

Status of MICE

Daniel M. Kaplan



MAP Friday Meeting
Fermilab
26 July 2013

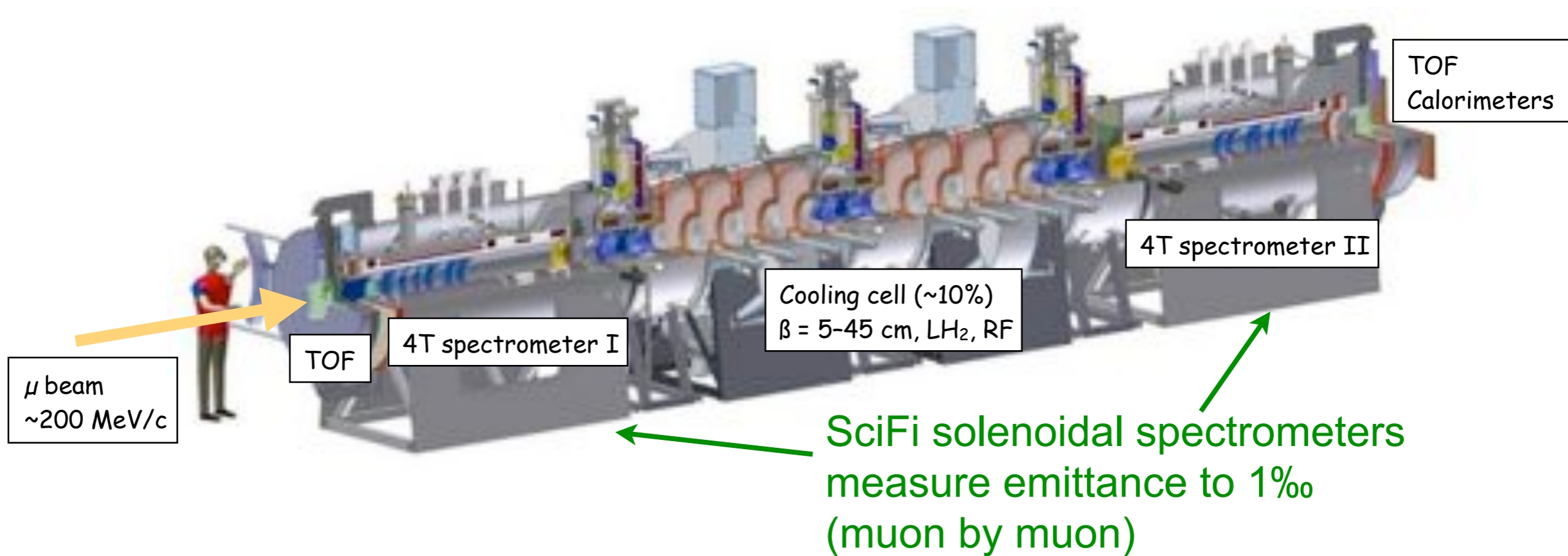


Outline

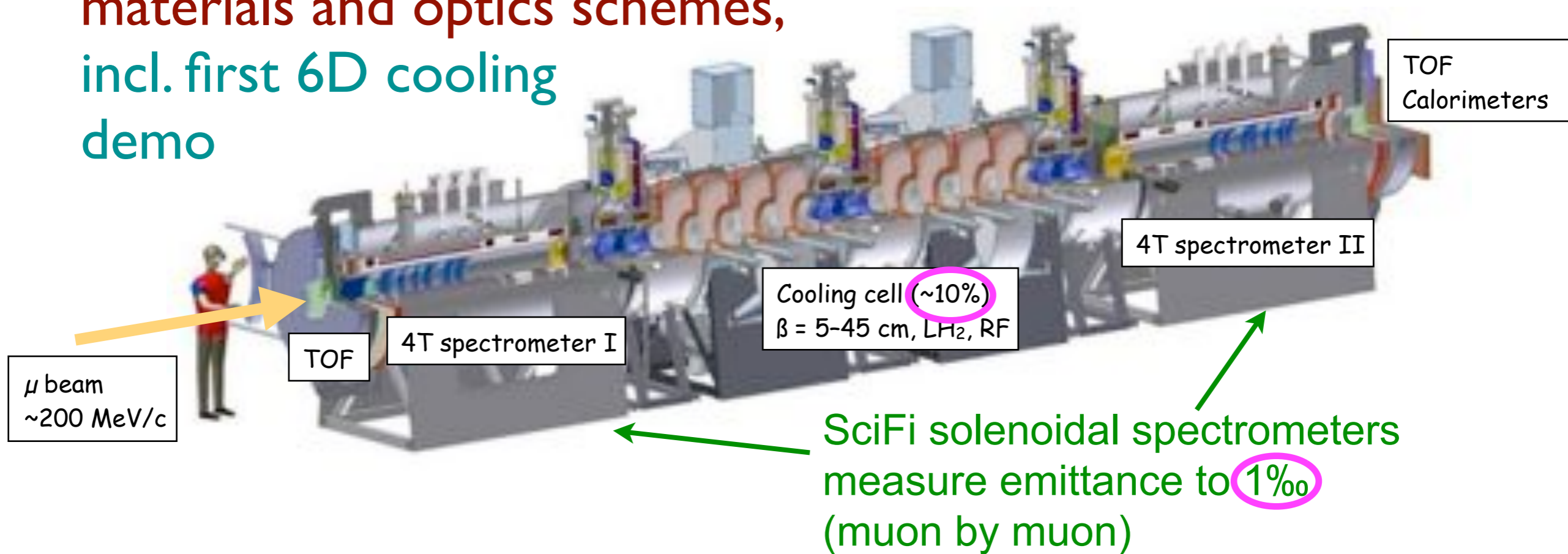


- MICE overview
- Detector status
- Magnets & other equipment
- Software status
- Summary & outlook

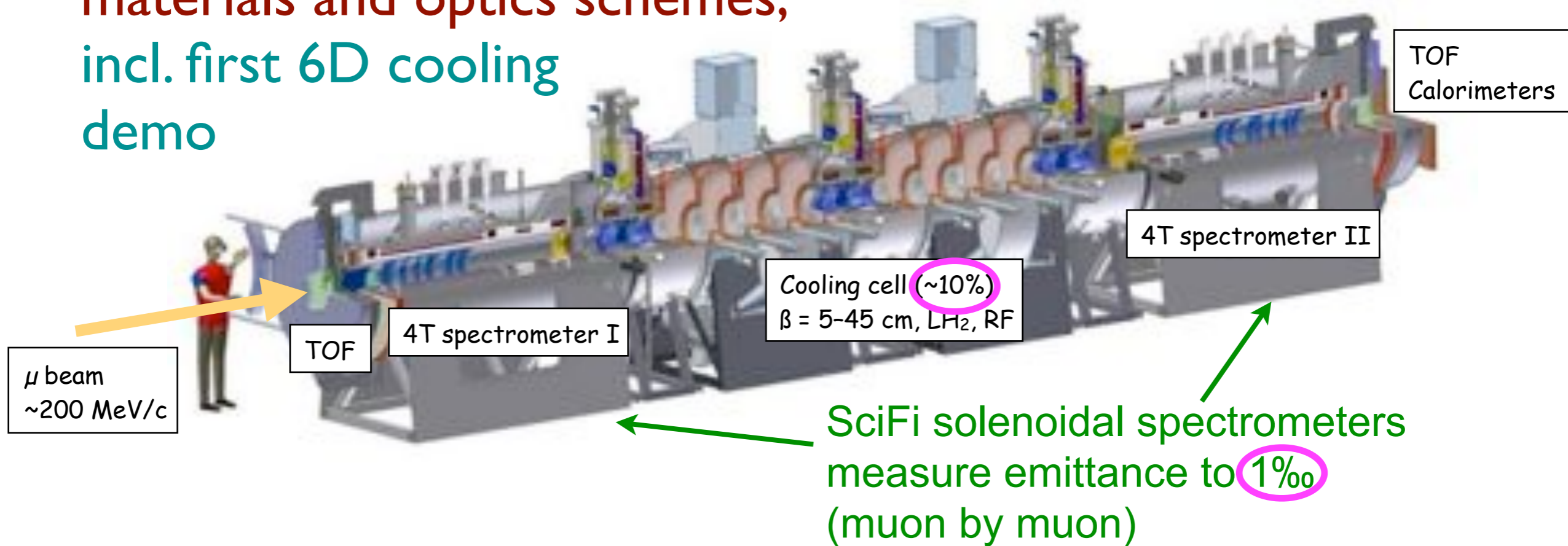
- International **M**uon **I**onization **C**ooling **E**xperiment at UK's Rutherford Appleton Laboratory (RAL)



- International Muon Ionization Cooling Experiment at UK's Rutherford Appleton Laboratory (RAL)
- Has flexibility to test several absorber materials and optics schemes, incl. first 6D cooling demo



- International **M**uon **I**onization **C**ooling **E**xperiment at UK's Rutherford Appleton Laboratory (RAL)
- Has flexibility to test several absorber materials and optics schemes, incl. first 6D cooling demo



- **Nutshell:** under construction, program complete ~2020



Steps of MICE



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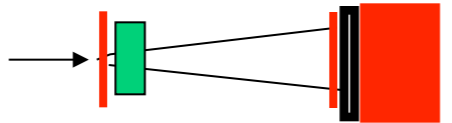


μ

Provisional MICE SCHEDULE
update: June 2013

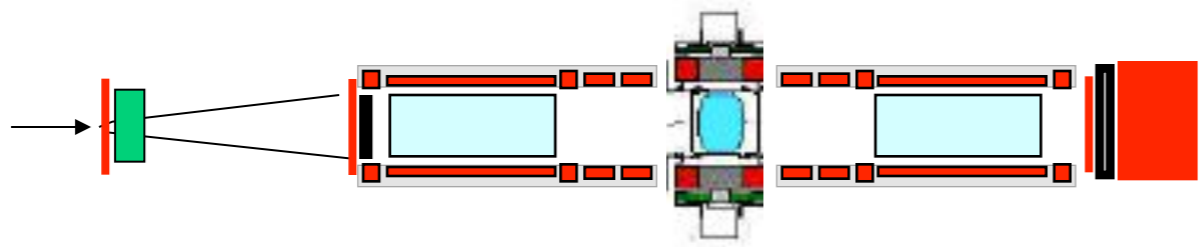


Run date: 



STEP I

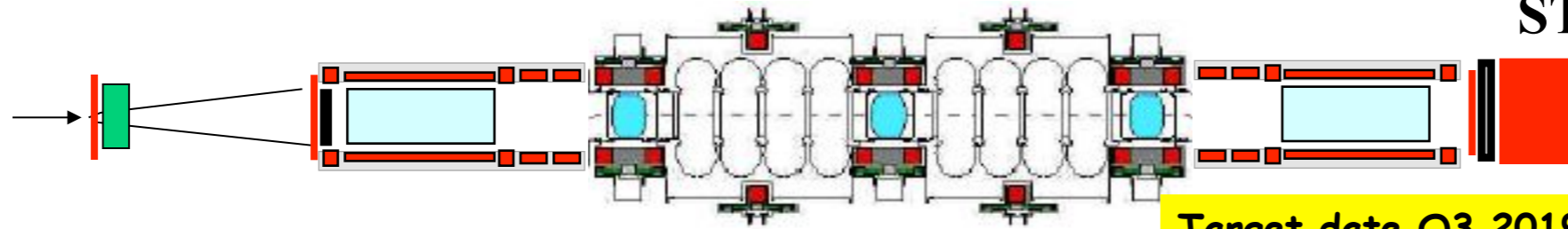
EMR run Oct 2013



STEP IV

(possibly w/o field: Q2 2014)
Q1 2015 to Q1 2016

Under construction:



STEP VI

Target date Q3 2019
Step V run possible 2018

Resource Loaded Schedule -- MIPO's hard work!

Steps of MICE



μ

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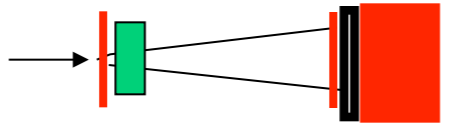


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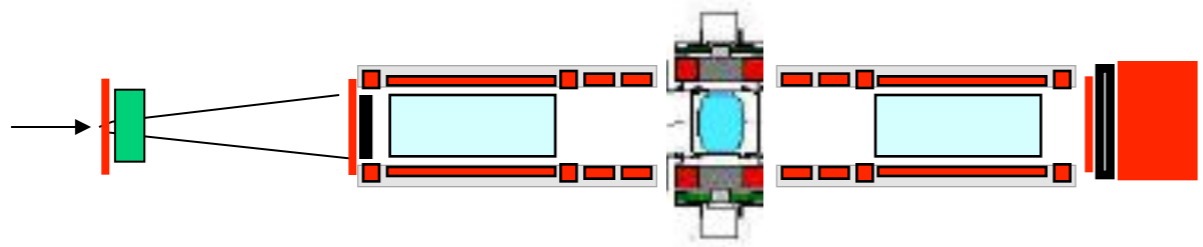
STEP I



STEP IV

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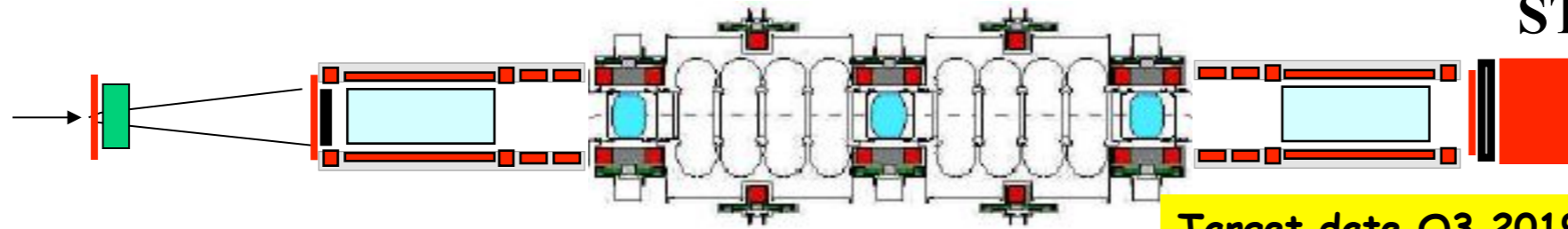
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Under construction:

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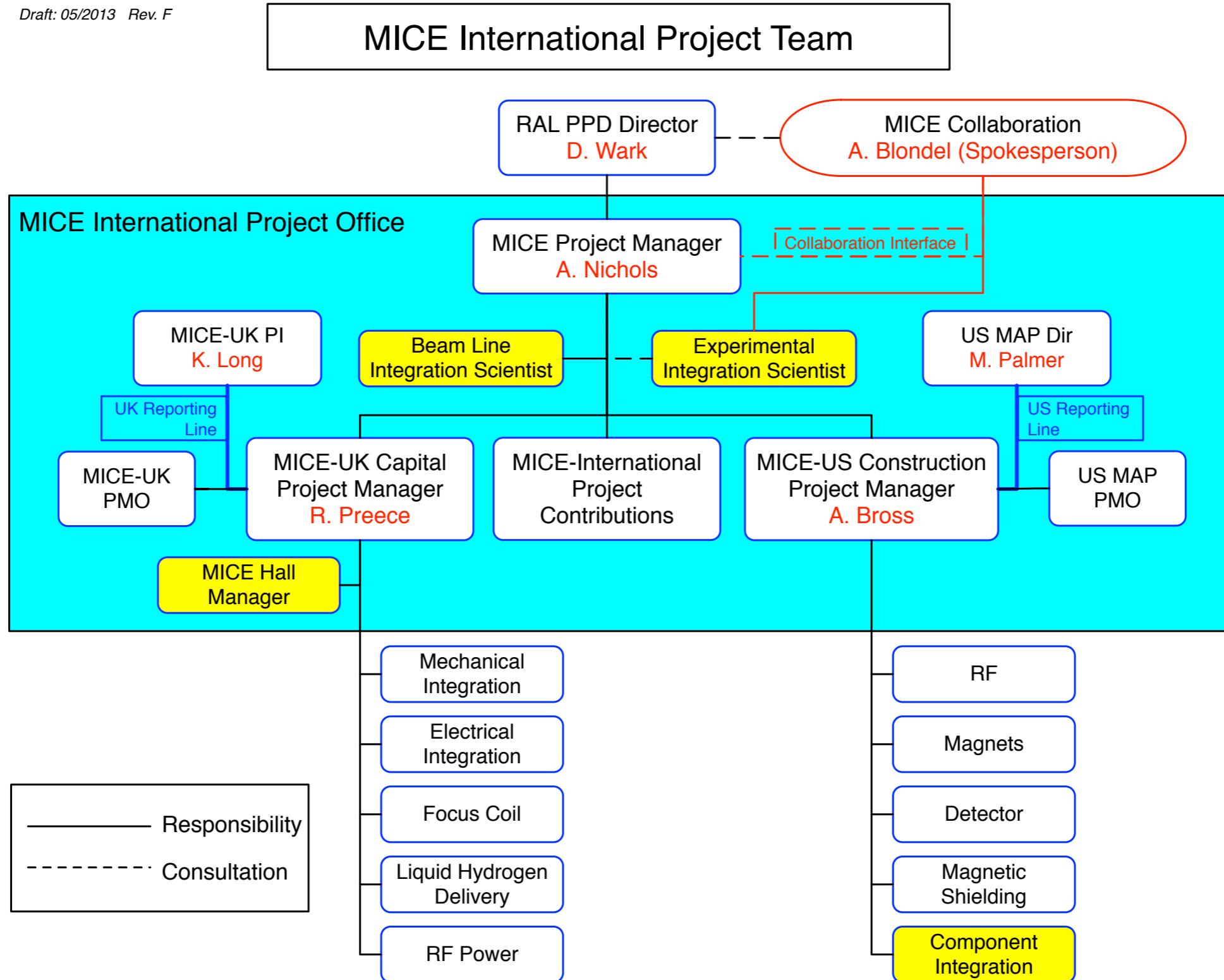
Resource Loaded Schedule -- MIPO's hard work!

I Want My Maypo!



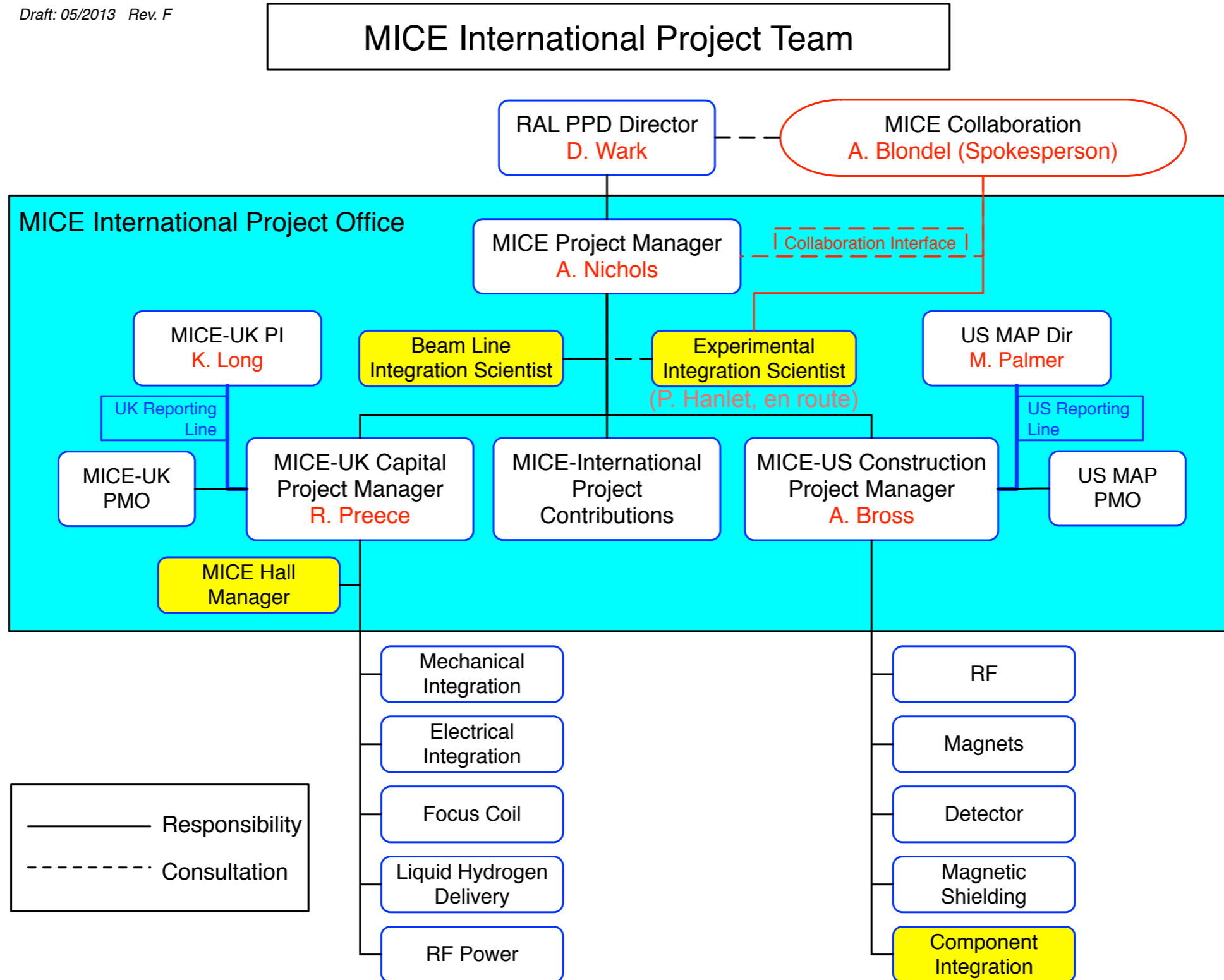
I Want My MIPO!

Draft: 05/2013 Rev. F



I Want My MIPO!

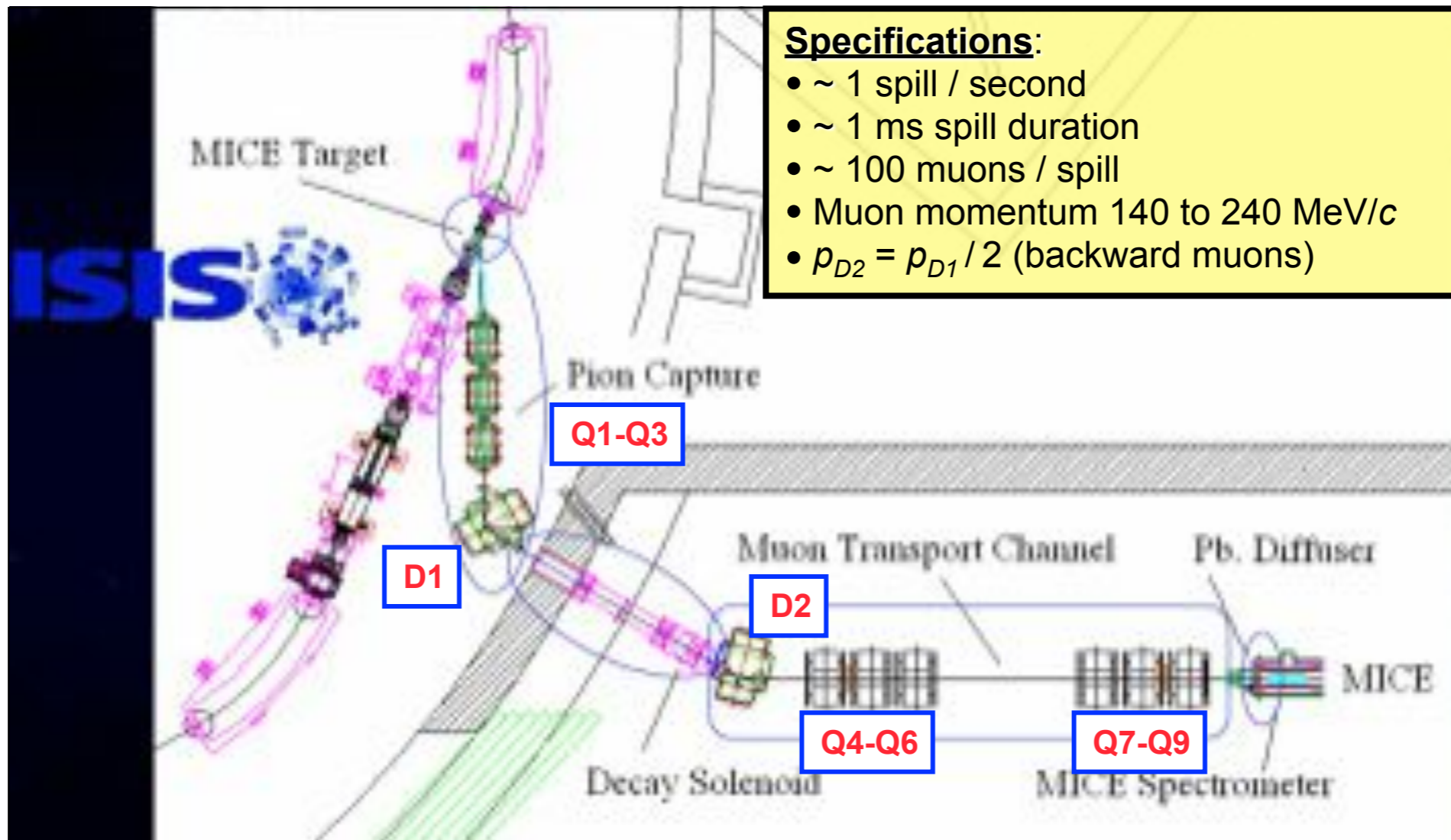
Draft: 05/2013 Rev. F



MICE Beamline

[RAL]

- Installed 2007–8



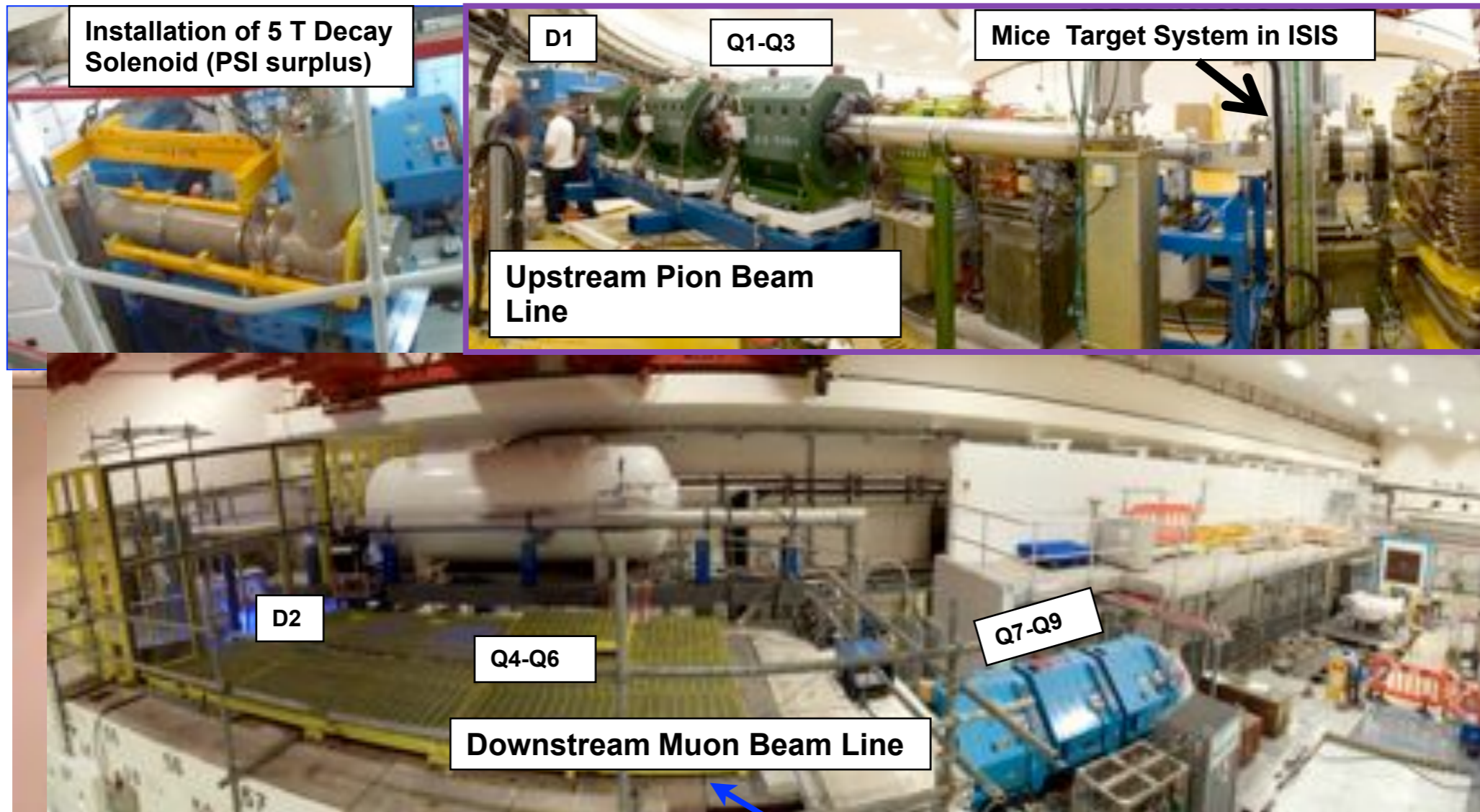
- Works well

see M. Bogomilov *et al.*, JINST 7 (2012) P05009

MICE Beamline

[RAL]

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- Works well

see M. Bogomilov *et al.*, JINST 7 (2012) P05009

Decay Solenoid Area (DSA)
– shielded against possible neutron spray from ISIS



Detectors & Performance



MICE Particle ID



- Need to suppress (to $< 10^{-3}$ level) undecayed π in beam & decay electrons
- Performed using
 - 3 sets of TOF counters (Milan/Pavia/Geneva/Sofia),
 - 2 Cherenkov counters (U Miss/IIT/U Iowa)
 - KL sampling EM Calorimeter (Rome III), and
 - Electron-Muon Ranger (Geneva/FNAL/Trieste/Como)



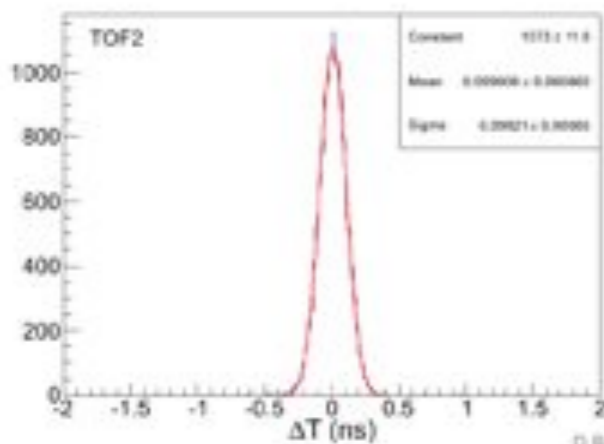
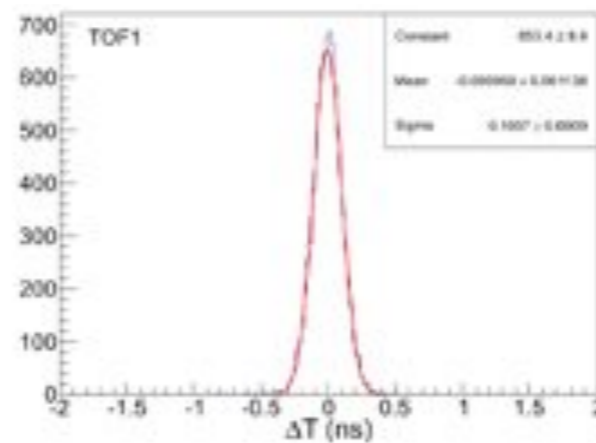
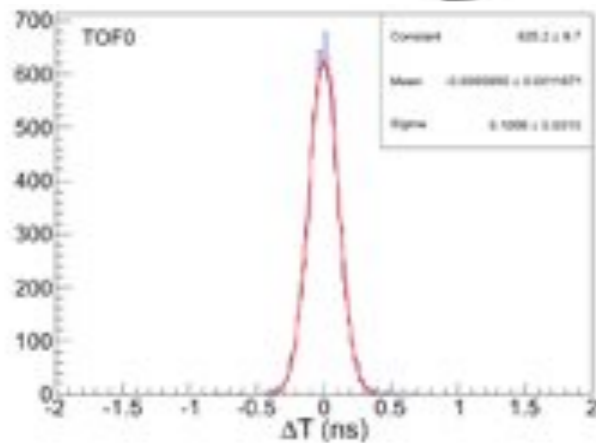
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 - 2 Cherenkov counters (U Miss/IIT/U Iowa) ✓
 - KL sampling EM Calorimeter (Rome III), and ✓
 - Electron-Muon Ranger (Geneva/FNAL/Trieste/Como) due in Sept

Time-of-Flight Counters

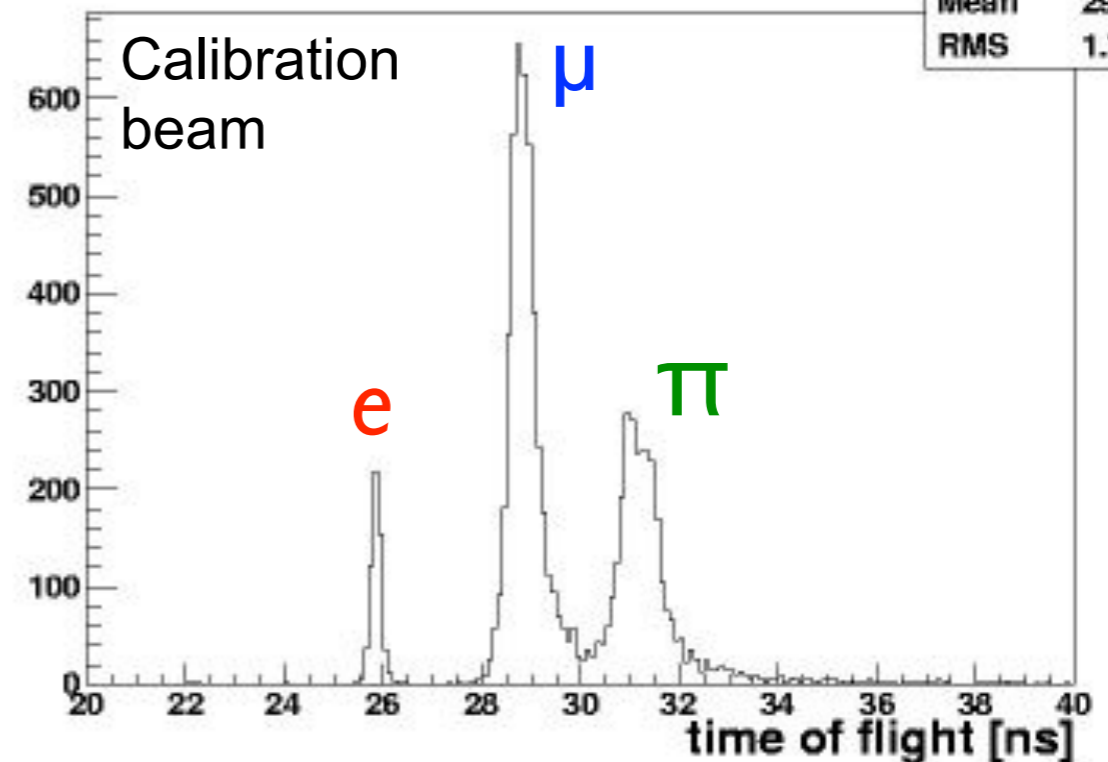
[Milan, Pavia, Geneva, Sofia]



- Resolutions**
- TOF0: 55 ps
 - TOF1: 53 ps (improved)
 - TOF2: 50 ps

D.Rajaram, IIT, 2/9/12

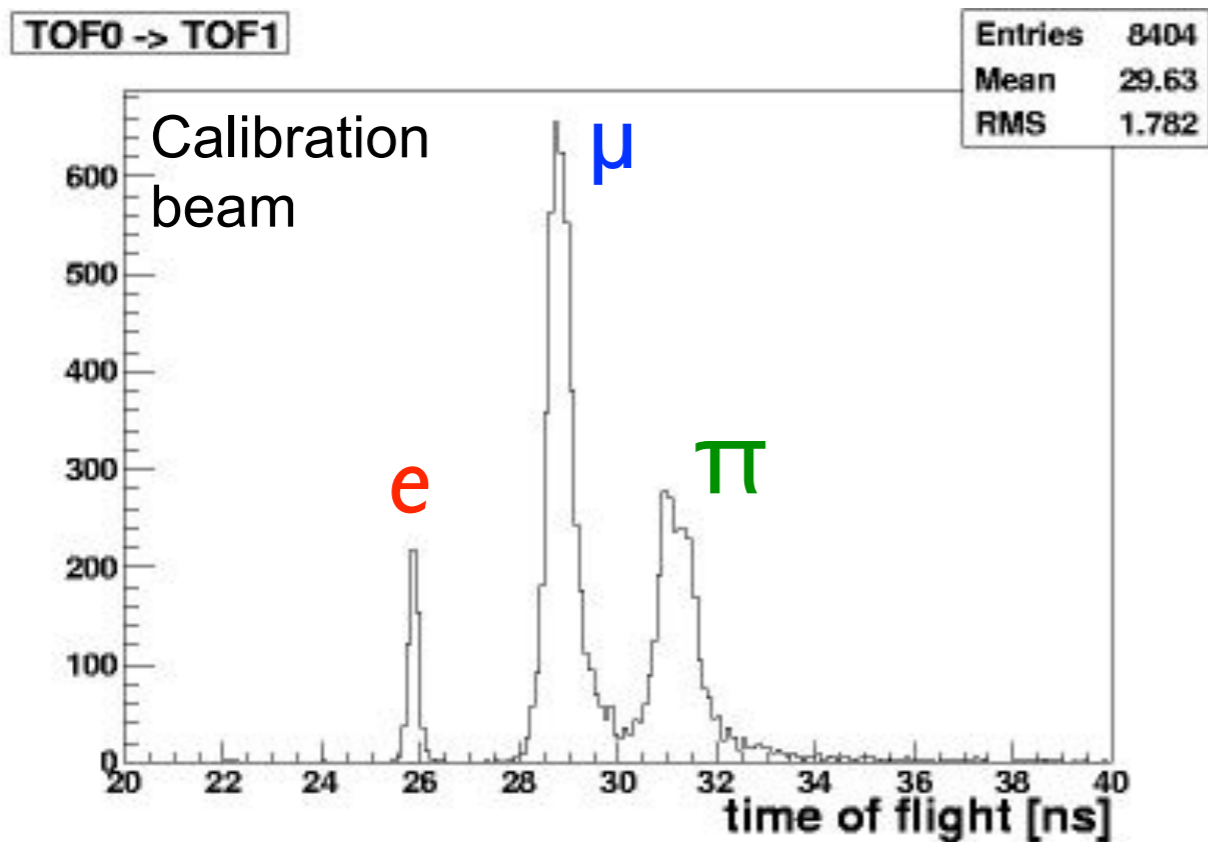
TOF0 -> TOF1



Time-of-Flight Counters

[Milan, Pavia, Geneva, Sofia]

- Setting $p_{D2} = p_{D1}$ gives $\pi/\mu/e$ calibration beam:

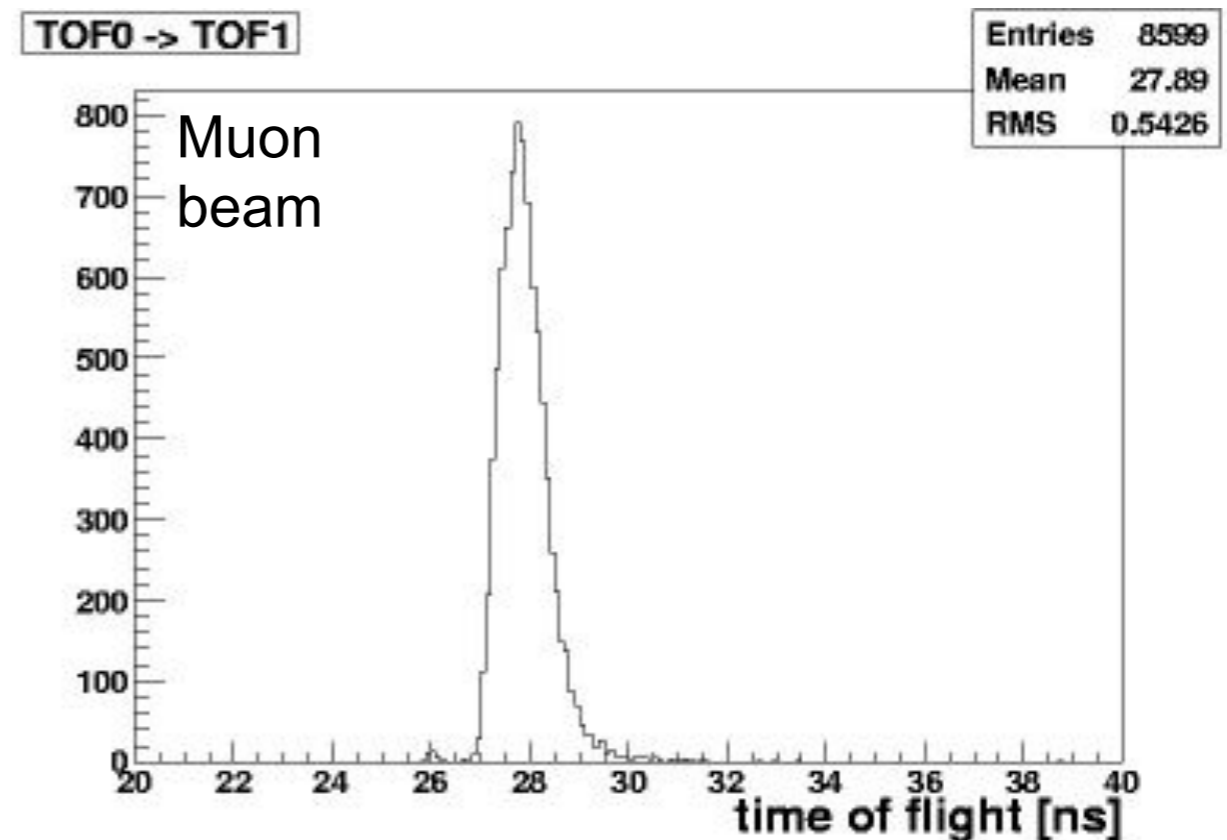
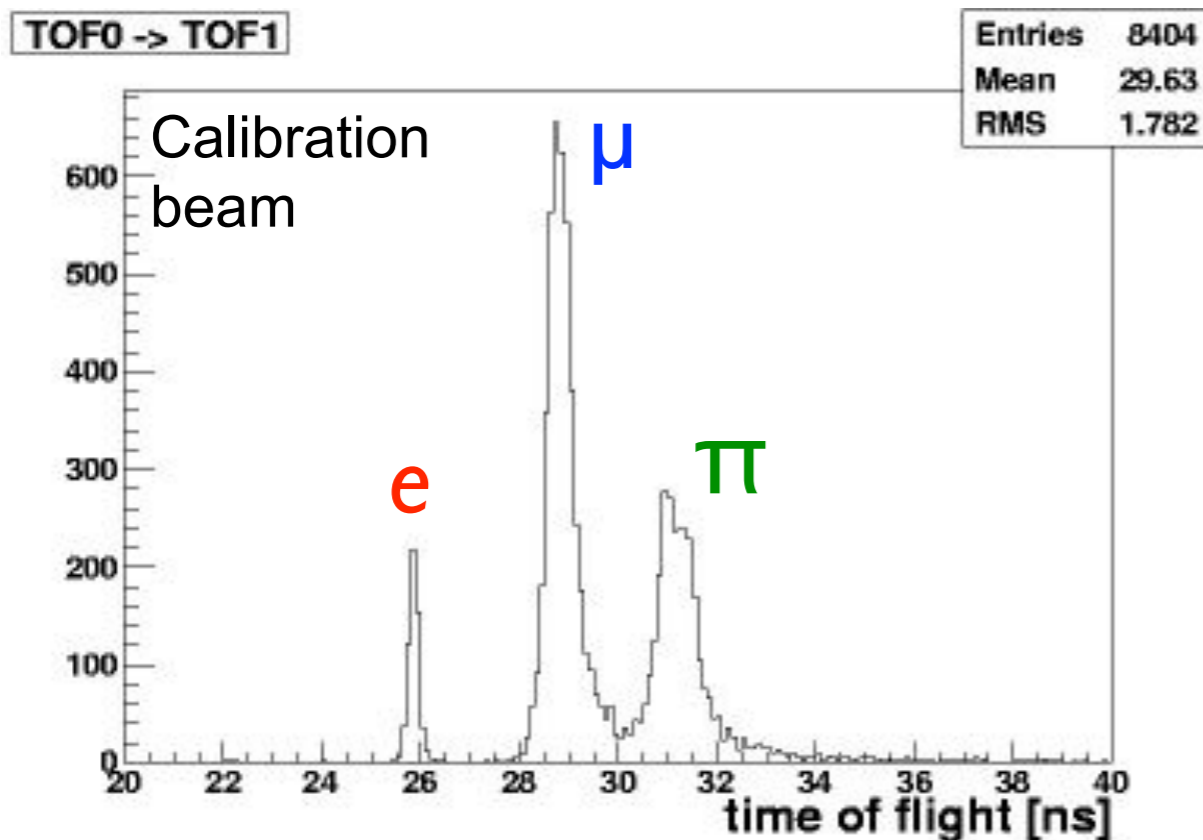


Time-of-Flight Counters

[Milan, Pavia, Geneva, Sofia]

- Setting $p_{D2} = p_{D1}$ gives $\pi/\mu/e$ calibration beam:

- Can select “pure” μ beam by $p_{D2} = 0.5 p_{D1}$:

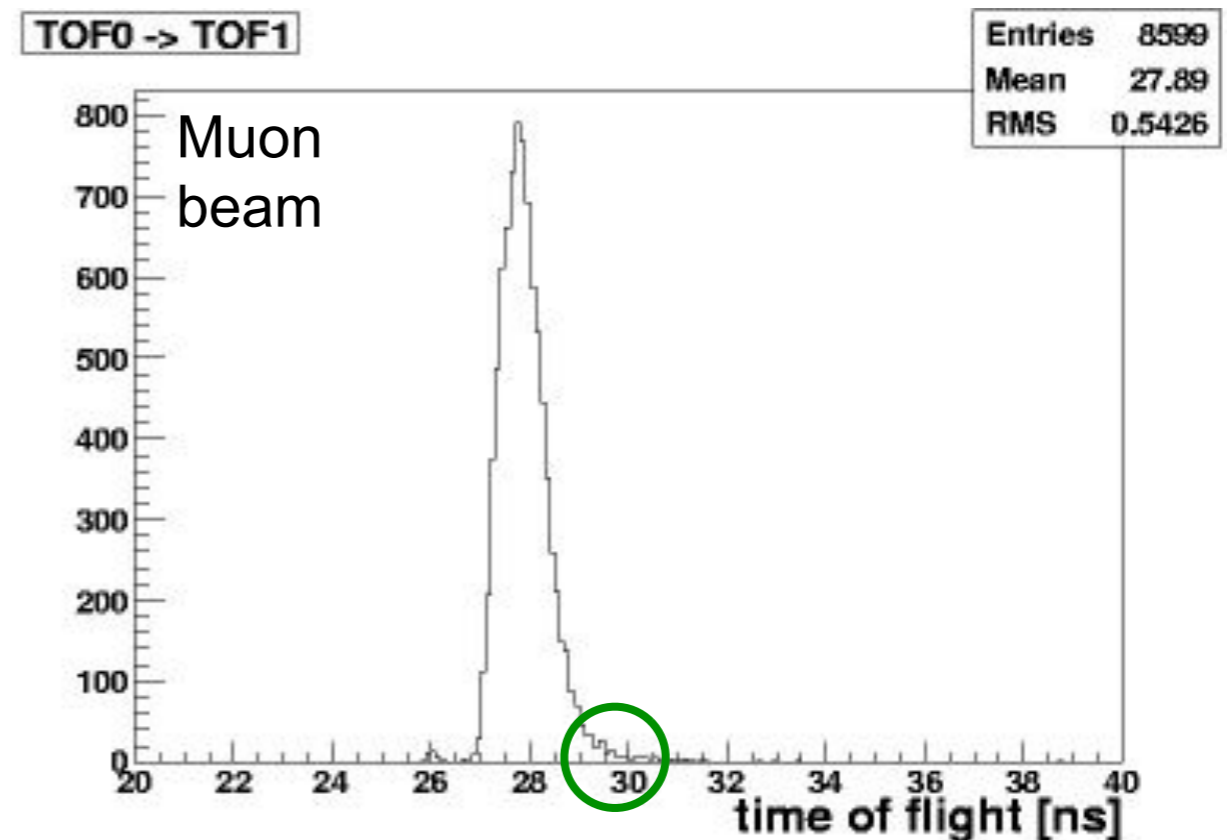
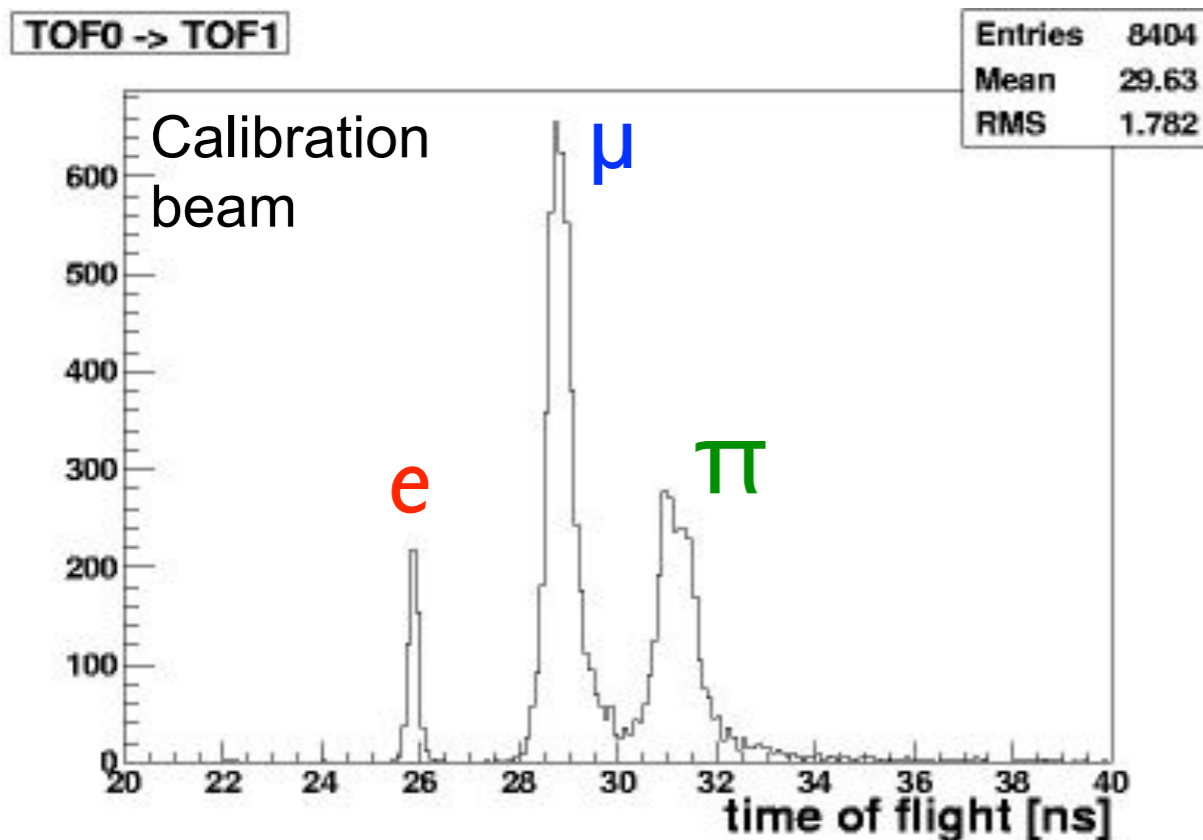


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- $\mathcal{O}(\%)$ residual pions in MICE muon beam (to be suppressed via Cherenkov counters)
 - paper in preparation

TOF Emittance Analysis

- **Emittance analysis without spectrometers**

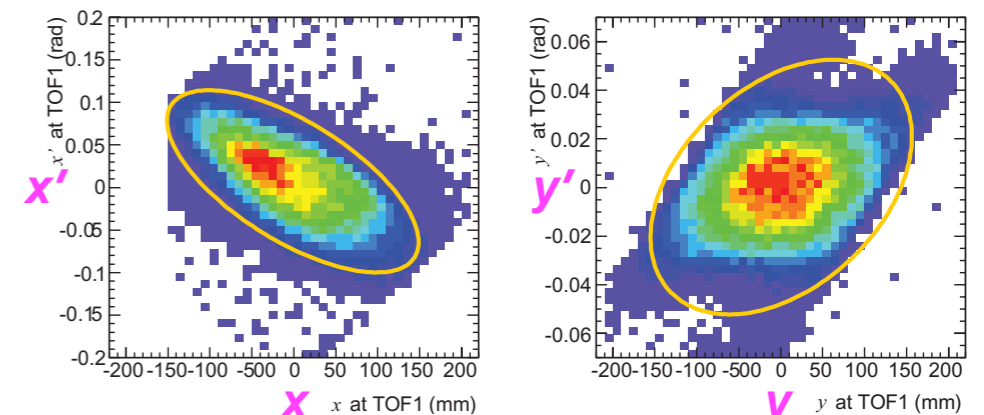
(done because SS delayed):

- PMTs at each end allow position interpolation via Δt to ≈ 1 cm
- TOFs thus measure x' to 18 mrad, y' to 5 mrad, p to $\approx 2\%$
- see D. Adams *et al.*, [arXiv:1306.1509](https://arxiv.org/abs/1306.1509)

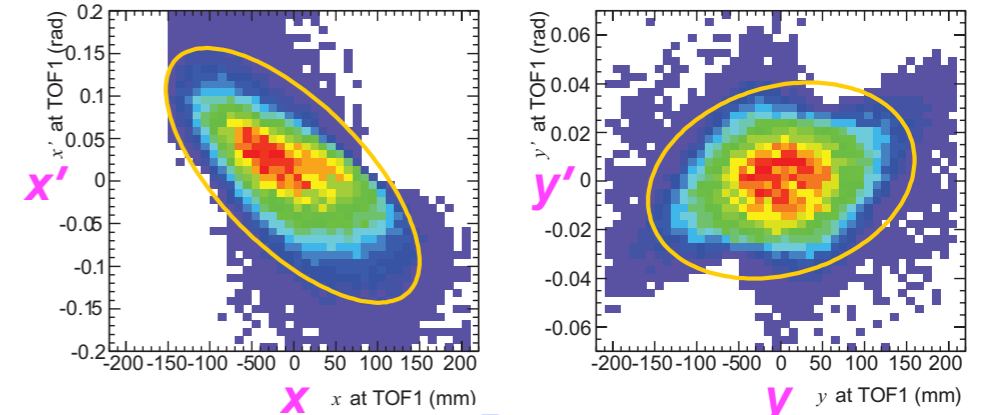
- **Conclusion:** beam well understood and suitable for MICE program

- Submitted for publication in EPJC

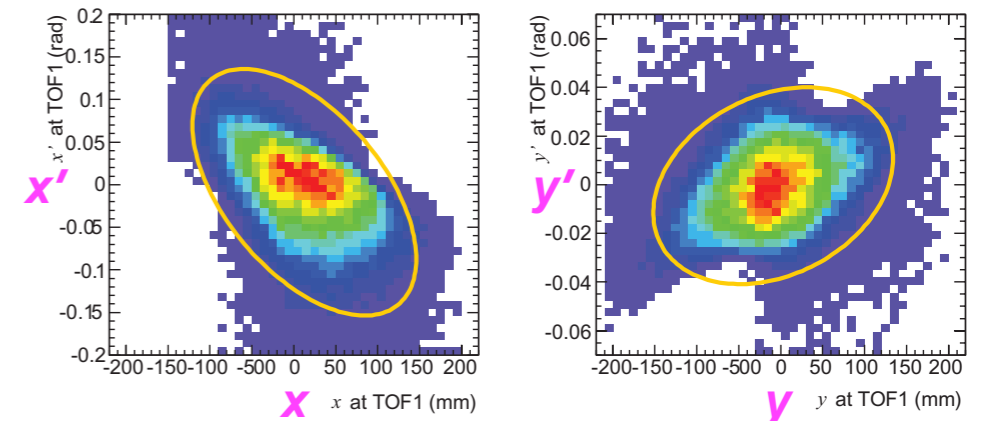
Simulation



Reconstructed Simulation



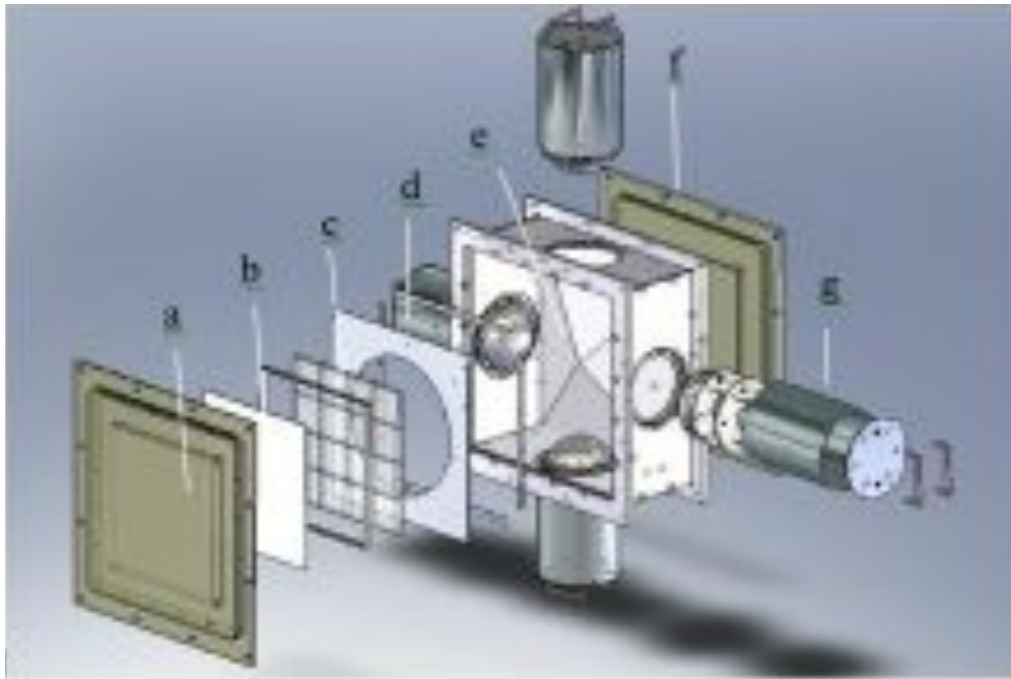
Data



Cherenkov Counters

[U Miss, IIT, U Iowa]

- 2 Cherenkov counters with high- n aerogel radiators:

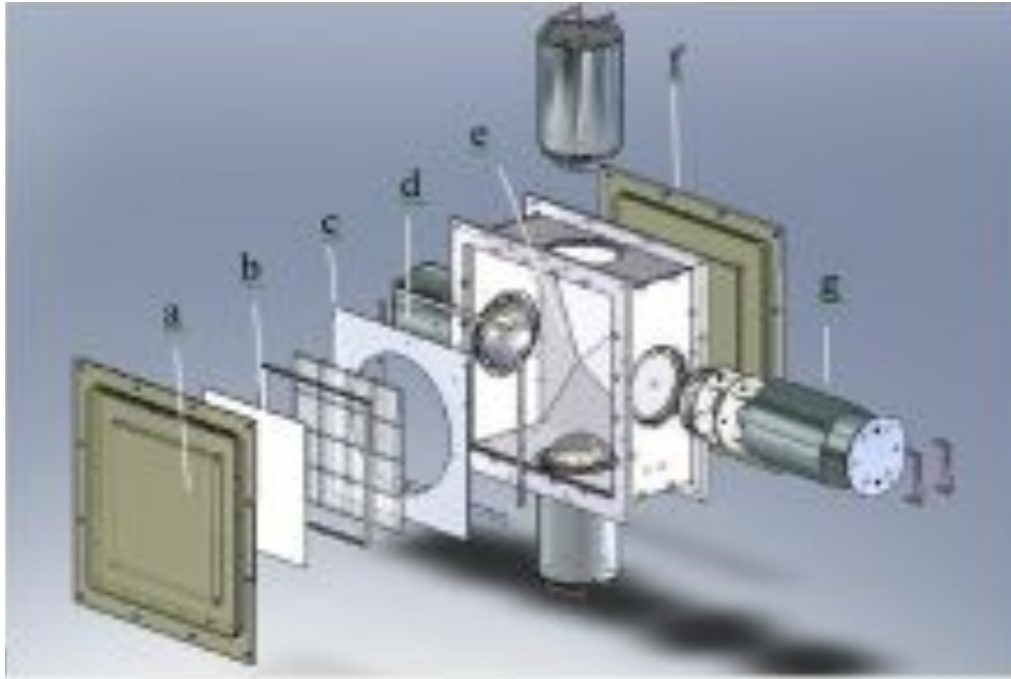


- Located in DSA, downstream of Q9 & TOF0
- 1 GS/s FADC readout
- Software update (MAUS):
in progress

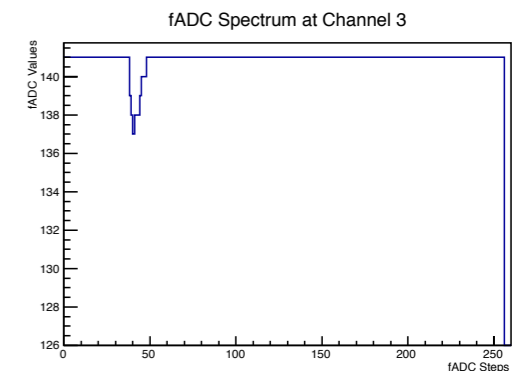
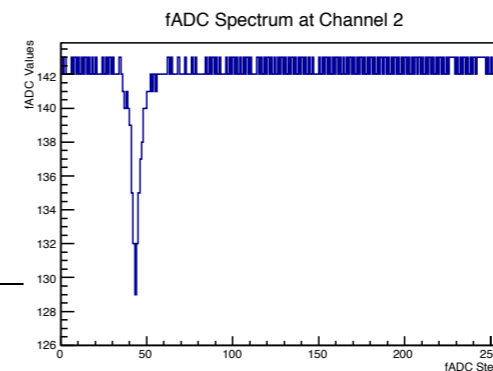
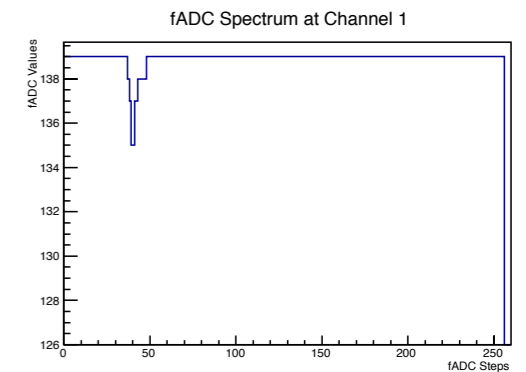
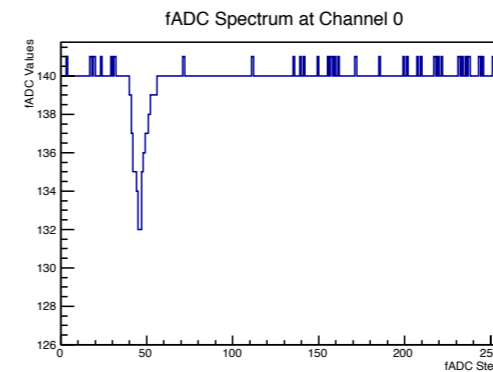
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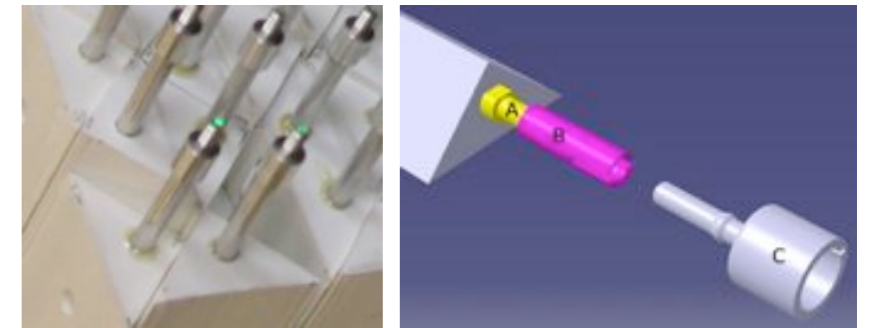
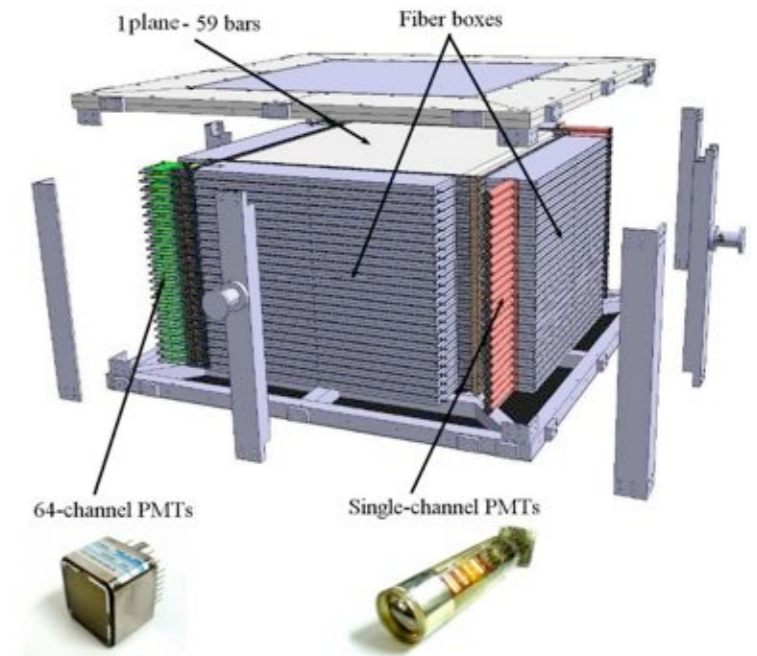
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- Under construction at U Geneva



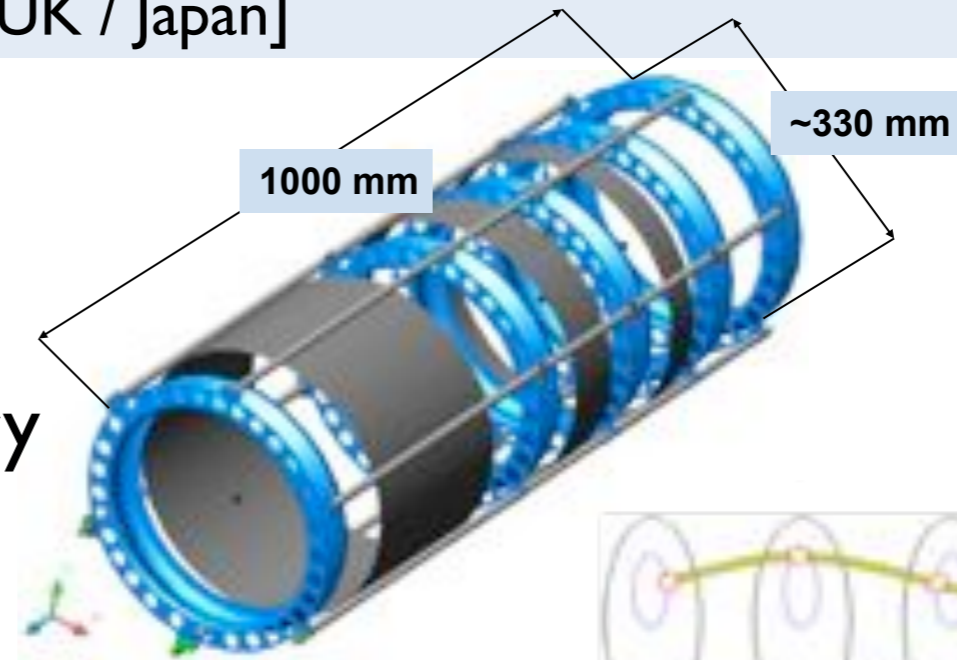
- Prototype already tested at MICE
- To be delivered & installed in Sept., commissioned with beam Oct.



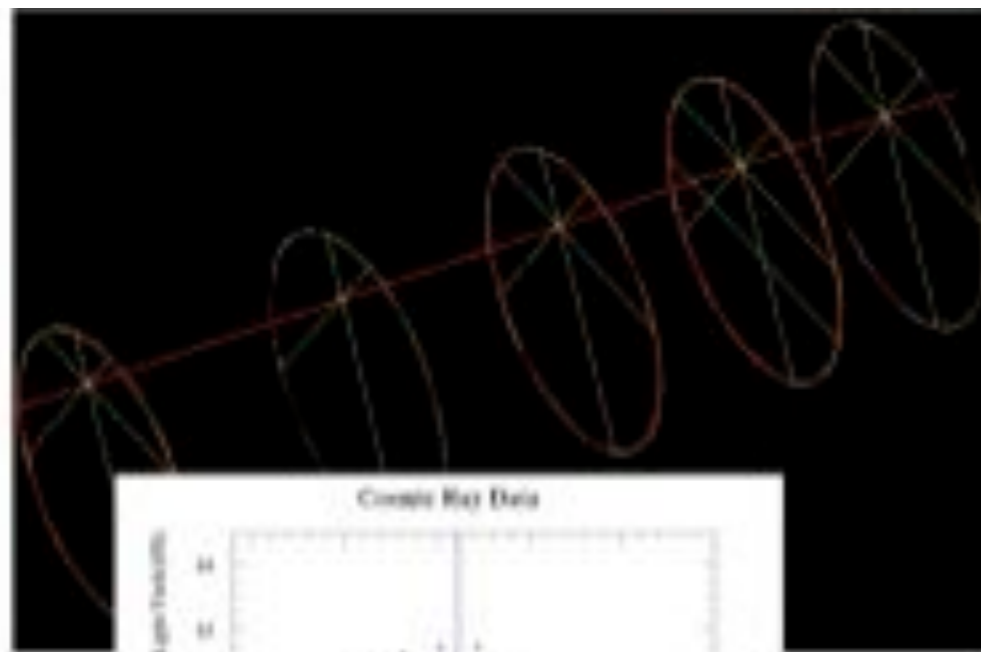
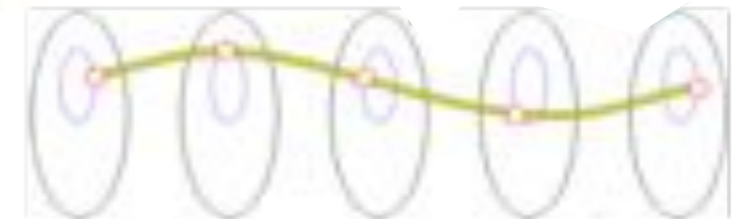
SciFi Spectrometers

[US / UK / Japan]

- Trackers complete & tested with cosmic rays
 - installation awaiting SS delivery



5 stations of 350 μm SciFi



← Typical cosmic track

← Light yield ≈ 10 p.e.



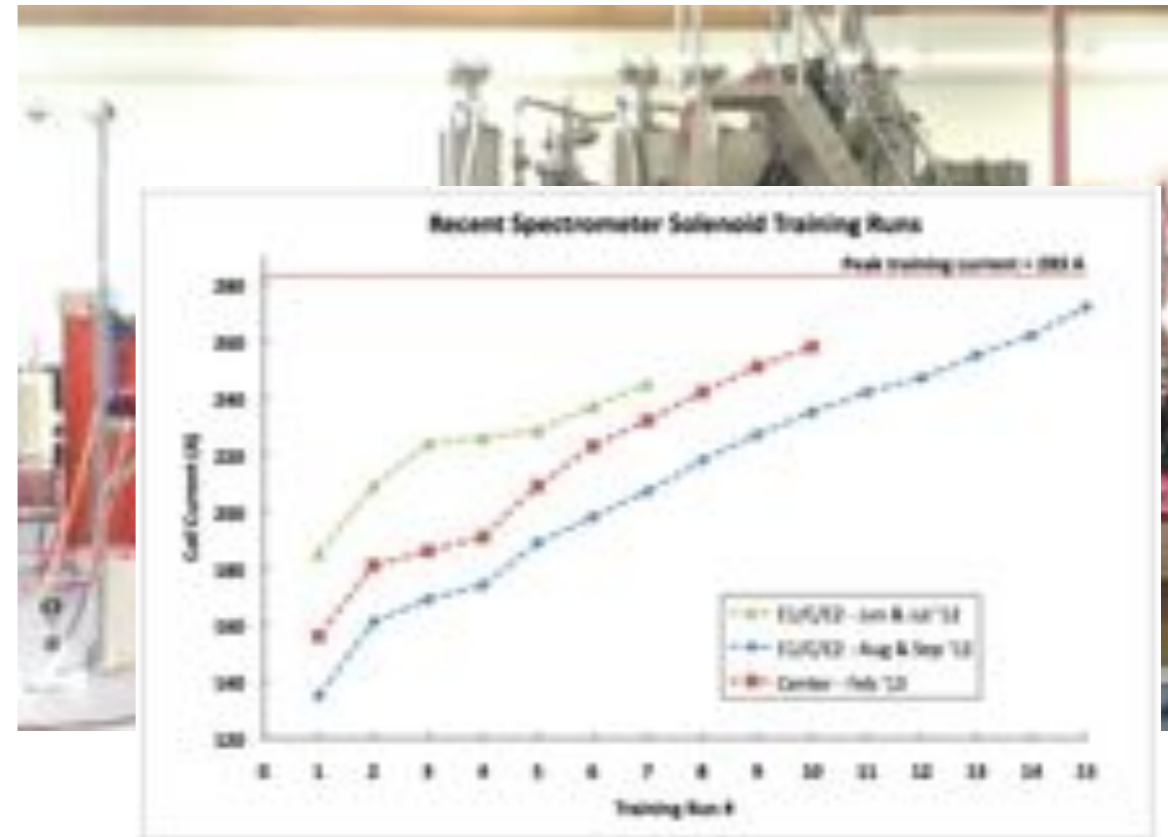


Other Components

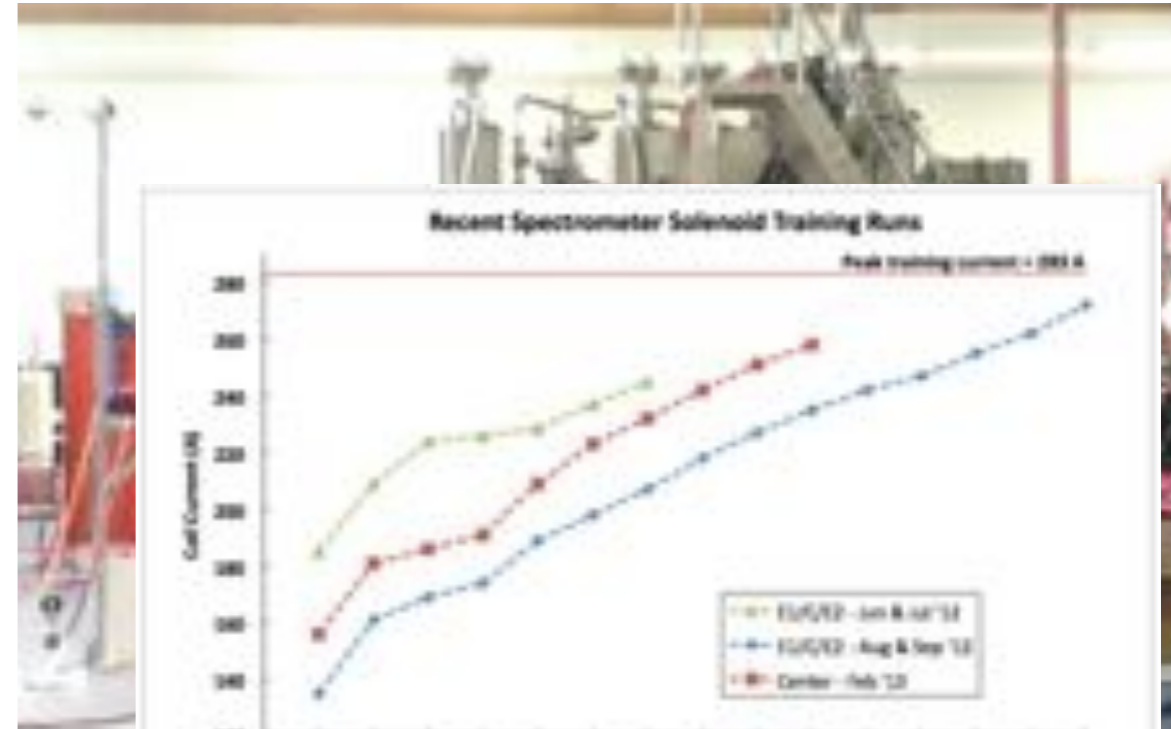
- US provides SS & CC magnets
 - 1st SS trained & mapped, shipping soon
 - 2nd soon ready for training
- UK providing FC – status:
 - 1st FC completed, successful training in solenoid mode
 - flip-mode training problematic?
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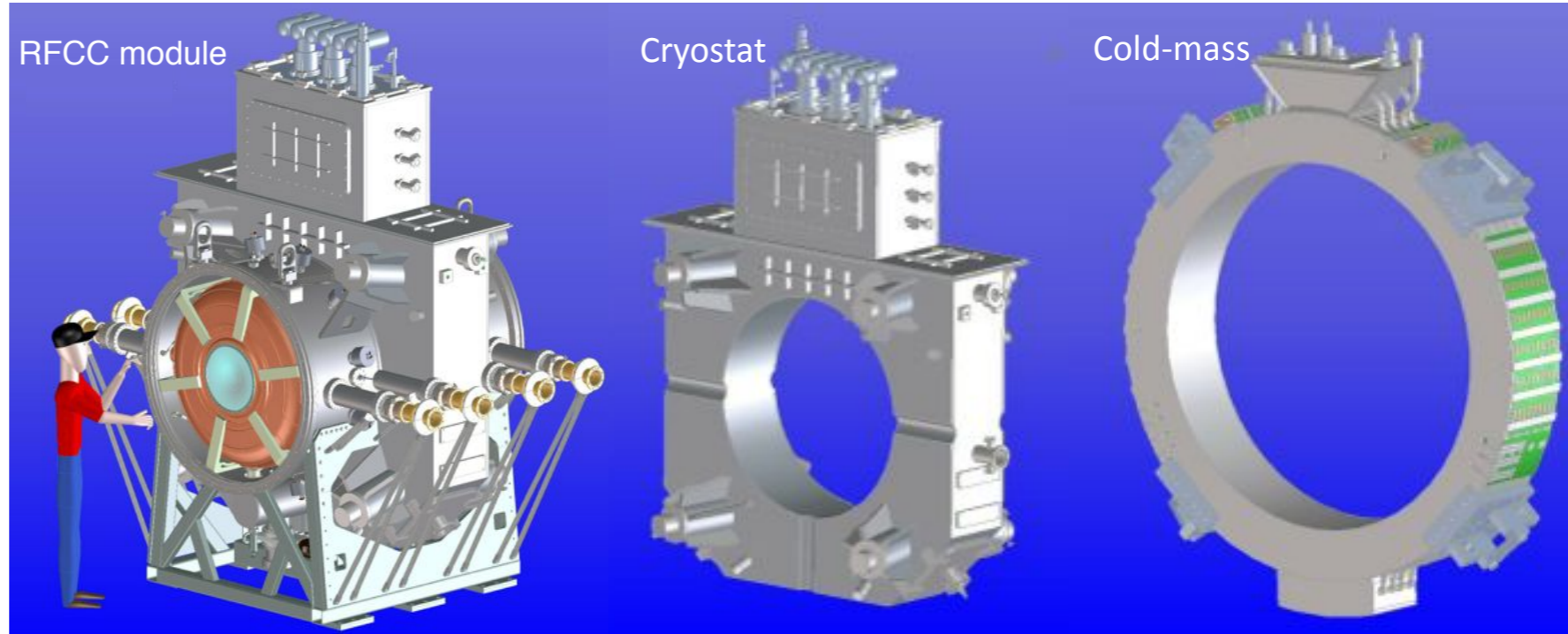
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RFCC Modules

[LBNL, HIT, U Miss]

- Design \approx done
- RF cavities built
 - 1st cavity at FNAL for MTA tests
 - much work on couplers, tuners & assembly procedure
- Coupling Coil fab in China (HIT, Qi Huan, SINAP) led by LBNL
 - 1st CC cold mass delivered, test at FNAL STF
 - working on cryogenics issues

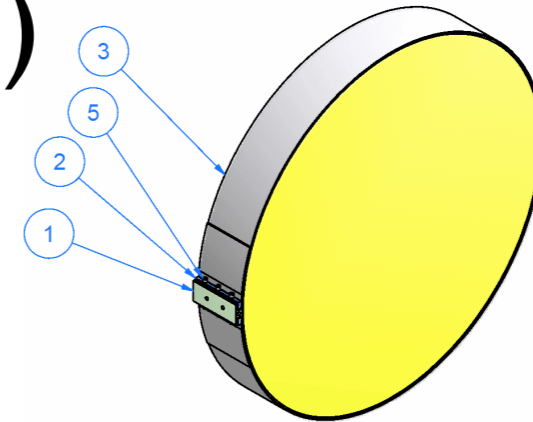


LiH Absorbers

[FNAL]

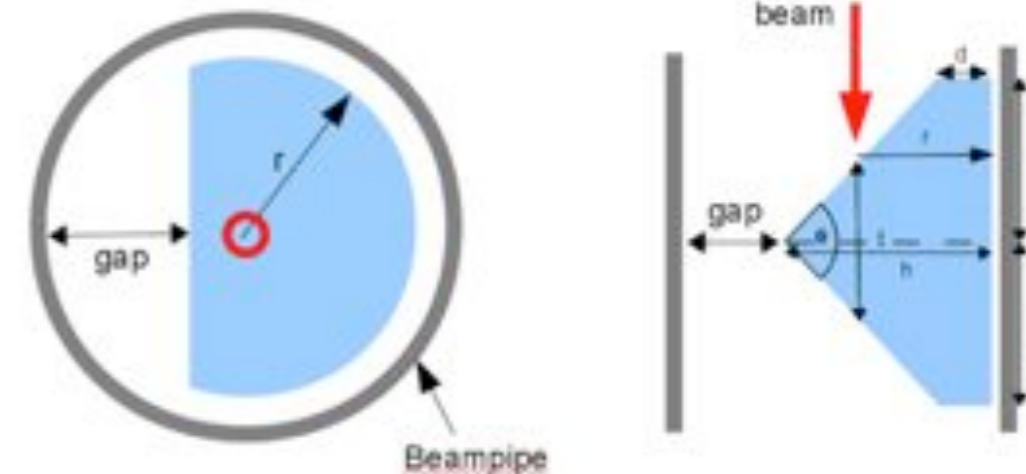
- Fabrication at Y12 (Oak Ridge)

- both disks and wedges ordered
- disks done, awaiting approvals for delivery to RAL (CRADA with STFC)



- Other solid absorbers also under consideration:

- C, Al, polyethylene,...



LiH Absorbers

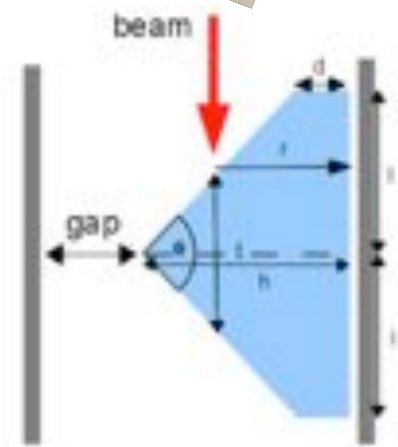
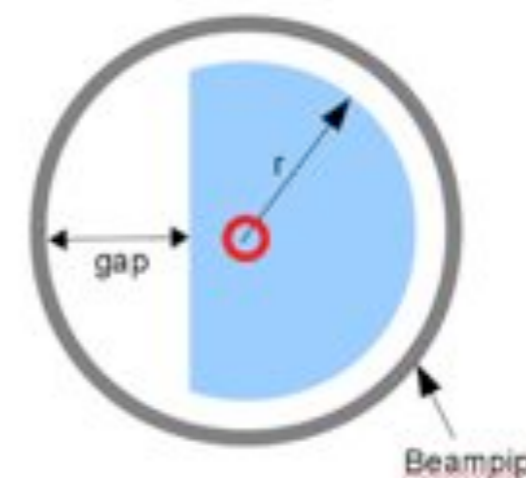
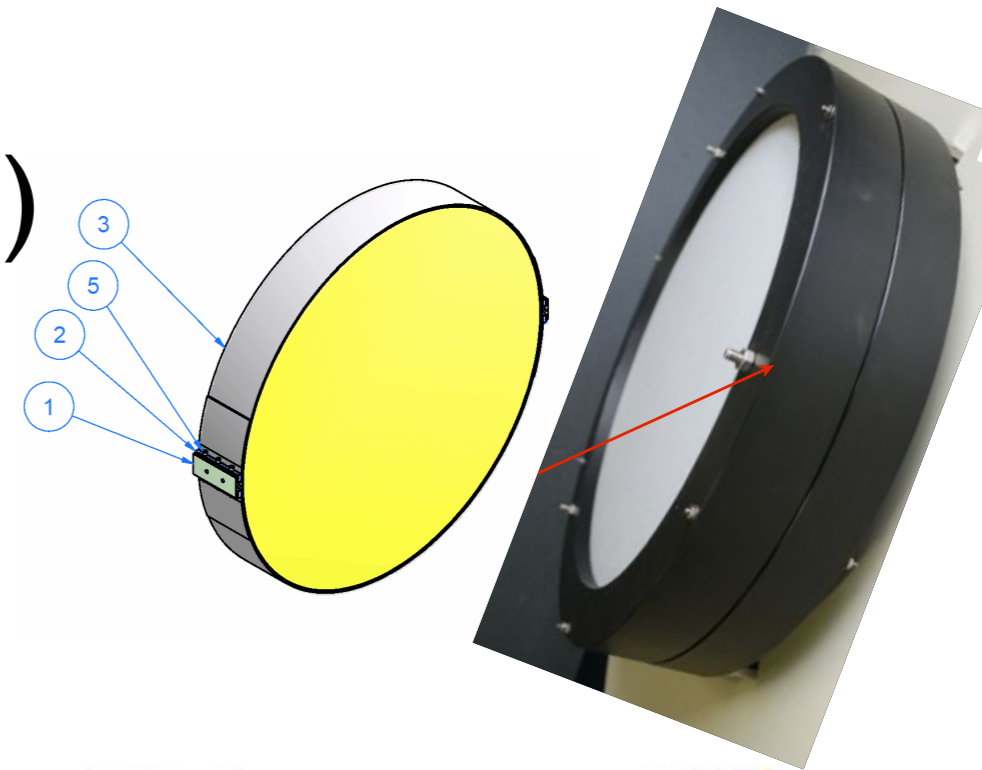
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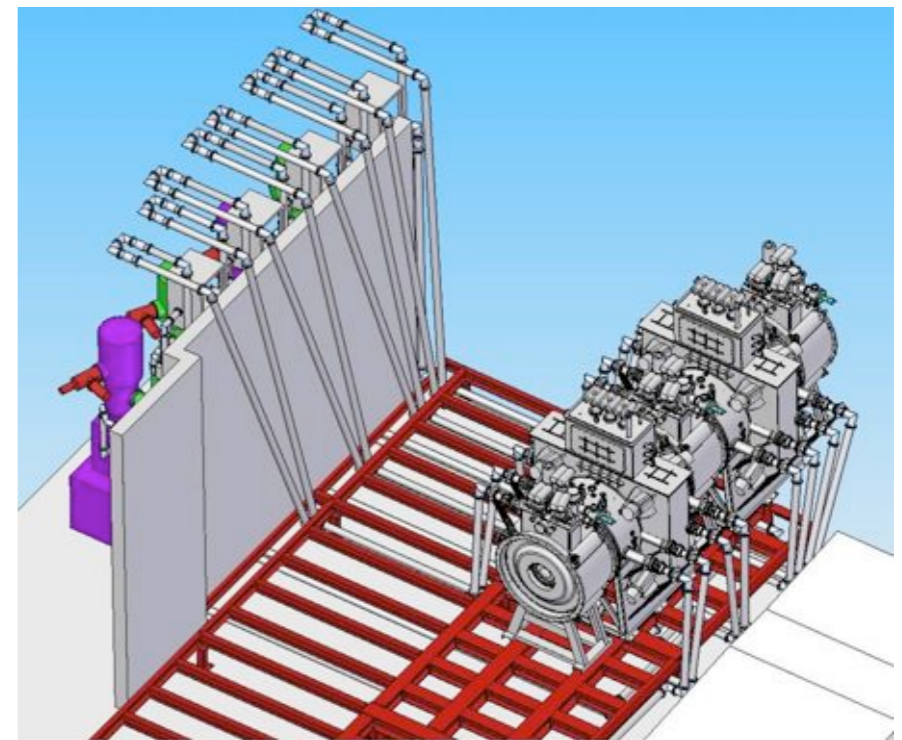
- C, Al, polyethylene,...



RF Power

[DL, LBNL, U Miss, U Strathclyde]

- 4 used 2 MW triode supplies
 - 2 from LBNL, 2 from CERN
 - refurbishment in progress at DL
 - as of CM36, 1st tested at 1 MW
 - crowbar circuit improvements were needed for 2 MW test
- Installation plan devised
- LLRF design in progress
- TIARA test this year



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 - refurbishment in progress at DL
 - as of CM36, 1st tested at 1 MW



! NEWS FLASH !

Begin forwarded message:

From: Andrew Moss <andrew.moss@STFC.AC.UK>

Subject: Re: Fwd: 1.5 Megawatt

Date: July 5, 2013 5:03:24 PM CDT

To: MICE-RF-POWER@JISCMAIL.AC.UK

Reply-To: MICE RF power distribution system <MICE-RF-POWER@JISCMAIL.AC.UK>

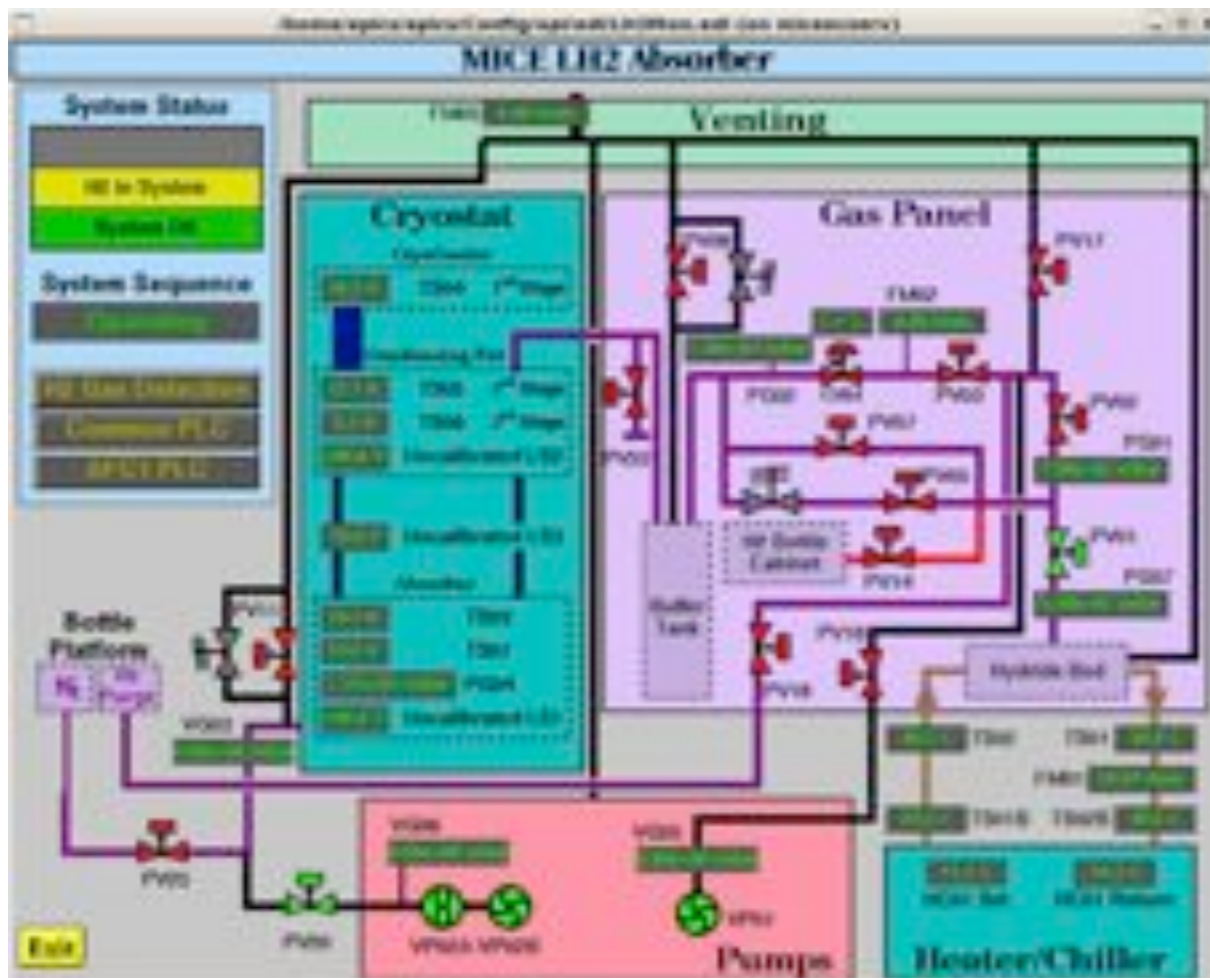
2MW from mice amplifier

Andy

Sent from my Windows Phone



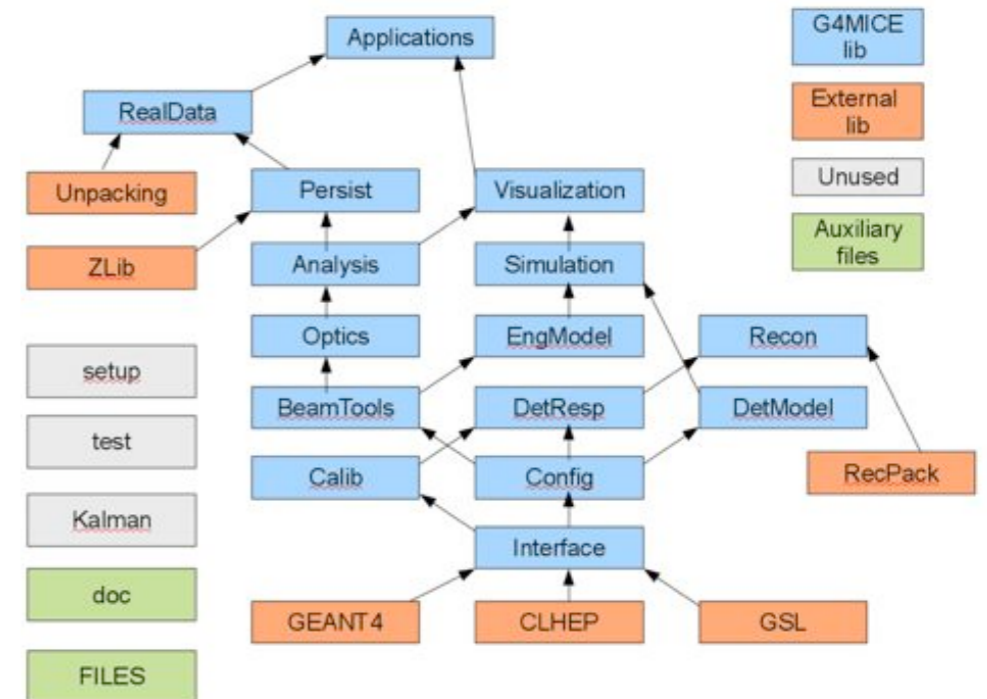
- Liquid-hydrogen system successfully tested
 - uses hydride-bed H₂ storage



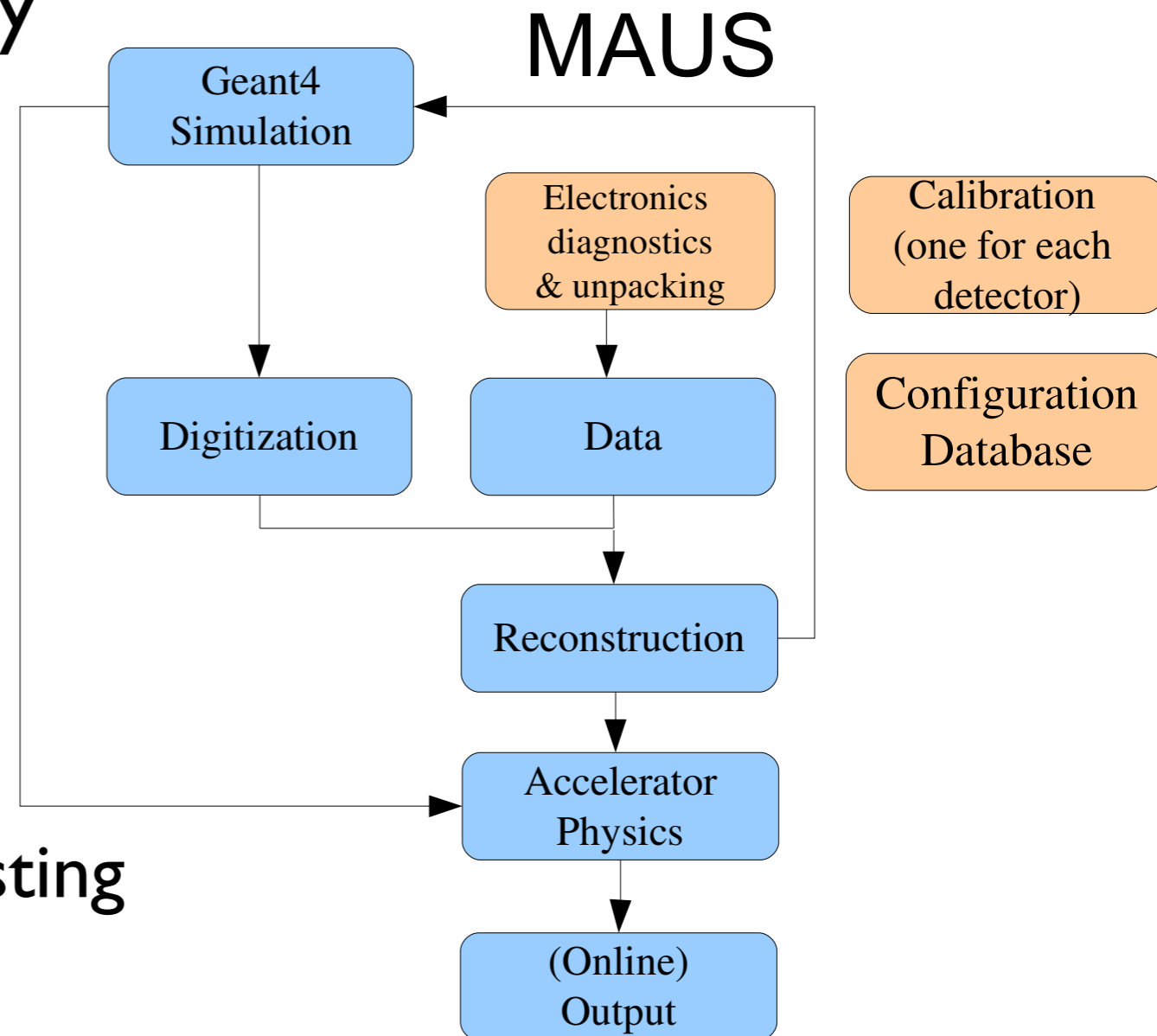
MICE Software

- G4MICE developed initially by Y.Torun (IIT)

G4MICE



- G4MICE developed initially by Y.Torun (IIT)
- Succeeded by MAUS (MICE Analysis User Software) framework
 - simplifies maintenance & use
 - strong emphasis on good documentation & thorough testing
 - making good progress but not all there yet



○ much to be done to be ready for Step IV!



B-Field Mitigation



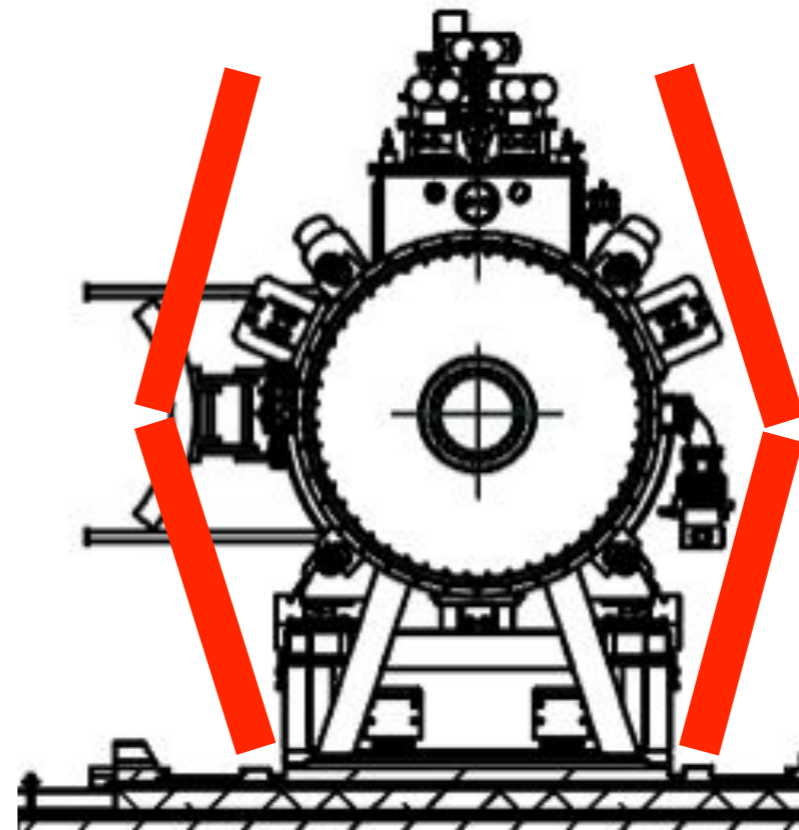
- 2 concepts:
 - partial return yoke (PRY)
 - suppress the fringe field at its source
 - “local” shielding
 - shield (or move) each sensitive component
- PRY currently seems favored
 - local solution may be riskier: hard to identify all sensitive devices & assess their degree of sensitivity
 - SS delay leaves more time for PRY implementation

B-Field Mitigation

Concept

BROOKHAVEN
NATIONAL LABORATORY

- Partial Return Yoke (a.k.a. “shield”, PRY?)
- Concept presented at MICE CM 2012
- Shielding plates
 - wall thickness >10 cm
 - weight: 35t
- Performance
 - Reduces stray field outside of shield to 5-10 Gauss



H Witte. Step IV & VI: Local Flux Return.
MICE CM 34, October 2012.

(Note: not to scale)

July 25, 13

3

- Engineering continues; review & decide in Sept.

B-Field Mitigation

- Review panel selected:

Tom Taylor, CERN - Chair (limited to 23/24th Sept) or 1/2nd October

Jim Clarke, AsTec - magnet group Division Head, (alternative chair to above)

Mark Hatch, CERN - experience of integration, services and safety in ATLAS

Ken Bell, STFC - Experience of CMS field mitigation problem on electronics and hardware

John Thomasson, STFC - newly appointed Head of ISIS Accelerator Division, replacing David Findlay

Mike Glover, STFC - Head of ISIS Electrical engineering

Martin Hughes, STFC - experience of ISIS electronics hardware

Vladimir Kashikin, FNAL - S/C magnet expert



MICE Outlook



- Beefing up
 - construction management: MIPO
 - & support staff: two integration scientists
- ... to focus on Step IV readiness
- Equipment coming together (SSs, AFCs, RFCCs...)
 - but there's a long road ahead!
 - to complete Step IV (proof of principle) by 2016
 - & Step VI (thorough study of transverse cooling) by 2020
 - with first cooling demo/MC validation in 2015
 - & first demo of 6D cooling (Step IV.1)
 - & possibly Step V in 2018



Upcoming meetings

(Alain's summary)



Upcoming MICE VCs

Thursdays:

11 July

8 August

5 September

Will feature magnetic mitigation issues in high place

10 October

Next collaboration meeting 6-8 November (dates confirmed)

Can have a software workshop 4-5 November.

-- 13 November RLSR

-- 14 November MPB

-- 15 November FAC