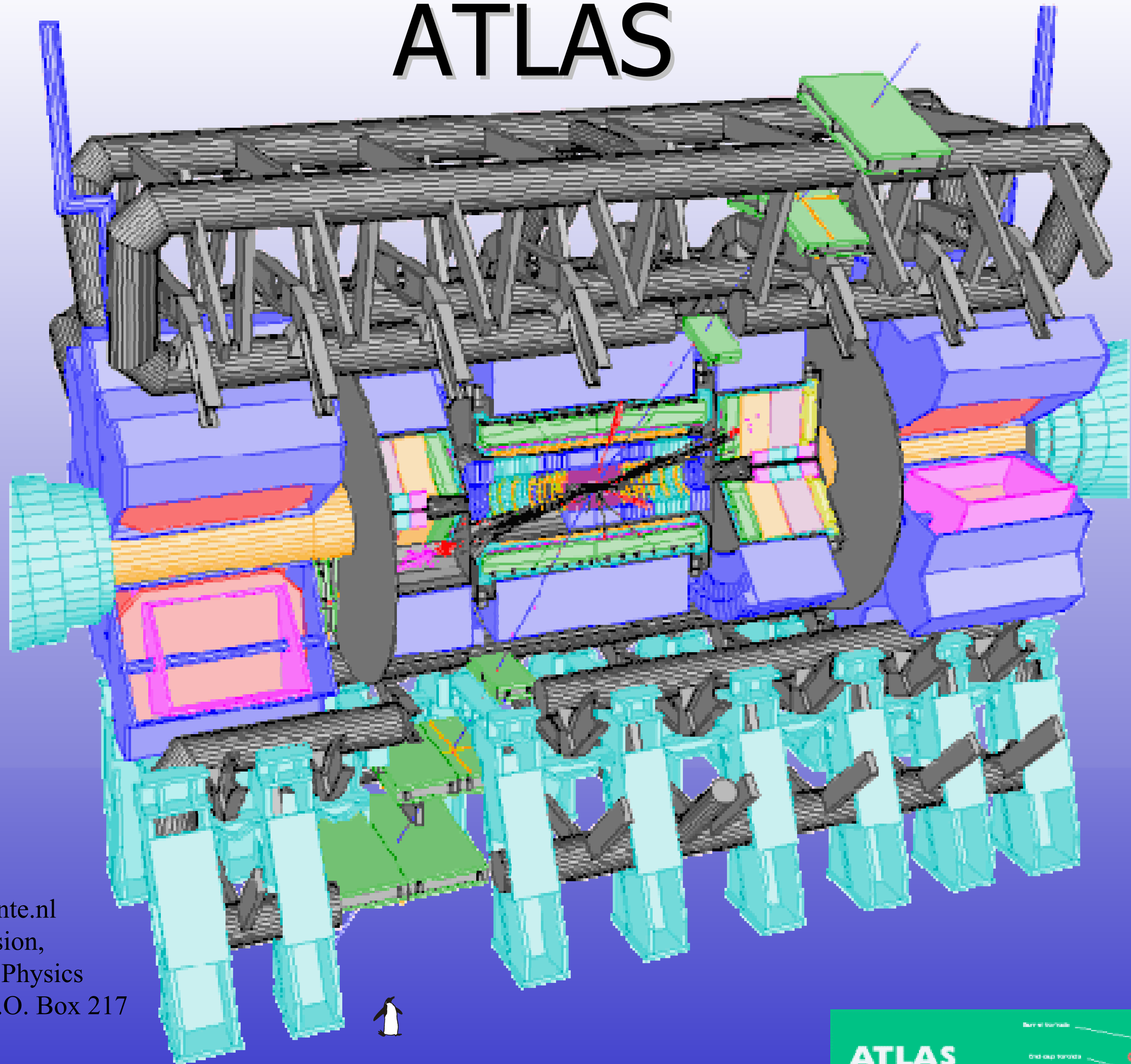
ATLAS



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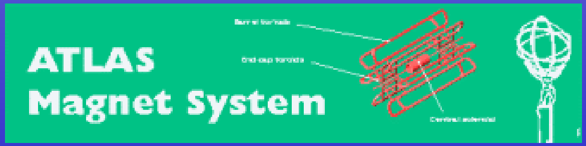
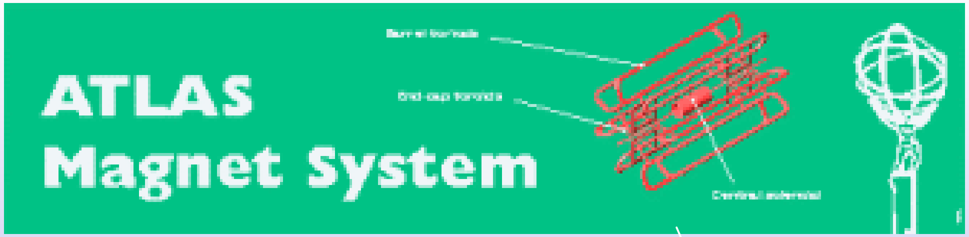
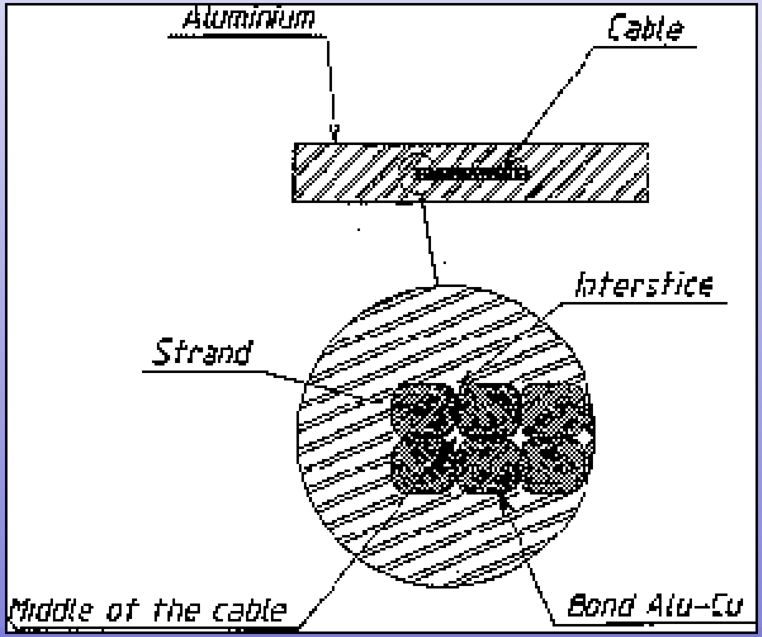


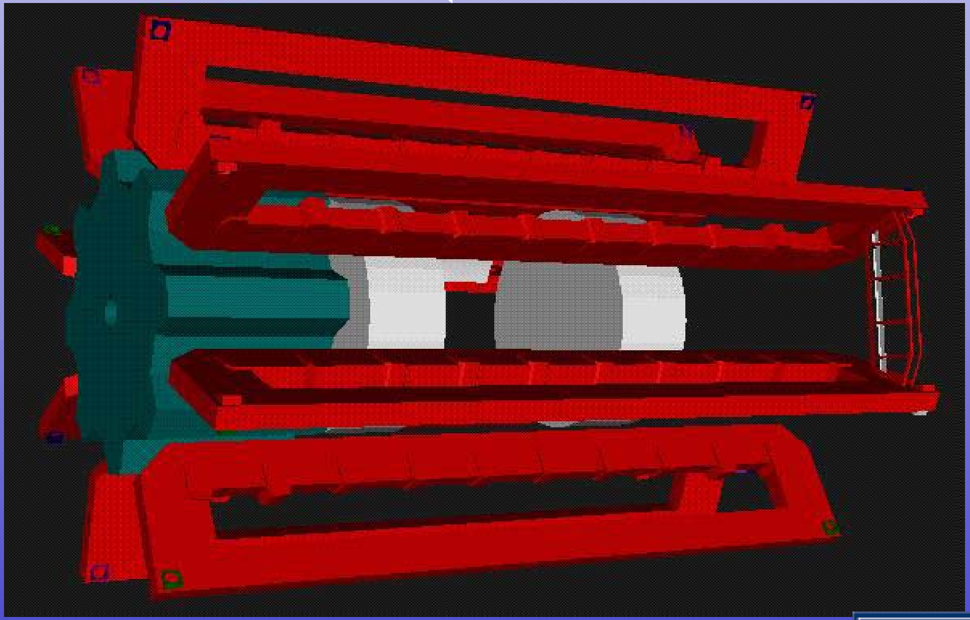
Topics to be discussed

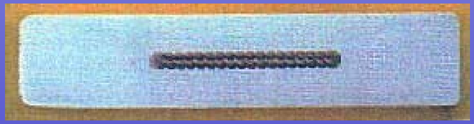
- The B00 and B0 model coils for Atlas
- Normal Zone propagation inside stabilized superconductors
- Local change of current at the normal zone front
- Conclusions



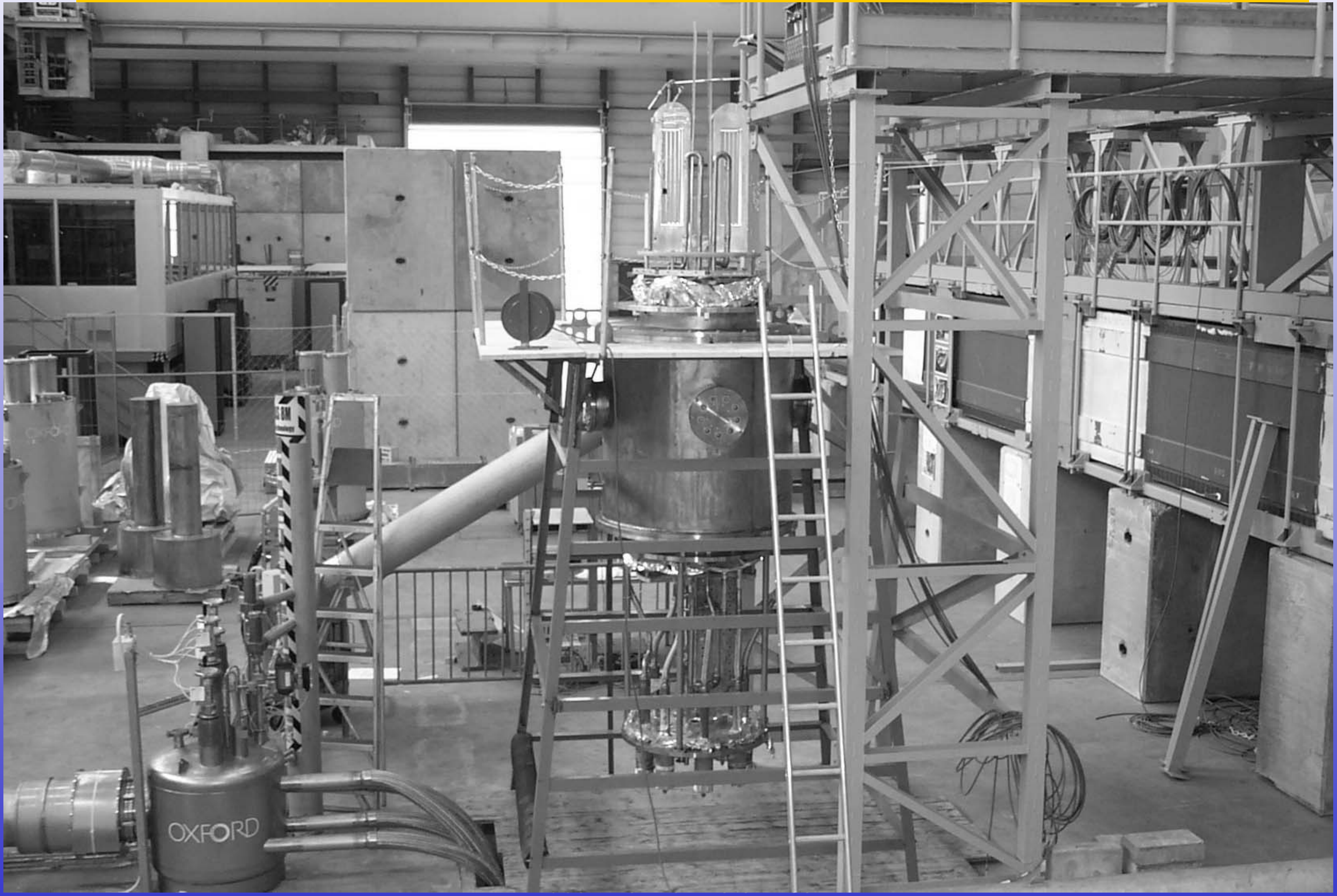


- Barrel Toroid (57*12 mm)
- End Cap Toroid (41*12 mm)
- Central Solenoid (4.25*30 mm)

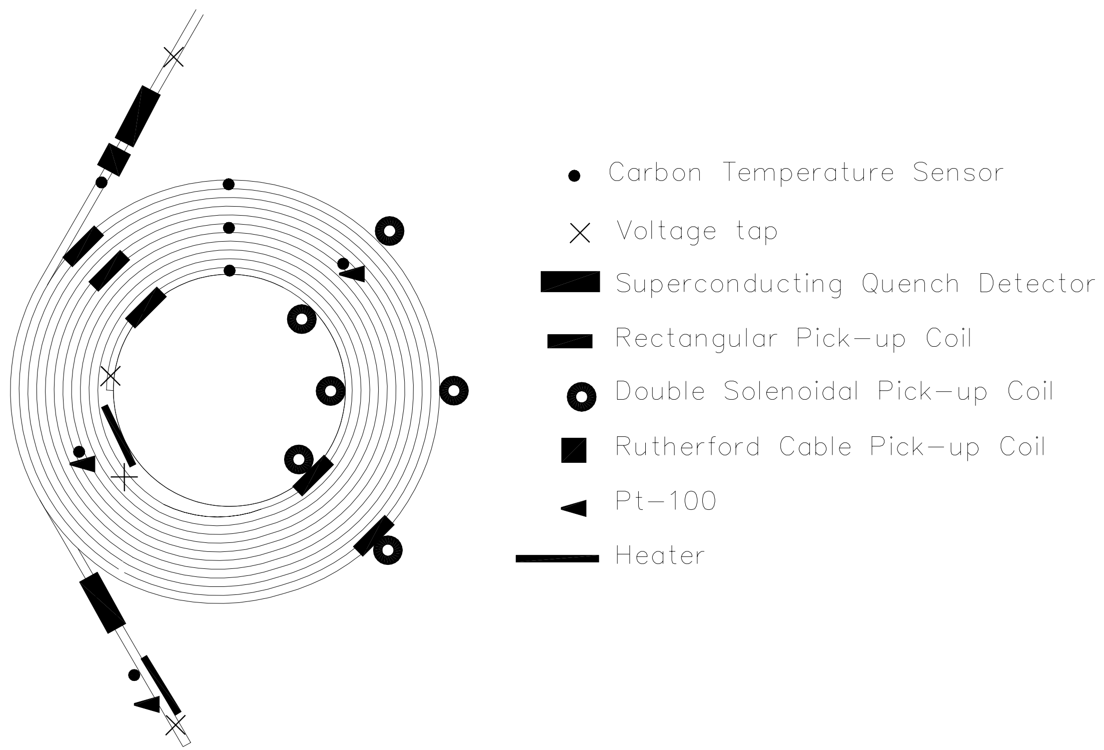




B0 model coil for Atlas



B00 model coil for Atlas



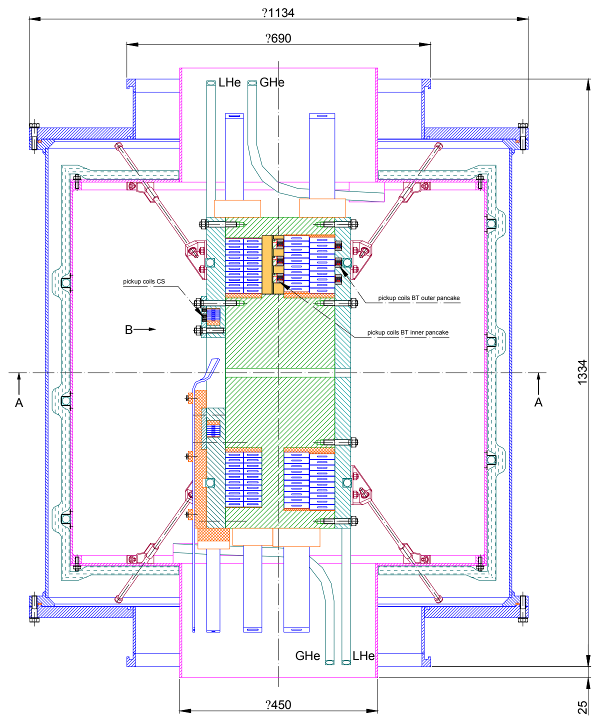
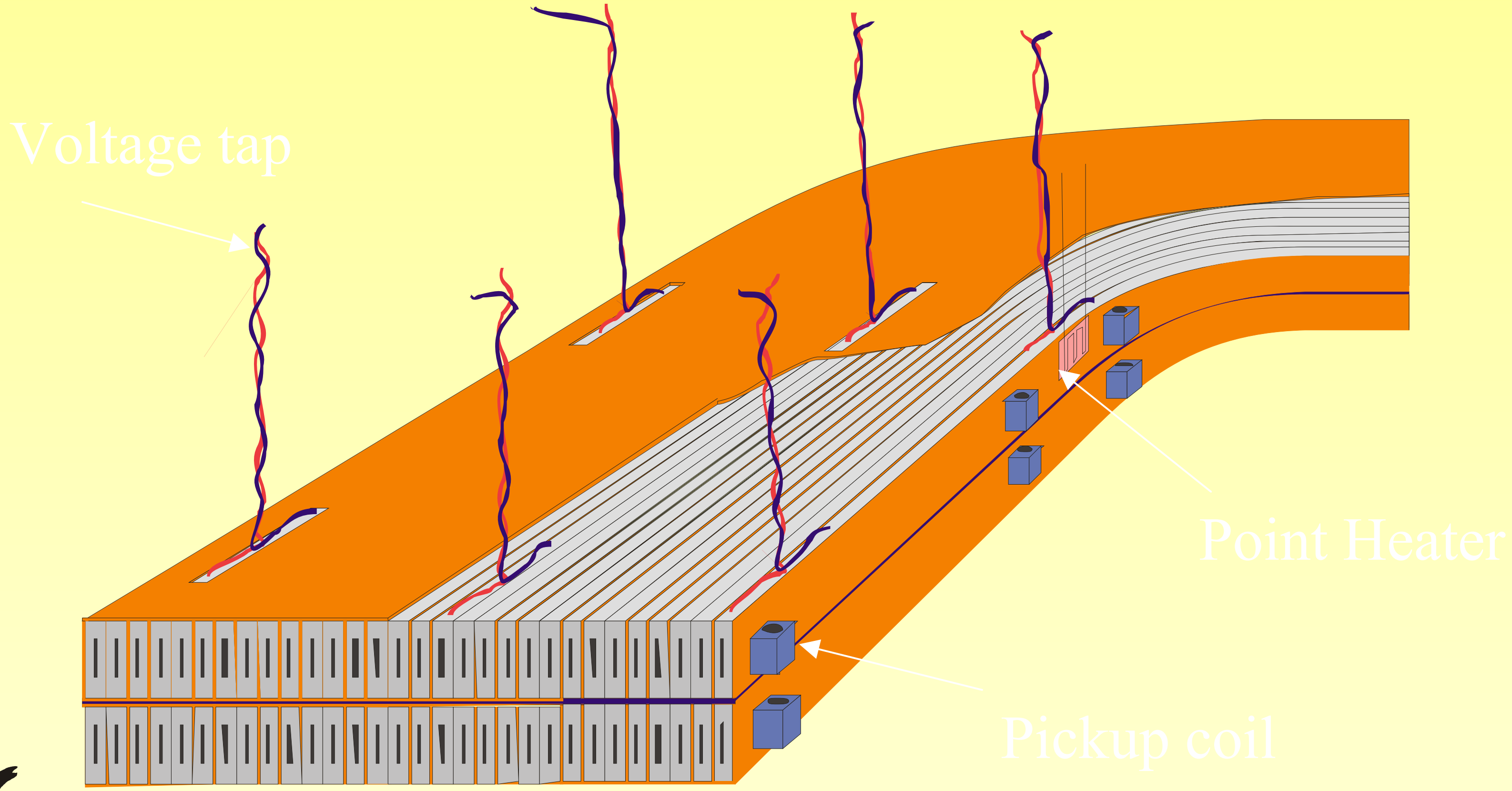
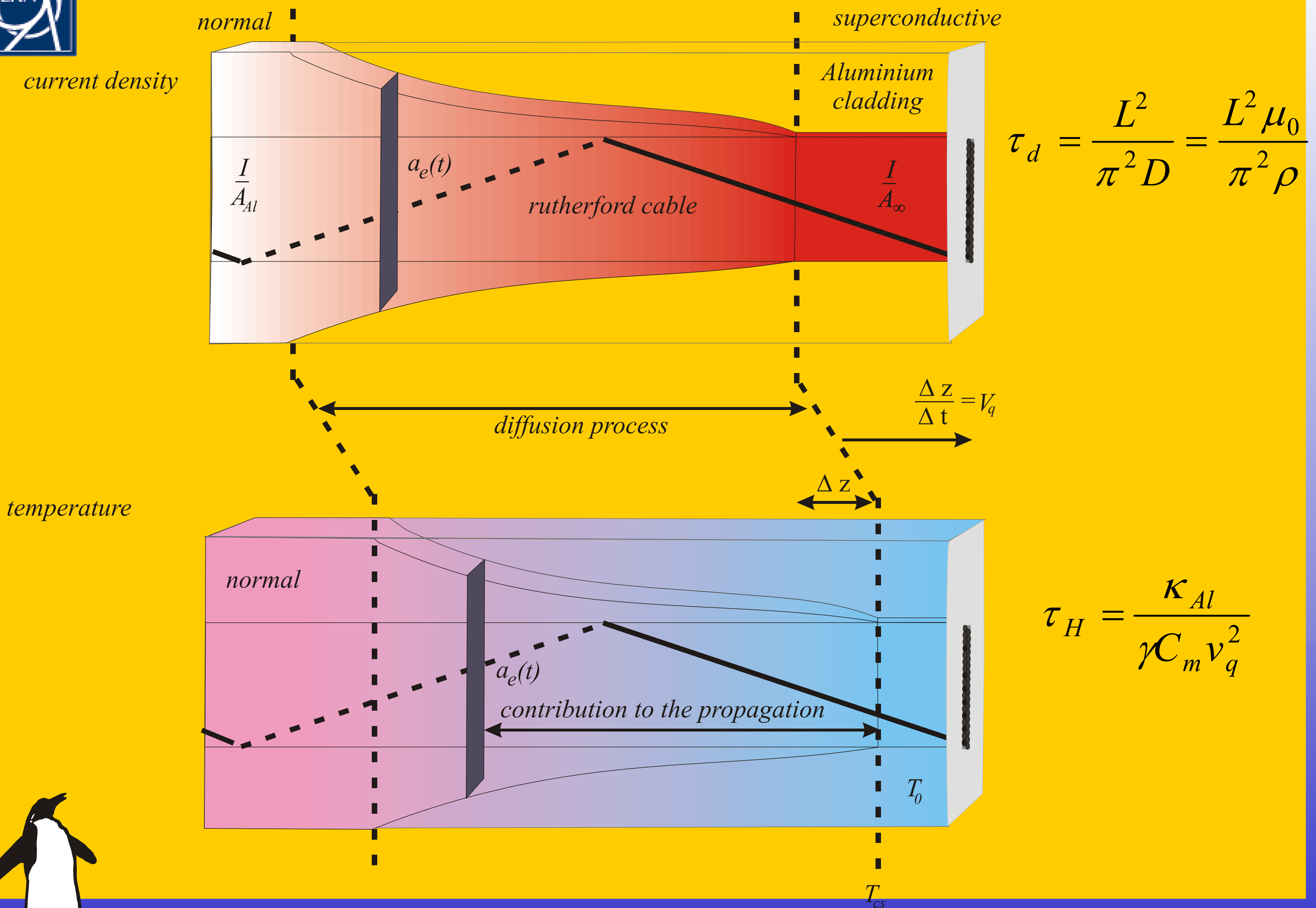


Fig.3.7. Magnet system cryostat.

B0 model coil for Atlas

Position of the sensors inside B0




normal
superconductive
current density
Aluminium cladding
$\frac{I}{A_{Al}}$
$a_e(t)$
rutherford cable
$\frac{I}{A_\infty}$
$\tau_d = \frac{L^2}{\pi^2 D} = \frac{L^2 \mu_0}{\pi^2 \rho}$
diffusion process
$\frac{\Delta z}{\Delta t} = V_q$
Δz
temperature
normal
$a_e(t)$
contribution to the propagation
$\tau_H = \frac{\kappa_{Al}}{\gamma C_m v_q^2}$
T_0
T_{cs}
normal zone front

Longitudinal Propagation including the diffusion of the current into the Aluminium stabiliser

$$\frac{\partial}{\partial x}\left(\left(kA_{Al}+k_{cu}A_{cu}\right)\frac{\partial T}{\partial x}\right)-\left(\gamma C_m A_{Al}+\gamma_{cu}C_{m\_cu}A_{cu}\right)\frac{\partial T}{\partial t}-hP\left(T-T_0\right)+G\left(a_e(t)\right)=0$$

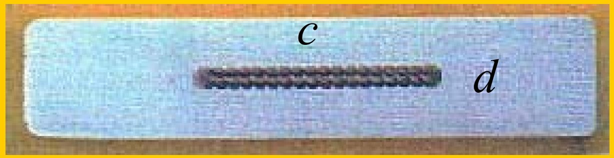
In the adiabatic case:

$$v_q=\frac{I}{\gamma C_m f(t)}\cdot\left(\frac{\rho_{Cu}\cdot\rho_{Al}\cdot\kappa_{Al}}{\left(T_{sc}-T_0\right)}\right)^{1/2} \qquad f(t)=\sqrt{\frac{\left(A^2\right)\left(A_{cu}\rho_{Al}+a_{Al}(t)\rho_{Cu}\right)}{A-A_{ruth}}}$$

With the expression for the area:

$$a_{Al}(t)=\left[(a-a_0)\cdot\left(1-e^{-\frac{t}{\tau_{dx}}}\right)+c\sqrt{\alpha}\right]\cdot\left[(b-b_0)\cdot\left(1-e^{-\frac{t}{\tau_{dy}}}\right)+d\sqrt{\alpha}\right]$$

b



a

Limit cases

Taylor expansion gives an analytical expression:

$$v_q = \left[R_{Iv}\left(\left(v_0 - v_d\right)\right)\right]^{1/2}$$

$$R_{Iv} = \left(\frac{\rho_{Cu}\rho_{Al}\kappa_{Al}}{\gamma C_m\left(A_{Cu}\rho_{Al} + \left(A_{NbTi}\right)\rho_{Cu}\right)}\right)$$

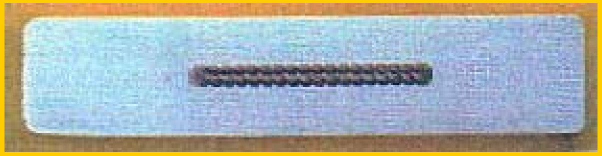
$$v_0 = \frac{I^2 (A - A_{ruth})}{\gamma C_m A^2 (T_{sc} - T_0)}$$

$$v_d = \frac{4\pi^2}{\mu_0}\left(\frac{(b - b_0)c\sqrt{\alpha}}{(b-d)^2} + \frac{(a - a_0)d\sqrt{\alpha}}{(a-c)^2}\right)$$

High current : (heat-sink)

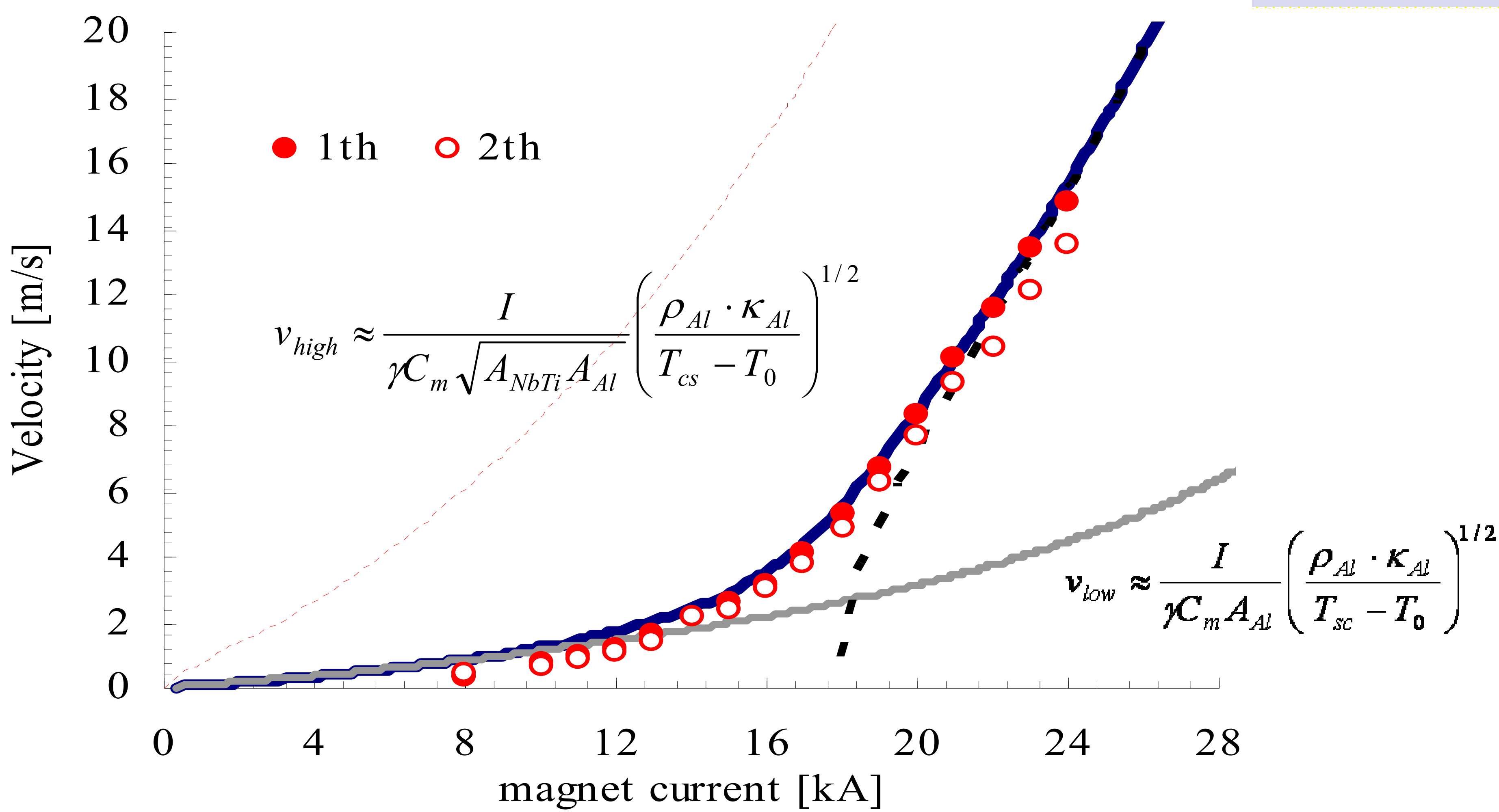
$$v_{high} \approx \frac{I}{\gamma C_m \sqrt{A_{ruth} A_{Al}}}\left(\frac{\rho_{Cu}\cdot\kappa_{Al}}{T_{sc} - T_0}\right)^{1/2}$$

Low current :

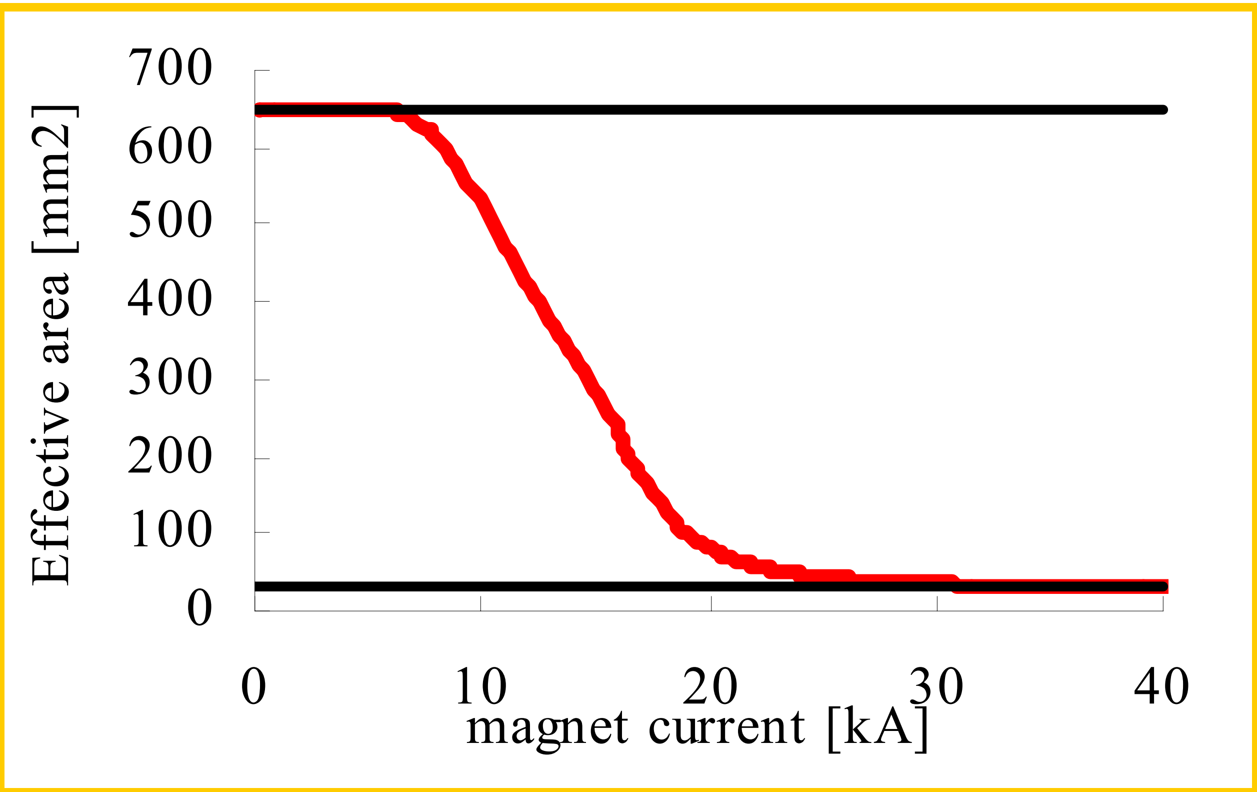


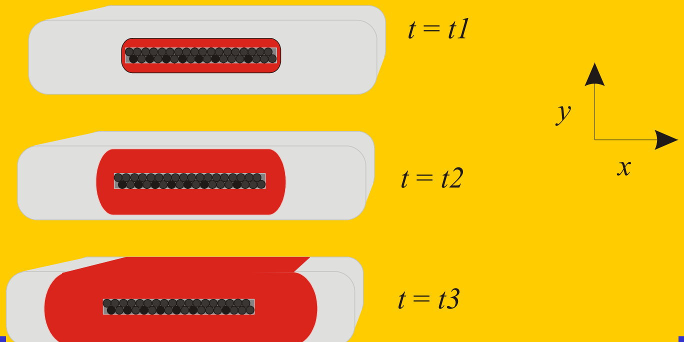
$$v_{low} \approx \frac{I}{\gamma C_m A_{Al}}\left(\frac{\rho_{Al}\cdot\kappa_{Al}}{T_{sc} - T_0}\right)^{1/2}$$

Longitudinal Propagation Velocity of the BT (Barrel Toroid) Conductor



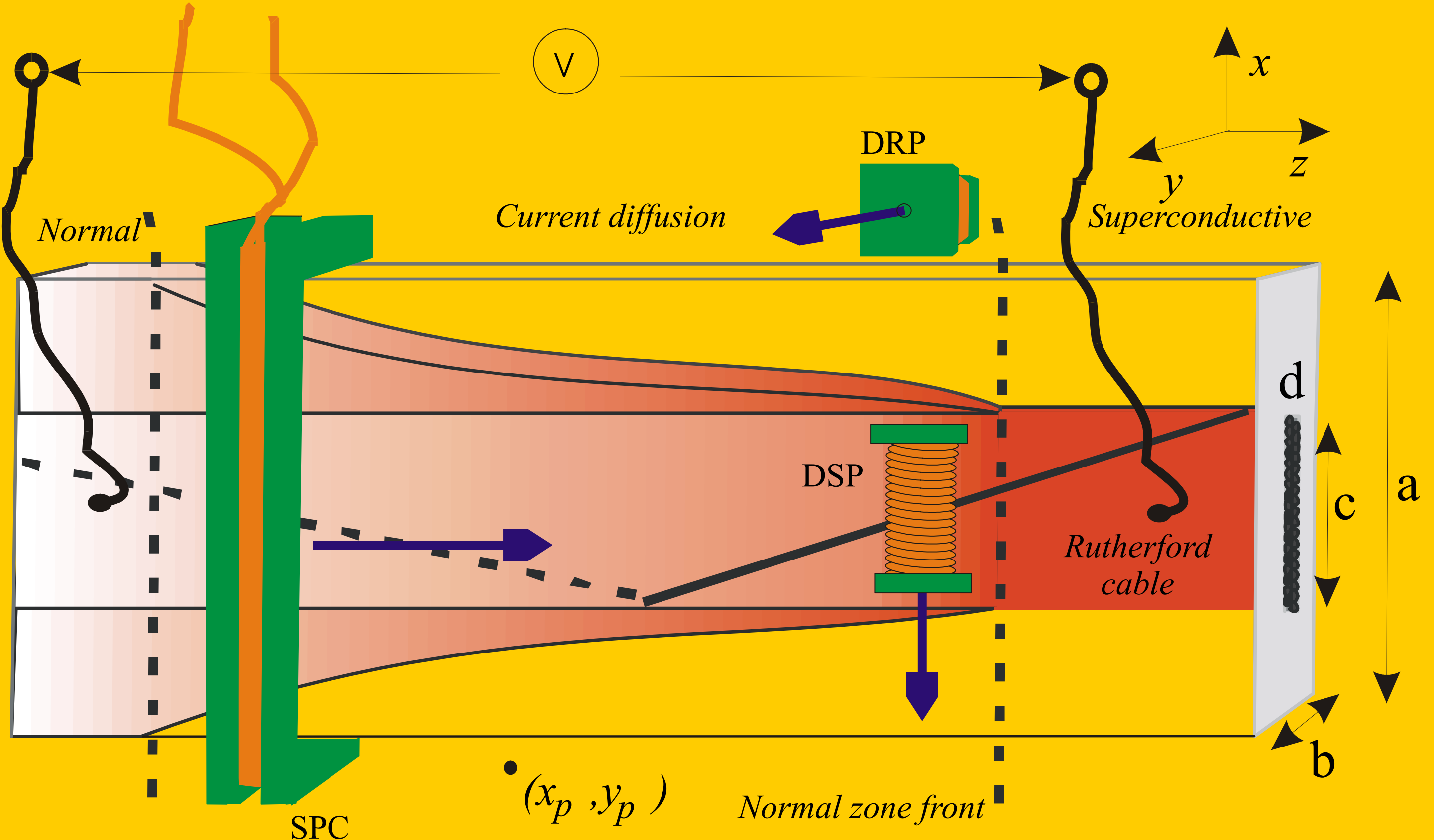
Effective Area of the Current at the Normal Zone Front



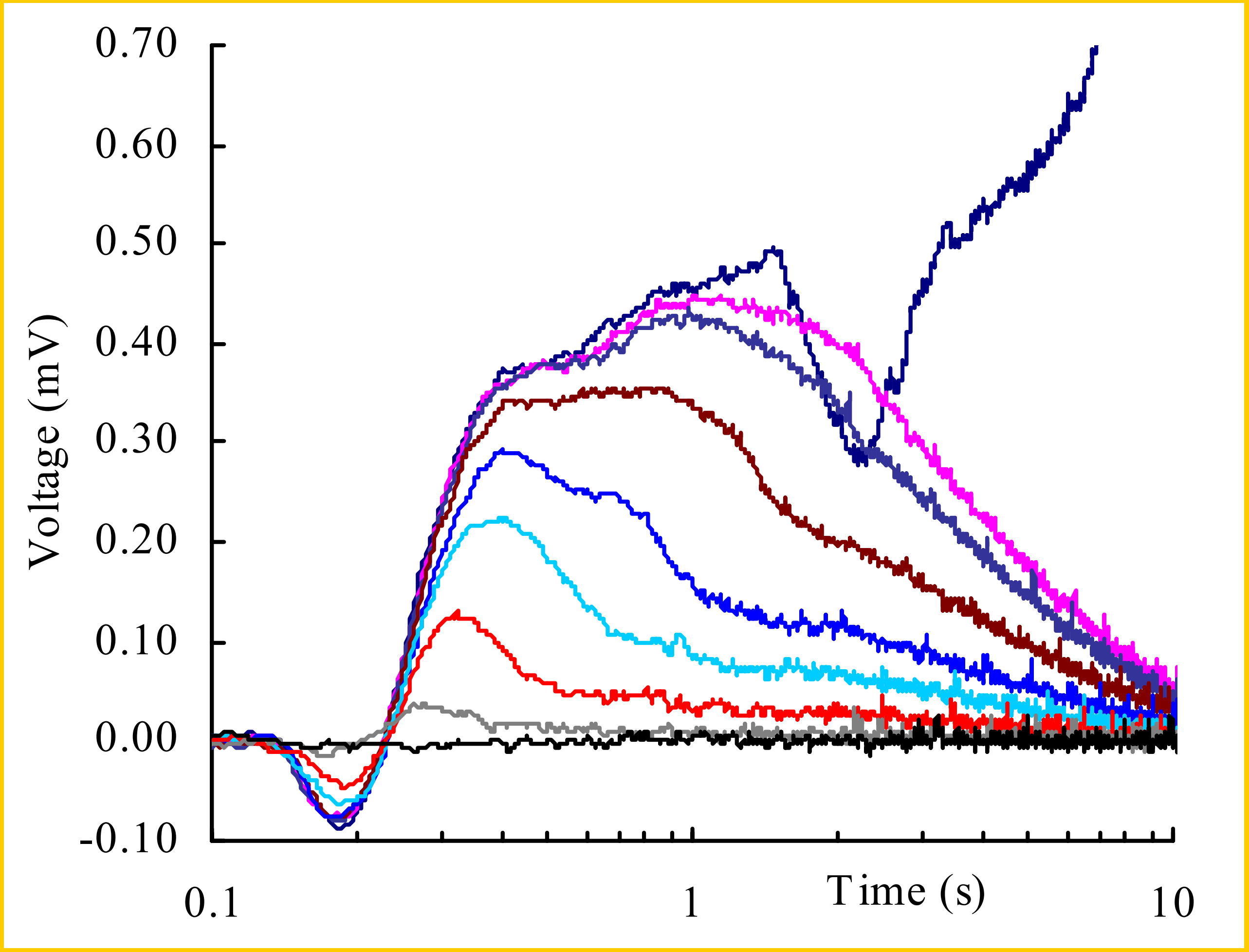


Pick up coils

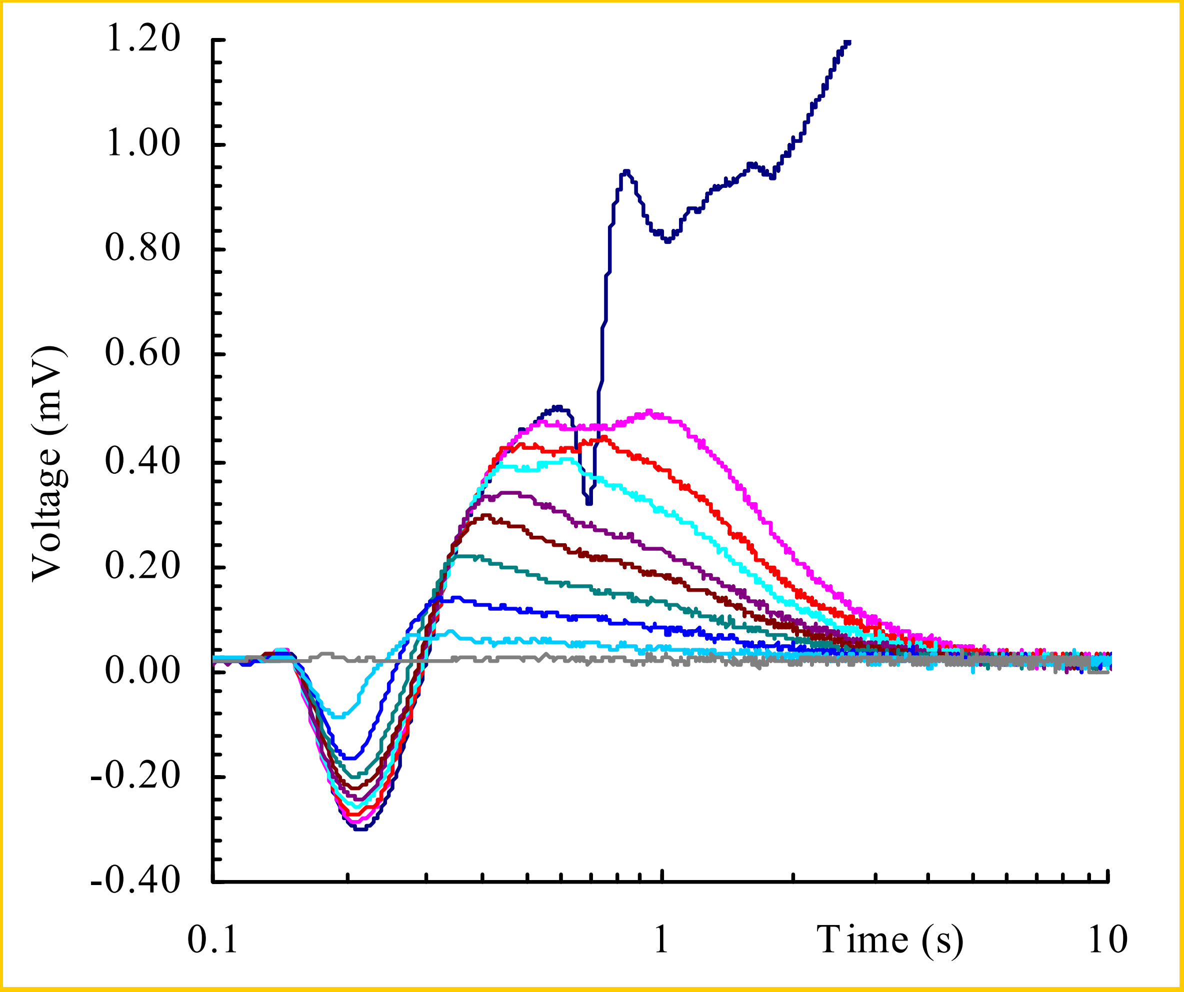
The position of the several pickup coils used in the B0 and the B00 model coils for ATLAS.



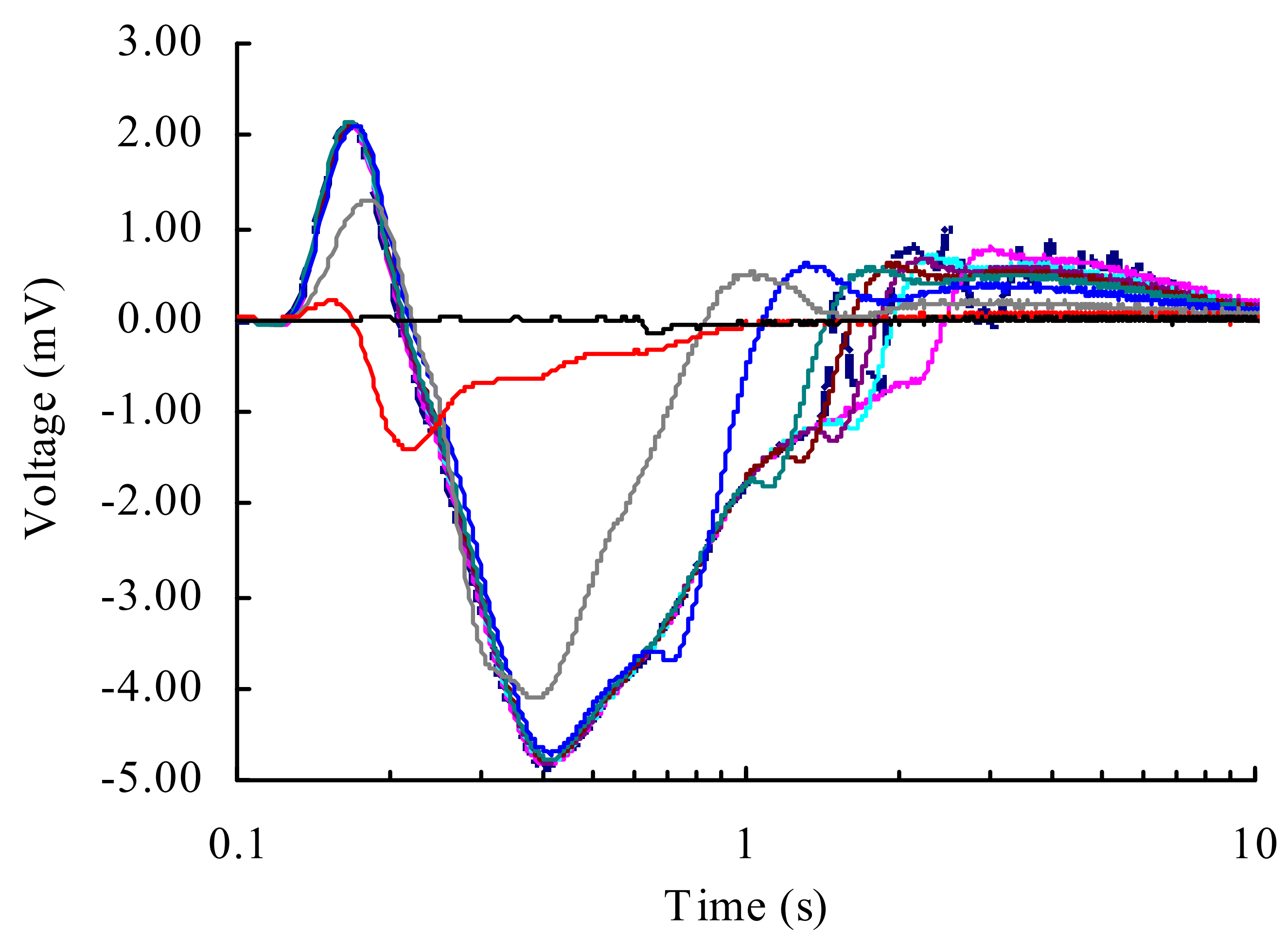
The signals coming from the voltage tab on the first turn of the ECT double pancake in the B00 model coil at 14kA.



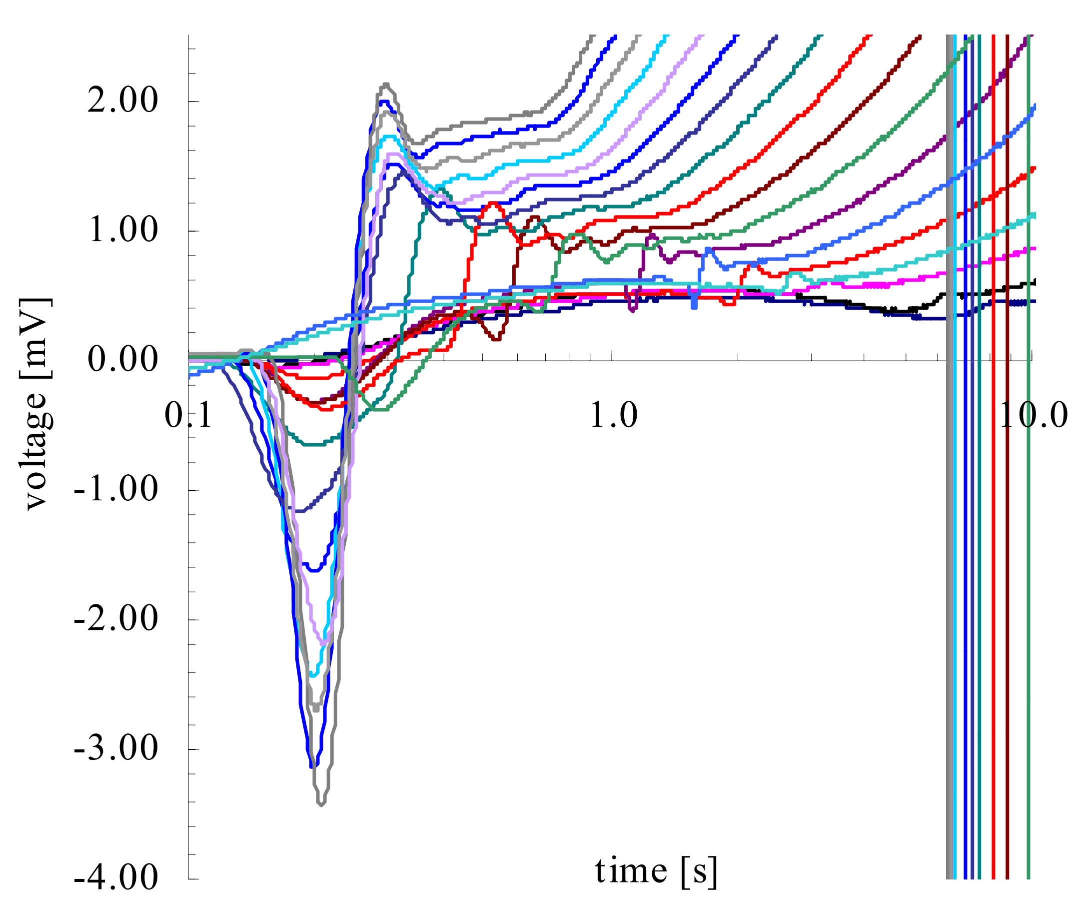
The signals coming from the voltage tab on the first turn of the ECT double pancake in the B00 model coil at 14 kA.



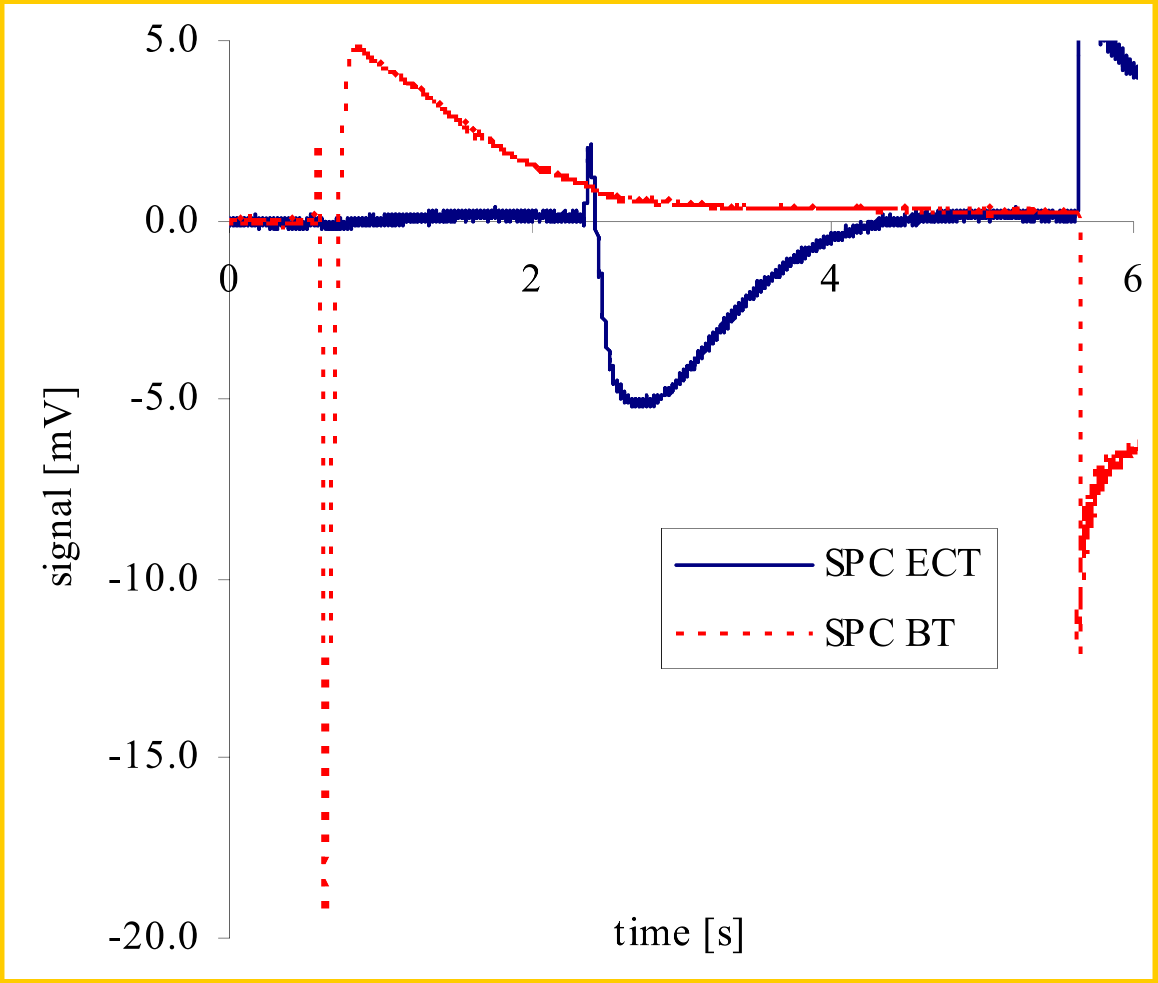
The signals coming from the pick-up coil situated on the first turn of the BT double pancake of the B00 model coil at 11kA. The energy of the quench heater is varied between (17 and 51 Joules).



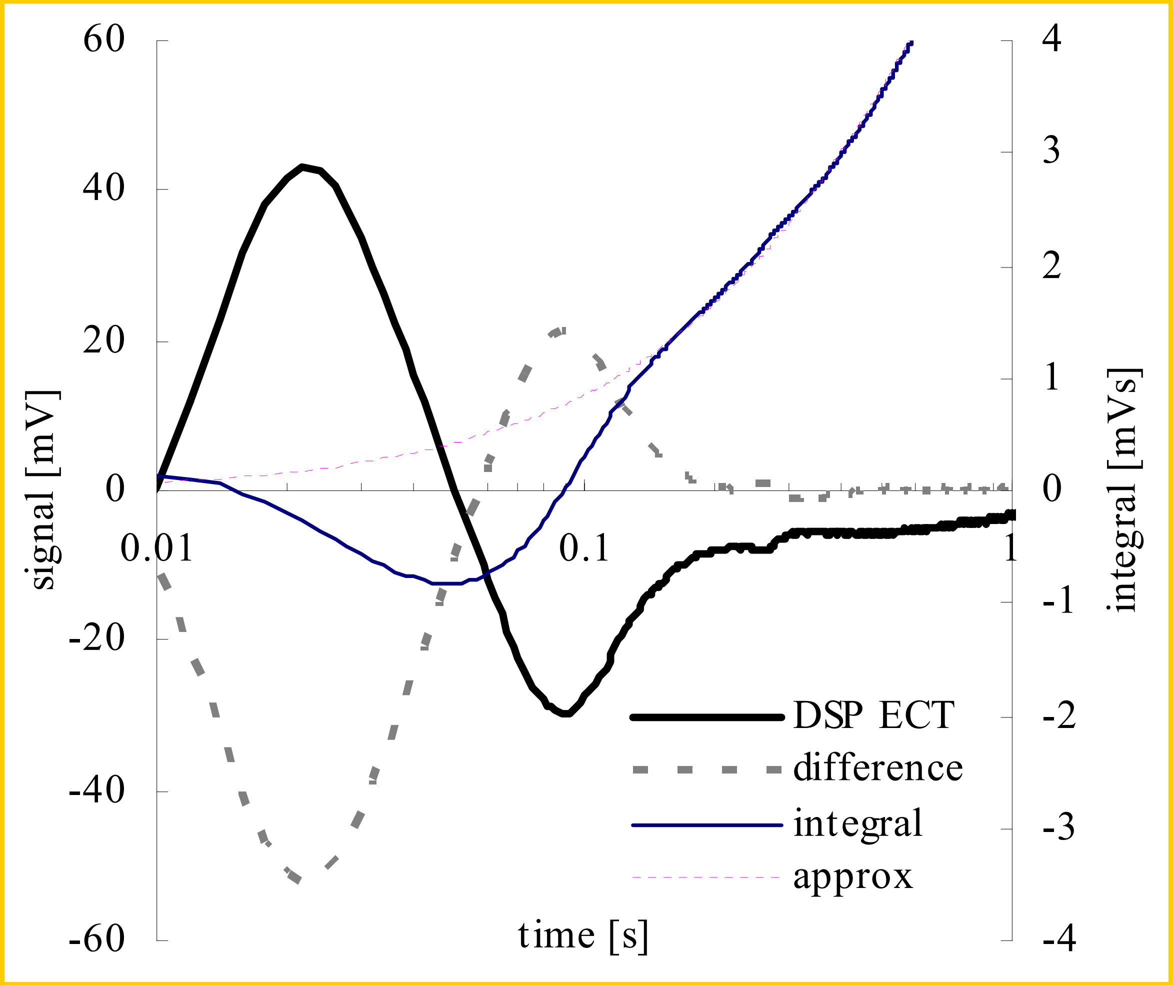
The signals coming from the voltage tab on the first turn of the ECT double pancake of the B00 model coil after a quench. The magnet currents are varied between 7 and 24 kA.



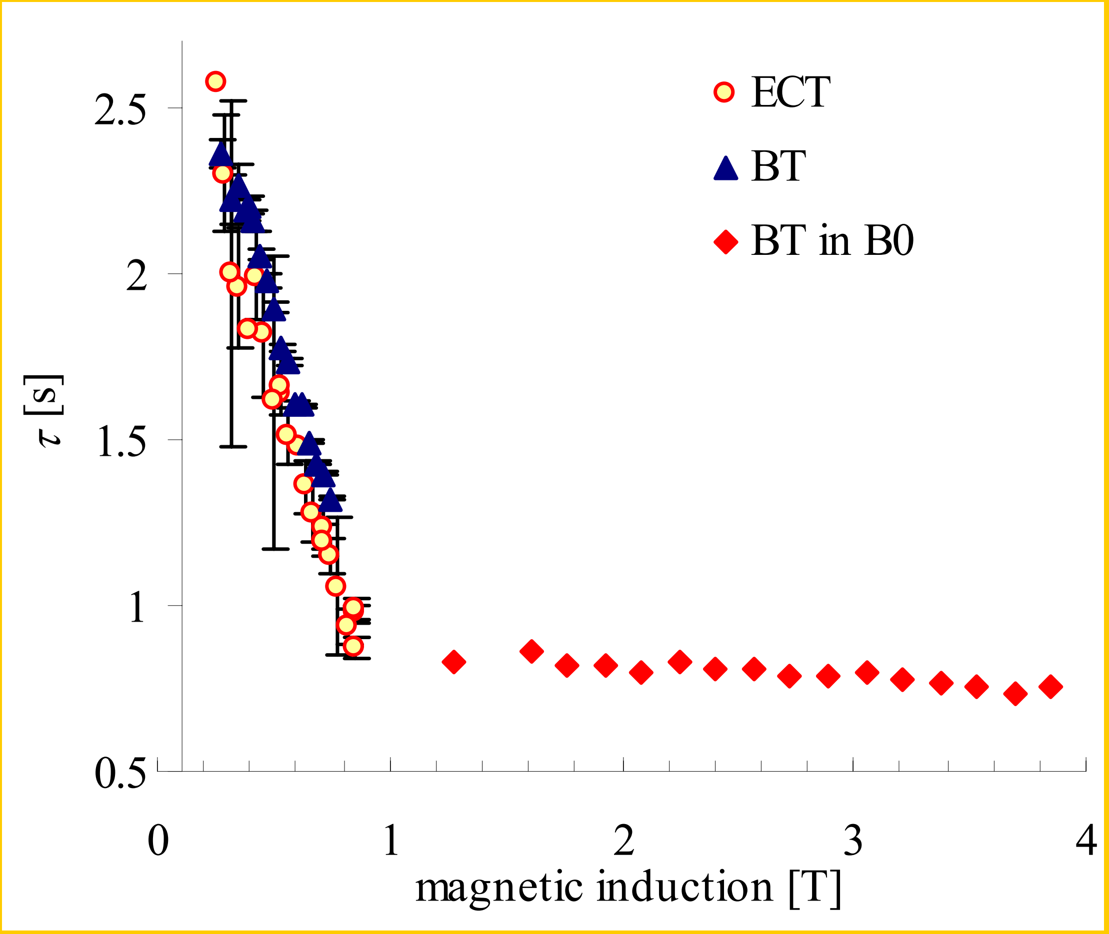
The SPC signal after a quench. It shows the change of the longitudinal magnetic field component of the self field inside Atlas type superconductors.



The DSP signal situated on the most outer turn of the ECT double pancake inside the B00 model coil.



The characteristic diffusion time constant vs. magnetic field of the three conductors.



Conclusions

The B0 and B00 quench tests are successfully done up to magnet currents of 24kA.

Typical values for the longitudinal quench propagation in B0 are 8 m/s at 20 kA and 14 m/s at 24kA. It is measured, using the time information from pickup coil and voltage tabs signals. Both methods gave similar results.

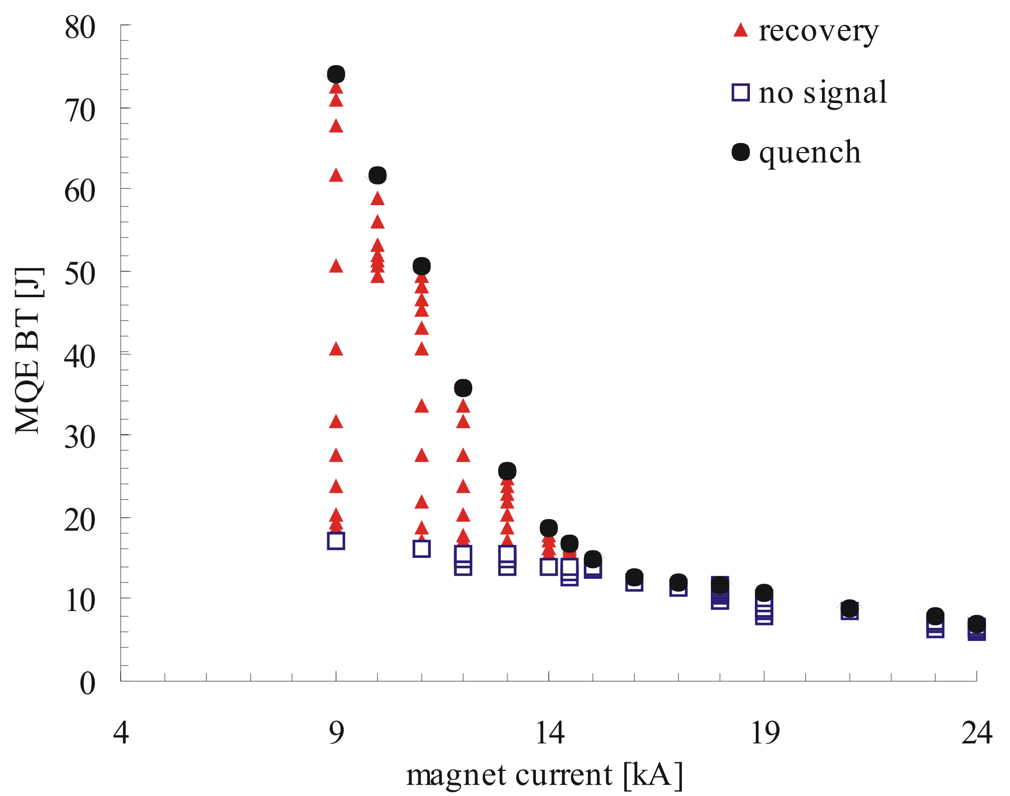
A model is developed that can describe the longitudinal quench propagation velocity in stabilised superconductors. It considers also the diffusion of the current into the Aluminium cladding.

It is expected that from the analytical solution for the longitudinal normal zone propagation, a design parameter for future Aluminium stabilised superconductors can be defined.

At the front of a normal-conducting zone in Aluminium stabilized superconductors, a change of the self-field can be detected. The mechanism behind this effect could be due to the fast displacement of the current from the superconductor to a thin layer in the Aluminium. It results in a fast change of the self-field component of the Rutherford-shape cable.

The signals coming from the voltage tab on the first turn of the ECT double pancake in the B00 model coil at 14 kA.

MQE for B00 model coil



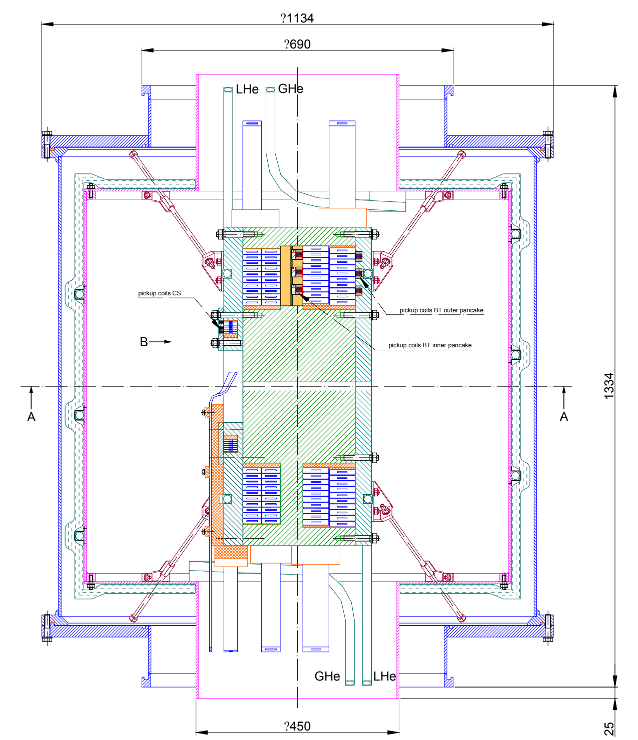
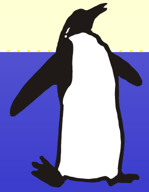


Fig.3.7. Magnet system cryostat.



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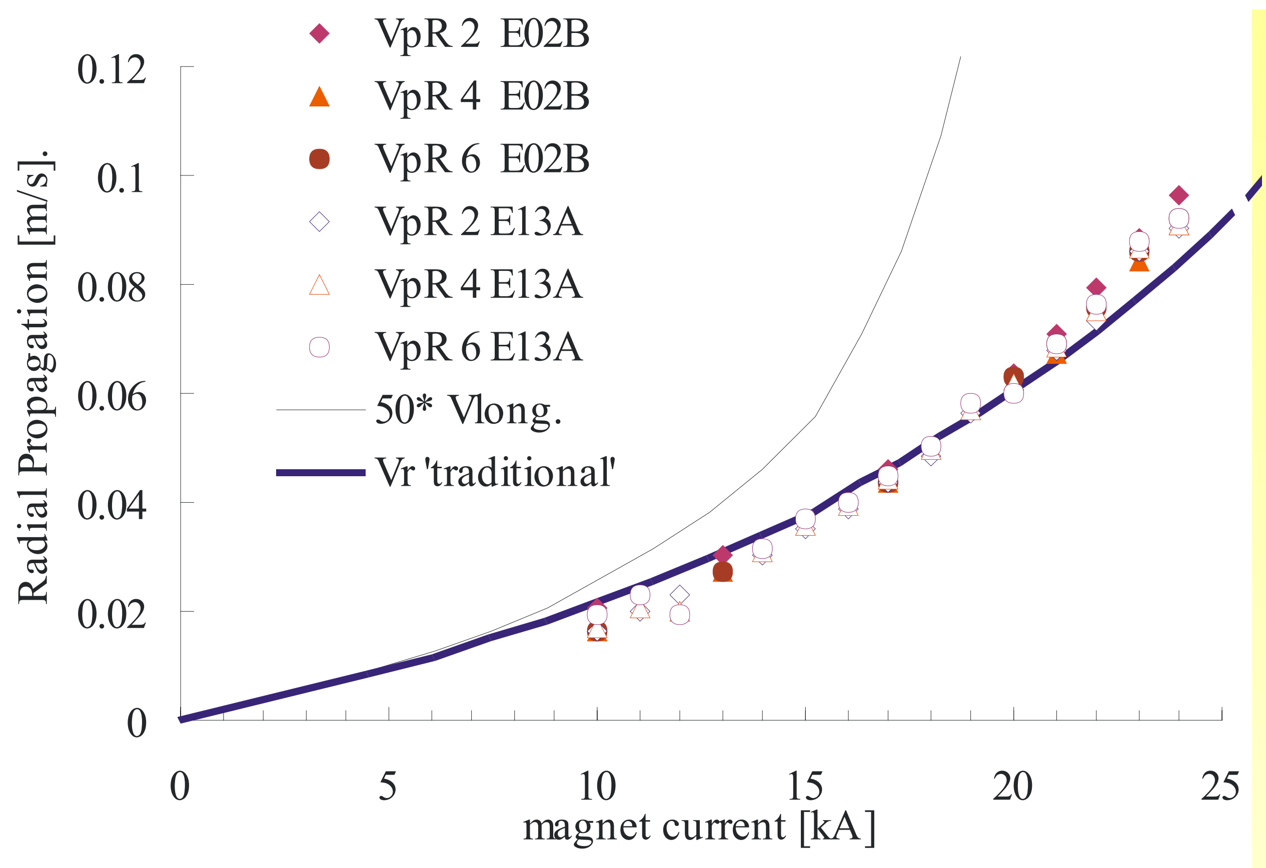
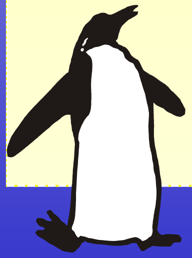
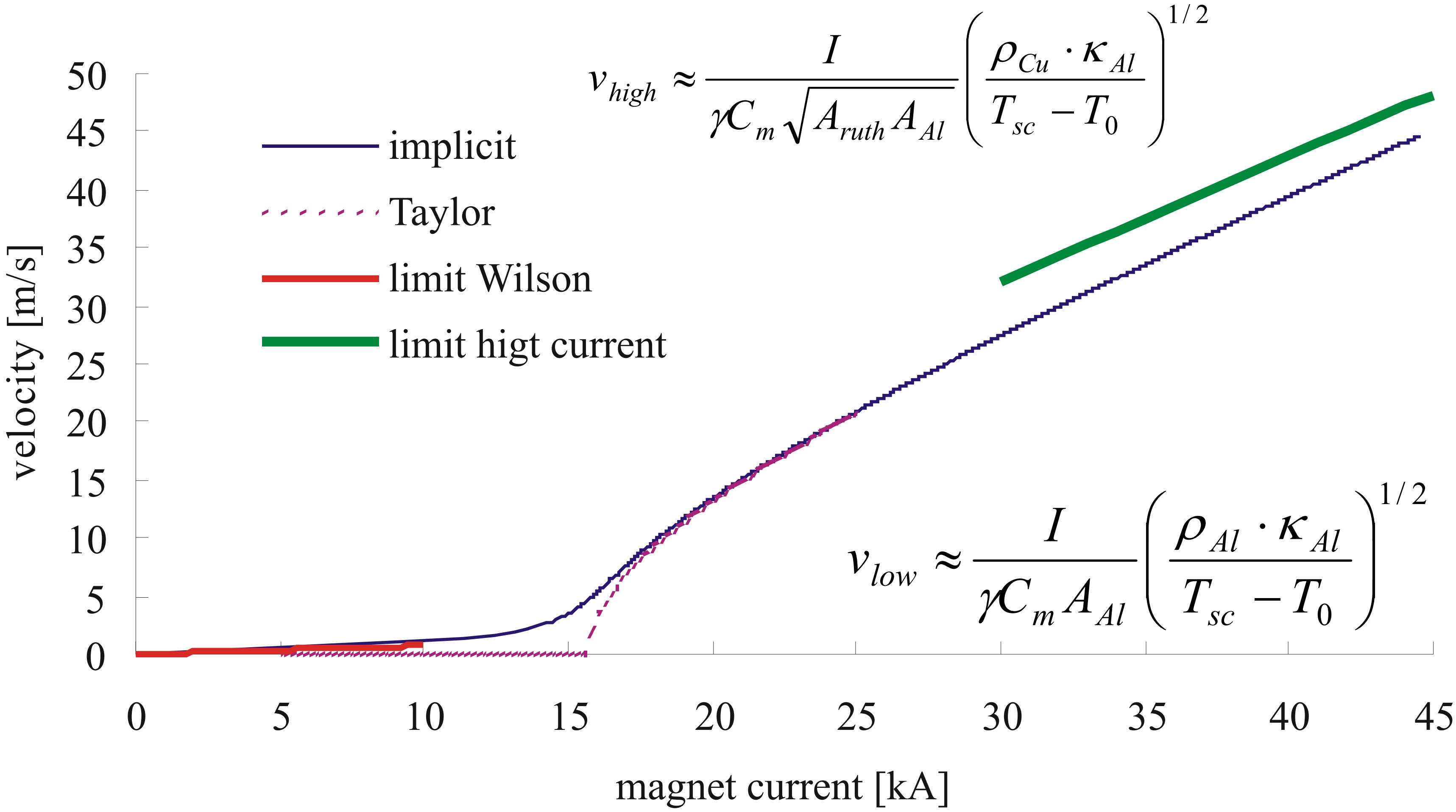
Radial propagation using the point heater and the quench heater



$$v_{radial} = \frac{(\gamma C)_{aver.metals}}{(\gamma C)_{aver.}} \sqrt{\frac{k_r}{k_l}} \cdot v_l \approx \sqrt{\frac{k_r}{k_l}} \cdot v_l \approx \frac{v_l}{50}$$



Limit cases



$v_{high} \approx \frac{I}{\gamma C_m \sqrt{A_{ruth} A_{Al}}} \left(\frac{\rho_{Cu} \cdot \kappa_{Al}}{T_{sc} - T_0} \right)^{1/2}$
$v_{low} \approx \frac{I}{\gamma C_m A_{Al}} \left(\frac{\rho_{Al} \cdot \kappa_{Al}}{T_{sc} - T_0} \right)^{1/2}$
implicit
Taylor
limit Wilson
limit higt current
velocity [m/s]
magnet current [kA]
0
5
10
15
20
25
30
35
40
45
50