Radiation Protection Studies for the Passive Absorber Design

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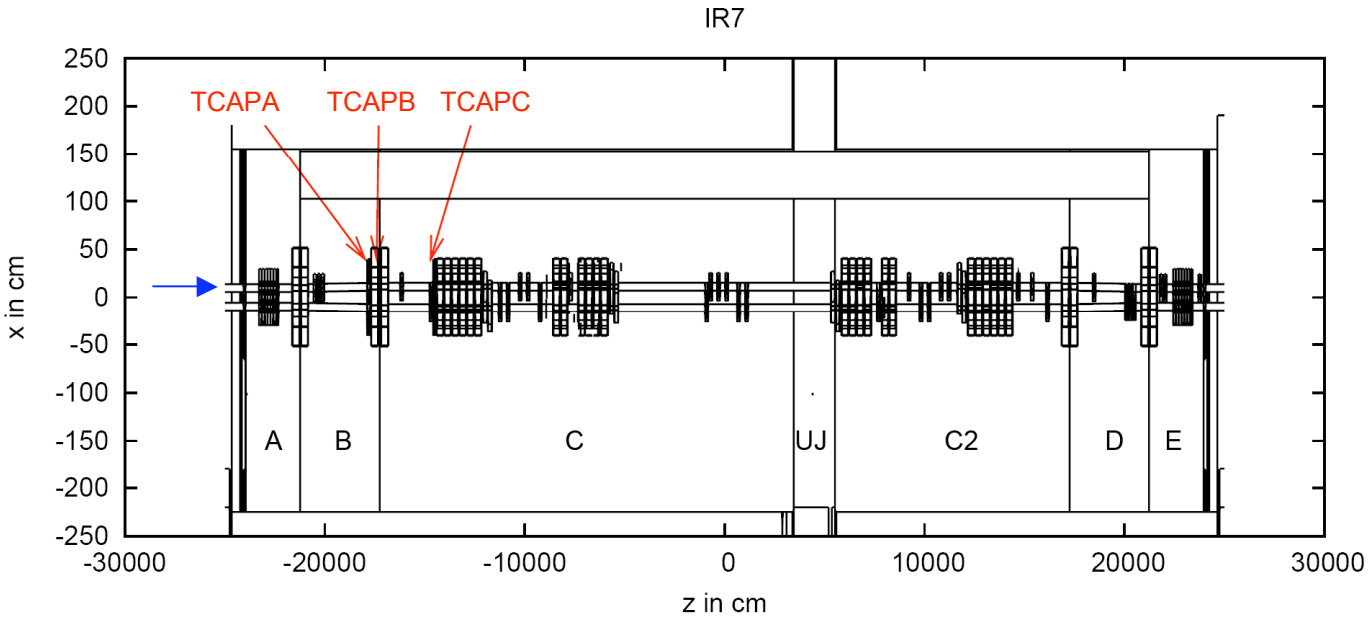
Collimation Working Group
12 July 2007

Radiation Protection Aspects

"Direct"
1) Induced radioactivity in components – dose to personnel
2) Air activation – dose to population and personnel
3) Cooling water activation – dose to population and personnel

"Indirect"
4) Damage to equipment – dose to personnel

FLUKA calculations



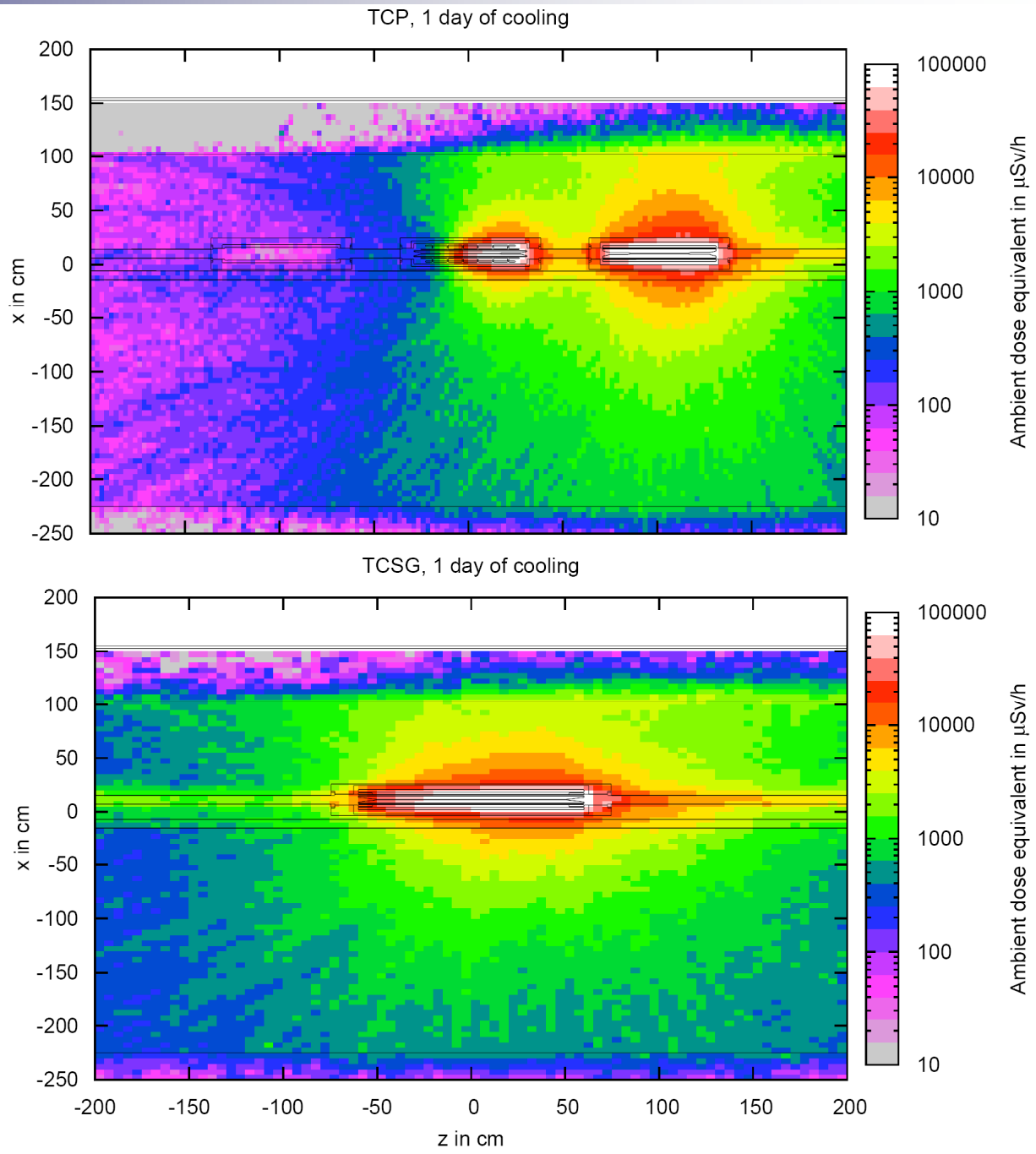
- same geometry as for energy deposition studies
- passive absorber with and without iron shielding
- 180 days of operation at nominal intensity
- annual loss (M.Lamont): 1.15 x 10^{16} protons per beam
- horizontal losses

Residual dose rates

One day of cooling

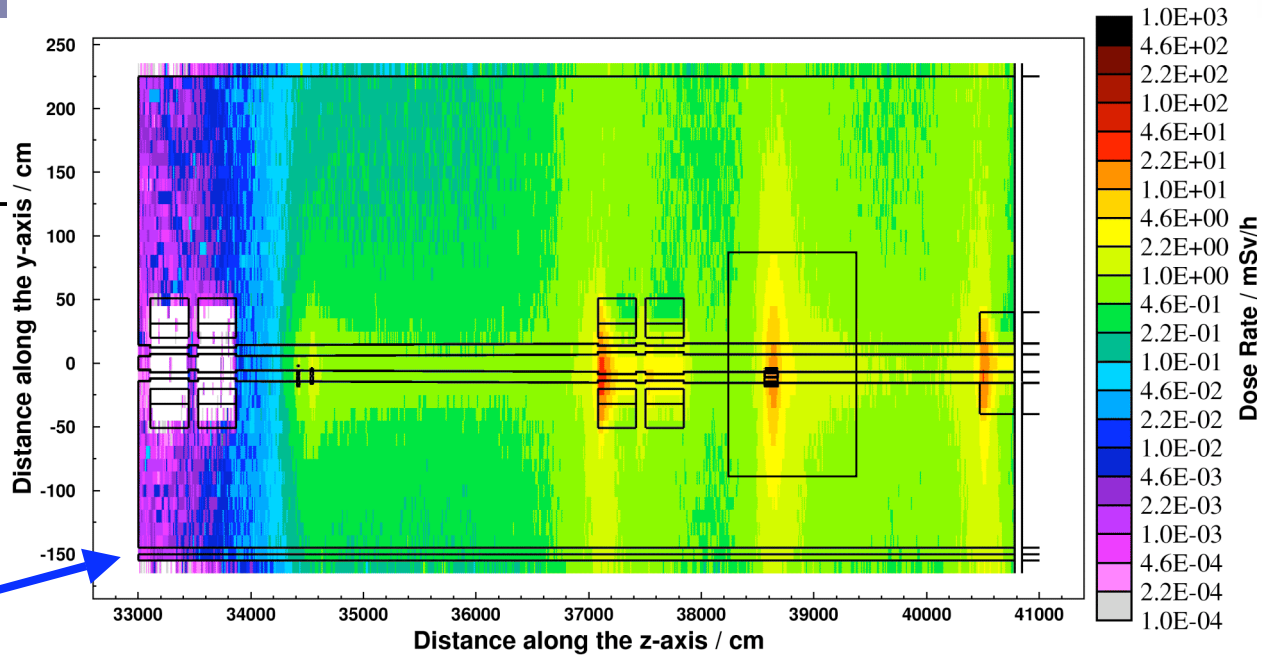
primary collimator

first secondary collimator



Residual dose rates

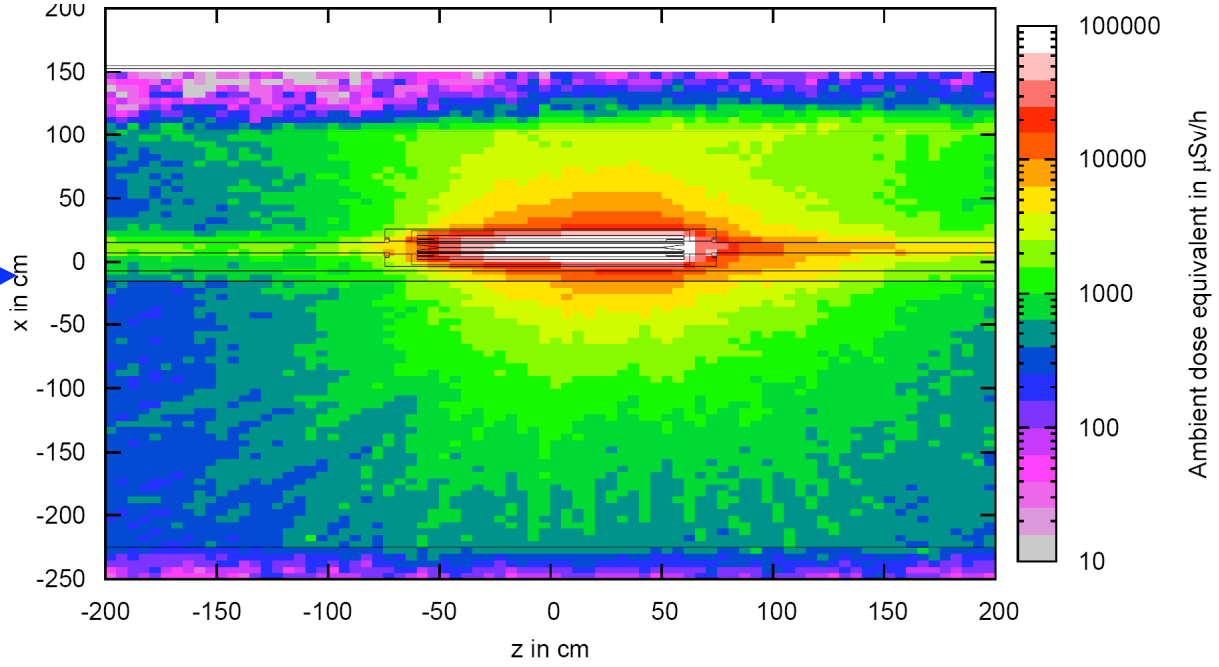
One day of cooling
first secondary collimator



Brugger et al. (2005)

- less sophisticated geometry
- factor 2 higher losses

This study



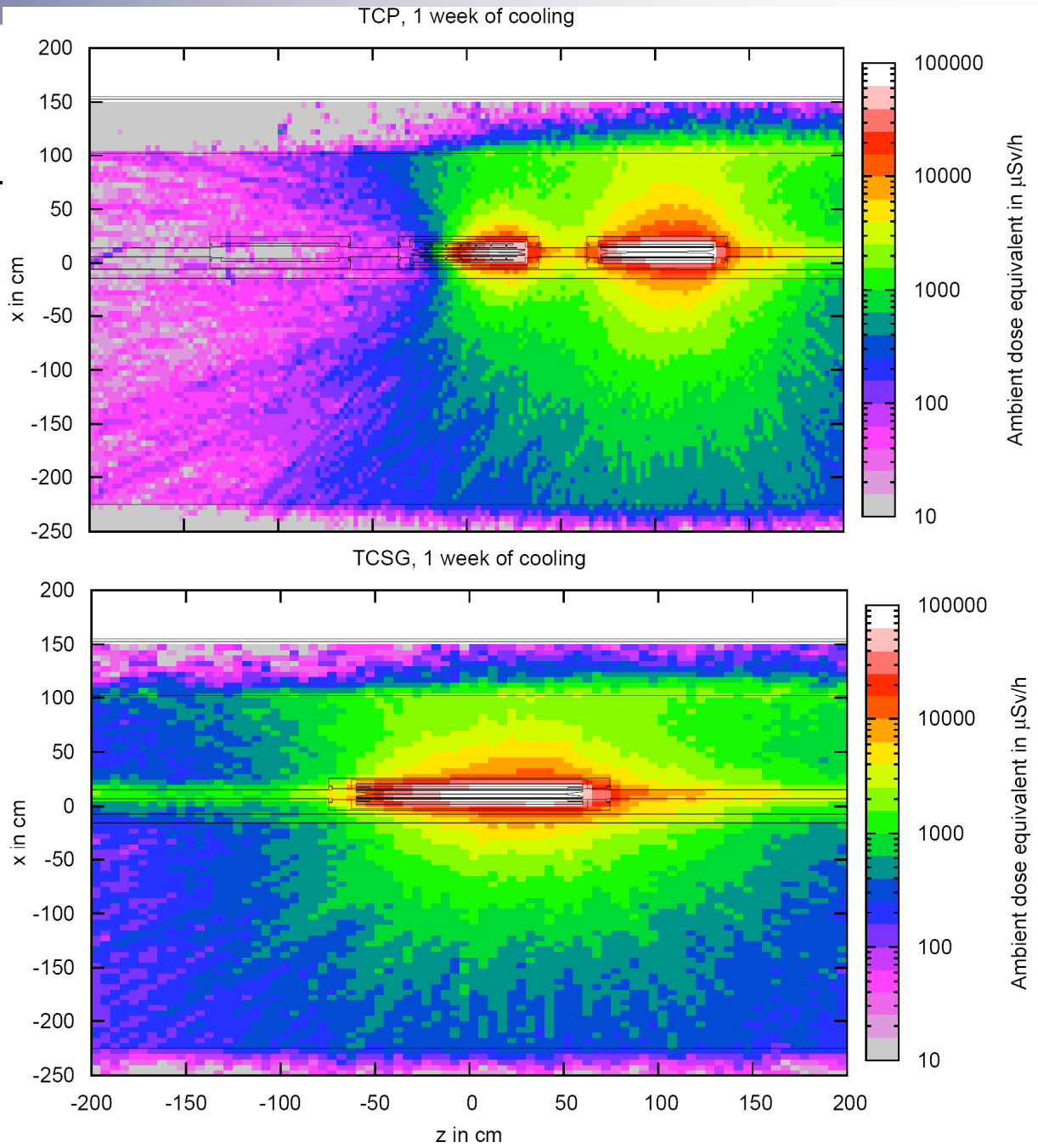
Good agreement with previous studies !

Residual dose rates

One week of cooling

primary collimator

first secondary collimator

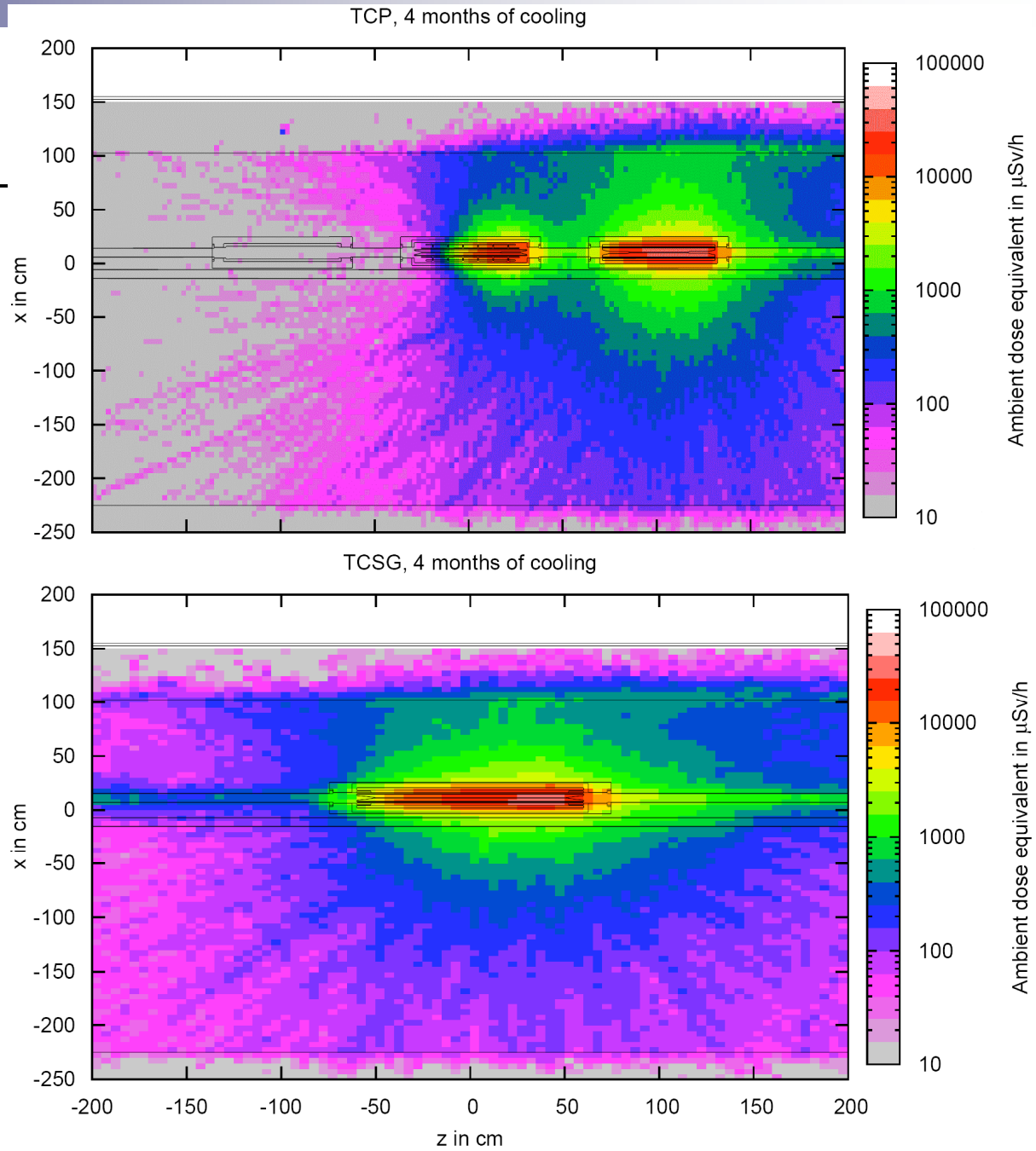


Residual dose rates

Four months of cooling

primary collimator

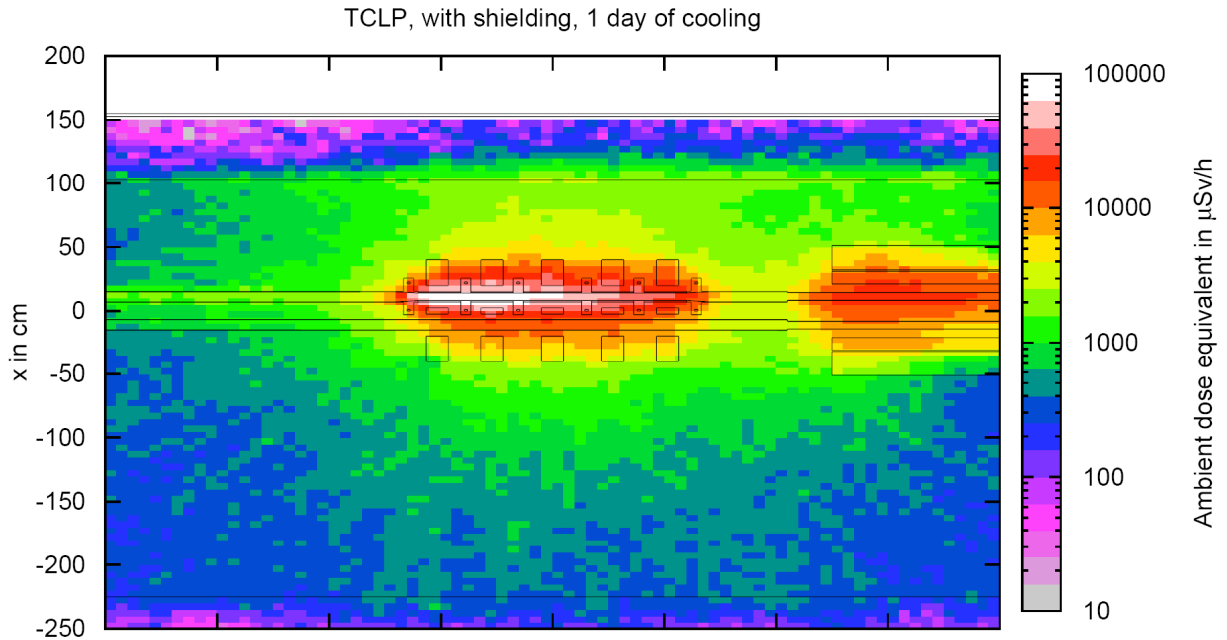
first secondary collimator



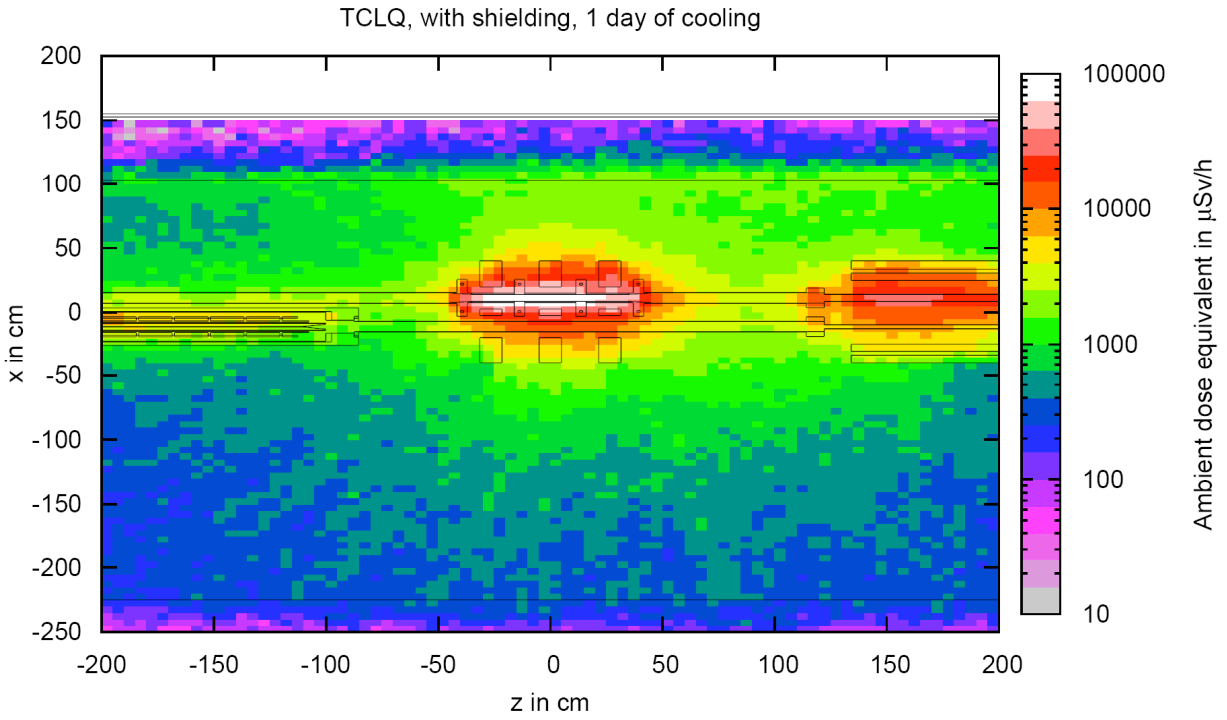
Residual dose rates

One day of cooling

TCAPA



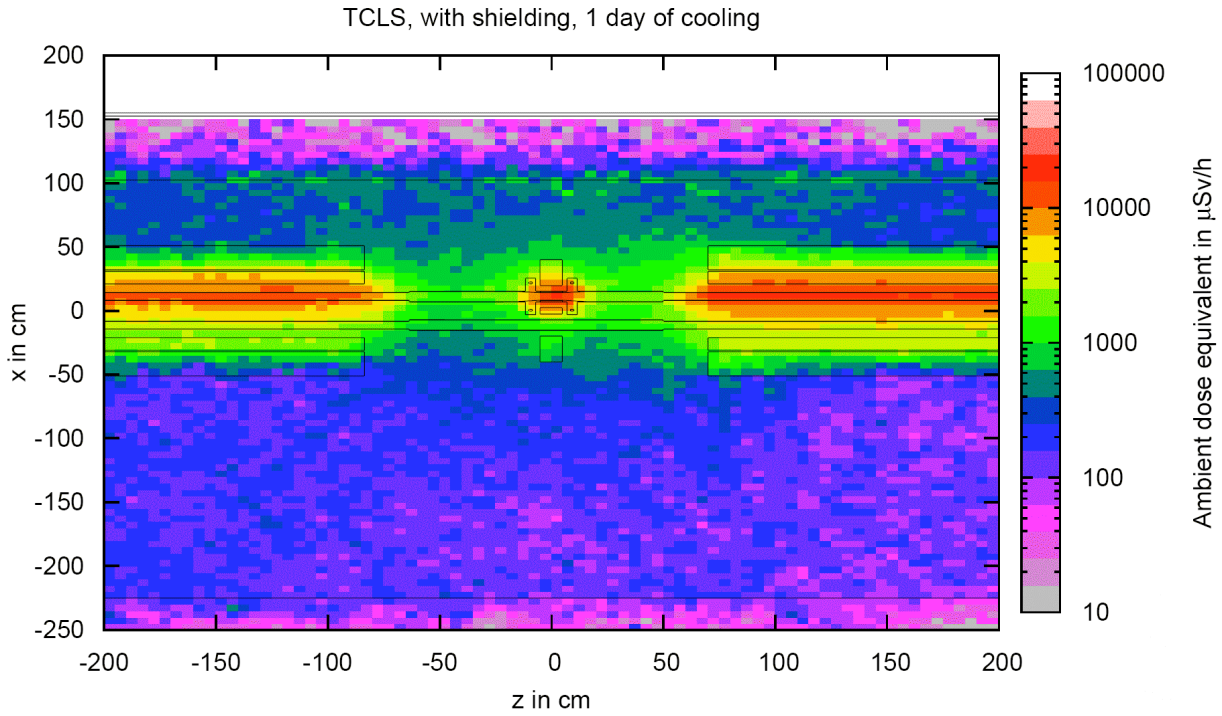
TCAPC



Residual dose rates

One day of cooling

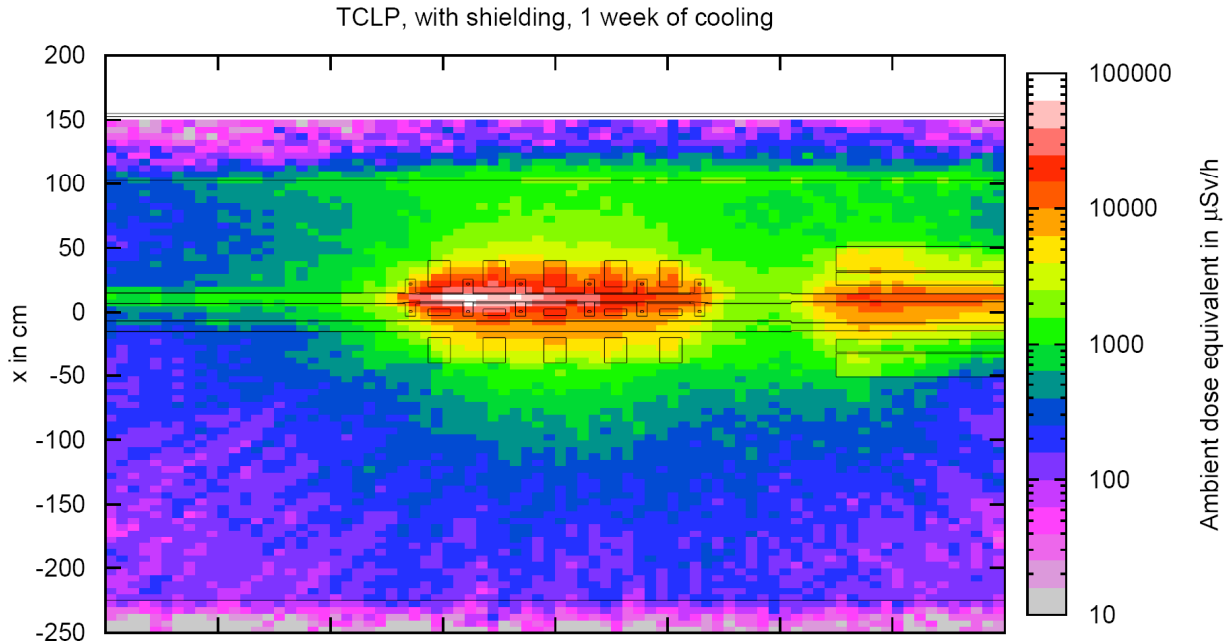
TCAPB



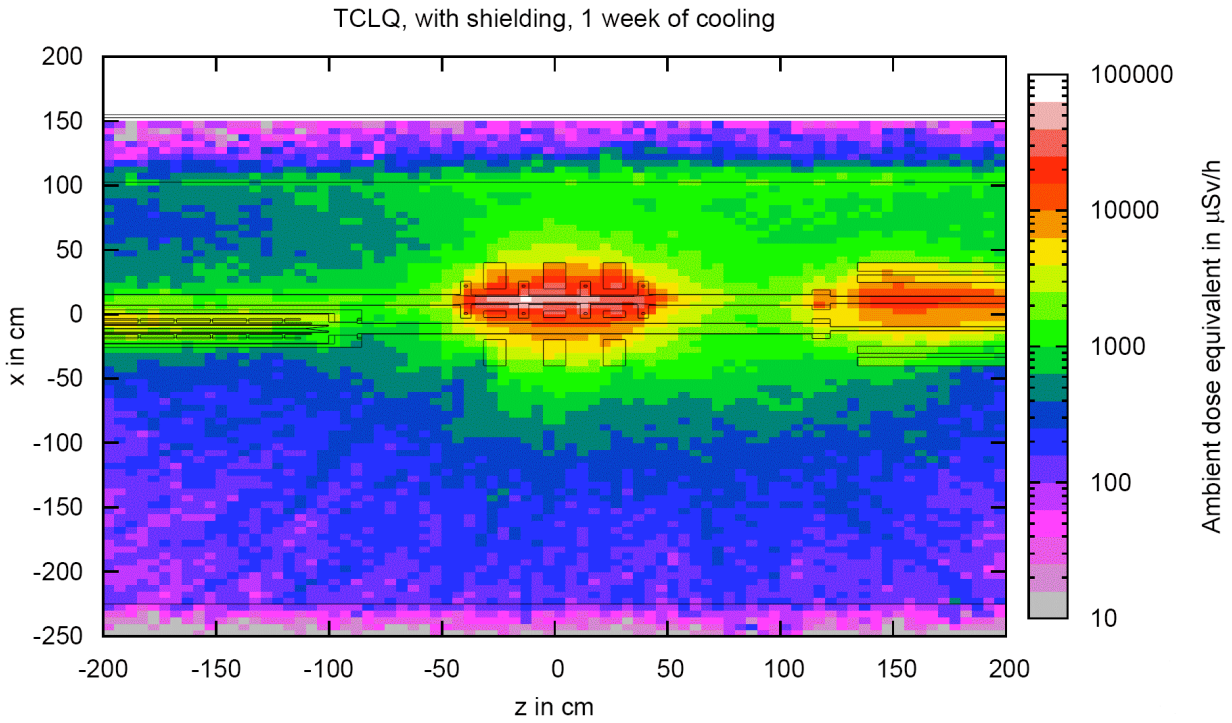
Residual dose rates

One week of cooling

TCAPA



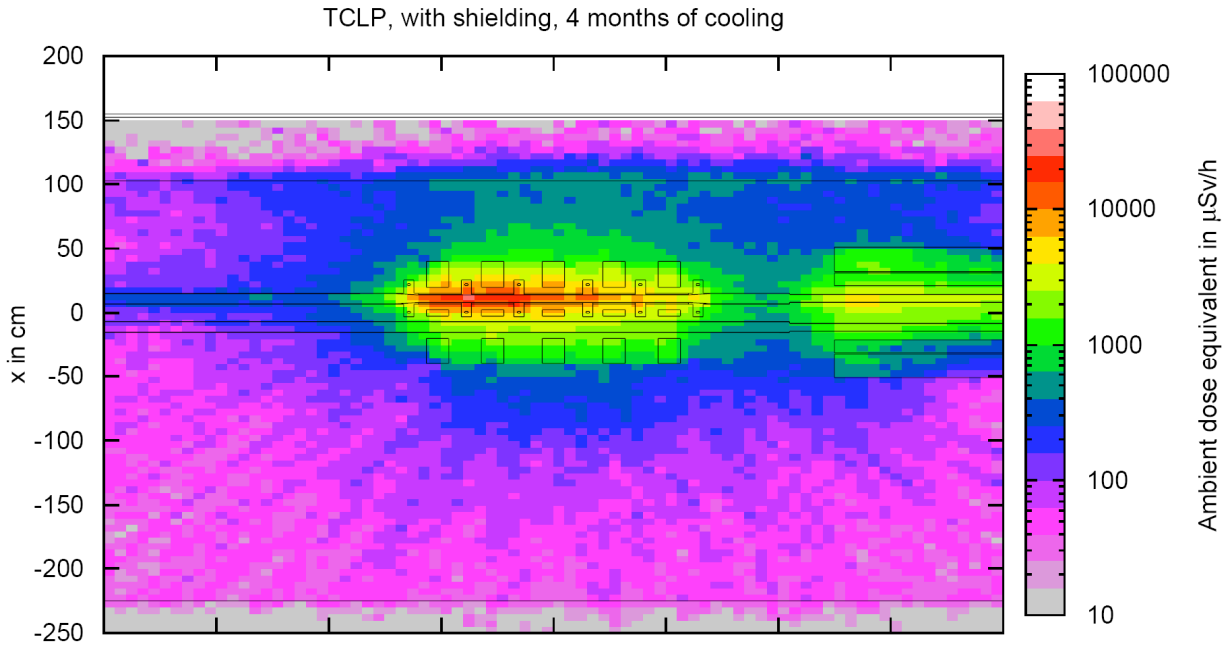
TCAPC



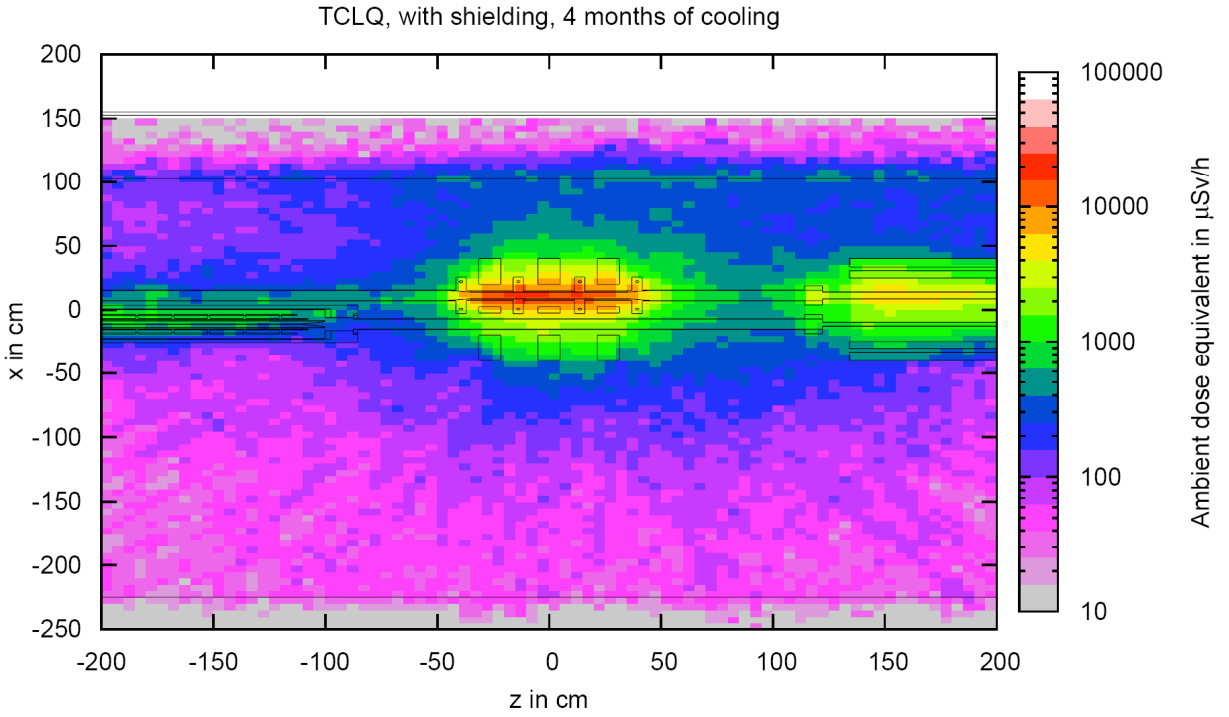
Residual dose rates

Four months of cooling

TCAPA



TCAPC

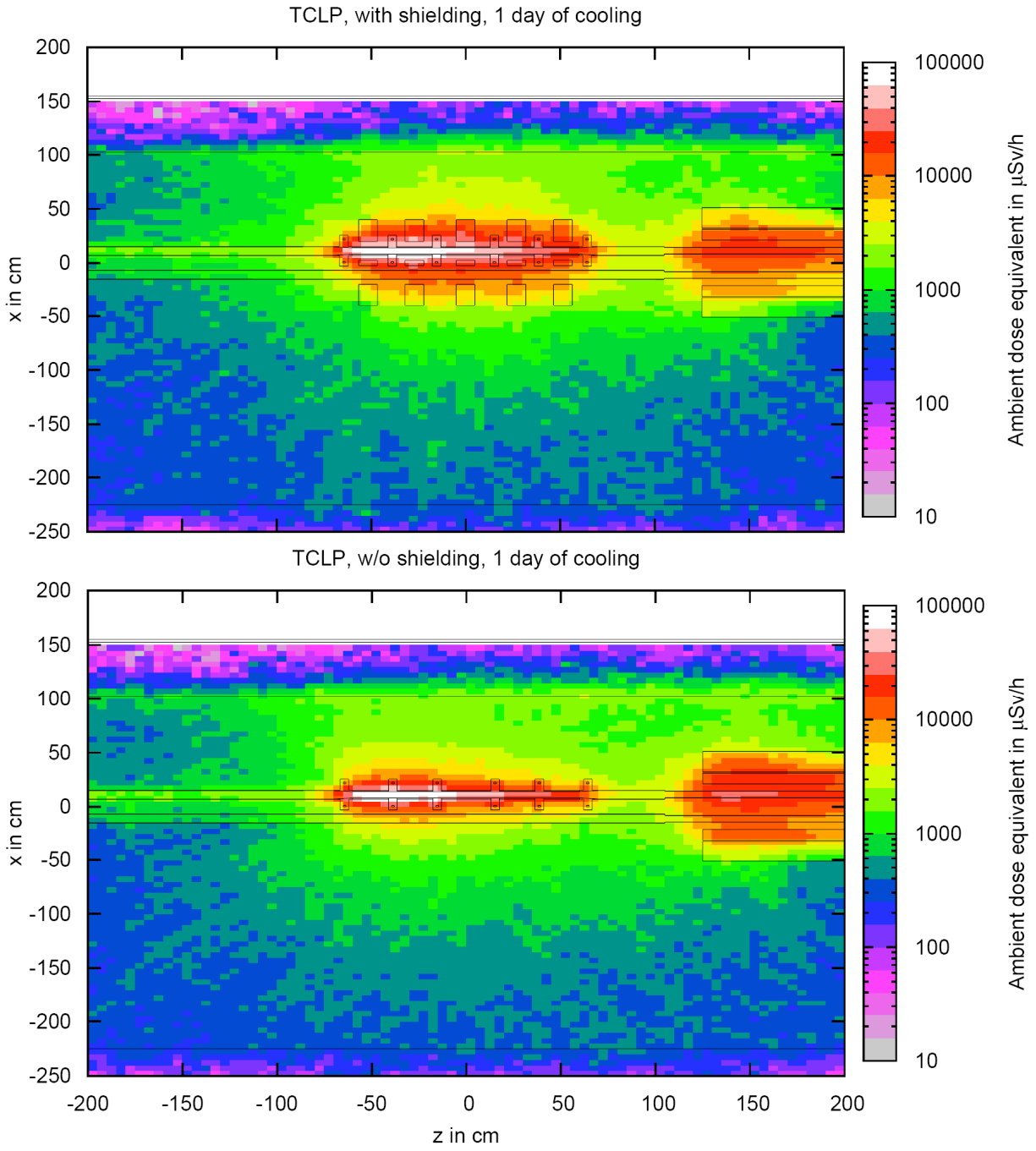


Residual dose rates

One day of cooling

TCAPA *with* shielding

TCAPA *without* shielding

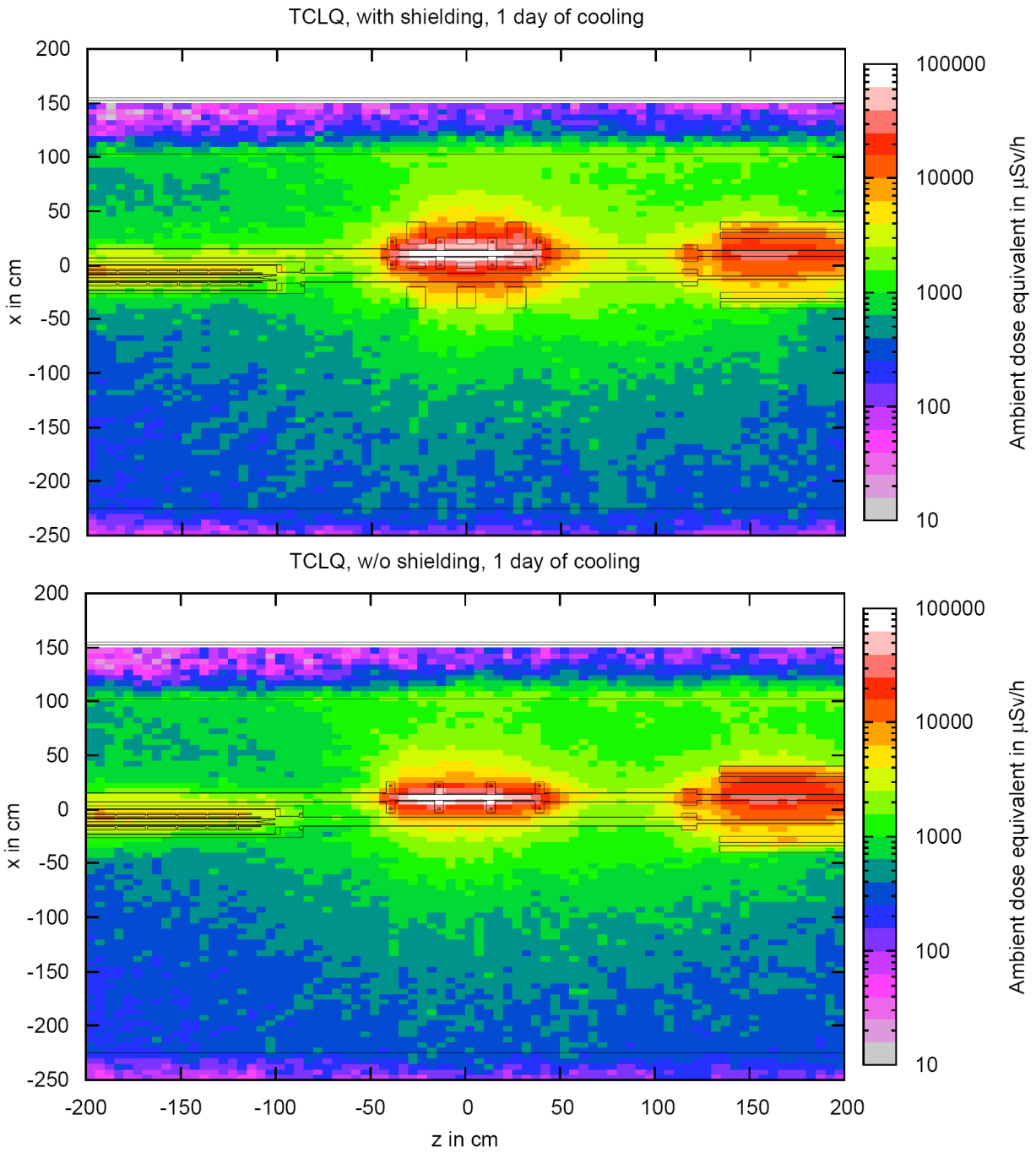


Residual dose rates

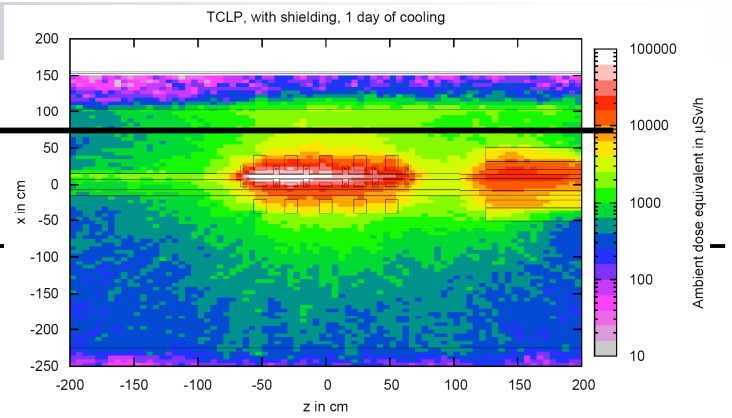
One day of cooling

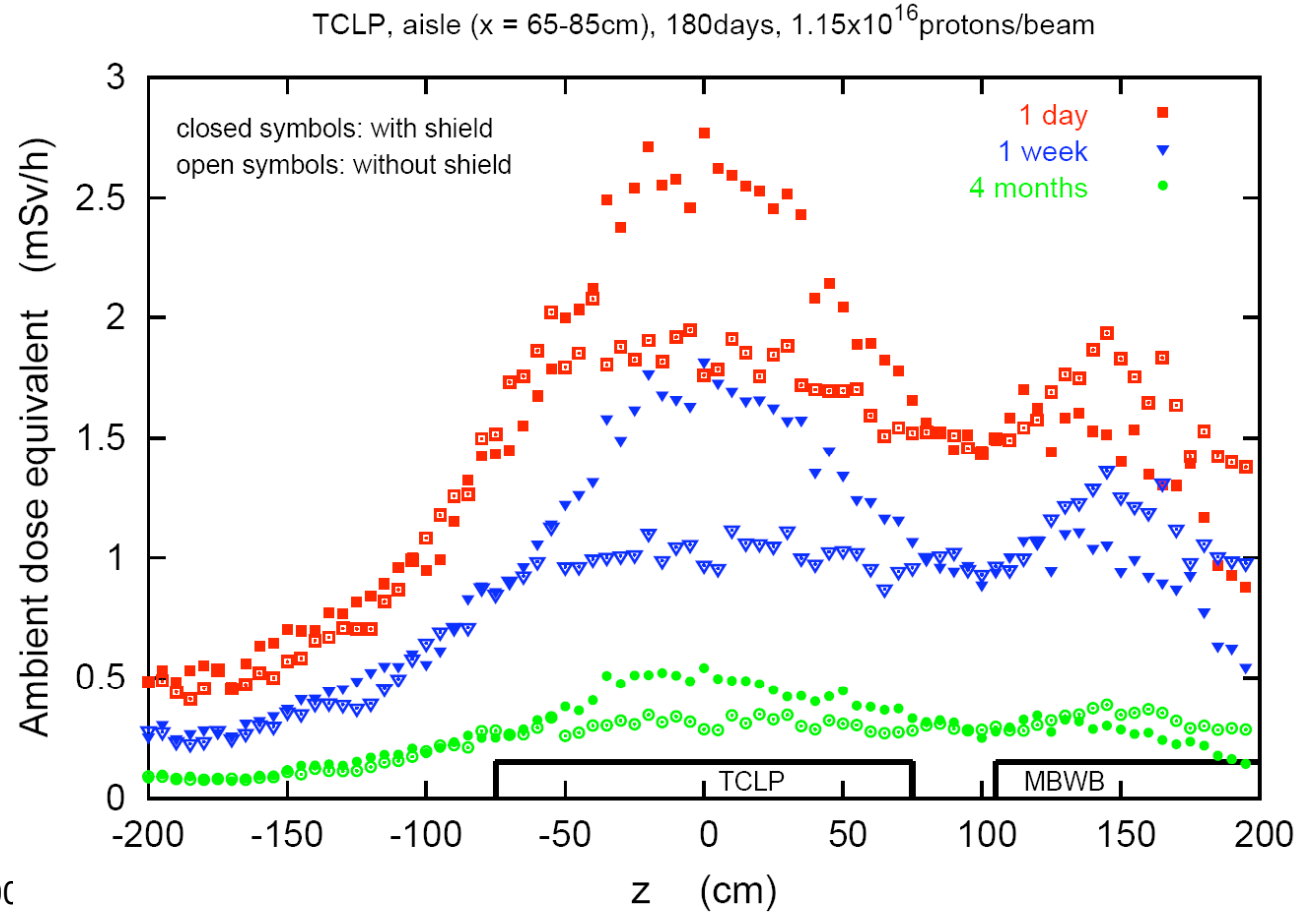
TCAPC *with* shielding

TCAPC *without* shielding

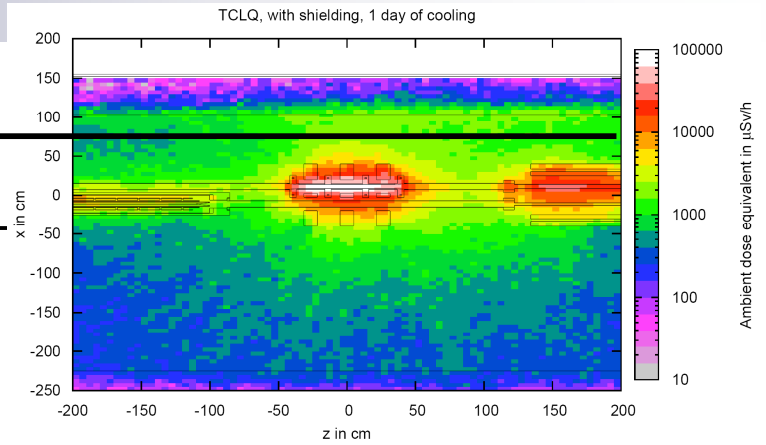


Residual dose rates - *TCAPA*

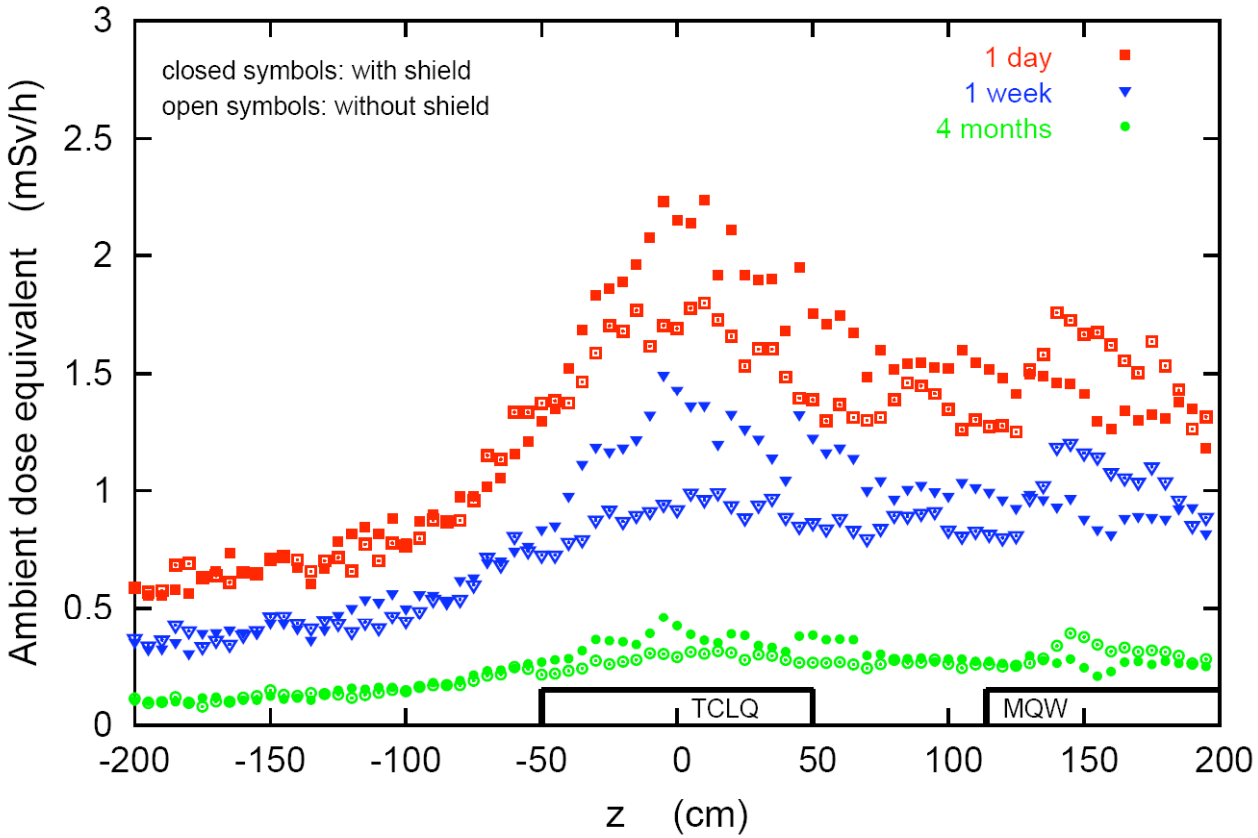




Residual dose rates - *TCAPC*

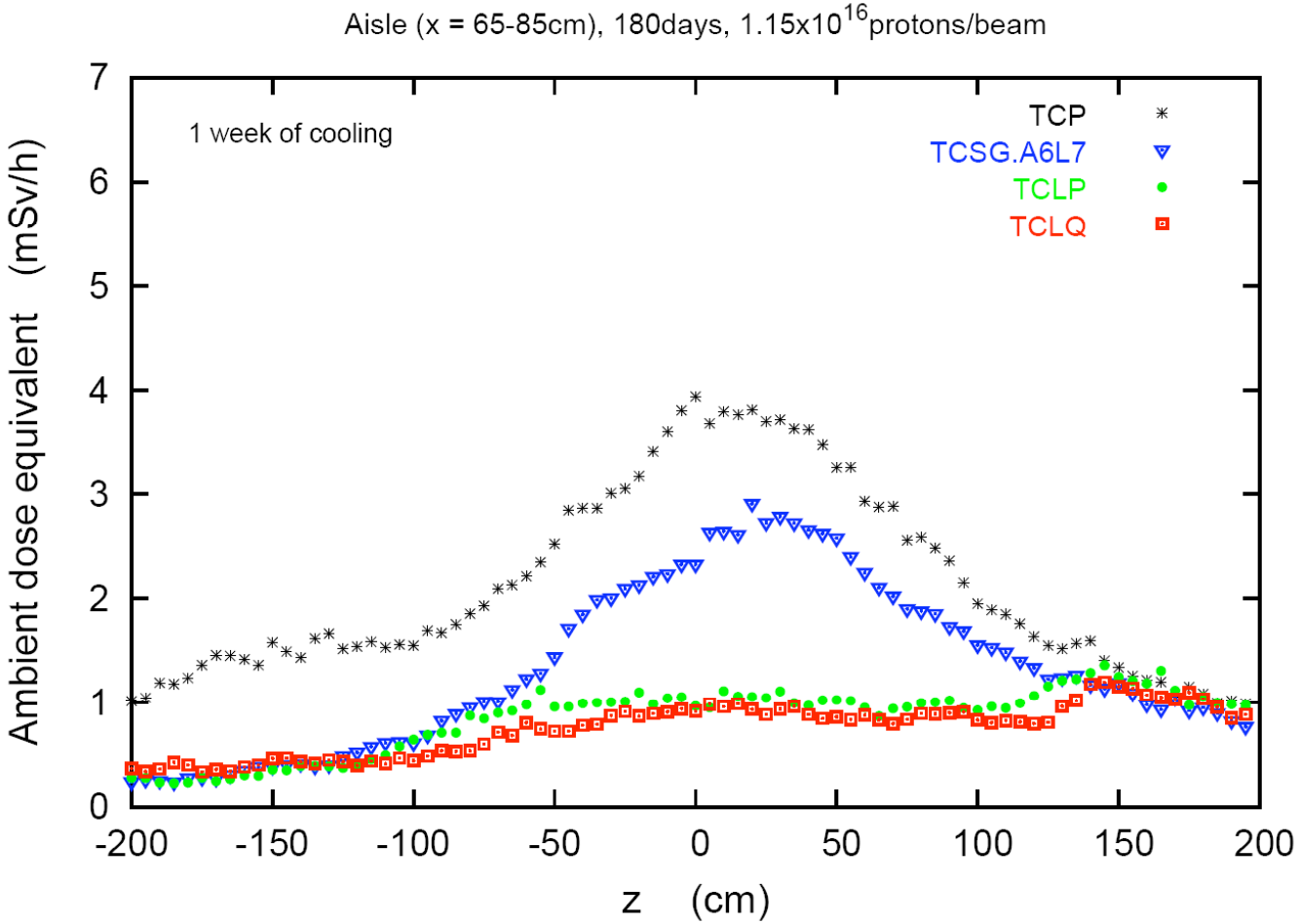


TCLQ, aisle (x = 65-85cm), 180days, 1.15x10^{16}protons/beam



Residual dose rates – *TCP / TCSG / TCAPA / TCAPC*

One week of cooling



Area classification

6. TABLES

Table 1 — Synopsis of the classification of Non-designated and Radiation Areas at CERN

	Area classification	Dose limit	Ambient dose equivalent rate		Specific airborne radioactivity	Specific surface contamination	Access, Personnel categories	Monitoring, Personal dosimetry
			At permant workplaces	In low-occupancy areas				
	Non-designated Area	1 mSv / y	< 0.5 µSv h^{-1}	< 2.5 µSv h^{-1}	0.05 CA	-	no restriction, all	passive or active, not required
	Supervised Radiation Area	6 mSv / y	< 3 µSv h^{-1}	< 15 µSv h^{-1}	< 0.1 CA		supervised, radiation workers and VCT	passive or active, personal dosimeter
Controlled Radiation Area	Simple Controlled Radiation Area		< 10 µSv h^{-1}	< 50 µSv h^{-1}	< 0.1 CA			active, personal dosimeter
	Limited Stay Area	20 mSv / y		< 2 mSv h^{-1}	<100 CA	< 4000 CS	controlled, radiation workers	active, personal dosimeter and operational dosimeter
	High Radiation Area			<100 mSv h^{-1}	< 1000 CA	< 40000 CS		
	Prohibited Area			> 100 mSv h^{-1}	> 1000 CA	> 40000 CS		

ALARA - 1

CERN
CH1211 Genève 23
Suisse

Nº EDMS	REV.	VALIDITÉ
810176	**1.0**	**APPROUVÉ**

RÉFÉRENCE
RGE section **9 / S5-GSI1**

Date : 2006-12-20

INSTRUCTION GÉNÉRALE DE SÉCURITÉ

RÈGLES GÉNÉRALES D'EXPLOITATION
CONSIGNES GÉNÉRALES DE RADIOPROTECTION

CRITÈRES ET EXIGENCES ALARA
APPLICABLES AUX INTERVENTIONS

DOCUMENT PRÉPARÉ PAR :	DOCUMENT VÉRIFIÉ PAR :	DOCUMENT APPROUVÉ PAR :
Pierre Bonnal / AB Doris Forkel-Wirth / SC	Thomas Otto / SC	Hans-Georg Menzel / SC

GROUPE D'APPROBATION

2. CRITÈRES

2.1 CRITÈRE DE DÉBIT DE DOSE

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

	50 µSv·h^{-1}	**2 mSv·h^{-1}**
niveau I	niveau II	niveau III

2.2 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

2.3 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 µSv	**10 mSv**
niveau I	niveau II	niveau III

ALARA - 2

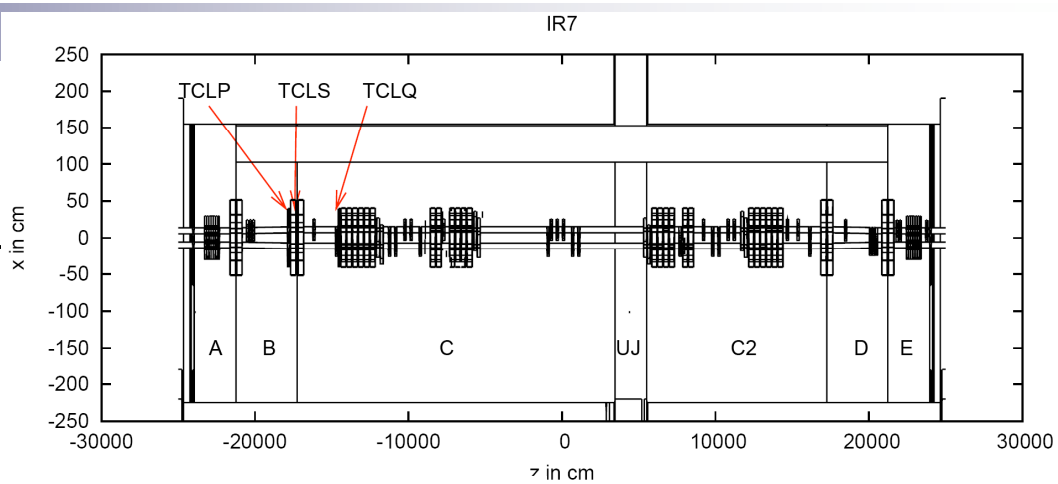
Tableau 1 — Synthèse des exigences.

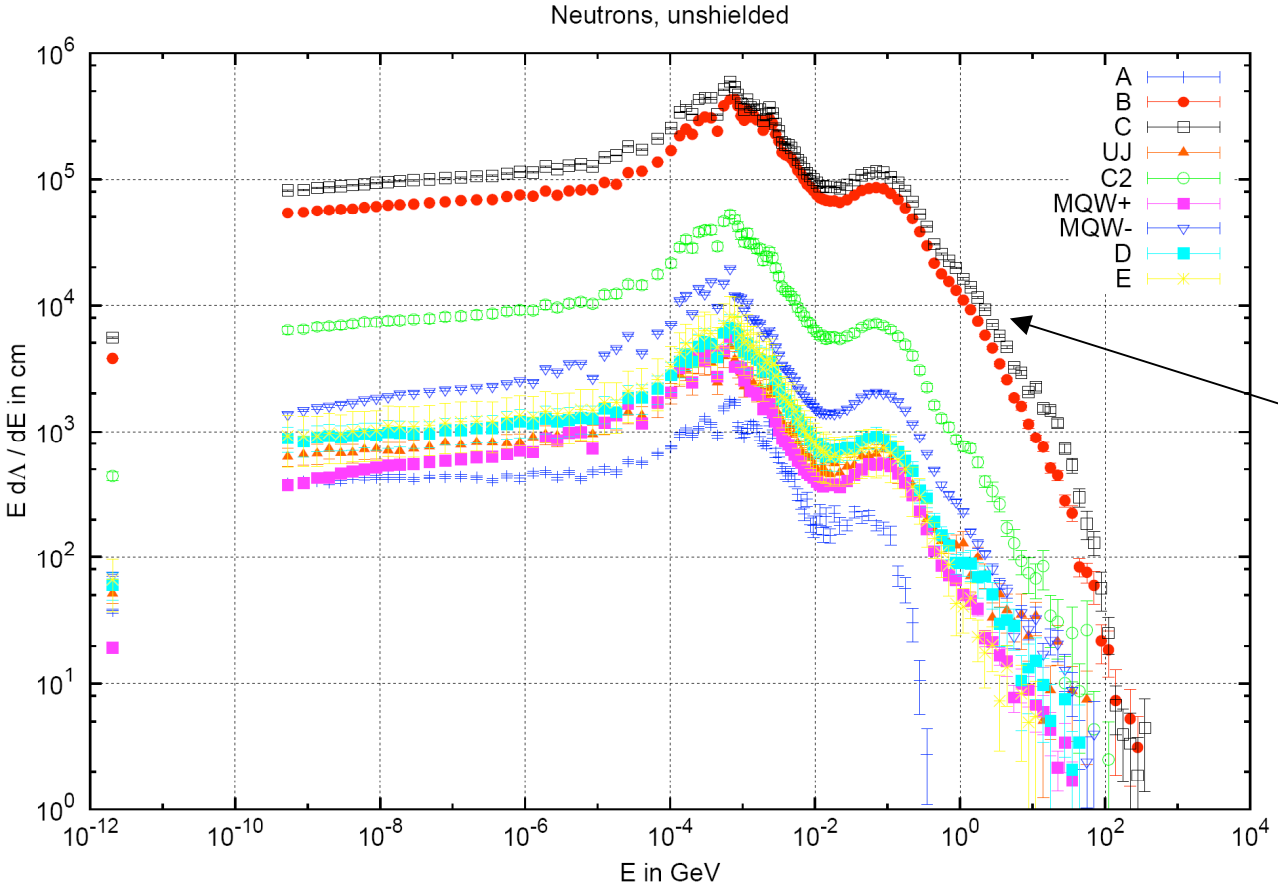
Type d'intervention		répétitives / génériques			ponctuels / unitaires		
Niveau de risque		I	II	III	I	II	III
Dosimétrie individuelle		●	●	●	●	●	●
Dosimétrie opérationnelle sans alarme		●			●		
Dosimétrie opérationnelle avec alarme			●	●		●	●
Dossier de sécurité	Docts. descriptifs		○	○			○
	Docts. justificatifs		○	●			●
	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
○ recommended

Air activation

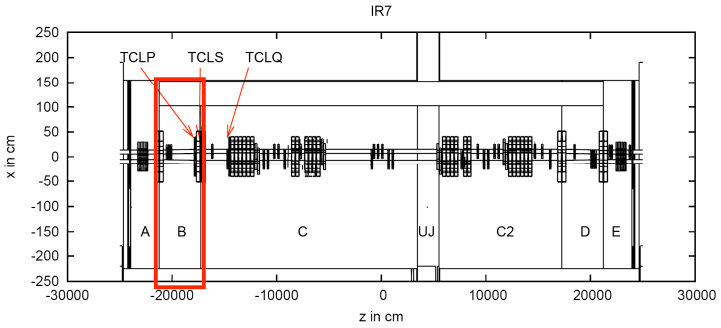
Track-length spectra

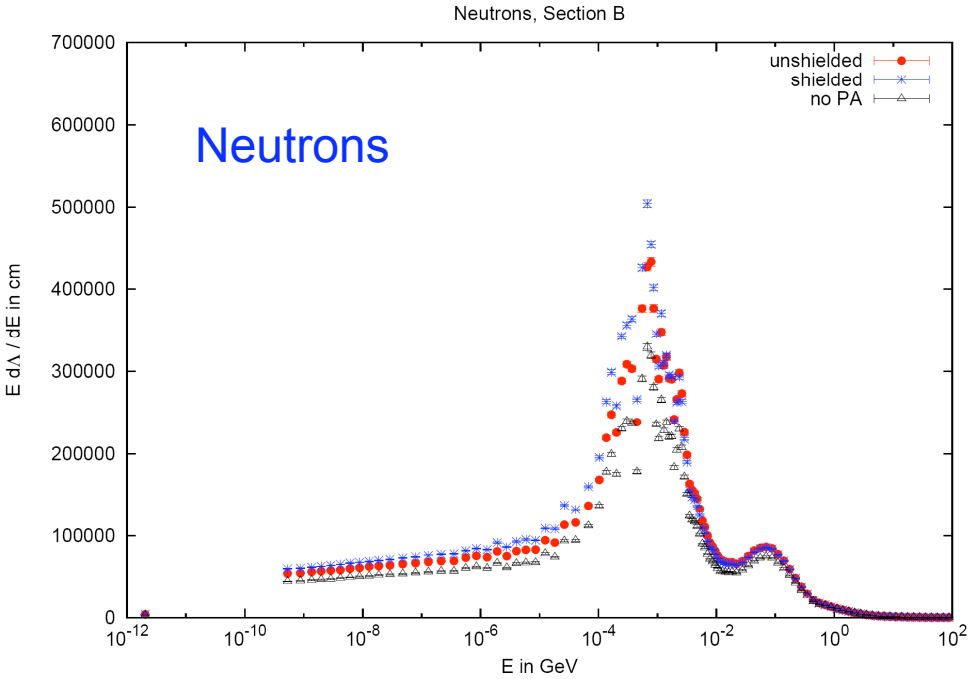


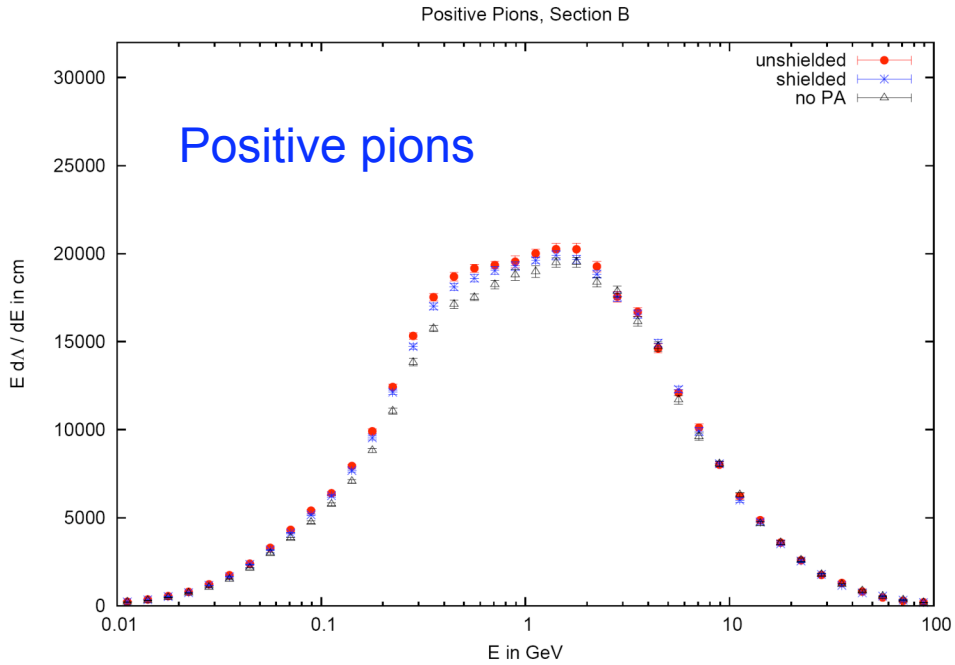


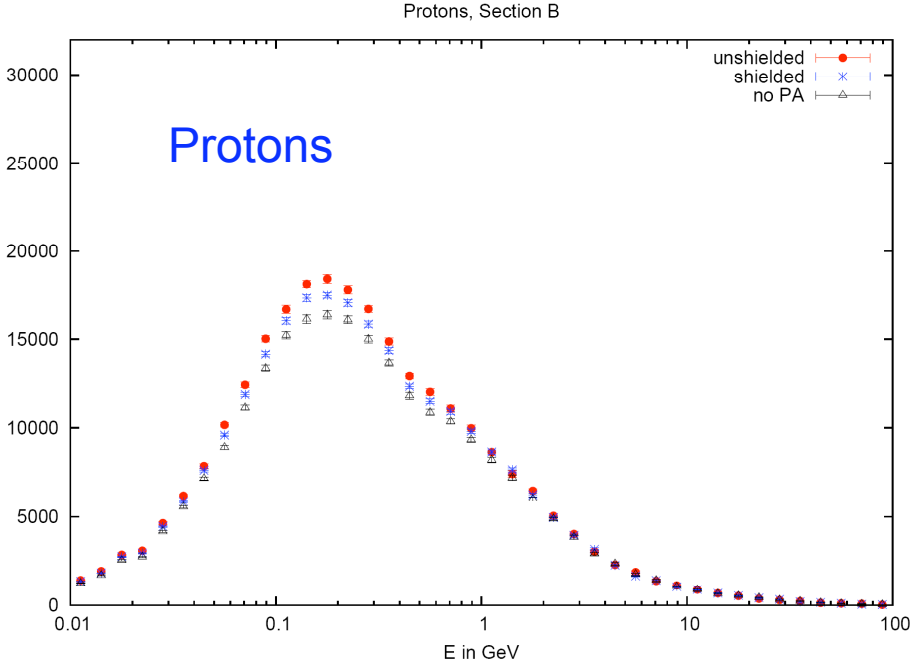
activation in sections B and C dominates

Air activation – *Section B*

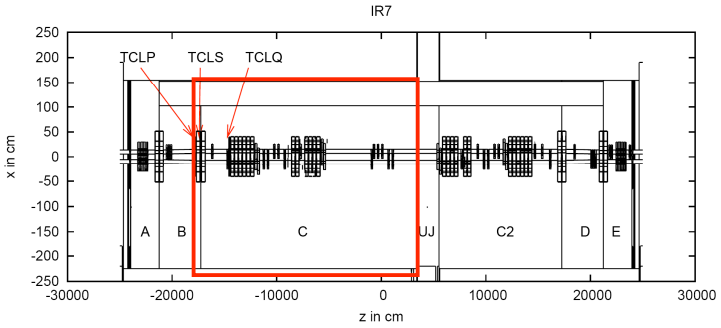


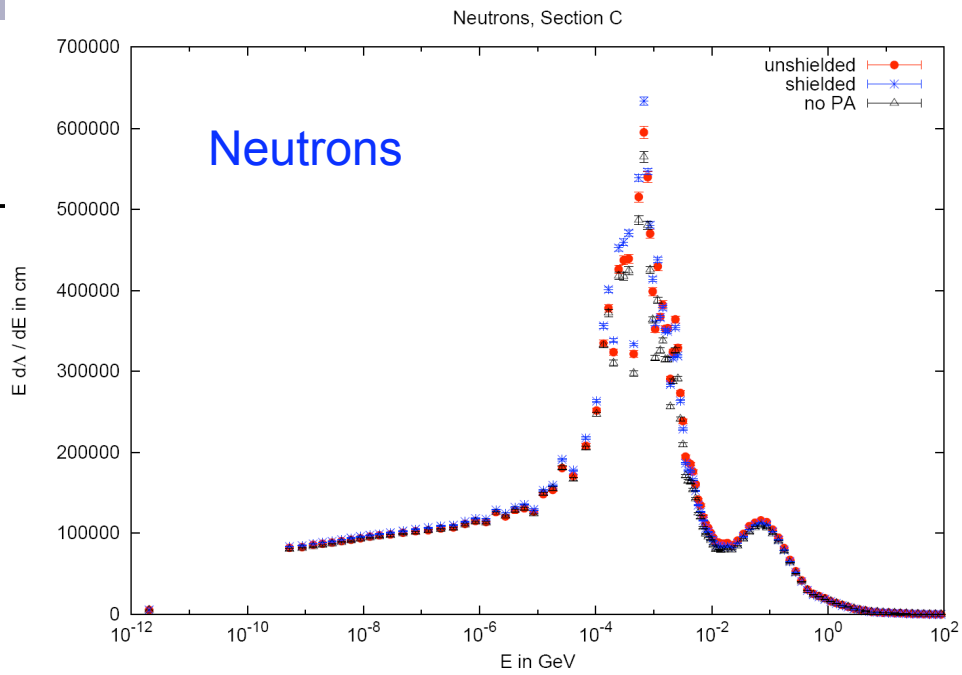


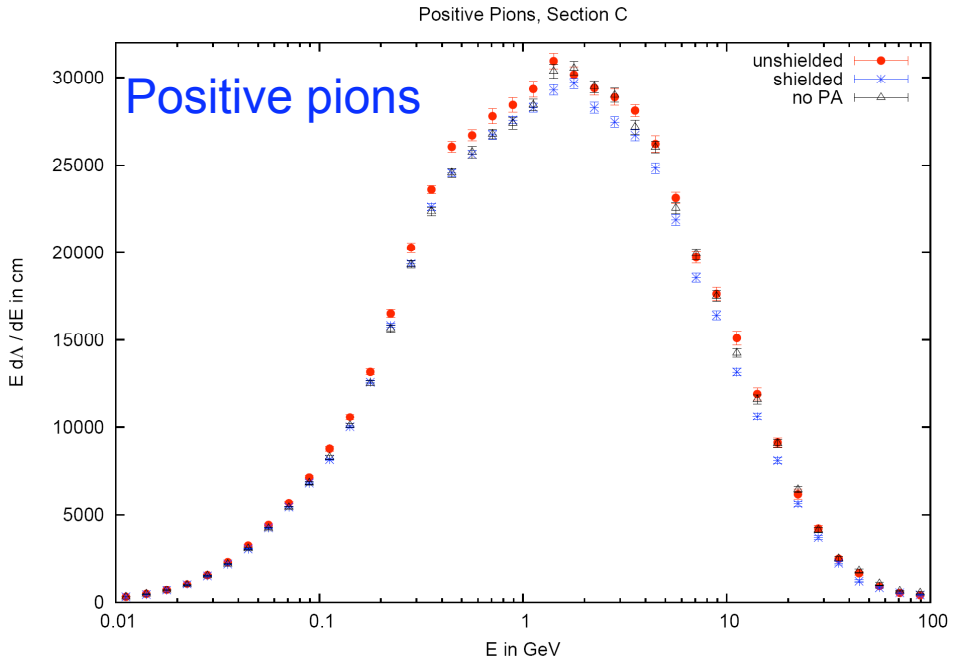


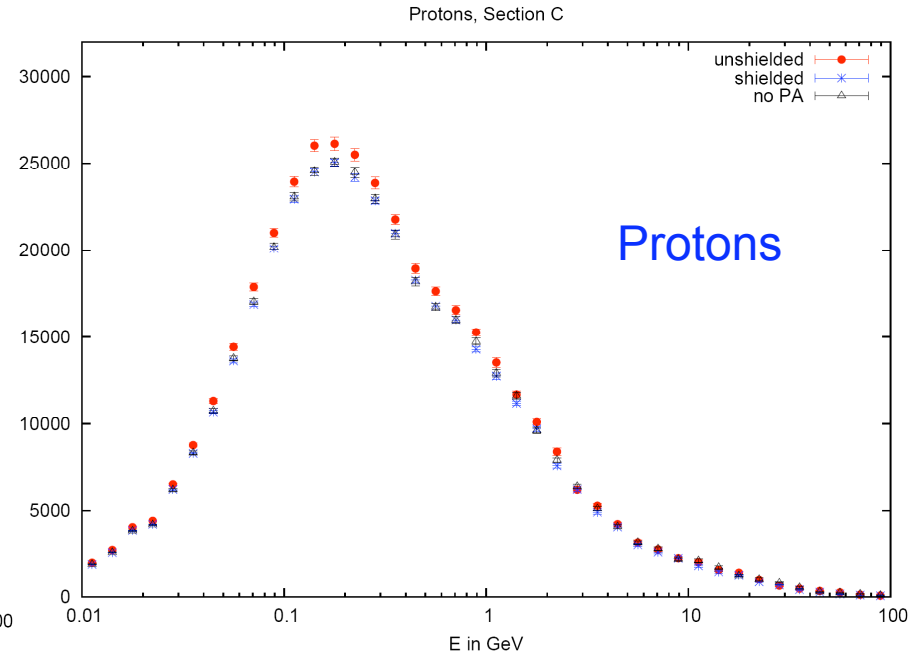


Air activation – *Section C*









Summary - 1

"Direct" 1) Induced radioactivity in components – dose to personnel

- dose rates at PA about one half of that at first secondary collimator
- iron slabs increase dose rates at PA by 20-30% and decrease dose rates at magnets by about 20%
- short cooling times (up to one week): several 10 mSv/h on contact
  about 1 mSv/h in aisle
- long cooling times (>1 month): several mSv/h on contact
  several 100 μSv/h in aisle
- received doses have not yet been calculated (scenarios needed)
- classification as high radiation area
- work planning and optimization according to ALARA Level 2 or 3

2) Air activation – dose to population and personnel

- small impact on air activation expected (within 10%)
- isotope production has still to be calculated

Summary - 2

"Direct" 3) Cooling water activation – dose to population

- additional contribution not yet studied but no significant change of total activity expected
- cautions for PA handling similar to collimators and magnets

"Indirect" 4) Damage to equipment – dose to personnel

- increased lifetime of warm magnets (positive!)
- increased damage to cables in vicinity, not yet studied but expected to be similar or lower than at collimators

Summary - 3

Uncertainties:

- annual loss (1.15 x 10^{16} protons per beam)
- Phase 2 collimators not considered (but losses at nominal intensity used)
- distribution of losses among different collimators, here only horizontal losses considered (conservative?), will change with Phase 2 collimators
- FLUKA geometry (factor 2?), models and methods (< 30%)
- statistical uncertainties (~10%)

Open questions (?):

- water flow control
- water handling during exchange
- alignment
- scenarios for work on PA's (*e.g.,* replacement) and on any components in their vicinity
- structural damage and containment of the tungsten (brittle under radiation?)