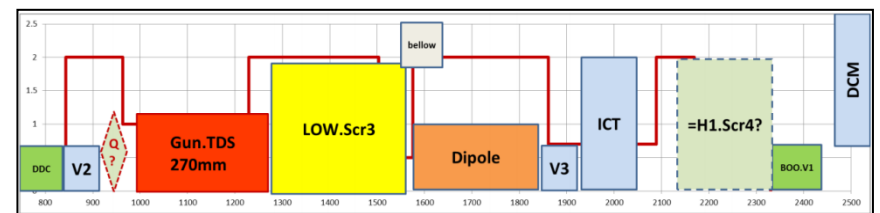
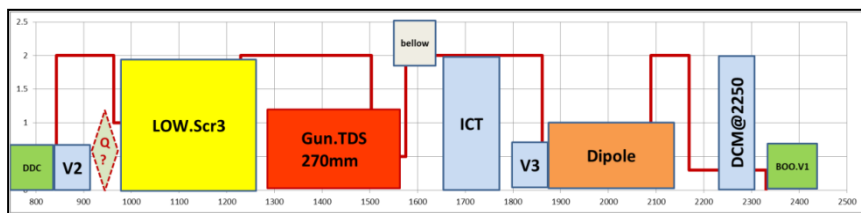
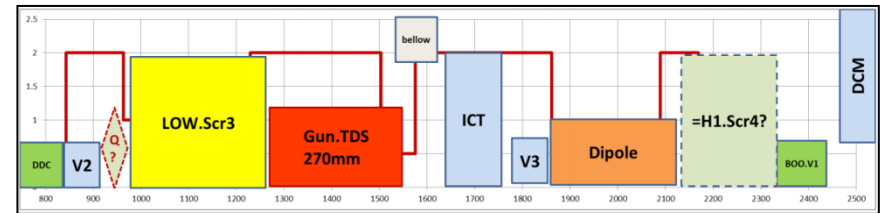
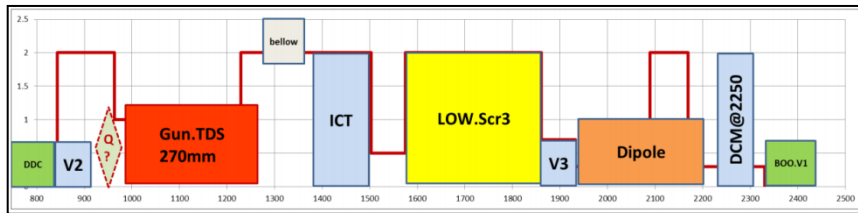
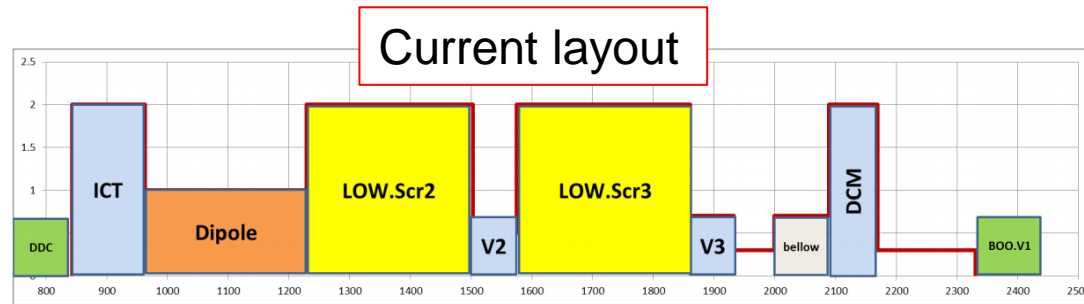


# Momentum measurement at LEDA

- **Simulation using ASTRA**
- **Experimental measurement**
- **Comparisons**
- **Discussions**

# INTRODUCTION

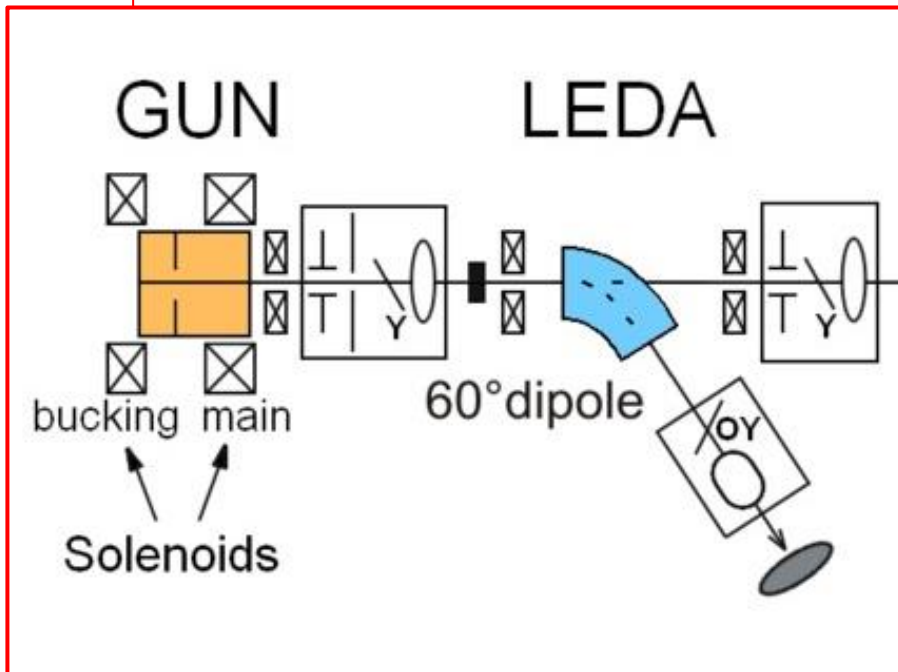
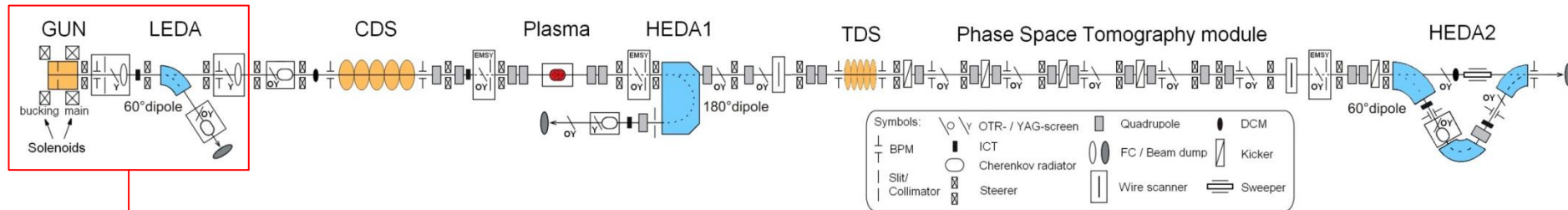
- Mikhail proposes some options for rearrange the Low energy section with a TDS.
- The momentum measurement at LEDA is the first thing to study.



# PITZ3 Beamline

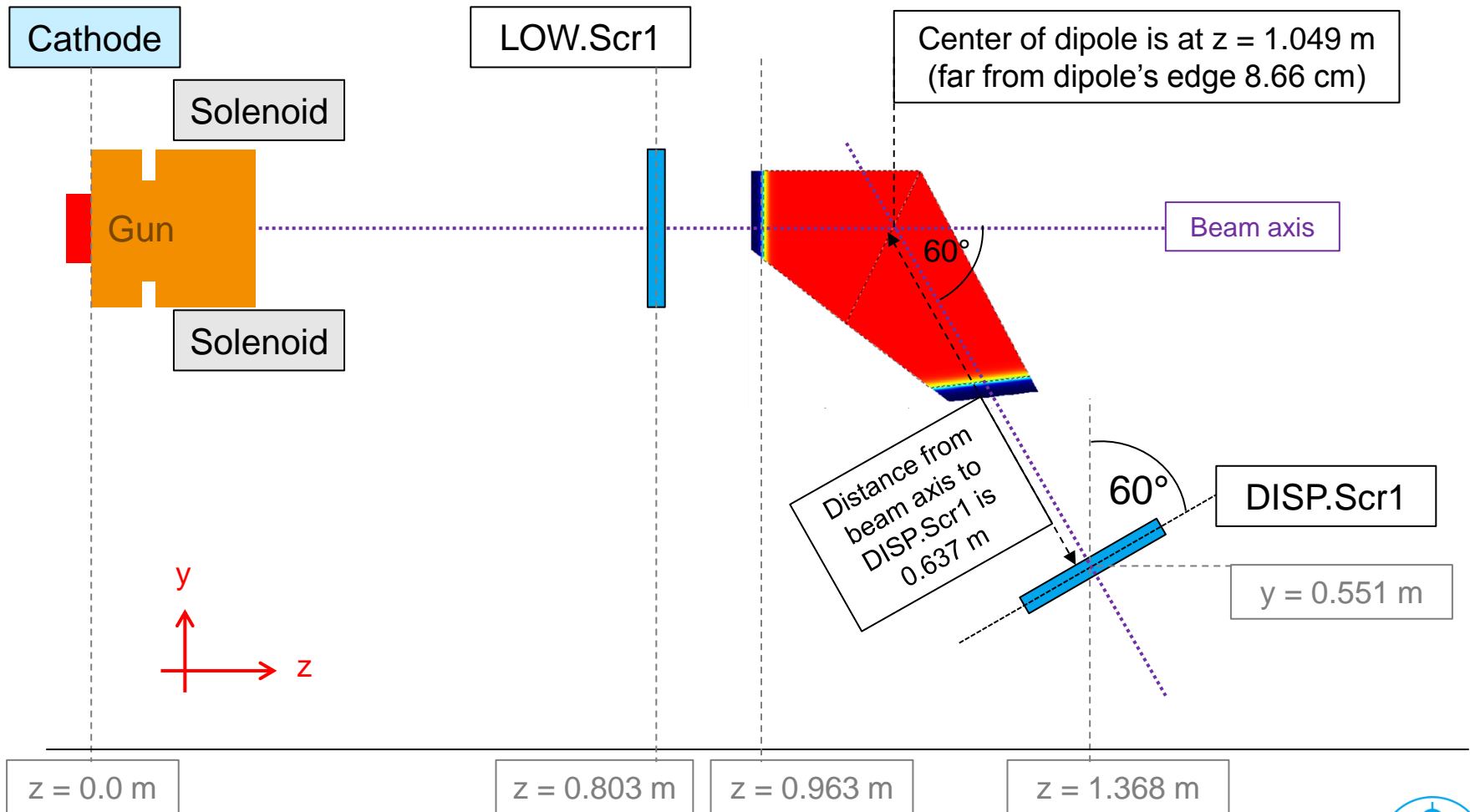
➤ The scope of this study is in the Low Energy Section

- from cathode to LEDA (Low Energy Dispersive Arm)



# ASTRA Simulation of Momentum measurement at LEDA

> Layout for ASTRA simulation \*not to be scaled\*



# ASTRA Simulation of Momentum measurement at LEDA

- Dipole fields distribution at LEDA was desired by Juliane Rönsch, shown in her PhD Thesis, 2009

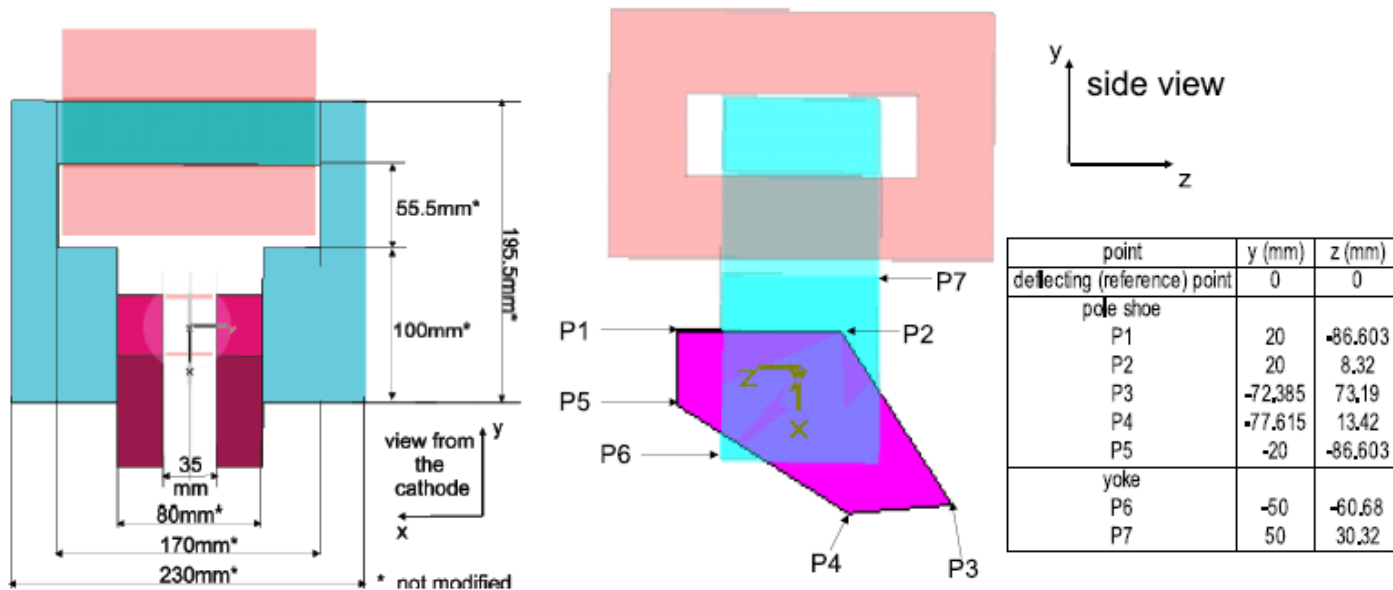
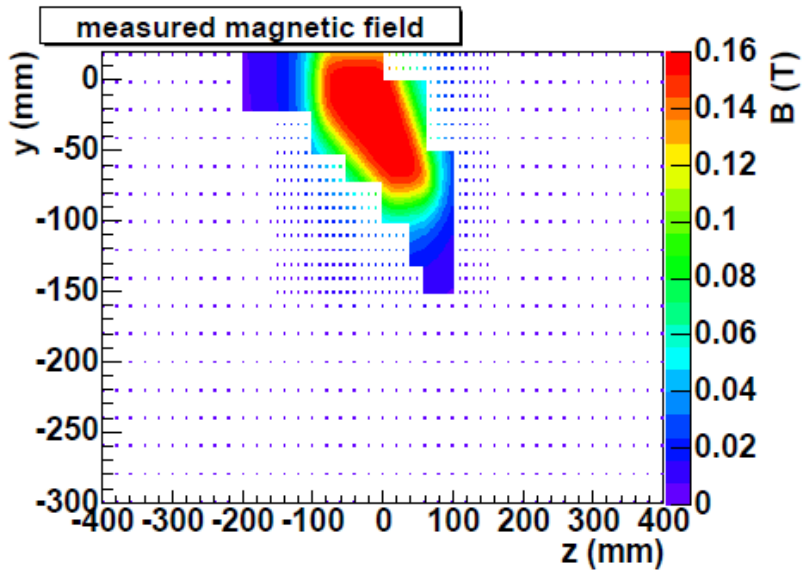


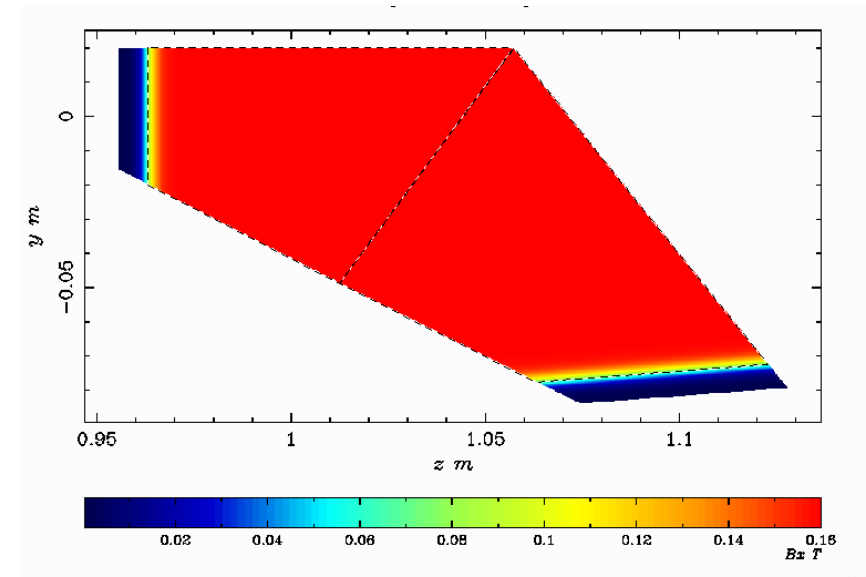
Figure 4.16: *Spermatical layout of the modified dipole spectrometer.*

# ASTRA Simulation of Momentum measurement at LEDA

- Dipole fields distribution at LEDA was constructed by 'DIPOLE namelist' in ASTRA
- Bending radius = 150 mm



Dipole distribution from  
J. Rönsch's PhD Thesis, 2009



Dipole distribution from ASTRA

# BEAM DISTRIBUTION

- Initial beam distribution in ASTRA corresponding to the experiment (11.06.2018)
  - Transverse beamsizes,  $\sigma_x, \sigma_y = 0.30 \text{ mm}$  as radial uniform distribution.
  - Temporal profile, FWHM = 4 ps  $\rightarrow \sigma_t = 1.698 \text{ ps}$  as Gaussian distribution. (laser spot size of 1.2 mm)
  - **Bunch Charge, Q = 100 pC**

Image from VC2

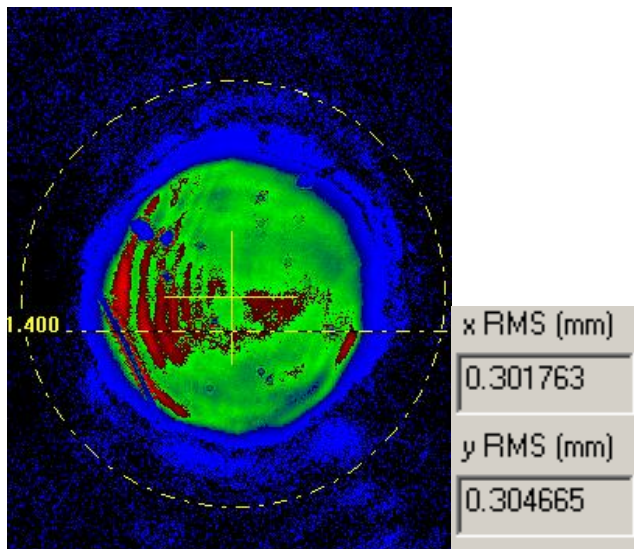
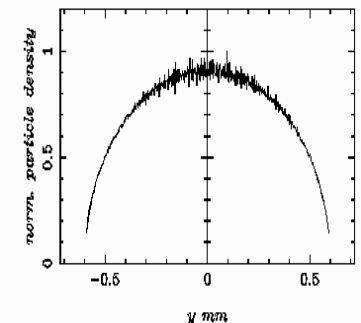
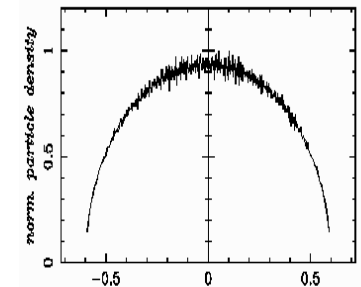
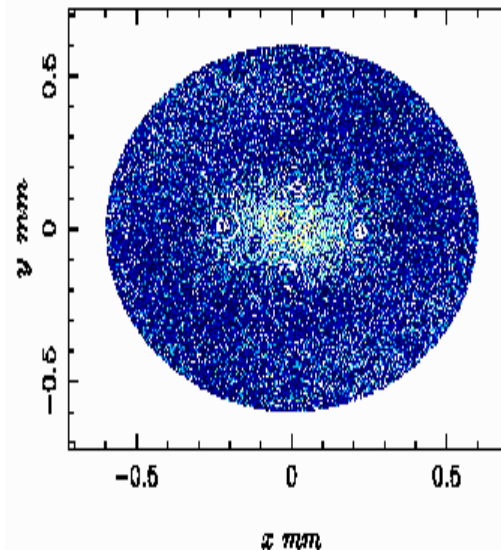


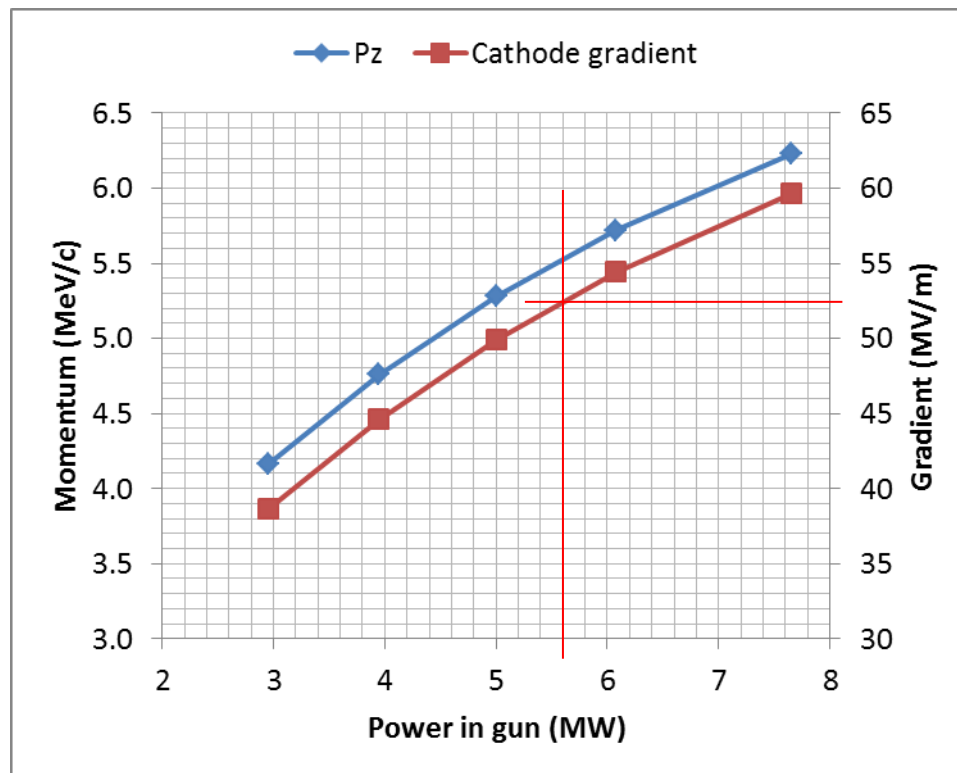
Image from ASTRA



5.0

# BEAM DISTRIBUTION

- Acceleration in ASTRA corresponding to the experiment (11.06.2018)
  - From experiment,  $P_{\text{gun}} = 5.6 \text{ MW}$  was used for momentum measurement.
  - In ASTRA,  $\text{RF}_{\text{gun}}$  gradient,  $E_{\text{max}} = 52.5 \text{ MV/m}$  (calibrated from this graph from PITZ logbook.)

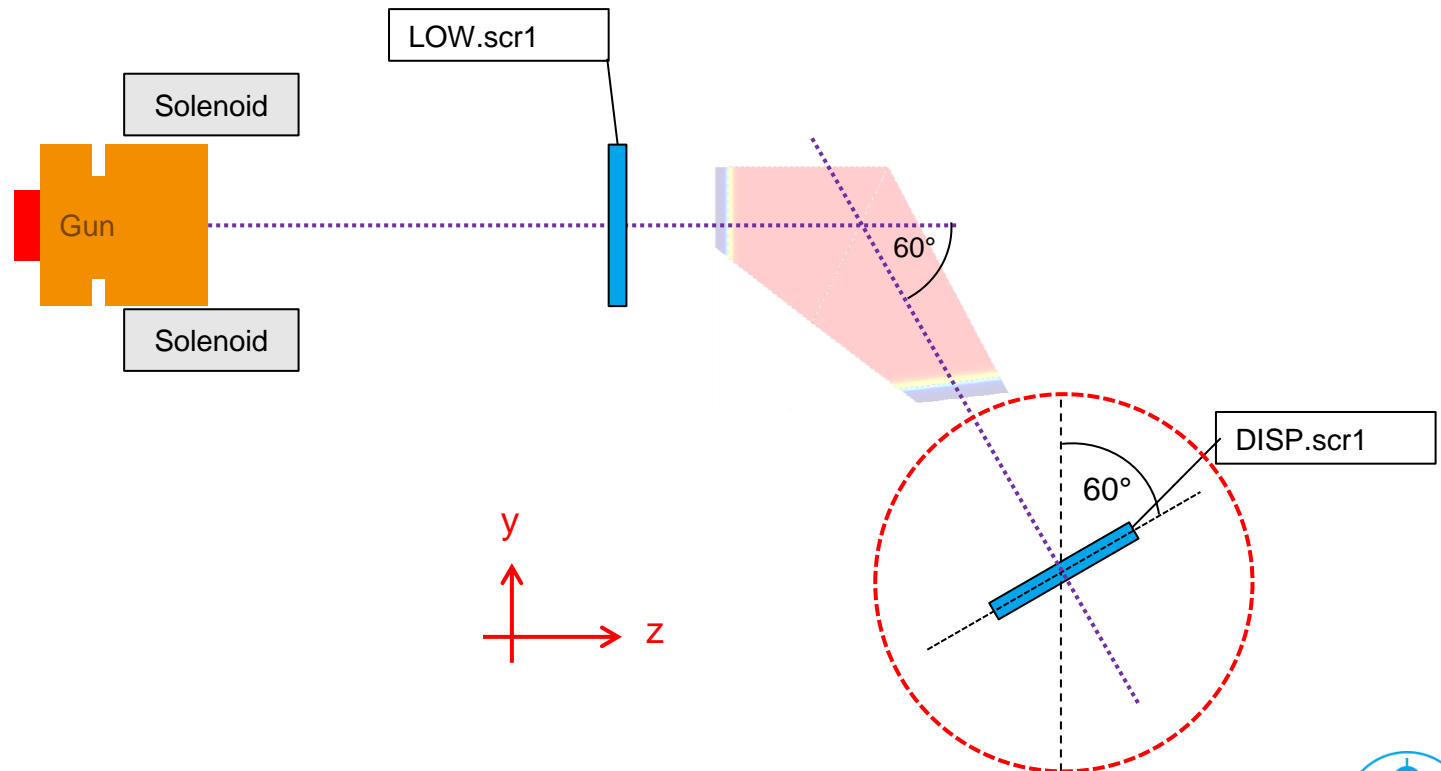




# Momentum Measurement in ASTRA

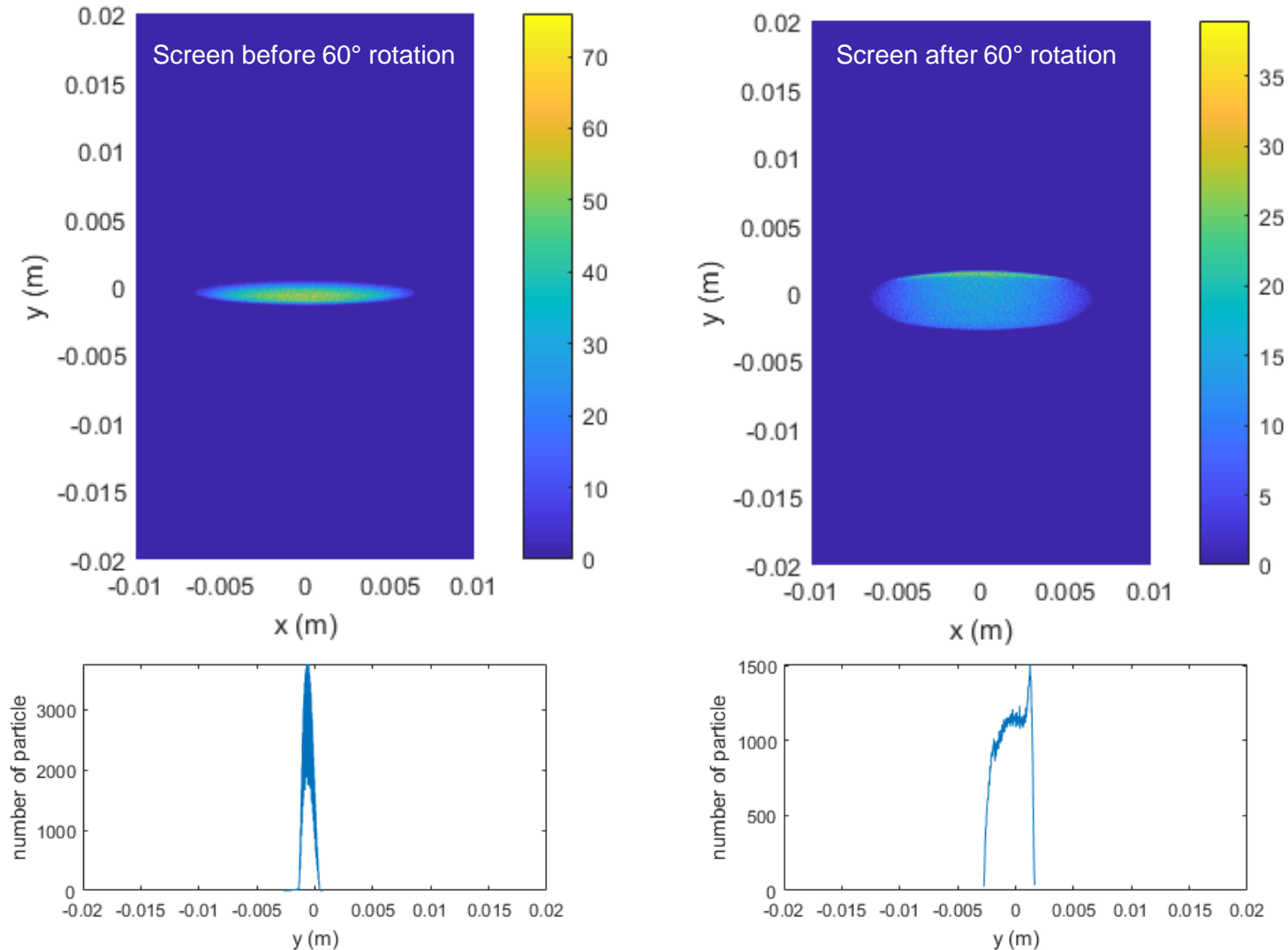
- Transverse beam distribution at DISP.Scr1 must be rotated vertically for  $60^\circ$ , calculated by this equation

$$\begin{bmatrix} y' \\ z' \end{bmatrix} = \begin{bmatrix} \cos 60^\circ & \sin 60^\circ \\ -\sin 60^\circ & \cos 60^\circ \end{bmatrix} \begin{bmatrix} y \\ z \end{bmatrix}$$



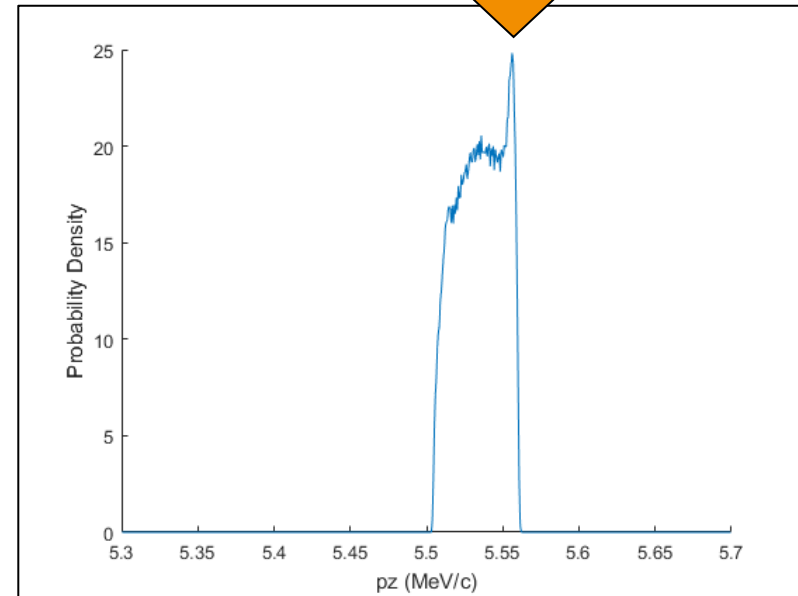
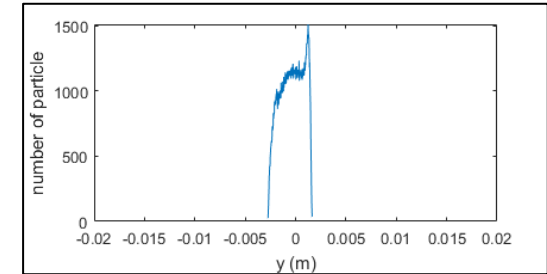
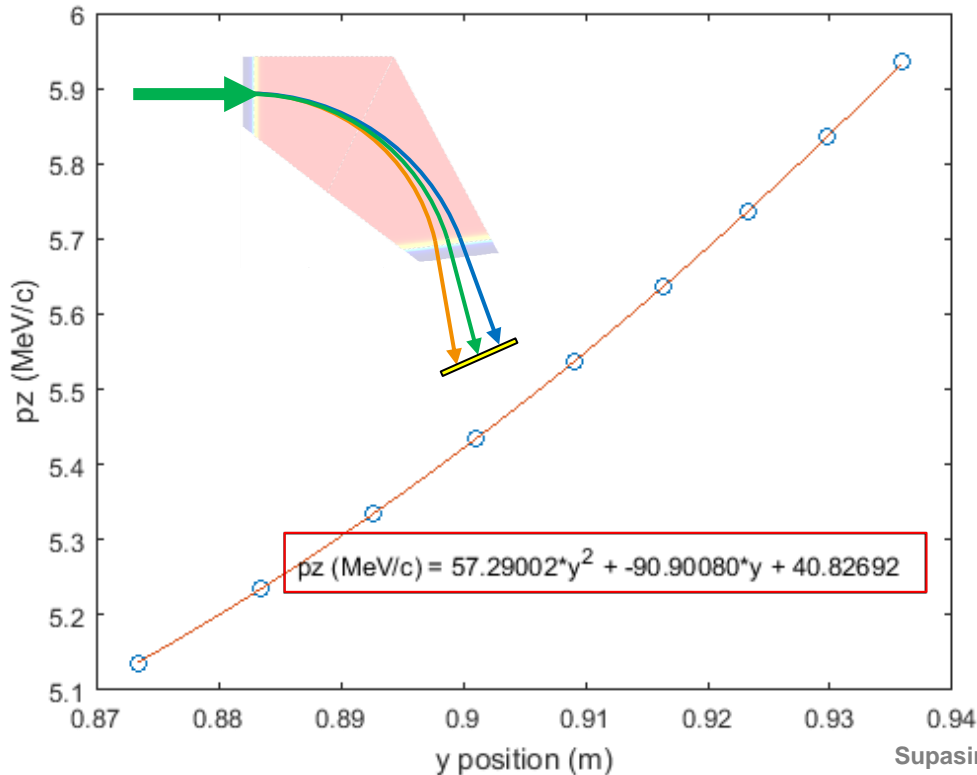
# Momentum Measurement in ASTRA

- Transverse beam profile at DISP.Scr1 before and after 60° rotation



# Momentum Measurement in ASTRA

- Calibration curve from vertical transverse distribution to momentum
- From simulation using bending radius = 150 mm
  - Used maximum magnetic field = 0.1231 T
- Calibrated by simulation single e- trough Dipole



# ASTRA SIMULATION

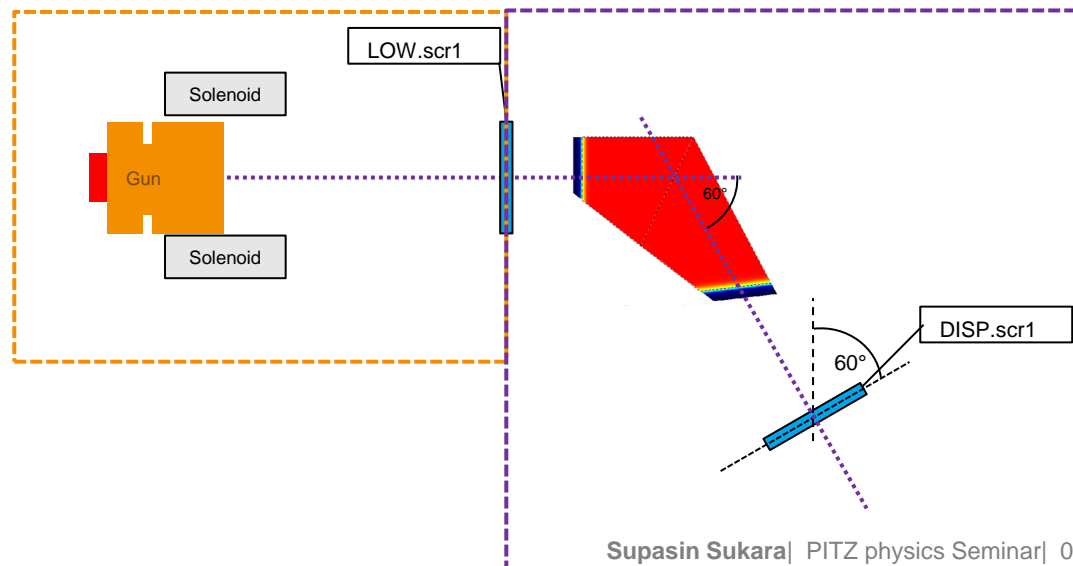
> Space charge calculation is needed for including in simulation

> Cathode to LOW.Scr1 section

Simulated with cylindrical symmetric space charge calculation including image charge

> LOW.Scr1 to DISP.Scr1 section has 3 options of simulation

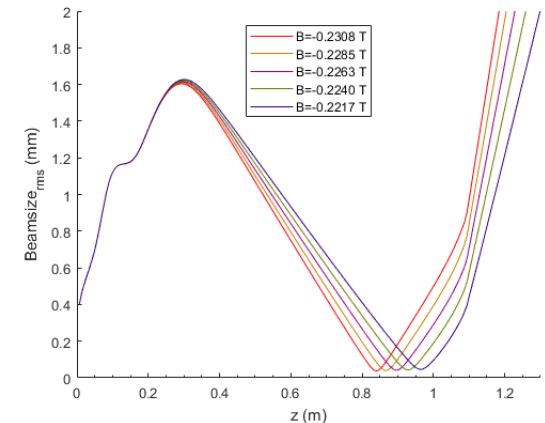
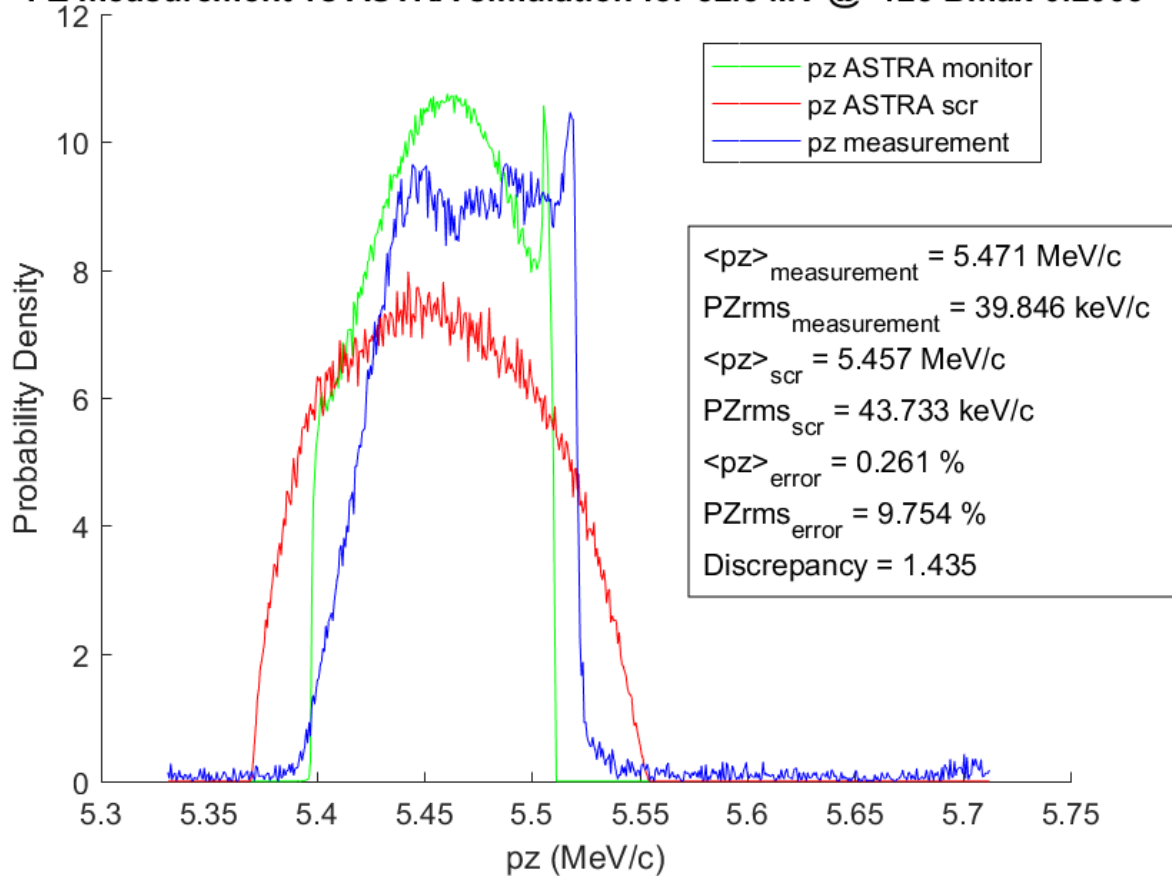
1. Simulated without space charge calculation
2. Simulated with cylindrical space charge calculation
3. Simulated with 3D space charge calculation



# SOLENOID SCAN IN ASTRA

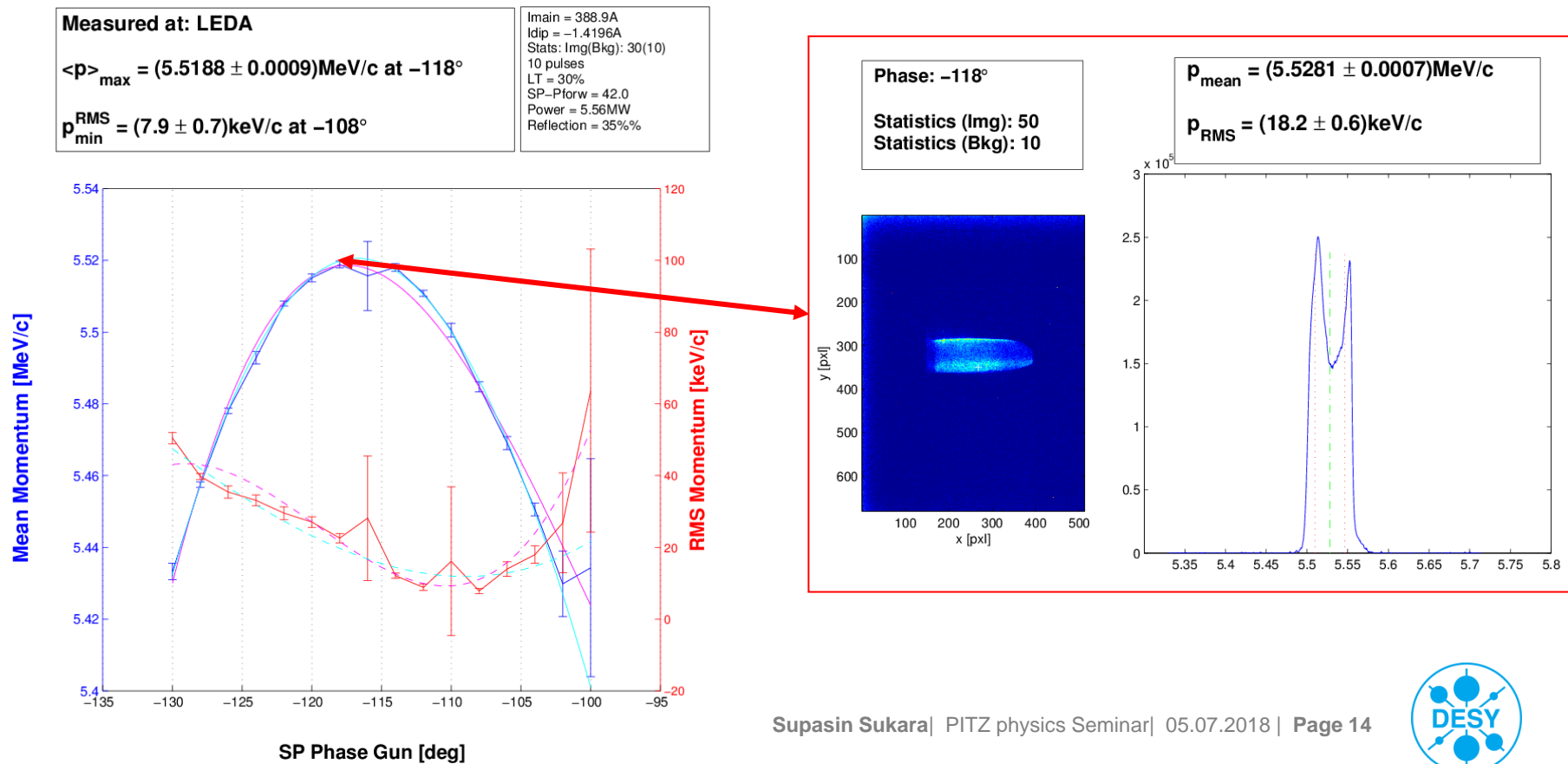
- Vary the solenoid field ( $B_{\max}$ ) for the best focus on the screen

PZ measurement vs ASTRA simulation for 52.5 MV @ -123 Bmax-0.2063



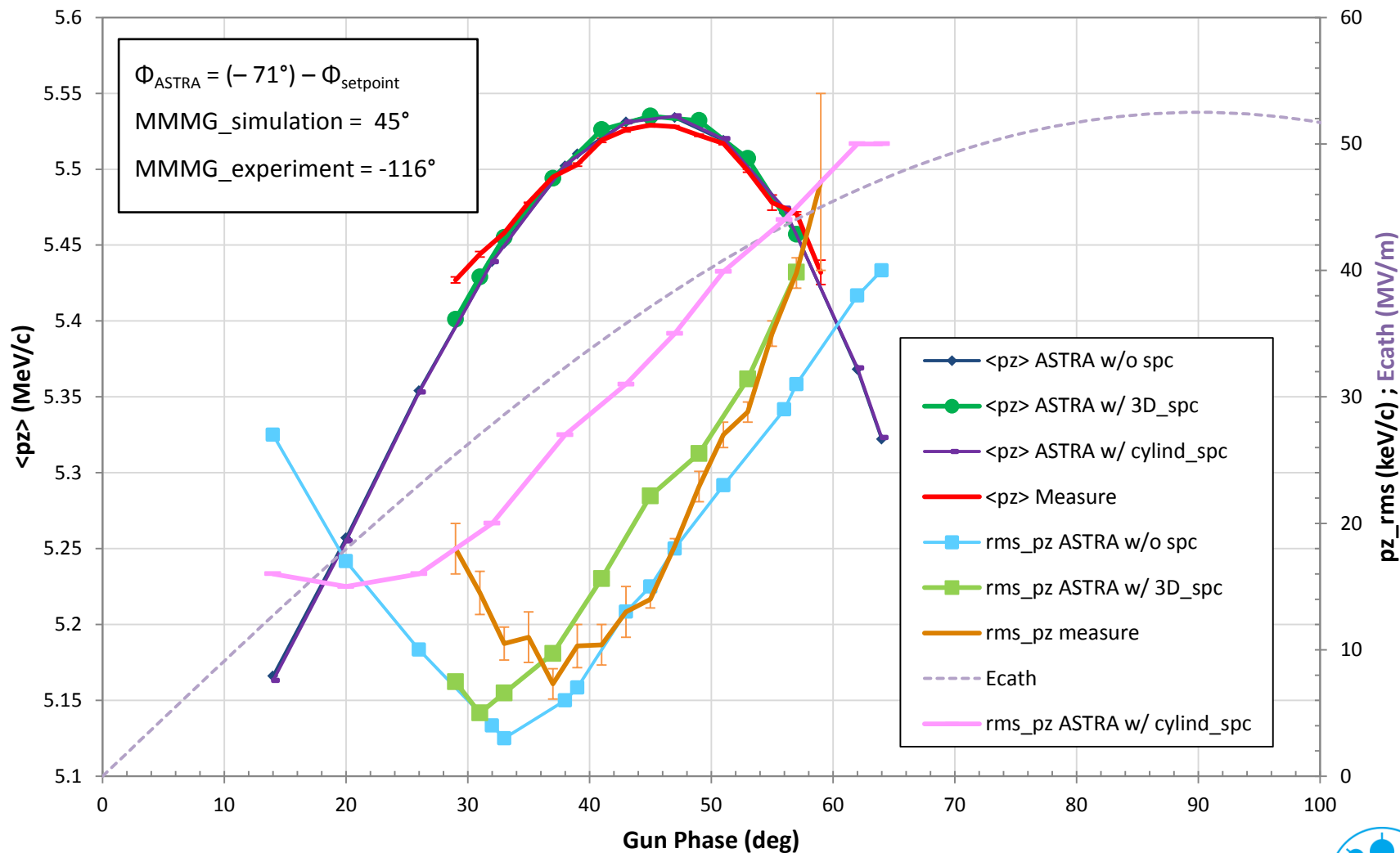
# PROCEDURE

- Measure the mean momentum and rms momentum (energy spread)
- Momentum distribution can be measured from transverse distribution at screen after dipole (DISP.Scr1)



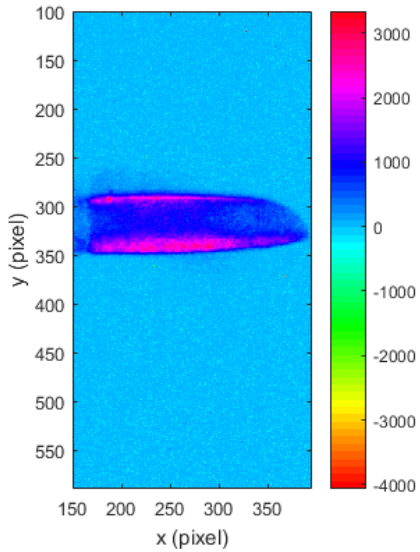
# RESULT

## Momentum measurement at LEDA by experiment for 'Pgun = 5.6 MW' and simulation for 'maxE = -52.5 MV/m'

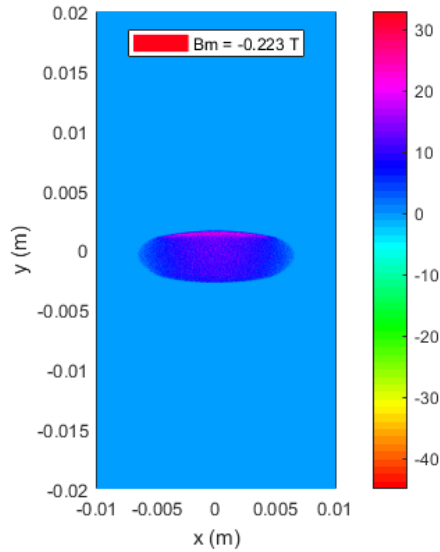


# Beam Profile at DISP.Scr1

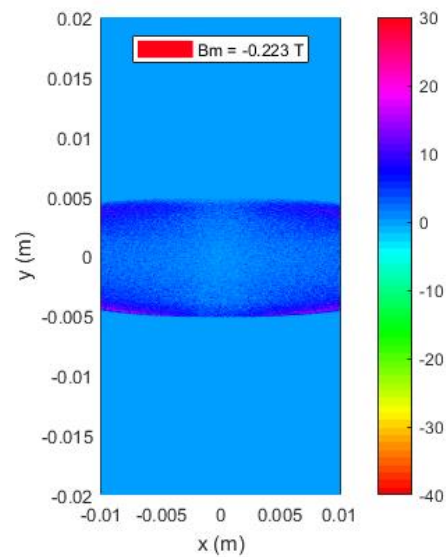
➤ They are on screen with dimension of  $x*y = 20*40$  mm



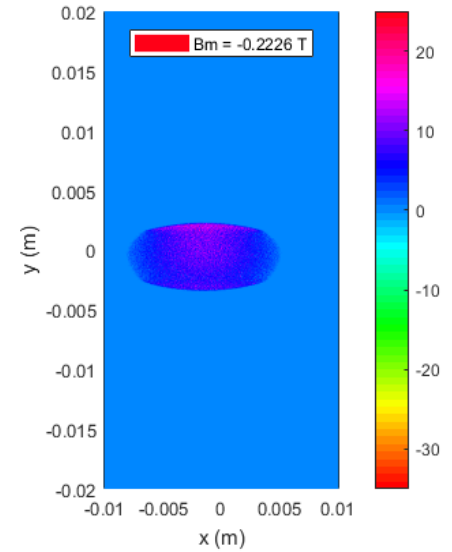
From measurement



w/o space charge calculation



w/ cylindrical space charge calculation

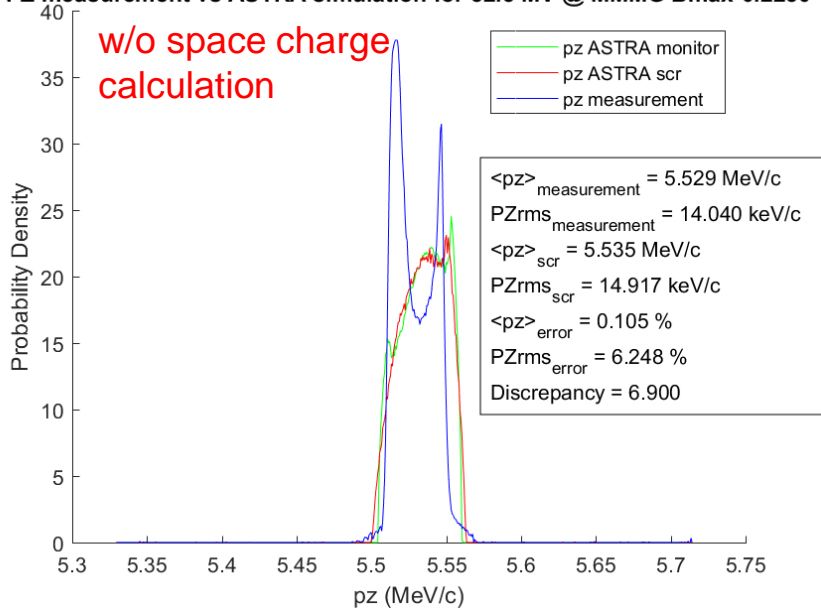


w/ 3D space charge calculation

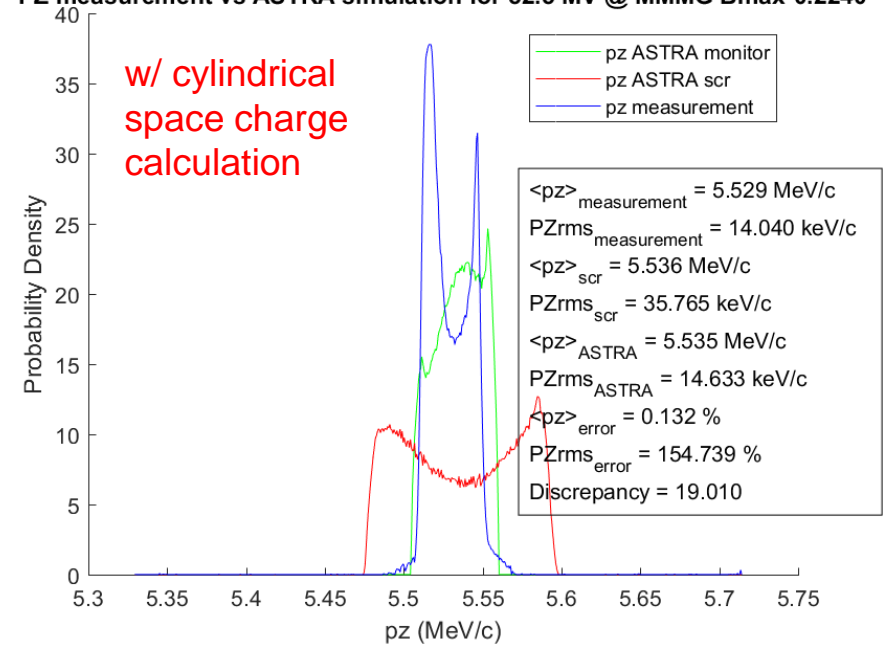


# Comparison of Momentum distribution at MMMG phase

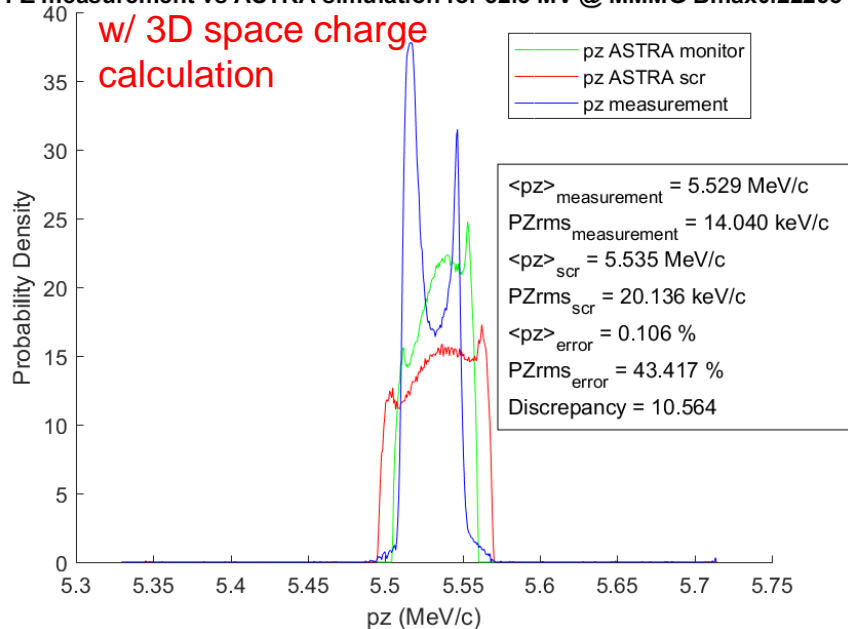
PZ measurement vs ASTRA simulation for 52.5 MV @ MMMG Bmax-0.2250



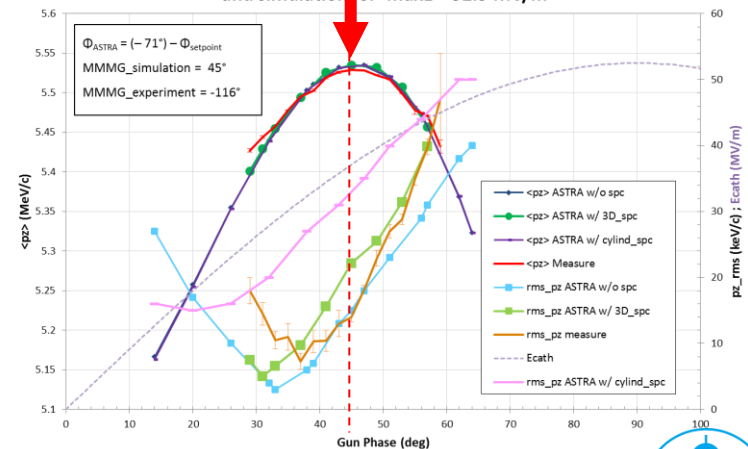
PZ measurement vs ASTRA simulation for 52.5 MV @ MMMG Bmax-0.2240



PZ measurement vs ASTRA simulation for 52.5 MV @ MMMG Bmax0.22263

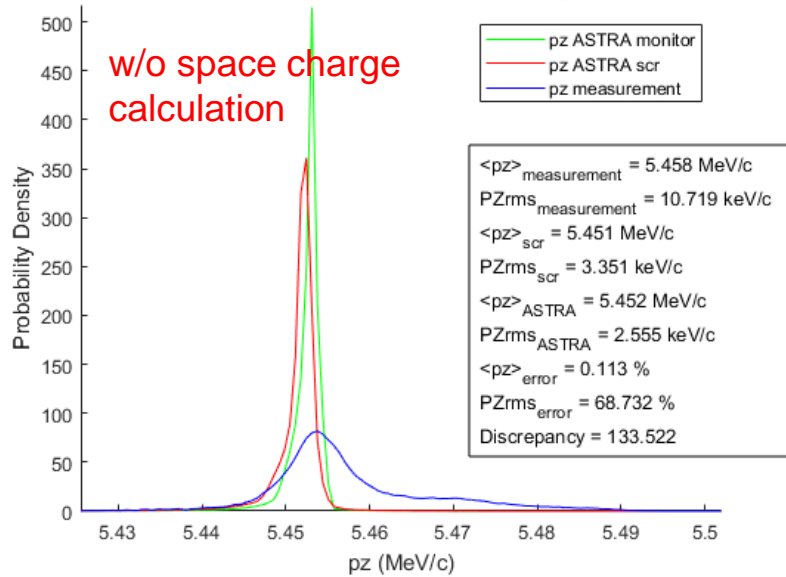


Momentum measurement at LDA by experiment for 'Pgun = 5.6 MW' and simulation for 'maxE = 52.5 MV/m'

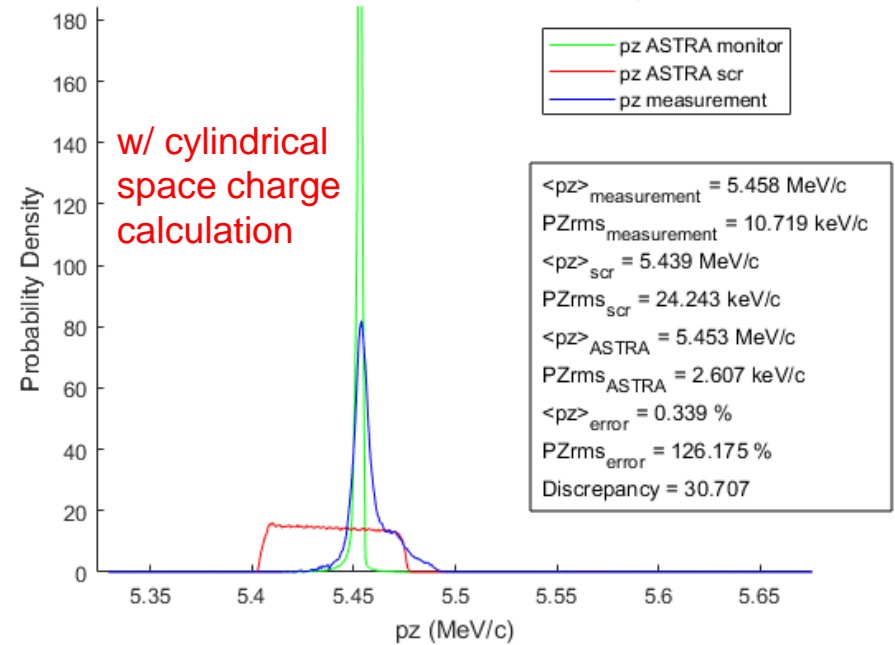


# Comparison of Momentum distribution at off MMMG phase

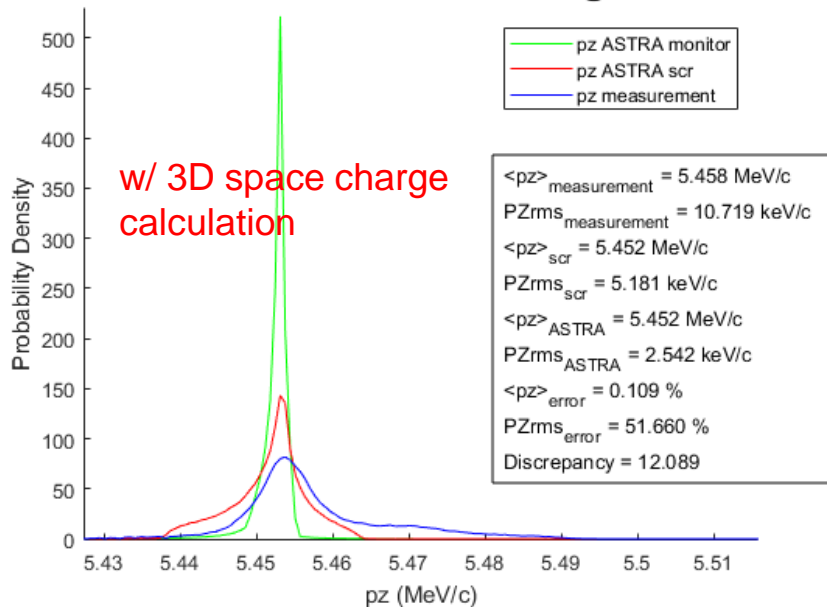
PZ measurement vs ASTRA simulation for 52.5 MV @ P -147 Bmax-0.2210



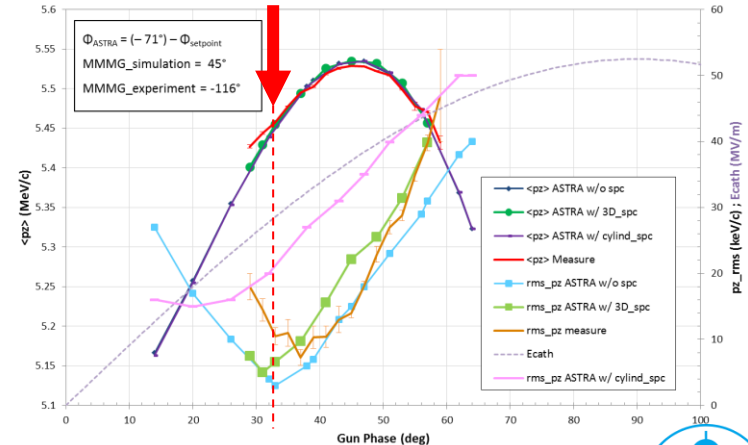
PZ measurement vs ASTRA simulation for 52.5 MV @ P -147 Bmax-0.2190



PZ measurement vs ASTRA simulation for 52.5 MV @ P -147 Bmax-0.2213

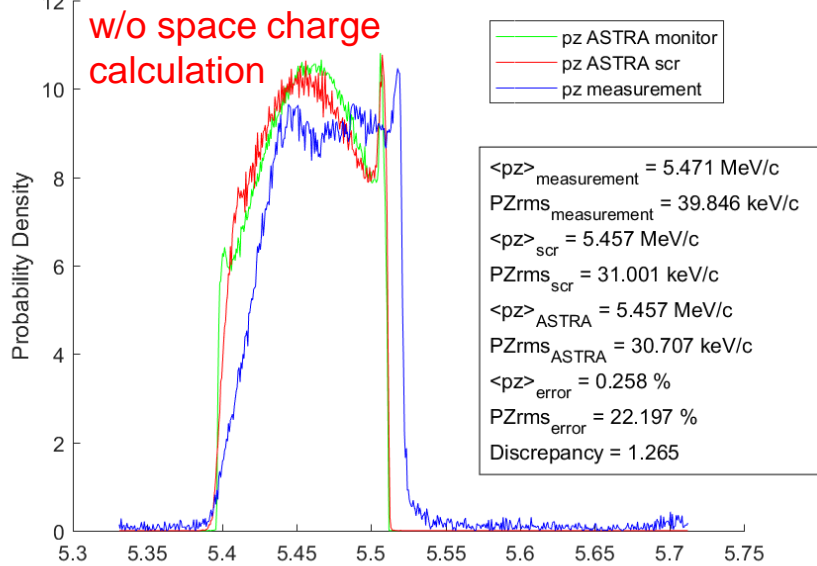


Momentum measurement at LEDA by experiment for 'Pgun = 5.6 MW' and simulation for 'maxE = 52.5 MV/m'

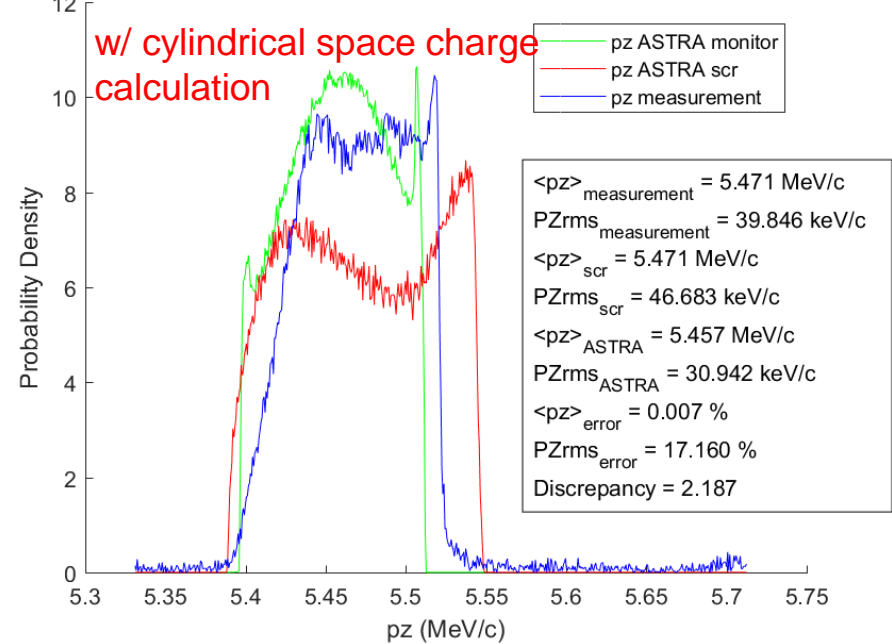


# Comparison of Momentum distribution at off MMMG phase

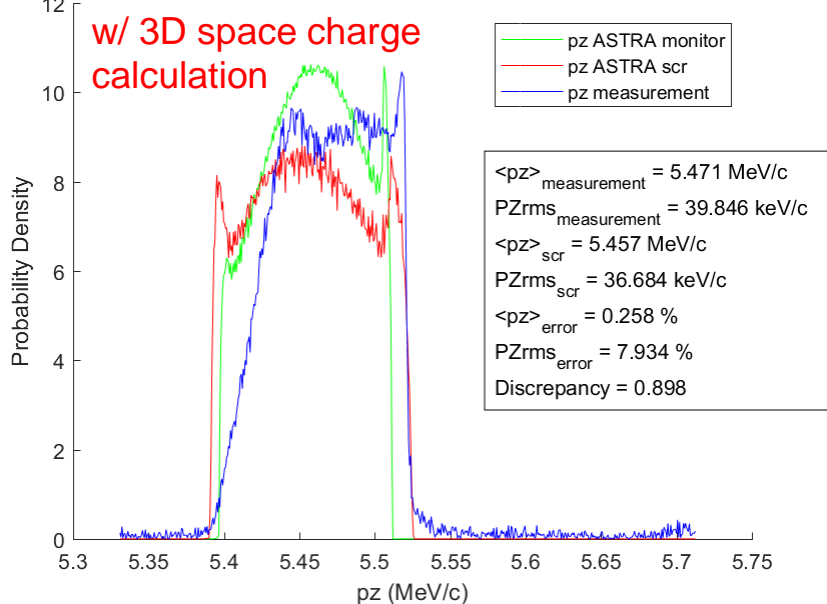
PZ measurement vs ASTRA simulation for 52.5 MV @ -123 Bmax-0.2190



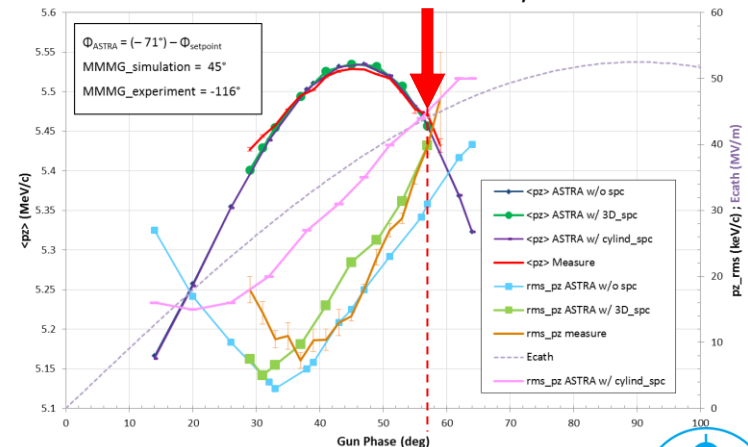
PZ measurement vs ASTRA simulation for 52.5 MV @ -123 Bmax-0.2230



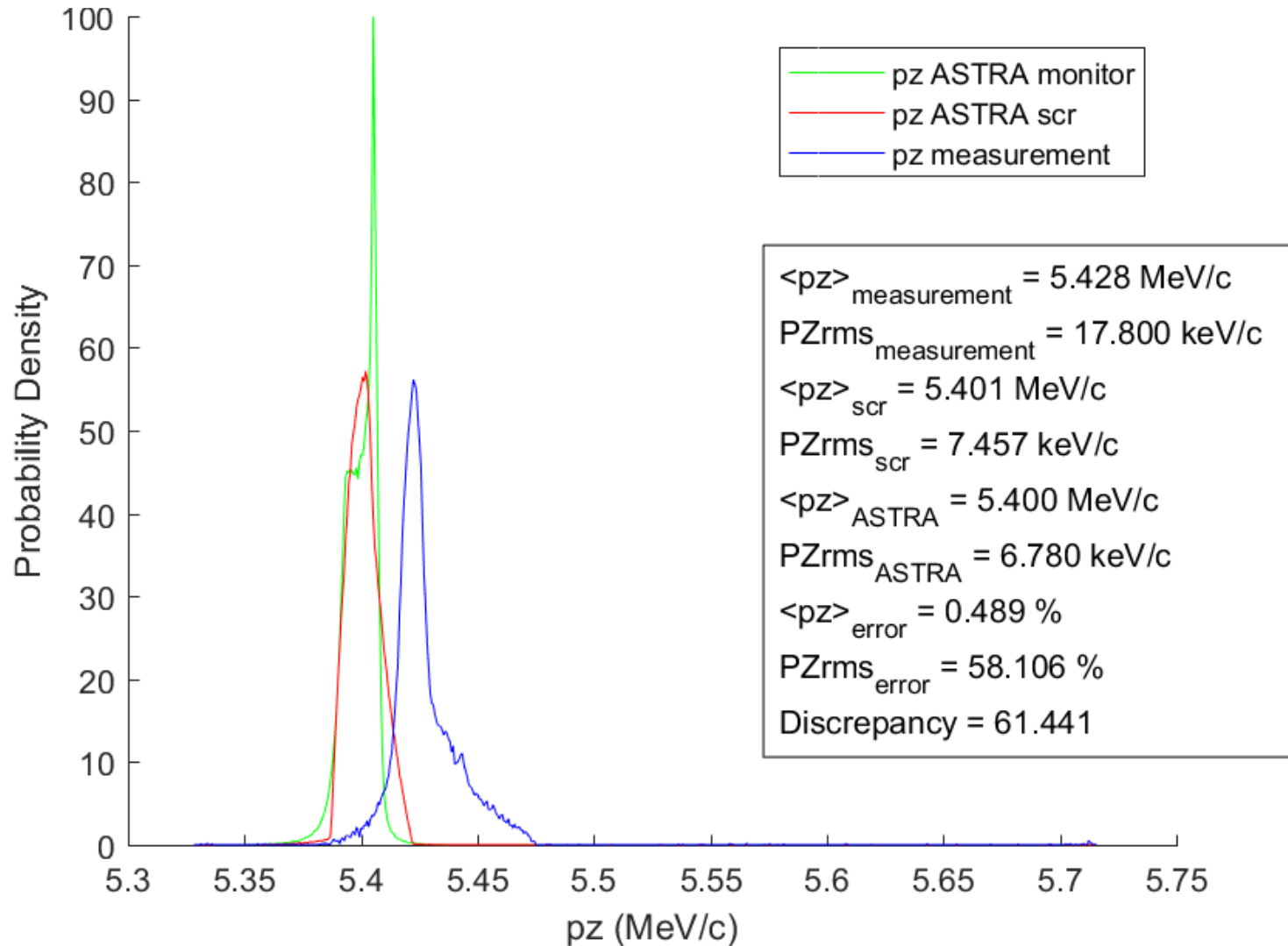
PZ measurement vs ASTRA simulation for 52.5 MV @ -123 Bmax-0.2167



Momentum measurement at LEDA by experiment for 'Pgun = 5.6 MW' and simulation for 'maxE = 52.5 MV/m'



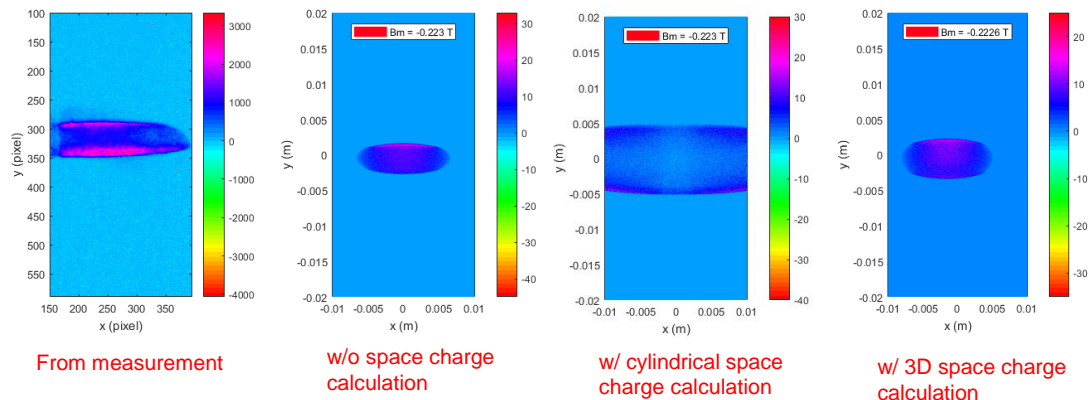
# The pz distribution at each phase from ASTRA with 3D spc



# CONCLUSION

## Conclusions of ASTRA simulation with 3 options

- **Simulation without space charge calculation after Low.scr1** can provide the momentum distribution at LEDA same as the momentum distribution at Low.scr1
- **Cylindrical space charge calculation** is not work for momentum measurement at LEDA. The distributions are too different from experiment.
- **3D space charge calculation** is work but a little bit not accuracy. Some distributions have 2 peaks at same as the distribution from experiment.



**THANK YOU**  
**For Your Attention.**