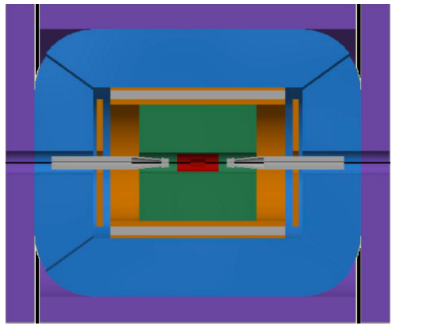

Future projects in WP7

Muon detection systems for future accelerators & MPGDs

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INFN Bologna

Contacts

- In these last months we had the opportunity to develop many new contacts with the European community of FCC, as well as with the Chinese community of CepC and SppC.
- In particular, given the relevant experience that INFN has on muon detectors and on MPGDs and RPCs, there are many projects in which our contribution would be highly appreciated and valued.

Plans and timetable of CDRs

- The CDR for CepC is meant to be ready for the end of 2017. While I believe that this is highly ambitious, it is clear that our chinese friends want to have their CDR ready before the FCC one.. so we can assume that spring-summer 2018 is an almost sure bet. The CDR will mainly focus on the e^+e^- CepC machine and will also include a chapter on SppC, the proton-proton collider of 100 TeV.

- The FCC CDR will be a gigantic document, with many volumes and ramifications. Of interest to us are certainly the FCC-ee and the FCC-hh parts. Timescale is end 2018, certainly before the next European strategy document, which I believe is now scheduled to happen in 2020.

Sinergie tra CepC e FCC-ee

- Nell'ultimo disegno dell'acceleratore CepC, che ci e' stato mostrato qualche mese fa a Hong Kong, l'acceleratore e' sostanzialmente diventato la copia carbone di FCC-ee.
  - Il diametro e' ora di 100 km
  - Il final focusing usa lo stesso schema crab waist di FCC-ee
  - Le ecm previste sono al picco della Z, a 240 GeV (picco Higgstrahlung), e al picco top-antitop (~350 GeV)
- Questa "similitudine" tra i due acceleratori ci semplifica la vita.
  - Possiamo usare lo stesso disegno di rivelatore
  - Possiamo avere la stessa configurazione in Delphes
  - Possiamo usare questa configurazione e alcuni canali di fisica di benchmark per entrambe le macchine
  - Possiamo ossia prendere i classici due piccioni con una fava…

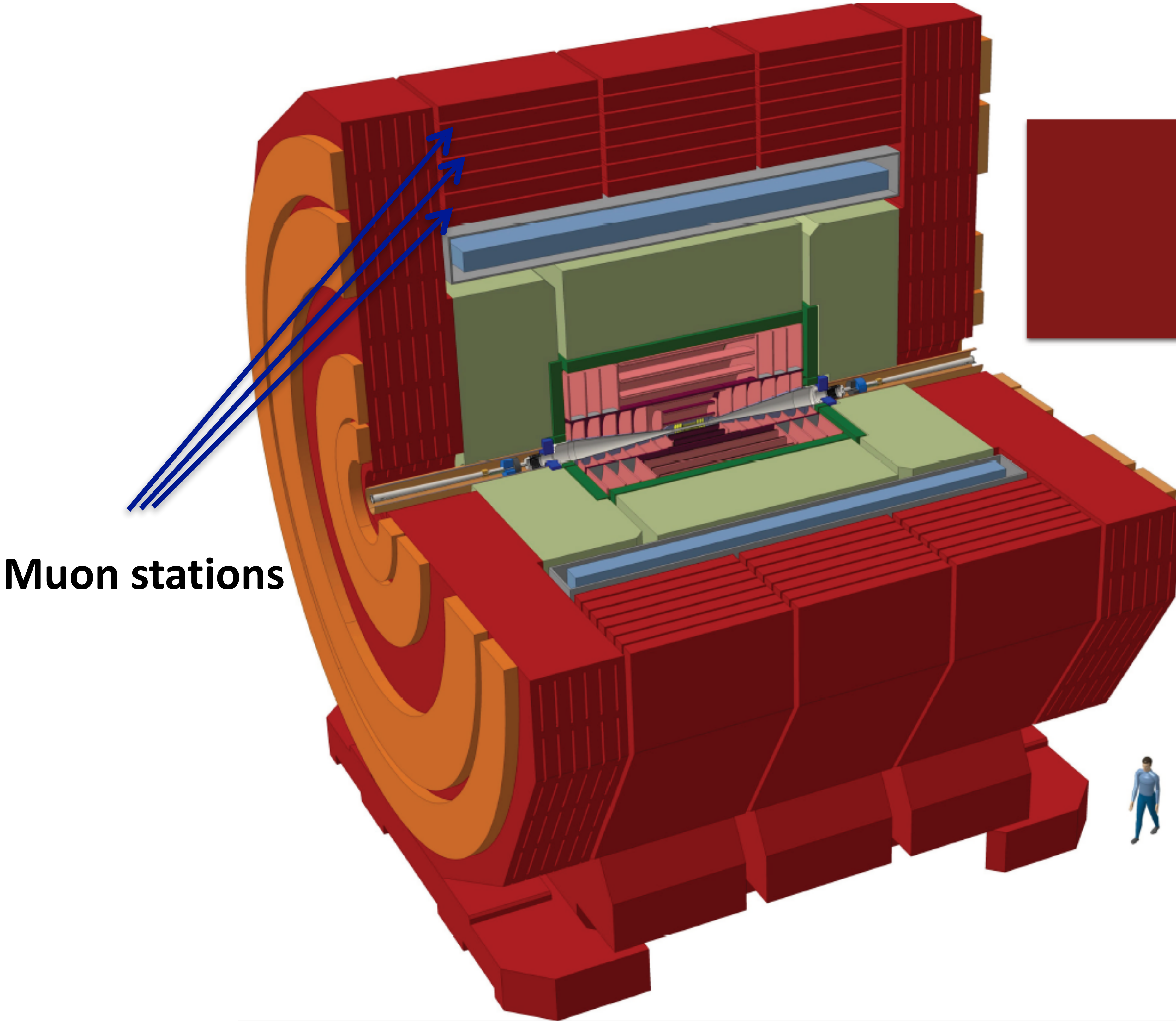
Rivelatore di muoni per CepC

- Nel rivelatore baseline, ispirato da ILD, il rivelatore di muoni e' basato su due stazioni di RPC. I cinesi non hanno grande esperienza in rivelatori di muoni e hanno implementato un rivelatore minimale che potremmo molto facilmente migliorare dal punto di vista delle prestazioni. I cinesi sono molto interessati a questa possibilità.
- Nel rivelatore IDEA da noi proposto consideriamo invece un rivelatore di muoni piu' performante che potrebbe essere composto da almeno tre stazioni di MPGD, che forniscano una buona risoluzione spaziale e temporale e provvedano un trigger indipendente.

Muon detector for FCC-ee

- There are two detector concepts for FCC-ee: a CLIC-inspired detector and IDEA
- In the CLIC-inspired detector the muon system is made of 7 muon stations interleaved in the iron return yoke, and every muon station is made of RPCs.
- In the IDEA concept, the muon system is made of 3-4 men stations, also interleaved in the iron return yoke, each station is equipped with PMGS detectors, (could be microRWells or Micromegas)

Muon detector for FCC-ee



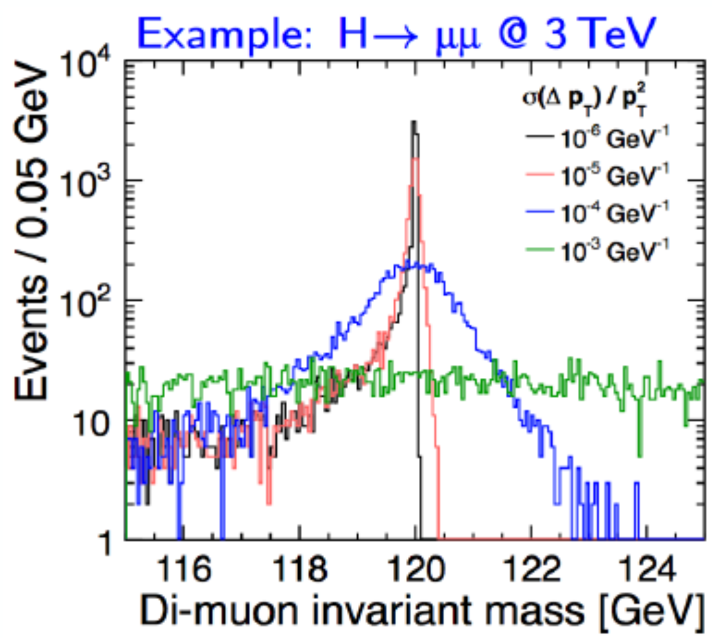
CLIC detector layout and performances

Muon detector for FCC-ee

CLIC Detector requirements from physics

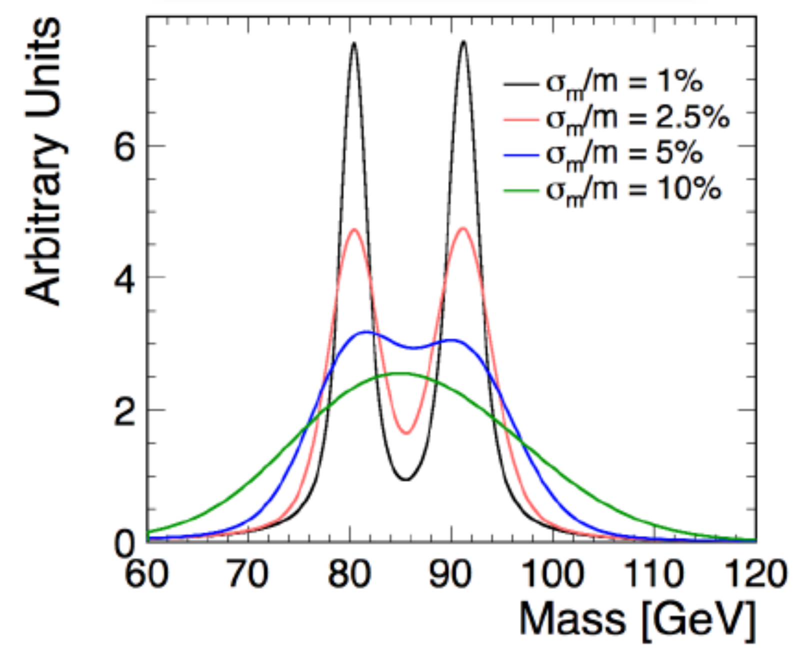
- momentum resolution
  - Higgs recoil mass, Higgs coupling to muons, BSM (smuon and neutralino masses)
  - for high p_T tracks

$$\sigma_{p_T}/p_T^2 \simeq 2 \times 10^{-5} GeV^{-1}$$



- jet energy resolution
  - W/Z di-jet mass separation
  - jet energy up to 1 TeV

$$\sigma_E/E \simeq 3.5\%$$



- impact parameter resolution
  - c/b tagging, Higgs BR

$$\sigma_{d_0}^2 = a^2 + \frac{b^2}{p^2 \sin^3 \theta}$$

$$a \lesssim 5 \mu m \quad b \lesssim 15 \mu m GeV$$

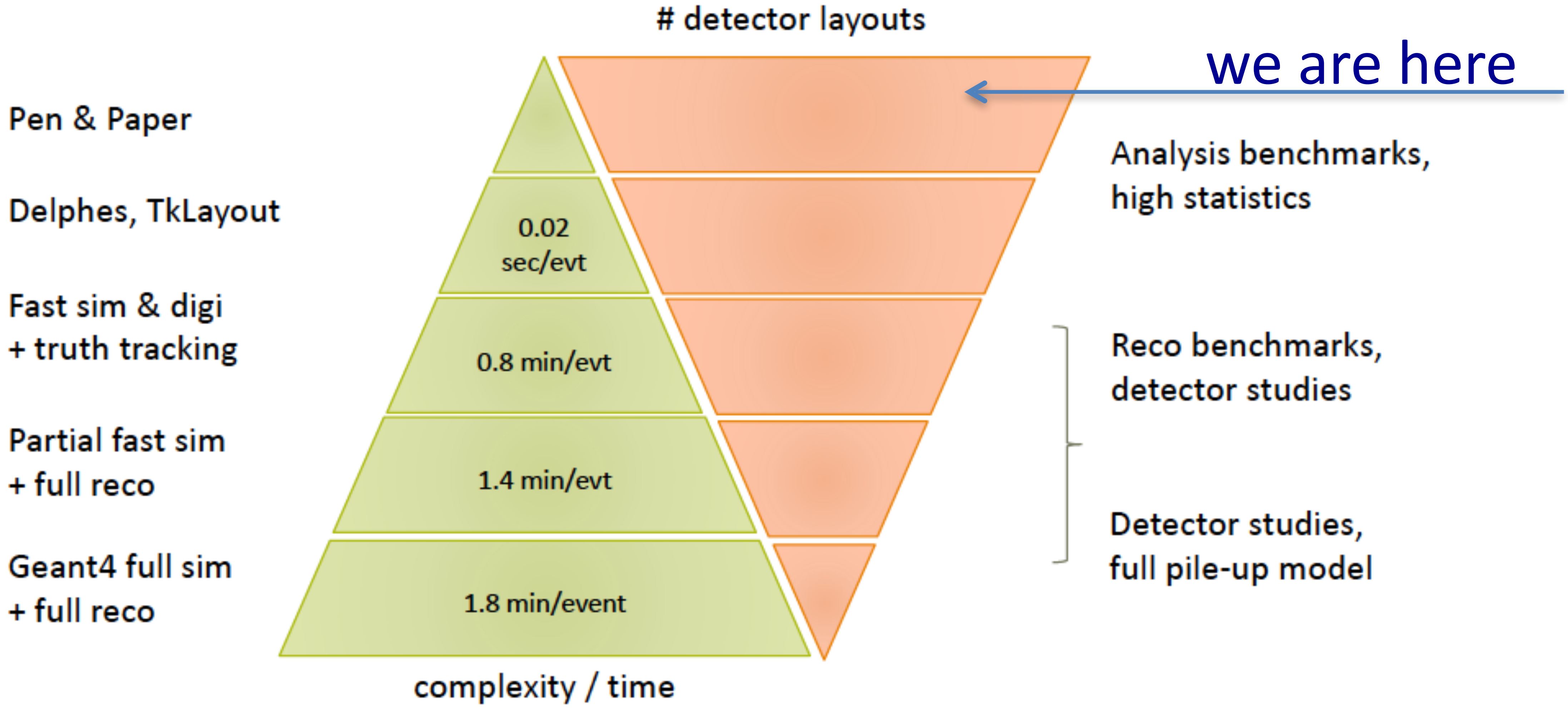
- lepton ID efficiency > 95 %
  - over full energy range

- forward coverage
  - electron and photon tagging (e.g. dark matter studies)

Presented t Berlin at the FCC week by W. Riegler

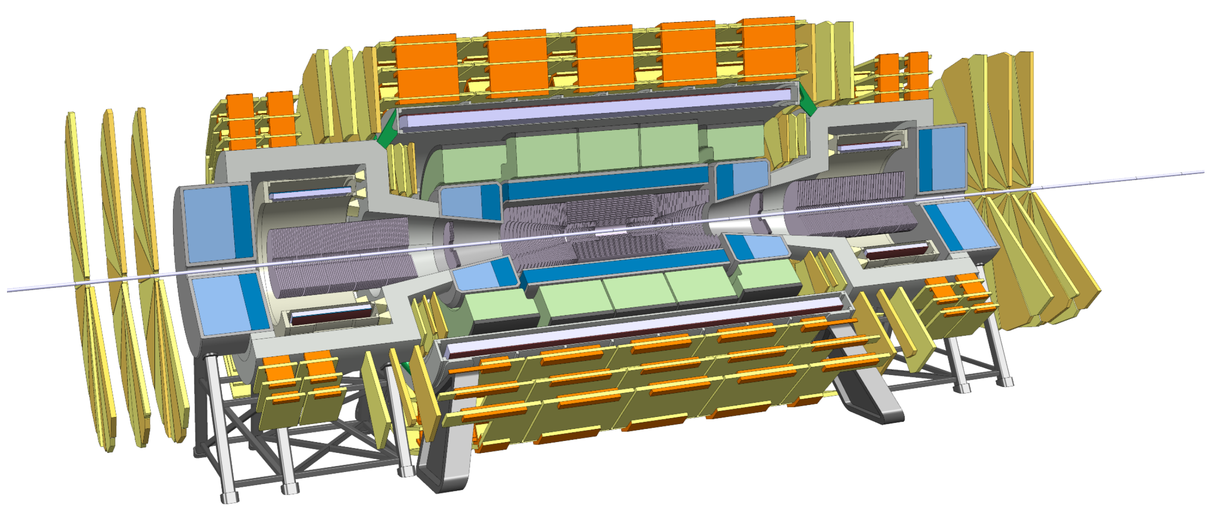
Status of Muon System Studies for FCC-hh

The right tools for the right job



Muon detector for FCC-hh

Muon Systems



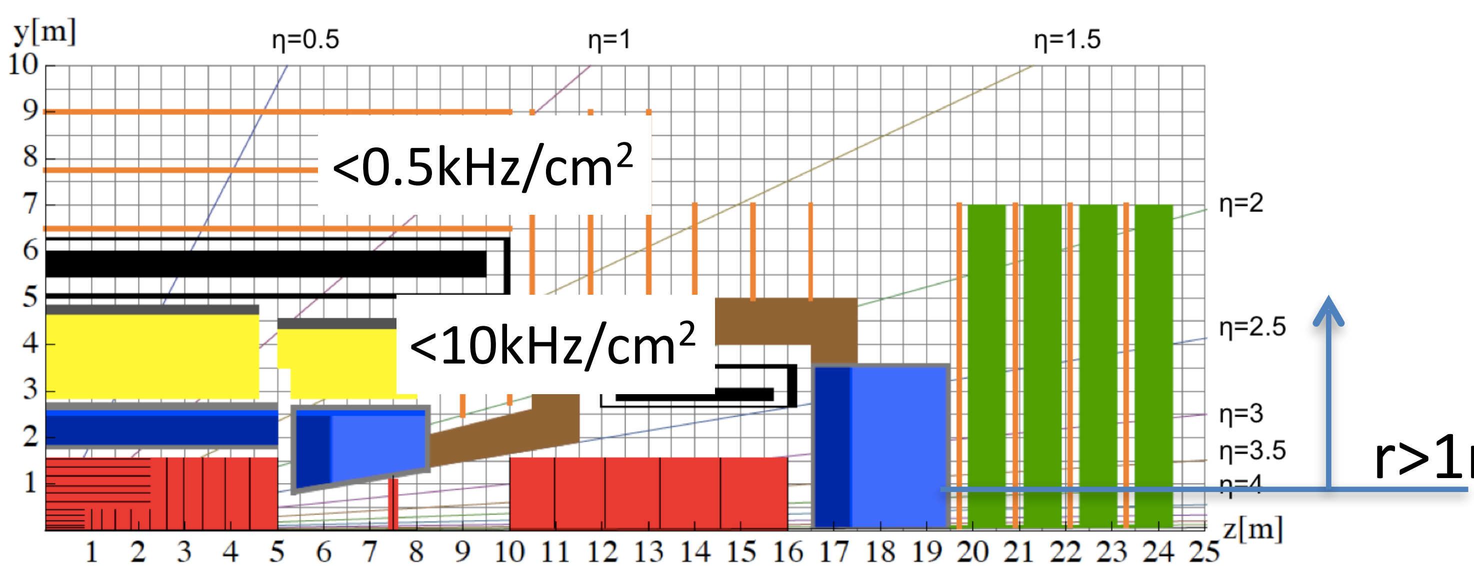
ATLAS muon system HL-LHC rates (kHz/cm^2):

MDTs barrel:	0.28
MDTs endcap:	0.42
RPCs:	0.35
TGCs:	2
Micromegas und sTGCs:	9-10

Table 4.5: Expected rates on the muon detector when operating at an instantaneous luminosity of 2×10^{33} cm^{-2}s^{-1} at a collision energy of 14 TeV. The values are averages, in kHz/cm^2, over the chamber with the minimum illumination, the whole region and the chamber with maximum illumination. The values are extrapolated from measured rates at 8 TeV.

LHCb

Region	Minimum	Average	Maximum
M2R1	162 ± 28	327 ± 60	590 ± 110
M2R2	15.0 ± 2.6	52 ± 8	97 ± 15
M2R3	0.90 ± 0.17	5.4 ± 0.9	13.4 ± 2.0
M2R4	0.12 ± 0.02	0.63 ± 0.10	2.6 ± 0.4
M3R1	39 ± 6	123 ± 18	216 ± 32
M3R2	3.3 ± 0.5	11.9 ± 1.7	29 ± 4
M3R3	0.17 ± 0.02	1.12 ± 0.16	2.9 ± 0.4
M3R4	0.017 ± 0.002	0.12 ± 0.02	0.63 ± 0.09
M4R1	17.5 ± 2.5	52 ± 8	86 ± 13
M4R2	1.58 ± 0.23	5.5 ± 0.8	12.6 ± 1.8
M4R3	0.096 ± 0.014	0.54 ± 0.08	1.37 ± 0.20
M4R4	0.007 ± 0.001	0.056 ± 0.008	0.31 ± 0.04
M5R1	19.7 ± 2.9	54 ± 8	91 ± 13
M5R2	1.58 ± 0.23	4.8 ± 0.7	10.8 ± 1.6
M5R3	0.29 ± 0.04	0.79 ± 0.11	1.69 ± 0.25
M5R4	0.23 ± 0.03	2.1 ± 0.3	9.0 ± 1.3



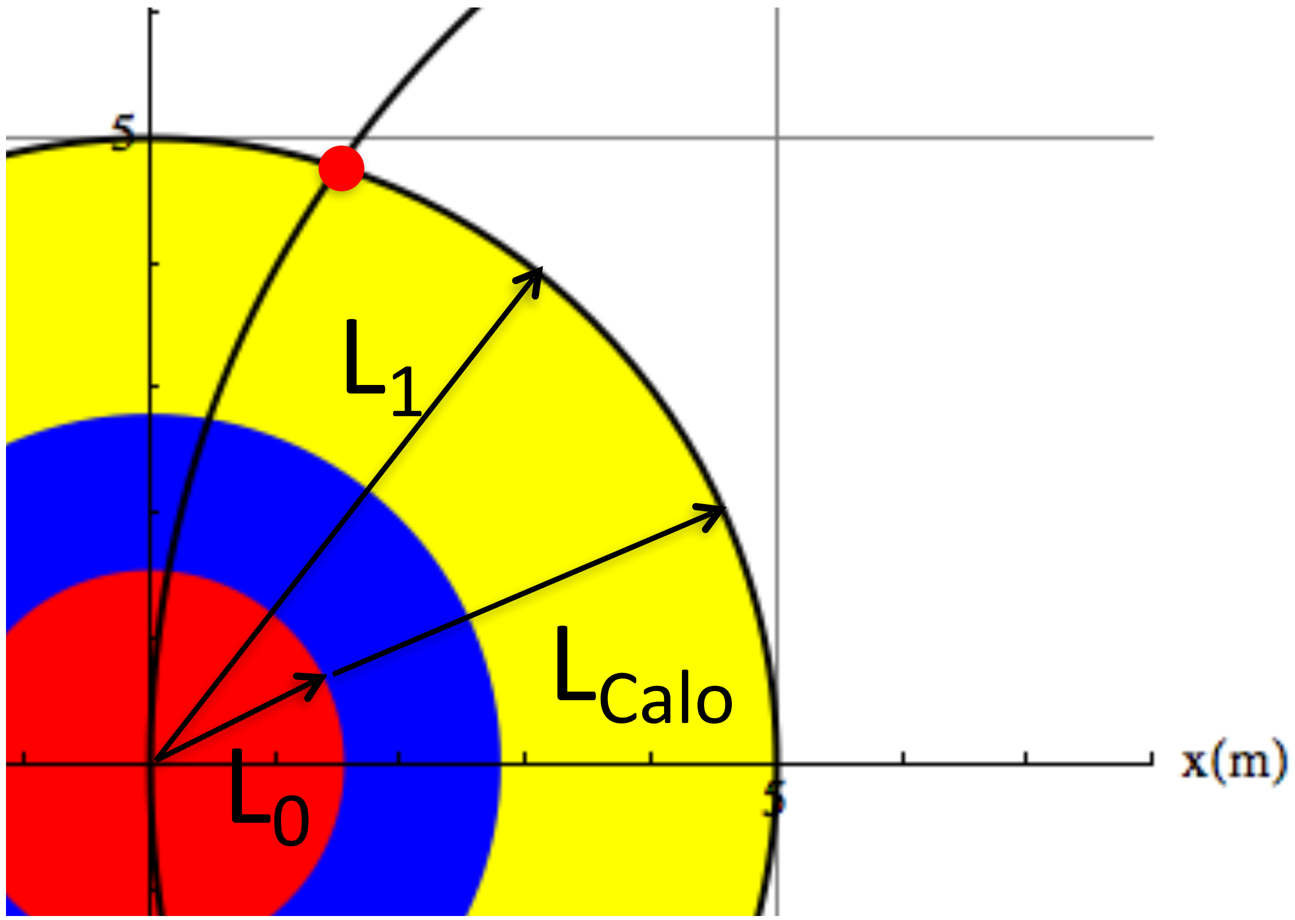
r>1m rate<500kHz/cm^2

HL-LHC muon system gas detector technology will work for most of the FCC detector area

Muon system performance estimate

Three ways to measure the muon momentum

1) Tracker only with identification in the muon system
2) Muon system only by measuring the muon angle where it exits the coil
3) Tracker combined with the position of the muon where it exists the coil



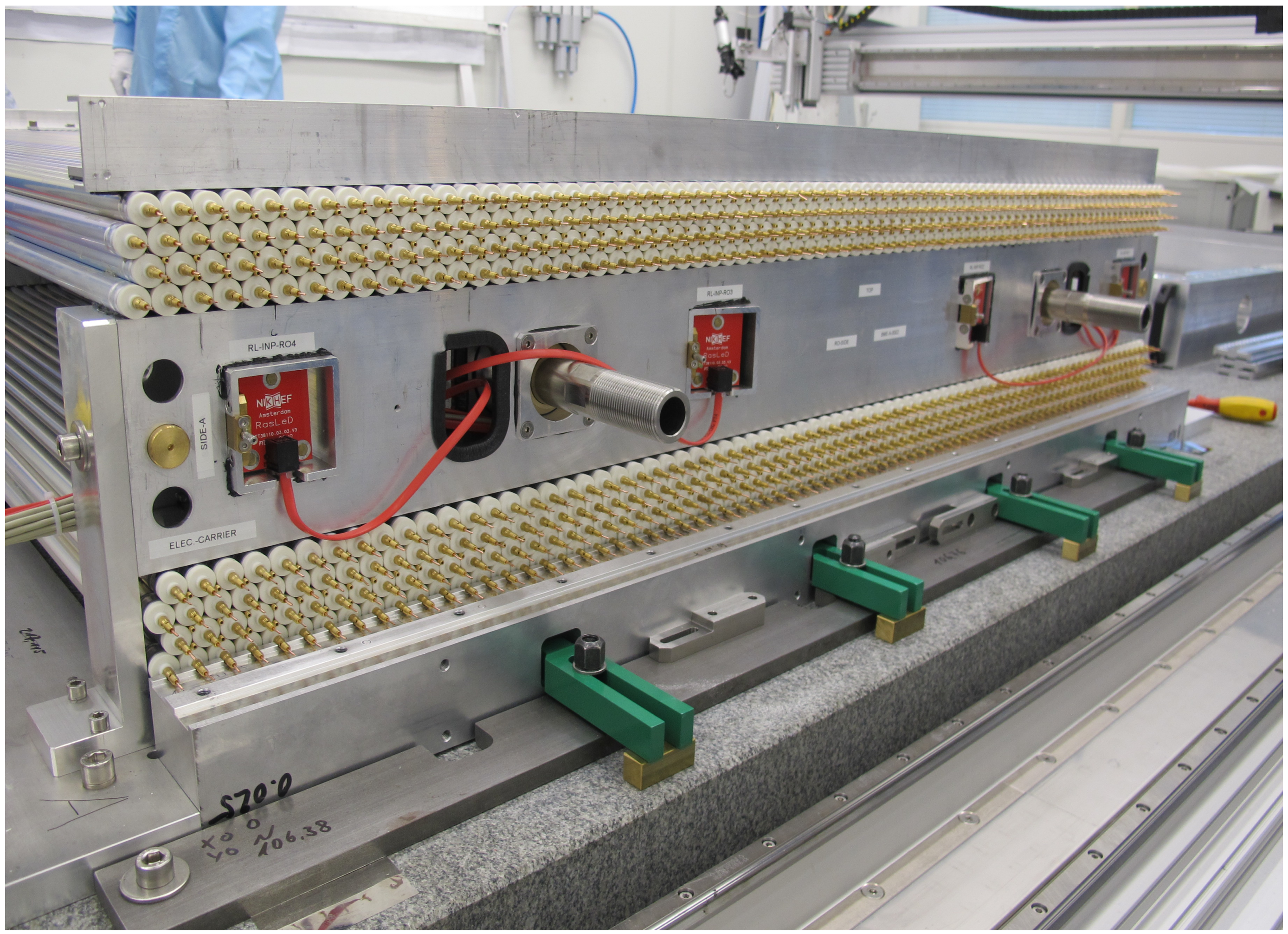
We assume a constant magnetic field inside the coil radius L_1.

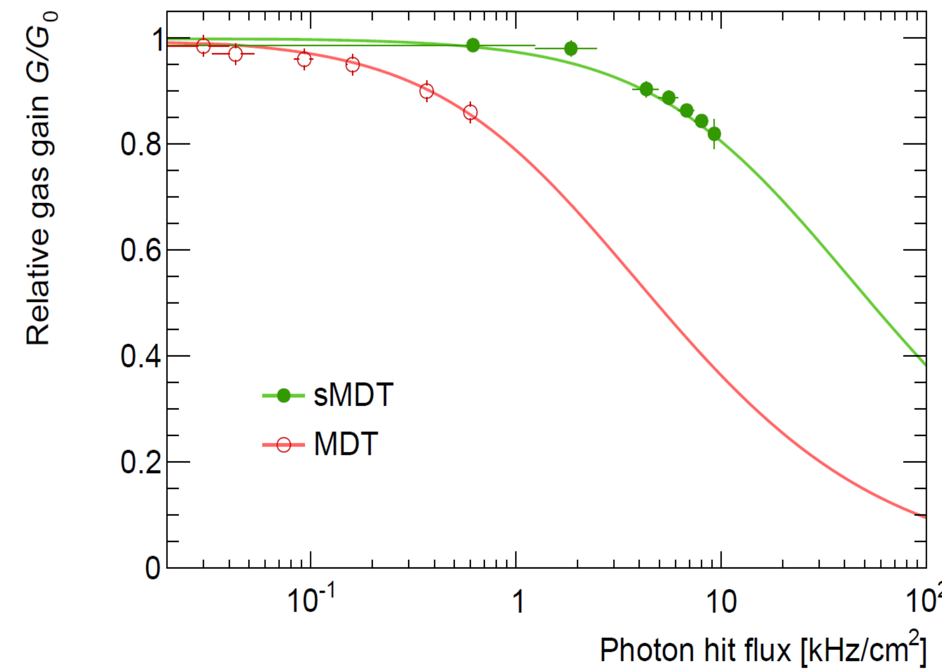
The measurement points in the tracker of radius L_0 are equidistant and have all the same resolution σ_0.

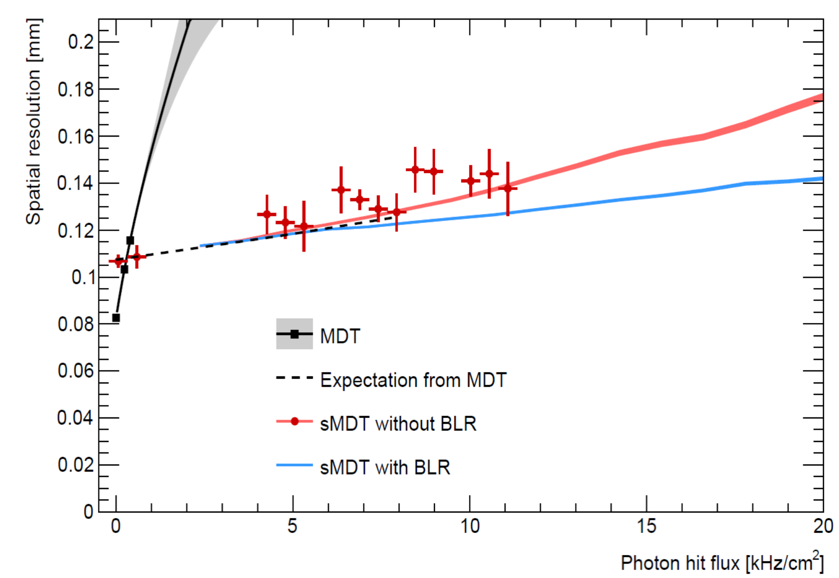
The measurement point at L_1 has a position error σ_1 that is given by the multiple scattering inside the calorimeters (σ_y in the following).

The formula for the momentum resolution is given in the next slide.

Example ATLAS MDT Drift Tubes



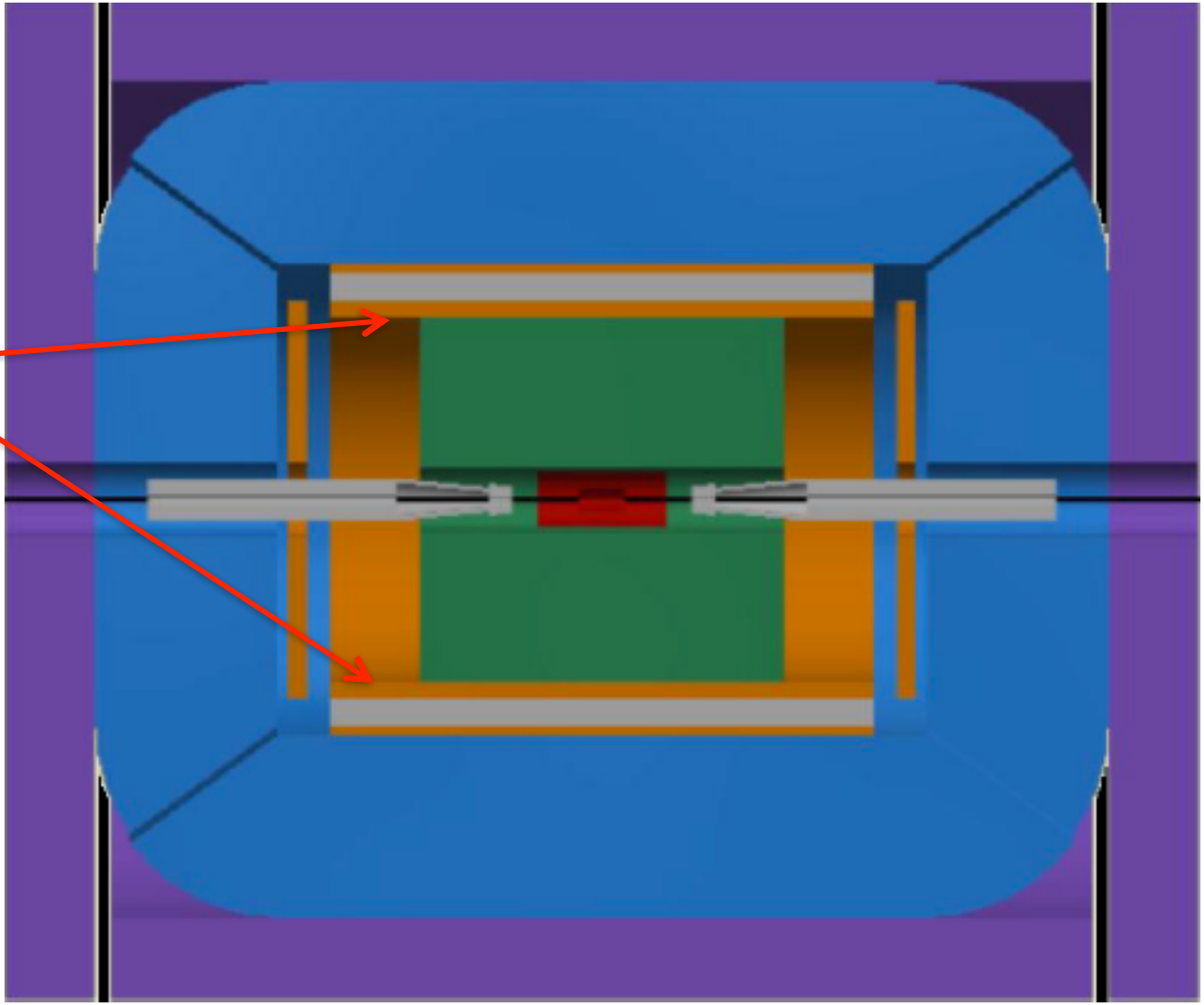




Rivelatore di muoni per FCC-hh

- Ho parlato di persona con Riegler che mi ha detto che sarebbe molto contento di avere un contributo dall'INFN
- In particolare vorrebbe che pensassimo al disegno globale del rivelatore di muoni (quante stazioni, che precisione e' richiesta, trigger indipendente sui mu per ridurre il rate, ecc.) piu' ancora che al tipo di tecnologia, visto che sa che varie delle tecnologie che noi conosciamo bene (Micromega, GEM, microRWell) sarebbero adeguate

IDEA Preshower



Preshower

Preshower

- Il preshower potrebbe probabilmente essere realizzato in gran parte con MPGD, usando al massimo due ring esterni con rivelatori al silicio per fornire una precisione sull'accettante del rivelatore di pochi micron.
- Dovremmo includere il preshower nel Montecarlo di IDEA e studiarne gli effetti
  - Possiamo fare una FullSim o basterebbe una simulazione con DELPHES?
  - Questi studi ci permetterebbero di definire i parametri del preshower
- Nel 2018-19 potremmo pensare di realizzare un piccolo prototipo di calorimetro dual readout con un preshower davanti?

Other R&D projects for 2018-2019

- Together with Franco we have discussed many times about asking INFN for money for a few (2-3) hardware R&D projects in 2018-2019
- One of these could be a “slice” test of a combined calorimeter with a MPGD-based preshower.
- Another one could be the engineering and development of a high-rate MPGD (microRWell) detector for very high-rate applications
- Other ideas?

Applications for funding opportunities

- Headed by Bencivenni and Cibinetto, we have prepared and submitted a proposal for the Italian-China co-fuding scheme MAECI. Sections involved are: Bari, Bologna, Ferrara, Frascati, Torino
- We should look for possible synergies and eventually apply to the (as yet not clearly specified) premiale project no. 2 from INFN, which involves, among other things, high-rate muon detector systems for HL-LHC. RD_FA could be seen as a future evolution of R&D for HL-LHC
- Look into possibilities from the EU. Maybe a Marie Curie RISE call could be of interest for the development of MPGDs in collaboration with european industries and chinese academic partners.

Conclusions

- There are vast possibilities of collaboration between CepC, FCC-ee e FCC-hh
- We have a great deal of experience that can shield be usefully deployed
- We can participate to both the overall muon detector design as well as to the R&D and definition of the detector technology to adopt
- The manpower we have is experienced but NOT infinite as we are all involved in major running experiments:
  - Use all possible synergies and try to be maximally efficient
  - The chinese are certainly interested to collaborate with us
  - Strong interest also demonstrated from the European FCC community and we have a few colleagues here today
  - If we want to play a strong role in the preparation of the various CDRs we have to start working now…