Magnetic Bubble for CR experiments in Space

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Attempts to put sc magnets in space for measuring momentum of CR:

- Astromag (Green et al. 1988)
- 2D torus (Green et al. 1988)
- Helmoholtz-like (DePascale et al. 1997)
- Dipol magnet (AMS, 2008)

All based on

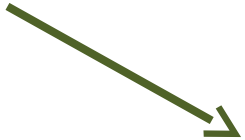
NbTi cable (at 2K,
superfluid LHe tank,
narrow thermodinamical stability)

New technologies:

- Wide scale production of ITS (MgB2) and HTS cables
- Higher operative temperature (cryocoolers CFSM)
- Magnetic system simplified new configurations (e.g. shield from CR)
- Innovative 3D calorimeter for extending GF by an order of magnitude.

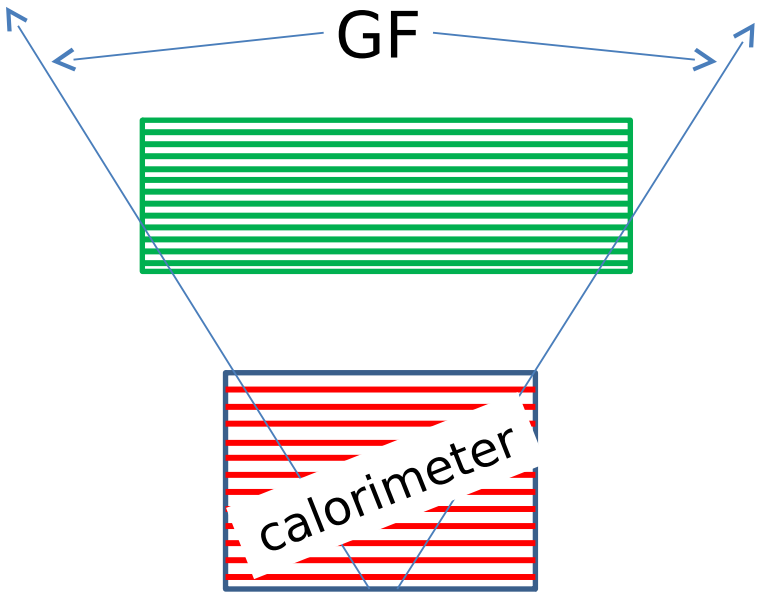
New physics results:

The increase of positron fraction with energy claims for robust identification of e+ (as well antip and antiN) up to TeV region



Large GF
High MDR

tandard telescope for CR in space

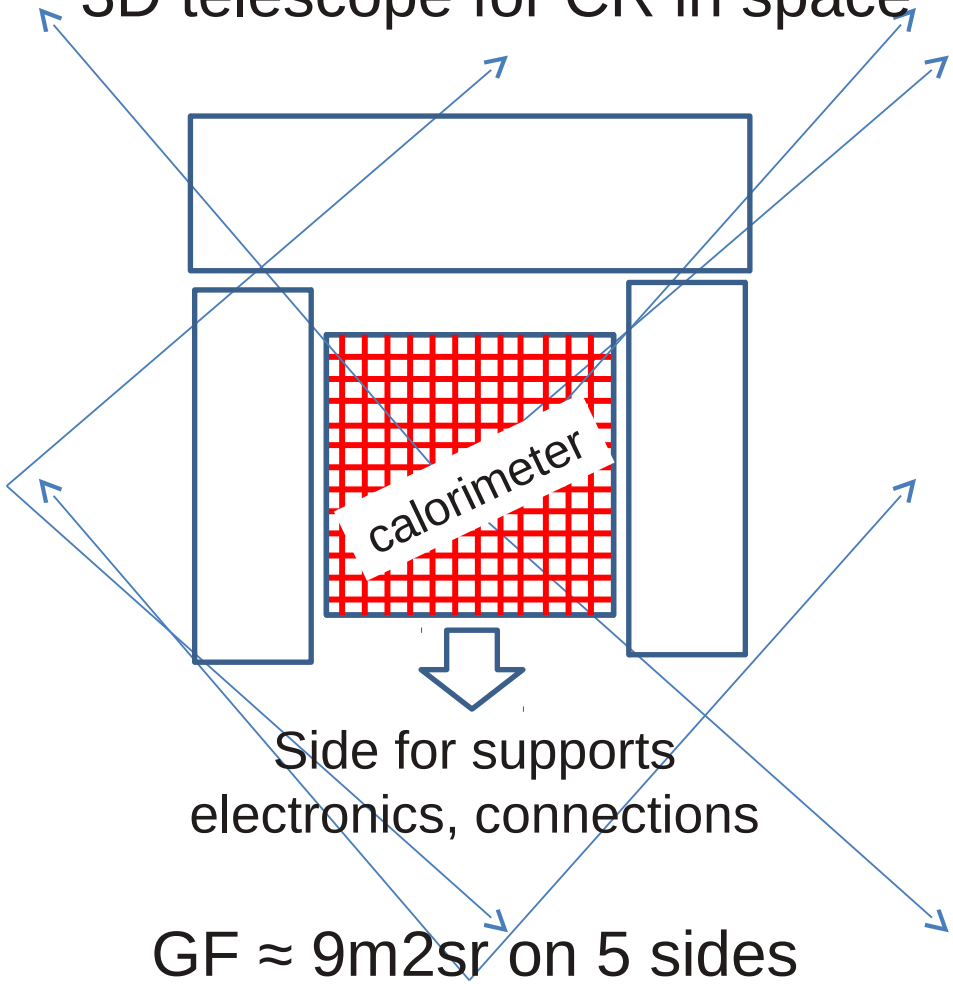


≤1m2

GF ≤ 0.5m2sr

≈ for experiments in LEO

Cubic calorimeter + 3D telescope for CR in space

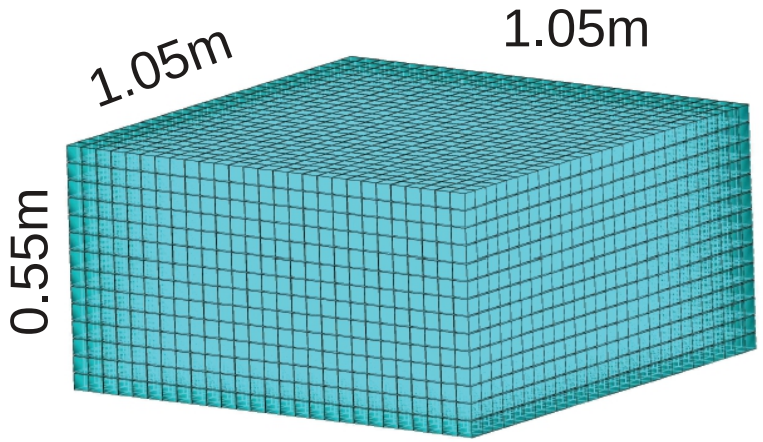


Side for supports
electronics, connections

GF ≈ 9m2sr on 5 sides

important for experiments in high orbit

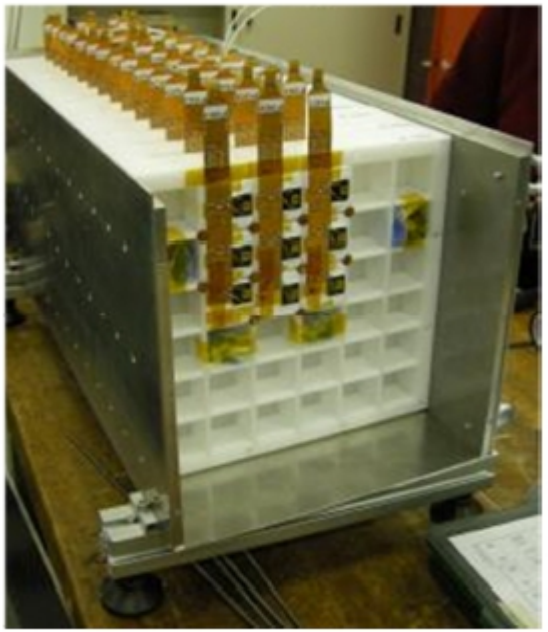
Example: ‘quasi-cubic’ calorimeter in Gamma-400



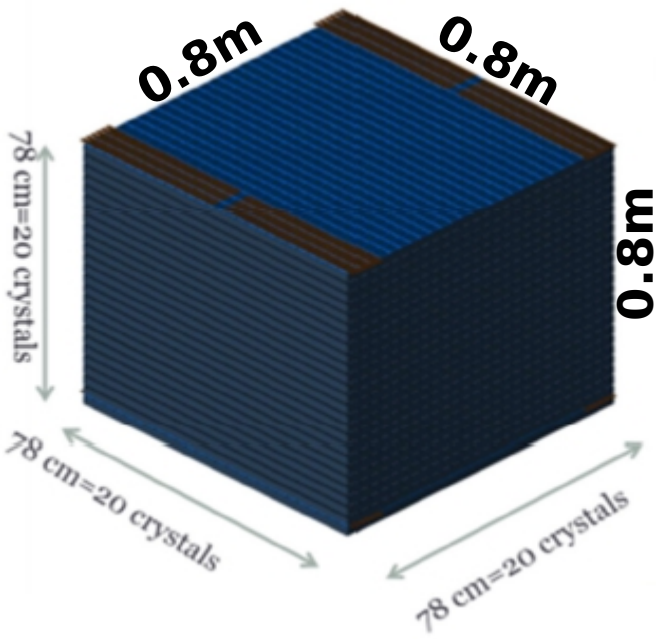
3D matrix of CsI(Tl) crystals
(10,200 crystals 3.6x3.6x3.6 cm3)

GF for electrons = 3.4m2sr E up to 10 Te
GF for protons = 4.0m2sr E up to 3 PeV
GF for ions = 4.8m2sr E up to 4 PeV

Tests in CERN and in LNF
- pre-prototype a few crystals
- prototype ≈ 100 crystals



3 years INFN program: CALOCUBE development



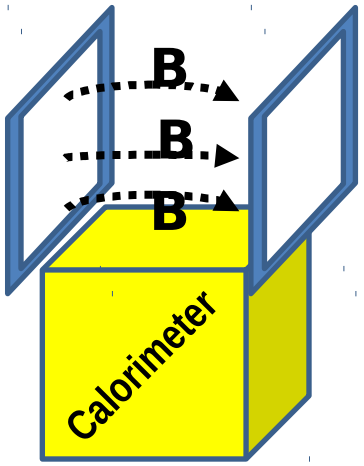
Study with:

CsI with different doping
other crystals
different read out schemes
different mechanical concepts

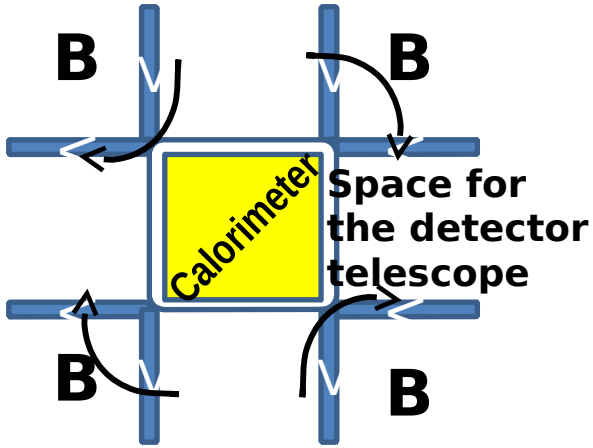
Tests of prototypes

8,000 crystals 3.6x3.6x3.6cm3

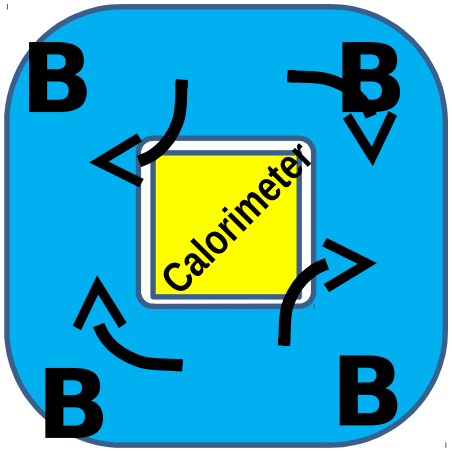
F= 9.55m2sr (5 sides) x efficiency
≈ 4-5m2sr for e and p



(a)

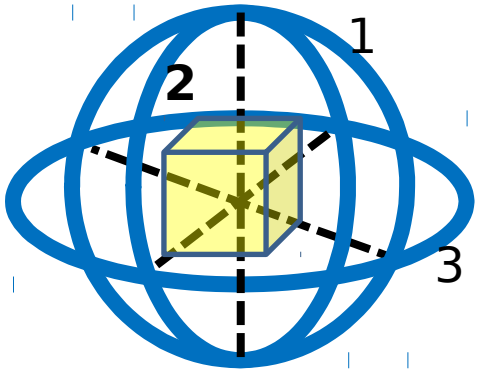


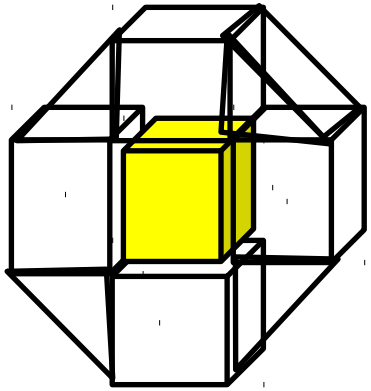
(b)

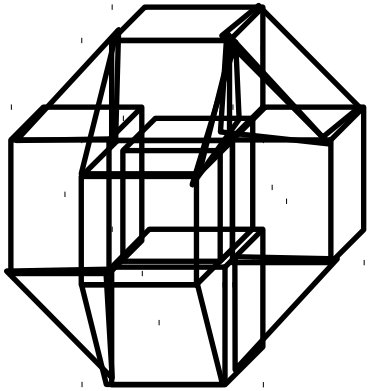


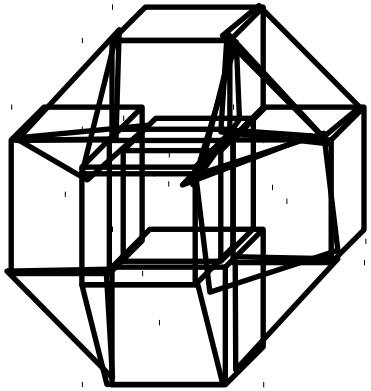
(c)

The ‘torus’ concept, running outside around four faces of the calorimeter
Magnetic dipole = null





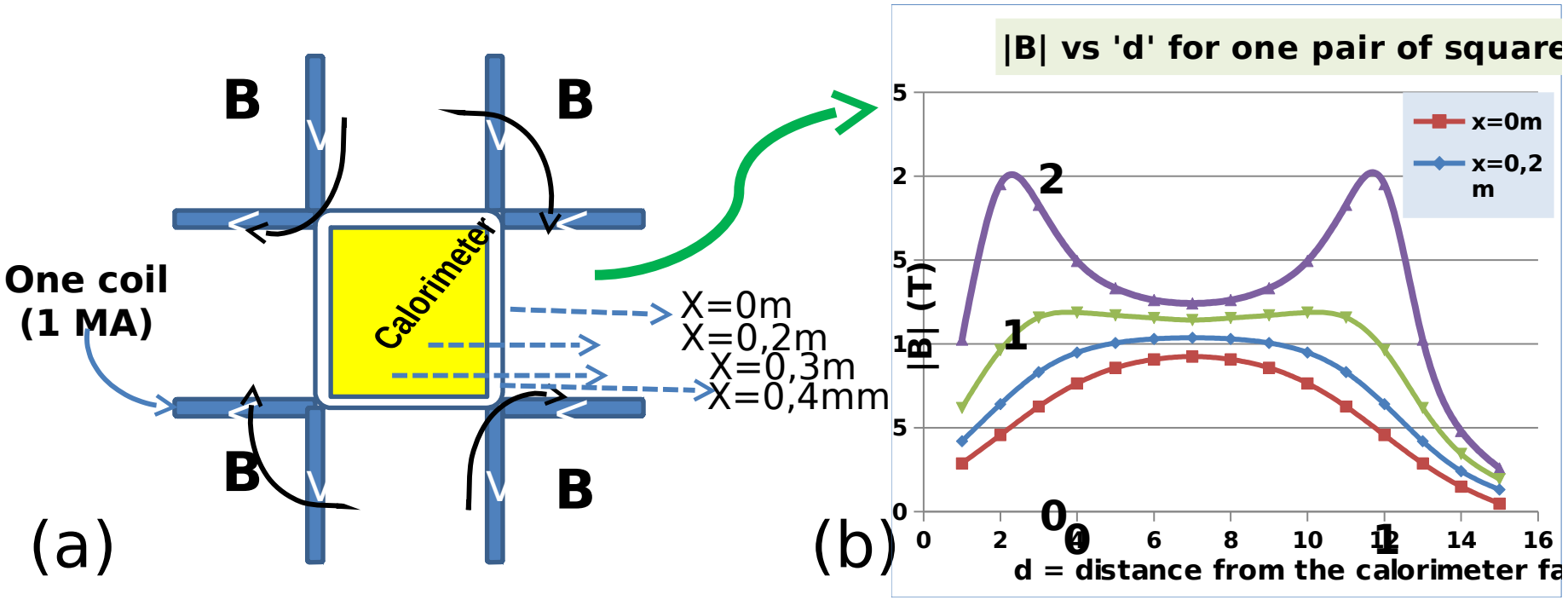




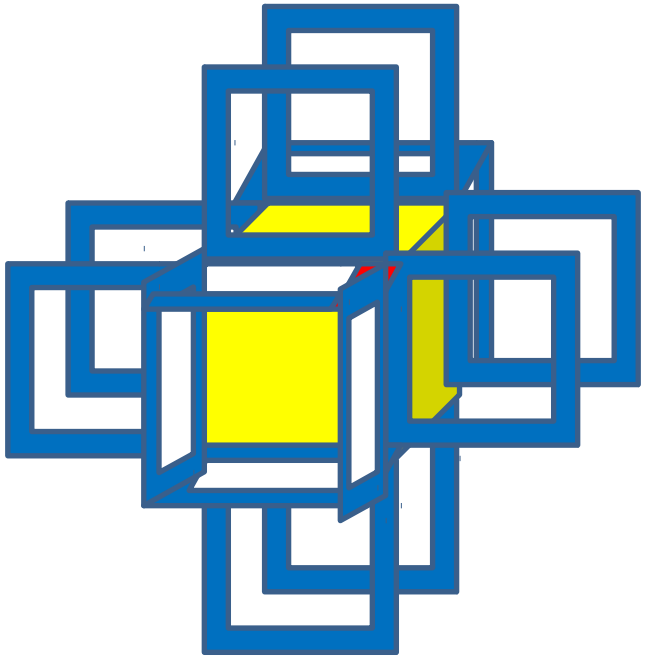
(a) (b) (c) (d)

Concept of the 3D magnetic bubble:

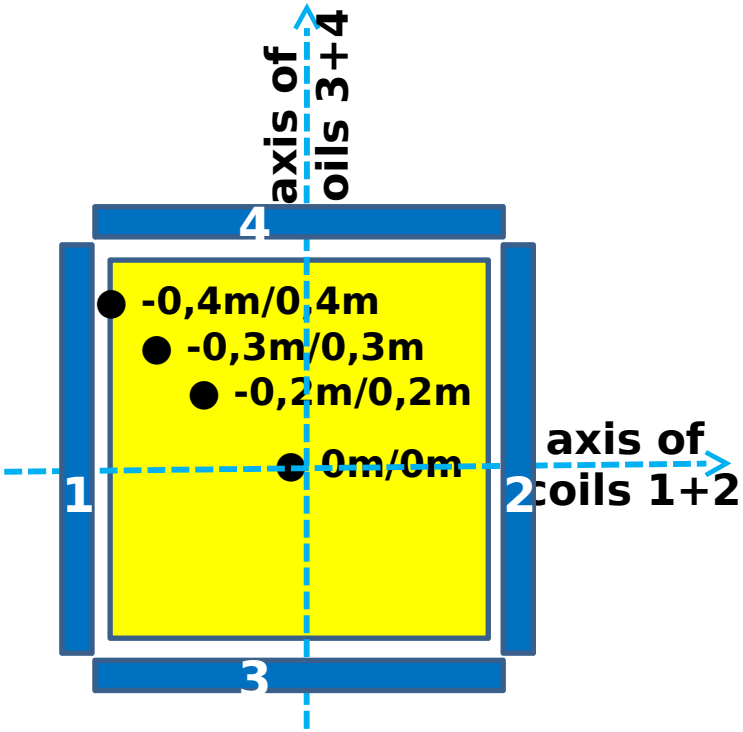
(a) scheme of three torus's surrounding the cube;
(b) schematic of one torus;
(c) two crossing at 90°;
(d) three crossing at 90°.

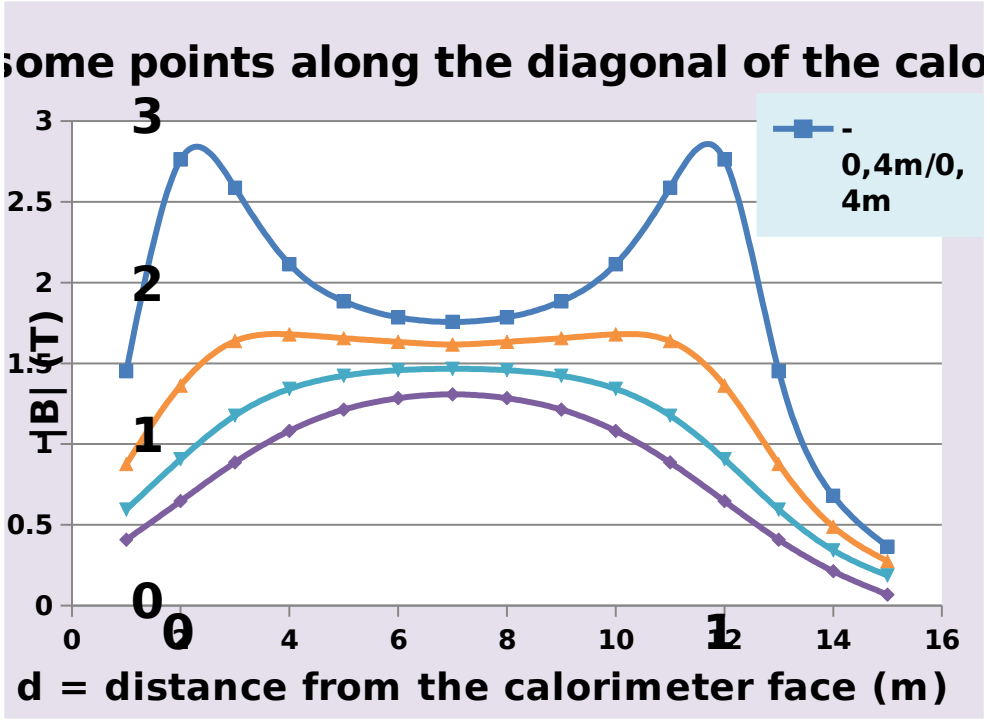


(a) scheme with pairs of 2 parallel 1mx1m coils, and
(b) the magnetic field produced by two coils at various distances from the center of the calorimeter face.

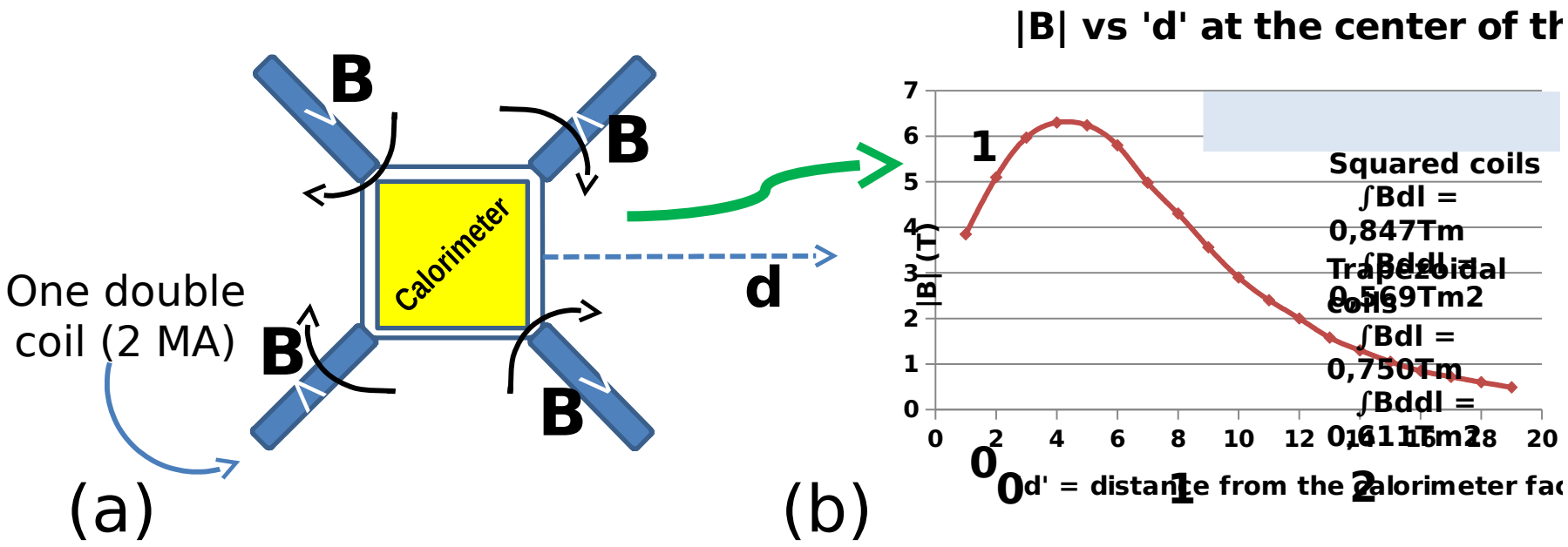


Artistic view of the system of three torus’s:
24 square 1mx1m identical coils (16 coils in the figure because one of the torus is not represented in the figure for clearness reason)



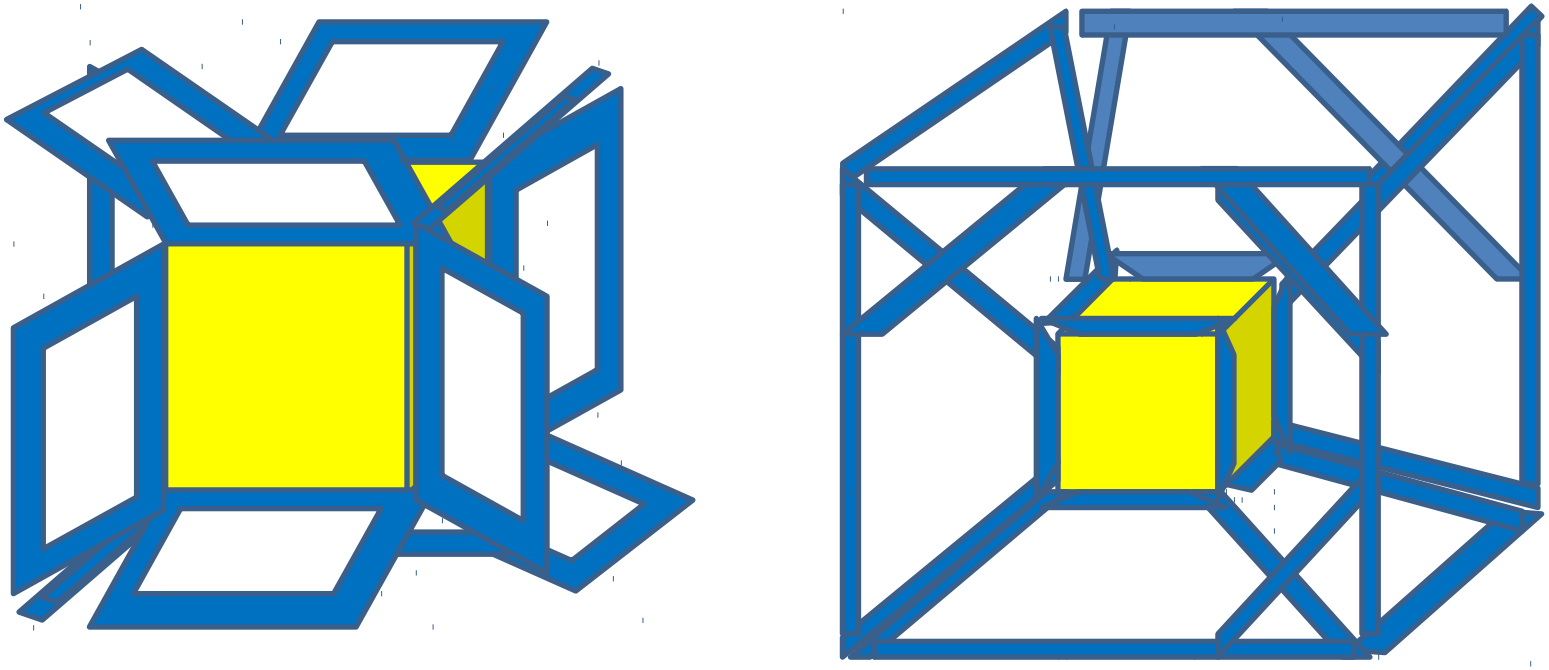


Magnetic field vs distance from the calorimeter face at some points along the diagonal of the calorimeter face. 1-2 (3-4) indicate the couple of coils producing the field along 1-2 (3-4) axis



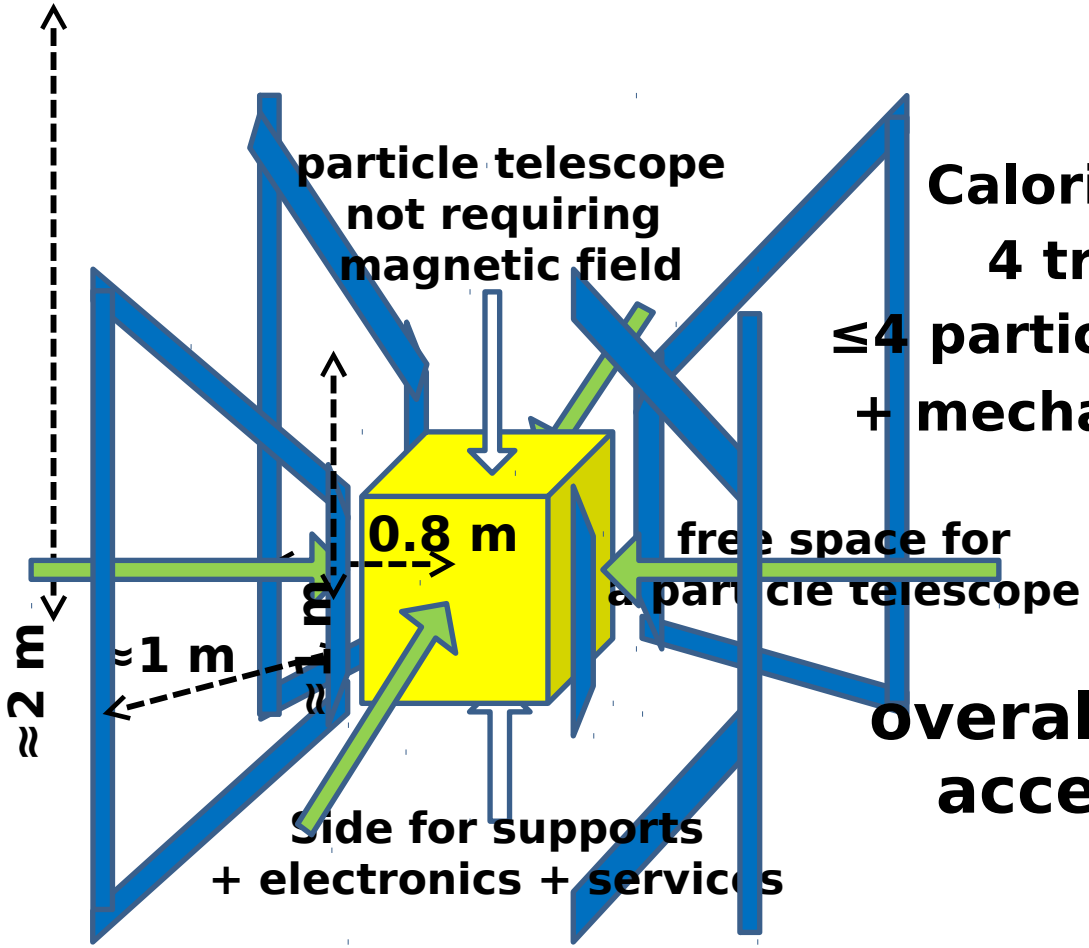
(a)scheme of one torus with two squared 1mx1m coils joined at each edge of the cube (‘double coil’);

(b)magnetic field perpendicular to the calorimeter face produced by a pair of two double coils.



(a) (b)

The system of three torus’s composed
(a) by 12 double square 1mx1m coils
(b) by 12 trapezoidal coils.



Calorimeter 0.8x0.8x0.8 m3 =

4 trapezoidal coils 4x0.24 =

≤4 particle telescopes ≤4x0.5t =

+ mechanics + electronics + serv

overal dimensions 4x4x4 m

acceptance ≅4x1≅4m2sr

One torus consisting of 4 ‘trapezoidal’ coils

Parameters of sc cable

Hypothesis – use of MgB2 @ T =10K @ few tesla (B≤4T)

with δ = 200A/mm2 (engineering value)

for 1MA cable section = 50cm2 (r=4cm)

cable mass = 20kg/m coil = 120kg

for 2MA cable section = 100cm2 (r=5.6cm)

cable mass = 40kg/m coil = 240kg

with δ = 600A/mm2 (short samples, engineering in next years)

for 1MA cable section = 17cm2 (r=2.3cm)

cable mass = 6.7kg/m coil = 40kg

for 2MA cable section = 35cm2 (r=3.3cm)

cable mass = 13kg/m coil = 80kg

Spasibo za vnimanie

Grazie per l’attenzione

Thanks for your attention