Cavity Integration

summary

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April 25, 2008 ILC-SCRF meeting @FNAL

Followings were discussed

- Tuner performance
- Tuner Motor location
- Tuner specification profile table
- Input coupler industrialization
- Input coupler tunability
- Input coupler specification profile table
- ‘S1 Global’ issues

Tuner performance

- Lorentz detuning simulation (Y. Yamamoto)

  discussion: need more clear discussion why we need stiff tuner,
  cost of stiff vs. cost of robust piezo?

- Ball-screw tuner performance results (T. Saeki)

  preliminary report on LD compensation, dø/dt detuning measurement, microphonics, etc.

- Blade tuner update (C. Pagani)

  version 3 blade tuner tested at DESY, BESSY. 8 unit will be delivered to FNAL in May.

- Comment on tuner motor reliability (S. Noguchi)

discussion: difficult to estimate MTBF,

need to compare benefit of motor outside vs. risk increase like vac leak.

repaireble with minimum cost (with minimum design change and minimum risk) should be consensus.

Spec. Profile Table (Slow tuner) @Apr.2008 GDE FNAL meeting

Red box and red filled column will be decide later

tuner	specification item	specification	unit and comments	further comments
Slow tuner	Tuning range	>600	kHz	
	Hysteresis in Slow tuning	<10	μm	
	Motor requirement	step-motor use, Power-off Holding, magnetic shielding		
	Motor specification	ex) 5 phase, xxA/phase, ...	match to driver unit, match to connector pin asignment,...	decide later
	Motor location	insdie 4K? / outside 300K? / inside 300K accessible from outside?	need availability discussion, MTBF	decide later
	Magnetic shielding	<20	mG at Cavity surface, average on equater	
	Heat Load by motor	<50	mW at 2K	
	Physical envelope	do not conflict with GRP, 2-phase line, vessel support, alignment references, Invar rod, flange connection,...		cable connection, Mag shield
	Survive Frequency Change in Lifetime of machine	~20 Mio. steps	could be total number of steps in 20 years,	

Spec. Profile Table (Fast tuner) @Apr.2008 GDE FNAL meeting

Red box and red filled column will be decide later

tuner	specification item	specification	unit and comments	further comments
Fast tuner	Tuning range	>1	kHz over flat-top at 2K	
	Lorentz detuning residuals	<50	Hz at 31.5MV/m flat-top	need precise definition (LD and microphinics? or LD only?)
	Actuator specification	ex) low voltage piezo 0-1000V, ...	match to driver unit, match to connector pin asignment, ...	decide later
	Actuator location	insdie 4K?/inside 4K accessible/inside 100K? accesible / inside 300K accessible from outside?		decide later
	Magnetic shielding	<20	mG at Cavity surface average	
	Heat Load in operation	<50	mW	
	Physical envelope	do not conflict with GRP, 2-phase line, vessel support, alignment references, Invar rod, flange connection,...		
	Survive Frequency Change in Lifetime of machine	$>10^{10}$	number of pulses over 20 years, ($2x10^{9}$:operational number)	

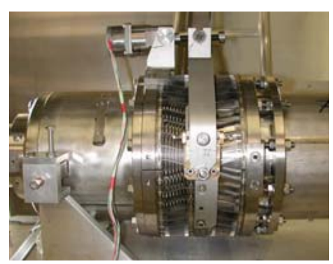
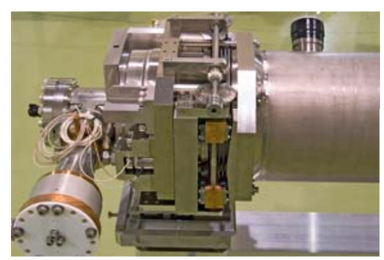
Plan for developing Tuner Work Package

- Finalize spec. profile table, today.
- Upload to EDMS team workspace now.
- Revise any spec. in any time, if it is inconsistent.

- Develop tuner comparison table and R&D of each tuner for EDR baseline selection.
- Write and develop ‘recommendation of motor/acutuator location’ according to the past presentations and R&D, report it to PM by the next Chicago meeting.

Example of comparison table

Slow Tuner					
		TTF		STF	STF
		Saclay -1	**Blade**	**Slide Jack**	**Ball Screw**
		Lifetime Test (~ 0.1mm x 10000 Times) is necessary.			
Mechanism		Double Lever	Blade+Lever+Screw	Wedge+Screw+Gear	Screw+Worm Gear
			Blade has the potential Problem of Fatigue.		Life time of Coating?
Stiffens	N / μm	40	25	290	1000
		Not Stiff	Not Stiff. If used to TESLA Cavity DLD at Flat-Top becomes ~900Hz.		
Stroke	mm		< 2	3.5	Long enough
Location		Beam Pipe	Jacket Cylinder	Jacket Cylinder	Jacket Cylinder
		The room for tuner is small. Top Heavy. Alignment?			
Cost					


Cont.

Fast Tuner

		TTF		STF	STF
		Saclay -1	**Blade**	**Slide Jack**	**Ball Screw**
		Piezo(200V)	Piezo(200V)	Piezo(150V)	Piezo+Blade
			Speed ?		Blade has the potential Problem of Fatigue. Speed ?
		NORIAC (1 Spare)	NORIAC (1 Spare)	Piezo Mechanic x 1	Piezo Mechanic x 1
Size	mm	10 x 10 x 26	10 x 10 x 38	φ20 x 18	
Stiffness	N / µm	105	70	500	
Max. Load	kN	4	4	14	
Stroke:RT	µm	40	60	20	
Stroke:2k	µm	4	6	2	
Compensation	µm	3.4	6	1	
Speed					
Delay		0.6 msec.			

Repairability

Motor		need Disassemble	need Disassemble	Outside	Poor
Piezo		need Disassemble	need Disassemble	Repairable	need Disassemble
		US Study on this Subject exists.			
		How to check Piezos just we install. There are no experience for long term operation in Pulsed mode. Life time Test is necessary.			

Coupler discussion

- XFEL coupler (S. Prat)

  Information on coupler industrialization status, plan, cost, etc.

- Fixed coupler operation (S. Noguchi)

  grouping cavity concept for maximum E operation with rough cost comparison.

  discussion: gaussian cavity gradient distribution is feasible?
  optimistic estimation? Error will be more small.
  Cost minimum for matched condition?
  Small LLRF margin.

- Variable/Fixed coupler technical issue (E. Kako)

  Visualized discussion of variable/fixed coupler installation.

Spec. Profile Table @Apr.2008 GDE FNAL meeting

Red box and red filled column will be decide later

Yellow box are Revised in this Meeting.

specification items	condition	specification	unit and comments	further comments
Power requirements	Operation	>400	kW for 1600 us	
	Proccessing	>1200	kW upto 400 us	need after vac break, cool-down
		>600	kW larger than 400 us	need after vac break, cool-down
	Processing with reflection mode	>600	kW for 1600us	in Test stand
Processing time	warm	<50	hours	after installation, definition of power/pulse_width target are the same as 'Power Requirement' above.
	cold	<30	hours	after installation, definition of power/pulse_width target are the same as 'Power Requirement' above.
Heat loads /coupler	2K static	< 0.063	W	
	5K static	< 0.171	W	depend on tunability
	40 K static	< 1.79	W	
	2K dynamic	< 0.018	W	
	5K dynamic	< 0.152	W	
	40K dynamic	< 6.93	W	
Cavity vacuum integrety		2	# of windows	
		yes	bias capablity	
RF Properties	Qext	Yes/No	tunable	decide later
	Tuning range	1-10	10^6 if tunable	
Physical envelope	Position		compatible to TTF-III	decide later
	Flange		compatible to TTF-III	decide later
	waveguide		compatible to TTF-III	decide later
	support		compatible to TTF-III	decide later
Instrumentation				
vacuum level		>= 1		
spark detection		0	at window	
electron current detection		>= 1	at coax	
temperature		>= 1	at window	
*comment: yellow boxes indicate change/discussion at FNAL-meeting April 2008				

Plan for developing Coupler Work Package

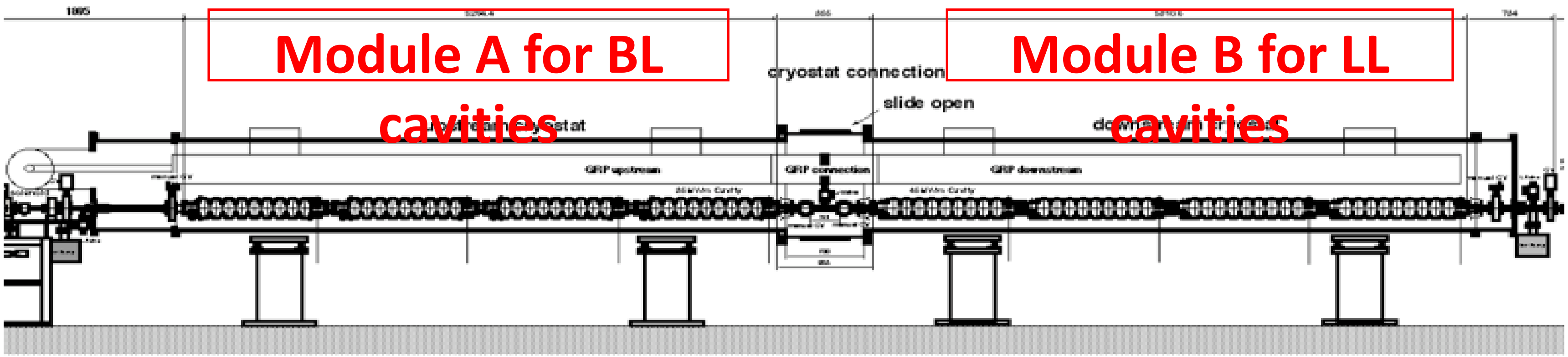
- Finalize spec. profile table, today.
- Upload to EDMS team workspace now.
- Revise any spec. in any time, if it is inconsistent.

- Develop pros/cons table for tunability.
- Write and develop ‘recommendation of tunability’ according to the past presentations, report it to PM, by the next Chicago meeting.

S1-Global at KEK STF

Technical points of S1-Global;

1. Two STF cryomodules have different design for STF-BL and LL cavities, respectively.
   - Module A cryostat was designed for accommodating four BL cavities, and Module B cryostat for four LL cavities.
2. The helium vessel design of STF-LL cavity has geometrically common concept with DESY and FNAL vessels. The design of STF-BL cavity package has many different points to DESY and FNAL vessels.
3. Proposed combination of different types of cavities for S1-Global,
   - Module A will consist of 4 BL cavities or 3 BL cavities + 1 LL cavity.
   - Module B will consist of 2 DESY cavities + 2 FNAL cavities or DESY + FNAL + LL cavities.



S1 Global original concept

(DESY or US)	BL#2	BL#5	BL#6	DESY1	DESY2	FNAL1	FNAL2
>32MV/m (or BL#7?)	29MV/m	??MV/m	??MV/m	>32MV/m	>32MV/m	>32MV/m	>32MV/m

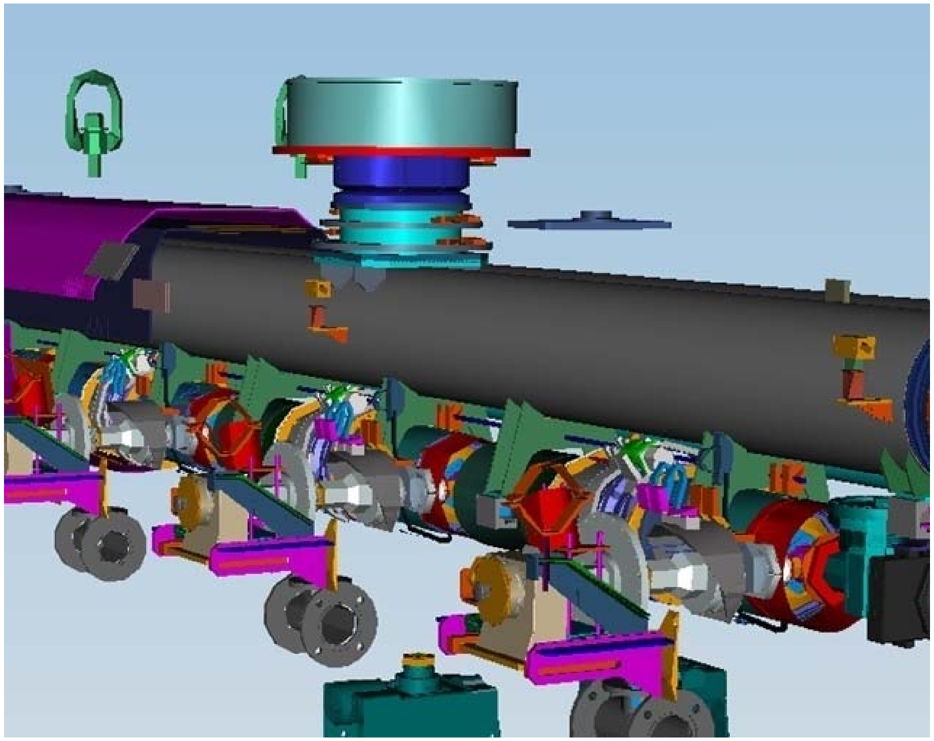
(or LL #7? LL#8?)

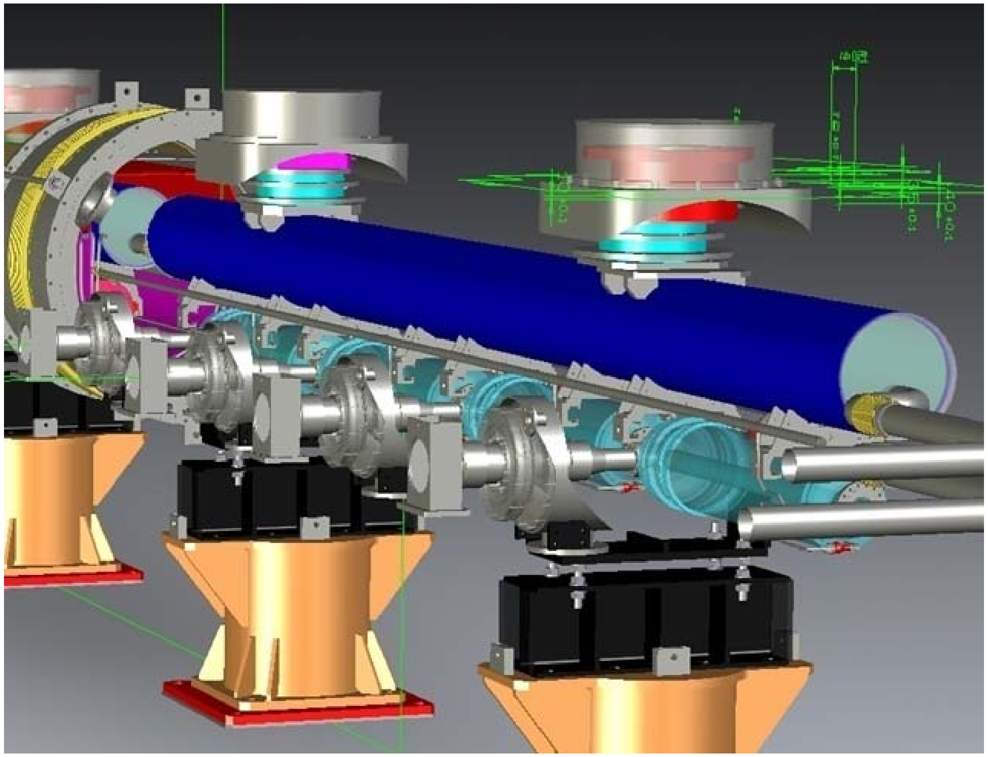
4 KEK-BL cavities

2 DESY cavities + 2 FNAL cavities

DESY and FNAL cavities are considered to be assembled in the Module B.

Problem-1:
Incompatibility between DESY & FNAL cavity package and STF cavity package



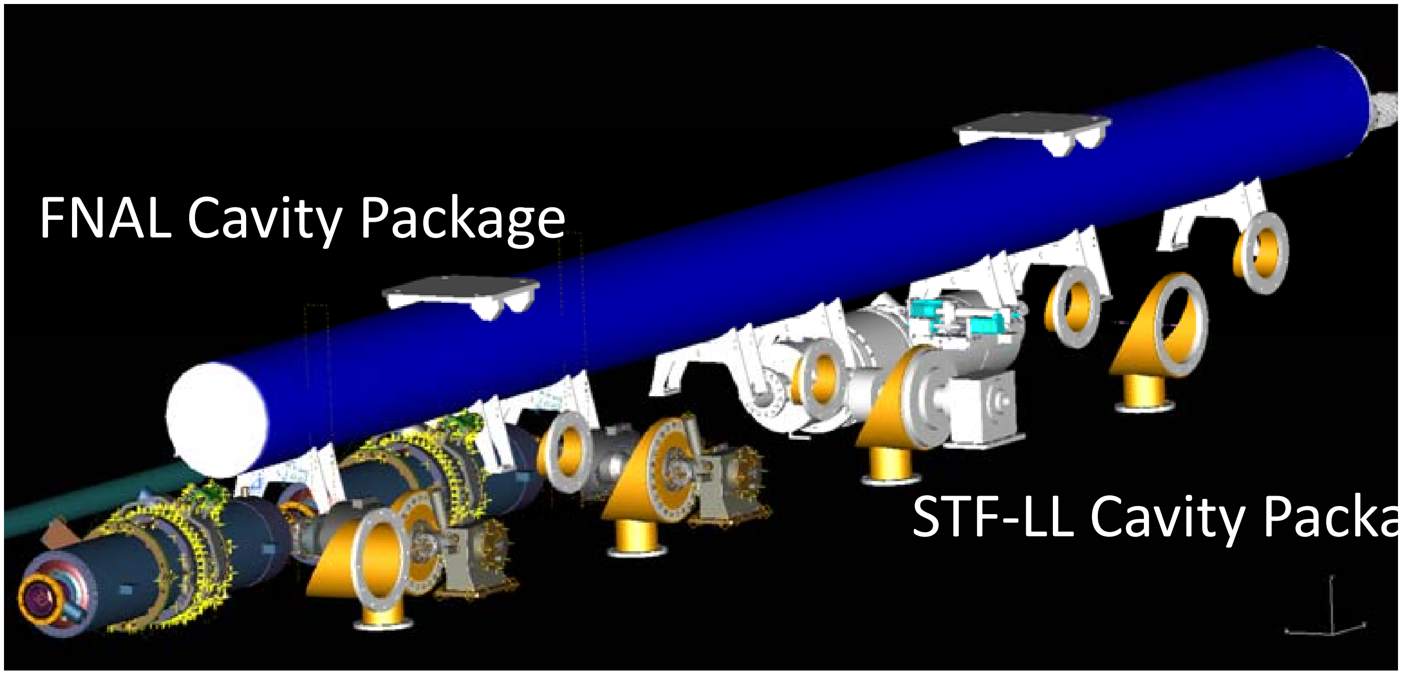


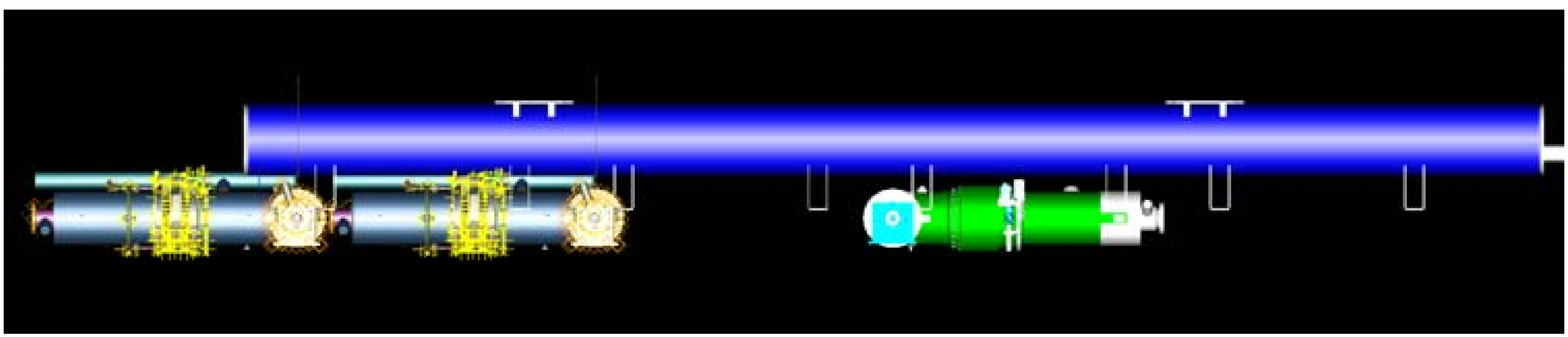
DESY & FNAL Cavity Package

STF Cavity Package

Input couplers and LHe supply cross connect pipes of KEK and DESY & FNAL locate in the opposite side with respect to the direction of cavity package

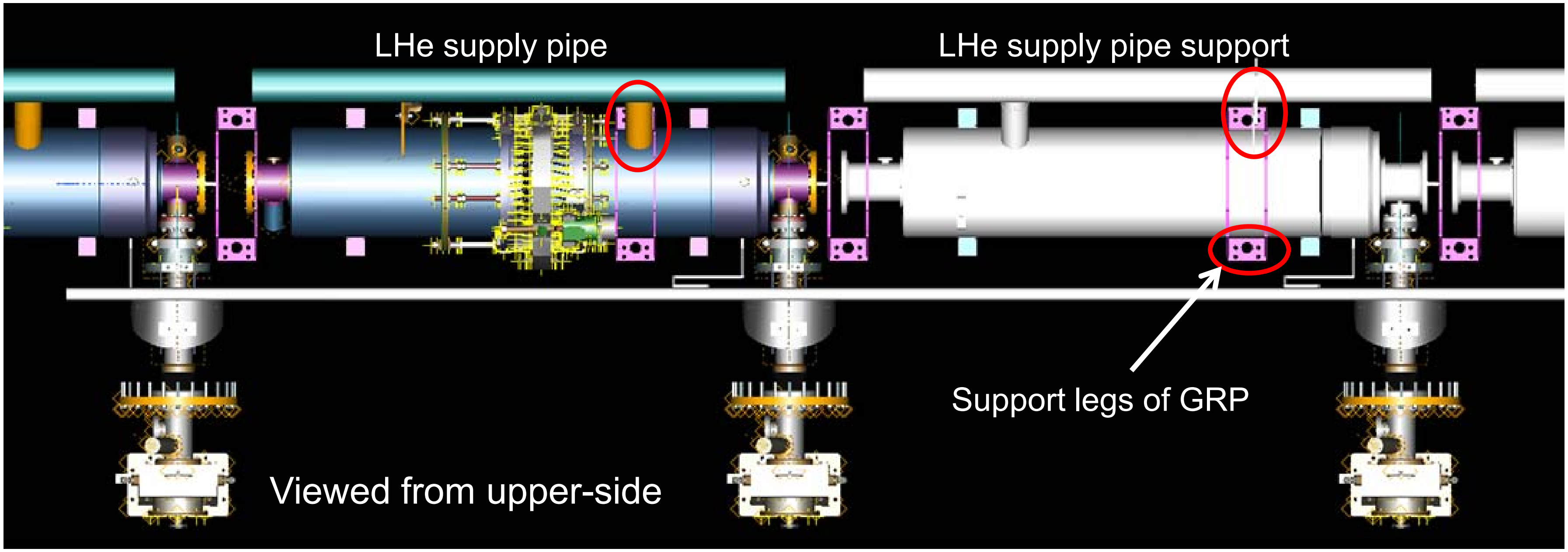
Problem-2:
The length of the GRP is not enough for supporting FNAL or DESY cavities when they are installed in STF module.

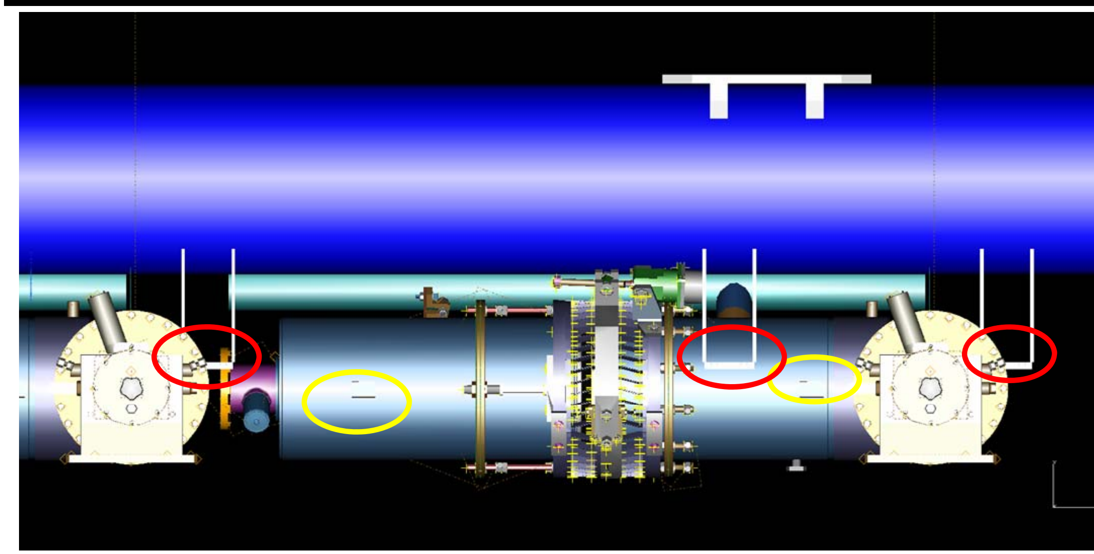




Problem-3:

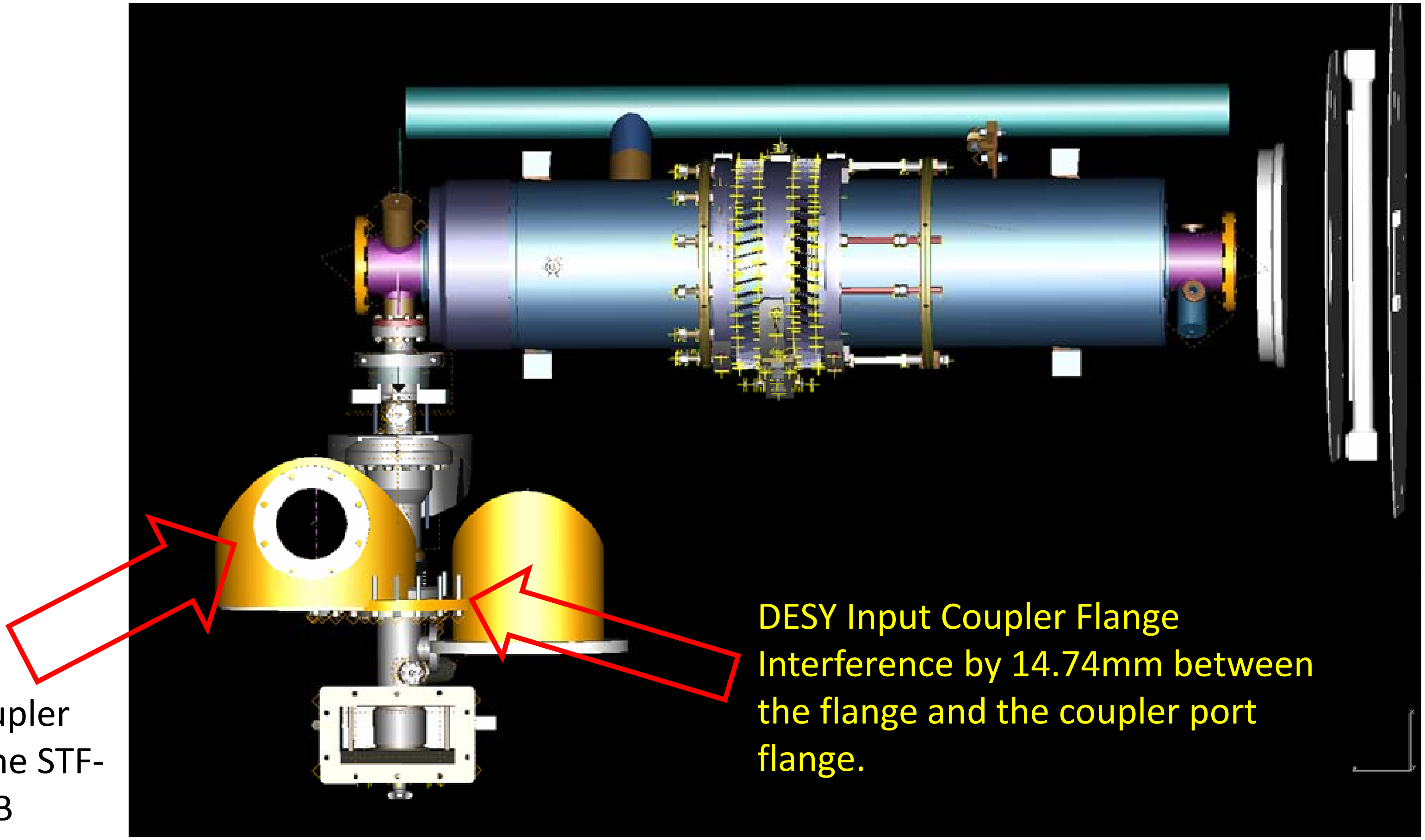
Pipes & support Interference between DESY & FNAL cavity package and STF GRP





1. FNAL LHe supply pipe cross connect and DESY LHe supply pipe support conflict with STF GRP support legs.
2. Locations of support legs and support tabs are not consistent.

Problem-4:
Coupler port Interference
between Module-B cryostat and DESY & FNAL cavity packages



Input coupler port of the STF-Module-B cryostat

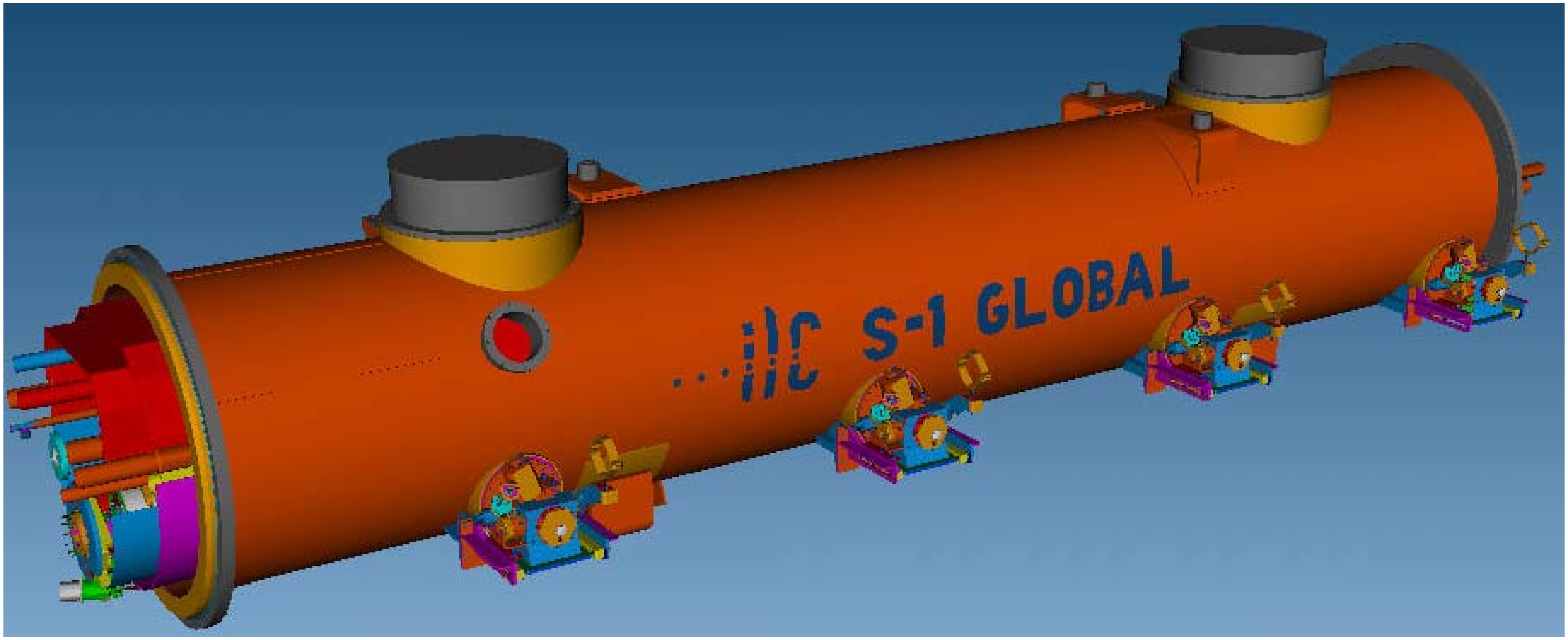
The coupler ports on the Module-B need to be modified to accommodate both KEK Input Coupler and DESY Input Coupler.

	Module A	Module B	Required items for construction S1-Global
C 1	4 KEK-BL cavities	2 DESY cavities 2 FNAL cavities	Module A : No requirement Module B : 1. Gas return pipe, LHe supply pipe, cooing pipes 2. Vacuum vessel extension (1.2 m) 3. Additional thermal shields of 5K and 80K 4. Sliding C-clamp supports and sensors, etc 5. Modification of coupler ports on vacuum vessel 6. Connection parts between the couplers and the ports
C 2	3 KEK-BL cavities 1 KEK-LL cavities	2 DESY cavities 2 FNAL cavities	Module A: 1. Additional components between support legs and tabs for LL cavity 2. Additional flange for connecting the input coupler of LL cavity to the coupler port on the vacuum vessel 3. No modification of Module A vacuum vessel Module B: 1. Same as case 1
C 3	4 KEK-BL cavities	4 cavities with DESY, FNAL and 1 KEK-LL cavities	Module A: No requirement Module B : 1. Re-designing the helium vessel of LL cavity to be matched to FNAL and DESY cavities 2. Same items as Case-1, however, for three types of cavity packages
C 4	4 KEK- BL cavities	2 DESY cavities 2 FNAL cavities	Module A: No requirement Module C (Short Type III+): No modification of STF-module B. 1. Short vacuum vessel and cold mass by INFN (complete matching between cavities and cold-mass. 2. KEK should make attachments of the assembly tools well functioned under the STF infrastructure by helps of DESY and FNAL groups. 3. Connection bellows and flanges are supplied by DESY and FNAL.
C5	4 KEK- BL cavities	2 DESY cavities 2 FNAL cavities	Module A: No requirement Module C (Short Type III+): No modification of STF-module B. 1. Short vacuum vessel , cold mass and components by KEK 2. KEK need all drawing for constructing the cryomodule.

S1-Global cavity & module combination

- Plan C4 and C5 are technically preferable :
  - No additional work for Module A, B (except module connections)
    - KEK : will optimize the selection of cavities within module A
  - Type III+ design can be used for Module B (name it Module C).
    - Minor modification is required, and the design must be checked. (LHe supply pipe position and cross-section design.)
  - International collaboration more widely (INFN participation)
  - KEK will have experience of Type-III. (3 regions have the same opportunity for assembly of the same cryomodule.)
- Need more consideration
  - Conflict on schedule of STF-2 work.
  - Production schedule of cavity-packages in each region.
  - More consideration and discussion on module B modification or new module C production.

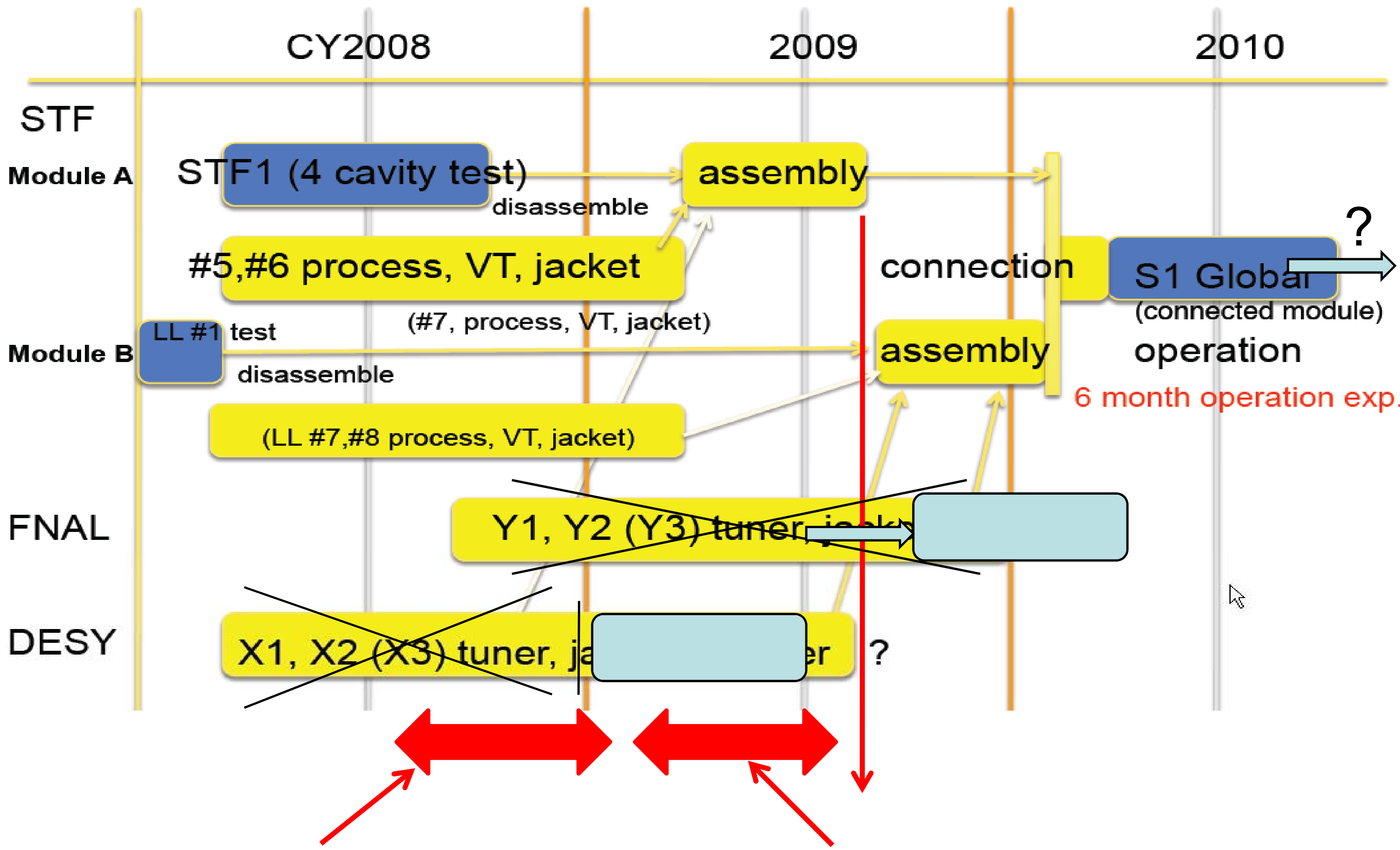
S1 Global : Module-C



By Don
Mitchell

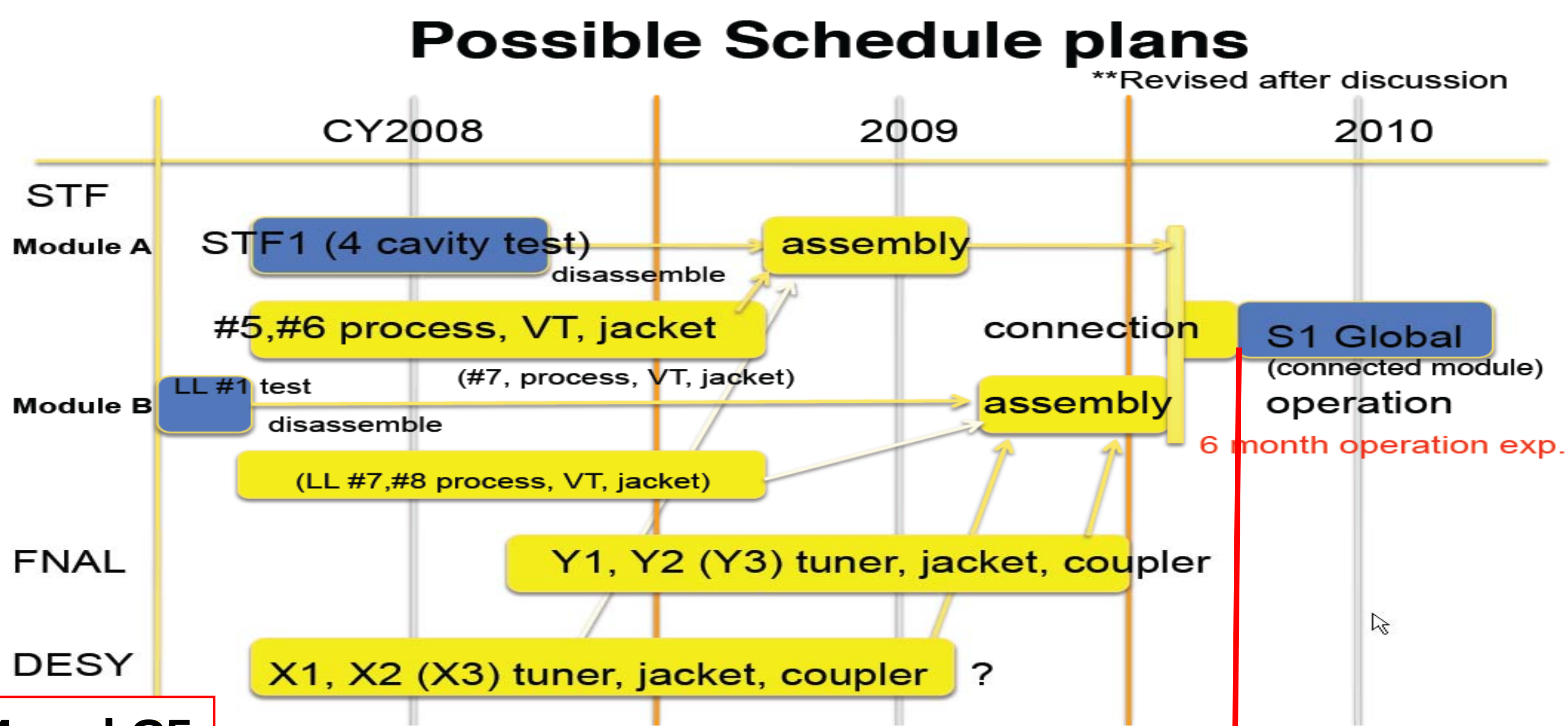
Possible Schedule plans

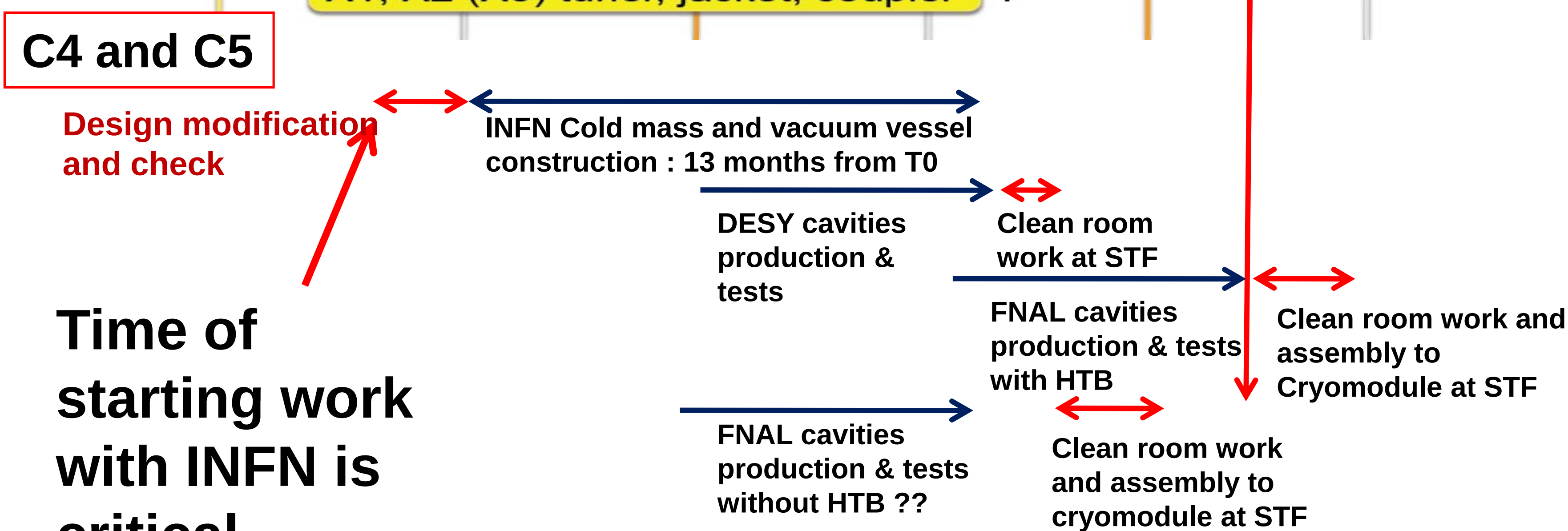
**Revised after discussion



Completing the design of S1-Global : 6 months
The combination of cavities for S1-Global
should be decided in 2008.

Manufacturing components :
6 months



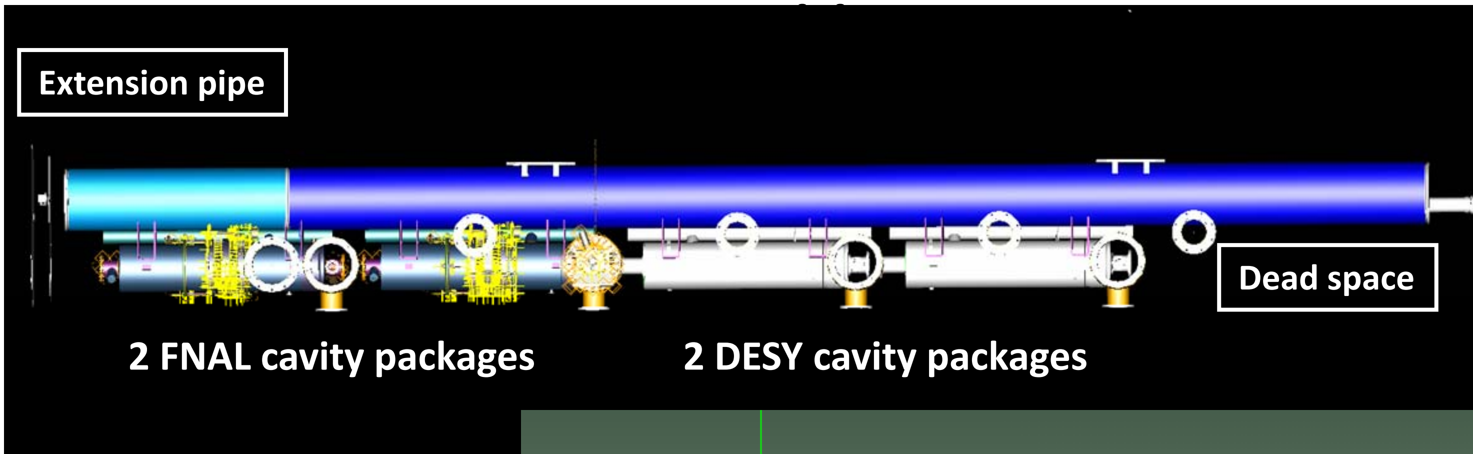


Time of starting work with INFN is critical.

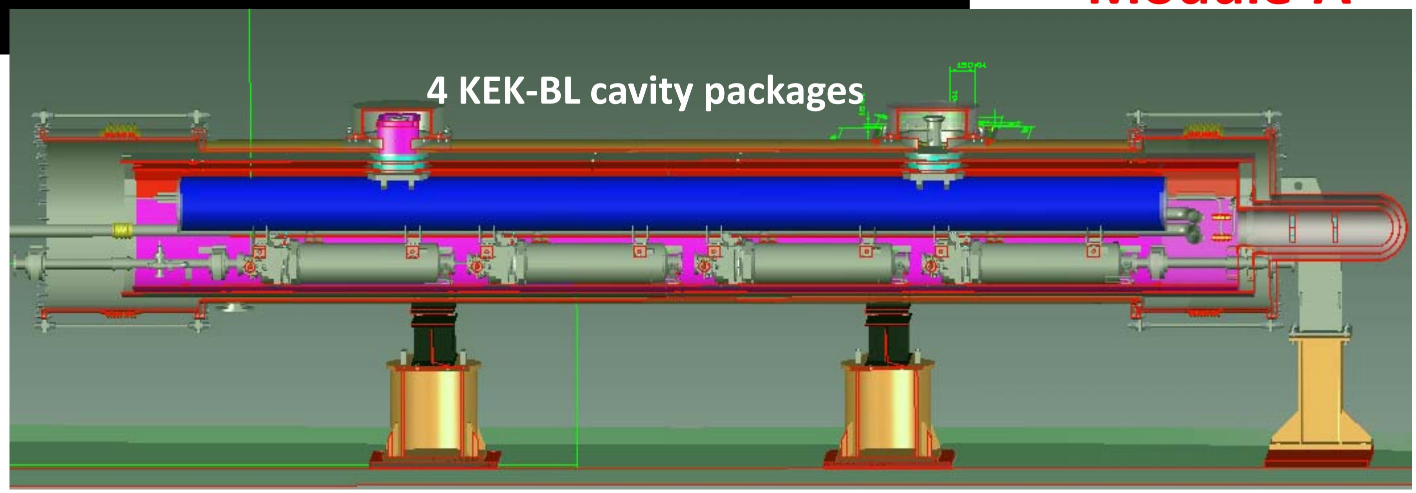
end

Case-1

2 DESY cavities + 2 FNAL + 4 KEK-BL cavities



Module-A



Module-B

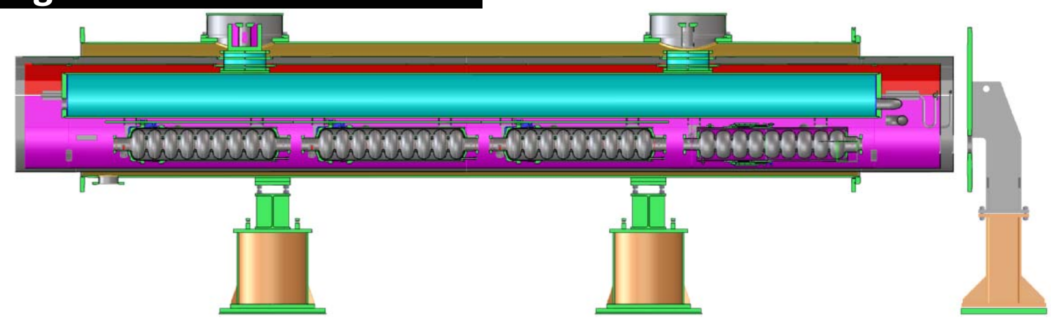
2 FNAL and 2 DESY cavity-packages assembled in the STF-Module-B.

1. Gas return pipe in Module-B needs to be extended for supporting the FNAL cavity in the end .
2. Locations of support legs and support tabs are not consistent.
3. There are some interference between support legs and cross connect pipes and LHe supply pipe supports.

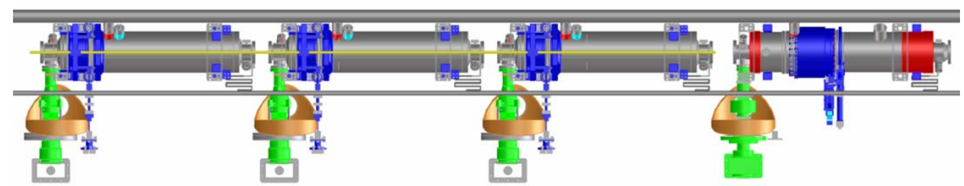
1. Required components for Module-B
   - New Gas Return Pipe which can support DESY and FNAL cavities
   - LHe supply pipe, cross connect pipes and bellows
   - Additional thermal shields of 5K and 80K in the end
   - Sliding C-clamp supports and sensors, etc
2. Modification of Module B input coupler ports
   - Connection components between the coupler and the port
3. No modification for Module A

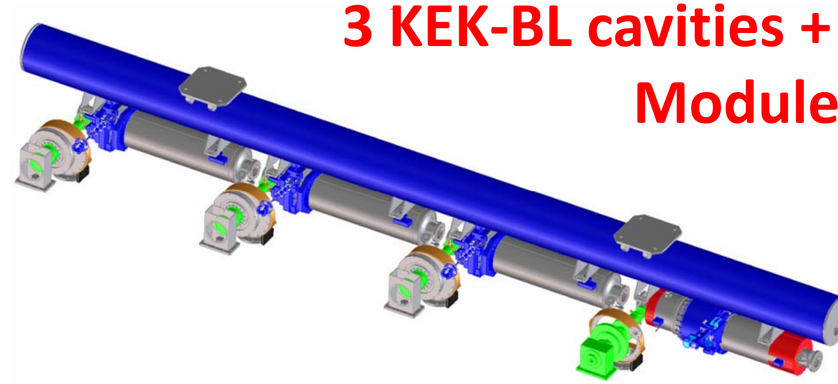
Case-2

2 DESY cavities + 2 FNAL cavities + **3 KEK-BL cavities + LL ca**



Module-B





3 KEK-BL cavities + one LL Module-A

1. Same requirements for Module B as the Case-1
2. Required components for Module A
   - Additional components between support legs and lugs for LL cavity.
     - Positions of legs and lugs are different between BL and LL
   - Additional flange for connecting the input coupler of LL cavity with the input coupler port on the vacuum vessel.
   - No modification of the input coupler ports of Module A

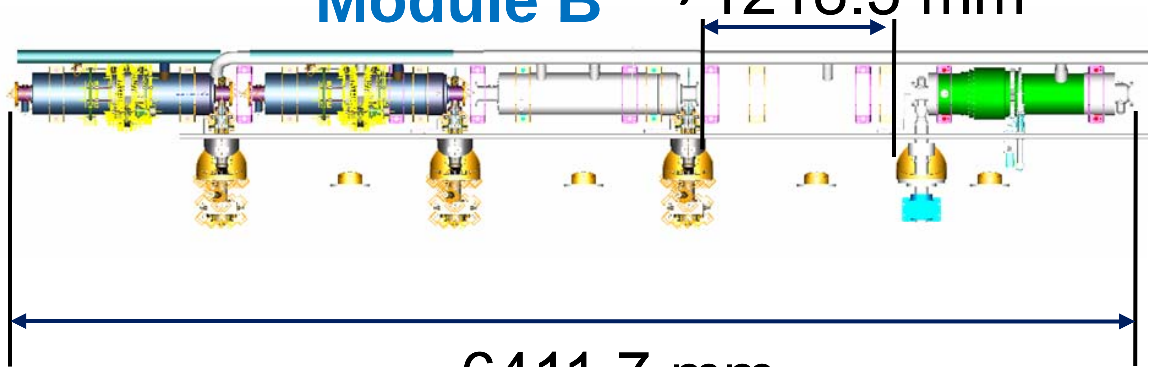
Case-3

LL cavity + 1 DESY cavities + 2 FNAL cavities,
2 LL cavities + 2 DESY cavities or 2 FNAL cavities,

+

4 KEK-BL cavities

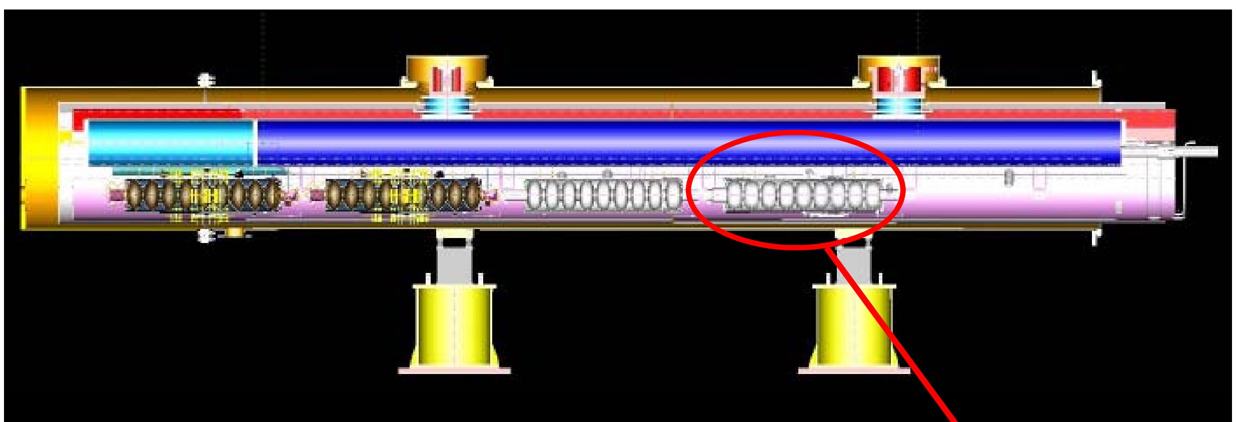
Module B



1. By the space limitation of STF clean room, the four-cavity-string with FNAL, DESY and KEK cavities can not be completed.

⇩

1. Re-designing the helium vessel of LL cavity to be matched to FNAL and DESY cavities.
2. Required components for Module B
   - Same items as Case-1

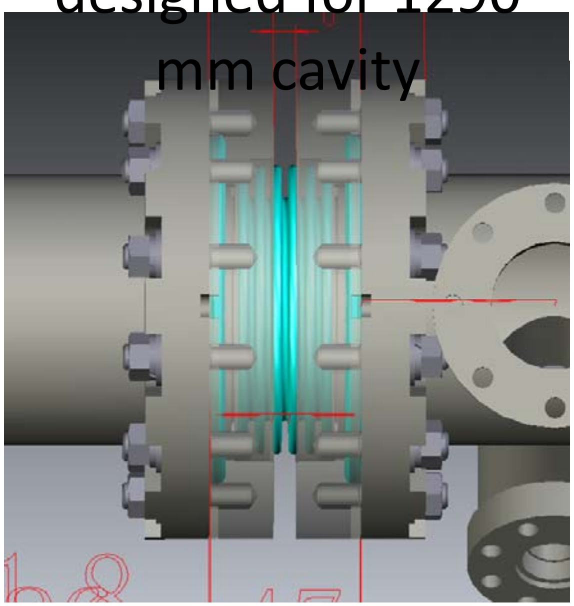


Re-designed LL cavity package

Connection flanges between different cavities

- Distance between the connection flanges of different cavities in STF module.
  - L(DESY-DESY)= 53.6 mm,   L(DESY-FNAL)= 53.6 mm
  - L(FNAL-FNAL)= 89.6 mm,   L(DESY-STF_LL)= 62.5 mm
  - L(STF_BL-STF_LL)= 60.9 mm
- Cavity length
  - DESY=1283.4, FNAL=1247.4, STF-BL=1258.6, STF-LL=1254.5

Connection flange designed for 1290 mm cavity



Two flanges with bellows are tapped.

The screwed holes do not penetrate the flanges.

Designed bellow length: 29.1 mm

Number of waves: 6

Changeability of length: ± 2mm