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LNF-76/14(P)
23 Febbraio 1976

G. Bologna, B. D'Ettorre Piazzoli, F.L. Fabbri, G. Mannocchi, P. Picchi, L. Satta, P. Spillantini and A. Zallo :

A POSSIBLE COMPACT CORE FOR e^+e^- EXPERIMENTS. -

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ABSTRACT. -

We consider a possible structure of a device consisting of a compact system of cylindrical chambers and a toroidal magnetic field. This core seems to be suitable as a vertex detector for the central region in multihadron production.

INTRODUCTION. -

During the preparation of the vertex detector for the experiment planned at SPS(1) we had to face the realization of a very compact wide solid angle apparatus, capable of a fast acquisition of high multiplicity multihadron events. The compactness, lightness and flexibility are also particularly important for a 4π-solid angle hadron and gamma detector in e^+e^- interactions at the PEP and PETRA energies.

This is an exercise to design the core for the central region in multihadron production. It consists of a toroidal coil equipped with a cylindrical multiwire proportional chamber system around the machina pipe. The system of the chambers is an adaptation of the real chambers we are presently testing for our SPS experiment(2).

THE COMPACT CORE DESIGN. -

Some properties already pointed out relative to toroidal solution(3) are the following:

- The absence of fringing fields and of iron yokes for flux return;
- A good transparency for γ-rays at any angle;
- The perpendicularity between the magnetic field and the particle velocity, so that the three-dimensional motion is reduced to a two dimensional one in the plane φ = constant. This feature preserves the azimuthal pattern of the event.

The momentum measurements in a toroidal coil configuration require the determination of the directions before the magnetic field. The high multiplicity forseen for charged products requires the events to be easily hardware processed. The straighforward solution consists of cylindrical multiwire proportional chamber coaxial to the beams, with a suitable azimuthal hodoscope arrangement. A longitudinal cross section of a possible "three gaps" cylindrical multiwire chamber is shown in Fig. 1. The mechanical structure is based on cylindrical sandwiches of plastic foam and kapton foils[2].

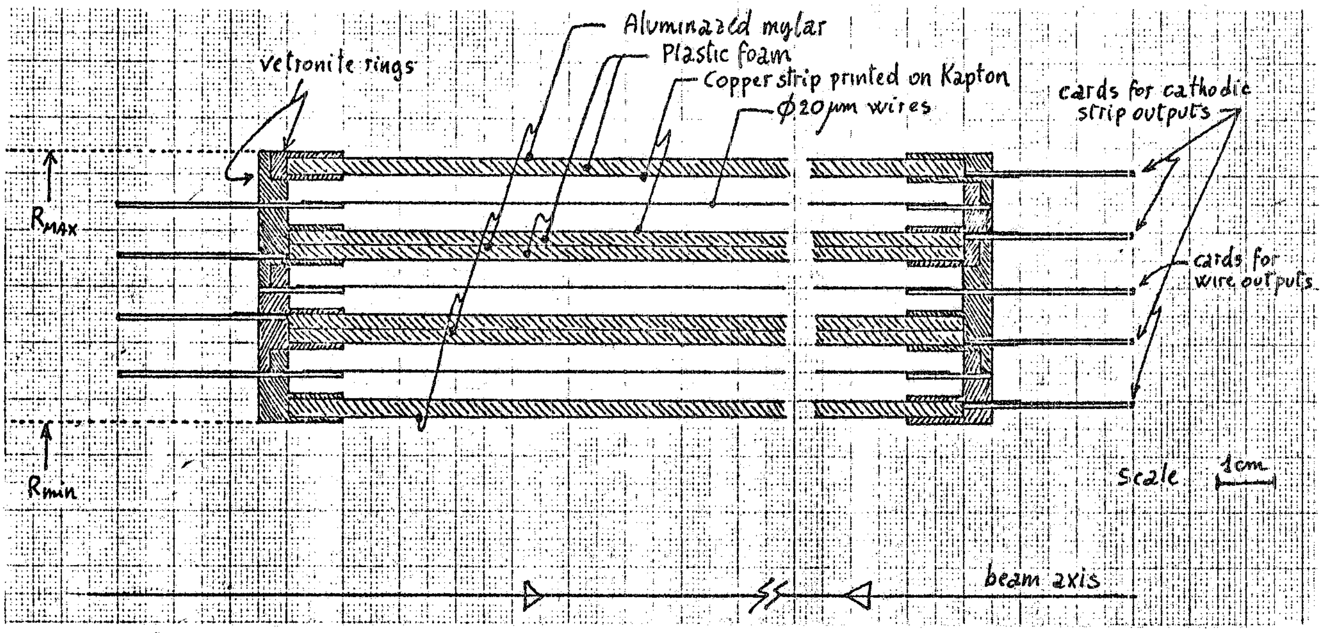
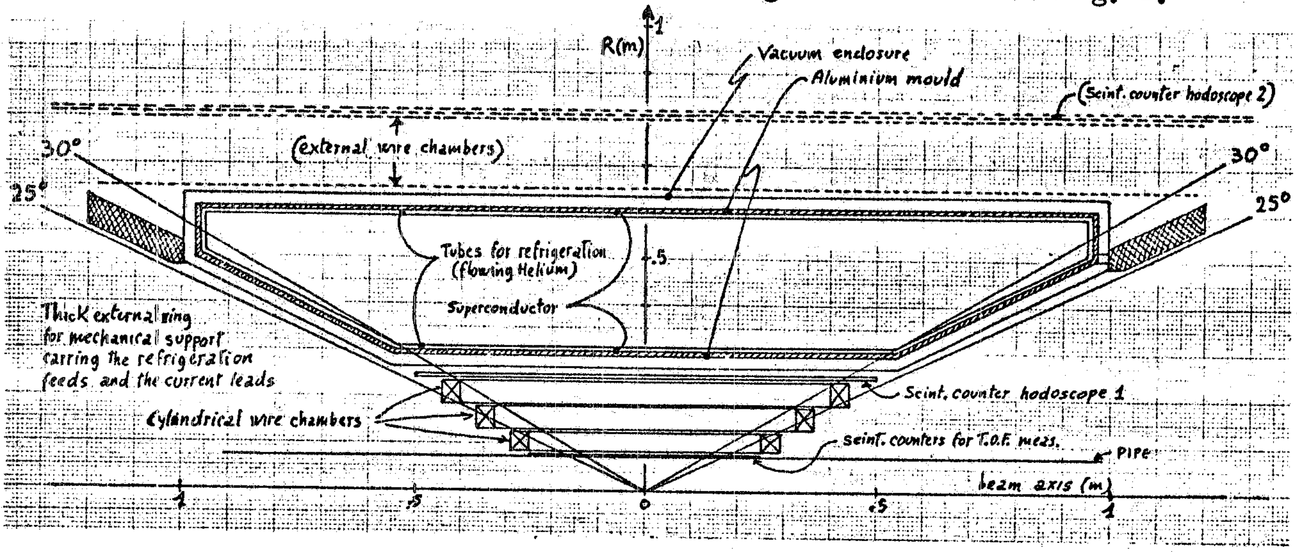


FIG. 1 - Longitudinal cross section of a three gap cylindrical multiwire chamber. Wire spacing 3 mm, cathode spacing 10 mm. Total thickness 130 mg/cm^2.

The sense wires (3 mm spaced) are strecthed parallel to the cylinder axis. Strips are printed on the cathodes, at an angle with the wires, to give the polar angle by the analogic read out of the pulses induced by the avalanche on fixed wire[x]. This method gives the maximum

(x) - In our SPS experiment we require only a 2 mm FWHM precision along the fixed wire, but by a suitable analogic read out of the cathodic strips we can hope a precision better than 0.5 mm[4] possible density of read points along a track. The geometry of the cathode strips can concentrate the read out of the coordinates of each gap at the two ends of the cylinder ensuring the completeness and the uniformity of azimuthal detection.

The apparatus with a superconducting coil is shown in Fig. 2.



SUPERCONDUCTING TOROIDAL COIL

Overall dimension :	Length	2.4 m			
	Max. Radius	0.64 m			
	Min. Radius	0.26 m			
Solid angle fraction ($\Delta\Omega/4\pi$)		0.87 m			
Max. Magnetic Field in s.c. (at R = 0.30 m)		25.2 Kgauss			
Max. Pressure from Field (at R = 0.30 m)		25.3 Atm			
Current density in the superconductor		5.9×10^8 Am^{-2}			
Coil stored energy		0.98 MJ			

Some different solutions (see below)		A1	A2	M1	M2
Total Thickness (inner + outer)	g/cm^2	10	13	7	8
	r.l.	0.4	0.5	0.3	0.4
	L_{abs}	0.09	0.11	0.05	0.08
Momentum resolution at p = 5 GeV/c	$\theta = 90^\circ$	0.087	0.083	0.083	0.078
	$\theta = 30^\circ$	0.057	0.044	0.053	0.044
Weight (Kg)	Superconductor	260	260	260	260
	Magnet Cold Mass	510	510	390	390
	Total	700	880	480	580

A1 : Solution with the inner and the outer conductors are in one same vacuum tank.
A2 : Inner and outer conductors in two distinct vacuum tanks, to insert detectors (chambers, Cerenkovs,..) inside the magnetic volume.
M1 (M2) : The same as A1 (A2), with the Aluminum replaced by Magnesium in all the structures.

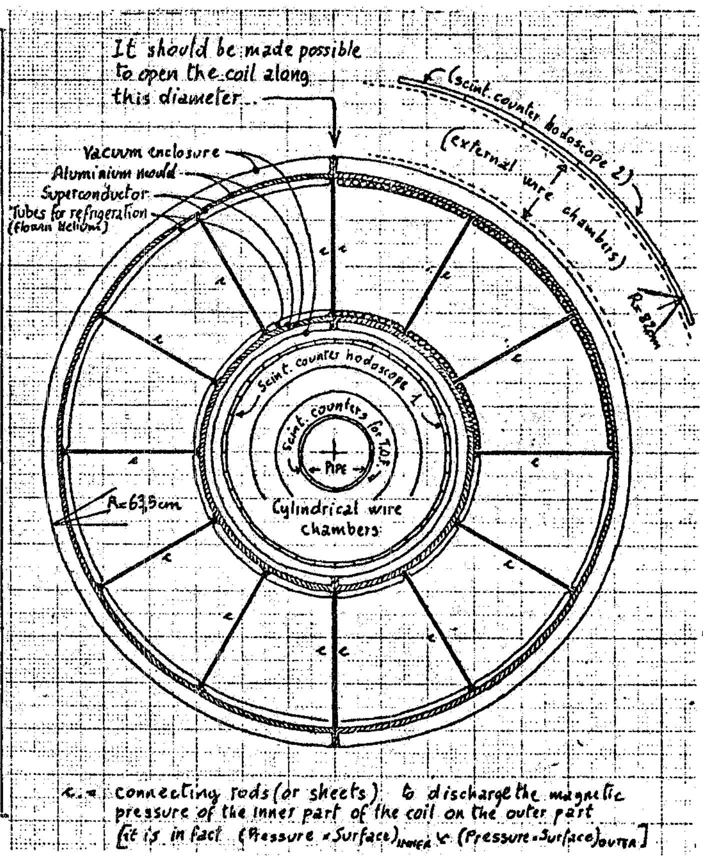


FIG. 2 - Longitudinal and transversal cross sections of the superconducting toroidal coil and its detection equipment. The drawings refer to the solution with one simple vacuum tank (solution A1).

The superconducting coil design is based on the parameters used for the "L.B.L. Experimental Test Program for Thin Magnet". Around the pipe the direction of the charged prongs is measured with a $\pm$ 5 mrad azimuthal precision and a $\pm$ 1 mrad zenithal precision by a 9 gap system of chambers (three times the module of Fig. 1). The characteristics of this system are shown in Fig. 3. If the zenithal angle is measured with a similar precision outside the coil, we get the momentum resolutions reported in Fig. 5a.

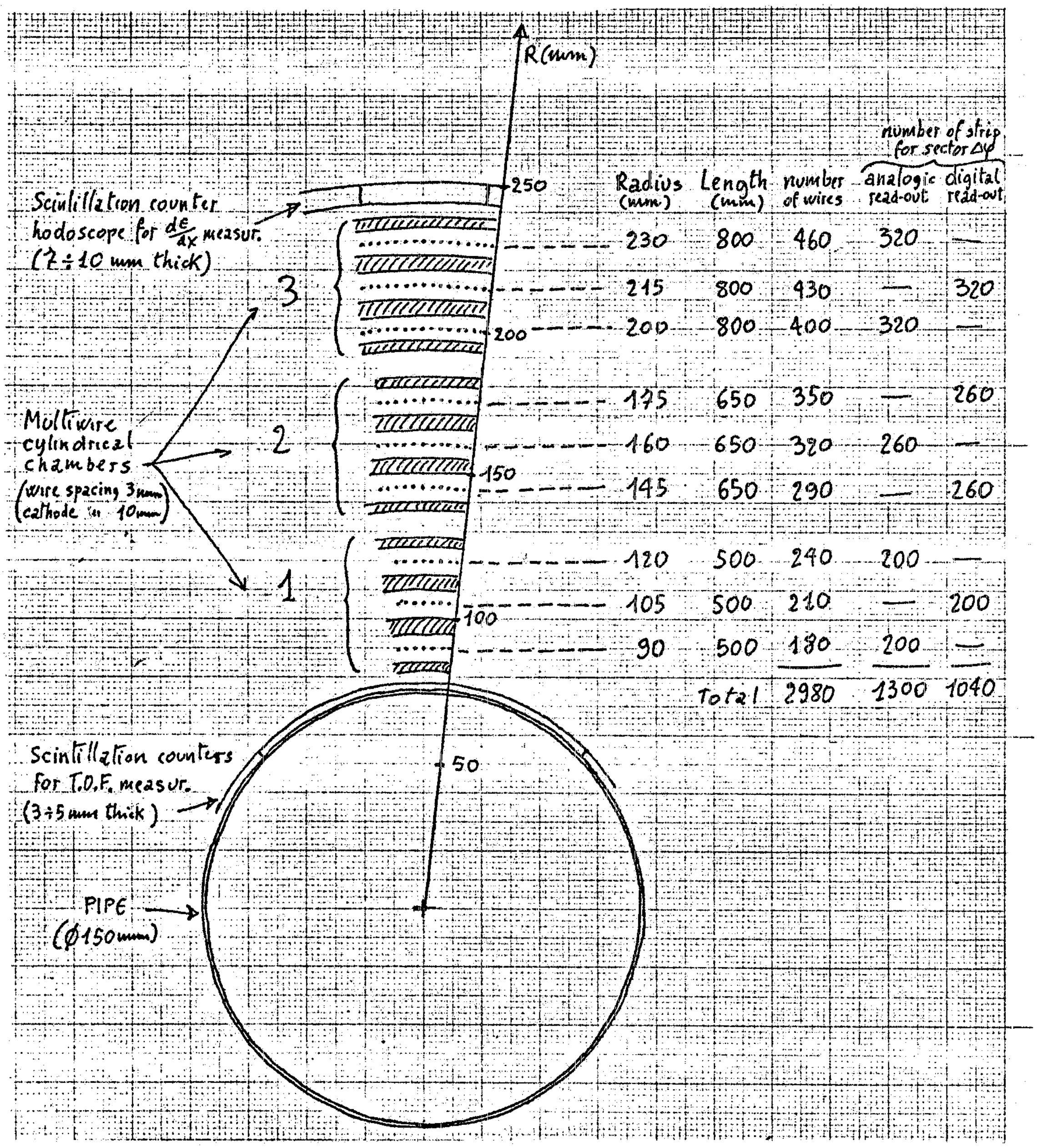
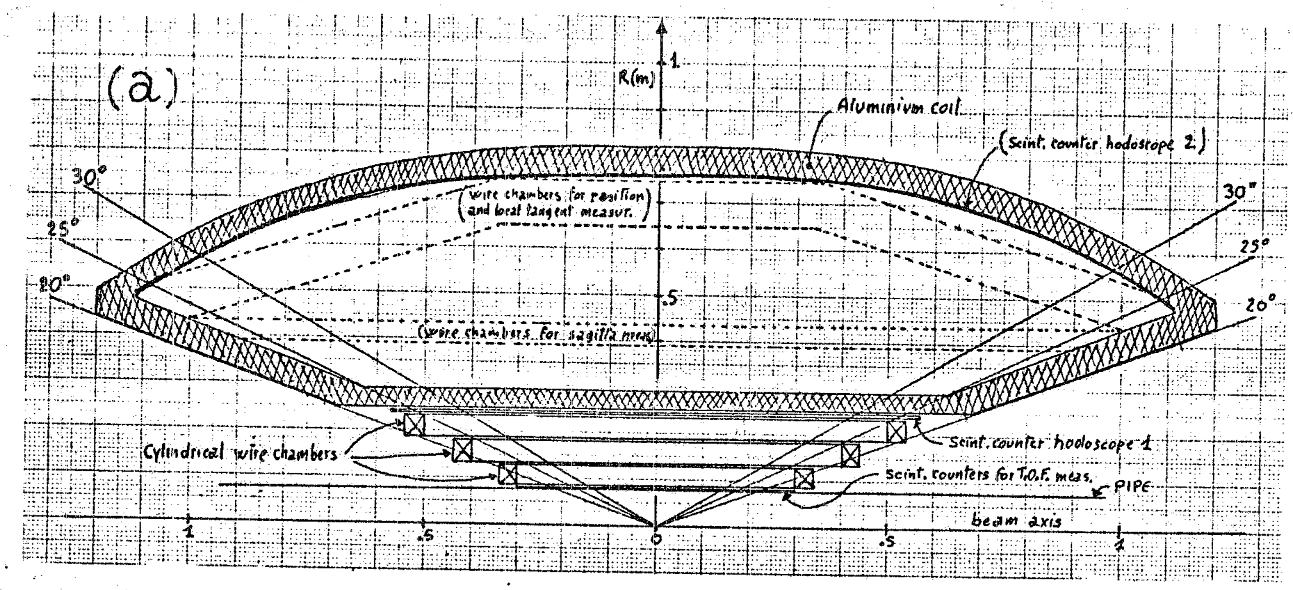


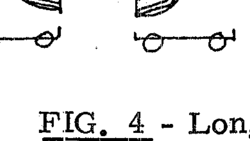
FIG. 3 - Chamber system surrounding the pipe.

A more conservative design which assumes the use of a traditional water cooled coil is shown in Fig. 4. Its overall dimensions are



USUAL ALUMINIUM COIL				
Overall dimensions: Length	2.4 m			
Max. R.	0.82 m			
Min. R.	0.25 m			
Solid angle fraction ($\Delta\Omega/4\pi$)	0.91			
Inner part thickness = 3 cm Al	(0.08 Labs)			
Outer part thickness = 5 cm Al	(0.13 Labs)			
Outer part shape:	'continuous'		'open fan'	
with power	1MW	2MW	1MW	2MW
Max. magn. field (Kgauss)	6.7	9.5	5.7	8.1
Max. pressure (Atm)	1.8	3.6	1.3	2.6
Max. current density (MAm^{-2})	18	25	15	21
Momentum resol. at p = 5 GeV/c				
$\theta = 90^{\circ}$	0.22	0.16	0.24	0.17
$\theta = 30^{\circ}$	0.14	0.10	0.16	0.11
Weight (tons)	2.1		1.1	

- It should be possible to open the coil in some distinct azimuthal sectors, complete of their detectors, so:



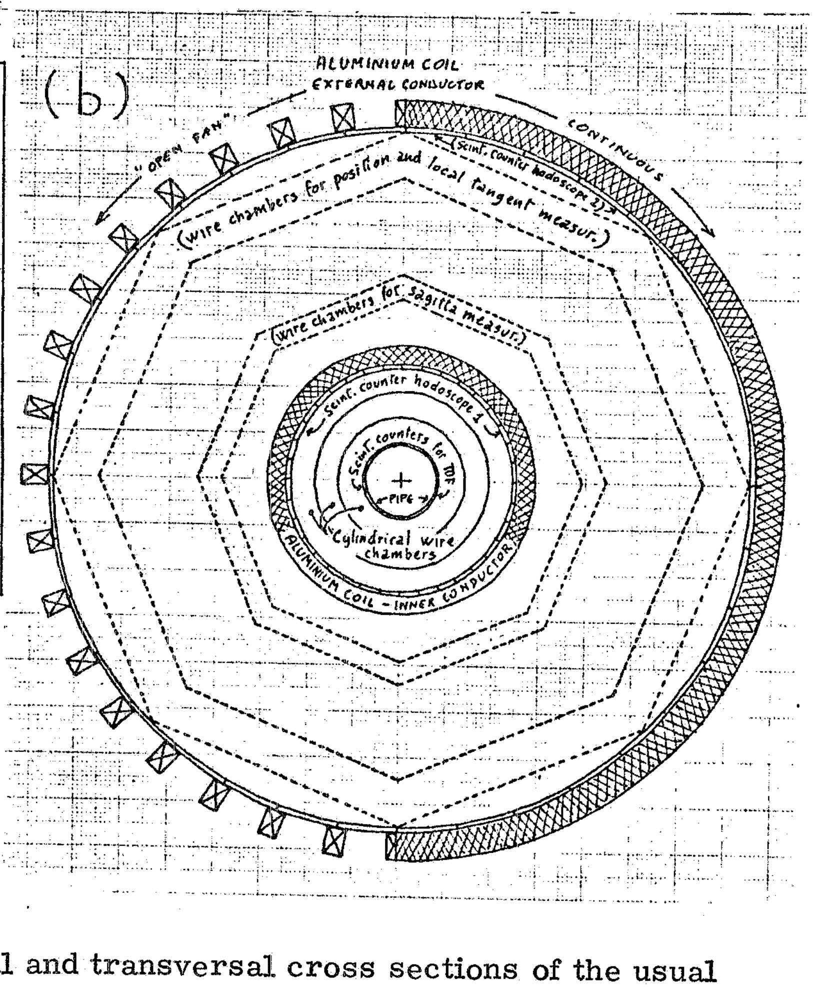


FIG. 4 - Longitudinal and transversal cross sections of the usual Aluminium coil and its detection system.

the same of the superconducting solution. In this case it is convenient to increase the thickness of the outer conductors to save electric power. The chamber for the momentum determination must be positioned inside the magnetic volume. The momentum resolutions are reported in Fig. 5b.

Finally an artistic view of central compact core, cylindrical chamber system and aluminium toroid with an open form external conductor, is shown in Fig. 6, toghether with a schematic idea of a desiderable momentum chamber system.

The resolution in toroidal scheme are of course worse than the resolutions quoted for the solenoidal magnets. However in our opinion a toroidal solution, really compact and light shall constitute the most effective core in any explorative experiment regarding multiparticle final states, when the momentum of the charged particles should not be a priviliged kinematical variable and the overall prices should be not divergent.

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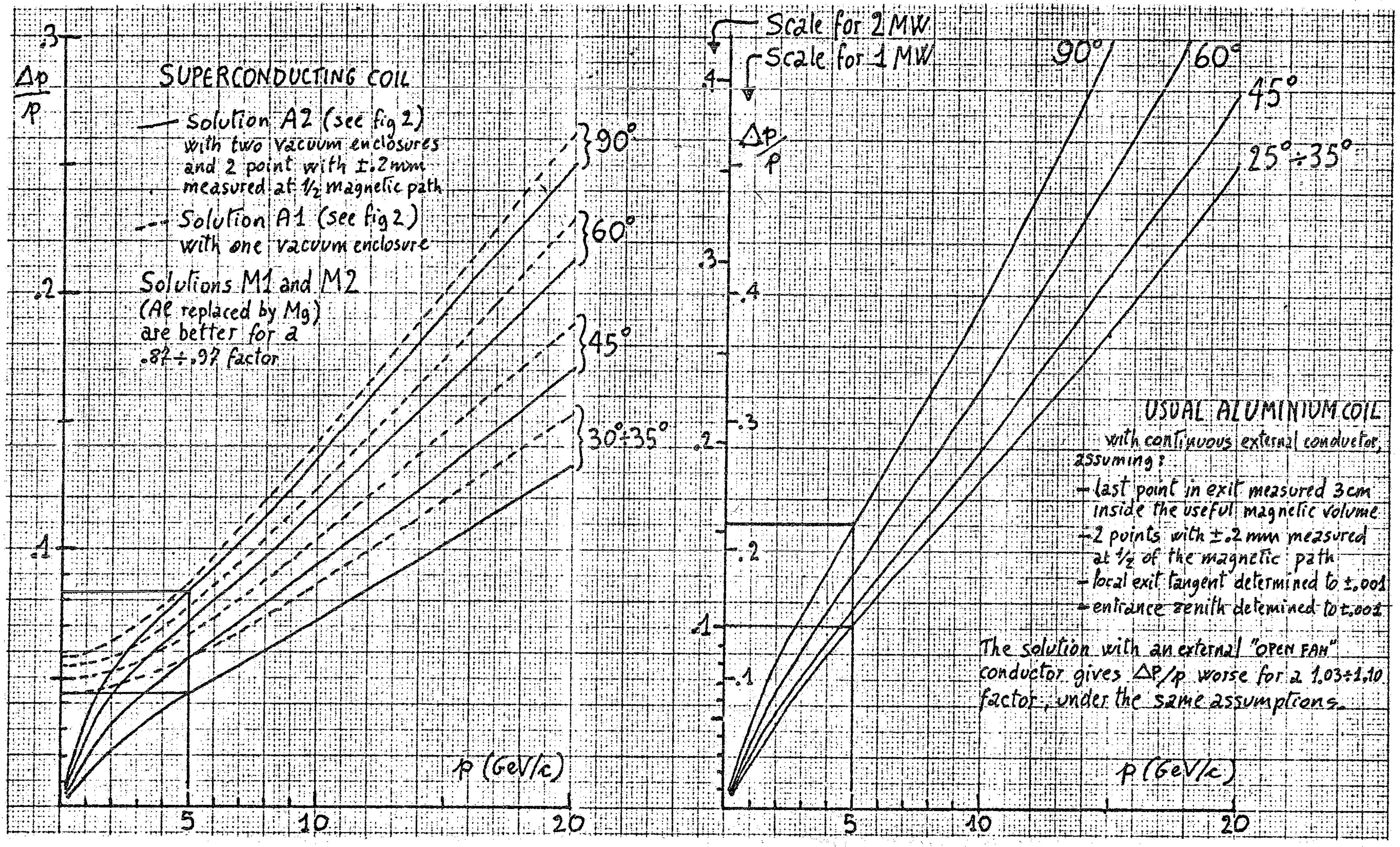

FIG. 5 - Momentum resolutions for the core systems with the superconducting toroidal coil of Fig. 2 and the usual Aluminium coil of Fig. 4.

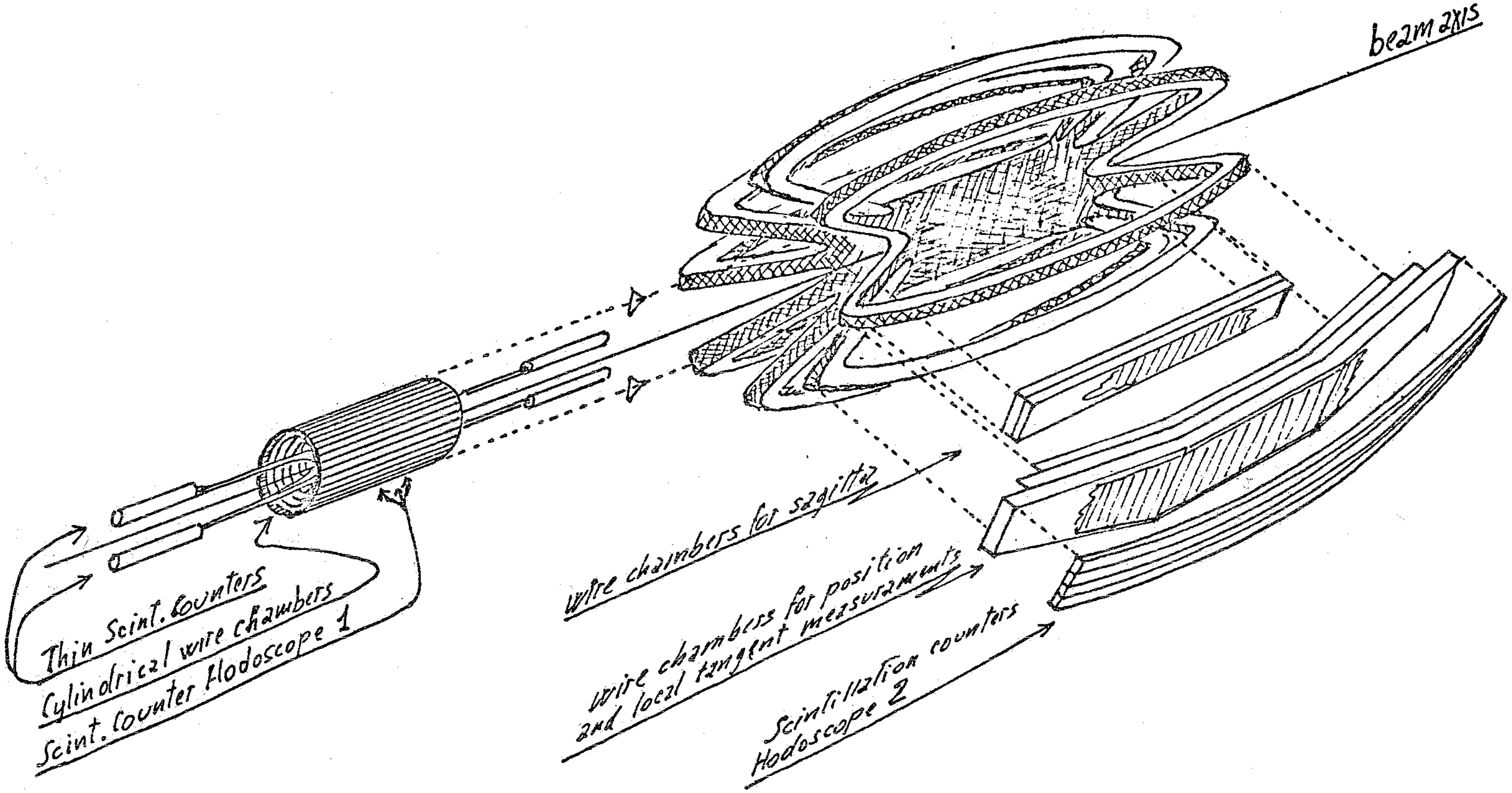

FIG. 6 - Expanded artistic view of a 'open fan' toroidal central coil equiped with the direction measurement and counter trigger devices and one azimuthal sector of the momentum measurement system.