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DISCUSSION ON FILL MODES

TWG MEETING

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BACKGROUND

- MBA lattice installation starts in June 2022 and completes in June 2023
- APS-U parameters:

Quantity	APS Now	APS MBA Timing Mode	APS MBA Brightness Mode	Units
Beam Energy	7	6	6	GeV
Beam Current	100	200	200	mA
Number of Bunches	24	48	324	
Bunch Duration (rms)	34	104	88	ps
Energy Spread (rms)	0.095	0.156	0.135	%
Bunch Spacing	153	76.7	11.4	ns
Emittance Ratio	0.013	1	0.1	
Horizontal Emittance	3100	31.9	41.7	pm-rad
Horizontal Beam Size (rms)	275	12.9	14.7	μm
Horizontal Divergence (rms)	11	2.5	2.8	μrad
Vertical Emittance	40	31.7	4.2	pm-rad
Vertical Beam Size (rms)	10	8.7	3.2	μm
Vertical Divergence (rms)	3.5	3.6	1.3	μrad

ESTIMATED SCHEDULE TO REACH KEY PERFORMANCE PARAMETERS (KPP)

Begin installation (accelerator removal, install new systems)	T_0 - 12 months
Begin ring tests with beam	T_0 – 3 months
Initial ring operation (threshold KPPs: 25 mA, >5.7 GeV, <130 pm)	**T_0**
Initial feature beamline operation (25 mA, 6 GeV, threshold TTOPs	T_0 + 6 months
100 mA, 6 GeV, 42 pm (Run 3)	T_0 + 8 months
200 mA, 6 GeV, 42 pm (ring objective KPPs, Run 4)	T_0 + 12 months
Feature beamline brightness (objective KPPs, TTOPs, Run 5)	T_0 + 16 months

AFTER INSTALLATION AND COMMISSIONING

- Within the T_0 + 6-month period, various operational bunch patterns will be developed, including 25 mA in 48 bunches
- Most challenging pattern for higher current is 48 bunches when operating with more than 150 mA
  - This requires operating the injector chain with higher bunch charge than presently possible
- APS Operations and Upgrade are working to develop this capability with a targeted completion before the ring shut-down dark period (T_0 –12 months)

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POSSIBILITY OF HYBRID MODE IN THE APS-U

- Hybrid modes should be possible in APS-U, but might require some time to develop depending on how much space is needed on either side of the isolated bunch.
- Michael Borland simulated three cases*:
  - 48-bunch, 200 mA mode with ± 1.1μs gaps on the either side of the isolated bunches
  - 48-bunch, 200 mA mode with ± 0.7μs gaps on the either side of the isolated bunches
  - 1+45 bunches, 200 mA mode, created by removing two bunches from either side of the isolated bunches starting from a uniform 48-bunch pattern
- 1+45 bunches most promising

*https://icmsdocs.aps.anl.gov/docs/idcplg?IdcService=GET_FILE&dID=195194&dDocName=APS_1685083&allowInterrupt=1

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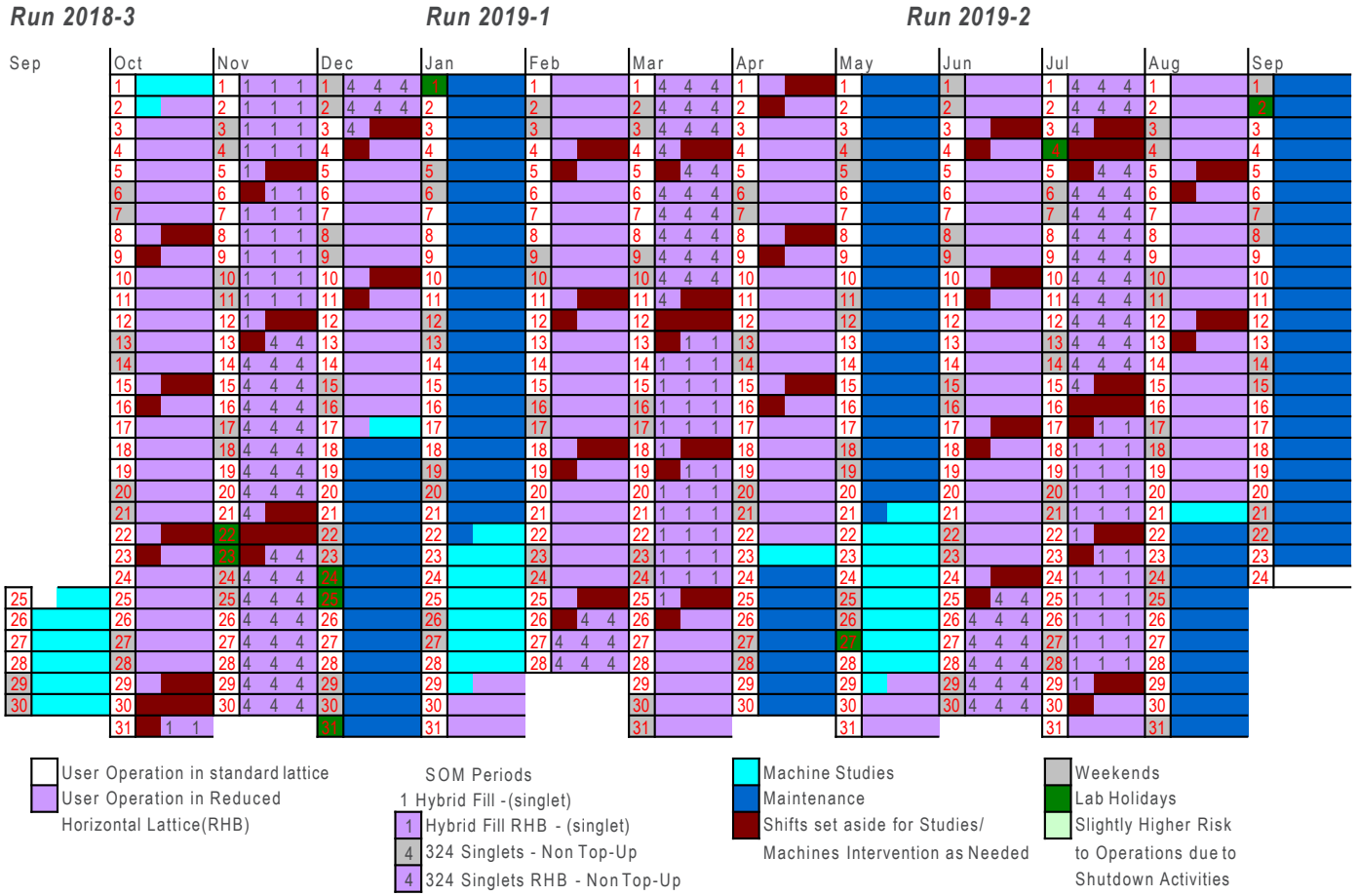
APS LONG-RANGE OPERATIONS SCHEDULE (FISCAL YEAR 2019)



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FY2019 - Breakdown of Shifts by User Fill Pattern

Run	24 Singlets (Top-Up)	Hybrid Fill (Top-Up)	324 Singlets (Non Top-Up)	Total Shifts	Total Hours
2018-3	108	33	54	195	1560
2019-1	146	33	36	215	1720
2019-2	128	33	54	215	1720
Total:	382	99	144	625	5000

FY2018 - Breakdown of Shifts by User Fill Pattern

Run	24 Singlets (Top-Up)	Hybrid Fill (Top-Up)	324 Singlets (Non Top-Up)	Total Shifts	Total Hours
2017-3	126	33	35	194	1552
2018-1	126	33	59	218	1744
2018-2	144	33	36	213	1704
Total:	396	99	130	625	5000

SUMMARY OF SHIFTS DISTRIBUTION 2010-2019

FY	24 Singlets (Top-Up)	Hybrid Fill (Top-Up)	324 Singlets (Non Top-Up)	Total Shifts	Total Hours
2019	382	99	144	625	5000
2018	396	99	130	625	5000
2017	377	99	149	625	5000
2016	395	105	125	625	5000
2015	377	99	149	625	5000
2014	392	114	119	625	5000
2013	389	102	134	625	5000
2012	392	102	131	625	5000
2011	374	105	146	625	5000
2010	397	108	120	625	5000

ACCELERATOR DRIVERS FOR 324-BUNCH MODE

- Studies to reach high-current mode in 48 bunches for APS-U
- MCR operators training due to frequent staff change
- Investigation and repair of equipment problems
- Equipment and software upgrade and testing
- Maintenance of fallback configurations for injectors to maintain operational availability
- Study of bunch cleaning (related to SR bunch purity in timing mode)

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DISCUSSION TOPICS

- Pros and cons for retaining the overall (average) distribution
  - 62% for 24-singets (top-up)
  - 16.5% for hybrid (top-up)
  - 21.5% for 324-singlets (non top-up)

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