# MDI Overview

T. Tauchi, KEK

ILCでの測定器に関する研究会
3 March, 2005, KEK

# What is MDI ?

MDI is Machine Detector Interface.

Machine : Beam Delivery System (BDS)
from LINAC-end to beam dump

collimation, energy/polarization, final focus,
extraction (energy/polarization) and beam dump

Detector : Interaction Region

experiment (physics; Higgs, Top, W/Z, SUSY, extra-D ...)

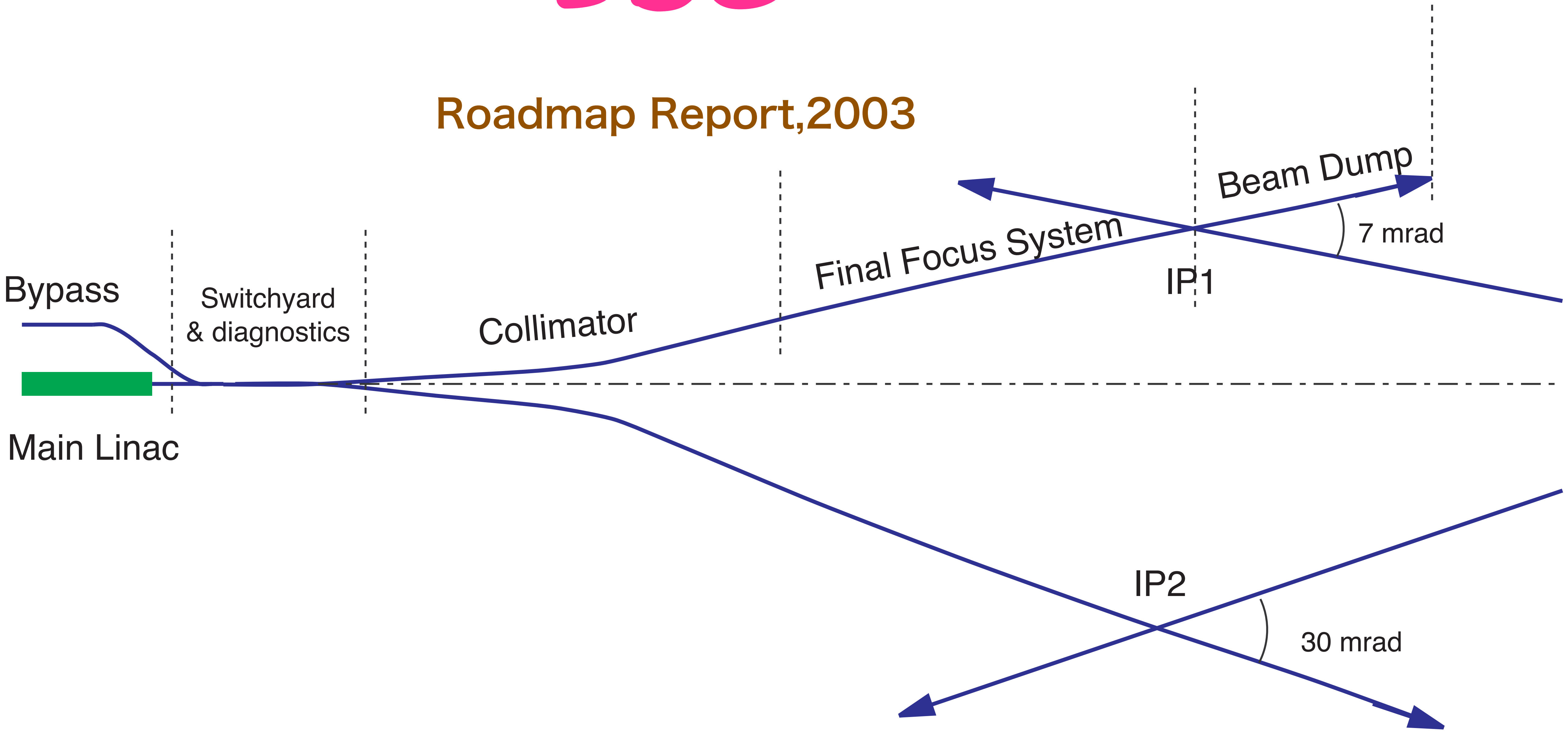
luminosity, background and minimum veto-angle

# Primary Role of MDI

Major task of MDI is to compile requirements from the experimental side in order to communicate the accelerator physicists for designing the BDS.

# BDS

Roadmap Report,2003




**Crossing angle** **(headon, V–0.3mrad, 2mrad, 7mrad, 20mrad, >30mrad@γγ)**

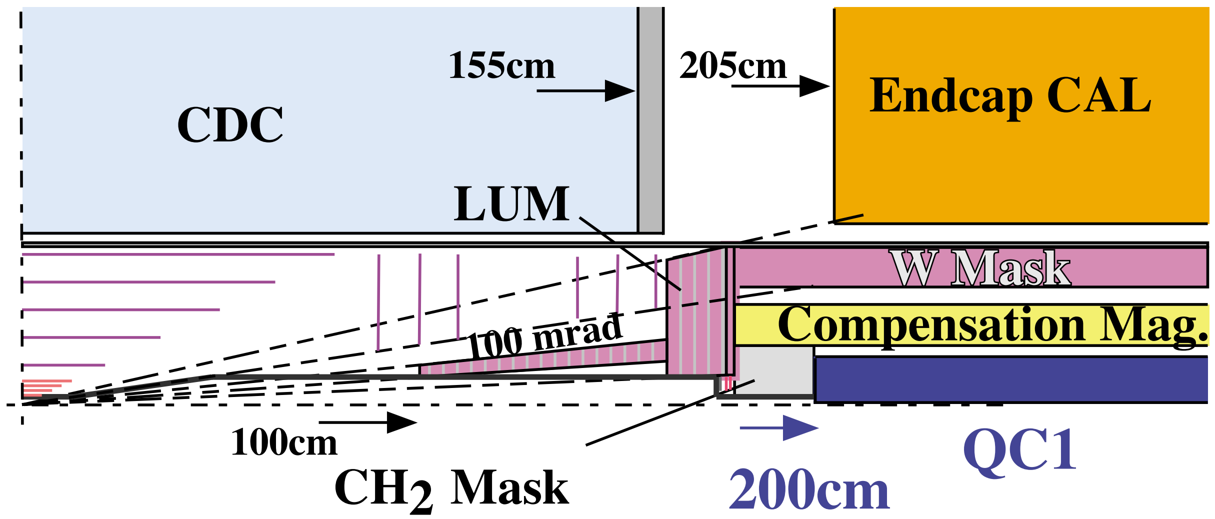
**2 IP's for 2 "identical experiments"**

**Precise energy and polarization measurements**

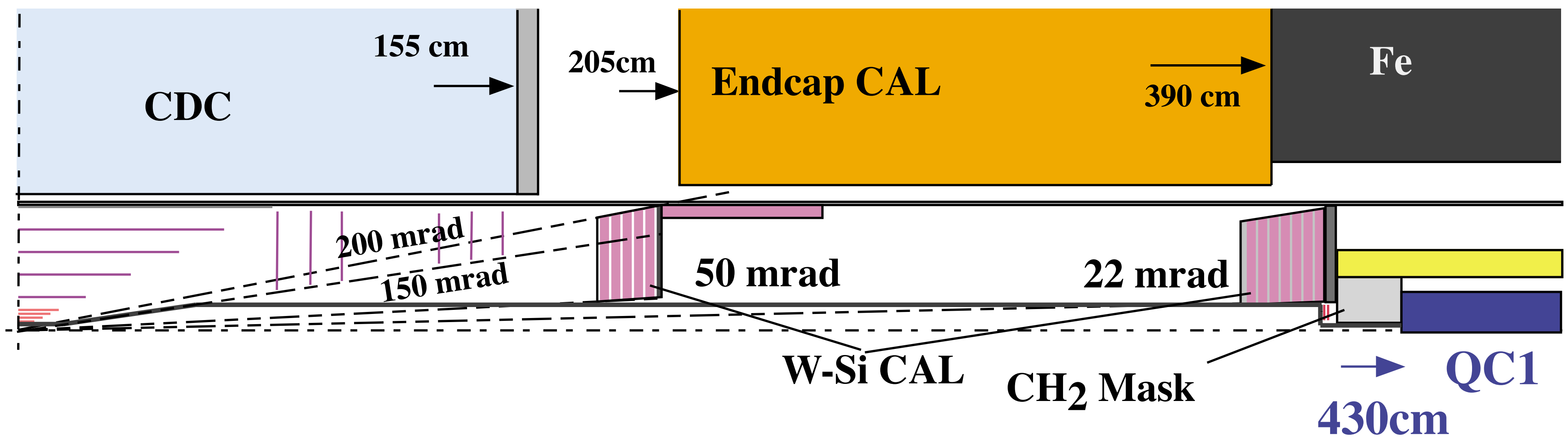
Backgrounds (muons and synchrotron radiations)

# IR

Y. Sugimoto, LCWS2000




L*=2m




L*=4.3m

**L* : Distance of QC1 from IP**

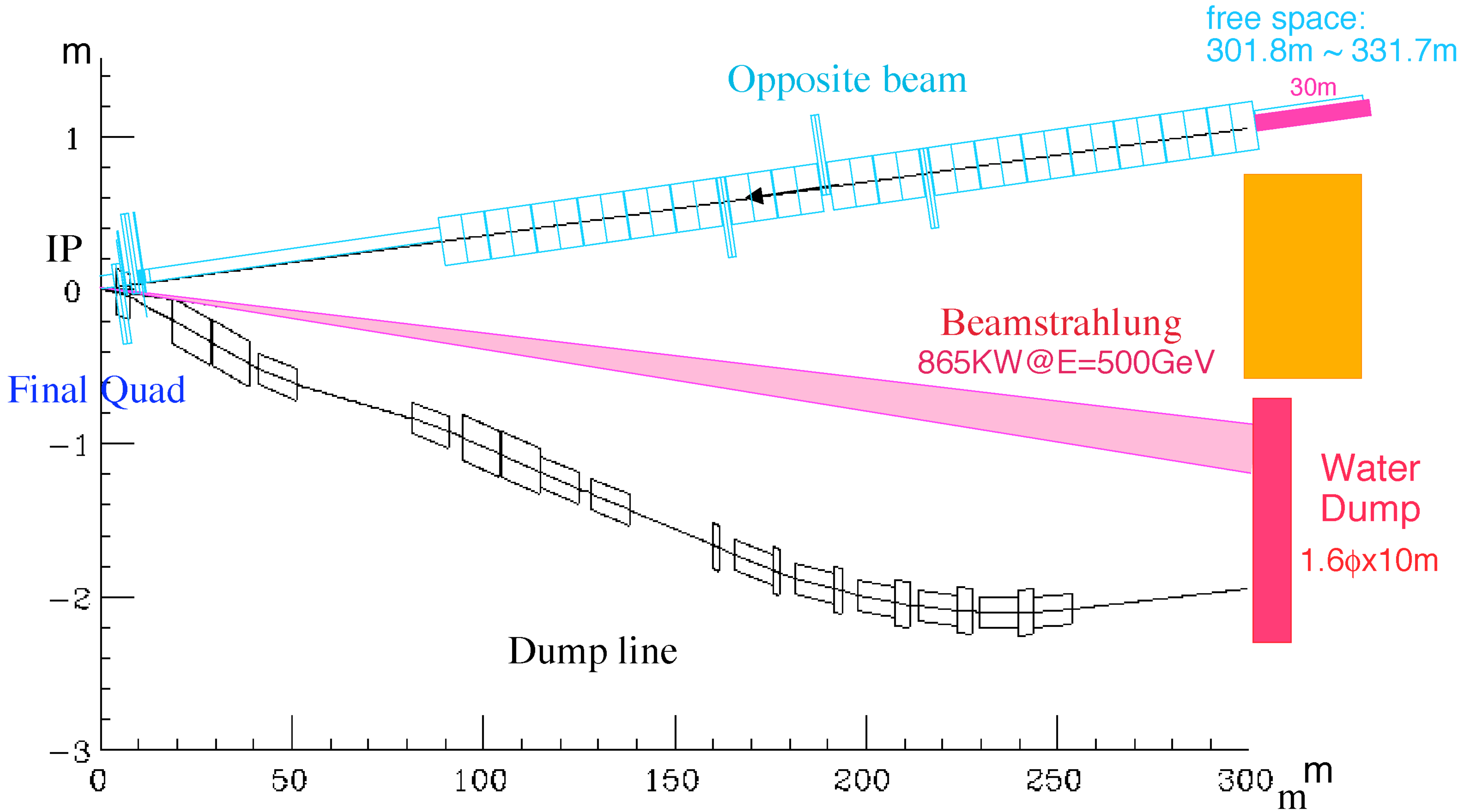
Vertex R ( the innermost radius )

Minimum veto-angle (very forward calorimeter)

Backgrounds (pairs, mini-jets, backscattered γ and n)

Instrumentations (pair monitor, feedback, Shintake monitor ...)

# BDS: Extraction Line




**Crossing angle**

**Choice of final quadrupoles ( L* )**

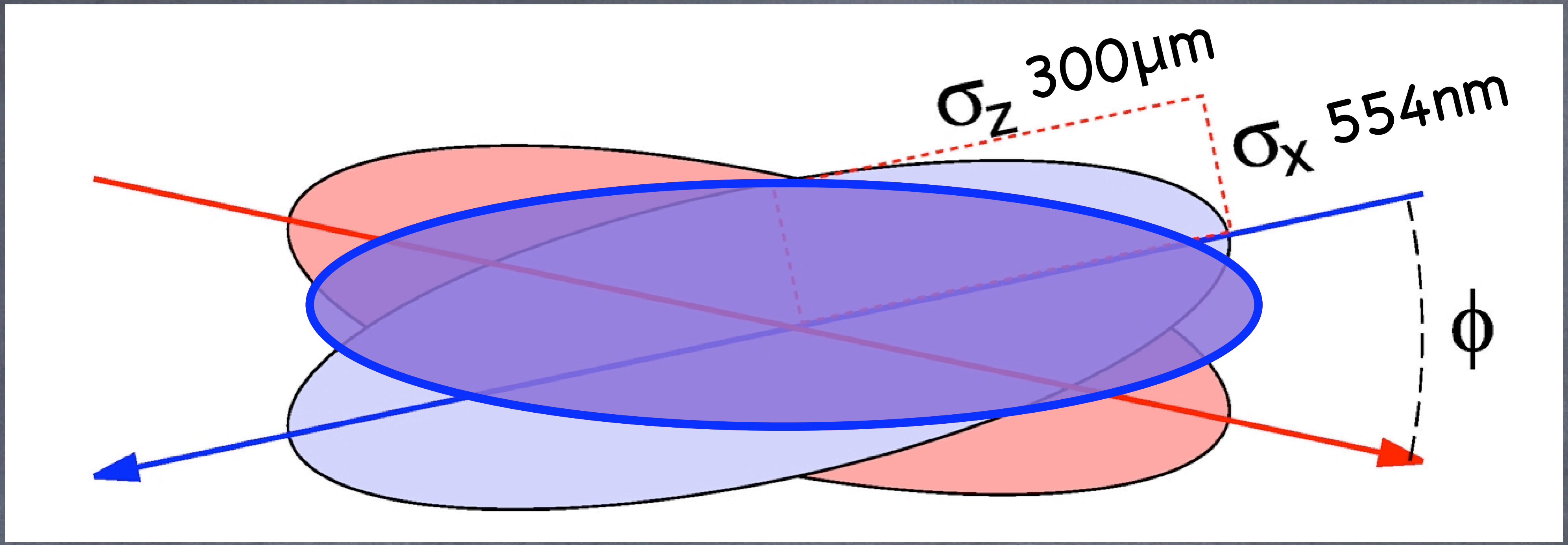
**Precise energy and polarization measurements**

Backgrounds (disrupted beam, back-scattered n and γ. )

# Summary of MDI issues

| System | Machine | Detector |
|---|---|---|
| **BDS** | Crossing angle<br>2 IPs; "identical" experiments<br>Collimation depth<br>Precise E/P measurements | Backgrounds: μ, synchrotron γ |
| **IR** | L* : distance of Final-Q from IP | Min. angle: very forward cal.<br>Precise luminosity measurement<br>Backgrounds; pairs, mini-jets, back-scattered γ, n<br>Instrumentation; pair/Shintake monitors, feedback, Nano-BPM, laser-wire etc. |
| **Extraction** | Crossing angle<br>Choice of Final-Q (L*)<br>Precise E/P measurements | Backgrounds; disrupted beam, back-scattered γ, n<br>Beamstrahlung monitor |

# Horizontal Crossing Angle




Small angle : $\Phi < 2\sigma_x/\sigma_z > \Phi$ : Large angle

**3.7mrad**

timing of two crab cavities
16(50)fsec at Φ=20(7)mrad

easy extraction line

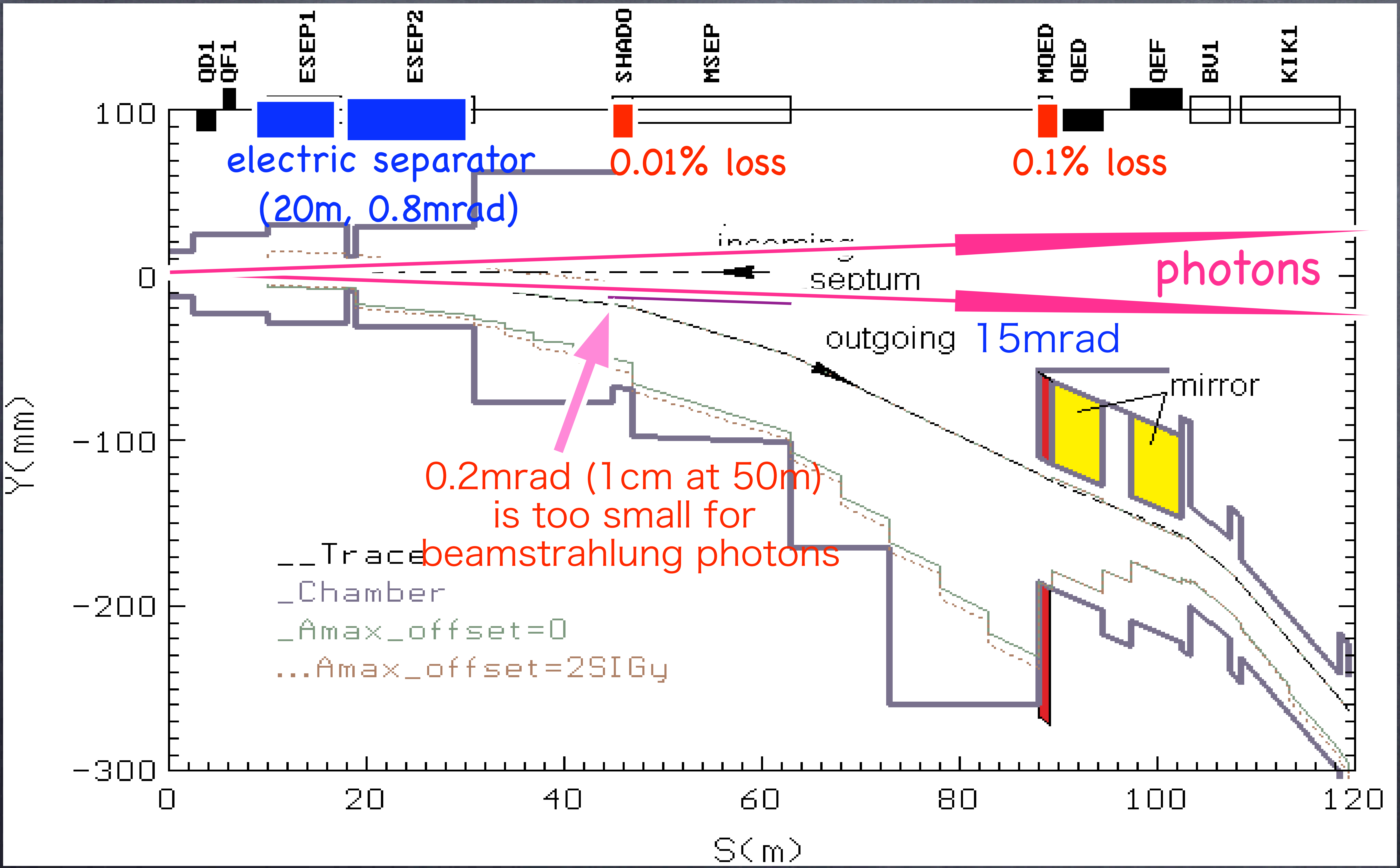
smaller dead cone (θ)

smaller back scattering

radiation in solenoid magnet

multi-bunch instability
irrelevant in "cold"

# Extraction line (head-on) at TESLA-TDR



# Small angle crossing (2x1mrad)

P.Bambade, B.Mouton(Orsay), O.Napoly, J.Payet(Saclay)

(TESLA bunch-spacing → no multi-bunch kink instability)

No Septum, of course

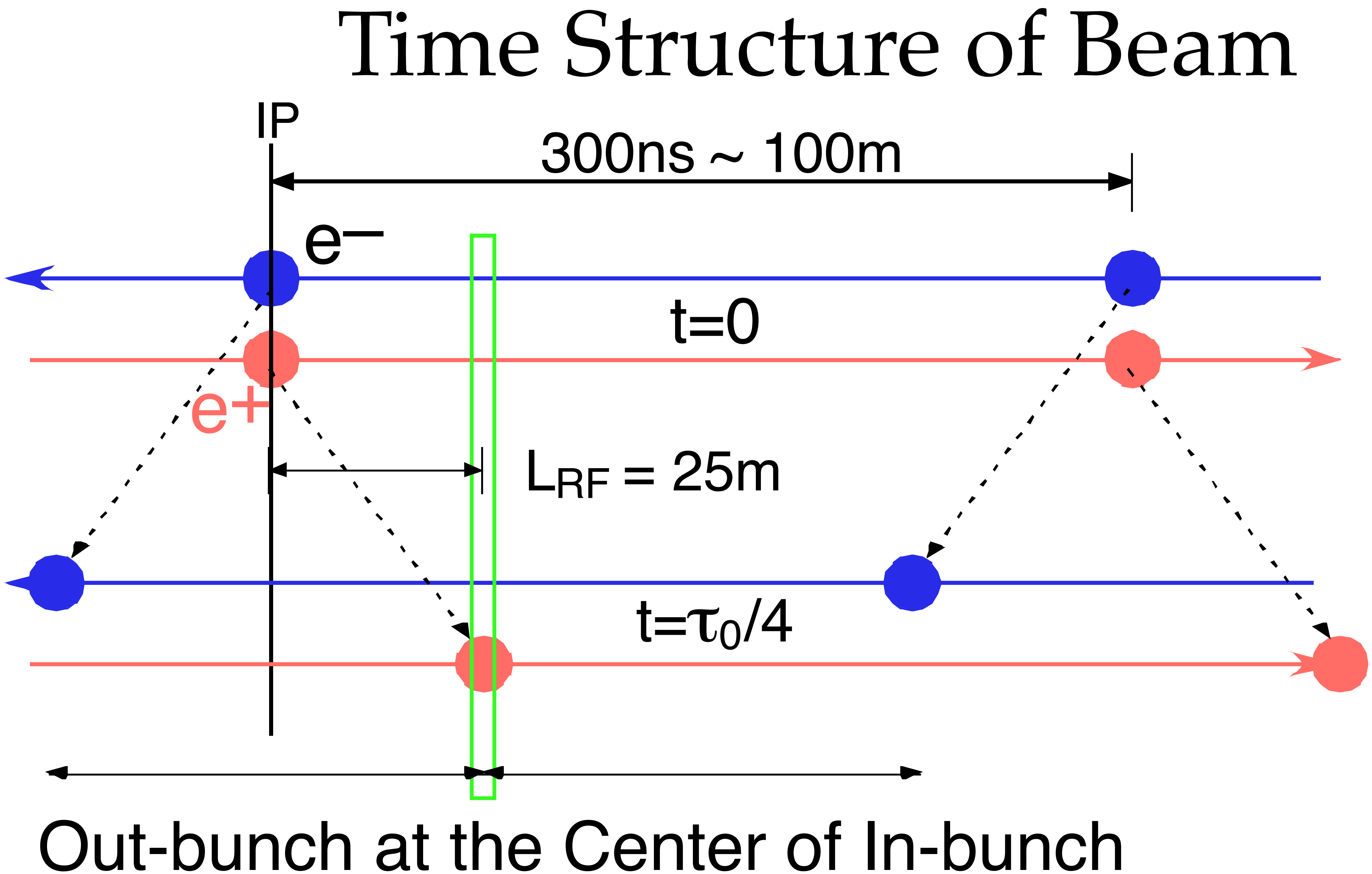
- only ~15% luminosity loss without crab-crossing (2 mrad)
- correction possible without cavities exploiting the natural η' in the local chromatic correction scheme used

$\theta\,\sigma_z = \eta_x \delta p/p$, $\eta_x' = 10\text{mrad}$, $\delta p/p = 0.1\%$

- no miniature SC final doublet needed
- no strong electrostatic separators needed
- both beams only in last QD → more freedom in optics

- negligible effects on physics
- diagnostics of spent beam should be easier

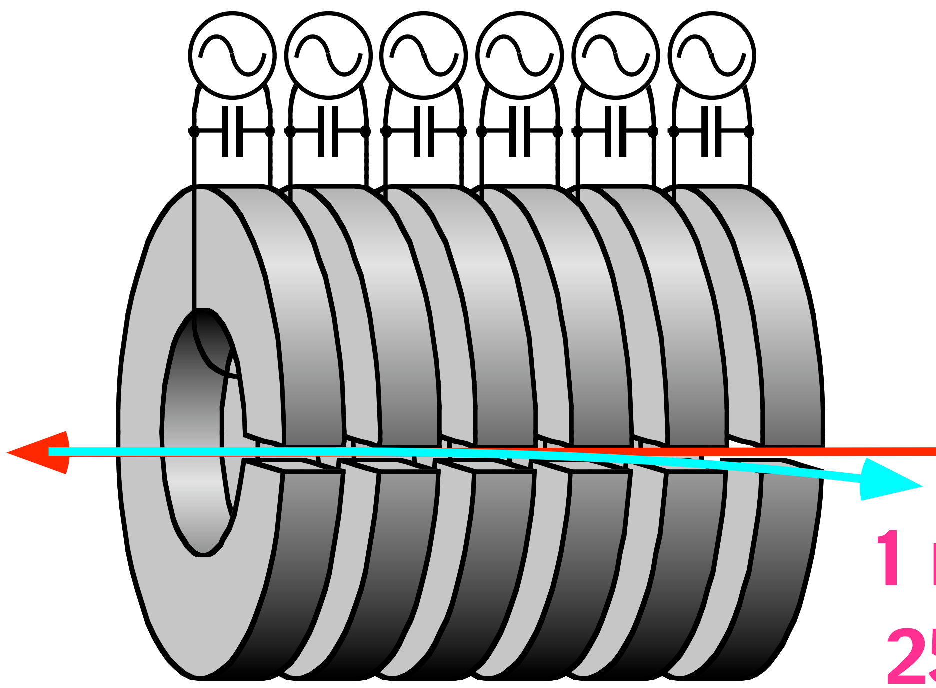
# RF Kicker for Head-ON Collision



Y. Iwashita, MDI workshop, 7 Jan.05
corrected on 23 Feb.05

# Sketch of a Kicker

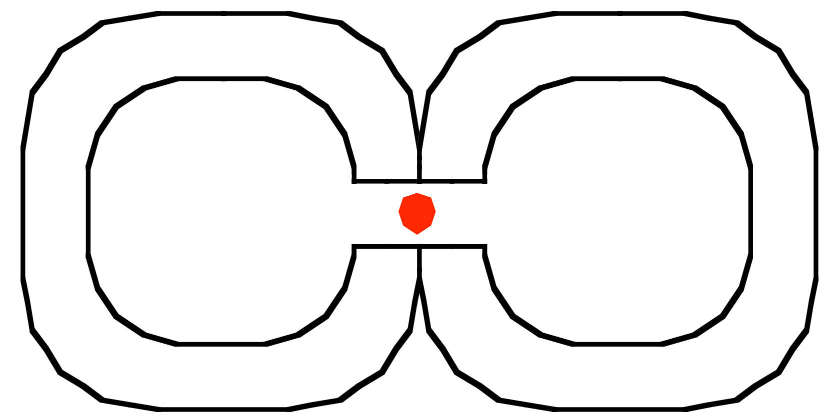
## DC+3MHz (+9MHz)



L=4m

1 mrad for 250GeV beam

## Variant



Double C-type

Better shielding

Step at center?

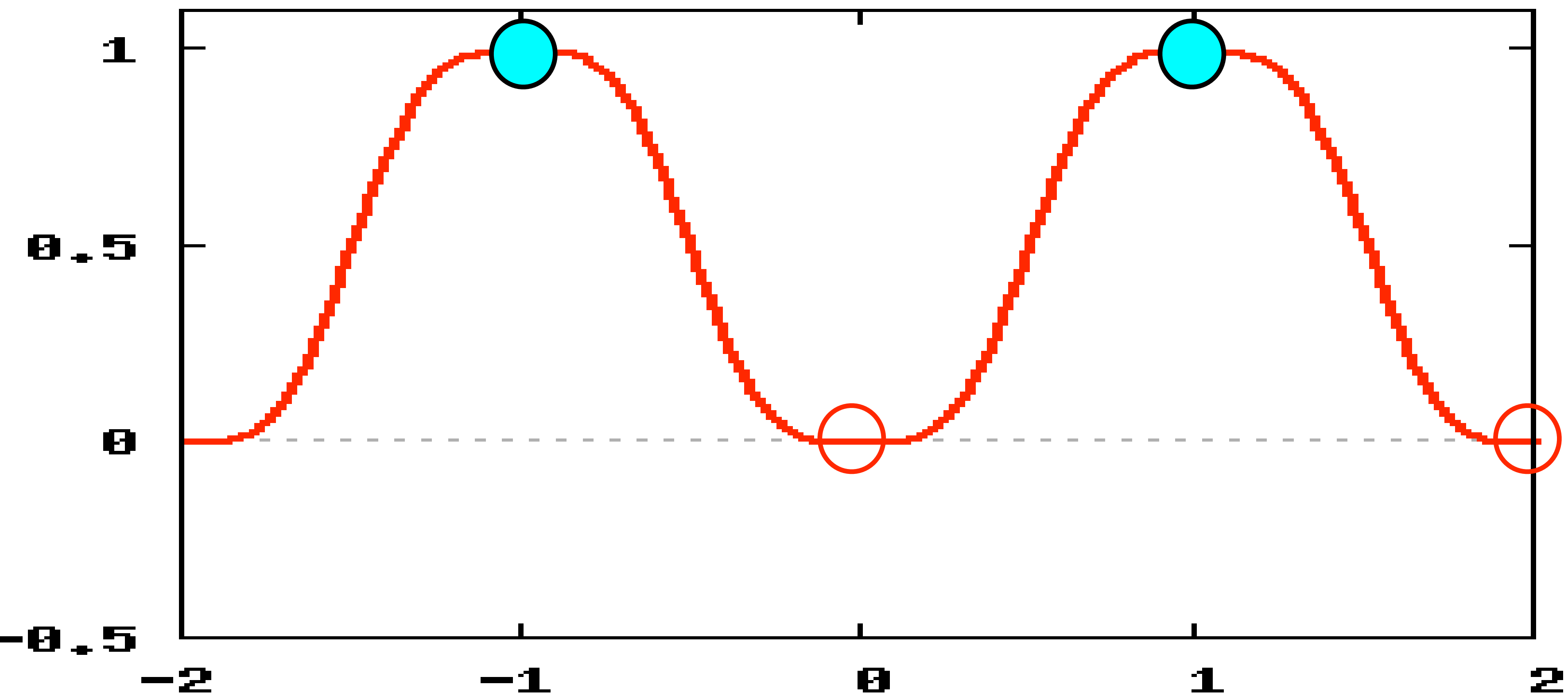
Stored Energy W ~ 100[J] @0.25T

x3MHz/Q(~100?)/(4m/3cm) ~ 45kWpk /unit

( x133 units -> 6 MWpk in total)

H. Souda, ILC-Asia WG4 meeting
2 Feb. 2005

## (1) Waveform: $f(t)=\frac{8}{9}-\cos(\omega t)+\frac{1}{9}\cos(3\omega t)$



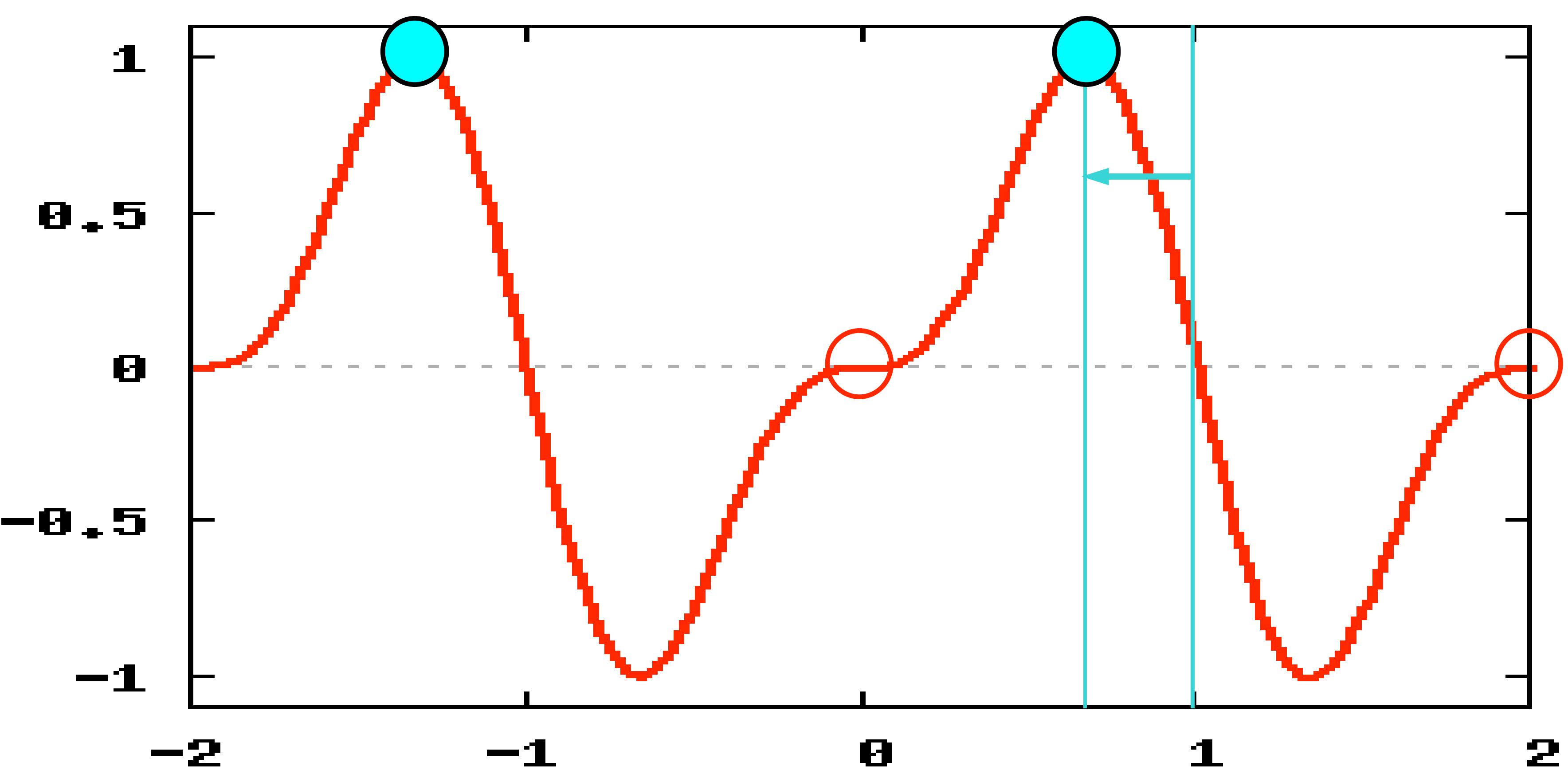

Phase division=1

$\theta_x=4.65\times10^{-8}$ at ○

$\theta_x=1\times10^{-3}$ at ●

$\theta_x < 3\times10^{-7}$

## (2) Waveform: $f(t)=-\sin(\omega t)+\frac{1}{2}\sin(2\omega t)$



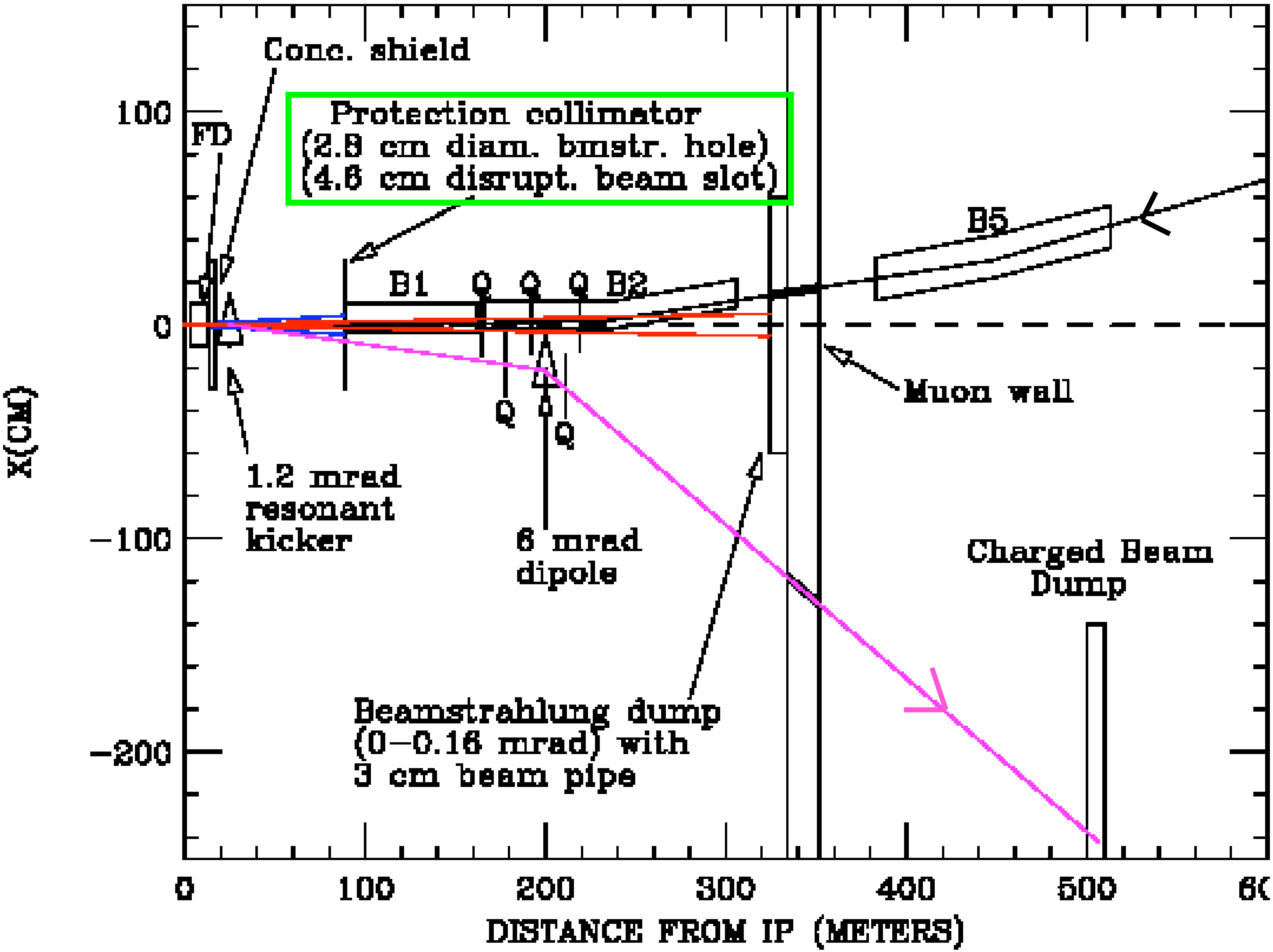

Phase division=2

$\theta_x=9.58\times10^{-8}$ at ○

$\theta_x=1\times10^{-3}$ at ●

Dark current?

# Tunnel Layout for ILC Head-on Collisions – Zero Degree Extraction



# Crossing Angle Choice

T.Tauchi, P.Bambade, 14Nov.2004

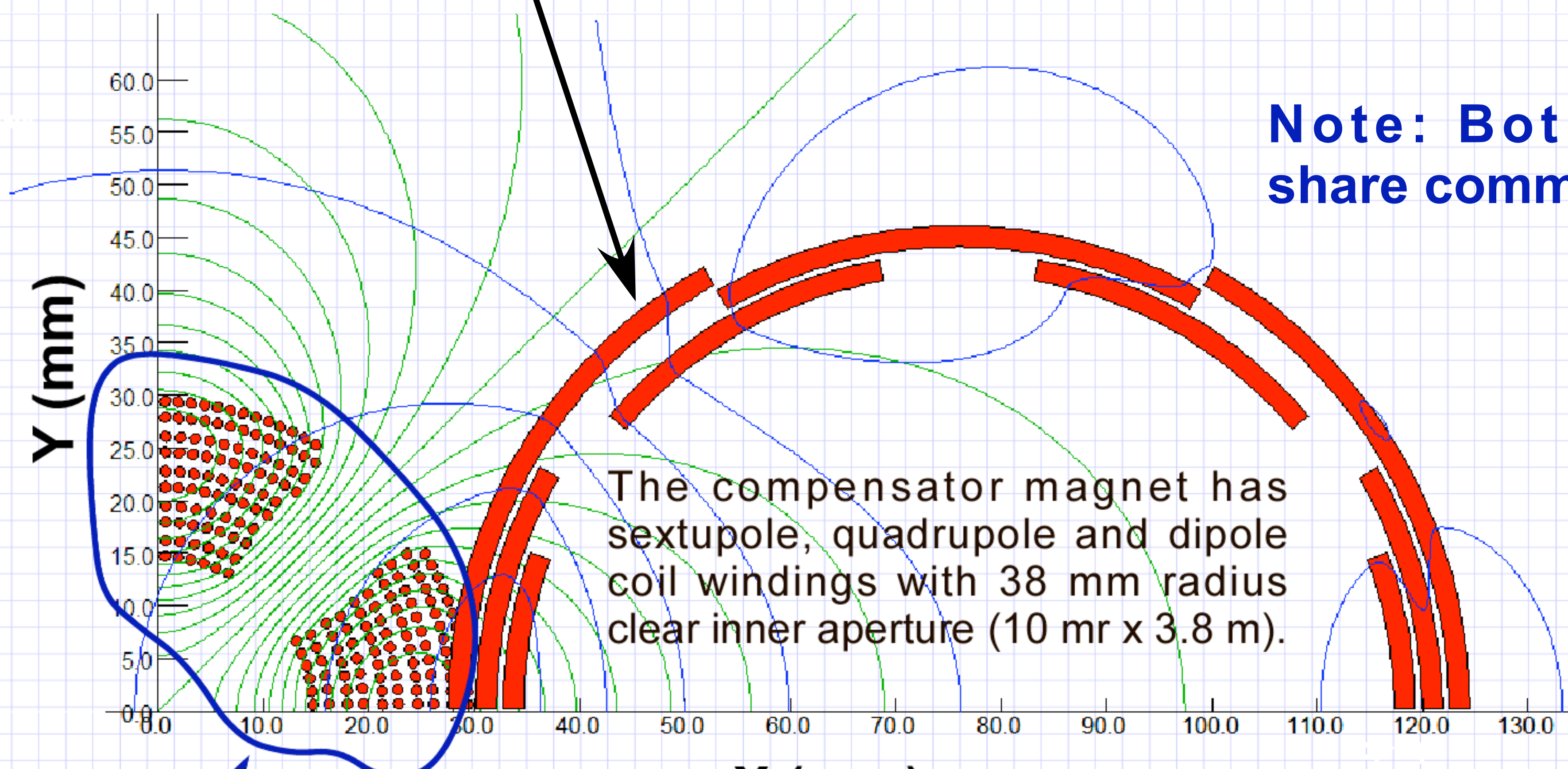
| Criteria | head-on | v:0.3mrad | h:2mrad | h:7mrad | h:20mrad |
|---|---|---|---|---|---|
| Septum at 50m from IP | must | must | no | no | no |
| Irradiation at Septum | 80W/0.3W | no | no | no | no |
| Electrostatic separator | must | must | no | no | no |
| Crab cavity | no:L=100% | must:L=0% 200kV,1.3GHz | option: L=85% | option:L=40% | must:L=0% |
| γ, beam dumps, Extraction line | 2 dumps, 240m free | 2 dumps, 240m free | 1 dump, 240m? free | 1 dump, 90m? free | 1 dump, "no" free |
| Final Q (FQ) | SQ:48mmΦ large bore | SQ:48mmΦ large bore | SQ:48mmΦ large bore | SQ:large bore conventional | SQ: compact permanent |
| Synchrotron γ, bent in ext-FQ | no | yes | yes | yes small | no |
| Spent electrons over-focused | yes | yes | yes | yes small | no |
| E/P measurement after IP | no | no | probably yes | yes | yes |
| Physics impact: min. veto angle | 2mrad for beam pipe | 2mrad | 4mrad | 9mrad | 15-20mrad |
| Physics impact: background at VTX | no hot spot | no hot spot | no hot spot | no hot spot | hot spot |

International Linear Collider

BROOKHAVEN NATIONAL LABORATORY
Superconducting Magnet Division

# A Motivation for Making QD0 Coil Even More Compact.

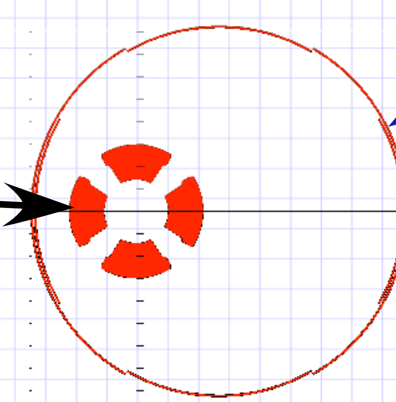
This is the first of two coil geometries proposed for a gamma-gamma IR.




**Note: Both magnets share common cryostat.**

**QD0 is now more compact and made only from cable with inner coil gone (outer layers have moved inward).**

**Second solution with QD0 inside compensator.**



**For normal IR outer magnet has a much smaller radius.**

# Spin Precession

$$\theta_{spin} = \gamma \frac{g-2}{2} \cdot \theta_{bend} = \frac{E(GeV)}{0.44065} \cdot \theta_{bend}$$

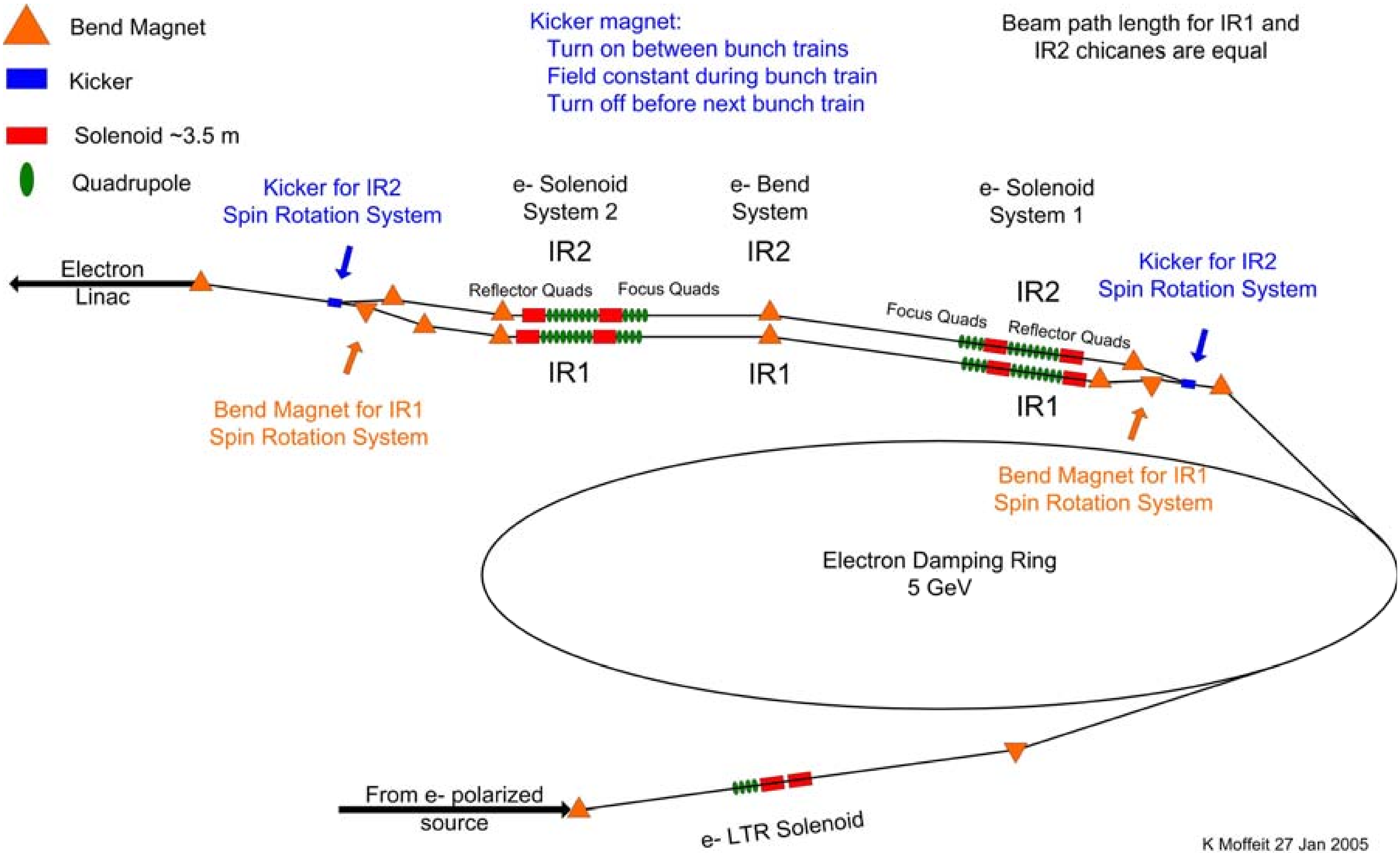
| Change in Bend Angle | Change in Spin Direction | Longitudinal Polarization Projection |
|---|---|---|
| 1 mrad | 32.5 $^{o}$ | 84.3% |
| 275 $\mu$rad | 8.9 $^{o}$ | 98.8% |
| 100 $\mu$rad | 3.25 $^{o}$ | 99.8% |

Change in spin direction for various bend angles and the projection of the longitudinal polarization. Electron beam energy is 250 GeV.

# Spin Rotation Schemes at the ILC for Two Interaction Regions and Positron Polarization with Both Helicities,

by K.Moffeit, M.Woods, P.Schuler, K. Moenig and P. Bambade

LCC-0159
SLAC-TN-05-045
IPBI TN-2005-2
Feb. 2005

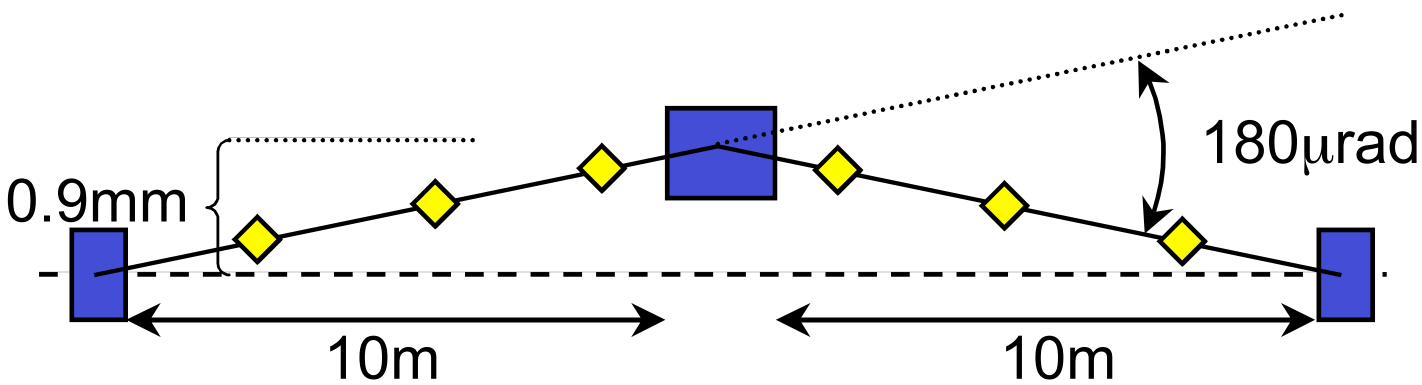


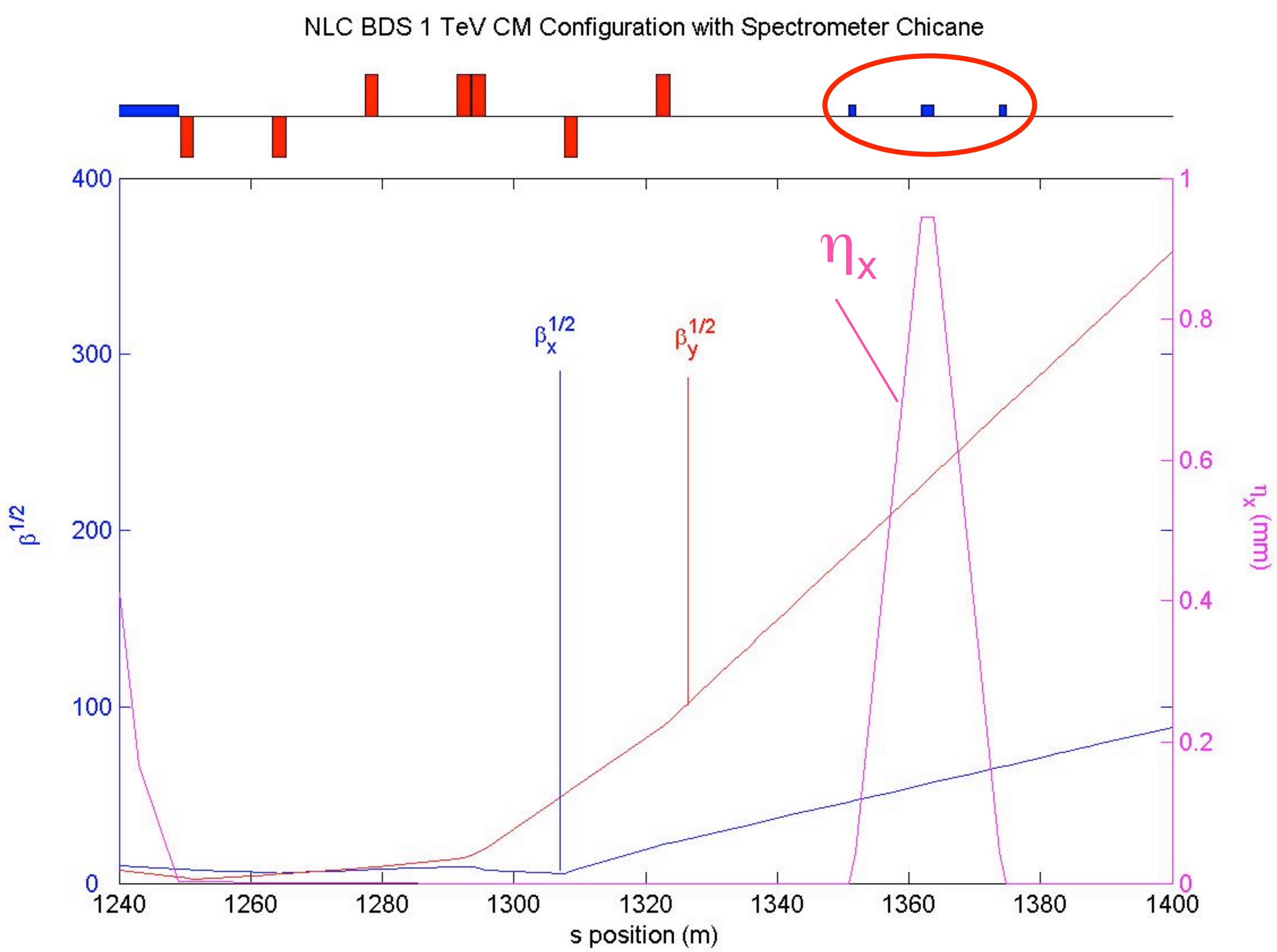
# E measurement

TESLA-TDR

M.Hildreth, LCWS04, 21 April 2004

## BPM-based Spectrometer



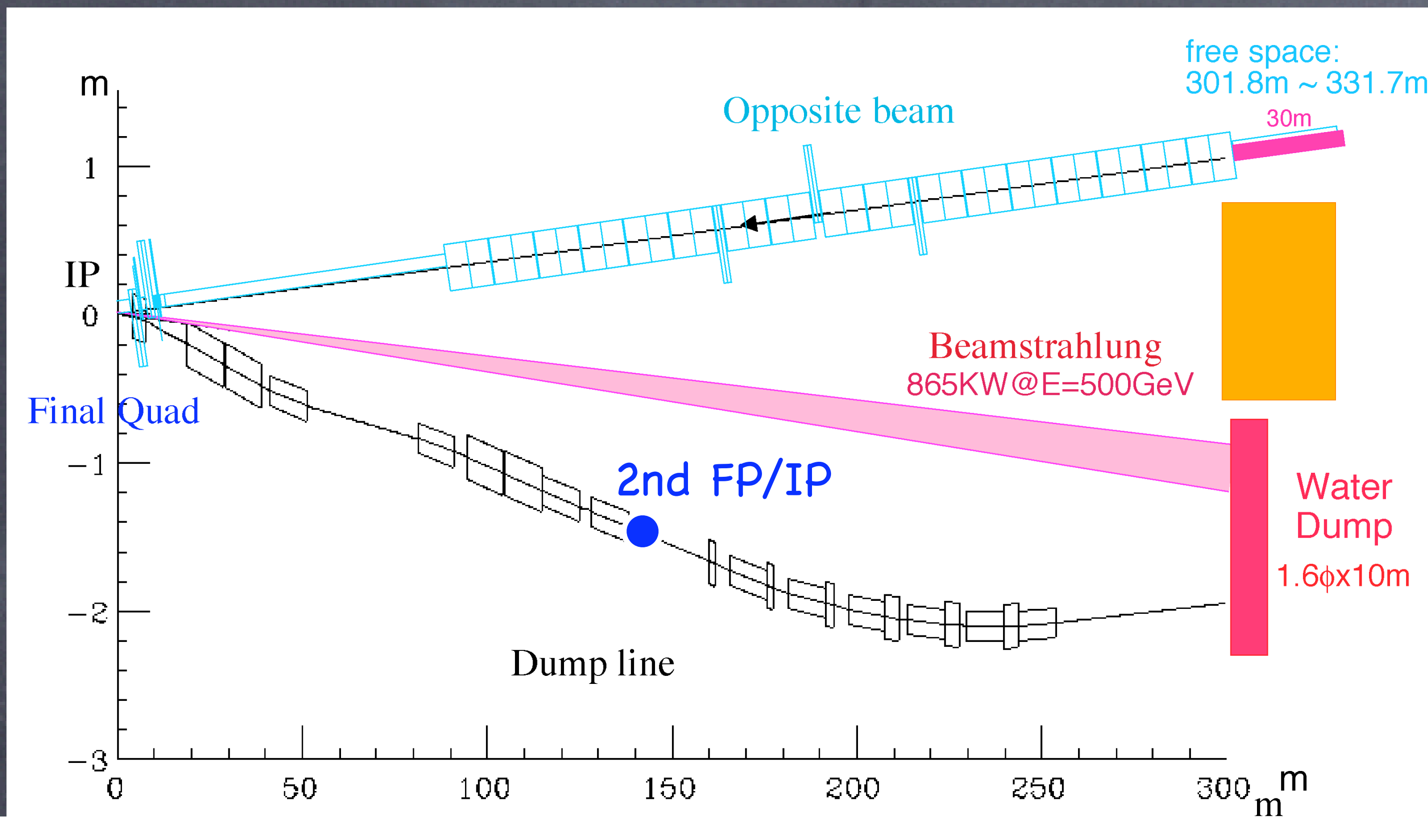



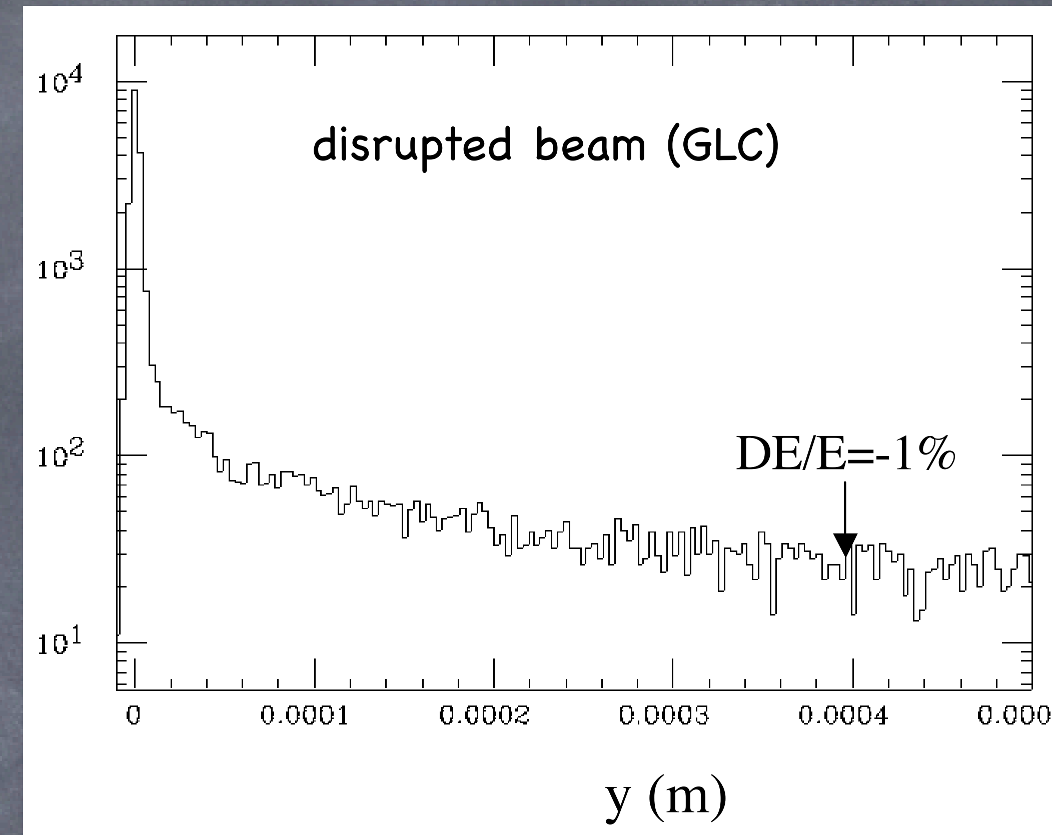

Design Considerations:

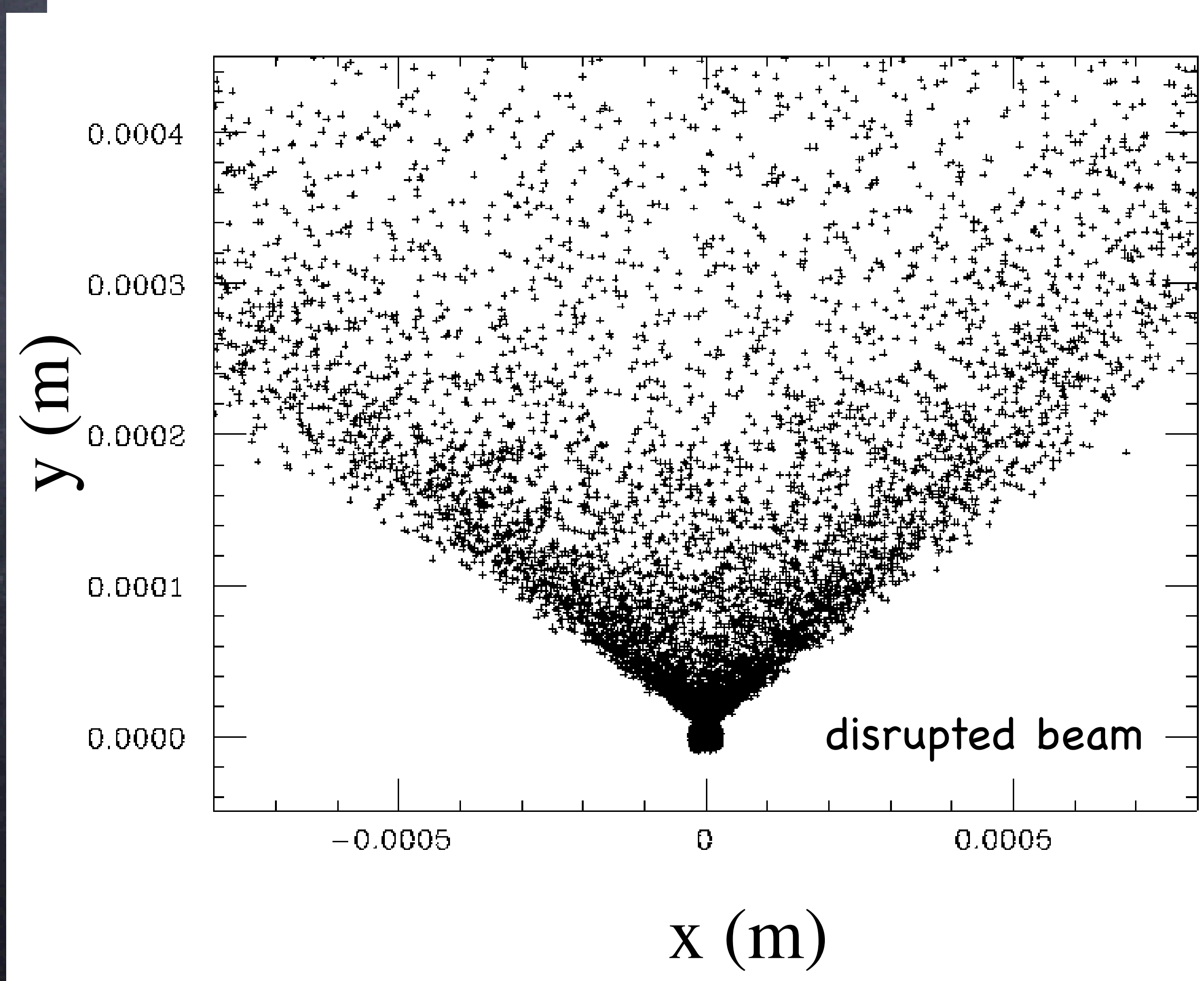
- limit SR emittance growth
  - 360μrad total bend ⇒ 0.5%
- available space in lattice
  - no modifications necessary, yet
- 10m drift space maximum one can consider for mechanical stabilization, alignment
- 37m total empty space allows for BPMs outside of chicane to constrain external trajectories
- *Tiny* energy loss before IP
- non-ideal β-variation?

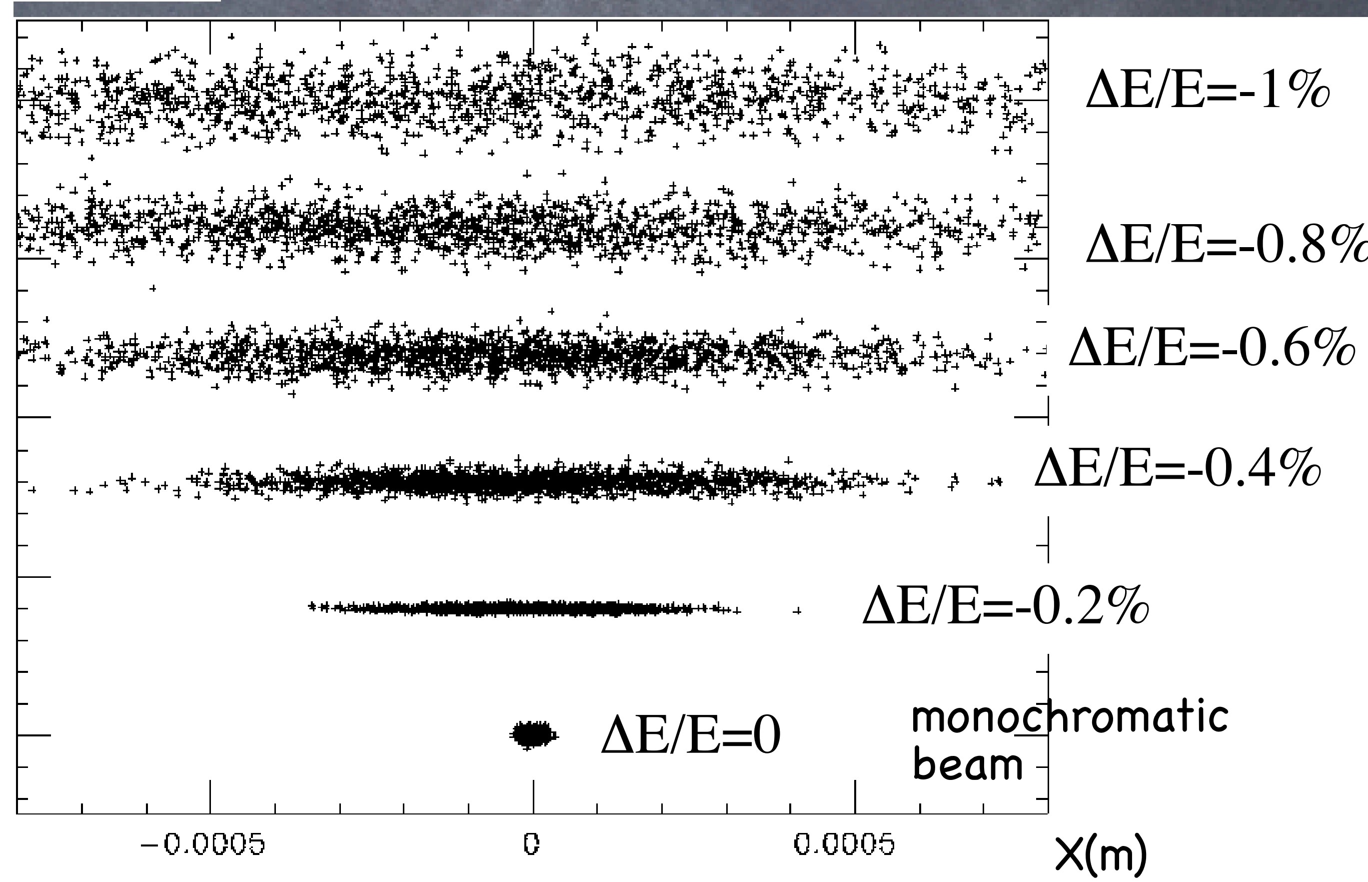
⇒ Constraints lead to a required BPM resolution of ~100nm (Resolution ⊕ Stability)

# ΔE/E measurement at the 2nd FP/IP



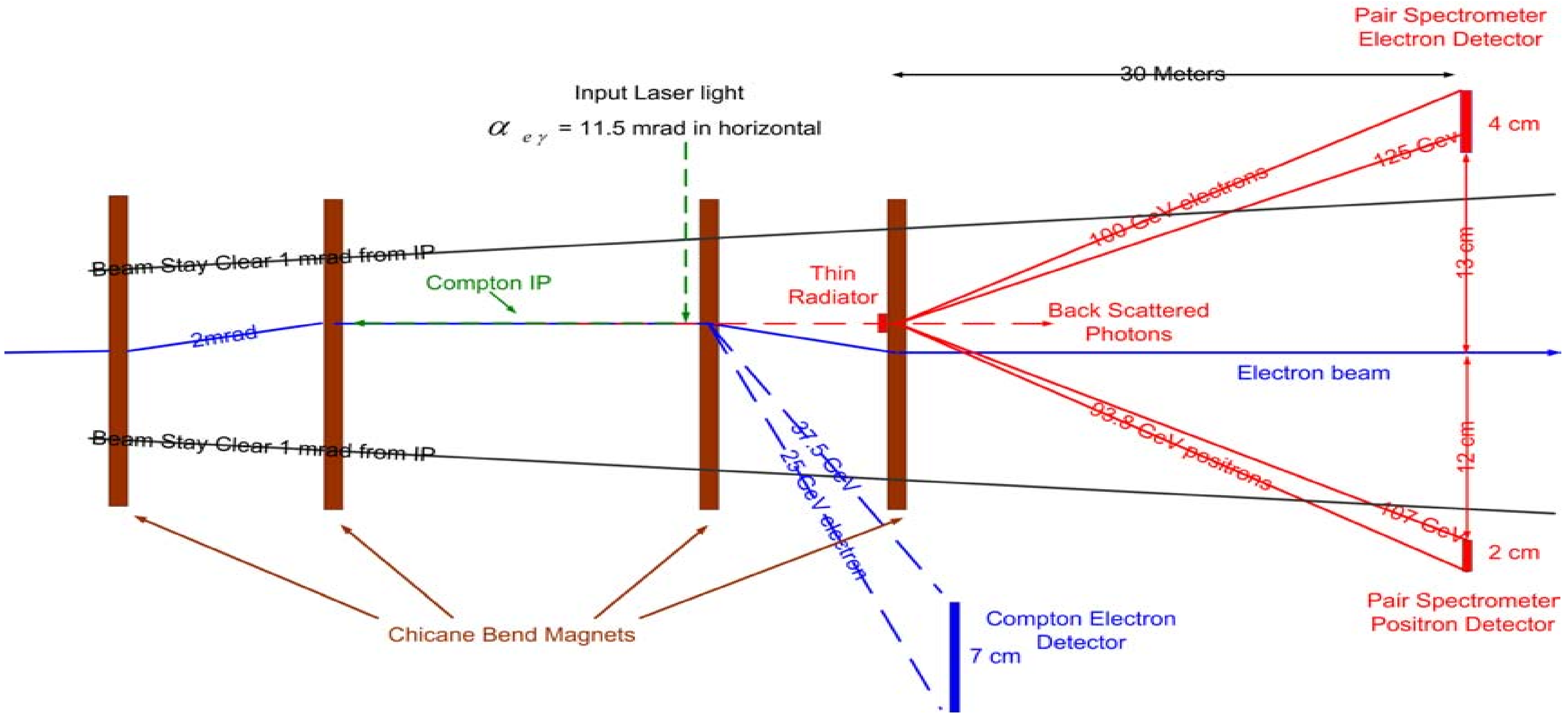




K.Kubo, LCWS2004

# Extraction Line Compton Polarimeter




- Compton IP 60 meters downstream of $e^+e^-$ IP
- 2mrad bend angle from analyzing magnet
- segmented gas Cherenkov detector, similar to SLD design
- multi-Compton mode with high power pulsed laser at ~17Hz

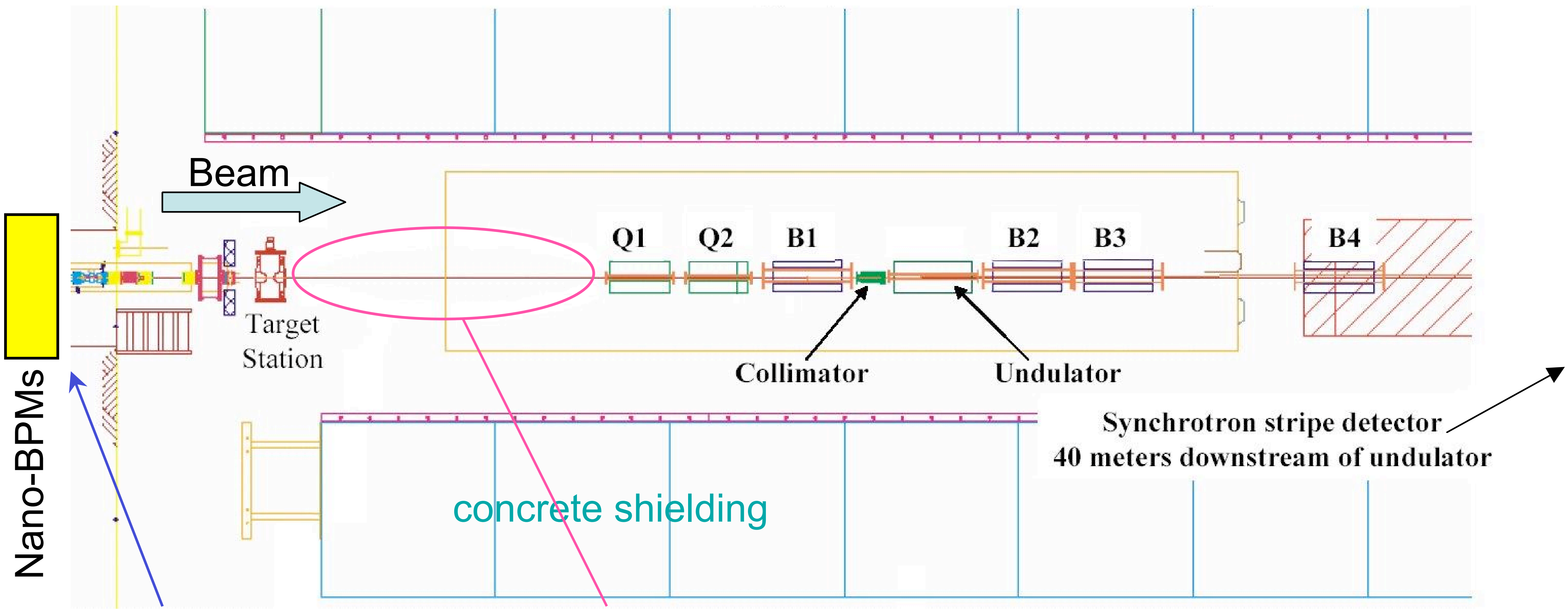
**Also considering,**

- pair spectrometer for backscattered photon measurement
- alternate detector technologies (ex. quartz fiber)

M.Woods, LCWS2004

# SLAC End Station A Test Program

- BDI equipment tests in “realistic” (=dirty) environment




Existing RF BPMs can be used for stability, resolution tests

5 meter region to mock up IR/forward region with masking, FONT, pair detectors

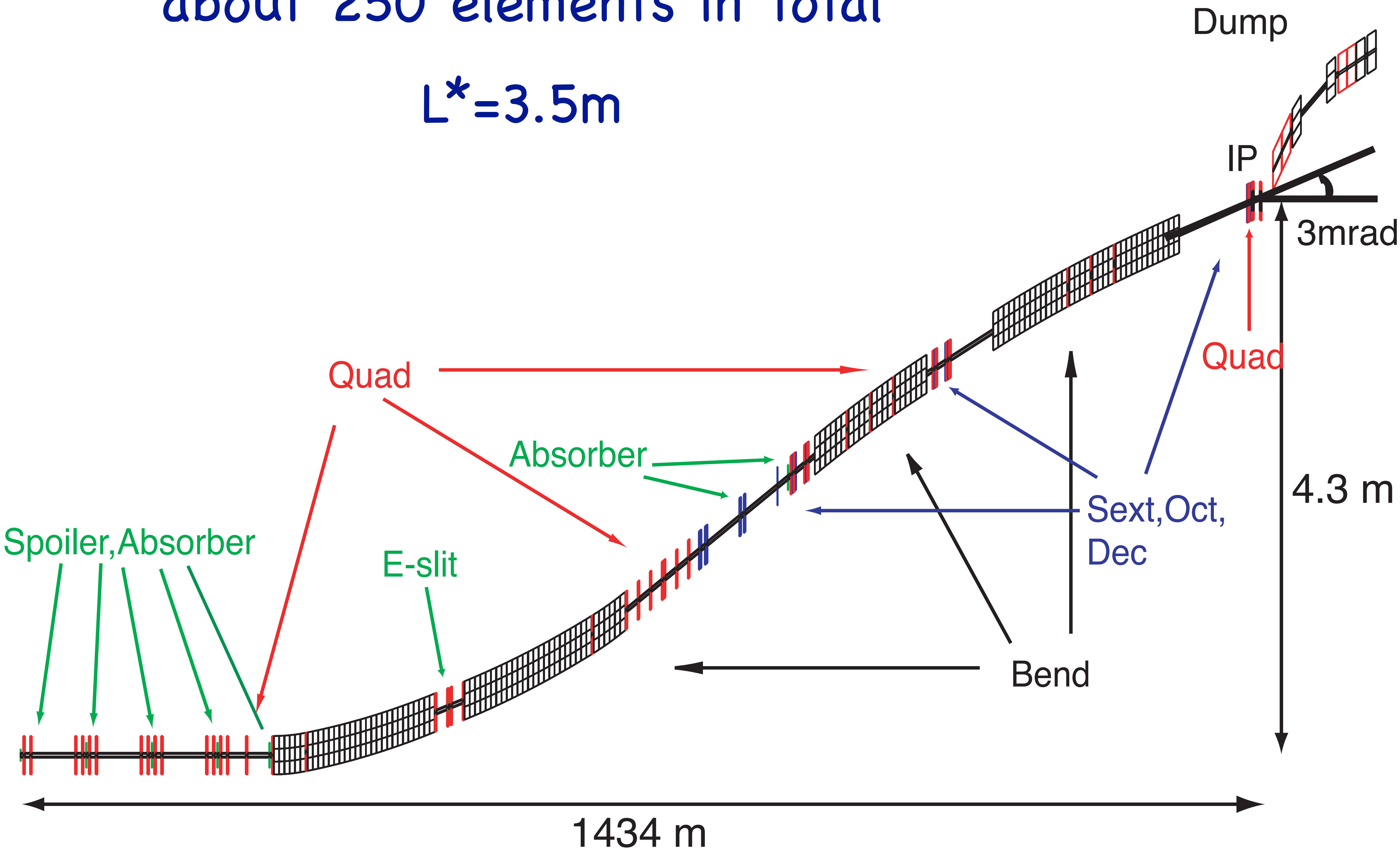
Beamline components scavenged from SPEAR, other SLAC surplus

# BDS Simulation

Roadmap Report,2003

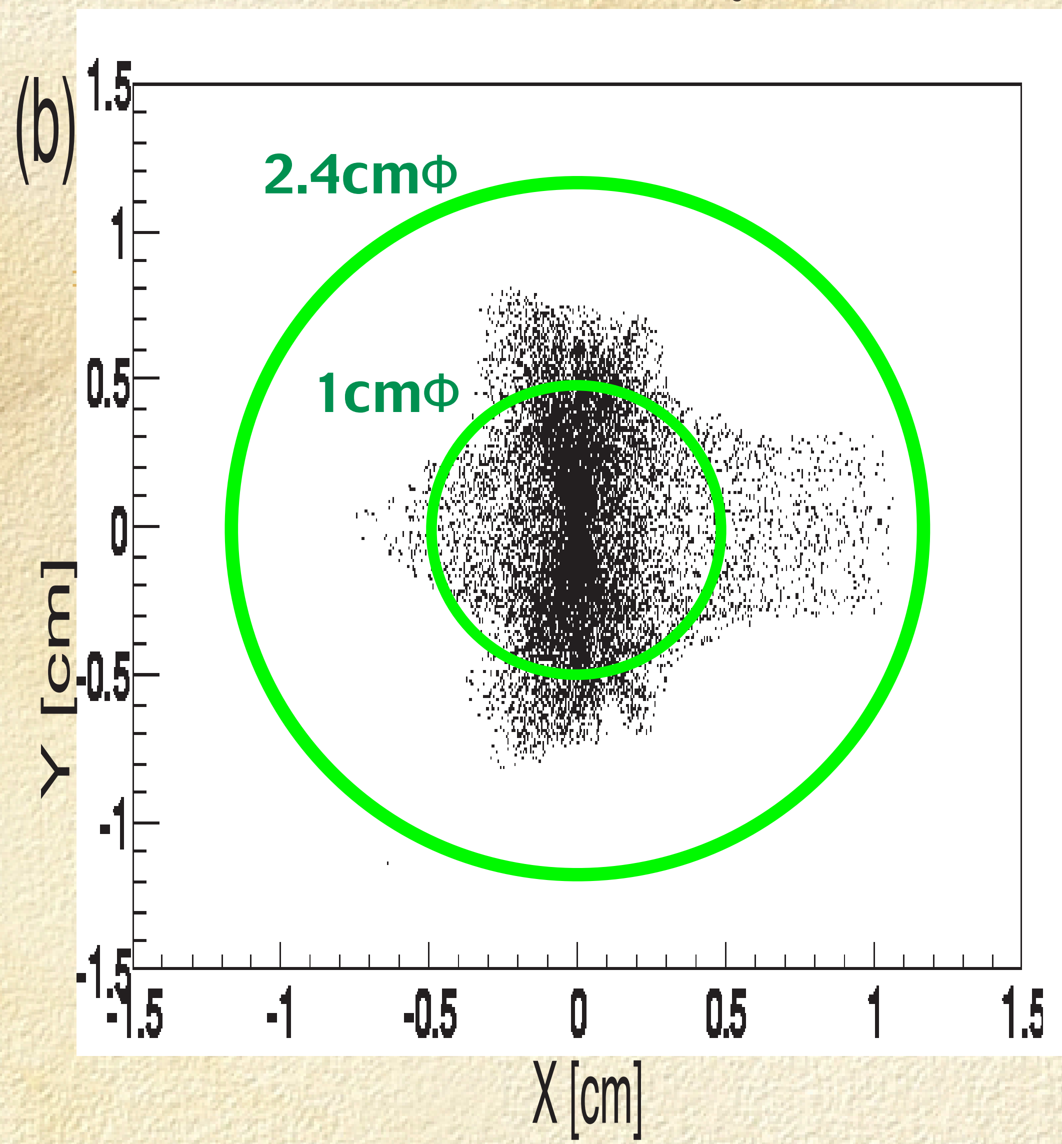
about 250 elements in total

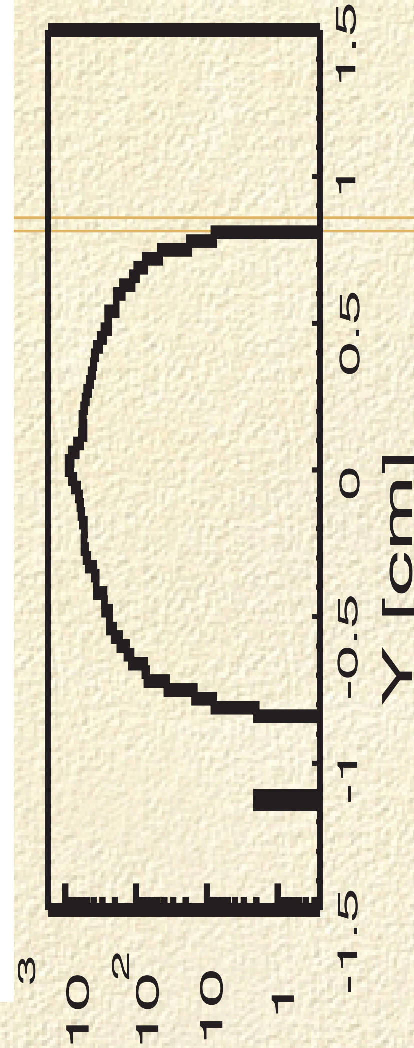
L*=3.5m

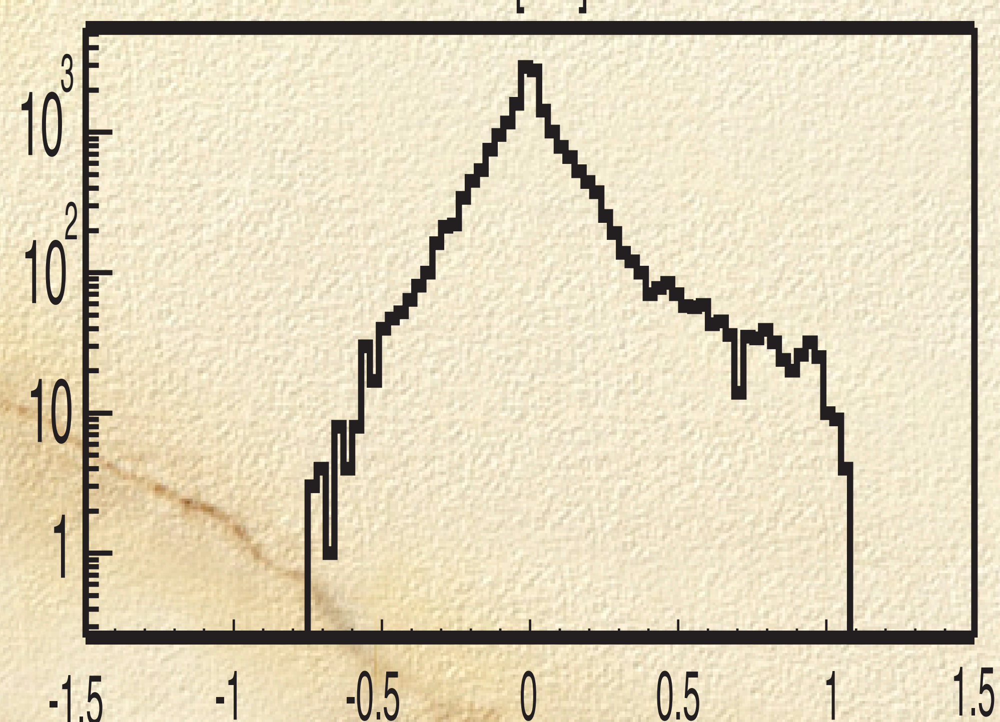


# Vertex R : Synchrotron Radiations

BDS-Simulation (GEANT4) by K.Tanabe



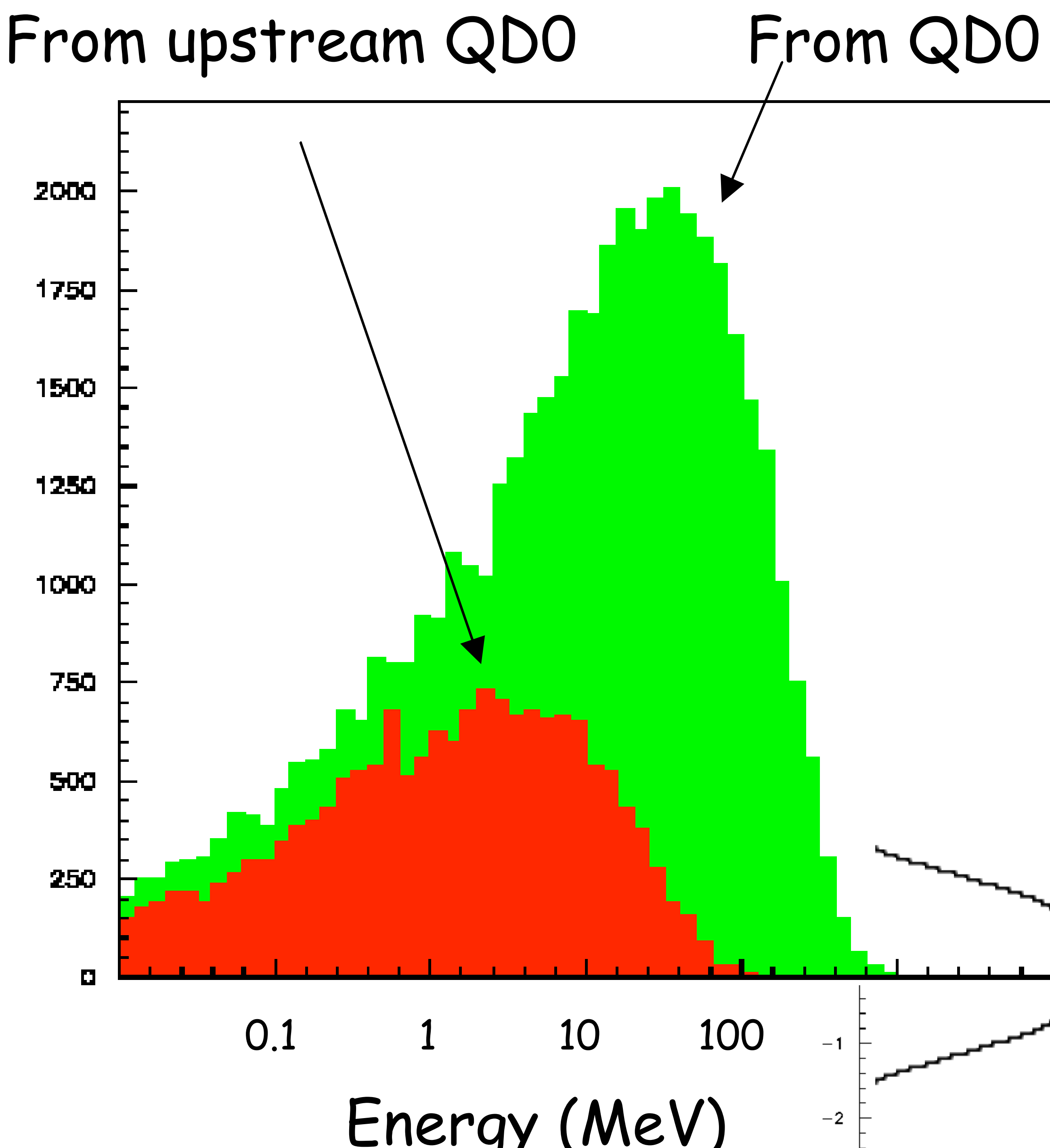




from Halo at IP
<E>=4.8MeV

GLC: $L^*$=3.5m
$\theta_c$=7mrad
$L/L_0$=0.6
$12\sigma_x$ $53\sigma_y$

# Sync radiations in 2mrad crossing

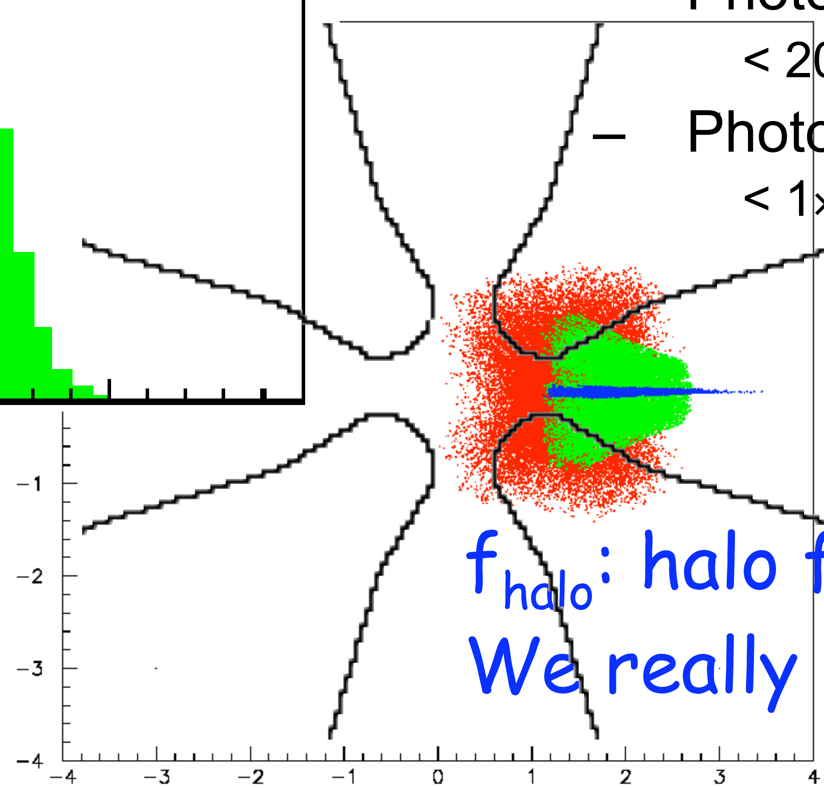



- No sync radiations from beam core or disrupted beam would hit QF1.
- Sync radiations from beam halo hit QF1.

| | QD0 | upstream QD0 |
|---|---|---|
| <E> (MeV) | 43. | 5.7 |
| # N/e- | 23.5 | 8.6 |
| Hit rate (%) | 4.4 | 35. |
| Power (kW) | $2.0*f_{halo}$ | $0.78*f_{halo}$ |

– Photons backscattered to IP
  < 200 photons/BX for $f_{halo}=10^{-3}$

– Photo-neutrons (FLUKA)
  < $1\times10^{8}$ neutrons/cm$^2$/yr for $f_{halo}=10^{-3}$




$f_{halo}$: halo fraction
We really don't know.

# Minimum Veto Angle

## Primary requirement from SUSY

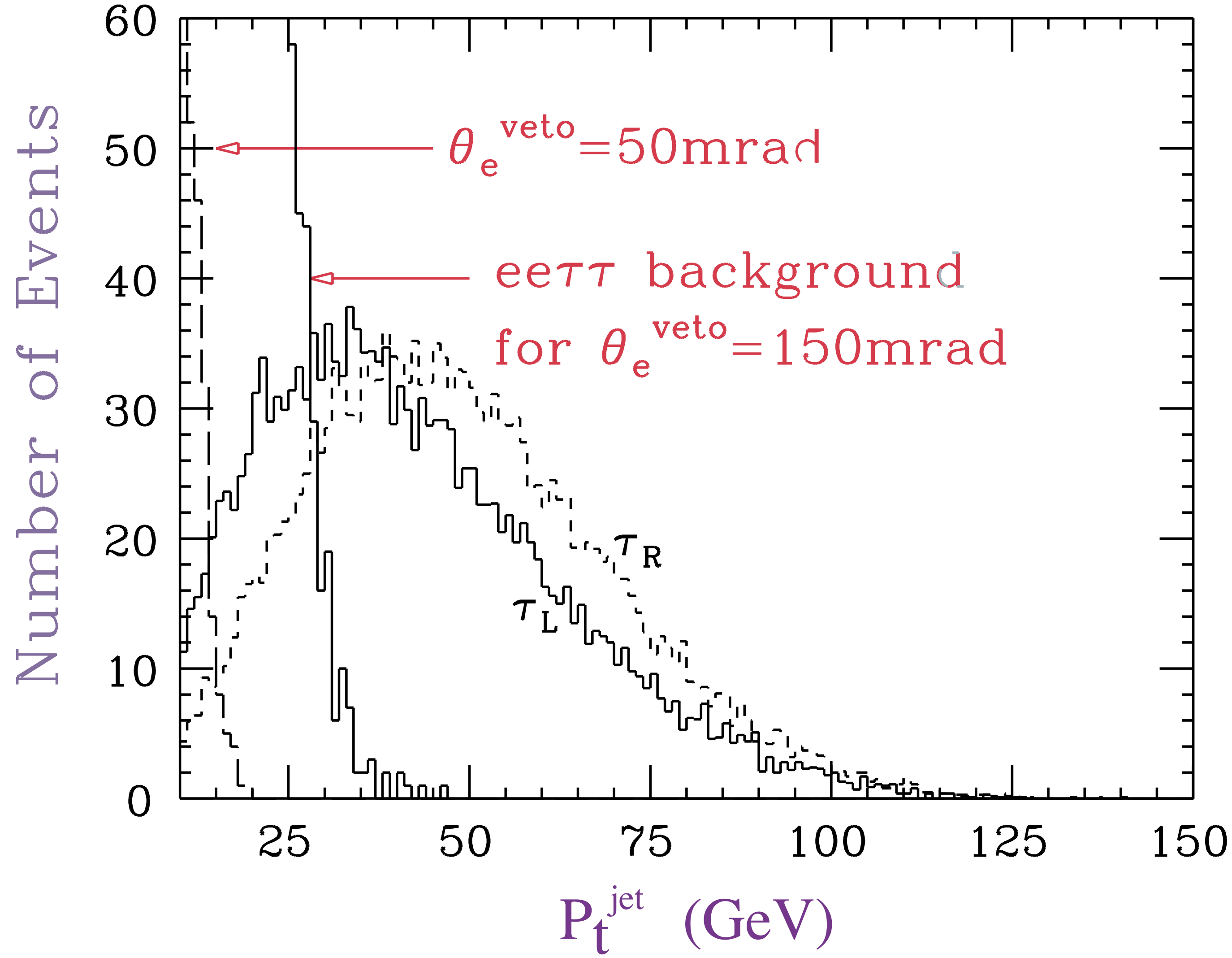
$e^+e^- \rightarrow \tilde{\tau}^+_{L(R)}\tilde{\tau}^-_{L(R)}$

M.Nojiri, K.Fujii and T.Tsukamoto, Phys. Rev. D54(1996)6756.

$\sqrt{s} = 500\text{GeV}$

$m_{\tilde{\tau}} = 150\text{GeV},\ m_{\tilde{\chi}^0_1} = 100\text{GeV}$ → $\Delta m$=50GeV

$\theta_{veto}$ =50mrad




mSUGRA
WMAP data

$\Omega_{CDM}h^2$ =0.094 - 0.129
( 2 σ )

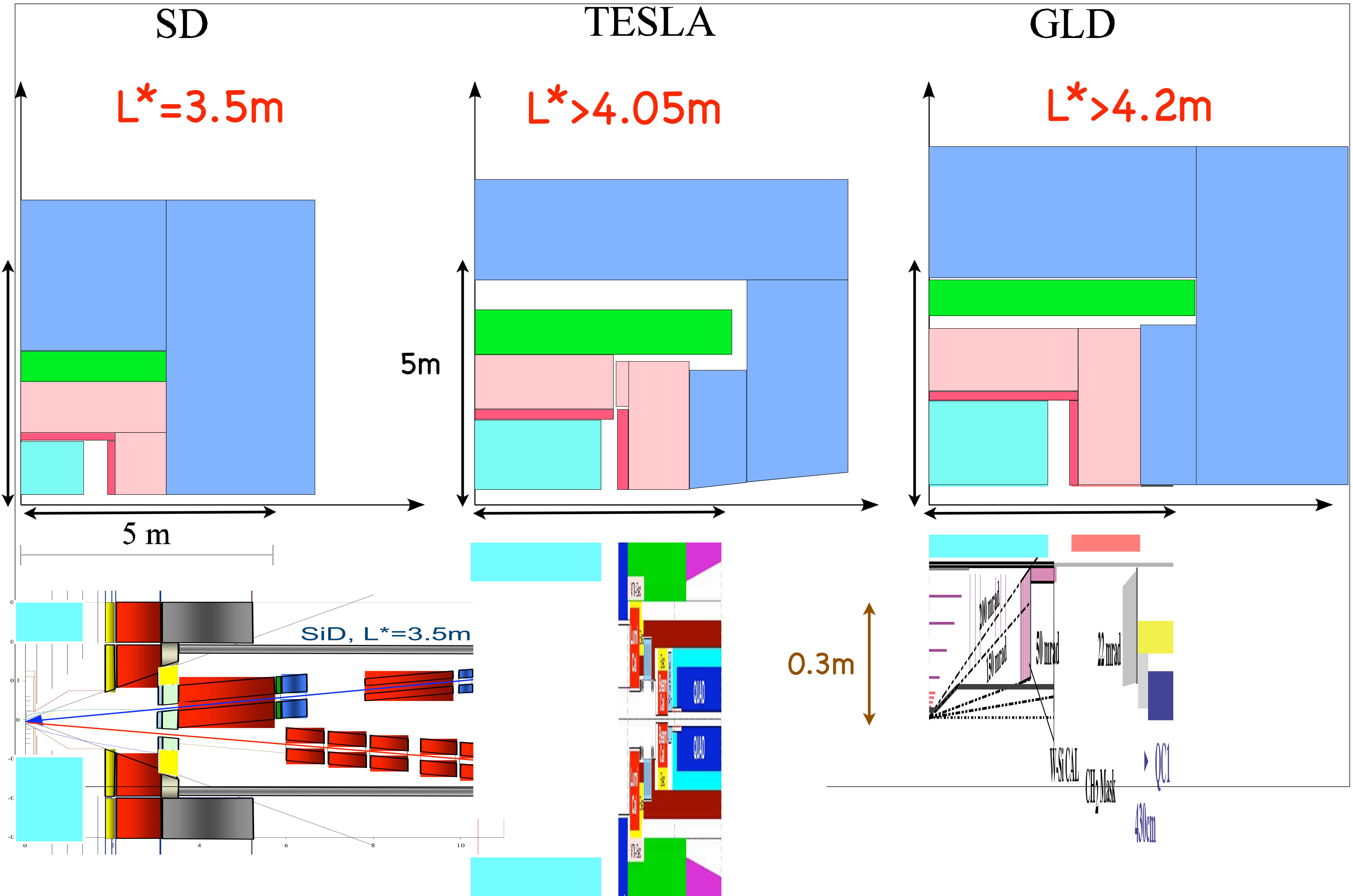
**more stringent**

$\Delta m$=5GeV

$\theta_{veto}$ =5mrad

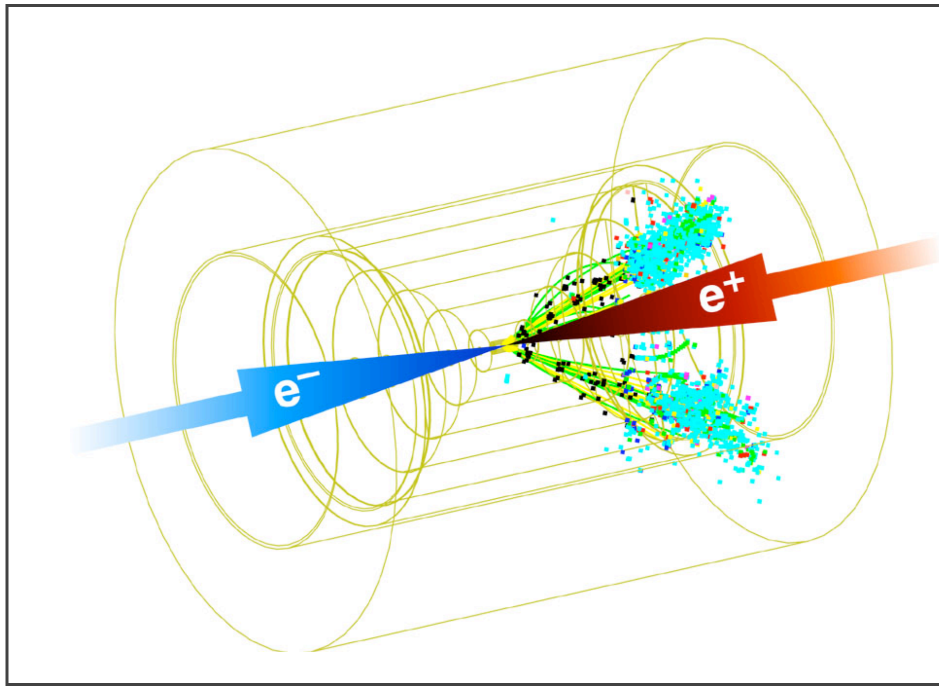
P. Bambade et al.
hep-ph/0406010

# Choice of L*


SD
TESLA
GLD
L*=3.5m
L*>4.05m
L*>4.2m
5m
5 m
SiD, L*=3.5m
0.3m
QUAD
QUAD
200 mrad
150 mrad
50 mrad
22 mrad
W-Si CAL
QC1
430cm

# Schedule of workshops

- 1 November 2004, EUROTeV Kick-off meeting at DESY
- 9-12 November 2004, ACFA-LC workshop, Taipei
- 13-15 November 2004, ILC workshop at KEK; WG4
- 6-8 January 2005, MDI mini-workshop at SLAC
- 18-22 March 2005, LCWS05 at SLAC
- 20-23 June 2005, BDIR workshop at Oxford/RHUL
- 11-14 July, 8th ACFA LC workshop at Taegue, Korea
- 14-27 August 2005, ILC workshop at SNOWMASS




# WORKSHOP

## Machine-Detector Interface at the *International Linear Collider*

International Linear Collider at Stanford Linear Accelerator Center

**SLAC**
**January 6-8, 2005**

Home
Committees
Program
List of Registrants
Accommodations
Travel Information
Tourism Information
Visa Information
Location
ATF2 Mini-Workshop
Workshop News
Computing

## Scope and Goals

- Evaluate "experiment impact" of the ILC design. The ILC Design impacts the ILC Detector and Physics, beyond just the delivered luminosity and energy reach. The Machine-Detector Interface (MDI) group needs to evaluate how the ILC design impacts the Experiment (Detector design and physics capabilities) and how the Experimental requirements impact the ILC design.
- Give input to both the ***ILC Beam Delivery Group*** and the ***World-wide Study for ILC Physics and Detectors*** regarding critical choices, beam tests, the CDR and the TDR.
- Address viability and issues for crossing angle choices: head-on, 300-mrad vertical, 2-mrad horizontal, 7-mrad horizontal, 12-25 mrad horizontal
- Form international sub-groups working on individual topics, and identify available and needed resources.
- This Workshop is an important milestone: preparing for the CDR and for subsequent meetings at ***LCWS*** (March 2005) and ***Snowmass*** (August 2005).

*Latest Workshop News ...*

*Workshop Photos*

# Under the GDI/GDE
## (Global Design Initiative/Effort)

**Detector /Physics**

WWS
detector R&D panel
concept costing panel
concept support
MDI panel

**MDI**

collective view of requirements from detector /physics

**Machine**

ILC-WG4
for BDS Design

MDI consists of WWS-MDI and ILC-WG4,
and it is coordinated by the MDI panel ?

# MDI sub groups

| Main MDI topics ⇒ | session convenors |
|---|---|
| • Energy and luminosity spectrum | **M.Hildreth,** S. Boogart, K. Kubo |
| • Polarimetry | **T.Omori,** K. Moffeit, K. Mönig |
| • Very forward region | **E.Torrence,** W. Lohmann, H. Yamamoto |
| • Backgrounds | **A.Sugiyama,** K. Büsser, T. Maruyama |
| • IR layout, crossing-angles | **P.bambade,** T. Tauchi, A. Seryi |
| • Beam RF effects | **Y.Sugimoto,** M. Woods |

Layout of Two BDSs: ILC-WG1 ?