Vacuum Science and Technology in Accelerators

Ron Reid

Consultant

ASTeC Vacuum Science Group

(ron.reid@stfc.ac.uk)

Session 7

Basic Vacuum Design of Accelerators I

Aim

- To use some of the concepts and information from earlier lectures as an introduction to the process of delivering a working accelerator from the vacuum system viewpoint

Specifications

Vacuum performance

- Base Pressure
- Dynamic Pressure

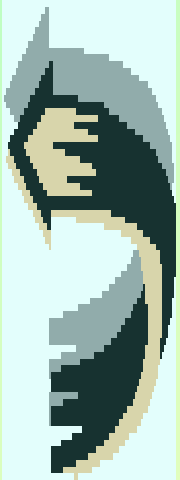
Lattice design

- Preliminary mechanical layout
- Apertures

Vacuum design

- Pumping

Design specification



Preliminary questions

What sort of machine is it?

- Experimental (“Toy”)
- Data collector
- User Facility

Implications

- Reliability
- Servicability
- Access
  - Physical
  - Duty cycle

Initial Rough Design

Guess internal surface area, A m^2

Assume an outgassing rate, q_{th} mbar l sec^{-1} m^{-2}

Determine total required pumping speed, S l sec^{-1} to reach the base pressure, P_B

$$S = \frac{Aq_{th}}{P_B} = \frac{Q_{th}}{P_B}$$

Initial Rough Design

Work out the significance of any stimulated desorption

- Location
  - Direct
  - Scattered
- Intensity
- Desorption coefficients

This will result in a dynamic gas load, Q_d (integrated along the machine)

Initial Rough Design

If $Q_d << Q_{th}$, it may be ignored and $P_d \sim P_B$.

Otherwise, calculate the extra pumping speed, $S_{d,}$ required from

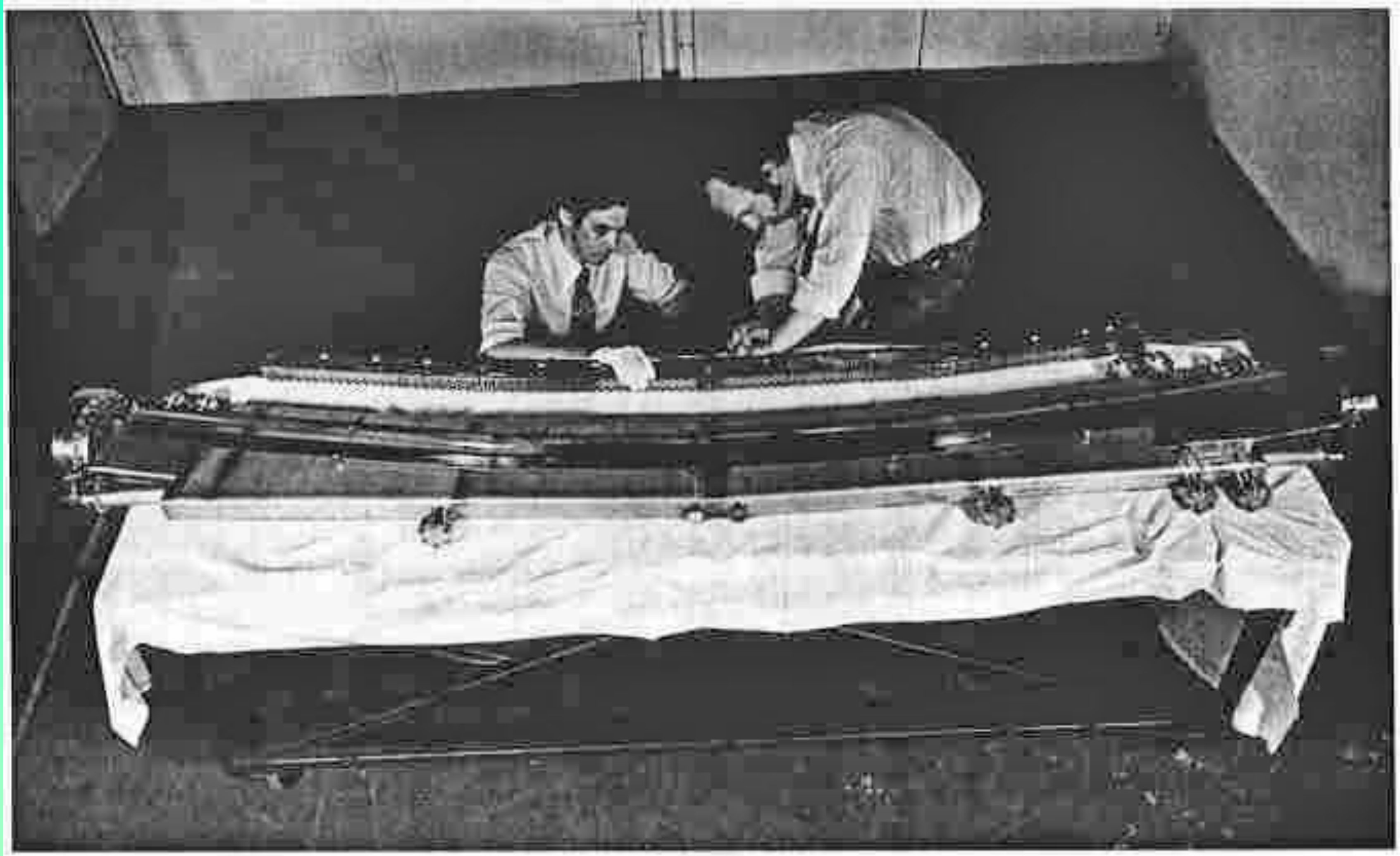
$$S_d = \frac{Q_d}{P_d}$$

If $Q_d >> Q_{th}$, then the base pressure has probably been badly chosen!

Initial Rough Design

Determine type of pumps to use

- Ion
  - Lumped
  - Distributed



Initial Rough Design

Determine type of pumps to use

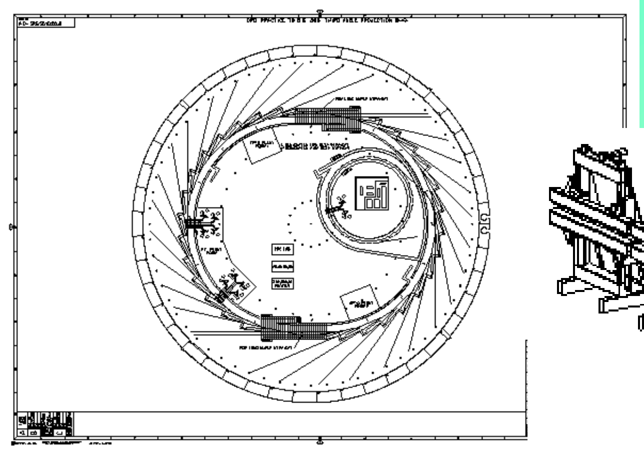
- Ion
  - Lumped
  - Distributed
- TSP
- NEG
  - Lumped
  - Distributed
  - Coatings

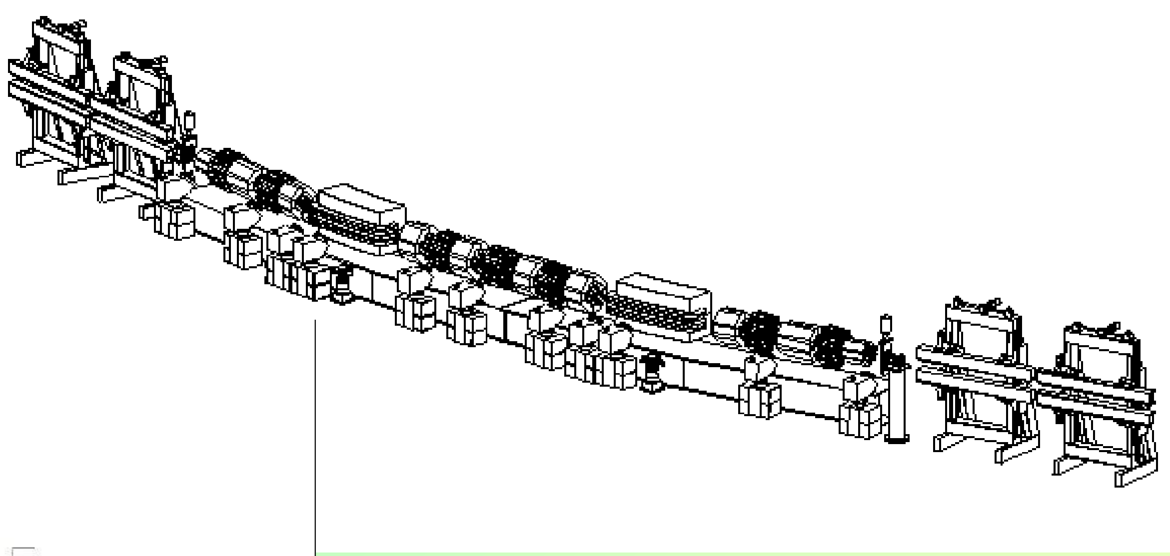
Initial Rough Design

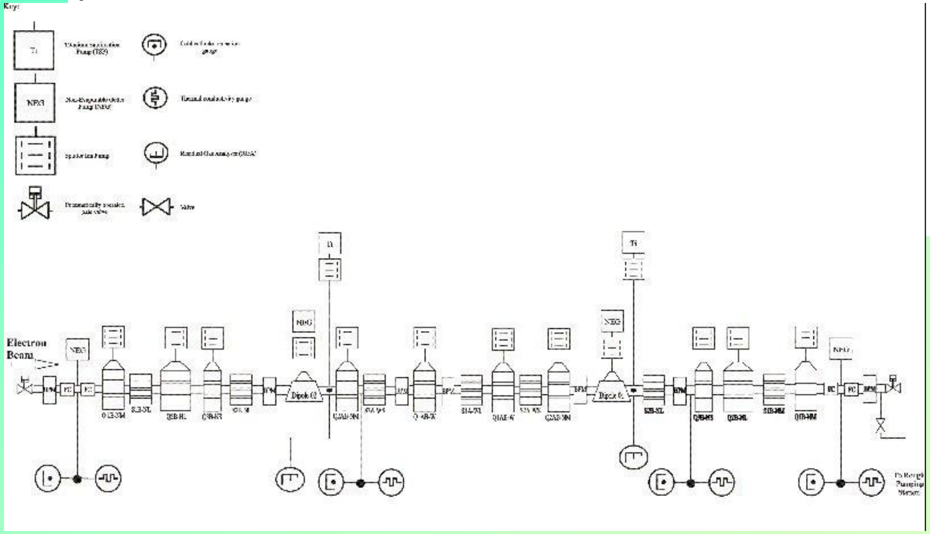
From a knowledge of what is available, with an eye on economics, and a dash of know-how, work out how many pumps of each type will be required overall.

Then, using the preliminary mechanical layout, draw up a rough vacuum design layout.

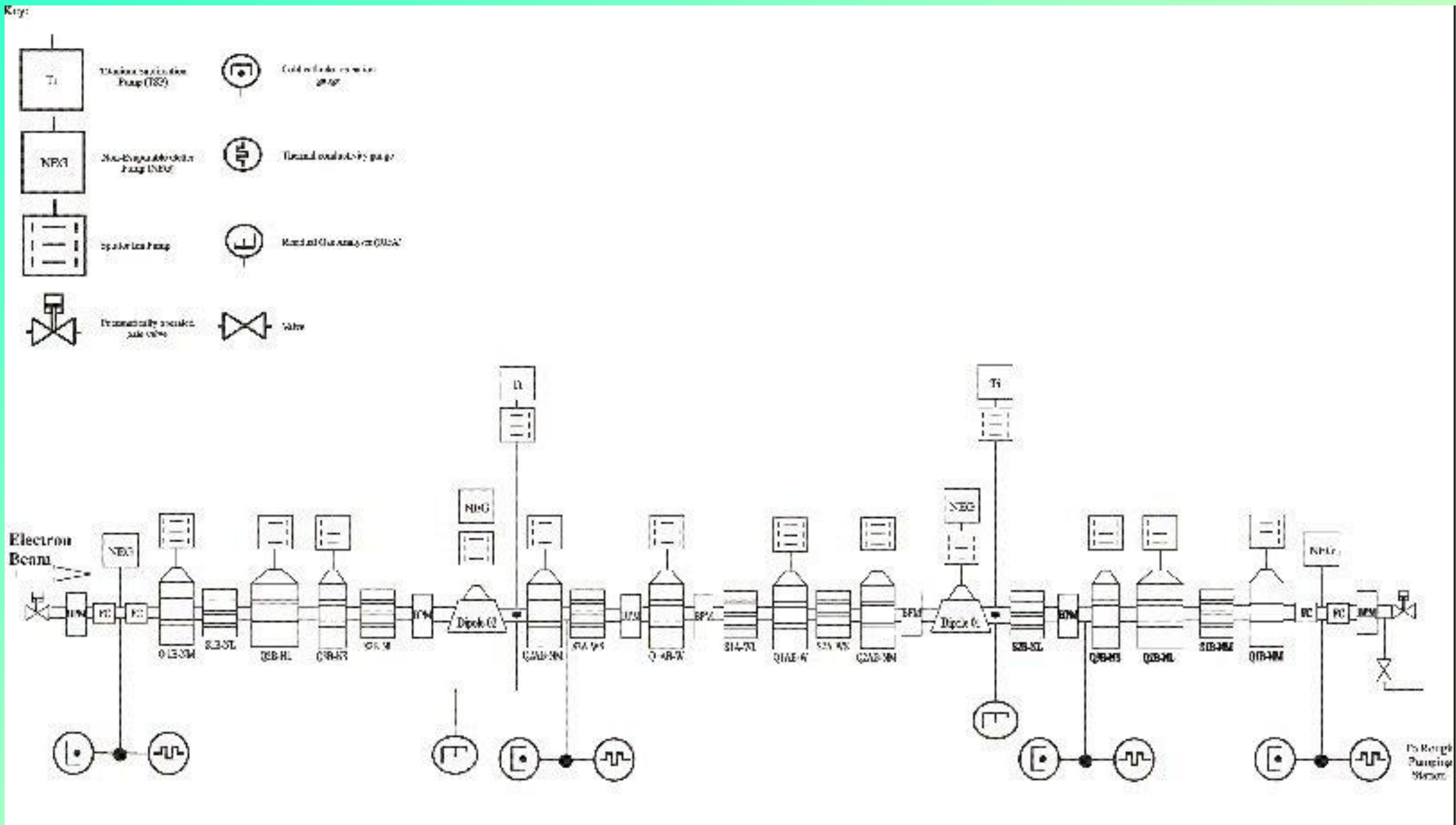
Initial Rough Design







Vacuum Flow Diagram



Towards the final design

Using the preliminary layout, carry out a full pressure distribution calculation. This will use a more detailed mechanical layout which takes into account all the conductances which the preliminary layout has ignored.

Refine the design (position, size and type of pump) to achieve the basic specification.

This may well involve re-iteration of the mechanical design (often more than once!)

Overlay the vacuum diagnostics needed to obtain the required information.

Add in valves and other necessary bits and pieces, such as roughing pump positions.

Towards the final design

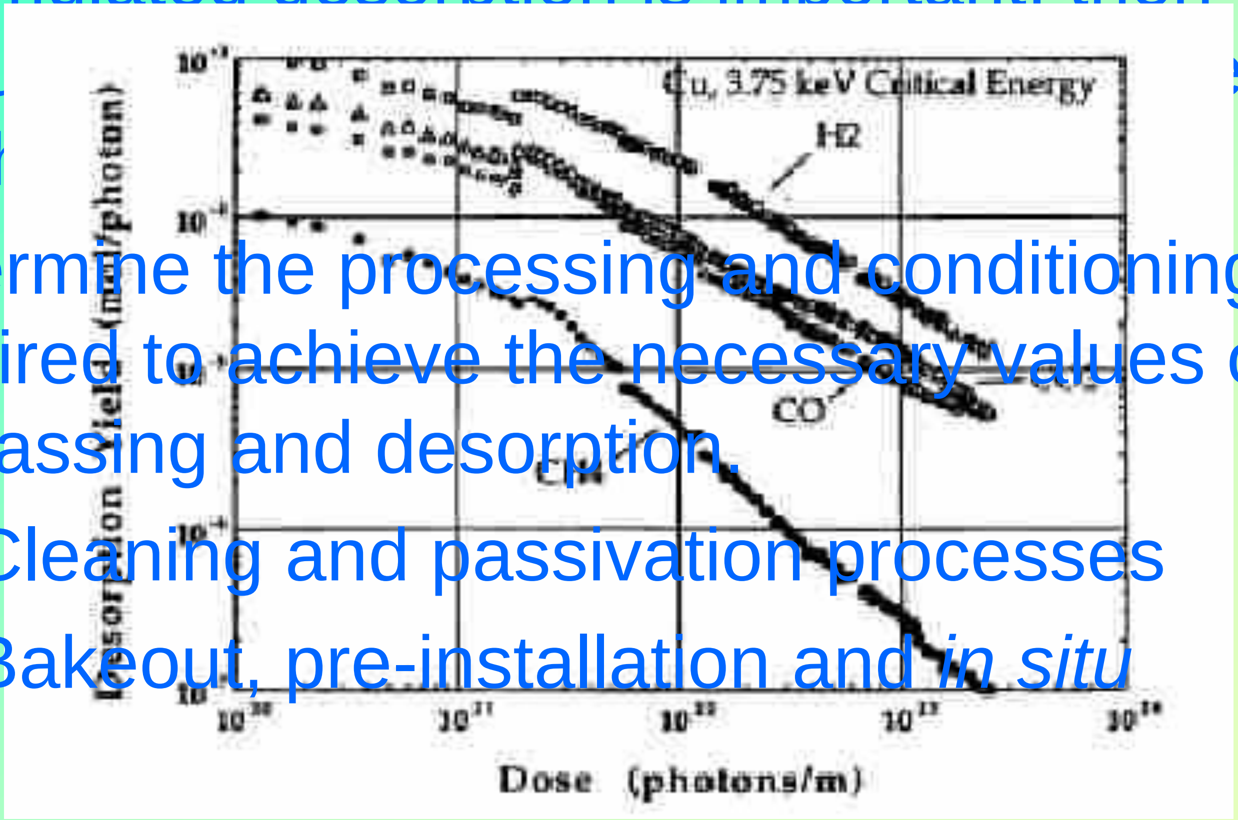
If stimulated desorption is important, then calculate the conditioning behaviour of the machine.

Determine the processing and conditioning required to achieve the necessary values of outgassing and desorption.

- Cleaning and passivation processes
- Bakeout, pre-installation and *in situ*

Towards the final design

If stimulated desorption is important, then calcu… e mach…



Determine the processing and conditioning required to achieve the necessary values of outgassing and desorption.

- Cleaning and passivation processes
- Bakeout, pre-installation and *in situ*

Towards the final design

Proceed with the mechanical engineers to produce design and manufacturing specifications and drawings for vessels and components

- Build to print
- Design and manufacture

Liaise with accelerator physicists over vessel impedances

- Transitions
- Tapers
- Spring fingers

Vacuum Diagnostics

Total and Partial Pressure measurement

- Matched to requirements
- Inherent accuracy

Location

- Representative readings
- Gauge interactions
- External influences
  - Magnetic fields
  - Radiation

Towards the final design

Draw up test and acceptance specifications and schedules.

- Leak testing
- Cleanliness
- Factory and Goods Inward

Draw up installation procedures.

… and finally

A good design is one which

- meets its specification
- allows for later improvements
- is economical
- is reliable
- is maintainable