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CAMPUS
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INTERNACIONAL

Universidad Politécnica de Madrid

Nuclear Technology Teaching and Research in the Technical University of Madrid

César Queral, Kevin Fernandez-Cosials

Seminarium Zakładu Energetyki Jądrowej i Analiz Środowiska
January 17, 2023

Nuclear Technology Teaching and Research in the Technical University of Madrid

Personnel:

- School of Industrial Engineering (ETSII): 6 Prof., 8 PhD
- School of Mining and Energy Engineering (ETSIME): 5 Prof., 6 PhD
- School of Naval Architecture and Ocean Engineering (ETSIN): 1 Prof.
- School of Civil Engineering (ETSICCP): 3 Prof., 1 PhD

+ Nuclear Fusion Institute

Teaching:

- Several bachelor diplomas include nuclear technology courses.
- Master:
    - “Nuclear Science and Technology”,
    - “Energy Engineering”,
    - MSc in SAfe and Reliable Nuclear Applications (SARENA)
- Doctorate “Sustainable Energy, Nuclear and renewable”

INDUSTRIALES
ETSII | UPM

IFN
Instituto de Fusión Nuclear

Nuclear Technology Research in the Technical University of Madrid

Research lines

- Nuclear safety and radiological protection
- Thermo-hydraulics for nuclear power plants
- Probabilistic Safety Analysis
- Decision support systems for emergency preparedness and response
- Severe accident management
- Computational analysis of advanced nuclear fission systems
- Neutron detection and dosimetry applications
- Reactor noise analysis
- Structural integrity of nuclear fuel cladding

SPAR-CSN project (CSN – UPM agreement)

- **Standardized Plant Analysis Risk (SPAR) models:** PRA models developed by regulatory bodies (USA, China) to evaluate the risk of nuclear power plants with licensee-independent standardized criteria.

- **SPAR-CSN:** **Six** years agreement aiming to elaborate SPAR models for Spanish PWR-W NPPs.

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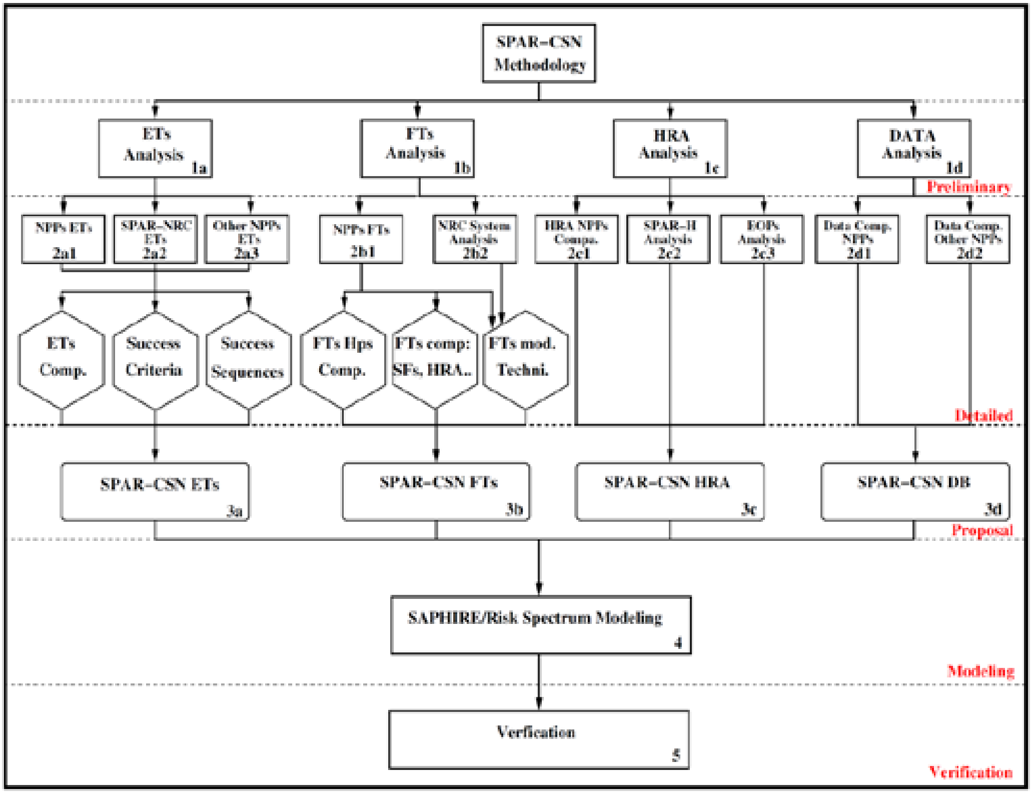
- **The standardization process** covers **ETs, FTs, HRA** and **Data**.

- It includes a comparison between the PSAs of the different plants, identifying which model differences are justified by real design differences (**non-standardizable**) and which are due to modeling discrepancies (**standardizable**).



High-Performance Advanced Methods and Experimental Investigations for the Safety Evaluation of Generic Small Modular Reactors (McSafer)

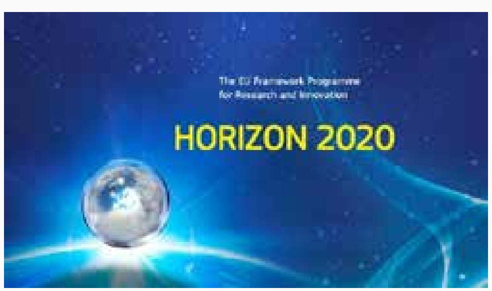
McSAFER: Work Package Structure

- WP1: Project Management (KIT; M01-M36)
- WP2: Experimental Investigations and Validation (LUT; M01-M34)
- WP3: Multiphysics Core Analysis (VTT; M01 - M36)
- WP4: Multi-scale RPV Analysis (UJV; M01 - M36)
- WP5: Multi-physics/-scale Plant Analysis (HZDR; M01 - M36)
- WP6: Dissemination, Exploitation and Communication (UPM; M01-M36)
- WP7: Ethics Requirements (KIT; M01-M36)

Universities: KIT Karlsruhe Institute of Technology; KTH Vetenskap och Konst; LUT University; Politécnica

R&D, TSOs: European Commission; HZDR Helmholtz Zentrum Dresden Rossendorf; cea; CNEA; VTT; ÚJV

Industry: Preussen Elektra; Jacobs; Tractebel Engie



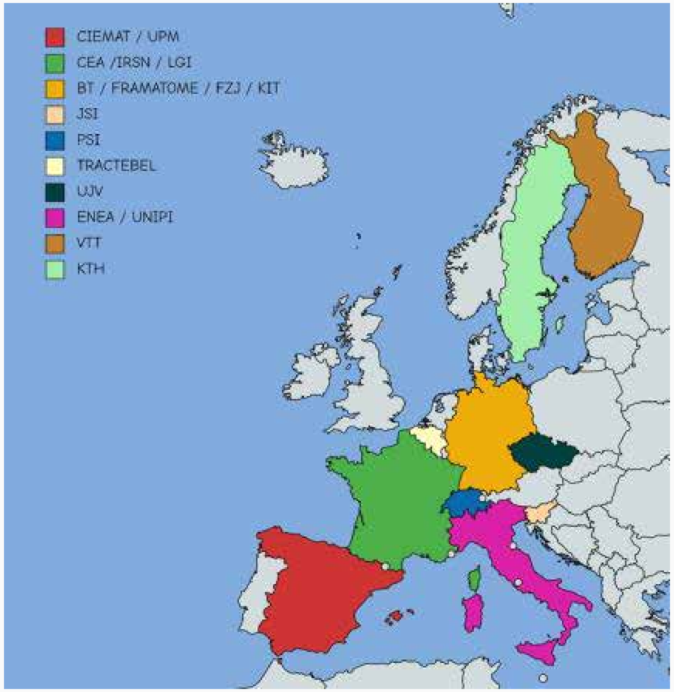
www.mcsafer-h2020.eu

SEVERE ACCIDENT RESEARCH AND KNOWLEDGE MANAGEMENT FOR LWRS (SEAKNOT)

SEAKNOT

2022-2026

WP1: Phenomena Identification Ranking Table on SA (PIRTSA)
WP2: Validation DataBase Directory (VADD)
WP3: Severe Accident Infrastructure NETwork (SAINET)
WP4: KNOwledge Spreading (KNOS)
WP5: Project Coordination (PROC)



Severe Accident Phenomenology short course - SAP 2023
Universidad Politécnica de Madrid
19 - 23 June 2023
https://sap.industriales.upm.es/

Testing and Simulation for Advanced Technology and Accident Tolerant Fuels (ATF-TS). IAEA CRP Project

- **Task 1: Experimental Program**
  - **Round Robin tests**
  - **Bundle tests**
  - **Irradiation tests data**
- **Task 2: Modelling**
  Fuel performance codes benchmarks, including modeling improvements and uncertainty analysis
- **Task 3: LOCA evaluation methodology development for NPP Applications**
- **Task 4: Material properties database for ATF**

ATF simulations with MELCOR, TRACE and TU

IAEA
International Atomic Energy Agency

https://www.iaea.org/projects/crp/t12032

Safety Margins increase in LWR by means of Accident Tolerant Fuel.

- Simulation of MBLOCA and SBLOCA sequences in PWR to quantify the time margins for operator performance with conventional fuel and ATF (TRACE).
- Simulation of SBO sequences in PWR to quantify the time margins for operators' performance with conventional fuel and ATF (TRACE).
- Simulation of load following sequences in PWR reactors. Impact of ATF fuel (SEANAP).
- Simulation of LBLOCA sequences in PWR using Monte Carlo techniques to quantify safety margins with conventional fuel and ATF (TRACE).
- Simulation of LBLOCA sequences in BWR using Monte Carlo techniques to quantify safety margins with conventional fuel and ATF (TRACE).
- Severe accident study in plants with ATF fuel (MELCOR).
- Dissemination activities

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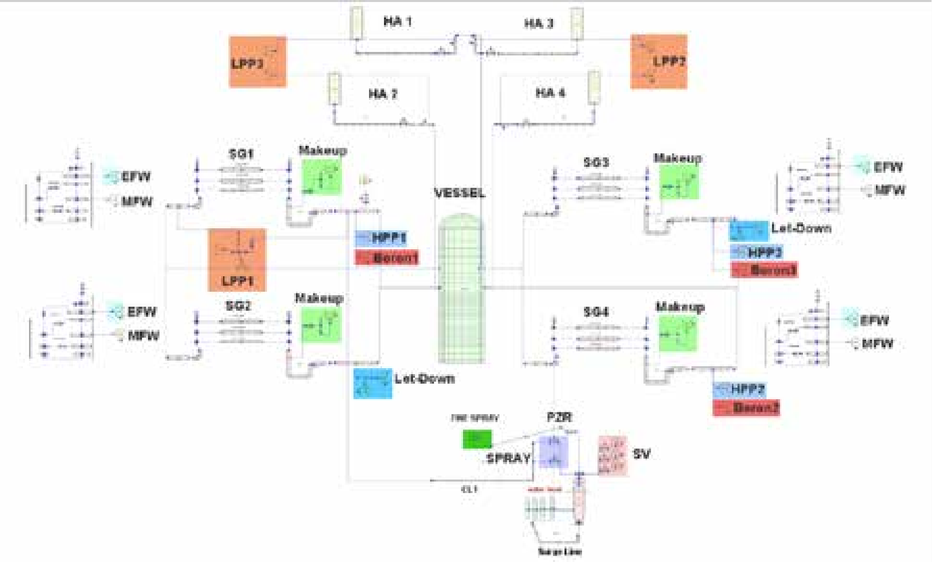
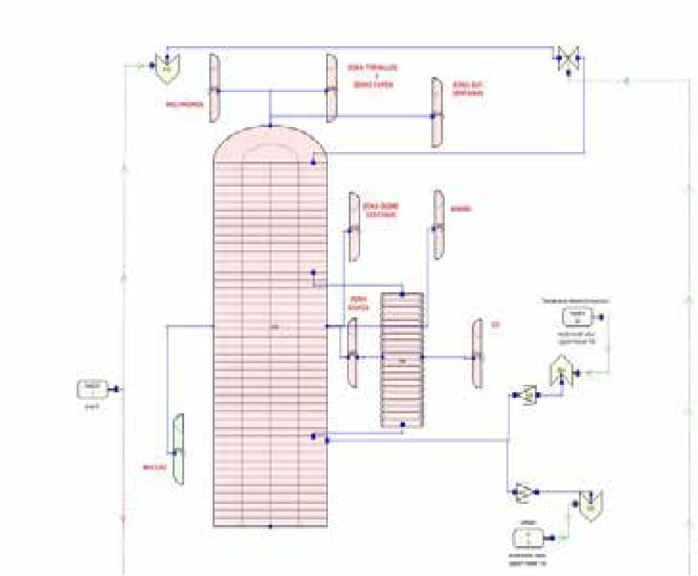
Integrated Safety Analysis of Modular and Evolutive Reactors (ISASMORE)

- Creation of a full **VVER-1000**, **including passive safety systems**, and **CAREM-like** models (TRACE code)
- Fuel performance analysis with Transuranus
- Simulation of different accidental sequences (SBLOCA, LBLOCA, SBO).





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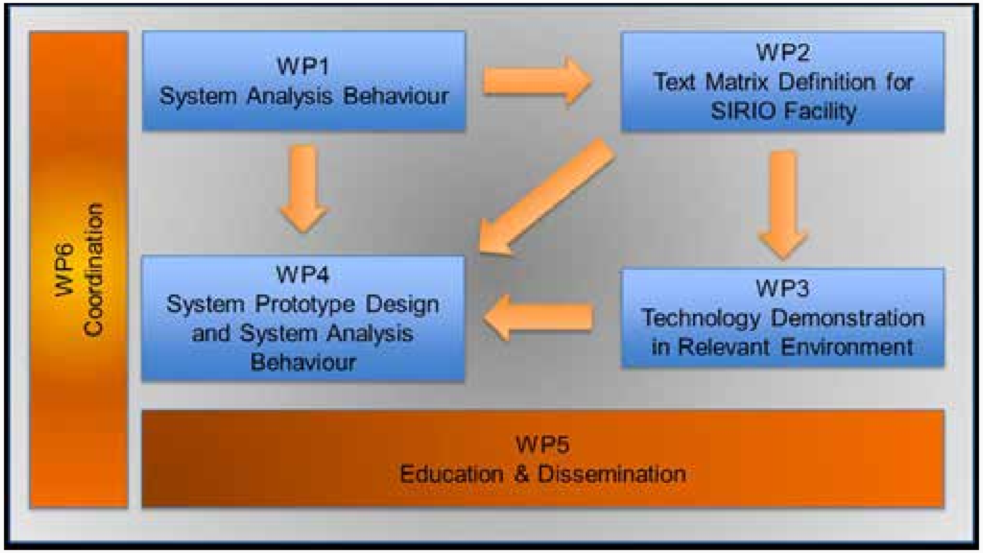
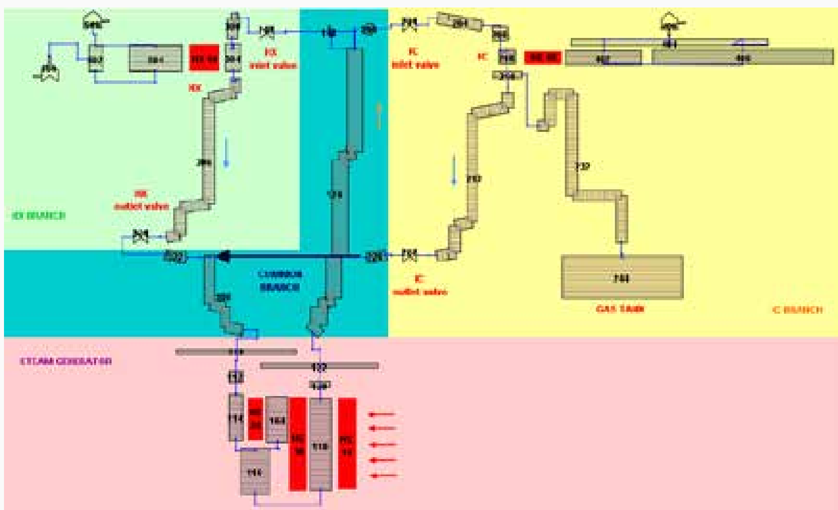
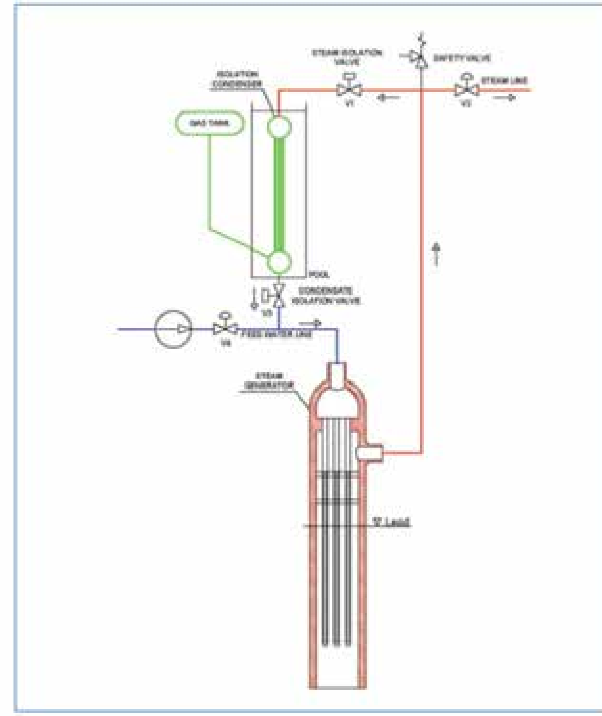
PASSIVE ISOLATION CONDENSER (PIACE)

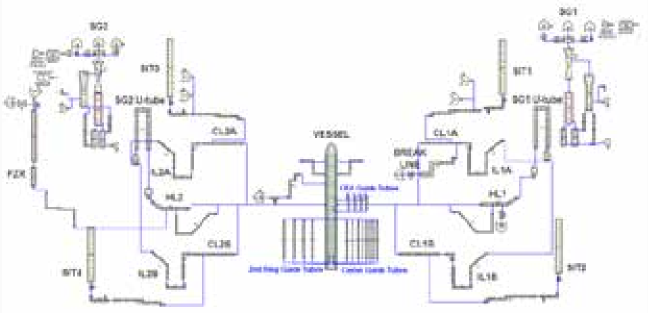




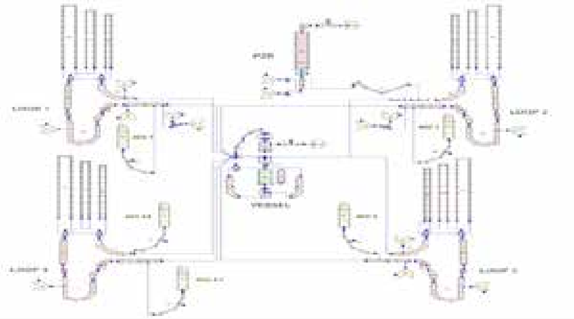


CAMP Project (CSN – UPM agreement)

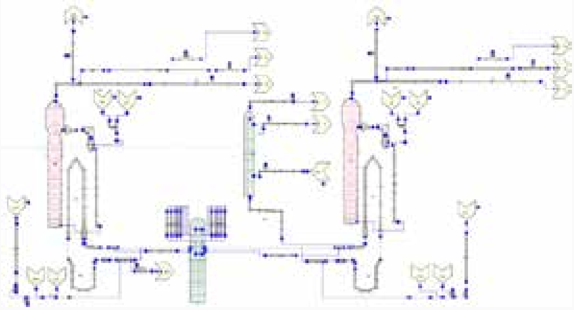
- Spanish CAMP Agreements between
  - CSN,
  - the Technical Universities (UPC, **UPM**, UPV)
  - UNESA
- allow to participate in **CAMP NRC project** including the use of TRACE and RELAP5 TH codes,
- but also the participation in several **OECD/NEA projects**: **SETH, ROSA-I/II, PKL-I/II/III, ATLAS**.
- UPM also participated in **NEA-SM2A** exercise.
- Available TRACE models
  - Almaraz NPP (PWR-W 3 loop)
  - AP1000
  - Zion NPP (PWR-W 4 loop)
  - BWR/6
  - **ATLAS, PKL, ACME and LSTF Facilities**
- Collaboration with CSN, Almaraz NPP, UNESA



ATLAS facility (South Korea)



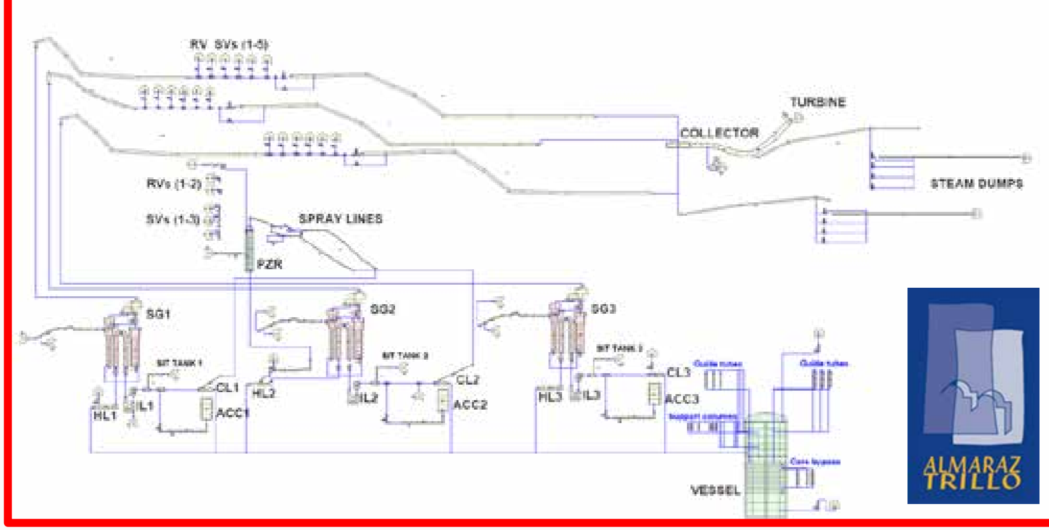
PKL facility (Germany)



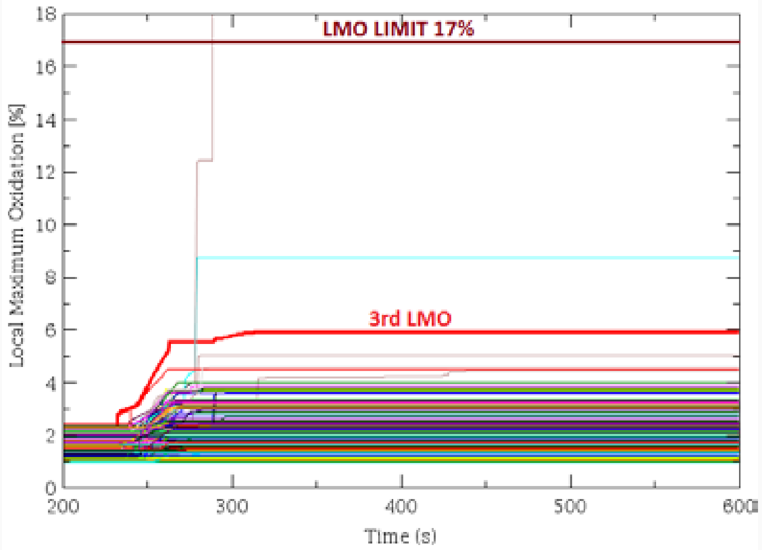
LSTF/ROSA facility (Japan)

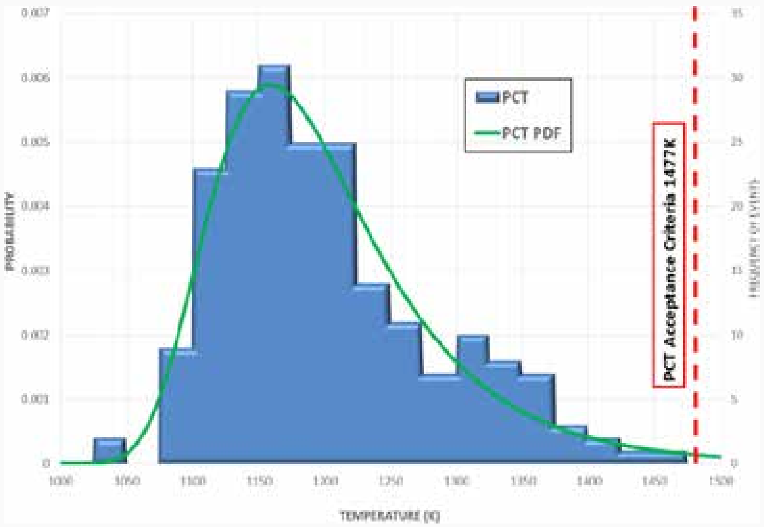
TRACE code: Almaraz NPP model (Almaraz NPP – UPM agreement)

- **Almaraz NPP – UPM agreement since 2006**
- **Almaraz NPP model for SNAP-TRACE.**
- The model has been validated with a reactor SCRAM and a load rejection.



- **Applications:**
  - **LBLOCA**: Thermomechanical analysis + BEPU (Monte Carlo Sampling with DAKOTA).
  - **SBLOCA** and **MBLOCA** (EOPs verification).

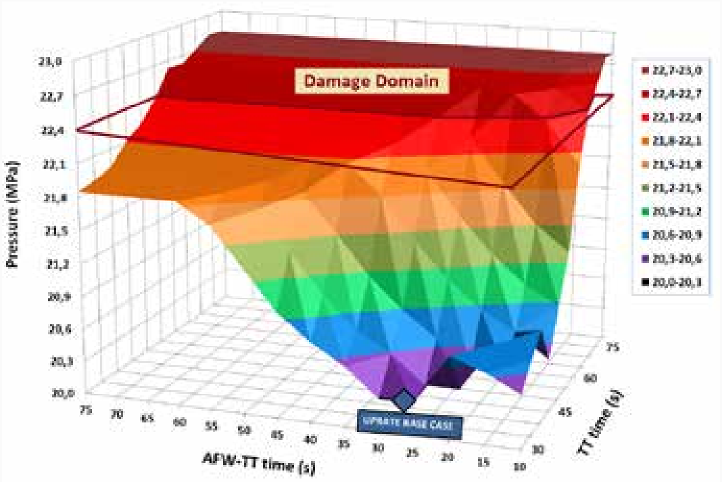


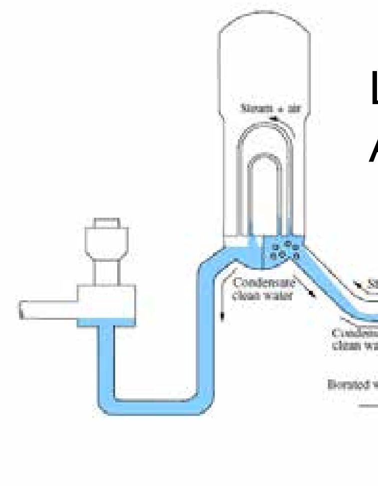


TRACE code: Almaraz NPP model (Almaraz NPP – UPM agreement)

- **Applications:**
  - **LONF-ATWS**:
    - Sensitivity analysis and PIRT proposal
    - AMSAC optimization
  - **SGTR** (including dose calculations performed with **RADTRAD**).
    - DSA methodologies comparison
    - Plant improvements proposal
  - **Loss of RHRS** (mid-loop conditions):
    - Boron dilution.
    - Procedures verification
    - Event trees analyses

ATWS



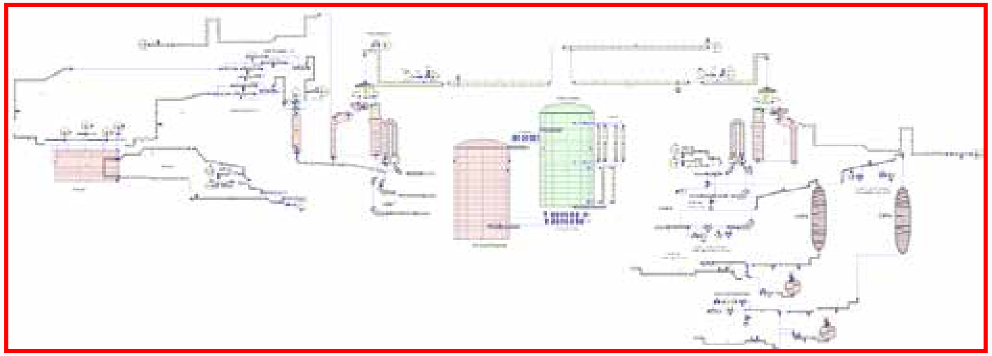


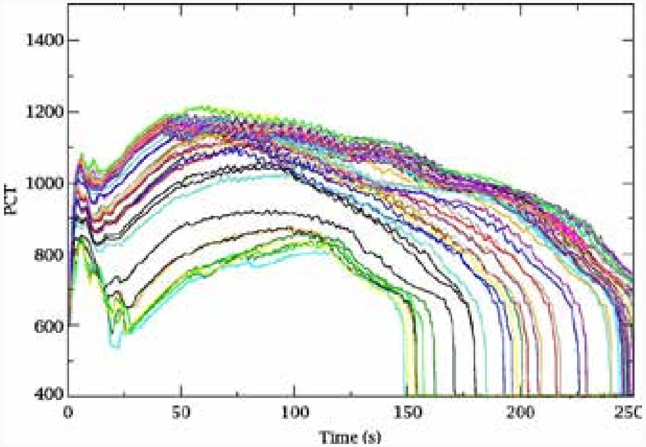
Loss of RHRS
And B dilution

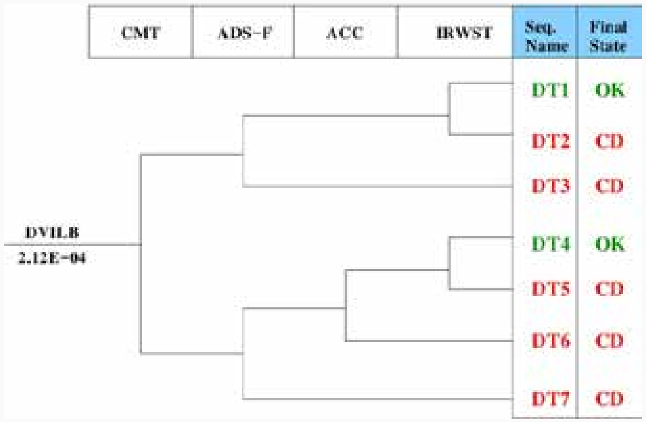
TRACE models: AP1000 applications (ISAMAR/PYGAS Projects)

Deterministic Safety Analysis (DSA):

- SBLOCA and DVILB analyses verification. Comparison with proprietary codes.
- LBLOCA BEPU analysis with DAKOTA







Probabilistic Safety Analysis (PSA):

- Verification of AP1000 LBLOCA & DVILB ETs
- Impact of RNS modification of AP1000 reactor design to meet EUR.
- Low margin AP1000 PRA sequences

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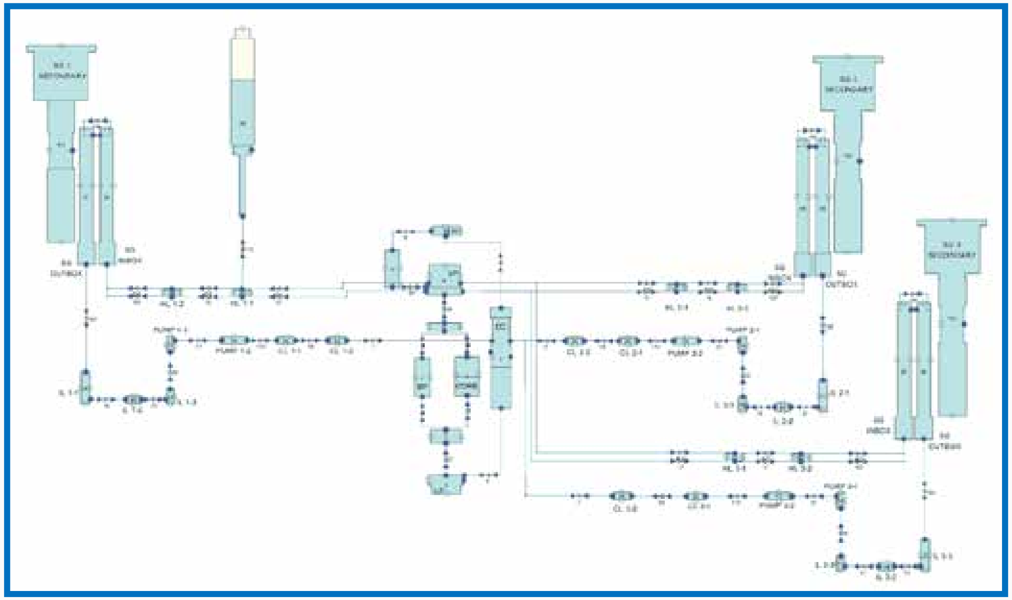
MELCOR Applications in the UPM (CSARP Agreement)

- CSARP Agreement UPM-CSN allows the use of MELCOR code
- Available models
  - PWR-W
  - PWR-KWU
  - Fukushima Dai-ichi
  - BWR/6 Mark-III
  - BWR/5 Mark-II
- Development of AP1000 MELCOR model is on progress



Three loop Westinghouse-PWR MELCOR 2.1 Model

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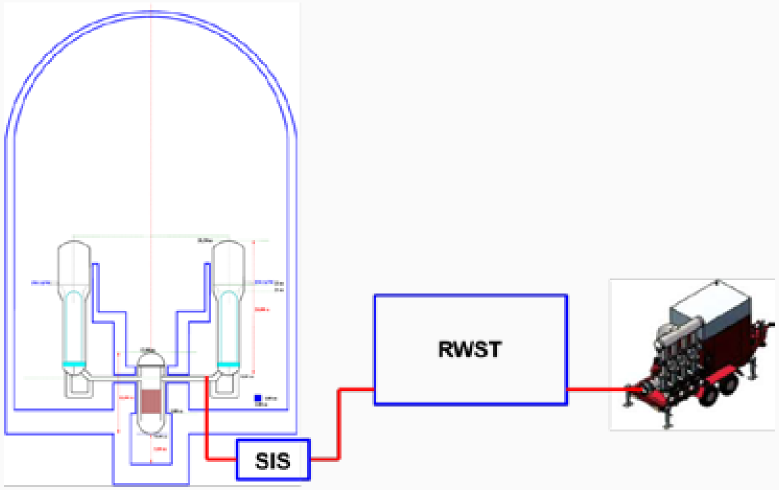
Sandia National Laboratories

U.S.NRC United States Nuclear Regulatory Commission
Protecting People and the Environment

MELCOR Application Example: PWR-W LBLOCA (CSARP Agreement)

- **Refill RWST** via low pressure pump or fire pump.
- **Direct injection into RCS** via the RHRS (Residual Heat Removal System) using a medium pressure pump.
- An **early actuation** avoids vessel failure regardless of recirculation failure time
- **Later performances** will only avoid vessel failure if recirculation works for at least 4 h since the beginning of the sequence



G= 60 kg/s	Recirculation failure time			
Injection time from failure	0,5 h	1 h	2h	4h
1h	Corium in lower plenum	Corium in lower plenum	Corium in lower plenum	Corium in core
2h	Vessel failure	Vessel failure	Vessel failure	Corium in lower plenum
3h	Vessel failure	Vessel failure	Vessel failure	Corium in lower plenum

Damage state when injection begins	End damage state
(yellow)	Corium in core
(orange)	Corium in lower plenum
(red)	Vessel failure

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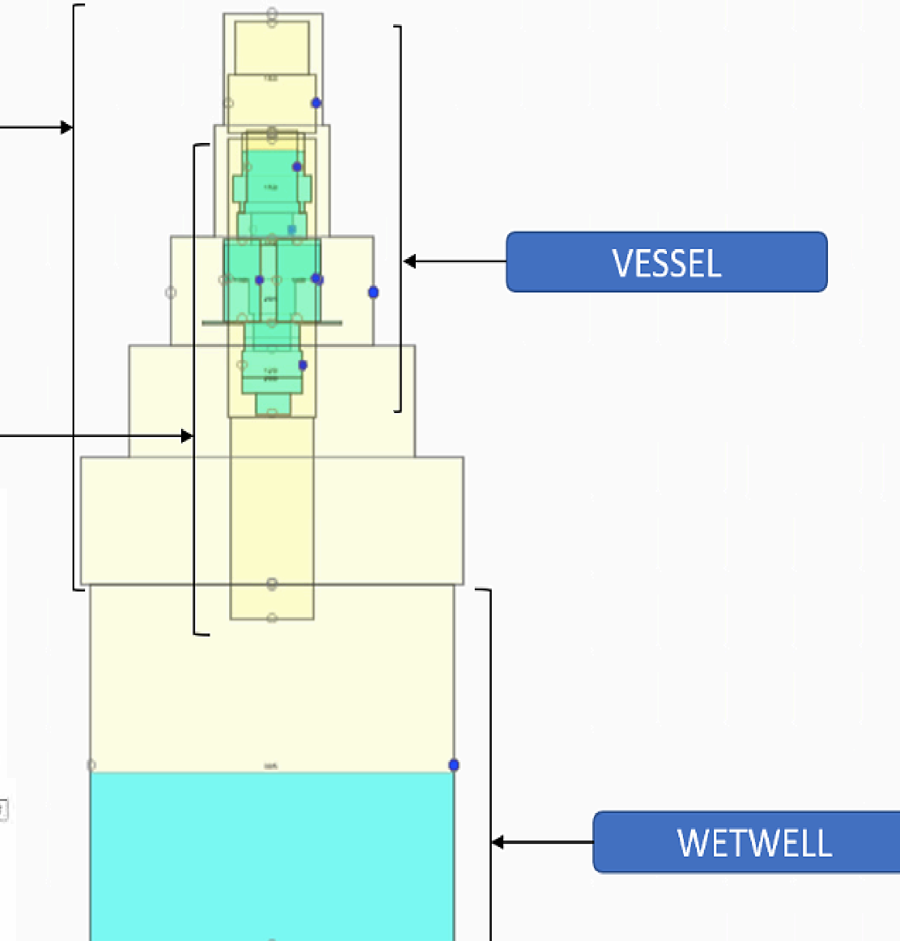
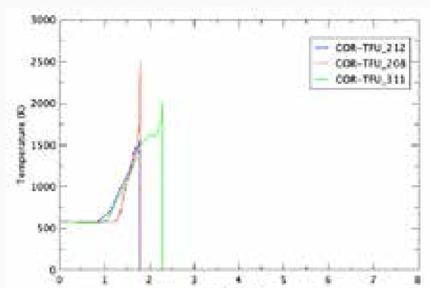
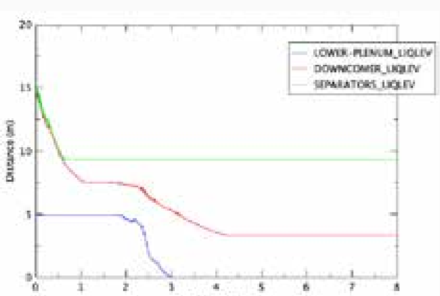
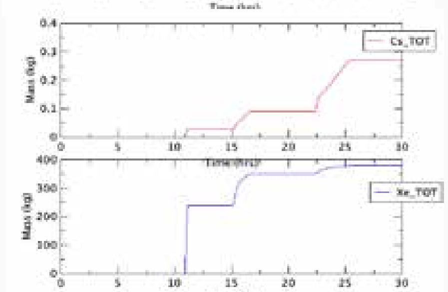
MELCOR Application Example: BWR Mark-II SBO (CSARP Agreement)





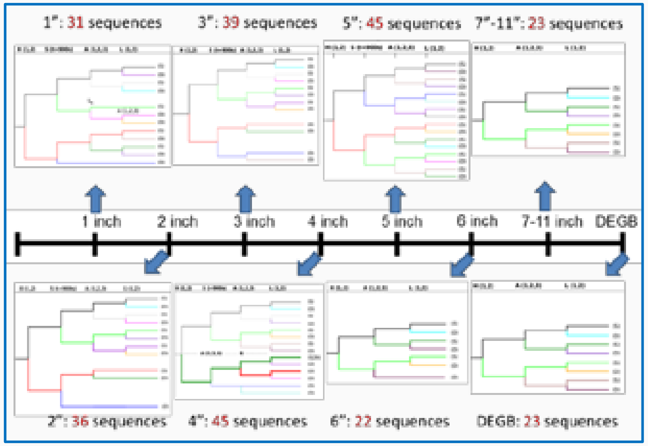




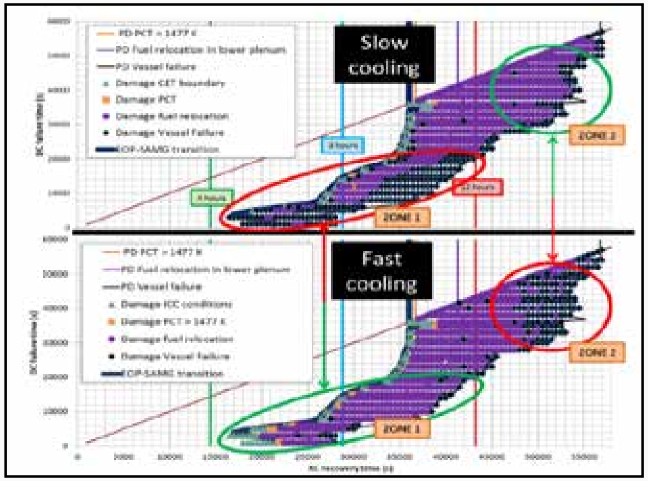
Dynamic PSA. Integrated Safety Analysis Methodology (ISA)

- Several projects related with **Dynamic PSA**: STIM, ISAMAR, PYGAS, OECD/SM2A, Kindelan Chair (CSN). **ISA Methodology (CSN)**

- **OECD/SM2A**: Safety margins decrease due to power uprate. UPM: Loss of CCWS (Zion NPP, simulations performed with **MAAP4** & **TRACE**.
- **STIM Project**: Full spectrum LOCA analysis (PWR-3L, **SCAIS/MAAP**)
- **ISAMAR Project**: SBLOCA, DVILB (AP1000 and PWR-3L, **TRACE**)
- **PYGAS Project**: SBO, SBLOCA & LBLOCA (PWR-3L and AP1000; **SCAIS/MAAP, MELCOR, GOTHIC**)
- **Kindelan Chair**: SBO (SAMGs, PWR-3L, **SCAIS/MAAP**), SGTR and Feed and Bleed (PWR-3L, EOPs, **SCAIS/MAAP**); ATWS (PWR-3L, **TRACE**)



Dynamic Event Trees in Full spectrum LOCA



Comparison between slow and fast cooling in SBO sequences

UPM Collaboration with Mexican institutions (IPN – ININ – CNSNS)

- IPN:
  - Uncertainty and sensitivity analysis
  - 3 courses and seminars (2018, 2019, 2022),
  - pre-doctoral research stays
- ININ:
  - Severe accident management
  - Hydrogen Risk
  - Uncertainty and sensitivity analysis
- CNSNS:
  - Probabilistic safety analysis
  - MELCOR models
- Several research papers

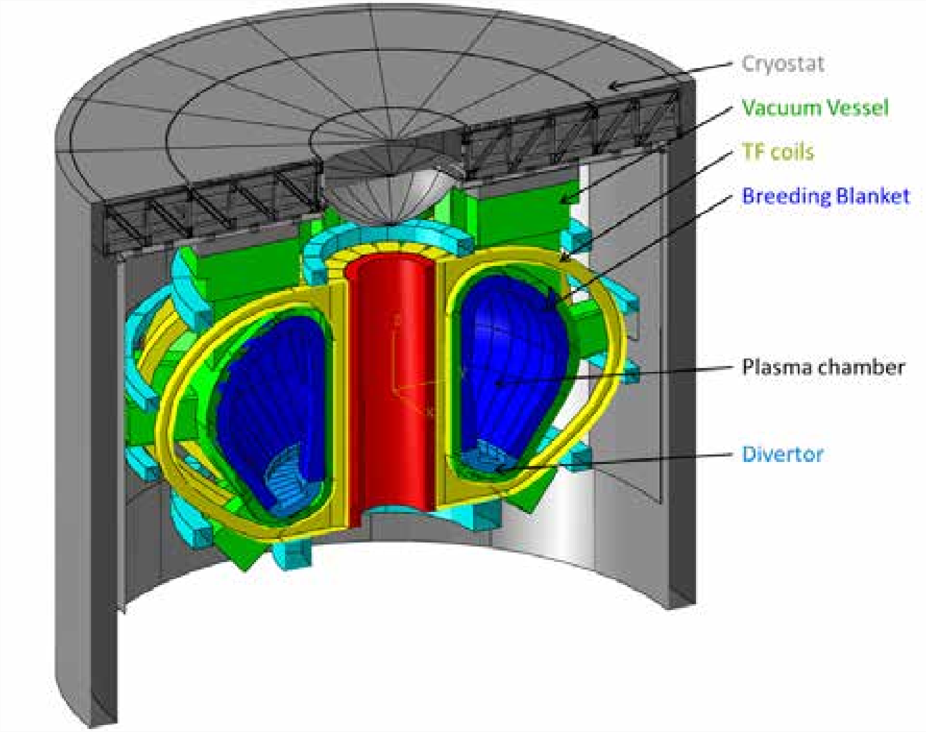
Instituto Politécnico Nacional

ININ
INSTITUTO NACIONAL DE INVESTIGACIONES NUCLEARES

CNSNS
COMISIÓN NACIONAL DE SEGURIDAD NUCLEAR Y SALVAGUARDIAS

EUROfusion

Simulations with MELCOR –fusion related with accidental sequences in DEMO reactor

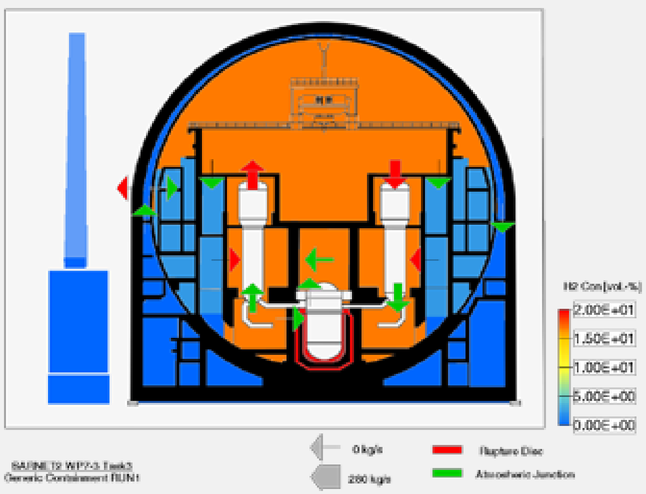


TOWARDS AN ENHANCED ACCIDENT MANAGEMENT OF THE HYDROGEN/CO COMBUSTION RISK (2020-2024)

The AMHYCO project main objective is **to propose innovative enhancements on the way combustible gases are managed in case of a severe accident in EU Gen II/III reactors in operation.**

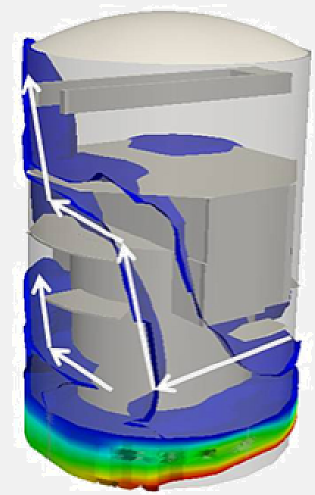
AMHYCO
Enhancing H_2 & CO Combustion Risk Management

LP / System codes
(most penalizing scenarios from WP2)



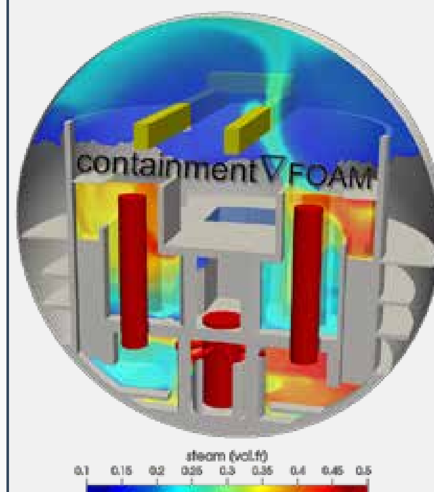
Ref: RUB

GOTHIC-3D
(Selected transients)



Ref: UPM

CFD
(Selected compartments)

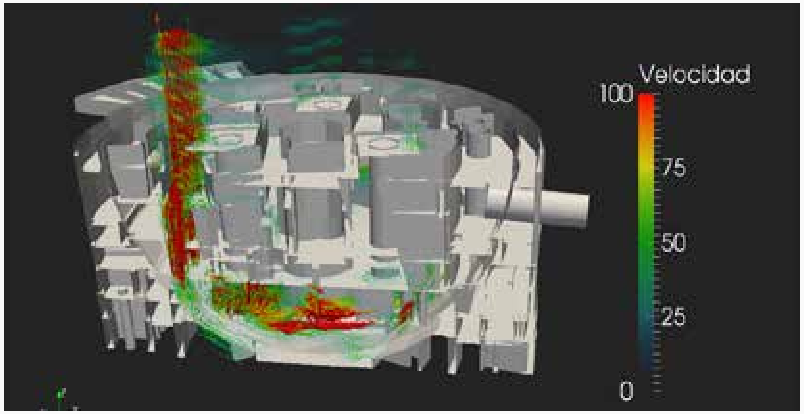


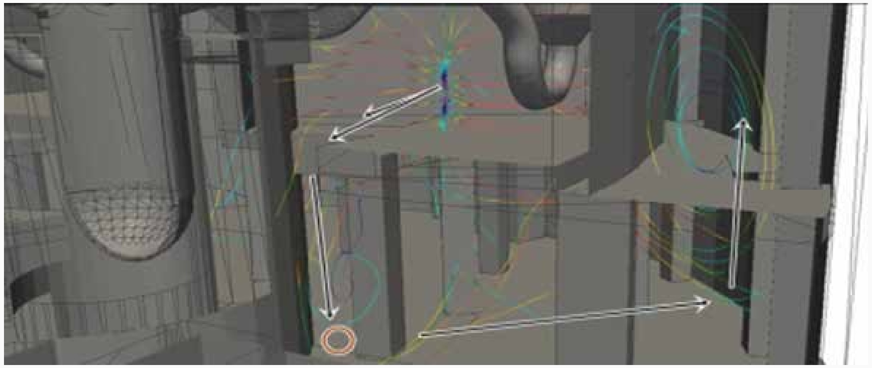
Ref: JÜLICH

https://amhyco.eu/

Almaraz and Trillo NPP containment thermal-hydraulics analyses (CNAT – UPM agreement)

- Creation of a full containment models for **Almaraz NPP** (PWR-W) and **Trillo NPP** (PWR-KWU) with **GOTHIC** code
- Creation of lumped parameter models for both containments.
- Simulation of design basis accidents (LBLOCA, SBLOCA) and severe accident (future works)





Ref: 3D containment modeling of PWR-KWU Trillo NPP with the GOTHIC code. Kevin Fernández-Cosials, Samanta Estévez-Albuja, Gonzalo Jiménez, Rafael Bocanegra, Carlos Vázquez-Rodríguez, Luis Rey, Juan Carlos Martínez-Murillo. Annals of Nuclear Energy 133 (2019) 387–399.
Ref: Toward Conservatism in Containment Design Basis Accident Analyses. Lumped parameters and 3D Approaches. Carlos Vazquez-Rodriguez, Rafael Bocanegra, Gonzalo Jimenez, Luis Rey, Andrea Cadenas, José María Posada, Juan Carlos Martínez-Murillo. ICAPP 2019 – International Congress on Advances in Nuclear Power Plants, France, Juan-les-pins – 2019, May 12-15. Paper # 000174

AP1000 containment analyses (PYGAS Project, MINECO)

- Creation of a full containment model for AP1000 with **GOTHIC**
- Creation of a IRWST 3D model with **GOTHIC**
- Creation of a Shield Building model with **STAR-CCM+** and **GOTHIC**
- Simulation of a steam injection experiment done with the **Technical University of Munich (TUM)**
- Simulation of design basis accidents (LBLOCA, SBLOCA) and severe accident (future works)

Ref: Steam condensation simulation in a scaled IRWST-ADS simulator with GOTHIC 8.1. Samanta Estévez-Albuja, Gonzalo Jimenez, Suleiman Al Issa, Rafael Macián-Juan, Kevin Fernández-Cosials, César Queral. Nuclear Engineering and Design 334 (2018) 96–109.

Ref: AP1000 Passive Containment Cooling System study under LBLOCA conditions using the GOTHIC code. Samanta Estévez-Albuja, Kevin Fernández-Cosials, Carlos Vázquez-Rodríguez, Zuriñe Goñi-Velilla, Gonzalo Jiménez. Nuclear Engineering and Design 384 (2021) 111442

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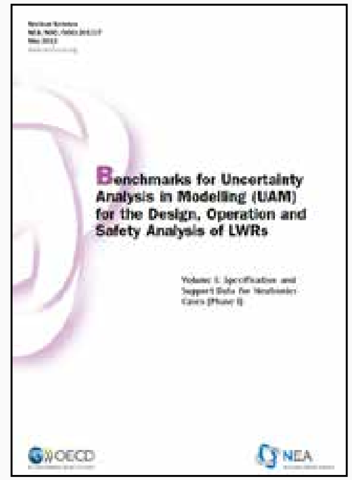
Technische Universität München

Uncertainty analysis in Modelling of LWR (OECD/NEA - CSN)

- Best estimate predictions to be provided with their confidence bounds: *Best Estimate Plus Uncertainties (BEPU)* methods
- Methodology for Uncertainty Quantification (UQ) in COBAYA/COBRA-TF calculations:
  - **SCALE6.2** for UQ of few-group cross-section libraries
  - **UQ capabilities in COBAYA:** 1st. Order Perturbation Theory and Sampled-based
  - **UQ capabilities in COBRA-TF:** Sampled-based
- **Objective**: multi-physics applications


Benchmarks for Uncertainty Analysis in Modelling (UAM) for the Design, Operation and Safety Analysis of LWRs

OECD NEA

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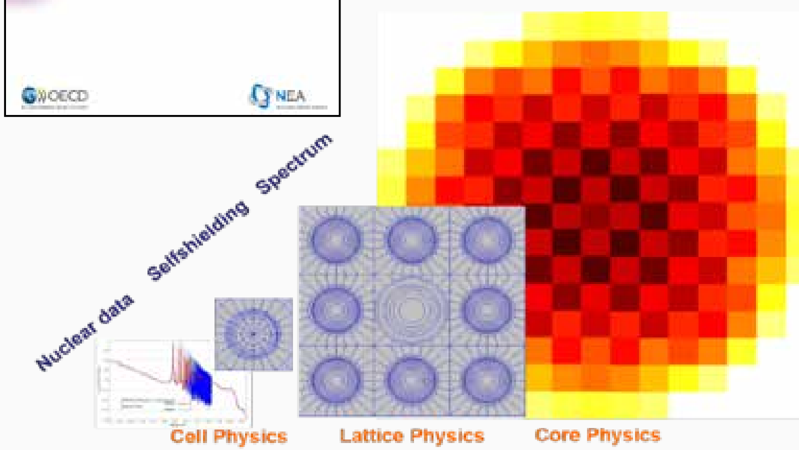


Castro et al., *Impact of the nodal or pin-by-pin homogenization level on the uncertainty quantification with core simulators*, Progress in Nuclear Energy (2017) (http://dx.doi.org/10.1016/j.pnucene.2017.10.001)

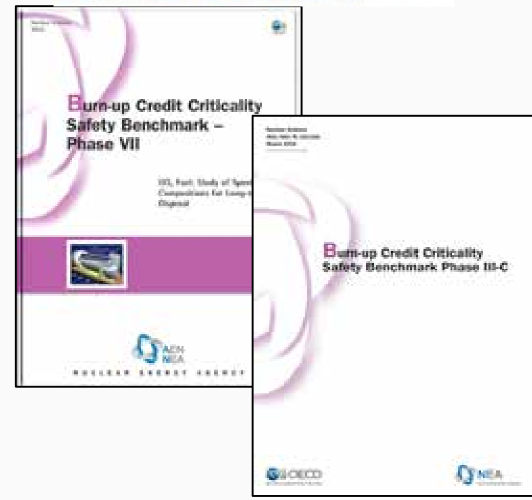
Burnup Credit Criticality Safety (OECD/NEA - CSN)

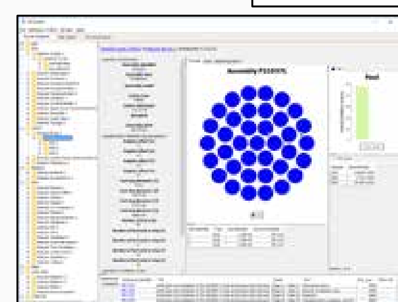
Methodologies to **handle irradiation history of the samples within the reactor core**

- Methodologies for an improved prediction of the isotopic content in high burnup samples
    - Impact of nuclear data uncertainties on burnup
- Participating in Benchmarks
- OECD/NEA WPNCS(“Working Party on Nuclear Criticality Safety”)
    - Expert Group on Burn-up Credit Criticality Safety (BUC)
    - Expert Group on Assay Data of Spent Nuclear Fuel
- SFCOMPO 2.0 - Spent Fuel Isotopic Composition Database (https://www.oecd-nea.org/sfcompo/)

SFCOMPO 2.0

CSN
CONSEJO DE SEGURIDAD NUCLEAR



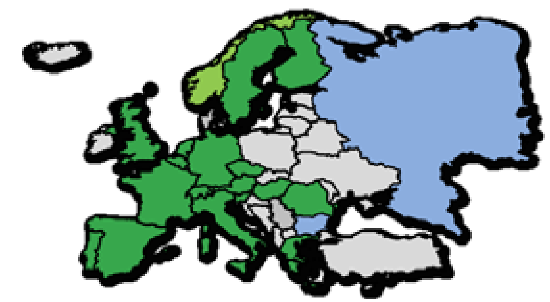


Solving Challenges in Nuclear Data for the Safety of European Nuclear Facilities
CHANDA - EURATOM FP7 (2013-2018)

Improving all elements involved in nuclear data to overcome standing challenges:

- to provide the nuclear data required for the safe and sustainable operation, and development, of existing and new reactors and nuclear fuel cycle facilities
- to prepare solutions for the challenges risen by the nuclear data measurements needed by nuclear systems, like the data for highly radioactive, short lived or rare materials
- to prepare tools that solve the challenges of quantifying and certifying the accuracy of the results of simulations based on available nuclear data and models (uncertainties)

Allowing EU to upgrade the nuclear data up to the level needed by simulation codes to fulfill present requirements.



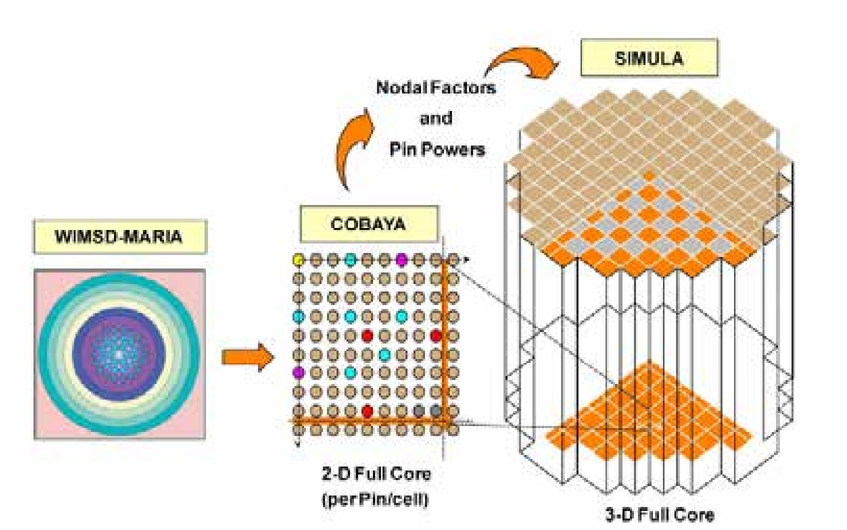
CHANDA: 35 participants (18 countries)

Nuclear Data Activities

- NEA – JEFF project
- NEA – WPEC, CIELO,…
- IAEA – CPRs, TMs,…

Integrated system for PWR analysis

- **SEANAP** system (**S**istema **E**spañol de **A**nálisis de **N**úcleos de **A**gua a **P**resión)
- Integrated system of codes and procedures developed at UPM for PWR analysis
- Applied for the last 25 years to the Spanish PWR units: Ascó I, Ascó II, and Vandellós NPP
- Applications:
  - Fuel loading pattern evaluations
  - Nuclear design analysis (start-up physics tests, boron letdown curves, …)
  - Online 3D simulations
  - Planning of Optimal Operational Maneuvers
  - Dynamic Core Analysis
- Uncertainty quantification



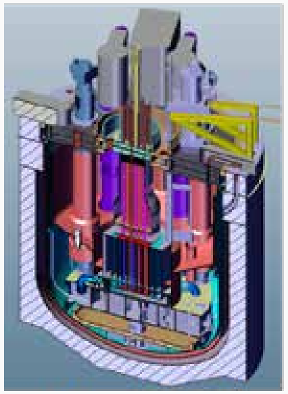
Castro E., *Improving PWR core simulations by Monte Carlo uncertainty analysis and Bayesian inference*, Annals of Nuclear Energy 95, pp. 148–156 (2016)

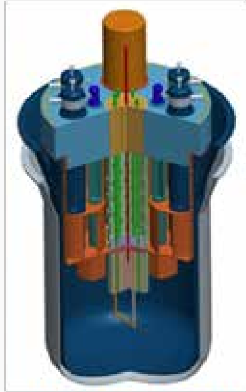
European Sustainable Industrial Initiative - ESNII (Euratom)

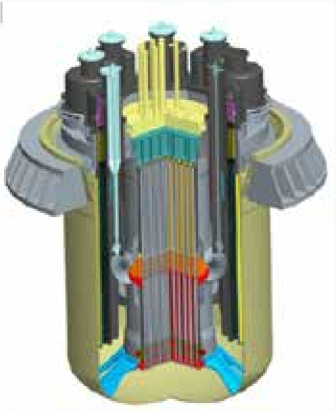
- ESNII+ and ESFR-SMART projects aim at enhancing further the safety of Gen-IV reactors
- Core-physics analysis of fast reactors using Monte Carlo neutron transport codes
- S/U analysis to nuclear data of:
    - o reactor core parameters (criticality, feedback reactivity coefficients, …)
    - o fuel cycle and repository parameters (isotopics, decay heat, …)

ESNII+

ESFR-SMART sodium fast reactor safety


SFR prototype (ASTRID)

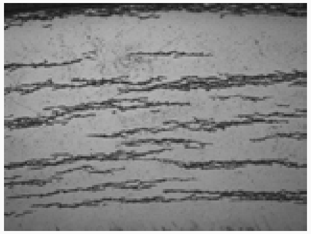

LFR pilot plant (MYRRHA)


LFR demonstrator (ALFRED)

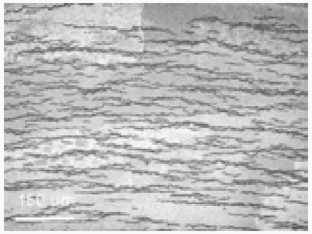
García-Herranz N. et al., *Nuclear data S/U assessment of sodium voiding reactivity coefficients of an ASTRID-like SFR*, EPJ Web of Conferences 146 (2017)
Romojaro et al., *Nuclear data S/U analysis of effective neutron multiplication factor in various MYRRHA core configurations*, Annals of Nuclear Energy 101 (2017)
Grasso et al., *Stress-testing the ALFRED design: Impact of Nuclear Data Uncertainties on Design Extension Condition Transients*, submitted Progress in Nuclear Energy

Nuclear fuel cladding integrity group (Materials Science Department, ETSICCP-UPM, ENUSA, CSN, ENRESA)

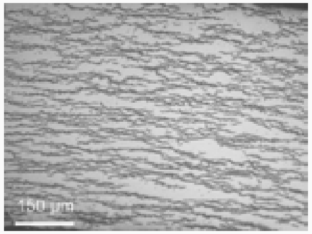
Hydrogen charging of cladding samples



150 ppm

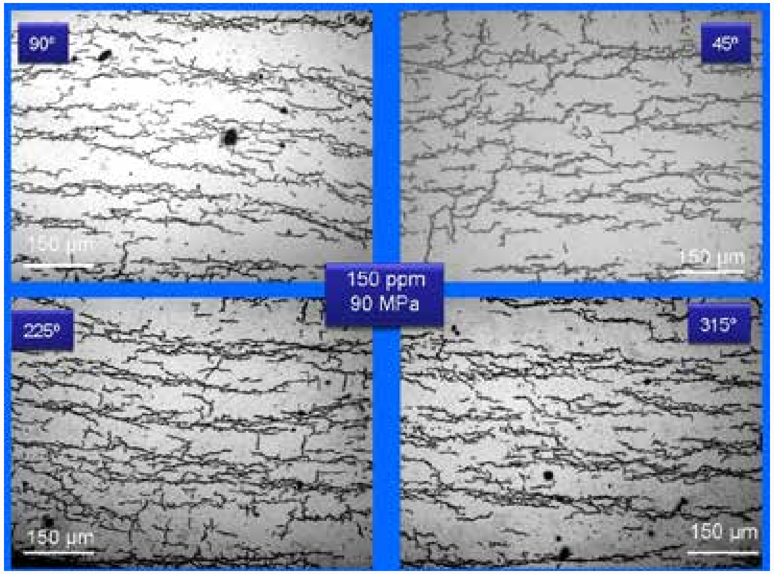


500 ppm

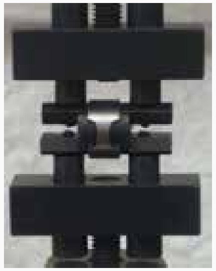


1200 ppm

Hydride reorientation



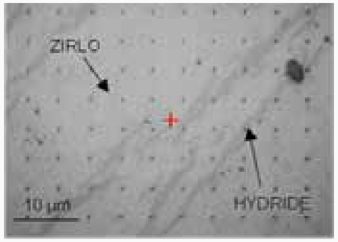
Mechanical Tests: mechanical properties and fracture behavior of unirradiated fuel cladding.



Ring tensile test

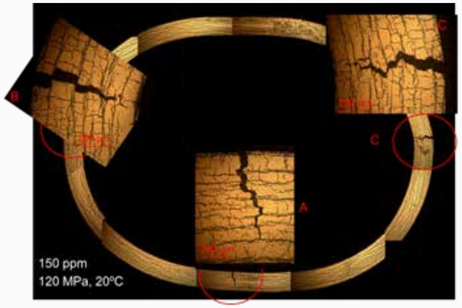
Ring compression

3-point bending

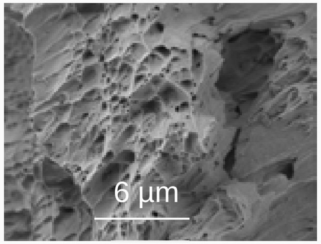


Nanoindentation Measurements

Burst Test



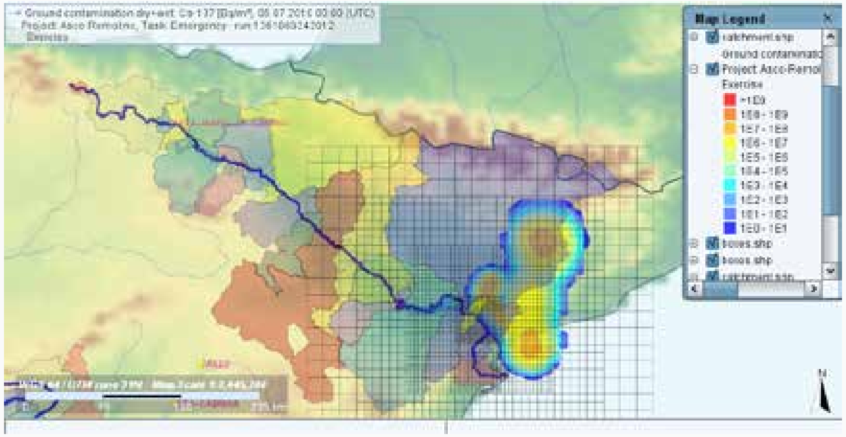
Cladding sample section



SEM image ductile fracture

Integration of atmospheric dispersion models with river and lake catchment models in the JRODOS decision support system (DSS) for nuclear accidents (PREPARE project, EURATOM FP7)

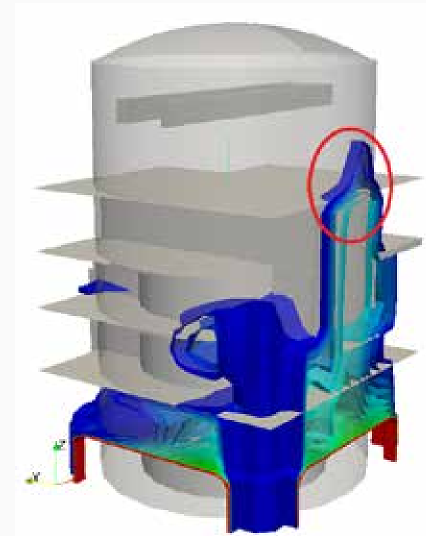
- **JRODOS** has increased capabilities by incorporating new modules from **MOIRA DSS**, which allow to model the long-term fate (years) of radionuclides (^{137}Cs and ^{90}Sr) in freshwater systems: lakes and rivers.
- The new models also estimate the **effectiveness of countermeasures** to reduce radionuclide concentrations in water, sediments and fish.
- The **new modules**, integrated with the food and dose model FDMA, **also assess radiation dose to people and livestock**, as well as the impact of bans to reduce doses.



- Extensive testing has been performed that show a correct integration of the MOIRA Lake and River models, as well as the GIS and fallout distribution tools.

Cofrentes NPP hydrogen risk analysis and PAR installation (Iberdrola – UPM agreement)

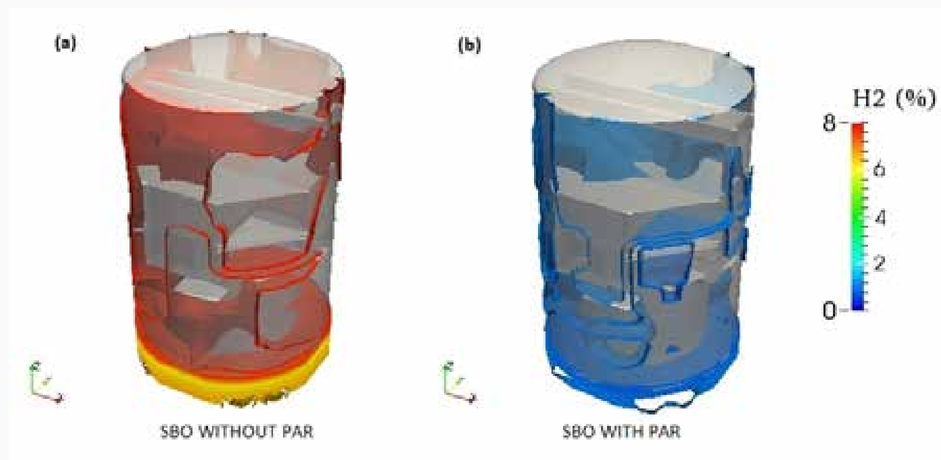
- Creation of a full containment model for Cofrentes NPP (BWR/6) with **GOTHIC**
- Simulation of severe accident sequences for analyzing the hydrogen flowpaths in the containment.
- Analysis of hydrogen combustion risk and optimal **PAR sizing and location**



Ref: Proposed methodology for Passive Autocatalytic Recombiner sizing and location for a BWR Mark-III reactor containment building. César Serrano, Gonzalo Jimenez, M. del Carmen Molina, Emma López-Alonso, Daniel Justo, J. Vicente Zuriaga, Montserrat González. Annals of Nuclear Energy 94 (2016) 589–602.

Ref: BWR Mark III containment analyses using a GOTHIC 8.0 3D model. Gonzalo Jimenez, César Serrano, Emma Lopez-Alonso, Ma del Carmen Molina, Daniel Calvo, Javier García, César Queral, J. Vicente Zuriaga, Montserrat González. Annals of Nuclear Energy 85 (2015) 687–703.

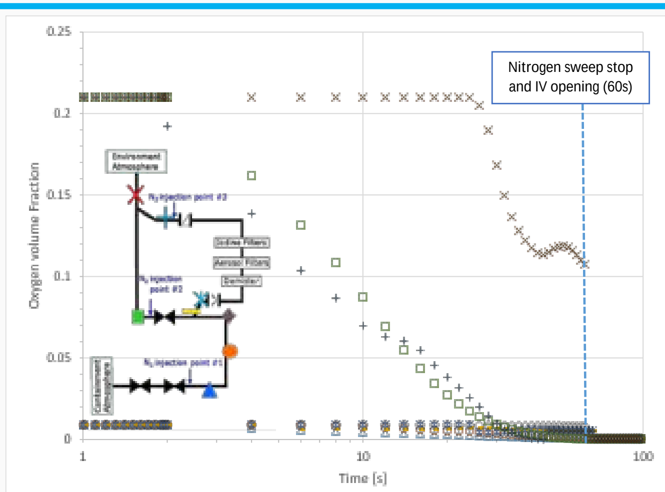
Ref: Analysis of venting strategies and hydrogen concentration evolution during a station blackout in a BWR-6 containment using GOTHIC 8.3. Pino Díez, Samanta Estévez, Gonzalo Jiménez, Carlos Gavilán. Progress in Nuclear Energ 141 (2021) 103930

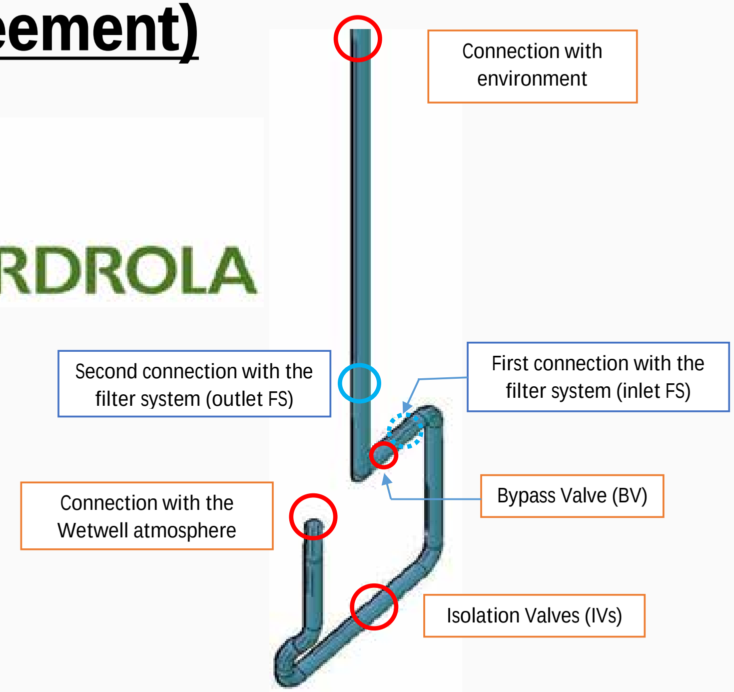


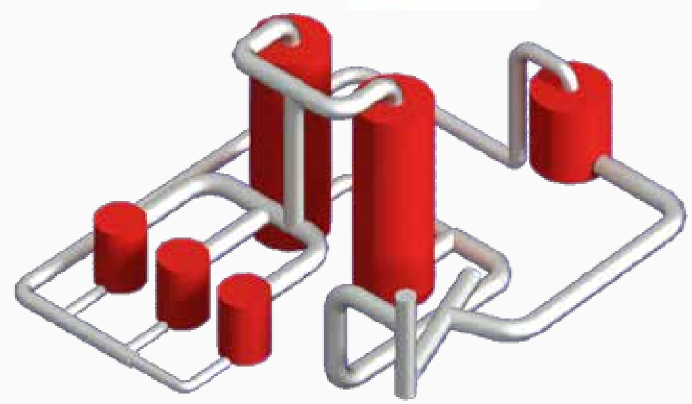
Cofrentes NPP Filtered Venting Containment System Simulation (Iberdrola – UPM agreement)

- Creation of a full FCVS model for Cofrentes NPP (BWR/6) with **GOTHIC**
- Simulation of severe accident sequences for analyzing the hydrogen risk in the FCVS.

IBERDROLA







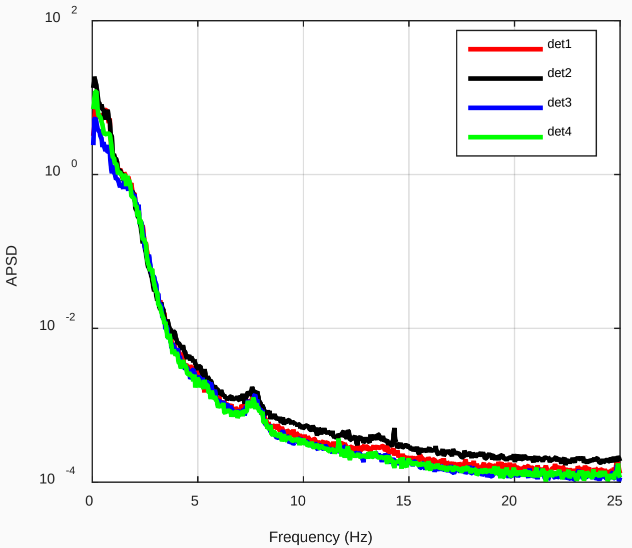
Ref: Analysis of Inertization Strategies for the Filtered Containment Venting System in Cofrentes Nuclear Power Plant. Kevin Fernández-Cosials, Gonzalo Jiménez, César Serrano, Luisa Ibáñez, Ángel Peinado. Journal of Nuclear Engineering and Radiation Science. JULY 2018, Vol. 4 / 031016-1

On line monitoring techniques in PWR

- **EU project CORTEX H2020 (2017-2021)**
- **Trillo NPP and Almaraz NPP – UPM agreement since 2012**
- **Research collaboration with Chalmers University of Technology and Ringhals NPP**

- o **Neutron noise** levels monitoring and spectral analysis
- o Estimation of fluid velocity in the core thorugh noise analysis
- o MTC estimation through noise analysis-
- o Vibration monitoring using modal analysis techniques
- o Neutron detectors APSD fitting through Breit-Wigner formula

CORTEX
Core monitoring techniques and experimental validation and demonstration



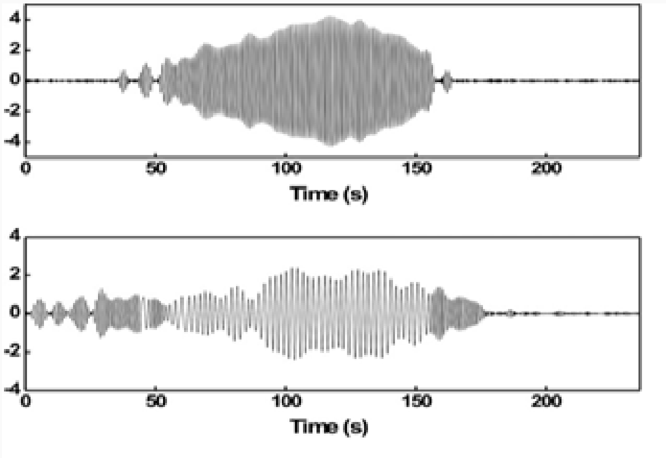
ALMARAZ TRILLO

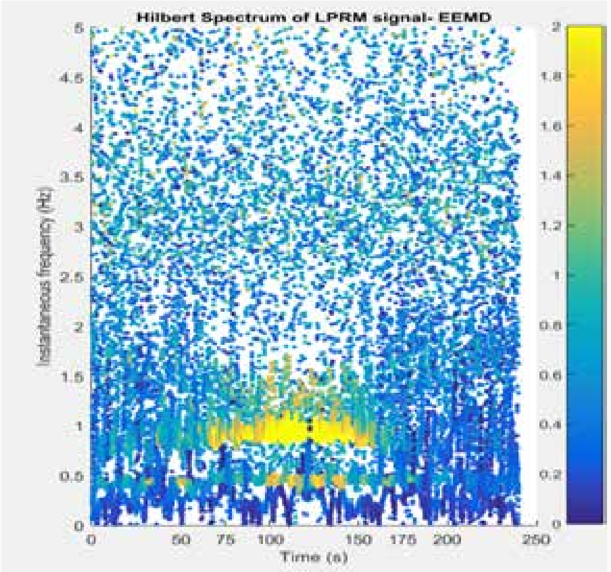
CHALMERS

On line monitoring techniques in BWR

Research collaboration with Cofrentes NPP (BWR)

- Spectral analysis
- Use of advance signal processing techniques for stability monitoring:
  - o Hilbert-Huang transform (HHT),
  - o Ensemble Hibelrt-Huang Transform (EHHT)
- Univariate ARMA models
- Multivariate ARMA models





Design and construction of an enhanced thermal neutron source based on ^{241}Am-^{9}Be (FANT)

- A **thermal neutron source called FANT** has been designed using Monte Carlo methods. It uses a ^{241}Am/^{9}Be neutron source inside a HDPE box.
- The neutron spectrum is thermalized by scattering in the walls, with about 70% of thermal neutrons, depending on the irradiation plane, and fluence rates quite homogeneous and above 1000 cm^{-2}·s^{-1}.
- H*(10) rate in function of the distance has also been evaluated. The dose rate values at 1 m distance of FANT are always well below 10 µSv/h.
- The system can be used to calibrate neutron monitors and dosimeters in a thermal field and for PGNAA

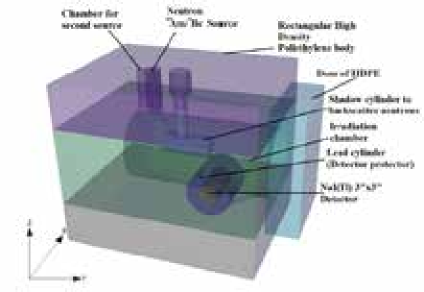


Figure 1, Isometric view of FANT MCNP6 model

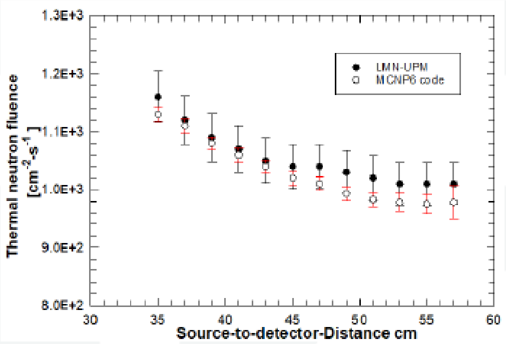


Figure 4, Thermal neutron (E<0.4 eV) fluence rate measured and calculated at points along the main axis of the irradiation chamber

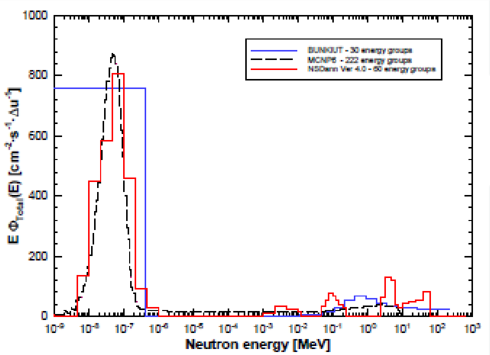


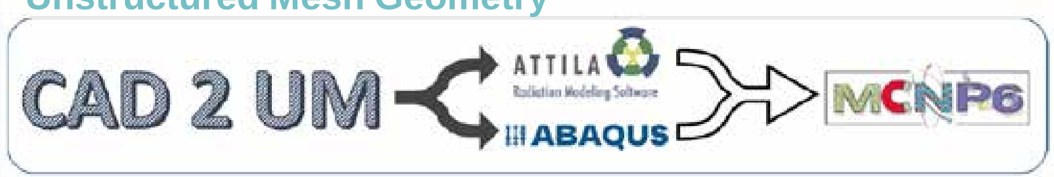
Figure 5, Measured and calculated spectra (lethargy) with the Bonner spheres inside FANT chamber

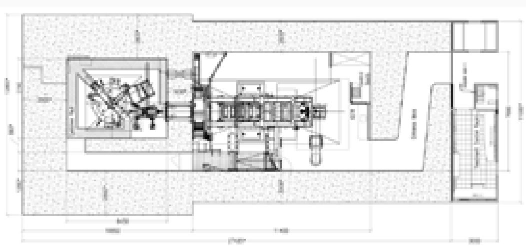
Neutron Dosimetry and shielding in proton therapy centers

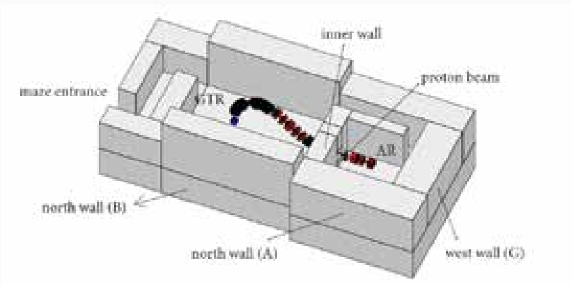
Aim of the work:

- Characterize the effectiveness of the shielding
- Estimate neutron dose that may affect workers and the general public
- Calculate and measure ambient equivalent dose, H*(10)
- (Outside the bunker of CPTC)

Unstructured Mesh Geometry

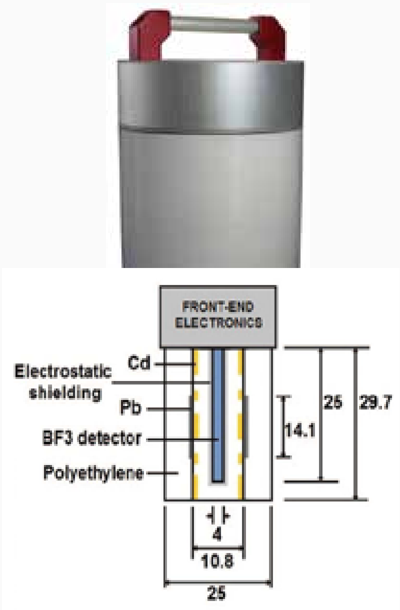




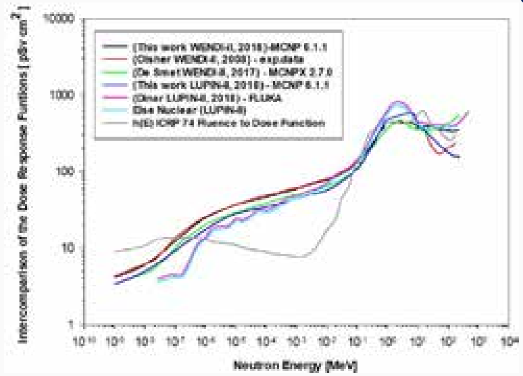


MCNP6 modelling of the Facility

Extended range neutron area monitors

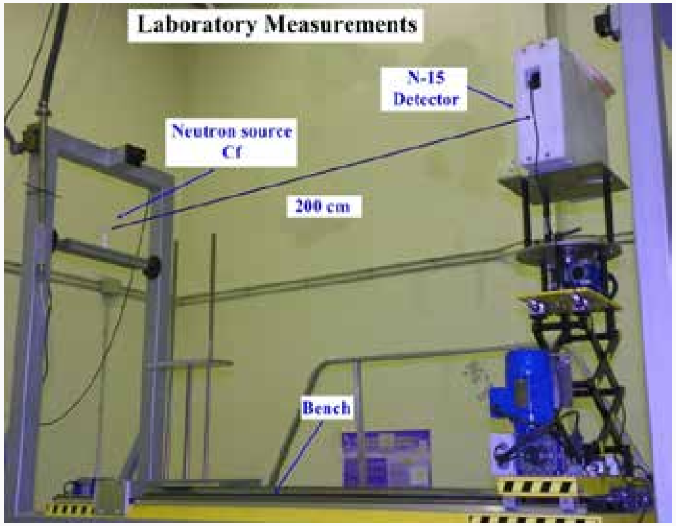


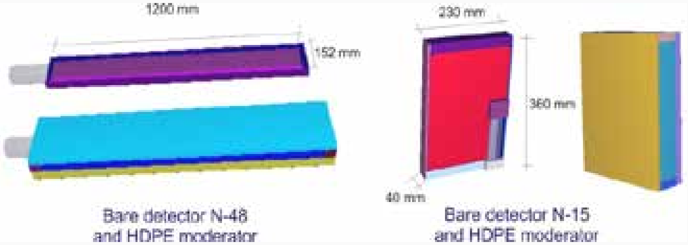
WENDI-II **LUPIN BF_3**



Study of neutron detectors for Radiation Portal Monitors (RPM)
$^{10}B+ZnS(Ag)$ as an alternative to ^{3}He (with ETSICCP-UPM)

- Using **Monte Carlo methods** the response functions of two models of **$^{10}B+ZnS(Ag)$ detectors** were calculated, as well their performance against ^{252}Cf neutrons. Measurements were carried out indoors under laboratory conditions and outdoors emulating their use in border checking points
- Detector position with respect to ground is an important feature due to its response to scattered neutrons.
- **$^{10}B+ZnS(Ag)$ detectors are an alternative to replace ^{3}He detectors** in RPMs. Model **N-48 detector is close to be considered a replacement for ^{3}He detectors**. An improvement in the geometry of the detector raising the amount of ^{10}B increases the detector efficiency.





Detector N-48A Detector N-15A

Nuclear Safety Chair "Federico Goded" (CSN-ETSII) and Nuclear Safety Chair "Juan Manuel Kindelán" (CSN-ETSIME)

CSN-UPM Chairs are a mean to establish a strategic and long term partnership in order to carry out education and research in **Radioprotection** and **Nuclear Safety**.

- **GRANTS**
  - PhD / cofounding of PhD contracts
  - Final Master Thesis
  - Collaboration grants
- **TRAVEL GRANTS**
  - Short stays in research centres
  - Attendance and participation in Congresses / Training schools
- **COURSES AND SEMINARS**
  - Specialized training courses (≈25):
    - Concrete in nuclear industry
    - Metallic materials in nuclear industry
    - Nuclear fuel
  - Advanced short seminars

CSN CONSEJO DE SEGURIDAD NUCLEAR

INDUSTRIALES ETSII | UPM

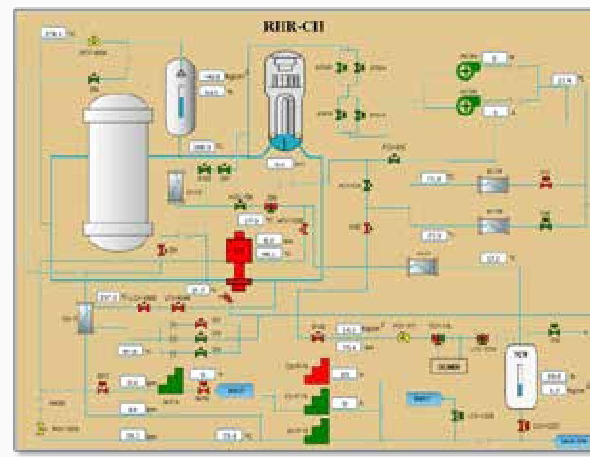
ESCUELA TÉCNICA SUPERIOR DE INGENIEROS DE MINAS Y ENERGÍA DE MADRID

"Aula José Cabrera Gas Natural-ETSII" Graphical Interface Simulator

- Training of PWR control room personnel and Technical Support Engineers
- Illustrative screens show the plant systems
- Plant responses during normal operation and accident situations.
- Allow to act directly on the system components
- Allows students to explore and operate a NPP
- Interactive and team working experience.
- Improve the quality of the nuclear technology education
- Alarm control panels
- Analyze plant dynamics

gasNatural fenosa

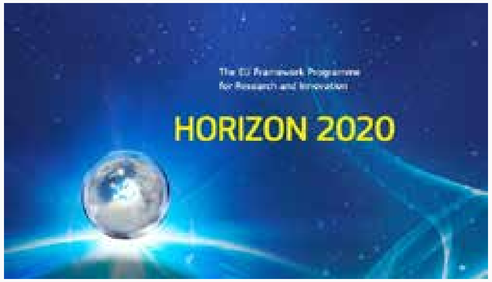
tecnatom



C. Ahnert et al, "Education and training of future nuclear engineers through the use of an interactive plant simulator. International Journal of Engineering Education Vol. 27, No. 4, pp. 722–732 (2011)

ENEN2plus "Building European Nuclear Competence through continuous Advanced and Structured Education and Training Actions"

- **The primary motivation of the ENEN2plus project is to substantially contribute to the revival of the interest of young generations in the careers in nuclear sector.**
- **This is to be achieved by pursuing the following main objectives:**
  - Attract new talents to careers in nuclear.
  - Develop the attracted talents beyond academic curricula.
  - Increase the retention of attracted talents in nuclear careers.
  - Involve the nuclear stakeholders within EU and beyond.
  - Sustain the revived interest for nuclear careers.



- **The ENEN consortium will focus on the learners and careers in the following nuclear disciplines:** Nuclear reactor engineering and safety, Waste management and geological disposal, Radiation protection and Medical applications.

https://enen.eu/index.php/portfolio/enen2plus-project/

GRADUATE EDUCATION ALLIANCE FOR TEACHING THE PHYSICS AND SAFETY OF NUCLEAR REACTORS (GREaT-PIONEeR)

- WP1 Mapping of the stakeholder needs versus course offering and teaching methods
- WP2 Development of a course package on nuclear data for energy and nonenergy applications
- WP3 Development of a course package on neutron transport at the fuel cell and assembly levels
- WP4 Development of a course package on core modelling for core design
- WP5 Development of a course package on core modelling for transients
- WP6 Development of a course package on reactor transients, nuclear safety and U&S analysis
- WP7 Development of a course package on radiation protection in nuclear environment
- WP8 Promotion, dissemination and courses teaching
- WP9 Project management
- WP10 Ethics requirements

GRE@T-PIONEER

https://great-pioneer.eu/

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UPM members who have collaborated in this presentation

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- Cristina Montalvo Martin, PhD
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- Diana Cuervo Gomez, PhD
- Miguel Ángel Martín Rengel, PhD

Sponsoring institutions

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enusa
Horizon 2020
Gobierno de España, Ministerio de Economía y Competitividad
unesa Asociación Española de la Industria Eléctrica
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