

Radiation Protection constraints for the operation of CERN's beam facilities

ATC/ABOC Days

21-23/1/2008

Heinz Vincke for SC-RP

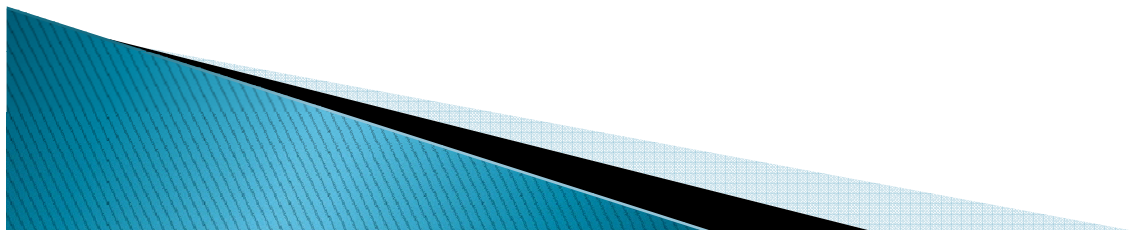
Outline

Revised Safety Code F 2006

- ▶ Legal Dose Limits of workers at CERN
- ▶ Reference Levels
- ▶ New Area Classification
- ▶ CERN's Approach to ALARA

**Impact on
machine
operation**

Summary and outlook



Safety code F

- ▶ Revised Safety code F (Radiation protection) was issued in November 2006 to bring CERN in line with European radiation protection legislations and regulations
- ▶ CERN's revised Radiation Protection rules and regulations were endorsed by the Swiss and French authorities
- ▶ Safety Code F 1996 (Radiation Protection Manual) has been replaced by:
 - Safety Code F 2006 and is being completed by radiation protections instructions
 - + specific area- and work procedures

Note that Safety Instructions for radiation protection contained in the CERN Radiation Protection Manual (1996) remain valid for a transition period until all instructions are revised.

CERN legal limits

- ▶ **Occupationally exposed :**
 - **Safety Code F 1996:**
 - < 20 mSv/12 months

 - **Safety Code F 2006:**
 - Class A < 20 mSv / 12 months
 - Class B < 6 mSv / 12 months

- ▶ **Short term visitors:**
 - < 1 mSv / 12 months
 - (not classified as occupationally exposed)

- ▶ **Not occupationally exposed:**
 - < 1 mSv / 12 months

CERN Reference Levels

I) Annual individual, effective dose of occupationally exposed persons should stay below 6 mSv

Year	Number of persons with effective doses above 6 mSv/year	Activity
2000	13	Cable changes, maintenance of beam instrumentation, transport, radiation protection
2001	2	Transport, maintenance of beam instrumentation
2002	2	Transport
2003	5	Transport, radiation protection, Gamma radiography
2004	0	
2005	0	
2006	0	
2007	0 (preliminary)	

CERN Reference Levels

II) The effective dose due to internal exposure should be less than 1 μSv per hour of stay

Main risk:

inhalation of radioactive aerosols

Areas of risk: target areas, extraction and injection areas

TCC2	}	Access procedures exists.
CNGS		Delayed access, several hours of waiting time

Preliminary results from air measurements:

TCC2: < 150 nSv effective dose for one hour of stay after two hours of waiting time

CNGS: < 5 nSv effective dose for one hour of stay after 12 hours waiting time

→ Studies need to be continued

CERN Reference Levels

III) The annual effective dose to the members of the reference group of the population (the most exposed group outside CERN) should stay below 10 μSv per year. The legal limit is 300 μSv per year.

Effective dose in $\mu\text{Sv}/\text{year}$

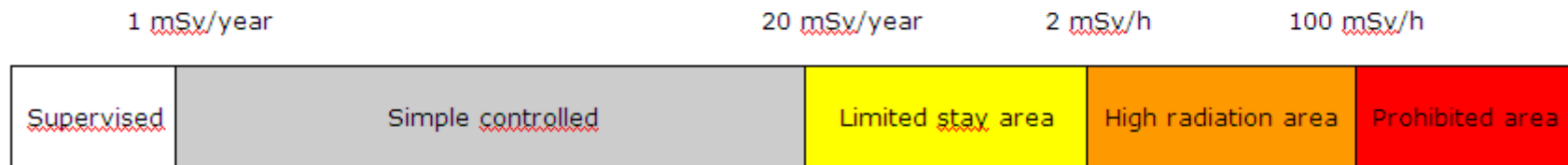
Year	From air/water releases	From stray radiation	Total
2003	3	21	24
2004	5	10	15
2005	2	10	12
2006	5	3	8

Courtesy: P. Vojtyla SC-IE

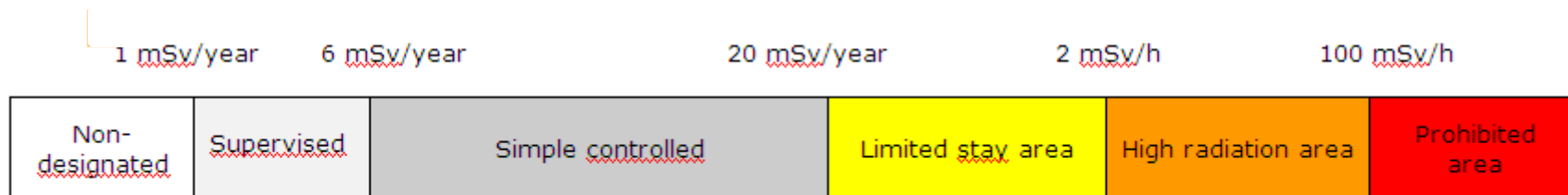
Natural radiation in the environment:
~800 μSv per year

CERN's Area Classification

CERN Area Classification until 2006




CERN Area Classification since end of 2006



Safety Instruction S3-GSI1,
EDMS 810149

Radiation areas: classification and warning panels


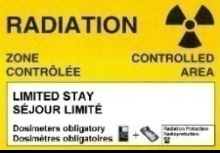
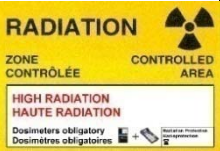
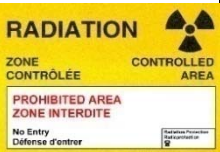
< 2007 <2.5 $\mu\text{Sv h}^{-1}$ <7.5 $\mu\text{Sv h}^{-1}$

Area Classification	Dose limit	Ambient dose equivalent rate <i>At work places</i>	Ambient dose equivalent rate <i>In low occupancy areas</i>	Access, Personnel categories	Monitoring Personal dosimetry	Warning sign
Non-designated area	1 mSv / y	< 0.5 $\mu\text{Sv h}^{-1}$	< 2.5 $\mu\text{Sv h}^{-1}$	no restriction, all	passive or active, not required	n.a.
Supervised radiation area	6 mSv / y	< 3 $\mu\text{Sv h}^{-1}$	< 15 $\mu\text{Sv h}^{-1}$	supervised, radiation workers and VCT	passive or active, personal dosimeter	

Safety Instruction S3-GSI1, EDMS 810149

Radiation areas: classification and warning panels

< 2007 <25 $\mu\text{Sv h}^{-1}$ <100 $\mu\text{Sv h}^{-1}$

Area Classification	Dose limit	Ambient dose equivalent rate <i>At work places</i>	Ambient dose equivalent rate <i>In low occupancy areas</i>	Access Personnel categories	Monitoring Personal dosimetry	Warning sign
Simple Controlled Radiation area	20 mSv/y	< 10 $\mu\text{Sv/h}$	< 50 $\mu\text{Sv/h}$	Controlled Class A workers Class B with time limit	Active Personal dosimeter	
Limited stay area	20 mSv/y		< 2 mSv/h	Controlled Class A workers + Class B with time limit	Active Personal dosimeter + Operational dosimeter	
High radiation area			<100 mSv/h			
Prohibited area			>100 mSv/h			

Type of area	Category A	Category B	VCT
Supervised area	Unlimited stay*	Unlimited stay*	Stay allowed up to 2 months/year
Simple controlled area		Limited stay	Access prohibited
Controlled area: - limited stay - high radiation	Limited stay	Limited stay	Access prohibited

*) with respect to legal limits only

but

**jobs have to be optimized and doses minimized
in ALL areas**

CERN's Premises: revision of radiological classification

Goal:

- ▶ to bring CERN's area classification in line with Safety Code F 2006
- ▶ to keep the classification of an area as "low" as reasonable possible

Non-designated

supervised

simple controlled

.....

By

Minimize beam loss

Shielding

ARCON/RAMSES alarms and interlocks

Restricted access procedures

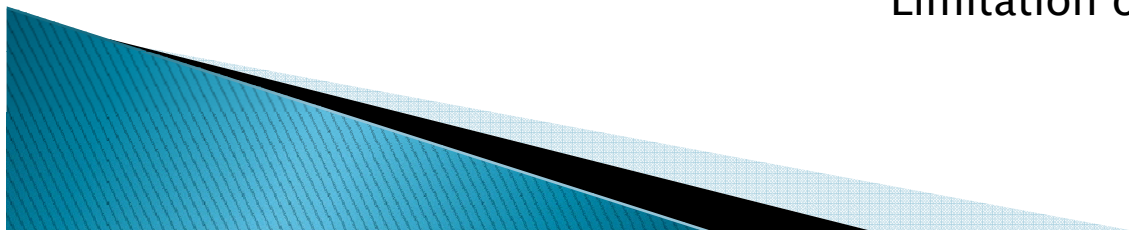
Limitation of beam intensities



Order of preference



Order of preference



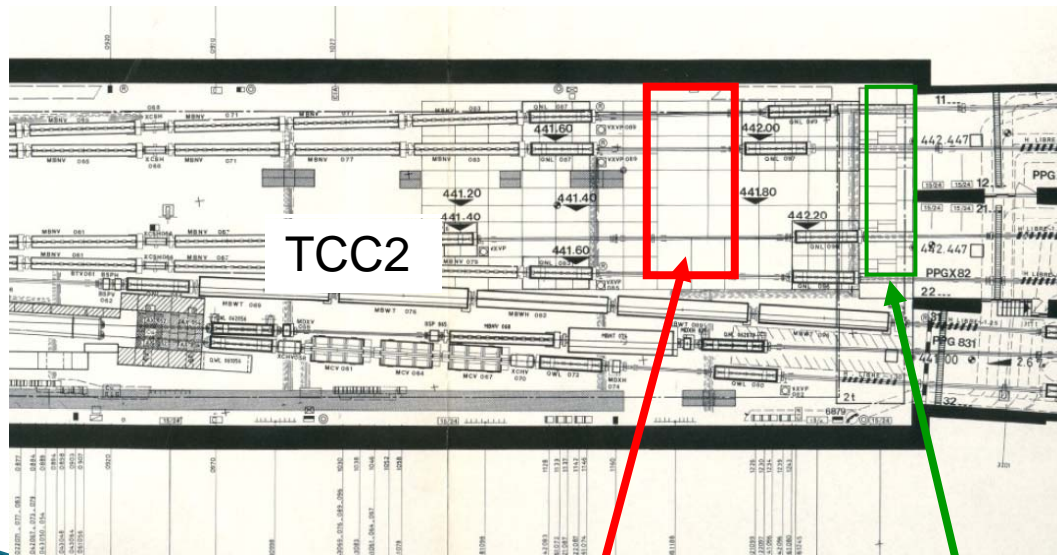
Classification of EHN1 (North Hall)

< 2006:

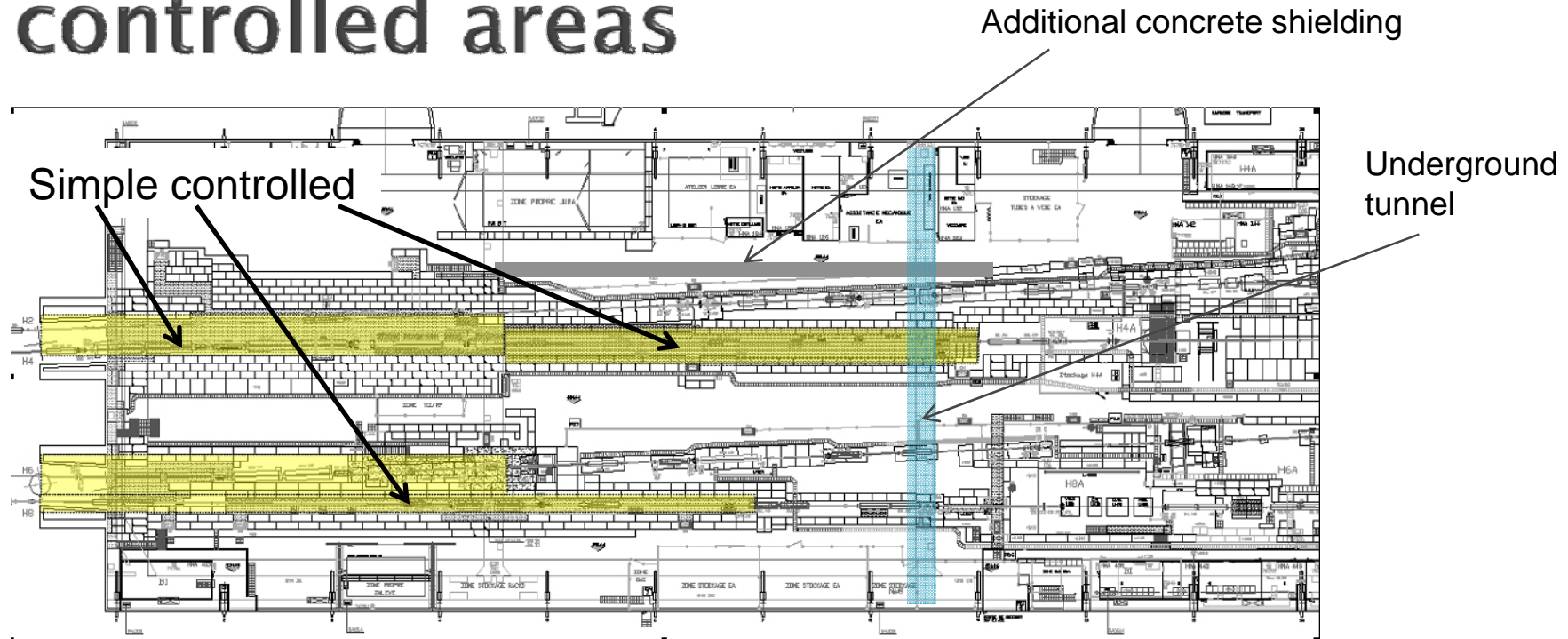
- ~160 $\mu\text{Sv/h}$ on top of H6 beam line

2007:

- ~20 $\mu\text{Sv/h}$ due to additional 6.4 m thick iron shielding in TCC2

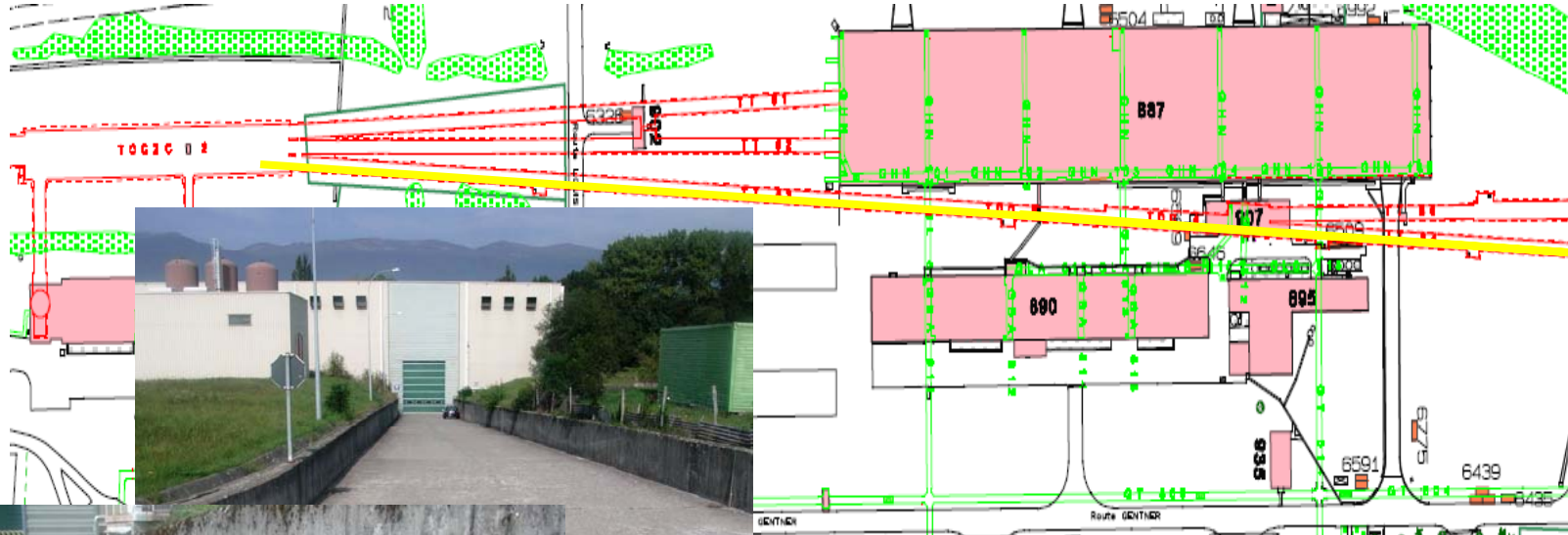


EHN1: supervised and simple controlled areas



- Presently alarm levels of radiation monitors correspond to 'supervised' area levels
- In 2007 several beam cuts occurred and all of them could be backtracked to either placement of material into unshielded beam lines or unauthorized opening of collimators.
- Access to underground tunnel was prohibited when beam was dumped into upstream target in H4 beam line
- Measuring campaign will be continued in 2008

M2 beam line



Radiation measurement in 2004 at the ramp: $9 \mu\text{Sv/h}$

Installation of a magnetic collimator (SCRAPER) and a magnetized iron block in the transfer tunnel TT83 during the long shutdown in 2005.

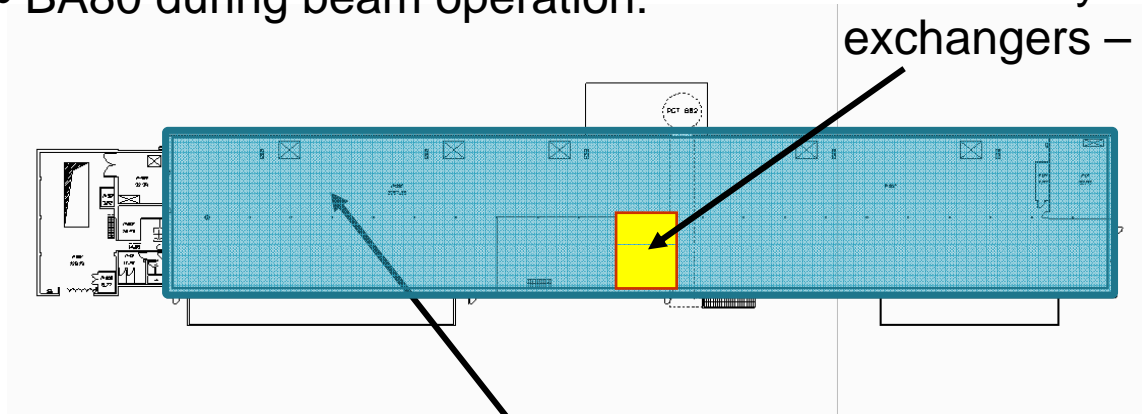
Radiation measurement in 2006 at the ramp: $5 \mu\text{Sv/h}$ on floor level and $2.4 \mu\text{Sv/h}$ at 100 cm height.

More CERN areas have been revised....

- EHN2: COMPASS - supervised area even during hadron run

- BA80 during beam operation:

Limited stay area around ion exchangers – to be fenced



Simple controlled area

Issues with other areas:

TT10

TT20

PS bridge

Route Goward

see presentation S. Gilardoni

Implementation of ALARA at CERN

All work in radiation areas has to be optimised


- ▶ Supervised area: general optimisation by shielding, optimised location of workplaces...
- ▶ Controlled radiation areas: **All** work must be planned and optimised including an estimate of the collective dose and of the individual effective doses to the workers participating in the completion of the task.

ALARA at CERN


most of the ALARA elements were already used all over CERN in the past

since December 2006:

- ▶ systematic, formalized approach
- ▶ requires “close collaboration” between RP and the workers performing the job

CERN CH1211 Genève 23 Suisse	<table border="1"><tr><td>N° EDMS 810169</td><td>REV. 1.0</td><td>VALIDITÉ APPROUVÉ</td></tr></table>	N° EDMS 810169	REV. 1.0	VALIDITÉ APPROUVÉ
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	RÉFÉRENCE RGE section 9 / S5-N11			
Date : 2006-12-20				
NOTE D'INFORMATION				
RÈGLES GÉNÉRALES D'EXPLOITATION CONSIGNES GÉNÉRALES DE RADIOPROTECTION				
L'APPROCHE ALARA AU CERN				
DOCUMENT PRÉPARÉ PAR : Pierre Bonnal / AB Doris Forkel-Wirth / SC	DOCUMENT VÉRIFIÉ PAR : Thomas Otto / SC	DOCUMENT APPROUVÉ PAR : Hans-Georg Menzel / SC		
GROUPE L'APPROBATION				

ALARA at CERN – 3 levels

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	RÉFÉRENCE RGE section 9 / S5-GSI1			
Date : 2006-12-20				
<p>INSTRUCTION GÉNÉRALE DE SÉCURITÉ</p> <p>RÈGLES GÉNÉRALES D'EXPLOITATION CONSIGNES GÉNÉRALES DE RADIOPROTECTION</p> <p>CRITÈRES ET EXIGENCES ALARA APPLICABLES AUX INTERVENTIONS</p>				
DOCUMENT PRÉPARÉ PAR : Pierre Bonnal / AB Doris Forkel-Wirth / SC	DOCUMENT VÉRIFIÉ PAR : Thomas Otto / SC	DOCUMENT APPROUVÉ PAR : Hans-Georg Menzel / SC		
GROUPE D'APPROBATION				

ALARA procedures – 3 levels:

- If the rad. risk is **low**
<> light procedure
- If it is **medium**
<> an optimization effort is required
- If it is **high**
<> an optimization effort is required, the procedure will be submitted to the ALARA committee

ALARA Criteria

CRITÈRE DE DÉBIT DE DOSE

Débit d'équivalent de dose prévisionnel (\dot{H}) dans la zone d'intervention :

50 $\mu\text{Sv}\cdot\text{h}^{-1}$	2 $\text{mSv}\cdot\text{h}^{-1}$	
niveau I	niveau II	niveau III

CRITÈRE DE DOSE INDIVIDUELLE

Équivalent de dose prévisionnel individuel (H_i) pour l'intervention, ou pour l'ensemble des interventions de même nature lorsque celles-ci sont répétées plusieurs fois sur une année :

100 μSv	1 mSv	
niveau I	niveau II	niveau III

EDMS 810169

ALARA Criteria

CRITÈRE DE DOSE COLLECTIVE

Équivalent de dose prévisionnel collective (H_c) pour l'intervention, ou pour l'ensemble des interventions de même nature lorsque celles-ci sont répétées plusieurs fois sur une année :

500 μ Sv		10 mSv
niveau I	niveau II	niveau III

CRITÈRE DE CONTAMINATION ATMOSPHERIQUE

Activité aérienne spécifique CA :

5 CA	200 CA	
niveau I	niveau II	niveau III

CRITÈRE DE CONTAMINATION SURFACIQUE

Activité surfacique spécifique CA :

10 CS	100 CS	
niveau I	niveau II	niveau III

EDMS
810169

ALARA at CERN

When to apply which kind of procedure ?

Type d'intervention	répétitives / génériques			ponctuels / unitaires		
	I	II	III	I	II	III
Dosimétrie individuelle	●	●	●	●	●	●
Dosimétrie opérationnelle sans alarme	●			●		
Dosimétrie opérationnelle avec alarme		●	●		●	●
Dossier de sécurité	Docts. descriptifs	○	○			●
	Docts. justificatifs		○	●		●
	Docts. d'exploitation		○	○		○
Analyse de risques radiologiques	●	●	●	●	●	●
Calculs radiologiques / codes simples			●			●
Calculs radiologiques / codes élaborés			●			●
Justification par analyses multi-critères		○	●		○	●
Prise en compte du retour d'expérience	●	●	●	●	●	●
Dossier d'intervention en milieu radioactif	DIMR de niveau I	●		●		
	DIMR de niveau II		●		●	
	DIMR de niveau III			●		●
Cartographie dosimétrique	○	●	●	○	●	●
Relevé de décisions du comité ALARA			●			○
Fiche d'écart / Retour d'expérience	○	○	○	○	○	○

● required

○ optional

ALARA

Run



Shutdown



- 1 ■ Establish list of maintenance tasks
- 2 ■ Evaluate the radiological risks
- 3 ■ Planning of interventions
- 4 ||||| Preparatory meetings
- 5 ★ ALARA committee – if required
- 6 ■ Maintenance work
- 7 ■ Analysis, lessons learned

ALARA committee (7 members):

- Chef d'installation (president)
- Scientifique secretary
- 2 Representatives of the owner equipment group
- 2 Members of RP
- 1 External person, e.g. RSO of another department

ALARA

Radiological classification of
shut-down activities for the
SPS complex in 2007/2008
(Not exhaustive)
22 August 2007

Shut-down activity	Radiological risk
Rénovation 80 aimants y compris transport, vide géomètres	III
Remplacement TPSG4 y compris transport, vide, géomètres	I
Entretien général hydraulique MST/MSE en LSS2 en LSS4 et LSS6	II - III I
Remise en eau et circulation MST/MSE en LSS 2 en LSS4 et LSS6	II - III I
Entretien équipements ZS en LSS2	II - III
Tirage de câble HT (AB-BT) point 2 de ZS a MSE	III
Remplacement MKDV en LSS6 (intervention vide)	I
Contrôles radiologiques RP dans le SPS et les tunnels de transferts	III
Eclairage Securite	III
Controles altimetriques	III

ALARA committee

- ▶ First ALARA committee meeting was held 19/11/2007
(only part of class III works were discussed, the rest will be done in January 2008)
- ▶ Conclusions and recommendations
 - Many jobs are already optimised thanks to
 - experience
 - good co-ordination of the work by machine superintendants
 - earlier investments (e.g. SPS magnet repair: workshop in ECA5, purchase of additional magnet transport vehicle to compensate for the longer transport time of a magnet (circumventing BA1!))
 - Improvements are still possible
 - Remote radiation measurement device
 - Remote visual inspection device
 - Use of fluorescence tubes which double the life time
 - Switching off the light during beam operation
 -

Summary and Outlook

- ▶ Revised RP rules, regulations and instructions are already applied at CERN since end of 2006
- ▶ More Safety Instructions still need to be completed e.g.
 - on the control, handling and release of activated material
 - on radioactive laboratories etc.
- ▶ More procedures still need to be completed e.g.
 - compensate for ARCON and RAMSES failures (e.g. stop of SPS when environmental station in TT10 fails)
- ▶ Revision of area classification needs to be continued
 - activities not directly correlated to beam operation should be moved out of radiation areas
 - Areas need to be shielded or fenced (e.g. North Area, SPS and CNGS ion exchangers, more areas see S. Gilardoni's talk)

Final remarks

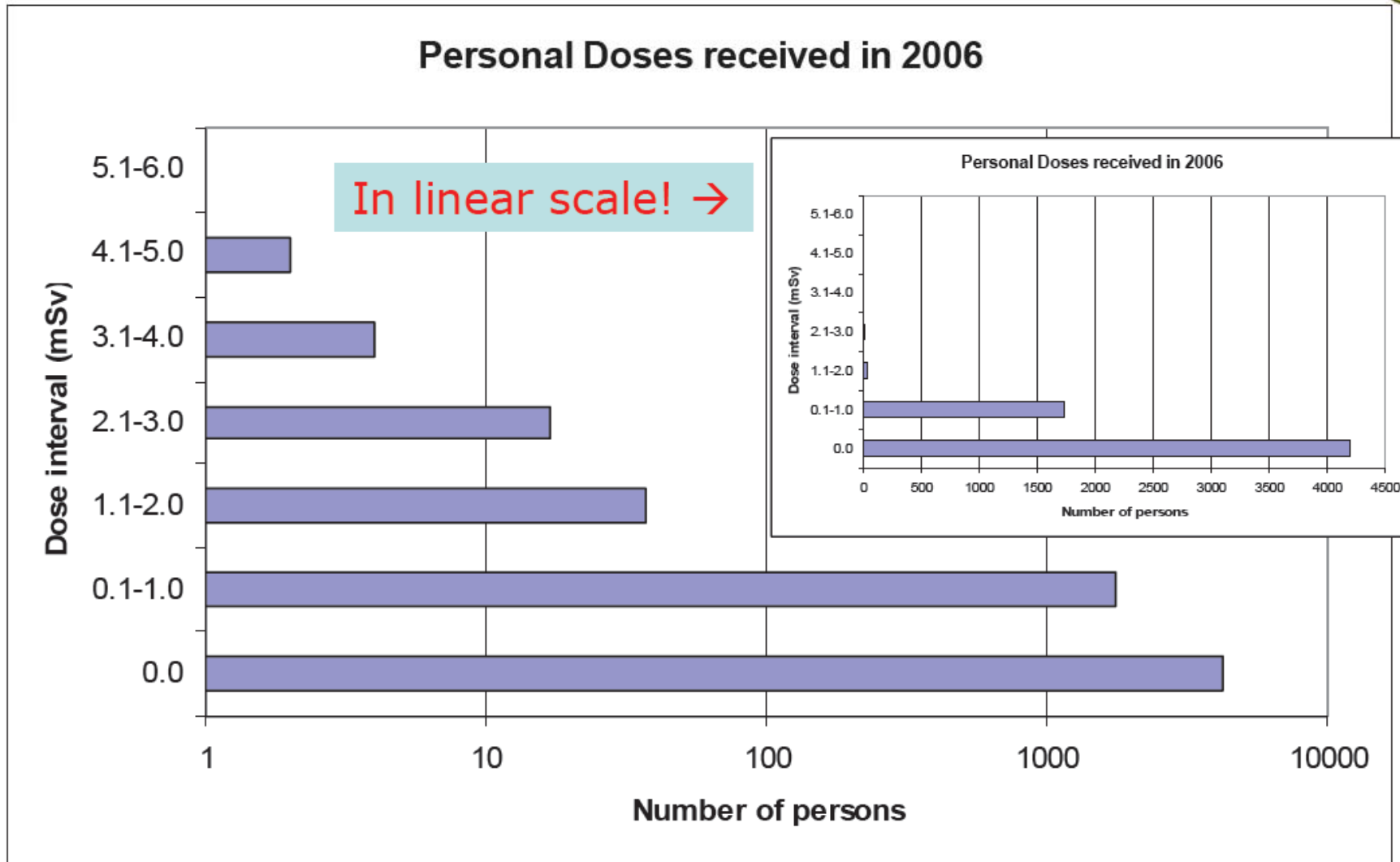
- ▶ Radioactive waste
 - Note that minimisation of radioactive waste is an integral part of the ALARA approach. Optimisation of the installation design with respect to material choice and maintenance interventions helps in reducing the total amount of radioactive waste and collective doses.

- ▶ New general radiation protection training course.
 - By decision of the Director- General the course is mandatory for all people under dosimetry control (i.e. in possession of a personal dosimeter).
 - Daily sessions started on Monday 14 January 2008.
 - More information can be found in the present CERN Bulletin (Issue No.04-05/2008).

Design and work procedures have to be adapted to the operation under new rules. To date excellent collaboration between SC-RP and all departments involved

Additional slides

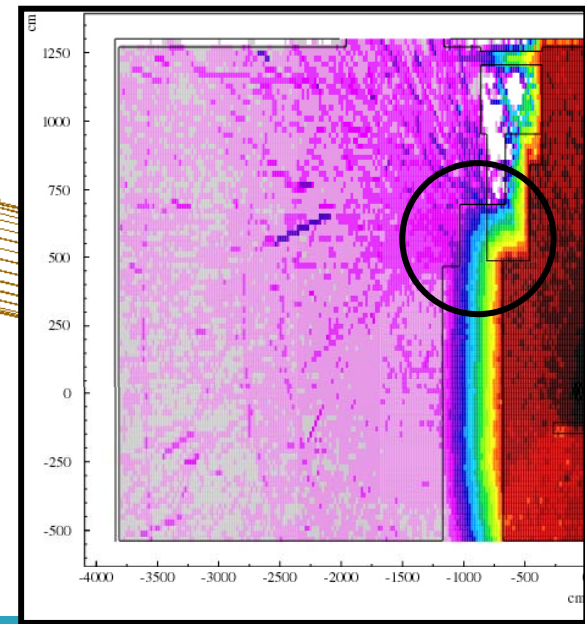
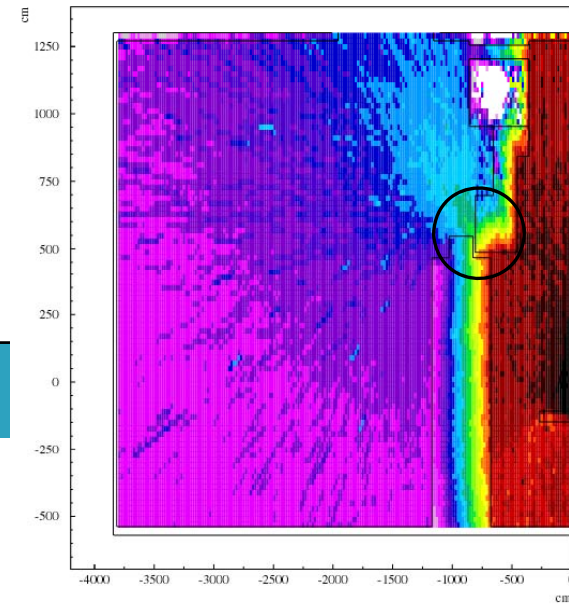
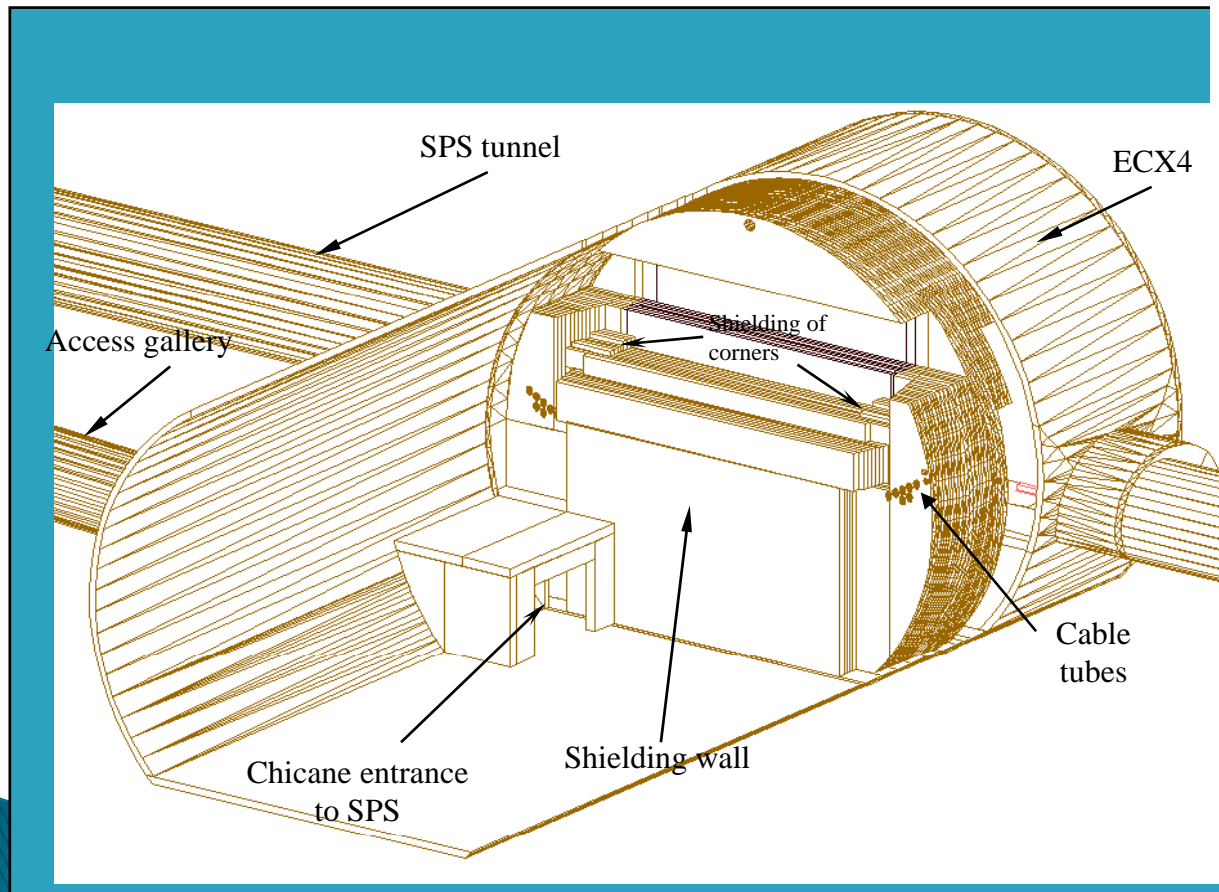
Dose statistics for 2006



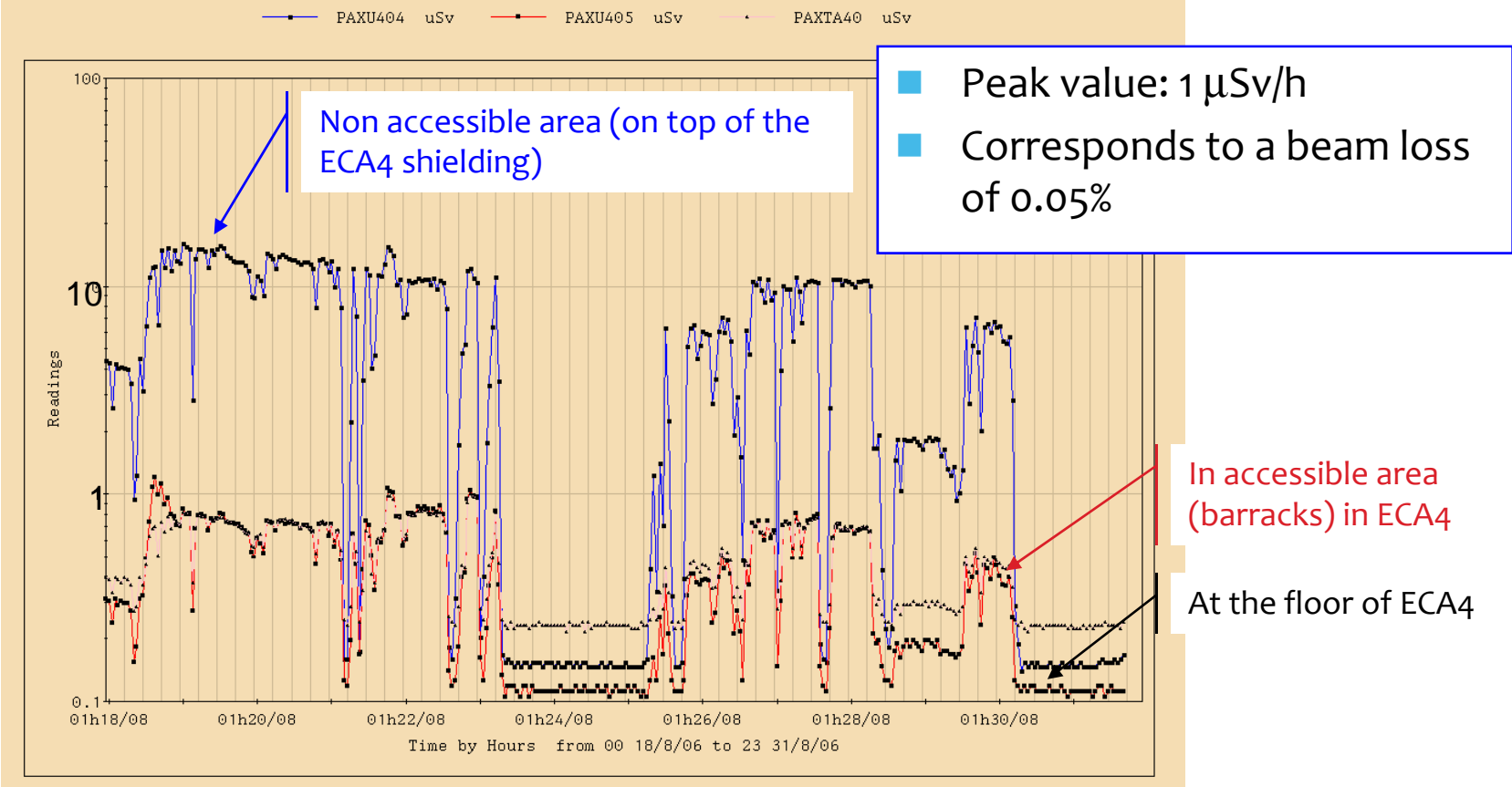
Example: ECA4

Aim: supervised area

-> reinforcement of shielding



ECA4: supervised area



Supervised area up to 4.8×10^{13} protons/6 sec – nominal CNGS intensity