

Group 1

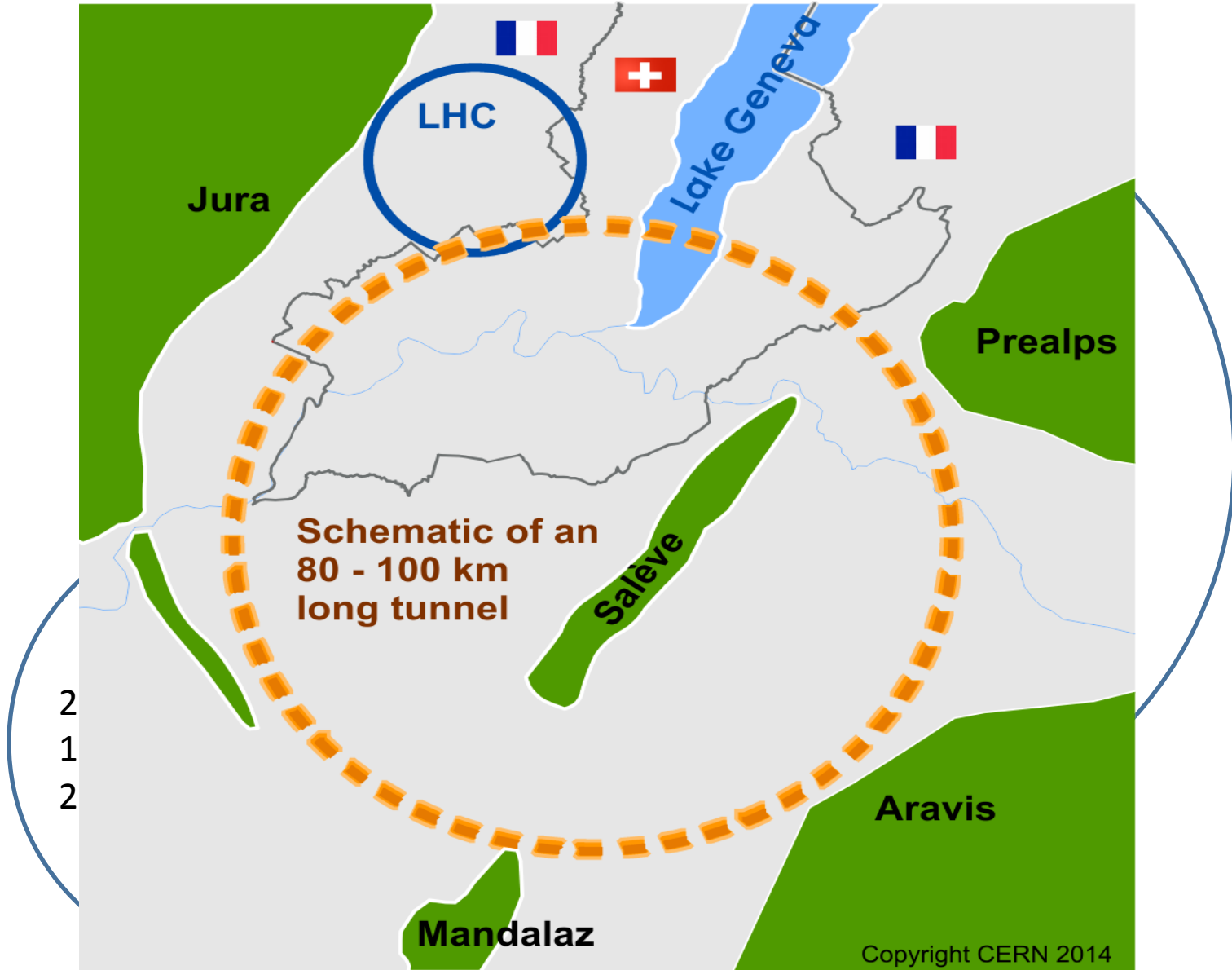
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LHC to FCC-hh

Joint Accelerator School Particle
Injection Extraction Region

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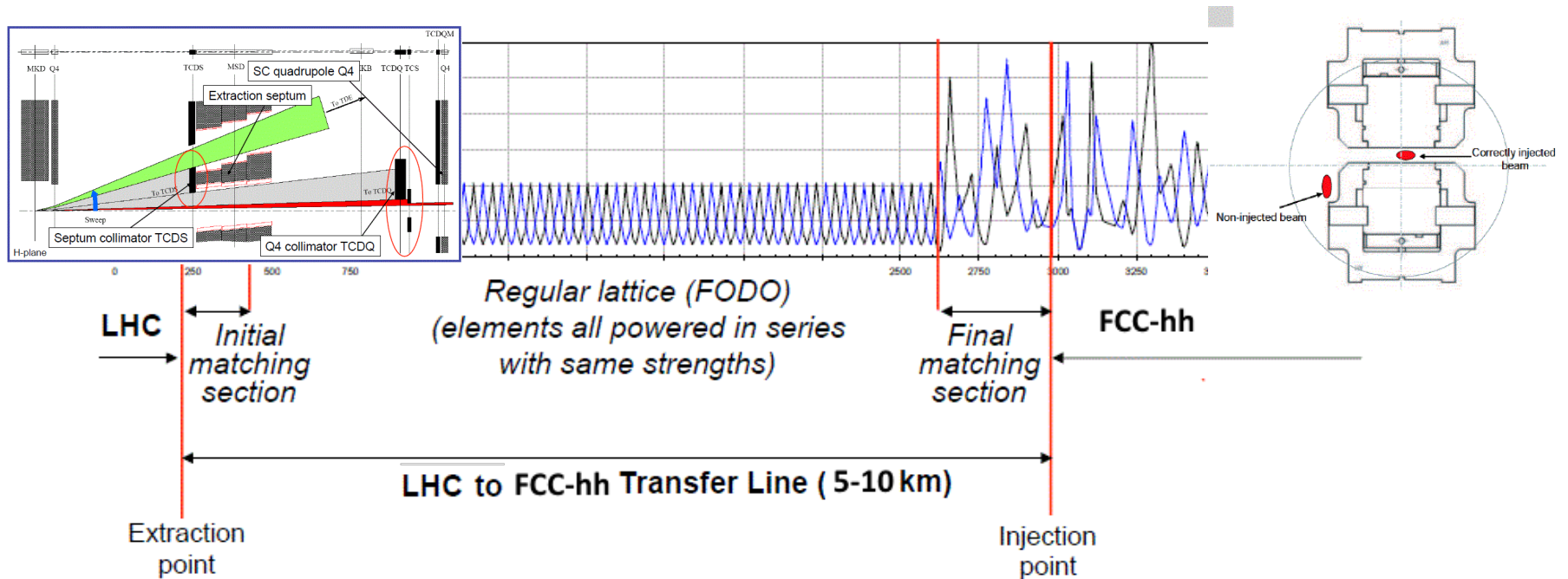
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The beamline lattice from LHC to FCC-hh

SPS to LHC Ctrl + C (copy) Ctrl + V (paste) approach is put in place.



At least as a starting point...

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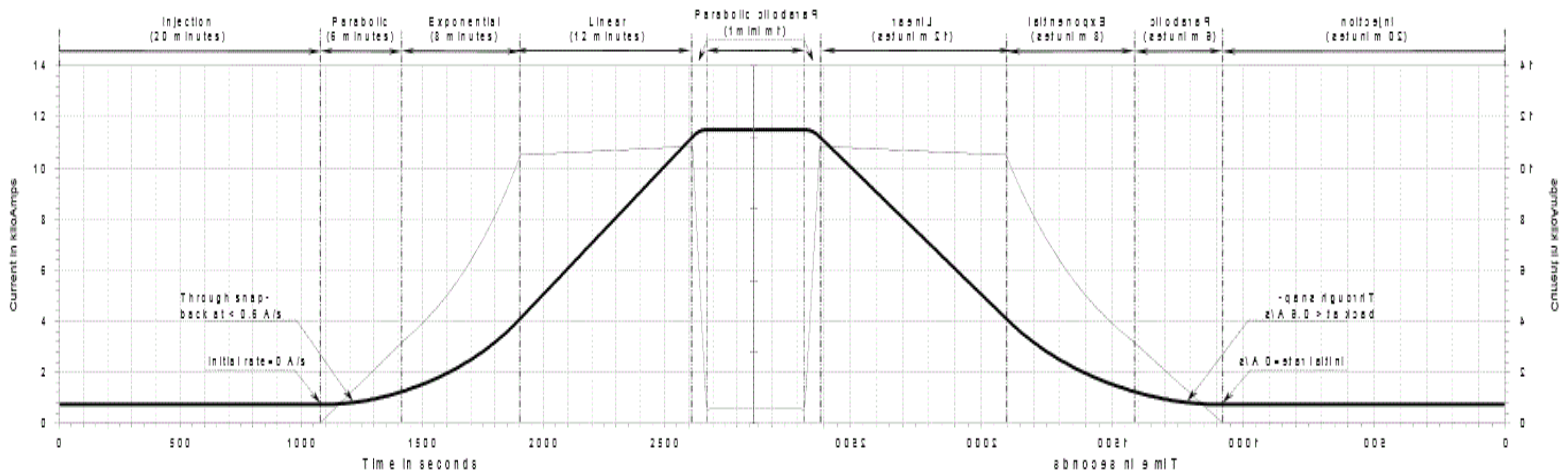
Transfer energy

- FCC aims for 10600 bunches
 - LHC has only place for 2800
 - It is natural to have 4x LHC fills to feed FCC...
 - ... hopefully not more.
- Transfer Energy (recommended factor of 20 less than FCC):
 - 2.5TeV
- Let's extract all in one...
 - 2.5TeV it is 135MJ
 - That's still a lot of chocolate (6kg, not for Mike...)
- Let's take one train of 288 bunches of $1e11$ protons/bunch
 - We have to transport 11.6MJ train (only 600g, Mike's breakfast)
- Still a bit too much for safe operation with transferring
 - SPS/LHC operates with 2.1MJ...

JASPIER Injector cycle

LHC ramp time to load FCC through JASPIER is ~1200 seconds
Based on ramp waveforms provided:

- Injection 190 s for SPS injections
- Ramp up 500s
- Flat top of 10 s – 8min for injection syncing to FCC-hh
- Ramp down 500 s
- Need to maintain di/dt from preventing quenching



JASPIER Kickers

		FCC
		MKI
# units (magnets)		204
Technology		Delay line
Magnetic length	m	72.6
System length	m	90
Kick	mrad	0.85
System impedance	Ω	5
Operation voltage	kV	52
B.dI	T.m	11.4
Rise/fall time	μs	0.28
Flat top length	μs	1.25 – 1.75
# generators		102
Surface area	m^2	1'920
GFR h/v	mm	13

09/01/15

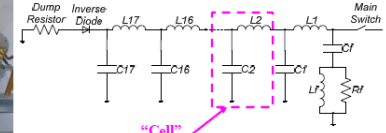
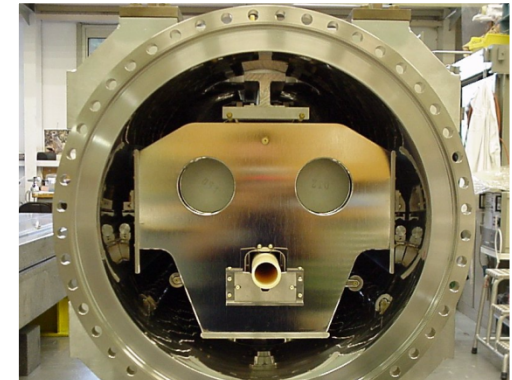


Fig. 16: The SPS extraction PFNs at CERN have 17 cells which are individually 'adjustable'

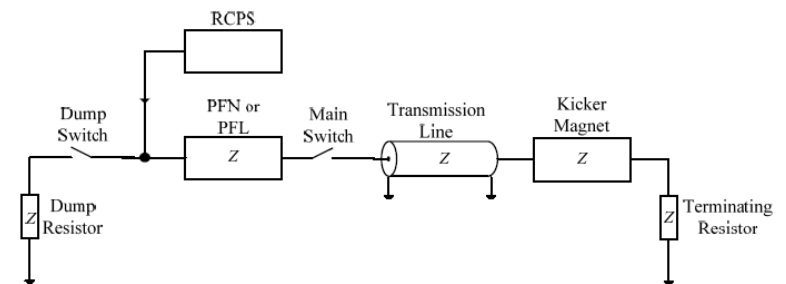


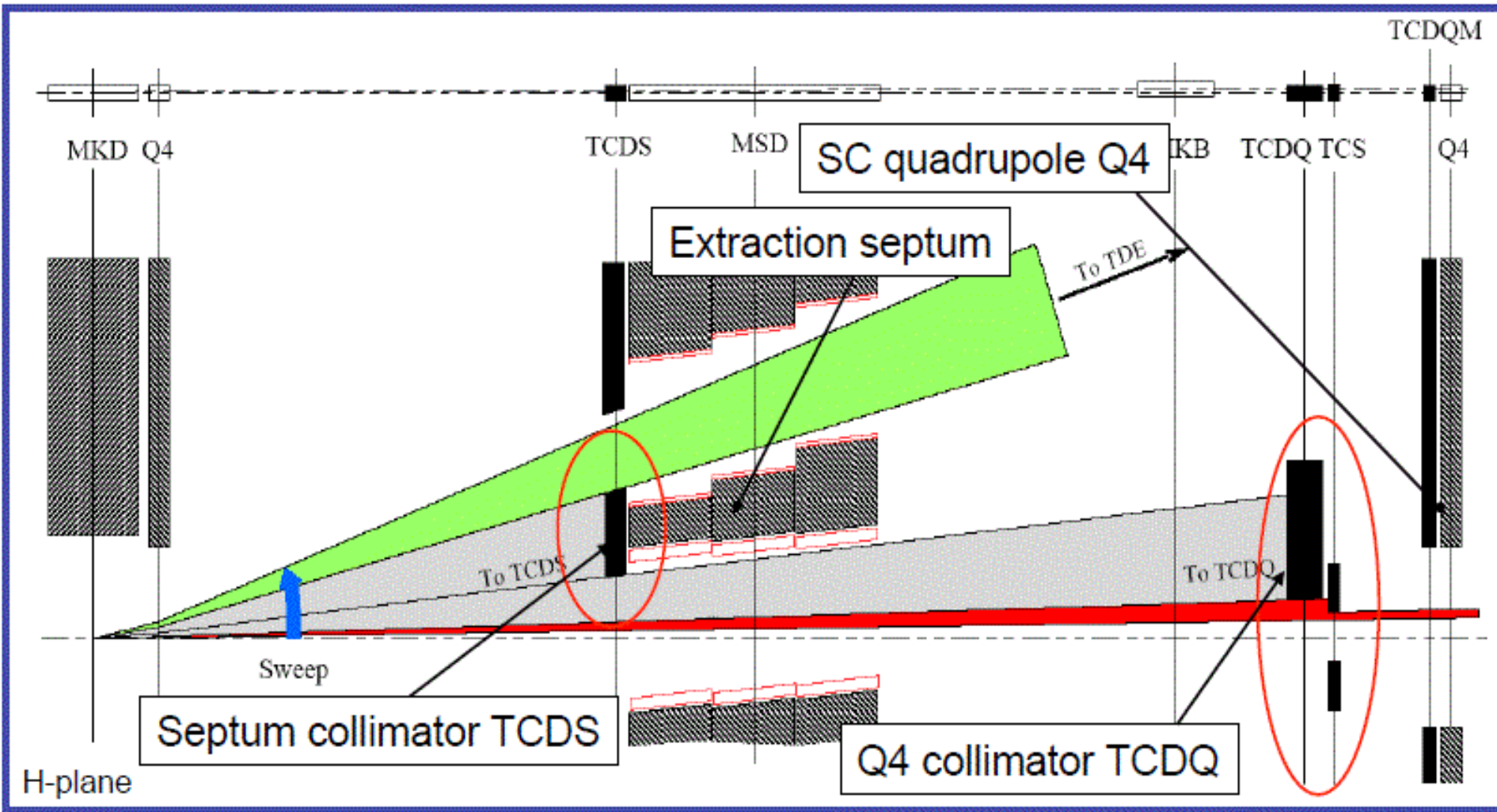
Fig. 4: Simplified schematic of a kicker system

Filling schemes – kicker and batch energy

- Pilot bunch $1e10$, beam presence concept
- Extraction times:
 - Few seconds per shot
 - Total time max of 13min
- possible patterns:

bunch/train	trains	MJ at 2.5TeV	MJ at 3.3TeV
72	38	2,9	3,8
108	25	4,3	5,7
144	20	5,8	7,6
180	16	7,2	9,5
288	10	11,5	15,2

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FCC injection absorber

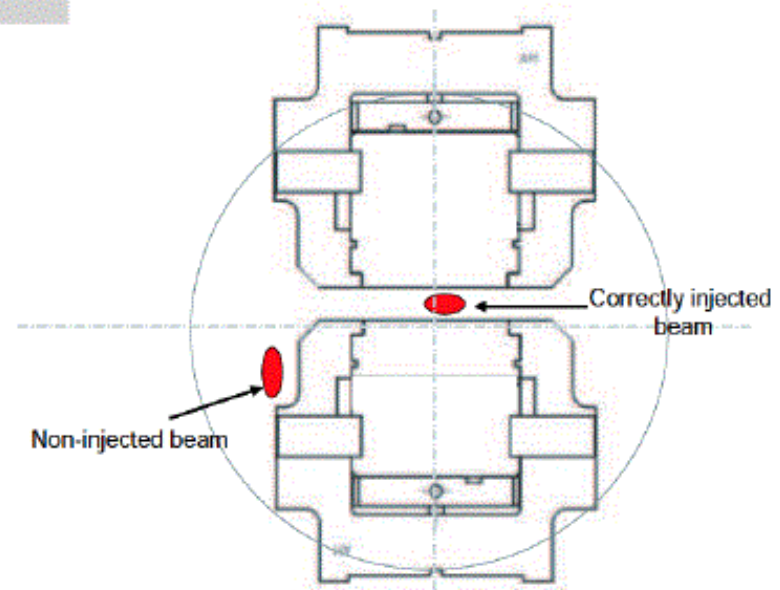
Roughly 4 m long vertical absorber

Device	Materials	Density	Active length
TDI	BN5000	1.92 g/cm ³	2.85 m
	Al	2.67 g/cm ³	0.6 m
	Cu-Be	8.96 g/cm ³	0.7 m
TCLIA	Graphite R4550	1.83 g/cm ³	1 m
TCLIB	C/C AC150	1.67 g/cm ³	1 m

← Injection stopper

← Auxiliary collimators

Two vertical jaws for the TDI



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Beam interlocks for the transfer line include signals from:

BPMs

- Useful for high charge bunch
- Dynamic range to compensate for the pilot bunch
- Spare Intensity readings

BLMs

- Instantaneous loss pattern
- Early detection via pilot bunch

BCM Toroids

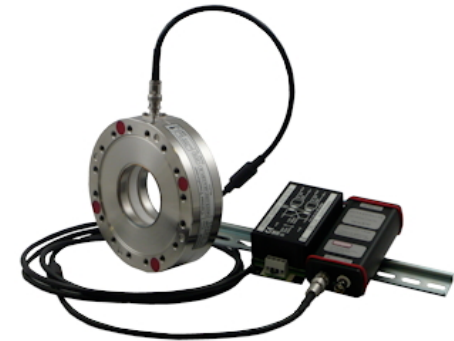
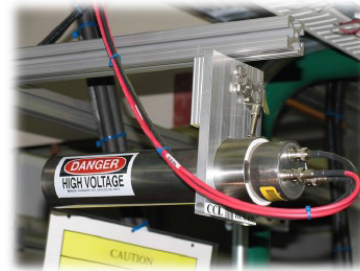
- Primary Intensity Efficiency
- Two located upstream and downstream in each beamline

SWIC, HARP, PM, Phosphorous screen, wire scanner

- All removable
- Typically used for tune-up

Ion pumps, valves, gate valves, gauges

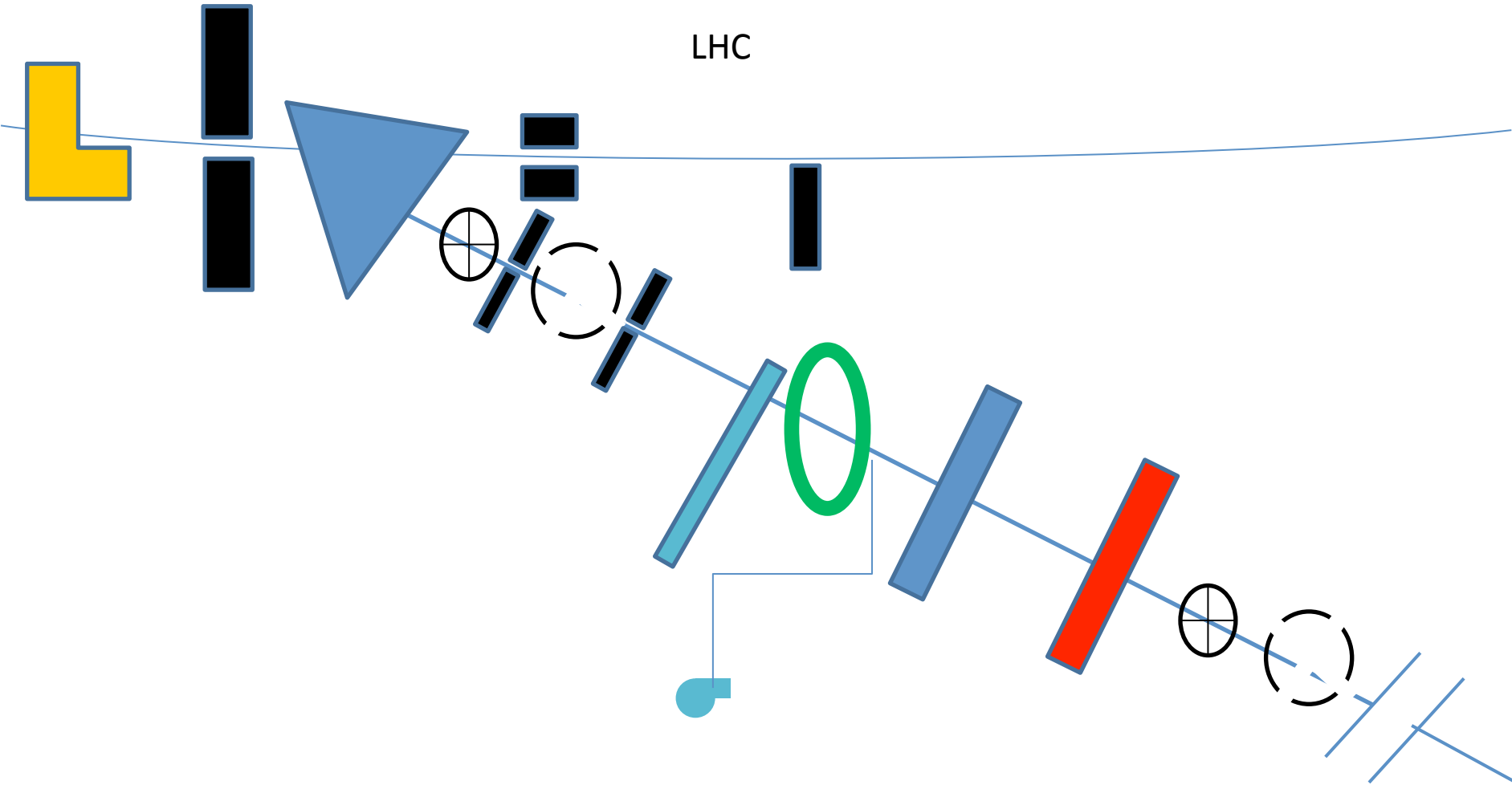
- Interlocked to Beam permit system
- Vacuum reading and valve position



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Critical device

Magnet Septum

First Vertical bending magnet

Power Supply Interlocks

Ground Fault

Overcurrent

RMS current

Tracking error

Low Input Voltage

Over temp

Magnets

QPM

Klixons

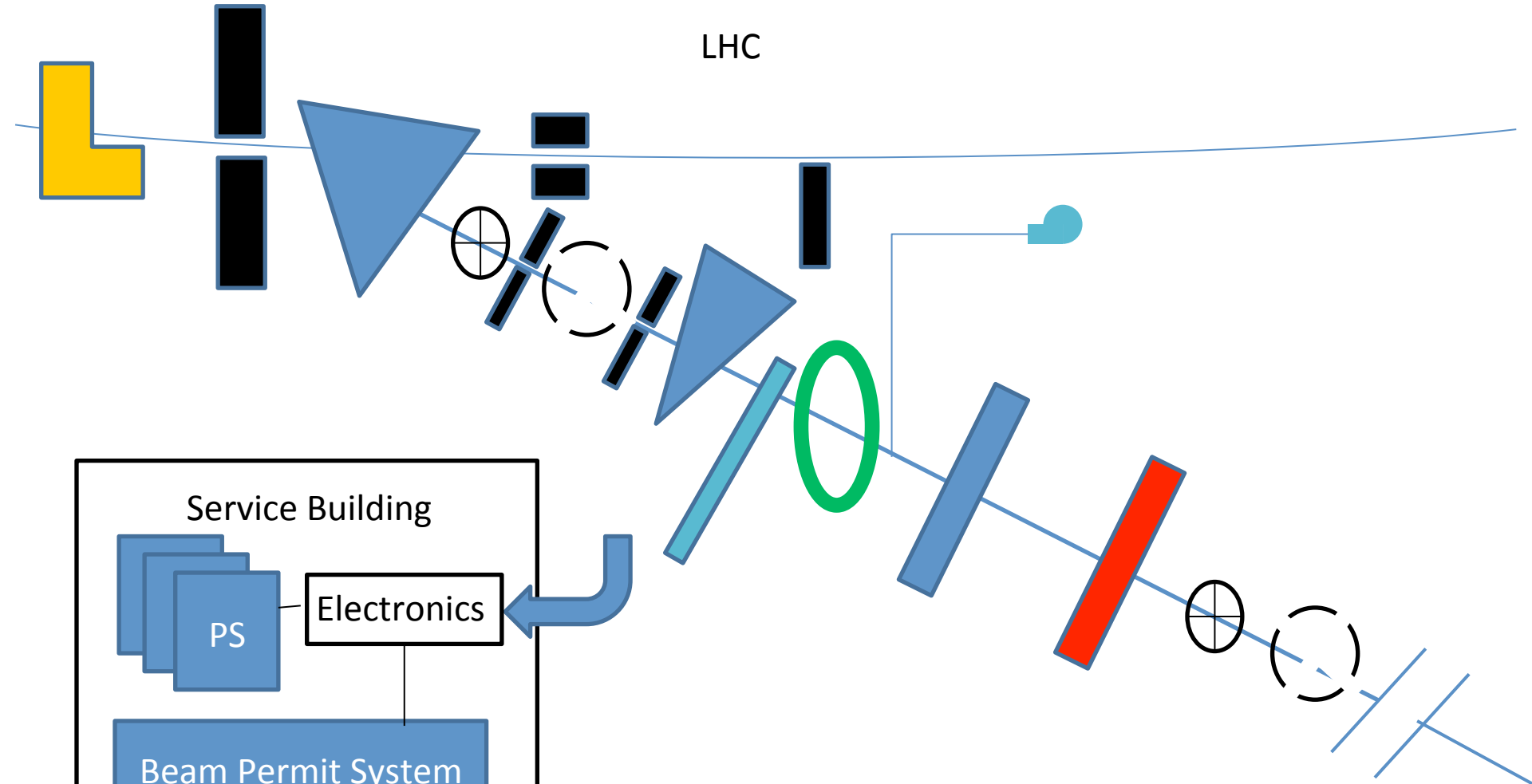
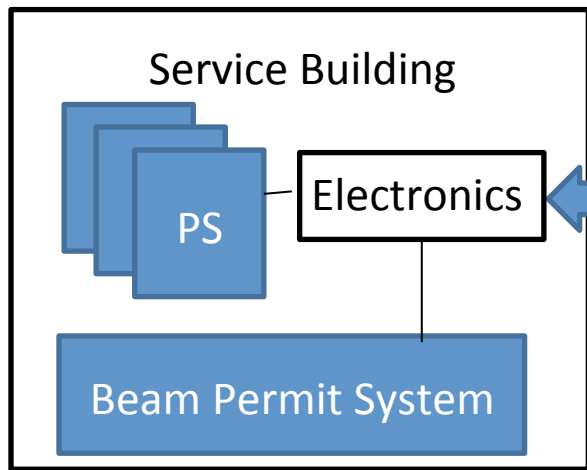
Water flow and pressure



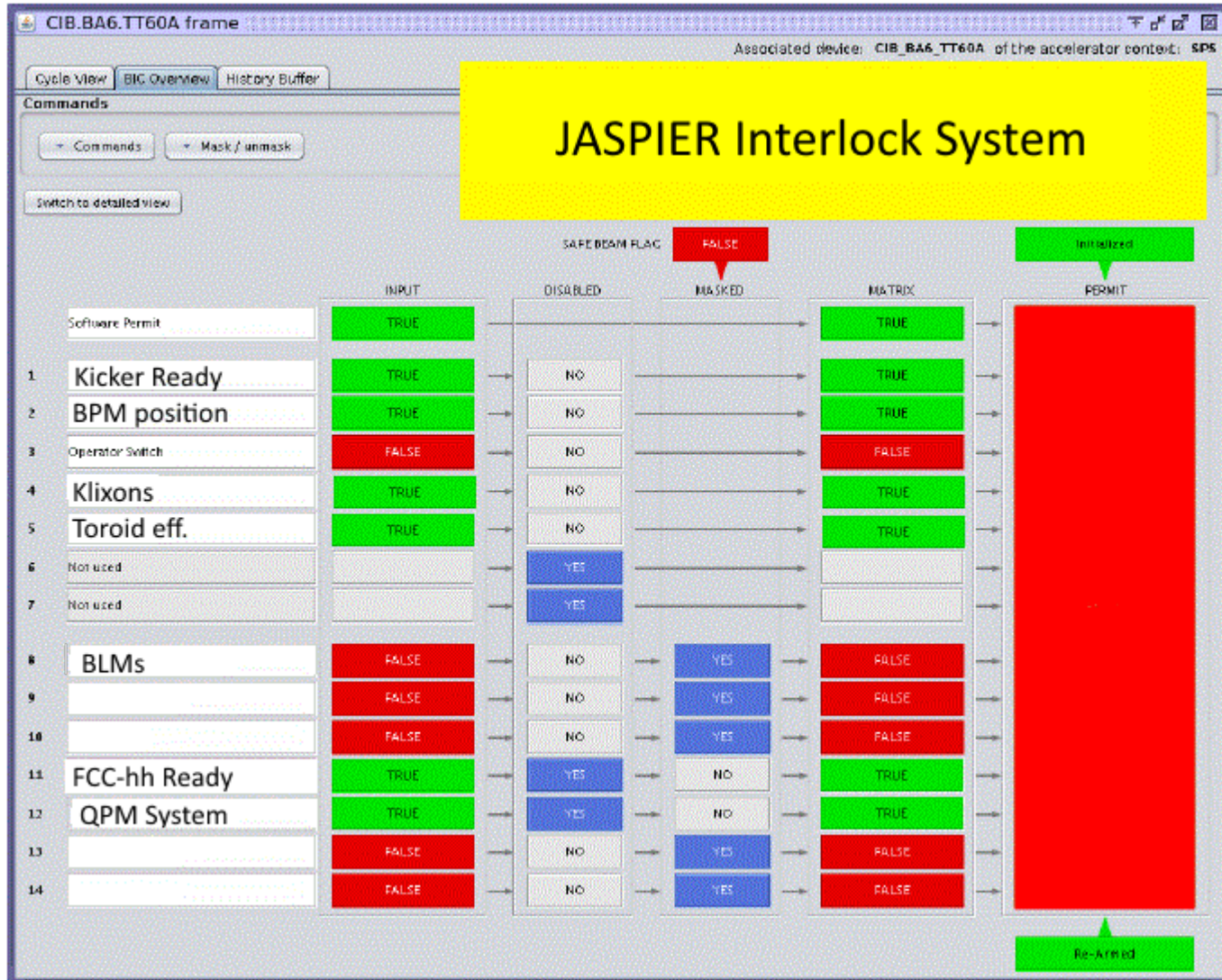
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Notice the input from the FCC-hh for a good signal to extract beam from the LHC

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References

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