FIFC report

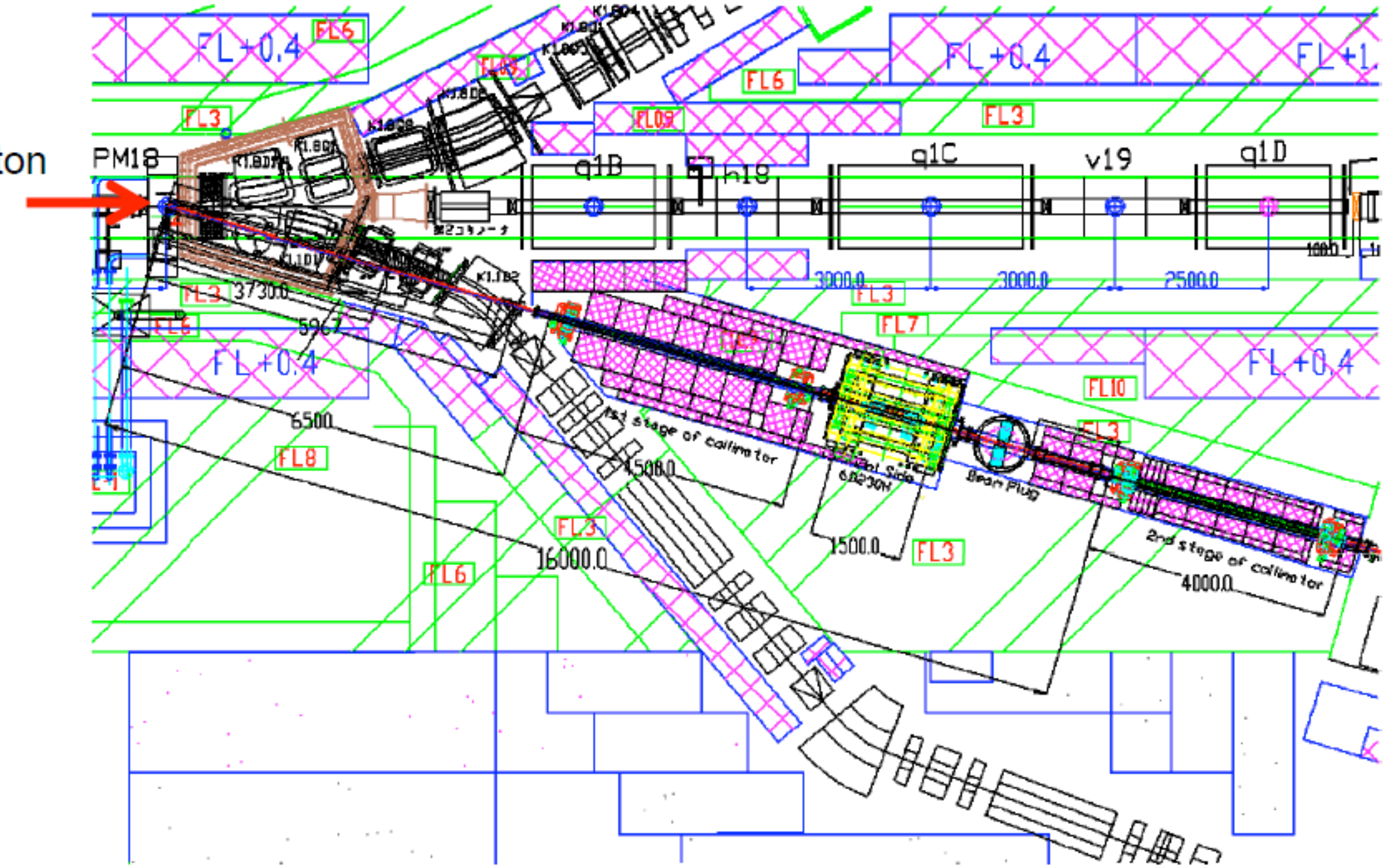
Junji Haba
IPNS, KEK

KL and K1.1 beam line

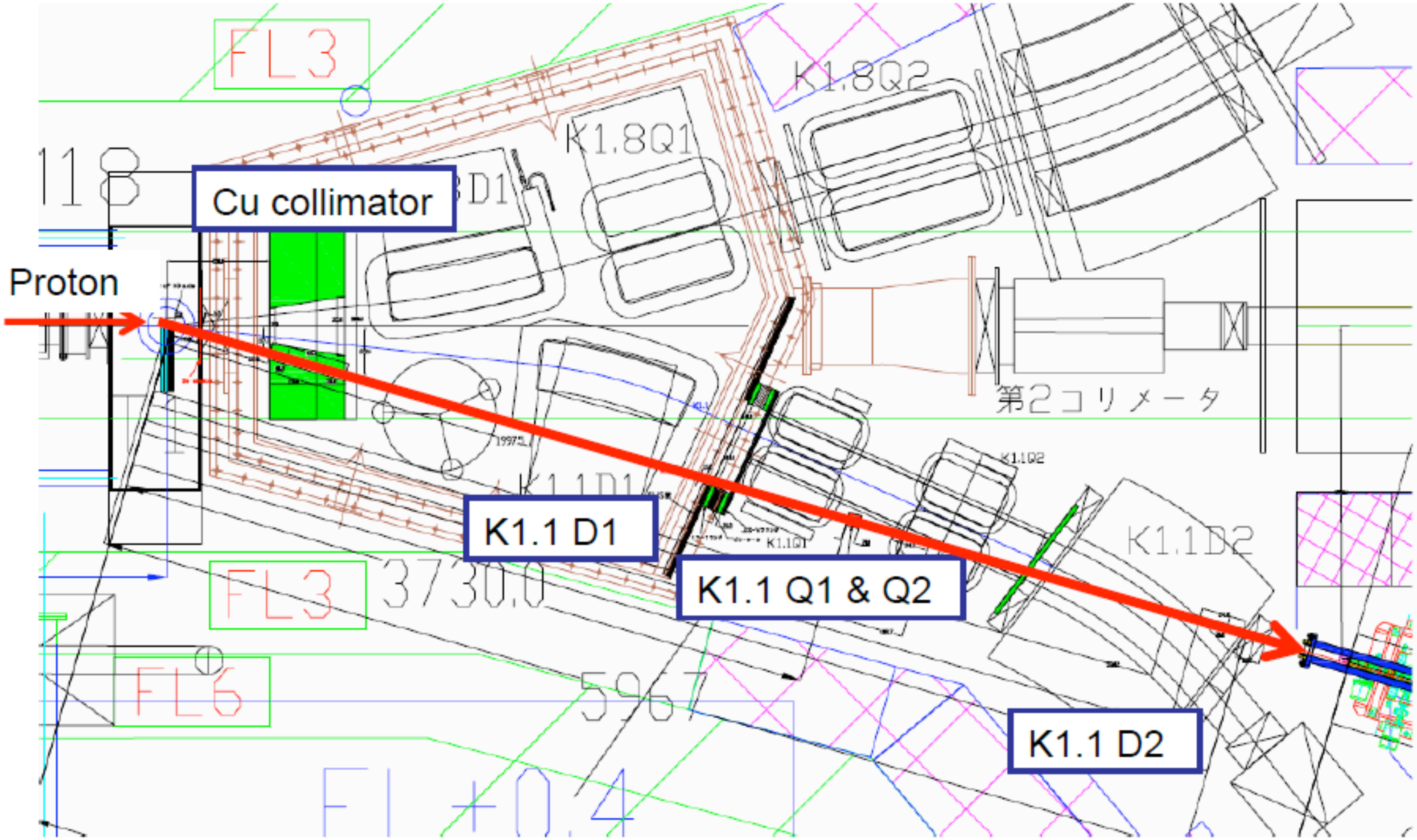
- Reminder: What was the issue?
- Possible degradation of KL beam performance by K1.1 materials in
  - Reduction of KL yield
  - Increase of hallo neutron
- K1.1 should not endanger the ultimate sensitivity of E14.

KL beam line at the hadron hall

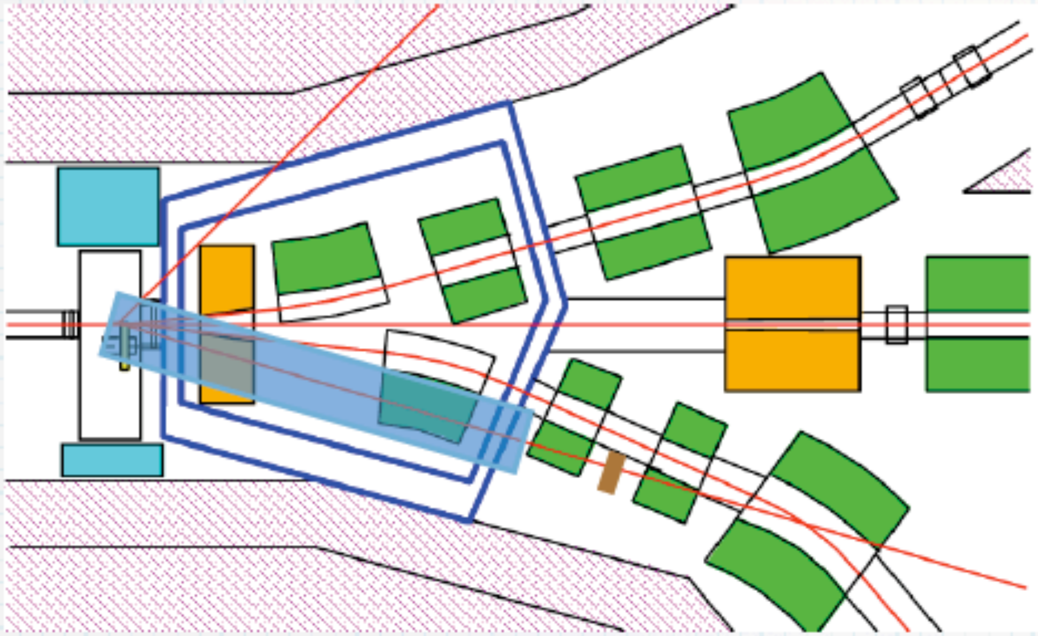
Proton



Upstream materials

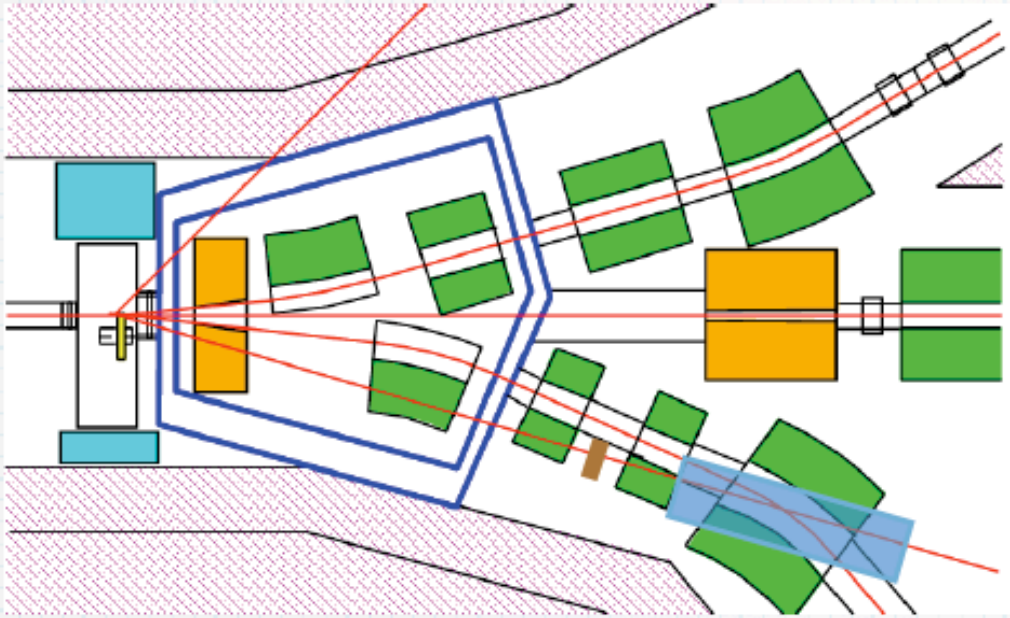


K1.1 components (1)



	name	material	material in beam	starting position (mm)	thickness (mm) modified	original	comments
target	T1 target	Ni	Ni air 1atm	0.0			
vacuum vessel	vacuum window	Be	Be	149.8	4.7	4.7	cross the beam
			vacuum				
	collimator	Cu	vacuum	537.8	416.1	416.1	40mm×40mm square ϕ30mm-hole
			vacuum				
	K1.1D1 yoke	Fe	vacuum	1997.5	687.6	687.6	ϕ30mm-hole
			vacuum				
	flange	SUS304	SUS304	3097.2	0.2	20.2	cross the beam

K1.1 components (3)

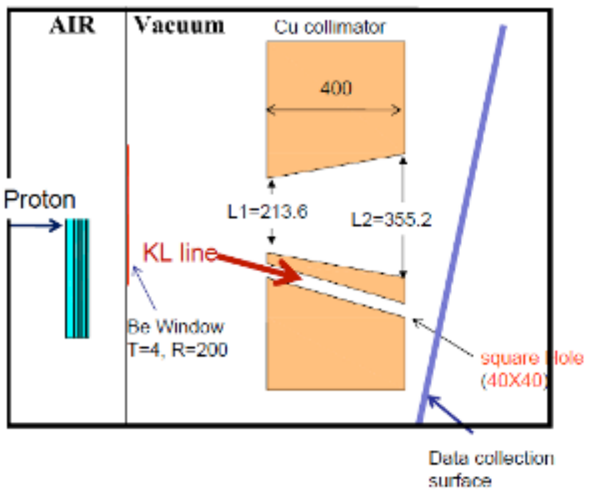


beam duct

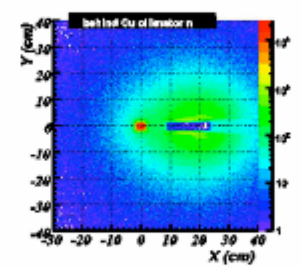
D2 magnet

name	material	material in beam	starting position (mm)	thickness (mm) modified	original	comments
K1.1 duct	SUS304	SUS304	4181.7	0.2	5.0	cross the beam at 7°
		vacuum				
K1.1 duct	SUS304	SUS304	5510.2	0.2	5.1	cross the beam at 7°
		air 1atm				
K1.1 D2 core	Cu	air 1atm	5672.4	241.8	241.8	ϕ30mm-hole
		air 1atm				
K1.1 D2 coil	Cu	air 1atm	5935.7	107.1	107.1	ϕ30mm-hole
		air 1atm				

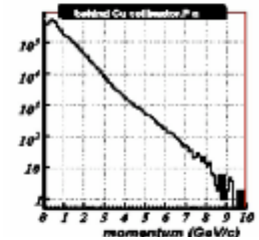
Target M.C.



Neutron profile behind Cu collimator (KL coordinate)



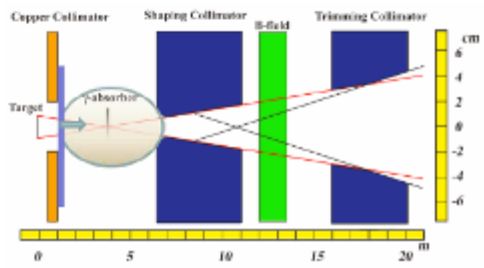
Neutron momentum



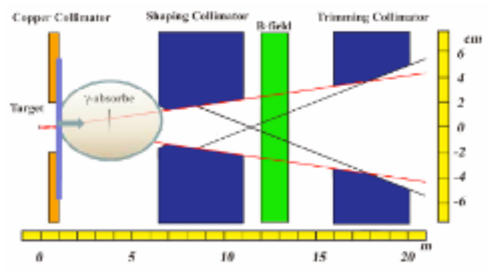
Beam line M.C.

- Target image is quite different in x- and y-directions
- Different collimation and trimming lines
- To make square beam at the front of calorimeter surface

x-direction



y-direction



leutron profile at the CsI calorimeter (z=27m)

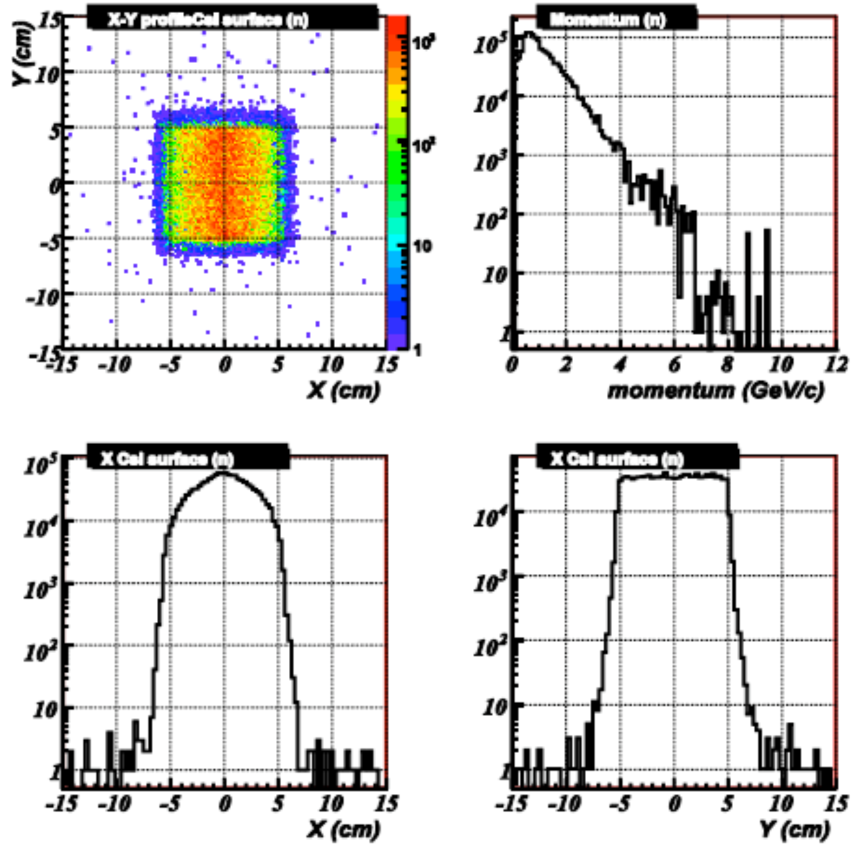


Table 3: Number of the core neutrons, halo neutorns and K_L's per spill (2×10^{14} protons) at the three different configurations.

	Core neutron ($E_n > 100MeV$)	halo neutron ($R > 8cm$ at CsI Surface, $P_n > 2GeV/c$)	K_L (At the exit of beam line)
KL line alone	3.21×10^8	$(0.72 \pm 0.15) \times 10^4$	$(7.79 \pm 0.11) \times 10^6$
modified K1.1	3.15×10^8	$(1.17 \pm 0.19) \times 10^4$	$(7.77 \pm 0.11) \times 10^6$
original K1.1	[illegible]	[illegible]	[illegible]

	Default	Without K1.1 materials	With K1.1-D1 only
Core n	4.7×10^8	5.0×10^8	4.8×10^8
Halo n	$(4.0 \pm 0.4) \times 10^4$	$(6.3 \pm 0.5) \times 10^4$	$(3.8 \pm 0.4) \times 10^4$

$$\frac{N\_halo}{N\_core} = 8.5 \times 10^{-5}$$

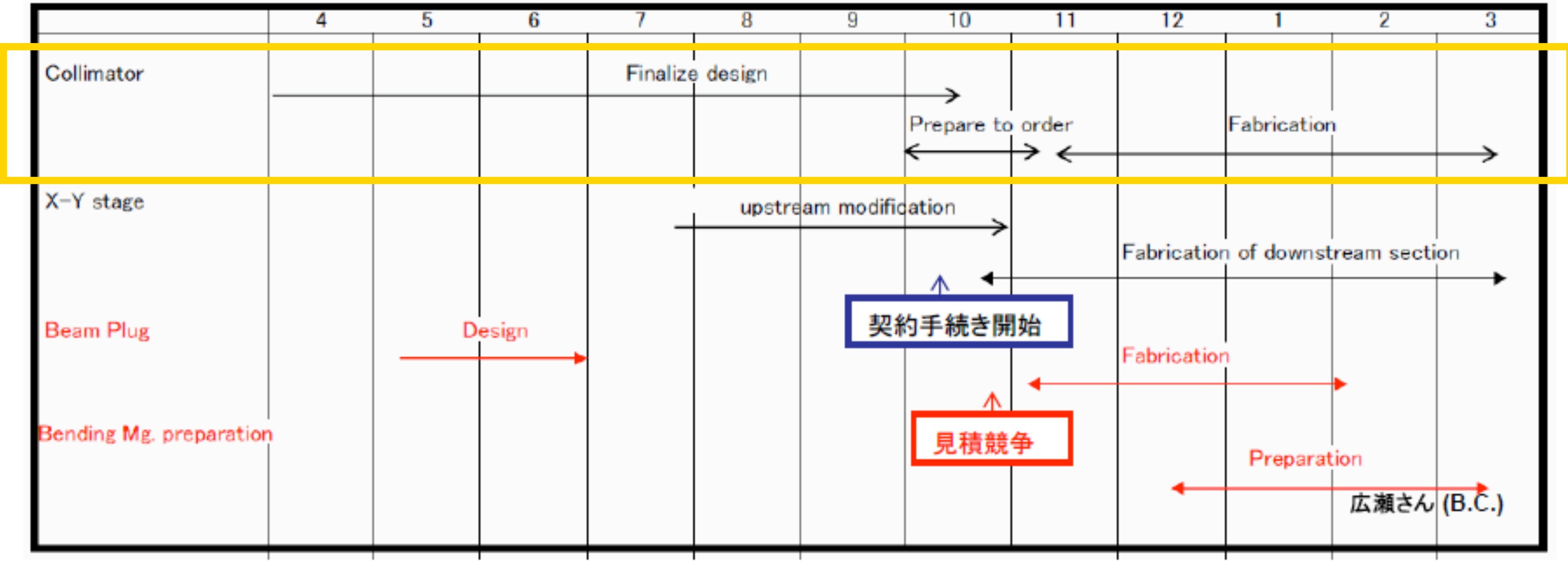
Neutron related background is suppressed less than that from KL decay.

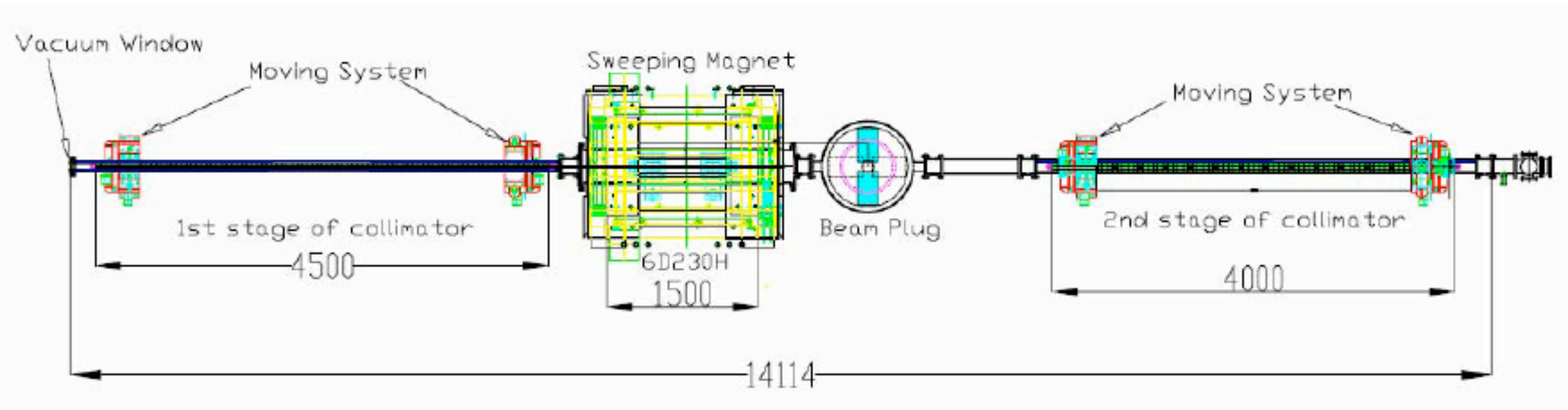
Coexistence of KL and K1.1

- Loss of KL by K1.1 beam line material is now acceptable level.
- Thanks to the hole on K1.1 D1 which is smaller than the copper collimator, the yield of hallo neutron is reduced by 60%.

- Are there any room to optimize more?

Schedule in FY2008



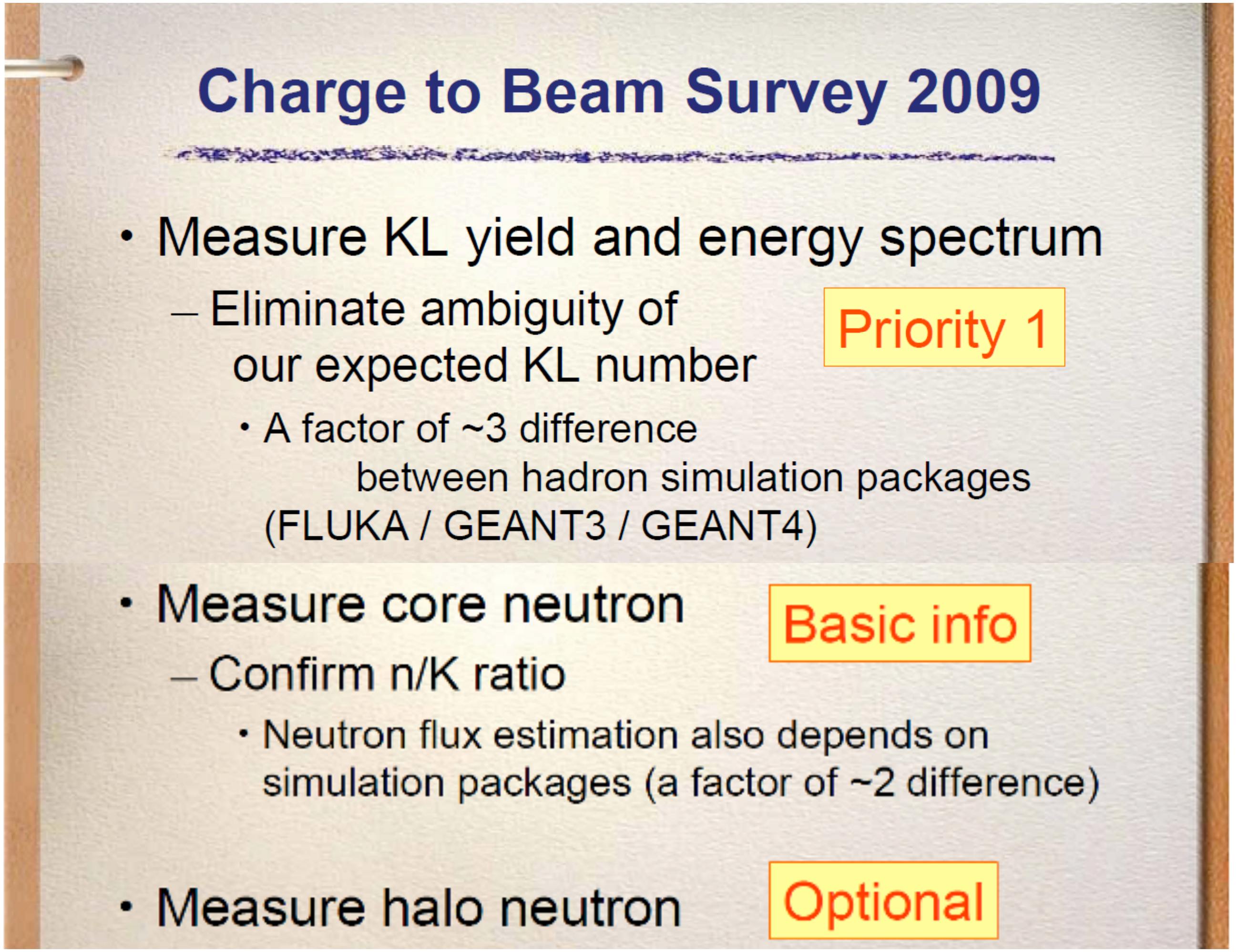


- Fabrication of main beam-line collimators is delayed.
  - Final decision about the shape of the collimator hole (circular or rectangular) yet to be made.
  - Discussion on fabrication detail has not yet started. No engineering drawings!
- →FIFC recommend strongly that the group should fix the final design of the collimators, contact a manufacture and start the fabrication as soon as possible.

- In order to complete the construction of KL beam line in the first half of JFY 2009 on time, the experimental group and facility construction team should have close contact and start preparation of beam line elements needed in the early days of the construction.
- →FIFC recommends the experimental team to ask for some support by the mechanical engineering group to IPNS.

KL beam survey

- Scheduled in Oct-Dec 2009.



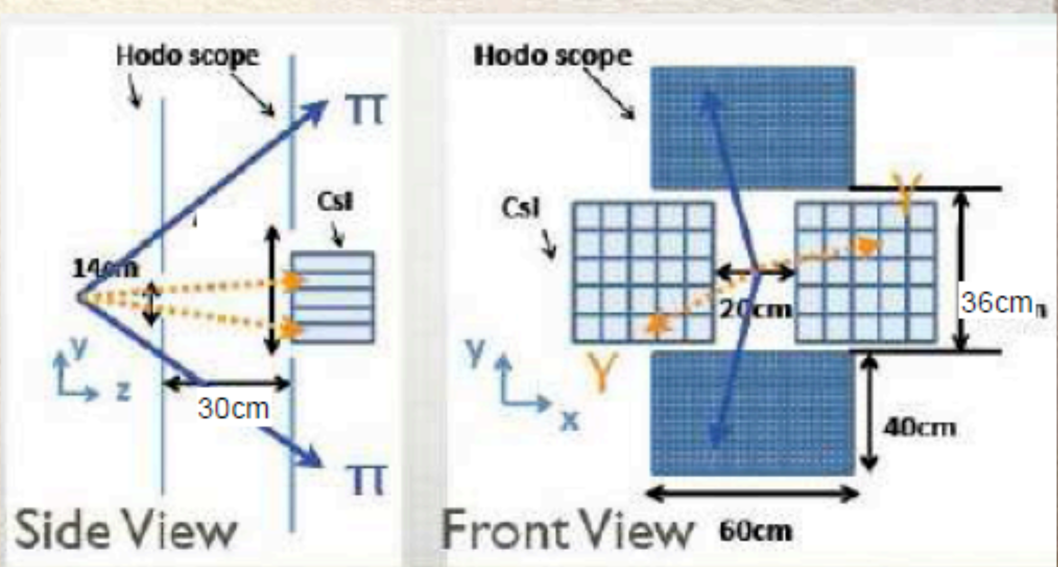
Progresses seem also in this order.

Beam Survey Procedure

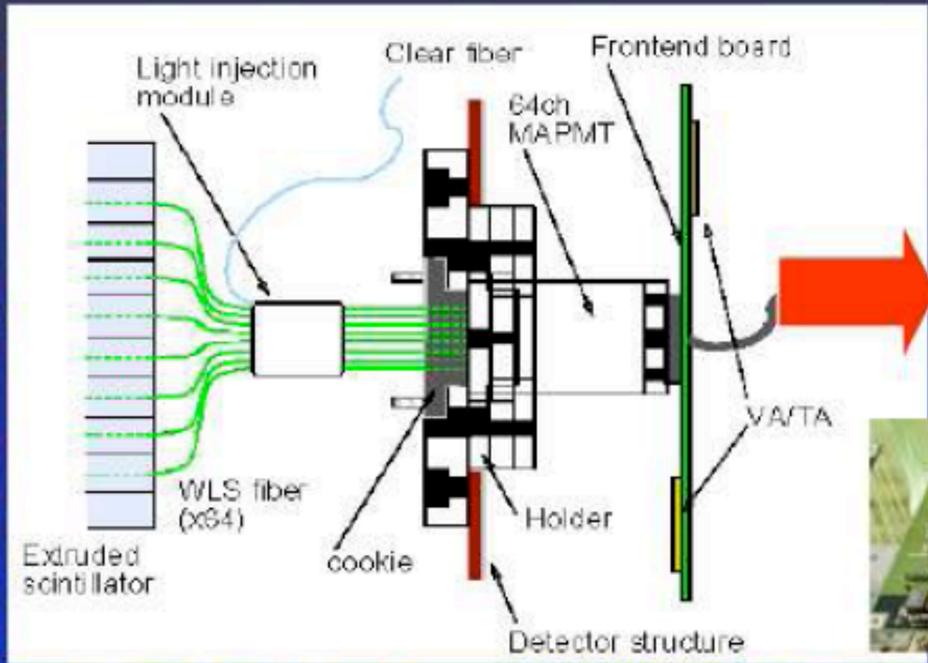
1. Collimator alignment / adjustment
   - preparation
2. K_L measurement
   - Main issue
3. Core neutron measurement
4. Trial of halo neutron measurement
   - Depend on beam quality, available beam time

2. K_L Measurement

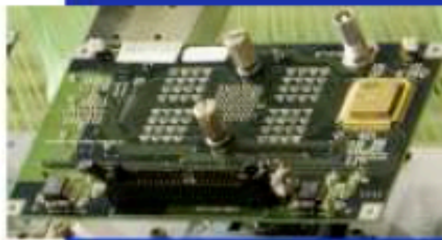
- $K_L \rightarrow \pi^+\pi^-\pi^0$ measurement
- Simple (no magnet, no chamber)
  - Tracker
    - Scinti+WLSF
    - 1cm pitch
    - 400ch in total
  - Calorimeter
    - E391a-CsI
    - 25x2 blocks



SciBar Readout



64 charge info.
2 timing info.



Extruded Scintillator (1.3×2.5×300cm^3)
- made by FNAL (same as MINOS)

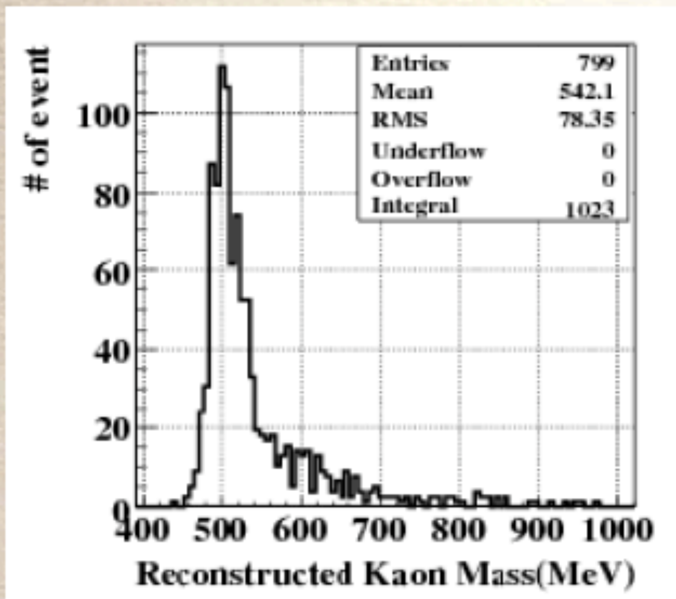
Wave length shifting fiber (1.5mmΦ)
- Long attenuation length (~350cm)

Multi-Anode PMT
- 2x2mm^2 pixel (3% cross talk@1.5mmΦ)
- Gain Uniformity (20% RMS)
- Good linearity (~200p.e. @6×10^5)

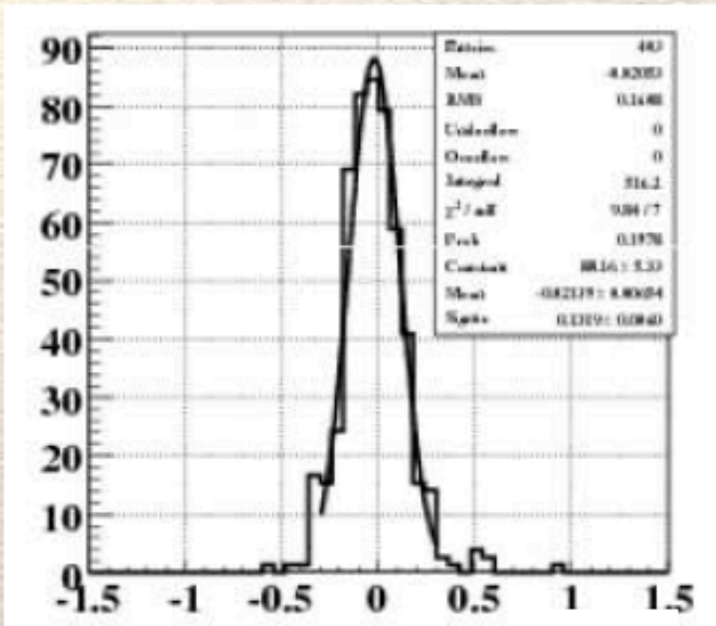
Readout electronics with VA/TA
- ADC for all 14,336 channels
- TDC for 448 sets (32 channels-OR)

Expected Performance

Reconstructed K_L mass



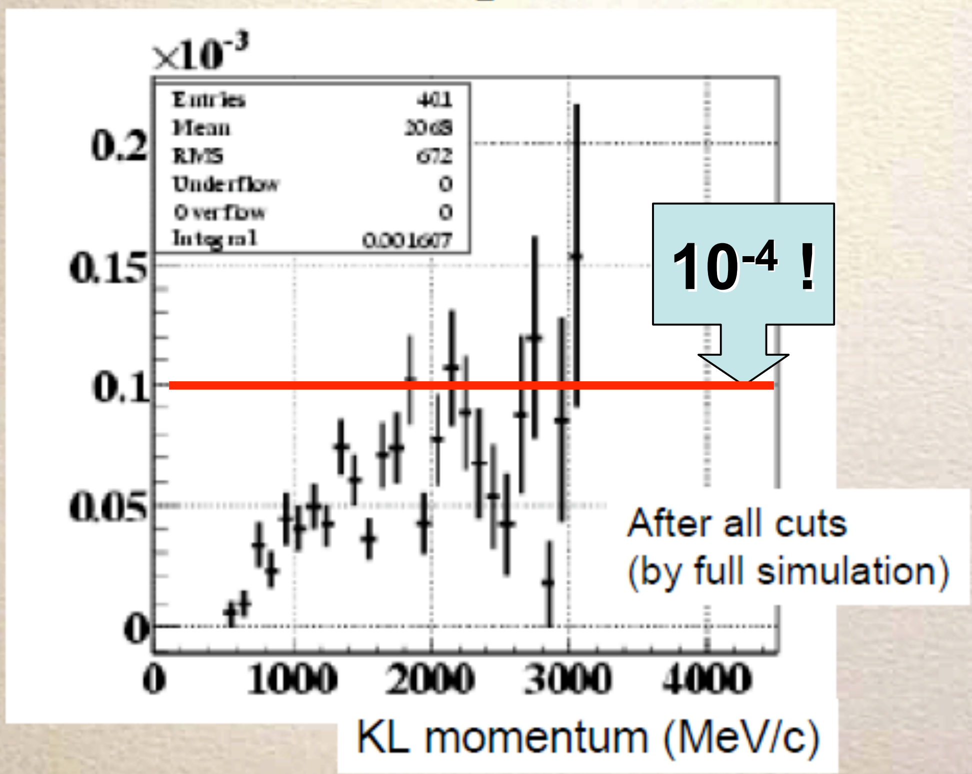
K_L Momentum resolution:
{P(Recons)-P(True)}/P(True)



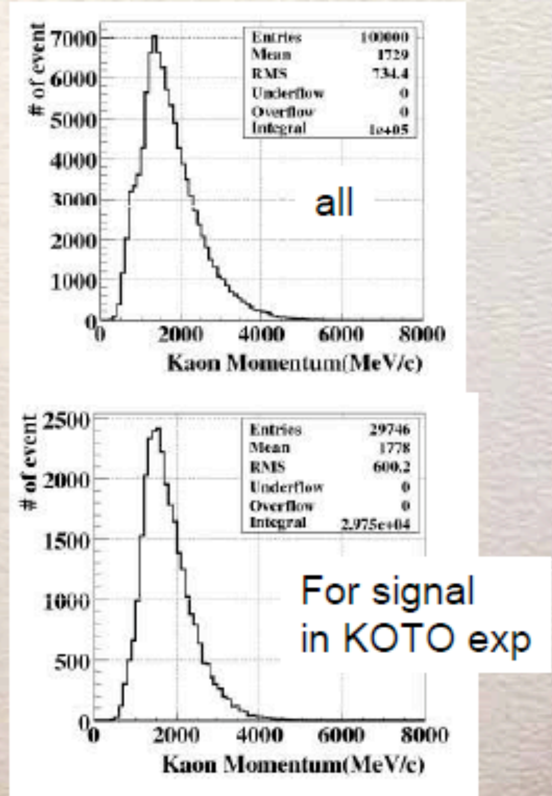
$\Delta p / p$

Expected Performance

Acceptance vs K_L momentum



(cf.) expected K_L spectrum



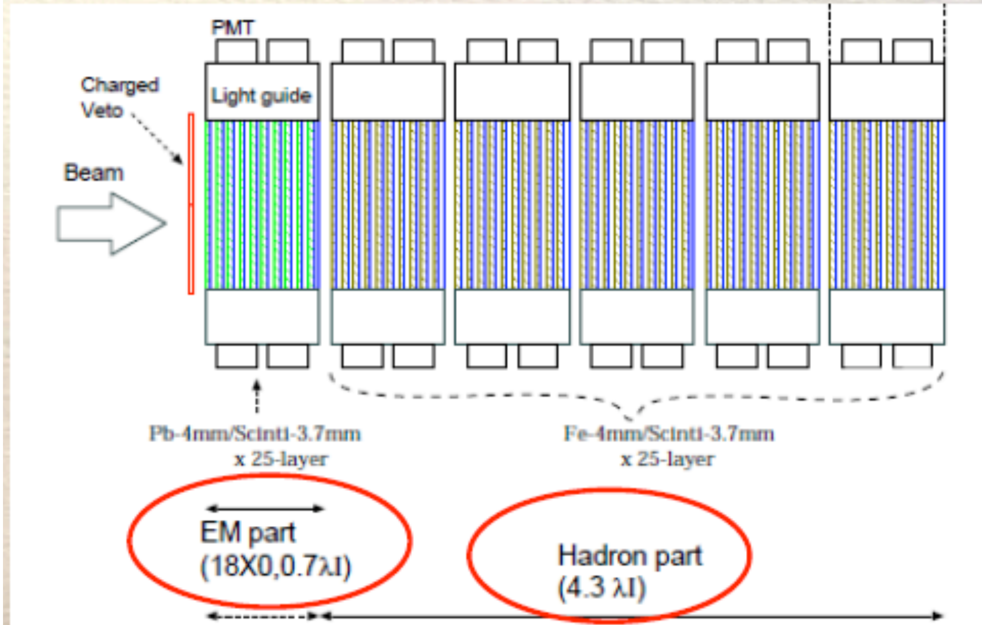
Core Neutron Measurement

- "Cerberus" hadron calorimeter
  - used in E391a beam survey

threshold	1MeV	5MeV	10MeV
EM	4.6	3.6	3
Had0	4	3	2.4
Had1	2.4	1.7	1.3
Had2	1.3	0.9	0.7
Had3	0.6	0.4	0.3
Had4	0.3	0.2	0.1

	1MeV	5MeV	10MeV
EM	91.6	44.2	27.3
Had0	13.5	6.7	4.9
Had1	5.1	3.3	2.5
Had2	2.52	1.75	1.3
Had3	1.2	0.83	0.63
Had4	0.6	0.4	0.3

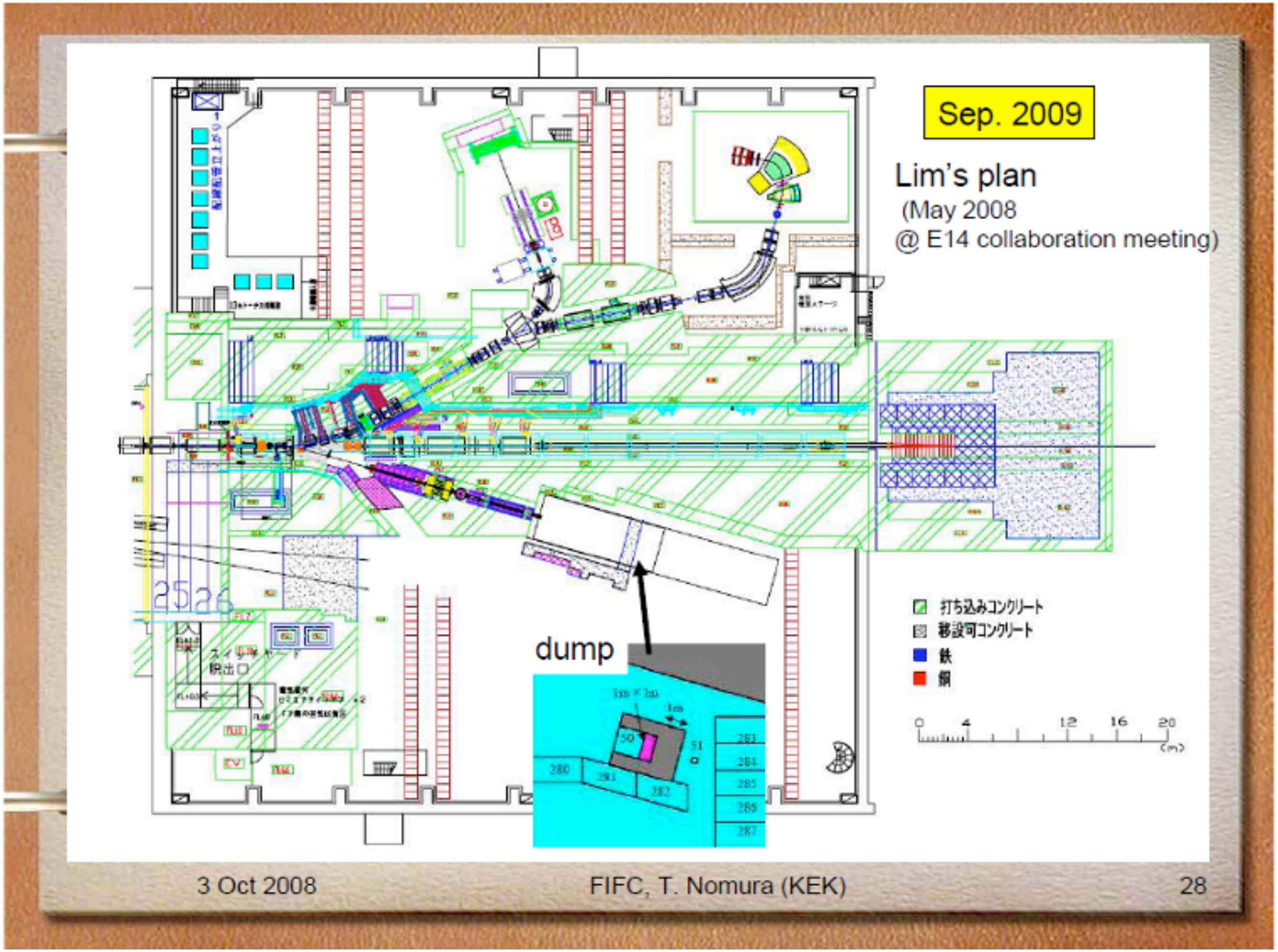
With/Without γ absober



Rate capability is an issue

FIFC’s view

- “No redundancy measurement”
  - Kinematics just determined by all the measurements other than KL mass constraint
  - Very little tolerance for background hit. Stability against background is not clear.
- Independent check/ measurement of acceptance/ efficiency seems important.
- Stability /monitor of primary beam condition (intensity, position, time structure …) is essential. Not yet been investigated fully.



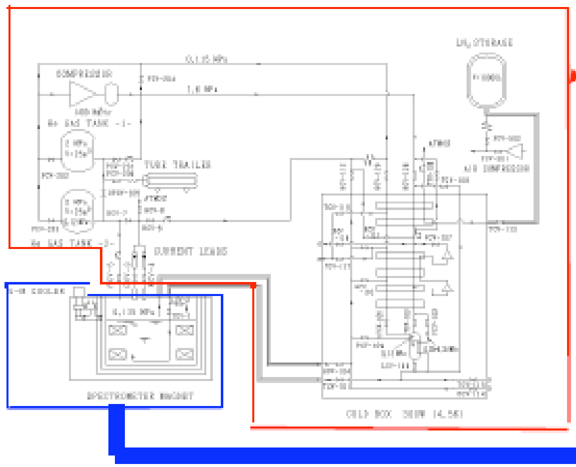
All the necessary arrangements for a formal application of radiation safety (April09) should be started immediately.

Trouble in the SKS renovation

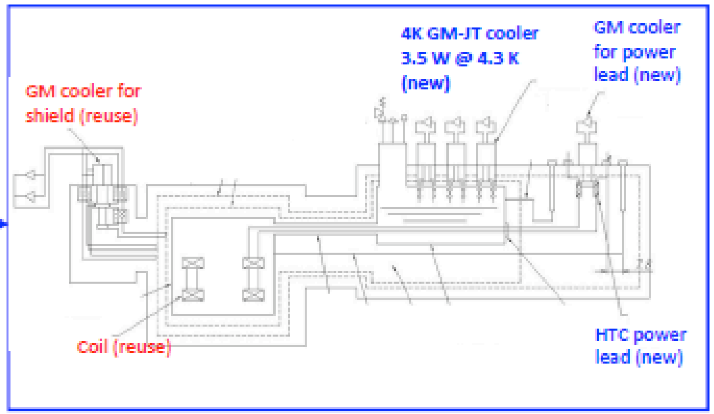
Modification of Cooling System

Before reconstraction

Not to be used



After reconstraction



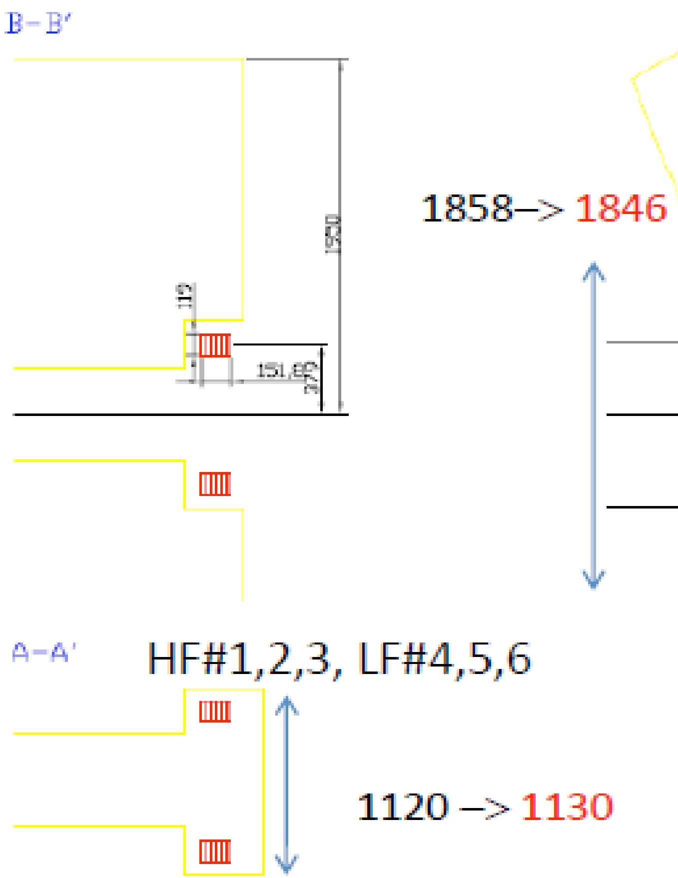
- 300W He refregirator
  - Cold Box
  - (Medium) Compressor
  - He Transfer line
  - LN_2 storages
  - etc...
- Cu current leads

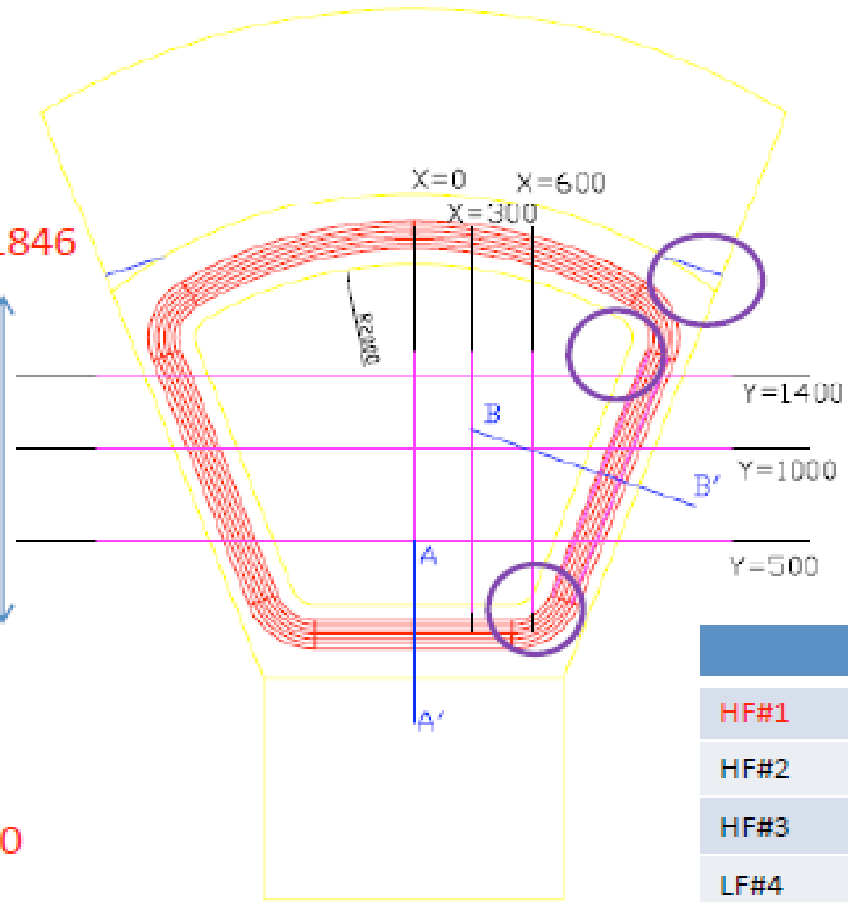
Head load (operation) ~ 5W

- 3.5W GM-JT cryo-cooler x 3
  - shield cooler
- HTC current leads
  with GM cryo-cooler

can maintain liquid state of He

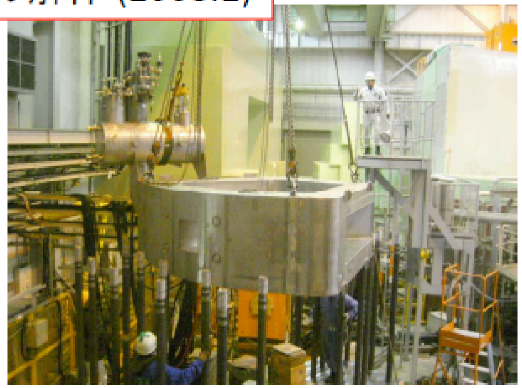
Shape of Yoke & Coil using in the Calculation





	#turns	
HF#1	330	330
HF#2	330	660
HF#3	330	
LF#4	350	1120
LF#5	350	
LF#6	420	
Total	2108	

Something happened during disassemble, transport …….



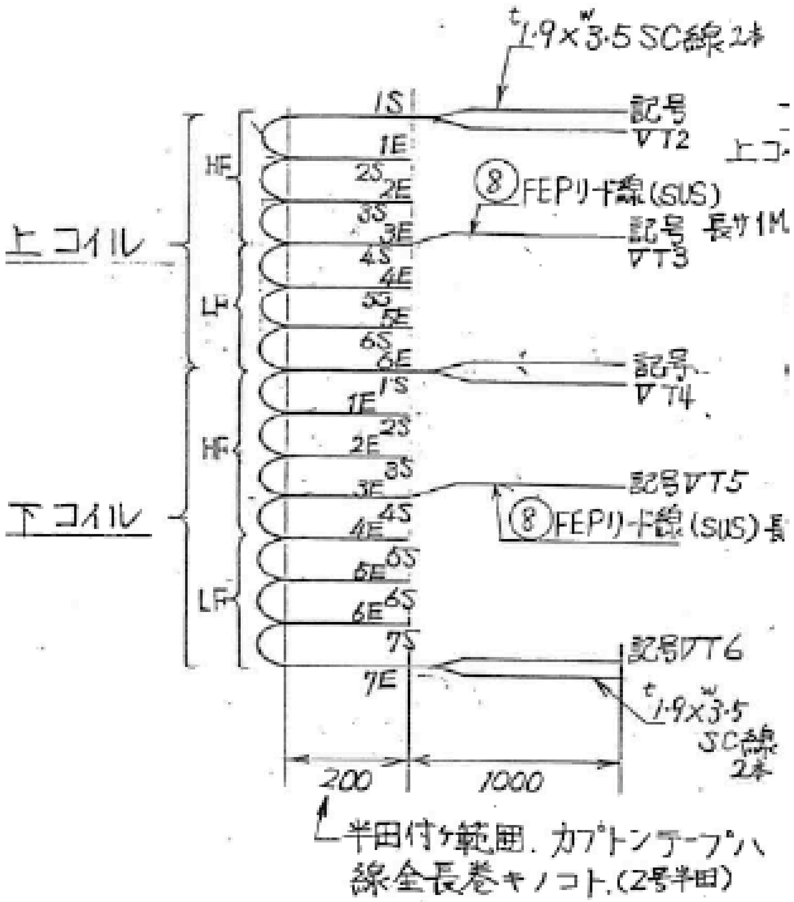
北CHでの解体 (2008.1)

コイル容器@東芝工場

北CHでの解体 (2008.9)

J-PARCハドロンホール
への輸送 (2008.9)

Earth fault found in the TOSHIBA factory (July)



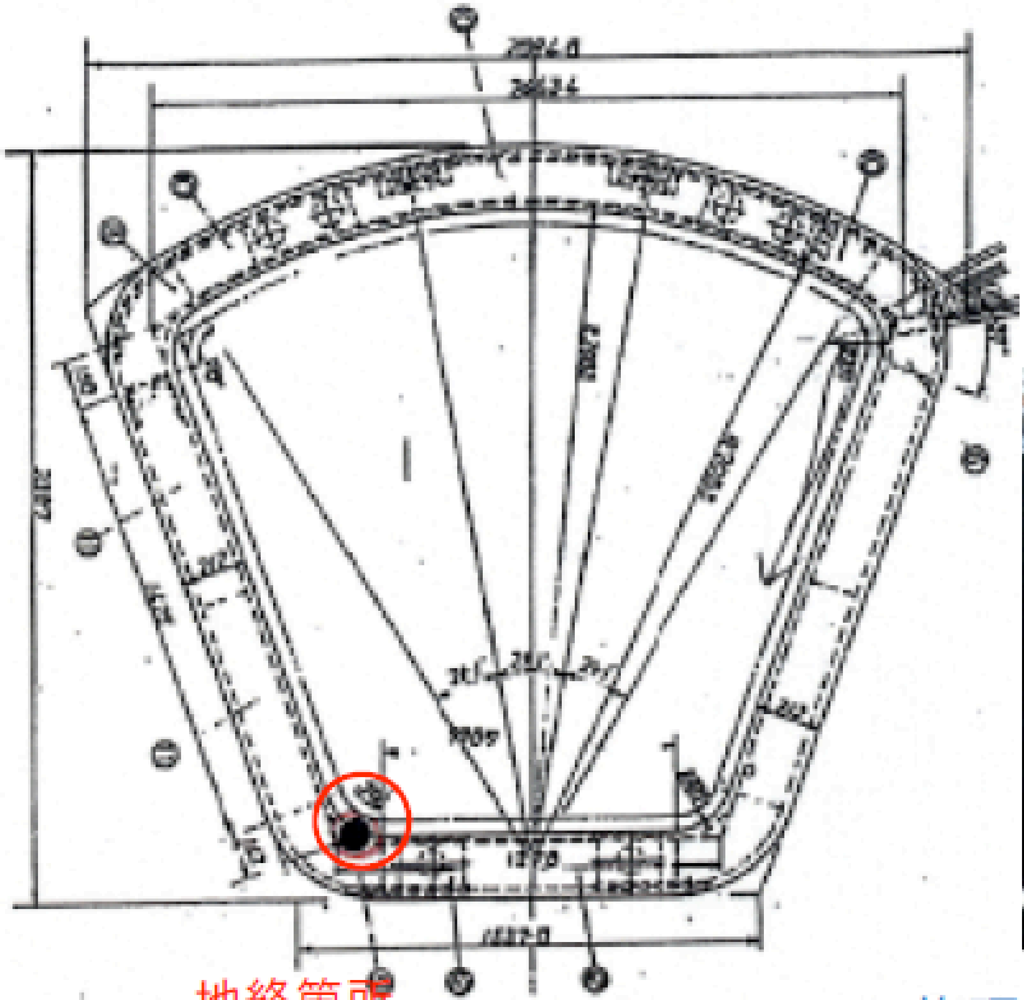
SKS各コイル端子ーアース間の電位測定
と各コイルの抵抗値

			対アース間		コイルブロック	コイルブロック	
		端子記号	電位(V)	コイルブロック	毎電位(V)	抵抗(Ω)	注記
P	1	1S	1.01E−03				0.2A通電で測定したので測定値*0.5L
				上HF1	−0.713	7.13	
上	2	1E,2S	−0.712				
コ				上HF2	−0.735	7.35	
イ	3	2E,3S	−1.447				
ル				上HF3	−0.742	7.42	
	4	3E,4S	−2.189				
				上LF1	−0.896	8.96	
	5	4E,5S	−3.085				
				上LF2	−0.912	9.12	
	6	5E,6S	−3.997				
				上LF3	−1.112	11.12	
中点	7	6E,1S	−5.109				仮の値として全電圧*1/2とした
				下HF1	−0.721	7.21	
	8	1E,2S	−5.830				
下				下HF2	−0.720	7.20	
コ	9	2E,3S	−6.550				
イ				下HF3−1	−0.440	4.40	下コイルHF3は2分割されているので
ル	10	3E,4S	−6.990				抵抗値は 4.4+3.0=7.4Ω
				下HF3−2	−0.300	3.00	
	11	4E,5S	−7.290				
				下LF1	−0.900	9.00	
	12	5E,6S	−8.190				
				下LF2	−0.920	9.20	
	13	6E,7S	−9.110				
				下LF3	−1.110	11.10	
N	14	7E	−10.220				

*通電は約0.1A　　*通電電流が正確でないので参考値

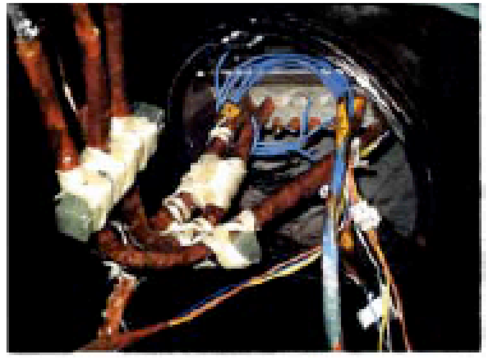
ターン数：330,330,330 (HFCoil), 350,350,420 (LFCoil)
ただし、総ターン数は、2108ターン

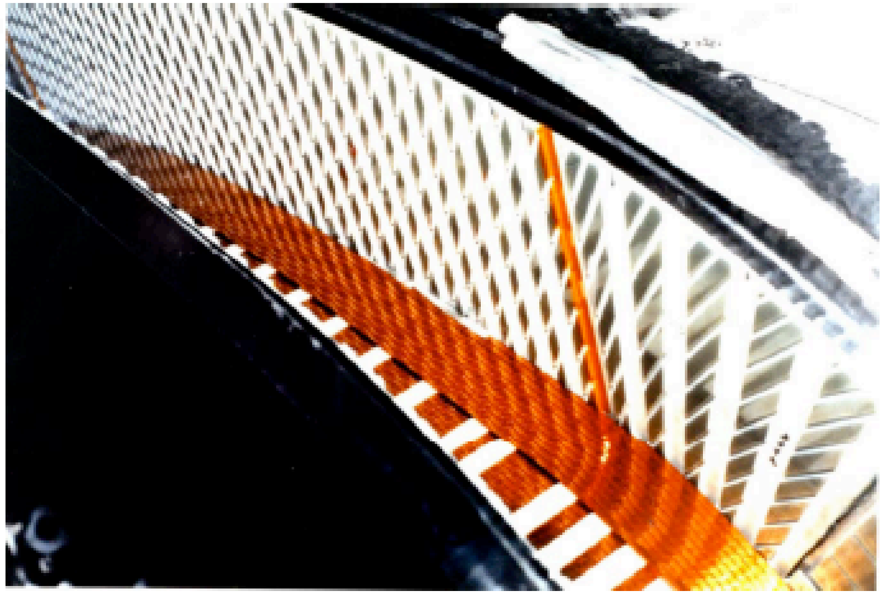
地絡場所：　1S端子から3.4m（コイル半周）のところ



地絡箇所
最内側半ターンのところ

コイル口出し線
冷凍機ポートへ





- 修理はほぼ不可能
  - ヘリウム容器の最内部
- 非破壊検査(X線)も望み薄い
  - 容器壁　厚さ30mm, ステンレス

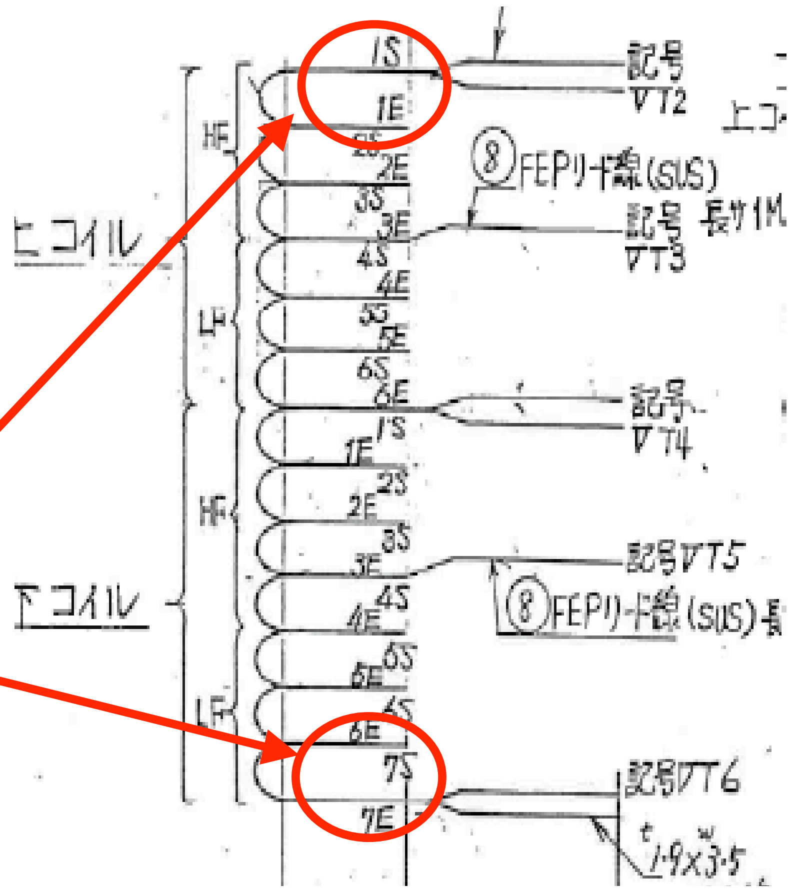
	SKS完成時(1991)	対策前	対策後
コイルターン数　[/Coil]	2108		1778
インダクタンス　[H]	90		78.4
定格（最高）電流 [A]	500	400*	400
中心磁場 [T]	3.0	2.7	2.48
蓄積エネルギー [MJ]	11.3	???	6.3

* 1993年　大クエンチ・コイルサポート修理後、400A以上の使用を禁止

電流と中心磁場

電流　[A]	Full Coil 磁場 [T]	5/6　Coil磁場 [T]
272	2.2	
322		2.2
400	2.7	2.48
470		2.7

Skip



SKS移設･コイル改造作業

- 2008.1 Disassemble the yoke
- 2008.7 Coil insulation test @ TOSHIBA
  Earth fault found
- 2008.8 Coil renovation & Insulation @1kV
- 2008.9 Yoke transport to Tokai
- (2008.10.E Coil renovation finished @TOSHIBA
- (2008.11 Cooling test
- (2009.1-2? Assemble the yoke

- No time to map the modified field.
- Calculated filed map will be used in future experiment in J-Parc.
- Detailed study with the calculated map has been made.
  - Sks0-high resolution
    - No serious effect once enough calibration data collected.
  - SksPlus
    - No prolem in acceptance, slight worse resolution
  - SksMinus
    - Slight change in acceptance (need setup modification), resolution dominated by target material

SKS trouble summary

- Cause of the trouble not identified.
- Renovation and test are reasonable.
- Preparation is necessary for future happening of another earth fault.
- Thanks to the new refrigerator system, thermal cycling can be much less frequent. (regulation framework can be changed for simpler operation/shift)