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Using Rescheduling and Flexible Execution to Address Uncertainty in Execution Duration for a Planetary Rover – Software Demo

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Background

- The Mars 2020 Scheduler is a (Rabideau and Benowitz 2017)
 - single-shot, non-backtracking scheduler that
 - schedules in *priority first order* and
 - never removes or moves an activity after it is placed during a single scheduler run.
 - Activities are not preempted
 - It does not search except for
 - Valid intervals calculations
 - sleep and preheat scheduling

Challenge- How to Address Execution Uncertainty Given Non-zero Runtime Scheduler

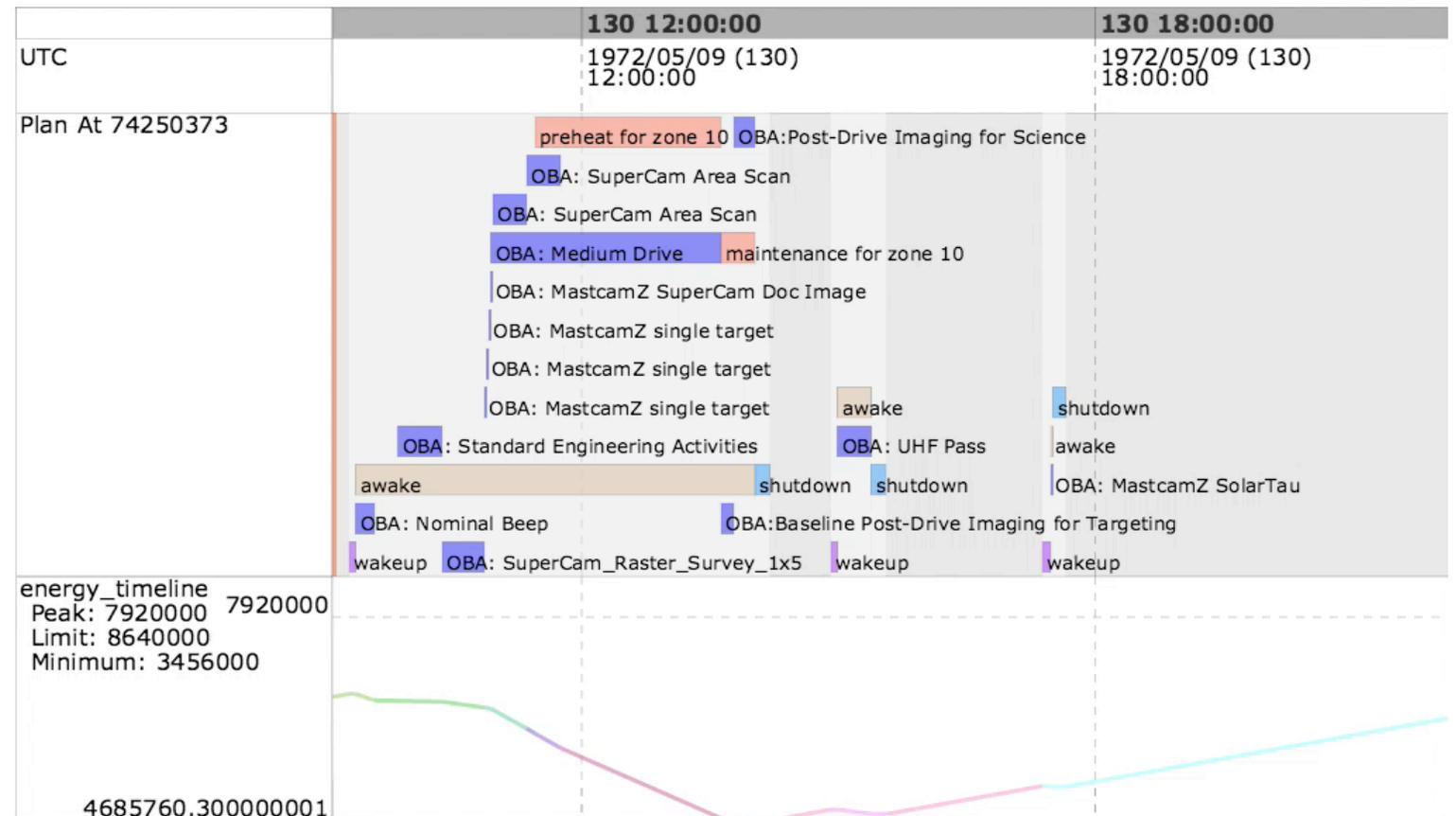
- Reality (execution) consistently differs from our scheduling models
 - Activities may use fewer resources (time, energy, data volume) than expected
 - Activities may use more resources than expected, risking failure to perform all tasks
 - We consider effects of changes in specifically activity duration
 - Energy and data volume modeled as rates so they are implicitly affected
- Can respond to changes in activity duration by
 - 1) rescheduling to incorporate execution feedback
 - 2) allow generated schedule to adapt to changes during execution (Flexible Execution)
- The scheduler takes non-zero time to (re) schedule
 - Activities could start executing while the scheduler is running.
 - New changes may occur while the scheduler is running.
 - Scheduler runtime (T_{sc}) cannot be predicted exactly (non-determinism).

Demo- What will we show?

- Shows:
 - How Event-Driven Scheduling allows to generate a new schedule in response to changes during execution
 - Compare to Fixed Cadence Scheduling
 - How Flexible Execution is used to:
 - Recoup time by:
 - 1) starting activities earlier than specified by the generated schedule if prior activities end earlier than expected
 - 2) starting activities earlier if scheduler itself takes less time to complete running than expected
 - Start activities later/properly handle if prior activities take longer to execute than expected
 - Show various ways through which to handle activities running long
 - Extended Veto and Extended Push Algorithm
 - Show how FE and Event-driven scheduling interact

Demo- How will we show it?

- We will click through the simulation of a Sol Type- currently best available data on expected M2020 rover operations, contains ~30 activities
 - Show FE and rescheduling techniques a activities vary from predicted duration
- Video on this slide shows what it will look like when we click through it
- Screenshots on next slides show specific instances of what exactly we want to show, but the demo itself will look more like the video to the right



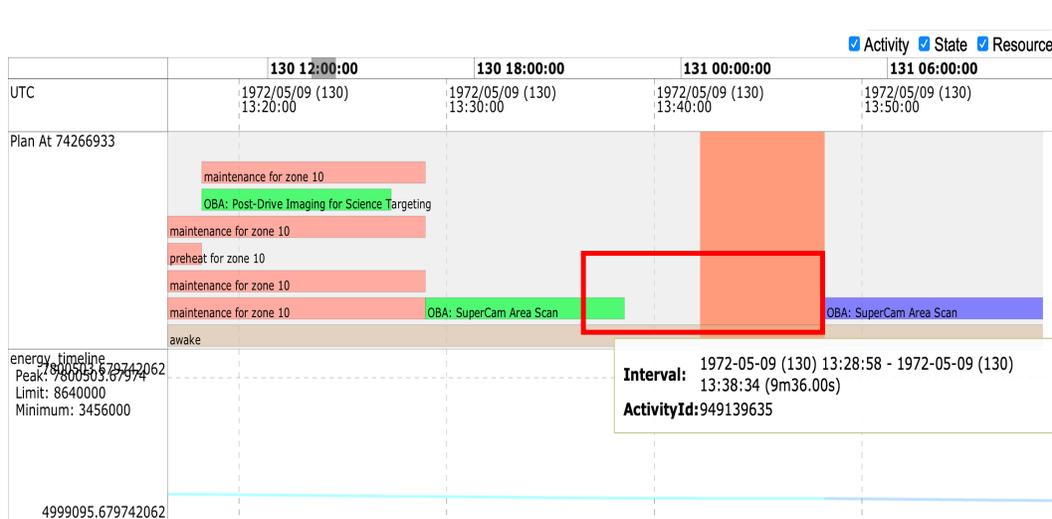
- Purple- OBAs (onboard activities), orange- heating, pink/blue- wakeups/shutdown, light brown- awakes
- When orange vertical bar moves → scheduler is reinvoked and updated schedule is generated
- When activities turn from purple to green → they have been executed

Legend for Screenshots of Execution in Next Slides:

- X-axis is time
- **Orange vertical bar**- scheduler invocations
- **Purple/Blue**- activities that have not started
- **Green**- activities that have completed execution
- **Yellow**- activities that are in progress
- **Pink**- setup activities (e.g. Preheats)

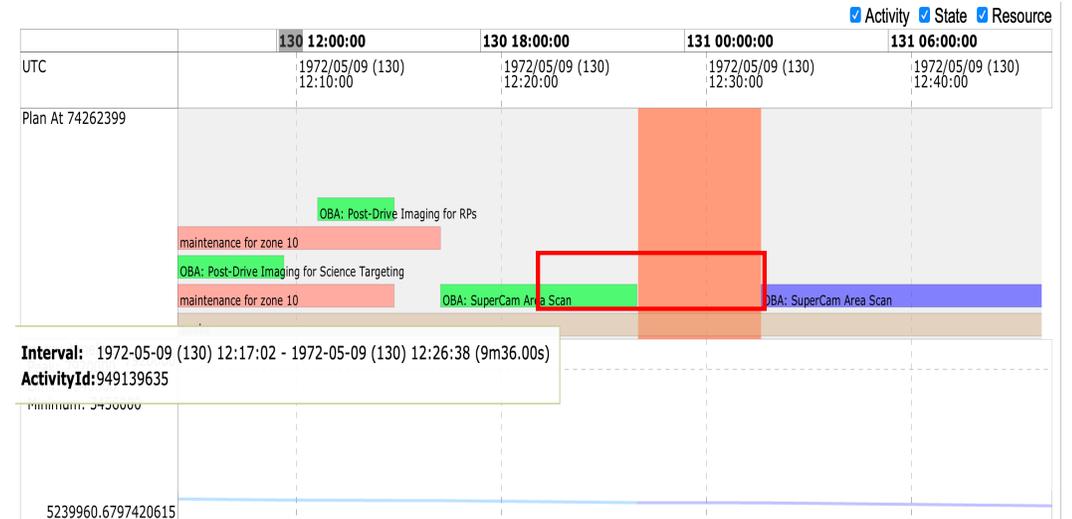
Fixed Cadence vs. Event Driven Scheduling

Fixed Cadence



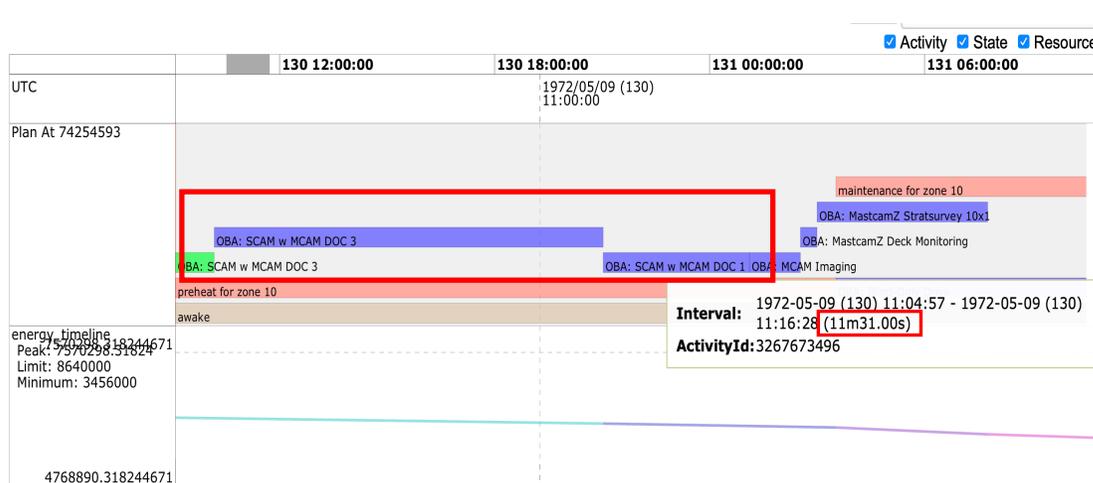
- Scheduler is only invoked at a fixed cadence, so it is unable to recoup time when activity (SuperCam in green) ends early

Event Driven

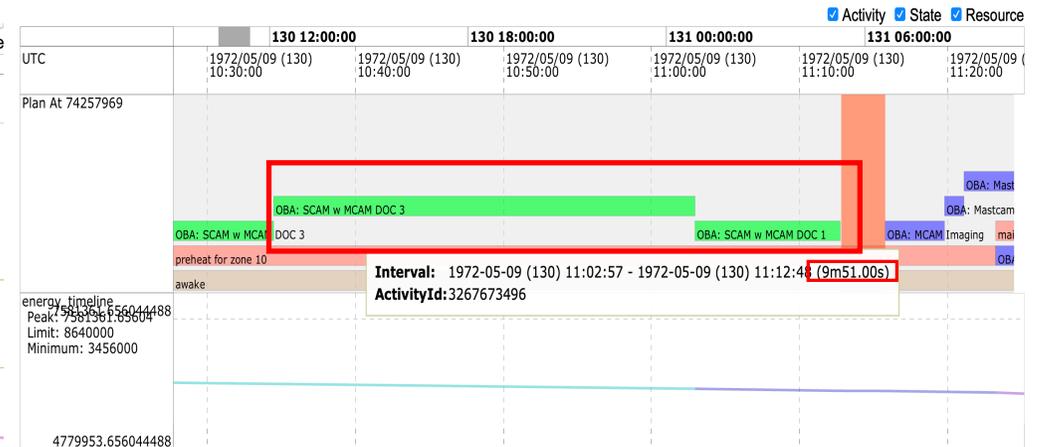


- Scheduler is invoked immediately after activity ends early by some threshold (Event threshold) and is able to recoup some time

Flexible Execution- Activities End Early by less than Event threshold



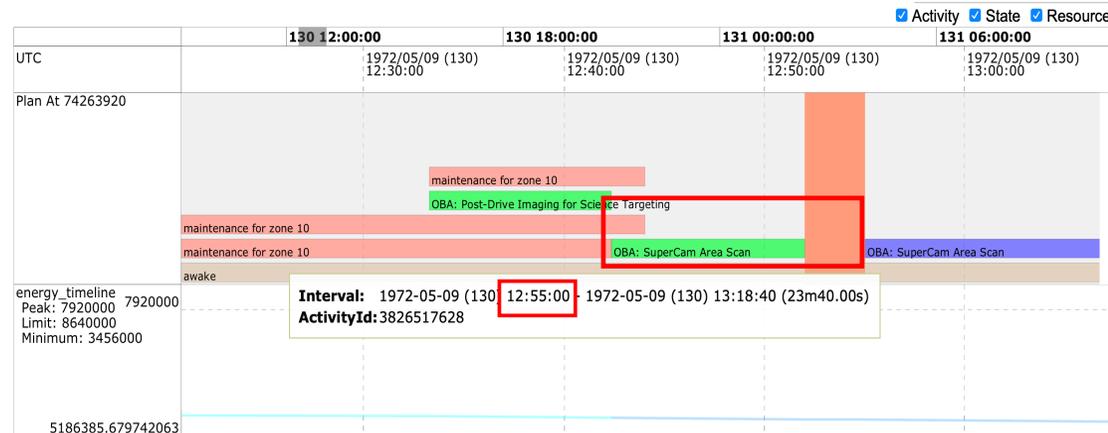
- SCAM V MCAM DOC 3 predicted to take 11 min 31 sec



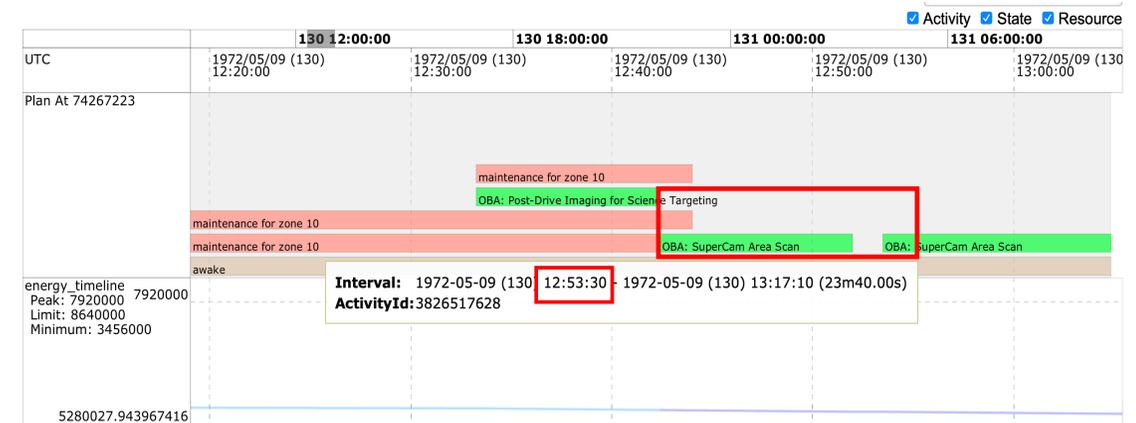
- After SCAM V MCAM DOC 3 ends early by less than event threshold, SCAM V MCAM DOC 1 is able to be pulled

Flexible Execution- Scheduler takes less time to run than expected

- Scheduler expected to take 180 sec



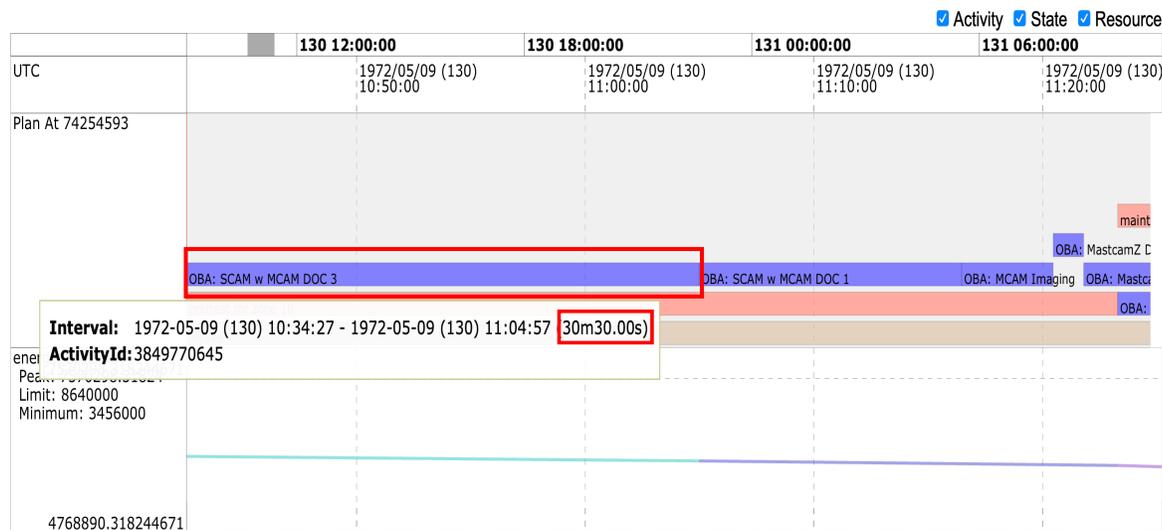
- Orange vertical bar gives predicted scheduler runtime



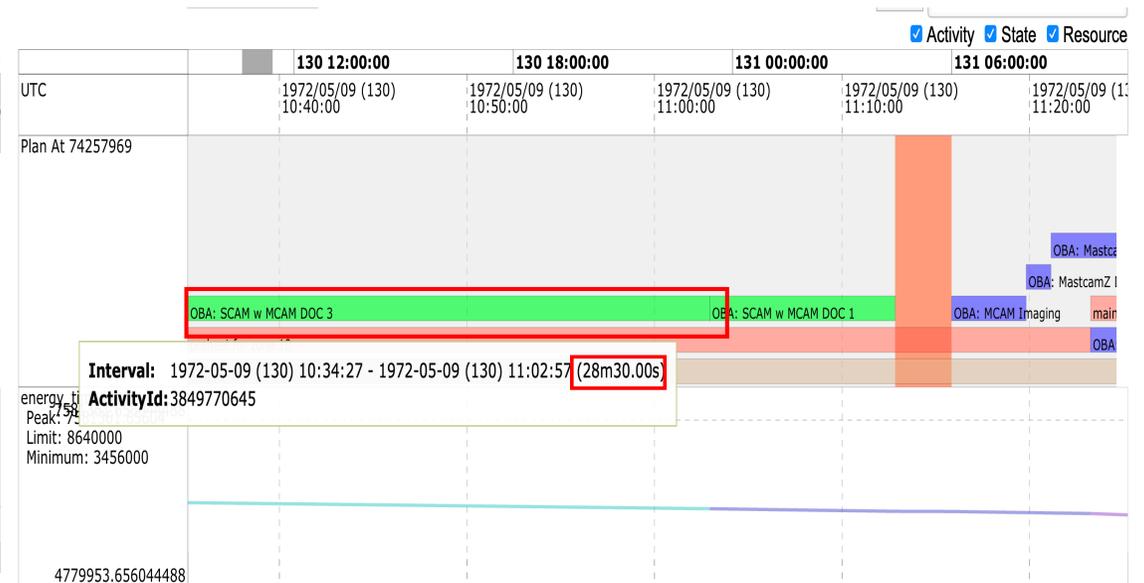
- FE pulls FE SuperCam Area Scan to when scheduler actually ended 90 sec early (look at difference in start time of activity)

Flexible Execution- Activities ending Early can cause events that would not have occurred otherwise

- Event threshold is 180 sec



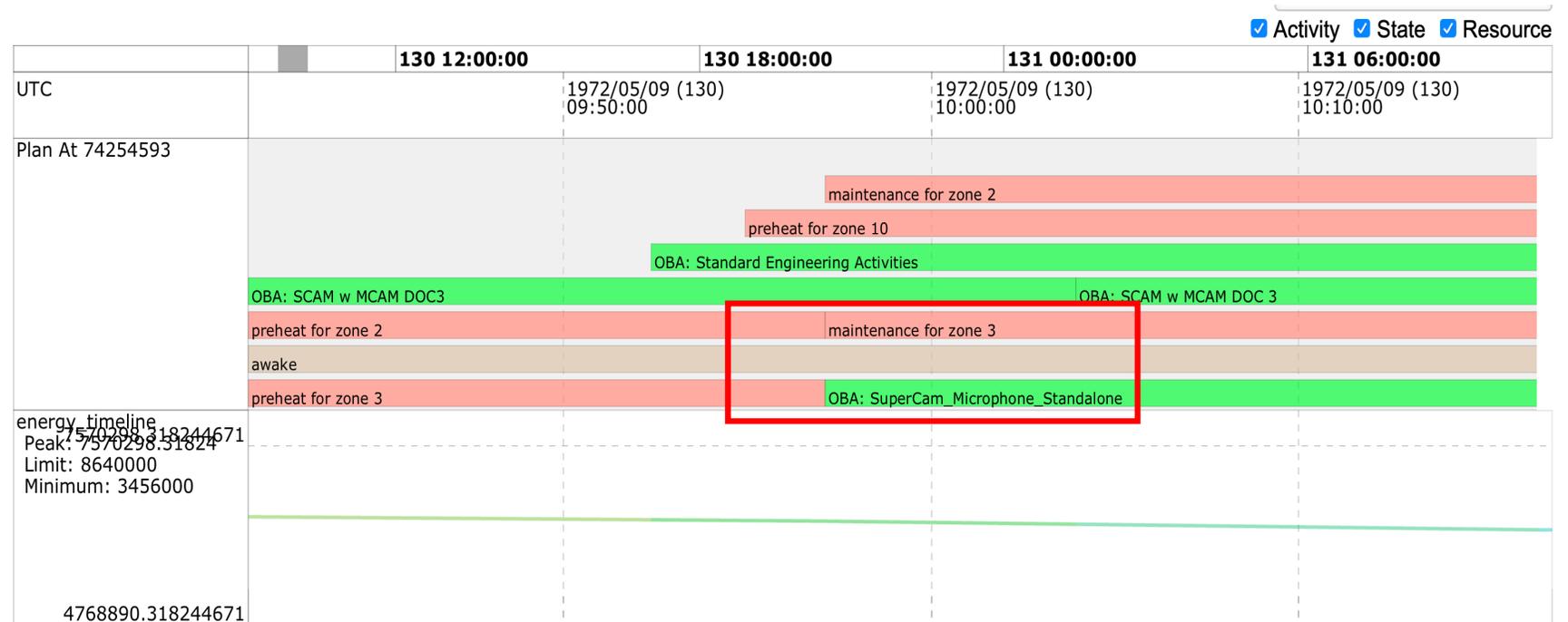
- Before SCAM V MCAM DOC 3 ends early- predicted to take 30 min 30 sec



- Time by which SCAM W MCAM DOC 1 is pulled because SCAM V MCAM DOC 3 ends early (by 120 sec) + time by which SCAM W MCAM DOC 1 ends early (100 sec) > Event threshold

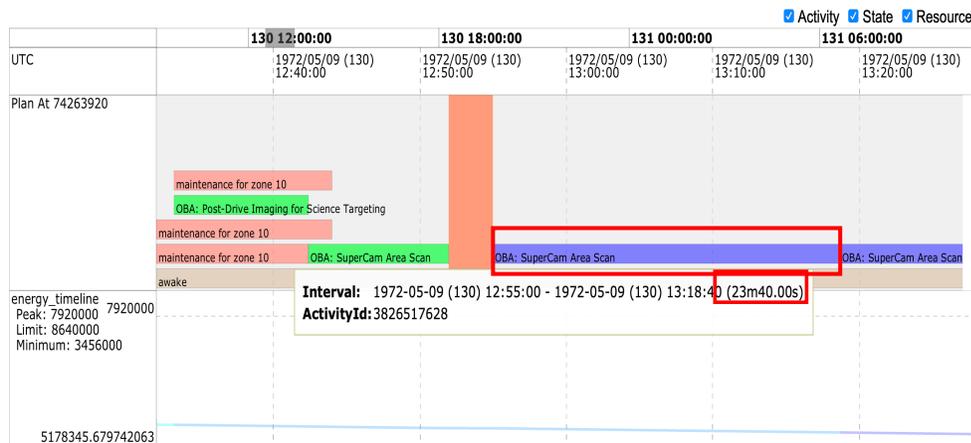
Flexible Execution- Activities Cannot be Pulled Forward due to Preheat

- Supercam_Microphone_Standalone cannot start until preheats for zone 1 and 2 complete even if it has no other execution constraints

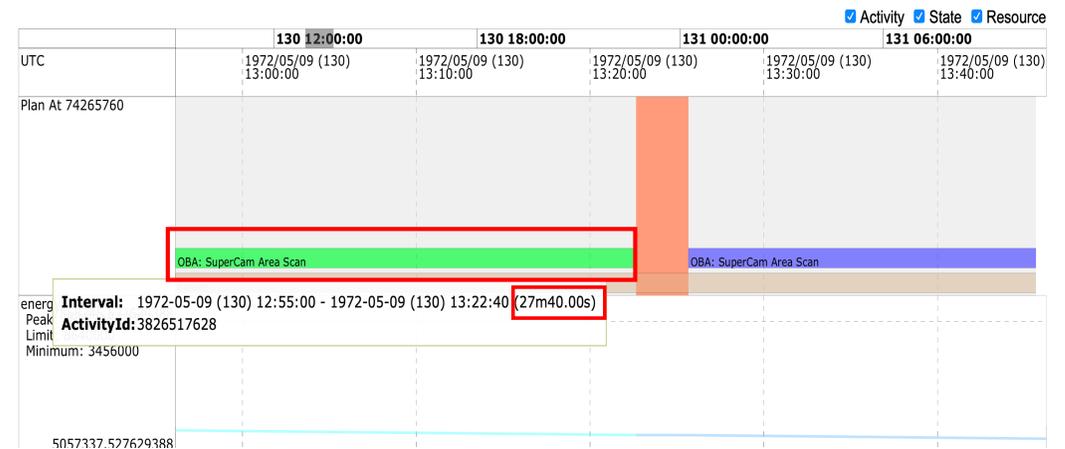


Flexible Execution Extended Veto- Activities End Late Case 1

- Veto activity and reinvoke scheduler if it is pushed beyond a threshold (4 minutes)
- When activity is vetoed it is removed from current scheduler invocation



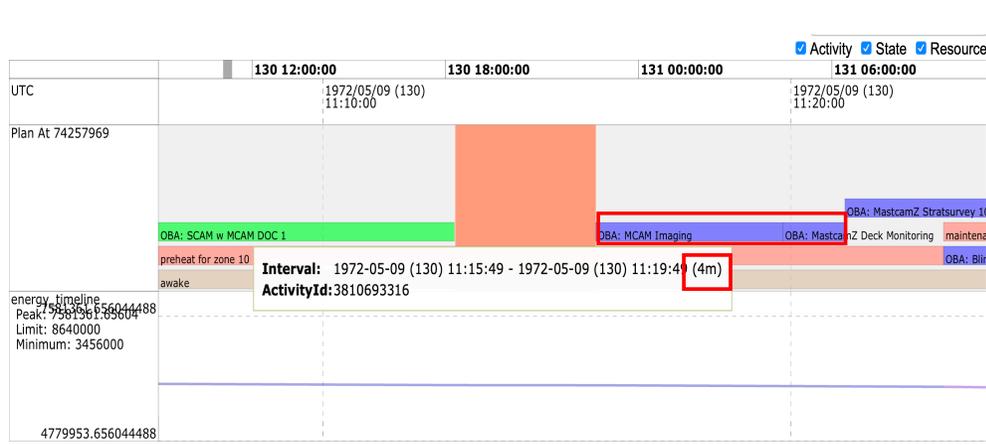
- SuperCam Area Scan in purple is predicted to take 23 min 40 sec



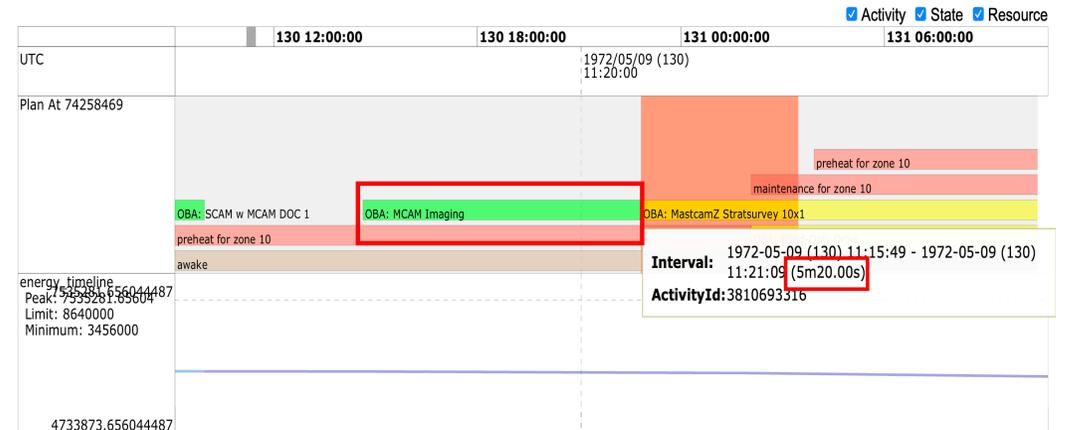
- SuperCam Area Scan in purple is takes more than 27 min 40 sec (4 min) so scheduler is reinvoked

Flexible Execution Extended Veto- Activities End Late Case 2

- If activity being pushed exceeds start time of another scheduled activity, it will be vetoed and scheduler will be reinvoked

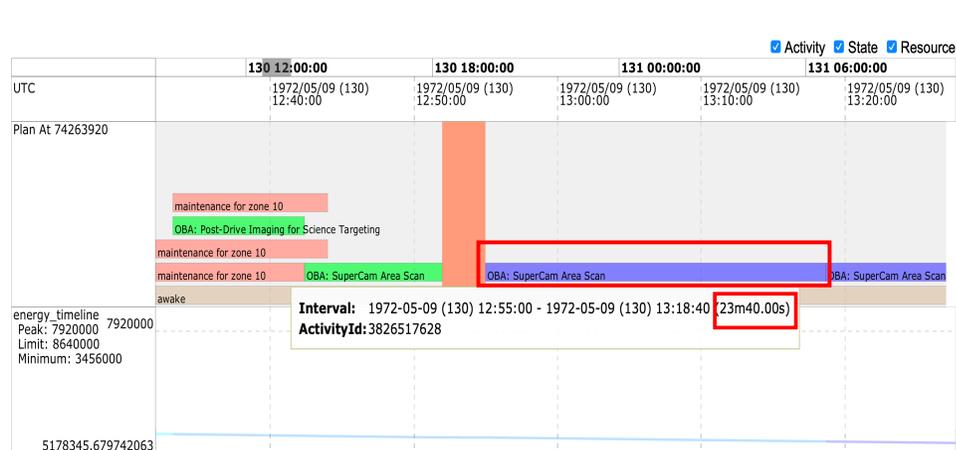


- MCAM Imaging is expected to take 4 min but will take longer than duration of MastcamZ Deck Monitoring (80 sec)

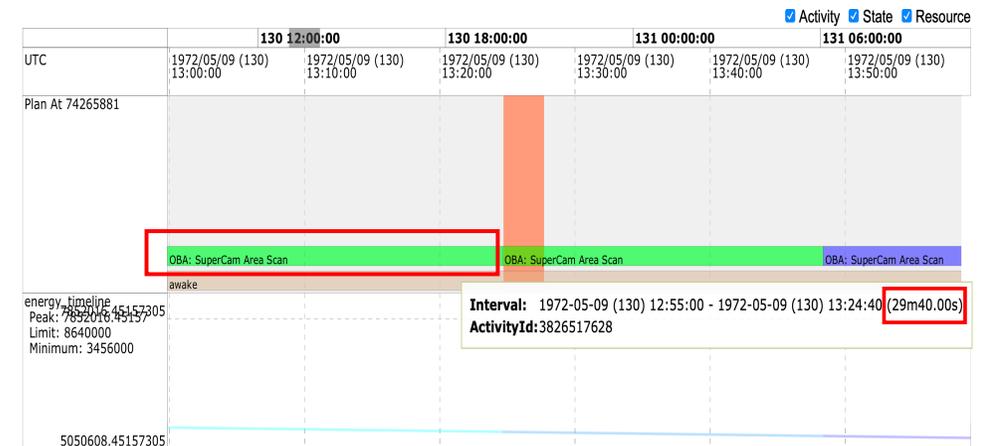


- MCAM Imaging takes longer and scheduler is invoked when it takes more than duration of MastcamZ Deck Monitoring and MastcamZ Deck Monitoring is vetoed

Flexible Execution Extended Push- Activities End Late



- SuperCam Area Scan in purple is predicted to take 23 min 40 sec



- Activities are pushed until activity running long finishes- when SuperCam Area Scan finishes, it has taken 29 min 40 sec (6 min longer than expected)