Beam Monitoring from Beam Strahlung

work mainly by summer students

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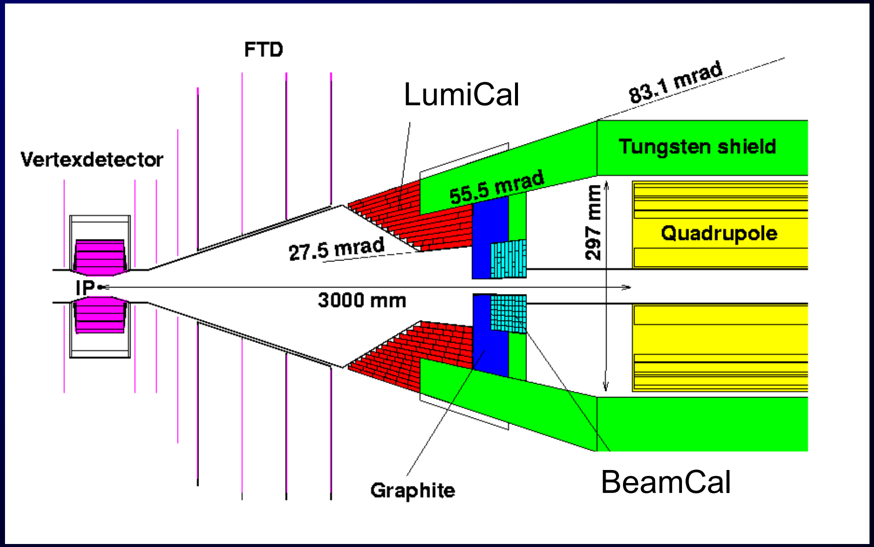
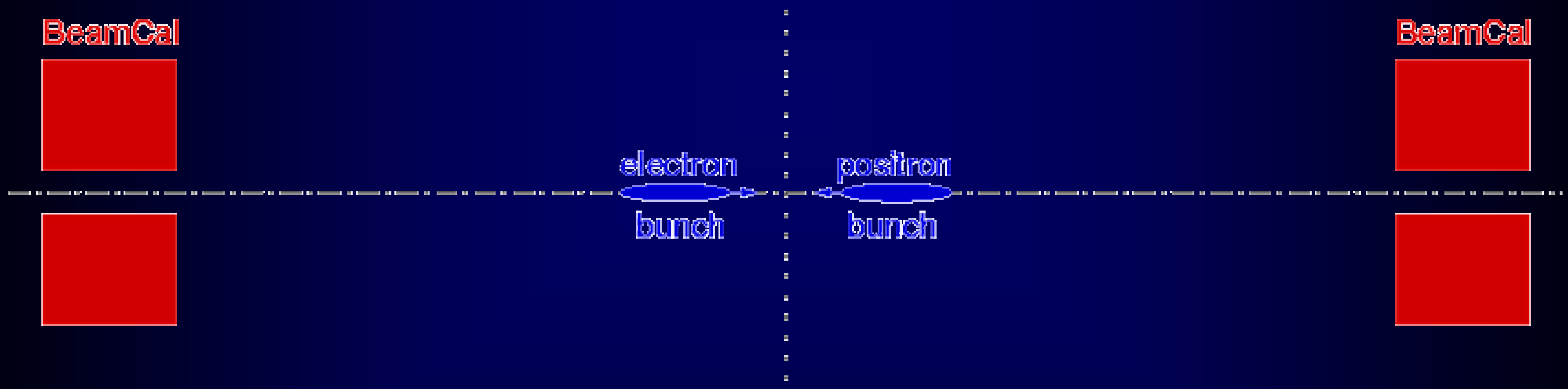


Achim Stahl DESY Zeuthen 21.Jan.2004

Beam Strahlung

TESLA: small bunches (5nm x 550nm x 300μm)

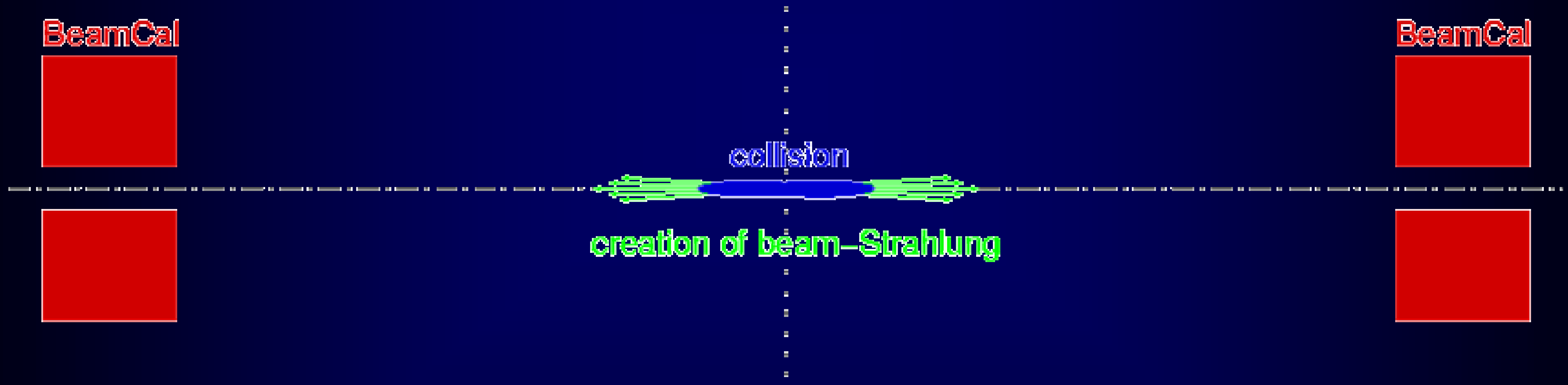
huge electric/magnetic fields



Beam Strahlung

Particles accelerated by electric field

→ creation of photon radiation (beamstrahlung)

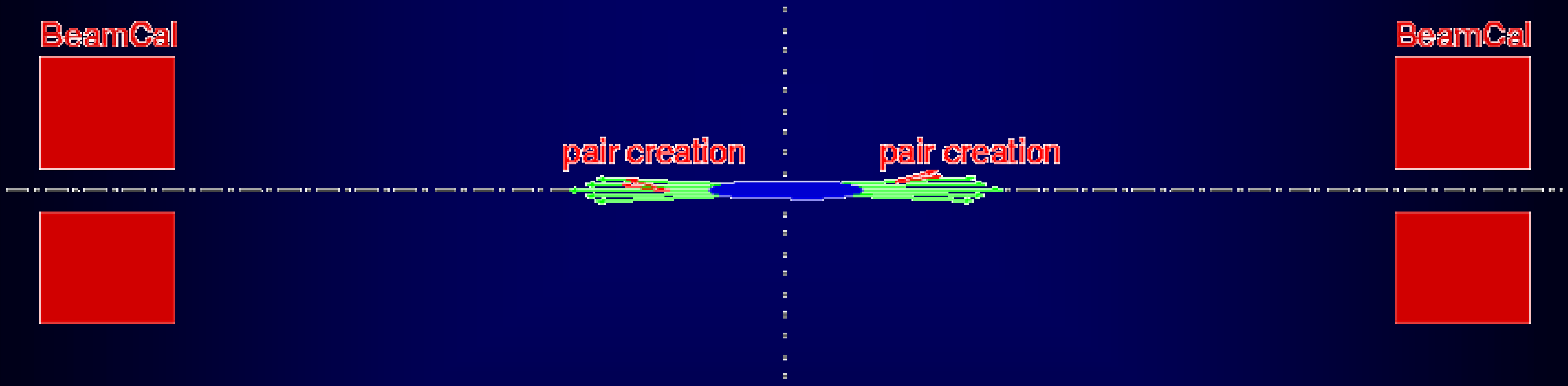


Simulation of collisions
by guinea-pig

Beam Strahlung

Creation of e^+e^- pairs by photon-photon interactions

(2nd order effect, $e^+e^- \ll \gamma s$)

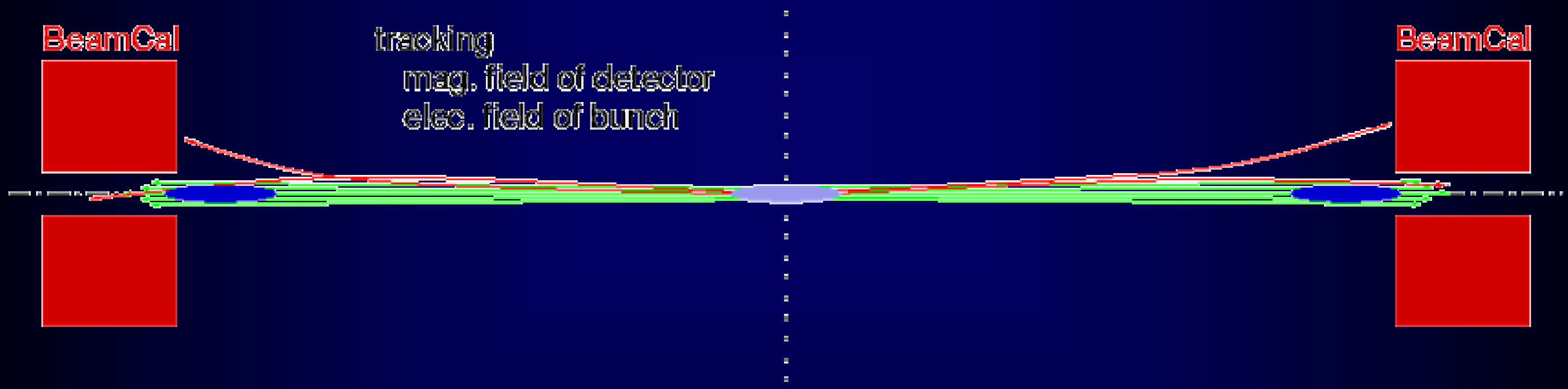


Simulation of collisions
by guinea-pig

Beam Strahlung

Tracking of particles into the forward region

(e^+e^- confined by magnetic field of detector)



Tracking by simple stand-alone program

Beam Strahlung

Creation of signals in detectors (LCal + Collimators?)

→ fast diagnosis + offline analysis

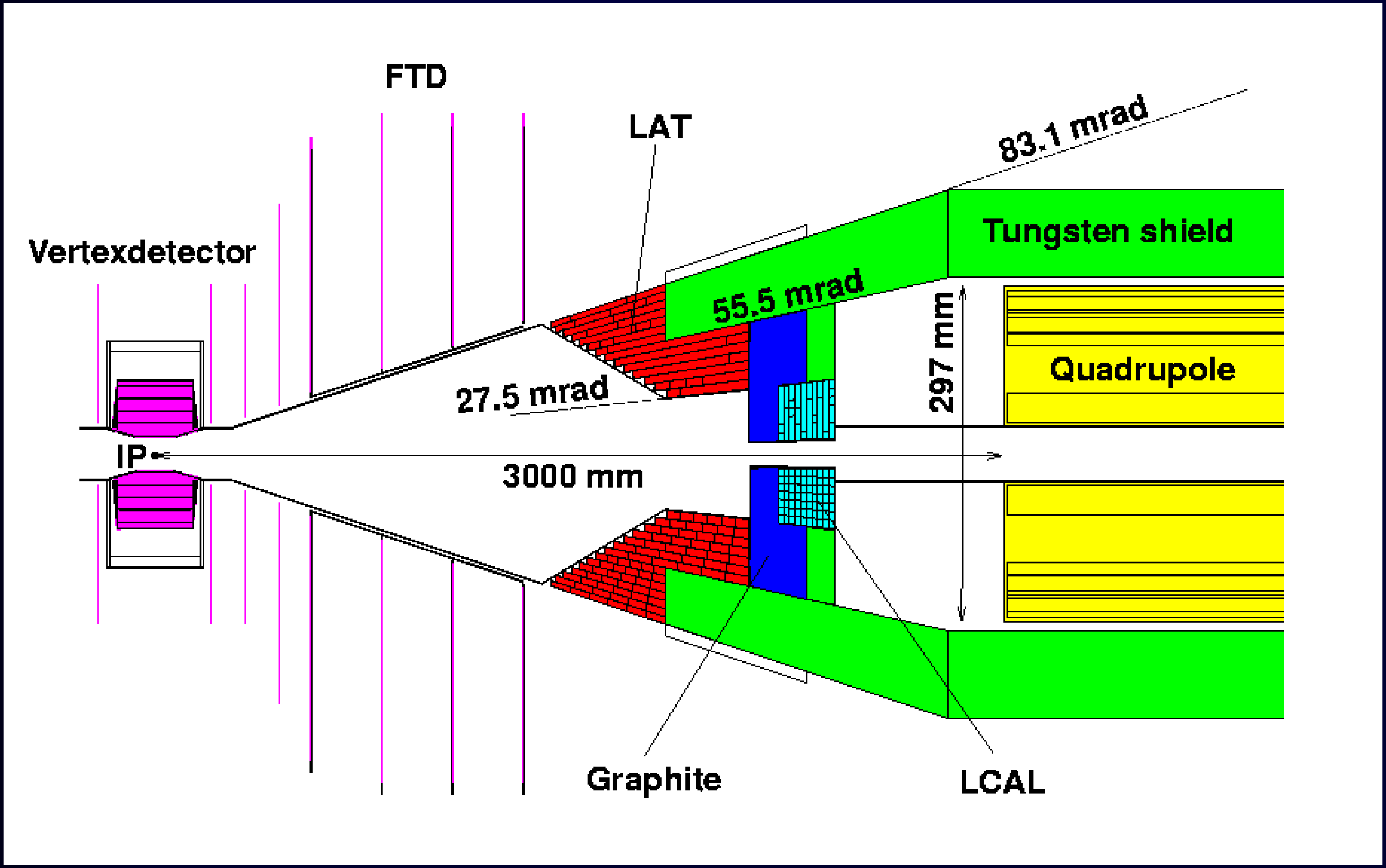
Over-simplified detector simulation

- detectors subdivided into cells
- sum energy impact on cells

3 potential sources of information

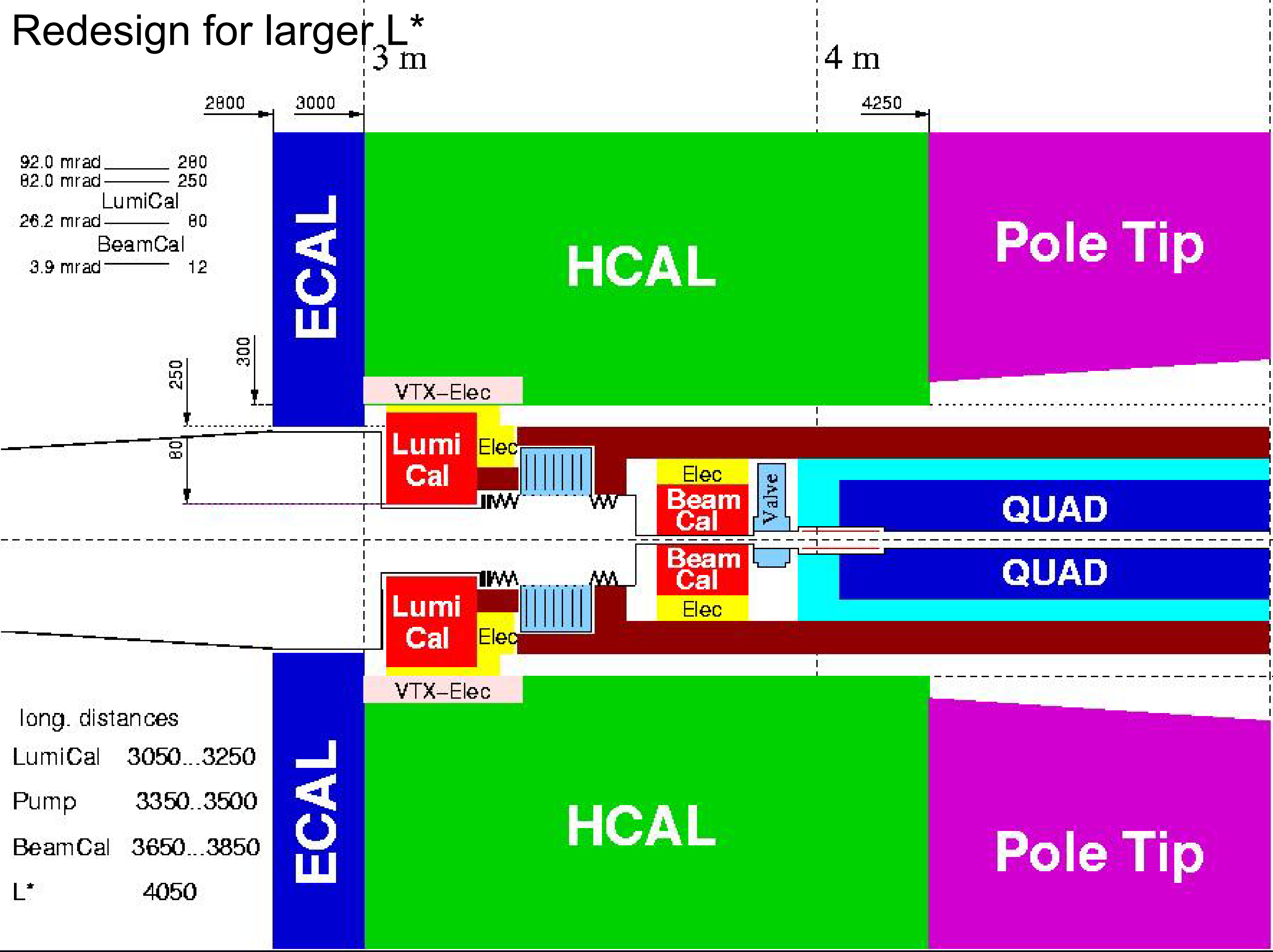
- energy-distribution of pairs
- number-distribution of pairs
- distribution of photons

Detector



TDR design

Redesign for larger L*



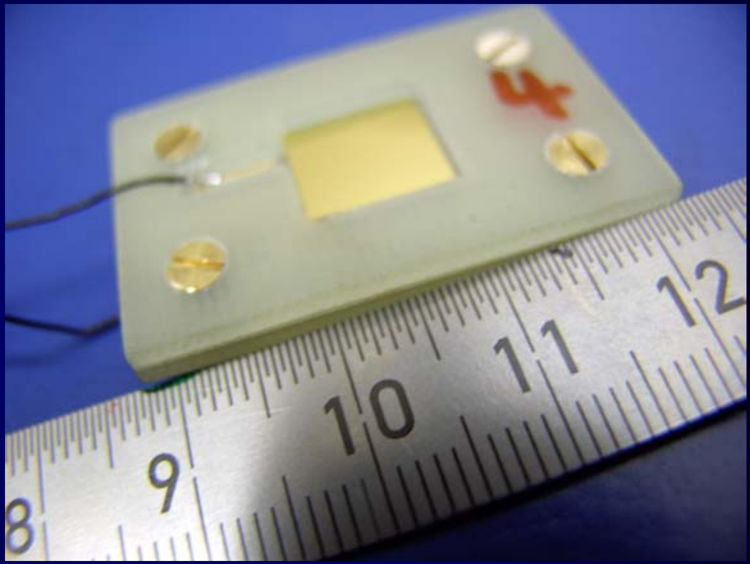
long. distances

LumiCal	3050...3250
Pump	3350..3500
BeamCal	3650...3850
L*	4050

Detector Technology

R&D Project: TESLA Forward Calorimeters

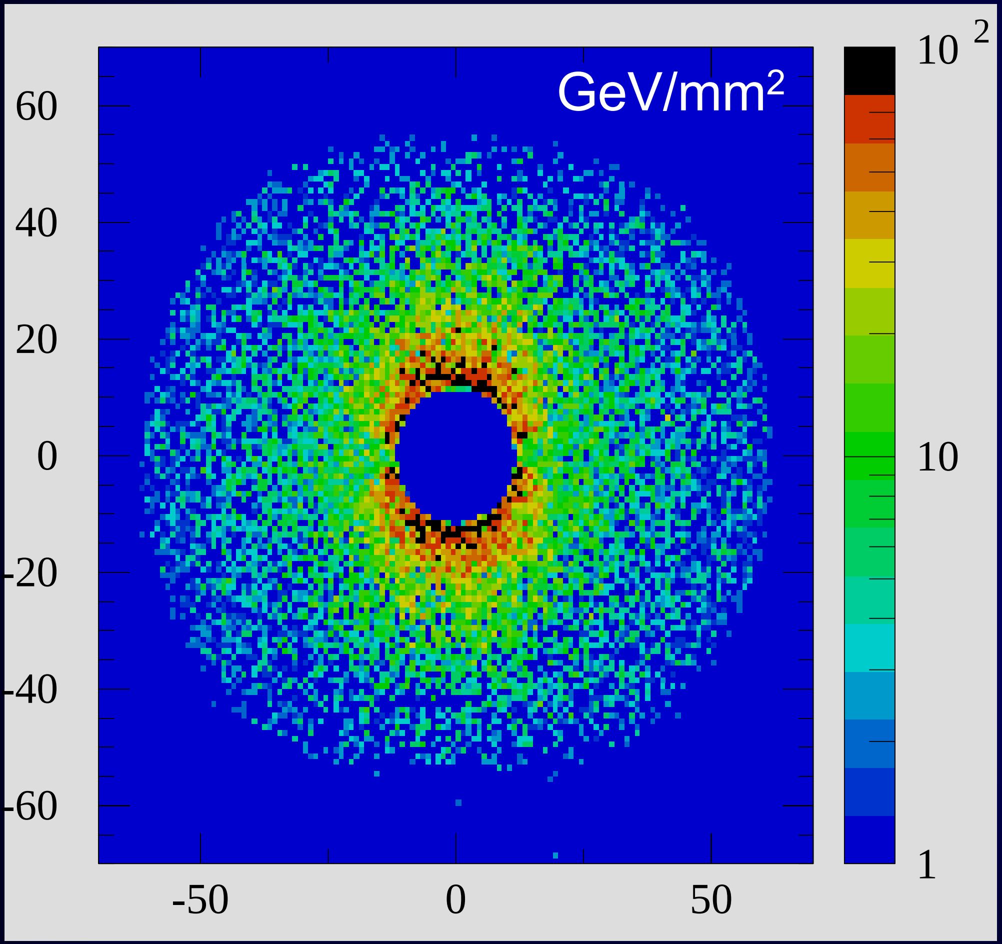
- Univ. of Colorado, Bolder
- AGH Univ. Cracow
- Inst Nucl Phys, Cracow
- Joint Inst Nucl Res., Dubna
- UC London
- NSEC, Minsk
- Inst Phys., Prague
- Inst HEP, Protvino
- Univ. Tel Aviv
- DESY Zeuthen



most promising technology: Sandwich Calorimeter

- Tungsten Absorber
- Diamond Sensors

Detector



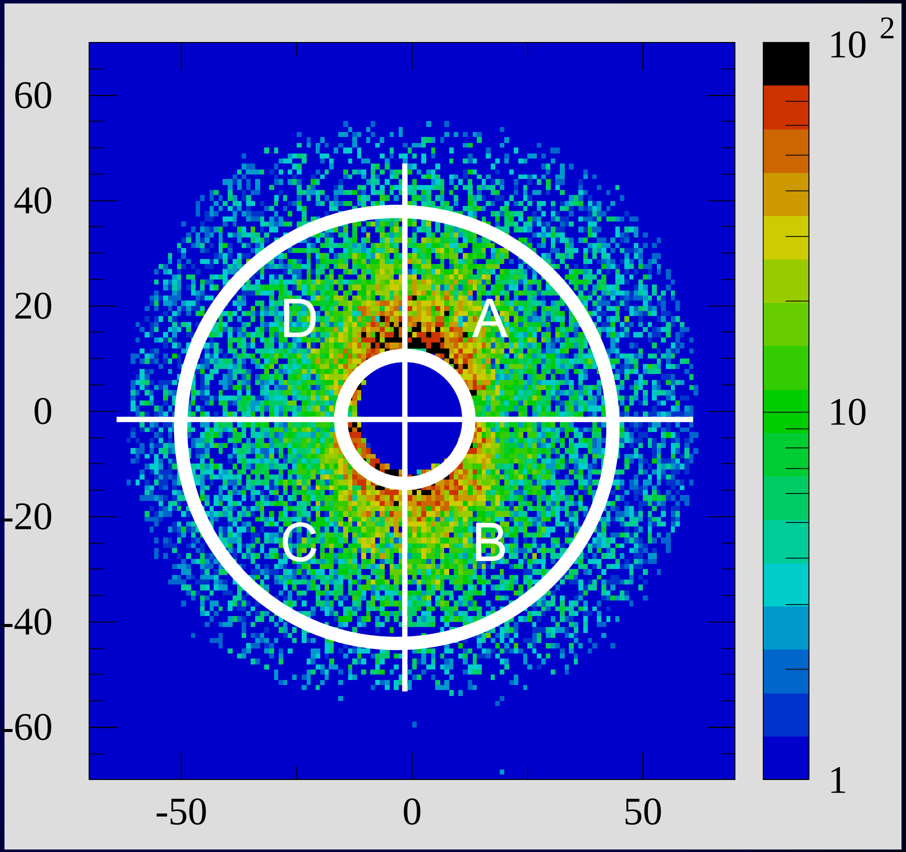
photons → beam pipe

pairs:

- 100 TeV/BX total
- 20 TeV/BX in detector

Example: Observables

- total energy
- first radial moment
- direction of thrust axis
- E(ring ≥ 4) / E_{tot}
- (A + D) – (B + C)
- (A + B) – (C + D)
- (A + C) – (B + D)



Current Analysis Concept

Beam Parameters

- determine collision
- creation of beamstr.
- creation of e^+e^- pairs

guinea-pig

1^{st} order Taylor-Exp.

Observables

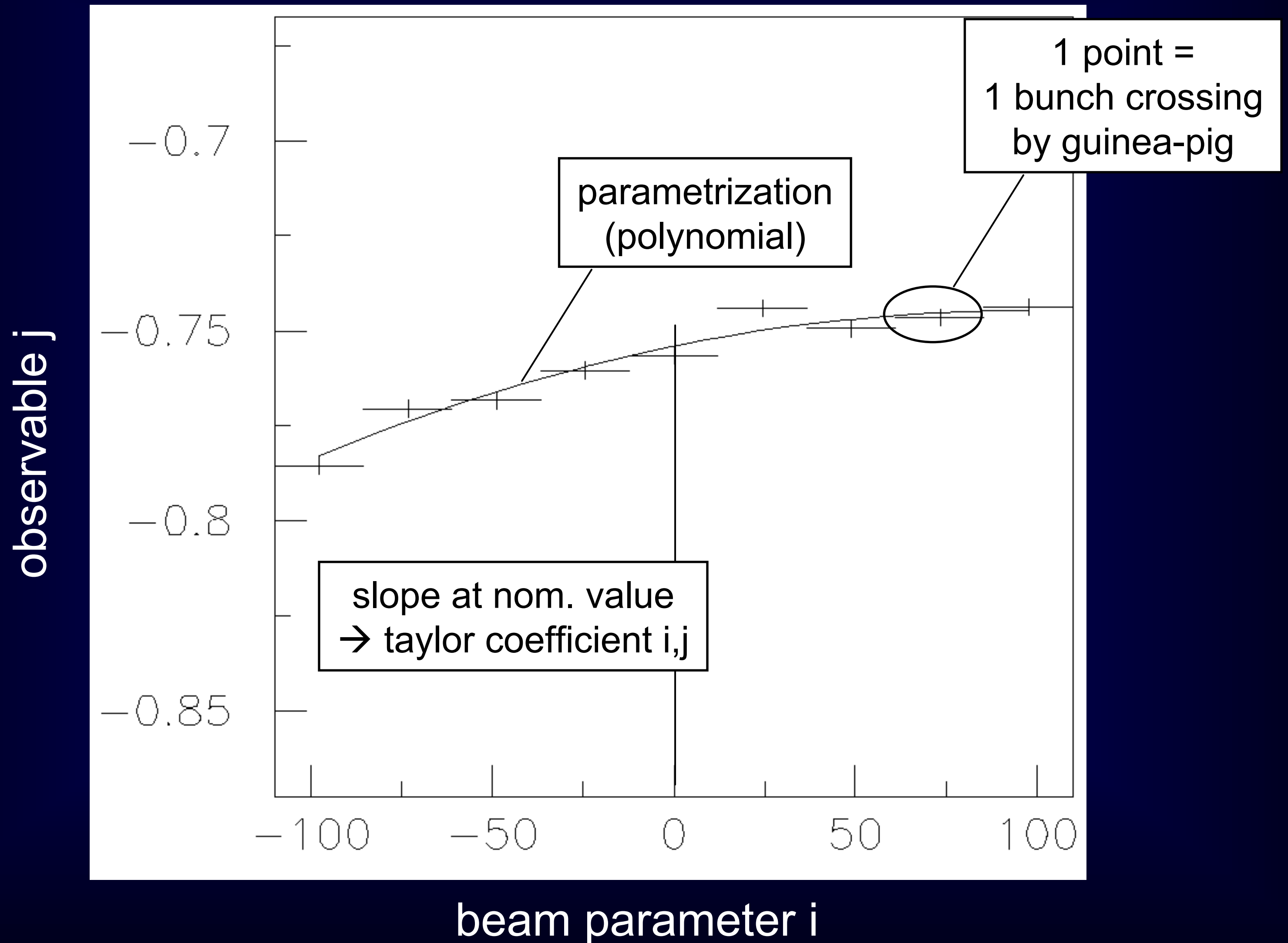
- characterize energy distributions in detectors

analysis program

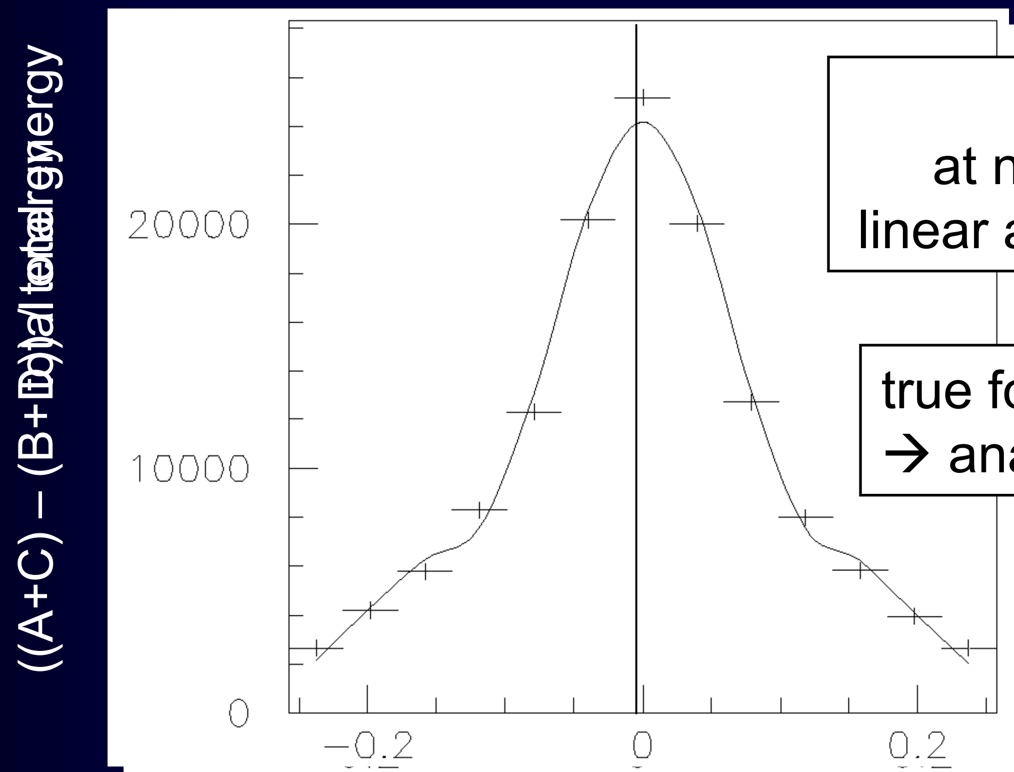
$$\begin{pmatrix} \text{Observables} \end{pmatrix} = \begin{pmatrix} \text{Observables} \end{pmatrix}_{\text{nom}} + \begin{pmatrix} \text{Taylor} \\ \text{Matrix} \end{pmatrix} * \begin{pmatrix} \Delta\ \text{BeamPar} \end{pmatrix}$$

Solve by matrix inversion
(Moore-Penrose Inverse)

Example: Slopes



Analysis Problem



slope = 0
at nom. Parameter
linear approximation fails

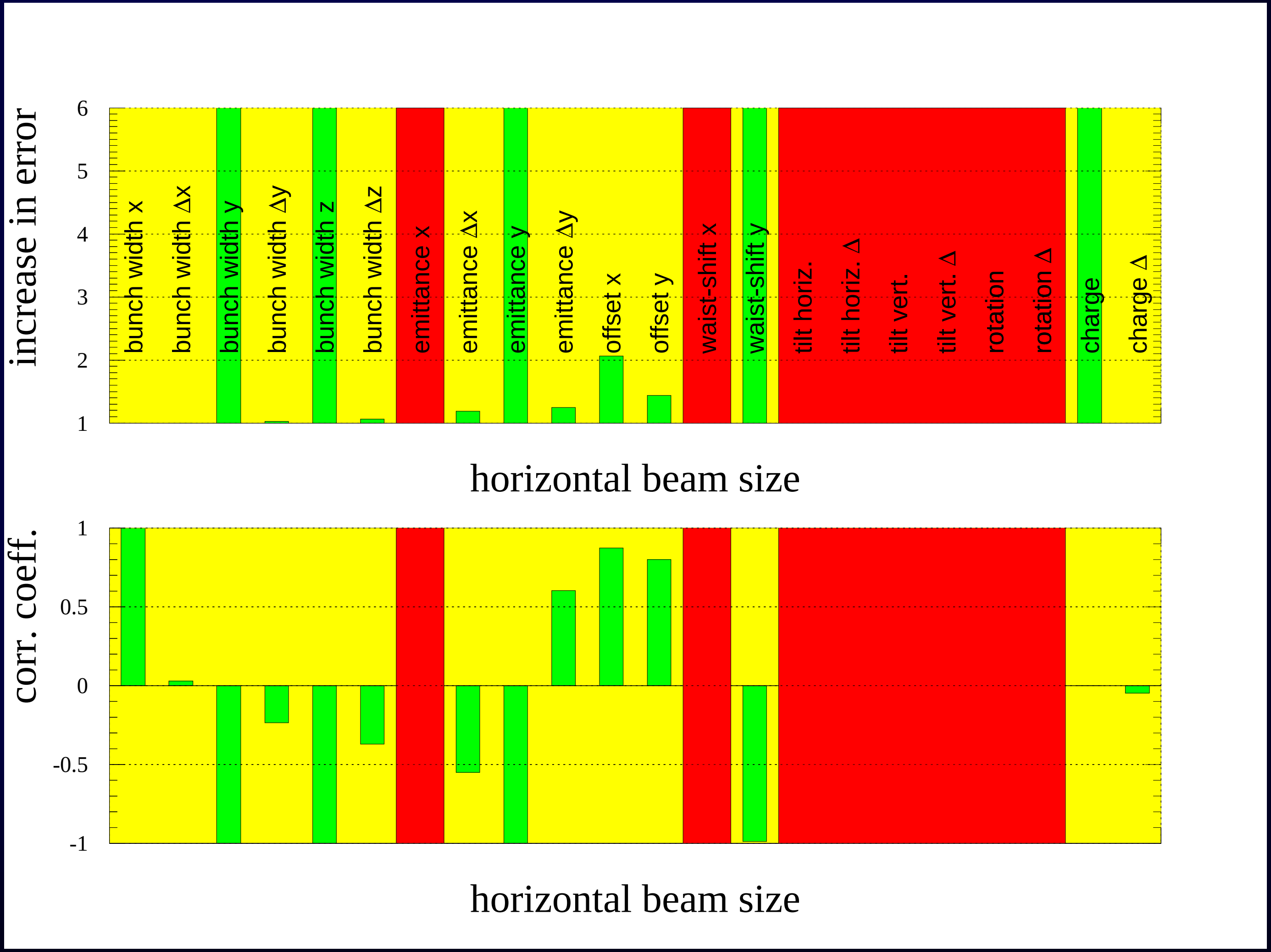
true for all observables
→ analysis fails

1st Results:
Single Parameter Analysis

	nominal	our precision	Beam Diag.
Bunch width x Ave. Diff.	553 nm	2.1 nm 3.8 nm	~ 10 % ~ 10 %
Bunch width y Ave. Diff.	5.0 nm	0.2 nm 0.6 nm	Shintake Monitor
Bunch length z Ave. Diff.	300 μm	7.9 μm 3.7 μm	~ 10 % ~ 10 %
Emittance in x Ave. Diff.	10.0 mm mrad	None 1.2 mm mrad	? ?
Emittance in y Ave. Diff.	0.03 mm mrad	0.002 mm mrad 0.004 mm mrad	? ?
Beam offset in x Beam offset in y	0 0	50 nm 1 nm	5 nm 0.1 nm
Horizontal waist shift Vertical waist shift	0 μm 360 μm	None 40 μm	None None

1st Results:
Two Parameter Analysis

Example: horizontal beam size
Sngl Param Resao: 2.1 nm

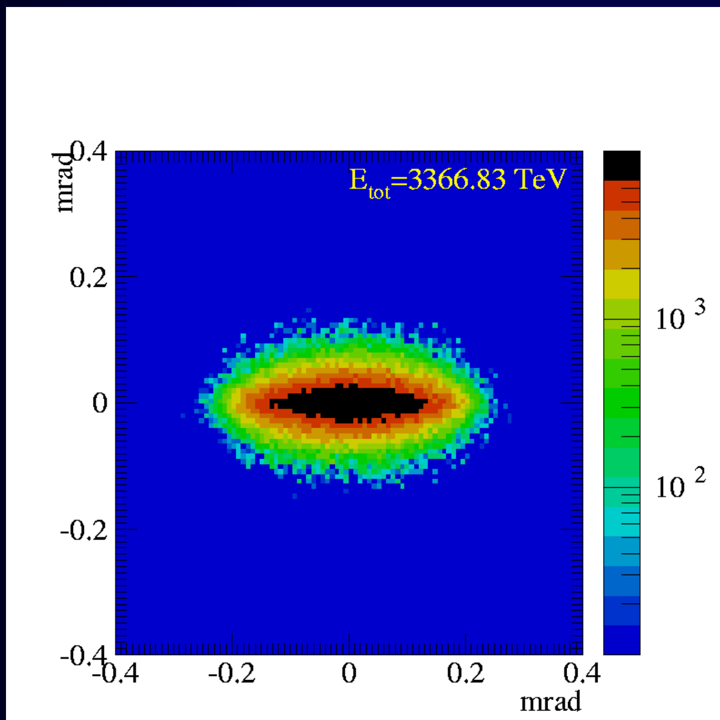


1st Results:

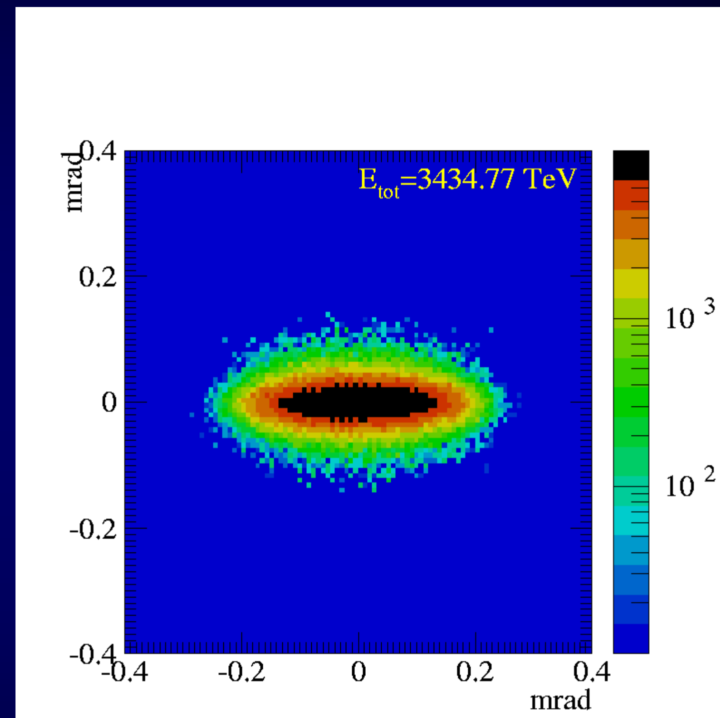
Multi Parameter Analysis

σ_x	$\Delta\sigma_x$	σ_y	$\Delta\sigma_y$	σ_z	$\Delta\sigma_z$
0.4 %	0.7 %	4.9 %	11 %	2.7 %	1.2 %
0.4 %	0.7 %	4.8 %	11 %	2.8 %	1.3 %
2.1 %	5.7 %	9.4 %	8.4 %		
		3.6 %	12 %	3.9 %	0.9 %
38 %	82 %	360 %	2000 %	42 %	370 %

First Look at Photons



nominal setting
(550 nm x 5 nm)



σ_x = 650 nm
σ_y = 3 nm

Next Steps:

- Test on realistic beam simulation
- Include photons from beamstrahlung
- Input on the detector design
- Think about hardware implementation

Thanks