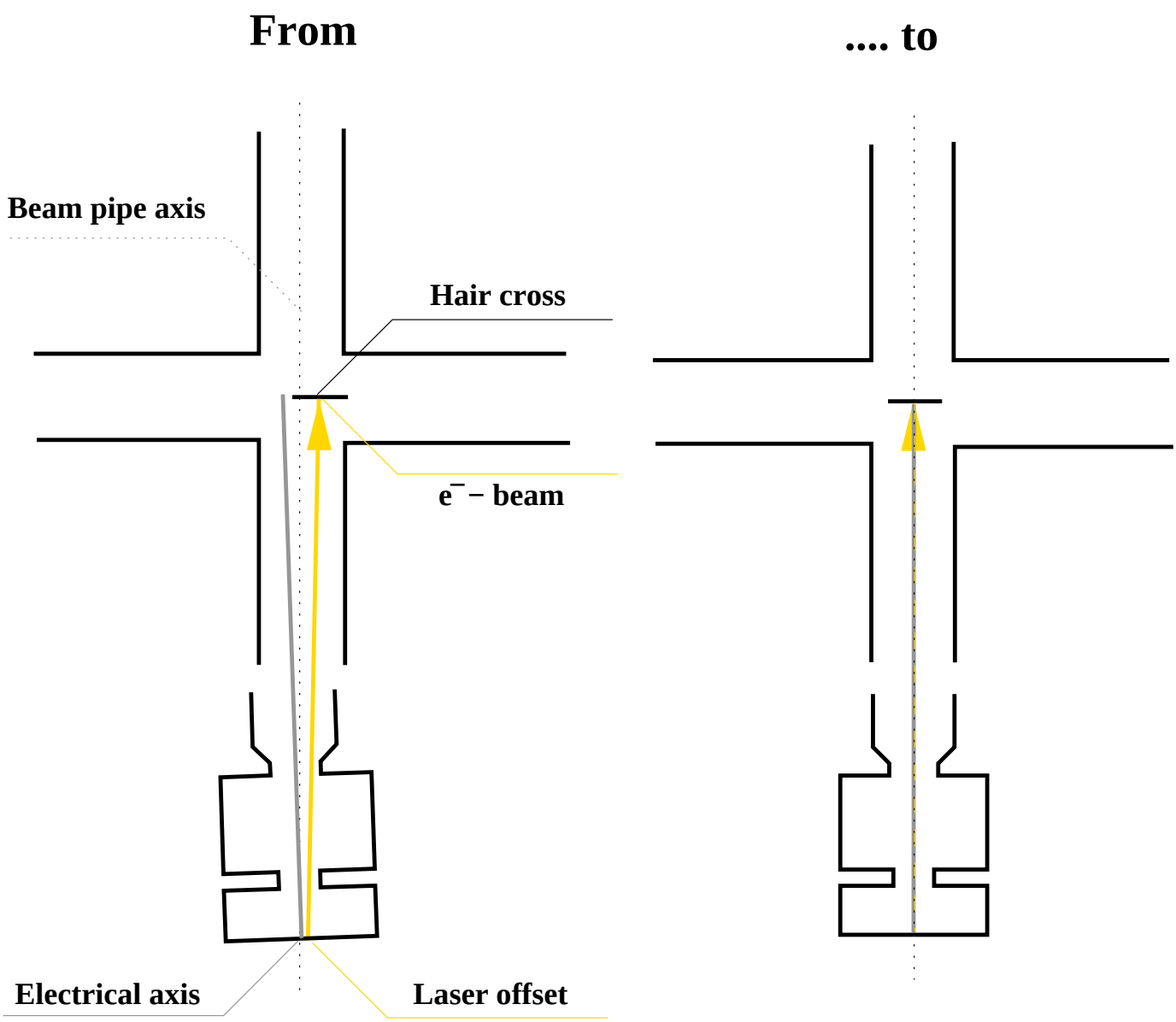
# Beam based laser allignment by RF focussing.
# Sreen optical diagnostics:

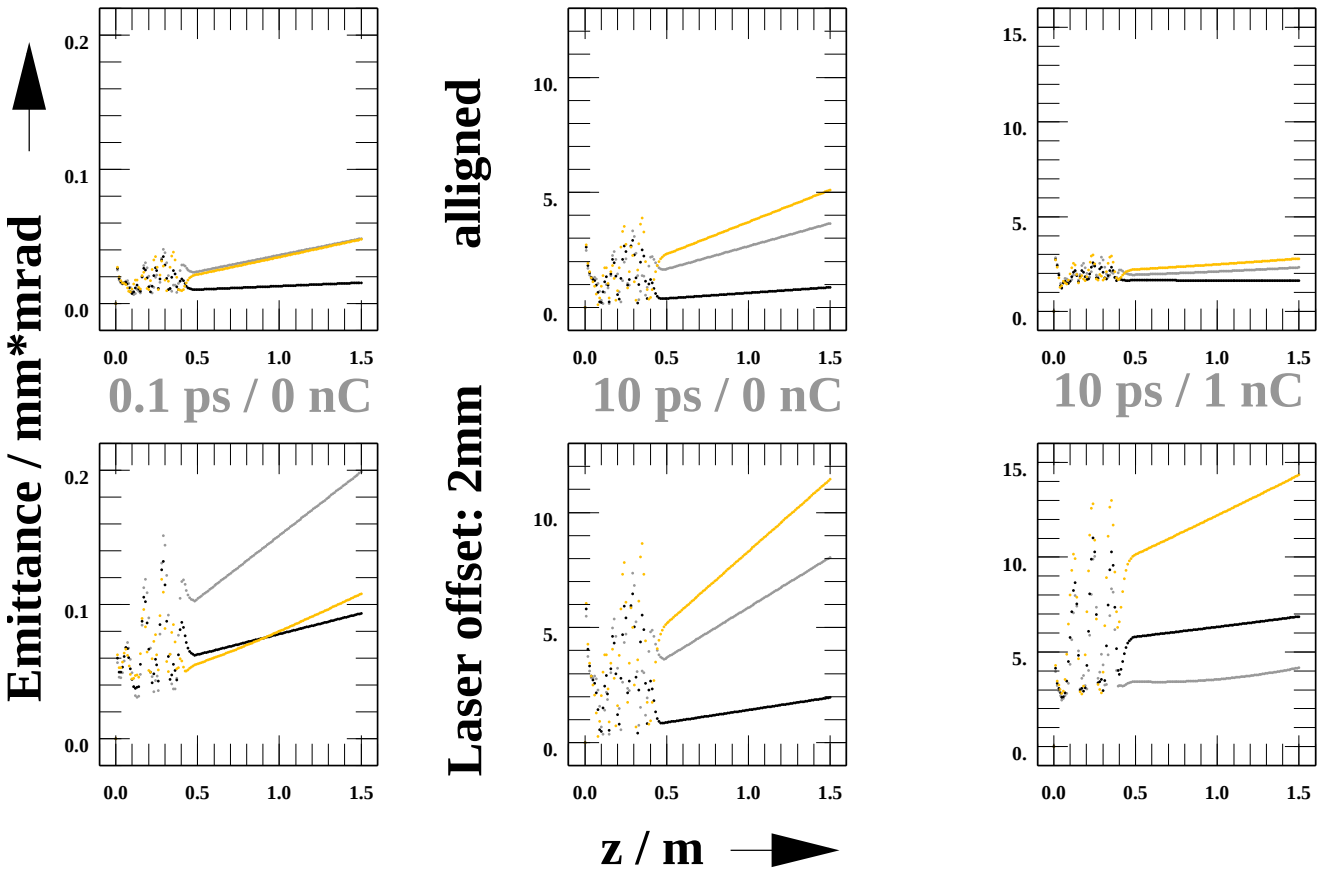
1. **The problem:**
   **Cavity - beam pipe - laser allignment.**
2. **Single particle kinematics in NC and SC system, inherent RF focussing.**
3. **Beam: ensembles of low energy particles.**
   **Behaviour of focus spots**

# Resonator−cathode−laser allignment

## − no magnetic fields −



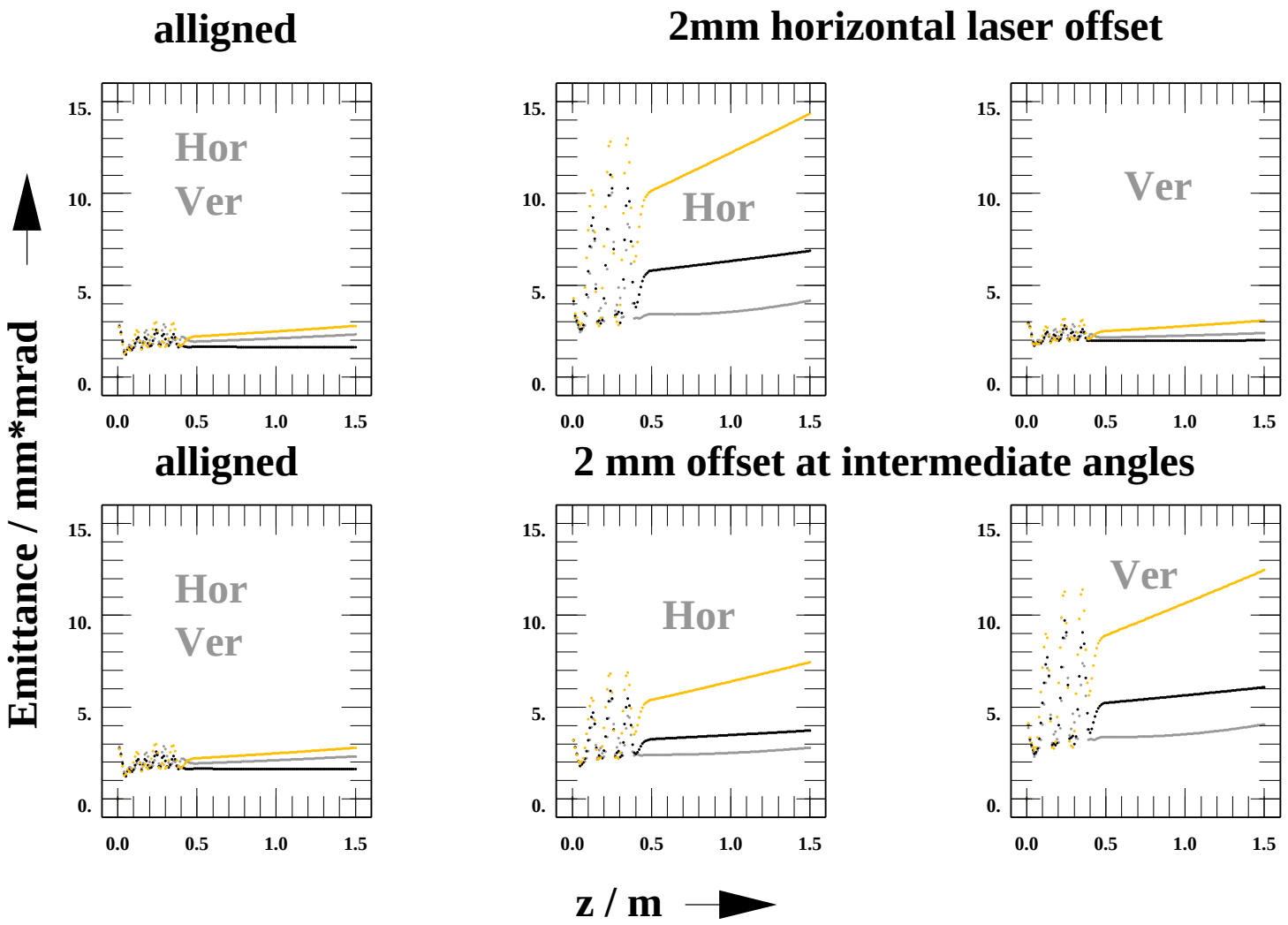
# Missallignment: emittance degradation (Scgun35)




**Gradient 40MV/m**
**Laser spot 2 mm Ø**
**Phase**

- 68°
- 78° = max. energy gain
- 88°

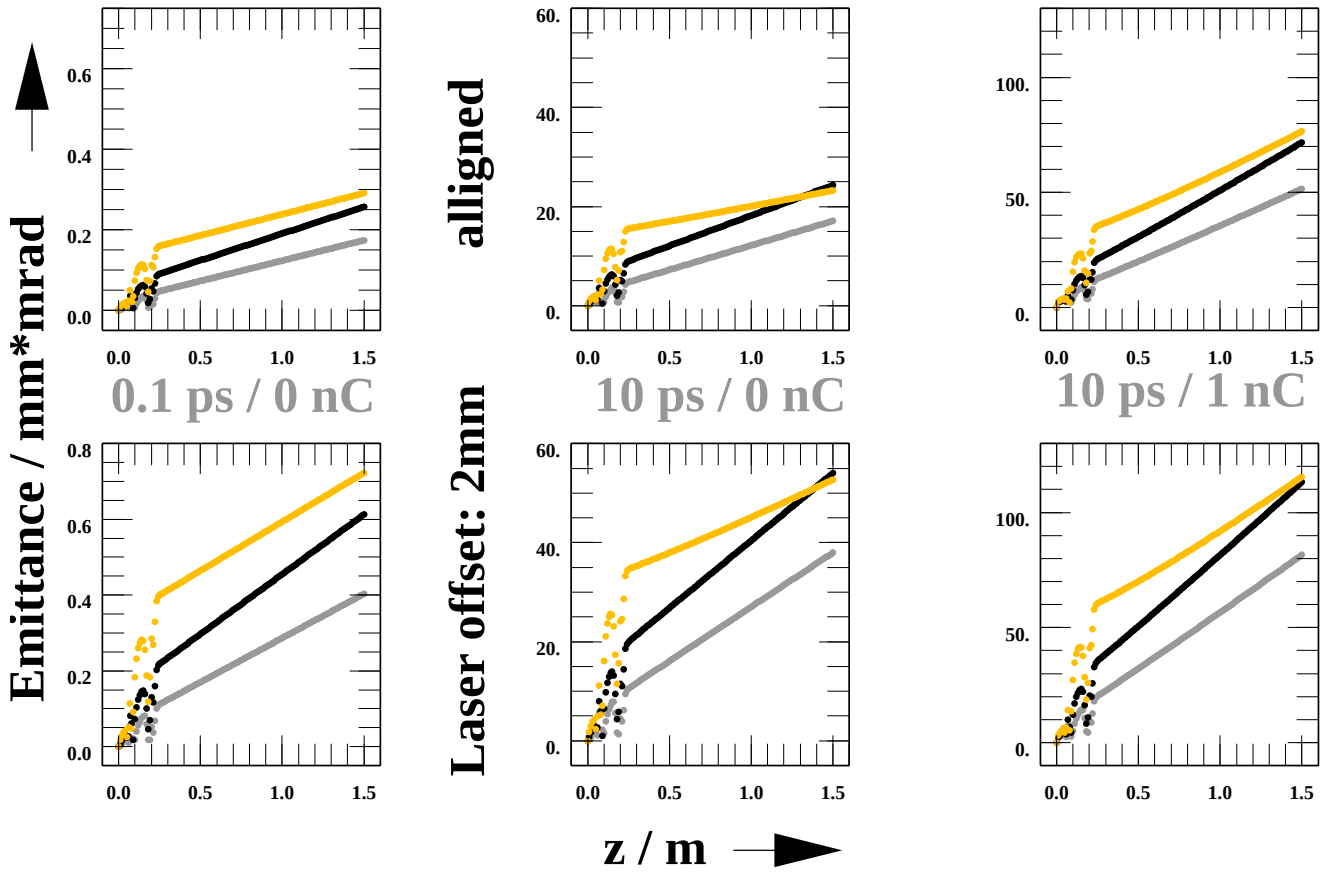
# Emittance asymmetry (Scgun35)




**Gradient 40MV/m**
**Laser spot 2 mm Ø**
**10 ps / 1 nC**
**Phase**

- 68°
- 78° = max. energy gain
- 88°

# Laser missallignment: impact on emittance (Zeuthen1)



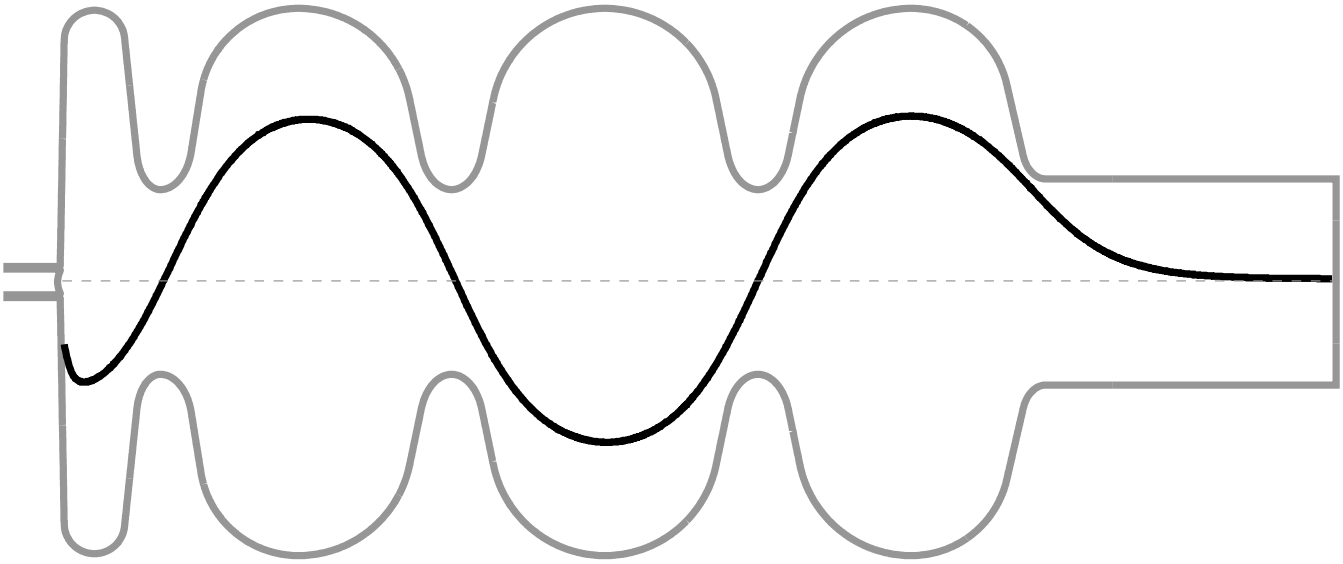

**Gradient 40MV/m**
**Laser spot 2 mm Ø**
**Phase**

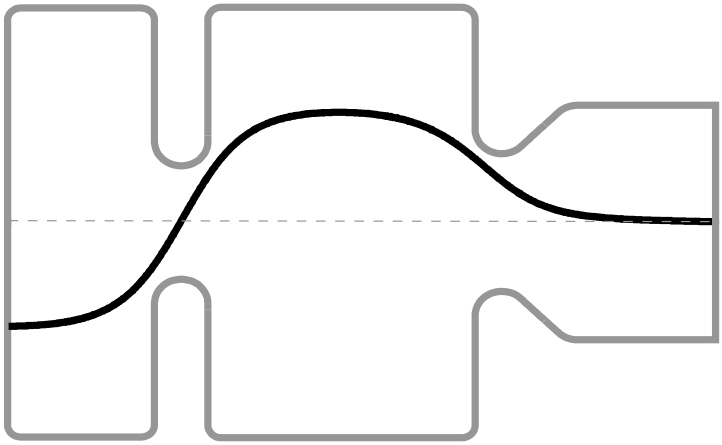
- 38°
- 48° = max. energy gain
- 58°

# Beam based allignment to ....

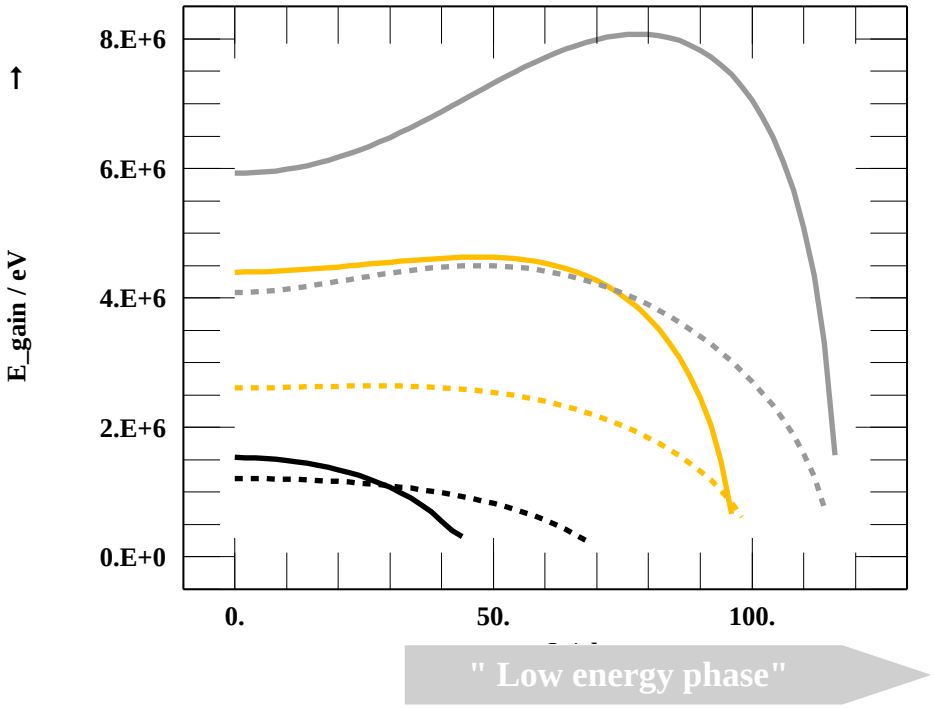
- **improve collinearity:**
  **resonator electrical axis - beam tube axis.**
- **minimize laser offset on cathode.**

# SCGUN35 & ZEUTHEN1





# Energy gain vs. injection phase




Scgun35

Zeuthen1

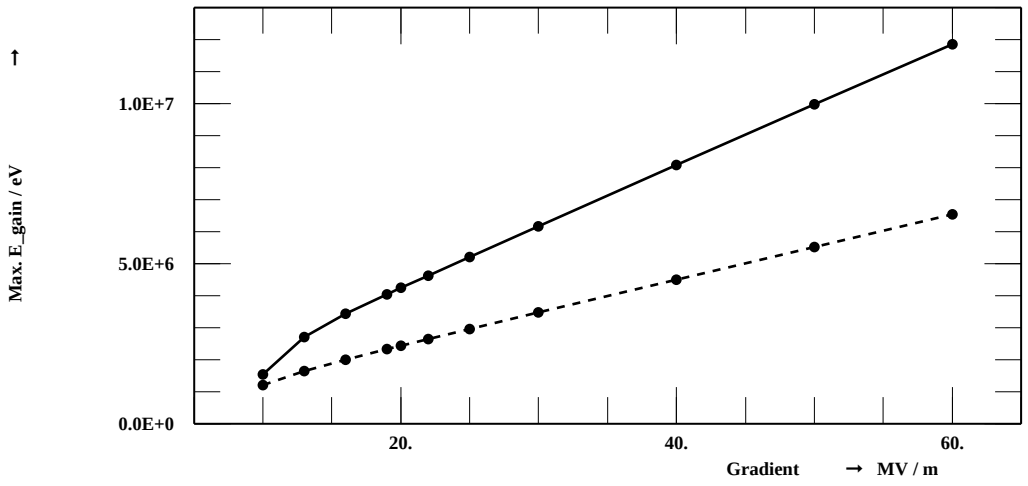
**Gradient / MV/m**

10.

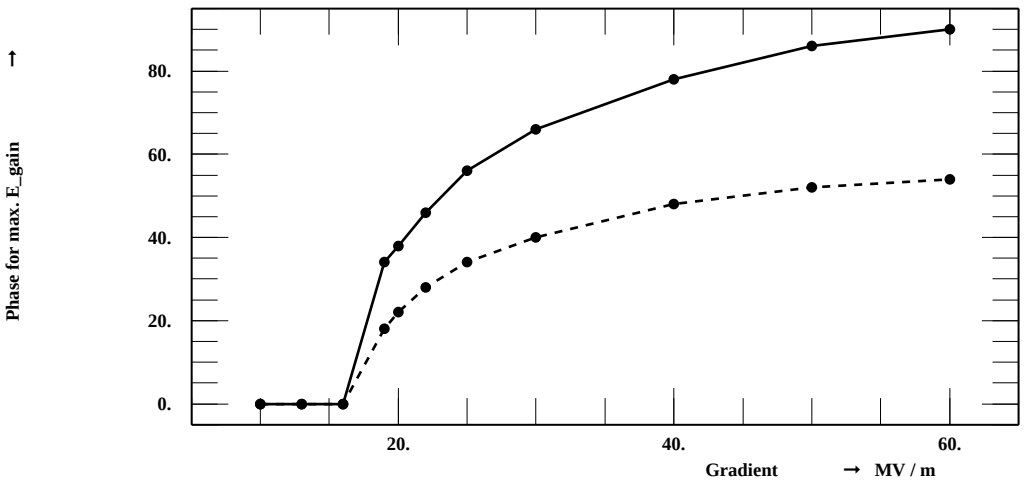
25.

60.

# Max. energy gain vs. gradient



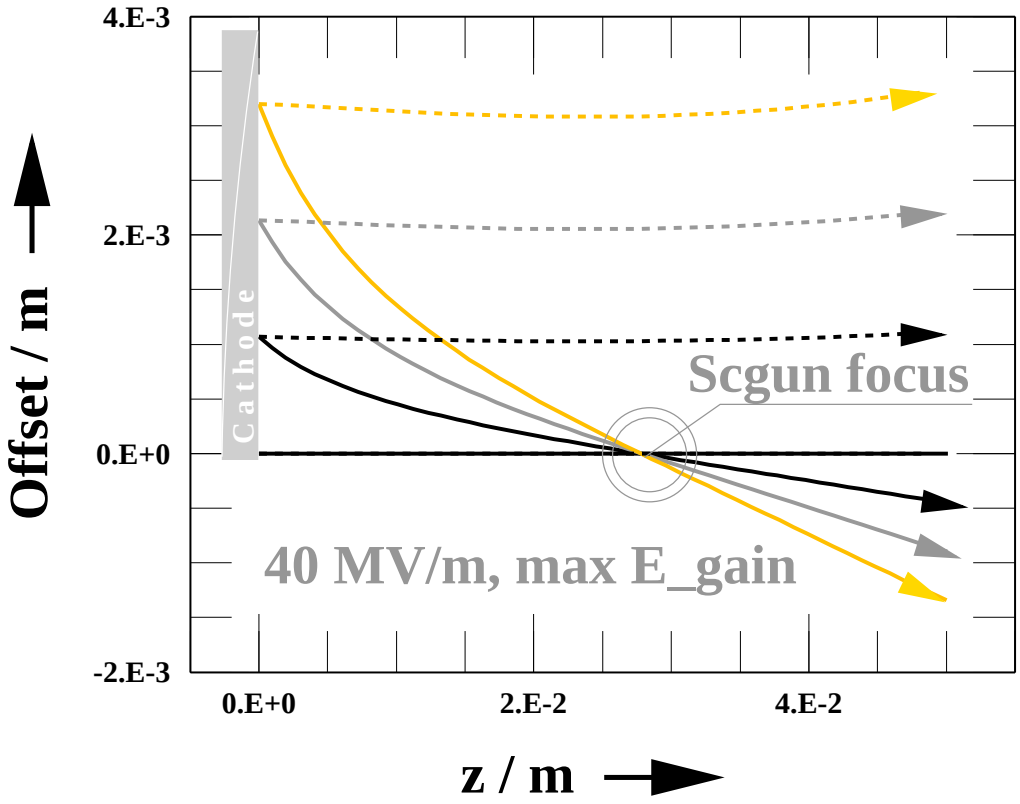

# Phase: max energy gain vs. gradient




——— **Scgun35**

- - - - - **Zeuthen1**

# Cathode surface shape: Trajectories near cathode




Scgun35: recess

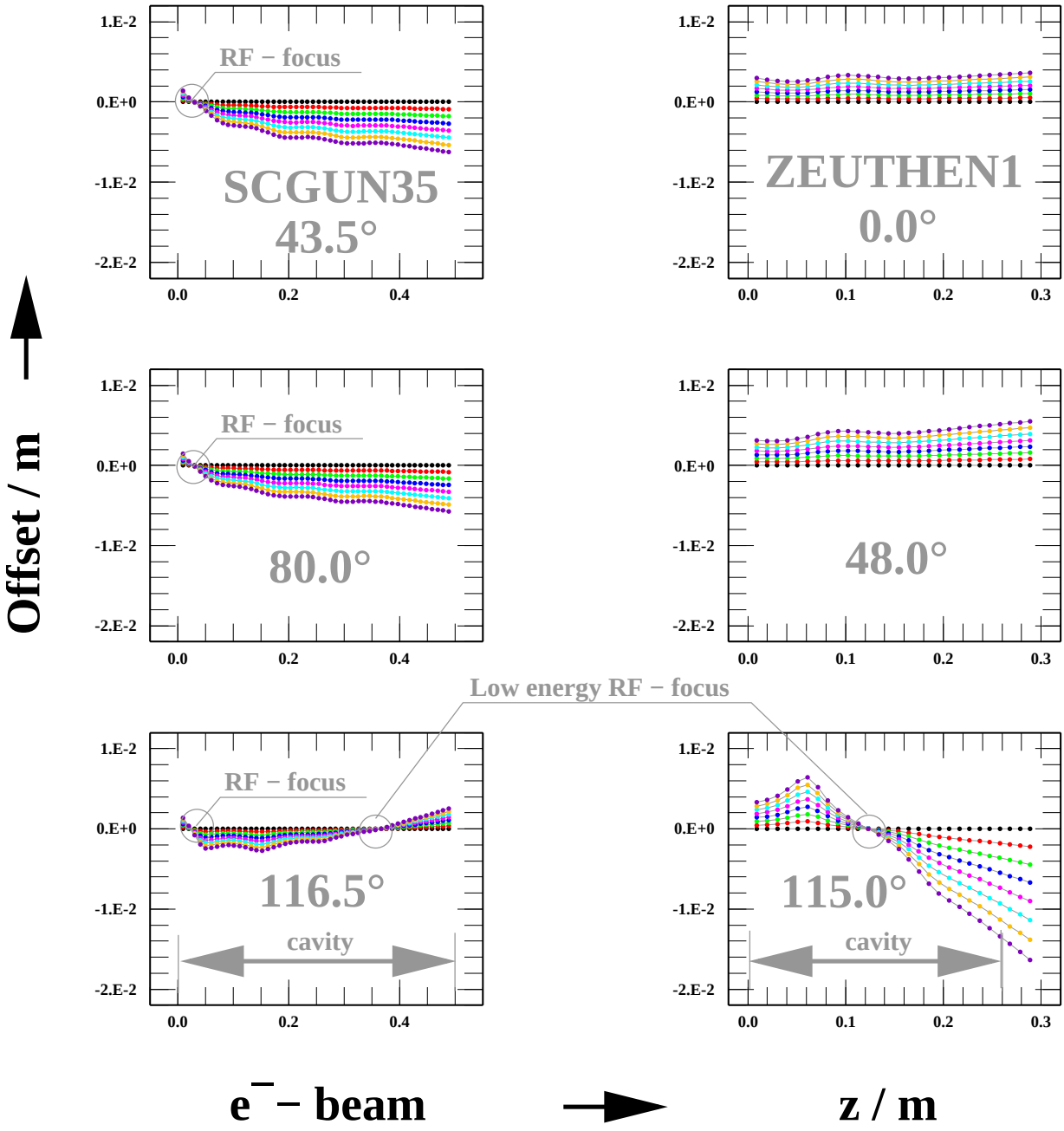
Zeuthen1: flat

**Offset at cathode / mm**

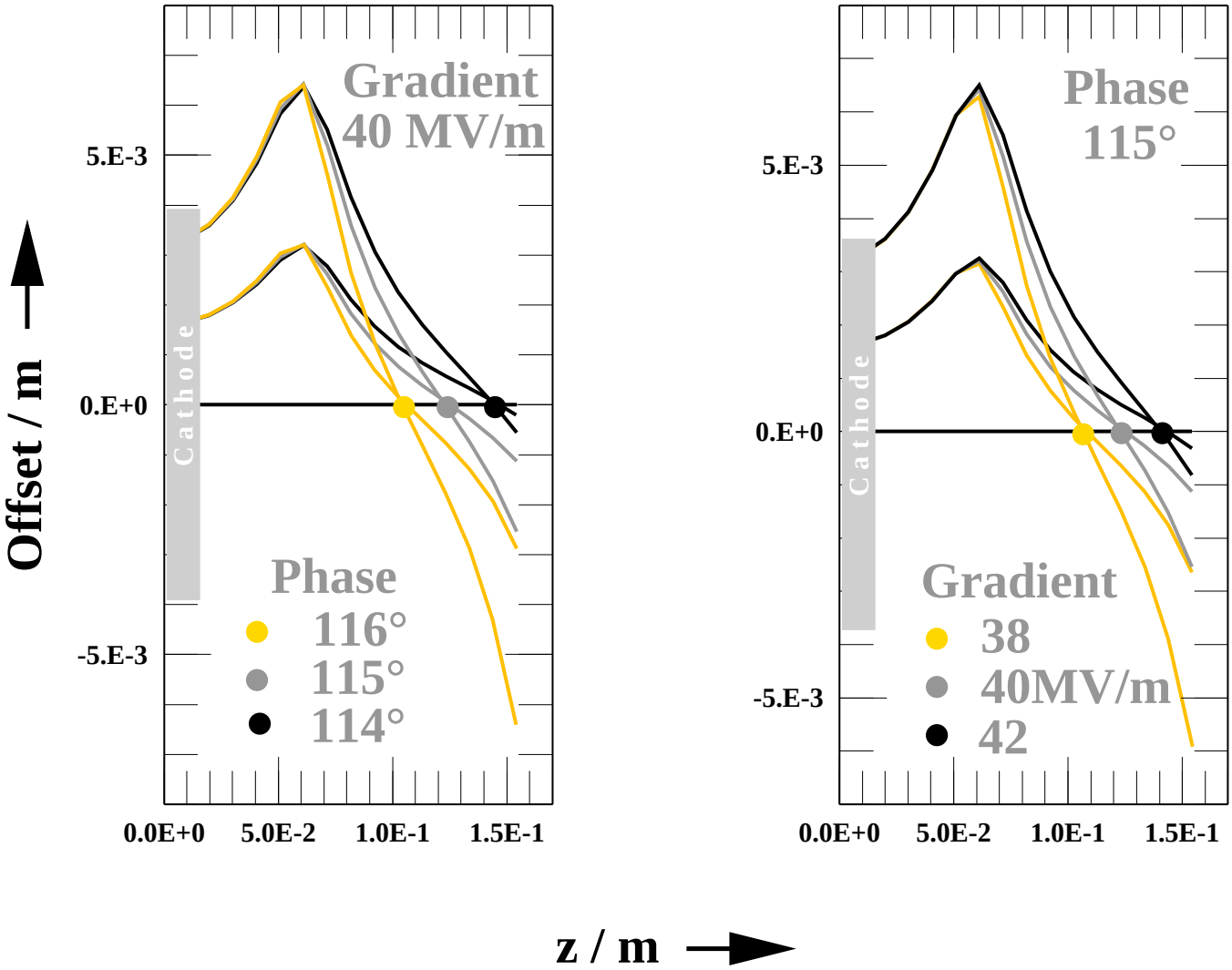
- 1.1
- 2.1
- 3.2

# Trajectories at 40 MV/m

# Parameter: offset on cathode 0 − 3.2 mm



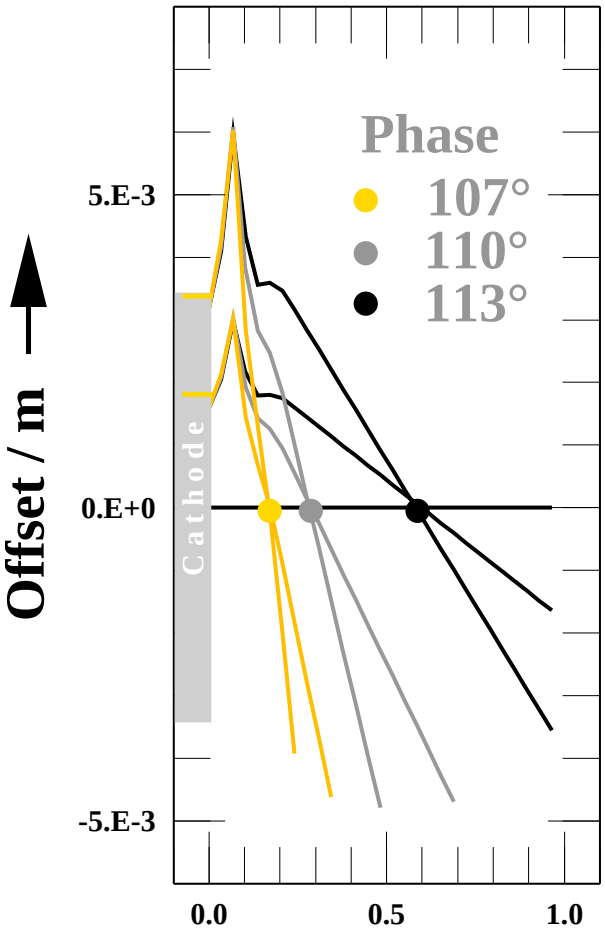
# Low energy RF focus: focal width.
# (Zeuthen1)



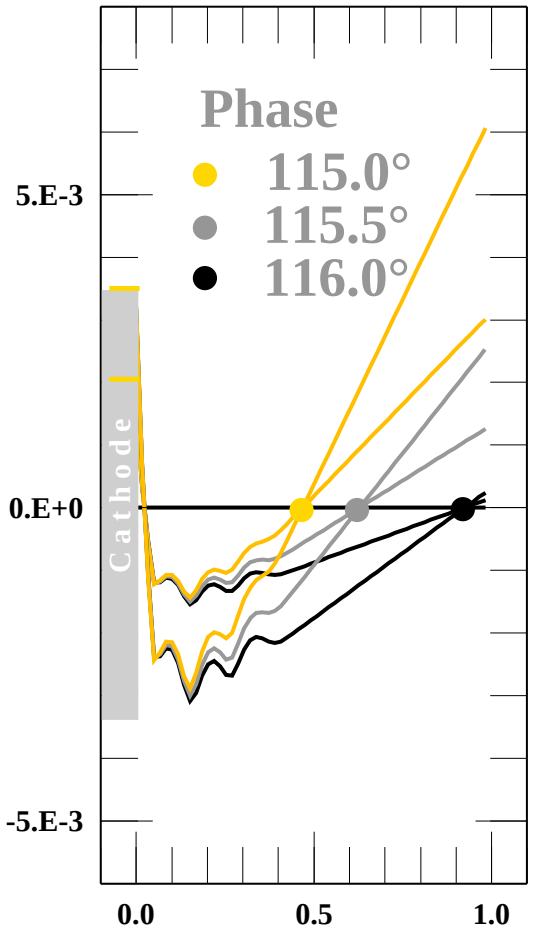

**High energy −> far focus**
**Low energy −> near focus**

# Directional relations: Laser offset − beam offset

## Correlation: Zeuthen1




## Anticorrelation: Scgun35

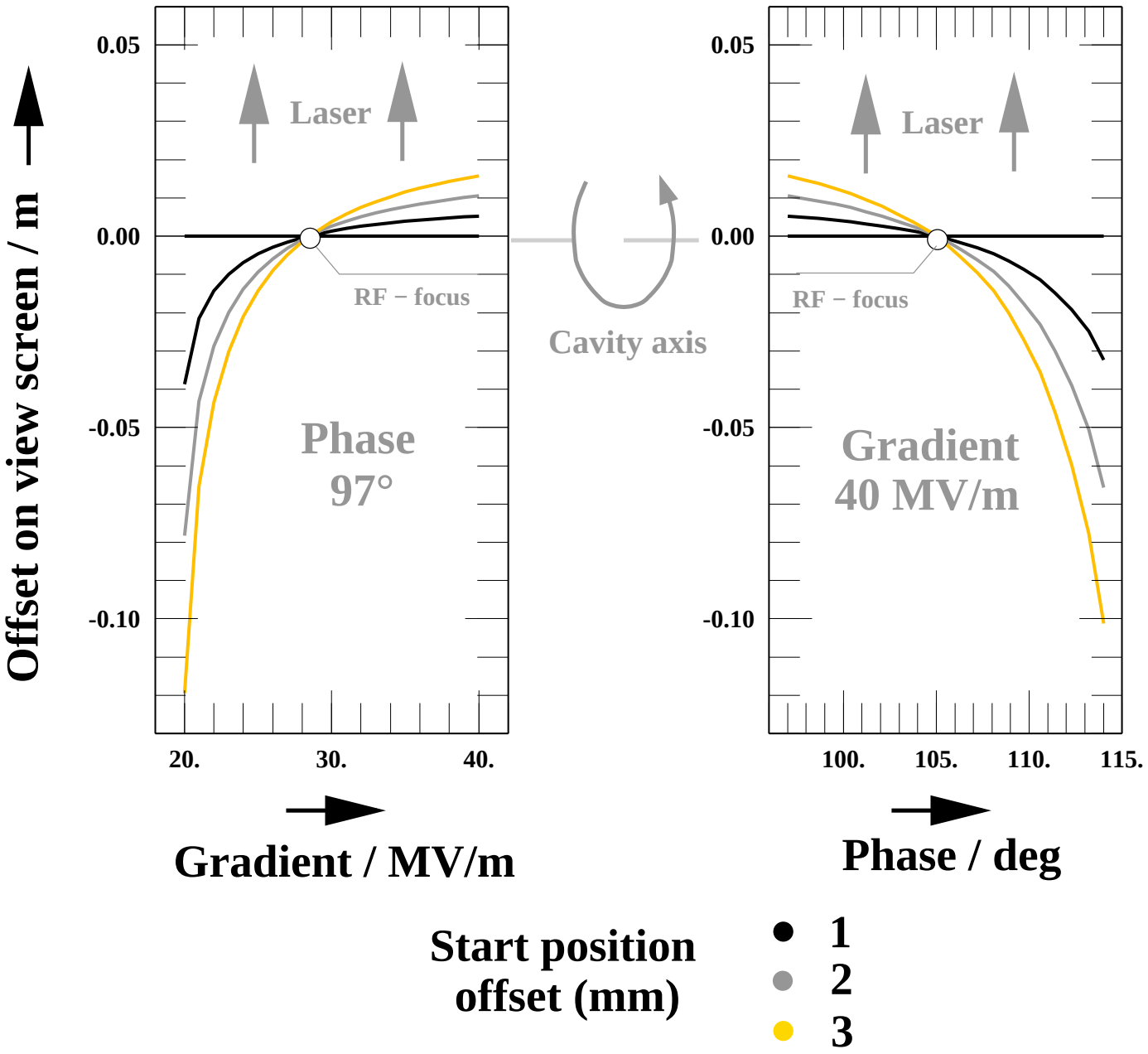



Offset / m →

z / m →

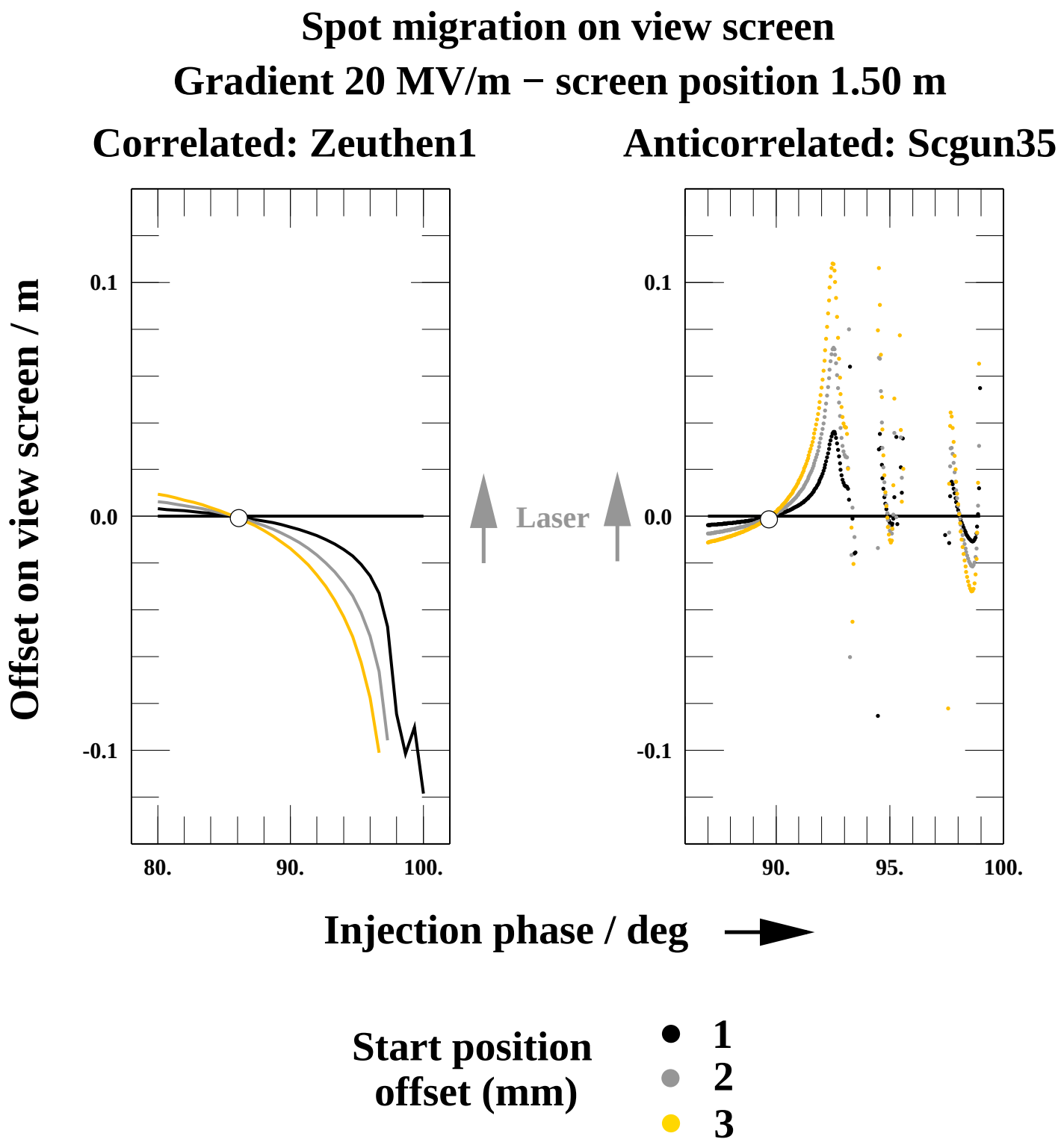
(40 MV/m)

# Motion and contraction:
# Behaviour of low energy spot on view screen
# (Zeuthen1, 1.5 m down stream)

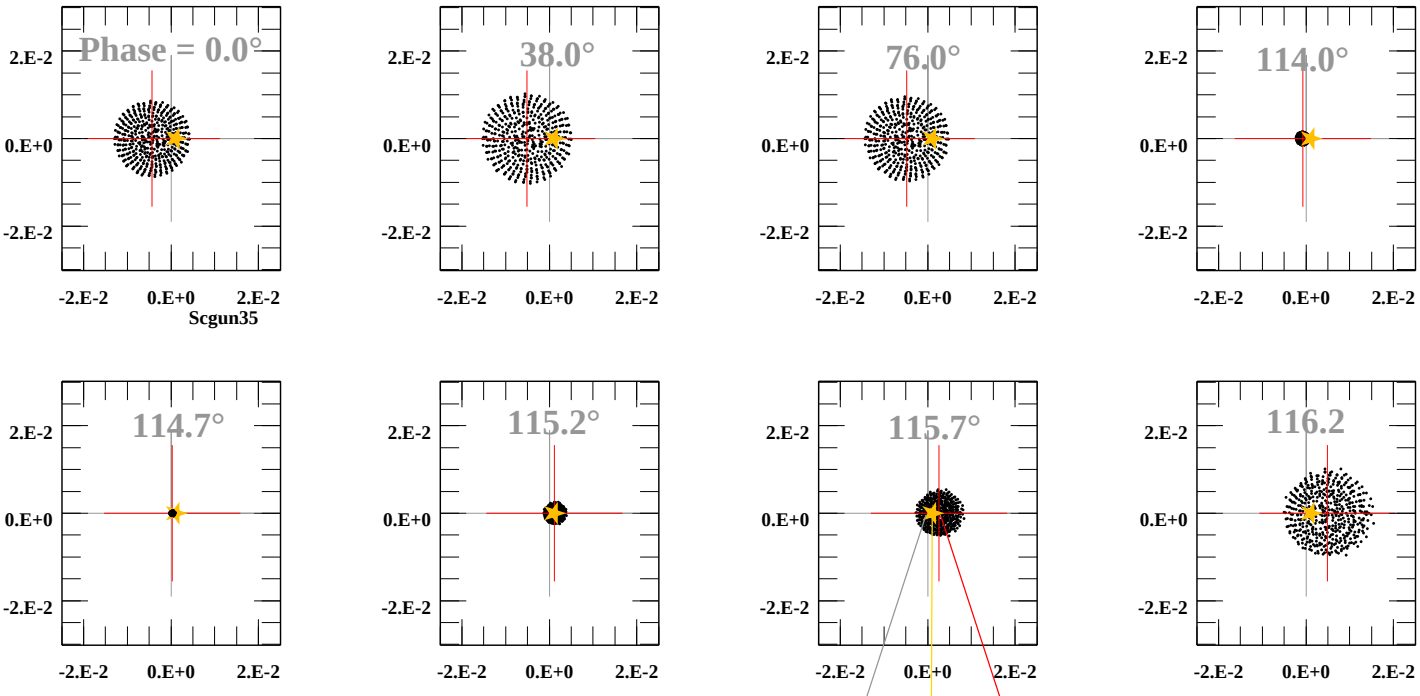



**Start position offset (mm)**

- 1
- 2
- 3


Spot migration on view screen
Gradient 20 MV/m − screen position 1.50 m
Correlated: Zeuthen1
Anticorrelated: Scgun35
Offset on view screen / m
0.1
0.0
-0.1
80.
90.
100.
Laser
0.1
0.0
-0.1
90.
95.
100.
Injection phase / deg
Start position offset (mm)
1
2
3

# Size & position vs. phase:
# Focus spot behaviour on view screen (scgun35)




**screen center**

**bunch center**

**hor. laser offset +1 mm**

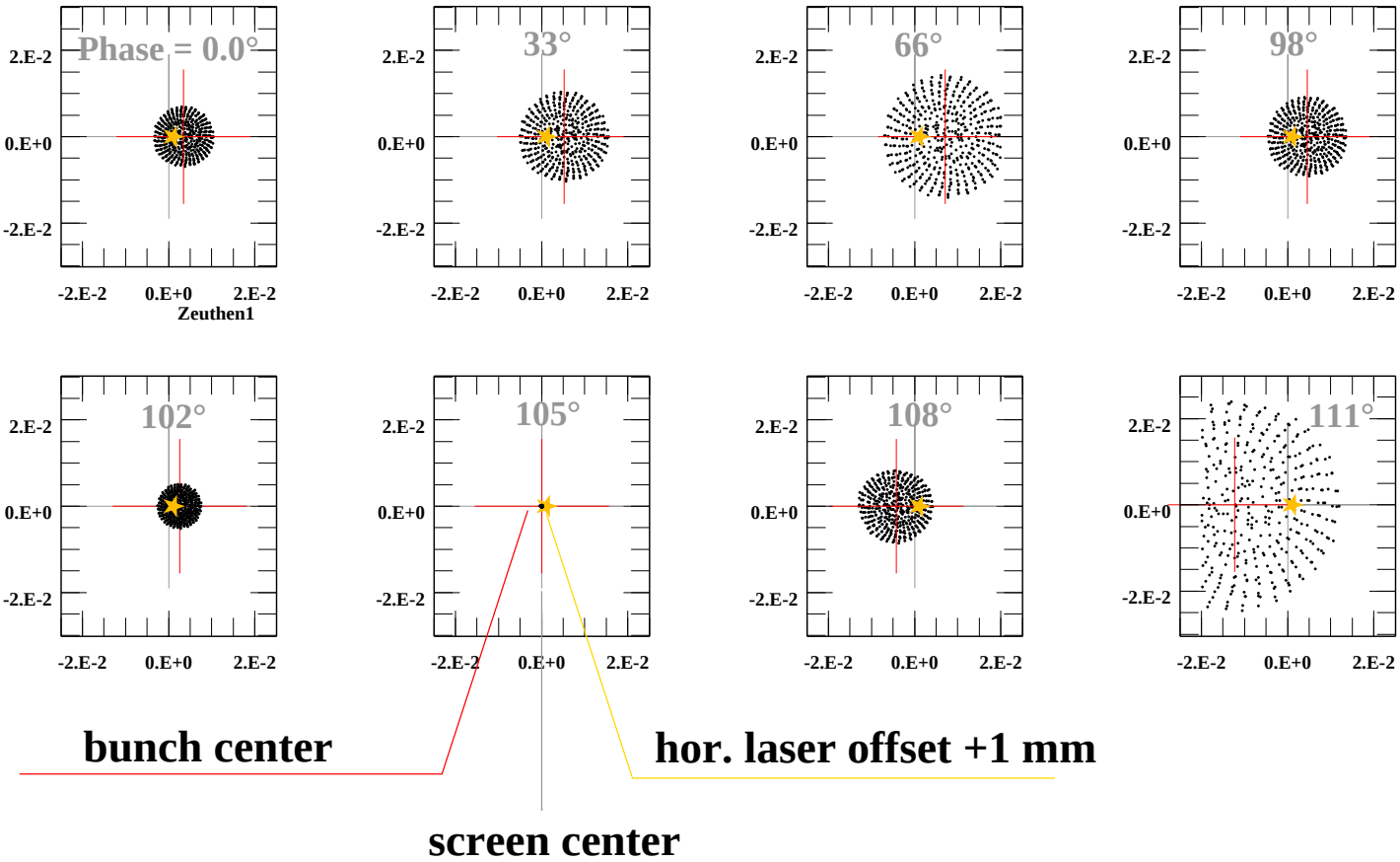
| | |
|---|---|
| **Screen position** | **1.5 m** |
| **Spot radius** | **1.0 mm** |
| **bunch length** | **0.1 ps** |
| **charge** | **0.0 nC** |
| **Gradient** | **40.0 MV/m** |

# Facit for application:

- **Perfect allignment of all entities:**
  - **no spot migration.**
  - **focus appears on screen center.**
- **Cavity axis not collinear beamtube axis, laser centered on cathode**
  - **no spot migration.**
  - **focus appears off screen center**
- **Cavity axis collinear beamtube axis, laser offset on cathode**
  - **Spot migrates**
  - **focus indicates screen center**
- **Cavity axis not collinear beamtube axis, laser offset on cathode**
  - **Spot migrates**
  - **focus appears off screen center**

# Zeuthen1

## Spot behaviour on sceen: Size & position vs. phase




**bunch center**

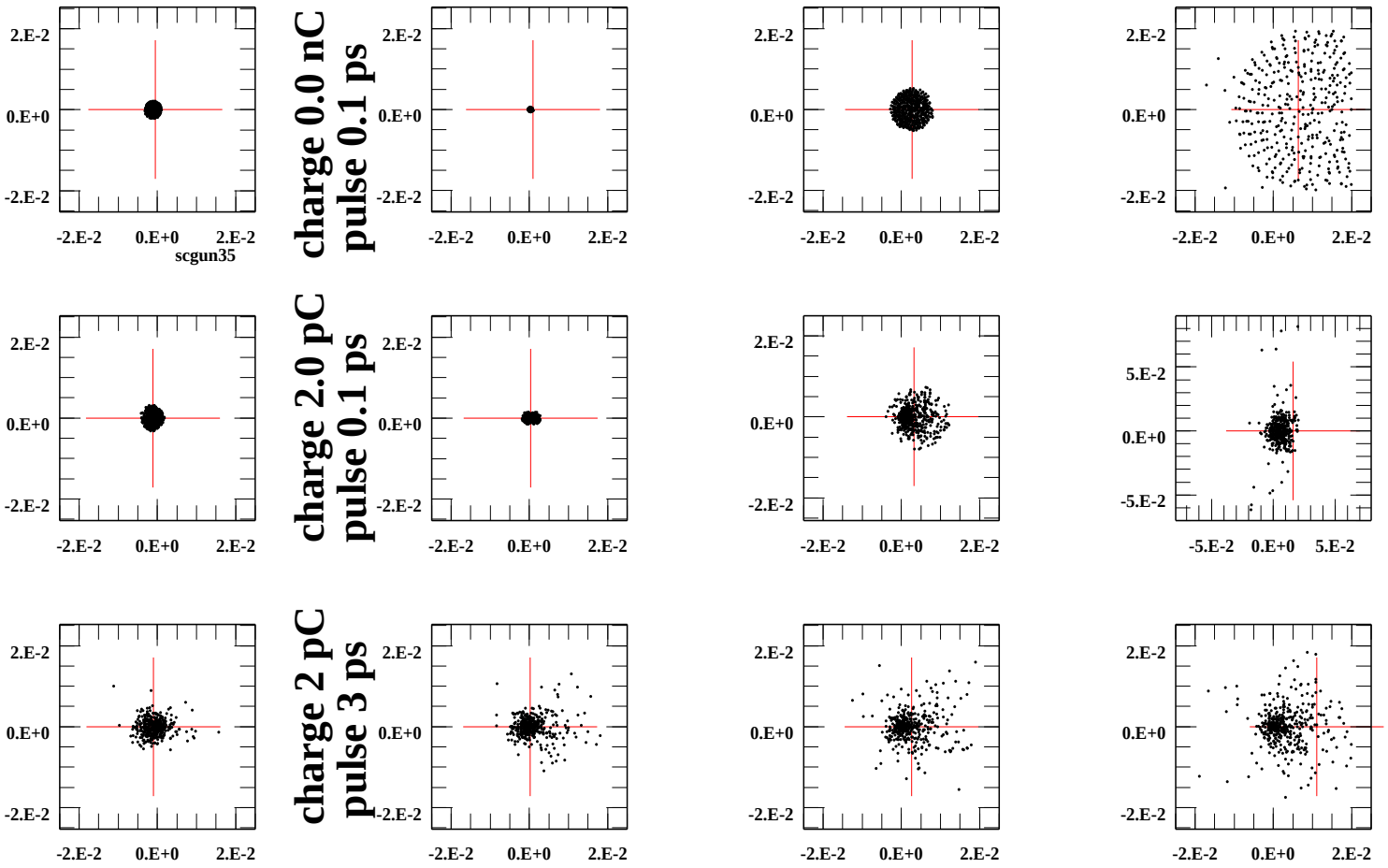
**hor. laser offset +1 mm**

**screen center**

| | |
|---|---|
| **Screen position** | **1.5 m** |
| **Spot radius** | **1.0 mm** |
| **bunch length** | **0.1 ps** |
| **charge** | **0.0 nC** |
| **Gradient** | **40.0 MV/m** |

# Finite laser puls − finite space charge

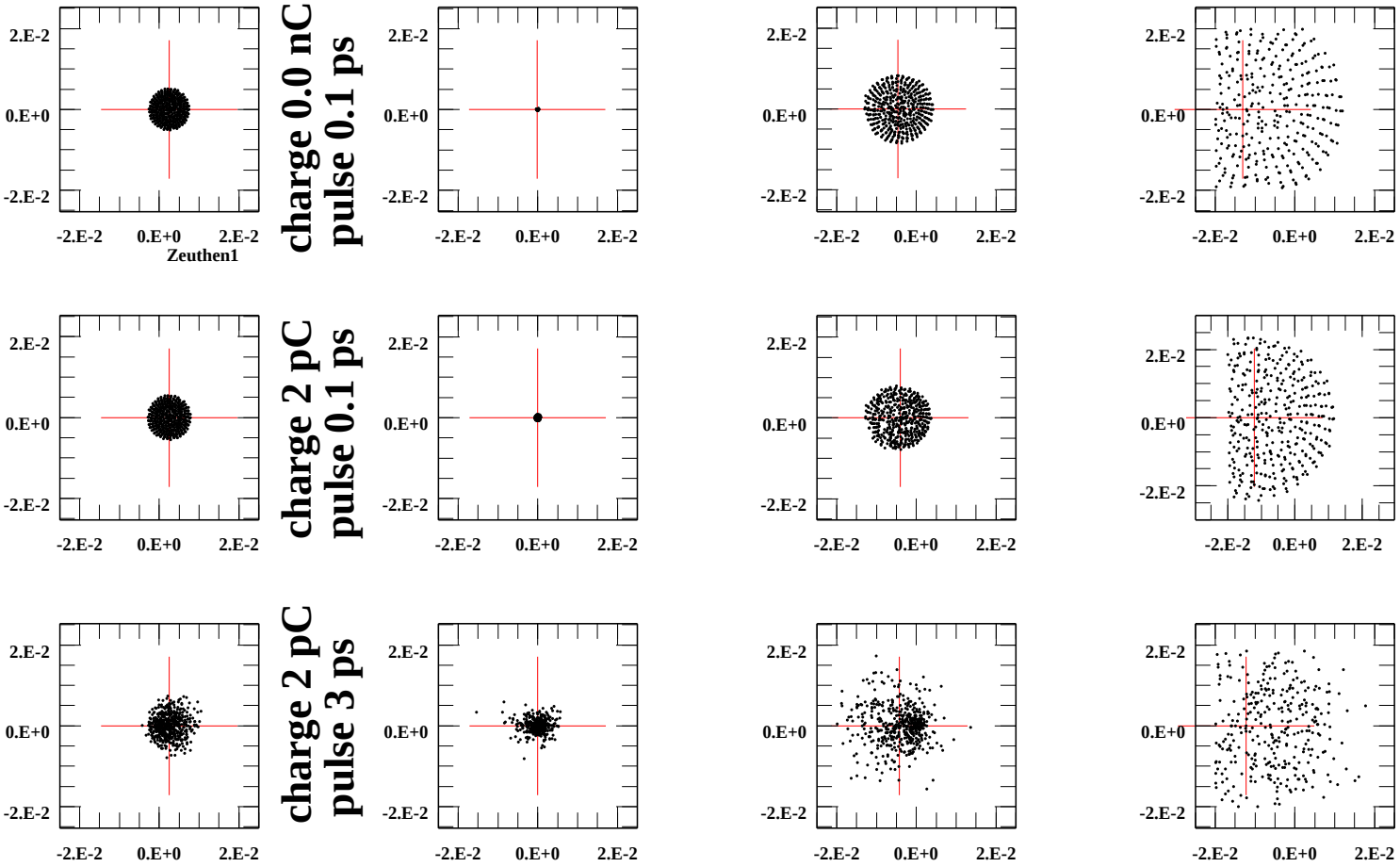
## Scgun35, 1 mm laser displacement




**Phase 113.7°** **114.7°** **115.7°** **116.7°**

| | |
|---|---|
| **Screen position** | **1.5 m** |
| **laser spot** | **1.0 mm** |
| **Gradient** | **40.0 MV/m** |

# Zeuthen1
# Finite laser puls − finite space charge
## 1 mm laser displacement




**Phase 102°** **105°** **108°** **111°**

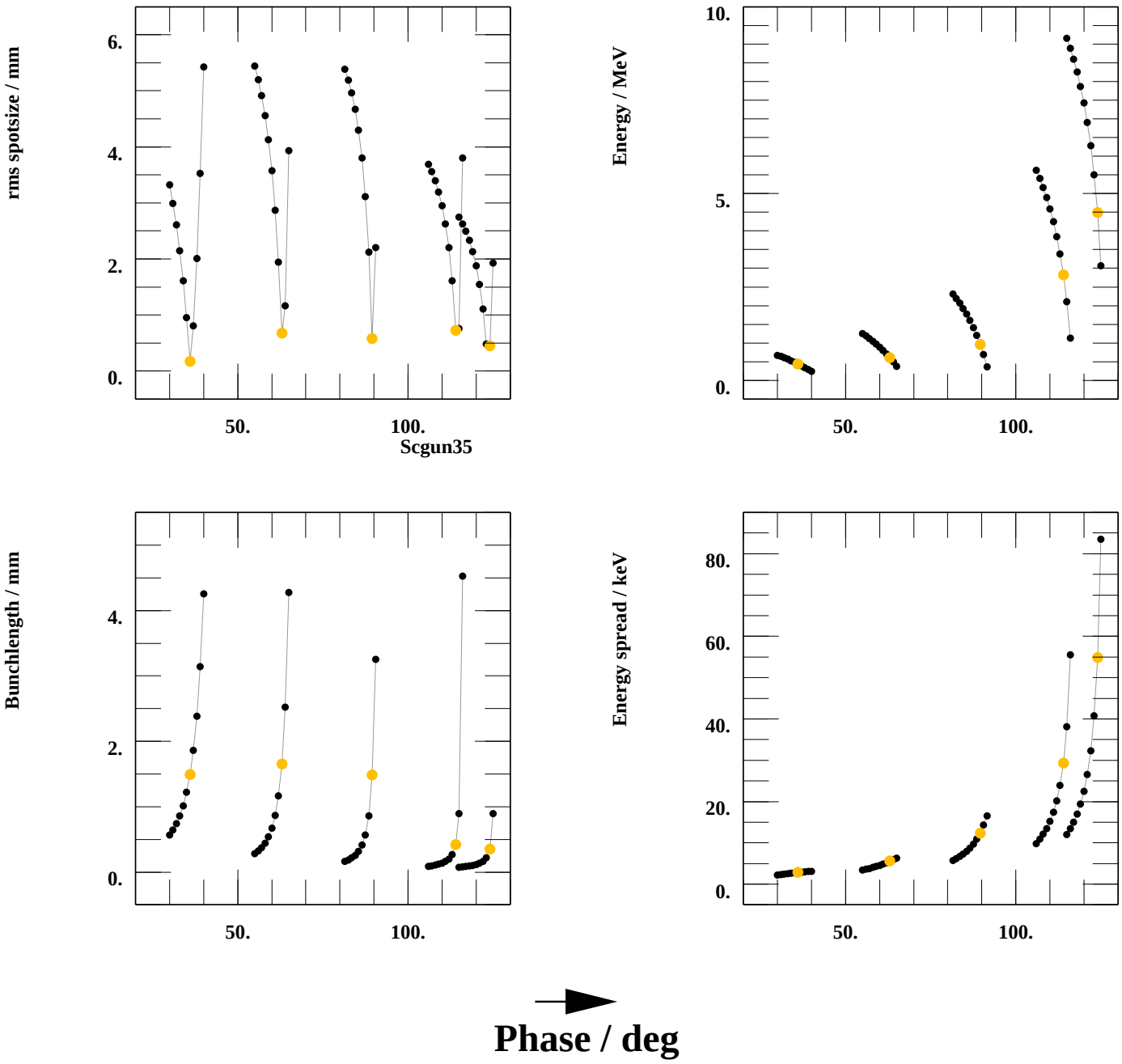
| | |
|---|---|
| **Screen position** | **1.5 m** |
| **laser spot** | **1.0 mm** |
| **Gradient** | **40.0 MV/m** |

# Preferable application conditions:

- **Laser puls as short as possible:**
  **... to avoid unsharp focus spot by phase spread.**
- **As low charge as possible,**
  **counteract with micro pulse train:**
  **... to avoid unsharp focus spot by space charge.**
- **Gradient as low as possible:**
  **... to avoid background by dark current**

# Near low energy focus: beam dynamical quantities

## Gradient: 10, 13, 20, 40, 60 MV/m



# General trends: gradient dependence at focus

# (scgun35, screen 1.50 m)