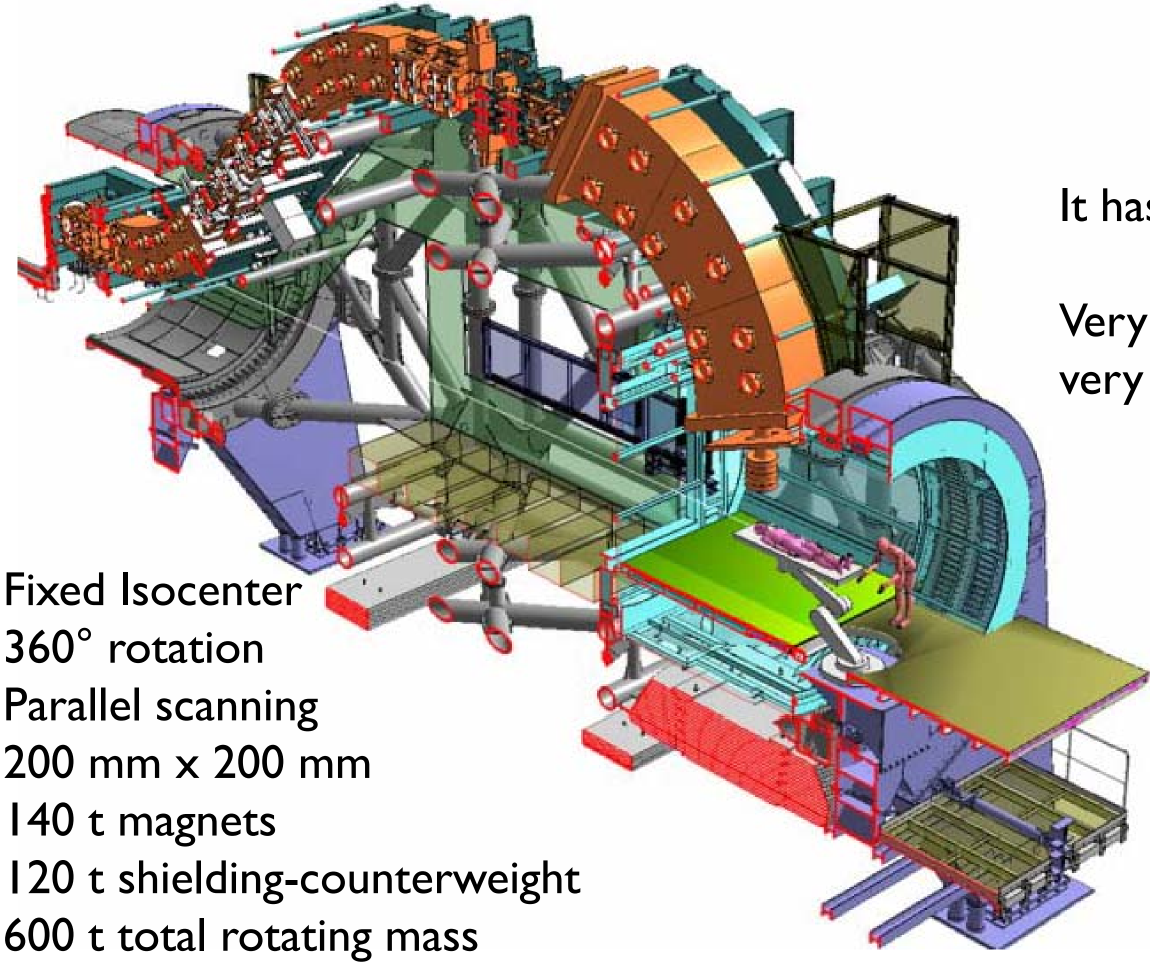
Improving ion gantries

Marco Pullia

Fondazione CNAO

Present

Only one gantry worldwide: L = 25 m x ϕ = 13 m, 600 t



It has everything, but it is

Very large, very heavy, very expensive

Fixed Isocenter
360° rotation
Parallel scanning
200 mm x 200 mm
140 t magnets
120 t shielding-counterweight
600 t total rotating mass

(Udo Weinrich, GSI)

Can we make it better?

- As usual we want everything and its opposite at the same time…
  - Small aperture final magnet to lower power consumption, but scanning upstream
  - Small radius, but space around isocenter
  - Light magnets, but possibly non superconducting
  - Maximum performance, but cheap
  - …

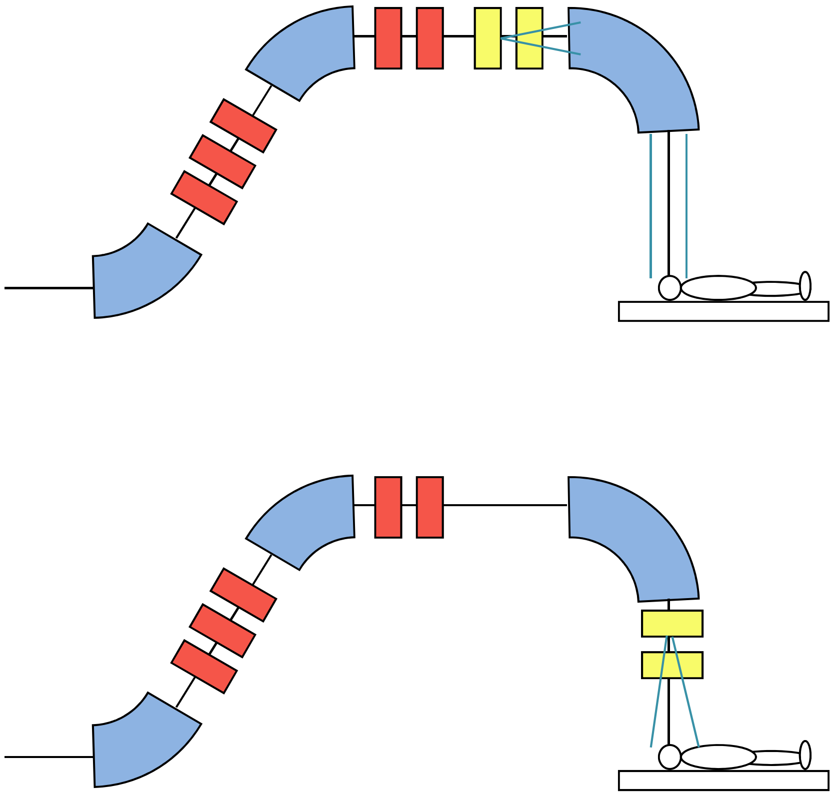
Aspects and ideas to be considered

- Scanning or ~~scattering~~ — Not really a choice

Aspects and ideas to be considered

- Scanning
- SAD and scanning magnets position

Scanning magnets position



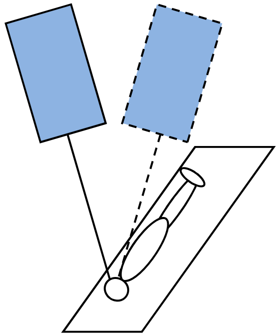
- Large aperture dipole: weight and power consumption
- Large gantry radius and large room size

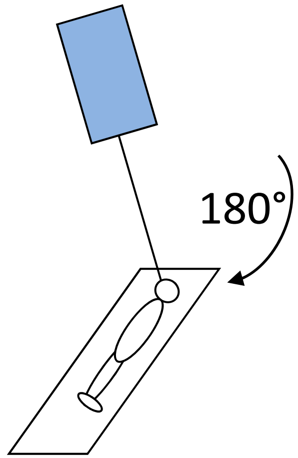
Aspects and ideas to be considered

- Scanning
- SAD and scanning magnets position
- 360° vs 180°

360° vs 180°

- By rotating the couch by 180°, all the beam directions are possible also with only 180° of rotation of the gantry





- Saves on room size, but no counterweight opposite to dipole (mechanics and shielding)

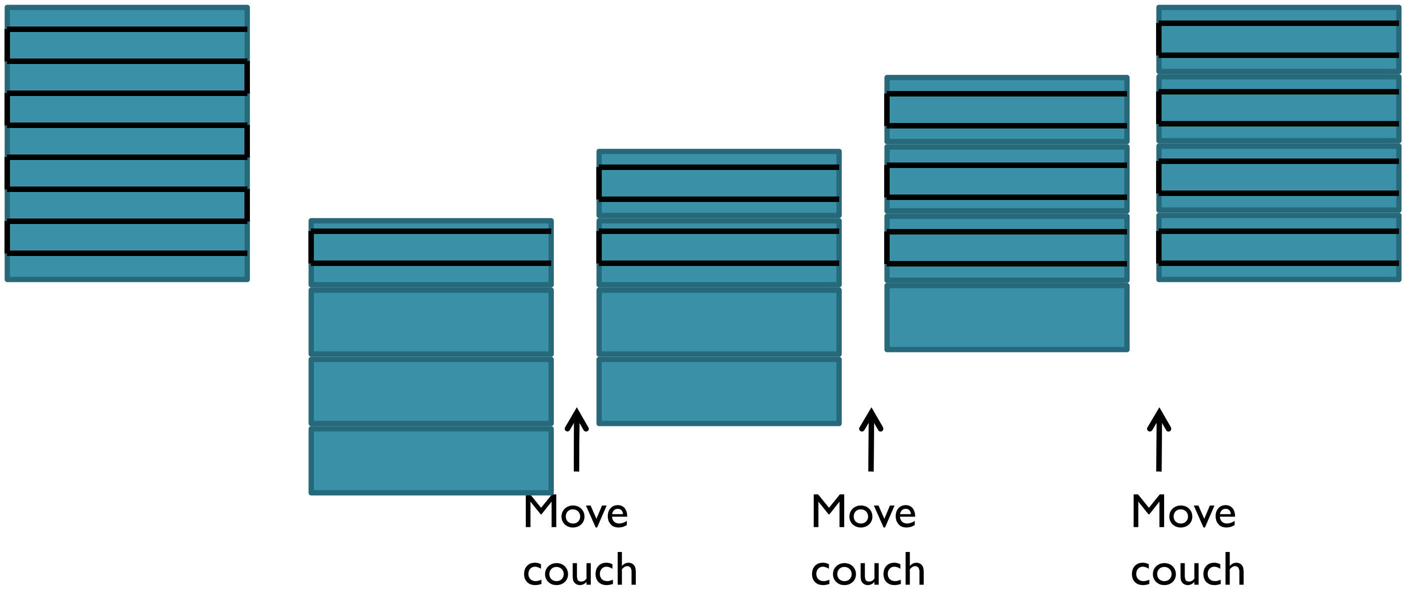
Aspects and ideas to be considered

- Scanning
- SAD and scanning magnets position
- 360° vs 180°
- Field patching

Field patching

Scan in one go

Scan and move (~PSI gantry 1)



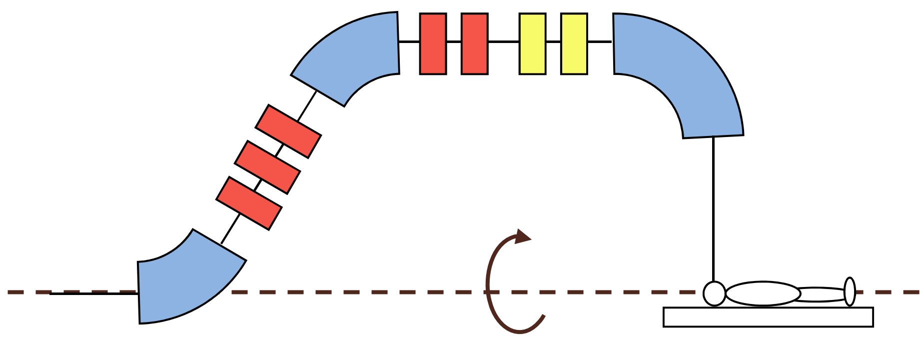
Reduces magnet aperture, but
Slower procedure and
Difficulties somehow similar to simultaneous optimisation of multiple fields with IMPT

Aspects and ideas to be considered

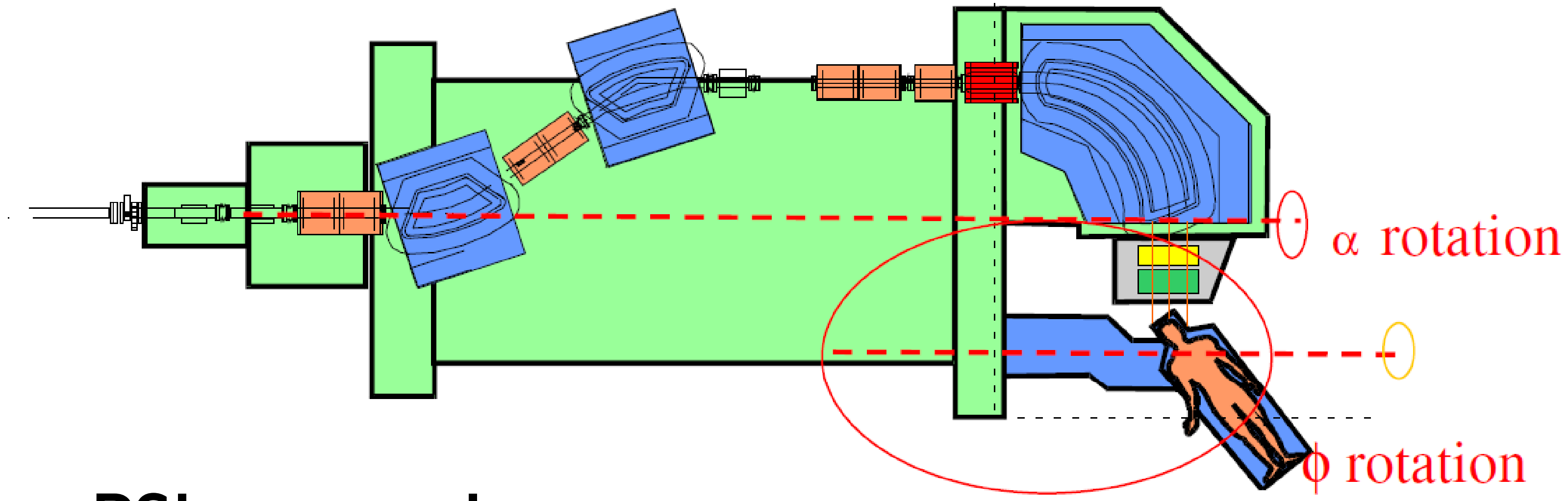
- Scanning
- SAD and scanning magnets position
- 360° vs 180°
- Field patching
- Fixed or mobile isocenter

Fixed or mobile isocenter

- Most of the existing gantries have a fixed isocenter on the rotation axis of the gantry. This implies large masses rotating at large radius.



Mobile isocenter

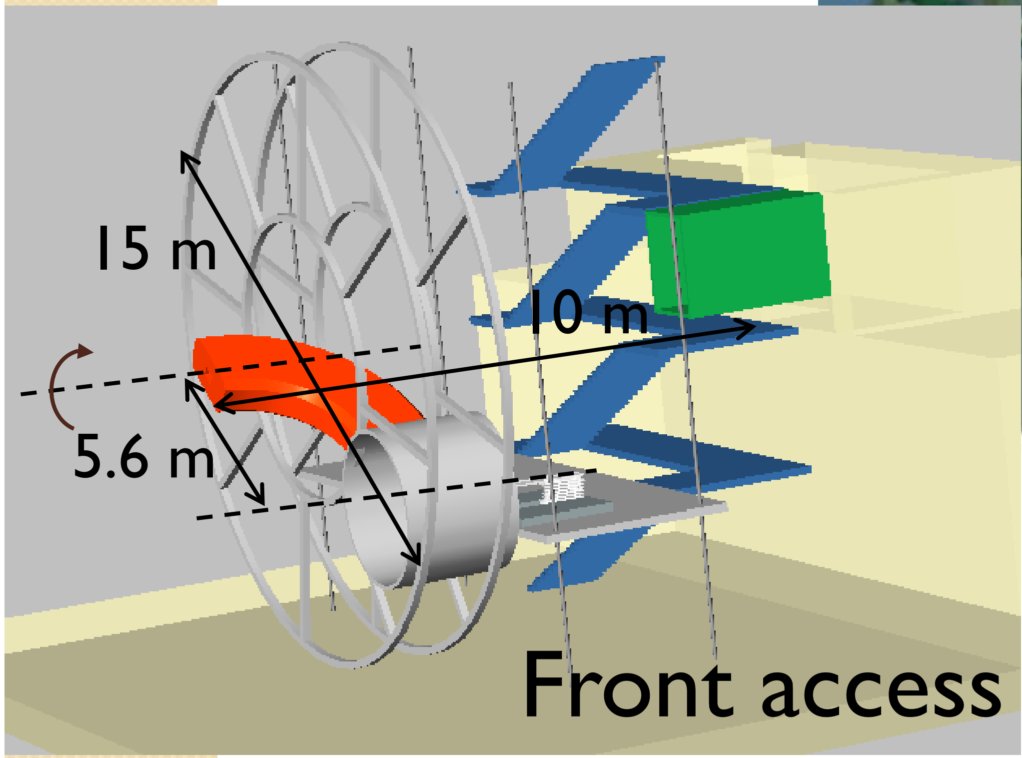


PSI gantry 1

An isocenter, through which all the directions pass, exists but its position depends on gantry orientation.

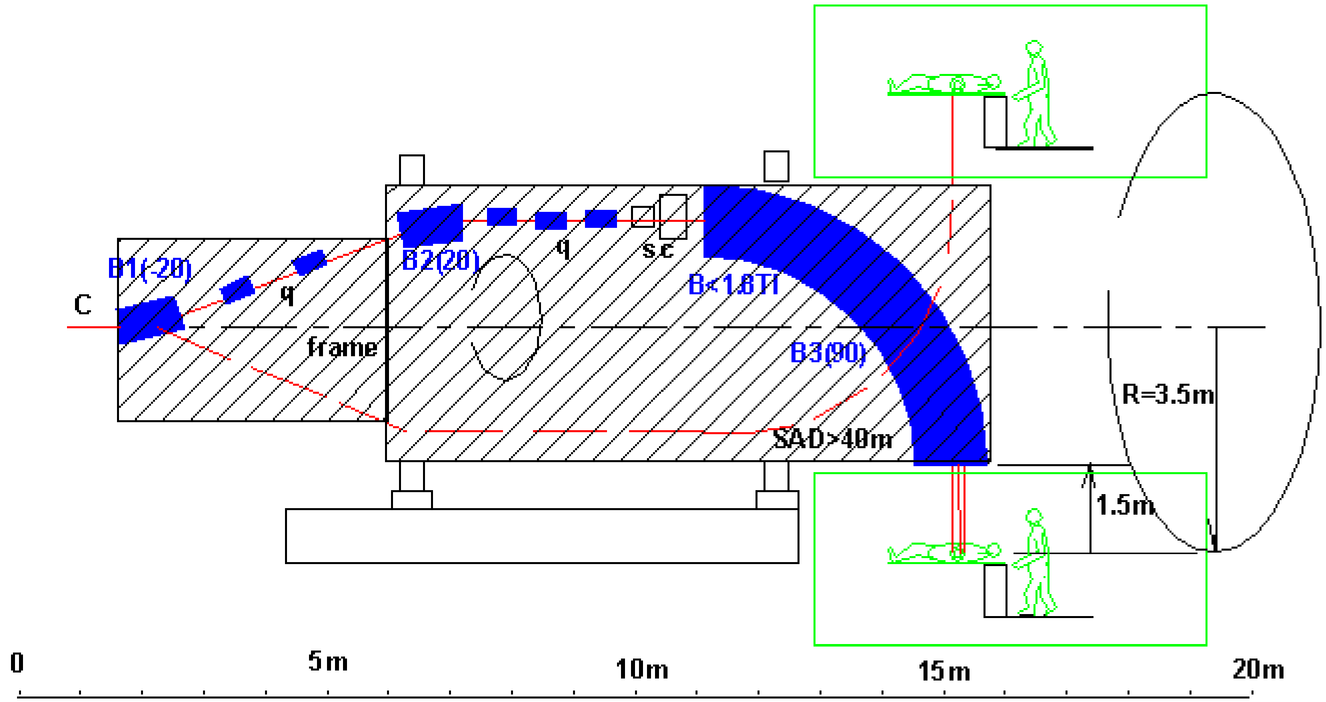
Mobile isocenter - 2

Patient positioned
in a small room "somewhere"



Gantry is longer, than just the last magnet but at small *r*

Carbon ion gantry, 'a la' PSI gantry-1



(*M. Kats, 2002*)

Considerations

- Shielding: No counterweight on the beam path
- Access to patient
- Shielding: surface of the room

  25x15x15 => 1950 m^2

  10x17x17 => 1258 m^2
- Room volume (to dig, to cool)

  25x15x15 = 5625 m^3

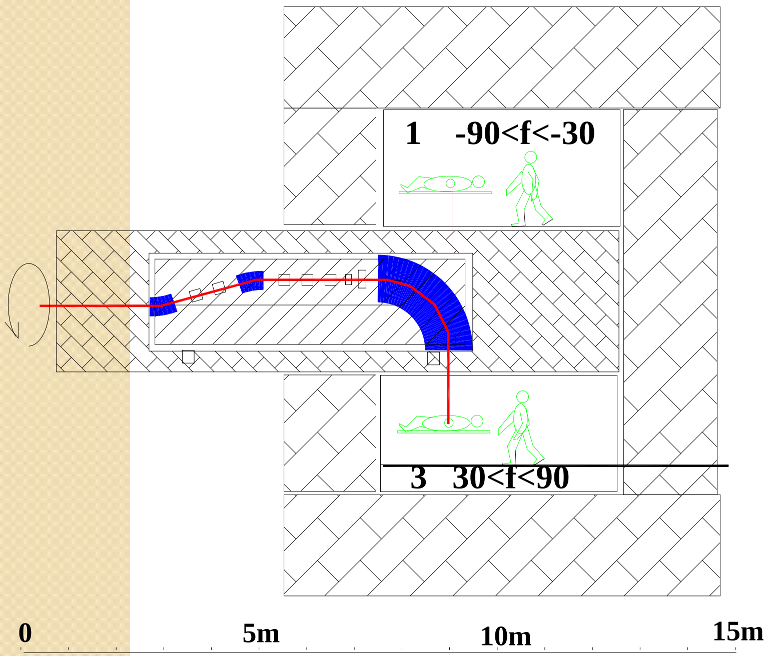
  10x17x17 = 2890 m^3
- Smaller masses and masses on axis

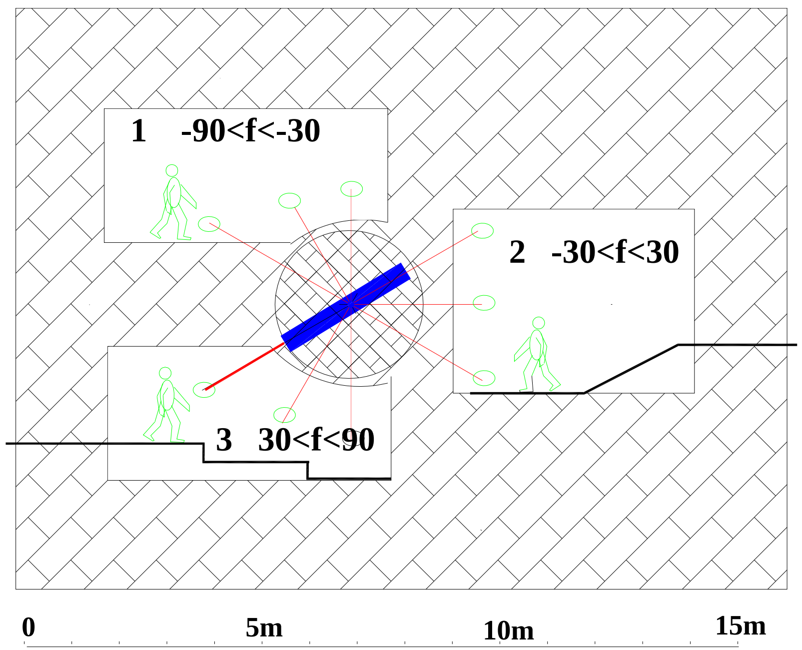
Aspects and ideas to be considered

- Scanning
- SAD and scanning magnets position
- 360° vs 180°
- Field patching
- Fixed or mobile isocenter
- Multi-room system

Multi-room system

- Proposed by A.Brahme





(*M. Kats*)

Aspects and ideas to be considered

- Scanning
- SAD and scanning magnets position
- 360° vs 180°
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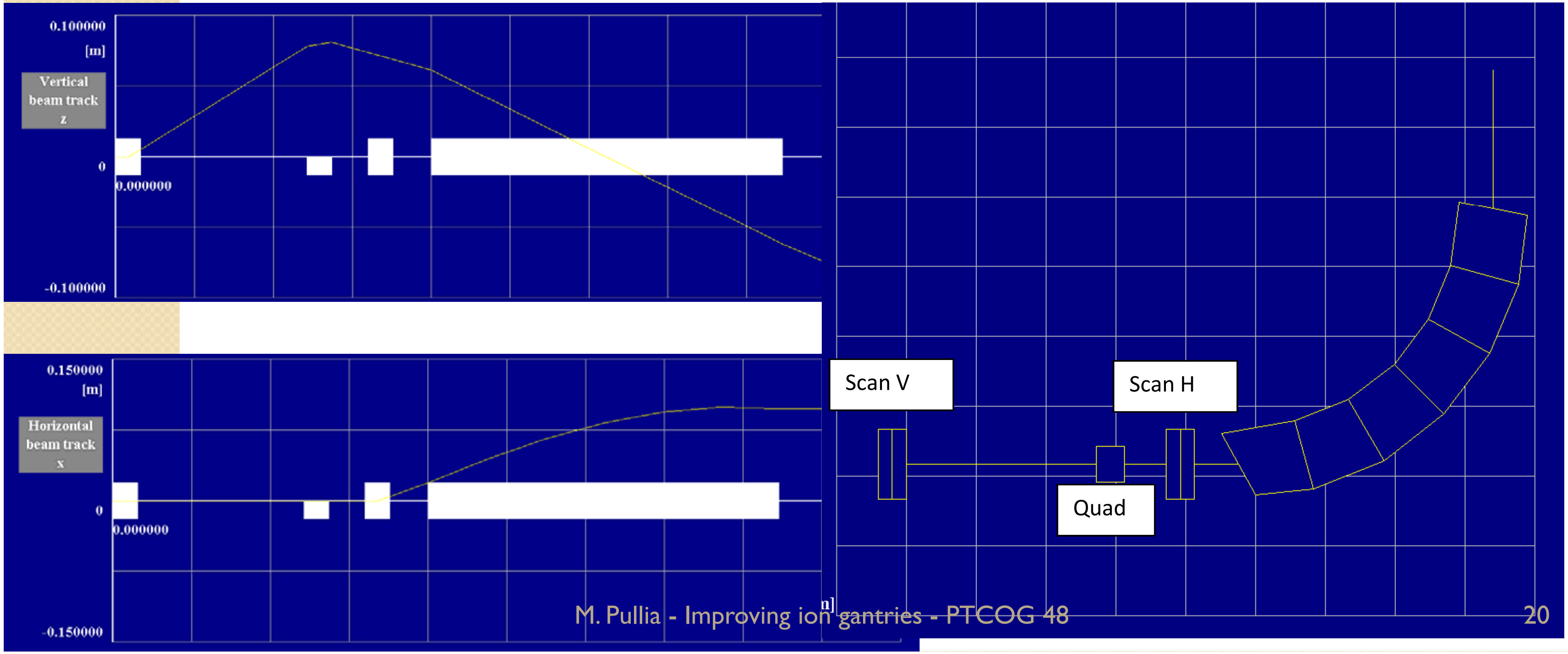
- Fixed or mobile isocenter
- Multi-room system
- Divergent scanning

Divergent scanning

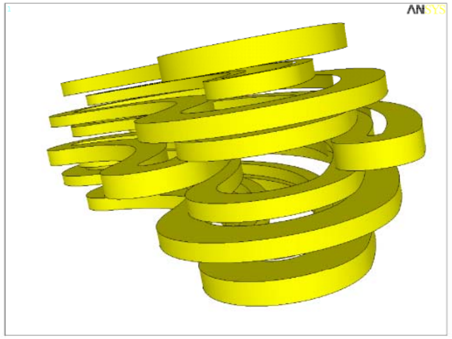
- Last drift 2m
- Quad g = 8 T/m
- SAD 5.5 m (1 plane only!)
- Gap reduced by 30%

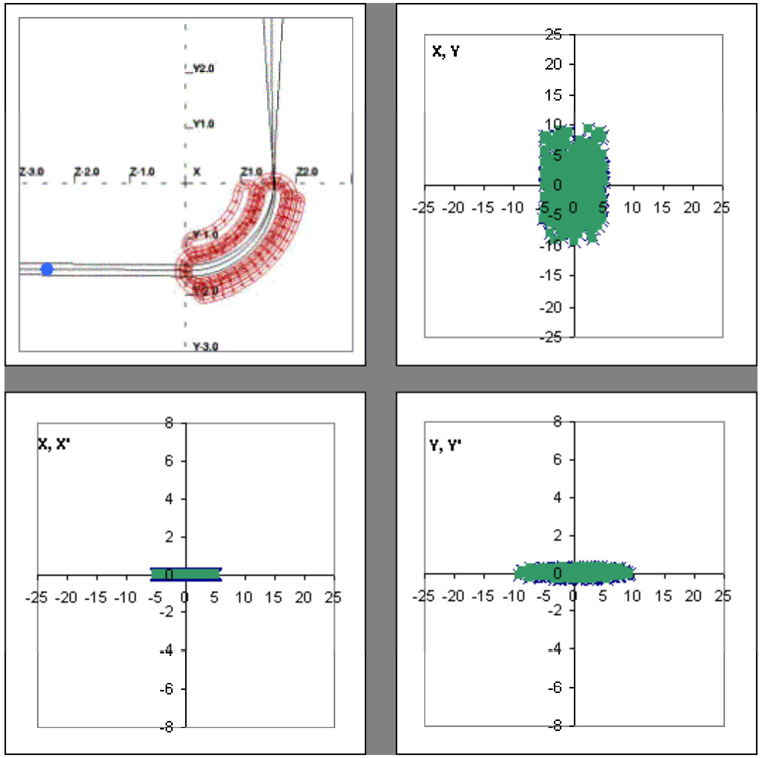


Aspects and ideas to be considered

- Scanning
- SAD and scanning magnets position
- 360° vs 180°
- Field patching
- Fixed or mobile isocenter
- Multi-room system
- Divergent scanning
- Superconducting magnets

Superconducting magnets



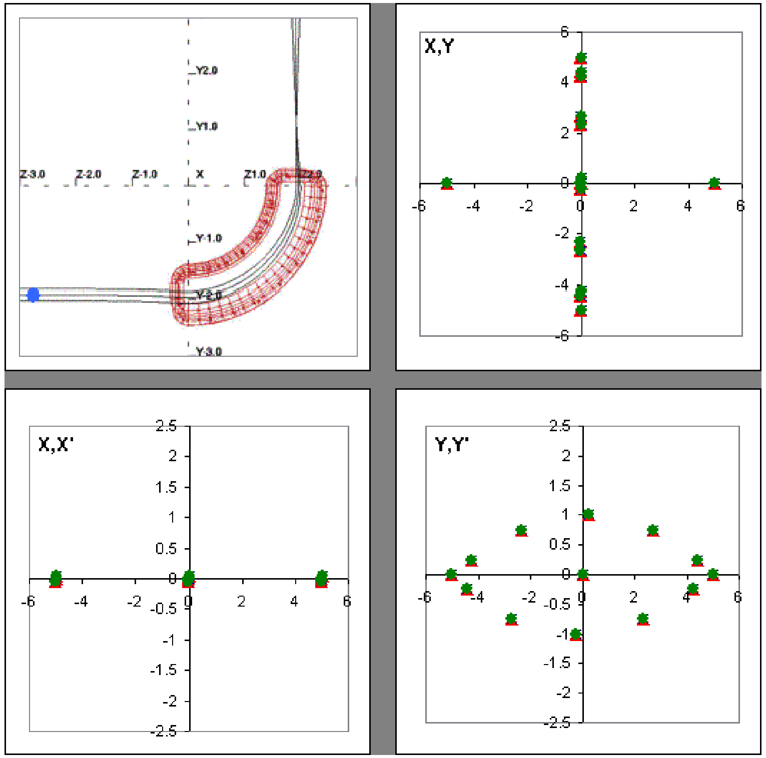


If possible no He,
use cryo-coolers

Priano et al, 2001

Straight coil heads
Difficult to wind

GFR 200 mm x 60 mm
(field patching)

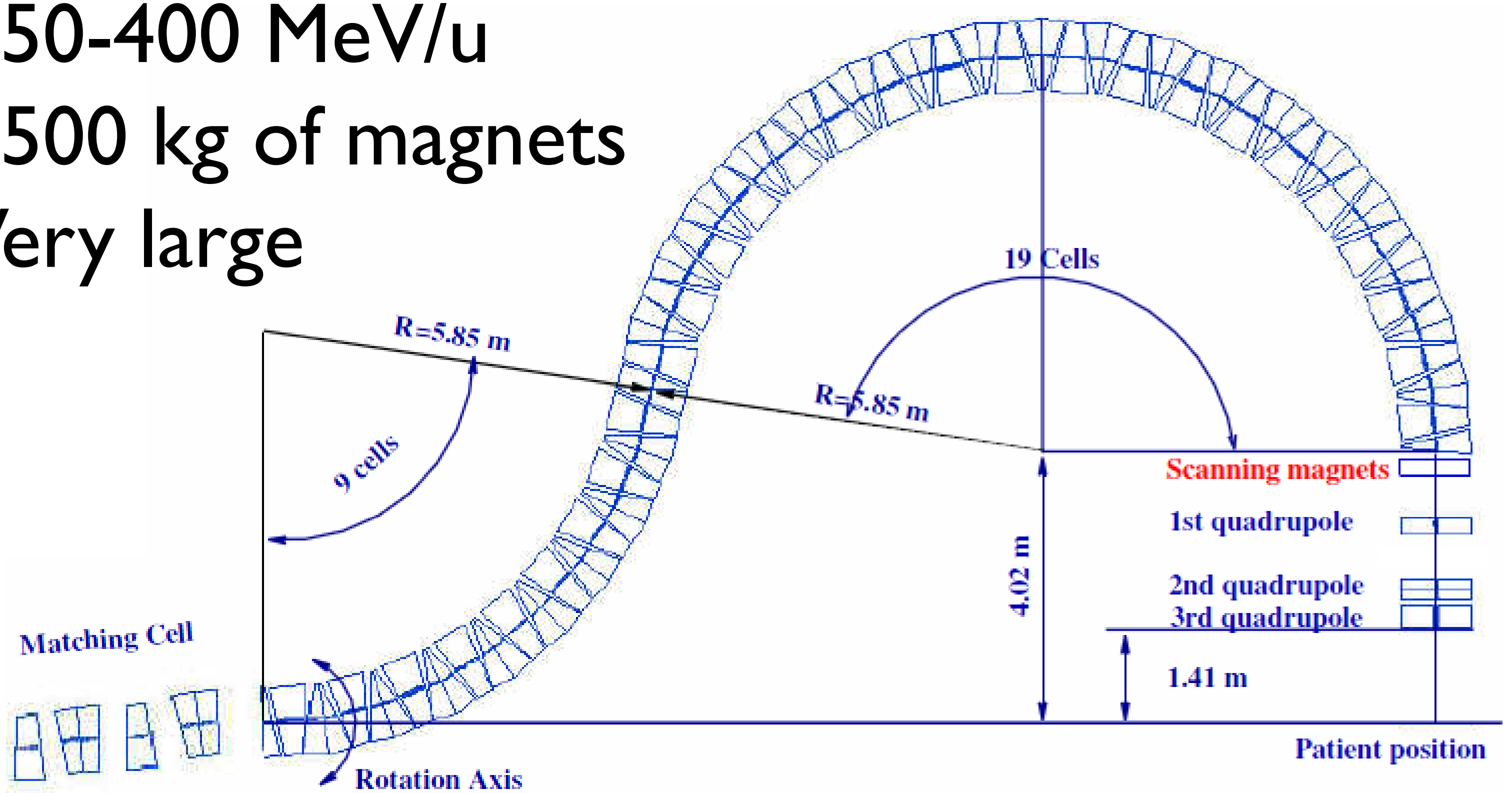


Aspects and ideas to be considered

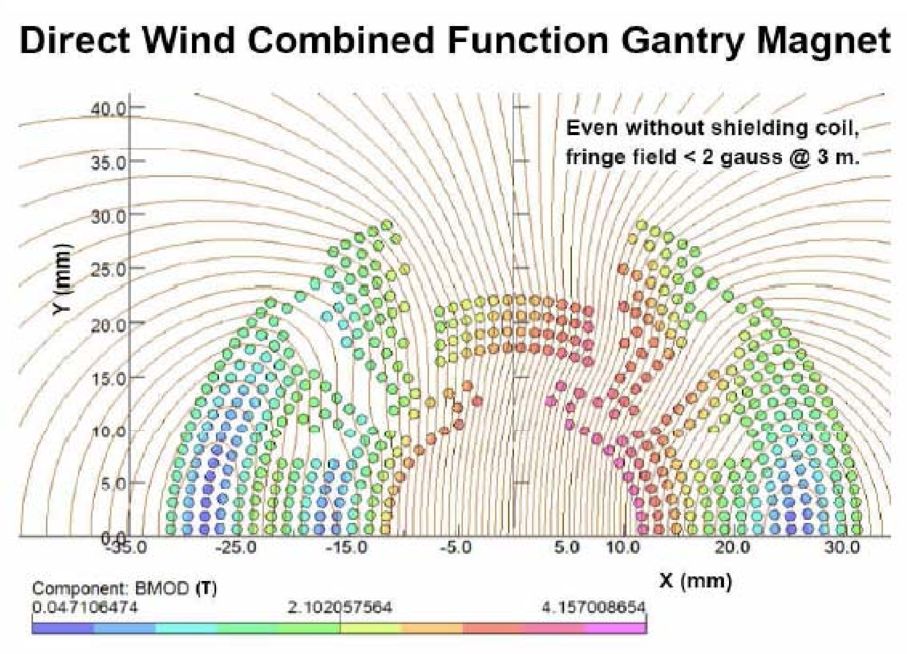
- Scanning
- SAD and scanning magnets position
- 360° vs 180°
- Field patching
- Fixed or mobile isocenter
- Multi-room system
- Divergent scanning
- Superconducting magnets
- FFAG gantry

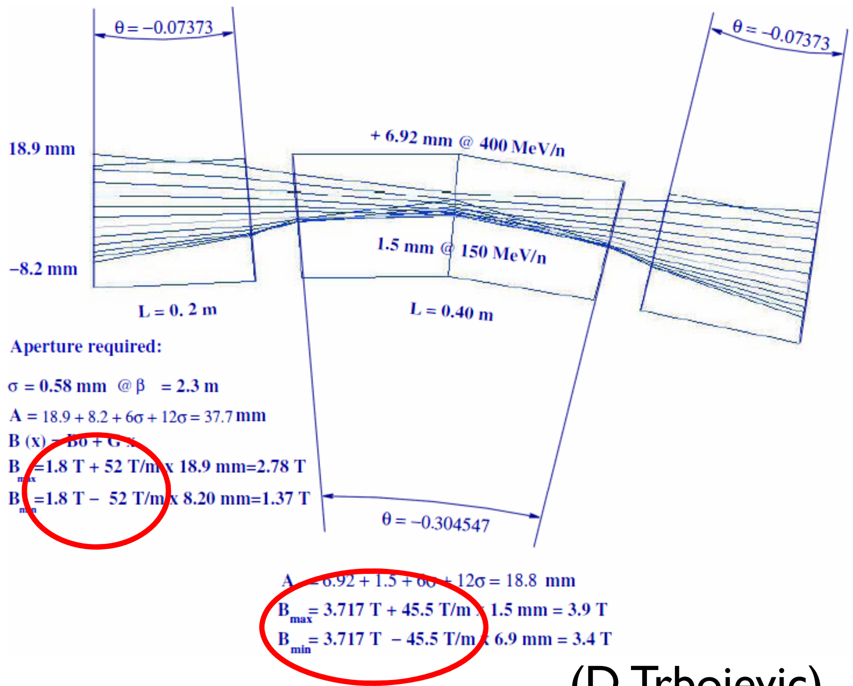
FFAG Gantry

150-400 MeV/u
1500 kg of magnets
Very large



FFAG Gantry





(D. Trbojevic)

FFAG Gantry

- (complicated) scanning upstream gantry?

Other ideas

- Active alignment
- Active compensation of magnetic defects (scanning quadrupoles and sextupoles)
- Scanning by moving magnets
- …

Conclusions

- There are margins to improve the present schemes
- There are embrional ideas for new schemes
- There are large margins for compromise solutions and combinations of ideas


That's all Folks!