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
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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 $K^- + p \rightarrow \Omega^- + K^+ + K^0$

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

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 $\mu$ 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.
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 1 psi max. Tracks viewed from above through a plate glass cover and mirrors.

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

We also used 3 former neutrino chambers to detect the scattered µ.
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.
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.
Then Bill Sippach and I and others worked in great detail on a Drift Chamber Processor 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
The following has arrived from Nevis together with a Software simulator which is being installed in a Computer Program under *INESK NIKOMX

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

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 lower limit. An outer signal projects a view mask and a Z view mask onto the next chamber. Each point common to these masks, together with the source point, projects a narrower view-Z view mask pair onto the next lower chamber. Points common to this view and Z mask, form 3 point sets which predict points (very narrow masks in view 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 (~ 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.
For any point \( \mathbf{r}, \phi, \delta \) on the trajectory \( \tau \) is a constant

\[
\tau = R (\mathbf{r} - \mathbf{v} R)
\]

\[
\mathbf{v} = \frac{1}{2\tau} (\phi, \lambda n)
\]

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

\[
\frac{1}{2\tau} \text{cm}^{-1} = 2.9979 \times 10^{-3} \frac{B(T)}{Z P_l (\text{GeV/c})}
\]
NEW THOUGHTS ON THE PARABOLIC LIMIT

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 4th 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 \( a_3, b_3, \lambda_3 \) represent the Sippach 3 point solution. Then, the exact solution is

\[
\begin{align*}
\alpha &= a_3 + \delta \alpha \\
b &= b_3 + \delta b \\
\lambda &= \lambda_3 + \delta \lambda
\end{align*}
\]

Let \( \Phi_i \) represent the measured angles and \( \Phi_i' \) represent the predicted angles:

\[
\Phi_i' = \lambda_i + \Delta \Phi_i (a_{R_i} - b_{R_i})
\]

The trick is to Taylor expand \( \Phi_i' \) to first order in \( \delta a, \delta b, \delta \lambda \) about \( a_3, b_3, \lambda_3 \):

\[
\Phi_i' = \lambda_3 + \Delta \Phi_i (a_{R_i} - b_{R_i}) + \delta \lambda + \frac{\delta a_{R_i} - \delta b_{R_i}}{\sqrt{1 - (a_{R_i} - b_{R_i})^2}}
\]
DEAR MIKE,

HERE IS A SIMPLIFIED $x^2$ DERIVATION. IT MUST BE WRONG.

SINCE IT'S 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 $x^2$ TO DO THE TRACK SELECTION FROM THE TREE. IF THE AVER VALUE OF THE K, J, I CHAMBER POINTS ARE USED, LOTS OF TERMS DROP OUT.

BEST WISHES,

Bill

\[
\phi_n = \cos^{-1}\left( \frac{BR_n}{R_n^2} \right) + \theta
\]

\[
\chi^2 = \sum \left[ \frac{1}{\sigma^2} (\phi_n - \phi_{n}(B, C, \theta)) \right]^2
\]

\[
\begin{align*}
2\phi_{n} &= 0 \\
2\phi_{n}' &= 0 \\
2\phi_{n}'' &= 0
\end{align*}
\]

SOLVE FOR $B, C, \theta$

WHERE $\phi_n$ ARE MEASURED DATA POINTS.

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

Let $B = B_0 + A_B$  
$C = C_0 + A_C$  
$\phi = \phi_0 + A_\phi$

\[
\begin{align*}
\phi_n - \phi_{n}(B_0, C_0, \theta_0) &= A_{\phi} \theta + \Delta \phi \\
\Delta B &= \frac{R_n}{\sqrt{1 - (R_n/B_0)^2}} \\
\Delta C &= \frac{R_n}{\sqrt{1 - (R_n/C_0)^2}} \\
\theta &= \theta_0 + \Delta \theta
\end{align*}
\]
Let $\Phi = \Phi^0 = \cos^{-1} \left( \frac{B \cdot \Delta B}{Q^0} \right) - \Theta$

\[ F^0 = \frac{1}{\sqrt{1 - (B \cdot \Delta B)^2}} \]

\[ G^0 = \frac{1}{\sqrt{1 - (B \cdot \Delta B)^2}} \]

\[ \Delta B = \sum \left[ \frac{\phi - F^0 \Delta B - G^0 \Delta C - \Delta \Theta}{\sigma^2} \right]^2 \]

\[ \Delta C = \sum \left[ \frac{\phi - F^0 \Delta B - G^0 \Delta C - \Delta \Theta}{\sigma^2} \right]^2 \]

\[ \Delta \theta = \sum \left[ \frac{\phi - F^0 \Delta B - G^0 \Delta C - \Delta \Theta}{\sigma^2} \right]^2 \]

\[ \chi^2 = \sum \left[ \frac{\phi - F^0 \Delta B - G^0 \Delta C - \Delta \Theta}{\sigma^2} \right]^2 \]
\[ M_1 = \left( \frac{\varepsilon}{\varepsilon_{\text{ref}}} \right)^2 - \left( \frac{\varepsilon}{\varepsilon_{\text{ref}}} \right)^2 \]
\[ M_2 = \left( \frac{\varepsilon}{\varepsilon_{\text{ref}}} \right)^2 \left( \frac{\varepsilon}{\varepsilon_{\text{ref}}} \right)^2 \]
\[ M_3 = \left( \frac{\varepsilon}{\varepsilon_{\text{ref}}} \right)^2 \left( \frac{\varepsilon}{\varepsilon_{\text{ref}}} \right)^2 \]
\[ M_4 = \left( \frac{\varepsilon}{\varepsilon_{\text{ref}}} \right)^2 \left( \frac{\varepsilon}{\varepsilon_{\text{ref}}} \right)^2 \]
\[ M_5 = \left( \frac{\varepsilon}{\varepsilon_{\text{ref}}} \right)^2 \left( \frac{\varepsilon}{\varepsilon_{\text{ref}}} \right)^2 \]
\[ M_6 = \left( \frac{\varepsilon}{\varepsilon_{\text{ref}}} \right)^2 \left( \frac{\varepsilon}{\varepsilon_{\text{ref}}} \right)^2 \]

\[ \Delta B = \frac{M_1 \varepsilon_1 (\varepsilon_{\text{ref}}) + M_4 \varepsilon_4 (\varepsilon_{\text{ref}}) + M_5 \varepsilon_5 (\varepsilon_{\text{ref}})}{\Delta} \]
\[ \Delta C = \frac{M_2 \varepsilon_2 (\varepsilon_{\text{ref}}) + M_4 \varepsilon_4 (\varepsilon_{\text{ref}}) + M_6 \varepsilon_6 (\varepsilon_{\text{ref}})}{\Delta} \]
\[ \Delta = \frac{M_3 \varepsilon_3 (\varepsilon_{\text{ref}}) + M_5 \varepsilon_5 (\varepsilon_{\text{ref}}) + M_6 \varepsilon_6 (\varepsilon_{\text{ref}})}{\Delta} \]

\[ \chi^2 = \sum \left[ \varphi_i - F_i \Delta B - G_i \Delta C - \Delta \right]^2 \]

Where \( \varphi_i = \theta_i - \cos^{-1} \left( \frac{\rho_i R_i - \varepsilon_{\text{ref}}}{\varepsilon_{\text{ref}}} \right) \)
\[ F_i = \frac{-P_i \sqrt{1 - (\rho_i R_i - \varepsilon_{\text{ref}})^2}}{\rho_{\text{ref}}} \]
\[ G_i = \frac{P_i \sqrt{1 - (\rho_i R_i - \varepsilon_{\text{ref}})^2}}{\rho_{\text{ref}}} \]
10/25/1978 the beginning of the end

Discussion with Sippach & Benvenuti
10/15/78

1) They are working very hard on the project. They spent over half their time but

2) Their project is to isolate a set of building block functions which are non-measureable by experiments. They have done this but their big problem remaining is packaging. They want reusable modular packages.

3) They have designed a 35-plane, straight line system for windonics to plug into gas spares, fitting. They have someone already 10-20% is functional. They got the go ahead for 60K from Windonics to build it but it still has to pass the Nevis hurdle. They say that elsewhere they build, it is reusable since they still have the modular functional boards. For this coming year one of their key parts a 32x16

4) For our problem they have block diagrams for & & & & for & & &

5) For our project Sippach estimated:

- 6 months before association & machine simulation software of June 28

- 6 months design & build

- 6 months manual download to get work

Also if he has to do rotation & translation of half cylinders this has not been worked out at all.

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PHOENIX
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Even though we had to do track reconstruction off line we showed that QCD worked using our EMcalorimeter angular distribution of $\pi^0$ pair.

\[ \sqrt{s} = 62.4 \text{ GeV} \]

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