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Sagitta Measurement Error and Cost

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Abstract:

This document presents a discussion of the mechanical alignment tolerance stackup of the muon system. The objective is to determine how these parameters combine to create the total sagitta measurement error.

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Memorandum

To: Distribution
From: R. Sawicki
Subject: Sagitta measurement error and cost
Date: February 5, 1993

I recently discussed the mechanical alignment tolerance stackup of the muon system with J. Sullivan, A. Ostapchuk, J. Paradiso and others. The objective was to determine how these parameters combine to create the total sagitta measurement error. There was not unanimous agreement as to the specific algorithm that should be used. The following describes what I believe was the final consensus of opinion along with a sensitivity study of how the sagitta measurement error changes as a function of superlayer configuration and cost.

Figure 1 identifies the tolerances that contribute to sagitta measurement error. These errors and their assumed RMS magnitude are

Error	RMS value micron
Strip to strip fiducial placement	17
Layer to layer placement	17
Fiducialization placement	10
Alignment measurement (including interpolation)	25
Intrinsic measurement	75
Multiscattering error	1

The intrinsic measurement error, strip placement and layer to layer placement tolerances are assumed to add in quadrature and are reduced in magnitude by the square root of the number of layers. This adds in quadrature to the fiducialization error to establish a total superlayer measurement accuracy. Each superlayer measurement accuracy is then added in quadrature scaled by the geometric weighting factor defined in Figure 1. Finally, total measurement error is obtained by adding in quadrature this sum to the alignment measurement and multiscattering error.

Table 1 includes an EXCEL spreadsheet that calculates the total measurement error for two extreme chamber layer configurations, 8/6/6 and 6/4/4. Results show RMS errors of 47.5 and 54.5 microns for these two cases respectively. Figures 2 and 3 plot the error as a function of the number of layers in the middle and outer superlayers. Figure 2 assumes 8 layers in the inner superlayer and Figure 3 assumes 6.

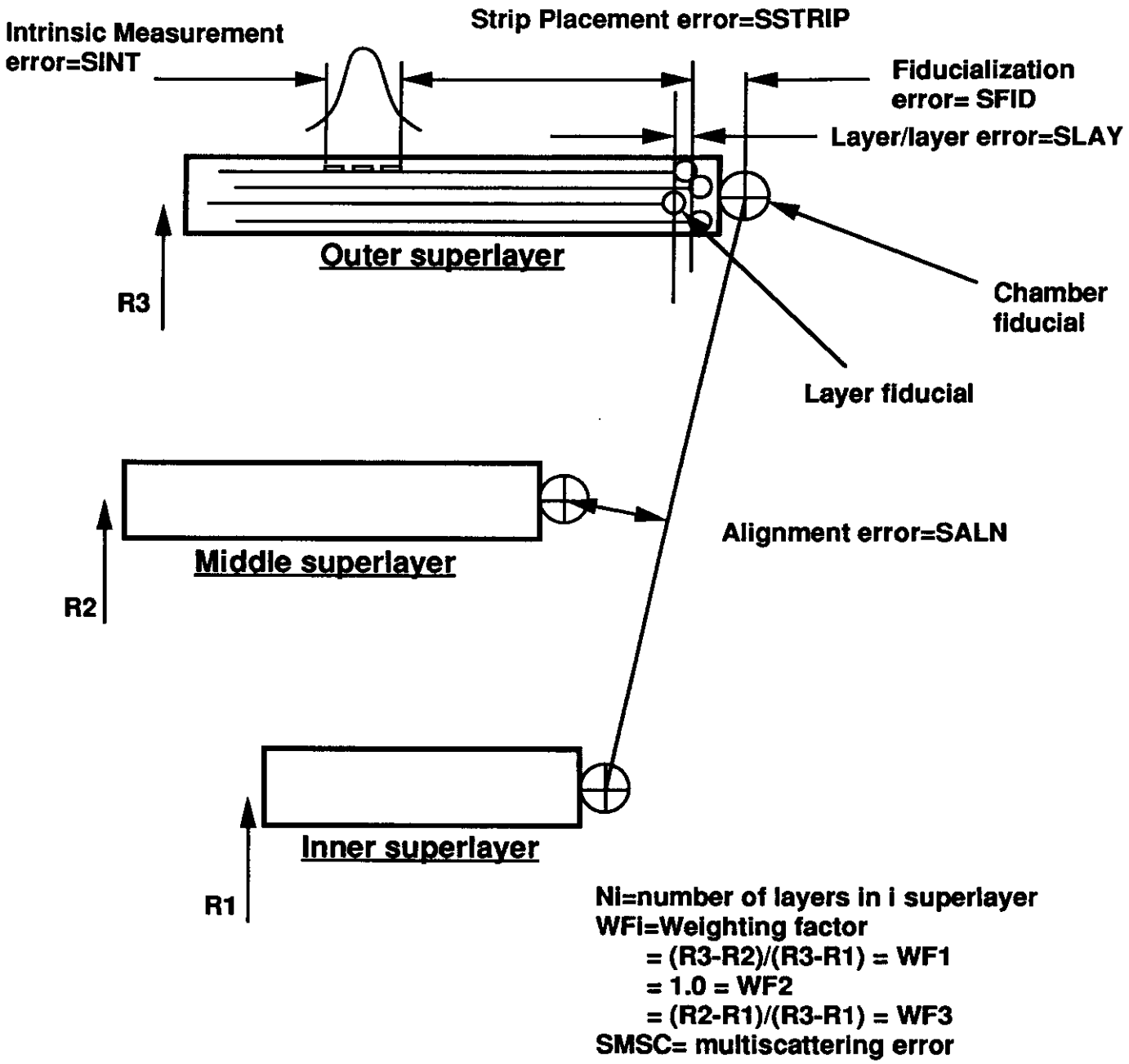
Sensitivity of the muon system cost to the measurement error is also of interest. I incorporated the herein described algorithms into the muon cost model which I recently developed. I then ran the cost model for various chamber configurations that have been considered. I used all of the same assumptions as presented during the Jan 19 meeting except that I lowered the electronic

channel cost to $8/channel which I believe is the latest number which is supported by D. Marlowe. Please also note that in this model I included the dependence of intrinsic resolution on strip pitch rather than a constant 75 microns as assumed above. The dependency that I used was provided by Y. Kuryushin which is that the resolution is 60 microns for a 6 mm gap and varies linearly to 70 microns for a 10 mm gap. Results show that improving the resolution of the lowest performing configuration can be quite expensive. From the least expensive configuration to the most expensiver the resolution is improved by 5.9 microns at a cost of over 17.5 M$.

Configuration	Measurement error microns	Cost K$
8/6/6	43.6	130,663
6/4/4	49.5	113,084

This is more than 3 times the entire cost of the alignment system. All configurations satisfy the 75 micron sagitta measurement requirement.

cc: M. Harris
C. Johnson
M. Marx
G. Mitselmahker
F. Nimblett
A. Ostapchuk
J. Paradiso
F. Taylor
C. Wuest



Superlayer measurement accuracy= SQRT((SINT^2+SSTRIP^2+SLAY^2)/Ni + SFID^2)
= Si

Sagittta measurement accuracy = SQRT(SUM(WF^2i*Si^2) + SALN^2+SMSC^2)

Figure 1. Tolerance stackup

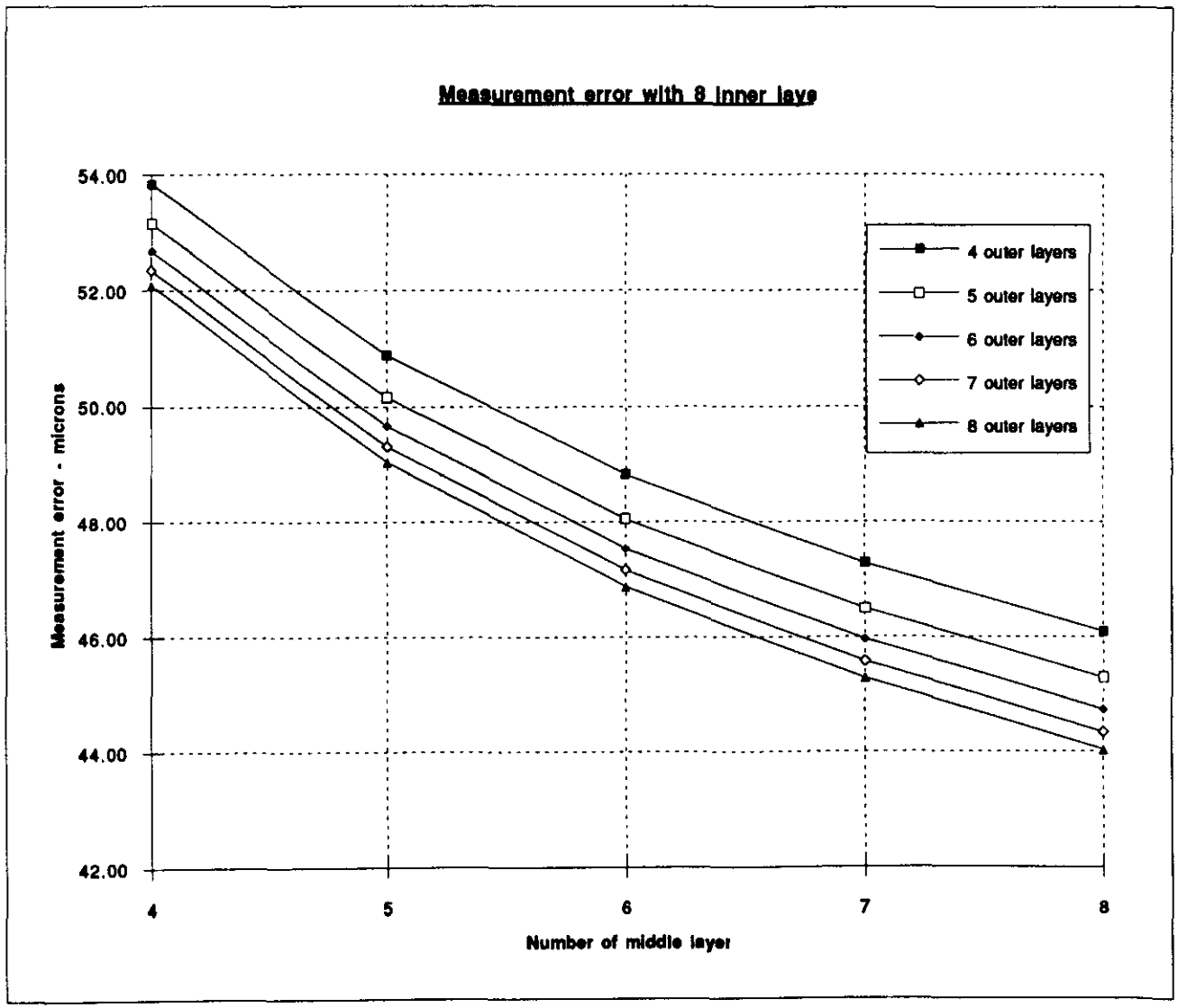


Figure 2. Measurement error with 8 inner layers

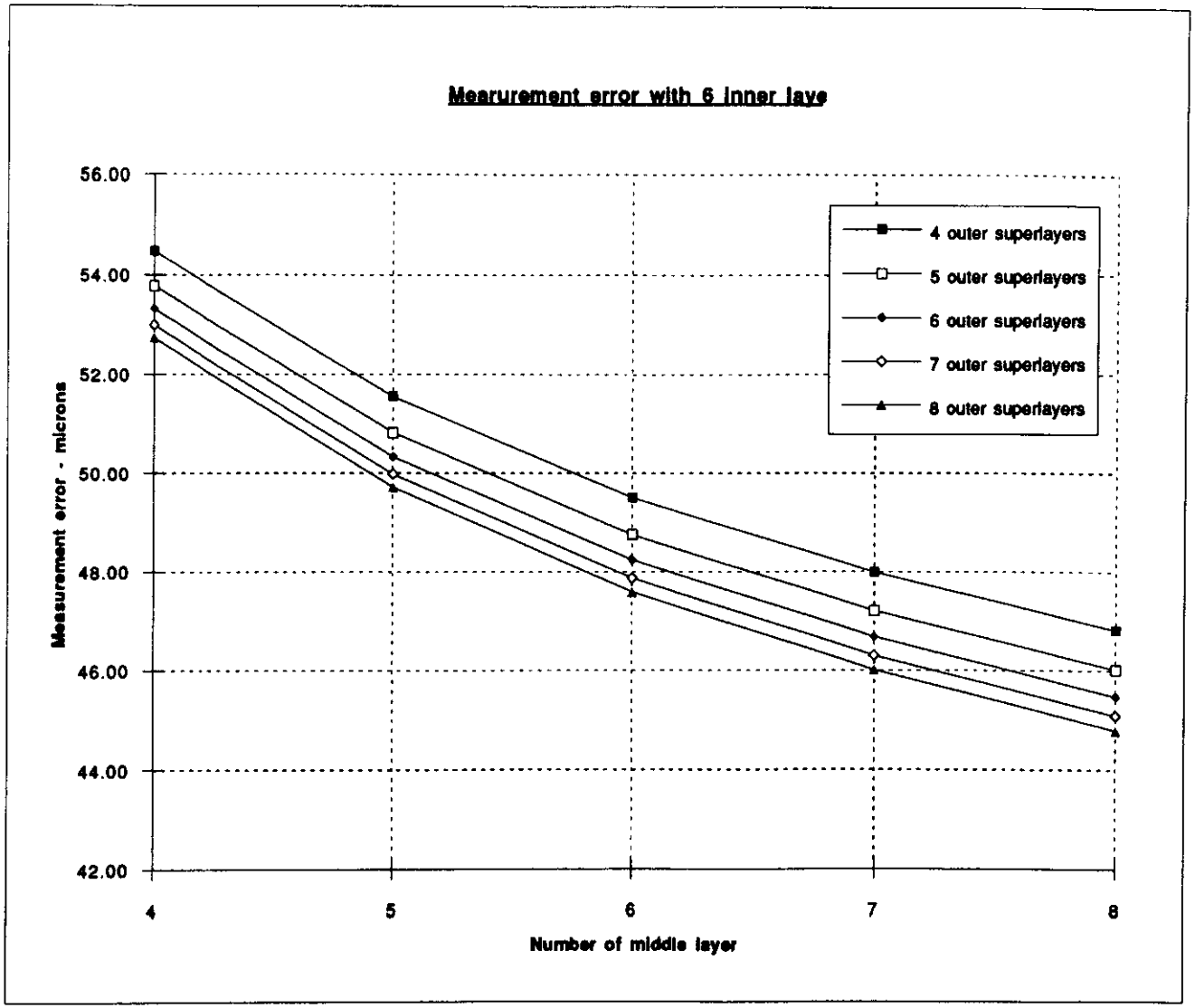


Figure 3. Measurement error with 6 inner layers

Muon System Measurement Analysis

R1	Radius of inner superlayer	m	4.2	4.2
R2	Radius of middle super layer	m	6.4	6.4
R3	Radius of outer superlayer	m	8.7	8.7
WF1	Weighting factor of inner superlayer	(R3-R2)/(R3-R1)	0.51	0.51
WF2	Weighting factor of middle superlayer	1	1.00	1.00
WF3	Weighting factor of outer superlayer	(R2-R1)/(R3-R1)	0.49	0.49
NP1	number of planes in inner superlayer	#	8	6
NP2	number of planes in middle superlayer	#	6	4
NP3	number of planes in outer superlayer	#	6	4
SSP1	Strip placement error in inner superlayer	microns	17	17
SSP2	Strip placement error in middle superlayer	microns	17	17
SSP3	Strip placement error in outer superlayer	microns	17	17
SLL1	Layer/layer placement error in inner superlayer	microns	17	17
SLL2	Layer/layer placement error in middle superlayer	microns	17	17
SLL3	Layer/layer placement error in outer superlayer	microns	17	17
SFID1	Fiducialization error in inner superlayer	microns	10	10
SFID2	Fiducialization error in middle superlayer	microns	10	10
SFID3	Fiducialization error in outer superlayer	microns	10	10
SINT1	Intrinsic resolution of a single inner superlayer plane	microns	75	75
SINT2	Intrinsic resolution of a single middle superlayer plane	microns	75	75
SINT	Intrinsic resolution of a single outer superlayer plane	microns	75	75
S1	Measurement error of inner superlayer	SQRT((SINT1^2+SSP1^2+SLL1^2)/NP1+SFID1^2)	29.59	33.67
S2	Measurement error of middle superlayer	SQRT((SINT2^2+SSP2^2+SLL2^2)/NP2+SFID2^2)	33.67	40.63
S3	Measurement error of outer superlayer	SQRT((SINT3^2+SSP3^2+SLL3^2)/NP3+SFID3^2)	33.67	40.63
SALGN	Alignment error*	microns	25	25
SMSC	Multiple scattering error	microns	1	1
STOTAL	Total sagitta error	SQRT(S/^2*WF/^2)+SALGN^2+SMSC^2)	47.53	54.47

* alignment error includes total measurment error of LED/lens system including interpolation errors

Table 1. Measurement error

# Phi segments	#planes/ barrrel superlayer			pitch (mm)			# Barrel E/channels	Measure. error(barrel) (microns)	Total Cost (K$)
	I	M	O	I	M	O			
12	6	4	4	5	8	10	473088	49.5	113084
12	6	6	4	5	8	10	559104	45.4	120012
12	6	6	6	5	8	10	645120	44.1	128760
12	8	6	4	5	8	10	602112	44.9	121915
12	8	6	6	5	8	10	688128	43.6	130663
12	8	8	4	5	8	10	688128	42.7	127574

*cost of endcap is included but is not varied. Assumes 2/19/93 cost.

Table 2. Muon system cost parameterization