E/B PEDM R&D

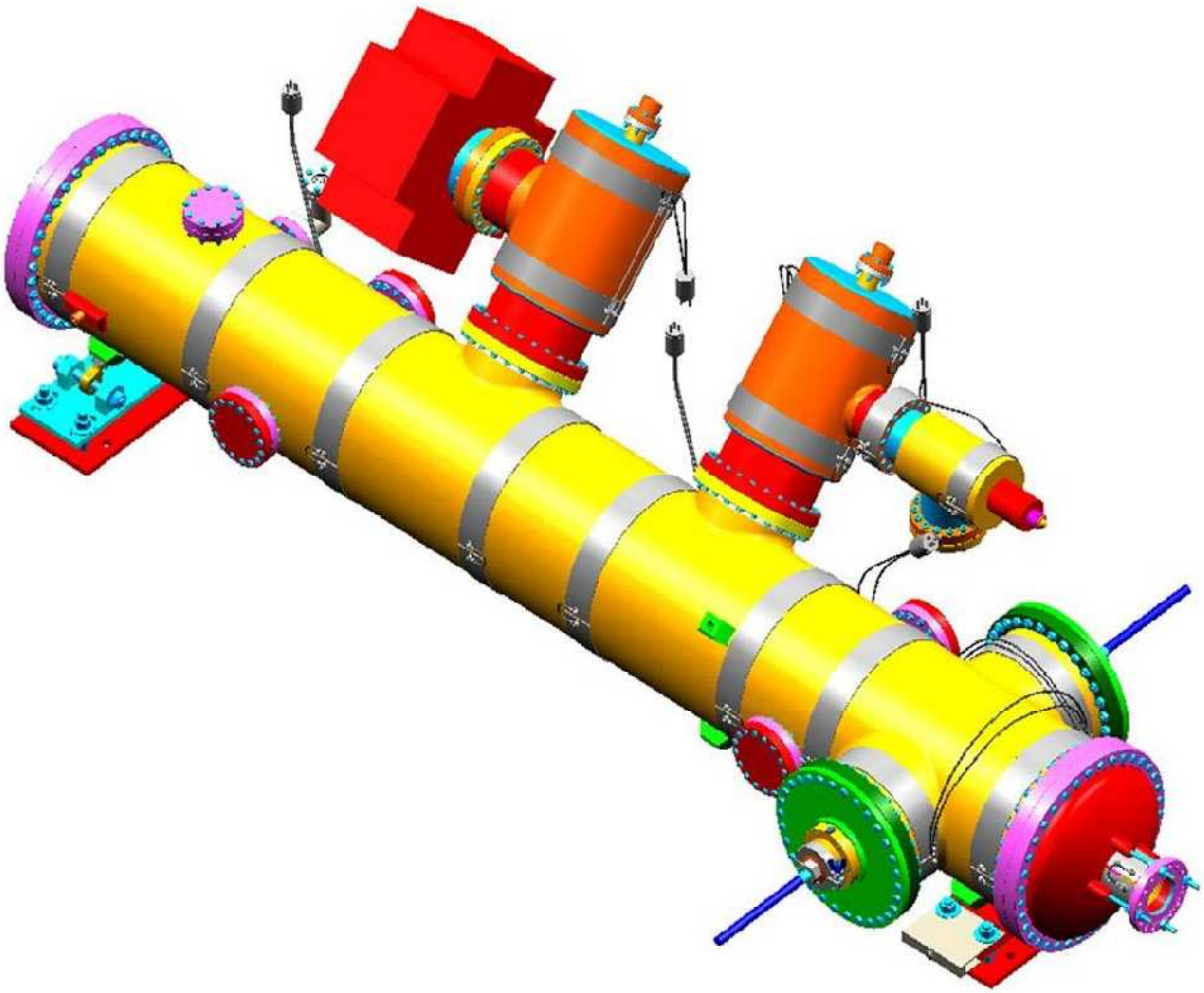
W. Morse

12/7/2009

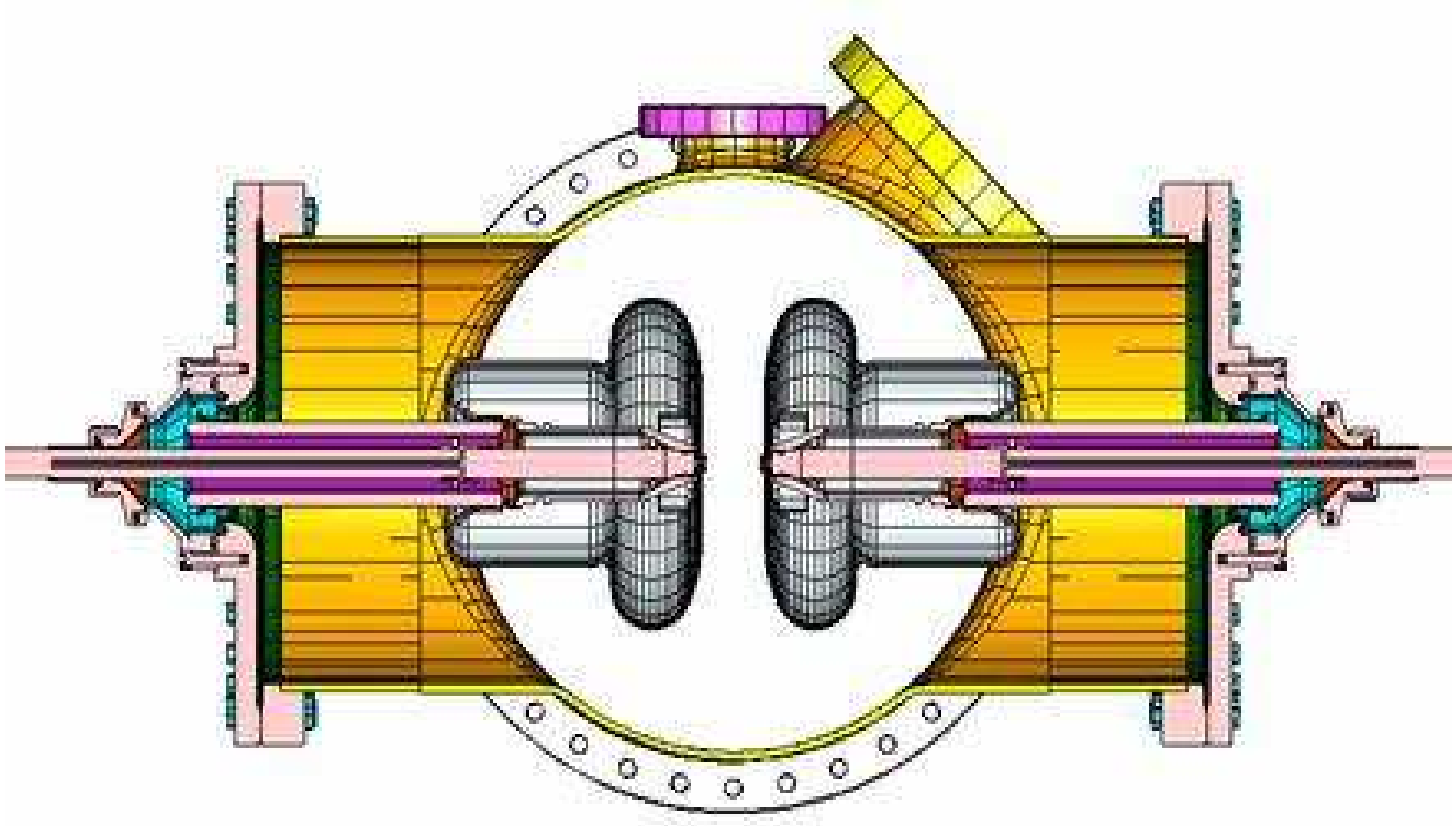
Large Scale Electrodes

Parameter	Tevatron pbar-p Separators	BNL K-pi Separators	PEDM
Length	2.6m	4.5m	2.4m
Gap	5cm	10cm	2cm
Height	0.2m	0.4m	0.2m
Number	24	2	64
Max. HV	±180KV	±200KV	±190KV

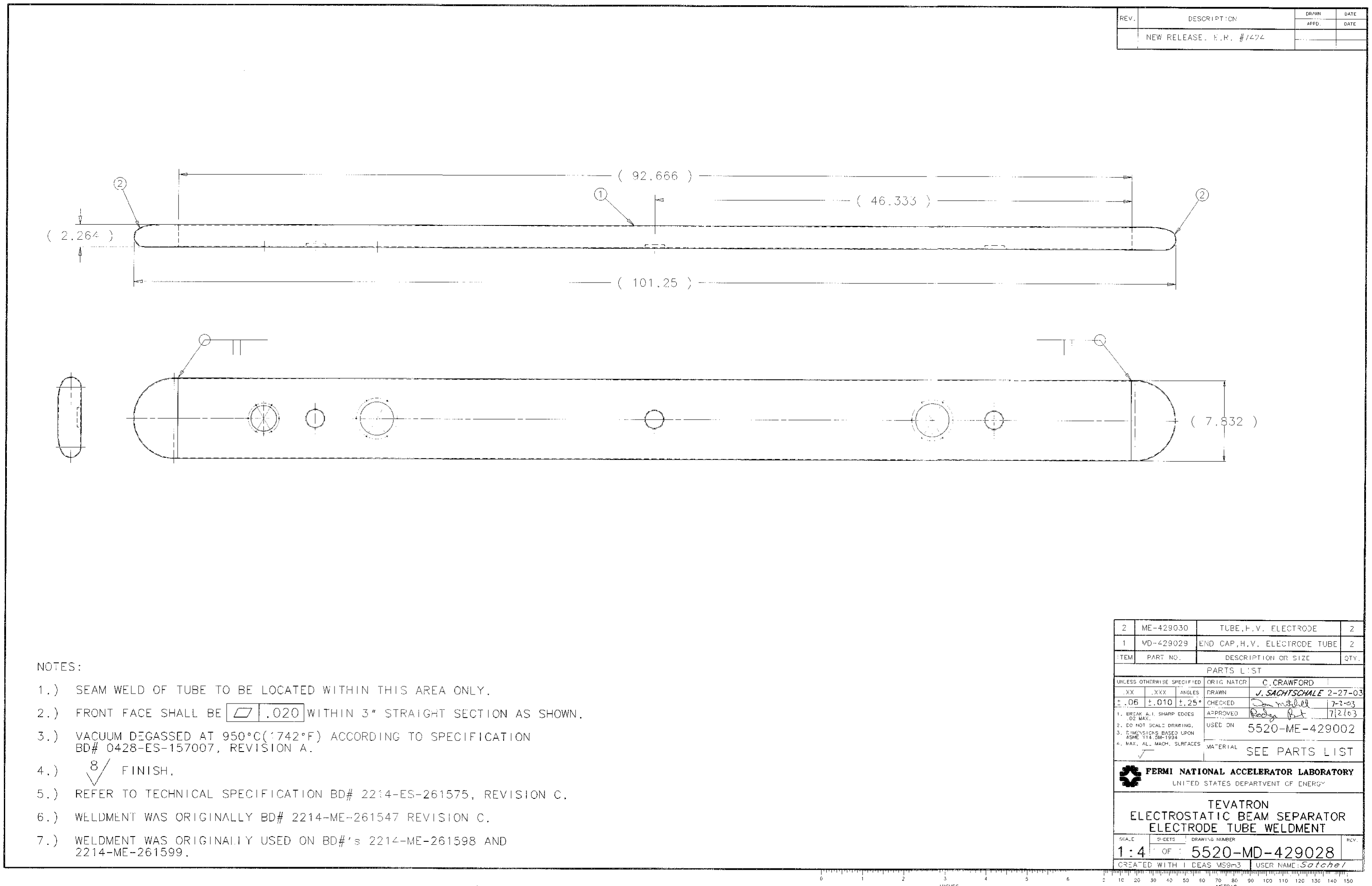
Tevatron pbar-p Separator Module



HV Feedthrough to 0.2m High Electrodes

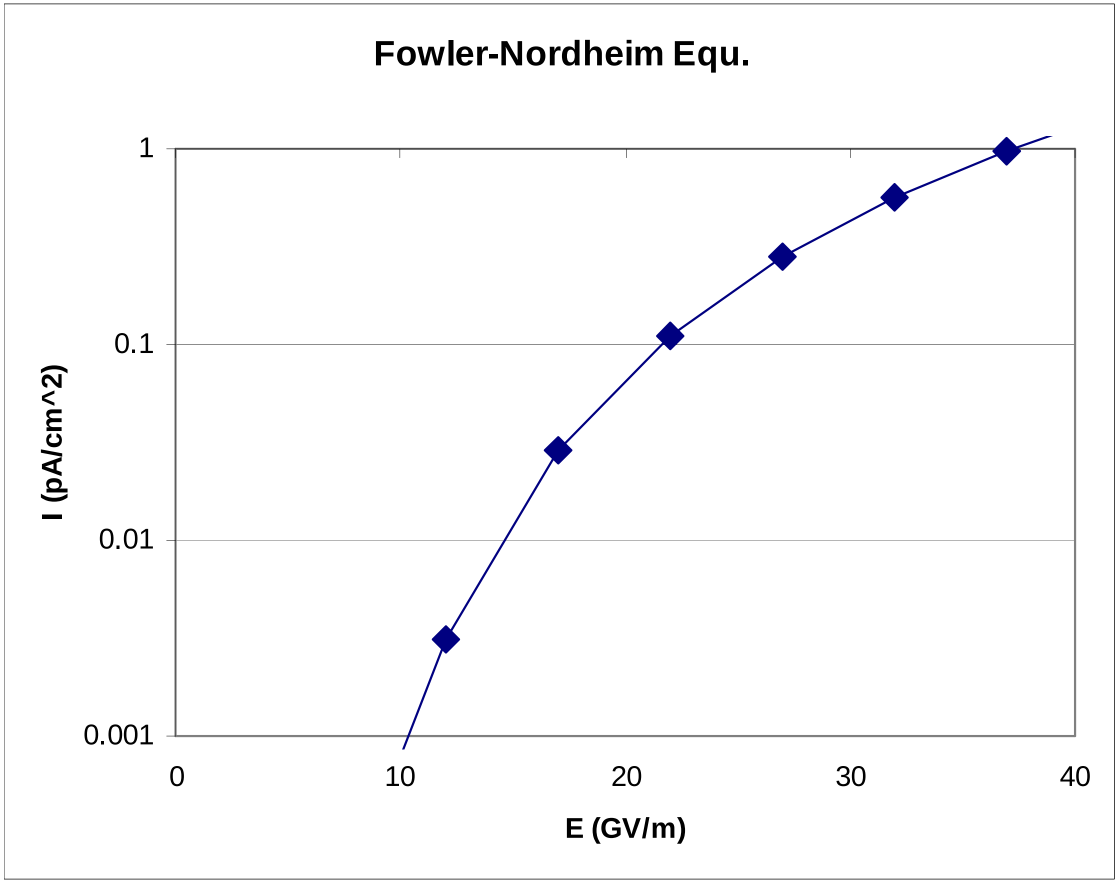


101in. Long Separator Electrode



Construction of 101 in. Long Separator Electrode

FN Field Emission Current vs. E



Recent Progress from LC/ERL R&D (5mm gap tests) Cornell/JLab

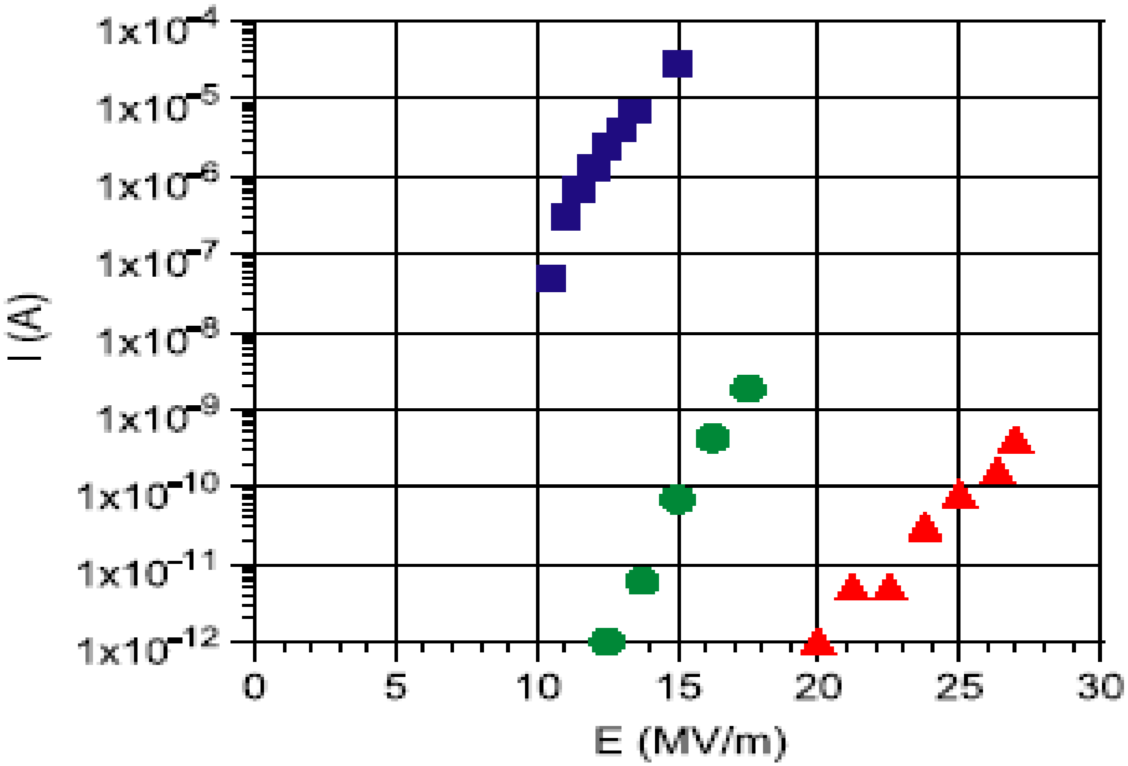


Fig. 4. Field emission current as a function of applied gradient for a 150-mm-diameter stainless steel electrodes: (squares) a typical untreated sample, (circles) first measurement of GCIB treated sample, (triangles) re-measurement of GCIB treated sample after high-voltage conditioning [14].

V vs. Gap: Fengnian & Weihan, IEEE Tran. Electrical Insulation 25, 557 (1990)

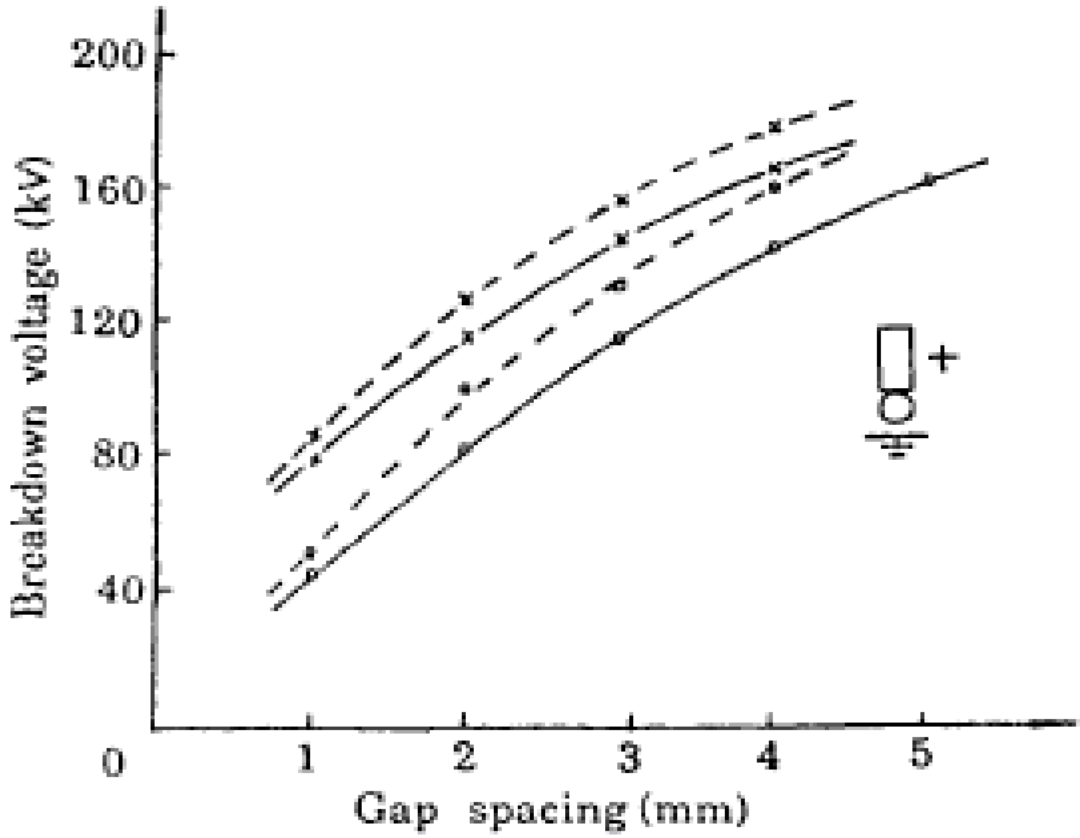
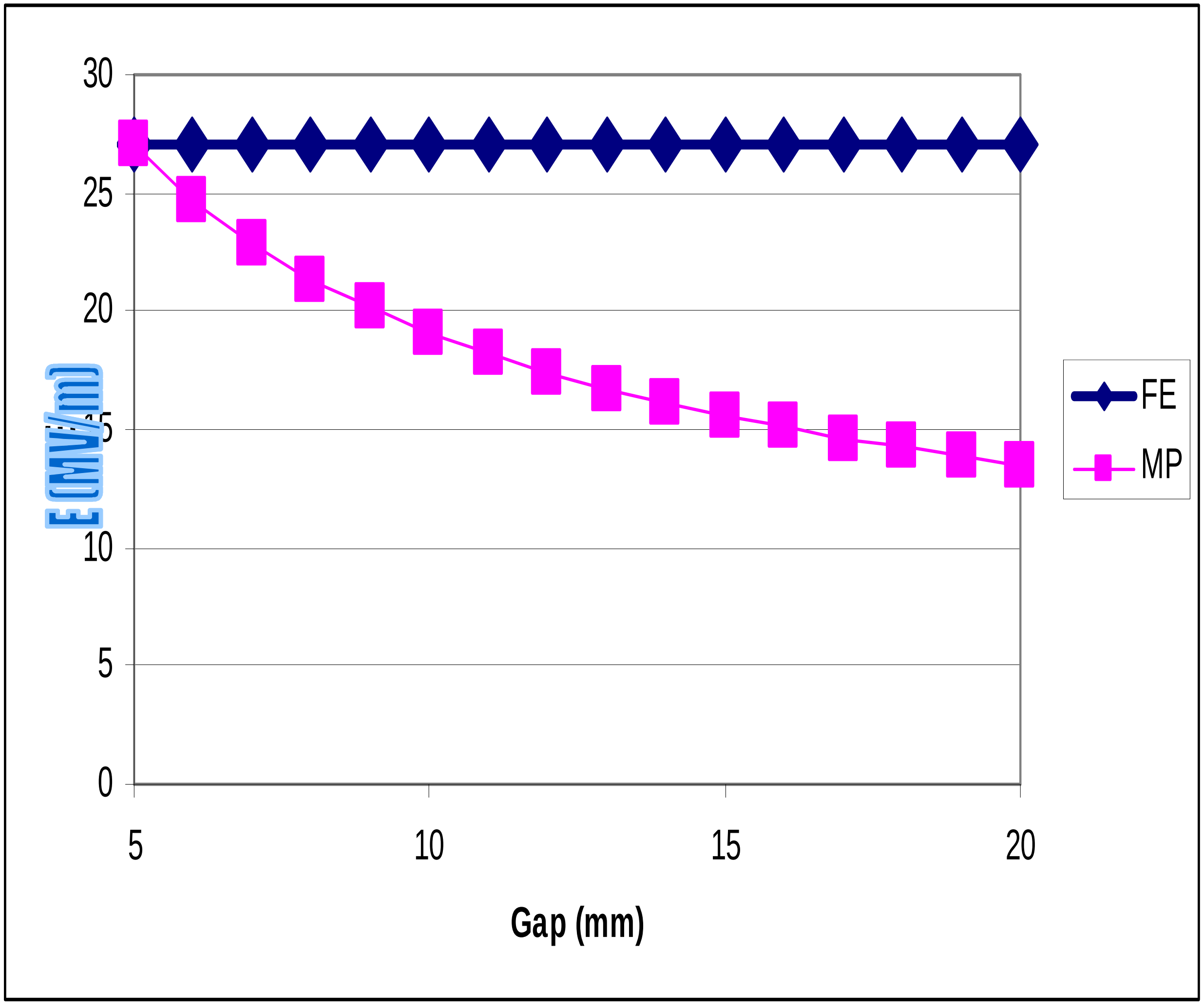


Figure 5.

Positive dc breakdown voltage vs. gap spacing.
o o o: Aluminum, × × ×: stainless steel.
—— : room temperature, - - -: cooled by liquid N_2.

How to Scale from 5mm Gap to 2cm?

Field Emission Heating or Macro-Particle Heating for New Methods?



Sparks

- Oleg Prokofiev, the Tevatron pbar-p separator team leader:
- Current conditioning – HVPS in current limiting mode,
- Gas conditioning – 10^{-4} Torr glow discharge region,
- Spark conditioning – start out at many sparks/hr, 1 spark/day after several days, run for one week.
- “To reach ±150-170KV for PEDM electrodes and have ~1spark/month, conditioning will be performed at ±165-190KV”.
- Tevatron pbar-p separator goal was 1spark/yr per module – pbars are precious.

Beam Impedance

- J. Crisp and B. Fellenz, FNAL-TM-2202 and K. Ng, Proc. 2003 Part. Acc. Conf. IEEE7803-7739-9.
- "The conclusion points to the fact that the separators actually contribute negligibly when compared with other discontinuities in the Tevatron vacuum chamber, except for the rather large resonance at 22.5MHz".
- The Tevatron runs with 0.1A average proton current, while PEDM has only 3mA.
- Tevatron separator measured Re (Z_{L0}/n) and Re (Z_{T1}) impedances were 0.08Ω, 0.01Ω, 0.2MΩ/m, and 0.04MΩ/m at the peak of the 22.5 and 67.8 MHz resonances, respectively. Need C-AD help to avoid resonances.

Longitudinal Beam Impedance

- Systematic error for spin.
- Beam power loss = I^2 Re (Z_{L0}).
- RF makes up beam power loss.
- If RF cavity is inclined, CW and CCW beams see *different* E_v, which is a systematic error for magnetic focusing, as Yannis described.
- Require ring Re (Z_{L0}) < 10KΩ. Need C-AD help to avoid resonances.
- This is not a systematic for electric focusing.

Vertical Electric Field Systematic

- If CW/CCW beams see *different* E_v, this is a systematic for magnetic focusing (<5nV/m).
- Image charges, etc.
- Solution: keep plates high enough.

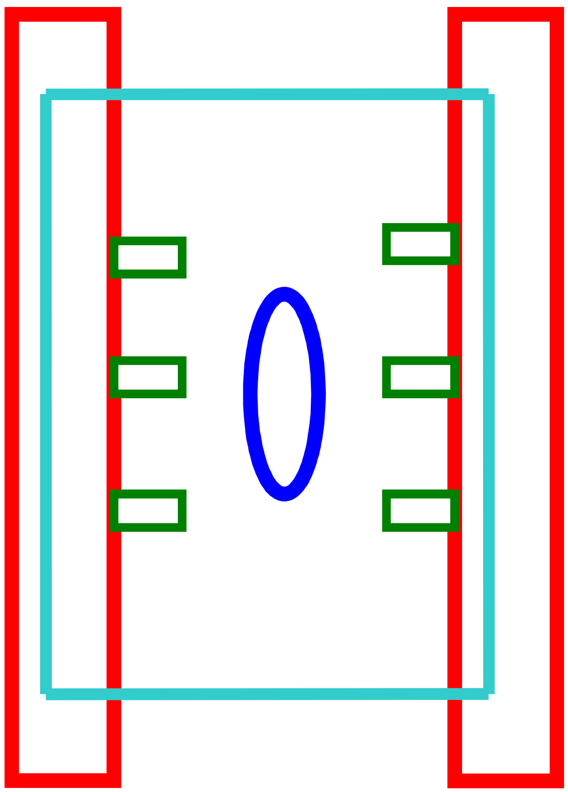
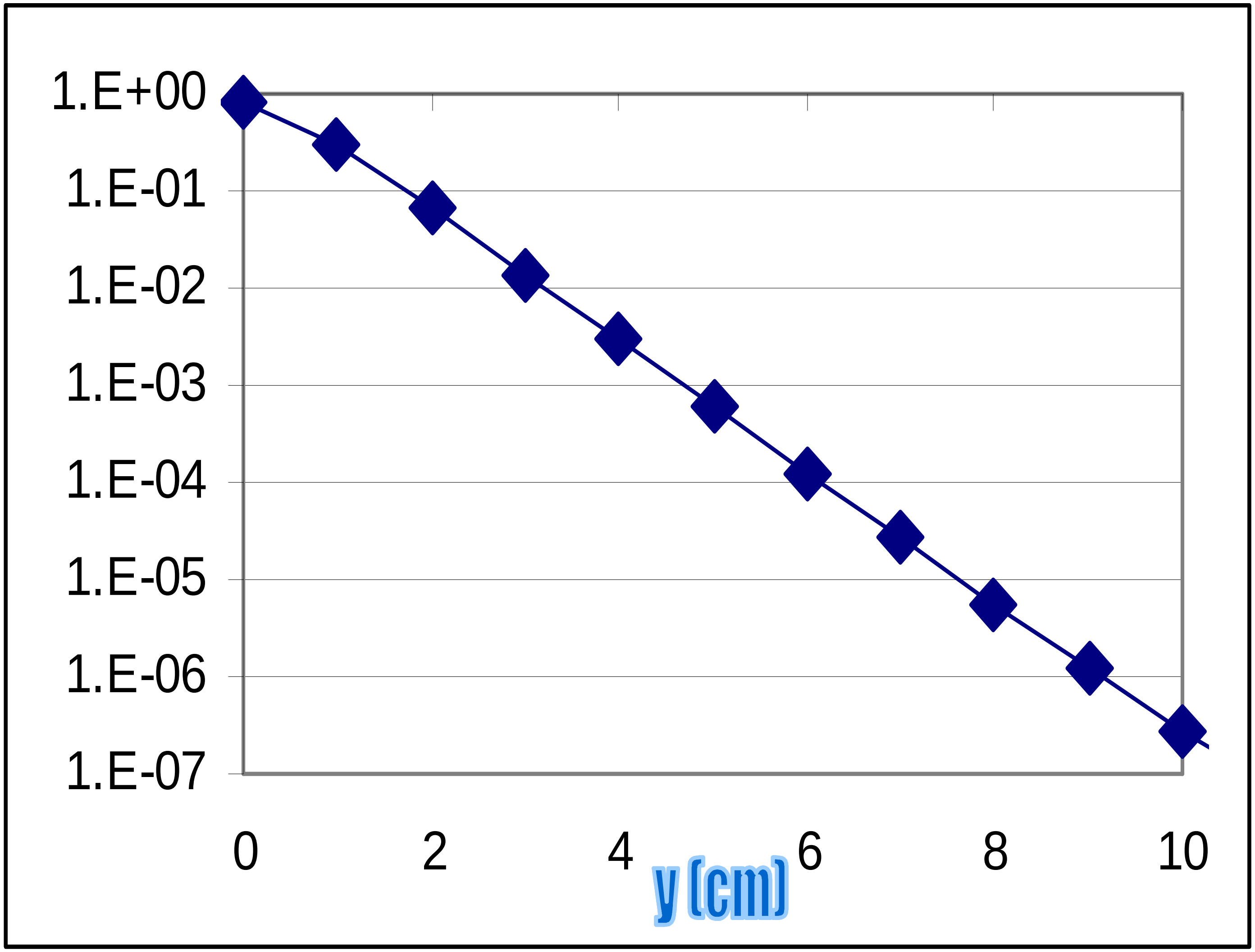
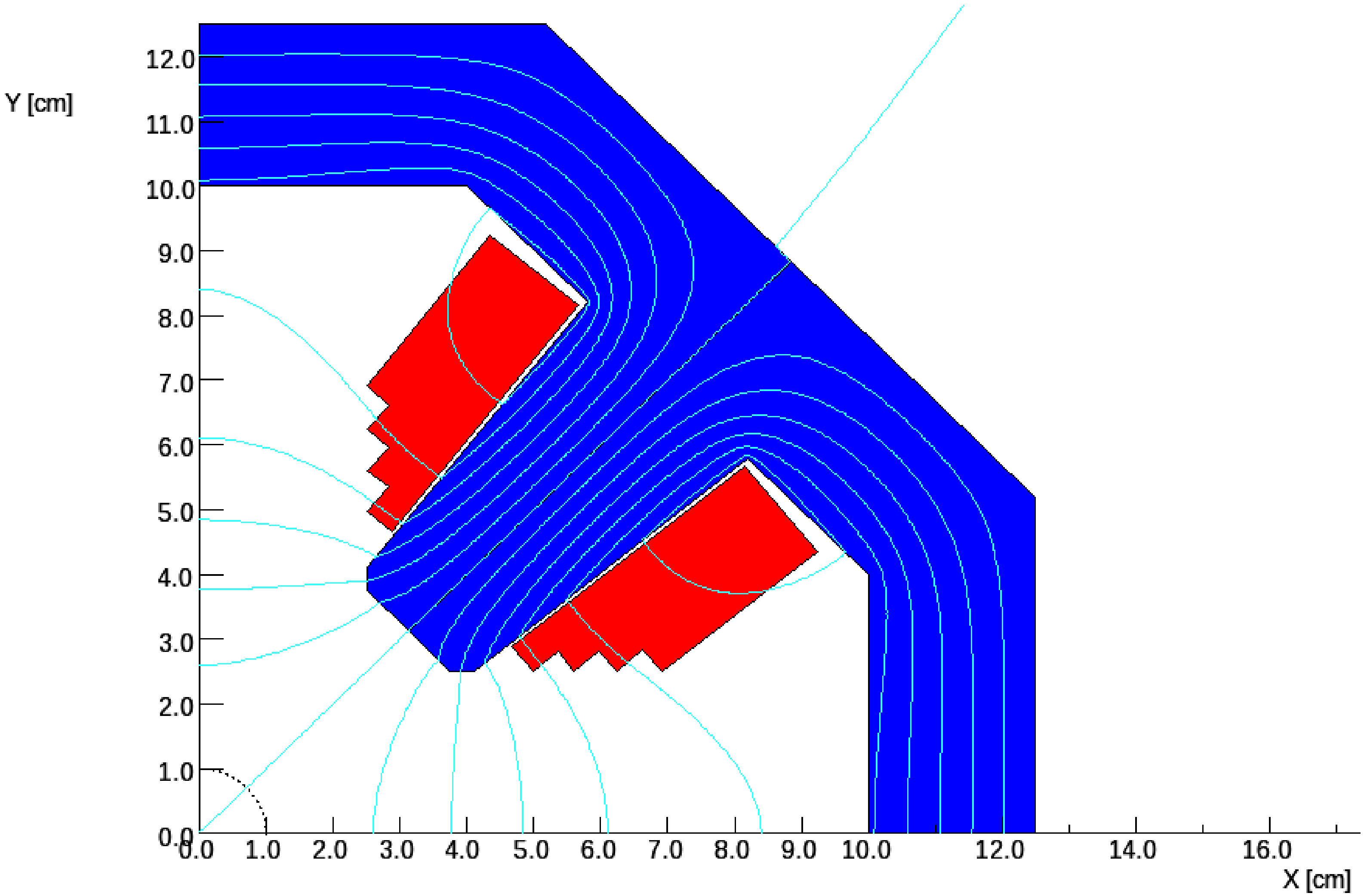


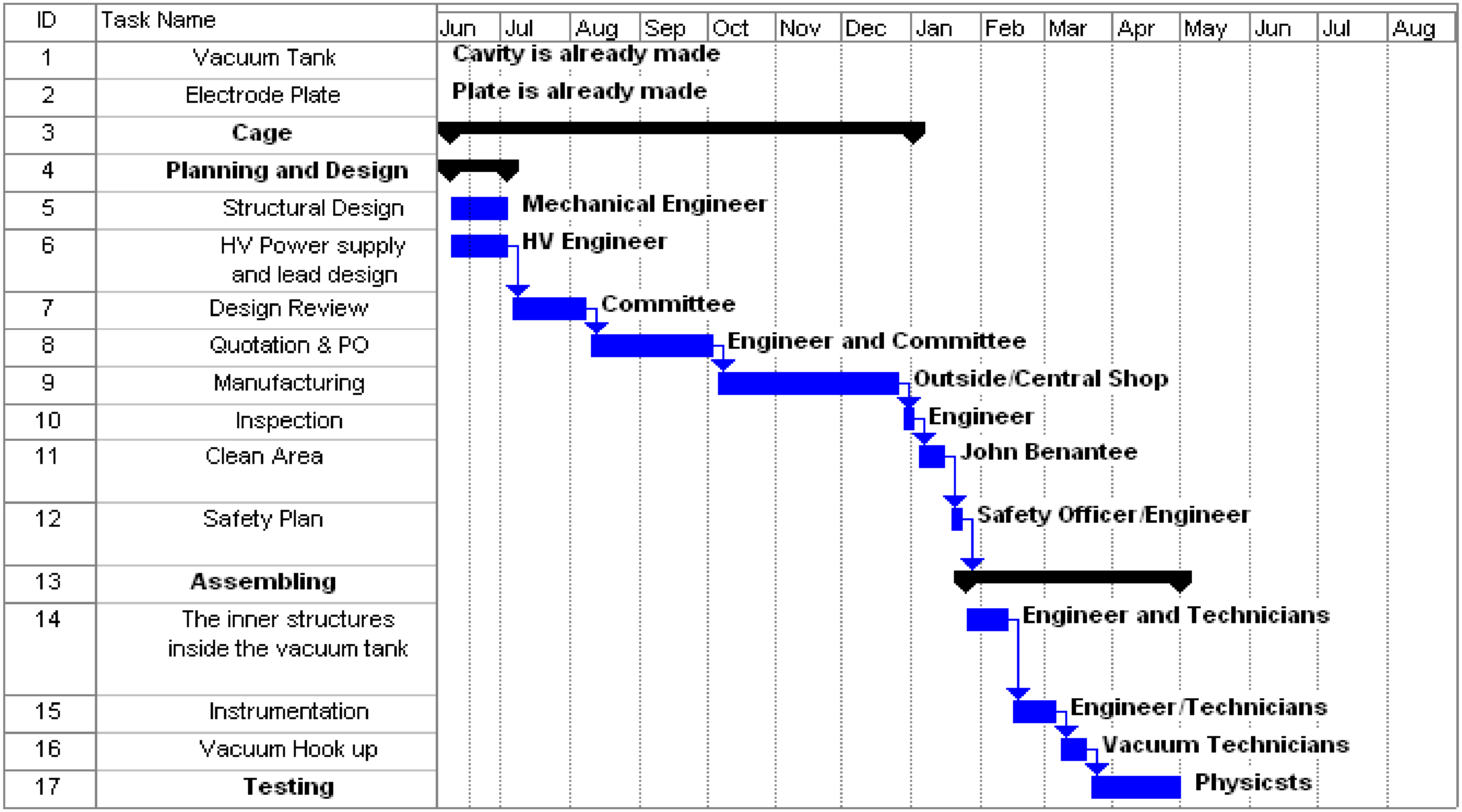
Image Charge vs. y for Infinite Plates



Quadrupole Magnet Design – W. Meng Collider-Accelerator Dept.



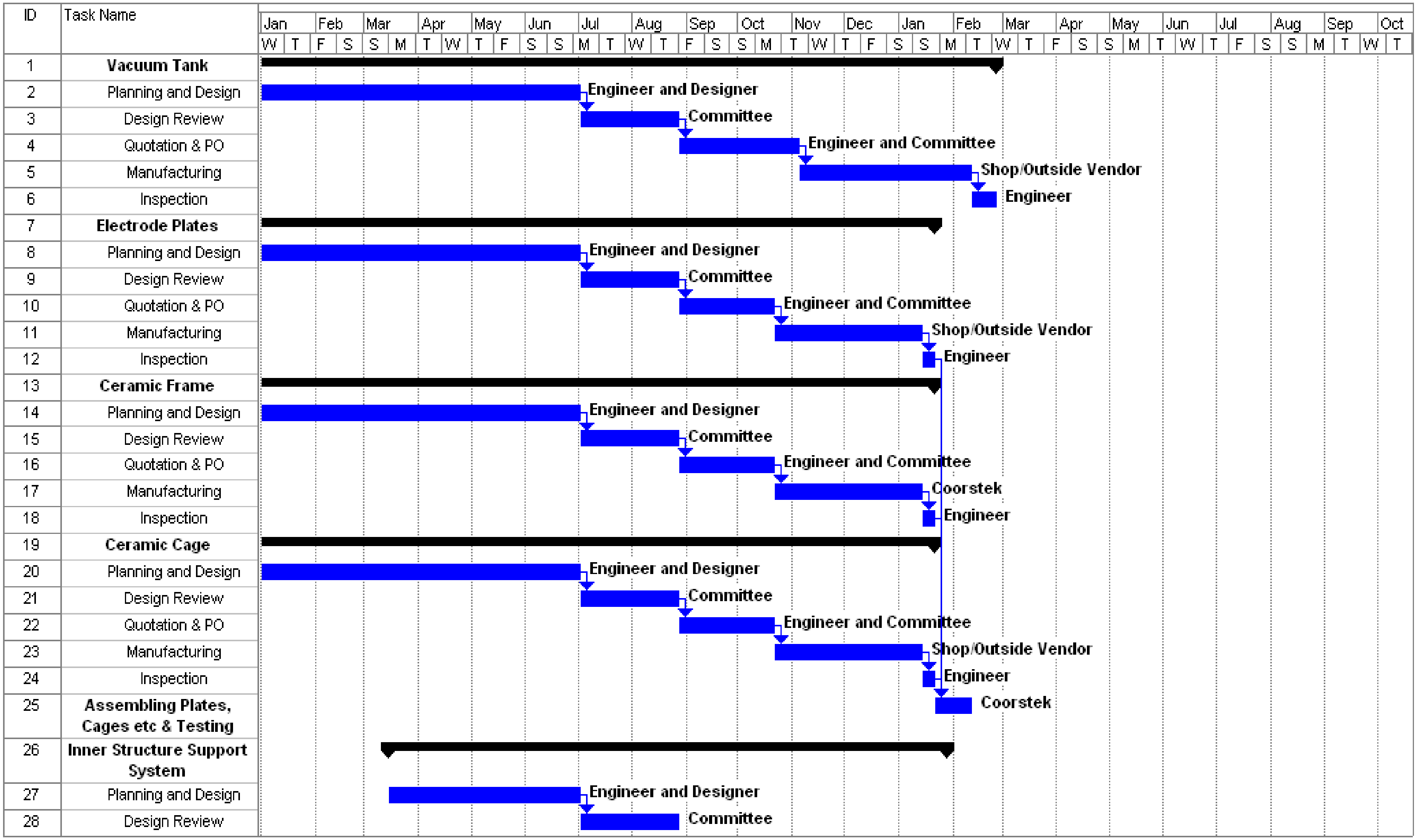
E vs. Gap Test from June 2009 C-AD Review



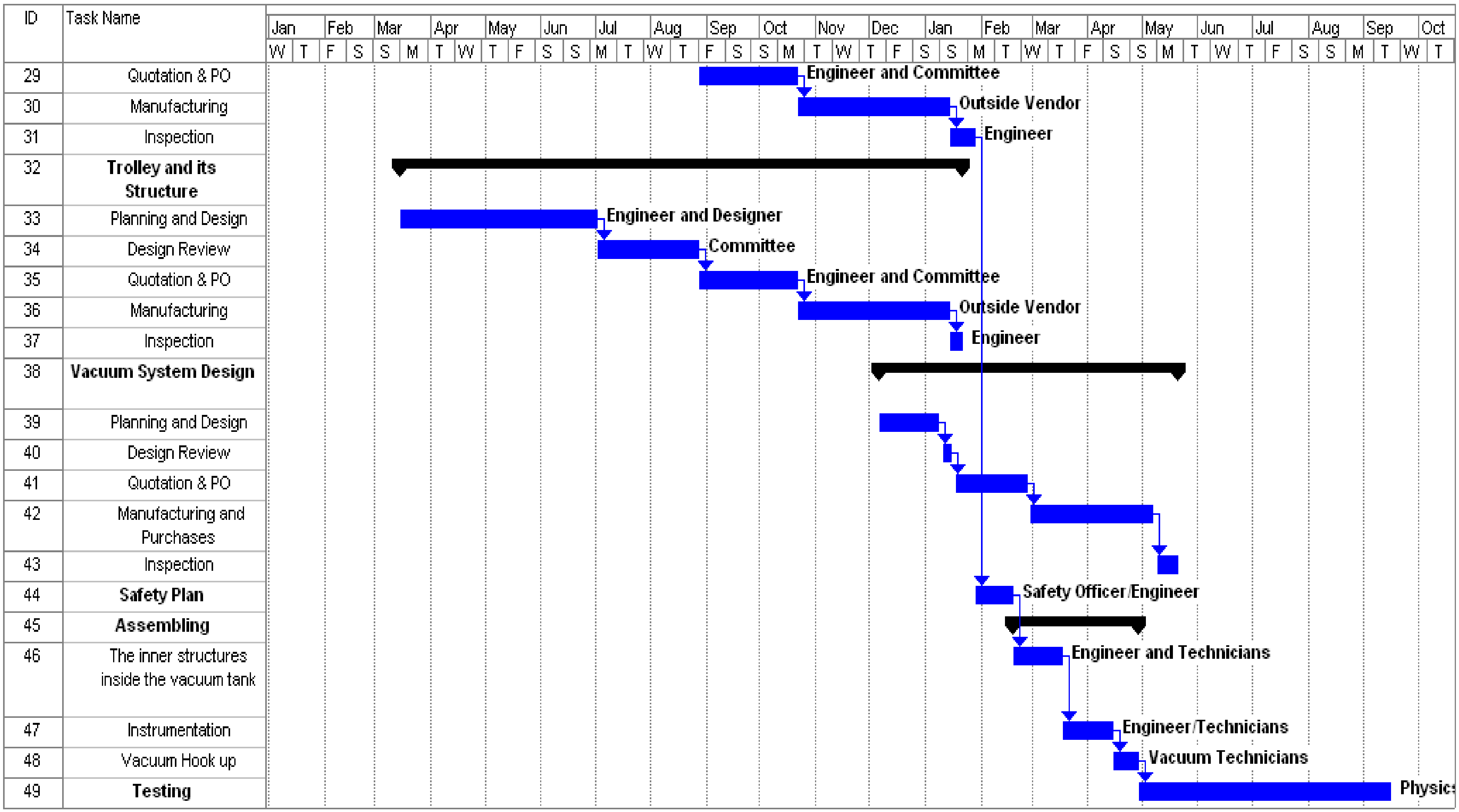
E vs. Gap Test Level of Effort

Construction – Tech.	200mh	$20K
Construction – Eng.	100mh	$10K
Material	$24K	$24K
Testing - Physicist	$120K	$120K
Testing – Tech.	$35K	$35K
Total		**$209K**

First E Module



Start date set arbitrarily to Jan. Natural time to start is June 2010.



First E Module Level of Effort

Item	K$
Electrode Plate	27.5
Vacuum Tank	35.7
End Flange	13.5
Ports	35.5
Vacuum Tank Assembly	6.3
Electrode Assembly	3.8
Inner Support Structure	48.1
Gauges	22.5
Vacuum Equipment	104.1
Vacuum Hookup	5.0
Instrumentation and Commissioning	52.5
Total	**356.4**

Milestones

- May, 2010 – Commission E vs. gap test setup.
- June, 2010 – Start first E module design.
- October, 2010 – E vs. gap results.
- February, 2012 – Commission first E module test.
- May, 2012 – Finish first E module test.

Conclusions

- \$0.6M E/B R&D over 3 years
- Relatively low technical/cost risk
- X% lower E field strength:
- increases the ring length by X%
- and decreases edm sensitivity by X%.

Extra Slides

RF Inclined

- Beam is blue.
- Electric field is red.