Update on Beamdiagnostics using BeamCal

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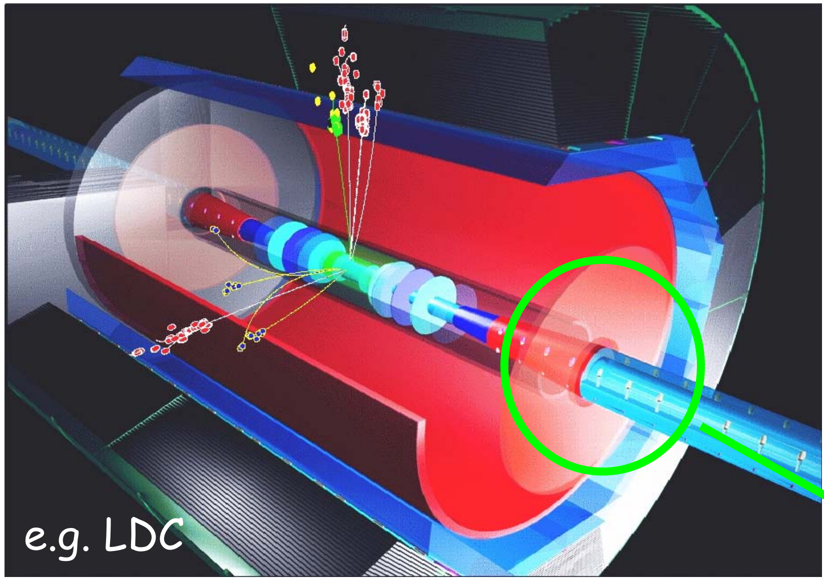
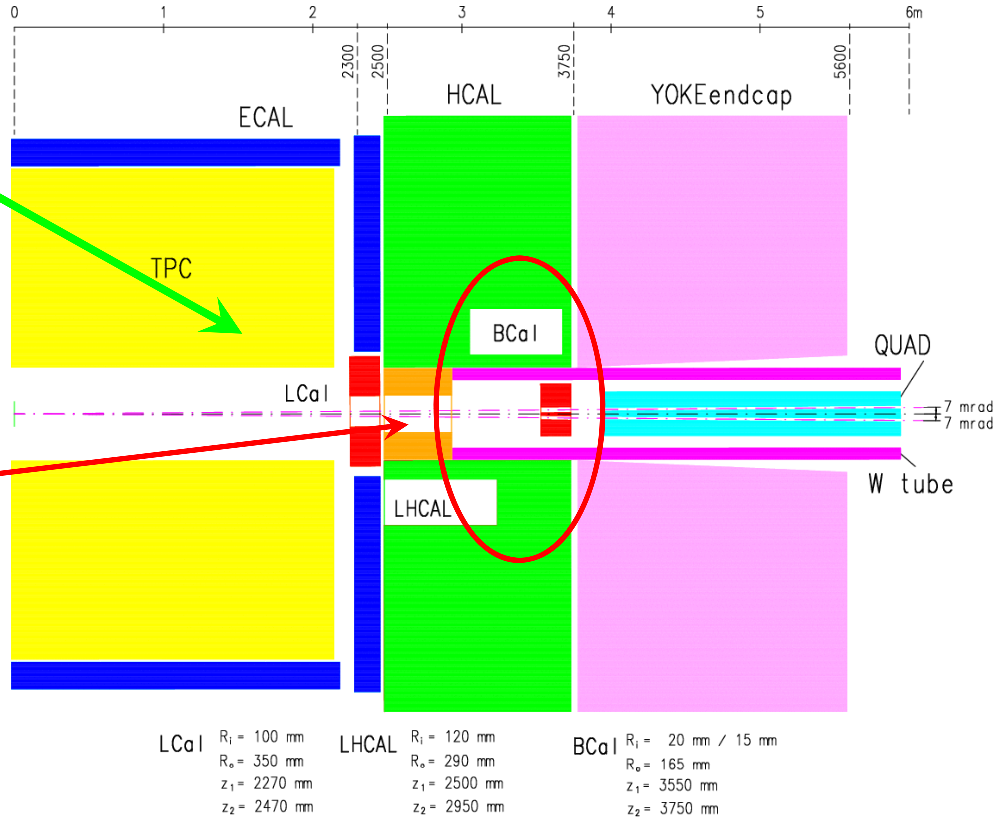
Overview

- Very Forward Region and BeamCal
- Fast beam parameter reconstruction using the Geant4 based simulation BeCaS
- Including Beamstrahlung photons
- Possible reduction of information for beamdiagnostics (readout electronics)

The Forward Region

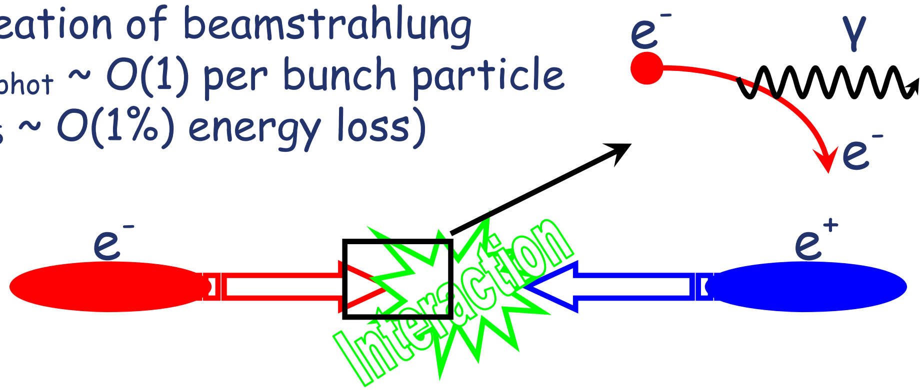


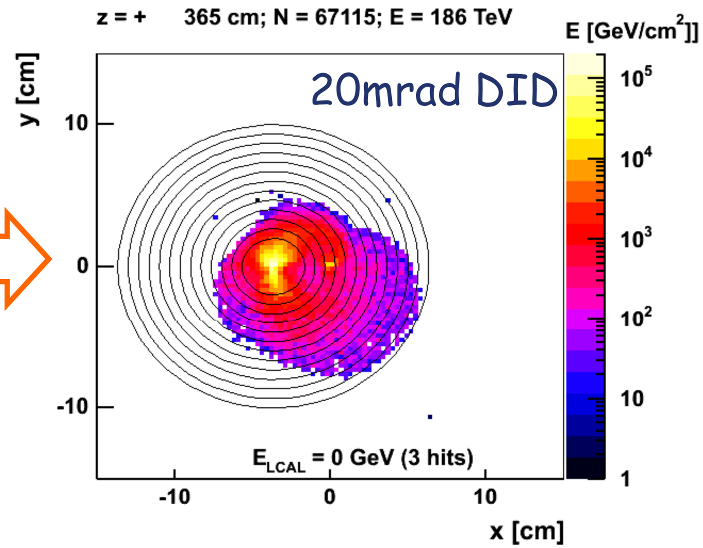


BeamCal will be hit by a large amount of electron-positron pairs stemming from beamstrahlung.

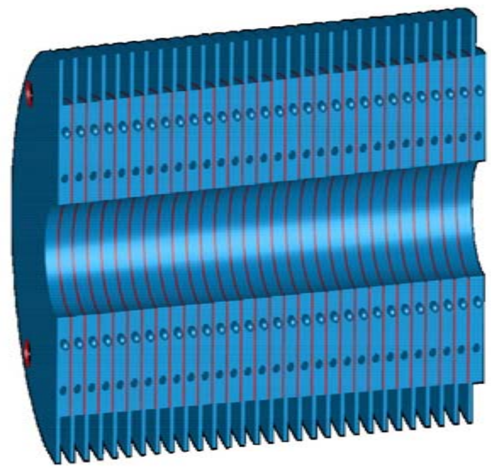
BeamCal Details

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





BeamCal: sandwich em. calorimeter
Length = 30 X_0
3.5mm W + .5mm radiation hard sensor
~ 10^4 - 10^5 channels of ~0.8 R_M
~ 1.5 cm < R < ~10(+2) cm
Each sensor layer divided into 8-9 sectors.



Space for electronics

BeamCal: 4 < θ < 28 mrad

What can we learn about the collision from the pair background?

- The spatial distribution of the energy deposition from beamstrahlung pairs contains a lot of information about the collision.
- Use a **fast** algorithm to extract beam parameters like:

beam sizes (σ_x, σ_y and σ_z)
emittances (ε_x and ε_y)
offsets (Δ_x and Δ_y)
waist shifts (w_x and w_y)
angles and rotation (α_h, α_v and φ)
Particles per bunch (N_b)

Concepts 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: 2nd 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)

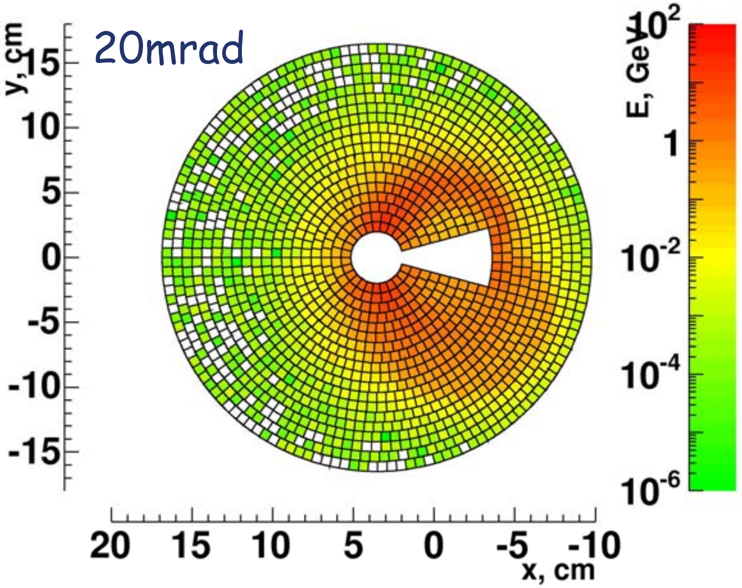
Calculate Observables and write summary file

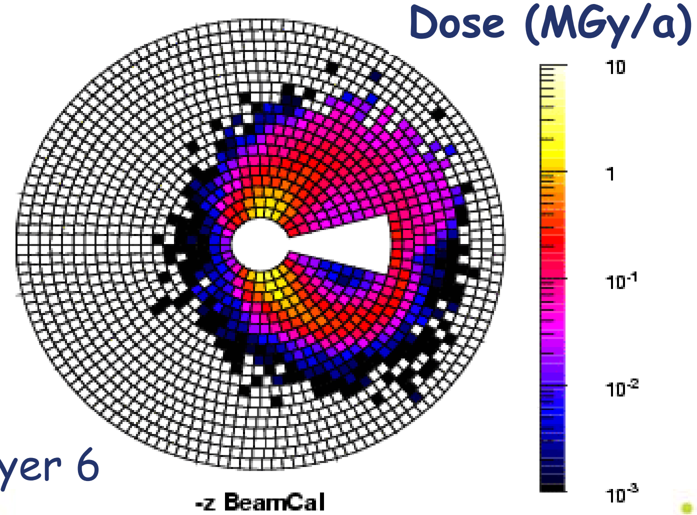
Do the parameter reconstruction using
1.) linear approximation (Moore Penrose Inversion Method)
2.) using fits to describe non linear dependencies

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

Geant 4 Simulation - BeCaS

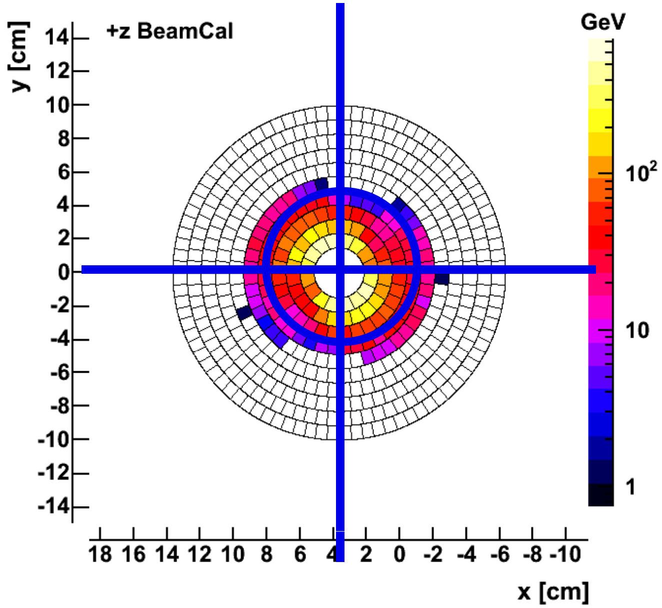
- A Geant4 (4.8.0) BeamCal simulation has been set up (A.Sapronov).
- BeCaS can be configured using a configuration file to run with:
  - different crossing angles: 0, 2, 14, 20mrad corresponding geometry is chosen
  - various magnetic field types (solenoid, (Anti) DID, use field map)
  - detailed material composition of BeamCal including sensors with metallization, absorber, PCB, air gap
  - Root tree output containing energy deposition per cell





Moore Penrose Method

(Observables) = (Observables)$_{nom}$ + (Taylor Matrix) * (Δ BeamPar)



- observables:
  - total energy
  - first radial moment
  - inv. radial moment
  - l/r, u/d, diag asymmetries
  - E(ring ≥ 4) / Etot
  - E / N
  - phi moment
  - inv. phi moment
  - f/b asymmetries
  - total photon enegery (extern)

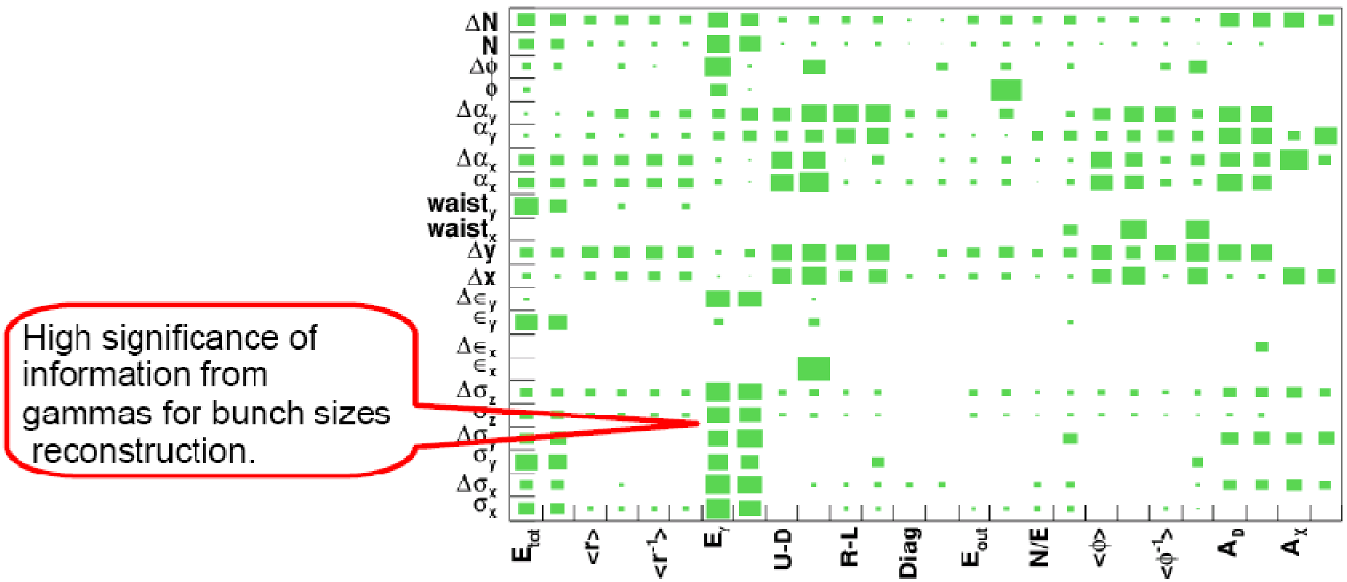
⇨

- beam parameters (diff and av)
  - bunch sizes
  - emittances
  - beam offsets
  - waist shifts
  - bunch rotations
  - profile rotations
  - number of particles

Beam Parameter Reconstruction

Single parameter reconstruction using whole calorimeter data

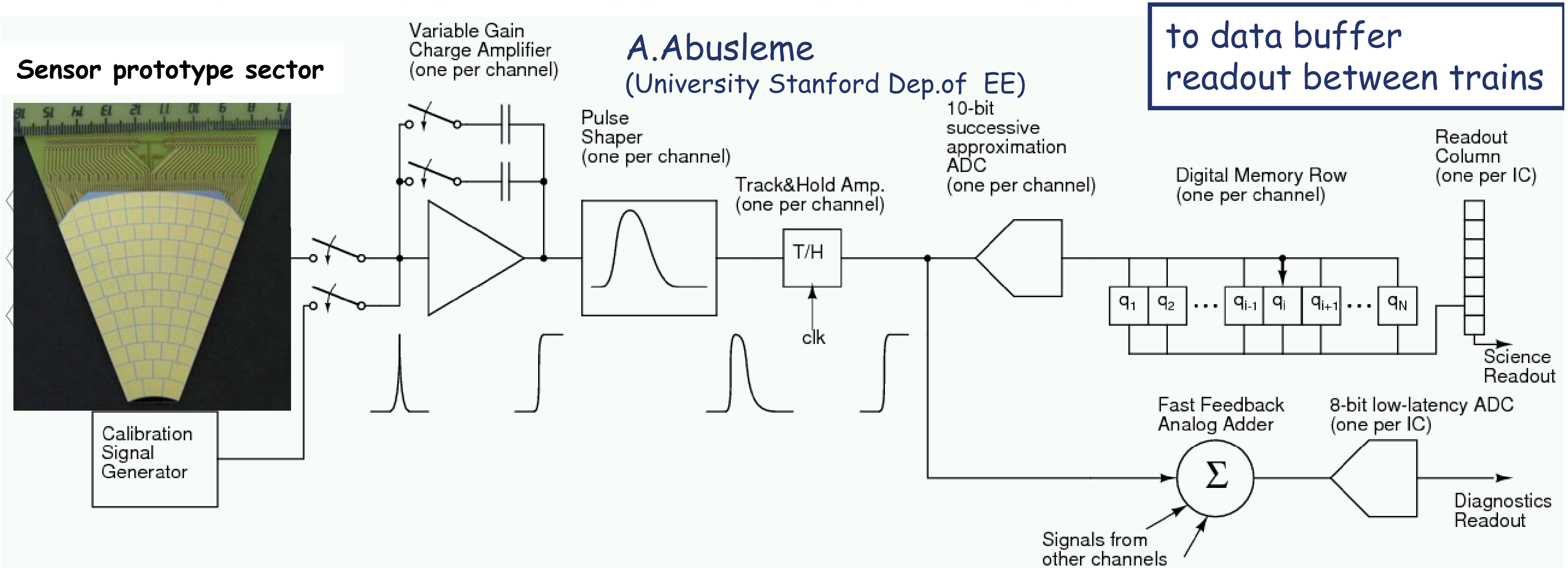
			2mrad (old)		20mrad DID		20mrad DID + Ephot		14mrad antiDID + Ephot	
BP	Unit	Nom.	μ	σ	μ	σ	μ	σ	μ	σ
σ_z	μm	300	300.75	**4.56**	307.98	**4.72**	299.80	**1.69**	301.09	**1.65**
ε_x	10^{-6}m rad	10	11.99	**7.61**	-	**-**	-	**-**	9.94	**2.16**
Δx	nm	0	4.77	**14.24**	4.55	**8.14**	4.57	**8.13**	-3.84	**11.80**
α_x	rad	0	0.002	**0.016**	0.010	**0.025**	-0.001	**0.025**	-0.071	**0.017.**



BeamCal Electronics

to data buffer
readout between trains

A.Abusleme
(University Stanford Dep.of EE)



to feedback system
(FONT)
real time + low latency!

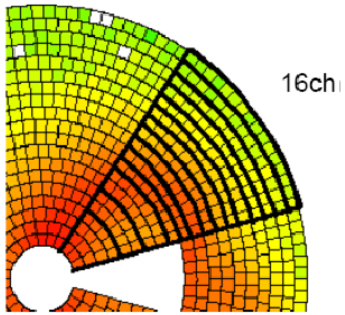
- Dual gain front-end
- Successive approximation ADC 1/ch
- Digital memory to store information of 1 train/ch
- Analog addition <u>of 32 ch</u> for fast feedback

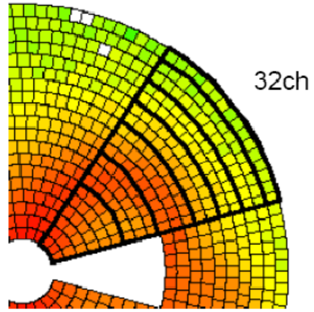
see also: EUROTeV-Memo-2006-004-1

Data Reduction

Scenarios of data reduction for the reconstruction of beam parameters:

- use not all layers (6th layer)
- use 32/16 channel clusters
- digitized information





			full details		digitized		16 channels		32 channels	
BP	Unit	Nom.	μ	σ	μ	σ	μ	σ	μ	σ
σ_x	μm	655	653.72	**1.29**	653.84	**1.35**	653.97	**1.30**	654.04	**1.27**
$\Delta\sigma_x$	μm	0.	-1.72	**2.01**	-1.87	**2.08**	-1.65	**2.01**	-1.65	**2.02**
σ_z	μm	300	300.90	**1.69**	300.35	**1.63**	300.48	**1.56**	300.39	**1.47**
$\Delta\sigma_z$	μm	0.	-0.59	**1.82**	-1.26	**1.97**	-0.41	**1.77**	-0.33	**1.82**
ε_x	10^{-6}m rad	10	10.18	**2.62**	9.71	**2.62**	10.18	**2.62**	10.18	**2.62**
Δx	nm	0	-5.35	**11.51**	-9.82	**12.63**	-7.26	**9.80**	-7.78	**9.76**
α_x	rad	0	-0.056	**0.019**	-0.119	**0.017**	-0.076	**0.025**	-0.077	**0.025**

Bhabha Events

- Overlayed a Bhabha event in each reconstructed event (expected: 0.13/BX) (COMPHEP)

			full BeamCal no bhabbhas		bhabhas	
BP	Unit	Nom.	μ	σ	μ	σ
σ_x	μm	655	653.799	**1.33**	653.17	**1.56**
$\Delta\sigma_x$	μm	0.	-0.96	**2.12**	-1.15	**2.47**
σ_z	μm	300	301.09	**1.65**	300.10	**2.47**
$\Delta\sigma_z$	μm	0.	-0.67	**1.90**	-0.79	**2.17**
ε_x	10^{-6}m rad	10	9.94	**2.16**	10.45	**2.93**
Δx	nm	0	-3.84	**11.08**	-5.03	**16.83**

Summary & Further Plans

- A Geant4 simulation of BeamCal (BeCaS) is ready for usage. The geometry is for a large part parameterized.
- The photon energy is a valuable information to be included in the reconstruction.
- A subset of the detector information seems sufficient for beam parameter reconstruction.
- Overlayed bhabhas decrease the resolution slightly.

- Look on effects for a multiparameter reconstruction.
- Use full detector information for MP calculation and reduced set for reconstruction. Redefine clusters.
- **Implement BeamCal into Mokka.**
- Get/use the Real Beam simulation data.