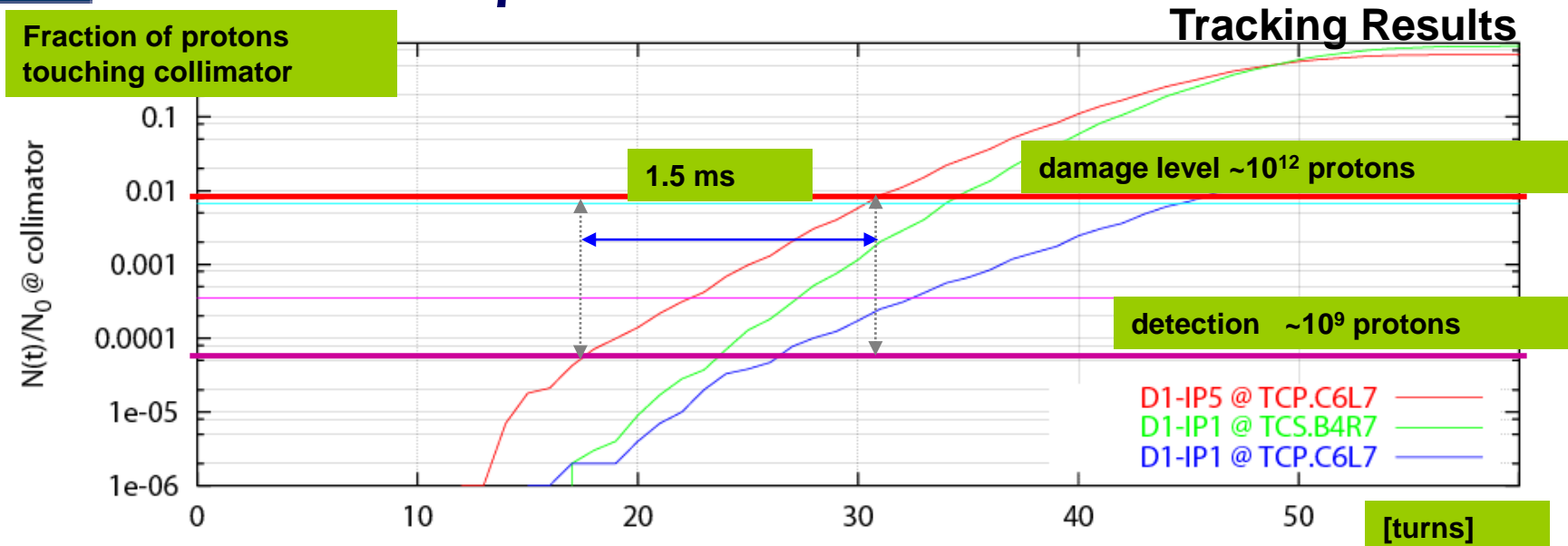




Requirements for a
Fast Magnet Current
Change Monitor
(FMCCM)
for LHC and Injection
V.Kain AB/CO



LHC - normal conducting D1: Requirements for FMCCM



**Power Converter Fault of normal conducting D1
in IR1 or IR5.**

Assumption: Exponential decay: $\tau=2.5$ s

After 15 turns: $\Delta I = 0.05\%$ in D1

After 30 turns: $\Delta I = 0.1\%$ in D1

Threshold for FMCCM: after 10 turns: $\Delta I = 0.035\%$,

required reaction time after detection: 10 turns

Availability for the whole system: better than 1 false dump a year

Safety: ?

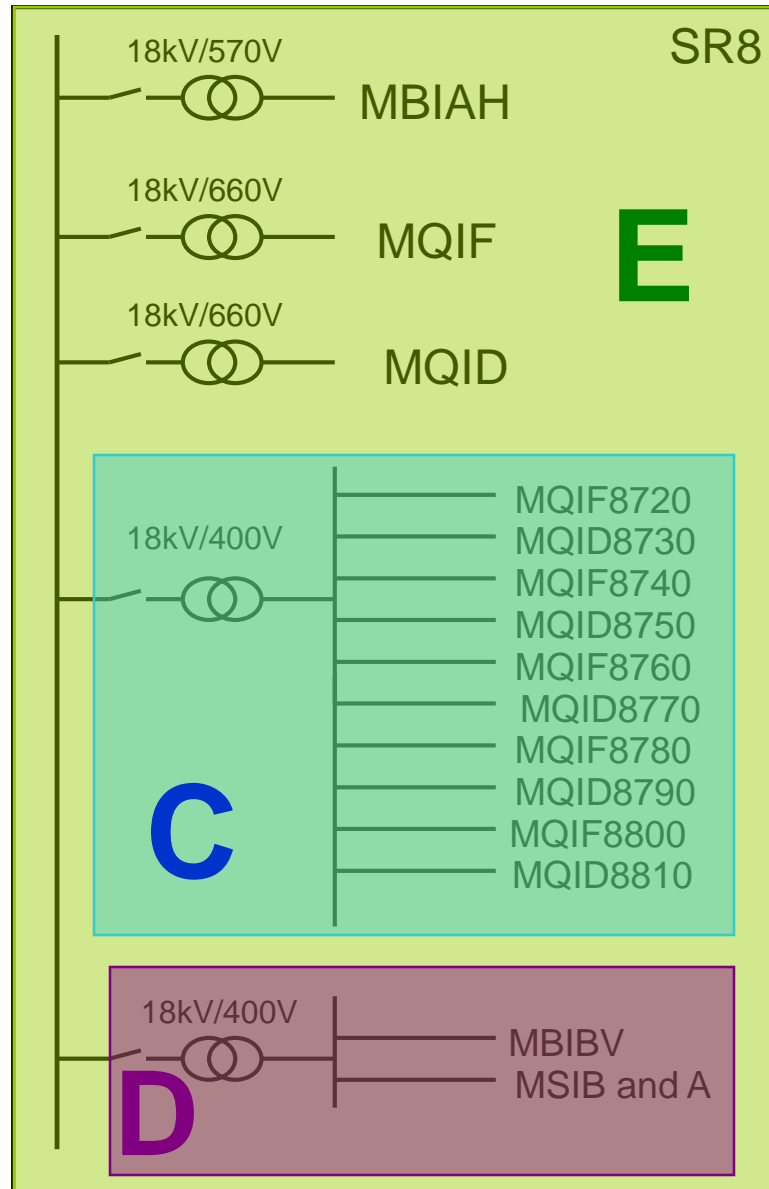
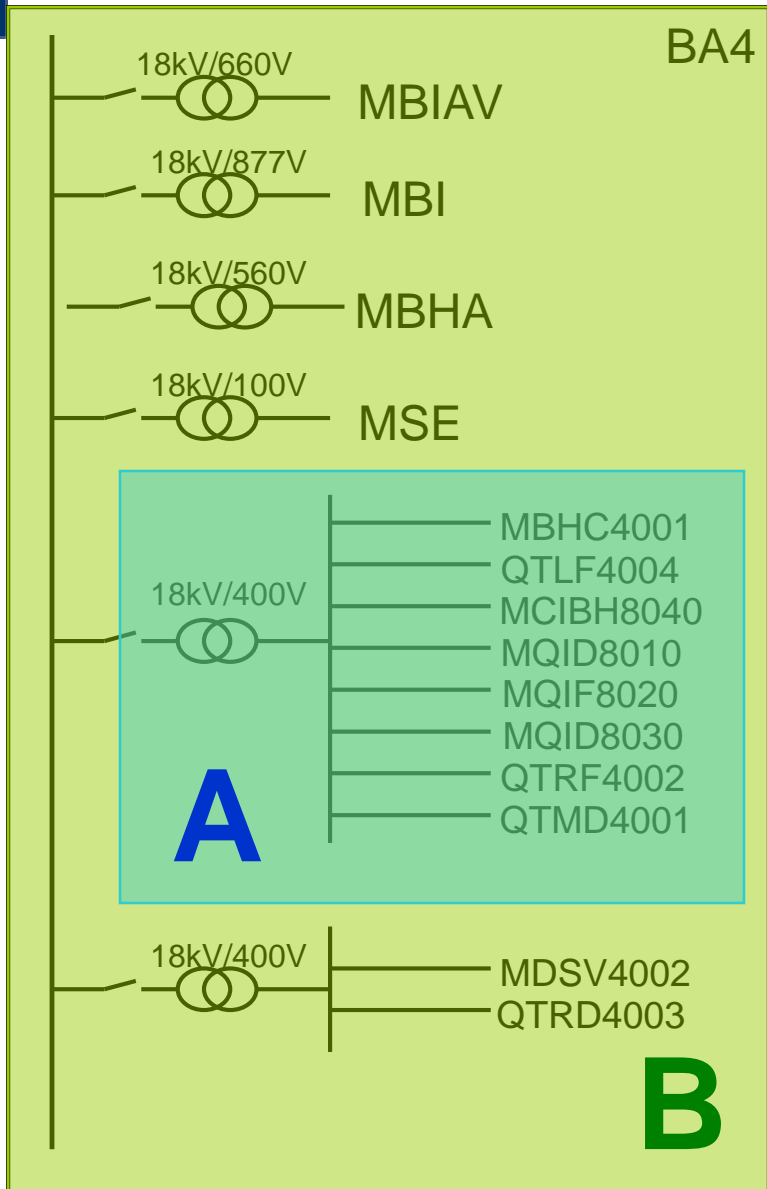


SPS Extraction - Transfer - LHC Injection

- No passive protection for most of the Transfer Lines
- No passive protection in the horizontal plane in injection region
 - MSI failures?
- Normal conducting magnets with very short time constants: MSE: $\tau=23\text{ms}$... 40σ in 1ms
- Aperture is tight in transfer line (only 7σ at some locations)
- PCS: reaction time $> 3\text{ms}$



Failures





Single failure tracking Monte Carlo results (1000 seeds per failure)

Family	Tolerable error [$\Delta k/k_0$]	required reaction time [ms]	Covered by	
			LHC	TL
MPLH (LSS4 bumper)	0.185	201.0	TCDI	PCS
MKE (LSS4 kicker)	0.125	-	TCDI	-
MSE (LSS4 septum, $\tau=23\text{ms}$)	0.005	0.1	TCDI	FMCCM
MBHC (TT40 H bend)	0.005	5.1	TCDI	FMCCM
MBHA (TT40 H bend)	0.012	31.47	TCDI	PCS
MBI (main TI 8 bends)	0.003	2.7	TCDI	FMCCM
MCIBH (start TI 8 H bend)	0.630	389.0	TCDI	PCS
MBIAH (end TI 8 H bend)	0.003	7.9	FMCCM	FMCCM
MBIBV (end TI 8 V bend)	0.003	43.4	PCS	PCS
3MCIAV (end TI 8 V bend)	0.183	98.43	PCS	TCDI
MSI (LHC injection septum)	0.0035	3.5	FMCCM	n/a

↑
For exponential decay

- PCS = standard Power Convertor Surveillance ($\geq 3\text{ms}$)
- FMCCM = Fast Magnet Current Change Monitor, dedicated new system



Grouped failure tracking Monte Carlo results (1000 seeds per failure)

Group	Tolerable time after switch-off [ms]	Covered by	
		LHC	TL
A	1.3	TCDI	FCCM on MBHC (0.1% tolerable error)
B	0.1	TCDI	FCCM on MSE
C	15.8	TCDI	PCS
D	3.5-5.8, > 20	FCCM on MSI	TCDI/PCS
E	4.0-5.4, > 20	FCCM on MBIAH, MSI	FCCM on MBIAH (0.15% tolerable error)

- In some cases grouped failures can be ~ 5 times worse than single failures
 - e. g. MBHC
- Grouped failures covered with protection for single failures BUT: requires increased performance



Resulting Requirements for FMCCM for Injection Process

- Specification for FMCCM: $\Delta I/I=0.1\%$,
reaction time $\sim 50\mu\text{s}$
- Proposed magnet families (TI 2, TI 8, TT41, IR8, IR2):
 - MSI, MSE, MST, MBI, MBSG, MBHC, MBI, MBG, MBIAH, MBIBH
- Availability of whole system: better than 100 false inhibits of injection/extraction
- Comment:
 - Conservative assumption: exponential current decay
 - additional safety margin