CARE-HHH
Panel Discussion

Impedance Codes

Thomas Weiland
\[ \vec{F}(\vec{r},t)_{total} = q \left[ \vec{E}(\vec{r},t)_{External} + \vec{v} \times \vec{B}(\vec{r},t)_{External} \right] + q^2 \left[ \vec{E}'(\vec{r},t)_{Self} + \vec{v} \times \vec{B}'_{Self} \right] \]
\[
F(\vec{r}, t)_{\text{total}} = q \left[ \tilde{E}(\vec{r}, t)_{\text{External}} + \vec{v} \times \tilde{B}(\vec{r}, t)_{\text{External}} \right] \\
+ q^2 \left[ \tilde{E}'(\vec{r}, t)_{\text{Self}} + \vec{v} \times \tilde{B}'_{\text{Self}} \right]
\]

Accel.Cavities, Kickers
Bending Magnets, Quadrupoles,…..

Geometrical Wakefields, Cavities,
Surface Roughness, Resistive Wall,…..
Integrating

\( \tilde{W}(\vec{r}, s) = \int_{-\infty}^{+\infty} \tilde{F}(\vec{r}, t) \, d(\text{ct}) \bigg|_{z=\text{ct}+s} \)

\( \tilde{W}(\vec{r}, s) = \int \tilde{F}(\vec{r}, t) \, d(\text{ct}) \bigg|_{z=\text{ct}+s} \)

Fourier Transform

\( \tilde{Z}(\vec{r}, \omega) = \frac{1}{2\pi} \int_{-\infty}^{+\infty} \tilde{W}(\vec{r}, s) \, e^{i\omega s} \, ds \)

In general **NOT** possible for some applications, e.g. XFEL, ILC?

OK for LHC
Impedance Classification

• Impedance
  – Resonant / Non-resonant Impedance
    Accelerating cavities / steps in vacuum chamber
  – High-Q / Low-Q
    SC-cavities / Ferrite loaded cavities
  – Broad band / Narrow band
    Cavities / Vacuum chamber transitions
  – Low frequency / High frequency
    Kicker impedance / Accelerator cavities
  – Parasitic (wakes) / Technical (full field)
    (Bellows, Vacuum chambers / Kickers, BPMs)
  – External Forces / Self-Forces
    Cavities / Bellows impedance

• General Beam-Environment Interaction
  – Forces are time and location dependant
    wake fields of short bunches in e.g. TESLA/ILC
    impedance concept not valid
• **Frequency Domain**
  - Eigenvalue Solvers
    *Accelerating cavities / steps in vacuum chamber*
  - Driven Problems Solvers
    *SC-cavities / Ferrite loaded cavities*
  - Lossy / Lossfree (Complex Solvers)
    *Copper / Ferrite Cavities*
  - Low frequency / High frequency
    *Kicker impedance / Accelerator cavities*
  - Parasitic / Technical
    *Bellows, Vacuum chambers / Accelerating cavities*

• **Time Domain**
  - Slowly varying fields
    *Kicker magnets*
  - Fast varying fields
    *wake fields of short bunches in e.g. TESLA/ILC impedance concept not valid*
• General Purpose Codes
  – MAFIA / GDFIDL (both 32 Bit and 64 Bit)
  – CST MICROWAVE STUDIO (32 Bit and 64 Bit)
  – CST EM STUDIO (32 Bit and 64 Bit)
  – HFSS (32 Bit and 64 Bit)
  – CONCERTO (32 Bit)
  – …

• Dedicated Codes
  – xxBCI / TBCI / ABCI
  – URMELxx
  – ECHO
  – ECHO 3D
  – …
Frequency vs. Time Domain

We need both – Time and Frequency Domain
Full choice of Meshes (in EMS/MWS)

\[ \varepsilon_1, \mu_1, K_1 \]

\[ \varepsilon_2, \mu_2, K_2 \]
<table>
<thead>
<tr>
<th>Frequency-Domain</th>
<th>Frequency-Domain</th>
<th>Frequency-Domain</th>
<th>Frequency-Domain</th>
<th>Time-Domain</th>
<th>Time-Domain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resonant</td>
<td>Resonant</td>
<td>Non-Resonant</td>
<td>Non-Resonant</td>
<td>Non-Resonant</td>
<td>Non-Resonant</td>
</tr>
<tr>
<td>Eigenmode</td>
<td>Eigenmode</td>
<td>Driven Problems</td>
<td>Driven Problems</td>
<td>Wakefields</td>
<td>Wakefields</td>
</tr>
<tr>
<td>Low-Q</td>
<td>High-Q</td>
<td>Low-Freq.</td>
<td>High-Freq.</td>
<td>Normal Size</td>
<td>XXXXL</td>
</tr>
<tr>
<td>Anisotropic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>+++</td>
<td>(+)</td>
<td>+</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>(CST-MWS)</td>
<td>CST-MWS</td>
<td>(CST-MWS)</td>
<td>MAFIA</td>
<td>ECHO</td>
<td></td>
</tr>
<tr>
<td>(HFSS)</td>
<td>HFSS</td>
<td>Extension at TEMF</td>
<td>Extensions at TEMF</td>
<td>ECHO3D</td>
<td></td>
</tr>
<tr>
<td>(MAFIA)</td>
<td>MAFIA</td>
<td></td>
<td>TBCI/ABCI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(GDFIDL)</td>
<td>GDFIDL</td>
<td></td>
<td>GDFIDL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In the works</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ferrite-loaded</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cavities</td>
<td>Accelerating</td>
<td>Kicker-Magnets</td>
<td>Above-Cutoff</td>
<td>Wakefields</td>
<td>Wakefields</td>
</tr>
<tr>
<td></td>
<td>Cavities SC / LC</td>
<td></td>
<td>Impedance</td>
<td>Any kind</td>
<td>in VERY</td>
</tr>
<tr>
<td></td>
<td>/ ... Bellows /</td>
<td></td>
<td></td>
<td></td>
<td>long</td>
</tr>
<tr>
<td></td>
<td>Vacuum Chambers</td>
<td></td>
<td></td>
<td></td>
<td>structures</td>
</tr>
</tbody>
</table>
Questions ??

1) Is there any need for more software than already available today? 
And if so, what kind of?

2) Do we need entirely new software packages or would it be sufficient to extend existing tools?

3) Is there any completely new area of computation and type of physics which no software as of today can deal with?

4) What are the pro's and con's of commercial and research software tools?

5) What is the limitation when applying existing tools for current problems, memory or computational power?

6) Do we need optimization tools in this area?
Let’s discuss with

- K. Bane, SLAC
- W. Bruns, GDFIDL company
- F. Caspers, CERN
- E. Jensen, CERN
- M. Dohlus, DESY
- M. Zobov, LNF-INFN Frascati
- T. Weiland, TU-Darmstadt (80%), CST (20%)