PEP-N
Detector Layout

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e+e- Physics at Intermediate Energies
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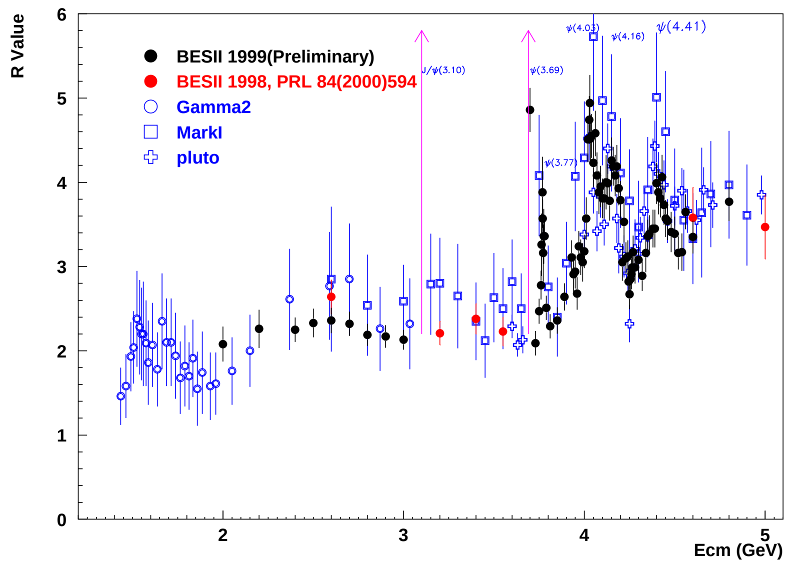
OUTLINE

- Introduction
- Physics motivations
- Detector Requirements
- Detector Layout
- Conclusions

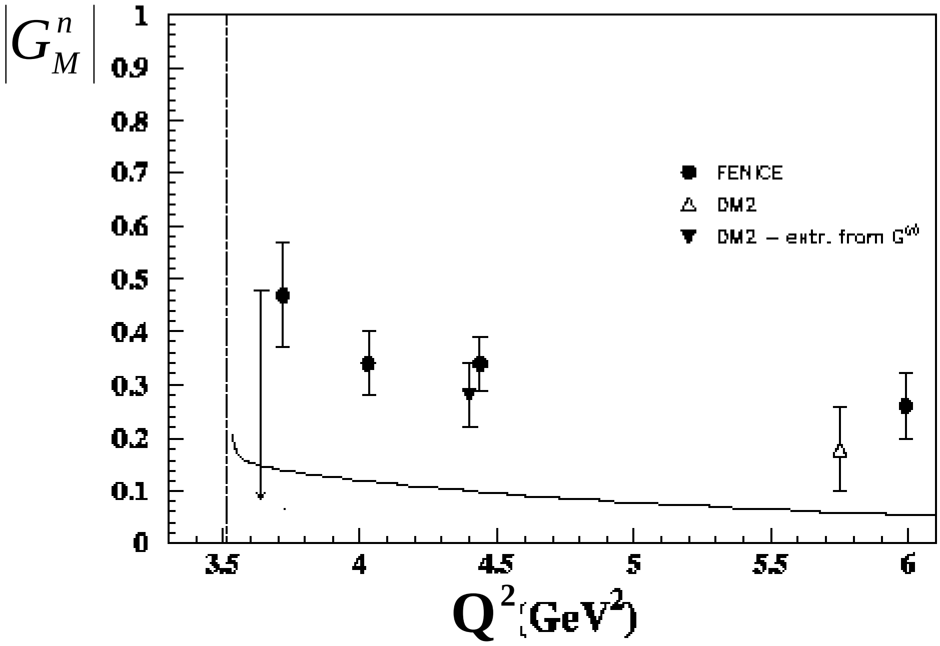
Physics Motivations

- R measurement
  - evolution of α_{EM}
  - hadronic contribution to g_{μ}-2
- Nucleon form factors
- Other baryon form factors
- Meson form factors
- Vector meson spectroscopy
- Multihadron channels
- $\gamma\gamma^*$ interactions

R measurements at low energy



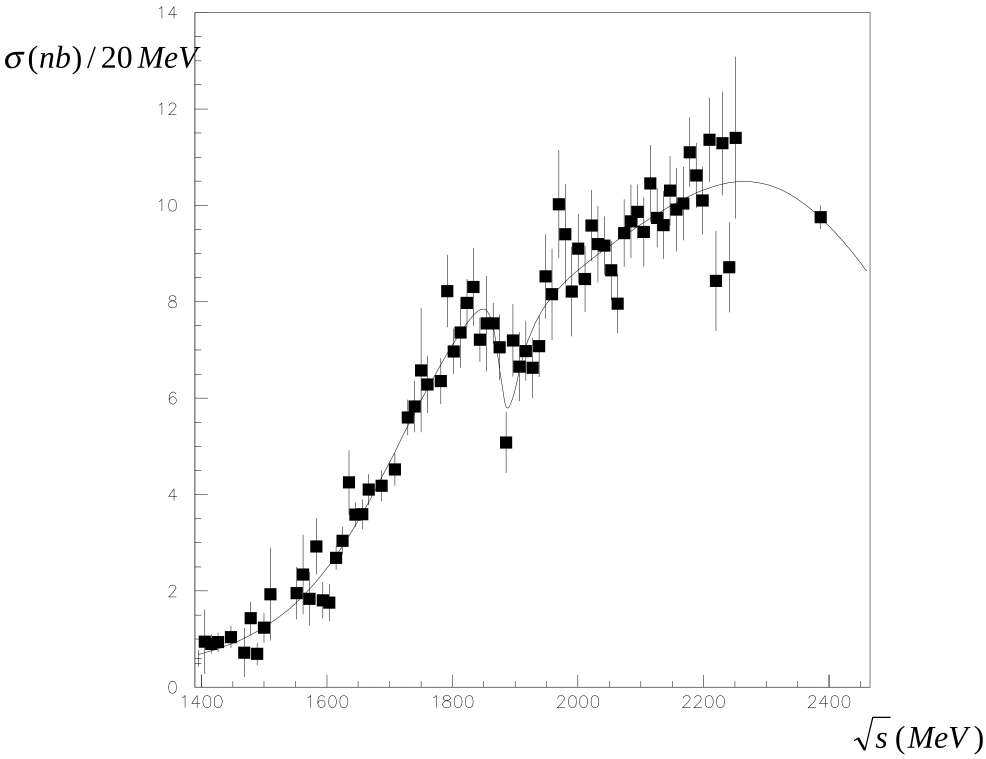
Ratio between neutron and proton form factors



Data obtained primarily by the FENICE experiment (Adone, Frascati). $\int Ldt = 0.4\ pb^{-1}$ 80 events.

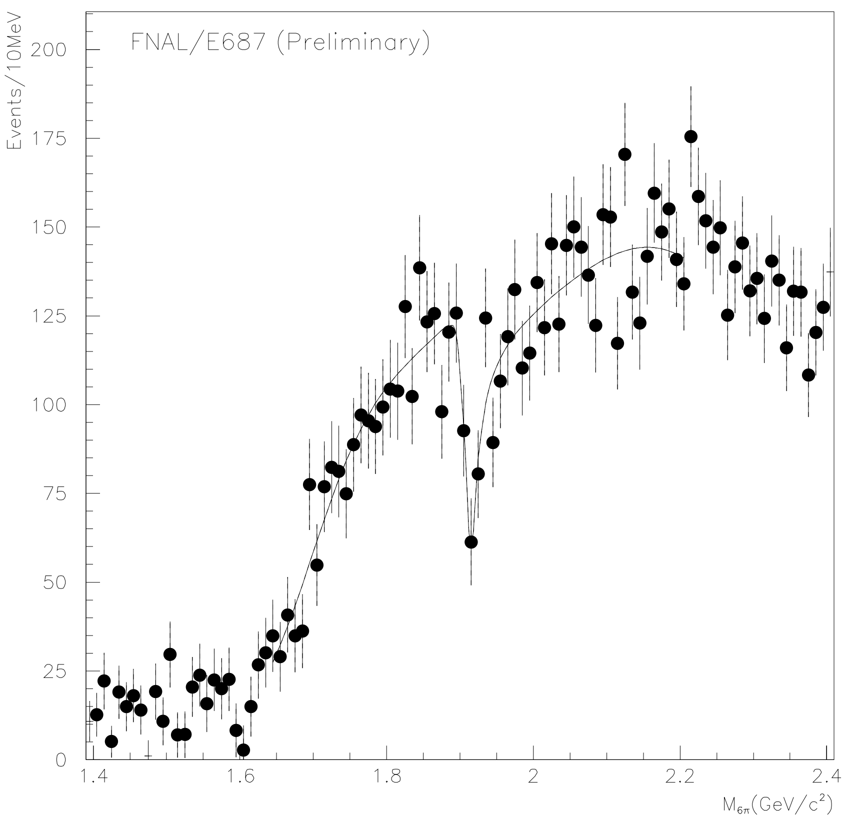
The neutron form factor is bigger than that of the proton !!!

Assumes $G_E=G_M$ near threshold for both proton and neutron. New, high-statistics measurement needed to separate electric and magnetic form factors.



$e^{+}e^{-} \rightarrow 3\pi^{+}3\pi^{-}$

DM2 data



FNAL E687

$3\pi^{+}3\pi^{-}$ inv. mass distribution in high energy photoproduction

Experimental Requirements

- For the measurement of **R** one would want ideally a hermetic detector. Hadronic events can be defined inclusively by requiring a minimum number of particles within the detector acceptance, e.g.:
  - 3 charged particles, or
  - 2 charged particles and 1 γ at large angle, or
  - 1 charged particles and 2 γ reconstructing a π^0.

Potentially large systematic errors associated with calculation of overall acceptance.

Reconstruct the event completely and measure the cross section of each individual channel contributing to **R**.

- The study of exclusive final states (e.g. vector meson spectroscopy, multihadronic channels) will also require the ability to reconstruct the event completely.
- The study of nucleon form factors requires the additional capability to detect neutrons and antineutrons.

Detector Requirements

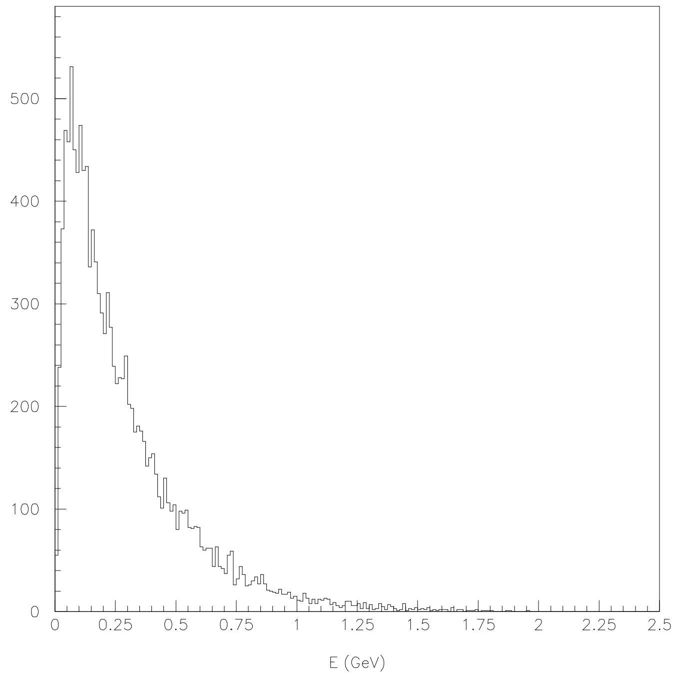
- low mass tracking
- momentum measurement with good precision
- EM calorimetry
- luminosity measurement
- $N\ \bar{N}$ detector
- particle ID
- modest cost

Some important characteristics

- magnet: 0.1-0.3 T vertical B field (must NOT disturb LER and HER)
- The contribution of multiple scattering to the momentum resolution as high as 2 %.
- $\beta_{cm} \approx 0.8$
- event rate: < 1 Hz

$$e^+e^- \rightarrow hadrons$$

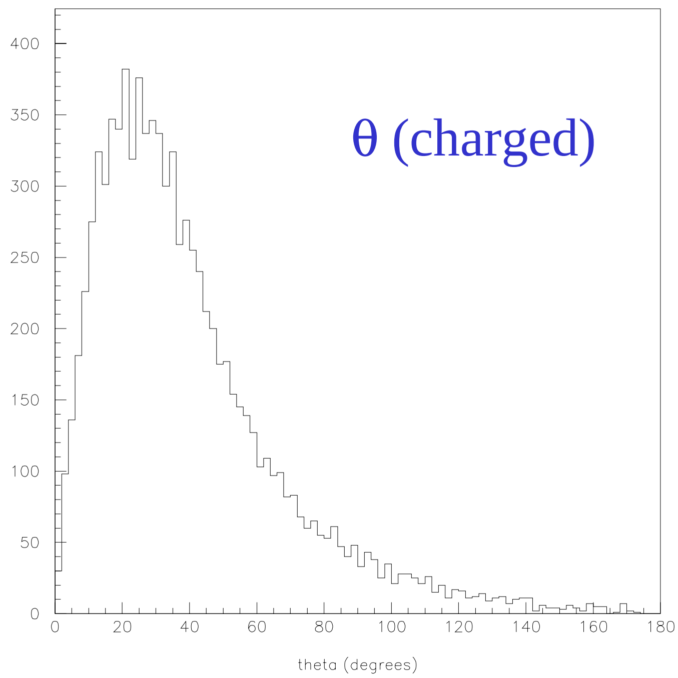
Photon energy distribution

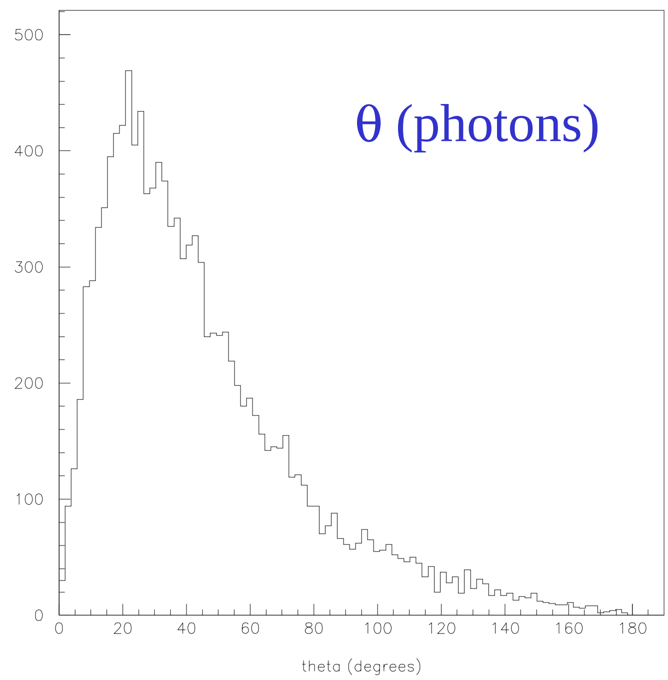


Full efficiency and good energy resolution needed down to very low energies (<100 MeV)

Acceptance

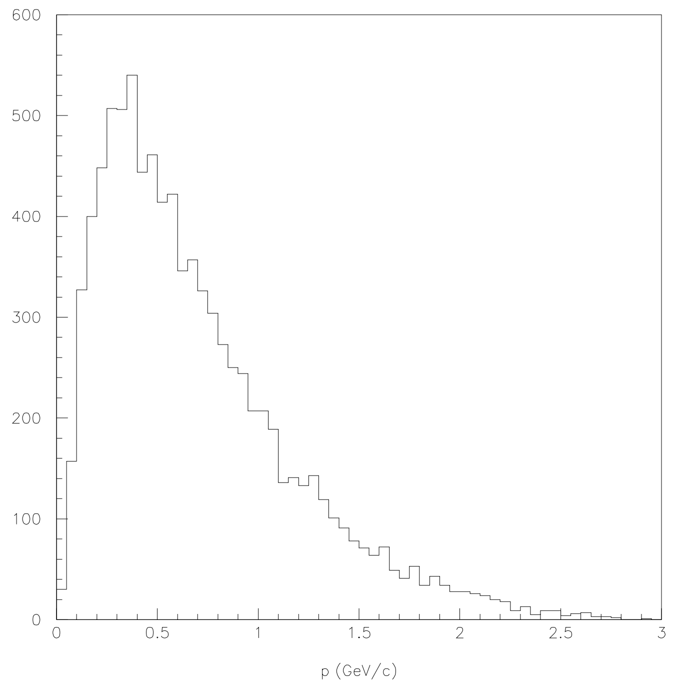
$$e^+e^- \to hadrons$$





$$e^+e^- \to hadrons$$

Charged particle momentum distribution



Event Rate

The cross-sections for the processes we wish to study vary over a significant range.

$$\sigma_{\mu\mu}(\sqrt{s} = 2\,GeV) = 21.7\,nb$$

$$\sigma_{had}(\sqrt{s} = 2\,GeV) \approx 43\,nb \quad (R = 2)$$

$$\sigma_{\bar{p}p} \approx \sigma_{\bar{n}n} \approx 1\,nb$$

Rates		
	$\mu\mu$	0.22 Hz
	had	0.43 Hz
	$p\,\bar{p}$	0.01 Hz
	$n\,\bar{n}$	0.01 Hz

Taking a maximum total cross-section of 100 nb and a maximum possible instantaneous luminosity of $10^{31} cm^{-2} s^{-1}$, the **maximum rate is 1 Hz**.

Data Taking

Average instantaneous luminosity: $5\times10^{30}cm^{-2}s^{-1}$
($\approx$ 0.5 pb^{-1}/day)

Measurement of R

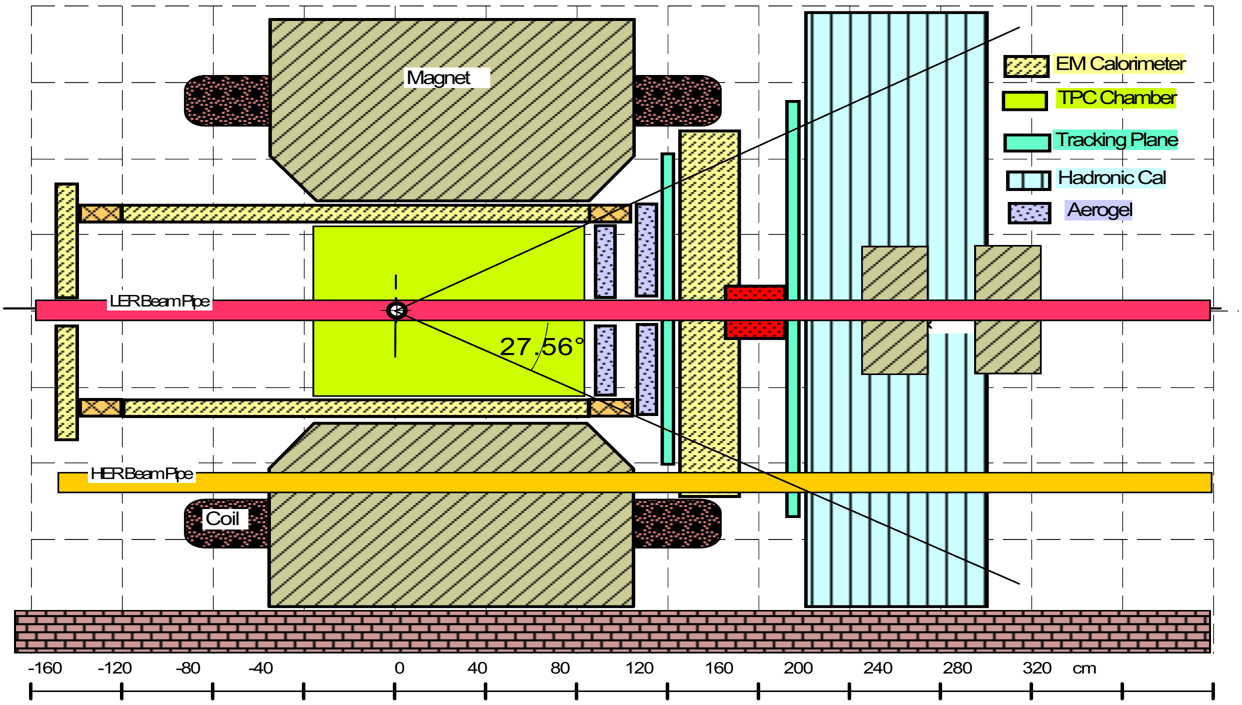
Event Rate: $\approx$ 0.25 Hz   10000/day
(assuming a detection efficiency of 50 %).
i.e. 1 point/day
assuming 200 points in 10 MeV intervals
200 days data taking.

Nucleon Form Factors

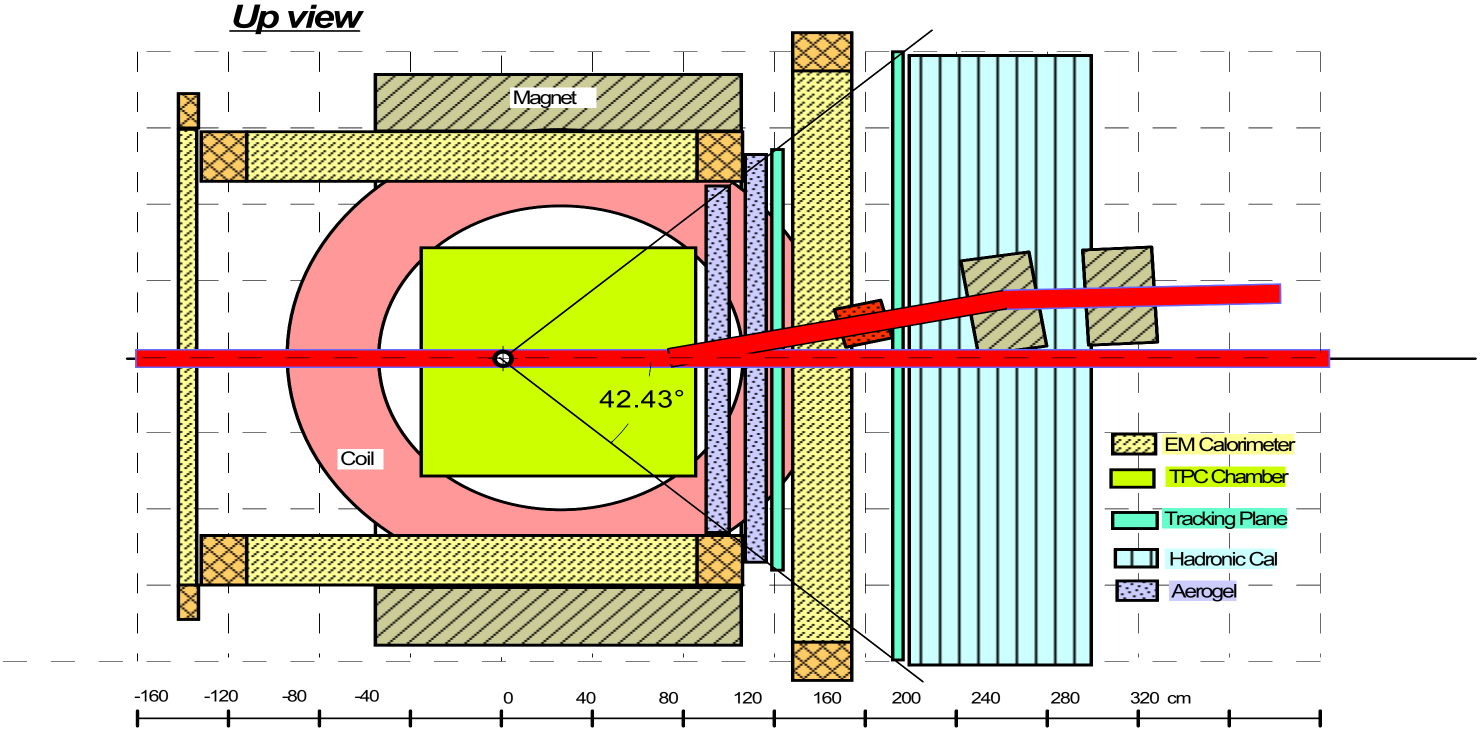
$\approx$ 200 events/day (more than the total statistics of FENICE)
10 days/point

Detector Layout

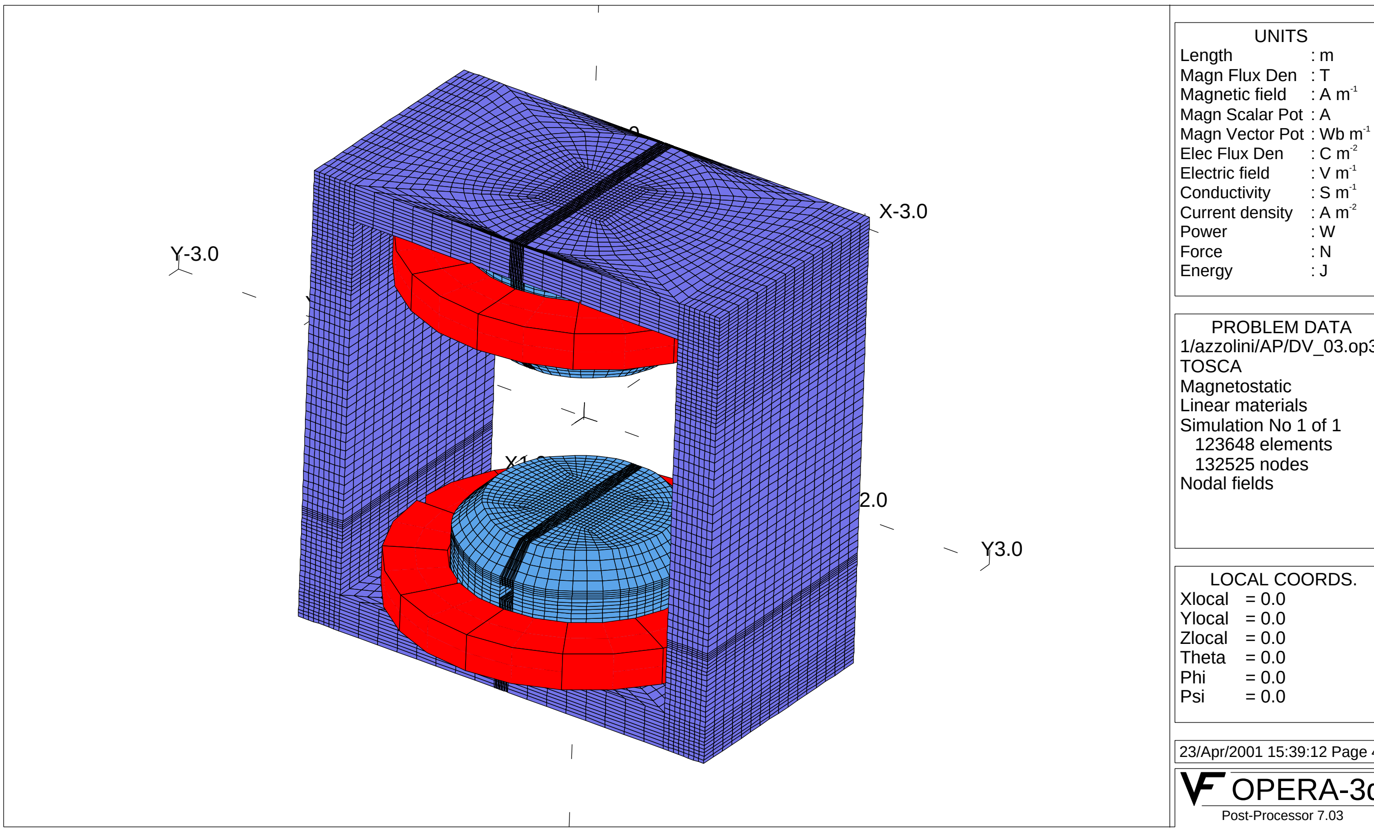
Side view



Up view

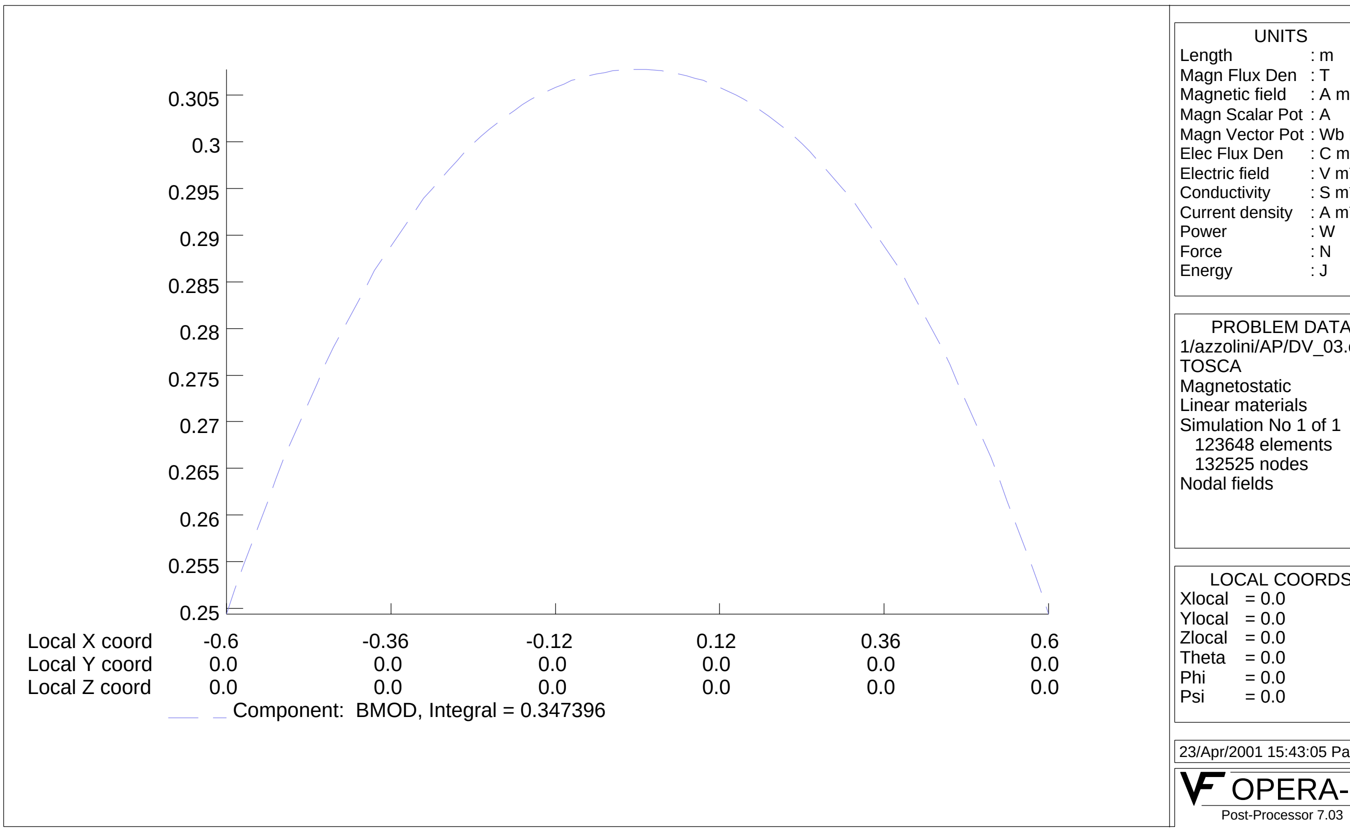


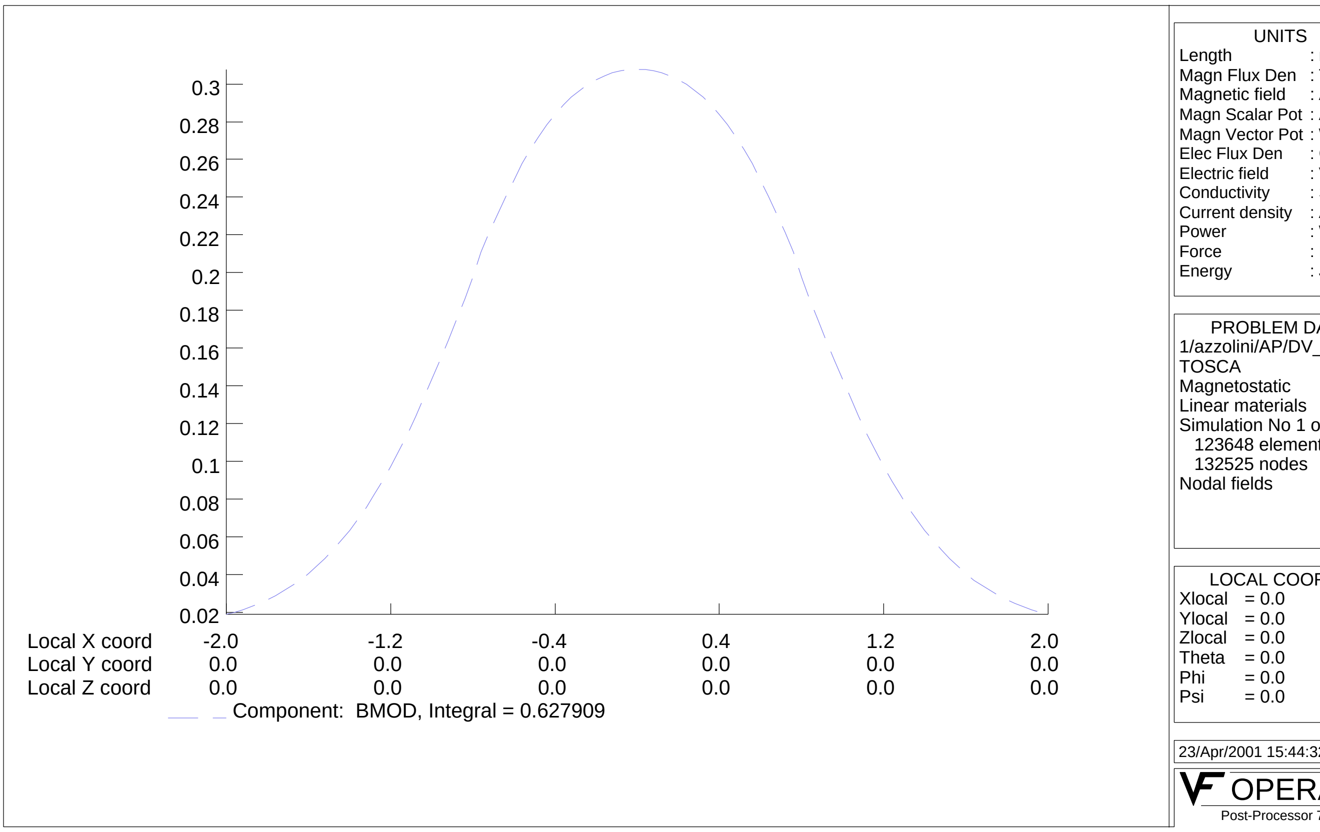
PEP-N Dipole Magnet



distance between poles (y)	1.2 m
pole diameter	1.56 m
horizontal thickness (x)	1.6 m
coil internal diameter	1.6 m
coil external diameter	2.4 m
height (z)	3.1 m
current density	1.58 A/mm^2

Magnetic field along the beam line





Tracking

Requirements:

- Good space resolution: σ = 200÷300 μm
- dE/dx capability for particle ID
- low mass (to minimize multiple scattering)
- minimize dead spaces (frames, supports etc)

TPC with slow He-based gas

(to minimize distortions due to magnetic field non-uniformity).

Forward tracking:

- helps correct distortions in TPC
- veto for neutrons
- help with muon identification

E.M. Calorimeter

Requirements:

- high acceptance
- good efficiency and good energy resolution (few %) down to low energy (< 100 MeV)
- good time resolution

Lead and scintillating fibers calorimeter

(à la KLOE).

KLOE calorimeter

99 % efficiency for 20 Mev < E_γ < 500 MeV

$$\frac{\sigma(E)}{E} = \frac{5.7\%}{\sqrt{E(GeV)}}$$

$$\sigma_z = \frac{1.24\ cm}{\sqrt{E(GeV)}}$$

$$\sigma_t = \frac{54\ ps}{\sqrt{E(GeV)}} + 110\ ps$$

Particle ID

Particle identification is achieved by means of two aerogel counters, each 10 cm thick (total thickness 0.15 r.l.), which can achieve 4σ π-K separation in the momentum range 0.6÷1.5 GeV.
Below 0.6 GeV particle ID will be based on dE/dx in the tracking chamber and on TOF in the forward EM calorimeter.

Hadron Calorimeter

It is the main n $\bar{n}$ detector and thus it should:

- be efficient for neutrons
- allow antineutrons to interact
- provide TOF and position of both n and $\bar{n}$.

The hadron calorimeter will be used also for muon ID.

Luminosity Measurement

Online

Required for machine tuning and monitoring. PEP-II monitor, based on single Bremsstrahlung at zero degrees, seems appropriate.

Offline

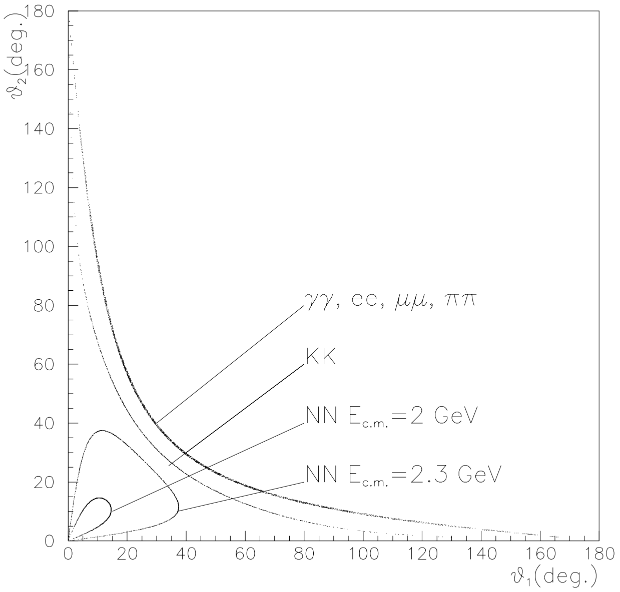
The necessary 1 % accuracy in the integrated luminosity measurement can be achieved using Bhabhas.

Muon pairs will be useful as a check.

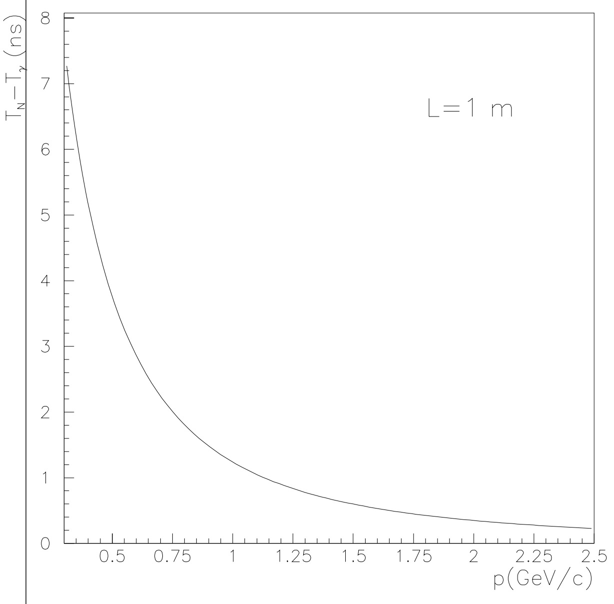
$N\bar{N}$ Identification and measurement

- Angular Correlation

-good angular resolution
-difficult at small E_{cm}.



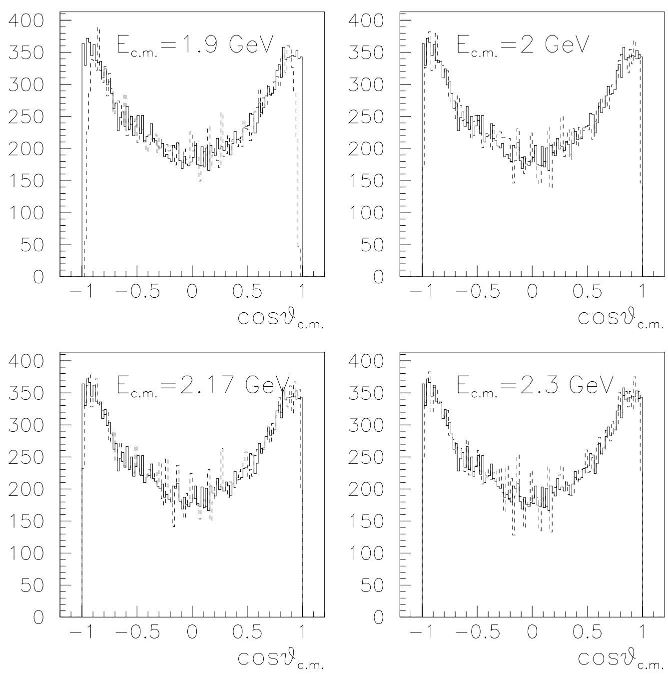
- Time-of-flight to identify events and reject prompt photons and other fast backgrounds.



- Momentum analysis for $\bar{p}p$
- Calorimetric measurement

$N\bar{N}$ angular distribution

- θ_{cm} on an event by event basis.
- θ_{cm} from θ_{lab} with two-fold ambiguity.
- tof for n $\bar{n}$ and/or p for p $\bar{p}$
- over-constrained fit with 2 particles
- fit to G_E/G_M
- Example:
  - 5 m flight
  - 3 cm, 250 ps resolution
  - acceptance from 1^0 to 45^0
  - G_E=0



$N\bar{N}$ detector requirements

- Angular coverage between 1^0 and 40^0 in polar angle.
- Detection of nucleons and antinucleons between 0.3 and 2.5 GeV/c with good efficiency.
- Momentum analysis for p and $\bar{p}$.

Tracking device + Calorimeter

Tracking:

- measure p and $\bar{p}$ direction and momenta.

Calorimeter:

- efficient for neutrons
- allow antineutrons to interact
- TOF and position of both n and $\bar{n}$.

Distance between detector face and interaction point: tof and angular resolution vs acceptance

CONCLUSIONS

A detector layout has been presented suitable for the measurement of R, of exclusive hadronic final states and of nucleon form factors.

The various detector components are being studied in detail and will be presented in dedicated talks.

The overall performances of the detector are being studied by means of Monte Carlo Simulation, whose results will also be shown in the dedicated talk.

Monday, 4/30

M.E.Biagini Interaction Region and Lattice Design

M.Negrini Simulation and Detection Efficiencies

M.Placidi Magnet Design

J.Va'vra Tracking Design

Tuesday,5/1

J.Seeman Accelerator Layout

M.Sullivan More on Interaction Region

L.Keller Background

M.Mandelkern Luminosity Monitor

A.Onuchin Aerogel and Particle ID

P.Patteri Electromagnetic Calorimeter

E.Pasqualucci Trigger

Wednesday, 5/2

P.Bosted Baryon Form Factor Measurement at PEP-N

D.Michael Hadron Calorimetry with MINOS technique

S.Rock Nucleon Polarization Measurement

D.Bettoni Detector Design Summary

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