Nevis in the 1950's and 1960's and my interactions with Bill Sippach in the 1970's

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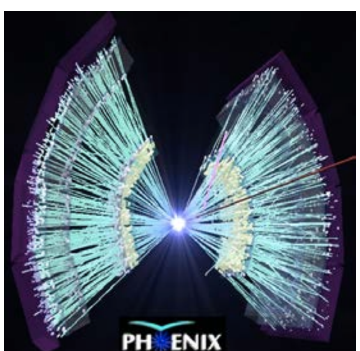
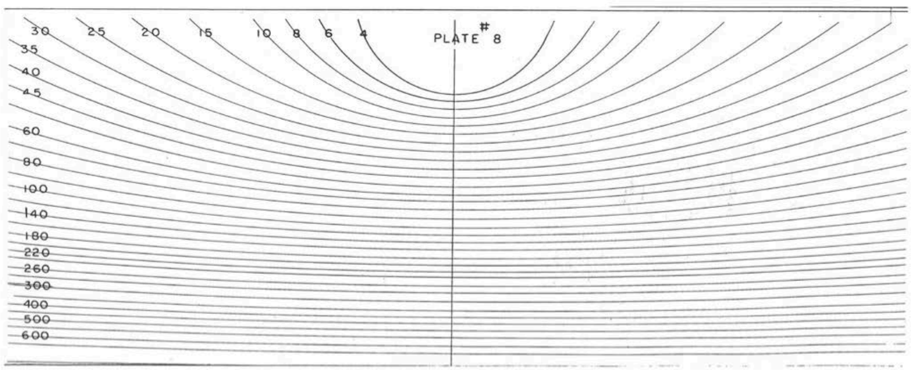


Sippach Fest—A Celebration of the Career and Accomplishments of Bill Sippach
November 9, 2018
Nevis Labs, Irvington NY10533

My first time at Nevis was as a summer student in 1957



Bob Eisenstein and I made these templates for bubble chamber measurements in the hallway on the 9th floor of Pupin using a beam compass made by Dick Plano which ruled precision circles on blackened photographic plates. After finishing this we went to Nevis and I met Nick Samios CC53, famous for discovering the Omega Minus, being director of BNL and converting ISABELLE to RHIC

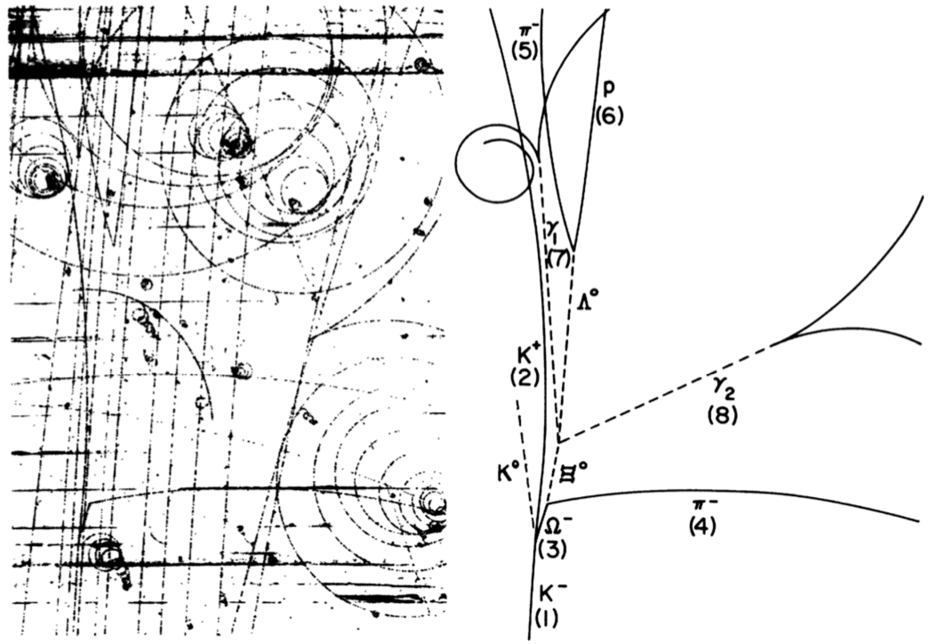


Photo of $K^- + p \dashrightarrow \Omega^- + K^+ + K^0$ Discovery PRL12(1964)204

I doubt that they used templates then

1957 was also the year of the discovery of Parity Violation by Columbia Professors

PR105(1957)1415

Observations of the Failure of Conservation of Parity and Charge Conjugation in Meson Decays: the Magnetic Moment of the Free Muon*

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Physics Department, Nevis Cyclotron Laboratories, Columbia University, Irvington-on-Hudson, New York

(Received January 15, 1957)

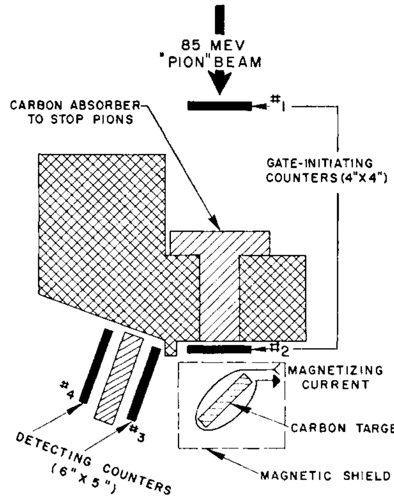


FIG. 1. Experimental arrangement. The magnetizing coil was close wound directly on the carbon to provide a uniform vertical field of 79 gauss per ampere.

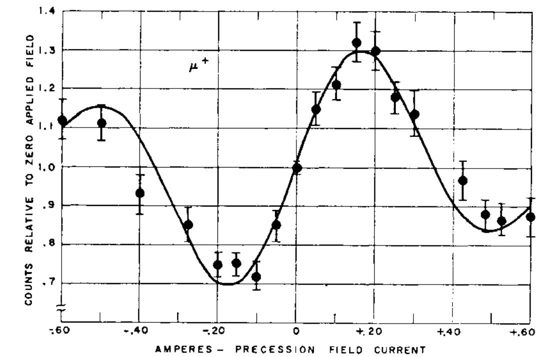
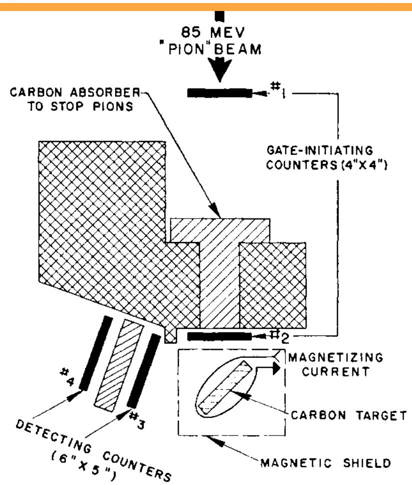


FIG. 2. Variation of gated 3–4 counting rate with magnetizing current. The solid curve is computed from an assumed electron angular distribution $1-\frac{1}{3}\cos\theta$, with counter and gate-width resolution folded in.

There is a good story that goes along with this Nevis discovery that was told to me at the final dinner at a conference in Erice in 2010. Zichichi had left and I was seated across from T.D.Lee and Dick Garwin who somehow decided to explain to me in great detail what happened at Nevis during the famous weekend run of the Garwin Lederman Weinrich experiment. Just before the Friday lunch, C.S.Wu had phoned T.D. from the NBS that they had found parity violation in beta decay. T.D. then asked Leon if he could do it with μ decay at Nevis. Leon said that it would take 23 days and T.D. said that they couldn't wait that long so they asked Dick Garwin for suggestions.

1957 the discovery of Parity Violation at Nevis



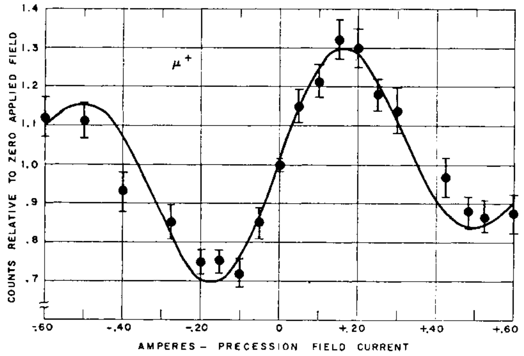


FIG. 2. Variation of gated 3–4 counting rate with magnetizing current. The solid curve is computed from an assumed electron angular distribution $1-\frac{1}{3}\cos\theta$, with counter and gate-width resolution folded in.

Lee and Yang said parity nonconservation implies a polarization of the spin of the muon emitted from stopped pions along the direction of motion and that the angular distribution of electrons should serve as an analyzer for the muon polarization.
Leon thought that he would have to rotate the detector to measure the angle of the electron from mu decay with respect to the muon direction but Garwin suggested that they stop the muon in a magnetic field which would precess the spin so that they could keep the detector fixed. Garwin wound the magnetic coil and they had a signal by Friday night but it suddenly vanished! At that time the cyclotron operators went home at 5PM and didn't return until Monday morning so Leon and Dick couldn't go inside. On Monday morning they found that the paraffin on which the coil was wound had melted and the coil had fallen. They fixed it and then found the precession!!!

I also worked at Nevis in the summer of 1958

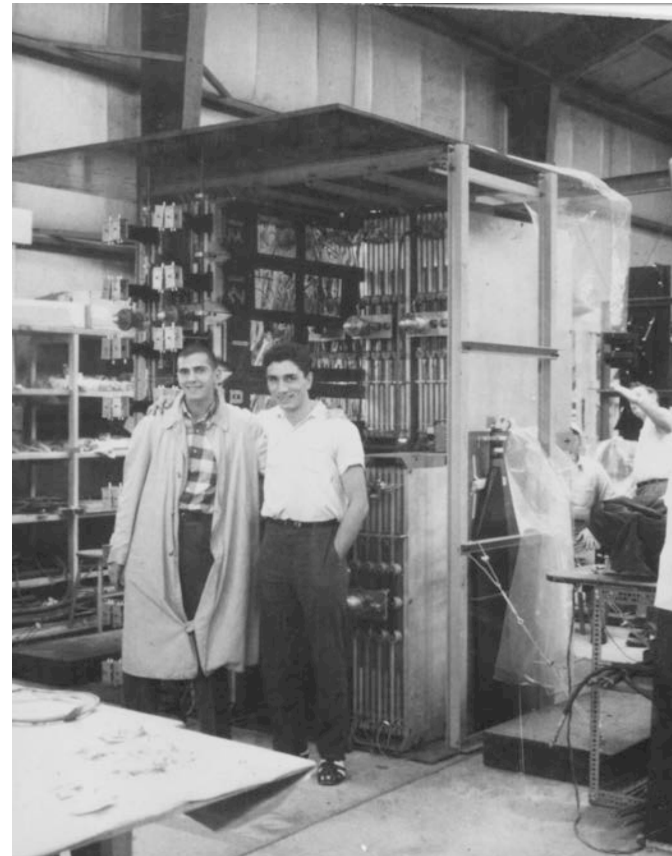
My summer job in 1958 was again at Nevis and I got another taste of the Columbia Physics spirit. I was working for Sheldon Penman, building a vacuum tube double-pulser that he designed. It took me a while because it had some parasitic oscillations, which I figured out and fixed. I got it working at the end of one day and went home before I could tell anybody. Sure enough, the next morning it had vanished from my workbench, already in use in an experiment on the cyclotron floor.

I worked at Nevis again part-time in the fall semester of 1960 in graduate school

In the fall of 1960, I worked part-time at the muon helicity experiment at Nevis PRL7(1961)23-25 (which, including travel back and forth to Nevis amounted to ~30 hours for week---Columbia for part time!) because I still had to finish my course requirements and couldn't devote full-time to thesis research. I really enjoyed working with Marcel Bardon who was scrupulous about treating the graduate students to lunch from time to time.

I started my own thesis work in the summer of 1971 at BNL with equipment that was built at Nevis

Recoil proton range chamber built out of specially flattened aluminum plates and thin window with a pressure of 1psi max. Tracks viewed from above through a plate glass cover and mirrors



We also used 3 former neutrino chambers to detect the scattered μ

Walter LeCroy was the EE then, and I don't remember whether Bill had started yet.

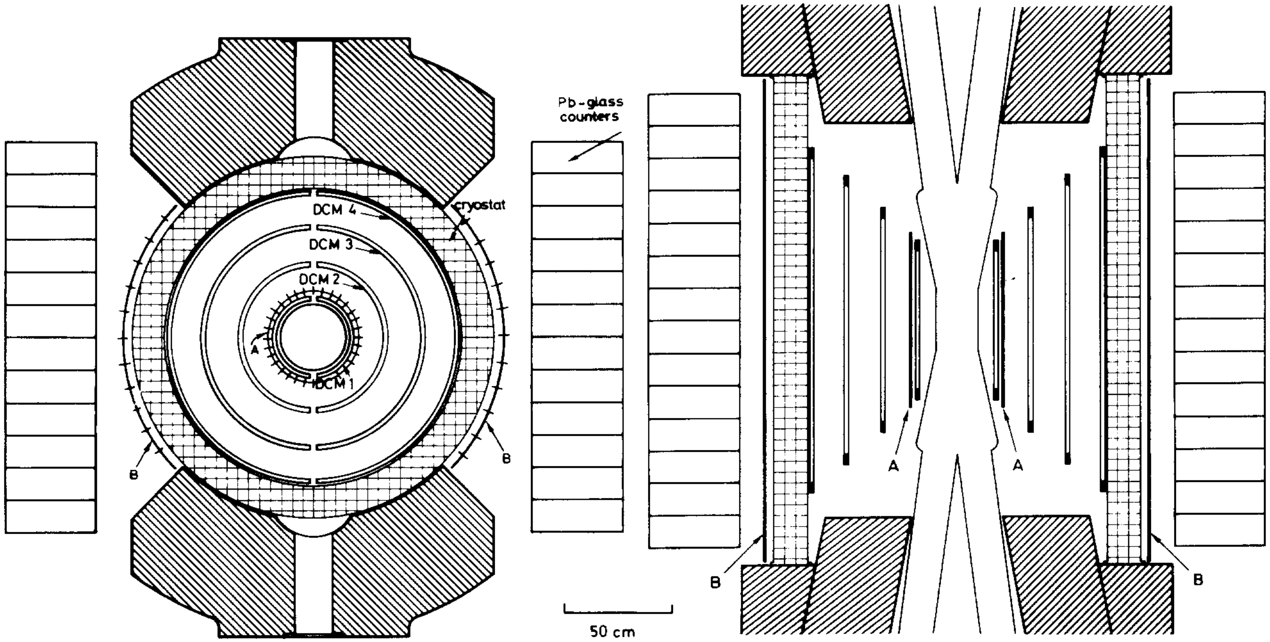
I built electronics to put gas in the spark chamber and for the High Voltage trigger and I had excellent supervision

John Tinlot (Rochester), Rod Cool (BNL), MJT and Leon Lederman (Columbia)

I went to CERN as a post-doc from March 1965-August 1966 and I worked with Jack (and Cynthia) Steinberger, Carlo Rubbia and others on $K_{L,}$ K_S interference and then with Emilio Picasso, Francis Farley and Simon van der Meer on muon g-2. From 1966-1971, I was assistant then associate Professor at Harvard, then I was hired by Rod Cool at the Rockefeller University to help start a new experimental group. Rod and Leon had proposed an experiment at CERN which discovered high p_T scattering, so I then went to CERN to work on the next CCR experiment which was the first to use a thin coil superconducting solenoid This is where Nevis and Bill Sippach came in.

CERN Columbia Oxford Rockefeller (CCOR)

NIM156(1978)275-A system of cylindrical drift chambers in a superconducting solenoid



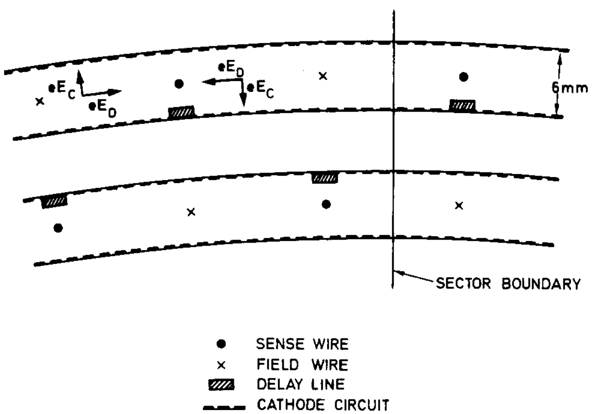


Fig. 2. Basic drift cell of DCM-1.

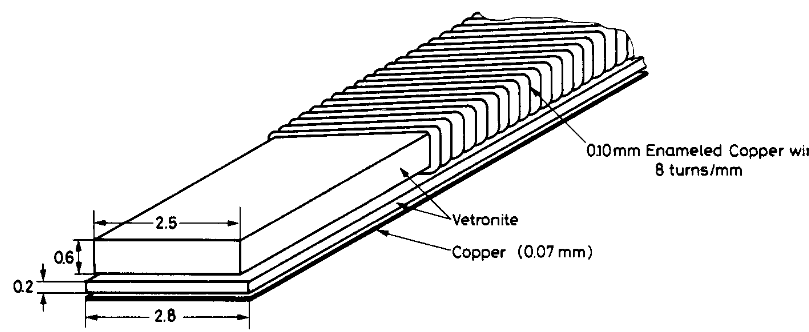


Fig. 3. Delay line construction. All dimensions are in mm.

The drift chamber had 3 dimensional space points thanks to the delay line and the electronics designed mostly by Bill Sippach. Bob Hollebeek did the programming

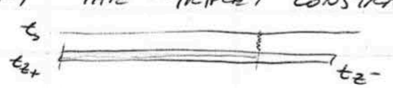
SUMMARY OF DISCUSSION ON
PROGRAM WITH RJH - 1/JUNE/77

1) TIME ASSOCIATION

i) PROBLEMS
a) WHAT IS t_0
b) WHAT IS V_D
c) WHAT IS DRIFT CORRECTION FOR ANGLE

ii) METHOD - USE ALL TRIPLETS + MATCHED S Z DOUBLETS NOT ASSOCIATED WITH TRIPLETS. IN THE CASE WHERE A SENSE AMPLIFIER IS KNOWN TO BE DEAD THEN Z^+Z^- DOUBLETS ARE USED.

A TRIPLET IS A SET OF S Z^+Z^- TIMES WHICH SATISFY THE "TRIPLET" CONSTRAINT



$$(t_{z+}-t_s)+(t_{z-}-t_s)=\frac{L_z}{V_z}$$

A DOUBLET IS A S Z PAIR SATISFYING THE CONSTRAINT $t_z - t_s \le \frac{L_z}{V_z}$

A MATCHED DOUBLET - IS A DOUBLET WHICH ALSO HAS A STRUCK SENSE WIRE ON AN ADJACENT WIRE IN THE ADJACENT GAP

2) TRACK FINDING ALGORITHM - TAKES ACCOUNT OF MISSING OR BAD HITS -

A TRACK IS DEFINED BY 3 GAPS, K, J, I. THEN THE 4TH GAP L IS SEARCHED FOR CONFIRMATION & A FIT IS DONE. IF A POINT IS NOT FOUND IN

Then Bill Sippach and I and others worked in great detail on a Drift Chamber Processer which would read out and fully reconstruct all the tracks and their momenta in an event in less than 50 μsec. It never got built, but I'll now review the impressive work that Bill also did that was way beyond making the electronics

HJT

CCOR MEMO : 206

W. Sippach
R. Garland
6 Dec. 1976

BLACK BOX

The following has arrived from Nevis together with a Software simulator which is being installed in a Computer Program under *IDENT BLKBOX

In addition R.J. Hollebeek has some preliminary block diagrams.

Circuit

- Translation of Program to Hardware
Expensive [illegible] - Compromises -

- Momentum Resolution of Box -

- Ambiguities -

DRIFT CHAMBER PROCESSOR

INTRODUCTION

The processor is divided into three parts; a signal associator, a track finder and a momentum calculator.

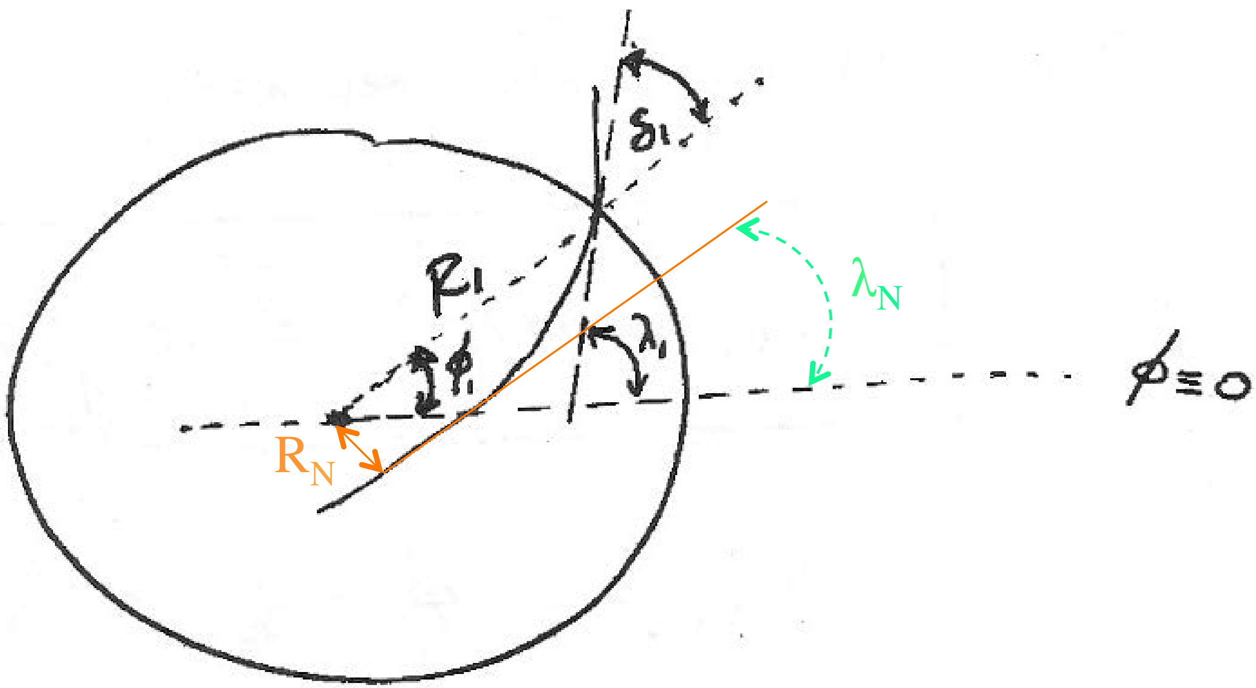
The "signal associator" sorts input data into triplets, doublets, singles and writes the normalized data into a map-list form.

The "track finder" initiates a tree search from each signal in the outer chamber. Masks are defined from the diamond size and a $P_\perp$ lower limit. An outer signal projects a Ø view mask and a Z view mask onto the next chamber. Each point common to those masks, together with the source point, projects a narrower Ø view- Z view mask pair onto the next lower chamber. Points common to this Ø and Z mask, form 3 point sets which predict points (very narrow masks in Ø and Z) in the inner chamber. The tree branching from each mask is ordered in terms of most likely pairs through singles so the tree can be cut when a strong candidate is found. Deviations are formed at the 3 point level to aid in the track candidate discrimination.

The "momentum calculator" estimates the momentum of the best (if any) candidate from each tree, and accumulates a vector sum. If this sum exceeds a given threshold, data is read into the computer. Data from the processor is a list of wire number-signal number for each track included in the momentum sum. The raw data from the readout system is then read into the computer.

The processor is organized as a pipeline so that each branch in the tree is one clock cycle (about 50 nanoseconds). This should result in an event processing time of less than 50 microseconds for a complicated event.

Reconstructing a Circle in polar coordinates is much more complicated than $r=R_i$ when the origin is at the center of the circle



R_N is the minimum radius from the solenoid axis, the distance of closest approach

October 1976 The Sippach-Rothenberg Equation for the circle in polar coordinates

For any point u.R,ϕ,δ on the trajectory τ is a constant

$$\boxed{\tau \equiv R(\sin\delta - uR)}$$

$$u \equiv \frac{1}{Zr(\mathrm{cm})}$$

where r is the radius of the particle trajectory that we are trying to measure

$$\frac{1}{Zr(\mathrm{cm})} = \frac{2.9979\ B(T)\times 10^{-3}}{Z\ P_\perp\ (\mathrm{GeV/c})}$$

$$\boxed{\sin(\phi - \lambda_N) = \frac{uR - \frac{\tau}{R}}{\sqrt{1-4u\tau}}} \qquad (B50)$$

THESE ϕ ANGLES ARE SYMMETRIC ABOUT ϕ_N, AND THE δ ANGLES ARE COMPLEMENTARY ($\sin\delta = uR + \frac{\tau}{R}$) (B52a)

b) NICE FEATURES OF THE EQUATION:

THIS EQUATION (B50) HAS SEVERAL NICE FEATURES:

i) IT INVOLVES λ_N, WHICH IS CONTINUOUS FOR ALL SOLUTIONS; AND THE 2 CONSTANTS OF THE MOTION u & τ.

ii) THIS LEADS TO A CONVENIENT DESCRIPTION OF THE ORBIT BY THE 3 PARAMETERS u, τ, λ_N.

iii) EQUATION B50 IS MUCH SIMPLER THAN EITHER EQUATIONS A1-A9 OR B1-B4

iv) THE EQUATION HAS THE ORBIT PARAMETERS (u, τ & λ_N) AND THE ORBIT POINTS (R, ϕ) COMPLETELY SEPARATED. EACH TERM IN THE EQUATION HAS A SIMPLE FACTOR INVOLVING ONLY THE ORBIT PARAMETERS TIMES A SIMPLE FACTOR INVOLVING ONLY THE POINTS.

I PROPOSE TO CALL THIS EQUATION THE SIPPACH-ROTHENBERG EQUATION SINCE IT FIRST APPEARED IN AFR'S MEMO "SOLENOIDS ARE SIMPLE" (3RD BOX) BUT ITS NICE FEATURES WERE FIRST POINTED OUT TO ME BY BILL SIPPACH IN DISCUSSIONS ABOUT THE BLACK BOX.

① CCOR MEMO: 258

NEW THOUGHTS ON THE PARABOLIC LIMIT

MJT, 12/5/77

I) INTRODUCTION –

BILL SIPPACH HAS BEEN WORRYING LATELY ABOUT WHETHER A LEAST SQUARES FIT WOULD IMPROVE HIS TRACK FINDING ALGORITHM. BASICALLY, HE HAS A BEAUTIFUL 3 POINT SOLUTION AND IS WORRIED ABOUT HOW TO INCLUDE THE 4^{TH} POINT.

I SENT HIM A SHEAF OF MEMOS.

II) SIPPACH'S LEAST-SQUARES SOLUTION:

IN RESPONSE, BILL PROPOSED HIS OWN SOLUTION WHICH GOES AS FOLLOWS:

LET a_3 b_3 λ_3 REPRESENT THE SIPPACH 3 POINT SOLUTION. THEN, THE EXACT SOLUTION IS

$$a \equiv a_3 + \delta a$$
$$b \equiv b_3 + \delta b$$
$$\lambda_N \equiv \lambda_3 + \delta\lambda$$

LET ϕ_i REPRESENT THE MEASURED ANGLES + Φ_i REPRESENT THE PREDICTED ANGLES:

$$\Phi_i = \lambda_N + \sin^{-1}(aR_i - b/R_i)$$

THE TRICK IS TO ~~T~~ TAYLOR EXPAND Φ TO FIRST ORDER IN $\delta a, \delta b, \delta\lambda$ ABOUT a_3, b_3, λ_3

$$\boxed{\Phi_i \cong \lambda_3 + \sin^{-1}(a_3R_i - b_3/R_i) + \delta\lambda + \frac{\delta a R_i - \delta b/R_i}{\sqrt{1-(a_3R_i - b_3/R_i)^2}}} \quad (1)$$

DEAR MIKE,

HERE IS A SIMPLIFIED χ^2 DERIVATION. IT MUST BE WRONG SINCE ITS VERY SIMPLE. PLEASE TAKE A LOOK AT IT AND LET ME KNOW WHAT YOU THINK.

IF IT'S CORRECT, IT LEADS TO THE POSSIBILITY OF GENERATING A χ^2 TO DO THE TRACK SELECTION FROM THE TREE. IF THE MEAN VALUE OF THE K, J, I CHAMBER POINTS ARE USED, LOTS OF TERMS DROP OUT.

BEST WISHES

Bill Sippach

3

χ^2 FOR CIRCLE IN POLAR COORDINATES

$$\phi_i = \cos^{-1}\left(BR_i - \frac{C}{R_i}\right) + \theta$$

$$\chi^2 = \sum_i \frac{[\Phi_i - \phi_i(B, C, \theta)]^2}{\sigma_i^2}$$

$$\frac{\partial(\chi^2)}{\partial B} = 0$$

$$\frac{\partial(\chi^2)}{\partial C} = 0 \qquad \text{SOLVE FOR } B, C, \theta$$

$$\frac{\partial(\chi^2)}{\partial C} = 0 \qquad \text{WHERE } \Phi_i \text{ ARE MEASURED DATA POINTS.}$$

SINCE THE PATTERN RECOGNITION PRODUCES TREE CANDIDATE CIRCLES BASED ON SETS OF THREE TRIAL POINTS, IT SEEMS BEST TO EXPAND THE FUNCTION ϕ_i AROUND THIS CANDIDATE CIRCLE, USING A TRUNCATED TAYLOR EXPANSION. THIS WILL LEAD TO A LINEAR SET OF EQUATIONS THAT CAN BE SOLVED EXACTLY.

Let

$$B = B_0 + \Delta B$$
$$C = C_0 + \Delta C$$
$$\phi = \phi_0 + \Delta\phi$$

$\Delta B, \Delta C, \Delta\phi$ ARE NOW THE VARIABLES.

THAN

$$\phi_i \approx \cos^{-1}\left(B_0 R_i - \frac{C_0}{R_i}\right) - \frac{R_i}{\sqrt{(1-(B_0 R_i - \frac{C_0}{R_i})^2}}\Delta B + \frac{\frac{1}{R_i}}{\sqrt{1-(B_0 R_i - \frac{C_0}{R_i})^2}}\Delta C + \theta_0 + \Delta\theta$$

LET $\varphi_i = \Phi_i - \cos^{-1}\left(B_0 R_i - \frac{C_0}{R_i}\right) - \theta_0$

$$F_i = \frac{-R_i}{\sqrt{1-\left(B_0 R_i - \frac{C_0}{R_i}\right)^2}} = \frac{\partial(\varphi_i)}{\partial B_0}$$

$$G_i = \frac{\frac{1}{R_i}}{\sqrt{1-\left(B_0 R_i - \frac{C_0}{R_i}\right)^2}} = \frac{\partial(\varphi_i)}{\partial C_0}$$

THAN $\chi^2 = \sum_i \left[\frac{\varphi_i - F_i \Delta B - G_i \Delta C - \Delta\theta}{\sigma_i}\right]^2$

$$\frac{\partial(\chi^2)}{\partial \Delta B} = \sum_i \frac{-2F_i}{\sigma_i^2}\left[\varphi_i - F_i\Delta B - G_i \Delta C - \Delta\theta\right] = 0$$

$$\frac{\partial(\chi^2)}{\partial \Delta C} = \sum_i \frac{-2G_i}{\sigma_i^2}\left[\varphi_i - F_i\Delta B - G_i \Delta C - \Delta\theta\right] = 0$$

$$\frac{\partial(\chi^2)}{\partial \Delta \theta} = \sum_i \frac{-2}{\sigma_i^2}\left[\varphi_i - F_i\Delta B - G_i \Delta C - \Delta\theta\right] = 0$$

THAN

$$\sum_i\left(\frac{F_i\varphi_i}{\sigma_i^2}\right) = \sum_i\left(\frac{F_i^2}{\sigma_i^2}\right)\Delta B + \sum_i\left(\frac{F_iG_i}{\sigma_i^2}\right)\Delta C + \sum_i\left(\frac{F_i}{\sigma_i^2}\right)\Delta\theta$$

$$\sum_i\left(\frac{G_i\varphi_i}{\sigma_i^2}\right) = \sum_i\left(\frac{G_iF_i}{\sigma_i^2}\right)\Delta B + \sum_i\left(\frac{G_i^2}{\sigma_i^2}\right)\Delta C + \sum_i\left(\frac{G_i}{\sigma_i^2}\right)\Delta\theta$$

$$\sum_i\left(\frac{\varphi_i}{\sigma_i^2}\right) = \sum_i\left(\frac{F_i}{\sigma_i^2}\right)\Delta B + \sum_i\left(\frac{G_i}{\sigma_i^2}\right)\Delta C + \sum_i\left(\frac{1}{\sigma_i^2}\right)\Delta\theta$$

$$\Delta = \begin{vmatrix} \sum_i\left(\frac{F_i^2}{\sigma_i^2}\right) & \sum_i\left(\frac{F_iG_i}{\sigma_i^2}\right) & \sum_i\left(\frac{F_i}{\sigma_i^2}\right) \\ \sum_i\left(\frac{G_iF_i}{\sigma_i^2}\right) & \sum_i\left(\frac{G_i^2}{\sigma_i^2}\right) & \sum_i\left(\frac{G_i}{\sigma_i^2}\right) \\ \sum_i\left(\frac{F_i}{\sigma_i^2}\right) & \sum_i\left(\frac{G_i}{\sigma_i^2}\right) & \sum_i\left(\frac{1}{\sigma_i^2}\right) \end{vmatrix}$$

$$\Delta B = \frac{\begin{vmatrix} \sum_i\left(\frac{F_i\varphi_i}{\sigma_i^2}\right) & \sum_i\left(\frac{F_iG_i}{\sigma_i^2}\right) & \sum_i\left(\frac{F_i}{\sigma_i^2}\right) \\ \sum_i\left(\frac{G_i\varphi_i}{\sigma_i^2}\right) & \sum_i\left(\frac{G_i^2}{\sigma_i^2}\right) & \sum_i\left(\frac{G_i}{\sigma_i^2}\right) \\ \sum_i\left(\frac{\varphi_i}{\sigma_i^2}\right) & \sum_i\left(\frac{G_i}{\sigma_i^2}\right) & \sum_i\left(\frac{1}{\sigma_i^2}\right) \end{vmatrix}}{\Delta}$$

$$\Delta C = \frac{\begin{vmatrix} \sum_i\left(\frac{F_i^2}{\sigma_i^2}\right) & \sum_i\left(\frac{F_i\varphi_i}{\sigma_i^2}\right) & \sum_i\left(\frac{F_i}{\sigma_i^2}\right) \\ \sum_i\left(\frac{G_iF_i}{\sigma_i^2}\right) & \sum_i\left(\frac{G_i\varphi_i}{\sigma_i^2}\right) & \sum_i\left(\frac{G_i}{\sigma_i^2}\right) \\ \sum_i\left(\frac{F_i}{\sigma_i^2}\right) & \sum_i\left(\frac{\varphi_i}{\sigma_i^2}\right) & \sum_i\left(\frac{1}{\sigma_i^2}\right) \end{vmatrix}}{\Delta}$$

$$\Delta \theta = \frac{\begin{vmatrix} \sum_i\left(\frac{F_i^2}{\sigma_i^2}\right) & \sum_i\left(\frac{F_iG_i}{\sigma_i^2}\right) & \sum_i\left(\frac{F_i\varphi_i}{\sigma_i^2}\right) \\ \sum_i\left(\frac{G_iF_i}{\sigma_i^2}\right) & \sum_i\left(G_i^2\right) & \sum_i\left(G_i\varphi_i\right) \\ \sum_i\left(\frac{F_i}{\sigma_i^2}\right) & \sum_i\left(\frac{G_i}{\sigma_i^2}\right) & \sum_i\left(\frac{\varphi_i}{\sigma_i^2}\right) \end{vmatrix}}{\Delta}$$

$$\chi^2 = \sum_i \left[\frac{\varphi_i - F_i\Delta B - G_i\Delta C - \Delta\theta}{\sigma_i}\right]^2$$

LET
$$M1 = \left(\sum_i \frac{1}{\sigma_i^2}\right)\left(\sum_i \frac{G_i^2}{\sigma_i^2}\right) - \left(\sum_i \frac{G_i}{\sigma_i^2}\right)^2$$
$$M2 = \left(\sum_i \frac{1}{\sigma_i^2}\right)\left(\sum_i \frac{F_i^2}{\sigma_i^2}\right) - \left(\sum_i \frac{F_i}{\sigma_i^2}\right)^2$$
$$M3 = \left(\sum_i \frac{F_i^2}{\sigma_i^2}\right)\left(\sum_i \frac{G_i^2}{\sigma_i^2}\right) - \left(\sum_i \frac{F_i G_i}{\sigma_i^2}\right)^2$$
$$M4 = \left(\sum_i \frac{F_i}{\sigma_i^2}\right)\left(\sum_i \frac{G_i}{\sigma_i^2}\right) - \left(\sum_i \frac{1}{\sigma_i^2}\right)\left(\sum_i \frac{F_i G_i}{\sigma_i^2}\right)$$
$$M5 = \left(\sum_i \frac{G_i}{\sigma_i^2}\right)\left(\sum_i \frac{F_i G_i}{\sigma_i^2}\right) - \left(\sum_i \frac{F_i}{\sigma_i^2}\right)\left(\sum_i \frac{G_i^2}{\sigma_i^2}\right)$$
$$M6 = \left(\sum \frac{F_i}{\sigma_i^2}\right)\left(\sum_i \frac{F_i G_i}{\sigma_i^2}\right) - \left(\sum_i \frac{G_i}{\sigma_i^2}\right)\left(\sum_i \frac{F_i^2}{\sigma_i^2}\right)$$

THAN
$$\Delta B = \frac{M1 \sum_i \left(\frac{F_i \varphi_i}{\sigma_i^2}\right) + M4 \sum_i \left(\frac{G_i \varphi_i}{\sigma_i^2}\right) + M5 \sum_i \left(\frac{\varphi_i}{\sigma_i^2}\right)}{\Delta}$$
$$\Delta C = \frac{M2 \sum_i \left(\frac{G_i \varphi_i}{\sigma_i^2}\right) + M4 \sum_i \left(\frac{F_i \varphi_i}{\sigma_i^2}\right) + M6 \sum_i \left(\frac{\varphi_i}{\sigma_i^2}\right)}{\Delta}$$
$$\Delta \theta = \frac{M3 \sum_i \left(\frac{\varphi_i}{\sigma_i^2}\right) + M5 \sum_i \left(\frac{F_i \varphi_i}{\sigma_i^2}\right) + M6 \sum_i \left(\frac{G_i \varphi_i}{\sigma_i^2}\right)}{\Delta}$$
$$\Delta = M3 \sum_i \left(\frac{1}{\sigma_i^2}\right) + M5 \sum_i \left(\frac{F_i}{\sigma_i^2}\right) + M6 \sum_i \left(\frac{G_i}{\sigma_i^2}\right)$$
$$\chi^2 = \sum_i \left[\frac{\varphi_i - F_i \Delta B - G_i \Delta C - \Delta\theta}{\sigma_i^2} \right]^2$$

WHERE
$$\varphi_i = \Phi_i - \cos^{-1}\left(B_0 R_i - \frac{C_0}{R_i}\right) - \theta_0$$
$$F_i = -R_i \Big/ \sqrt{1 - \left(B_0 R_i - \frac{C_0}{R_i}\right)^2}$$
$$G_i = \frac{1}{R_i} \Big/ \sqrt{1 - \left(B_0 R_i - \frac{C_0}{R_i}\right)^2}$$

NOTE: FOR THE USUAL CONSTRAINTS, $F_i \approx -R_i$, $G_i \approx \frac{1}{R_i}$, THAN $M1, M2, M3, M4, M5, M6, \Delta$ ARE CONSTANTS, $\Delta B, \Delta C, \Delta\theta$ ARE THAN LINEAR, WEIGHTED SUMS OF THE DEVIATIONS OF THE MEASURED POINTS FROM THE TRIAL TRAJECTORY.

χ^2 IS EASILY IMPLEMENTED IN HARDWARE WITH (OR WITHOUT) THE F_i, G_i APPROXIMATIONS.

10/25/1978 the beginning of the end

(1)

DISCUSSION WITH SIPPACH & BENENSON
10/25/78

RE: FUTURE OF BLACK BOX

1) THEY ARE WORKING VERY HARD ON THE PROJECT
THEY SPEND OVER HALF THEIR TIME BUT

2) THEIR PROJECT IS TO ISOLATE A SET OF
BUILDING BLOCK FUNCTIONS WHICH ARE INDEPENDENT
OF PARTICULAR EXPERIMENTS. THEY HAVE DONE THIS BUT
THEIR BIG PROBLEM REMAINING IS PACKAGEING.
THEY WANT REUSEABLE MODULAR PACKAGEING.

3) THEY HAVE DESIGNED A 15 PLANE STRAIGHT LINE
SYSTEM FOR WONYONG & BRUCE KNAPP INCLUDING LEAST
SQUARES FITTING. THEY HAVE SOFTWARE MODELED IT +
IT WORKS. THEY GOT THE GO AHEAD FOR 60K
FROM WONYONG TO BUILD IT BUT IT STILL HAS TO PASS
THE NEVIS HIERARCHY. THEY SAY THAT WHAT EVER
THEY BUILD, IT'S REUSEABLE SINCE THEY STILL HAVE
THE MODULAR FUNCTIONAL BOARDS. FOR THIS
COMING YEAR ONE OF THEIR KEY PARTS A 256×4
ECL 10 NSEC MEMORY (MADE BY FUJITSU & SOON
FAIRCHILD & MOTOROLA) IS NOT QUITE ~~AVAILABLE~~
AVAILABLE - DELIVERIES ARE TOUGH.

4) FOR OUR PROBLEM THEY HAVE BLOCK
DIAGRAMS FOR POINT ASSOCIATOR 3 TIMES ϕ & z TRIPLETS ~~DOUBLE~~

(2)

~~PLANE ASSOCIATOR~~ & DOUBLETS - THEY CAN ALLOW
ax+b FOR EACH WIRE S, N, F TO NORMALIZE THESE TIMES.
THEY ~~[illegible]~~ WANT HAVE 2 STREAMS IN SENSE TIME TO CORRECT
FOR THE ~~[illegible]~~ SENSE PROPAGATION DOWN THE WIRE;

iA) PLANE ASSOCIATOR - THEY FIND VALID INNER OUTER
COMBINATIONS ON EITHER ADJACENT WIRE + PRE
COMPUTE SOME $\Delta\phi$ CASE FOR THE 4 POSSIBLE L-R COMBINATIONS
THEY PROPAGATE ALL OF THESE.

iiB) TRACK FINDER - INCLUDES 4 CORRELATION

THEY STILL NEED TO DO LEAST SQUARES FIT, ~~VERTEX FINDER~~
~~MULTIPLE SIT~~ DUPLICATE TRACK REMOVER & VERTEX FINDER

5) FOR OUR PROJECT SIPPACH ESTIMATED
- 6 MONTHS - REFINE ~~SOFTWARE~~ ALGORITHM & MAKE
SIMULATION SOFTWARE eg JUNE '78

- 6 MONTHS DESIGN & BUILD

- 6 MONTHS NORMAL DELAYS & TO GET WORKING.

~~THUS~~ ~~[illegible]~~ IF WE SUPPLIED SOMEONE FROM GROUP WHO
KNOWS WHAT THEY ARE DOING WHO WOULD WORK FULL
TIME

ALSO, IF HE HAS TO DO ROTATION & TRANSLATION
OF HALF CYLINDERS - THIS HAS NOT BEEN
WORKED OUT AT ALL

Even though we had to do track reconstruction off line we showed that QCD worked using our EMcalorimeter angular distribution of π^0pair