Accelerator Complex uptime and availability in the PIP-II era and interfaces between PIP-II and AC

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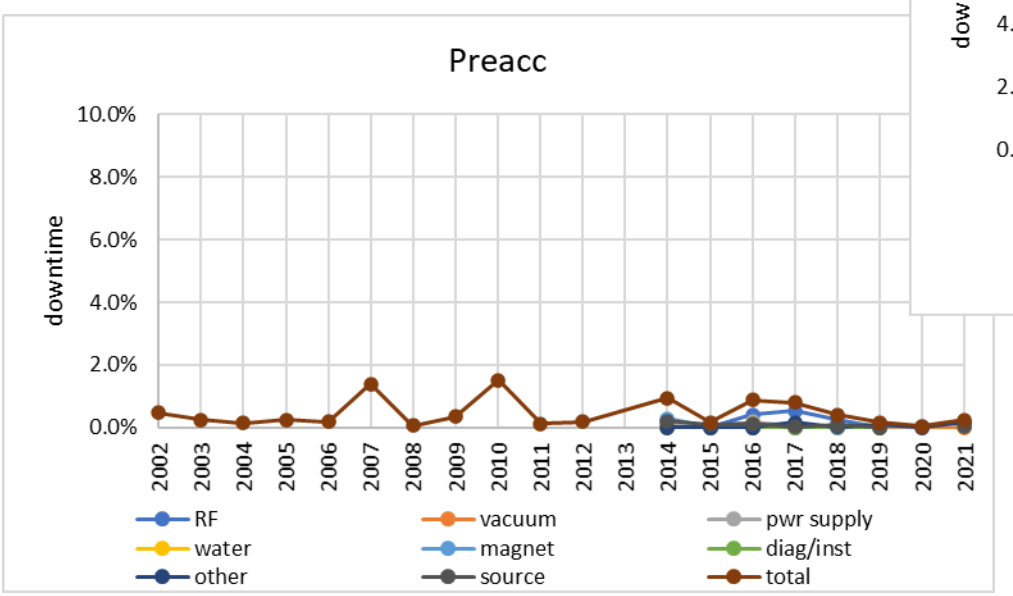
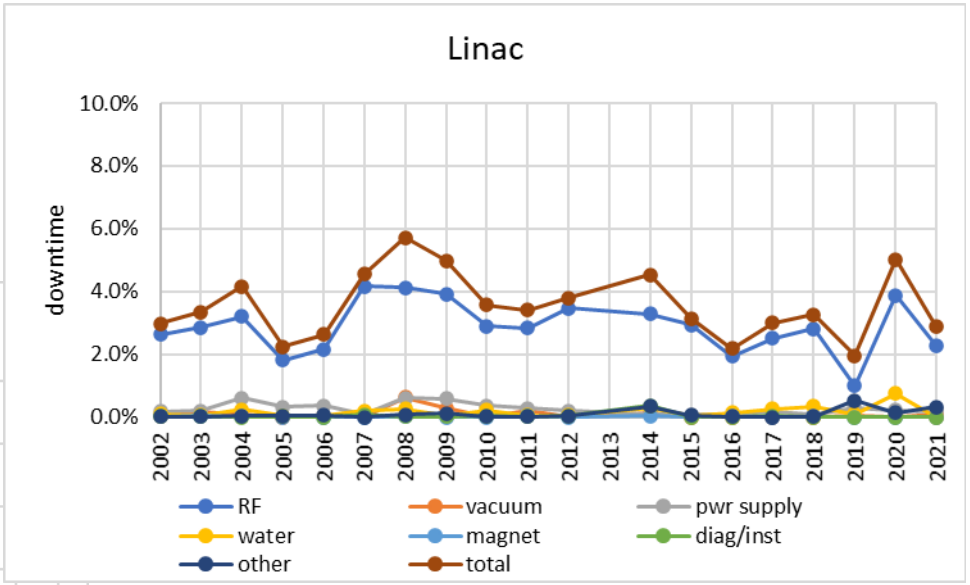
Accelerator Complex downtime statistics

- Operators log downtimes and attribute them to machines and causes by hand – this is not a perfect system
- Downtimes can hide behind others, e.g. we accessed to fix a water leak in the Main Injector, and while we were down, we did RF repairs in the Booster
- The statistics shown in the following slides are from periods of stable running (I excluded startup periods)

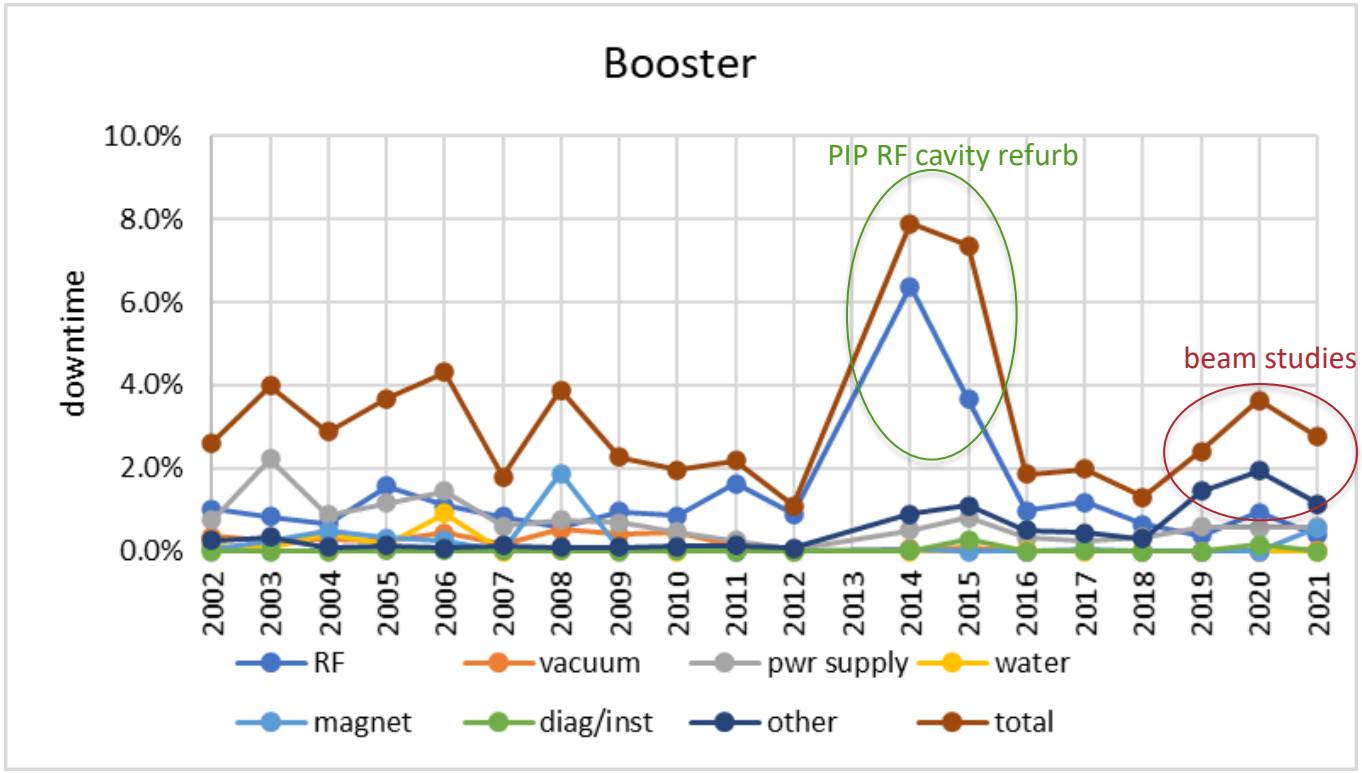
Existing Linac

- Preacc contributes essentially no downtime
- Linac downtime ~2-5% driven by RF



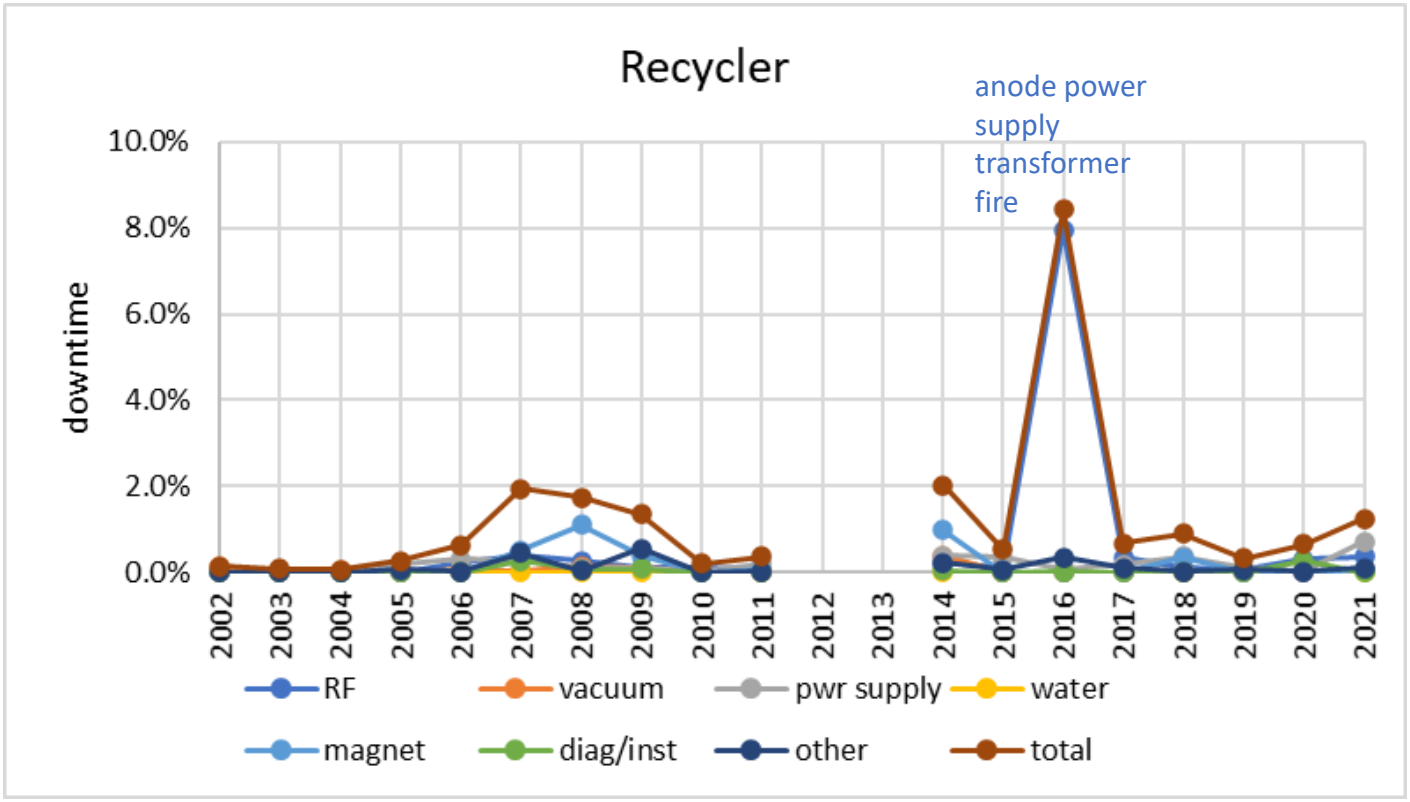


Booster



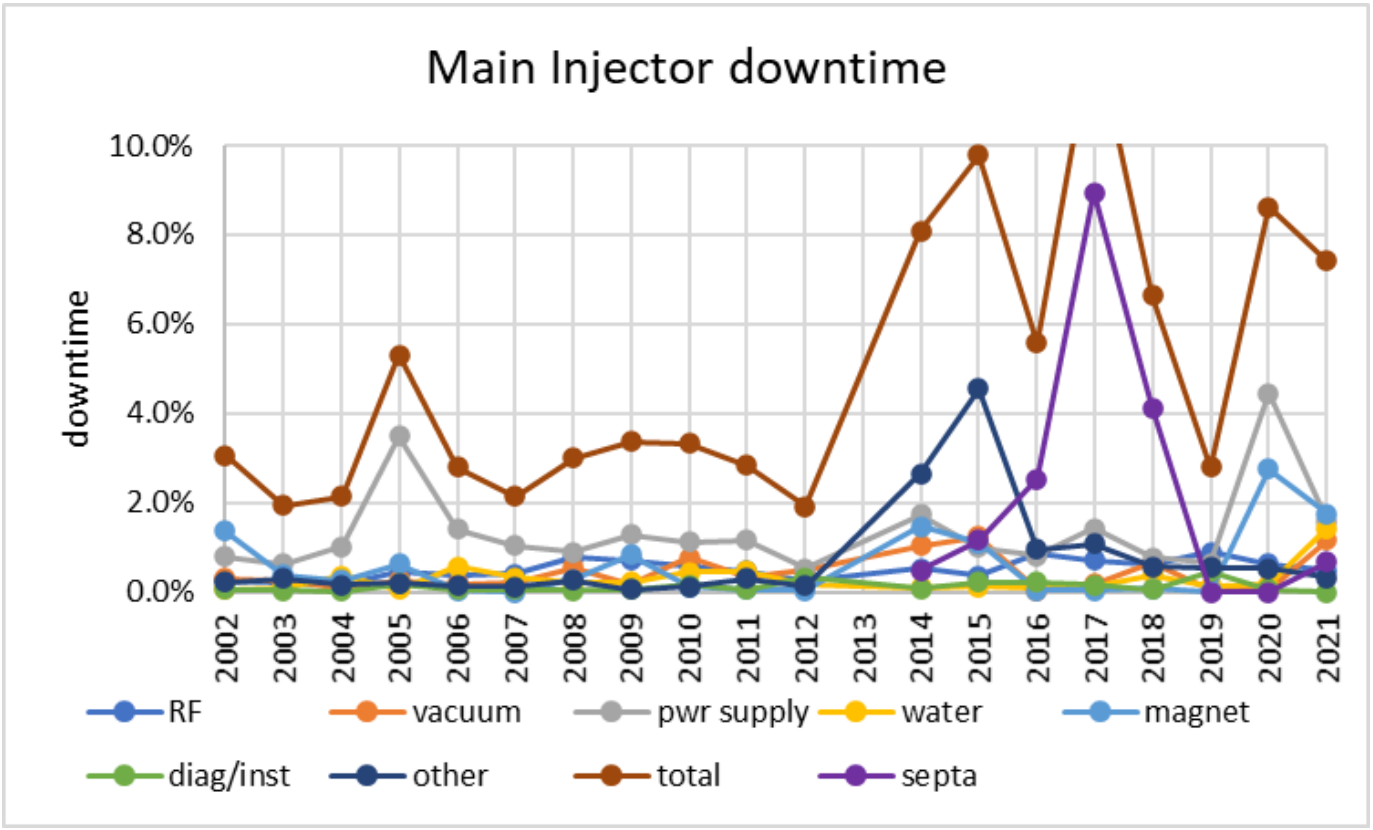
- Recent downtime ~2-4% including 1-2 shifts of scheduled beam studies per month
- Downtime due to RF was reduced by PIP adding cavities

Recycler



- Converted from pbar storage to proton slipstacking in 2013
- Downtime typically <2%

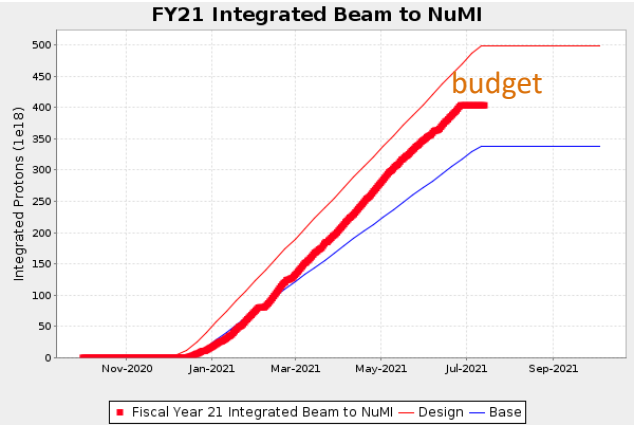
Main Injector

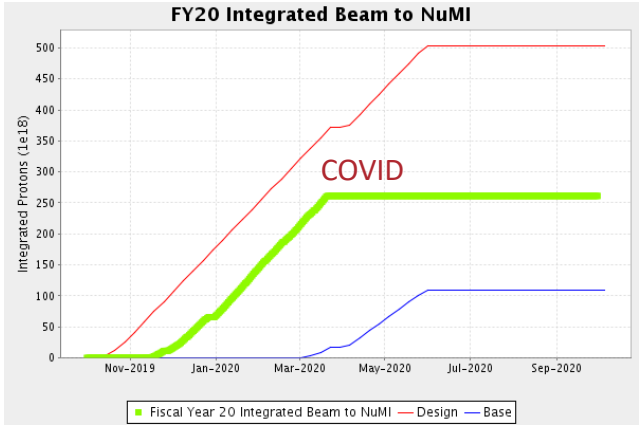


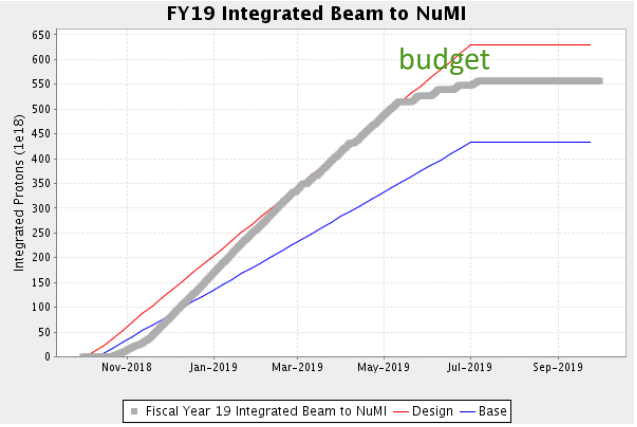
- During the Tevatron era (–2011), tunnel accesses were strictly limited; following the ANU upgrade in 2013, accesses more common (“other”)
- No single dominant source of downtime, though power supplies are common issue

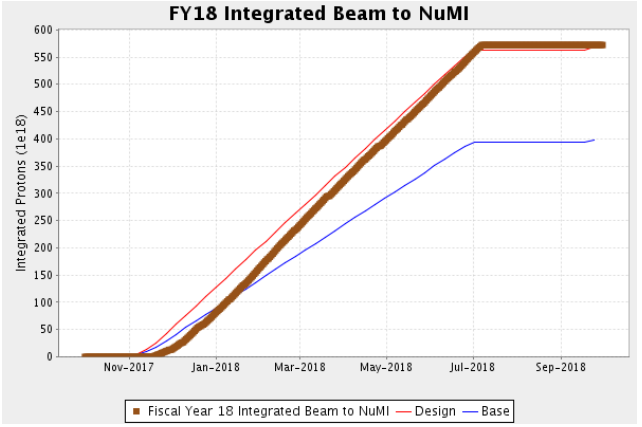
Beam to NuMI in the 700-kW era

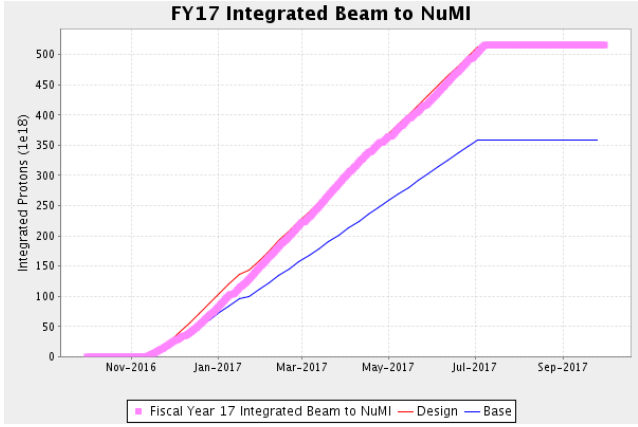
- Red line assumes 85% uptime from Proton Source, 95% uptime from MI/Recycler (~81% from Complex)





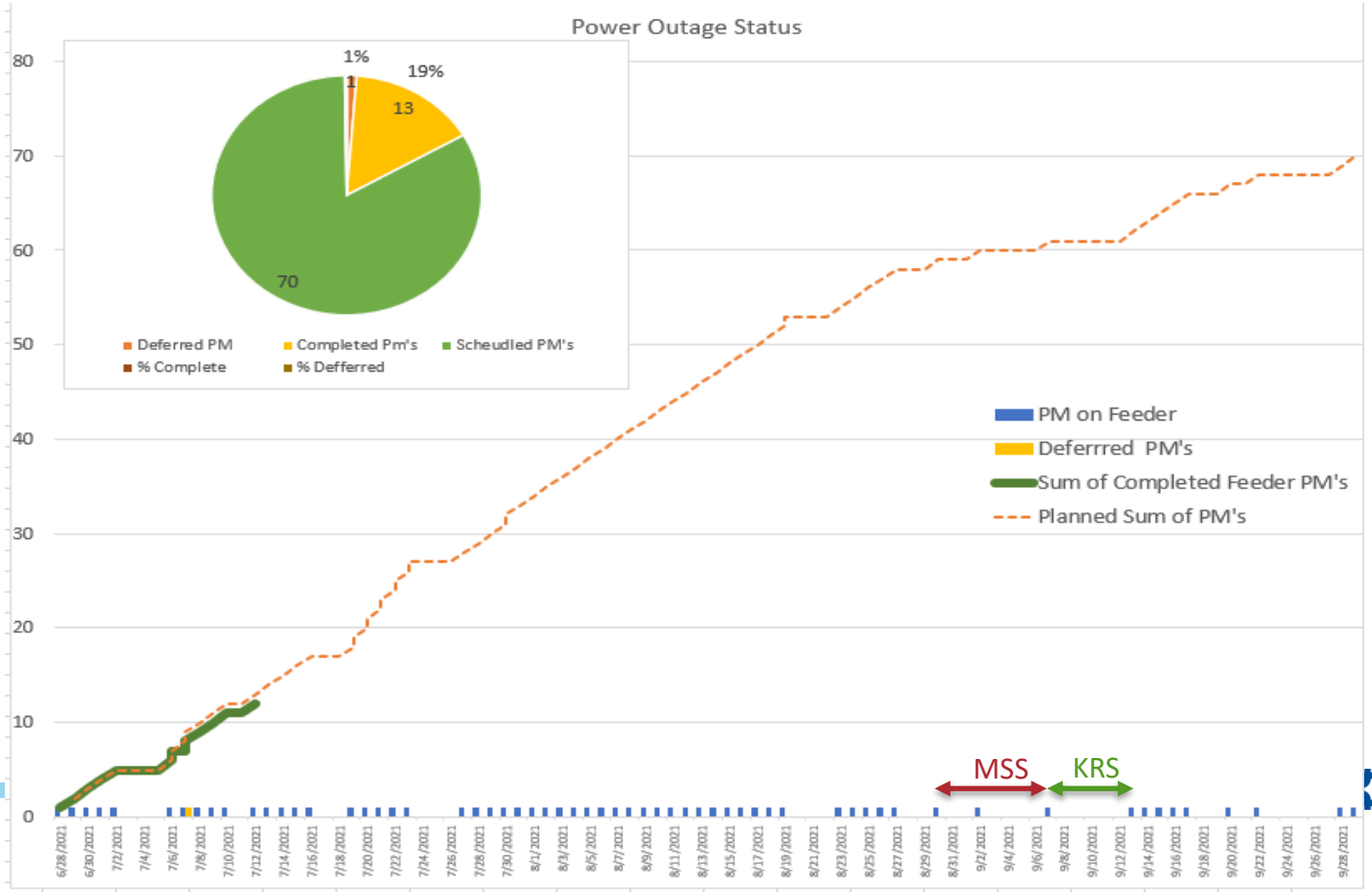






Typical shutdown start / end

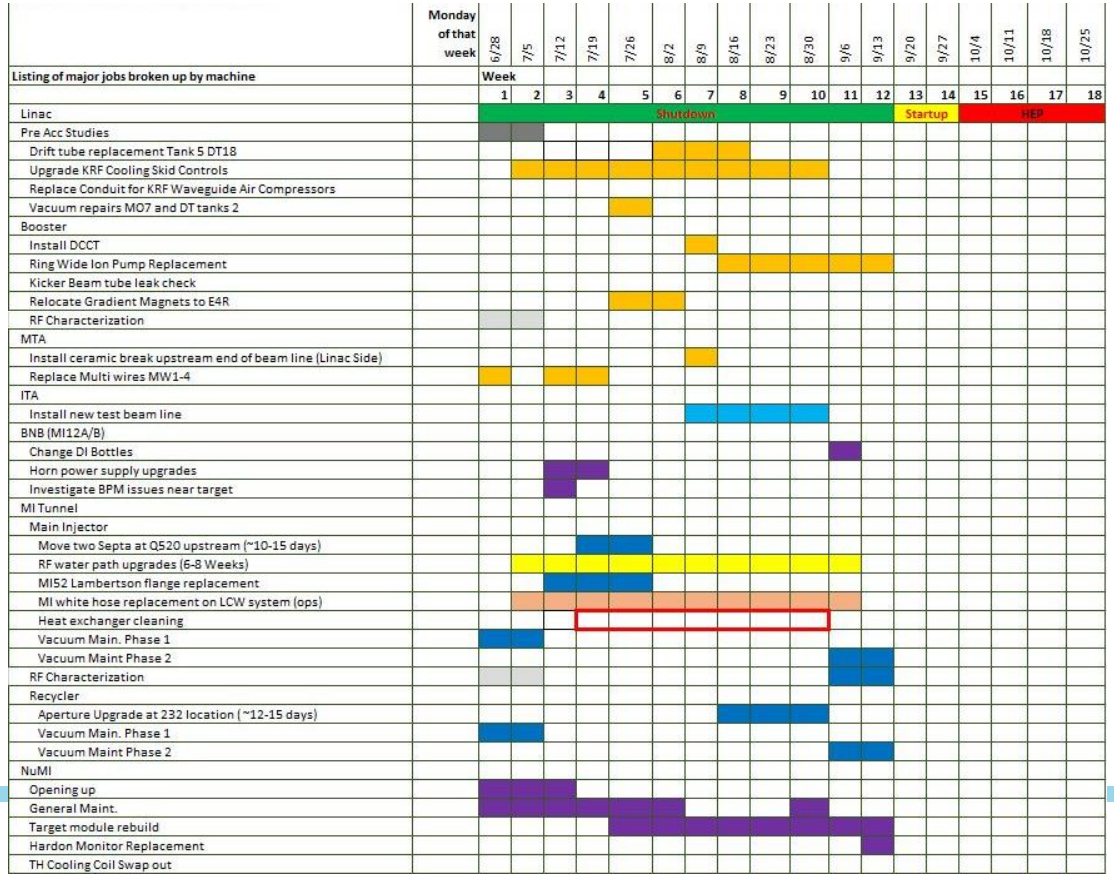
- Turn off in July when MI operation would be limited by cooling-pond temperatures
- ComEd will not do their maintenance during the summer, so startup not before mid September



Fermilab

Typical shutdown drivers

- Water maintenance across the complex currently takes ~12 weeks; could be reduced with more technicians
- Work is structured to turn on Linac first, then Booster, then MI/Recycler for efficient beam commissioning



Fermilab

Present Linac maintenance

Job	Duration	Start	Finish
RIL Work			
Source Maintenance	30 days	7/13/2021	8/24/2021
Einzel Lens Maintenance	10 days	7/13/2021	7/27/2021
RFQ Maintenance	30 days	7/13/2021	8/24/2021
Linac Work			
Water Skid Preventative Maintenance	1 week	7/1/2021	7/14/2021
Replace Tank 5 DT18	11 days	8/2/2021	8/17/2021
LRF Preventative Maintenance	3 weeks	7/1/2021	7/26/2021
KRF Preventative Maintenance	3 weeks	7/1/2021	7/26/2021
Vacuum preventative maintenance	.5 day	7/1/2021	7/1/2021
Leak check/Repair SCL Module 7 ceramic	2 days	7/27/2021	7/29/2021
Tank 2 Thimble Replacement/Leak Repai	2 days	7/29/2021	8/2/2021
Install conduit for waveguide compresso	2 days	6/28/2021	6/29/2021
Upgrade KRF cooling skid controls	5 weeks	7/1/2021	8/5/2021
Replace L2 breakers	1 day	8/15/2021	8/16/2021
Misc.			
Tunnel Cleaning	1 day	8/24/2021	8/25/2021
Safety System Testing	1 day	9/6/2021	9/7/2021
Power Outages			
Feeder 42 (CUB)	1 day	8/14/2021	8/14/2021
Feeder 40 (Linac, X-Gallery)	1 day	8/15/2021	8/15/2021
MSS-KRS backfeed	30 min	0700 8/30/2021	0730 8/30/2021
MSS return to normal config	30 min	0700 9/7/2021	0730 9/7/2021

Maintenance model during PIP-II era

- Expect we will continue to need an annual 10-12 week shutdown for maintenance
- Will still need ~2 weeks for ComEd substation maintenance as well as annual feeder maintenance
  - 1 week MSS, 1 week KRS, ~1h down while transfer MSS load to KRS and again when switch back
  - Can we support the cryo load on KRS while doing maintenance on MSS?
    - Note the Tevatron had ½ cryo on MSS and ½ on KRS
  - Could look into doing these outages at start of shutdown instead of end if it helps with cryo recovery (May? June? Would need additional cooling for MI to run in summer)
- Will want to reestablish Linac beam ~2 weeks before MI
  - Can also do Linac / Booster studies during this period

Summary

- Plan on at least 80% Accelerator Complex uptime during running period
  - 85% from Linac + Booster, 95% from MI / Recycler
  - Booster uptime depends on having overhead on RF
  - Running harder at 20 Hz may make this challenging
- Expect 10-12 week annual shutdowns for maintenance including 1 week Master Substation power outage plus feeder maintenance
- Will want to reestablish Linac beam ~2 weeks before MI