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NuMI air injection proposal for possible partial tritium redirection to evaporator from MINOS sump

Jim Hylen

NuMI beam meeting & Tritium Task Force

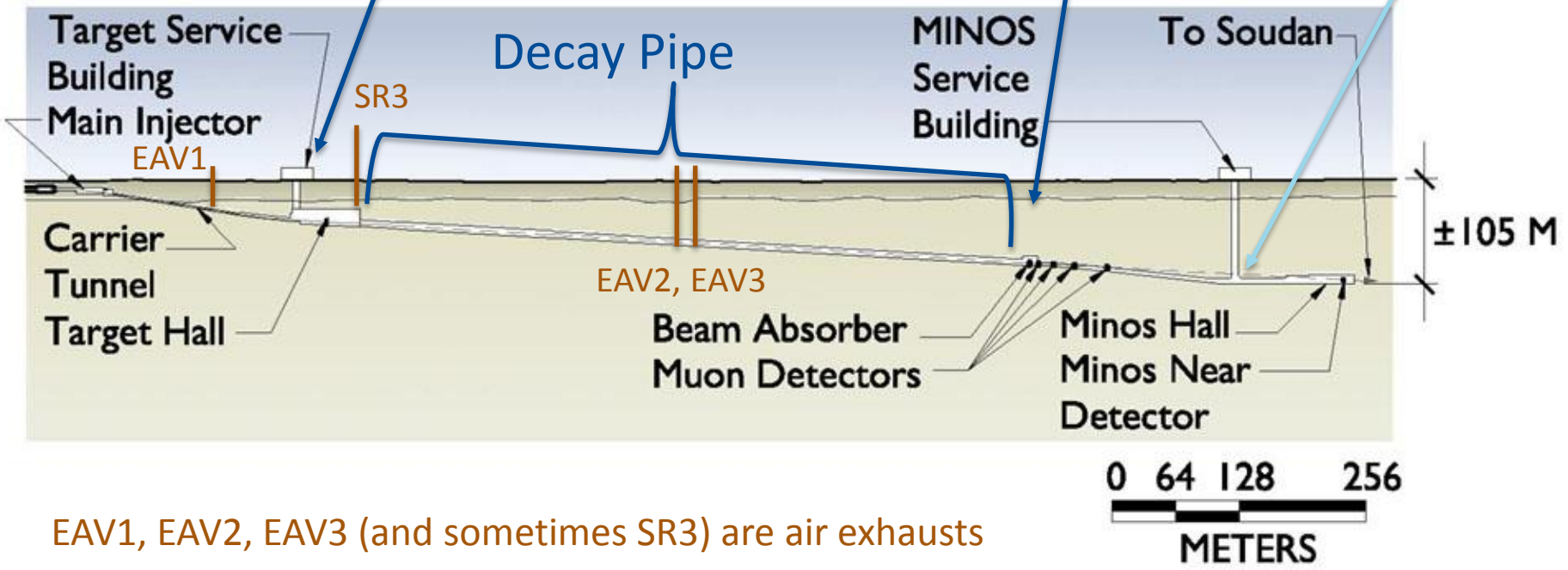
23 August 2016

NuMI areas - energy deposition, air & water paths

Evaporator of condensate ~ 250 gallon/day

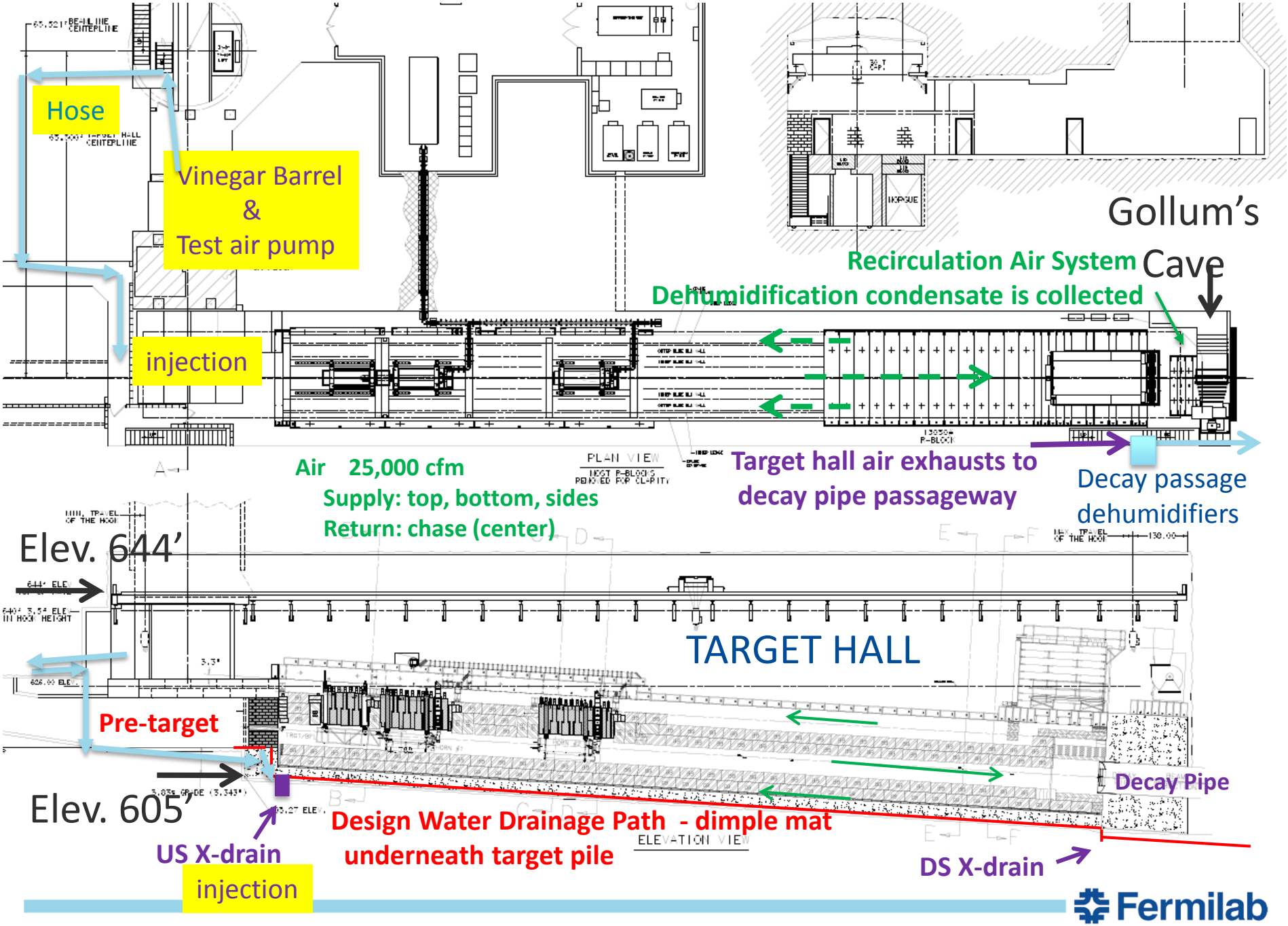
Absorber dehumidifier condensate is pumped to target hall, mixed with target pile condensate

Underdrain water all flows to MINOS sump, then pumped to CUB cooling towers and ICW ~ 110 gallon/minute



EAV1, EAV2, EAV3 (and sometimes SR3) are air exhausts

Tritium producing particle shower power is deposited ~ 1/3 in each of (i) target hall, (ii) decay pipe, and (iii) absorber at end of decay pipe

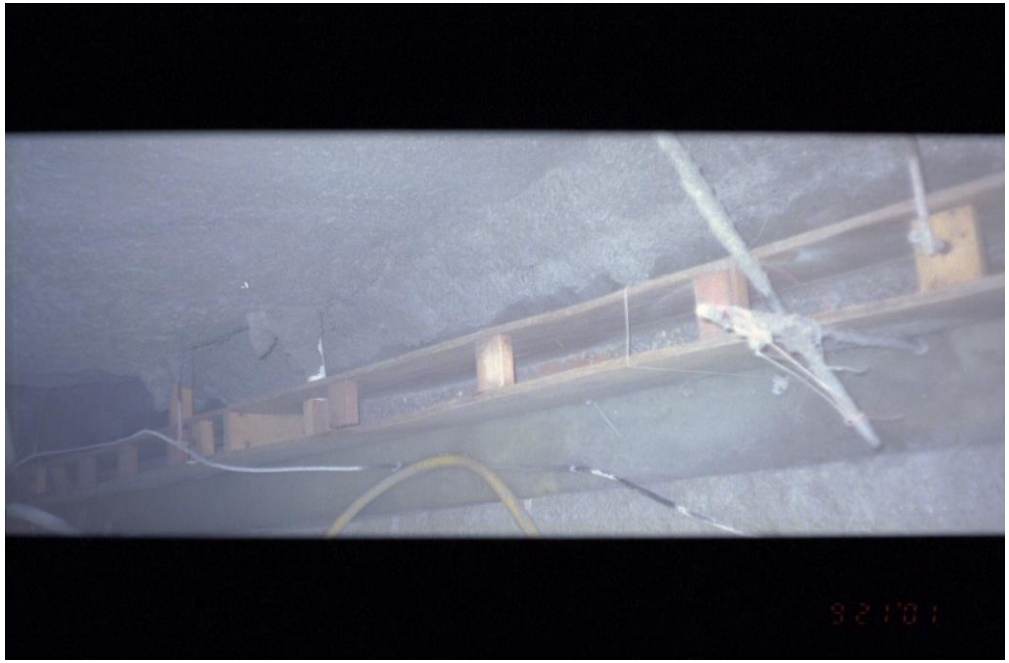

Hose
Vinegar Barrel
&
Test air pump
injection
Gollum's
Cave
Recirculation Air System
Dehumidification condensate is collected
Air 25,000 cfm
Supply: top, bottom, sides
Return: chase (center)
Target hall air exhausts to
decay pipe passageway
Decay passage
dehumidifiers
Elev. 644'
TARGET HALL
Pre-target
Elev. 605'
Decay Pipe
Design Water Drainage Path - dimple mat
underneath target pile
US X-drain
injection
DS X-drain

Target pile cross-drain, before being buried in concrete

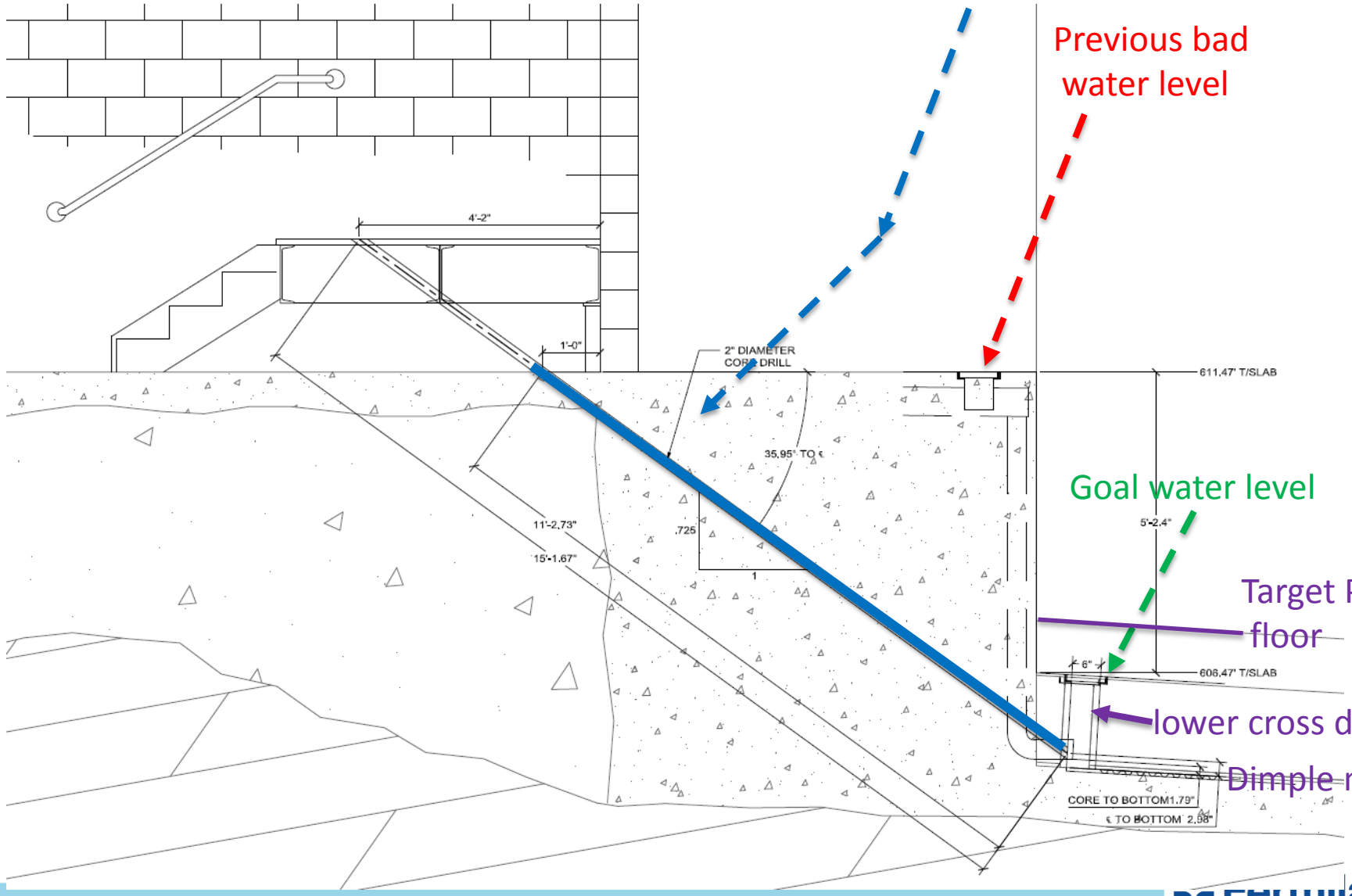
(I think these are the correct pictures)

This is what pre-target gutters drained into, through the PVC pipes (before we started upgrades)

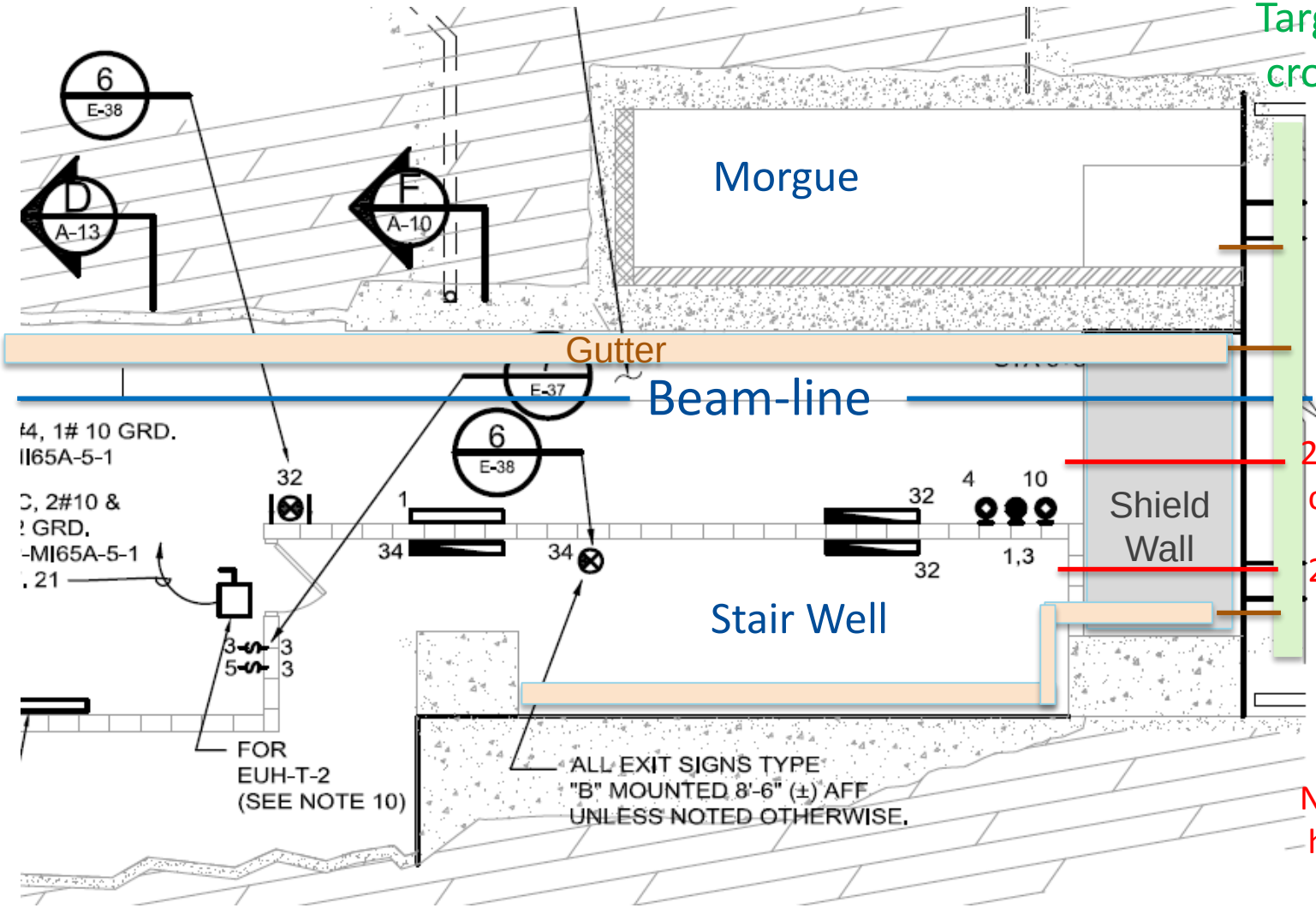
They drain to mat underneath



Coring down to target hall US cross-drain from Pre-target



Where is proposed new core, plan view



Target pile cross drain

Will seal

Orig. drain

Orig. drain

Now vinegar inject

2016 proposed coring 6” diam.

2015 coring 3”

Orig. drain

Note 2015 coring has backup pump

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First for some good news, and context

Critical that drainage under target pile works, and target pile not flood.

Previously, have had underdrain water back up into pre-target area.

Blame calcification of dimple mat under target pile.

- After a year of weekly dumps of 100 gallon of 12% vinegar
  - Water level is at bottom of target pile upstream cross under-drain
  - No water pumping needed from under-drain (compare to 4 gpm last fall)
  - Appears a lot of the calcification in cross underdrain has been de-scaled

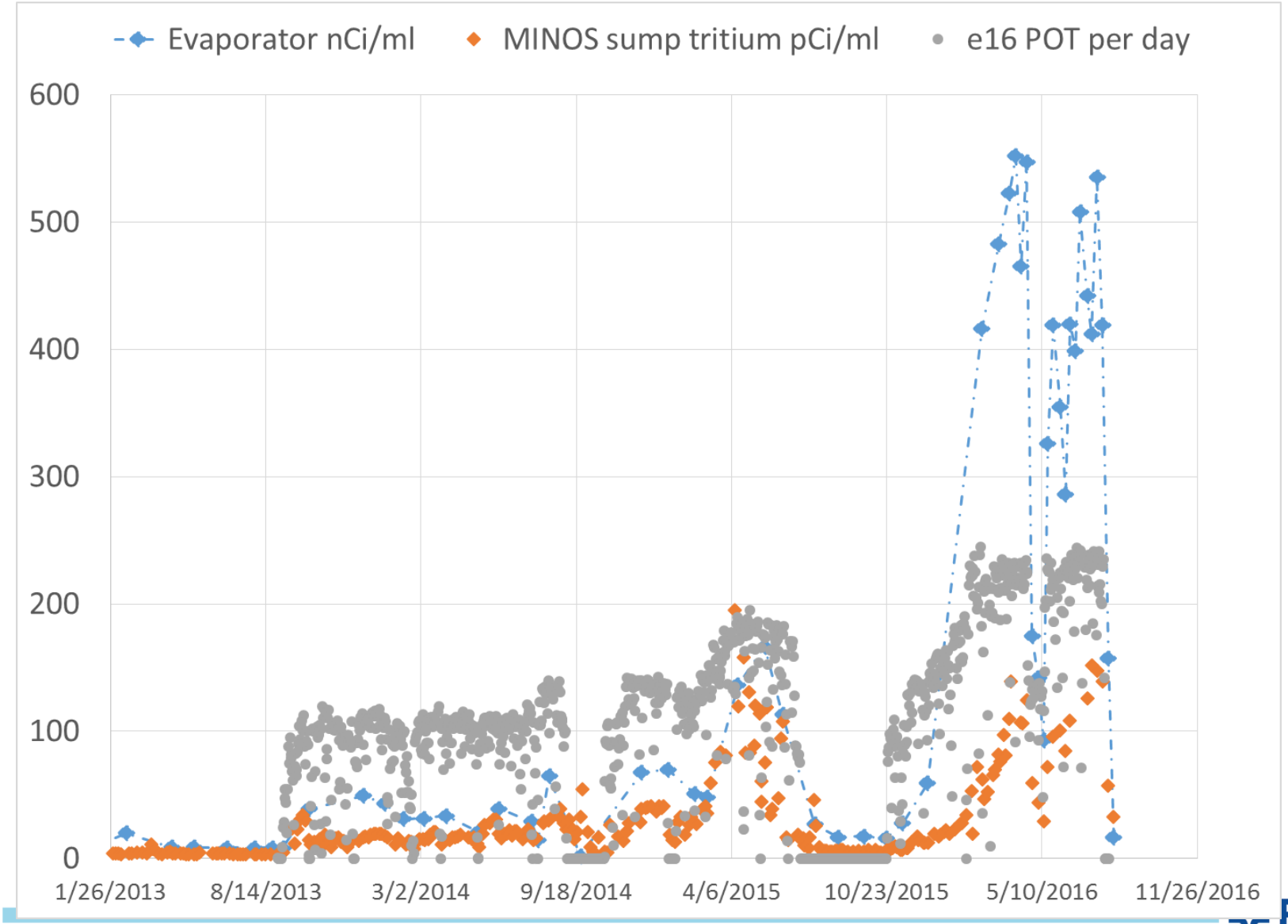
- This shutdown, replacing weekly manual dumps with nearly continuous automated injection (about 3 times the vinegar useage)
  - Enough vinegar to treat entire estimated flow under target pile
  - Goal: Nearly continuously de-scaling, rather than de-scale/scale cycle
  - (last fall, water level drop for couple days after dump, then start rising again)

Saw increased tritium release last spring

- Recent high tritium level in NuMI evaporator, ~ 450,000 pCi/ml
  - Tritium to evaporator increasing much faster than linearly with increased beam power
  - Best theory: due to exponential increase of tritium diffusion with temperature in shielding
    - Temperature will be even higher when beam power goes up next year
  - If temperature related, it may get worse, but at some point limited by production rate
  - *Believe release is already at half of the production rate in shielding*

- Recent high tritium level in NuMI/MINOS sump water, ~ 140 pCi/ml ave.
  - Several times as high as previously
  - Presumably also related to the heating of shielding

Tritium concentration in Evaporator (and MINOS sump) have increased non-linearly with beam power



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ALARA

- Preferable to exhaust tritium via evaporator instead of MINOS sump
  - MINOS sump water goes to ICW and ponds, where it has chance to contaminate other systems

- Possible partial mitigation
  - Recirculating air around steel shielding of target pile is overpressure relative to everything else because that is just after the fan; the downstream end of the target pile around the decay pipe window and up gollum's cave through the filters is under-pressure because it is just before the fan.
  - So drainage water to MINOS sump may be contaminated with tritium by air seeping through cracks to the underdrain system from re-circulating air.
  - If correct, may be able to reduce tritium to MINOS sump by increasing fresh air pressure in drainage system; more tritium should end up in the evaporator instead

Air injection test data, extrapolation

- Wednesday May 11 was a beam-off access day, and we did a short test of injecting air through the vinegar injection hose to the cross-drain.
  - Before injection: cross-drain was 0.25 inch water column higher pressure than the stairwell – fact that it is over-pressure supports idea that target pile air leaks into the under-drain system
  - During injection of 13 scfm of air, cross-drain pressure increased to 0.35 inch water column. (This used a spare air pump we had on hand)
  - Extrapolating roughly, would need ~ 144 cfm to get pressure to 1 inch, (which would be greater than the 0.8" pressure measured near the upstream end of the target pile at the scuttle door a decade ago during air balancing).

- June 23, 2016 the 13 scfm of air injection was turned on to run continuously
  - Not surprisingly, MINOS sump tritium results consistent with 13 cfm making no difference, so need higher air flow if this is to work

- Propose air injection tunable between 100 and 500 cfm
  - Start tuned to between 1.0" to 1.5" water column pressure in cross-drain

Tritium balance

- Guesstimate of target pile air contribution to MINOS sump – is it at all in range for this idea to work?

- Take 450,000 pCi/ml humidity in target pile air, assume 150 cfm leak at 60% RH at 20 C = 68 F; would contaminate 114 gpm of MINOS sump water to 46 pCi/ml

- So possible this is mechanism and we could disrupt it, but not slam dunk…

Possible harm from this ?

- The target pile recirculation air flow is 25,000 cfm
- The leak rate of air from target pile to target hall is ~ 300 cfm
- The air flow from target hall through decay passage to EAV2 is ~ 1,200 cfm

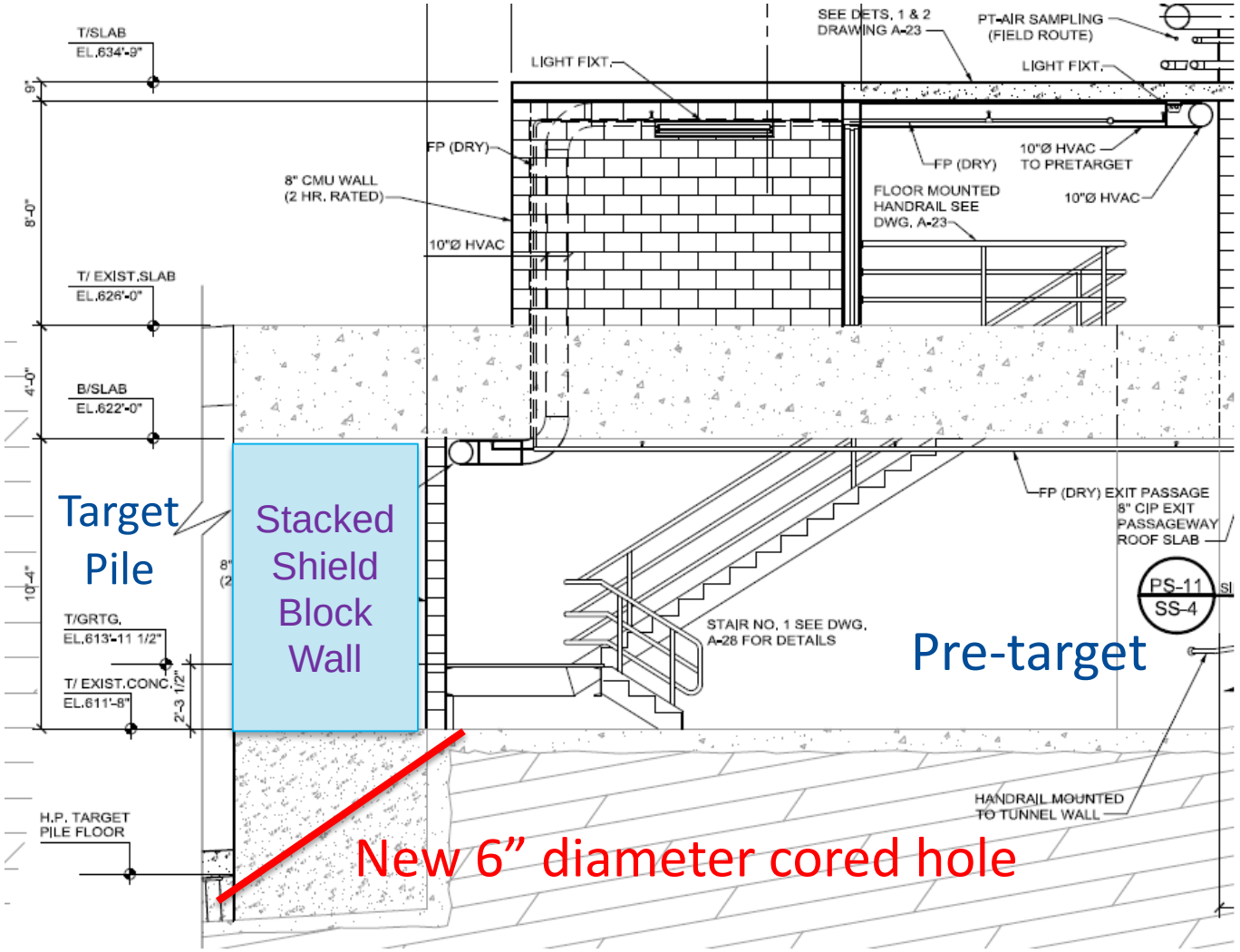
- Introducing up to 300 cfm of clean air into the underdrain could affect air pressure and flows in target hall at the level of one of the five decay passageway Munters dehumidifier units. We have run with only 4 of the 5 on; makes us closer to the edge of pressure wrong way when a storm front moves through, but is doable. So I don't expect bad things from air injection, but air balance may be somewhat different.

Coordination

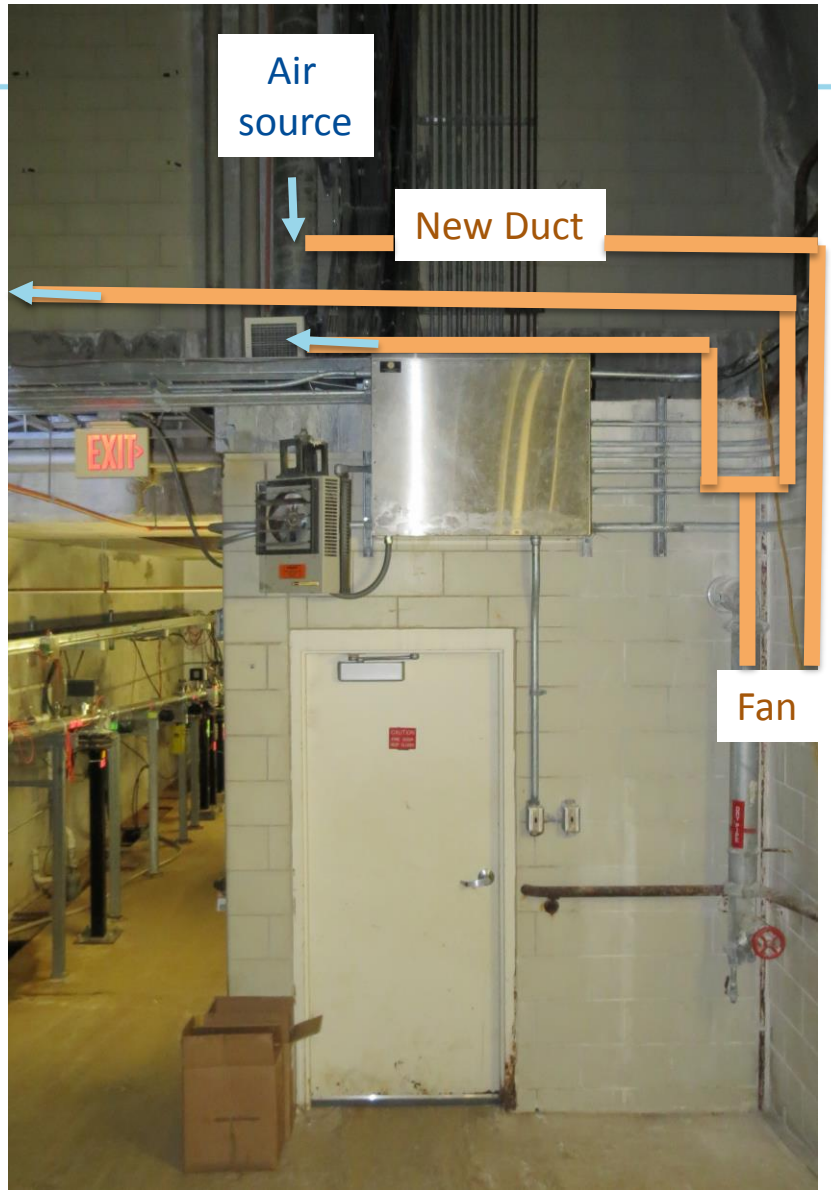
- Can duct & coring be placed to have minimal impact on pre-target activities, in particular magnet replacement?

- Duct (mostly) tucks under the lip of the hatch

  – Fallback: if duct in way, could be temporarily removed for a magnet swap – are people OK with that?


T/SLAB
EL.634'-9"
9"
8'-0"
T/ EXIST.SLAB
EL.626'-0"
4'-0"
B/SLAB
EL.622'-0"
10'-4"
T/GRTG.
EL.613'-11 1/2"
T/ EXIST.CONC.
EL.611'-8"
2'-3 1/2"
H.P. TARGET
PILE FLOOR
8" CMU WALL
(2 HR. RATED)
FP (DRY)
10"Ø HVAC
LIGHT FIXT.
SEE DETS. 1 & 2
DRAWING A-23
PT-AIR SAMPLING
(FIELD ROUTE)
LIGHT FIXT.
FP (DRY)
10"Ø HVAC
TO PRETARGET
10"Ø HVAC
FLOOR MOUNTED
HANDRAIL SEE
DWG. A-23
FP (DRY) EXIT PASSAGE
8" CIP EXIT
PASSAGEWAY
ROOF SLAB
PS-11
SS-4
STAIR NO. 1 SEE DWG.
A-28 FOR DETAILS
HANDRAIL MOUNTED
TO TUNNEL WALL
Target
Pile
Stacked
Shield
Block
Wall
Pre-target
New 6" diameter cored hole

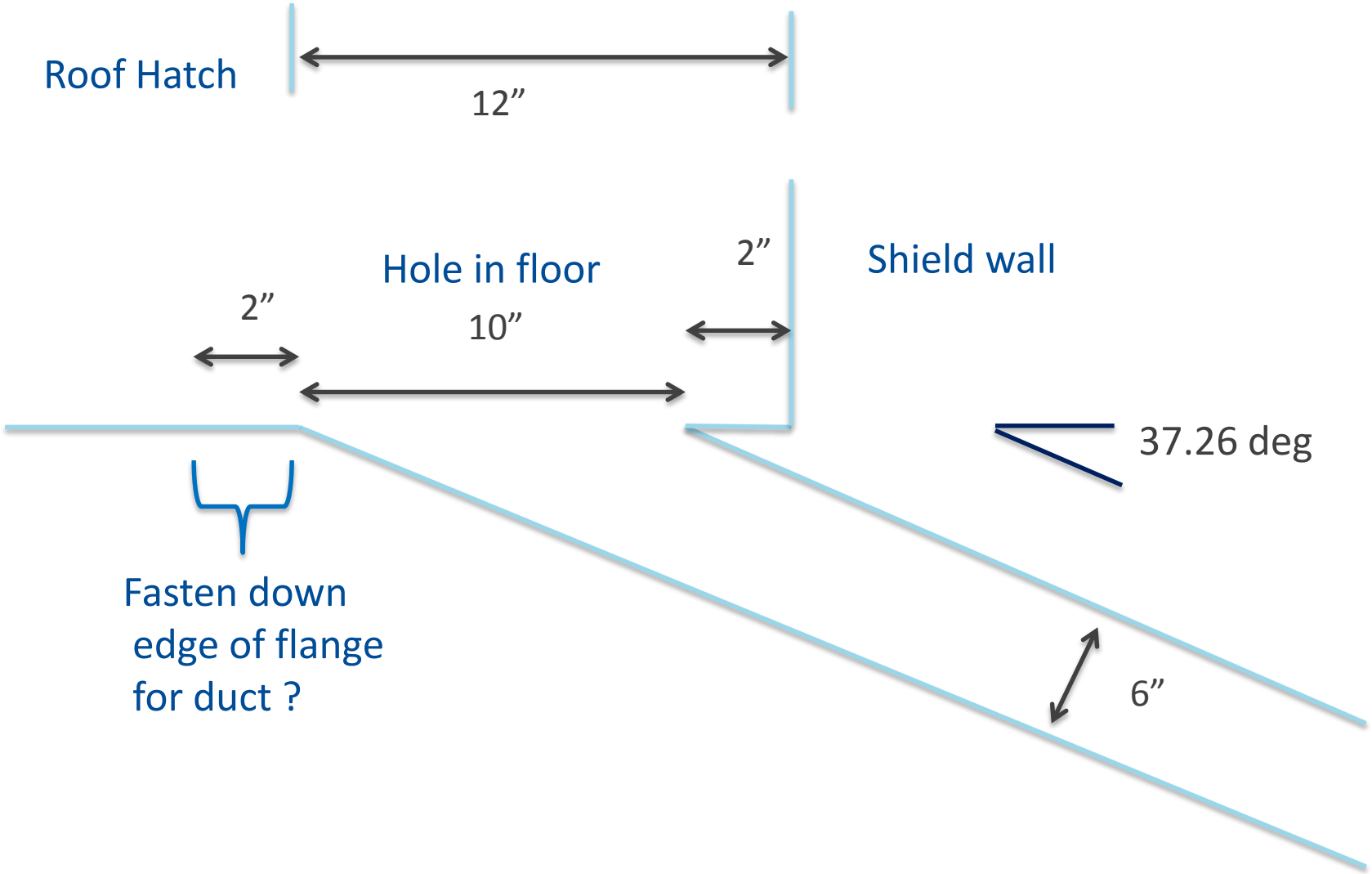

Existing
Air
To PT
EXIT


Air
source
New Duct
Fan
EXIT

New duct routing

Duct at pre-target hatch

Geometry at hole in pre-target floor



Source of fresh air & power

- Air handler that supplies that pre-target duct (among other things) is 3000 cfm unit, currently running at 75%. So can get another ~750 cfm from it if needed. More than we estimate we need.

- Will probably plug fan into local 208 V power plug (few amps)

How some issues will be addressed

- Will cover beam-line components before coring, to protect them from concrete dust. (Since this is a wet-coring process, should not be lots of dust). Will clean area after coring.
- Core drillers will have required PPE to prevent breathing concrete dust (new lab requirement)
- Will have an automatic back-draft damper that will shut off air path to coring hole if fan fails, to prevent target pile air from getting to pre-target
- ACNET will have input from sensor showing fan is running or not
- ACNET will have readout of air pressure in cross-drain

Outlook

- Cost estimate: $10k to $20k
- Schedule estimate:
  - 1 to 2 days to do coring
  - 1 week to install duct, fan, backdraft damper and instrumentation
  - 2 days to commission (balance air); need target pile sealed & recirculating air
  - Long lead time items? (fan may be 2 weeks)
  - Time to approval?
- Not guaranteed to work, but modest cost for possible significant reduction in tritium to MINOS sump
- Cannot be installed while running; if wanted before the 630 kW beam running, must install this shutdown.
- Needed quickly: buy-in from stake-holders, then funding approval

Backup

Measurement of tritium release during recent high power peaks

	Water flow	Concentration	Tritium	
Evaporated Condensate	**240 gpd**	**550,000 pCi/ml**	**0.502 Ci/day**	Use this
Absorber Condensate	*90 gpd*	*18,700 pCi/ml*	*0.006 Ci/day*	*Included in Evaporated*
TH = EC - AC	*150 gpd*		*0.496 Ci/day*	*Included in Evaporated*
MINOS sump	*108 gpm*	*218 pCi/ml*	*0.128 Ci/day*	*1 dehumid. broke*
MINOS sump	**108 gpm**	**100 pCi/ml**	**0.059 Ci/day**	Use this
Stacks – small				
TOTAL			**0.561 Ci/day**	Evap. + Sump
Norm. to POT			**26 Ci/10^{20} POT**	**~2.2x10^{18} POT/day**

NuMI Tritium Production and Release

Old MARS Ci/10^{20} POT	New MARS Ci/10^{20} POT	Produced in
50	24	target pile steel
20	11	decay pipe concrete
9	2.5	decay pipe steel
1.1	0.22	chase air
0.12	0.03	decay pipe helium
??	??	absorber
??	1.3	horns
1.0	1.7 - 4.2	Target
81	**41 - 44**	**TOTAL**

MARS Monte Carlo of Tritium production

note work in progress

Old by Byron Lundberg and others

New by Igor Rakhno

Old and new differ by:

hadronic model

Target (LE vs MET)

Horn 2 (LE vs ME)

Geometry modeling

6 Ci/10^{20} POT Measured Release 2008 – 2011 at 300 kW

~ 26 Ci/10^{20} POT Measured Release now at 520 kW

Especially since absorber and decay pipe tritium is probably pretty well trapped, *don't think rate can get significantly worse over long term, since release is approaching production rate*