Cost Issues

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Estimation Procedure

- Get unit cost from the cost estimation for GLD(DOD)
- Estimate (relative) amount of return-yoke iron which gives same leakage field for 3T, 3.5T, and 4T models
- Calculate volume or weight of components (CAL and return yoke) of GLDc, and scale it to 3T and 4T model
- Derive the cost for 3 models, 3T, 3.5T,4T

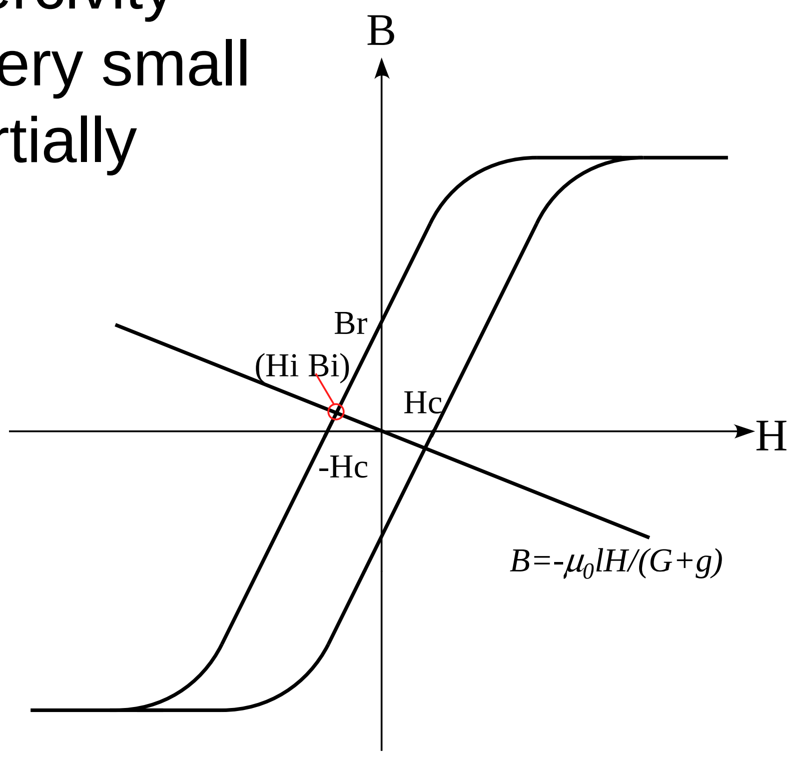
GLD ➔ GLDc (3.5T) ➔ 3T and 4T models

Unit Cost of GLD

- Return-yoke iron
  - 500 kV/ton
- Solenoid
  - 50.3 MV(MJ)$^{0.662}$
- ECAL
  - 8.87 GV20.8m^3 = 426 MVm^3
- HCAL
  - 3.39 GV222m^3 = 15.2 MVm^3

Return-yoke Iron

- Good iron (S10C) is used for GLD
  - High saturation field
  - As strong as standard iron
  - Low remanence (Br) and coercivity (Hc) ➔ Field in the gaps is very small at I=0A, and gaps can be partially filled with iron

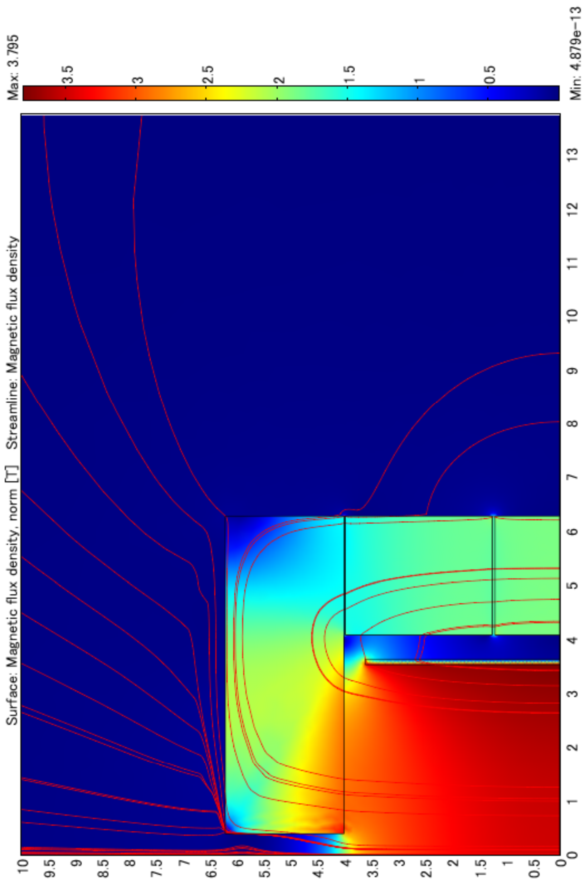


Return-yoke Iron

- B-field calculation based on simple models for 3, 3.5, and 4T with various iron thickness
- Maximum stray field at R=Rdet+1m was obtained as a function of iron thickness
- Thickness which give the 300G stray field was obtained for each central B-field
- Relative volume of iron and relative stored energy with respect to 3.5T case are used for the cost estimation

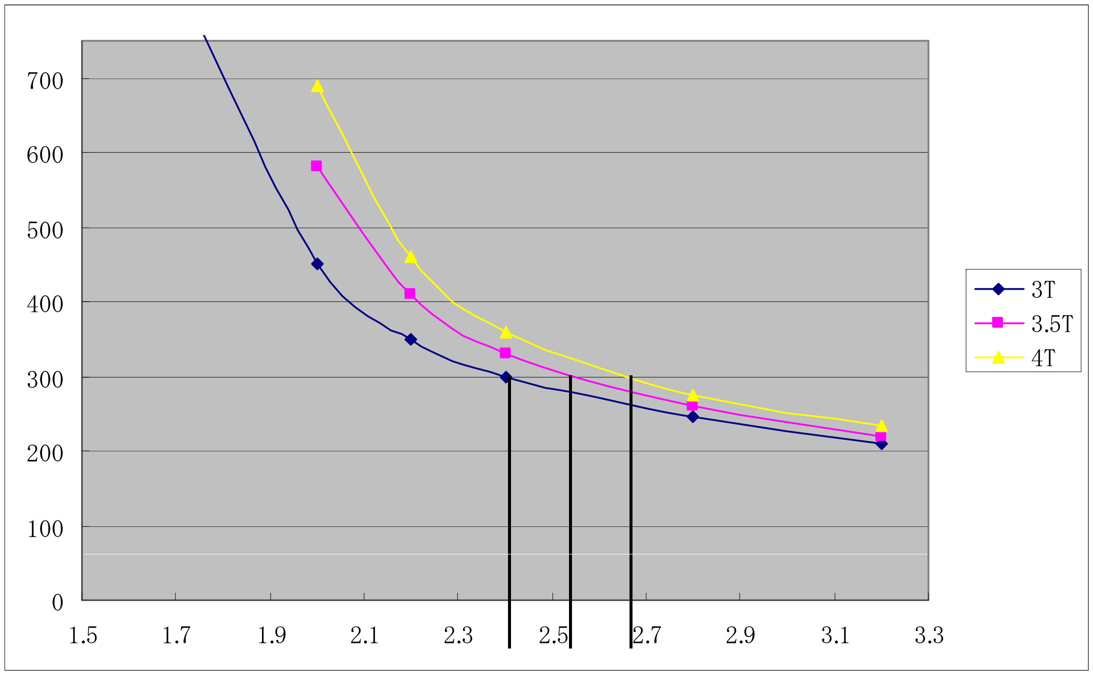
	4T	3.5T	3T
Coil radius (m)	3.35	3.6	3.85
Coil length (m)	6.7	7.2	7.7
Barrel inner radius (m)	3.85	4.1	4.35
End-cap Z (m)	3.75	4.0	4.25

Return-yoke Iron



Simplified model

Maximum stray field at R=Rdet+1m



Iron thickness (m)

Necessary volume is almost same for 3 cases

Detector Parameters

	GLD	3T	3.5T (GLDc)	4T
BR^2	13.3	13.3	12.0	10.2
ECAL Volume (m^3)	20.8	21.5	16.9	12.8
HCAL Volume (m^3)	222	193	161	132
Yoke Iron (ton)	1.66e+4	1.13e+4	1.12e+4	1.11e+4
Stored Energy (GJ)	1.6	1.50	1.70	1.80

Note
R_{CAL}=1.6, 1.85, 2.1m for 4T,3.5T,3T, respectively
ECAL thickness: 20cm
HCAL thickness: 1.2m for GLD, 1.1m for others

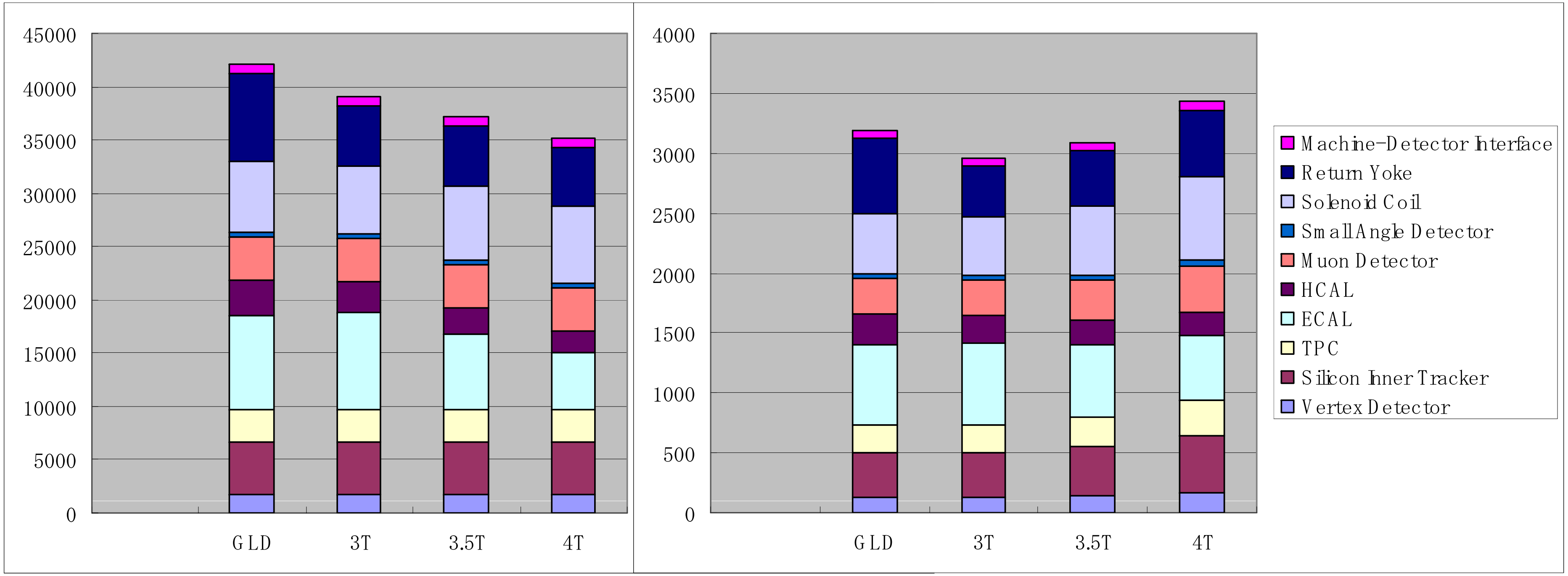
Cost

(M\)	GLD	3T	3.5T	4T
Vertex Det	1700	1700	1700	1700
Si Inner Tracker	4902	4902	4902	4902
TPC	3036	3036	3036	3036
ECAL	8861	9159	7199	5453
HCAL	3374	2934	2447	2006
Muon Det	3992	3992	3992	3992
Small Angle Det	500	500	500	500
Solenoid	6640	6373	6915	7178
Return Yoke	8300	5660	5600	5540
MDI	824	824	824	824
Total	42132	39075	37115	35135
Relative cost	1.14	1.05	1	0.95

DAQ system and off-line computing not included

Cost

(M\)



Cost

Cost normalized by BR^2

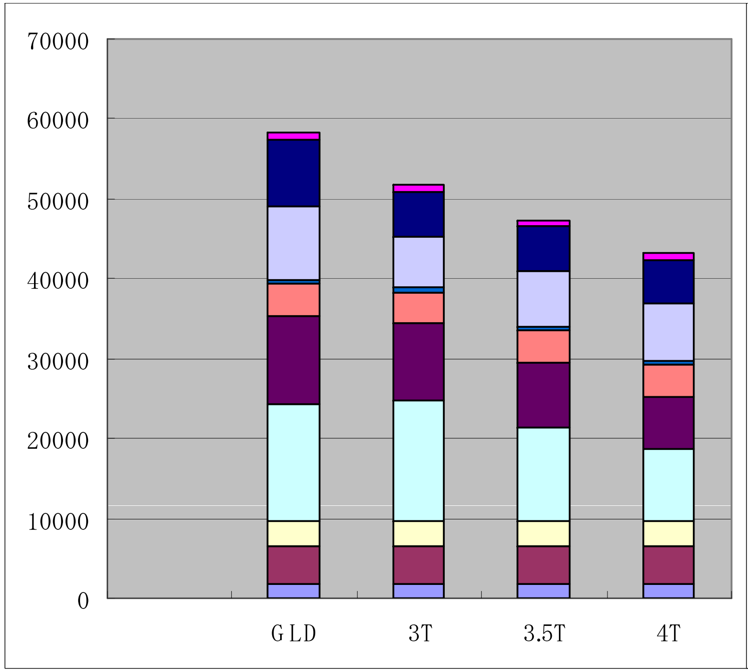
Cost with different assumption

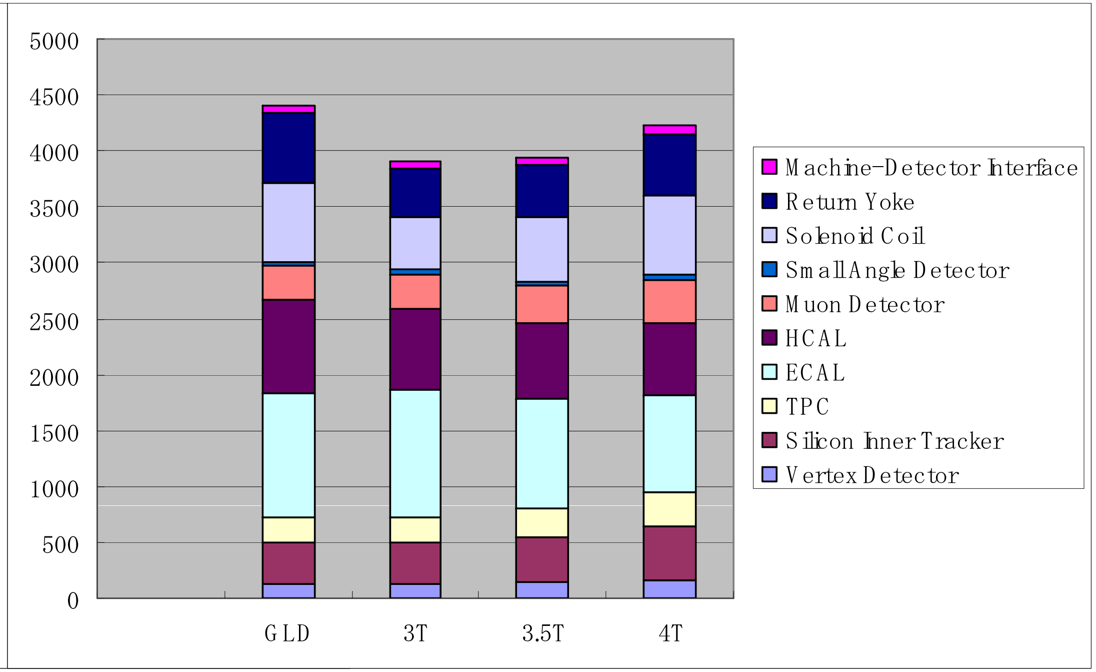
- Different unit cost for ECAL and HCAL
  - ECAL: 426 M\/m^3 → 700 M\/ m^3
  - HCAL: 15.2 M\/ m^3 → 50 M\/ m^3

(M\)	GLD	3T	3.5T	4T
Vertex Det	1700	1700	1700	1700
Si Inner Tracker	4902	4902	4902	4902
TPC	3036	3036	3036	3036
ECAL	14560	15050	11830	8960
HCAL	11100	9650	8050	6600
Muon Det	3992	3992	3992	3992
Small Angle Det	500	500	500	500
Solenoid	6640	6373	6915	7178
Return Yoke	8300	5660	5600	5540
MDI	824	824	824	824
Total	58297	51676	47342	43228
Relative cost	1.23	1.09	1	0.91

Cost with different assumption

(M\)





Cost

Cost normalized by BR^2

Conclusions

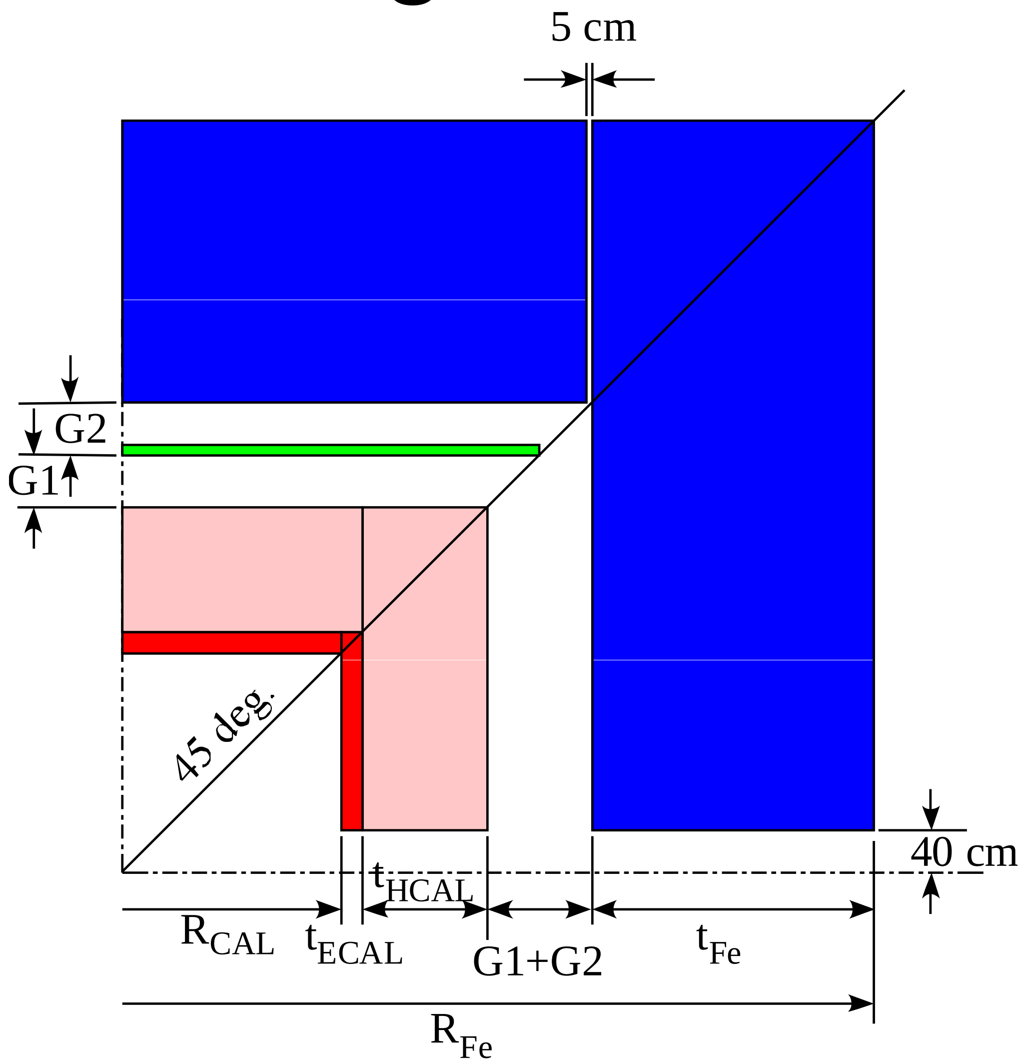
- Very rough cost estimation is made for GLDc (~GLD') 3.5T detector based on GLD cost estimate, and scaled to 3T and 4T GLDc-like models
- Difference between 3.5T model and 3 or 4T model is rather small ~+-5% with GLD assumption, and ~+-10% for more expensive CAL assumption
- If normalized by BR^2, larger R_{CAL} detector is less expensive
- There are many discrepancies in cost estimation of each items. Once the ILD parameters are fixed, sub-detector experts of GLD and LDC should talk to each other to give agreed unit costs.

Backup Slides

Slides from my talk at
GLD/LDC meeting in LCWS2007

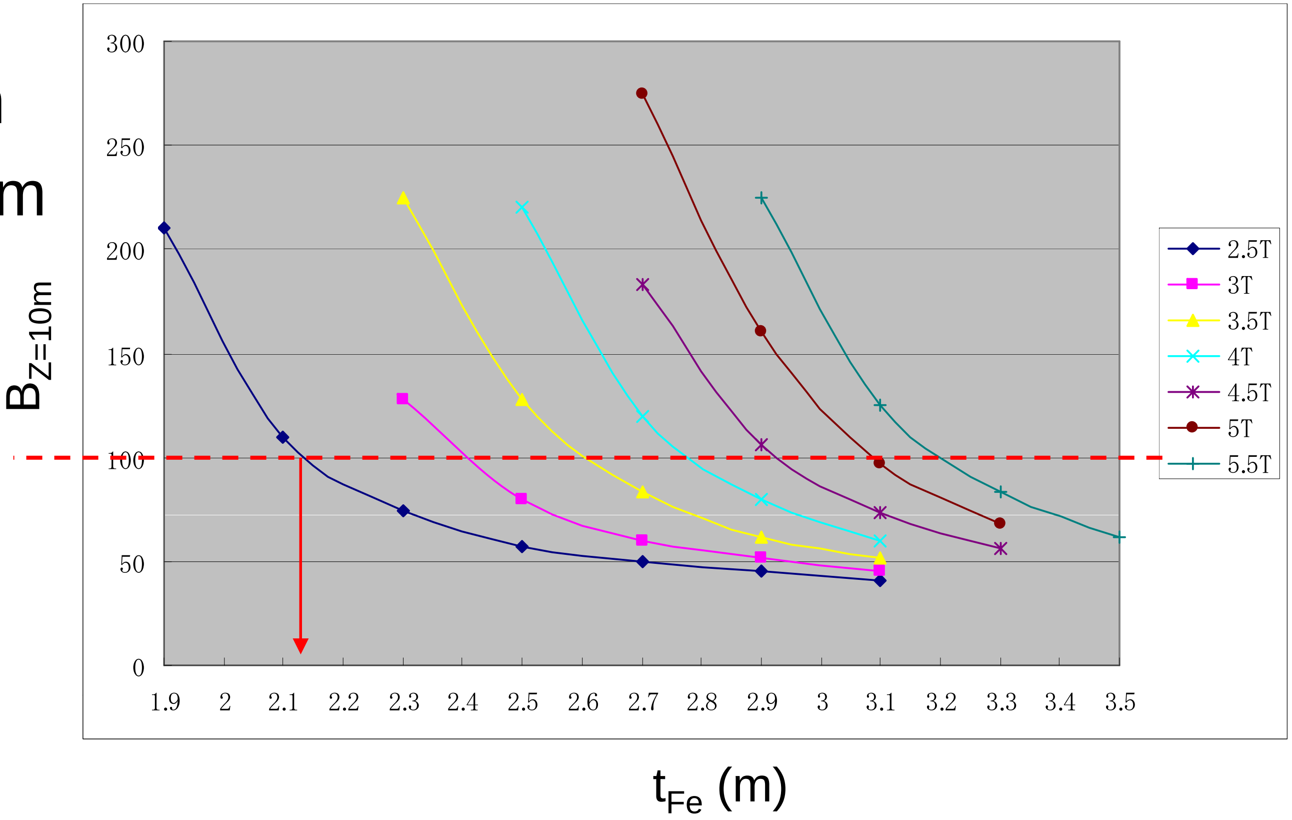
Why is GLD large?

- How much iron do we need?
  - B-field calculation based on a toy model using a FEA program was done
  - BR^2, t_{ECAL}, t_{HCAL}, G1, G2; fixed
  - Leakage field at Z=10 m was estimated as a function of B, and t_{Fe}
  - t_{Fe} to satisfy the leakage limit of 100G was obtained for each B



Leakage B-field

- GLD-like
  - $BR^2=13.23$
  - $t_{ECAL}=0.17m$
  - $t_{HCAL}=1.23m$
  - G1=G2=0.5m

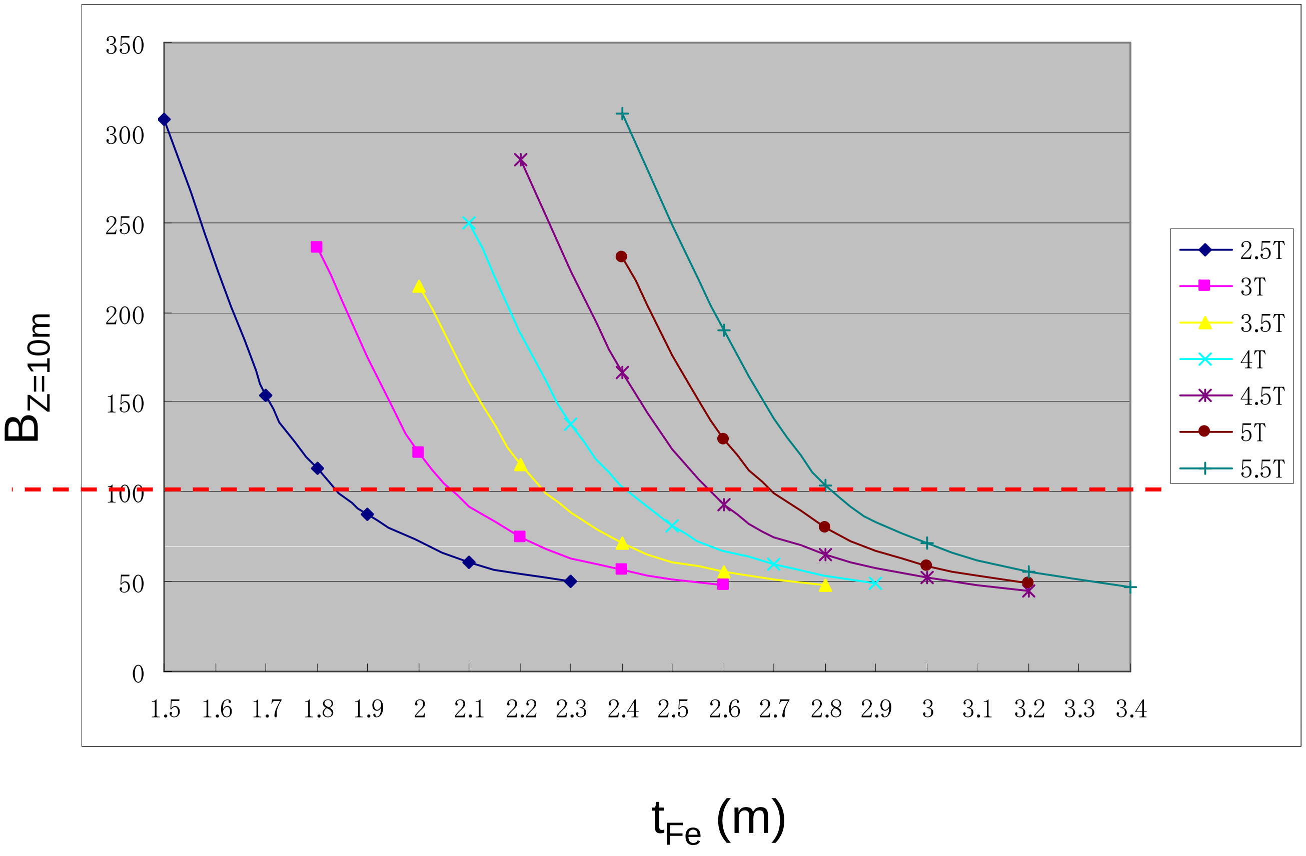


Leakage limit

Andrei put the limit to 50G, but 100G can be reduced to <50G by low cost Helmholtz coil

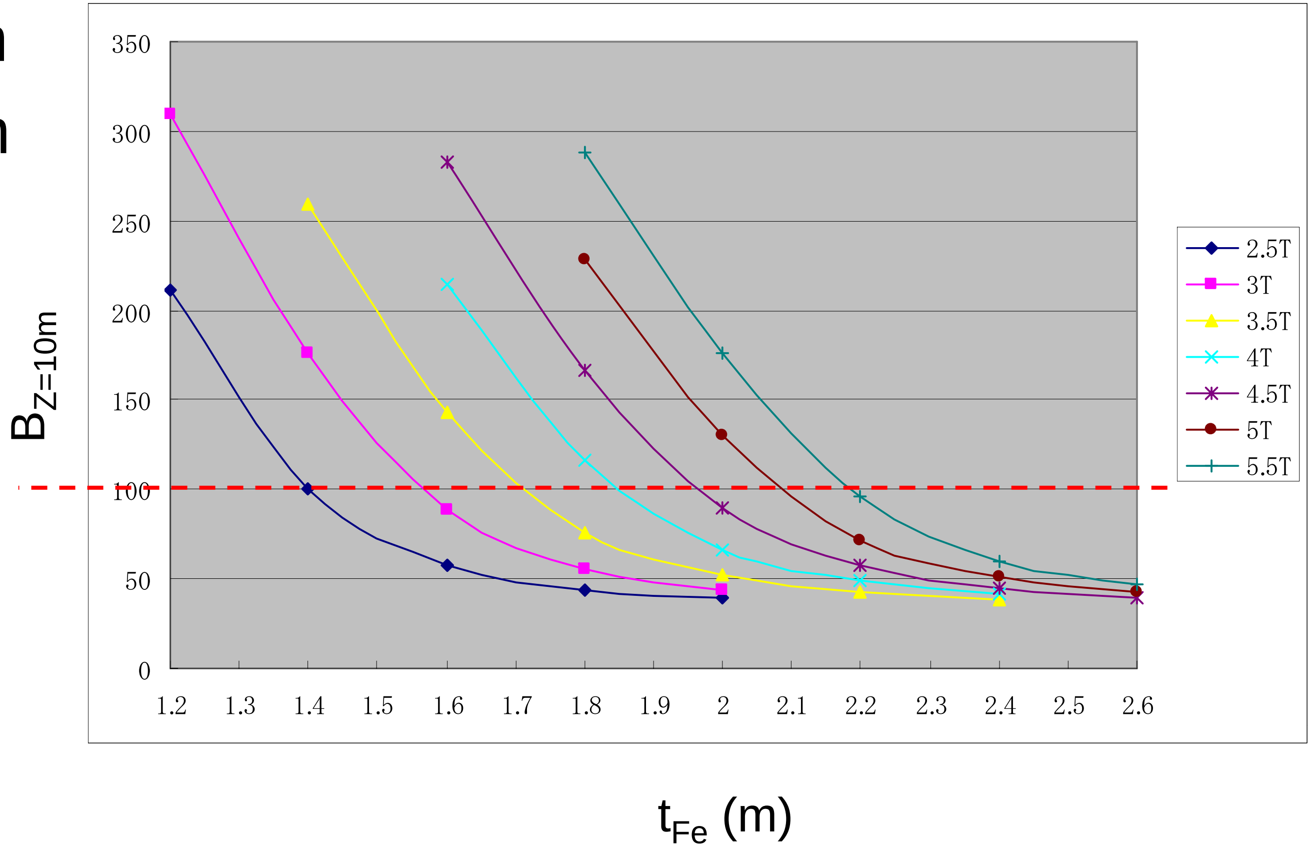
Leakage B-field

- LDC-like
  - BR^2=10.24
  - t_{ECAL}=0.17m
  - t_{HCAL}=1.13m
  - G1=0.46m
  - G2=0.49m

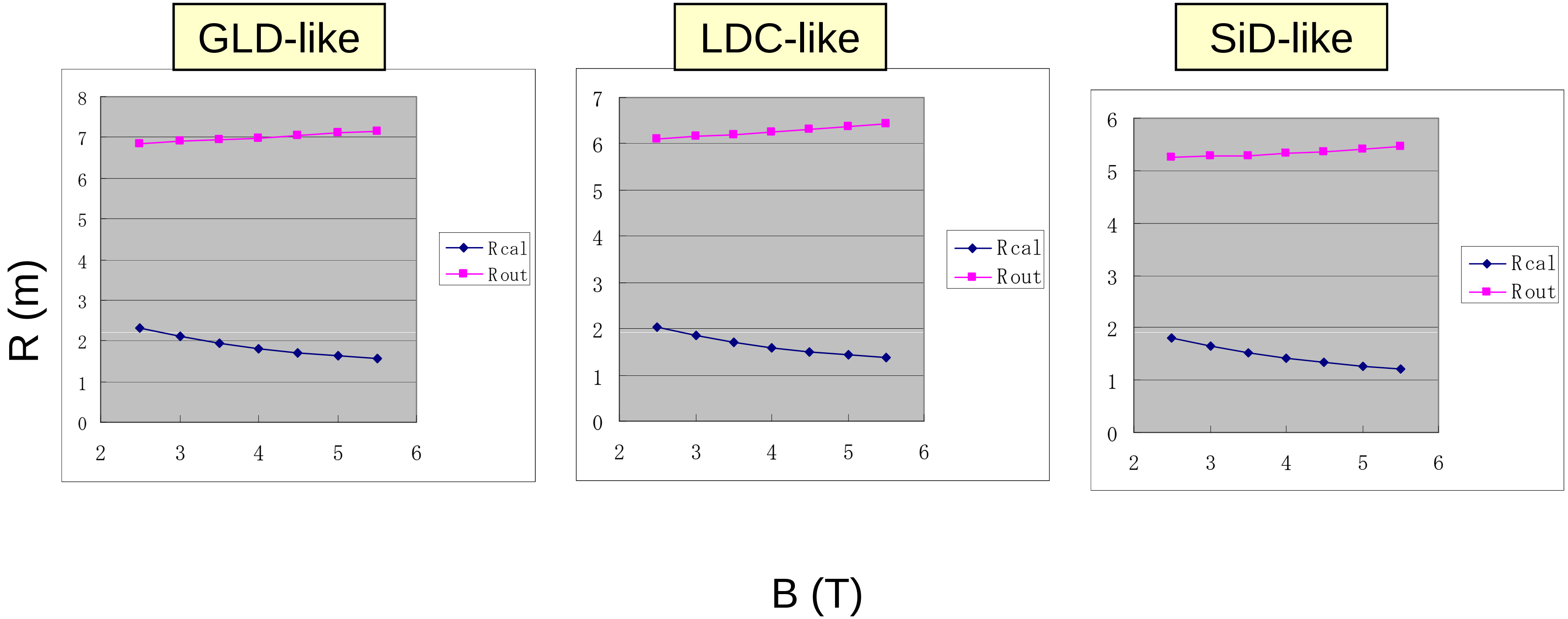


Leakage B-field

- SiD-like
  - $BR^2=8.06$
  - $t_{ECAL}=0.13m$
  - $t_{HCAL}=1.09m$
  - G1=0.21m
  - G2=0.63m



B and R

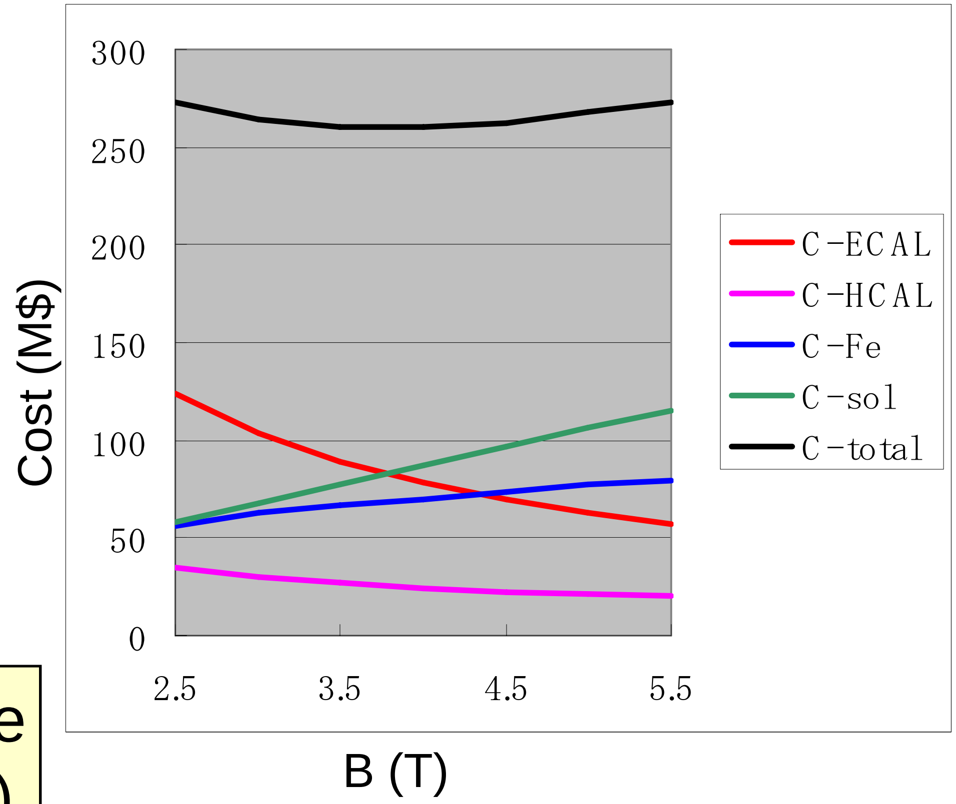


For a given BR^2, larger B (smaller R_{CAL}) gives larger detector size

B and Cost

- GLD-like detector model
- Unit cost assumption
  - ECAL: 6.8M$/m^3
  - HCAL: 0.16M$/m^3
  - Fe: 42k$/m^3
  - Solenoid: 0.523x[Estore]$^{0.662}$ M$

B-field dependence of the total cost (CAL+Sol.+Fe) is very small



Summary

- GLD is the largest detector among the three PFA detectors
- GLD is the largest NOT because it has the largest inner radius of the calorimeter, but because it has the largest BR^2, the thickest HCAL, and the smallest leakage field