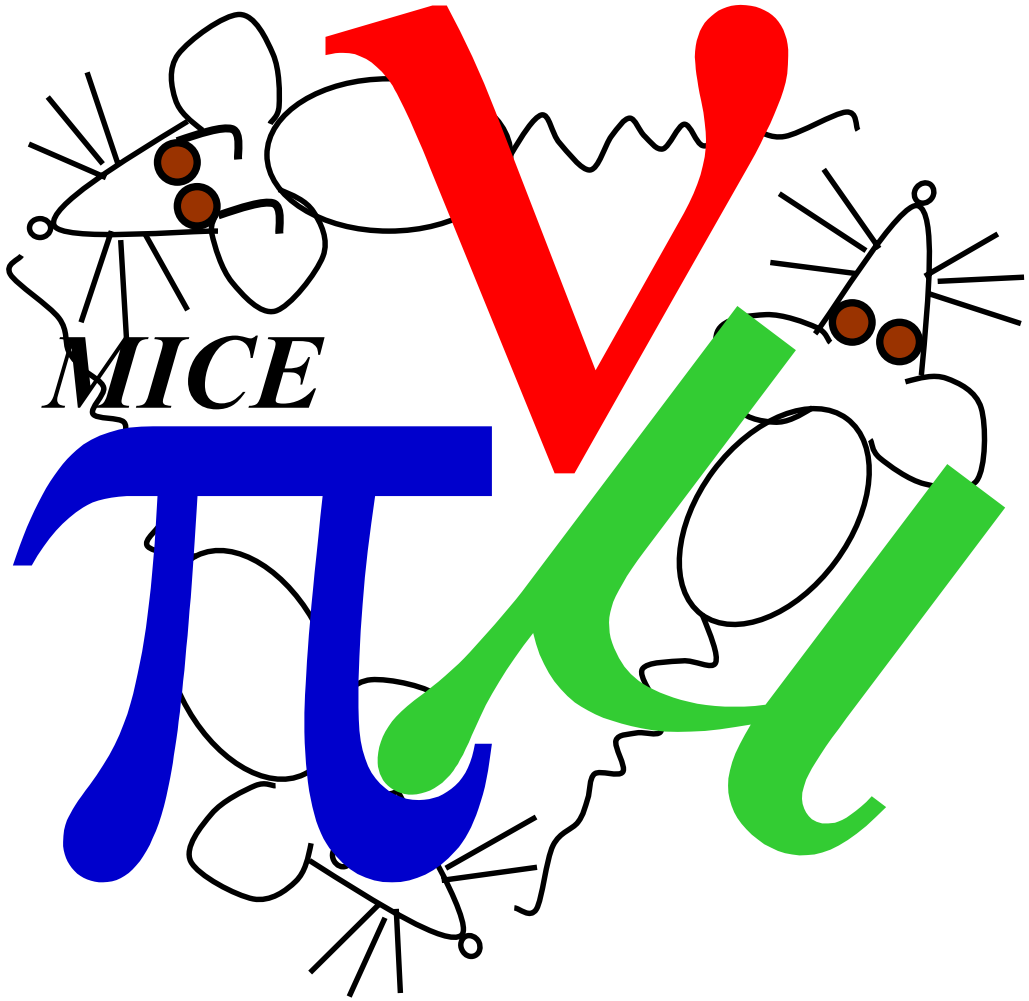
An International Muon Ionization Cooling Experiment

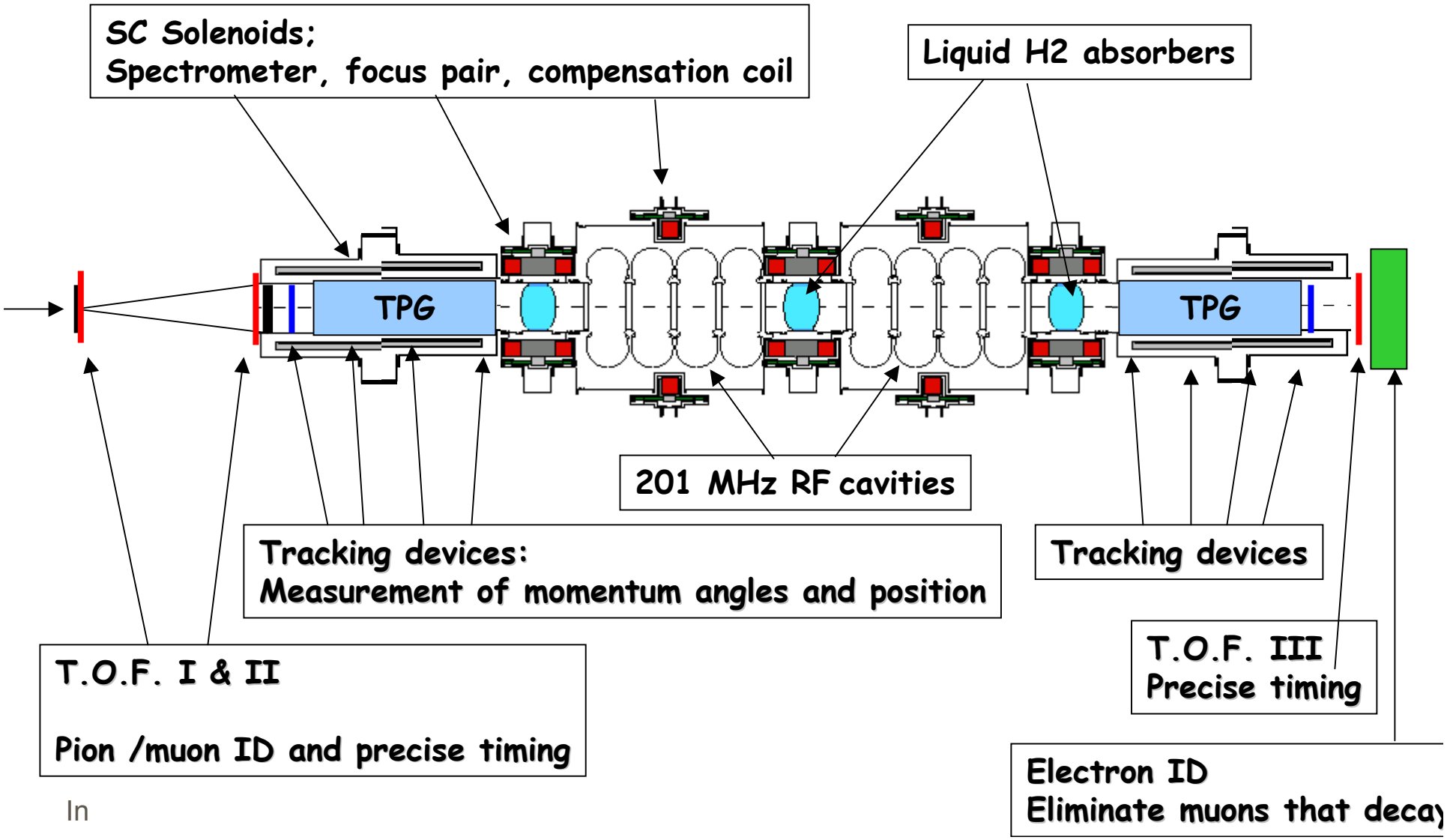


TOWARDS A PROPOSAL

10% cooling of 200 MeV muons requires ~ 20 MV of RF

single particle measurements =>

measurement precision can be as good as $\Delta (\varepsilon_{out}/\varepsilon_{in}) = 10^{-3}$



on 25 March, the MICE collaboration was
invited to present a proposal to RAL,
with the help of RAL

since then RAL nominated a project engineer
(Iouri Ivanichenkov)
study beam and experimental layout (autocad drawing exists)

MICE found a home!

questions:

What will MICE be?
Who will do what?
Who will pay what?
When can/should this be done?

MICE Video Conferences and collaboration meetings

Monday April 8
Monday April 29
Tuesday May 21 <= Note change 17:00 CEST
Monday June 10

Collaboration Meeting 8+9 July 2002 RAL

Please register

aims:
.. get a good idea of technical choices
.. Conceptual design of everything
who could be responsible for what.

MUCOOL/MICE Collaboration meeting 23-24-25 October @Berkeley
Finalize who does what and cost estimates
Schedule remaining open questions (decision tree)
at that time the input to the proposal should be defined and proposal drafting underway.

date of submission: toward end of 2002

from MICE LOI:

2002

The schedule of activities can be envisaged as follows,
assuming all milestones are passed successfully.

2002: Preparation of proposal and fund raising

Integrated simulation of experiment including beam, detectors and cooling cells
Evaluation of possible sources of systematic errors
Investigation of low equilibrium emittance lattice and of the compatibility with ring coolers
Continuous comparison of the 200 MHz and 88 MHz scenarios
Test of detectors in X ray environment (already underway) and choice of tracking devices
Operation of 88 MHz cavity at CERN and of the test facilities at Fermilab
Continued development of liquid hydrogen absorbers
Development of alternative schemes for absorbers
Competitive design and cost estimates for the solenoids
Constitution of a collaboration structure and more detailed distribution of tasks and financial responsibilities
Evaluation with the host laboratory of the requirements on space, facilities, safety and radiation issues, and infrastructure

Submission of proposal in the course of 2002.

PRIORITIES

1. **Find a home for the experiment** DONE

2. **Understand the X ray issue and quantify it in terms of particle detector performance**

2.' Develop reconstruction with noise and efficiencies

3. Chose detectors and finalize magnet parameters

4. Establish technical specs and cost estimates
4' Distribute contributions and begin fund hunt mission

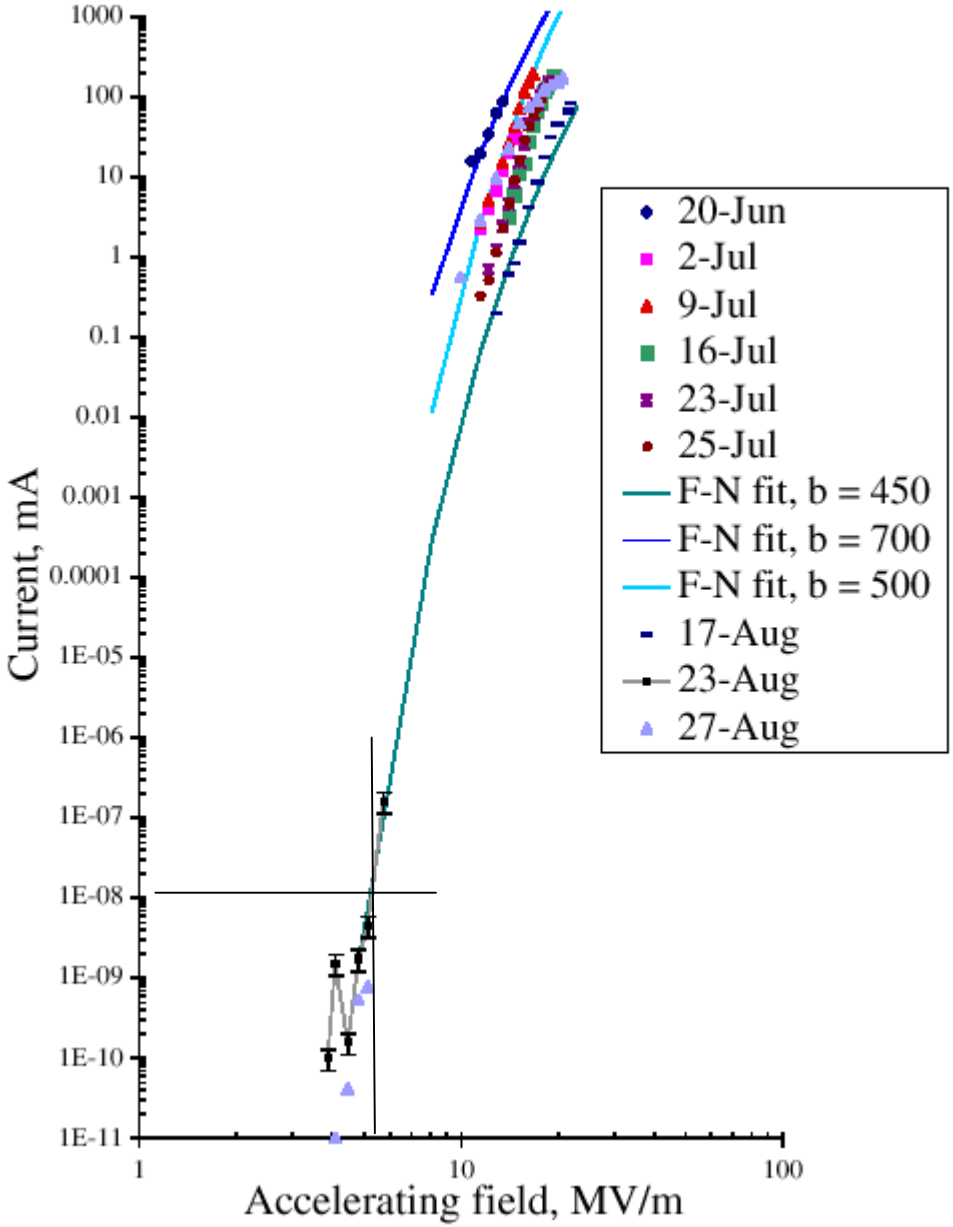
5. write proposal

. Observed dark currents in 800MHz cavity in lab G.

The cavity could not be run at a gradient higher than 5 MV/m without emitting one electron or more within a time window of 20 ns. (i.e. 10^{-8} mA)

improvement needed:
to push this up to 7 MV/m

Q. Is this the right figure of merit?
Better probably: observed noise rate in actual detector near the cavity.



=> 6.70 MV/m

=> 4.65 MV/m

Available power supplies	Voltage from one 4-cell cavity	Voltage from two 4-cell cavities
1 X 4 MW	11.5 MV on crest 5.7 MV at 30°	16 MV on crest 8 MV at 30°
2 X 4 MW	16 MV on crest 8 MV at 30°	23 MV on crest 11.5 MV at 30°
8 X 4 MW		46 MV on crest 23 MV at 30°

Table VII.1: Achievable muon acceleration for various configurations of number of cavities and available RF power.

.43 X 4 cells = 1.7 m ⇒ 11.5 MV for 1X 4 = 6.70 MV/m

16 MV for 2X4 = 4.65 MV/m

Is this correct?

Pending design issues

cooling cell:
integration of LH_2 absorbers, safety windows, flip coils
alternative absorbers? *(MUCOOL, Green & Black)*

RF power sources *(CERN, RAL)*

Spectrometer: *(detector WG, Bross&Palladino + Simulation team)*
choice of tracking devices (Sci-fi ++ or Sci-fi + TPG?)
definition of detectors for upstream particle ID
conception and design of downstream PID (Cerenkov or range?)

Finalize magnetic configuration: *(simulation team)*
match solenoids with cooling cell;
define # trims and power supplies needed to perform
the desired experiments
to vary: momentum, beta, #flips….

First go at very incomplete tables of who does what

item	comm.	resp.	LOI cost	rev. cost	US	EU	RAL	JP
RF cells	critical path item	LNBL	0.8-1.3	0.8-1.3	0.8-1.3	--	--	--
power sources plumbing	CERN refurb FNAL refurb RAL refurb	CERN FNAL RAL	0.2 0.2(?) --	0.2 0.5-1. 0.2	-- 0.5-1	0.2	 0.2	
rad. monitors	rad. safety dark current	RAL ANL	--	? ?	 ?		?	
Beam line		RAL (+PSI)	--	--	--	?	?	

First go at very incomplete tables of who does what

item	comments	resp.	LOI cost	revised cost	US	EU	RAL	JP
flip coils	**global supervision of coils necessary (Green)**	**among Oxford/ MUCOOL/ RAL/ LBL/ Saclay/ Italy**	3-4	1.6	**to be shared as common fund**			
comp. coils			2-3	2				
solenoids			2	1.6		**1.6**		
Helium plant	same as beam	RAL	--	?			?	

Suggestion: Mike Green will organize a get-together of those who could bid for the magnets and share (at least the cost, maybe construction) and come up with a proposal.

First go at very incomplete tables of who does what

item	comm.	resp.	LOI cost	revised cost	US	EU	RAL	JP
H2 absorbers	MUCOOL /KEK	MUCOOL/ KEK	.7-.8	.7-.8	x_1	--	--	x_2
LH_2 Plant + safety		RAL	2(?)	2(?)			2(?)	
solid absorbers	?							

First go at very incomplete tables of who does what

item	comm.	resp	LOI cost	revised cost	US	EU	RAL	JP
Sci fi	>>2 planes of 3 layers	ICL/FNAL/KEK Long/Bross/ yoshimura	NA	NA	to be shared			
TPG	Needs validation!	Legnaro/CERN/ GVA (Gastaldi)	--	NA		0.5 (?)		
TOF	most exists adequate	Milano/Padova	--	0.1		0.1		
beam cerenkov	very precise timing	Mississipi(?)	--	0.1	0.1			
down-stream PID	technique not decided	Louvain/Greece/ Roma	--			0.1		
DAQ		Bari (Radicioni)	.32			.32		

SIMULATIONS

Simulation of performance of cooling cell fairly well understood.

Now needed :
… simulation of detector response, for design of e.g. downstream PID
or to understand performance of TPG.

… groundwork by Janot needs to be recuperated.(-> Gruber)
program is on AFS

…
Yagmur has started with a GEANT4 version of MICE.
⇨ others (Steve Kahn, Vladimir Grichine, more needed)
begin or volunteered
to to implement detector responses and reconstruction

conceptual thinking of systematic uncertainties in the measurement needed

Proposed agenda:

2001 **Expose detectors to RF radiation (potential show stopper)**
write first description of experiment with two options
US design (200 MHz) or CERN design (88 MHz)
US simulate CERN scheme [and vice versa if possible]
Evaluate availability and cost of main cost drivers:
RF cavities / amplifiers/ power supplies/solenoids
for each scheme
evaluate beams + host labs

1st workshop 25-27 October 2001, CERN

! 16 Nov. 2001 ! Chose technology + host lab, write +
submit LETTER OF INTENT

2002 Technical proposal

summer 2004 1st beam (debugging of spectrometers)

MICE : WHEN?

GOAL: The long-term goal is to have a Conceptual Design Report for a world Neutrino Factory Complex by the time of LHC start-up, so that, by that date, this would be a valid option for the future of HEP

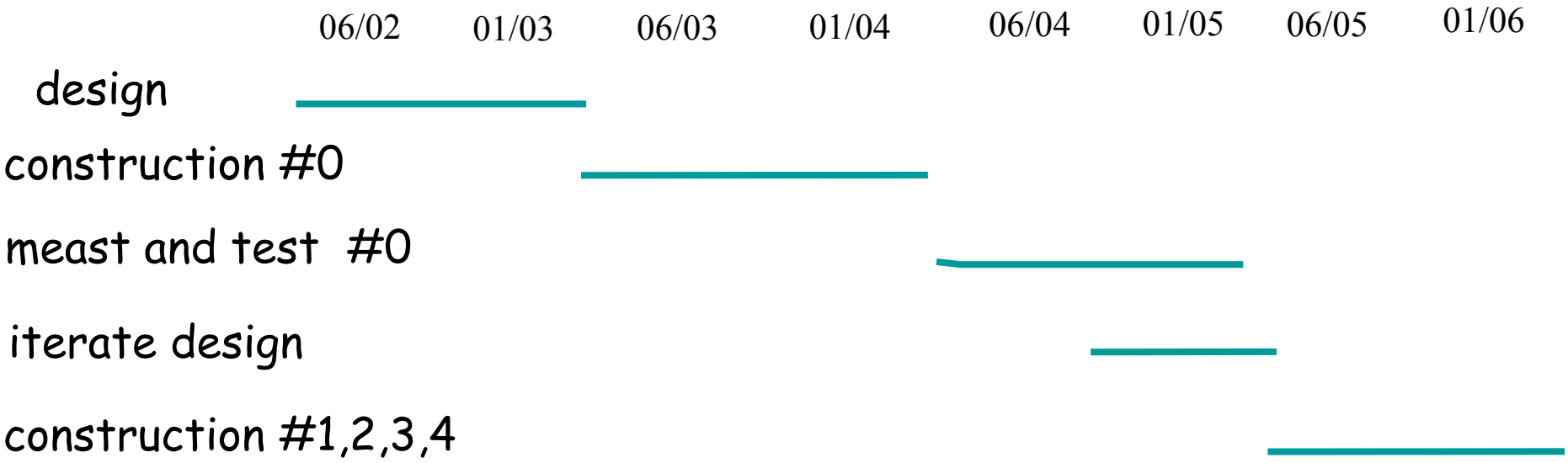
(European Muon Coordination and Oversight Group, April 2002)

= ‘ 2007 ’

MICE must have measured cooling by the end of the previous year
= ‘ end 2006 ‘

When?
what is The critical item?

200 MHz RF cavity……



unless the initial step is shortened
this 0.3 M$ item risks to delay the whole thing.

PRELIMINARY and INDICATIVE COSTING OF MICE						
			1 cavity 4 MW	1 cavity 8 MW	2 cavities 4 MW	2 cavities 8 MW
cooling DE (On crest)			11.5MV	16 MV	16 MV	23 MV
Approx. Δε/ε (%)			5%	7%	7%	10%
Cost estimate in US$, US accounting	Fixed cost	Unit cost				
COOLING CELLS						
RF Cavities						
4 cell cavity 200 MHz	0.3	0.5	0.8	0.8	1.3	1.3
RF Power						
CERN-refurbish		0.2	0.2	0.2	0.2	0.2
FNAL-refurbish (?)		0.2	0	0.2		0.2
Magnets						
Focus pair	1	1	3	3	4	4
Coupling coil	1	1	2	2	3	3
Liquid H2 absorbers						
	0.5	0.1	0.7	0.7	0.8	0.8
H2 safety	2		2	2	2	2
Total for cooling cell US $ (US costing)			8.7	8.9	11.3	11.5
SPECTROMETERS						
Solenoids		1	2	2	2	2
Detectors		2	2	2	2	2
Total spectrometers			4	4	4	4
Subtotal	4		12.7	12.9	15.3	15.5
Infrastr., extras(20%)						
TOTAL	**4.8**		**14.6**	**14.9**	**17.5**	**17.8**

Table VII.1: preliminary cost break-down.

PRELIMINARY AND INDICATIVE COST EVALUATION OF MICE (US ACCOUNTING)								
	MUCOOL fixed cost development	fixed cost development	Add. unit cost					
COOLING CELL				**1 cavity 4**	1 cav. 8 MW	2 cav. 4 MW	**2 cav. 8 M**	2 cav. 32 MW
cooling DE (On crest)				**12 MV**	17 MV	17 MV	**24 MV**	48 MV
$\Delta\varepsilon/\varepsilon$ (%)				**5%**	7%	7%	**10%**	20%
RF Cavities								
4 cell cavity 200 MHz	0.3	0	0.5	**0.5**	0.5	1	**1**	1
RF POWER:								
CERN-refurbish			0.2	**0.2**	0.2	0.2	**0.2**	0.2
RAL-refurbish			?	**?**	?	?	**?**	?
FNAL-refurbish (?)			0		0	0	**0**	0
NEW diacrodes		1	1.2		0	0	**0**	8.2
MAGNETS				**0**				
focus pair	0.2	0.35	0.45	**1.25**	1.25	1.7	**1.7**	1.7
coupling loop	0.4		1	**1**	1	2	**2**	2
Liquid H2 absorbers				**0**				
tanks and mechanics	0.5		0.1	**0.2**	0.2	0.3	**0.3**	0.3
Liq H2 plant& safety(?)		2		**2**	2	2	**2**	2
				0				
Total cooling section	1.4	2.35		**5.15**	5.15	7.2	**7.2**	15.4
				0				
DIAGNOSTICS				**0**				
solenoids		0.69	0.5	**1.69**	1.69	1.69	**1.69**	1.69
detectors			2	**2**	2	2	**2**	2
total diagnostics	0			**3.69**	3.69	3.69	**3.69**	3.69
				0				
subtotal				**8.84**	8.84	10.89	**10.89**	19.09
infrastr., extras(20%)				**0**				
total				**10.608**	10.608	13.068	**13.068**	22.908
total magnets	0.6	1.04	1.95	**3.94**	3.94	5.39	**5.39**	5.39
assumptions: RAL provides beam and safety and fluids.				**2**	2	2	**2**	2
UK provides 20% cost								
rest of EU provides 25%				**2.652**	2.652	3.267	**3.267**	5.727
US provides 45%				**4.7736**	4.7736	5.8806	**5.8806**	10.3086
Japan provides 10%				**1.0608**	1.0608	1.3068	**1.3068**	2.2908

Conclusions & discussion

MICE builds up on MUCOOL component development towards an actual precision measurement of cooling performance.

MICE has already shown to be a beneficial approach:
- RF emissions
- cost reductions
- safety windows .. etc..

There will be undoubtedly many other annoying discoveries,
….. followed by clever inventions

MICE is essential to convince ourselves – and others –
that we know how to build realistic cooling channels

Getting a first measurement of cooling before LHC start-up
should be feasible but requires good organization and priorities.
Funding needs to be found also from outside MC.

Seems to be using components similar to those of the cooling rings

RAL is inviting us… we must take our chance.