

# Handling Electronics from Radiation Areas

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# Radiation Protection

The protection of people from the effects of ionizing radiation, and the means for achieving this.

It implies

- risk assessment of workplaces in radiation areas
- risk assessment of handling and transforming material from radiation areas

The outcome of the risk assessment defines the precautions to be respected



Isotope	Copper		Iron		Titanium		Stainless Steel		Aluminum		Concrete	
<sup>7</sup> Be 53.29d	1.47 ± 0.19	M	1.65 ± 0.22		1.50 ± 0.19		0.98 ± 0.24	M, C, N	0.71 ± 0.09	Al	1.17 ± 0.14	O, C
	0.84 ± 0.25		0.90 ± 0.15									
<sup>22</sup> Na 2.60y	0.72 ± 0.11		0.70 ± 0.13	M	0.85 ± 0.11				0.76 ± 0.07	Al	0.86 ± 0.09	Ca, (Si, Mg)
<sup>24</sup> Na 14.96h	0.42 ± 0.03		0.48 ± 0.02		0.63 ± 0.02		0.37 ± 0.02	Fe, (Cr, Si)	0.81 ± 0.03	Al, Mg	0.62 ± 0.02	Ca, (Si, Al)
<sup>27</sup> Mg 9.46m					0.79 ± 0.14	M			1.52 ± 0.25	Al, Mg		
<sup>28</sup> Mg 20.91h	0.25 ± 0.04	-	0.23 ± 0.03	-	0.31 ± 0.02	-	0.29 ± 0.10	M- Fe, Ni, Si			0.29 ± 0.02	- Ca, (Si)
<sup>28</sup> Al 2.24m	0.25 ± 0.03	-	0.21 ± 0.02	-	0.31 ± 0.02	-	0.29 ± 0.10	M- Fe, Ni, Si			0.29 ± 0.03	- Ca, (Si)
<sup>28</sup> Al 6.56m					0.93 ± 0.25	M						
<sup>38</sup> S 2.84h					0.60 ± 0.12	-						
<sup>m34</sup> Cl 32.00m			0.91 ± 0.19	M	1.19 ± 0.16		0.77 ± 0.15	Fe, Cr, (Mn)			1.25 ± 0.07	Ca
<sup>38</sup> Cl 37.24m			0.61 ± 0.08		0.60 ± 0.01		0.58 ± 0.07	Fe, Cr, (Mn)				
<sup>39</sup> Cl 55.60m			0.64 ± 0.11	M	0.73 ± 0.08		0.66 ± 0.12	Fe, Cr, (Mn)				
<sup>41</sup> Ar 1.82h	0.39 ± 0.06		0.46 ± 0.05		0.47 ± 0.04	-	0.38 ± 0.05	Fe, Cr, (Mn)			0.98 ± 0.14	Ca
<sup>38</sup> K 7.64m											1.76 ± 0.20	- Ca
<sup>42</sup> K 12.36h	0.86 ± 0.10		0.83 ± 0.06		0.95 ± 0.05		0.76 ± 0.09	Fe, Cr, (Mn)			1.21 ± 0.08	Ca
<sup>43</sup> K 22.30h	0.81 ± 0.10	-	0.77 ± 0.05		0.85 ± 0.03		0.74 ± 0.04	Fe, Cr, (Mn)			1.16 ± 0.05	Ca
<sup>44</sup> K 22.13m												
<sup>45</sup> K 17.30m												
<sup>47</sup> Ca 4.54d	0.59 ± 0.16		0.56 ± 0.17	M	0.73 ± 0.12		0.51 ± 0.15	M Fe, Cr, (Mn)			0.79 ± 0.12	Ca
<sup>43</sup> Sc 3.89h	0.40 ± 0.07	-	1.01 ± 0.14		1.28 ± 0.28	-	0.93 ± 0.15	Fe, Cr, (Mn)				
<sup>44</sup> Sc 3.93h	0.89 ± 0.07		1.06 ± 0.06		0.88 ± 0.05		0.96 ± 0.08	Fe, Cr, (Mn)			0.83 ± 0.06	Fe, (Ti)
<sup>m44</sup> Sc 58.60h	0.95 ± 0.12		1.20 ± 0.09		2.13 ± 0.12		1.24 ± 0.09	Fe, Cr, (Mn)	1.08 ± 0.17	Fe, Mn	1.67 ± 0.22	Fe, (Ti)
<sup>46</sup> Sc 83.79d	0.81 ± 0.07		0.86 ± 0.07		0.93 ± 0.08		0.89 ± 0.08	Fe, Cr, (Mn)	0.79 ± 0.18	Mn, (Ti, Fe)	0.88 ± 0.10	Fe, (Ti)
<sup>47</sup> Sc 80.28h	1.09 ± 0.14		1.17 ± 0.10	-	0.87 ± 0.07		1.06 ± 0.09	Fe, Cr, (Mn)	1.04 ± 0.15	Mn, (Ti, Fe)	1.00 ± 0.09	Fe, Ti, (Ca)
<sup>48</sup> Sc 43.67h	1.39 ± 0.16		1.47 ± 0.10		1.10 ± 0.04		1.42 ± 0.08	Fe, Cr, (Mn)			1.36 ± 0.25	Fe, Ti, (Ca)
<sup>48</sup> V 15.97d	1.16 ± 0.08		1.45 ± 0.06		1.11 ± 0.07		1.44 ± 0.11	Fe, Cr, (Mn)	1.07 ± 0.13	Fe, Mn	1.63 ± 0.16	Fe
<sup>48</sup> Cr 21.56h	0.92 ± 0.14		0.97 ± 0.07				1.02 ± 0.08	Fe, (Cr)			1.06 ± 0.23	M Fe
<sup>49</sup> Cr 42.30m	1.00 ± 0.22	M	1.24 ± 0.12	-			1.06 ± 0.12	Fe, (Cr)				
<sup>51</sup> Cr 27.70d	1.06 ± 0.13		1.15 ± 0.12		0.64 ± 0.24	M	1.24 ± 0.16	Fe, Cr	0.86 ± 0.16	Fe, Mn	1.33 ± 0.22	Fe
<sup>52</sup> Mn 5.59d	0.68 ± 0.05		1.15 ± 0.04				1.09 ± 0.03	Fe, (Mn)	0.88 ± 0.07	Fe, Mn	1.39 ± 0.07	Fe
<sup>m62</sup> Mn 21.10m	1.68 ± 0.35		1.24 ± 0.09				1.12 ± 0.10	Fe, (Mn)			1.75 ± 0.79	M Fe
<sup>54</sup> Mn 312.12d	1.13 ± 0.12		1.01 ± 0.10				1.08 ± 0.11	Fe, (Mn)	0.96 ± 0.12	Mn, Fe	1.06 ± 0.13	Fe
<sup>56</sup> Mn 2.58h	0.81 ± 0.06		0.99 ± 0.05				1.33 ± 0.10	Fe	1.53 ± 0.25	Mn	1.03 ± 0.25	Mn, Fe
<sup>57</sup> Fe 8.28h			1.09 ± 0.13				0.99 ± 0.19	M Fe, (Mn)				
<sup>58</sup> Fe 8.51m												
<sup>59</sup> Fe 44.50d	0.82 ± 0.09											
<sup>55</sup> Co 17.53h	0.66 ± 0.09		0.76 ± 0.04				1.03 ± 0.05	Fe, Ni				
			1.13 ± 0.10									
<sup>56</sup> Co 77.27d	1.04 ± 0.08		1.15 ± 0.10				1.37 ± 0.11	Fe, Ni			0.80 ± 0.20	M Fe
			1.79 ± 0.15									
<sup>57</sup> Co 271.79d	0.85 ± 0.09		0.38 ± 0.09	M			1.16 ± 0.13	Ni	0.66 ± 0.24	M Cu, Zn, Ni		
<sup>58</sup> Co 70.82d	0.91 ± 0.09		0.31 ± 0.08	M			0.98 ± 0.10	Ni	0.82 ± 0.19	Cu, Zn, Ni		
<sup>60</sup> Co 5.27y	0.90 ± 0.08											
<sup>61</sup> Co 99.00m	0.68 ± 0.08											
<sup>62</sup> Co 90.00s												
<sup>57</sup> Ni 35.60h	0.76 ± 0.11						1.44 ± 0.07	Ni				
<sup>60</sup> Ni 2.52h	1.46 ± 0.29											
<sup>60</sup> Cu 23.70m	0.78 ± 0.08											
<sup>61</sup> Cu 3.33h	0.87 ± 0.25											
<sup>64</sup> Cu 12.70h	0.63 ± 0.10											
<sup>62</sup> Zn 9.19h	1.05 ± 0.23											
<sup>63</sup> Zn 38.47m												
<sup>65</sup> Zn 244.26d	0.62 ± 0.08											
	0.97 ± 0.20											

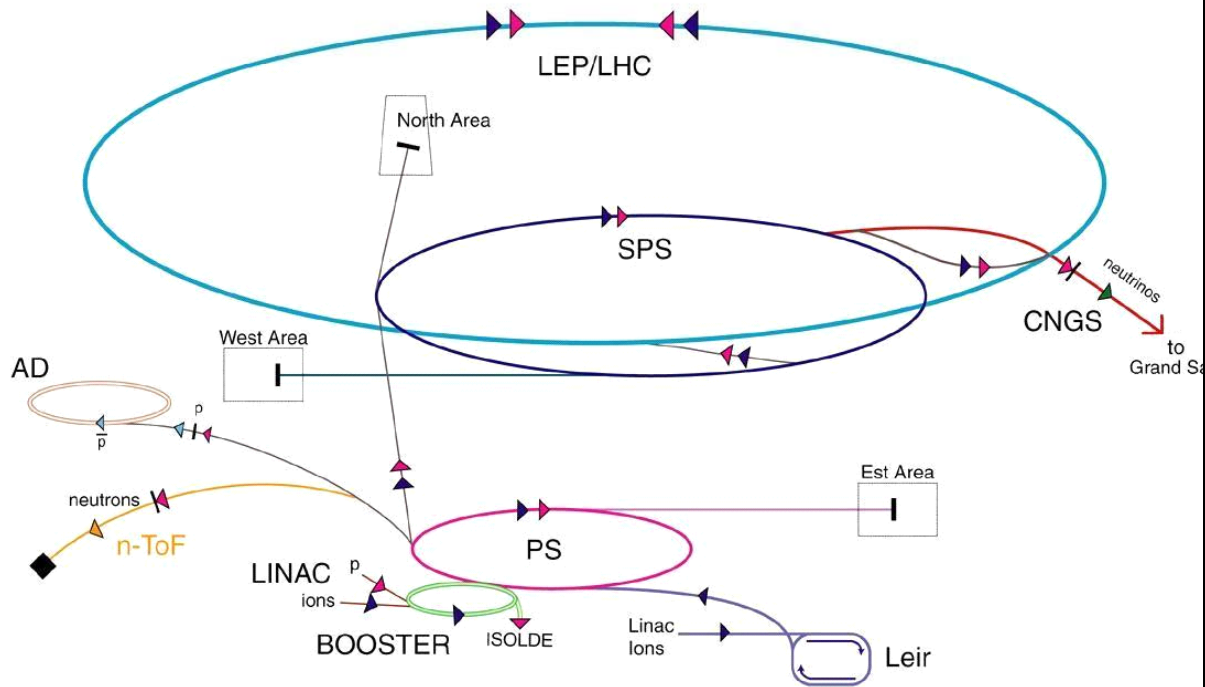
# Activation of Material

$$\sum_{t=1}^n A_t / L_{ct} < 1$$

M. Brugger, A. Ferrari, S. Roesler and L. Ulrici, "Validation of the FLUKA Monte Carlo code for predicting induced radioactivity at highenergy accelerators", *Nucl. Instr. and Meth. A* **562**, p. 814 (2006)

Similar study ongoing for electronic boards  
C. Theis et al.

# Material's Control



All material and waste (electronics included) leaving CERN's accelerator tunnels, target areas or experimental areas needs to be controlled by DG-SCR (=RP). (~ 50 km of radiation areas!)

Only DG-SCR is allowed to take the decision if the material has to be considered as radioactive or not

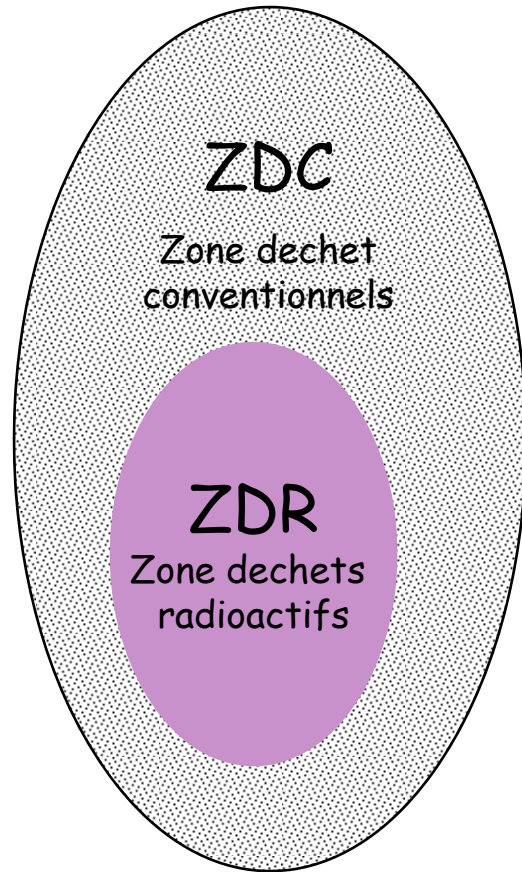
# Removal of Material and Waste

All material and waste leaving radiation areas have to be subject to a radiological control

Subsequent handling procedures for the material and waste depend on

- radiological classification of the material  
-> non-radioactive or radioactive
- so-called waste zoning (for SPS, CNGS and LHC)  
"Zone Déchets Conventionnels, "Zone Déchets Radioactifs"

# Waste Zoning (only CNGS, SPS and LHC)



LHC

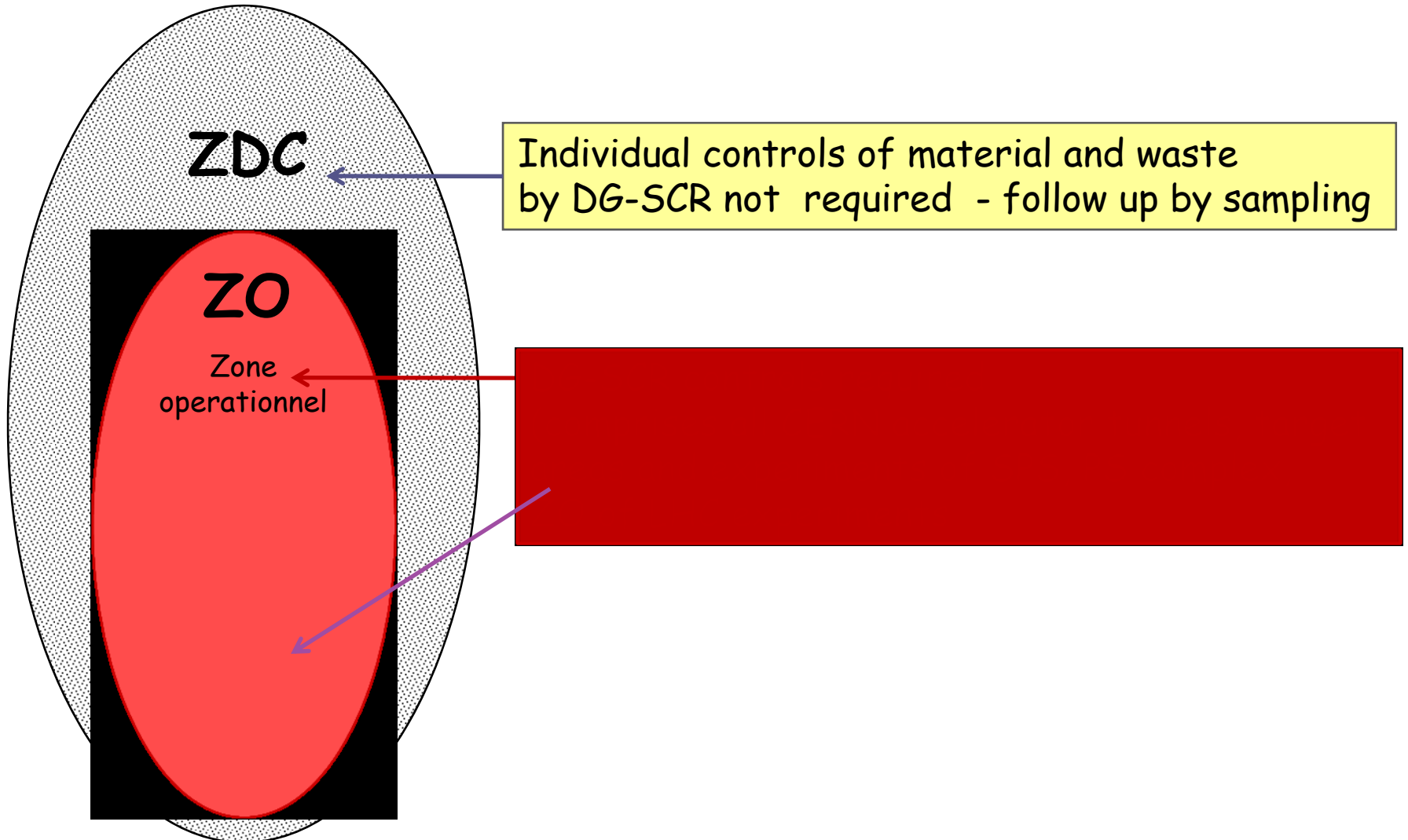
Purpose:

To predict the nature and amount of radioactive waste produced at the dismantling of the facility

"Zone Déchets Radioactifs"  
kept to the minimum

Good news:  
most of the LHC and CNGS  
electronics outside ZDR

# Material Controls & Waste Zoning

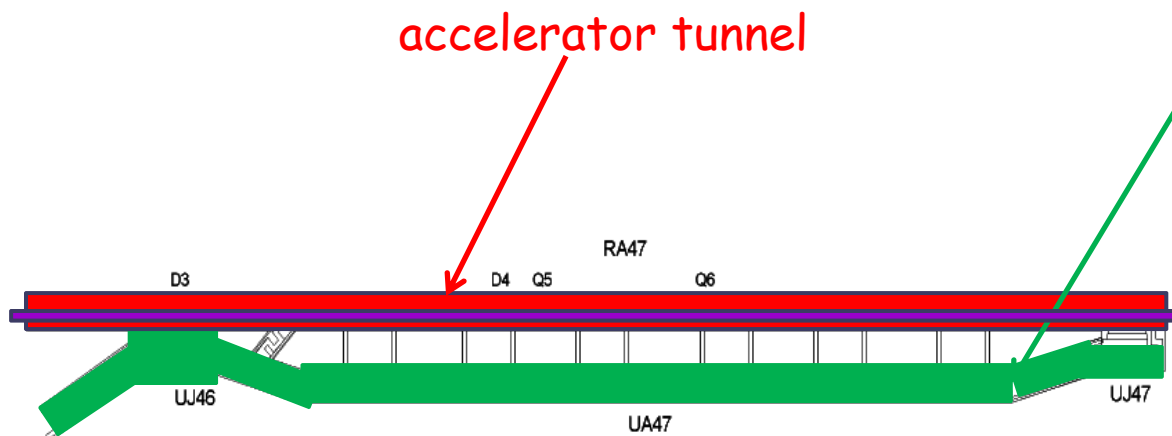




# Controls at LHC

Zone Opérationnelle (ZO)  
including Zone Déchets Radioactifs (ZDR)

Zone Déchets  
Conventionnels  
(ZDC)  
side galleries  
UAs - behind  
shielding!



LHC4 RA 47

# Removal of Material from "Zone Déchets Conventionnels - outside ZO"

Only applicable to LHC - does not exist for other machines

- RP controls the classification as Zone Déchets Conventionnels ZDC - outside ZO (e.g. UA) by representative measurements (sampling,  $\gamma$ -spectroscopy mapping)

- as we are starting up a new, rather clean machine (LHC)
  - material is non-radioactive,
  - can be removed by equipment owner,
  - equipment owner performs control measurements using "Picomur" (for 2009)

- In case of alarm: call SC-RP immediately

- Classification of area to be reconsidered, in the worst case: up-grade of cleared ZDCs to ZO

**Don't bring any radioactive material into ZDC !!!**



Instrumentation will be upgraded in near future



# "Removal of Material from Zone Operationnel" (1)

RP controls ALL material from Zone operationnel (ZO)  
(Procedure applies also to all other CERN radiation areas)

Areas of low level radioactivity (equivalent to supervised and simple controlled radiation area):

Equipment owners

labels their materials

*(nature, origin, ZDR yes or no, destination + identification of the owner)*

brings the material into the buffer zone, entry into logbook

Radiation Protection

controls the material (regular campaigns)

SC-RP gives feed back to the owner

Equipment owner

traces all material that is radioactive

traces all material that comes from ZDR (LHC, CNGS only)

# Removal of Material from "Zone Operationnel" (2)

RP controls ALL material from Zone Operationnel  
(Procedure applies also to all other CERN radiation areas)

Areas of elevated radioactivity (limited stay radiation area and above,  
radiation veto is applied):

Handling procedure of material part of job and dose planning done in  
collaboration between equipment owner and RP  
(ALARA procedure II,III)

Radiation Protection

controls the material  
RP gives feed back to the owner

Equipment owner

traces all material that is radioactive  
traces all material that comes from ZDR (LHC and CNGS)

# Removal of Material from "Zone Operationnel"= Accelerator Tunnels...



See Buffer zones SPS



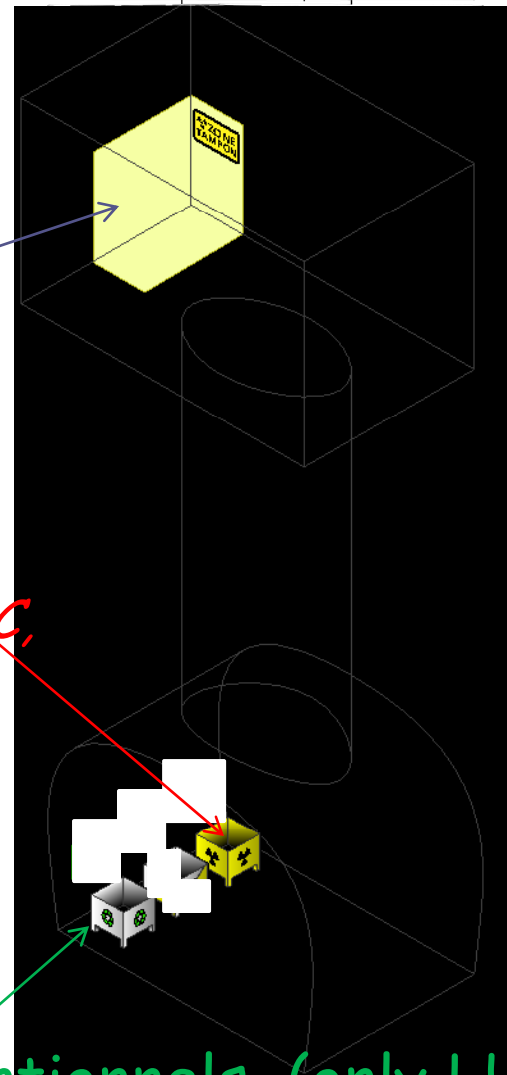
# Waste Handling

Buffer zone

Waste from accelerator tunnel

Equipment owner labels his waste  
(nature, origin, ZDR yes or no - only LHC,  
CNGS))

Waste from Zone Déchets Conventionnels (only LHC -  
does not exist at other facilities)



# Transport

- All material from radiation areas and ZO needs to be controlled by RP prior to any transport
- All radioactive material needs to be properly packed - and to be traced
- Radioactive electronic card or unit:
  - $< 5 \text{ uSv/h}$  on contact -> transport by equipment owner, CERN car, insured for transport of dangerous goods
  - $> 5 \text{ uSv/h}$  on contact -> transport with CERN transport service (via EDH)
- In any case RP needs to fill in a yellow transfer slip prior to any "CERN intersite" transport of radioactive material:
  - a copy into the box "transfer file" when leaving the area (you!)
  - a copy for the guards at the entrance at the point of destination (you!)
  - A copy for RP
  - A copy for you

# Shipping

Only material classified as non-radioactive by RP can be shipped without special precautions.

Material declared as radioactive:

<http://service-rp-shipping.web.cern.ch/service-rp-shipping/>

The receiving company, university etc. needs an authorization for handling of radioactivity by its national authority



# Handling and Transforming Radioactive Electronic Equipment

For the time being:

work areas handling and transforming of radioactive electronic equipment will be limited to supervised or simple controlled radiation areas (for pure handling) and to Class C laboratories for destructive work.

As a rough rule of thumb:

- Only material of up to 50  $\mu\text{Sv/h}$  on contact will be allowed for non-destructive handling (testing, etc.)
- Only material with less than 5  $\mu\text{Sv/h}$  on contact is allowed for destructive transformation (soldering, grinding, etc.)
- Special precautions need to be applied for any kind of destructive work (extraction hood, etc.)

# Centralisation of Workshops

Individual workshops per equipment group imply the following disadvantages and risks:

- Dispersion of radioactive activities, mixture of radioactive and non-radioactive activities.
  - Dispersion of radioactive material  
*(at least once per week radioactive items are detected in "non-radioactive" waste bins)*
  - Too resource intensive with respect to installation, maintenance and RP control of the laboratories.
- > working group (L. Bruno, P. Strubin, RSOs) had been mandated by S. Myers to collect and to analyze CERN needs with respect to work areas for handling and transforming radioactive material, electronics included

# Summary

RP rules are complex due to the co-existence of two sets (French-INB and CERN (=very similar to Swiss) rules)

But:

- All material that leaves CERN's accelerator tunnels, target areas and experiments (ZO for LHC experiments) needs to be controlled by DG-SCR
- Handling and transforming of radioactive material requires special work areas and procedures
- In general an individual laboratory per equipment group will not be permitted because of
  - Lack of control
  - Risk of dispersion of radioactive material
  - Too costly
- Contact your department representative (RSO, L. Bruno, P. Strubin (TE)) in case you need a workshop for handling and transforming electronic equipment