FERMILAB TEST BEAM
& THE INTERNATIONAL LINEAR COLLIDER

Brajesh Choudhary, **Fermilab**

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ACKNOWLEDGEMENTS

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✓Craig D. Moore

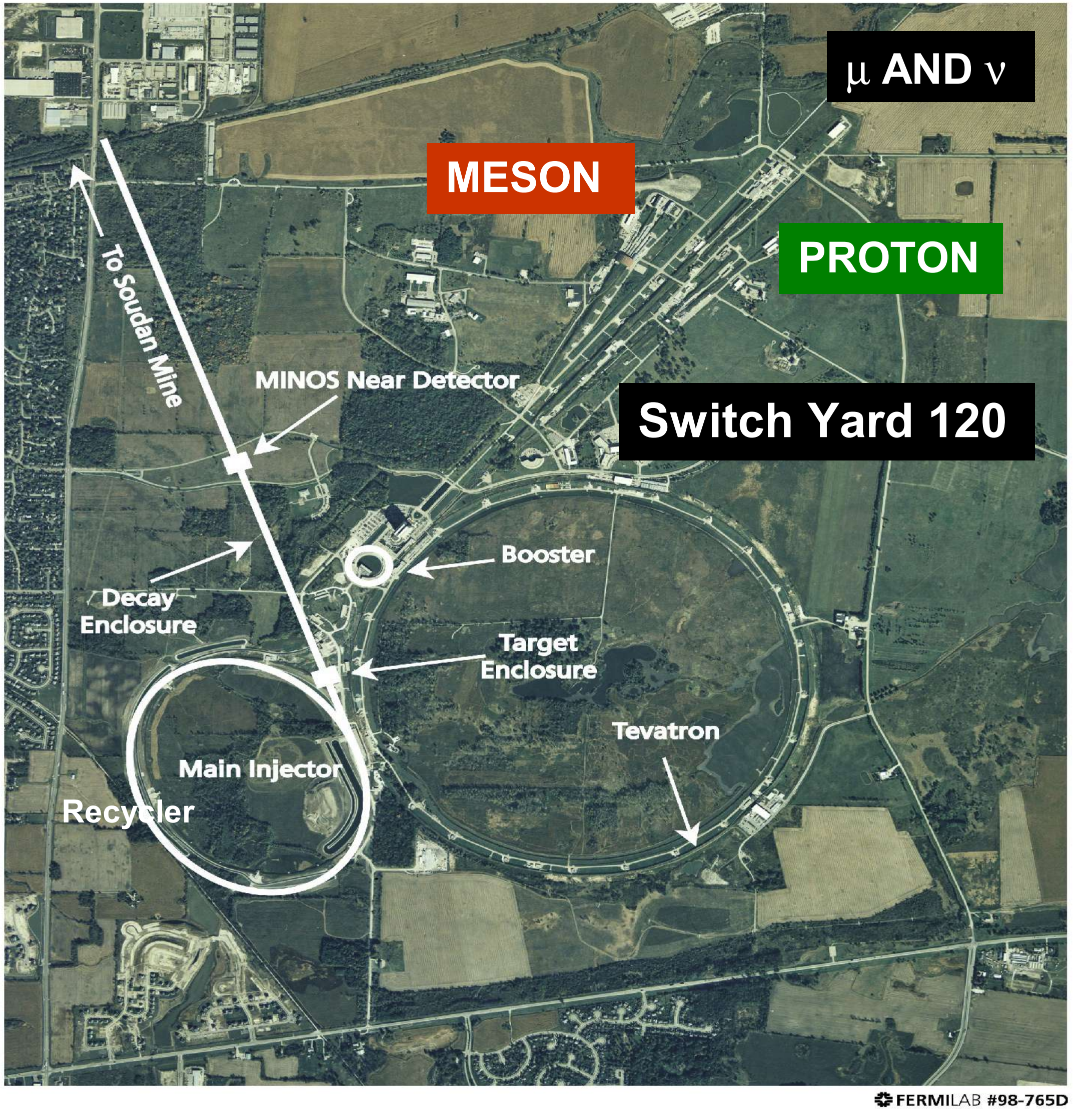
✓Erik Ramberg

THANKS!

PLAN OF THE TALK

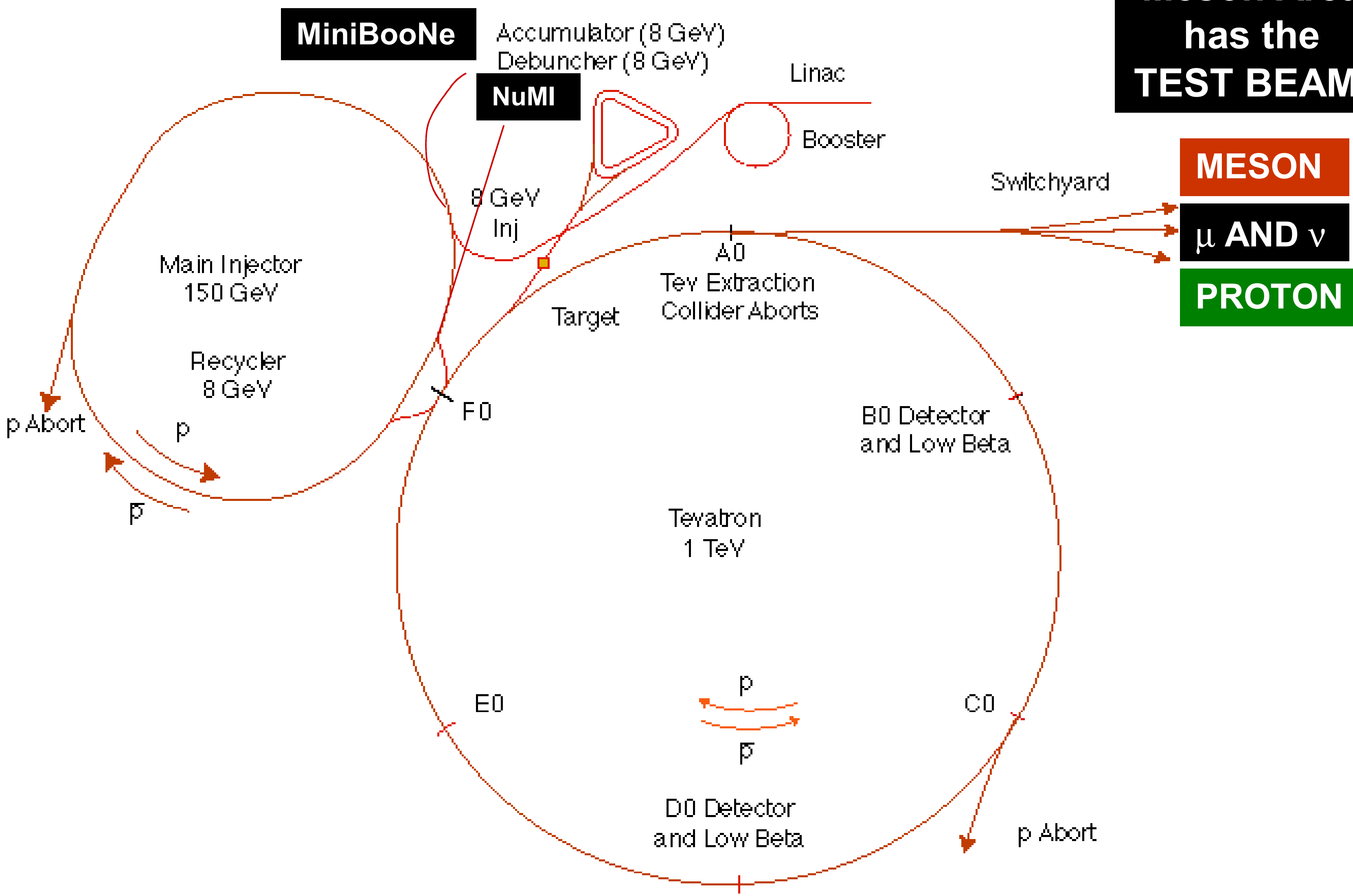
1. Introduction to Fermilab Accelerator Complex
2. Introduction to Fermilab Fixed Target Beamlines
3. Fermilab Test Beam Facility
4. Present Test Beam Capabilities
5. Approved and Planned Experiments – A Brief Overview
6. What We Intend to do for "YOU" – YES "You the Users"
   - ✓ Gain from Reducing Material in the MTest Beamline
   - ✓ Further Gain from Reduced Length of the MTest Beamline
   - ✓ Meson Center as a possible Test Beam Option
7. Test beams for LHC, NOνA, MINERνA & the ILC
8. Summary & Conclusion

THE FERMILAB ACCELERATOR COMPLEX



THE FERMILAB ACCELERATORS

Meson Area has the TEST BEAM.



Brajesh Choudhary, FNAL

FERMILAB TEST BEAM – WE ARE EVEN ON THE WEB

Meson Test Beam Facility http://www-ppd.fnal.gov/MTBF-w/

Meson Test Beam Facility

Introduction

The Meson Test Beam Facility is a versatile beamline in which users can test equipment or detectors in a beam of moderate energy particles (5-120 GeV) at moderate intensities (<1 MHz). Beamtime is available to qualified users as discussed below.

Weekly schedule for primary user

Assignment of user areas

MT6 Phone Numbers

Beamline and experimental area details

How to become a test beam user

Resources available for approved test beam users

"How to..." Pages

Meson Test Beam Facility MOU's

Meetings and Talks

Email archive for test_beam@fnal.gov

Useful links to Beams Division status and logs

Pictures

1 of 2 8/16/05 7:50 PM

Beamline Details http://www-ppd.fnal.gov/MTBF-w/MTBF_beamline.htm

Details of beamline and user areas:

A layout of the Meson Lab, MTest beamline elements and MTest user areas can be found here:

- MTest User Areas Rough Outline (ps,ppt)
- Meson Lab Drawings (pdf) (ps)
- Meson Lab Autocad file (AutoCad) (IDEAS)
- MTest User Areas with radiation survey data (ps)
- MTest Beamline Elements (pdf)
- All SY120 Beamline Elements (pdf)
- Electrical system at Mtest (pdf)

A description of the time structure of the beam: (txt)

Results on composition of beam using Cerenkov detectors:
- Threshold plots: 120 GeV , 66 GeV , 33 GeV , 16 GeV , 8 GeV
- Threshold pressures vs momentum (Excel)
- Documentation of threshold curves

Study of multiple tracks as a function of rate and gate width: (postscript)

Tune parameters:

- 120 Gev, narrow beam (pdf)
- 120 Gev, recent tune (pdf)
- 66 Gev (pdf)

A spreadsheet has been made by the beamline physicist, Tom Kobilarcik. Here is the latest version of this spreadsheet and the resulting predicted rates as a function of momentum. (pdf,word)

MTest beam sheet and data file

Safety documents related to the MTest facility are here:

- PPD Safety Assessment Document/Readiness Review (doc)
- MTest User Areas Radiation Assessment Calculation (ps)
- Radiation Shielding Assessment for the MT6 area (doc)

The MTest beamline was operated in 1999 for test purposes with an 800 GeV primary energy and a description of the operation of that run is in this memo:

- A New MTest Beamline for the 1999 Fixed Target Run
  T. Kobilarcik, C. Brown (ps, pdf)

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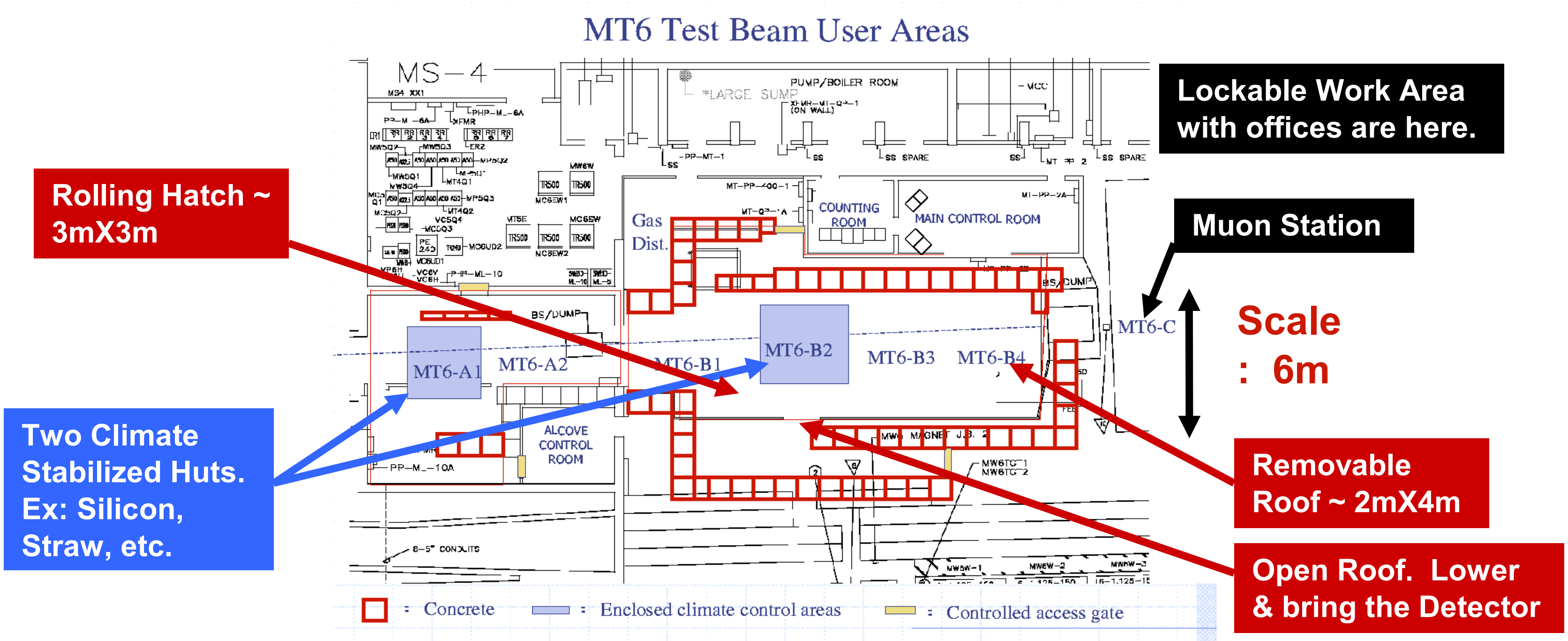
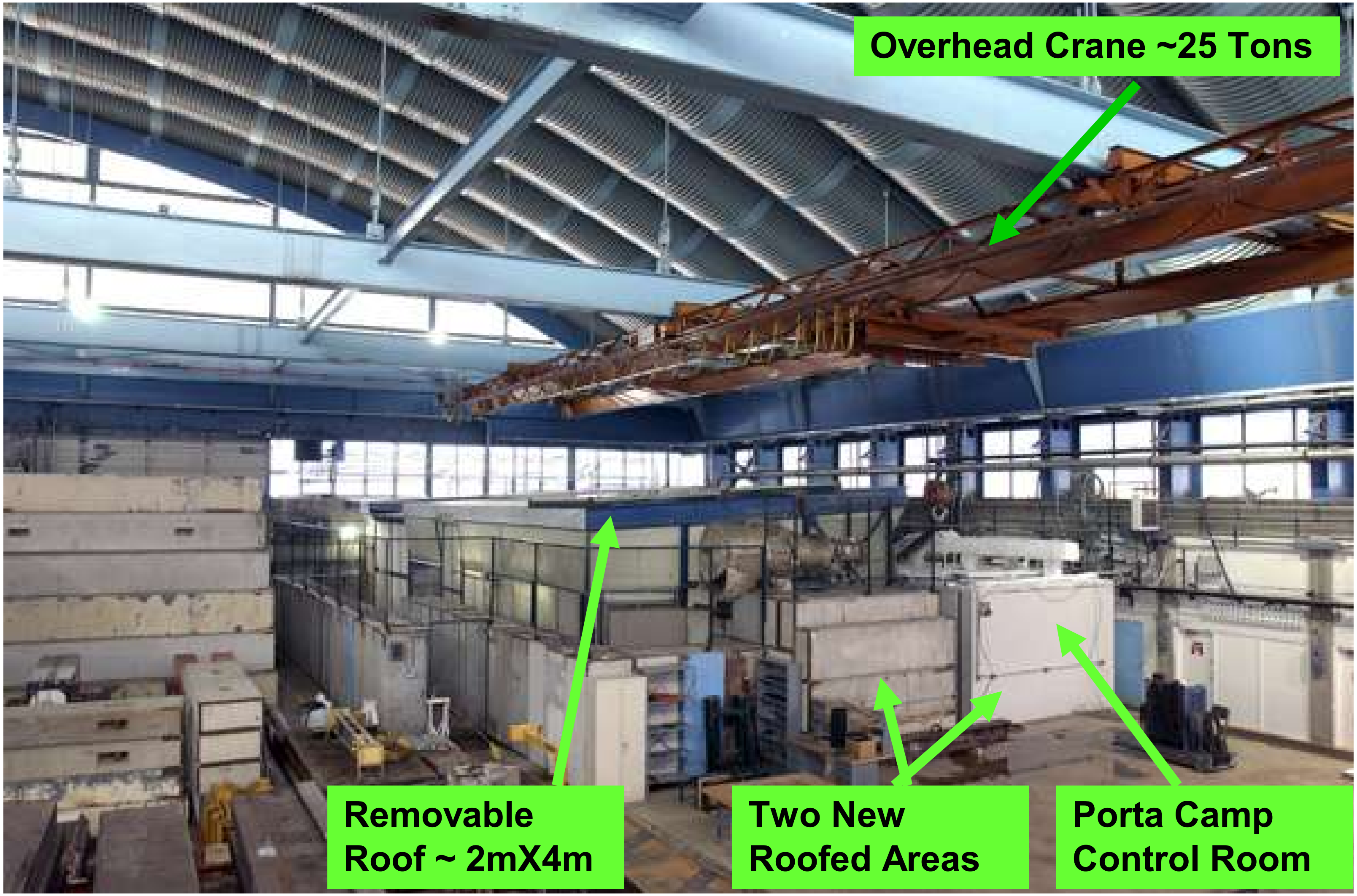
- ✓ **Web page for Test Beam at Fermilab http://www-ppd.fnal.gov/MTBF-w**
- ✓ **Test Beam Coordinator: Erik Ramberg - ramberg@fnal.gov**
- ✓ **MTest Beamline Physicist : Brajesh Choudhary - brajesh@fnal.gov**

MTEST BEAM USERS AREA



- ✓ 2 beam enclosures, but cannot be operated independently. A survey of MT6B with beam ON in MT6A, showed levels to be too high to allow access. Work on beam stop and some more shielding is needed in MT6A to operate both areas independently. Not a major job.
- ✓ 6 user stations, with a 7th downstream of the beam dump. Can be easily used for muon data. An experiment can take up more than one station.
- ✓ 2 climate stabilized huts with air conditioning.
- ✓ 2 separate control rooms.
- ✓ Outside gas shed + inside gas delivery system brings 2 generic gas lines, 1 nitrogen line and 2 exhaust lines to each of the user areas
- ✓ Lockable work area with 3 offices for small scale staging or repairs, plus 2 open work areas.

MESON LINE – THE BLUE & RED BUILDING – INSIDE VIEW

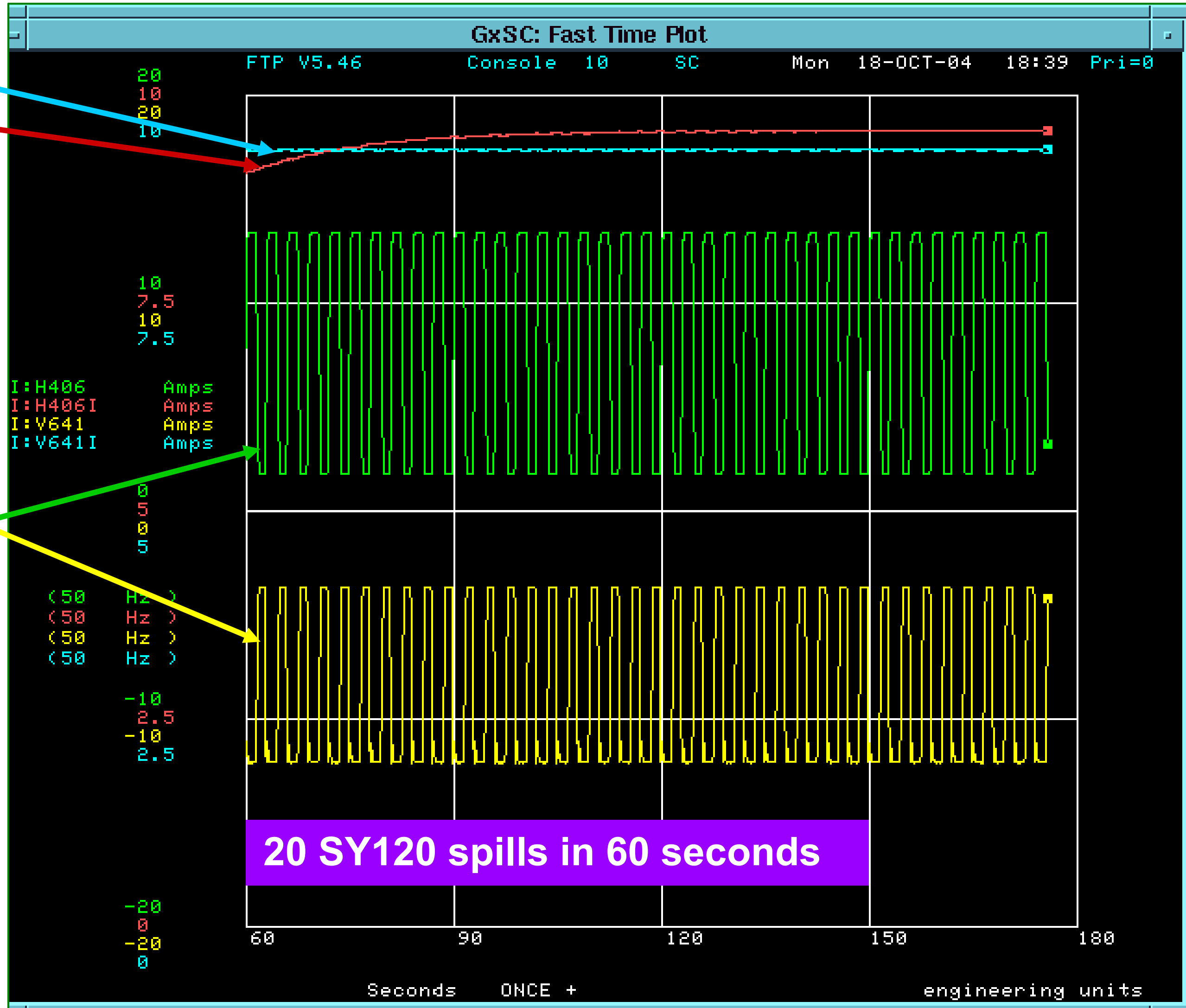


TIME STRUCTURE OF THE TEST BEAM

1. The test beam originates from varying number of Booster batches (from 1 to 6, but usually 1 or 2 batches) injected in Main Injector (MI) at 8 GeV and accelerated to 120 GeV in the MI and resonantly extracted.
2. Each batch can consist upto 84 RF “buckets” (usually we run with 30 to 60 buckets) with each RF bucket 18.8ns (53103202 Hz) long. Thus the beam train is usually ~0.6μs to 1.2 μs long.
3. The full circumference of the MI is ~11μs.
4. The length and duty cycle of the spill is determined by the Accelerator Division (AD), with guidance from Program Planning.
5. For most of 2004 SY ran with single ~3 sec cycle, 0.6 second flat top per minute. In late 2004, early 2005 we did run with 5-6 cycles/minute (0.6 sec flat top each) when pbar stack was getting larger and the cycle time for pbar was increasing.
6. A test was done to see how many 3sec cycle (0.6 sec flat top) one can run. If MI is completely dedicated for SY one can run upto 20, 3sec cycles/minute.
7. With NuMI and MIPP in operation, since April 2005 we operate with a single slow spill of 6 sec with a 4 sec flat top duration every one or two minutes as decided by the Program Planning and the Run Coordinator.

THE BEST THE ACCELERATOR CAN DO

Ramp RMS Current < 10A



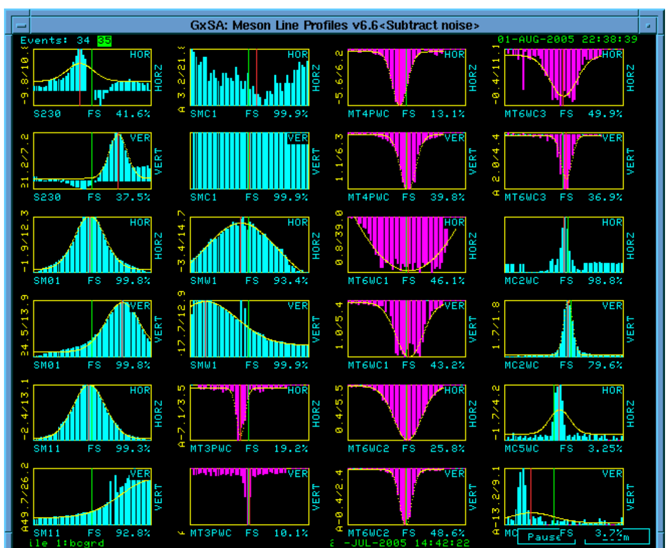
Ramp Corrector Current

Courtesy

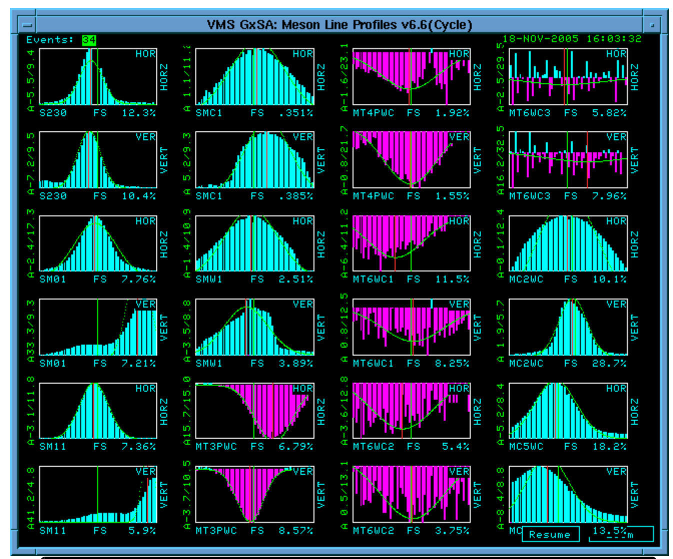
Dave E Johnson

OPERATIONAL CHARACTERISTICS OF MTEST LINE

- **120 GeV protons from MI impact on a 40 cm long block of Aluminum as a production target.**
- **There are two operational modes of the Meson test beamline:**
  - **Proton Mode:** Tune the beamline for 120 GeV protons that get transmitted to the target
  - **Secondary Mode:** Vary the tune of the beamline according to the requested momentum. Maximum secondary momentum is 66 GeV, while the minimum momentum achieved so far is 3GeV. Lower than 3GeV momentum beam is possible, but in the present setup pion rate will be quite low and electron scattering will probably be quite high. But if the target is moved downstream then higher pion and electron rate could be achieved simultaneously.
- Spot sizes can be made as small as 2-5 mm RMS and as large as 5 cm RMS with 120 GeV protons.
- Momentum spread – From Calorimeteric studies – 1-2% peak in the electron data.



1st August 2005 – 120 GeV Beam - 1mm wire spacing – 2-5mm RMS in vertical & horizontal @MT6SC2

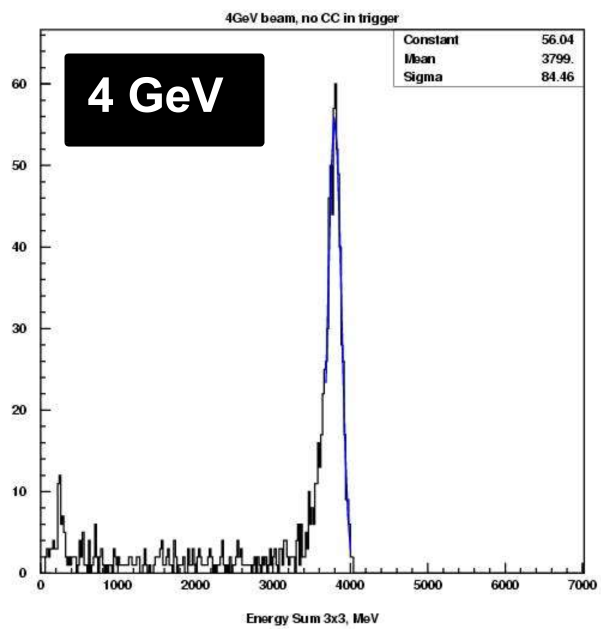


18th November 2005 – 8 GeV Beam - 1mm wire spacing – ~12mm RMS in both planes @MT6SC2

ELECTRONS AT MTEST

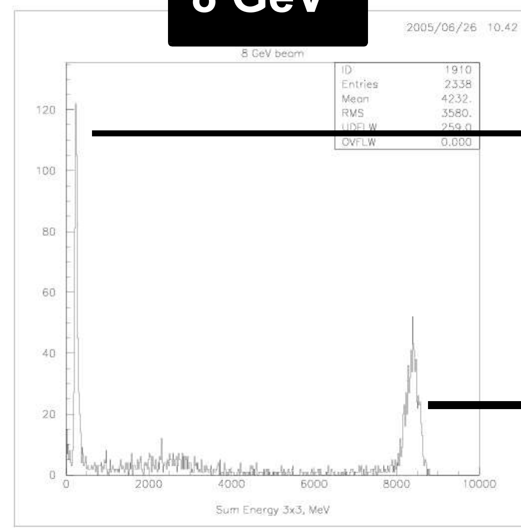
- ✓ Lead tungstate calorimeter calibrated using MIP peaks
- ✓ Momentum selected electrons identified in 4, 8, 16 & 33 GeV beam.
- ✓ Vacuum improvement during summer of 2005 lead to better electron peak
- ✓ Two Cerenkov counters used in trigger for 4 & 33 GeV data

4 GeV



~60% Electrons

8 GeV



MIPs p, π's and μ's @ 250 MeV.

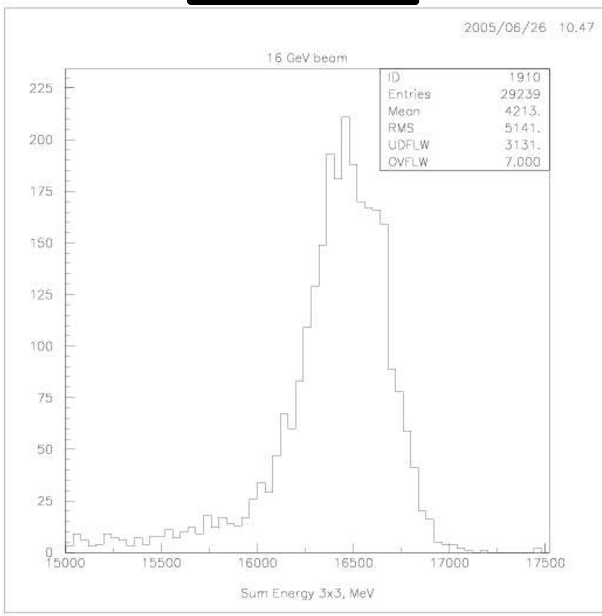
e peak

~30% Electrons

Trigger was coincidence of two scintillation counters only

ELECTRONS AT MTEST

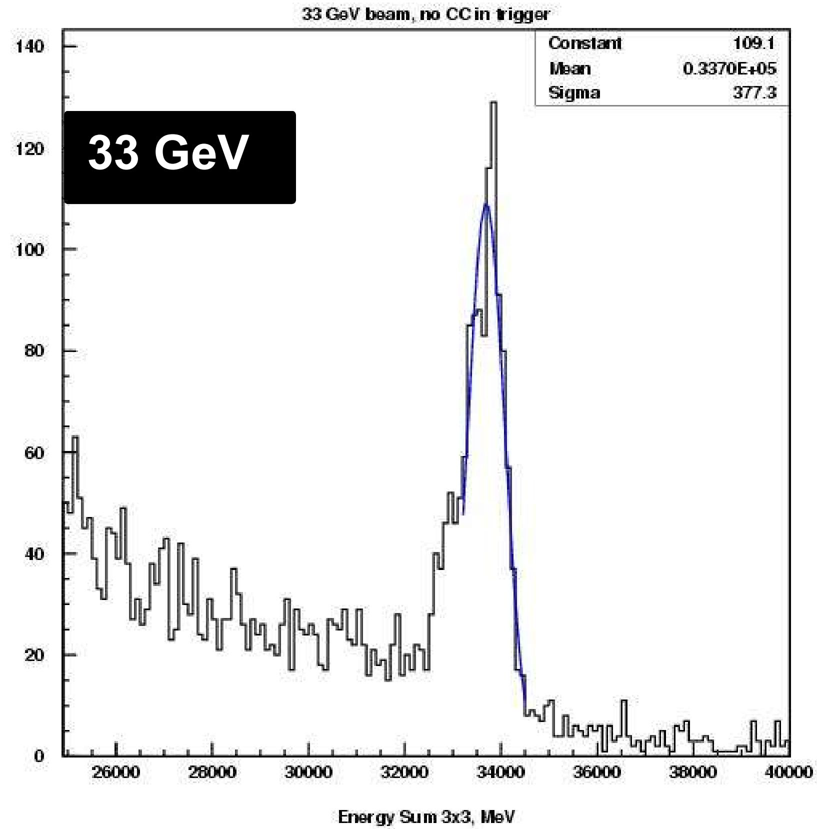
16 GeV



~10% Electrons

Trigger was coincidence of two scintillation counters only

33 GeV



~0.7% Electrons

For Plots – Thanks to

Pavel Semenov & Justine Hietala

PRESENT RATE IN THE MTEST BEAMLINE

Particle Energy (GeV)	Protons/spill from the Main Injector	Rate measured @MT6SC2	Beam Condition (Batches, Bunches, Turns)	MT6SC2 rate normalized to 1E12 protons/spill from MI	Electron Fraction
120	2E12	850-900K	5, 84, 1	~400-450K	---
66	2.1E12	205K	2, 84, 3	~100K	---
33	2.1E12	61K	2, 84, 3	~30K	~0.7%
16	2.1E12	42K	2, 84, 3	~20K	~10%
8	2.1E12	11K	2, 84, 3	~5K	~30%
4	1.5E12	1050	2, 84, 2	~700	~60%
3	1.5E12	250	2, 84, 2	~160	Mostly Electrons

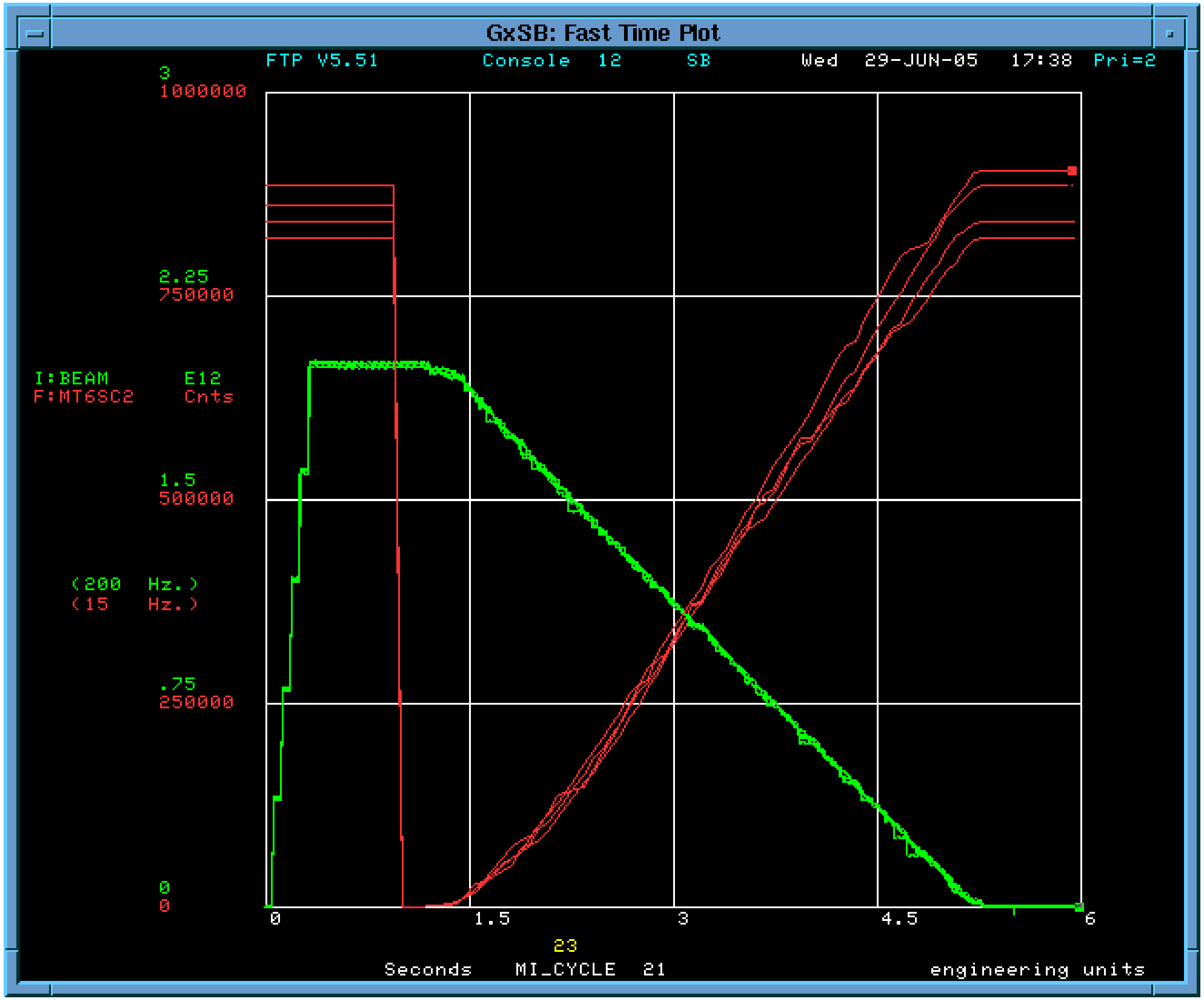
Shielding limits in various sections of MTEST are:

2E12 protons/2.9sec from M02 to M03 pinhole collimator

2E7 particles/2.9sec from M03 pinhole collimator and downstream

7E5 particles/2.9sec in the MT6 experimental area.

SY120 TIME STRUCTURE & RATE – 120 GeV



Wed Jun 29 17:48:43 comment by...Brajesh --

MTEST high intensity run at 120 GeV.
We are running 5 batches, 84 bunches, 1 turn, IBEAM ~1.9E12.
With 6 batches, 84 bunches, 1 turn the beam in MI becomes unstable.
The same happens when we go to 3 batches, 84 bunches and 2 turns.
More high intensity tests next time.

SY120 TIME STRUCTURE & RATE – 4 GeV

Thu Nov 24 12:22:27 comment by...chuckb --

This is a 4 GeV tune in Mtest that is getting ~1000 counts with an intensity of about 1.5E12 in the MI (2 batches, 2 turns, 84 bunches).

Brajesh Choudhary, FNAL

SY120 TIME STRUCTURE & RATE – 3 GeV

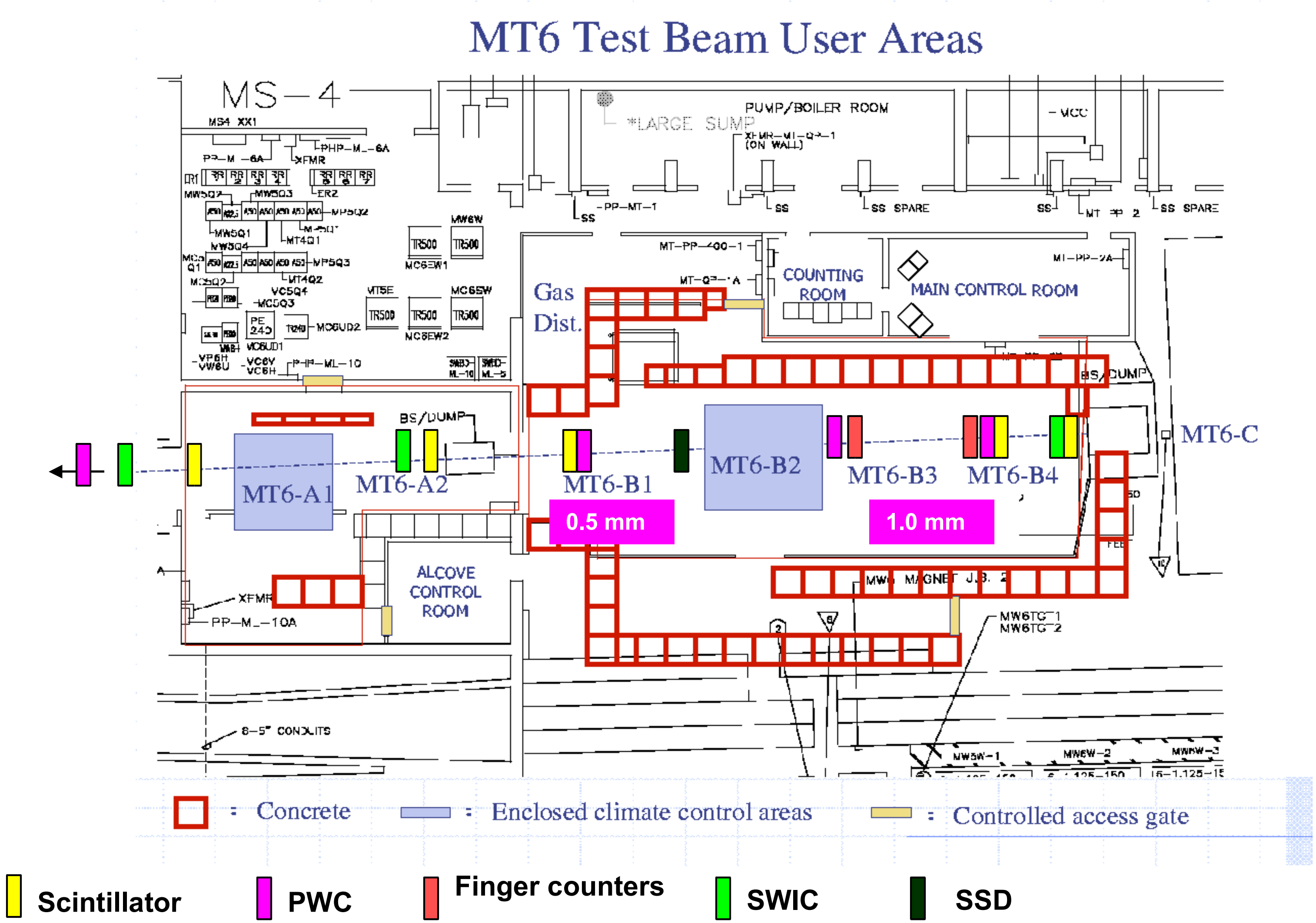
Thu Nov 24 12:50:46 comment by...chuckb --

A +3 GeV tune in MTest that gets about 200+ counts per spill at 2 batches, 2 turns, 84 bunches or about 1.5e12 protons/pulse.

WHAT DETECTORS DO WE HAVE ?

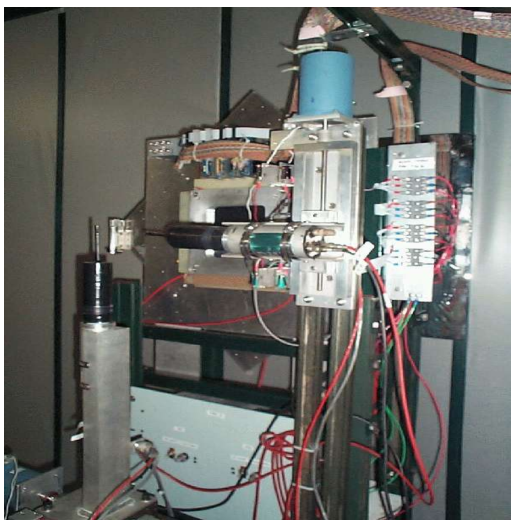
- ✓ Two beamline threshold Cerenkov counters 50’ and 80’ long can be operated independently for good particle identification
- ✓ One stations of X, Y silicon strip detectors are installed
- ✓ One 0.5mm pitch and two 1.0mm pitch MWPC in the DAQ system
- ✓ Three 1.0mm pitch MWPC into the accelerator ACNET control system
- ✓ DAQ accepts custom triggers and dead time veto. The data from scintillators, Cerenkov counters, silicon and MWPC goes into an event buffers.
- ✓ Buffers are readout during and after the spill and this data is accessible to experimenters. A three bit event identification is included in each event
- ✓ Experimenters can add their own trigger and dead time signals.

MTEST BEAM FACILITY DETECTORS



DETECTOR PHOTOGRAPHS

One of the Cerenkov Counters



Remote Controlled Scintillator Finger Counter

One of the Three PWC Stations

Silicon Tracker

FINISHED, APPROVED & PLANNED EXPERIMENTS?

T926: RICE

T927: BTeV Pixel

T930: BTeV Straw

T931: BTeV Muon

T932: Diamond Detector Research– Signed – Will Take Data

T933: BTeV ECAL

T935: BTeV RICH

T936: US-CMS Forward Pixel – Need More Data

T941: U. Iowa PPAC Test

T943: U. Hawaii – Monolithic Active Pixel Detector

T950: Straw Tracker – Need More Data

T951: ALICE EMCAL Prototype Test

T953: U. Iowa - Cerenkov Light Tests

T955: RPC Detector for ILC – Need More Data

T956: ILC Muon Detector Test – Indiana U., UCD, Notre Dame, Wayne State & Fermilab/ILC – Need More Data.

T957: NIU Tail Catcher/Muon Tracker for ILC

Jim Russ – CMU - Silicon Tracker for the LHC Upgrade

John Hauptman – Iowa U. - Dual Readout Calorimetry for the ILC

Wojtek Dulinski - Strasbourg - Irradiation Tests for the CMOS Chip

Victor Rykalin - NIU - Extruded Scintillator Light Yield – ILC

Mike Albrow – FNAL - FP420 Silicon Tracking & Timing counters

Jae Yu – UTA - ILC Calorimetry - CALICE

HOW MUCH MORE IN THE PRESENT SITUATION?

At present, at lower momentum we may be limited in rate. ***Without any change in the present situation a rate increase of 8-10 can be easily achieved by:***

1. Timeline - SY runs for 5% of the timeline, that is 1 spill every 2 minutes. If timeline can be increased to 10% as done for MINOS/MIPP study, **one can gain by a X2.** This increase in my opinion doesn't seriously impact either the collider or the neutrino experiments. This increase needs Director's approval and need to have physics justification. Usually MTEST by itself seldom runs for 24 hours. In case of MC does not have a running experiment, one can easily run Mtest for 12-16 hours/day with higher repetition rate. These depend on evolving situation at Fermilab.

2. Spill Structure – Is one 6 sec cycle with 4 sec flat top adequate? Perhaps NO. In post MIPP era, one can go to 2, 3sec spill every minute, with one second flat top. **This will lead to a gain of X2** if one is not limited due to DAQ rate.

3. Beam Intensity - The quoted rates are for 1E12 ppp in the MI. One can easily go to 2.0-2.5E12ppp. We have run with such rates. **This gives a factor or 2.0 to 2.5.**

ISSUES WITH THE PRESENT SITUATION

What are the issues with the present situation as I have learnt?

2. Thermal cycling of the Quad – it is difficult to cool the quad for longer flat-top. But if one goes to shorter flat-top, one can definitely run more cycles. LCW temperature was looked into by some people and it is not sure that several (>1) cycles per minutes cannot be run with 4 sec flat-top.
3. Main Injector Power Supply Feeder Current Limitations – In order to ramp the MI power supply, certain supply voltage and current is needed. One can ramp the MI power supply and once at the flat top one can fall back at a different (lower) value. Need to be understood.
4. Power in MI RF stations – Technically thought not to be a problem.
5. MI corrector RMS Current Limit – is/was 10A. Raised on few to 12A. Trip limit on correctors can be raised – Requires some effort.

These are some of the issues which need to be better understood.

GAIN FROM REDUCING MATERIAL IN THE PRESENT MTEST BEAMLINE

The transmission of secondary beam in the present MT beamline gets degraded due to large air gaps, several windows and various instrumentation materials. It is possible to reduce the total material that the secondary beam encounters. ***A GEANT model was used to study the hadron and electron yields at the standard beamline energies.***

Type of Material	**Radiation Length (X_0)**	**Interaction Lengths (λ)**
Air	**0.055**	**0.022**
17 Windows	**0.049**	**0.007**
Scintillators	**0.038**	**0.020**
PWCs	**0.036**	**0.008**
Total	**0.18**	**0.057**

Materials up to MT6SC1

The exact thickness of windows are not known, so we have used a typical 4mils of Titanium.

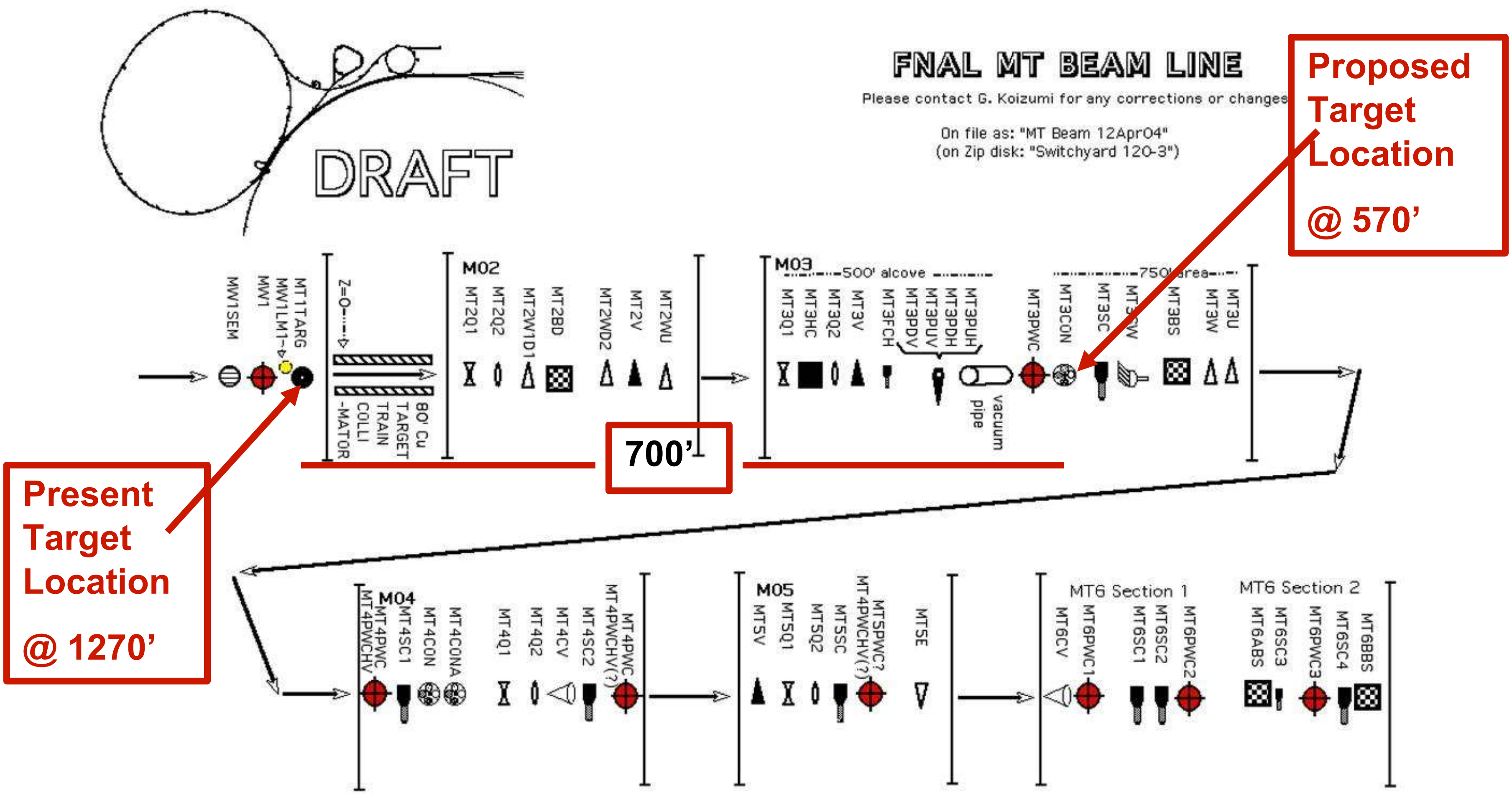
Energy (GeV)	Hadron Reduction due to Presence of Material in Beam	Electron Reduction due to Presence of Material in Beam
4	25	~90
8	6.4	14
16	2.5	6.3
33	1.4	4.2
66	1.2	1.9

Lets assume that we can remove only 50% of the material.
Lets be Conservative.

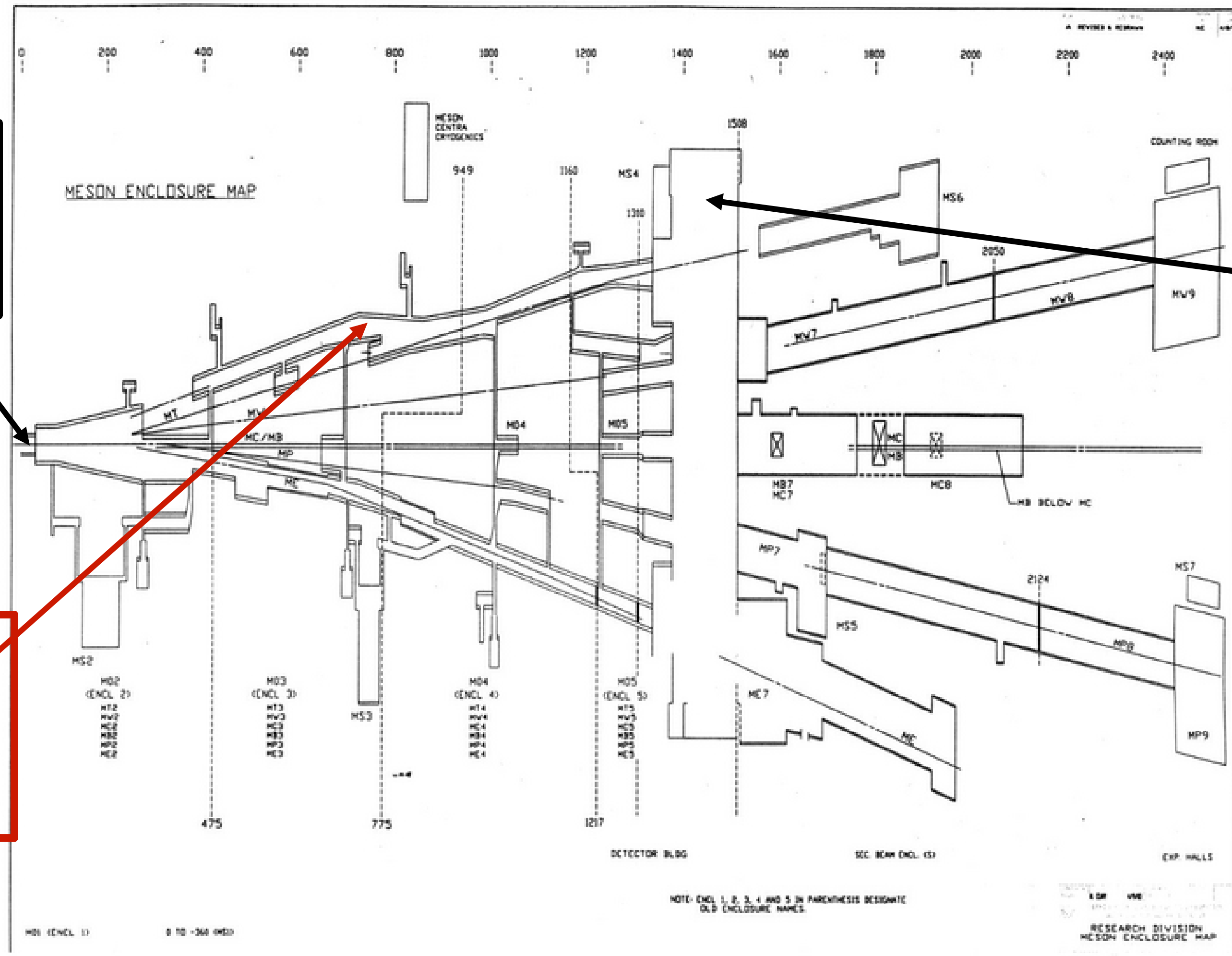
HOW MUCH MORE IN THE PRESENT SITUATION?

Energy (GeV)	Present MT6SC2 Rate for 1E12 PPS from MI	What can be done with the Present Long MTEST Beamline?	Gain due to Reduction of 50% material in the Beamline	Possible Overall Gain	Expected New Rate
1	---	Possible Gain by a Factor of **8 to10** due to Increased Beam Current X2.0-2.5, Rep Rate X2 & Spill Structure X2	----	----	
2	---		----	----	
3	~150		10	~100	10K+
4	~700		10	~100	50K+
8	~5K		3.0	~30	100K+
16	~20K		1.5	~15	200K+
33	~30K		1.2	~12	300K+
66	~100K		1.0	~10	~1000K

SCHEMATIC DIAGRAM OF THE MTEST BEAMLINE



THE MTEST BEAMLINE



40 cm Aluminum Target

Meson Detector Building

Proposed Target Location ~700' down

GAIN FROM MOVING PRIMARY TARGET DOWNSTREAM TO MT3CON

- Moving the target 700' downstream to MT3CON will
  - Reduce the amount of the material in the secondary beamline
  - Reduce the loss due to decays at lower momentum
  - Increase the fraction of pions at lower momentum compared to present rate

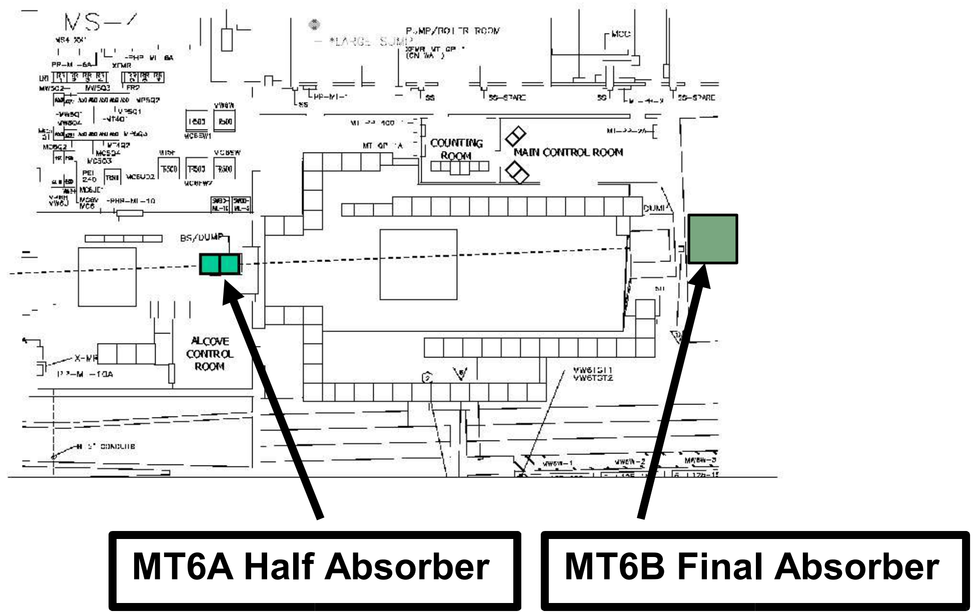
Energy (GeV)	Present MT6SC2 Rate for 1E12 PPS from MI	What can be done with the Present Long MTEST Beamline?	Gain due to Pion Decay factor	Gain due to reduced material in the shorter Beamline	Available gain due to momentum bite and phase space	Possible Gain due to Shorter Beamline	Possible Overall Gain
1	---	Possible Gain by a factor of **8 to10** due to Increased Beam Current X2.0-2.5, Rep rate X2 & Spill structure X2	45	---	Approximately **4 to 20** Momentum bite increases X1 to X5 And phase space increases by X4		
2	---		6.8	---			
3	~150		3.6	4.0		50 - 250	> 400 - 2000
4	~700		2.6	3.5		35 - 170	> 250 – 1200
8	~5K		1.6	2.0		12 - 60	> 100 – 500
16	~20K		1.3	1.5		7 - 30	> 50 – 250
33	~30K		1.1	1.0		4 - 20	> 35 – 200
66	~100K		1.0	1.0		4 - 20	> 30 – 150

WHAT DO WE HAVE AND WHAT CAN WE ACHIEVE?

Energy (GeV)	Present MT6SC2 Rate for 1E12 PPS from MI	With the Present Beamline – How Do You Increase the Rate?	Possible Rate with the Upgraded Present Beamline	With Target Moved Downstream – How Do You Increase the Rate?	Possible Rate with the shorter Beamline
1	---	Increased Beam Current + Rep rate + Spill structure + 50% Reduction in Beamline Material	---	Gain Due to Increased Beam Current + Rep Rate+ Spill Structure + Pion Decay Factor + 50% Reduced Material + Momentum Bite Spread + Phase Space Increase	---
2	---		---		---
3	~150		10K+		60K – 300K
4	~700		50K+		150K – 750K
8	~5K		100K+		0.5M – 2.5M
16	~20K		200K+		1M – 5M
33	~30K		300K+		1M – 5M
66	~100K		~1000K		3M – 15M

MUON RATE IN MTEST

- Beam absorber between MT6A and MT6B is composed of two 4.5 ft sections of steel.
- With both sections in place, and 120 GeV beam incident, rate of muons at back of MT6B is ~10^{-6} μ/p/cm^2
- With only one section in place, and 120 GeV beam incident, rate of muons at back of MT6B is ~2 x 10^{-5} μ/p/cm^2
- Results above have been verified behind last absorber as well.



MESON CENTER AS THE TEST BEAM OPTION

MCENTER is a relatively smaller beam line and hence the rates are higher compared to MTEST. Particles up to momentum of 1 GeV has been measured.

MCenter is currently unscheduled. A number of possible uses, including test beam use, have been suggested. Decisions will depend on proposals, scheduling, funding, and priorities at the time that decisions will need to be made.

TEST BEAM FOR LHC, NOυA, MINERυA & THE ILC

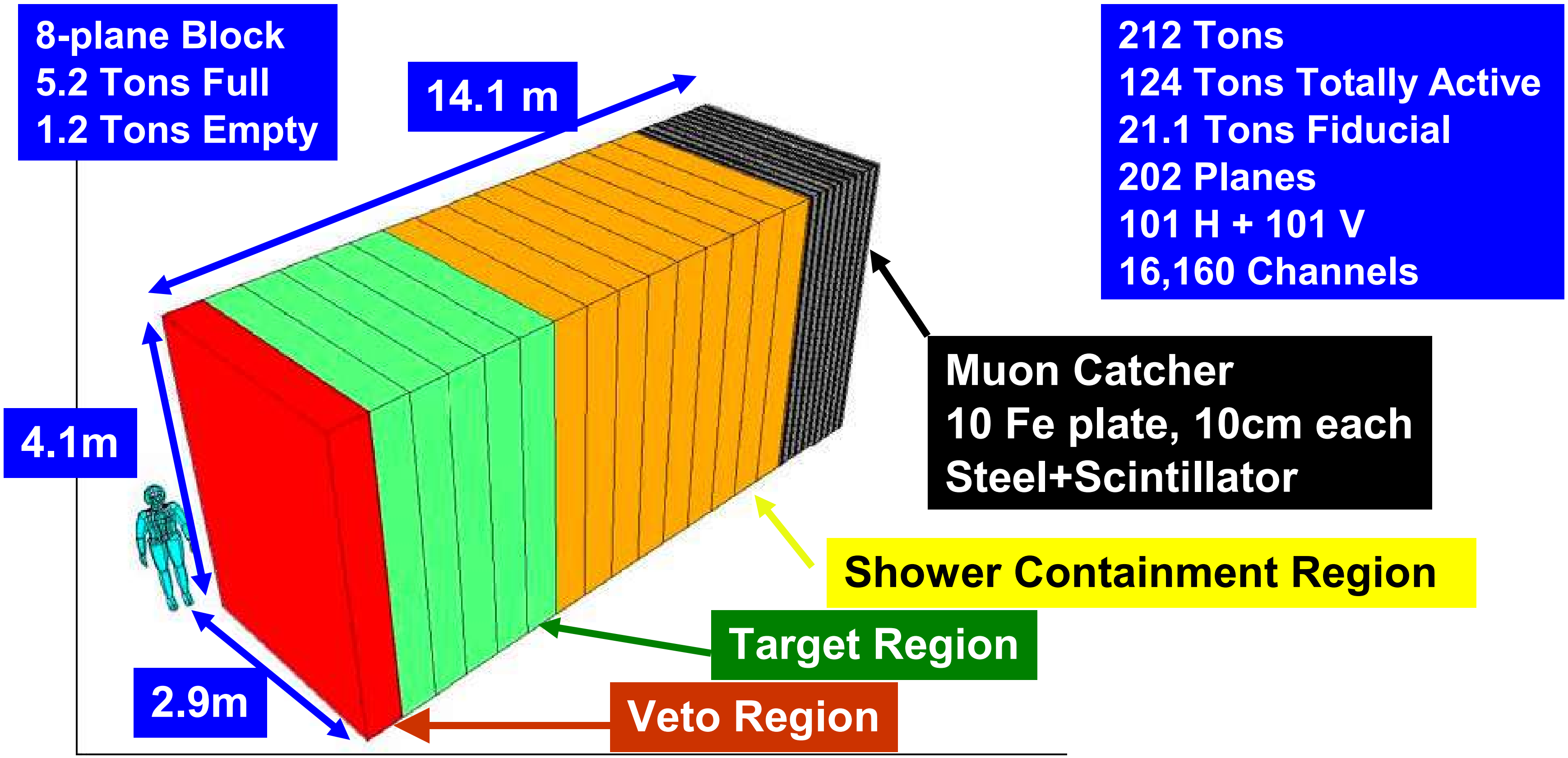
- ✓ LHC – *The Last Hadron Collider?* You don't need me to tell you about the LHC but they do use Fermilab's test beam facility.

- ✓ NOυA is a Fermilab experiment to measure sub-dominant $\nu_\mu \rightarrow \nu_e$ oscillation and thus θ_{13}, matter effect or hierarchy, and the CP violating phase δ in the lepton sector in a staged manner using a 30 KTon totally active liquid scintillator detector situated ~810 Km from Fermilab and ~12-15 Kms Off-Axis of the NuMI ν (and anti-ν) beam. NOυA will have a 212 Tons fully active movable near detector to measure ν_e content of the beam, characterize detector response to neutrino events & perform crucial background studies.

- ✓ MINERυA is a high statistics, high-resolution ν and anti-ν nucleon/nucleus scattering experiment to measure neutrino cross-section and probe nuclear effects essential to present and future neutrino-oscillation experiments. It will use ν and anti-ν beam from NuMI and a fully active 8.3 Tons target scintillator detector surrounded by sampling EMCAL, HCAL, and a muon system, located 1.5m upstream of the MINOS Near Detector in the MINOS hall.

- ✓ ***ILC – International Linear Collider.***

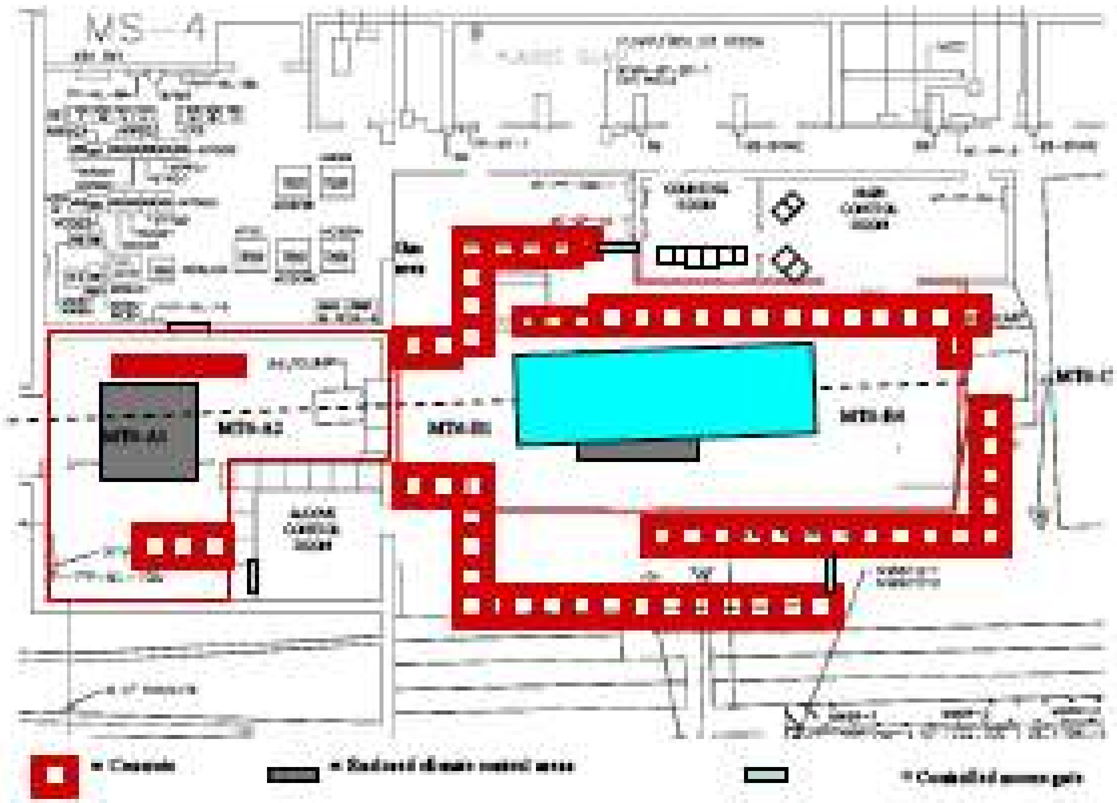
NOυA NEAR DETECTOR



- ✓ ND will measure ν_e content of the beam at Fermilab
- ✓ Characterize the detector response to neutrino events, &
- ✓ Perform the crucial background studies

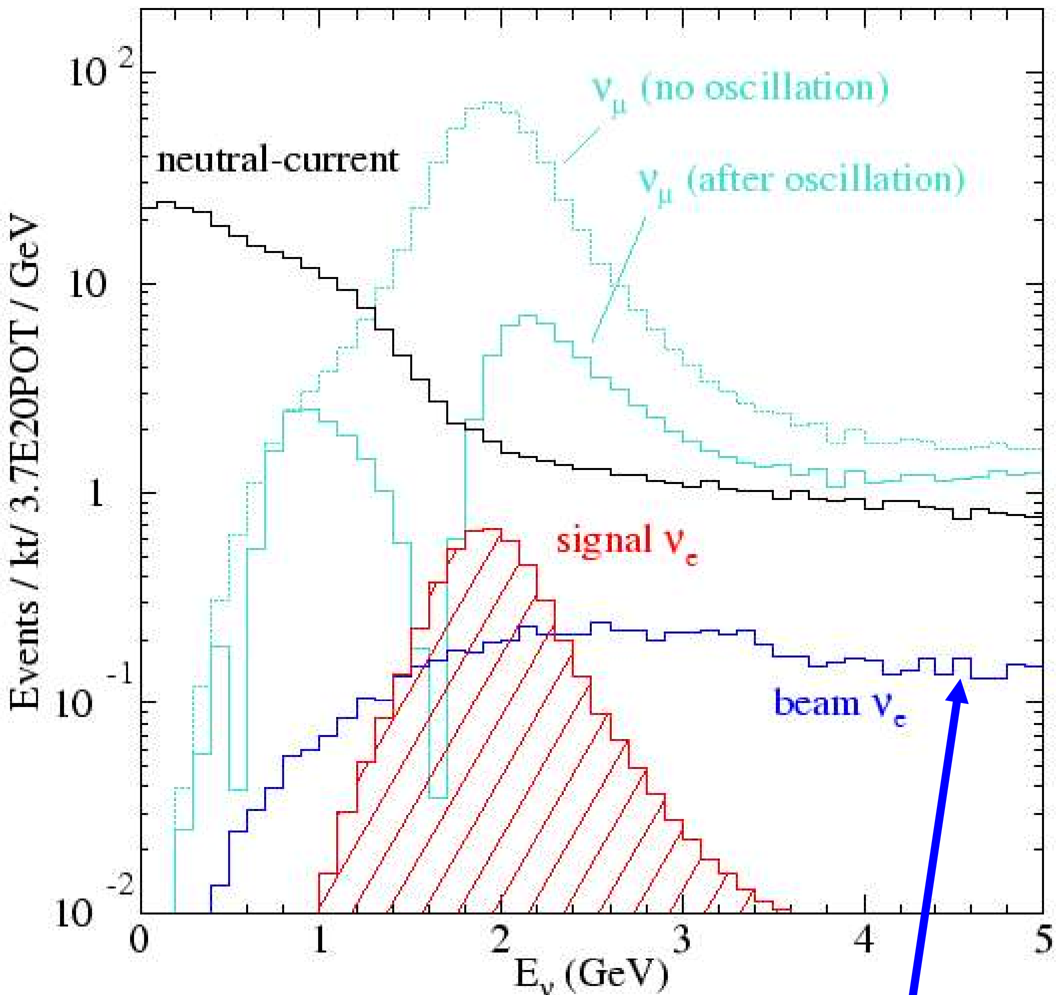
NOυA NEAR DETECTOR IN THE TEST BEAM

MT6 Test Beam User Areas



FNAL MTEST EXPERIMENTAL AREA WITH NOνA NEAR DETECTOR (IN BLUE) SUPERIMPOSED

NOυA SIMULATED ENERGY DISTRIBUTION



Mostly from μ and K_{e3} decays

EVENT RATES OFF NuMI BEAM AXIS

L = 810 Km

Off-Axis Distance = 12 Km

$\Delta m^2 2\theta_{23} = 2.5 \times 10^{-3}\ eV^2$

$Sin^2 2\theta_{23} = 1.0$

$Sin^2 2\theta_{23} = 0.01$

GOALS FOR THE DETECTOR

Most ν_μ oscillate away - Need only 50:1 ν_μ CC rejection

For NC background
- Need 100:1 rejection
- Fine grained low density detector does the job

To reject beam ν_e – Good detector energy resolution

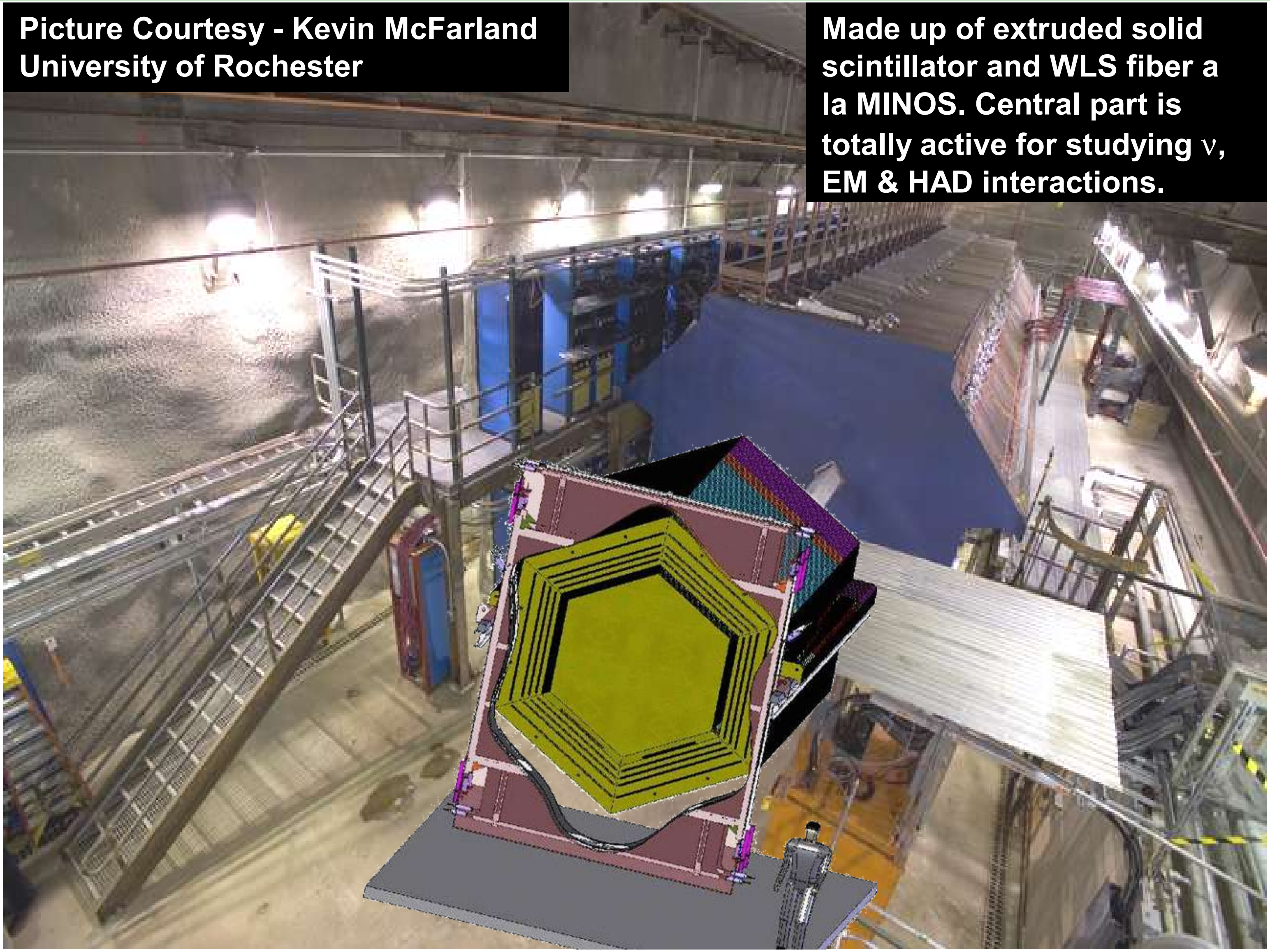
WHAT NOυA NEEDS?

1. NOυA Far Detector will be ~12-14 mrad (12-15Km) off-axis.
2. The tail of the ME NuMI beam for off-axis extends to 5 GeV and beyond.
3. Background from beam $\upsilon_{e,}$ NC feed-down etc. need to be studied.
4. Initially a small section of the NOυA near detector (ND) can be used to in the test beam. But it is possible that the entire ND could be put in the test beam.
5. NOυA ND will be made up of PVC extrusions, liquid scintillator with WLS Fiber and read out with APD's.
6. Oscillated υ_e signal will be in the neutrino energy range of ~ 0.7 – 3.5 GeV, but the background neutrino events extends in energy upto 5 GeV or more.
7. Electrons, pions, kaons, with momentum $p > 500$ MeV to ~ 4-5 GeV is needed to understand the backgrounds. The particle momentum should be known to a few percent, with an integrated particle identification system.
8. Muons catcher will also be needed.
9. Time Frame for test beam - 2008 – 2009 and beyond.
10. Rate – not yet defined. But proposed MTEST rate should be sufficient.

MINERνA IN THE TEST BEAM

Picture Courtesy - Kevin McFarland
University of Rochester

Made up of extruded solid scintillator and WLS fiber a la MINOS. Central part is totally active for studying ν, EM & HAD interactions.



WHAT MINERυA NEEDS?

- ✓ Minerνa needs to reconstruct beams of $\pi^{\pm}$, p, e, $\mu^{\pm}$ and $K^{\pm}$.
- ✓ It needs to measure response relative to minimum ionizing before showering, shower development and stopping signature.
- ✓ Muons and kaons will be used to study stopping particles.
- ✓ Protons, electrons and pions are needed at 0.25 GeV interval from 0.25 GeV to upto 3 GeV and at 0.50 GeV intervals from 3 GeV to 10 GeV.
- ✓ Muons and kaons are needed upto 2 GeV.
- ✓ Instrumentation to give the momentum better than 30% to 5% depending on p.
- ✓ Minerνa would like to install a configurable small detector (size yet to be decided) as a stand-in for the actual detector.
- ✓ Spot size to depend on the test module.
- ✓ 5-10K events of each particle type per momentum interval at rate yet to be understood.
- ✓ Expects to be ready for test beam by summer 2008.

Courtesy Jorge Morfin & Kevin McFarland

WHAT ILC WILL NEED?

- ✓ ILC will need electrons, pions, hadrons and muons at various momenta.
- ✓ Pions, hadrons and electrons of momenta 1 GeV and above will be needed.
- ✓ Test with high energy electrons can be done at DESY, SLAC or CERN as CALICE has done.
- ✓ We already provide electrons, pions, protons at a reasonable rate upto momenta of 3 GeV and above.
- ✓ We are hopeful that we can go to a momenta of 2 GeV and below.
- ✓ It is our understanding that good rate for electrons, pions, and hadrons from very low momenta (~1 GeV) to high momenta should be available after the Mtest beamline upgrade.

SUMMARY & CONCLUSIONS

1. MTest has successfully delivered and continues to deliver beam of various momentum to CMS pixel, ALICE, and PHENIX EMCAL, other test detector groups, including ILC RPC, muon tracker etc.
2. NOυA will need low energy electrons, pions, and hadrons.
3. MINERυA will like to reconstruct 0.3 - 5GeV energy pions and electrons, 1-5 GeV protons, and kaons/muons to study stopping particles.
4. In future we expect the ILC to be the major test beam user. ILC will need low energy pions, hadrons, electrons/positrons, and muons.
5. Studies are ongoing to upgrade the MTest beam line with the possibility of going down to lower momentum (~1GeV and below) and to have a reasonably good rate for electrons, pions and hadrons at all energies.
6. It is definitely possible to increase the particle yield at very low momenta by a factor of ~1000 or more.

7. We welcome the larger international community, especially the ILC world. COME TO FERMILAB.