ACE workshop: LBNF PB

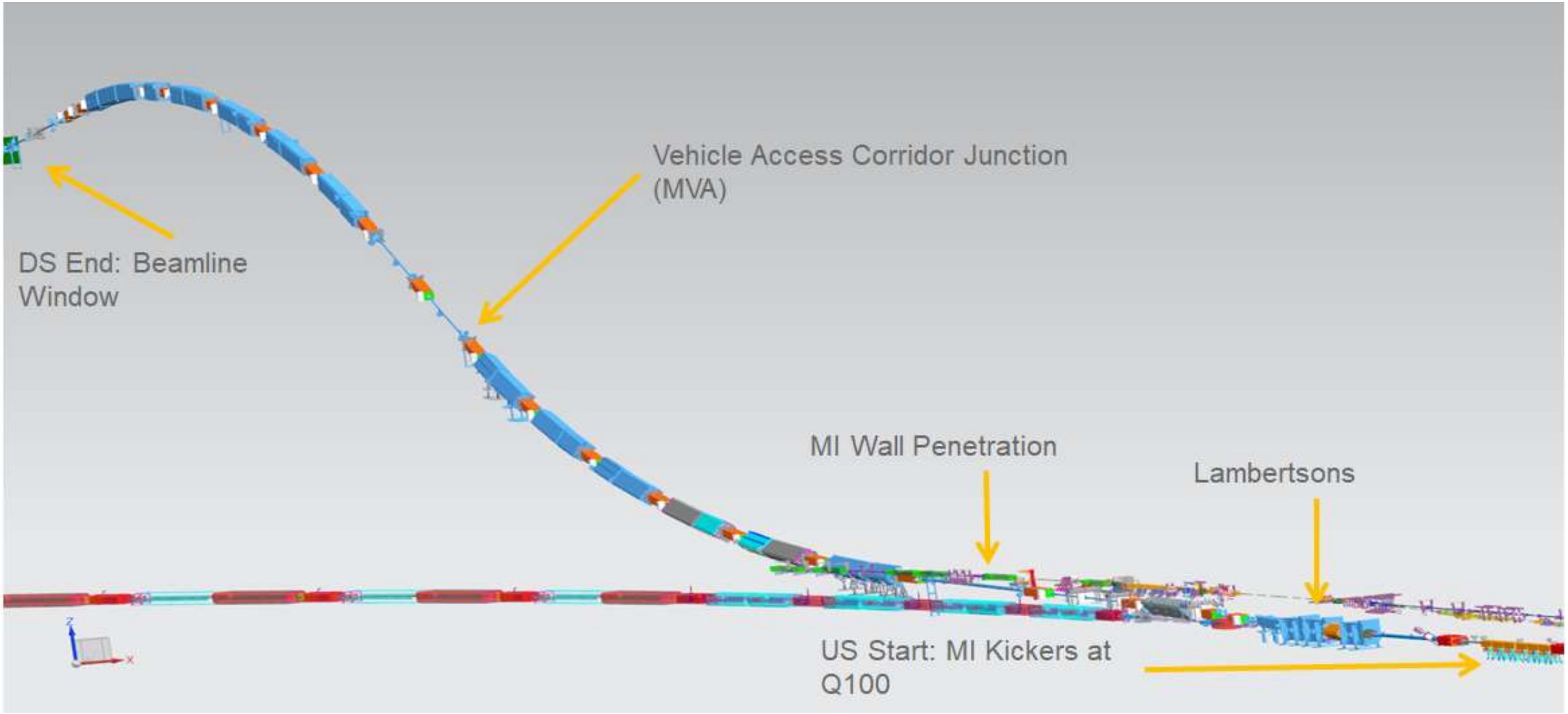
Schlabach

Summary

- Doable with relatively modest $$, will require more real estate volume within buildings, try to build taller rather than wider in the 3 relevant buildings: LBNF5, MI10, MI14
- If we absolutely can't make things fit and need to "enlarge" a building, it's going to be immodest $$ very quickly, this is unlikely (IMHO)
- Note:
  - PB and NB talk about power differently
    - I try not to hit anything until I hit the target (dead on every time ☺) so power for me is how much heat I need to pull out and exhaust
    - Downstream it's beam power deposited in various things which again has some aspect of pulling it out and exhausting it but it's different
  - Optics for me is quad focusing (spot size on target); downstream, horn focusing

Outline

- I'll cover everything from the kicker to the primary beam window
- I'll throw in my opinions on the PB window (kicker and horn power supply similar)
- I'll discuss things by "thing"
  - Power supplies
  - LCW (heat load)
  - Cables (heat load)
  - PB window
  - Kicker and Horn PS
  - Anything not mentioned did not rise to the level of concern that would warrant consideration here (assuming I've forgotten nothing)


Vehicle Access Corridor Junction
(MVA)
DS End: Beamline
Window
MI Wall Penetration
Lambertsons
US Start: MI Kickers at
Q100

Notes

Parameter	Protons per cycle	Cycle Time (sec)	Beam Power (MW)
≤ 1.2 MW Operation - Current Maximum Value for LBNF			
Proton Beam Energy (GeV):			
60	7.5E+13	0.7	1.03
80	7.5E+13	0.9	1.07
120	7.5E+13	1.2	1.20

Note

- LBNF PB is spec-d for (per previous slide: DUNE-doc-21582-v6)
  - 60 GeV, 0.7s rep rate
  - 120 GeV, 1.2s rep rate
- This exercise requires 0.6s, 120 GeV
  - I'll assert the difference between 0.6 and 0.7s isn't so different, the beam energy is
  - P=I^2 R so the power generated and removed is x4

Power supplies

- While they are designed for 0.7s rep rate at 60 GeV, we are requesting twice the energy (120 GeV), thus twice the current at 0.6s
  - We need to slew ~twice as fast to flat top
  - We need twice the voltage
  - That requires larger power supplies
    - It implies they are physically bigger in some dimension
      - The footprint of the building is fixed
      - We can try to build taller but will quickly get in trouble if we build wider
      - Some of the supplies have a “hard” connection to the transformer yard outside
        - We can try to not disturb those
    - This will require design
- I wag the cost at 3-5 million to replace the supplies
- No estimate for design effort (comment later on retrofit)
- I assume what I say about LBNF5 space applies to MI10 and MI14: space is limited

LCW

- Needs to remove and exhaust 4x the heat
  - It is not obvious to me whether or not it can do that
  - I think it highly likely that the piping and bus work are adequate at least from LBNF5 to the PBE
  - Let’s say we rebuild the pump room at LBNF5
- I wag the cost at 1-2 million to replace pumps and other parts (skids)
- No estimate for design effort (comment later on retrofit)

Cables

- 4x the heat
  - It is not obvious to me where that ends up, but it's more likely that they are adequate than that the LCW doesn't need changes
    - We already went from 2s to 1s ish in NUMI
    - At 1.2s with switchyard running, the LAM61 cables cool off during the SY cycle resulting in a slightly different current at flat top and a noticeable difference in position at the targeting positions
      - We have compensated with the BuLB regulation
      - I can conceive of some slightly more complicated ways
      - Cables will get hotter
  - I deem this unlikely to be necessary
  - To rebuild or replace or upgrade or increase the cable plant only concerns me at MI10 and MI14 (lams, c-magnet, kicker) due to limited penetration space

PB window

- The heat generated where the beam passes through doesn’t get to the perimeter so one is dependent on ambient cooling to the surrounding gas (N2 in this case)
- My opinion is even with the reduced rep rate this is fine
- Theoretically, fatigue lifetime is halved (I’m not particularly concerned)
  - See downstream talk

Kicker (Horn) PS

- Both have to charge faster
- Both charge capacitors ahead of time and then discharge “instantaneously” into the kicker (stripline)
- Meredith has a wag for replacement of the horn charging supply
- Should be similar for kicker

Retrofitting

- Retrofitting bus or piping in LBNF5 is going to cost $$
  - It's not nearly as easy as a green field install; it takes a shoehorn sometimes
  - The pipefitter meter runs whether the taxi is moving or not
- My guess is if either or both are required it's $1-2 million
- Conduit replacement or modification between the outside transformer yard and the LBNF5 power supplies may be in the same range (if necessary)
- Cost:
  - Summing up everything I guess something more than 5 and less than 10 million $$
  - I do not include design or technician labor
  - If the pond doesn't support exhausting our extra heat
    - pond study from early days
    - Adding a coiling tower is ~5 million additional $

What you do next (ordered list)

- Get a concept of what the new power supply packages would look like (electrical engineer)
- Evaluate whether LCW needs any changes
  - If so, get a concept of what they are (fluids engineer)
- Think at least a bit more about the kicker (electrical engineer/physicist)
- Once you've gotten the first two you can proceed to think about cost and schedule; you'll also know more about the buildings
- Time scale is up to you as to when "next" begins but remember the old adage about robbing Peter to pay Paul…

Backups