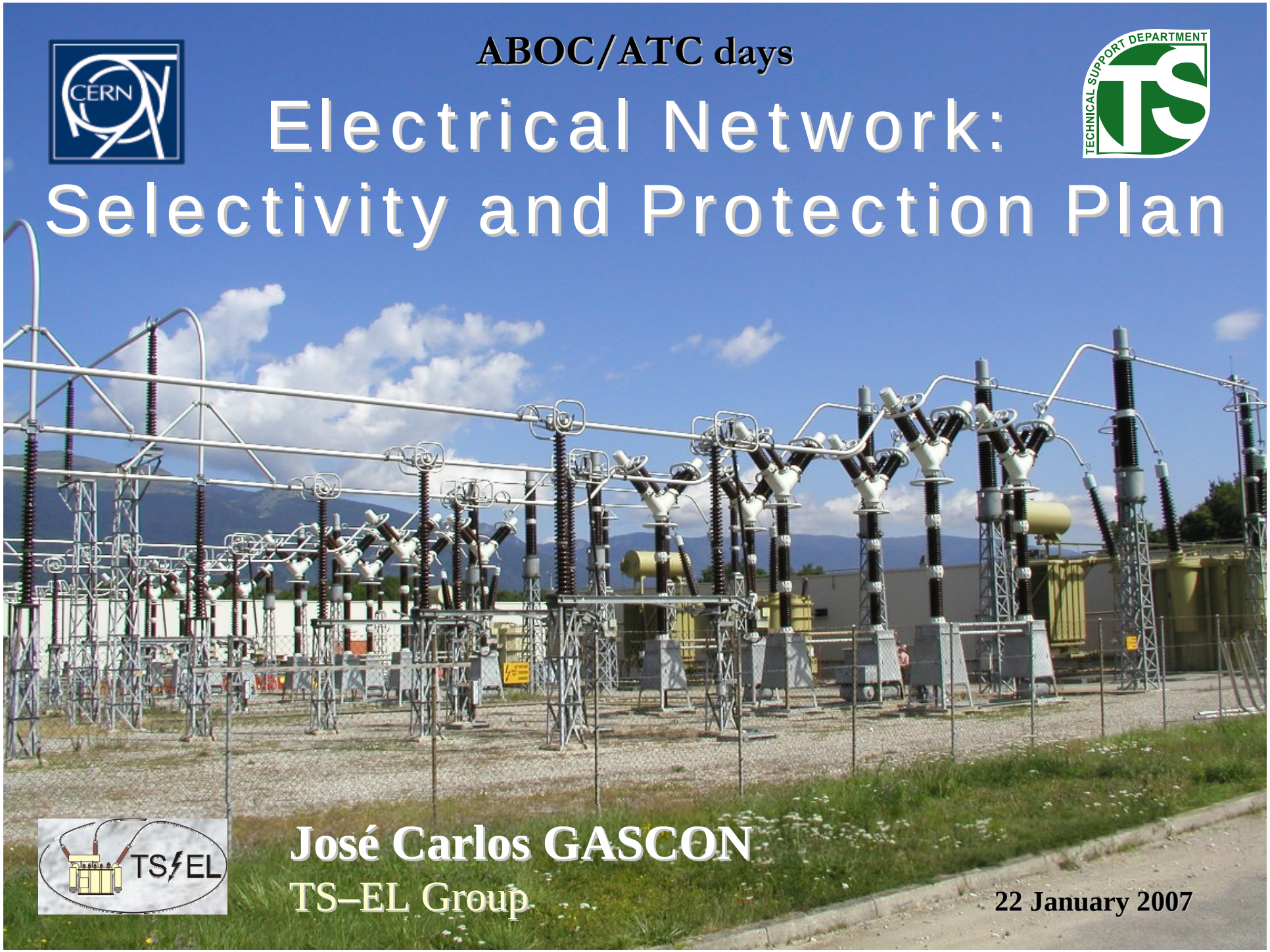
ABOC/ATC days

Electrical Network: Selectivity and Protection Plan



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22 January 2007

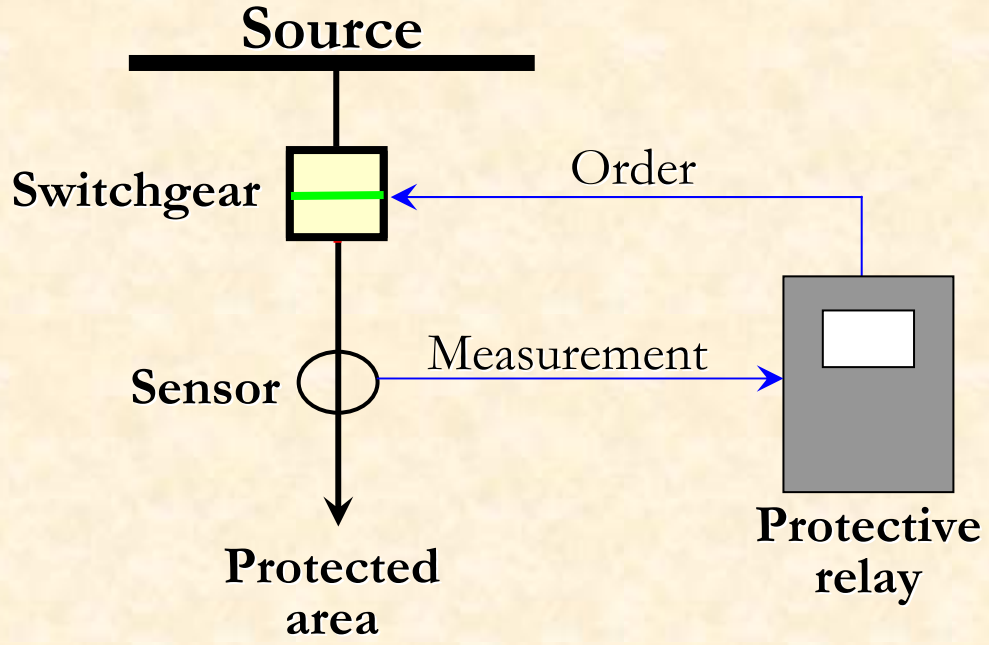
Summary

- Introduction
- Selectivity
- CERN HV electrical
- 29th July 2006
- 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

⇨ 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

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

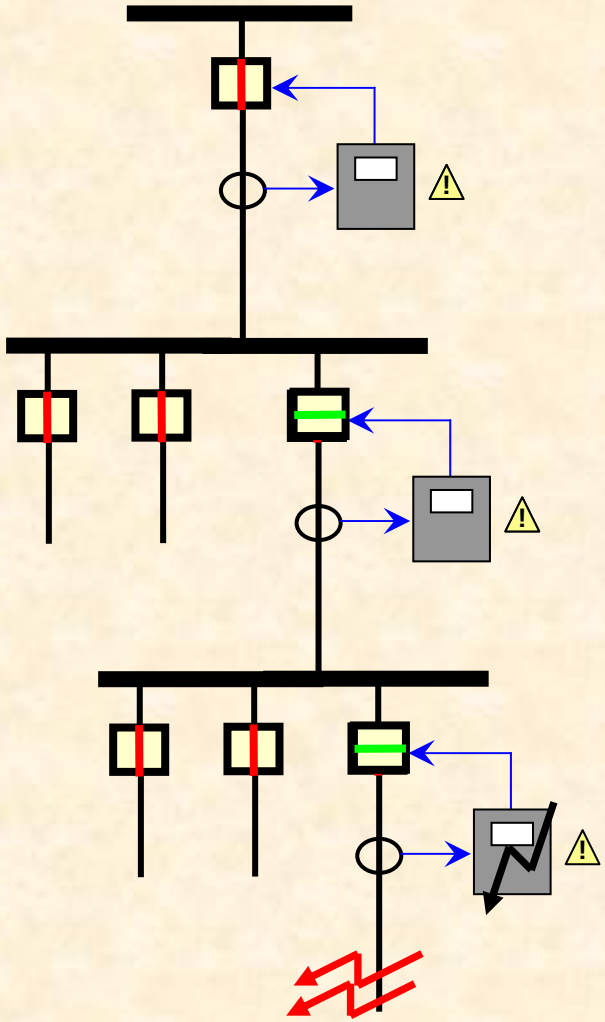
Selectivity

⇨ Parameters

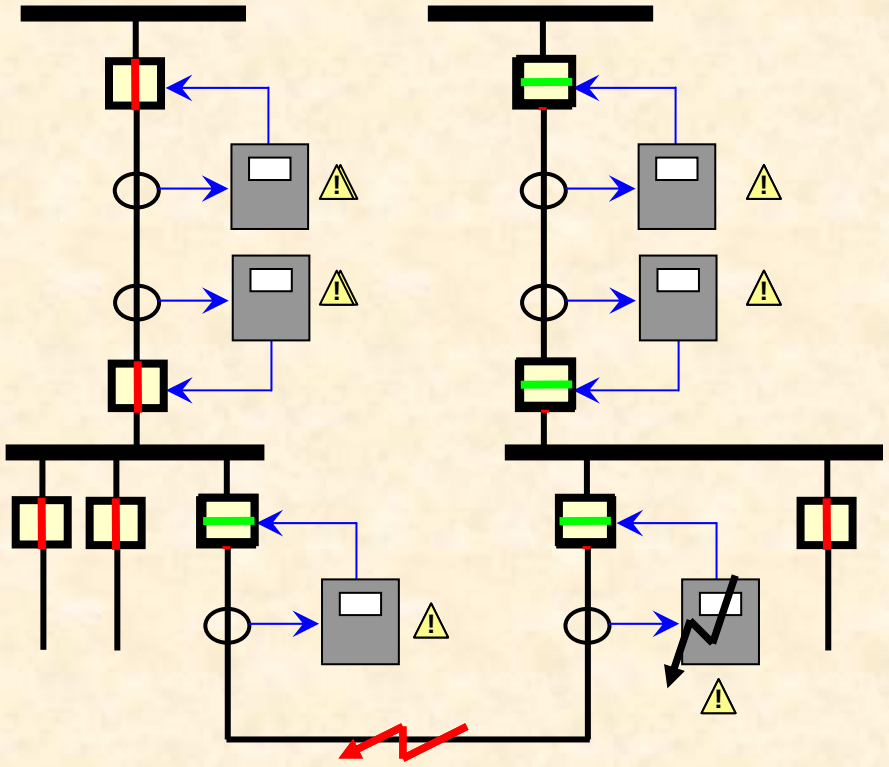
- The complexity and size of the electrical network
- Network architecture
- Existing sources and their response in the event of a fault
- Operating time of each protection system
- Backup time
- Compromise continuity of service vs. degree of protection

Selectivity: examples

Radial distribution



Loop distribution (ex.: SPS)



CERN HV Electrical Network

⇨ Complexity

- Voltage levels: 400kV, 130kV, 66kV, 20kV, 18kV and 3,3kV
- 94 HV substations: 38 LHC, 26 SPS and 30 Meyrin
- 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
- About 1,000 protective relays and switchgears
- Compensators and harmonic filters
- Diversity of loads: pumps, converters, dipoles, transformers, compressors

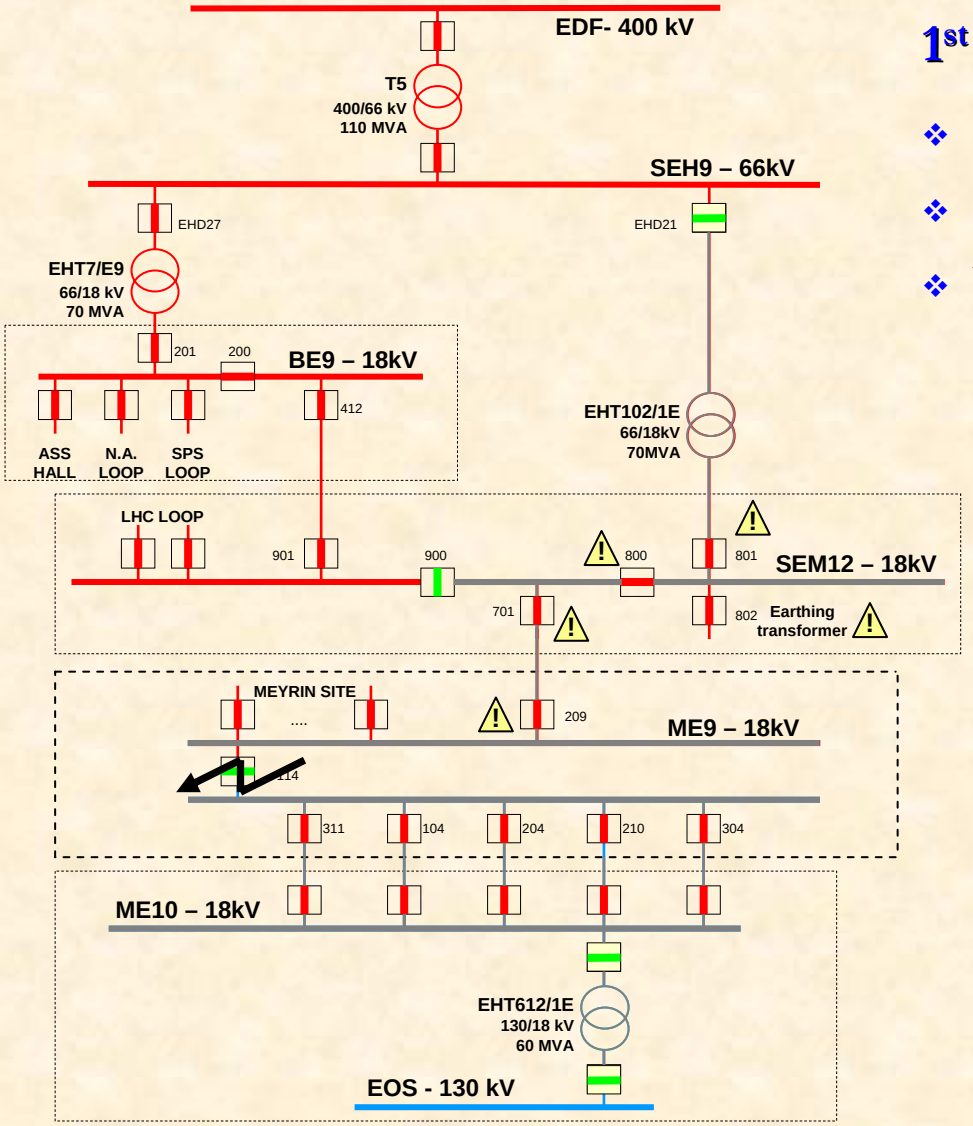
CERN HV Electrical Network

⇨ Protection system

- Switchgears from all ages: specific clearing time for each generation
- Different technologies in protective relays

  40% digital, 40% electronics and 20% electromechanical

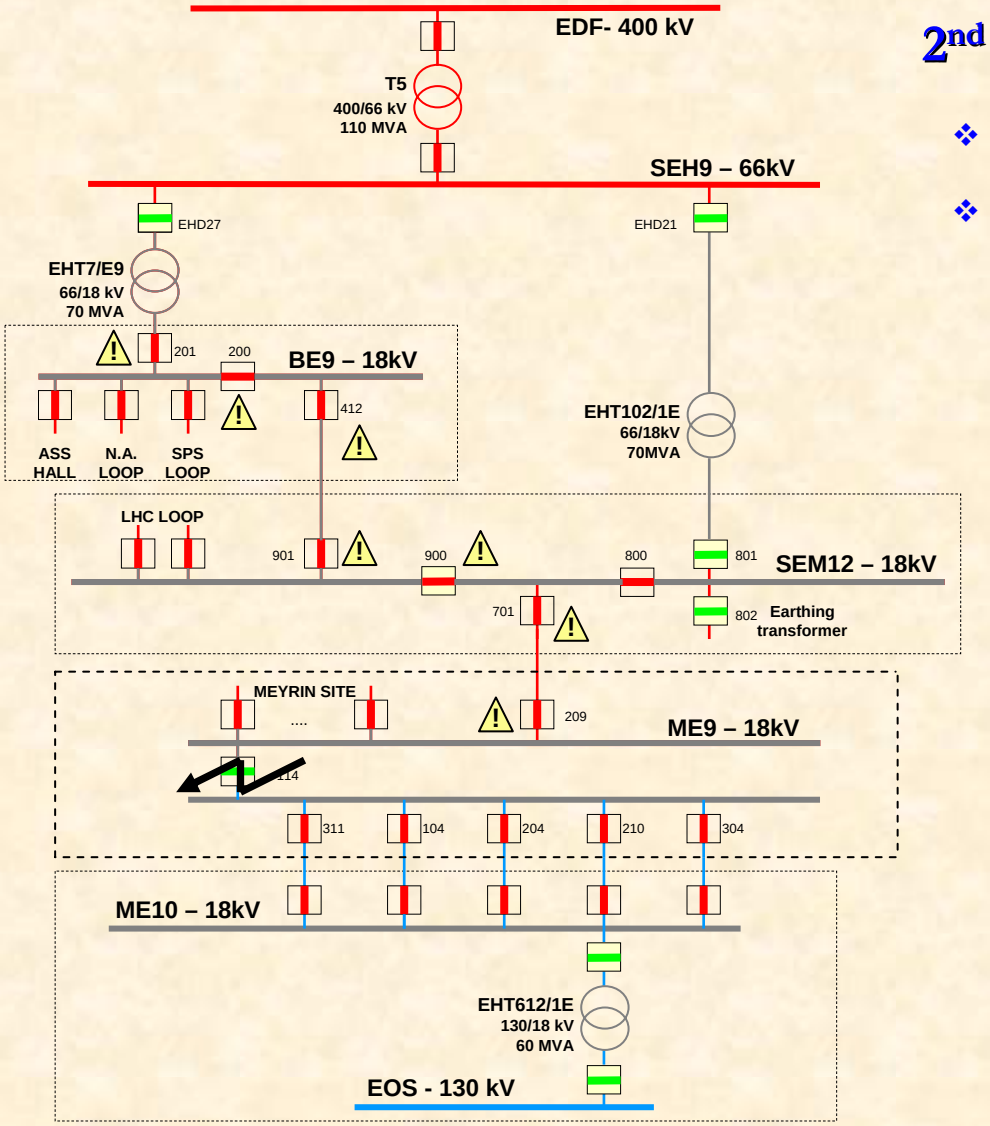
29th July 2006 (I)



1st fault events

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

29th July 2006 (II)



2nd fault after "autotransfer system"

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

29th July 2006: consequences

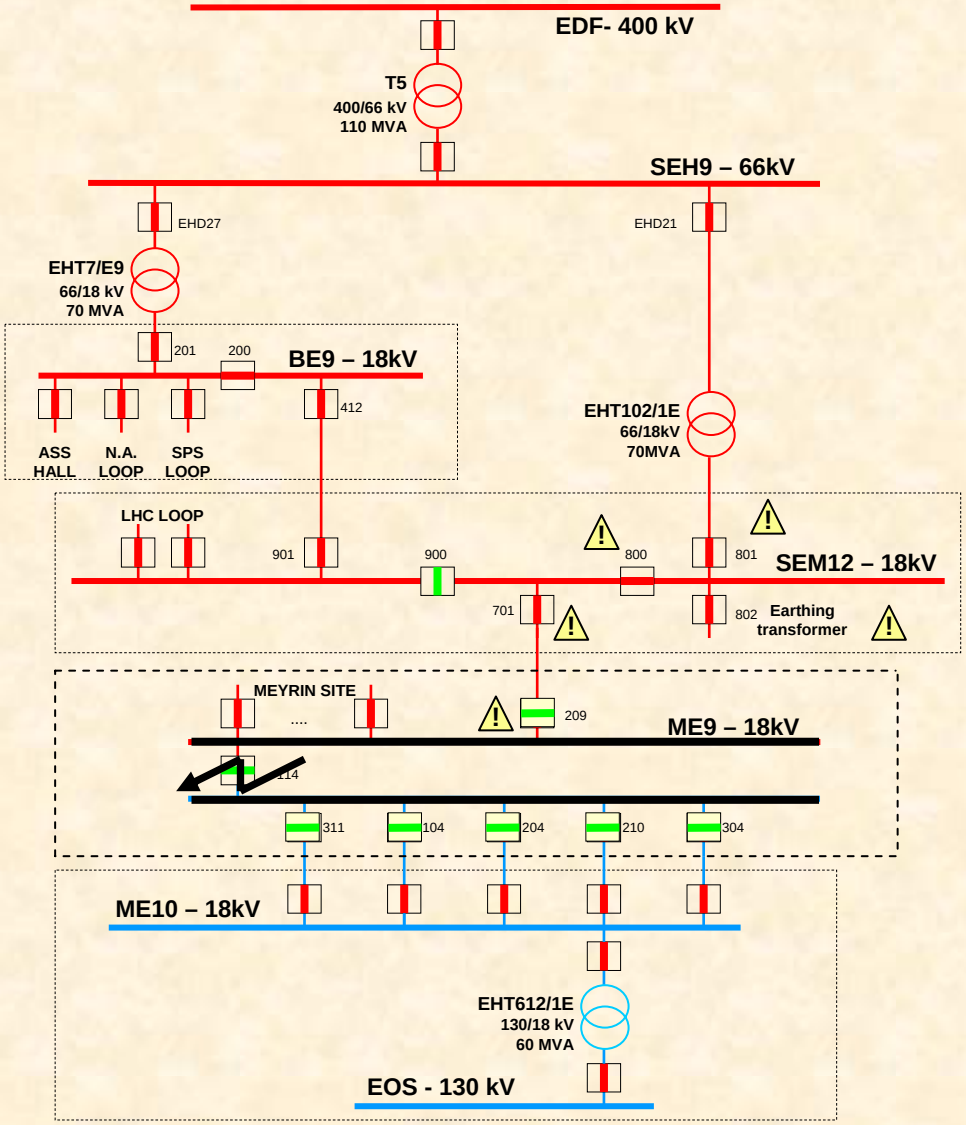
⇨ Power cuts

- 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

29th July 2006: selective



Selectivity at CERN

⇨ 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)

⇨ 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)

⇨ 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)

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Questions?

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