Compass measurements results

B. Wojtsekhowski, SBS weekly meeting 3/2024

A polarized e^- beam on a polarized target => A => GEn/GMn

$$A_{\text{phys}} = -\frac{2\sqrt{\tau(\tau+1)}\tan(\frac{\theta}{2})G_E^n G_M^n \sin\theta^* \cos\phi^*}{(G_E^n)^2 + (G_M^n)^2(\tau + 2\tau(1+\tau)\tan^2(\frac{\theta}{2}))}$$

~ 90 deg.

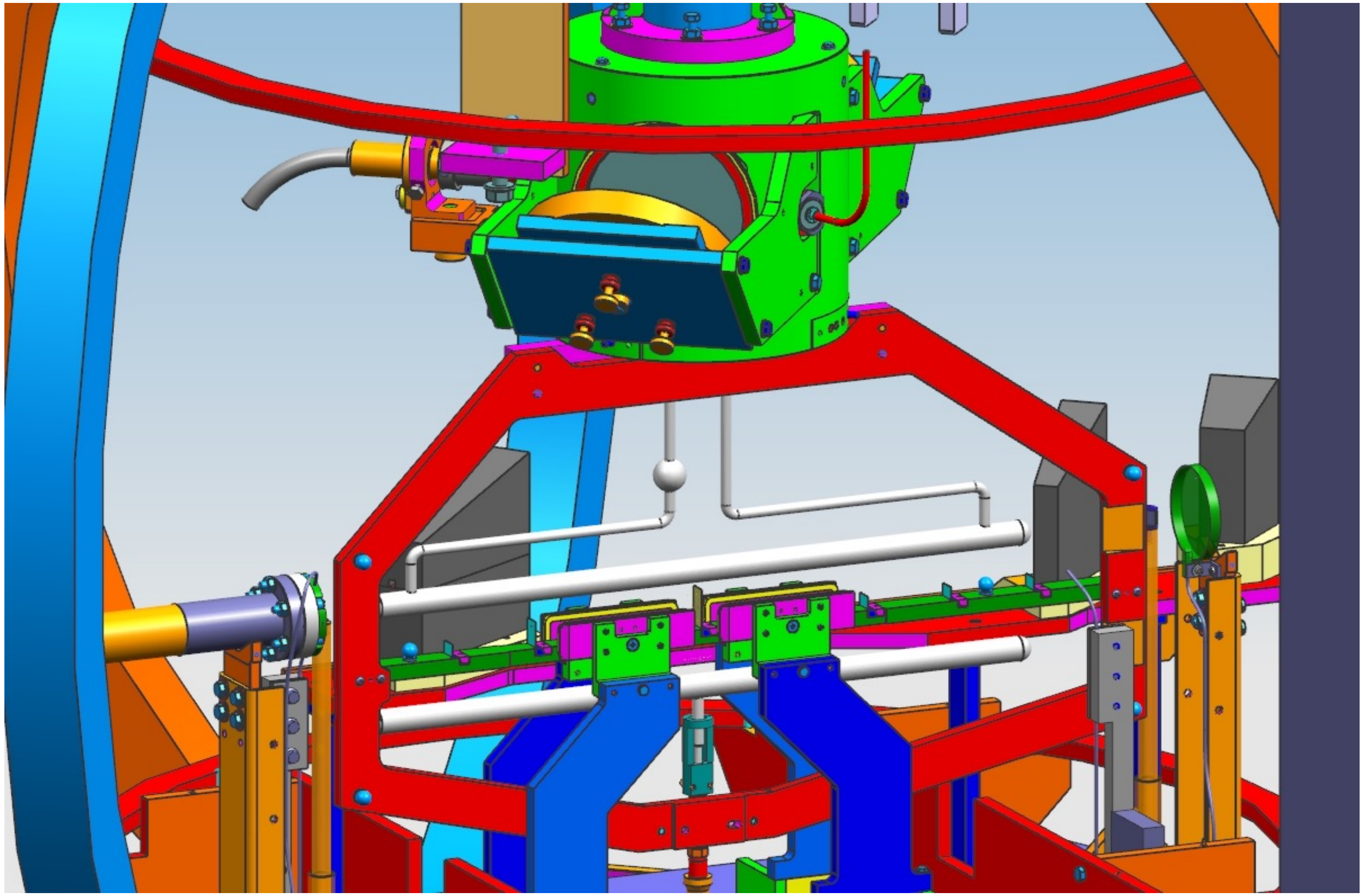
$$-\frac{2\tau\sqrt{1+\tau+(1+\tau)^2\tan^2(\frac{\theta}{2})}\tan(\frac{\theta}{2})(G_M^n)^2\cos\theta^*}{(G_E^n)^2 + (G_M^n)^2(\tau + 2\tau(1+\tau)\tan^2(\frac{\theta}{2}))}$$

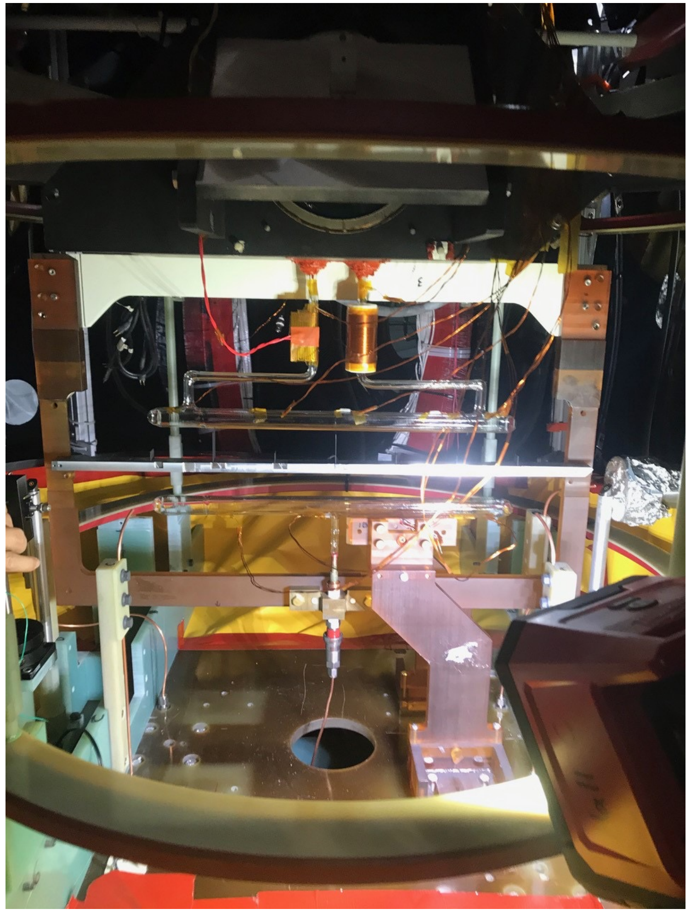
For 11 GeV beam, $Q^2 = 10$ GeV^2

the relative uncertainty (for Galster's GEn)

$\delta A/A \sim 0.01$ for $\delta\theta^* = 1$ mrad

A He-3 polarized target





Concept of a new compass

Separate functions: detection of misalignment and correction of the spin direction

a) Detection of the field vector and the compass axis misalignment by using the transverse component of the magnetic field –> oscillating signal from a Hall probe. No problem with calibration, sensitivity drift, alignment of the probe's plane.

b) Correction of the compass axis direction by means of e.g. a set of fine screws

Spinning Hall Probe Compass

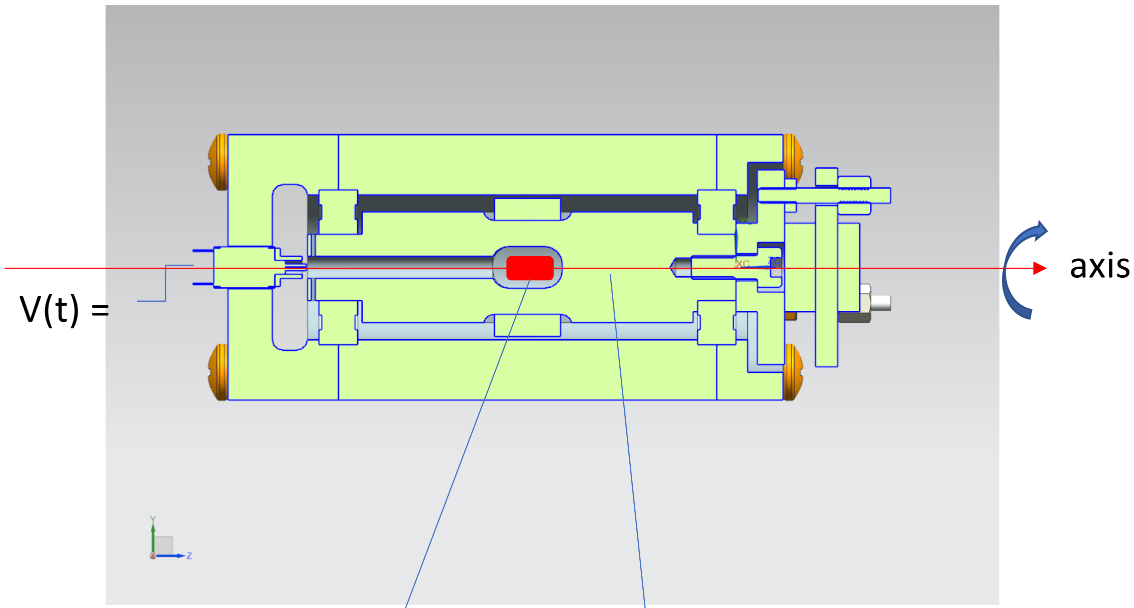
TEXAS INSTRUMENTS

DRV5053 Analog-

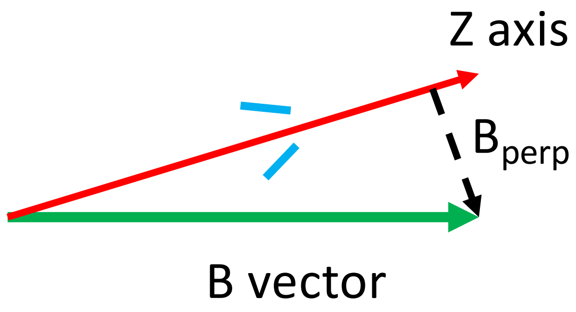
1 Features

- Linear Output Hall Sensor
- Superior Temperature Stability
  - Sensitivity ±10% Over Temperature
- High Sensitivity Options:
  - –11 mV/mT (OA, See Figure 17)
  - –23 mV/mT (PA)
  - –45 mV/mT (RA)
  - –90 mV/mT (VA)
  - +23 mV/mT (CA)
  - +45 mV/mT (EA)

9 mV/Gauss



The B vector has no transverse components relative to itself!



when $B_{perp} = 0$, the compass is aligned!

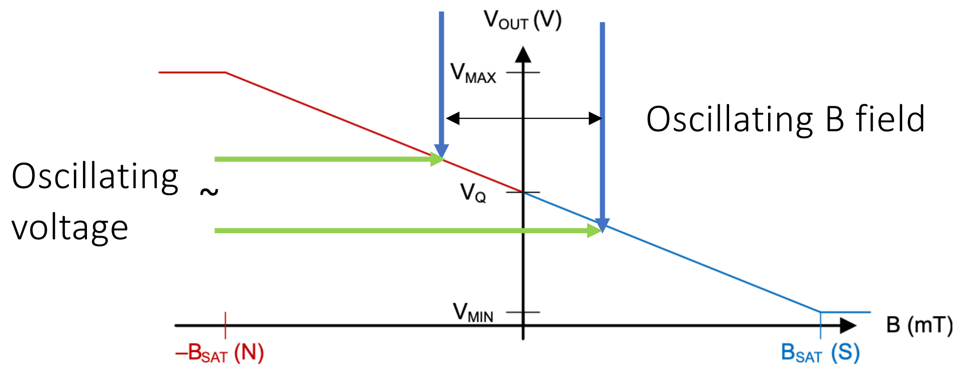
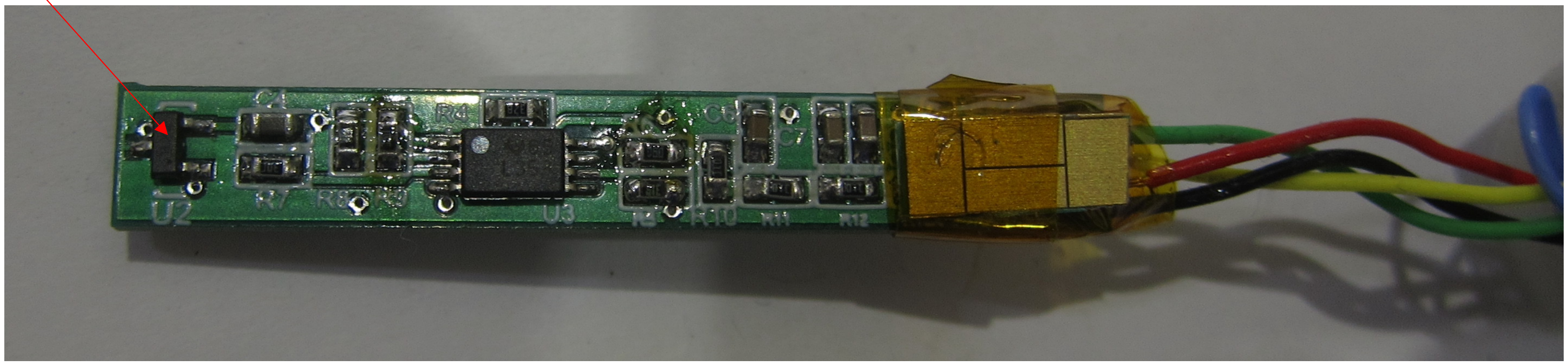


Figure 8. DRV5053 – Negative Sensitivity

Electronic noise is below 0.5 mV at 10 Hz

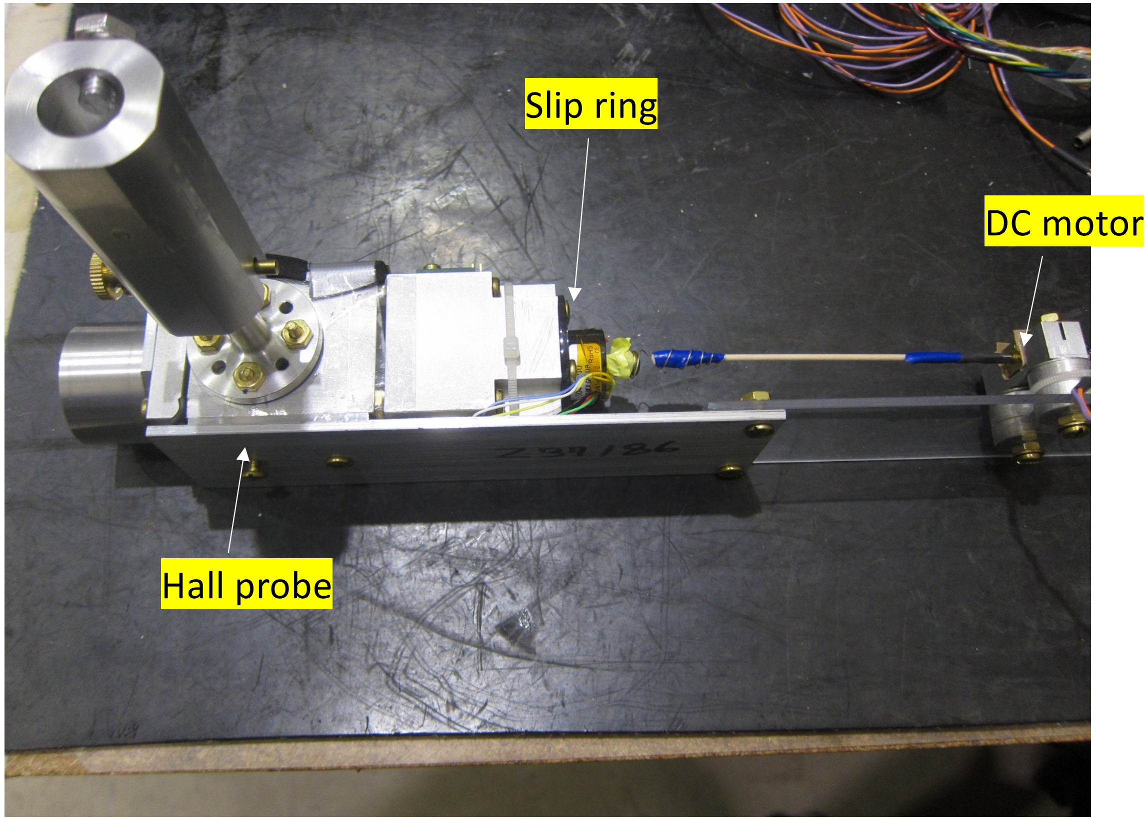
Sensor with the front-end

Hall probe



Front-end provides an additional signal gain by a factor of 10

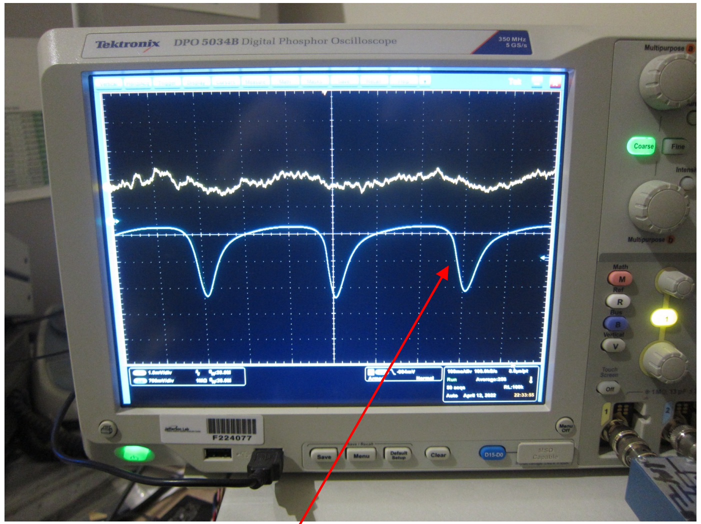
Spinning Hall probe compass

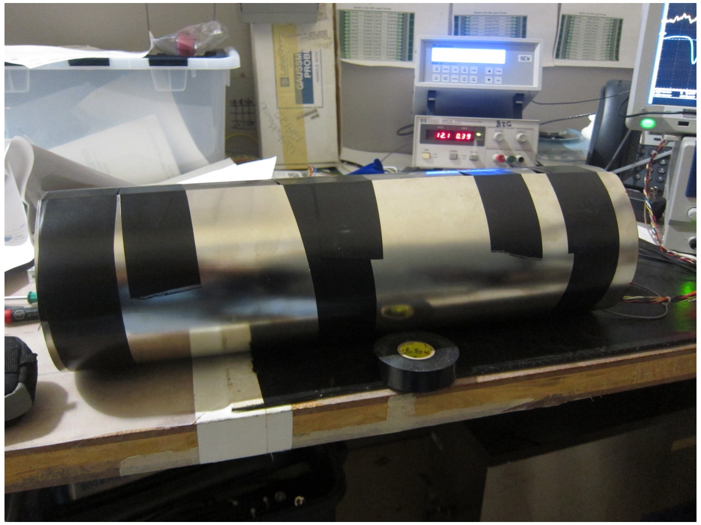


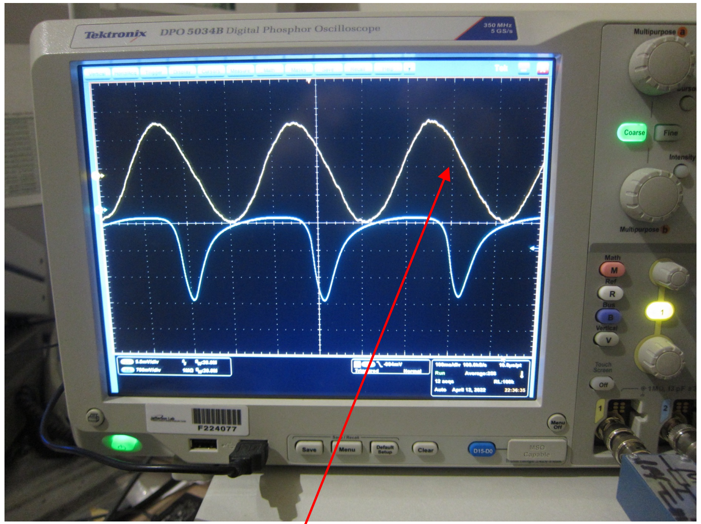
Test in Earth field

Inside magnetic shield ~ 0.5 mV
noise level of 0.1 mV

In ~ 0.50 Gauss => 17 mV





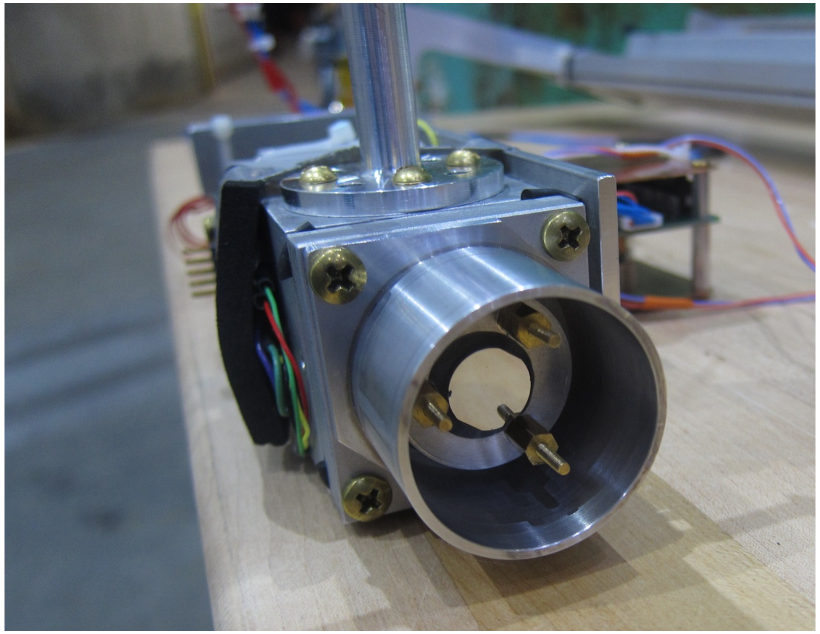


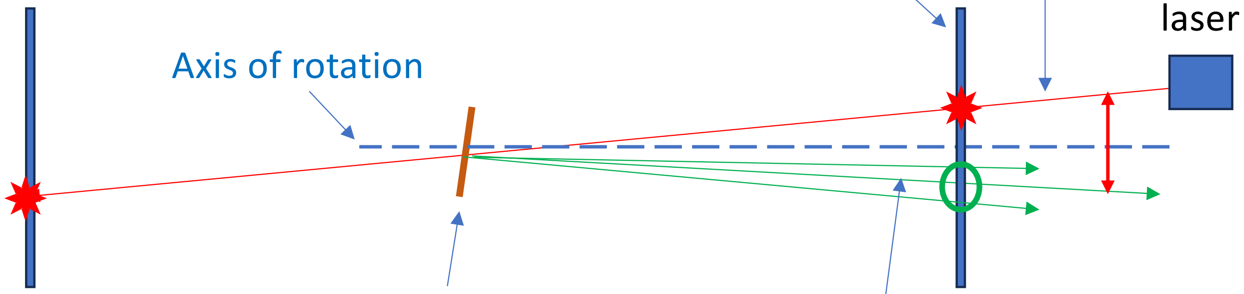
reference signal from spinning LED

Hall probe signal

Estimate of the field sensitivity – 0.5 G x 0.5/17 ~ 0.015 G
In case of He-3 target 0.015 G /25 G => 0.6 milli radian

Determination of the direction of the axis of rotation





TO: B. Wojtsekhowski, D. Spiers		**DATE:** 10/11/2022
FROM: Elena Balan	**Checked:** cg	**# :** A2052

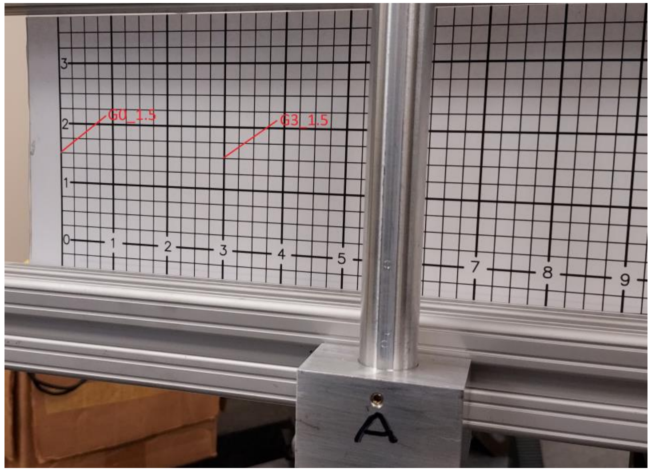
DETAILS: M:\align\DATA\Inspection\HallA\GEn_22\221006A

The results for the 6th September, 2022 compass screens survey are presented. Locations below are in a Beam Following System in reference to the Hall A GEN22 target. In a BFS, a positive dx value is to the beam left looking downstream along beam from the ideal; a positive dy is higher vertically from ideal; a positive dz is downstream from ideal position. Accuracy for defining the intersection is 0.5mm.

For the Primary screen, the position of the points was considered at the intersection of the 1.5-inch horizontal line and every 3-inch vertical lines.

Screen #1 for Point P3

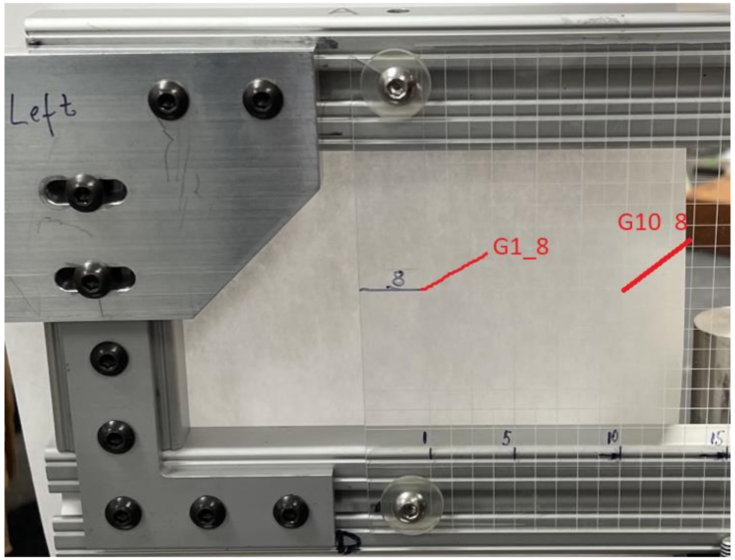
Primary Screen			
Component	dx[mm]	dy[mm]	dz[mm]
G0_1.5	1163.60	-1.37	188.92
G3_1.5	1107.20	-1.55	239.39
G7_1.5	1031.51	-1.29	307.11
G9_1.5	993.49	-1.41	341.13
G12_1.5	936.50	-1.00	392.12
G15_1.5	880.17	-1.23	442.51
G16.25_1.5	856.55	-1.36	463.65
G16_1.5	860.87	-1.15	459.78
G18_1	823.22	-14.10	493.50
G18_1.5	823.30	-1.27	493.40
G18_2	823.38	11.48	493.30
G21_1.5	766.45	-1.03	544.26
G24_1.5	709.67	-1.55	595.06
G27_1.5	652.93	-1.23	645.83
G30_1.5	596.16	-1.16	696.62
G33_1.5	539.38	-1.36	747.42
G33_1.5REP	539.51	-1.36	747.31
G34.725_1.5	506.42	-1.17	776.91



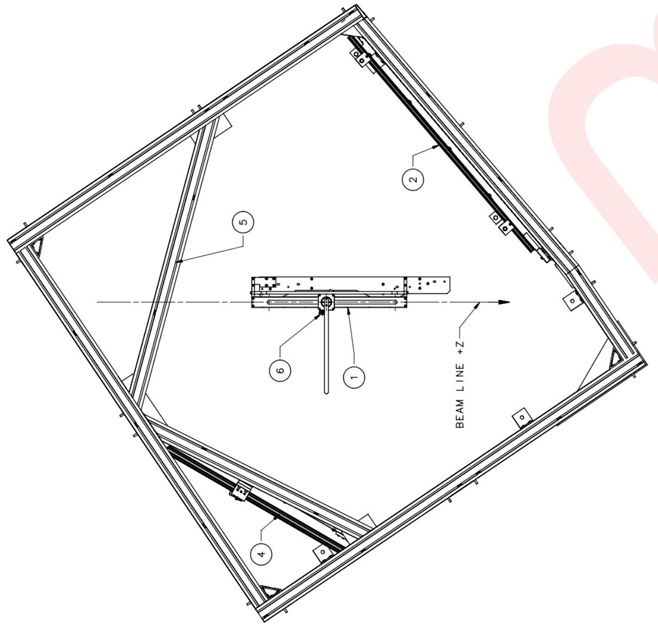
For the Secondary screen, points were considered at the intersection of the 8th horizontal line and every 10th vertical line.

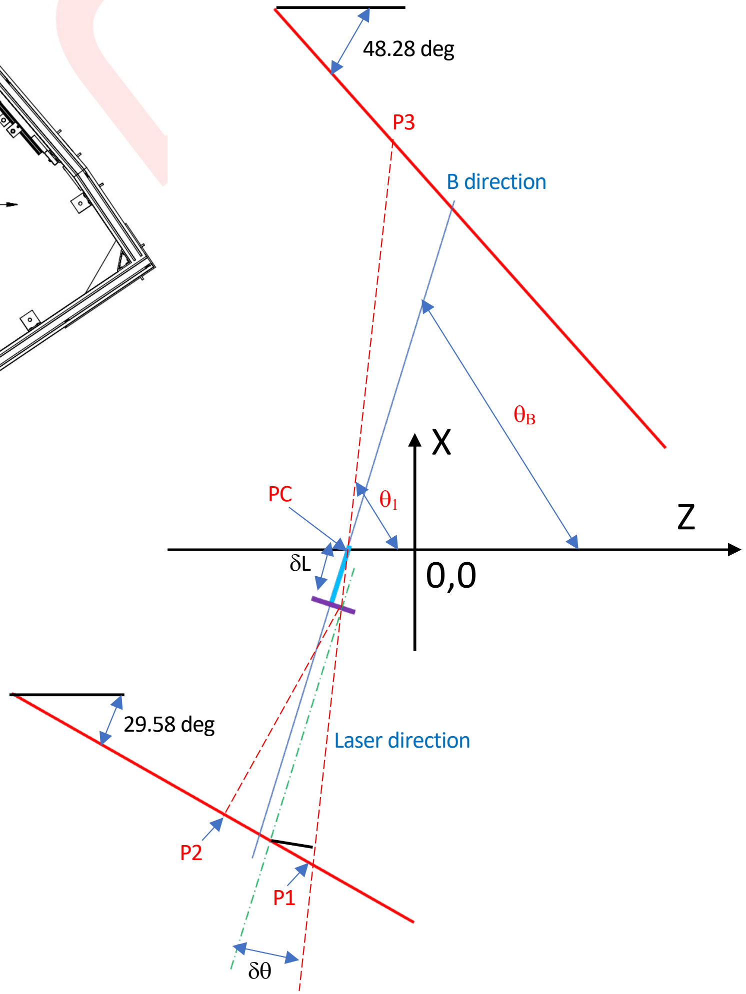
Screen #2 for Points P1 & P2

Secondary Screen			
Component	dx[mm]	dy[mm]	dz[mm]
G1_8	-690.25	-4.45	-650.66
G10_8	-718.42	-4.52	-601.03
G20_8	-749.63	-3.48	-546.07
G30_8	-781.04	-4.33	-490.72
G40_8	-812.36	-4.58	-435.54
G50_8	-843.71	-5.36	-380.30
G60_8	-875.05	-4.41	-325.10
G70_8	-906.38	-4.80	-269.90
G80_8	-937.70	-4.71	-214.72
G90_8	-969.13	-4.34	-159.36
G100_8	-1000.35	-4.59	-104.36
G110_8	-1031.68	-4.30	-49.17
G120_8	-1063.06	-4.86	6.12



Results for GEn kin#4 measurement #1





Recorded information are locations of the P1, P2, P3

P1 and P3 allow to find the angle θ_1 = 73.07 degrees

The mirror is shifted along B direction by δL = 1.5”

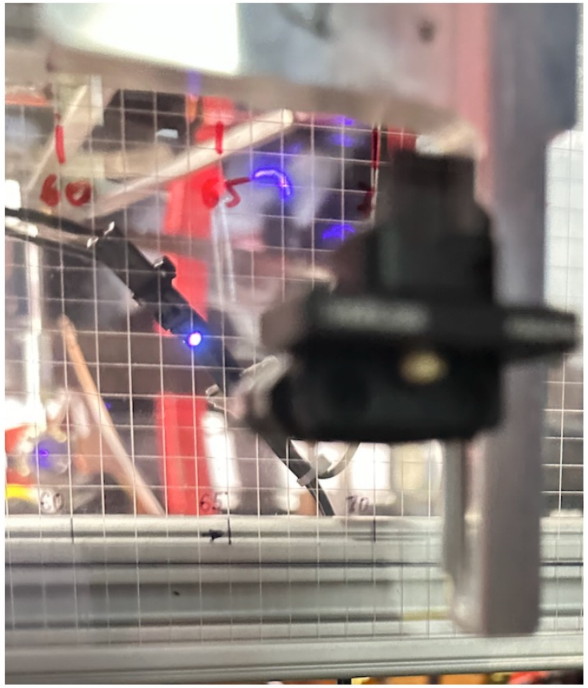
The open angle $\delta\theta$ calculated from P1, P2, P3 and δL

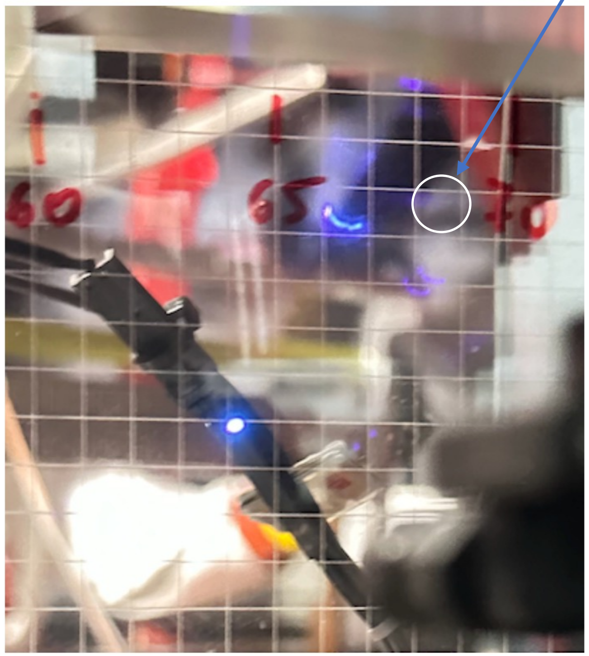
The final angle $\theta_B = \theta_1 - \delta\theta$ = 74.07 degrees

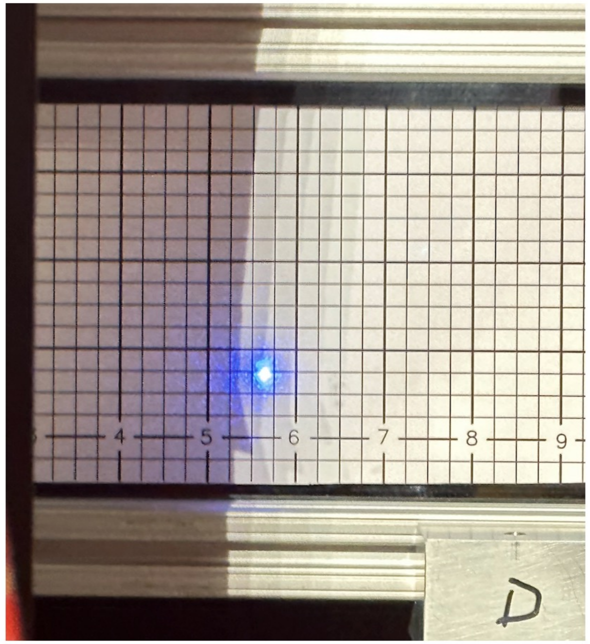
Probe location PC = -31 mm

Pictures of the light spots

circle (shifted)





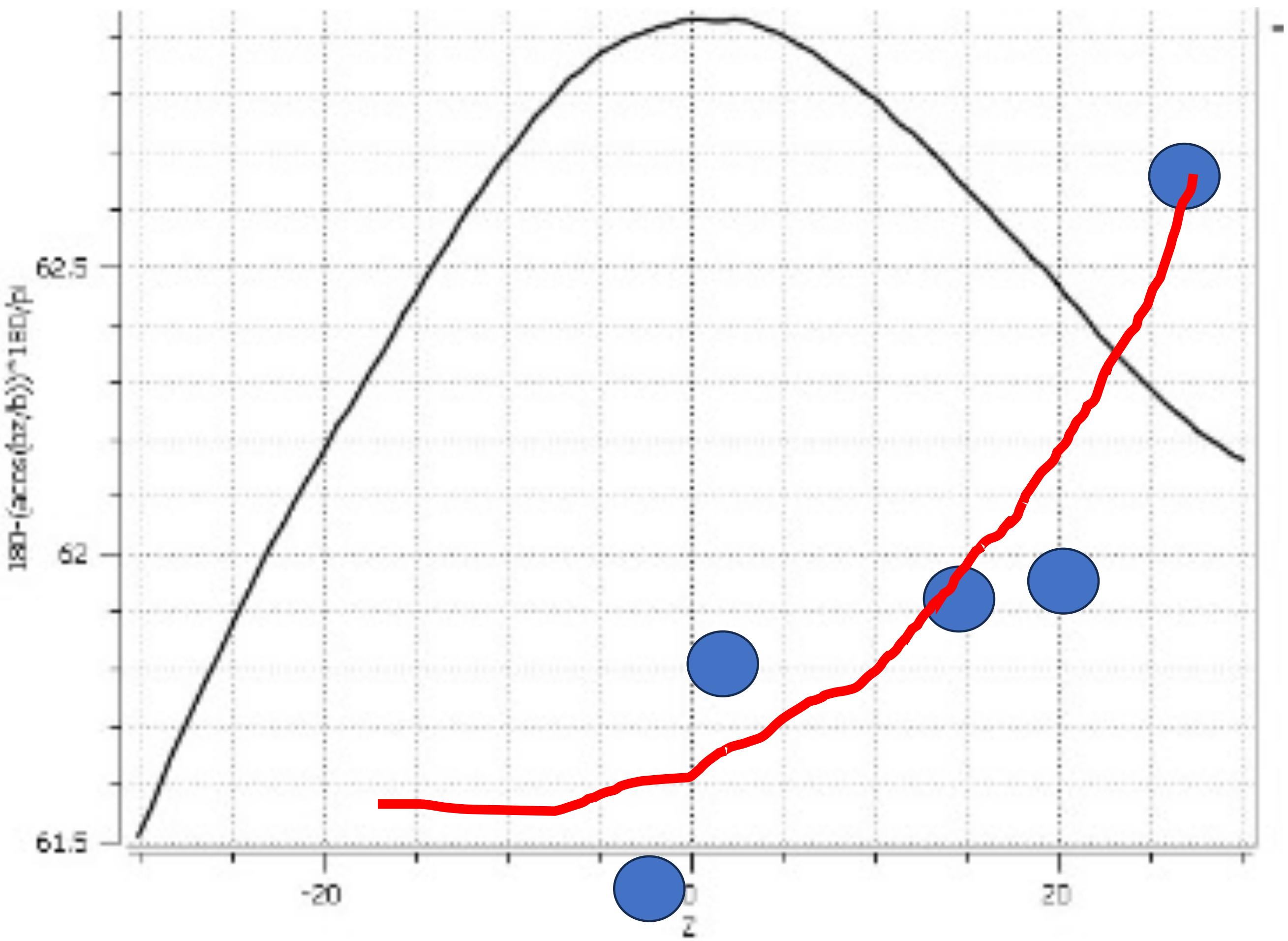


Field direction results

Kinematics	Date	Meas-ment	Point1 x	Point1 y	Z, mm	Angle horiz	Angle vert.
#4	Early 2023	1	G 64.2 /4	-13.34			
		screen	60 to 70				
		xB/yB/zB	-875.05	-4.41			
		E-B, mm	-31.33				
		final mm	-888.21	-17.75	-31	74.07	0.55
		2	G 79.9 /4	-12.7			
		screen	70 to 80				
		xB/yB/zB	-906.38	-4.8			
		E-B, mm	-31.32				
		mm	-937.39	-17.5	70.1	74.17	0.62
		3	G 44 /4	-13.97			
		screen	40 to 50				
		xB/yB/zB	-812.36	-4.58			
		E-B, mm	-31.35				
		mm	-824.9	-18.55	-161.3	73.95	0.56
ALL	Dec-23	1	G 34.0 /4	-14.61			
		screen	30 to 40				
		xB/yB/zB	-781.04	-4.33			
		E-B, mm	-31.32				
		mm	-793.57	-18.94	-25	61.4	0.34
		2	G 39.3 /4	-14.61			
		screen	30 to 40				
		xB/yB/zB	-781.04	-4.33			
		E-B, mm	-31.32				
		mm	-810.17	-18.94	9.5	61.76	0.53
		3	G 59.5 /4	-8.26			
		screen	60 to 70				
		xB/yB/zB	-875.05	-4.41			
		E-B, mm	-31.33				
		mm	-873.48	-12.67	155.6	61.84	0.74
		4	G 65.7 /4	-8.26			
		screen	60 to 70				
		xB/yB/zB	-875.05	-4.41			
		E-B, mm	-31.33				
		mm	-892.91	-12.67	201.4	61.91	0.62
		5	G 75.4 /4	-6.99			
		screen	70 to 80				
		xB/yB/zB	-906.38	-4.8			
		E-B, mm	-31.32				
		mm	-923.29	-11.79	272.3	62.62	0.5

Kinematics	Date	Meas-ment	Point1 x	Point1 y	Z, mm	Angle horiz	Angle vert.
#2	z = 0"	1	G 33.8 /4	27.31			
Oct-22		screen	30 to 40				
		xB/yB/zB	-781.04	-4.33			
		E-B, mm	-31.32				
		mm	-792.94	22.98	-9.5	61.65	1.25
	z = 4"	2	G 48.05 /4	27.94			
		screen	40 to 50				
		xB/yB/zB	-812.36	-4.58			
		E-B, mm	-31.35				
		mm	-837.6	23.36	94.7	60.19	1.85
	z = -4"	3	G 20.0 /4	26.99			
		screen	20 to 40				
		xB/yB/zB	-749.63	-3.48			
		E-B, mm					
		mm	-749.63	23.51	-9.7	59.34	1.84
	z = -7"	4	G 1.9 /4	26.04			
		screen	1 to 10				
		xB/yB/zB	-690.25	-4.45			
		E-B, mm	-28.17				
		mm	-696.2	21.59	-234.9	60.2	2.12
#3	z = ?? cm	*1	G 63.05 /4	-12.07			
		screen	60 to 70				
		xB/yB/zB	-875.05	-4.41			
		E-B, mm	-31.32				
		mm	-884.6	-16.48	69	68.33	0.75
	z =29 cm	*2	G 99.05 /4	-12.38			
		screen	90 to 100				
		xB/yB/zB	-969.13	-4.34			
		E-B, mm	-31.22				
		mm	-997.38	-16.72	256.76	71.1	0.85
	z =-6.4 cm	*3	G 44.1 /4	-12.07			
		screen	40 to 50				
		xB/yB/zB	-812.36	-4.58			
		E-B, mm	-31.35				
		mm	-825.21	-16.65	-97.2	70.94	0.51
	z =-26.7 cm	*4	G 14.8 /4	-5.72			
		screen	10 to 20				
		xB/yB/zB	-718.42	-4.52			
		E-B, mm	-31.21				
		mm	-733.4	-10.24	-295	71.12	0.85
	z = ?? cm	*5	G 93.8 /4	-12.07			
		screen	90 to 100				
		xB/yB/zB	-969.13	-4.34			
		E-B, mm	-31.22				
		mm	-980.99	-16.41	102.5	77.6	0.56

First calculation for ALL configuration



Need to be done

- Results from the “gradiometer”
- Results from the OPERA models
- Final function of angle vs. z (along the beam)
- Combined report for GEn data analysis