

Kirk McDonald, Particle Physicist and Scholar

**Symposium to honour
our great friend and
colleague on his
retirement from
Princeton**

AJS Smith

June 17, 2016



Early days: Kirk in Tucson, class of '66

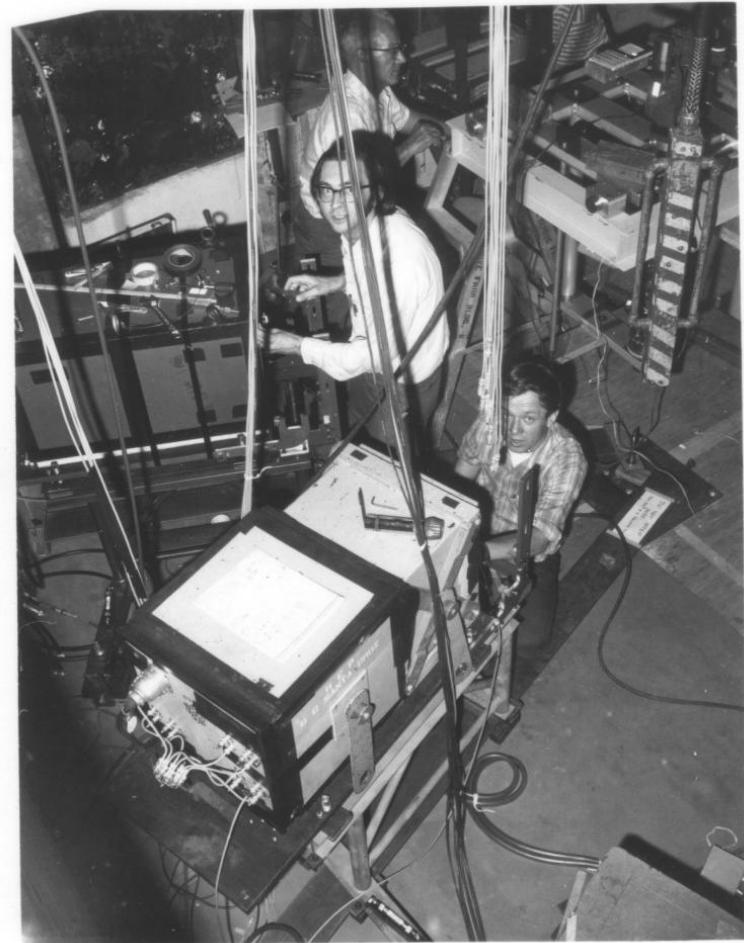


Grad School at Caltech 1966-71

- CP violation furor – Weak? EM? Strong?
 - ▶ Apparent evidence for T violation in the EM sector, in comparing $n p \leftrightarrow d \gamma$, but neutrons were tough to work with
 - ▶ Kirk's thesis measured $p d \leftrightarrow \text{He}^3 \gamma$
 - No neutrons to deal with
 - Photoproduction experiment the last at the Caltech synchrotron
 - Inverse reaction at LBL
 - ▶ He found that T invariance held.

LBL 1971

$p d \rightarrow \text{He}^3 \gamma$

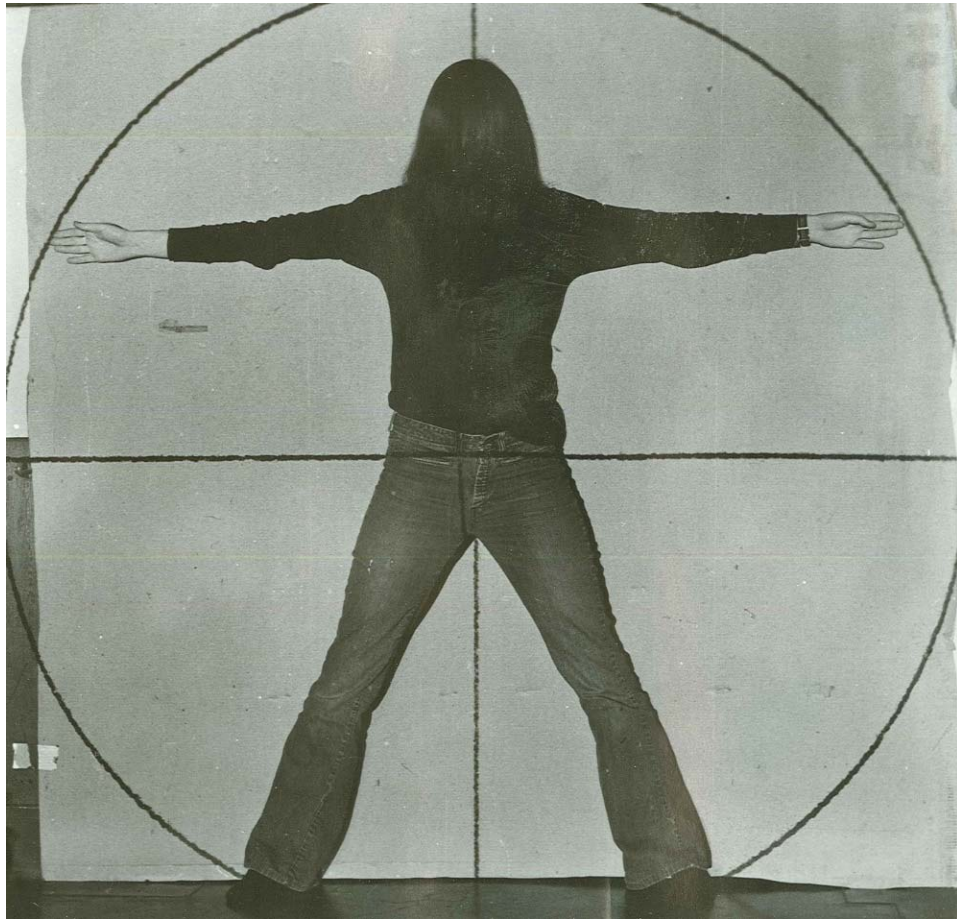


The Heusch Puppies, Caltech 2002



**Charles Prescott, Elliott Bloom, Leon Rochester, Bruce Winstein,
Bill McNeely, Steve Yellin, Kirk McDonald, Abe Seiden**

Clemens Heusch



Nancy Schaefer,
Vitruvian Woman, Caltech, ~ 1971



At CERN 1972 -1974

- Intersecting Storage Rings (ISR) provided world's highest energy collisions, and hope to gain insight on strong interactions
- Kirk won a CERN fellowship to work with Pierre Darriulat, Klaus Tittel, Martin Holder et al on experiments studying the correlations of high-transverse-momentum photons and π^0 's.
- NO photos from this period at all! What does this imply?

Fermi Fellow, U Chicago 1974-76

- Production of mu- pairs by pions and protons – E 331 at Fermilab. (Jim Pilcher's talk.)
 - ▶ J/Psi production spectrum
 - ▶ Contribution of mu pairs to the single prompt muon spectrum
 - ▶ Observation of the Drell-Yan process

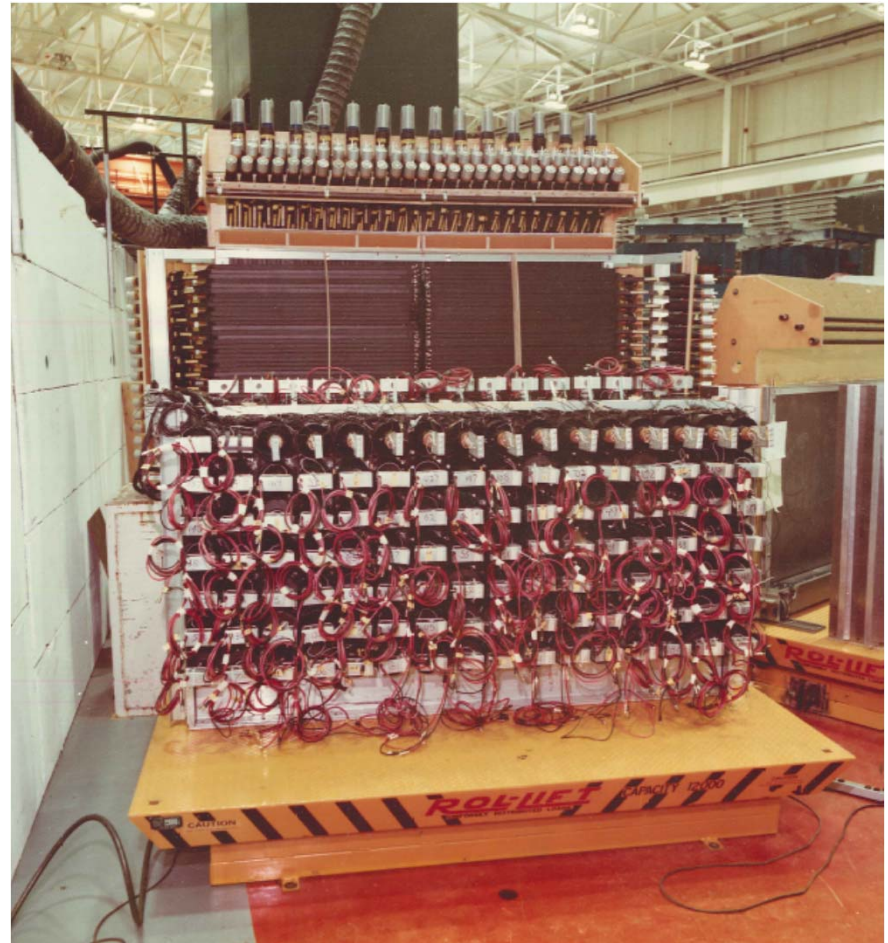


To Princeton in 1976: mu-pair physics continues (JEP, CB and SP will describe)

- E-444: Comprehensive study of hadronic mu-pairs
 - ▶ Search for higher-mass vector mesons beyond the J/psi and Psi-prime
 - ▶ Clear confirmation that mu pairs with $M > 4 \text{ GeV}$ were produced by the Drell Yan mechanism.
 - ▶ Structure function measurements for pions, protons and kaons.
 - ▶ Hint of higher-twist effects at high $x = p_{\parallel} / p_{beam}$.
- E-615: high-precision measurement of structure functions, emphasizing high x and higher twist.

BNL E 732: Search for the η_c at the AGS (1979-82)

- $\pi^- A \rightarrow \eta_c + X$
 $\quad \quad \quad \downarrow$
 $\quad \quad \quad \gamma\gamma$
- This experiment introduced Kirk to BNL and to the Kycia-Littenberg group.



Princeton HEP Group ~1984



High-field QED → Matter from Light (SLAC E 144 during the 1990's)

- Photons from high-power laser collide with high energy photons from SLAC 50-GeV electron beam to produce $e^+ e^-$ pairs
- Created a popular-science sensation – subject of Adrian's talk.



Kirk and B physics

- b quark discovered in 1977 at Fermilab, studied systematically at Cornell and DESY for 20 years.
 - ▶ B lifetime found to be “long” (1.5 ps), and $B^0 - \bar{B}^0$ mixing observed .
 - ▶ Potentially large CP Asymmetries (0.5 vs 0.002).
 - **Alas, not measurable at available accelerators.**
- In the late 80's Kirk and Changuo Lu at Princeton partnered with Nigel Lockyer and folks at Penn to spearhead an R&D effort toward a dedicated B physics experiment at the SSC, named BCD. Spawned R&D on CsI photocathodes. Alas, what might have been.....
- e+e- colliders, the “B Factories,” came on line in 1999 at Stanford and in Tsukuba Japan, tuned to $E_{cm} = 10.53$ GeV
 - ▶ Main goal -- to discover and characterise CP violation.
 - ▶ To do this, they needed ~100 times as much “luminosity” as produced by previous accelerators
 - ▶ Even more challenging, the beams had to have different energies.

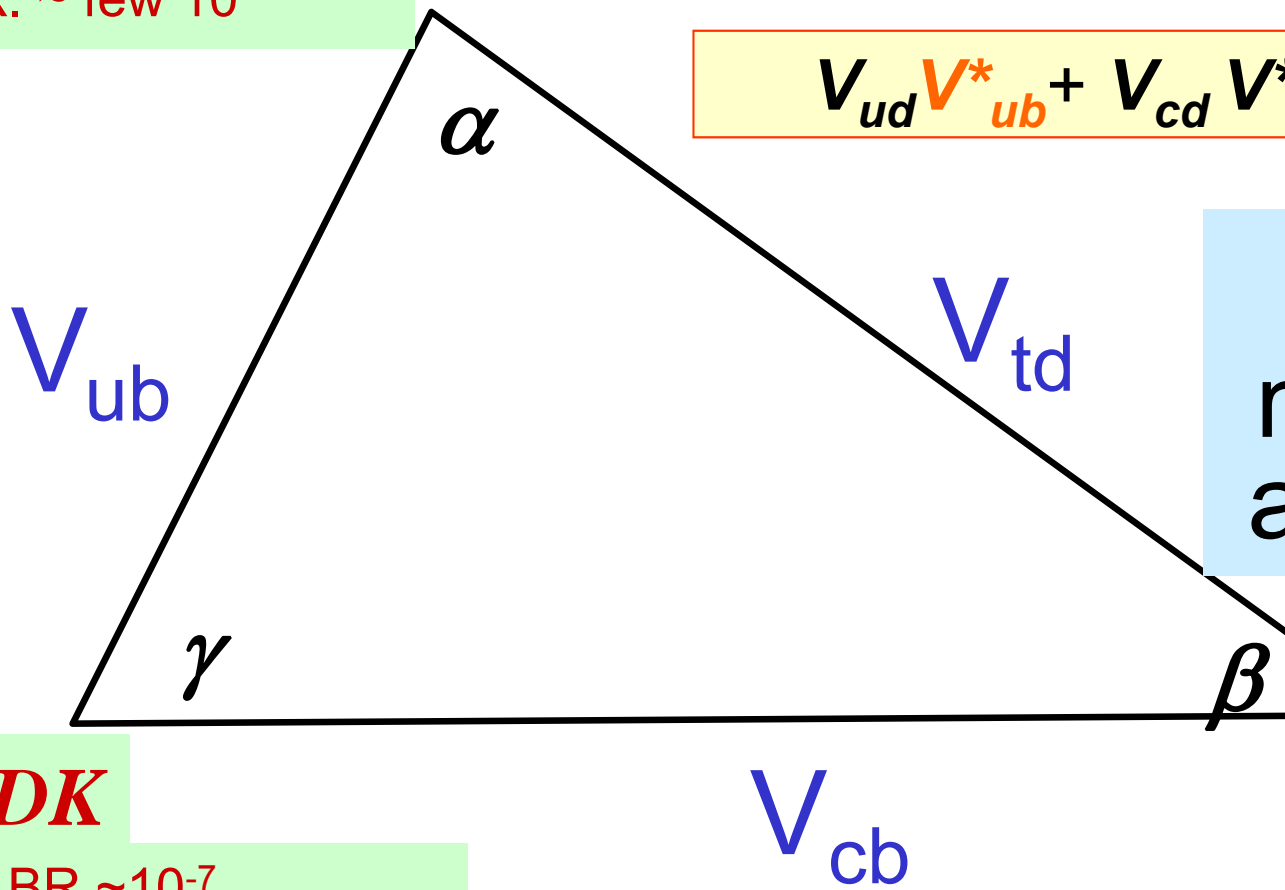
Measuring CKM angles in the B^0_d system

$$V_{\text{CKM}} = \begin{bmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{bmatrix}$$

$B^0 \rightarrow \pi\pi, \rho\rho, \rho\pi, a^0\pi$

B.R. \sim few 10^{-6}

$$V_{ud}V_{ub}^* + V_{cd}V_{cb}^* + V_{td}V_{tb}^* = 0$$



$\sim 500 \text{ fb}^{-1}$
needed for
a first pass

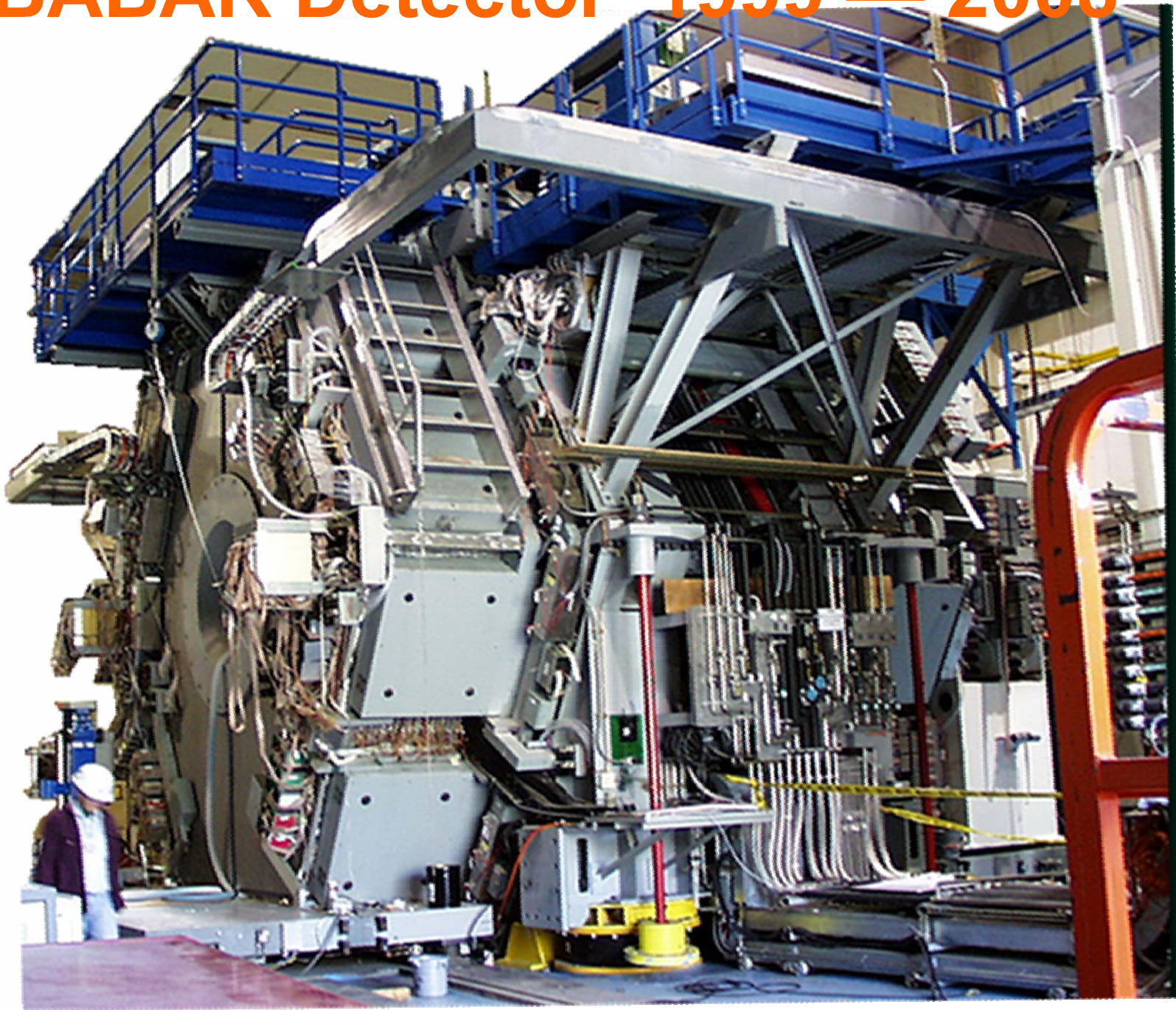
$B^0 \rightarrow DK$

Useful BR $\sim 10^{-7}$
Tough!!

$B^0 \rightarrow J/\psi K^0_S$
very clean,
Eff B.R. $\sim 10^{-4}$

BABAR Detector 1999 — 2008

■



Kirk and BaBar

- Founding member in 1993-4
- Member, original executive board
- Contributed in every possible way to all phases of the BaBar drift chamber project
 - Cell design, response to stresses
 - Destructive testing!!
 - End plates and wire were two of the biggest challenges – we took them on.
 - Tension measurements – Kirk figured out that Madam Wu's solenoid coils were perfect.
- Once Drift Chamber problems had been solved, Kirk's interests changed to accelerator physics.

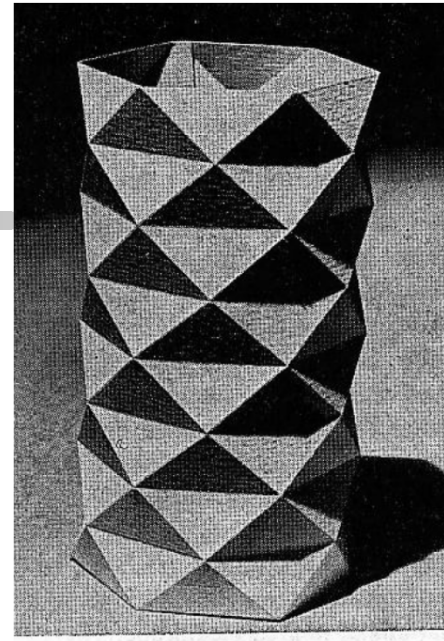
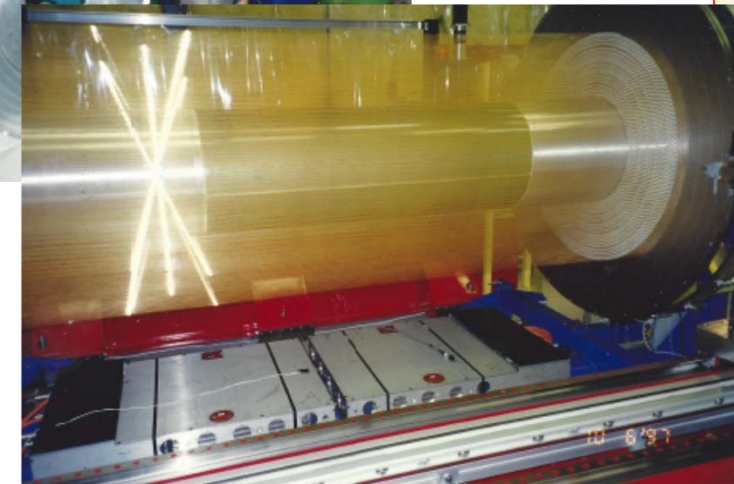


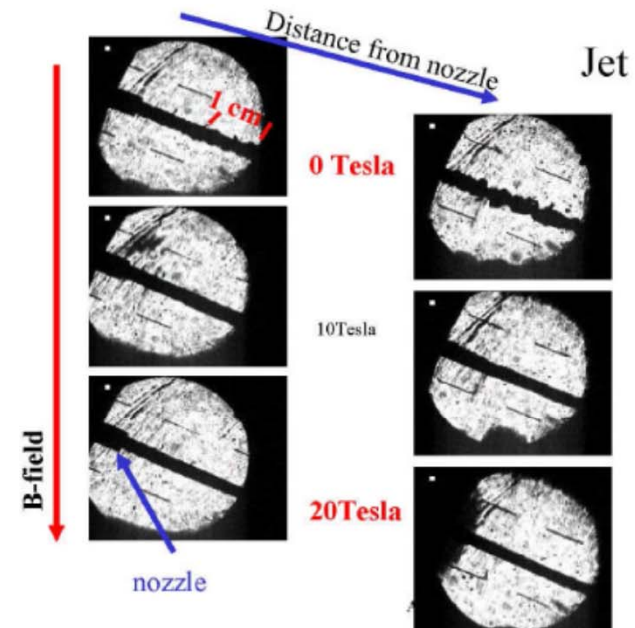
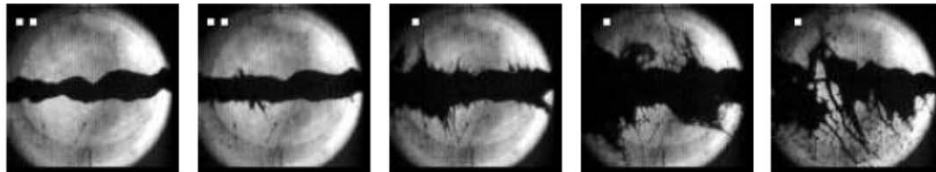
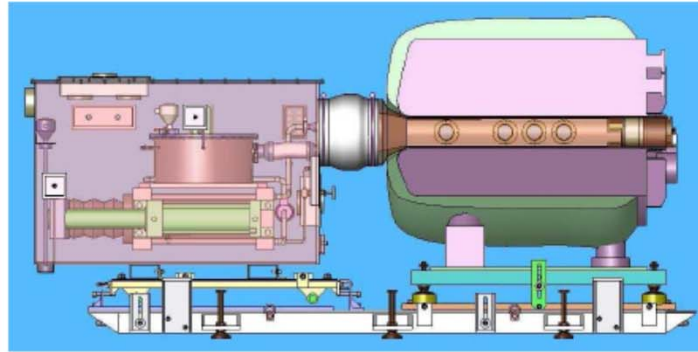
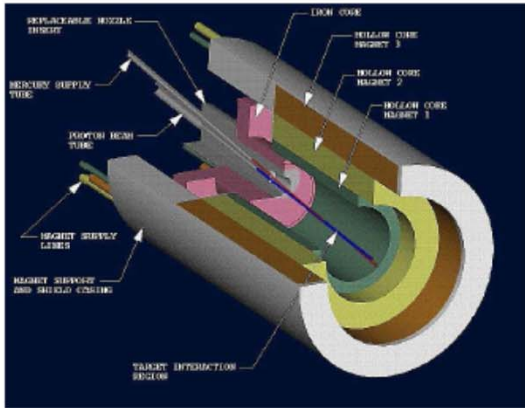
Fig. 2.6. The Yoshimura-pattern



Kirk and Accelerator Physics

- SLAC E-144 sparked his interest, with Dave Burke *et al.*
- Long-term focus on muon colliders and neutrino factories
 - ▶ Muon capture and transport systems
 - ▶ R&D and construction of mercury-jet targets
 - ▶ Subject of Bob Palmer's talk
- SLAC E-166: Linear Collider R&D – polarized positrons from an undulator-based source

MERIT Experiment Review



K.T. McDonald

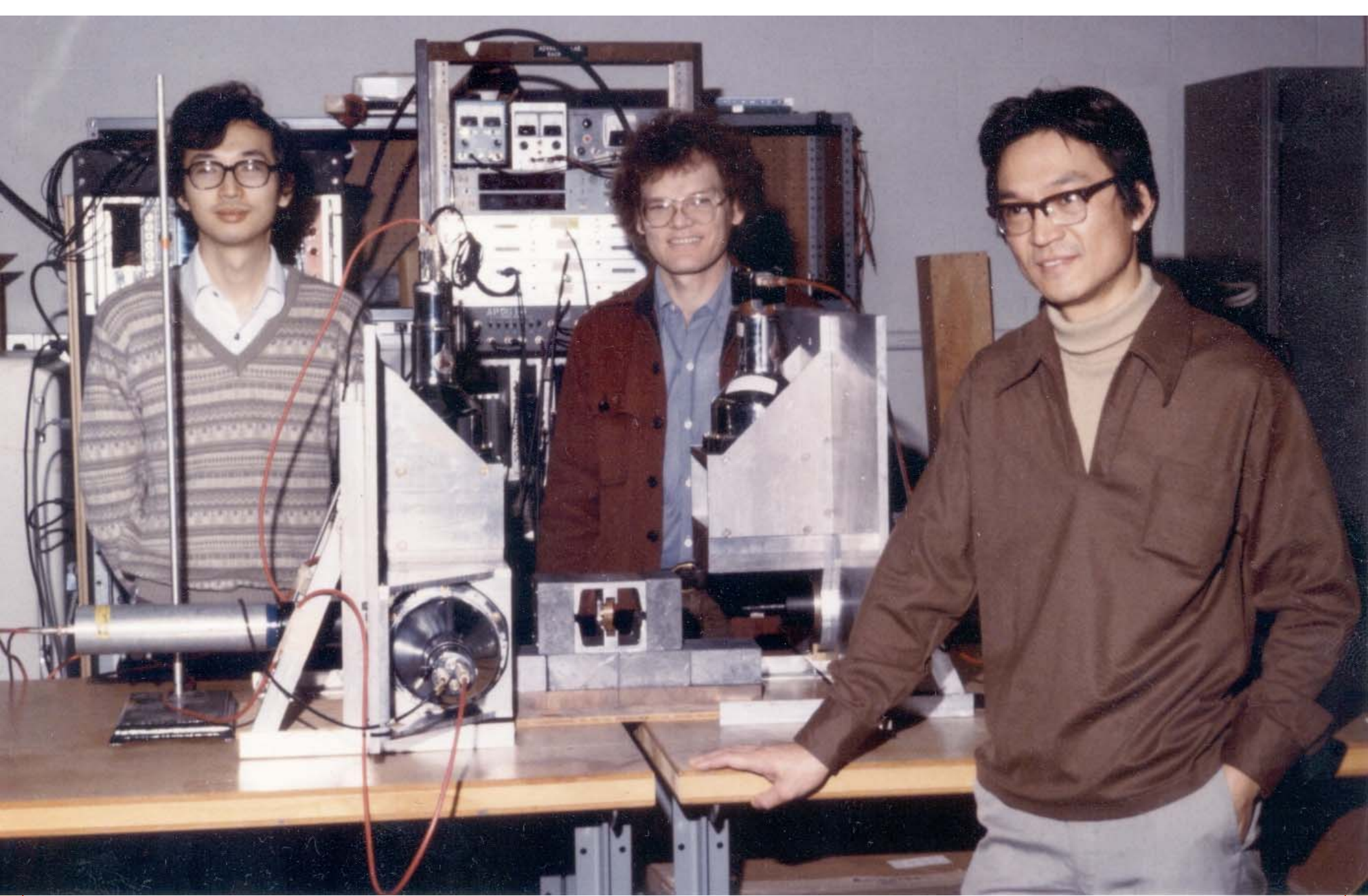
Princeton U.

Dec 12, 2005

<http://puhep1.princeton.edu/mumu/target/>

Kirk and Changguo Lu

- T D Lee called us in 1979 to propose that we host two Chinese scientists after the cultural revolution. Kirk and I excitedly accepted – Ye Ming Han and Lu Changguo arrived in December. They worked with us on E-732 at Brookhaven, and Lu soon became umbilically connected with Kirk. They have been partners ever since to the great benefit of all the experiments they have worked on.
- Perhaps the most outstanding Kirk-Lu collaboration was on the Daya Bay experiment, where Lu not only contributed to the detector, especially the RPC system, but also helped enormously as a liason to IHEP scientists.



Yoshihisa Kitazawa, KTM, Changguo Lu, 1981 (Test of Bell's Inequality in $e^+e^- \rightarrow \gamma\gamma$)



Changuo Lu, KTM, Mulberry St, Princeton, ~ 1981,
after a midnight bluefish expedition with John Gomany

Kirk as a Scholar and Teacher

Kirk's publication list says it best

<http://physics.princeton.edu/~mcdonald/tex/bib.pdf>

Thanks so much, Kirk, for everything you've done for Princeton, for science, and for all of your colleagues and friends over more than 40 years.

Let me close by asking everyone to join me in wishing Kirk and Nancy all the best.