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CARE-HHH
Panel Discussion

Impedance Codes

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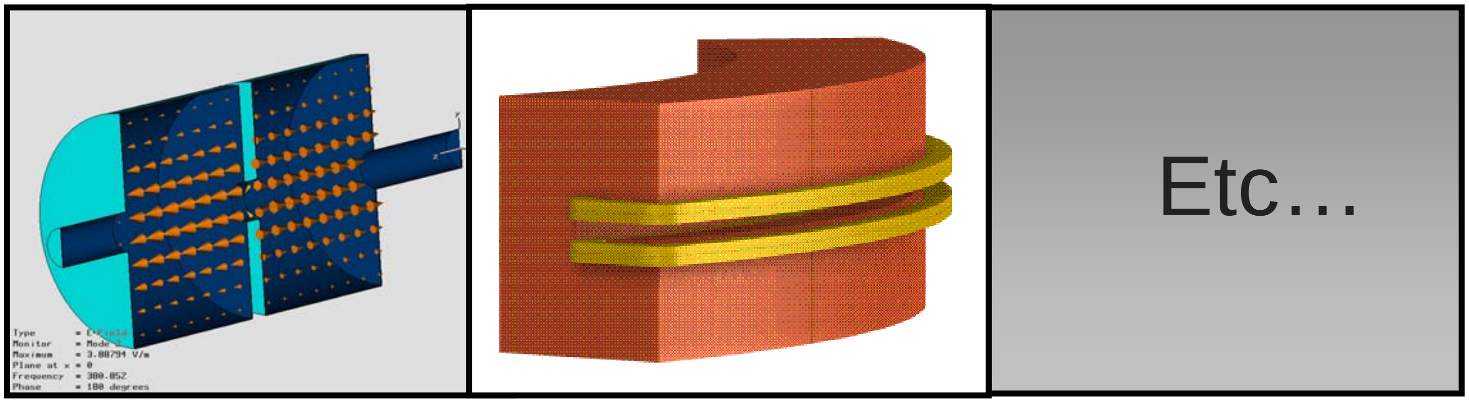
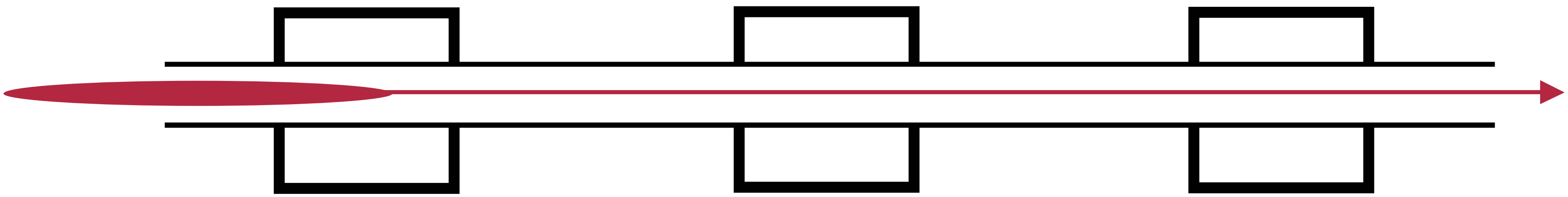
Impedance = ?





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

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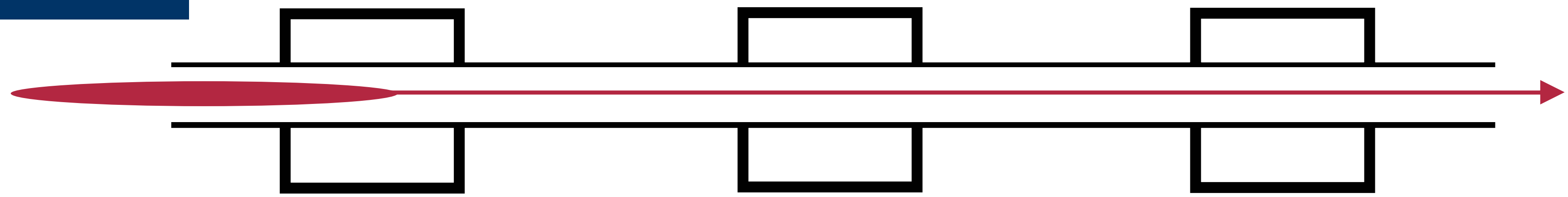

Accel.Cavities, Kickers

Bending Magnets, Quadrupoles,…..

$$\vec{F}(\vec{r},t)_{total} = q\left[\vec{E}(\vec{r},t)_{External} + \vec{v}\times\vec{B}(\vec{r},t)_{External}\right]$$

$$+q^2\left[\vec{E}'(\vec{r},t)_{Self} + \vec{v}\times\vec{B}'_{Self}\right]$$

Geometrical Wakefields, Cavities,

Surface Roughness, Resistive Wall,…..

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Impedance Concept

Integrating (=averaging) the force

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

In co-moving frame

$$\vec{W}(\vec{r},s) = \oint \vec{F}(\vec{r},t)\, d(ct)\Big|_{z=ct+s}$$

Fourier Transform yields "Impedance"

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

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

Software Classification

- 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

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Software Available

- 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) 2D
  - ….
- Dedicated Codes
  - xxBCI / TBCI / ABCI
  - URMELxx
  - ECHO
  - ECHO 3D
  - ….

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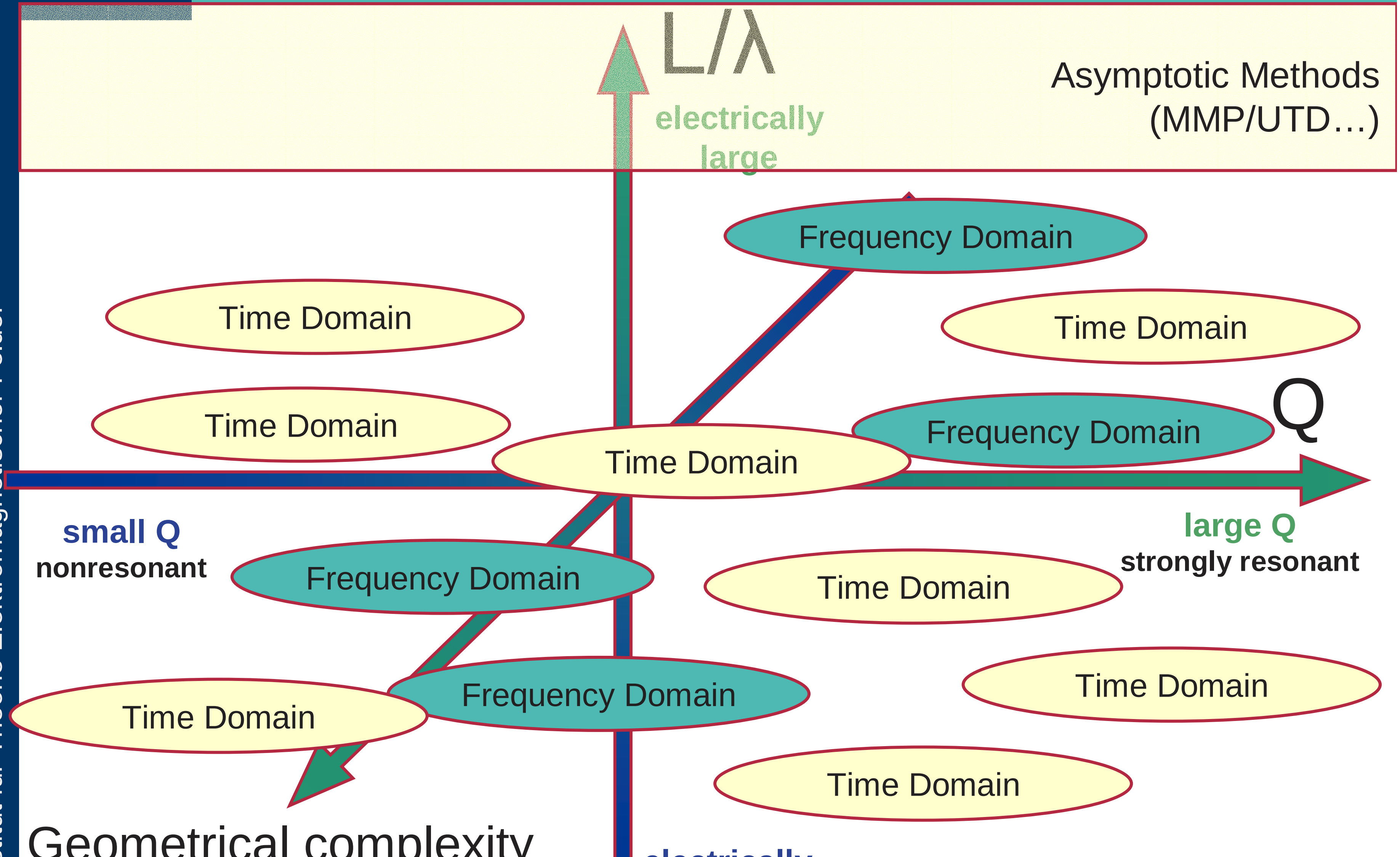
Frequency vs. Time Domain



We need both – Time and Frequency Domain

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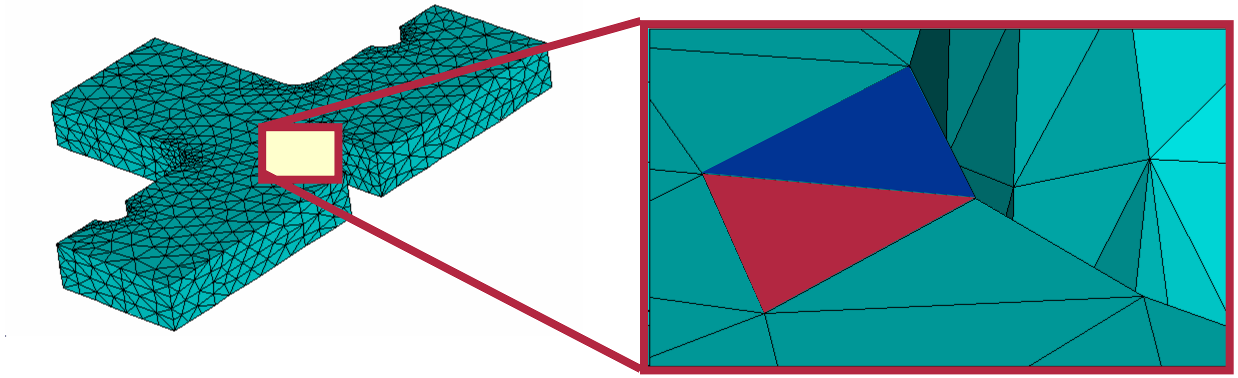
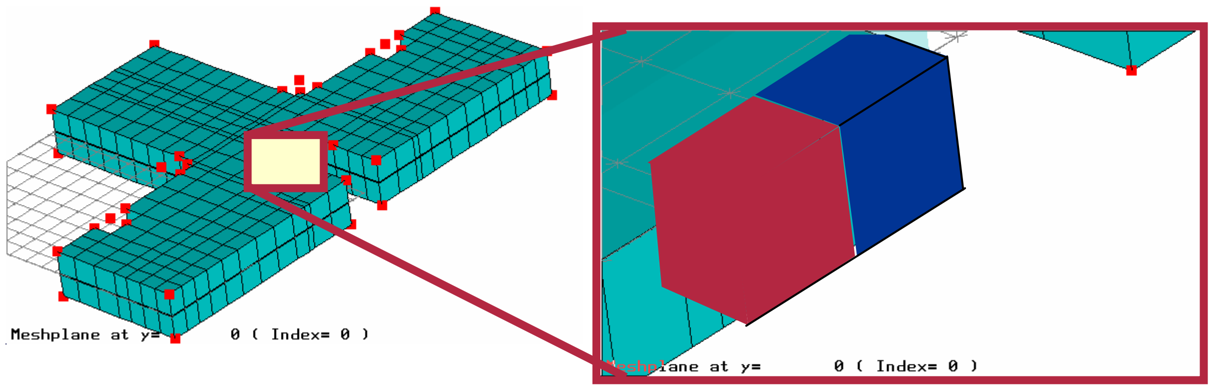
Full choice of Meshes (in EMS/MWS)



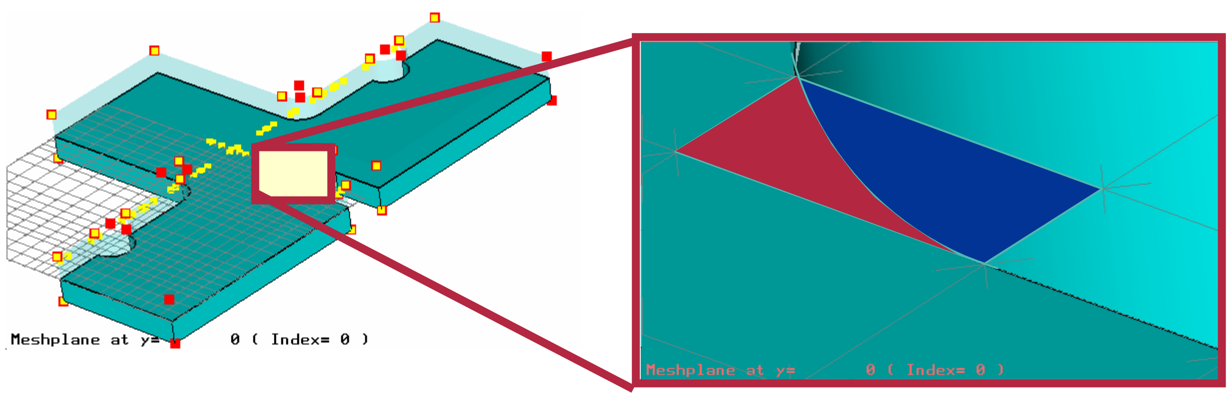
$\varepsilon_1, \mu_1, \kappa_1$

$\varepsilon_2, \mu_2, \kappa_2$



$\varepsilon_1, \mu_1, \kappa_1$

$\varepsilon_2, \mu_2, \kappa_2$



$\varepsilon_1, \mu_1, \kappa_1$

$\varepsilon_2, \mu_2, \kappa_2$

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Overview

Frequency-Domain	Frequency-Domain	Frequency-Domain	Frequency-Domain	Time-Domain	Time-Domain
Resonant	Resonant	Non-Resonant	Non-Resonant	Non-Resonant	Non-Resonant
Eigenmode Low-Q Anisotropic	Eigenmode High-Q	Driven Problems Low-Freq.	Driven Problems High-Freq.	Wakefields Normal Size	Wakefields XXXXL
---	+++	(+)	+	+++	+++
(CST-MWS) (HFSS) (MAFIA) (GDFIDL) In the works	CST-MWS HFSS MAFIA GDFIDL	(CST-MWS) Extension at TEMF	(CST-MWS) Extensions at TEMF	MAFIA TBCI/ABCI GDFIDL	ECHO ECHO3D
Ferrite-loaded Cavities	Accelerating Cavities SC / LC / … Bellows / Vacuum Chambers	Kicker-Magnets	Above-Cutoff Impedance	Wakefields Any kind	Wakefields in VERY long structures

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?

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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%)