τ-c COLLIDER - PROPERTIES - PROSPECTS

SLAC - MAR 6-9 '99

INTRO.

- τ-cF HISTORY > DECADE → many interesting ideas. WILL NOT REVIEW DEVT.

- MOST new IDEAS INCORP. IN "REFERENCE DESIGN" of 1996 = "BTCF FEASIBILITY STUDY"

- THIS REVIEW BASED ON '96 STUDY: IF START TODAY ?? "DREAMS" OF FUTURE ??

BASICS

- e^+e^- SR COLLIDER : VERY E SPECIFIC (RADIATION) → E_{opt}, $E(\hat{L})$ - Ref. Des. - ~2 GeV / bm. [atten' paid to 1.5 GeV oper as well] $\hat{E} \approx 2.5$

- $\mathcal{L} \propto \frac{\xi \cdot E \cdot I}{\beta^*}$; E (specified), ξ ("constant" of Nat.)

  β* (technology, physics constr - some variability)

  $I = k N_b e f_0$; N_b limited, f_0 heavy constraints,

  → go for big k (# bunches)

- BIG k → small S_{B} → fast separation at IP to avoid sacrifice ξ uselessly → separate rings → constrained IR

REF. DES.

- ≥2 MODES, e.g. Hi $\mathcal{L}$, $\vec{n}$, mono...
  CONDENSE TO 2': (Hi $\mathcal{L}$, $\vec{n}$, 2GeV); (+ mono, 1.55GeV)

- See Layouts
  - ✓ 2 RINGS (2)
  - ✓ IR (3)

- Hi $\mathcal{L}$, $\vec{n}$ (See Param List)
  (X-$\mathcal{L}$??)

- Monochromater - $D_y \rightarrow \Delta y_E \gg \Delta y_\beta$
  (See Param List) (X-$\mathcal{L}$??)

CHALLENGES IN IR - DETECTOR / ACC. INTERFACE peculiar to τ-cF (w.r.t. B-fac)

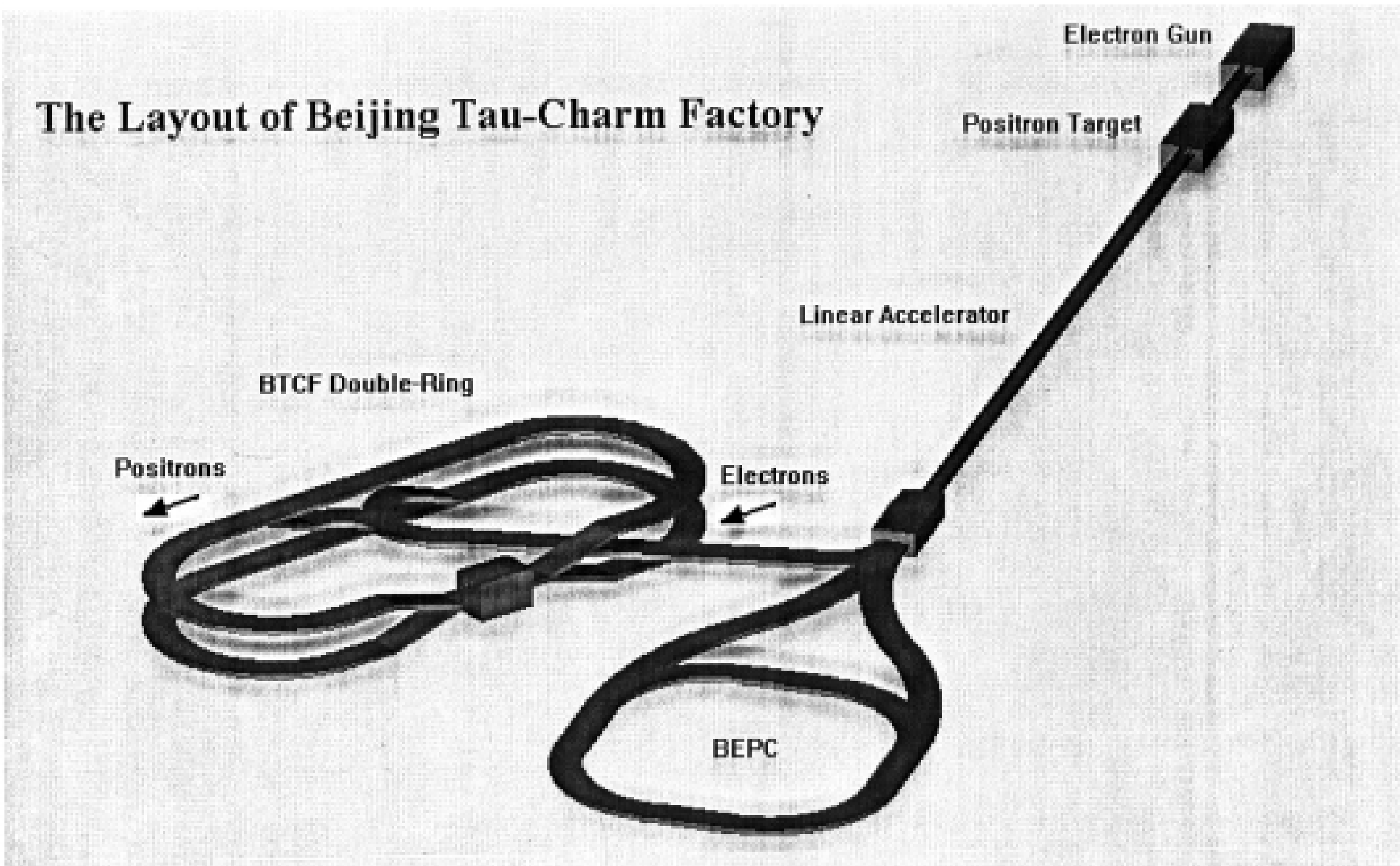
- ✓ Hi B-sol / Bp : compensation steals free sp.
- ✓ Pol'n adds some constraints (maybe not bad-v)
- ✓ SR less than B-fac
- ✓ BEAM-GAS (Brems + Coulomb) ≈ same [DETAILS]
- ✓ TOUSCHEK MUCH worse (STUDY ESSENTIAL!!)

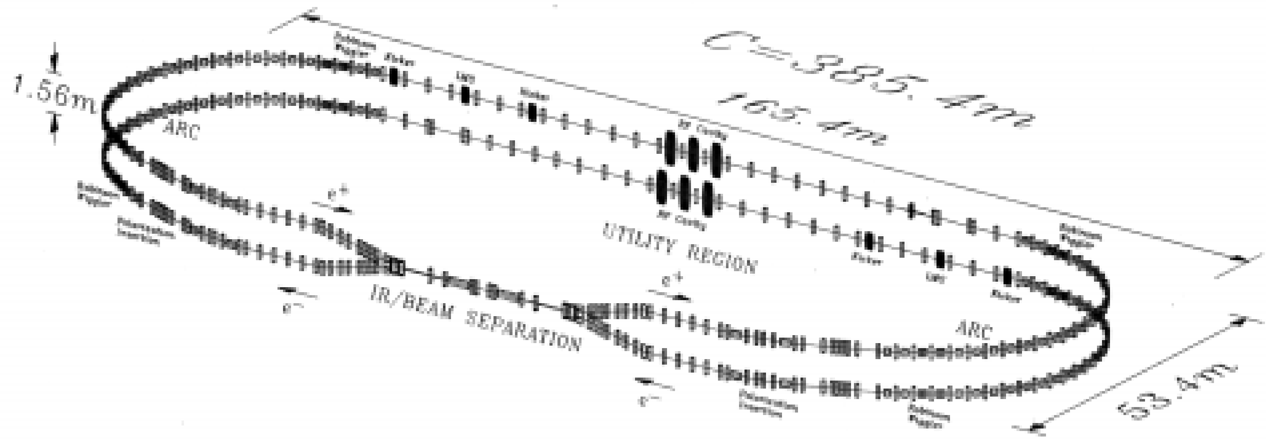
e.g. BTCF: $\tau_{TK} < \frac{1}{2}\,\tau_{BG}$ — gas can be pumped, Touschek trickier?

(See Prelim Bkgnd Calcs - Zhang Dehong)

THEN

(See POLARIZATION - Wang Dong's wk)

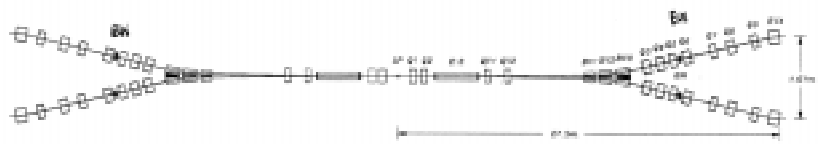

The Layout of Beijing Tau-Charm Factory
Electron Gun
Positron Target
Linear Accelerator
BTCF Double-Ring
Positrons
Electrons
BEPC


C=385.4m
165.4m
1.56m
ARC
e+
e−
UTILITY REGION
IR/BEAM SEPARATION
ARC
53.4m

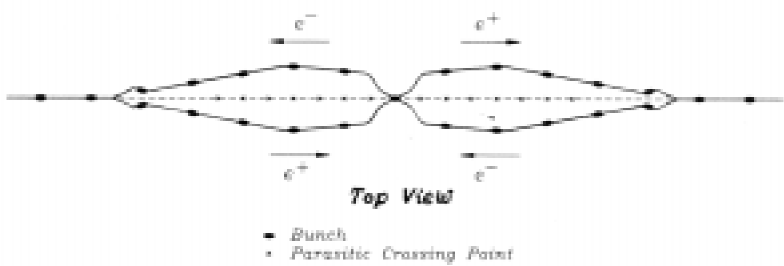
(3) Compatibility for Different Modes

a) The crossing angle collision optics

- The crossing angle by a pair of horizontal dipoles BHs.



Side View



Top View

- Main parameter choice

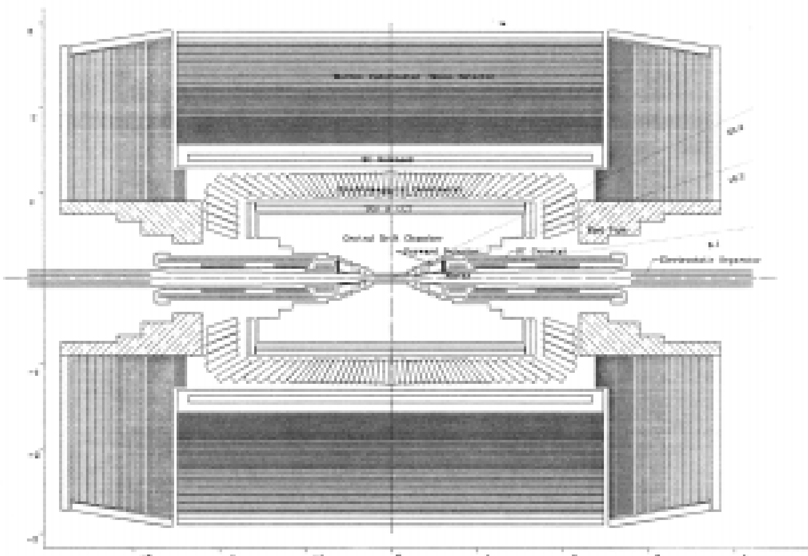
crossing angle	$2\phi_c = 2.6 \times 2$ mrad
bunch spacing	3.78 m
bunch number	86
natural emittance	ε_{x0}=140nmrad
beam current	570 mA
$\beta_x^* \ / \ \beta_y^*$	0.65 m / 0.01 m

(1) Interaction Region

a) Detector boundary conditions

- The accelerator components must fit within a conical space with an opening angle of 18.2°, and must be located beyond 0.6m from the IP.

- The superconducting solenoid of the detector has a field strength of 1.0 T over a distance of ±2.65 m around the IP.

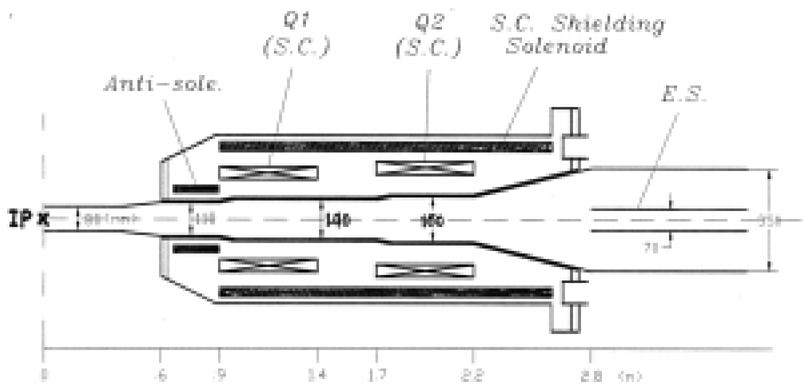


Schematic layout of the detector facilities and IR accelerator components

c) Compensation Solenoids and IR Aperture

- Anti-solenoid with -3.0 T, 0.3 m long to cancel the detector solenoid field between IP and Q1.

  Shielding solenoid to eliminate the detector solenoid field in the Q1, Q2 region.



Vacuum chamber and cryostat in the IR

- All the aperture in the IR are designed for a beam with at least 14σ in detector .

- The inside diameter of the vacuum chamber in IR is 80 mm at the IP, 140 mm at Q1 and 160 mm at Q2; the vacuum chamber with 0.8 m long at the IP will be made of pure beryllium.

Table 3.1 Machine parameters for high luminosity mode with a horizontal crossing angl

Beam energy E (GeV)	2.0
Circumference C (m)	385.447
Revolution frequency f_0 (MHz)	0.778
Crossing angle at IP $2\phi_c$ (mrad)	5.2
β-function at IP $\beta_x^*/\beta_y^*(m)$	0.65/0.01
Dispersion at IP D_x^*/D_y^* (m)	0.0 /0.0
Betatron tunes Q_x/Q_y	11.8/12.6
Momentum compaction α_p	0.014
Synch. rad. loss/turn U_0 (keV)	172
Damping time $\tau_x/\tau_y/\tau_\epsilon$ (ms)	30/30/15
Natural emittance ϵ_{x0} (nm)	153
Vertical emittance ϵ_y (nm)	2.3
Momentum spread σ_ϵ	5.84×10^{-4}
Synchrotron tune Q_s	0.068
Natural chromaticity Q'_x/Q'_y	-20/-36
Total current per beam I (A)	0.57
Number of bunches k_b	86
Particles per bunch $N_b(10^{11})$	0.54
RF frequency f_{rf} (MHz)	476
RF voltage V_{rf} (MV)	6.8
Natural bunch length σ_l (cm)	0.76
Beam-beam effect ξ_x/ξ_y	0.04/0.04
Luminosity L (cm^{-2}s^{-1})	1×10^{33}
CM energy spread σ_w (MeV)	1.7

Table 3.14 Machine parameters of the monochromator mode

Beam energy E (GeV)	1.55
Circumference C (m)	385.447
Revolution frequency f_0 (MHz)	0.778
Crossing angle at IP $2\phi_c$ (mrad)	0.0
β-function at IP β_x^*/β_y^* (m)	0.01/0.15
Dispersion at IP D_x^*/D_y^*(m)	0.0/0.35
Betatron tunes Q_x/Q_y	13.08/11.11
Momentum compaction α_p	0.0115
Synch. rad. loss/turn U_0 (keV)	71
Damping time $\tau_x/\tau_y/\tau_\epsilon$ (ms)	25/59/95 (with wig.)
Natural emittance ϵ_{x0} (nm)	48 (with wigglers, Jx=2.37)
Vertical emittance ϵ_y (nm)	4.0
Momentum spread σ_p	8.0×10^{-4}(with wigglers)
Synchrotron tune Q_s	0.057
Natural chromaticity Q'_x/Q'_y	-37/-29
Total current per beam I(A)	0.2
Number of bunches k_b	29
particle per bunch $N_b(10^{11})$	0.57
Bunch space S_b (m)	11.97
RF frequency f_{rf} (MHz)	476
RF voltage V_{rf} (MV)	4.4
Bunch length σ_l (cm)	1.0
Beam-Beam effect ξ_x/ξ_y	0.014/0.015
Beam life time τ (hrs)	$\geq$1
Luminosity L (cm^{-2}s^{-1})	1×10^{32}
CM energy spread σ_ω (MeV)	0.12

Table 3.15 Touschek lifetime of the monochromator mode

Energy acceptance 10^{-3}	Emittance x/y (nm)	Touschek lifetime hours
8	13/2	0.5
8	48/4	1.7
9	13/2	0.7
9	48/4	2.2

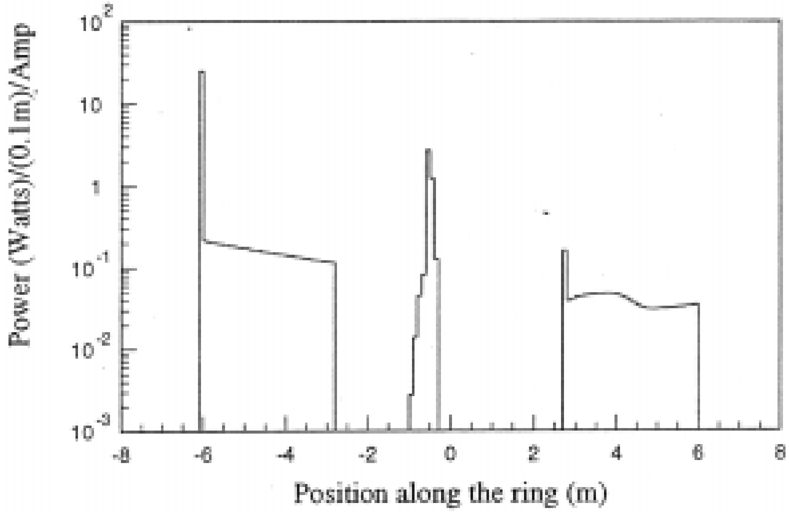
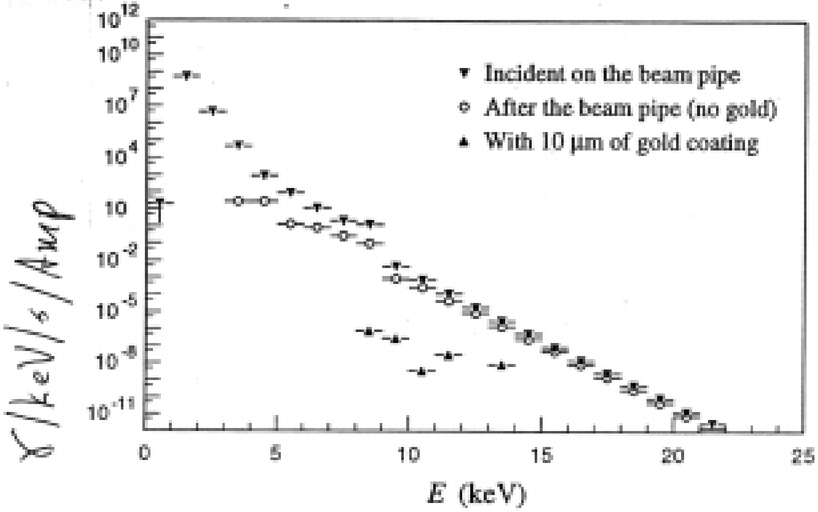
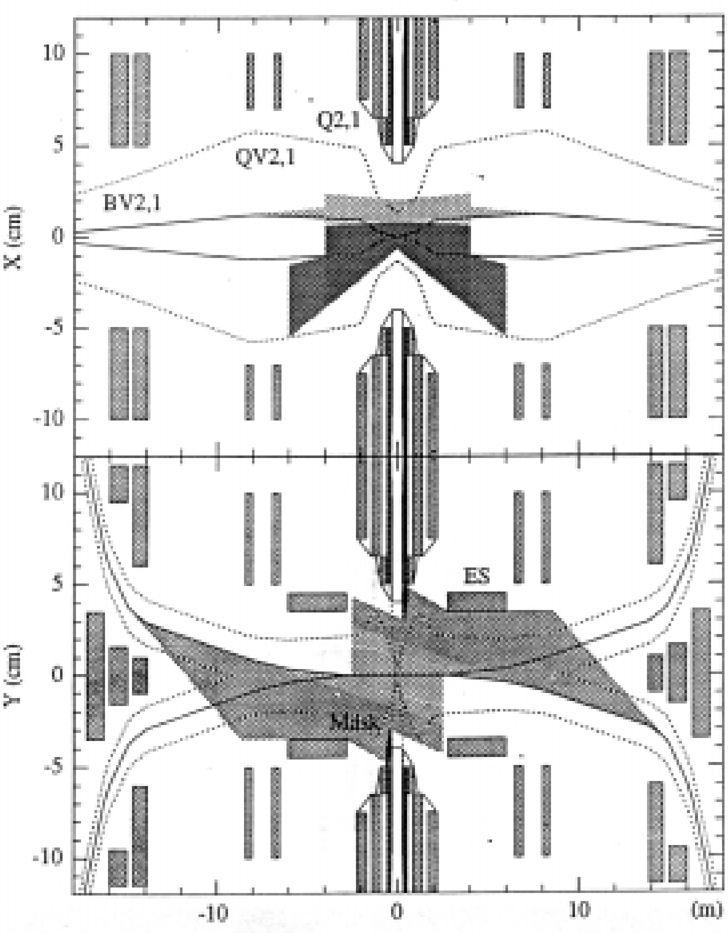


Figure 3.17 SR power deposited by the electron beam into the vacuum chamber wall within ±8 m of the IP.



γ/keV/s/Amp
E (keV)
Incident on the beam pipe
After the beam pipe (no gold)
With 10 μm of gold coating



X (cm)
Y (cm)
Q2,1
QV2,1
BV2,1
ES
Mask
(m)

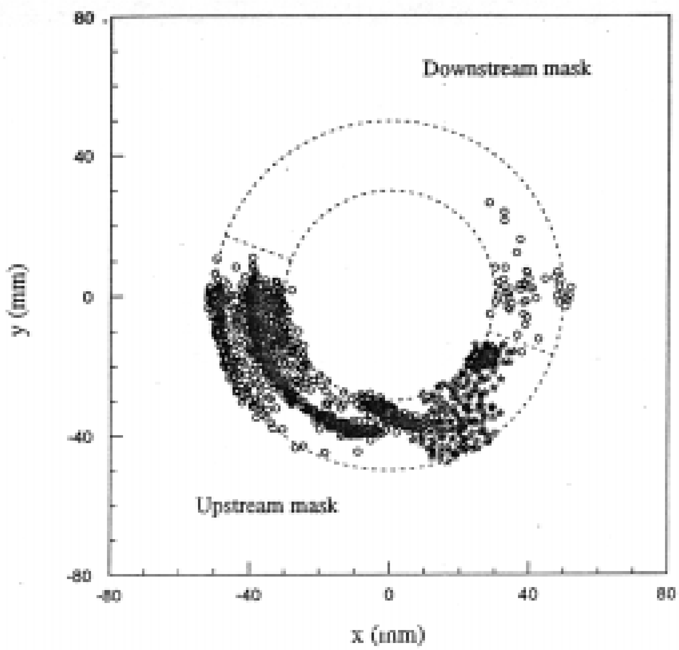
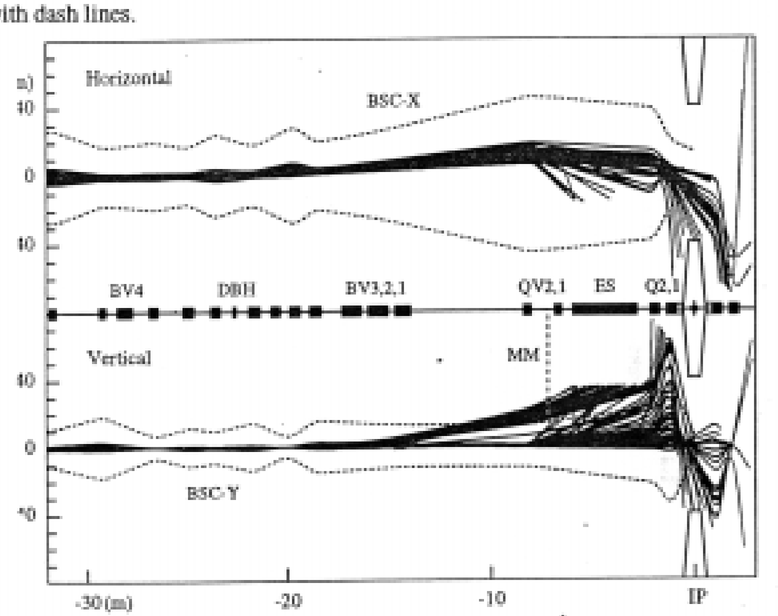


Figure 3.21 Spatial distribution for bremsstrahlung particles (circles) and photons (stars) when they hit the upstream mask and the beam pipe. The half-circle shaped masks are shown with dash lines.



3.19 Typical trajectories for bremsstrahlung particles which hit the vacuum chamber the IR. Also shown is the position to place a movable mask (MM).

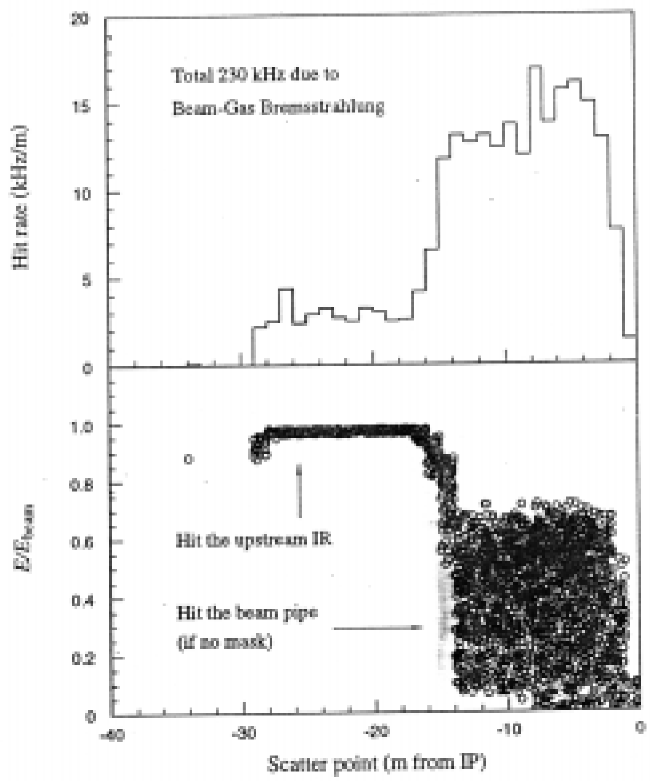


Figure 3.20 Hit rate as a function of the bremsstrahlung point for one beam (top) and the correlation between energy and the scatter point (bottom).

- CONVERSION OF REF. DES. TO WORKING DES.

✓ RETHINK ENTIRE DESIGN i.l.of. progress:

✓✓ BEGIN W. IR & WORK OUTWARDS i.l.of:

- BACKGROUND - INCL. TOUSCHEK - from start
- DYNAMIC APERTURE*
- POLARIZATION CONSTRAINTS
- POSSIBILITY OF "MONO" W. PLANAR RINGS
- DIFFICULTIES OF VERTICAL SEPARATION
- UPGRADE POTENTIAL

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✓✓ REVIEW ARC DESIGN

- DYNAMIC APERTURE / TOUSCHEK AMELIORATION
- PEI
- POLARIZATION CONTROL

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✓✓ INJECTION SCHEMES & INJECTORS

- REEXAMINE ALTERNATIVES FOR SIMPLICITY

\- - - - -

* INTERPLAY OF SOLENOID COMPENSATION AND L^*

TECHNICAL PROSPECTS (10^{33}, 2GeV, $\vec{\mu}$ e^-)

✓ PRETTY GOOD: WILL LEARN A GREAT DEAL FROM CURRENT GENERATION + THEIR BUILDERS WILL BE AVAILABLE TO HELP:

FACILITY	Knowledge useful for τCF
BEPC	Background Studies - Touschek + PEI + Ion
CESR	Möbius; L-Xing
DAΦNE	Large X L, σ_z(nat) ~ 5 mm, Hi Bad/BO, Novel Sol. Comp., Heavy Touschek, PEI, Ions
KEK-B	Large X L, σ_z ~ 4 mm, Crab Xing, Heavy Touschek, local ξ, PEI, ions, Super feedback
PEP-II	VERTICAL DISPOSITION, ion, PEI, Super feedback, LER Vac., Local ξ corr.

• TECHNICAL PROSPECTS ("Mono") ⑥

✓ IDEA WILL WORK TO SOME EXTENT. Q: Optimum balance among Touschek life/bkgnd, $\mathcal{L}$ and σ_w (~~se~~ cm)

✓✓ small ε → small D → τ short owing to small beam size

✓✓ small D → strong 6-pole → reduced dynamic aperture

✓✓ Large D_x at IP compromises ΔE/p in IR → shorter life → higher background.

⇓

ROUGH SLEDDING → MUCH TIME TO BRING UP.

• TECHNICAL PROSPECTS (5–10 × $\mathcal{L}_{33}$ "Dream") 2 GeV

✓ IF B-FACS → 10^{34}, τCF @ 5×10^{33} not crazy.
" " higher, so τCF : $\mathcal{L} \propto EI$

✓✓ More q / bunch (optics, Z)
✓✓ more K ~~#~~, bigger ξL from bunches
✓✓ higher $\mathcal{L}/I$ ∃ bk. mat., Möbius, phase conjugation ...

• TECHNICAL PROSPECTS (mono "Dream")

✓ as never been done, no basis for upgrade discussion.