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# Beam Imperfection Studies

## - Status of RF coupler asymmetry studies

**DESY-TEMF Collaboration Meeting**
**S2/17 • R 114 • TEMF • Darmstadt**
**24.06.2016**

# Content

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- Introduction
- Field simulation using asymmetric model (with coupler)
- Field map implementation
- Beam dynamics simulation using a field map
- Summary

# Introduction

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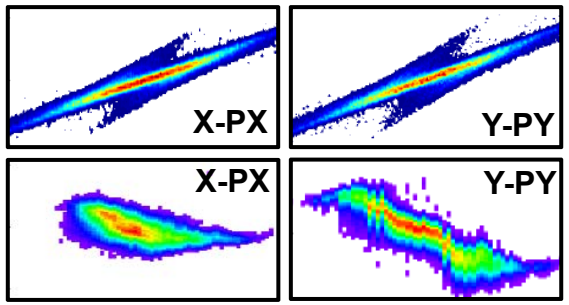
❖ **To identify the source for imperfections in beam profiles / phase spaces**

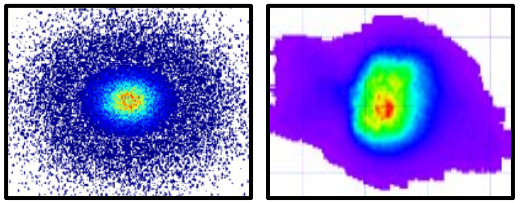
**Phase spaces at EMSY1 (BSA=1.6 mm, 1 nC)**

**Simulation →**




**← Measurement**

**Beam Profiles at EMSY1**



**Simulated X-Y** **Measured X-Y**

**→ Simulations including coaxial RF couplers**

# RF field simulations in CST-MWS

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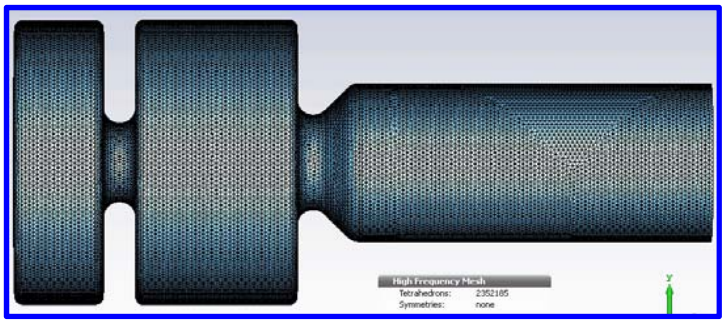
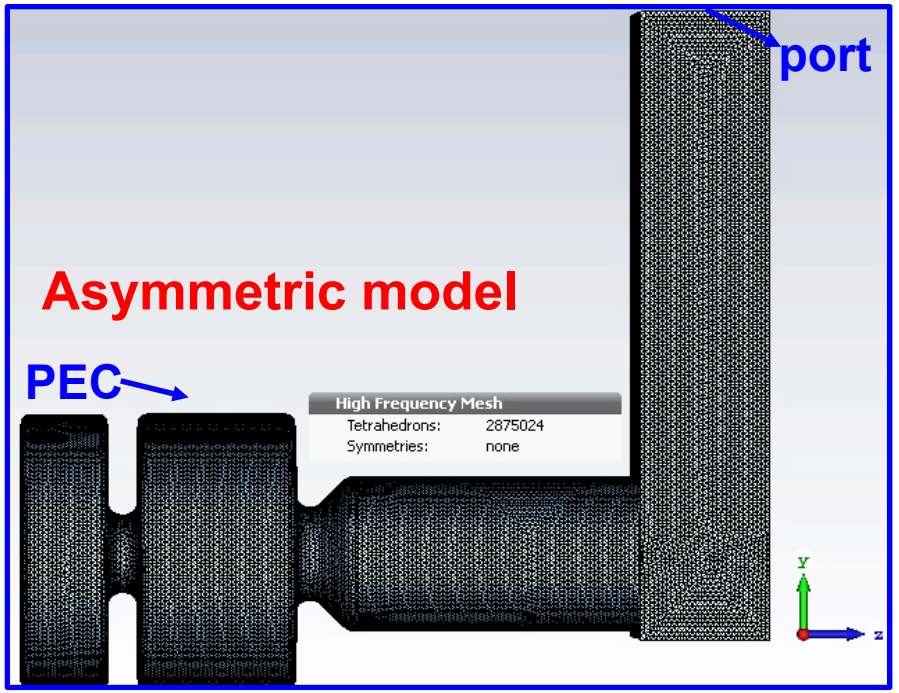
– **Simulation models**

**Symmetric model**
**(mesh view)**



**Asymmetric model**



# Quantifications of field asymmetries

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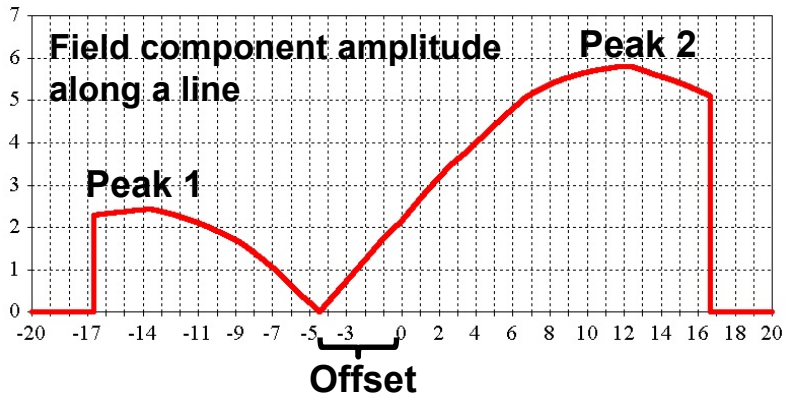
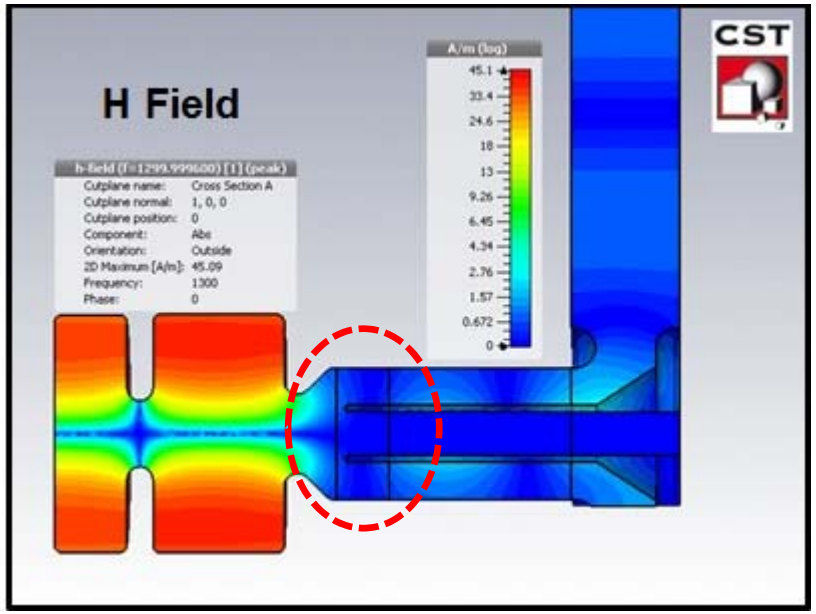
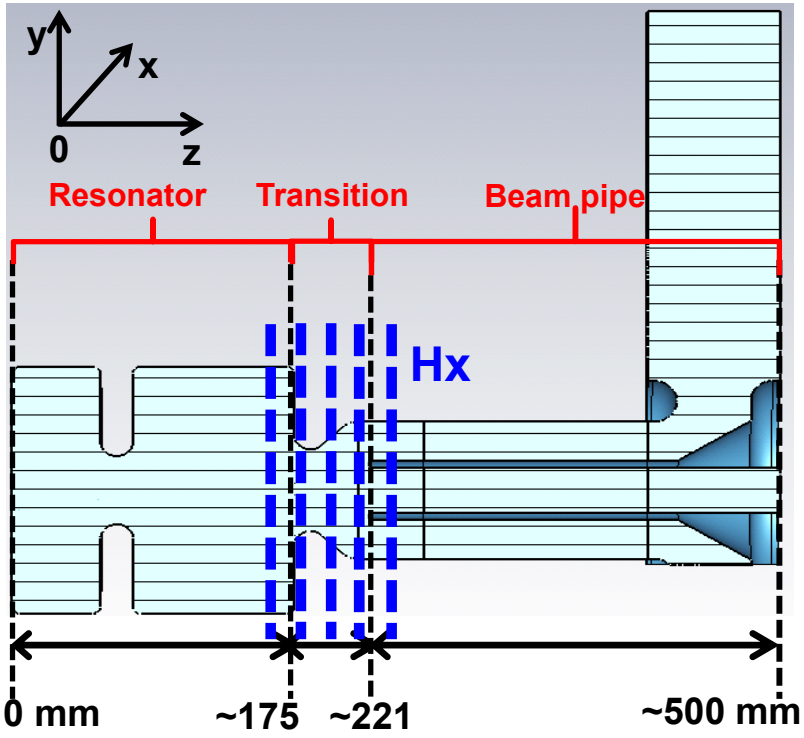
- **Defined quantities for field asymmetries:**

  1. **Peak field amplitude**
  2. **Flatness:** ratio of peak field amplitudes, flatness=1: no asymmetries
  3. **Offset of zero-crossing:** offset of field zero crossing from axis

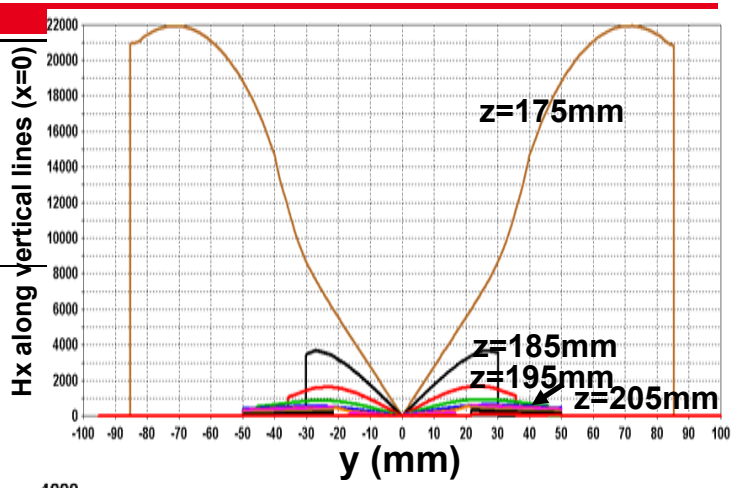


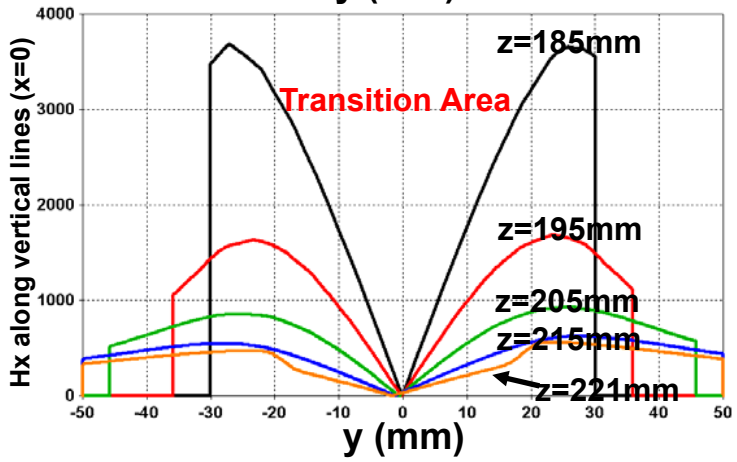



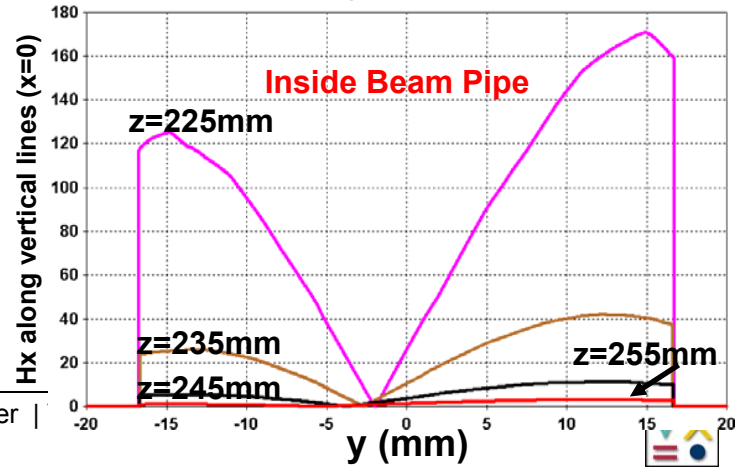
# Quantifications of field asymmetries




**Hx along vertical lines at different z positions**



# Quantifications of field asymmetries

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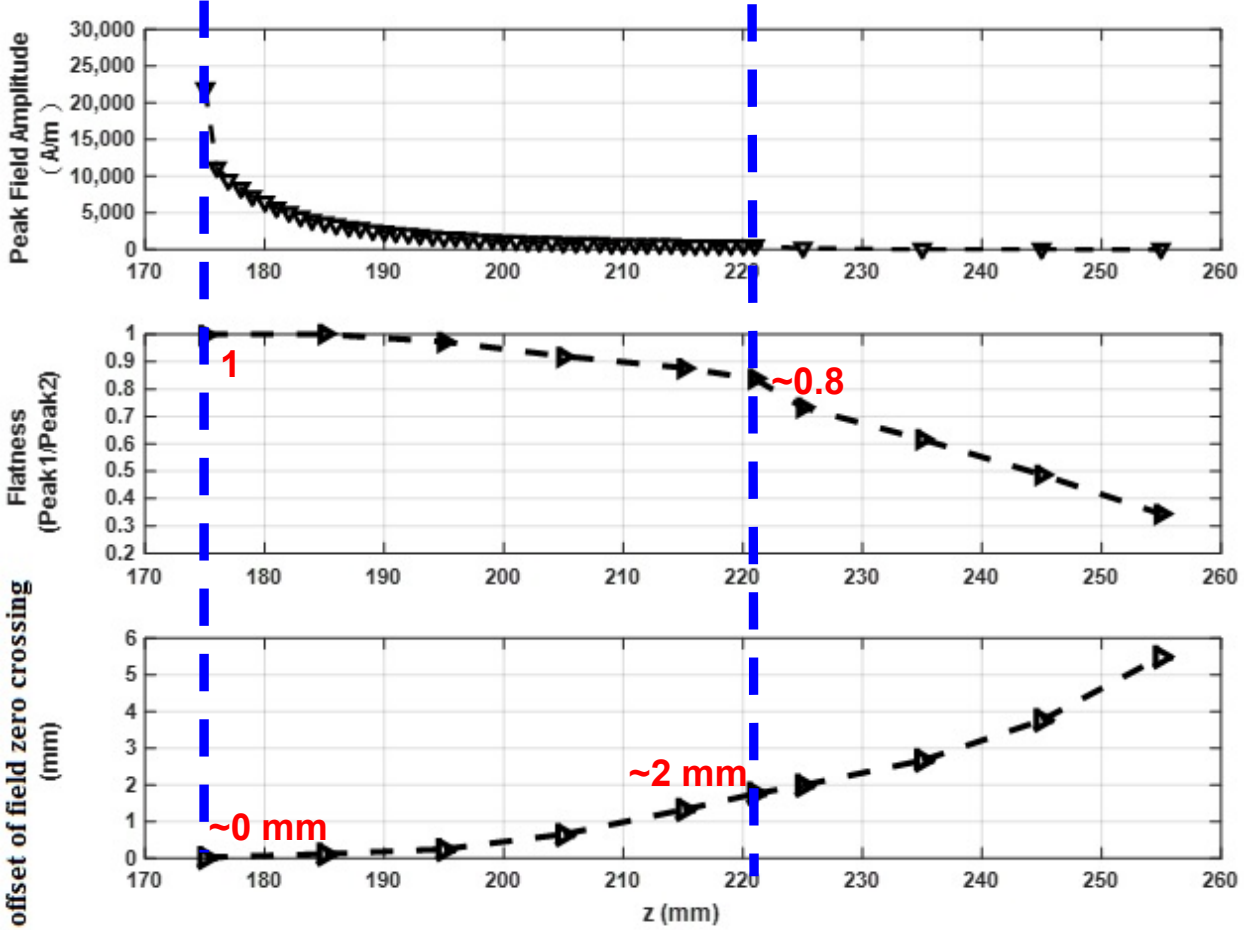
← Gun cavity--------Transition area-------Beam pipe →

**Peak field amplitude**

**Flatness**

**Offset of field zero crossing from axis**



# RF field map implementation

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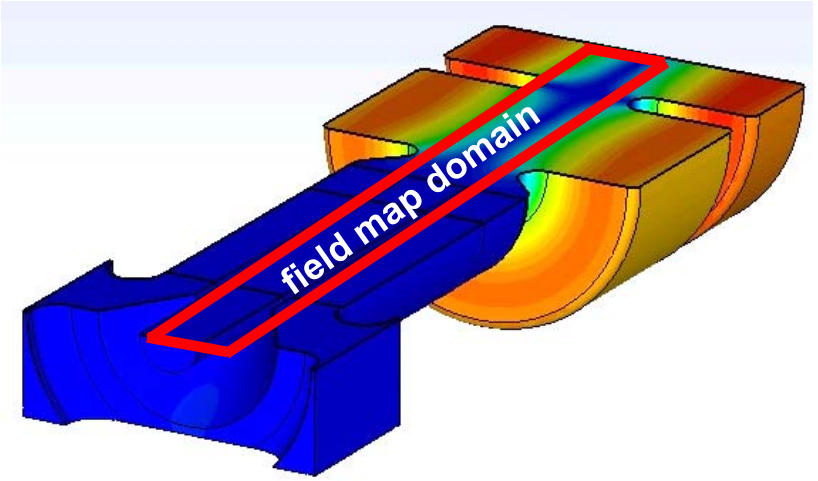
## ➢ Quantifications for all E and H components

**Hx along y ⟶ flatness: 1 (resonator) to ~0.8 (entering beam pipe); Offset: 0 to ~2 mm**
Hy along x ⟶ flatness: ~ 1; Offset: ~0.01 mm
Hx along x, Hy along y, Hz ⟶ very weak contributions
Ez along x/y/z ⟶ no asymmetries found
Ex along x ⟶ flatness: 1; Offset: ~0.1 mm
**Ey along y ⟶ flatness: ~2% change; Offset: ~ 0.3 mm**
Ex along y, Ey along x ⟶ very weak contributions

## ➢ Implementation of 3D RF field map (real number)

- Fields computed with CST-MWS
- Field map implemented with ASTRA
- Field map settings
  - **Scale** (for $\sigma_{rms}$ = 0.4 mm): transversely **~20 mm**; longitudinally **~350 mm**
  - **Grid setting:** uniform grid sets; **Dx = Dy ≤ 0.1 mm, Dz ≤ 0.2 mm** (grid size in each direction)



# ASTRA simulations using RF field map

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## ❖ ASTRA simulations

- XY_rms = 0.4 mm, Q = 1nC
- Flat-top bunch of ~21.5 ps
- Uniform transverse distribution
- Ezmax≈60MV/m, at MMMG phase, Bzmax≈0.227901T, booster included

## ❖ Comparisons between 3 cases

**Case A: Using Paraxial field with symmetric model**

Given only the **on-axis (z)** electric field, the transverse field components are analytically calculated from the derivatives of the on-axis field.

**Case B: Using 3D RF field map with symmetric model**

RF fields computed from CST-MWS simulations without RF couplers.

**Case C: Using 3D RF field map with asymmetric model**

RF fields computed from CST-MWS simulations with RF couplers.

# ASTRA simulations using RF field map

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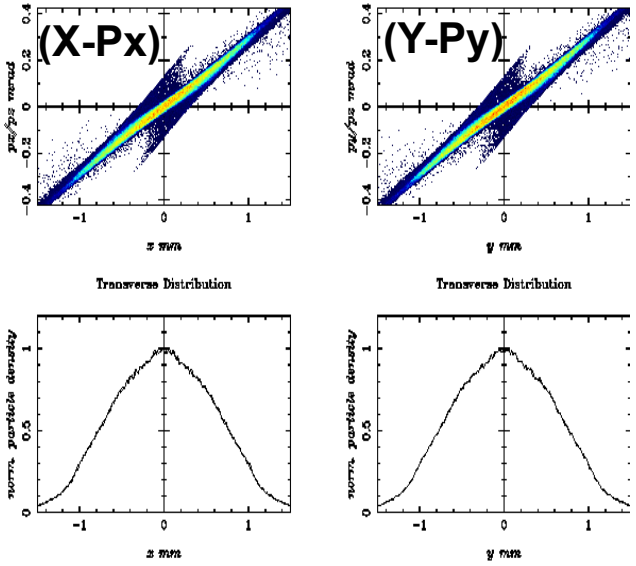
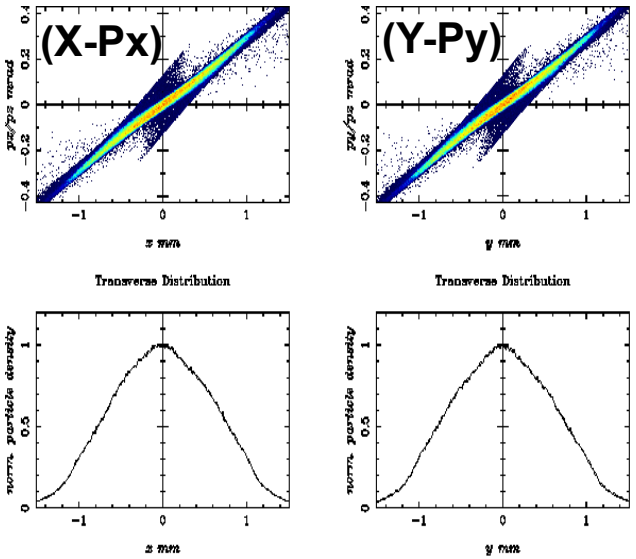
(Paraxial fields) **Case A vs. Case B** (3D fields using symmetric model)

**Case A**




**Case B**

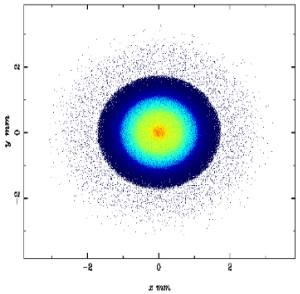



Transverse phase spaces @ EMSY1

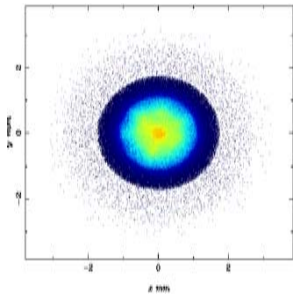
**Emittance: $\varepsilon_{xy}$ = 0.6872 mm mrad**

**Emittance: $\varepsilon_{xy}$ = 0.6867 mm mrad**

(X-Y)



Transverse beam profiles @ EMSY1



(X-Y)

# ASTRA simulations using RF field map

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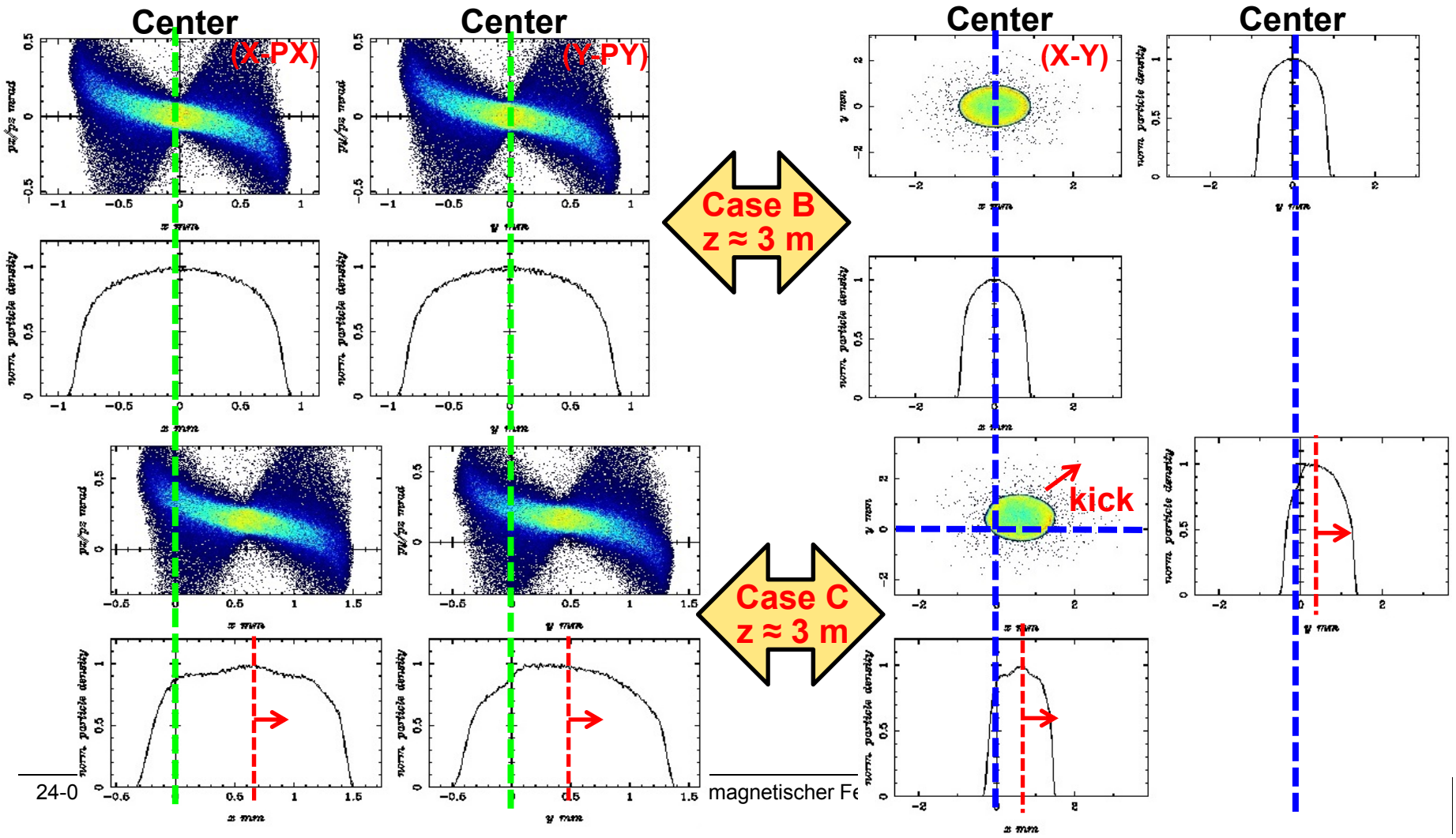
(3D fields using symmetric model) **Case B vs. Case C** (3D fields using asymmetric model)






magnetischer Fe

# ASTRA simulations using RF field map

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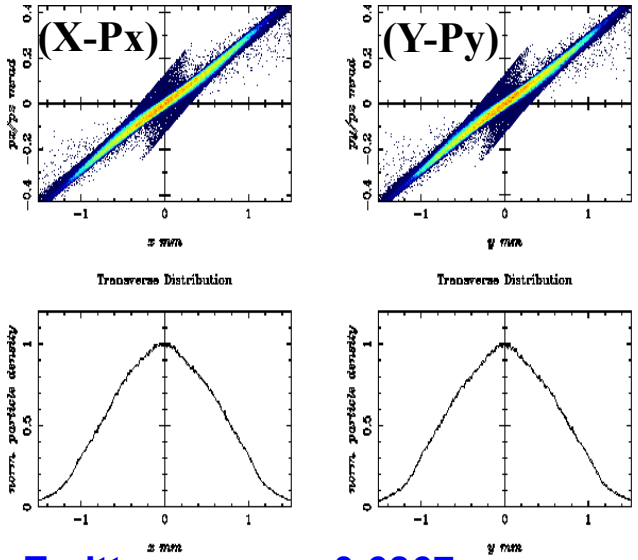
(3D fields using symmetric model) **Case B vs. Case C** (3D fields using asymmetric model)

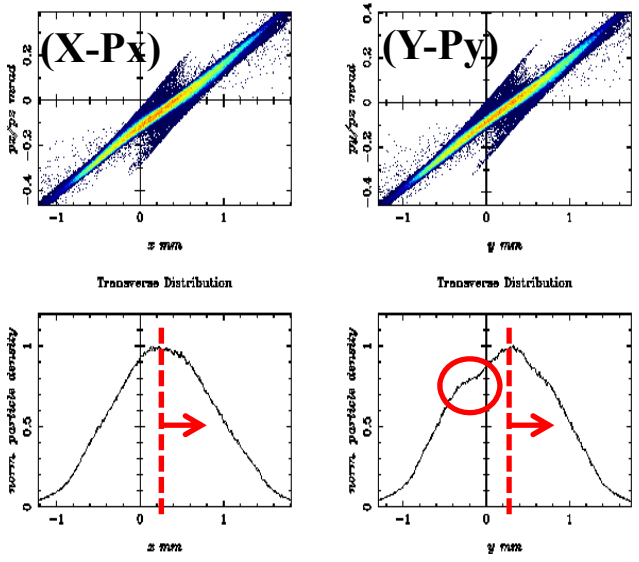
**Case B**




**Emittance: $\varepsilon_{xy}$ = 0.6867 mm mrad**

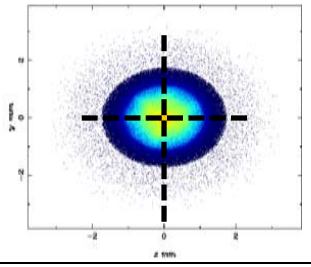
**Transverse phase spaces @ EMSY1 z ≈ 5.7 m**

**Case C**

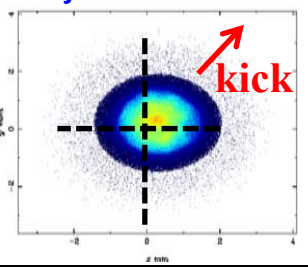



**Emittance: $\varepsilon_x$ = 0.7055 mm mrad**
**$\varepsilon_y$ = 0.7158 mm mrad**

**(X-Y)**



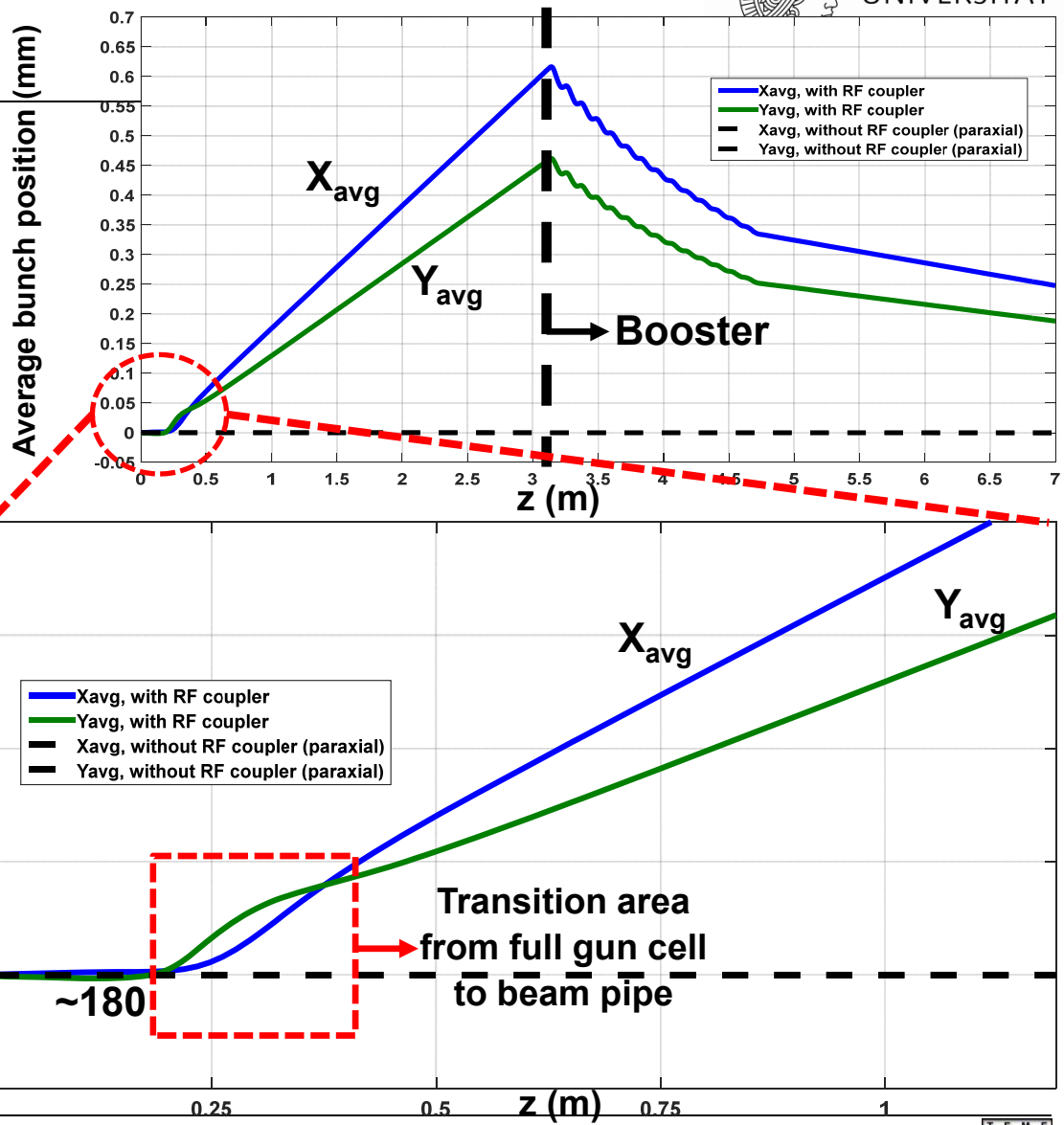
**Transverse beam profiles @ EMSY1 z ≈ 5.7 m**




**(X-Y)**

# Location of the kick

- **Transverse kick**
  - **Before booster:** ~0.6 mm in x and ~0.45 mm in y at z ≈ 3 m
  - **At EMSY1,** smaller kick~0.3 mm
- **Source of the kick**
  - **Region:** from the full cell (end) of the gun to the beam pipe
  - **Source:** RF coupler asymmetries induced field asymmetries



# Summary

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## Summary

1. Field simulations including RF couplers
2. RF field asymmetries found in the transition region due to the coaxial coupler
3. RF field map implemented and used in ASTRA simulations
4. A transverse kick to the whole bunch (~0.6 mm at z≈3 m before booster), beam size nearly conserves, emittance slightly higher