Cooling Status

Diktys Stratakis

Brookhaven National Laboratory

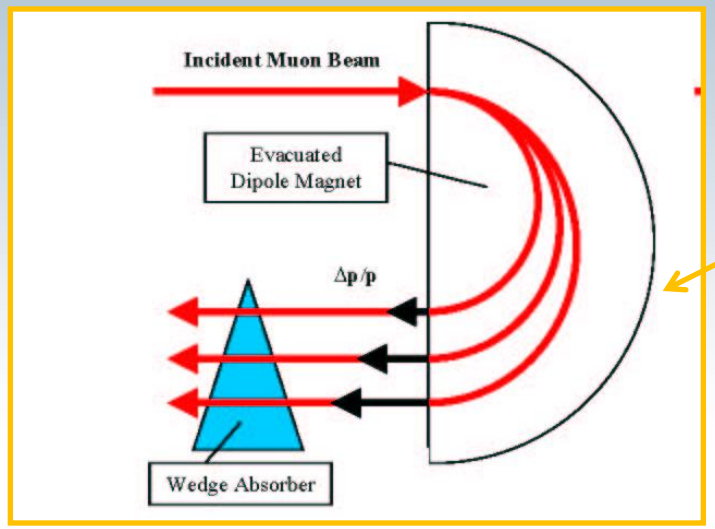
Vacuum RF Meeting 3

May 13, 2014

VCC Workshop Procedure

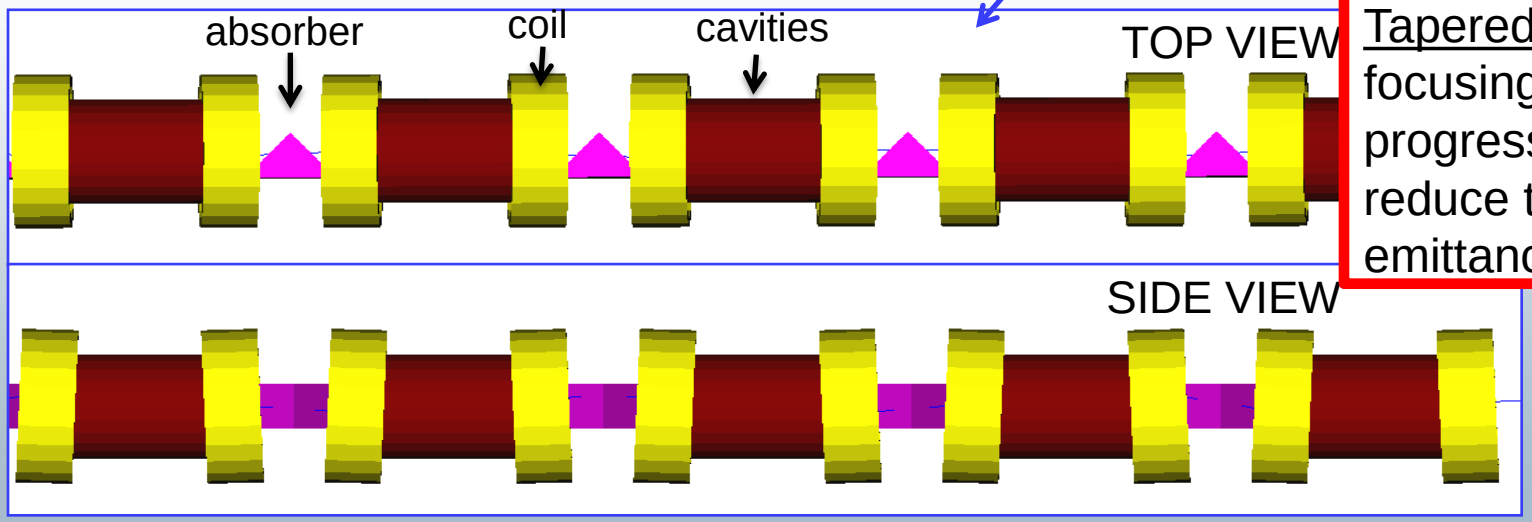
- Day 1: Tuesday, 9 am to 6 pm
- Day 2: Wednesday, 9 am to noon.
- Visit to Materion at 2 pm on Wednesday
- Three working groups:
  - Lattice design group
  - Magnet group
  - RF group
- Meet at regular intervals to discuss progress (11am, 3 pm, 5 pm).
- Summaries are due the morning of Day 2

Vacuum RF Cooling Channel



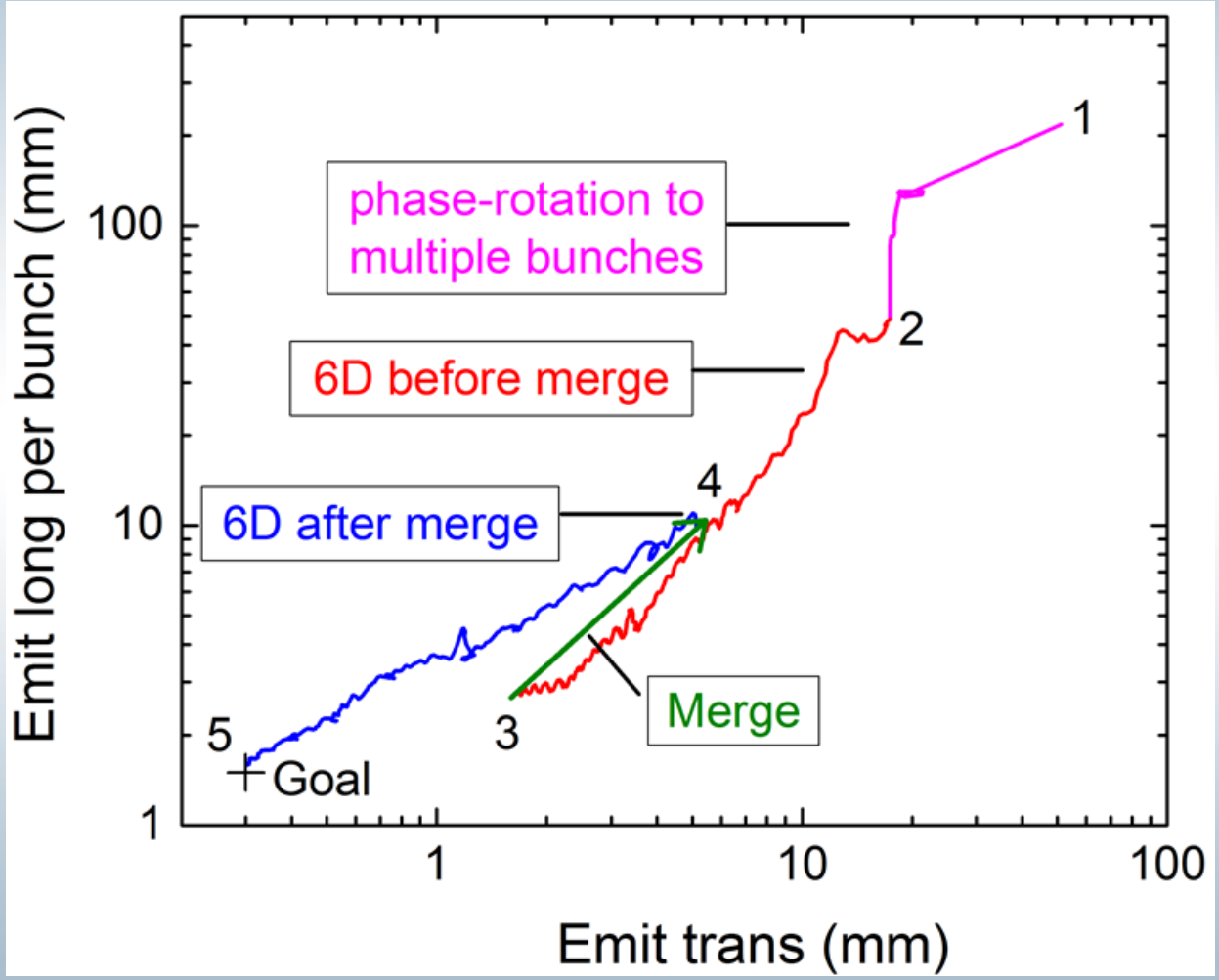
Concept: Generate dispersion and cool via emittance exchange in a wedge absorber

Proposed solution: Rectilinear channel with tilted alternating solenoids and wedge absorbers



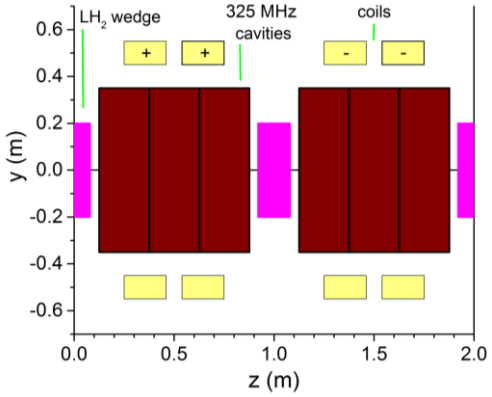
Tapered channel: The focusing field becomes progressively stronger to reduce the equilibrium emittance.

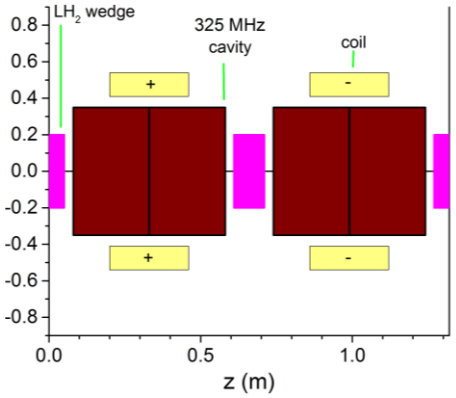
Overall performance

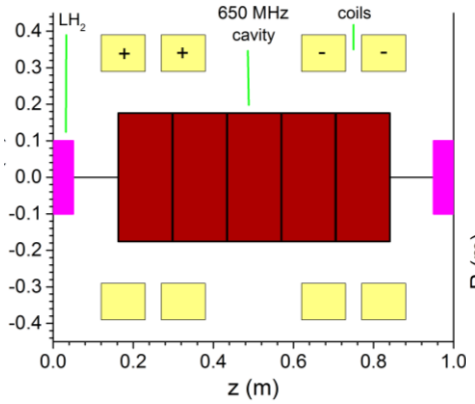


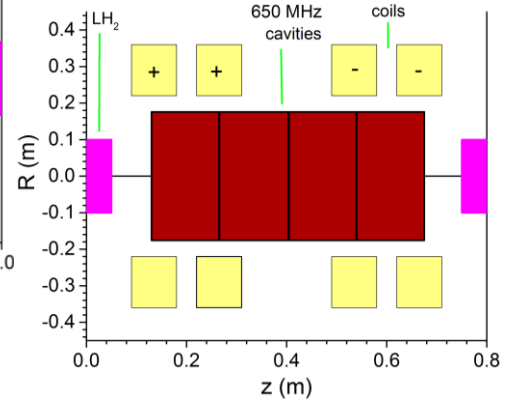
Cooling before merging (4 stages)

STAGE 1	STAGE 2	STAGE 3	STAGE 4
132 m (66 cells)	171.6 m (130 cells)	107 m (107 cells)	70.4 m (88 cells)









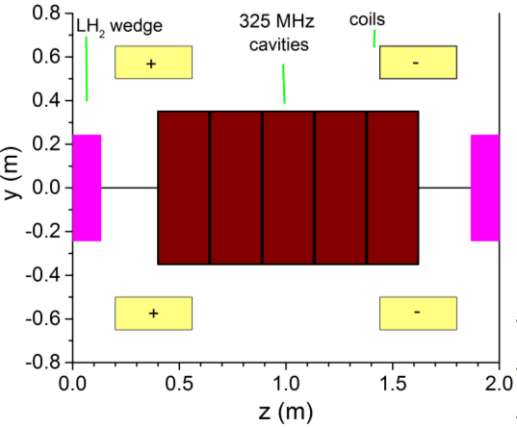
Absorber TOP VIEW
LiH or LH

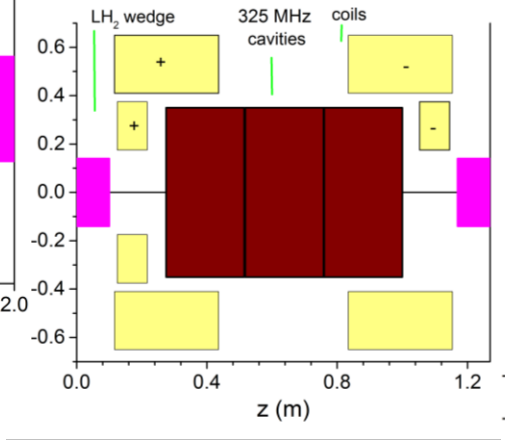
2.3 T (4.2 T) 3.5 T (8.4 T) 4.8 T (9.5 T) 6.0 T (11.8 T)

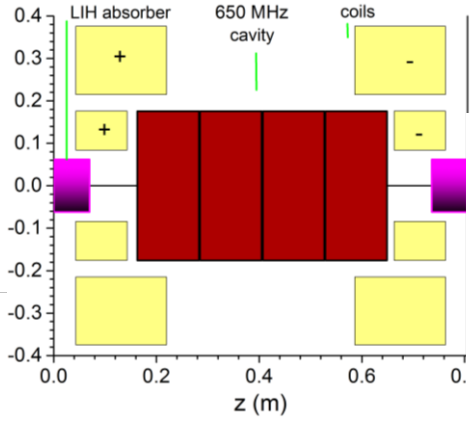
MAGNETIC FIELD axis (coil)

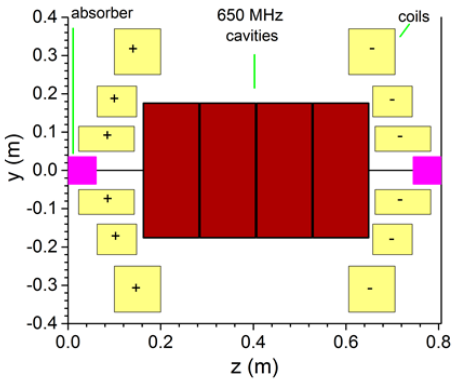
Cooling after merging (8 stages)

STAGE 2	STAGE 4	STAGE 6	STAGE 8
64 m (32 cells)	62.5 m (50 cells)	62 m (77 cells)	41.1 m (51 cells)





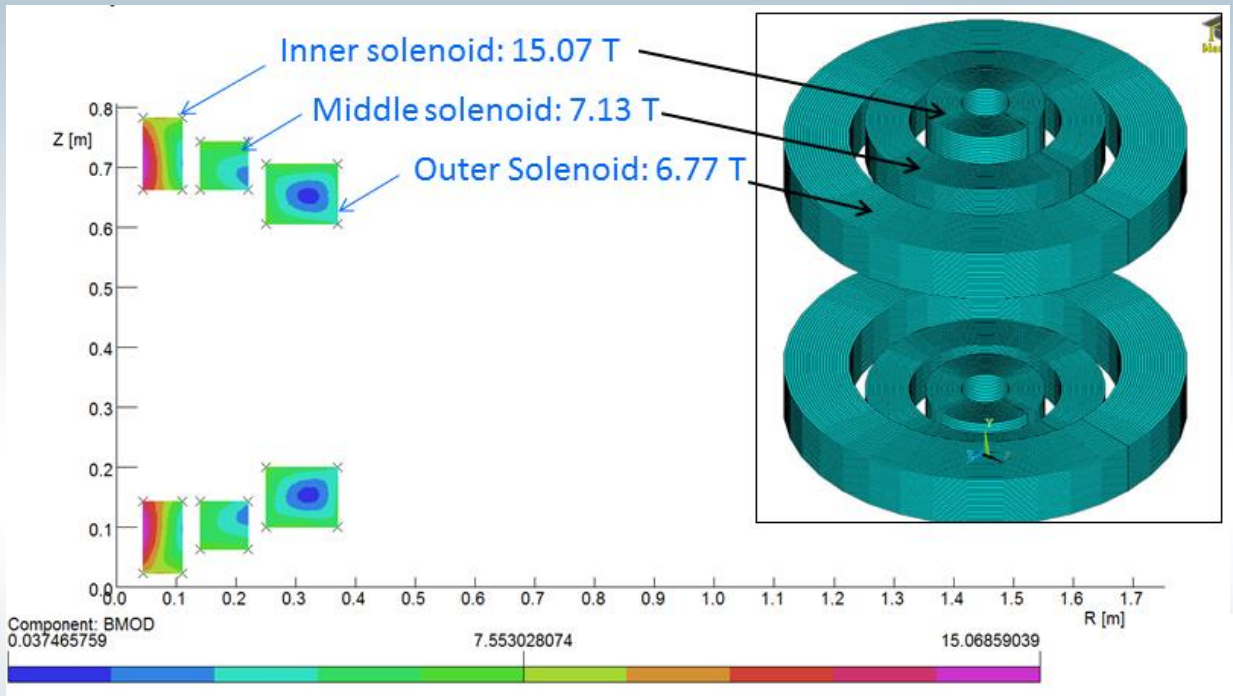


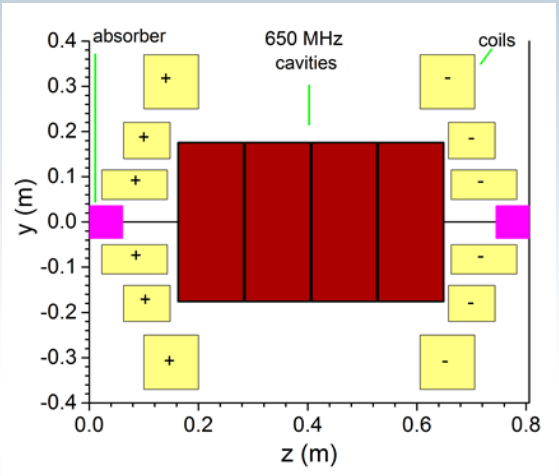


3.7 T (8.4 T) 6.0 T (9.2 T) 10.8 T (14.2 T) 13.6 T (15.0 T)

MAGNETIC FIELD axis (coil)

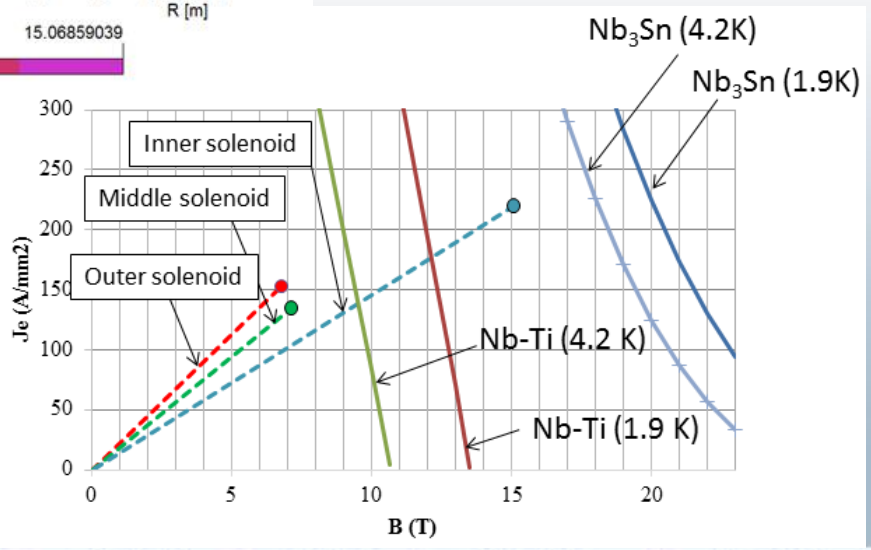
Concept for magnet design (Stg. 8)



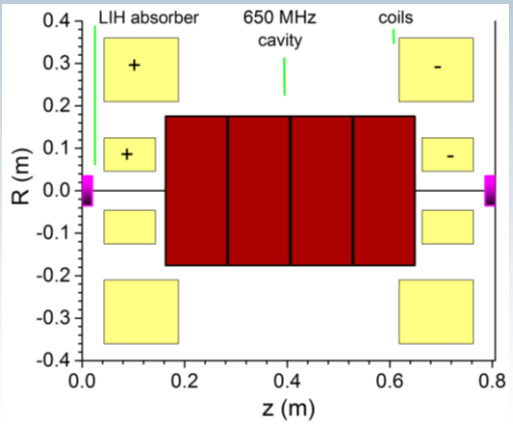


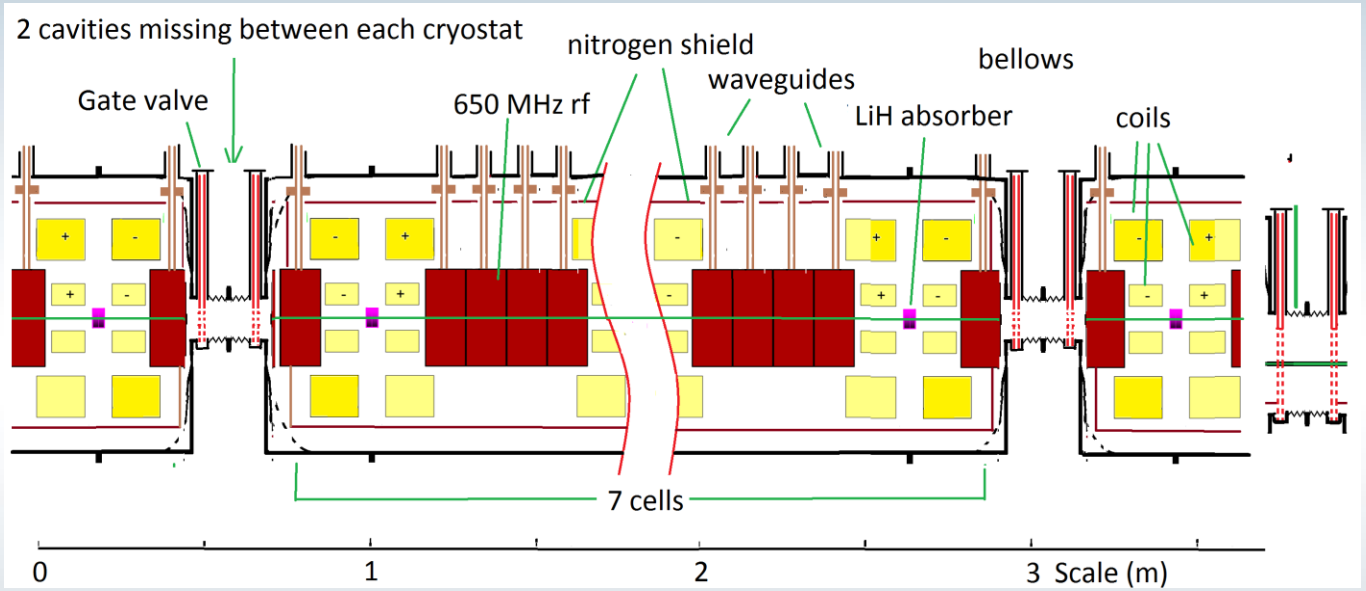
- Inner coil: Nb3Sn
- Middle, outer: Nb-Ti

Viable?



Concept for cryostats

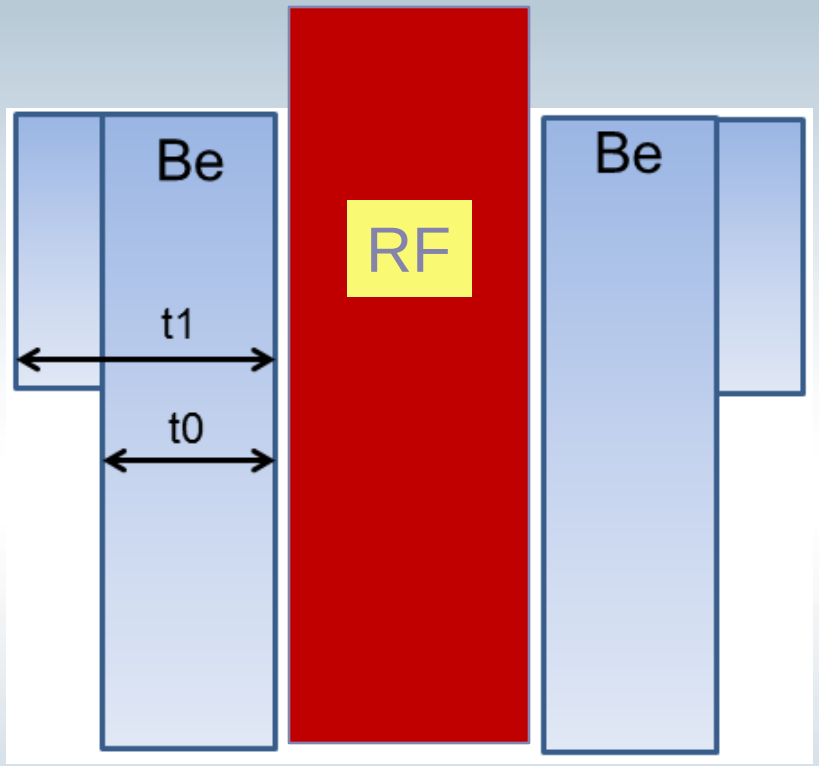




- Space created by omitting absorbers or some rf cavities
- Space generated can be used to separate cryostats or add diagnostics

Viable?

Concept for Be Windows



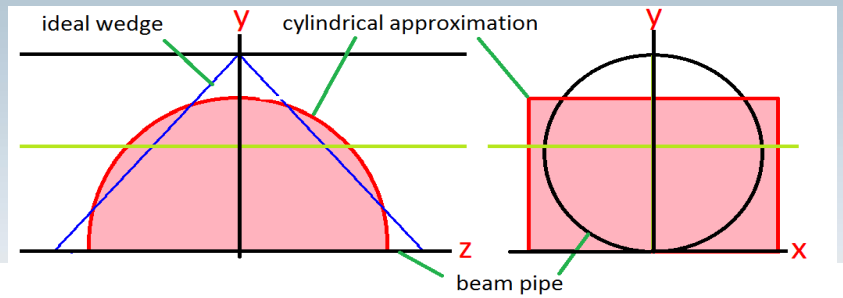
Channel before merge, ONLY!

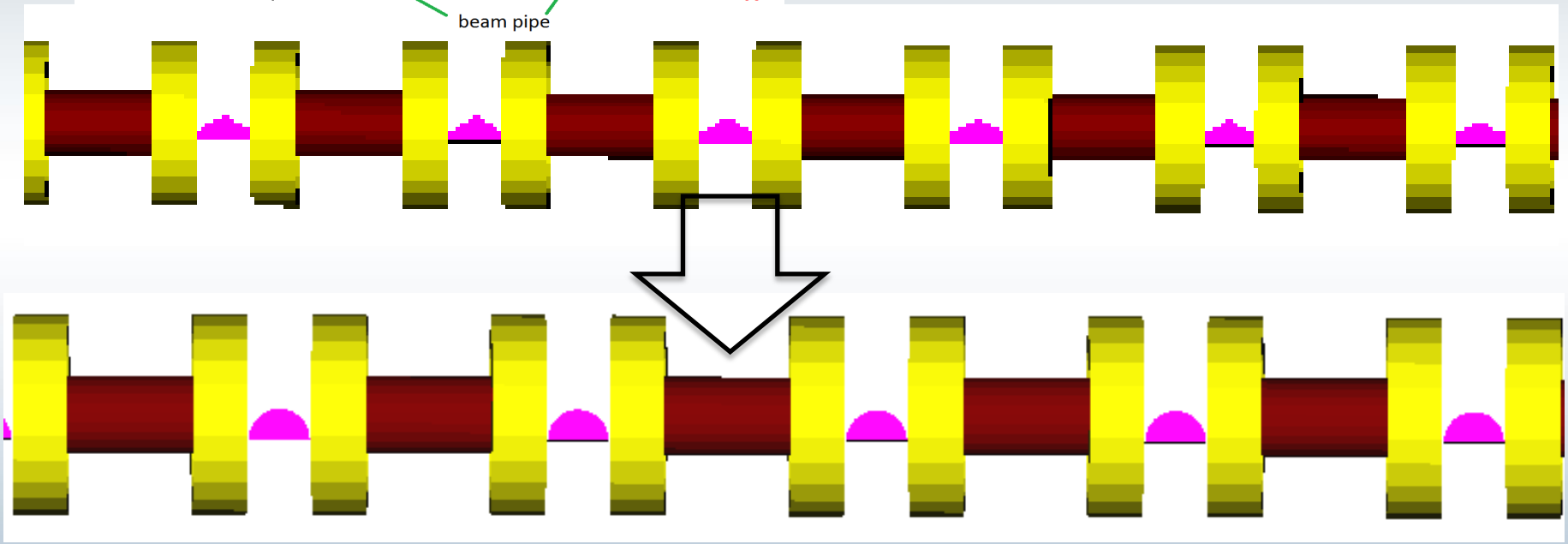
Stage	f (MHz)	rWin (cm)	rStep (cm)	t0 (mm)	t1 (mm)
1	325	30	16	0.3	1.4
2	325	25	15	0.2	0.8
3	650	19	10	0.2	0.6
4	650	13.2	11.4	0.125	0.38

- Stepped Be window: All stages have two steps.

Viable?

Concept for LH absorbers



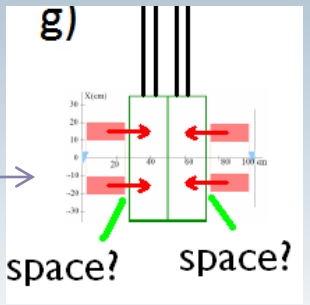


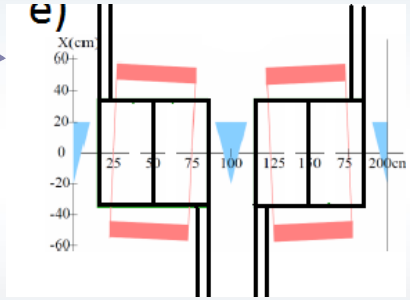
- Replace liquid hydrogen (LH) absorber wedges with cylindrical absorbers.

Viable?

Questions to the RF Group

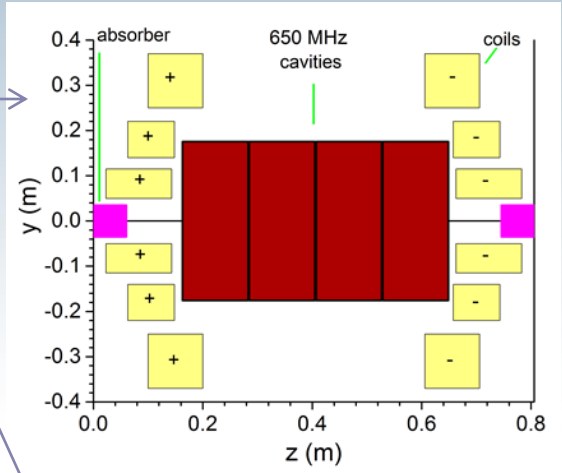
- Operation of RF at 77 K. Power requirements?
- Space needed between rf & coil?
- Is it ok if waveguide connects to rf not from the center?
- Maximum length of cryostat?
- Missing cell configuration by removing rf is feasible?
- RF length: 24 cm (325 MHz), 12 cm (650 MHz) ok?
- Space between cavities? waveguide thickness?
- Integration of Be windows into cavity (Materion)
  - Two step graded rf windows (Slide 8). Feasible?
  - Stage 1 need a 30 cm radius window. Feasible?
  - Last stage has 4.5 cm. Minimum Be thickness?

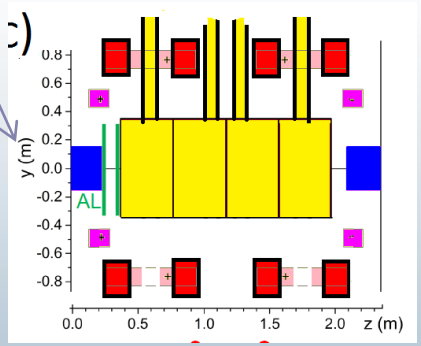




Questions to the magnet group

- Space for wire feed in/ out enough?
- Waveguides interfere with coils. Feasible?
- Space needed between individual coils?
- Magnet tolerances to errors.
- Dipole field vs. coil tilt?
- **More details in Holger's talk**





Appendix

Lattice parameters

Parameters	Stage 1	Stage 2	Stage 3	Stage 4
Coil tilt (deg.)	3.13	1.80	1.60	0.70
Current density (A/mm^2)	63.25	126.6	165.0	195.0
Max B on coil (T)	4.20	8.47	9.56	11.83
Max B on axis (T)	2.35	3.50	4.82	6.06
Trans. beta (cm)	81.9	54.8	38.3	30.3
Absorber angle (deg.)	40	44	100	110
Absorber type	LH_2	LH_2	LH_2	LH_2
Rf frequency (MHz)	**325**	**325**	650	650
RF gradient (MV/m)	22	22	28	30
Ref. Momentum (MeV/c)	220	215	212	210
Cell length (m)	2.0	1.32	1.0	0.8
Total length (m)	132	171.6	107	70.4

Lattice parameters

Parameters	St. 1	St. 2	St. 3	St. 4	St. 5	St. 6	St. 7	St. 8
Coil tilt (deg.)	0.9	1.3	1.1	1.1	0.66	0.7	0.8	0.8
Cur. Density (A/mm^2)	69.8	90.0	123.0	94.0	168.1	185.0	198.0	198.
Max B on coil (T)	6.8	8.4	12.2	9.2	14.1	14.2	14.20	15.0
Max B on axis (T)	2.6	3.70	4.9	6.0	9.8	10.8	12.50	13.6
Trans. beta (cm)	42.0	27.4	20.2	14.0	8.1	5.9	4.2	3.7
Wedge ang. (deg.)	120	117	113	124	61	90	90	90
Absorber type	LH_2	LH_2	LH_2	LH_2	LiH	LiH	LiH	LiH
Rf freq. (MHz)	325	325	325	325	650	650	650	650
RF grad. (MV/m)	19.0	19.5	21.0	22.0	27.0	28.5	26.0	26.0
Cell length (m)	2.75	2.00	1.50	1.27	0.806	0.806	0.806	0.806
Total length (m)	55.0	64.0	81.0	63.5	73.3	62.0	40.3	41.1