Ideas of
Forward Si Tracker
for Super-KEKB

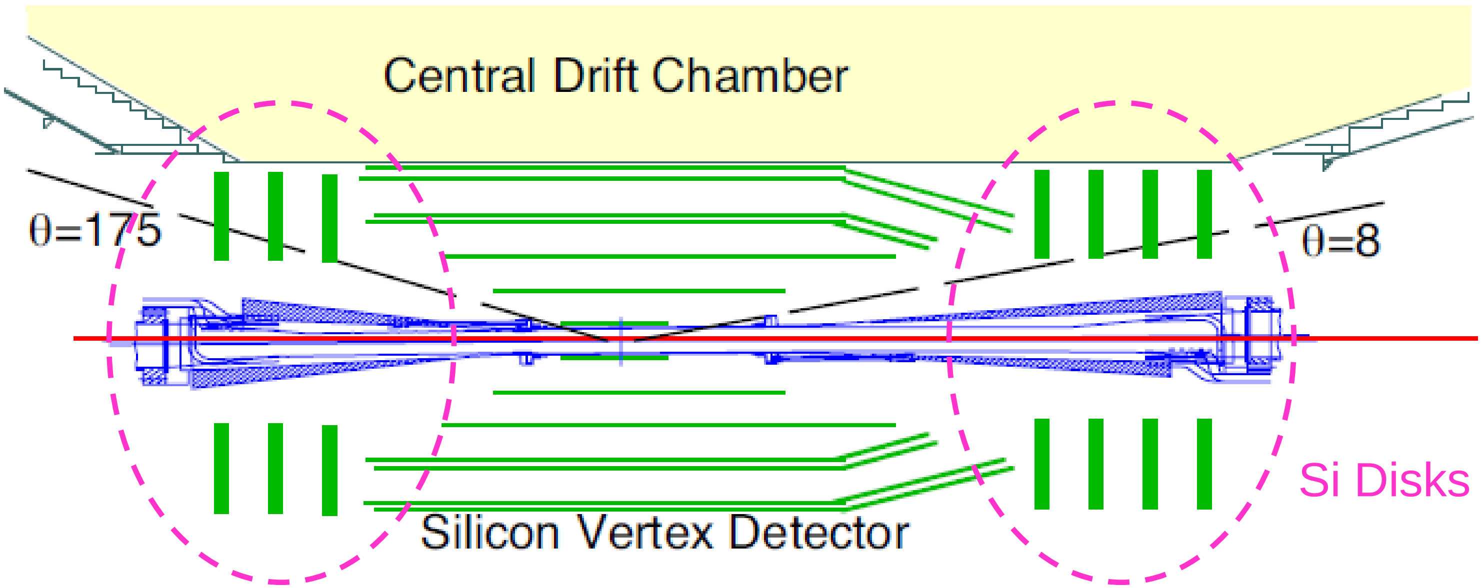
2009/3/18
M.Iwasaki and H.Aihara (Univ. of Tokyo)
T.Tsuboyama, S.Uehara, T.Higuchi, and Y.Ushiroda (KEK)

Forward Si tracker

Forward Si tracker might be a good device to

1. Extend the tracker acceptance

→ May improve the performance of B reconstruction, missing particle analysis, Two-photon analysis, …



2. Measure the IP beam size

→ May also use the Si tracker as an e^+e^- pair monitor which is developed and considered to be used for ILC

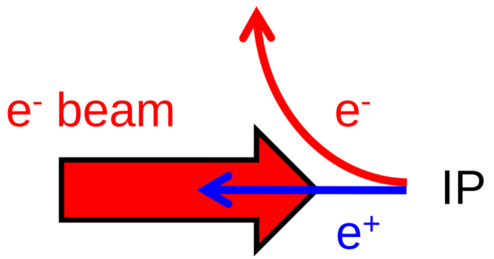
T.Tauchi and K.Yokoya, Phys. Rev. E 51 (1995) 6119

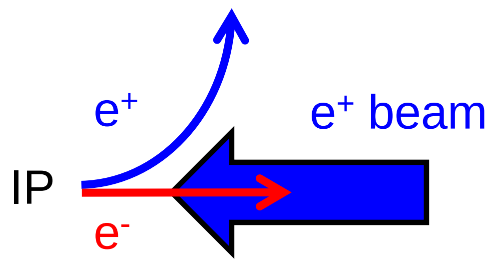
Beam size measurement with an e^+e^- pair monitor

Method

<u>e^+e^- pairs produced at IP have the beam size information</u>

1. Beam produces the magnetic field which depends on the beam structure
2. e^+/e^- particles produced at IP are scattered by the beam magnetic field
   Same charge → Repulsive force
   → Scattered to the detector region
3. e^+e^- pair monitor detects the scattered e^+/e^- particles





e^+e^- pair (incoherent pair) is produced via

- $\gamma\gamma \rightarrow e^+e^-$
- $\gamma e \rightarrow e\, e^+e^-$
- $e^+e^- \rightarrow e^+e^-\, e^+e^-$ ← σ is proportional to the <u>luminosity</u>

can use for Super-KEKB?

Incoherent pair simulation

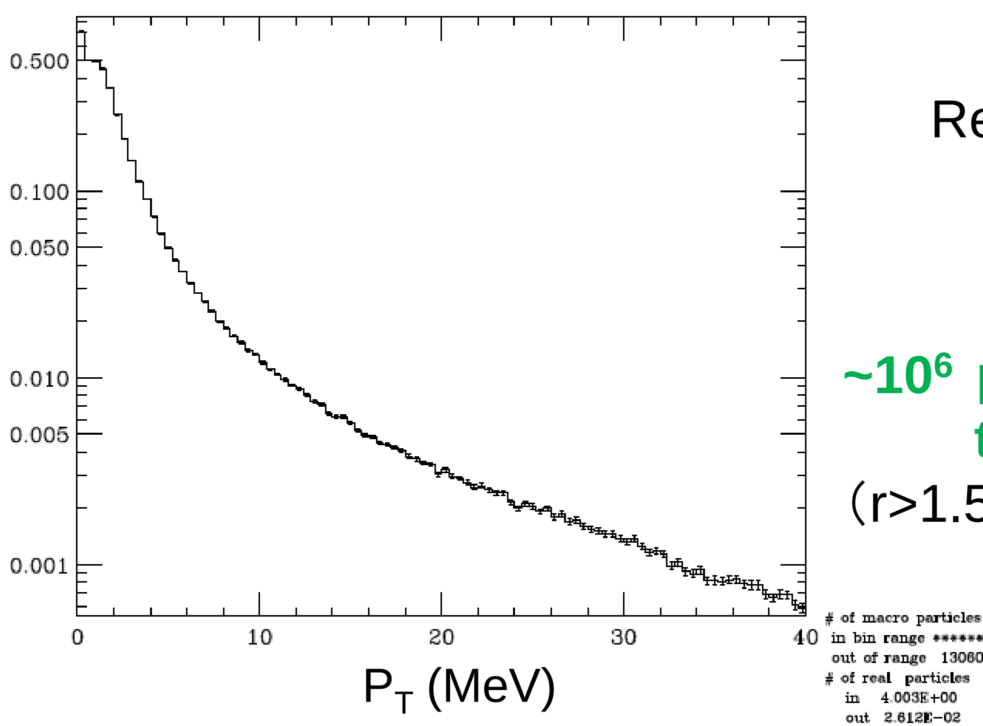
We do the incoherent pair generation and beam-beam simulation for super-KEKB using CAIN (developed for ILC)

CAIN results

Luminosity = 2.91×10^{35}

#Pairs in a bunch=1.82pairs(e^{+} direction)+2.21pairs(e^{-} direction)

Incoherent Pair P_T Spectrum (for a bunch)



Repetition rate = 500MHz

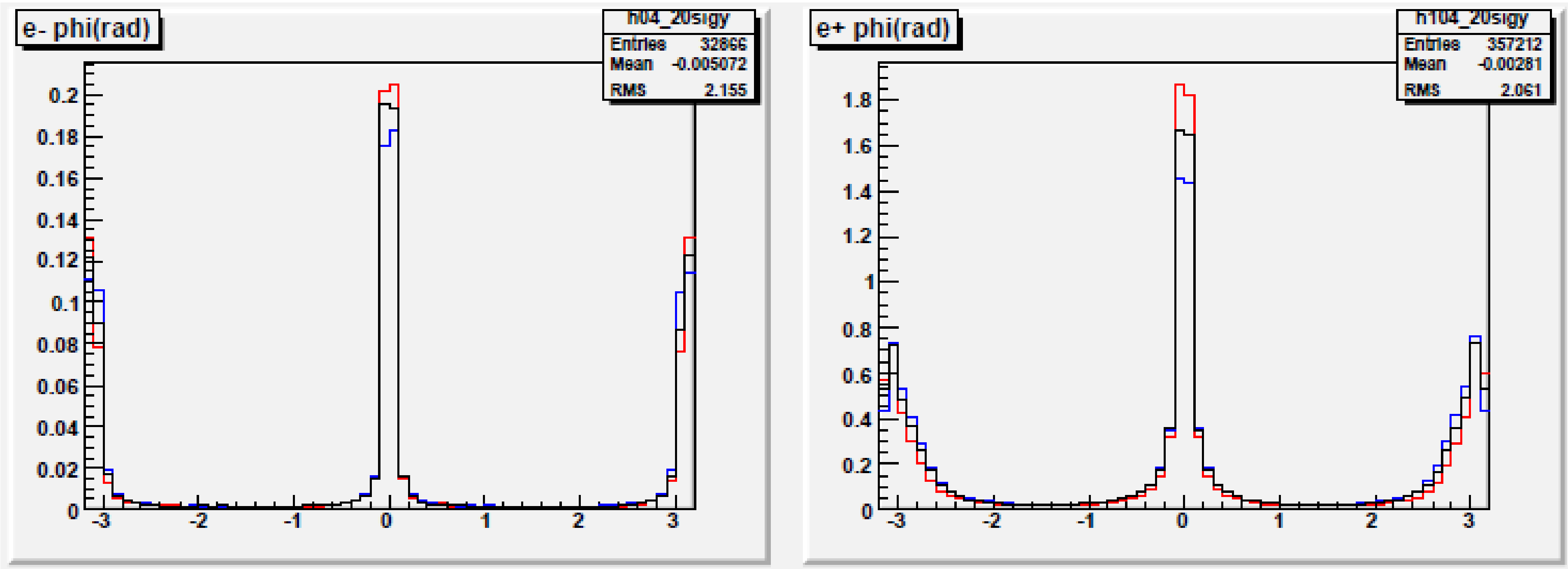
~10^6 pair particles/sec. can reach to the detector region (r>1.5cm)

(r>1.5cm → P_T > ~10MeV under 1.5T)

CAIN results

HER side

LER side



Incoherent Pair ϕ Distribution at IP (rad)

$\sigma_y = 2\sigma_y^0$

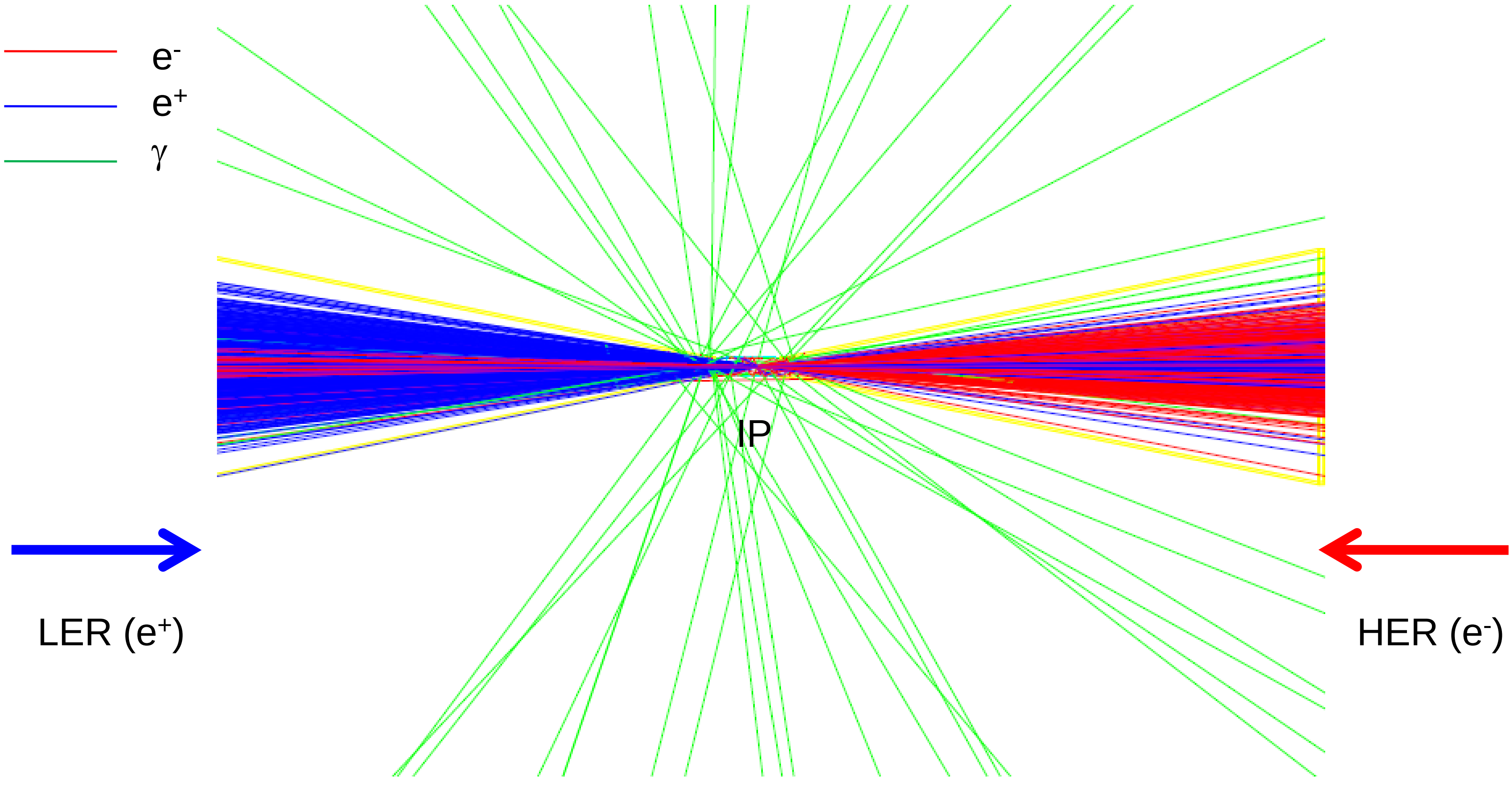
$\sigma_y = 0.5\sigma_y^0$

Nominal beam parameters

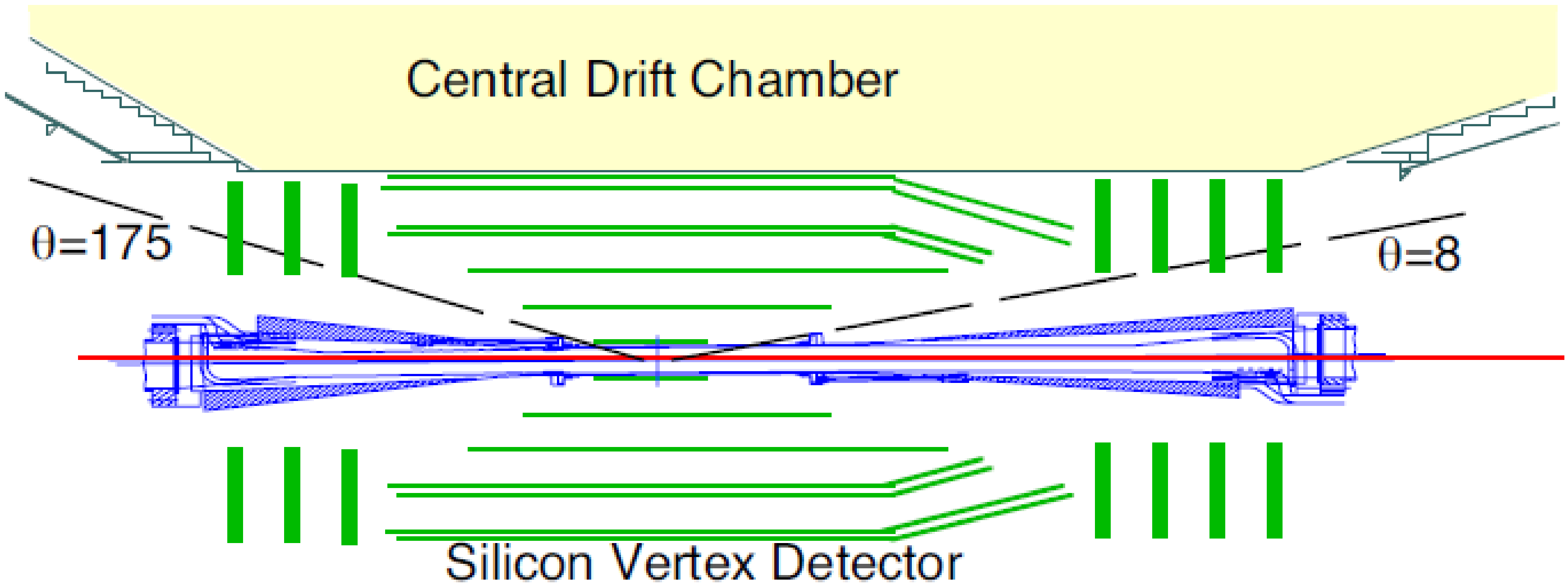
By measuring the ϕ distribution, we can obtain the beam size information

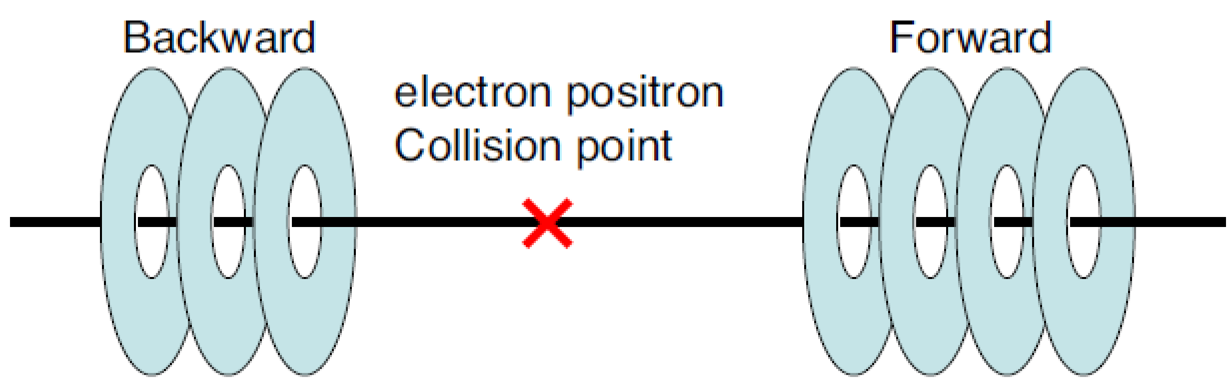
GEANT4 detector simulation

After CAIN event generation, we apply GEANT4 detector simulation



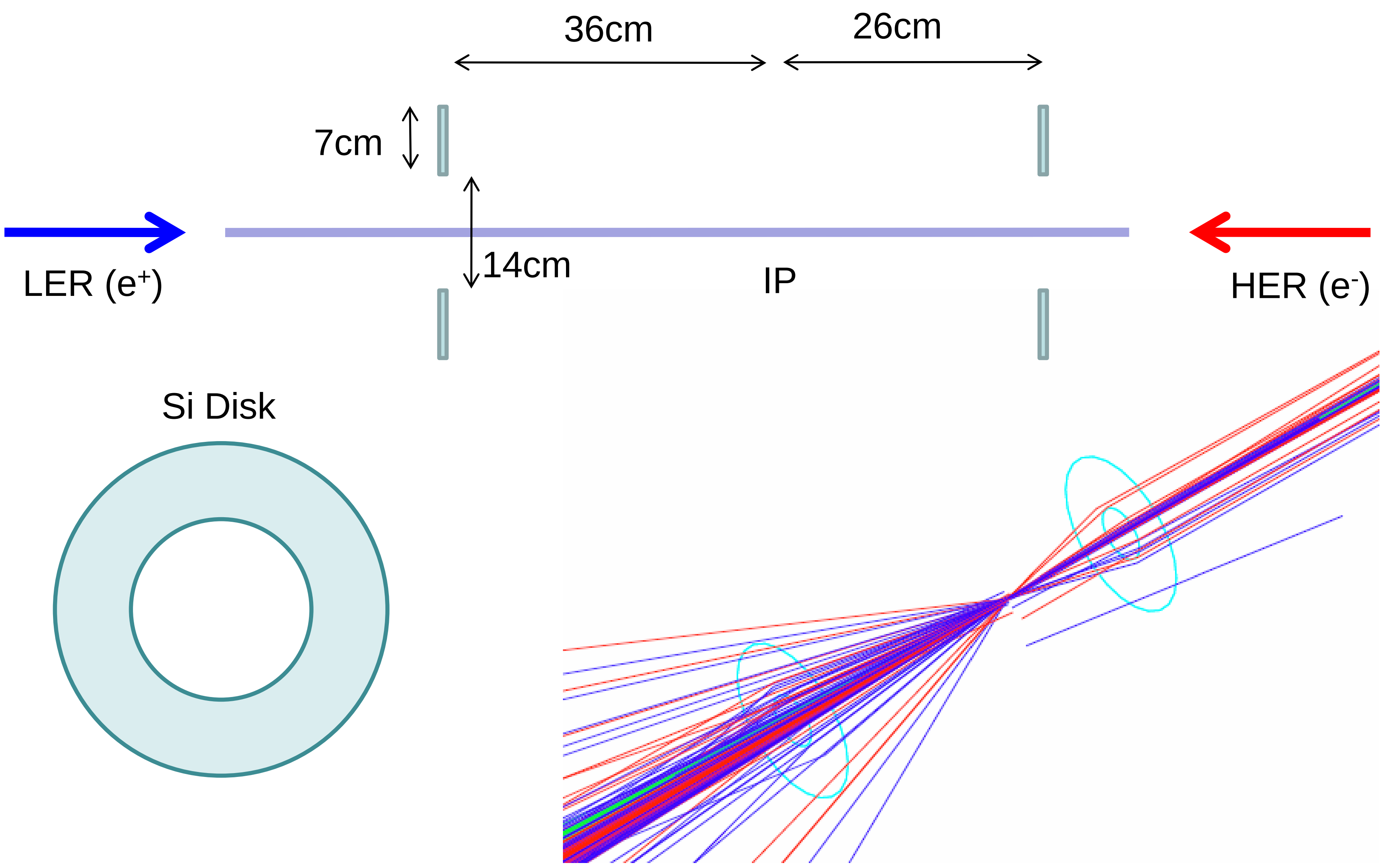
Geometry of the Si tracker





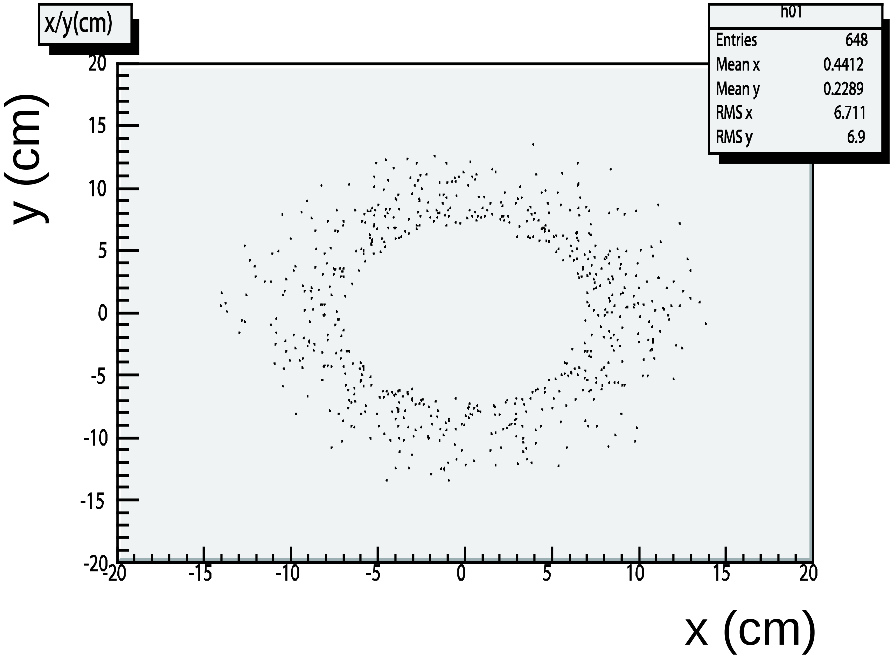
Geometry in the simulation

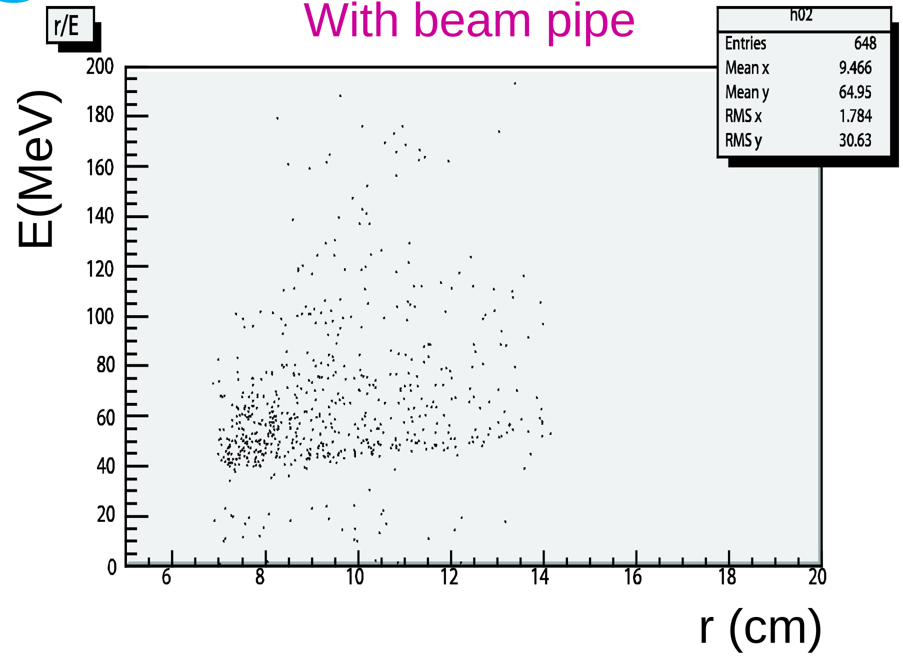
1^{st} layer Si Disk only

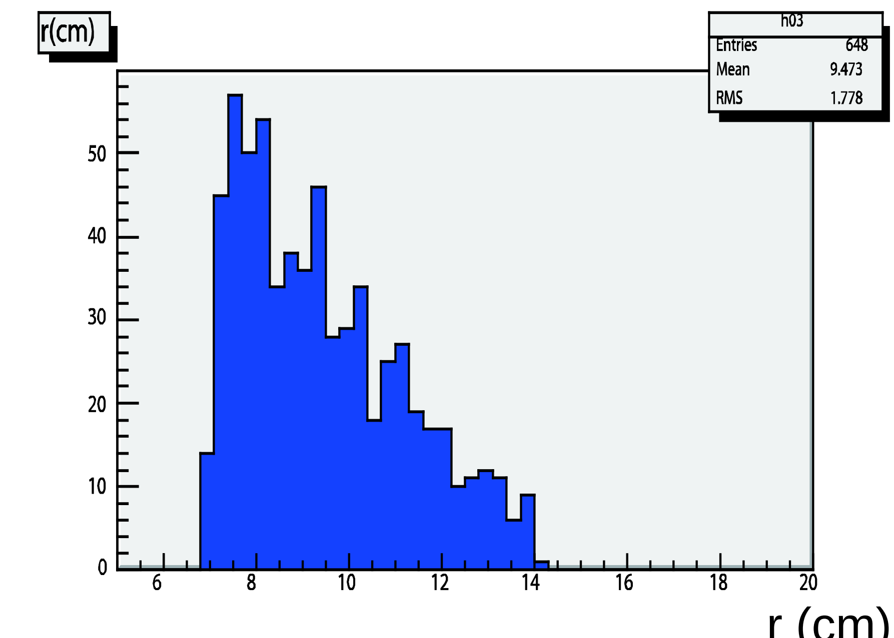


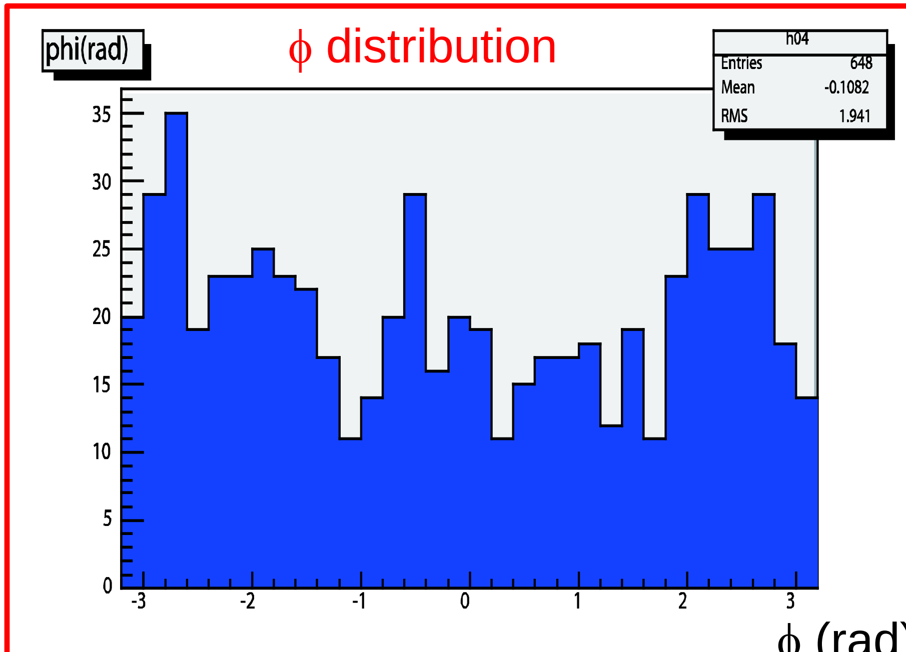
GEANT4 results

Nominal beam (for 10^{-2} sec)
With beam pipe



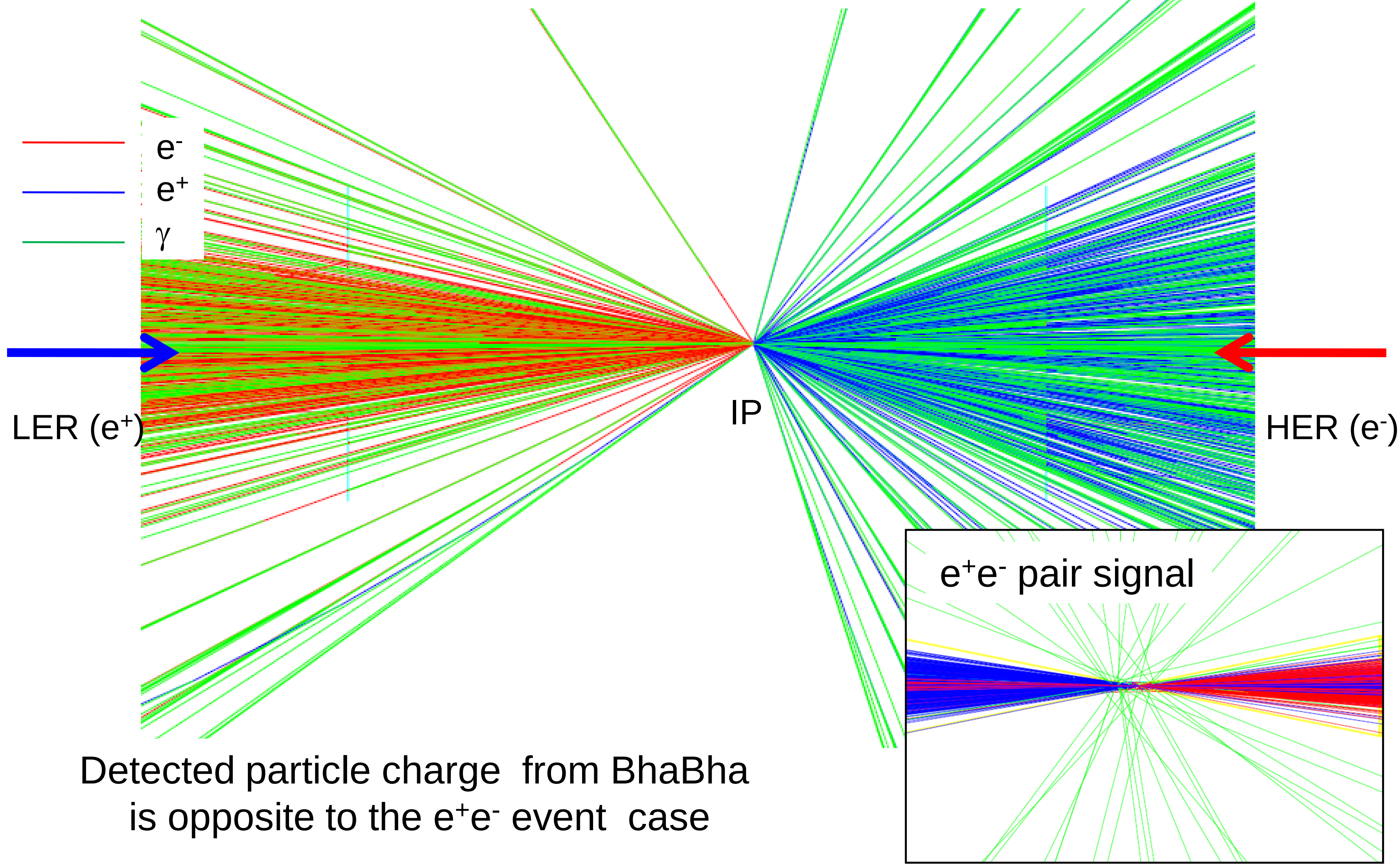






Radiative-BhaBha BG estimation

The main BG source of the e^+e^- pair → radiative BhaBha

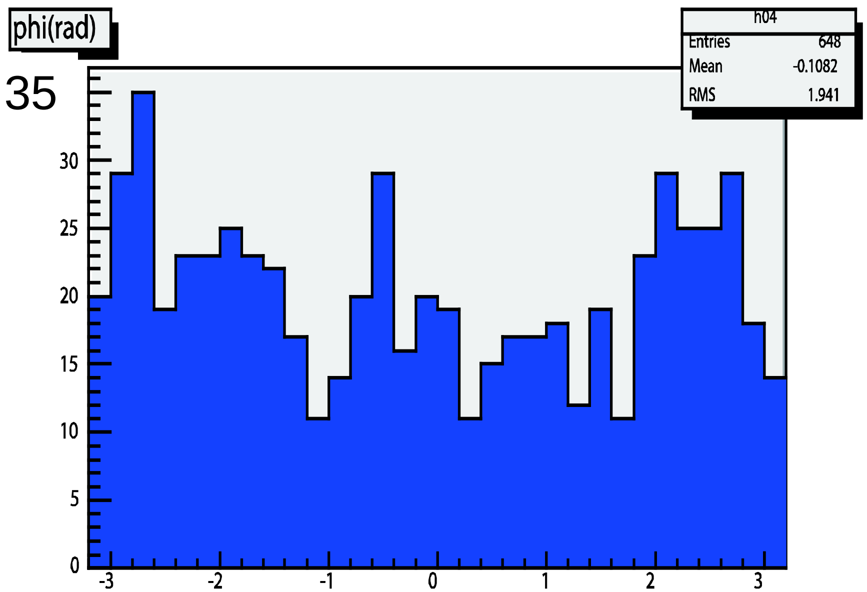


Detected particle charge from BhaBha is opposite to the e^+e^- event case

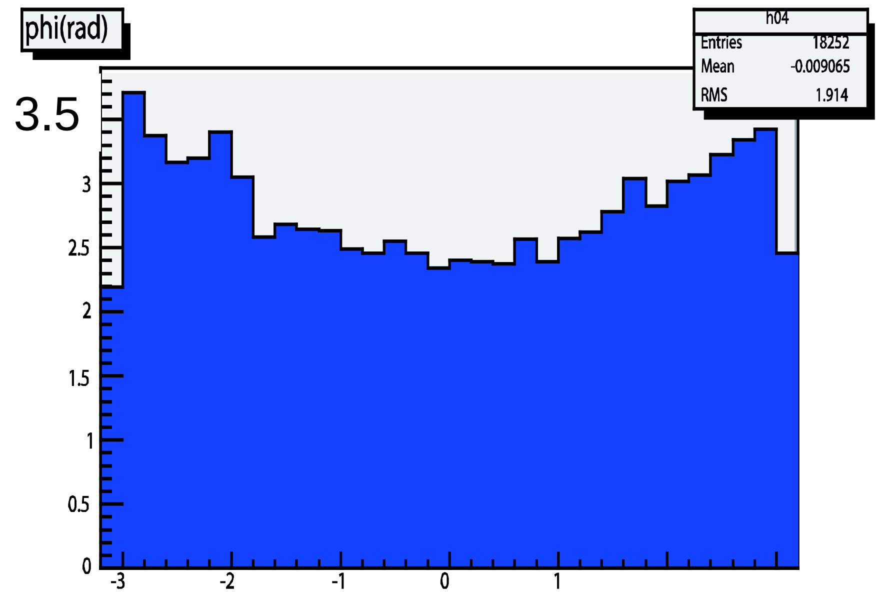
ϕ distribution : e^+e^- pair vs BhaBha

(for 10^{-2} sec)

e^+e^- pair



BhaBha



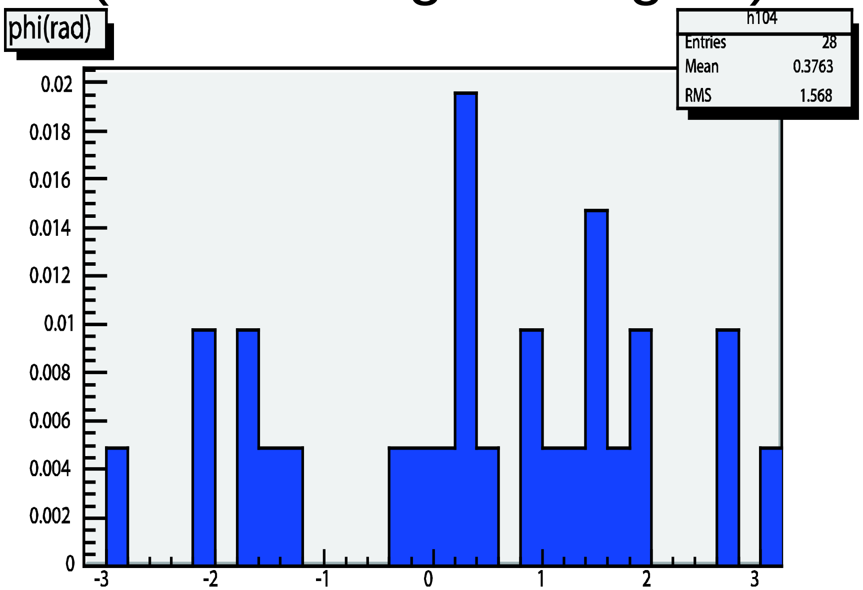
ϕ (rad)

Radiative-BhaBha BG → ~10% of e^+e^- pair

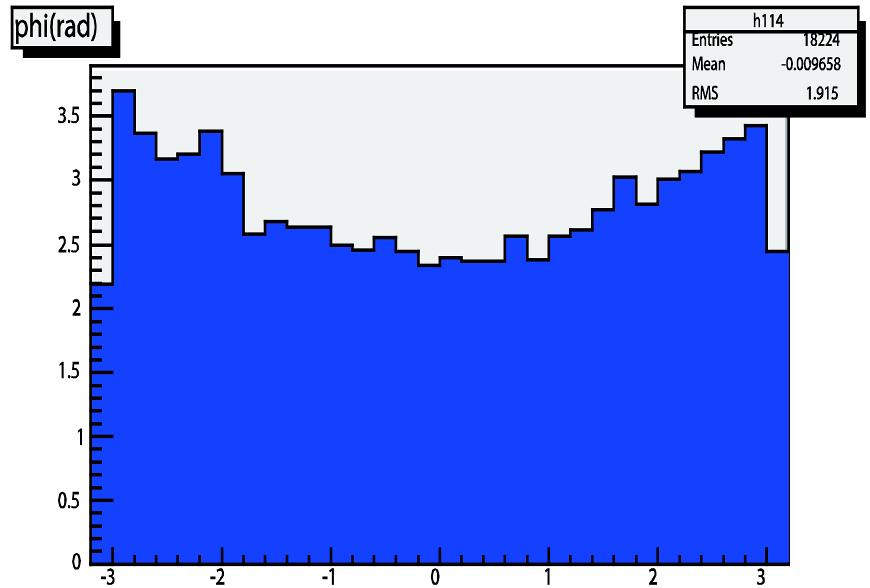
BhaBha BG estimation :
If we have charge information

LER-side disk (for 10^{-2} sec)

e^- (same charge as signal)



e^+



ϕ (rad)

If we have charge information, BhaBha BG can be ignored

→ Self-tracking by 3-layer Si Disk?!

Trigger consideration

At first, we assume to use the APV25 chip for the Si Disk readout

→ gate width = 150 nsec

- 1st priority should be the physics trigger
- For the beam-size measurement,

we want to take data via random trigger

1. Measure the beam size at the beginning of the shift

   Random trigger rate = 10kHz

   To take the 1/100 sec data, we need

   (1/100 sec) / (10kHz * 150 nsec) ~7sec.

   → We like to use ~1 min. to measure the beam-size / shift

2. Measure the beam size stability every hour

   (By accumulating 1 hour data)

   To accumulate 1/100 sec. data in 1 hour:

   we want the random trigger rate of 20Hz

Summary

We just start considering the Si disk forward tracker

1) The 1st priority is for the physics
- We need simulation studies
  B reconstruction, missing particle analysis, etc..
- Based on the simulation, we design the Si tracker

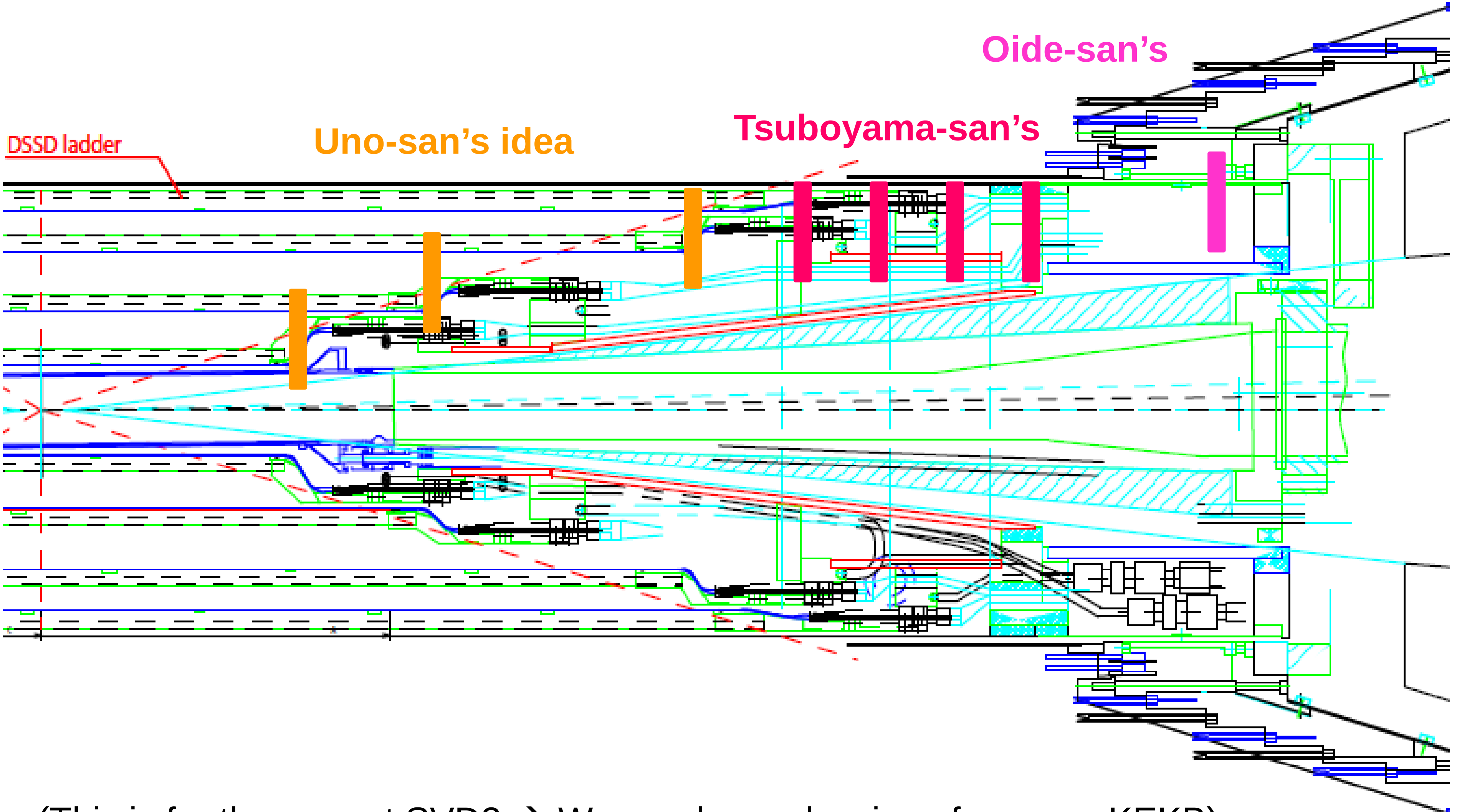
2) We also like to measure the beam-size if possible
- Further simulation studies
- BG rejection by self-tracking with the 3-layer Si disk?

3) To design the forward tracker, we need to consider
- Magnetic field non-uniformity near the final Q-system
- Space around the IP region

New contributions are highly appreciated!

Back up

Where can we put the Si disks?



(This is for the current SVD2 → We need new drawings for super-KEKB)

Incoherent pair simulation

Incoherent pair generation and beam-beam simulation with CAIN based on the Super-KEKB beam parameters

Setup

β_x, β_y at IP =(38.14, 1.00)mm ε_x, ε_y =($6.43*10^{-08}$, $4.8*10^{-10}$) rad·m

σ_z = 5mm

N_p = $1.2*10^{11}$(LER) $0.5*10^{11}$(HER)

#bunch = 5000 T_{rep} 10^{-5} sec Gaussian tail cut off = 4.5σ

E_{beam} = e+ 3.5GeV e- 8.0GeV

Crossing angle 30mrad Crab angle 15mrad+15mrad (= head on)

CAIN results

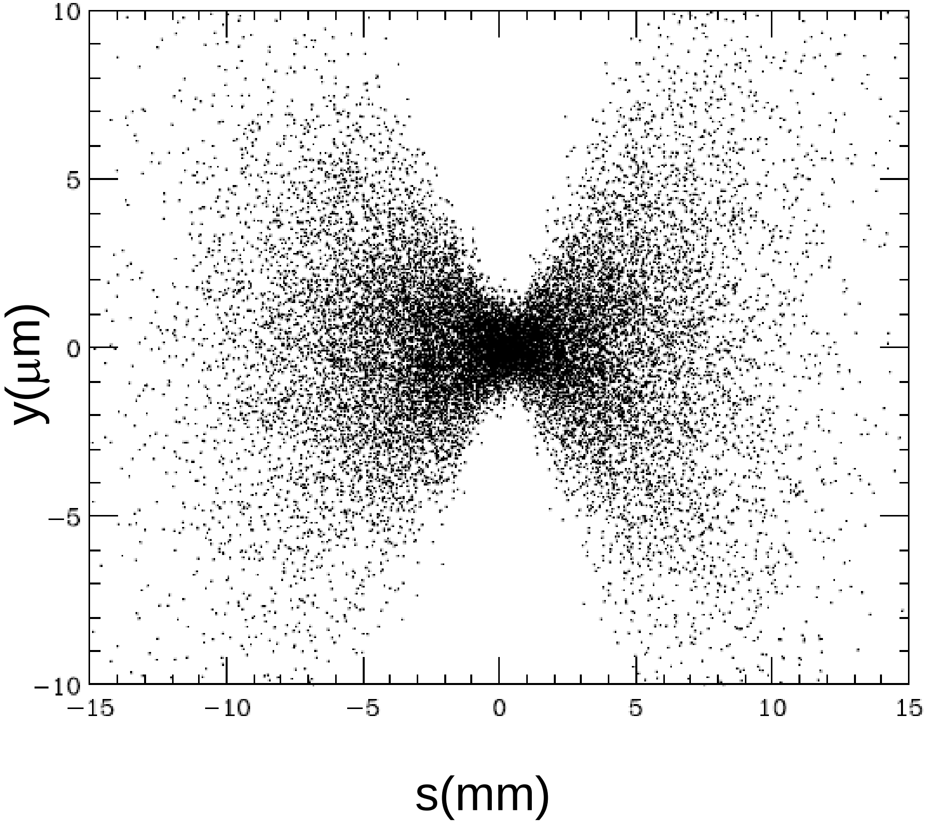
Luminosity = 2.91E35

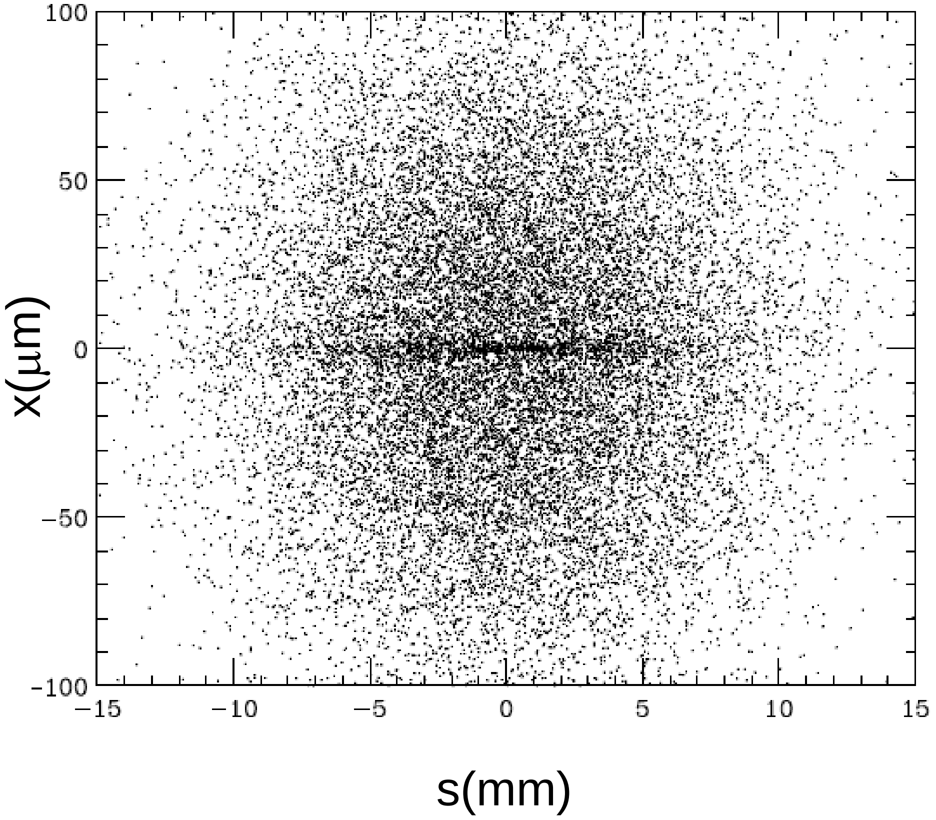
#pairs in a bunch = 1.82pair(e^+ direction) + 2.21pair(e^- direction)

(#γ in a bunch = 4.8E9 (e^+ direction) +5.0E9 (e^- direction))

CAIN results

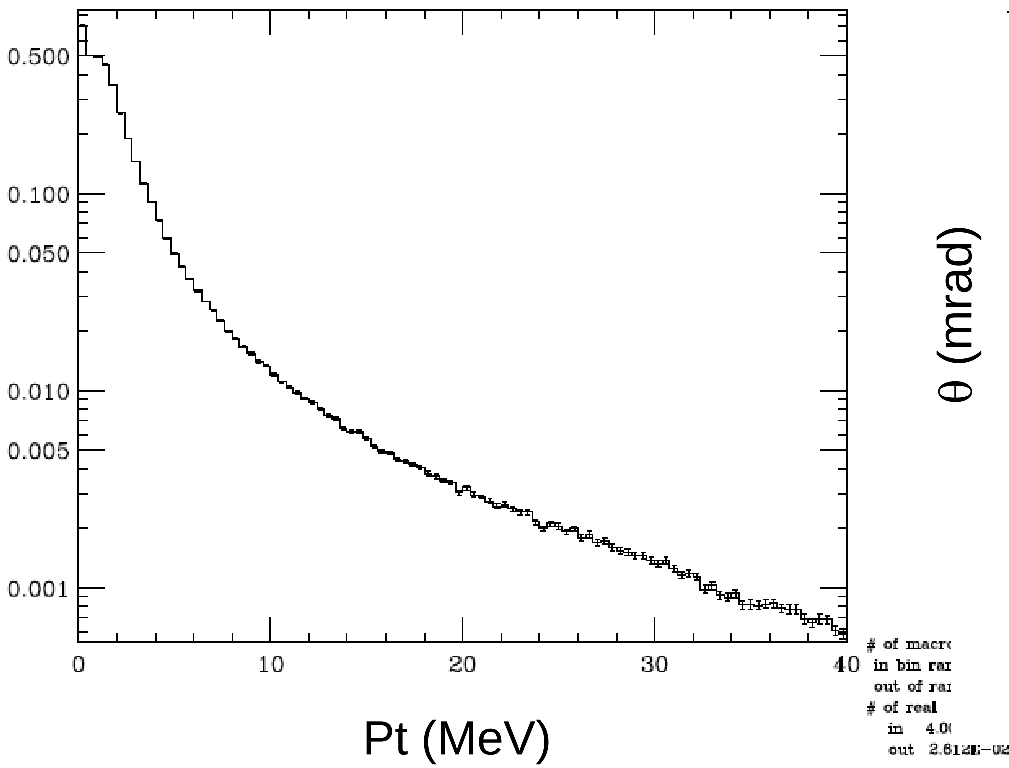
Electron Profile at T=0



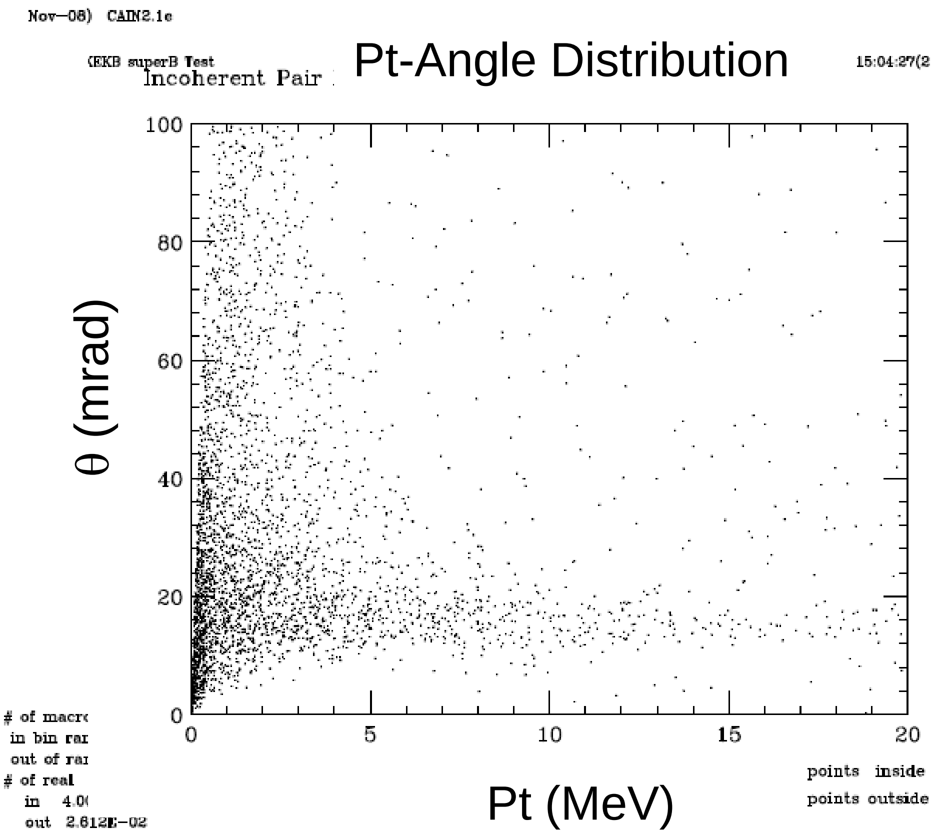


CAIN results

Incoherent Pair Pt Spectrum (for a bunch)



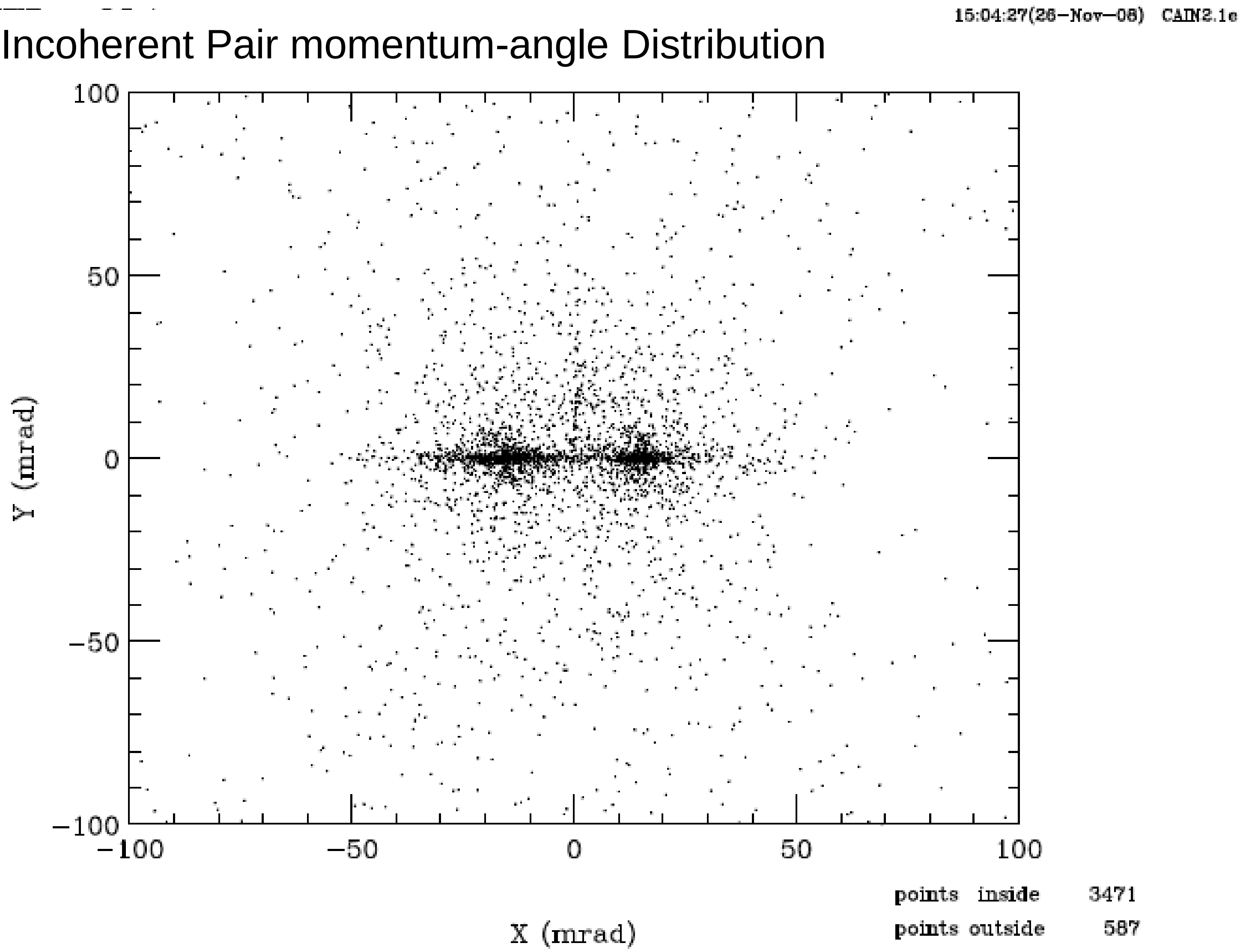
Pt-Angle Distribution



~10^6 pair particles / sec can reach to the detector region (r>1.5cm)
(r>1.5cm → Pt > ~10MeV under 1.5T)

CAIN results

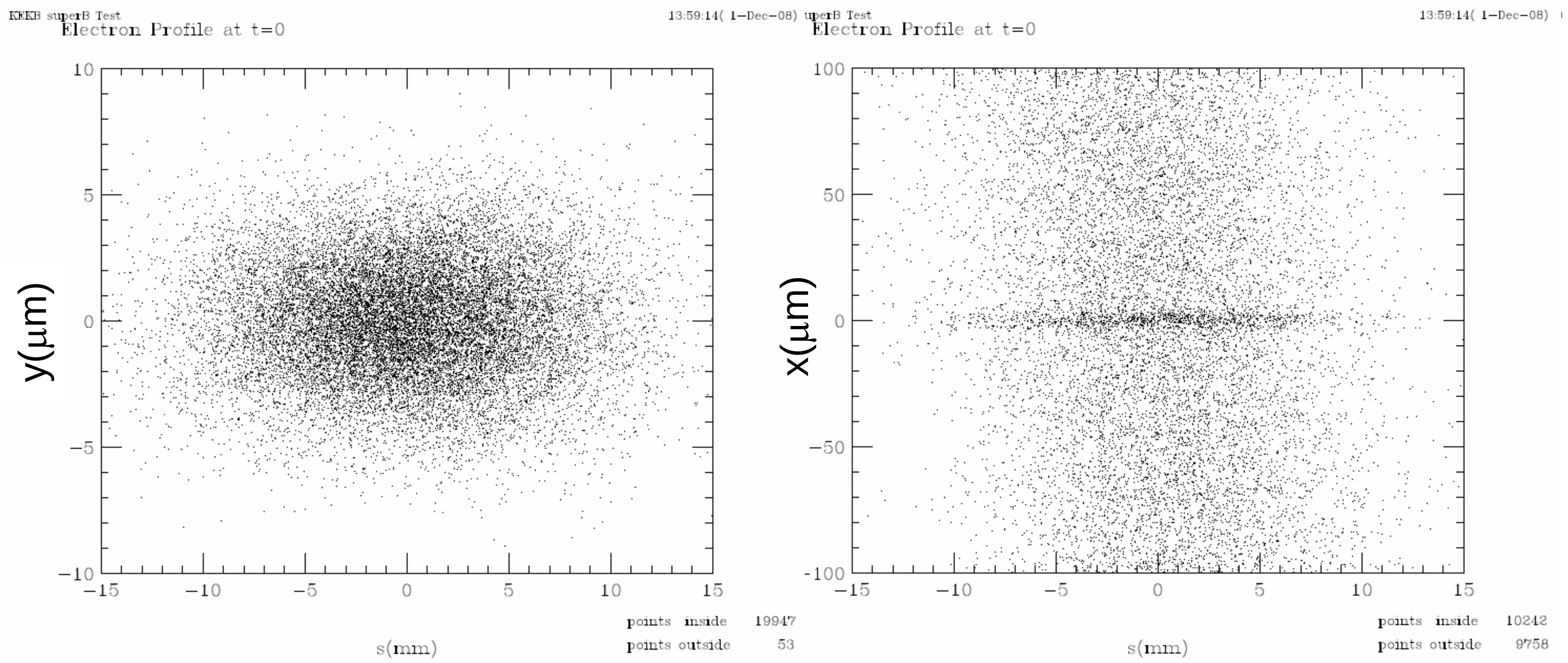
Incoherent Pair momentum-angle Distribution



There is some non-uniform ϕ-distribution → information of the beam size

CAIN results (for KEKB)

Electron Profile at T=0

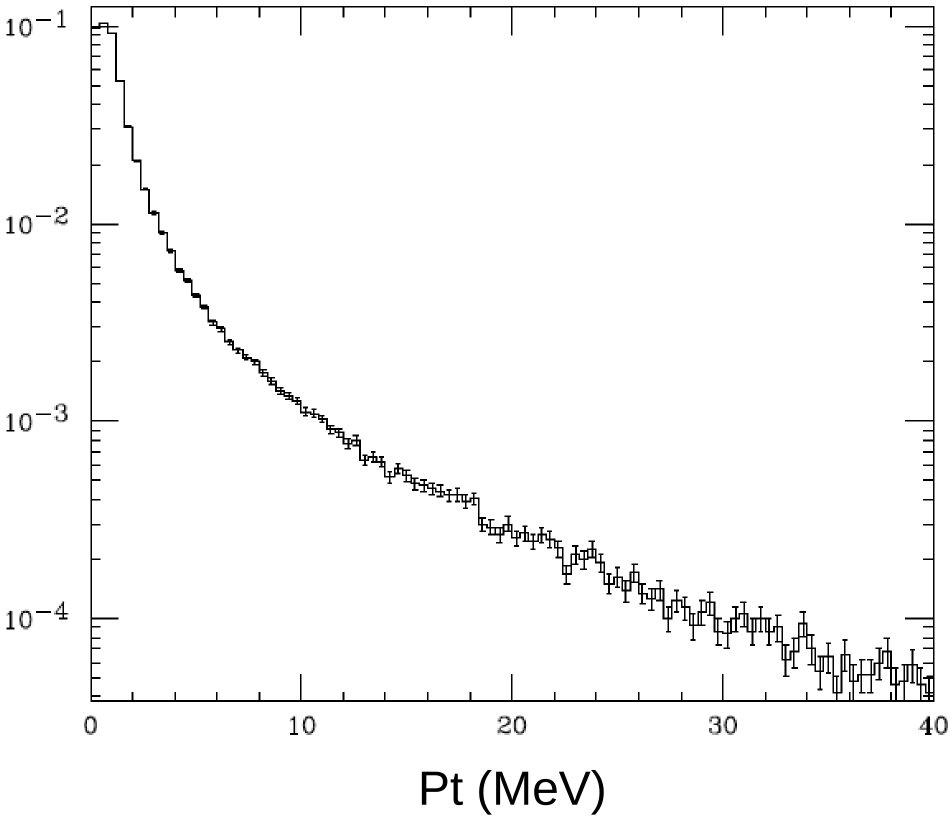


s(mm)

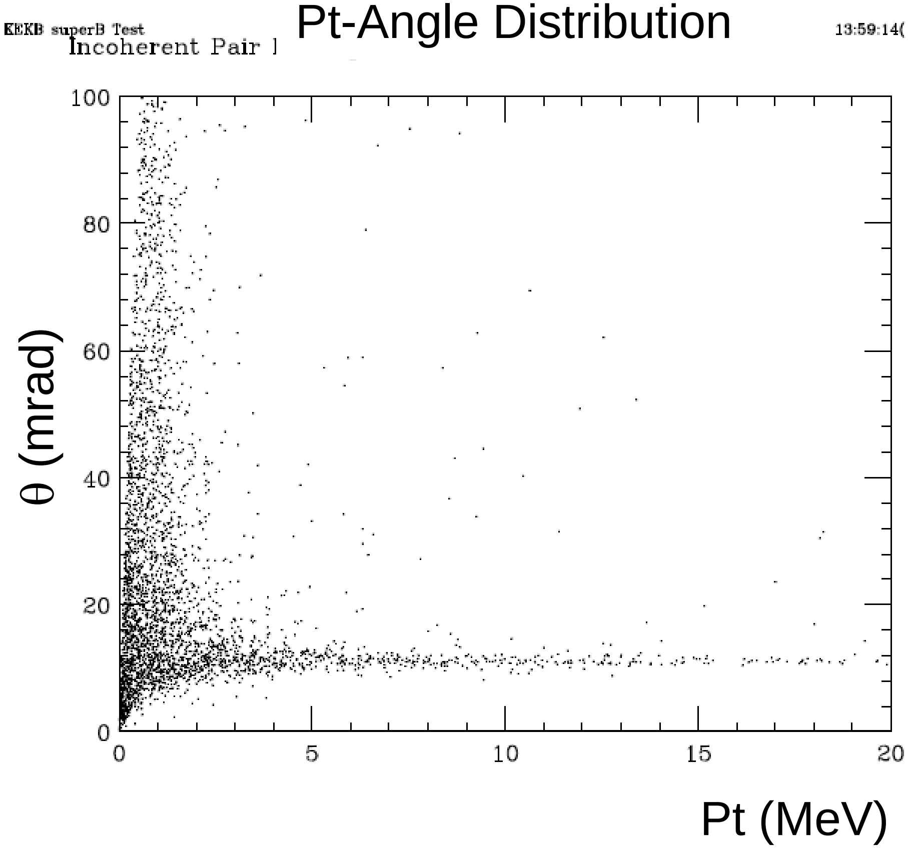
s(mm)

CAIN results (for KEKB)

Incoherent Pair Pt Spectrum (for a bunch)



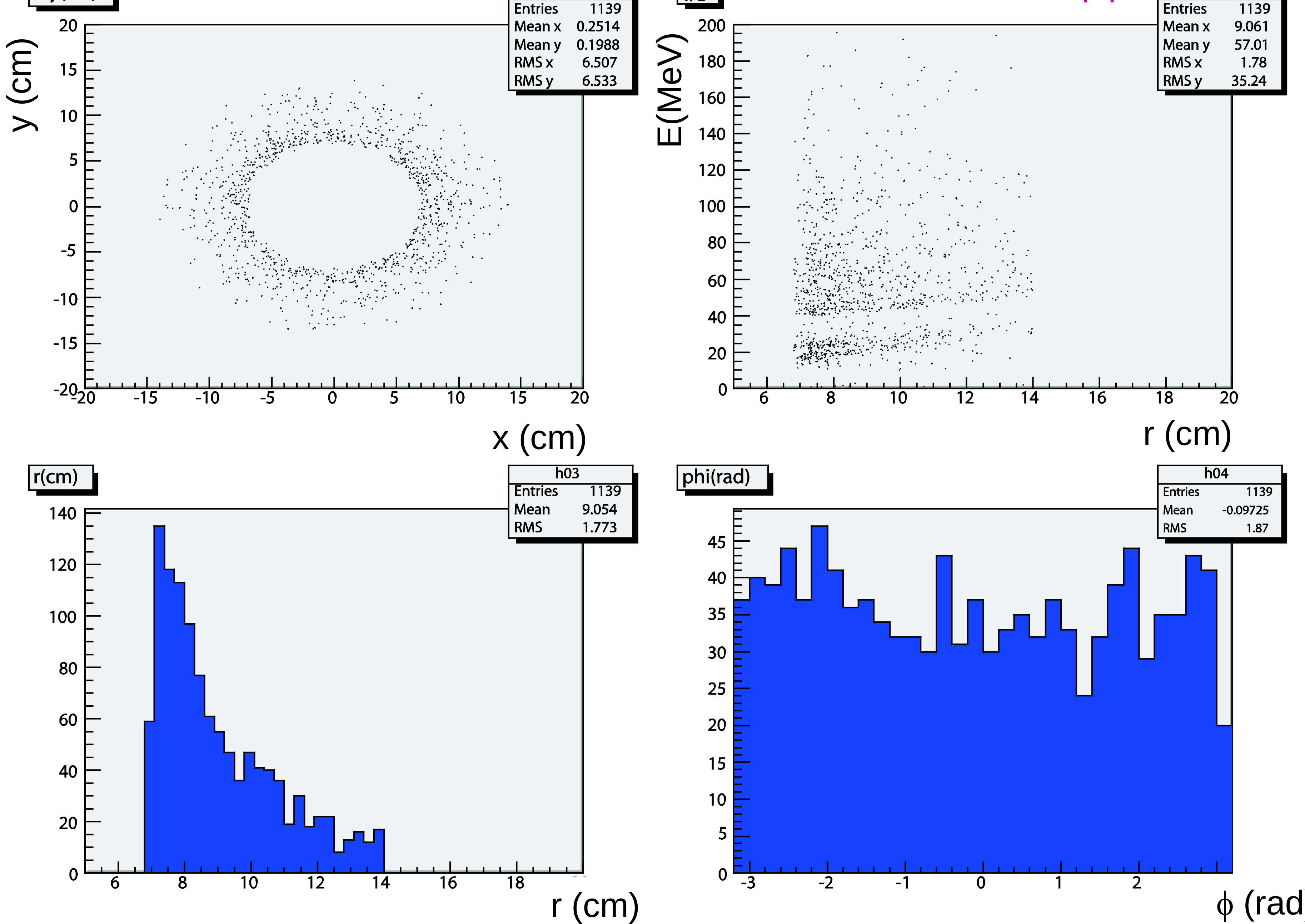
Pt-Angle Distribution



- 1-2 order smaller numbers of the Pt>10MeV pairs than that for super-KEKB
- The angle of the pair particle direction (for Pt>10MeV) is very small
  - → **It is very difficult to use the pair monitor for current KEKB**

GEANT4 results

Nominal beam (for 10^{-2} sec)
Without beam pipe



Radiative BhaBha simulation

Using BHLUMI, we generate the BhaBha events

Setup

CMS energy = 10.95GeV

θ_min(CM) = 140 mrad θ_max = 1000[mrad]

→ 8 [deg] – 57[deg] in CM

BHLUMI results

σ = 168.9 nb

generate = 1000,000 events

→ corresponds to ~2 sec data

(at Luminosity = 2.91E35 by CAIN)