

# Proposal of 3rd RADSYNCH Survey: Update from 2017 survey and Extending to Accident Scenarios

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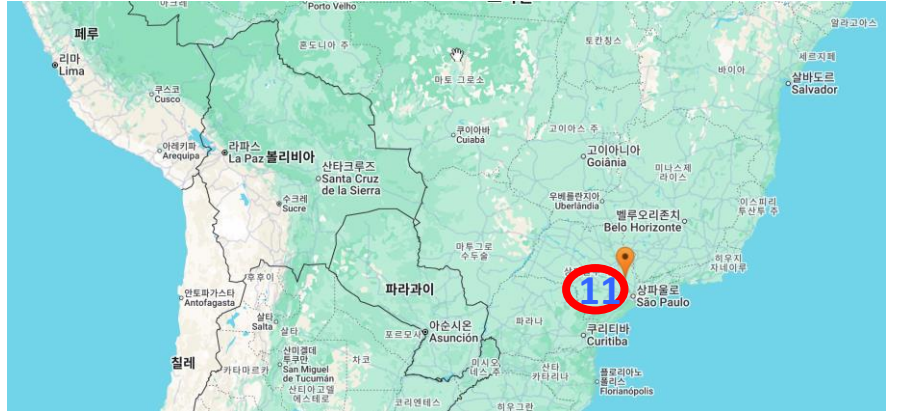
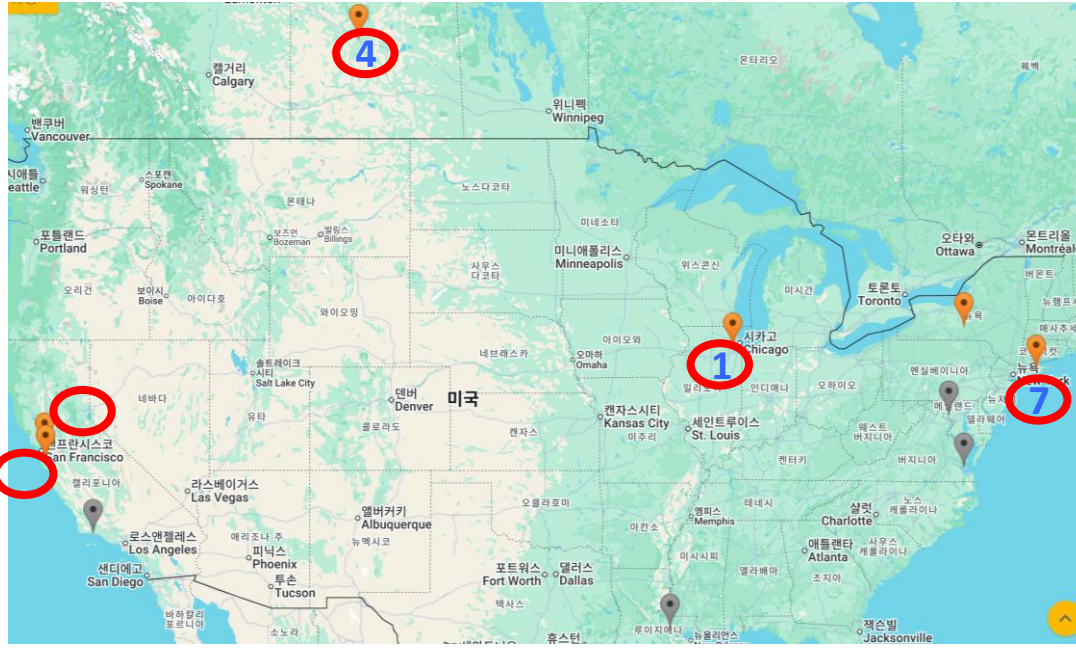
1. Introduction of Radsynch Survey
2. 1<sup>st</sup> Survey Question List and Issues
3. 2<sup>nd</sup> Survey Question List and Issues
4. Update of Radsynch Survey and Extension
5. Risk & Accidental Scenarios
6. Modes : Normal / Abnormal Operations, Accidents
7. Accidental Scenario Examples
8. Summary

# Light Sources at PAL (Project years)



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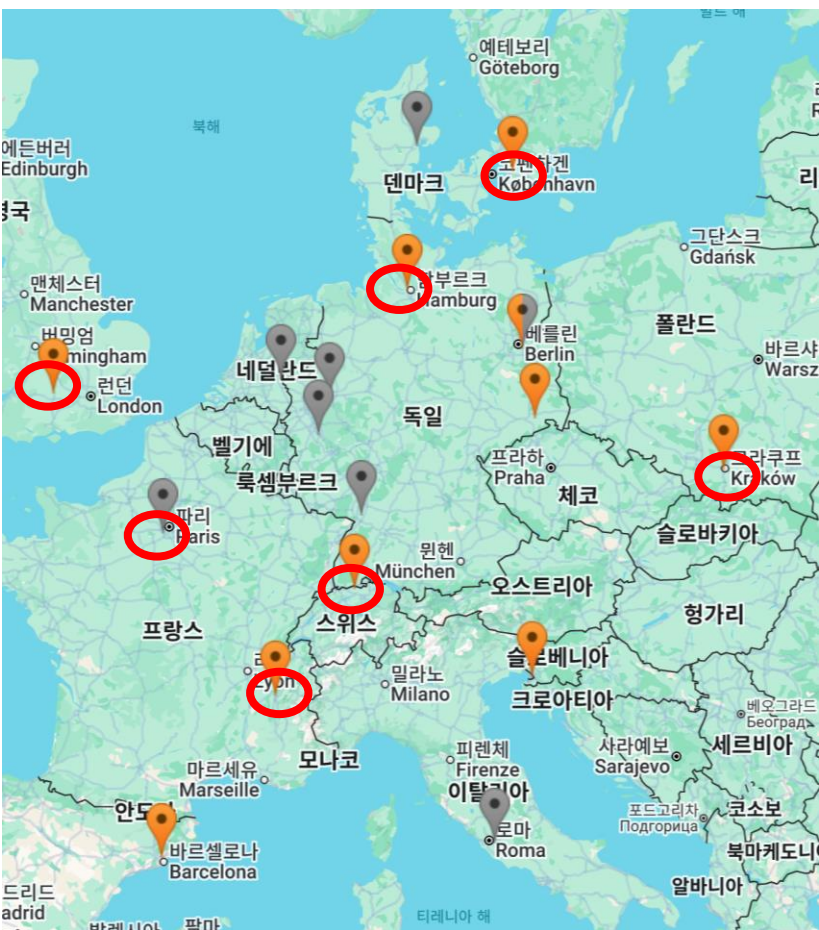
From lightsources.org (Major SR : > 3<sup>rd</sup> or 2.5<sup>th</sup>) : 23 facilities



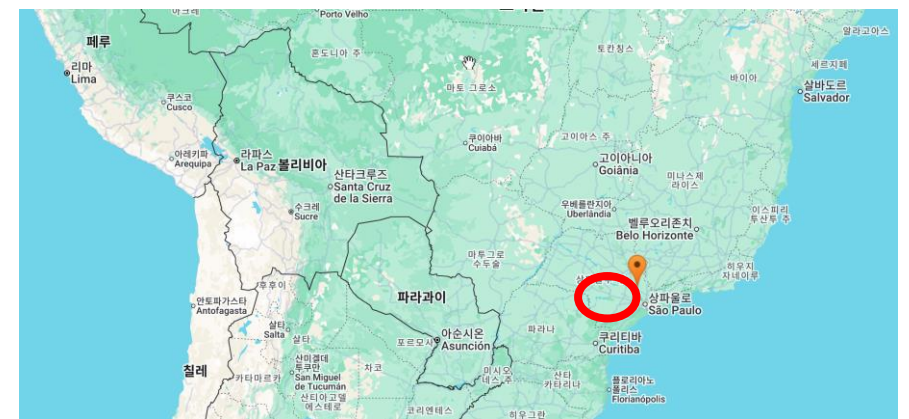
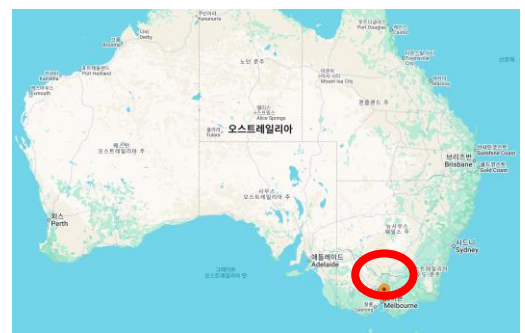
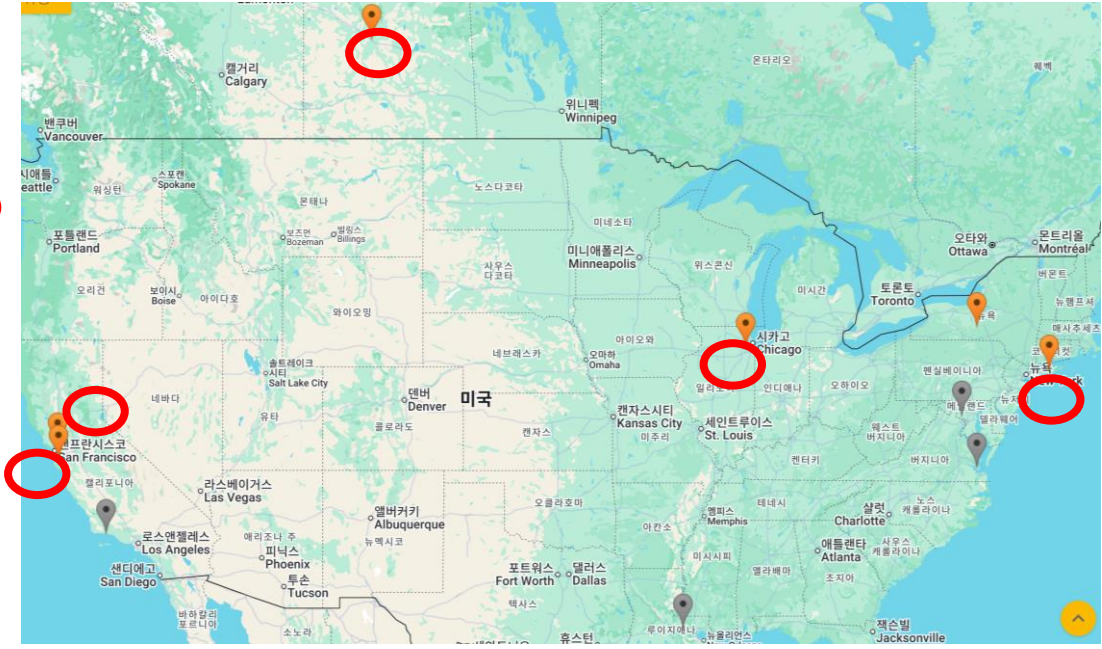
XFELs are not marked

# Light Sources at PAL (Project years)

## Light Sources which I visited (Major SR : > 3<sup>rd</sup> or 2.5<sup>th</sup>): 20 facilities



XFELs are not marked



## □ Intercomparison of Radiation Protection of each synchrotron radiation facilities.

- 1) One of Radsynch's Purposes
- 2) A way to solve **Ambiguity** and to reduce **Uncertainty**
- 3) Mainly Shielding Analysis, Safety System Design (RMS, PSIS), & Safety Control
- 4) Very helpful to change some strict and too conservative regulation or policy of each countries  
e.g. – PLS (SR User), NanoTERASU (Experimental Hall)
- 5) No One Model of Standard ! → Every country has its own regulation and Every facility has its policy

## 2. 1<sup>ST</sup> Survey Question List & Issues

- Joseph C. Liu (TLS) suggested at Radsynch2011 (in PAL/Korea). But the results was not reported clearly.
  - 1) Which place inside the front end is better to install bremsstrahlung collimators? Front or rear? Why? → **Raytracing of high energy bremsstrahlung**
  - 2) Do you require two independent circuits for the beamline interlock system? → **Redundancy of PPS/PSIS**
  - 3) How many heavy metal shutters or beam shutters do you have inside the front and in your facility? → **Reliability of safety shutter (redundancy), photon shutter**  
e.g. Troubles of photon shutter of PLS
  - 4) What has been done at your facility to exclude the possibility that electrons could enter optics enclosure (hutch) with front ends open? → **BM power supply chain, power drop speed (compare to electron revolution time)**
  - 5) Is the dose rate limit on the surface of the accelerator tunnel walls the same as that on the hutch walls of beamlines? Why(not)? → **Radiation worker & General public user.**

## 2. 1<sup>ST</sup> Survey Question List & Issues

- ❑ Joseph C. Liu (TLS) suggested at Radsynch 2011 (in PAL/Korea) But the results was not gathered.
  - 6) Does the action triggered by the emergency stop buttons in the beamline hutches depend on the status of the beamline? → **Locally close shutters or Kill a stored beam**
  - 7) What kind of measures do you take to protect people from neutrons that are produced from bremsstrahlung in the closed beam shutter? (White BL) → **location of the shutter & gas bremsstrahlung**
  - 8) How is the space between the beam tube downstream the beam shutter and hutch wall shielded? Can multiple scattered synchrotron radiation penetrate the vacuum tube, transfer the wall in the tube and come out behind the wall (when the beam shutter is closed)? → **No for SR but some protection shield is needed for secondary radiation in the tunnel**

- ❑ Hee-Seock Lee, Nam-Suk Jung (PAL) and Jeshep C. Liu (TPS) prepared at [Radsynch2017 \(in TPS/Taiwan\)](#) and the results were summarized by Hee-Seock Lee.
- ❑ **21 facilities (17 countries)** contributed.
- ❑ To get the standard model of the safety policy, the questionnaire including these items is prepared.
  - Which category do the SR users belong to in radiation protection policy and what is required for the users including the dose limit?
  - Which interlock criteria are applied at each facility?
  - What is the control level of experimental hall, especially, the hutch in area classification?
  - What is the procedure to install and operate new beamline?
- ❑ **Details**
  - 1) Basic Information
  - 2) Dose limit : Annual / Regulatory dose limit, Detector interlock limit for accelerator / for beamline

## □ Details

- 3) **Area (Zone) classification**
- 4) **Is the experimental hall classified to the “radiation control area”? Why? / why not?**
- 5) **Which area categories are applied to the experimental hutch and optical hutch (Shutter opened or closed)? Why?**
- 6) **The SR user is classified as Radiation worker or General public or the others.**
- 7) **Requirements for the SR user before using SR: medical check, what kind of training, personal dosimeter.**
- 8) **Do you need extra operation permit from governmental authority to install or use new SR beamline?**

# 3-1. 2<sup>nd</sup> Survey Question List & Contributed Facilities

Table 1. List of facility and contributor to this survey

Facility	Contributor	
1	MAX IV lab.	Magnus Hörling
2	Elettra	Katia Casarin
3	ALBA	Arnaud Devienne
4	SOLARIS	Justyna Wiklacz
5	BESSY-II	Yvonne Bergmann
6	ANKA	Michael Hagelstein
7	European XFEL	Eric Boyd
8	PETRA III	Albrecht Leuschner
9	SOLEIL	Jean-Baptiste PRUVOST
10	iRSD (formerly LURE)	Jean-Michel Horodyski
11	SSRL LCLS	Sayed Rokni Johannes Bauer
12	CLS	Brian Bewer
13	TLS / TPS	Joseph C. Liu
14	PLS-II / PAL-XFEL	Hee-Seock Lee, Nam Suk Jung
15	Spring-8 / NewSUBARU	Yoshihiro Asano
16	KEK-PF / KEK-PFAR	Hiroshi Iwase
17	SLRI	Methee Sopelhn
18	SSLS	Yang Ping
19	Indus-2	Prasanta Kumar Sahani
20	ESRF	Paul Berkvens
21	APS	Bradley Micklich
22	Australian Synchrotron	Hock Ch'ng

1. Basic Information

Name of Facility	
Location & Country	
Electron Beam Energy	
Stored Beam Current	
Operation Mode	<input type="checkbox"/> Top-up <input type="checkbox"/> decay <input type="checkbox"/> other :
Number of Beamlines	(    ea) for Used Photon Energy < 5 keV (    ea) for Used Photon Energy > 5 keV

2. Dose limit

Facility annual dose limit	Staff : __mSv, User : __mSv, Contractor: __mSv, Note:
Regulatory annual dose limit	Staff : __mSv, User : __mSv, Contractor: __mSv, Note:
Detector interlock limit for accelerator	Note: At <input type="checkbox"/> shielding surface, <input type="checkbox"/> experimental floor, <input type="checkbox"/> other :
Detector interlock limit for beamline	Note: At <input type="checkbox"/> hutch surface, <input type="checkbox"/> user end station, <input type="checkbox"/> other :

3. Introduce area (zone) classification in your facility

4. Is the experimental hall of your facility classified to the "radiation control area"?

No  Yes

If yes, what is the reason?

If no, which area category is applied to there?

5. Which area categories are applied to the experimental hutch and optical hutch of your facility?

	Beam On (Shutter Opened)	Beam Off (Shutter Closed)
Optical Hutch		
Experimental Hutch		

- What is the reason of such classification?

6. The SR user classified as

Radiation worker (if multi-level of RW is, please mark)

General public

The other (                    )

What is the base policy for classification of the SR user?

7. Requirements for the SR user

- (annual) Medical Check  No  Yes

- what kind of training is done for user? (                    )

- Does the SR user wear the personnel dosimeter at the experimental hall?

No  Yes, Always  Yes, on special occasions (                    )

8. Do you need extra operation permit from governmental authority to install or use new SR beamline?

### Annual Dose Limits / Detector Interlock Limits

- 1) 0.5, 1, 2, 5, 6, 20 mSv, different limits for user and contractor.
- 2) 2 uSv/4h, 1.5 uSv/4h, 0.5 uSv/h, 50 uSv/h (rate) .... for accelerator & for beamline

### Area Classification

- 1) How to control Experimental Hall and Users' access
- 2) Variable depending on operation mode
- 3) Hutches ?? (Use different names : Controlled, Interdicted, Prohibited, Radiologically-controlled, No access..)

### SR User

- 1) General Public with/without dosimeter
- 2) Radiation worker, Occupationally exposed person, ..
- 3) What kind of requirements for SR user? Dosimeter, Training, Medical check

### Additional Permit for New BL (By The Authority) is required or not.

## ❑ Candidated new facilities

- Sirius / HEPS / Shanghai / NSLS-II / NanoTERASU

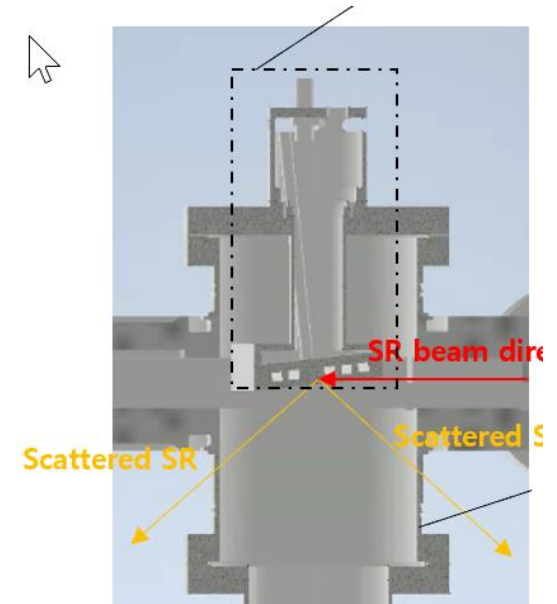
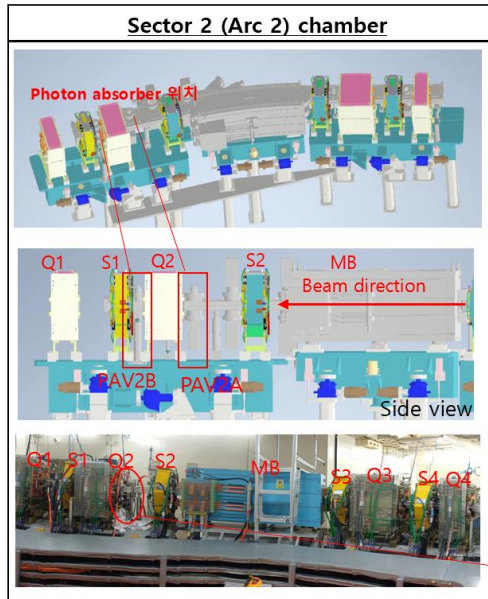
## ❑ Suggested Extension

- Interlock System (PPS/PSIS) : many subjects are available like beam containment.
- Radiation Detector for Top-up operation interlock
- X-ray generating machine control : RF cavity, Klystron, E-gun, etc
- Safety-based requirement for devices
- Beam Loss Information / Abnormal Operation / Accident Scenario
- Lesson-learnt (including Near-miss and machine damage)

**Any recommendations are very-welcomed!**  
**For Administrative Barriers and Physical Barriers**

# 4-1. Update of Radsynch Survey and Extension

- Preparing 3<sup>rd</sup> Survey : after 11<sup>th</sup> Workshop
  - Any volunteer for making questionnaire
  
- Results will be published or reported depending on the proceedings plan.
  - 3 months survey
  - Reported to Radsynch community until the end of 2025



## □ Risk (i) = Frequency (i) x Consequence (i)

i : issued condition or event

### □ How to estimate consequence

- Nowadays Monte Carlo calculation gives very detail numbers of dose & exposed dose.
- But there are many uncertainty factors which are usually neglected at the number.
- For examples,
  - ① Beam loss rate : available depending on accelerator group (designer & operator)
  - ② Real or major beam interaction condition
  - ③ Uncertainty in the Monte Carlo code itself (data library, method)
  - ④ Simplified geometry
  - ⑤ Unknown or imprecise material information
  - ⑥ Safety margin can be obtained by the detail estimation.
- Nevertheless, the number is very important even though we can not verify all uncertainty factors and get the safety margin information.

- ❑ **Fundamental Requirements of PAL Personnel Safety & Interlock System (PSIS)**
  - **Reliability (event number per 10000 h operation) → to be checked, such as MTBF**
  - **Fail-safe → Mandatory**
  - **Redundancy → Mandatory but there are several ways to achieve**
  - **Self-Test → Necessary for routine maintenance & inspection**
  - **Simplicity**
  - **Cable Protection**
  
- ❑ **How SIL3 become mandatory? How is it to set up SIL3 system using SIL2 devices?**
  
- ❑ **Please enjoy other colleagues' presentations in next session for details of frequency and risk.**

# 5-1. How to estimate the frequency



## Investigation of Accident Risk Assessment Methodologies for Large Accelerator Facilities

Jonghun Jang\*, UkJae Lee, Kyungmin Kim, Areum Jeong, Nam-Suk Jung, Hee-Seock Lee

Pohang Accelerator Laboratory, POSTECH, Pohang, Republic of Korea

Presented at ISORD12, next week

### ◆ CH PSI (Paul Scherrer Institute)

- Matrix-based assessment [5] : 6-level frequency × 5-level severity

Table 2. Frequency (Left) and Severity (Right) Categories Used in PSI's Risk Assessment

Risk	Occurrence	Severity	Effect
1. Incredible	Once in 100 years	1. Negligible	Little or no effect
2. Improbable	Once in 10 years	2. Minor	Minor injury (benefit ≥ harm)
3. Remote	Once per year	3. Marginal	Moderate injury (benefit insecure)
4. Occasional	Once per month	4. Critical	Serious injury (harm ≤ benefit)
5. Probable	Once per week	5. Catastrophic	Death(s) or multiple serious injuries
6. Frequent	Once per day		

- Risk levels : A (Acceptable), B (Needs mitigation), C (Immediate action)

Table 3. Risk Assessment Matrix Adopted by PSI

Risk	Severity				
	1 Negligible	2 Minor	3 Marginal	4 Critical	5 Catastrophic
1 Incredible	A	A	A	B	B
2 Improbable	A	A	B	B	C
3 Remote	A	B	B	C	C
4 Occasional	A	B	C	C	C
5 Probable	B	C	C	C	C
6 Frequent	C	C	C	C	C

### ◆ US TPX (Tokamak Physics Experiment)

- Semi-quantitative matrix [6] : 5-level probability × 4-level consequence
- Risk levels: Negligible, Low, Moderate, High

- Probability (5 levels) : Incredible, Extremely Unlikely, Unlikely, Anticipated, Likely
- Consequence (4 levels) : No Impact, Low, Moderate, High
- Risk Level Classification (4 tiers) : Negligible, Low, Moderate, High

※ "Probability" refers to qualitative estimation, not exact frequency.

Table 4. Probability Categories Used in TPX Risk Assessment

Probability [Level (Symbol)]	Description	Estimated Range of Occurrence Rate Per Year
1. Incredible (A)	Probability of occurrence is so small that a reasonable accident scenario is not conceivable. These events are <b>not</b> considered in the SAR accident analysis.	< 10 <sup>-6</sup>
2. Extremely Unlikely (B)	Event is not expected to occur during the life of the facility. Events are limiting faults considered in evaluation basis accidents.	10 <sup>-6</sup> ~ 10 <sup>-4</sup>
3. Unlikely (C)	Event is not expected to occur but may occur during the life of the facility.	10 <sup>-4</sup> ~ 10 <sup>-2</sup>
4. Anticipated (D)	Event is likely to occur during the life of the facility.	10 <sup>-2</sup> ~ 10 <sup>-1</sup>
5. Likely (E)	Event is likely to occur several times during the life of the facility.	> 10 <sup>-1</sup>

## Conclusion and Future Plan

- Risk assessment practices at major international accelerator facilities are *typically customized* rather than standardized, reflecting each facility's operational context.
- While matrix-based methods are widely adopted for their *clarity and usability*, limitations remain in defining risk boundaries and interpreting results consistently.
- Korea's regulatory framework also supports *flexible methodologies*, but the need for commonly applicable evaluation elements deserves further review.
- This study is expected to serve as foundational input for updating regulatory documents such as the *Radiation Safety Report Preparation Guide and Review Criteria*.

## 6. Modes : Normal / Abnormal Operation, Accidents

- ❑ The case classification is necessary for shielding analysis and risk estimation.
- ❑ **Abnormal Operations** can be identified and treated using administrative barriers or physical barriers like interlock system (Reviewed and Controlled)
- ❑ **Accidents (Uncontrolled)**
  - 1) Accidental exposure should be requested by the authority normally.
  - 2) This is the basement for a barrier design.
  - 3) **Advanced-prevention is the best way.**
- \* US DOE concept – Unreviewed Safety Issues (USI)
- ❑ **Near-Miss** : (from Google AI) An unplanned event that could have caused injury or damage but did not, due to a lucky break or timely intervention. (Very useful information for all RPs !)

# 7. Accidental Scenario Examples

- ❑ **Somebody stay in the accelerator tunnel during beam operation**
  - **Location-dependent radiation level.**
  
- ❑ **Somebody stay in the hutch during using SR by opening all shutters.**
  - **Low energy but high intensity SR make serious affect.**
  
- ❑ **What is the standard limit to define an accident?**
  - e.g.1) **Somebody access to activated zone without dosimeter (Accident?).**
  - e.g.2) **Electron beam pass through the SR BL hole of storage ring tunnel.**
    - ➔ **The worst scenario suggested by NSLS in 1991.**

- Last two Radsynch Survey Campaigns were reviewed briefly. Question lists reflect the demands for shielding analysis and radiation safety system**
  
- For the update of survey and extension, several subjects and plan were suggested. Any recommendations and comments are very welcomed.**
  - **Administrative Barriers and Physical Barriers**
  - **Interlock System and Accidental Scenario**
  - **Lesson-learnt and Near-Miss**
  
- After this Radsynch workshop at SIRIUS, we will start the practical procedure.  
How is your feeling? Do you agree to join this survey?**

***Thank You for Your Attention!***

***At Oct. 2026, please visit Korea  
to attend ICRS15-RPSD2026, in Jeju  
and SATIF17, in Daejeon***

