Electrostatic separator limits

With input from:

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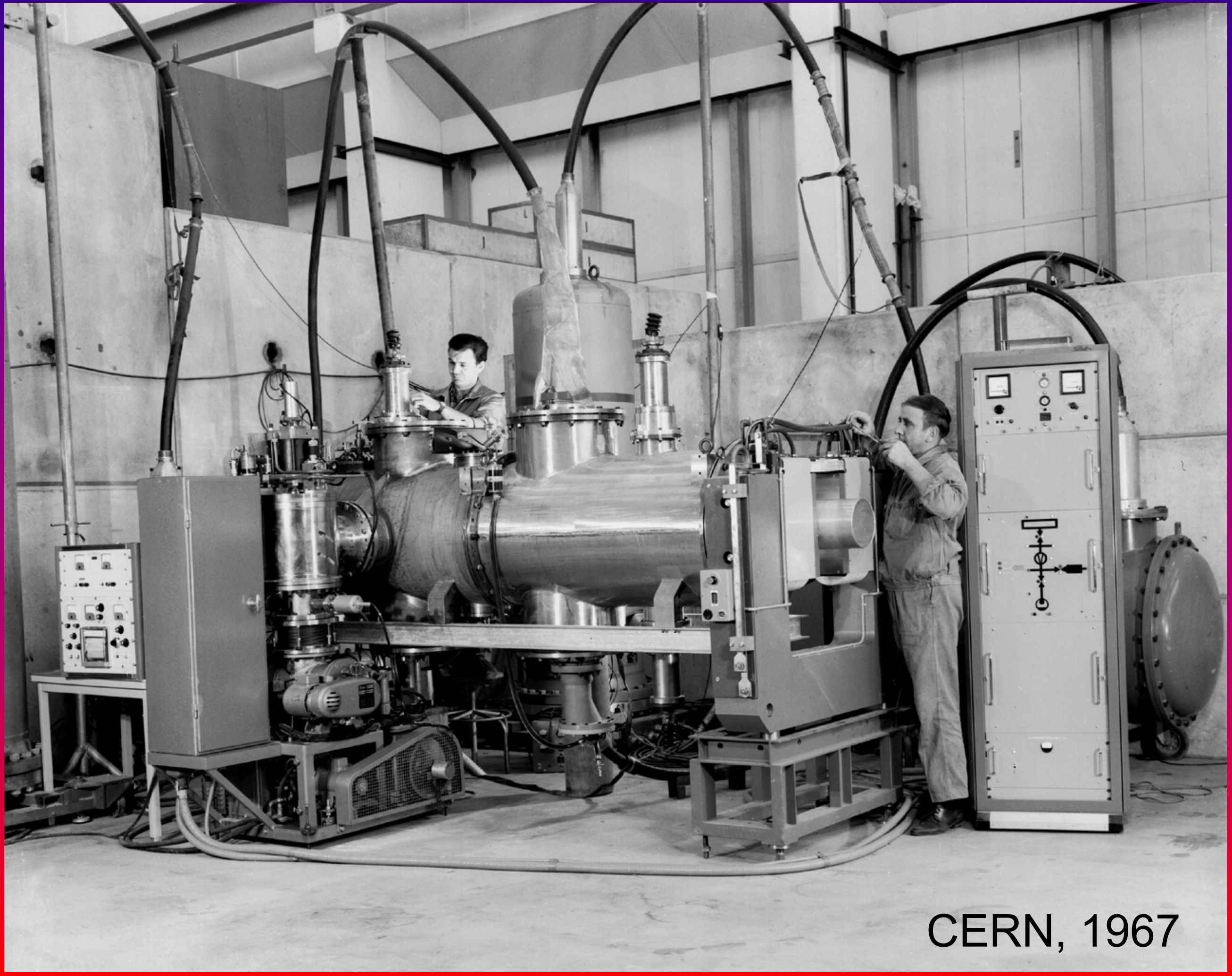
B. Goddard



CERN, 1967

Design issues

- Field strength
  - Electrode material (Al alloy, Ti, Stainless steel)
  - Surface preparation (electro polishing, mechanical polishing, anodization)
- Mechanical issues
  - Electrode configuration (continuous or split electrodes)
  - Vertical / horizontal (stresses on electrode supports)
  - Number of units / redundancy in case of failure
  - Bake-ability
  - Variable gap vs. fixed gap

Maximum field strength limits [1]

Field strength maxima strongly depend on:

- Electrostatic vs. pulsed application
- Size of the electrodes
- Gap width
- Electrode material and preparation
- Vacuum

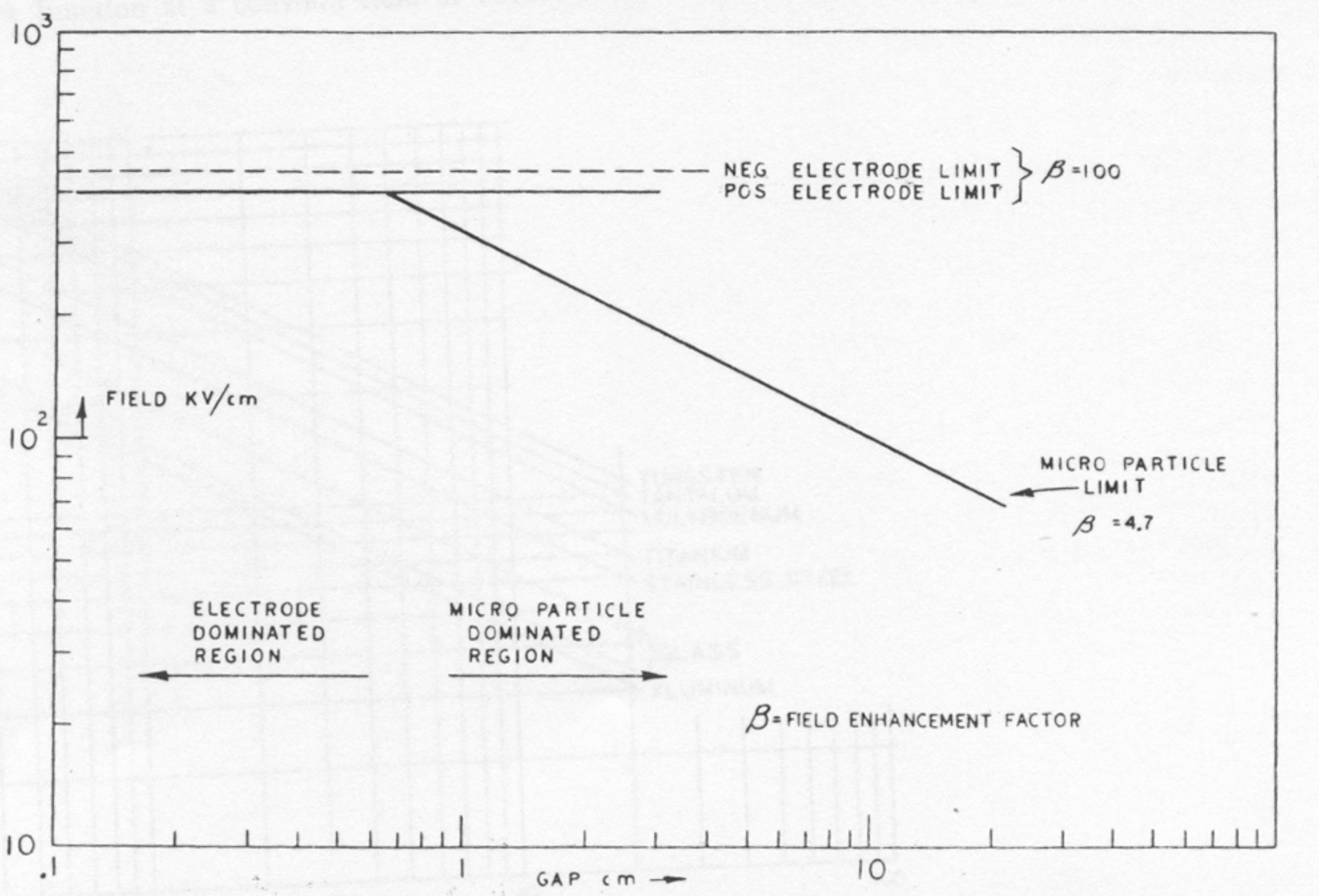


Fig. 3. hv breakdown as a function of initiatory mechanisms.

PS SEH septa experience

- Field strength used in operation approx. 8.2 MV/m
- Unipolar power supply: -180kV in operation
- Cathode Al alloy, anodised. Length 1850 mm

- Severe performance degradation over time
  - Cathode technology cannot withstand direct or scattered SR
  - Mo foil warping due to local heating by beam

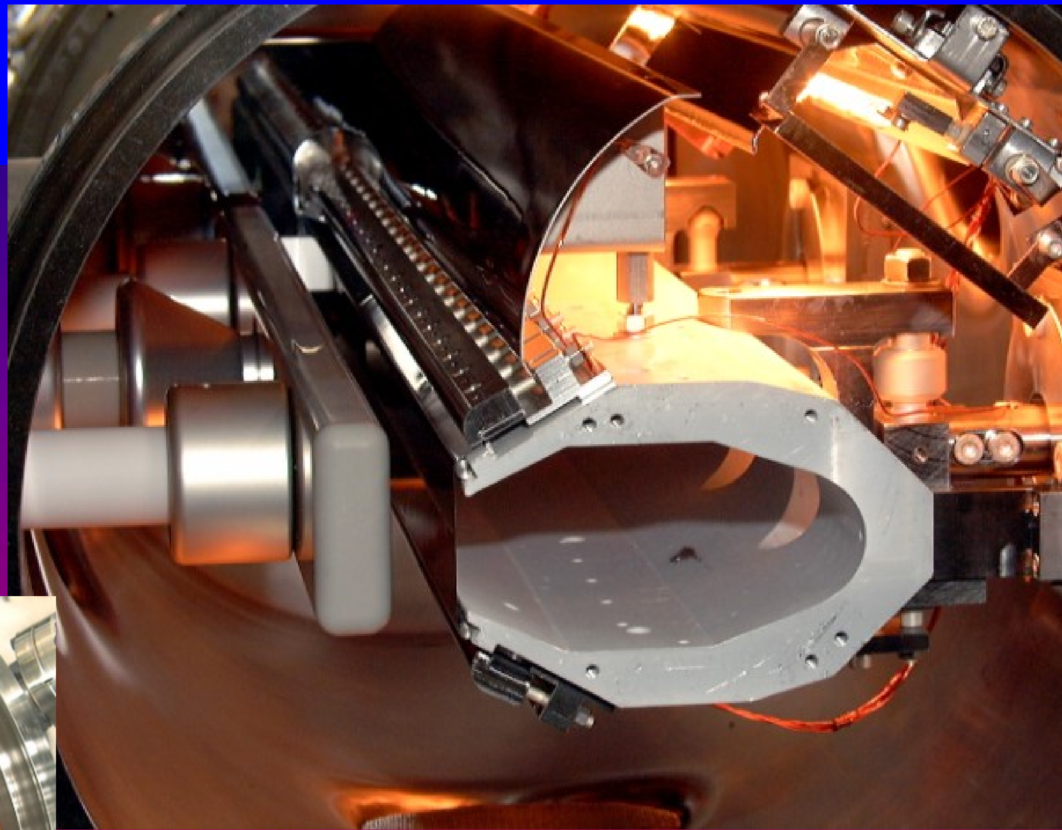
- Severe performance degradation from ions accelerated onto cathode
  - System of slow ion screening
  - Sensitivity to vacuum pressure and quality
  - Not bakeable at present

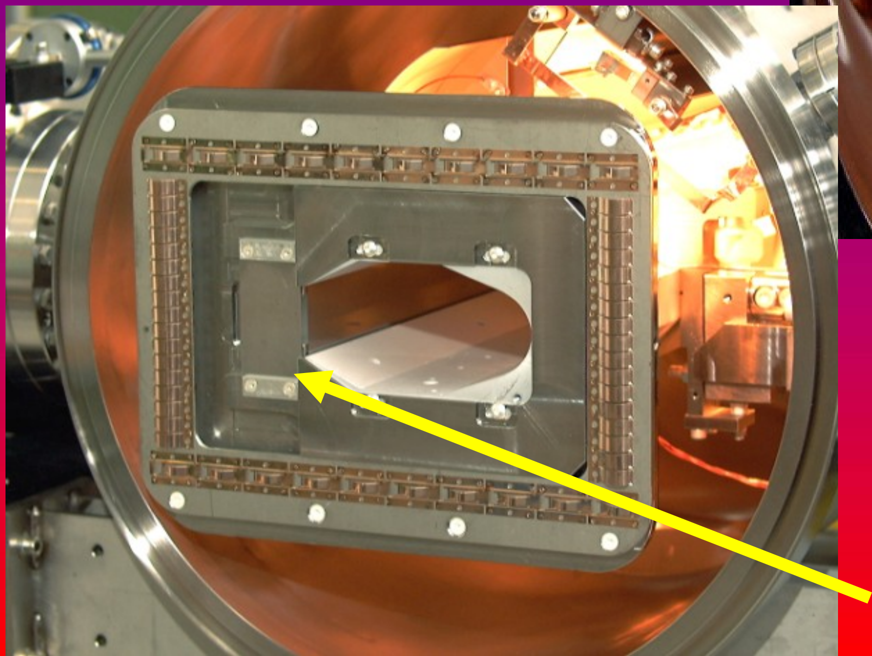
- Limited lifetime
  - cathodes 2 years typically
  - Oil filled feedthroughs > 10 yrs
  - 3M filled feedthroughs significantly less (3 yrs?)
  - Lifetime increase since improved vacuum design of vacuum vessel and pumping

→ the PS design is not ‘robust’ at all

PS septa

Anodized Al alloy cathode
and Mo septum foil





Al screen at entry of ‘active’ area

SPS ZS septa experience

- Field strength used in operation approx. 10 MV/m
- Unipolar power supply: -220kV in operation
- Cathode Al alloy, anodised. Length 2997 mm

- Generally ~50,000 sparks per year (total for 10 septa)
  - ‘Acceptable’ because SPS is a pulsed machine (~15 s cycle)
  - Virtually all sparks caused by beam (but not always synchronous with it)
  - 5 adjacent units decoupled by 400MΩ resistors

- Severe performance degradation with SR from leptons
  - Cathode technology cannot withstand direct or scattered SR

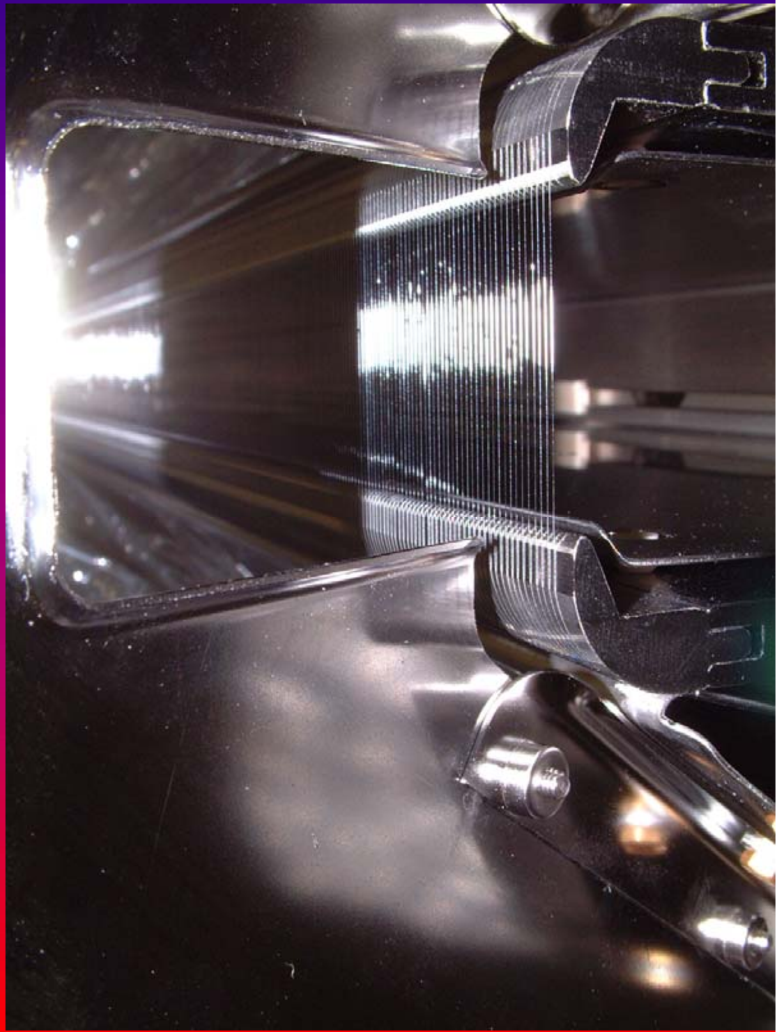
- Severe performance degradation from ions accelerated onto cathode
  - System of ion trapping electrodes required (~7 kV)
  - Sensitivity to vacuum pressure
  - Bakeable design (90 ºC in situe, 300 ºC in the laboratory before insertion of anodised cathode and deflectors)

- Limited lifetime of cathodes and HT feedthroughs
  - 4-6 years typically

→ the SPS design is not ‘robust’

SPS ZS

SPS ZS anode with the ion traps on the assembly bench



Replacement rate (10 years operation)

- LEP ZL separators ~1 (40 installed =0.25 %/yr)
- SPS ZS septa ~12 (10 installed = 12 %/yr)
- PS septa ~ 14 (2 installed = 70 %/yr)

- But… no systematic experience of LEP separators exposed to high flux of charged particles.

Design issues (cont.)

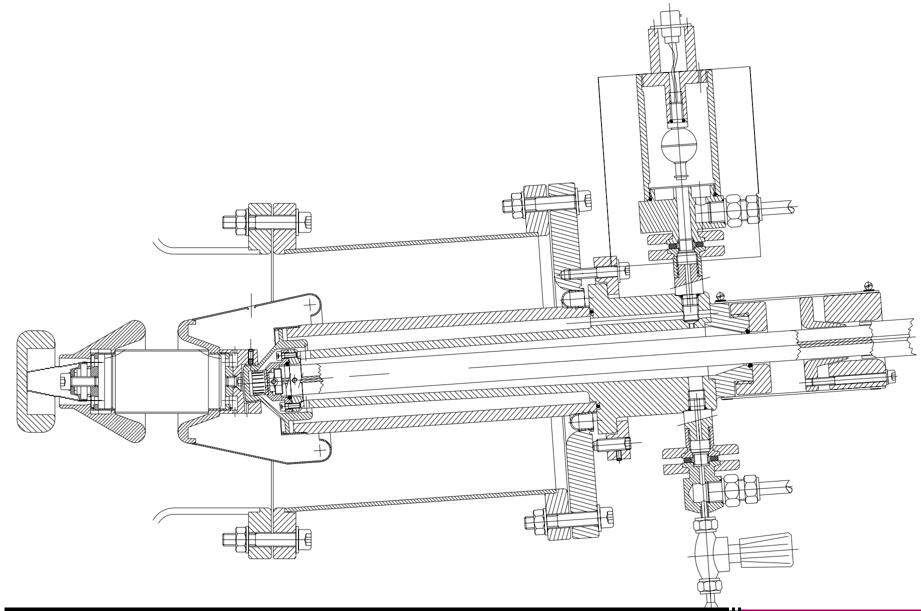
- Electrode supports (insulators) design
  - Insulator treatments (ion implantation, ..), device glow discharge
- HV circuit
  - Recovery after sparking, HV resistors
  - Feedthrough
  - Cables and connectors
  - H.V. generator, Voltage margin for conditioning, Current margin to cope with dark current / beam loading / recovery after sparking
  - Spark detection

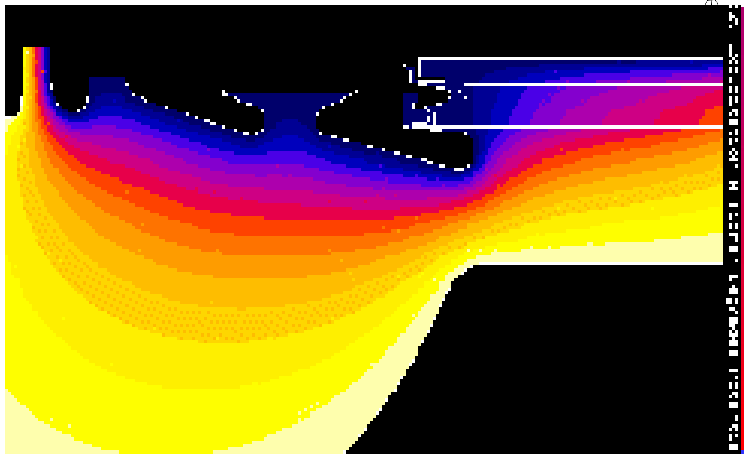
Feedthrough

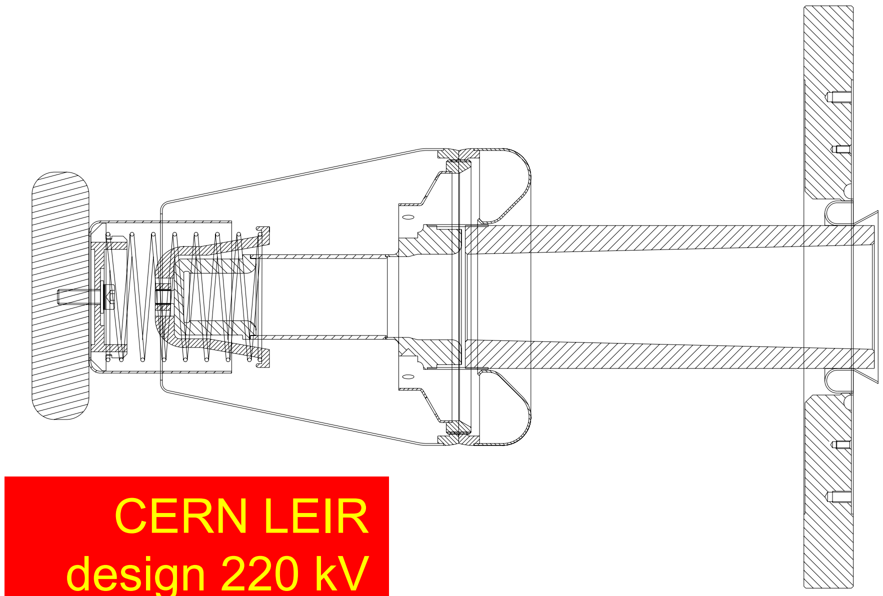
- Reliable design up to 300 kV available at CERN
- 600 kV design used in laboratory still available
- Modular: can be exchanged in case of failure without removal of separator from beam line
- Insulating liquid
  - SHELL Diala M ™, needs outgassing before use and regular replacement because of radiation
  - 3M Fluorinert FC-77 ™ with continuous "regeneration" avoid the creation of hydro fluoric acid

Feedthrough

CERN PS design 300 kV







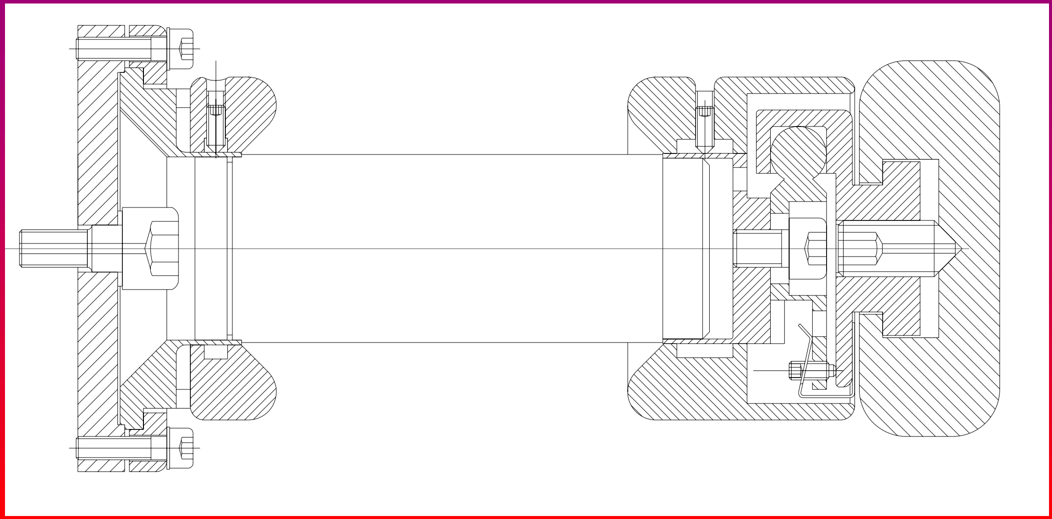
CERN LEIR design 220 kV

Design and Technical Challenges of the ILC Small Angle Interaction Regions

October 19th, 2006 **J. Borburgh, CERN, AB/BT**

Electrode support

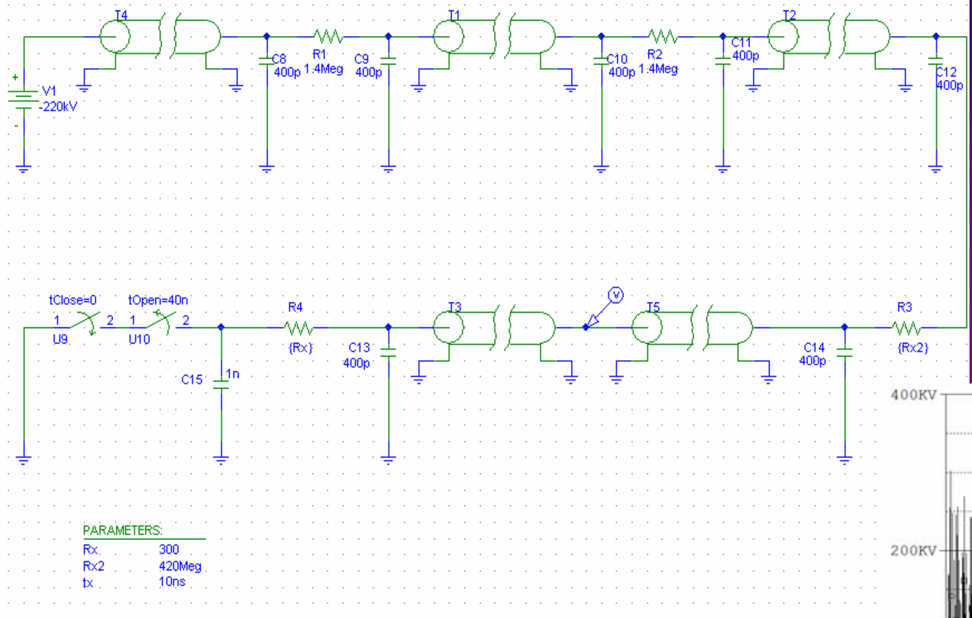
- Choice of insulator material
  - Pure insulator / slightly conductive
  - Some work on insulator treatments available at CERN
  - Glow discharge experience at KEK
- HV deflector design



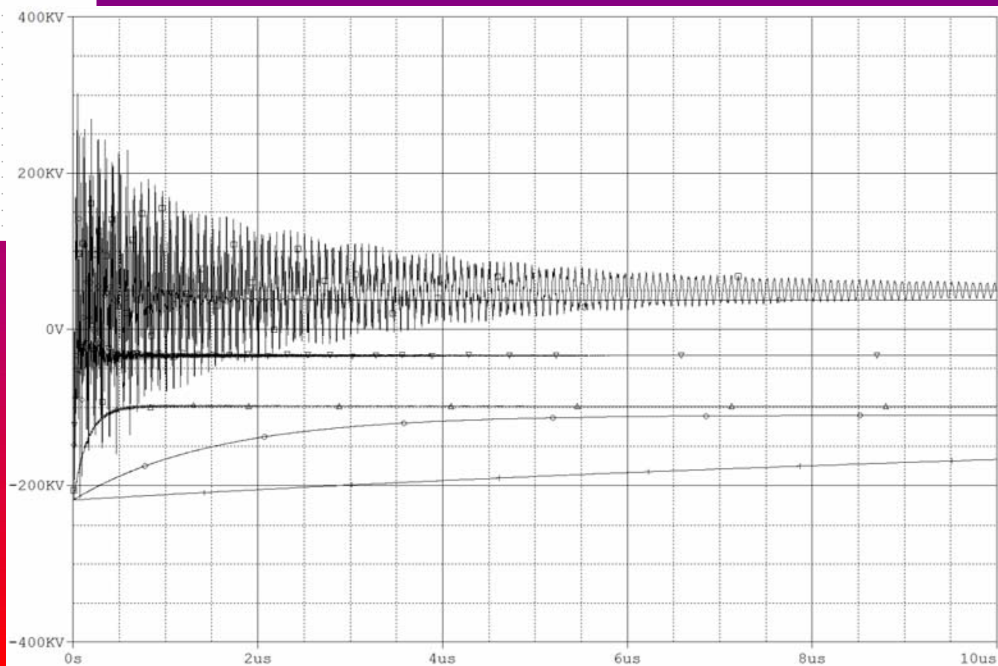
HV circuit

- Used in SPS septa
  - Single HT generator decoupled from long (>200 m) coaxial cable by means of a HV resistor (1 MΩ)
  - 400MΩ decoupling resistors, with short cable lengths to electrodes to limit discharge energy; decoupling of sparking
  - Spark detection per device
- LEP separators:
  - bi-polar set-up with 1.2 MΩ decoupling resistors
  - Automatic conditioning system

HV circuit (cont.)



Decoupling of stored energy in coaxial cables from power supply by means of large series resistors (in SPS 400 MΩ)



Influence of the feedthrough resistor on reflections

Cables / connectors

- Reliable connector and HV resistor design exists at CERN up to 300 kV
- Standard cable from manufacturers limited, in particular above 300 kV DC for cable reasonably resistant to radiation and compatible with under ground installation safety regulations
- Cabling most exposed to radiation should be easily replaceable
- Industrially available HV cables from terrestrial electrical power applications: EPR, XLPE and oiled paper insulation up to approx. 420 kV AC

References

[1] V. Kovarik et al., “The modernization and improvement of the BNL short separators”, NIMB 158, 1979