Design Study of the SiD Detector Solenoid

a KEK version

Oct. 27, 2006

K. Tanaka, Y. Makida, A. Yamamoto (KEK) and
H. Aihara (Tokyo)

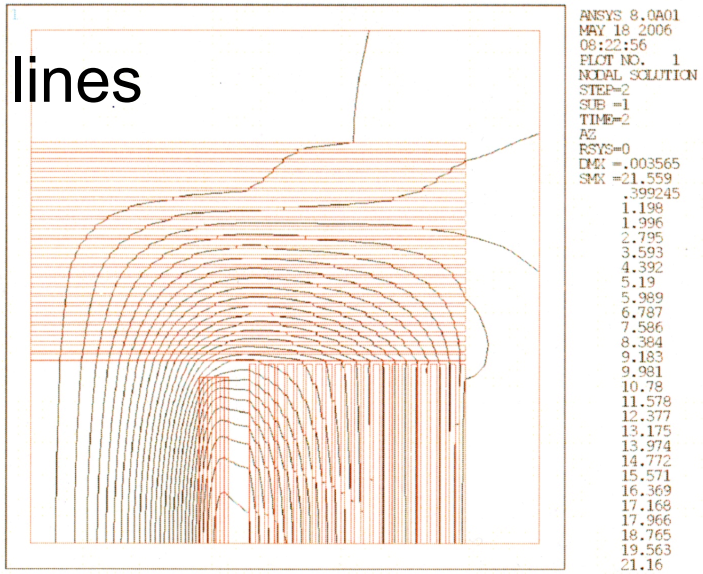
Design Concept

- High Field Compact Solenoid
  - Central field 5 T
  - Inner Bore Diameter 5 m
  - Length 5 m
- Safety and Protection
  - Stored-energy/cold-mass ratio (E/M) :

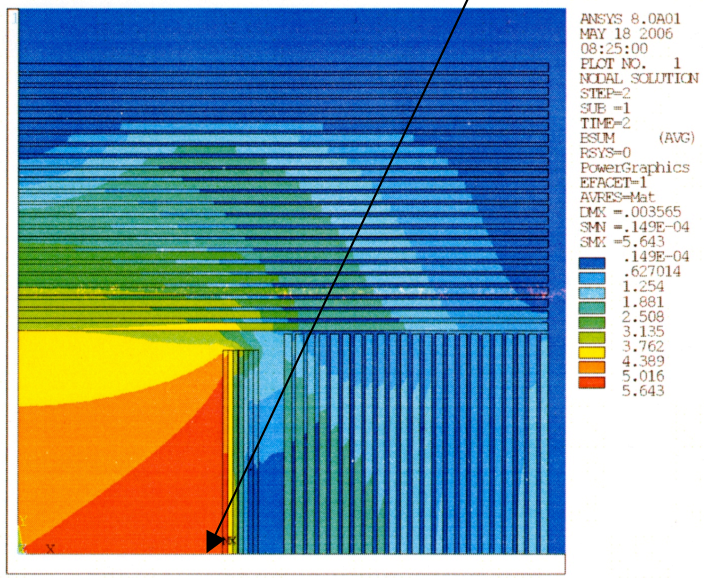
    15 kJ/kg or less under the conditions of
    - A half energy to be extracted to dump resister in case of quench.
    - Back-up Protection with Quench Protection heater (QPHT)

Field and Stress

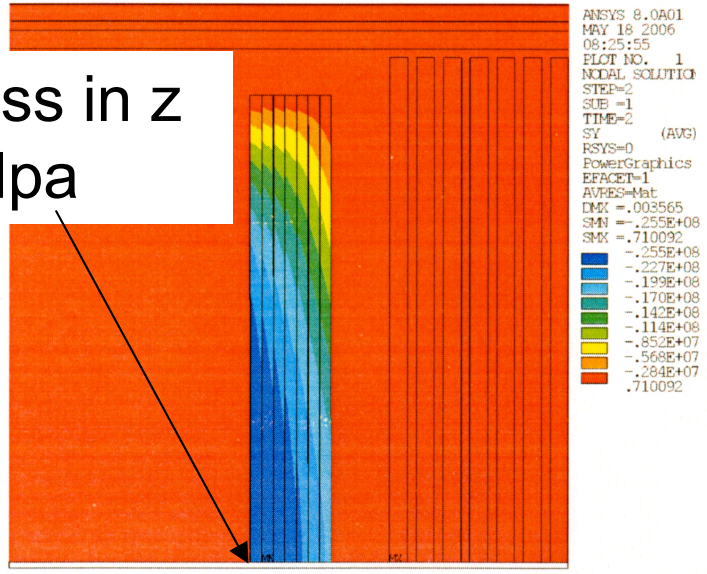
field lines



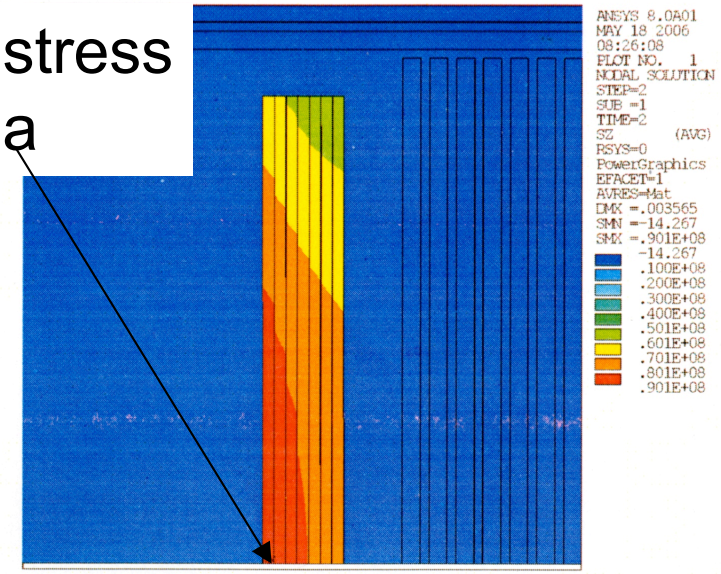
Bmax=5.6T



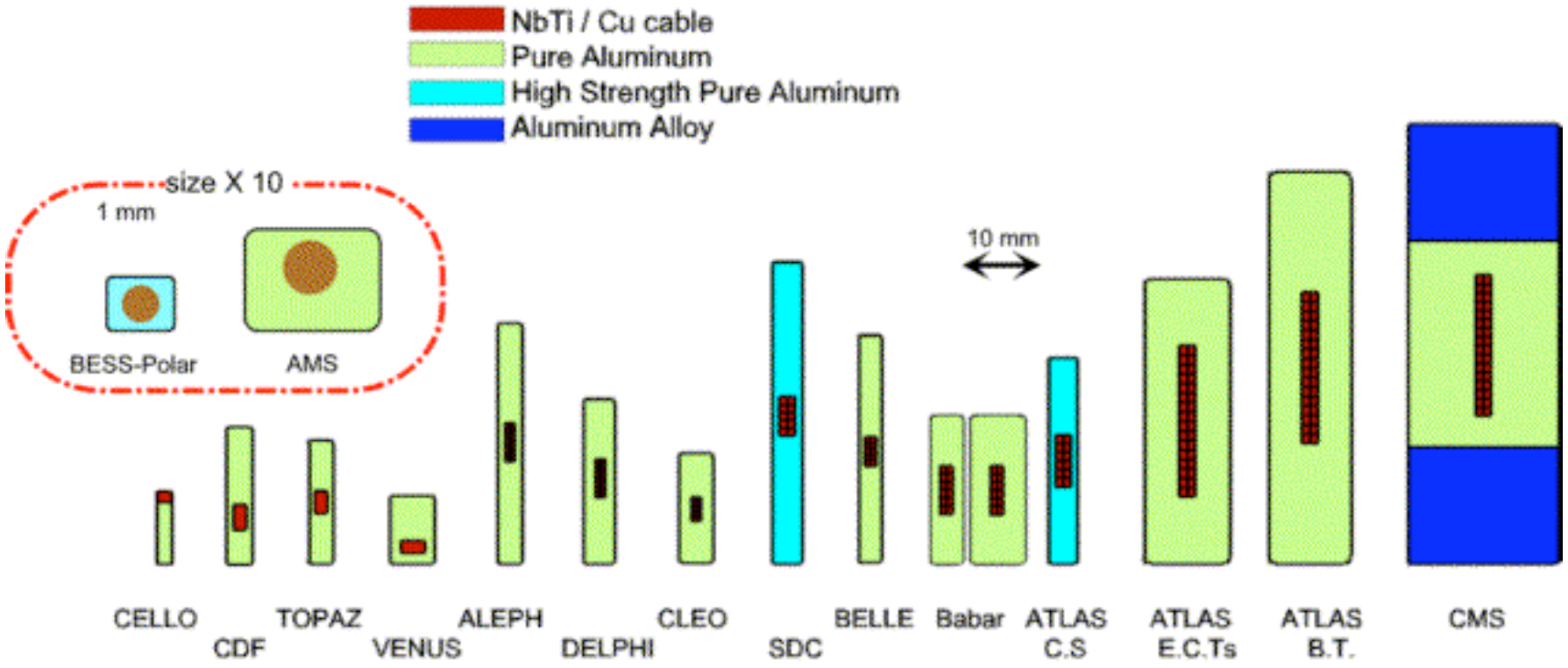
Stress in z
25Mpa



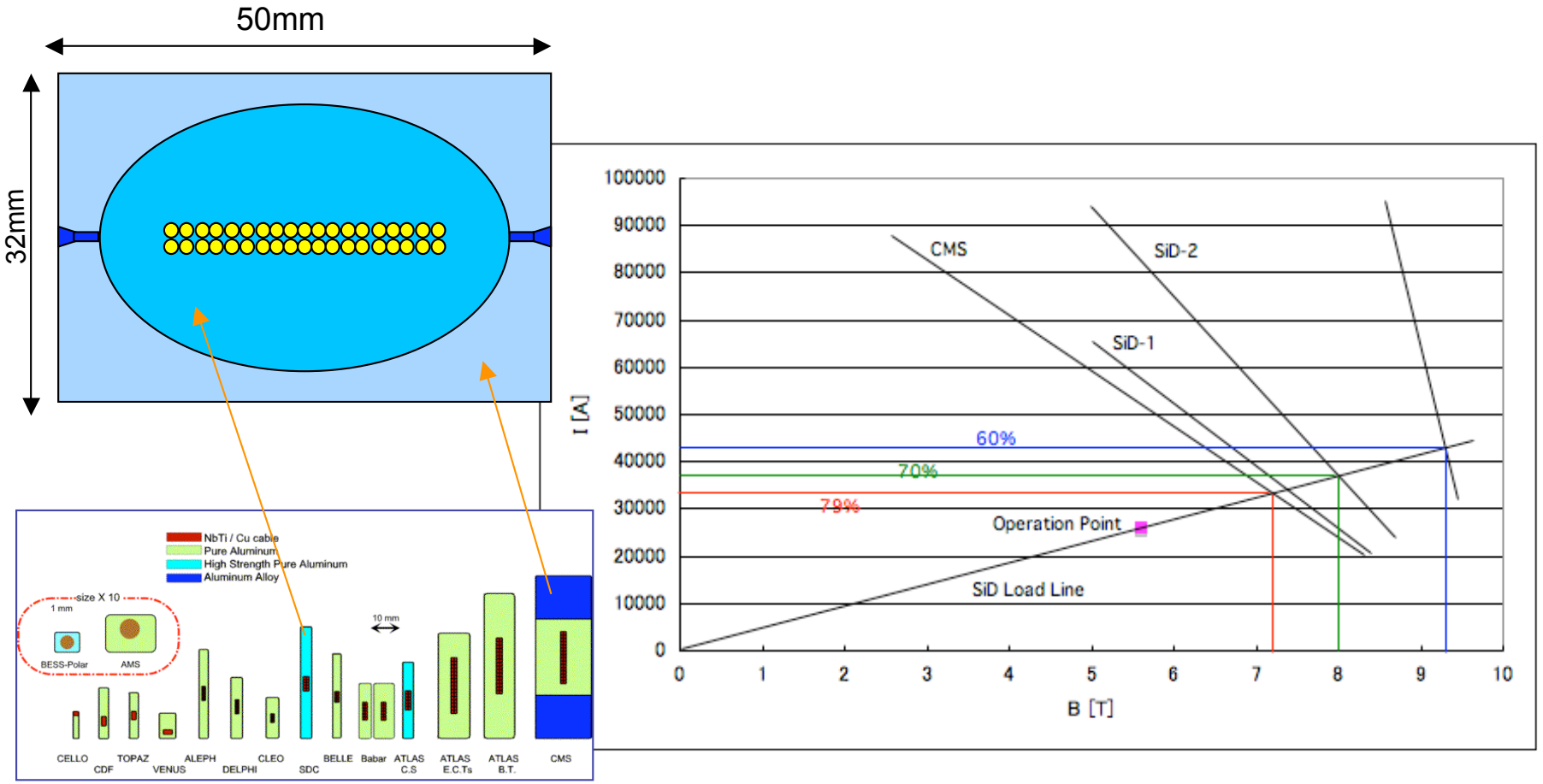
hoop stress
90Mpa



Progress of Al-stabilized SC



KEK Conductor Design

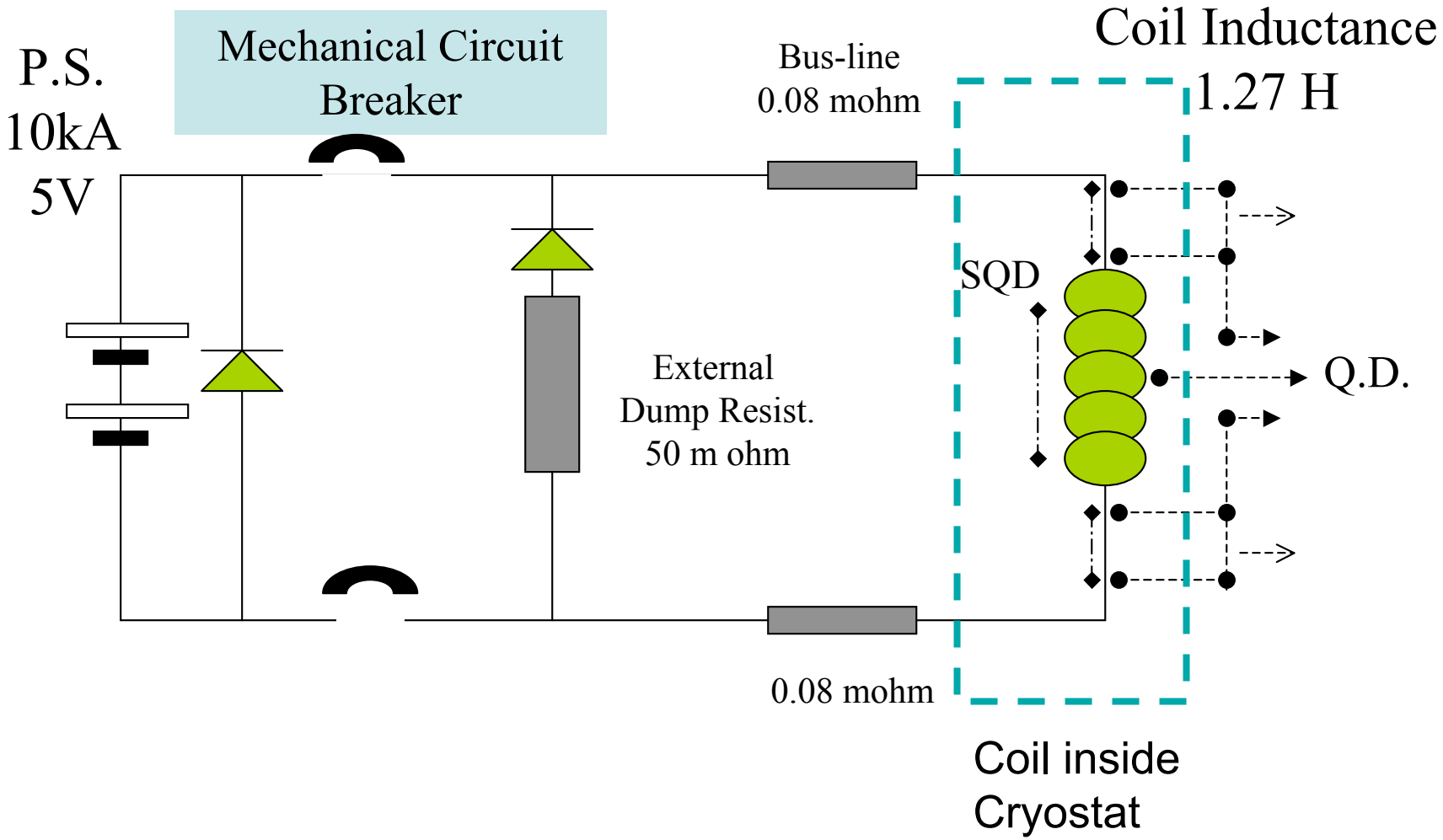


- A hybrid conductor consisting of Al/Ni-alloy stabilized superconductor supported by High Strength Aluminum shell

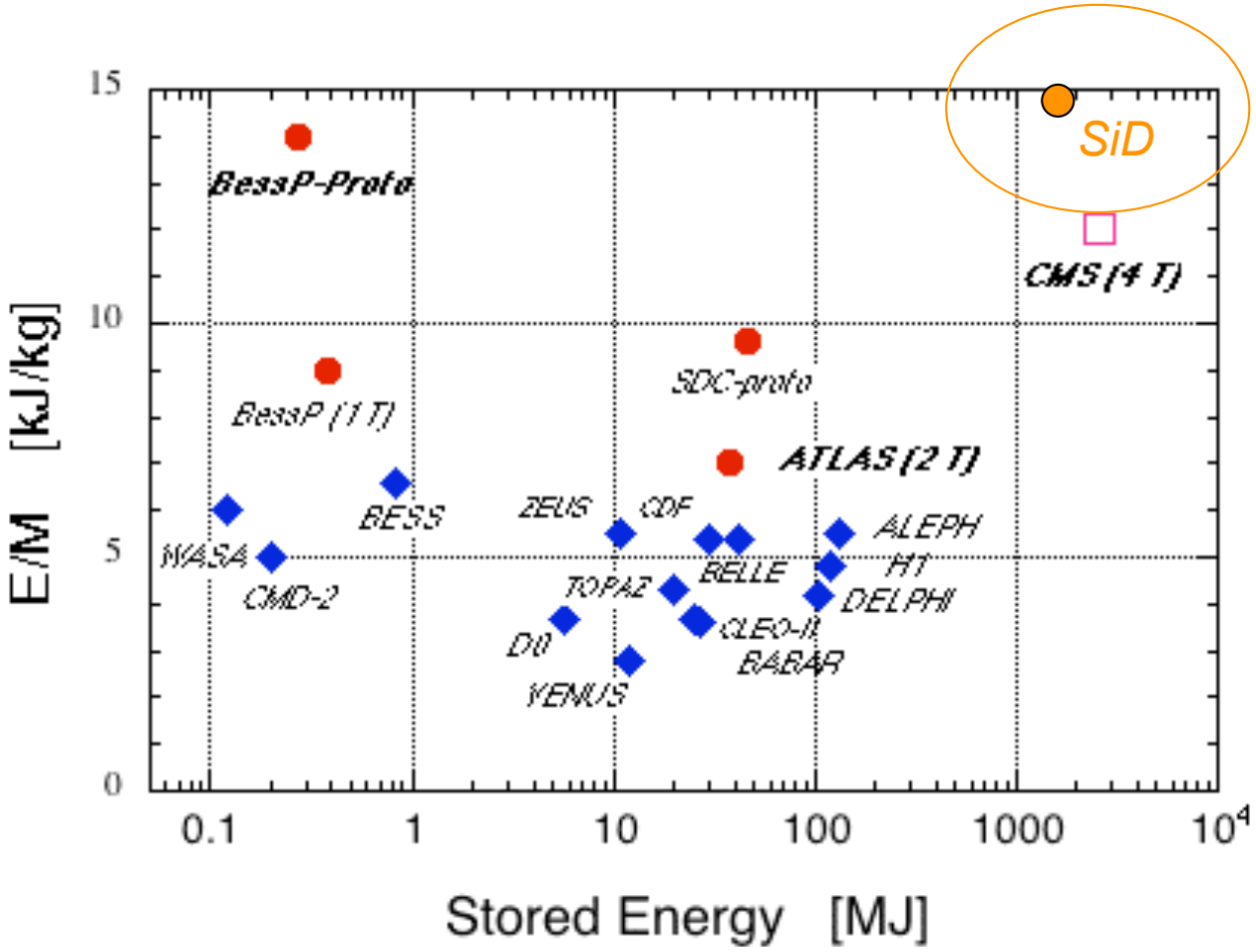
NbTi/Cu Cable Design

	CMS	SiD Cable-1	SiD Cable-2
Ic (@5T)[kA]	59	66	95
Ic (@8T)[kA]		27	38
I-op [kA]	19.5	~26	~26
Strand diameter[mm]	1.28	1.28	1.60
Num. of Strands	32	36	38
B-max[T]	4.6	5.6	5.6
Cable crosssection [mmxmm]	20.68x2.34	23.3x2.34	28.8x2.74
Load Line Ratio		~77%	~70%

Electrical Circuit with quench protection



Progress in E/M Ratio in Detector Magnets



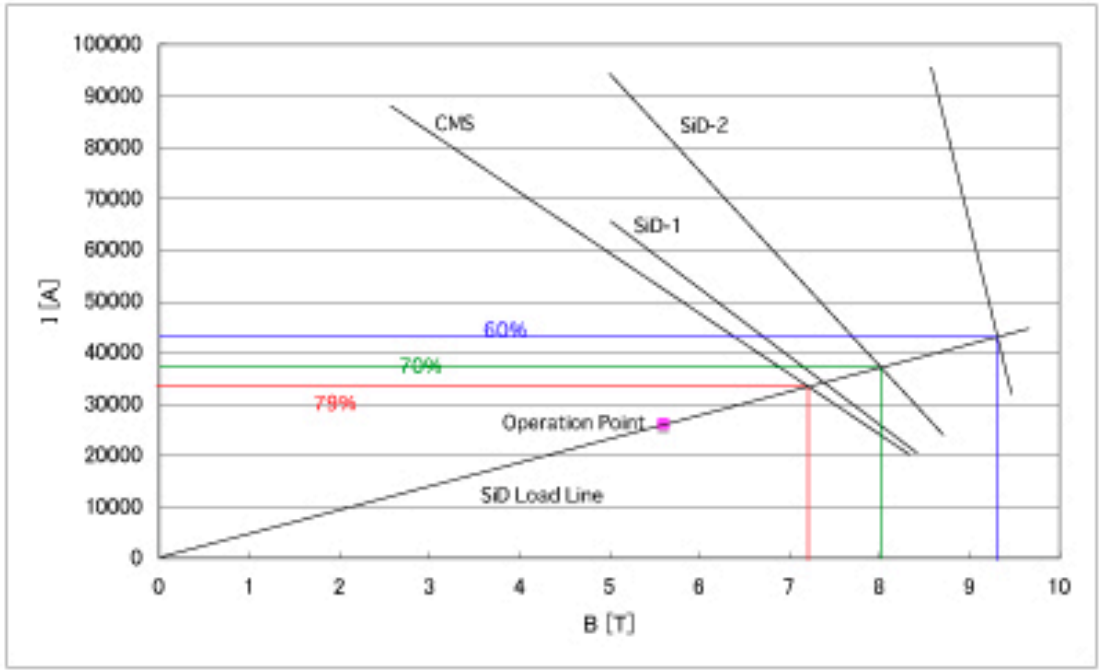
Rough idea about the cost

SC magnet (+cryostat)	~$50M + $10M (contingency)
He Cryogenic system	~$10M + $2M
Return yoke iron	~7700tons x 1Myen/ton(as of Jun06)=7,700Myen ~$65M + $13M
Sum	~$125M + $25M

He not included.

DID not included.

End



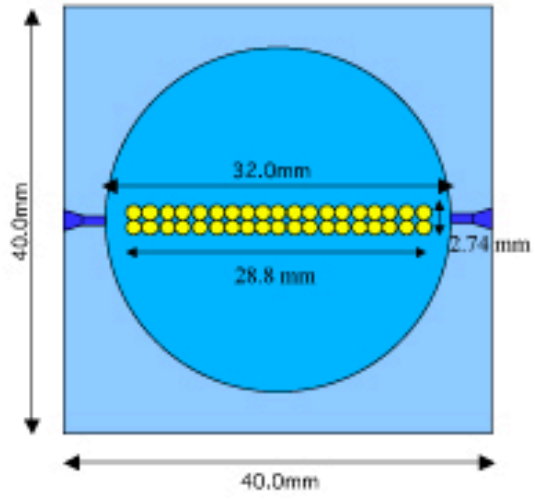
	CMS	SiD-1	SiD-2
Ic @5T [A]	59000	66000	95000
Ic @6T [A]		27000	38000
I-op [A]	19500	~26000	~26000
Strand Diameter [mm]	1.28	1.28	1.60
Strand Number	32	36	38
Bmax [T]	4.6	5.6	5.6
SC-Cable Dim. [mm]	20.68x2.34	23.3x2.34	28.8x2.74
Load Line Rtio		~77%	~70%

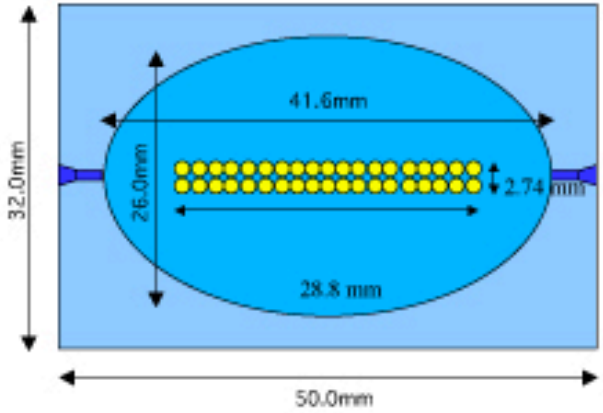
When
Jc(NbTi) = 2750A/mm2(at 5T, 4.2K)
Jc(NbTi) = 1000A/mm2(at 8T, 4.2K)
Cu/S ratio : 1.0

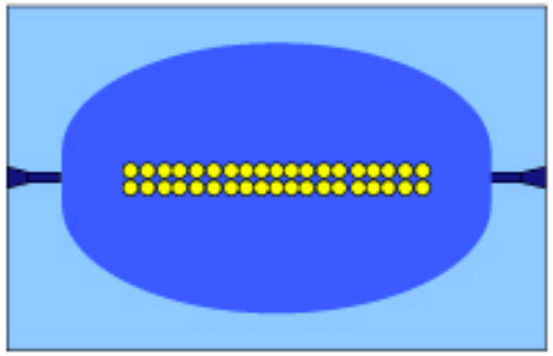
Jc(strand) = 500A/mm2 (at 8T, 4.2K)
In the case of "Load Line Ratio"=70%
Ic (cable) = 38000 A (at 8T, 4.2K)

When we have 38 strands

Ic(strand) = 38000 / 38 = 1000
s = Ic(strand) / Jc(strand) = 1000 / 500 = 2
r = √(s / π) = 0.798
d = 1.6
(s : Cross-section of strand, r : strand radius, d : strand diameter)







Design Image in Construction