SiD Superconducting Solenoid Status and Future Design Effort

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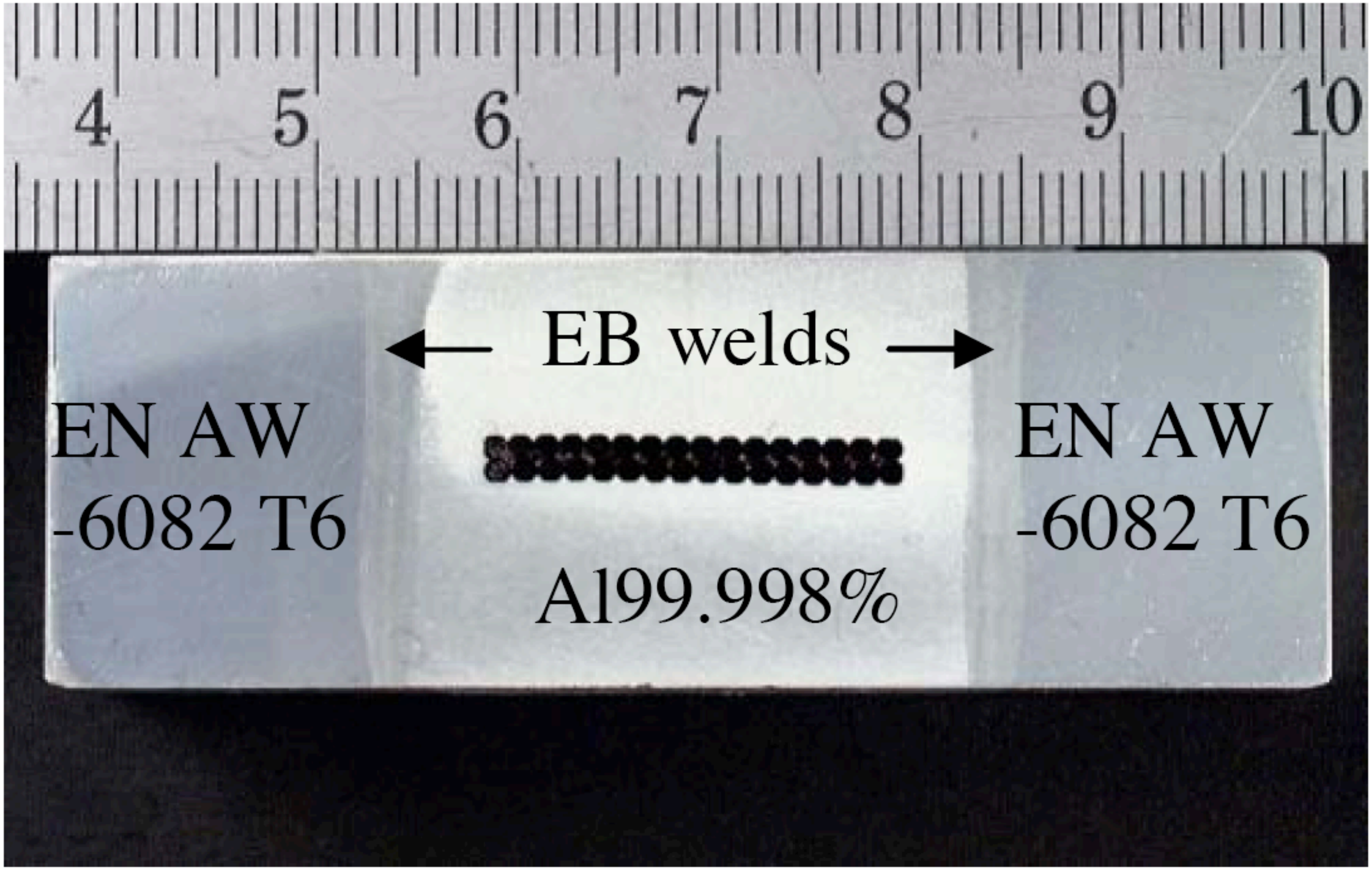
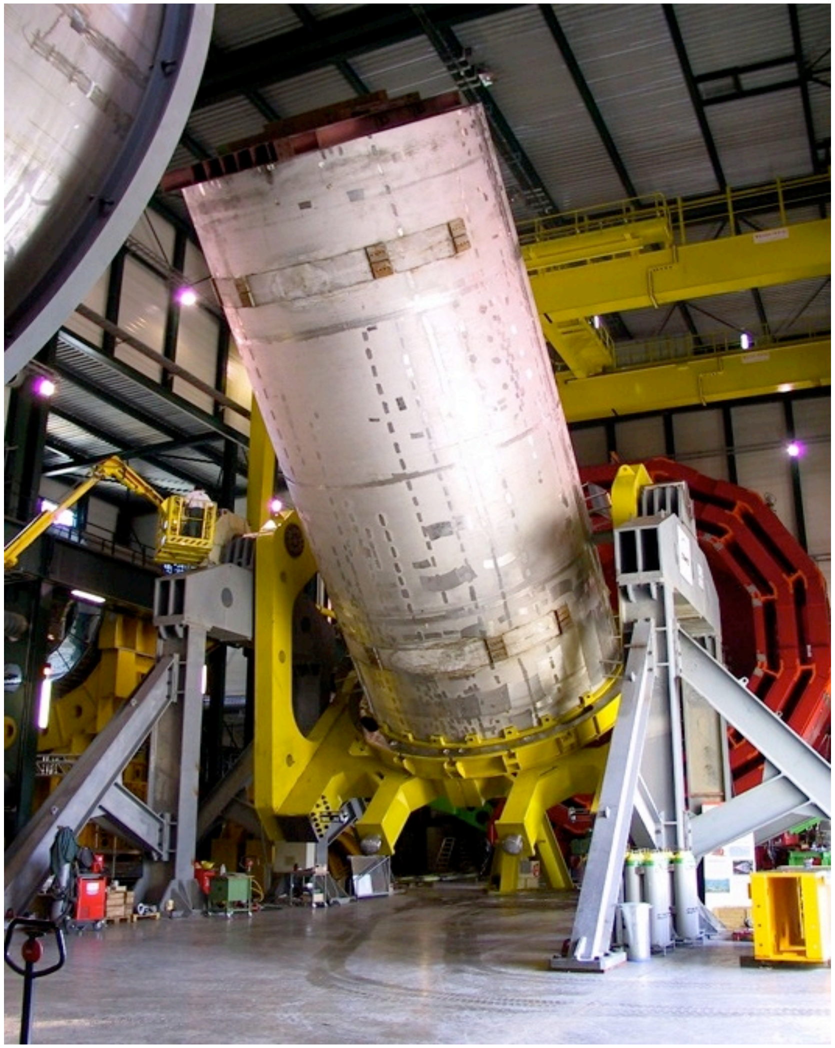
CURRENT STATUS

- A preliminary design based on the CMS solenoid and conductor exists but has not progressed much since 2006.
- Rich Smith (deceased) and Bob Wands of Fermilab created most of the design.
- The present design concept is most likely workable with minor tweaks and lots of engineering.
- In some respects the SiD solenoid is much easier to build, but it is also significantly more difficult in other aspects.
  - **Easier because it is half the stored energy and half the length**
  - **More difficult because it is 5 T vs. 4 T, 6 layers vs. 4 layers and 16% smaller inner conductor radius**
  - **Slightly easier because the cold specific stored energy is 10.8 kj/kg vs. 11.6 kj/kg.**

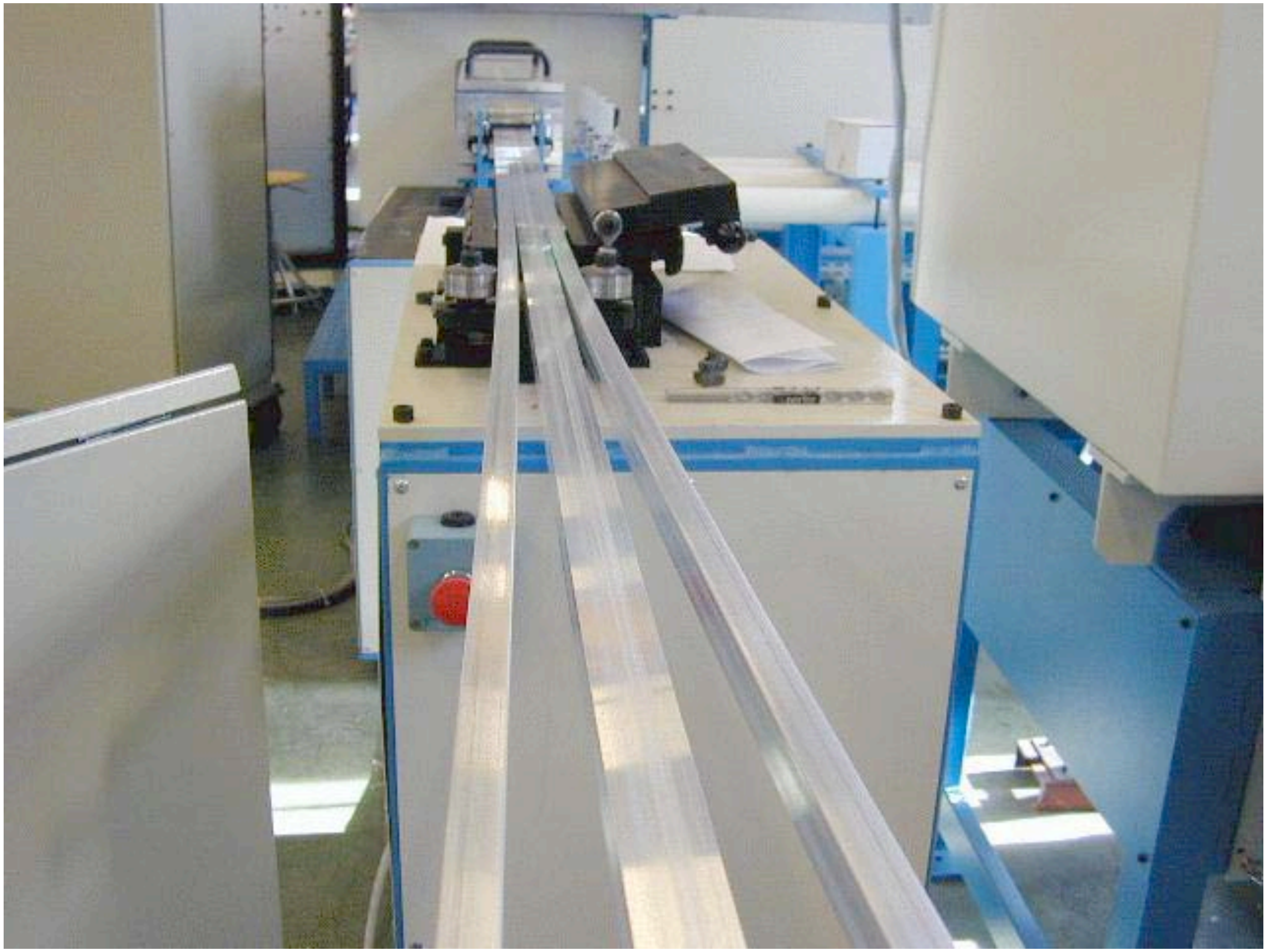
CMS CONDUCTOR



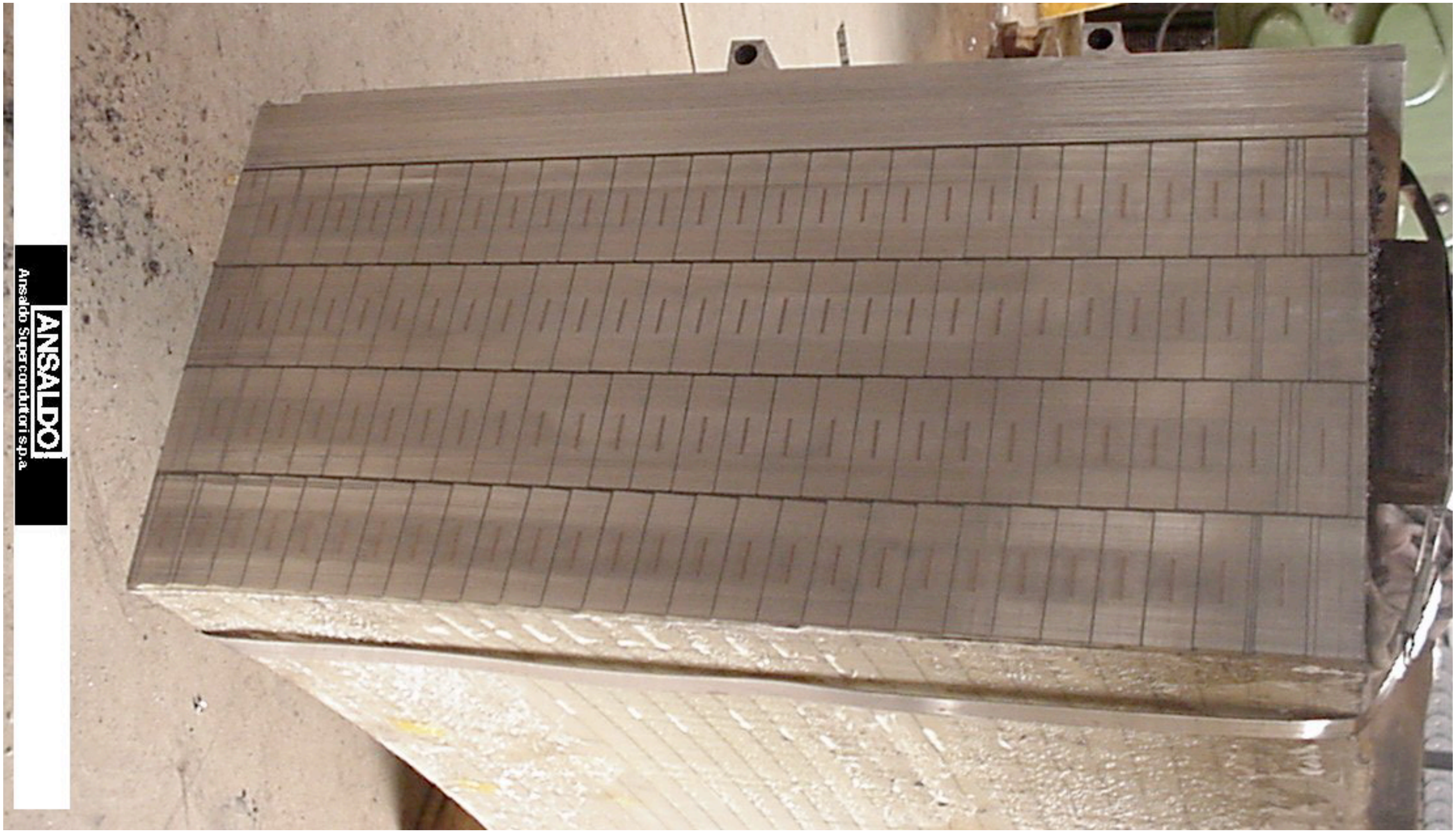
CMS OUTER MANDREL AND VACUUM CAN INSERTION /ROTATION DEVICE



CMS CONDUCTOR WELDING LINE



CMS PROTOTYPE COIL CUT THROUGH



TASKS REMAINING FOR A FIRST PASS "CMS" ENGINEERING DESIGN

- Size and placement of the cryo chimney(s)
- FEM work emphasizing conductor stress
- Conductor stability at the higher field
- Quench propagation and energy extraction
- Conductor package thermal cooling
- Mechanical design of current leads, thermal shields, cooling tubes, liquefier interface, etc.
- Power supply, dump breaker, dump resistor, instrumentation and grounding.

“CMS” OPTIMIZATION

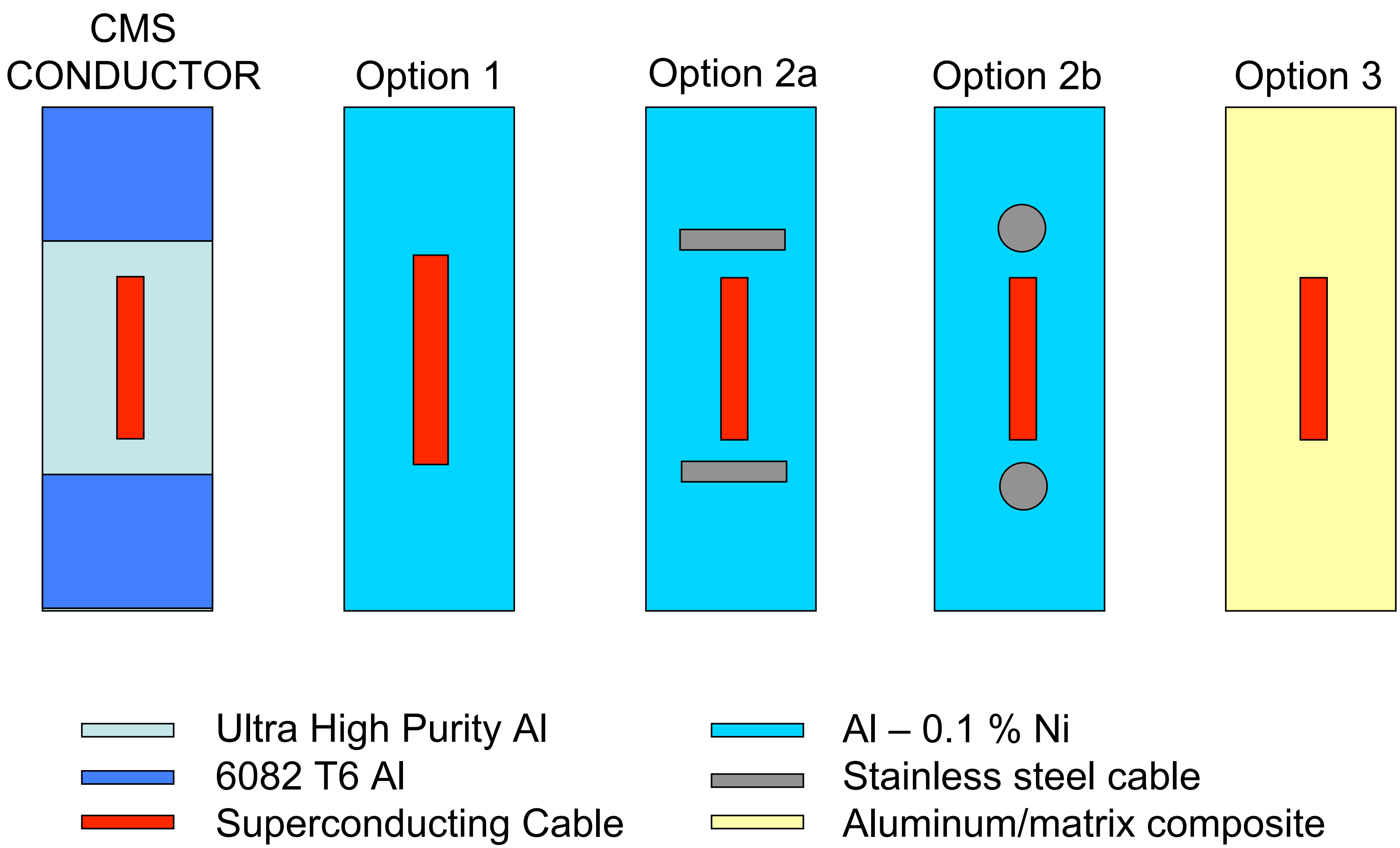
- The current design utilizes the CMS conductor. This can almost certainly be optimized for SiD with the goal of eliminating one or more layers and reducing cost.
- Pick a higher current
- Use a larger superconducting cable
- Make use of improving Jc with passing time
- Use a slightly different NbTi ratio for higher fields
- Optimize the cable for different layers

ADVANCED CONDUCTOR

- PROBLEM: The CMS conductor is very stiff and complicated to produce.
- Three Alternatives are considered:

1) Brute Force: Use Al – 0.1 % Ni and a larger superconducting cable to add mechanical strength and increase stability by decreasing the % of short sample.
2) Use Al – 0.1 % Ni and internal cable reinforcing.
3) Develop a superior high purity aluminum matrix composite

Possible SiD Conductor Options



POSSIBLE CONDUCTOR MATERIALS

#	MATERIAL	RRR	4.2 K Yield Strength MPa (ksi)	4.2 K Ultimate Strength MPa (ksi)	R.T. Yield Strength MPa (ksi)	R.T. Ultimate Strength MPa (ksi)
1	CMS UHP Al; minimum RRR @ 0 T for stability	> 800	10 (1.5)			
2	CMS UHP Al billet RRR specification @ 0 T (= 20 ppm impurity)	> 1500	10 (1.5)			
3	CMS UHP Al billets procured RRR @ 0T	> 3000	10 (1.5)			
4	CMS UHP extracted after coextrusion @ 0T	3020				
5	CMS UHP extracted after coextrusion @ 5T	990				
6	CMS Al 6082 T51 (as received, underaged)	N/A			187 (27)	316 (46)
7	CMS Al 6082 T6 (full aged after epoxy cure cycle)	N/A	428 (62)	687 (57)	313 (45)	392 (57)
8	CMS Full Conductor (before epoxy curing cycle)				130 (19)	214 (31)
9	CMS Full Conductor (after epoxy curing cycle) @ 0T	1420 eqv.	258 (37)	406 (59)	188 (27)	250 (36)
10	CMS Full Conductor (after epoxy curing cycle) @ 5T	465 eqv.				
11	*CMS Full Conductor average hoop stress*		94 (14)			
12	Al-0.1 wt% Ni 21% cold worked after cure (ATLAS)	590	110 (16)		80 (12)	
13	316 Stainless steel annealed	N/A	640 (93)	1590 (230)	276 (40)	620 (90)
14	Inconel 718 annealed and aged		1380 (200)	1900 (275)	1080 (155)	1320 (195)

Conductor Development

- Conductor R&D will be the primary driver for any hope of significantly reducing cost and construction time. Thus collaboration and partnerships will be key.

1) Developers of the Al-Ni and other alloys
2) University metallurgy and material science departments for Al-element and Al-matrix
3) University and national labs for testing
4) Industry SBIR or other for co extrusion