Beamdiagnostics by Beamstrahlung Analysis

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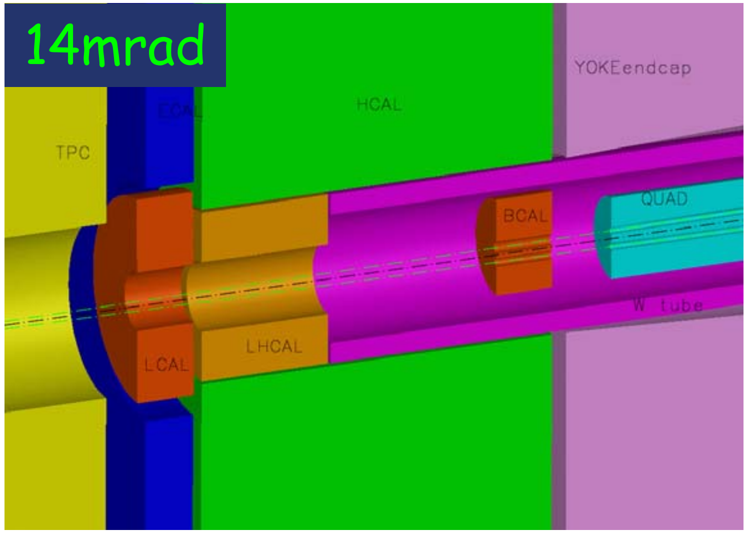
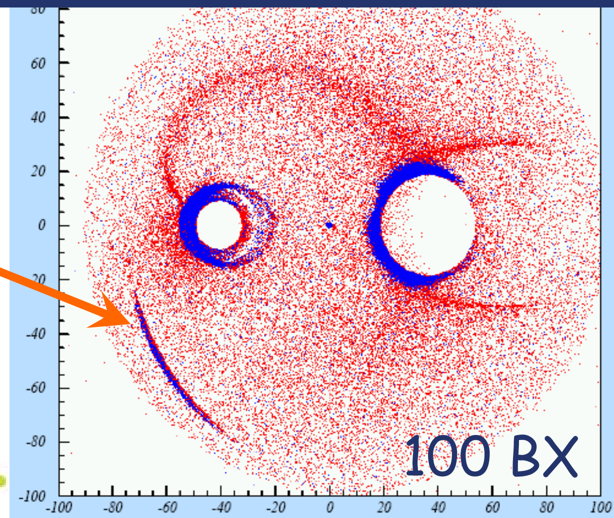
- Overview
  - **Geometries and Parameter Sets**
- Beamstrahlung Pair Analysis
- Results of Pair Analysis
  - **Comparison between 2mrad, and 14mrad for different magnetic field configurations**
- Look on the Geant4 Simulation BeCaS and first results (A.Sapronov)
- Look on potential of combined photon/pair analysis

The New Baseline - 14mrad

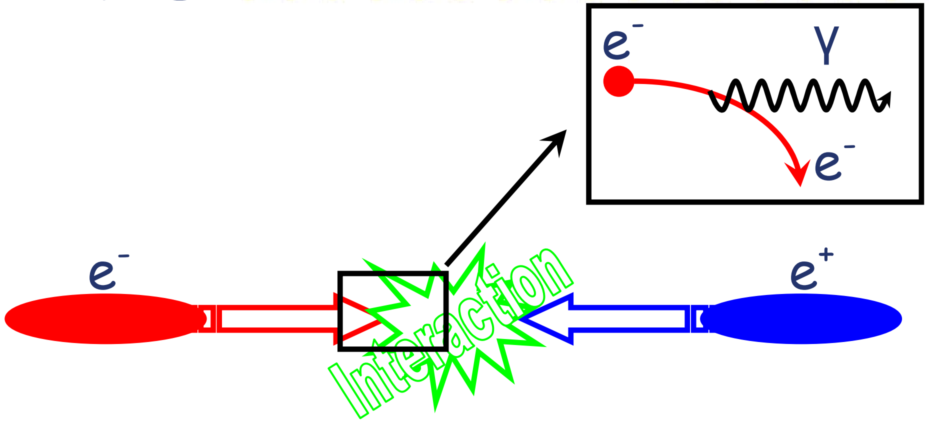
- The new baseline configuration is:
  - **two IR's with 14mrad crossing angle**
- We should be prepared for both magnetic field configurations: DID and Anti-DID
- Found that the LumiCal aperture for 20mrad should be increased (to ~120mm).
- For now we keep the aperture of 100mm for 14mrad.



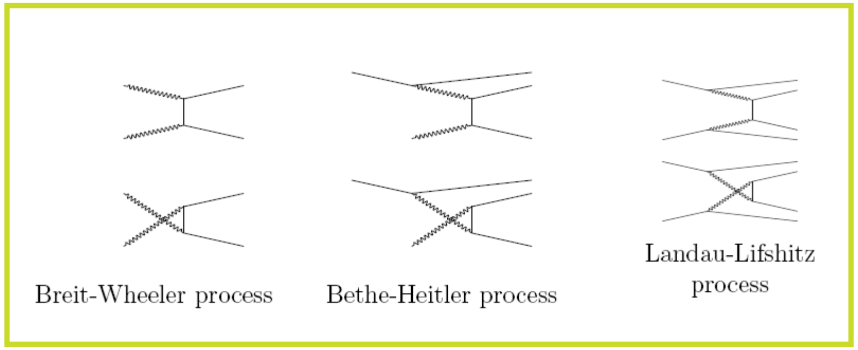
Origin of backscattered particles for 20mrad Anti-DID. (A.Vogel)



Beamstrahlung Pair Analysis



Creation of beamstrahlung
(N_{phot} ~ O(1) per bunch particle
δ_{BS} ~ O(1%) energy loss)

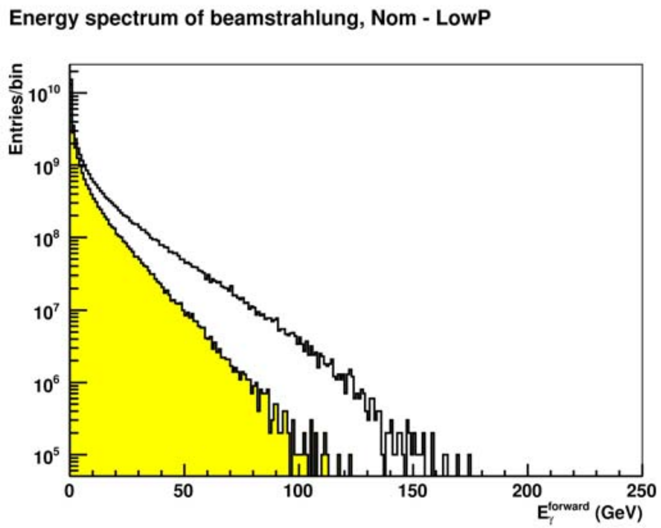


Production of incoherent e^+e^- pairs

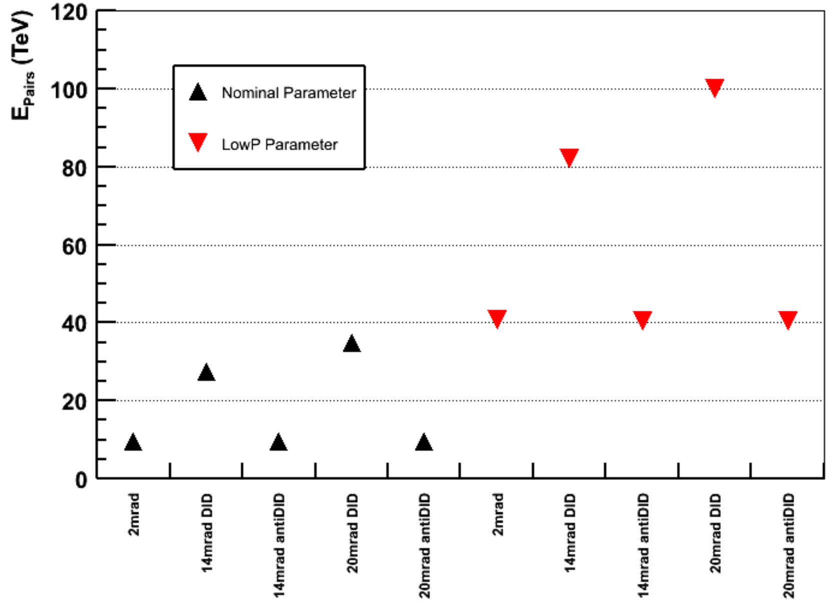
- e+e- pairs from beamstrahlung are deflected into the BeamCal
- 15000 e^+e^- per BX => 10 – 20 TeV
- ~ 10 MGy per year => radiation hard sensors
- The spectra and spatial distribution contain information about the initial collision.

Under Discussion – LowP Parameter Set

- Also under discussion: ½ RF power
- IF we want to achieve the same luminosity the beam parameters will be quite aggressive
  - N_{bunch} = 2880 => 1330
  - ε_y = 40 => 35 x 10^{-9}m rad
  - σ_x = 655 => 452 nm
  - σ_y = 5.7 => 3.8 nm
  - σ_z = 300 => 200 μm
  - δ_{BS} = 2.2 => 5.7 %



Energy from pairs in BeamCal per BX

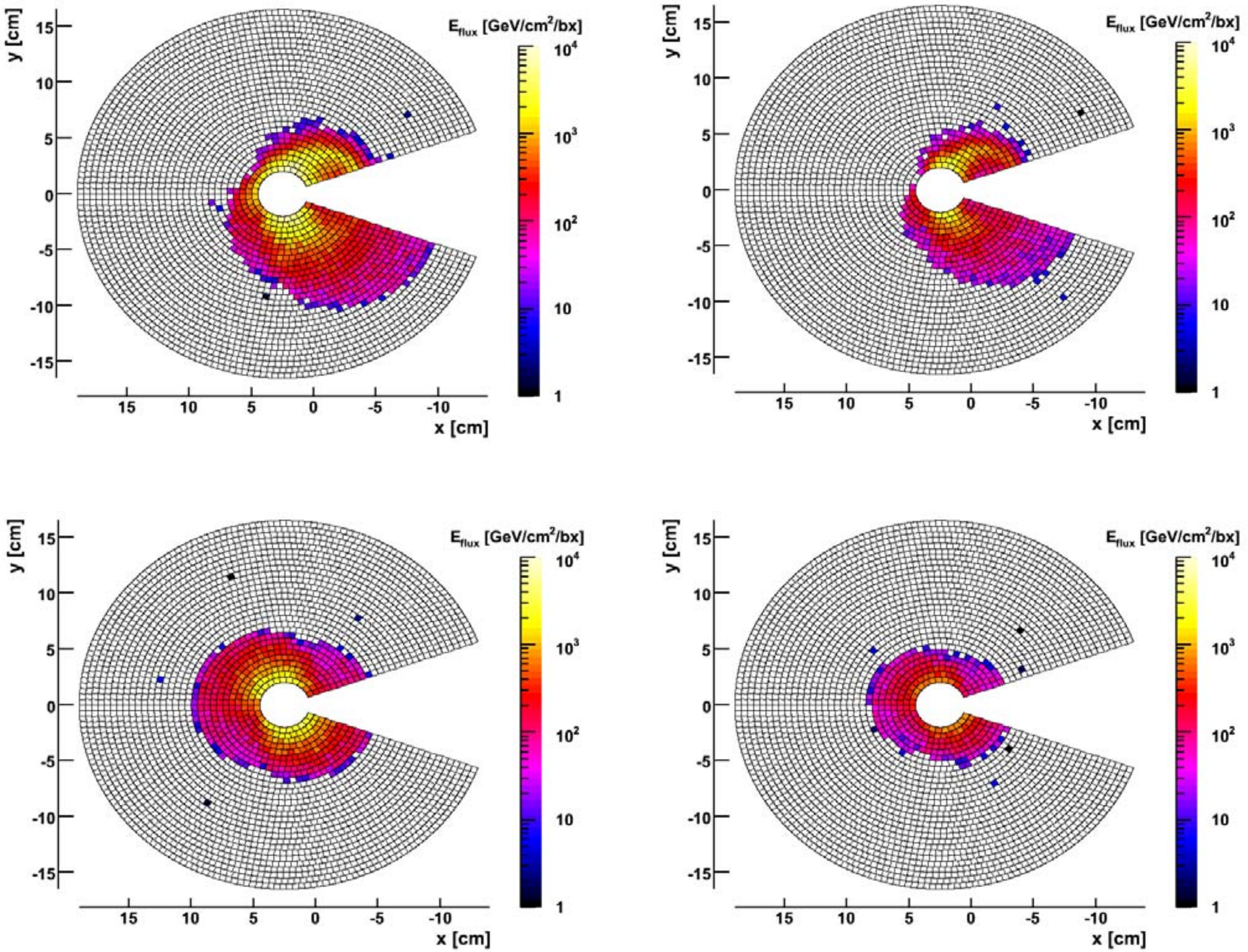


Pair Distributions for 14mrad

LowP — Nominal

DID

Anti DID

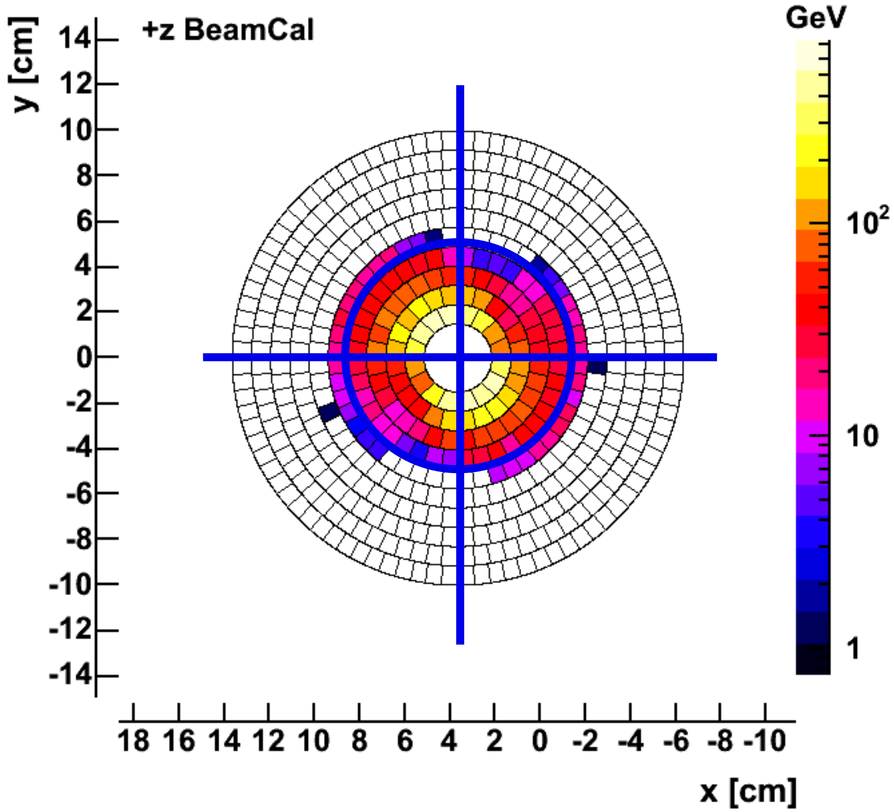


Larger blind area compared to 20 mrad (30° => 40°)

Moore Penrose Method

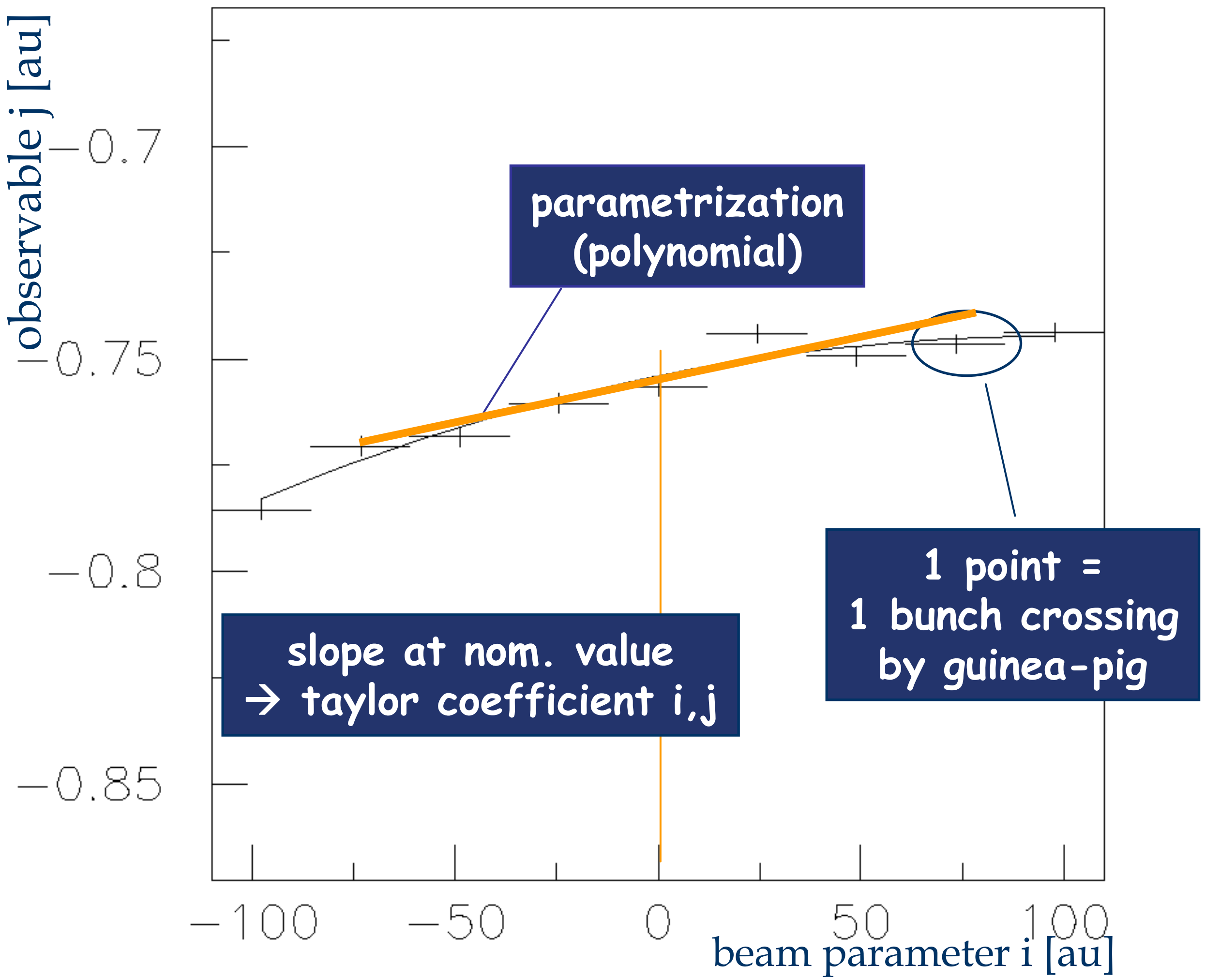
- Observables (examples):
  - total energy
  - first radial moment
  - thrust value
  - angular spread
  - E(ring ≥ 4) / Etot
  - r-φ observables T1, T2
  - E / N
  - l/r, u/d, f/b asymmetries

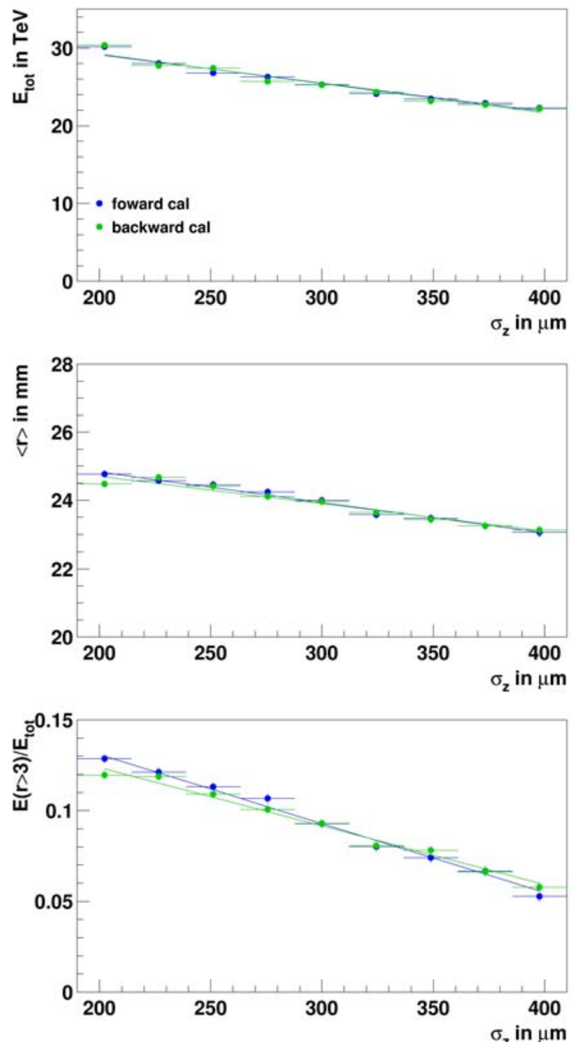
$$\left(\text{Observables}\right) = \left(\text{Observables}\right)_{nom} + \left(\text{Taylor Matrix}\right) * \left(\Delta\,\text{BeamPar}\right)$$



detector: realistic segmentation, ideal resolution, bunch by bunch resolution

1st order Taylor Matrix





Beam Parameter Reconstruction

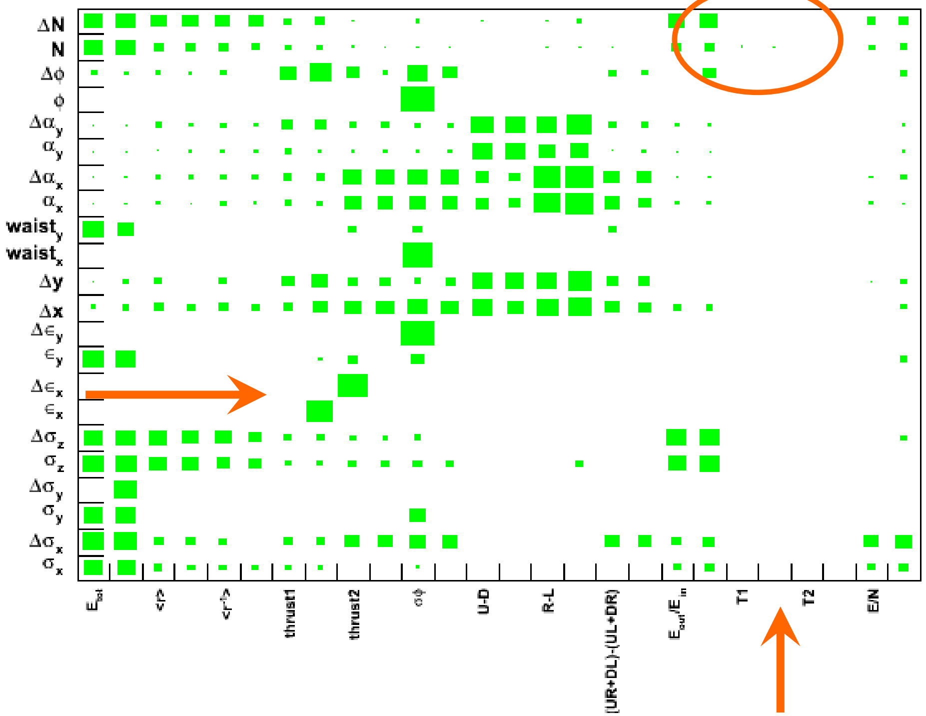
Single parameter reconstruction

			2mrad		14mrad DID		14mrad antiDID	
Parameter	Unit	Nom.	μ	σ	μ	σ	μ	σ
σ_x	nm	655	653.42	1.95	653.66	3.42	653.89	2.27
σ_y	nm	5.7	5.208	0.371	5.464	0.520	5.395	0.229
σ_z	μm	300	300.75	4.56	306.60	5.13	299.83	4.11
ε_x	10^{-6}m rad	10	11.99	7.61	-	-	-	-
ε_y	10^{-9}m rad	40	40.41	1.29	40.22	1.19	40.72	1.19
Δx	nm	0	4.77	14.24	3.86	9.16	-3.24	10.70
Δy	nm	0	0.44	0.66	-2.07	0.81	0.05	0.65
waistx	μm	0	-69	141	-230.	828.	218.	349.
waisty	μm	0	12	24	-6.	19.	19.	25.
N_{bunch}	10^{10} part	2	2.009	0.005	2.001	0.007	2.009	0.005

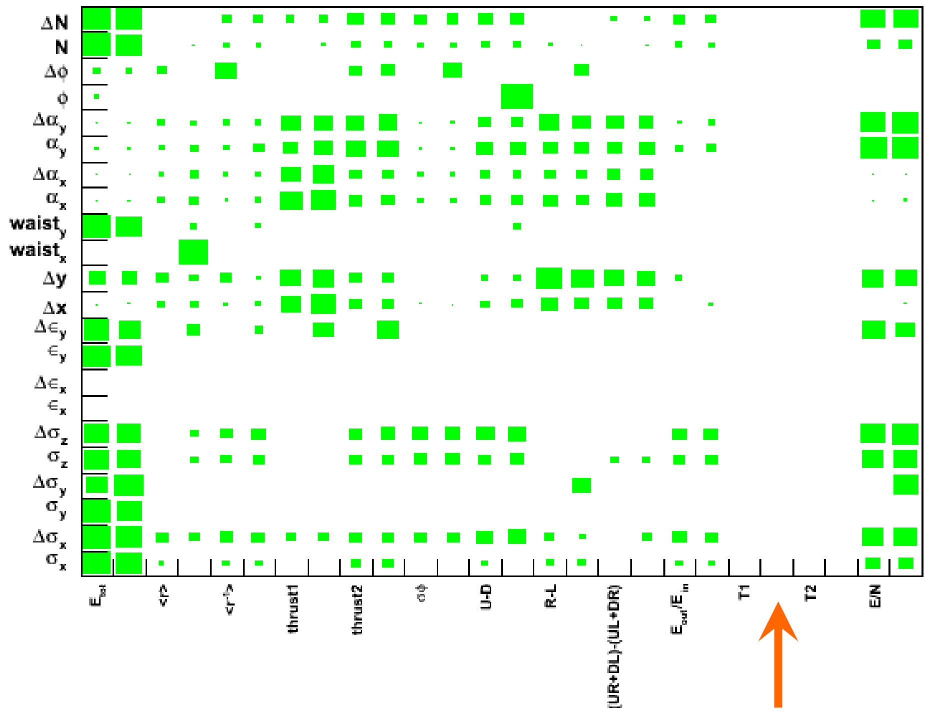
Beam Parameter Reconstruction

Beamparameters vs Observables
slopes (significance) normalized to sigmas

2mrad

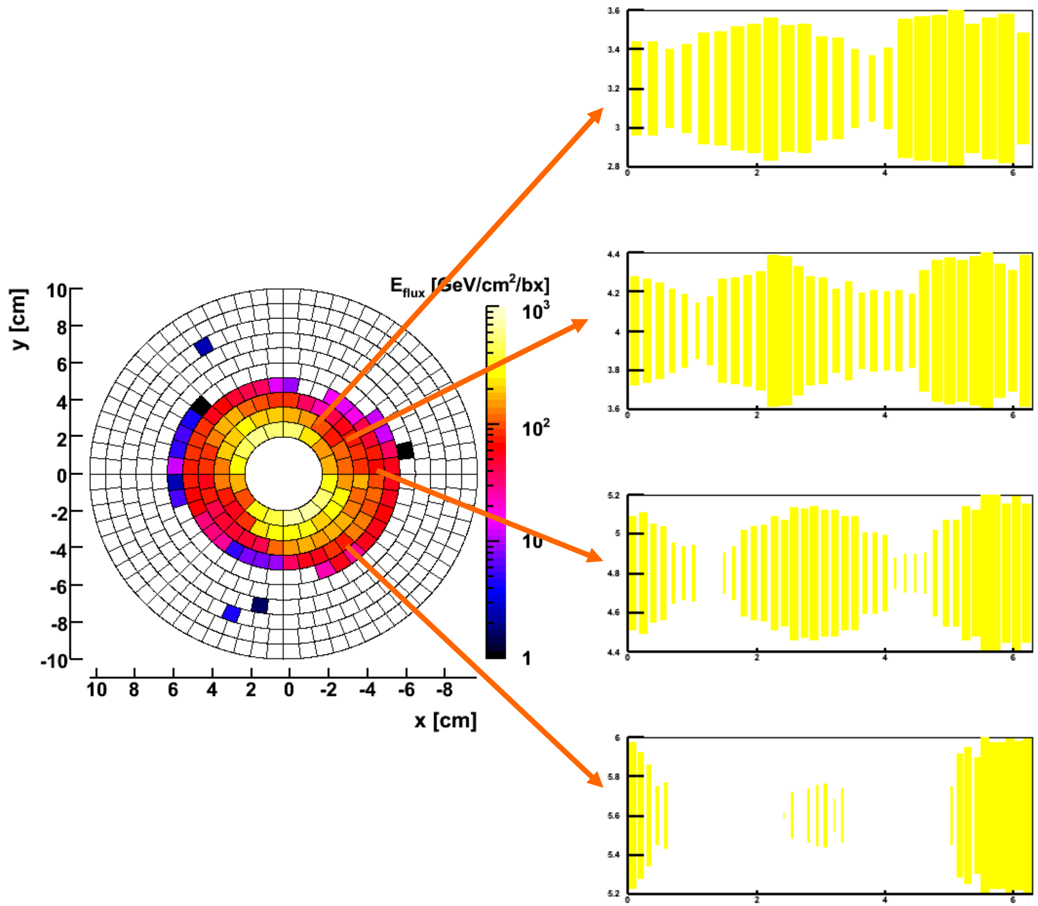


14mrad DID



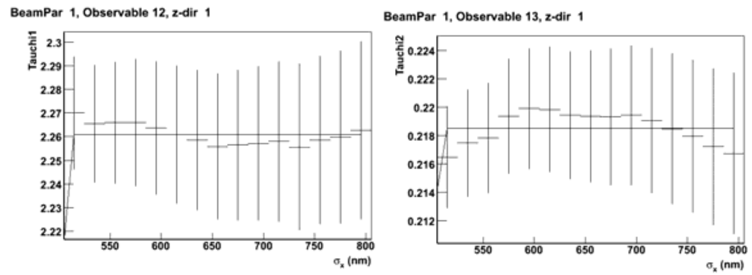
Observables(r-φ)

- Tauchi & Yokoya, Phys Rev E51, (1995) 6119



Define 2 x 2 regions with:
high energy deposition
low energy deposition

T1 = (Low1 + Low2)/(High1+High2)
T2= High1/High2



Has to be redefined for each geometry/magnetic field. Optimum not found yet.

Concept of the Beamstrahlung Pair Analysis

Simulate Collision
with **Guineapig**
1.) nominal parameter set
2.) with variation of a specific beam parameter
(e.g. σ_x, σ_y, σ_z, $\Delta\sigma_x$, $\Delta\sigma_y$, $\Delta\sigma_z$)
G.White: 2[nd] order dependencies

Produce photon/pair output ASCII File

A.Stahl: beammon.f

Extrapolate pairs to BeamCal front face and
determine energy deposition
(geometry and magnetic field dependent)

Calculate Observables and write summary file

A.Sapronov: BeCaS1.0

Run full GEANT4 simulation BeCaS and calculate energy deposition per cell
(geometry and magnetic field dependent)

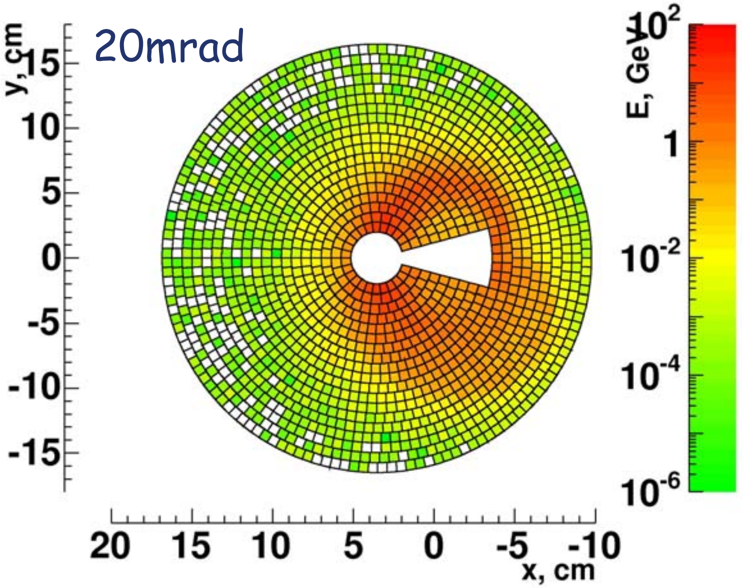
Calculate Observables and write summary file

Do the parameter reconstruction using
1.) linear approximation (Moore Penrose Inversion Method)
2.) using fits to describe non linear dependencies

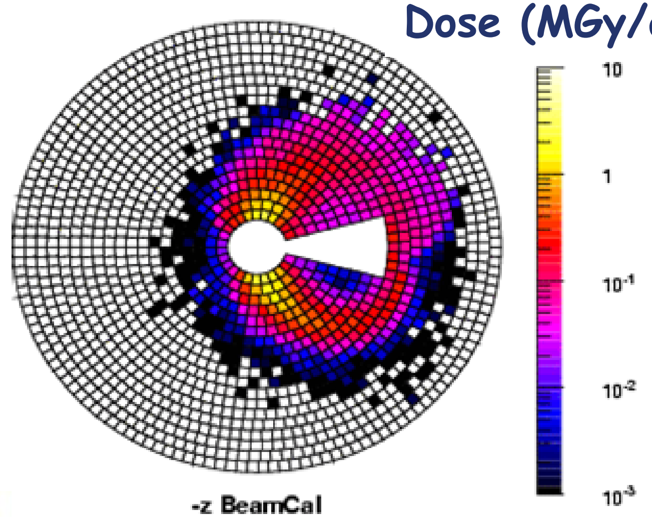
LC-DET-2005-003
Diagnostics of Colliding Bunches from Pair Production and Beam Strahlung at the IP
Achim Stahl

Geant 4 Simulation - BeCaS

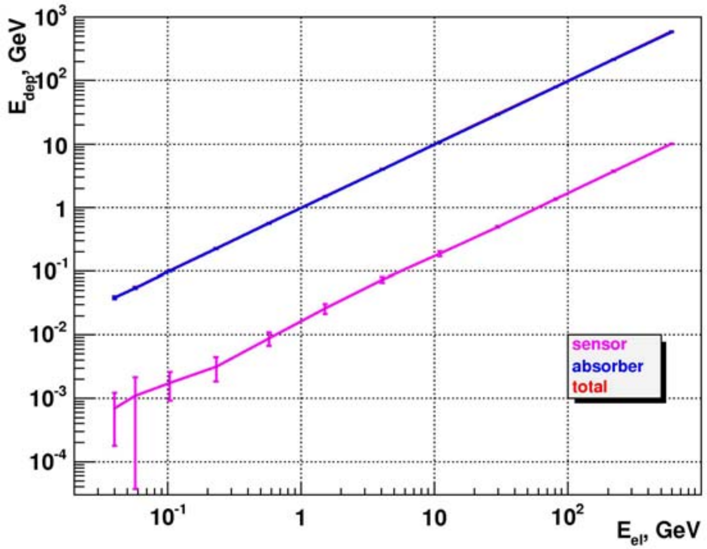
- A Geant4 BeamCal simulation has been set up (A.Sapronov).
- Energy distribution for 2mrad and 20mrad DID (14mrad not yet simulated).
- BeCaS can be configured to run with:
  - **different crossing angles (corresponding geometry is chosen)**
  - **magnetic field (solenoid, (Anti) DID, use field map)**
  - **detailed material composition of BeamCal including sensors with metallization, absorber, PCB, air gap**

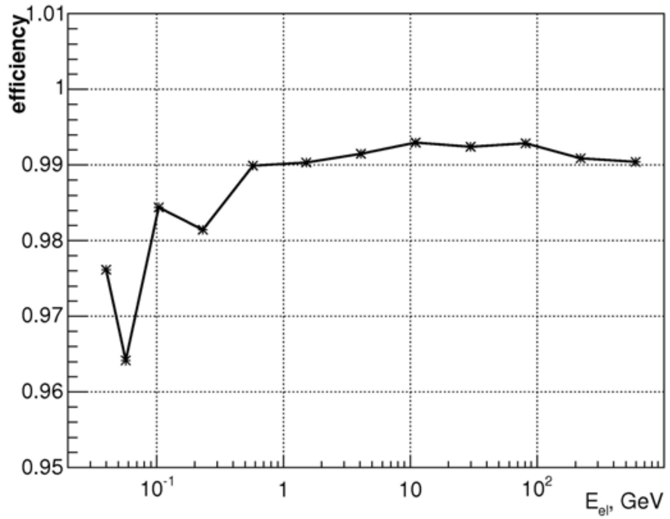


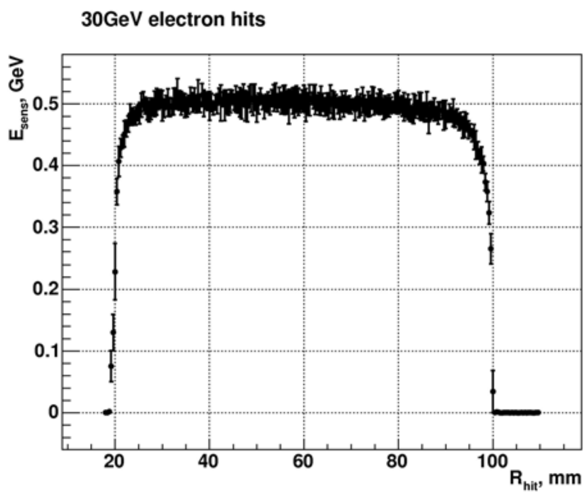
Dose (MGy/a)



BeCaS - Checkplots

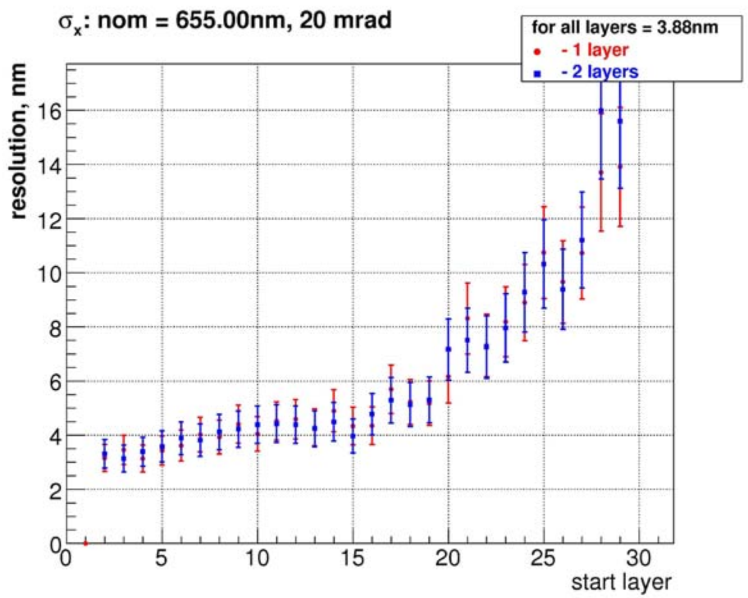






Beamparameter Reconstruction

- Using the observables:
  - Etot // (1) Total energy
  - Rmom // (2) Average radius
  - Irmom // (3) radial moment
  - UDimb // (4) U-D imbalance
  - RLimb // (5) R-L imbalance
  - Eout // (6) Energy with r>=6
  - PhiMom // (7) Phi moment
  - NoverE // (15) N/E

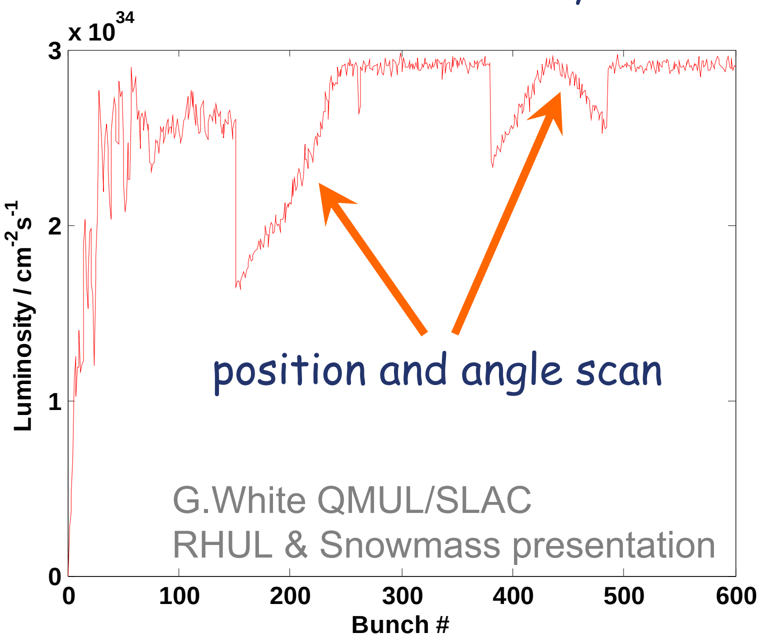


GamCal – Using Photon Information

- Use as much information about the collision as possible.
- BeamCal measures the energy of pairs originating from beamstrahlung.
- GamCal will measure the energy of the beamstrahlung photons (see B.Parker's talk).

1. Investigate correlation to learn how we can improve the beamdiagnostics and
2. define a signal proportional to the luminosity which can be fed to the feedback system.

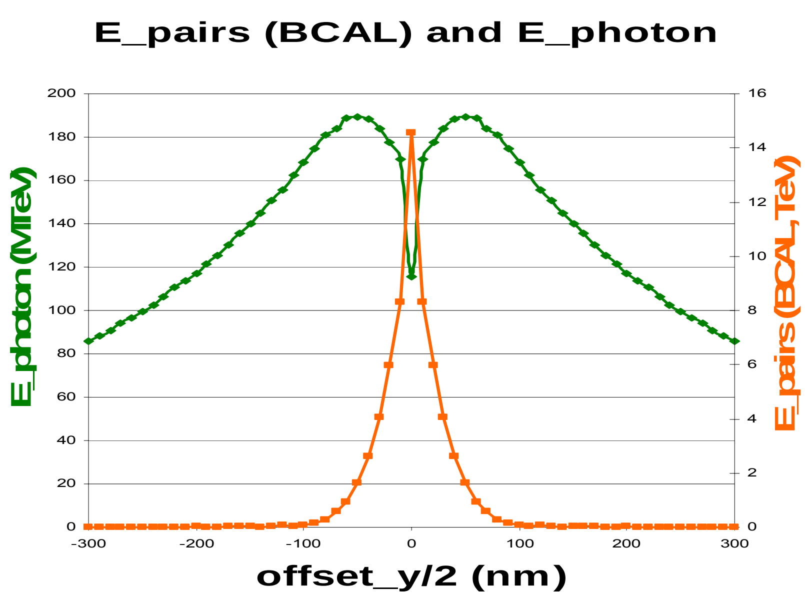
Simulation of the Fast Feedback System of the ILC.

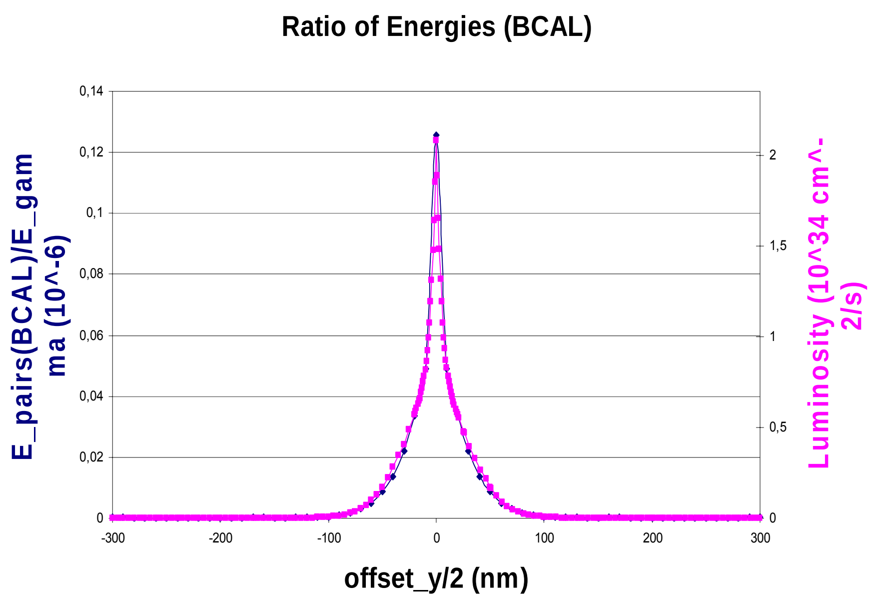


1. Standard procedur (using BPMs)
2. Include pair signal (N) as additional input to the sytsem

Increase of luminosity of 10 - 15%

Vertical Offset (y-direction)





complementary information from

1. total photon energy vs offset_y
2. BeamCal pair energy vs offset_y

ratio of E_pairs/E_gam vs offset_y is proportional to the luminosity

similar behaviour for angle_y, waist_y …

Studies by M.Ohlerich

Summary

- The geometry for a 14mrad beam crossing angle is the same as for 20mrad. The 20mrad geometry should be changed due to background.
- The LowP parameter set is under discussion => lower L or higher background.
- Consolidated guineapig steering parameters and reproduced pair/photon files.
- Tested 2, 14 and 20 mrad configurations with DID/AntiDID field.
- A Geant4 simulation of BeamCal (BeCaS) is ready for usage. First tests show that a subset of the detector information seems sufficient for beam parameter reconstruction.
  - Include this into Mokka
  - Build additional fast FCAL simulation (?)
- GamCal could provide valuable information about the collision
  - partly complenentary to BeamCal information
  - E_{pair}/E_{γ} is a signal proportional to the luminosity for several beam parameters