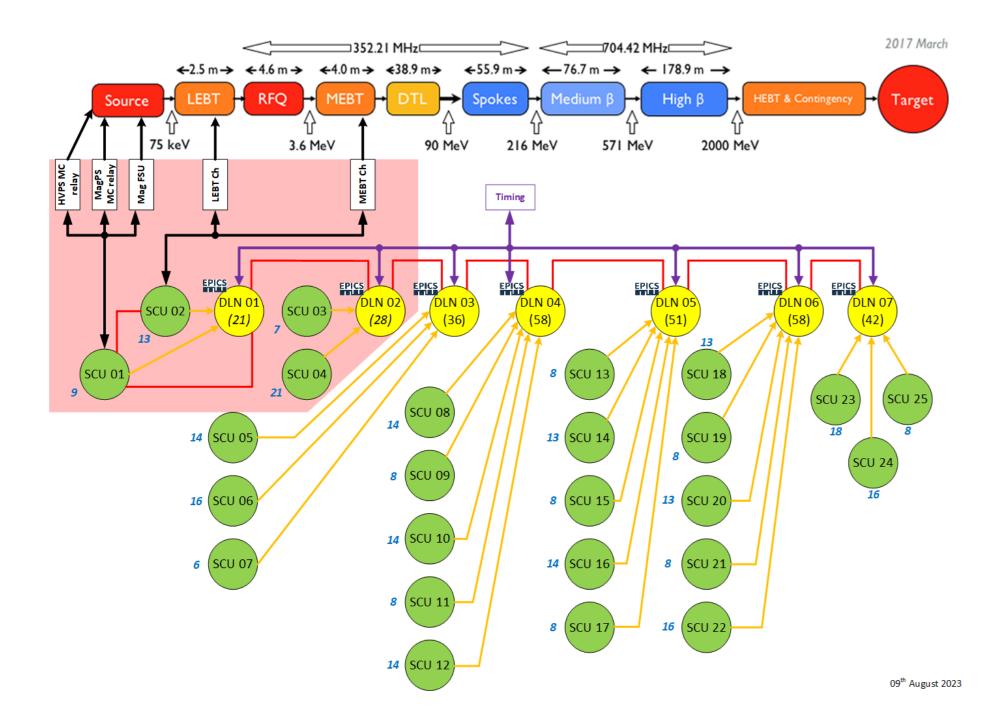
The ESS Fast Beam Interlock System -Design, Deployment and Commissioning of the Normal Conducting Linac

S. Pavinato, M. Carroll, S. Gabourin, A. Gorzawski, A. Nordt European Spallation Source, Lund, Sweden



The FBIS for the full Linac is constituted of 7 **mTCA** DLNs and 25 **cPCI** SCUs. For the Normal Conducting Linac (NCL) commissioning phase to DTL4 Faraday Cup (FC), a subset of 2 DLNs and 4 SCUs was installed.

The High level OPI has been designed following a matrix approach composed by a set of rows (corresponding to the inputs to FBIS represented as round LEDs) and columns (corresponding to the outputs from FBIS represented as square LEDs).

Machine Protection System of Systems

80

O Act

FBIS full deployment with DTL4 FC installation highlighted.

Rolling History Buffer (HB) of the latest 1023
events that occurred. To understand the
sequence of events during particular
situation, especially after unclear Beam Stops
or during commissioning.

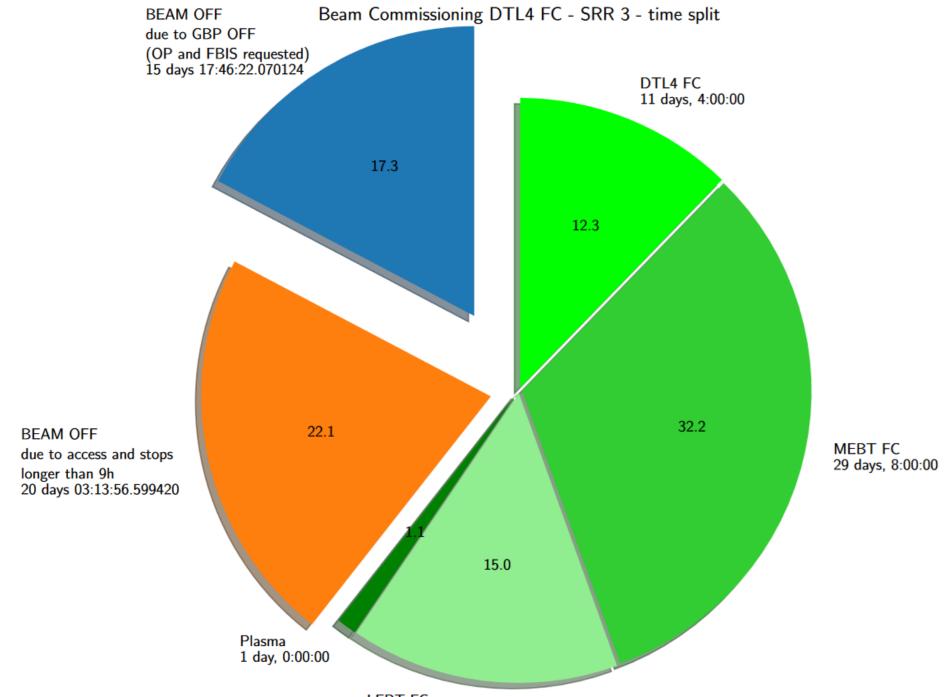
Signal	SubType	Туре	BI	RBI	EBI	GBP	SuperType	ns	Date	
	ОК	GBP	0	0	õ	0	BSO	710,000,623.6	2023-06-26 13:54:26	
NOK	4	SPU	•	•	0	•	PU DLV out	843,698,577.4	2023-06-26 13:57:59	
NOK	5	SPU	•	•	0	•	PU DLV out	843,698,577.4	2023-06-26 13:57:59	
	NOK	Local BI	•	•	0	•	BSO	843,698,585.6	2023-06-26 13:57:59	
	NOK	Local RBI	•	•	0	•	BSO	843,698,593.8	2023-06-26 13:57:59	
	NOK	GBP	•	•	0	•	BSO	843,698,602.0	2023-06-26 13:57:59	
OK	4	SPU	•	•	0	•	PU DLV out	716,866,002.9	2023-06-26 14:02:06	
OK	5	SPU	0	0	0	•	PU DLV out	716,867,387.4	2023-06-26 14:02:06	
	OK	Local BI	0	0	0	•	BSO	716,867,395.6	2023-06-26 14:02:06	
	OK	Local RBI	0	0	0	0	BSO	716,867,395.6	2023-06-26 14:02:06	
	ОК	GBP	0	0	0	0	BSO	716,870,475.8	2023-06-26 14:02:06	

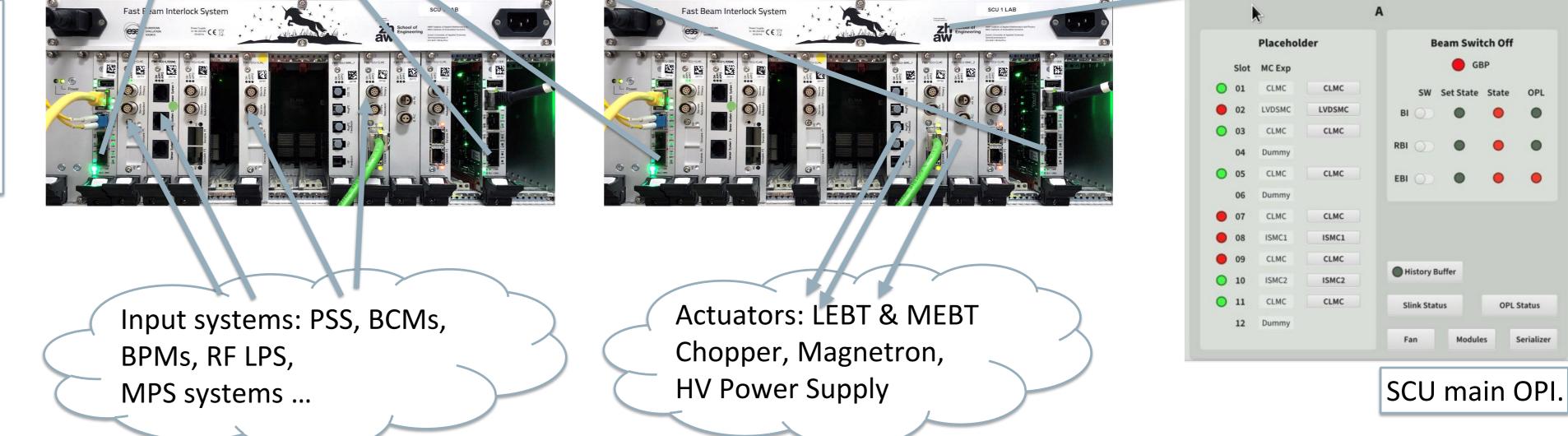
DLN is responsible for implementing the protection logic utilized by the FBIS. It is built upon the mTCA standard and employs a 3U chassis to accommodate the redundant IFC1410 Intelligent FMC Carrier which serves as the core component for FBIS functionality.



e Protect	ion Sys	tem of s	System	s							High Le	vel Operating Scre
		0-	O Section 1		Out ()	Section 3	out () In () - (Out in Section 4	0	FBIS Destina Overview Actuations	tion: DTL4	al Beam Permit Nor Beam Inhibit paration Check atus Interlock
HINS		ISrc		LEBT FC	MEBT FC		DTL2 FC	D	TL4 FC	Status	KOK	HOK
ble Devices	MPSID		0		D	0		•			OK	HOK
spole Nagneta	MPSMag				•						ОК	NOK
(MPSVac		•		•	•		•			ОК	NOK
e Interlack	515										ОК	OK
ce & LEBT	ISre	0		(0						OK	HOK
ma	RF				•	•		•			ОК	OK
	Acc PSS										ок	NOK
hopper LPS	MEBT CH										OK	OK
opper Fault	EBT CH										OK	OK
	1										OK	HOK
	BPM										OK	OK
r Feedbacks	FBIS FB										Emergency:	HOX
										Re		Rearm
				Status In	put System		Ma	isk	Filte	red Che	ck In	put
				O PS	s		0	00				Detail
			_	1	FE	BIS C)PI. C	Detail	ls abc	out an	input	system
		- 1	SPU	РВ	D PE	BM	SSPU					O FW version
RE I			State La	abel			ID	Input	Mas	k Filtere	d Latched	
-884			•	PSS_Beam_P	ermit		0	NOK	•		0	Details
			-	PSS_Red_Bea			1	NOK	0	ŎŎ	ŏ	Details
					m_Absence_1	_	2	NOK	-	DO	0	Details
							DLN	OPI.	Proc	essing	Units	details
						_	FI	BIS-SCL	J01:			

SCU is a concentrator for Sensor Systems connections. It is based on a cPCI standard chassis with custom electronic cards. An SCU hosts up to 12 Mezzanine Cards (MC) on which Sensor Systems connect. Two more cards, called Serializers, host a MPSoC Zynq Ultrascale+ .



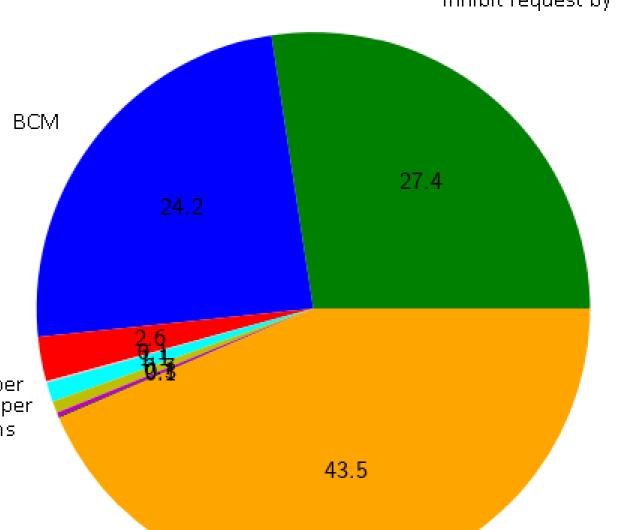


Occurances split [%]

Inhibit request by Operations

The percentage of available beam time w.r.t the time when the beam was off due to the FBIS (and/or) operator request. The intended stops were counted for planned accesses and scheduled stops. The time with Beam ON represents time spent with studies on various destinations in the ESS linac.

ESS NCL commissioning trips split by the FBIS input. The dominant part is intended by operations usually used for machine configuration adjustments. The next three players are inputs related to Ion Source the RF systems, Beam LEBT Chopper MEBT Chopper Current Monitor, and Ion MPS Systems Source. The remaining < 6% covers all other active







RF Systems and Cavities

Conclusions

The FBIS has been fully operational for the NCL commissioning to the DTL4 Faraday Cup. Beam stops were triggered when necessary for machine protection purpose, but also in many more circumstances. A rough minimum availability of the machine can be estimated around 60% the ratio between the Beam Off (22.1 % + 17.3 % of total time) and the total time of the commissioning. When running in full operation, the machine availability is foreseen to be above 95%. This will be achievable by reducing drastically access time, by reducing the time to restart beam thanks to more advanced post-mortem analysis tools, and by making more use of the inhibit feature of the FBIS that allows automatic recovery of the GBP, in particular for the RF systems.

Acknowledgements

Zurich University of Applied Sciences for their contributions to the development of the Fast Beam Interlock system.

European Spallation Source ERIC, Partikelgatan 2, P.O. Box 176, SE-221 00 Lund, SWEDEN

www.ess.eu