Status of QLASA Tool Adapter

Vittorio Marinozzi

Outline:

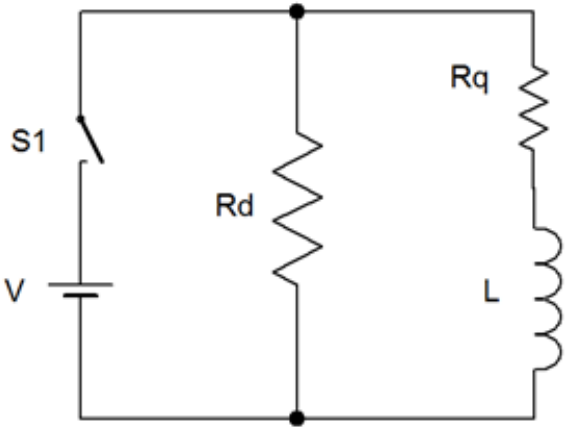
1. Introduction to QLASA
2. Example: modelling of a full magnet
3. Example: modelling of quench detection
4. What's new?
5. Conclusions

1.1 Introduction to QLASA

QLASA is a quench simulation software written at LASA (Milan University-INFN)

QLASA has been originally written for solenoids

- Can be adapted to any kind of magnet



QLASA is pseudo-analytical

- Quench propagation velocities are analytical formules (according to Wilson model)
- Thermal calculation is numeric (adiabatic approximation).
- The resistive zone is a 3D ellipse with the three axes growing according to propagation velocities.
- The coil is a homogenous material
- Numeric solution for the circuit
- Material properties from MATPRO, dependence on temperature, magnetic field, RRR.

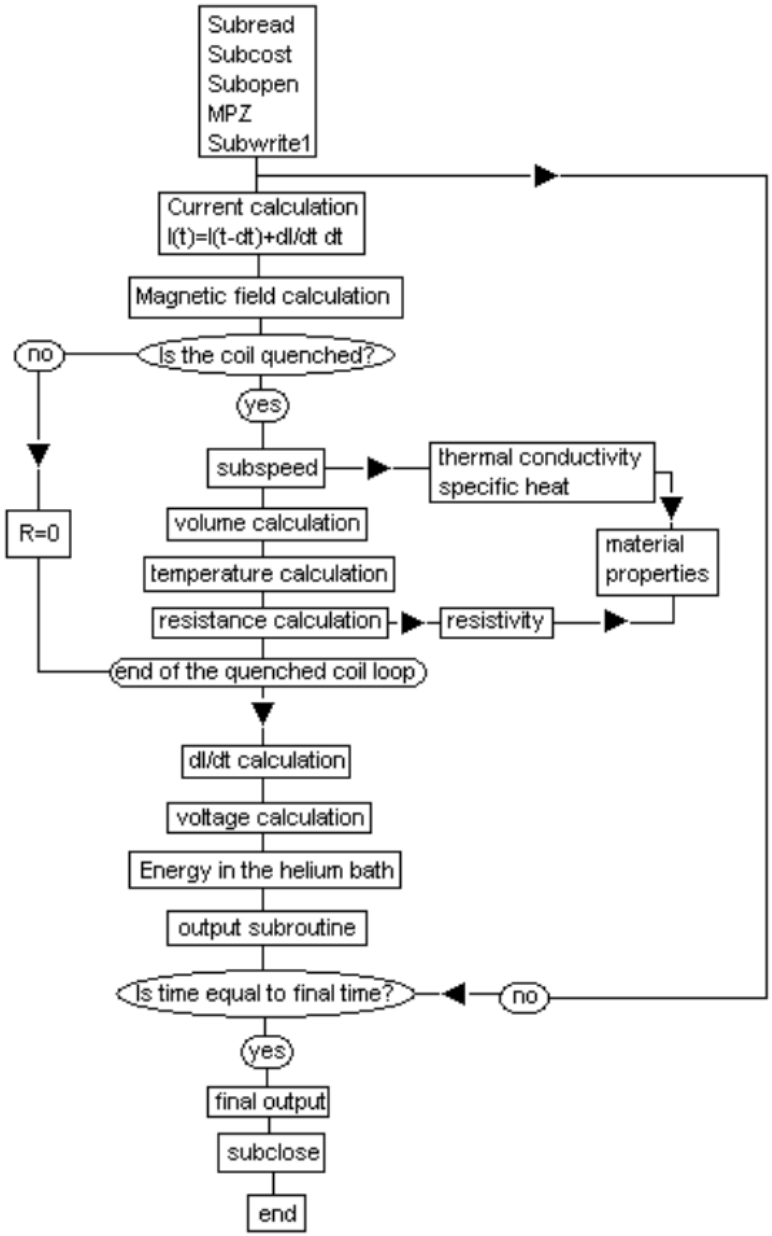
Advantages:

- Very fast (10 -100 s per run)
- 3D quench

Disadvantages (or not):

- All main quantities are input (magnetic field, inductance, etc…)

1.2 Introduction to QLASA



At each time step the code computes:

- the current using the current derivative
- the magnetic field
- the temperature of the ellipse-sheets in the quenched coils
- the resistance of the quenched coils
- the new current derivative
- the new quenched volumes

1.3 Introduction to QLASA

The input file is a tabular text file

- Extension .inp

The input file describes the geometry and the electromagnetic features of maximum 10 solenoids, and the features of the protection circuit

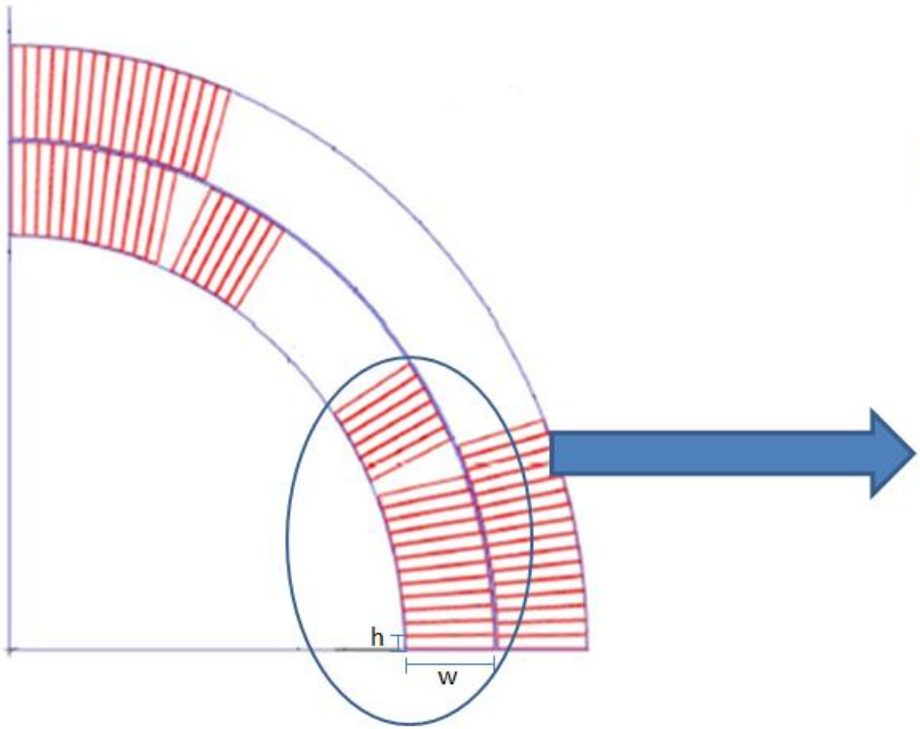
- Since all electromagnetic features are input, one can describe as a solenoid each kind of magnet.

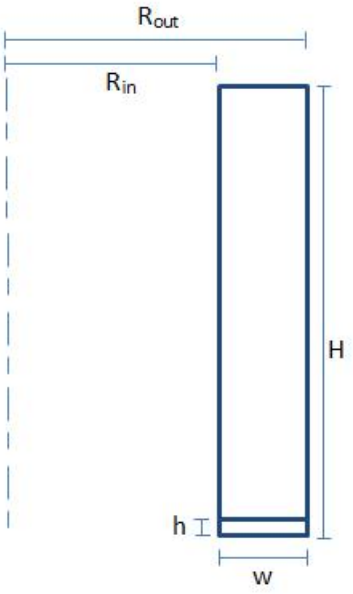
-> Steam Meeting at PSI-Nov 2016: details on input file and outputs

L. Rossi and M. Sorbi, "QLASA: A computer code for quench simulation in adiabatic multicoil superconducting windings," Nat. Inst. of Nucl. Phys. (INFN), Rome, Italy, Tech. Rep. TC-04-13,2004.

2.1 Example – double layer cosθ quadrupole Geometry

- Each coil can be represented as a solenoid
- It is important to preserve the volume in order to simulate the right resistance





Quadrupole length

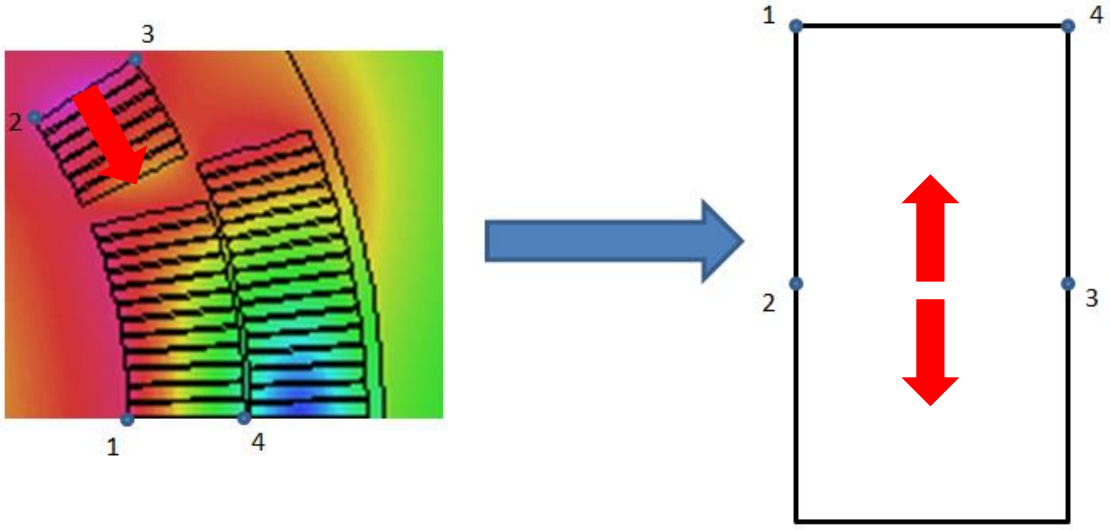
$$R_{in} = \frac{L}{\pi} - \frac{w}{2}$$

$$R_{out} = R_{in} + \frac{w}{2}$$

$$H = Nh$$

2.2 Example – double layer cosθ quadrupole Magnetic field

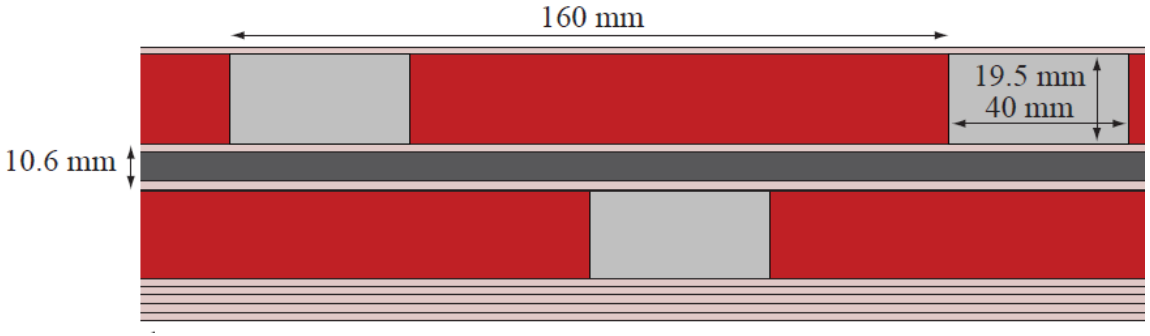
- We have symmetry on the mid-plane, and linear interpolation
- The best solution could be to put the high-field region in the middle, and begin the eventual quench there, correcting the transversal velocity with a 0.5 factor



2.3 Example – double layer cosθ quadrupole Protection heaters

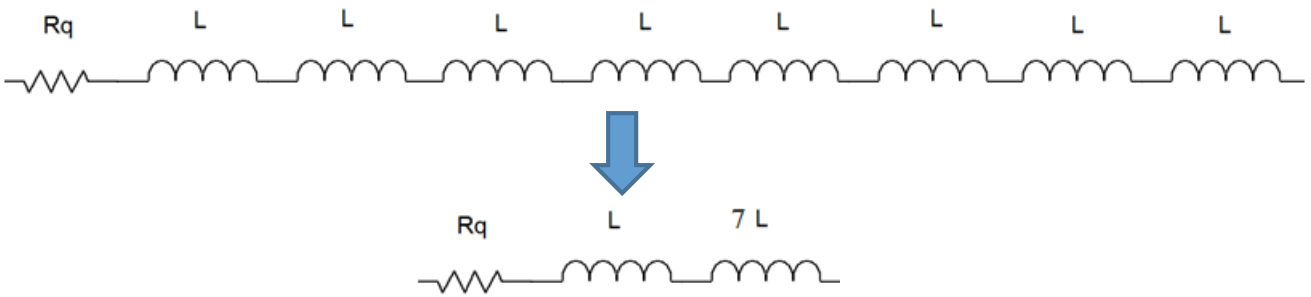
```
0.0005   5.338386088    0.005445        0       0               0               !timq, Rque, yque, rrqui, hhqui, llqui
0.035    5.338386088    0.00726         0       0.00726         0.0125          !timq, Rque, yque, rrqui, hhqui, llqui
0.036    5.338386088    0.00726         0       0.0045375       0.0125          !timq, Rque, yque, rrqui, hhqui, llqui
0.035    16.03359826    0.0099825       0       0.0081675       0.0125          !timq, Rque, yque, rrqui, hhqui, llqui
0.036    16.03359826    0.0099825       0       0.00726         0.0125          !timq, Rque, yque, rrqui, hhqui, llqui
2.037    21.38120435    0.012705        0       0.01            0.02            !timq, Rque, yque, rrqui, hhqui, llqui
0.041    21.38120435    0.012705        0       0.01            0.02            !timq, Rque, yque, rrqui, hhqui, llqui
```

- The heaters delay time has to be inserted as input
- The quench heaters can be simulated as a quench with
  - Null radial dimension
  - Axial dimensions equal to the number of covered turns times the turn thickness
  - Longitudinal dimensions equal to the number of heating stations times the heating stations length

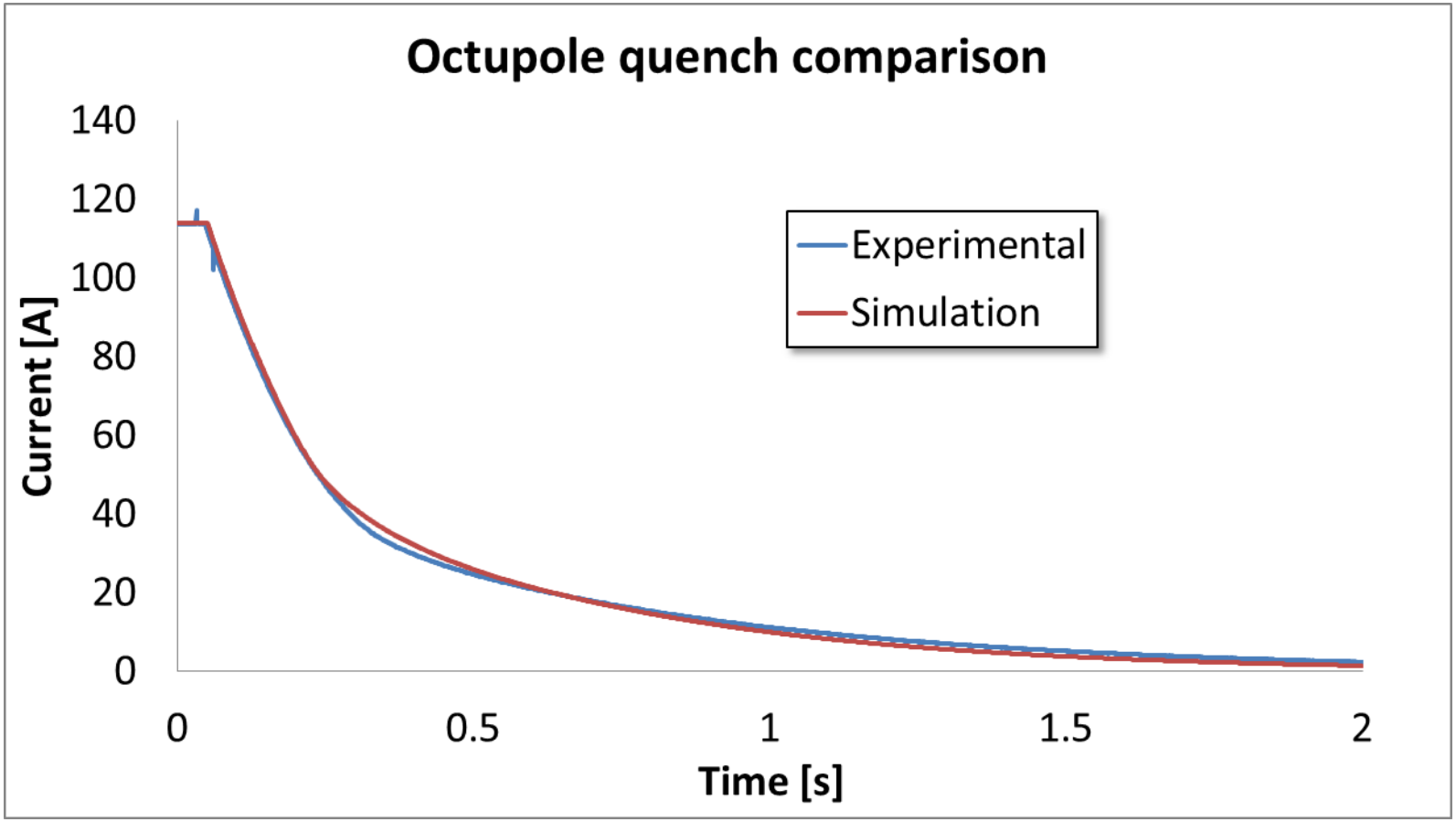


3.1 Example – Quench detection simulation

- QLASA can be used just to simulate spontaneous quench growth, and its detection
  - Very fast, and 3D!
- You have to model the coil you want to quench like in the previous example, but…
- All other coils are just inductance!
  - They can be modeled as one coil, with random geometry, random field, right inductance
  - Take care of the inductance modeling to get “exact” voltage
- Very interesting for STEAM application



3.2 Example – Quench detection simulation



4.1 What's new? – Current driven!

- Current driven mode has been implemented!
  - "input_file_name.current" file to input whatever current shape you would like
  - 3000 points, each one for a time step
    - You have to insert 3000 even if you need 10

  - Voltage and resistance computed accordingly

- Very interesting for implementation in the STEAM framework as a computer of 3D resistance, in combination with other softwares for circuit solutions
  - 1 run takes ~10 s

4.2 What's new? – Scripting

- Past versions of QLASA **could not** be launched using external script
  - (Or at least **I** could not)
  - Beacuse name of input file was requested to be inserted as input from keyboard.

- Now, input file can be put in the string together with the executable
  - -> qlasa.exe input_name.inp

- I know, now you are thinking: this is obvious!...
  - Trust me... in **fortran77**, it is not!

4.3 What's new? – Magnetic field

- Magnetic field improvement is under going
  - Not just 4 points, but a full 100 x 100 matrix per coil, which can be generated by other softwares (Roxie, Comsol…)
  - input_file_name.field
- Now, it affects only differential inductance
- It is planned to improve computation of quench resistance and propagation velocity

5.1 Conclusions

- QLASA is a quench simulation program
- It is pseudo-analytic, and therefore very fast
- It is for solenoids, but adaptable to any kind of magnet
- The input file is a text tabular file easy to generate starting from the magnet parameters
- QLASA can simulate a full quench on a full magnet, or just quench detection
- Current driven mode has been implemented, in order to integrate QLASA in the STEAM framework as a 3D resistance computation tool
- Magnetic field improvement is under going