The Experiment and Machine Detector Interface

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Interaction Region and MDI Design

The high luminosity requires:

- Low beta-function at the IP (few cm)
- High number of muons per bunch ($N_\mu \sim 2 \cdot 10^{12}$)

Muons decay particles…back of the envelope evaluation:

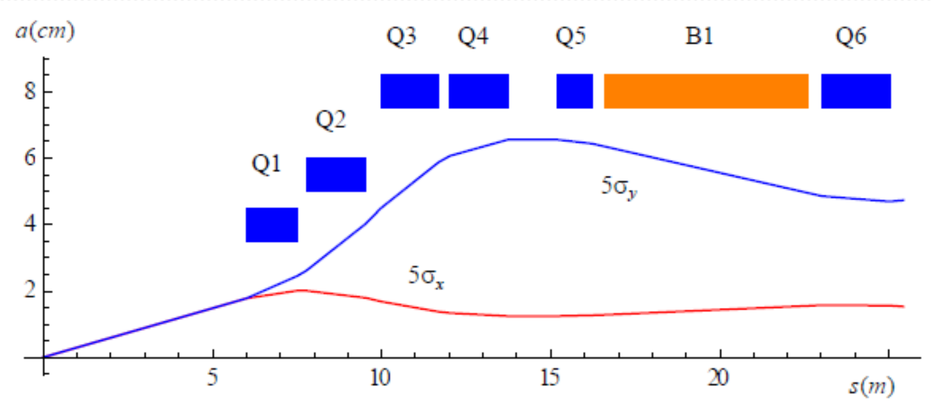
beam 1.5 TeV $\lambda = 9.3{\times}10^6$m, with $2{\times}10^{12}\,\mu$/bunch $\Rightarrow$ $2{\times}10^5$decay per meter of lattice.

Beam induced background (BIB), if not properly treated, could be critical for:

- Magnets, they need to be protected.
- People, due to neutrino induced radiation.
- Detector, the performance depends on the rate of background particles arriving to each subdetector.

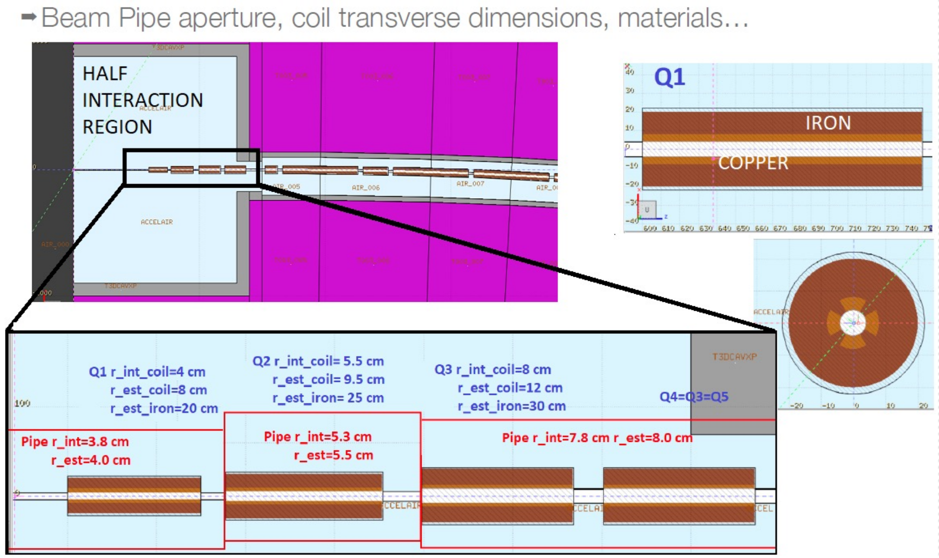
A holistic approach is needed, tight together the development of the IR optics, the magnets and the shielding strategies (magnets and detector).

Beam-Induced Background production



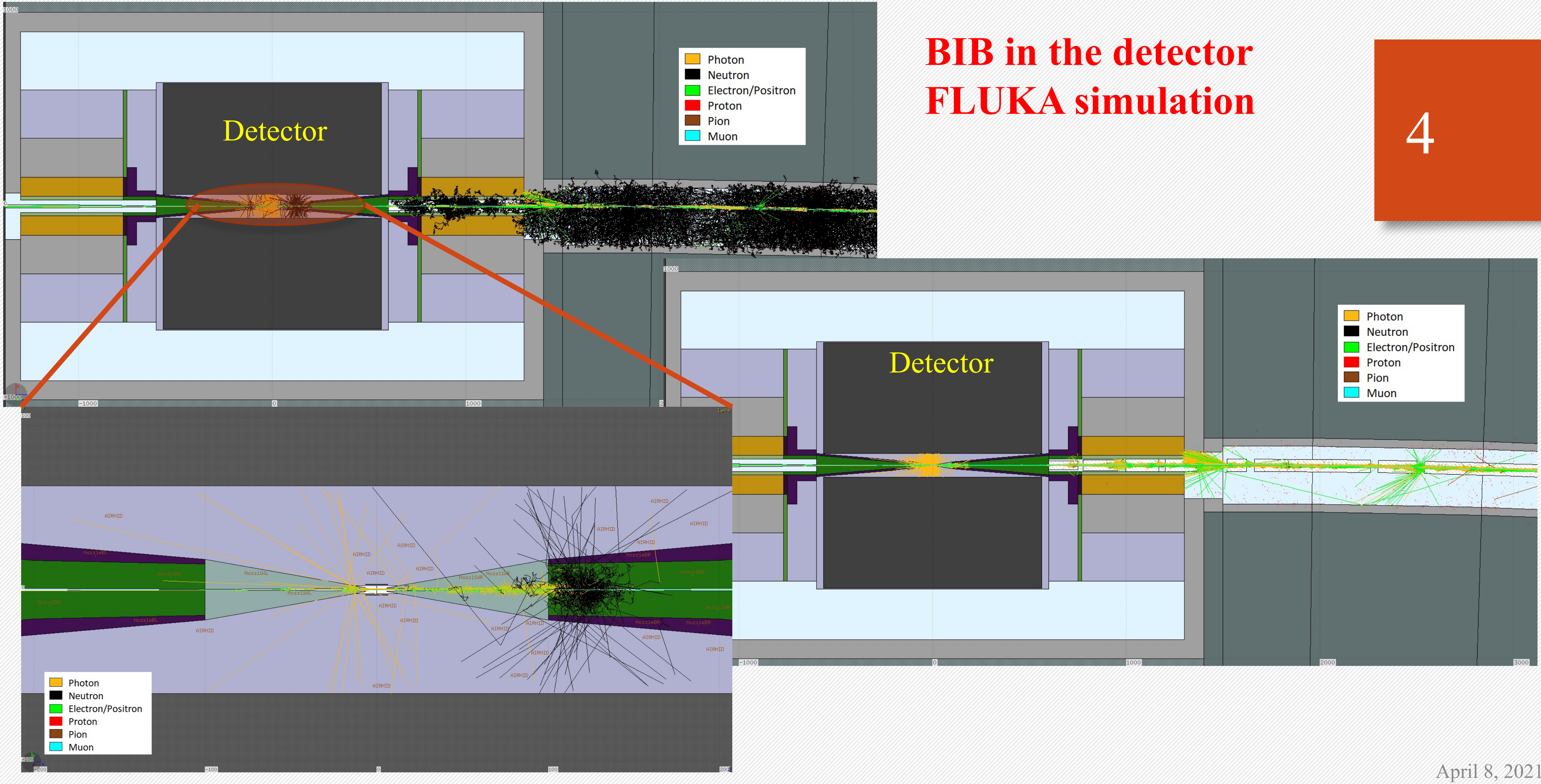
IR optics designed by MAP collaboration for $\sqrt{s} = 1.5$ TeV and $\sqrt{s} = 3$ TeV.

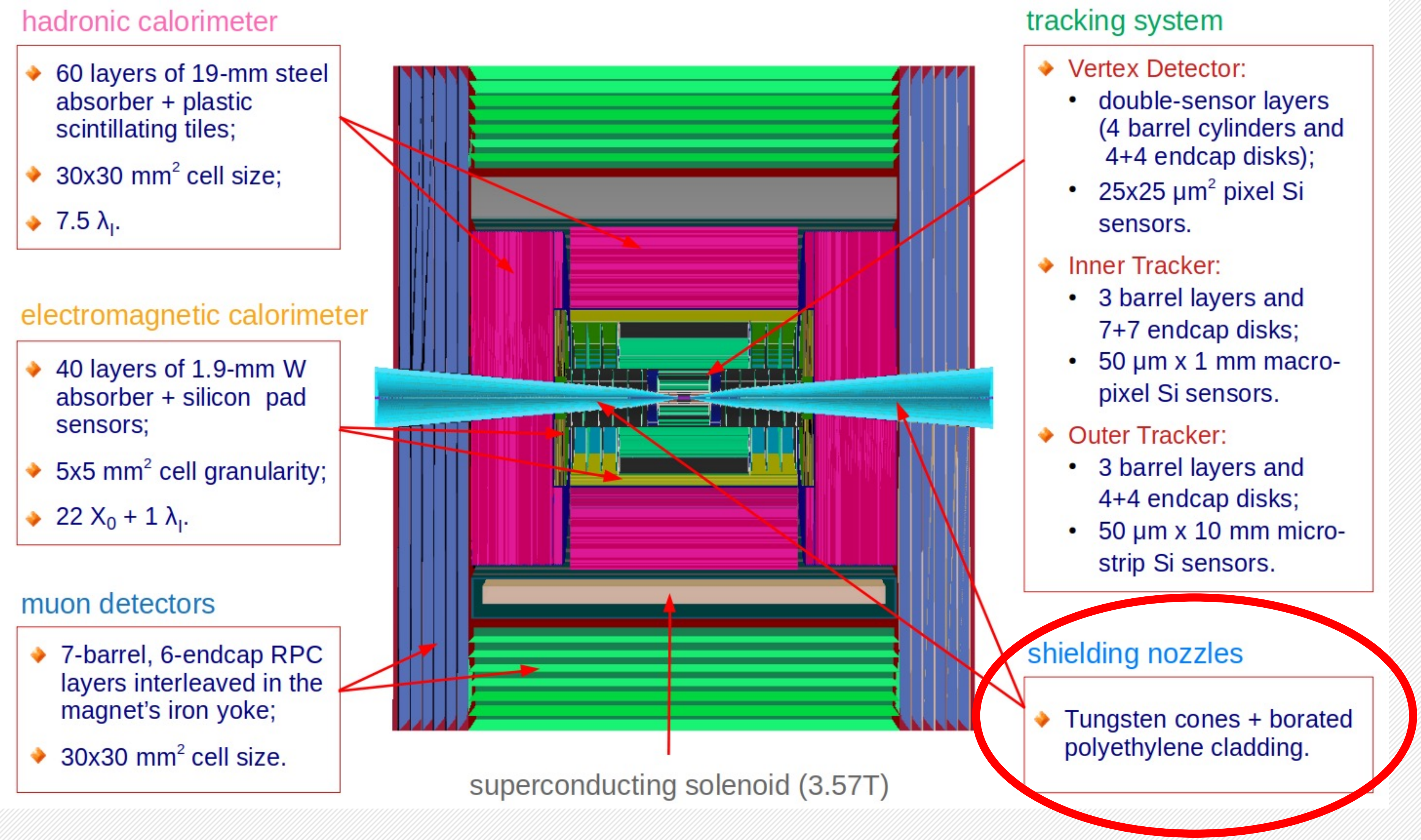
Starting from the IR optics a machine "geometry" is produced by using LineBuilder.
The geometry is read by FLUKA and the BIB is generated.



To protect the detector by the effects of the huge amount of beam-induced background two conical shaped absorbers, nozzles, are introduced. Shape, angles, materials optimized as a function of $\sqrt{s}$.

BIB in the detector
FLUKA simulation




hadronic calorimeter
60 layers of 19-mm steel absorber + plastic scintillating tiles;
30x30 mm^2 cell size;
7.5 λ_I.
electromagnetic calorimeter
40 layers of 1.9-mm W absorber + silicon pad sensors;
5x5 mm^2 cell granularity;
22 X_0 + 1 λ_I.
muon detectors
7-barrel, 6-endcap RPC layers interleaved in the magnet's iron yoke;
30x30 mm^2 cell size.
superconducting solenoid (3.57T)
tracking system
Vertex Detector:
double-sensor layers (4 barrel cylinders and 4+4 endcap disks);
25x25 μm^2 pixel Si sensors.
Inner Tracker:
3 barrel layers and 7+7 endcap disks;
50 μm x 1 mm macro-pixel Si sensors.
Outer Tracker:
3 barrel layers and 4+4 endcap disks;
50 μm x 10 mm micro-strip Si sensors.
shielding nozzles
Tungsten cones + borated polyethylene cladding.

People involved in MDI

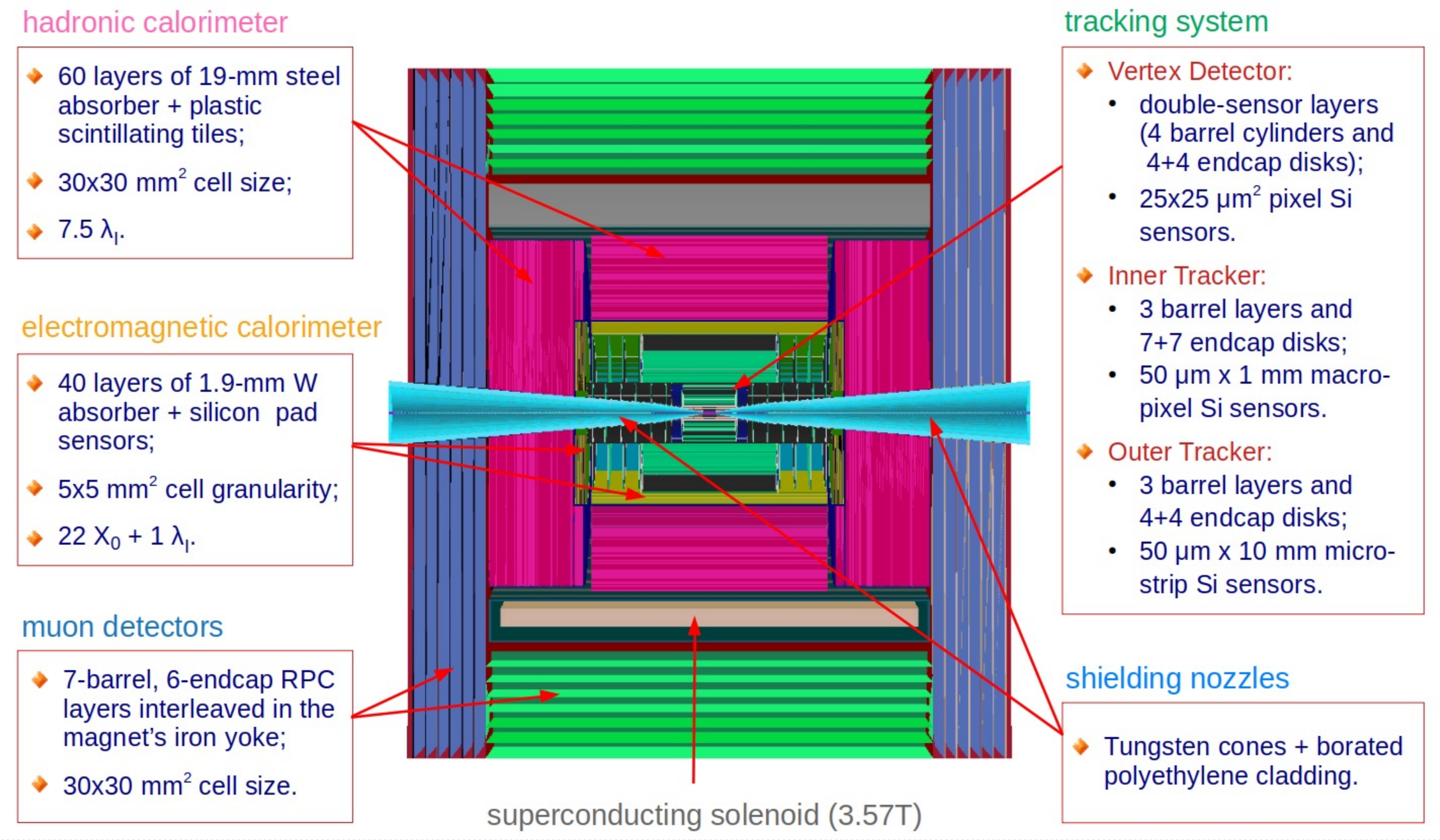
N. Bartosik, INFN-To
M. Biagini, S. Guiducci, INFN-LNF
M. Casarsa INFN-TS
F. Collamati, INFN-Roma1
C. Curatolo, D. Lucchesi Universita' e INFN PD
A. Mereghetti, CNAO
N. V. Mokhov, FNAL
M. Palmer, BNL
P. Sala INFN-Mi

Additional people from CERN are joining the effort.
Task force is starting involving accelerator and detector experts

INFN Leadership that we would like to keep and strengthen

Physics and Detector Studies

INFN Confluence Site

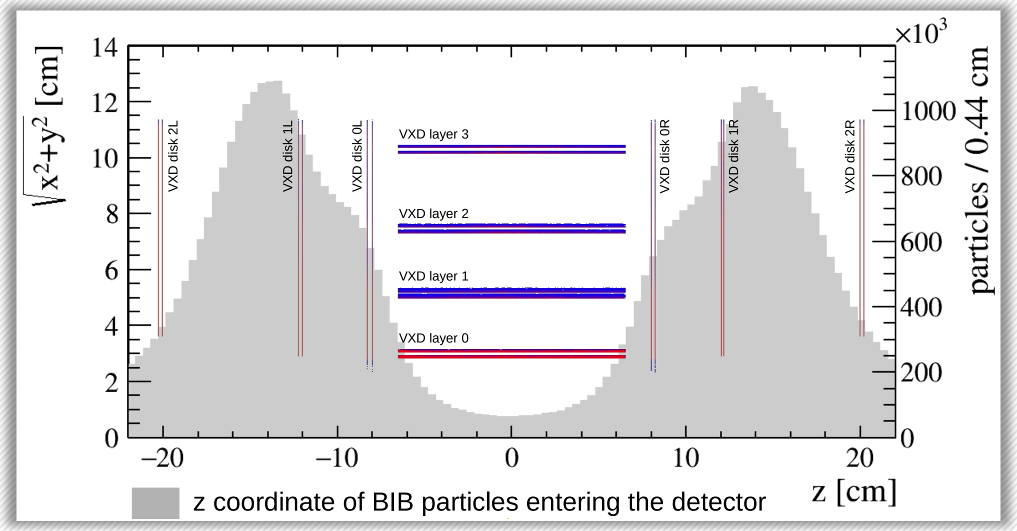


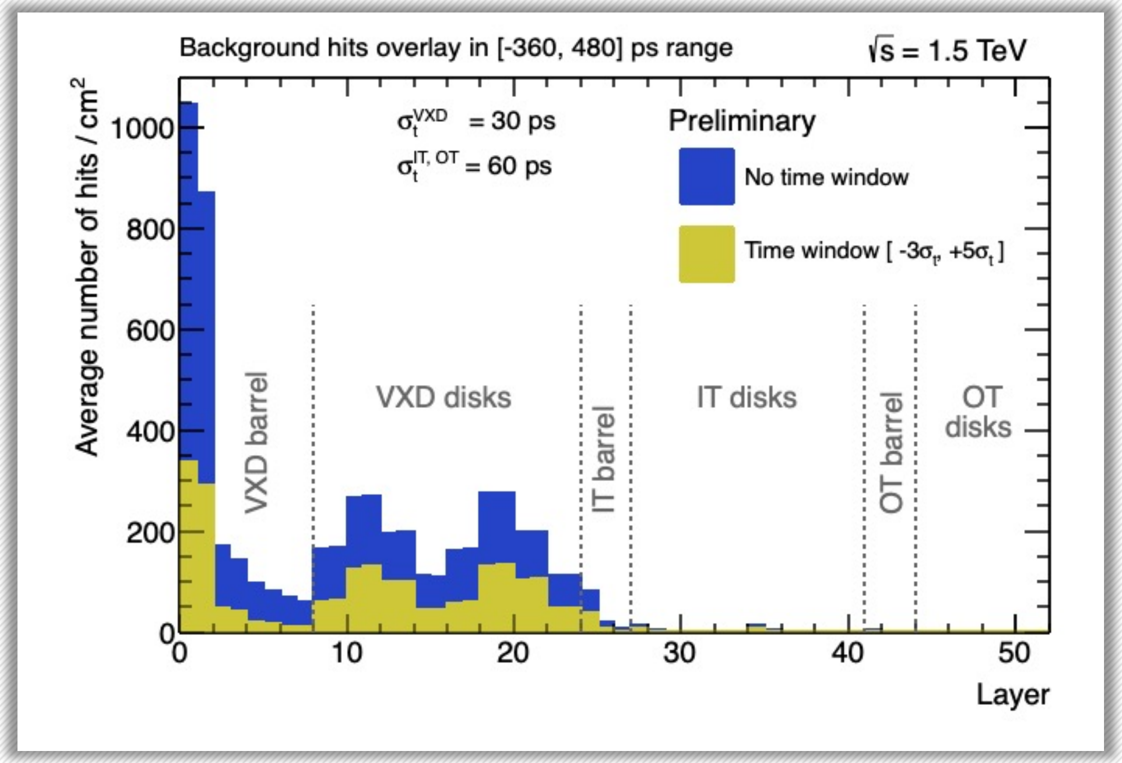
CLIC Detector technologies adopted with important modifications to cope with BIB.

Example of Detector optimization: Tracker at $\sqrt{s}$ =1.5 TeV

The impact of BIB on tracking system could be severe if not mitigated

Vertex detector barrel properly designed to not overlap with the BIB hottest spots around the interaction region

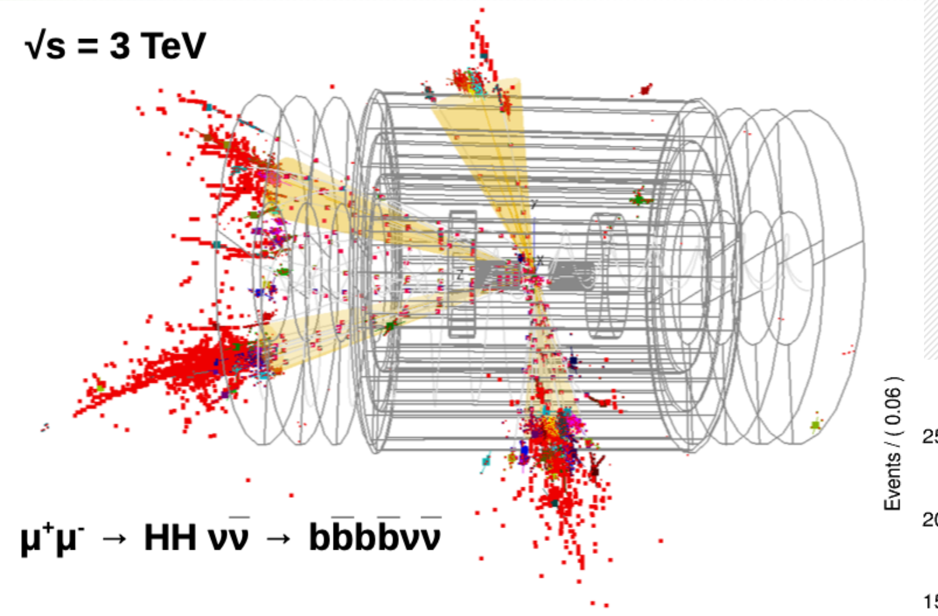




Tracking performance have been studied applying timing and energy cuts on clusters reconstruction compatible with IP time spread

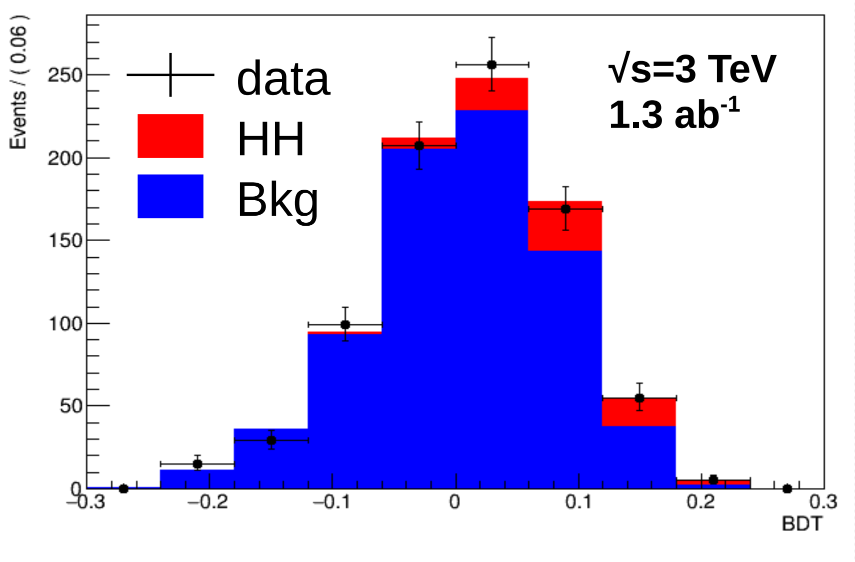
Physics measurements are possible with the full simulated detector

The process $\mu^+\mu^- \to HH\nu\bar{\nu} \to b\bar{b}b\bar{b}\nu\bar{\nu}$ at $\sqrt{s} = 3\text{TeV}$ is under study by using the full detector simulation



Assumptions

- $\mathcal{L}_{int} = 1.3\ ab^{-1}$
- Running time = $4 \cdot 10^7$ s
- one detector



With a simple fit to the BDT output

$$\frac{\Delta\sigma}{\sigma} = 0.33$$

CLIC has 10% with 5 ab^{-1} and very refined analysis

Organization of Physics and Detector

Currently

- Theory and Phenomenology: A. Wulzer and F. Maltoni
- Physics and Detector Studies — D. Lucchesi
  - Trackers and tracks reconstruction — M. Casarsa
  - Calorimeter and jets reconstruction — L. Sestini

New Proposal
Officialize the Physics and Detector coordination team within the collaboration, in progress

INFN leadership that we would like to keep

People involved Detector and Physics

INFN:

C. Aimè, P. Andreetto, N. Bartosik, L. Buonincontri, M. Casarsa, A. Colaleo, U. Dosselli, A. Gianelle, D. Lucchesi, P. Mastrapasqua, A. Montella, N. Pastrone, C. Riccardi, P. Salvini, I. Sarra, L. Sestini, I. Vai, R. Venditti, A. Zaza

DESY: F. Meloni

Dresda: A. Ferrari

UK: A. Cerri

Fermilab: S. Jindariani, H. Weber, R. Lipton

Harvard University: L. Lee

LBL: E. Resseguie, S. Pagan Griso, K. Krizka

TRIUMF:M. Swiatlowski, M. Valente

Express interest but not yet involved: Portugal, France (CEA).
Several other US University and Lab people ready to resume withing Snowmass activities

Software and Computing

People involved on detector and physics simulation are developing code, but code and infrastructure supported and maintained by P. Andreetto and A. Gianelle, INFN-PD

- Starting point ILCSoft, full simulation of detector and objects reconstruction made developed by INFN.
- Code available on github and distributed via DockerHub we are at Version v02-06-MC
- Tutorial on INFN-Confluence

- VO muoncoll.infn.it supported by CNAF
- CVMFS repository supported by CNAF
- Storage Element @CNAF (storm-fe-archive.cr.cnaf.infn.it)
- CPU and Disk space available mainly at CloudVeneto and starting at CNAF
- Fermilab contributing with CPU and disk space.

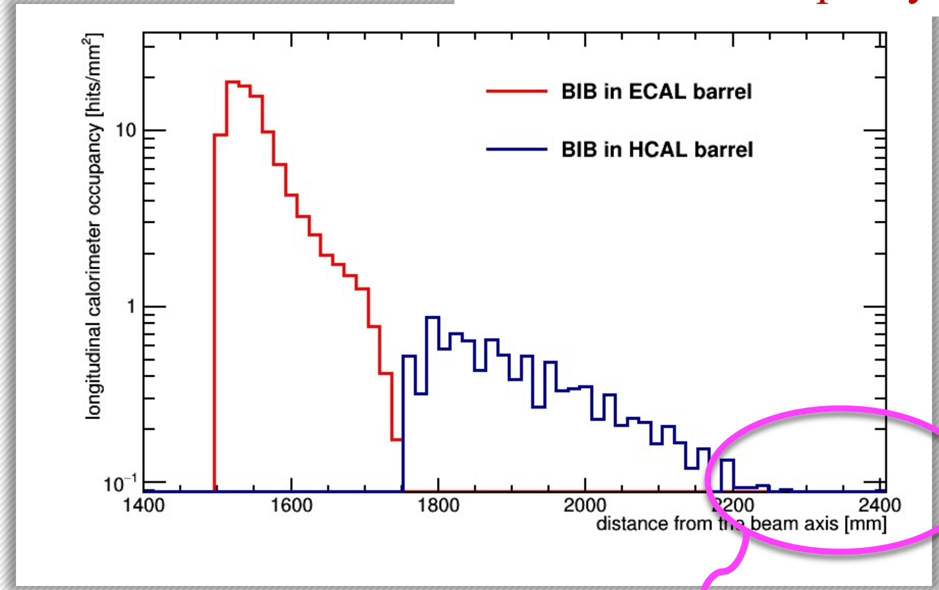
INFN leadership on software and infrastructure, an added value, that we want to keep

Part of AIDAInnova task 12.2 Turnkey Software (unfunded)

Backup

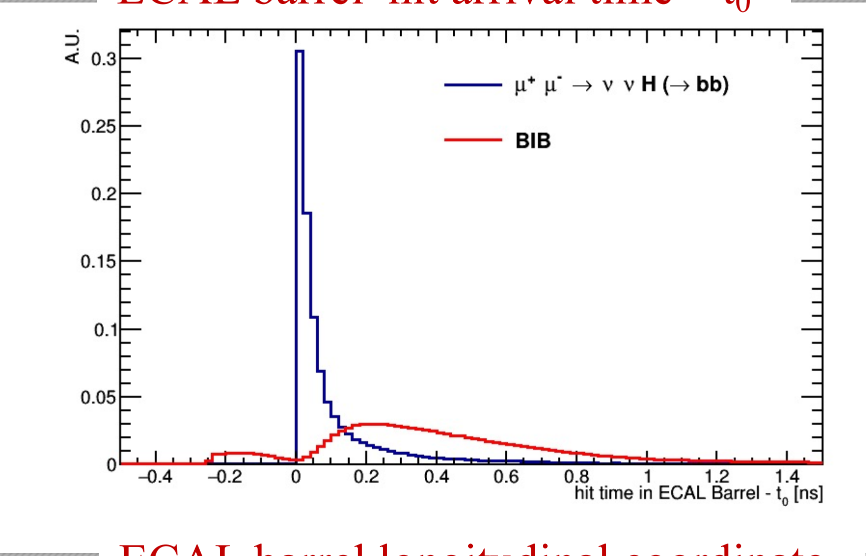
Calorimeter System at $\sqrt{s}$ =1.5 TeV

Calorimeter Occupancy

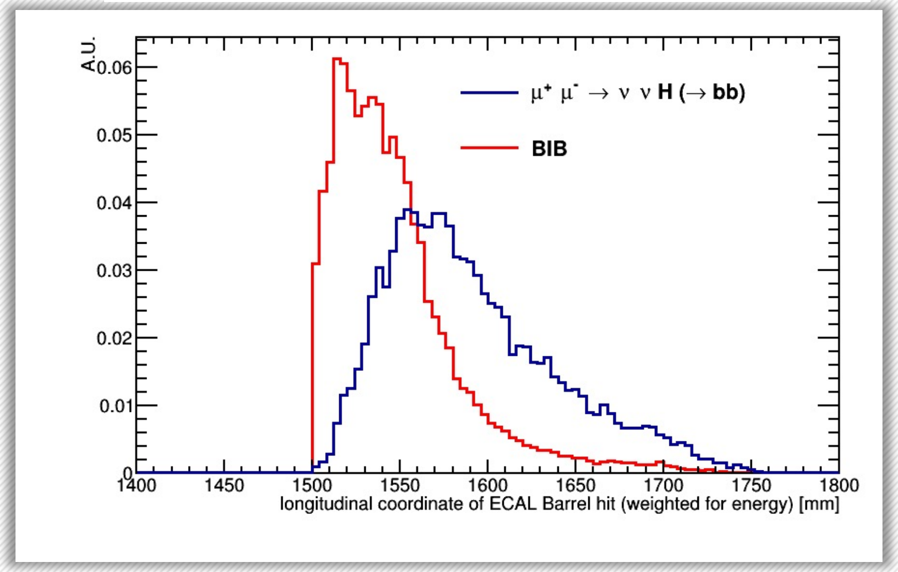


Few BIB hits arrive to the muon detectors

ECAL barrel hit arrival time – t_0



ECAL barrel longitudinal coordinate

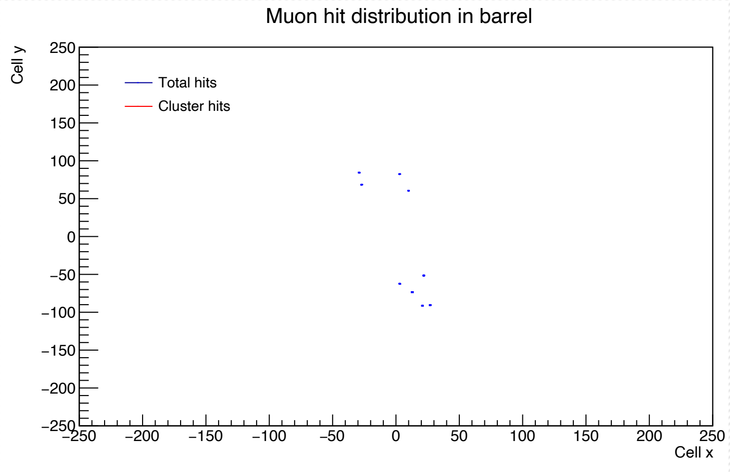


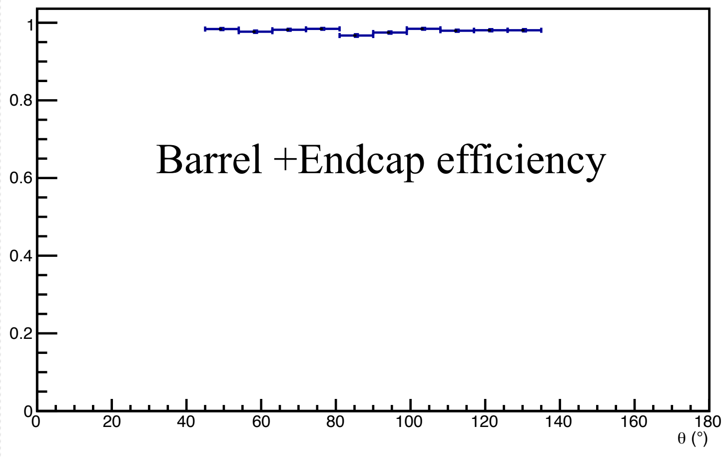
BIB characteristics to be exploited to:

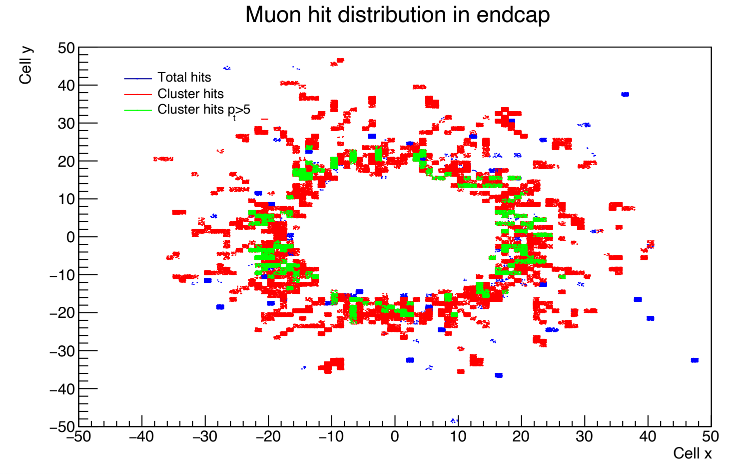
- Design appropriated calorimeter system
- Optimize jet reconstruction algorithm and design appropriate algorithm to identify b-jets.

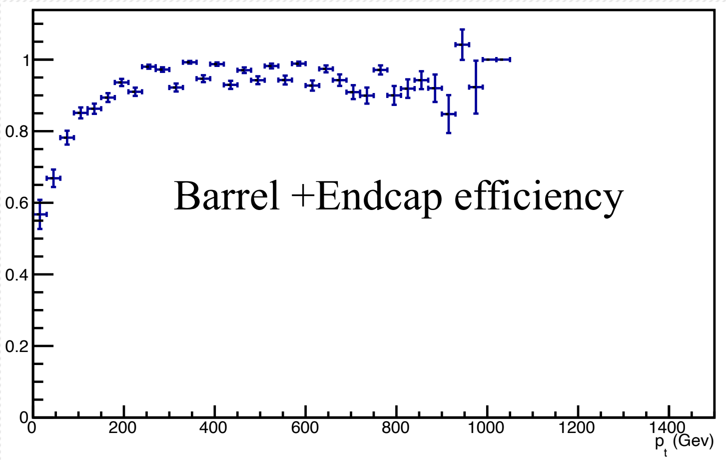
Muon Reconstruction

Muon Reconstruction with BIB at $\sqrt{s} = 1.5$ TeV









Marginally affected by BIB