Measurement of the longitudinal phase space for the Photo Injector Test Facility at DESY Zeuthen

1. Diagnostics
2. Bunch length
3. Longitudinal phase space
4. Summary and Outlook

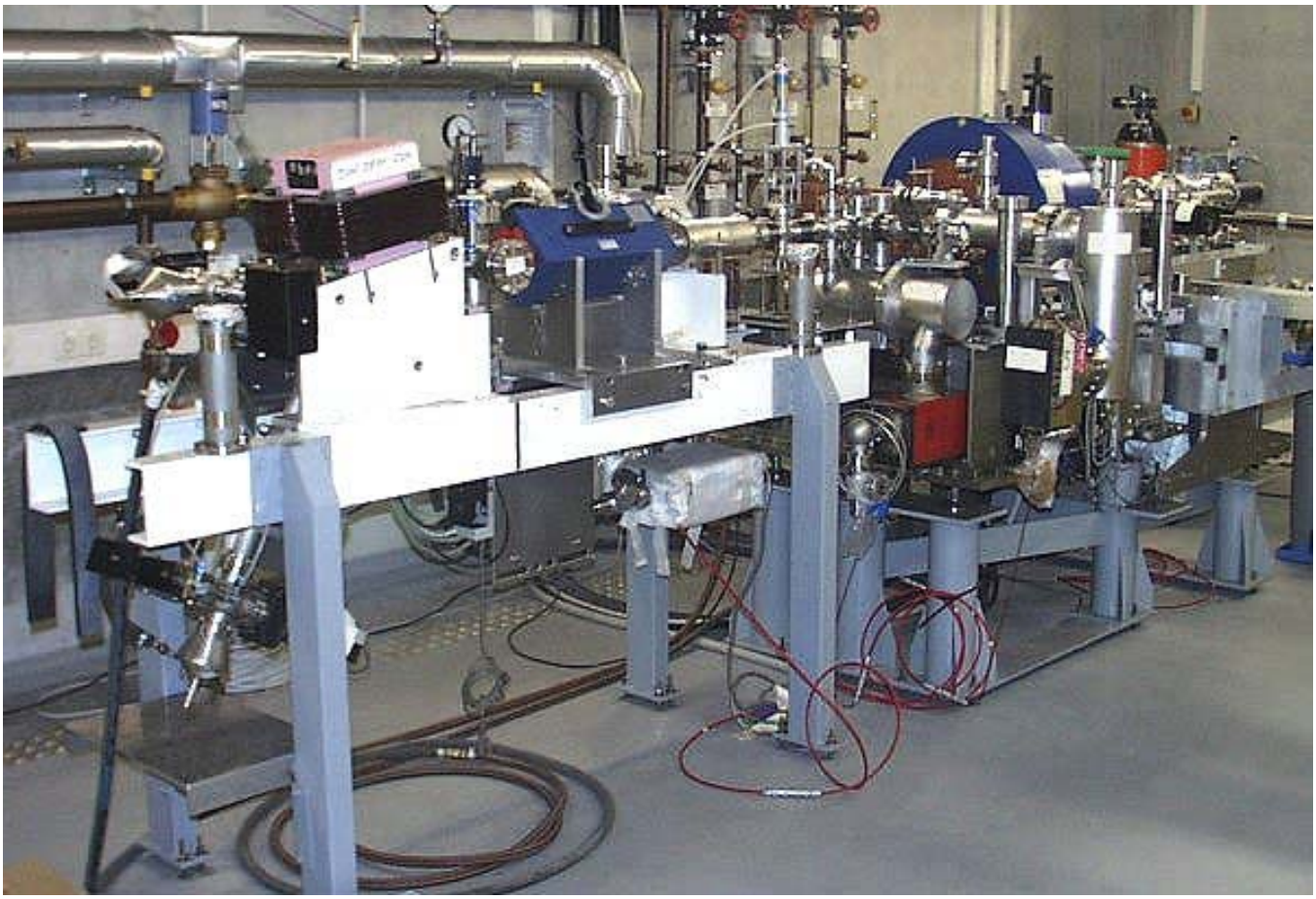
Collaboration:
BESSY, DESY, Max-Born-Institute, TU Darmstadt

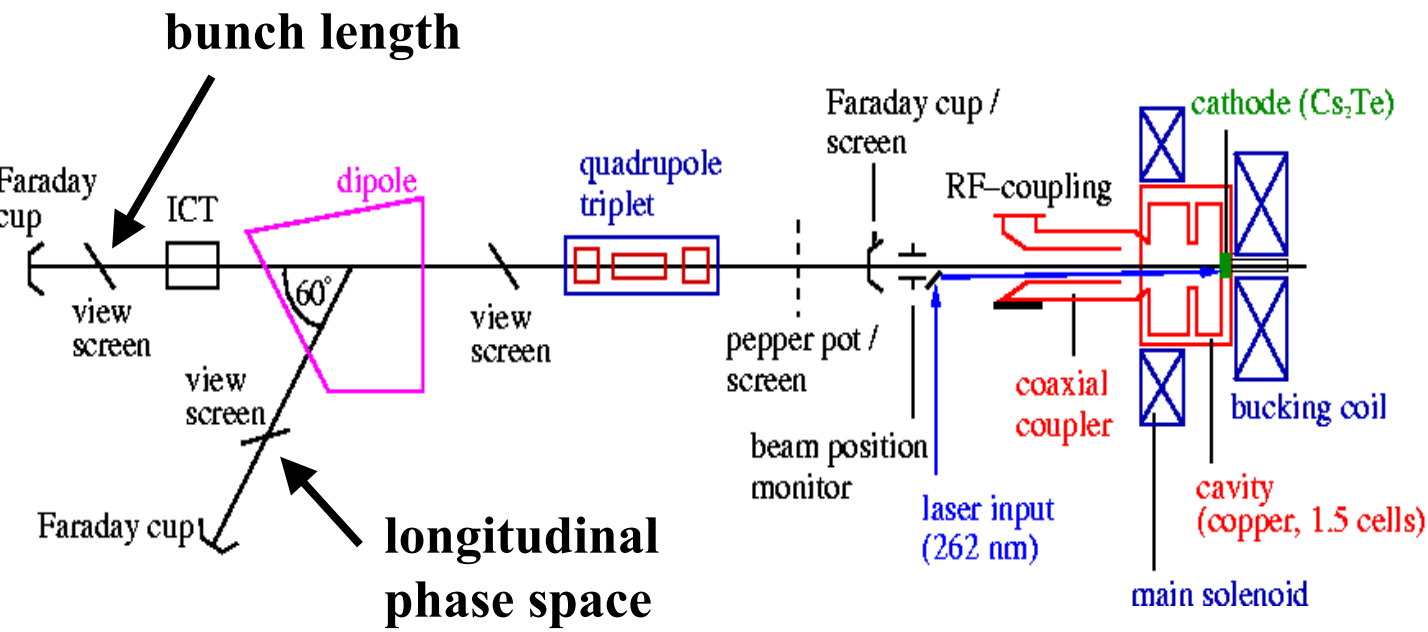
ICFA workshop @ sardinia, Italy

July 2002

D. Lipka (DESY Zeuthen)
for the PITZ collaboration

Diagnostics





July 2002

D. Lipka (DESY Zeuthen)
for the PITZ collaboration

Bunch length

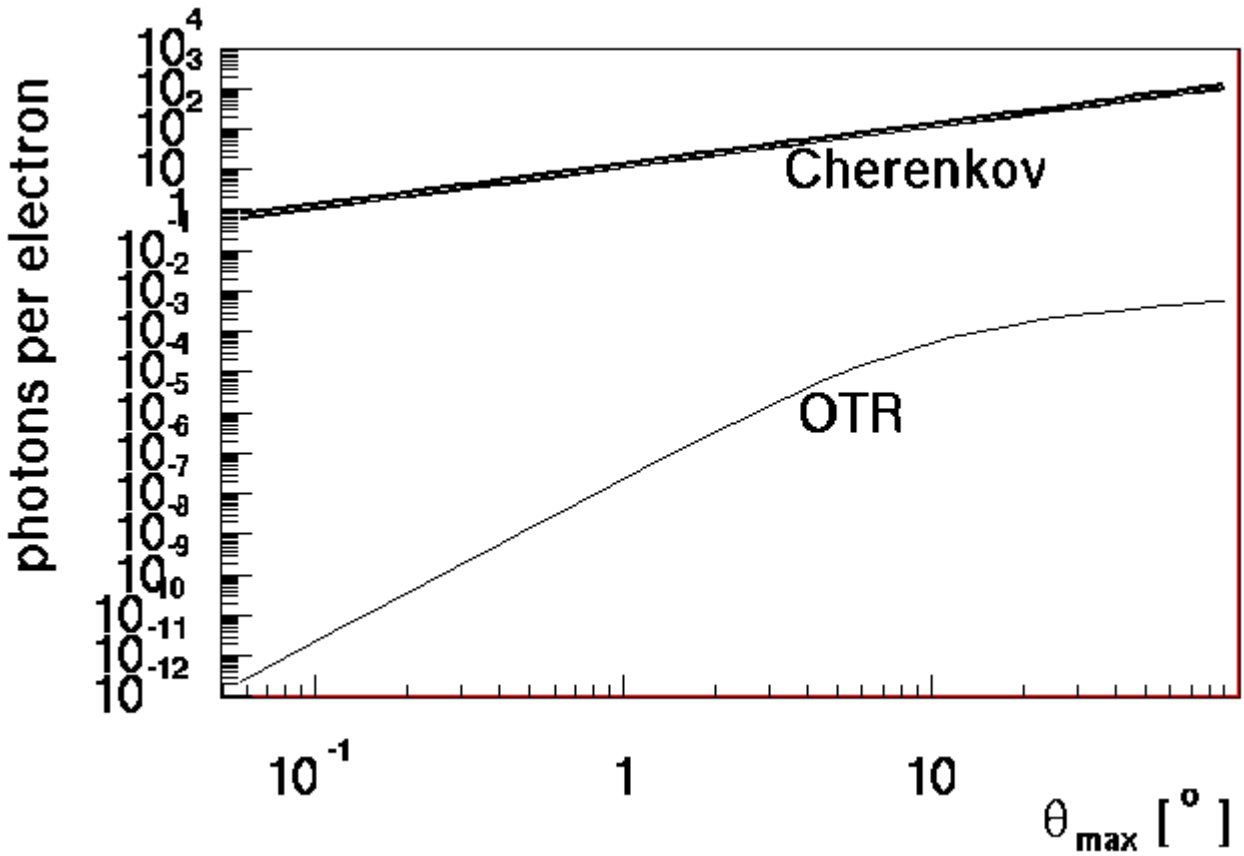
Conversion of electron bunch in photon bunch:

- **needs good time resolution**
- **needs enough photons in a small acceptance angle Θ_{max}**

Options:

- **optical transition radiation (OTR)**
- **Cherenkov radiation**

electron momentum of 4 MeV/c:

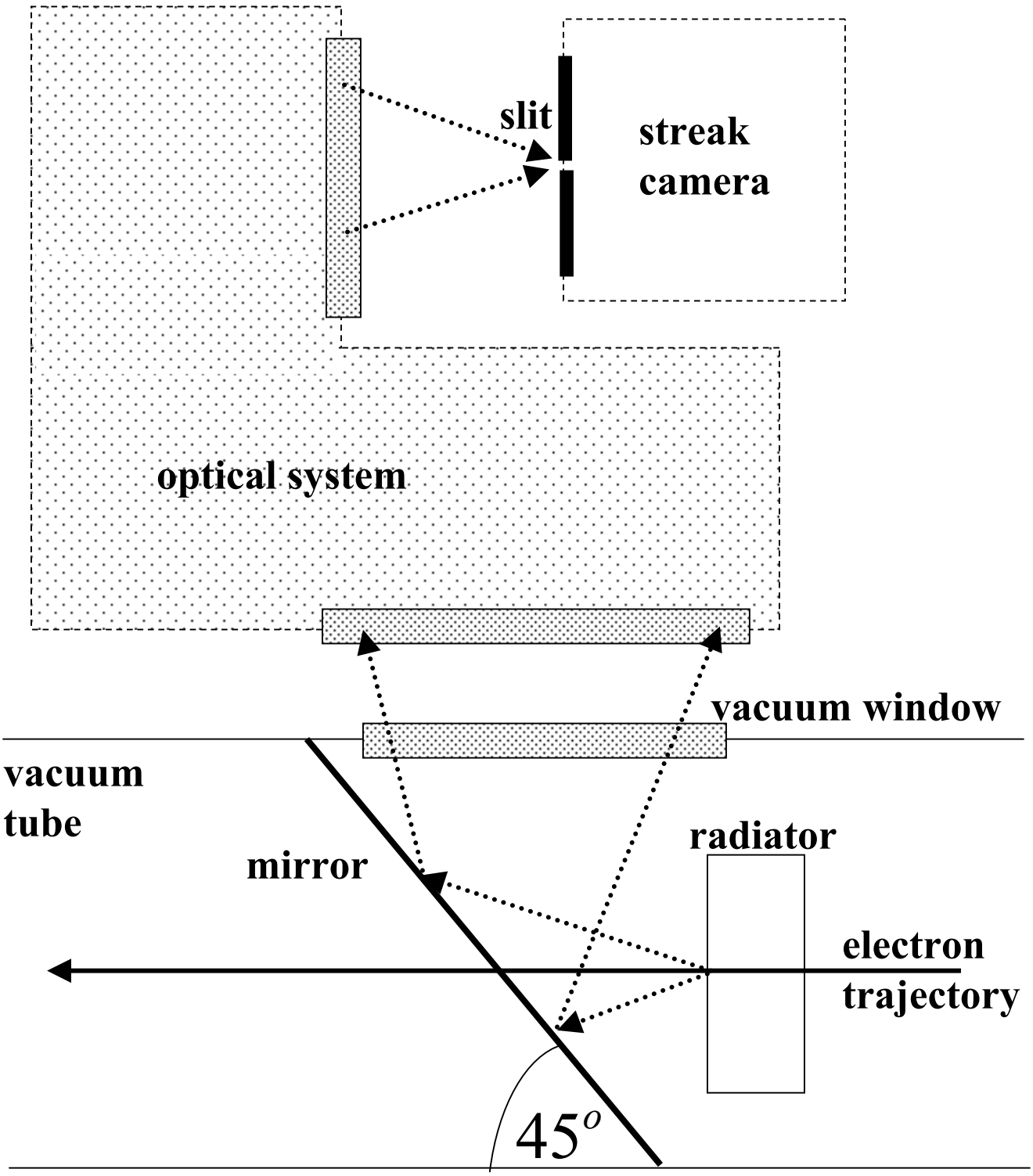


Cherenkov radiators will be used

D. Lipka (DESY Zeuthen)
for the PITZ collaboration

Bunch length

Read out system:



D. Lipka (DESY Zeuthen)
for the PITZ collaboration

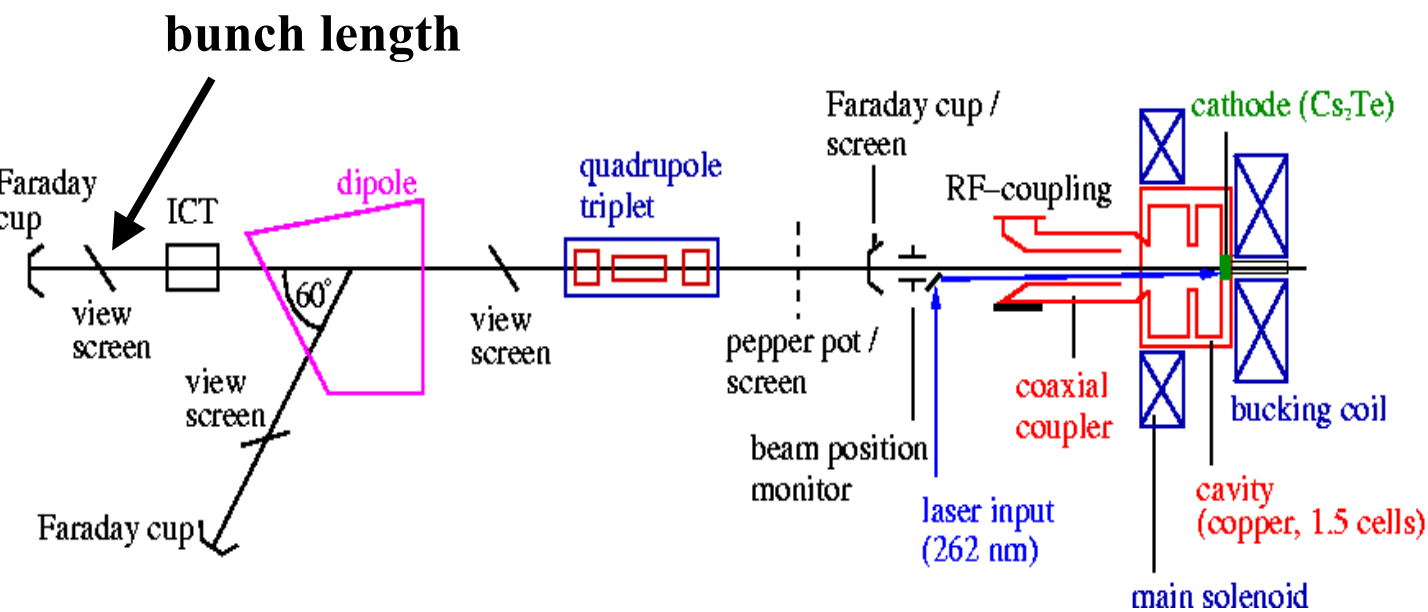
Bunch length

Choice of radiator material:

for low refractive index:

- **smaller output angle -> better photon collection, better time resolution for same material thickness**
- **to avoid total reflection in the material**

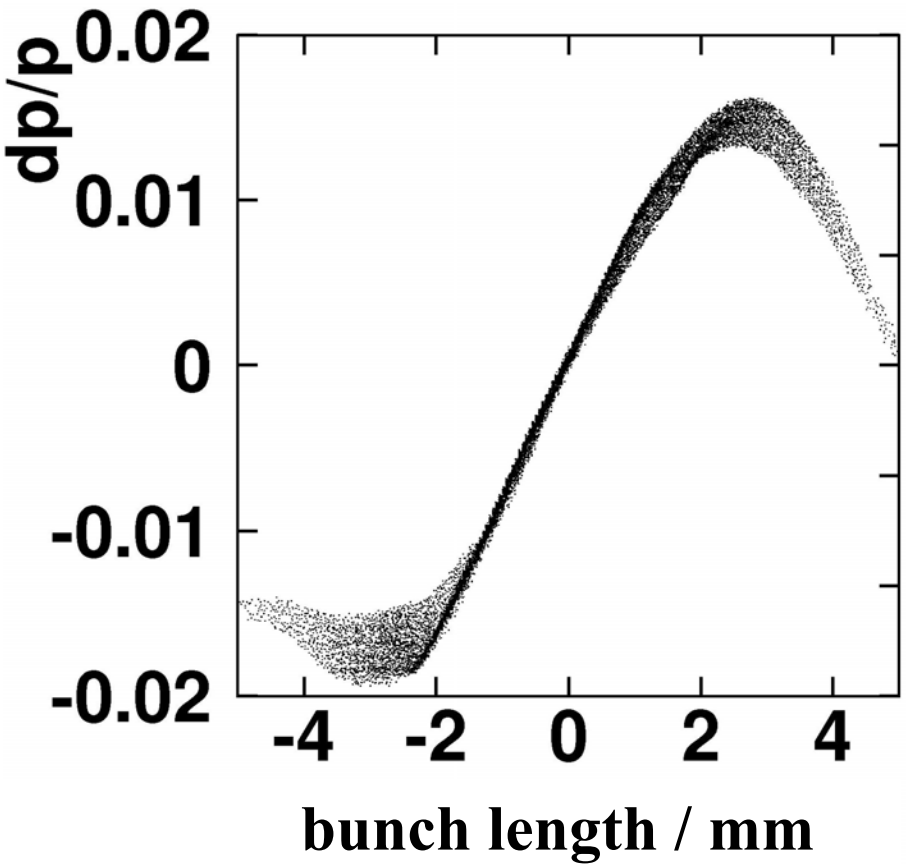
Solution: Silica Aerogel $(Si\,O_2)$ **n=1.01-1.05**



D. Lipka (DESY Zeuthen)
for the PITZ collaboration

Longitudinal phase space

Simulation:

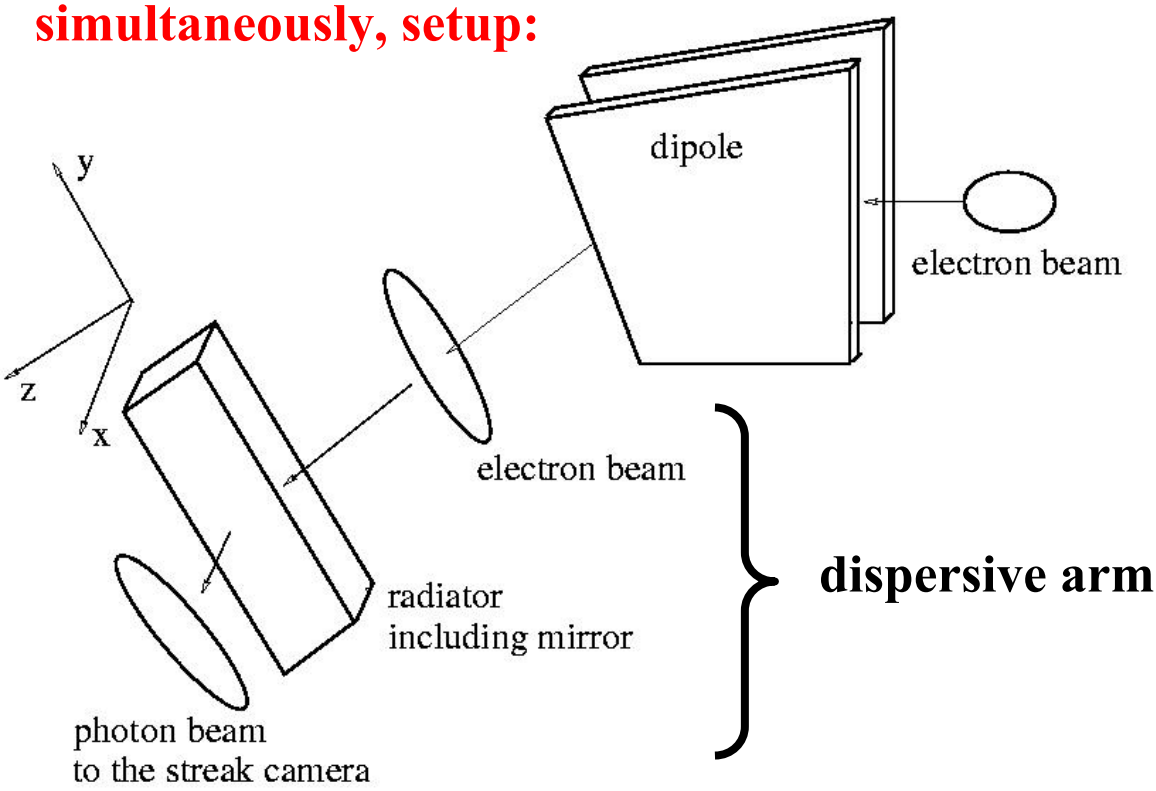


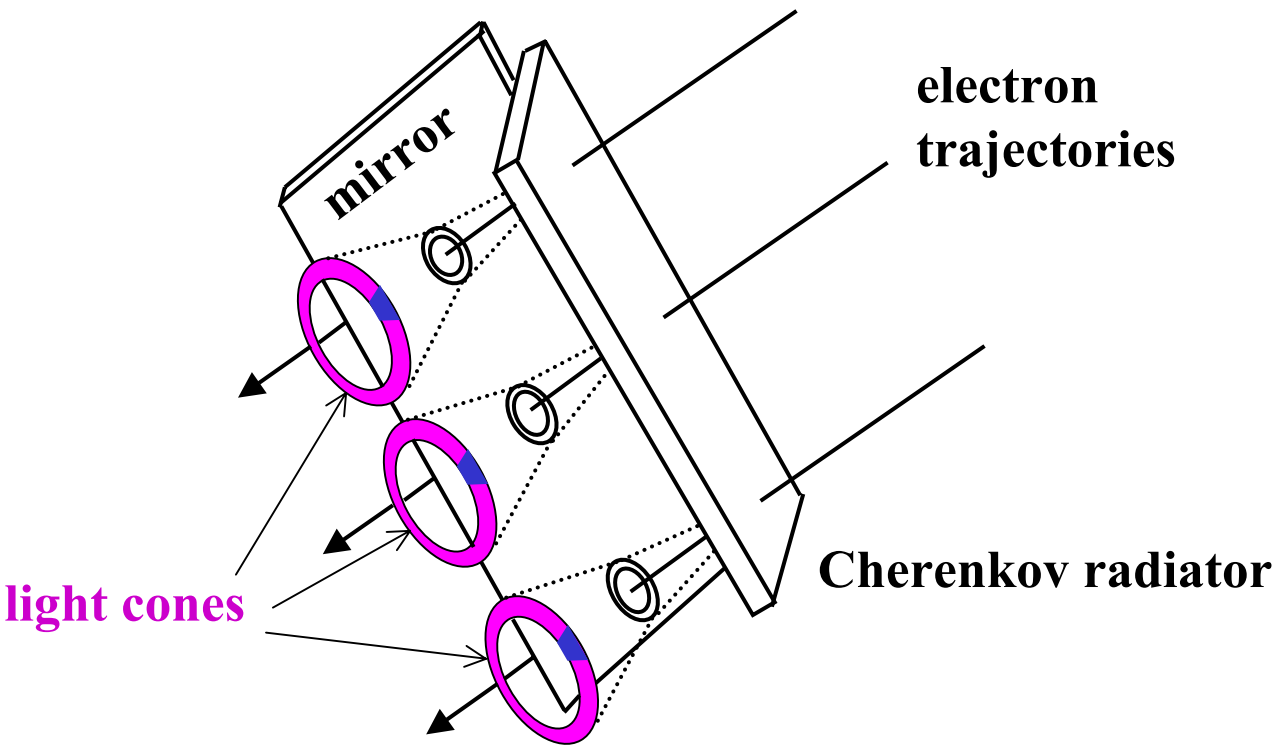
Measure:
Momentum spread,
Bunch length and
correlation

D. Lipka (DESY Zeuthen)
for the PITZ collaboration

Longitudinal phase space

Measurement of bunch length and momentum spread simultaneously, setup:



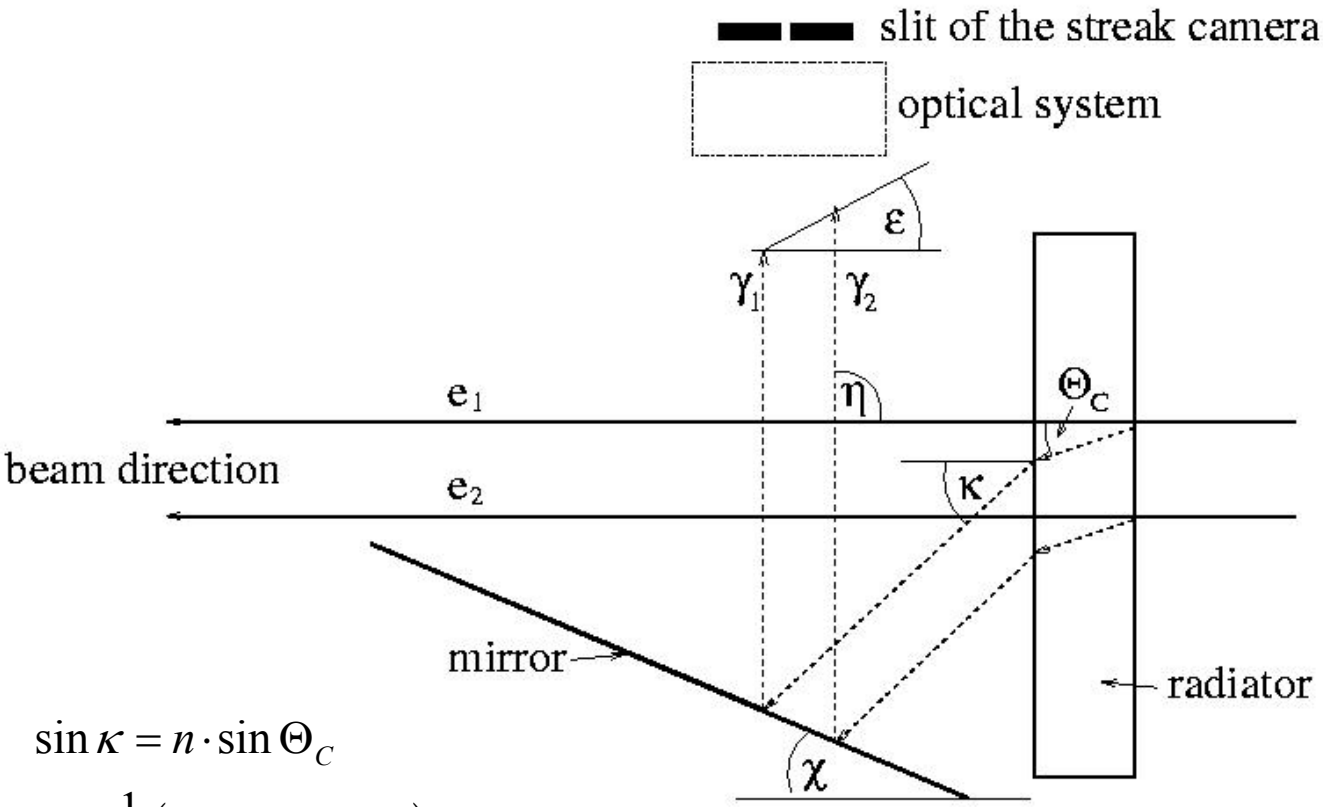


July 2002

D. Lipka (DESY Zeuthen)
for the PITZ collaboration

Longitudinal phase space

Setup with Aerogel:



$$\sin\kappa = n \cdot \sin\Theta_C$$

$$\chi = \frac{1}{2}\left(180^o - \kappa - \eta\right)$$

$$\tan\varepsilon = \tan\kappa$$

mirror tilted so that $\eta = 90^o$

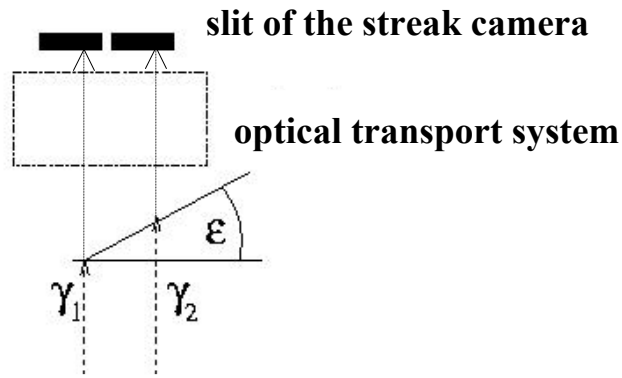
problem: vacuum, time resolution

D. Lipka (DESY Zeuthen)
for the PITZ collaboration

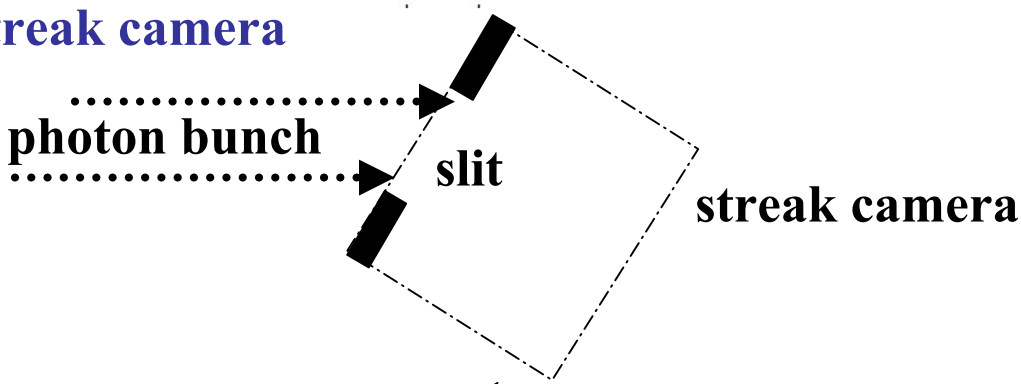
Longitudinal phase space

to avoid bad time resolution:

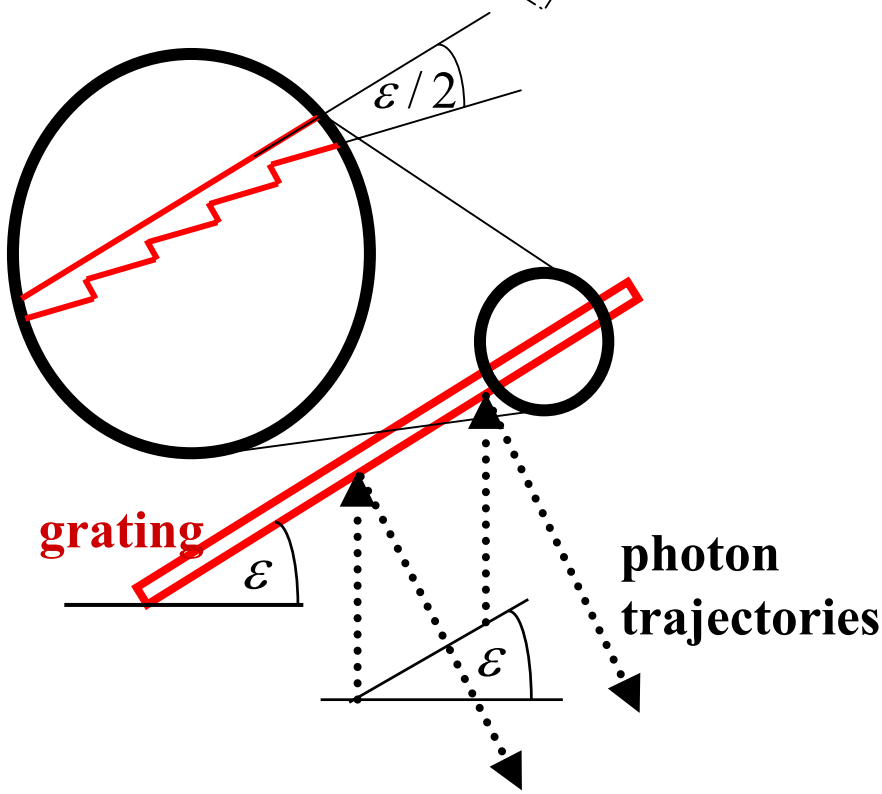
- **cut the light with the slit of the streak camera**



- **turn the streak camera**



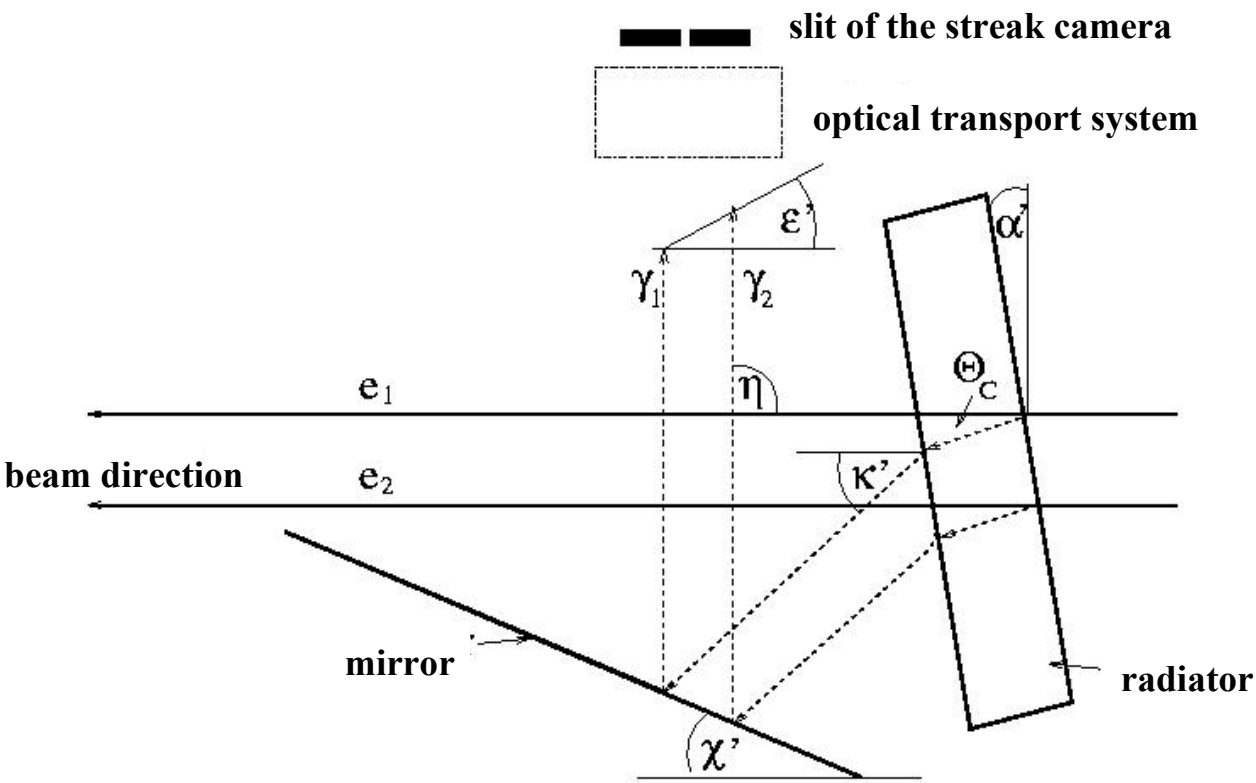
- **grating**



D. Lipka (DESY Zeuthen)
for the PITZ collaboration

Longitudinal phase space

Setup with quartz:



quartz plate is tilted to avoid total reflection

$$\kappa' = \arcsin\left(n \cdot \sin\left(\Theta_C - \alpha'\right)\right) + \alpha'$$

$$\chi' = \frac{1}{2}\left(180^o - \kappa' - \eta\right)$$

$$\tan\varepsilon' = \frac{\sin\alpha' + \sin\left(\kappa' - \alpha'\right)}{\cos\left(\kappa' - \alpha'\right)}$$

n=1.46

$$\eta = 90^o$$

problem: time resolution

D. Lipka (DESY Zeuthen)
for the PITZ collaboration

Longitudinal phase space

time resolution:

thickness of the Cherenkov radiator (same photon yield)

p = 4.0 MeV/c

n	l / mm	Δ_{pl} / *ps*	$\Delta_{\alpha''}$ / *ps*	Δ_{MS} / *ps*	Δt_S / *ps*	Δt_L / *ps*
1.01	20.0	0.25	0.26	3.98	0.02	0.01
1.03	2.0	0.30	0.30	0.43	0.07	0.04
1.05	1.0	0.29	0.29	0.35	0.10	0.05
1.46	0.1	0.37	0.37	0.41	0.69	0.15

time difference electron - light

angle distribution of the electron bunch

multiple scattering

cut with the slit

use of the grating

best time resolution with Aerogel (n=1.05), quartz will also be used

D. Lipka (DESY Zeuthen)
for the PITZ collaboration

Summary and Outlook

Preparation for the bunch length measurement:

- this month, the setup to measure the bunch length and the optical transport system will be installed in the diagnostics section
- perform bunch length measurements
- tests for dispersive arm

Work in progress for the dispersive section:

- after successful tests in the straight section the Cherenkov radiators will be installed in the dispersive section
- measurement of the entire longitudinal phase space (momentum spread, bunch length, correlation)
- optimization of the photo injector

D. Lipka (DESY Zeuthen)
for the PITZ collaboration