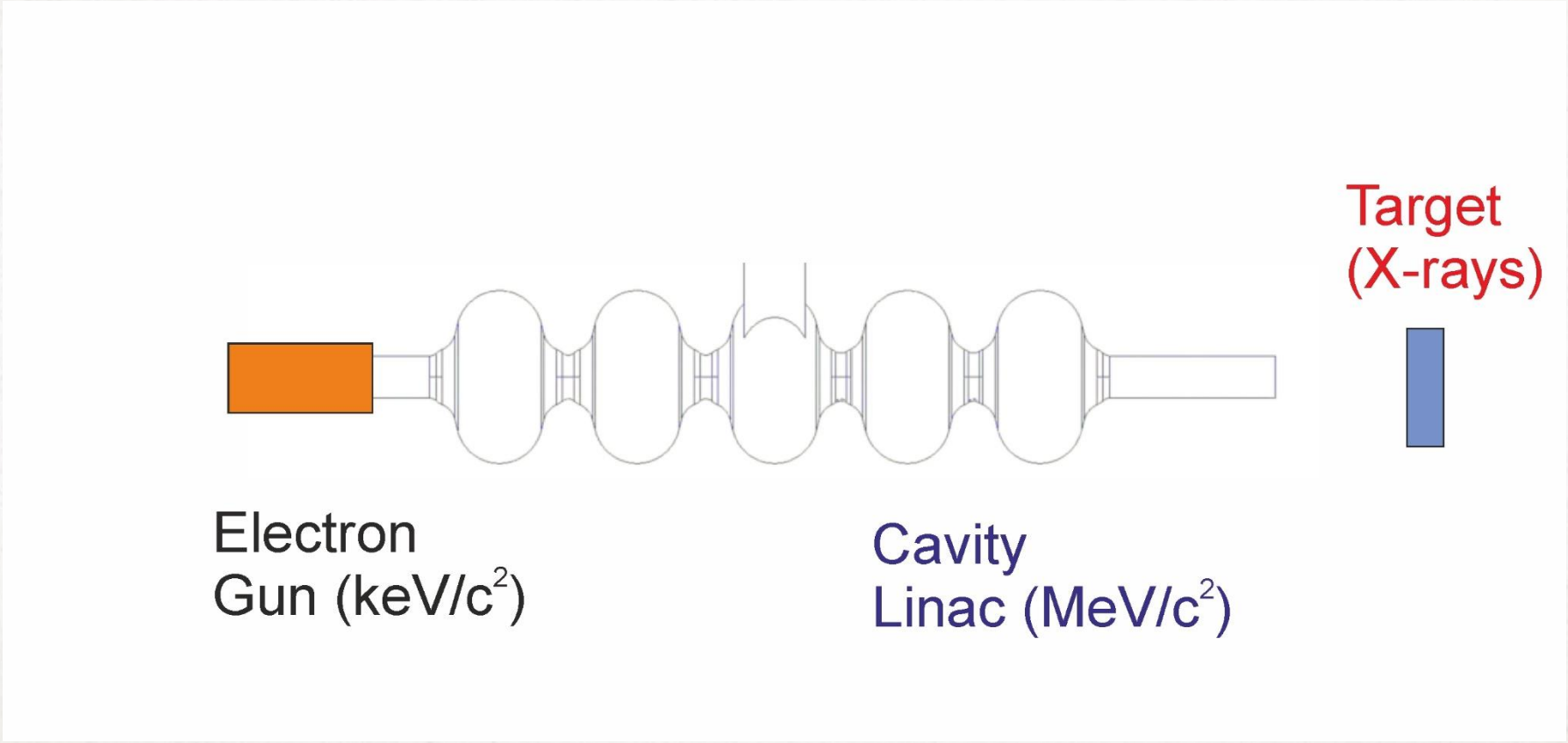
# LINAC CAVITY SIMPLIFICATION

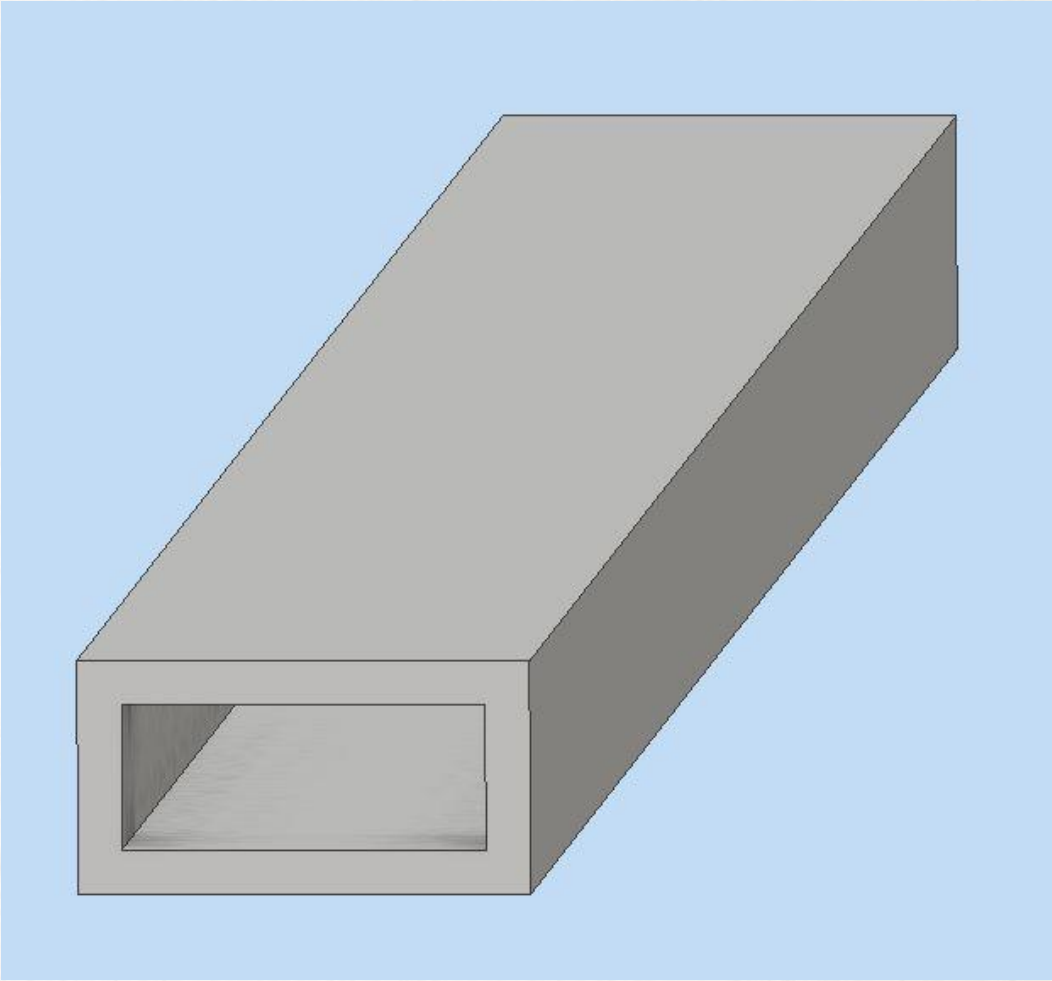
TOWARDS COST-EFFECTIVE ELECTRON BEAM ACCELERATION

# WANT ELECTRONS TO GAIN ENERGY

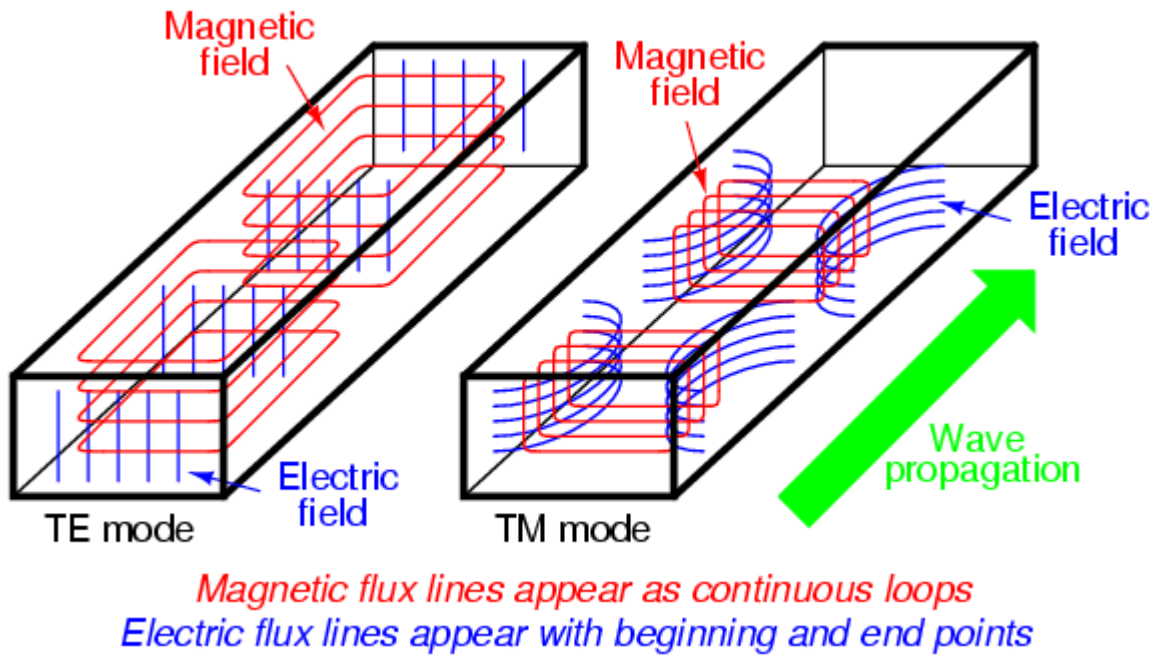


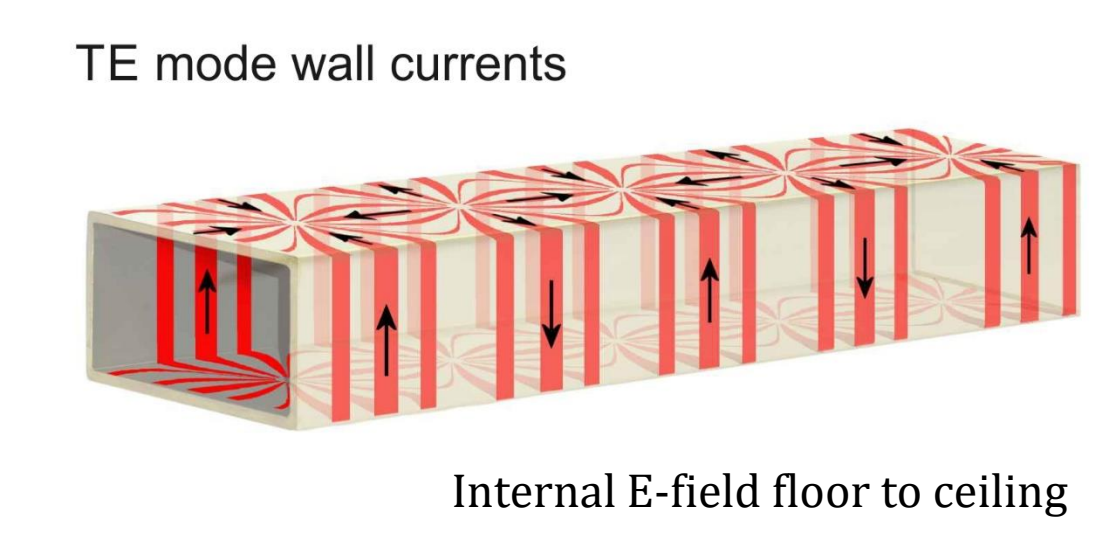
# RF WAVEGUIDE BASICS

- Waveguide purpose
  - Confine electromagnetic waves
- General form for primitive guides
  - conducting walls formed into prism shape
    - e.g. box section
    - e.g. cylinder
- Effect of confinement
  - excludes TEM mode from propagating
  - [just as light is not TEM in focal plane]
  - Useful modes TM, TE
    - (TE not used for cavity)



# WAVEGUIDE FIELDS & CURRENTS

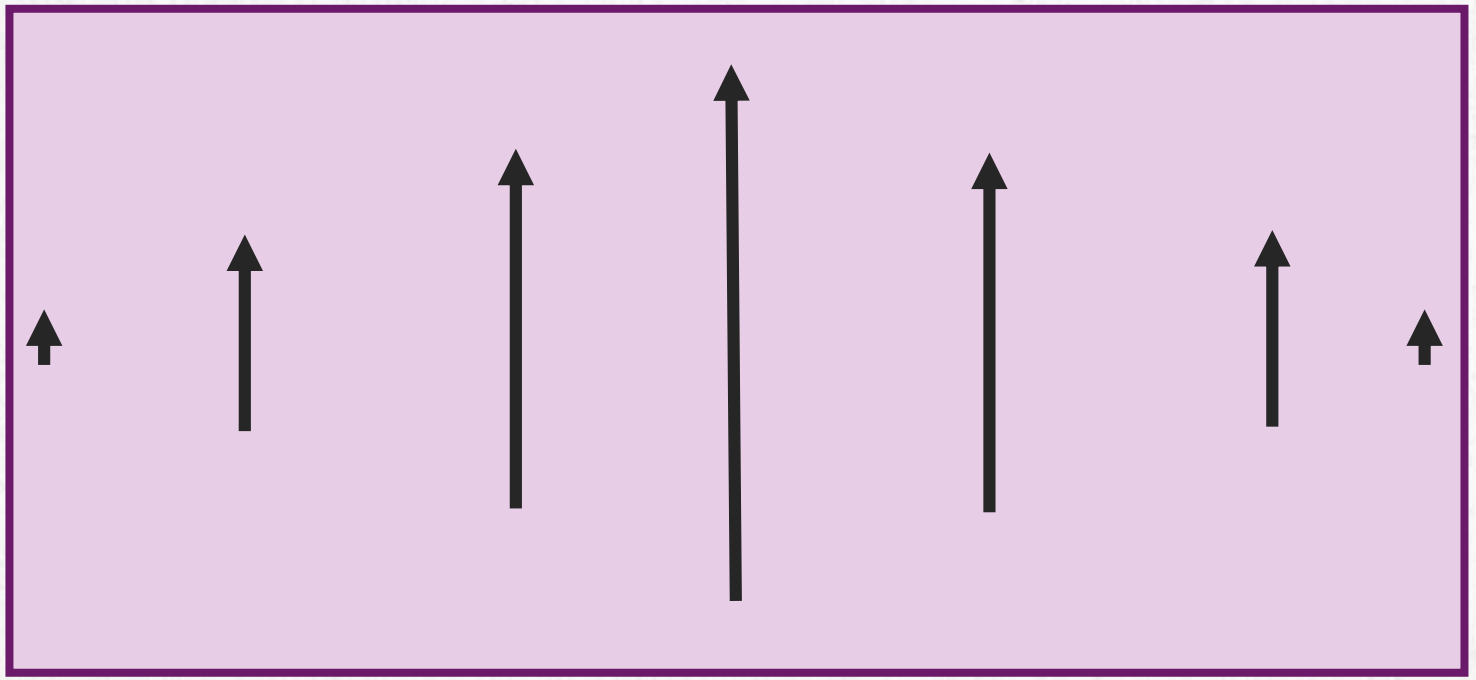



- Conventional currents positive
- Charge imbalance changes during RF cycle

# E-FIELD PROFILE OF TE MODE (AT ONE INSTANT)

Negative charge on ceiling [centre line]



Positive charge on floor

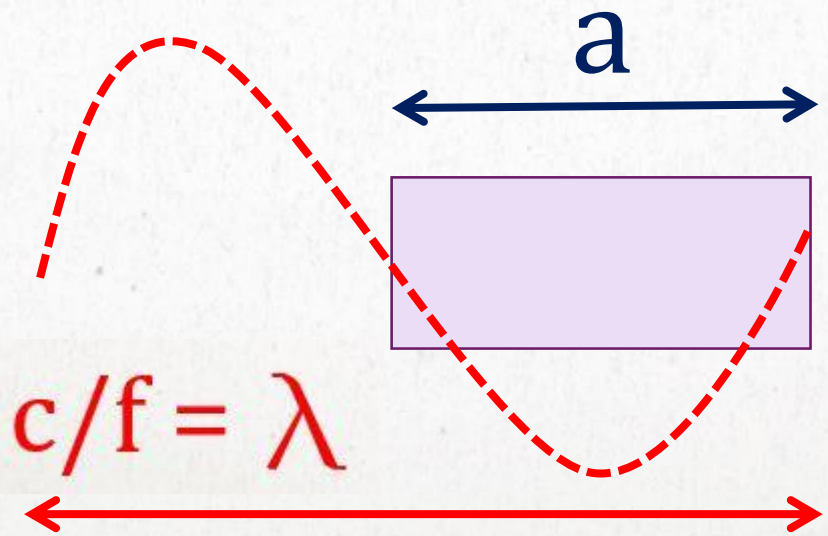
# LENGTH SCALE: TE MODE CUT-OFF FREQUENCY

- At cut-off: One half wavelength spans waveguide width **a**
  - From side wall node
    - zero vertical E-field
    - E-field screened completely by current flowing up the wall
  - to opposite wall node
- Longer waves
  - lower frequencies

    decay exponentially

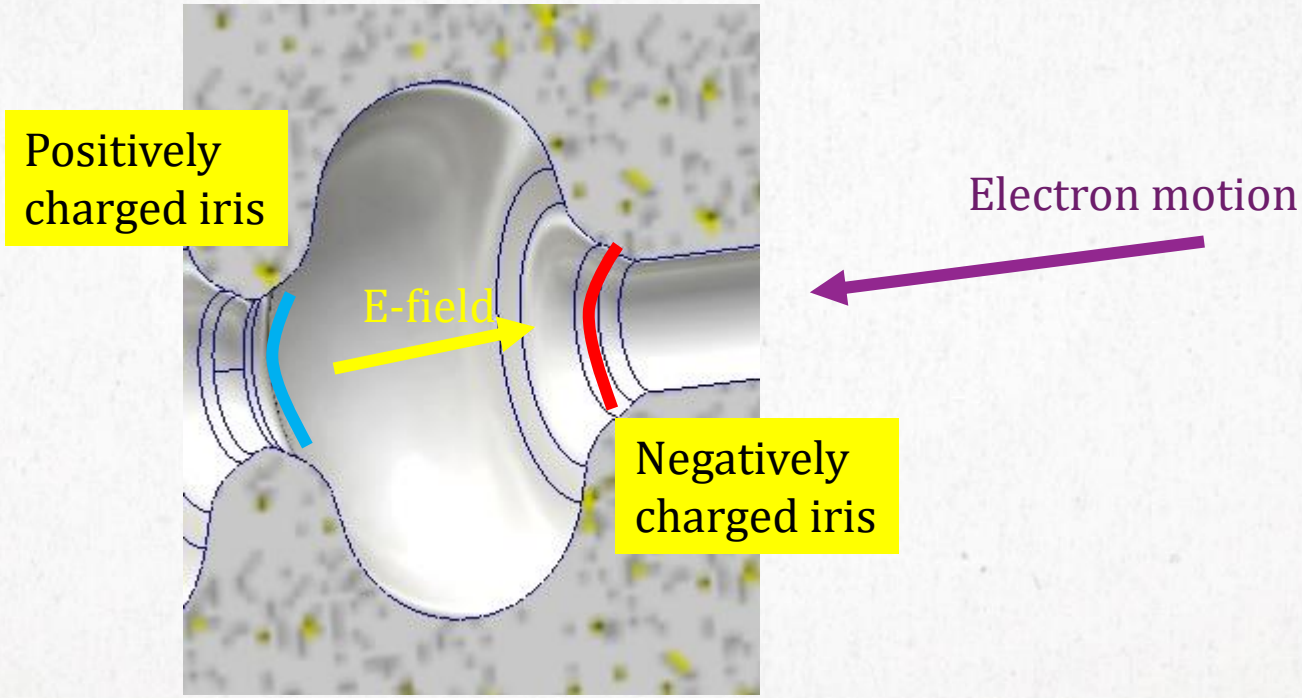
    along z : non-propagating

$$c/f = 2a$$



# TM MODE - USED IN ACCELERATOR CAVITIES

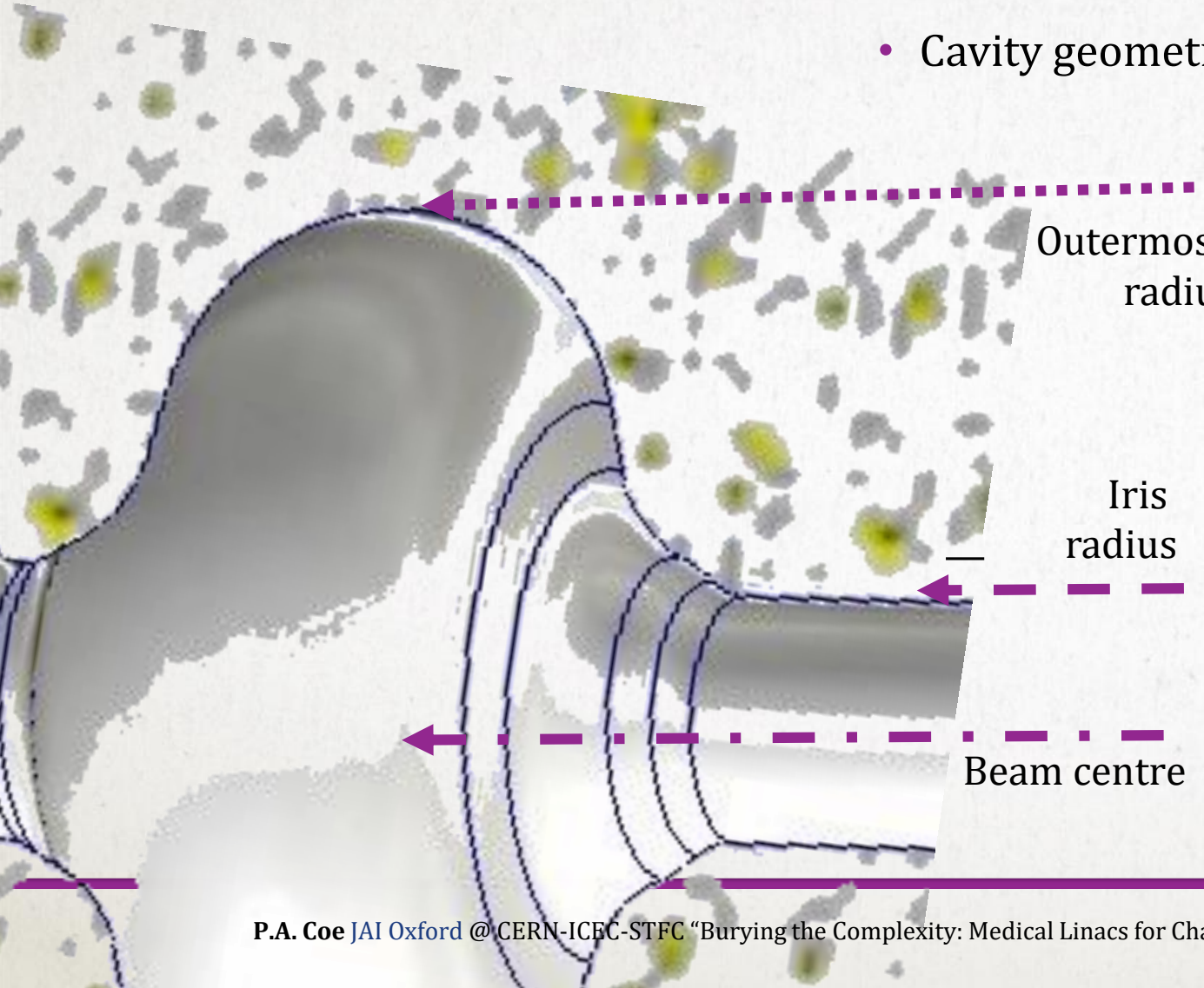
When accelerating electrons, currents flow along the walls in z directions, from iris to iris

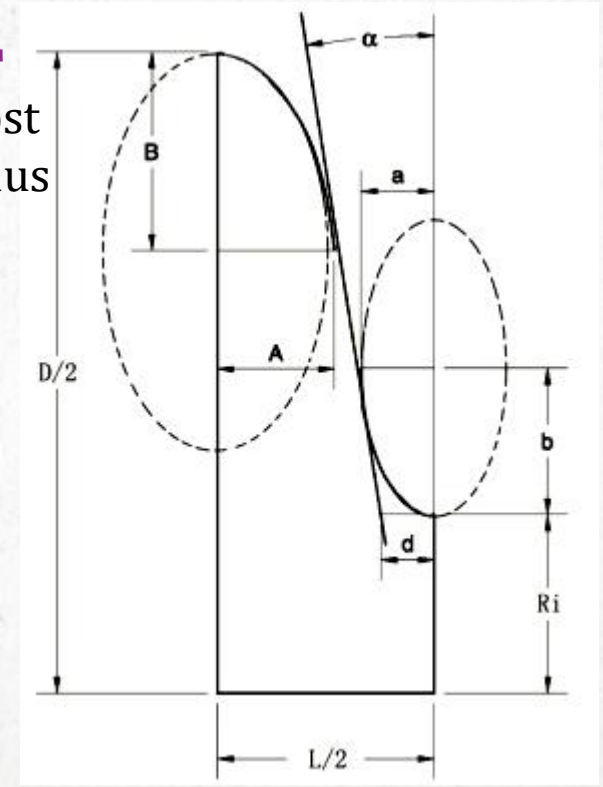



When accelerating electrons, need e- and E to be in opposite directions

# ELLIPTICAL CAVITIES

- Cavity geometry constructed using reference ellipses



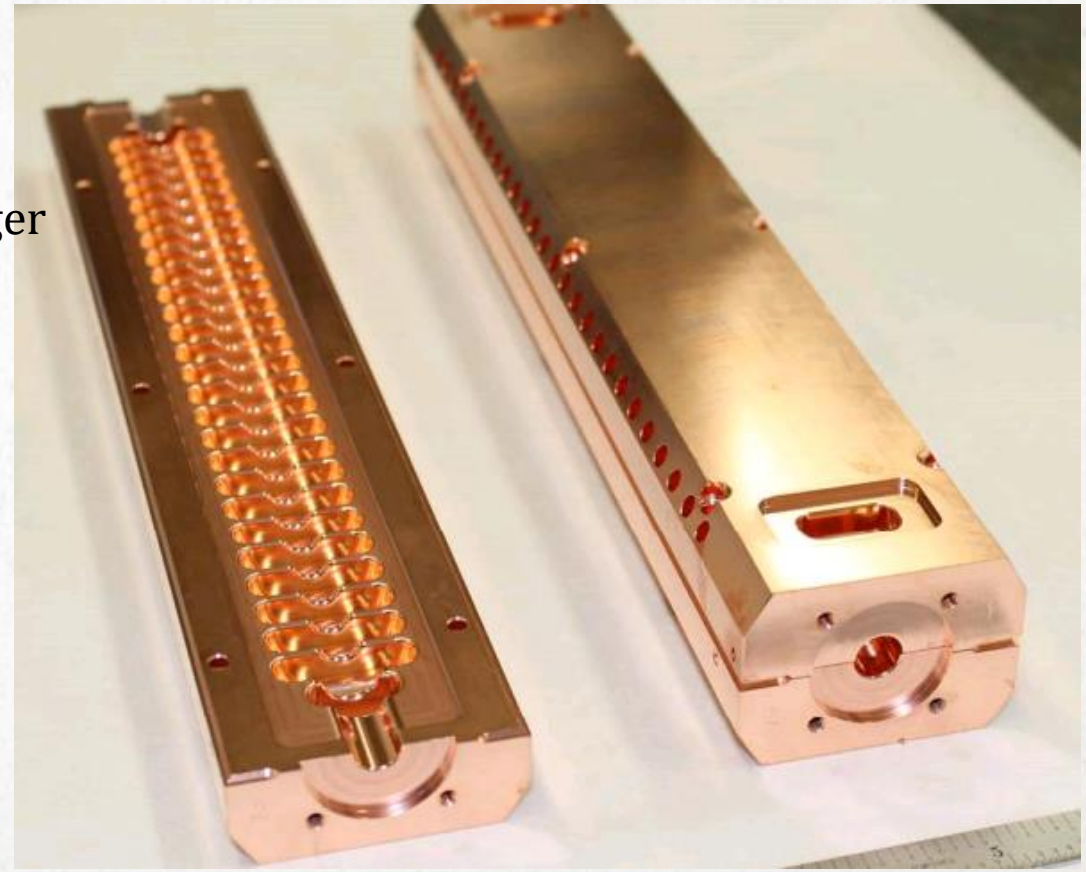

$$R = x_{01}\left[\frac{c}{\omega}\right]$$

$$2.40483 = x_{01}$$

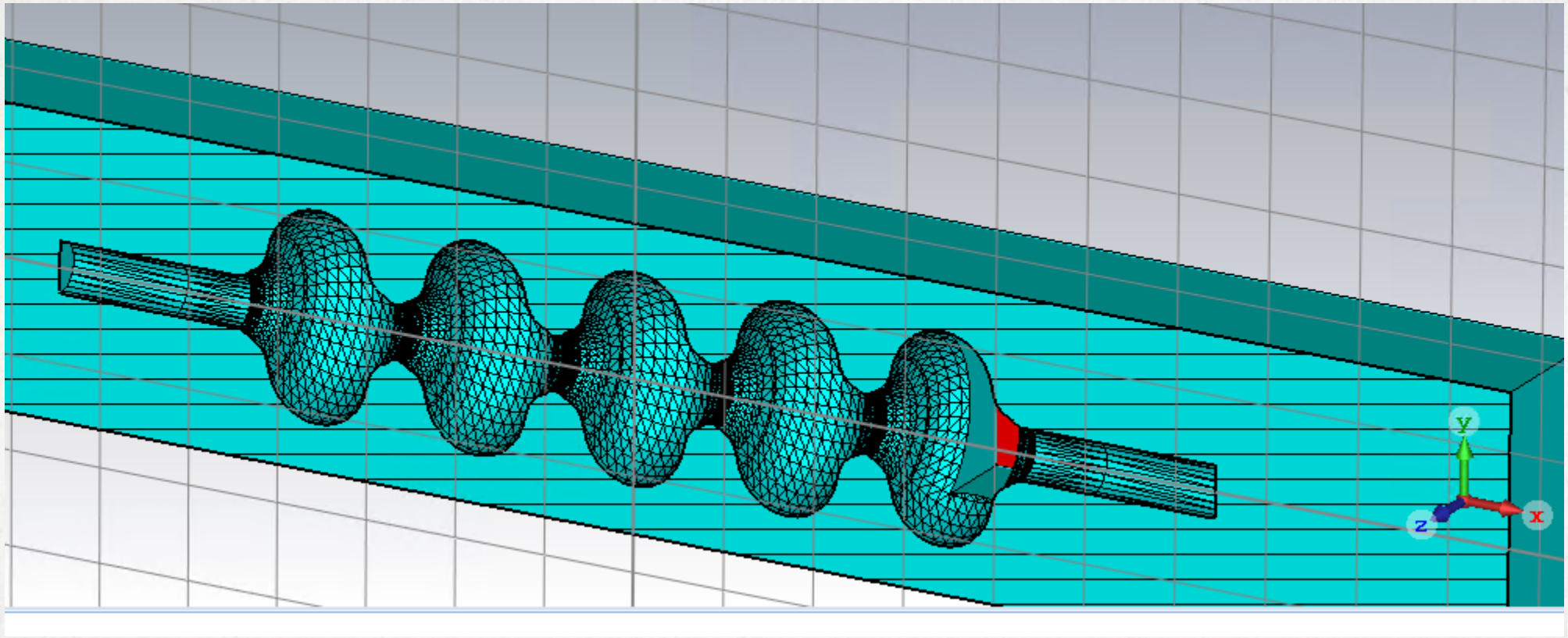
# SPLIT CAVITY – BASIC "CLAM SHELL" HALVES

- Idea (right) implemented as CLIC prototype
  - Courtesy Walter Wuensch (CERN)

- First design prototype (9.3 GHz) slightly larger
  - Approx ½ inch radius
  - Desired length ~few 100 mm



# STUDYING CAVITY RF PROPAGATION - CST




- Using simulation tool CST to model E-field, H-field in designs
- Will be taking up CERN offer of cavity design training week

# RADIO FREQUENCY SOURCES FOR ACCELERATION

- Aim to use commercially available RF power sources
  - First examples based on 9.3 GHz

- Simple metallic cavity design
  - two halves joined like clamshells
  - aluminium alloy
    - readily machinable
    - good conductor of electricity (used in HV cables)
    - good thermal conductor
    - cheap
    - lightweight 2.7 x water density (vs ~9 for copper)

L3 Electron Devices

L6145
X-Band
Klystron Amplifier

The L6145 is a fixed-tuned, cathode-pulsed X-band klystron amplifier for use in high energy linear accelerator systems.

Peak output power exceeds 5.0 megawatts at 0.4% duty; average power capability is 20 kilowatts.

DS61450313

**Performance**

| | |
|---|---|
| Frequency | 9300 MHz |
| Peak Output Power | 5.0 MW min |
| Beam Voltage | 135 kV max |
| Beam Current | 86 A max |
| Drive Power | 50 W max |
| Duty | 0.4 % RF |
| RF Pulse Width | 3.2 µs typical |
| Beam Pulse Width | 4.0 µs typica |
| Heater Voltage | 7.0 $V_{rms}$ or Vdc |
| Heater Current | 21 $A_{rms}$ or Adc |
| Ion Pump Voltage | 3.0 kV min |
| Solenoid Voltage | 130 Vdc max |
| Solenoid Current | 35±1 Adc |
| Bucking Coil Current | 1.5 Adc max |

**Operational Requirements**

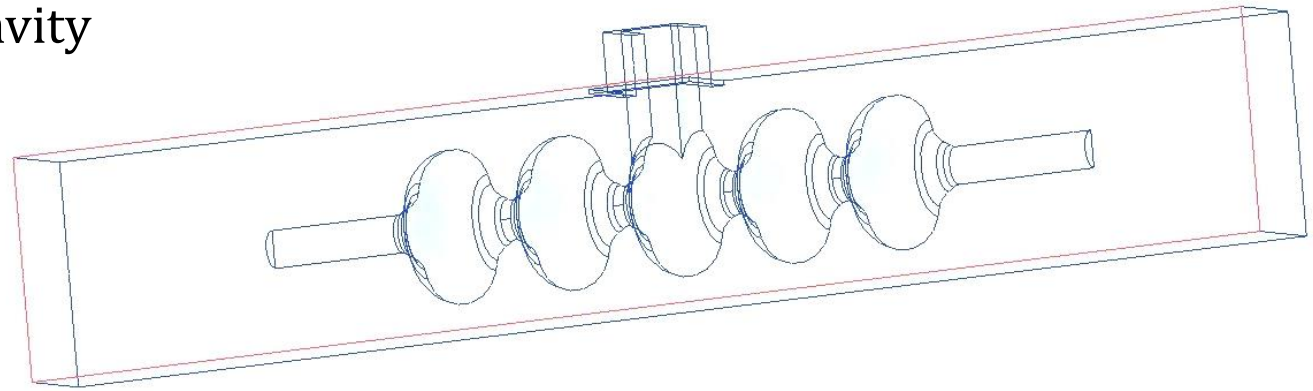
| | |
|---|---|
| Coolant, Water | |
| Inlet Temperature | 35°±15 °C |
| Body-Collector Flow Rate | 12 GPM duty dependent min |
| Solenoid Flow Rate | 3.0 GPM min |
| Waveguide Pressurization | $SF_6$ or Vacuum |
| Waveguide Pressure | 35 PSIG max |

**Mechanical Characteristics**

| | |
|---|---|
| Physical Dimensions | 29.1 in. L x 10.4 in. W x 14.2 in. H |
| Weight | 91 lb. |
| Focusing Solenoid | per L-3 P/N 0490453 |
| Focusing Solenoid Weight | 360 lb. |
| Mounting Position | Vertical, Collector up |
| RF Input Connector | Coaxial, type-N female |
| RF Output Waveguide | WR-112 |

# FORTHCOMING WORK

- Taking up offer of training in CST & Accelerator design approaches at CERN
- Work on preliminary “clam shell” cavity
  - Design (mechanical)
  - Study (simulate RF)
  - Make (Cut metal, assemble)
  - Measure (Q factor)



- Base assumption is RF in 6 GHz to 12 GHz (C or X band)
  - Starting by looking at 9.3 GHz