A COMPARISON OF THE RADIATION PROPERTIES OF A SINUSOIDAL CURRENT FILAMENT AND A PEC DIPOLE OF VANISHING RADIUS

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PRESENTATION EXAMINES BEHAVIOR OF A PEC DIPOLE AS RADIUS ---> 0 FOR COMPARISON WITH A SCF

- **APPROACH USED**
  - **--RESULTS OBTAINED FROM NEC FOR DIPOLE RADII VARYING FROM 10^{-2} TO 10^{-20} WAVELENGTHS IN RADIUS**
- WAYS IN WHICH SINUSOIDAL CURRENT FILAMENT AND PEC DIPOLE ARE SIMILAR
  - **--RADIATED POWER AS A FUNCTION OF CURRENT LENGTH**
  - **--RADIATION PATTERN**
  - **--LENGTH-WISE DISTRIBUTION OF RADIATED POWER**
  - **--THE SCHELKUNOFF-FELDMAN SPATIAL RADIATION RESISTANCE**
- WAYS IN WHICH THEY DIFFER
  - **--SLIGHT, BUT SIGNIFICANT, DIFFERENCE IN THEIR CURRENTS**
  - **--POYNTING VECTORS PARALLEL TO THE CURRENT**
  - **--TANGENTIAL ELECTRIC FIELDS**
  - **--DISTRIBUTIONS OF INDUCED EMF POWER**
- CONCLUDING OBSERVATIONS AND COMMENTS

NEC WAS USED TO OBTAIN RESULTS FOR DIPOLE OF VARYING RADIUS AND NOMINAL 10-wls LONG . . .

- THE USUAL QUANTITIES SUCH AS INPUT POWER, CURRENT DISTRIBUTION, BOUNDARY E-FIELDS, RADIATED POWER, . . .

- FARS (Far-field Analysis of Radiation Sources) FOR DETERMINING THE DISTRIBUTION OF RADIATED POWER ALONG THE DIPOLE

. . . WHILE ANALYTICAL FORMULAS WERE EVALUATED FOR THE SCF

- RADIATED POWER, BOUNDARY FIELDS, INDUCED-EMF POWER

- SCHEDLKUNOFF-FELDMAN RESULTS FOR DISTRIBUTED RADIATION RESISTANCE

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WAYS IN WHICH THE ~0 RADIUS PEC DIPOLE IS SIMILAR TO THE SCF INCLUDE:

- RADIATED POWER AS A FUNCTION OF CURRENT LENGTH
- RADIATION PATTERN
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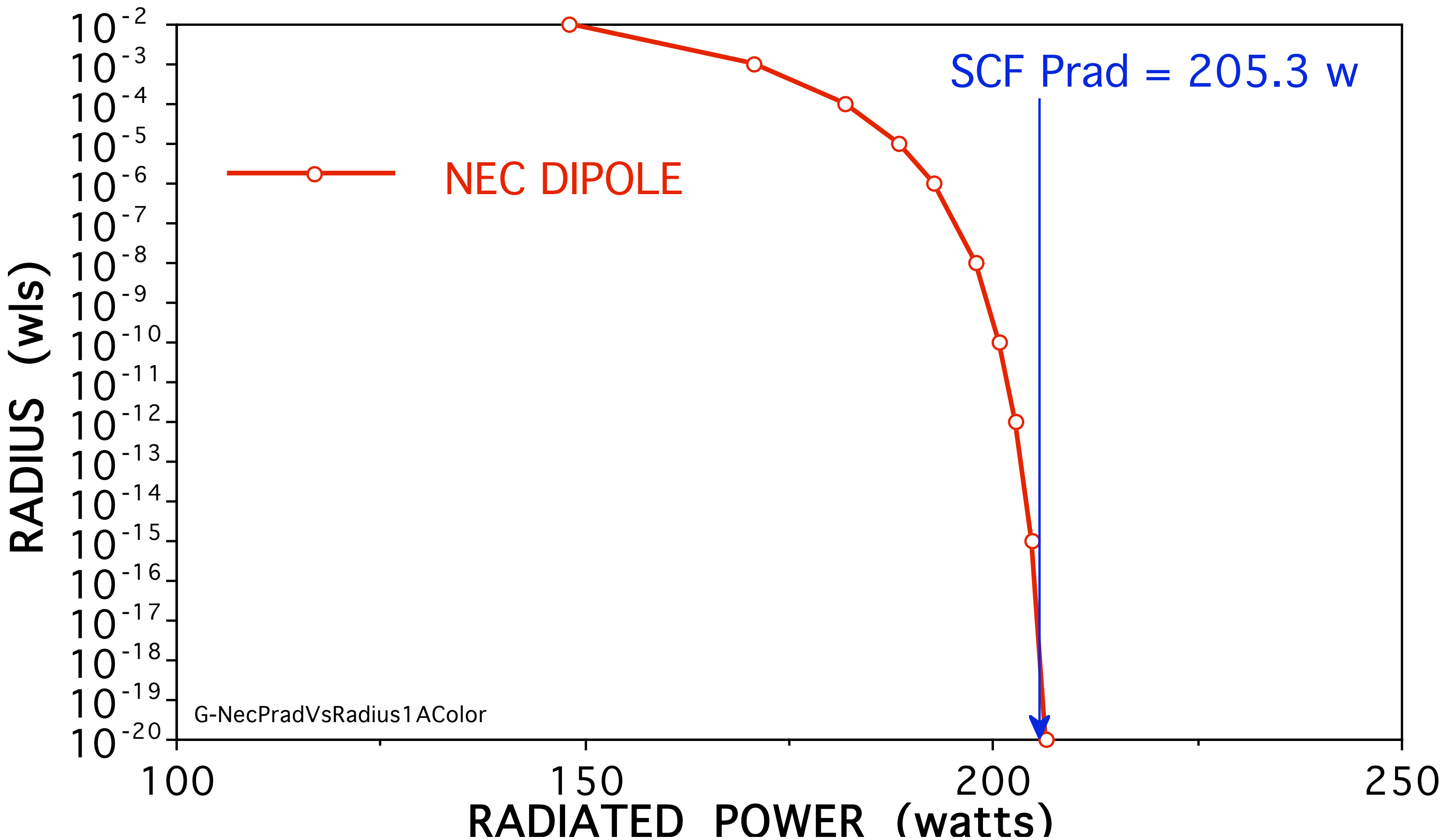
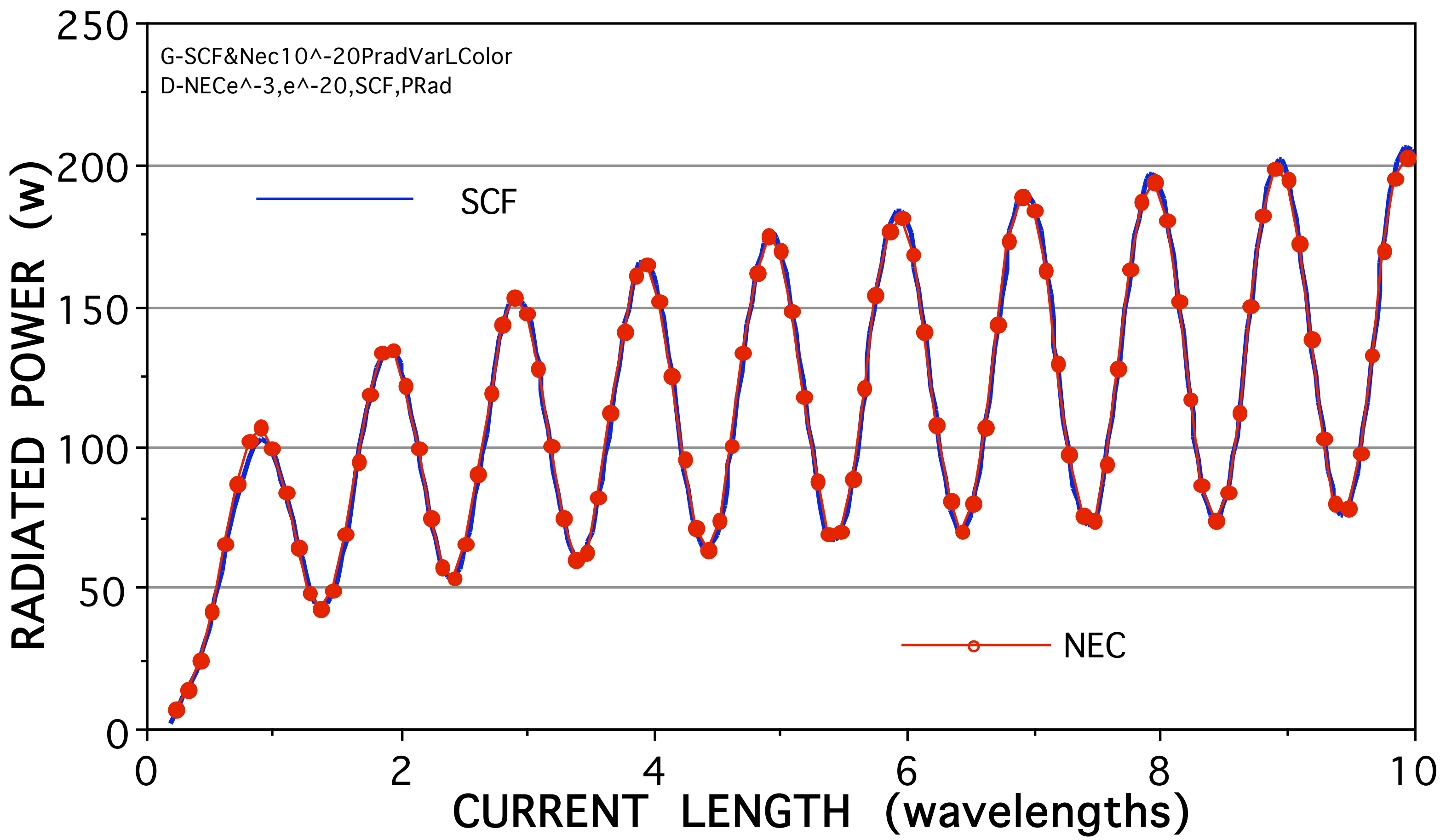
- THE SCHELKUNOFF-FELDMAN SPATIAL RADIATION RESISTANCE

THE POWER RADIATED BY A PEC DIPOLE OF DECREASING RADIUS APPROACHES THAT OF A SCF



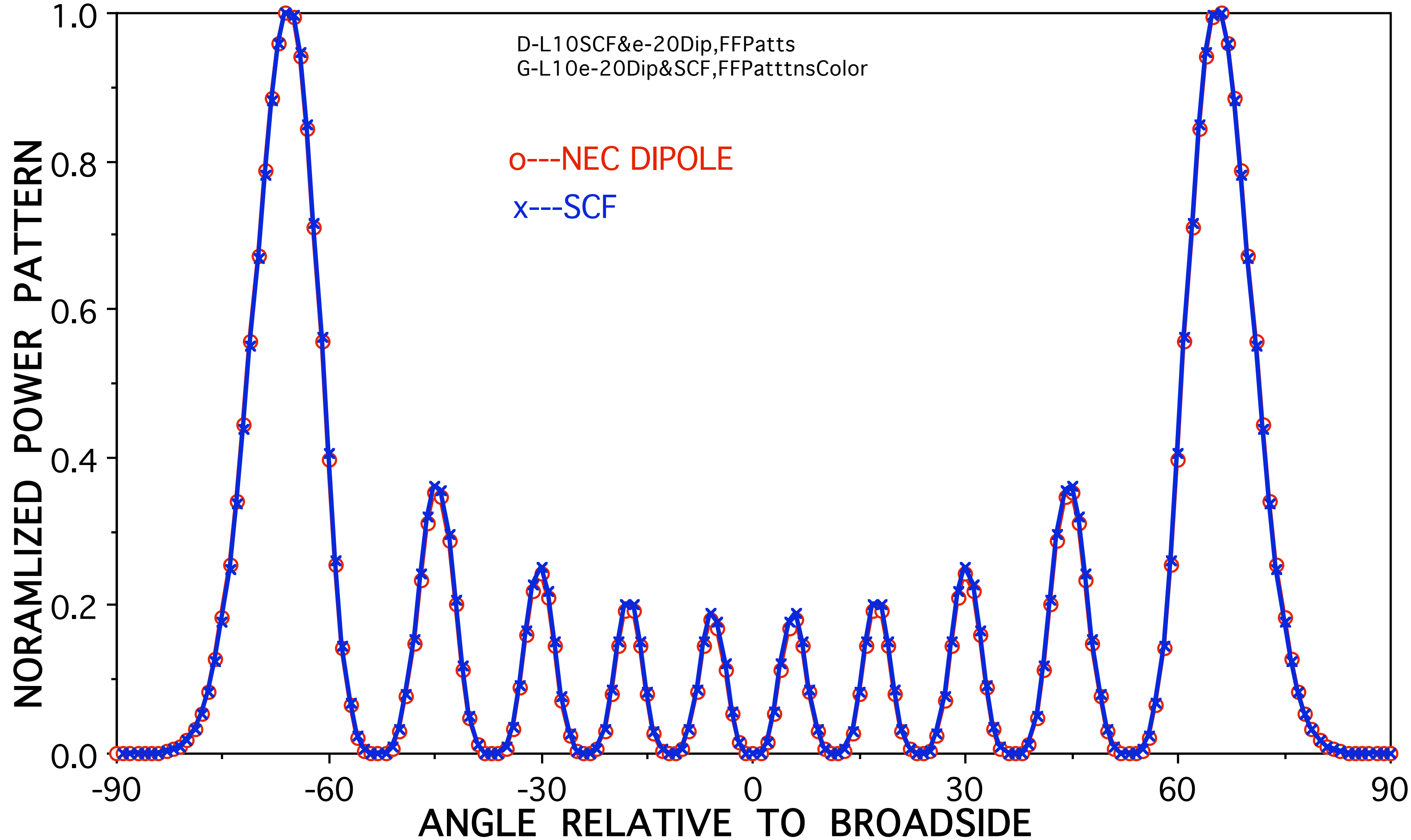
- 10-WAVELENGTH, CENTER-FED, PEC NEC DIPOLE
- 1-A MAXIMUM CURRENT MAGNITUDE ON EACH
- SCF POWER FROM ANALYTICAL FORMULA

POWER RADIATED BY DIPOLE 10^{-20} wls RADIUS IS WITHIN A FEW % OF THE SCF POWER AS A FUNCTION OF LENGTH



- IT MIGHT BE INFERRED FROM THIS THAT THEIR CURRENTS ARE ESSENTIALLY IDENTICAL
- THIS TURNS OUT NOT TO BE THE CASE, HOWEVER

THE POWER PATTERNS OF THE SCF AND ~0 RADIUS NEC DIPOLE ALSO AGREE TO WITHIN A FEW %



- FOR A 10-WAVELENGTH SCF & DIPOLE

FARS* INVOLVES THE USUAL FAR-FIELD INTEGRATION . . .

- PER-SEGMENT FAR FIELD POWER IS DEFINED BY

$$p_{i,FARS}(\theta,\phi) \equiv \frac{1}{2\eta}\mathrm{Re}[e_{i,\theta}(\theta,\phi)E^*_\theta(\theta,\phi) + e_{i,\phi}(\theta,\phi)E^*_\phi(\theta,\phi)]$$

WHERE $e_{i,\_(\theta,\varphi)}$ IS THE FAR FIELD (FF) OF SEGMENT *i* AND

$$E_\theta(\theta,\phi) = \sum_{i=1}^{N} e_{i,\theta}(\theta,\phi), E_\phi(\theta,\phi) = \sum_{i=1}^{N} e_{i,\phi}(\theta,\phi)$$ ARE THE TOTAL FFs

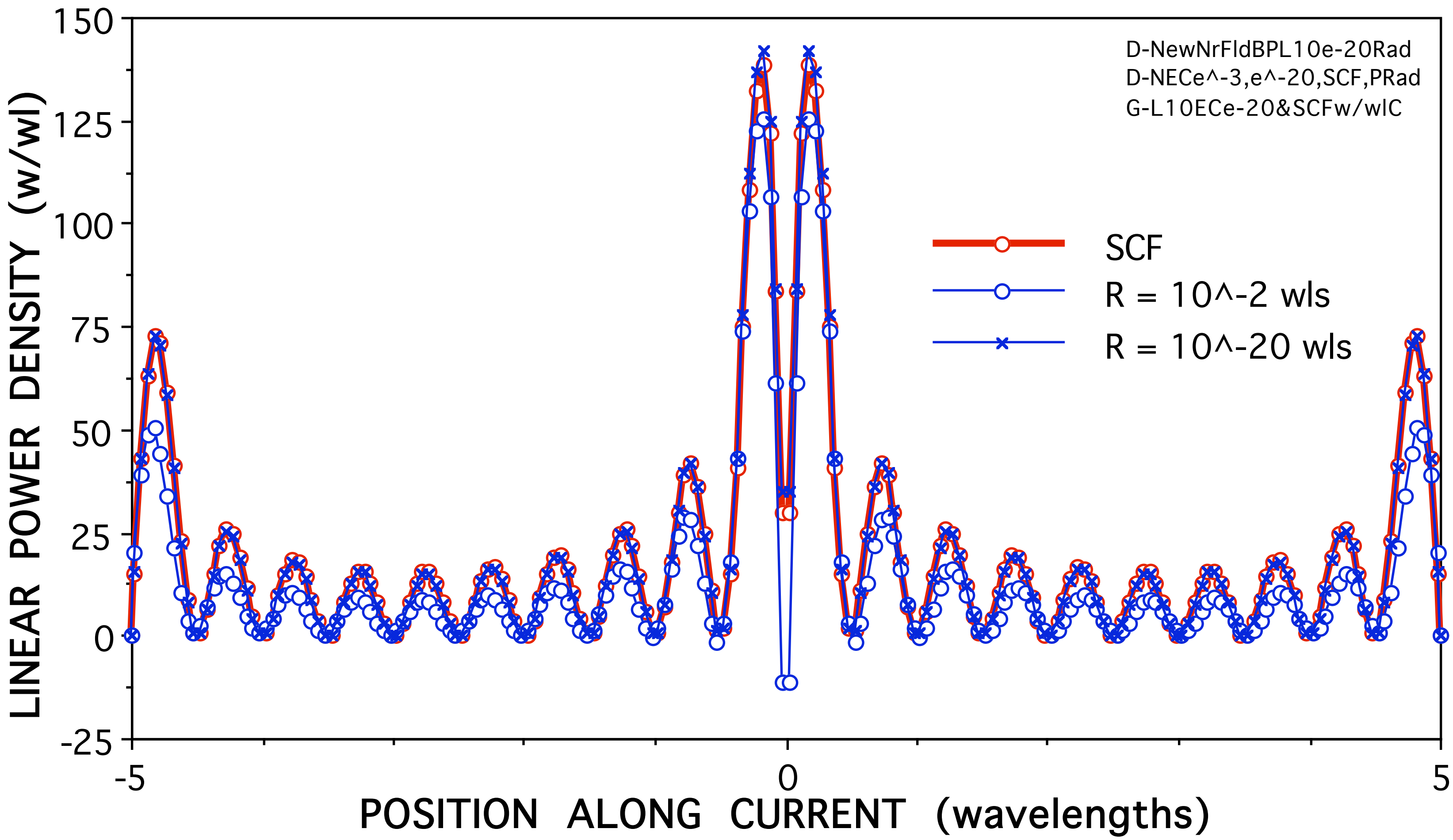
- **THEN** $P_{i,FARS} = r^2 \int_0^{2\pi}\int_0^{\pi} p_{i,FARS}(\theta,\phi)\sin(\theta)d\theta d\phi$ **IS THE TOTAL FF POWER PROVIDED BY SEGMENT *i*, CALLED HERE THE LINEAR POWER DENSITY (LPD)**

- AND $P_{FARS} = \sum_{i=1}^{N} P_{i,FARS}$ IS THE USUAL TOTAL FF POWER

. . . WITH ANGLE AND SPACE INTEGRATION ORDERS SIMPLY INTERCHANGED

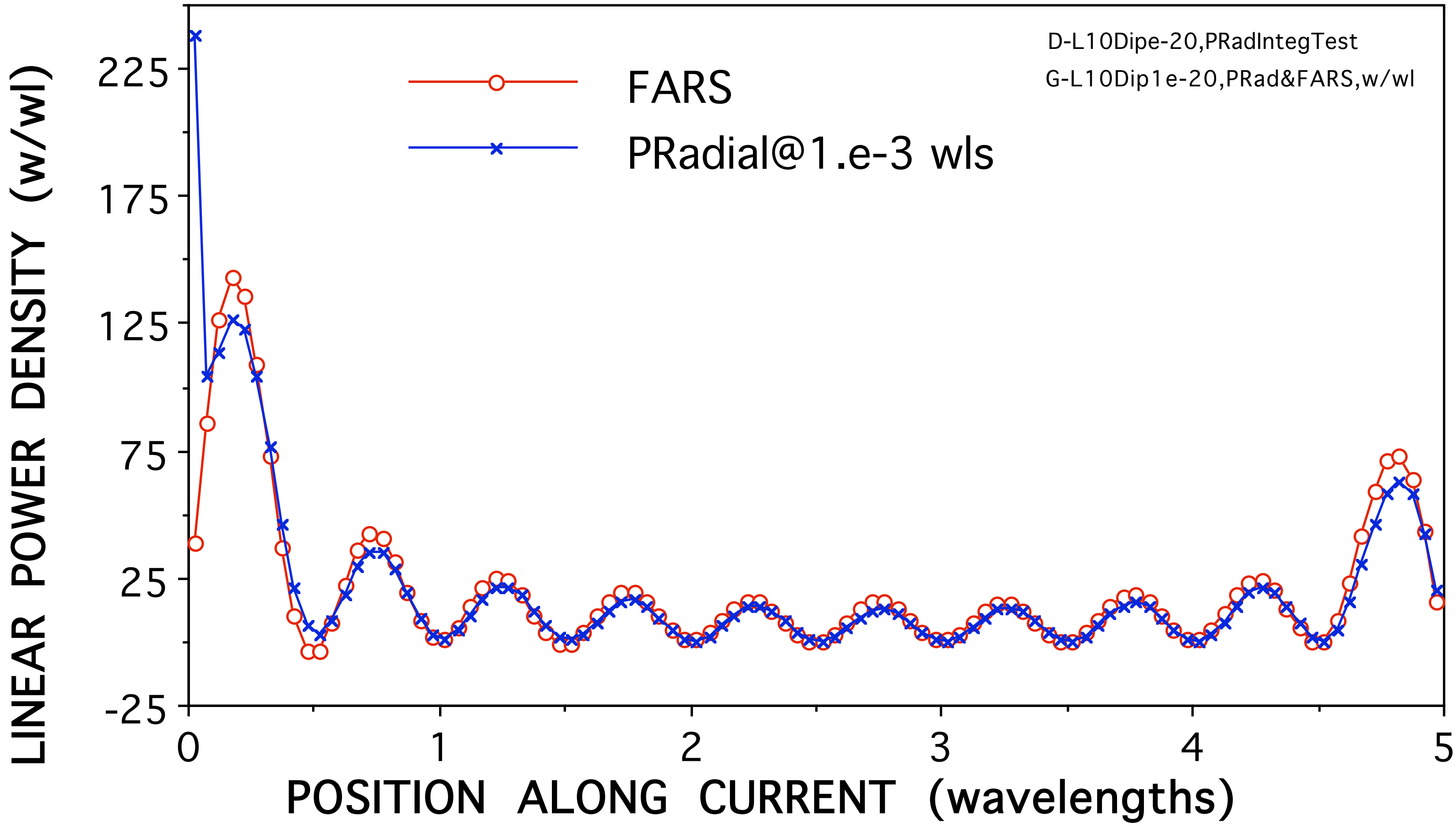
***E. K. Miller (2000), "Some Further Results from FARS: Far-Field Analysis of Radiation Sources," in *Proceedings of 16th Annual Review of Progress in Applied Computational Electromagnetics*, Naval Postgraduate School, Monterey, CA, pp. 278-285.**

FARS LINEAR POWER DENSITY (LPD) OF THE ~0 RADIUS, 10-wl, 1-A PEC DIPOLE AND SCF ARE ALSO NEARLY IDENTICAL



- GREATEST DIFFERENCE IS IN SOURCE REGION
- FARS FOR 10^{-20} wl DIPOLE = 202.6 w AND SCF = 201.9 w

FARS FOR ~0 RADIUS DIPOLE IS CLOSE TO RADIAL POWER FLOW 10^{-3} wls AWAY



- SPATIAL DIFFERENCE GENERALLY ≤ 3%
- P_{FARS} = 201.2 w, P_{In} = 202.6 w, P_{Radial} = 206.9 w
- PROVIDES ADDITIONAL SUPPORT FOR FARS APPROACH
- FARS USES FAR-FIELD SOURCE INTEGRATION ONLY

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WAY IN WHICH THE ~0 RADIUS PEC DIPOLE DIFFERS FROM THE SCF INCLUDE:

- SLIGHT, BUT SIGNIFICANT, DIFFERENCE IN THEIR CURRENT DISTRIBUTIONS
- POYNTING VECTORS PARALLEL TO THE CURRENT
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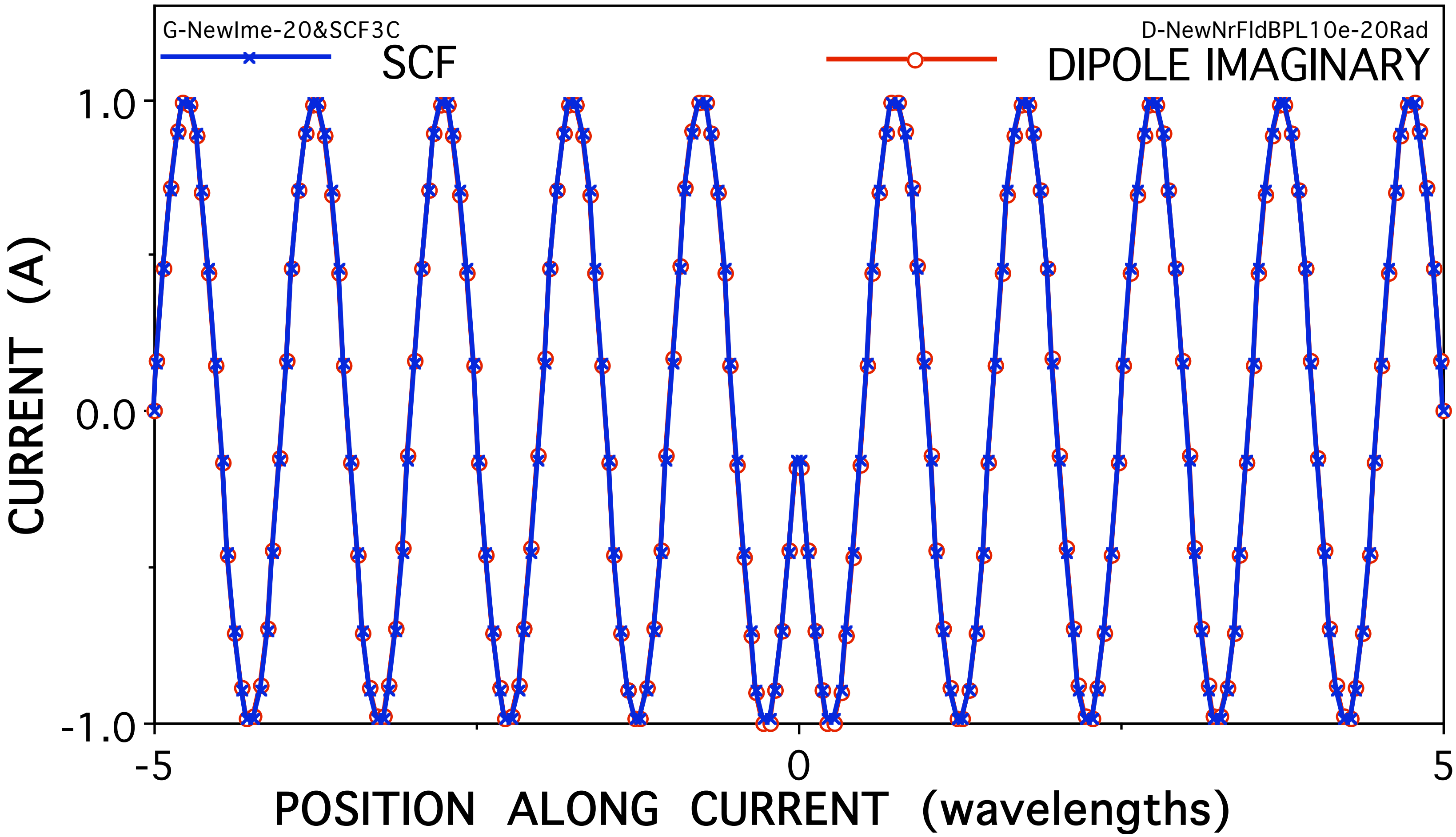
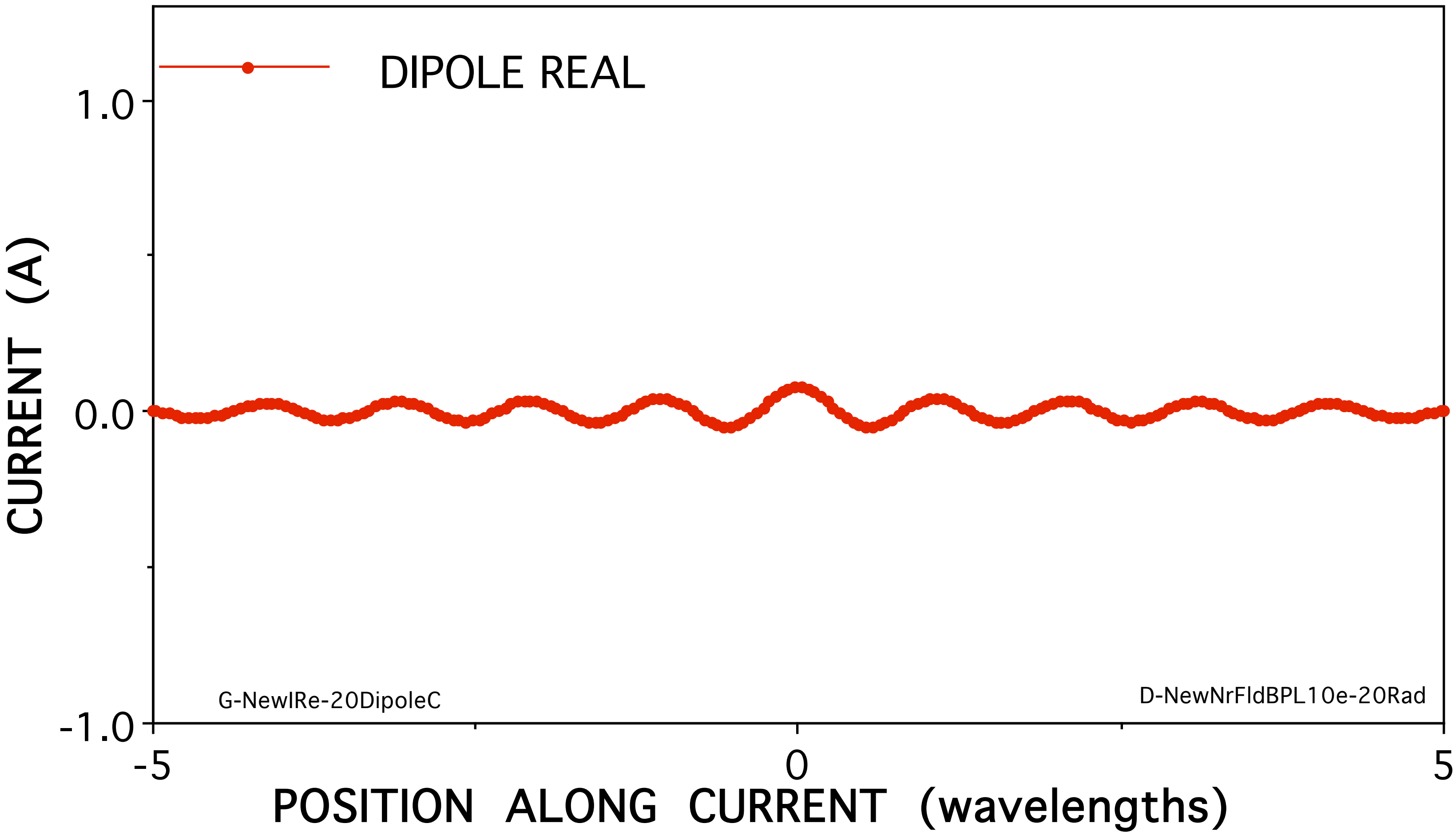
WHILE THE IMAGINARY COMPONENT THE OF 10^{-20} wl-RADIUS DIPOLE CURRENT ESSENTIALLY EQUALS THAT OF A SCF. . .



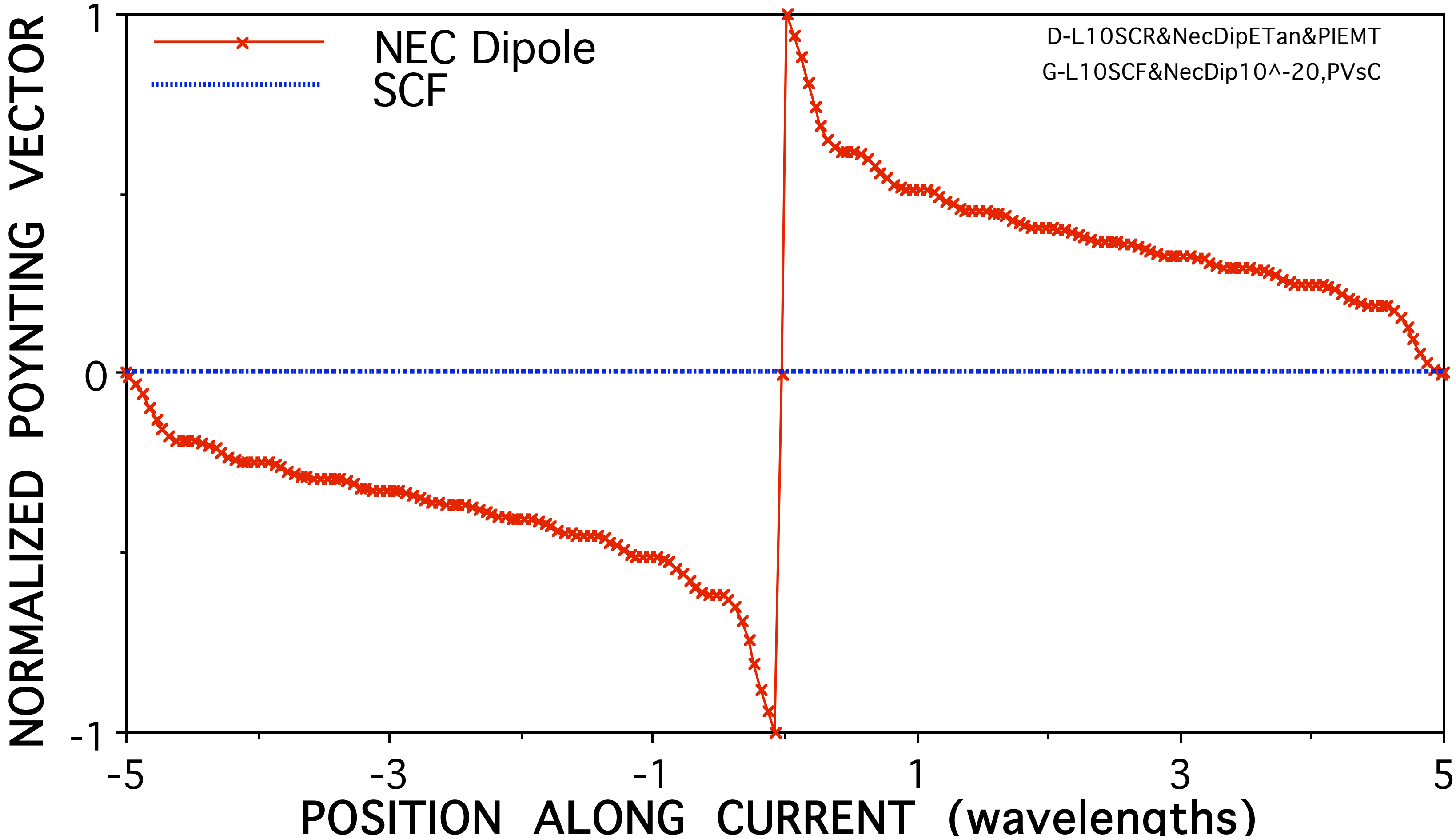
- FOR THE 10-WAVELENGTH SCF AND DIPOLE

. . . A SMALL REAL COMPONENT OF DIPOLE CURRENT REMAINS



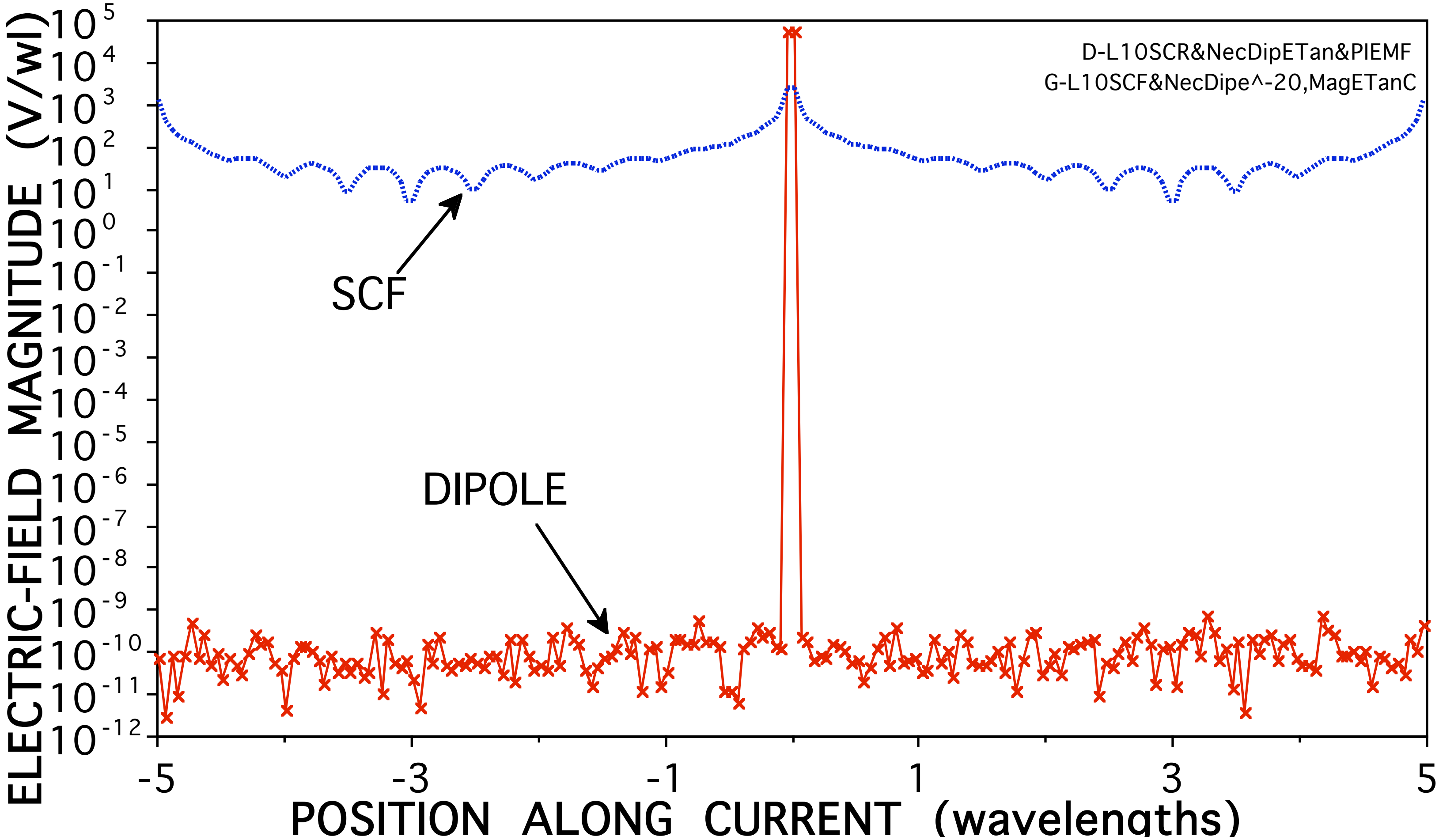
- EVIDENTLY REQUIRED FOR DIPOLE TO SATISFY BOUNDARY CONDITION ON TANGENTIAL E-FIELD
- CORRESPONDING QUADRATURE COMPONENT FOR SCF = 0

THE RESPECTIVE AXIAL POWER FLOWS ALONG SCF AND DIPOLE ARE CONSE-QUENTLY VERY DIFFERENT . . .



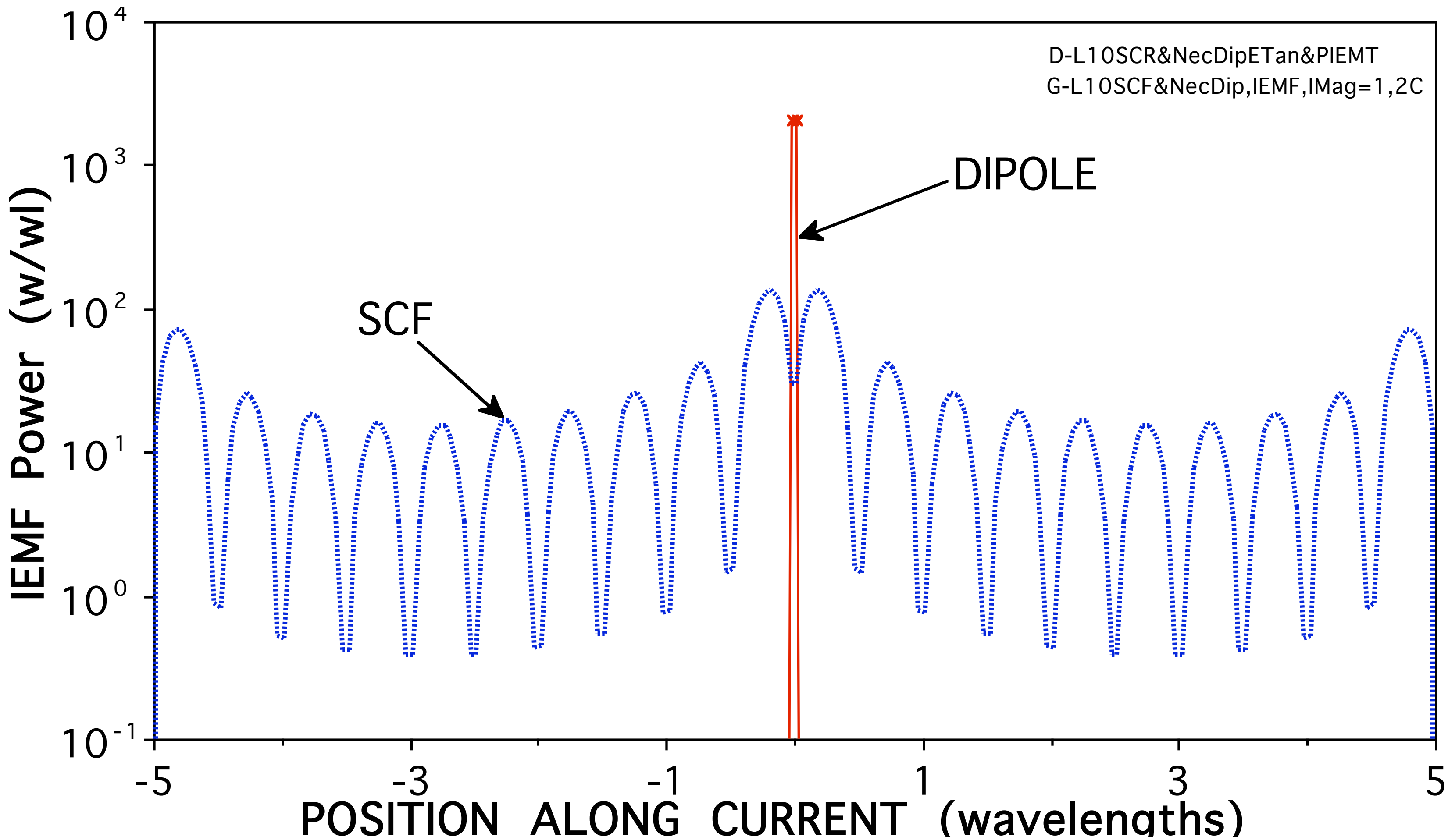
- THE STANDING WAVE SCF TRANSPORTS NO TIME-AVERAGE POWER ALONG ITS LENGTH
- POWER FLOW MONOTONICALLY DECAYS ALONG DIPOLE

. . . AS WELL AS VERY DIFFERENT TANGENTIAL E-FIELDS



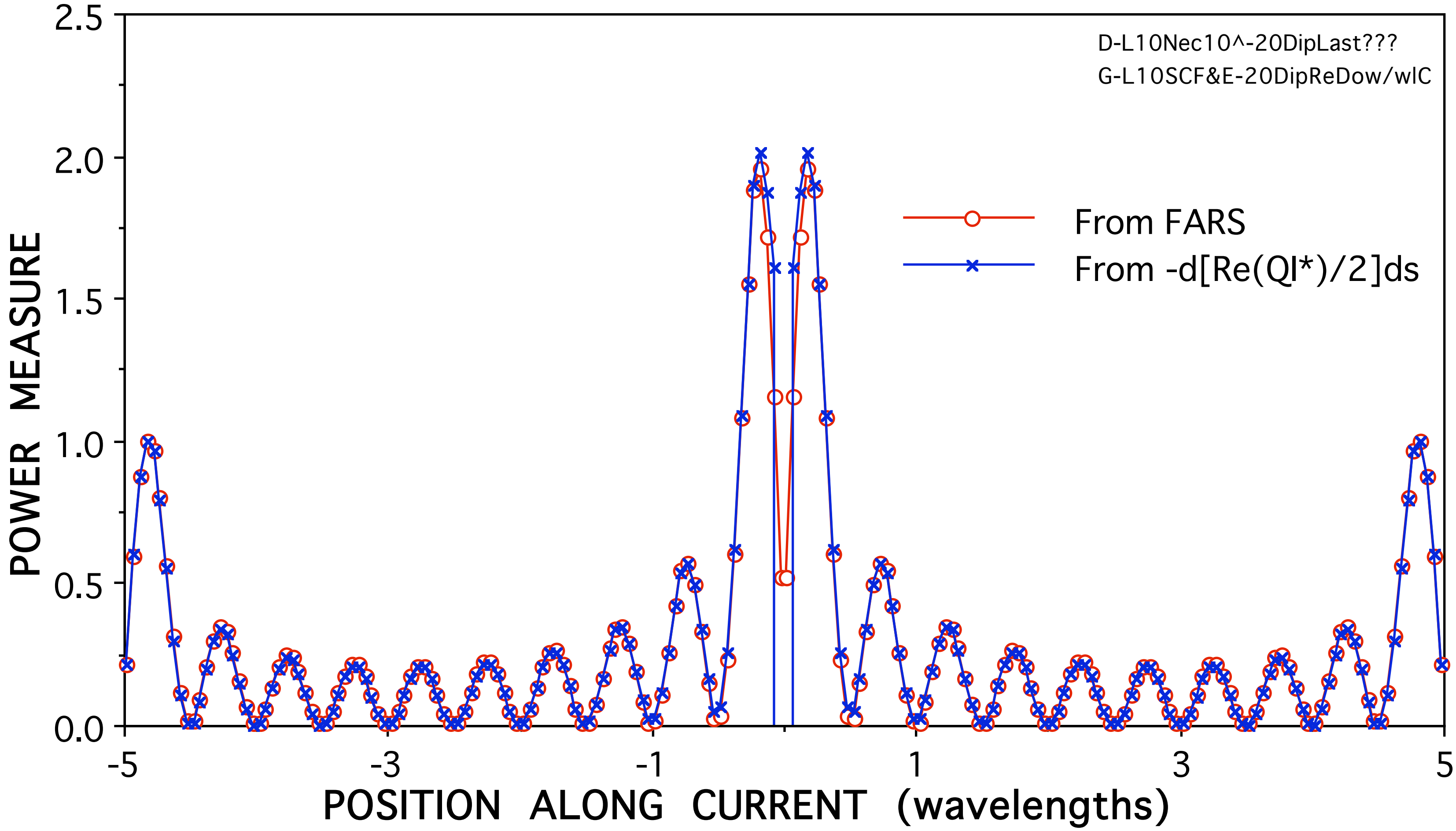
- COMPUTED AT SURFACE OF DIPOLE AND AT A DISTANCE OF 10^{-20} FROM THE SCF
- SCF FIELD ~ INDEPENDENT OF RADIUS OUT TO 10^{-3} wls

THIS PRODUCES A COMPARABLE DIFFERENCE BETWEEN THE IEMF POWER DISTRIBUTIONS FOR THE SCF & DIPOLE



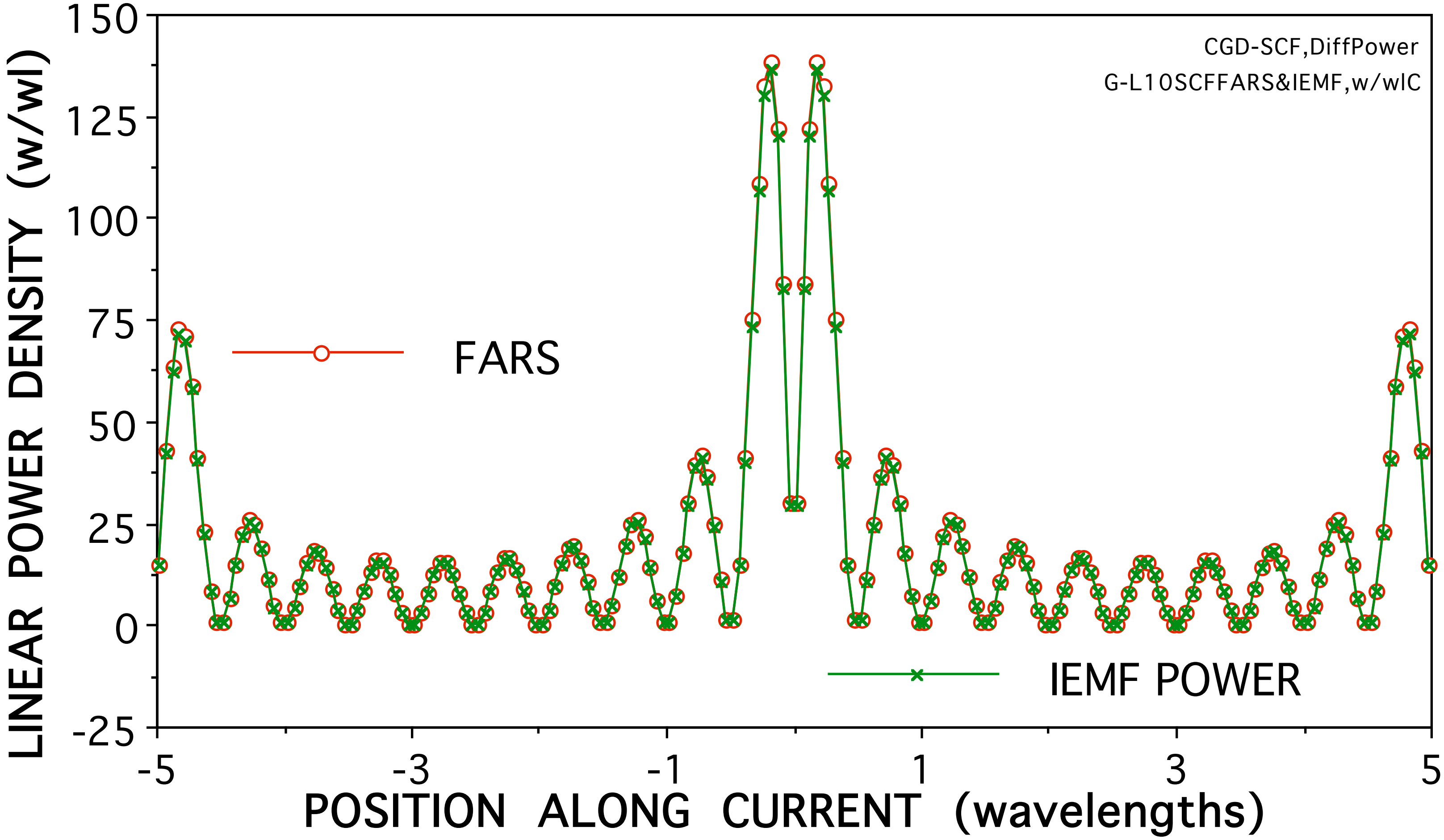
- DIPOLE IEMF POWER CONFINED TO SOURCE REGION
- SCF IEMF POWER DISTRIBUTED ALONG ITS LENGTH

DIFFERENTIATED POYNTING VECTOR ALONG PEC DIPOLE IS WITHIN A FEW % OF FARS EXCEPT IN SOURCE REGION



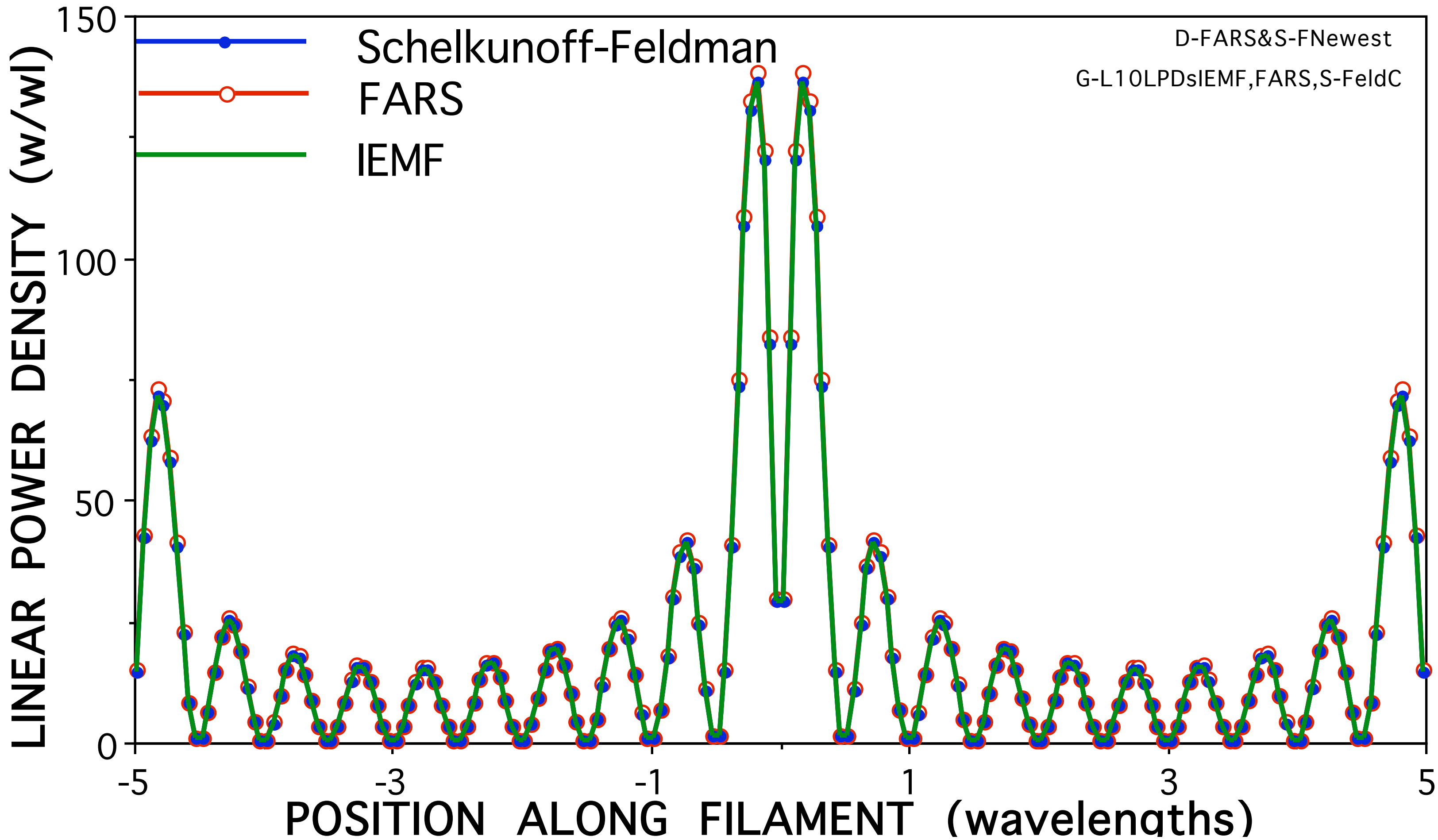
- NORMALIZED TO THE END PEAKS

FARS AND IEMF LPDs FOR THE SCF ARE ALSO ESSENTIALLY IDENTICAL . . .



- SINCE TIME-AVERAGE PROPAGATING POWER IS ZERO, RADIATED POWER SHOULD MATCH THE INPUT (IEMF) POWER DISTRIBUTION

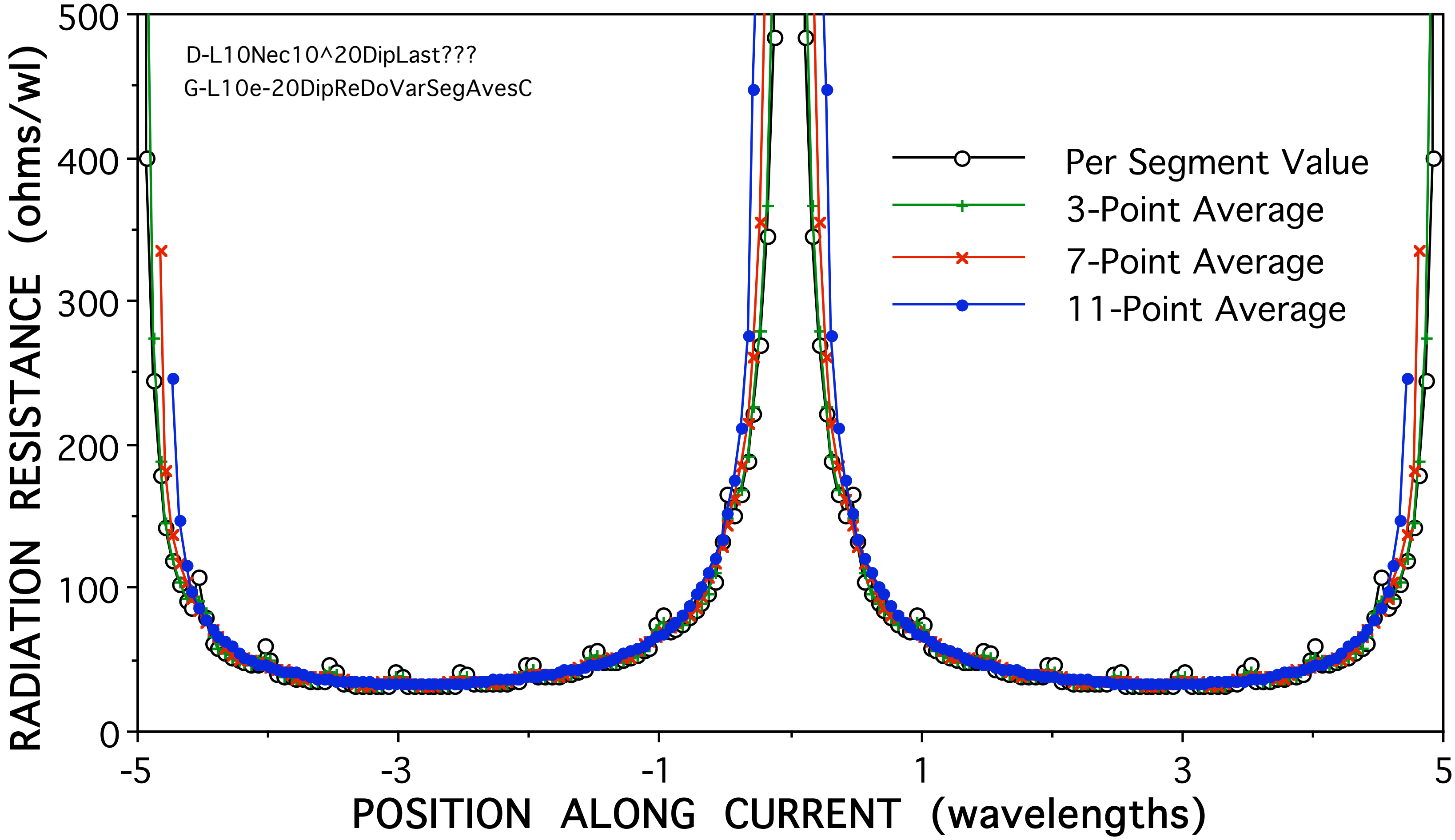
. . . & ARE FOUND AS WELL TO BE IN AGREEMENT WITH THE S-F* APPROACH



- BASED ON $I^2 R_{rad}$ COMPUTED FROM THEIR DERIVED RADIATION RESISTANCE FOR A SCF

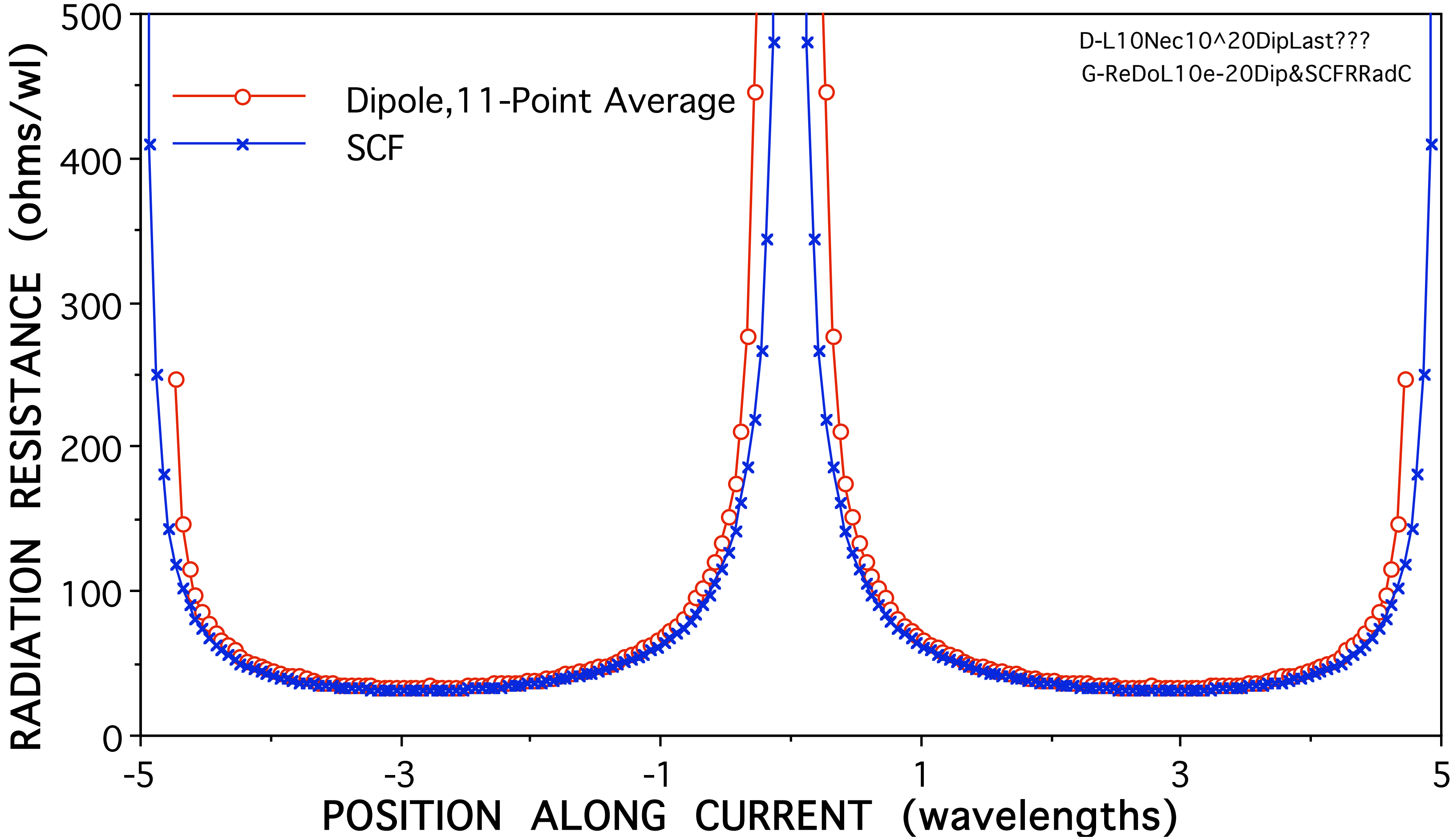
*S. A. Schelkunoff and C. B. Feldman, "On Radiation from Antennas," *Proceedings of the IRE*, Vol. 30, November 1942, pp. 511-516

THE S-F APPROACH SUGGEST DEVELOPING A DISTRIBUTED RADIATION RESISTANCE FOR THE PEC DIPOLE



- OBTAINED USING FARS RESULTS FROM NEC
- AVERAGING SMOOTHES VALUES NEAR FARS AND CURRENT MINIMA

DISTRIBUTED RADIATION RESISTANCE FOR PEC DIPOLE APPROXIMATES SCF



- 11-SEGMENT AVERAGE USED FOR 10^{-20} wl-RADIUS DIPOLE
- $R_{rad,S-F} = \dfrac{60h^2}{(h^2 - s'^2)\,|s'|}$ FOR SCF Nλ LONG, N = 1,2,...,

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