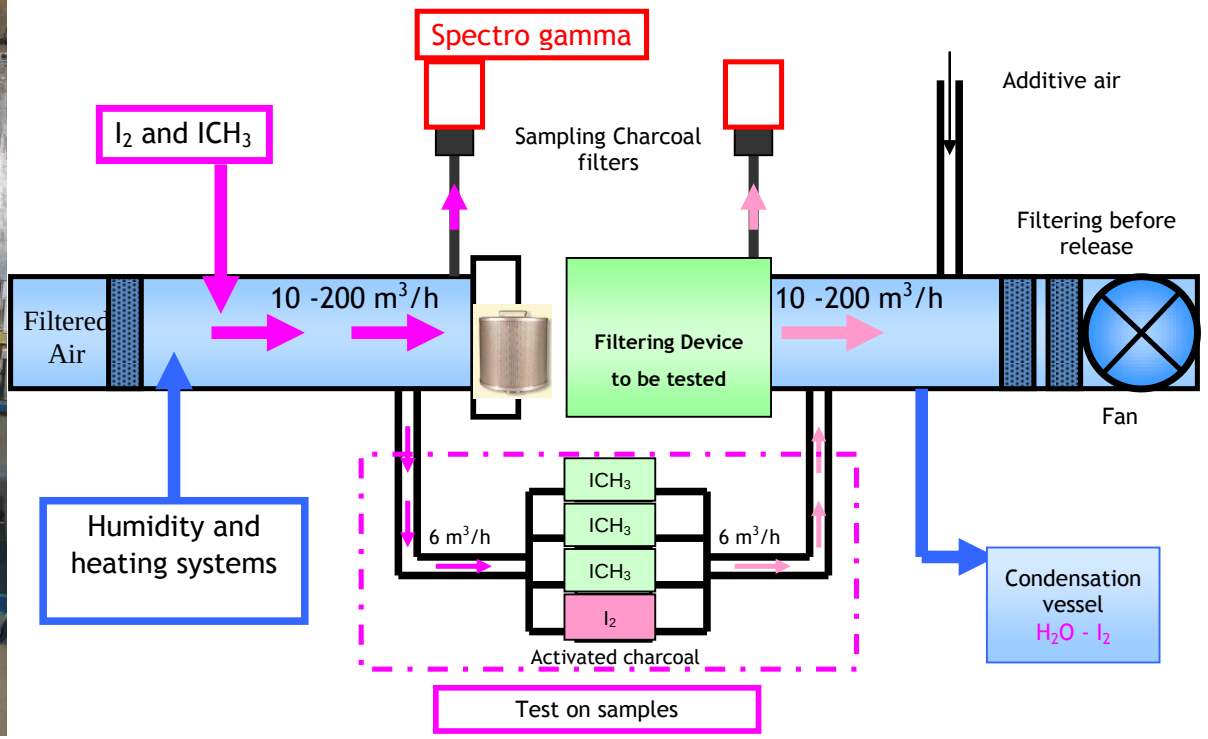
THANKS FOR YOUR ATTENTION

PSI: TRISTAN facility for investigation of two-phase flow characteristics

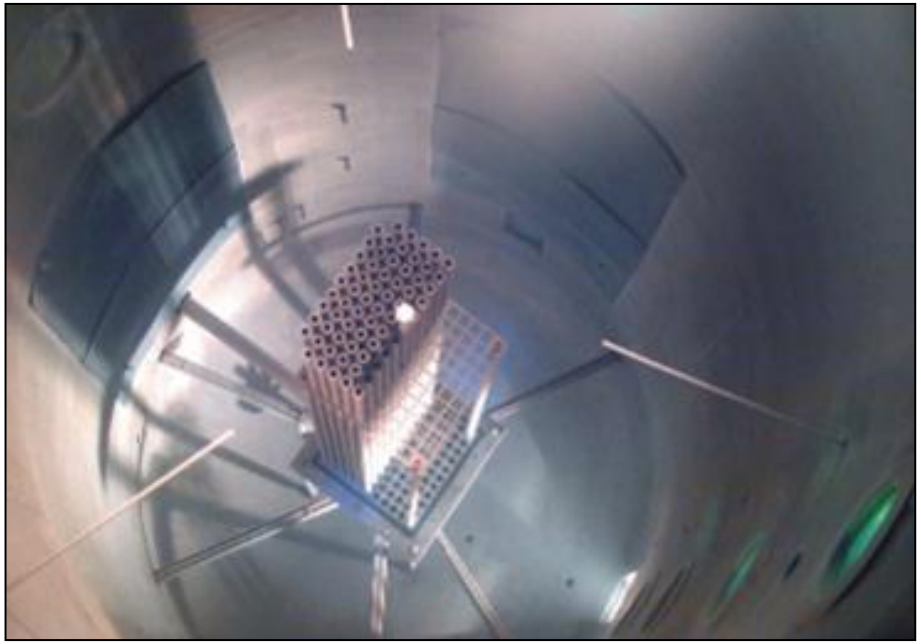
PSI: Small scale, single tube facility, for analytical tests

View of EPICUR facility

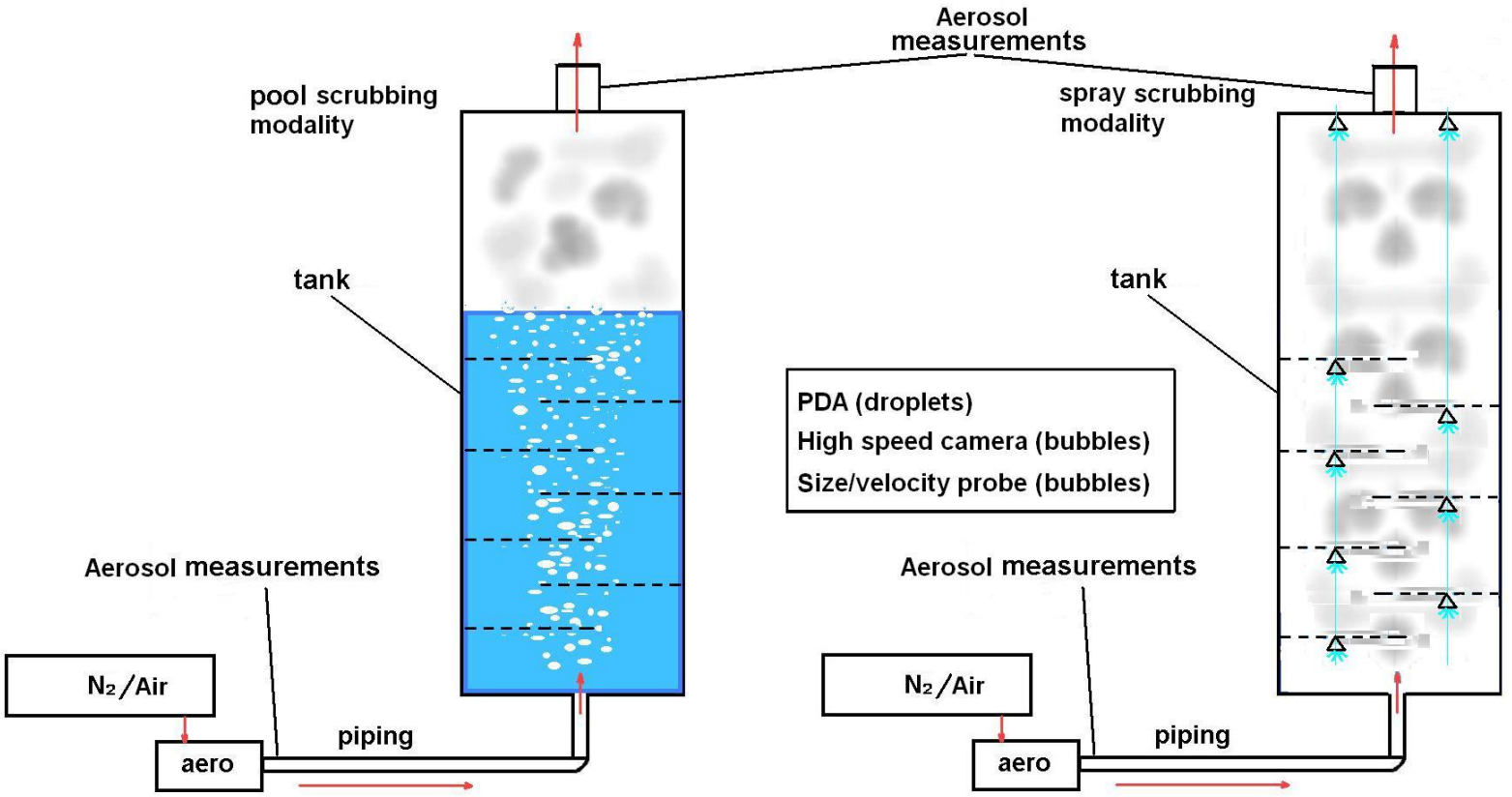
General scheme of the PERSEE facility



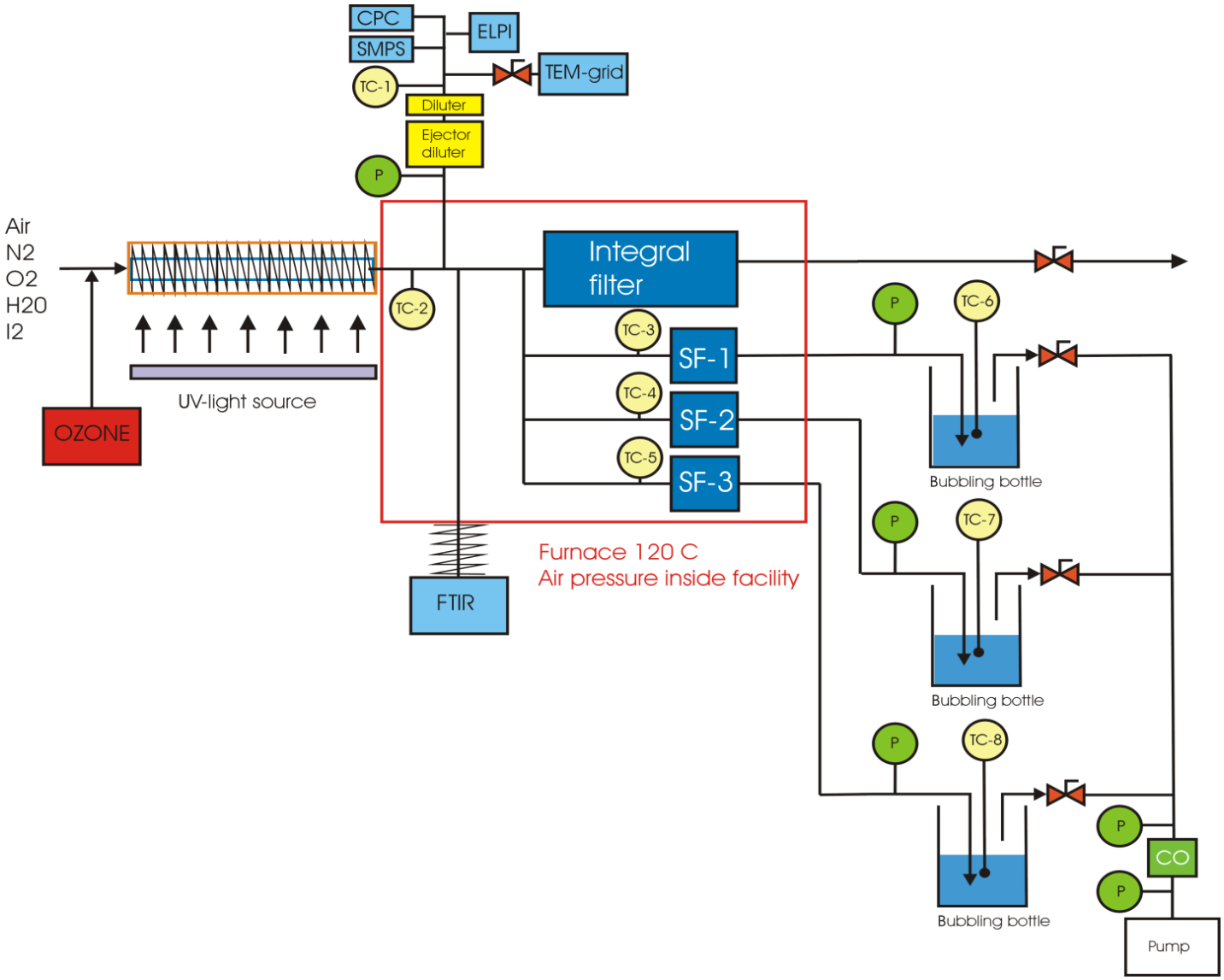
PECA-PASSAM facility



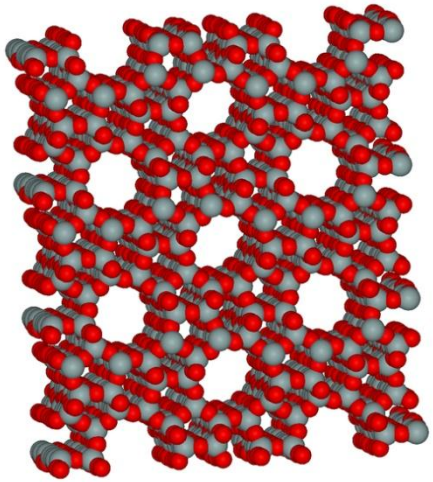
SCRUPOS Picture

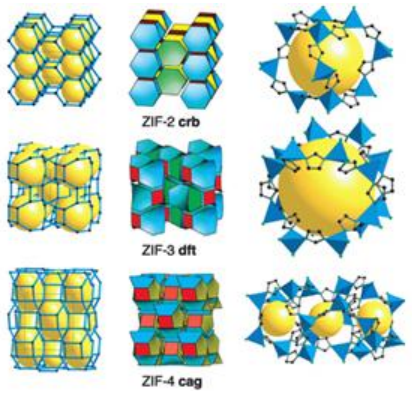


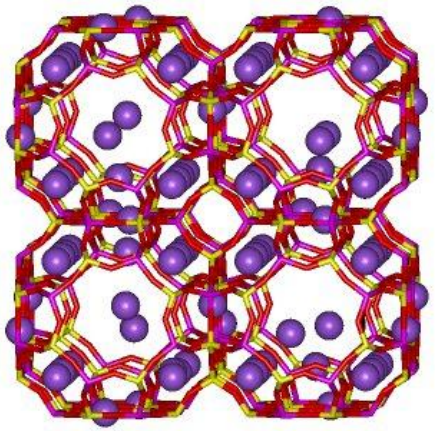
Schematic picture of EXSI CONT facility

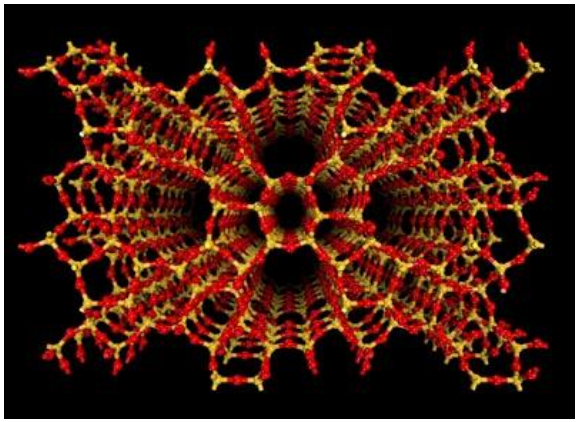


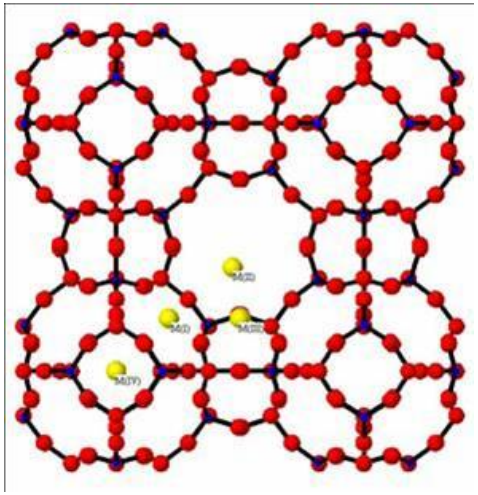
Examples of ZEOLITE Structures

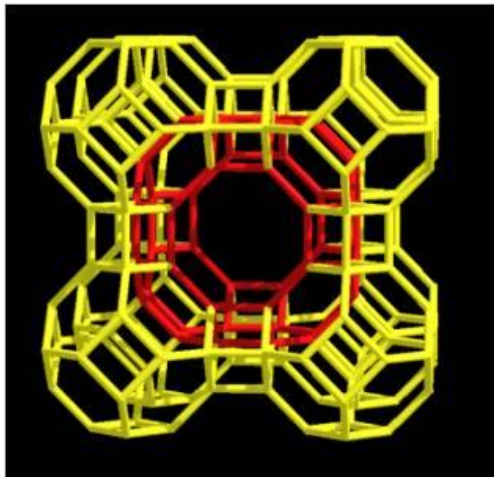












JAVA Facility

PASSAM Main Milestones

Milestone name	WP(s) N°	Expected date (months)
State-of-the-art report on current knowledge on existing and innovative filtration systems for nuclear power plants	2	10
Test matrices, with associated planning (including the connected analysis/modelling phase), defined for each type of system to be tested and all series of tests started or ready to start	2, 3 and 4	12
Workshop on the state of the art	5	14
All experimental programmes and experimental reports completed	3 and 4	42
Report on development of models/correlations	2	46
Final synthesis report	5	48
Final workshop	5	48