Solutions for Polls for Beam Diagnostics

JUAS 2025, ESI-Archamps at CERN

Peter Forck (GSI and University Frankfurt)

European Scientific Institute

Joint Universities Accelerator School

Poll concerning Beam Current Transformers

Poll 2.1:

What is the **sensitivity** for a current transformer? It is the ratio between the measurable voltage and…

1) the beam current
2) the current in the transformer windings
3) the beam induced current flowing in the vacuum wall

Poll 2.2:

Which statement is correct concerning the comparison of **FCT** versus **ACT**?

An **FCT** has a …

1) **lower** bandwidth and a **lower** sensitivity
2) **higher** bandwidth and a **lower** sensitivity
3) **higher** bandwidth and a **higher** sensitivity

Poll 2.3:

What is the correct relation between the rise time and the cut-off frequencies?

1) $\tau_{rise} = \frac{1}{2\pi f_{low}}$
2) $\tau_{rise} = \frac{1}{2\pi f_{high}}$
3) The rise time does not depend on the cut-off frequencies
4) For transformers the rise time and the droop time are equal

Poll concerning dc Beam Current Transformers

Poll 2.4:

A DCCT can be used …

1) at **only electro-static** accelerators such as Van-de-Graaff, TANDEM or behind an ion source
2) at **only** a synchrotron storing a **coasting** (= un-bunched) beam
3) at a synchrotron with coasting and bunched beam

Poll 2.5:

The principle of a dc current transformer DCCT is related to …

1) direct transformation of a dc current
2) modulation of the particle beam in terms of on ↔ off
3) modulation of two transformer cores with 180^0 degree phase shift
4) modulation of two transformer cores with 0^0 degree phase shift

Poll concerning invasive Instrumentation and Faraday Cups

Poll 2.7:

What mean invasive beam instrumentation?

1) A gas is injected in the beam path
2) A detector is moved in the beam path
3) The beam is stopped
4) A tip is injected at the beam halo

Poll 2.8:

A Faraday Cup is used to measure…

1) the beam's electric field
2) the beam voltage
3) the beam current
4) the charge state of an ion beam

Poll 2.10:

Electronic stopping is mediated by…

1) exchange of electrons between projectile and target
2) Coulomb interaction
3) strong interaction
4) weak interaction

Poll 2.11:

Comparing the energy loss of protons and heavy ions of same velocity: What is correct?

The energy loss of protons…

1) are **higher** than of ions
2) are **lower** than of ions

Poll 2.12:

Comparing the energy loss of protons and heavy ions of same velocity: What is correct for energies **above** 10 MeV/u?

The range of protons are…

1) **longer** than of ions
2) **shorter** than of ions

Poll concerning Particle Detectors

Poll 2.13:

What is the basis of an ionization chamber?

1) It detects only ions
2) It contains always ions
3) It is based on ionizations of a gas

Poll 2.14:

What is scintillation? It is light emitted cause by the energy loss of the particles and …

1) excitation of electronic states
2) excitation of lattice vibration
3) related mechanical stress
4) emission of thermal photon

Poll 2.15:

What is a photomultiplier?

1) It amplifies directly photons
2) It only amplifies incoming electrons
3) It converts photon to electrons and amplifiers the electrons
4) It contains active electronics (e.g. transistors)

Poll 2.16:

The principle of an SEM is based on:

1) Emission of electrons from the beam ions
2) Emission on electrons from an intersecting metal
3) Back-scattering of beam ions
4) Emission of ions form an intersecting metal

Poll concerning Scintillation Screens

Poll 3.1:

What is correct concerning scintillation?

1. Every material create scintillation photons when a charged particle passes through.
2. Only proton and ion beams give rise to scintillation photons.
3. All inorganic material creates the same amount of scintillation photons.
4. The emitted light is proportional to the energy loss.

Poll 3.2:

Why is **optical** light from scintillation screens are frequently used?

1. Every person can check the detector in case of any doubt concerning its functionality.
2. Generally, only light in this wavelength range is emitted.
3. High quality optics is available with reasonable financial costs.
4. All other wavelengths are absorbed by air.

Poll concerning Optical Transition Radiation

Poll 3.3:

What is correct concerning OTR?

1. It is only emitted by impact of electron beams.
2. It is a classical process related to a moving charge.
3. It depends on the atomic energy levels of the metal atoms.
4. It involves nuclear processes.

Poll 3.4:

What is correct concerning scintillator & OTR?

1. Scintillation delivers always more light than OTR.
2. The spatial resolution of OTR is always better.
3. Scintillation screen set-up are always much cheaper then set-ups for OTR.
4. Both methods use comparable optical set-ups.

Poll concerning Grids and Scanners

Poll 3.5:

The resolution of a **SEM-Grid** is given by the …

1. wire thickness
2. wire spacing
3. noise contributions for the electronics measuring the current from the emitted secondary electrons
4. noise from the frequently used beam loss monitors

Poll 3.6:

The resolution of a **linear wire scanner** is given by the …

1. wire thickness
2. wire spacing between the horizontal and vertical direction
3. noise contributions for the electronics measuring the current from the emitted secondary electrons
4. noise from the frequently used beam loss monitors

Poll 3.7:

The resolution of a **flying wire scanner** is given by the …

1. wire thickness
2. mechanical deformation of the wire
3. noise contributions for the electronics measuring the current from the emitted secondary electrons
4. noise from the frequently used beam loss monitors

Poll 3.8:

The recorded signal from a **wire scanner** is related to:

1. In **all** cases to the emitted secondary electrons
2. In **no** case to the emitted secondary electrons
3. For protons at **low** energies $E_{kin} < 100$ MeV to nuclear processes
4. For protons at **high** energies $E_{kin} > 100$ MeV to nuclear processes

Poll concerning non-invasive Profile Measurement by IPMs

Poll 3.9:

IPMs are based on the residual gas detection of …

1. electrons only
2. ion only
3. alternatively either electrons or ions
4. simultaneously electrons and ions

Poll 3.11:

For which beam purpose a magnetic field is applied at IPMs?

1. In all conditions a magnetic field increases the spatial resolution.
2. For strong space charge the residual gas **electrons** is guided by the magnetic field.
3. For strong space charge the residual gas **ions** is guided by the magnetic field.
4. The cyclotron radius is independent on the mass of the moving residual gas particle.

Poll 3.10:

Which statement is correct for IPMs?

1. IPMs are only suited for proton and ion beams.
2. They require necessarily a vacuum pressure much higher than typical accelerator vacuum.
3. The electric field is used to detect the residual gas electrons or ion within a '4π-geometry', i.e. all ionic products can be detected
4. Any collision between beam ions and the residual gas molecule leads to an ionization.

Poll 3.11a:

IPMs are normally **not** installed a synchrotron light facilities. What might be the reason? Mark the **wrong** answer!

1. The spatial resolution is about 50 µm, which is **too low** for a typical beam size of 10…100 µm.
2. Electrons do **not** ionize the residual gas.
3. The usage of **synchrotron radiation monitors** is a better method.

Poll concerning non-invasive Profile Measurement

Poll 3.12:

Which statement is correct for BIF monitors?

1. BIF monitors are only suited for proton and ion beams.
2. Any collision between beam ions and the residual gas molecule leads to an fluorescence level and a detectable photon.
3. BIF monitors needs always a single photon detection via an image intensifier
4. Different species of residual gas molecules leads to different transition wavelength.

Poll 3.13:

Which statement is correct for IPM and BIF?

1. Both types have the same signal strength.
2. They require necessarily a vacuum pressure much higher than within a typical accelerator vacuum tube.
3. The signal strength scales approximately with the energy loss of the beam particles in gases.
4. Any ionization of a residual gas atom or molecule leads to the emission of an optical photon.

Poll concerning Synchrotron Light Monitors

Poll 3.14:

Why are synchrotron light monitors are often used in the **optical** wavelength range?

1. Synchrotron light has its maximal emission in the optical wavelength range.
2. High quality optics is available with reasonable financial costs.
3. The highest resolution is achieved in the optical wavelength range.
4. For safety reasons only optical light is allowed in a typical hutch at light sources.

Poll 3.15:

Which method using synchrotron light gives the highest resolution?

1. Imaging method in the optical range
2. Imaging methods in the X-ray range
3. Interference methods in the optical range

Poll concerning linear Transformations

Poll 4.1:

Which optical elements are **non**-linear?

1) Dipole
2) Quadrupole
3) Sextupole

Poll 4.2:

What is **wrong** concerning linear transformations?

1) The trajectories can be calculated by a matrix.
2) The coordinate vector is $\vec{x} = (x, x', y, y', l, \delta)^T$
3) All elements within a typical accelerator can be described by linear transformations.
4) The emittance is preserved.

Poll concerning Emittance Measurement by linear Transformations

Poll 4.3:

What is **correct** concerning the emittance measurement by linear transformations?

1) Only the 2nd statistical moments are determined to characterize the beam distribution.
2) Any beam distribution can be reliably determined by this methods.
3) The transfer line can contain any optical element.
4) In all cases, three measurements are sufficient for an emittance determination.

Poll concerning normalized Emittance

Poll 4.4:

A typical slit-grid emittance installation can be applied for …

1) **all beams** and all energies
2) **electron** beams for all energies
3) **proton** beam energies **below** 100 MeV only
4) **proton** beam energies **above** 100 MeV only

Poll 4.5:

Assuming an electron and proton beam of 10 MeV (starting from the same source). What do expect concerning the emittance of both beams?

1) The electron beam has a **smaller** emittance than the proton beam.
2) The electron beam has a **larger** emittance than the proton beam.
3) Both beams have the **same** emittance as it relates to the beam energy.

Poll concerning normalized Emittance

Poll 4.6:

In a synchrotron no special emittance measurement for a **stable circulating** beam is discussed.

What is the reason?

1) The emittance has **no** practical meaning.
2) The emittance of a circulating beam is **always** constant.
3) For emittance measurement, the beam **must be** extracted from the synchrotron and methods in transfer lines must be applied
4) For a stable circulating beam, the emittance is directly **linked** to the transverse profile $x = \sqrt{\varepsilon\beta}$ as related to a relation between Twiss parameter α, β and γ at one location.

Poll concerning Fourier Transformation

Poll 5.1:

Which statement is **wrong**?

1. Fourier Transformation is a integral transformation
2. Any continuous function can be Fourier transformed
3. Experimentally, the Fourier Transformation amplitude is observed by a spectrum analyser

Poll 5.2:

What is **correct** concerning the Fourier Transformation (FT) in general?

1. Convolution in time domain can be calculated as a multiplication of the individual FTs
2. Convolution in time domain can be calculated by multiplication with the factor $i\omega$ of the FT
3. The amplitude of the FT contains **all** required information
4. The mathematically calculated FT can **not** be displayed in an appropriate manner experientially

Poll concerning Transfer Impedance

Poll 5.3:

What is **correct** concerning the transfer impedance?

1) It can only be applied in frequency domain
2) It is the ratio between the measurable voltage and ***beam*** current
3) It is the ratio between the measurable voltage and ***wall*** current

Poll 5.4:

What is **correct** concerning BPM measurements in general?

1) Beams of all types of ***time structure*** can be monitored
2) Only positive beam particles (i.e. protons & ions) can be measured
3) The BPM circuit acts as a ***high*** pass filter

Poll 5.5:

Using a BPM, the position x is determined by opposite plates via…

1) Difference divided by sum $x = \frac{1}{S} \cdot \frac{\Delta U}{\Sigma U}$
2) Sum divided by difference $x = \frac{1}{S} \cdot \frac{\Sigma U}{\Delta U}$

Poll 5.6:

Using a BPM: What is true concerning the absolute value of the sum $|U_\Sigma|$ & difference $|U_\Delta|$:

1) $|U_\Sigma| > |U_\Delta|$
2) $|U_\Sigma| < |U_\Delta|$
3) Both cases can appear

Poll concerning Button BPMs and Signal Shape

Poll 5.7:

What is correct? For button BPMs the position sensitivity ***S(x)*** is …

1) **in**dependent with respect to the beam-pipe size

2) **linear** with respect to ***x*** (**in**dependent on the button geometry)

3) **non-linear** with respect to ***x*** (it depends on the button geometry)

4) The horizontal ***S(x)*** is **in**dependent on the vertical beam offset ***y***

Poll 5.8:

Assume a small button BPM with a cut-off frequency of f_{cut} = 3 GHz and a beam bunch of 1 ns length. The signal is proportional …

1) to the bunch current

2) to the derivative of the bunch current

3) to the button diameter

Poll concerning linear-cut BPMs

Poll 5.9:

Linear-cut BPMs …

1) are used at proton synchrotrons with an acceleration frequency $f_{acc} \gg 10$ MHz
2) can distinguish between counter-propagating beams within a collider
3) provide a linear position sensitivity over a wide range of beam offsets

Poll concerning BPM Electronics

Poll 5.10:

Which type of electronics delivers a better position resolution?

1) Broadband signal processing
2) Narrowband signal processing 

Poll 5.11:

Within a transfer line between two synchtrotrons, the positon of a single bunch should be measured. What type of electronics is appropriate?

1) Broadband signal processing 
2) Narrowband signal processing using the synchrotron bunching
3) The position of a single bunch can **not** be measured

Poll 5.12:

Assume turn-by-turn position evaluation within a synchrotron.
What type of electronics is appropriate?

1) Broadband signal processing 
2) Narrowband signal processing
3) Digital signal processing as the only possible solution

Poll concerning Tune and Lattice Function Measurement

Poll 5.13:

A **tune** measurement is related to excitation of …

1) coherent transverse oscillations ←
2) incoherent transverse oscillations
3) coherent longitudinal oscillations
4) incoherent longitudinal oscillations

Poll 5.14:

The **dispersion** function along a transfer line is measured using a beam with momentum offset and measuring …

1) the **arrival time** at several locations
2) the beam **position** at several locations ←
3) the beam **profile** at several locations
4) nothing, as dispersion is only a **theoretical** quantity

Poll 5.15:

What is a **closed orbit feedback** system at a synchrotron?

1) The alignment of the trajectory of the injected beam during its first turn
2) The correction of individual bunches during storage
3) The correction of the beam position averaged over more than 1000 turns ←
4) The mechanical movement of the synchrotron magnets

Poll concerning longitudinal Phase Space and ToF

Poll 6.1:

Compare the longitudinal to the transverse phase space:
The relative momentum spread $\Delta p/p_0$ corresponds to the transverse …

1) beam centre
2) beam width
3) beam divergence ⟵
4) beam emittance

Poll 6.2:

The mean energy can be measured via…

1) two BPMs for relativistic beams only
2) two BPMs for non-relativistic beams only ⟵
3) two SEM-Grids and the known dispersion

Poll 6.3:

What is **correct** for a proton facility comprising of several LINAC cavities?
ToF measurement are used to align …

1) the beam position
2) the quadrupole settings
3) all cavity amplitudes ⟵
4) the last cavity amplitude to reach the correct final energy

Poll concerning longitudinal Mismatch, long. Emittance

Poll 6.4:

Assume a LINAC facility.

The bunch length variation by a buncher followed by a bunch shape measurement corresponds to an transverse emittance measurement of type

1) Quadrupole variation
2) Three grid method
3) Slit-grid method

Poll 6.5:

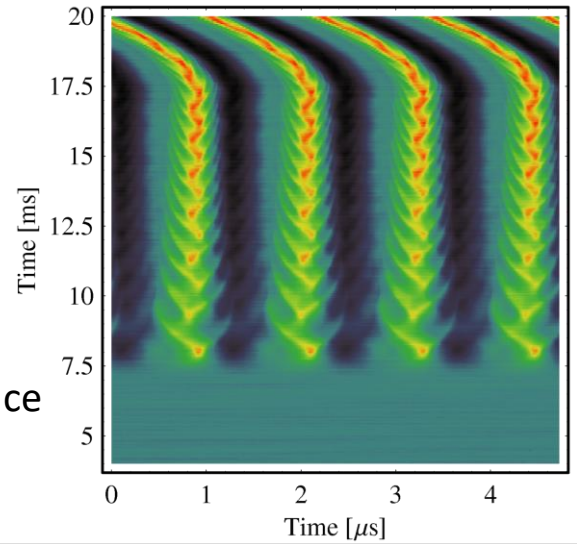
f_{acc} **shift by 0.2% of nominal value**
⇒ Coherent longi. oscillation

Assume an injection from a proton LINAC to a synchrotron.

What happens if injection energy is **not** correct?

(i.e. the particles' revolution frequency differs from the acc. frequency)

1) The particles perform coherent synchrotron oscillations
2) The particles perform **in**coherent synchrotron oscillations
3) The tune is changed significantly
4) Nothing, as long as the particles stay within the longitudinal acceptance



Poll concerning Electron Beam Bunch Length Measurement

Poll 6.6:

Optical synchrotron light is emitted from …

1) electrons only
2) electron everywhere along their path
3) highly relativistic neutral particles if the Lorentz factor is larger than 1000
4) any charged particles on a curved trajectory

Poll 6.7:

A question related to a typical bunch length at circular synchrotron light sources with f_{rf}=500 MHz: What is the time resolution of a typical streak camera?

1) 1 fs
2) 1 ps
3) 1 ns

Poll 6.8:

The short bunches with 100 fs length at FEL-facilities are measured with electro-optical methods. Could the same method be applied for 10 MeV proton beams with a bunch length of 100 ps?

1) **Yes**, assuming the number of particle per bunch is sufficient

2) **Yes**, but the method is very cumbersome and more simple method are available

3) **No**, protons at that energy don't emit synchrotron light in the optical range

4) **No**, the transverse electric field does not represent the particle distribution

Poll concerning BLM Types

Poll 7.1:

Which type of BLM measures the dose directly?

1) Scintillator
2) Ionization chamber
3) Solid state diodes
4) Cherenkov detectors

Poll 7.2:

Which type of BLM is most sensitive to neutrons?

1) Scintillator
2) Ionization chamber
3) Solid state diodes
4) Cherenkov detectors

Poll 7.3:

Which type of BLM can distinguish between beam particles and secondaries?

1) Scintillator
2) Ionization chamber
3) Solid state diodes
4) Cherenkov detectors

Poll concerning Usage of BLMs

Poll 7.4:

Which answer is **wrong**? Beam loss monitors are used …

1) to prevent for unnecessary activation
2) as a system to restrict people access outside of the accelerator shielding
3) for quench protection for super-conducting components
4) for beam alignment