MTTR & Spare Policy for the LHC Injectors

Magnets for the PS Complex

T. Zickler

Outline

Accelerator Technology Department

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Thanks to A. Newborough, D. Bodart, A. Hue for their contribution

Introduction

PS- Complex: structure grown during 50 years

- Linac2, Linac3, Booster, PS, LEIR, AD, Isolde, Experimental Areas, beam lines …
- More than 1200 magnets, more than 200 different types

In the past: responsibility of machine superintendent

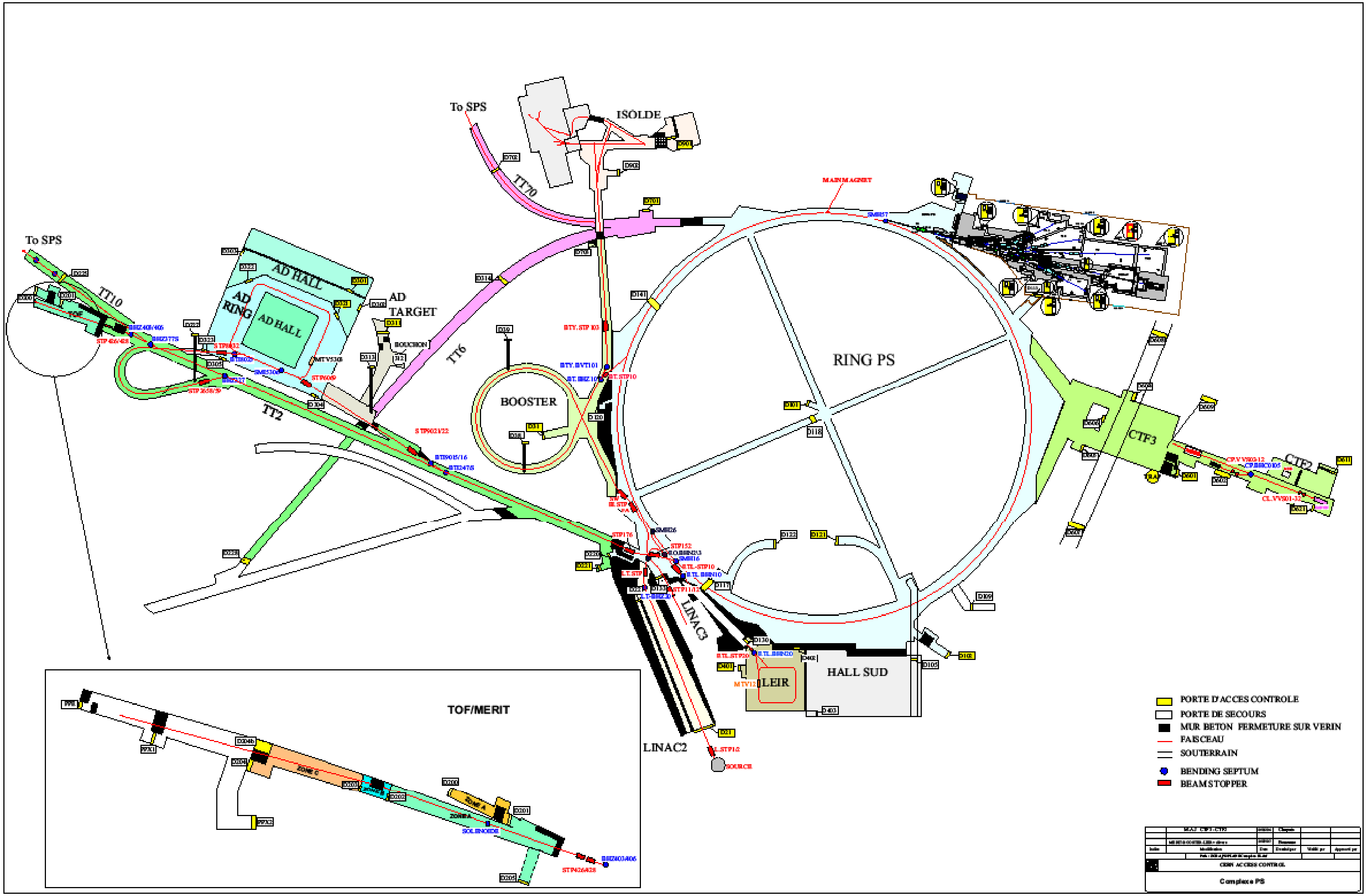
- → No central data base
- → Documentation kept in ‘private’ archives
- → Spare components distributed all over CERN

2003: responsibility of all nc magnets successively transferred to AT-MEL

2007: start to set up nc magnet database

- Unique naming system
- Inventory of installed and spare magnets
- Upload magnet characteristics
- Gather and scan related documents (drawings, specifications, measurement reports...)
- Link to layout database

Scope: the LHC-injector



Magnet types

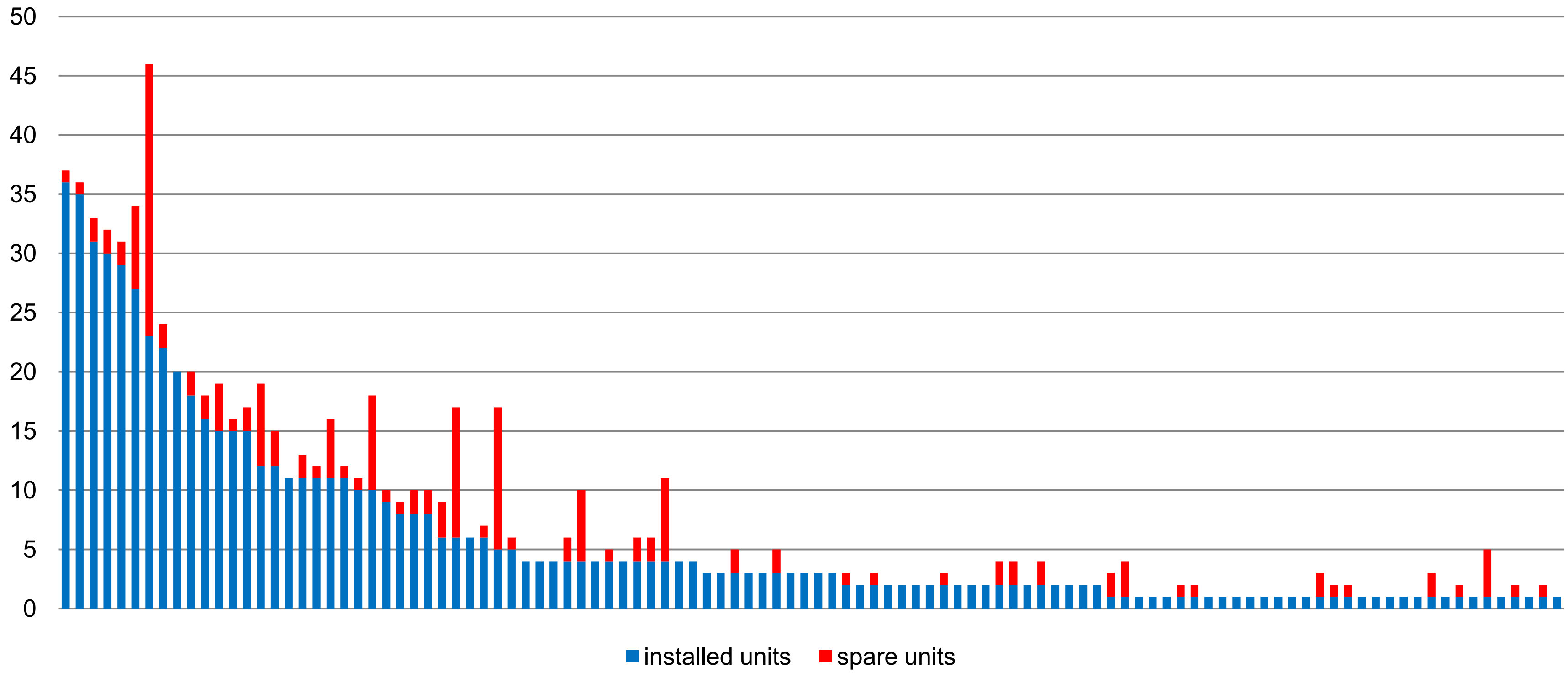
	Installed units	Magnet types
Linac 2 + TL	52	14
Booster	253	15
Booster TL	70	16
PS	243	24
TT2	49	9
Linac 3	40	19
Ion Beam Lines	47	20
LEIR	44	7
Total	**798**	**108**

All types:
Bending, combined function, corrector, dipole, multipole, octupole, quadrupole, sextupole, solenoid, water cooled, indirect water cooled, air cooled, iron-less, PFW, pulsed, continuous, etc…

Scope: the LHC-injector

Accelerator Technology Department

LHC injector (PS-Complex): 800 Magnets of 108 different types



Policy:

- Systematic refurbishment of PS main magnets (106 units)
- All other: keep sufficient spare magnets and spare components (coils)

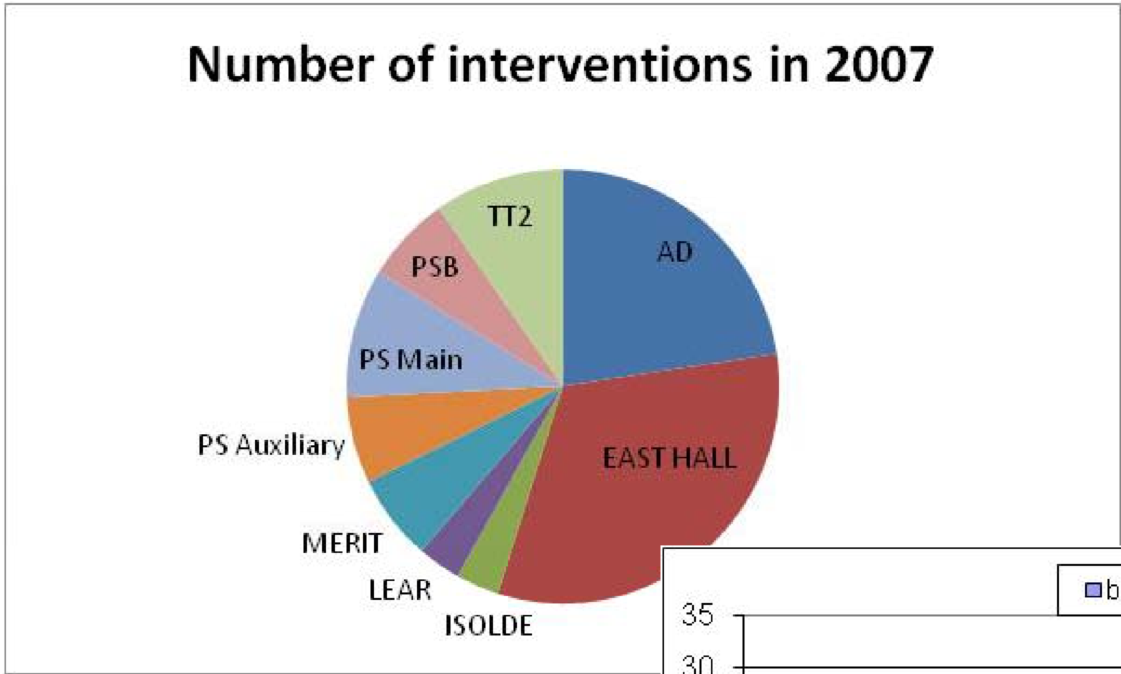
Typical problems and failures

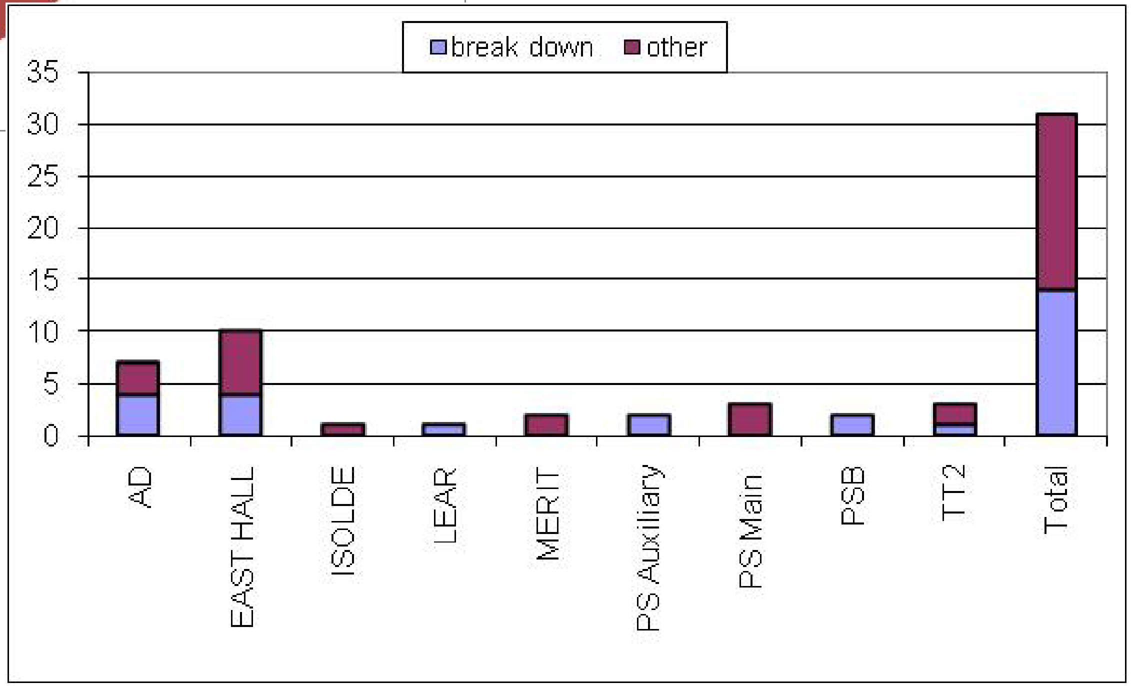
Typical problems and failures which occur on magnets due to aging, radiation and fatigue, which lead to repair interventions or magnet replacement:

- Water leaks in cooling circuits
- Electrical short circuits to ground
- Obstructed cooling ducts
- Degradation of coil shimming
- Broken cable insulation
- Inter-turn short circuits

Pictures courtesy of A. Newborough and D. Bodart

Interventions in 2007





Risk analysis - Method

Based on CERN Risk Management System (EDMS No. 832542)

Reliability (design)	
1	high; air cooled; low power;
2	medium; water cooled; medium power
3	low; high power; high voltage; high flow

X

State (age)	
1	new; fabrication < 10 y
2	old; fabrication > 10 y
3	old; indication of degradation

Impact on LHC Operation
no
yes

∩

MTTR (Mean Time To Recover)
Cooling down time (0 < t < 2 d)
Time to repair and/or replace magnet
Time to re-establish vacuum (0 < t <10 d)

Availability of spares
Complete spare units
Spare coils
Spare yokes

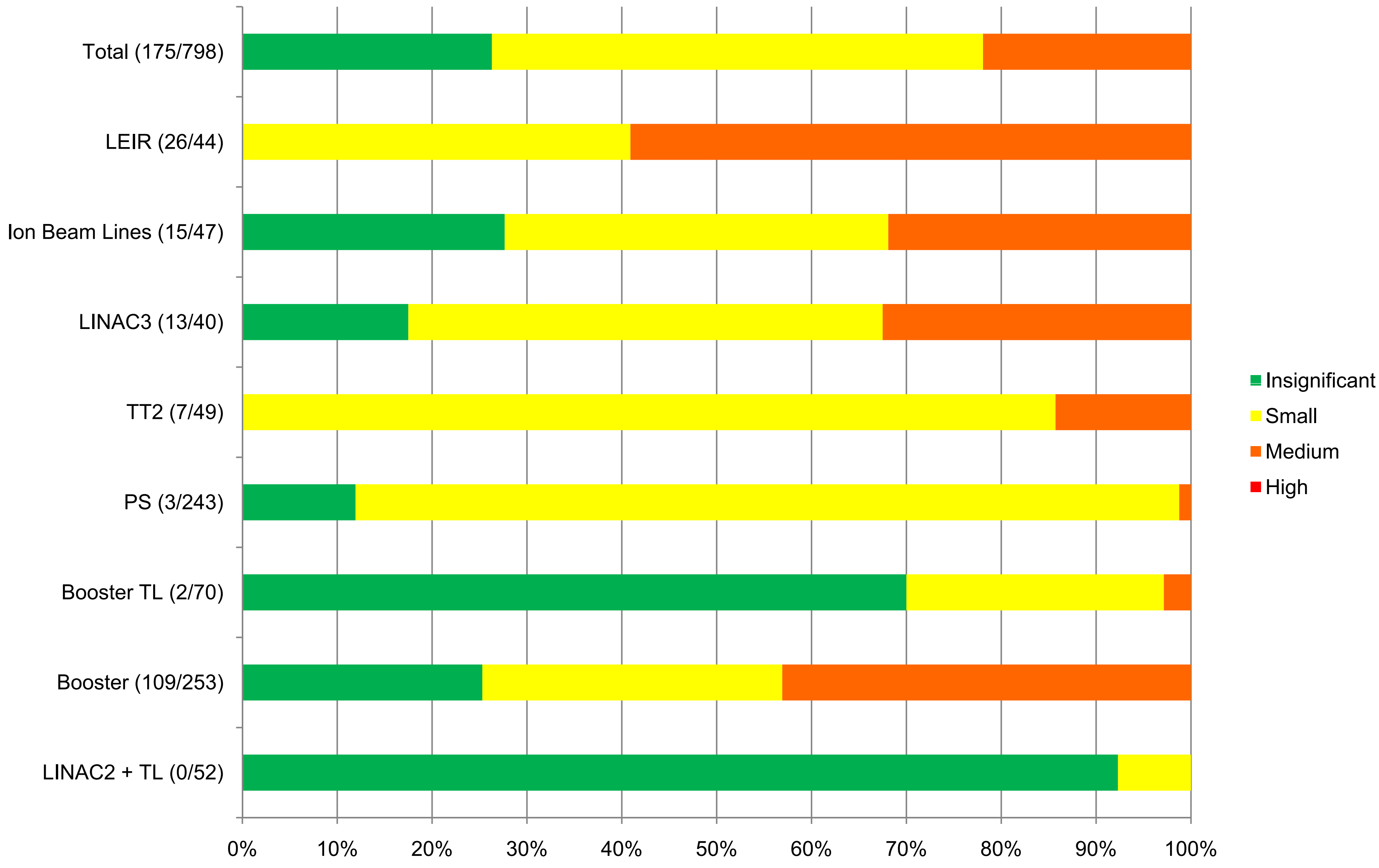
Probability of Failure [P]	
1	exceptional
2	rare
3	probable
4	frequent

X

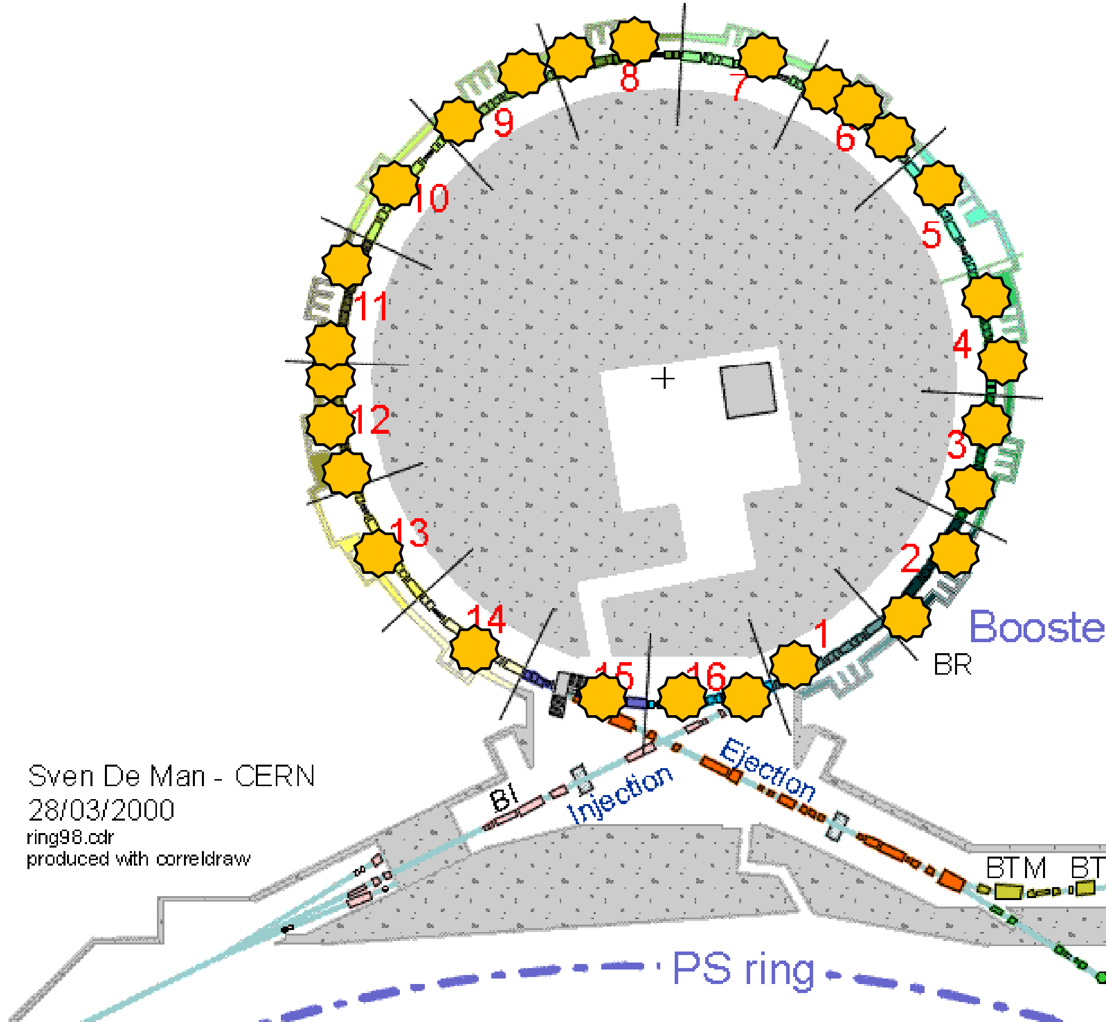
Severity of Impacts [I]	
1	insignificant: loss of phyiscs < 1 day
2	moderate: less of physics < 1 week
3	major: physics loss < 1 month
4	catastrophic: failure to meet scientific objectives

Risk Score S = P x I		
Not significant	S ≤ 2	Acceptance
Low risk	3 ≤ S ≤ 6	Acceptance
Medium risk	7 ≤ S ≤ 10	Action required
High risk	10 ≤ S ≤ 16	Action required

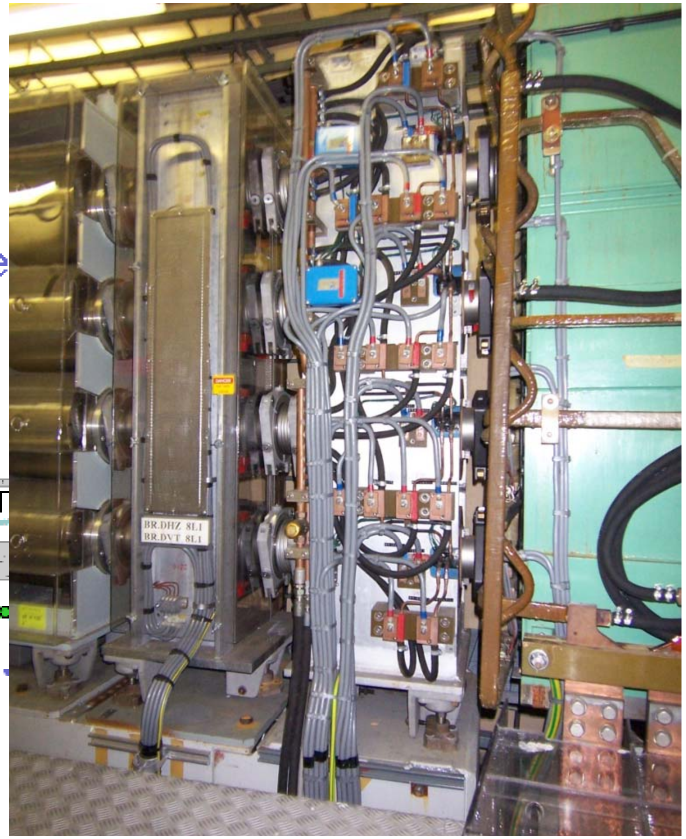
Risk analysis - Results



Risk analysis: Booster



Medium Risk
Multipoles
11 ONO/XNO/QSK (Type I)
4 ONO/XNO/QNO (Type II)
1 OSK/XSK/QNO (Type III B)
4 ONO/OSK/XNO/XSK (Type A)
4 OSK/XSK/DVT/DHZ (Type B)



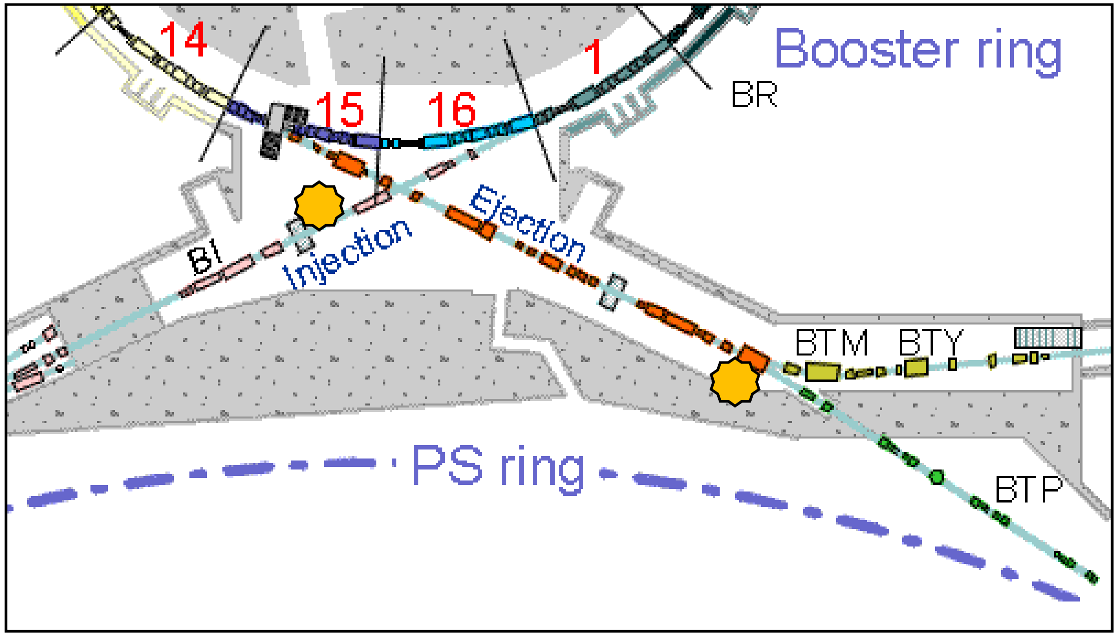
Mitigation: produce spare units of each type

Ressources needed:
400 kCHF, 0.8 FTE*y, 1.5y delay

Risk analysis: Booster Transfer Lines

Medium Risk: BI.DVT

Mitigation: new magnet foreseen for H^- injection from Linac 4

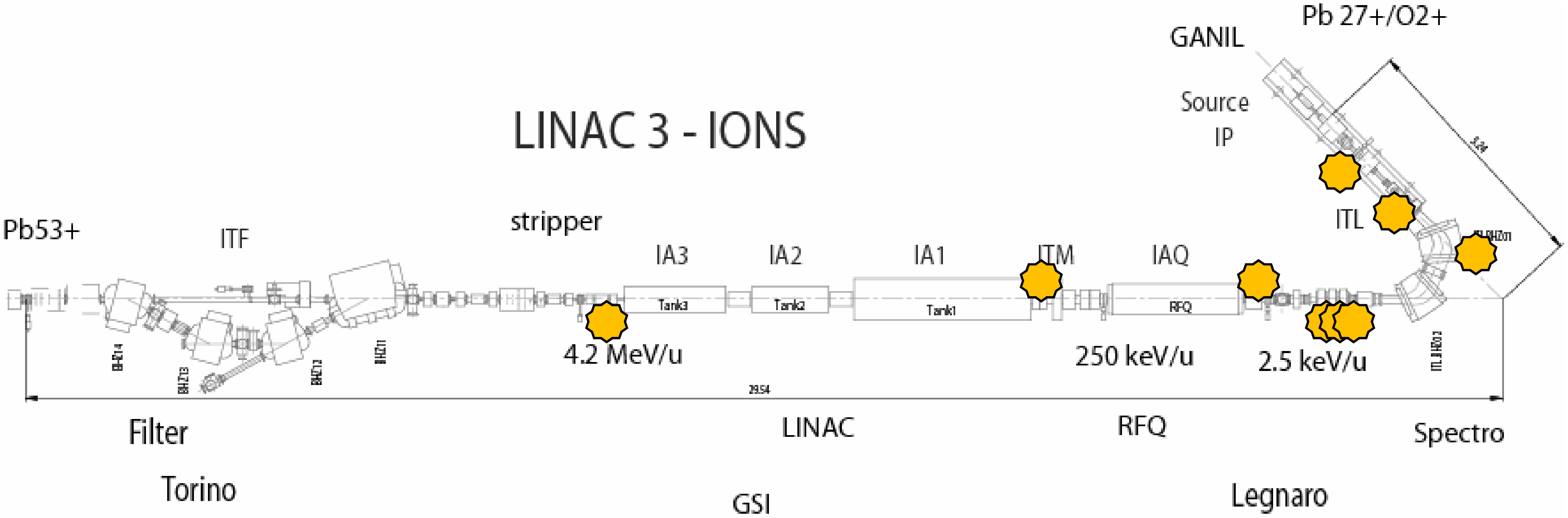


Medium Risk: BT.BHZ10

Mitigation: find or produce spare coils

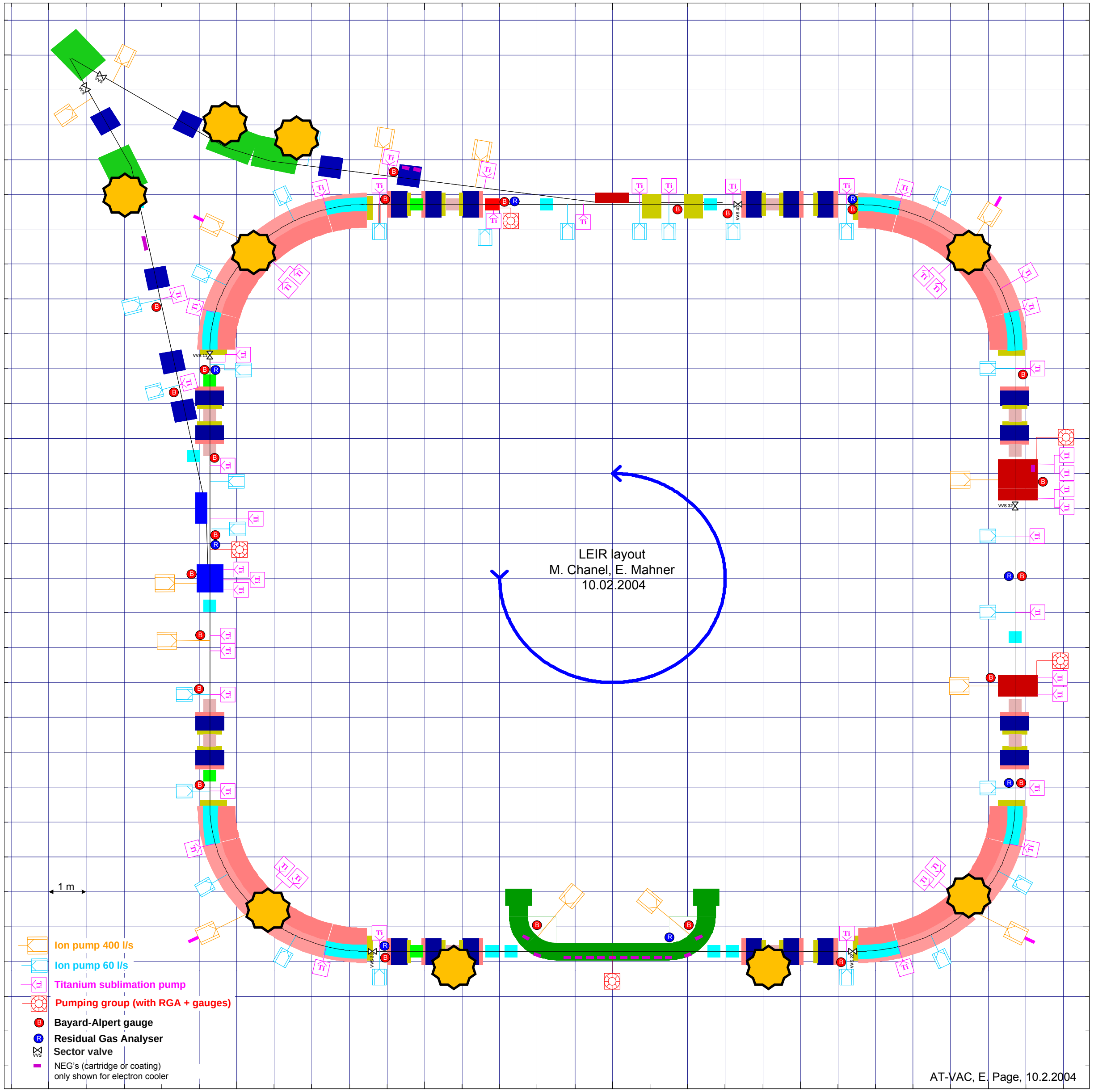
Ressources needed:
40 kCHF, 0.3 FTE*y, 1y delay

Risk analysis: Linac 3



Medium Risk	Solenoid (2)	Bruker quads (4)	Spectrometer (2)	Doublet B (2)	Triplet (3)	Bending 106º (2)
Proposed Mitigation	Produce spare coils	Produce spare coils	Produce spare coils	Produce spare coils	Produce spare coils	Produce spare coils
Costs [kCHF]	35	25	40	25	40	50
Manpower [FTE*y]	0.2	0.2	0.2	0.2	0.2	0.3
Delay [months]	12	12	12	12	12	18

Risk analysis: LEIR



Pictures courtesy of E. Page

Medium Risk: MC 100 (3)

Mitigation: find possible replacement magnets at CERN

Medium Risk: Main Bending (4)

Mitigation: produce spare coils

Ressources needed:
100 kCHF, 0.5 FTE*y, 1.5 y delay

Medium Risk: Main Quads (20)

Mitigation: produce spare coils

Ressources needed:
50 kCHF, 0.3 FTE*y, 1.5 y delay

Medium Risk: Skew Quads (2)

Mitigation: find spares at CERN

Conclusion and Future

- Situation OK for:
  - Linac 2, PS, TT2
- Spare situation to be improved for:
  - Booster, Linac 3, Ion Beam TL, LEIR
  - Total required: 800 kCHF, 3 FTE*y, 2 years delay
- Extend magnet inventory to other machines and beam lines
  - CTF3, AD, Isolde, East Hall EA, n-TOF, SPS, North Area
- Complete data base
  - Upload all relevant documents
  - Link to layout data base to ease maintenance and traceability
- Central storage for PS Complex magnets
  - Regroup all spare magnets and magnet components in 150

Spare Slides

Risk analysis – Results (types)