Desired Action Plan of Solenoid + Anti-DID during Preparation Phase

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ILD mini-workshop
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Preparation Phase

- Ensure a smooth start of the construction phase
- Importance of the preparation phase at least four years
- Importance of the each years budget and man power with proper for preparation phase

Action Plan for Preparation Phase

- Detailed designs of Followings are needed.
  - Solenoid with Anti-DID (AD)
  - Iron Yokes
  - Superconducting Conductor
- Cost estimation
- Specification for tender

FY2016

- Focusing on the conceptual design of ILD solenoid with Anti-DID from the manufacturing view point.
  - With Toshiba co. ltd.
  1. Magnetic field calculation for two cases
     - TDR based size case.
     - Smaller size case. (40cm reduction of the radius)
  2. Structure analyses to sustain solenoid + AD
     - Several problems in TDR design (especially AD)
  3. Consideration about AD with following different structure.
     - TDR based design
       - Located outer side of the detector sol.
       - Difficulty of support structure for ANTI-DID
     - Solenoid like structure with Helical Coil Winding.
       - (Proposed by Brett Parker)
       - Located inner side of the detector sol.
       - Easier to support of ANTI-DID
       - Deeply consideration about conductor.

FY2017

- Focusing on Following two items.
  - Detailed Design of Iron Yoke
    - with Kawasaki Heavy Industry.
    - Estimation of fabrication, assembly scheme and cost
  - Detailed design of Sol + Anti-DID
    - Estimation of magnetic field and stray field
      - by reflecting Design of Iron yoke
    - Support Structures.
    - Winding scheme
    - Winding machine
    - Shield design
    - Cooling design

FY2018

- R&D of superconductor
  - with Sumitomo cable co. ltd. or Furukawa co. ltd.
  - Conductor for Sol.
    - Al stabilized NbTi without electron beam welding process
    - Study on Lengthening of conductor
      - Process consideration on Co-extrusion of NbTi/Cu cable clad with Aluminum Alloy
  - Conductor for Anti-DID
    - Kind of conductor depends on the design of the AD

FY2019

- Short sample fabrication
  - Mechanical characteristics measurement
    - Stiffness
  - Cool down test and excitation test
    - Preparation of 20kA P.S.
    - Reliability of lengthening
    - Reliability of thermal cycle.
    - Joint technique
  - Test coil with small size
    - Test winding using prototype of small winding machine.
    - Excitation, Field measurement, Quench test

FY2020

- Cost estimation
  - Sol. + Anti-DID + Conductor
  - Cold Box, other equipment for cryogenics

- Preparation of the specification for tender.

Present approach of Conductor (CMS Type)

Electron beam welding technique has to be applied to joint pure Al and Al alloy layer.

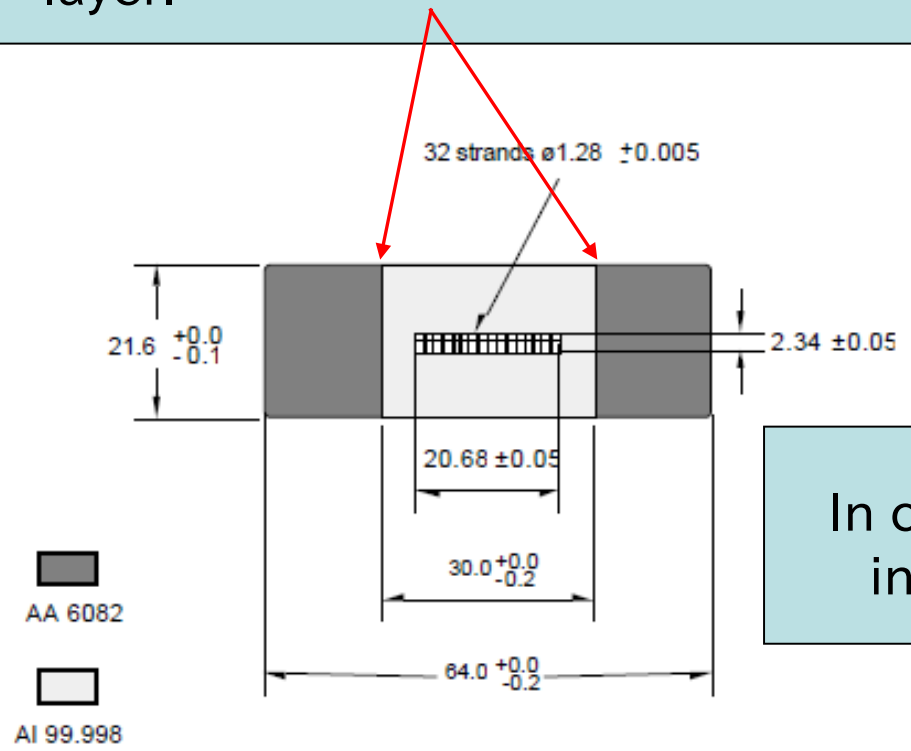


Fig. 1. Cross section of the high purity aluminium stabilized and reinforced CMS conductor.

The size of ILD is very huge, therefore it is necessary to fabricate superconductor with the length of around 30 km

In case of CMS type, Production cost increase due to electron welding process

Rutherford Cable clad with Aluminum alloy without pure Al is developed

1. to reduce the production cost
2. to ensure the mechanical strength of solenoid

Background of this proposal

Current redistribution into low resistive aluminum stabilizer takes the time for second order.

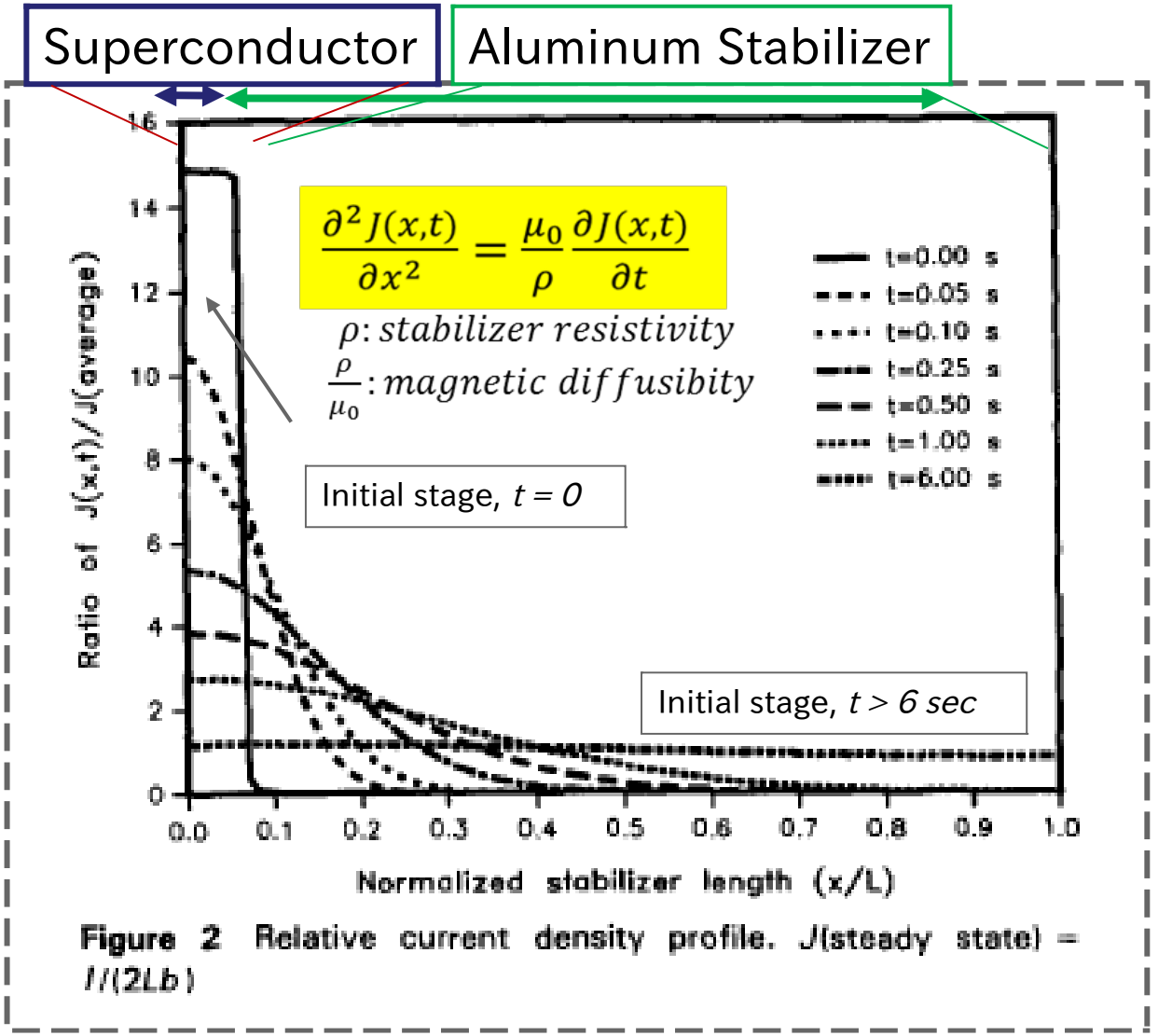


Figure 2 Relative current density profile. *J*(steady state) = *I*/(2*Lb*)

From A. Lee, R.H. Wands and R.W. Fast, "Study of current redistribution in an aluminum stabilized superconductor", Cryogenics 1992 Vol 32, No.10, p.865

From view point of **Superconducting Stability** :

Larger area ratio of cupper matrix in close proximity to NbTi multi filaments is more effective.

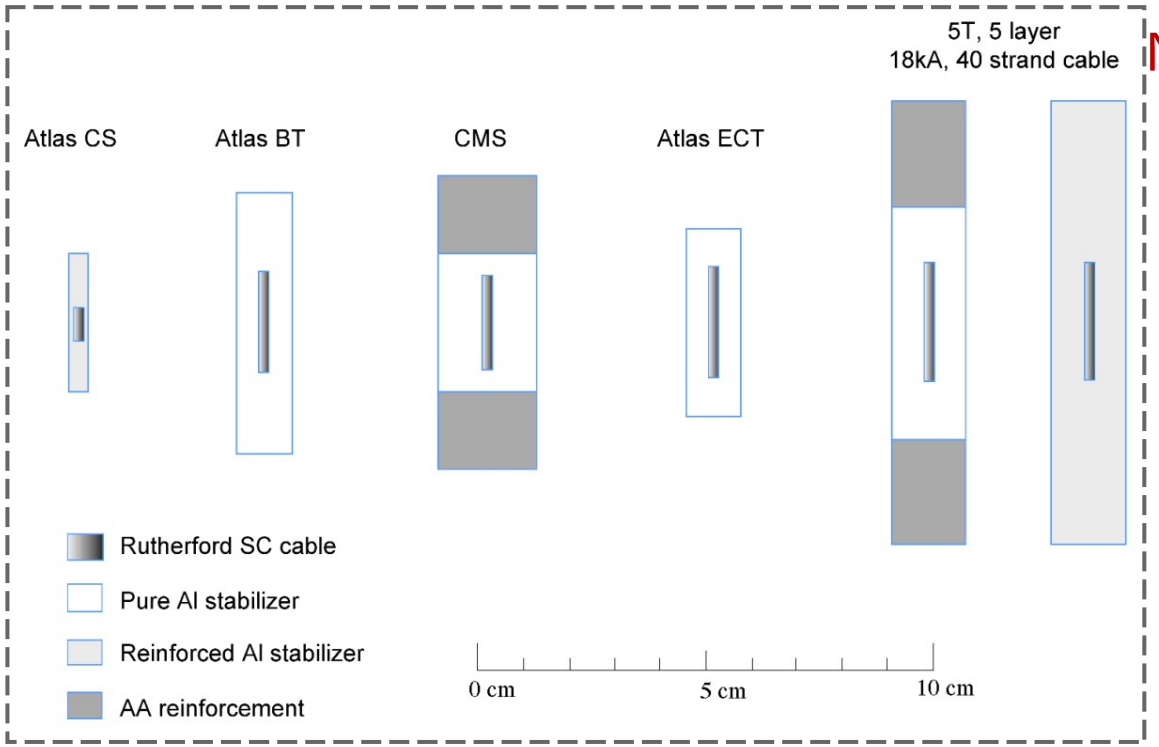
Accelerator magnets are wound with NbTi/Cu cables.

From view point of **Quench Safety** :

Large area of Al or Al Alloy give large thermal capacity which prevent the conductor from being burnt out after quench.

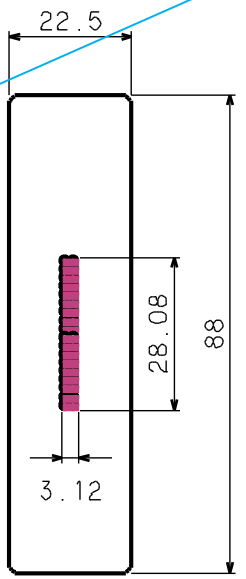
First, we'd like to make simulation study to confirm

Cross Sections of Al Stabilized Superconductor in LHC detectors and R&D



New Proposal

Aluminum Alloy Clad
A6061
$\sigma_{0.2}$ > 250 MPa



Cu/NbTi Ratio : 1~1.3

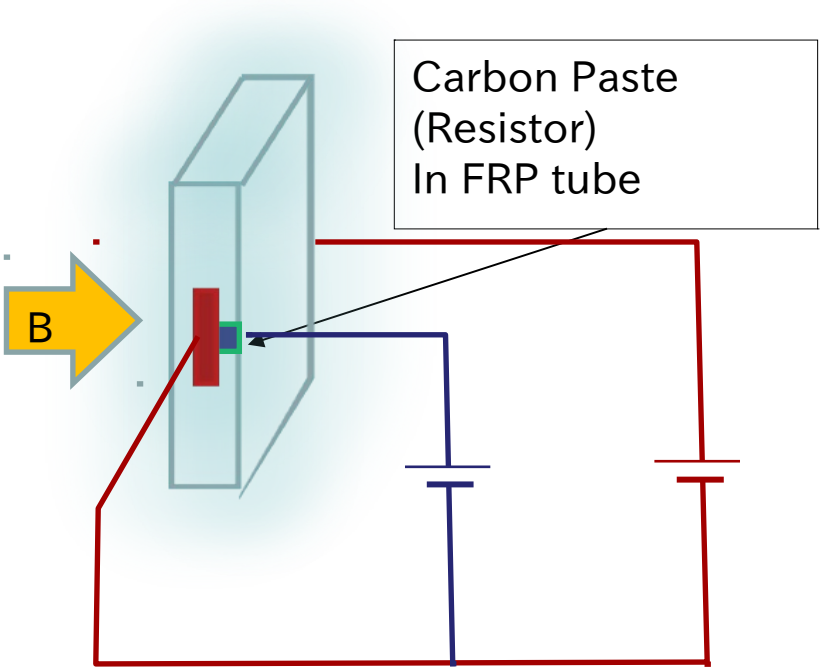
From presentation material by Andrea Gaddi & Benoit Curé about "LCD Solenoid Design Reinforced Conductor R&D Magnet Services" at ILD Workshop, LAL/Paris, May 22-25, 2011

Strands
ϕ1.6 Nb –Ti
Cu to SC ratio > 4
Ic > 650 A at 5 T
RRR of Cu > 180
$\sigma_{0.2}$ > 200 MPa

Cable
36 strands
Cu to SC ratio > 4
Ic > 23000 A at 5 T

Conductor R&D plan

- Simulation and Experimental Confirmation about Superconducting Stability in Aluminum Alloy Clad Conductor.
  - Core cable is heated by carbon paste directly.
  - Normal zone recover to Superconductor or propagate to quench (MQE measurement)
  - Compare MQE in Pure Al clad cond. and that in Aluminum Alloy clad cond..



- Trial Co-extrusion of NbTi/Cu cable clad with Aluminum Alloy (A6061 or others)
  - Metallurgical check on cladding process with aluminum alloy.
  - Mechanical and electrical contact b/w Cu and aluminum alloy.