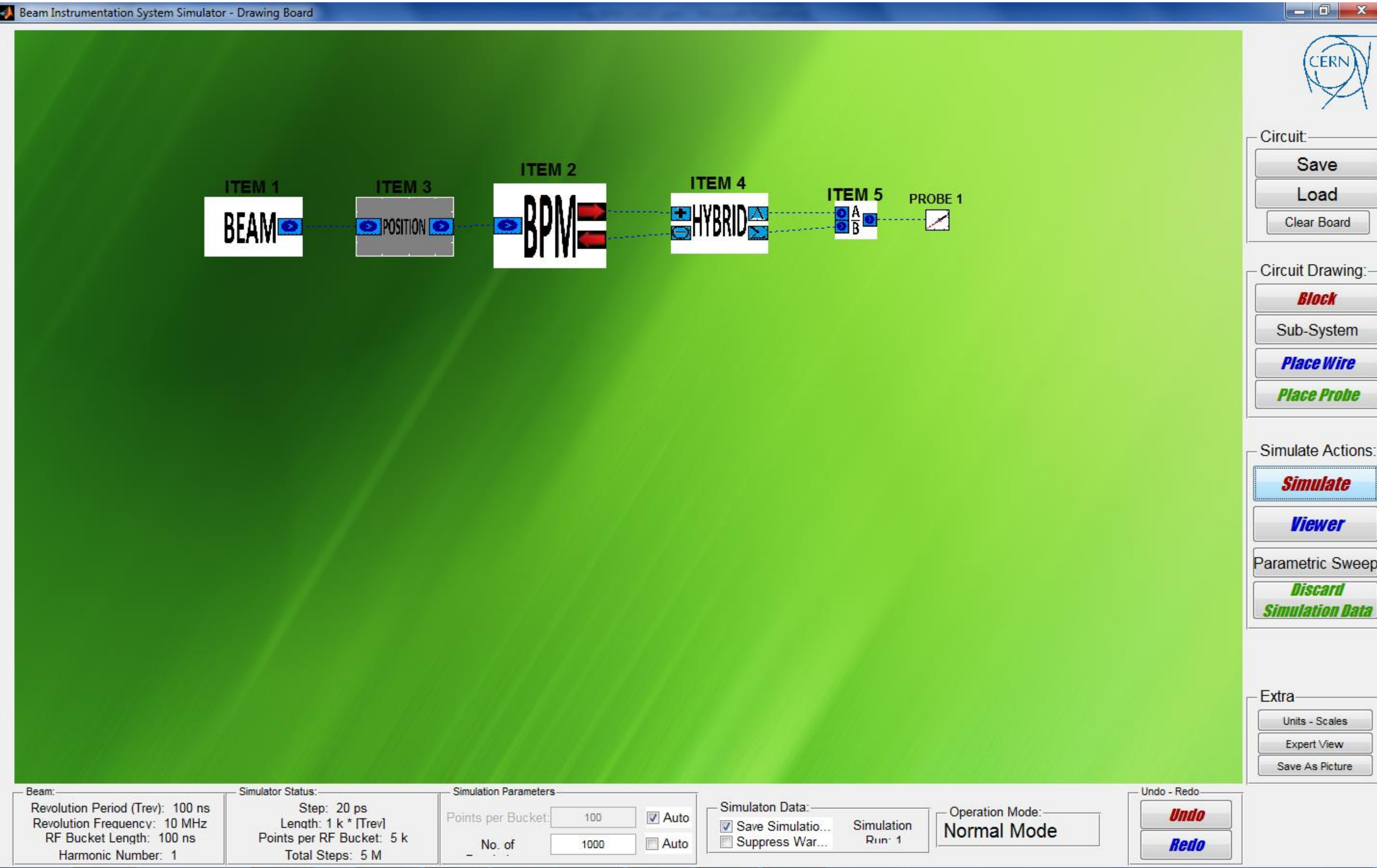
Calibration of Button Type Beam Position Monitors

Yellow: Your Tasks T1 – T4

Simulation

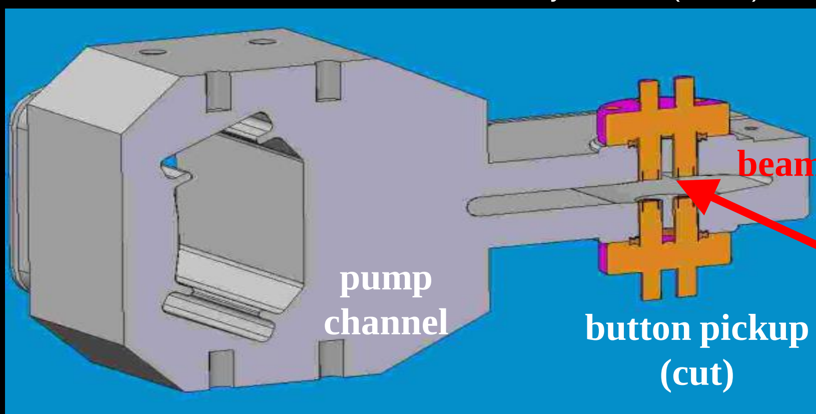

Beam Instrumentation System Simulator - Drawing Board
ITEM 1
BEAM
ITEM 3
POSITION
ITEM 2
BPM
ITEM 4
HYBRID
ITEM 5
A
B
PROBE 1
CERN
Circuit:
Save
Load
Clear Board
Circuit Drawing:
Block
Sub-System
Place Wire
Place Probe
Simulate Actions:
Simulate
Viewer
Parametric Sweep
Discard Simulation Data
Extra
Units - Scales
Expert View
Save As Picture
Beam:
Revolution Period (Trev): 100 ns
Revolution Frequency: 10 MHz
RF Bucket Length: 100 ns
Harmonic Number: 1
Simulator Status:
Step: 20 ps
Length: 1 k * [Trev]
Points per RF Bucket: 5 k
Total Steps: 5 M
Simulation Parameters
Points per Bucket: 100
Auto
No. of
1000
Auto
Simulaton Data:
Save Simulatio...
Suppress War...
Simulation
Operation Mode:
Normal Mode
Undo - Redo
Undo
Redo

Electrostatic Pick-up – Button

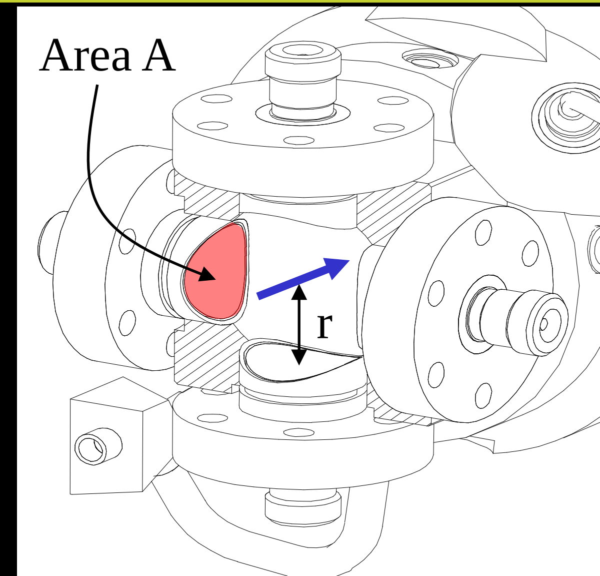
Non-linear

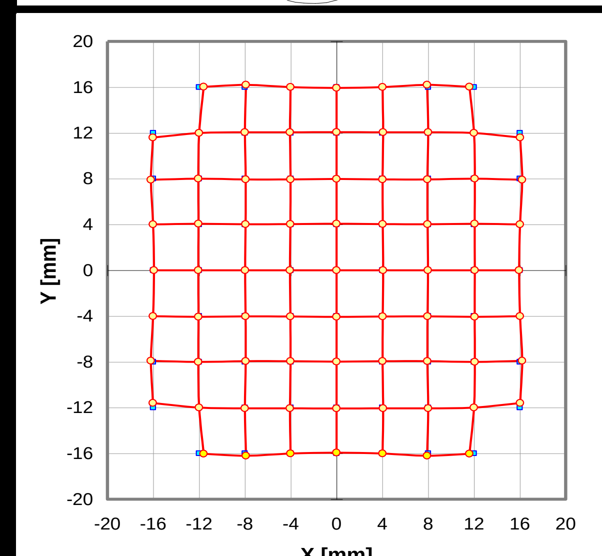
- requires correction algorithm when beam is off-centre
- vacuum chamber not rotational symmetric (SR-source)

courtesy: A.Delfs (DESY)

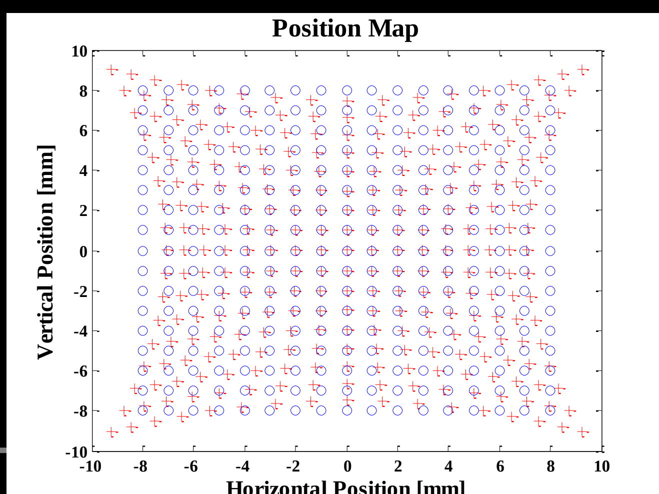


PETRA-III BPM close to ID

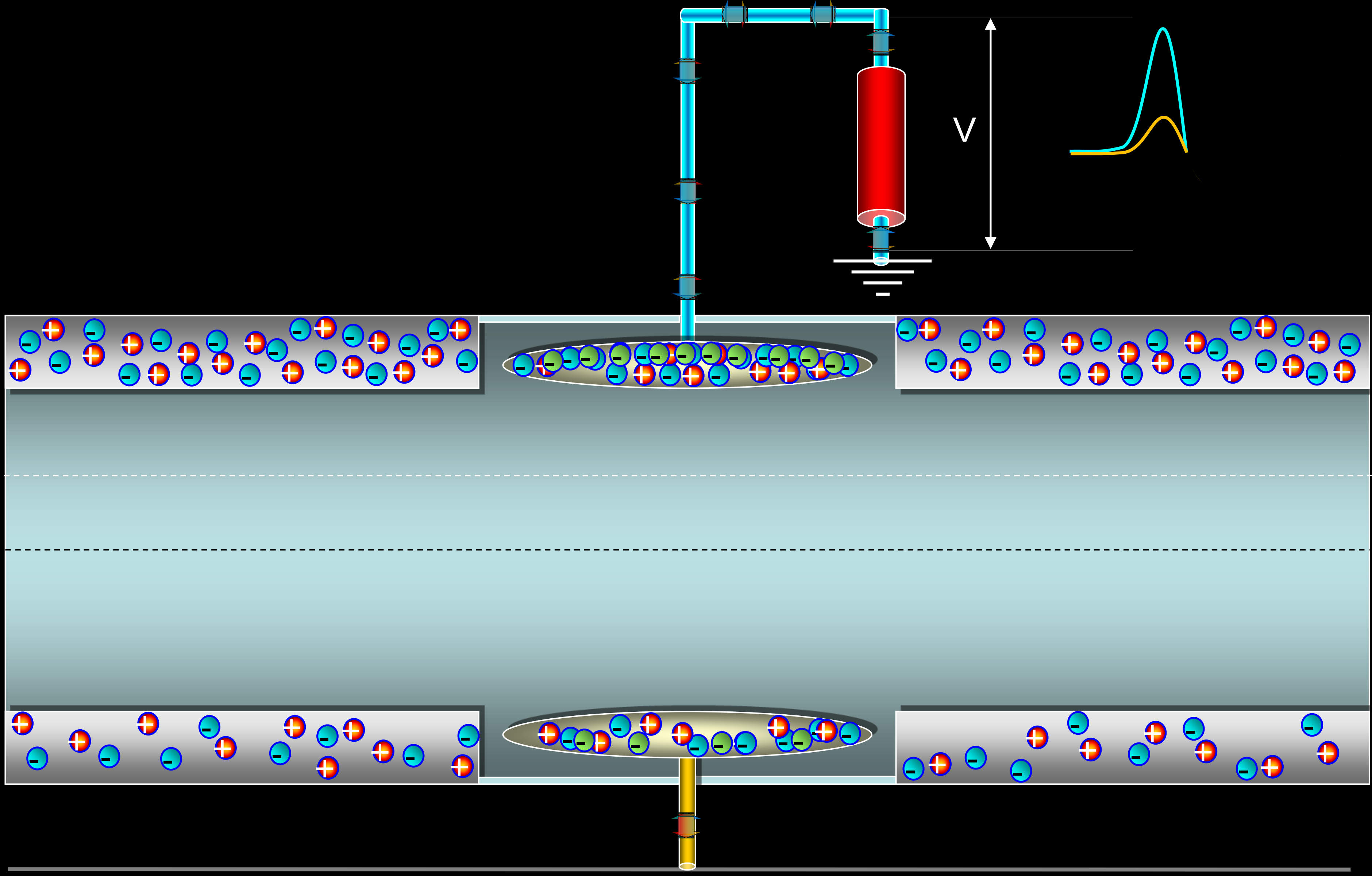


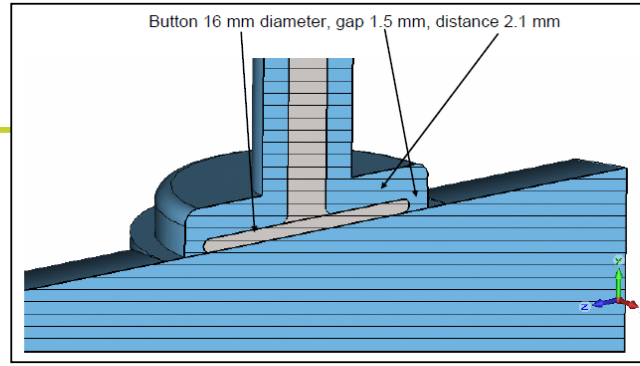


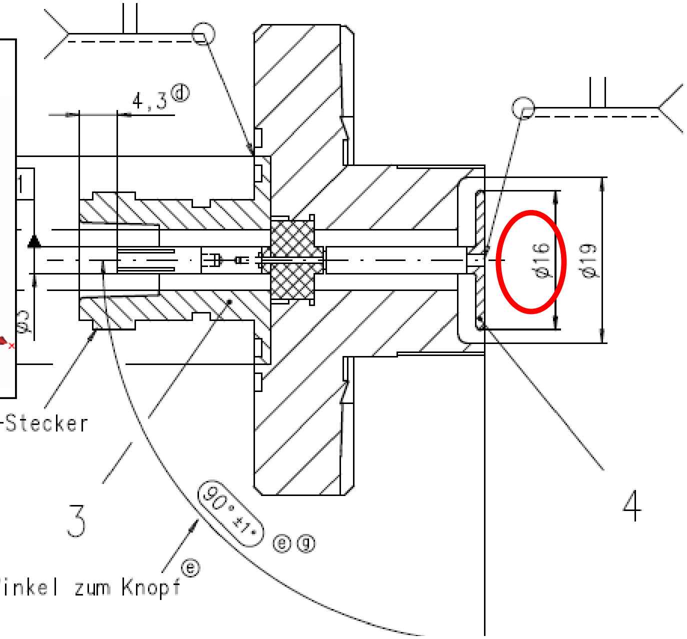
$$X = 2.30\cdot10^{-5}X_1^{5} + 3.70\cdot10^{-5}X_1^{3} + 1.035X_1 + 7.53\cdot10^{-6}X_1^{3}Y_1^{2} + 1.53\cdot10^{-5}X_1Y_1^{4}$$

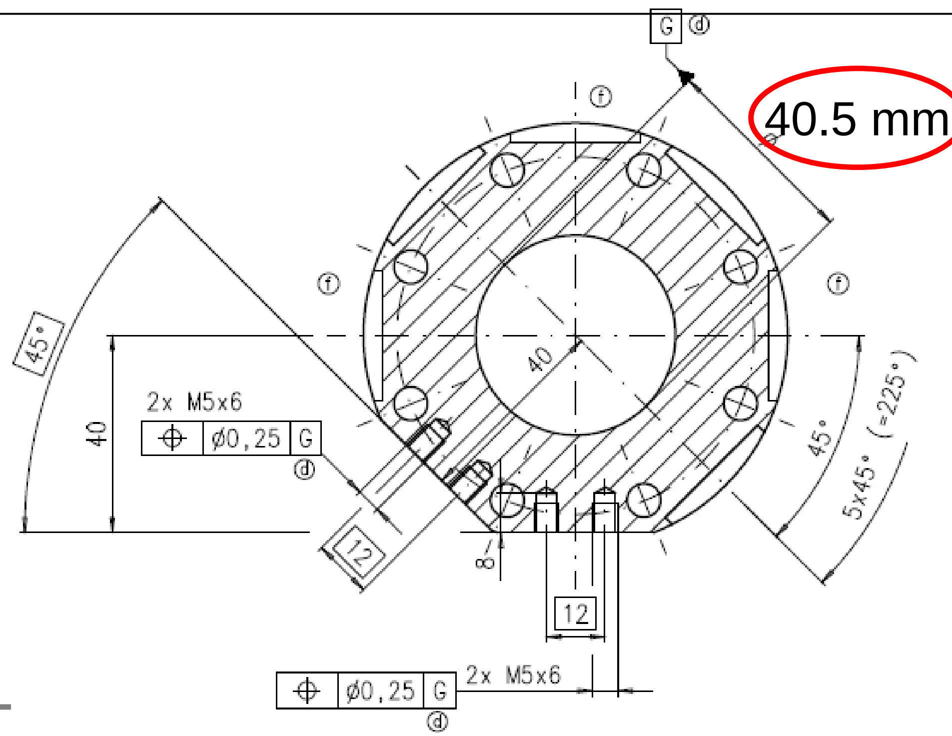


Electrostatic Beam Position Monitor




Button 16 mm diameter, gap 1.5 mm, distance 2.1 mm

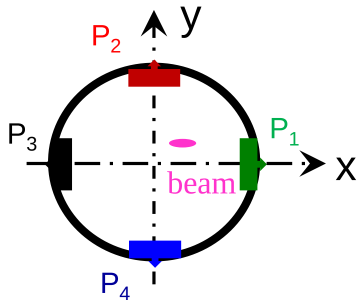

4,3
ø16
ø19
N-Stecker
3
4
90° ±1°
Winkel zum Knopf


G
40.5 mm
45°
40
2x M5x6
ø0,25 G
12
8
45°
5x45° (=225°)
12
2x M5x6
ø0,25 G

Position Reconstruction

- **Two common monitor geometries**
  - difference in position reconstruction

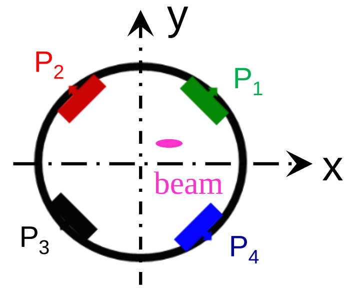
linac-type



$$x = K_x \frac{P_1 - P_3}{P_1 + P_3}$$

$$y = K_y \frac{P_2 - P_4}{P_2 + P_4}$$

storage ring-type



$$x = K_x \frac{(P_1+P_4) - (P_2+P_3)}{P_1+P_2+P_3+P_4}$$

$$y = K_y \frac{(P_1+P_2) - (P_3+P_4)}{P_1+P_2+P_3+P_4}$$

$\Rightarrow$ difference-over-sum or $Position = K \cdot \frac{\Delta}{\Sigma}$

Beampipe: round: r = 20.25 mm
Button Diameter: d = 16.0 mm

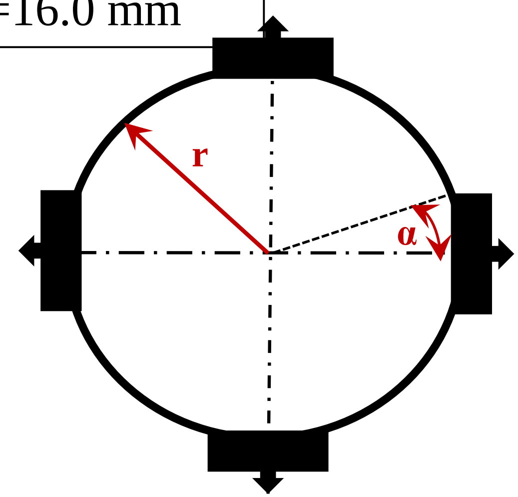
- **Position Information**
  - **requires knowledge of monitor constant K_x, K_y**
    - $\rightarrow$ rule of thumb (circular duct)

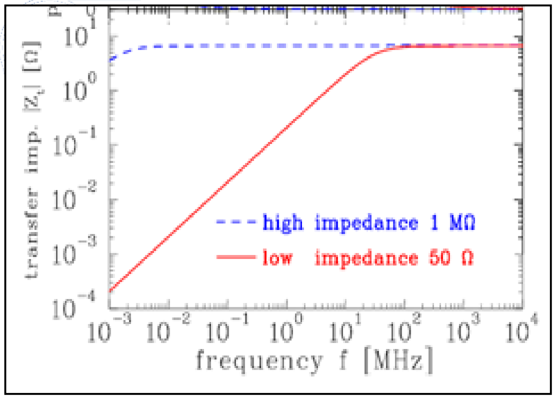
Linac-type	$K_{x,y} = \frac{r}{2} \frac{\alpha}{\sin\alpha}$

storage ring-type $K_{x,y} = \frac{r}{\sqrt{2}} \frac{\alpha}{\sin\alpha}$

T1) Calculate K_x, for Linac type

sin(α) ≈
α/sinα ≈
K_x ≈

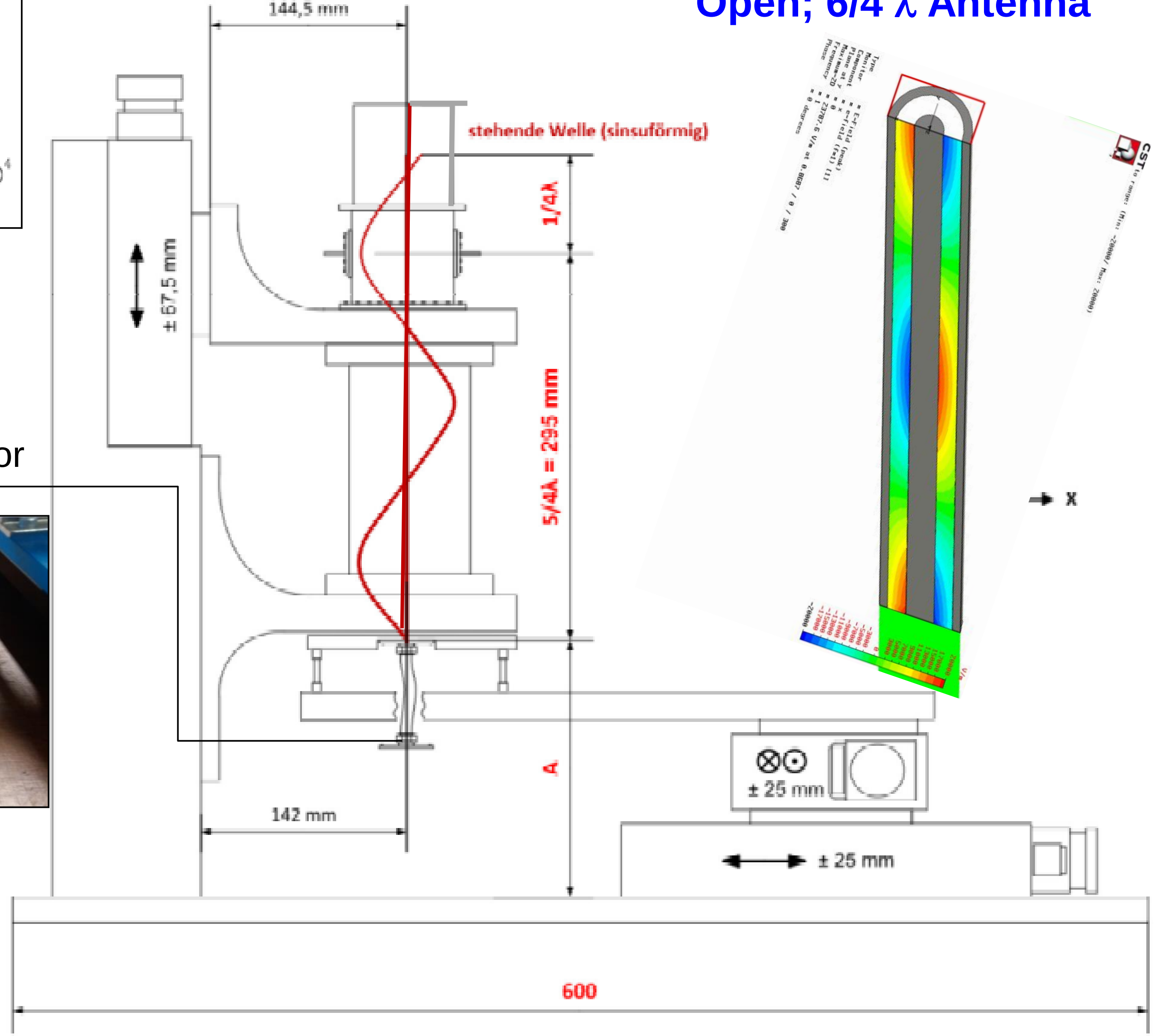


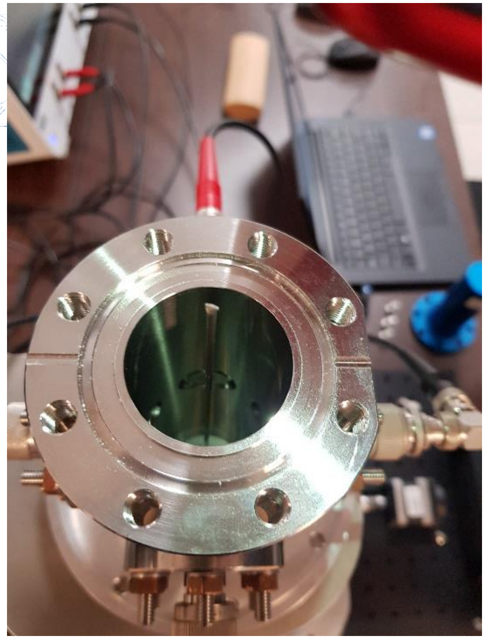


standing wave

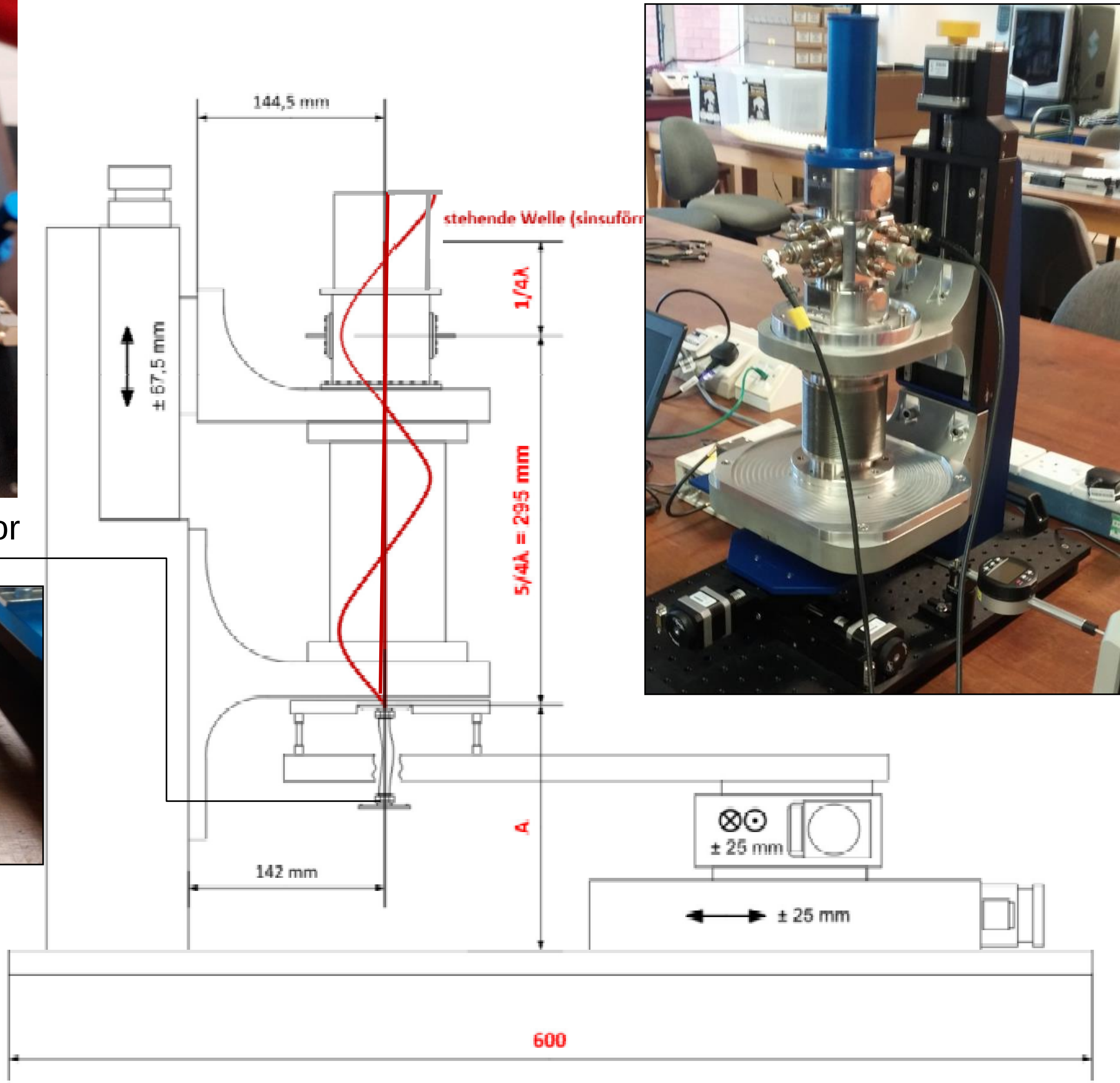
Open; 6/4 λ Antenna

1.3 GHz sine wave generator





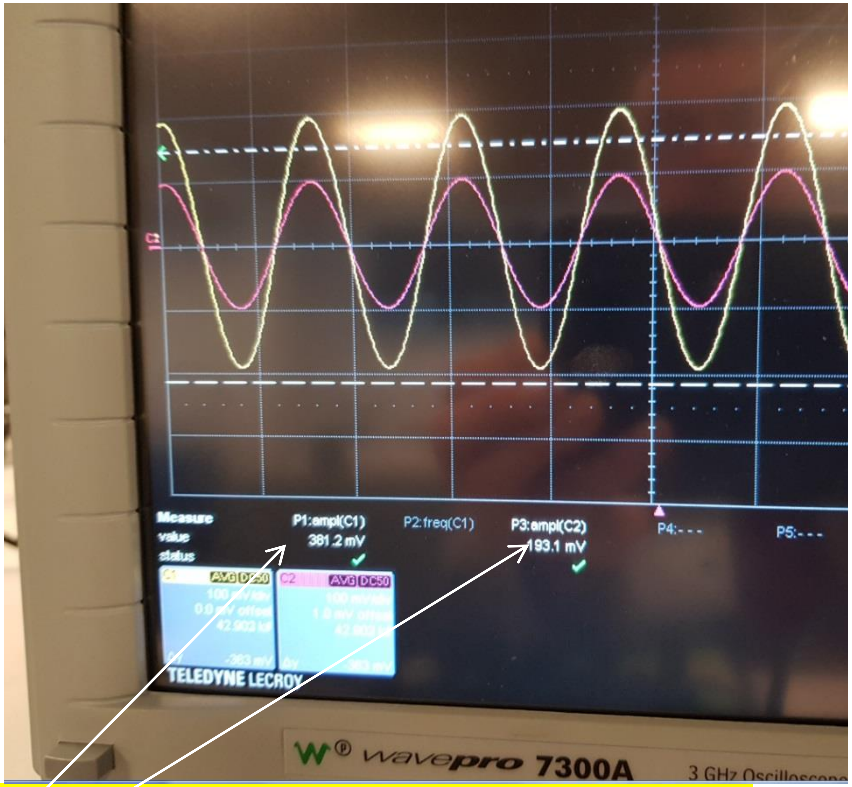
1.3 GHz sine wave generator



Tasks: BPMs

Signal generation by button BPM

- calculate monitor constants for BPMs
  - use rule-of-thumb formulae



- measure XFEL BPM monitor constants
  - T2) define electrical center of both planes and calibrate movers
  - T3) perform 1-dim. scan along one axis → max. wire position: ± 15 mm (!!!)

→ 3a) measure signal amplitudes from each button (x-plane only)
→ 3b) calculate Δ/Σ from measured signals
→ 3c) plot Δ/Σ versus wire position

- T4) determine monitor constant from slope at origin and compare with rule-of-thumb

Monitor Constant Calculation

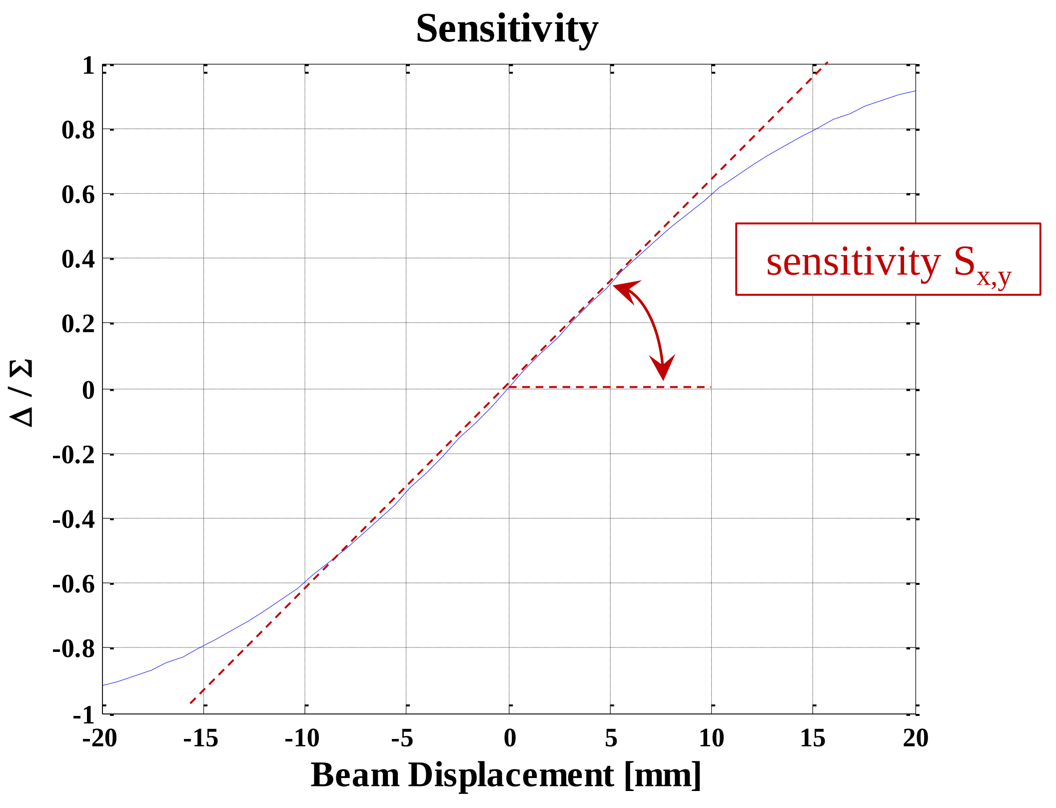
$x = K_x \frac{P_1 - P_3}{P_1 + P_3}$ $= K_x * \Delta/\Sigma \Rightarrow \Delta/\Sigma = 1/K_x * x$

- sensitivity: slope at origin

Please stay in the middle of Chamber!!!!-

Maximum ± 15 mm

(more might damage the antenna)



- monitor constant: $K_{x,y} = S_{x,y}^{-1}$