ABOC / ATC workshop

22 January 2007

Situation of the Static Var Compensators at CERN.

Risk analysis, maintenance and consolidation strategy

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Situation of the Static Var Compensators at CERN

1. Introduction
2. General risk analysis for SVC's
   - typical faults
   - how to reduce the risk
3. The SVC's at CERN in detail
   - technical state
   - maintenance strategy
   - consolidation
4. Summary

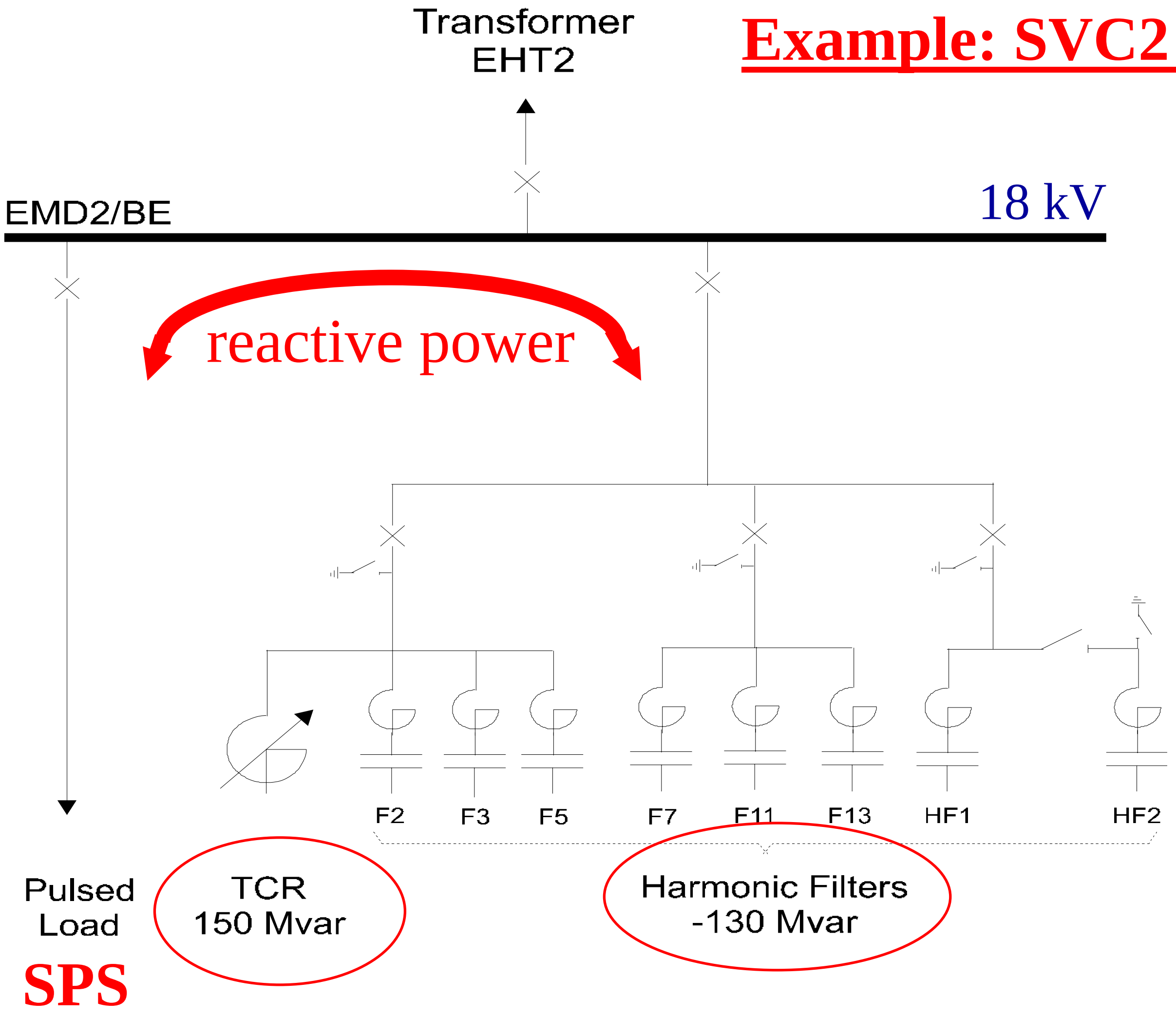
Introduction

Purpose of an SVC:

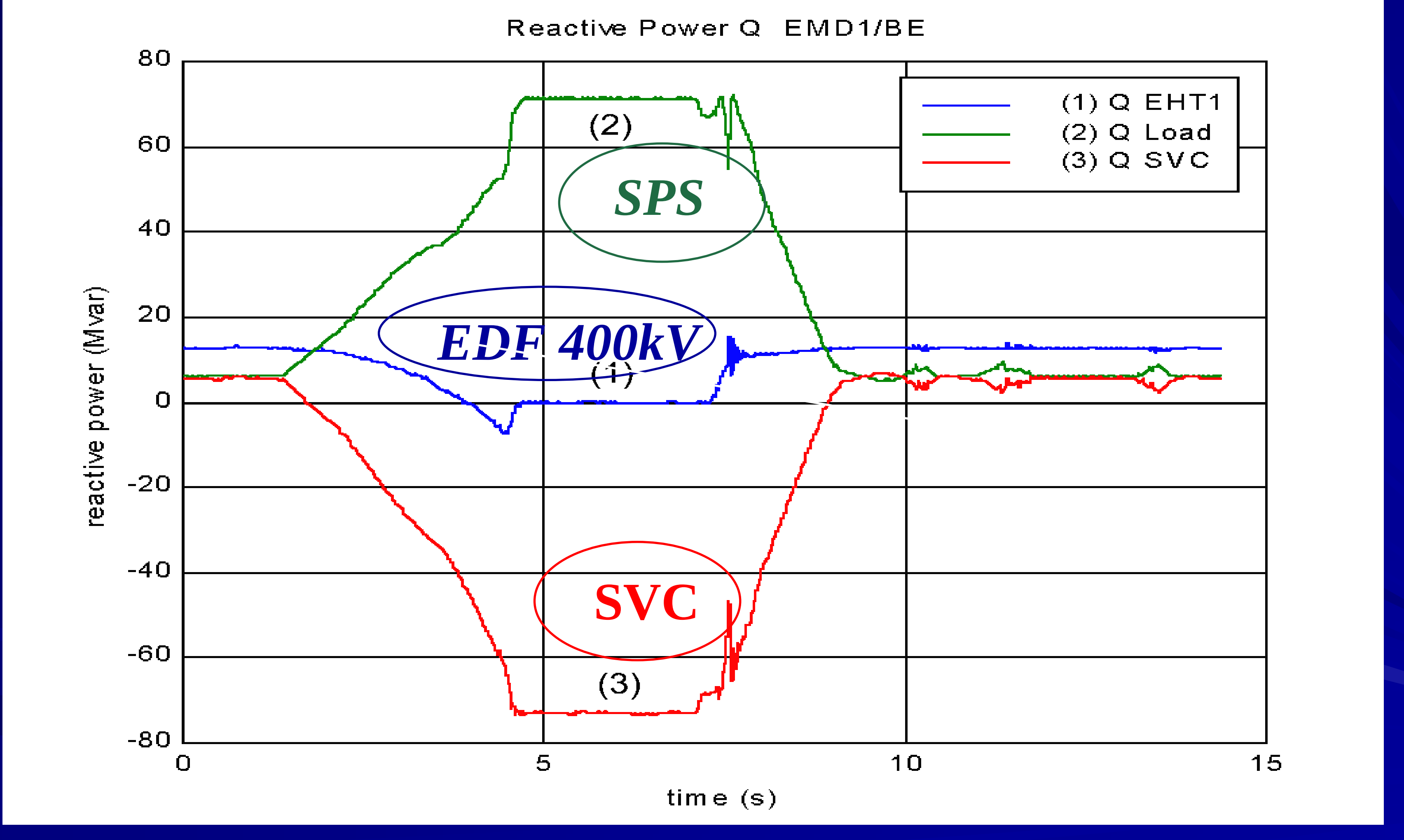
- Reactive Power compensation
- Voltage stabilization 18 kV
- Harmonic filtering

Introduction

Example: SVC2 for SPS



Purpose: Reactive power compensation



Introduction

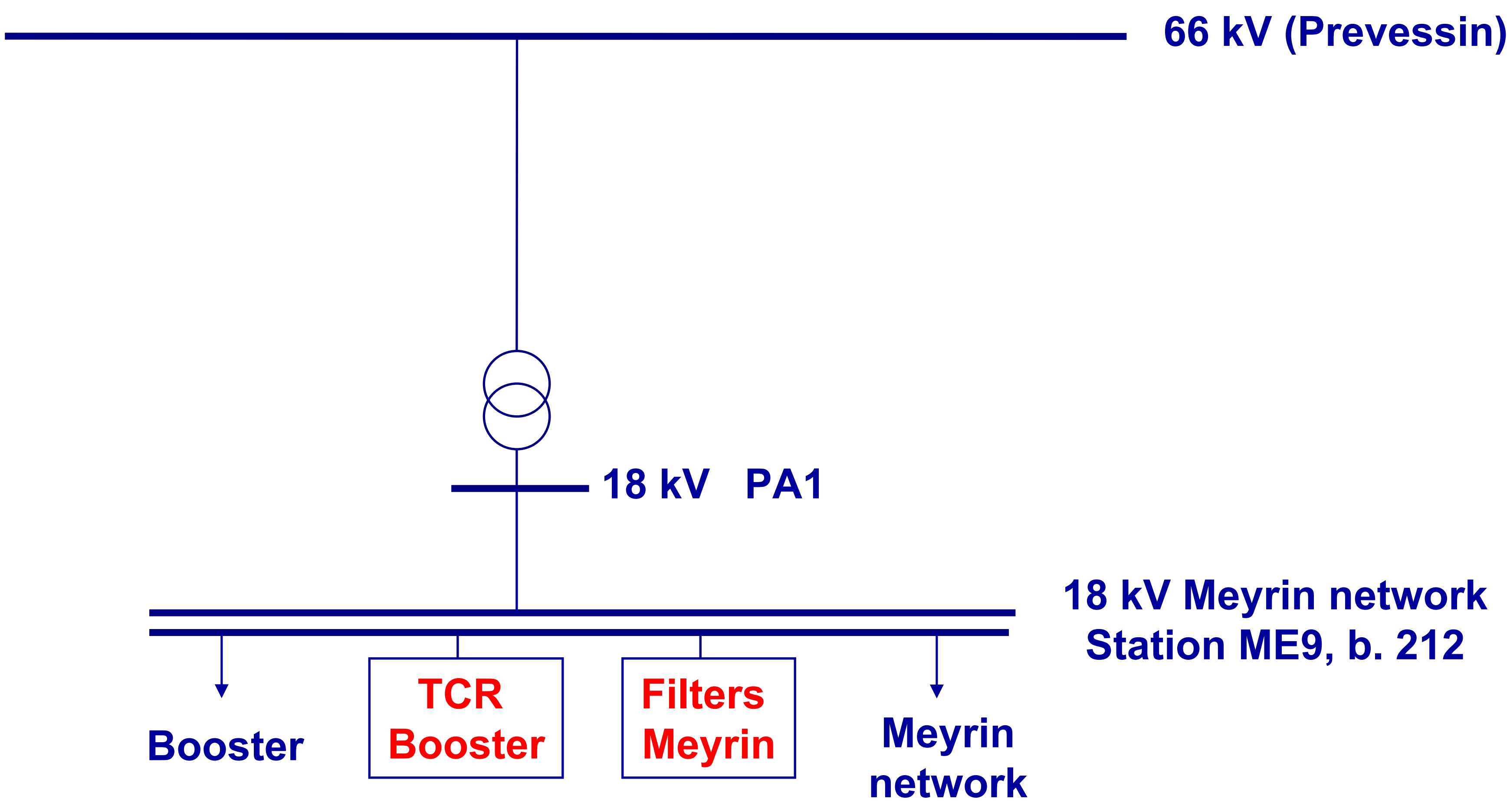
SVC's and harmonic filters at CERN (status end 2007):

- Total of SVC's / filter inst.: 12
- Rated voltage: 18 kV
- Total surface: 14'000 m^2
- Total value (prices 2007): 45 MCHF

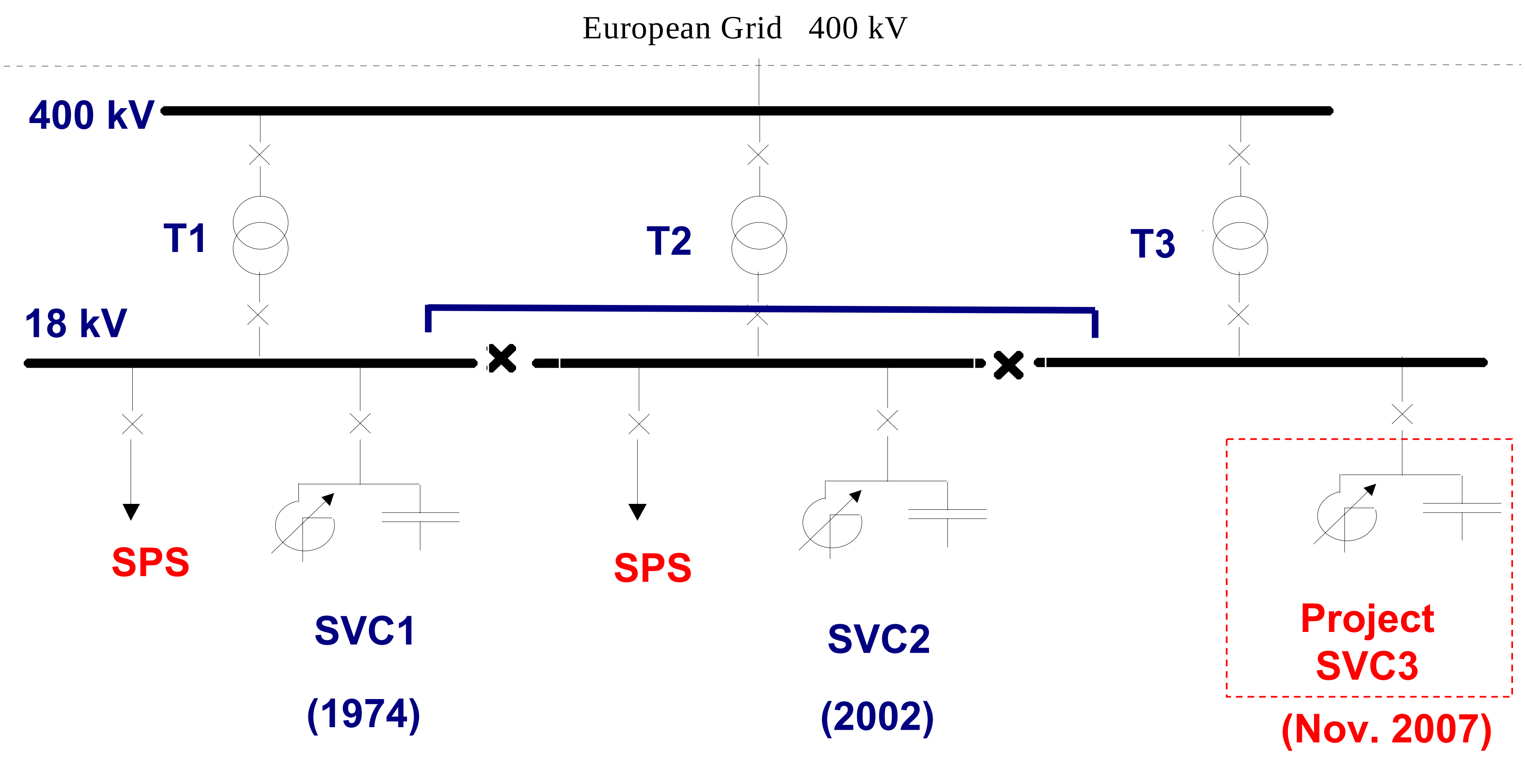
- Total capacitive power: 550 Mvar (=17.6 kA @ 18 kV)
- For comparison:

  CERN consumption 2008: 380 MVA peak (=12.2 kA peak @ 18 kV)

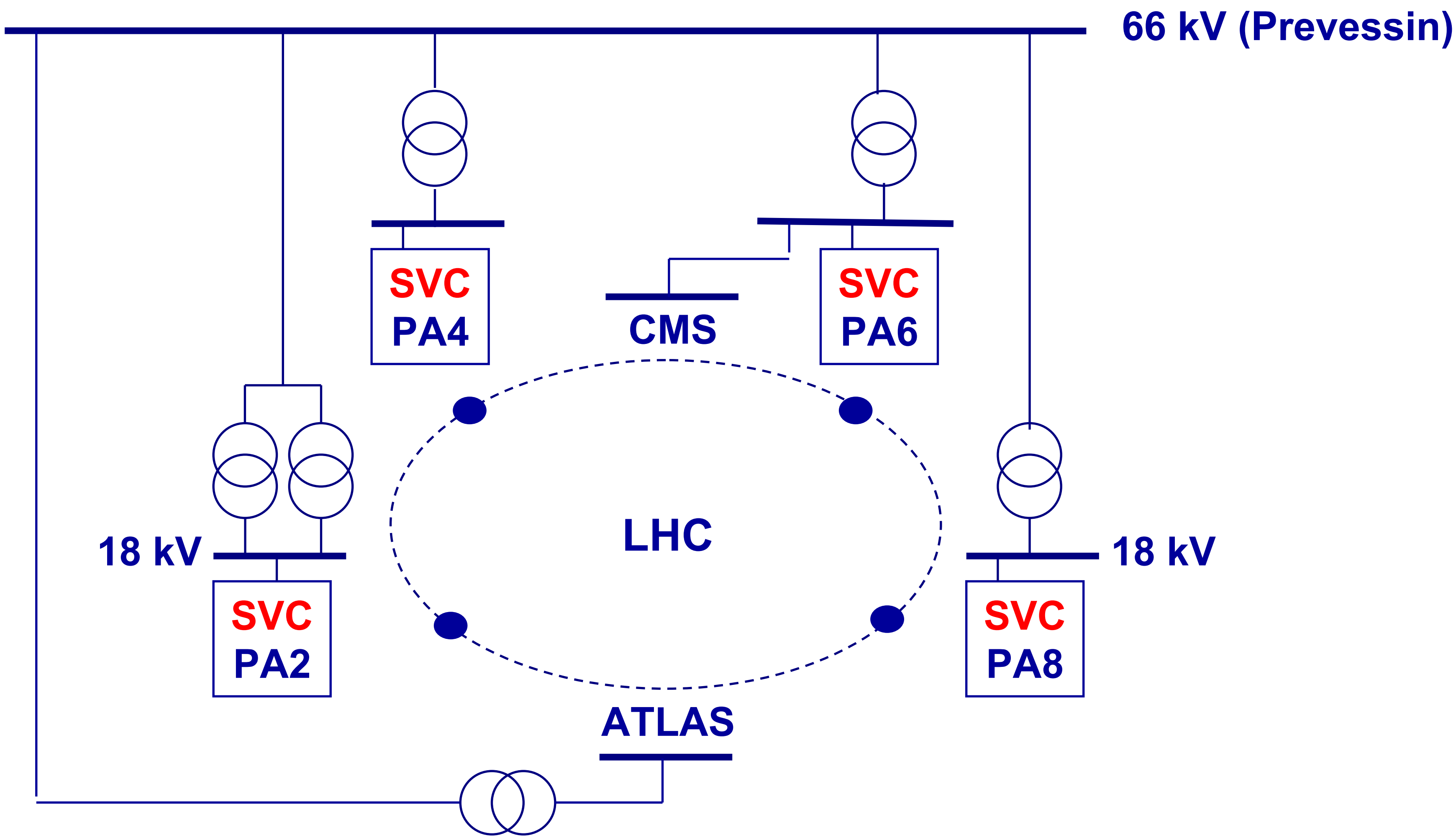
Introduction: Meyrin network and Booster



Introduction: SPS electrical network



Introduction: LHC machine network



Filters Meyrin Booster (build. 202)

1st floor: capacitors

2nd floor: reactors

3rd floor: resistors

Filters Meyrin Booster (build. 202)

Reactors

(1971)

NB: LHC operation depends on them.

TCR Booster (build. 242, Meyrin)

TCR

(1997)

SVC1 (build. 884, Prevessin)

Harmonic filters

Saturated reactor
(1974)

SVC2 (build. 980, Prevessin)

(year 2002)

Risk Analysis (types of faults) 1/3

Faults with low severity

type of fault	typical downtime TS-EL	probability of event	severity	preventive measures
disturbance of network 400 kV (external cause)	1 h	high	**low**	none
false trip of protection	1 h	high	**low**	optimize protection
lack of cooling water, water filter clogged etc.	2 h	high	**low**	none
miscellaneous (small) failures such as animal entry, Emergency Stop operation etc.	½ day	medium	**low**	none

Risk Analysis (types of faults) 2/3

Faults with medium severity

type of fault	typical downtime TS-EL	probability of event	severity	preventive measures
Trip: capacitor bank unbalance (small capacitor failures)	½ day	high	**medium**	- annual maintenance, - monitor capacitor unbalance currents, - spare capacitors
Trip: thyristor failure (one thyristor per phase)	½ day	low / medium	**medium**	- spare thyristors

Risk Analysis (types of faults) 3/3

Faults with high++ severity (major events)

type of fault	typical downtime TS-EL	probability of event	severity	preventive measures
overheating of bad electrical connection (short-circuit) - ex: 2003 SVC1	up to 3 days	low	**high**	- IR thermography - maintenance
capacitor bank avalanche failure - ex: 2006 SVC1	several weeks	low	**very high**	- annual maintenance, - monitor ub currents, - spare capacitors
thyristor avalanche failure - ex: 1998 BB3 & 1998 PA2	1 ... 5 days	very low	**very high**	- annual maintenance, - spare thyristors
Failure of air-core coil - ex: 1999 LEP PA4	2 ... 3 months	very low	**very high**	- annual maintenance, - spare coils ? (45 types at CERN)
Major internal failure of Saturated reactor (SVC1)	repair impossible	medium	**extremely high**	- annual maintenance, - oil analysis, - redundant SVC3

Risk Analysis - Summary

How to reduce the risk?

- consolidation
- redundancy for large SVC's (e.g. SPS)
- annual maintenance
- IR thermography
- sufficient spare parts

SVC Meyrin for Booster

● TCR (20.5 Mvar, 1997)

Technical state	Risk of major breakdown	actions
- good state - annual maintenance was done	low risk	- Annual maintenance - check avail. spare parts

● Meyrin Filters (17 Mvar, 1972)

Technical state	Risk of major breakdown	actions
- ageing equipment (35 years) - unknown technical state - capacitors (1990)	high	- 2007: Annual maintenance - consolidation project (will be studied)

SVC1 for SPS

● Saturated Reactor (117 Mvar, 1974)

Technical state	Risk of major breakdown	actions
- approaching end of life time	(very) high risk	- annual maintenance - oil analysis / oil treatment

● Harmonic filters (92.1 Mvar, 1974)

Technical state	Risk of major breakdown	Actions
- capacitors (1992) - 2 identical faults (1991, 2006) - sufficient spare capacitors are available to cover breakdowns	medium risk of major capacitor failure (again)	- annual maintenance - consolidation project (Will be studied. Additional spare parts for SVC2+SVC3 or SVC1 consolidation?)

SVC1: Major breakdown on 8.5.2006 [EDMS 813568]

● Causes:

- identical breakdown happened 1991
- ageing of capacitors
- status of maintenance
- low impedance of HF filter (filter design) ?
- breakdown not linked to manual operation on 1.5.2006

● What has been done so far ?

- re-commissioning in May/June 2006, only minor techn. modifications
- prevention of manual energization
- sufficient spare capacitors available
- major maintenance scheduled for spring 2007

● Risk

- Risk is reduced, but cannot be eliminated

SVC2 for SPS

● **TCR (150 Mvar) and harmonic filters (130 Mvar)** **(2002)**

Technical state	Risk of major breakdown	actions
- good technical state - annual maintenance during previous years - sufficient spare parts in stock	low risk	- annual maintenance

SVC3 for SPS

● TCR (150 Mvar) and harmonic filters (130 Mvar) **(2007)**

Technical state	Risk of major breakdown	actions
- work in progress - energization 1.11.2007 - will be identical to SVC2 - budget about 6 MCHF		

Auxiliary Compensator BB3 for SPS

BB3 is required as long as SVC1 is in operation. As soon as SVC1 is out of service (e.g. saturat. Reactor h/s), we can dismantle BB3.

● TCR (18 Mvar, 1982)

Technical state	Risk of major breakdown	actions
- ageing equipment (25 years) - has been maintained regularly	medium risk	- annual maintenance

● Capacitor bank (18 Mvar, 1982)

Technical state	Risk of major breakdown	actions
- ageing equipment (25 years) - has been maintained regularly	medium risk	- annual maintenance - increase spare capacitors

Stable Filter BEF4 for Stable Network

- **Stable Filter (21 Mvar, 1977)**

Technical state	Risk of major breakdown	actions
- ageing equipment (30 years) - major capacitor failure in 2006	medium	- 2007: Annual maintenance - increase spare capacitors

4 SVC's for LEP/LHC in PA2, PA4, PA6, PA8

- **TCR (50 Mvar) and harmonic filters (50 Mvar) in PA2** **(1987)**
- **TCR (25 Mvar) and harmonic filters (25 Mvar) in PA4** **(1992)**
- **TCR (25 Mvar) and harmonic filters (25 Mvar) in PA6** **(1987)**
- **TCR (25 Mvar) and harmonic filters (25 Mvar) in PA8** **(1992)**

Technical state	Risk of major breakdown	actions
- all SVC's are out of service		- 2007: consolidation progr. (Techn. Note EDMS 768037) - budget 1.2 MCHF

Summary 1/2

- Goals: - prevention of major SVC failures (high severity)
  - repair a.s.a.p.

- Actions for 2007 and beyond:
  - consolidation (4 SVC's for LHC, Meyrin Filters ?, SVC1 ?)
  - commissioning of SVC3 for 1.11.2007 (= redundant SVC for SPS)
  - annual maintenance of all SVC's in service
  - IR thermography
  - intermediate checks during operation (early detection)
  - increase of spare parts in stock (e.g. to cover major failures)

Summary 2/2

- Order of priorities:

1. terminate SVC3 project 2007
2. consolidation PA2 and PA4 (most critical for LHC) 2007
3. consolidation Meyrin Filters for Booster *) 2007..08
4. consolidation PA6 and PA8 (less critical for LHC) *) 2007..08

*) order of priority, depending on

- technical state of Meyrin Filters
- future strategy for Meyrin network (PS2, SPL, LINAC's etc.)

Outlook

Spring 2007: - annual maintenance for all SVC's in service

End 2007: - 3 SVC's for SPS (redundant SVC for SPS)

- 2 most critical SVC's for LHC renovated (PA2, PA4)

- strategy for Meyrin network, incl. Meyrin Filter for Booster

Mid 2008: - all 4 SVC's for LHC renovated

End 2008: - depending on strategy: Meyrin Filter for Booster renovated

Questions?