Beam Line Status update

Present situation reviewed in submitted written statement additional information addressed below:

1. πE5 Test Beam Overview :

- *Aims + Requirements*
- *Zone Layout + Measurement Plan*
- *Schedule + Manpower*

2. Update Information since Review Paper :

- *Modified Numbers*
- *New Information on Target Material*

Experimental Requirements & Solutions

Experimental Requirements :

- ***Stop a high intensity surface muon beam in a thin target***
- ***Minimum beam size at target (COBRA principle, angular definition)***
- ***Minimum of contaminant beam e^+ to reach the detectors***
- ***Stopping material should pose a minimum of influence on decay products***

Solutions:

- ***Combined solution involving Degrader & separation via Energy-loss***
  (residual range matches target thickness, ΔE difference for μ^+ & e^+ separation in following magnetic elements)
- ***WIEN Filter (crossed E^B fields - mass selector) to eliminate beam e^+ in combination with sub-surface μ^+–beam & thin target or surface μ^+–beam & degrader***

πE5 July 2002 Test Beam Overview

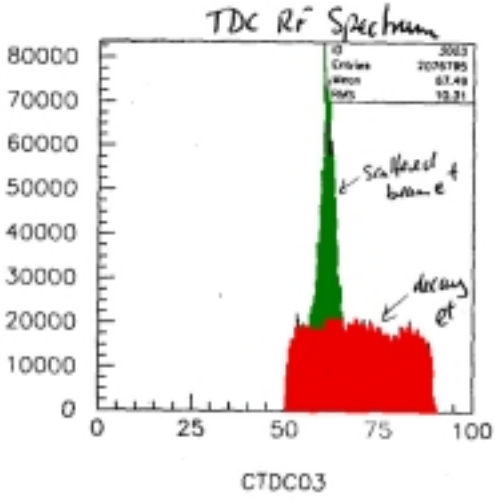
Aims :

- ***Simulate full transport system up to COBRA***
- ***Measurement of beam phase space at the entrance to transport solenoid***
  (needed for design of solenoid)
- ***Measurement of phase space at the exit to the transport solenoid***
  (needed for new simulation of beam up to target in COBRA)
- ***Measure muon stopping distribution width using foils***

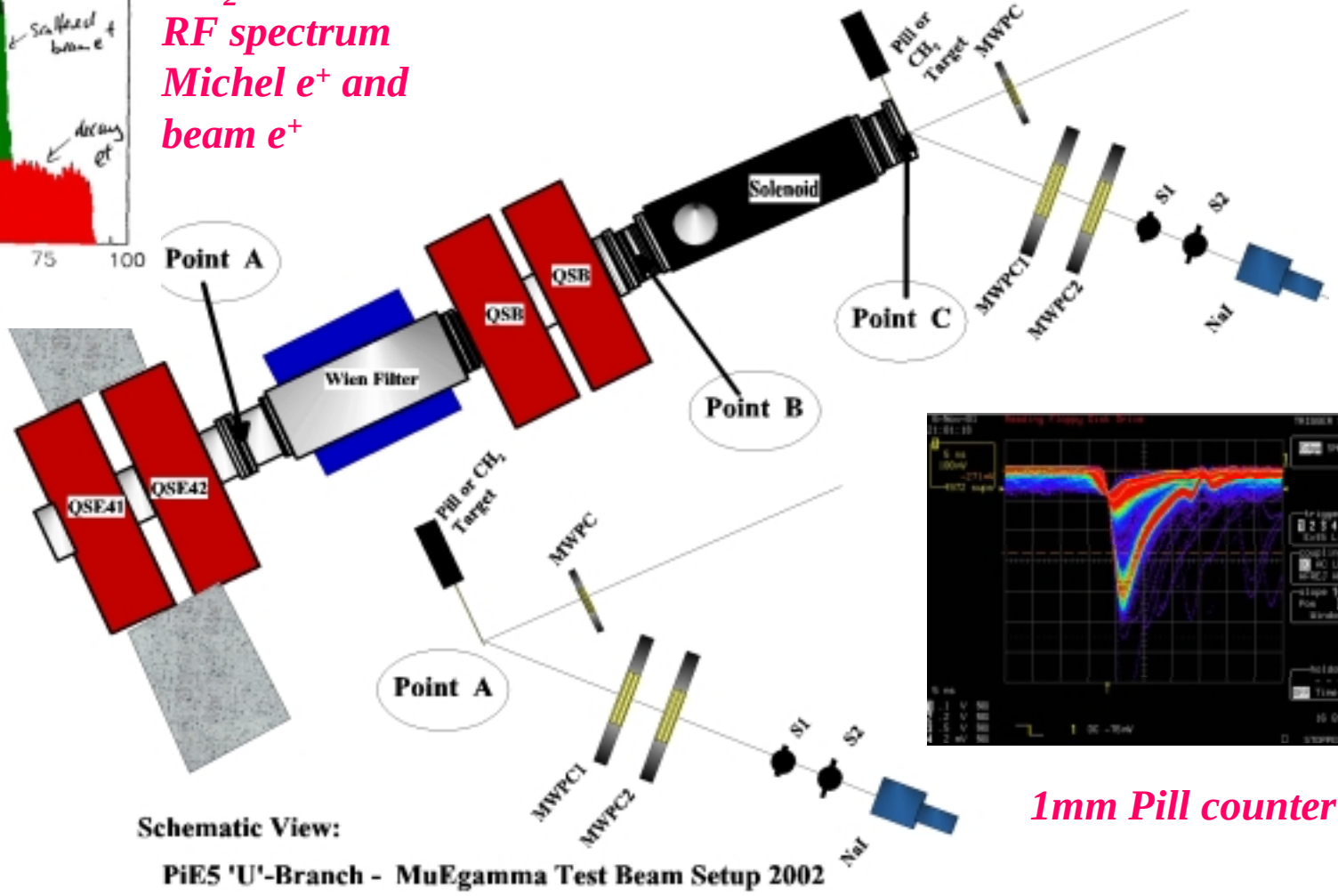
Requirements :

- ***Maximum muon stopping rate in 37 mg/cm^2 thick target (in beam direction)***
  want $1 \cdot 10^8$ $\mu^+ s^{-1}$
- ***Minimum beam e^+–contamination***
- ***Beam spot size at target*** *want $\sigma_X \sim \sigma_Y \sim 5$ mm*

Experimental Setup + Technique



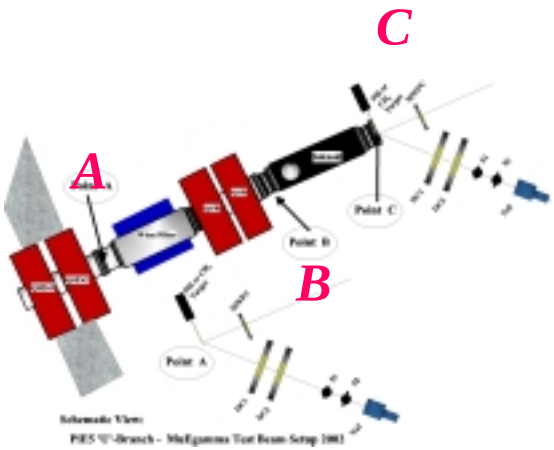
CH_2
RF spectrum
Michel e^+ and
beam e^+



1mm Pill counter

Measurement Plan

3 Measurement Positions / Phases A, B, C :



Position A (post QSE42):

(i) Optimize focus after QSE42

(ii) Measure μ^+ & beam e^+ rates
+ spot sizes
with pill + scanner

(iii) 2mm CH_2 measure
Michel e^+ rate with
NaI + MWPC
Check Consistency of Rates

(iv) Measure remaining phase space
parameters (divergencies)
with profile MWPC

(v) Measure momentum spectrum
(23 ~ 32) Mev/c

Position B (post Seperator):

(i) Optimize focus at
entrance solenoid

(ii) Repeat A (ii) & (iv)
rates + phase space

(iii) Study
μ-e separation

Position C (post Solenoid):

(i) Optimize focus after
solenoid no collimator
no degrader

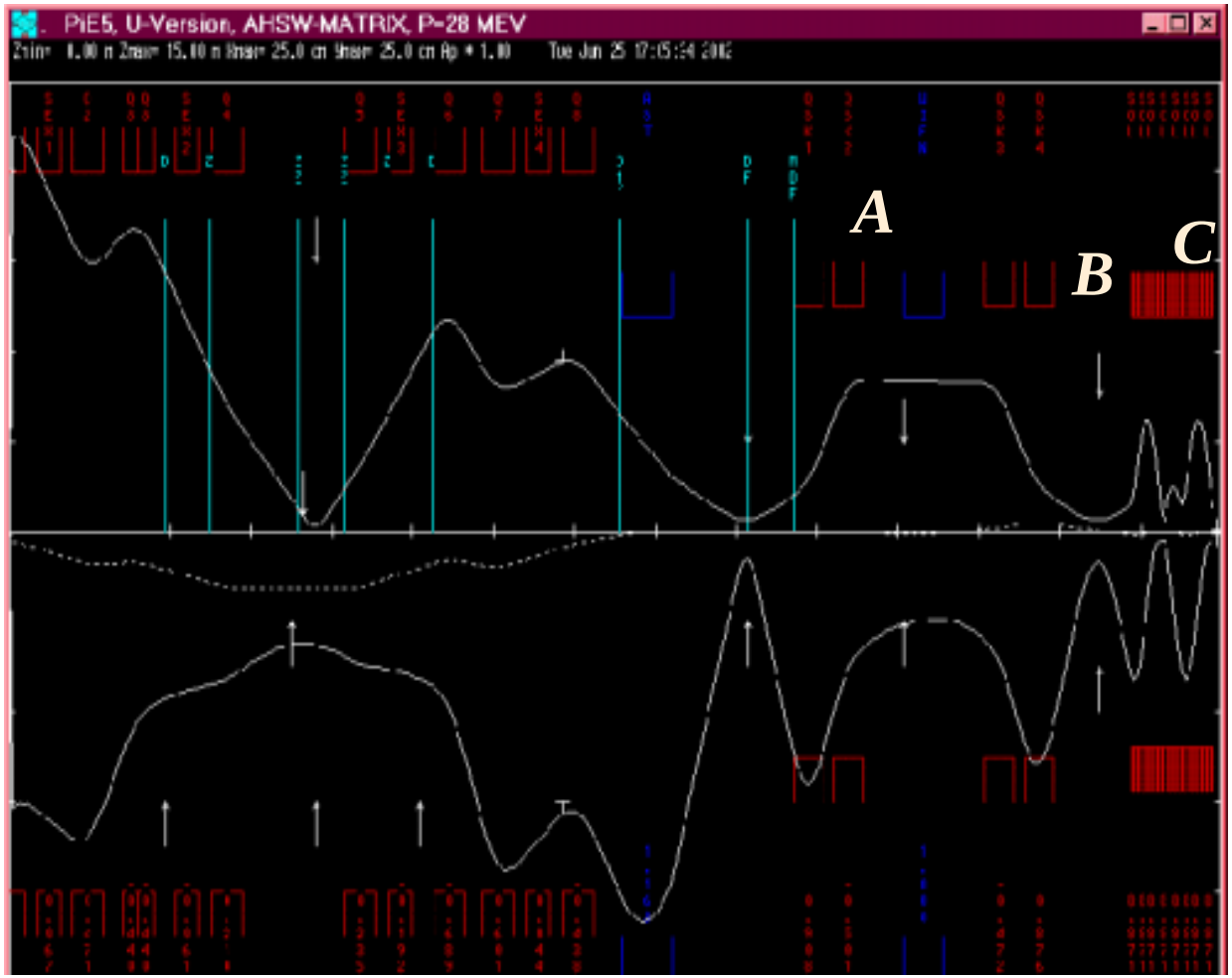
(ii) Repeat A (ii) – (iv)
rates + phase space
pill & NaI 2mm CH_2

(iii) 660 microns CH_2
with foils measure
stop-distribution

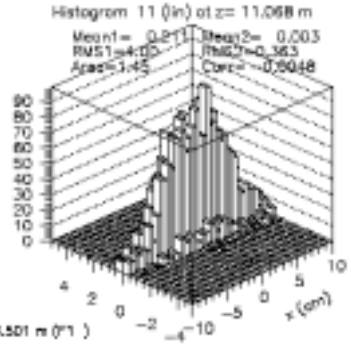
(iv) Repeat C(ii)
rates + phase space

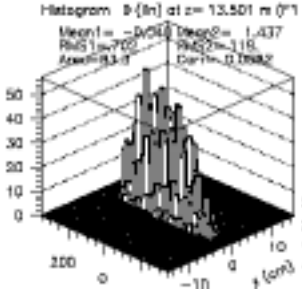
(v) Study rate vs. p-slits

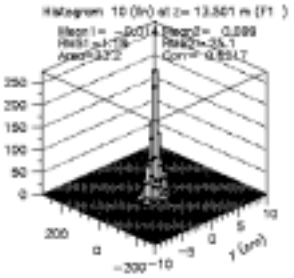
Transport / Turtle



A
σ_X ~40 mm
σ_Y ~4 mm

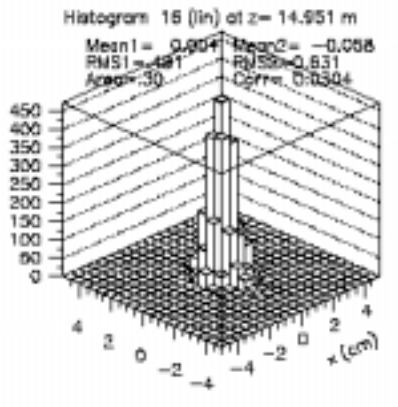






B
σ_X ~7 mm
σ_Y ~12 mm

C
σ_X ~4 mm
σ_Y ~5 mm
without degrader



Beam Time Schedule

Overview of July/August 2002 Beam Time

15-Jul M	16-Jul T	17-Jul W	18-Jul Th	19-Jul F	20-Jul Sa	21-Jul Su	22-Jul M	23-Jul T	24-Jul W	25-Jul Th	26-Jul F	27-Jul Sa	28-Jul Su	29-Jul M	30-Jul T	31-Jul W
Collab. Meeting	Review Meeting		Area Physical Setup			Optimization up to QSE42 Initial Rate + Phase Space Measurements			No Beam	Compare Scint. & NaI Rates for Consistency		Connect Separator Initial Beam Tuning plus Separation Quality				No Beam
		No Beam														

Phase A

Chambers + Wien Filter Available

Phase

1-Aug Th	2-Aug F	3-Aug Sa	4-Aug Su	5-Aug M	6-Aug T	7-Aug W	8-Aug Th	9-Aug F	10-Aug Sa	11-Aug Su	12-Aug M	13-Aug T	14-Aug W
Separation Quality Studies			Phase Space Measurements entrance to Solenoid		Tune Solenoid	No Beam		Degrader plus Solenoid Studies Measurement of Phase Space & Final Stop Rate in Thin Target with NaI & Chambers					Clear Zone

B

Chambers + Wien Filter Available

Phase C

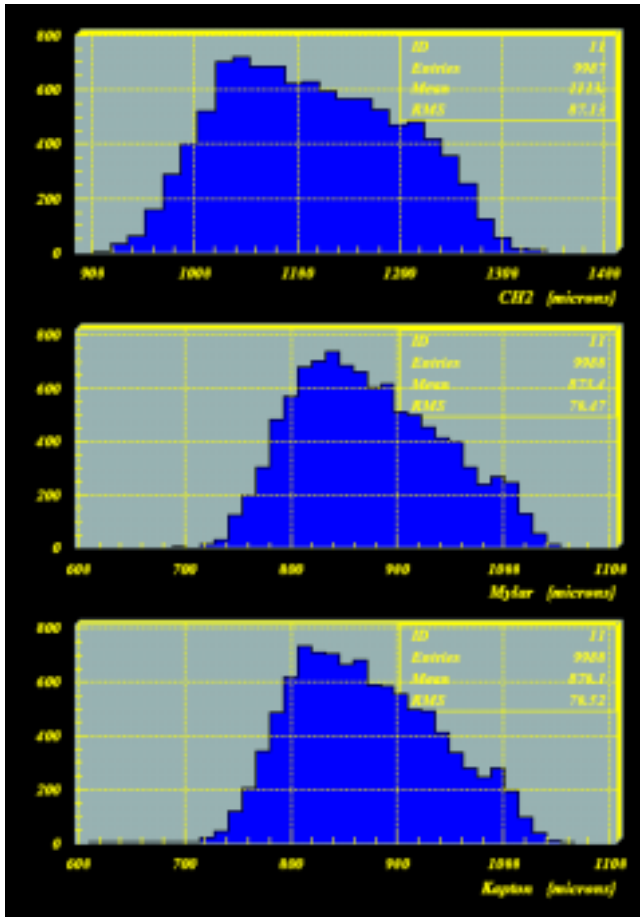
Equipment needed
(i) Wien Filter
(ii) Solenoid
(iii) Quadruplole Doublet
(iv) Pill Counter + Scanner
(v) NaI + Table
(vi) MWPC (Johny)
(vii) Profile MWPC
(viii) Degrader

Manpower Required
Min. man 2 x 8-18hr shift/day
P.-R. - Full Time
D.R. -Part Time
J.E. -Part time Chambers
S.R. - Part Time Computing
S.Y. (Tokyo) - 6th-15th Aug
Pisa 1- 2 persons 24th July -6th Aug. ?

Review Updated Numbers

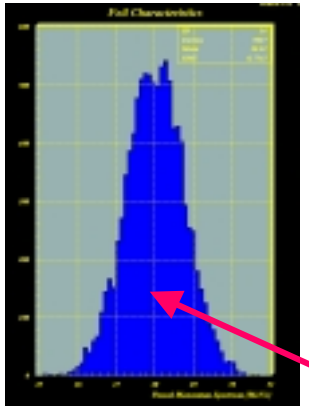
Degrader Studies:

Stop Distribution in CH_2/Mylar/Kapton for $\Delta P/P$ ~ 6.4 % FWHM Flat
P_0 ~ 28 MeV/c

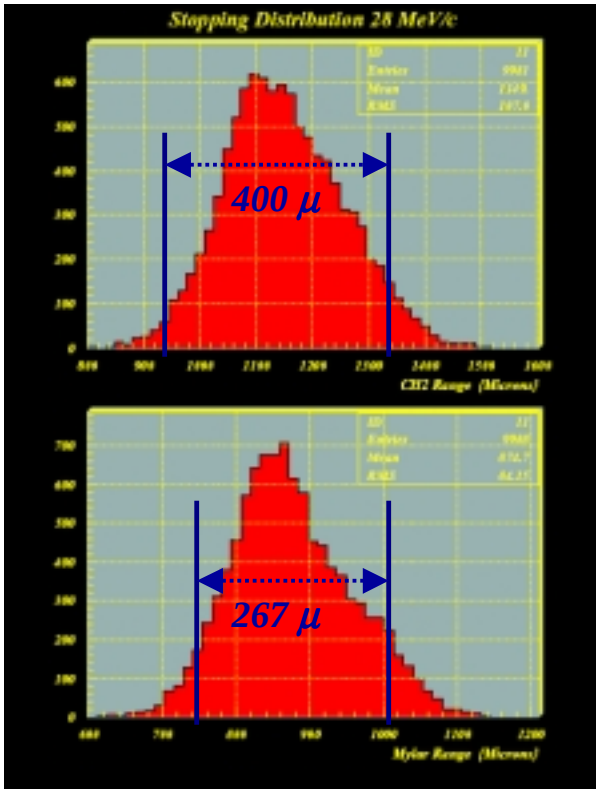


ρ~ 0.95 g/cm³
Range to stop all: 1350 microns
Degrader: 950 microns
Target : 150 microns at 22 deg.

ρ~ 1.39 g/cm³
Range to stop all: 1050 microns
Degrader: 750 microns
Target : 100 microns at 22 deg.



Stop Distribution in CH_2/Mylar/Kapton for $\Delta P/P$ ~ 5.6 % FWHM Gaussian
P_0 ~ 28 MeV/c



P_0 ~ (28 +/- 0.75)MeV/c

Depolarizing Properties of CH_2

PR 1958

PHYSICAL REVIEW VOLUME 112, NUMBER 1 OCTOBER 15, 1958

Depolarization of Positive Muons in Condensed Matter*†

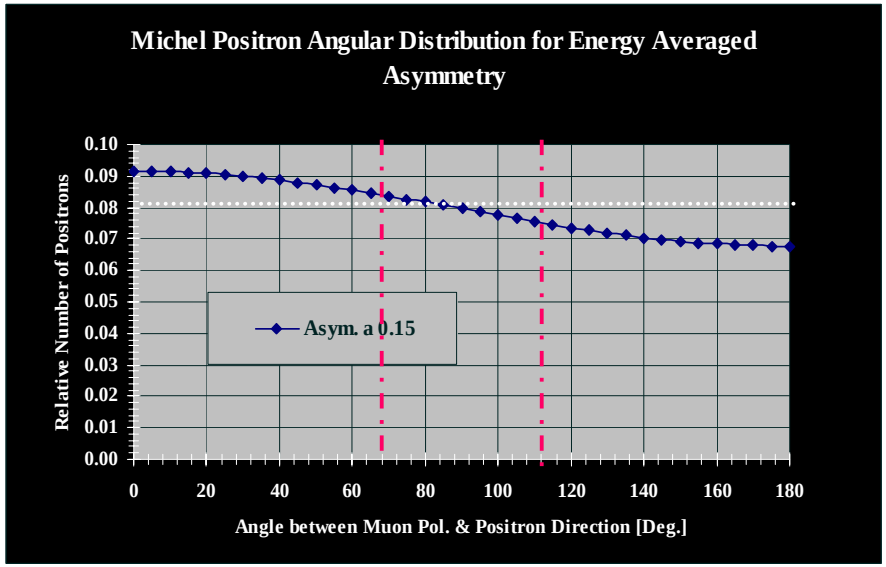
ROBERT A. SWANSON‡
The Enrico Fermi Institute for Nuclear Studies, The University of Chicago, Chicago, Illinois
(Received June 27, 1958)

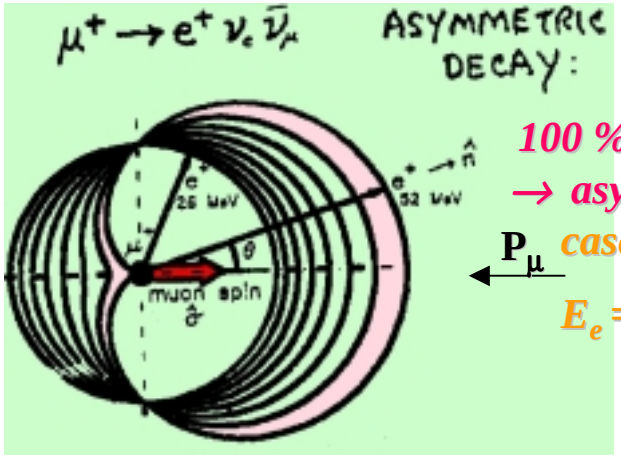
The effects of parity nonconservation in the π-μ-e decay chain are used to measure the depolarization of positive muons in solids and liquids. Depolarization factors are given for some 30 materials, including commonly used experimental media. The asymmetry coefficient a for the angular distribution of positrons emitted by muons from positive pions at rest is found to be 0.303 ± 0.048.

For 100 % Polarized μ^+ $\bar{a}$~ 1/3
for CH_2 $\bar{a}$~ 0.15 for B≤ 3.5 KG

Data Swansen et al. & Gurevich et al

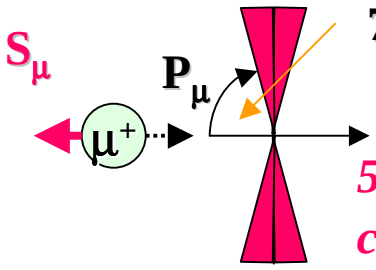
Material	T [K]	B[G]	asymmetry
Polyethylene	300	50	0.146 ± 0.012
Polyethylene	300	800	0.179 ± 0.009
Polyethylene	300	3500	0.153 ± 0.009





100 % Depolarization
→ asymmetry a = 0
P_μ case at $\theta^* = 90^\circ$
or
E_e = 26 MeV

In Experiment interested in:



$70^\circ \le \theta^* \le 110^\circ$ E_e large !

Beam Axis

5% effect in CH_2 for $\bar{a}$
c.f. 100% depolarized

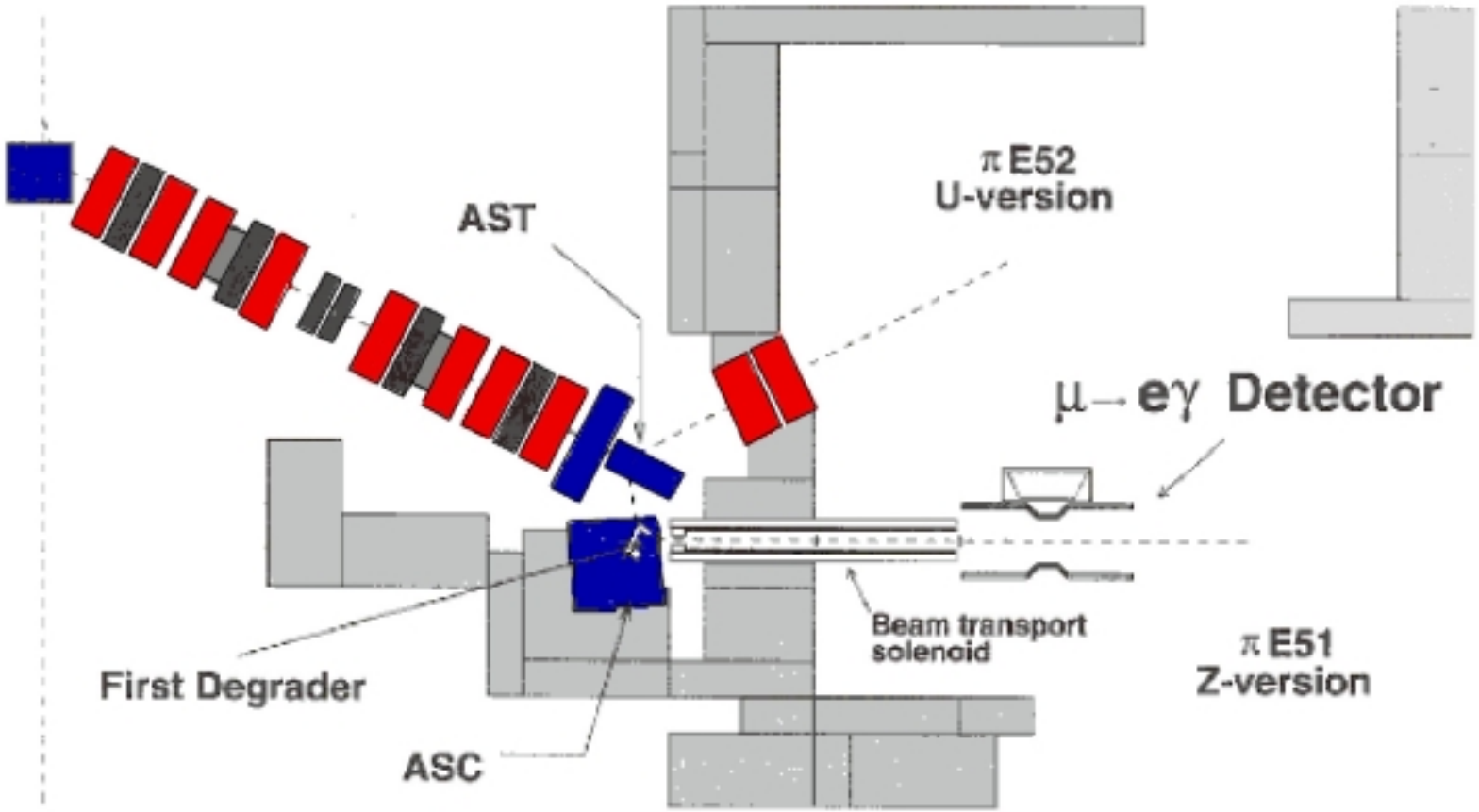
Target & Beam Monitoring (ideas)

Monitoring Questions: *solutions presently under study*

- ***Target attached to drift chamber assembly***
- ***possibility to exchange different targets***
- ***survey of target + position calibration with e^+–reconstruction of target periphery*** *(dedicated low rate runs)*

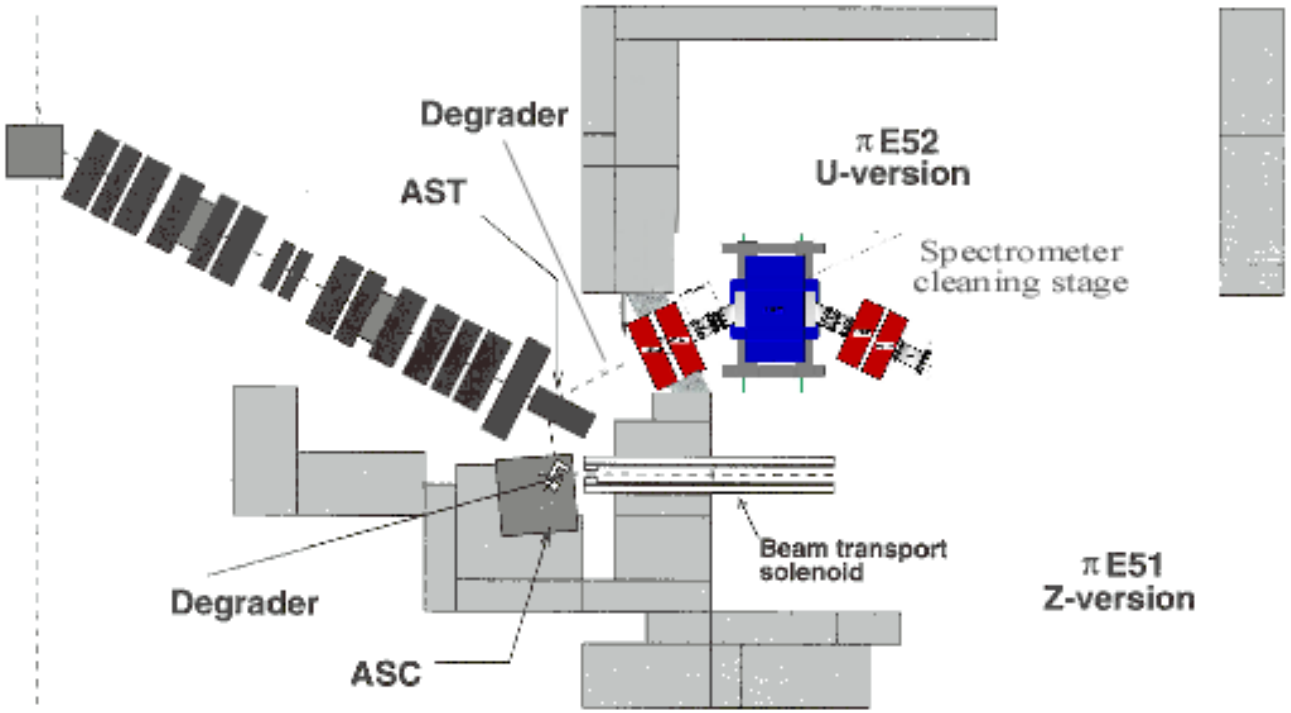
- ***Muon normalization using scintillation hodoscopes during data-taking as well as proton monitor***
  dedicated low-rate calibration runs for hodoscopes with scintillator/diode counters

Proposal Layout



After initial measurements , 'Z'-branch proposed but 'U'-branch still had to be studied

‘U’-Branch Degrader Measurements



The layout of πE5

Use Degrader & Cleaning Stage

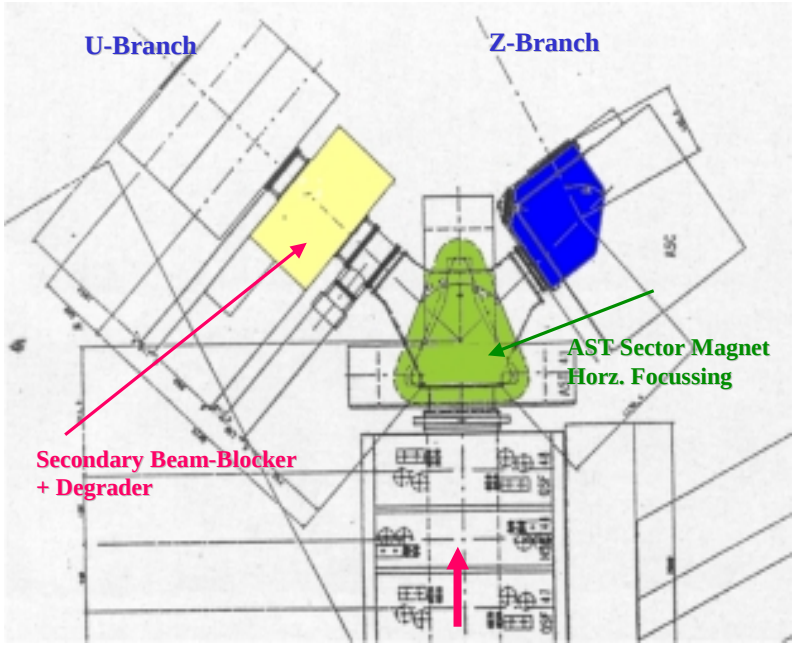
Special Degrader system needed
location fixed by optics
Secondary Beam-blocker

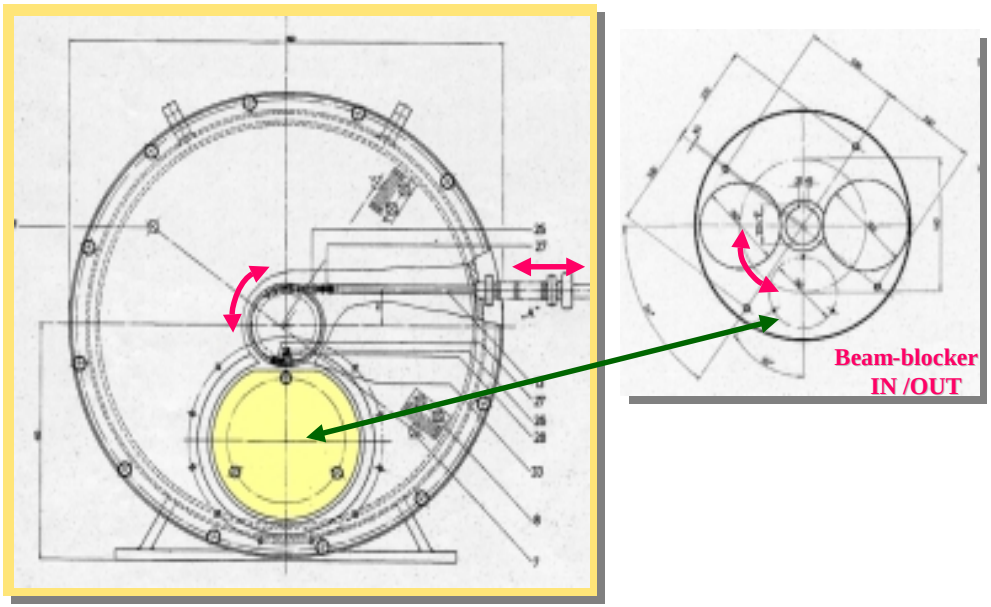
Degrader Location

Degrader System:

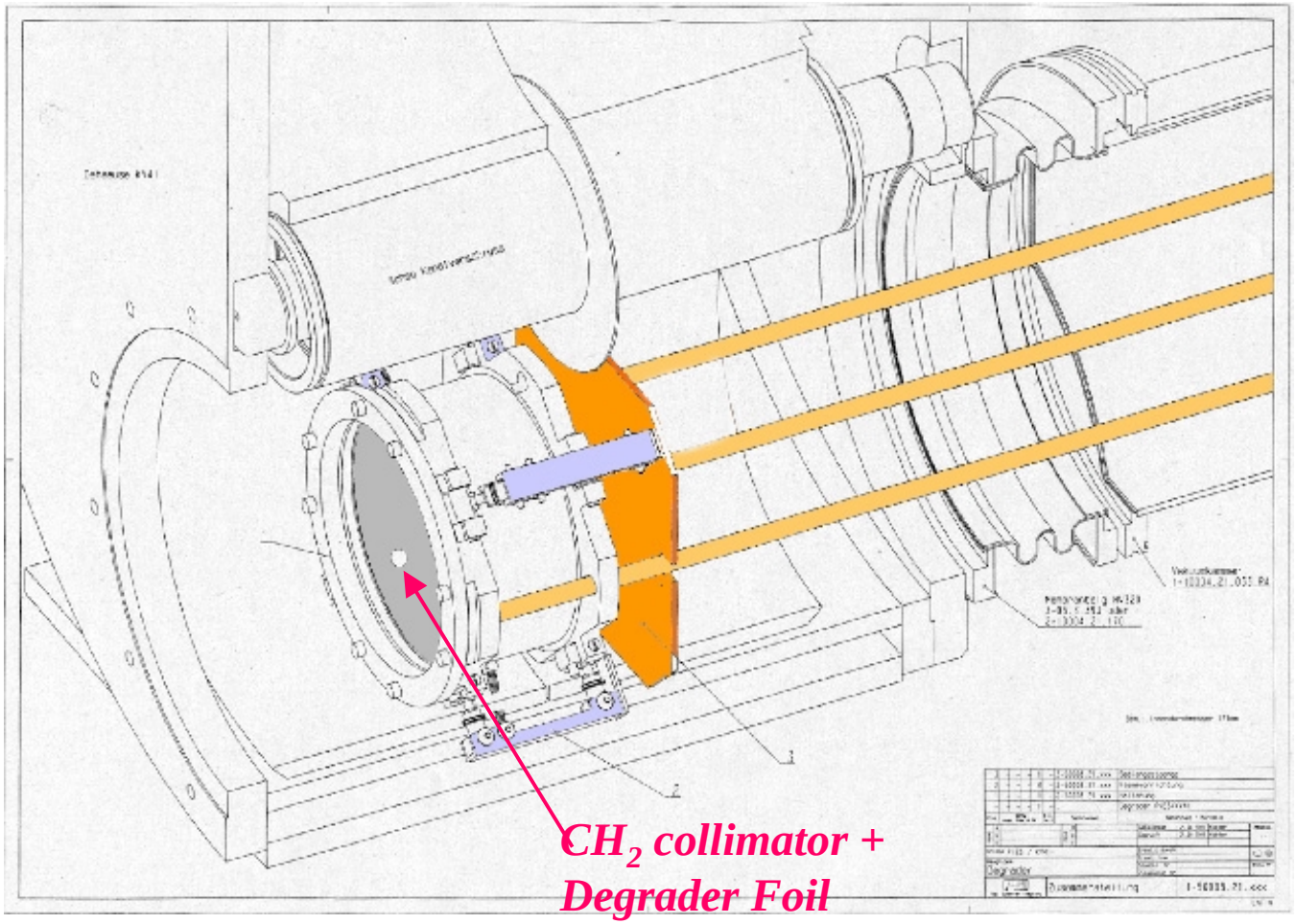
- Degrader must be placed at a **FOCUS** (divergence max) - because of AST Magnet, this is **within Beam-Blocker**
- Relatively complicated structure since it has to be introduced into a Safety Element (Beam-Blocker) via the vacuum chamber of the last fixed quadrupole doublet

Beam-Blocker: Motor driven shaft rotates massive cylinder with off-centre hole in & out of the beam axis. Our Degrader must be positioned within this hole





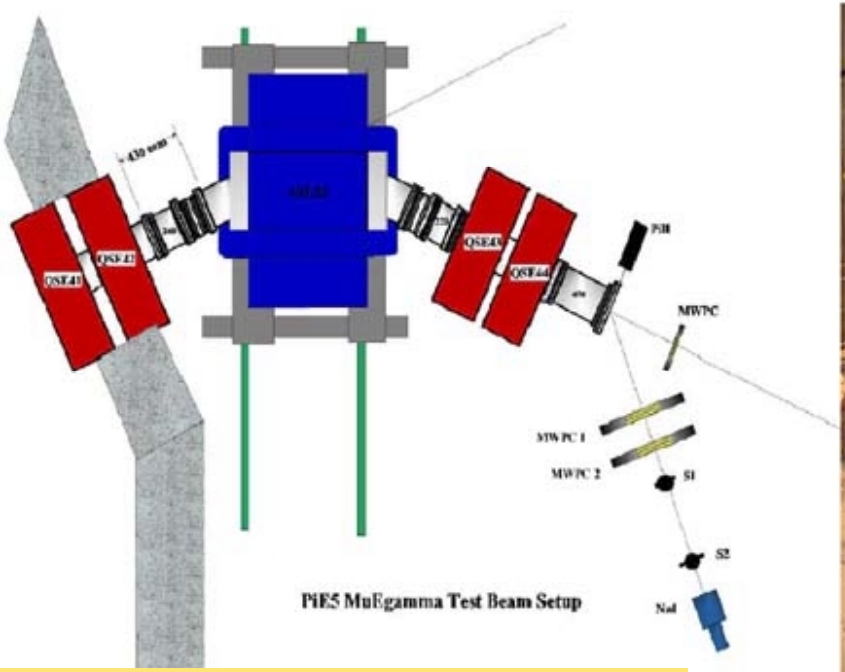
Degrader System

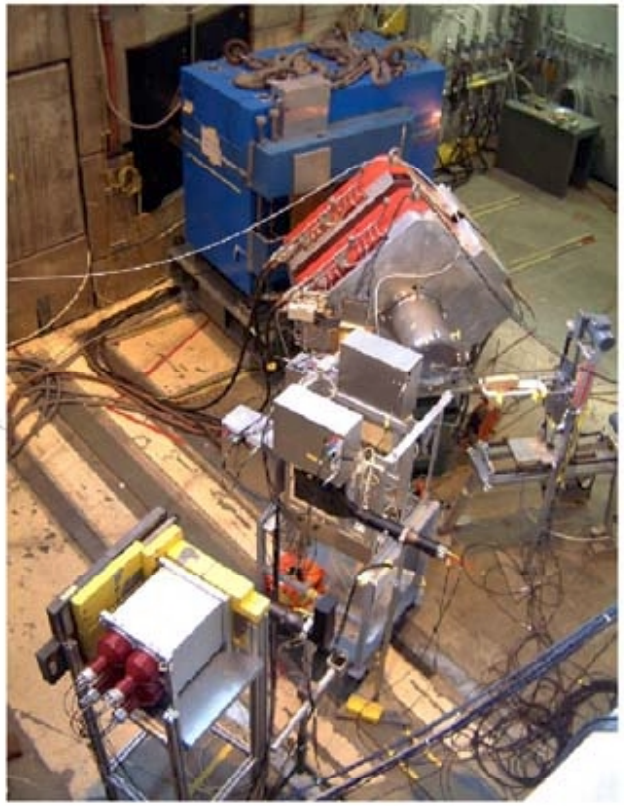


Access through last Doublet QSE41/42

spectrometer on rails to allow quick access without crane

Experimental Setup





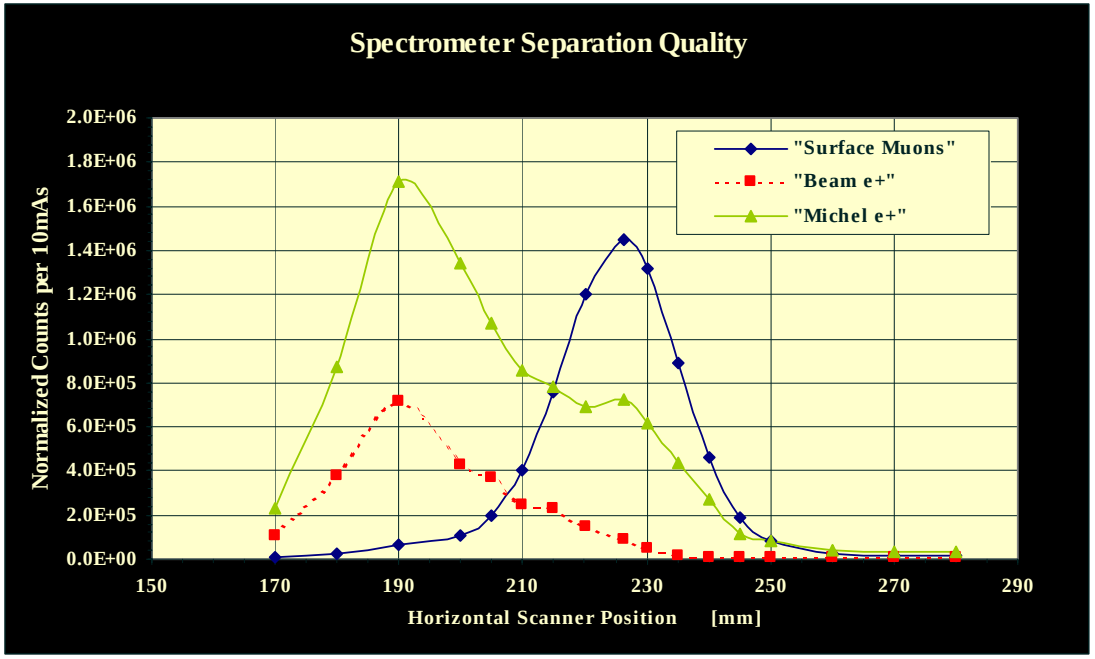
Measurements made: (Sept.- Oct. 2001)

- Total of 31 measurements
- 16 different Beam Tunes tried
- 2 different locations
  (post QSE42, post Spectrometer i.e. QSE44)
- 5 different detectors tried

Beam Time Prematurely ended - main Beam Blocker defective repair shutdown 2002

Results

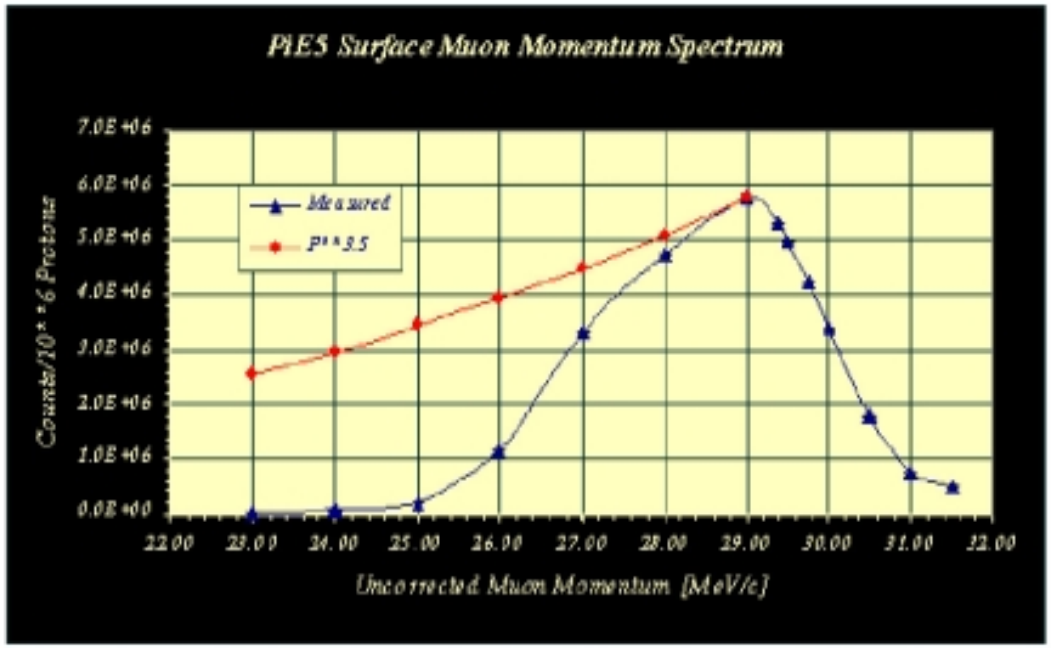
Condition	"Z"-branch	"U"-branch
No Degrader, Transmitted to Zone	$3.6 \cdot 10^8\ \mu^+s^{-1}$ $6.0 \cdot 10^8\ e^+s^{-1}$	$3.5 \cdot 10^8\ \mu^+s^{-1}$ $1.6 \cdot 10^9\ e^+s^{-1}$
Degrader, at Final Focus	$2.0 \cdot 10^8\ \mu^+s^{-1}$	$3.2 \cdot 10^7\ \mu^+s^{-1}$
μ/e ratio at Muon Peak	9	16.5



- *Transmitted rates without degrader equivalent*
- *beam e^+ rate 2.7 times higher in 'U'-branch*
- *with spectrometer loss of factor 2.1 independent of condition*
- *with degrader unexpected loss of factor 5.5 before area (increased vertical divergence due to multiple scatt. & QSE apertures r~12.5cm , rest of beam line r~ 20cm.)*
- *Beam e^+ suppression good*
- *High Michel background origin upstream of spect. (same characteristic as beam e^+)*

Conclusion: Cannot use Degrader at focus of AST with small aperture quadrupoles following → Wien Filter

Momentum Spectrum



- Central Momentum 1.4 % higher
- $\Delta P/P \sim 3.4\%$ FWHM equivalent to momentum byte set
- drop-off to small P much steeper than $P^{3.5}$
- GEANT says $P^{3.5}$ should be valid down to ~ 23 MeV/c

subsequently :

All magnet power supplies checked

For offset + Linearity

< few per mille

→ check by

Tuning whole beam line each time, not just scaling