Plans for the beam test

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MEMORANDUM OF UNDERSTANDING

FOR THE 2010 FERMILAB TEST BEAM FACILITY PROGRAM

T-1008

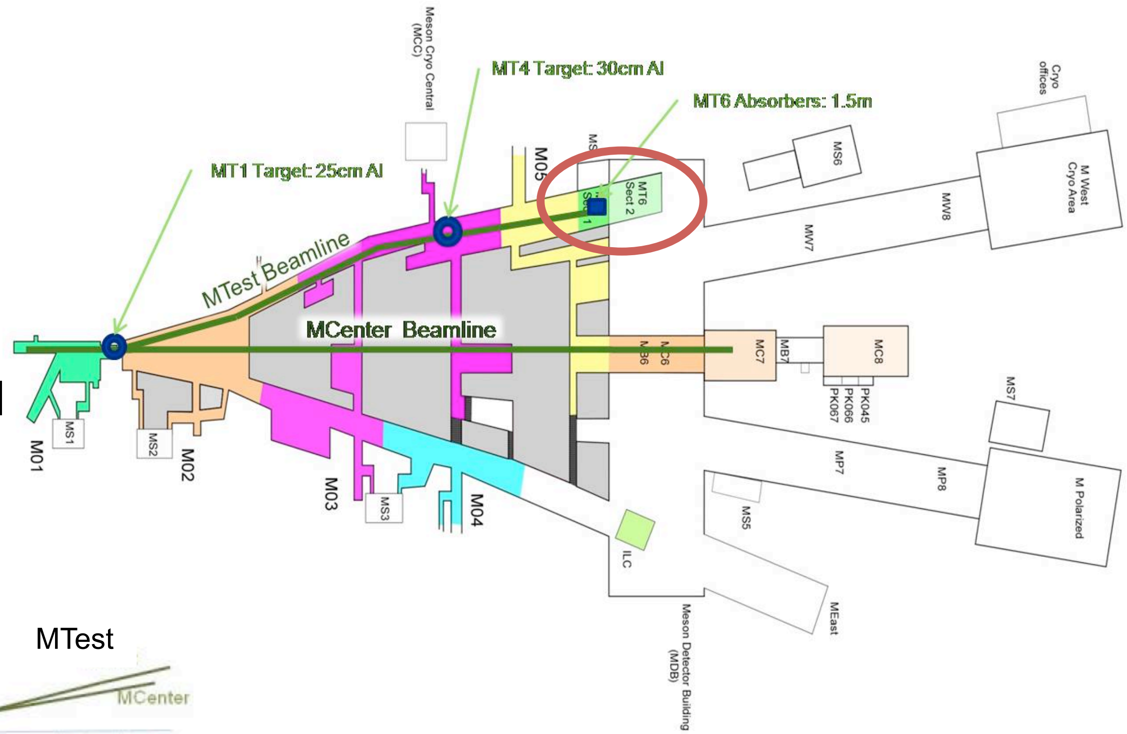
SuperB Muon Detector Prototype

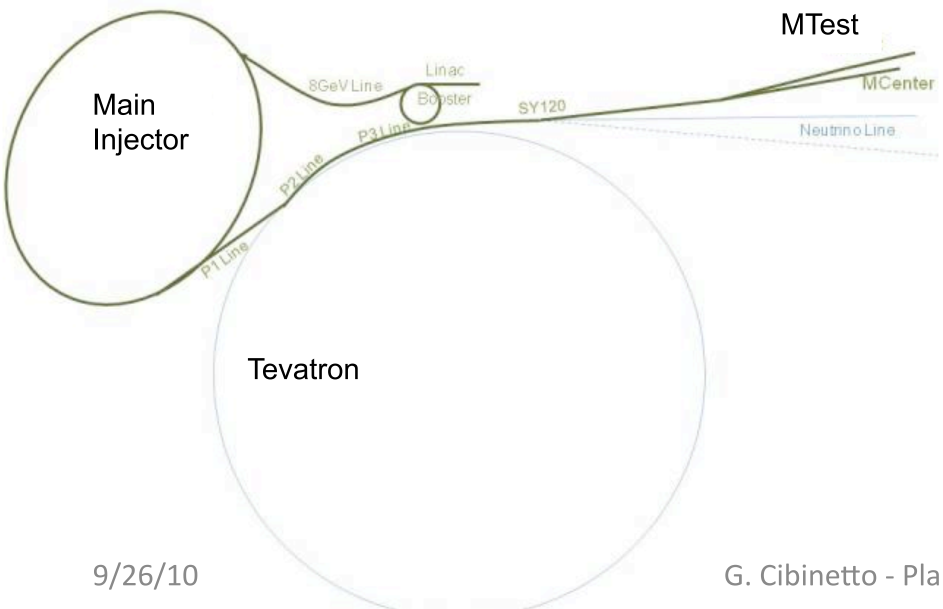
September 2, 2010

The facility

Extraction of beam from Main Injector:

- From 1 to 6 batches in the Main Injector
- Each batch from 0.2 to 1.6 μsec in length – Full batch equals 2E11 protons.
- A fraction of the beam is resonantly extracted in a slow spill for each Main Injector rotation





Single 4 sec spill/minute

This is the first magic number

Expected rates for our test

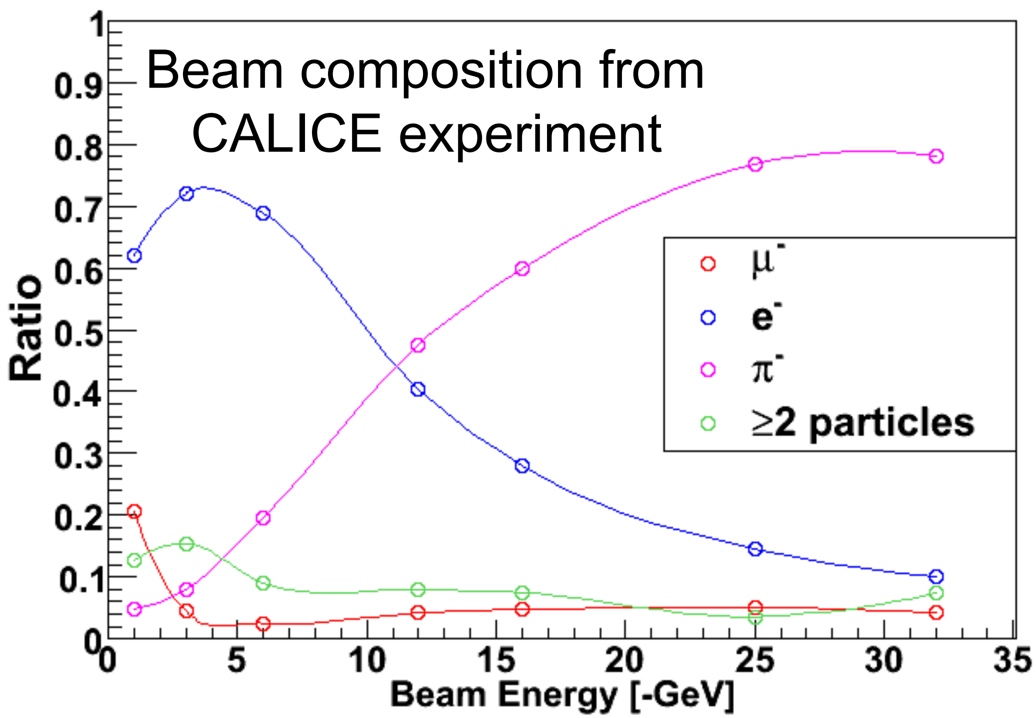
About 100 muon/pions per spill at 1 GeV; ~10 times at 5 GeV.

Counting 1 spill per minute it makes 6000 mu/pi per hour at 1GeV. and about 60k per hour at 5GeV.

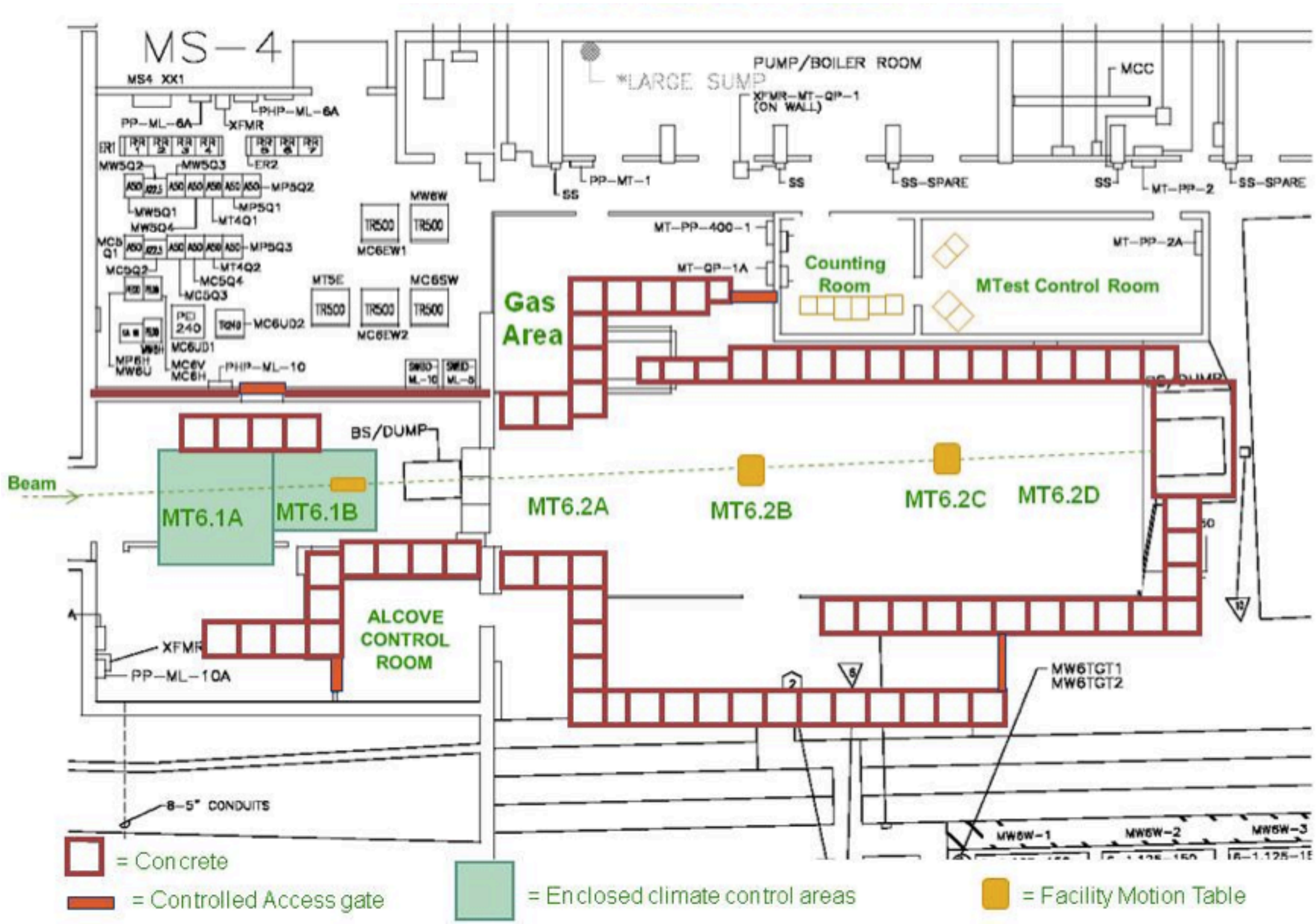
The area of the beam matches the active area of the MWPC (about $10x10cm^2$).

Already several challenges:

-get rid of the huge amount of electrons: Cherenkov veto and 18cm iron plate.
-multiple particle in ~10% of events (not easy to reconstruct)
-low rate at low momentum (need time for measurements)



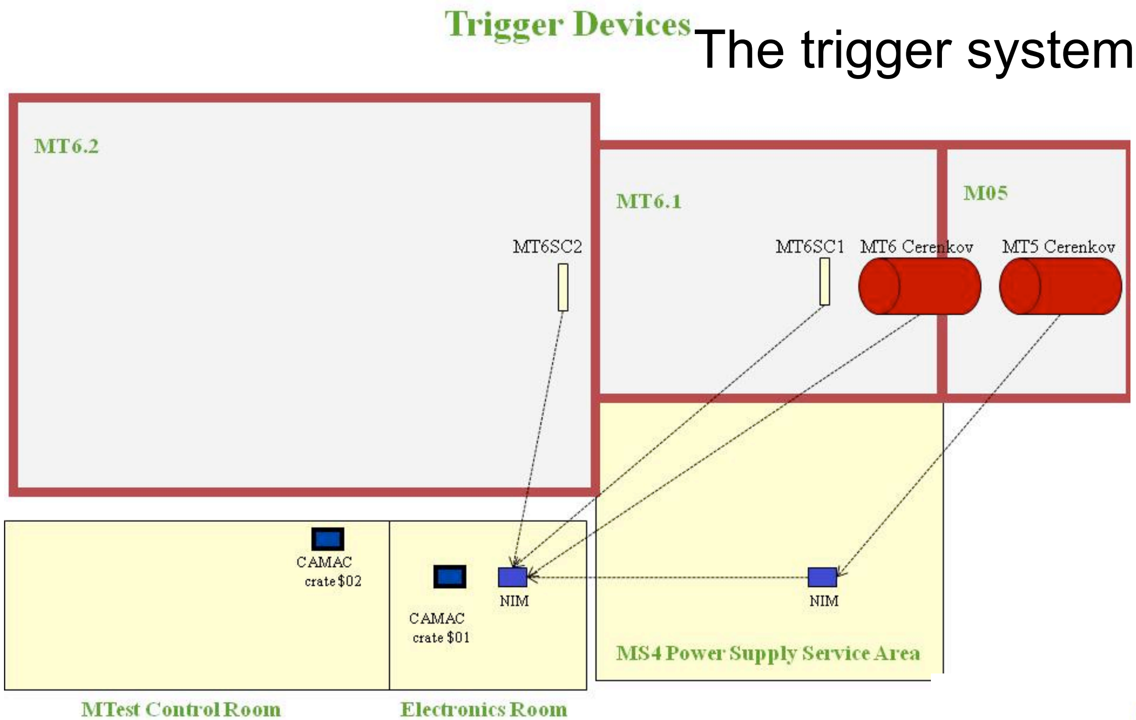
The experimental area



The arrow should be about 5 meters on the map

The detector

The trigger system

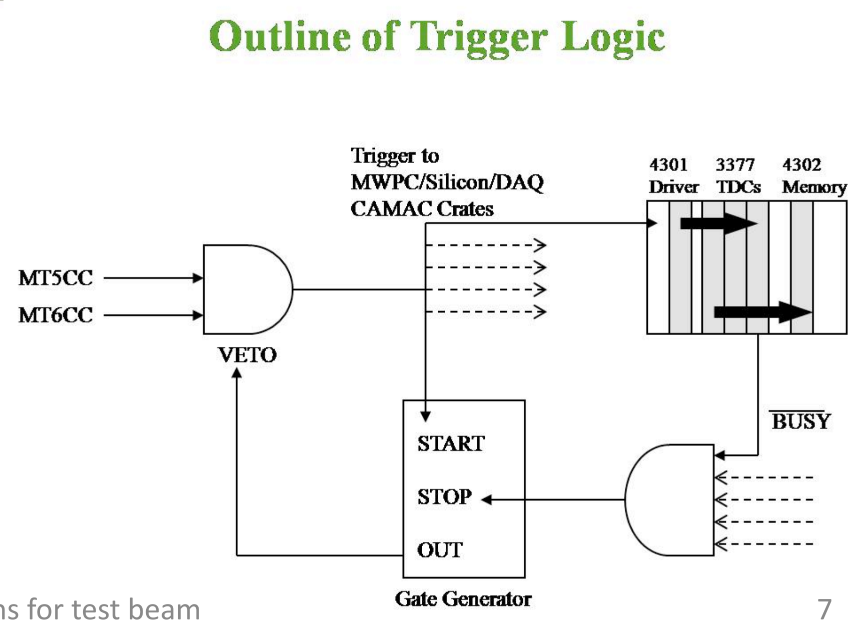


A trigger system is already present.
It combines signals from the two Cerenkov counters and a veto coming from the busy of each detector.

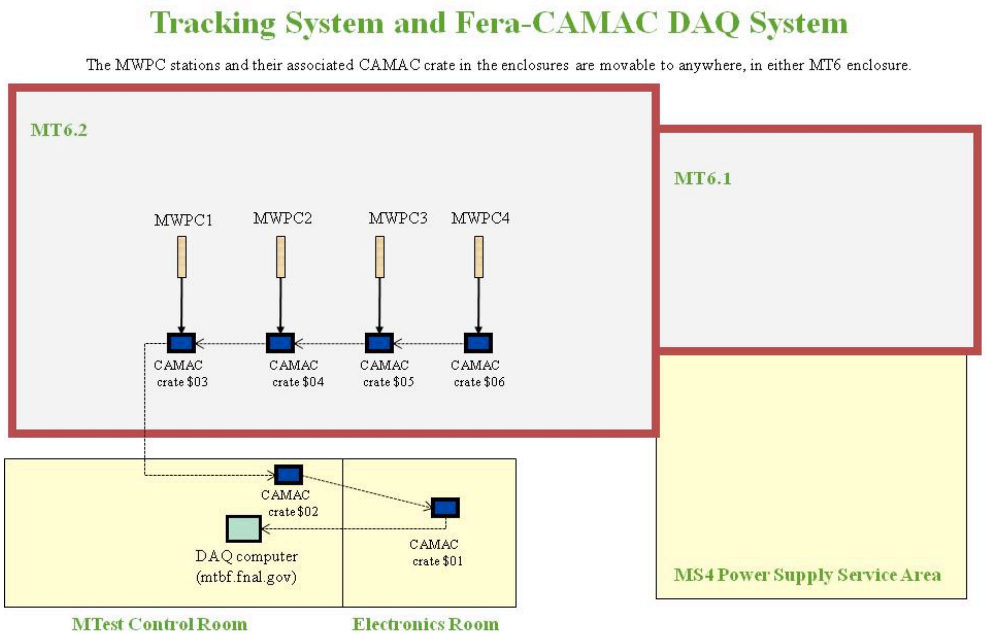
Setting up the trigger system will be another challenge!

We will replace the Cherenkov signals with the ones from a couple of trigger scintillators placed in front of the prototype.

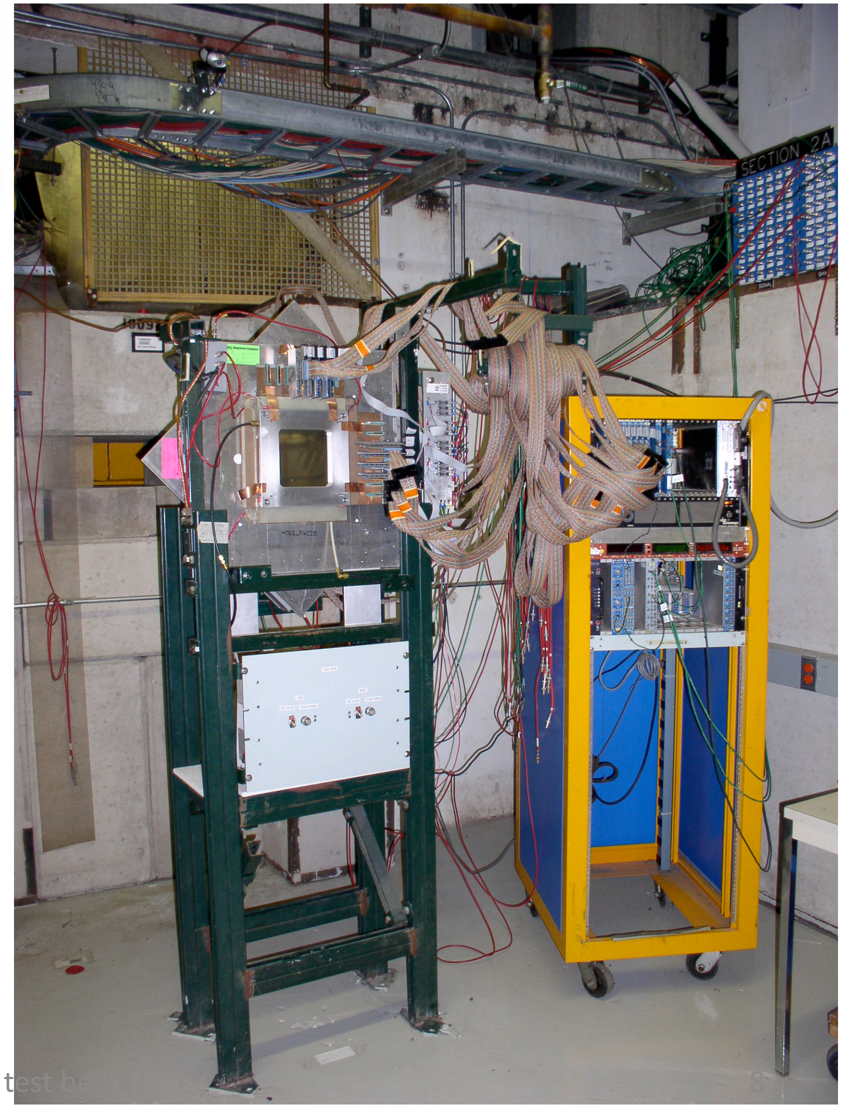
Data taking will start between 2 spills.



The tracking



The MWPC Tracking System is made up of 4 stations, and an associated DAQ system. Each Station consists of 2 wire modules, set at a 45° angle from each other, and the necessary CAMAC hardware to support them.



The system is pretty reliable and needs only some small adjustment and alignment, here the challenge will be to handle the amount of data coming from their DAQ and merge it with our data and extract useful information for the analysis.

Particle ID

Problem number one: get rid of the huge amount of electrons (this is really problem number one because they could saturate our rate capability. Many would be stopped by the 18-cm iron plate in front of the prototype; the best solution is to use one of the two Cerenkov counters as veto (need to accurately synchronize signals from different detectors)

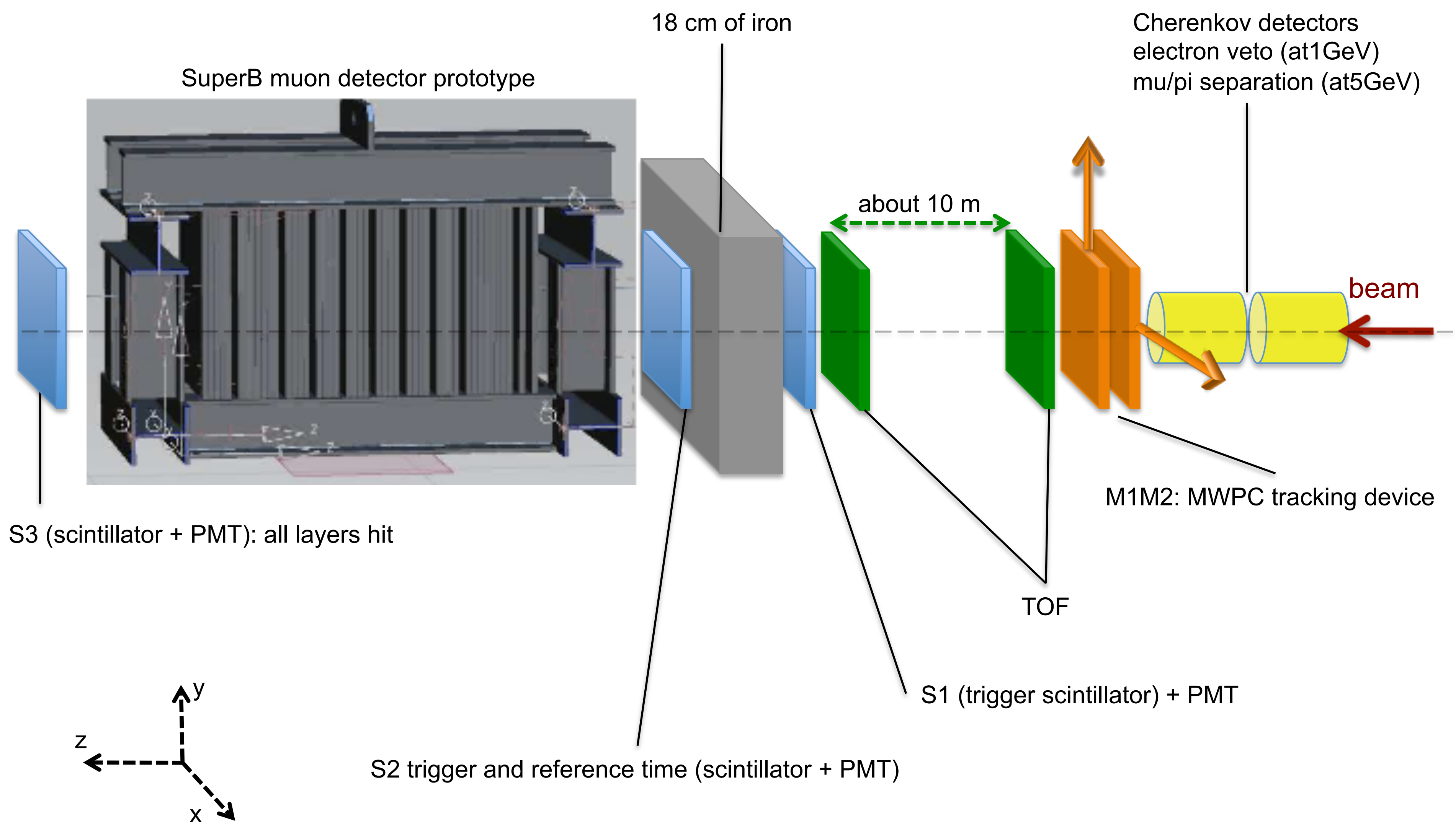
Problem number two: muons/pions separation:

- Erik is willing to setup for us the TOF system that can work pretty fine at 1GeV and 2GeV (ideally it works also at 3GeV but I wouldn't count on it).

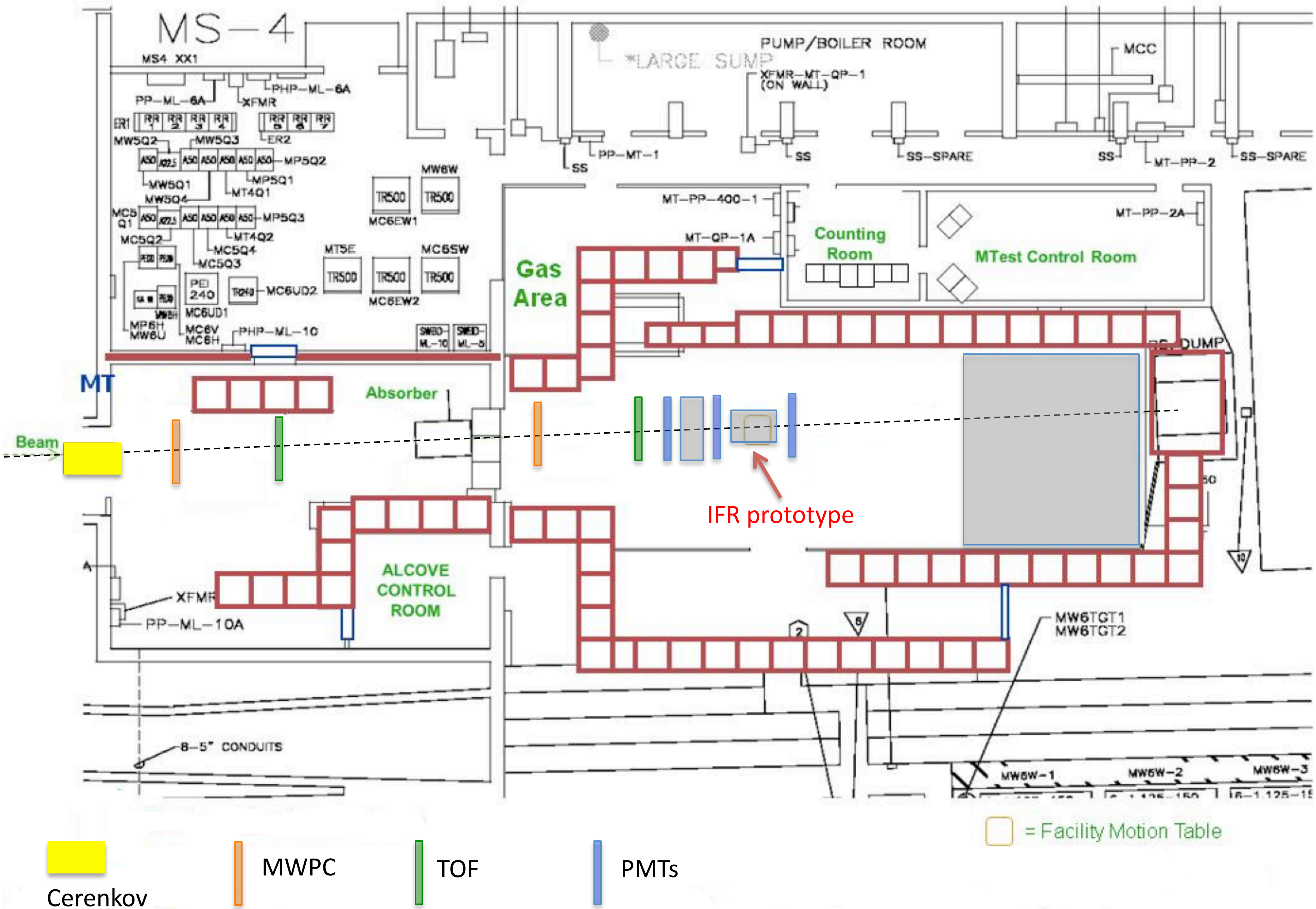
- To separate muons and pions from ~2.2 GeV the best choice is to use a dense gas (i.e. C_4F_8O) in the Cerenkov to effectively lower the momentum threshold at which you can distinguish muons and pions. Just received an offer for the gas: about 3keuro.

Putting everything together

not in scale



Inside the hall



The test

What can we do

Things to learn…	…they depend on (parameter to change)…	… and need (number of events)
Detection performances (efficiency, dark count, occupancy)	SiPM settings (gain, thr)	Even 10 kevents per conf: very fast at high momentum
Tracking performances (time resolution, track reconstruction, multiple tracks detection)	Mainly SiPM settings	~50 kevents, we can change parameters only with high rate (i.e. high momentum)
Particle ID (muon pion separation)	Mainly beam momentum and absorber configuration but also on SiPM settings	~500 kevents distributed over the entire momentum range (1GeV – 5GeV)

time time time…

Parameter to change	How fast	How many times
Module configuration	~1 hour	2 main configurations + one with special modules
Beam energy	~30 minutes	5 momentum bins for the two main configurations. This may need the steel absorber.
SiPM gain	Prompt	We can do some 1-hour tests at 5GeV
SiPM threshold	Prompt	A couple of tests at 5GeV should be enough

Time estimate for a particle ID test

About 100 muon/pions per spill at 1 GeV; ~10 times at 5 GeV

Counting 1 spill per minute it makes 6000 mu/pi per hour at 1GeV. and about 60k at 5GeV.

Beam momentum	Approximate rate	Time of data taking (h)	Number of events
1 GeV	6k/hour	10	60k
2 GeV		5	60k
3 GeV		3.5	60k
4 GeV		2.5	60k
5 GeV	60k/hour	1	60k
Total		22	360k

In addition we have to take into account about a couple of hours to setup the beam for each step.

The beam is available from 4am to 6pm except a couple of hours for the TeVatron.

A good number of events for a complete particle ID studies is about 500k

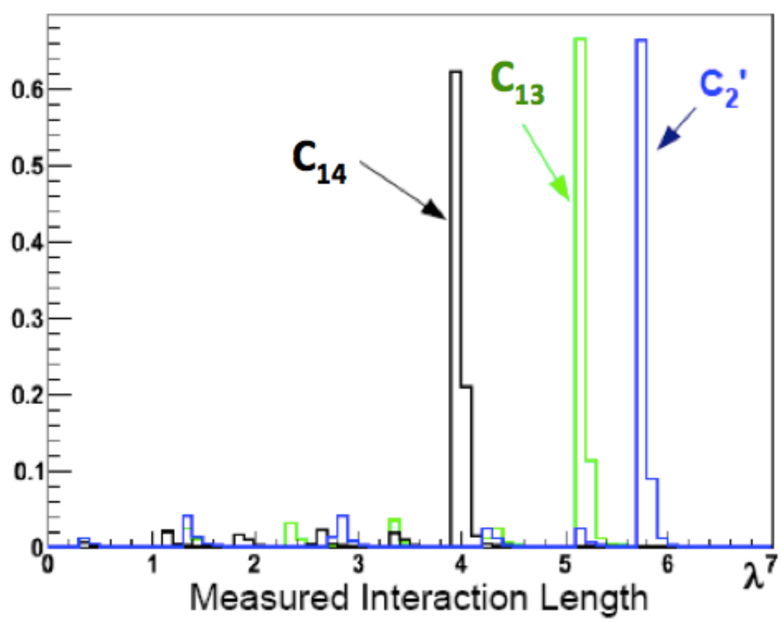
To have a complete test of a detector configuration it would take about 3 days running at least 10 hours a day.

Which configurations?

```
|=|=|========|============|============|=======|=====|   C2'  Fe 920mm
|2|2|   16   |     24     |     24     |  14   | 10  |

|=|=|========|========|========|========|=======|      C13  Fe 820mm
|2|2|   16   |   16   |   16   |   16   |  14   |

|=|=|======|======|======|======|=====|               C14  Fe 620mm
|2|2|  12  |  12  |  12  |  12  | 10  |
```



Up to now in the simulation we tested 4 different configurations:

8 layers
- 920 cm iron
- 820 cm iron
- 620 cm iron

9layers
- 920 cm iron

Prototype segmentation

|=|=|========|====|====|====|====|====|====|=======|=====|

2 2 16 8 8 8 8 8 8 14 10

Up to now in the simulation we tested 4 different configurations:

8 layers
- 920 cm iron
- 820 cm iron
- 620 cm iron

9layers
- 920 cm iron

For the beam test we will study these two 9-layers configurations (the 8-layers will come for free by ignoring one plane).

More or less all the relevant configurations studied during the optimization will be tested.

Only two layers need to be moved to switch from the two configurations: this save time.

Layers 0, 2, 4, 6 and 8 will have Binary readout, layers 1, 3, 5 and 7 TDC readout in all the configuration including the one with special modules. ?

I really like this scheme. Do we have one more TDC? Are we fast enough with 3? Use it to readout BiRO modules we can learn something. And use some channels for PMTs and Cherenkov signal. you don't like it? ok, but let's decide.

```
CP1   |=|=|========|====|====|====|====|====|====|=======|=====|
       2 2    16      8    8    8    8    8    8     14     10

CP2   |=|=|========|====|====|====|====|====|====|=======|=====|
       2 2    16      8    8    8    8    8    8     14     10
```

Back to the test: some general considerations

It's impossible to test all the combinations of different parameters and configurations and perhaps it is not needed, for instance:

- We don't need to extract muon ID from special modules, we are interested only in efficiency/timing performances for them.
- We don't need to change thresholds and to do a gain scan for all the configurations, maybe just one configuration is enough and for only one momentum bin.
- Some tracking and special modules test can be done nicely even with cosmic runs.

Priority must be given to test the muon ID performance on the most reliable detector configurations (where "most reliable" comes from MC, R&D and cosmic run).

It's now time to start working on a schedule

Day	Conf	First shift	Beam energy	Second shift	Beam energy	After beam
1st	CP2	Beam tuning and DAQ/ trigger test	5 GeV	inherit test from first shift, begin gain and thr test	5 GeV 1 GeV (about one hour to check the rate)	review the plan for the week
2nd	CP2	gain and thr scan	5-4 GeV (for scan)	Steady run	3-2 GeV	Eat at Texas roadhouse
3rd	CP2	Steady run	1 GeV	Steady run	1 GeV	Change configuration
4th	CP1	Steady run	5-4-3 GeV	Steady run	3-2 GeV	
5th	CP1	Steady run	2-1 GeV	Steady run	1GeV	
6th	CP1	Steady run	1 GeV	Increase the statistics	? GeV	Change configuration
7th	CP2 special	test special modules, gain and thr scan	5 GeV	Start dismount	-	Dismount

Test Beam Schedule

Sep 8	Meson Power Outages				
Sep 15 - Sep 29	T992	SLHC sensor tests	Yun	1-B	Primary
Oct 6 - Oct 9	Facility Development (No Beam)				
Sep 30 - Nov 2	T978	CALICE	Repond	2-D	Primary
Nov 3 - Nov 9	T1004	Dual Readout Calorimetry	Para	2-B	Primary
Nov 10 - Nov 16	T979	Fast Timing Counters for PSEC	Albrow	2-B	Secondary
Nov 10 - Nov 23	T992	SLHC sensor tests	Yun	1-B	Primary
Nov 29 - Nov 30	T1008	Set up for SuperB prototype	Posocco	2-B/C	Primary
Dec 1 - Dec 7	T1008	SuperB prototype	Posocco	2-B/C	Primary
Dec 8 - Dec 23	T994	JASMIN	Nakashima	2	Primary

We have two weeks reserved, one for the setup and the other for the test.

Test beam is approaching, time to take decisions is now.