Beam-beam diagnostics
→ introduction

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LAL-Orsay

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Issues for discussion

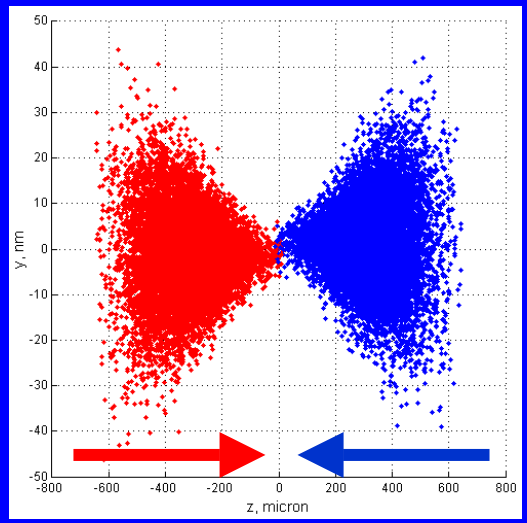
- Beam-beam signals to tune / measure → luminosity (fast)
  electromagnetic deflections, disruption, beamstrahlung,
  incoherent & coherent pairs, Bhabhas, radiative Bhabhas

- Integration : 2 interaction regions
  3 detector concepts

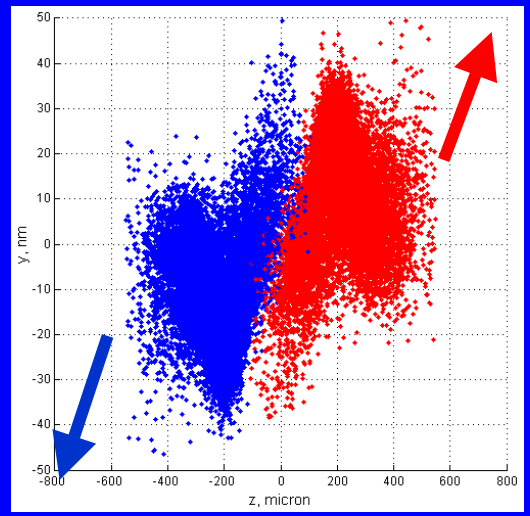
- Instrumentation : development
  feasibility with backgrounds

Beam-beam mutual focusing

simulate collision with initial Δy offset



detectable post-IP deflection



main tool at SLC (and LEP)

SLAC-PUB-6790

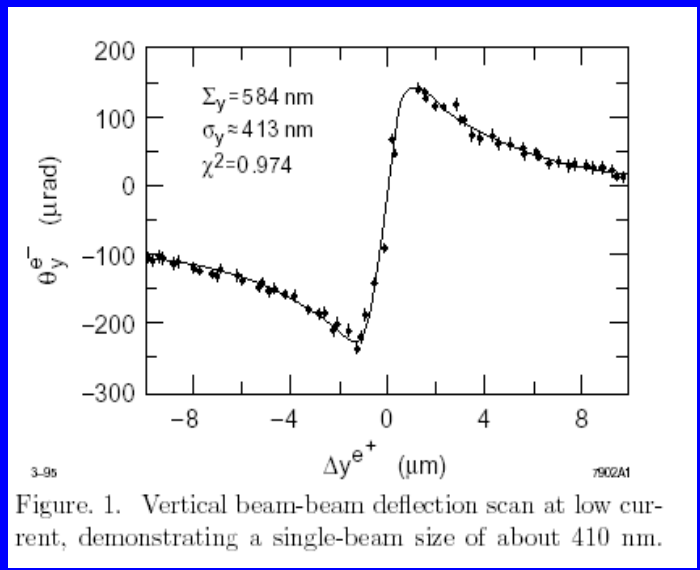
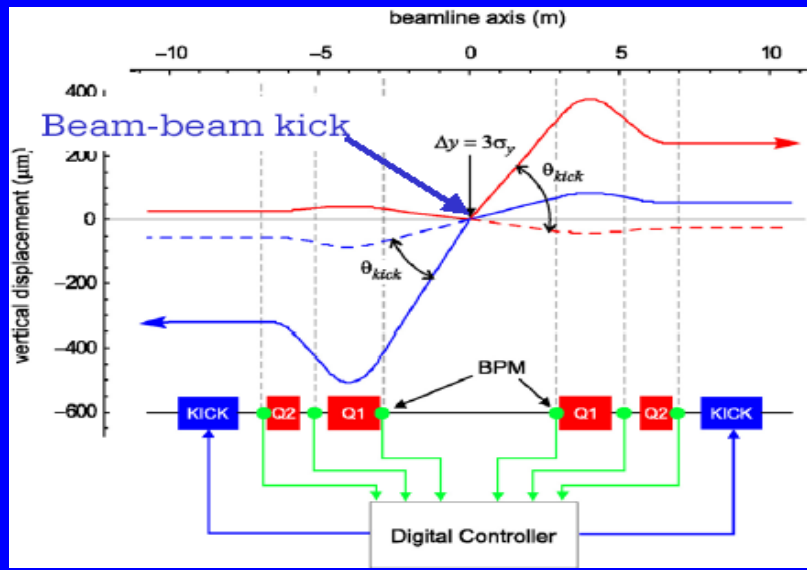


Figure. 1. Vertical beam-beam deflection scan at low current, demonstrating a single-beam size of about 410 nm.

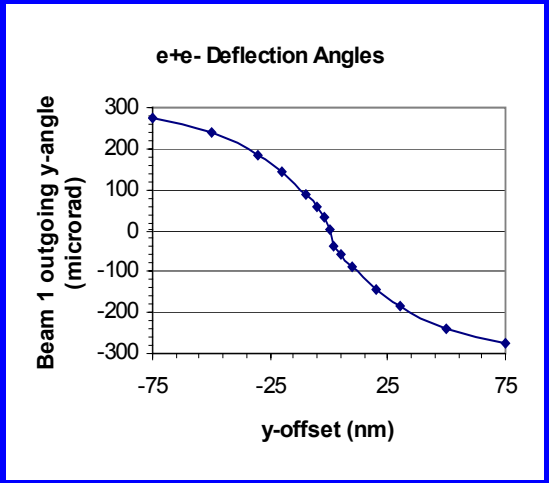


Questions for beam-beam deflections

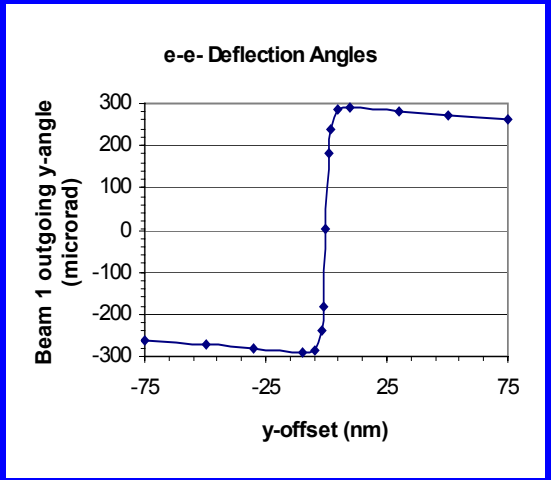
- Primary tool beam centering tool (feedback !)
  $\rightarrow$ importance of redundancy (e.g. other signals…)
- Beam size information (combine with other methods)
- Simulate / test BPM performance with (high) background
- Directional BPM for 2 mrad scheme
- Disruption angle imaging in extraction line
- Case of e-e- collisions

Beam-beam effects for e-e- collisions *

e+e-



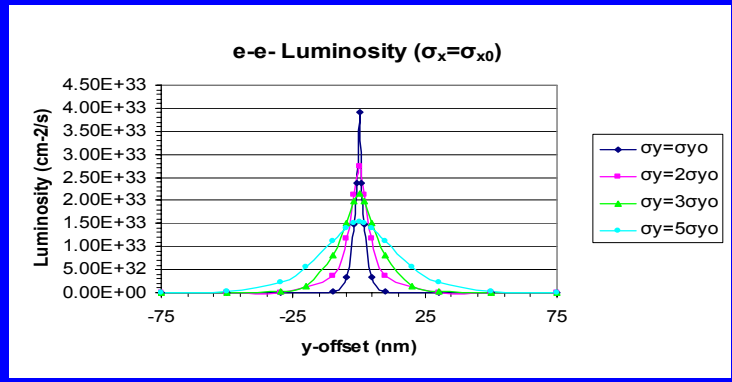
e-e-

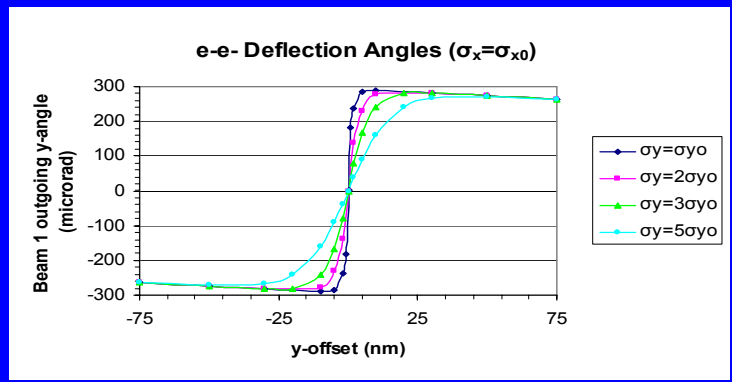


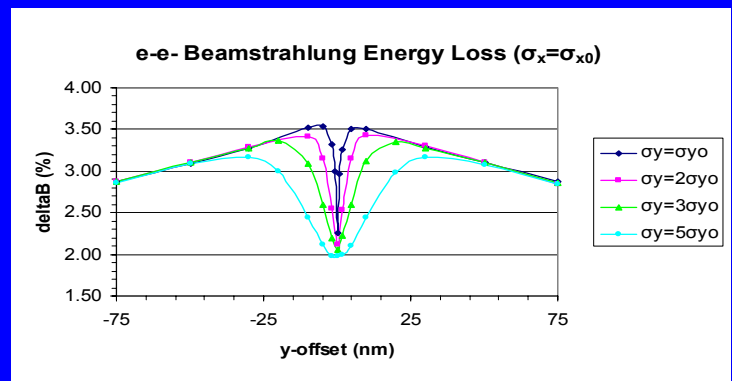
L

Δy'

ΔE



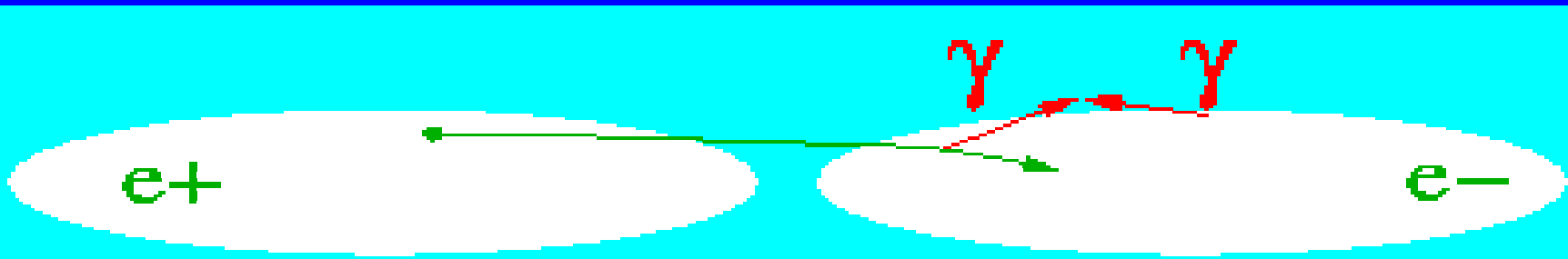




Δy

* M. Alabau and A. Faus-Golfe, University of Valencia

Secondary particles from beam-beam field



Beamstrahlung photons, e+e– pairs, hadrons, muons
Bhabhas, radiative Bhabhas

~ 1.5 beamstrahlung γ / e $\rightarrow$ 360 kW / beam

~ 100000 e+e– with <E> ~ 3 GeV $\rightarrow$ 300 TeV / crossing

~ 20000 e+e– γ events / crossing with E < 100 GeV

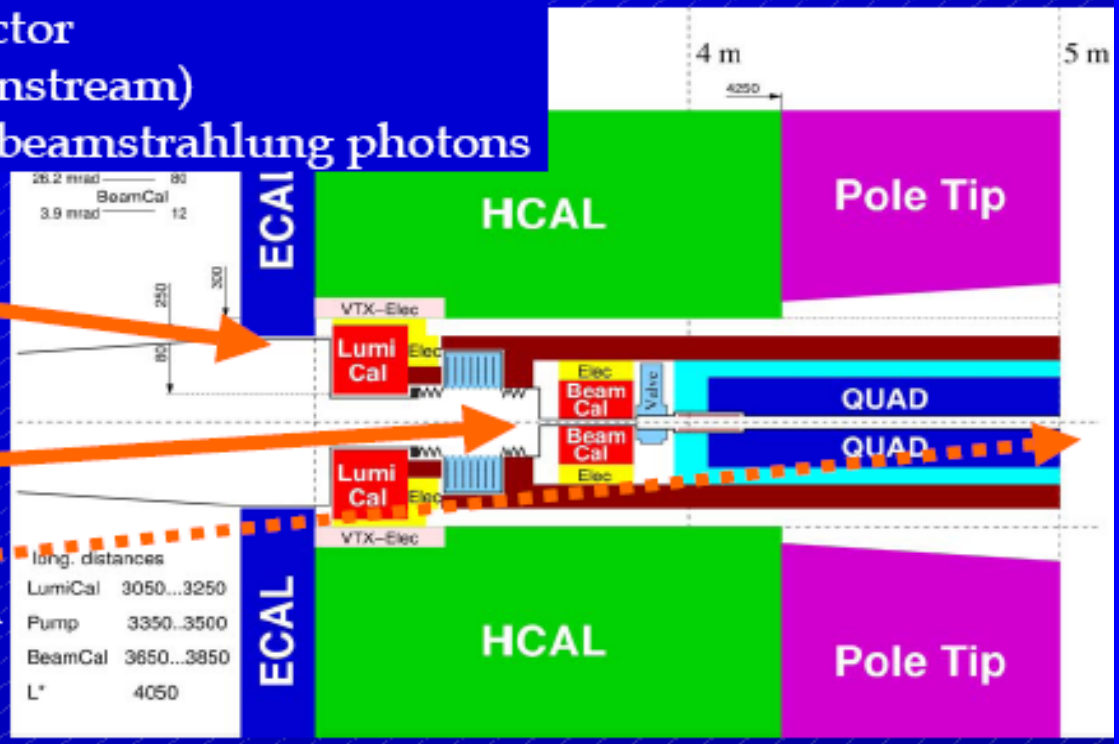
Very Forward Region

- BeamCal:
  - detection of electrons/photons at low angle
  - beam diagnostics from beamstrahlung electrons/positron pairs
  - shielding of Inner Detector
- Photocal (not drawn ~ downstream)
  - beam diagnostics from beamstrahlung photons

(LumiCal: 26 < θ < 82 mrad)

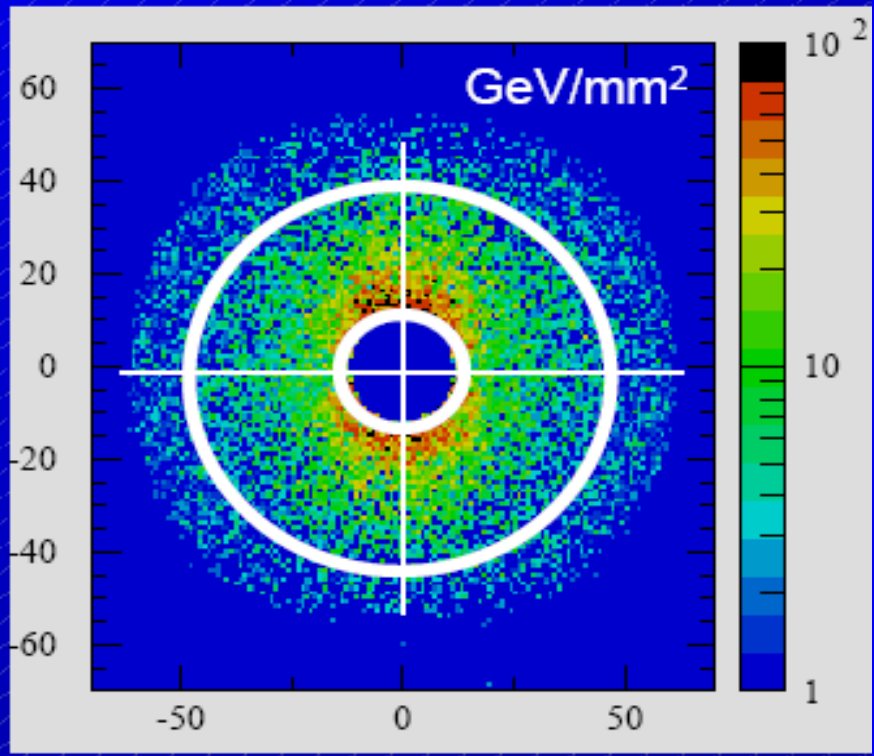
BeamCal: 4 < θ < 28 mrad

PhotoCal: 100 < θ < 400 μrad
(recent idea, not mentioned in TESLA TDR, distance to IP > 100m)



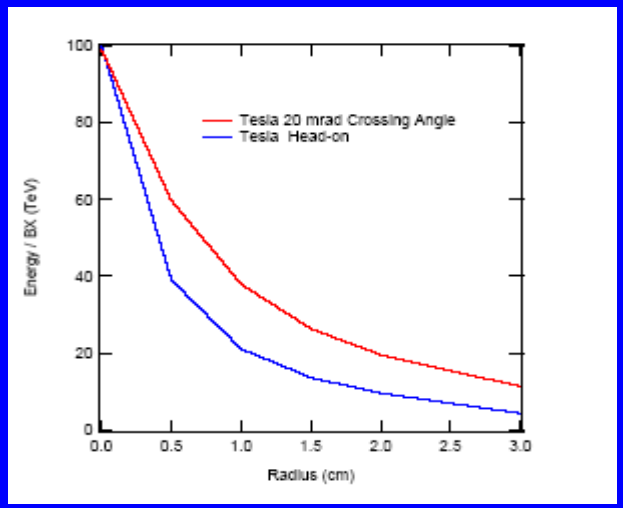
Beamstrahlung Pairs

- Observables (examples):
  - total energy
  - first radial moment
  - thrust value
  - angular spread
  - E(ring ≥ 4) / Etot
  - E / N
  - left/right, up/down, forward/backward asymmetries

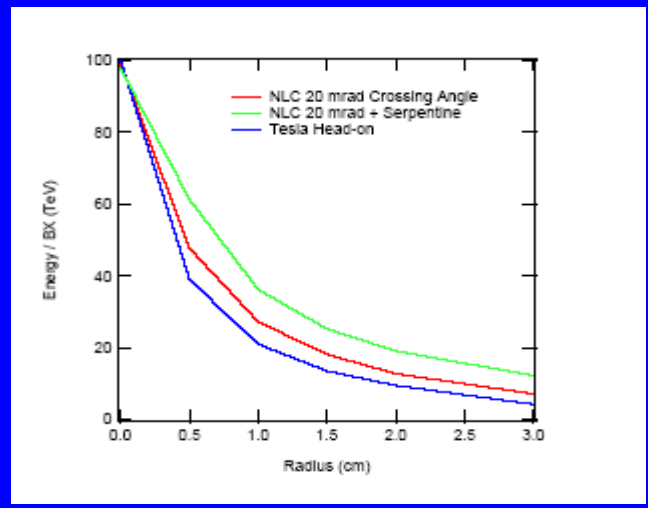


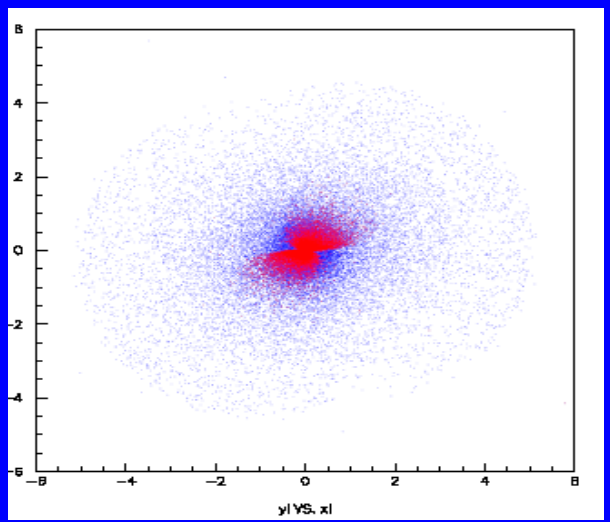
detector: realistic segmentation, ideal resolution
bunch by bunch resolution

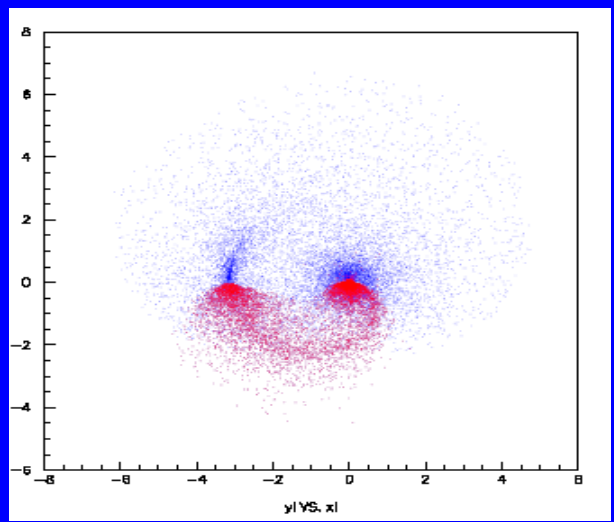
Increased pair deposition from 20 mrad + solenoid local compensation → analysis

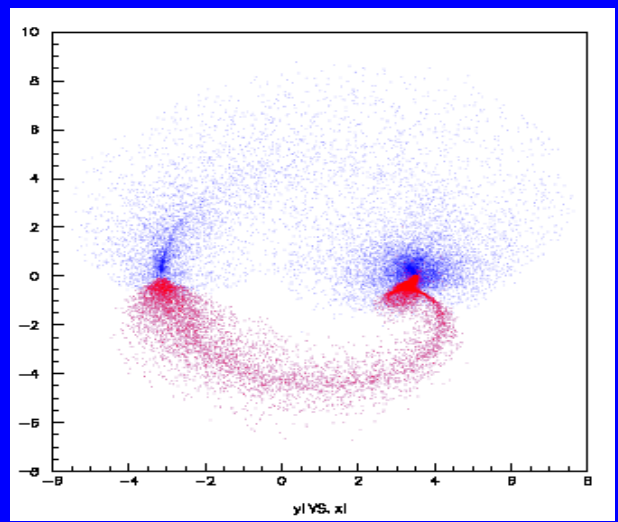


T. Maruyama









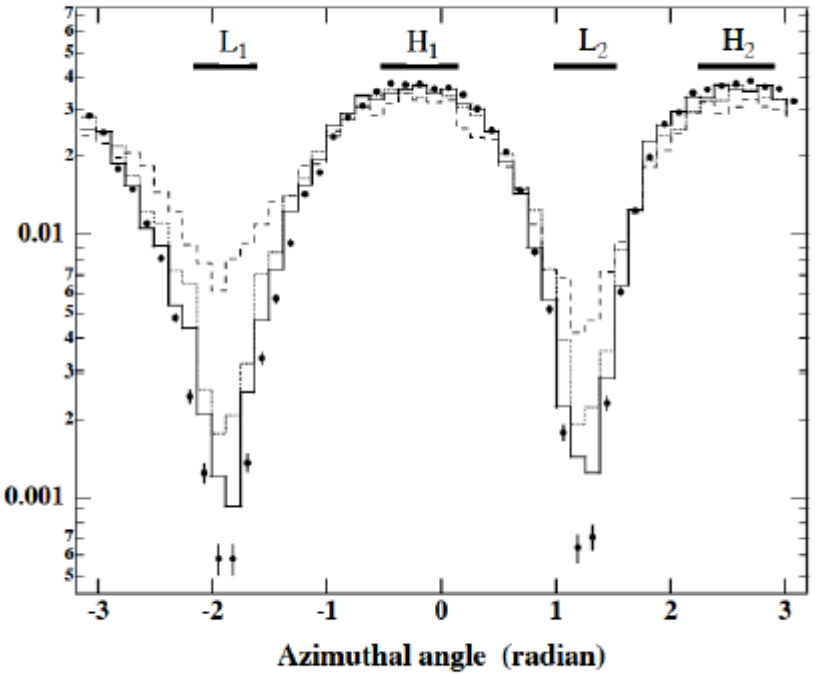
H. Yamamoto

Form ratio

$$R_{pv} = \frac{L_1 + L_2}{H_1 + H_2}$$

Round beam $\rightarrow$ no ϕ dependence,
ϕ dependence $\rightarrow$ σ_y/σ_x ratio.

Find regions where σ_y information exist



$6 < r < 7$cm, $\sigma_y = n \times \sigma_y^0 : n = 1, 2, 3, 10$ (GLC)

σ_y resolutions

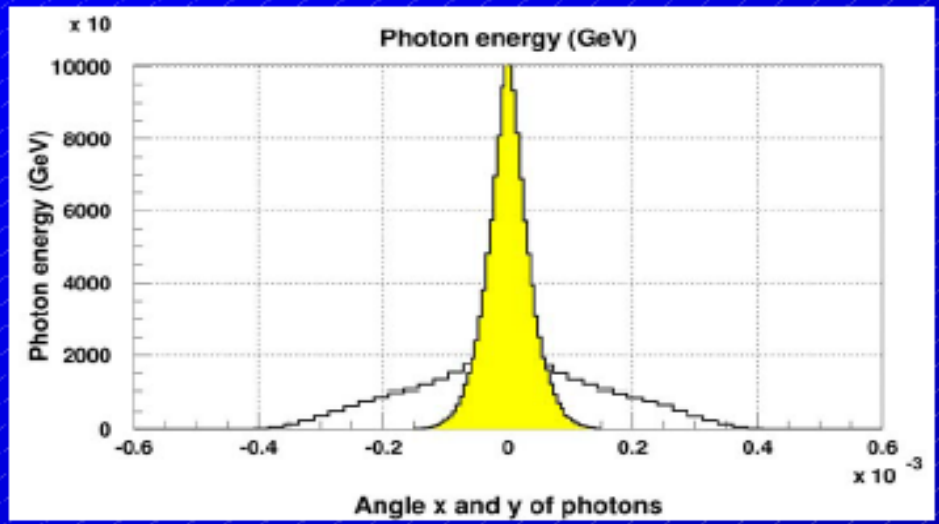
Tesla-500 parameters, 20 readings/train
Average resolution of $2 \times \sigma_y$ and $4 \times \sigma_y$

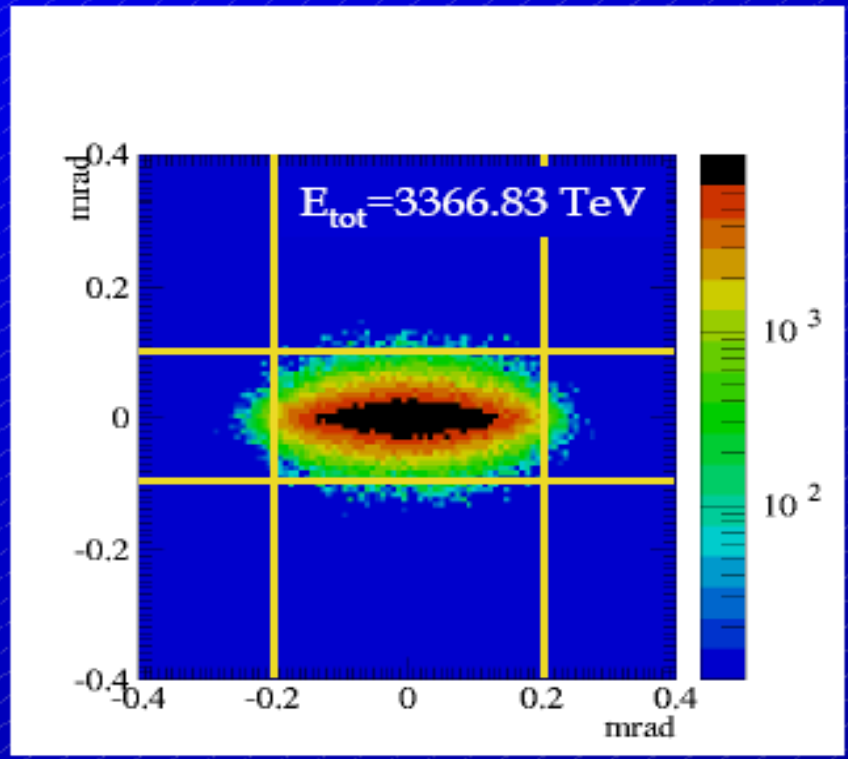
		3T	4T	5T
z = 400cm	0mrad	11%	13%	13%
z = 400cm	7mrad	9%	11%	12%
z = 400cm	20mrad	22%	19%	28%
z = 176cm	20mrad	12%	15%	20%

Caveat : Resolution depends on the selection of sampling regions.

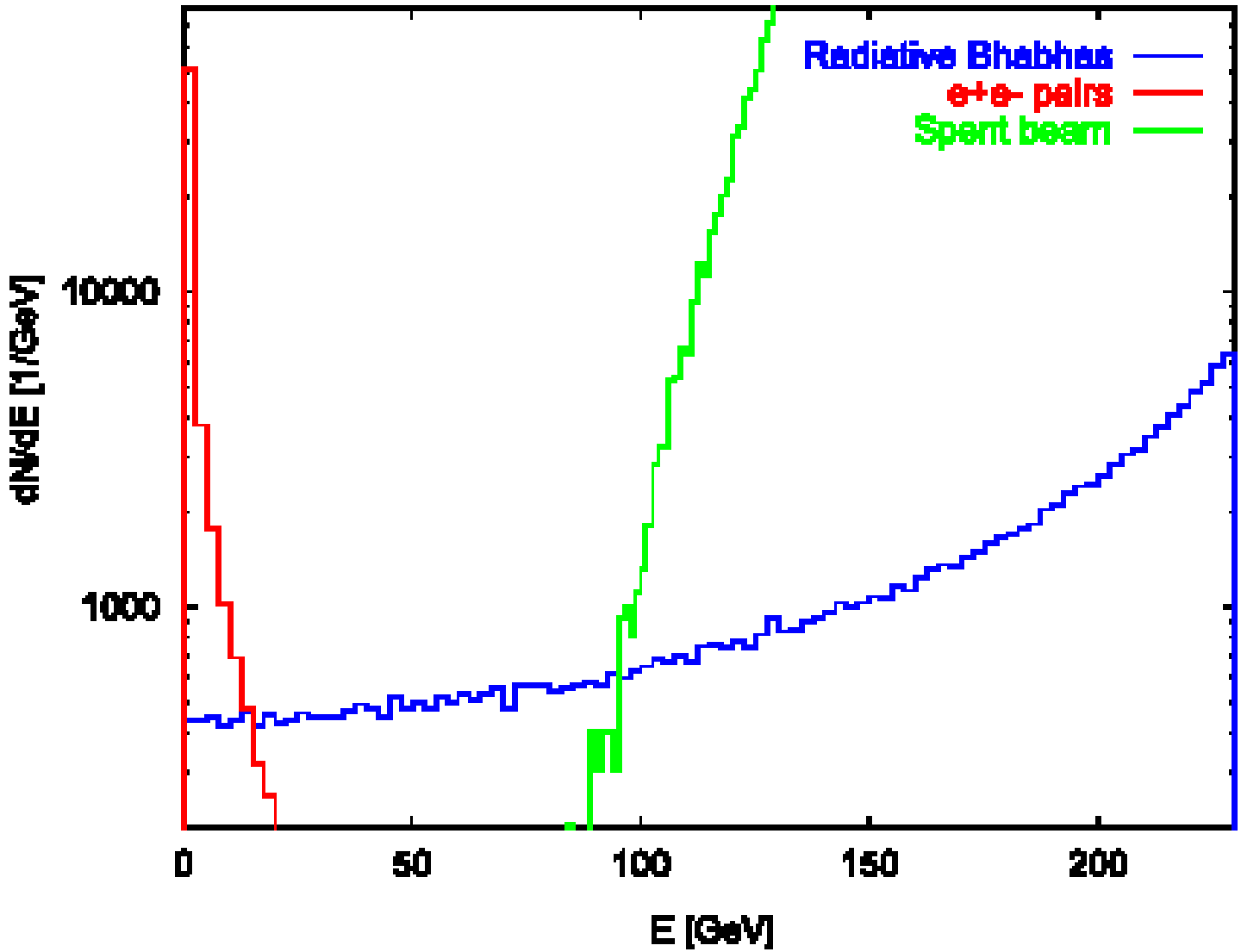
Photon Distribution and Selection

- Photon selection:
  |angle x| > 0.2 mrad
  |angle y| > 0.1 mrad





nominal setting
(550 nm x 5 nm)


Radiative Bhabhas
e+e- pairs
Spent beam
dN/dE [1/GeV]
10000
1000
0
50
100
150
200
E [GeV]