Beam Instrumentation
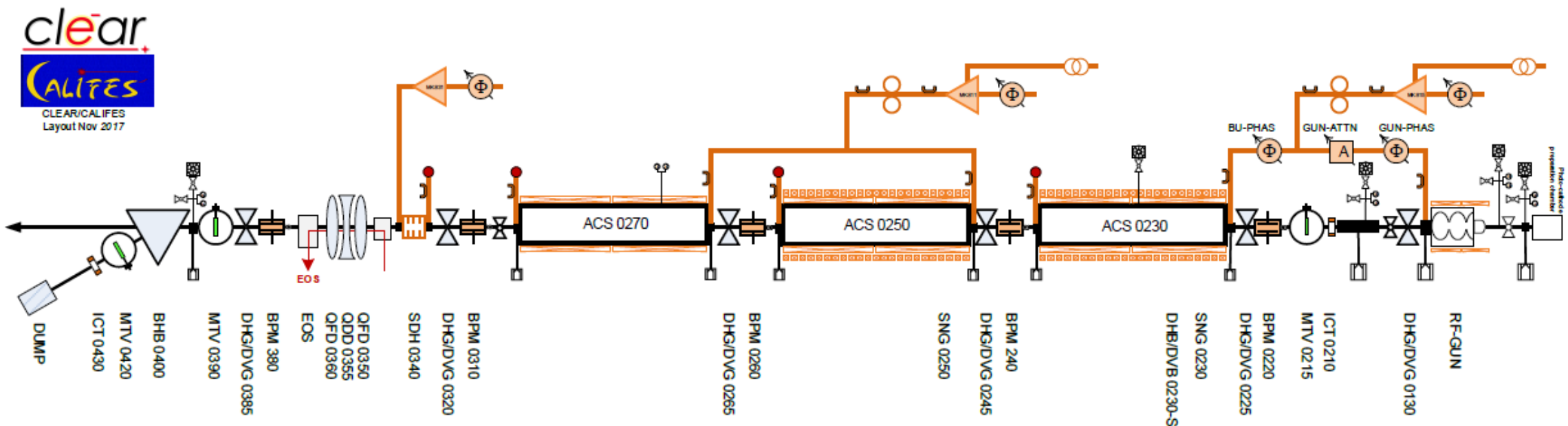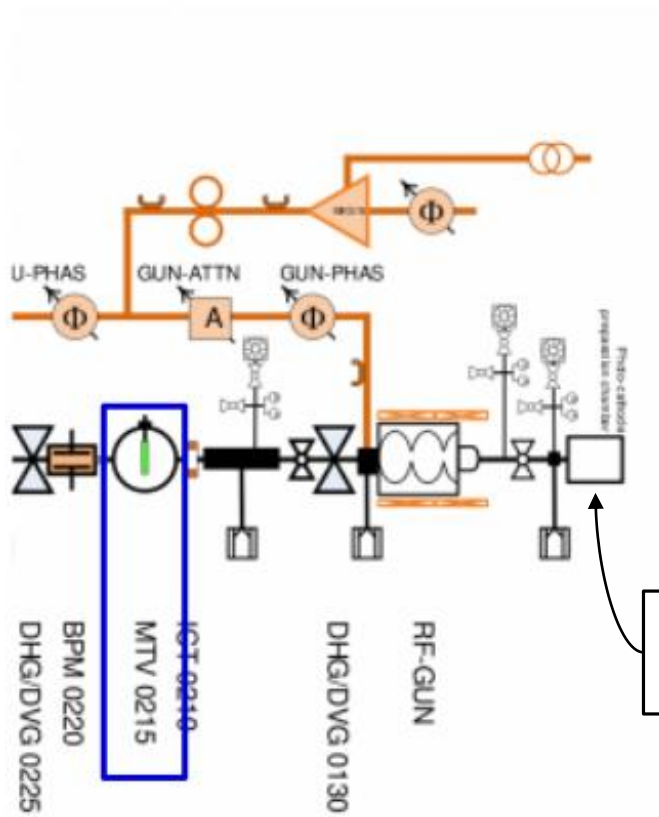
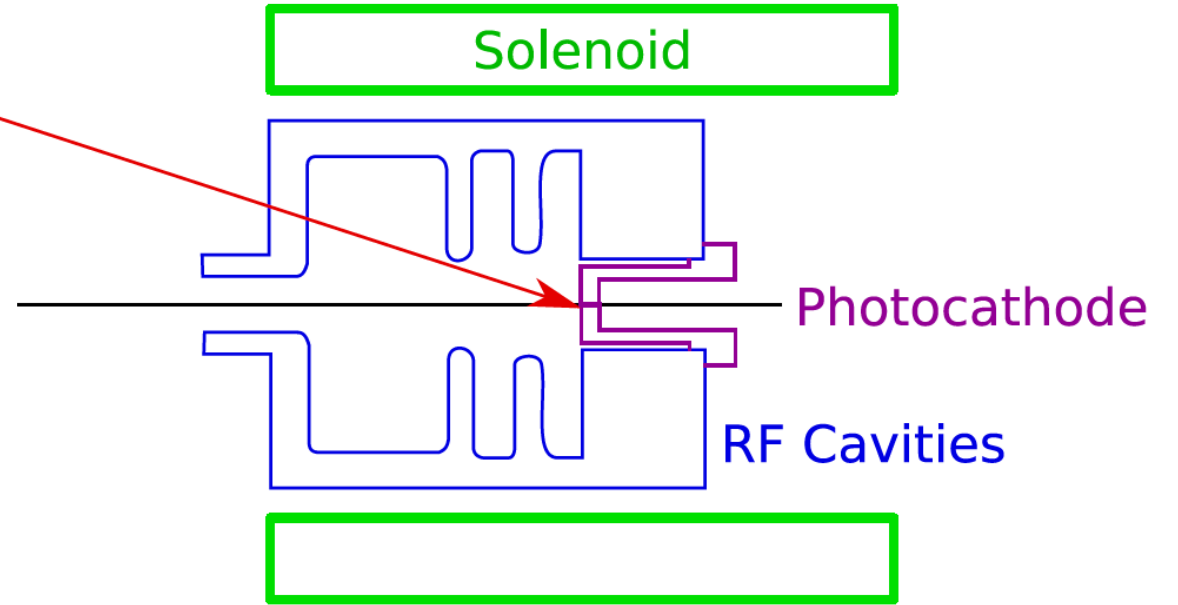PRESENTATION 2
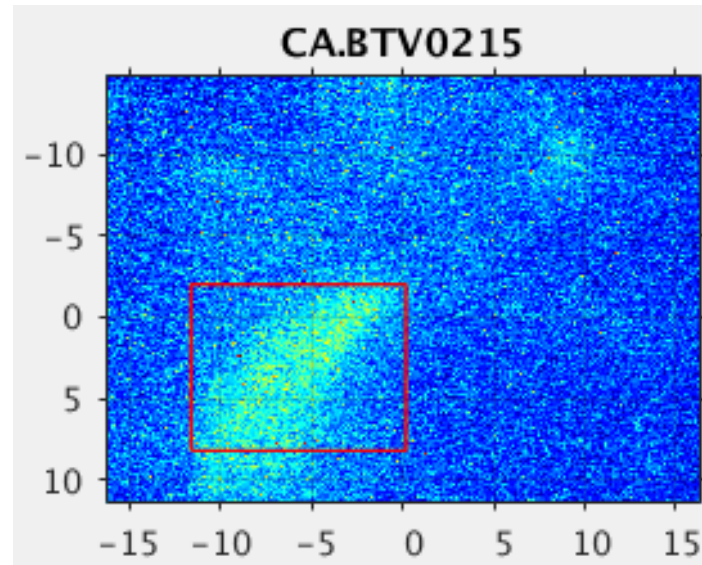
PANDOLFI MATTEO, PASTUSHENKO ANDRII, HURIER SOPHIE

Introduction

RF gun source
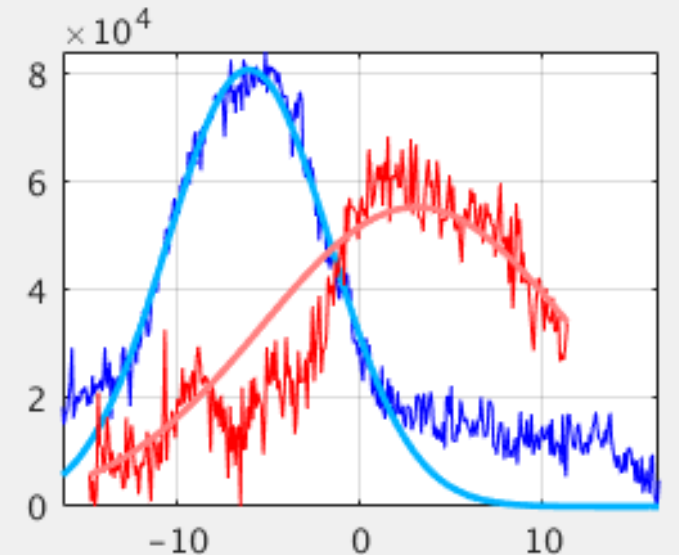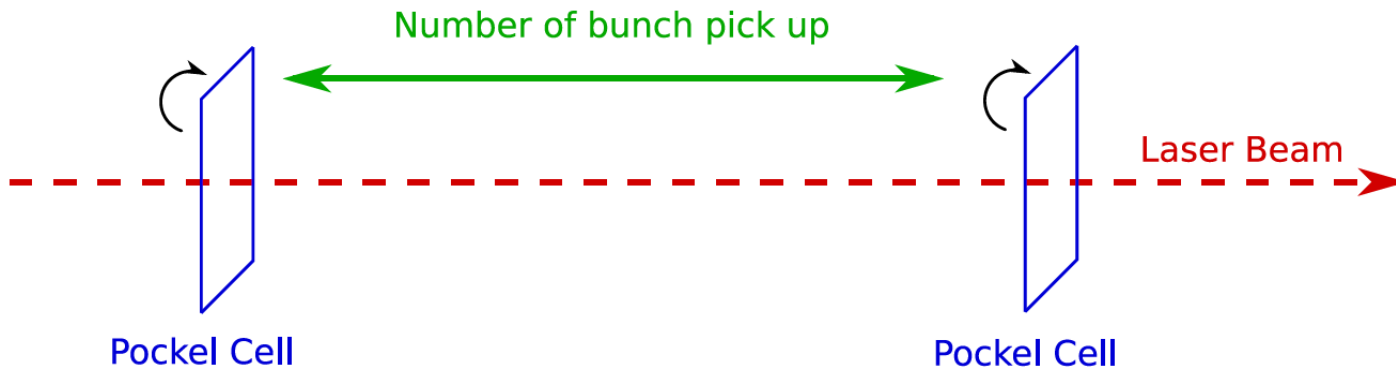

Pulsed Laser

UV LASER on Cs2Te photocatode

Solenoid

Photocathode

RF Cavities

U-PHAS   GUN-ATTN   GUN-PHAS

DHG/DVG 0225
BPM 0220
MTV 0215
ICT 0210
DHG/DVG 0130
RF-GUN

Dark current measurement

Laser OFF
Dark Current

Scintillator: YAG Screen

Leakage of the bunch picker

Number of bunch pick up

Laser Beam

Pockel Cell

Pockel Cell

Laser ON
Dark Current + Leakage

SATURATED .BTV0215

One laser bunch

Number of bunch pick up

Laser Beam

Pockel Cell

Pockel Cell
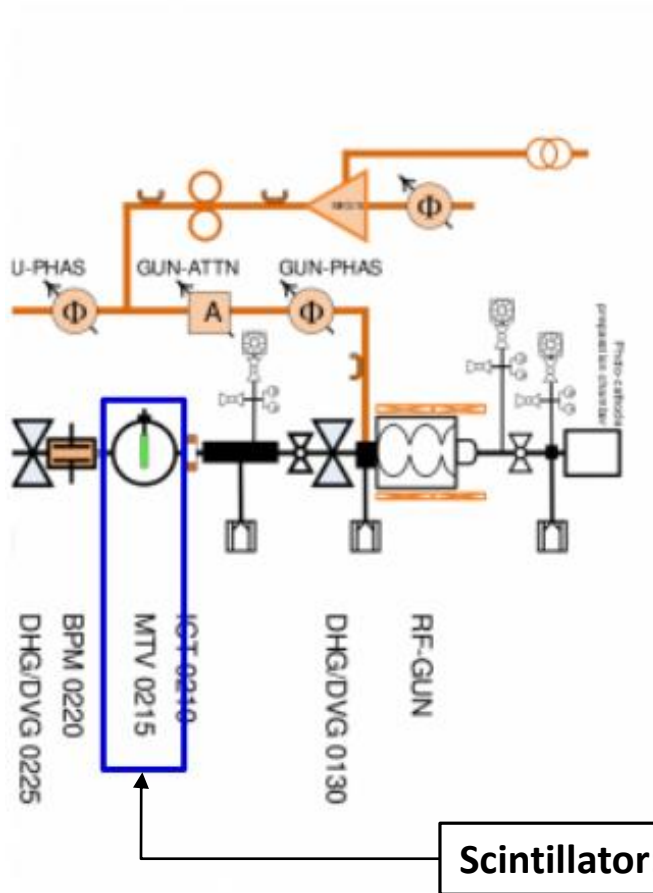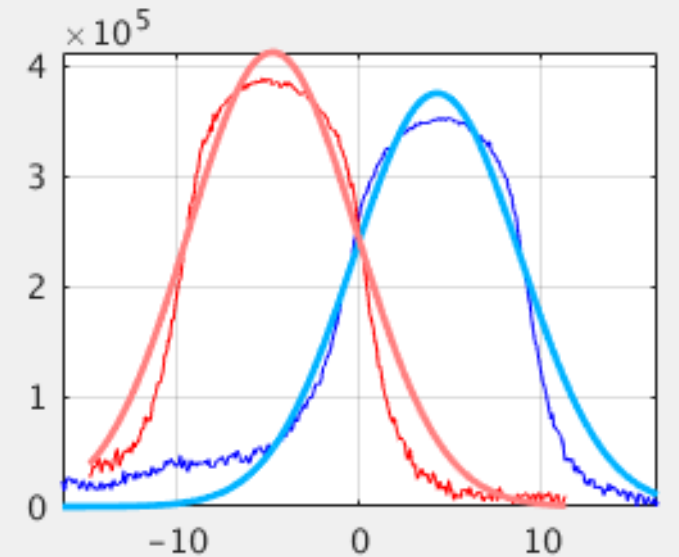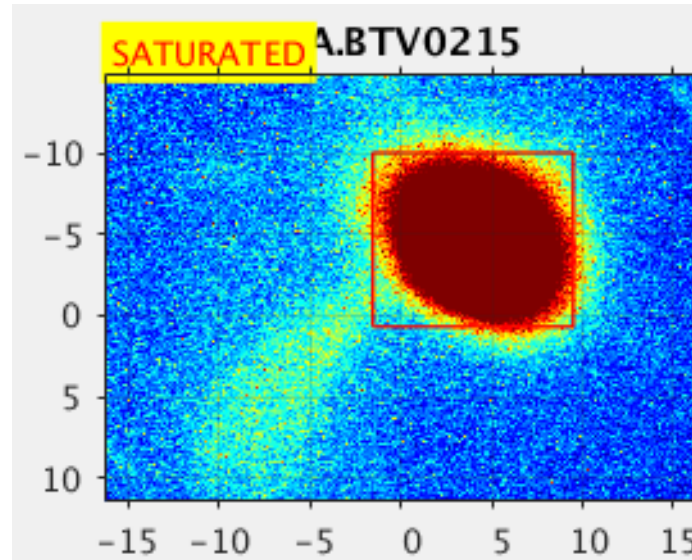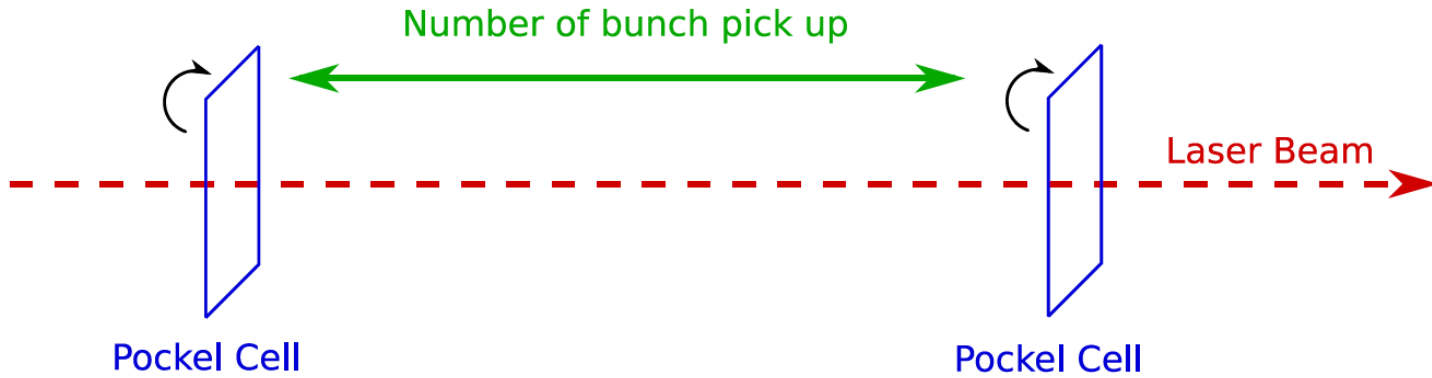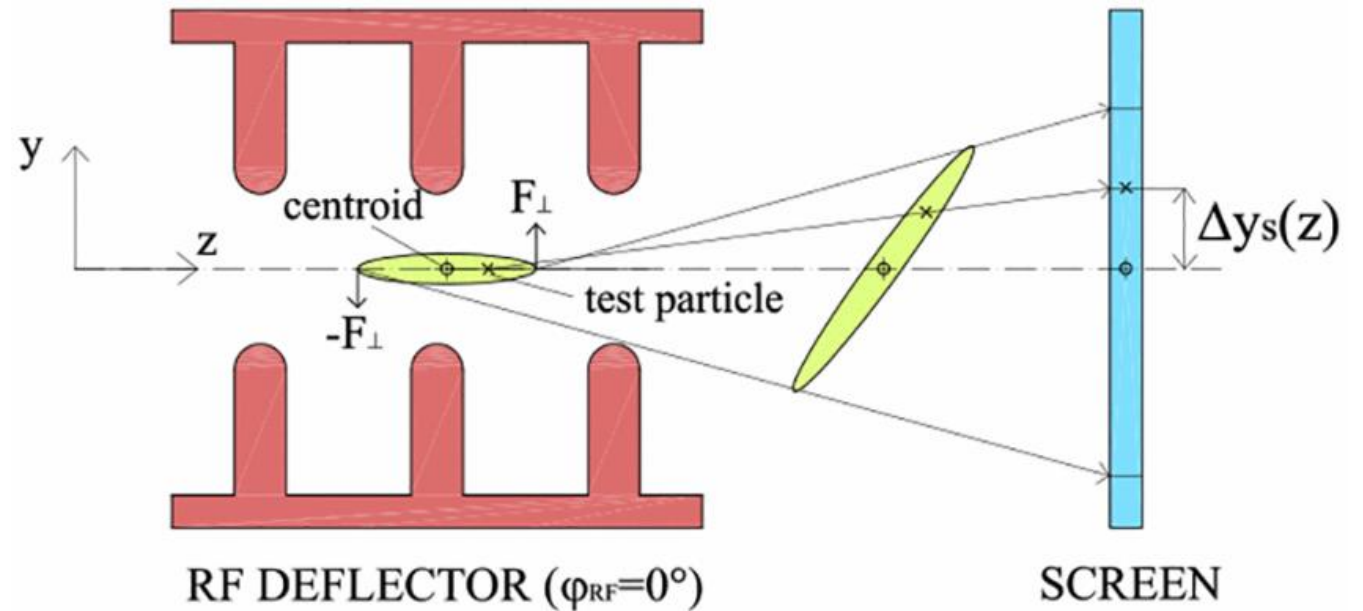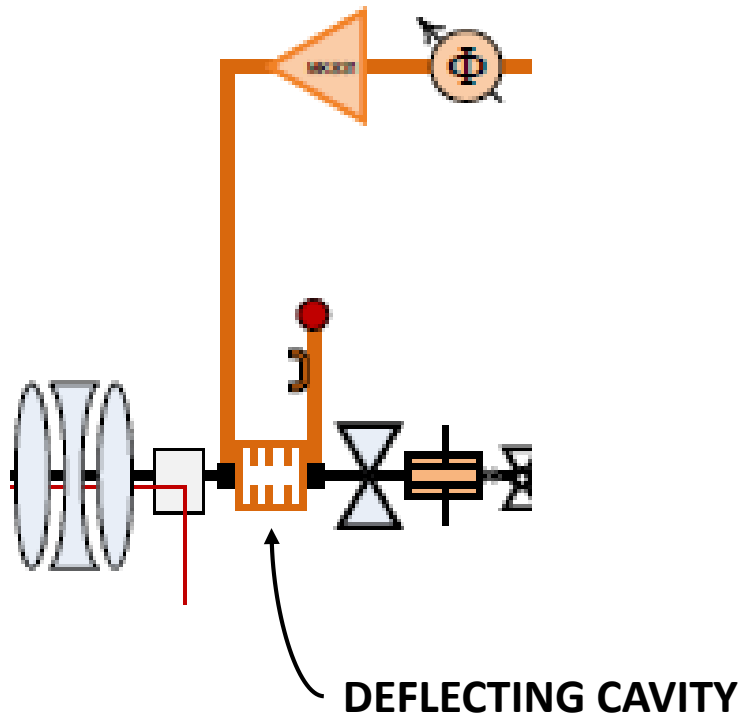
Laser ON
Dark Current + Leakage + One Bunch
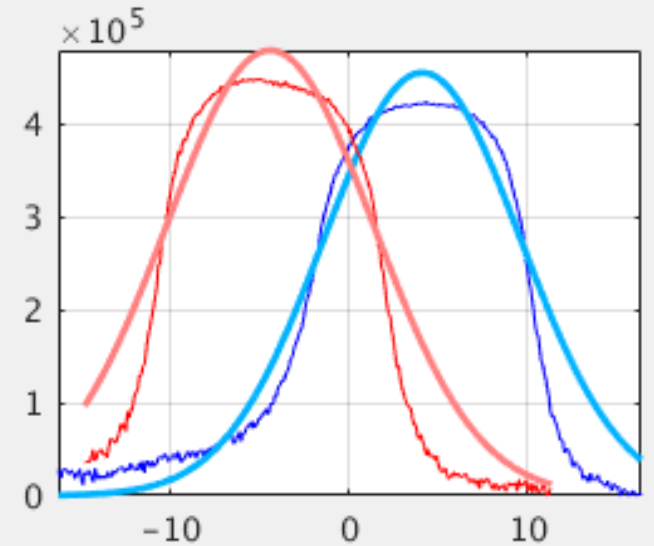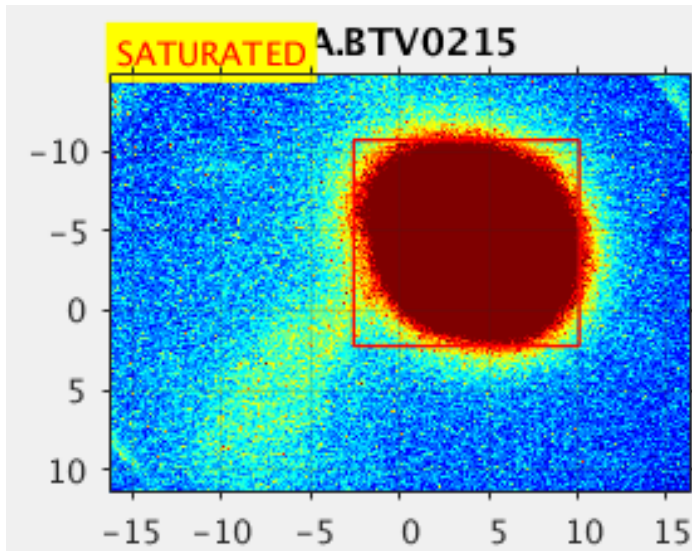
Deflecting Cavity

Normal conducting RF cavity operating in S band (3 GHz, 333 ps)

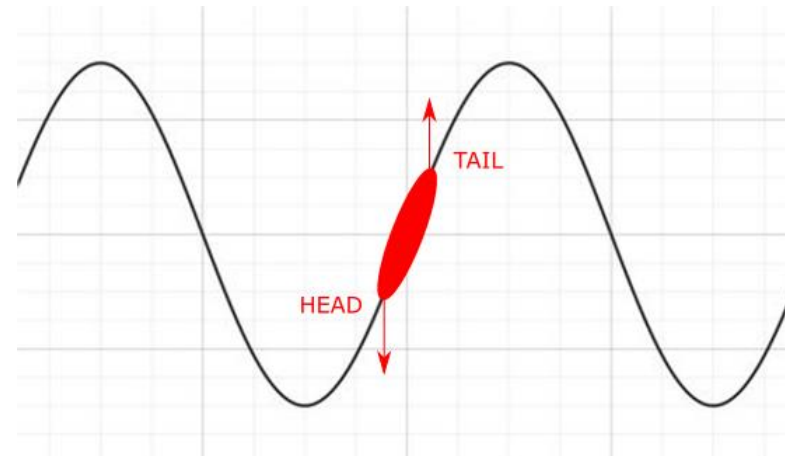Used for Bunch length measurement

DEFLECTING CAVITY

RF DEFLECTOR ($\varphi_{RF}=0°$)   SCREEN
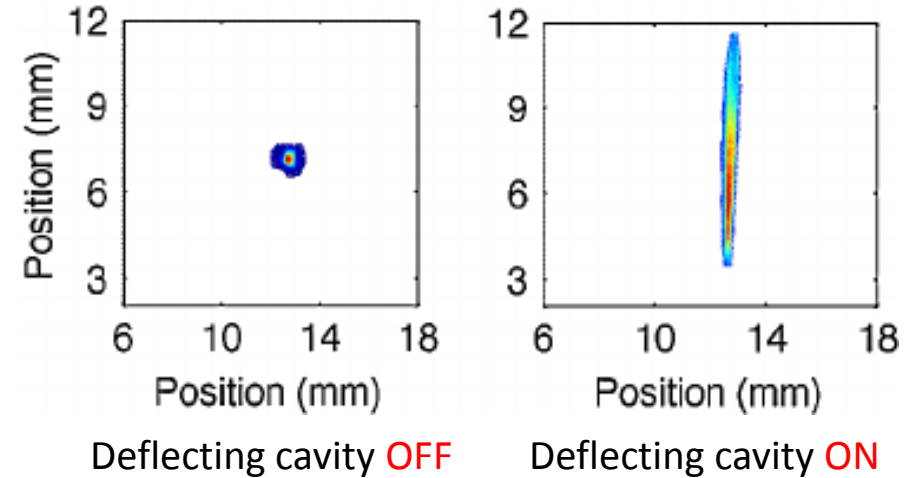
Bunch length measurement

Operating principle:

- Bunch pass at zero crossing in a deflecting cavity

- Bunch head experiences a transverse kick downward

- Bunch head experiences a transverse kick upward

- Bunch transverse size is then downstream measured on a beam profile monitor

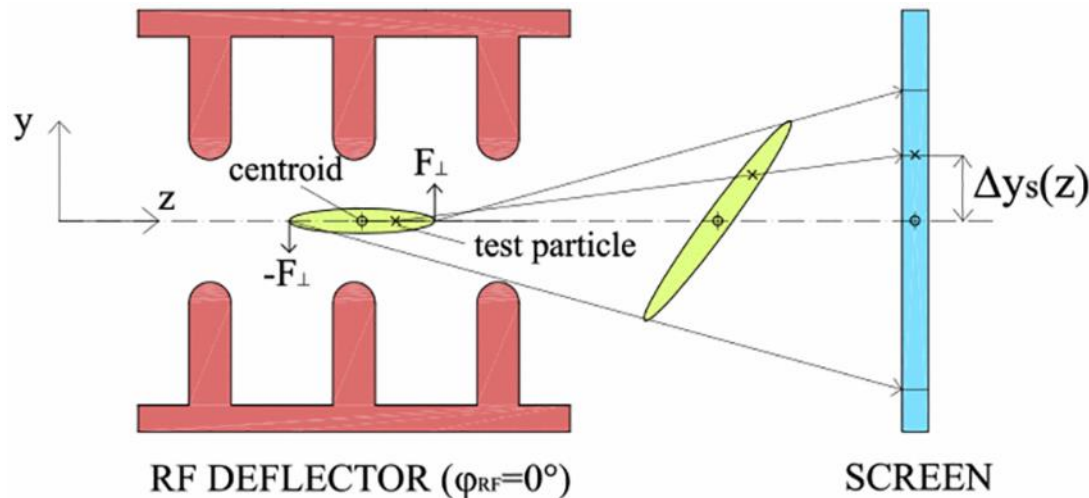Deflecting cavity OFF   Deflecting cavity ON

Bunch length measurement theory 1

$$\begin{bmatrix} x \\ x' \\ y \\ y' \\ z \\ z' \end{bmatrix} = \begin{bmatrix} R_{11} & R_{12} & \ldots & R_{16} \\ R_{21} & R_{22} & \ldots & R_{26} \\ \ldots & \ldots & \ldots & \ldots \\ R_{61} & R_{62} & \ldots & R_{66} \end{bmatrix} * \begin{bmatrix} x_0 \\ x_0' \\ y_0 \\ y_0' \\ z_0 \\ z_0' \end{bmatrix} \longrightarrow \begin{bmatrix} x' \\ z \end{bmatrix} = \begin{bmatrix} 1 & R_{25} \\ 0 & 1 \end{bmatrix} * \begin{bmatrix} x_0' \\ z_0 \end{bmatrix} \longrightarrow x' = x_0' + R_{25} z_0$$

Coordinates transformation
of the particles

Deflecting cavity case

$$x = x_0 + x_0'(L + L_{cavity}) + R_{25} z_0 L$$

Deflecting cavity ON

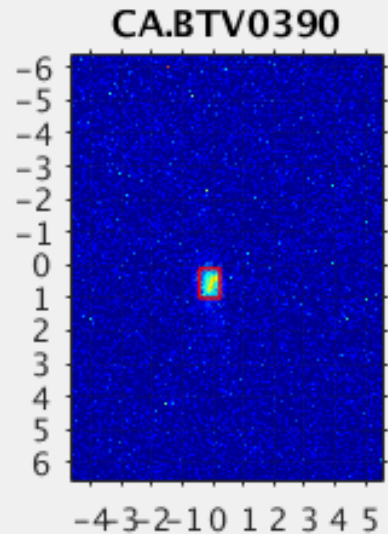$$x = x_0 + (x_0' + R_{25} z_0)L = x_0 + x_0'(L + L_{cavity})$$

Deflecting cavity OFF

RF DEFLECTOR (φ_{RF}=0°)   SCREEN

Bunch length measurement theory 2

$$\sigma_x = \frac{1}{N}\sum x^2$$

$$\sigma_{\Delta z} = \frac{1}{N}\sum (\Delta z)^2$$

Beam size
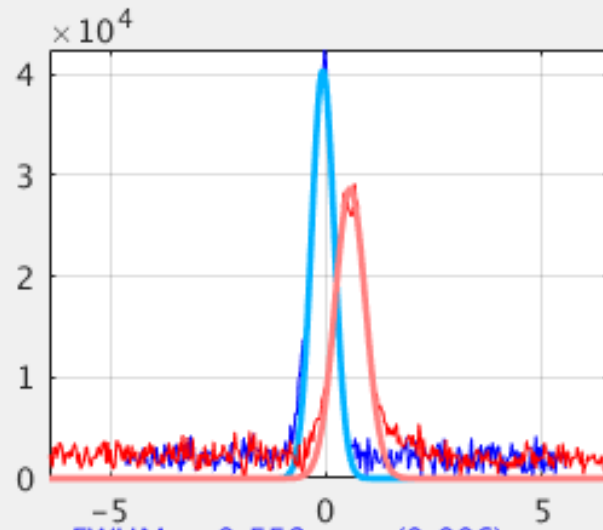
Bunch length

$$\sigma_{\Delta z} = \frac{1}{R_{25}L}\sqrt{\sigma^2_{x,cavity\_on} - \sigma^2_{x,cavity\_off}}$$

Cavity calibration 1

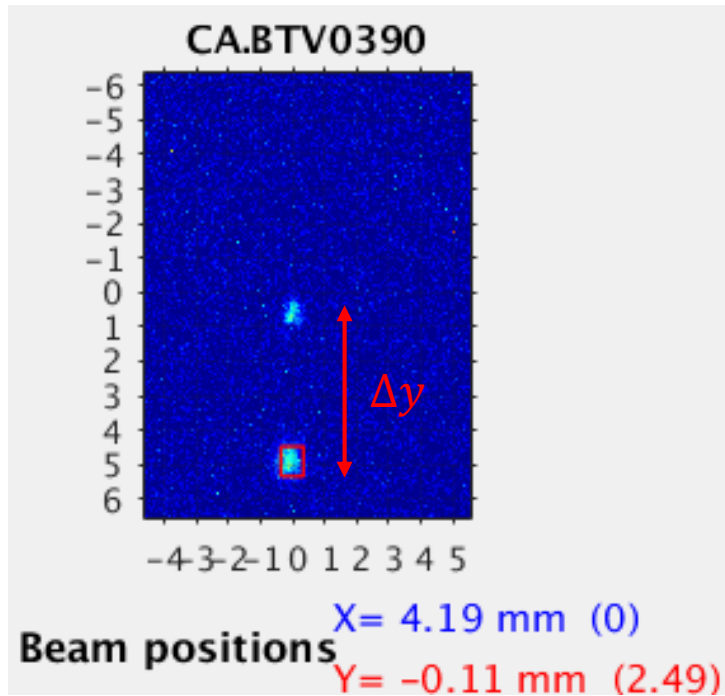In order to make a correct measurement of the bunch length a calibration is needed
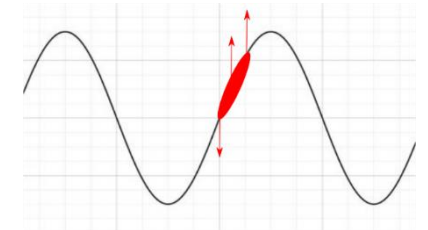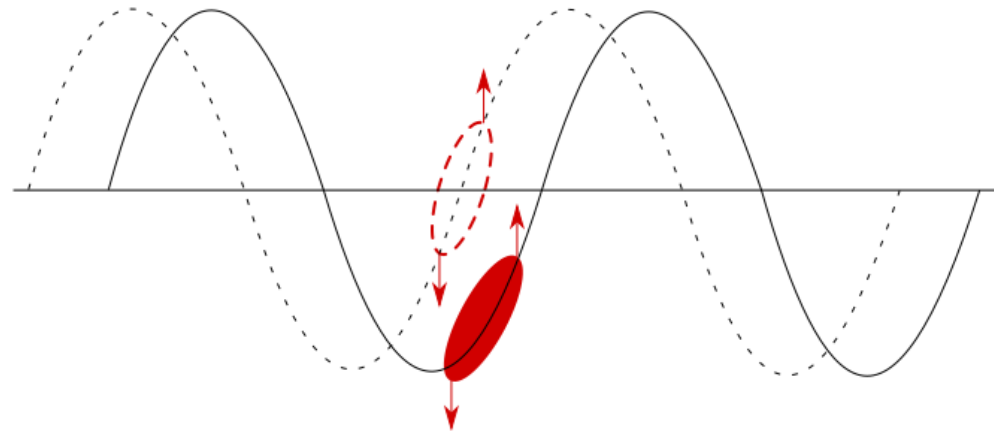

85 deg

110 deg

120 deg
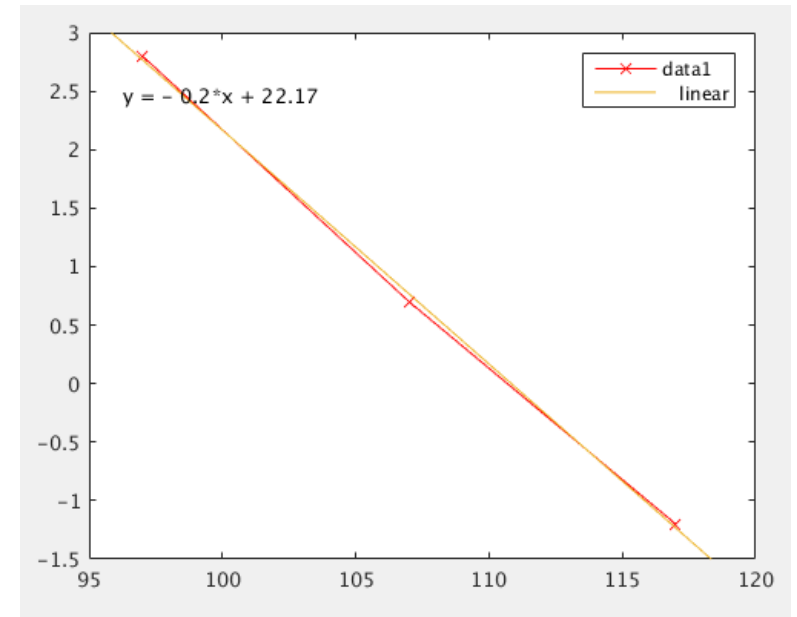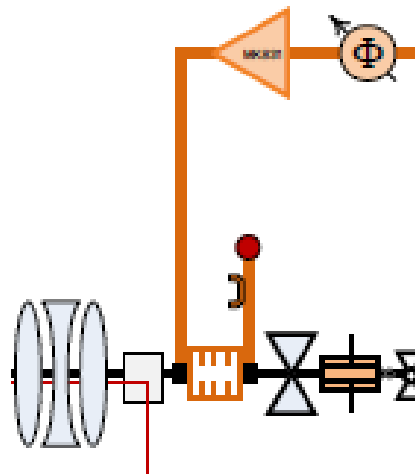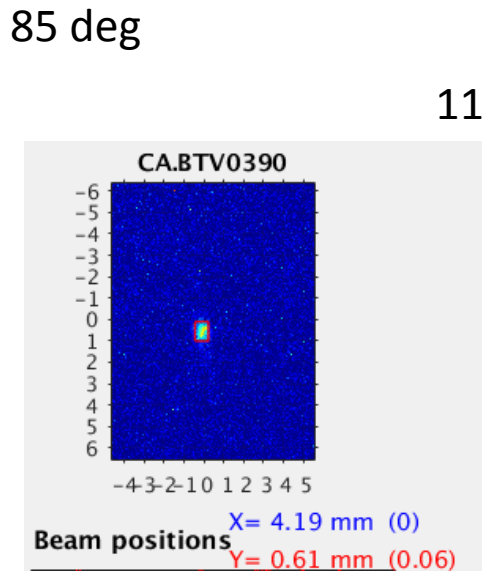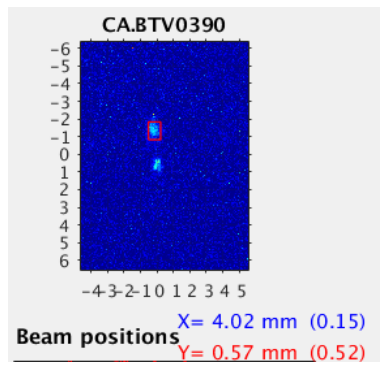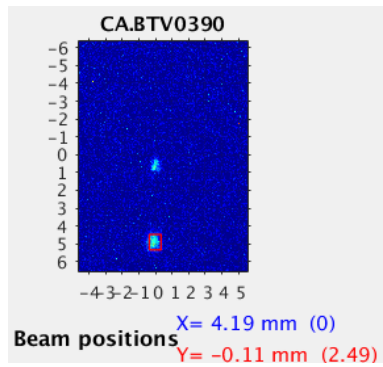
Power phase shifter allows to vary the bunch length via the velocity bunching structure
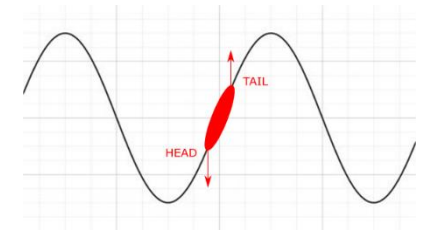
Cavity calibration 2

$$T_{RF} = 333 \text{ ps } (F_{RF} = 3\text{GHz}) \quad \frac{T_{RF}}{360°} = 0.925 \left[\frac{\text{ps}}{\text{deg}}\right] \quad \rightarrow \quad \text{DEG}_{\text{phase shifter}} = \frac{0.925}{\Delta y}$$

CA.BTV0390

Δy

Beam positions
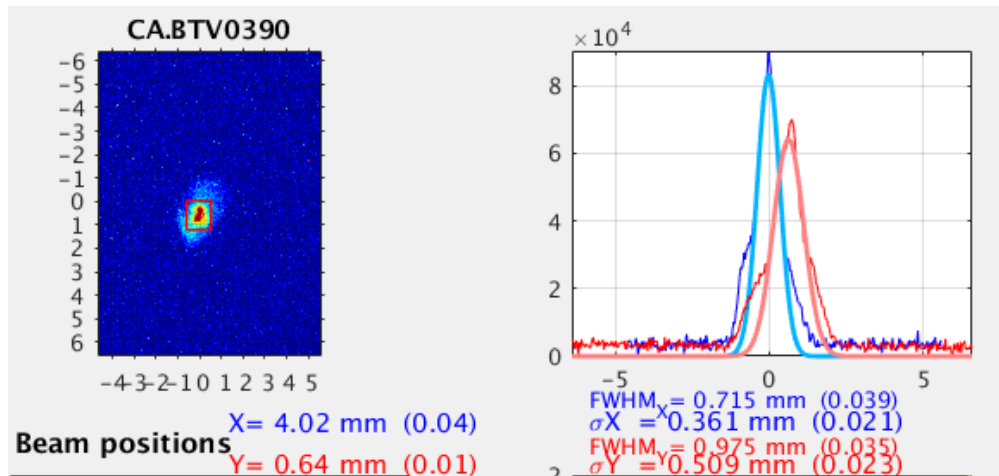X= 4.19 mm (0)
Y= −0.11 mm (2.49)

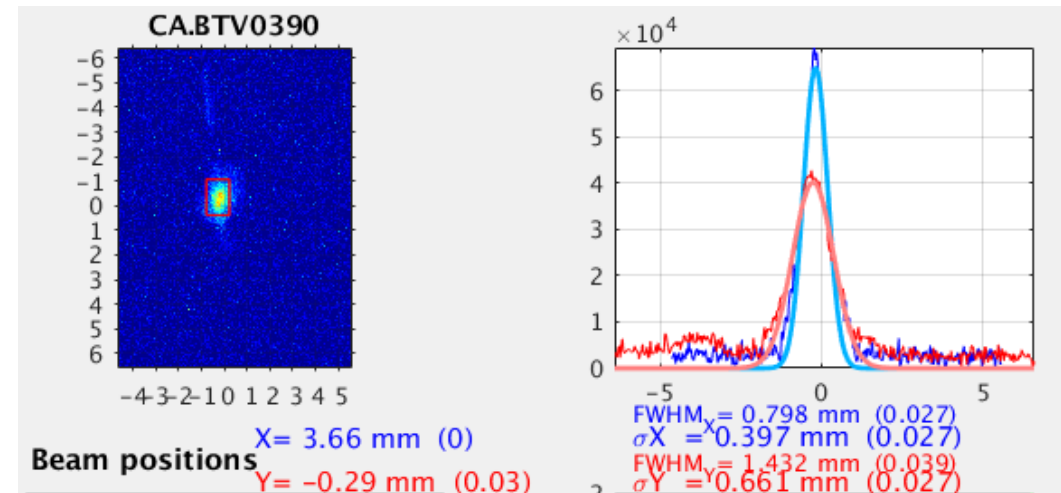Is possible to calibrate the Cavity measuring the Δy of the beam

Calibration

TAIL

HEAD

Experimental measurement

Deflecting cavity OFF

Deflecting cavity ON

$$\sigma_{\Delta z} = \sqrt{\sigma_{rf_{ON}}^2 - \sigma_{rf_{OFF}}^2} = \sqrt{0.68^2 - 0.52^2} = 0.44 \ mm$$

$$Bunch \ lenght = 0.44 \ mm \cdot \frac{9.25 \ ps}{2 \ mm} = 2.0 \ ps$$

Calibration results

Conclusion

With this structures we have a way to measure the bunch length

Thank you for your attention!