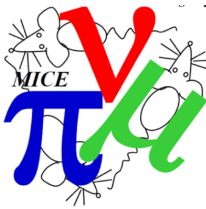


# **Tuning the MICE muon beam**

CM47

P. Franchini

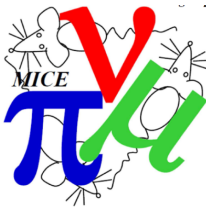
2<sup>nd</sup> February 2017



# Beamline definition

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- MC (G4BL) is not sufficient to model the beamline in order to define the magnets currents for a matched beam
- E.g. usually the momentum delivered in the beamline is lower than the simulated one
- Moreover the Twiss parameters delivered upstream of the cooling channel do not correspond to a matched beam (as expected from the MC)



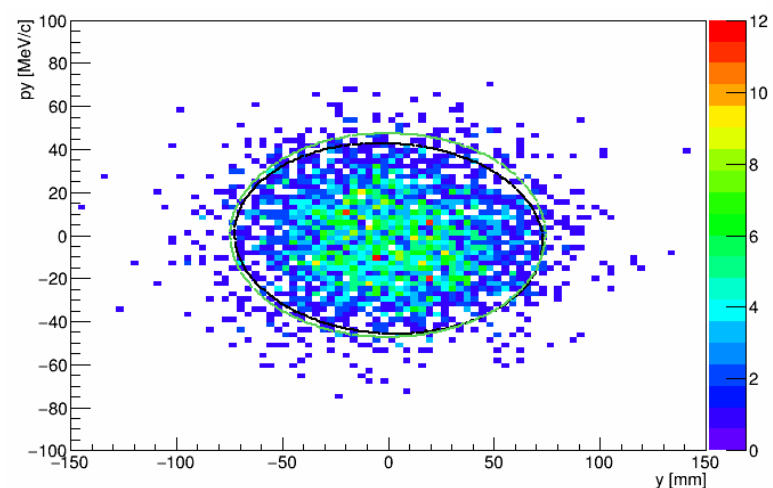
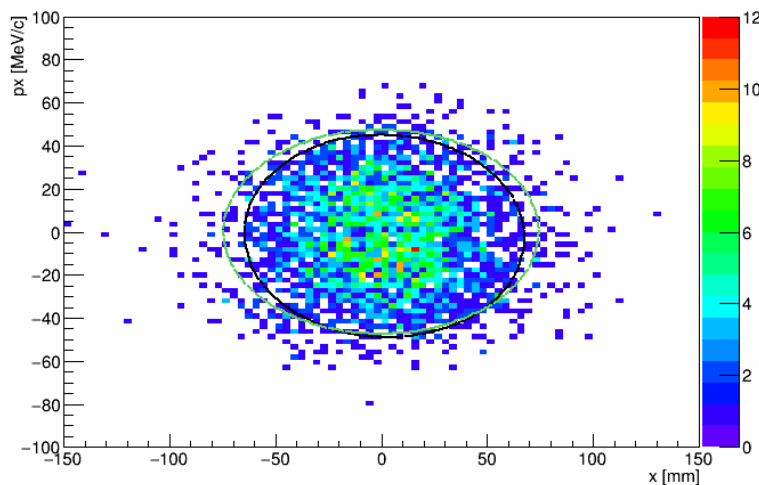
# Optimization procedure

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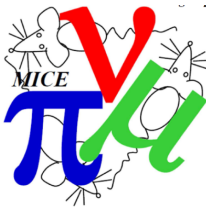
- Taking advantage of the beam time available, the optimization has been done directly using the data in the Control Room:
  - Use of different **diffusers** combinations to match the beta function and the emittance
  - Tune of the momentum using dipole **D1**
  - Scan of the last 3 quadrupoles: **Q7/Q8/Q9**
  - Transverse position of the beam using dipole **D2**

# Optimization

- Attempts to match the beam ad-hoc for several cooling channel settings
  - 3, 6 and 10 mm emittance
  - 140, 200 and 240 MeV/c
- We were not able to get a matched beam without the diffuser
- Example: 6-140



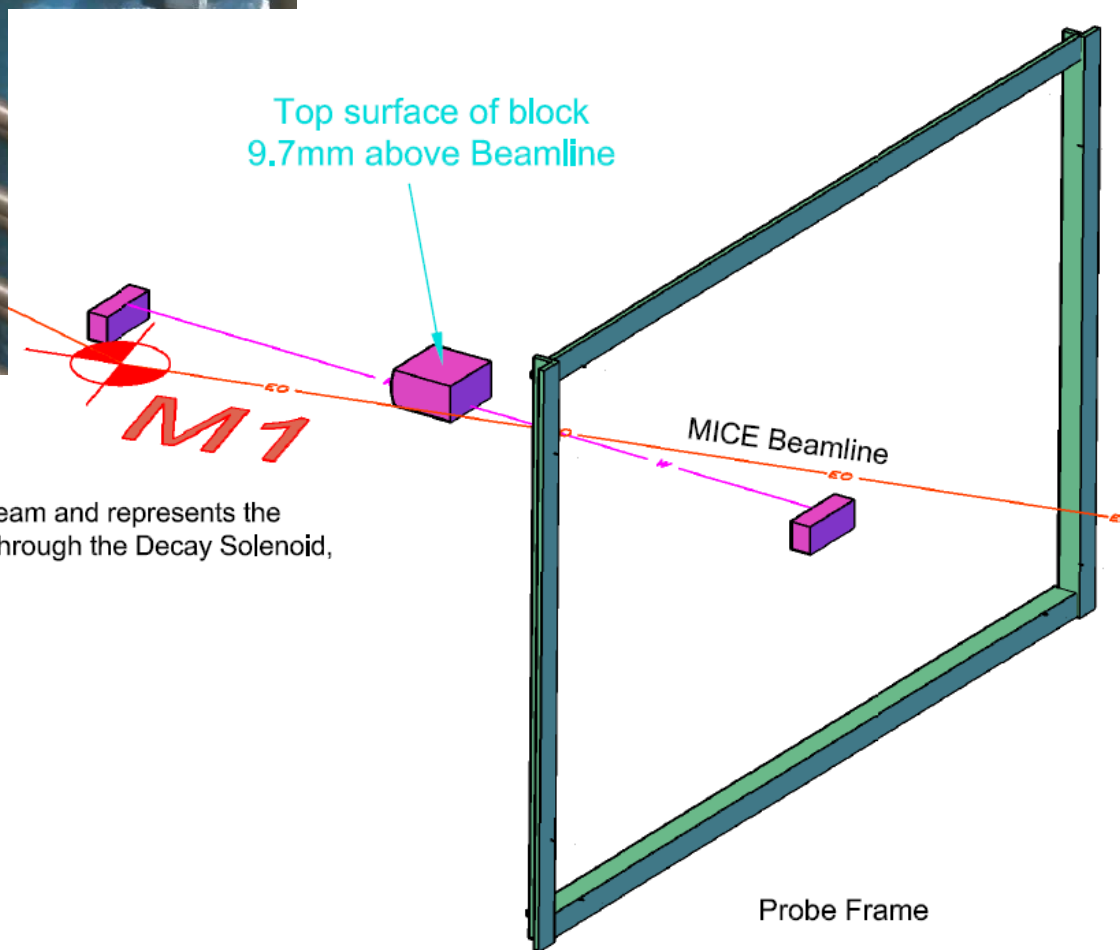
**Black** ellipse = measured  
**Green** ellipse = target



# Dipole field measurement

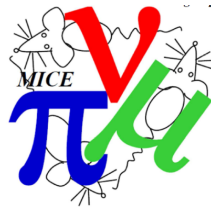
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- D2 is a Nimrod 6" Type 1 dipole (pole ~15 cm)
- Frame bolted on D2 in the DSA
- Calibrated HIRST GM08 gaussmeter
- Sensitivity  $\pm 1$  mT
- Transverse 1-axis probe, 3 m lead
- Probe inside the pole on a rail
- Maximum current in D2: 200 A
- Survey of the frame position wrt the MICE beamline



Point M1 is the Origin Point for the MICE Beam and represents the intersection of the Beam from Magnet D1, through the Decay Solenoid, with the MICE Beamline  
Point M1 is located below Magnet D2

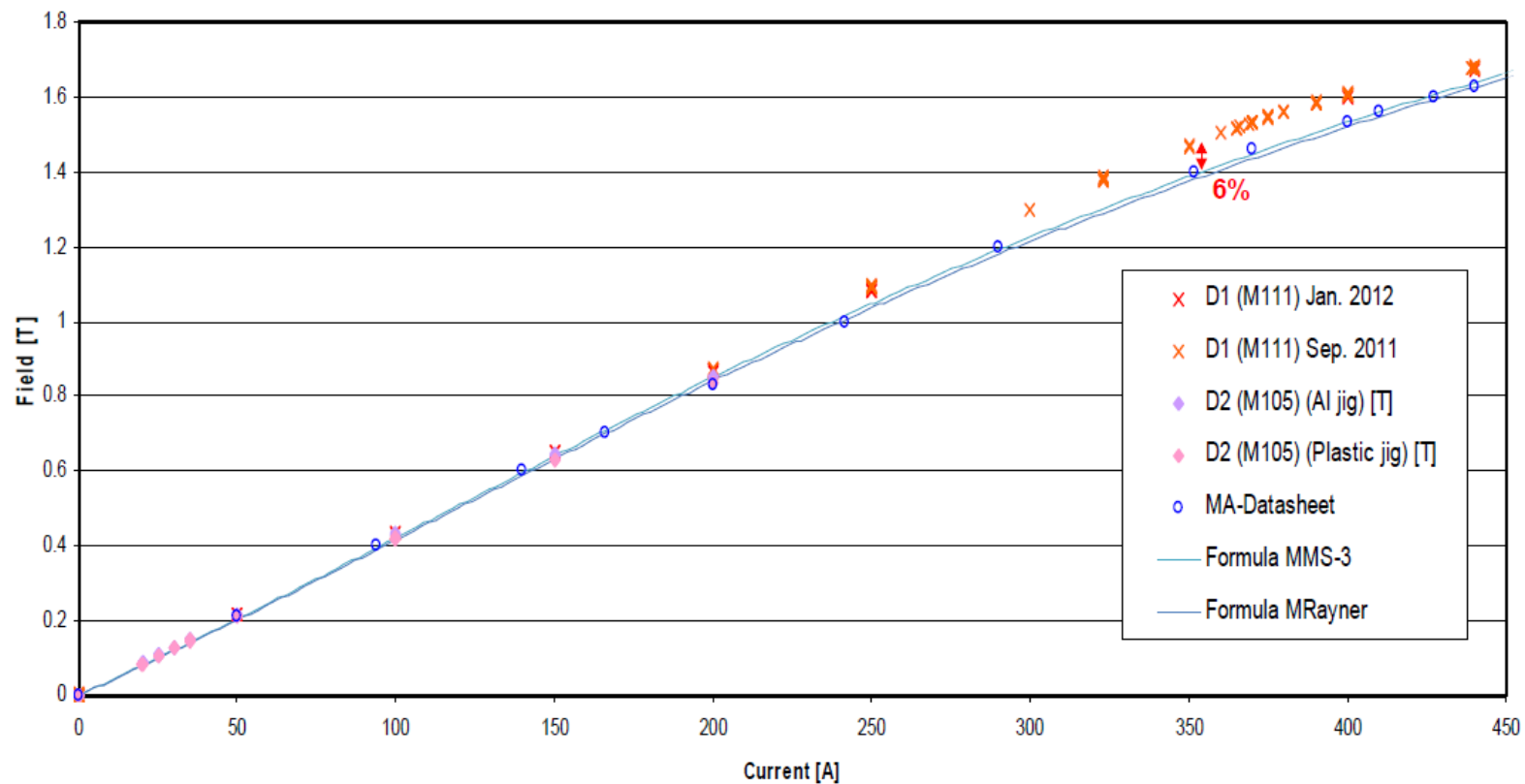
# Previous measurements (2013)



## Measurements and Formulae

**Brunel**  
UNIVERSITY  
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Field-Current Relationship for Nimrod Type 1 Dipole (6" Tapered)



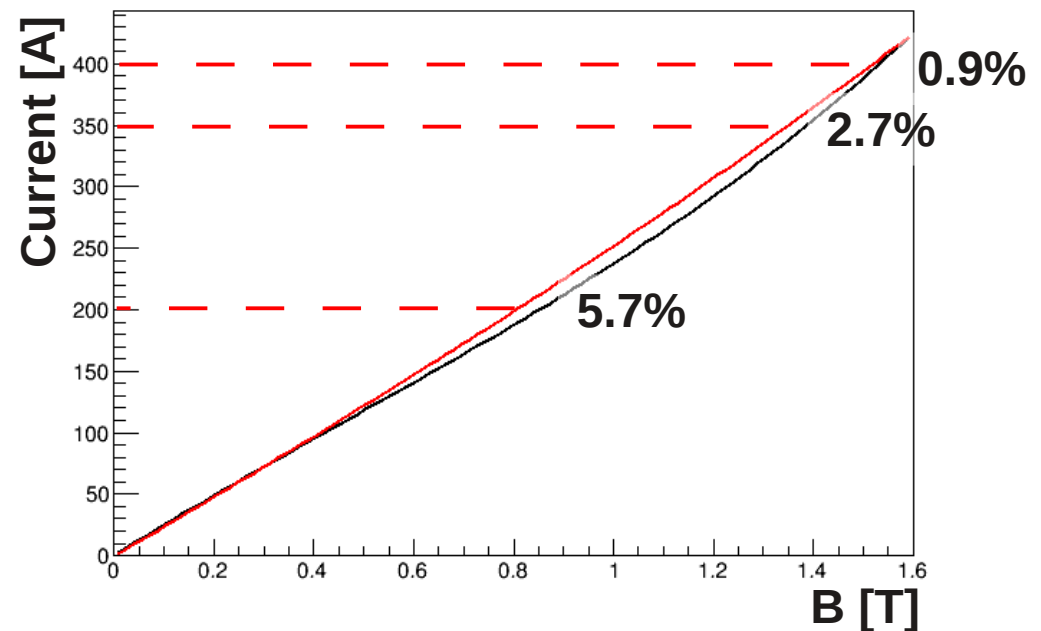
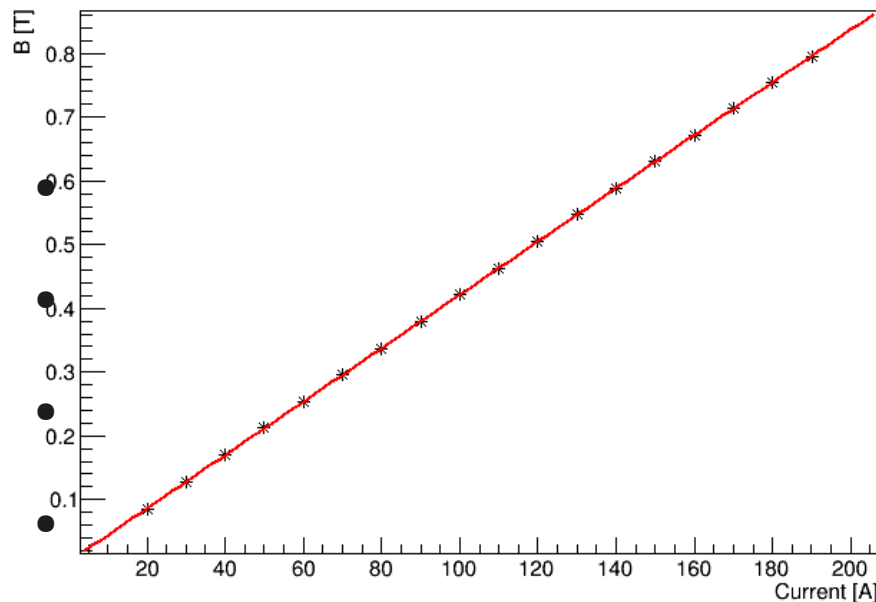
# Saturation curve

- Function used in the Magic Spreadsheet:

$$I = + 253.91 * B - 55.998 * B^2 + 39.59 * B^3$$

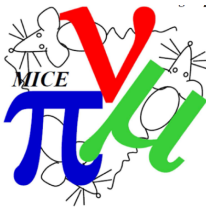
- Fit for D2:

$$I = -0.67 + 240.36 * B - 6.000 * B^2 + 6.18 * B^3$$



- Lower field than expected
- Max equivalent discrepancy **~15 A**



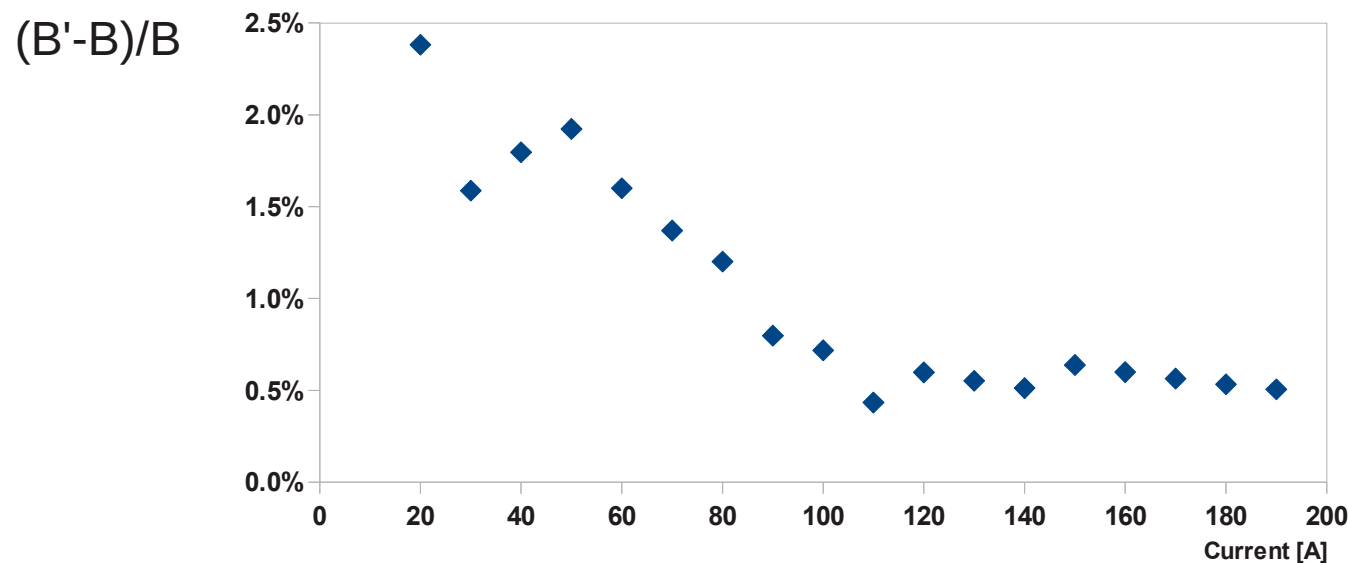


# MC

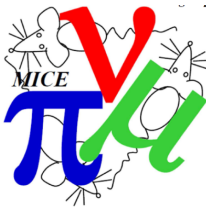
- Using the fitted saturation curve both for D1 and D2
- Momentum selection done by D1
- Example:
  - **run 8681**, 3mm-140 MeV/c, muon peak at 133 MeV/c
  - difference in D1 current: 4.2%
  - Peak in MC at 132 MeV/c (before was 138 MeV/c)

# Hysteresis

- Ramp up:  $B(0 \text{ A} \rightarrow 200 \text{ A})$
- Ramp down:  $B(200 \text{ A} \rightarrow 0 \text{ A})$
- No residual magnetization:  $B(0 \text{ A})=0 \text{ T}$



- Equivalent current discrepancy  $< 1 \text{ A}$
- PSU is precise at 0.1% level



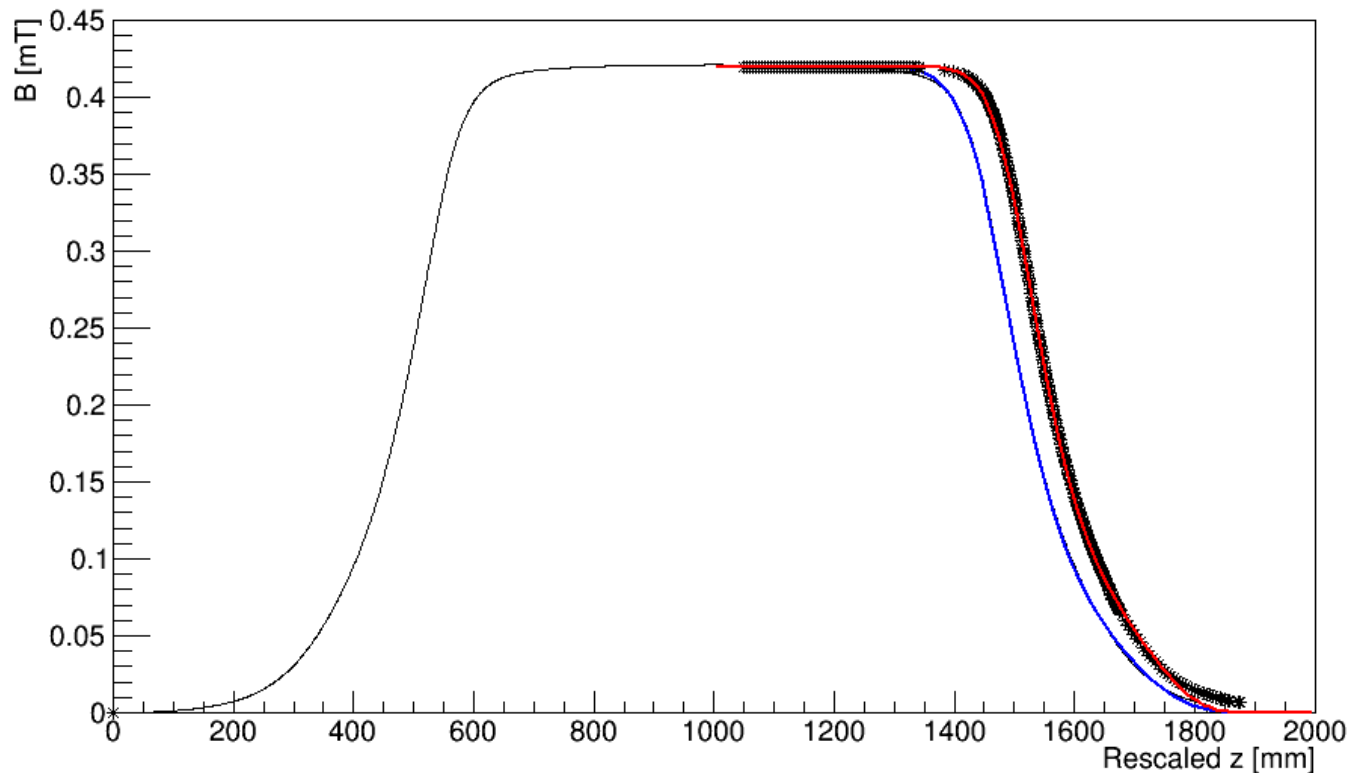
# Stability

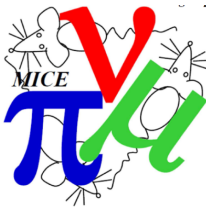
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- Magnet reaches a stable field value as soon as the current is stable
- Magnet sitting at 100 A for 75 minutes  
 $B = 0.419 \pm 0.001 \text{ T}$

# Field on axis

- **MC**: G4BL uses a field map
- **Data**: probe moved on axis for 80 cm from the “center” outwards
- Rescaled the position according to the survey
- Enge function  $\frac{B_0}{1 + e^{P_5(z)}}$





# Conclusions

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- Attempt to match the beam on live data
- Dipole stable during the operations and no huge evidence of magnetic memory
- MC can be improved assuming that D1 has the same behavior as D2
- Next shutdown:
  - Measurement on D1 with currents up to 400 A
    - The frame should fit with some restrictions
  - Repeat the measurement in D2 after one user cycle