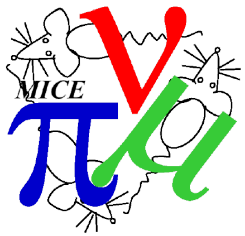
Solid Absorber Status

Pavel Snopok
Illinois Institute of Technology, Chicago, IL
and Fermilab, Batavia, IL

MAP meeting, SLAC



ILLINOIS INSTITUTE OF TECHNOLOGY

MICE Schedule



μ

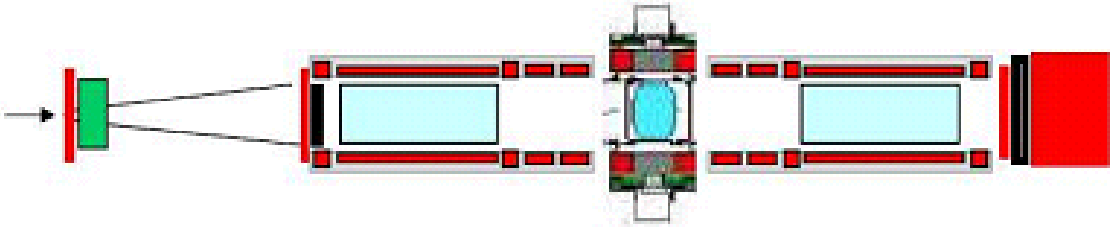
MICE SCHEDULE
update February 2012 V1

Run date:



STEP I

EMR run Q2 2012

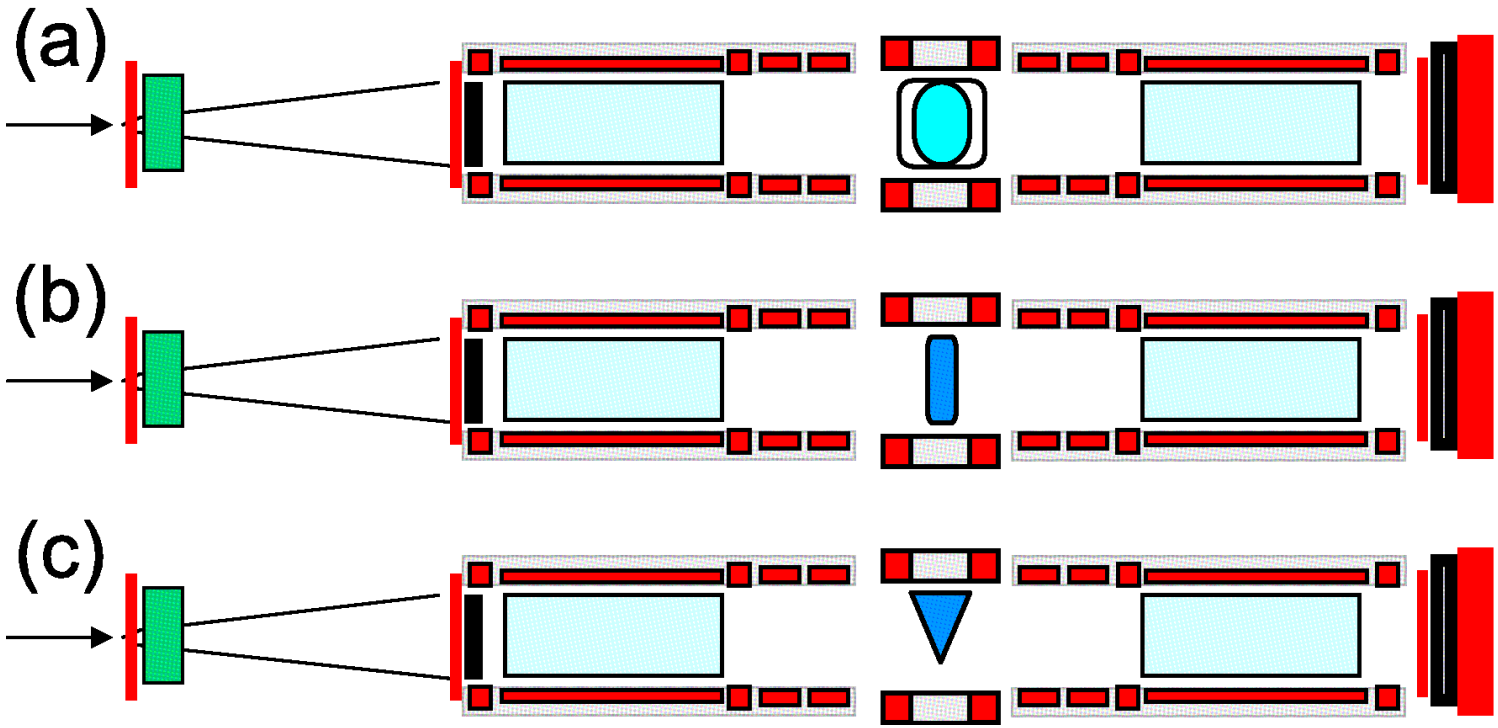


STEP IV

Q1 2013

- Step IV is just around the corner.
- First demonstration of muon ionization cooling.
- Whichever goes first: liquid Hydrogen absorber or solid absorbers is still not decided (“stay flexible” mode).
- Step IV measurements will take 4 to 5 ISIS run periods (Feb–Dec 2013).

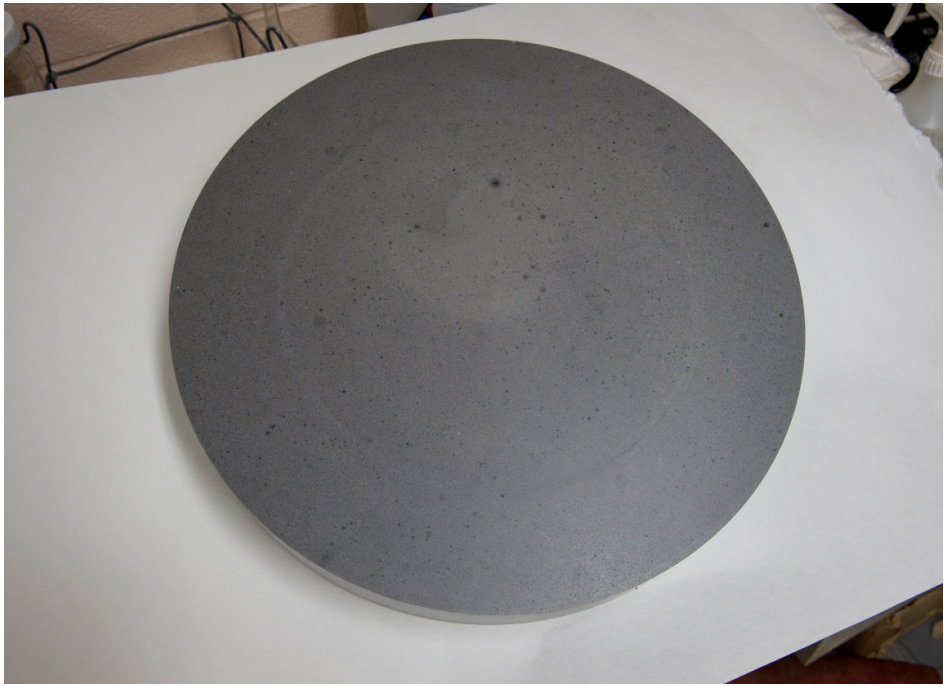
Various absorbers



(a) liquid hydrogen; (b) solid flat (LiH, Al, PE); (c) solid wedge (LiH, PE)

Flat absorber support

Flat LiH absorber



- LiH absorber is complete.
- Will be at Fermilab in a few weeks.
- In order to start fabricating absorber support parts need to finalize engineering drawings.
- Work in progress, issues are being sorted out (below).

Flat LiH absorber support

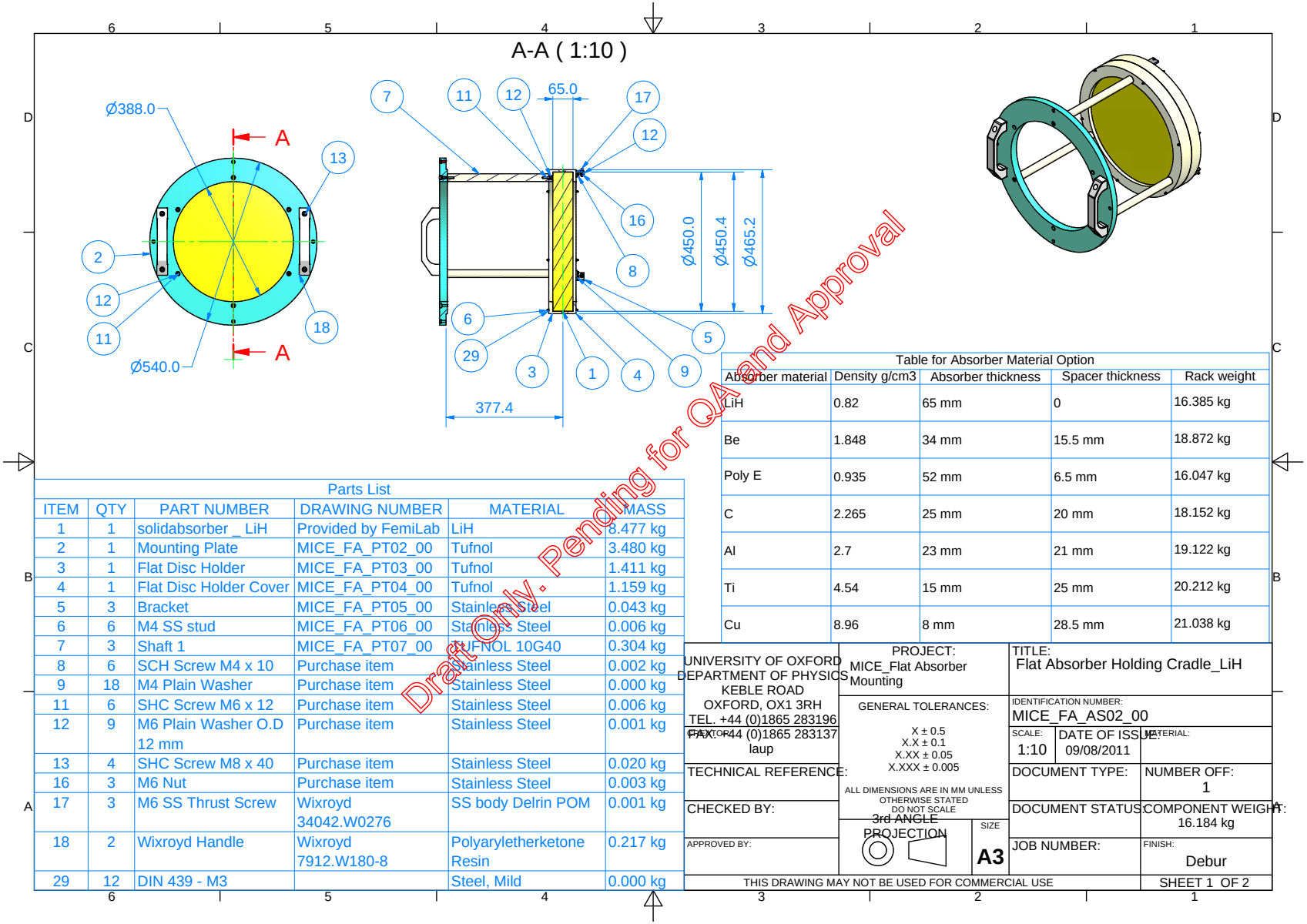


Table for Absorber Material Option

Absorber material	Density g/cm3	Absorber thickness	Spacer thickness	Rack weight
LiH	0.82	65 mm	0	16.385 kg
Be	1.848	34 mm	15.5 mm	18.872 kg
Poly E	0.935	52 mm	6.5 mm	16.047 kg
C	2.265	25 mm	20 mm	18.152 kg
Al	2.7	23 mm	21 mm	19.122 kg
Ti	4.54	15 mm	25 mm	20.212 kg
Cu	8.96	8 mm	28.5 mm	21.038 kg

Parts List

ITEM	QTY	PART NUMBER	DRAWING NUMBER	MATERIAL	MASS
1	1	solidabsorber _ LiH	Provided by FemiLab	LiH	8.477 kg
2	1	Mounting Plate	MICE_FA_PT02_00	Tufnol	3.480 kg
3	1	Flat Disc Holder	MICE_FA_PT03_00	Tufnol	1.411 kg
4	1	Flat Disc Holder Cover	MICE_FA_PT04_00	Tufnol	1.159 kg
5	3	Bracket	MICE_FA_PT05_00	Stainless Steel	0.043 kg
6	6	M4 SS stud	MICE_FA_PT06_00	Stainless Steel	0.006 kg
7	3	Shaft 1	MICE_FA_PT07_00	TUFNOL 10G40	0.304 kg
8	6	SCH Screw M4 x 10	Purchase item	Stainless Steel	0.002 kg
9	18	M4 Plain Washer	Purchase item	Stainless Steel	0.000 kg
11	6	SHC Screw M6 x 12	Purchase item	Stainless Steel	0.006 kg
12	9	M6 Plain Washer O.D 12 mm	Purchase item	Stainless Steel	0.001 kg
13	4	SHC Screw M8 x 40	Purchase item	Stainless Steel	0.020 kg
16	3	M6 Nut	Purchase item	Stainless Steel	0.003 kg
17	3	M6 SS Thrust Screw	Wixroyd 34042.W0276	SS body Delrin POM	0.001 kg
18	2	Wixroyd Handle	Wixroyd 7912.W180-8	Polyaryletherketone Resin	0.217 kg
29	12	DIN 439 - M3		Steel, Mild	0.000 kg

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PROJECT: MICE_Flat Absorber Mounting

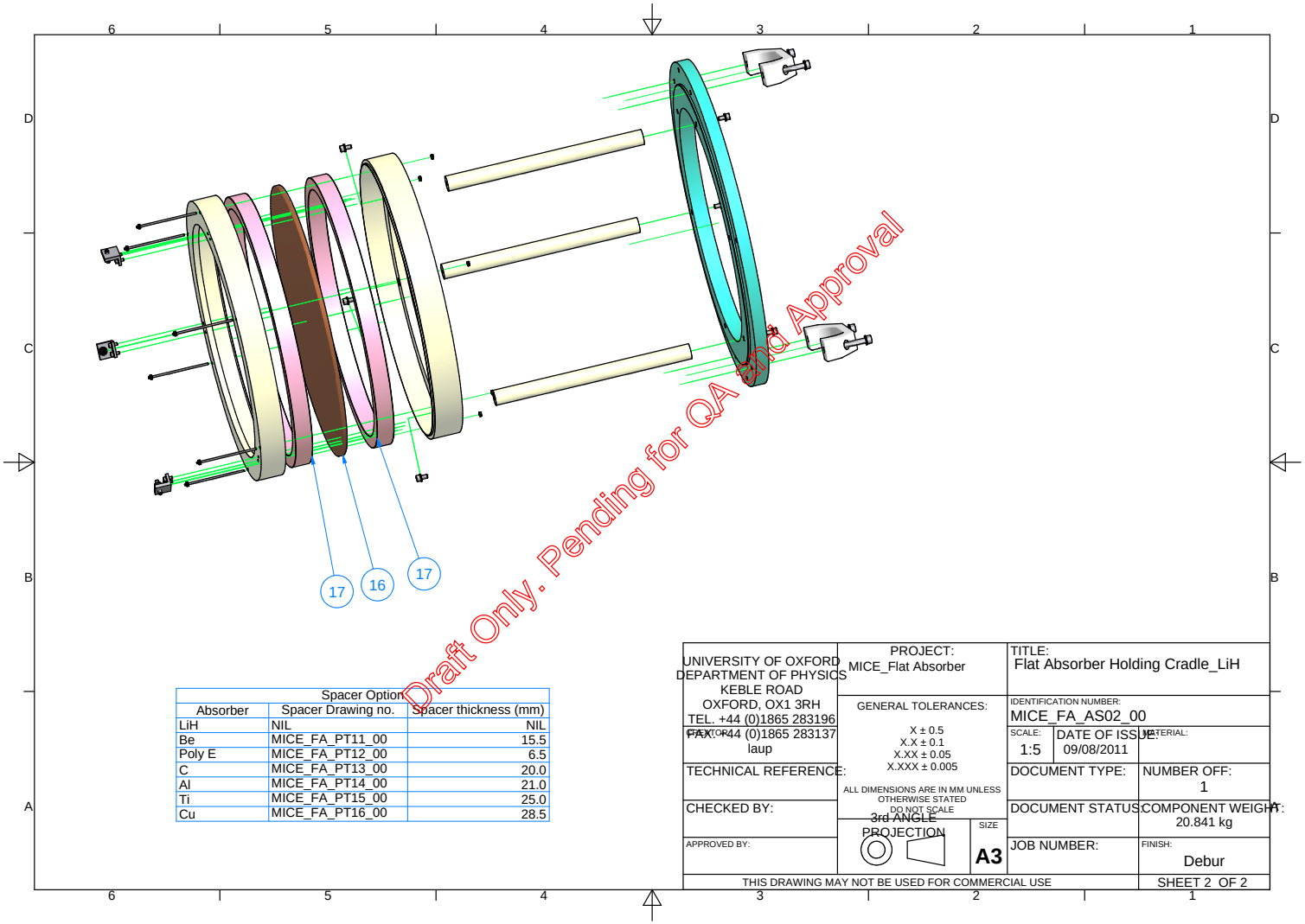
TITLE: Flat Absorber Holding Cradle_LiH

GENERAL TOLERANCES:
X ± 0.5
X.X ± 0.1
X.XX ± 0.05
X.XXX ± 0.005
ALL DIMENSIONS ARE IN MM UNLESS OTHERWISE STATED
DO NOT SCALE
3rd ANGLE PROJECTION

IDENTIFICATION NUMBER: MICE_FA_AS02_00
SCALE: 1:10
DATE OF ISSUE: 09/08/2011
MATERIAL:
TECHNICAL REFERENCE:
DOCUMENT TYPE:
NUMBER OFF: 1
CHECKED BY:
DOCUMENT STATUS:
COMPONENT WEIGHT: 16.184 kg
APPROVED BY:
SIZE A3
JOB NUMBER:
FINISH: Debur

THIS DRAWING MAY NOT BE USED FOR COMMERCIAL USE
SHEET 1 OF 2

Flat absorber support, other materials



Spacer Option		
Absorber	Spacer Drawing no.	Spacer thickness (mm)
LiH	NIL	NIL
Be	MICE_FA_PT11_00	15.5
Poly E	MICE_FA_PT12_00	6.5
C	MICE_FA_PT13_00	20.0
Al	MICE_FA_PT14_00	21.0
Ti	MICE_FA_PT15_00	25.0
Cu	MICE_FA_PT16_00	28.5

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laup

PROJECT: MICE_Flat Absorber

GENERAL TOLERANCES:
X ± 0.5
X.X ± 0.1
X.XX ± 0.05
X.XXX ± 0.005
ALL DIMENSIONS ARE IN MM UNLESS OTHERWISE STATED
DO NOT SCALE
3rd ANGLE PROJECTION

TITLE: Flat Absorber Holding Cradle_LiH

IDENTIFICATION NUMBER: MICE_FA_AS02_00

SCALE: 1:5
DATE OF ISSUE: 09/08/2011
MATERIAL:

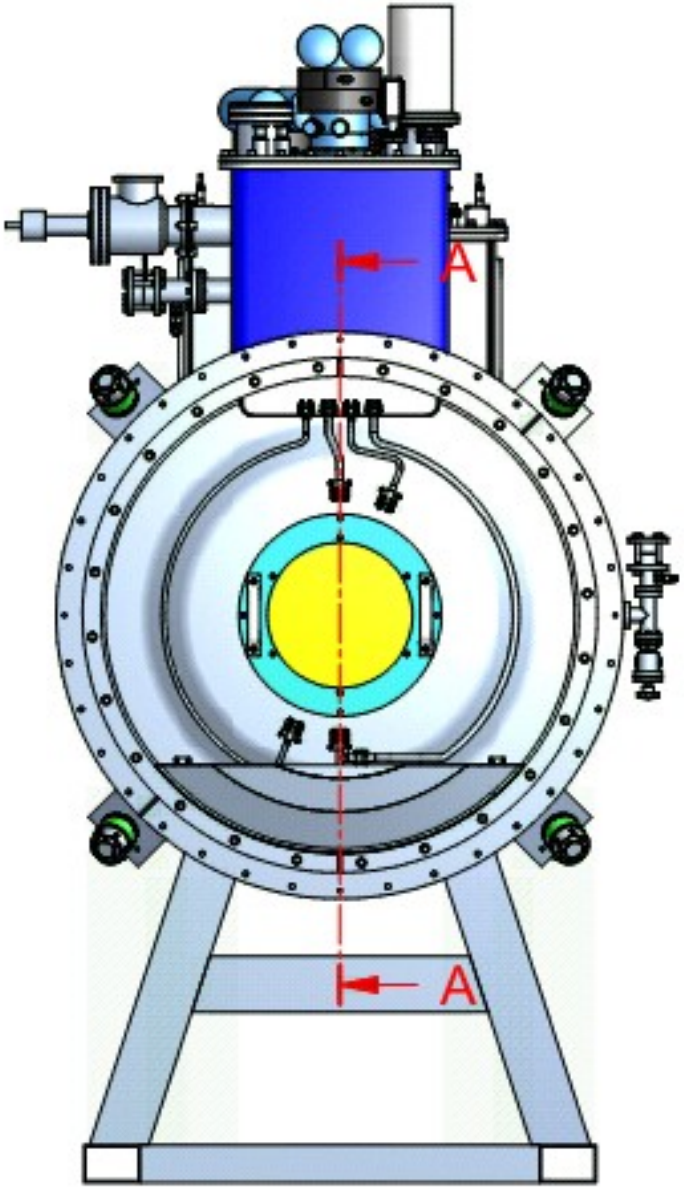
DRAWN BY: CRATOR
TECHNICAL REFERENCE:
CHECKED BY:
APPROVED BY:

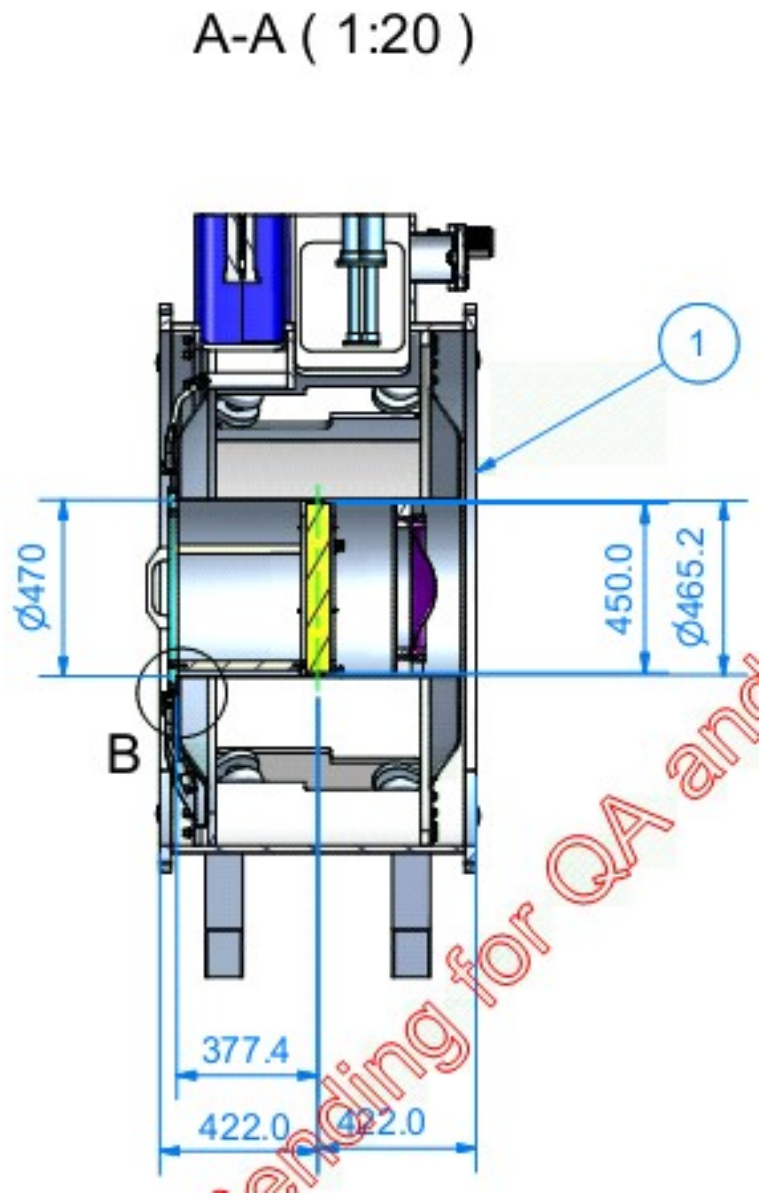
DOCUMENT TYPE:
NUMBER OFF: 1
DOCUMENT STATUS:
COMPONENT WEIGHT: 20.841 kg
SIZE: A3
JOB NUMBER:
FINISH: Debur

THIS DRAWING MAY NOT BE USED FOR COMMERCIAL USE
SHEET 2 OF 2

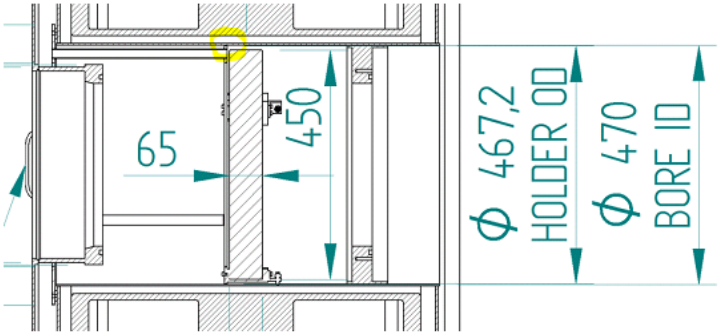
- Other materials allow to look at different equilibrium emittances.

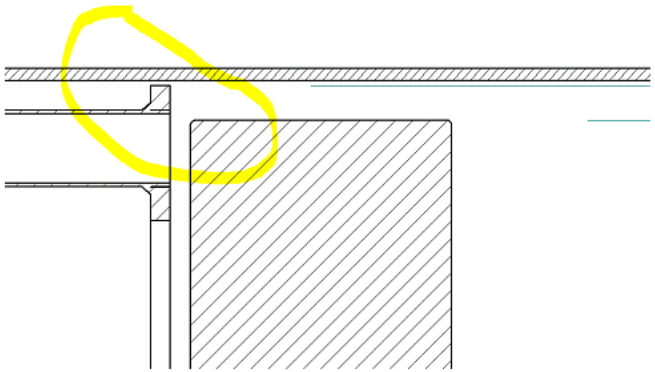
Flat LiH absorber mounting





Current status, outstanding issues



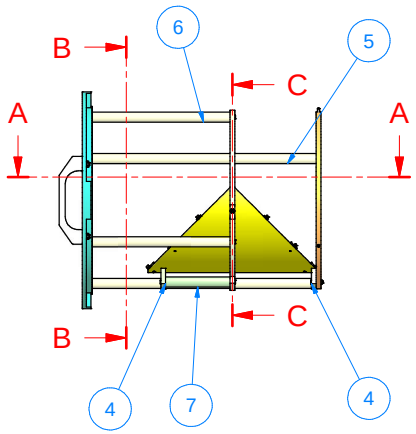


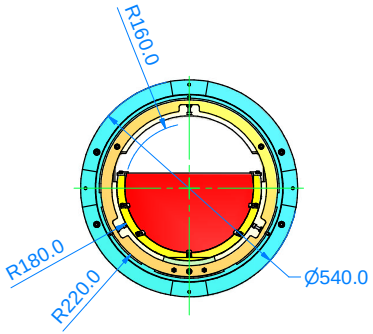
- Jason Tarrant compiled a review document on all the issues that need attention for the upcoming MICE Technical Board meeting.

- Support outer diameter is 467.2 mm, leaving only 1.4 mm gap between it and the AFC bore (shown on left) ⇒ reduced to 465.2 mm.
- Some fastener sizes need to be checked ⇒ update in progress.
- If the absorber is slightly oversize, there is a chance of undesired scraping ⇒ clamps are made of material soft enough not to create a problem.
- Absorber support handles protrude beyond the end of the AFC ⇒ handles removable.
- Phone meeting is planned for tomorrow, hopefully, have all the issues sorted out.
- Once finalized and approved, the drawings go to Fermilab, so we could start fabrication.

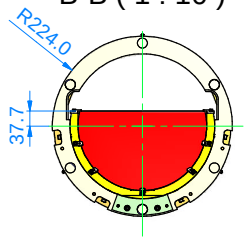
Wedge absorber support

90 degree wedge absorber support (OLD)

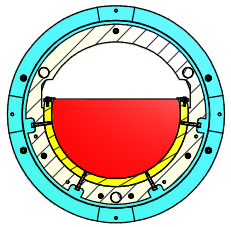




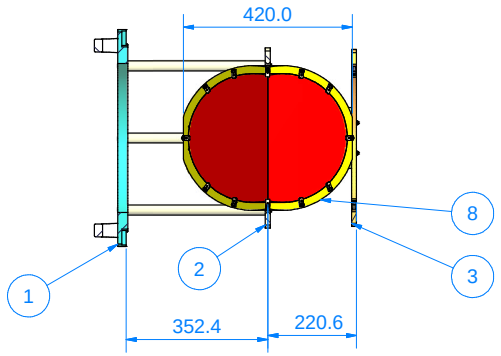
B-B (1 : 10)



C-C (1 : 10)



A-A (1 : 10)



Parts List

ITEM	QTY	PART NUMBER	DRAWING NUMBER	MATERIAL	Weight
1	1	Mounting Plate	MICE_WA_PT02_00	Tufnol	2.802 kg
2	1	Center Plate	MICE_WA_PT03_00	Tufnol	0.804 kg
3	1	End Plate	MICE_WA_PT04_00	Tufnol	0.544 kg
4	2	Absorber Support1	MICE_WA_PT05_00	Tufnol	0.083 kg
5	3	Shaft1	MICE_WA_PT06_00	Tufnol	0.376 kg
6	3	Shaft2	MICE_WA_PT07_00	Tufnol	0.231 kg
7	2	Shaft3	MICE_WA_PT08_00	Tufnol	0.107 kg
8	1	Wedge Absorber Holder Assembly	MICE_WA_SA03_00		10.954 kg
9	10	SHC screw M6 x 16	Purchase item	Stainless Steel	0.007 kg
10	8	SHC screw M6 x 25	Purchase item	Stainless Steel	0.009 kg
11	4	SHC screw M6 x 35	Purchase item	Stainless Steel	0.011 kg
12	26	Washer- M6	Purchase item	Stainless Steel	0.001 kg
13	4	SHC screw M8 x 40	Purchase item	Stainless Steel	0.023 kg
14	4	Washer M8	Purchase item	Stainless Steel	0.002 kg
15	4	Nut M8	Purchase item	Stainless Steel	0.004 kg
16	5	Nut M6	Purchase item	Stainless Steel	0.002 kg
17	3	Thrust Screw - M6	Wixroyd 3402W756	Stainless Steel	0.001 kg
18	2	Wixroyd Handle	Wixroyd 7912.W180-8	Plastic	0.217 kg

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FAX. +44 (0)1865 283137

CREATOR: laup

TECHNICAL REFERENCE:

CHECKED BY:

APPROVED BY:

PROJECT: MICE_Wedge Absorber

GENERAL TOLERANCES:

X ± 0.5
X.X ± 0.1
X.XX ± 0.05
X.XXX ± 0.005

ALL DIMENSIONS ARE IN MM UNLESS OTHERWISE STATED
DO NOT SCALE

3rd ANGLE PROJECTION

SIZE: A3

TITLE: Wedge Absorber Holding Rack

IDENTIFICATION NUMBER: MICE_WA_SA01_00

SCALE: 1:10 | DATE OF ISSUE: 03/08/2011 | MATERIAL:

DOCUMENT TYPE: | NUMBER OFF: 1

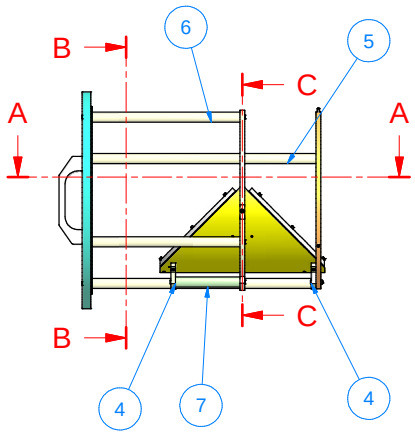
DOCUMENT STATUS: | COMPONENT WEIGHT: N/A

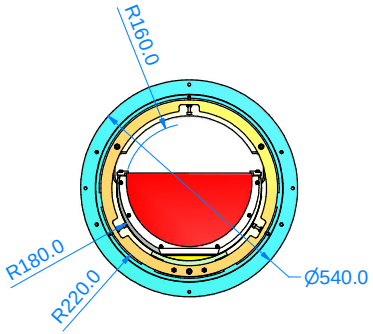
JOB NUMBER: | FINISH: Debur

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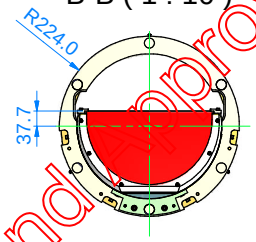
SHEET 1 OF 1

90 degree wedge absorber support (NEW)

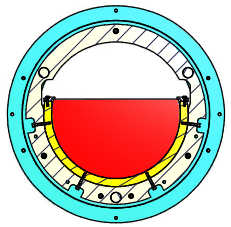




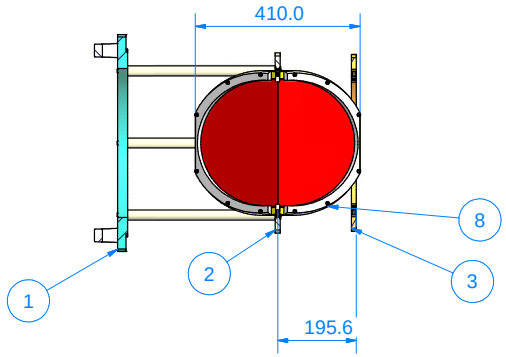
B-B (1 : 10)



C-C (1 : 10)



A-A (1 : 10)



Parts List

ITEM	QTY	PART NUMBER	DRAWING NUMBER	MATERIAL	Weight
1	1	Mounting Plate	MICE_WA_PT02_00	Tufnol	3.480 kg
2	1	Center Plate	MICE_WA_PT03_00	Tufnol	0.806 kg
3	1	End Plate	MICE_WA_PT04_00	Tufnol	0.544 kg
4	2	Absorber Support1	MICE_WA_PT05_00	Tufnol	0.093 kg
5	3	Shaft1	MICE_WA_PT06_00	Tufnol 10G40	0.376 kg
6	3	Shaft2	MICE_WA_PT07_00	Tufnol 10G40	0.248 kg
7	2	Shaft3	MICE_WA_PT08_00	Tufnol 10G40	0.107 kg
8	1	Wedge Absorber Holder Assembly	MICE_WA_SA05_00		11.508 kg
9	10	SHC screw M6 x 16	Purchase item	Stainless Steel	0.007 kg
10	8	SHC screw M6 x 25	Purchase item	Stainless Steel	0.009 kg
12	22	Washer- M6	Purchase item	Stainless Steel	0.001 kg
13	4	SHC screw M8 x 40	Purchase item	Stainless Steel	0.023 kg
16	5	Nut M6	Purchase item	Stainless Steel	0.002 kg
17	3	Thrust Screw - M6	Wixroyd 3402W756	Stainless Steel	0.001 kg
18	2	Wixroyd Handle	Wixroyd 7912.W180-8	Plastic	0.217 kg
21	8	SHC Screw M5 x 30		Stainless Steel	0.007 kg
22	8	Washer M5		Stainless Steel	0.000 kg

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CREATOR: laup

TECHNICAL REFERENCE:

CHECKED BY:

APPROVED BY:

PROJECT: MICE_Wedge Absorber

GENERAL TOLERANCES:

X ± 0.5
X.X ± 0.1
X.XX ± 0.05
X.XXX ± 0.005

ALL DIMENSIONS ARE IN MM UNLESS OTHERWISE STATED
DO NOT SCALE

3rd ANGLE PROJECTION

SIZE: A3

TITLE: Wedge Absorber Holding Cradle

IDENTIFICATION NUMBER: MICE_WA_SA03_00

SCALE: 1:10

DATE OF ISSUE: 03/08/2011

MATERIAL:

DOCUMENT TYPE:

NUMBER OFF: 1

DOCUMENT STATUS:

COMPONENT WEIGHT: 19.355 kg

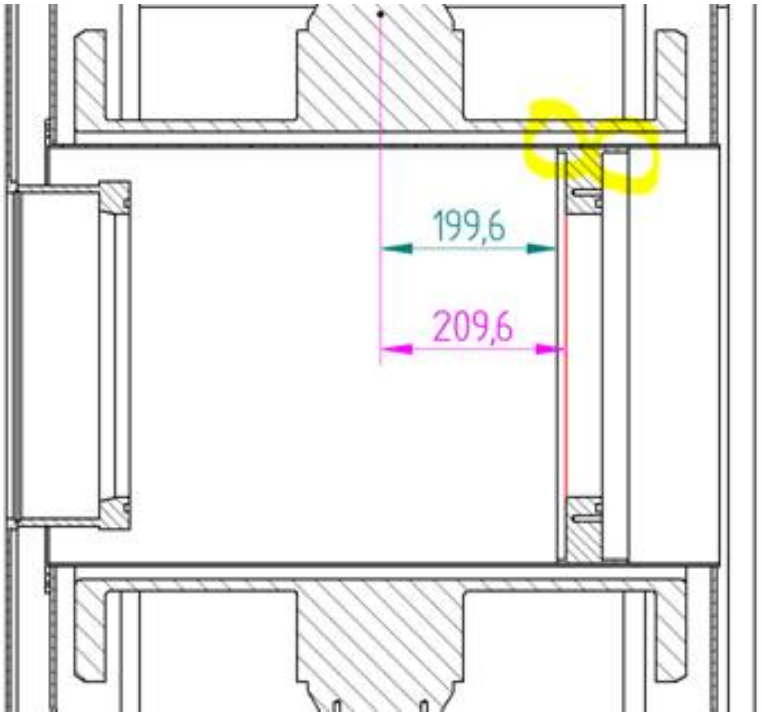
JOB NUMBER:

FINISH: Debur

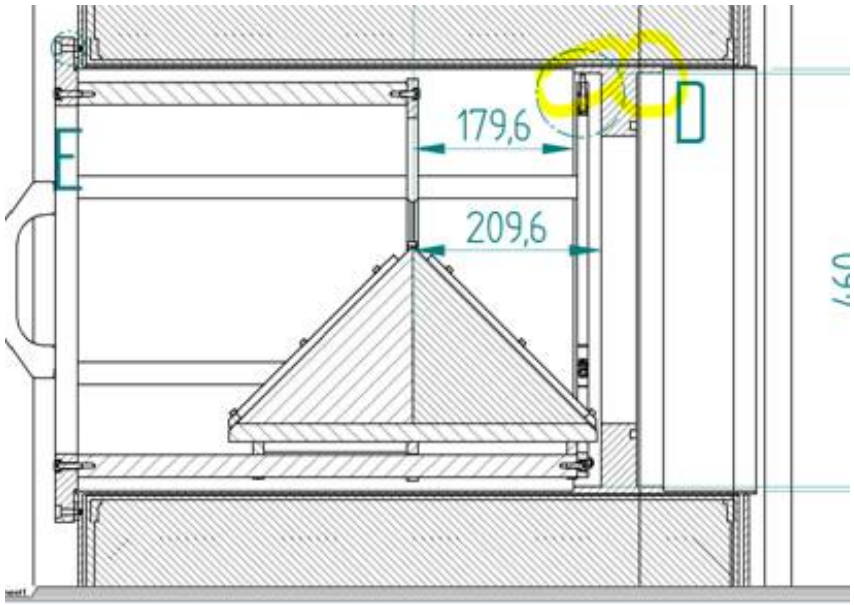
THIS DRAWING MAY NOT BE USED FOR COMMERCIAL USE

SHEET 1 OF 1

- Notice the change in the absorber holders: small clamps (old) vs arc (compare the two previous slides)
- Before this design can be called final, there are some comments from Jason Tarrant:



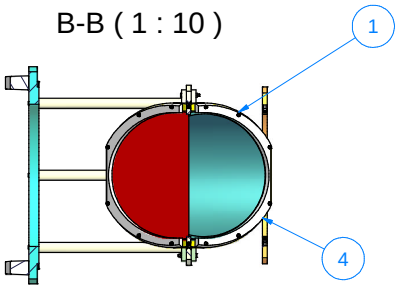
Actual downstream flange geometry.

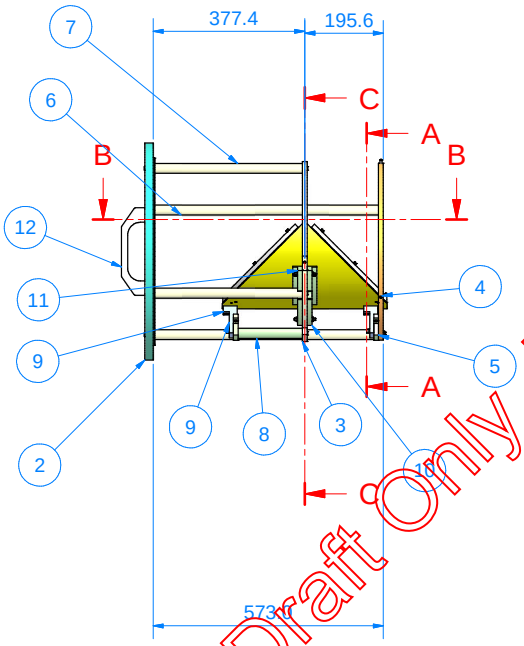


As designed (the downstream ring of the support was supposed to rest against the flange).

45 degree wedge absorber support

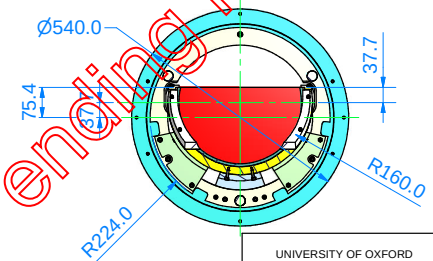
B-B (1 : 10)



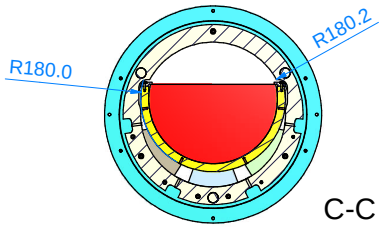


Parts List

ITEM	QTY	PART NUMBER	DRAWING NUMBER	MATERIAL	MASS
1	1	Wedge Absorber Holder Assembly 37.7	MICE_WA_SA06_00		8.423 kg
2	1	Mounting Plate	MICE_WA_PT02_00	Tufnol	3.480 kg
3	1	Center Plate	MICE_WA_PT03_00	Tufnol	0.806 kg
4	1	End Plate	MICE_WA_PT04_00	Tufnol	0.544 kg
5	2	Absorber Support1	MICE_WA_PT05_00	Tufnol	0.093 kg
6	3	Shaft1	MICE_WA_PT06_00	Tufnol 10G40	0.376 kg
7	3	Shaft2	MICE_WA_PT07_00	Tufnol 10G40	0.248 kg
8	2	Shaft3	MICE_WA_PT08_00	Tufnol 10G40	0.107 kg
9	2	Absorber Support3	MICE_WA_PT09_00	Tufnol	0.204 kg
10	2	Absorber Support4	MICE_WA_PT10_00	Tufnol	0.162 kg
11	2	Absorber Support5	MICE_WA_PT11_00	Tufnol	0.163 kg
12	2	Wixroyd Handle	Wixroyd 7912.W180_8	Plastic	0.217 kg
13	10	SHC Screw M6 x 16	Purchase item	Stainless Steel	0.007 kg
14	30	Washer M6	Purchase item	Stainless Steel	0.001 kg
15	7	SHC Screw M6 x 20	Purchase item	Stainless Steel	0.007 kg
16	5	SHC Screw M6 x 25	Purchase item	Stainless Steel	0.009 kg
17	8	SHC Screw M6 x 40	Purchase item	Stainless Steel	0.012 kg
18	9	Nut M6	Purchase item	Stainless Steel	0.002 kg
19	3	Thrust Screw - M6	Purchase item	SS body, Delrin POM	0.001 kg
25	8	Washer M5		Stainless Steel	0.000 kg
26	8	SHC Screw M5 x 20		Stainless Steel	0.005 kg



A-A (1 : 10)



C-C (1 : 10)

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UNIVERSITY OF OXFORD DEPARTMENT OF PHYSICS KEBLE ROAD OXFORD, OX1 3RH TEL. +44 (0)1865 283196 FAX. +44 (0)1865 283137	PROJECT: MICE_Wedge Absorber	TITLE: Wedge Absorber Holding Cradle 37.7
	GENERAL TOLERANCES: X ± 0.5 X.X ± 0.1 X.XX ± 0.05 X.XXX ± 0.005 ALL DIMENSIONS ARE IN MM UNLESS OTHERWISE STATED DO NOT SCALE	IDENTIFICATION NUMBER: MICE_WA_SA04_00
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Step IV run plan

Aims of Step IV

$$\frac{d\varepsilon_n}{dz} = \frac{-\varepsilon_n}{\beta^2 E}\left\langle \frac{dE}{dX} \right\rangle + \frac{\beta_t \left(0.014\ \mathrm{GeV}\right)^2}{2\beta^3 E m_\mu X_0}$$

- Demonstrate ionization cooling with materials typical of the cooling channels under consideration (liquid Hydrogen, LiH).
- Wedge absorbers: demonstrate longitudinal emittance reduction.
- Verify the cooling formula for various materials, beam parameters, optics settings.
- Develop and thoroughly test simulation and analysis tools.

Before we start

- No material in the cooling channel (one dedicated ISIS run, presumably Feb 2013).
- Check/understand magnet performance: ramp coils individually, compare experimental results with simulation.
- Check/understand the lattice: set the cooling channel parameters to the baseline $\varepsilon = 6\pi$ mm·rad, $p = 200$ MeV/c, run large emittance beam, scan beam momentum from 170 to 230 MeV/c.
- Repeat test with a different β function setting (time-permitting).
- Look at different reference momenta settings (240, 200, 140 MeV/c), emittance settings (10, 6, 3 π mm·rad), β function settings (42, 25, 15, 7 cm) magnetic configuration (flip, non-flip).

Step IV configurations

In preparation of the MICE Project Board report I put together a table of various configurations we may want to consider:

Parameters				Step IV Configurations						
Field flip	Beta [cm]	Momentum [MeV/c]	Emittance [mm rad]	Empty channel	Liquid Hydrogen	LiH disk	Al disk	PE disk	LiH 90^o wedge	LiH 45^o wedge
Yes	42	240	10		+	+	+		+	+
Yes	42	240	6	+	+	+	+	+	+	+
Yes	42	240	3		+	+		+	+	+
Yes	42	200	10	+	+	+	+		+	+
Yes	42	200	6	+	+	+	+	+	+	+
Yes	42	200	3	+	+	+		+	+	+
…	…	…	…	…	…	…	…	…	…	…
No	7	240	10		+	+				
No	7	240	6	+	+	+				
No	7	240	3		+	+				
No	7	200	10		+	+				
No	7	200	6	+	+	+				
No	7	200	3		+	+				
				14	36	36	9	9	24	24
									Total:	152

Step IV configurations (contd.)

- 152 configurations/settings, further refinement is required.
- One way to reduce the number of configurations is to use an online tool that allows to do some preliminary analysis in real-time and reject some configurations based on that analysis.
- Hardware configurations vs ISIS runs (dates are preliminary):
  - Empty channel (Feb 2013);
  - Liquid Hydrogen absorber (May 2013);
  - Flat solid absorbers, LiH and other materials (July 2013);
  - Wedge absorbers, 90° and 45° LiH (October 2013);
  - One more ISIS run may be available in Step IV configuration (November 2013).

Summary

- LiH flat absorber is complete, LiH wedge is underway.
- Final versions of the engineering drawings are just around the corner for both flat and wedge absorbers, hopefully, approved soon after the next TB meeting.
- There are no resources at either RAL or Oxford to fabricate the supports, will be fabricated at Fermilab, partially assembled and send to RAL along with the absorbers.
- Detailed Step IV run plan is being discussed and updated (next iteration = upcoming MICE Project Board meeting).
- Step IV measurements will take 4 to 5 ISIS run periods.