Introduction to the NUMI/MINOS Monitoring System

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on behalf of:
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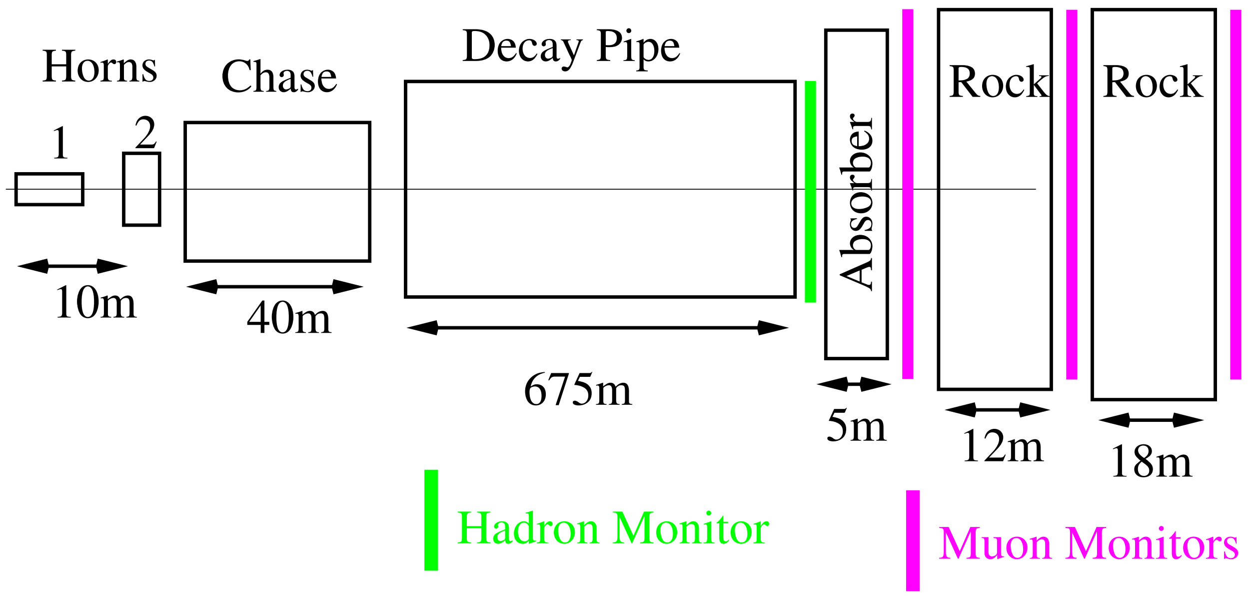
- Definition of System
- Report of Past Reviews
- Charge of Current Review
- Fluxes at Monitors
- Radiation Doses at Monitors

Role of Beamline Monitors



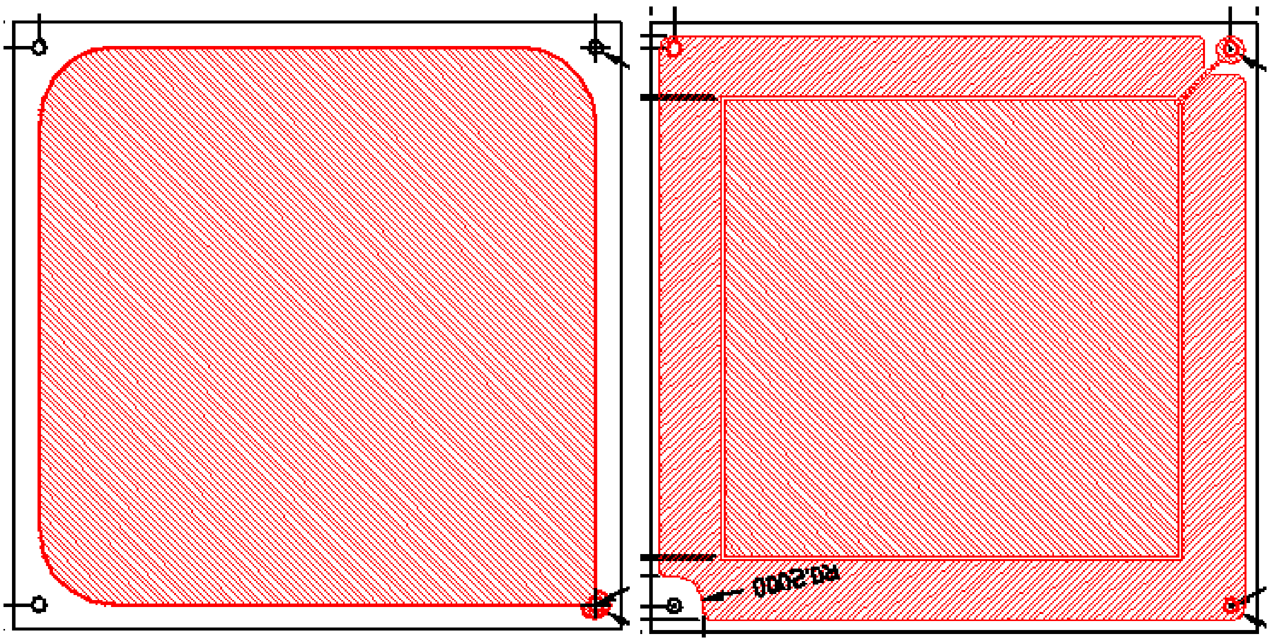
- Commissioning–check of alignment
- Normal Running –make sure optimal beam is being created
- Re-commissioning–any time beamline element is moved
  - → Primary beam instrumentation needs replacement
  - → Horns get moved/replaced

History of Monitoring System Reviews and Workshops

- February 4, 2000: so preliminary it hurts
- December 2, 2000 Muon Monitor Review
  - → Understanding Effects of Beamline Changes on Monitors
  - → Conceptual Design of Muon Monitors
  - → Worry at that time about rad hardness of initial design
- May 17, 2001 Hadron Monitor Review
  - → decided at that time that technical challenge was too high for upstream hadron monitor
  - → focus on muon and downstream hadron monitors

Review History, continued

- December 10, 2001 System Review
  - → Present “single Pixel” design
  - → ATF, FNAL Booster Test Results
  - → Operating Conditions (Φ, T, P, humidity)
  - → Electronics
  - → Pixel approved

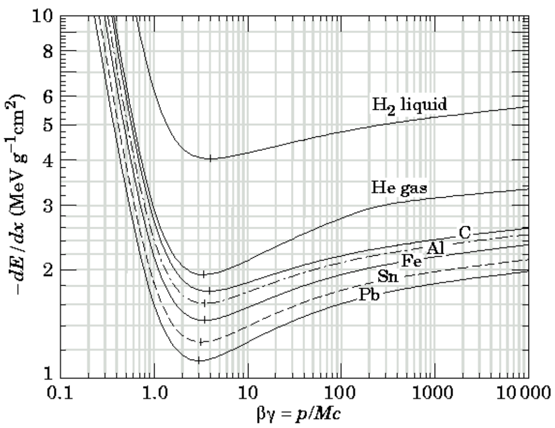


Review History, continued

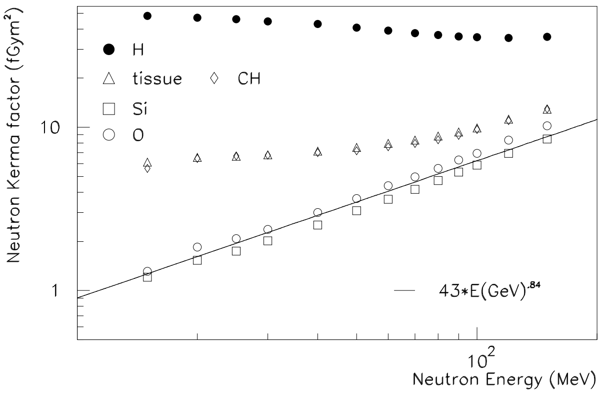
- April 24, 2001 Workshop
  - → Mechanical desgn
  - → Signal routing
  - → Stray Ionization Studies
- Today– Final Engineering Review
  - → Signal Routing
  - → Radiation Hardness
  - → Support Structures
  - → Safety Aspects
  - → Alignment
  - → Removal Procedure for Hadron Monitor

Fluxes and Dose Calculations

- GEANT-Based monte carlo simulation
- follow tracks down to 1MeV
- Aluminum Core absorber
- No hadron monitor material assumed
- Radiation Dose calculations using dE/dx and neutron kerma factors

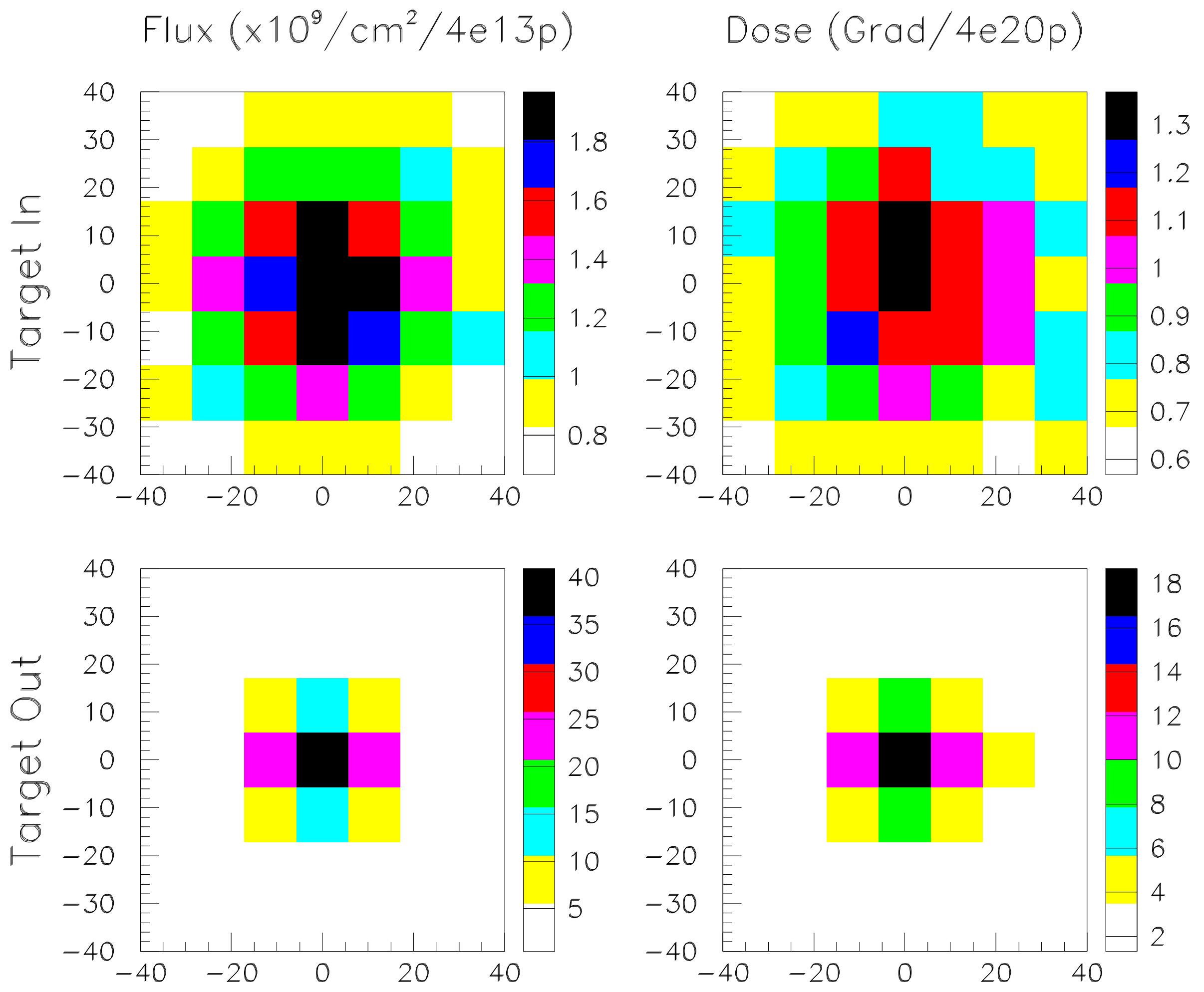


Ref: Particle Data Group, 2000



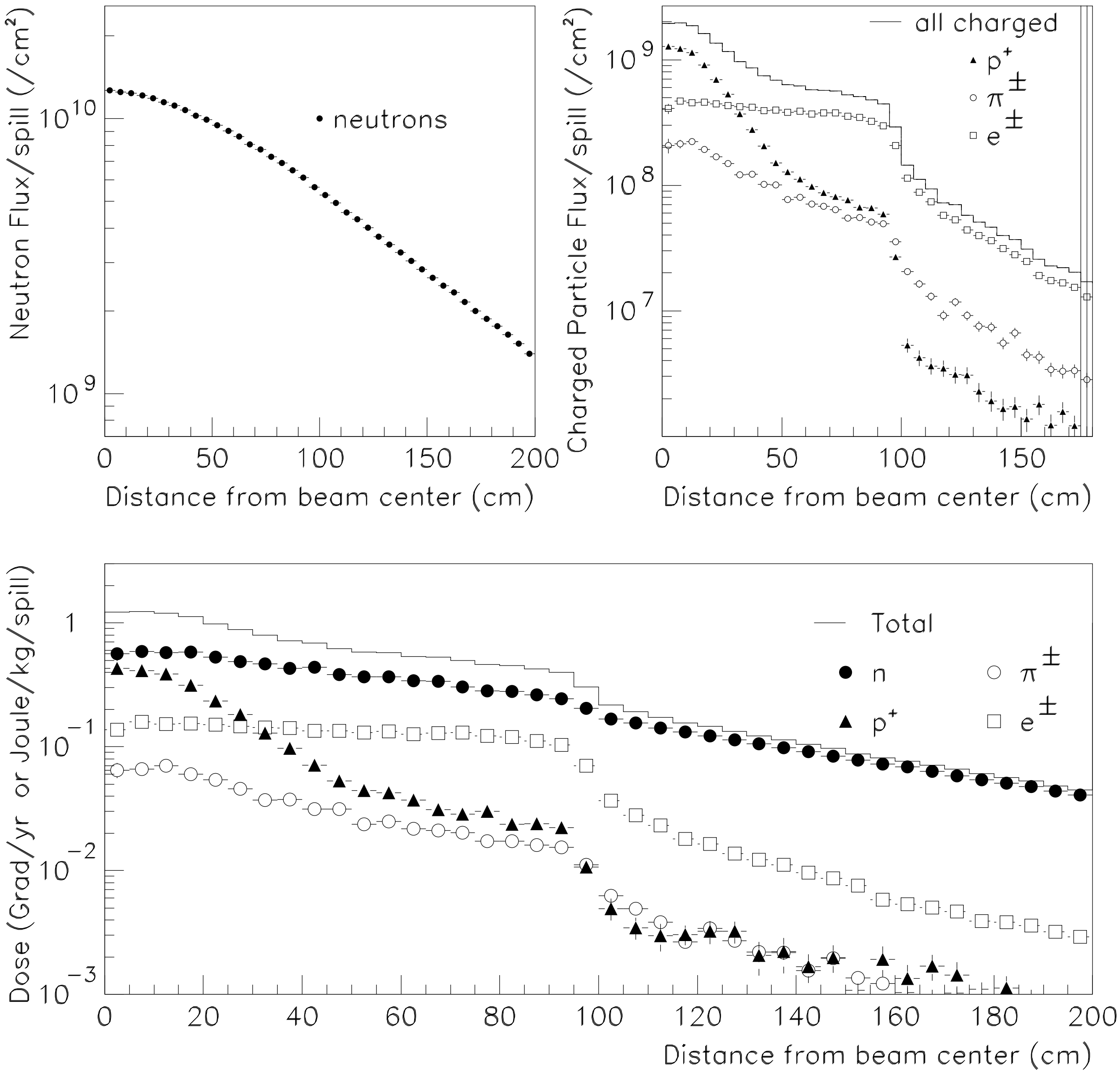
Ref: Nucl. Instr. Meth. **A388** 260 (1997)

Challenge of Hadron Monitoring



Neutron "background" will blur out the proton spot size a small amount, but not enough to change specs.

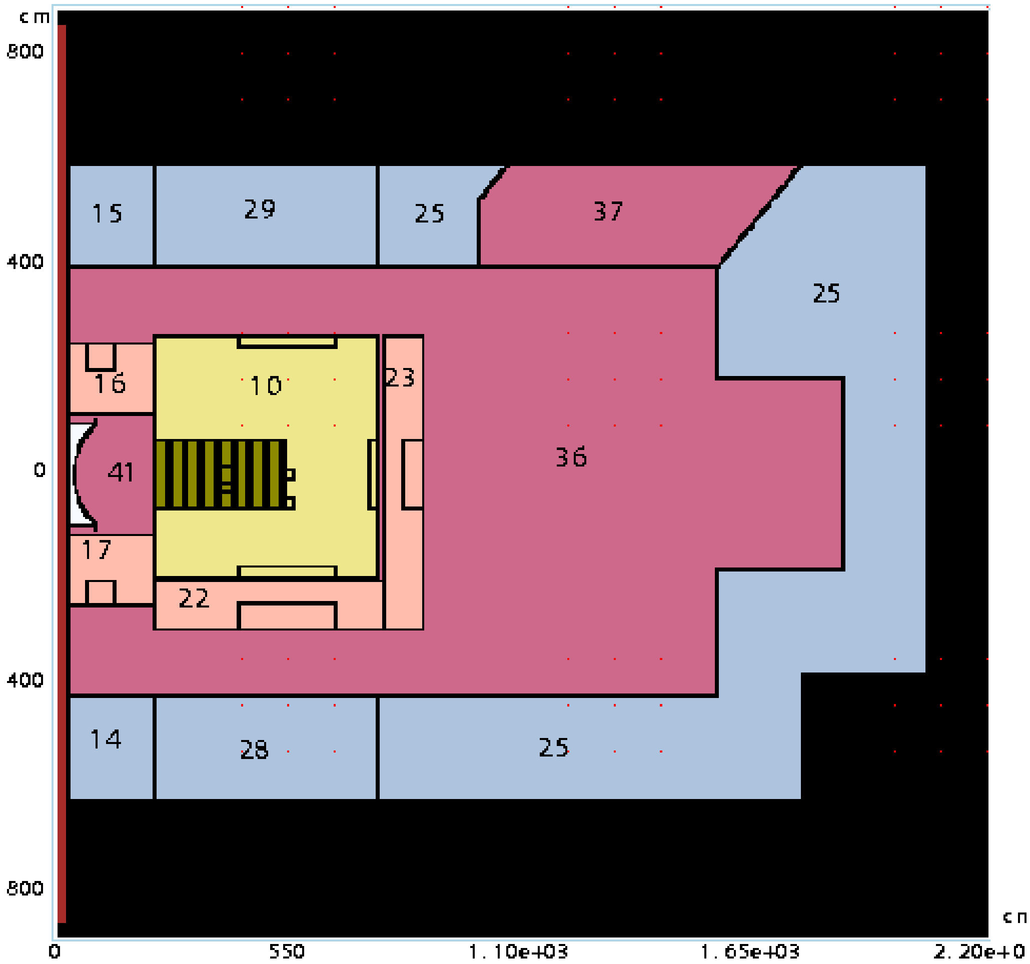
Challenge of Hadron Monitoring, II



Cross-Check: compares with MARS simulation, except neutron rates. (Factor of 30 higher in GEANT!)

MARS energy cutoff: 20MeV, GEANT rates quoted above for 1MeV cutoff

MARS Radiation Level Calculations



Zone	Region	Dose Rate (/year)
	Decay Pipe Window	0.10 Grad
41	Air Upstream of Absorber	0.32 Grad
2	First 12” of Aluminum in Absorber	3.6 Grad
10	Steel Surrounding Aluminum Core	35 Mrad
16,17	Concrete surrounding decay pipe	1.5 Mrad
23	Concrete downstream of Steel	0.50 Mrad
36	Air outside Absorber Shielding	0.36 Mrad
22	Concrete east of Steel	7 krad
37	Entrance to Labyrinth	< 5 krad (1.5 ± 0.5)

Activation of Hadron Monitor–3 ways

1. Thin target model, not material specific, insert cool-down by hand:
   150mRem/hr at 1 foot after 1 week cooldown
2. Material specific model, tuned on thick shielding, empirical geometry factors:
   70mRem/hr at 1 foot after 1 week cooldown

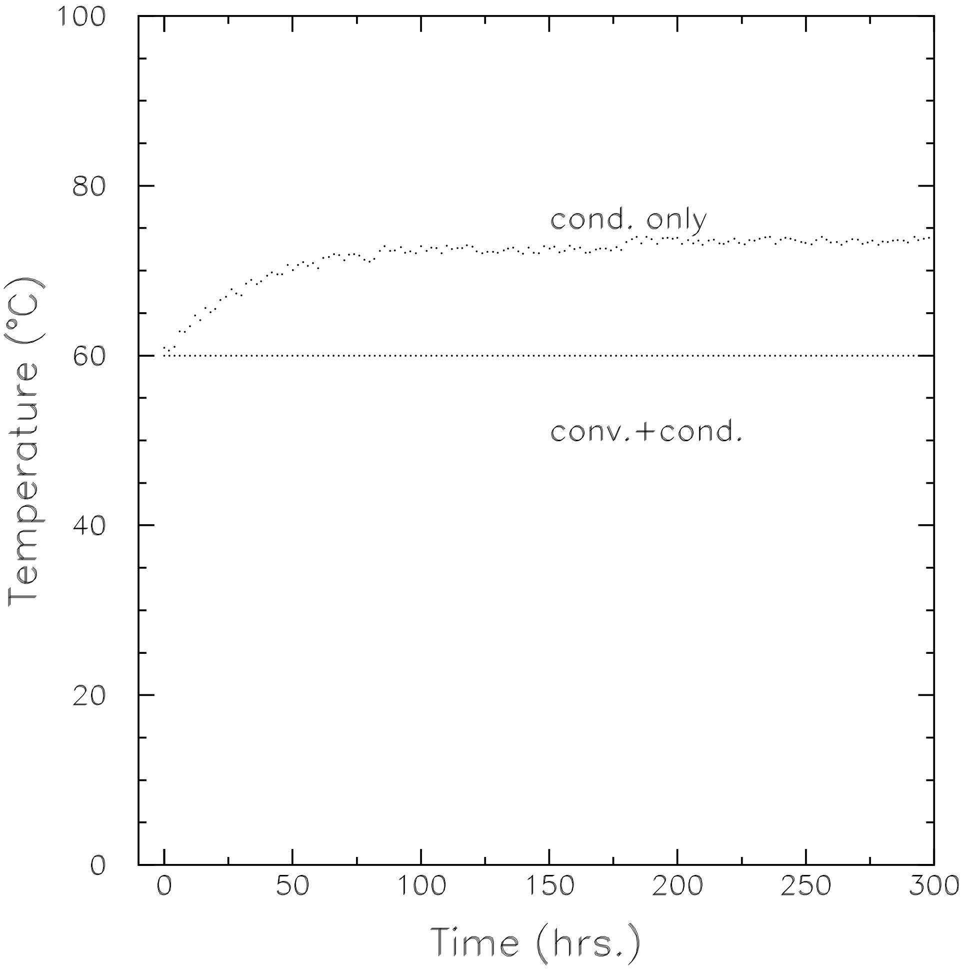
Monitor	Rad/hr on Contact			
Material	30d,1d	1y,1d	30d,1w	1y,1w
Aluminum	280	310	1	13
Steel	390	500	200	230
80/20 Al/Fe	300	350	40	57

   (worksheet courtesy N.Grossman)

3. MARS Calculation (A.Wehmann)
   160mRem/hr at 1 foot after 1 week down

Hadron Monitor Heating

- 47 Watts come from beam heating
- Air conduction coefficient is $0.024W-cm/cm^2C$
- Air convection (confined volume) $3W/cm^2C$
- Ambient Temperature (absorber plates) $60°C$
- Beam accident condition not considered



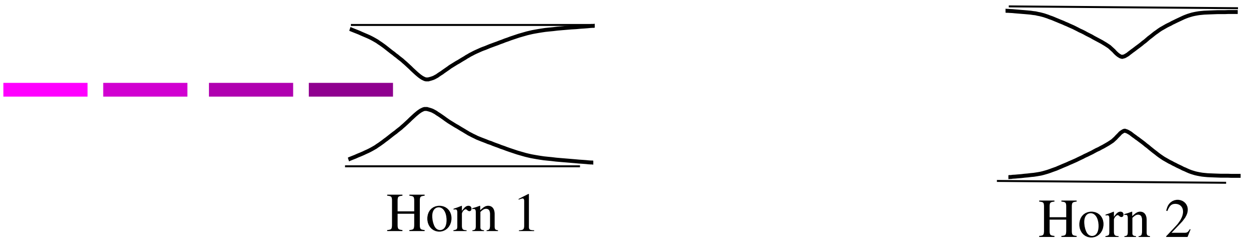
Muon Monitor Fluxes and Doses

Alcove	Particle	Flux $(10^7/cm^2/spill)$	dE/dx Dose (Mrad/year)
0	Muons	$1.1 \pm .07$	3.5 ± 0.23
0	Neutrons	9.3 ± 0.16	1.8 ± 0.038
0		Total	5.3 ± 0.2
1	Muons	$0.28 \pm .04$	0.88 ± 0.12
1	Neutrons	0.12 ± 0.02	0.018 ± 0.003
1		Total	1.0 ± 0.1
2	Muons	$0.12 \pm .03$	0.4 ± 0.1
2	Neutrons	0.0057 ± 0.004	0.00044 ± 0.00031
2		Total	$.4 \pm 0.1$

Note: this is for the target in
nominal position.
By moving the target upstream the muon rates
are up to 3.5
times higher in Alcove 0.

Role of Variable Energy Beam

Variable Energy Beam Concept



As target goes farther upstream, higher energy pions get focused–more collimated neutrino and muon beam...

Muon Rates:

Target	Peak Pad Flux $(/cm^2/4e13POT)$		
Position	Alcove 0	Alcove 1	Alcove 2
nominal	1.3	0.4	0.19
1m back	3.5	1.3	0.20
2m back	3.5	2.1	0.37

Alignment Requirements for Monitoring System

Because of Long Lever Arm,
Alignment requirements not very stringent

- Hadron Monitor
  - → Proton Steering Accuracy: 15μrad
  - → Multiwire Re-Position Accuracy: 50μm
    - ⋆ multiwire separation: 12.5m
    - ⋆ angular uncertainty: 6μrad
  - → Total Proton Alignment error: 10mm
  - → Absorber Alcove Accuracy: 25mm
  - → Want Positioning Accuracy to 10mm
  - → Spot Centering accuracy spec: 5mm
- Muon Monitors
  - → Absorber Alcove Accuracy: 25mm
  - → "Important" shifts in beam: $\mathcal{O}(10)$mm
  - → Design Positioning Accuracy to 10mm
  - → Center to Center Pad accuracy 1mm

Remaining Talks for This Review

- Hadron Monitor - Sacha Kopp
- Muon Monitor - Sacha Kopp
- Muon Monitor Support - Albert Erwin