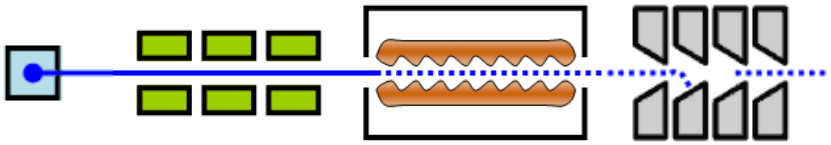
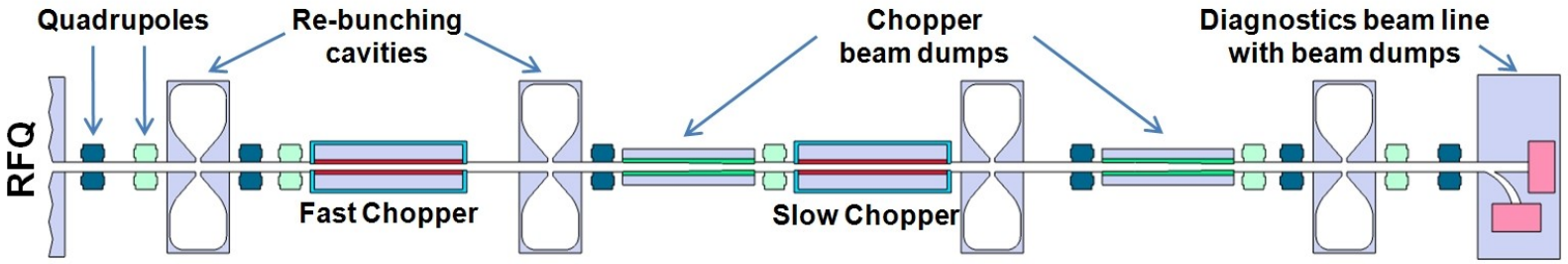


The Front End Test Stand Collaboration – FETS –

MEBT Quadrupoles Progress

FETS MEETING

07th March 2012



INDEX

1. POSSIBLE MANUFACTURERS

- **TESLA ENGINEERING (UK)**

Good quality *Expensive* *Long lead time* *Good location*

They have done EMMA quads, which are pretty similar to what we are trying to achieve.
They were 60% more expensive than Danfysik in one quotation for ISIS magnets.

- **SIGMAPHI (FRANCE)**

They recently accepted big projects in order to grow the company.
They have done EHB4 in the past. *Good quality* *Long lead time*

- **DANFYSIK (DENMARK)**

Good price *Good quality* *Normal lead time*

Company growing up very quickly. They have invested a lot of money.
They have done magnets type Q12 for the EPB TS2

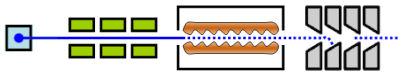
- **SCANDITRONIX (SWEDEN)**

Good quality *Long lead time*

They have done magnets type Q11 in the past.

- **BUDKER NUCLEAR INSTITUTE (RUSSIA)**

Scientific Institution that commercialize magnets. They have done magnets type Q13 in the past. Dipole Steering inserts as well for the EPB on TS2.



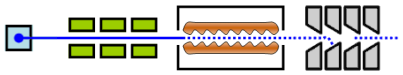
2. KICK OFF MEETING WITH AL, CP & AG (24TH FEB 2012)

- FIRST SPEC:
  - 11 magnets
  - Field strength = 6 – 30 T/m
    - If more than 30 T/m can be achieved would give more flexibility = 39 T/m
    - 30 T/m = ~ 0.6 – 0.7 T at the beam axis with a OD = 40mm.
  - Length = 70mm
  - Bore Ø ~ 45mm
    - Smaller pipe?
    - DN25 pipes are ~Ø33mm OD. Adaptor to KF40?

- Not similar magnets around ISIS
  - Other similar magnets around?
  - EMMA's quadrupoles at Daresbury Laboratories.
  - JPARC too expensive (electro formed winding) ~ £23k each
  - CERN uses spare magnets for LINAC4.

- First estimation between £8-16k. After looking at the specification in more detail: £5-10k per magnet.
  - Budget of £25k? Collaborations?

- Water cooling? Air cooling?
  - It will likely need to be water cooled
  - i.e: Chip's estimation: 3-4 kA = 40A to be dissipated in each turn for 100 turns winding



- First 3D Magnetic Design? AL? DF?
- Once more detailed parameters are established, AG will approach manufacturers to know a roughly price per magnet, also for 11 off, and a estimated lead time.
- Other characteristics discussed:
  - Required radius of good field region (GFR)? Beam size?
  - Integrated field gradient within GFR? %?
  - Maximum current? Power requirements? No. of turns? Cross-section of the coil?
  - What is needed to bias a dipole mode to be able to steer the beam?
  - Specific lamination on the coils?
  - Tests / measurements required?
    - Mapping for measured field strength
    - 3D Measurements for mechanical tolerances
    - Rotating coil for harmonics?
    - Helium leak? Vacuum or pressure tests?
- MEBT Layout – dimensions?
  - Choppers? BPMs? Cavities?
  - BPMs design it hasn't started yet.

3. EMMA'S QUADRUPOLES AT DARESBURY LABORATORY

Magnet Challenges

'Combined function' magnetsDipole and quadrupole fields

Independent field and gradient adjustmentMovable off-centre quads used

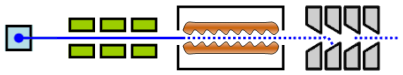
Very thin magnets
Yoke length of same order as inscribed radius
'End effects' dominate the field distribution
Full 3D modelling required from the outset

Large aperture + offsetGood field region (0.1%) must be very wide

Close to other componentsField leakage into long straight should be minimised

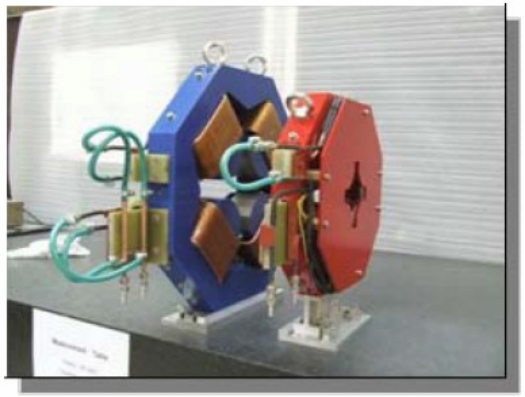
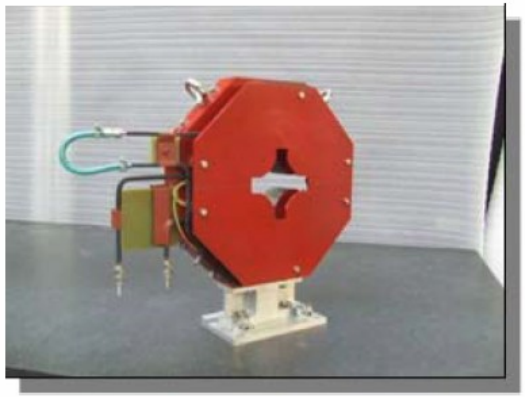
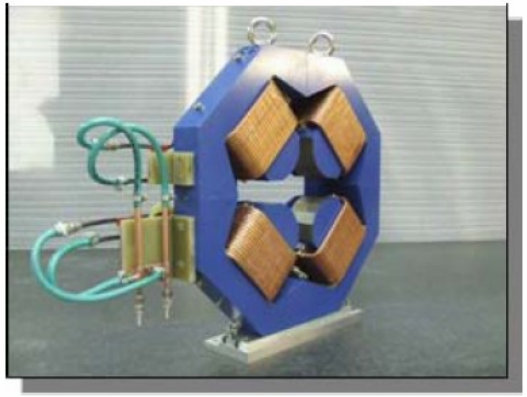
Close to each otherExtremely small gap between magnets
F & D fields interact

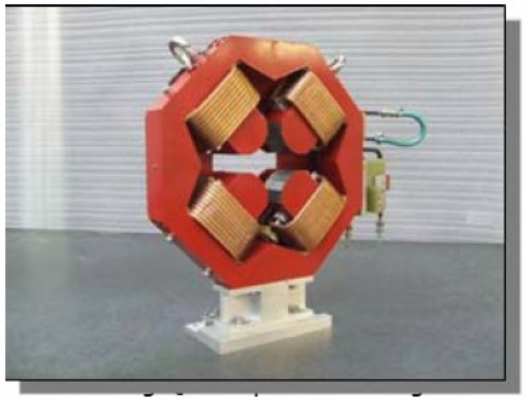
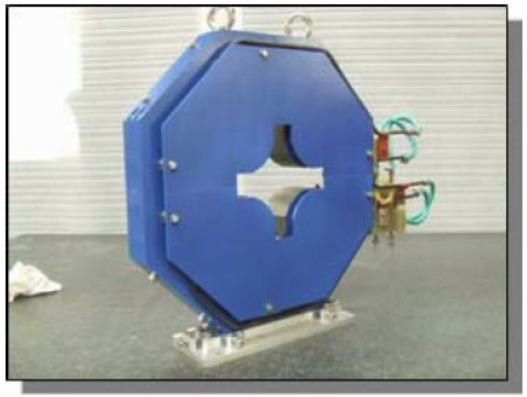
Full 3D modelling and prototyping essential!



Magnet Prototypes

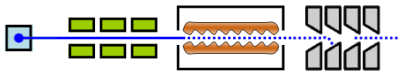
- Two prototypes were built by Tesla to verify the design

Conclusions from EMMA's quadrupoles

- Very challenging magnets to design!
- Old (hyperbolic + tangent) design insufficient
- New design uses straight line pole profiles
- Model results are much better
- Prototypes have been built and tested
- Test results show some differences to model –but prototypes still look reasonable
- Improvement to field quality probably still possible



4. ESS-BILBAO

ESS-BILBAO tends to design a Quadrupole magnet which integrates the BPM inside.

They will use standard DN 25 pipe ~ Ø33mm OD

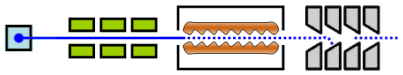
Collaborations? AG to get more details?

- Advantages?

More compact design

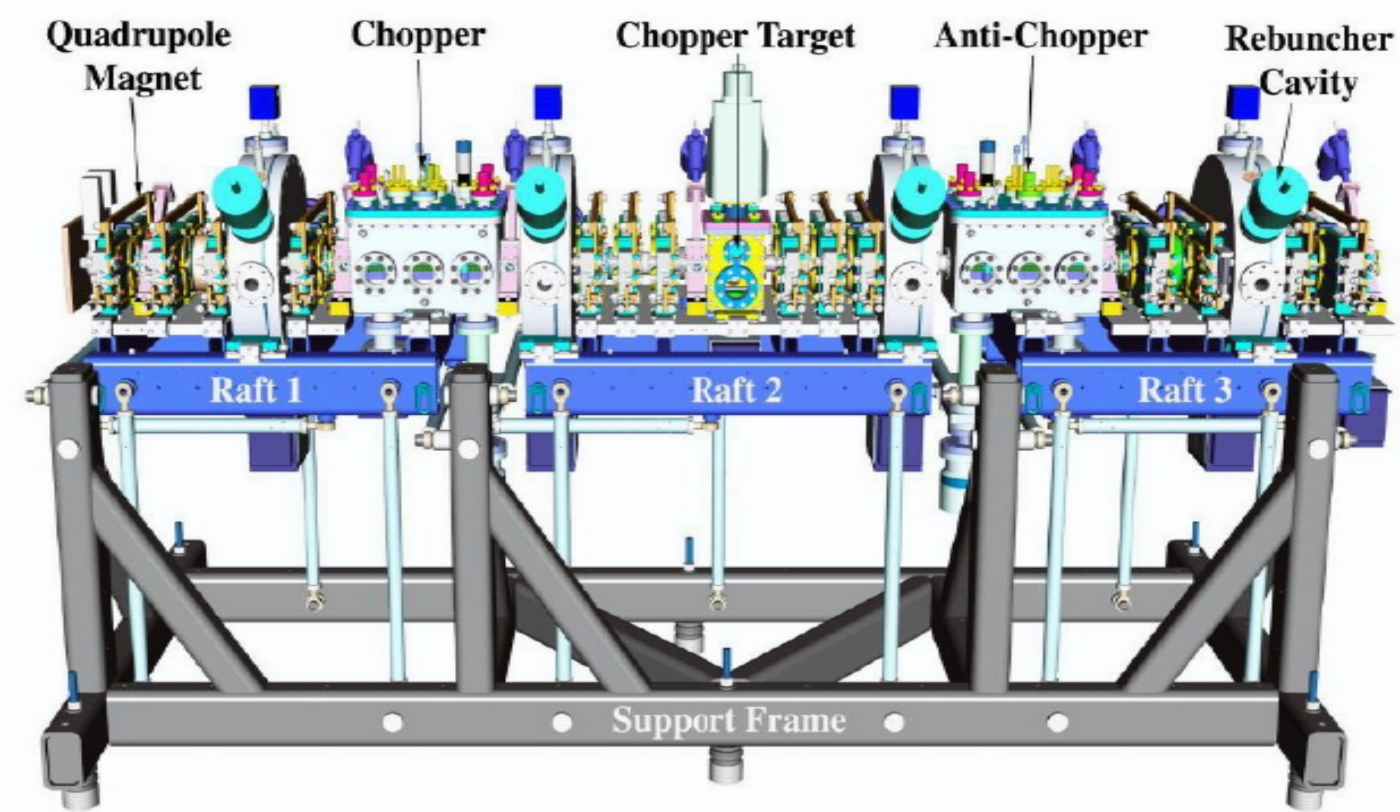
- Weaknesses?

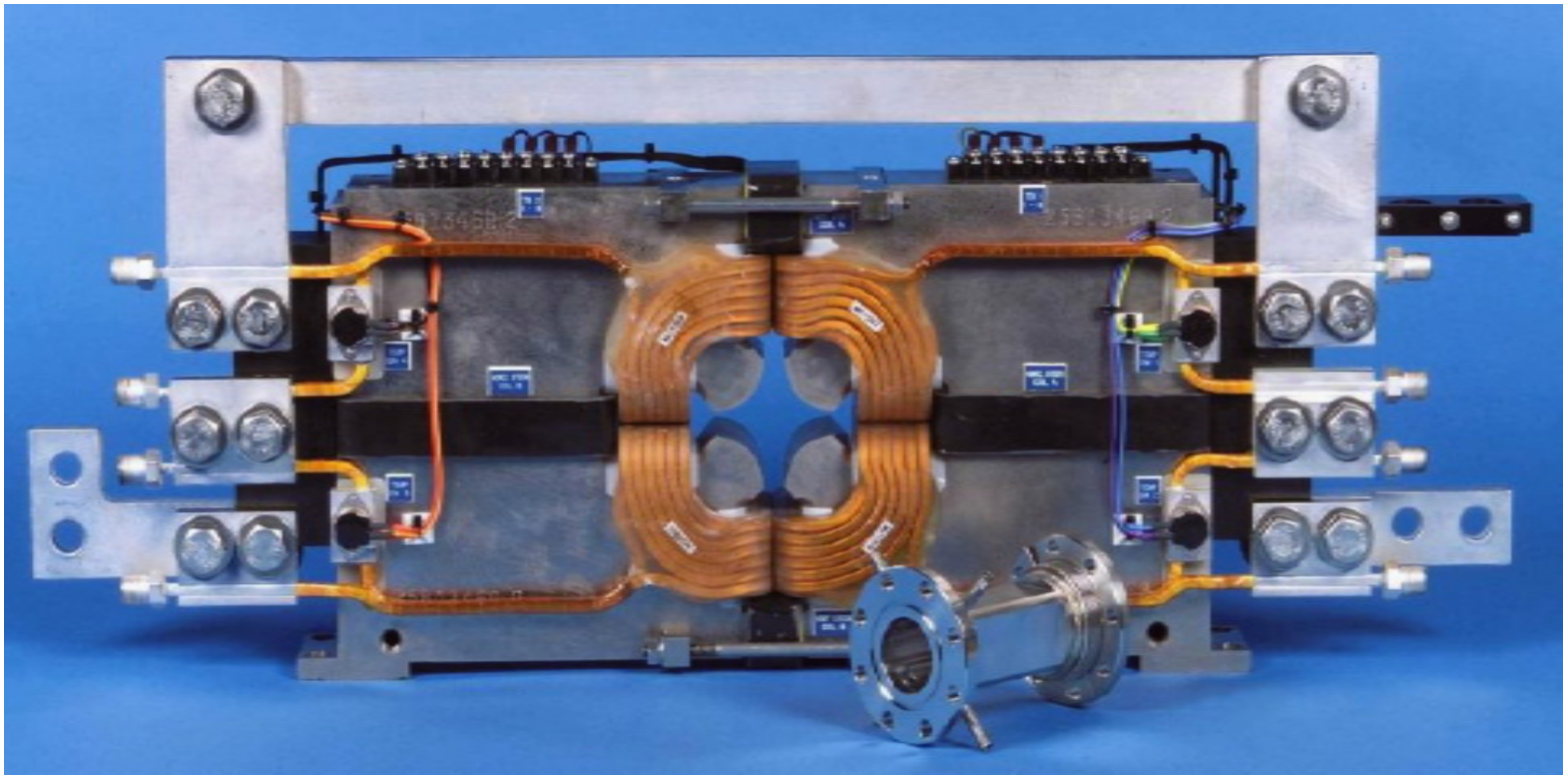
New design
No experience
Bore Diameter enough?
Dipole steering?



5. OTHER QUADS

SNS





SIGMAPHI

Recommendation: avoid big amount of epoxy on the corners of the winding (see picture).

Makes it easier to manufacturer but worse results