Instrumented Flux Return

G. Cibinetto on behalf of the IFR group

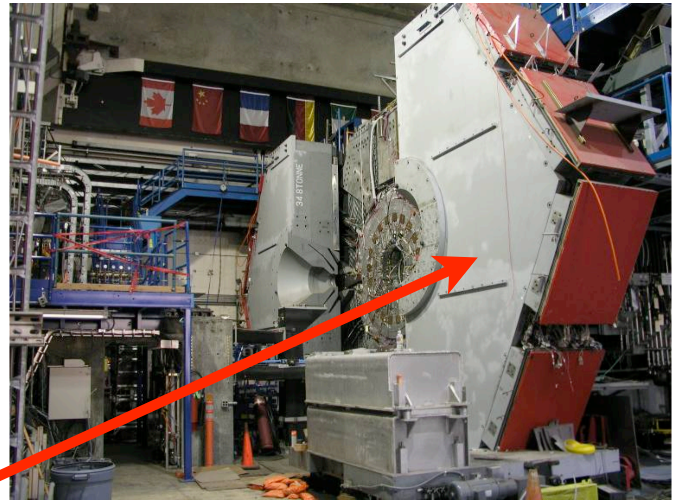
Super B workshop - Frascati 1-4 Dec 2009

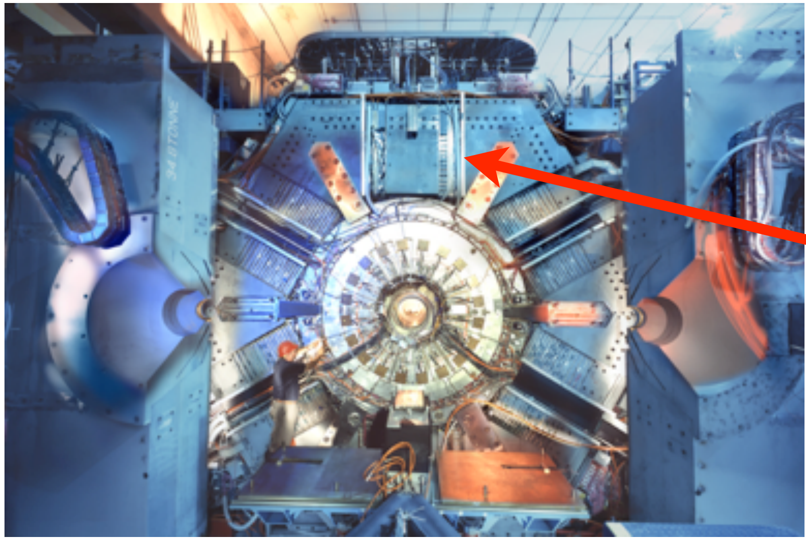
Outline

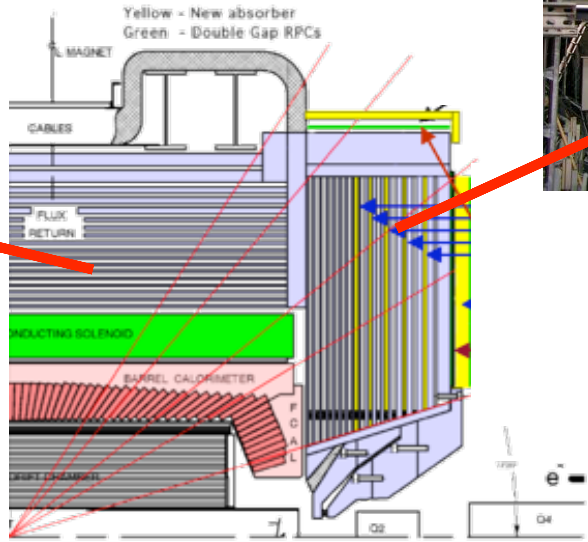
- Introduction
- Status of the IFR activities
  - R&D
  - Simulation studies (optimization, background and Fast Sim)
  - Prototype preparation
- Schedule and future plans

The Super B muon and K_L detector

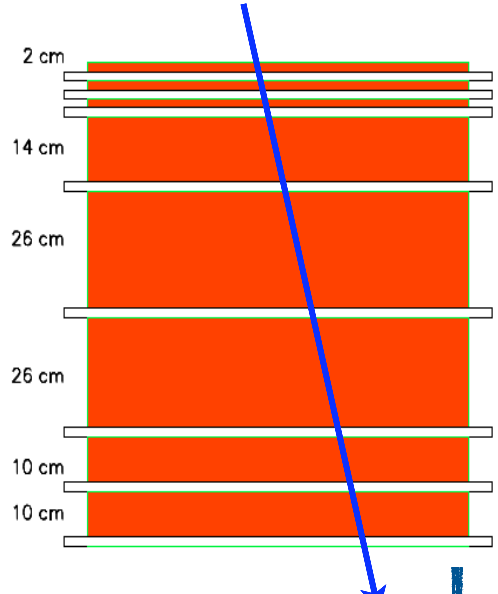
- The muon and K_L detector will be built in the magnet flux return
- It will be composed by one hexagonal barrel and two endcaps like in BaBar







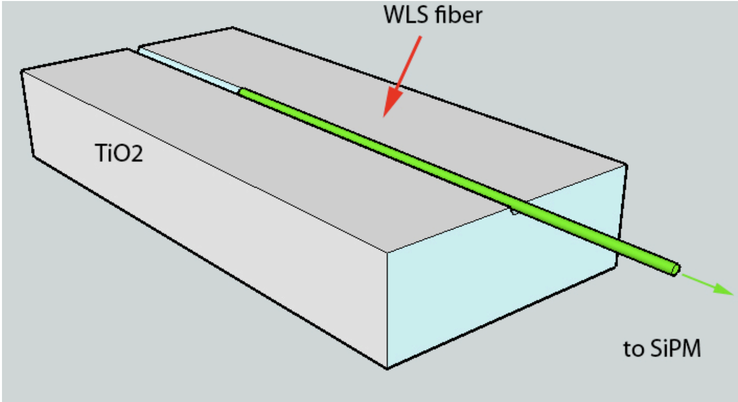
- Add iron to BaBar stack to improve the muon ID
- 8 detection layers instead of 12/16
- Keep same longitudinal segmentation in front of the stack to retain the K_L ID capability



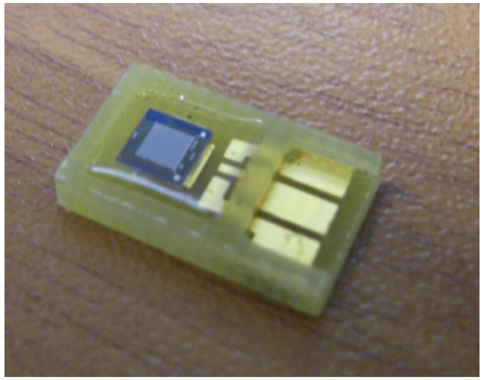
CDR stratigraphy of the IFR

The IFR detection technique

- Scintillator:
  - 2x4x400 cm^3 and 1x4x400 cm^3
  - scintillator bars coated with TiO_2
  - Light collection through WLS fibers
  - Fibers housed in embedded holes



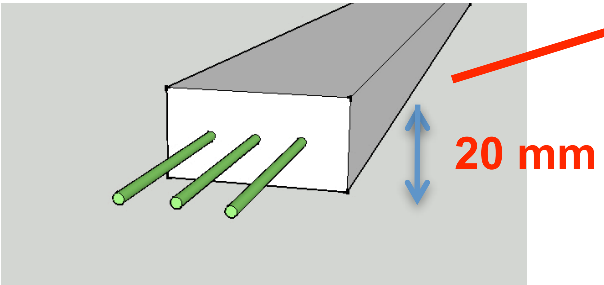
- WLS fibers:
  - φ = 1.0 mm type Y11(300) (Kuraray) and φ =1.2mm type BCF92 (Saint Gobain), Attenuation length $\lambda \approx$ 3.5m, trapping efficiency $\varepsilon \approx$ 5.5%

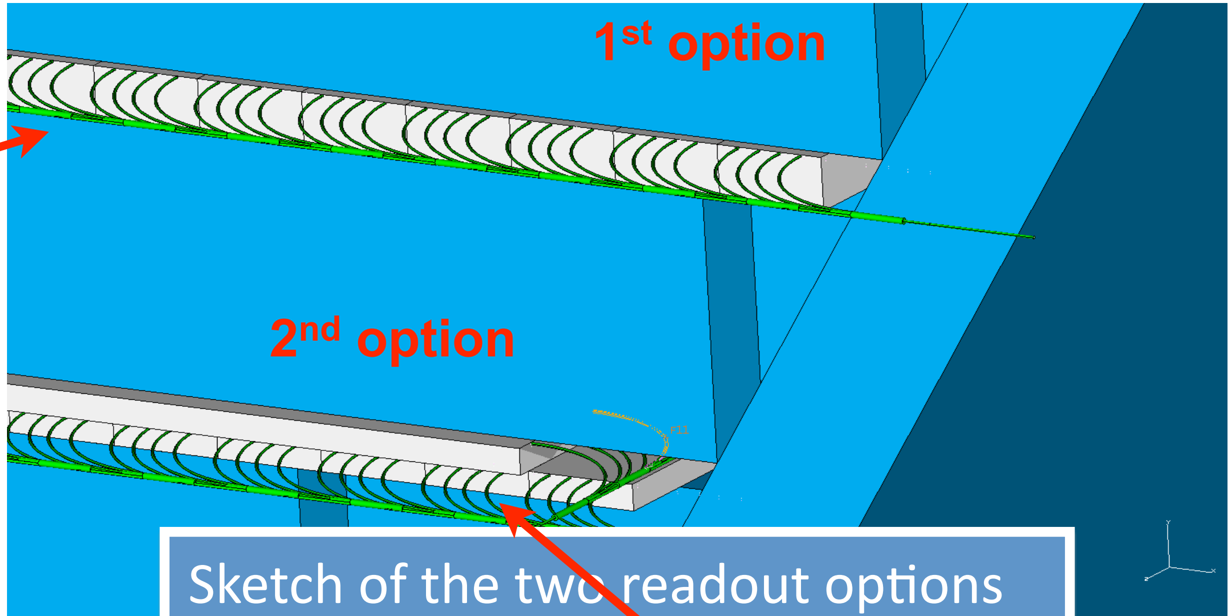


- Photodetectors:
  - Silicon Photo Multiplier (Fondazione Bruno Kessler- FBK Trento-Italy):
  - Gain $>10^5$
  - < 1ns risetime
  - Low bias voltage ($\approx$35V)
  - Dark current rate @ room temperature, $\approx$MHz @ 1.5 phe, few 100skHz @ 2.5 phe, few 10KHz @ 3.5 p.e.

Two readout modes

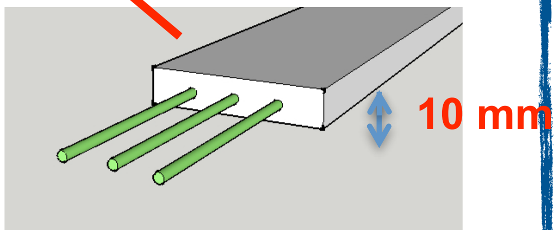
- Timing readout (Barrel): azimuthal coord φ measured from the hit bar, polar coord θ from the arrival time of the signal





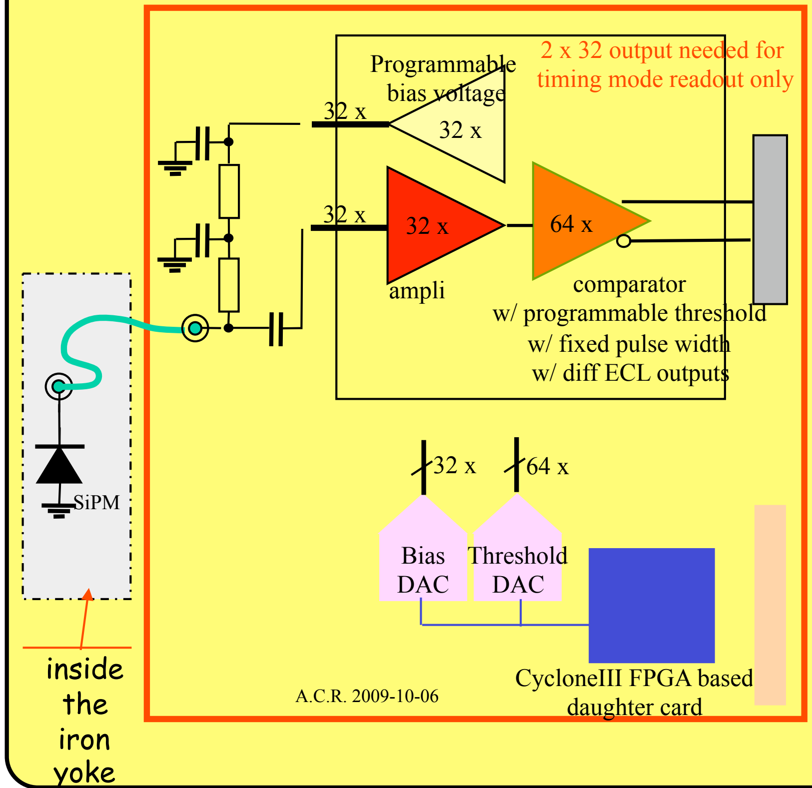
Sketch of the two readout options

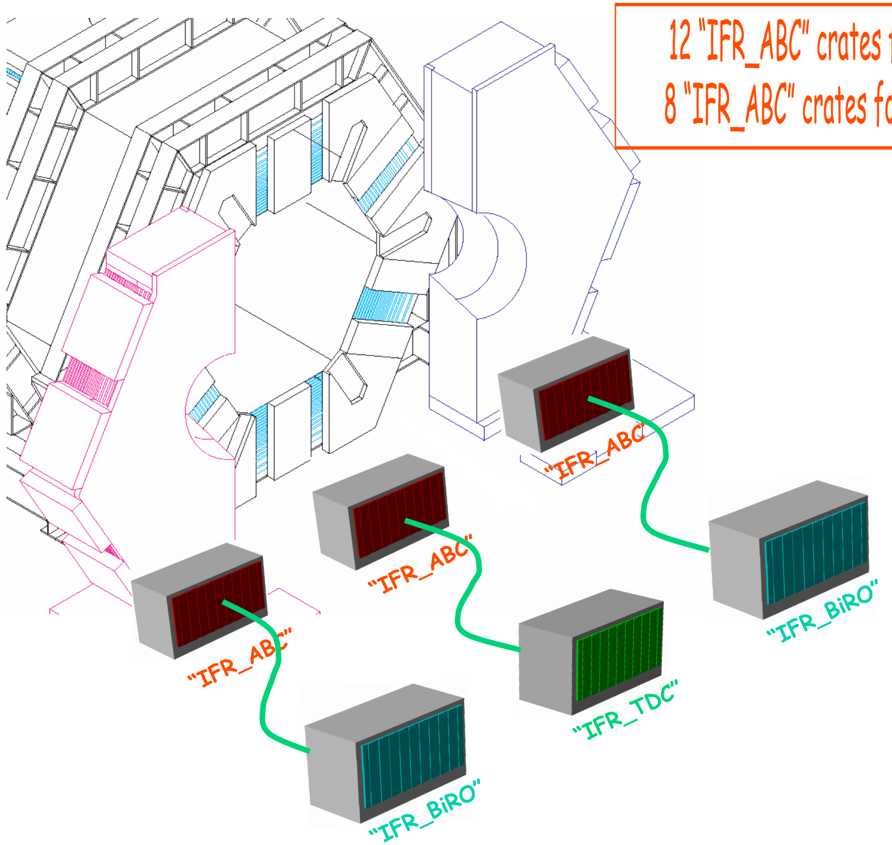
- Double coord binary readout (Endcaps): two layers of orthogonal scintillating bars provide directly the φ and θ coordinates. Easier from the point of view of electronics but more complicated for the mechanics.



Electronics

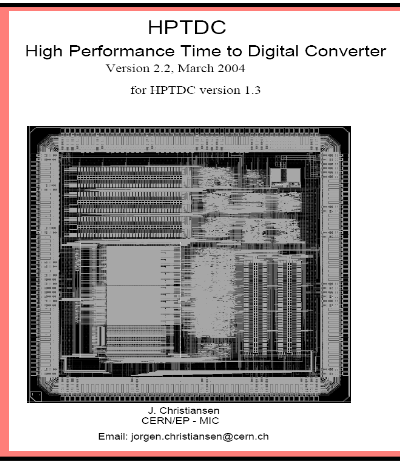
- The SiPM will be placed inside the iron and the signals will be amplified and discriminated in the ABC/D cards (placed outside)
- Amplifier stage based on the MMIC amplifiers BGA2748/BGA2716



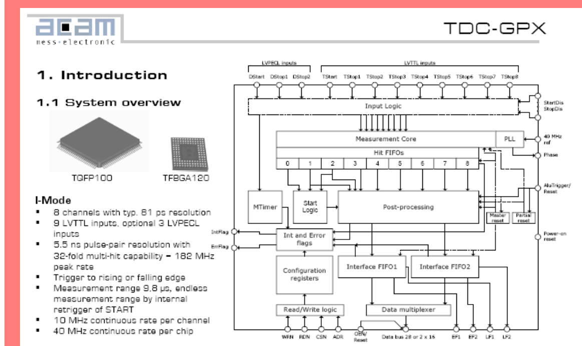


12 "IFR_ABC" crates for BARREL
8 "IFR_ABC" crates for ENDCAPS

- Still open the decision about the multihit TDC chip: two candidates


HPTDC
High Performance Time to Digital Converter
Version 2.2, March 2004
for HPTDC version 1.3

J. Christiansen
CERN/EP - MIC
Email: jorgen.christiansen@cern.ch


acam mess-electronic
TDC-GPX

1. Introduction

1.1 System overview

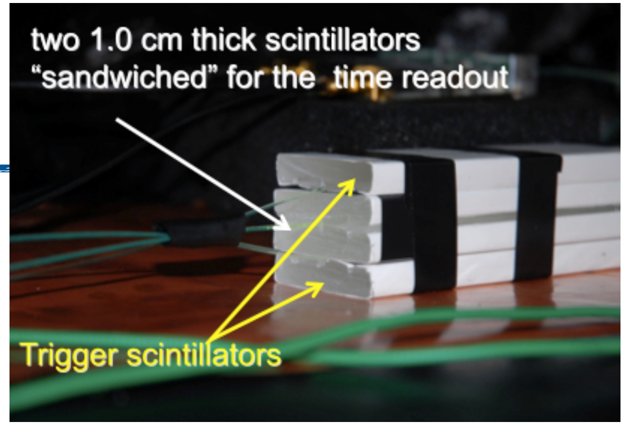
TQFP100
TFBGA120

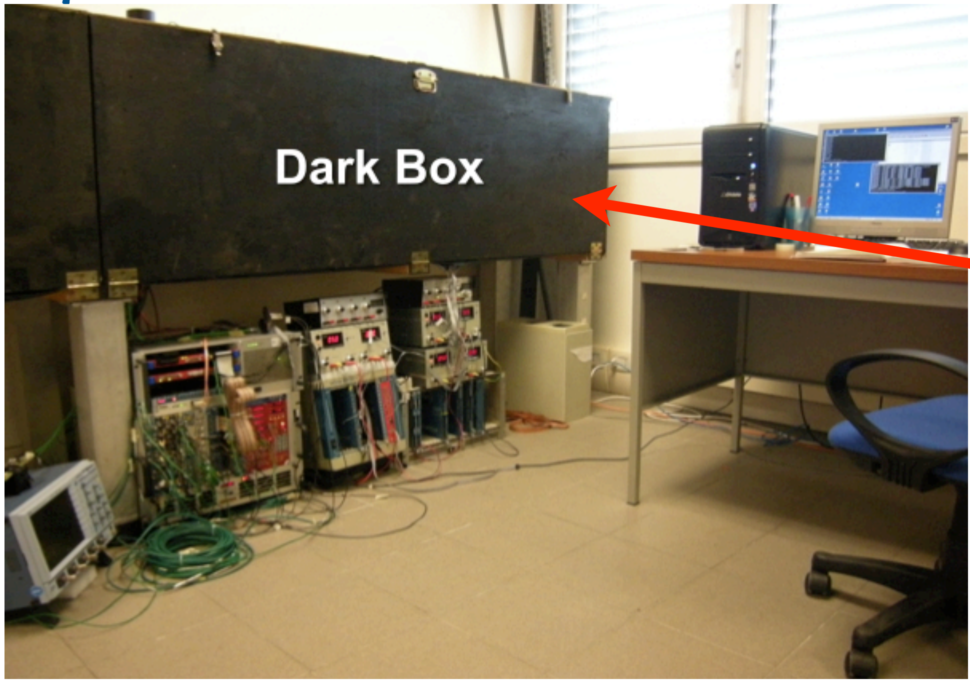
I-Mode
- 8 channels with typ. 81 ps resolution
- 9 LVTTL inputs, optional 3 LVPECL inputs
- 5.5 ns pulse-pair resolution with 32-fold multi-hit capability – 182 MHz peak rate
- Trigger to rising or falling edge
- Measurement range 9,8 µs, endless measurement range by internal retrigger of START
- 10 MHz continuous rate per channel
- 40 MHz continuous rate per chip

Update on detector design

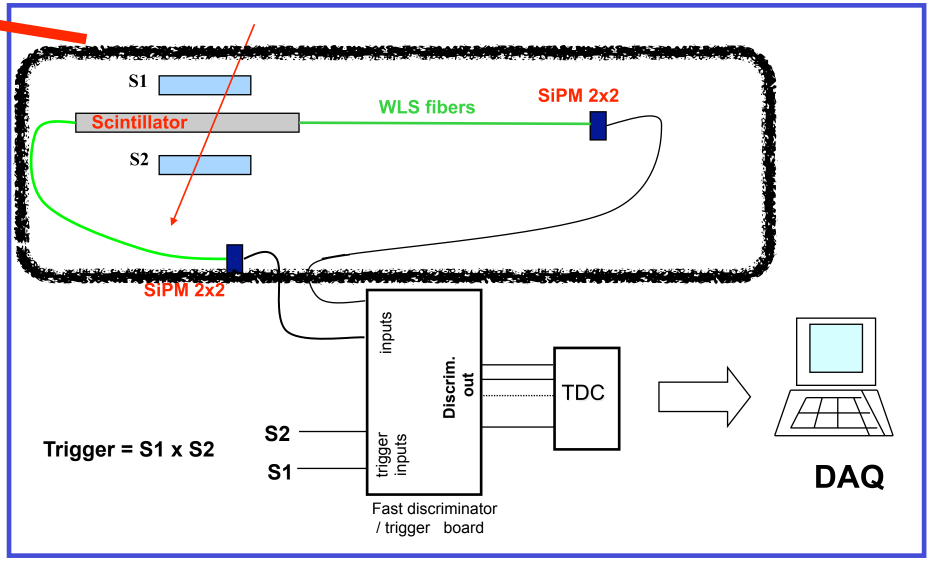
- Research & Development
- Detector optimization
- Background studies
- Fast Simulation status
- Mechanics

Update on detector R&D

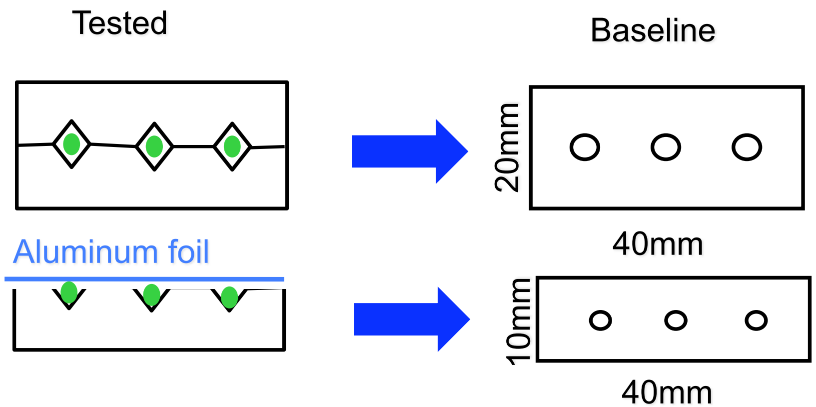


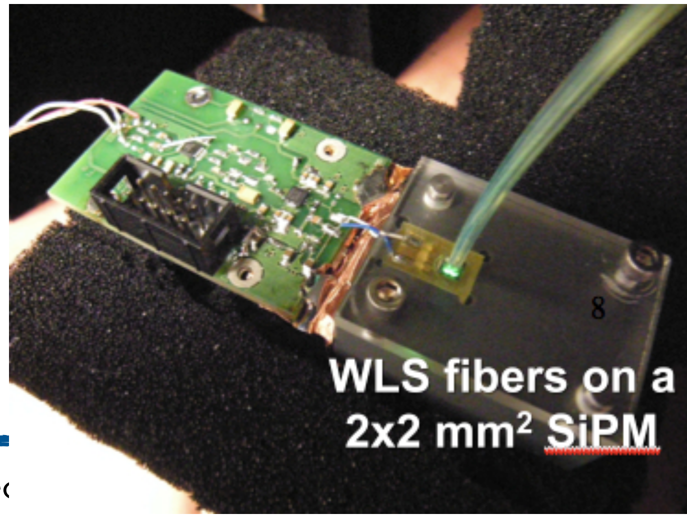


Experimental setup



Configuration tested and baseline





R&D results on baseline configurations

- Binary readout (the time resolution is not important)

		Time resolution			Efficiency		
		1.5pe	2.5pe	3.5pe	1.5pe	2.5pe	3.5pe
3 fibers	2.4 m grease	1.41	1.51	1.85	99.0%	99.4%	97.7%
	2.4m NO grease	1.73	1.88	2.15	98.8%	97.8%	89.2%

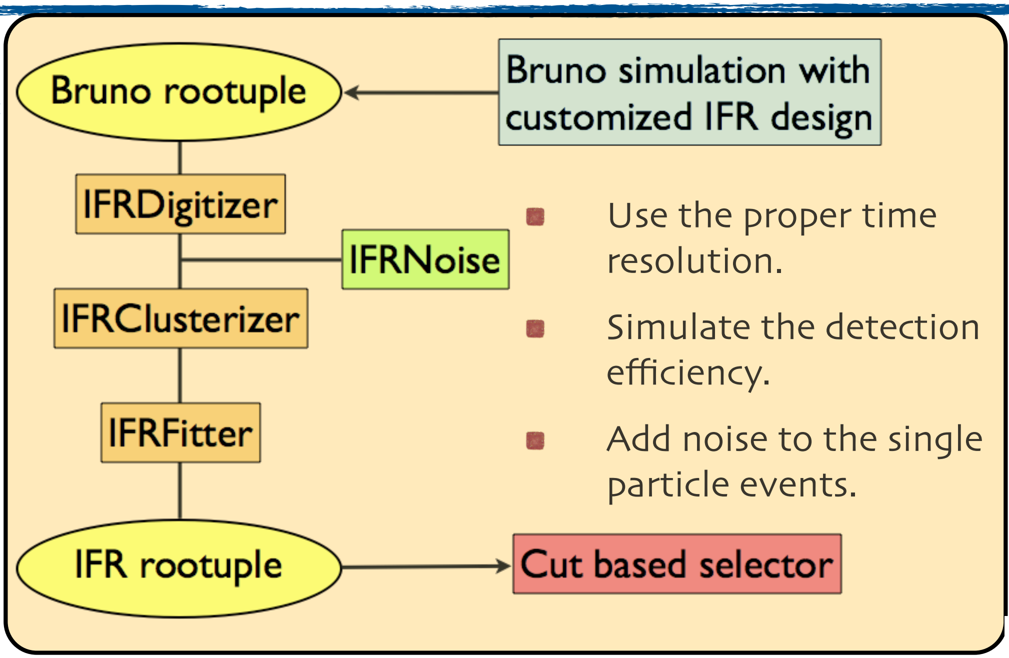
high detection efficiency - the threshold can be set at 3.5pe to reduce the dark counts

- Time readout (time resolution matters)

		Time resolution			Efficiency		
		1.5 pe	2.5pe	3.5pe	1.5pe	2.5pe	3.5pe
3 Fib.	2.2m with grease	1.16	1.17	1.26	95.9	99.1	99.1
	2.2m (no grease) SiPM1	1.32	1.37	1.26	96.1%	97.4%	94.4%
	2.2m (no grease) SiPM2	1.19	1.36	1.45	95.8%	95.8%	90.8%

plan to use double threshold readout to improve the time resolution

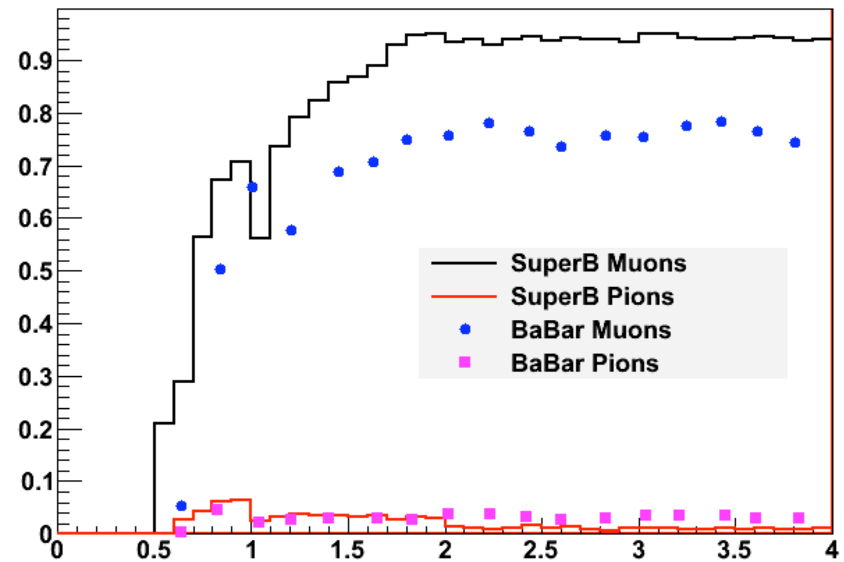
Detector optimization (using FullSim)



- A lot of code improvements have been done in the past few months.
- We are still developing but we have some nice results
- With our baseline configuration (CDR) the performances are

muon efficiency: 86.7 ± 0.1 %
pion efficiency: 2.1 ± 0.1%

Efficiency vs momentum in lab frame

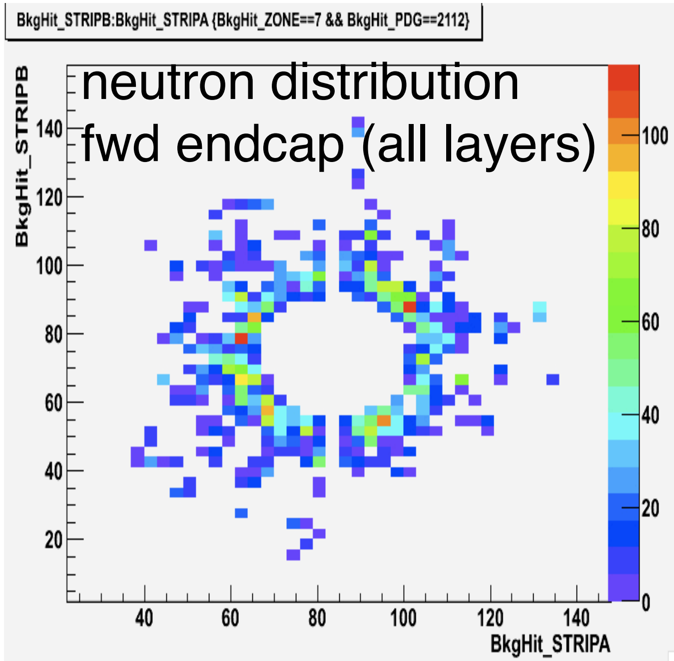


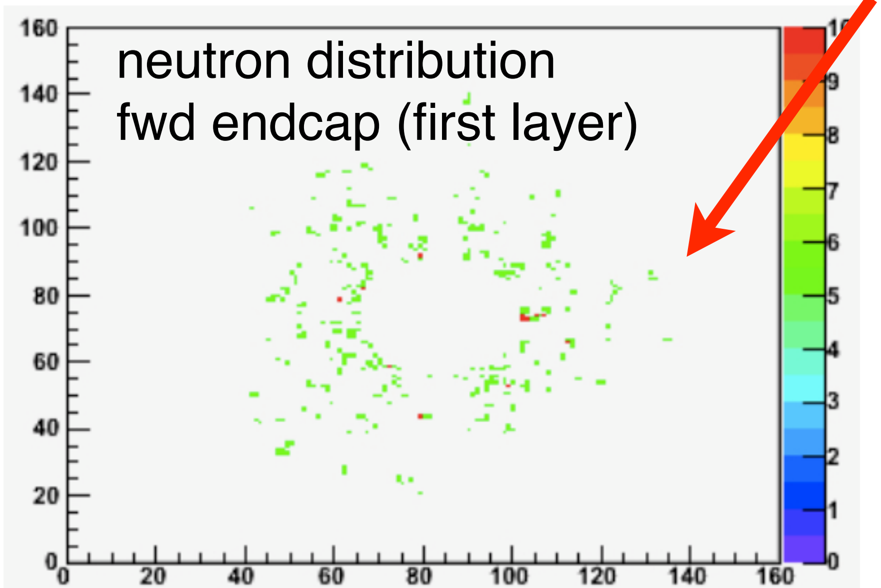
- We need to improve the possibility to discriminate among similar configurations (using NN or BDT algorithm)
- We need to add machine background to the present events (single particle + random noise)

Background studies

- Needed either for optimization studies and for photodetector aging and shielding.
- Slightly different digitization has been setup for background studies: scintillator planes have been divided in 4x4cm2 tiles to evaluate the rates.
- We simulate 5K events of radiative bhabhas to tune the machinery but we need more statistics.
- Endcap digitization for the endcaps has been also added

more statistics needed





We are also trying to identify where the neutrons are generated

More about neutron background

- SiPM/MPPC aging tests appeared in literature indicate that neutron irradiation ~~can be~~ is an issue.

See IFR session at Perugia meeting

- Waiting for simulations, in the worst case scenario we have to bring all the photodetectors out of the detector:

4m of WLS + 10m of clear fibers

Reduction of factor ~3 in number of p.e. to be recovered, keeping the same time resolution

4 fibers/scintill-bar on 2x2 mm^2 SiPM (or array of 4 1x1 mm^2 MPPC)

1.2mm fibers (ordered from Kuraray , expected end Feb.)

1.5mm clear fibers (ordered from Kuraray , expected end Feb.)

Coupling WLS/clear fiber

NOT feasible

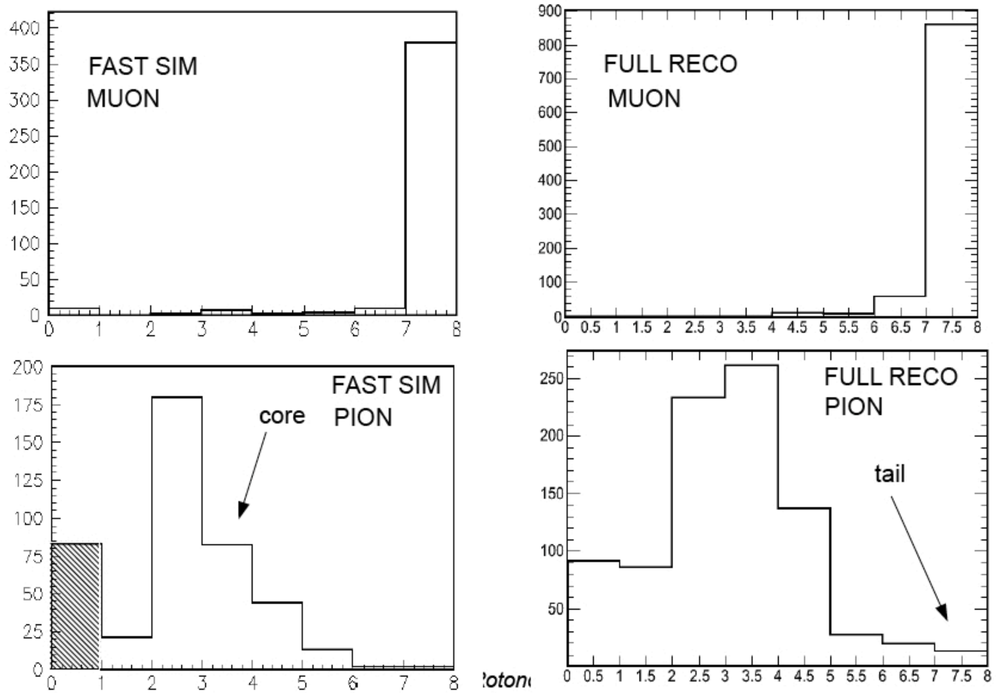
see Wander's talk at Perugia meeting

we are addressing this issue either with simulation and planning for new irradiation test with shielding

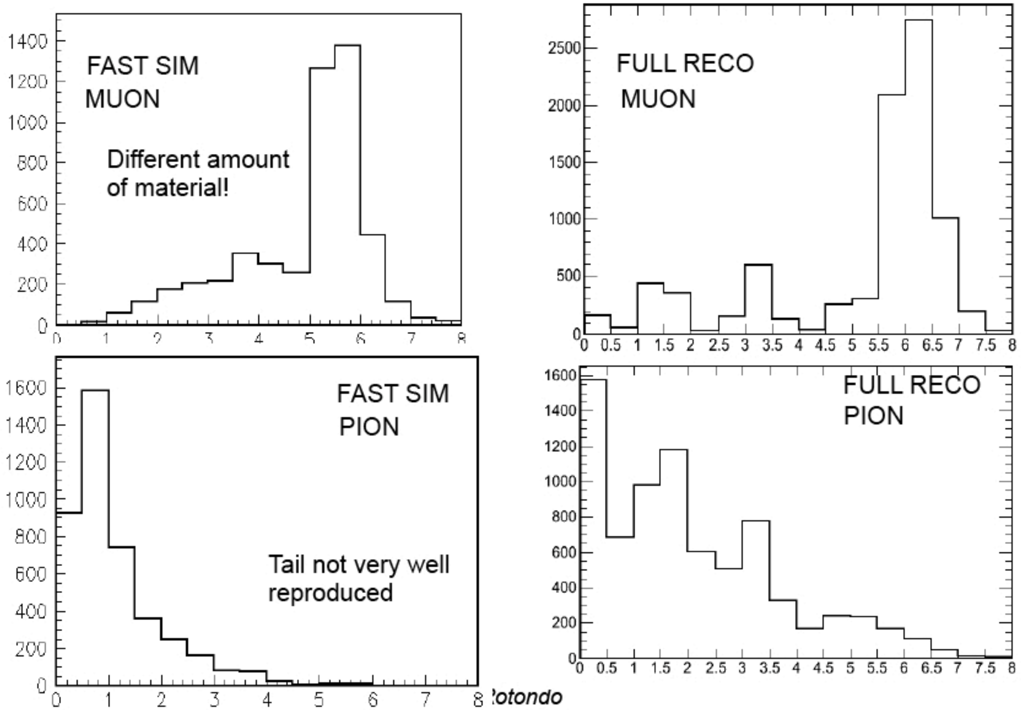
Tuning the FastSim

- Comparison between FullSim and FastSim of some quantities used in the muons selector

Fast .vs. Full simulation *N Last Layer 1.8<p<2.2 GeV*

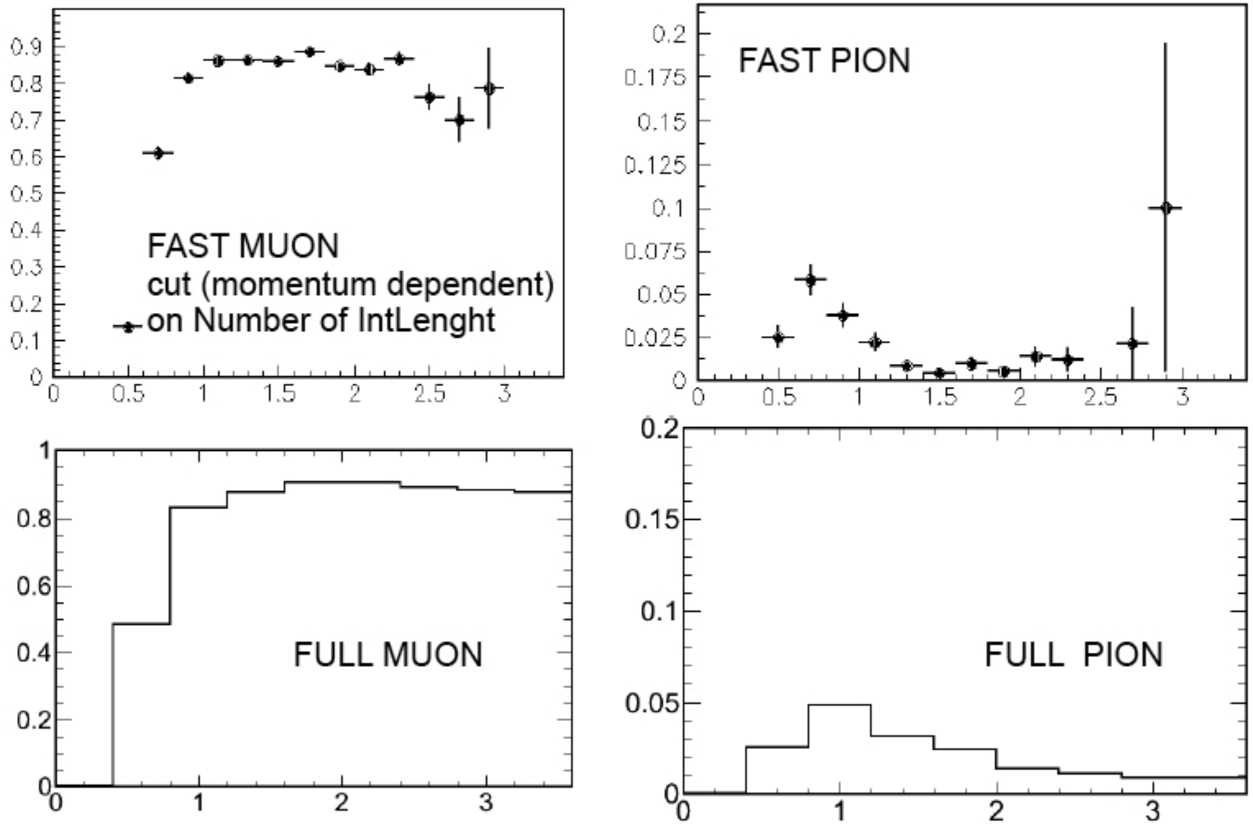


Fast .vs. Full simulation *N Interaction Lenght*



- There is an overall agreement but a better description of the hadronic showers is needed in the FastSim

Tuning the FastSim



- The agreement is not that bad
- But the tuning will be improved

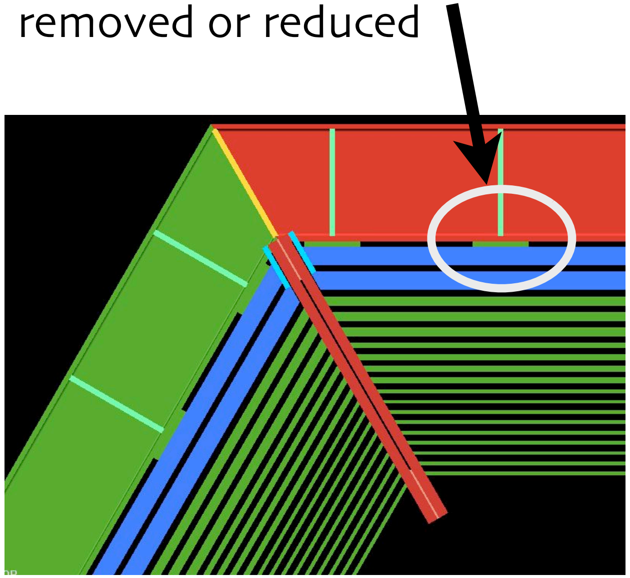
To Do

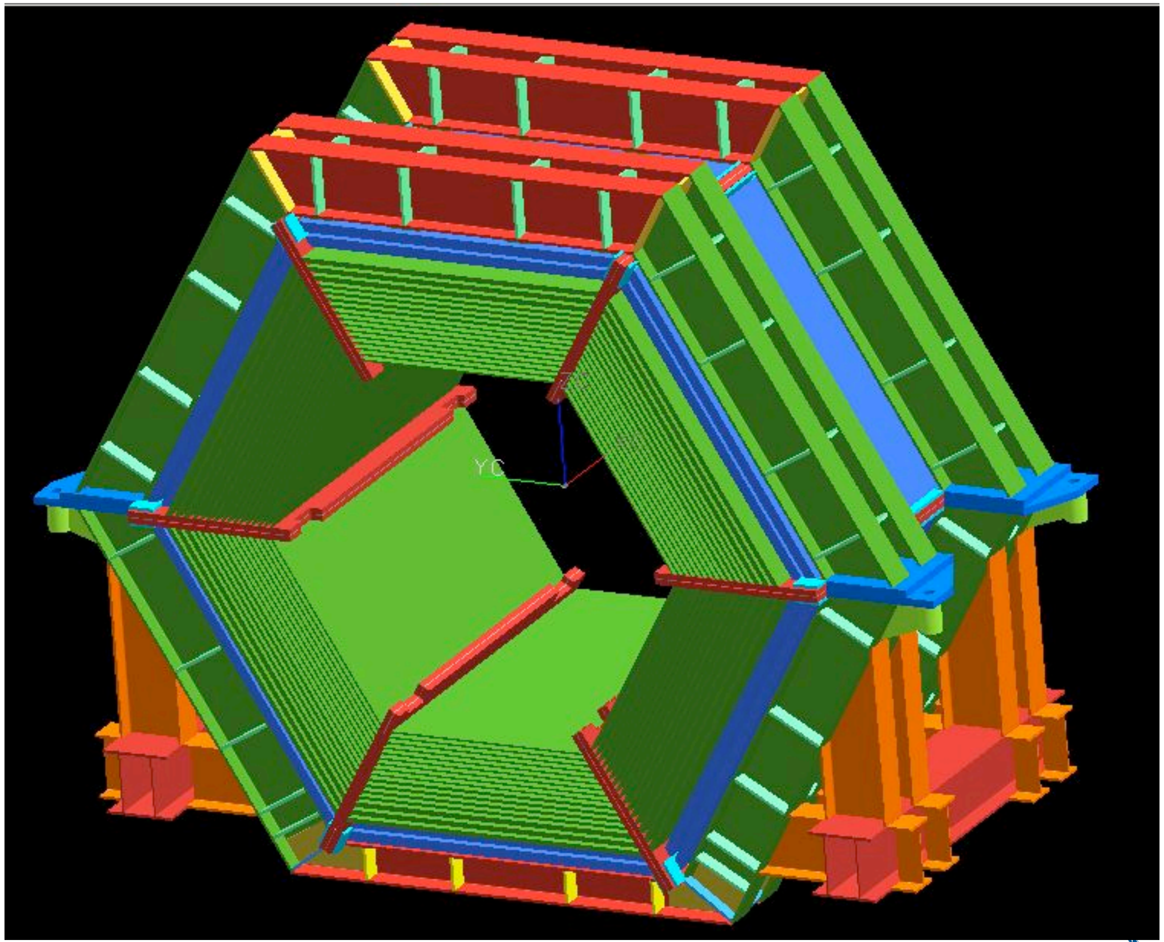
- Tune the pion hadronic interactions according to FullSim
  - Hit multiplicity per layer still not implemented
- Finish to implement reconstruction in FastSim
  - Reuse code developed for the Ifr detector optimization
- Implement a muon PID selector: performance guided by the FullSim

Iron structure

Remodeling of Babar IFR in progress to understand how it is assembled, how increase it and perform structural simulations of different scenarios.

To be studied if and how connection plates between beams and wedges could be removed or reduced



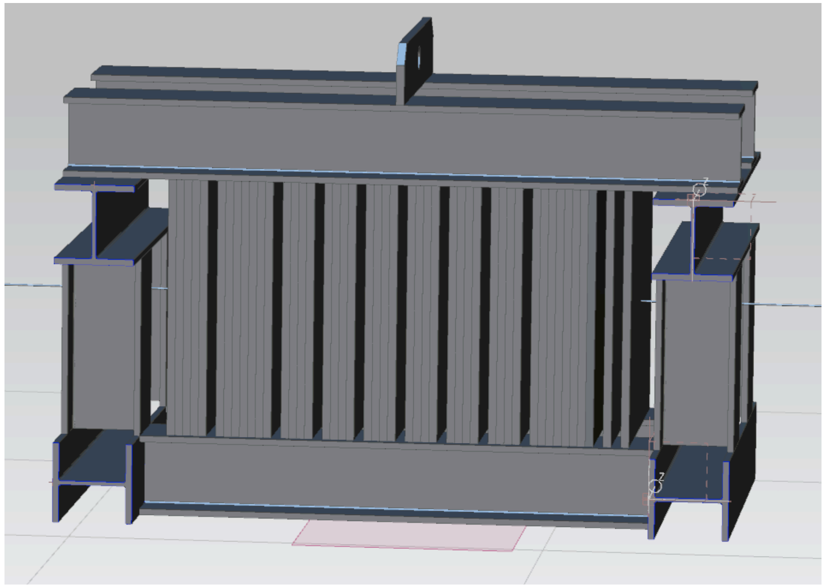


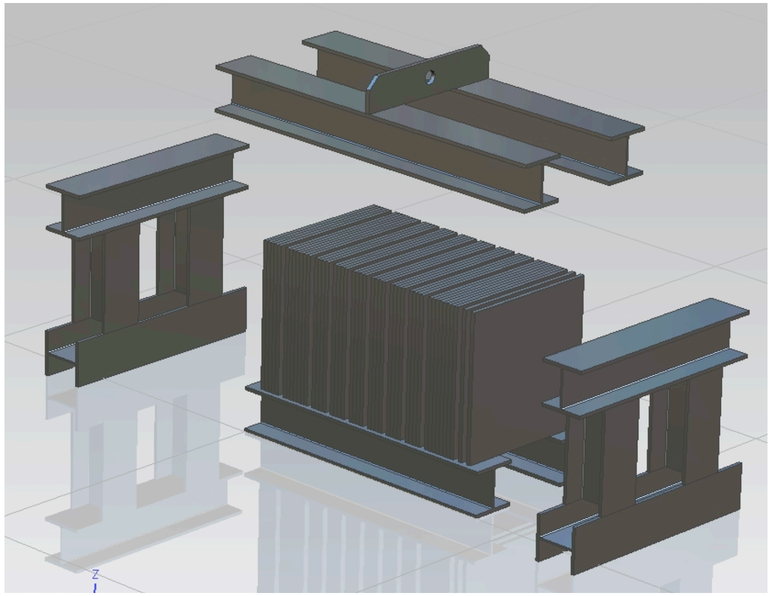
Preparing the prototype

- Mechanics
- Fiber readout
- Electronics

Prototyping the IFR

- Active area: 60x60cm2
- 8 Active Layers
- gap = 3cm to house the active layers
- 4 "Time Readout" modules
- 4 "Binary Readout" modules

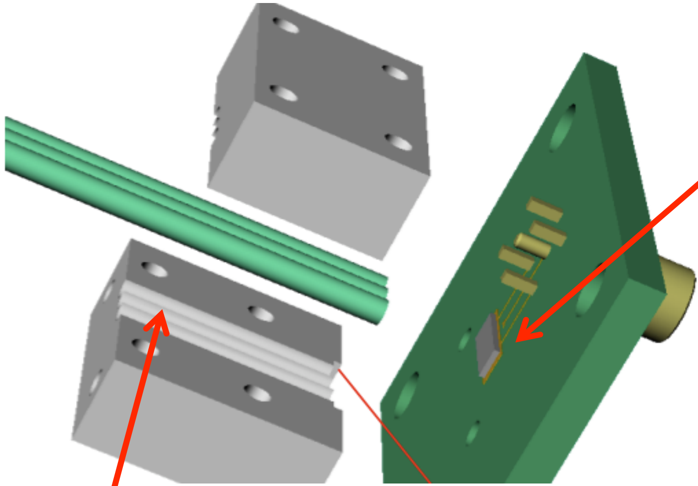




- Sketches are ready, final drawings in preparation. To be given to an external company for execution.
- Removable surrounding structure would allow vertical position for cosmics
- The prototype will be tested on a muon/pion beam at FNAL (summer 2010)

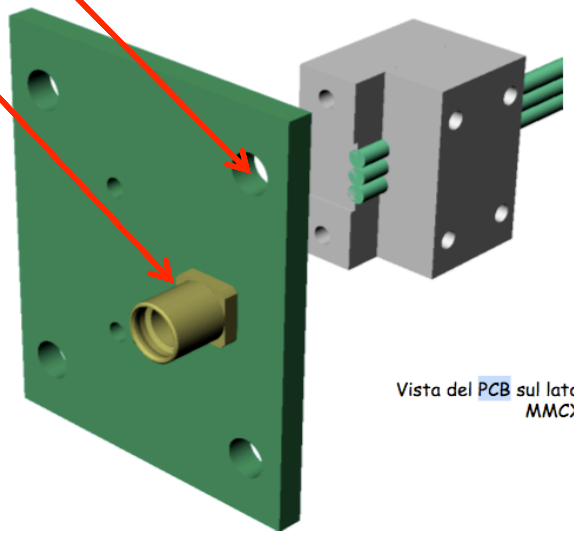
Fiber readout

Fibers-SiPM Coupling



- SiPM bonded directly on custom made PCBs: SiPM-card
- SiPM-card is fixed on the external sides of the pizza box
- The SiPM-card brings the signal from SiPM to an external coaxial connector

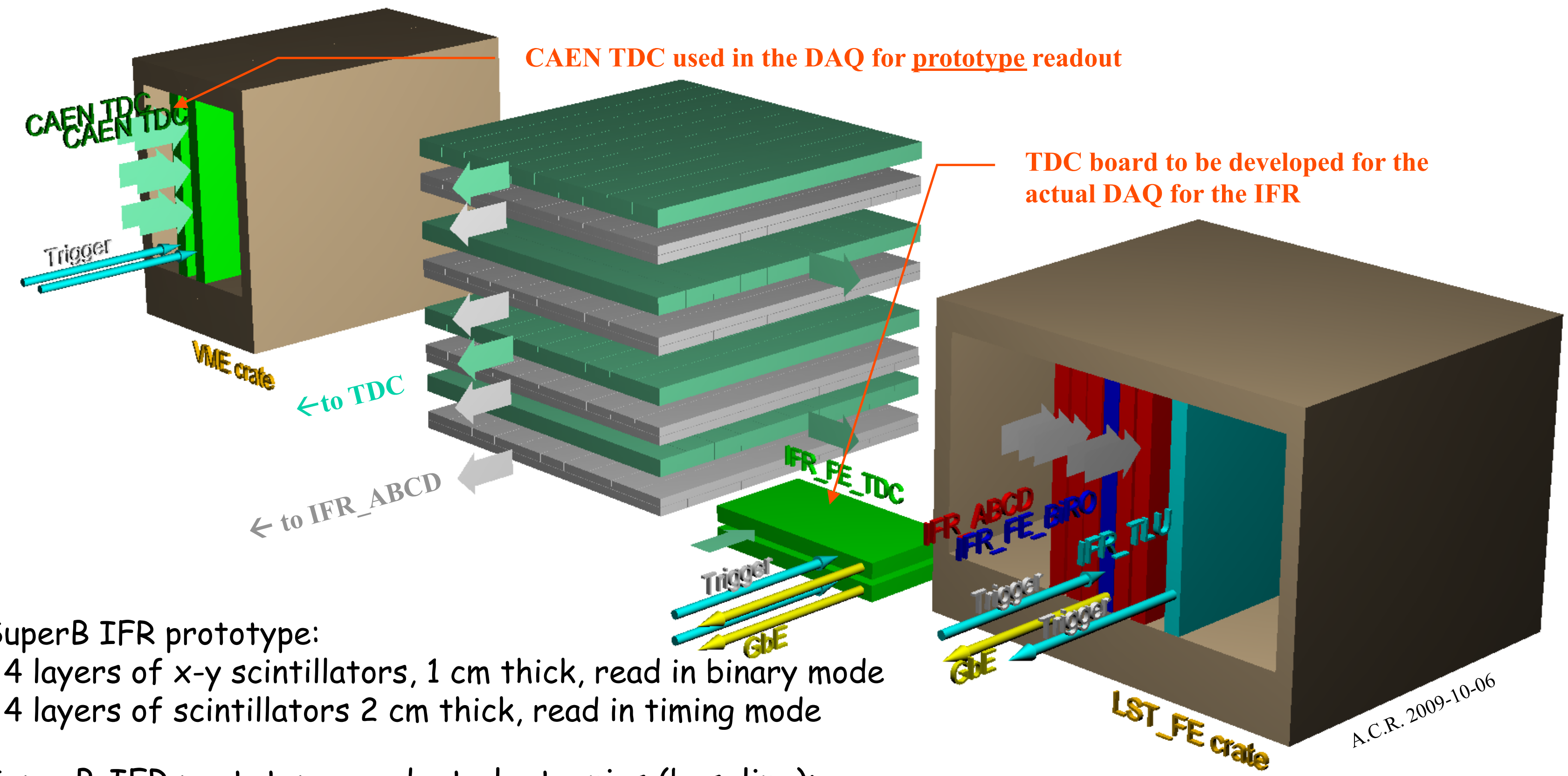
- Fibers are glued on the support and kept at about 0.1 mm from the SiPM surface
- It's important not to touch also the very fragile bonding wires
- Detailed design under definition



Vista del PCB sul lato del connettore MMCX

Prototype electronics

outline of the IFR DAQ electronics: prototype detector and electronics for a proof of principle



SuperB IFR prototype:
- 4 layers of x-y scintillators, 1 cm thick, read in binary mode
- 4 layers of scintillators 2 cm thick, read in timing mode

SuperB-IFR prototype readout electronics (baseline):
- "IFR_ABCD": sensor Amplification, Bias-conditioning, Comparators, (new!) Data processing: it samples and stores the comparators outputs, pending the trigger request
- "IFR_FE_BiRO": collects data from IFR_ABCD cards upon trigger request and sends it to DAQ PC (via GbE)
- "CAEN_TDC": a multi-hit TDC design based on CERN HP-TDC; hosted in a VME crate and read out via a VME CPU or via a VME-PCI bridge to the DAQ PC
- "IFR_TLU": a module (Trigger Logic Unit) to generate a fixed latency trigger based on primitives from the IFR prototype itself or from external sources

Schedule toward the TDR (aka future plans)

done	finalize prototype design (mechanics and electronics) .
done	place orders for prototype construction (needed simulation results first)
January 2010	begin prototype assembly
Spring 2010	prototype test with cosmics
Summer 2010	test beam

Then of course analyze the data and write the TDR

Summary and outlook

- The time from the SLAC workshop to here has been very intense.
- Advancements have been done in all areas:
  - R&D and detector design
  - simulation
  - prototype preparation
- A careful planning of the future activities has been done at this meeting with particular attention to the prototype construction and detector optimization.

Summary and outlook

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  - simulation
  - prototype preparation
- A careful planning of the future activities has been done at this meeting with particular attention to the prototype construction and detector optimization.
- If you think 2009 has been tough you don't know how hot will be next year!