Report on the Detector WG

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Overview

- The activity of the Detector WG began four years ago with full simulation studies based on a sample of beam-induced background and the simulation-reconstruction software provided by the US MAP.

- Over time, the original core activity with full simulation has branched out into several lines:
  - machine-induced background simulation and MDI-IR optimization;
  - full simulation studies with a baseline detector:
    - physical objects reconstruction;
    - Physics cases;
  - fast simulation studies;
  - maintenance and development of the simulation and reconstruction software;
  - hardware and software R&D.

Machine-induced background

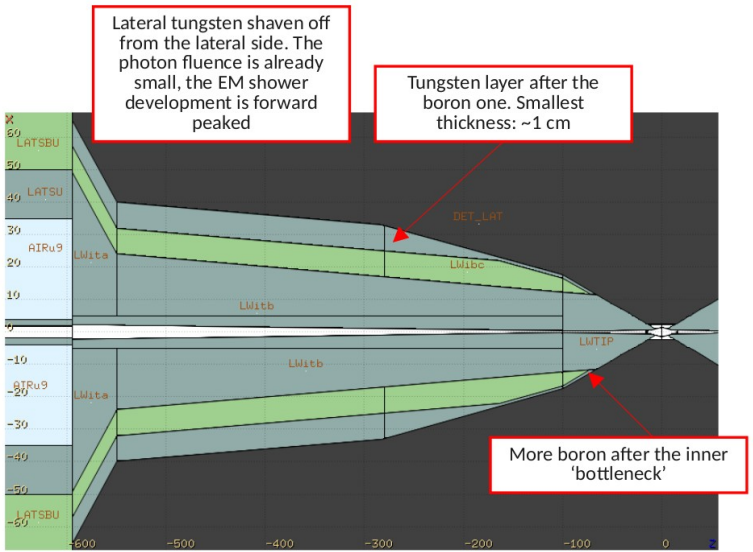
- Ultimately, the detector design and the development of the event reconstruction algorithms will be driven by the levels of machine-induced background.
- Available lattices for machines at $\sqrt{s}$ = 1.5, 3, 10 TeV
  ⇒ FLUKA simulation of beam-induced background.
- MDI and IR configurations are crucial to mitigate the amount of background entering the detector ⇒ have to be optimized for each collision energy.

Machine-induced background studies for 1.5 TeV and 3 TeV	*Dr Francesco Collamati*	
40/S2-D01 - Salle Dirac, CERN	10:50 - 11:10	
IR optics design for the 10 TeV Muon Collider	*Kyriacos Skoufaris*	
40/S2-D01 - Salle Dirac, CERN	11:10 - 11:30	
Machine-induced background studies for the 10 TeV Muon Collider	*Daniele Calzolari*	
40/S2-D01 - Salle Dirac, CERN	11:30 - 11:50	
How to use BIB data as input for the detector design	*Nazar Bartosik*	
40/S2-D01 - Salle Dirac, CERN	11:50 - 12:10	
Magnetic field configurations for the detector	*John Hauptman*	
40/S2-D01 - Salle Dirac, CERN	12:10 - 12:30	

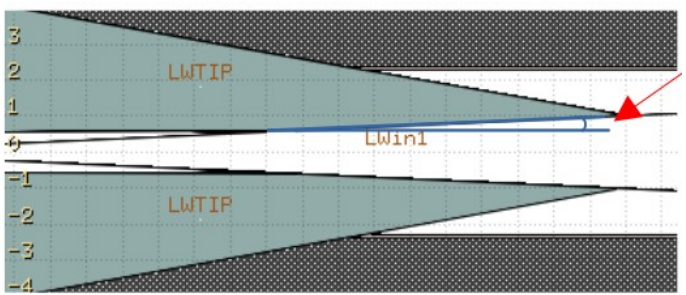
Physics ans Detectors Session on Wed at 11

MDI and IR optimizations

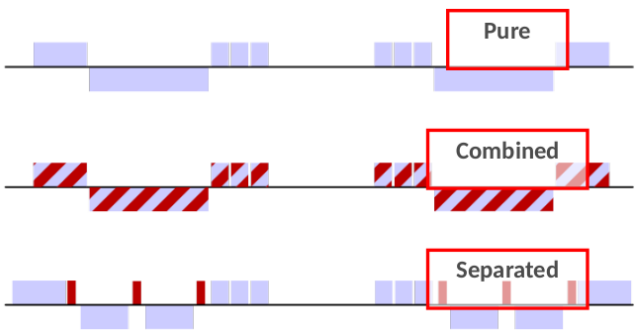
nozzle composition



nozzle tip angle



final focusing magnets



Some preliminary results

Total particle number: comparison with different collider energies

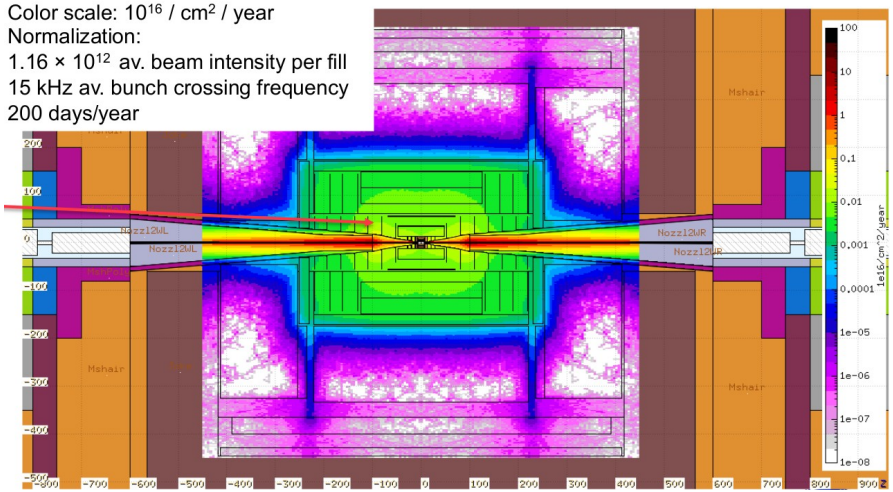
Collider energy	1.5 TeV	3 TeV	10 TeV
Photons	7.1E+7	9.6E+7	1.07E+8
Neutron	4.7E+7	5.8E+7	1.01E+8
e^+/e^-	7.1E+5	9.3E+5	9.6E+5
Ch. hadrons	1.7E+4	2.0E+4	4.3E+4
Muons	3.1E+3	3.3E+3	4.8E+3

Updated!

Non optimized [14-15]

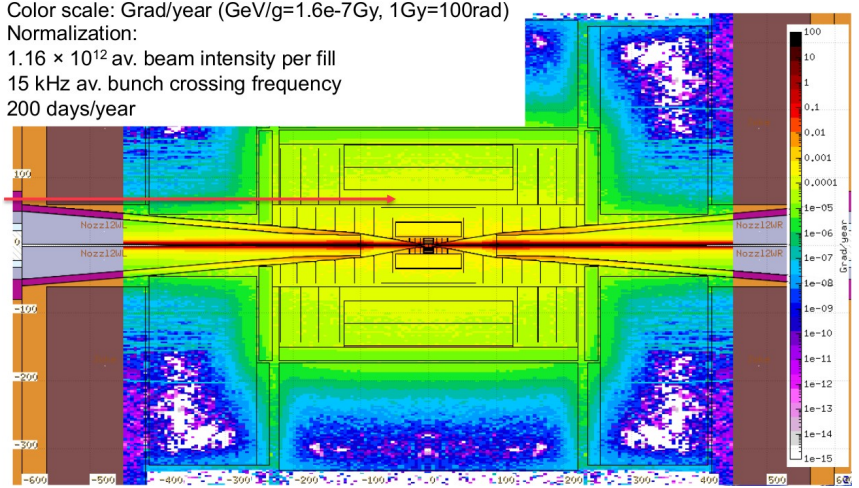
3 TeV: 1MeV neutron equivalent

Color scale: 10^{16} / cm^2 / year
Normalization:
1.16 × 10^{12} av. beam intensity per fill
15 kHz av. bunch crossing frequency
200 days/year



3 TeV: Total Ionizing Dose

Color scale: Grad/year (GeV/g=1.6e-7Gy, 1Gy=100rad)
Normalization:
1.16 × 10^{12} av. beam intensity per fill
15 kHz av. bunch crossing frequency
200 days/year



Physical objects reconstruction

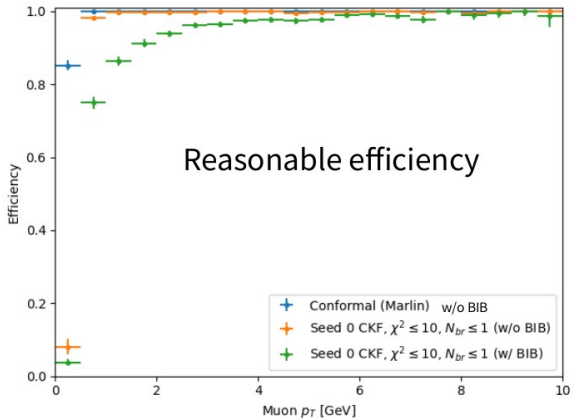
- Reconstruction of physical objects is made challenging by the BIB.
- Defined a baseline detector model based on CLIC's detector and developed custom reconstruction software from ILCSoft to deal with the BIB.
- First results show a good reconstruction performance, despite a nonoptimal detector, untuned reconstruction/identification algorithms, and sometimes very crude mitigation of BIB effects.

Tracks reconstruction algorithms performance	*Karol Krizka*	
40/S2-D01 - Salle Dirac, CERN	14:00 - 14:25	
Muon detectors performance	*Chiara Aime'*	
40/S2-D01 - Salle Dirac, CERN	14:25 - 14:50	
Electrons and photons reconstruction	*Massimo Casarsa*	
40/S2-D01 - Salle Dirac, CERN	14:50 - 15:15	
Jets reconstruction and b-tagging: leasson learned and new strategies	*Lorenzo Sestini*	
40/S2-D01 - Salle Dirac, CERN	15:15 - 15:55	

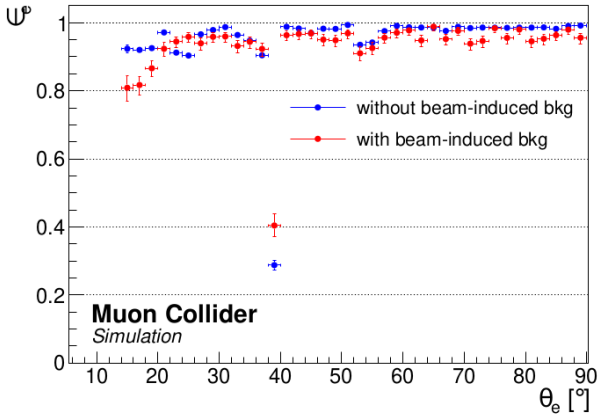
Physics ans Detectors Session on Wed at 14

Tracks, muons, electrons, and photons

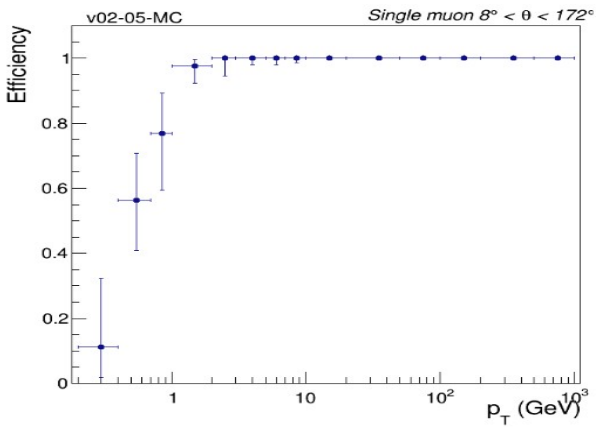
tracks



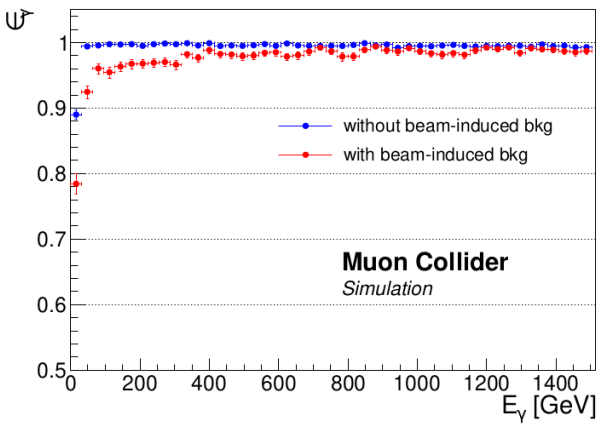
electrons



muons

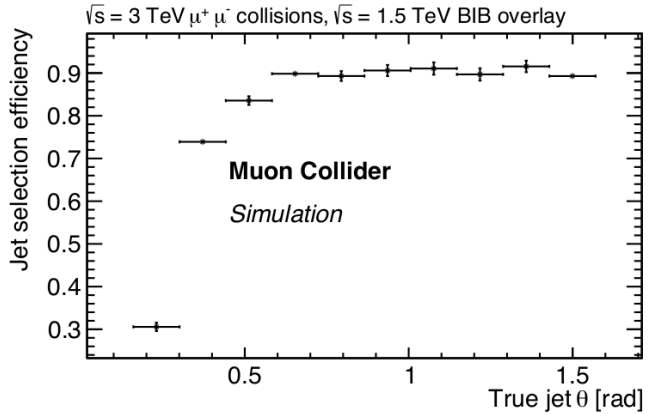


photons

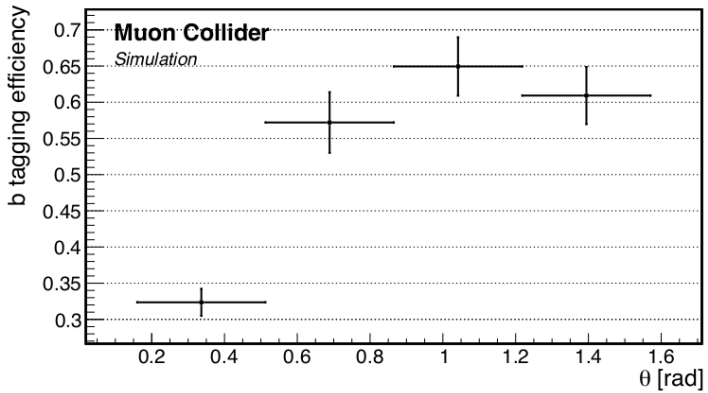


Jets reconstruction and b tagging

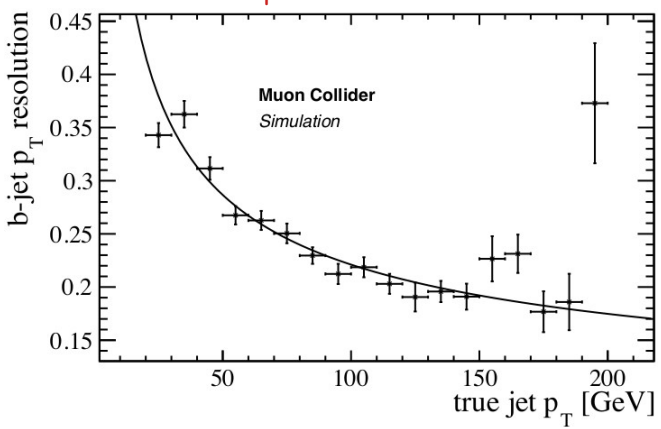
selection efficiency



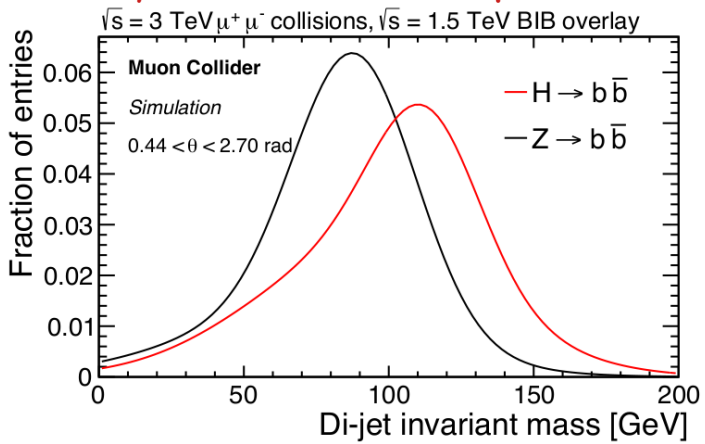
b tagging efficiency



p_T resolution



Z/H → bb̄ mass separation



Full-sim and fast-sim Physics studies

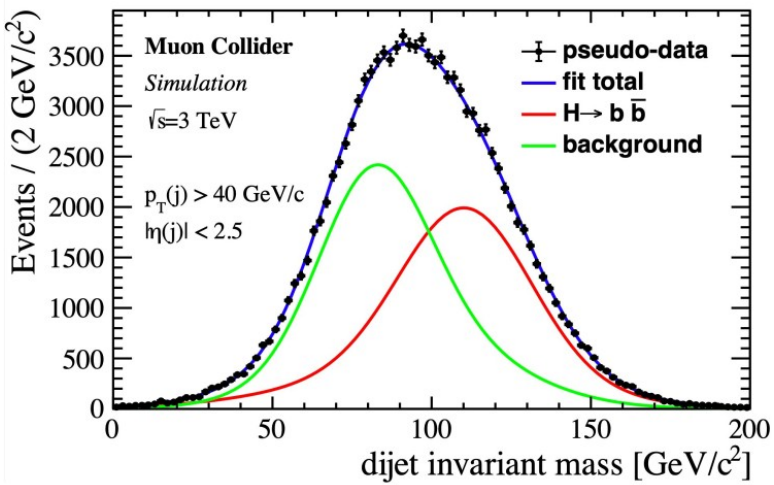
- Both full simulation and fast simulation (Delphes) are available for Physics studies:
  - several full-sim studies performed at 3 TeV.
- The detailed detector simulation is also used to check and validate the fast-sim cards.

Physics results with full sim and comparison with FastSim	*Luca Giambastiani*	
40/S2-D01 - Salle Dirac, CERN	16:20 - 16:45	
Future collider framework	*Andre Sailer*	
40/S2-D01 - Salle Dirac, CERN	16:45 - 17:10	
Software status and future developments	*Alessio Gianelle et al.*	
40/S2-D01 - Salle Dirac, CERN	17:10 - 17:35	
Shared resources, simulated sample, FastSim update	*Donatella Lucchesi*	
40/S2-D01 - Salle Dirac, CERN	17:35 - 17:55	
BIB usage	*Nazar Bartosik*	
40/S2-D01 - Salle Dirac, CERN	17:55 - 18:15	

Physics ans Detectors Session on Wed at 16:20

Fast-sim validation

full-sim $H \to b\bar{b}$



full-sim/fast-sim comparison

	Full sim		Fast sim	
Cross sections resolution	H->WW	2.9%	H->WW	1.7%
	H->ZZ	17%	H->ZZ	11%
	H->bb	0.75%	H->bb	0.76%
	H->μμ	38%	H->μμ	40%
	H->γγ	8.9%	H->γγ	6.1%
	HH->4b	30%		
Couplings resolution	g_{HWW}	0.9%	g_{HWW}	0.55%
	g_{HZZ}	8.2%	g_{HZZ}	5.1%
	g_{Hbb}	0.8%	g_{Hbb}	0.97%
	$g_{H\mu\mu}$	19%	$g_{H\mu\mu}$	20%
	$g_{H\gamma\gamma}$	4.5%	$g_{H\gamma\gamma}$	3.2%
	λ_3	20%	λ_3 (95% CL)	25%

Towards a 10-TeV collider

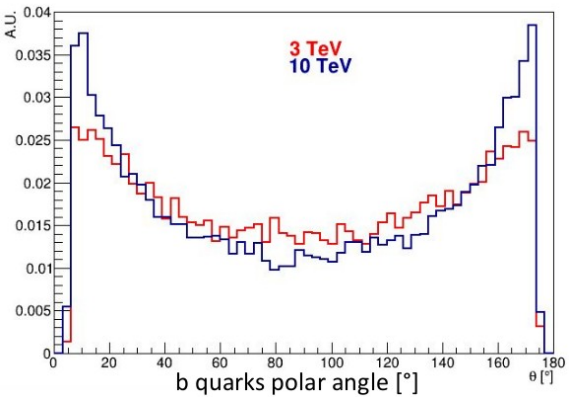
- Currently, MC event generators for $\sqrt{s}$ = 10 TeV available only at LO accuracy.
- The baseline detector was designed for CLIC up to 3 TeV collisions, need to re-think the detector for a 10-TeV collider:
  - as a first step, generator-level studies on the characteristics of the detectable particles produced in 10-TeV collisions.

Monte Carlo challenges for the multi-TeV muon collider	*Mauro Chiesa et al.*	
6/R-012 - conference room, CERN	14:00 - 14:20	
Toward 10 TeV detector studies	*Laura Buonincontri*	
6/R-012 - conference room, CERN	14:30 - 14:50	
Photon reconstruction	*Federico Nardi*	
6/R-012 - conference room, CERN	14:50 - 15:10	

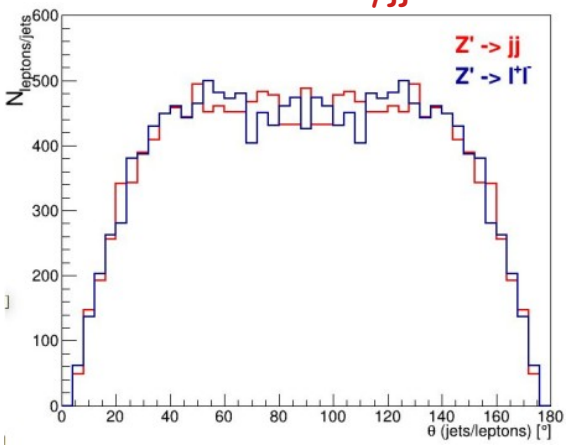
Physics ans Detectors Session on Thu at 14

First look at 10-TeV collisions

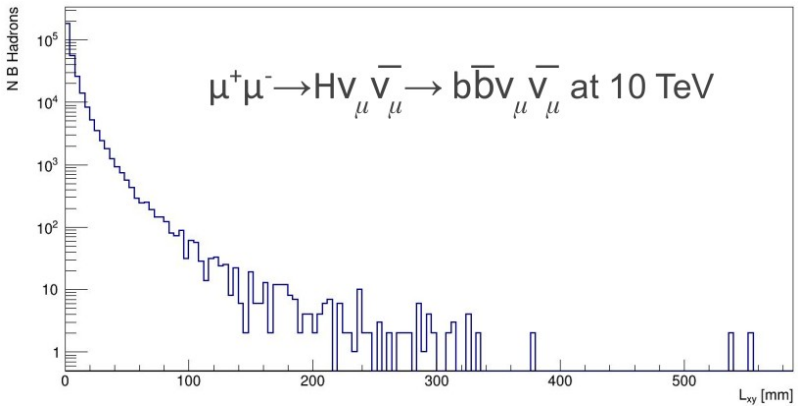
$H \to b\bar{b}$



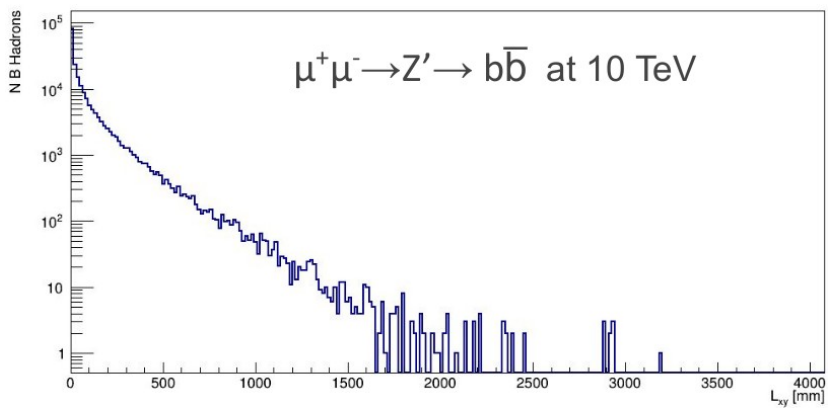
$Z' \to \ell\ell/jj$



b-hadrons transverse decay length



b-hadrons transverse decay length



Hardware and software developments

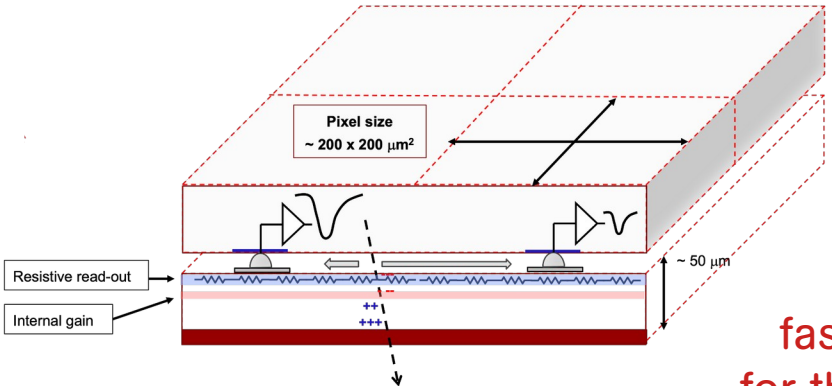
- The results with the detailed detector simulation are fostering:
  - dedicated hardware R&D aiming to explore alternative solutions to meet the muon collider requirements;
  - development of more sophisticated software algorithms to improve the event reconstruction and better exploit the capabilities of the new detectors.

R&D studies on tracking detector	*Nicolo Cartiglia*	
6/R-012 - conference room, CERN	09:00 - 09:15	
R&D studies on calorimeter detector	*ivano sarra*	
6/R-012 - conference room, CERN	09:20 - 09:35	
R&D studies on muon detector	*Ilaria Vai*	
6/R-012 - conference room, CERN	09:40 - 09:55	

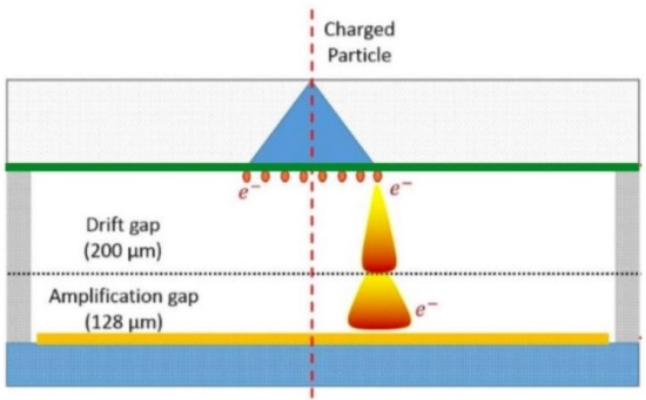
Physics ans Detectors Session on Thu at 9

Hardware R&D

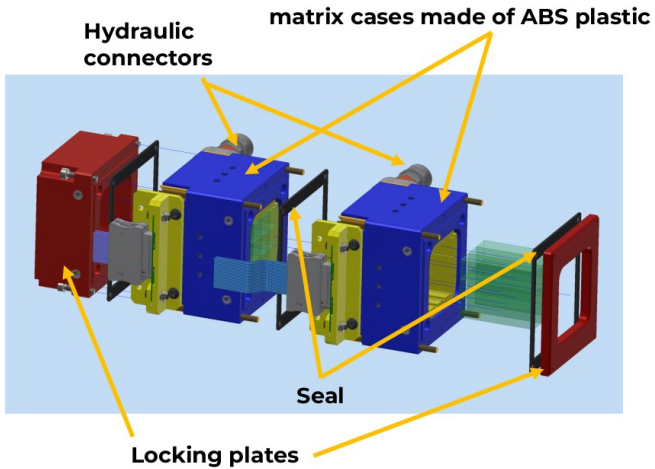
RSD-based tracker



fast-timing MPGD for the muon detector



PbF_2 crystal calorimeter



Final remarks

- A lot of productive discussions in all Sessions:
  - noteworthy the interesting idea of detecting/tagging the forward-scattered muons ⇒ a dedicated study to be done in collaboration with the MDI experts.
- Simulation and reconstruction software:
  - source code is available in github;
  - MuonColliderSoft releases are published in dockerhub and mirrored in /cvmfs/unpacked.cern.ch/registry.hub.docker.com/infnpd.

A lot of uncharted territory yet to be explored!
If anybody is interested in contributing, please contact us.