MEG – Beam Line Studies

Present Status & Overview since July 2002

Outline of Addressed Topics

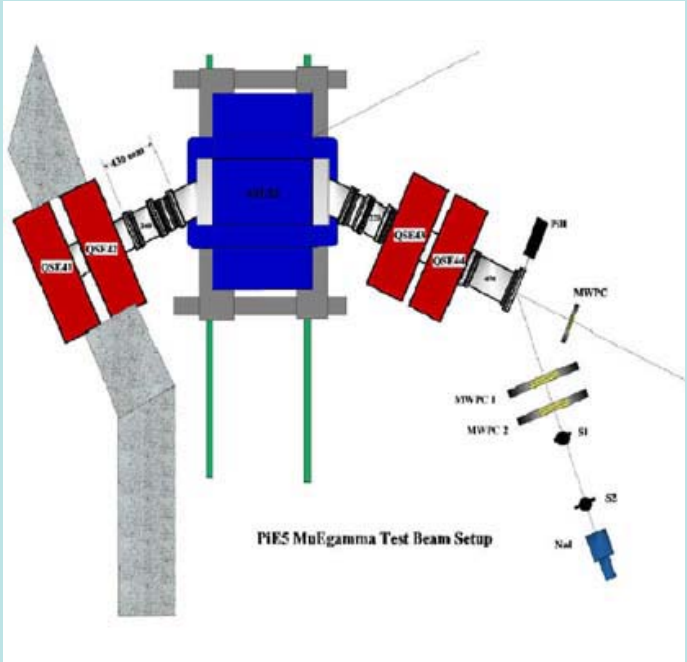
- Status at the time of the last Review
- July/August 2002 Run (πE5 U-Branch)
- November/December 2002 Run (πE5 Z-Branch)
- Beam Transport Solenoid
- Future
- Summary

Status at last Review July 2002

Present Series of Beam Studies started October 2001

"2-in-1" Method used in πE5 "U"-Branch

simultaneous degrading of μ^+ momentum & spatial separation of beam e^+ via an induced differential energy-loss to the particles using a degrader and spectrometer



Conclusion:

Stopped Surface Muon Beam of Sufficient Intensity & Free from Beam Correlated Positrons NOT POSSIBLE using "2-in-1" method in "U"-Branch, without channel modification –

limitation of vertical phase space acceptance of last doublet

Status at last Review July 2002 (continued)

Plan Presented → up to End 2002

Involving - 2 proposed Test Beam Periods within 6 months

July/August 2002 - πE5 "U"-Branch

November/December 2002 - πE5 "Z"-Branch

goals:

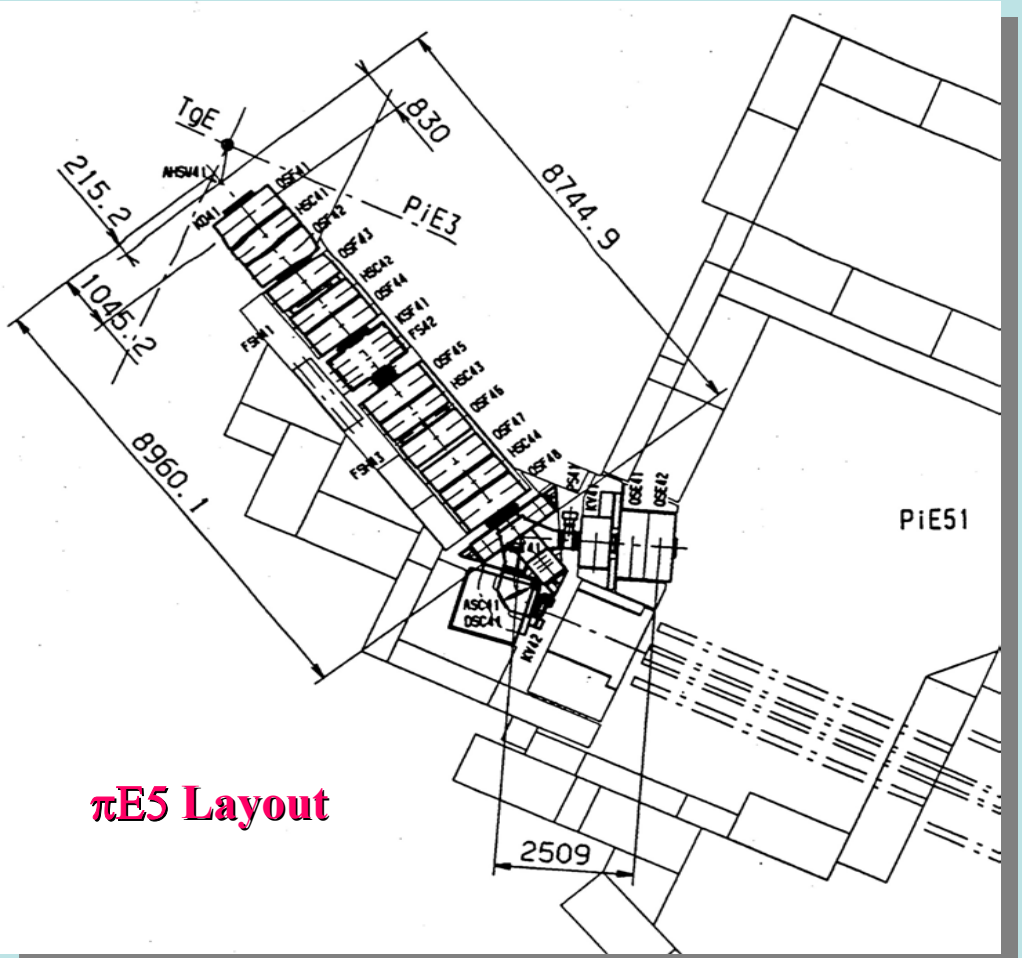
- Find viable alternative method to "2-in-1"
- Set up full beam line upto COBRA solenoid
- Comparitve study of both branches
- Collect data by end of 2002 to make optimal choice of branch for MEG experiment early in 2003

Possible Solutions:

1. Re-build last part of Beam Line & use Solenoid or Triplet
2. Use 2-Stage Separation & Degrading method → WIEN Filter & Solenoid

→ Method (2) chosen for "U"-branch July/August Run

July/August 2002 Beam Period



πE5 Layout

"U"-Branch Measurements

Leave existing Beam Line

Add WIEN-Filter (Crossed E &B fields)

➥ Particle Separation

Add Solenoid + Degrader System

➥ Momentum Reduction

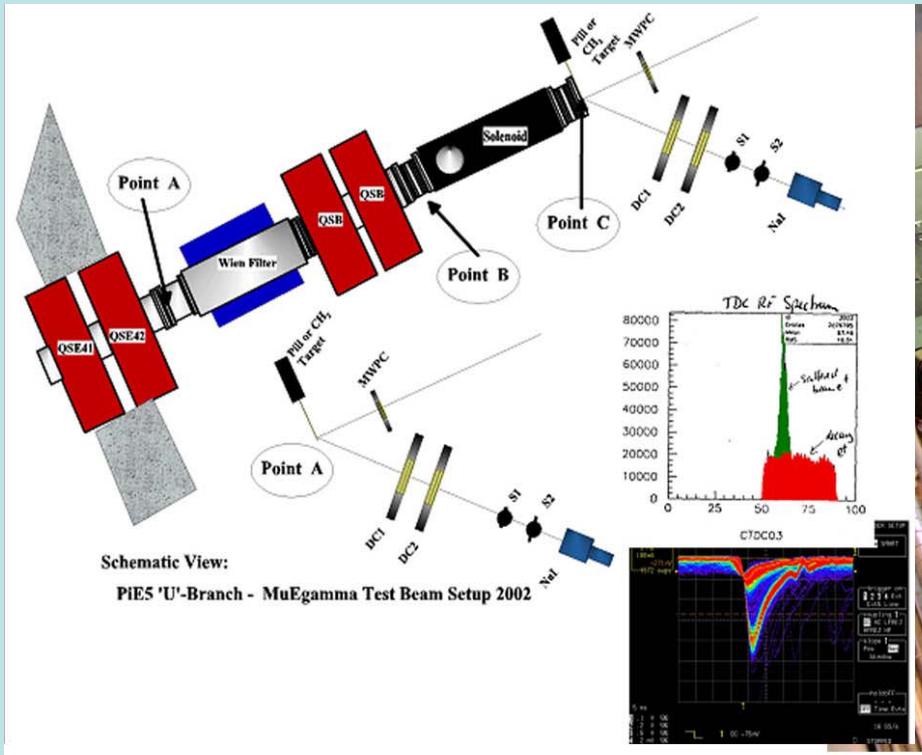
Provisional Results showed

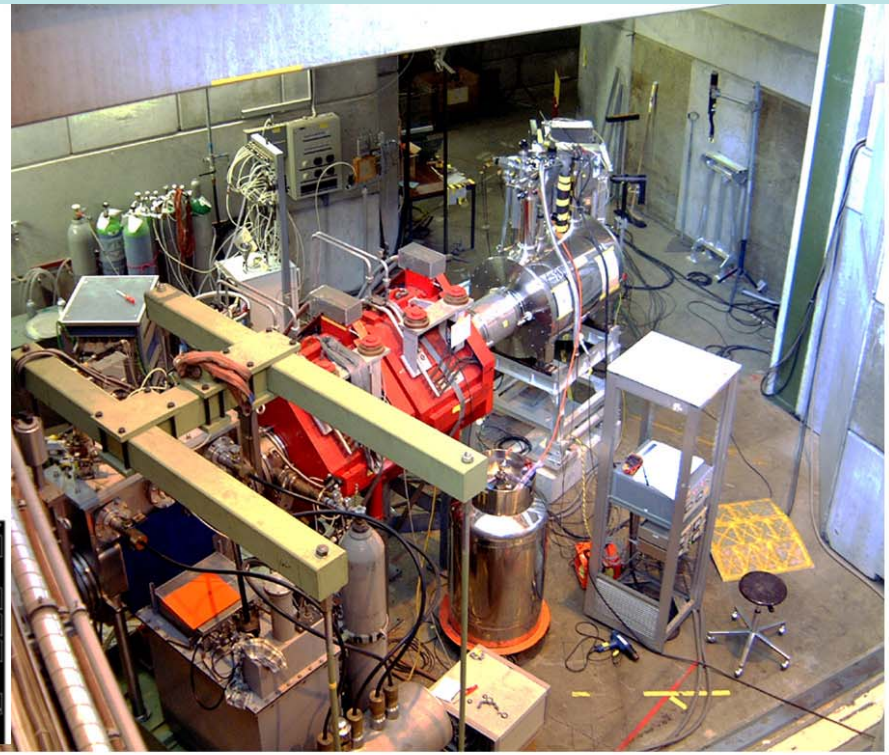
- Suitable beam CAN be achieved using this method
- Method should also be used as comparative study for "Z"-Branch

"U"-Branch Layout & Measurement Principle

Measurements in 3 Phases @ at 3 Locations using various methods:

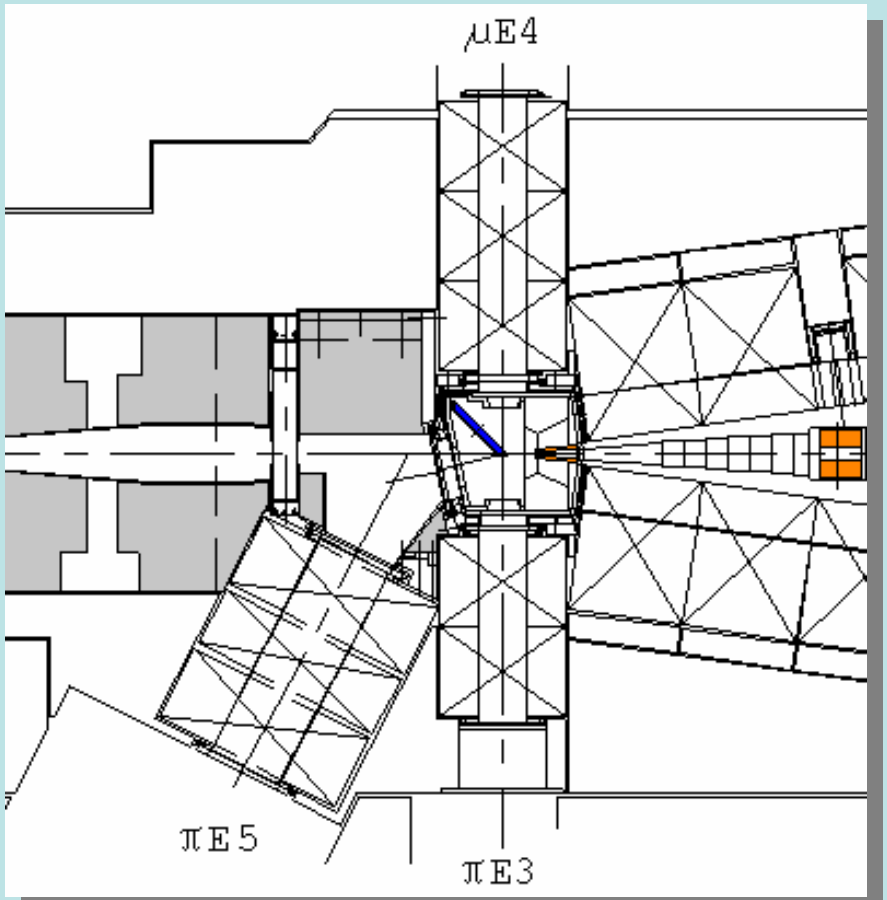
1. Point A – post QSE 41/42 doublet **(Normalization Measurement)**
2. Point B – post separator/entrance solenoid with/without Collimator **(Transmission)**
3. Point C – post solenoid, various target sizes & thicknesses & material **(Stop Rate)**





Target Geometry for 2002 Runs

Measuring Conditions 2002:
4 cm Target E (Proposal 6cm Target + different construction)
~ 1840 μA Proton current

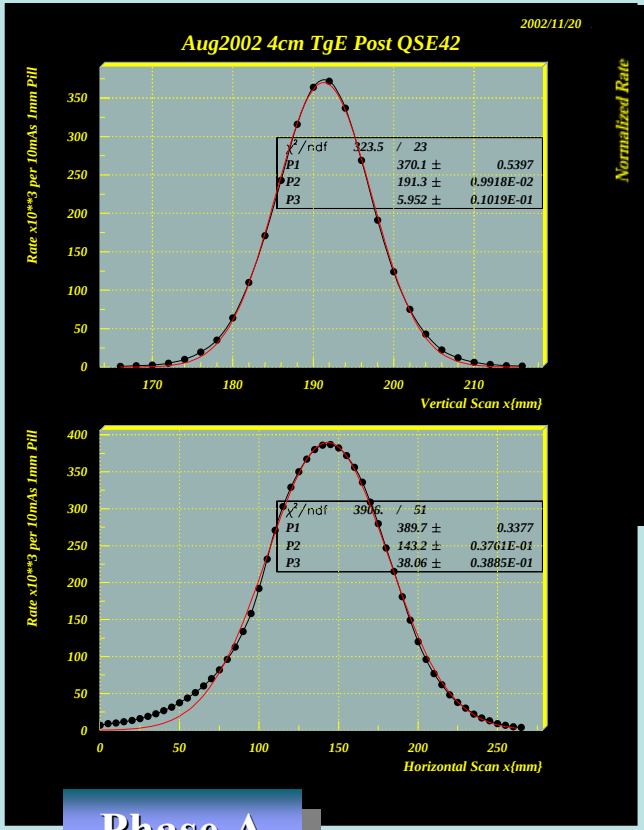


6cm Tg.E
as in Proposal
6 spokes continuous

4cm Tg.E
as now
12 spokes + slits

$R_{4cm}=(0.55\pm0.05)R_{6cm}$
Measured πE5 L. Simons et al
from geometry alone would expect ~ 0.67

Provisional Results July/August 2002 Run



Phase A

Integrated Rate

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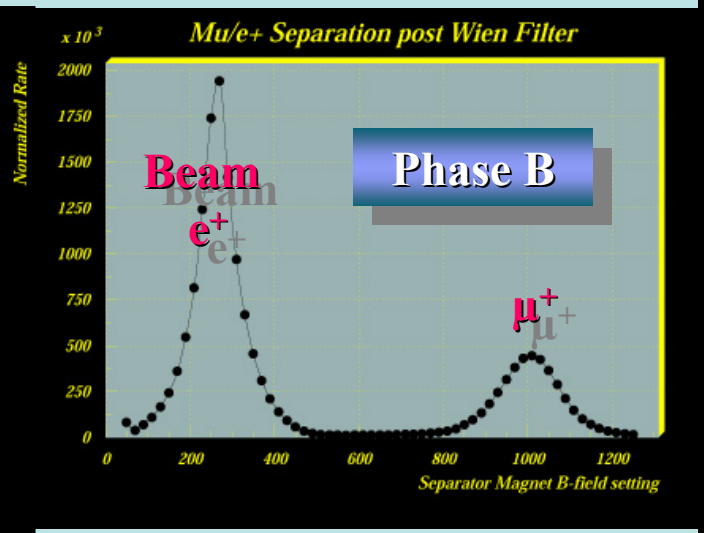
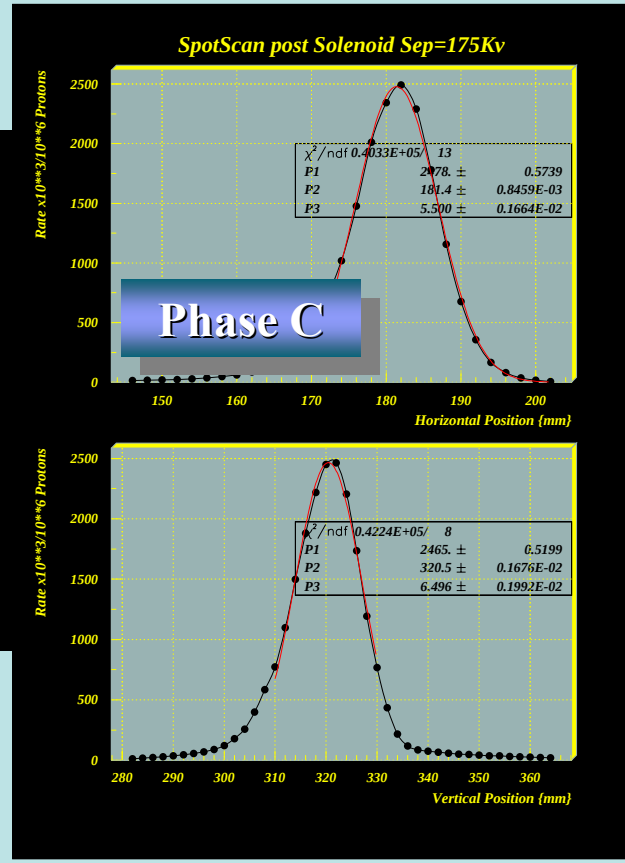


Phase B



Phase C

Separator 175kV
μ/e separation:
11σ !!!
24cm Vertically
Transmission Sep=ON:
56%
Corresponds to
$7.3 \cdot 10^7$ μ+/s 4cm 1800μA
($1.3 \cdot 10^8 \mu^+$/s 6cm Tg.)

Analysis continuing

~80%
N.B. Solenoid NOT matched

November/December 2002 "Z"-Branch Beam Period

- Extensive Preparations needed!

- No extraction mechanism easily available
  - ➥ planned SINDRUM 1 solenoid NOT AVAILABLE after all
  - ➥ Concrete beam-blocker after ASC(2m inside shielding)

- Triplet extraction system decided on
  - ➥ Brand new "Raw" Quads for LEM-beam borrowed … BUT

- ~$2^{1/2}$ months to Design & Construct shielding and insertion wagon for quads + build triplet & Insert new system
  - ➥ Only possible when Accelerator is OFF

Thanks to the excellent work of many of the Service Groups involved ⇨ Insertion during 2-day Shutdown end November 2002

"Z"-Branch Layout & Measurement Principle

Same Principle adopted as "U"-Branch but with Triplet instead of Doublet + Separator & Solenoid however Run split into 2 parts

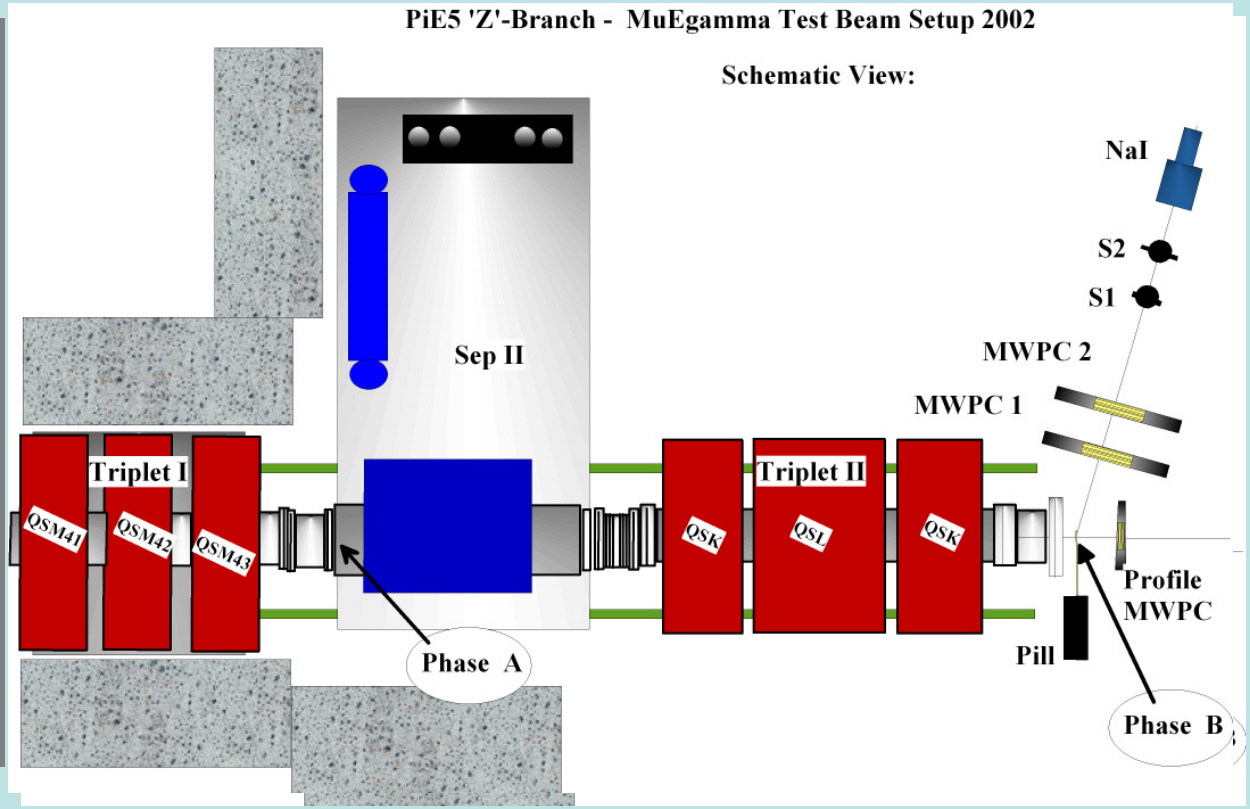
November/December 2002

Phase A – Post Triplet

Phase B - Post Separator

April/May 2003

Phase C – Solenoid + Stop Distribution

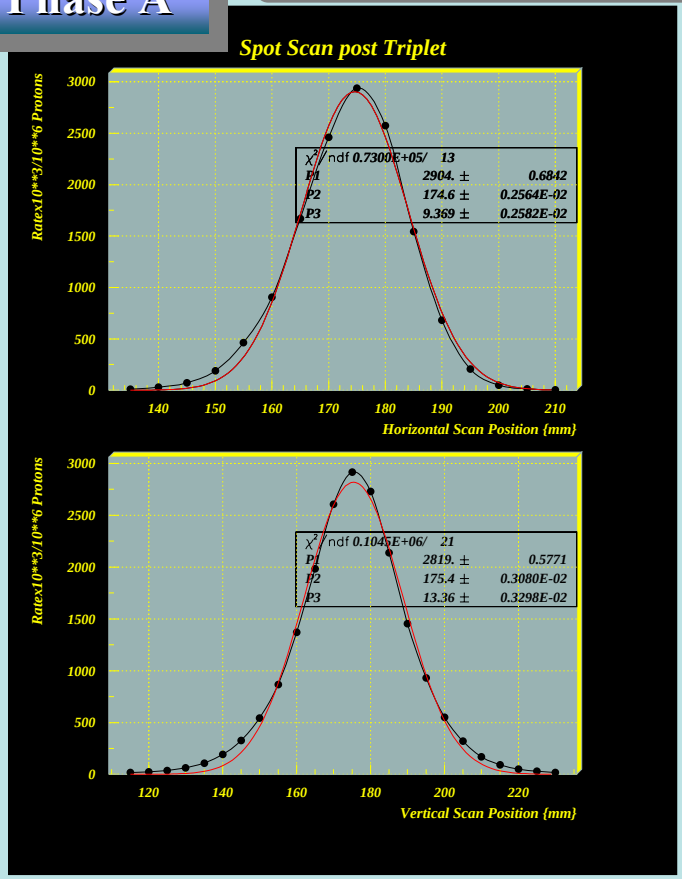


Large quantity of Data collected

Detailed Analysis – just started running in parallel to analysis From July/August Run

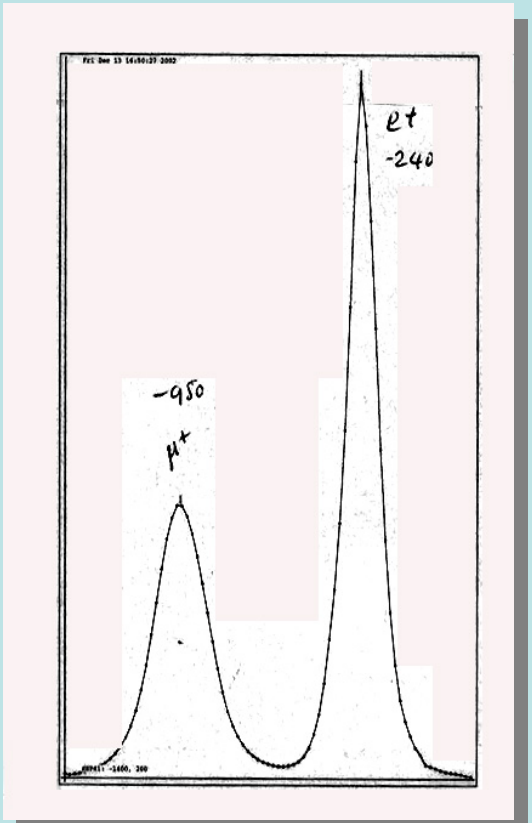
Very Provisional Results November/December 2002 Run

Phase A



Integrated Rate
4cm Tg.E @ 1800μA
N_μ~1.3·10^8 μ$^+$/s
(2.3·10^8 μ+/s 6cm Tg.)

Phase B



Separator 175kV
μ/e separation:

(1) 7σ
12cm Vertically
Transmission Sep=ON:
67%
Corresponds to
8.8·10^7 μ$^+$/s 4cm 1800μA
(1.6·10^{8}μ$^+$/s 6cm Tg.)

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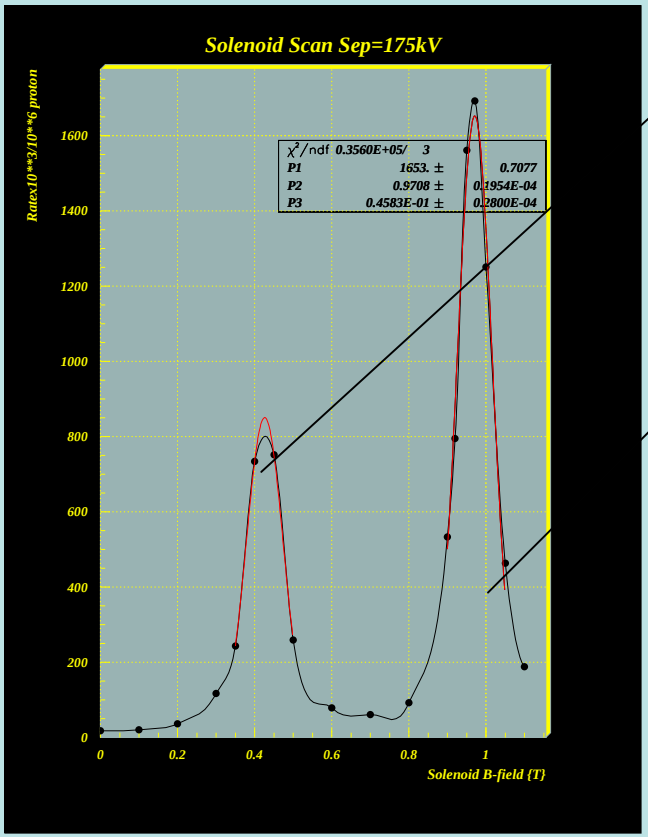
(2) 11cm Vertically
Transmission Sep=ON
73%
Corresponds to
9.5·10^7 μ$^+$/s 4cm 1800μA
(1.7·10^{8}μ$^+$/s 6cm Tg.)

MEG Transport Solenoid Considerations a First Look

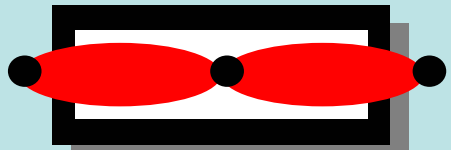
July/Aug. Solenoid Scan Rate vs. Bfield for 28 MeV/c surface muons



Single Node

B=0.426 T
I=6.39 A

Double Node



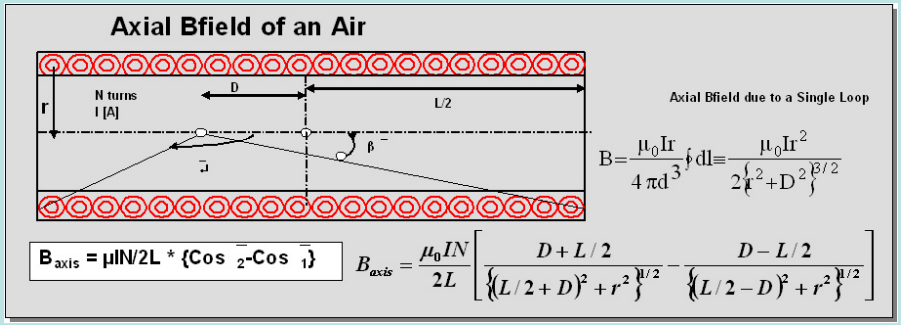
B=0.971 T
I=14.56 A

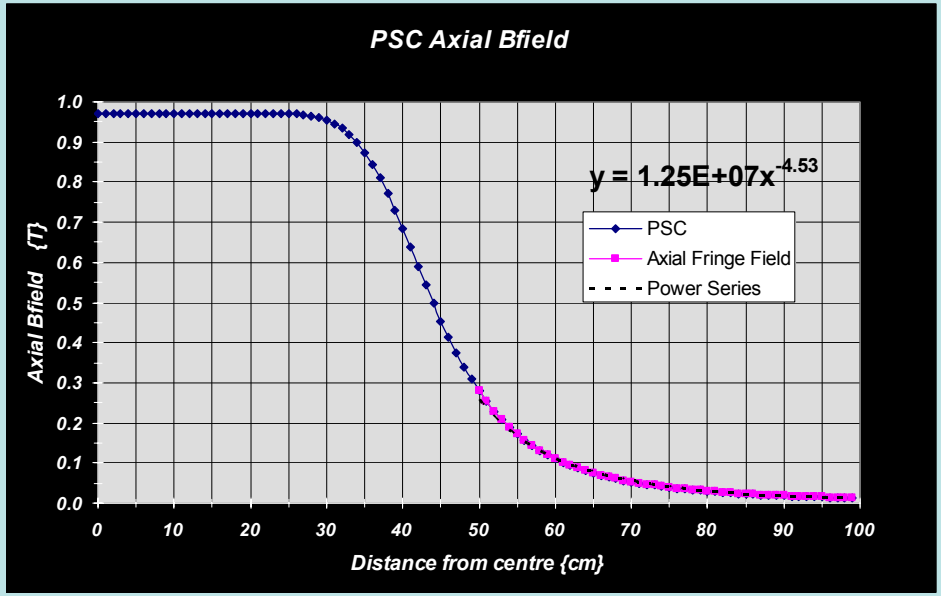
What does this mean for the Design of our Transport Solenoid ?

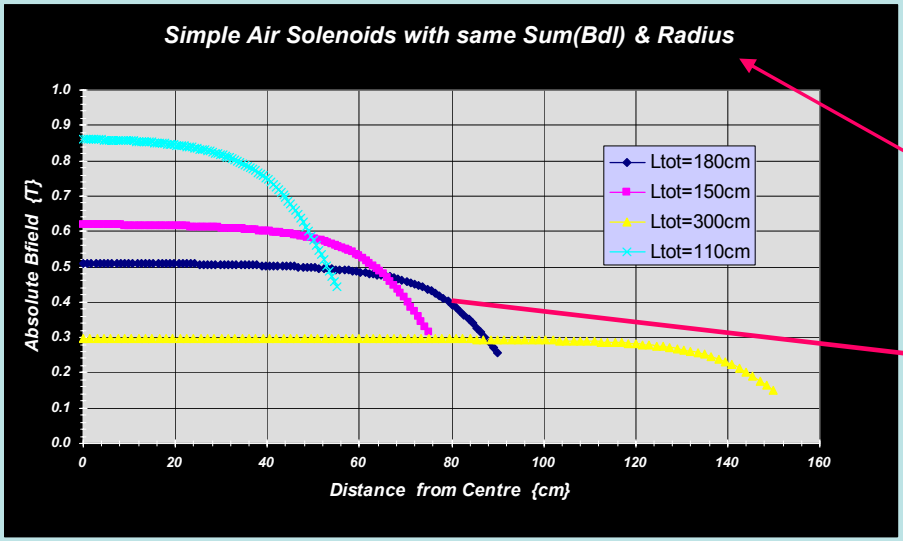
1. Above gives us ∫Bdl for 28MeV/c μ^+ 2-nodes
2. Have to couple to COBRA at 0.5T
3. Superconducting or Normal Conducting?
4. Air or Iron Warm Solenoid
5. Length
6. Coupling Homogeneity

work together with experts from Novosibirsk-Tokyo-KEK-PSI

Length of Transport Solenoid



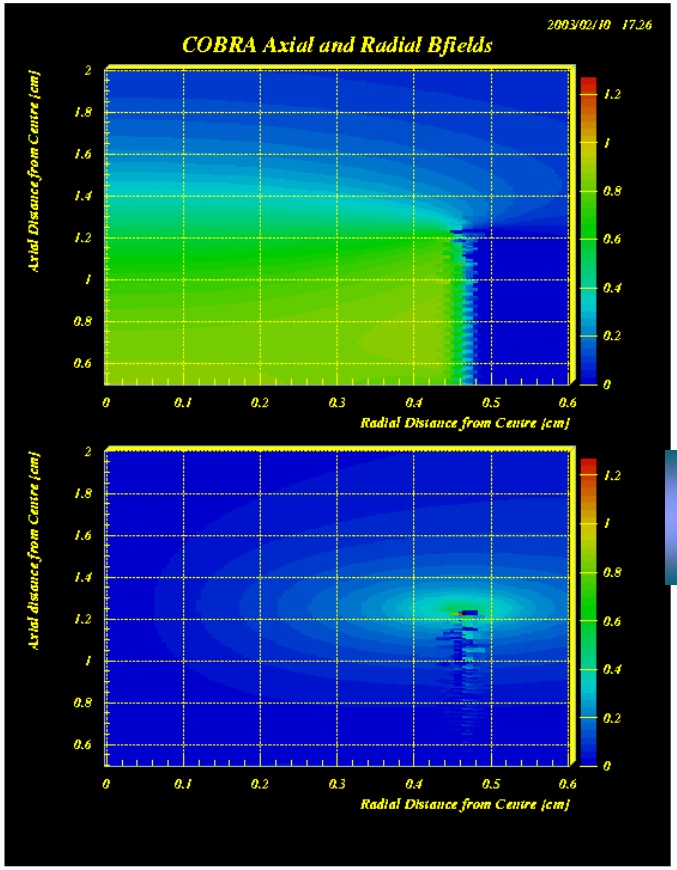




PSC/ALC Solenoid
Simulation = Field Map on axis
∫Bdl=0.8588 Tm physical length)

For ∫Bdl=0.8588 Tm & $B_{coupling}$ = 0.5T
$L_{sol} \leq 180cm$

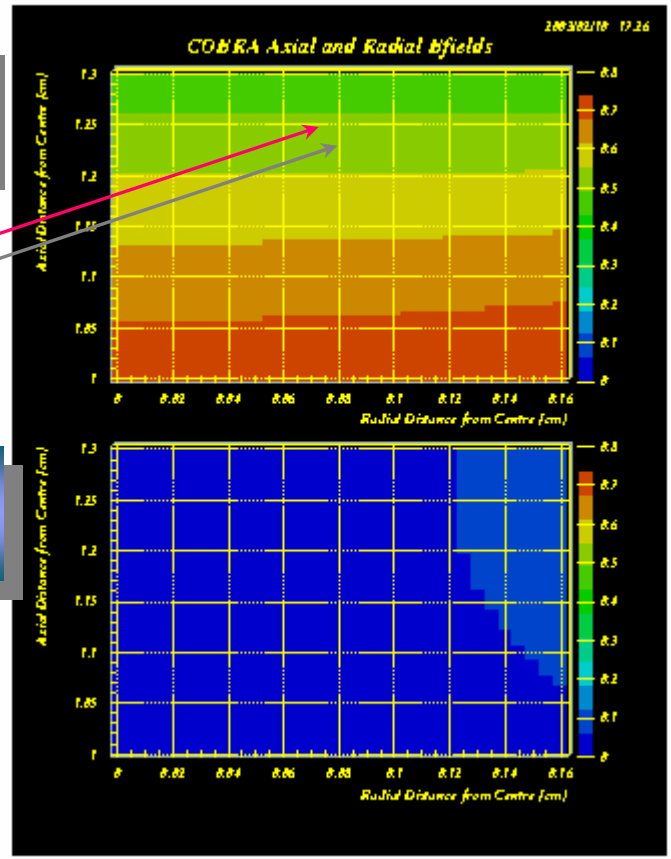
What about coupling to COBRA?



Axial Cobra Bfield

~2% homogeneity

Radial Cobra Bfield



Radius 0 – 60 cm

Radius 0 – 16cm (Transport sol)

Normal or Superconducting?

Rough Cost Estimate	Normal Conducting	Super-conducting
Solenoid	~ 50ksFr	150 ksFr
Power Supply	≤ 100ksFr	~ 10ksFr
Power Costs	~50sFr	-----
Cryogenic Parts (Process Control Logic)	-----	~100ksFr
Initial outlay	~ 150ksFr	~260ksFr
Costs 3yrs of Running	~150ksFr	------
Total Costs after 3 yrs	~ 300ksFr	~260ksFr

Other Arguments/Future Use:

- Cold – need LHe transfer line or dewars
- Cold – power supply easily transferable
- Cold – more useful for future B range larger for fixed supply

- Warm – Special Power Supply needed
- Warm – not easily movable

Very Rough Estimates
Only 1st Round!!!

Needs more realistic modelling & interaction with the experts

Future

Follow-up Points:

- **Start Design phase for Transport Solenoid**
- **Phase C of Test Beam Period – stats end April 2003 Solenoid + Stop Distribution Study**
- **Continue Analysis of Test Beam Data**
- **Start design of final Triplet + Wagon + Shielding after test Beam should be ready to install shutdown 2003/2004**
- **Design of Target System**

Summary

1. **Viable Solution for the MEG Beam Line FOUND using "Z"-Branch**
   using separate stages for particle separation & Momentum Degradation via triplet + WIEN Filter + Solenoid
   - excellent suppression of beam correlated background (~7σ possible with higher rate)
   - Rate of $9.5 \cdot 10^7 \mu^+/s$ @ 1800μA and 4cm Tg.E AFTER Separation (equivalent to ~ $1.7 \cdot 10^8 \mu+/s$ @ 1800μA and 6cm Tg. Proposal)
   - Transmission Factor of ~ 73% in WIEN-Filter
   - Final Target Beam-spot sizes equivalent to Proposal Values achieved $5.5mm \leq \sigma_x \sigma_y \leq 6.5mm$

2. Work on Transport Solenoid started
   - length ~180cm with B~0.5T needed
   - Warm or Cold? Etc
3. Solenoid + Degrader & Stop Distribution measurements
   - Final part Phase C of "Z"-Branch measurements April/May 2003
4. Continue Analysis + Preparations for final Triplet