I. PROJECT 1

BACKGAMMON: A scheme for Compton Backscattered Photoproduction at the Linear Collider

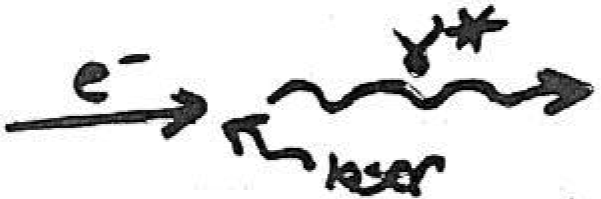
Sekazi Mtingwa
M.I.T.
North Carolina A&T

&

Mark Strikman
Ted Rogers

Penn State

I. Introduction

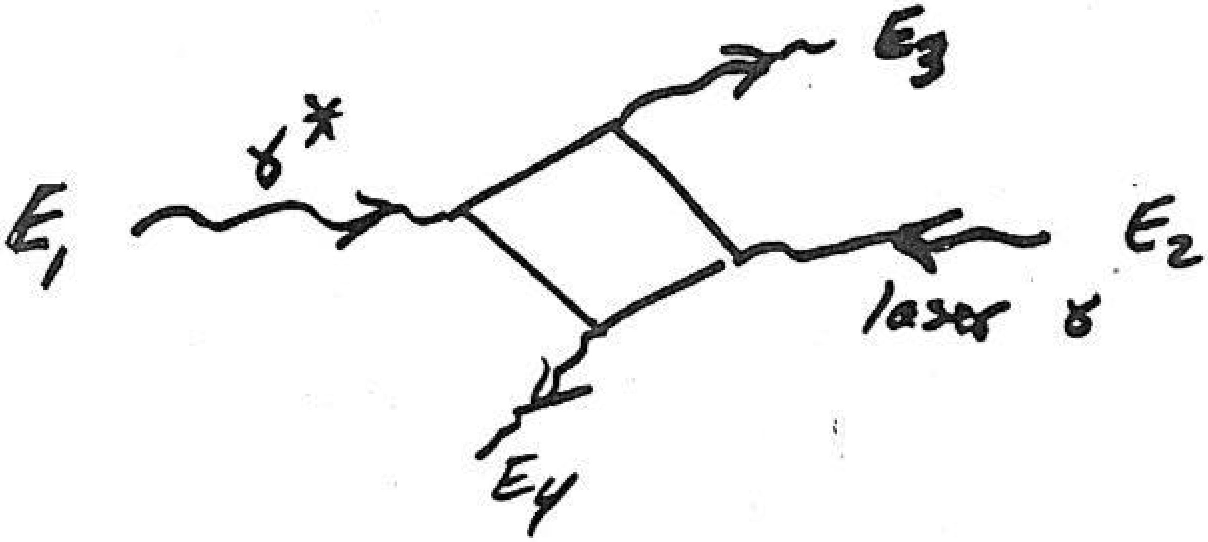


Using Compton backscattering to produce hot photons has been studied for some time.

R. Milburn, Phys. Rev. Lett 10, 75 (1963)
C. Akerlof, UM HE 81-59 (1981)
I. Ginzburg et al., NIM 205, 47 (1983)
F. Arutyunian & V. Tumanian, Phys. Lett 4, 176 (1963

Detailed discussion of polarization effects can be found in
I. Ginzburg et al., NIM 219, 5 (1984)

Using CB γ^* on laser γ to test higher order QED $\gamma\gamma$ scattering has been proposed by several



Y. Harutyunian et al., Phys. Lett, 6, 175('63)

K. Mikaelian, Phys. Lett, 115B, 267('82)

Proposes to detect $\gamma\gamma$ at SLAC
19.5 GeV γ^* on 4.66 eV laser γ

J. Ballam et al., Phys. Rev. Lett, 23, 498 (1969)

Nearly monochromatic high energy photon beam produced by CB of ruby laser was used to study photoproduction in hydrogen bubble chamber at SLAC.

Hadronic γp cross sections were measured.

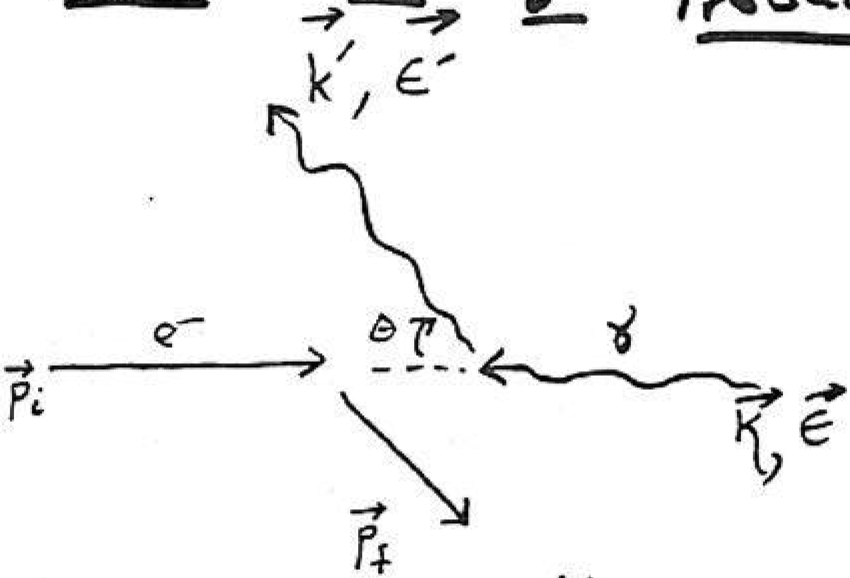
B Factory via γ Conversion

Sekazi Mtingwa
ANL, Leningrad Nucl. Phys., Yerevan Phys.
and
Mark Strikman
Leningrad Nuclear Phys. Inst.

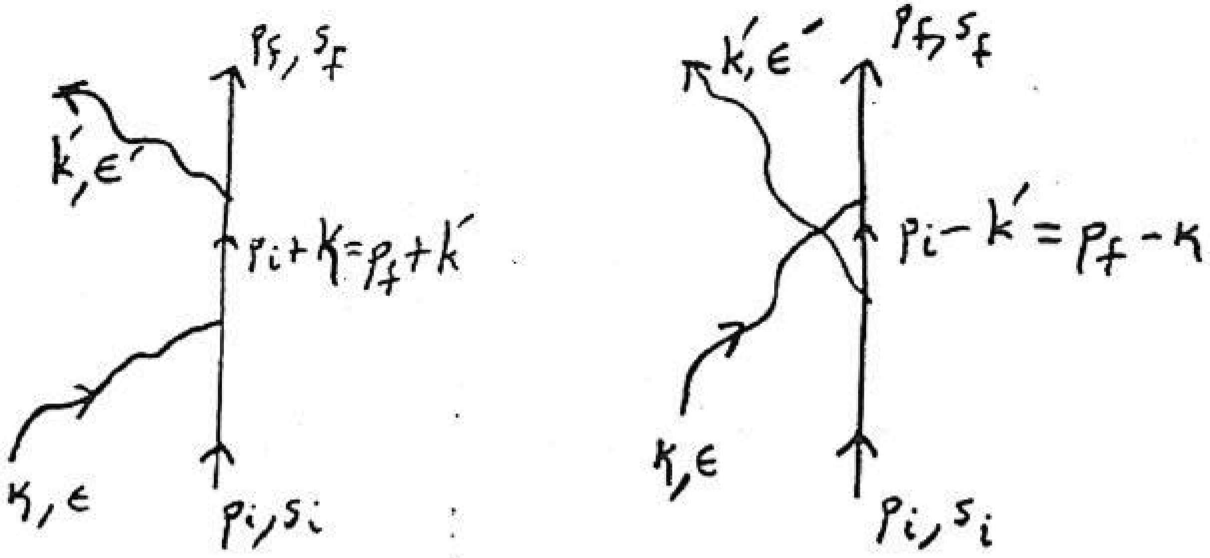
Published in Phys. Rev. Lett
64, 1522 (1990)

Particles & Fields 1991 Conf
Vancouver, B. C.

IV. Rate of γ^* Production



Compton Scattering



Feynman Graphs

for $\frac{dN^{\gamma^*}}{d\Omega dt} = f\left(\epsilon_H, \epsilon_V, \eta_{H,V}, \beta_{H,V}, \eta'_{H,V}, \beta'_{H,V}\right)$

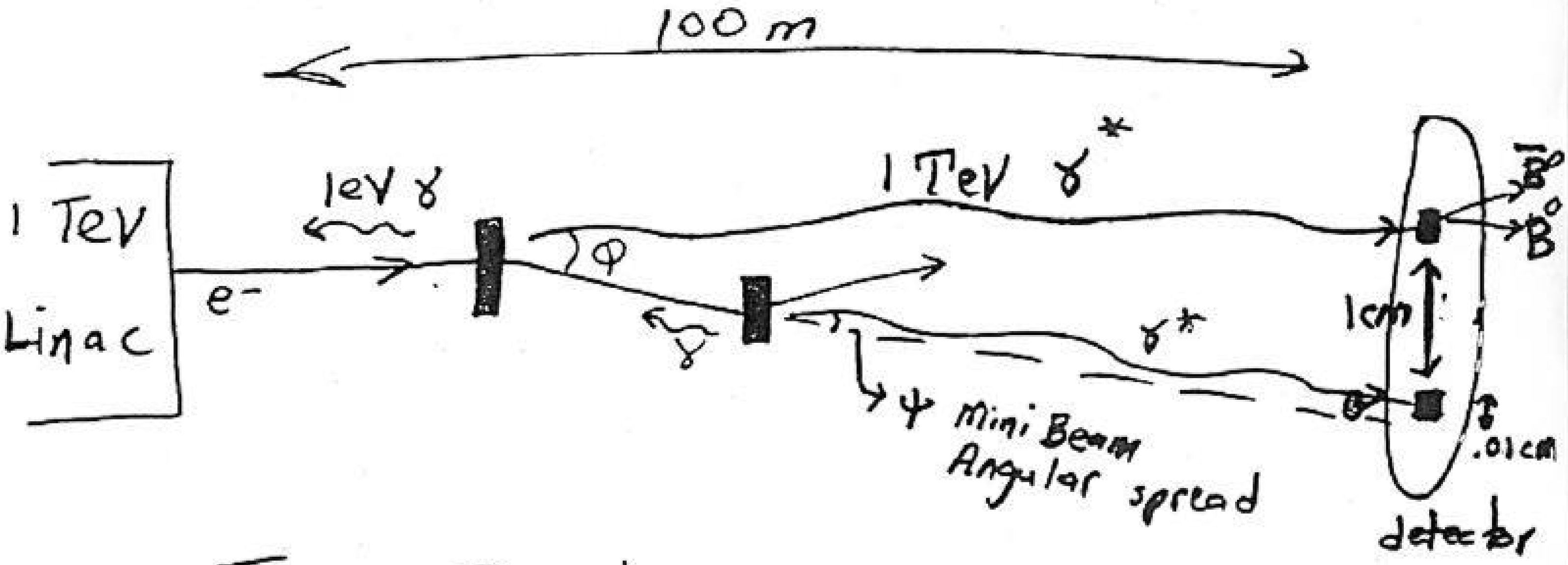
Interaction of lasers with strong-focussing accelerators.

BACK GAMMON

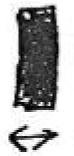
BACKscattered GAMMas
On Nucleons

$b\bar{b}$ Photoproduction

Phys. Rev. Lett. 64, 1572(1990)



Trim Dipole



$B = 1.6\,T$

$l = 20\,cm$

φ ~ Mini Beam Angular Separation

ψ ~ Angular spread of Minibeam

$\varphi \sim 10^{-4} - 10^{-5}$

$\psi \sim m_e/E_e \sim 10^{-6} - 10^{-7}$

γ^* scattered in transverse plane of detector.

I. Needed: $10^8 - 10^9$ $B\bar{B}$'s /year to study

(i) rare B decays

(ii) CP Violation

~100 lasers & trim dipoles are used.

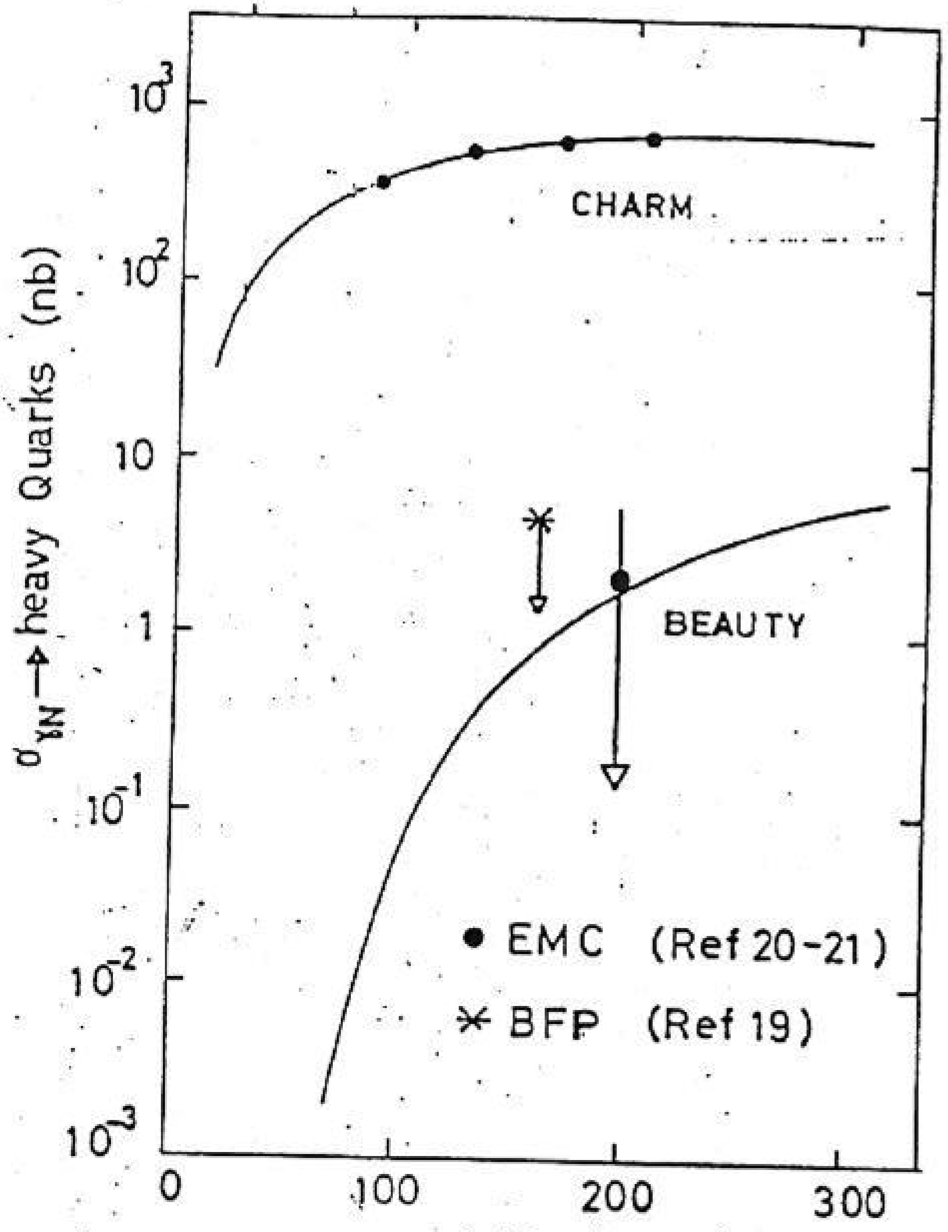


Figure 2

Cross section of B$\bar{B}$ pair photoproduction versus ν. Also shown are the data of the EMC for C$\bar{C}$ pairs. The curves represent the prediction of the γ-g fusion model (leading order, m_c = 1.5 and m_b = 5 GeV).

Comparison with FNAL Wideband Photon Beam Exp. FOCUS

	FOCUS	BACKGAMMON
Rep Rate	1/60 sec	10 kHz
γ^*/cycle	$\sim 10^8$	$\sim 10^8$
Seconds/yr	$\sim 10^7$	$\sim 10^7$
Target int. length	10%	10%
Hadronic/e^+e^-	10^{-3}	10^{-3}
B.R. to $b\bar{b}$	2×10^{-5}	2×10^{-5}
$b\bar{b}$/yr	$\sim 10^4$	$\sim 10^{10}$

Based upon trading 100 minibeams
with 1 hot beam
in BACKGAMMON

Possibility for τ Physics

BACKGAMMON can operate as τ Factory

See S. Mtingwa & M. Strikman in "Rare and Exclusive B & K Decays in Novel Flavor Factories" AIP Conf. Proc. 261, 236 ('92)

Using well-known

$$\sigma_{\ell^+\ell^-} = \frac{28}{9} Z^2 \alpha r_\ell^2 \left[\ln \frac{2\omega}{m_\ell} - \frac{109}{42} \right]$$

$$\Rightarrow \quad N_{\tau^+\tau^-} \sim 10^9 / \text{yr}$$

at $\omega = 250$ GeV

Compare with τ-charm Factories

$\mathcal{L} \sim 10^{33}\ \mathrm{cm}^{-2}\mathrm{s}^{-1}$

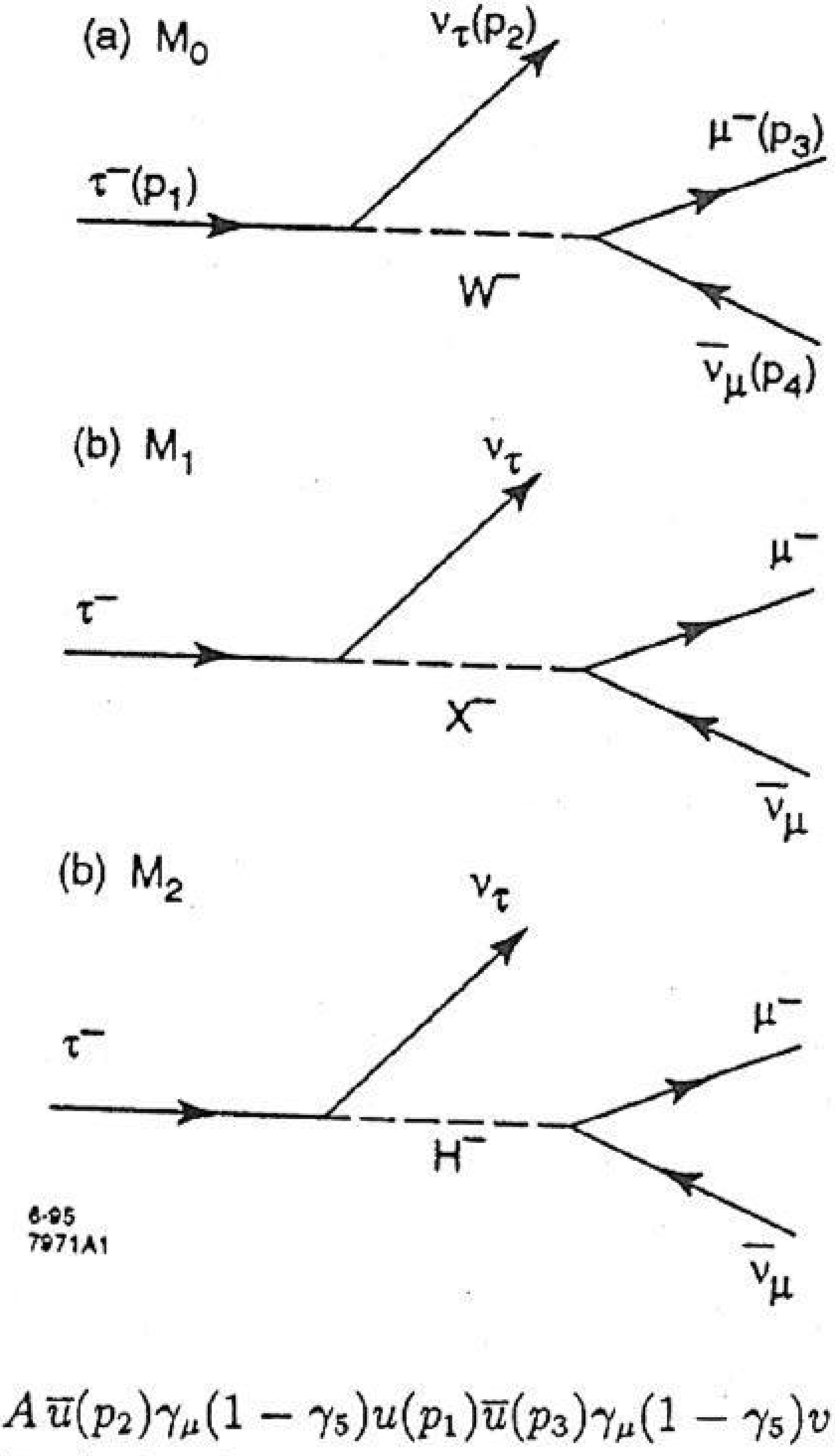
$\Rightarrow \sim 10^{7}\ \tau^{+}\tau^{-}/\mathrm{yr}$

Physics Issues

- Improve on ν_τ-mass limits from such decays as
  $\tau^- \rightarrow K^- K^+ \pi^- \nu_\tau$

- Search for CP violation in lepton sector of Standard Model (SM)

See Y. S. Tsai in Workshop on τcF (1995) at Argonne



$$
\begin{aligned}
M_0 &= A\,\overline{u}(p_2)\gamma_\mu(1-\gamma_5)u(p_1)\overline{u}(p_3)\gamma_\mu(1-\gamma_5)v(p_4)\ , \\
M_1 &= B\,\overline{u}(p_2)\gamma_\mu(1-\gamma_5)u(p_1)\overline{u}(p_3)\gamma_\mu(1-\gamma_5)v(p_4)\ , \\
M_2 &= C\,\overline{u}(p_2)(1+\gamma_5)u(p_1)\overline{u}(p_3)(1-\gamma_5)v(p_4)\ ,
\end{aligned}
$$

Compute ω_{3y} for μ^-

$$(M_0+M_1+M_2)^+(M_0+M_1+M_2) \approx A^2\mathcal{M}_0^+\mathcal{M}_0+iA\,\mathrm{Im}\,C\left(\mathcal{M}_0^+\mathcal{M}_2-\mathcal{M}_2^+\mathcal{M}_0\right)$$

$$w_{3y} = \frac{\begin{array}{c} i\,\mathrm{Im}\,C\int\left[(\mathcal{M}_0^+\mathcal{M}_2-\mathcal{M}_2^+\mathcal{M}_0)_{s=\hat{e}_y}-(\mathcal{M}_0^+\mathcal{M}_2-\mathcal{M}_2^+\mathcal{M}_0)_{s=-\hat{e}_y}\right] \\ \times\frac{d^3p_2}{2E_2}\,\frac{d^3p_4}{2E_4}\,\delta^4(p_1-p_2-p_3-p_4)\end{array}}{A\int\sum_{\text{Spin of }\mu}(\mathcal{M}_0^+\mathcal{M}_0)\,\frac{d^3p_2}{2E_2}\,\frac{d^3p_4}{2E_4}\,\delta^4(p_1-p_2-p_3-p_4)}\,.$$

$$w_{3y} = \frac{-(\overrightarrow{w}\times\overrightarrow{p}_3)_y}{8E_3}\,\frac{\left[3M-4E_3+\frac{m^2}{M}\right]\,\mathrm{Im}\,(C/A)}{3M-4E_3-\frac{2m^2}{E_3}+\frac{3m^2}{M}+(\overrightarrow{w}\cdot\overrightarrow{p}_3)\left(\frac{M}{E_3}-4+\frac{3m^2}{ME_3}\right)}$$

$\omega_{3y} \neq 0 \Rightarrow$ CP violation

- Search for rare + forbidden decays of τ

- Study Lorentz structure of τ decays

See A. Pich in Argonne Workshop on τcF (1995)

Let us consider the leptonic decays $l^- \to \nu_l l'^- \bar{\nu}_{l'}$, where the lepton pair (l, l') may be (μ, e), (τ, e), or (τ, μ). The most general, local, derivative-free, lepton number conserving, four-lepton interaction Hamiltonian, consistent with loca ity and Lorentz invariance

$$\mathcal{H} = 4\frac{G_{l'l}}{\sqrt{2}} \sum_{\epsilon,\omega=R,L}^{n=S,V,T} g^n_{l'_\epsilon l_\omega} \left[\overline{l'_\epsilon}\Gamma^n(\nu_{l'})_\sigma\right] \left[\overline{(\nu_l)_\lambda}\Gamma_n l_\omega\right] ,$$

$$\frac{d^2\Gamma}{dx\, d\cos\theta} = \frac{m_l\omega^4}{2\pi^3} G^2_{l'l}\sqrt{x^2 - x_0^2}\left\{x(1-x) + \frac{2}{9}\rho\left(4x^2 - 3x - x_0^2\right) + \eta\, x_0(1-x) \right.$$
$$\left. -\frac{1}{3}\mathcal{P}_l\,\xi\,\sqrt{x^2 - x_0^2}\cos\theta\left[1 - x + \frac{2}{3}\delta\left(4x - 4 + \sqrt{1 - x_0^2}\right)\right]\right\},$$

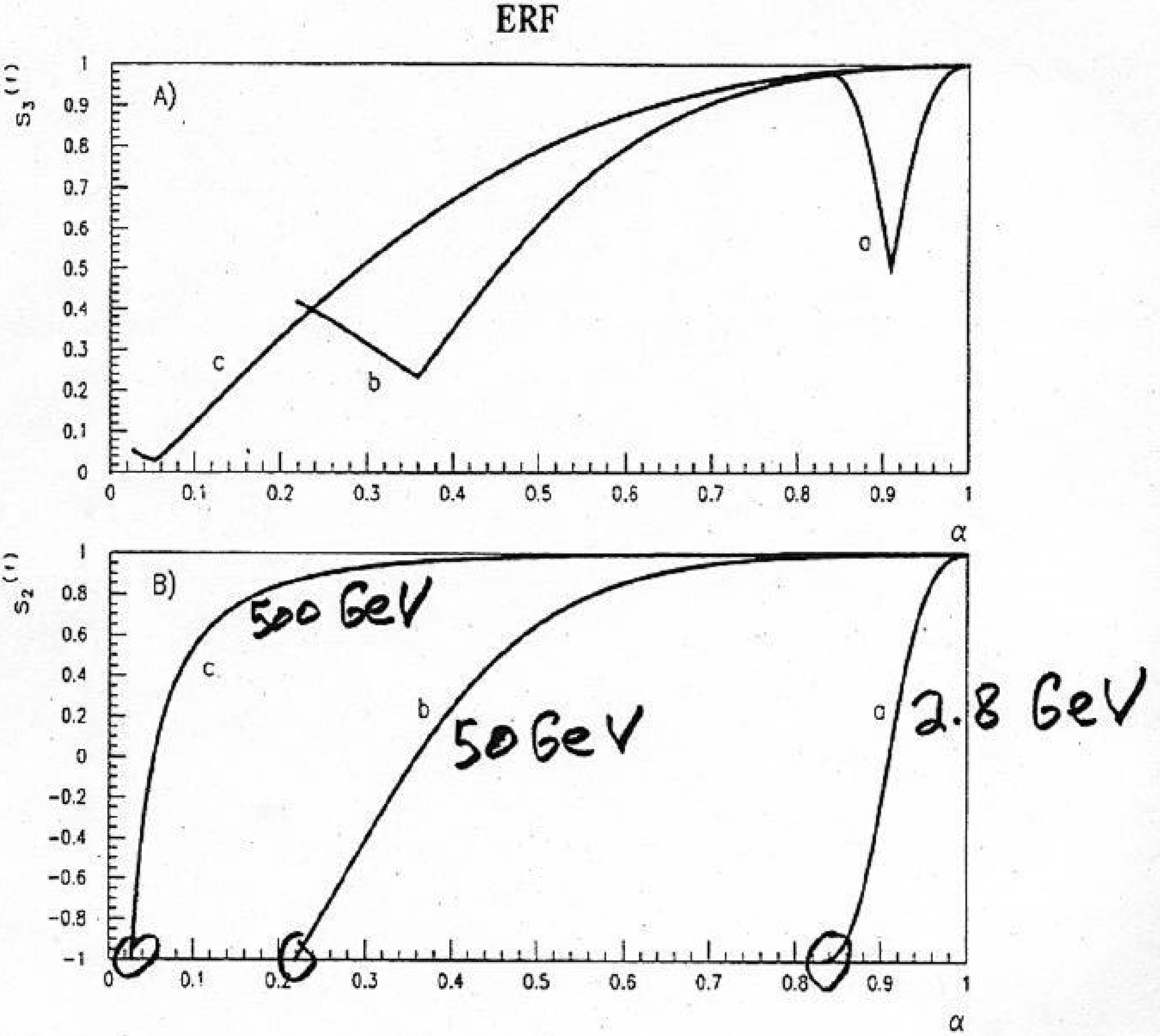
where θ is the angle between the l^- spin and the final charged-lepton momentum, $\omega \equiv (m_l^2 + m_{l'}^2)/2m_l$ is the maximum l'^- energy for massless neutrinos, $x \equiv E_{l'^-}/\omega$ is the reduced energy and $x_0 \equiv m_{l'}/\omega$. For unpolarized l's, the distribution is characterized by the so-called Michel [17] parameter ρ and the low-energy parameter η. Two more parameters, ξ and δ can be determined when the initial lepton polarization is known. If the polarization of the final charged lepton is also measured, 5 additional independent parameters [3] (ξ', ξ'', η'', α', β') appear.

from A. Pich

Polarization information is important.

Brookhaven Parameters

$\lambda_{laser} = 266 nm\ (4.66\ eV) \} E_{e^-} = 2.8 GeV$



g. 1. ϕ-averaged Stokes parameters of the final photon as function of $\alpha = \nu'/\nu'_{max}$ in the ERF-system: A) $s_3^{(f)}$ for linearly polarize ident photon $s^{(i)} = (0,0,1)$; B) $s_2^{(f)}$ for circularly polarized incident photon $s^{(i)} = (0,1,0)$. The curves in each figure refer to thre ferent values of the electron energy in the LAB-system: *a*) = 2.8 GeV; *b*) = 50 GeV; *c*) = 500 GeV.

For $\theta = \pi$

E_{e^-}	α
2.8 GeV	0.833
50 GeV	0.22
500 GeV	0.03

19

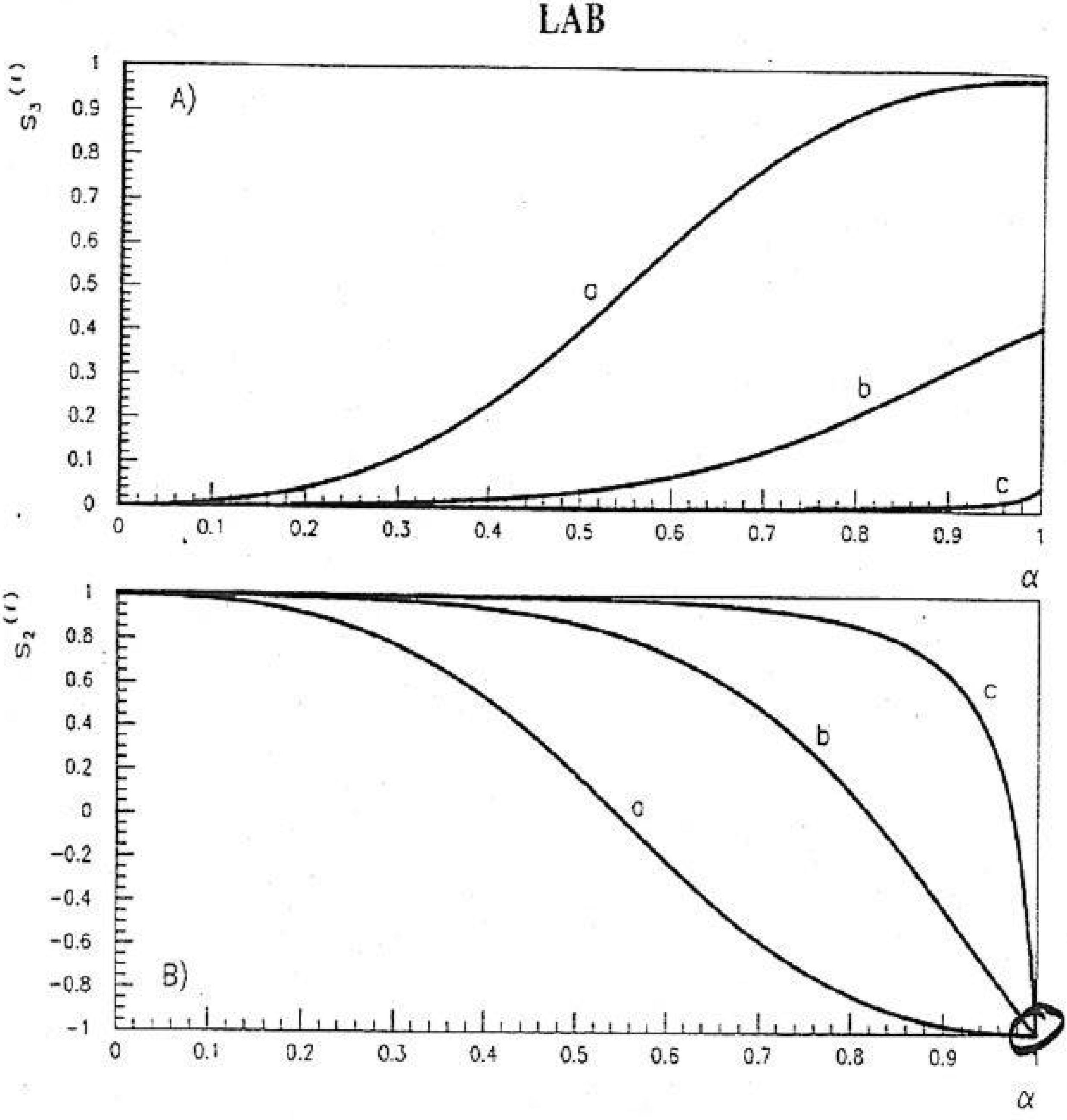


Fig. 2. The same as Fig. 1 in the LAB-system.

$\theta = \pi \Rightarrow \alpha = 1$

Using $\gamma_{CP}^{\text{Backsc.}}$, should be able to photoproduce polarized τ's.

See analysis by

Y. S. Tsai, PR D48, 96 ('93)

for

$\gamma + Z \rightarrow e^{+} e^{-} + \cdots$

Conclusions

- BACKGAMMON produces
  $\gtrsim 10^{10}\ B\bar{B}/\text{yr}$

  $\gtrsim 10^{9}\ \tau^{+}\tau^{-}/\text{yr}$
- Should yield good results for
  CP violation in B decay
  CP violation in τ decay
  Rare B, τ decays
  Mass limits on ν_τ
  Lorentz structure for τ decay
- Tune up for γ-γ Colliders
- Can do proton spin physics

Tasks

- Form Working Group
  - Ex-FOCUS members
  - Strikman's Student studying τ polarization vs θ
  - DESY
  - Hampton
  - Colorado
  - NCA&T
- Characterize Spent Beam Quality
- Design beamline to e-γ IP
- Laser technology

  Time multiplex?
- Detector design

  Lots of experience from FOCUS
- Theory $\begin{cases} c\bar{c} \quad \tau^+\tau^- \\ b\bar{b} \\ \text{Spin of Proton} \end{cases}$

II PROJECT 2 : S. Mtingwa

Damping Rings + IBS

- Could be major headache
- Ultimately IBS will be a major factor

[IBS rumored to be at the source of FNAL difficulties.]

- Present generation of machines coming online really challenging Mr. Coulomb
- For ATF, ALS, upcoming work at Cornell, disentangling IBS from other effects will be a challenge

(From Marc Ross)

$\varepsilon_{N,H}$ coming out of the damping ring is 3 mm-mrad & $\varepsilon_{N,V}$ two orders of magnitude smaller, with 10^{10} particles per bunch. Some of most urgent issues to untangle from IBS:

1. Electron cloud build-up that could limit the performance of the positron damping, and specifically taking into account effect of magnetic field of wiggler. High Priority

2. Residual gas ionization caused by the passage of a bunch train that could lead to tune spread and coherent betatron oscillations towards the end of the bunch train. High Priority

3. Injection efficiency of the damping rings, which have limited momentum acceptance. Need to improve both the dynamic aperture and p acceptance of the. High/Medium Priority

4. Interaction of beam with radiation in damping ring, leading to such effects as coherent synchrotron radiation and particle loss due to scatterings. MP

5. Injection of a new pulse train leading to the emittance growth of stored trains. This could be caused by wake field effects or the feedback system that damps injection transients. MP