Cavity matrix comparison of tools

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1 Introduction

1.1 Goal

- compute cavity matrix for different model fields

  use code GCM ("get cavity matrix"). The code is based on an on-line run of Astra and its Fortran form (gcm.f) is implemented in the Tk GUI.

- compare 4x4 part with the "Empirical Model" [1].

  Summary of the the two tools, both based on Astra, is shown in Table 1:

tool	file name	method
Empirical Model	`EmpiricalICMTinyVSRPCut01LinearData`	predefined interpolated tables
GCM	gcm.f and gcmMevc.f	on-line Astra run mixed Fortran and shell scripts

Table 1:

1.2 Method

- Section 3 describes GCM (not ready)
- script `compare_field_tables"` executes GCM (gcm.f) and finds $R_{i,j}$, $i, j = 1, 6$

  input: initial beam momentum P_{ini}, cavity gradient E_{max} in MV/m

  scans over cavity phase ϕ.

[1] Empirical Model Interpolation Tables (Y. Chao, September 18th, 2014), encoded form: `EmpiricalModelTableOnly`

- script `compare_cav_models"`

  executes Empirical and GCM (gcmMevc.f) and finds $R_{i,j}$, $i, j = 1, 4$ with the same input: initial beam momentum P_{ini}, cavity gradient E_{max} in MV/m

  scans over cavity phase ϕ.

1.3 Results

- Section 2 shows the three cavity fields [2]. Call them B,V and S.
- The V and B fields give peak energy gain phase ϕ_{PEG} different by $\sim$ 18 deg (253.7 vs 233 deg).
- for E_{ini} above $\sim$ 10 MeV the V and B matrix give same 4x4 matrix (to be confirmed, found by accident)
- Section 4 presents code comparison for ICM cavity, 300 KeV, $P_{ini} = 0.629764$ MeV. **The agreement is very good.**
- The third (S) field produces a vastly different matrix elements `R56`, `R66` – see Section 5.

[2] V. Zvyagintsev

2 Cavity model fields

See Figure 1 and Table 2.

The field occupied region, effective length of the cavity, may be a little different.

The S has smooth maxima.

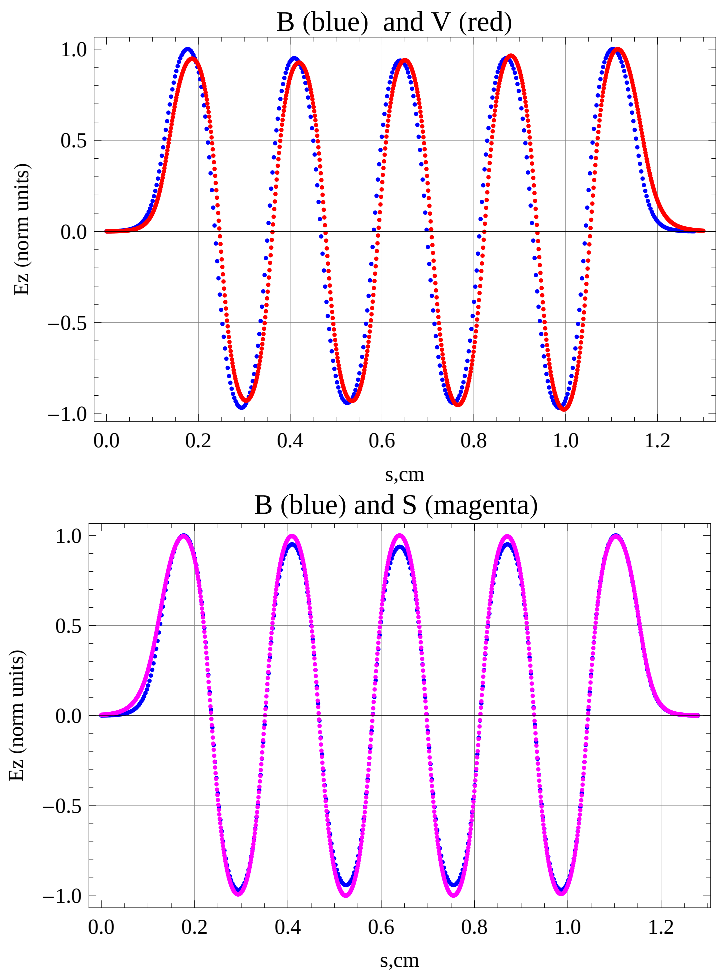

Figure 1: On-axis E_z fields. Top: V and B. Bottom: B and S. In the S case the field has more equal maximum values achieved by adjusting the target shape of cells on CST.

file	Astra Field length	acronym
ez9cellB.dat	128 cm	B
ez9cellV.dat	130 cm	V
9_cell_par_Ez.dat	128 cm	S (smooth)

Table 2: Data files for three fields

3 The GCM (gcm.f)

3.1 PEG phase

For a given E_{max}, Astra performs a scan over phases (by setting an appropriate flag). This PSscan module looks for 0< $\phi < 360$ deg and produces table $E_{\mathrm{kin}}(\phi)$. The PEG phase is the one corresponding to the maximum. This calculation has been verified using a *Mathematica* tool solving the Chamber's Equations of motion, see: `beam01:phase-scan.pdf`.

(more to add)

4 Code comparison for ELBT cavity, 300 KeV

For the same cavity field table, both codes should produce the same final energy and the same cavity matrix.

We will measure cavity phase as this is done in Astra, i.e. by the deviation $\Delta\phi$ from w.r.t. the peak energy gain phase ϕ_{PEG}. Thus no phase deviation $\Delta\phi = 0$ means ϕ is such that the reference particle acquires maximum energy during passage through the cavity field.

4.1 Energy and time of flight

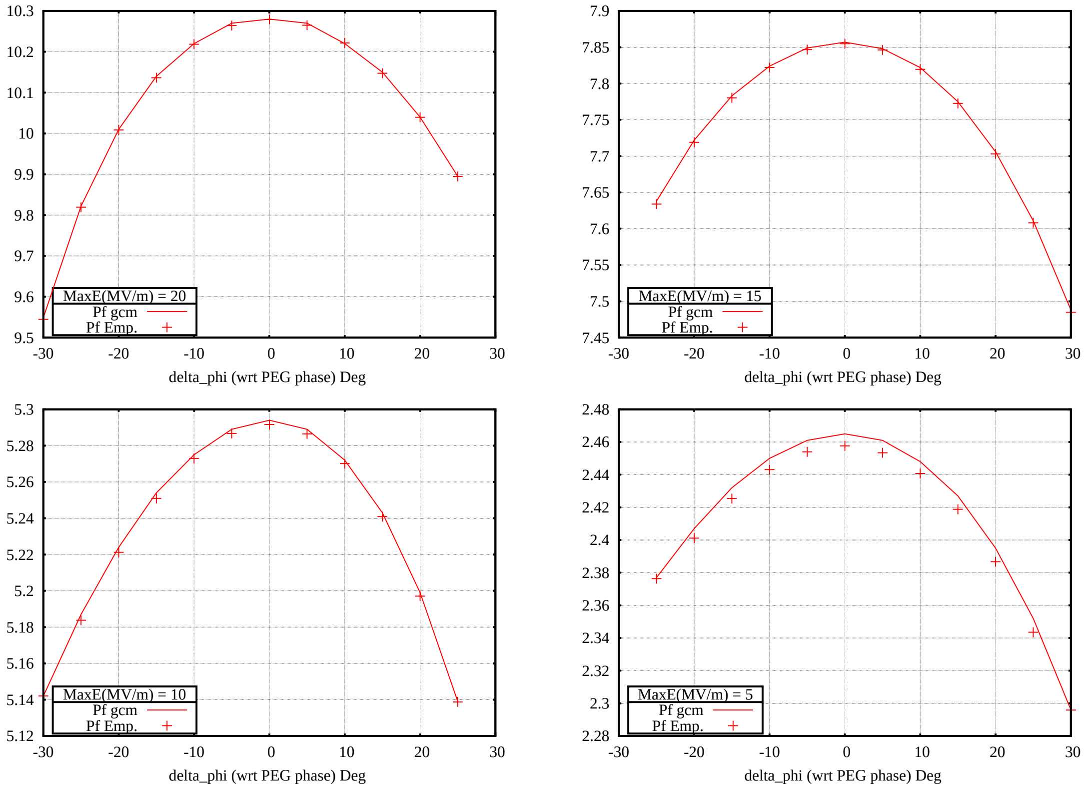

Figure 2: Code comparison for case ELBT (ICM) cavity at $E_{\rm ini}$ =300 kV with cavity field V. Four cavity gradients are used ($E_{\rm max}$ = 5,10,15,20 MV/m). Shown is reference particle final momentum vs cavity phase (as a deviation $\Delta\phi$ from $\phi_{\rm PEG}$ at this gradient.)

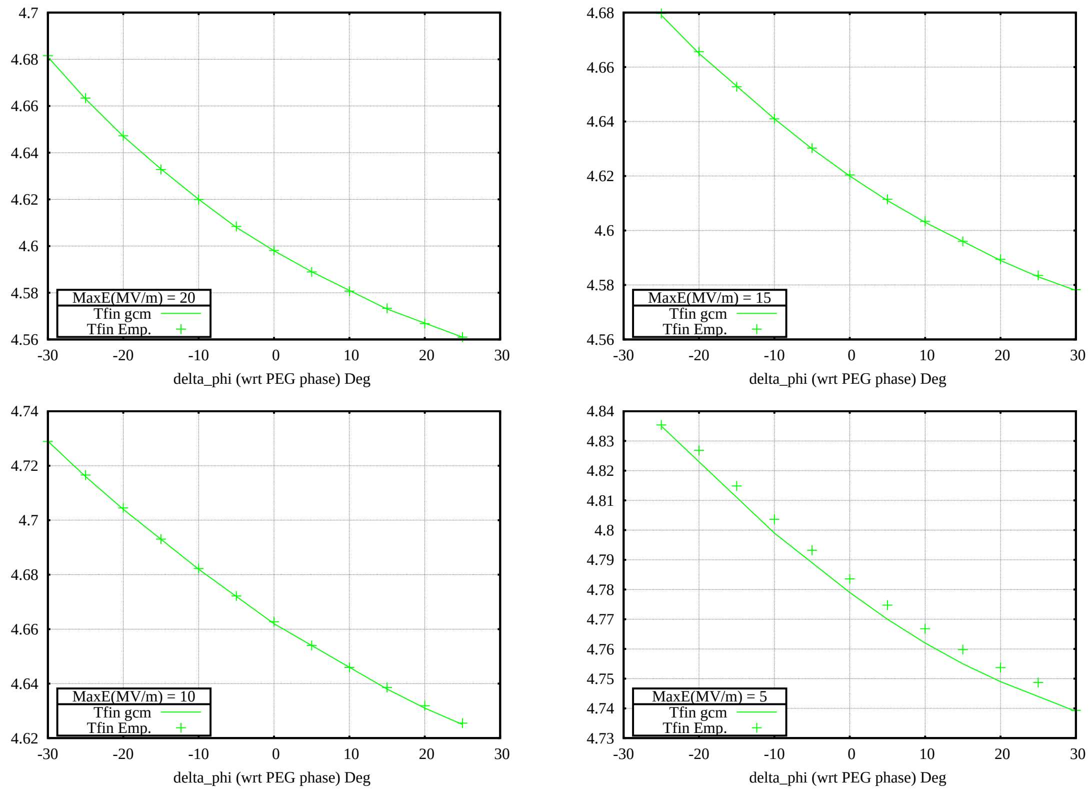

Figure 3: Code comparison – time of flight in nsec for the same cases as in Figure 2.

4.2 Matrix elements

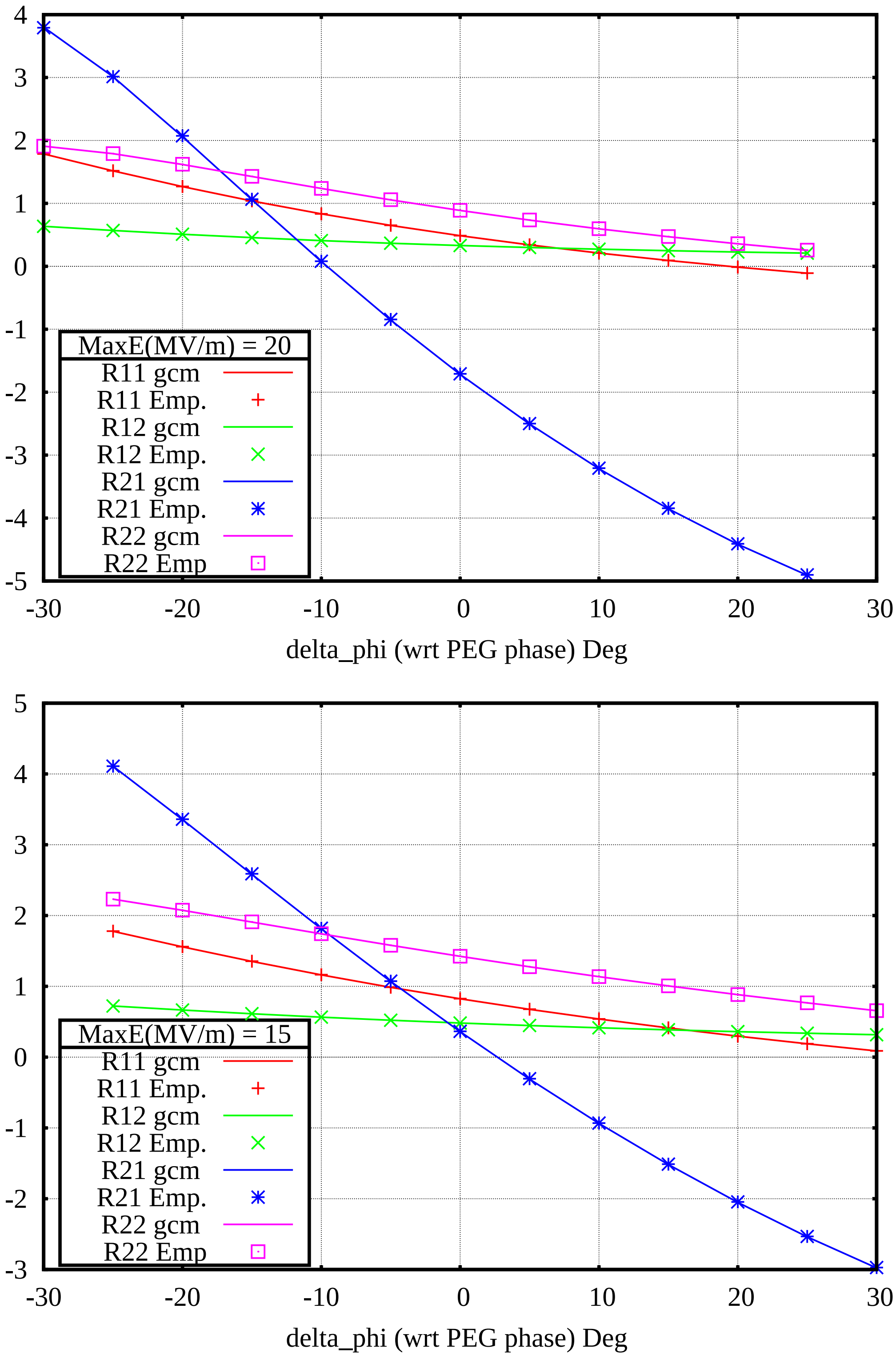

Figure 4: Code comparison – matrix elements in (meters,MeV/c) for the first two cases shown ($E_{\rm max}$ = 20 and 15 MV/m) on Figure 2.

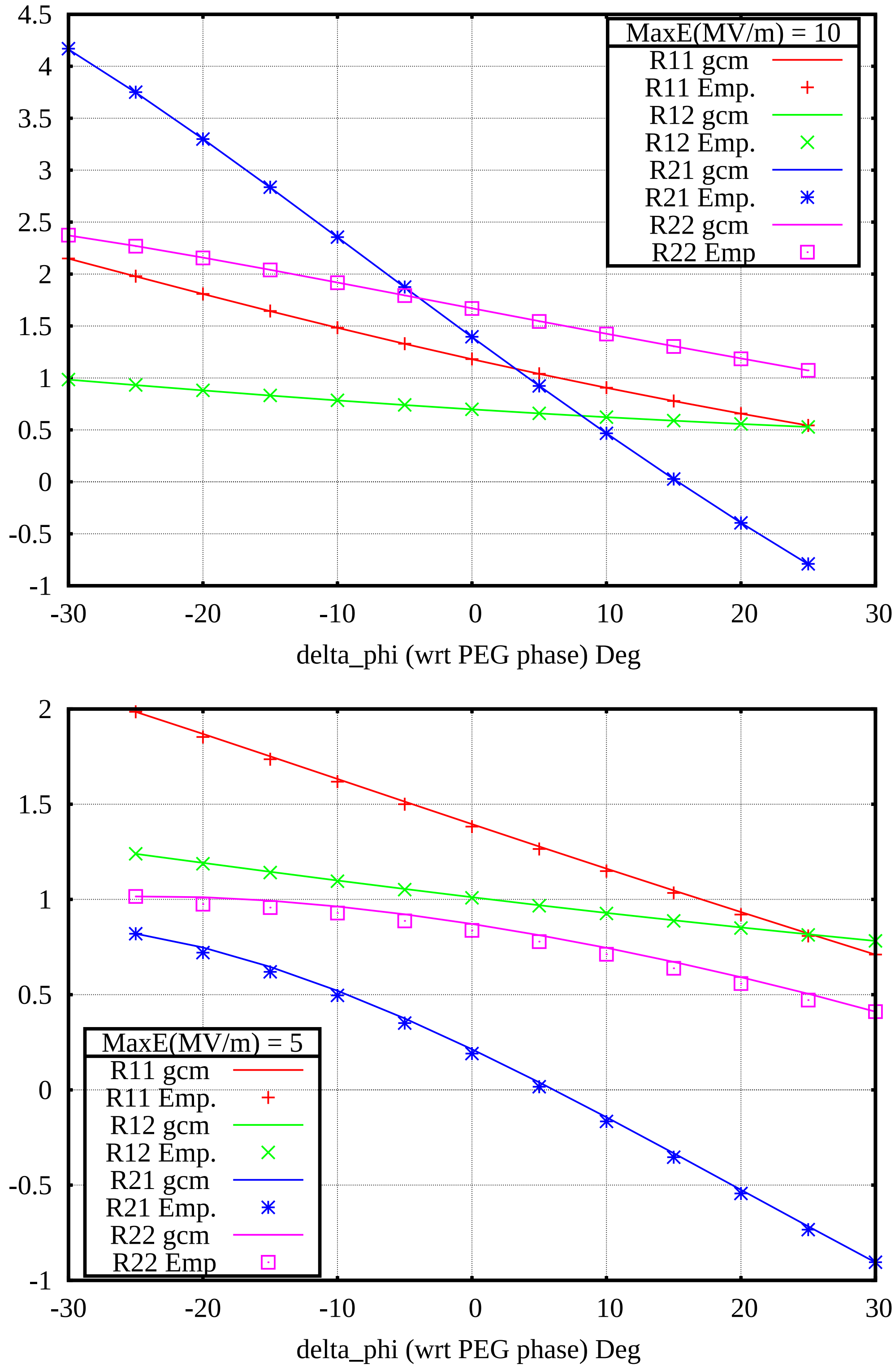

Figure 5: Code comparison – matrix elements in (meters,MeV/c) for the second two cases shown ($E_{\max} =$ 10 and 5 MV/m) on Figure 2.

5 Cav. matrix for different fields

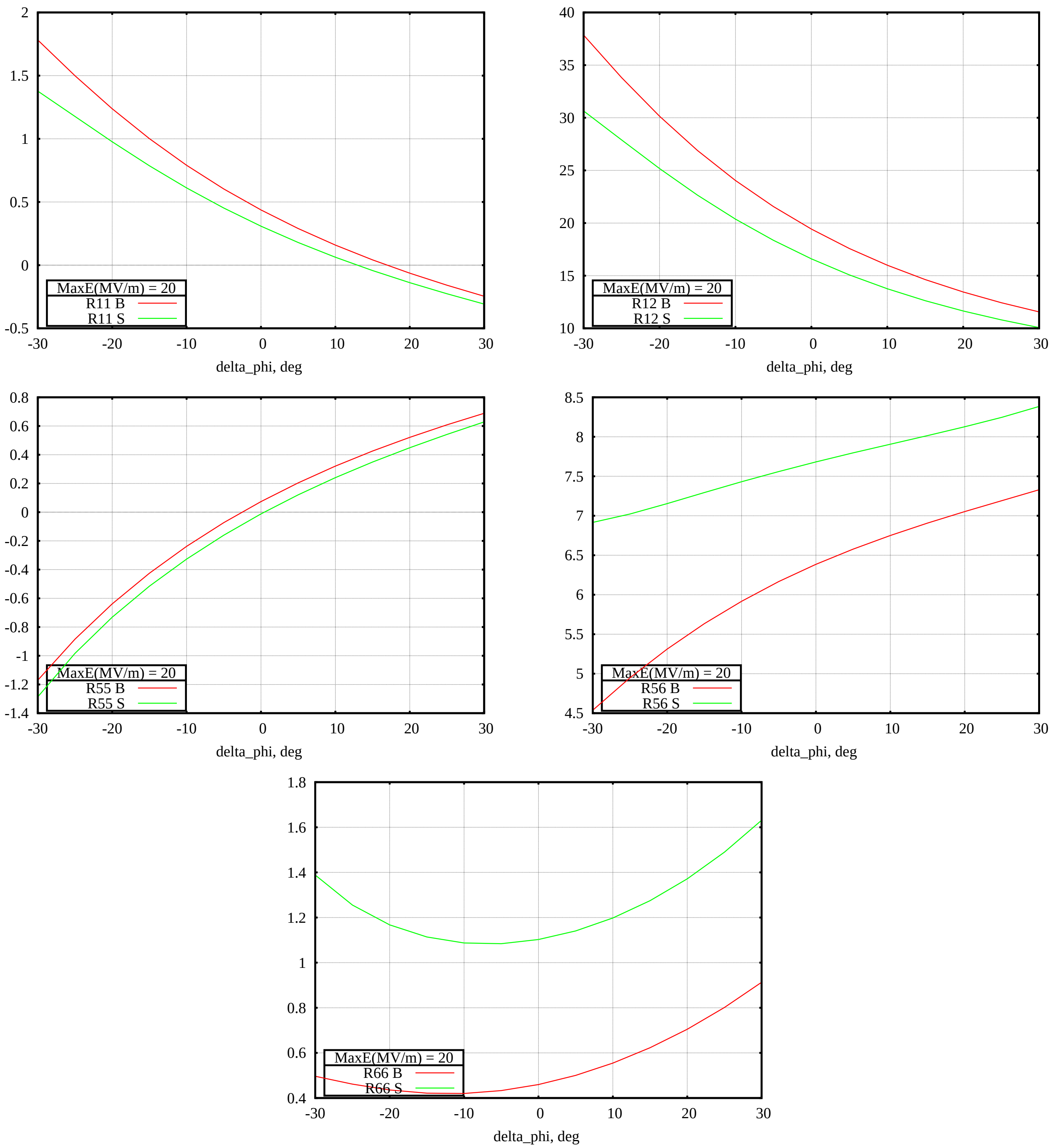

Figure 6: Code GCM (gcm.f): matrix elements in OPTR units (cm,rad) for the ICM cavity with B and S fields. All taken at PEG phase for $E_{\max}$= 20 MV/m). `R65` is near zero.