REQUEST FROM THE CCinS WORKING GROUP

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- **Proposition for the locations in the SPS of the future**
  - **KEKB Crab Cavity => 2012?**
  - **New CERN collimator (with integrated BPMS) => 2010**
  - **SLAC rotatable collimator => 2011?**
- **It satisfies Ralph Assmann's requests**
- **We have the green light from Gianluigi Arduini for aperture considerations**
  - **Dimensions of the SLAC collimator (full H × V): 60 mm × 60 (or 80) mm**
  - **Dimensions of the CERN collimator (full H × V): 66 mm × 80 mm**

POSITIONS OF THE EQUIPMENTS (1/4)

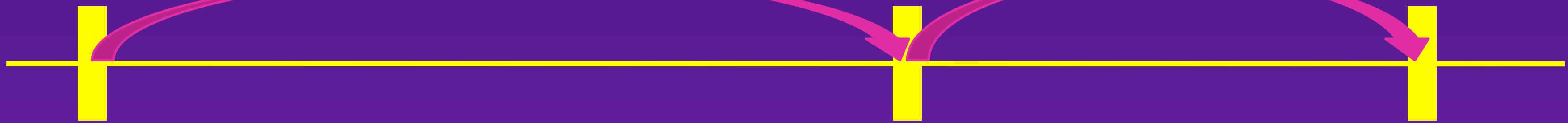
$\mu_{x1} - \mu_{x0} \approx 118$ deg
(should be ideally 113.4 deg to have no crab effect)

$\mu_{x2} - \mu_{x1} \approx 91$ deg
(should be ideally 90 deg to have maximum crab effect)

Horizontal Crab Cavity from KEK

1st horizontal collimator (SLAC)

2nd horizontal collimator (CERN)



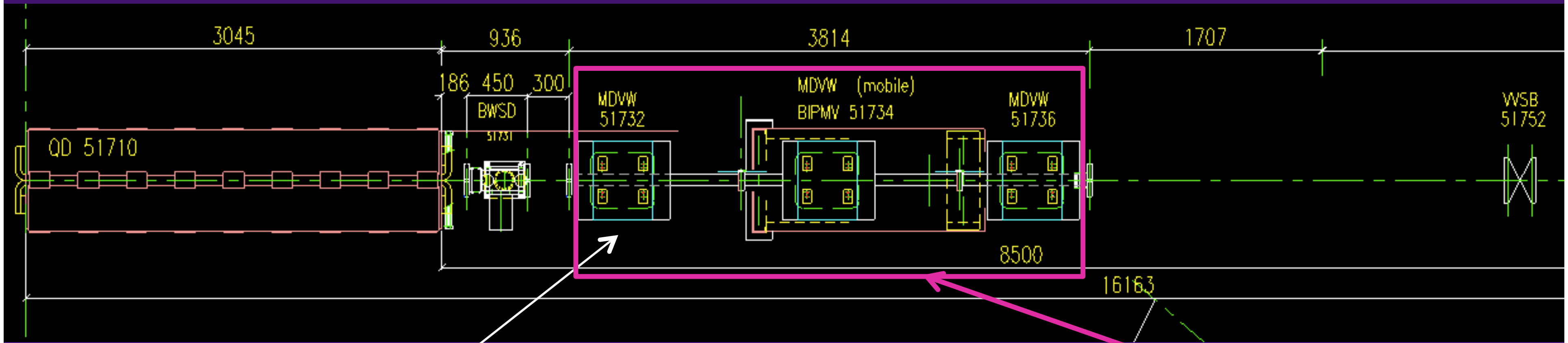
Horizontal Crab Cavity from KEK	1st horizontal collimator (SLAC)	2nd horizontal collimator (CERN)
Instead of COLDEX.41737	Instead of MDVW.51732	Same location as before: TCSP.51934
$s_0 = 4008.55$ m	$s_1 = 5156.04$ m	$s_2 = 5221.78$ m
$\beta_{x0} = 29.34$ m	$\beta_{x1} = 22.47$ m	$\beta_{x2} = 24.85$ m
$\mu_{x0} = 15.17 \times 2\pi$ = 95.34 rad = 62.47 deg [360 deg]	$\mu_{x1} = 19.50 \times 2\pi$ = 122.53 rad = 180.2 deg	$\mu_{x2} = 19.75 \times 2\pi$ = 124.12 rad = 271.56 deg

Using the 2009 LHC optics ($Q_x = 26.13$ and $Q_y = 26.18$)

POSITIONS OF THE EQUIPMENTS (2/4)

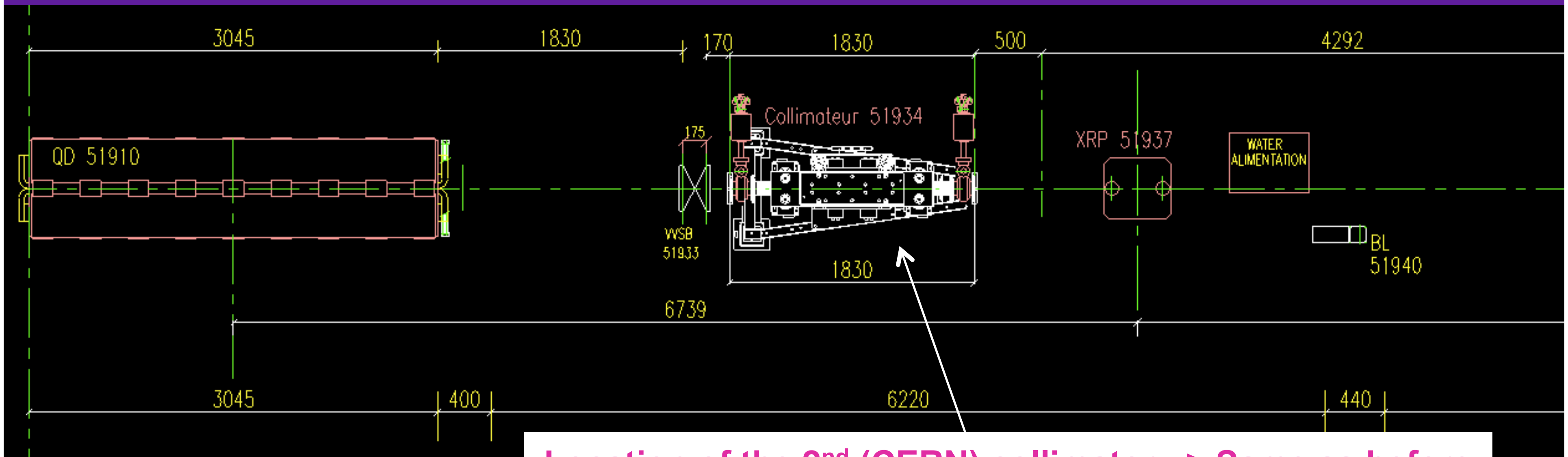
COLDEX.41737: Possible location for the Crab Cavity

POSITIONS OF THE EQUIPMENTS (3/4)



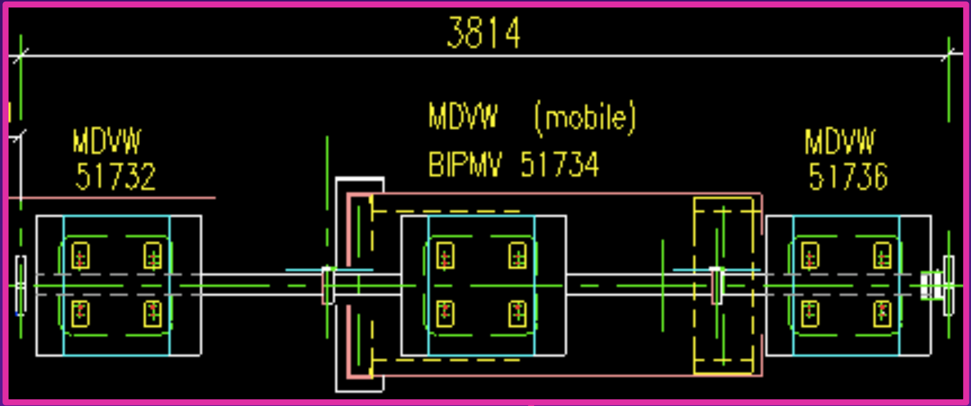
Proposition for the location of the 1st (SLAC) collimator => Instead of MDVW.51732

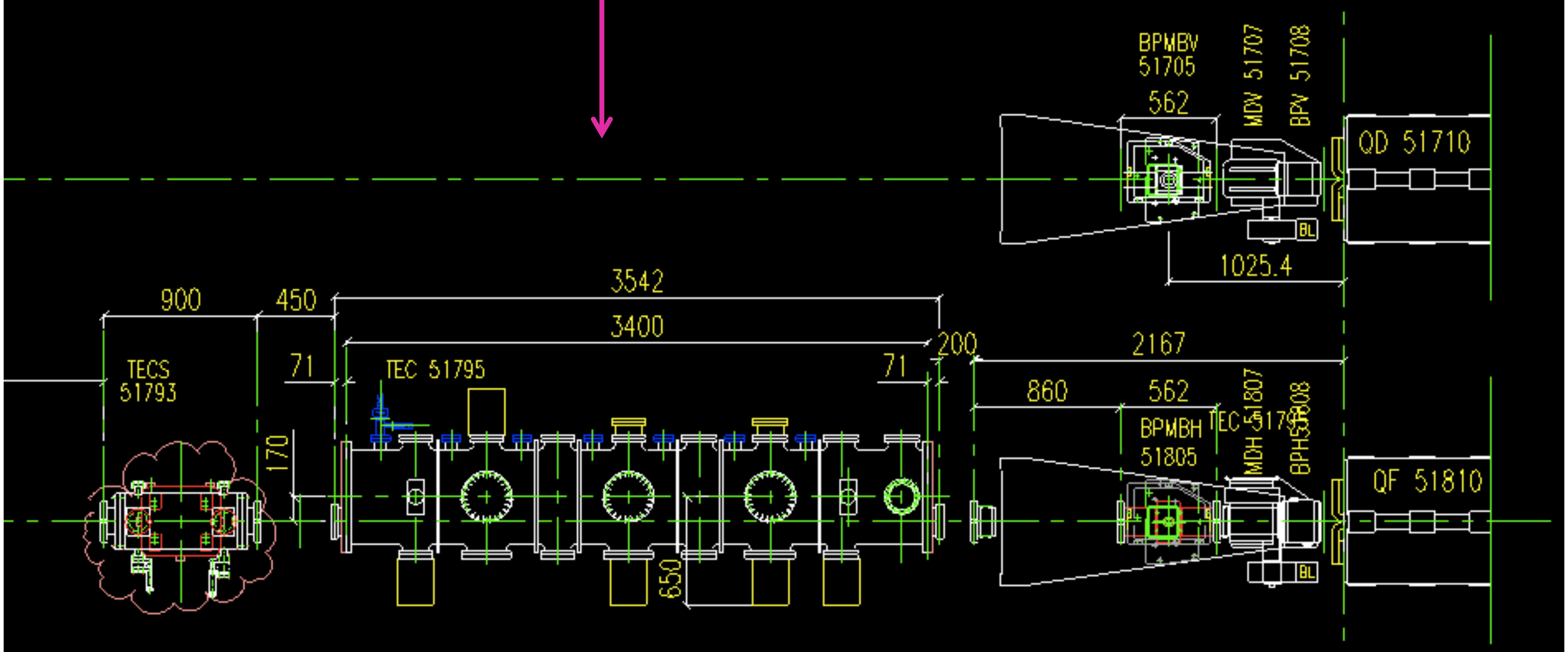
Move this 3 equipments (vertical Ionization Profile Monitor) in front of QD.51710 (see next slide)



Location of the 2nd (CERN) collimator => Same as before

POSITIONS OF THE EQUIPMENTS (4/4)





ORBIT SHIFTS DUE TO THE CRAB CAVITY KICK (1/4)

- **Linearized formula (only valid for a small bunch in RF wavelength)**

$$x_{1,2} = z \, \frac{V \, \omega \sqrt{\beta_{x0} \, \beta_{x1,2}}}{c \left(E / e \right)} \left| \frac{\cos\left(\mu_{x1,2} - \mu_{x0} - \pi \, Q_x \right)}{2 \sin\left(\pi \, Q_x \right)} \right|$$

- **Numerical values: *z* is the longitudinal distance from the bunch centre (σ_z = 15 cm), *V* = 1.5 MV is the CC voltage, *c* = 3E8 m/s, *p* = 120 GeV/c (*E* is the total energy in eV), *f* = 511 MHz (ω = 2 π f) for 4 × 24.95 = 99.8 ns bunch spacing, β_{x0} is the horiz. beta function at the CC and $\beta_{x1,2}$ is the horiz. beta function at the collimator (1 or 2), μ_{x0} is the horiz. betatron phase advance at the CC and $\mu_{x1,2}$ is the horiz. betatron phase advance at the collimator, and Q_x = 26.13 is the horizontal tune**

⇒ **x_1 = 0.05 mm at the 1st collimator for $z = \sigma_z$**

⇒ **x_2 = 0.68 mm at the 2nd collimator for $z = \sigma_z$**

ORBIT SHIFTS DUE TO THE CRAB CAVITY KICK (2/4)

- Assuming the nominal rms. norm. horizontal emittance for LHC beams (~ 3 μm), the horizontal beam size (neglecting dispersion) at the 2nd collimator is σ_{x2} = 0.76 mm

  ⇒ x_2 = 0.68 mm (at the 2nd collimator for $z = \sigma_z$) is comparable to the rms horiz. beam size σ_{x2} = 0.76 mm

  ⇒ For smaller horizontal emittances than 3 μm, the effect will be even larger

- Reminder: As the horizontal beam size scales with 1 / $E^{1/2}$ and the orbit shift scales with 1 / E, the lower the energy the better (to have the largest crab effect vs. the beam size)

  ⇒ At 55 GeV/c, x_2 = 1.48 mm (at the 2nd collimator for $z = \sigma_z$) and the rms horiz. beam size is σ_{x2} = 1.13 mm

ORBIT SHIFTS DUE TO THE CRAB CAVITY KICK (3/4)

- **Using the exact formula instead of the linearized one (as the bunch length is ~ RF wavelength), one has**

$$x_{1,2} = \sin\left(\phi_s + \frac{\omega z}{c}\right) \frac{V}{(E/e)} \sqrt{\beta_{x0}\,\beta_{x1,2}} \left| \frac{\cos(\mu_{x1,2} - \mu_{x0} - \pi Q_x)}{2\sin(\pi Q_x)} \right|$$

⇒ **x_1 = 0.03 mm at the 1st collimator for $z = \sigma_z$ (instead of 0.05 mm)**

⇒ **x_2 = 0.42 mm at the 2nd collimator for $z = \sigma_z$ (instead of 0.68 mm)**

ORBIT SHIFTS DUE TO THE CRAB CAVITY KICK (4/4)

- **In this case, x_2 = 0.42 mm (at the 2nd collimator for $z = \sigma_z$) is may be too small vs. the rms horiz. beam size σ_{x2} = 0.76 mm**
- **To increase the crab effect vs. the horizontal beam size, one should**
  - **Either use a smaller horizontal emittance: 2 μm**
    - **x_2 = 0.42 mm**
    - **σ_{x2} = 0.63 mm**
  - **Or use a lower beam energy: 55 GeV/c**
    - **x_2 = 0.92 mm**
    - **σ_{x2} = 1.13 mm (for 3 μm)**
  - **Or use both a smaller horiz. emittance (2 μm) and a lower beam energy (55 GeV/c)**
    - **x_2 = 0.92 mm**
    - **σ_{x2} = 0.92 mm**