Mu2e status 2020

S.Miscetti , LNF/INFN

Mu2e-ITALY

3-September-2020

Mu2e

2020

2020 is a big year for the Project → **DOE IPR 2020 on the coming months**

- All TS units will be delivered to Fermilab and tested. . On track
- TS cryostat will be delivered. On track
- HRS will be delivered. ✔
- Cryo Feedboxes will be delivered. On Track
- All calorimeter crystals delivered. ✔
- Tracker panel and plane production well underway.
  → Getting there. Significant COVID impact.
- Production Target and support frame will be delivered. On track.
- Stopping Target will be assembled. On track.
- Detector support rails will be delivered. ✔
- 60% of CRV Modules completed → Maybe 50%? + CRV LY issue

- Complete all but one CRR → **Nope (.. On OUR side still 2 CRR to go)**

COVID Delays @ June 2020

- **Biggest impacts are to TS and Detector construction.**

  → Full impact not yet realized as Pandemic continues.
- Most activity at Fermilab stopped for nearly 3 months

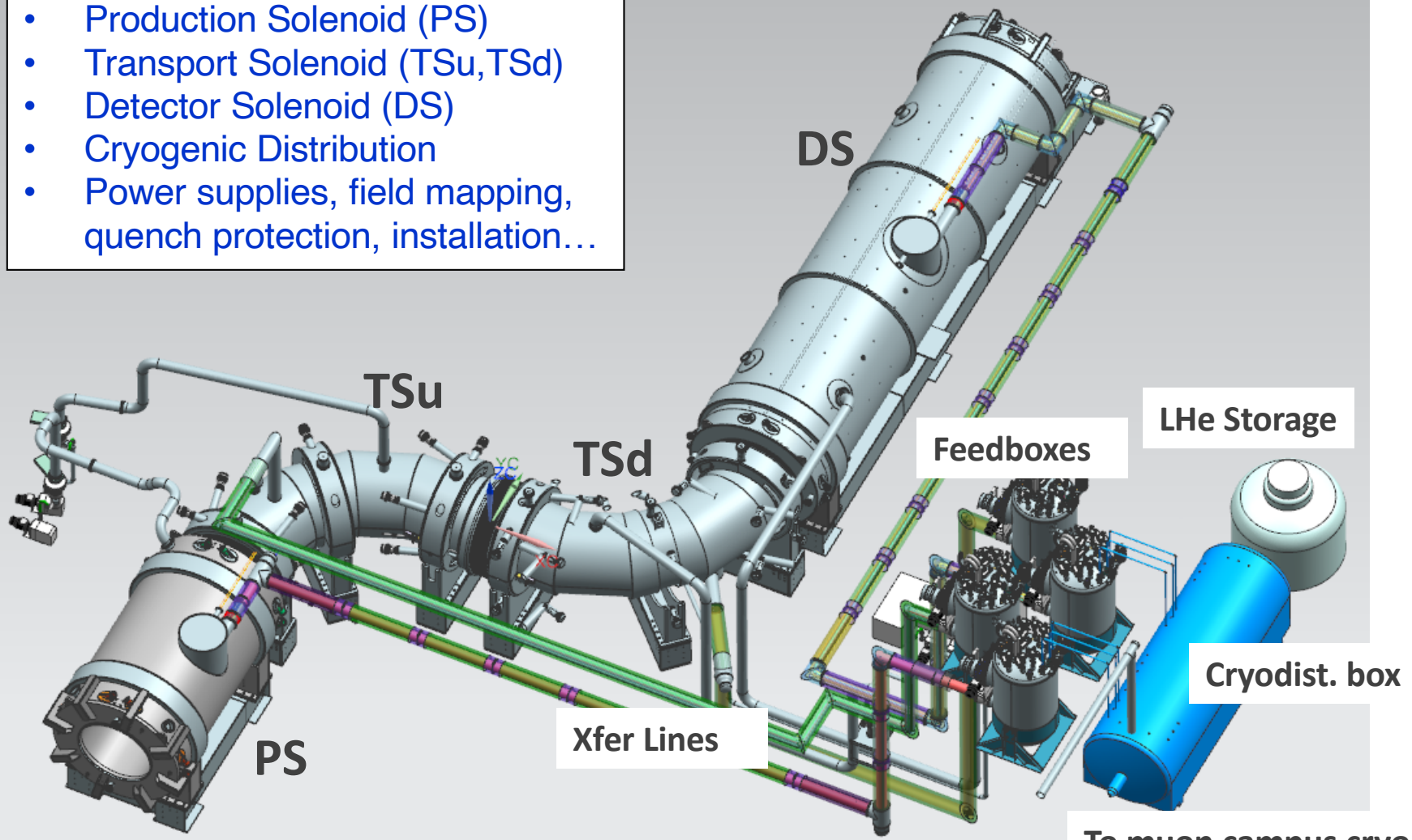
- Many subcontracted industrial firms continued working, with varying degrees of efficiency
  - Impact on General Atomics operations in Tupelo was modest.
    - Risk of shutdown in the future as COVID spread continues

- INFN personnel recalled to Italy and sheltered in place
  - Now returning to their labs in phases, similar to US.
    - **Unclear when they can return to Fermilab**

- Activity at most Universities were shut down for 3 months
  - Re-opening restricted undergraduate student labor until the Fall, at the earliest, at most institutions.

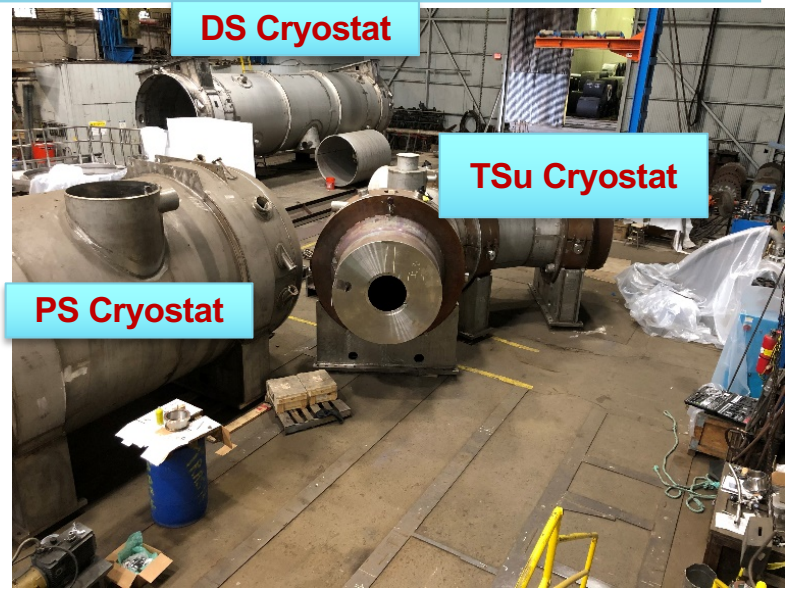
Mu2e Solenoid Scope

- Production Solenoid (PS)
- Transport Solenoid (TSu,TSd)
- Detector Solenoid (DS)
- Cryogenic Distribution
- Power supplies, field mapping, quench protection, installation…



Transport Solenoid (TS)

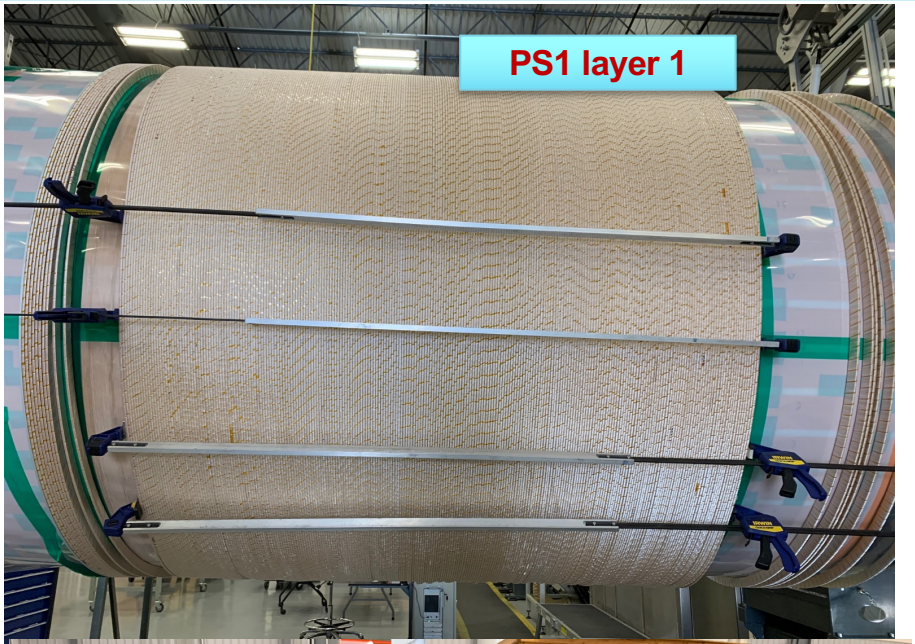
- **Test Units (ASG)**
  - 12 out of 14 delivered to Fermilab
  - Remaining 2 units to be delivered this month
  - At Fermilab 8 units fully tested and accepted
- At Fermilab HAB first 7 test units have been placed over the TSu inner cryostat and mechanically connected
  - Excellent agreement between coil survey and predicted position based on CAD model

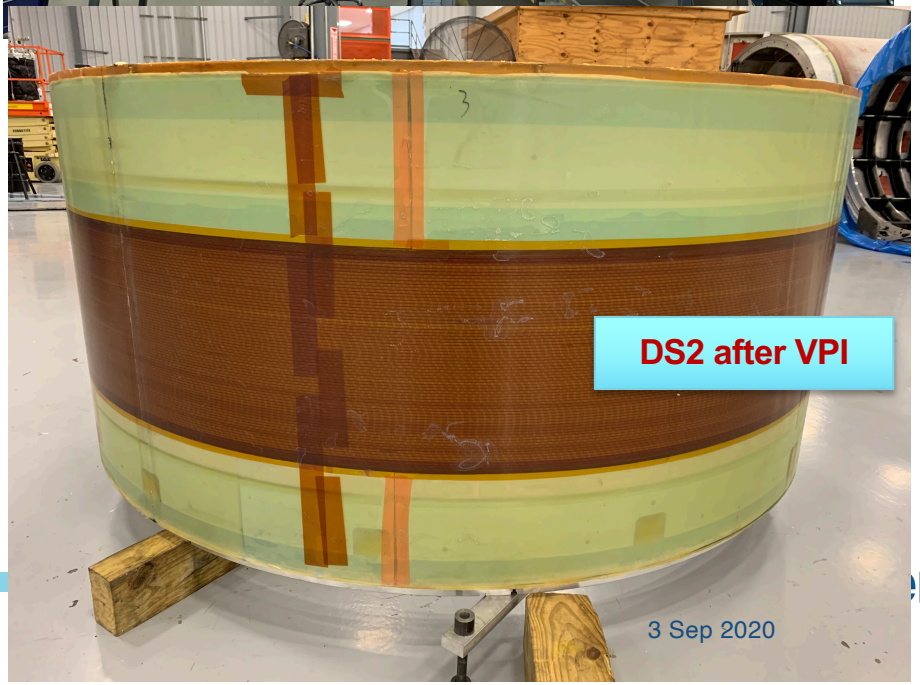


Production (PS) and Detector (DS) Solenoids

- **Production Solenoid Coils**
  PS1,PS2, PS3
  - PS3, PS2 completed
  - PS1 first layer successfully wound and compacted

- **Detector Solenoid Coils**
  DS1-DS11
  - DS1, DS9 wound and compacted
  - DS2 coil wound, compacted and VPI (Vacuum Pressure Impregnation) successfully completed





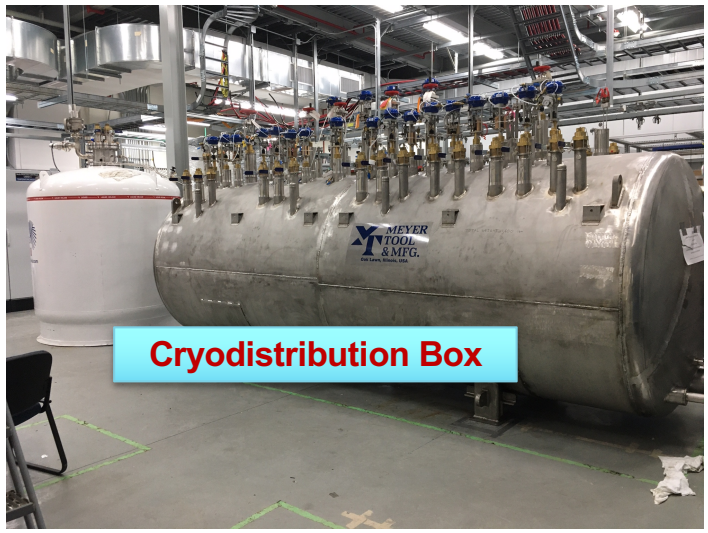
Production (PS) and Detector (DS) Solenoids

- **PS and DS cryostat fabricated by Joseph Oat, New Jersey**
  - Fabricated, vacuum and leak checks completed for DS, ongoing for PS
  - DS cryostat loaded on a truck for trip from vendor site in New Jersey to GA facility in Tupelo, Mississippi

DS Cryostat reading to leave vendor site

Mu2e Cryo distribution

- **Cryodistribution box**
  - Cryogenic pipes and insulating vacuum connected to Muon Campus Cryo Plant via 150 m outdoor transfer line
  - Vacuum and leak checking in progress
- **Feedboxes (PS, DS, TSu, TSd)**
  - PS,DS delivered to Mu2e building
    - Acceptance tests ongoing
  - TSu, TSd fabrication complete
    - FAT completed
    - To be delivered this Fall
- **Interior Transfer lines (not shown)**
  - 7 out of 8 segments completed
  - Final segment will be completed this month
  - 3 segments delivered to Mu2e building for installation



Tracker Delays

- Biggest COVID detector impact is to the Tracker
- 6-month COVID delay to Tracker so far. Delays due to:
  - University of Minnesota shutdown
  - 70% efficiency upon reopening due to social distancing
  - Limited undergraduate student pool
- Trying to mitigate delays by hiring recent experienced graduates as technicians and offloading some QC to Fermilab → will increase cost
- Help required also to INFN (see Gianfranco)

Panel Production Plan

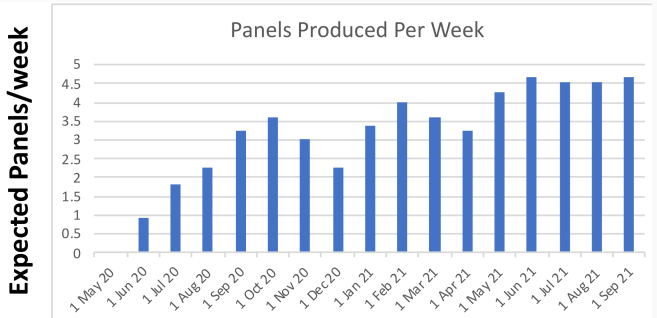
This projection builds 224 panels by October 2021.

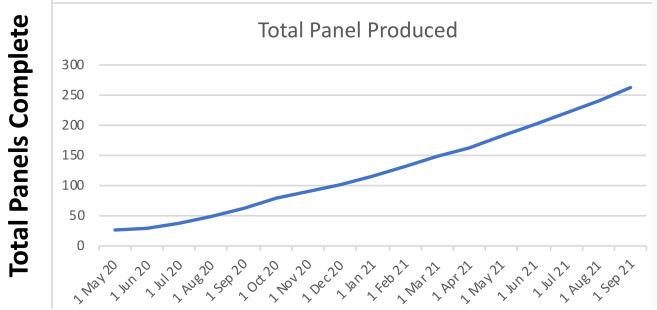
Approximately 16 production panels exist

Assuming a 20% time contingency gives a panel completion of February 2022

Mitigation would include working 6 days/wk

June Forecast





Current status – End August

Last week of August
- 2 panels completed;
-2 panels started;
- 11 panels worked on throughout week
- Reached Panel 54
- ~ OK with forecast

Panel
MN037
MN045
MN046
MN047
MN048
MN049
MN050
MN051
MN052
MN053
MN054

GA Delays

- Prior to COVID, GA delays had reduced CD-4 float to 2 months.

- **Mu2e worked with GA to develop a more credible schedule and discovered a significant logic problem in GA schedule**
  - Corrected logic problem results in additional delays to projected delivery dates **that push project completion date ~5 months beyond CD-4 milestone.**
  - Includes impact of double shifts on 11 activities/operations in Tupelo

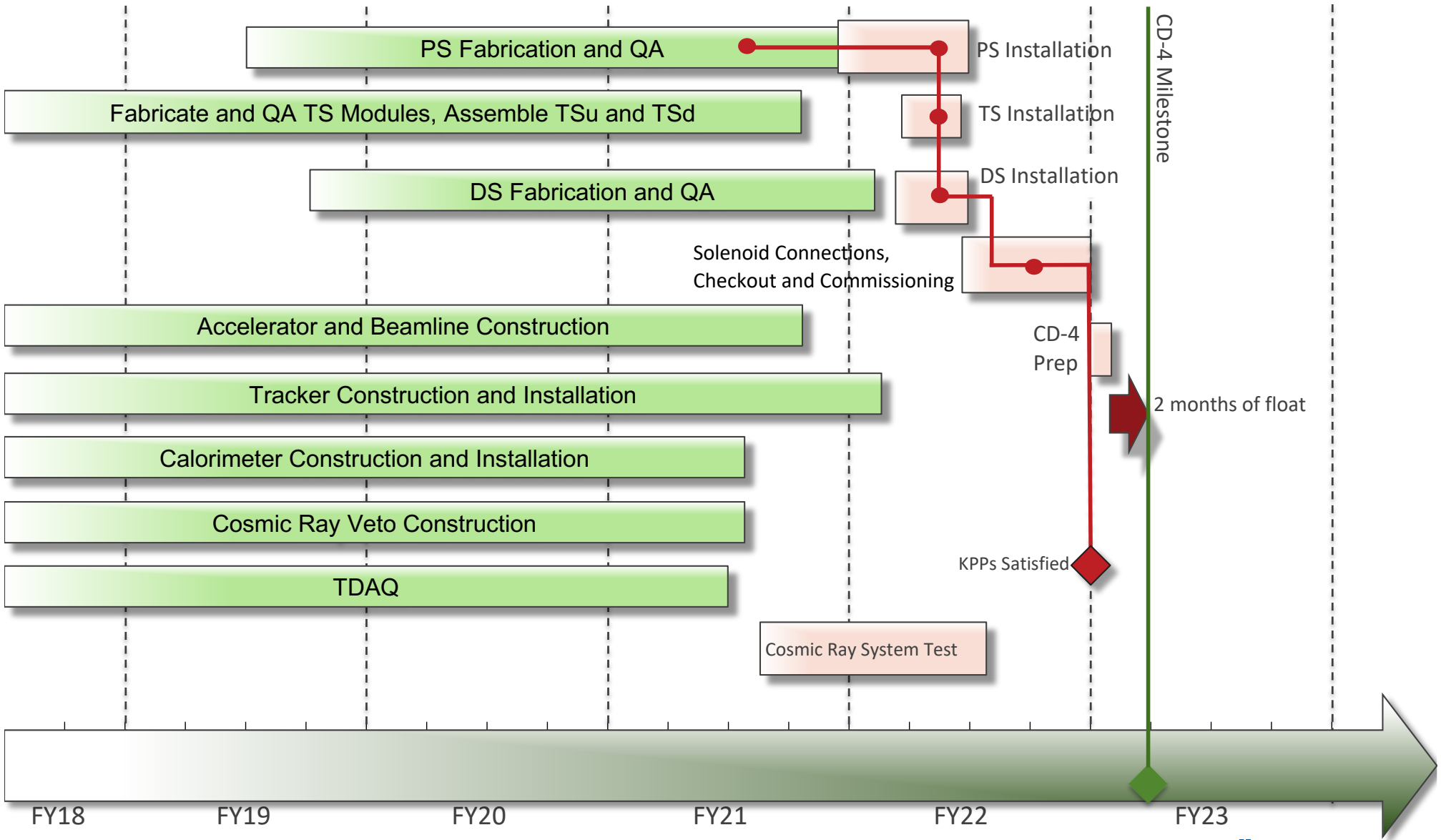
- **GA performed an activity-level risk analysis.**
  - **Mu2e analysis of GA risks indicates potential for an additional 9-month delay,** pushing project completion 14 months beyond CD-4.

- COVID has had a minimal impact on GA operations in Tupelo, but that could change as COVID continues to spread.
  - Lack of oversight from San Diego and Fermilab in Tupelo has impacted quality and delayed schedule by a few weeks.

- If COVID is still with us in 2022 it will impact Solenoid installation schedule at Fermilab.

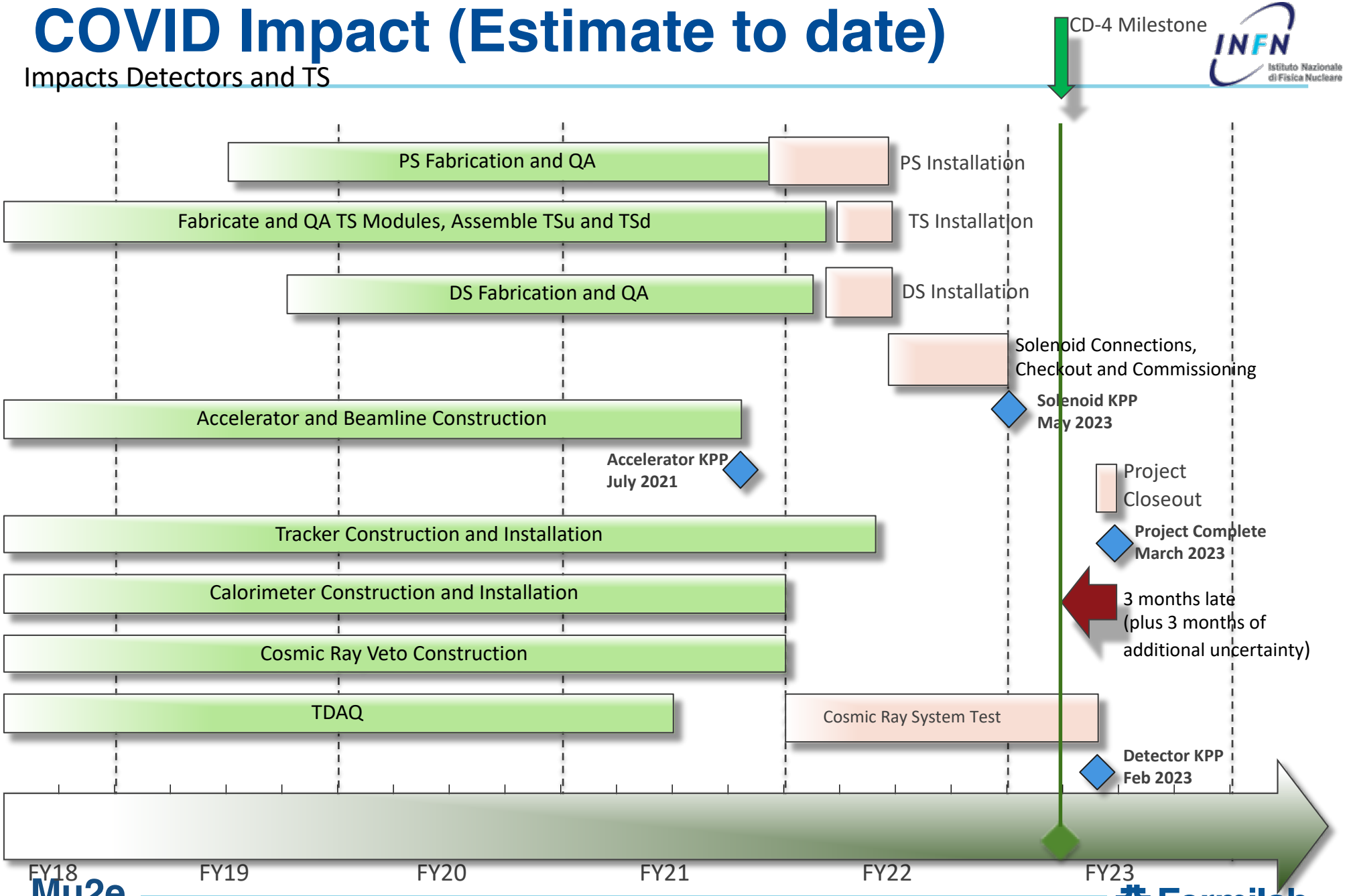
Pre-COVID Schedule

Based on GA dates from September.

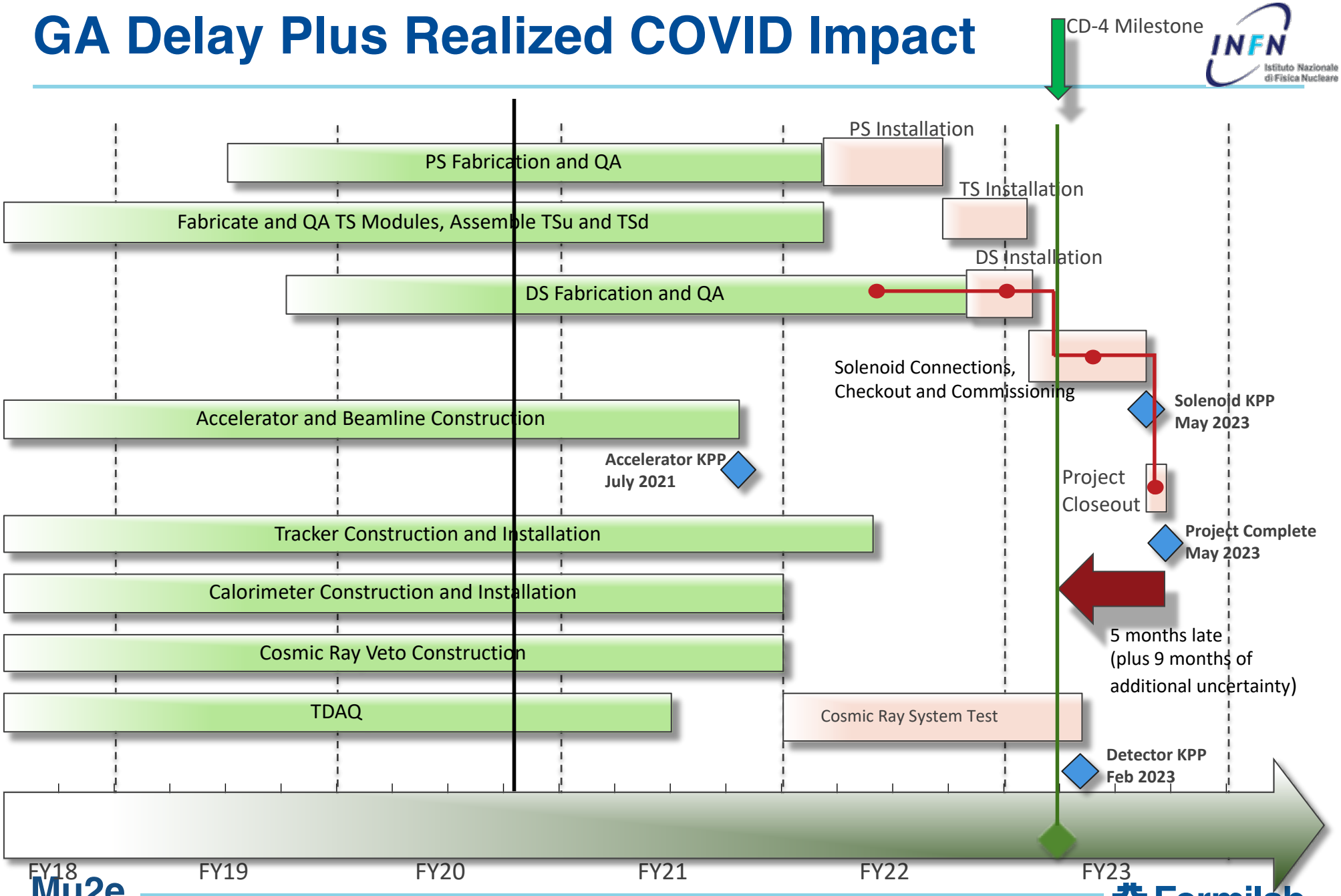


COVID Impact (Estimate to date)

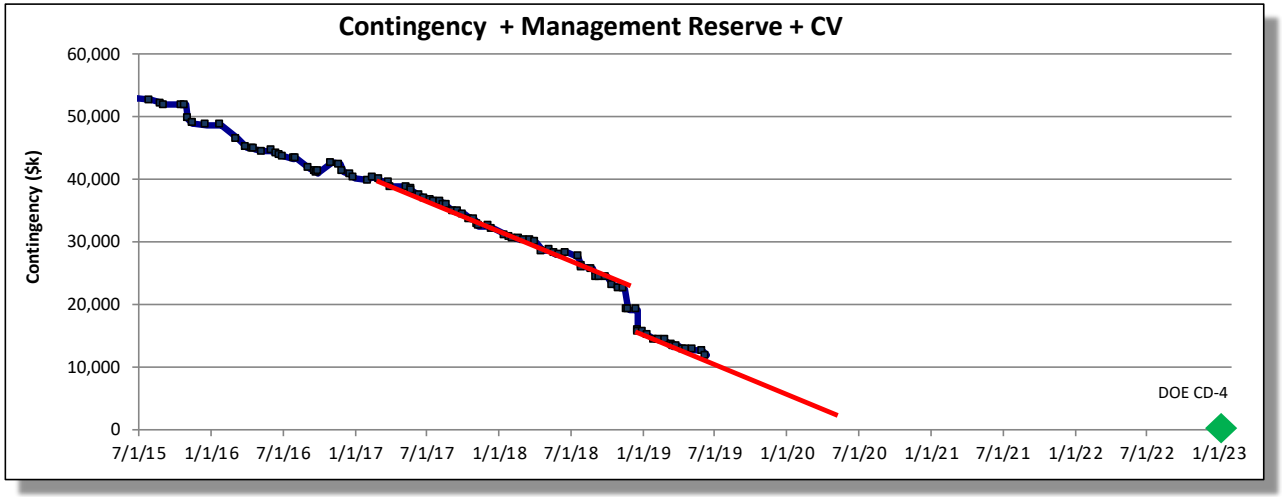
Impacts Detectors and TS

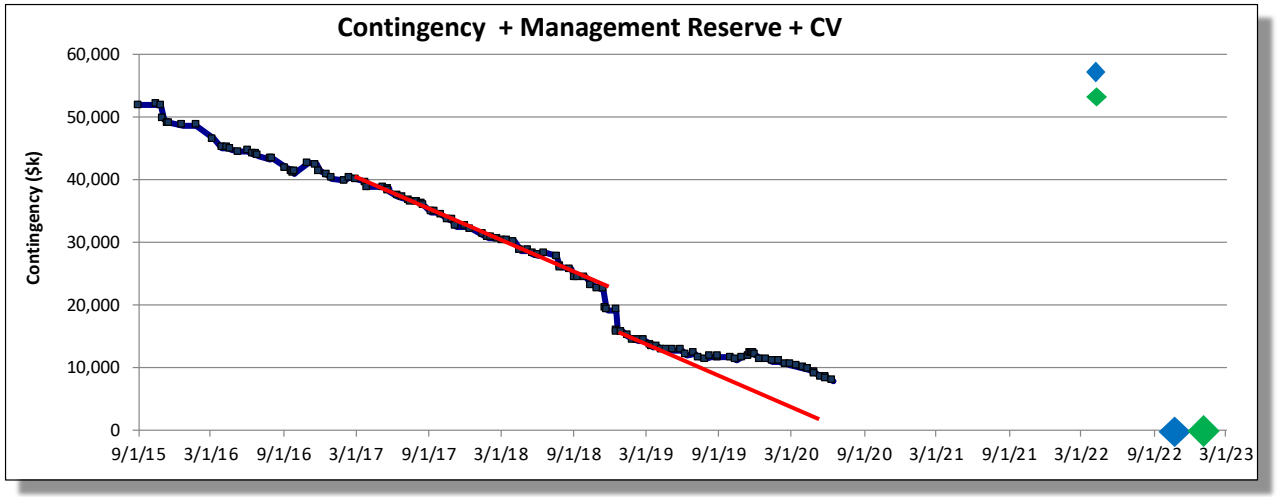


GA Delay Plus Realized COVID Impact



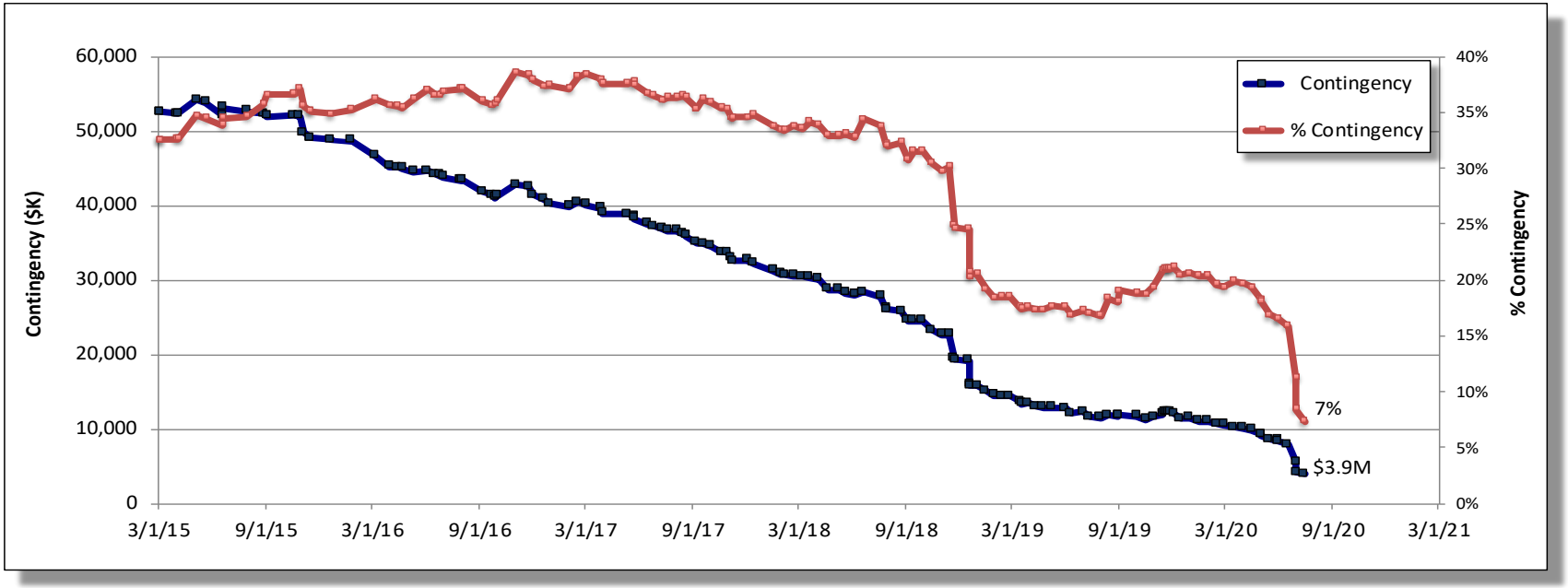
Contingency @ June 2019 vs June 2020





- Improved, but many remaining risks.
- Does not include HAB buy-back
- Does not include June's BCR that will include COVID impacts and impact of 7-month GA delay

Contingency @ July 2020



- This chart includes July's BCR that **takes into account COVID impacts and impact of 7-month GA delay**
- HAB payback not completed yet : O(+6 M$) bringing back contingency to 10 M$ (i.e. 15% of remaining work)
- Extrapolation to when we get "broke" will be set back to 2022 but not consistent with CD-4 date

➔ **There is a not-negligible possibility to be re-baselined**

➔ COVID costs (schedule, manpower, M&S) are being captured and will be used to be "supported" by DOE. In our case glue cost, shipments and so on.

➔ DOE IPR review expected in > 1 month. It is possible that a re-baseline will happen after that

COVID Impact → Project Cost

Mu2e Project
July 31, 2020
Currency in: $K

Work Package.WBS (2)	Cumulative to Date: Budget	Earned	Actuals	SV ($)	SV (%)	CV ($)	CV (%)	SPI	CPI	% Planned	% Complete	% Spent
475.01 Project Management	23.727	23.727	24.349	0	0%	-621	-3%	1,00	0,97	84%	84%	84%
475.02 Accelerator	39.921	36.694	39.631	-3.227	-8%	-2.937	-8%	0,92	0,93	90%	83%	83%
475.03 Conventional Construction	19.753	19.753	18.591	0	0%	1.163	6%	1,00	1,06	99%	99%	99%
475.04 Solenoids	86.124	81.786	94.124	-4.338	-5%	-12.338	-15%	0,95	0,87	83%	79%	81%
475.05 Muon Beamline	10.463	10.212	10.116	-251	-2%	96	1%	0,98	1,01	55%	53%	53%
475.06 Tracker	11.006	9.835	13.681	-1.171	-11%	-3.846	-39%	0,89	0,72	74%	66%	80%
475.07 Calorimeter	4.950	4.326	4.526	-624	-13%	-200	-5%	0,87	0,96	90%	78%	73%
475.08 Cosmic Ray Veto	9.281	7.974	8.023	-1.307	-14%	-49	-1%	0,86	0,99	96%	83%	82%
475.09 Trigger & DAQ	5.490	5.426	5.907	-65	-1%	-481	-9%	0,99	0,92	90%	89%	91%
Total	**210.717**	**199.733**	**218.947**	**-10.984**	**-5%**	**-19.214**	**-10%**	**0,95**	**0,91**	**84%**	**80%**	**81%**
Management Reserve												
TAB												

At Complete: BAC	EAC	VAC
28.404	28.930	-526
44.222	47.588	-3.367
19.886	18.724	1.163
103.342	116.583	-13.241
19.089	19.105	-15
14.792	17.106	-2.315
5.526	6.221	-695
9.654	9.729	-76
6.130	6.503	-373
251.045	**270.490**	**-19.444**
300	0	
251.345	270.490	
22.332	3.187	
273.677	273.677	

Report Options
Report Name: Mu2e_Earned Value_L2
Project File: Mu2e
Filter:
Criteria: Work Package.WBS (2)
Calendar: 18 Required Set
Cost Sets: Scheduled, Performed, Actuals, Estimate at complete

Project is 82% complete

IFC

- International Financial Committee established
  (Chair – N.Pastrone, INFN rep. R.Tenchini)
- Met for the first real run this summer
- Discussion still on-going howeve it looks like
  we will start paying our MOF starting since 2021
  with a rampup phase (from 15-20% in 2021).
- I am still waiting for Nadia, Roberto to discuss about this.
- Our effort will be to count the QC (Qualified Counts) to
  pay our percentage (at flattop ~ 8 k$/each QC)/year.
- Spare provided or being provided will be used to make INFN in-kind
  contributions. This should be equivalent to O(280 k$) of MOF

→ Discussion with Nadia & Roberto will clarify if we might use the surplus
  in Missioni to prepare a consistent contributions to our future MOF.

Conclusions

- **The Mu2e project is 82% complete but COVID-19 has badly impacted us**
  - → Winding of PS/DS are on-going. **Still their delivery poses serious delay**
  - → TS is proceeding well. TSU fully installed in HAB building
  - → Tracker panel production is getting momentum but with a forecast of tracker completion for spring 2022.
  - → Calorimeter Assembly has been delayed by 1.5 years w.r.t. its original schedule and starts impacting the schedule. **Still it is at least six months ahead of tracker. Estimated installation fall 2021.**
- **A continuous drop on contingency is happening since beginning 2019**
  - → **albeit HAB pay-back there is a serious risk to be re-baselined (DOE-IPR 2020)**
  - → **interaction with g-2 schedule are becoming evident**
- Mu2e current schedule foresees:
  - → **installation of the detectors for end of 2021**
  - → **a long phase of commissioning in extracted position**
  - → **+ commissioning with beams at end of 2023**

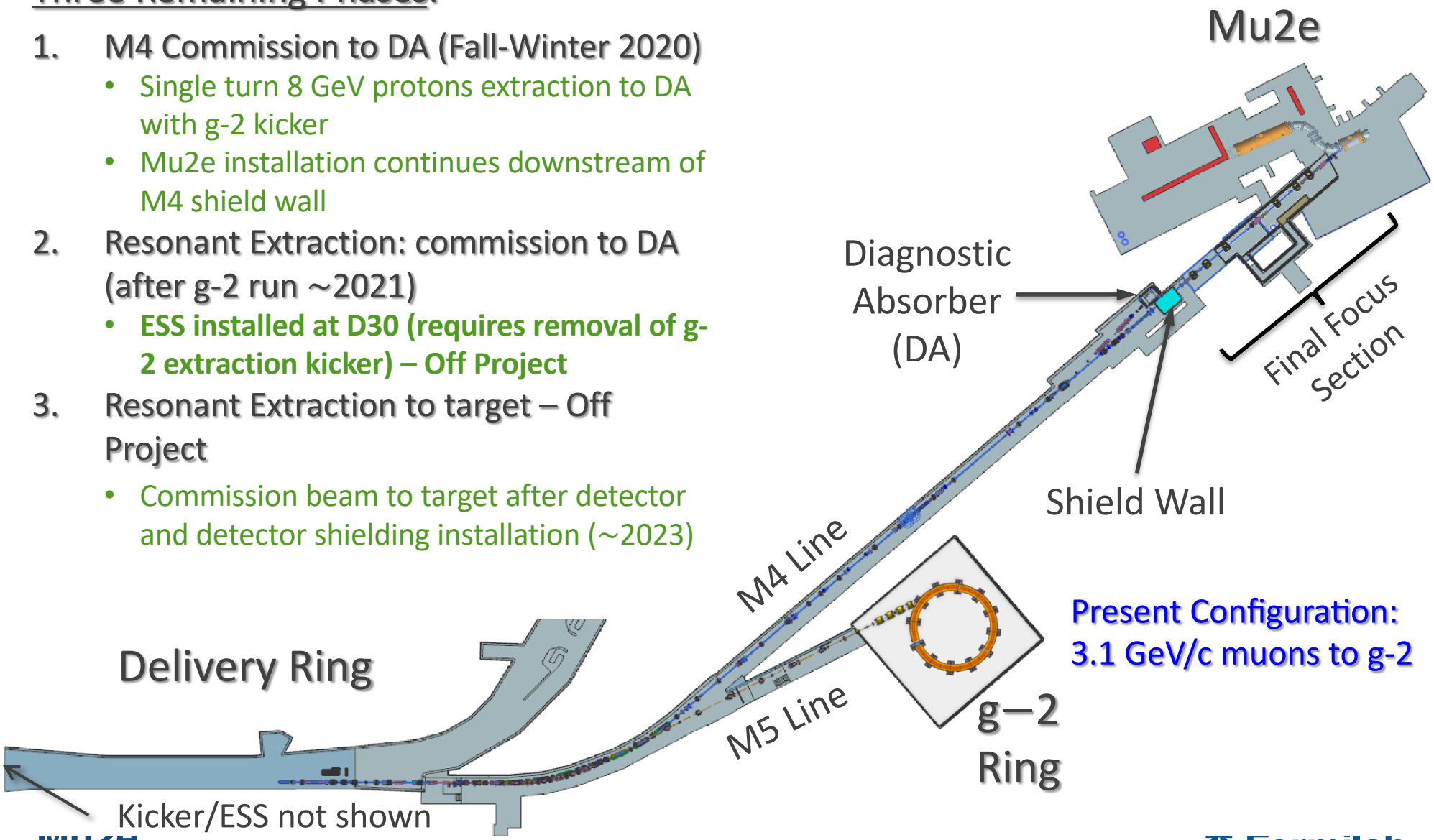
Other issues

- Accelerator : ESS and g-2 schedule
- LY of CRV

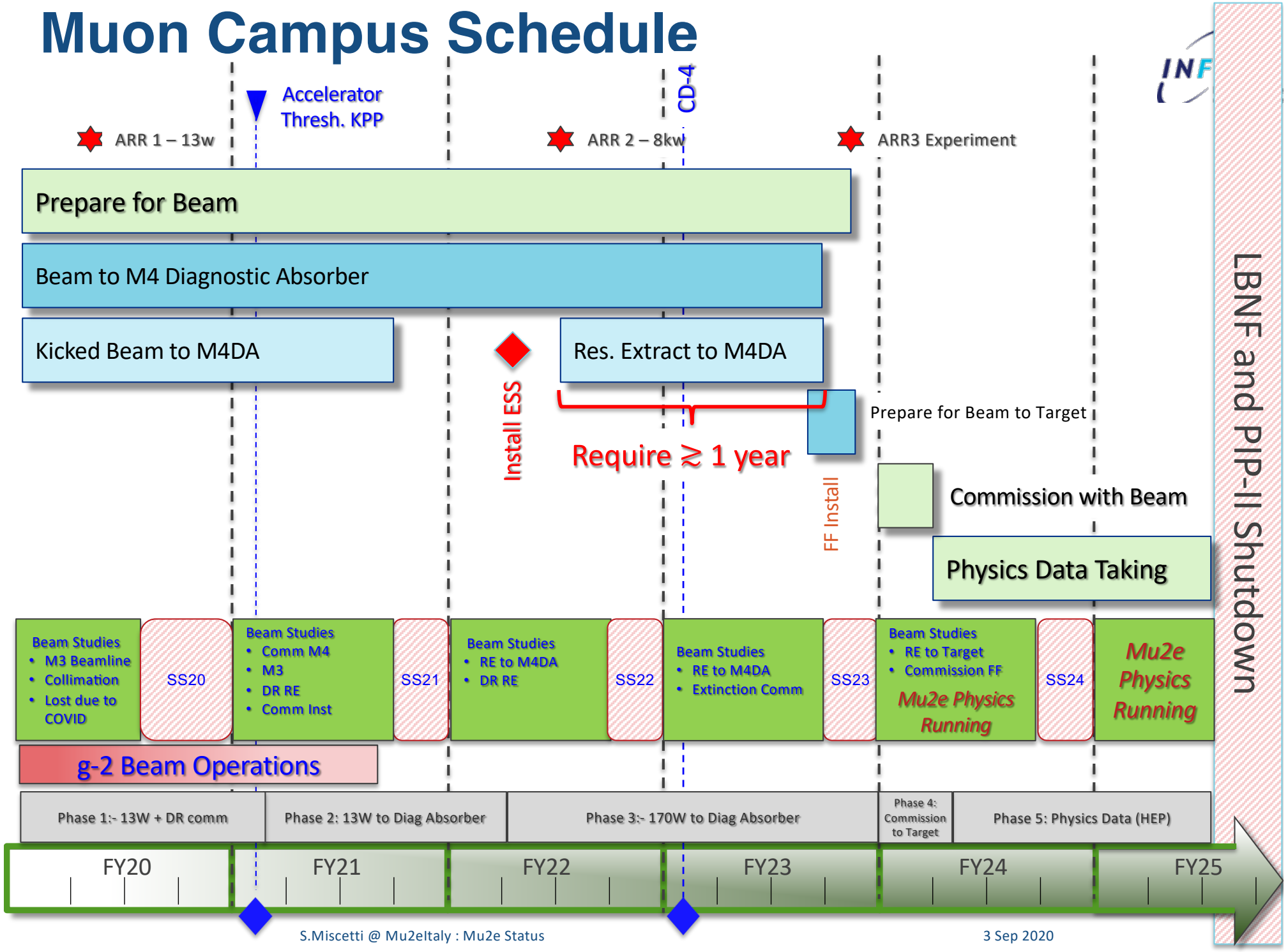
Mu2e Project → Mu2e Operations

Three Remaining Phases:

1. M4 Commission to DA (Fall-Winter 2020)
   - Single turn 8 GeV protons extraction to DA with g-2 kicker
   - Mu2e installation continues downstream of M4 shield wall
2. Resonant Extraction: commission to DA (after g-2 run ~2021)
   - **ESS installed at D30 (requires removal of g-2 extraction kicker) – Off Project**
3. Resonant Extraction to target – Off Project
   - Commission beam to target after detector and detector shielding installation (~2023)



Muon Campus Schedule



Electrostatic Septum and new kickers

- ESS is very difficult to build/run and is in delay (Jan 22 instal)
- If g-2 wants to have its Run-5 we will collide
- Very good interactions btw spokes to find solutions
- 1 new kicker will solve the problem
  providing flexibility btw g-2 and Mu2e running

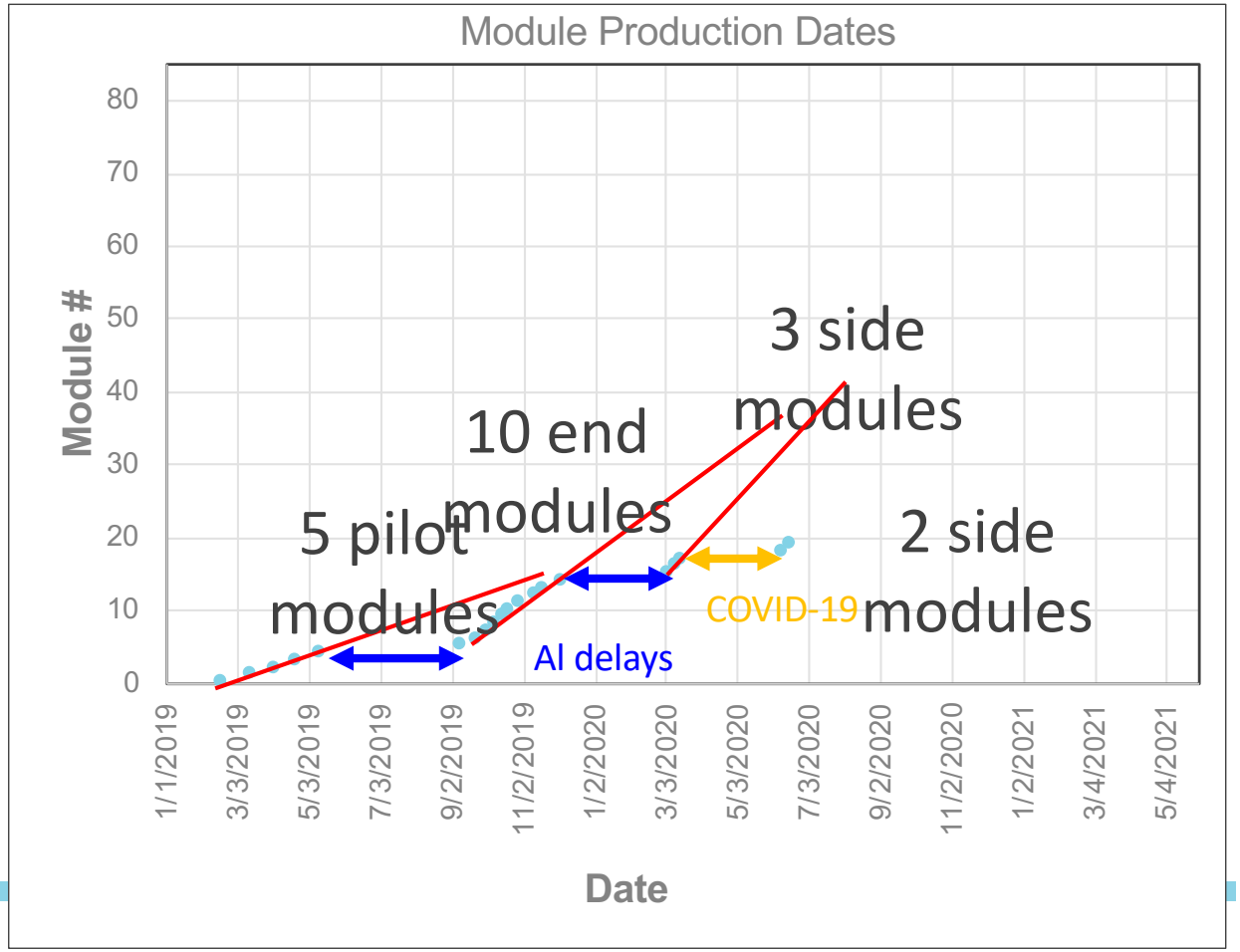
  → the new Kicker is under design

  → Cost is of O(1 M$)

CRV Module Fabrication (June 2020)

- After a hiatus of 86 days UVA is back in production two weeks ago (Note: Al unavailability delays were 120 and 91 days)
- We have made 20/83 (24%); **2 since shutdown**
- Note: Al is being delivered!

Group



CRV

- We've all heard a lot about light yield
- Dropping ~8.9%/yr from source; much less from test beam
- Size/source of yield drop hard to pin down: doc-db 28266:

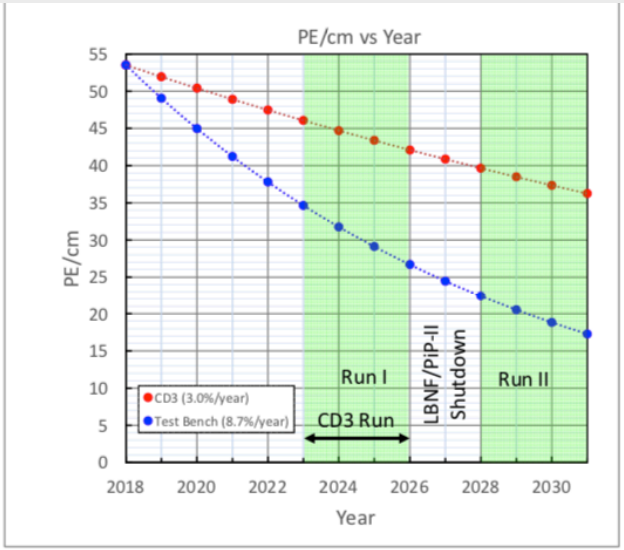


Figure 26: Light yeild per cm vs year. The red curve is the CD3 estimate; the blue curve our best estimate of 8.7%/year from bench-test studies Shaded regions refer to Run Plan A.

It is difficult to reconcile these results to a consistent narrative. What one can conclude is that significant aging is not unusual; the opposite is indeed the case. In fact, small aging rates are unusual, the MINOS aging of 3%, for example is the low end of the spectrum. There does not seem to be any particular aspect of scintillation counter, read out with or without WLS fibers, that appears to cause aging.

- Options summarized by CRV group in doc-db 28266
  - bigger diameter fibers
  - “pot” counters to slow down exposure to air
  - other options
  - everything has advantages/disadvantages/different risk/reward levels
  - and what do we do post-LBNF shutdown, or if shutdown is delayed and counters are degrading?