



How Viruses Infect

Ian Robinson
Department of Physics

21 April 2000



Outline

- **Life of Viruses**
- **Importance of Structure**
- **Fundamental Constraints**
- **X-ray Diffraction Method**
- **RNA Phages**
- **Plant Viruses**



Life of Viruses

- **Small containers of genetic material**
- **Characteristic life cycle**
 - **entry mechanism**
 - **disassembly**
 - **replication**
 - **reassembly**
 - **exit mechanism**
- **Require protective coat to survive**



Importance of Structure

• Available structural materials

- **nucleic acid**
- **carbohydrate**
- **protein**
- **lipids**

• Organization is the key

- **physical, not chemical, question**



Fundamental Constraints

- **Gene must code for the protein**
- **Minimum size of folded protein**
- **Deductions**
 - **Minimum overall size**
 - **Modular construction better**
 - **Room for other functions**



X-ray Diffraction Method

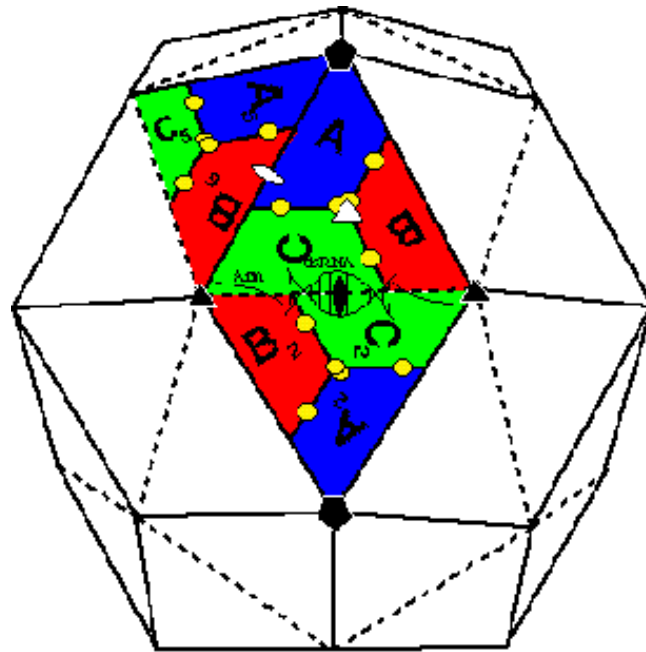
- **Crystals preserve orientation**
- **Wavelength matches atomic spacing**
- **Linear dependence of amplitude**
- **Phase is not measured directly**
- **Phase can be determined**
- **Powerful sources available**



RNA Phages

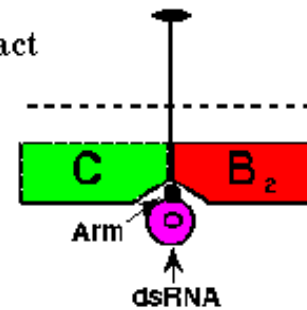
- **3500 base SS RNA**
- **3 genes**
- **MS2 has T=3 structure**
- **Q β uses disulfide bonds**

Quasiequivalent Contacts

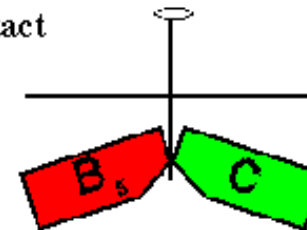


T=3

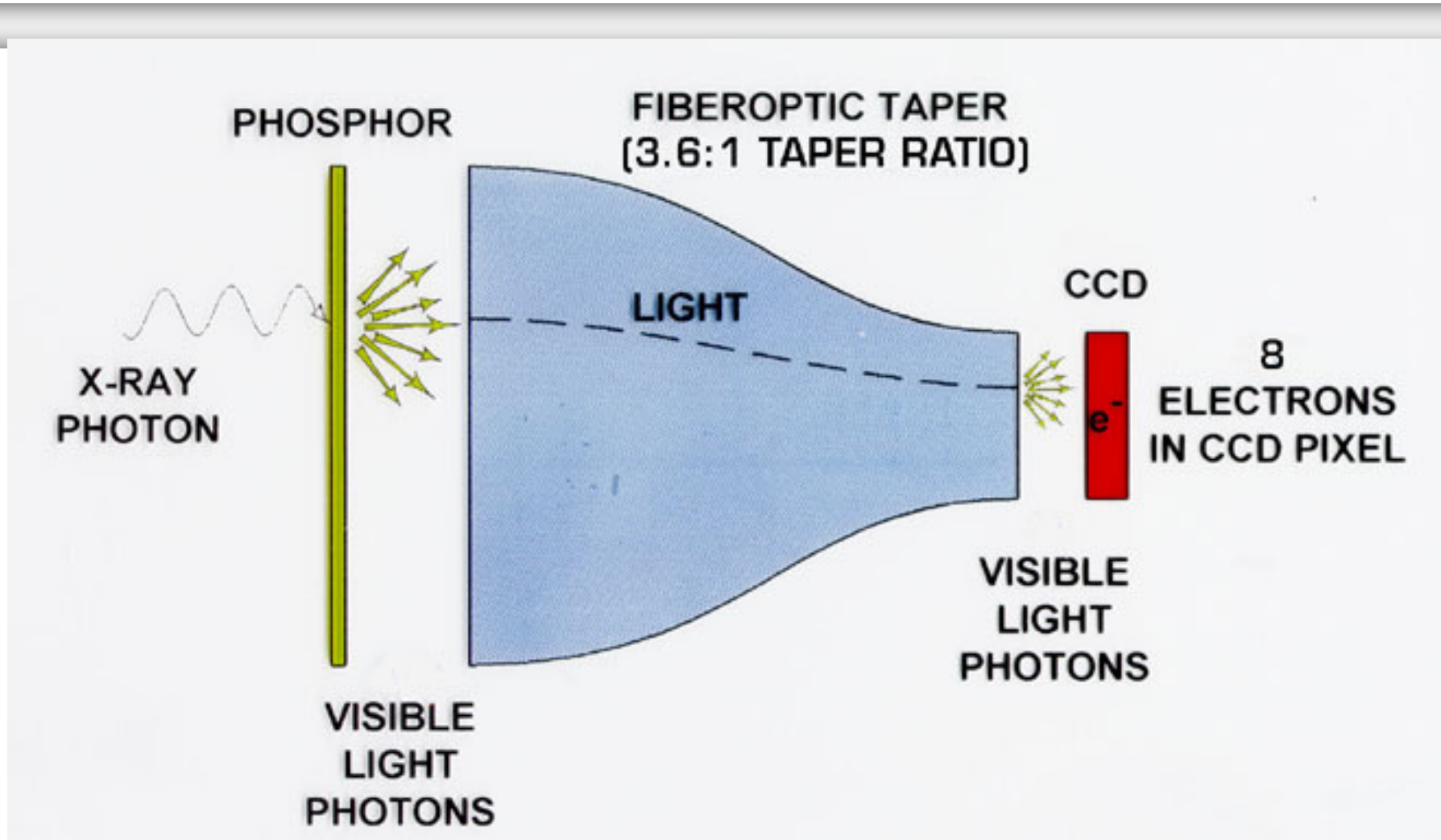
Flat contact



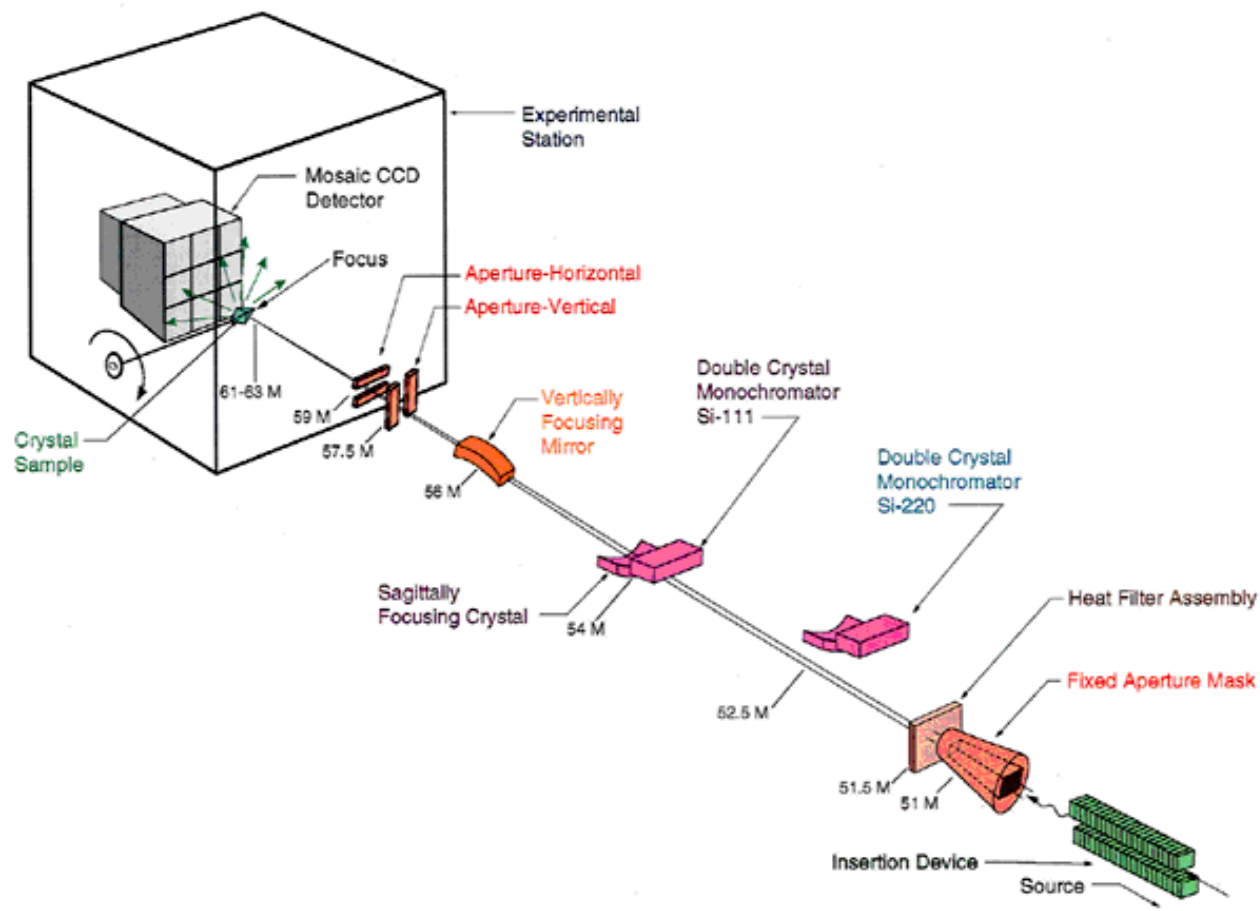
Bent contact



CCD detector with taper



APS beamline (SBC-CAT)



SBC Insertion Device Beamline



Plant Viruses

- **Smallest viruses known**
 - **Alfalfa mosaic virus (AMV)**
 - **Tomato bushy stunt virus (TBSV)**
 - **Turnip crinkle virus (TCV)**
- **Divalent cations, Ca⁺⁺**
- **Multiple configurations**
- **Assembly pathway**



Future Directions

- **Maturation pathways**
- **Cryo- and X-ray microscopy**
- **Energetics**
- **Kinetics of assembly/disassembly**
- **Drug design**



Conclusions

- **Structure can be known *exactly***
- **Simple geometric principles**