

^{5D}
~~6D~~ Proposed
Muon Cooling Experiment
at Fermilab

Andreas Jansson
Muon Collider Task Force



MCTF charge

i) Cooling Channel and Collider Design Concept.

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ii) Cooling Channel R&D.

Prepare a one year study plan to (a) evaluate the technical feasibility of the components (rf cavities, magnets, absorbers, etc) needed for a muon collider class 6D cooling channel as identified in i), (b) identify the technical issues that must be addressed before a 6D cooling channel could be built, and (c) **formulate a plan for** the associated component R&D and **6D cooling tests** that must be performed to establish basic viability of the cooling channel. The study plan should be documented in a short report in September 2006. The results of the one year study should be documented in a more detailed report in September 2007.

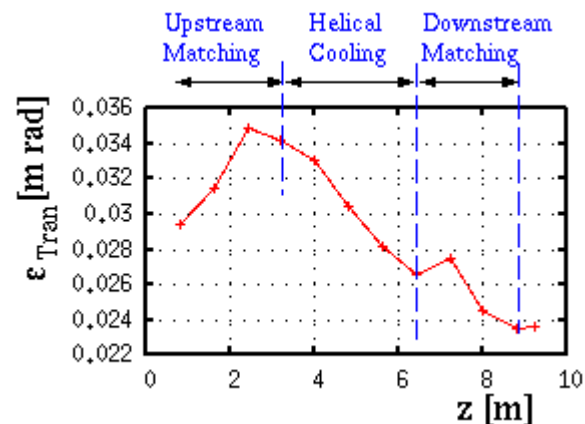
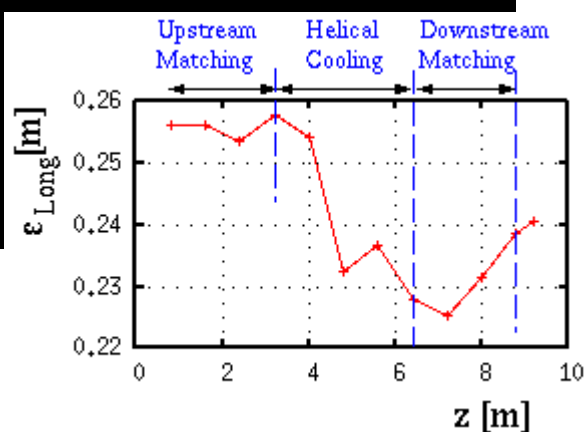
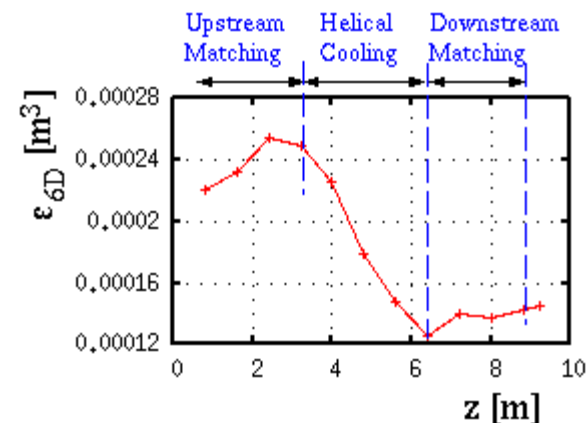
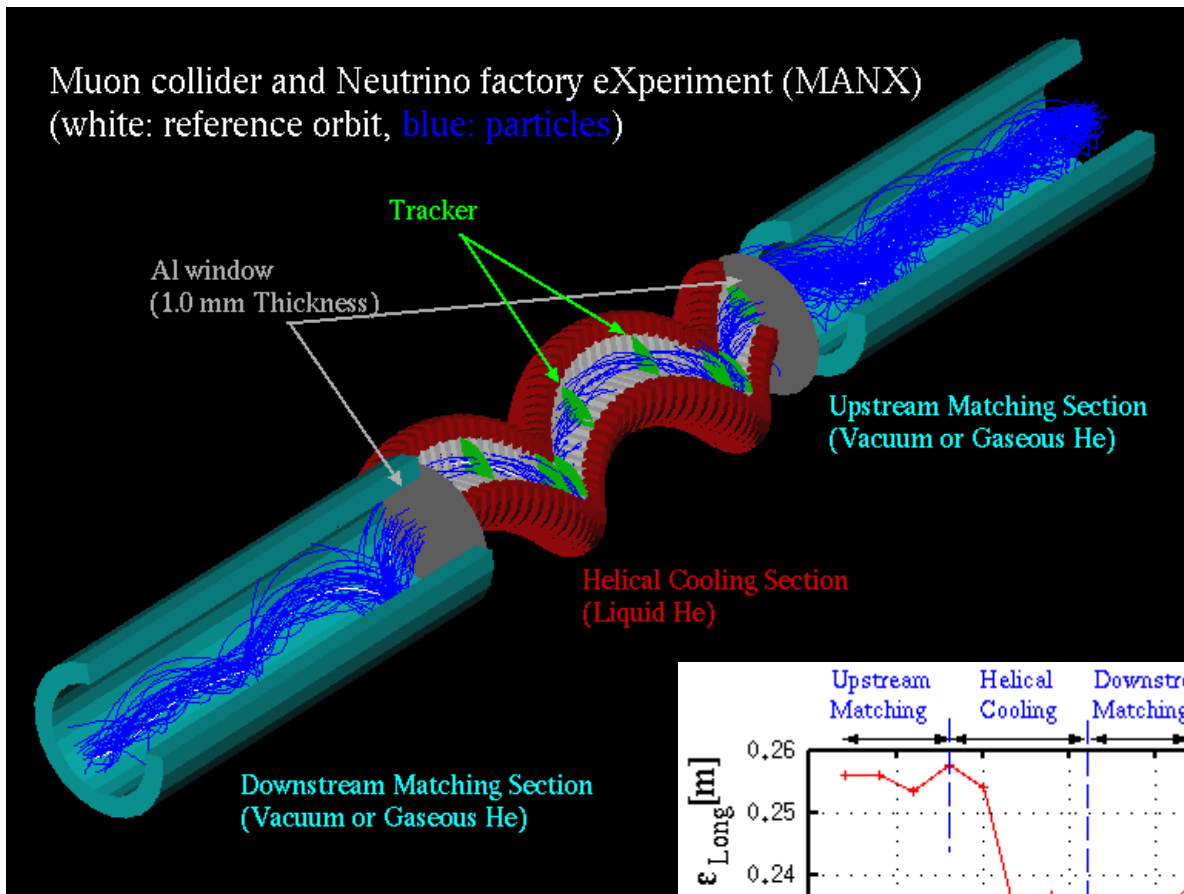
iii) Component Development and Testing.

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Helical Cooling Channel

Muon collider and Neutrino factory eXperiment (MANX)
 (white: reference orbit, blue: particles)



Muon beam cooling experiment

- Can we test this with a beam?
 - Would be complementary to MICE (single particle)!
 - Cooling of a beam would be a more tangible result than “cooling” of single particles.
 - Could potentially be done with simpler instruments (beam profiles vs tracking spectrometer).
 - Good case for doing it at Fermilab.



MTA properties



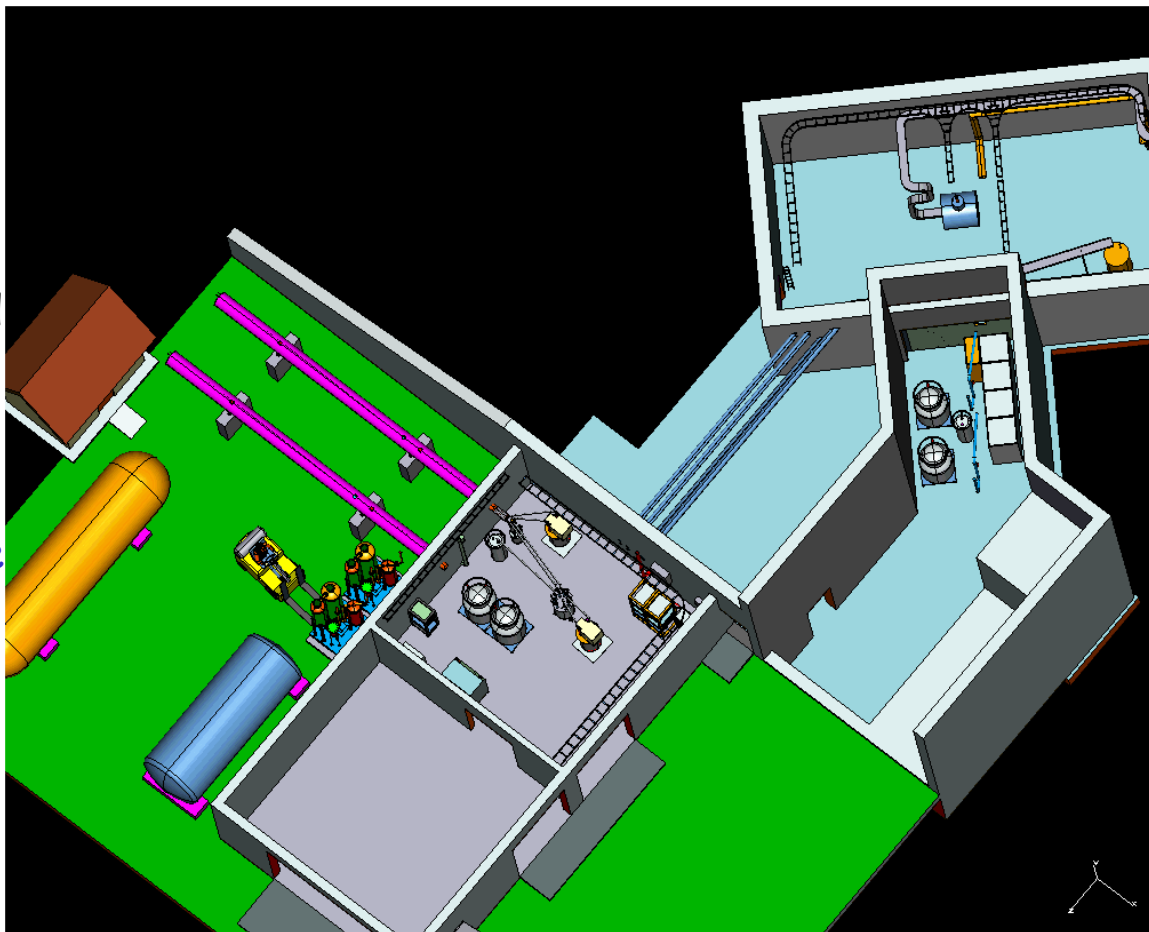
← Close to my office →

- 400MeV/c² protons from linac
- Relatively tight space.
- Infrastructure available (eg cryo for HCC) 😊
- High beam availability 😊
- Expect total pi⁺ yield few percent, usable yield of a few 10⁻⁵. Could get 10⁷ - 10⁸ muons per pulse within the acceptance of the HCC 😊



Muon Test Area

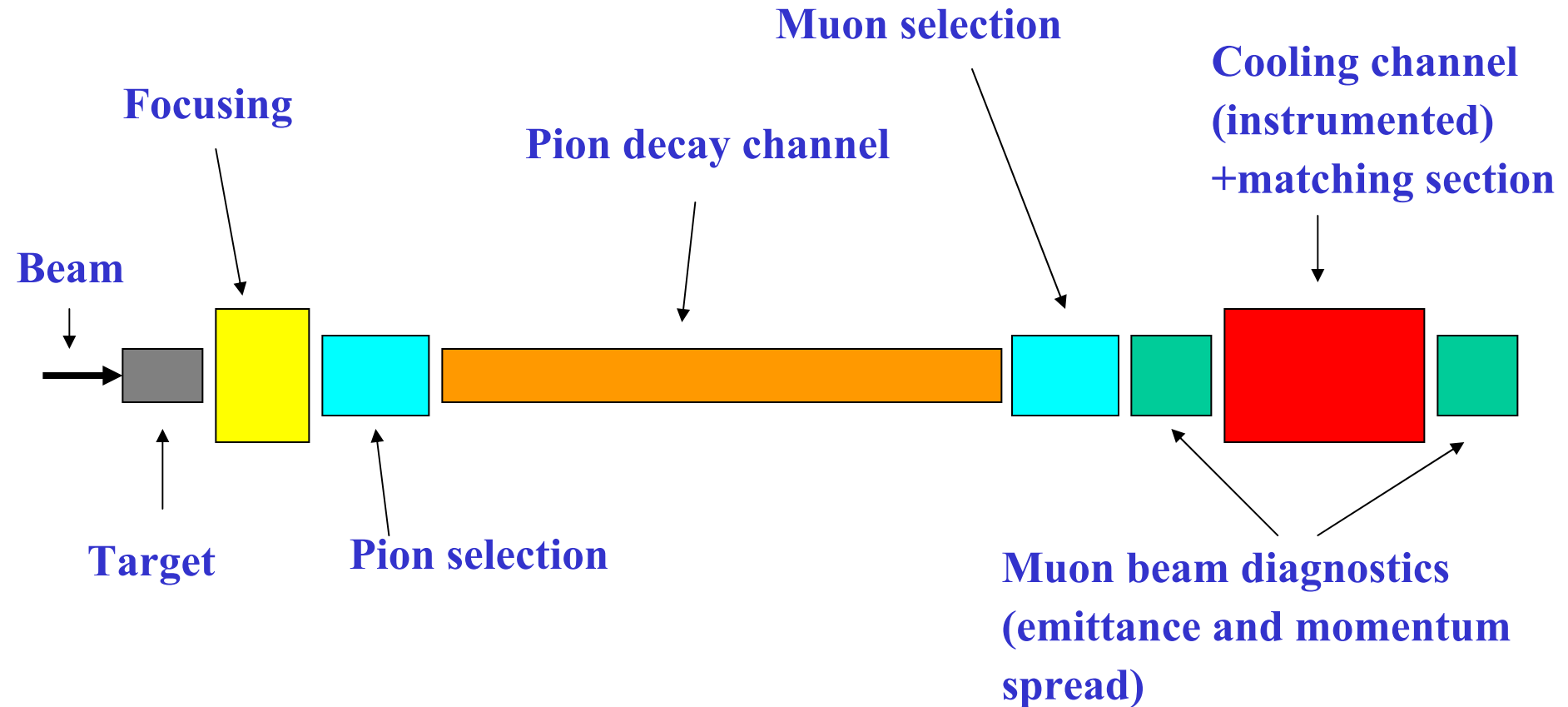
- Current R&D focus at the MTA
 - RF testing (805 and 201 MHz)
 - High pressure H₂ gas-filled RF
 - LH₂ Absorber tests
- Two parts of infrastructure yet to be completed
 - Cryo Plant
 - Low-intensity
 - High-intensity (part of MCTF)
 - Proton beam Line



MTA Hall



Conceptual experiment setup



Required muon beam properties

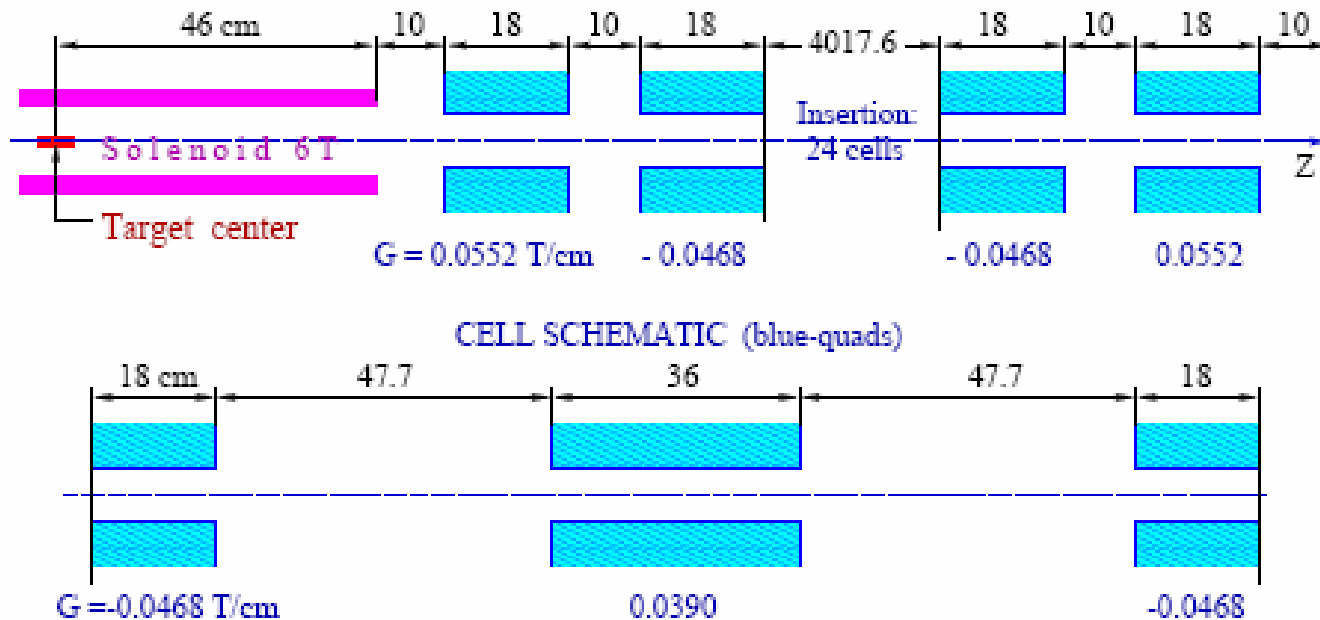
Covariance matrix at beginning of HCC matching section:

	x	px	y	py	z	pz
x	0.00011	0.00003	0.	0.00008	0.	0.
px	0.00003	0.00008	-0.00007	0.	0.	0.
y	0.	-0.00007	0.00011	0.00003	0.	0.
py	0.00008	0.	0.00003	0.00008	0.	0.
z	0.	0.	0.	0.	0.	0.
pz	0.	0.	0.	0.	0.	0.00036

- Angular momentum is much smaller than would be generated by fringe field.
 - The beam should have canonical momentum
 - Should be generated inside a solenoid



Target, pion capture and decay channel

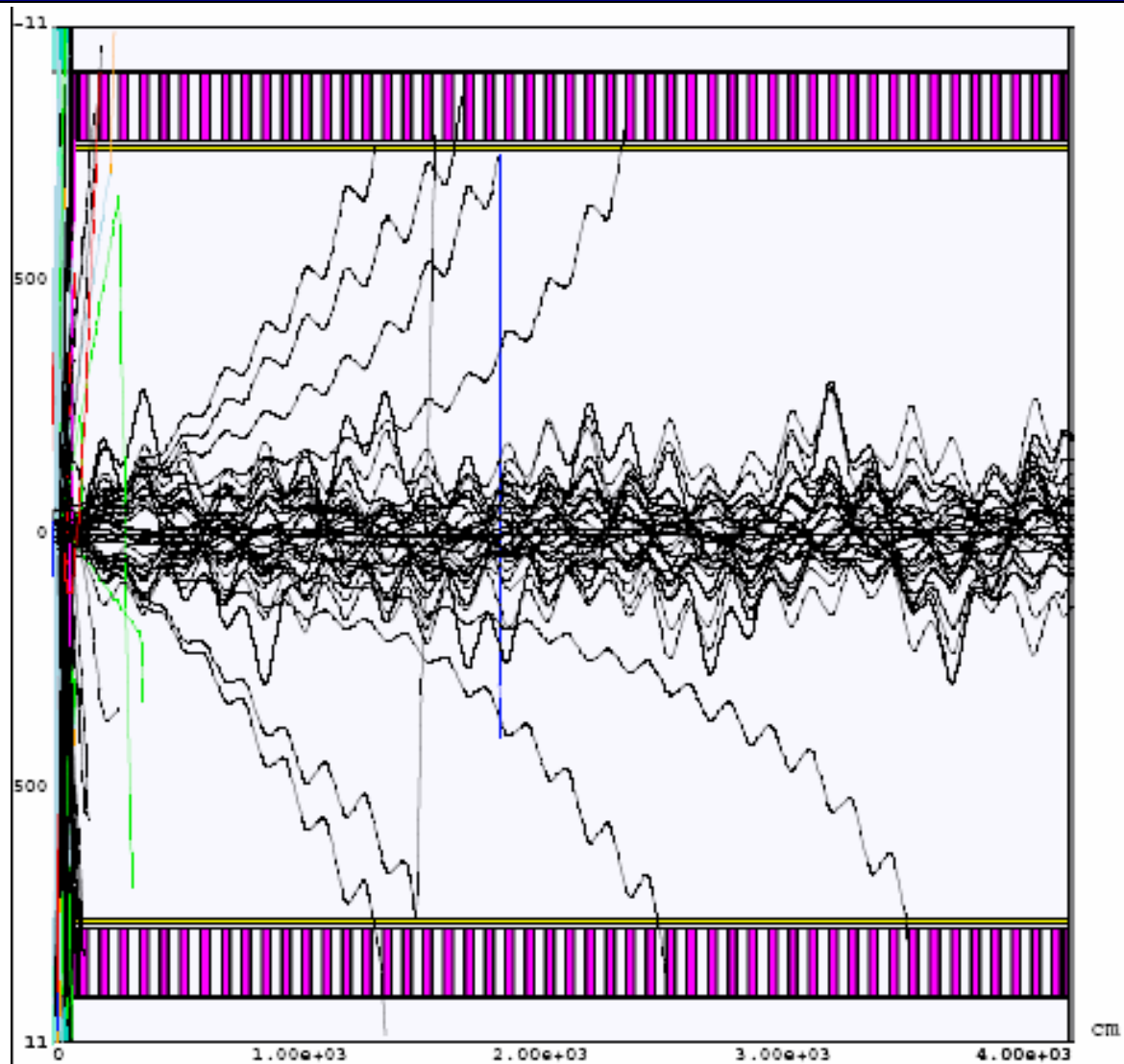


- Aluminum target in 6 T solenoid.
- Quadrupole decay channel (PAC'01 design)



Simulation results

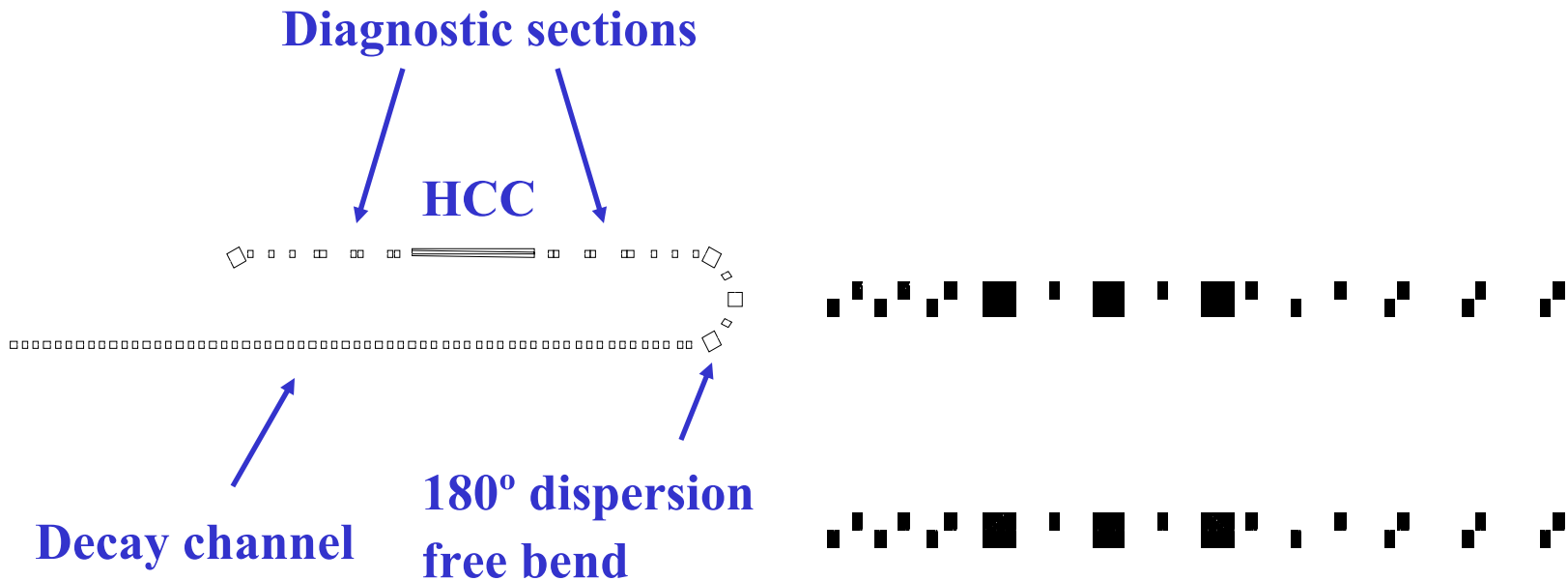
- MARS model of target and decay channel
- Simulations underway, expect results very soon...



cm



Preliminary optics design



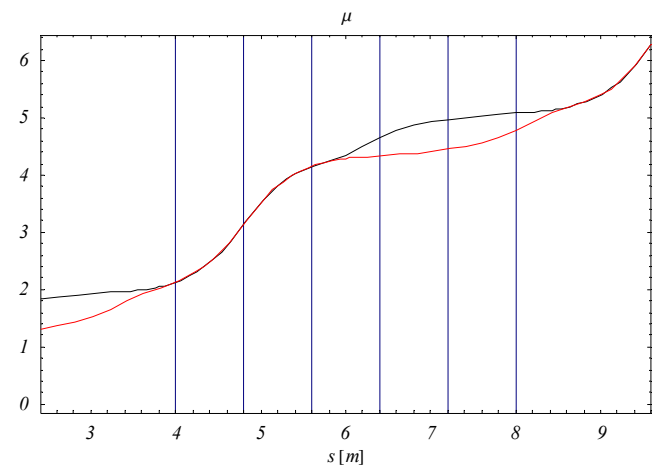
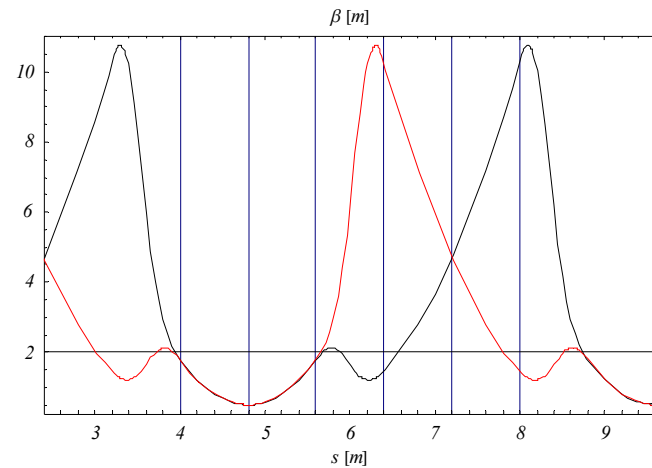
Uses BNL D2 quads

“Almost” fits in MTA

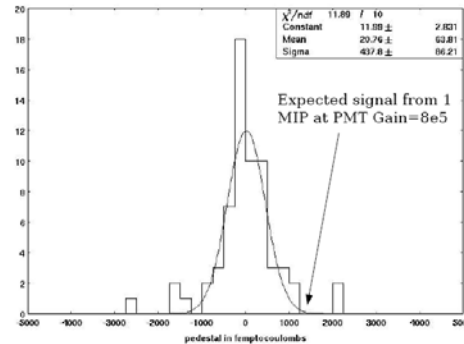


Measurement system

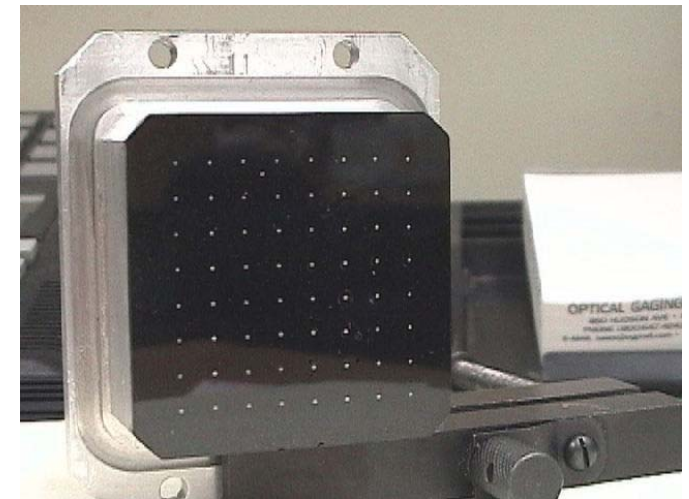
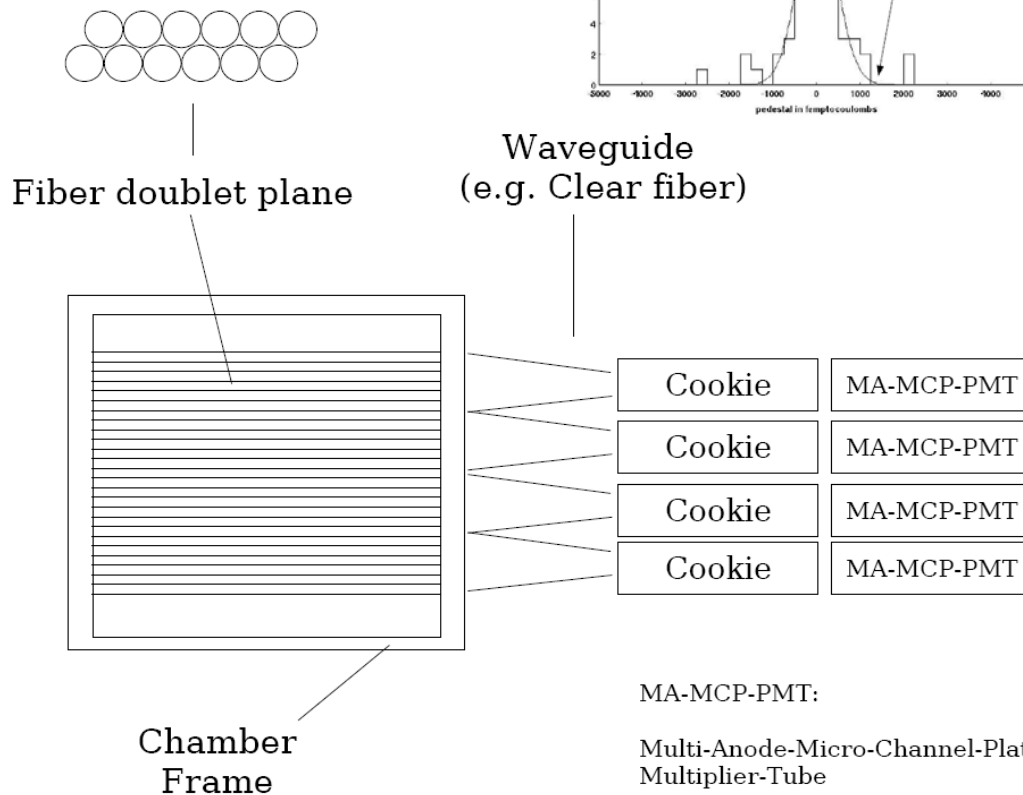
- Six profile detectors at strategic locations
- Horizontal, vertical and 45 degree profiles
- 18 data points for 12 variables (10 beam moments + 2 quad gradients)



Instrumentation

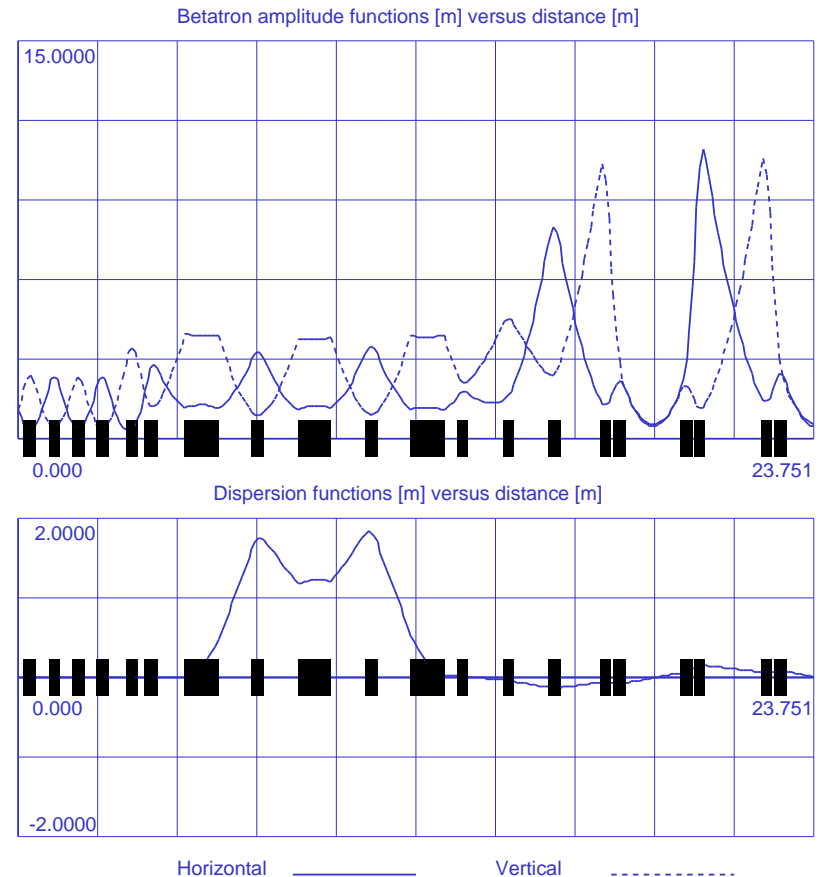


- Fiber tracker developed by PPD for MTEST
- Single MIP sensitivity depending on fiber size and electronics
- Can probably be used directly in beam lines
- May be modified for use in LHe?



Chromaticity issue

- Chromatic effects can spoil the measurement
- Possible solution: reduce the momentum spread
- Do "macro-particle experiment" in the longitudinal plane. Only need to control and measure average momentum!
- Need to design collimation system

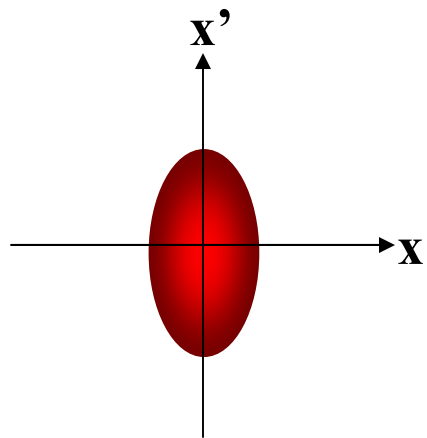
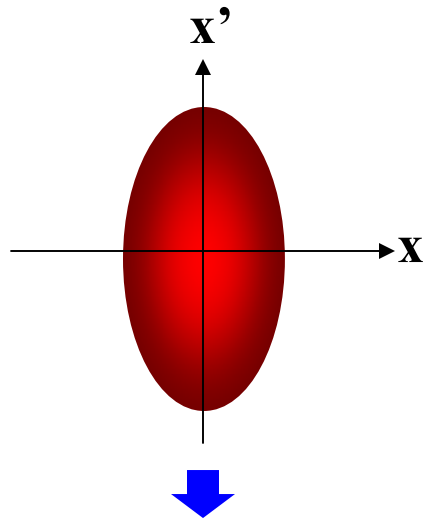


Off-momentum beta functions

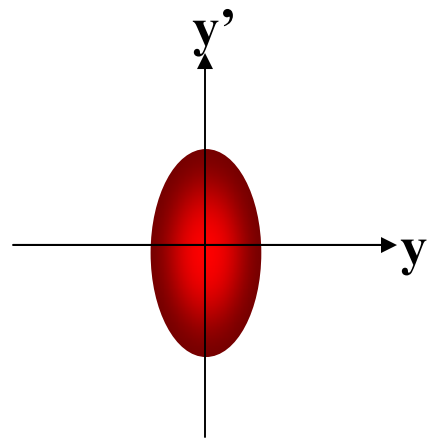
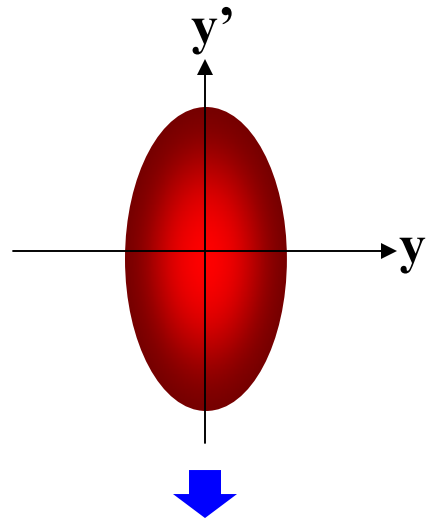


Hybrid 5D Cooling Experiment

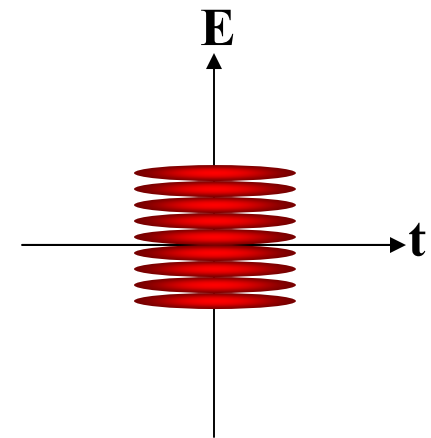
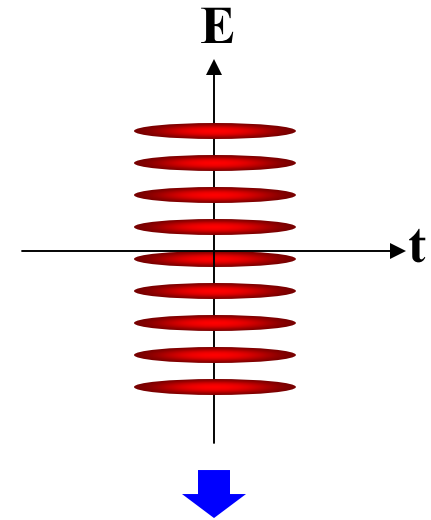
“Monochromatic beam”



Beam



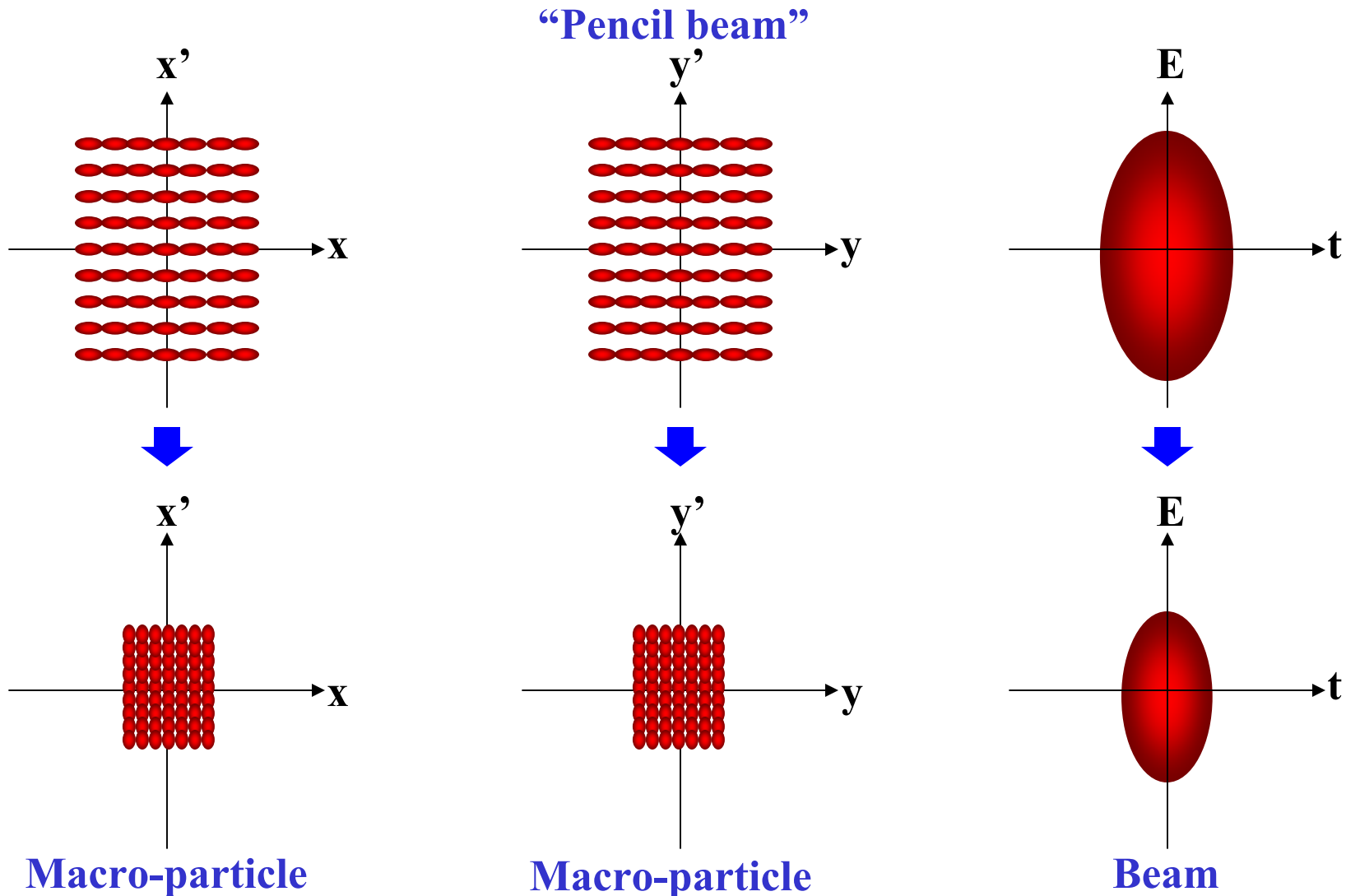
Beam



Macro-particle



Alternate Hybrid Cooling experiment

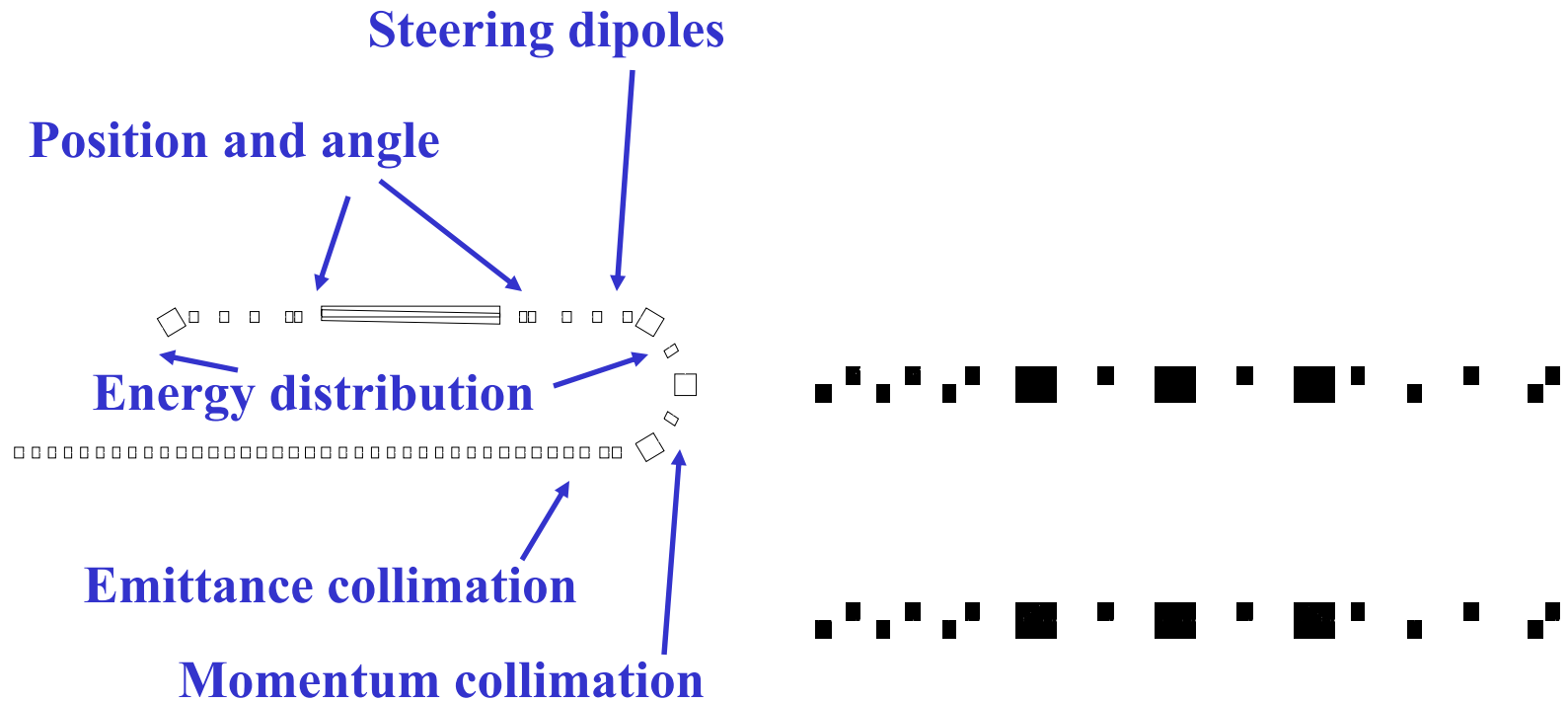


Pencil beam experiment

- Easy to generate pencil beam with large momentum spread.
- Position and angle easy to control.
- Diagnostics is simpler (mainly beam positions plus beam width in dispersive section) -> Better accuracy
- Simpler and shorter beam line.
- Can measure transverse non-linearities.



Pencil beam experiment layout



Current efforts

- Set up large scale G4BL simulation capability and refine HCC simulations.
- Simulate target and capture efficiency.
- Refine muon beamline design
- Detector development (eg SciFi in LHe)
- Coordinate with HCC design
- Think about extensions to the programme (e.g. Design and test of HCC with RF)



Conclusions

- The possibility of testing the HCC at Fermilab is being studied.
- Looks feasible to do this at MTA.
- Raster scan with pencil beam seems to be the preferred method.
- Could be relatively simple and cheap .
- More detail will be worked out over the next several months.

