TEST BEAM UPGRADE IN THE TIME OF MINERυA, NOυA, & THE ILC

Brajesh Choudhary, Fermilab for

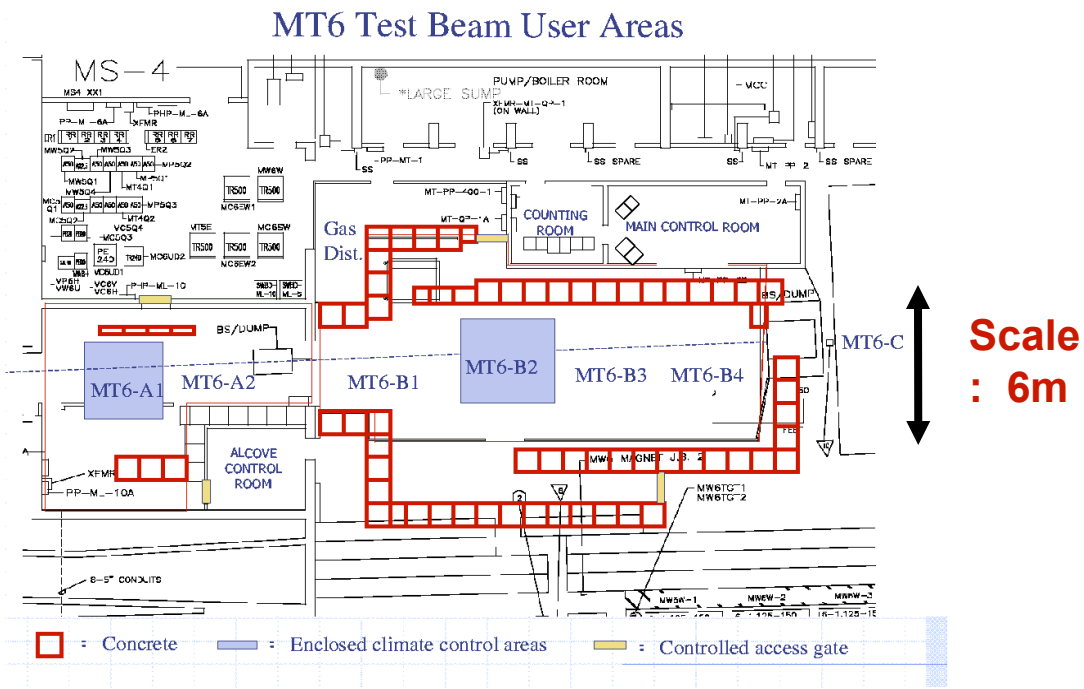
Charles Brown, BCC, Richard Coleman, Carol Johnstone, Craig Moore, & Erik Ramberg

13th December 2005

PLAN OF THE TALK

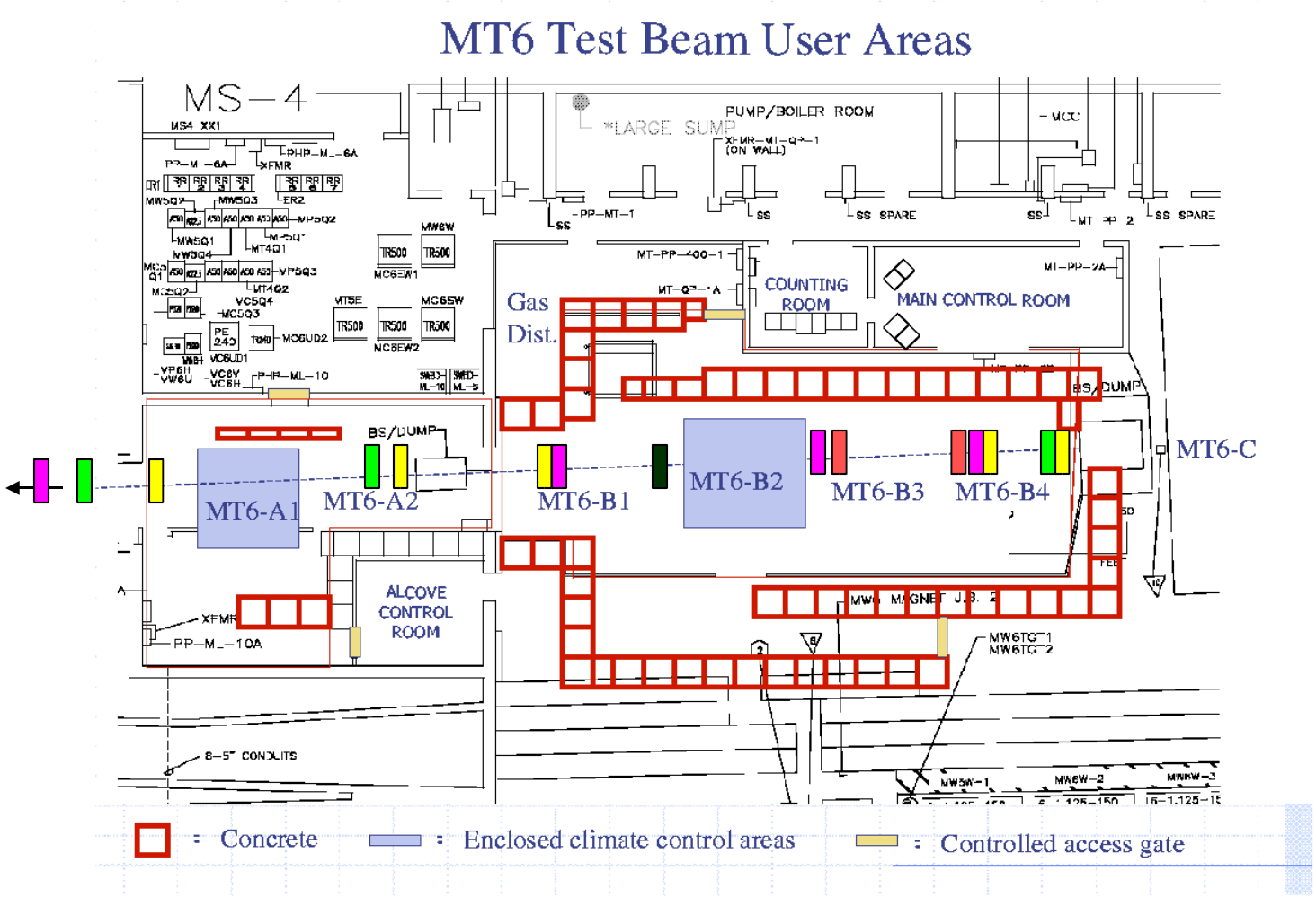
1. Introduction to Meson Test (MT) Beamline
2. Present Test Beam Capability
3. How Much More Without Fundamental Changes?
4. Gain From Reducing Material in the MT Beamline
5. Further Gain from Reduced Length of the MT Beamline
6. Summary & Conclusion

MTEST BEAM USERS AREA



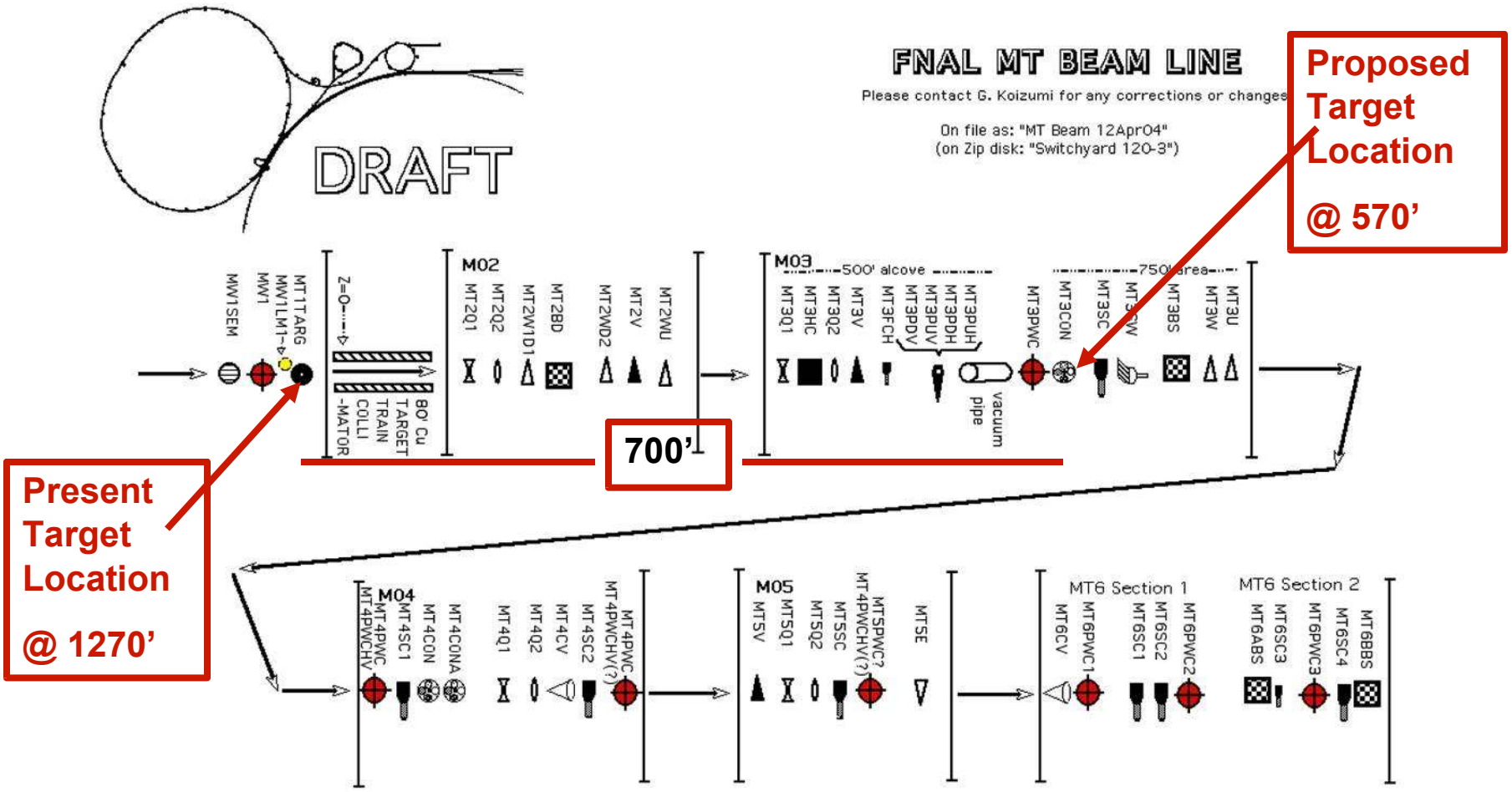
- ✓ 2 beam enclosures, but cannot be operated independently. A survey of MT6B with beam ON in MT6A, showed levels to be too high to allow access.
- ✓ 6 user stations, with a 7th downstream of the beam dump. An experiment can take up more than one station.
- ✓ 2 climate stabilized huts with air conditioning.
- ✓ 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.

MTEST BEAM FACILITY DETECTORS



Scintillator | PWC | Finger counters | SWIC | SSD

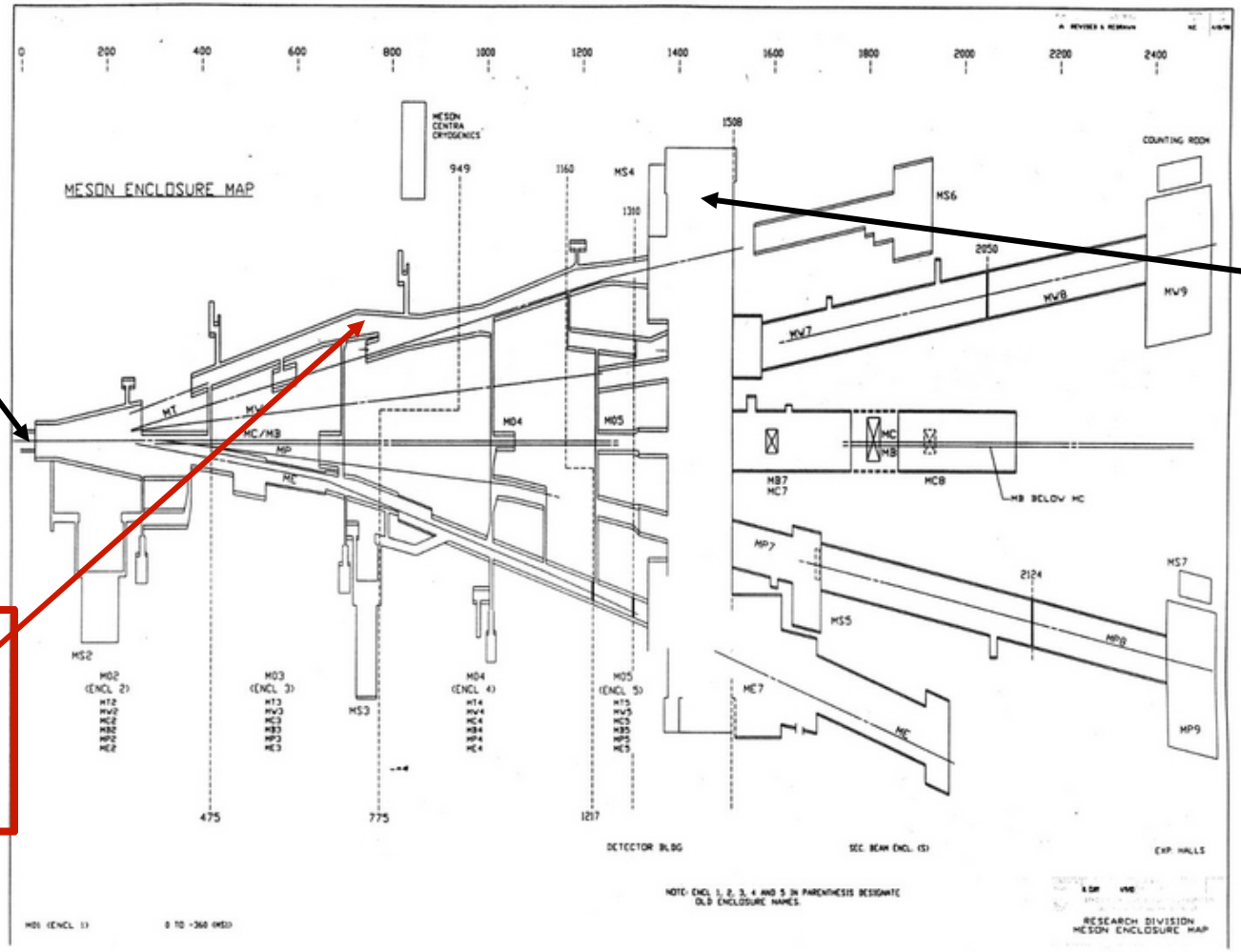
SCHEMATIC DIAGRAM OF THE MTEST BEAMLINE



40 cm Aluminum Target

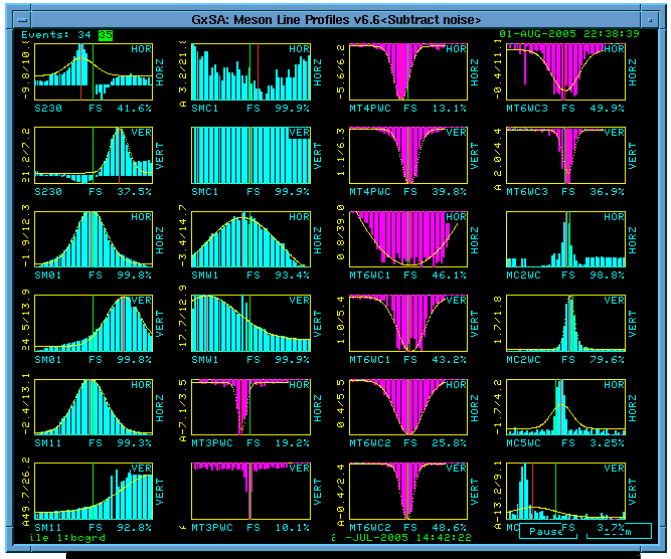
Meson Detector Building

Proposed Target Location ~700' down

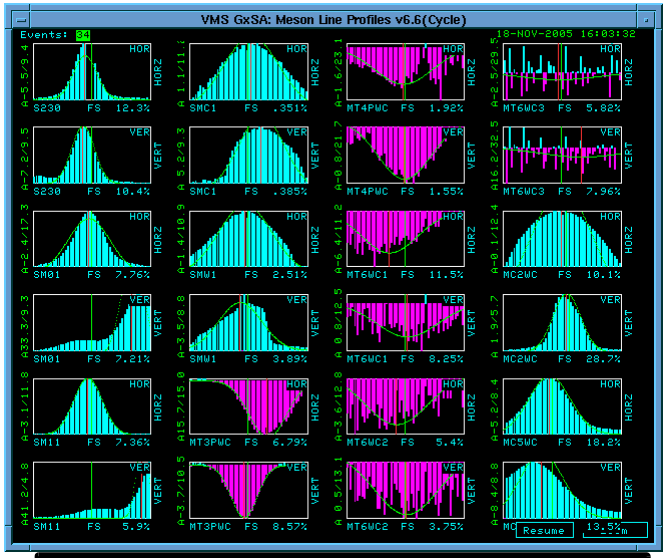


OPERATIONAL CHARACTERISTICS OF MTEST LINE

- **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 rate could be achieved.
- 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 BTeV calorimeter 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

PRESENT RATE IN THE MTEST BEAMLINE

Particle Energy (GeV)	Protons/spill (From the MI to SY120) - ***	Rate measured at MT6SC2	Date rate measured	Beam Condition (Batches, Bunches, Turns)	Source of Information	MT6SC2 rate normalized to 1E12 Protons/spill	Electron Fraction$$
120	0.5-0.6E12 2E12 1.0-1.2E12 2.1-2.2E12	150-180K 850-900K 400-500K 740K	1st Aug. 05 29th Jun. 05 29th Jun. 05 4th Dec. 05	1, 60, 2 5, 84, 1, 3, 84, 1 2, 84, 3	EBL BCC Log EBL EBL (IC)	 400-450K 325K (Not completely optimized)	0
66	1.0-1.1E12 2.1-2.2E12	35-40K 205K	28th Jun. 05 3rd Dec. 05	3, 84, 1 2, 84, 3	EBL EBL (IC)	35-40K ~100K – (Better Tuned)	~0
33	0.35E12 0.35E12 2.1E12	11K 12K 61K	18th Aug. 04 22nd Nov. 05 3rd Dec. 05	1, 60, 2 NA 2, 84, 3	EBL EBL EBL (IC)	30K (Seems 30K is the optimized number)	~0.7%
16	0.50-0.55E12 2.1-2.2E12	8.5K-9.5K 42K	10th Nov.05 4th Dec. 05	1, 60, 2 2, 84, 3	EBL EBL (IC)	~17-20K (Looks like optimized value)	~10%
8	1.1E12 0.85E12 2.1-2.2E12	5.5K 2.0K 11K	18th Nov.05 1st Jul. 05 4th Dec. 05	1, 84, 3 3, 84, 1 2, 84, 3	EBL EBL EBL (IC)	5K %%(Better Tuned) 2.4K 5K %%(Better Tuned)	~30%
4	1.0E12 0.8-0.9E12 1.5E12	~330 150-200 1050	19th Nov. 05 1st Jul. 05 24th Nov. 05	1, 84, 3 3, 84, 1 2. 84, 2	EBL EBL EBL	220-330 %% 700## (Better Tuned)	~60%
3	1.5E12	250	24th Nov. 05	2, 84, 2	EBL	160 (First Time)	Mostly electrons

1. IC – means incomplete information. Information on IBEAM is not in EB logbook. I plotted I:BEAM information for those days and it mostly varied between 2.1E12 to 2.2E12. A ±5% error on these numbers is not a big deal.
2. The spill length is 6 sec. Flat top for beam extraction is 4 sec. At present one spill every 2 minutes is allocated to SY120.
3. *** - Beam shared by MCenter and MTEST. Thus the actual proton used for secondary particle production in MTEST is less than what is defined in column 2. If only MTEST gets all the beam the rate in column 7 can be increased by ~25-33%.
4. $$ - Information from Erik Ramberg and test beam users.
5. %% - Although for 8 and 4 GeV, a large variation in measured rate is shown, I will be more inclined to take the larger of the numbers as baseline measured rate. At lower energy, especially at 8 GeV and below, proper tuning is very crucial for higher rate as evidenced from large rate variation.
6. ## - Effect of proper tuning. Chuck's Magic hand.
7. Shielding limit in MTEST is
    a. 2E12 protons/2.9Sec from M02 to M03 pinhole collimator, and
    b. 2E7 particles/2.9Sec from M03 pinhole collimator and downstream.

HOW MUCH MORE IN THE PRESENT SITUATION?

1. At present, at lower momentum we are limited in rate. *Without any change in the present situation a rate increase of 8-10 can be easily achieved by:*
   - ✓ 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 doesn't seriously impact either the collider or the neutrino experiments. This increase needs Director's approval and need to have physics justification.
   - ✓ Spill Structure – Is one 6 sec spill with 4 sec flat top adequate? NO. Longer flat top leads to heating of quads in MI and one gets limited to a 6 sec spill/minute. 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.
   - ✓ 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.
2. What are the limitations in the present situation?
   - ➢ Thermal cycling of the quad – cannot cool the quad for longer flat-top. But if one goes to shorter flat-top, one can definitely run more cycles. – From Ioanis Kourbanis.
   - ➢ Main Injector Power Supply Feeder Current Limitation – Not a big problem – DEJ.
   - ➢ Power in MI RF stations – A solvable Problem – DEJ.
   - ➢ MI Corrector RMS Current Limit – was 10A. Raised on few to 12A. Trip limit on correctors can be raised. – Difficult but a solvable problem – DEJ.

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

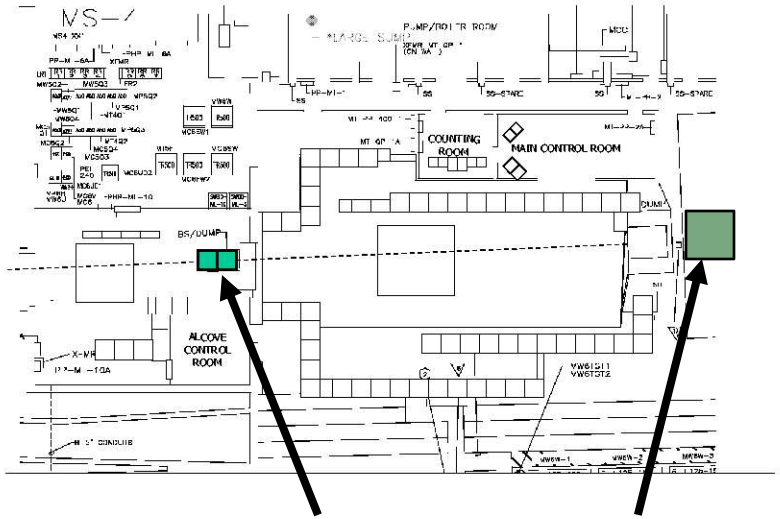
GAIN FROM MOVING PRIMARY TARGET DOWNSTREAM TO MT3CON

- Moving the target downstream to MT3CON will
  - Reduce the amount of the material in the secondary beam
  - Reduce the loss due to decays at lower momentum
  - Increase the fraction of pions in beam at lower momentum compared to present rate
  - Increase the spot size to ~ ±2” in both planes

Energy (GeV)	Present MT6SC2 rate for 1E12 PPS from MI	What we can do now with a 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 **20** Momentum bite increases **X5** And phase space increases by **X4**		
2	---		6.8	---			
3	~150		---	---			
4	~500		2.6	7.4		>300	>2000
8	~4K		1.6	3.8		~100	~1000
16	~18K		1.3	2.0		~50	~400
33	~30K		1.1	1.3		30	250
66	~100K		1.0	1.2		25	200

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.



MT6A Half Absorber

MT6B Final Absorber

SUMMARY & CONCLUSIONS

1. MTest has successfully delivered and continues to deliver beam of various momentum to CMS pixel, ALICE, and PHENIX EMCAL, and other test detector groups.
2. In future we expect the ILC to be the major test beam user. They will need low energy pions, low energy electrons/positrons, and muons.
3. MINERυA will like to reconstruct 0.3 - 5GeV energy pions and electrons, 1-5GeV protons, and kaons/muons to study stopping particles.
4. NOυA will also need low energy electrons, pions, and hadrons
5. Studies are ongoing to upgrade the Mtest beam line without incurring major expense.
6. We are studying the possibility of going down to lower momentum (2 GeV & below).
7. It may be possible to increase the yield at low momentum by a factor of ~1000.
8. We welcome the larger international community, especially the ILC world.