MORE ON REQUIREMENTS

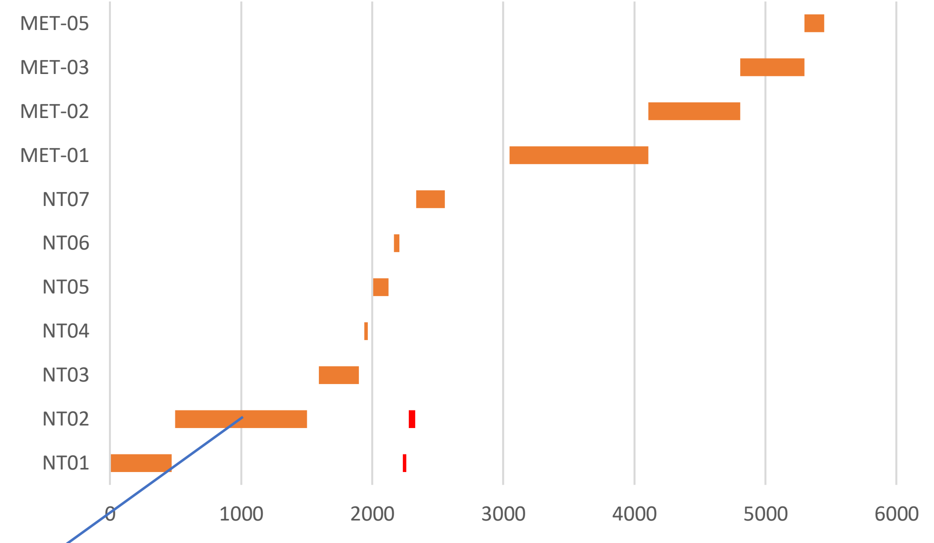
PROTONS AND OPERATIONAL TIME

- There were some questions about how to incorporate operational efficiency
  - The nominal figure is 56%
  - This accounts for summer maintenance (no operation) and inefficiency during operation
- 0.56 x 1.2 MW x 365 days x 3600 sec x 120 x 10^{9} eV/1.6x10^{-19} eV/proton = 1.1 x 10^{21} POT
  - This is the number that Luke and others have been using for statistics and doesn't need to change
- Time matters:
  - Apart from the ~2 month annual shutdown (17%), remaining down time (~30%) is random
    - Could be ~evenly spread over the operation period, in which we could assume 10 months/year
    - Could be concentrated in one period in which case effective operation is squeezed into 7 months/year
    - Should we conservatively assume 7 months?
- There is additionally a question of detector operational efficiency
  - This will have to factor into the requirements, but it would be good to have a reasonable assumption.

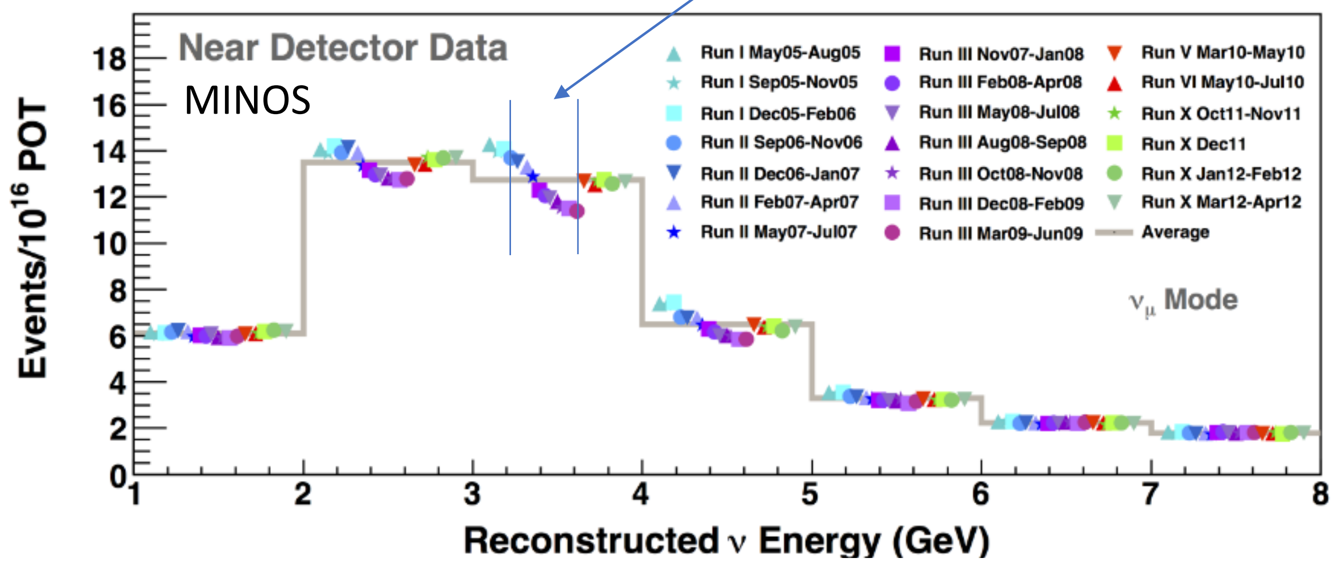
OPERATIONAL VARIATIONS:

- Presentation last week from Zarko Pavlovic about the NuMI experience on beam stability
- Bottom line:
  - Anything can happen at any time
    - May not know the physics impact until some time later after diagnostic, etc.
      - In some cases, off-axis measurements might be more robust (e.g. focussing effects
      - Normalization stability matters . . . not robust to target degradation, etc.)
      - As long as we can confidently model the change, in principle variations are fine
      - It's hard to plan around this . . . .
    - Issues may result in yearly component changes (replacement targets, horns, beam configuration, etc.)
- My takeaway:
  - At the least, we would be capable of performing a full-cycle of off-axis measurements in a year
  - If a significant variation is seen in the beam monitoring, want to be able to move back on-axis "as soon as possible" << 1 week

Same components
!=
Stable beam

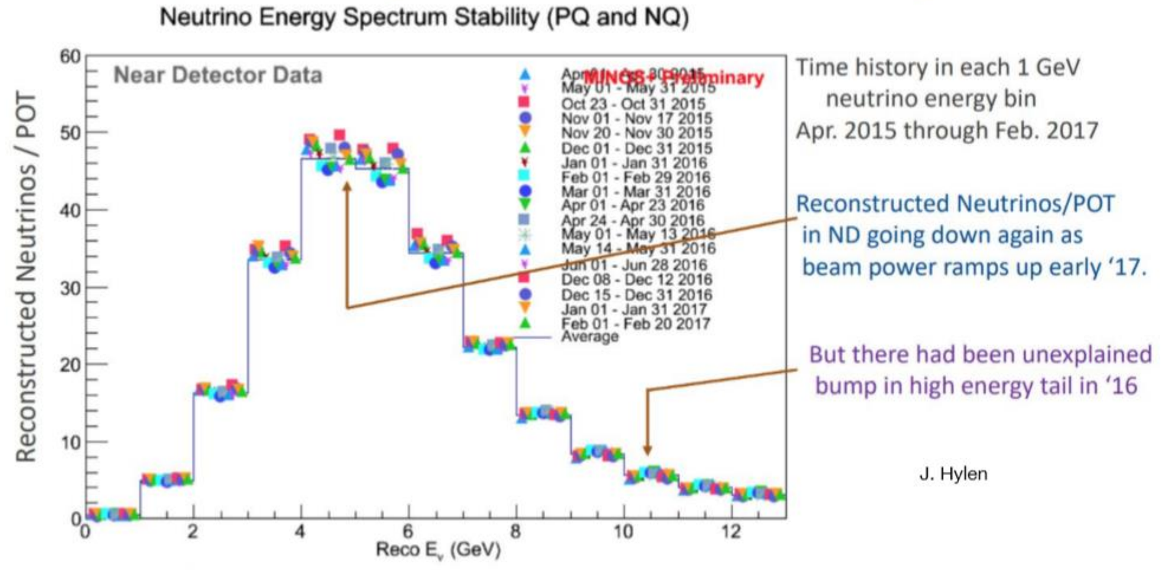


- MINOS Run II and III taken with same target



Horn tilt

- Broken bushing caused horn to tilt 1-2mm



From Luke Pickering

STATISTICS

- There was discussion last time about statistics, etc.
- I wasn't sure if this/similar tables have been shown in this meeting
  - Found them in MIke's backup slides

		Liquid				Gas
		All int.	Selected			All int.
Stop	Run duration	$N\nu_\mu CC$	NSel	WSB	NC	$N\nu_\mu CC$
On axis (293 kA) m	21 wks.	21.9M	10.2M	0.2%	1.3%	590,000
On axis (280 kA) m	1 wk.	1,000,000	470,000	0.3%	1.4%	27,000
4 m off axis m	18 dys.	2.3M	1.2M	0.3%	1.0%	61,000
8 m off axis m	18 dys.	1.3M	670,000	0.5%	0.9%	35,000
12 m off axis m	18 dys.	660,000	340,000	0.8%	0.7%	18,000
16 m off axis m	18 dys.	380,000	190,000	1.1%	0.7%	10,000
20 m off axis m	18 dys.	230,000	120,000	1.3%	0.7%	6,300
24 m off axis m	18 dys.	160,000	76,000	1.8%	0.7%	4,200
28 m off axis m	18 dys.	110,000	50,000	2.1%	0.8%	2,900
32 m off axis m	18 dys.	61,000	28,000	2.4%	0.7%	1,600

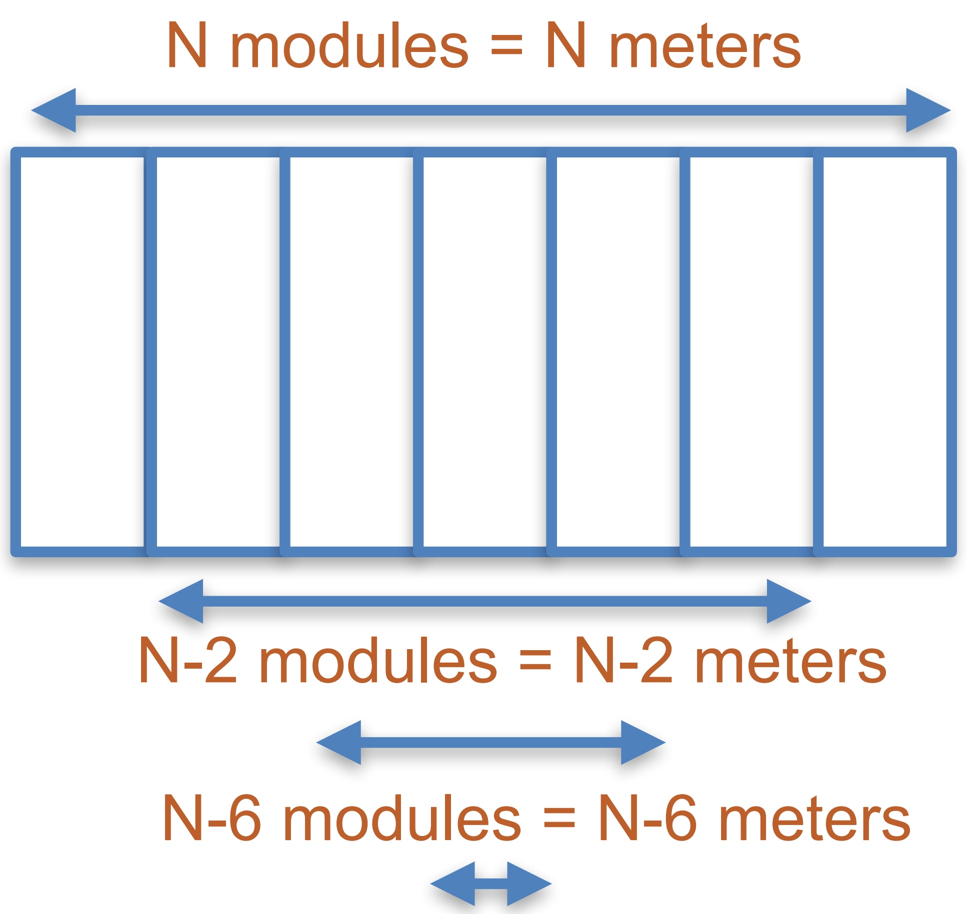
- As far as I can tell, nominally there is no issue with statistics in a one year run
- Likewise, having at least one measurement/year in the off-axis configuration doesn't seem to be an issue with currently discussed (8 hours ~O(1 day)) movement/recovery of operations.
- My current thinking is that requirements will be driven by how many total movements are needed/year
  - how much/often do we need to have on-axis measurements?
    - If the beam monitoring does not indicate any variations, are we comfortable with ~minimal on-axis running of LAr+MPD?
    - "beam monitoring" = SAND-based muon spectrum measurements
  - Or do we insist on periodically verifying the on-axis beam with LAr+MPD?
  - How much "staggered" running do we need? Do we distinguish between "large" movements (> O(1 m)) and small (< O(1 m))?
  - Do the movement systems have a lifetime (i.e. maximum number of total movements) based on wear, etc.?

I'm going to say a lot of the same things I did last time, but more explicitly in the context of these three related considerations

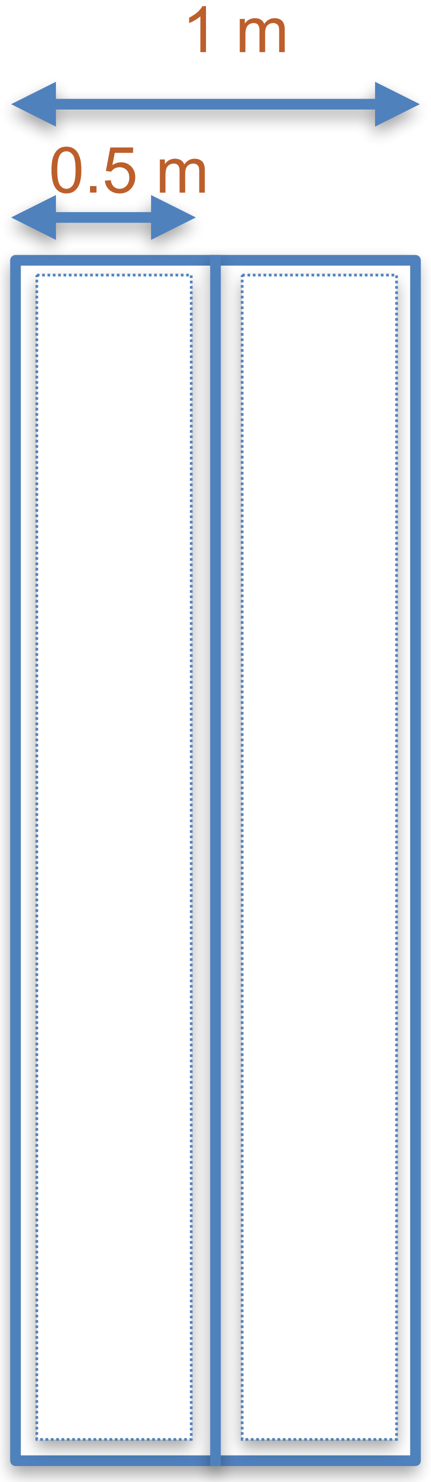
POSITIONING

- Propose: three related factors in determining positioning requirements:
- Granularity:
  - What is the granularity of the nominal stop positions?
  - We have been assuming effectively continuous, but we may want to refine the statement further
- Precision:
  - What is the precision with which the desired location can be achieved?
- Verification:
  - What is the accuracy with which the established position can be measured
    - External/bulk: overall position of the system (cryostat for LAr, magnet for MPD)
      - I hope this can be easily achieved at a level that is well-beyond our means, but still would be good to know what is required
    - Internal: any possible movement of components within the systems (e.g. module-to-module, etc.)
      - This is more subtle and would also include potential recalibration/realignment to recover any

GRANULARITY (LAR)

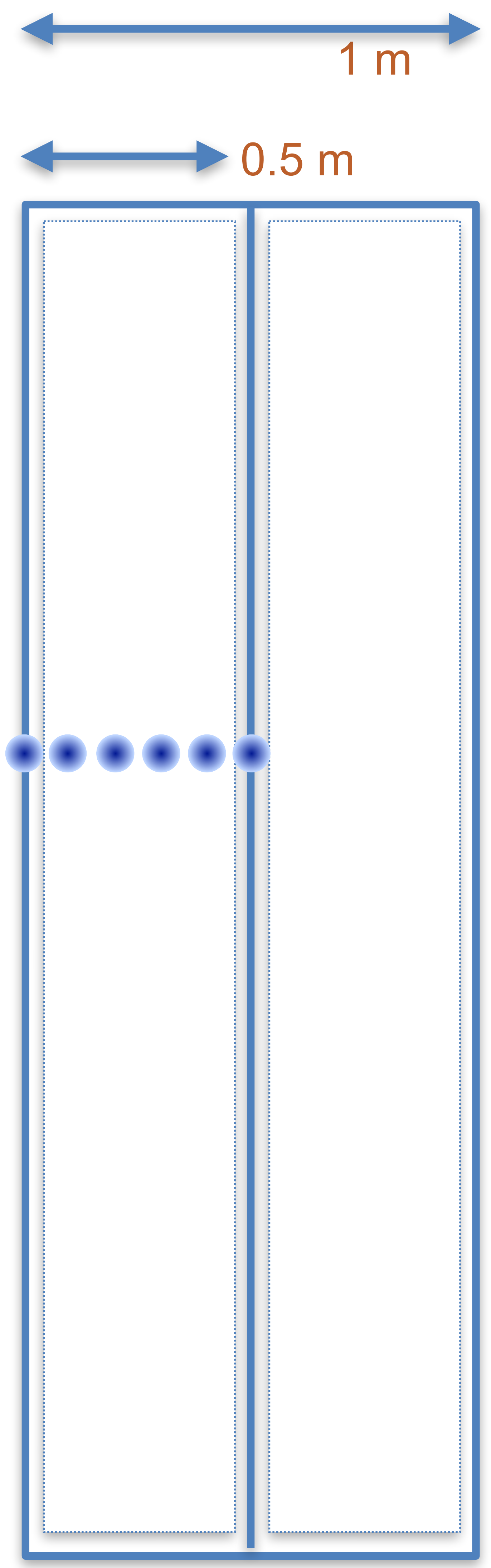


- At the overall system level (all N rows of modules)
  - (Excluding edge effects at the furthest off-axis position. . .)
  - we want to be sure that we don't have any gaps in the off-axis coverage
    - If we consider the fiducial modules to exclude the outer two modules -> N-2 meters
  - However, we know that there will be variations across the module rows
    - containment will vary, detector modules may have performance differences
    - position the desired off-axis displacement within the central module -> 1 meter granularity
    - this will also allow us to verify the row-to-row variation: important in using the furthest off-axis location
- At the module level:
  - performance will vary across the face of the module (e.g. on cathode vs. in middle of drift volume
  - should be able to place the desired off-axis displacement with sufficient granularity in the drift volume
- As we saw last time, both the flux variations and the detector variation scale are ~10 cm



PRECISION

- Granularity guides precision
  - Since the flux varies on the same scale (especially on-axis), this motivates actually positioning the detector to target a particular off-axis location in a particular transverse location
    - if we assumed that the flux was constant (enough) on this spatial scale, we wouldn't actually have to move the detector since we would "automatically" accumulate equivalent data across the dimension.
  - If we wanted have reasonable placement at this spatial scale, then the precision should be less than the desired granularity (<< 10 cm -> few cm)
- Questions:
  - Are these "microstep" measurements "requirements"?
  - If so, how would we incorporate them into a run plan?



VERIFICATION

- System-scale: Precision guides verification
  - We would want to verify at a level that is commensurate with the precision
  - This motivates <1 cm
- Module scale:
  - in principle it is possible to calibrate out movement with
  - it would be desirable that the corrections are small to ensure that they can really be calibrated out
    - This to me motivates module component stability on the voxel scale (~3 mm) or better.