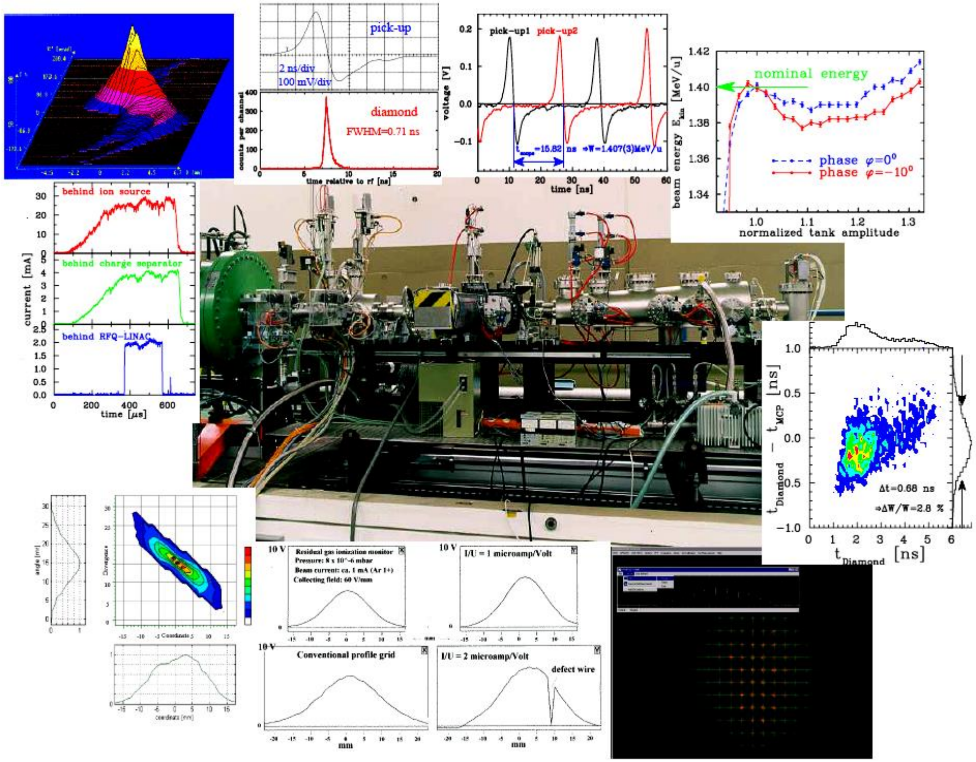
Conclusion on Beam Instrumentation and Diagnostics

JUAS 2025, ESI-Archamps at CERN

Peter Forck (GSI and University Frankfurt)



Diagnostics is the 'sensory organ' for the beam.

It required for operation and development of accelerators

Four types of demands leads to different installations:

- Quick, non-destructive measurements leading to a single number or simple plots.
- Instrumentation for daily check, malfunction diagnosis and wanted parameter variation.
- Complex instrumentation used for hard malfunction and accelerator development.
- Automated measurement and control of beam parameters i.e. feedback

A clear interpretation of the results is a important design criterion.

General comments:

- Good knowledge of accelerators, general physics and technologies is needed.
- Quite different technologies are used, based on various physics processes.
- Each task and each technology calls for an expert.
- Accelerator development goes parallel to diagnostics development.

$\Rightarrow$ Interesting and challenging subject!

LINAC & transport lines: Single pass ↔ **Synchrotron:** multi pass

Electrons: always relativistic ↔ **Protons/Ions:** non-relativistic for E_{kin} < 1 GeV/u

Depending on application: Low current ↔ high current

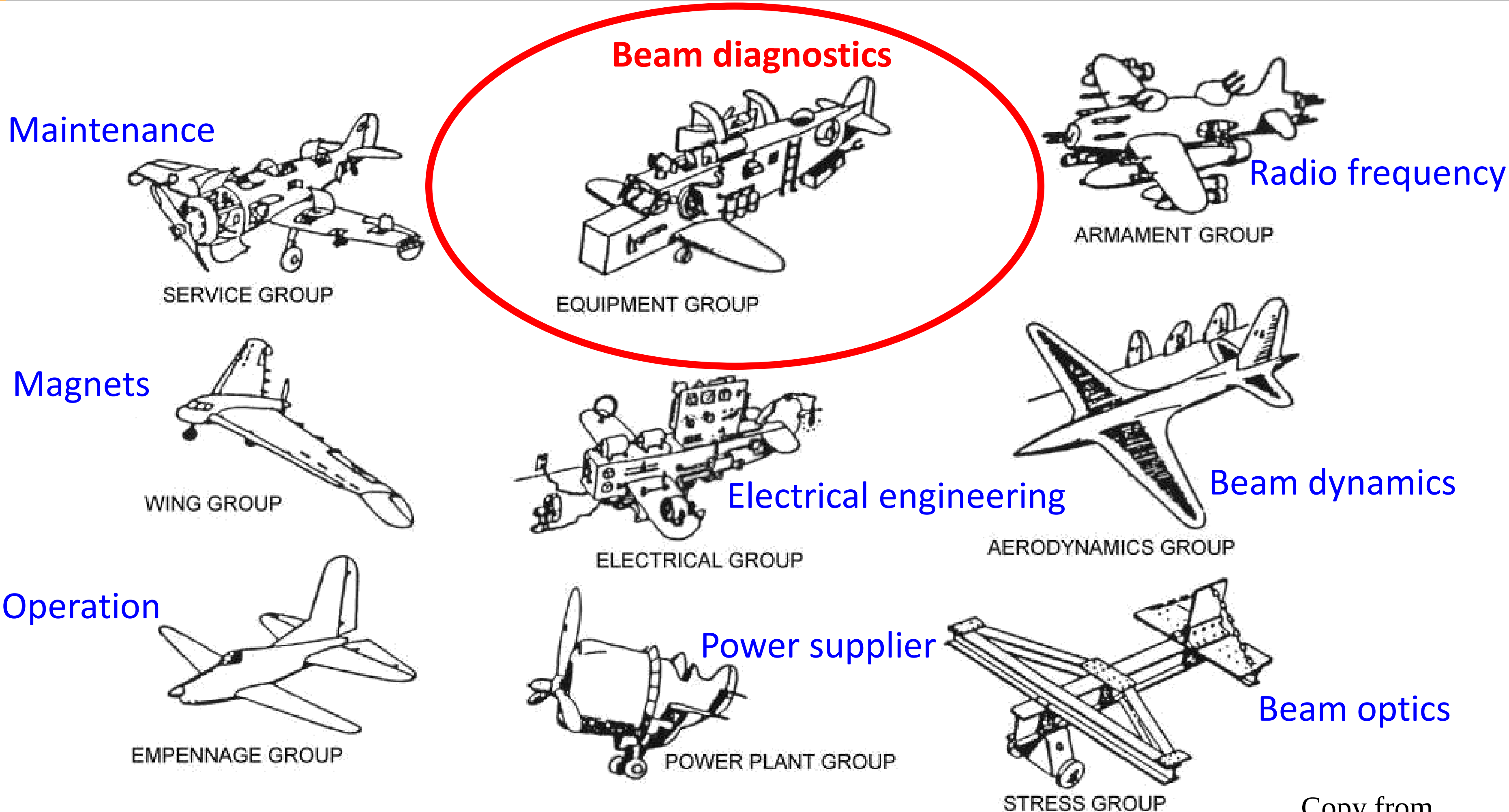
Overview of the most commonly used systems:

Beam quantity		LINAC & transfer line	Synchrotron
Current *I*	*General* *Special*	**Transformer, dc & ac** **Faraday Cup** **Particle Detectors**	**Transformer, dc & ac** Pick-up Signal (relative)
Profile x_{width}	*General* *Special*	**Screens, SEM-Grids** **Wire Scanners, OTR Screen** MWPC, **Fluorescence Light**	**Ionization Profile Monitor** **Wire Scanner,** **Synchrotron Light Monitor**
Position x_{cm}	*General* *Special*	**Pick-up (BPM)** Using profile measurement	**Pick-up (BPM)**
Transverse Emittance ε_{tran}	*General* *Special*	**Slit-grid** **Quadrupole Variation** Pepper-Pot	**Ionization Profile Monitor** **Wire Scanner** Transverse Schottky

Beam Quantities and their Diagnostics II

Beam quantity		LINAC & transfer line	Synchrotron
Bunch Length $\Delta\varphi$	*General* *Special*	**Pick-up** **Secondary electrons**	**Pick-up** Wall Current Monitor **Streak Camera** **Electro-optical laser mod.**
Momentum p **and** **Momentum Spread** $\Delta p/p$	*General* *Special*	**Pick-ups (Time-of-Flight)** Magnetic Spectrometer	**Pick-up (e.g. tomography)** Schottky Noise Spectrum
Longitudinal Emittance ε_{long}	*General* *Special*	**Buncher variation** Magnetic Spectrometer	 **Pick-up & tomography**
Tune and Chromaticity Q, ξ	*General* *Special*	--- ---	**Exciter + Pick-up** Transverse Schottky Spectrum
Beam Loss r_{loss}	*General*	**Particle Detectors**	
Polarization P	*General* *Special*	Particle Detectors Laser Scattering (Compton scattering)	
Luminocity L	*General*	Particle Detectors	

- Destructive and non-destructive devices depending on the beam parameter.
- Different techniques for the same quantity ↔ Same technique for the different quantities.



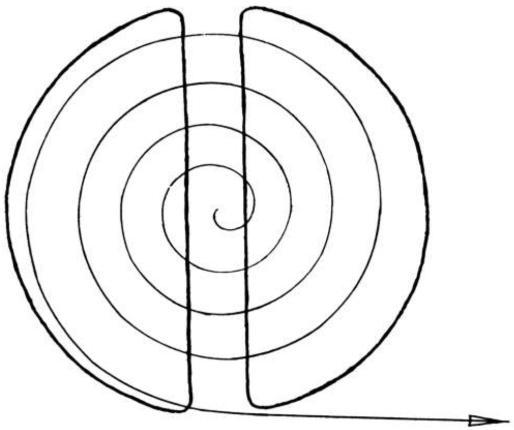
Copy from
Dream Airplanes
by C.W. Miller

Thank you for your attention!

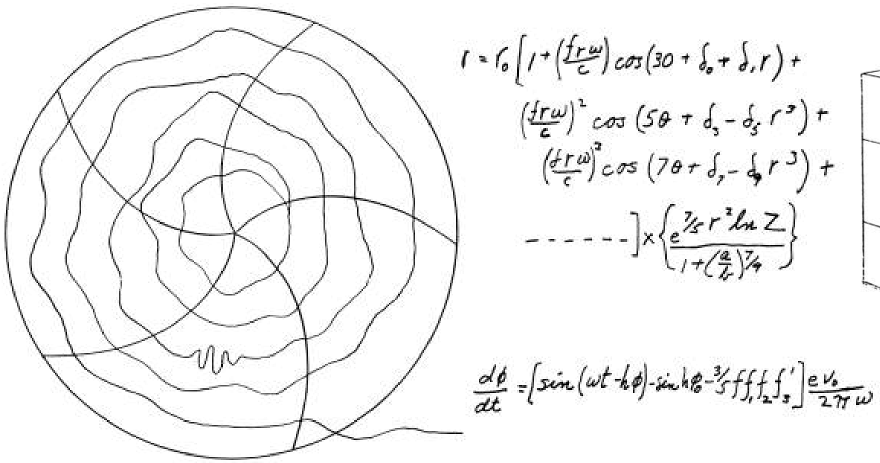
For a successful construction and operation of an accelerator,
the understand and appropriate balance of all disciplines is required!

Backup slides

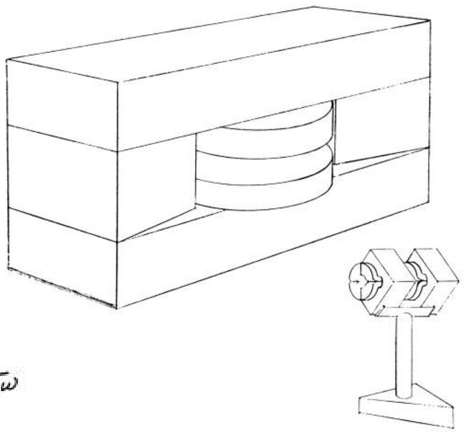
An Cyclotron Accelerator Facility as seen by....



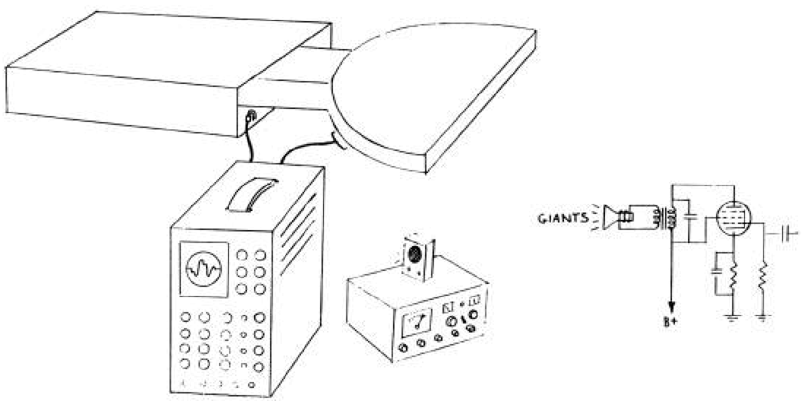
... the inventor



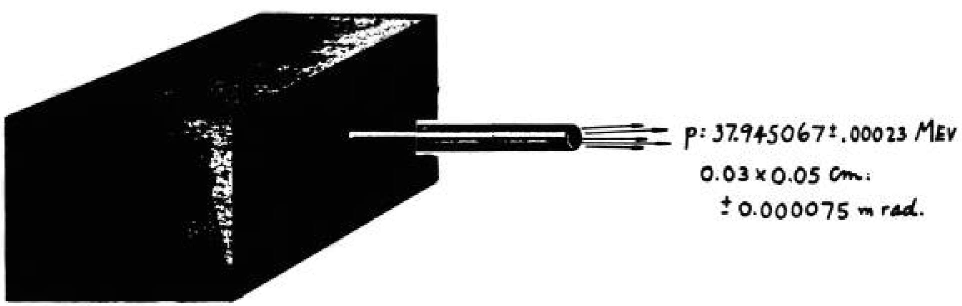
... the theoretical physicist



... the mechanical engineer



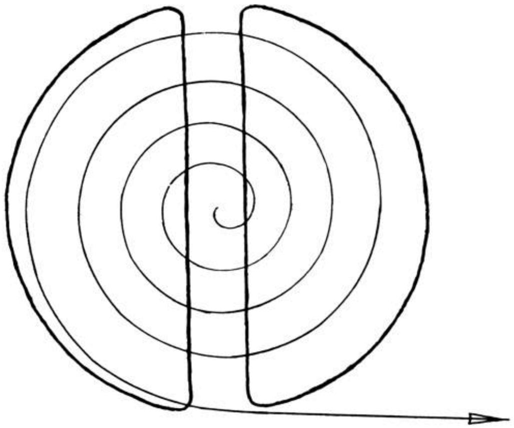
... the electrical engineer



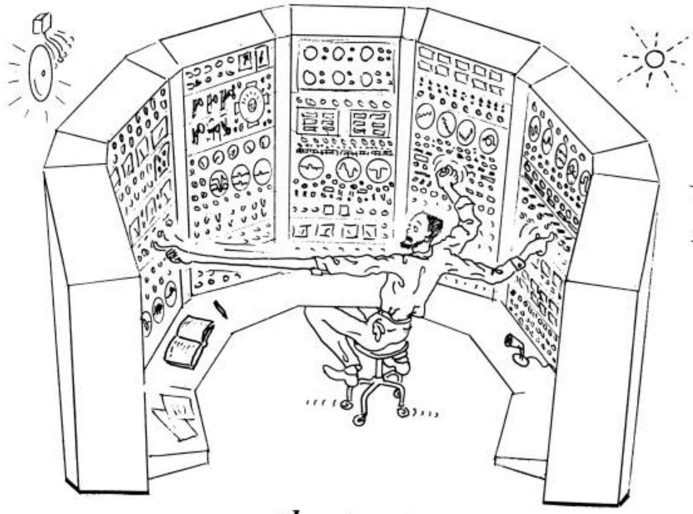
... the experimental physicist

Cartoons by Dave Judd and Ronn MacKenzie

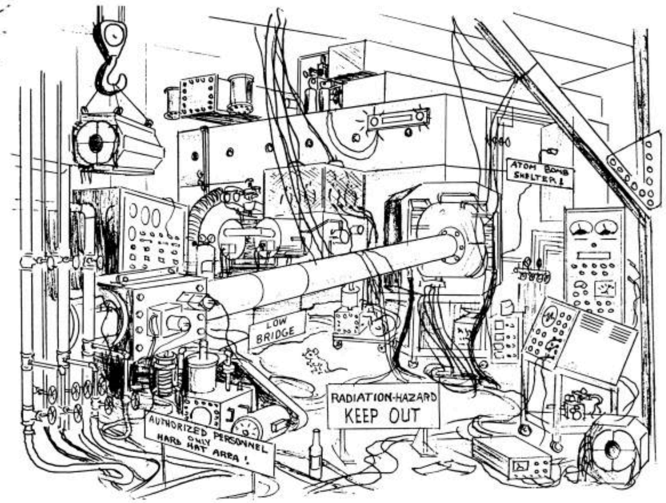
A Cyclotron Accelerator Facility as seen by....



. . . the inventor

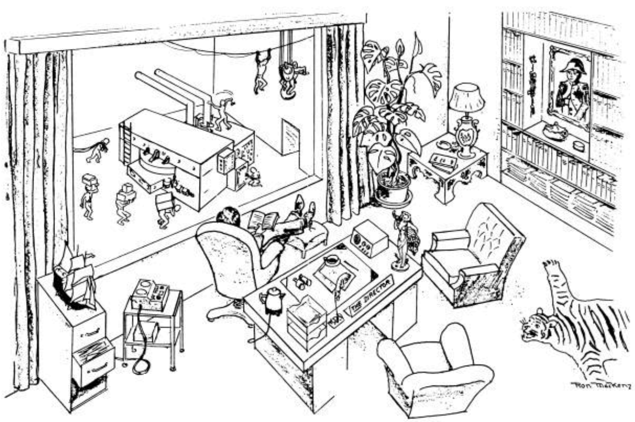


. . . the operator

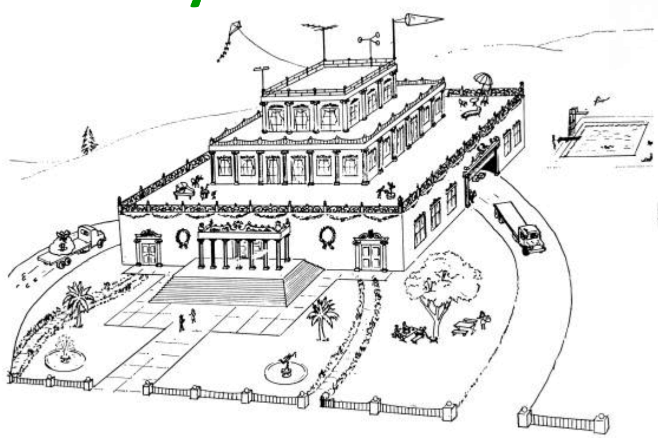


. . . the visitor

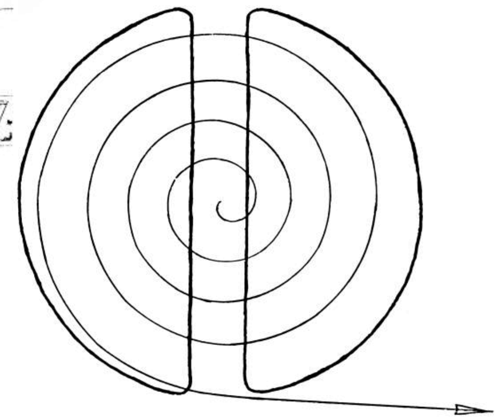
Thank you for your attention!



. . . the laboratory director



. . . the governmental funding agency



. . . the student

Cartoons by Dave Judd and Ronn MacKenzie