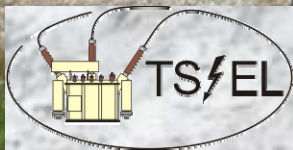
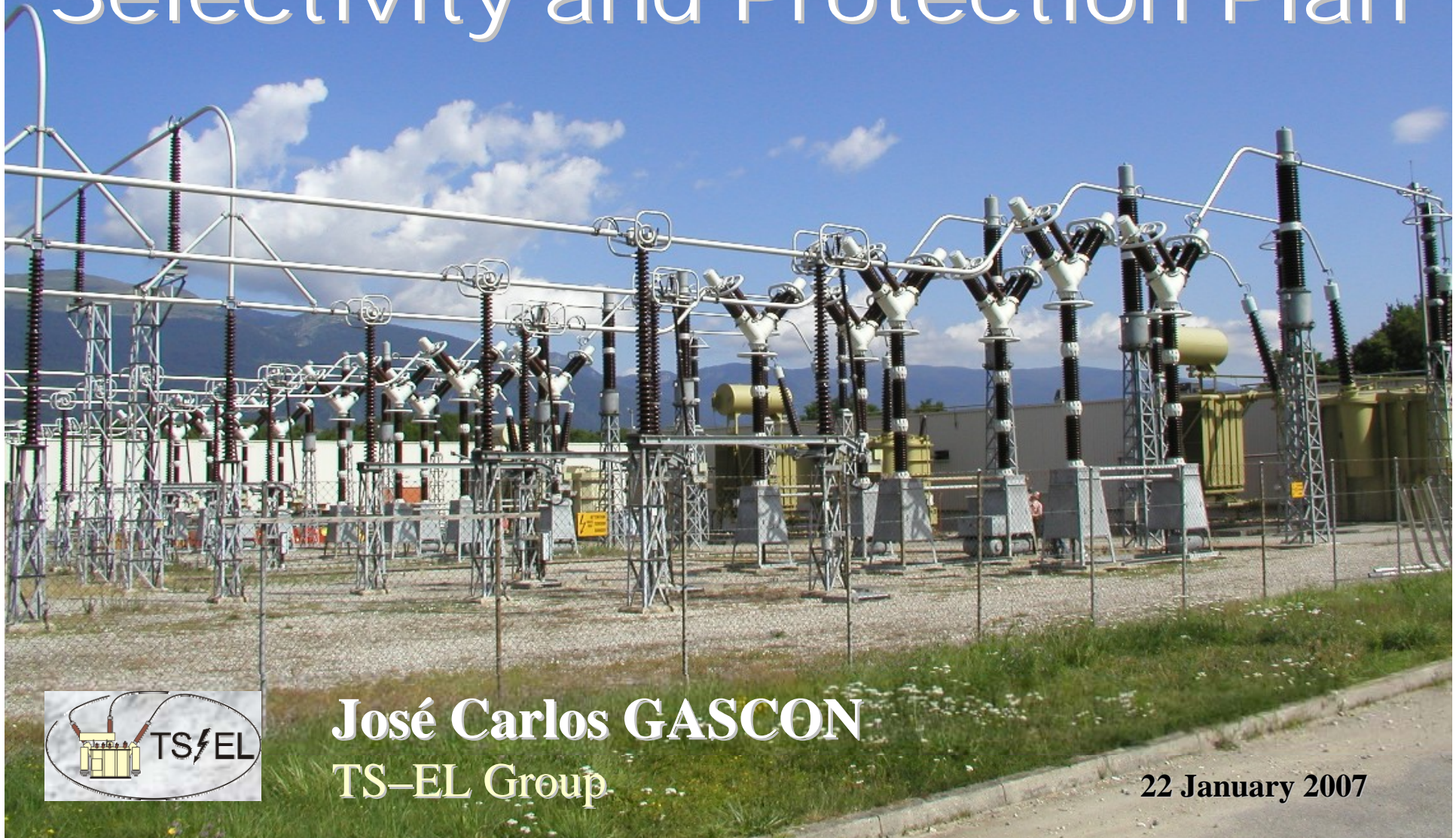




ABOC/ATC days

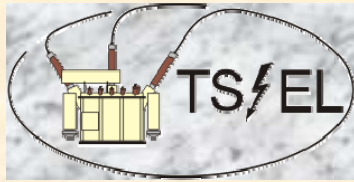


# Electrical Network: Selectivity and Protection Plan



**José Carlos GASCON**  
TS-EL Group

22 January 2007

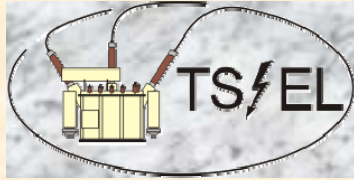


# Summary

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- ❖ Introduction
- ❖ Selectivity
- ❖ CERN HV electrical
- ❖ 29<sup>th</sup> July 2007
- ❖ Selectivity at CERN
- ❖ Project Planning

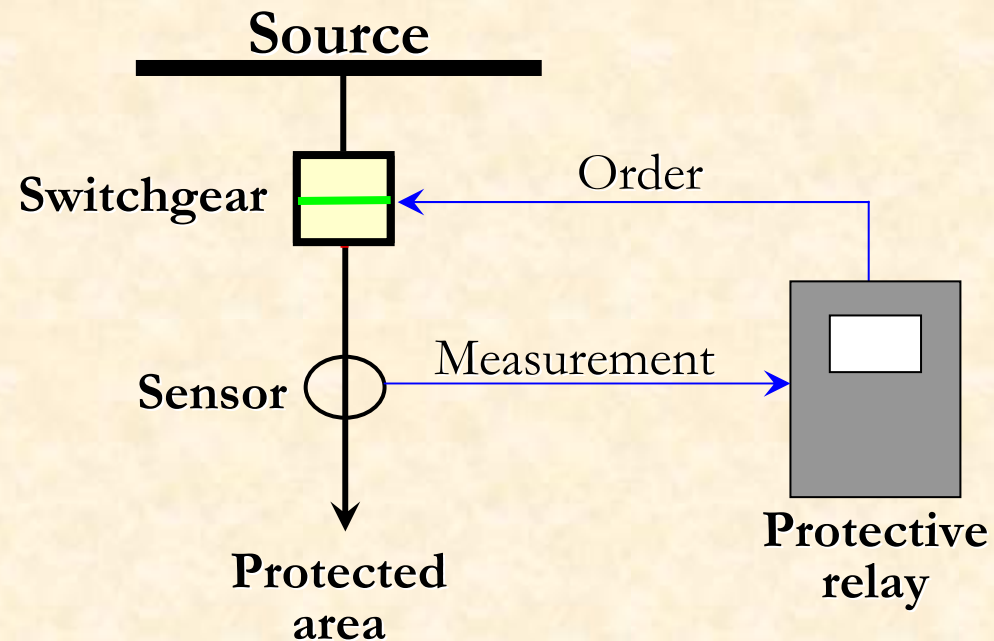


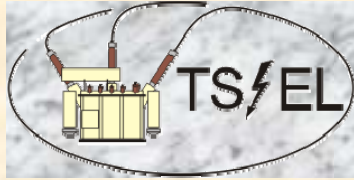


# Introduction

## ⇒ Protection system in the electrical network

- ❖ Switchgear: in charge of clearing faults
- ❖ Sensors: providing measurements to detect faults
- ❖ Protective relays: processing measurements and ordering to clear faults





# Introduction

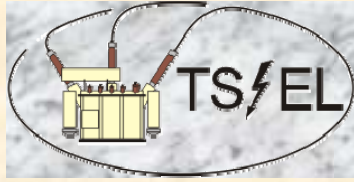
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## ⇒ Why protection system is needed

- ❖ Personnel safety against electrical hazards
- ❖ Avoid equipment stress: thermal, electrical and mechanical damages
- ❖ Assure network stability
- ❖ Clear electrical faults and maintain service continuity

## ⇒ Features of protection system

- ❖ Fast
- ❖ Reliable
- ❖ Selective



# Selectivity

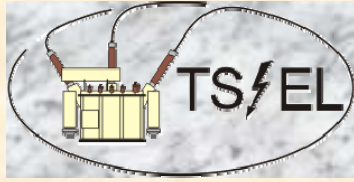
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## ⇒ Definition

- ❖ Discrimination between protection systems, isolating a faulty area of the electrical network as quickly as possible and leaving all the fault-free areas energized

## ⇒ How to do

- ❖ Time based discrimination
- ❖ Current based discrimination
- ❖ Logic discrimination
- ❖ Directional protection discrimination
- ❖ Differential protection discrimination
- ❖ Combined

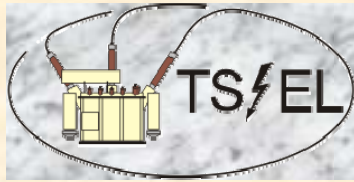


# Selectivity

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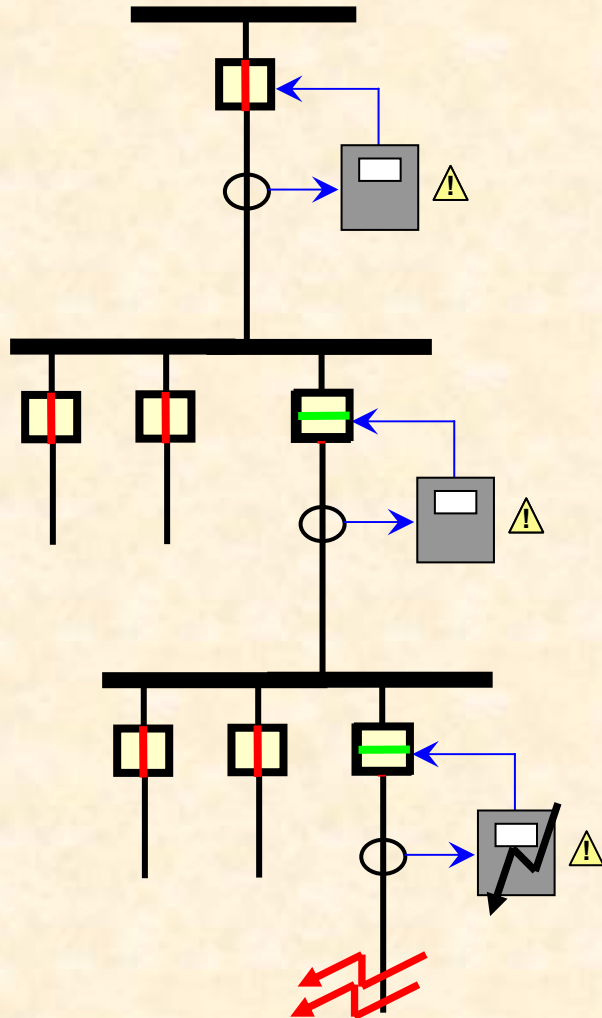
## ⇒ Parameters

- ❖ The complexity and size of the electrical network
- ❖ Network architecture
- ❖ Existing sources and their response in the event of a fault
- ❖ Operating time of each protection system
- ❖ Backup time
- ❖ Compromise continuity of service vs. degree of protection

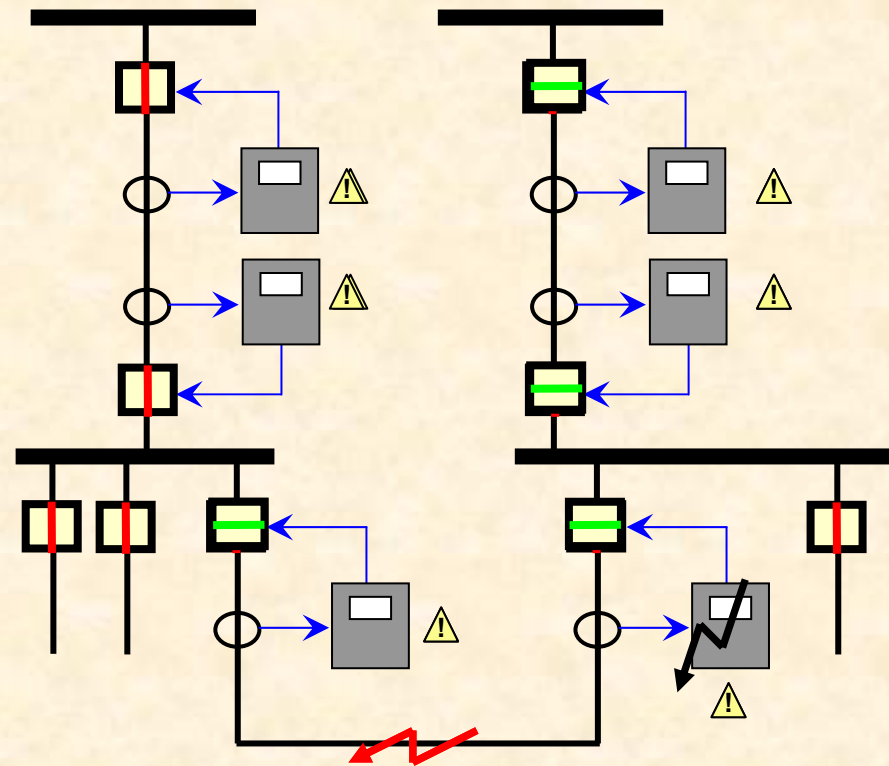


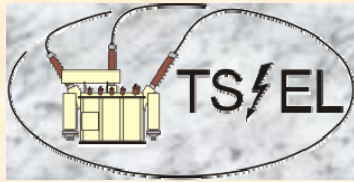
# Selectivity: examples

## Radial distribution



## Loop distribution (ex.: SPS)





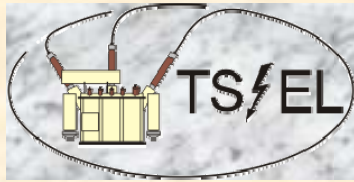
# CERN HV Electrical Network

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## ⇒ Complexity

- ❖ Voltage levels: 400kV, 66kV, 20kV, 18kV and 3,3kV
- ❖ 94 HV substations: 38 LHC, 26 SPS and 30 Meyrin
- ❖ About 1,000 protective relays and switchgears
- ❖ 4 sources: EDF (400kV & 20kV), EOS and Diesel Generators
- ❖ 3 different interconnected networks by site:
  - LHC: Machine, General Services and Safety (Assured)
  - SPS: Pulsed, Stable and Safety (Assured)
  - Meyrin: Pulsed, General Services and Safety (Assured)
- ❖ Sites interconnected by 18kV links
- ❖ Power flow direction depending on the configuration
- ❖ Compensators and harmonic filters
- ❖ Diversity of loads: pumps, converters, dipoles, transformers, compressors



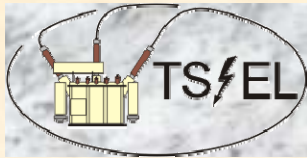


# CERN HV Electrical Network

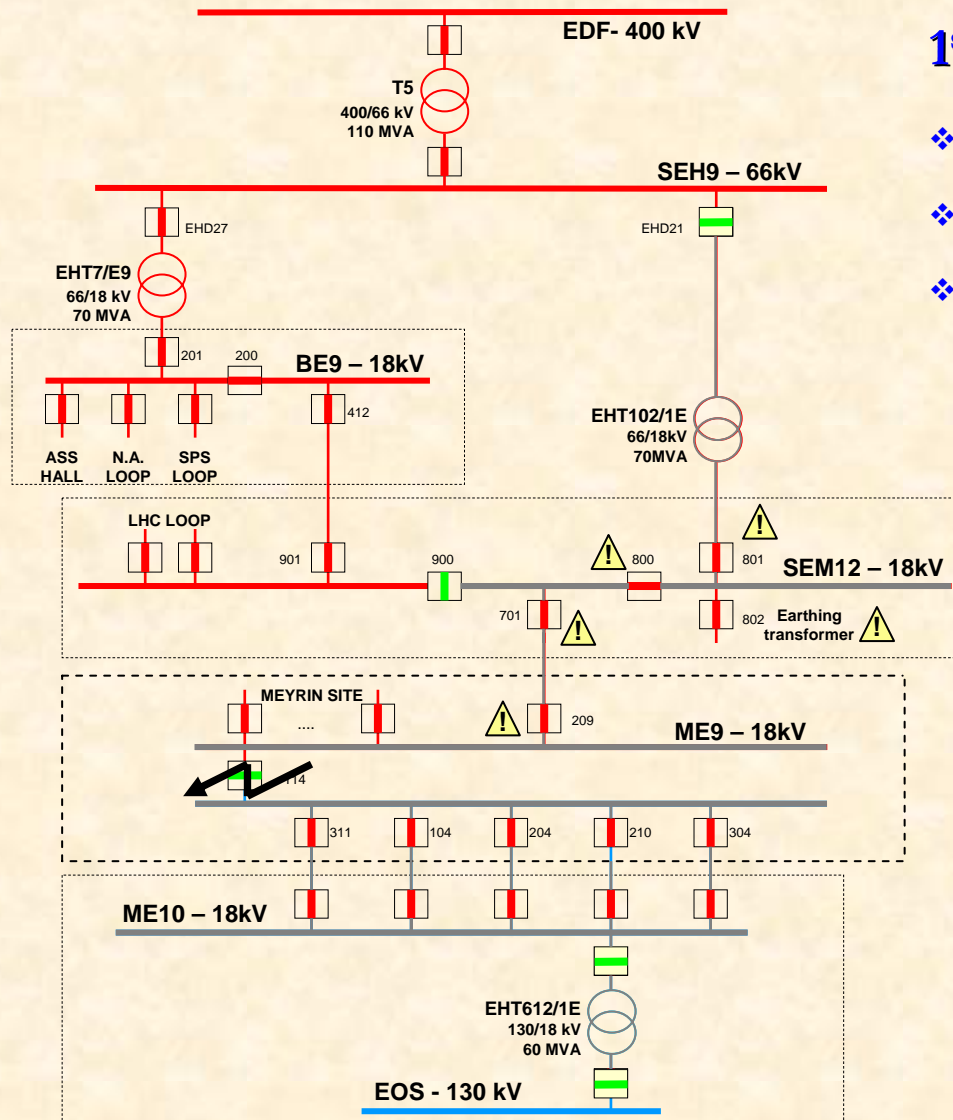
## ⇒ Protection system

- ❖ Switchgears from all ages: specific clearing time for each generation
- ❖ Different technologies in protective relays  
40% digital, 40% electronics and 20% electromechanical



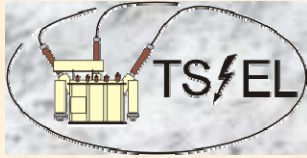


# 29<sup>th</sup> July 2006 (I)

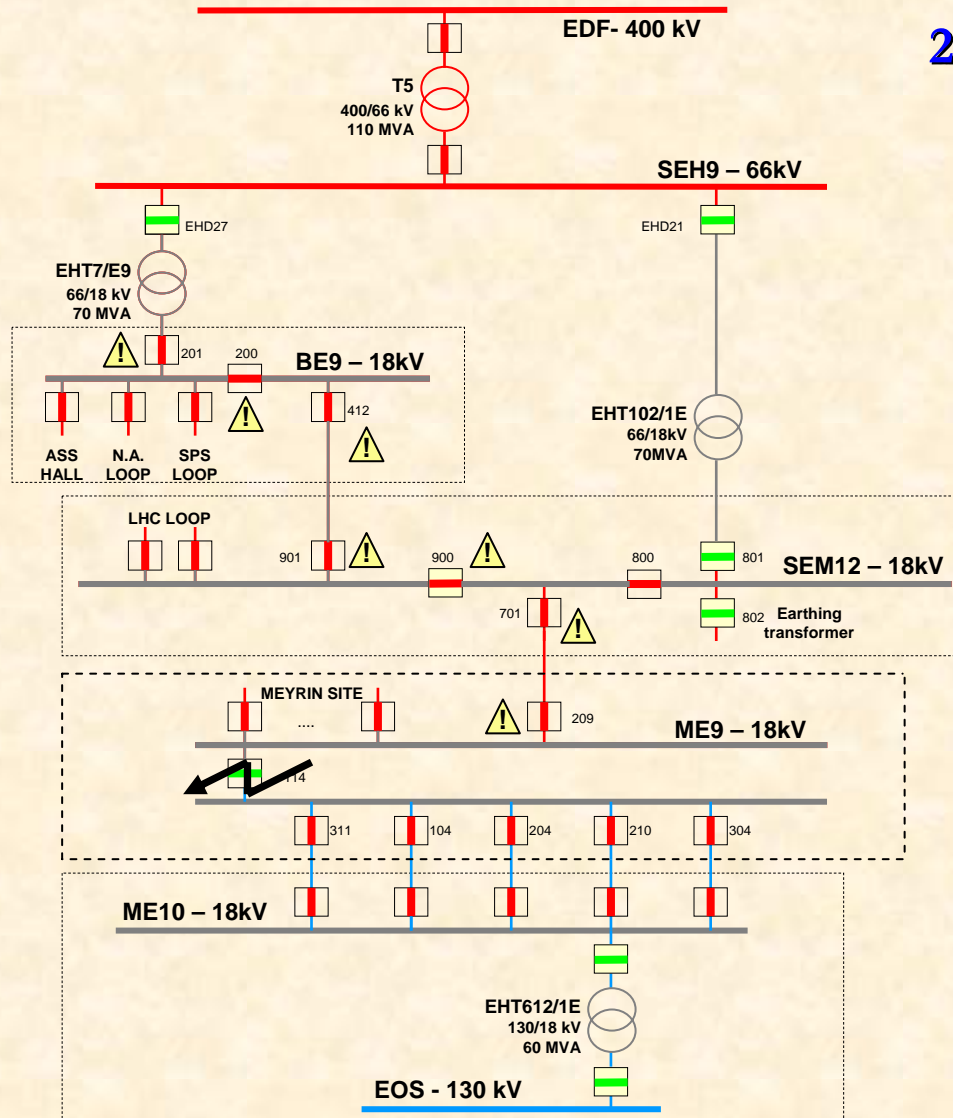


## 1<sup>st</sup> fault events

- ❖ 1 ph. fault detected in neutral reactance
- ❖ 3 ph. detected by all prot. but blocked
- ❖ Protections trip 66kV and 130kV sources

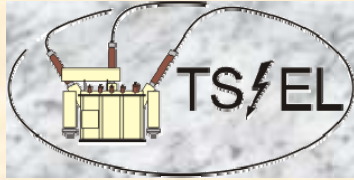


# 29<sup>th</sup> July 2006 (II)



## 2<sup>nd</sup> fault after “autotransfer system”

- ❖ 3 ph. detected by all prot. but blocked
- ❖ Protection trips at 66kV source



## 29<sup>th</sup> July 2006: consequences

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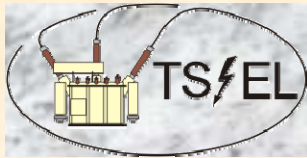
### ⇒ Power cuts

- ❖ LHC General Services
- ❖ SPS Stable loop
- ❖ North Area Stable loop
- ❖ Meyrin site: West Area and PS, ISOLDE and Administrative loops

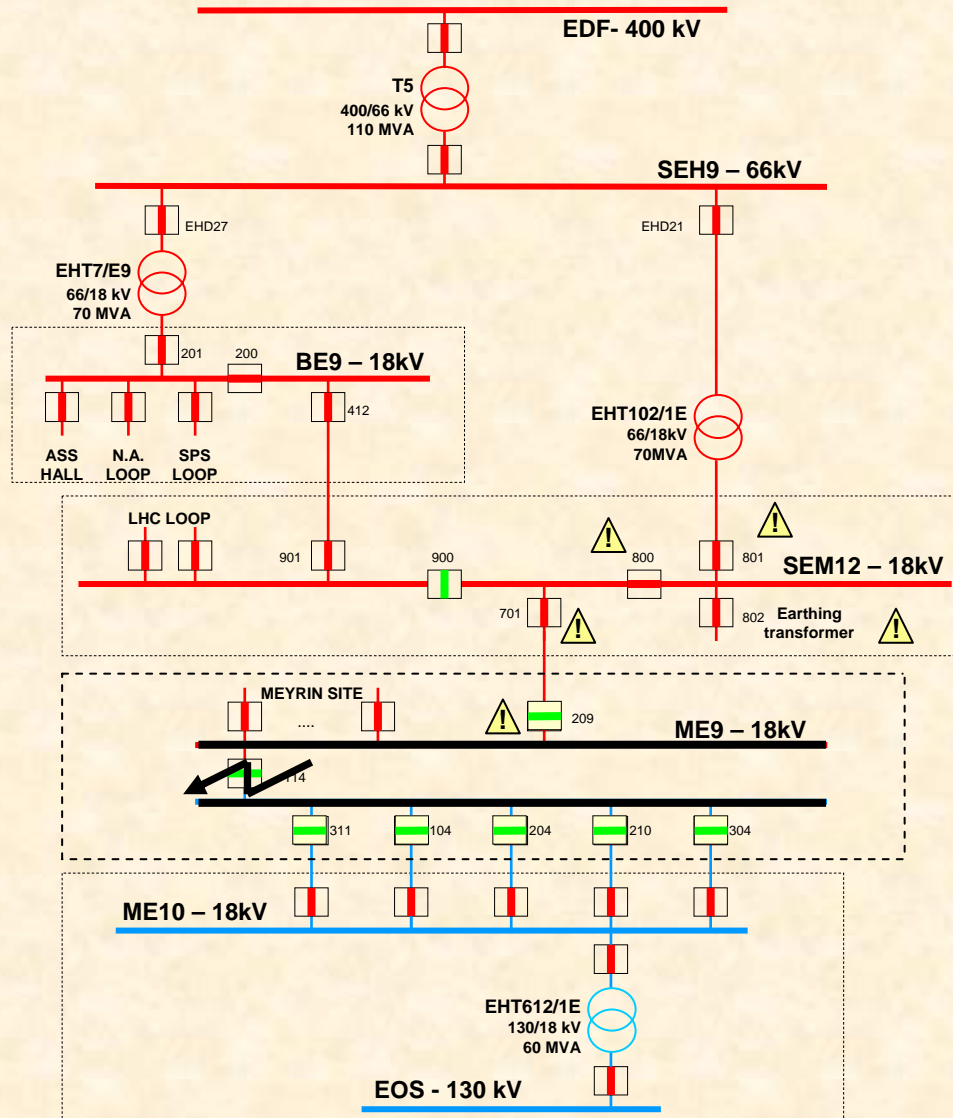
### ⇒ After analyse of the event

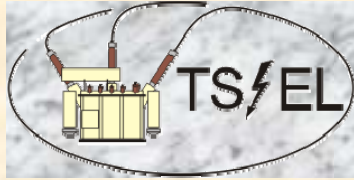
- ❖ Difficult selectivity between 66kV and 18kV levels
- ❖ Backup time not adapted for this scenario
- ❖ If selectivity, power cut reduced to the Meyrin site and lower reestablishment time





# 29<sup>th</sup> July 2006: selective





# Selectivity at CERN

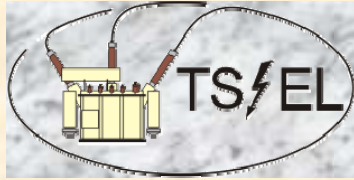
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## ⇒ Implemented selectivity

- ❖ 400kV backup agreed with EDF
- ❖ LHC General Services and Machine
- ❖ SPS pulsed and stable loops
- ❖ PS, ISOLDE and Administrative loops

## ⇒ Non-selective areas (tripping 66 kV)

- ❖ Autotransfert system (BE9, SEM12 and ME9 substations)
- ❖ West Area
- ❖ North Area
- ❖ LHC-1 and LHC-5 (in project)



# Planning (I)

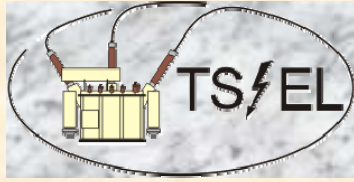
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## ⇒ **Activities in progress**

- ❖ Catalogue of protective relays: 60% completed
- ❖ Short circuit calculations: under approval

## ⇒ **Selectivity Phase 1 (April 2007)**

- ❖ Selectivity study for the non-selective areas
- ❖ Data base for all protective relays installed
- ❖ Provisional solution for the non-selective areas



## Planning (II)

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### ⇒ **Selectivity Phase 2 (January 2008)**

- ❖ Definitive solution for non-selective areas
- ❖ Complete selectivity map for main substations and configurations
- ❖ Implementation
- ❖ Commissioning

### ⇒ **Selectivity Phase 3 (in the course of 2008)**

- ❖ Selectivity map for the whole CERN HV network
- ❖ Transient simulations for main substations (BE, BE9, ME10, ME9, SEM12)



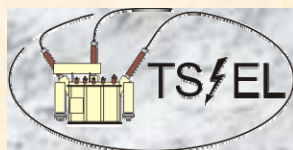


ABOC/ATC days



# Electrical Network: Selectivity and Protection Plan

**Questions?**



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TS-EL Group

22 January 2007