Country presentation

THAILAND

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- ***King Mongkut's University of Technology Thonburi***
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Mea Culpa

- All information in this presentation is based on current recognition and knowledge of the presenter (or the team).
- The presenter is responsible for all mistakes made in this presentation, not the authors whose articles are referred to.
- However, all credits shall be given to those authors, if the presentation was understood correctly

Content

- **Background** – Why do we need nuclear power safety research (and the collaborations)?
- **Available resources** – Who are the main players and how they have been doing so far
- **Gaps to be fulfilled** – Lacks of information, knowledge and human resources (and budget)
- **Current research activities** – thermal hydraulics, aerosol behavior, accident consequence assessment, etc.
- **Proposal of a benchmark problem** – What we have done with VINATOM

Background

Why do we need nuclear power safety research (and the collaborations)?

History of NP Program in Thailand

- EGAT was first interested in nuclear power **in 1967** due to sharp increase in electricity demand
  - **Suspended in late 1970s** due to public opposition, economic repercussion, etc.
- Reconsideration of nuclear power **in 1980** due to limitation of other sources
  - **Never implemented** due to economic crisis in 1999, and public opposition (caused by Chernobyl accident)
- **PDP 2007**: **two** 1000 MWe units **by 2021** (to reduce reliance on natural gas)
- **PDP 2010** (with several revisions): **four** 100 MWe units **by 2028 (delayed by the 1FNPP accident)**
- **PDP 2015**: **two** 1000 MWe units **by 2036**

Basically taken from R. Namwong, IAEA-CN-164-1P04

Fukushima Daiichi NPP Accident

Public anxiety in nuclear safety &
Public distrust of nuclear personnel

Attitude of People

- K. Jeamwittayanukul (submitted) found that **nuclear-related knowledge has strong relation with the attitude toward nuclear power**
  - He also found that **current level of knowledge is low**
- **Misunderstanding could have led to negative attitudes**
  - Atomic bomb VS Nuclear accidents
  - Chernobyl accident VS 1FNPP accident
  - Uncertainties in effects from low dose exposure
- Limited access to **evidence-based information**
- **Situations should not be so different in other ASEAN countries**

Circumstances in Surrounding Countries

- **Ninh Thuan 1 and 2 NPPs**
  - Vietnam decided to introduce NP in 2009
  - It **signed contracts** for two units each with Russia and Japan in 2010
  - Plan for **commissioning in 2027 and 2028**
  - Vietnam Government decided to **cancel** the project due to high investment in nuclear safety and lack of HR
- **Bataan NPP**
  - Consideration of **rehabilitation** of the NPP.
- **Serpong Experimental Nuclear Power Reactor**
  - Indonesia tries to gain its **public acceptance** in NP
  - **Partially local** construction and operation

Things a Technical Support Organization (TSO) Needs to Support & Know

To support

- Siting
- Safety analysis
- Design evaluation
- Construction
- Operation & maintenance
- Radiation protection
- Decommissioning & fuel cycle

To know

- Assessments based on NS-R-3
- Support periodic safety review
- Disaster management
- Safety/risk assessments
- Rx physics / thermal hydraulics
- I&C, electrical systems
- Structural evaluations
- Construction planning
- Aging management
- Operation control
- Fuel handling
- Cooling systems/turbine island
- Public and personnel protection
- Decommissioning planning
- Spent fuel management
- Fuel cycle planning

Fields

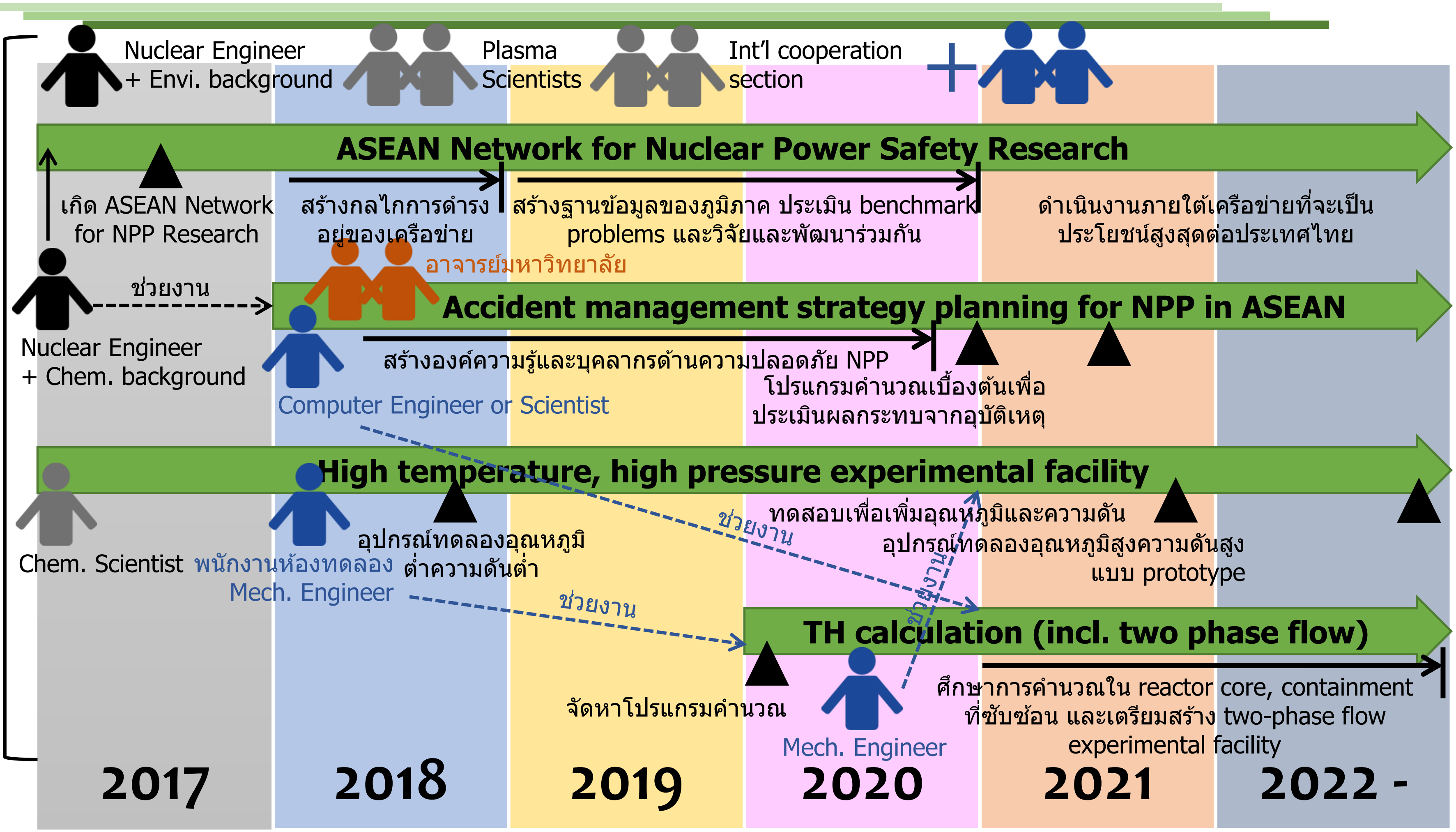
- Nuclear eng.
- Mechanical eng.
- Civil eng.
- Electrical eng.
- Chemical eng./sci.
- Health and nuc. phys.
- Computer eng./sci.
- Environmental eng./sci.
- Geology
- I&C, electronics
- Safety eng.
- Project management
- Social sci./economics

Based on TECDOC-1078

What are the Top Priorities

To support	To know	Fields
Safety analysis	Accident root cause eval.	Nuclear eng.
	TH in Rx during accidents	Mechanical eng.
	Containment vessel eval.	Computer sci.
	Source term evaluation	Chemical eng.
	Accident consequence asmt.	Geology
Radiation protection	Radiation protection for public and personnel	Health physics
	Emergency preparedness	Environmental eng.
	Cooperation with related organizations	Civil eng.
		Safety eng.

Plan for 2017 – 2022 (Tentative)



Available Resources

Who are the main players and
how they have been doing so far

Problems regarding R&D Human Resource Securement

- **Uncertainties in energy planning**, especially nuclear power program, led to
  - Uncertainties in HRD planning
  - **Hesitation in investment in HR**, e.g. abroad education
  - **Small number of personnel with very specific skills** due to concentration on high-level studies
- **Lack of cooperation** between organizations
  - Overlap in work coverage in different organizations
  - Ambiguity of host institutions
- Common issues among ASEAN countries (?)

OAEP → OAP

- Establishment of Office of Atomic Energy for Peace **in 1961**
- Aimed to do **R&D** to apply nuclear energy in all fields to develop the country and to **regulate safe nuclear use**.
- Changed to Office of Atoms for Peace in 2002 for larger coverage of nuclear/radiation applications
- Bureau of nuclear safety regulation possess HR in the field of nuclear safety, regulations and law (concentrating on research reactors)
- Bureau of technical support for safety regulations possess HR in the field of radiation safety (internal TSO)
- **Currently responsible for nuclear and radiation regulations**

OAP → OAP & TINT

- To achieve **independence of supporters and regulators**, Thailand Institute of Nuclear Technology (TINT) is separated from OAP **in 2006** to be **responsible for R&D and services**.
- TINT owns the current research reactor, with tens of staff knowing well about characteristics and safety of **pool-type reactor.**
- **Limited number of researchers** in Nuclear R&D Division is now working with professors and students in universities on NP safety R&D.

EGAT & MoE

- Electricity Generation Authority of Thailand and Ministry of Energy have similar situation.
  - They are always **affected by the changes in energy policy**.
- A section working on NP is established when nuclear power comes to the stage, and is demolished when the plan is postponed.
  - There is **no stable pool of staff**.
- A (tiny) **feasibility study** for the NP program plan is being carried on **to follow the timeline in PDP2015**.

Universities

- **CU**
  - Only univ. that has a Dept. of Nuclear Eng.
  - 1 Asst. Prof. and 3 students currently working closely with TINT on NP safety issues
  - Other Profs. Doing NP-related research constantly
  - Opening B.E. (nuclear eng.) for the first year
- **KMUTT**
  - Had a plan to open B.E. (nuclear eng.) before the 1FNPP accident
  - 1 Dr. working with our team from TINT
- CMU, KU, SUT, etc.
  - Nuclear physics or radiation application

External Resources (Experts)

Sources for HRD (workshops, trainings, etc.)

- **International Atomic Energy Agency (IAEA)**
  - **Our invited speaker**
- European Union (EU)
  - Currently helping OAP on emergency preparedness
- Japan Atomic Energy Agency (JAEA)
- Korea Atomic Energy Research Institute (KAERI)
- United States Department of Energy (USDoE)

etc.

Current Research Activities

thermal hydraulics, aerosol behavior, accident consequence assessment, etc.

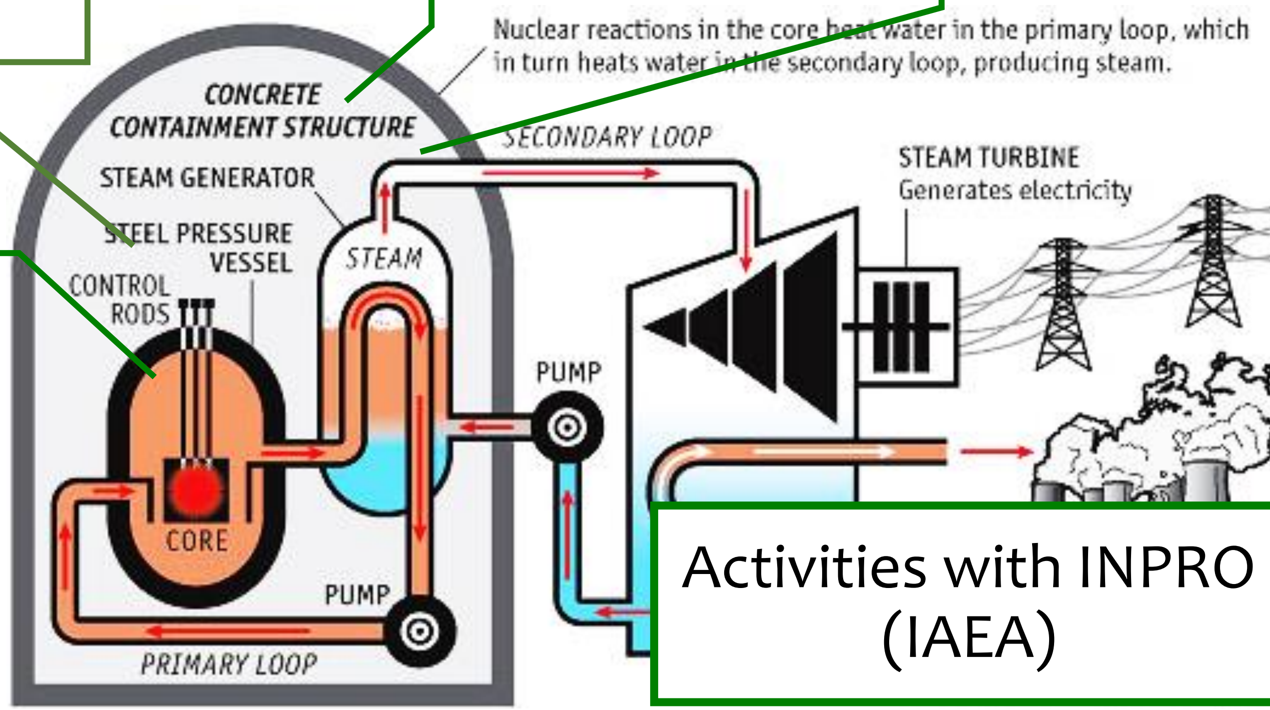
We have been doing research on NP safety aiming to understand the whole sequence of a severe accident from RCS to accident consequences

Cs compounds behavior in CV
ART Mod 2

Cs compounds experiment
(e.g. Cs_2MoO_4, CsI)

SA consequence assessment

TH in RCS
RELAP/SCDAPSIM

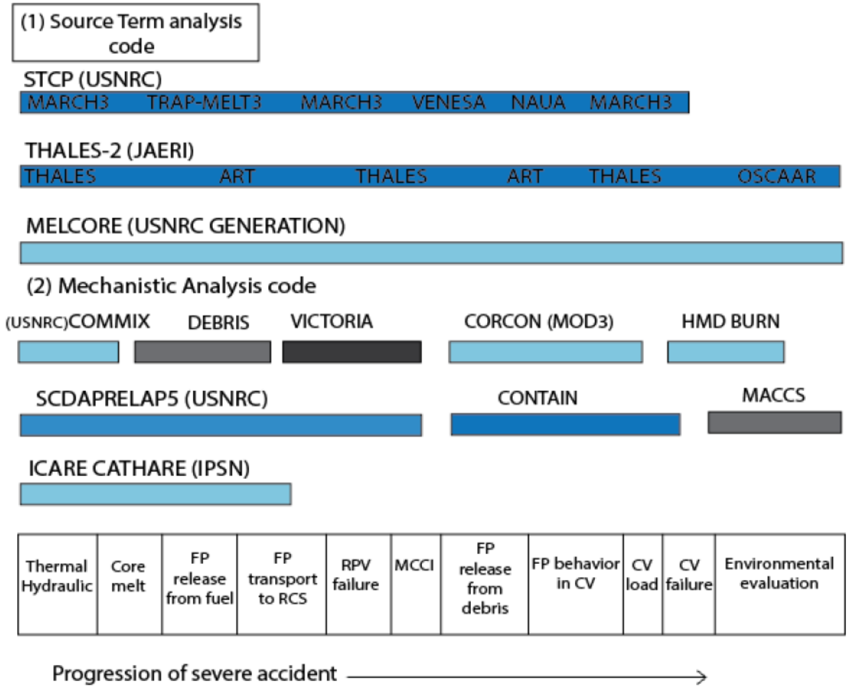


Activities with INPRO (IAEA)

Severe Accidental Analysis For Reactor Core Behaviors Using a Severe Accidental Code

Some severe accidental codes avalable for LWR

- ➢ MELCOR (NRC, USA)
- ➢ MACCS (NRC, USA)
- ➢ SCDAP/RELAP5 (NRC, USA)
- ➢ CONTAIN (NRC, USA)
- ➢ IFCI (NRC, USA)
- ➢ VICTORIA (NRC, USA)
- ➢ MAPP (EPRI, USA)
- ➢ ASTEC (IRSN/GRS, France/Germany)



Ref. H. Muhammad, 2013

RELAP/SCDAPSIM code

- Innovative Systems Software (ISS), (USA)
- International SCDAP Development and Training Program (SDTP)
- 60 organizations in 28 countries supporting the development of technology, software, and training materials for the nuclear industry
- Agreement between ISS and TINT for use of code in research works
- RELAP/SCDAPSIM/MOD3.4 and 4.0
  - ✓ Advanced numerical options such as improved time advancement algorithms, improved water property tables, and improved model coding

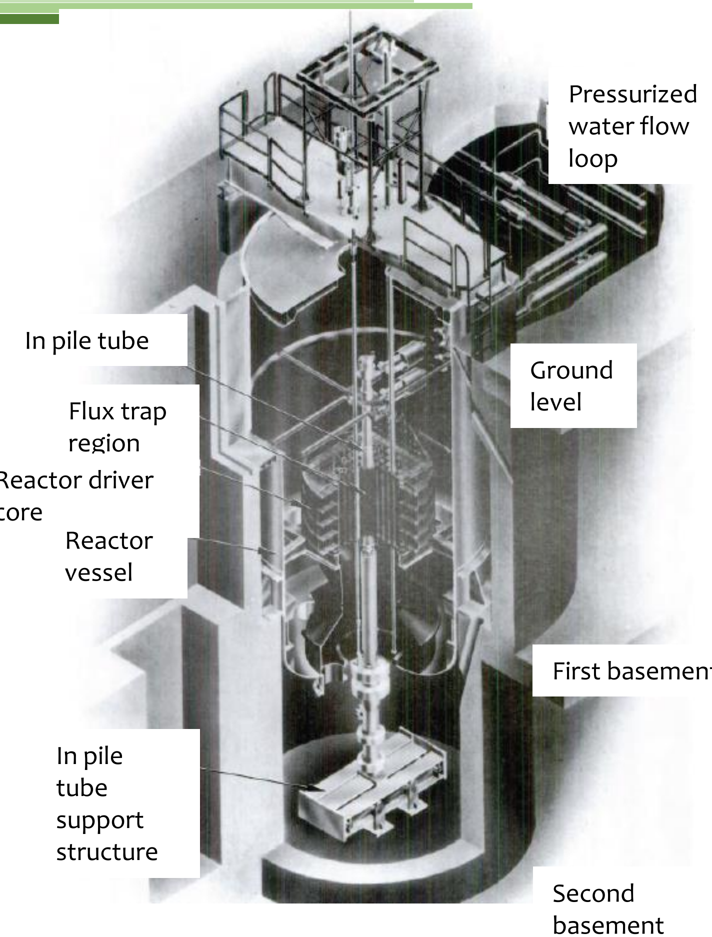
Our Current Focusing Experiment For Code Analysis

Power Burst Facility (PBF)

- Severe Fuel Damage (SFD) tests
- Idaho National Engineering Laboratory
- Part of an internationally sponsored light water reactor severe accident research program
- Initiatation by the US Nuclear Regulatory Commission (US NRC)
- Major experiments done during 1980-1990
- Valuable experimental data

Power Burst Facility (PBF)

Description	Part	Dimension	Note
Driver core	Core		Right-circular
		1.3 m	Diameter
		0.91 m	Length
	Vertical flux trap	0.21 m	Diameter
	Control rods	8 rods	Steady state
	Transient rods	4 rods	Rapid reactivity transients
Central flux trap	Nitrogen annulus		Between in-pile tube wall and aluminum core fuller piece
	In-pile tube (Inconel 718)	0.20 m	Outside diameter
		0.15 m	Inside diameter



Ref. PBE Severe Fuel Damage Scoping Test - Test result report, NUREG/CR-4883 EGG-2413, U.S. Nuclear Regulatory Commission, 1986

SFD Test Program during 1982-1985

Test	Test Bundle	Inlet Flow (g/s)	Target Heating Rate (K/s)	Cooling
SFD-ST (28 Oct 1982)	32 fresh rods	16.4	0.1 to 1600	Quench
SFD 1-1 (8 Sept 1983)	32 fresh rods	0.6	0.44 to 1300 1.4 to 1600	Slow, argon
SFD 1-3 (3 Aug 1984)	26 irradiate rods 2 fresh rods 4 zircaloy guide tubes	0.6	0.44 to 1300 1.4 to 1600	Slow, argon
SFD 1-4 (7 Feb 1985)	26 irradiate rods 2 fresh rods 4 Ag-In-Cd control rods with zircaloy guide tubes	0.9 to 1.5	0.44 to 1300 1.4 to 1600	Slow, argon

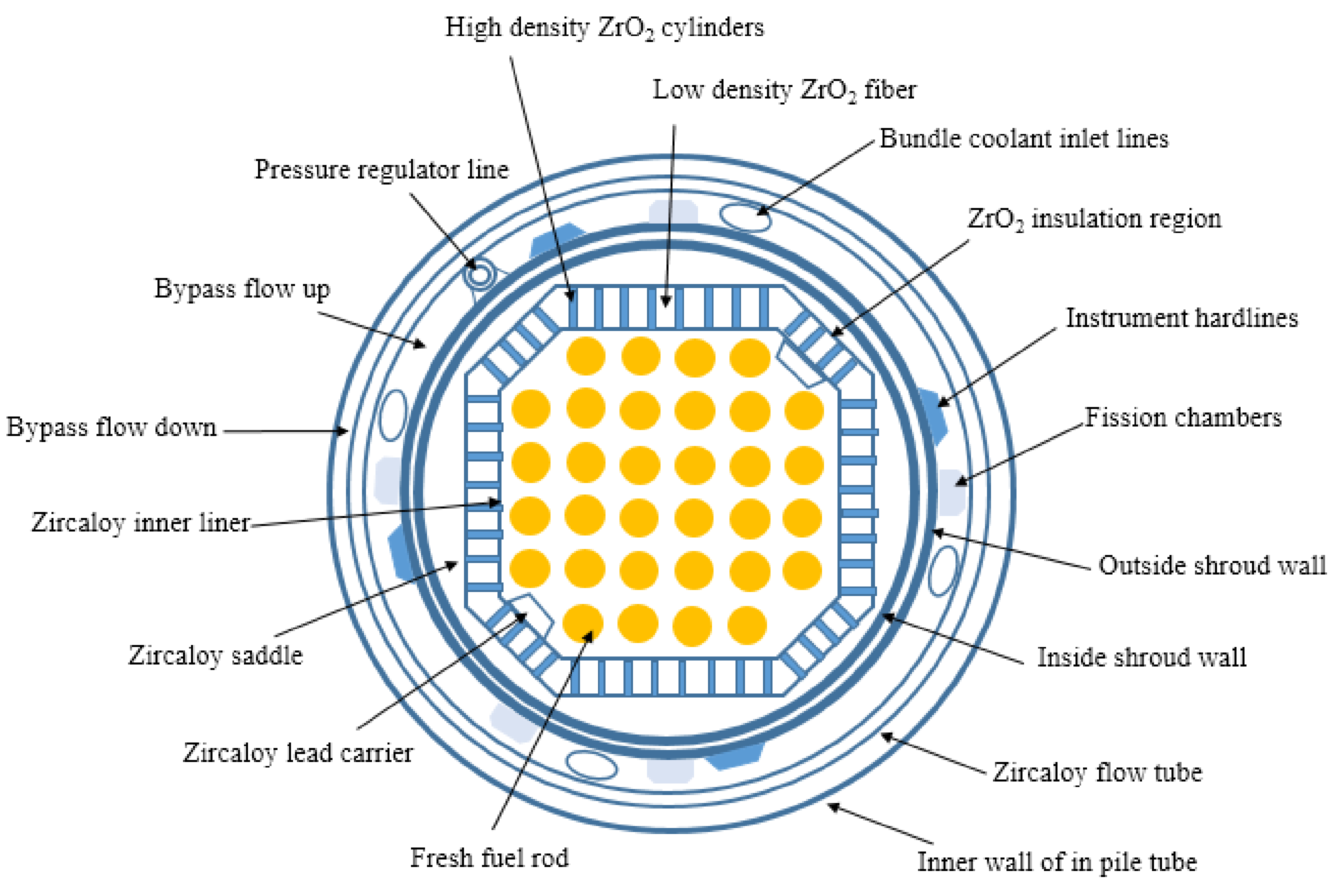
Done 2016

Planned 2018-19

Planned 2018-19

On-going 2017-2018

Cross Section View of SFD-ST Shroud and Bundle

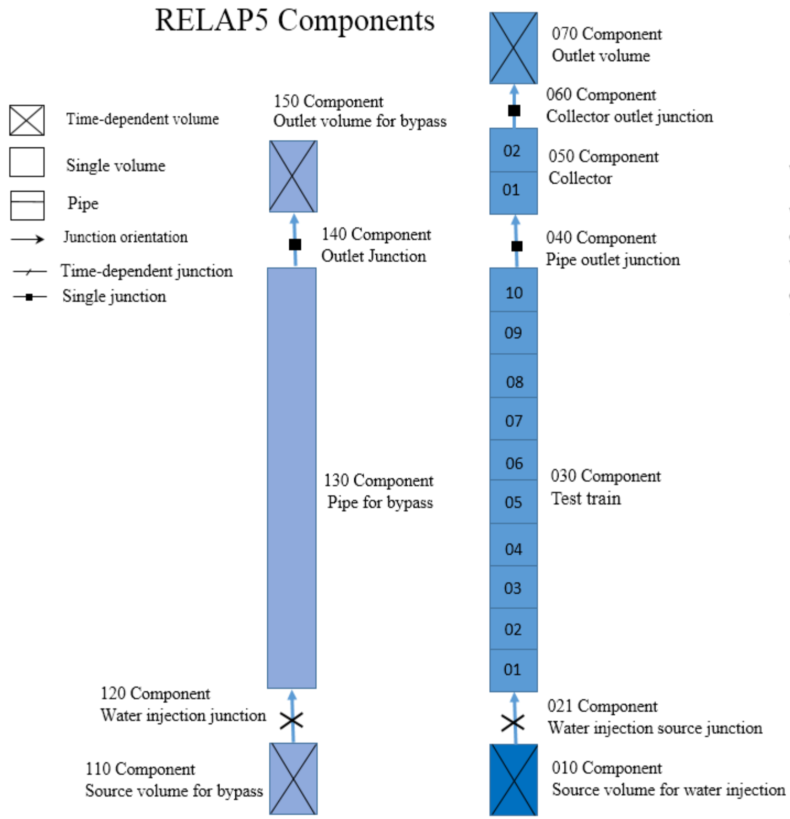


A.D. Knipe, S.A. Ploger and D.J. Osetek, *PBF Server Fuel Damage Scoping Test-Test Results Report*, pp. 1-120, EG&G Idaho Inc., Idaho falls, Idaho,USA (1986)

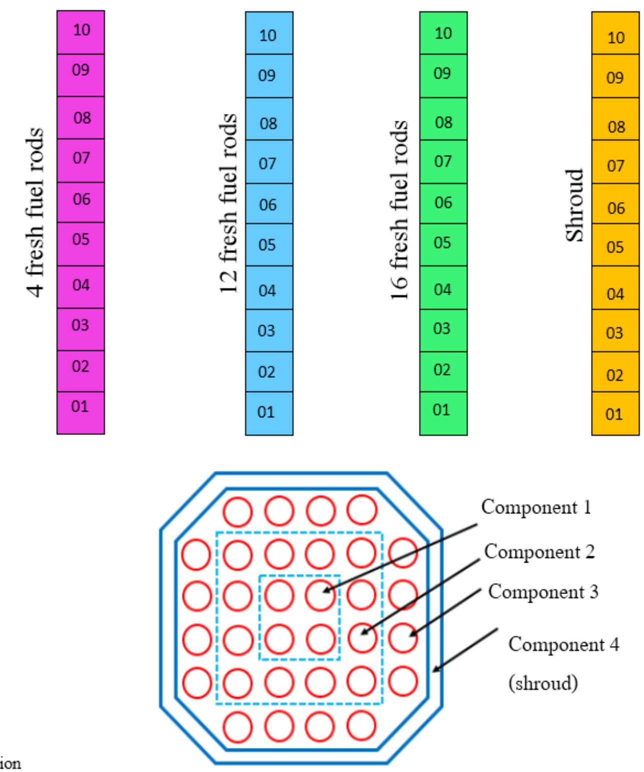
Nodalization of SFD-ST

Input for RELAP/SCDAPSIM

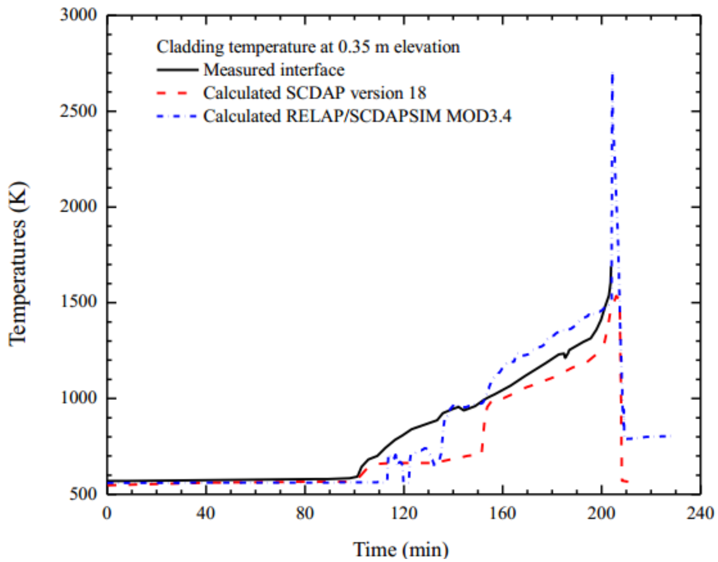
RELAP5 Components

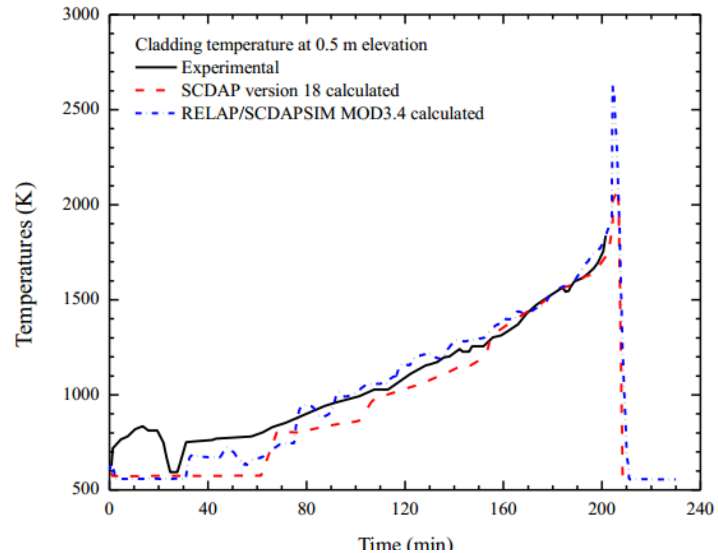


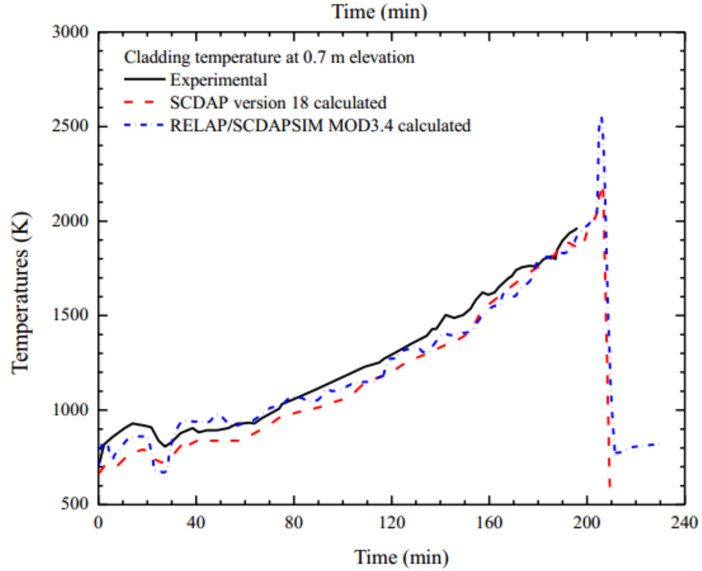
SCDAP Components

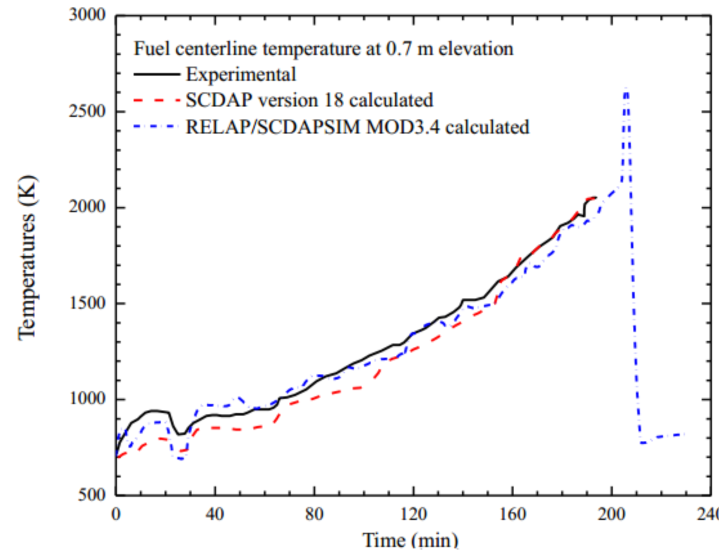


Examples of Results-1





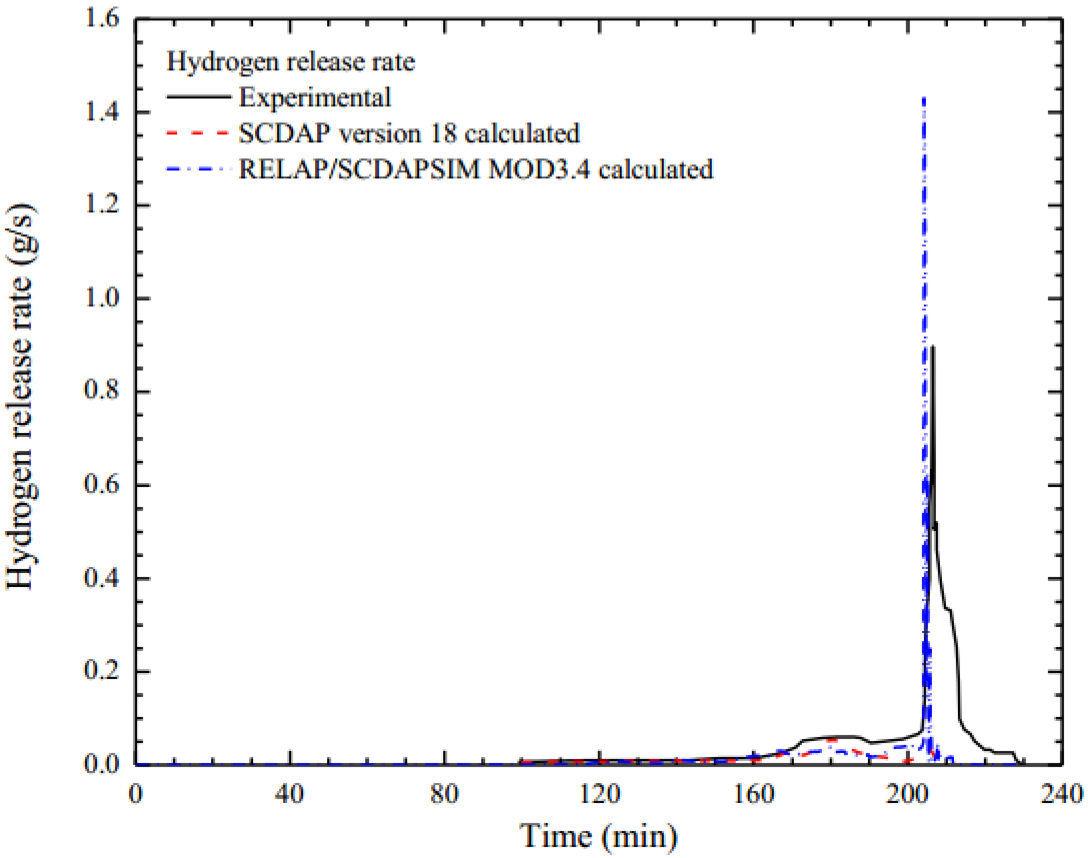




Examples of Results-2

Integral H_2

- MOD3.4 = 180 g
- Measurement
  - 235 – 515 g (on-line)
  - 132 – 260 g (PIE est.)



Near And Long-term Challenges for Our Research in Severe Accidental Analysis

Short-term

- Expanding of applications of RELAP/SCDAPSIM code benchmarking to other severe accidental analysis tests
- Using of other Severe accident (SA) codes such as MELCOR

Long-term

- Gaining of knowledgeable information of Fukushima Daiichi accident through SA code analysis
- Performing a simple experiment to study some aspect of SA

Containment Assessment

- Modification of the aerosol deposition models of ART Mod 2 (W. Vechgama)
- Aim
  - Precise release data
  - Need accurate CV behavior
- We use ART Mod 2 of JAEA
  - Out-of-date
  - Need model update
- Aerosol deposition models
  - Gravitational settling, Brownian diffusion, diffusiophoresis, thermophoresis

Volume 1 Containment ด้านบน
Volume 2 Wet Part Condenser
Volume 3 Dry Part Condenser
Volume 4 Feed Source and Stream
Volume 5 Containment ด้านล่าง
Volume 6 Sump

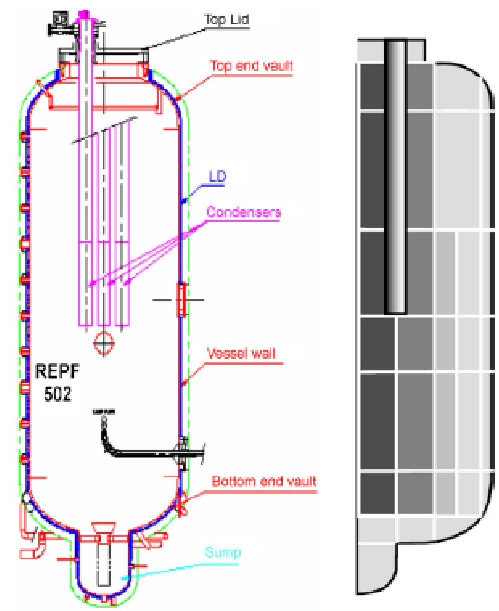


Fig. 3. CPA model of PHEBUS containment vessel.

Containment Assessment

- We compared the aerosol depositions of **Cs, I and Te** compounds with experimental data from **Phebus FP tests**, and found **good matches**.

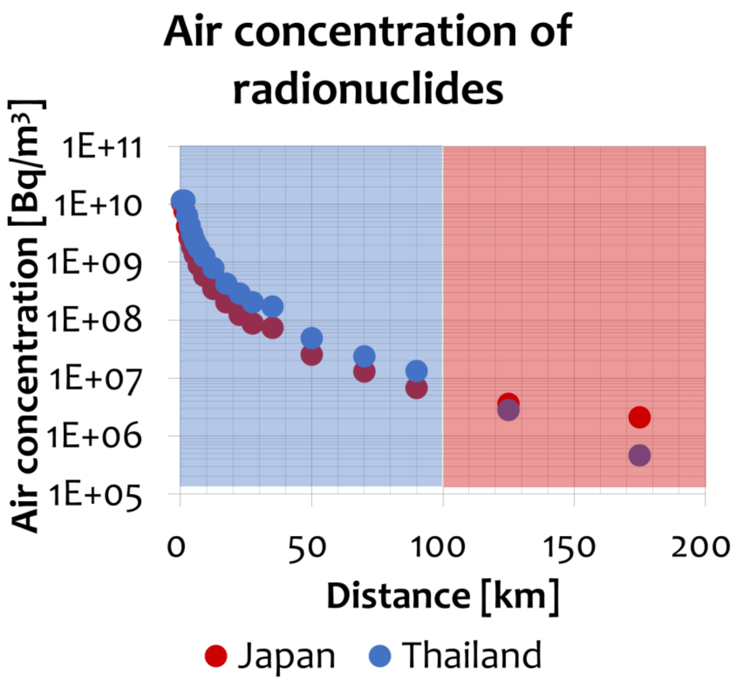
CsOH	GS	BD	DP	TP
Experiment	58	8	21	-
Simulation	71	5	23	<1

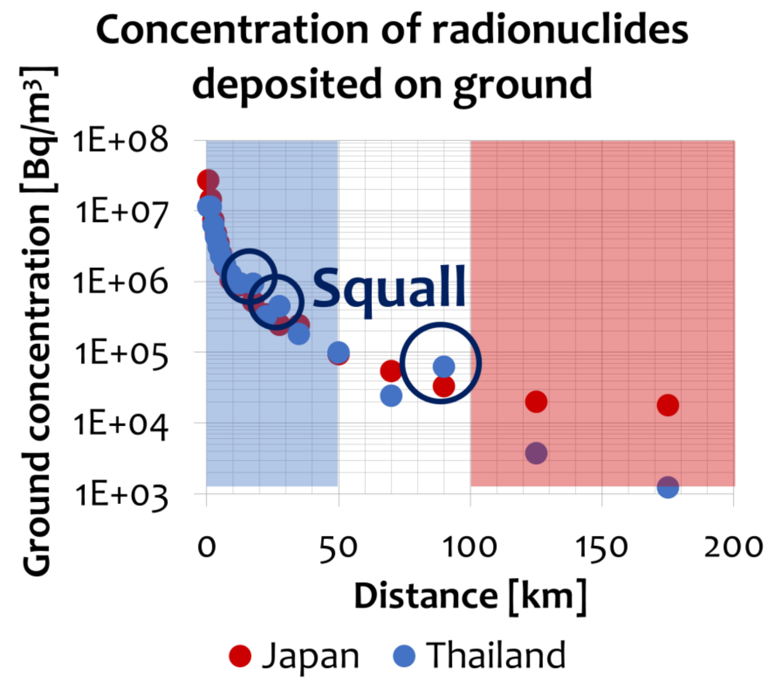
I_2	Floor	Wall	Condenser
Experiment	58	8	21
Simulation	71	5	23

Te	GS	BD	DP	TP
Experiment	52	12	21	-
Simulation	53	15	17	<1

Accident Consequence Assessment

- Comparison of meteorological conditions in Thailand and Japan (K. Silva)

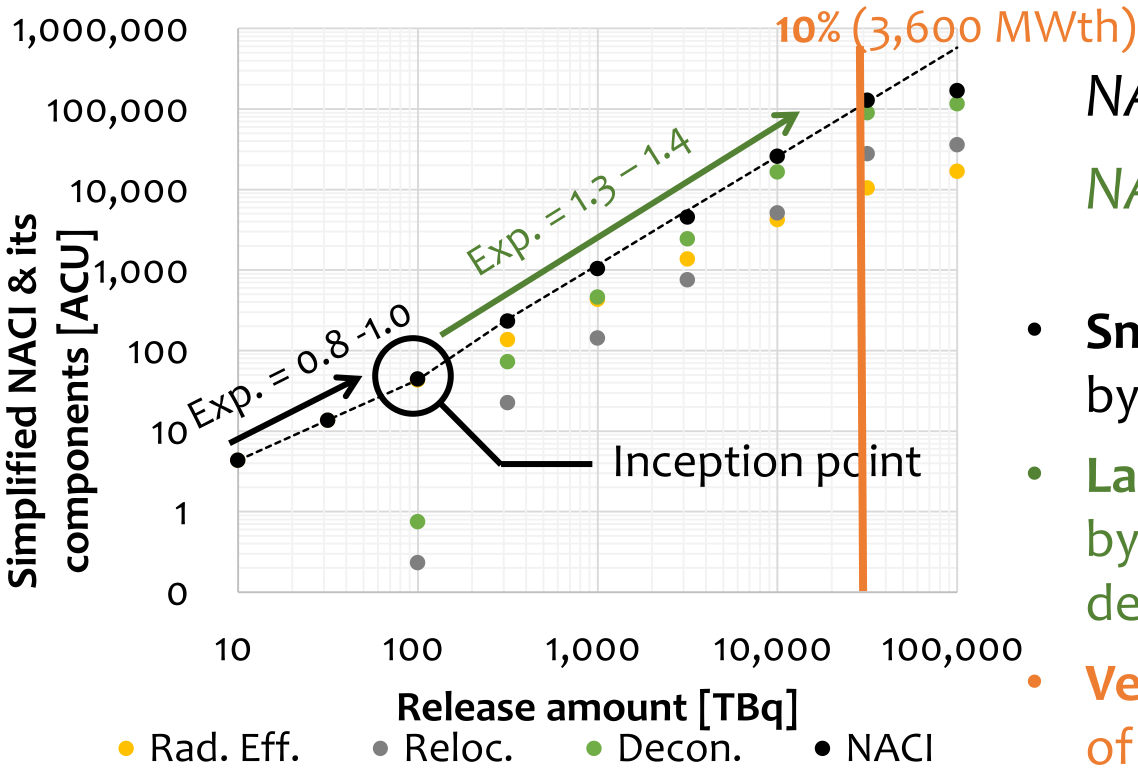




Country	Wind speed	Rain type
Thailand	Slow → centered	Squall → peaks
Japan	Fast → scattered	Continuous → no peak

Accident Consequence Assessment

- Relation between source term and accident consequences (K. Silva)



$NACI = k_4 \cdot R^{0.8\text{-}1.0}$ (RA ≤ 100)

$NACI = k_5 \cdot R^{1.3\text{-}1.4}$ (RA > 100)

- **Small release:** NACI is dominated by the radiation effect index.
- **Large release:** NACI is dominated by relocation and decontamination indices.
- **Very large release:** the increase of NACI will saturate.

Proposal of a Benchmark Problem

What we have done with VINATOM
Thailand: work basically done by N. Khunsrimek

Proposal from TINT to VINATOM

TINT and VINATOM will assess the two benchmark problems using their own calculation codes:

- **Atmospheric dispersion** of the radioactive plume from the hypothetical accidents level 4 to 7 in INES scale in a virtual unit in **Ninh Thuan 1 Nuclear Power Station (NPS) and Fangchenggang NPS**
- **Lead time** until the radioactive plume reach the border of selected ASEAN countries, e.g. Cambodia, Laos, Thailand
- **Consequences of the accidents to the public and the environment** using the consequence assessment platform of each party.

Boundary Conditions

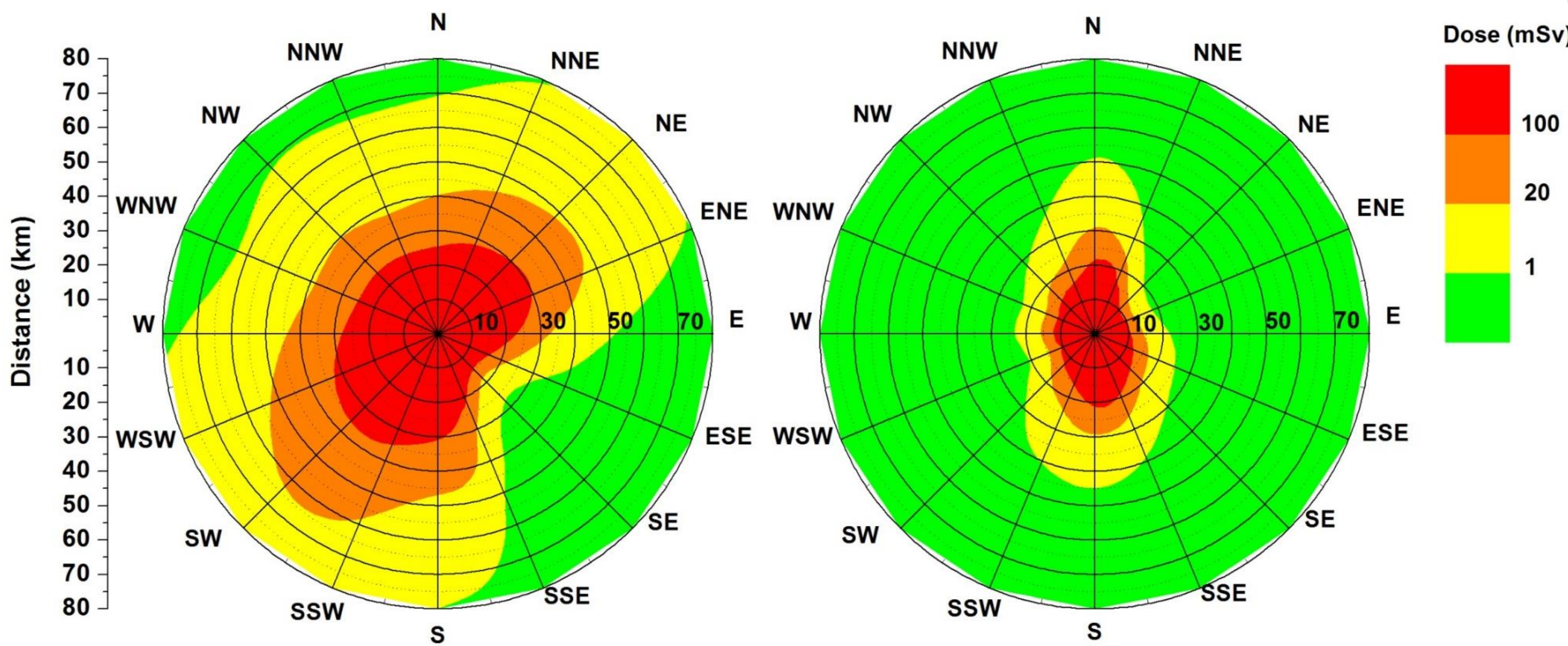
- **Release amount:** 2.45 TBq of Cesium-137 (1% of the total inventory of 3,000 MWe PWR)
- **Release starting time:** 24 hours after the accident starts
- **Release period:** 24 hours
- **Meteorological data** (wind speed, wind direction, rainfall, weather stability): hourly data of 2015
  - Ninh Thuan 1: latitude/longitude (11.5, 109)
  - Fangchenggang NPS: latitude/longitude (22, 108.5)
- **Calculation code:** HotSpot Ver. 3.0.7, OSCAAR

Summary of Meteorological Data

Direction	Stability		Rain (mm/h)		Wind speed (m/s)	
	Vietnam	China	Vietnam	China	Vietnam	China
N	D	E	0.22	0.58	3.78	2.06
NNE	D	E	0.16	0.54	5.92	1.42
NE	D	E	0.13	0.90	6.52	1.11
ENE	D	E	0.06	1.10	4.92	1.00
E	E	B	0.02	1.35	3.64	0.91
ESE	E	E	0.16	1.18	2.97	0.91
SE	E	E	0.06	1.50	2.91	1.27
SSE	E	B	0.05	1.13	3.01	1.55
S	E	E	0.10	0.73	3.42	2.33
SSW	D	E	0.16	0.65	4.04	2.07
SW	D	B	0.12	1.53	4.13	0.99
WSW	D	B	0.13	1.27	3.70	0.78
W	E	B	0.22	1.75	2.46	0.82
WNW	E	B	0.46	0.56	1.73	0.90
NW	E	E	0.20	1.13	1.26	1.39
NNW	E	E	0.22	0.80	2.05	1.96

Probable Dose Mapping

Vietnam **China**



Country	Wind speed	Rainfall
Vietnam	High (NE, SW)	Small
China	Low (N, S)	Large

Consideration of Radiation Protective Measures

- Accidents in Ninh Thuan NPS will lead to **larger area of contamination**, comparing to that of Fangchenggang NPS.
  - Due to high wind speed and small rainfall
- In order to avoid public exposure, **large-scale relocation** is needed.
- In order to mitigate the consequences to environment, **large-scale decontamination** is needed.
- Evaluation of release of **iodine-131** is needed to consider short-term protective measures

TEDE / area (km^2)	Vietnam	China
$100 \le X$	2261.69	660.89
$20 \le X < 100$	2917.02	620.65
$1 \le X < 20$	9355.14	1891.19

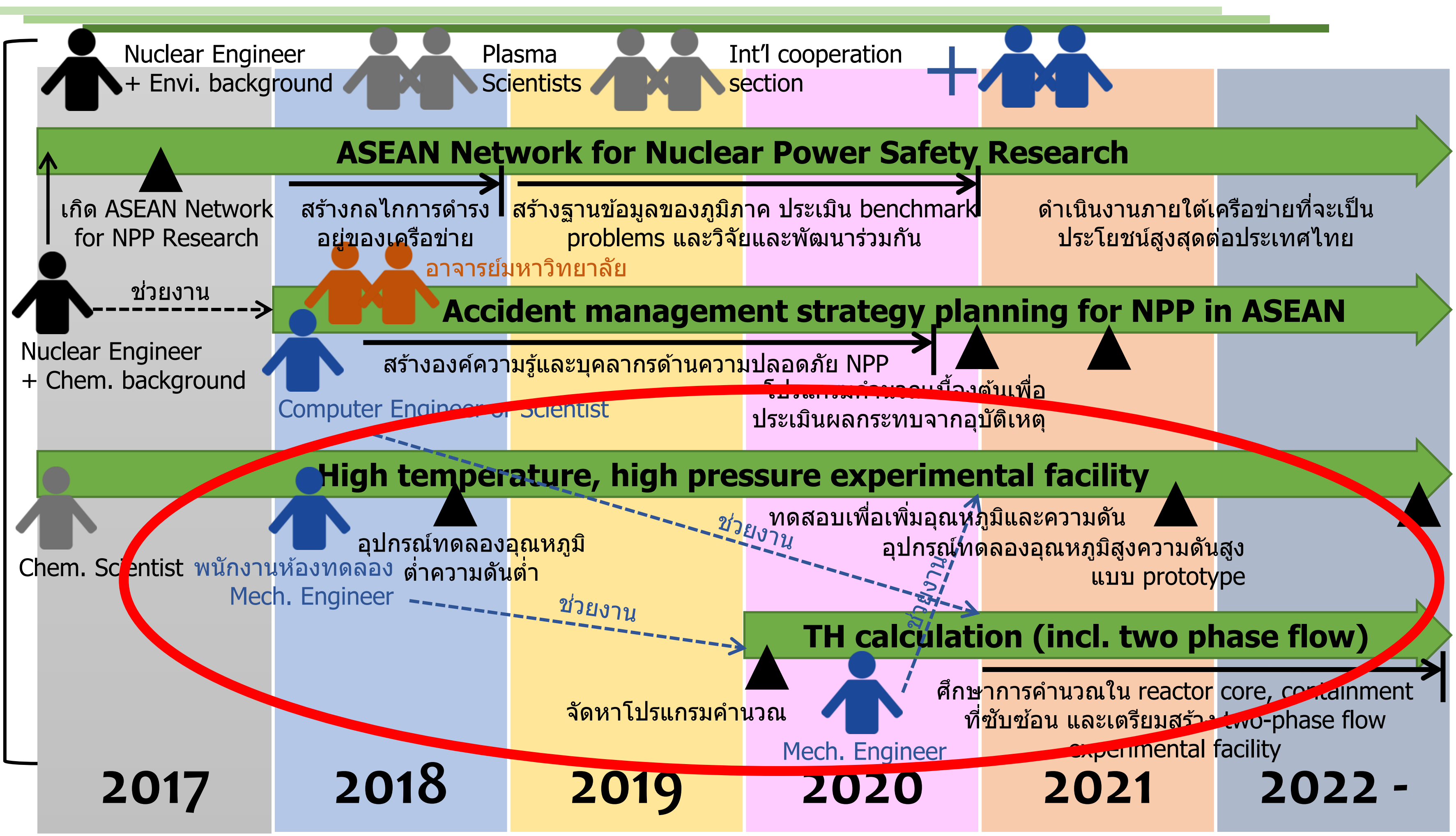
Future Plan – Comparison between HotSpot and OSCAAR

- HotSpot can consider only **single point** of meteorological data
  - Puff-trajectory model cannot be used
  - Not suitable for large scale dispersion
- HotSpot cannot consider **complicated release scenarios**
  - It cannot consider long-term release (1FNPP-like) or changes in release rate
- Based on these limitations, we concluded that HotSpot **cannot be used to calculate the lead time** until the plume reach the country boundaries.
- **We will compare the results of HotSpot and OSCAAR to prove these assumptions.**

Gaps to be Fulfilled

Lacks of information, knowledge and human resources

Based on the Five-Year-Plan



Based on the TSO Plan

To support

- Siting
- Safety analysis
- Design evaluation
- Construction
- Operation & maintenance
- Radiation protection
- Decommissioning & fuel cycle

To know

- Assessments based on NS-R-3
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Fields

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- Safety eng.
- Project management
- Social sci./economics

Collaboration with Neighboring Countries

- Points
  - **An accident in one country can affect the whole region.**
  - We can **share limited resources and information** that we have through ASEAN framework.
- Sharing resources
  - Each country may have good resources of some specific fields that others do not.
- Sharing information
  - Sometimes we need information of other countries.
  - We needed meteorological data from Vietnam to perform the **benchmark problem assessment**.

Summary and Conclusions

Concluding Remarks

- We need NP safety R&D to **prepare for NP program, and to ease public anxiety**.
- We have **limited human resources** scattered in different organizations.
- Our research activities focus on understanding the whole picture of a **severe accident in NPP.**
- We **propose a benchmark problem** to assess the release from NPPs.
  - TINT and VINATOM started the assessments.
- We lack HR for **TH experiments and for siting evaluation**.
- We have **no access to information of neighboring countries** when we need to perform accident assessments.

These are reasons we need an ASEAN network for cooperation in the field of NP safety research.

Thank you for your kind attention.