

양성자가속기  
방사선 안전 특성 및 현안  
@SMC

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1. SMC Proton Therapy System
  2. SMC's Radiation Protection:
  3. Radiation Protection: Design & Operation
  4. Future Work

# 1 SMC 양성자가속기 KINS 인허가 SMC Proton Therapy Project

## 일정

Mitsubishi, Hitachi, IBA, Accel,  
Sumitomo, Siemens 검토

2007, 04 ● 양성자 프로젝트 시작

2010, 10 ● Sumitomo Heavy Industry와 L.O.I  
교환

2011, 04 ● Sumitomo 사와 구매 계약

2011, 10 ● 건축공사시작

2013, 05 ● 장비설치 시작

2015, 12 ● 장비인도

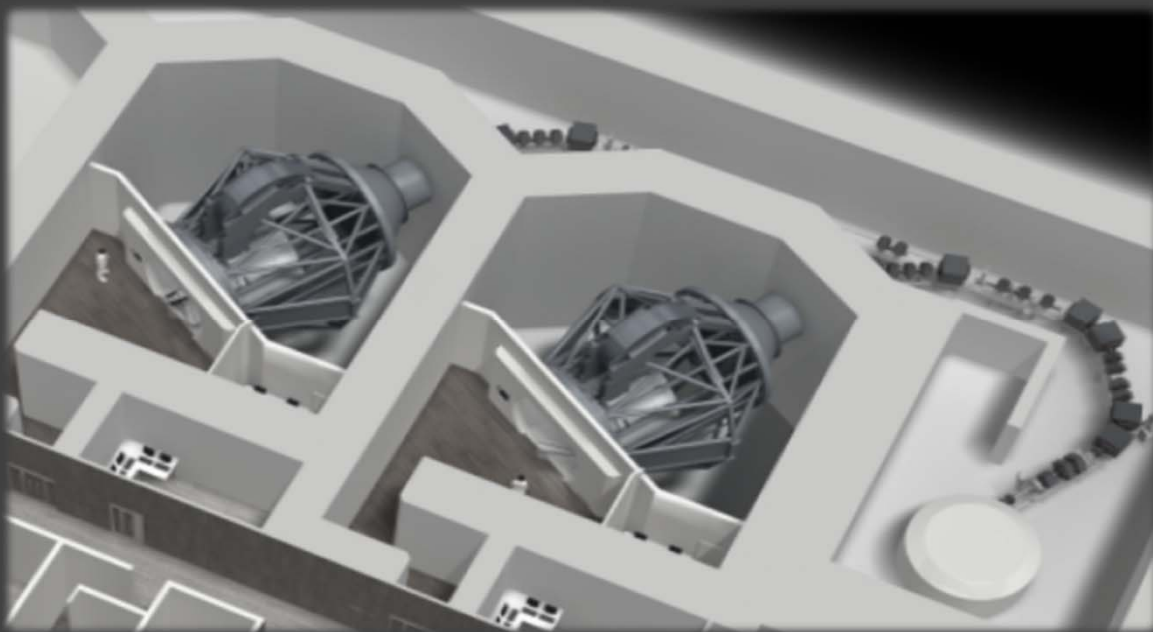
2015, 12 ● 양성자 치료시작.



# 1

## SMC 양성자가속기 Specification SMC Proton Therapy :

장비: Sumitomo Heavy Industry



1. 230 MeV Cyclotron,
2. 2 Rotating Gantry
3. Scanning, IMPT
4. Gating, CBCT
5. MLCs
6. Robotic Couch



# Hope, starts here

- Advanced technologies – CBCT, Line Scanning with Gating, Scanning + MLC, etc.

Comprehensive  
Treatment for  
patients

Personalized  
Wellness Care

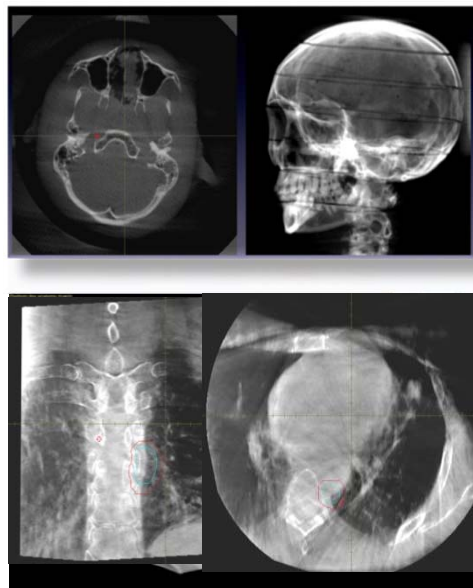
Next generation  
proton therapy  
device

## Intensity Modulated



High Dose  
Conformality

## Cone-Beam CT Guided



CT based target  
verification

## Robotic Couch



6 Dimensional  
Positioning

## Multi-Leaf Collimator



Reducing Lateral  
Penumbra of Scanning  
Beam

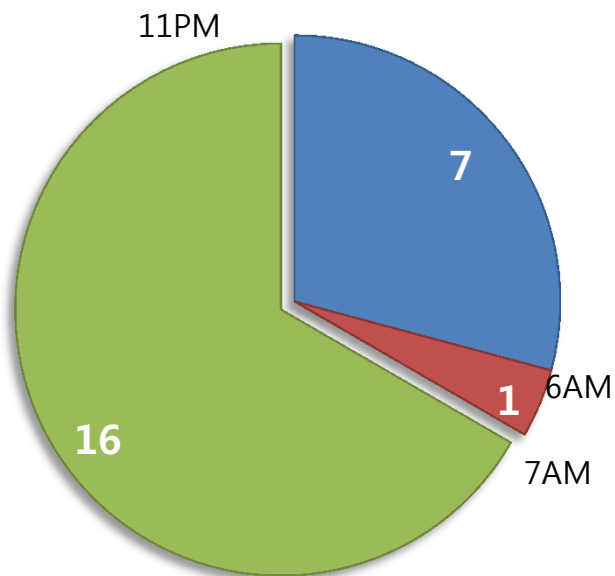
# Hope, starts here

- More than 500 patient cases (May 2017).
- Rapidly growing

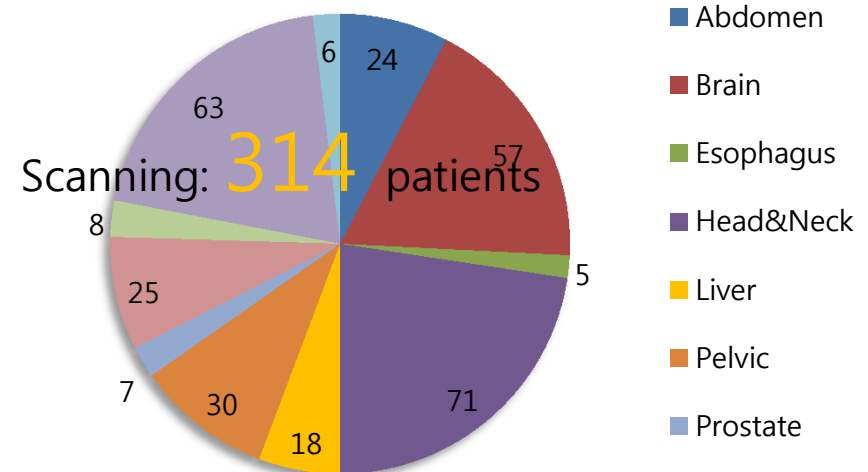
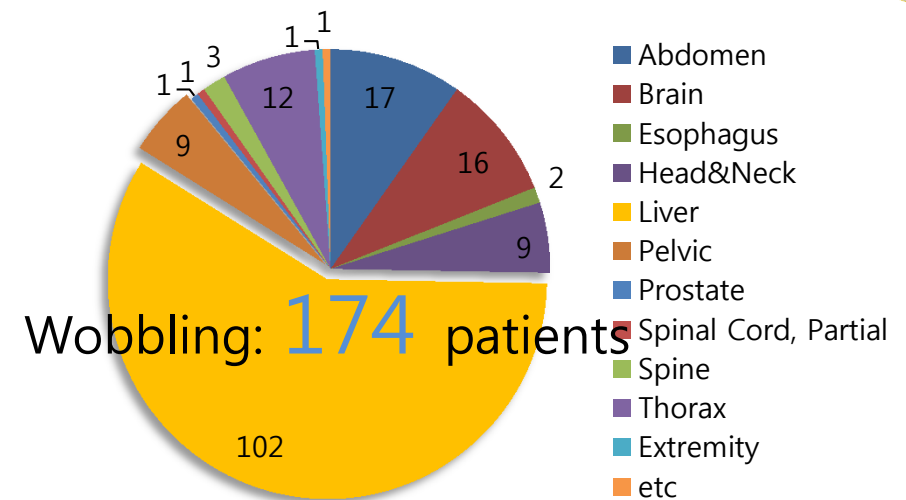
Comprehensive  
Treatment for  
patients

Personalized  
Wellness Care

Next generation  
proton therapy  
device



■ Patient QA  
■ Morning QA  
■ Patient TX

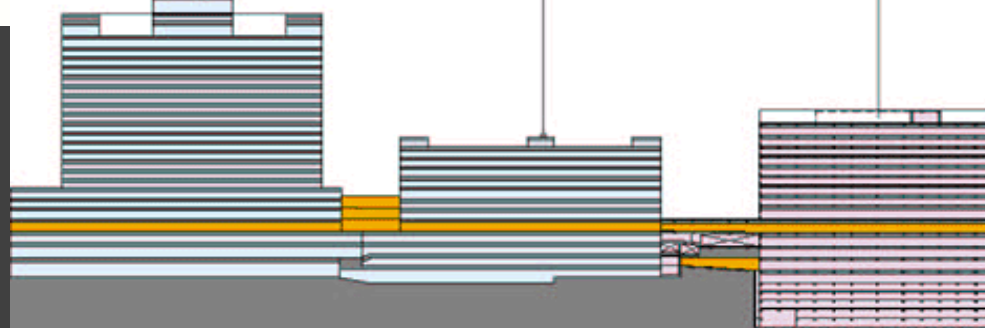
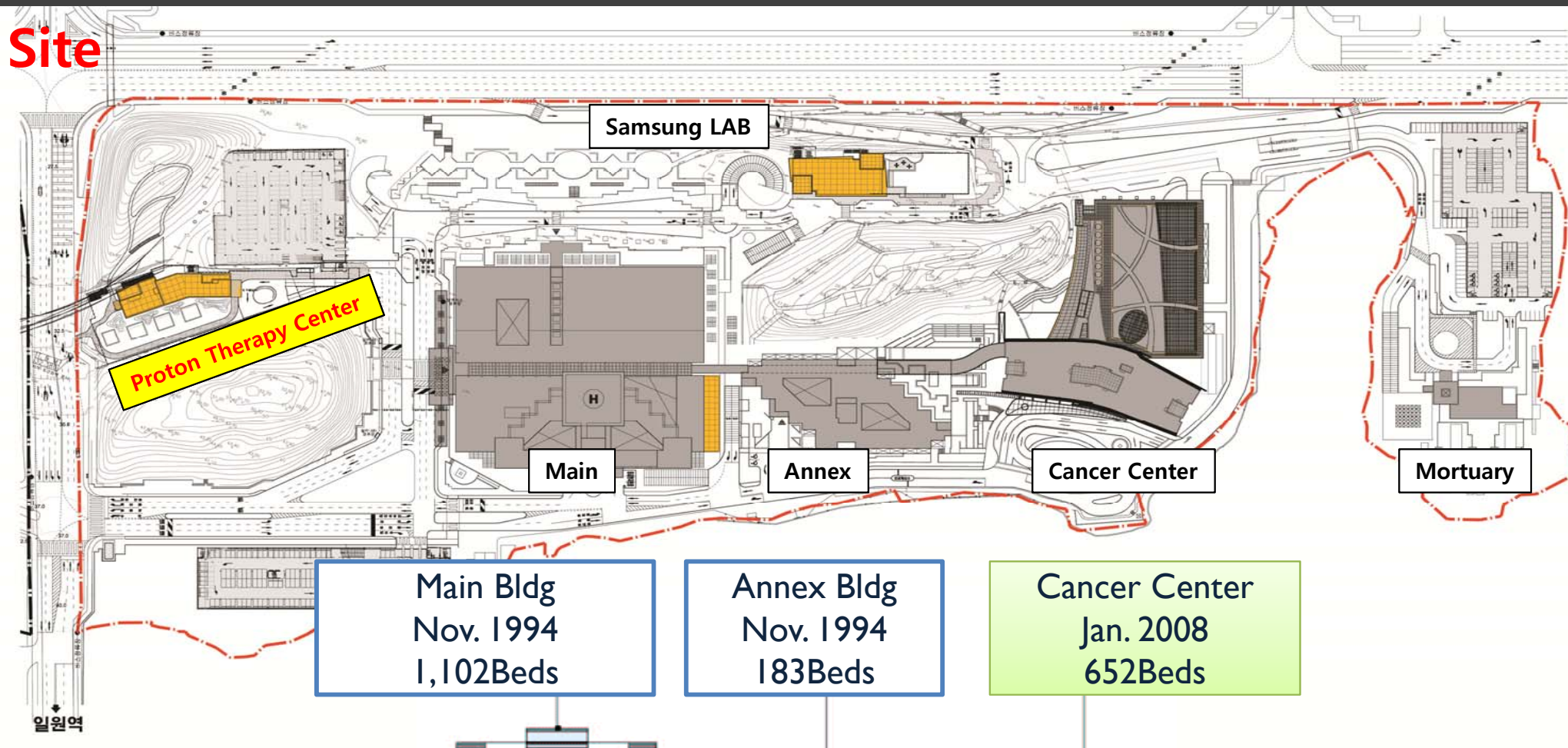


**SAMSUNG MEDICAL CENTER**  
Samsung Proton Therapy Center

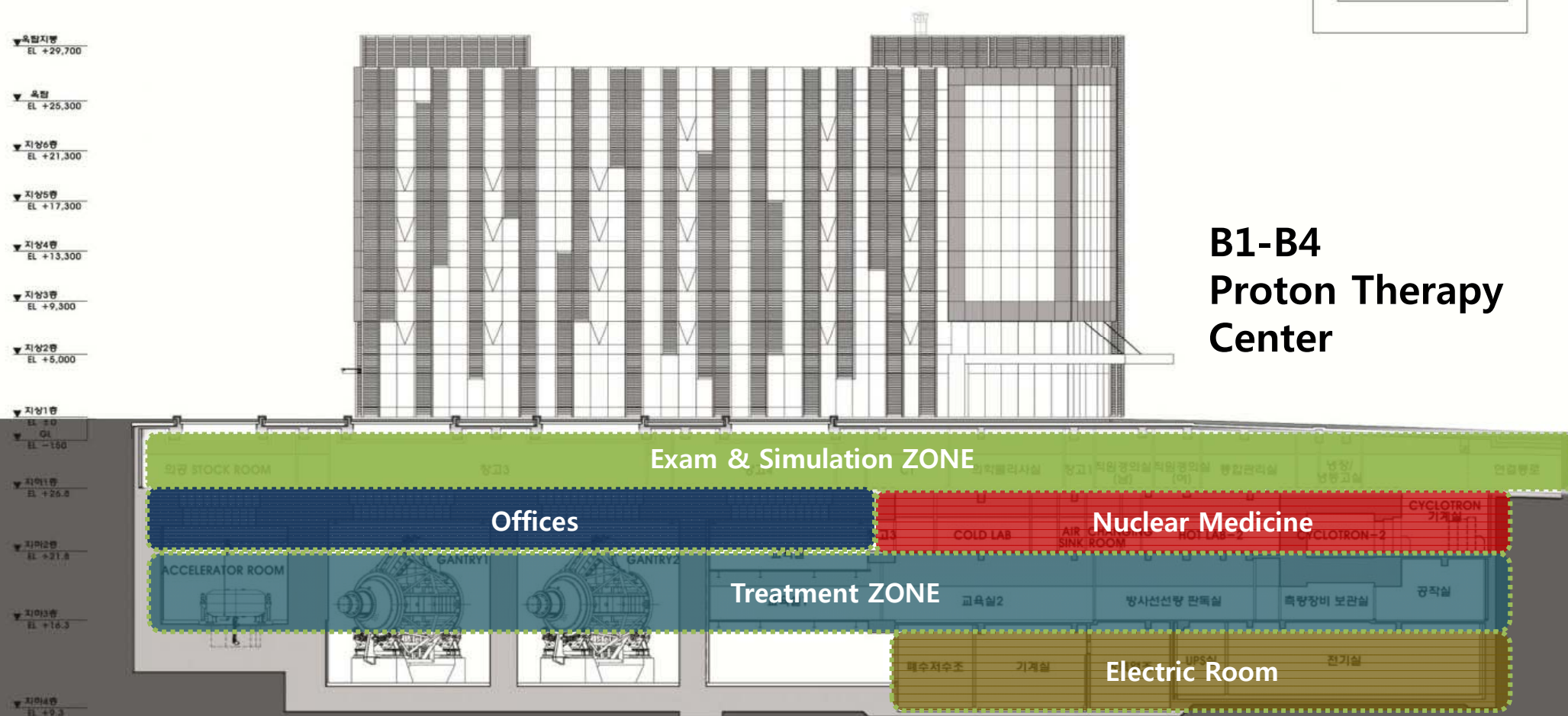


# 2

## SMC 양성자가속기 KINS 인허가 Radiation Safety



## Cross-sectional diagram - 1

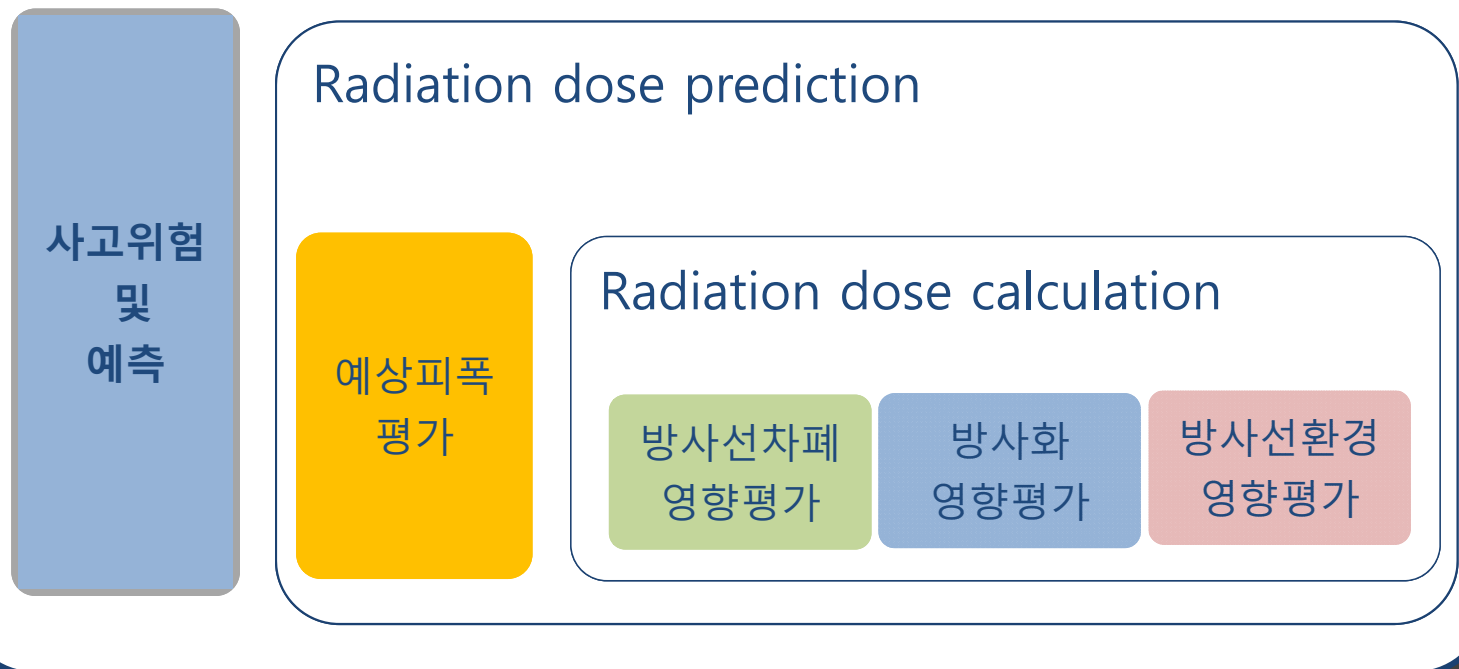




# 2 SMC양성자가속기

## Radiation Protection : Safety System Design

### Radiation protection design Concept

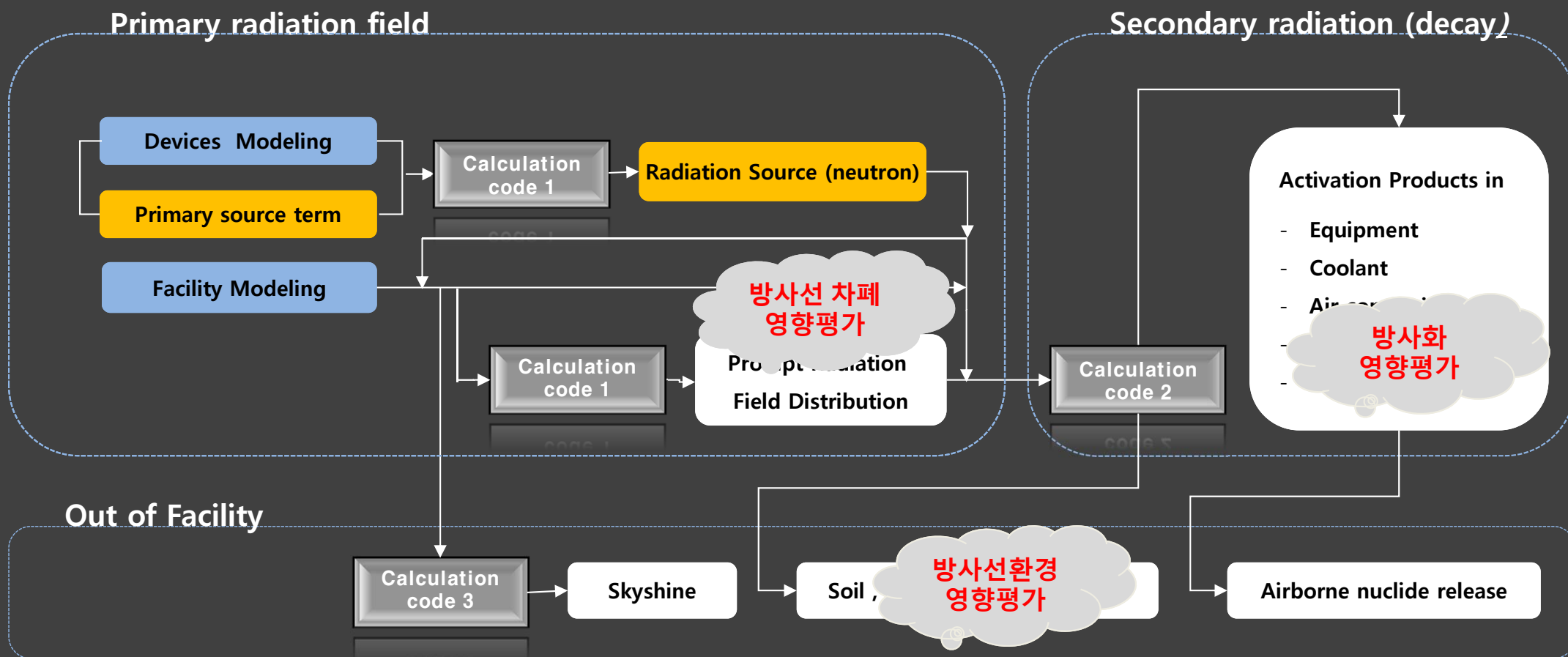


- Proton Facility Safety System
- Safety Operation

## 2

SMC양성자가속기

## Radiation Protection : Radiation Dose Prediction : Calculation System



Code 1 (Source Term & Prompt Radiation Field) : MCNP, FLUKA, PHITS, MARS, ...

Code 2 (Residual Radiation Field) : semi-empirical formula, Dchain-sp, Origin, ...

Code 3 (Out of facility) : semi-empirical formula, Sky-dose, Skyshine , MCNP 6, ...

# 2

SMC양성자가속기

## Radiation Protection : Radiation Dose Prediction

### Workload 산정

예상환자 추정

Expert 2~3 人

양성자센터 운영  
계획

### Treatment conditions

Patient ( / year)	963
average dose (Gy)	72
average fractions	36
treatment day per year	312
fraction ( / week)	667
dose per fraction (Gy)	2
Dosimetry / treatment (%)	50



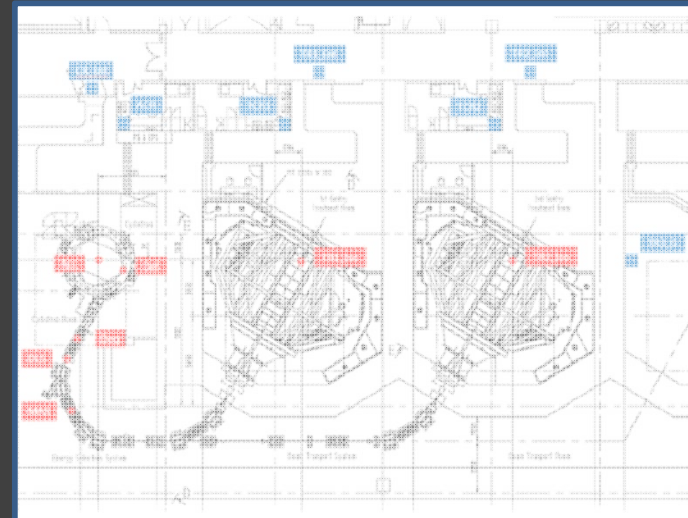
처방선량기준  
200,000 cGy/week

Case	energy (MeV)	Dose rate (Gy/min)	treatment ratio (%)	field diameter (cm)	SOBP size (cm)	treatment volume (cm <sup>3</sup> )	flatness eff. (%)	SOBP eff. (%)	Nozzle current (nA)	cyclotron current (nA)
A (H&N wobbling)	150	2	27%	18	10	2545	20	70	4	100
B (Lung wobbling)	150	2	21%	18	10	2545	20	70	4	100
C (Liver wobbling))	150	2	9%	18	10	2545	20	70	4	100
D (Prostate wobbling)	230	2	12%	8	10	503	20	40	1	2
E (H&N PBS)	150	2	27%	18	10	2545	50	70	2	40
F (Prostate PBS)	230	2	3%	8	10	503	50	40	0	1



## Radiation Protection : Radiation Dose Prediction:

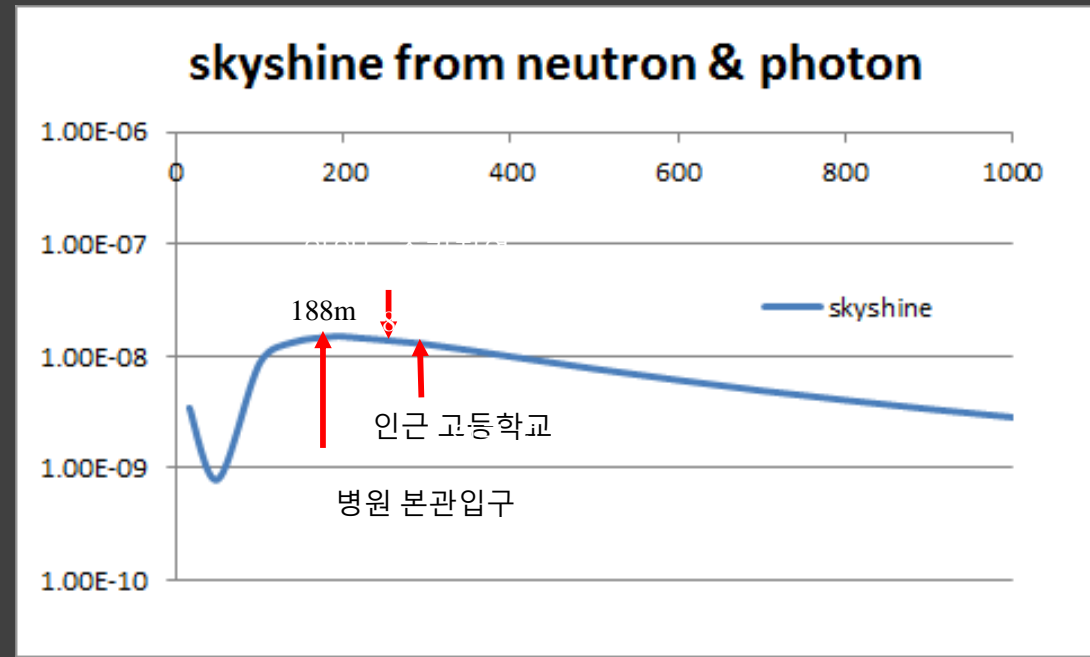
Evaluation point	Annual dose (mSv/yr)			
	Analytical method	Monte-Carlo method		
		ANISN	Fluka	MCNPX
CR_Ent	0.465	0.790	0.522	0.453 (0.040)
ACR	0.651	1.530	0.912	0.943 (0.063)
TR1_Ent	1.731	2.750	2.270	1.710 (0.023)
TR2_Ent	1.731	2.750	2.210	1.700 (0.023)
TCR1	0.527	0.655	0.546	0.399 (0.047)
TCR2	0.527	0.655	0.657	0.377 (0.055)
TR3_G	2.691	2.413	1.756	0.534 (0.046)
SR1	0.091	0.175	0.122	0.037 (0.063)
SR2	0.498	0.500	0.422	0.341 (0.052)
SR3	0.498	0.500	0.468	0.330 (0.060)



- Cyclotron 구조물질  
Decommissioning plan
- Cyclotron 구성부품  
방사성 폐기물 처리계획
- Concrete activation  
Decommissioning plan
- Coolant activation  
방사성 폐기물 처리계획
- Air contamination  
Air ventilation system, air filtering system

# 2 SMC 양성자가속기 Radiation Protection : 주변환경 영향평가

- 직접방사선의 영향 (Sky-shine)



최대값 지점 : 양성자가속기 시설의 중심부터 188 m 거리에 있는 지점 (병원 본관 입구)

$$1.58 \times 10^{-8} \mu Sv/hr$$

(비교 : 원자력안전법적 방사선 관리구역 설정 기준 :  $400 \mu Sv/week$ )



# 2

SMC 양성자가속기

## Radiation Protection : 주변환경 영향평가

- 배기구의 방사능 농도 (effect of airborne nuclide)

### ❖ 계산 가정

- ✓ 양성자 시설내부 4개 영역(Cyclotron, BTS, G1, G2)으로 구분
- ✓ 보수적인 평가를 위하여 공기중의 방사화된 모든 핵종이 모두 배출된다는 가정
- ✓ Ventilation ratio는 3회/1시간으로 산정

- 종사자의 최대 예상피폭선량 평가
  - 예상피폭선량 영향 요소 (년간 2000시간 작업시 가장 보수적인 선량)
    - 1) 외부피폭 (방사화 영향 제외) ( $2.691 \text{ mSv/yr}$ )
    - 2) 공기오염에 의한 내부피폭 ( $0.256 \text{ mSv/yr}$ )
    - 3) 시설내 가속장지, 빔이송관 및 빔조사장치 방사화에 의한 외부피폭 ( $4.0 \text{ mSv/yr}$  – 2명씩 2교대)
    - 4) 시설내 콘크리트 구조물 방사화에 의한 외부피폭 ( $0.288 \text{ mSv/yr}$ )
  - 가장 보수적인 관점의 예상합산피폭평가 ( $7.235 \text{ mSv/yr}$ )
- 주변인원의 예상피폭선량평가 (각 지점별 최대 예상피폭선량평가)

- 일반인의 최대 예상피폭선량 평가

- 예상피폭선량 영향 요소

- 1) 공기오염에 의한 내부피폭 (배기관리기준 허용도의 0.05%  $\approx 0.0005 \text{ mSv/yr}$  – filter effic. 99.95% 고려시)
- 2) 물의 방사화에 의한 내부피폭 (배수관리기준 허용도의 3%  $\approx 0.03 \text{ mSv/yr}$ )
- 3) Skyshine등 직접방사선에 의한 외부피폭 ( $0.0003 \text{ mSv/yr}$ )

- 가장 보수적인 관점의 일반인의 예상합산피폭평가 :  **$0.0308 \text{ mSv/yr}$**



# 2 SMC양성자가속기 Radiation Protection : 사고위험 및 예측 평가

- 가속기 시설 사고해석
  - HACCP 기반 사고해석 수행 (ISO-14971 기반)
    - Hazard Analysis and Critical Control Point
    - 유사한 가속기를 운영하고 있는 일본 전문가 10인이 모여 14년간의 경험을 바탕으로 사고의 종류, 우선 순위 및 확률을 선정
    - 시나리오 별로 확률 및 대응되는 저감화 조치를 통한 예상 피폭선량을 평가하여 기초설계에 반영
  - 삼성양성자가속기센터의 경우 최고빈도의 20가지 시나리오를 바탕으로 저감화조치 수립 시스템 적용

사고구분	확률수준	발생확률
4	빈번 (frequently)	1회 / 월
3	가능 (Probable)	1회 / 분기
2	가끔 (occasional)	1회 / 년
1	드문 (remote)	1회 / 10년
0	불가능 (impossible)	-

- HACCP 기반 사고해석 수행 (예)
  - 적당하지 않은 parameter로 양성자 치료 (Proton beam is irradiated with improper parameters)
    - 양성자 치료 시 변경 가능한 인자
      - 에너지 디그레이더의 부적절한 위치
      - 빔 자기장 세기의 부적절
      - 노즐 위치의 부적절
    - 위와 같은 경우의 사고 확률은 ‘사고구분 2’로서 확률은 1회/년 이다.
  - 저감화 조치
    - 독립적인 두 개의 위치 확인 시스템
    - 부적절한 값일 경우 빔의 즉각적인 멈춤
  - 이와 같은 저감화 조치로 발생 확률을 ‘사고구분 0’으로 낮출 수 있다.

1. 양성자센터의 안전성 검증
2. 양성자 치료기 운영계획 및 방사선 안전관리조직
3. 방사선 관리구역 및 감시장치
4. 개인안전연동계통
5. 작업자에 대한 방사선량 저감화 계획
6. 주변환경에 대한 방사선영향 저감화 계획
7. 방사성폐기물 발생 및 처리계획



## ● 양성자센터 안전성 확인 및 치료기기 안전성 검증

- 지반침하에 대한 안전성 확인 : 평판재하 시험결과 보고서
- 구조적 안전성 : 지반조사 보고서, 지반 시추 자료, 양성자센터 구조계산서, 비교토압 산정표
- 지진에 대한 안전성 확인 : 진동 측정 결과 (진동 측정 보고서)
- 화재에 대한 안전성 확인 : 내화재, 방화문, 스프링쿨러 – 방화구획내 2시간 이상 건전성 시험
- 정전시 비상전원 공급계획 : 비상전원공급장치 회로도
- 침수에 대한 안전성 확인 : PMP 산정결과에 따른 진입로 턱 높이 시공
  - 진입로 후문 22cm이상, 진입로 정문 20cm이상
- 차폐에 대한 안전성 확인 : 콘크리트 비중 확인 (공사중 품질관리 보고서), 콘크리트 sample의 공인기관 성적서 (양생강도 확인 : 압축강도 시험대장)
- 중성자에 의한 케이블의 건전성 평가

# 3 SMC 양성자가속기 Radiation Protection : Design & Operation

- 양성자치료기 운영계획
- 사용계획
  - 허가조건(사용 허가증): 양성자 가속기 (230MeV, 300nA)의 경우 주간부하 (workload)는 치료 및 품질 관리에 사용하는 양을 합하여 200,000 cGy/week (69,035 nA·min/week)를 초과하지 말 것.
  - 빔 사용량 기록시스템

Beam Scheduler (v1.0.0)

Machine Owner

Operator

Machine ID

Machine Name

Machine Type

Machine Status

Machine Location

Machine Model

Machine Year

Machine Serial

Machine Weight

Machine Height

Machine Width

Machine Depth

Machine Volume

Machine Area

Machine Perimeter

Machine Circumference

Machine Surface Area

Machine Volume

Machine Mass

Machine Density

Machine Pressure

Machine Temperature

Machine Humidity

Machine Air Quality

Machine Noise Level

Machine Vibration Level

Machine Electromagnetic Interference

Machine Radiation Level

Machine Magnetic Field

Machine Electric Field

Machine Gravitational Field

Machine Acoustic Field

Machine Optical Field

Machine Thermal Field

Machine Chemical Field

Machine Biological Field

Machine Psychological Field

Machine Sociological Field

Machine Political Field

Machine Economic Field

Machine Cultural Field

Machine Religious Field

Machine Philosophical Field

Machine Scientific Field

Machine Artistic Field

Machine Literary Field

Machine Musical Field

Machine Dramatic Field

Machine Cinematic Field

Machine Televisual Field

Machine Digital Field

Machine Virtual Field

Machine Augmented Reality Field

Machine Mixed Reality Field

Machine Metaverse Field

Machine Blockchain Field

Machine Cryptocurrency Field

Machine Artificial Intelligence Field

Machine Quantum Computing Field

Machine Nanotechnology Field

Machine Biotechnology Field

Machine Space Technology Field

Machine Aerospace Technology Field

Machine Maritime Technology Field

Machine Automotive Technology Field

Machine Agricultural Technology Field

Machine Environmental Technology Field

Machine Healthcare Technology Field

Machine Education Technology Field

Machine Entertainment Technology Field

Machine Sports Technology Field

Machine Military Technology Field

Machine Law Enforcement Technology Field

Machine Public Safety Technology Field

Machine Infrastructure Technology Field

Machine Construction Technology Field

Machine Manufacturing Technology Field

Machine Energy Technology Field

Machine Materials Technology Field

Machine Chemical Technology Field

Machine Physics Technology Field

Machine Mathematics Technology Field

Machine Computer Science Technology Field

Machine Engineering Technology Field

Machine Design Technology Field

Machine Architecture Technology Field

Machine Urban Planning Technology Field

Machine Transportation Technology Field

Machine Logistics Technology Field

Machine Supply Chain Technology Field

Machine Retail Technology Field

Machine E-commerce Technology Field

Machine Marketing Technology Field

Machine Advertising Technology Field

Machine Media Technology Field

Machine Journalism Technology Field

Machine Publishing Technology Field

Machine Entertainment Technology Field

Machine Music Technology Field

Machine Film Technology Field

Machine Television Technology Field

Machine Radio Technology Field

Machine News Technology Field

Machine Sports Technology Field

Machine Politics Technology Field

Machine Business Technology Field

Machine Finance Technology Field

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Machine Education Technology Field

Machine Entertainment Technology Field

Machine Sports Technology Field

Machine Military Technology Field

Machine Law Enforcement Technology Field

Machine Public Safety Technology Field

Machine Infrastructure Technology Field

Machine Construction Technology Field

Machine Manufacturing Technology Field

Machine Energy Technology Field

Machine Materials Technology Field

Machine Chemical Technology Field

Machine Physics Technology Field

Machine Mathematics Technology Field

Machine Computer Science Technology Field

Machine Engineering Technology Field

Machine Design Technology Field

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Machine Vibration Level

Machine Electromagnetic Interference

Machine Radiation Level

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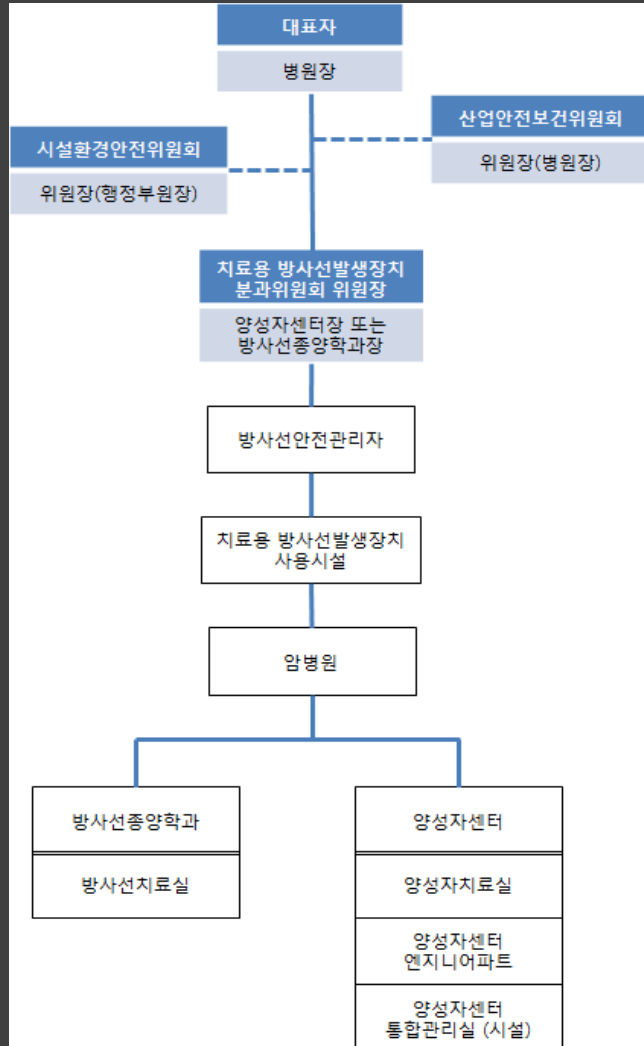
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## ● 방사선 안전관리 조직 정비



## 방사선 관리구역

- 방사선 관리구역 표지 및 주의사항 게시
- 방사선 관리구역 출입절차 준용
- 개인선량계 운용
  - 정규선량계로 열형광선량계 이용, 보조선량계로는 Pocket Dosimeter, Alarm Dosimeter 등을 사용
  - 손등 등가선량 측정을 위한 링 선량계 사용
- 물질 반출 및 반입 절차 준용
  - 고방사선구역 : 원자력법상 표면오염도 이하
  - 방사선관리구역 : 원자력법상 표면오염도의 1/10 이하
- 정규작업외 작업시 작업허가서로 사전허가
- 기록관리 : 사용기록, 방사선안전관리 기록
- 방사선 감시
- 필요시 보호장구 착용
- 유도공기중농도 (DAC)이하로 낮추기 위한 3회/1시간의 환기
- 면밀한 작업계획 및 교육
- 방사화 물질의 외부 유출을 막기 위한 음압 유지

# 3 SMC 양성자가속기 Radiation Protection : Design & Operation

## 방사선 감시

radiation source	item	장비	설치
Radiation monitoring system (RMS)	area monitoring system	neutron RMS : 4ea	가속기실 입구, 치료실 1, 치료실 2, 지하2층 가속기 위
		photon RMS : 5ea	가속기실 입구, BTS안쪽, 치료실 1, 치료실 2, 지하2층 가속기 위
	방사능 차폐시설 성능점검 시스템	photon survey meter : 1ea	휴대용으로 측정장비 보관실에서 운용
		neutron survey meter : 1ea	
Radioactivation source	cyclotron 구조물질의 방사화	-	방사능 차폐시설 성능점검 시스템으로 준용
	cyclotron 구성부품의 방사화	photon survey meter : 1ea	방사능 차폐시설 성능점검 시스템으로 준용
		personal dosimeter	Pocket Dosimeter (추후 유리 선량계로 준용)
	cyclotron 장치내 오일, 이온교환수지, 배수계통의 방사화	-	방사능 차폐시설 성능점검 시스템으로 준용
	cyclotron 장치내 내부 냉각수 방사화	photon survey meter : 1ea	방사능 차폐시설 성능점검 시스템으로 준용
	양성자 시설 내부 공기의 방사화	-	area monitoring system으로 준용
environment	방사화 기체의 배기시설	filter	법적 허용선량 이하로 낮추기 위한 filter 설치
		air monitor	배기구에 방사선량 확인목적 air monitor 설치
	방사화 액체의 배수시설	-	방사능 차폐시설 성능점검 시스템으로 준용
	방사화 고체의 폐기시설	-	방사능 차폐시설 성능점검 시스템으로 준용
	Skyshine	-	휴대용으로 준용
	양성자 시설의 폐기 (Decommissioning)	-	-



### 방사선 측정장비

- 방사능 측정장비
  - 지역방사능 측정장비 : RMS system (Thermo, Remtech. )
  - 공기중 방사능 측정장비 : air monitor system (TA technical associates, Unitech)
  - 개인방사선량 측정기 : MGP2000GN system (MIRION)
  - 오염측정기 : I90N/489-110D (Victoreen)
  - 감마 survey meter : FH 40G-L10 (Thermo)
  - 중성자 survey meter : I90N/RP-N (Victreen)

# 3 SMC 양성자가속기 Radiation Protection : Design & Operation

## 방사선 감시계통

- RMS (photon : 6 ea, neutron : 5ea)



B3

B2

- 휴대용 감시장치



# 3 SMC 양성자가속기 Radiation Protection : Design & Operation

## 방사선감시계통 검교정

The Order Plan for the Calibration of RMS and Survey Meter.

Rev.3 2014/9/29  
Sumitomo Heavy Industries, Ltd.

Bring-out Bring Back				8/8		9/1	9/1	9/15	9/15	9/17	9/17	140929 Check	
Weeks		S/N	No.	1	2	3	4	5	6	7	8	Reference	Sequence Stop
							9/17						
Cyclotron Room	Gamma	0166, 0167	G5			G						0167	
Treatment room 1	Gamma	163	G1					9/17				0165	
	Neutron	10428	N1	N								10428	I:22.02
Treatment room 2	Gamma	0165, 10186	G2			G		9/17				10186	
	Neutron	10427	N2					9/15					I:2203
PSR1	Gamma	0167	G3	G									
	Neutron	10429	N3	N									I:22.01
Accelerator Entrance	Gamma	10186, 0166	G4	G								0166	
	Neutron	10423	N4					9/15				10423	
Survey meter No.1 FH40G-10	Gamma	027187	G6	G					As monitor			027187	
Survey meter No.2 FH40G-10	Gamma	027182	G7	G					As monitor				
Survey meter No.3 FH40G-10	Gamma	027191	G8			G						027191	

# 3 SMC 양성자가속기

## Radiation Protection : Design & Operation

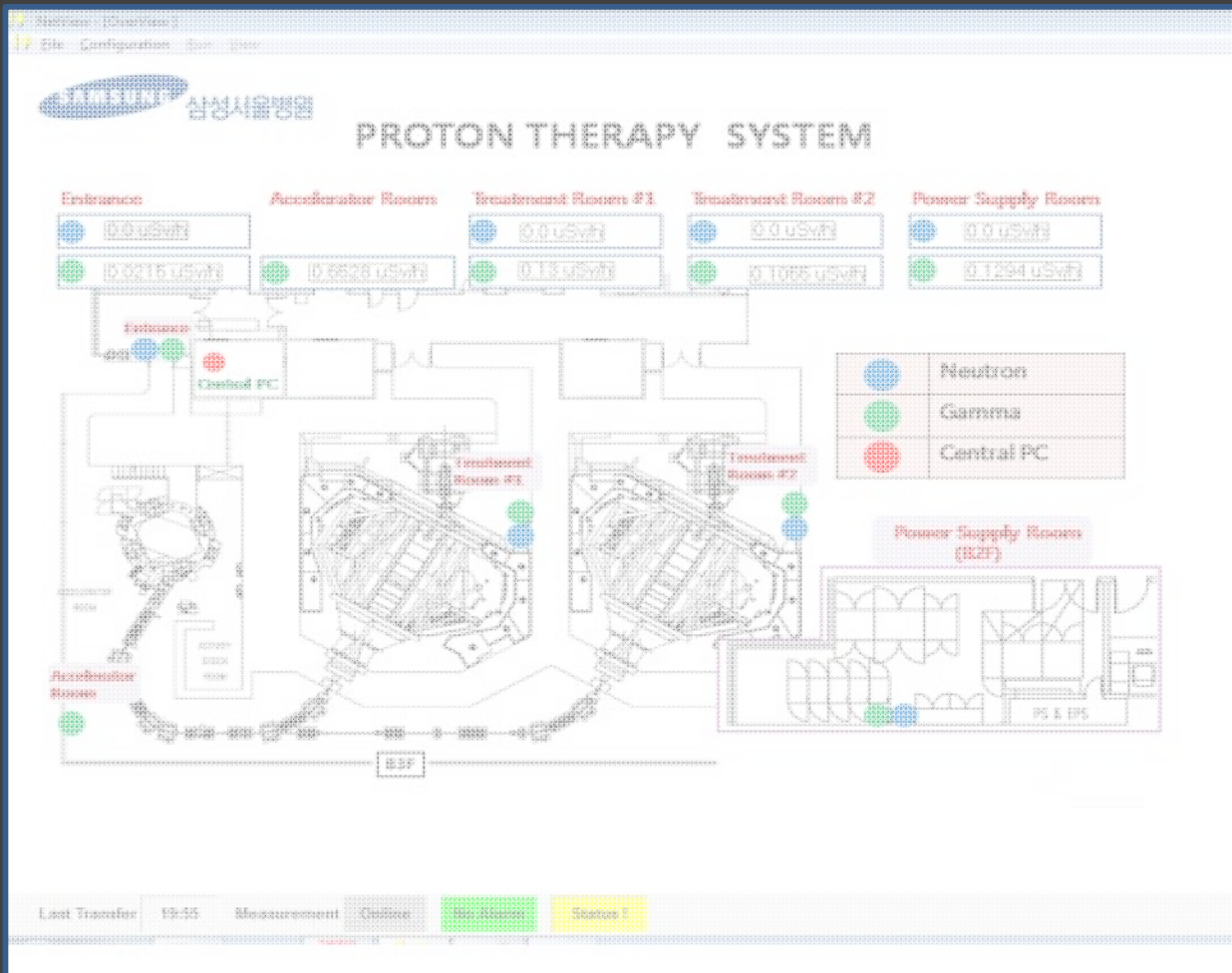
- Air monitor system





# 3 SMC양성자가속기 Radiation Protection : Design & Operation

- 방사선감시계통 통합관리 시스템



- Air monitor system



RMS data, Air monitor system

: 저장주기 변경 및 자동저장  
(현재 1분)

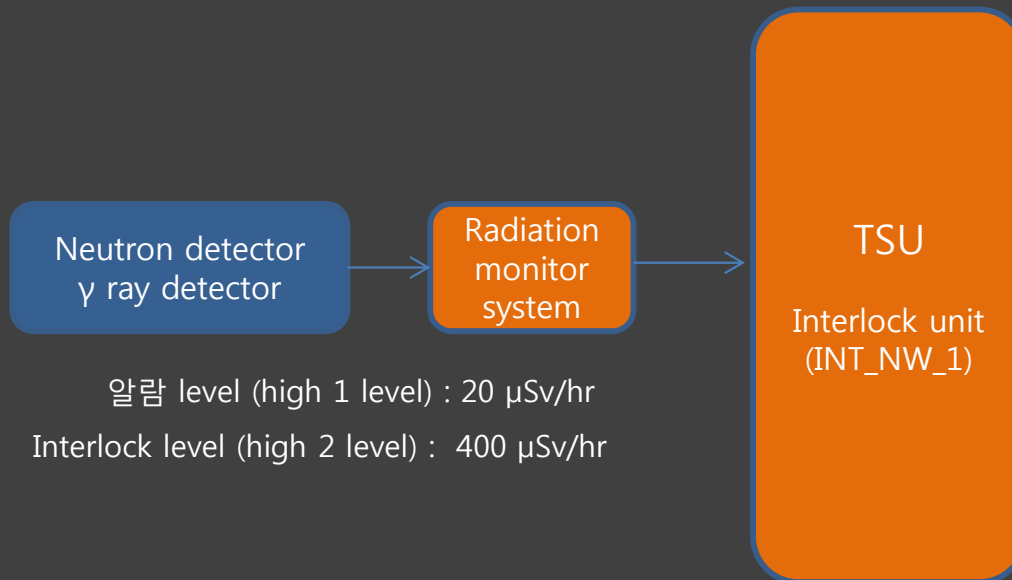


# 3

SMC 양성자가속기

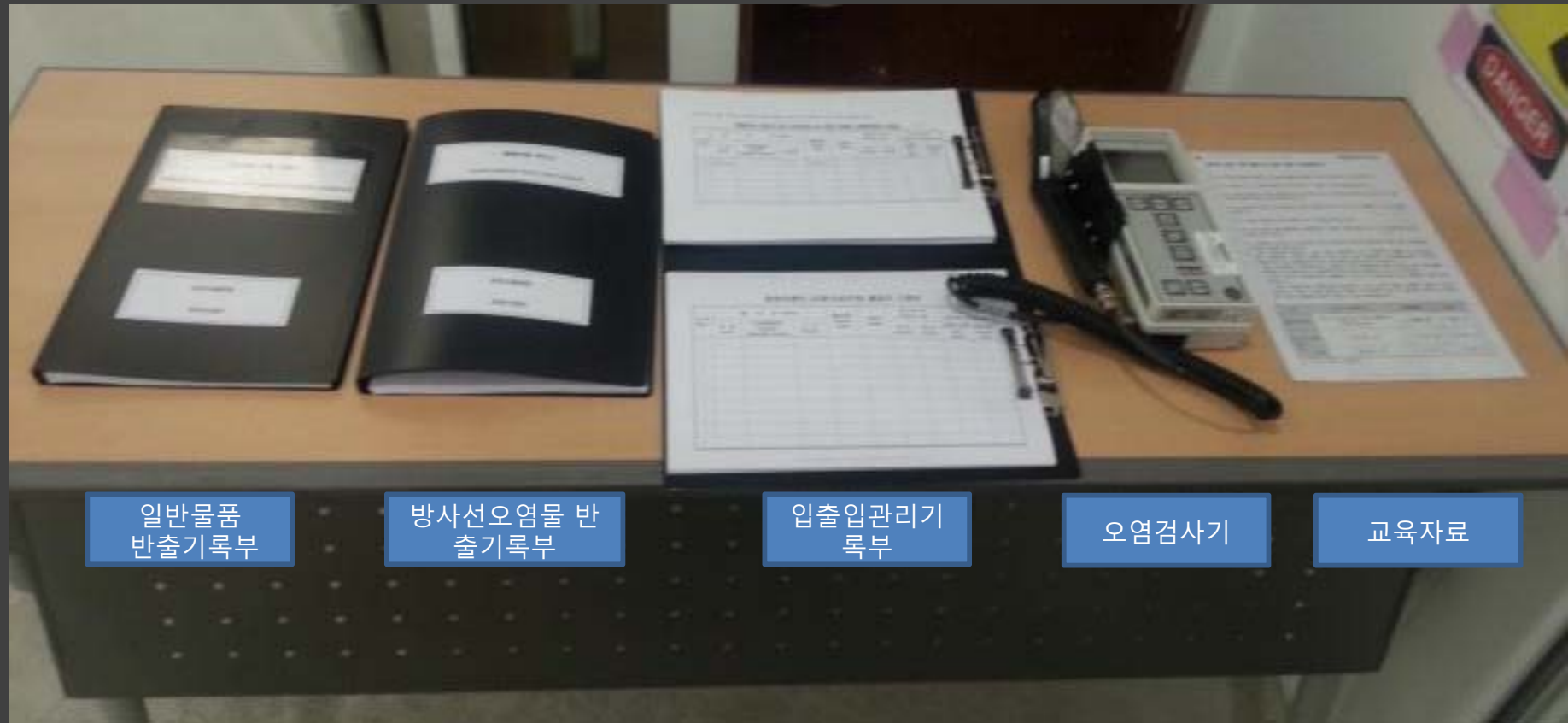
## Radiation Protection : Design & Operation

- 감시계통에 의한 interlock



## 입출입 관리

- 물품 및 출입 관리 기록부 및 교육사항



# 3 SMC 양성자가속기 Radiation Protection : Design & Operation

- 오염검사기 및 오염제거 설비

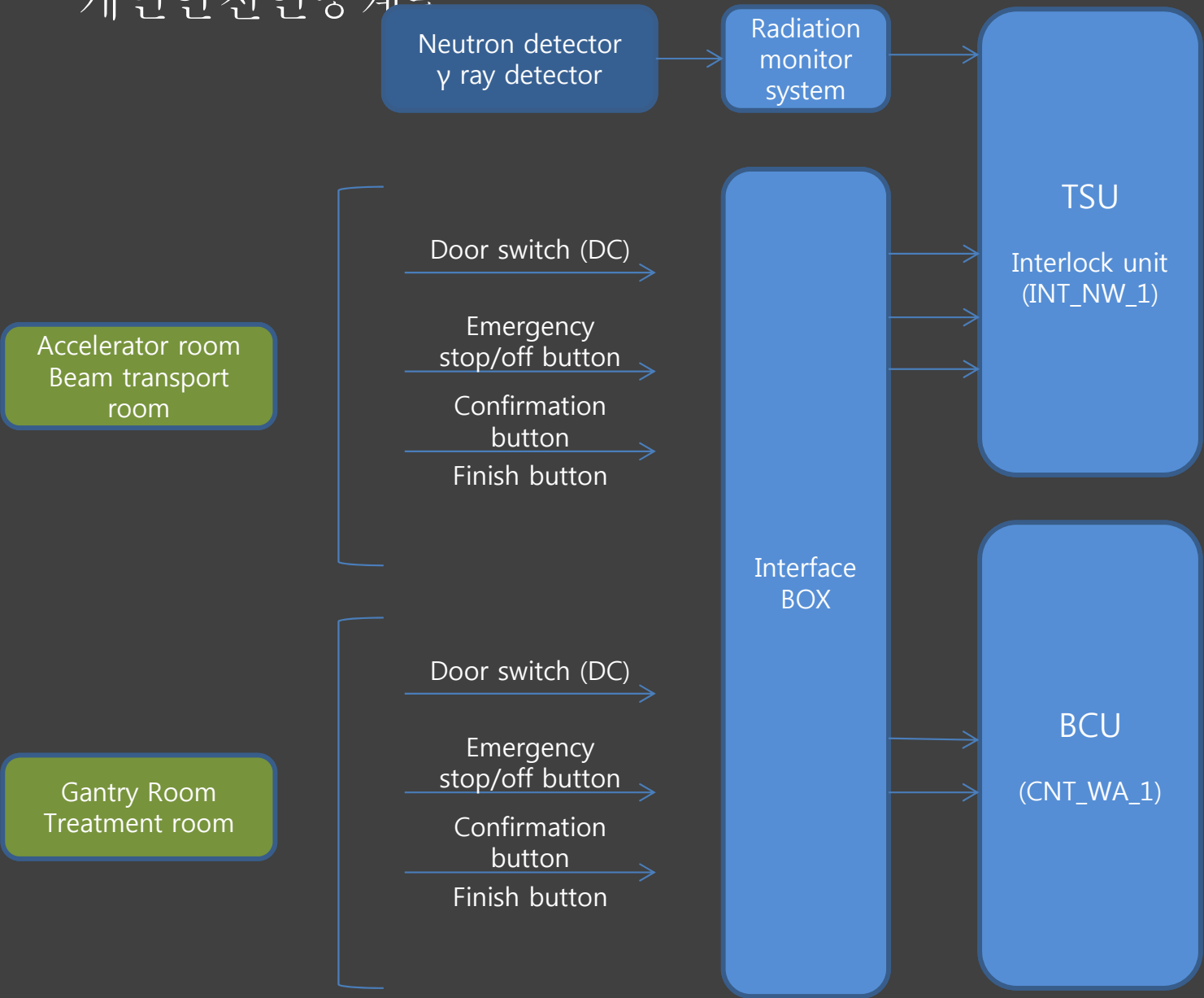


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SMC양성자가속기

Radiation Protection : Design & Operation

개인안전연동계통



# 3 SMC양성자가속기 Radiation Protection : Design & Operation

## 방사화 물질의 폐기

### 방사화 기체

- SHI 측정 : 분율의 합이 배기법적기준의 18 %
- MC 결과 : 분율의 합이 배기법적기준의 120 %



Filter 사용 배기  
(배기시설)

### 방사화 액체

- SHI 측정 :  $7.29 \times 10^{-1} \text{ Bq/cc}$  ( $4 \times 10^7 \text{ Bq/m}^3$ ) for  $\text{H}^3$
- MC 결과 :  $5.71 \times 10^4 \text{ Bq/cc}$  ( $4 \times 10^7 \text{ Bq/m}^3$ ) for  $\text{H}^3$



RI 폐수조 설치운  
용

### 방사화 고체

- 각부분 (CYC 구조물, 부품, 콘크리트)별 방사화 상이
- 각부분별 decay후 폐기물 처리



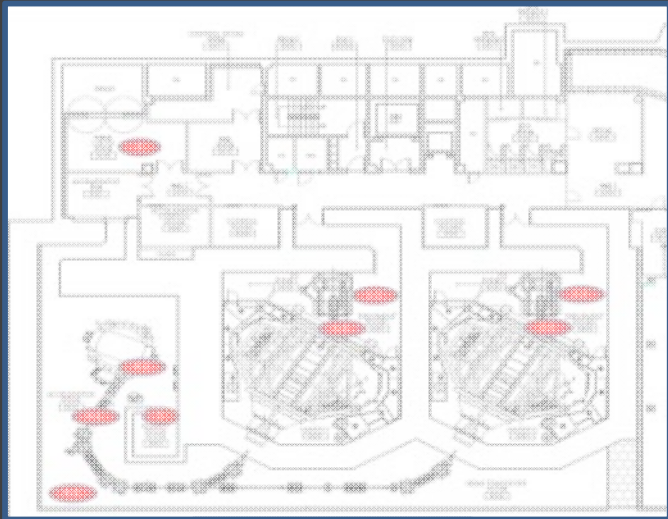
Activation storage  
room 운용

# 3 SMC 양성자가속기

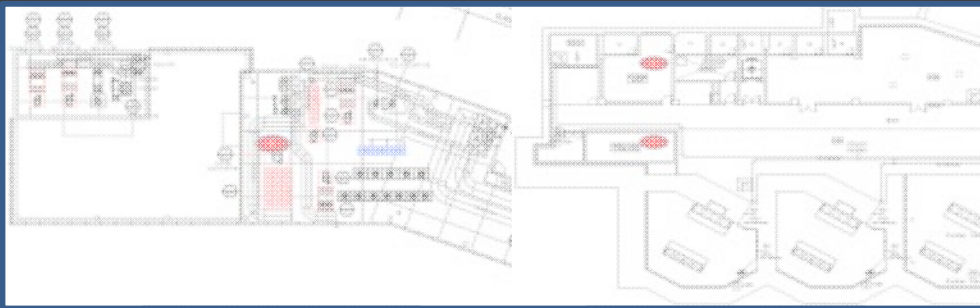
## Radiation Protection : Design & Operation

### 방사화 점검

- 방사화 측정 기록부 및 측정위치



지하 3층



옥탑층

지하 4층

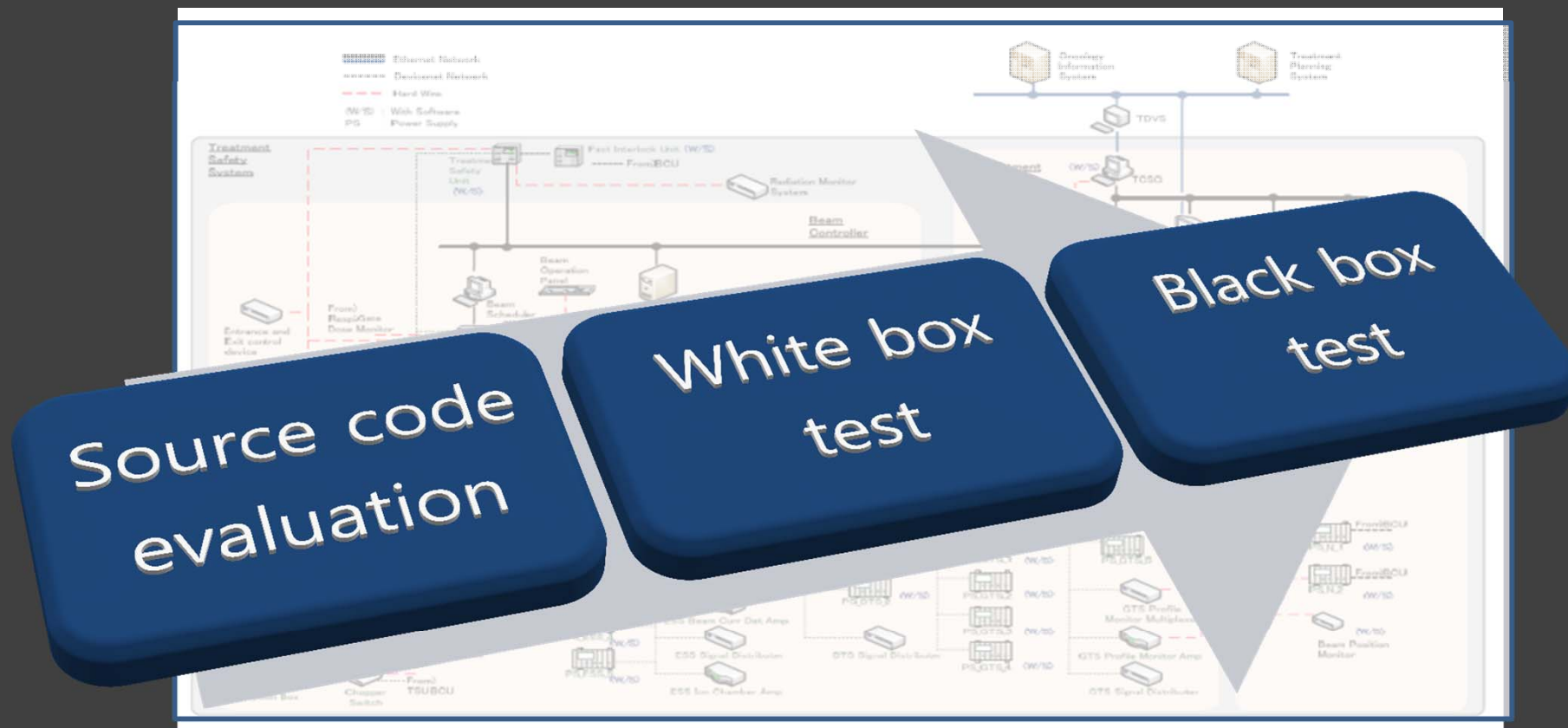
오염도 측정 기록부 (Sample)						
가. 측정자						
측정일자	2013년 10월 10일		측정자			
나. 측정 장비						
기기명	survey meter / neutron dose rate detector		측정범위	0.001~10000 mR/hr (감마선) 1nSv/h ~ 100 mSv/h (중성자선)		
제조회사	Thermo scientific / USA		검교정 일자			
model	FH 40 GL / FHT 6020 (감마선) FHT 762 WENDI-2 / FH 40 GL (중성자)		serial	(감마선) (중성자)		
다. 측정결과						
측정점	오염도	Regulatory limit			pass/fail	
		감마선 (mR/hr)	중성자선 (mSv/hr)	한계		
1. B326	치료기 노출 오염도					
	공기오염도					
2. B329	치료기 노출 오염도					
	공기오염도					
3. B319	표면오염도					
4. B322	E39 표면오염도					
	사이클로트론 표면오염도					
	공기오염도					
5. B323	공기오염도					
6. B412	표면오염도					
7. B414	표면오염도					
8. 건물측상	최종 배기가스 오염도					
COMMENT :						
방사선 안전관리 책임자 (인)						
삼성서울병원 양성자치료센터						

방사화 물질 저장실의 방사선 선량을 준위는 BTS안의 Activity stock room을 제외하고 전부 BG



# 3 SMC 양성자가속기 Radiation Protection : Design & Operation

치료사용 software의 건전성 확인



The component architecture and control systems for the Sumitomo Proton Therapy System

## 치료사용 software의 건전성 확인

- 운영제어시스템 : 하드웨어 패널의 제작사, 모델명, 운전이력 등

(Treatment Control System, Treatment Safety System, Beam controller)

- 비상정지 system : 제어 설계
- Hardware 및 Software 의 고장 및 오류에 대한 대비 설계
- 제어 시스템용 software의 유지관리
- Interlock System 설계 및 성능 유지
- 시설안전장치의 전원고장에 대한 대비 설계
- 제어 system ( computer)의 cyber 보안 대책
- Treatment Safety System 용 Software 개발 시 적용한 안전 관리 시스템 또는 방법:
  - ✓ 개발시 적용한 기법과 안전성 test 방법 및 자료 확인

## 방사선 긴급작업 및 사고시 방사선안전관리

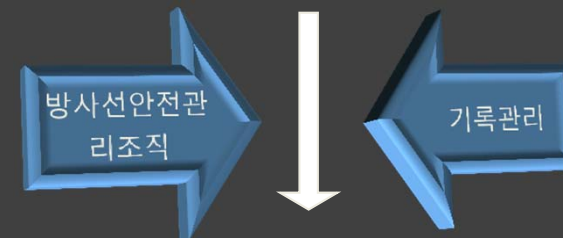
- 사고발생시 원칙 : 안전보호의 원칙, 통보의 원칙, 과대평가의 원칙
- 비정상상태 또는 긴급상황 발생시 방사선작업은 즉시 중단, 양성자 치료설비는 즉시 작동을 멈춤
- 긴급작업에 투입되는 방사선작업종사자의 유효선량은 500mSv, 피부등가선량은 5 Sv를 초과하지 않도록 함
  - 인명 구조를 목적으로 하는 긴급작업에는 적용하지 아니하며, 긴급작업으로 인한 피폭선량은 개인 피폭방사선량에 합산하지 않음
- ‘방사선긴급작업 동의 및 승인서’의 승인을 받은 경우 방사선구역의 출입에 대한 별도의 절차는 생략
- 긴급작업 종사자는 방사선안전관지자에 통보 & 적절한 방호조치
- 긴급작업에 투입된 종사자는 신체오염검사를 실시하고 오염된 경우 제염을 실시
- 고방사선구역에 출입하여 내부피폭의 우려가 있을 경우 내부 피폭여부 측정
- 긴급작업에 투입 시 종사자에게 지급된 별도의 TLD 및 직독식 개인보조선량계를 판독하여 피폭방사선량을 확인하고, 피폭방사선량이 15mSv이상인 경우 건강진단을 실시
- 작업 승인을 하기 전에 동 작업에 참여하는 자에게 다음 사항을 통보
  - ① 계획된 긴급작업의 목적
  - ② 작업수행으로 받게 되는 예상 피폭방사선량, 부수적인 잠재적 위험도, 구체적인 방사선준위 또는 기타 작업조건
  - ③ 방사선방호 조치에 관한 구체적인 지침
- 비상대응을 위한 방사선 긴급작업의 수행 후 보고사항 : 병원 경영진, 원자력안전기술원 및 원자력안전위원회

# 3 SMC양성자가속기 Radiation Protection : Design & Operation

## Summary of radiation protection management

1. 방사선 발생장치 관리
2. 구역관리
3. 작업관리
4. 개인피폭 / 건강관리
5. 오염관리
6. 방사선량 측정 및 측정장비 관리
7. 기록관리

Based on Safety analysis



Improved Radiation protection

사고 발생시 사고 대응

- 양성자가속기의 중성자 energy spectrum 측정
- 양성자센터 중성자 방사선량 mapping
- 사고 발생 시나리오의 추가 개발
- 사고발생 저감화조치 및 시스템 반영
- Safety & accident (event) management program
- 법정 개인선량계의 방사선량 측정 정확도 및 중성자 측정 시험
- 방사선종사자 이외 사람의 상주공간에 대한 공간 선량 측정
- 각종 절차서 추가 개발

Thank you for your attention !

Hope, starts here

희망은,  
이곳에서 시작됩니다

SAMSUNG  
PROTON THERAPY CENTER

