Introduction and Objectives of the HEC-WG

- Introduction and Overview
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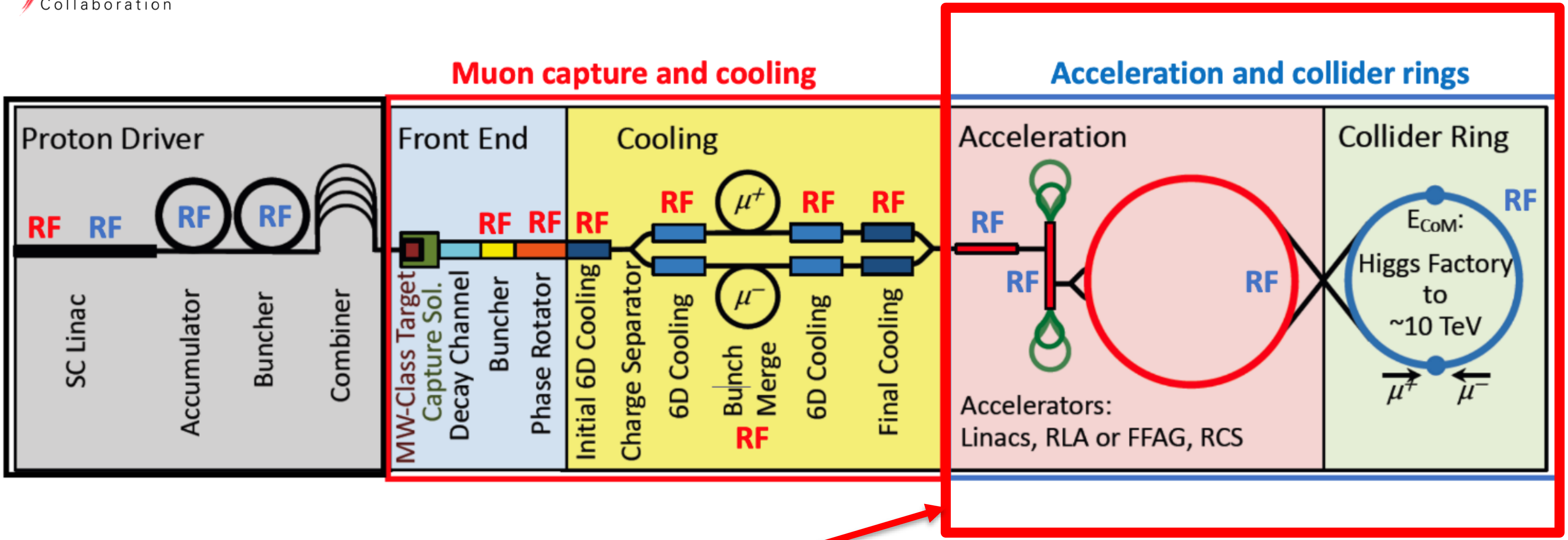
- Programme

Introduction and Overview

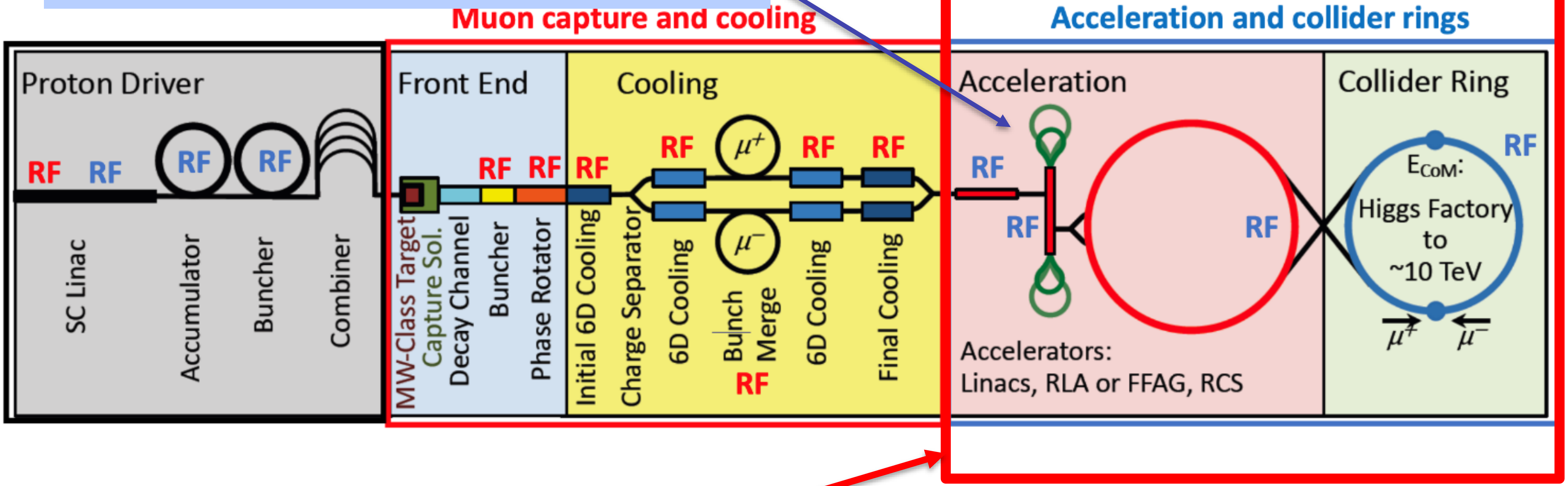


Objective of this WG

Courtesy of A. Grudiev et al.

Introduction and Overview

→ Low Energy acceleration: Linac & RLA (A. Bogacz, JLAB)



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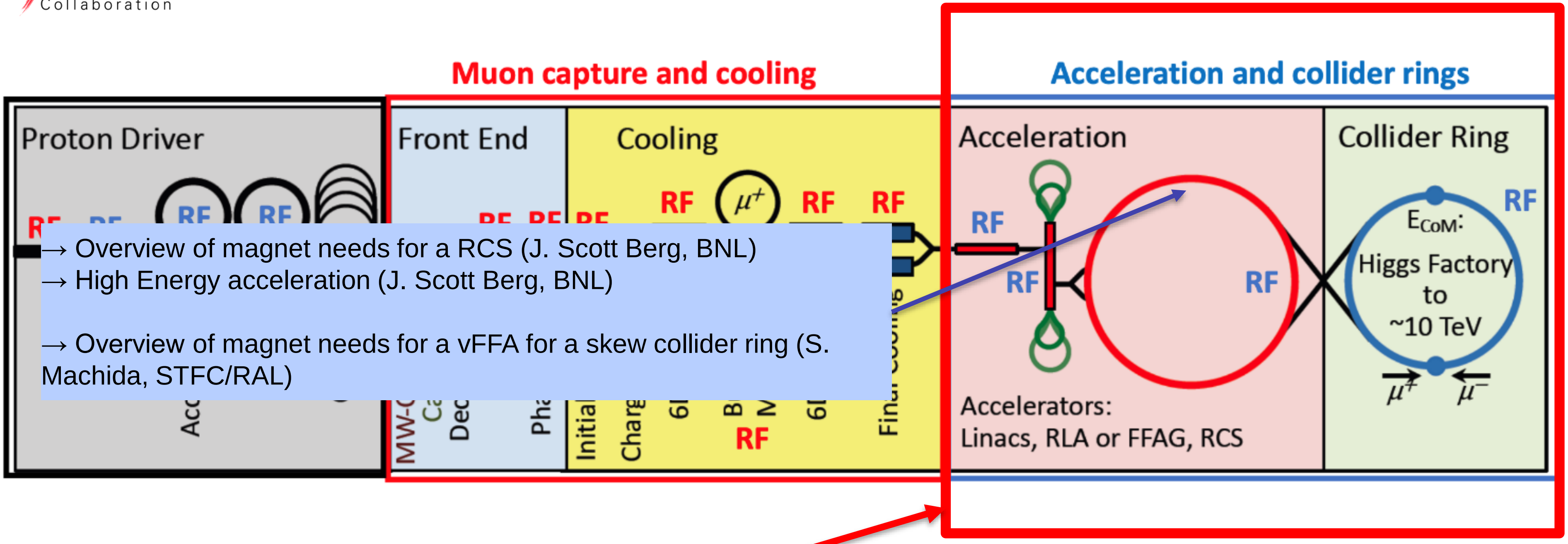

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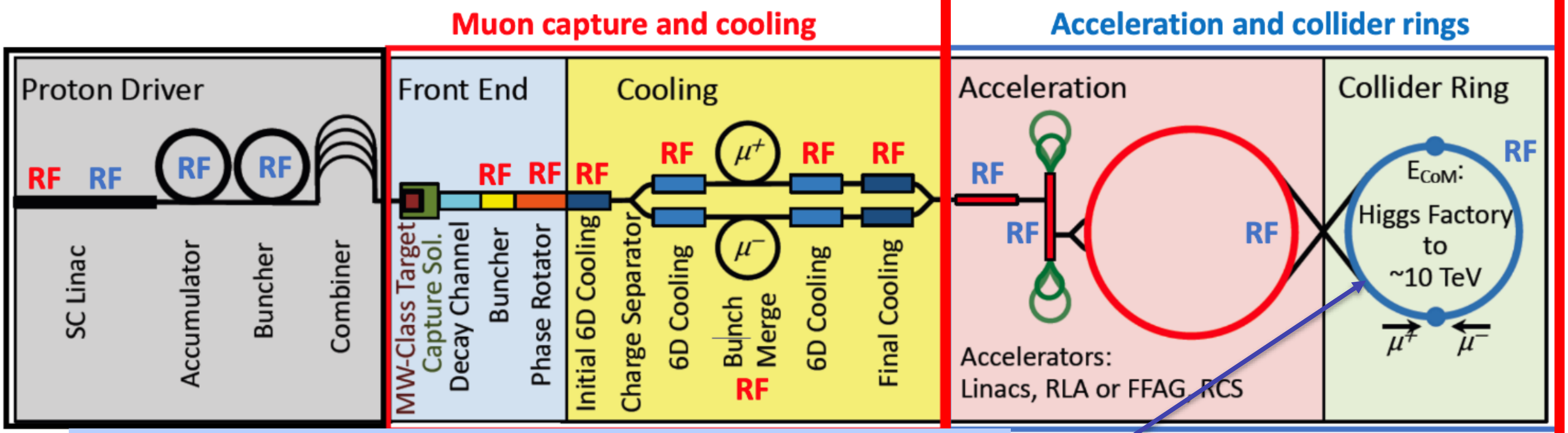

→ Overview of magnet needs for a collider (C. Carli, CERN)
→Lattice design for the collider and critical aspects (C. Carli, CERN)
Exotic option for the HE complex: vFFA and collider lattice with skew QPs (S.i Machida, STFC/RAL)

Courtesy of A. Grudiev et al.

International
UON Collider
Collaboration

Introduction and Overview
RF System

Courtesy of
J.P. Delahaye et al.

System			Driver			Front-End	Cooling			Acceleration			Collider	Total
Sub-system			Driver Linac H- (SPL like)		Accum &Comp		Initial	6D (2 lines)	Final (2 lines)	Injector Linac	RLA	RCS	Ring	
Reference expert			F.Gerigk		?	D.Neuffer	C.Rogers	D.Stratakis	C.Rogers	A. Bogacz		S.Berg	E.Gianfelic	
			NC	SC										
	Energy	GeV/c	0.16	5	5	0.255	0.255	0.255	0.255	1.25	62.5	1500	1500	
Beam (system exit)	# bunches (μ+ or μ-)	#	40 mA		1	12	12	1	1	1	1	1	1	
	Charge/bunch	E12			500	3.60	2.57	7.27	4.43	3.59	3.05	2.22	2.20	
	Rep Freq	Hz	5	5	5	5	5	5	5	5	5	5	5	
	Norm Transv Emitt	rad-m				1.5E-02	3.0E-03	8.3E-05	2.5E-05	2.5E-05	2.5E-05	2.5E-05	2.5E-05	
	Norm Long Emitt	rad-m				4.5E-02	1.5E-02	1.9E-03	1.1E-02	1.1E-02	1.1E-02	1.1E-02	1.1E-02	
	Pulse/Bunch length	m	2.2 ms		0.6 (2ns)	1.1E+01	1.1E+01	9.2E-02	9.2E-02	4.6E-02	2.3E-02	2.3E-02	5.0E-03	
	Power (μ+ and μ-)	W	6.40E+04	2.2E+06	2.0E+06	1.8E+04	1.3E+04	3.0E+03	1.8E+03	7.3E+03	3.1E+05	5.4E+06	5.3E+06	
RF cavities	Technology		Linac4HP	SC		0	NC	Vacuum	NC	SRF	SRF	SRF	SRF	
	Number of cavities	#	23	244		120	367	7182	32	52	360	2694	?	11074
	RF length	m	46	237		30	105	1274	151	82	1364	2802	?	6091
	Frf	MHz	352	704	4 ?	326to493	325	325-650	20-325	325	650-1300	1300	800	to 1300
	Grf	MV/m	1-3.7	19 - 25		20	20 to 25	19-28.5	7.2-25.5	20	25 to 38	35	?	7 to 35
	Magnetic Field	T	0	0		2	3T	1.7-9.6	1.5-4	0	0	0	0	0 to 9.6
	Installed RF field	MV	169	5700		434	2618	30447	1836	1640	50844	98062	250	.92E+05
	Energy gain	MeV	160	4840		0	0	0	0	1250	62500	1437000	0	.51E+06
	Recirculations	#	1	1		1	1	1	1	1	4.5 to 5	13 to 23	1000	to 1000
	RF Power	MW	25	282		?	?	?	?	52	360	48	?	?
RF power sources	Technology		klystron	klystron						Klytron-IOT				
	Cavities/Power Source	#	23	244		4				1 to 2	1 to 2			
	RF Pulse (beam) duration	ms	2.42	2.42		4.08E-04	5.04E-04	4.08E-03	5.64E-04	6.36E-04	3.72E-02	1.28E+00	8.70E-01	
	Prf/Power Source	MW	11.7	2.47						1	1			
	Total Power Sources	#	17	244		30				52	341			?
	Installed RF Power	MW	34	352		164				52	341			?
	Total RF Energy	MJ	2.99E-01	3.00E+00		3.35E-01	1.55E-01	4.26E-01	1.56E-02	8.63E-03	3.66E-01	6.13E+00	0.00E+00	10.74

A. Chance, 1st Muon Community Meeting, zoom, 20-21/05/2021

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Introduction and Overview
RCS chain parameters

Based on Neuffer, Shiltsev, JINST 13 (2018) T10003

	Parameter	Symbol	Unit	RCS-LE (SPS)	RCS-ME (LHC)	RCS-HE (LHC)	RCS-HE (new)	Remark
	Speed of light	c_0	[m/s]	299792458				
	Electron charge	e_0	[10^{-19} C]	1.602176634				
	Muon rest mass	m_μ	[MeV]	105.6583755				
	Muon lifetime (at rest)	τ_μ	[µs]	2.196981122				
			Unit	RCS-LE (SPS)	RCS-ME (LHC)	RCS-HE (LHC)	RCS-HE (new)	Remark
	Injection energy	E_{inj}	**[TeV]**	**0.063**	**0.3**	**1.5**	**1.5**	
	Ejection energy	E_{ej}	**[TeV]**	**0.3**	**1.5**	**10**	**10**	
	Muon survival rate	N_{ej}/N_{inj}		**0.9**	**0.9**	**0.9**	**0.9**	
	Circumference	$2\pi R$	[km]	6.912	26.659	26.659	50.000	
	Pack fraction		[]	0.67	0.71	0.71	0.80	
	Bending radius	ρ	[km]	0.741	3.026	3.026	6.366	Bending radius from SPS and LEP, ISR see E. Keil, ISR-TH/72-20
	Total straight section length	l_{SS}	[km]	2.254	7.643	7.643	10.000	
	Injection Bending field	B_{inj}	[T]	0.283	0.331	1.653	0.786	
	Ejection Bending field	B_{ej}	[T]	1.350	1.653	11.022	5.240	By far too large bending field for 10 TeV in LHC tunnel
	Injection relativistic mass factor	γ_{inj}	[]	596	2839	14197	14197	
	Injection relativistic mass factor	γ_{ej}	[]	2839	14197	94645	94645	
	Revolution frequency	f_{rev}	[kHz]	43.38	11.25	11.25	6.00	
Linear ramp	Gradient for survival	G	[MV/m]	2.38	2.45	2.89	2.89	Constant acceleration with linear energy increase
	Acceleration time	T_{acc}	[ms]	0.33	1.63	9.82	9.82	
	Number of turns	n_{turn}		14	18	110	59	
	Maximum energy gain per turn	ΔE	**[GeV]**	**16.42**	**65.33**	**77.00**	**144.43**	**No overvoltage!**
	Average gradient per straight length	$\Delta E/l$	**[MV/m]**	**7.286**	**8.547**	**10.075**	**14.443**	
Sinusoidal ramp	Maximum gradient for survival	G	[MV/m]	4.12	4.28	5.25	5.25	During maximum ramp rate
	Aceleration time	T_{acc}	[ms]	0.30	1.47	8.48	8.48	
	Number of turns	n_{turn}		13	17	95	51	
	Maximum energy gain per turn	ΔE	**[GeV]**	**28.50**	**114.05**	**139.93**	**262.45**	**No overvoltage!**
	Average gradient per straight length	$\Delta E/l$	**[MV/m]**	**12.642**	**14.923**	**18.308**	**26.245**	

Courtesy of
H. Damerau et al.

Introduction and Overview
Muon collider ring

Courtesy of D. Schulte

Tentative target parameters
Scaled from MAP parameters

Comparison:
CLIC at 3 TeV: 28 MW

Parameter	Unit	3 TeV	10 TeV	14 TeV
L	10^{34} $cm^{-2}s^{-1}$	1.8	20	40
N	10^{12}	2.2	1.8	1.8
f_r	Hz	5	5	5
P_{beam}	MW	5.3	14.4	20
C	km	4.5	10	14
<B>	T	7	10.5	10.5
ε_L	MeV m	7.5	7.5	7.5
σ_E / E	%	0.1	0.1	0.1
σ_z	mm	5	1.5	1.07
β	mm	5	1.5	1.07
ε	µm	25	25	25
$\sigma_{x,y}$	µm	3.0	0.9	0.63

Parameter	Symbol	Unit	3 TeV c.m.	14 TeV c.m.
Speed of light	c	[m/s]	299792458	
Electron charge	*e*	[10^{-19}C]	1.60	
Muon rest mass	mmu	[MeV]	105.66	
Muon lifetime (at rest)	taumu	[µs]	2.20	
Energy	E	[TeV]	1.5	7
Gamma			14197	66251
Circumference	C	[km]	4.5	14
Revolution frequency	frev	[kHz]	66.6	21.4
Revolution period	Trev	[µs]	15.0	46.7
Muon lifetime		[ms]	31	146
		[turn]	2078	3117
Average Beta function		[m]	50	50
Beta function at the IP	betaIP	[mm]	5	1.07
Rms bunch length	sigmaz	[mm]	5	1.07
Norm. transverse emittance	epsNorm	[microm]	25	25
Un-norm. transverse emittance	eps	[microm]	0.00176	0.00038
Average rms transv. bunch size	sigmatAvg	[microm]	296.7	137.4
Rms transv. bunch size at the IP	sigmatIP	[microm]	3.0	0.6

Objectives

Charge for this 1st Muon Community Meeting:

- The goal is to identify the R&D that has to be carried out before the next ESSU-PP to scientifically justify the investment into a full CDR for the muon collider and the corresponding demonstration programme

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- This includes R&D to develop a baseline collider concept, well-supported performance expectations and to assess the associated key risks, cost and power drivers. Further, the main components of the demonstration programme should be identified together with the corresponding preparatory work
- The working groups should propose realistic but ambitious targets for the performance goals of the different collider systems. In particular they should consider what could be assumed for the demonstration programme, i.e. in one or more test facilities starting in 2026, as well what one can anticipate to be available in 2035-2040 for a first collider stage and in 2050 for an energy upgrade.

Programme 20/05/2021

(https://indico.cern.ch/event/1030726/timetable/#all.detailed)

- Joined session with magnet people in HEC room 20/05/2021 14:00
  - Overview of magnet needs for a vFFA for a skew collider ring (Shinji Machida, STFC/RAL)
  - Overview of magnet needs for a RCS (J. Scott Berg, BNL)
  - Overview of magnet needs for a muon collider (Christian Carli, CERN)
- Joined session with RF and BD in RF room 20/05/2021 16:10
  - Low Energy acceleration: Linac & RLA (Alex Bogacz, JLAB)
  - High Energy acceleration (J. Scott Berg, BNL)
- Joined with MDI and RPOT in MDI room 17:15
- Joined with BD in HEC room 18:20
  - Needs in simulation tools for a vFFA (Jean-Baptiste Lagrange, STFC)

Programme 21/05/2021

(https://indico.cern.ch/event/1030726/timetable/#all.detailed)

- Session HEC 09h30 in HEC room
  - Lattice design for the collider and critical aspects (Christian Carli, CERN)
  - Exotic option for the HE complex: vFFA and collider lattice with skew QPs (Shinji Machida, STFC/RAL)
  - Preparation of the HEC summary + R&D list

Thank you for your attention