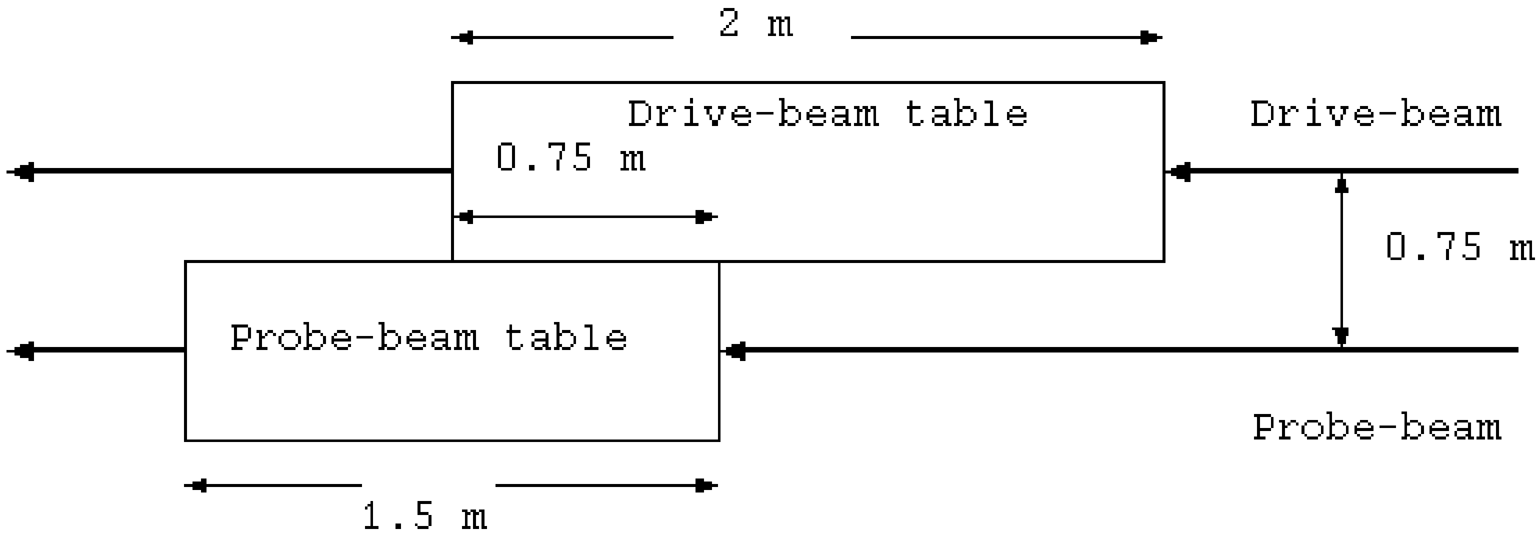
Two-Beam Test-Stand in CTF3

Volker Ziemann
Institute for Nuclear and Particle Physics
Uppsala University
Uppsala, Sweden

Purpose

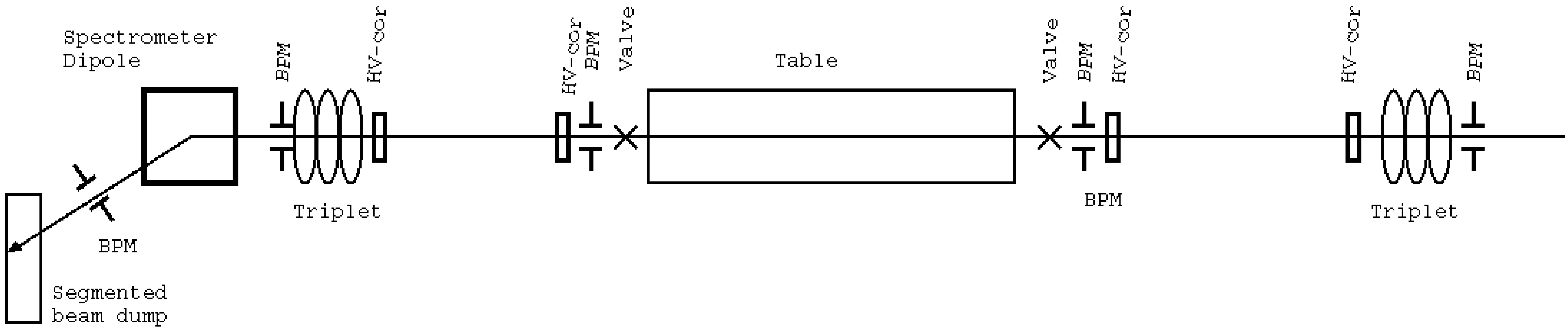
- Analyse the DUTs: PETS and accelerating structures
- (RF signals, water flow, temperature, light, shocks)
- Effect of breakdown on the beam (kicks and energy)
- Determine the longitudinal energy distribution along the pulse train (BPM or segmented dump)
- Prepare the beam for the DUTs (steering and triplets before and after)
- Propagate the beams to the respective dumps
- Measure signals that last 150 ns with a resolution of a few ns every 20 or 200 ms (5 or 50 Hz operation)

Experimental DUT-tables

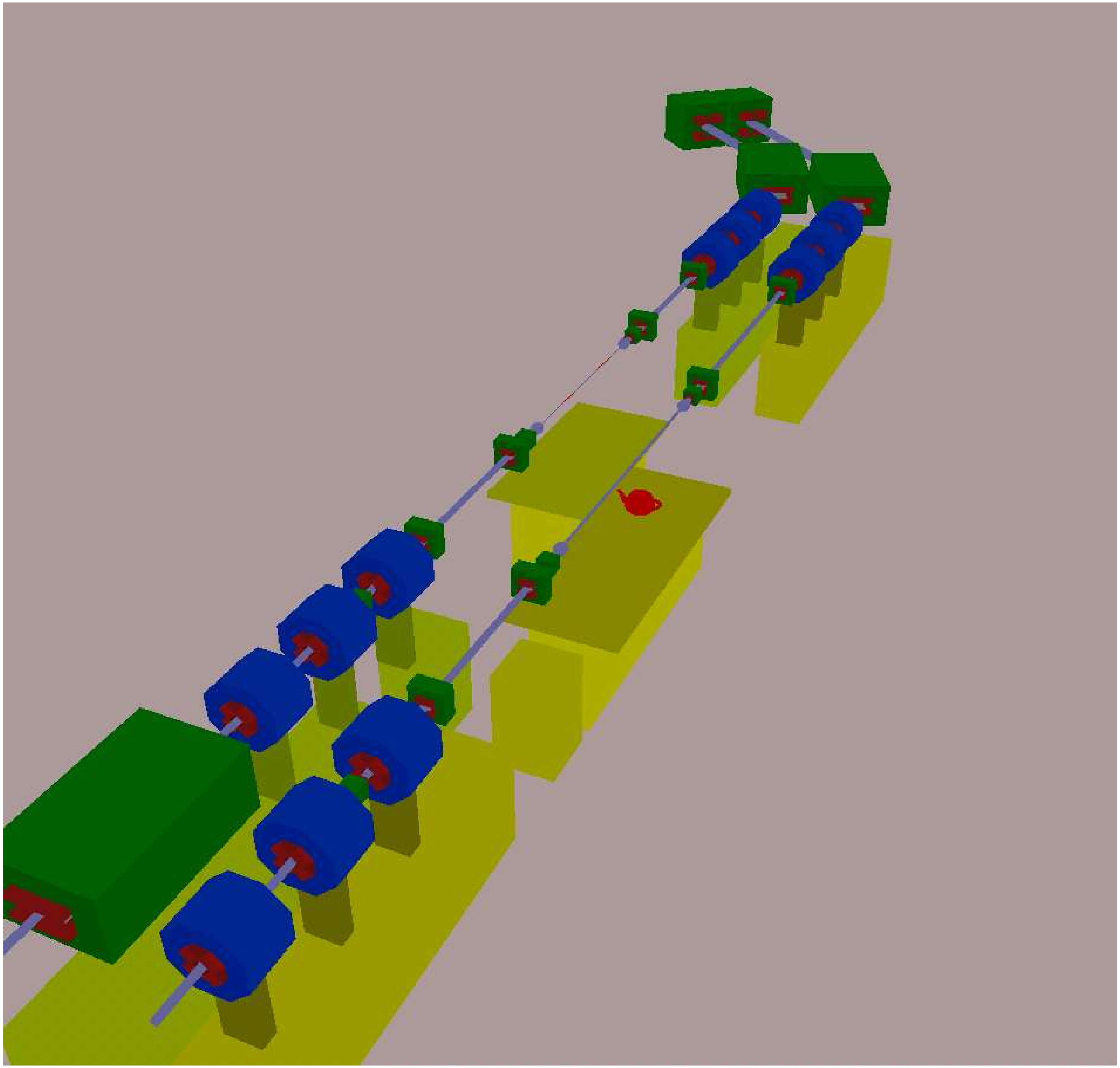


- Beam height 1.35 m above floor level
- Distance between the beams is 0.75 m
- Table width is about 0.5 m, with holes similar to optical table
- Table is 0.5 m under beam height
- Probe-beam table is shifted downstream for proper timing

Beam Line Layout



- Qualitative same layout for drive- and probe-beam.
- Two-steerers for parallel translation of beam
- Two BPM before and after for kick determination
- BPM in dump line for energy measurement
- OTR screen just before the dumps
- Both beams bend to their left
- No straight ahead dump ?



3D-view

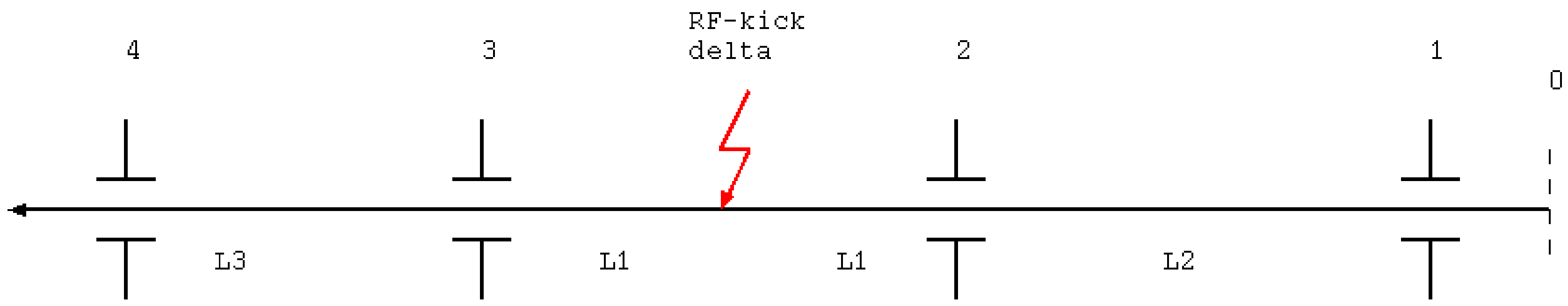
Drive-beam Features

- Aluminum vacuum pipe with 40 mm diameter
- Beam pipe in DUT must be designed for 12 mm diameter
- Steerers need to move the beam by about +/- 4 mm
- Two ion pumps in the downstream beamline
- Shared roughing turbo-pump for drive- and probe-beam
- Gasior BPM's bandwidth needs to be increased to 400 MHz
- No wall-current monitors, will use BPMs
- The upstream beamline TL2' is orphaned
- Can we use an available spectrometer magnet for the drive beam, please.

Probe-beam Features

- Stainless Steel vacuum system with 40 mm pipe
- Beam pipe in DUT must be designed for 3 mm diameter
- Steerers need to move the beam by about +/- 1 mm
- Follow Saclay's design for BPM
- Two ion pumps
- Movable turbo roughing pump
- Zero-degree port for light observation
- OTR screens see weaker beam and higher drive-beam background

Determination of RF-kicks 1

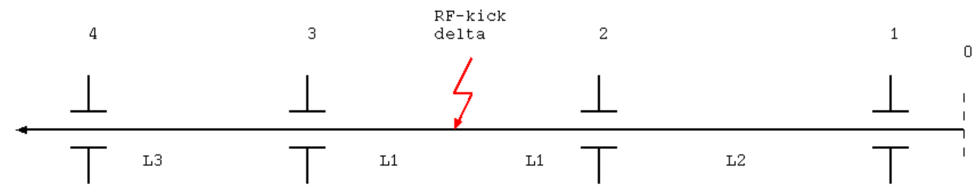


- Similar to determination of beam-beam kick in SLC
- But need to single shot resolve positions within a pulse
- Expected kicks according to Steffen: 1 kV/200 MeV = 5 μrad
- Easy to include energy determination with dispersive BPM in the dump line (not yet done)
- Determine x_0, x'_0, Δ from four BPM readings → 1 DOF in fit
- Removes incoming orbit jitter x_0, x'_0

Determination of RF-kicks 2

- Relating the unknowns to the measurements

$$
\begin{aligned}
x_1 &= R_{11}^{01} x_0 + R_{12}^{01} x'_0 \\
x_2 &= R_{11}^{02} x_0 + R_{12}^{02} x'_0 \\
x_3 &= R_{11}^{03} x_0 + R_{12}^{03} x_0 + R_{12}^{c3} \Delta \\
x_3 &= R_{11}^{04} x_0 + R_{12}^{04} x_0 + R_{12}^{c4} \Delta
\end{aligned}
$$



- Only drift spaces

$$
\begin{pmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 \\ 1 & L_2 & 0 \\ 1 & L_2 + 2L_1 & L_1 \\ 1 & 2L_1 + L_2 + L_3 & L_1 + L_3 \end{pmatrix} \begin{pmatrix} x_0 \\ x'_0 \\ \Delta \end{pmatrix}
$$

Determination of RF-kicks 3

- Can solve over-determined system of equations in the least-squares sense to determine x_0, x'_0, Δ from measurements
- The diagonal elements of the covariance matrix determines the error bars in terms of the BPM resolution σ $(A^T A)^{-1}\sigma^2$
- Error bar for Δ:

$$\sigma(\Delta) = \sqrt{[(A^T A)^{-1}]_{33}}\sigma$$

- Using $L_1 = 1.2\,\mathrm{m}, \quad L_2 = 2.0\,\mathrm{m}, \quad L_3 = 2.8\,\mathrm{m}$
- Results

$$\begin{aligned} \sigma(x_0) &= 0.96 \times \sigma \\ \sigma(x'_0) &= 0.51/\mathrm{m} \times \sigma \\ \sigma(\Delta) &= 0.85/\mathrm{m} \times \sigma \end{aligned}$$

- σ=10 μm BPM resolution will result in 8.5 μrad resolution. OK?

Conclusion

- Rough layout of the two-beam test-stand is known
- Many, many details need constant attention
- Need your input to define the capabilities
- Installation in fall 2007
- Need to order magnets this summer
- Will hire a full-time physicist to do local project coordination
- Will place a PhD student at CERN
- Need to make the money fit the requirements, otherwise
  "There's so much test-stand left at the end of the money"