MPS DESIGN HI ACCELERATOR - GROUP 8

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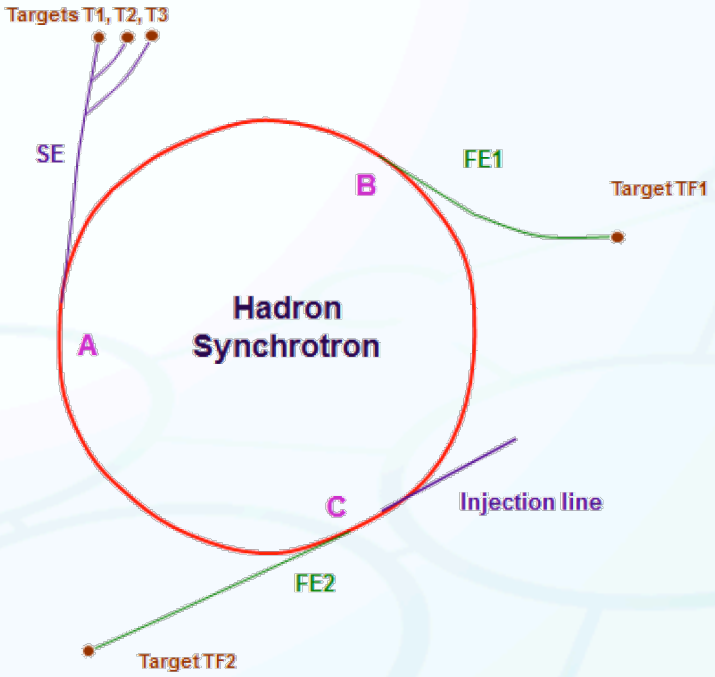
Introduction & requirements



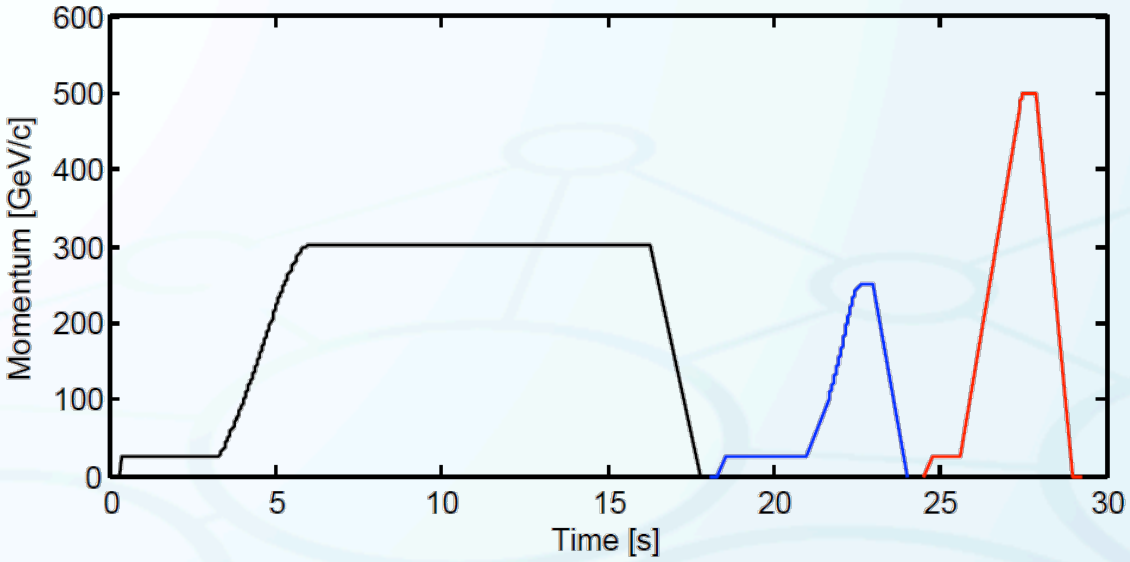
Development of a MPS for:

- providing beam to various targets
- acceleration of different intensities
- extraction at set of different energies
- implementation of slow extraction
- implementation of single turn fast extraction
- implementation of four consecutive fast extractions

Beam parameters

Extraction type	SE (T1, T2, T3)	FE1 (TF1)	FE2 (TF2)
Intensity [10^{13} p]	5	3	7
Momentum [GeV/c]	300	500	250
Stored beam energy [MJ]	2.4	2.4	2.8
Extraction duration	10 s	1 turn	30 ms

Modes of operation



- subsequent execution of three different cycles
- resulting in supercycle with length of 30 s
- long flat top for slow extraction (spill over 10 s)

  - debunched beam

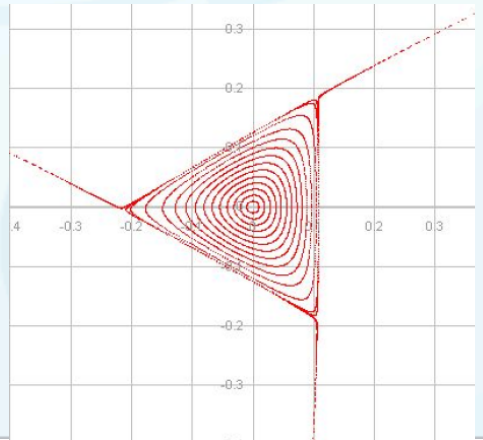
- short flat tops for fast extractions

  - bunched beam with different spacings

Extraction elements

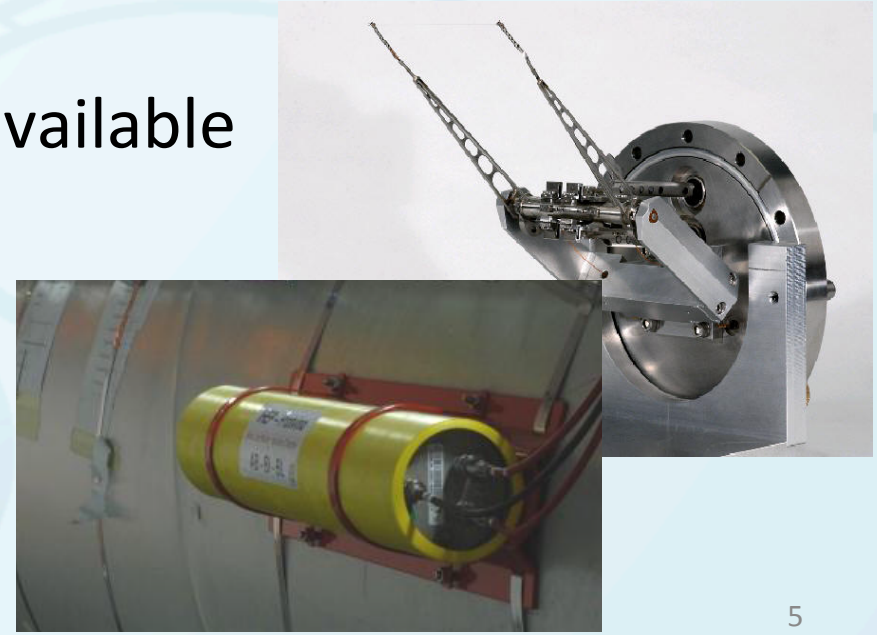
Slow extraction	
element	**purpose**
sextupoles	excitation of a 3rd order resonance
quadrupoles	tune change towards q=0.33
dipole magnets	closed local orbit bumps
electrostatic septum	kick large amplitude particles
magnetic septum	kick into extraction line

Fast extractions	
element	**purpose**
dipole magnets	closed local orbit bumps
kicker	kick the beam at a defined moment
magnetic septum	additional kick into extraction line



Assumptions

- External beam dump implemented (for ring)
- Injector provides adequate bunch structure and intensities
- Ring system diagnostics available
  - Beam energy monitoring
  - Beam position monitors
  - Beam profile monitors
  - Beam current monitors
  - Beam loss monitors



Design approach for MPS

MP contributes to operational availability by:

- Protecting equipment from beam-induced damage.
- Protecting equipment from damage due to a wrong configuration.
- Minimizing the number of false beam trips leading to unnecessary downtime.
- Shortening maintenance times by minimizing activation of equipment.
- Providing tools for a consistent and congruent failure tracing throughout the machine.

Follow IEC61508, IEC61511 where applicable

Hazards

Hazards

- **Fast beam losses: beam can severely damage equipment (in microseconds, milliseconds)**
  (like magnets, vacuum chamber, instrumentation)
  - **Faulty extraction due to equipment failure**
  - **Extraction at wrong energy**
  - **Extraction line not ready/failures in line**
  - **Beam size too small at target**

- **Long-term beam losses (over seconds, minutes):**
  - **Activation of equipment (hands-on maintenance)**

Approach to mitigate hazards

- Allow extraction only once all devices and extraction lines are ready → active monitoring
- Passive devices for faults that cannot be mitigated by active monitoring
  - At extraction point (if kickers do not work correctly)
  - In extraction lines (if beam is mis-steered)
- Beam monitoring inside extraction lines
- Post-mortem: analyze data to assure extraction was as intended

Safe-beam mode

Safe-beam mode

- Probe-beam is safe for extraction line: low-intensity beam
- If probe-beam successfully delivered, flag "previous extraction o.k." is set **for that line**
- Beam with intensity above probe beam needs "previous extraction o.k." from preceding extraction (probe beam, high intensity beam)
- Flag lost if problem in extraction
- Need to get flag back with probe-beam

Tune-up dump

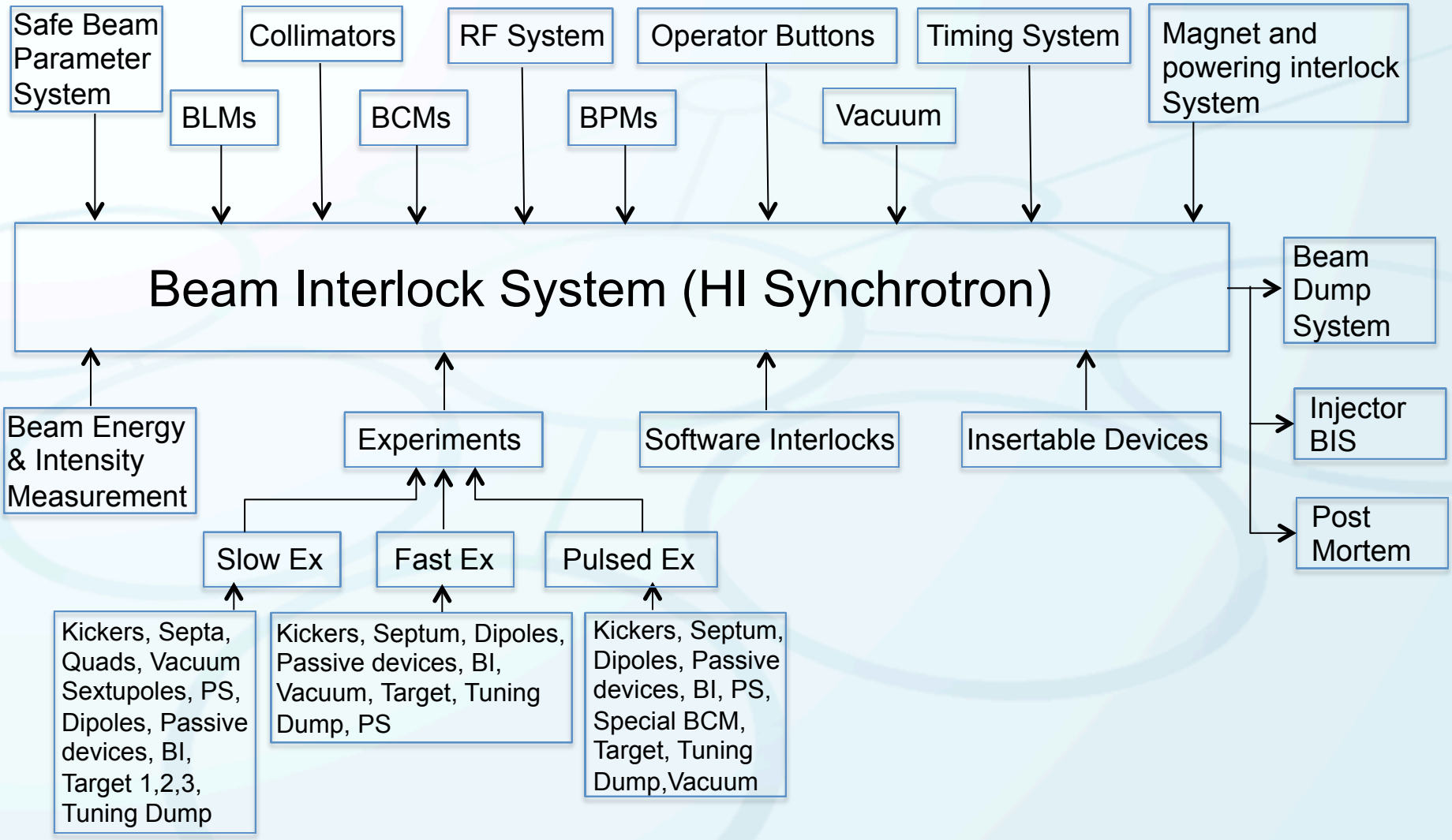
- Located before experimental area (allows users to set up experiment during tuning)

- Tune-up dump only to be used for beam up to medium intensity

Commissioning

- Test all interlocks before first beam
- Run with probe-beam
  - Always safe
  - Test that beam delivery system is working
  - Test systems (interlocks, diagnostics, etc.)
- Ramp up to medium intensity; deliver beam to tune-up dump or experimental areas
  - Test all diagnostic systems
- Then ramp up to full intensity; deliver beam to experimental areas

Beam Interlock System as vital part of MPS



Master truth table (defining destinations) - I

BIS Input Systems – Part 1	SE		FE1		FE2	
Safe beam flag	0	1	0	1	0	1
Previous extraction o.k. *	1	x	1	x	1	x
Ring beam dump o.k. *	1	1	1	1	1	1
SE line and SE line target o.k. *	1	1	0	0	0	0
FE1 line and FE1 line target o.k. *	0	0	1	1	0	0
FE2 line and FE2 line target o.k.*	0	0	0	0	1	1
Beam intensity and energy ring o.k. for SE Line *	1	x	0	x	0	x
Beam intensity and energy ring o.k. for FE1 Line *	0	x	1	x	0	x
Beam intensity and energy ring o.k. for FE2 Line *	0	x	0	x	1	x

Master truth table (defining destinations) - I

BIS Input Systems – Part 1	SE		FE1		FE2	
Safe beam flag	0	1	0	1	0	1
Previous extraction o.k. *	1	x	1	x	1	x
Ring beam dump o.k. *	1	1	1	1	1	1
SE line and SE line target o.k. *	1	1	0	0	0	0
FE1 line and FE1 line target o.k. *	0	0	1	1	0	0
FE2 line and FE2 line target o.k.*	0	0	0	0	1	1
Beam intensity and energy ring o.k. for SE Line *	1	x	0	x	0	x
Beam intensity and energy ring o.k. for FE1 Line *	0	x	1	x	0	x
Beam intensity and energy ring o.k. for FE2 Line *	0	x	0	x	1	x

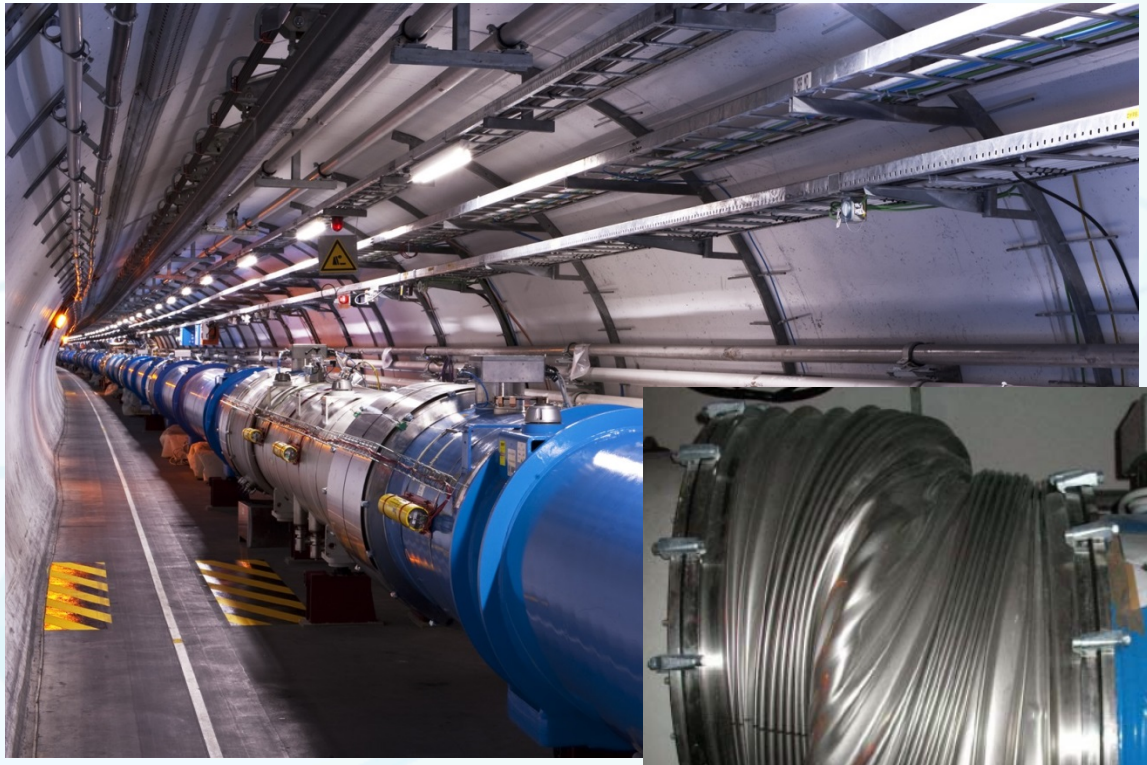
Master truth table (defining destinations) - II

BIS Input Systems – Part 2	SE		FE1		FE2	
Beam instrumentation ring (BCMs, BLMs, BPMs,..) *	1	x	1	x	1	x
Collimation ring o.k. *	1	1	1	1	1	1
Insertable devices (wire scanners, grids, slits) out	1	x	1	x	1	x
Insertable devices (wire scanners, grids, slits) in	0	x	0	x	0	x
Vacuum ring o.k. & all valves open *	1	1	1	1	1	1
RF system o.k. *	1	1	1	1	1	1
Magnet and powering system o.k. *	1	1	1	1	1	1
Timing system o.k.	1	1	1	1	1	1
Beam permit	**1**	**1**	**1**	**1**	**1**	**1**

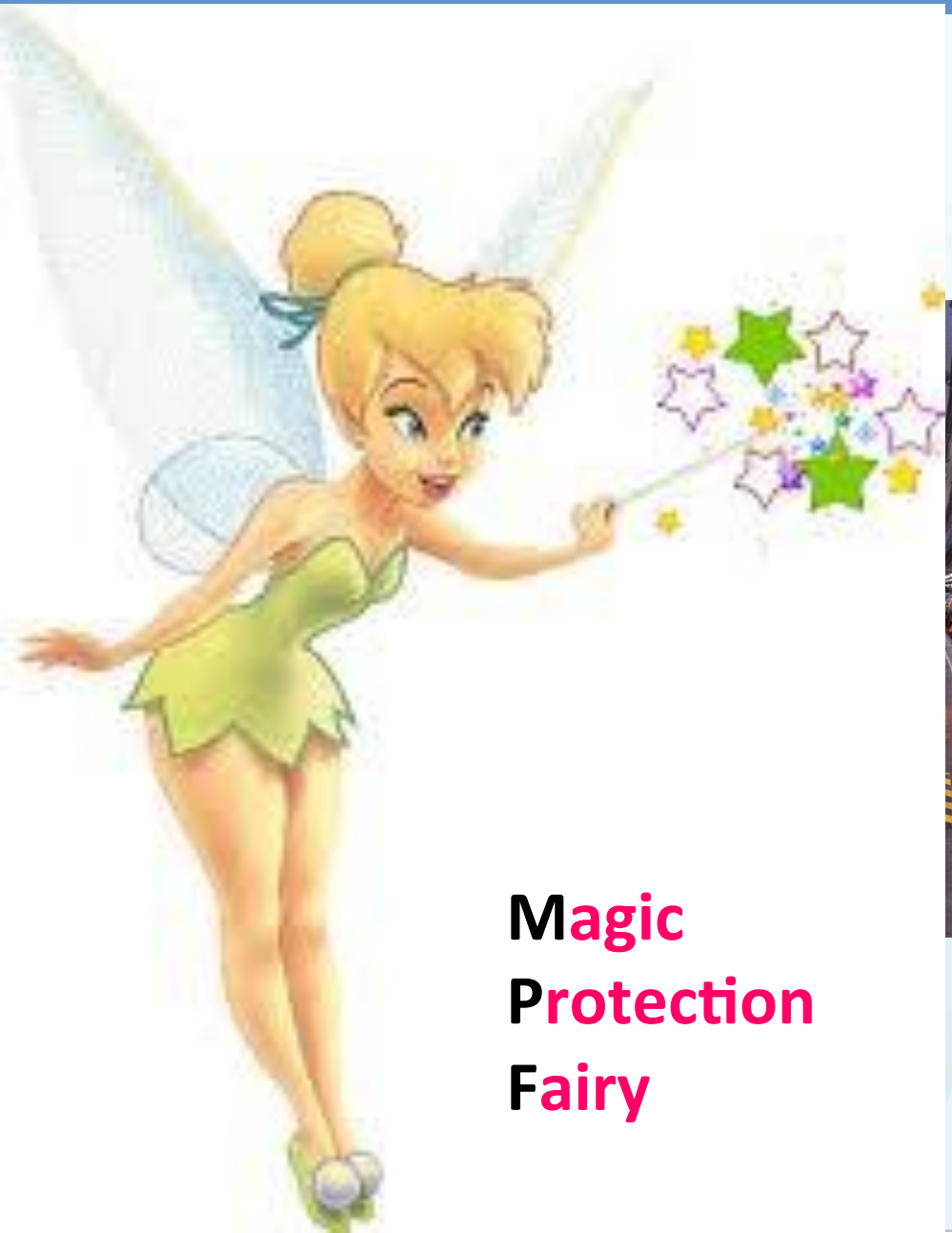
Truth table for FE1 line and target

FE1 line and target	Safe beam	Full intensity
Vacuum o.k.	1	1
BPMs o.k.	x	1
BLMs o.k.	x	1
BCMs o.k.	x	1
Target o.k.	x	1
Tuning dump o.k.	1	0
Insertable devices (wire scanners, grids, slits) in	x	0
Insertable devices (wire scanners, grids, slits) out	x	1
Kicker magnets for FE line o.k. and synchronized	1	1
Septum magnet	1	1
Passive Protection Devices	x	1
Extraction permit for FE1 line	**1**	**1**

Conclusion



Conclusion



Magic
Protection
Fairy