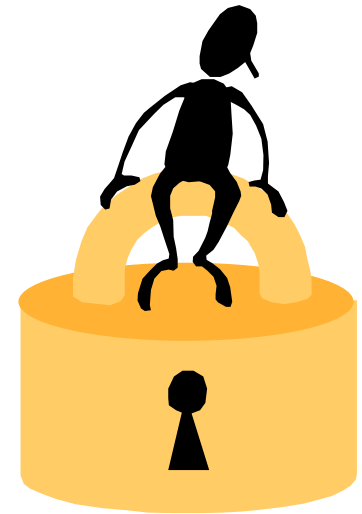# The Access System for the SPS Experimental Areas

Outline

- Generalities
- Experimental areas
- Safety elements and interlock chains
  - access rules to experimental areas
  - safety elements - explained
  - interlock chains – explained
- Special topics
  - area patrol
  - proton/Ion beam conditions
  - TAX ranges and BEND limitations
  - manual veto
  - modifications to the access system

Ilias Efthymiopoulos, AB/ATB-EA
SPS/EA Training Lecture Program
March 2003

Generalities

Legend:

🟥 Zone à haute radiation,
débit de dose susceptible d'être > 2 mSv/h (Zone cibles et extraction)

🟨 Zone à séjour limité,
débit de dose entre 0.1 et 2 mSv/h

🟦 Zone contrôlée simple
débit de dose entre 7.5 et 100 μSv/h
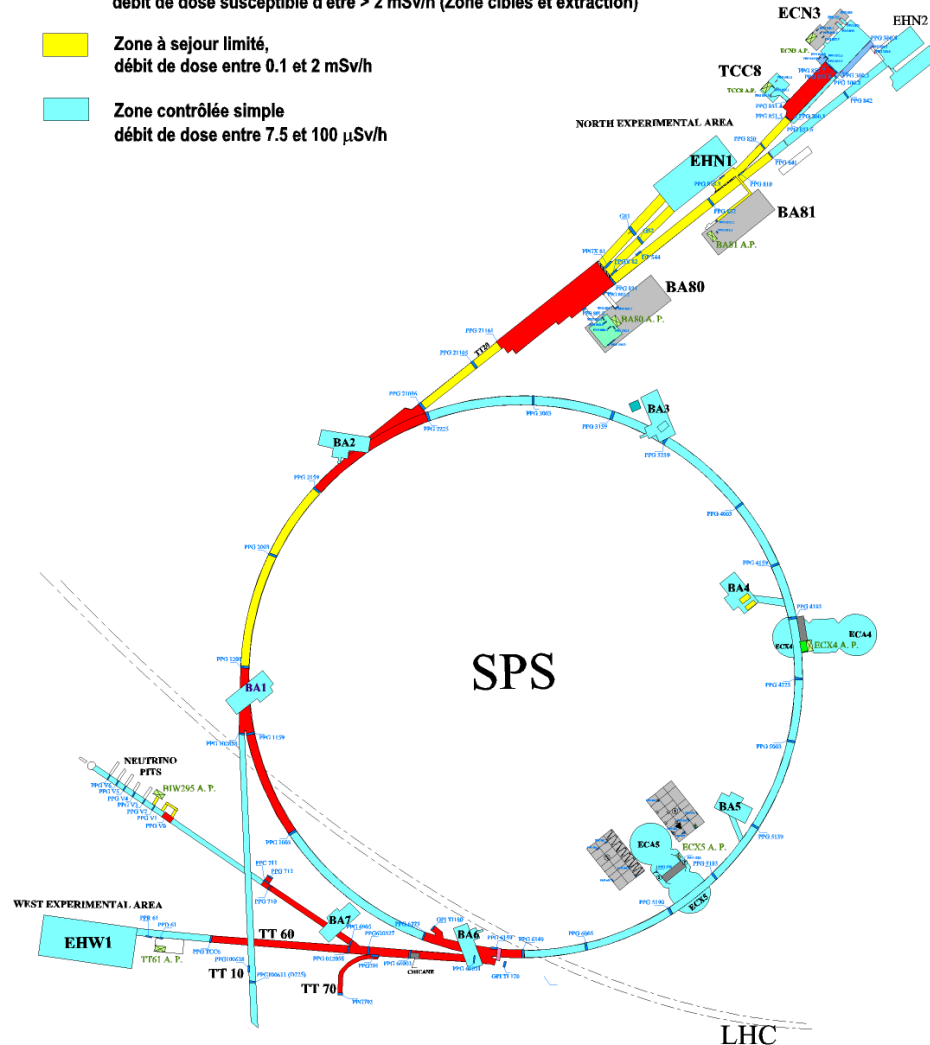
Beamline and Experimental Area classification

- **Secondary beam areas**
  - EHN1 (H2, H4, H6, H8)
  - EHN2 (P61/M2)
  - WA (X5, X7)
  - access granted locally
  - interlock system per beam line/area

- **Primary beam areas**
  - TCC2 (north area targets)
  - TCC6 (west area targets)
  - ECN3 (P0)
  - same access rules as SPS machine and target zones

- **Special case**
  - Gamma Irradiation Facility (GIF)

Access system

... **Generalities**

- The access system is used to prevent in-beam exposure for the personnel
- For EA can be separated in two categories: **Beam lines** and **Experimental areas**

Experimental Area

- Perimeter defined by concrete blocks and/or fences
  - typically at least 1m from the beam axis, exact shape depends on detector/installation size
  - high intensity ($>10^6$/ppp) proton or heavy-ion beams and exp. areas are completely shielded with concrete
  - visibility to the area should not be blocked
- Doors to access each area
  - the main one (PPE) and at least one emergency escape door (PPX, PPG)
- Several can exist in a single beam line
  - connected to the same or different interlock chains
- Access to downstream areas depend on beam conditions
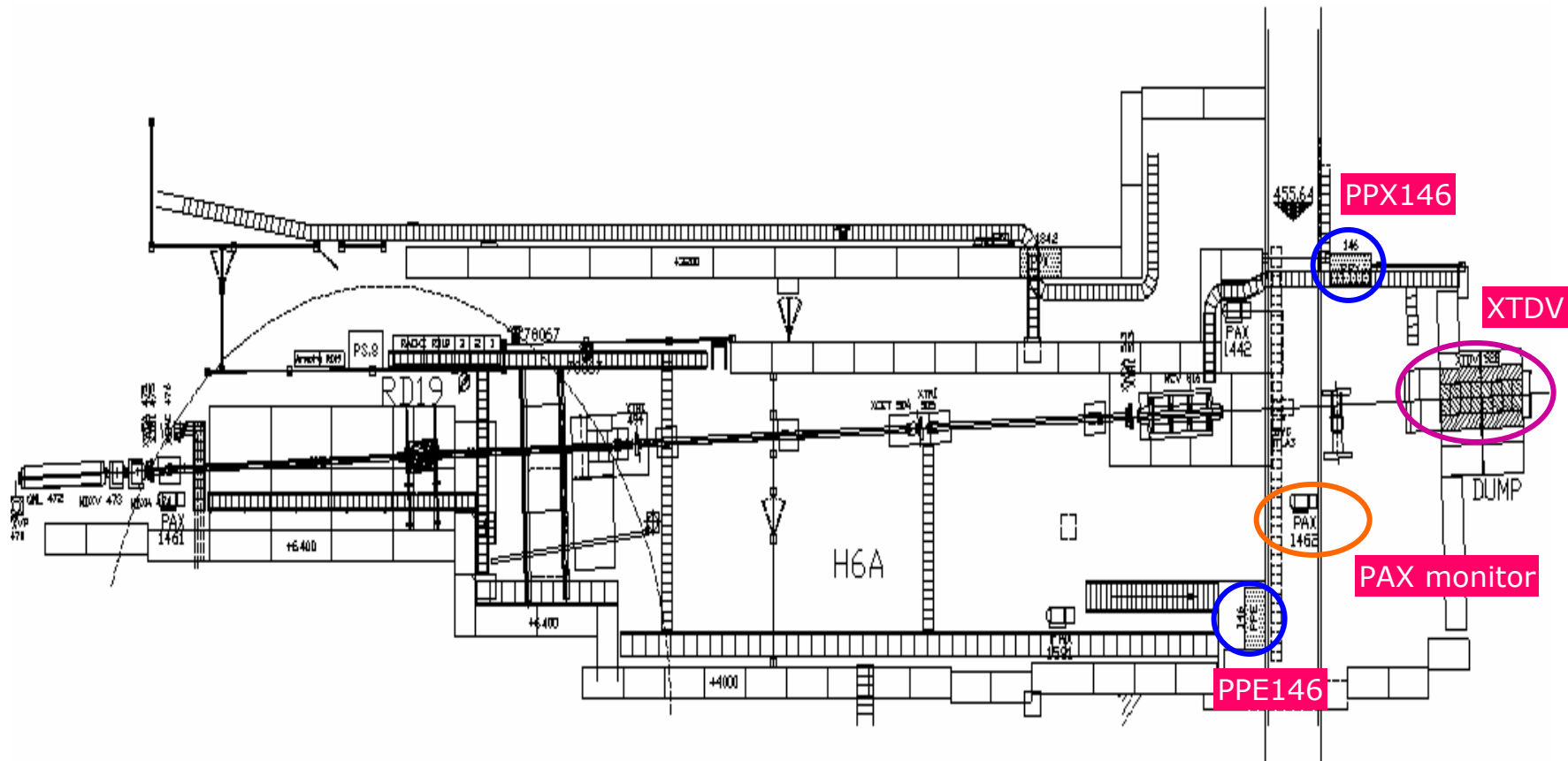 - provided there is a dump (XTDV, XTDX, "manual") in between

Beam Line

- The beam line: from the target → tunnel → exp.area(hall) → dump
- A beam line can contain a single or several interlock chains of experimental areas

Access system
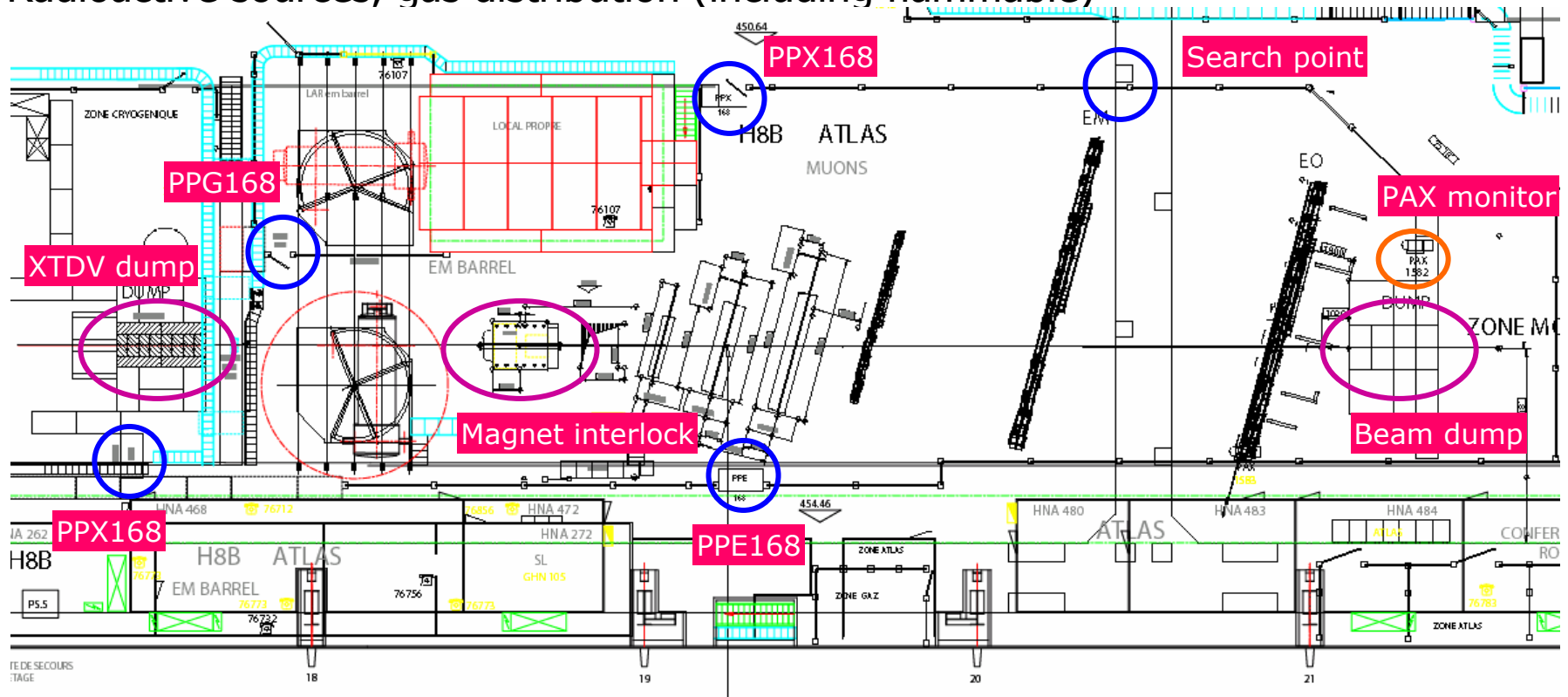
Experimental areas

PPE146 – H6A

■ Big but "empty"

… Experimental areas

PPE168 – H8B

- Large area with four doors and a search point
- Big and complicated detector installations
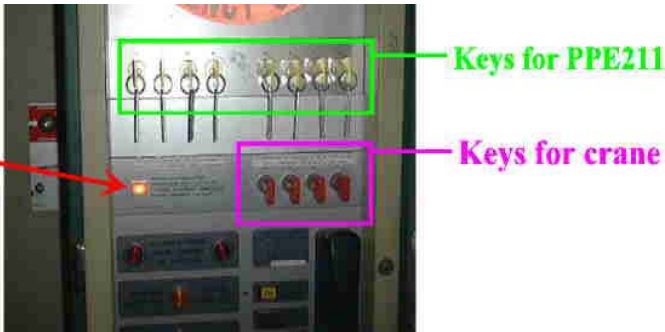- Radioactive sources, gas distribution (including flammable)
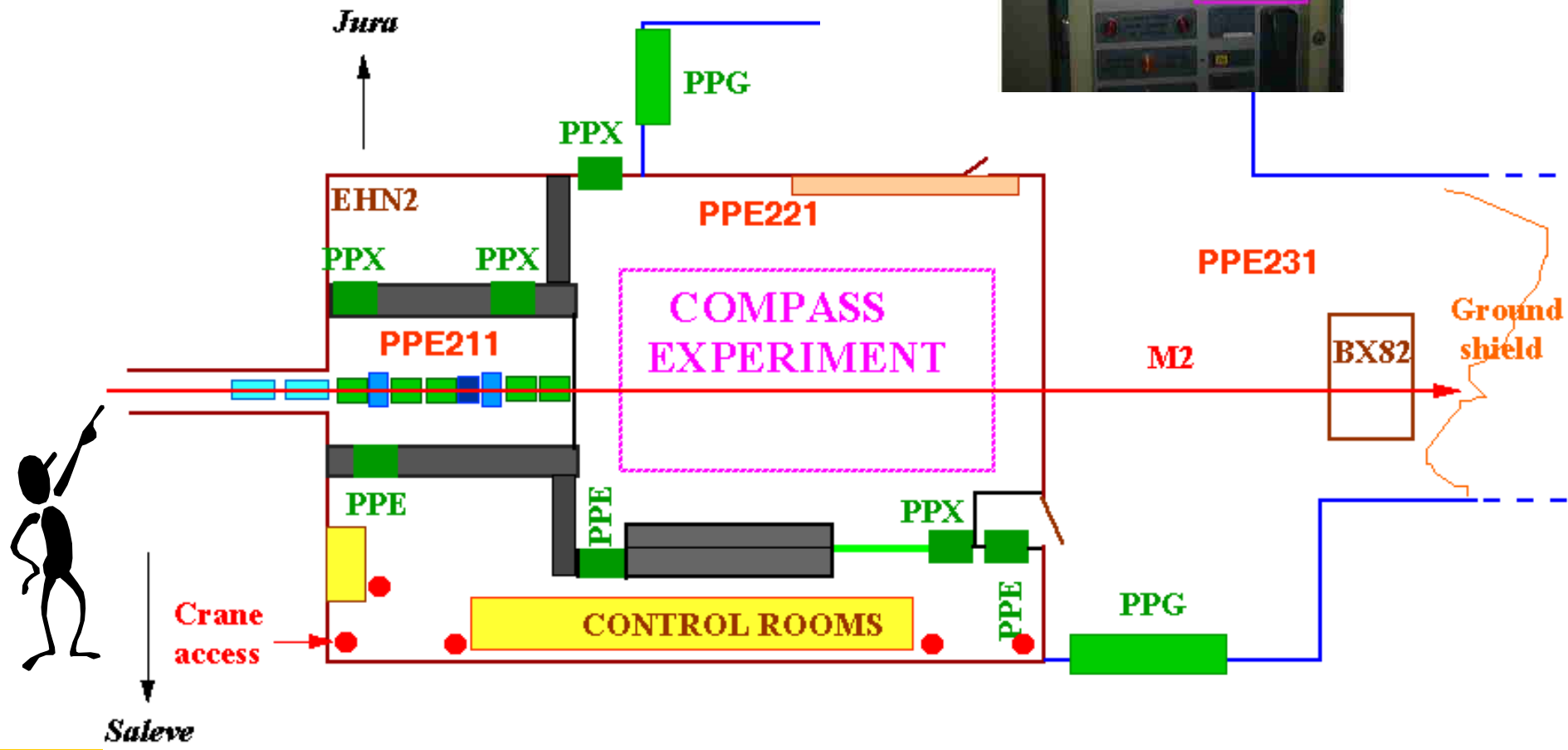

Access system

… **Experimental areas**

EHN2/COMPASS

- Very complicated area
- Special access conditions

Safety elements and interlock chains

Safety elements

- Physical elements that provide information for the access system
- **Doors:** allow access to the experimental areas and underground tunnels
- **Dumps:** motorized dumps to separate experimental areas in the same beam line
- **TAX:** motorized blocks "dumps with holes" to attenuate or dump the beam
- **Magnets:** stop the transport of a beam; ("champ null" detector, current limit, interlock)
- **Equipment**: has to be present and in a given configuration
- Special case: **radiation monitors**
    - can stop the beam if above threshold, but not included in the access system
- Status information available on the control room

Interlock chains

- Hardware system to define a status of a beam line
    - receives/treats information form various safety elements
    - specialized electronics and network
- Hierarchical organization
    - per beam line (several chains in each beam line)
    - tunnel (several beam lines)
    - building/tunnels/area (TTC2=North, TCC6=West) → SPS veto
- Interlock signal based on information from at least two safety elements

Access system
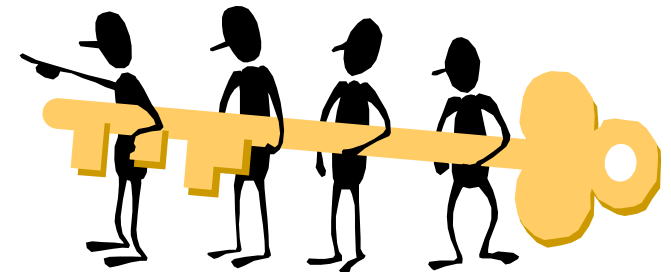
… **Safety elements and interlock chains**

Software Interlock chains - Matrices

- Implemented into NODAL (CESAR) system
- Should correspond to the actual hardware configuration
  - matrices describing the configuration of each interlock chain
- Used to facilitate the users/operators
  - avoid mistakes that can cause access alarms
  - fast help and monitor of the access system

however

- Mainly intended for high-level commands/programs
  - direct calls to the hardware (ie. move a TAX or XTDV) may still be possible
- Software interlocks are not considered as SAFE

Note:

- Hardware for the interlock system maintained by M.Grill (ST/MA)
- Annual inspection before SPS startup

Access system

Safety elements

Doors

- Control the access to experimental areas and beam lines
- Users have to take a key to open the door
  - must use the key to enter AND exit the area
- At least one PPE and one PPX in each area
  - marked at PPE xxx, PPX xxx (PPG xxx)
- Door status defines the status of the area BUT NOT of the beam line
  - free: people can enter without key
  - key access: to enter you have to take a key
  - beam ON/OFF: no access, beam can be present in the area
- Timeout (~1min)
  - if a door is left open more than 1min switches automatically to free state
- In complicated areas the PPExxx door is combined with a **search point**
  - acts like a door
  - forces the area patrol to pass by that point

Access Rules to Experimental Areas

- One person one key
  - no more than 8 people at a time in the area
  - if so, the door/area must go in free mode

- Change of door/area states:
  - free → key access
    - search of the area by SPS operators and the GLIMOS of the experiment
  - key access → beam (beam → key access)
    - press the end of access system
      - verify that the above rule was not violated
    - via computer system
  - key access → free
    - via computer system
    - door open timeout

Emergency button ("force the door")
- stops the beam
- drops the interlock chain of the door
- AND the next higher level interlock chain

… **Safety elements**

PPExxx Door

Access system

keys

door and area status and control panel

door handle

Area Closed

Key Access

Free Access

Key release button

End of Access button

Ring the CRN Operators

Intercom to CRN operators

Emergency Passage

Door knob

Insert your key here

… **Safety elements**

Dumps – Motorized XTDV, XTDX

- Used to separate experimental areas in the same beam line
  - attached to the interlock chain of the downstream area
- Motorized XTDV, XTDX dumps, 2-3m of Fe
- Two positions defined: IN/OUT
- Before moving a dump the beam must be stopped
  - this to avoid spraying particles as the edge of the dump crosses the beam

Magnets

- Power converter level
  - interlock on polarity
  - current limitation
- Direct measurement of the magnetic field
  - zero magnetic field detection ("champ null")
  - can be very tricky if we have to transport low energy beams

Access system

… Safety elements

TAXs – Target Attenuator

- Massive blocks of material (Al-Cu-Fe)
  - different configurations depending on the beam line
  - 3.2m long located downstream the primary targets
- Combined function:
  - **dump:** stop proton/hadron beam
    - can be quite "hot"; ~5 Sv/hr at the end of shutdown
  - **attenuator:** let the full (big hole) or attenuated beam (small holes with some material insert) to go through
- Fully motorized with remote control
  - two motors (XTAXxxxyyy) per beam
- Movement split in ranges
  - **SMALL range**:
    - move around the small holes
      - empty or with material insert
    - used for the primary proton beams
  - **MEDIUM range**:
  - **LARGE range**:
    - can move the full range including the big empty holes
    - used for secondary or ion beams

Access system

… Safety elements

T4 Target TAX Blocks
Update 2000
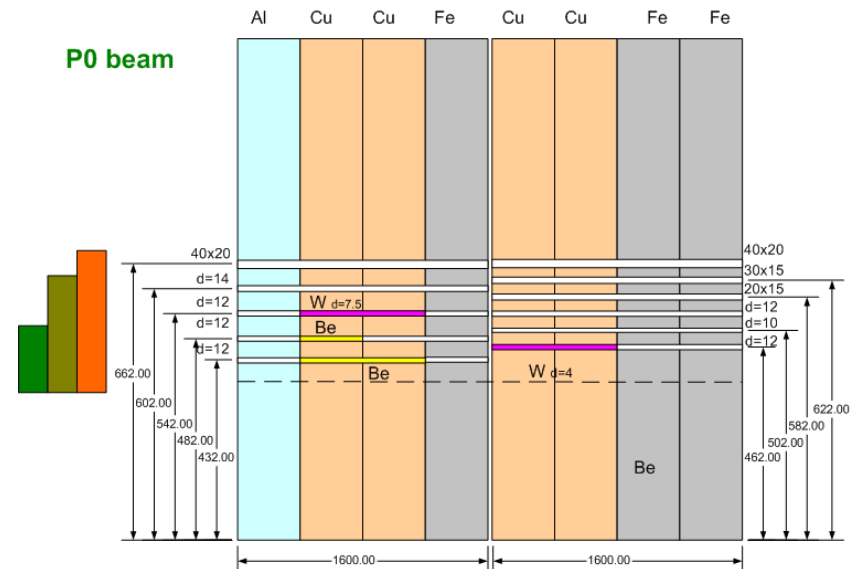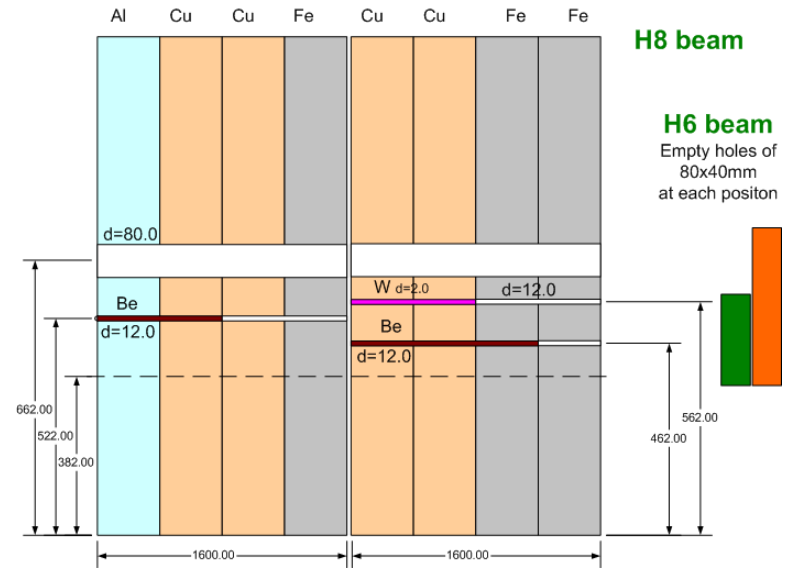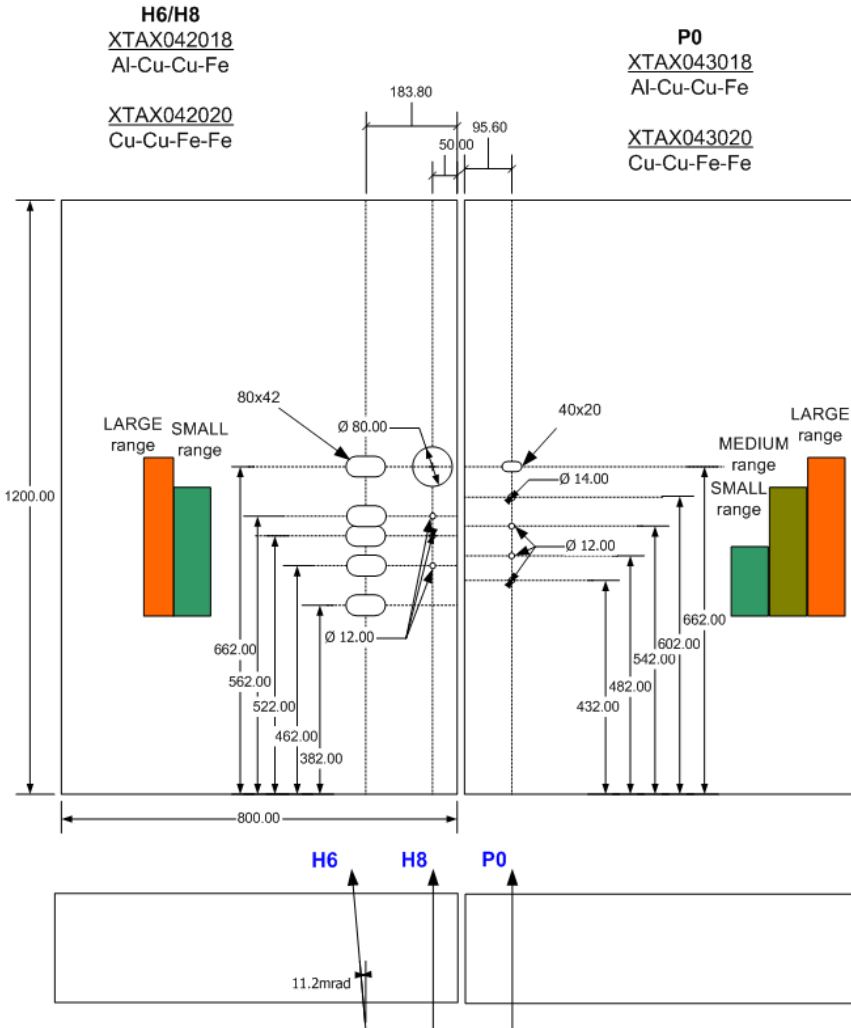
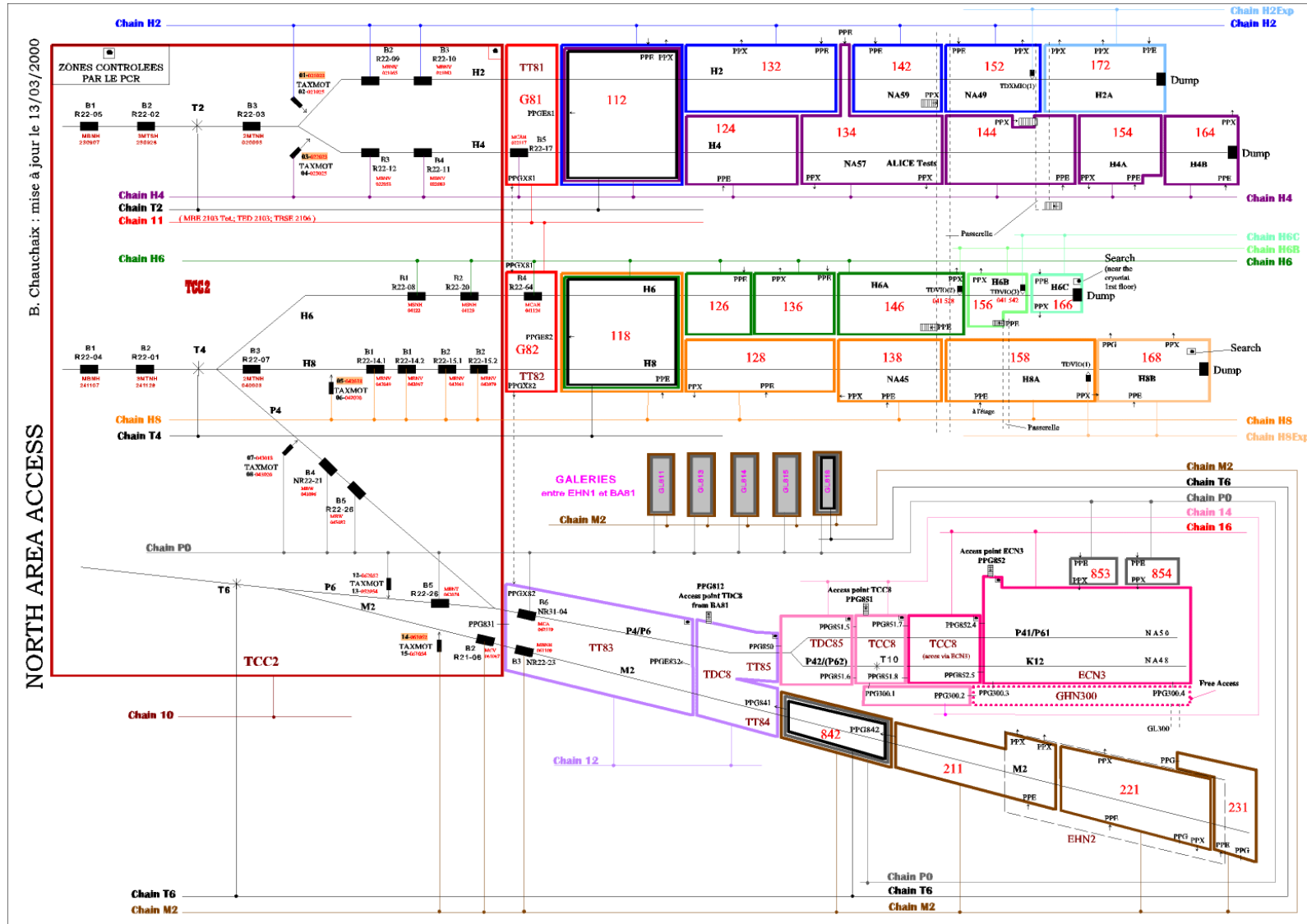# … **Safety elements**

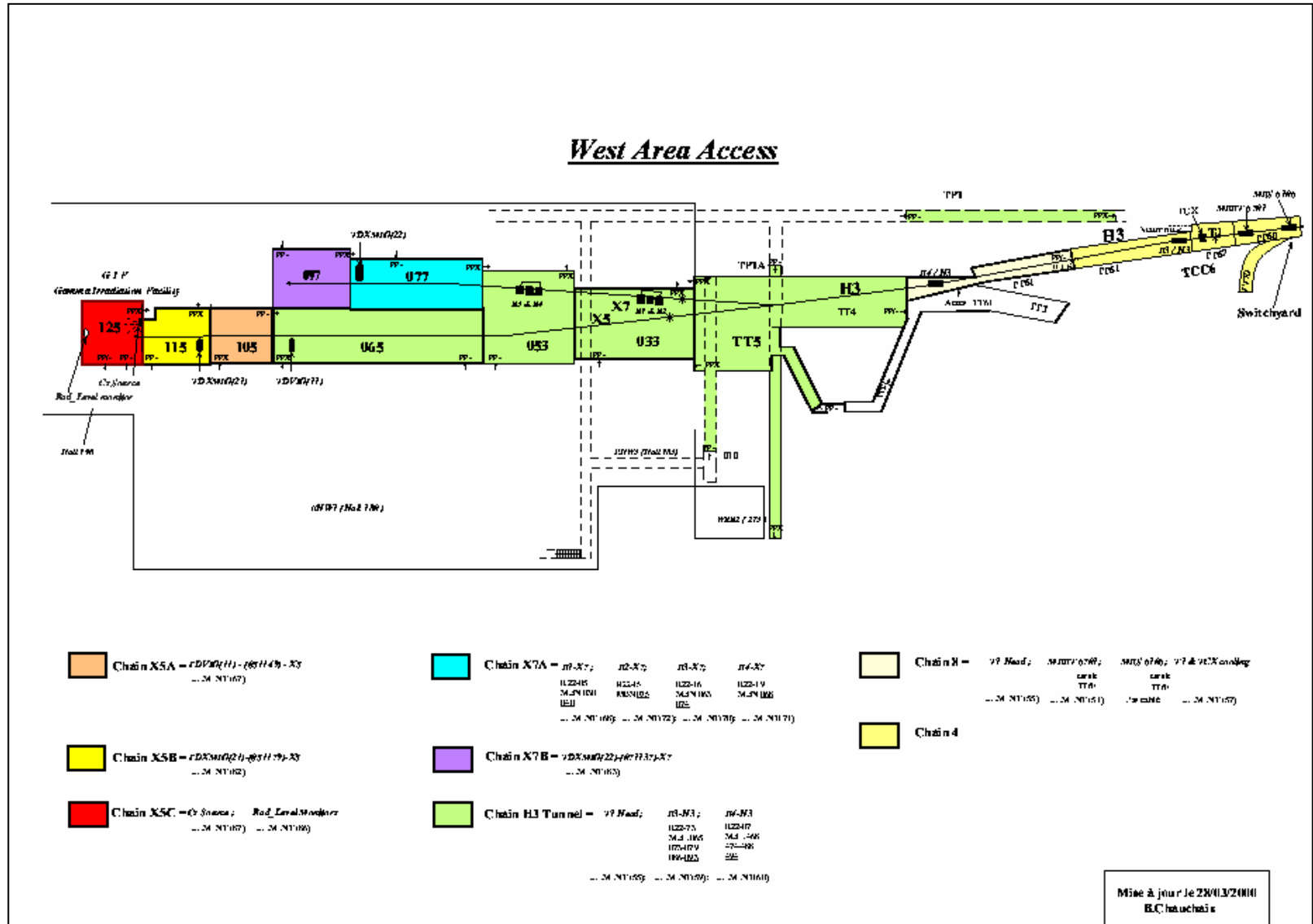## Equipment

MicroCollimator in H8 Beam Line

- Combined setup:
  - set of two collimators: XCRH and XCRV
  - their support table: XCRT
  - an IN/OUT collimator: XCIO
- Used for the "micro-beam" option in H8
  - attenuated primary proton beam in H8

Interlock chains - North Area

Access system

Interlock chains - West Area

Access system

Interlock chains – Access System Online

Interlock chain status
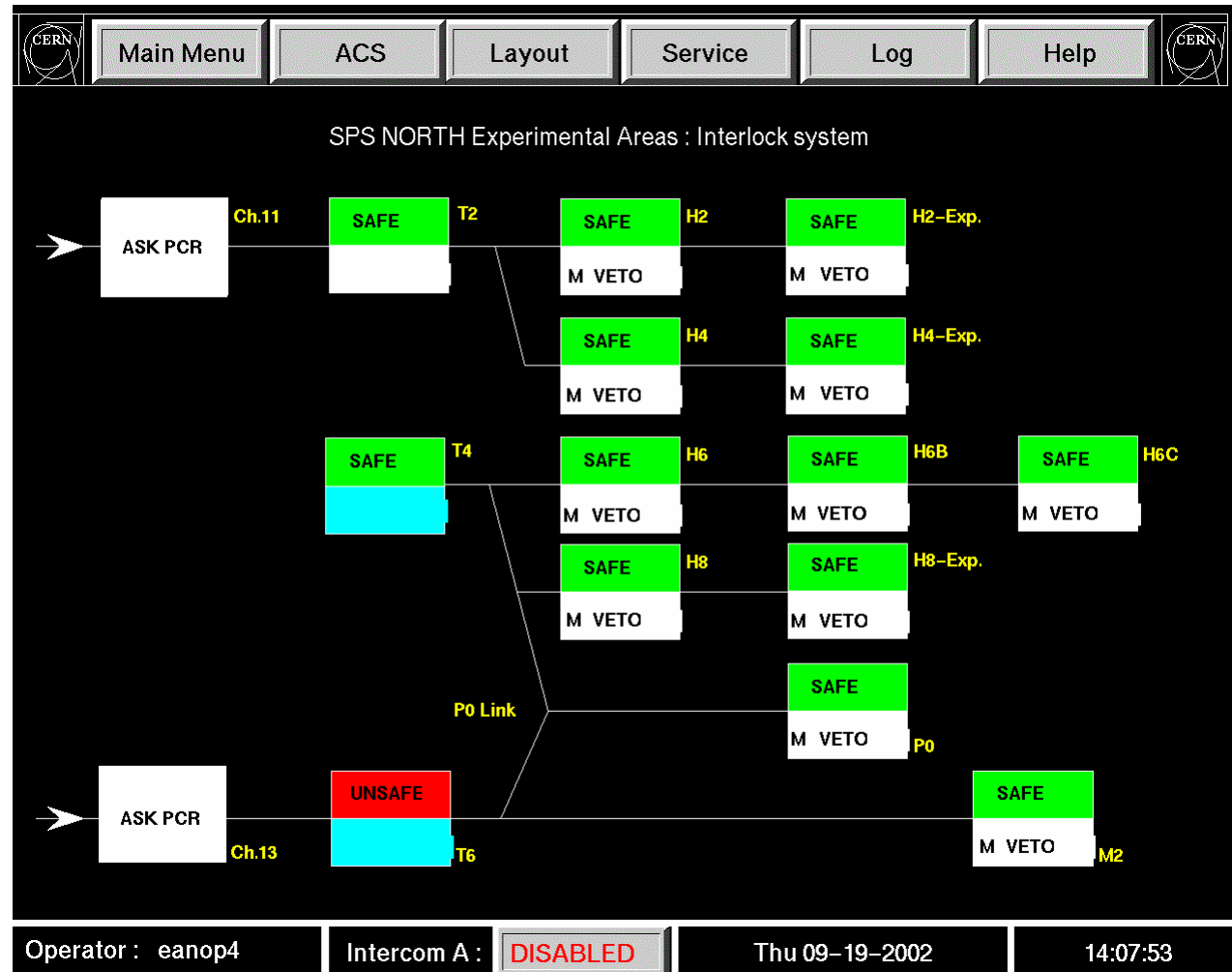
The chains can be:

SAFE

- If all the elements in the chain are in the SAFE state
    - **it means we can have access to the area**

or

UNSAFE

- If any of the elements in the chain is in UNSAFE state
    - **we can't have access**
    - **the beam is present**

Access system

Interlock chains – Access System Online

Door Status and Control Display

■ Displays the status of the PPE doors

■ Allows monitoring and control of their state

The doors can be in one of the following states

FREE (green)

■ No access control

KEY ACCESS (yellow)

■ Access with key

■ Limited number of people

CLOSED (red)

■ Beam present

Special topics – Area patrol

"Search the Area"

■ Is needed in order to switch from Free to Key access an Exp. Area

■ The search is conducted by
- the **search leader**
  - normally a PCR operator or the EA physicist
- and the **user**
  - normally the GLIMOS of the experiment or other authorized person(s)

■ Follow rigorously the defined procedure

■ At the end press the "End of Access" button in the PPE door of the area. This is important because:
- it creates an entry in the electronic log of the access system
- it allows after a short timeout to have the beam in the area
- from then on, the responsibility for the access to the area goes to the users
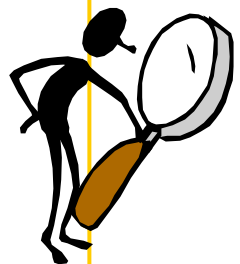
PROCEDURE:

1. ASK ALL THE PERSONS PRESENT IN THE AREA TO EXIT AND CLOSE ALL THE DOORS (PPE, PPX, PPG)

2. VERIFY THAT ALL FENCES AND BLOCKS DEFINING THE PERIMETER OF THE AREA ARE IN PLACE

3. REMOVE ALL LADDERS OR ANY OTHER EQUIPMENT CAN BE USED BY PEOPLE TO CLIMB OVER THE FENCES

4. GO TO THE PPE DOOR AND CALL THE PCR TO SWITCH IT FROM "FREE ACCESS" TO "KEY ACCESS"

5. LEAVE ONE PERSON AT THE PPE DOOR AND START THE SEARCH. ALL PERSONS ENTERING THE AREA MUST TAKE A KEY. AUDIBLE DEVICES CAN BE USED DURING THE SEARCH TO WARN PEOPLE. TAKE YOUR TIME AND LOOK CAREFULLY EVERYWHERE

6. IF THERE IS A "SEARCH BOX" YOU MUST RE-ARM IT
   - ALTHOUGH THERE IS A TIME-OUT TO DO SO, DON'T RUSH!
   - IT IS MORE TO FORCE YOU TO LOOK INTO THAT AREA NOT JUST TO TURN THE KEY!

7. RETURN ALL THE KEYS TO THE PPE DOOR AND PRESS THE "END OF ACCESS" BUTTON

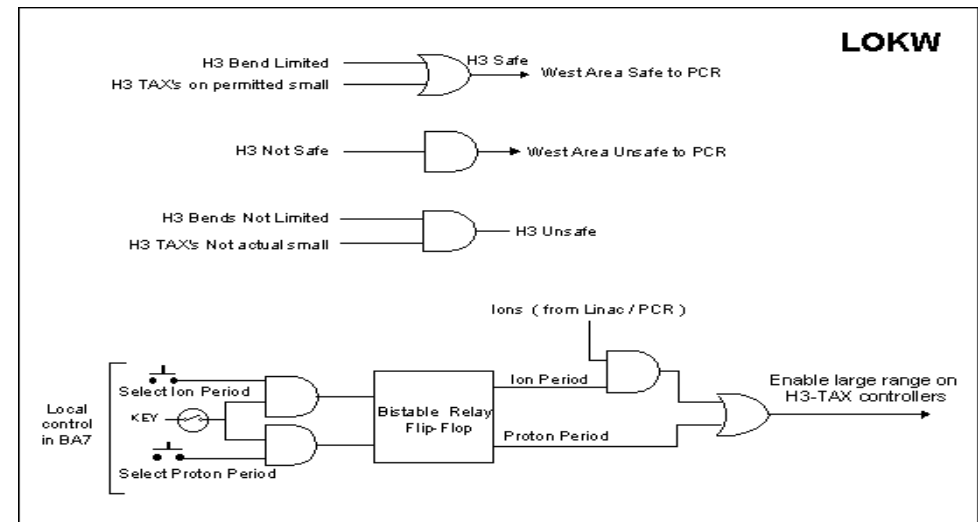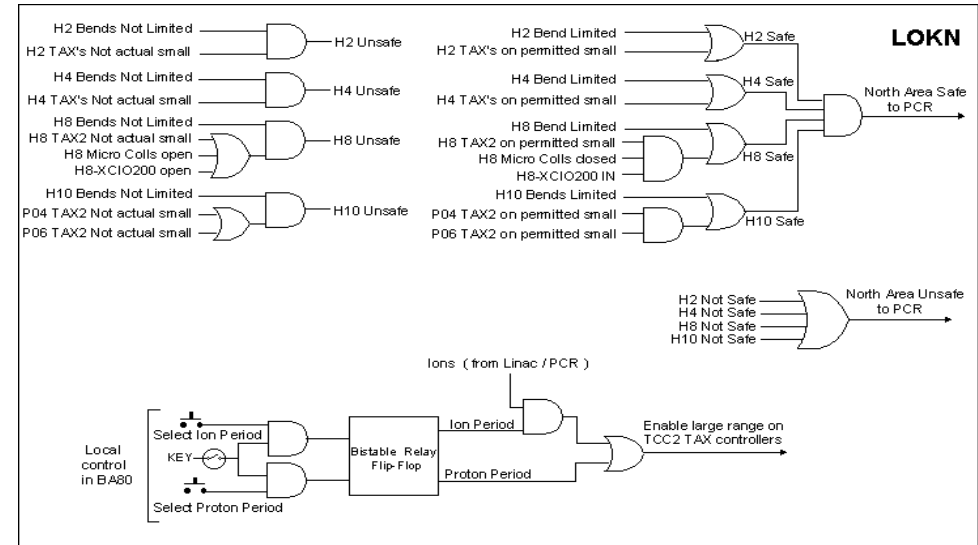# Special topics – Proton/Ion beam conditions

North/West Area Beam Interlock

Proton extraction to the North/West is allowed only if the North/West Area is in SAFE mode

- ■ **North/West Area SAFE** when ALL the corresponding Beam Lines are in safe mode

- ■ **Beam Line SAFE** if
  - **either** the nominal beam energy is limited below the energy of primary protons
    - ▪ ie. cannot transport primary protons
  - **or** the beam intensity is limited by beam attenuators (TAX's or combination of TAX's and other beam elements)

Ion beam extraction can always be done

- ■ Particle type identification from CPS
  - ▪ "Oxygen Interlock" signal
- ■ Manual operation – "ion key"

Access System

Special topics – ... Proton/Ion beam conditions

Example H8 Beam Line:

Element			Actual Status	Normal status		
				Micro Beam (primary protons)	**Protons** (secondary)	**Ions**
Beam Line	SAFE		0	1	1	x
	UNSAFE		1	0	0	x
TAX	TAXMOT(6)	NO RGE ALARM	1	1	1	1
Magnets	BEND	LIMITED	0	0	1	0
		NON LIMITED	1	1	0	1
Micro collimator table	TABLE201	SAFE	0	1	0	0
		UNSAFE	1	0	1	1
Micro collimator	XCRH201	SAFE	1	1	x	x
		UNSAFE	1	0	x	x
	XCRV201	SAFE	1	1	x	x
		UNSAFE	1	0	x	x
Protection collimator	XCIO200	SAFE	0	1	0	0
		UNSAFE	1	0	1	1

x in a position means that 1 or 0 is allowed

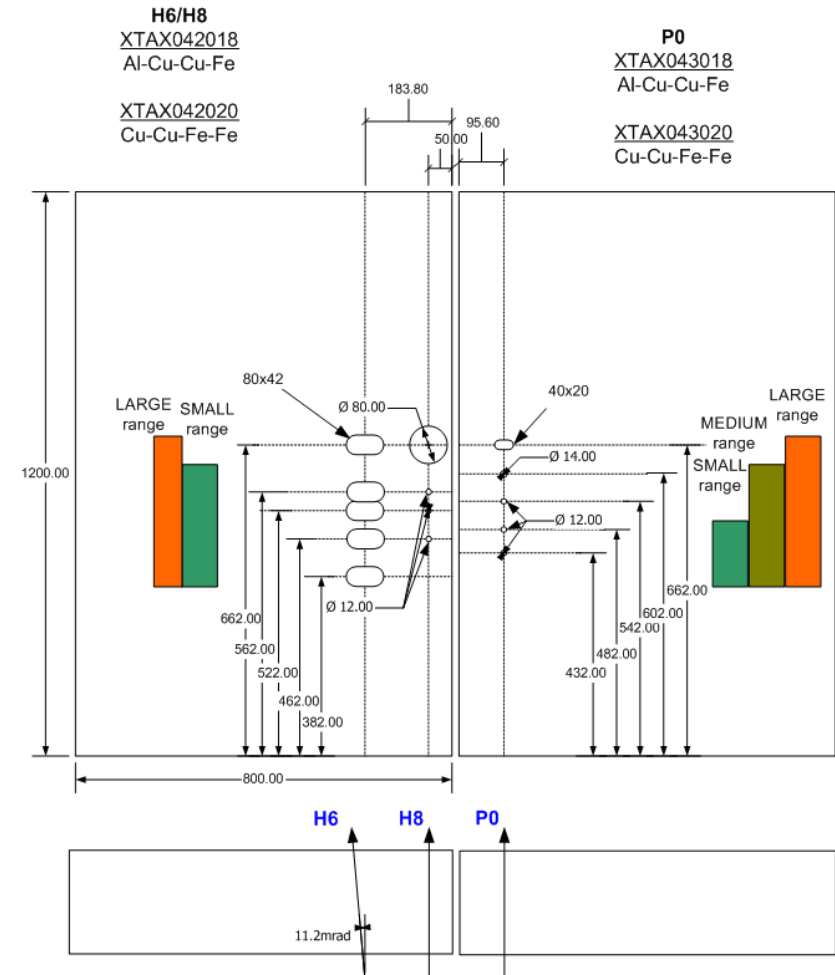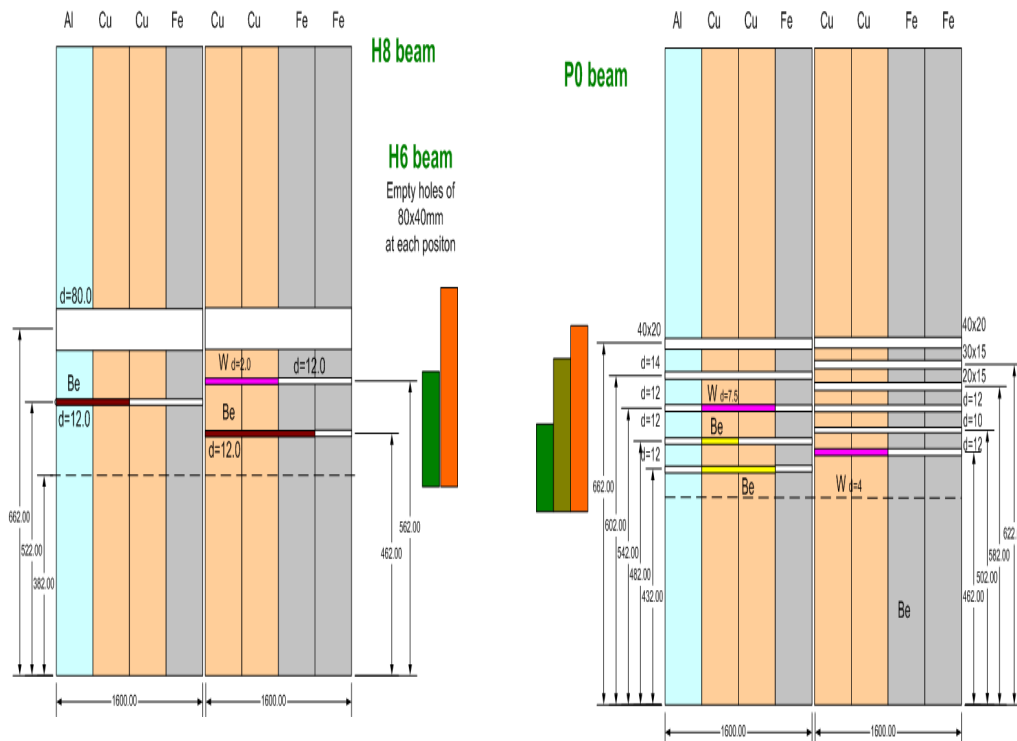■ available in NODAL branch: *EA/INTERLOCK/LOKN*

Access system

Special topics – TAX Range & BEND Limits

TAX Ranges

- SMALL/MEDIUM Range
  - allows only small holes or holes with insert, attenuated beam
- LARGE Range
  - big and/or empty holes possible, no attenuation

Access system

T4 Target TAX Blocks
Update 2000

Special topics – … TAX Range & BEND Limits

TAX Ranges

■ status and setting in NODAL branch: *EA/INTERLOCK/TAX*

```
BEAM    # EQ #  READ   #   TAXDT  #SELECT.RGE#ENABLE.RGE#CONTROL.RGE#ACTUAL.RGE
--------------------------------------------------------------------------------
H2      #  1 #  140.7 #   -20   #  LARGE   #  LARGE.  #  COMPUTER  #  SMALL
H2      #  2 #  140.6 #  -140   #  LARGE   #  LARGE.  #  COMPUTER  #  SMALL
H4      #  3 #  140   #  -140   #  LARGE   #  LARGE.  #  COMPUTER  #  SMALL
H4      #  4 #  140.1 #  -140   #  LARGE   #  LARGE.  #  COMPUTER  #  SMALL
H8      #  5 #  139.5 #  -140   #  LARGE   #  LARGE.  #  COMPUTER  #  SMALL
H8      #  6 #  140.4 #  -140   #  LARGE   #  LARGE.  #  COMPUTER  #  SMALL
P42     #  7 #  140.5 #   -20   #  SMALL   #  LARGE.  #  COMPUTER  #  SMALL
P42     #  8 #  139.5 #   145   #  SMALL   #  LARGE.  #  COMPUTER  #  SMALL
h4.     # 10 #    0   #  -140   #  SMALL   #  SMALL.  #   LOCKED   #  LARGE
h4.     # 11 #    0   #  -140   #  SMALL   #  SMALL.  #   LOCKED   #  LARGE
P61     # 12 # -108.1 #  -140   #  LARGE   #  LARGE.  #  COMPUTER  #  LARGE
P61     # 13 # -107.1 #  -140   #  LARGE   #  LARGE.  #  COMPUTER  #  LARGE
M2      # 14 # -392.1 #  -140   #  LARGE   #  LARGE.  #  COMPUTER  #  LARGE
M2      # 15 #  160.1 #   145   #  LARGE   #  LARGE.  #  COMPUTER  #  LARGE
K12     # 17 #   46.6 #    20   #  LARGE   #  LARGE.  #  COMPUTER  #  SMALL
K12     # 18 #  -43.9 #    47.5 #  LARGE   #  LARGE.  #  COMPUTER  #  SMALL
```

■ READ actual position (readout)
■ TAXDT set position (default, BIM-0). The position to reach at the end of an access
■ SELECT.RGE selected range (set)
■ ENABLE.RGE allowed (enabled) range based on the beam type in the machine/beamline
■ CONTROL.RGE control unit status (values: COMPUTER, LOCAL, LOCKED)
■ ACTUAL.RGE actual range (readout)

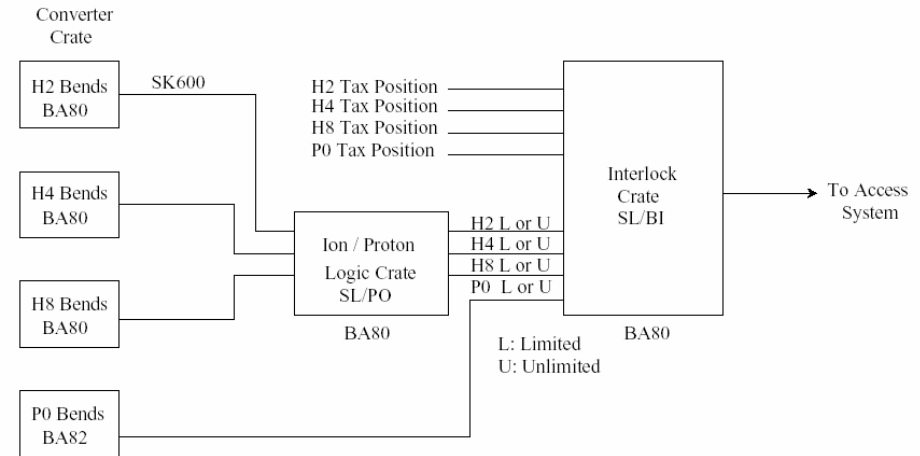# Special topics – … TAX Range & BEND Limits

BEND Limits

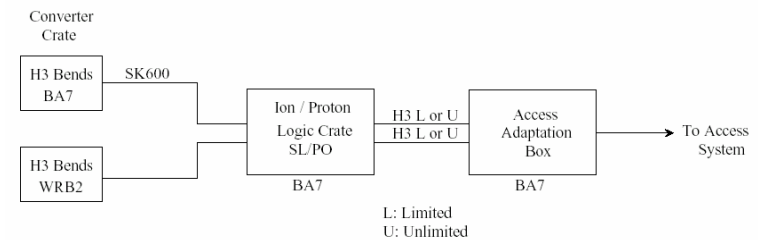Interlock condition on the maximum allowed current for the main BENDs of a beam line

- LIMITED: $I_{limit} < I_{SPS}$
  - the primary SPS beam cannot be transported
- UNLIMITED: $I_{limit} \geq I_{SPS}$
  - the primary SPS beam can be transported

ION / PROTON INTERLOCK

REGULATOR U2_5732 (SPECIAL)
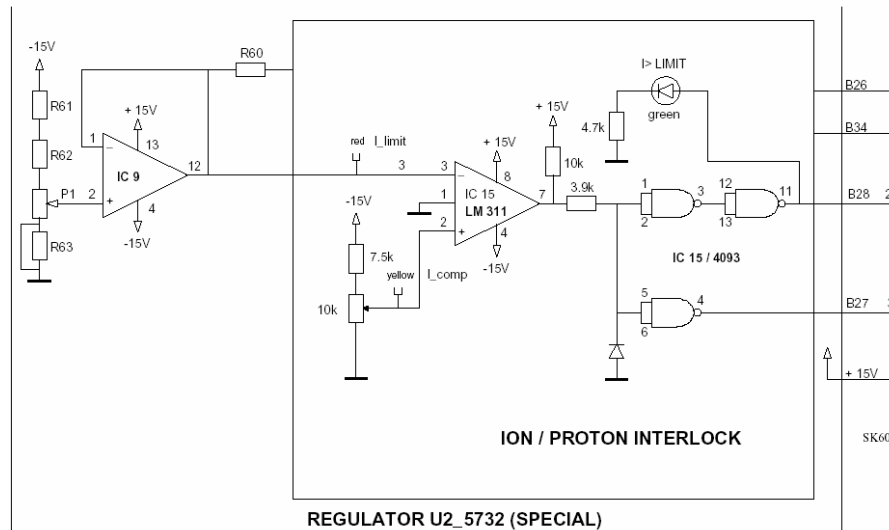
North Area

West Area

Access system

Special topics – Manual Veto

- ■ "Key" to veto an interlock chain of a beam line
  - ■ blocks the presence of the beam in an exp. area, regardless the status of the existing safety elements of the chain
- ■ Normal status of all exp. area chains during shutdown
- ■ Has to be set each time there is work foreseen that can modify the status of an exp. area
- ■ Can ONLY be lifted with the agreement (signature) of the EA physicist.
  - ■ The EA physicist must patrol the exp. area before signing to lift the Manual Veto
    - ▪ verify that its perimeter is correctly closed
    - ▪ the safety elements (dumps, doors, magnets) present and functional
  - i.e. must verify that the access system can function correctly

Access system

Special topics – Changes to the access system

■ Changes to the access system (new conditions from the users, modification in the beam line or exp. area) are initiated and are under the responsibility of the EA physicist

■ The EA physicist takes care that all the parties involved are consulted and agree on the proposed changes
  - ■ EA and BI beam line experts
  - ■ access system experts, ST/MA (M. Grill)
  - ■ TIS/RP and AB/RSO

■ All modifications are discussed in the EATC meetings and documented in the minutes
  - ■ 1st meeting of the year: summary of all modifications during the shutdown
  - ■ during operation, in the meeting before the SPS period concerned

■ The SPS operators follow the work and update the NODAL software matrices
  - ■ the EA physicist should verify the hardware access matrix (in bat 80) and sign the pages of the modified NODAL software matrices

Access system

Access system – Summary

- Safety is IMPORTANT, can have direct consequences to people

- Beam Lines and Areas can be simple but also VERY complicated

- The access system hardware guarantees the safety at all circumstances

- Pay attention to modifications
  - best way to find out is to READ THE EATC MEETING MINUTES

- Good practice: discuss things related to the access system with your colleague before doing them

- Ask for help at any time if you are in doubt!