

# A quick look at a 4 MeV FFAG (pretending to be a 6 MeV FFAG) and other items...

Thanks to:

Carol Johnstone for lattice design

Kyoko Makino for detailed field maps & COSY results for comparison

Martin Berz for advice & discussion

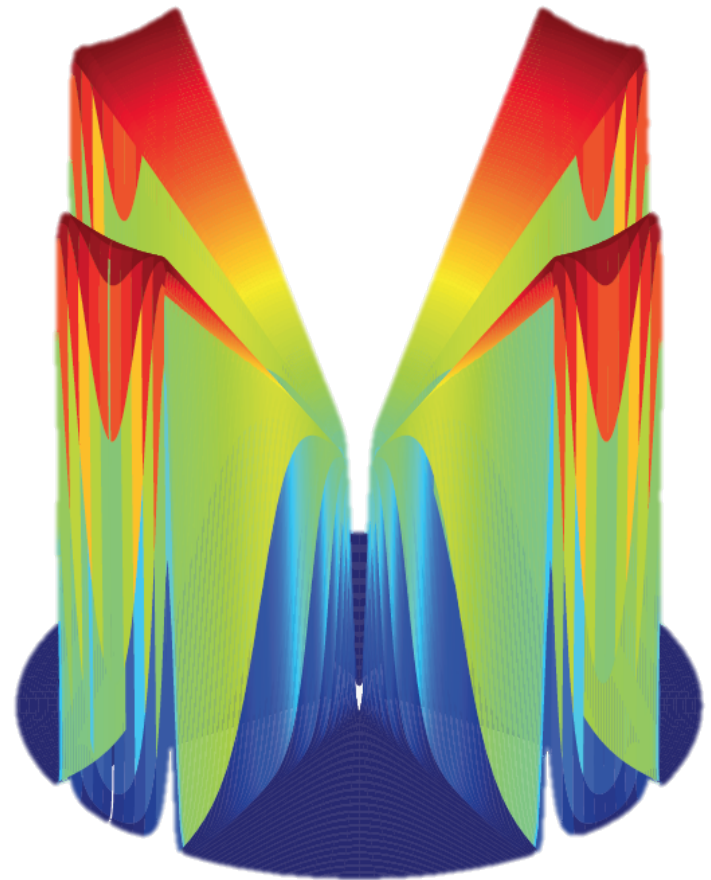
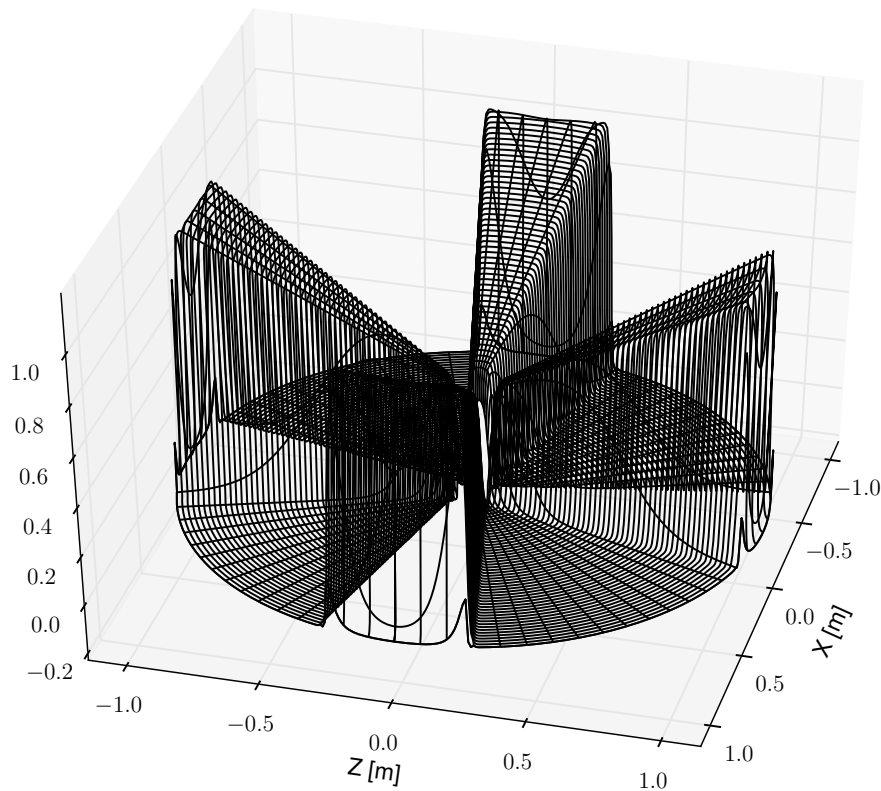
Pavel Snopok for organising the meeting!

# Field Map

Mid-plane map

$0.08 \text{ m} < r < 1.10 \text{ m}$  (2mm steps)

360 degrees (0.5 degree steps)



# Out of plane expansion

- Field is expanded in vertical direction
- Use approach by Gordon and Taivassalo
- Use magnetic potential & measured Bz on midplane
- 3<sup>rd</sup> order field:

$$\begin{aligned}B_r(r, \theta, z) &= z \frac{\partial B_z}{\partial r} - \frac{1}{6} z^3 C_r, \\B_\theta(r, \theta, z) &= \frac{z}{r} \frac{\partial B_z}{\partial \theta} - \frac{1}{6} \frac{z^3}{r} C_\theta, \\B_z(r, \theta, z) &= B_z - \frac{1}{2} z^2 C_z,\end{aligned}$$

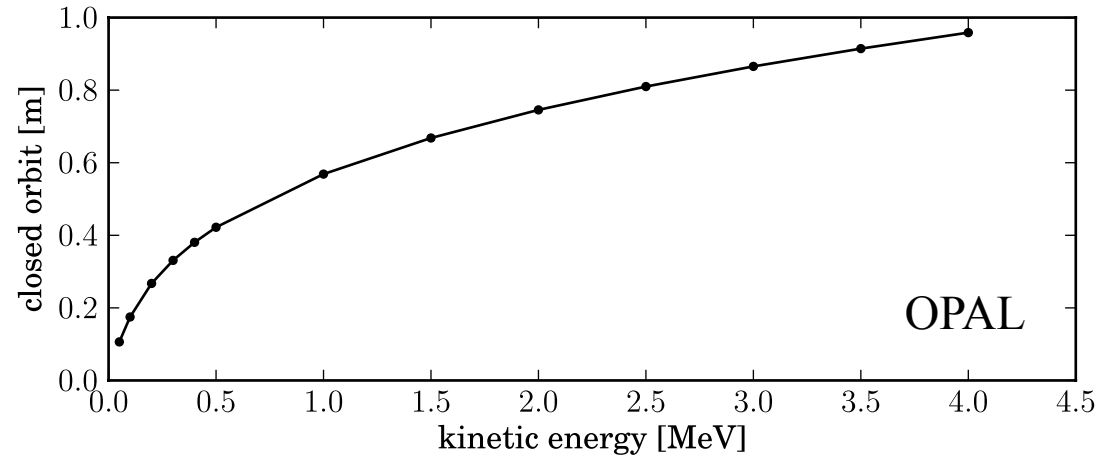
where  $B_z \equiv B_z(r, \theta, 0)$  and

$$\begin{aligned}C_r &= \frac{\partial^3 B_z}{\partial r^3} + \frac{1}{r} \frac{\partial^2 B_z}{\partial r^2} - \frac{1}{r^2} \frac{\partial B_z}{\partial r} + \frac{1}{r^2} \frac{\partial^3 B_z}{\partial r \partial \theta^2} - 2 \frac{1}{r^3} \frac{\partial^2 B_z}{\partial \theta^2}, \\C_\theta &= \frac{1}{r} \frac{\partial^2 B_z}{\partial r \partial \theta} + \frac{\partial^3 B_z}{\partial r^2 \partial \theta} + \frac{1}{r^2} \frac{\partial^3 B_z}{\partial \theta^3}, \\C_z &= \frac{1}{r} \frac{\partial B_z}{\partial r} + \frac{\partial^2 B_z}{\partial r^2} + \frac{1}{r^2} \frac{\partial^2 B_z}{\partial \theta^2}.\end{aligned}$$

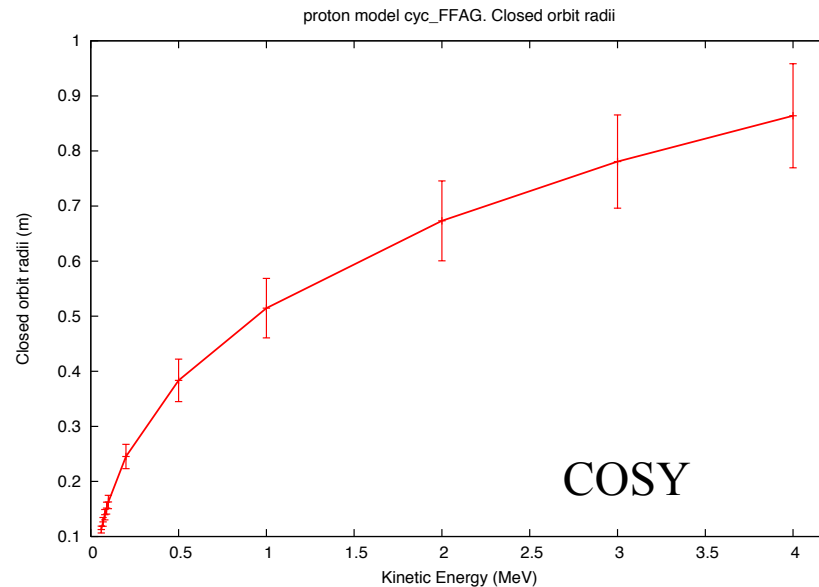
Until COSY does space charge, this will have to do!

# Closed orbit position

Single particle tracking used & minimise phase space area

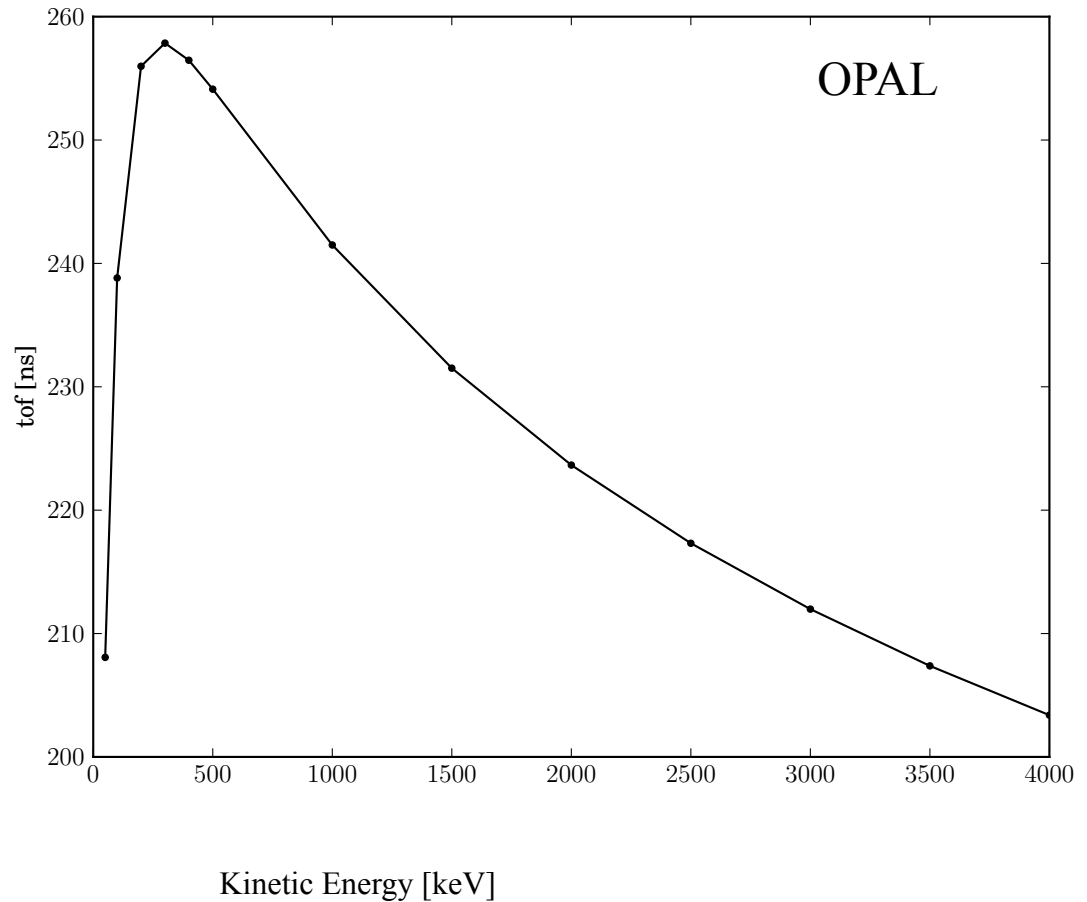


OPAL result should line up with “maximum” of COSY result (in mid-straight)

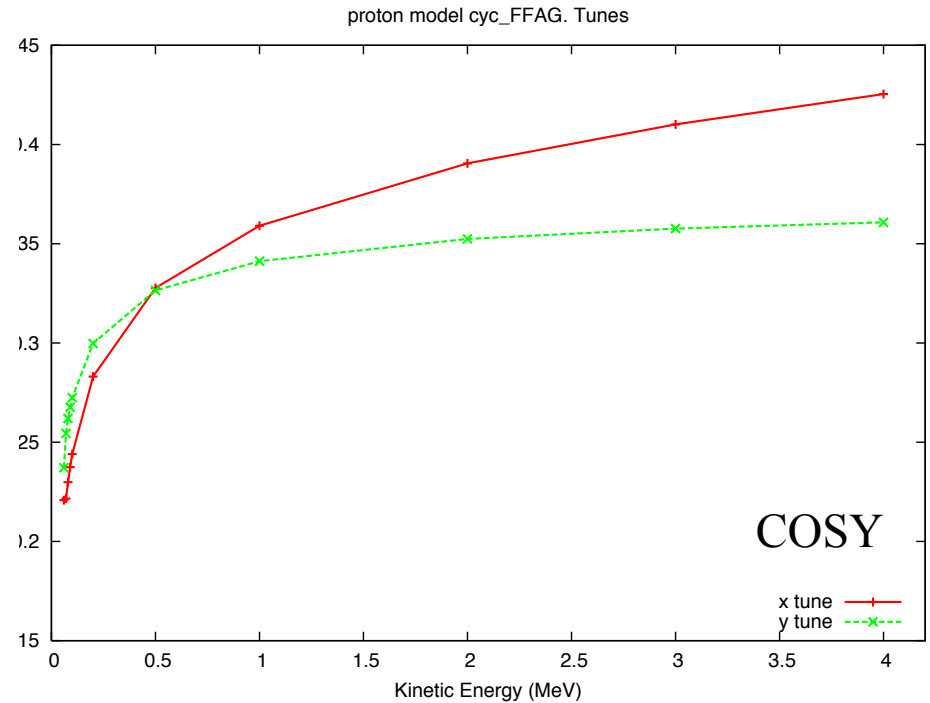
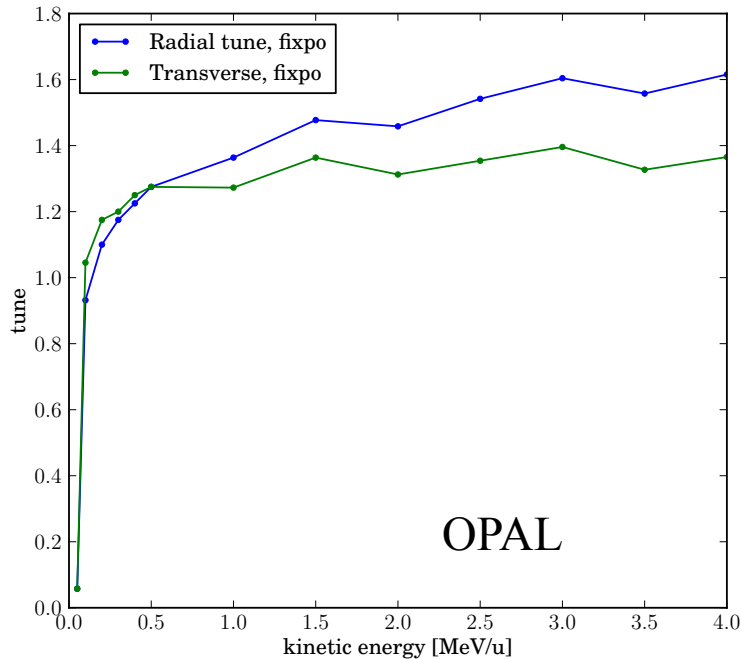


# Time of Flight

This looks to me like a large TOF variation, even at the “stabler” high energy region. This need some improvement!



# Tunes



**Note:** current method is 2 particles tracked (one on CO, one slightly off), fourier-based method to find radial & vertical tune.  
*This is proving to be very inaccurate... see later discussion*

# Tracking

- I haven't got around to tracking particles off the closed orbit (with an success) yet as closed orbits not being found with small enough tolerance...

I think this is caused by:

Difficulties/obscurities in OPAL:

- being a time-step code, difficult to define a 'turn' in the machine – some data is spat out "after each turn" but it is not clear how this is defined
- I have contacted the code authors about this... as the output ambiguity is holding up just about everything I'm doing!

NOTE: this may also affect my time-of-flight results and will almost definitely affect the tune results!

# Other items!

Data storage/access:

- We need a good way to store/share field maps, results, data etc... ideas?

Funding for collaboration/travel:

- Joint funding for collaboration would be great, but where to find it?

For individual visits (from UK -> abroad)

- EPSRC Overseas Travel Grants (for single researcher)
- Royal society international exchanges (for single researchers) – current round closes today, should be another within 3 months
- Others?



# Collaboration Names?

Do we need/want one??

CIPRANET ← is this taken already?

Compact Isochronous PRoton Accelerator NETwork

HiCAP

High Intensity Compact Accelerators for Protons

ARTEMIS

AcceleratoR TEchnology for Model Industrial Systems

CAIPRA

Compact Accelerators for Intense PRoton Applications

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