

# Radiation Protection at PETRA III

J. Knabe, A. Leuschner, B. Racky, D. Ramert, A. Wefer, T. Wroblewski  
DESY, Hamburg, Germany

**The PETRA III project**

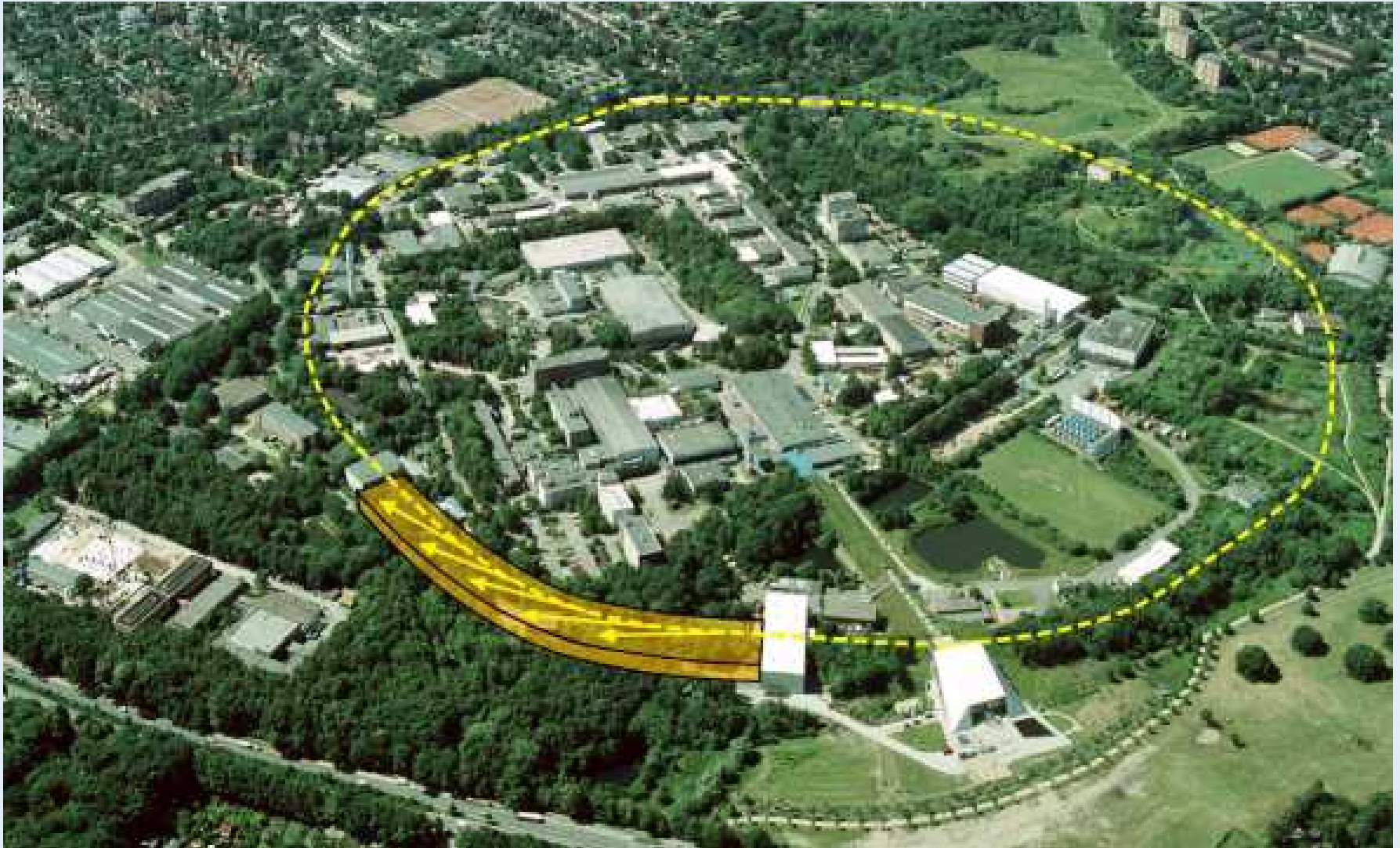
**Beam enclosure (Particles and photons)**

**Concrete shielding (Ring and optics hutches)**

**Lead shielding (Experiment hutches and beam tubes)**

**Personal interlock**

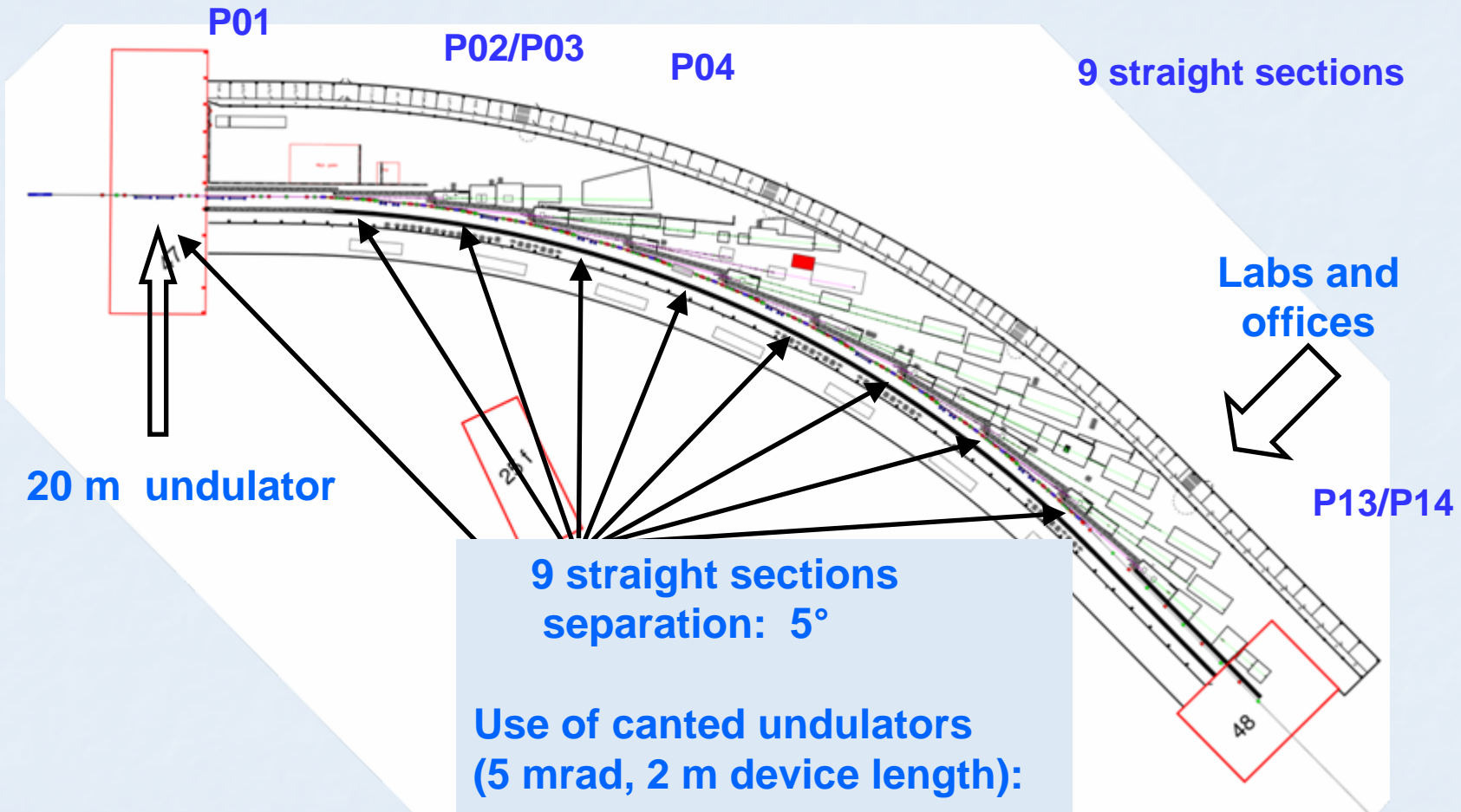
# PETRA III at DESY



# Experimental hall, a computer animation



# Experiments: ID-sectors



9 straight sections  
separation:  $5^\circ$

Use of canted undulators  
(5 mrad, 2 m device length):  
→ 14 separate undulator BLs

max. BL-length 103 m (from the source)

# PETRA III among other sources

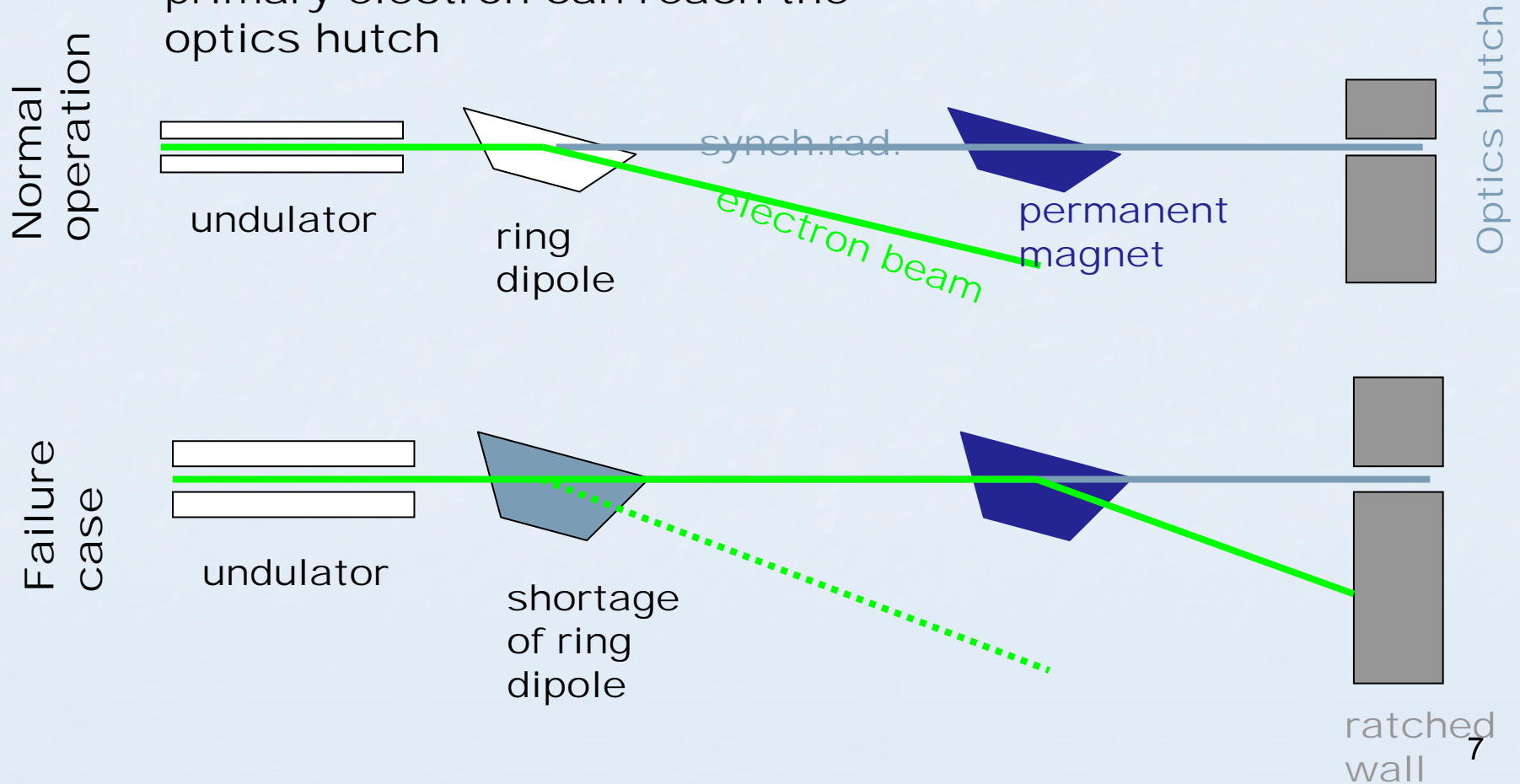
facility	circum. [m]	energy [GeV]	current [mA]	# e in ring	injected e in 2000 h
ESRF	840	6	200	$3.7 \cdot 10^{12}$	$1.7 \cdot 10^{15}$ operation 1999-2003
SPring8	1436	8	100	$3.0 \cdot 10^{12}$	$0.7 \cdot 10^{15}$ Top-up @ $\tau = 10$ h
PETRA-III	2304	6	100	$5.0 \cdot 10^{12}$	$6.0 \cdot 10^{15}$ Top-up @ $\tau = 2$ h
DIAMOND	562	3	300	$3.7 \cdot 10^{12}$	$0.9 \cdot 10^{15}$ Top-up @ $\tau = 10$ h
DORIS-III	289	5	800	$5.0 \cdot 10^{12}$	$2.0 \cdot 10^{15}$ permission @ $\tau = 5$ h

# PETRA III among other sources

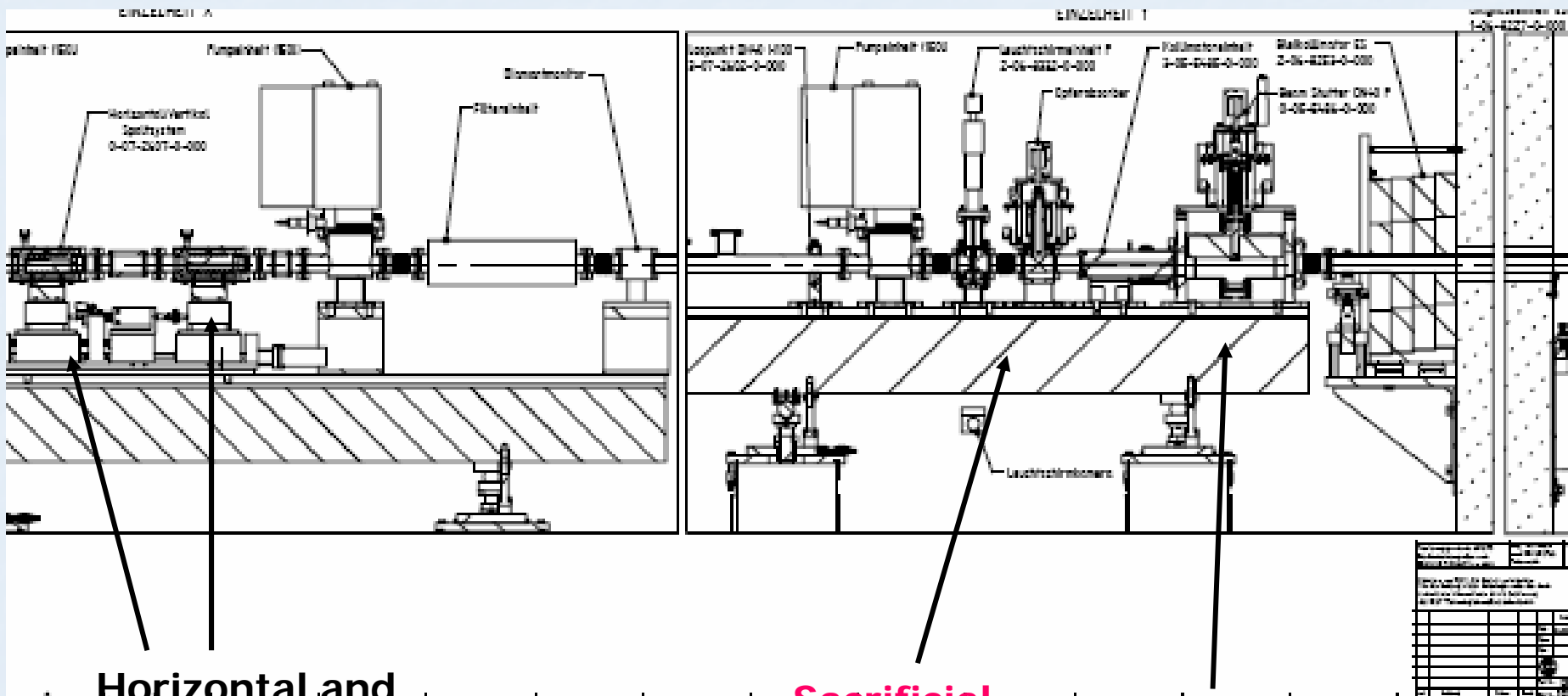
facility	injected e in 2000 h	Loss per standard cell	Dose Limit [mSv]	Lateral Shield status	Lateral Shield formula
ESRF	$1.7 \cdot 10^{15}$ operation 1999-2003	$0.8 \cdot 10^{14}$ 5 %	1	1.0 m HC	0.7 m HC
SPring8	$0.7 \cdot 10^{15}$ Top-up @ $\tau = 10$ h	$1.5 \cdot 10^{14}$ 20 %	12	1.0 m SC	0.6 m SC
<b>PETRA-III</b>	$6.0 \cdot 10^{15}$ Top-up @ $\tau = 2$ h	$3.0 \cdot 10^{14}$ 5 %	1	1.0 m HC	1.0 m HC
DIAMOND	$0.9 \cdot 10^{15}$ Top-up @ $\tau = 10$ h	$0.9 \cdot 10^{14}$ 10 %	1	0.95 m HC	0.6 m HC
DORIS-III	$2.0 \cdot 10^{15}$ permission @ $\tau = 5$ h	$0.6 \cdot 10^{14}$ 3 % 9m / 300m	1	0.8 m SC	0.8 m SC

# Primary electron beam confinement

A permanent magnet in the photon beam line guaranties that no primary electron can reach the optics hutch



# Beamline front end

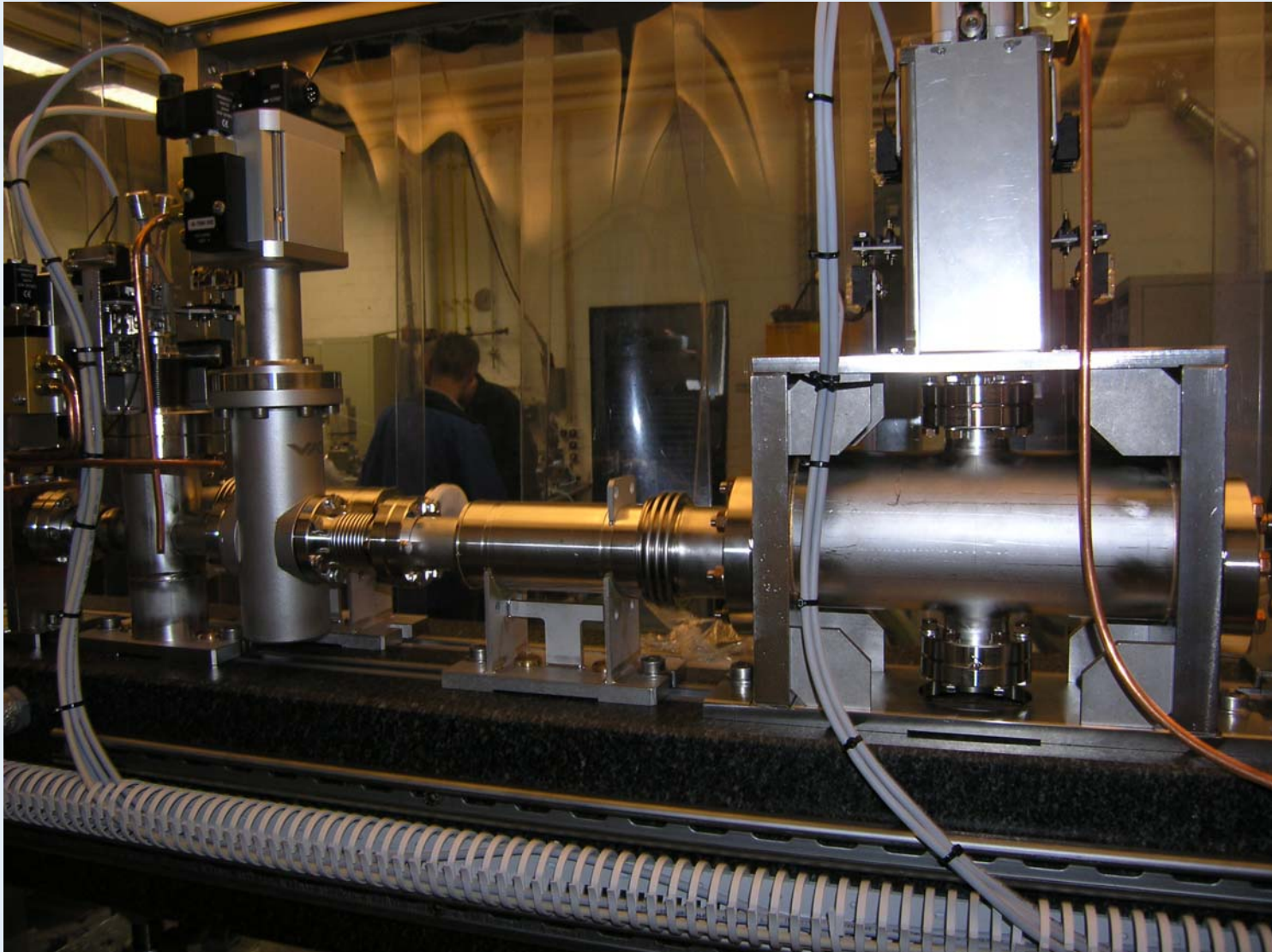


Horizontal and vertical slits

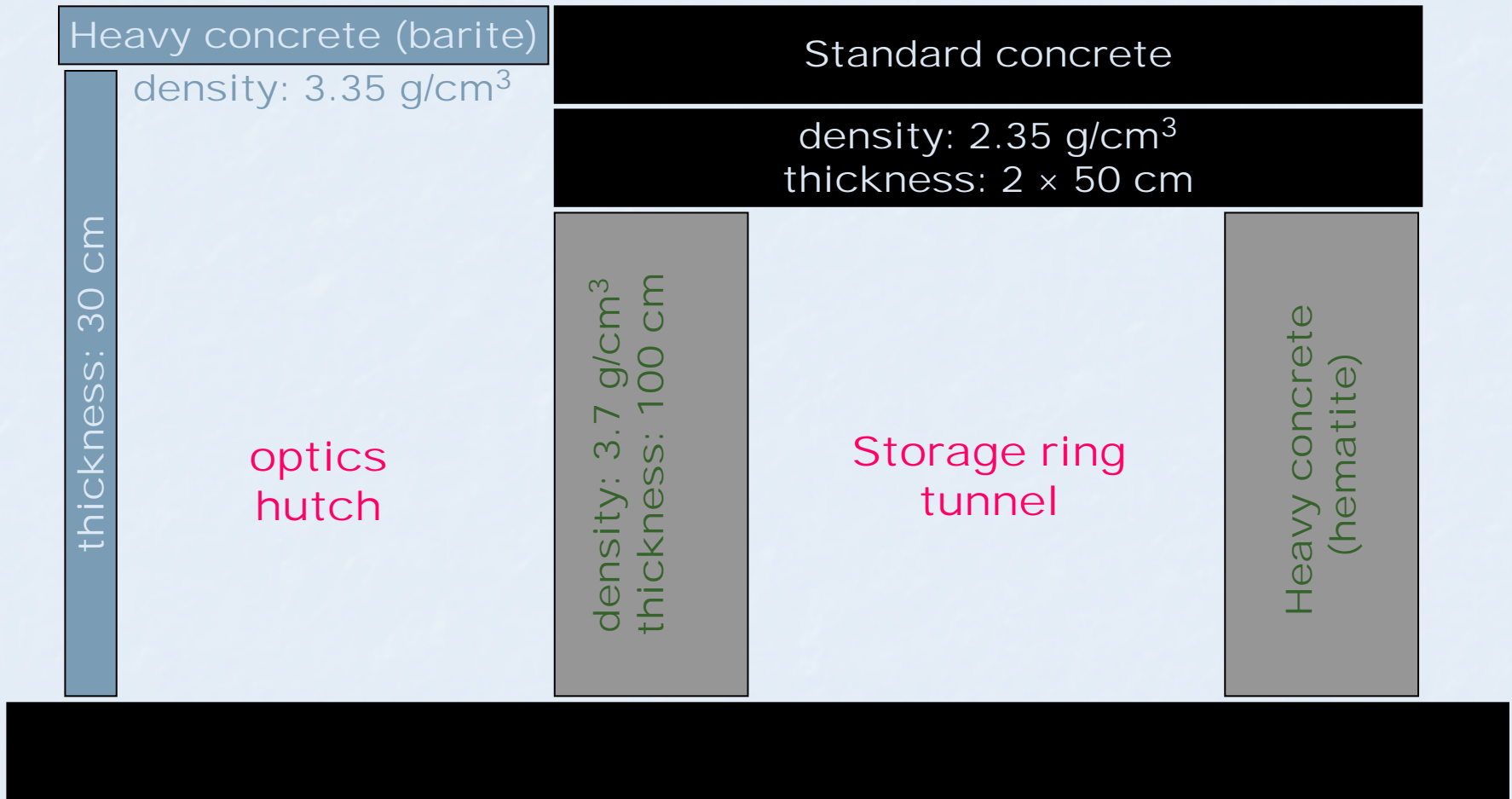
Sacrificial absorber

Beamshutter

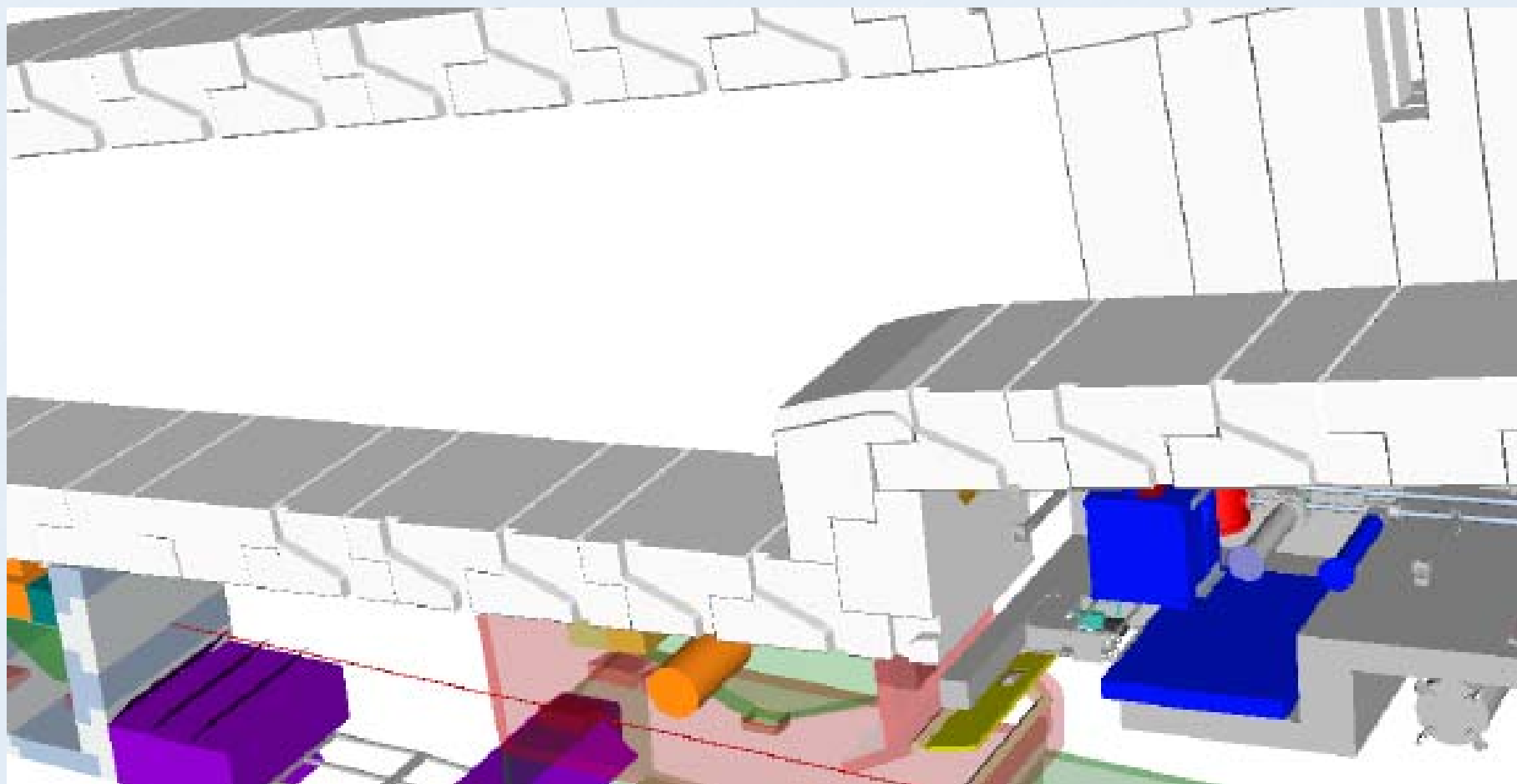
# Beamline front end



# Storage ring shielding



# Storage ring shielding

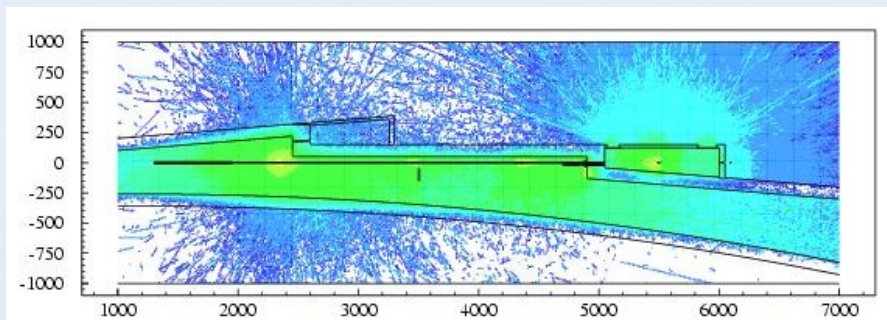
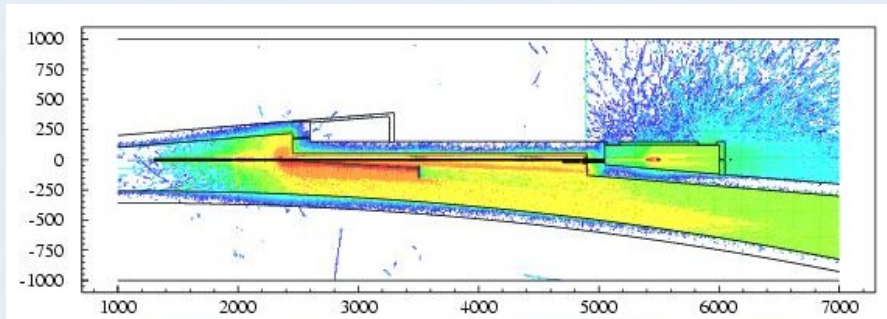


# Shielding calculations

## Optics hutch

FLUKA – 2005:  
Bremsstrahlung, Neutrons  
Few bunch mode: 100 mA  
Loss:  $10^{15}$  electrons per year

STAC8 v.2.3:  
Synchrotron radiation  
calculations by Asano-san

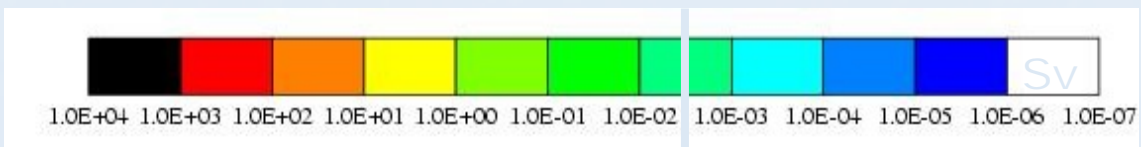
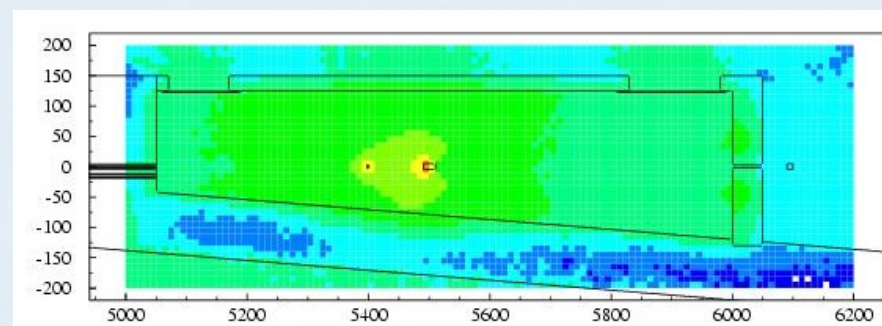
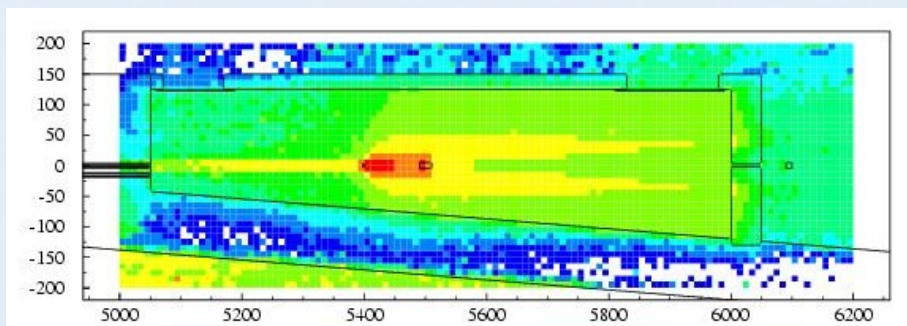
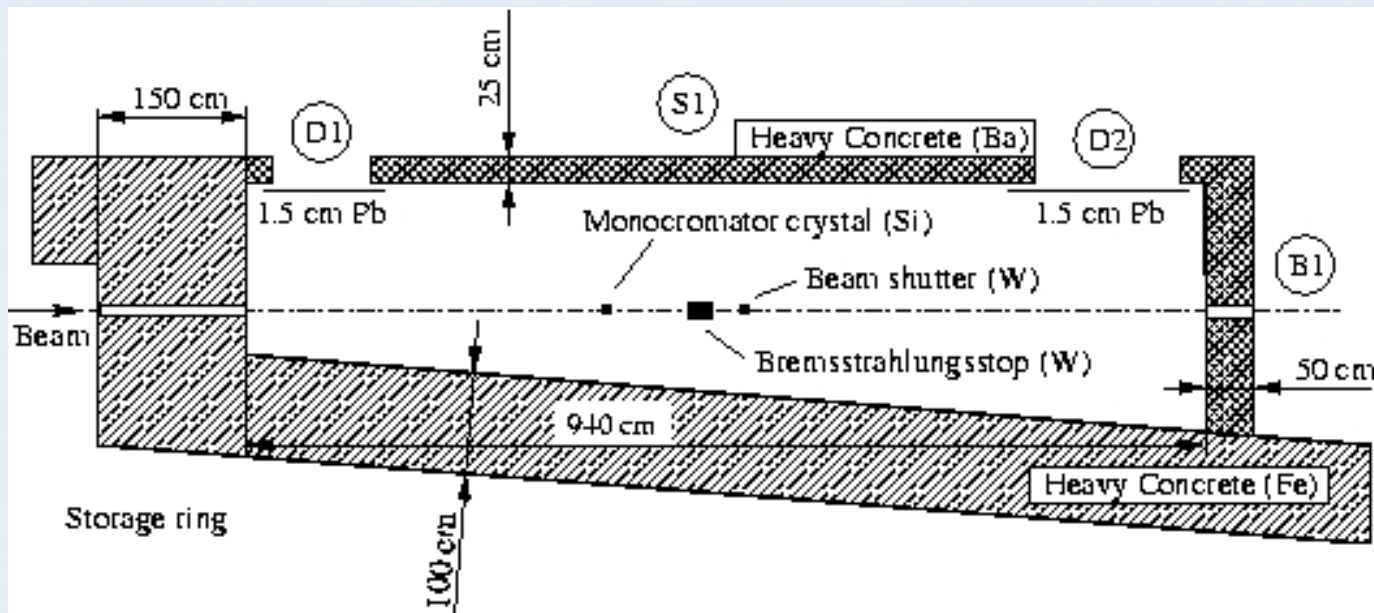


Spectroscopy beam line  
Multi bunch mode: 200 mA  
Power: 20 kW

# Optics hutch shielding

## - bremsstrahlung + neutrons -

Loss:  
 $1 \times 10^{15}$  electrons  
 equivalent to  
 $100 \text{ mA} \times 6000 \text{ h}$   
 $14.5 \text{ m}$  straight  
 $3.5 \times 10^{-08} \text{ mbar}$  air



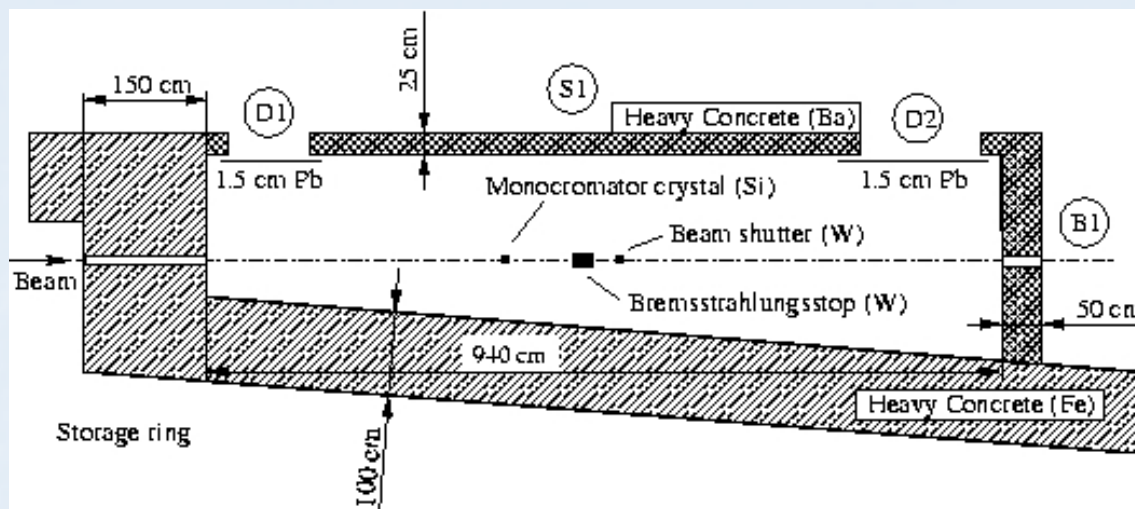
PLANNING GOAL: 3 mSv

# Optics hutch shielding - results

Loss:  
 $1 \times 10^{15}$  electrons

White beam:  
 200 mA  $\times$  6000 h

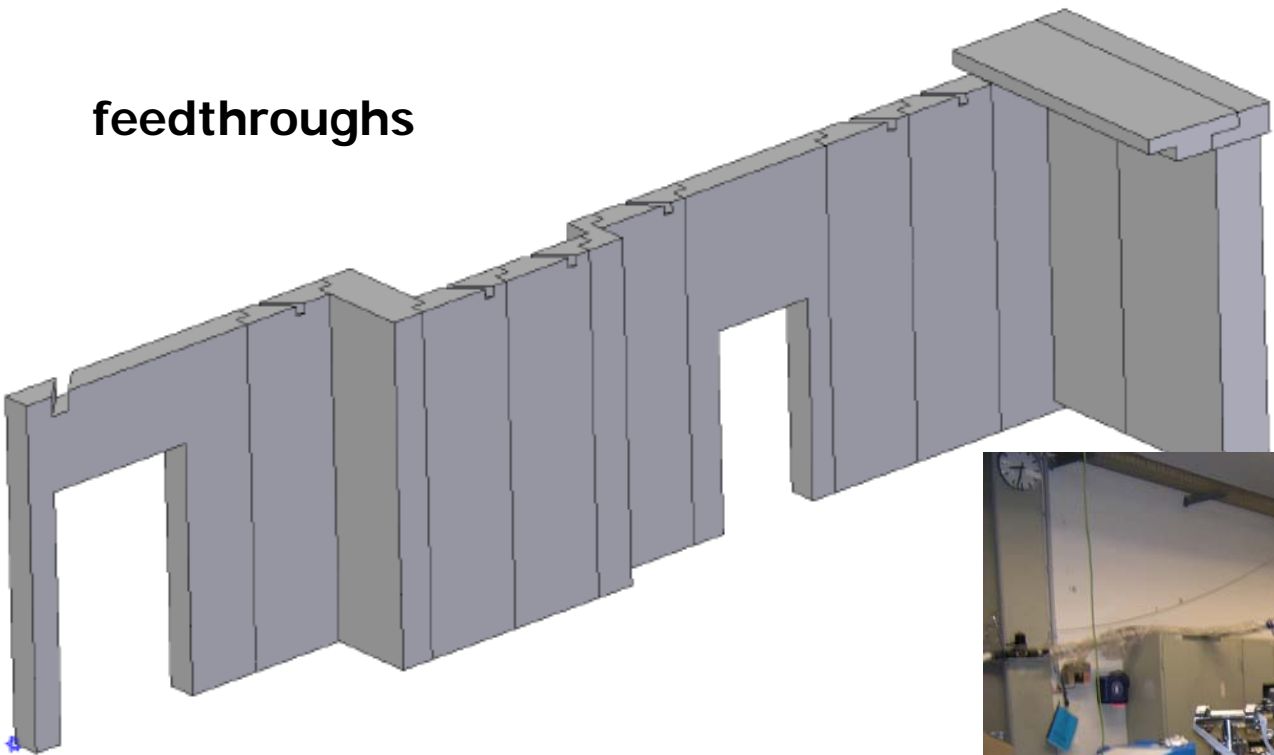
Normal case: Si  
 Worst case: Cu



Position	Brems. [mSv]		Neutrons [mSv]		Synch. [mSv]	
	Normal	Worst	Normal	Worst	Normal	Worst
D1	0.2	0.2	5.0	5.0		
S1	0.1	0.3	3.0	2.0	1.8	8.0
D2	0.3	5.0	2.0	3.0		
B1	2.0	10.0	0.2	1.0		

# Optics hutch

feedthroughs



Liquid nitrogen cooled optics



# Optics hutch



HARWI

Halfenschiene



# Experimental hutches

BL	Length [m]	period length [mm]	magnet. Field [T]	E <sub>Max</sub> [keV]	Bandwidth	side wall [mm]	Backwall [mm]		beamstop 30cmx30cm [mm]
							>115cm	<115cm	
P01	20	32	0.91	40					
P02	2	22	0.8	60					
P03	2	29	0.81	25	1%	6.5	7	7	20
P04	5	65.6	1.1	3					
P05	2	29	0.81	50	1%	10	11	11	20
P06	2	31.4	0.91	120	1%	16	30	45	80
P07	4	19	0.7	300	1%	10	20	30	60
P08	2	29	0.81	30	0.01%	5	11	11	30
P09	2	31.4	0.91	50	0.01%	5	11	11	30
P10	5	29	0.81	25	1%	7	6	7	20
P11	2	31.4	0.91	25	0.01%	4.5	5	5	20
P12	2	29	0.81	20	1%	3.5	3.5	3.5	20
P13	2	29	0.81	35	1%	14	18	18	30
P14	2	29	0.81	35	1%	14	18	18	30

**Approach: Layout of hutch static for highest load**

**Lead on carrier plates or as bricks (>10mm)**

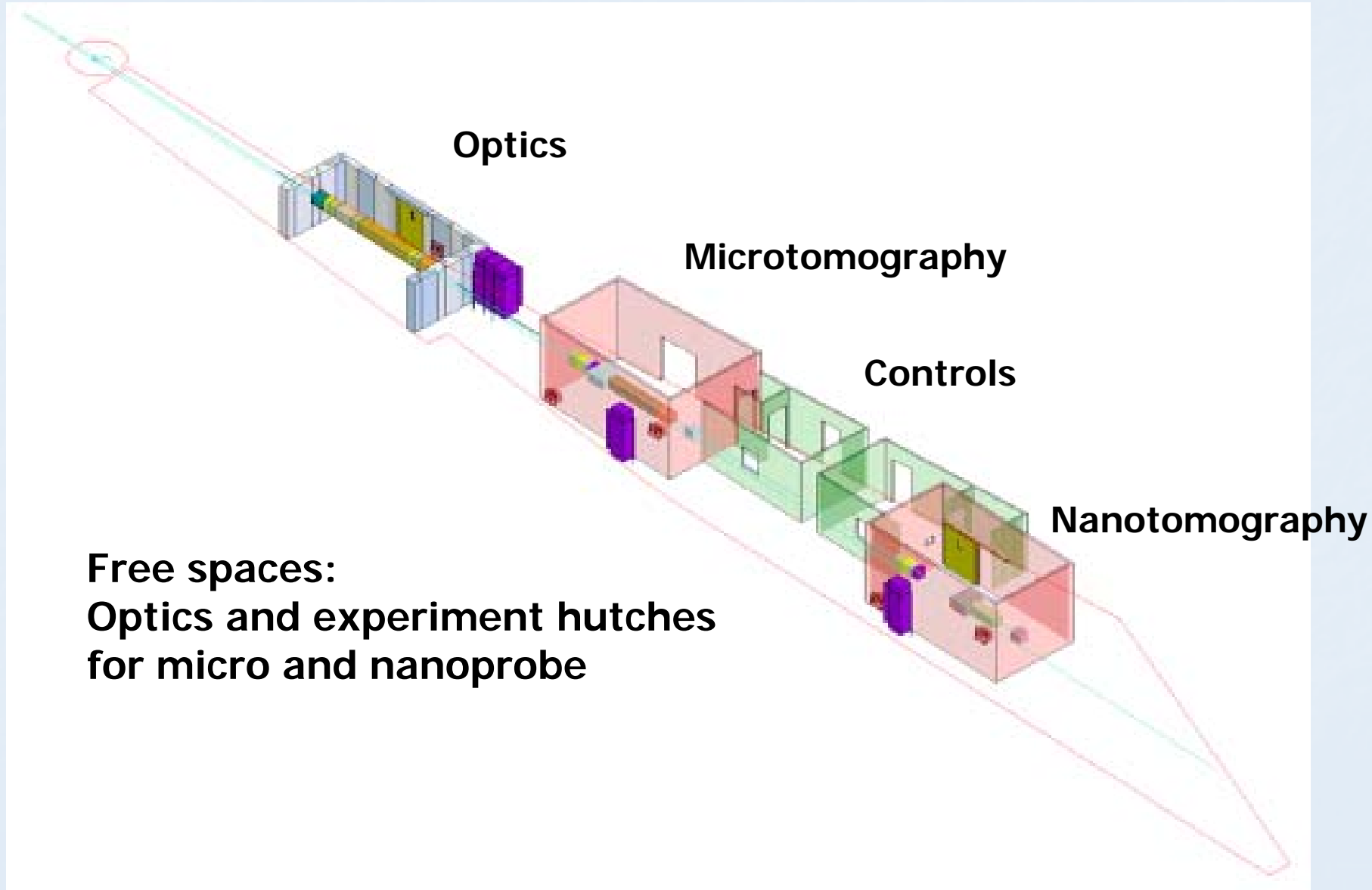
**Variable thickness of lead but constant wall thickness**

# Experimental hutches

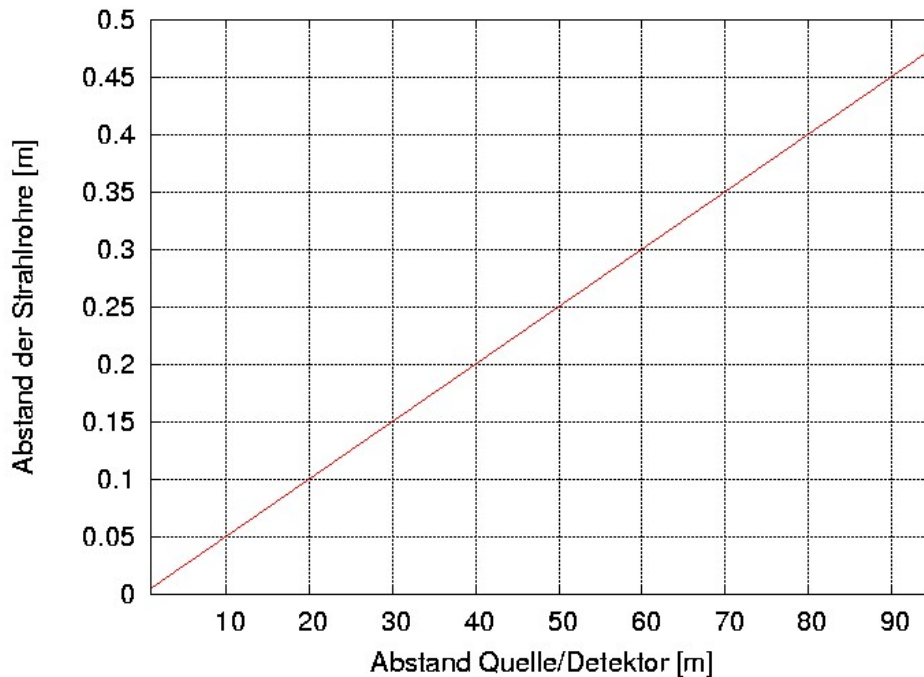
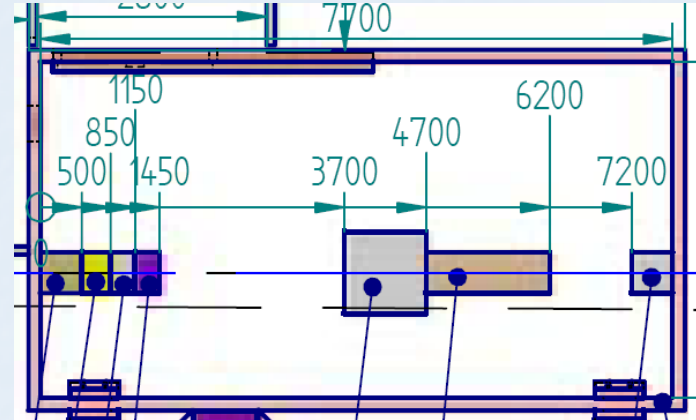


**Approach: Layout of hutch static for highest load  
Lead on carrier plates or as bricks (> 10mm)  
Variable thickness of lead but constant wall thickness**

# Example: Tomography

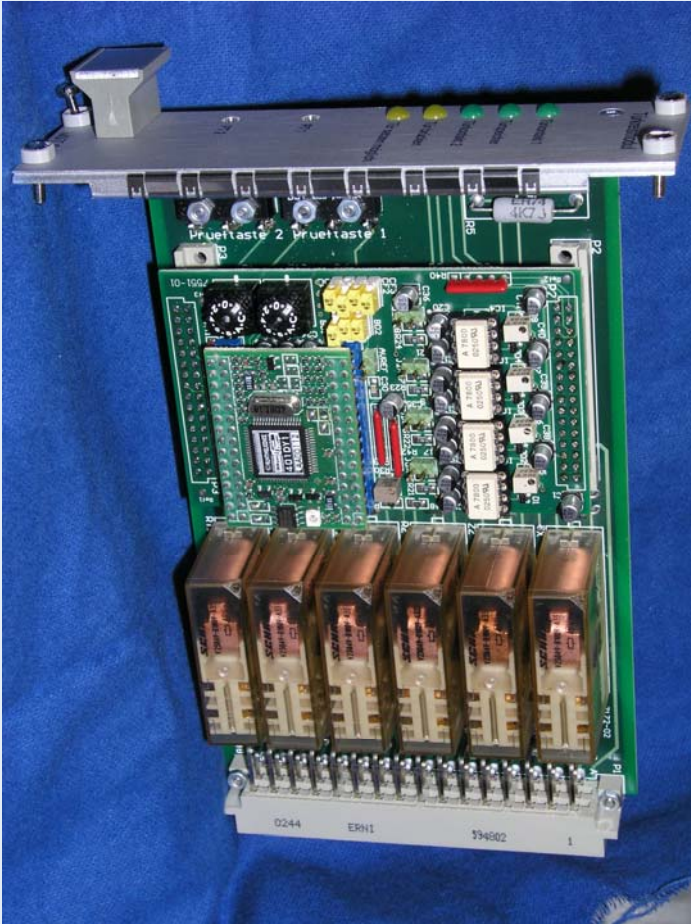


# Example: Tomography



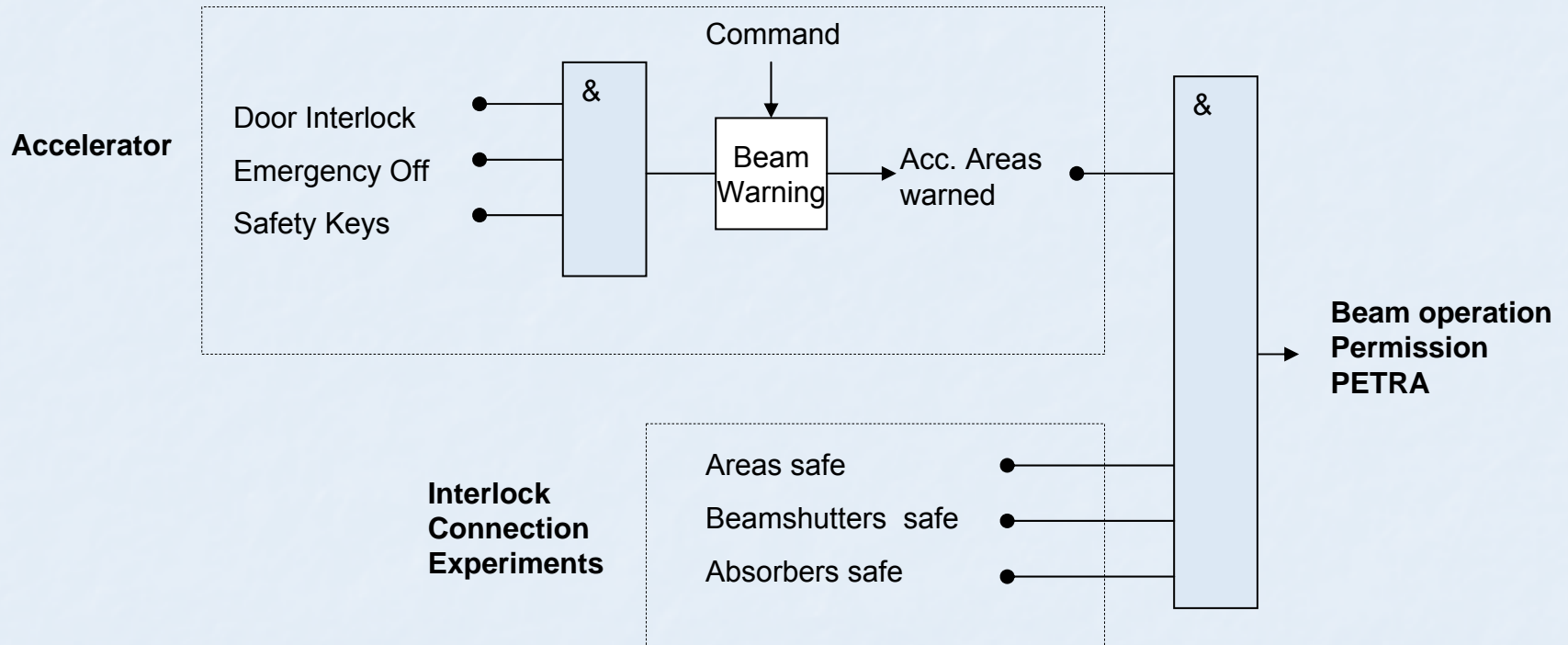
**Small distance of beamlines  
from canted undulators  
collimators and/or shielding  
Of beam tubes required**

# Interlock electronics

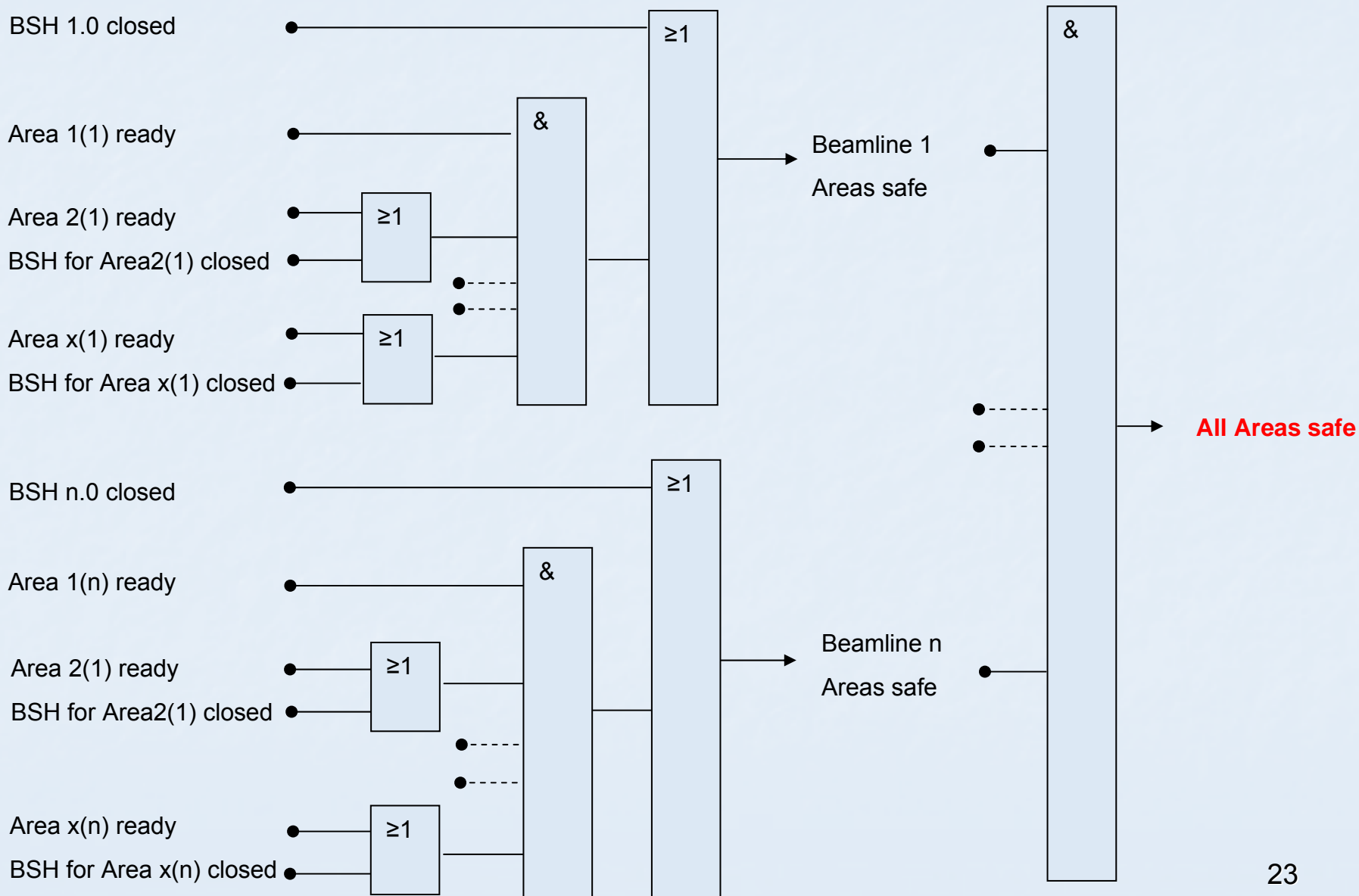


- 60V relay technique with forcible guided contacts
- few standard units housed in modules
- readout by opto coupler to local interface board
- interfaces connected by CANopen bus
- continuous remote supervision

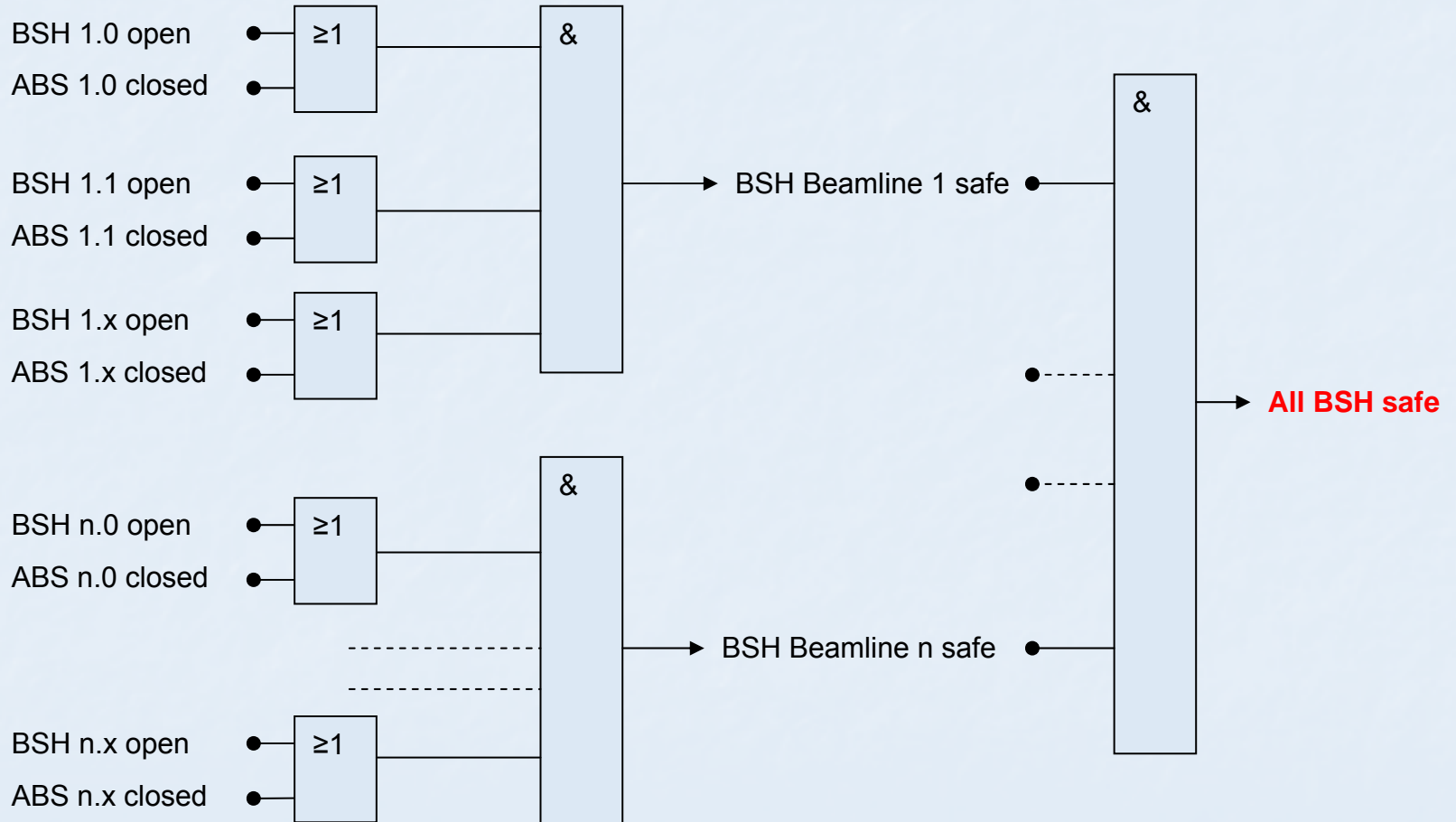
# PETRA Beam Operation Control



# Interlock Connection Experimental Areas



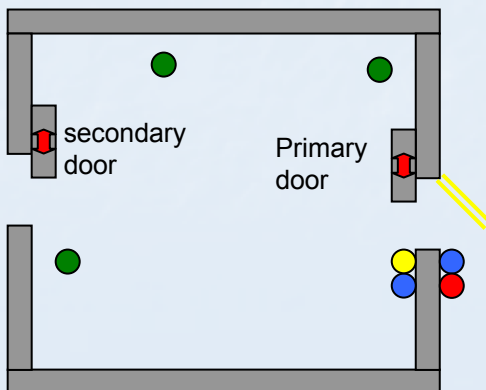
# Interlock Connection Beamshutters



## Demands

- Search by 1 Person possible
- Doors are supervised during search
- Special door for start/end of search
- Only by instructed persons
- No controlled access (ZZ)

## Optics Hutch



## Procedure

- Close all secondary doors
- Initialize search ●
- Acoustic search announcement in the area starts
- Person enters the area and activates light barrier ●
- All search buttons are activated (green LED) ●
- Search buttons are pressed (no special order)
- For leaving the area after search a button at the door is pressed ●
- deactivate the light curtain for ~ 5 s
- Person leaves the area and sets it within ~ 5 s ●

**Primary door can be shut (remote control) when search complete**

# Thank you

- Colleagues from DESY
  - Diamond, ESRF
  - Asano San (SPRING 8)
- 
- for your attention