Progress / Status / Plans for LCWS'99 (for Higgs physics study)

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1. Summary of 1st ACFA work shop at Tsinghua Univ. Beijing
2. Progress so far
3. Strategy towards LCWS '99
4. Scheduling and requirements

Very high activity now towards LCWS'99 !

Working members

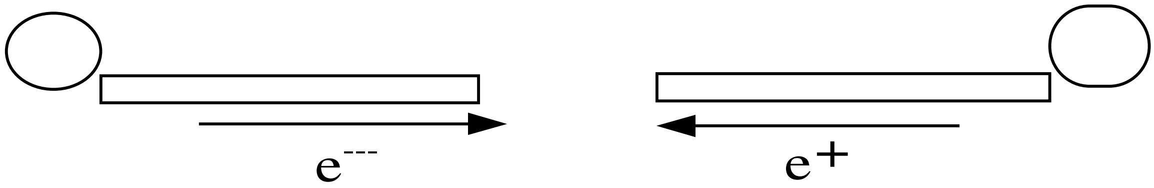
S. Yamashita (Tokyo), K.Ishii (JPS), I. Nakamura (JPS),
I. Ueda (Tokyo), N. Kanaya (Kobe)

J. Kanzaki (KEK)

K. Kawagoe (Kobe)

Close Collaboration with Simulation Working Group, IR Working Group, Vertex detector Working Group

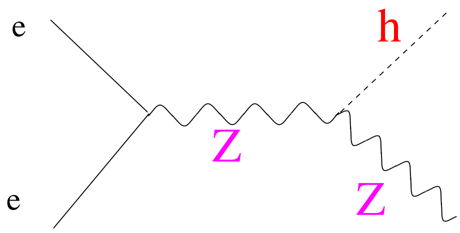
Higgs at ALC



Ecm = 250 - 340 GeV

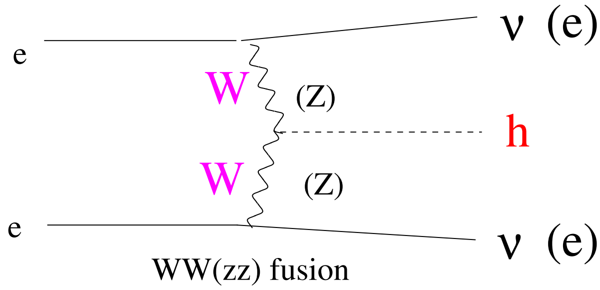
(below Top threshold = DISCOVERY phase)

ee → Z h



Higgs Strahlung

ee → νν h (ee → ee h)

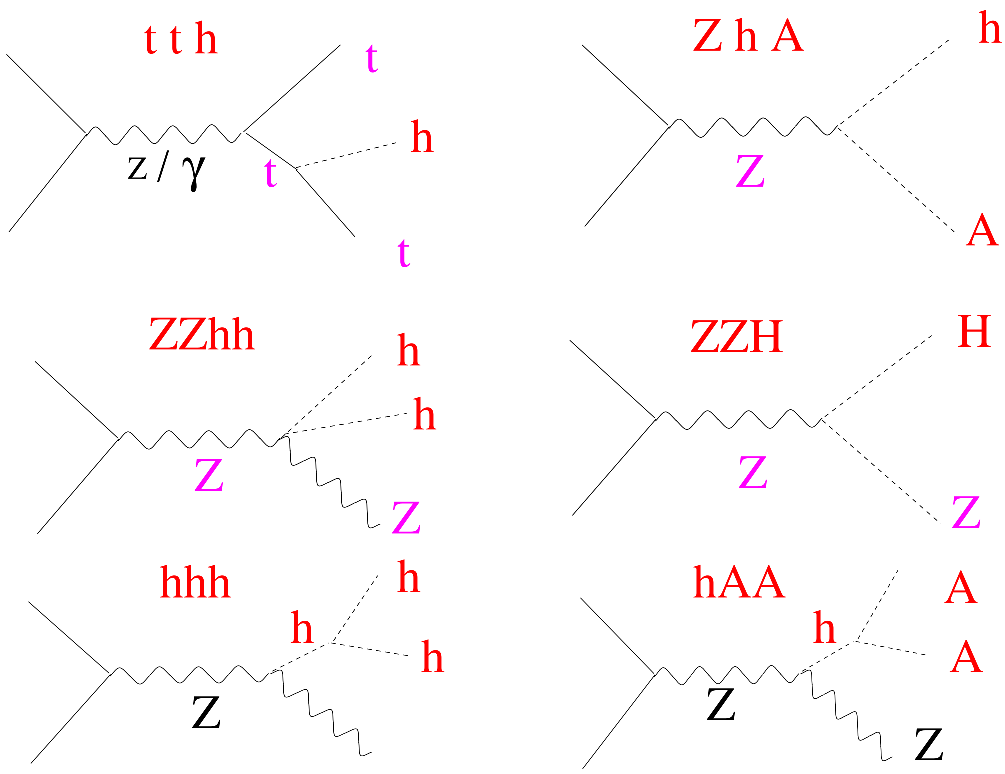


WW(zz) fusion

Ecm = 350 GeV (Top pair threshold)

Ecm = 400 - 500 GeV

(Multi-Higgs, Higgs couplings, Yukawa coupling)



We should measure (time ordering)

Ecm = 220 - 340 GeV

0. mass

   trivial at DISCOVERY

1. Cross-section for hZ process
2. spin / CP
3. σ ($\nu\nu$ h) / σ (h Z)

   W W h and ZZh gauge-coupling

4. Br (τ τ) / Br (b b)

   up-type fermion-Higgs coupling ratio

5. Br (cc + gg) / Br (b b)

   Towards next energy upgrade

6. Γ

   Missing particle, NMSSM

Ecm = 400- 500 GeV

7. Yukawa-coupling
8. Higgs self-coupling

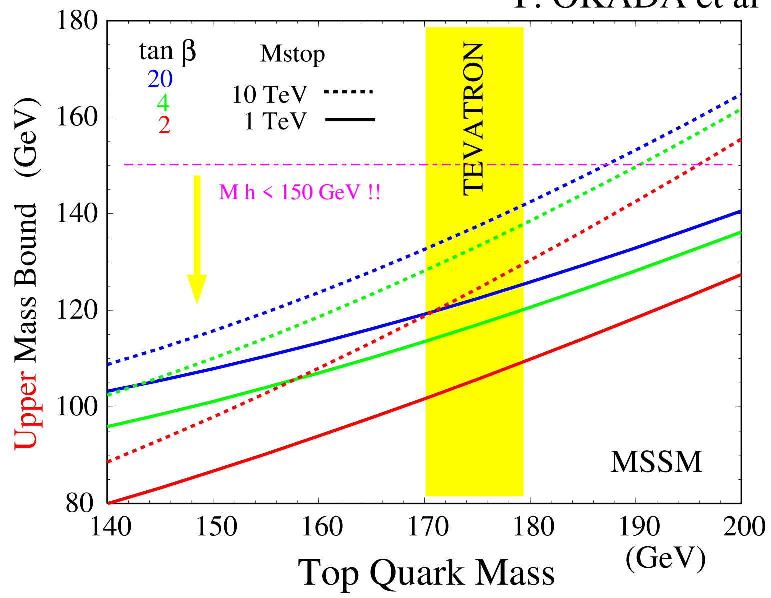
   Vacum structure

Where is Higgs ?

MSSM

At Tree Level   the lightest CP-even Higgs , h, must be lighter than Z-boson

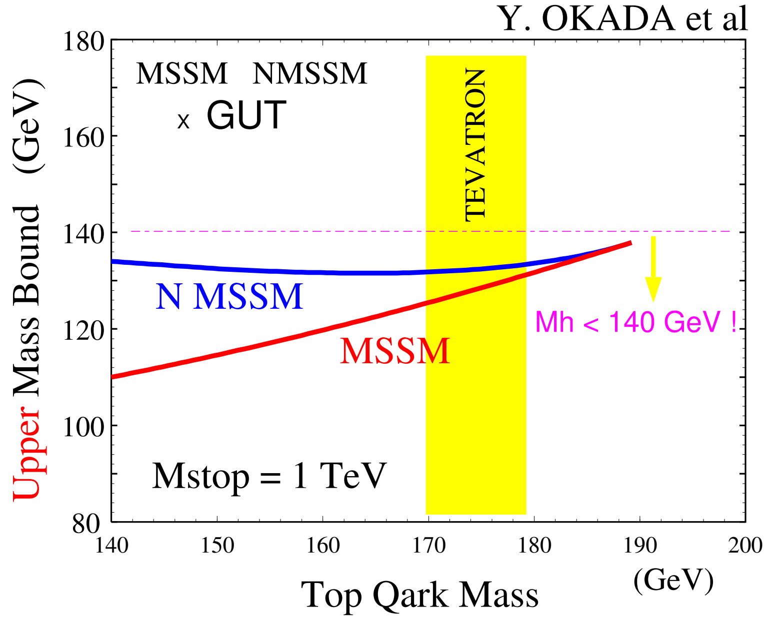
Top/Stop loop can make it larger, but limited



Mh < 150 GeV

NMSSM (MSSM + extra singlet)

if we assume the higgs coupling is finit upto GUT scale

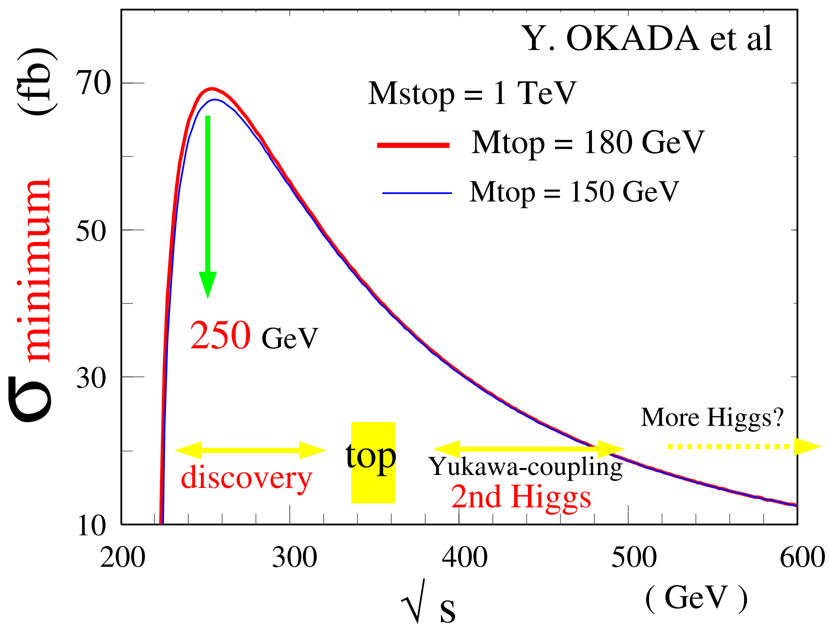


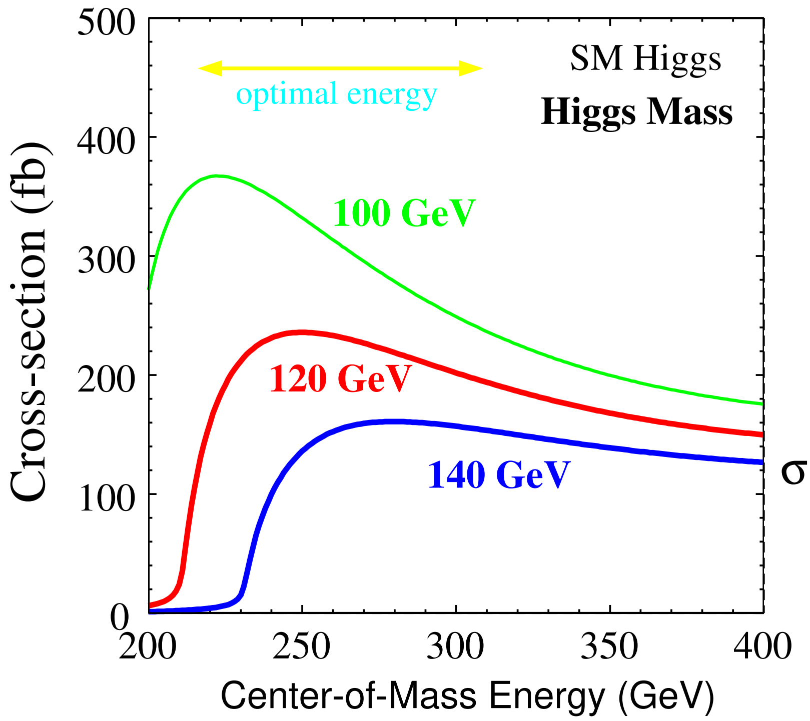
Mh < 140 GeV!

In general

σ (SM) > σ (MSSM) > σ (NMSSM)

Minimum Cross-section for lightest CP-even Higgs production
NMSSM





For h discovery

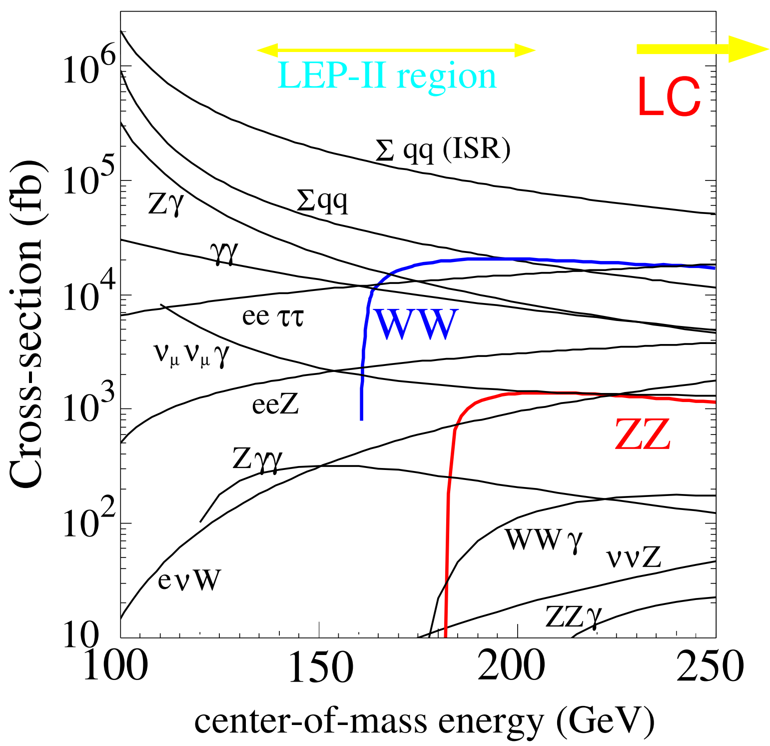
Ecm = 250 - 300 GeV

is optmal

This is also true

for MSSM Higgs

σ (MSSM) = sin^2($\alpha-\beta$) σ(SM)



Background σ

at LC energy region

WW ~ 10 - 15 pb

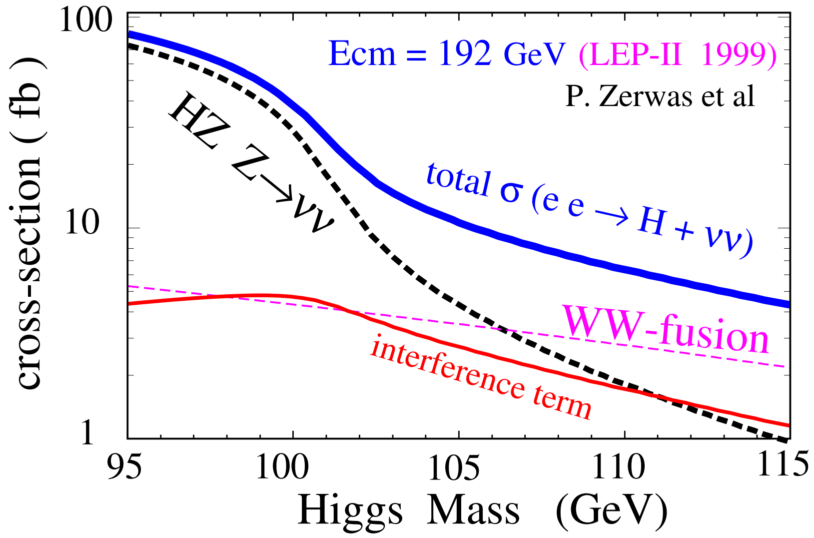
ZZ ~ 1 - 1.5 pb

qq ~ 50-70 pb

Example of Higgs Measurements

WW-fusion cross-section measurement

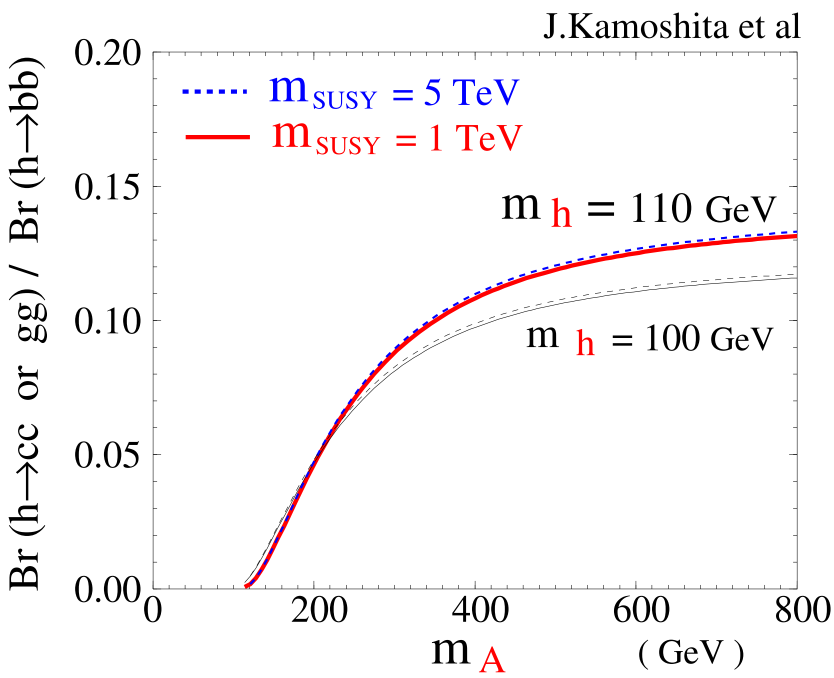
Verify Higgs Gauge Coupling



Measurement of the branching rate to cc or gg

SUSY parameter dependence is small !

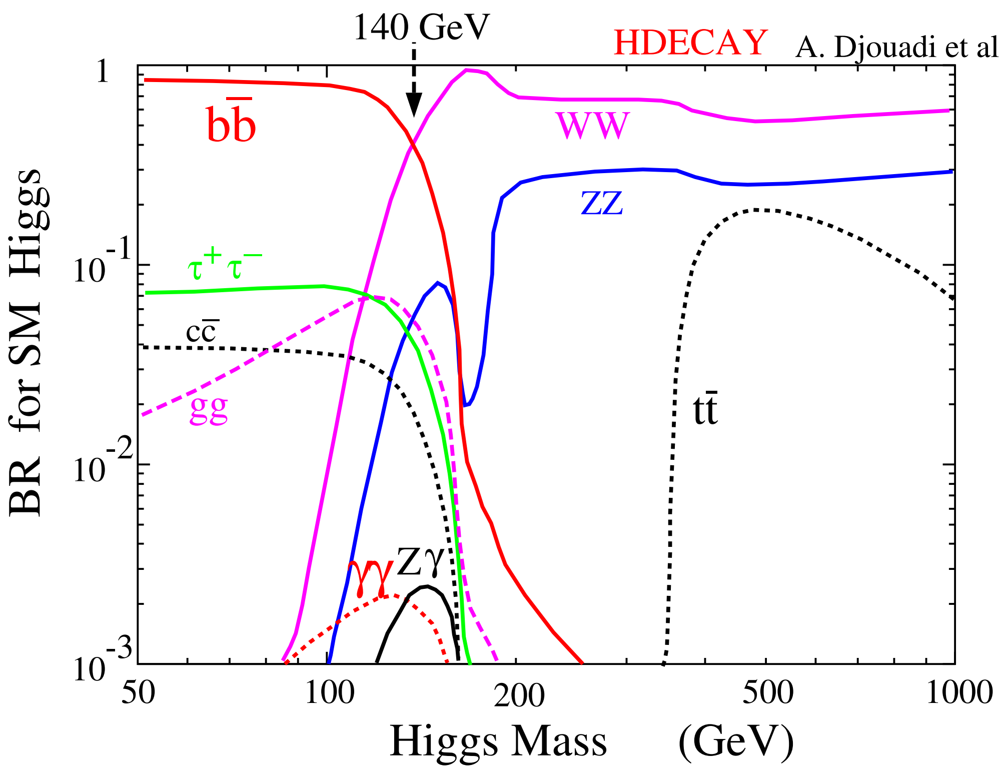
Know the A mass



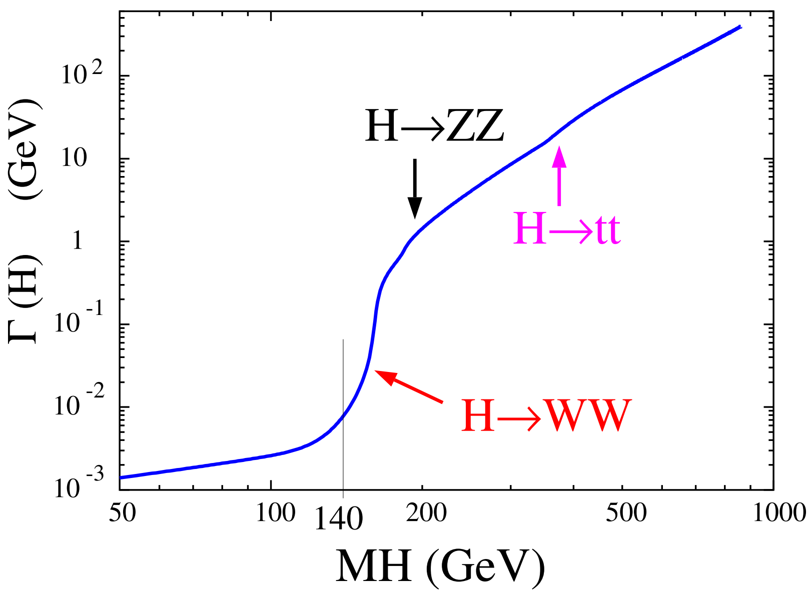
Key point for light Higgs discovery / measurement

Dominant decay of Higgs is bb = b-tagging !

SM Higgs decay Br



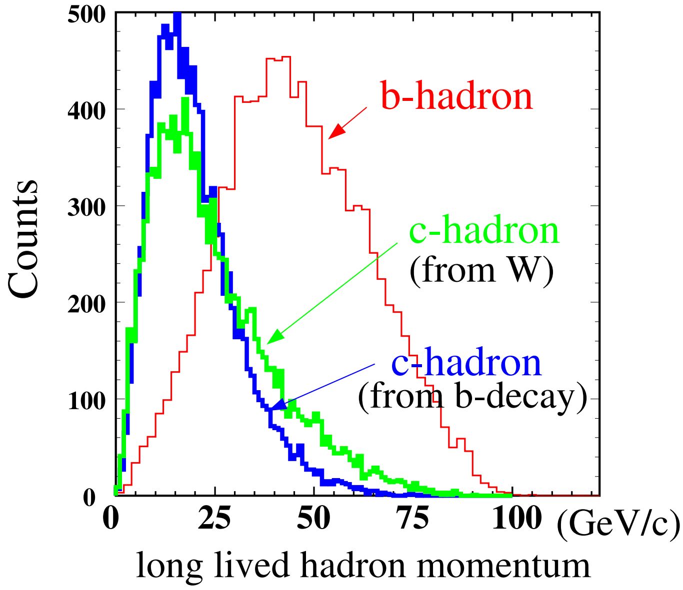
SM Higgs decay width



Several b related properties

Ecm = 250 GeV   Mh = 120 GeV

b/c hadron momentum spectrum for signal/WW



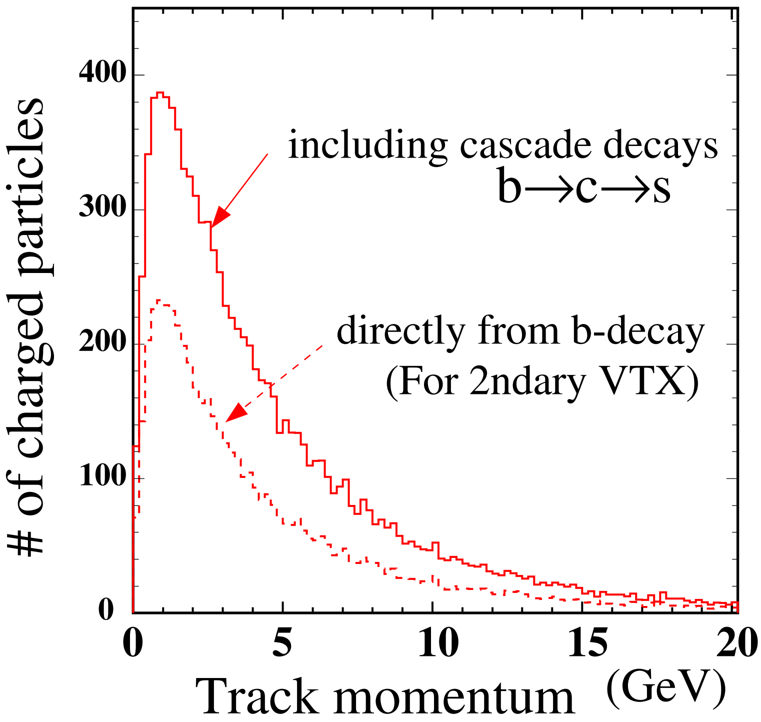
large boost (average $\gamma \sim 10$)

many tracks (hits)
in narrow detector region

b ~ 5 tracks / 10 mstr
c like τ at LEP-I

need good Si-CDC matching

Momentum Distribution of charged particles from b-decay



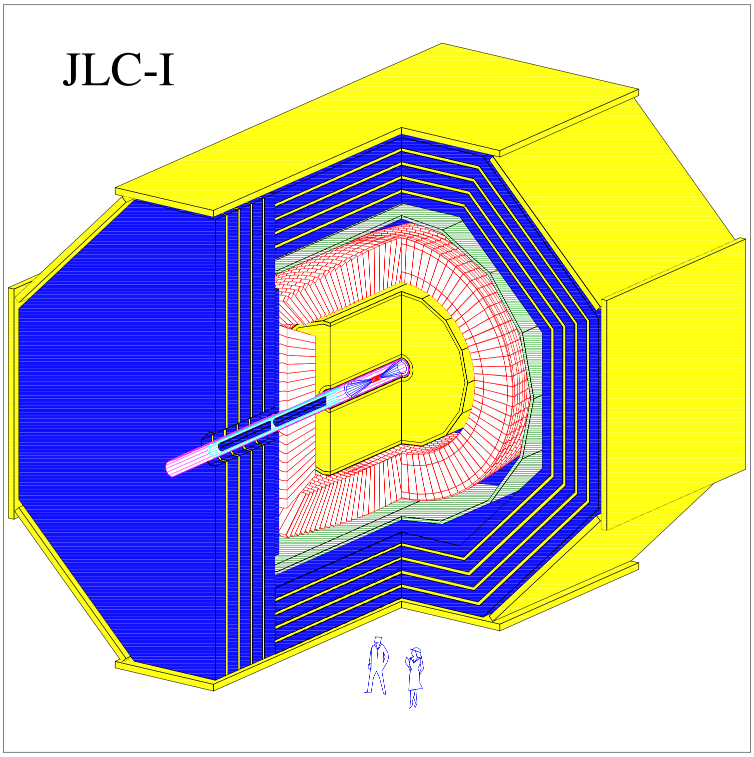
Due to many track sharing b-momentum

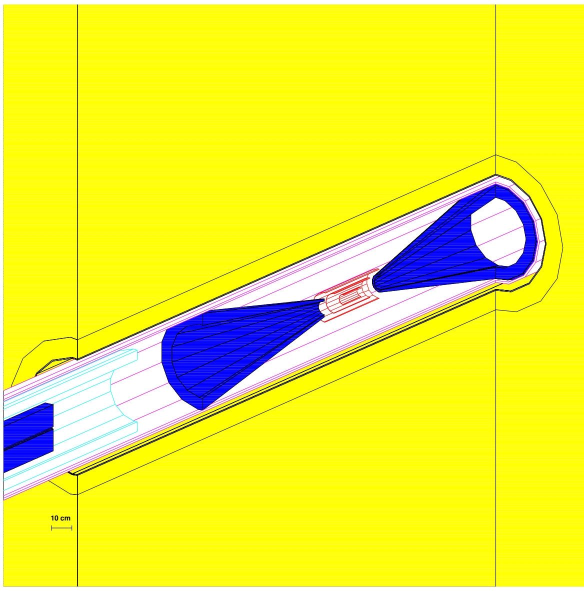
charged track momentum is
in general low

Low momentum tracks are important

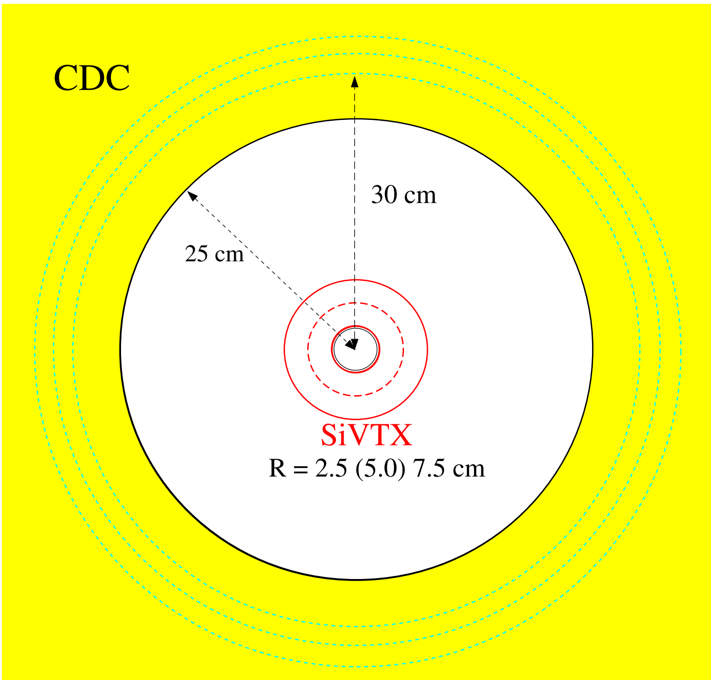
target : good reconstruction for P ~ 1 GeV/c

DETECTOR (current design) JLC-I





SiVTX and IP



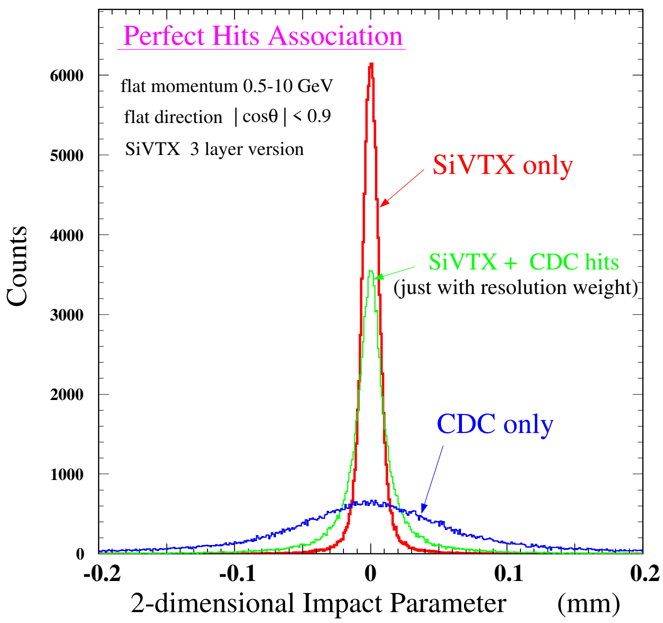
Study with smearing hits

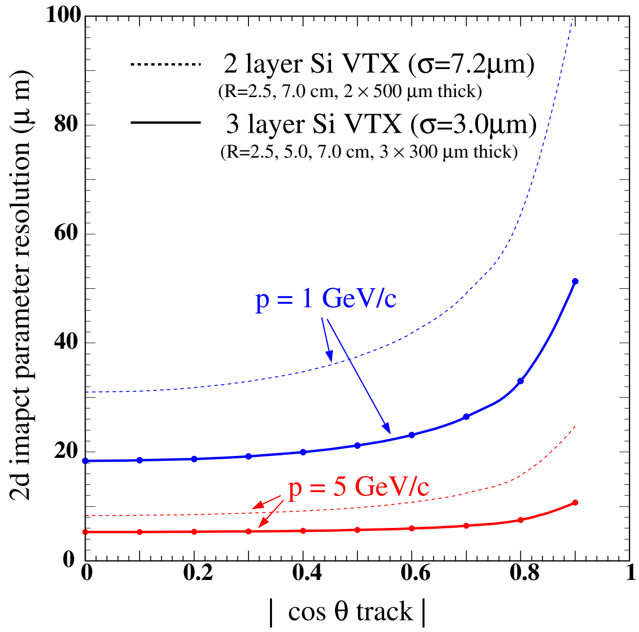
Just with multiple scattering + hit position smearing with given resolution

100 % efficiency

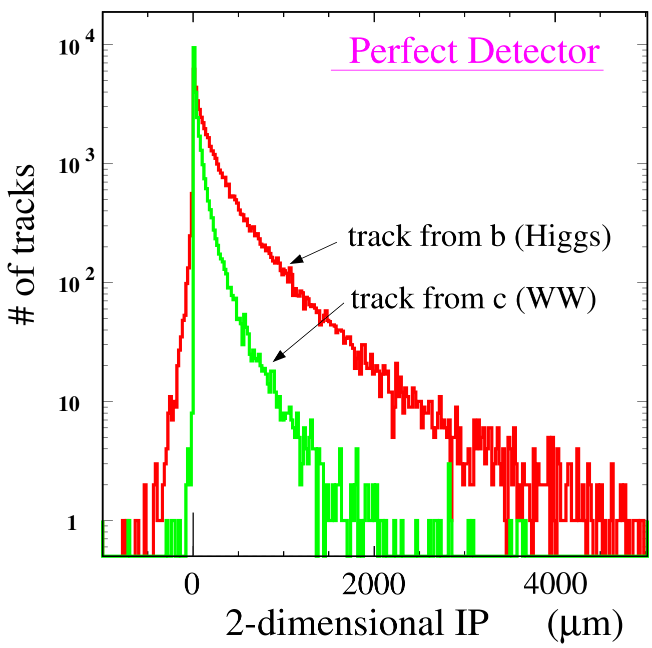
Fit hits for perfect association case

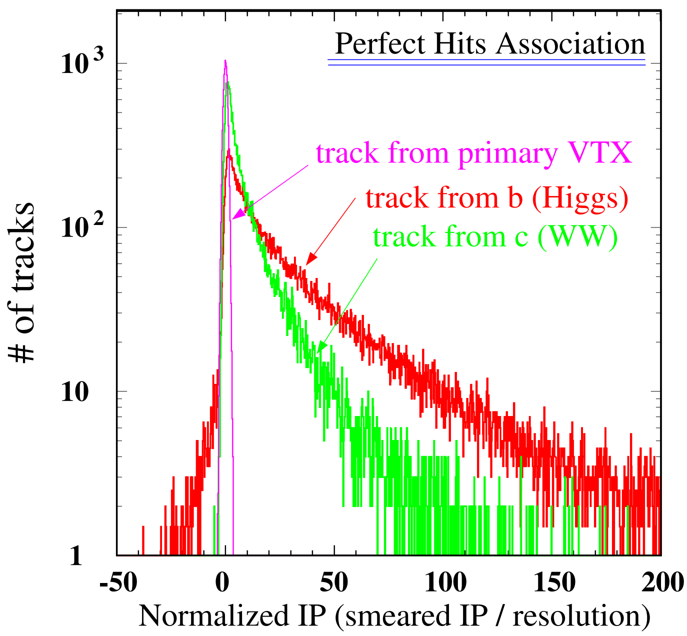
Primary vertex resolution is assumed to be 0





sigma^2 = 4.5^2 + (14.0/p)^2 / sin(theta)^3





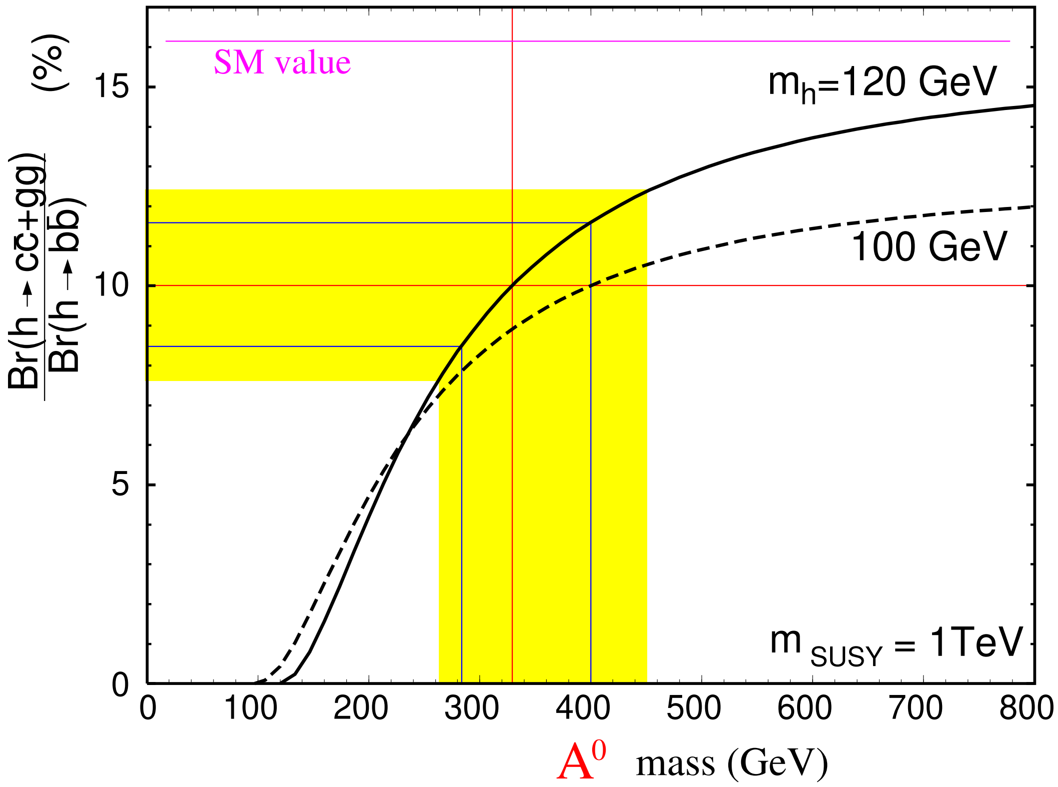
First check

for the Higgs cc-gg branching measurement with JLC-I detector

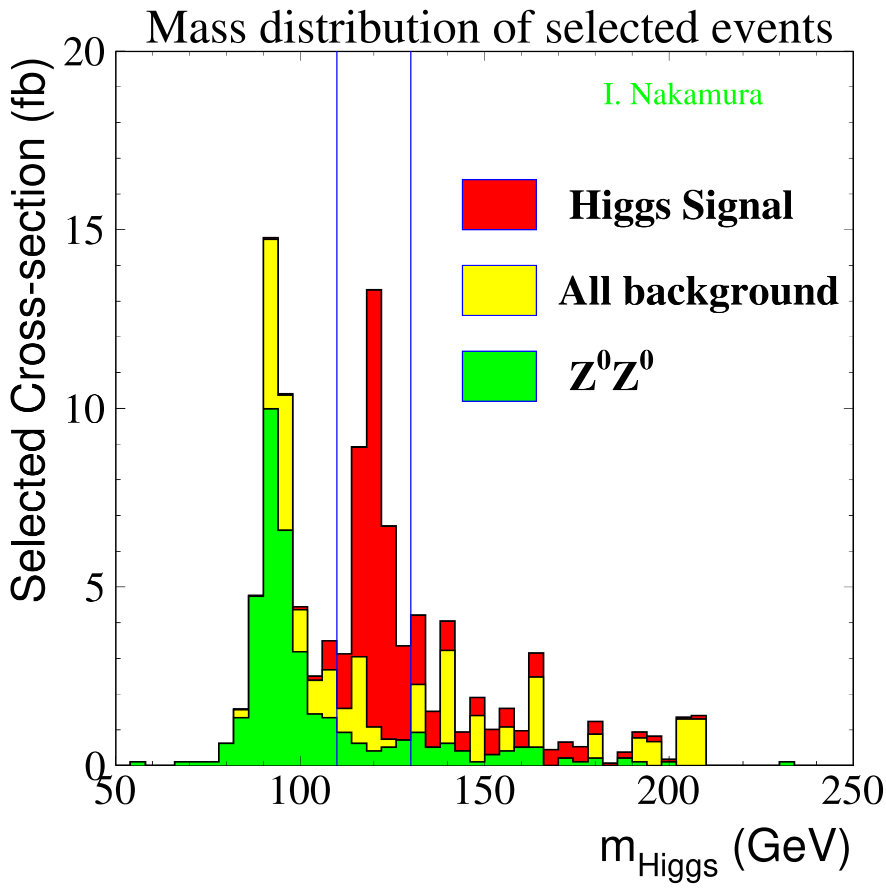
with track Impact Parameter smearing

Assuming perfect association of Si-CDC track hits

I. Nakamura and K. Kawagoe   Phys. Rev. D Vol 54 1996



Looks quite encoureging !



Channel	Total	in Mass sel
4-jet	~21 %	~15 %
nnH	~13 %	~9 %
mmH	~50 %	~40 %
eeH	~49 %	~39 %
Total	~20 %	~14 %

$\sigma_{H^0} \times \eta^{signal}_{selection}$ $\sigma_{bkg} \times \eta^{bkg}_{selection}$

28.2 fb 7.2 fb

(110 GeV < m_{Higgs} < 130 GeV)

$1\ fb^{-1}$ is enough for DISCOVERY even with OPAL Detector !!

BUT....Assuming as clean beam/experimental situation as LEP

No beamstrahlung effect

No two-photon (mini-jets)

No overlap events ....

More consideration

What is better for LC than LEP ?

0. High energy
1. High luminosity
2. Small beam size ⟶ Good Primary Vetex Resolution
3. New technologies can be used...

Worse ?

1. beam-beam interaction

Energy spread, tail : depending on luminosity

e+e- pair creation ⟶ SI hits

2. Short bunch/train with high luminosity

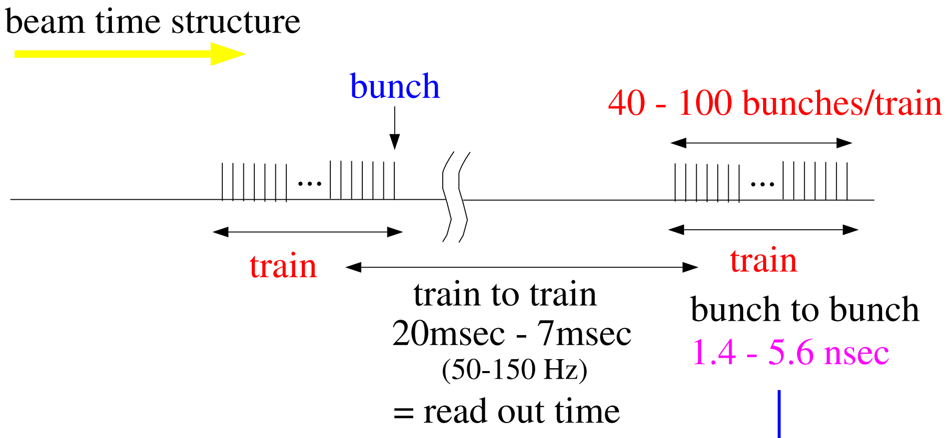
event overlap !!

two-photon process (mini-jet)
so many ee eeee creation in a train collision

3. Acceptance

can not cover very forward region

Time Structure of the Beam



We can not separate SiVTX Hits (CCD)

CDC track can be resolved with time resolution of 1 nsec for T0
(by self-fit)

Huge Number of Hits in Si / train

A) beam-beam interaction (incoherent scattering) (T.Tauchi)

for Most Inner Si (R=2.5 cm) ~ 100 hits / cm^2 !!!!

B) Mini-Jet Event Overlap (two-photon processes)

cross-section ~ 100 nb !!!!

0.2 event overlap / bunch ~ 10 - 20 overlap / train !!

Si Hits can be resolved with reference CDC track ?

beam-beam interaction : ABEL program + JIM

K. Yokoya, P.Chen Beam-beam phenomina in linear colliders
Frontiers of particle, Intensity limitations ; Lecture Notes in Physics Vol. 400

T.Tauchi, K.Yokoya, P.Chen Pair creation from beam-beam interaction in linear collider
Particle Accerelators 1993 Vol 41 pp29-39.

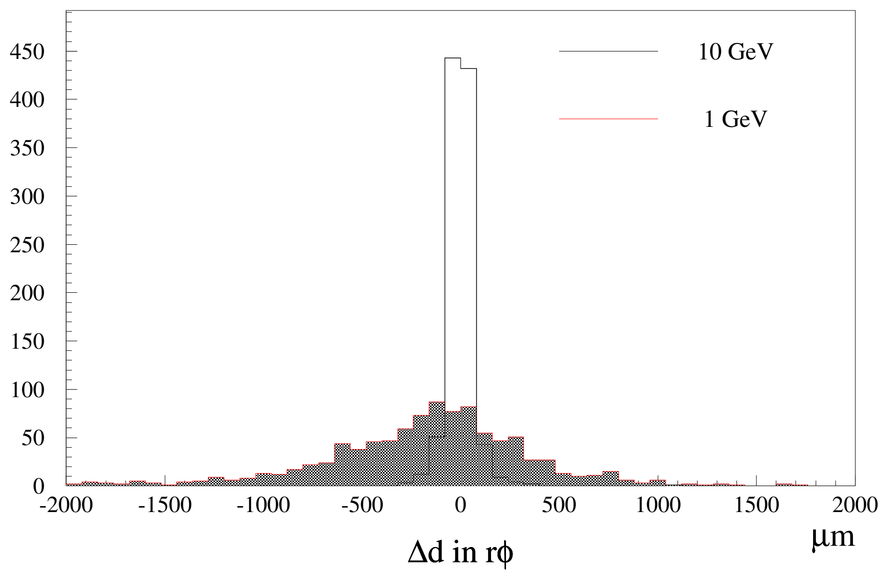
Simulated Events generated by T. Tauchi

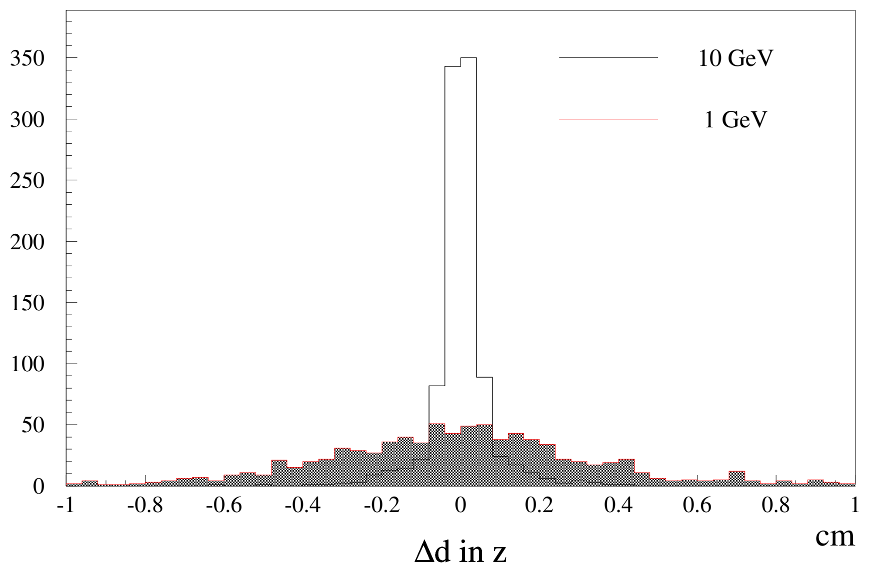
Mini-jets : PYTHIA+Jetset+JIM

Overlap with single track

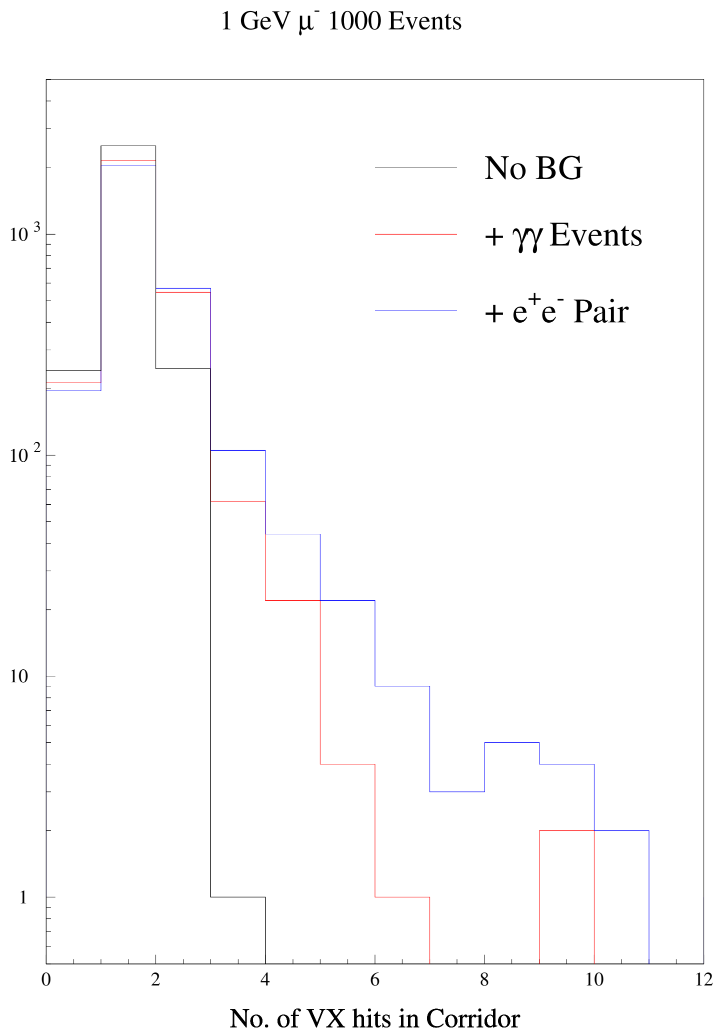
(muon with momentum 0.5-10 GeV θ 20 - 160 degree)

Distance between CDC tracks and VX hits





Number of Si Hits in CDC reference window



Indeed beam-beam and Mini-jet make many hits
even in narrow acceptance around CDC track extraporated position

Mainly due to wide tolerance of Si Hits - CDC track

This is caused by long distance between CDC and Si !
(and multiple scattering in CDC inner window / Gas)

How worse Impact Parameter may come from the wrong hits association ?

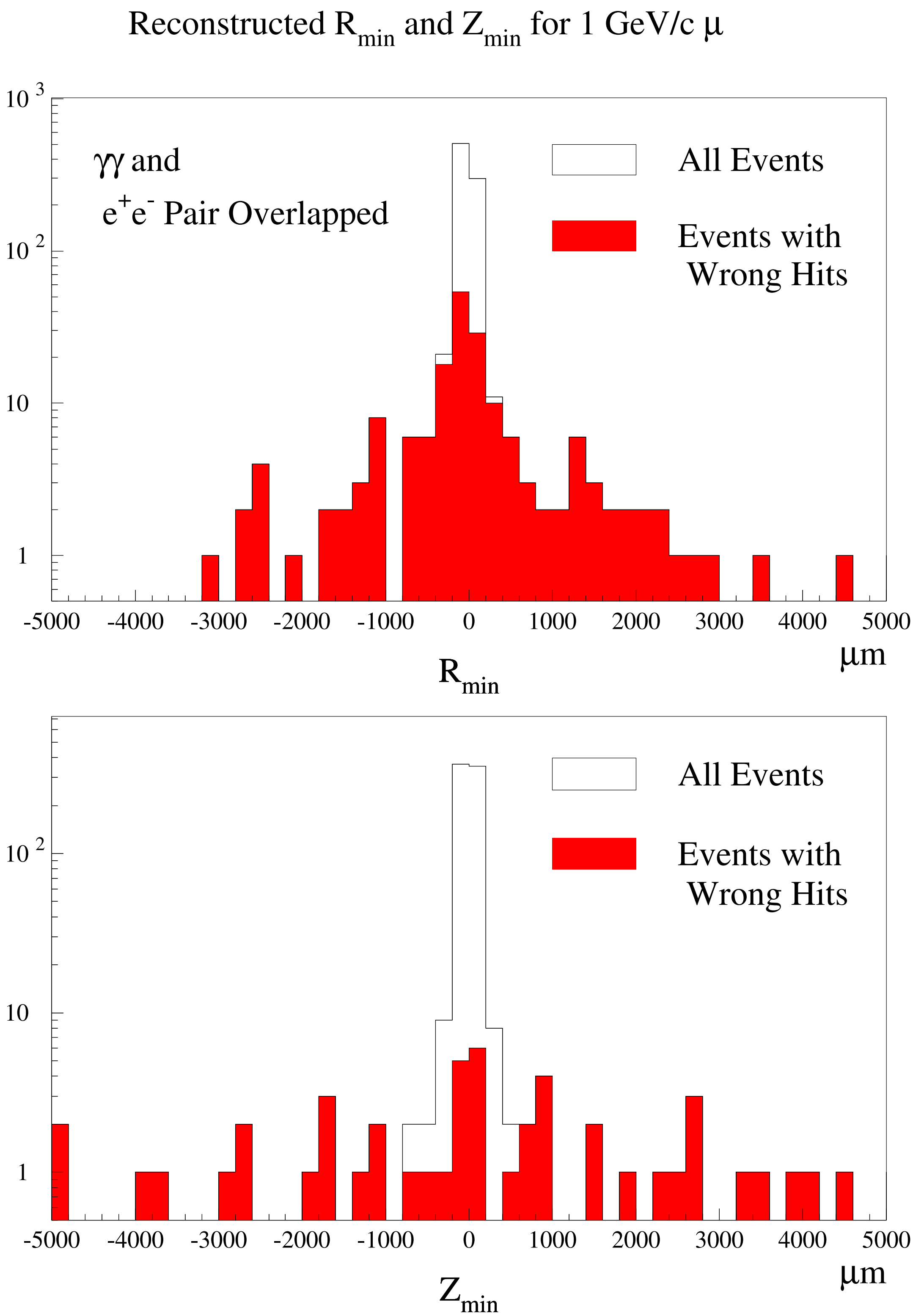


Table for wrong hits association and track quality

A : + Beam-Beam Interaction
M : + Mini-Jet (two photon process) overlap

Wrong Hits Association Rate

p(GeV)	A	M	A+M
0.5	55.2 %	75.3 %	77.0 %
1	5.8 %	10.8 %	13.4 %
2	2.2 %	3.5 %	5.1 %
5	0.7 %	0.7 %	1.3 %
10	0.5 %	0.17 %	0.67 %
20	0.17 %	0.07 %	0.23 %

Good Tracking Rate

p (GeV)	None (%)	A (%)	M (%)	A+M (%)
0.5	91.0	21.5	17.6	14.2
1	90.3	87.7	83.2	80.6
2	91.3	90.8	90.1	89.6
5	92.1	92.1	92.0	92.0
10	89.5	89.5	89.5	89.5
20	90.4	90.4	90.3	90.3

None - “A+M” ~ bad impact parameter due to wrong association

About 10 % badly reconstructed track for 1 GeV

We need better Hits Association for Higgs Physics

1. Detector Side

Si VTX 3 Layer $\longrightarrow$ 4 Layer

Insert Fast Detector between SiVTX and CDC
(R = 10 cm - 40 cm)

Better to have time resolution shorter than 20 nsec in some layer

3D device is Preferable

No need to have very good resolution

But need to have high eff with low noise

2. Analysis Soft-Ware Side

Need Better Algorithm for Tracking

Si Hit shape to reject low P track from beam-beam
(Y. Sugimoto's idea)

See I. Ueda 's study

LCWS '99 Higgs Session

Proposed Presentation in Experimental side from Asia

1. hZ cross-section measurement — Nobody yet

2. Higgs Branching Ratio Br(cc)/Br(bb) — (I. Nakamura)

3. Higgs Branching Ratio Br($\tau\tau$)/Br(bb)
   CAL structure and tau-ID performance — Nobody yet

4. WW-fusion cross-section measurement
   and forward acceptance effect — (K. Ishii)

5. Effects of Beam-beam, two-photon overlaps and bunch ID
   (J. Kanzaki / S. Yamashita)

6. Effects of beam strahlung in Higgs selection (I. Ueda)

We are encouraged to present Higgs measurement sensitivity

as functions of

Detector performance (Si resolution , track momentum resolution,
CAL energy resolution, CAL granurality, time resolution)
Luminosity
beam-beam interaction / event overlap rate / beam energy

Summary at Beijing (November 1998)
(+ after discussion at dinner time)

1. Higgs is light (Mh<150 GeV)
   if our understanding of nature is not so bad.

2. From cross-section point of view, Ecm = 250-300 GeV is optimal.

3. Discovery is very easy, but measurement is tough

Problem to be solved for measurement

A. Huge number of hits on Si due to beam-beam interaction makes unacceptable rate of track mis-reconstruction

B. Almost perfect Bunch ID is nessesary to avoid two-photon overlap

Proposed solution

A. Number of Si layer increased from 3 to 4.

B. Insert Intermediate Tracker between SiVTX and CDC

C. Shape analysis for Si hit to reduce beam-beam related noise hit.

D. For bunch ID, need optimized stereo sector in CDC, and good time resolution (1nsec) for CAL as expected now.

To study above things as well as to design Higgs measurement strategy

We need detector simulators

Quick : Just smearing (very quick ! sufficient for kinematics
Not enough for beam-beam etc..)

Fast : full simulation for trackers, but fast smearing for CAL
(moderate speed, enough for beam-beam)

Full : Complete full GEANT simulation (very slow...)

Progress since 1st work shop at Beijing

1. Distribution of Detector Simulators

   Quick Simulator   A.Miyamoto et al

   Fast Simulator   J .Kanzaki / K. Ishii et al

   Full Simulator   J. Kanzaki et al

   → Common Output Format (SIMDST)

2. Simulation CPU farm setting

   PC (400 MHz)   17 CPU

   HP K370   4 CPU

   200 Gbyte Disk Space

3. Various Software Tools

   Beam-beam related noise filter in Si clustering

   Vertex finders / Calorimeter clustering
   (tuning phase now)

Monte Carlo event samples to be generated for Higgs Study

1. Quick Simulation

(To be generated from Mar 22 to Mar 31)

Purpose of the study

- Ecm dependence (optimal energy for each Mh)
- Effect of Forward Acceptance
- Optimal kinematic selection design
- Effect of Calorimeter energy resolution

Ecm = 250, 290, 330 GeV
Sample size corresponds to 10 - 20 fb^{-1}

Background Processes (total ~ 3 M events)

q q	500,000	events
WW	150,000	events
ZZ	20,000	events
Weν	20,000	events
Zee	300,000	events

Signal Processes (total ~ 1. 5 M events)

hZ Mh=100,120,140,160 GeV
h decays into bb, cc, gg, WW, ZZ, ττ
each 3,000 - 10,000 events

Ah process (A, h decays into bb or ττ)

Preselection applied before data strage on disk

2. Fast JIM Simulation Sample

(Full simulation for tracker + Fast Sim for CAL)

(To be generated from Mar 25 to Apr 15)

Purpose of the study

Tracking Study
- Beam-beam related hits + two photon overlap
- Intermediate Tracker Optimization
- Vertexing Study

Beam Strahlung effects

Check Selection Performance estimated by Quick

Special Samples

single track (+beam-beam)+ Intermediate Tracker variation

Z-pole (91 GeV) sample for vertex finder

Ecm = 300 GeV

Sample size corresponds to 1 - 5 fb^{-1}

Beam Strahlung on/off samples

Background Processes

qq , WW , ZZ , Weν , Zee (total ~ 300 K events)

Beam-beam related ee pairs (CAIN/ABEL) (200 bunches)

two-photon background (100 K , recycling)

Signal Processes (total ~ 50 K events)

hZ Mh=120,140 GeV

h decays into bb, cc, gg, WW

What to do by LCWS '99

As Summary