The SuperB experiment

Sezione Roma 1, 8/4/2011

Riccardo Faccini

SuperB Detector

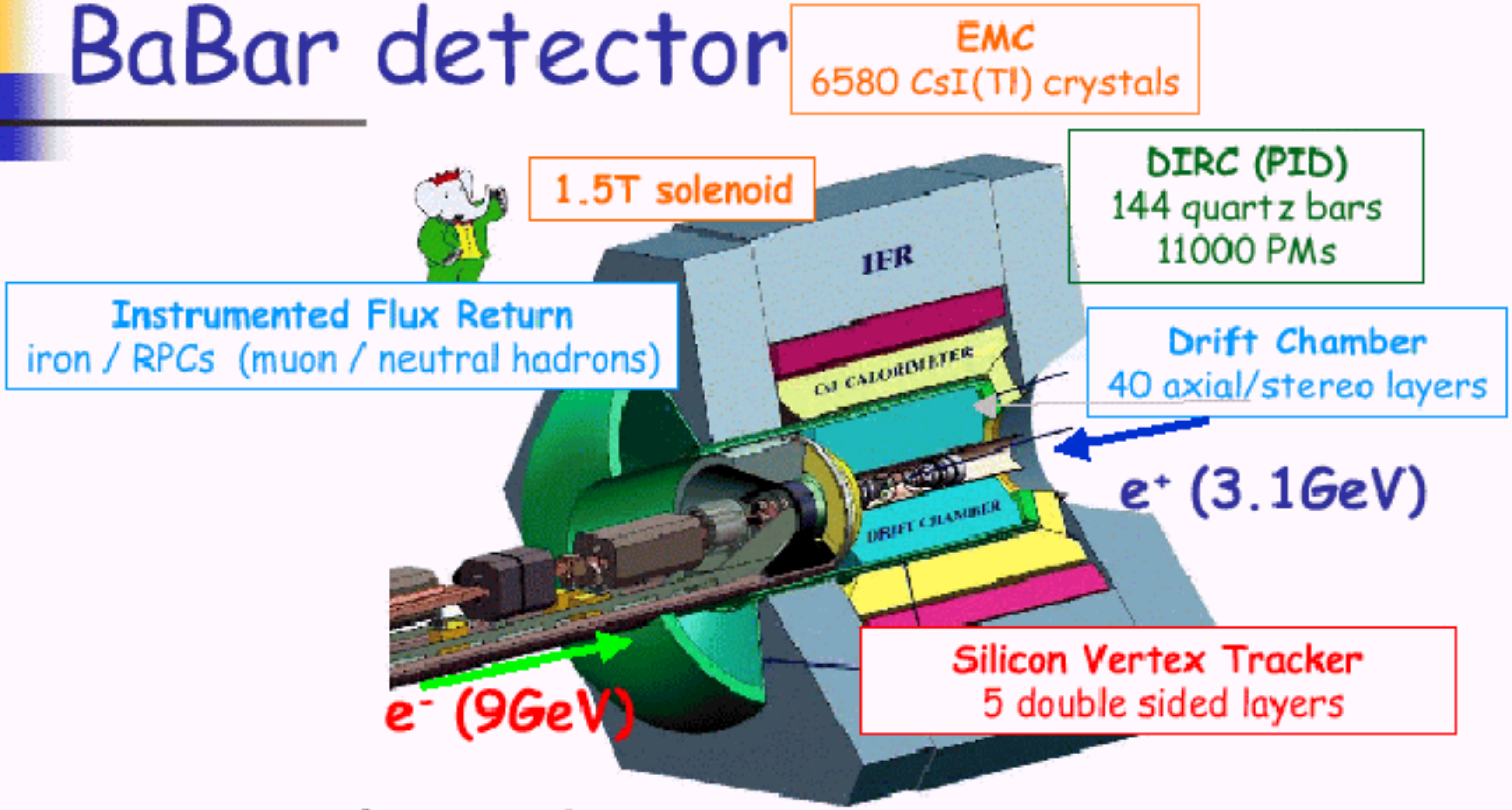
Mutuated from BaBar

- General Purpose
- Asymmetric beams (8 vs 4 GeV), but basically central detector
- main goals:
  - exclusive reconstruction of the whole decay chain
  - good vertex reconstruction
  - hermeticity
  - Particle Identification (PID)
- Recycle:
  - Quartz Bars for Barrel PID
  - EMC barrel
  - Superconducting coil and magnetic flux return

SuperB specific issues

- Larger Backgrounds
- Less Energy Asymmetry
- interaction with machine design

BaBar detector



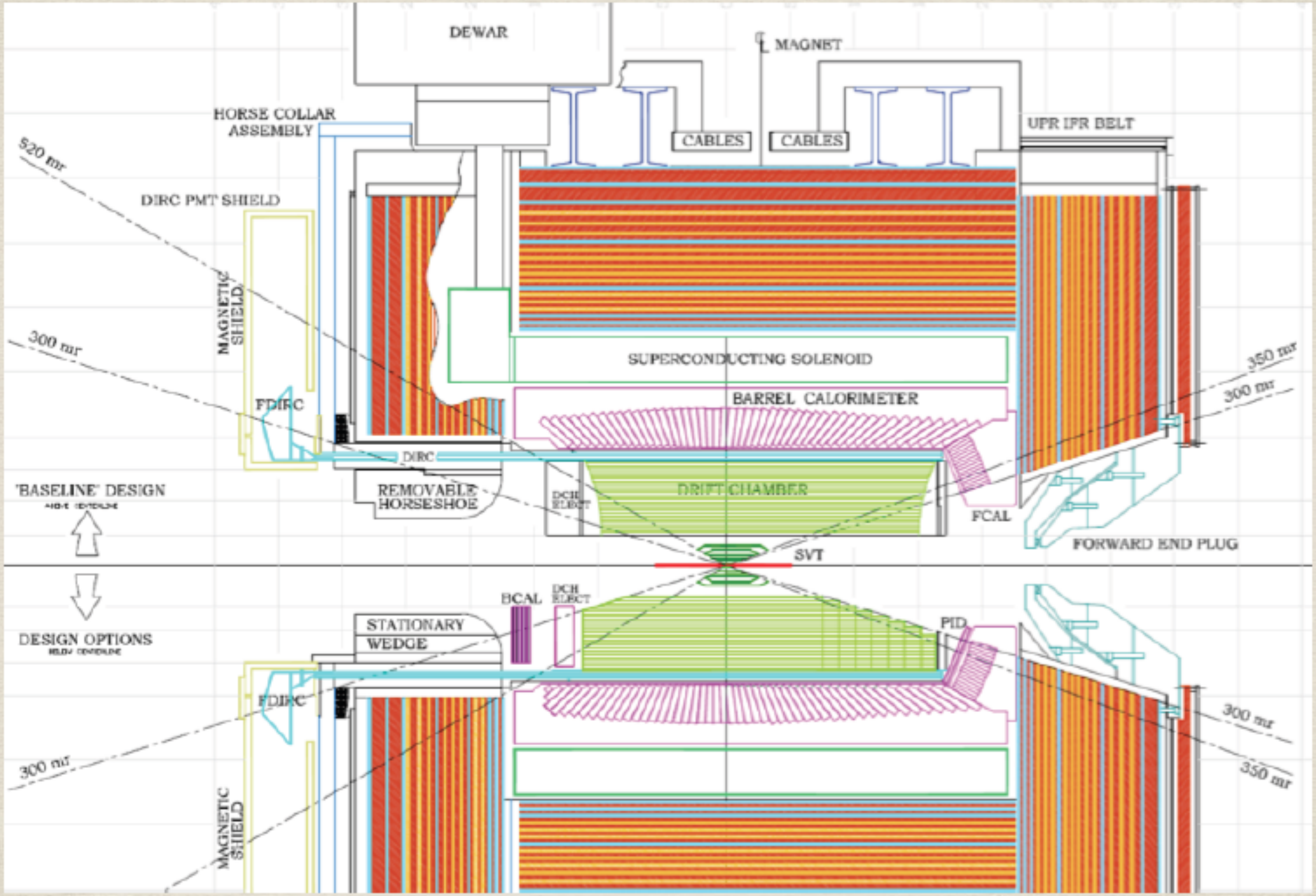
SVT: z resolution ~70 microns

Tracking: $\sigma(p_T)/p_T = 0.13\% \times p_T \oplus 0.45\%$

DIRC: K-π separation > 3.4σ for $P<3.5$GeV

EMC: $\sigma_E/E = 1.33\% \cdot E^{-1/4} \oplus 2.1\%$

SuperB Detector (with options)



Detector Proto-Techboard

Detector Coordinators – B.Ratcliff, F. Forti

Technical Coordinator – W.Wisnieswki

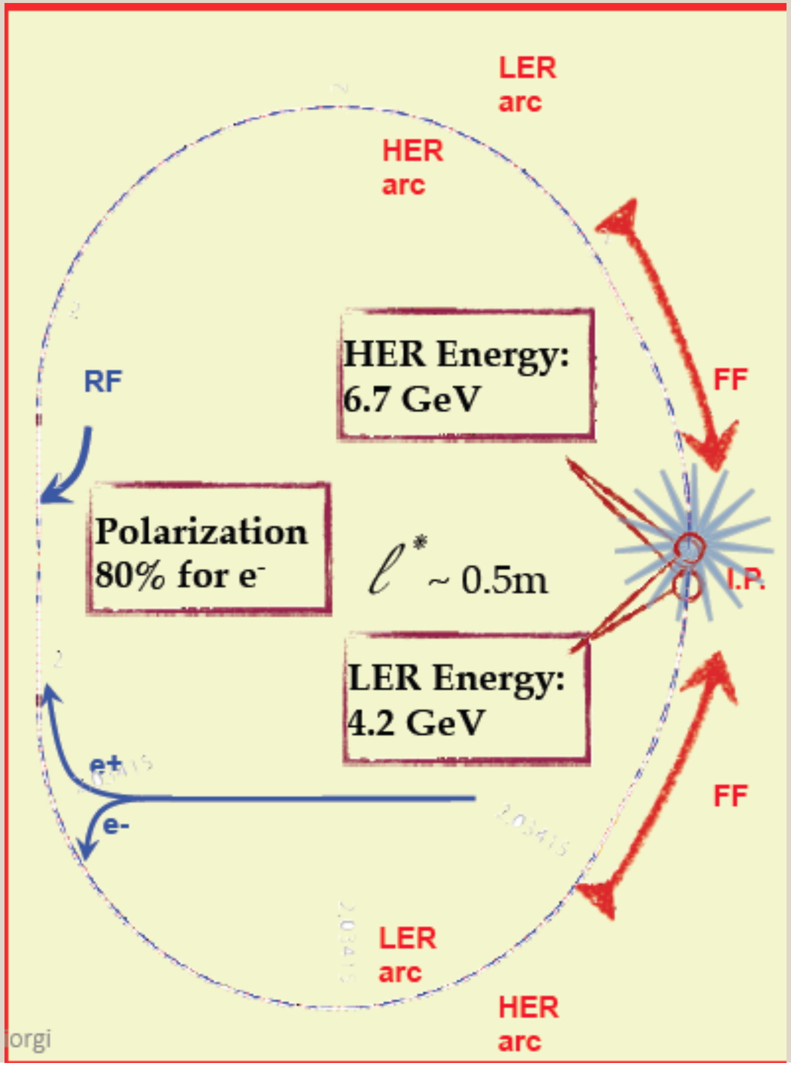
* SVT – G. Rizzo
* DCH – G. Finocchiaro, M.Roney
* PID – N.Arnaud, J.Va'vra
* EMC – F.Porter, C.Cecchi
* IFR – R.Calabrese
* Magnet – W.Wisniewski
* Electronics, Trigger, DAQ – D. Breton, U. Marconi
* Online/DAQ – S.Luitz
* Offline SW –
  * Simulation coordinator – D.Brown
  * Fast simulation – M. Rama
  * Full Simulation – F. Bianchi
* Rad monitor –
* Lumi monitor –
* Background simulation – M.Boscolo, E.Paoloni
* Machine Detector Interface –

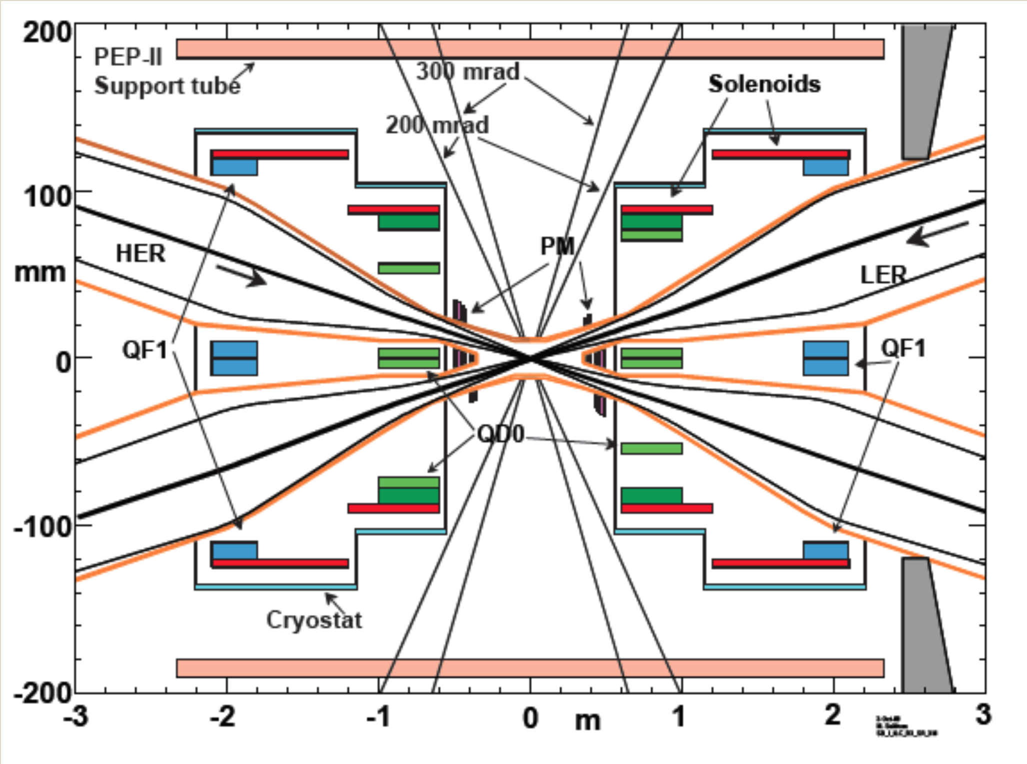
Detector Geometry Working Group
Chairs M.Rama, A.Stocchi

Geometry Selection Task Force
Chairs W.Wisniewski, H.Jawahery

Accelerator

Already talked by P.Raimondi on Mar. 23rd





Site committee should report within one month

Today: walk though of the Tor Vergata site

Accelerator Parameters

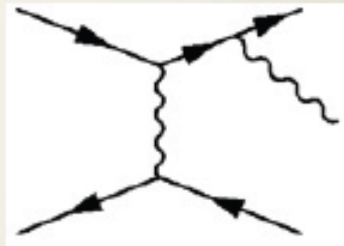
	PEP-II (SLAC)	SuperB (Italy)	SuperKEKB (KEK)
Luminosity (10^{30} $cm^{-2}s^{-1}$)	12069 (design: 3000)	1.0×10^6	8×10^5
Injection energy (GeV)	2.5–12	$e^-/e^+: 4.2/6.7$	$e^-/e^+: 7/4$
Transverse emittance ($10^{-9}\pi$ rad-m)	e^-: 48 (H), 1.5 (V) e^+: 24 (H), 1.5 (V)	e^-: 2.5 (H), 0.006 (V) e^+: 2.0 (H), 0.005 (V)	5 (H), 3 (V)
β^*, amplitude function at interaction point (m)	e^-: 0.50 (H), 0.012 (V) e^+: 0.50 (H), 0.012 (V)	e^-: 0.032 (H), 0.00021 (V) e^+: 0.026 (H), 0.00025 (V)	e^-: 0.025 (H), 3×10^{-4} (V) e^+: 0.032 (H), 2.7×10^{-4} (V)
Beam-beam tune shift per crossing (units 10^{-4})	e^-: 703 (H), 498 (V) e^+: 510 (H), 727 (V)	20 (H), 950 (V)	e^-: 12 (H), 807 (V) e^+: 28 (H), 893 (V)
RF frequency (MHz)	476	476	508.887
Particles per bunch (units 10^{10})	e^-/e^+: 5.2/8.0	e^-/e^+: 5.1/6.5	e^-/e^+: 6.53/9.04
Bunches per ring per species	1732	978	2500
Average beam current per species (mA)	e^-/e^+: 1960/3026	e^-/e^+: 1900/2400	e^-/e^+: 2600/3600

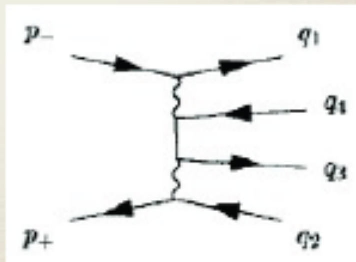
Machine backgrounds

E. Paoloni (Pisa) + representatives from detectors

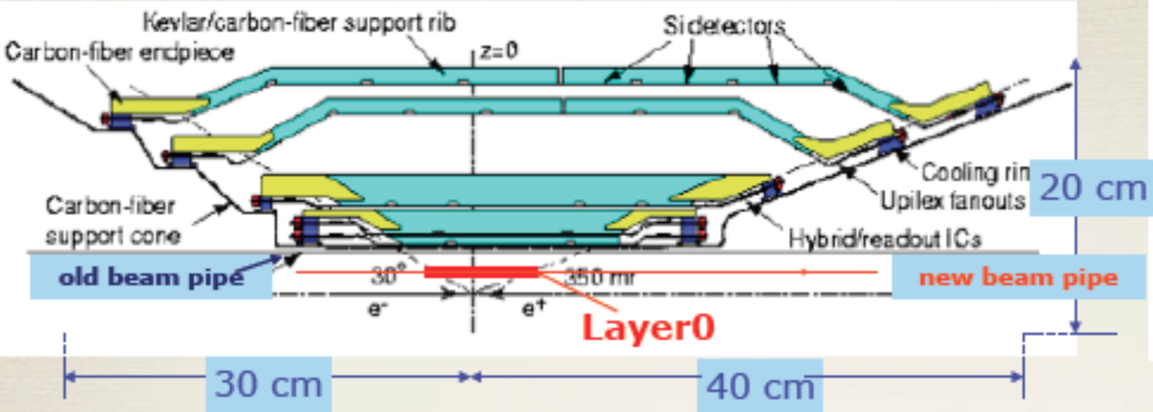
- Two colliding beams
  - radiative Bhabha → dominant effect on lifetime
  - e+e- e+e- production → ~3% contribution to lifetime, important source for SVT layer-0
- Single beam
  - synchrotron radiation → strictly connected to IR design
  - Touschek → negligible in BaBar, important in SuperB
  - beam-gas
  - intra-beam scattering

	Cross section	Evt/bunch$_{xing}$	Rate
Beam Strahlung	~ 340 mbarn (Eγ/Ebeam > 1%)	~680	0.3THz
	~ 40 mbarn (Eγ/Ebeam > 50%)	~80	35GHz
pair production	~7.3 mbarn	~15	7GHz
Elastic Bhabha	O(10^{-4}) mbarn (Det. acceptance)	~200/Million	100KHz
Υ(4S)	O(10^{-6}) mbarn	~2/Million	1 KHz





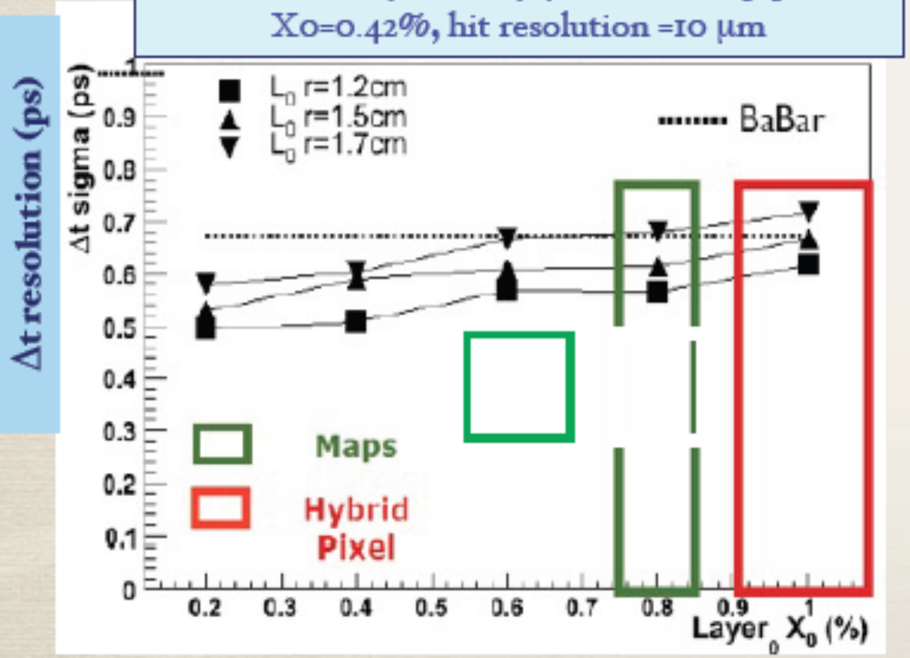
Silicon Vertex Tracker



BaBar SVT

- 5 Layers of double-sided Si strip sensor
- Low-mass design. (P_t < 2.7 GeV)
- Stand-alone tracking for slow particles.
- 97% reconstruction efficiency
- Resolution ~15μm at normal incidence

$B \to \pi\pi$ decay mode, $\beta\gamma$=0.28, beam pipe X/Xo=0.42%, hit resolution =10 μm



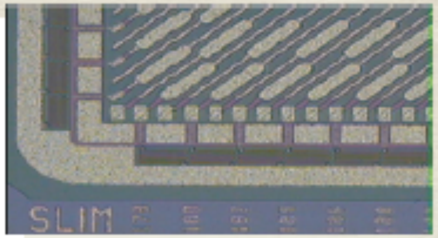
- ✳ SuperB SVT based on Babar SVT design for R>3cm. BUT:
- ✳ Reduced beam energy asymmetry (7x4 GeV vs. 9x3.1 GeV) requires improved vertex resolution (~ factor 2 needed)
  - → Layer0 very close to the IP (R~ 1.5 cm) with low material budget
  - → Layer0 area 100 cm2
- ✳ Background levels depends steeply on radius
  - → Layer0 needs to have fine granularity and radiation tolerance

- Layer0 subject to large background and needs to be extremely thin: > 5MHz/cm², > 3MRad/yr, < 1 %X_0

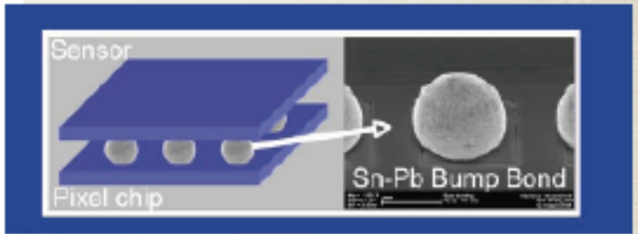
Bologna, Milano, Pavia, Pisa, Rome3, Torino, Trieste, Trento, LBNL, Queen Mary, RAL

SuperB SVT Layer 0 technology options

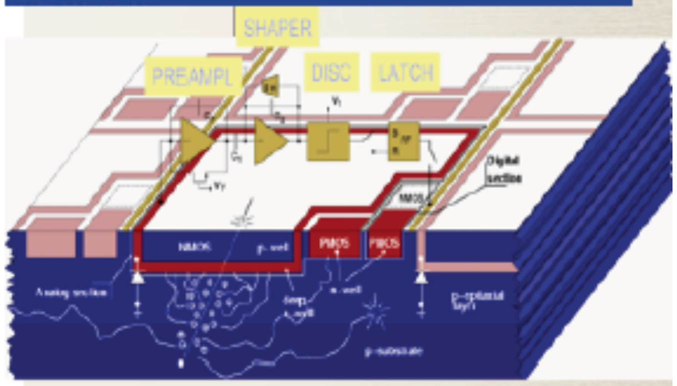
- **Striplets option:** mature technology, not so robust against background occupancy.
  - Marginal with back. track rate higher than ~ 5 MHz/cm²
  - Moderate R&D needed on module interconnection/mechanics/FE chip (FSSR2 or new chip)



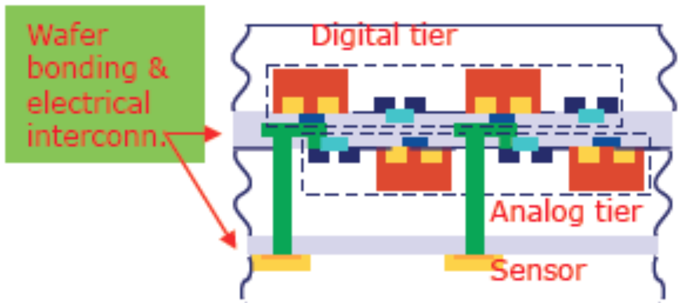
- **Hybrid Pixel option:** viable, although marginal.
  - Reduction of total material needed!
  - Reduction in the front-end pitch to 50x50 μm² with data push readout (developed for DNW MAPS)
    - → FE prototype chip (4k pixel, ST 130 nm) now under test.



- **CMOS MAPS option:** new & challenging technology.
  - Sensor & readout in 50 μm thick chip!
  - Extensive R&D (SLIM5-Collaboration) on
    - Deep N-well devices 50x50μm² with in-pixel sparsification.
    - Fast readout architecture implemented
  - CMOS MAPS (4k pixels) successfully tested with beams.



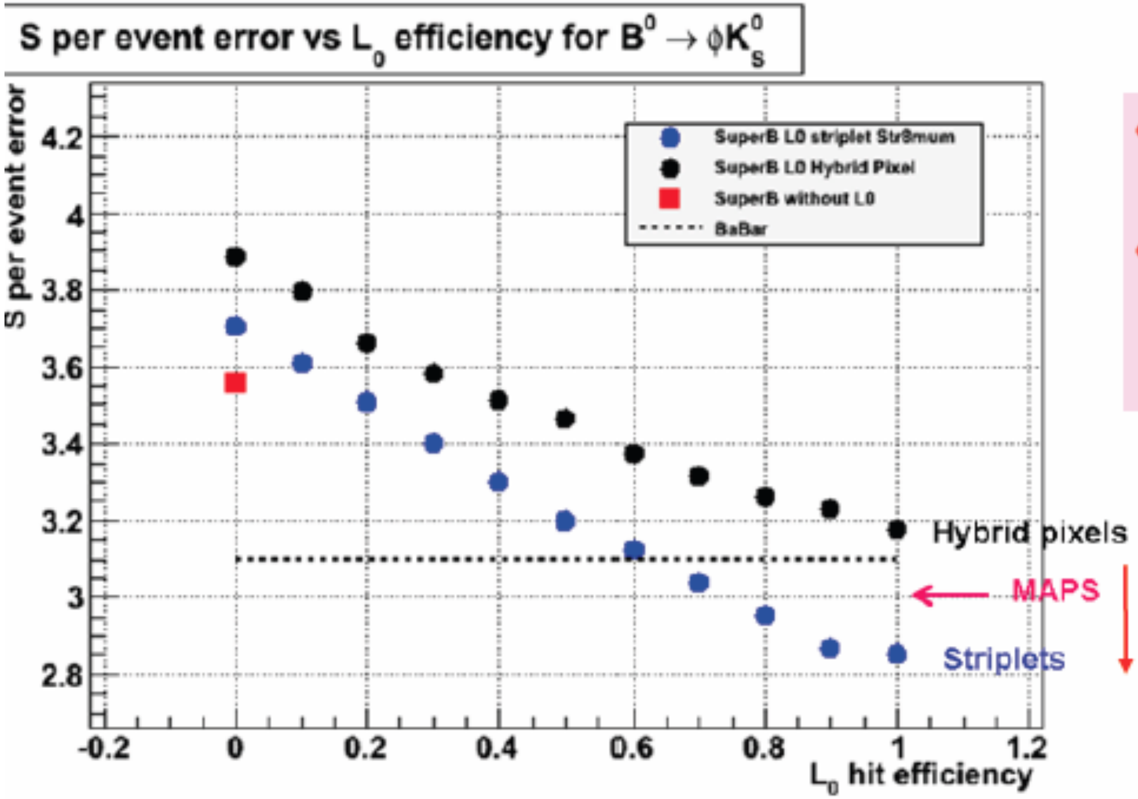
- **Thin pixels with Vertical Integration:** reduction of material and improved performance.
  - Two options are being pursued (VIPIX-Collaboration)
    - DNW MAPS with 2 tiers
    - Hybrid Pixel: FE chip with 2 tiers + high resistivity sensor



Layer 0 Strategy

Plan

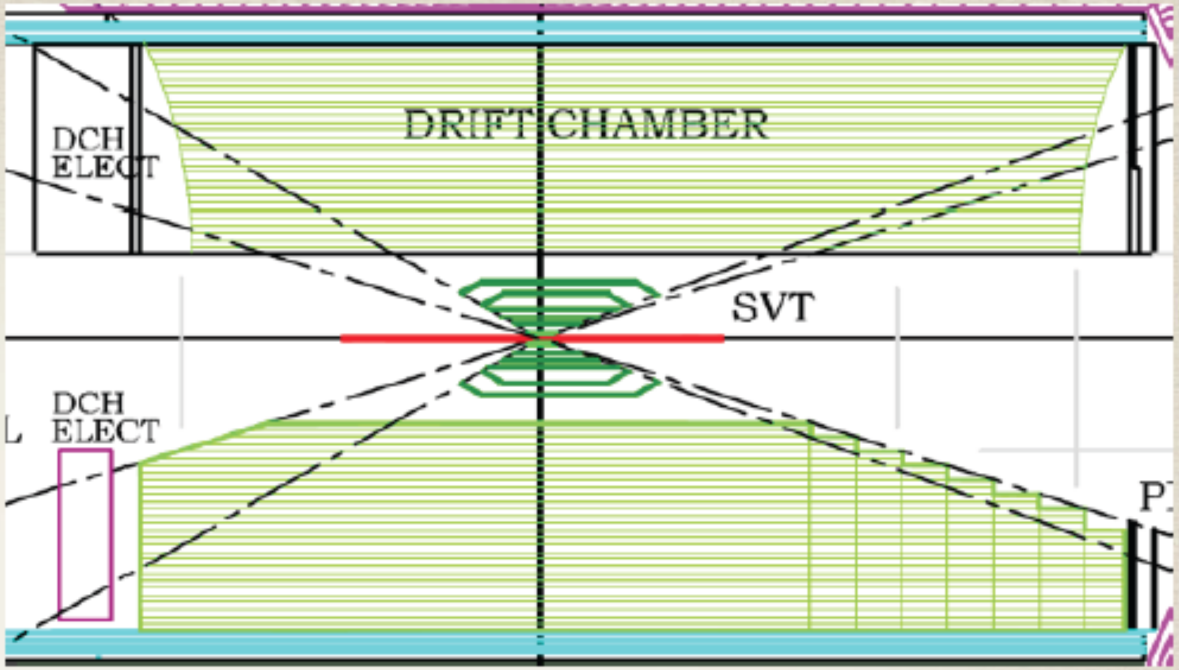
- Striplets baseline option for TDR:
  - Better physics performance (lower material ~0.5% vs 1% hybrid pixel, MAPS or thin hybrid pixel in between but not yet mature!)
- Upgrade to pixel
  foreseen for a second generation of Layer0 (1-2 yrs after t0)



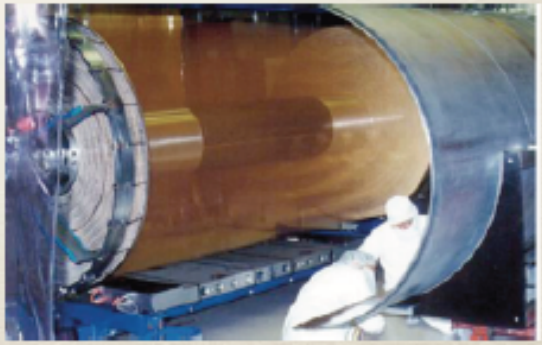
- *Need to continue thin pixel R&D at full speed*
- *SVT Mechanics will be designed to allow a quick access/removal of Layer0*

~10% better
~20% more
Luminosity

Drift CHamber



- Ottimizazione del progetto di Babar
  - ottimizzando il riempimento del volume di tracciatura
  - riducendo il materiale nel volume di tracciatura (diffusione multipla, dominante ai bassi impulsi di SuperB):
    - nel gas aumentando la percentuale di He, o usando un idrocarburo più leggero
    - riducendo la quantità di Al nei fili
  - Anche il materiale della struttura puo essere minimizzato
    - struttura meccanica
    - materiale dell'elettronica (incluso cooling)
- R&D su cluster couting
  - Miglioramento radicale per dE/dx, impulso



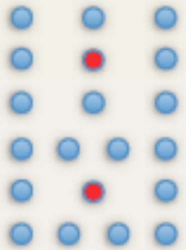
LNF, McGill, Montreal, TRIUMF, UBC, Victoria

Ottimizzazione

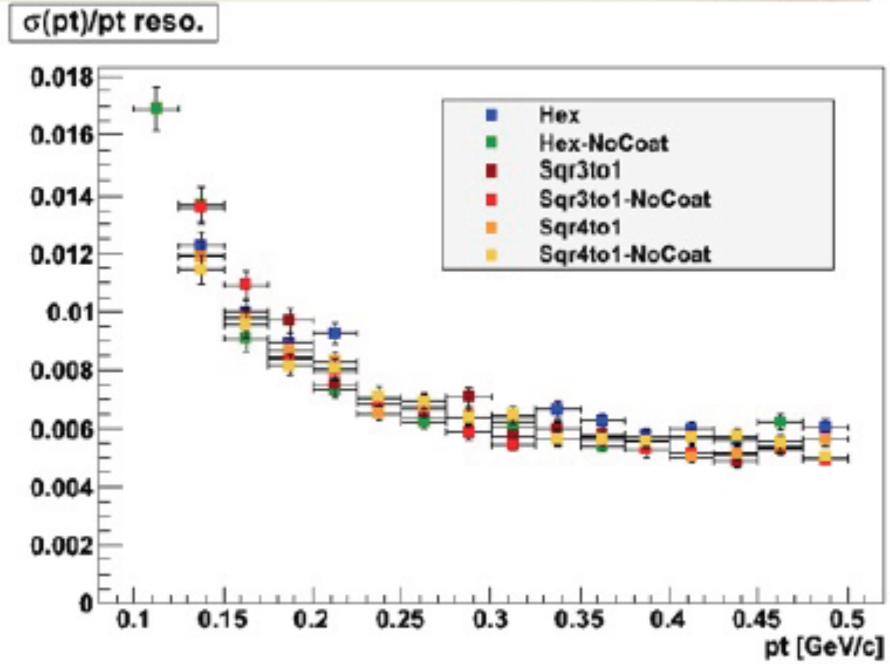
- Disposizione dei fili
  - "Nominal" (BABAR) :
  - AUVAUVAUVA
  - "Axial": AAAAAAAAAA
  - "Stereo SL" : AUVUVUVUVA
  - "Stereo layers" Auvuv.....uvuvA

- Misura di θ dominata da SVT: effetto piccolo della disposizione sul tracking
- Da studiare l'impatto della disposizione dei layer stereo sulla misura di θ a livello di trigger L1: RM3

- Layout e miscela
  - Hex (Babar) vs. square (KLOE)
  - Metano o isobutano



- Celle rettangolari permettono una del materiale nel volume di tracciamento.
  - miglioramento di 15-20% nella misura di impulso a bassi p.
- Miscela di gas più leggera riduce il materiale
  - trade-off delicato con la risoluzione spaziale e dE/dx, e con la stabilità di operazione della miscela
- I primi studi con mostrano che le celle quadrate sono OK.

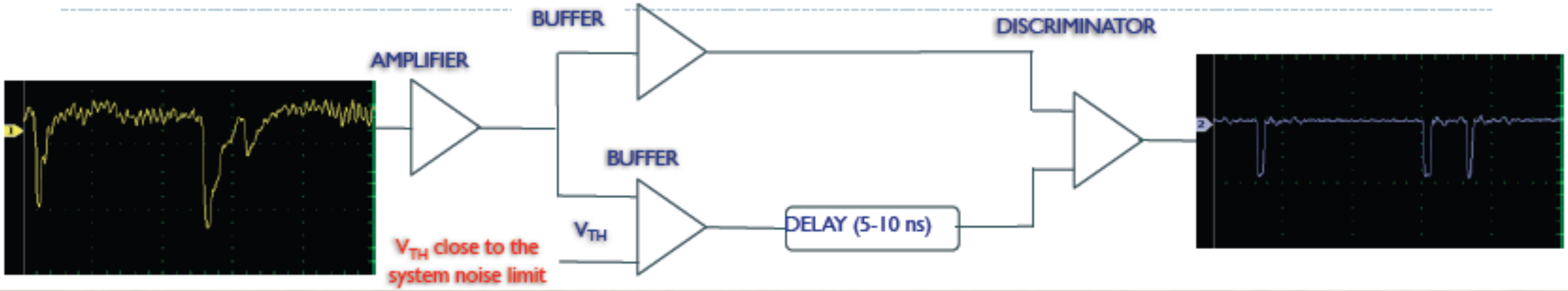


Miscela fissata ($80\%He-20\%iC_4H_{10}$) e diverse configurazioni di cella

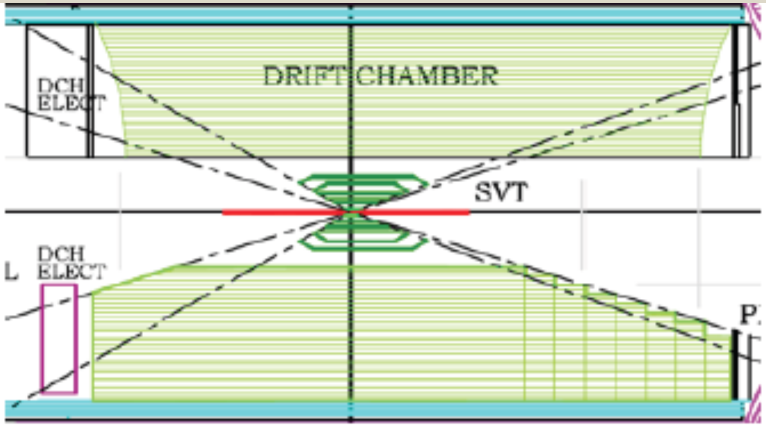
R&D on cluster counting

- Kaon-pion separation achieved by counting the number of released clusters
  - a more direct measurable rather than the integral energy
  - need time resolution to resolve clusters

Local derivative method



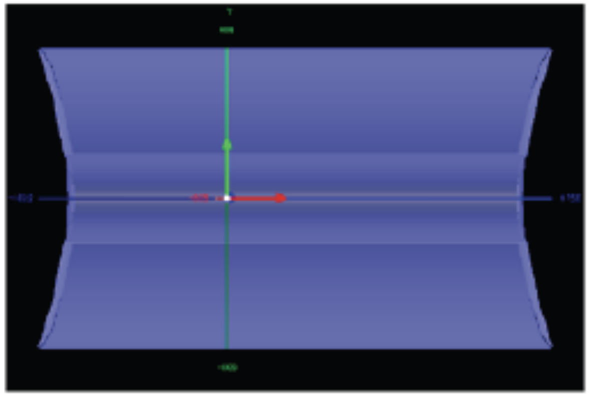
Struttura meccanica
Geometria endplates



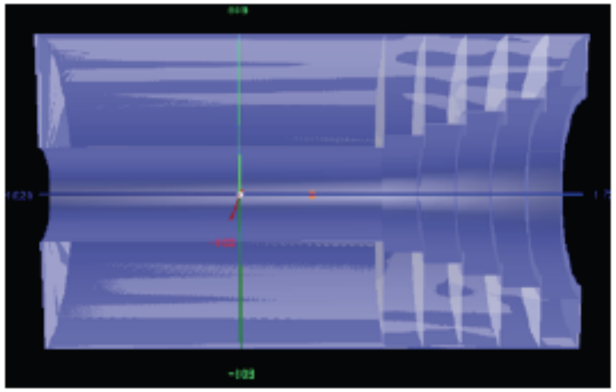
Struttura completamente in C.F.
Opzioni per geometria dei piatti:

- sferici à la KLOE (oppure con concavità opposta)

0.02X_0 da confrontare con 0.13X_0 di BABAR



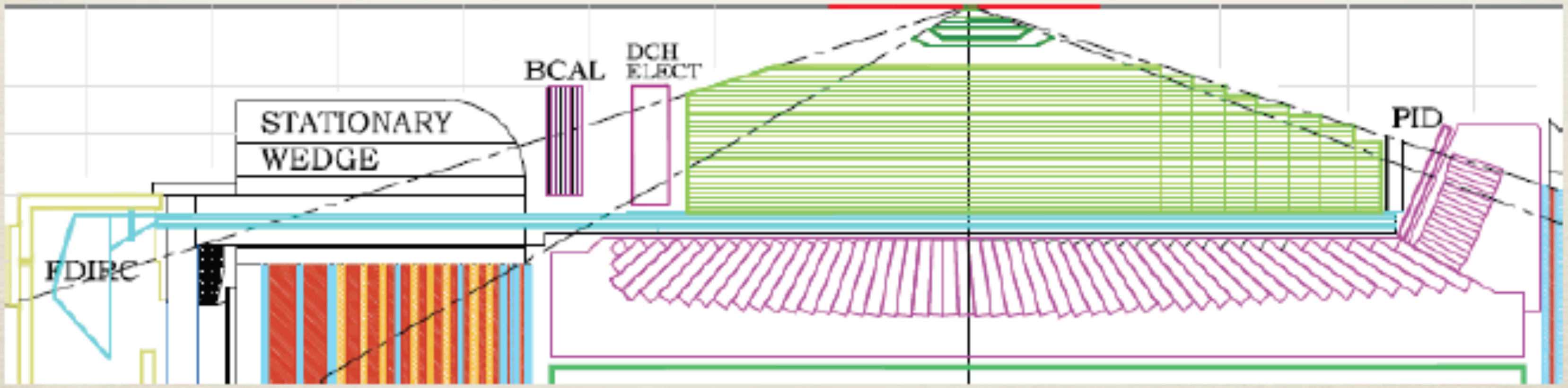
- conici, o a step per ridurre l'occupazione nella regione in avanti



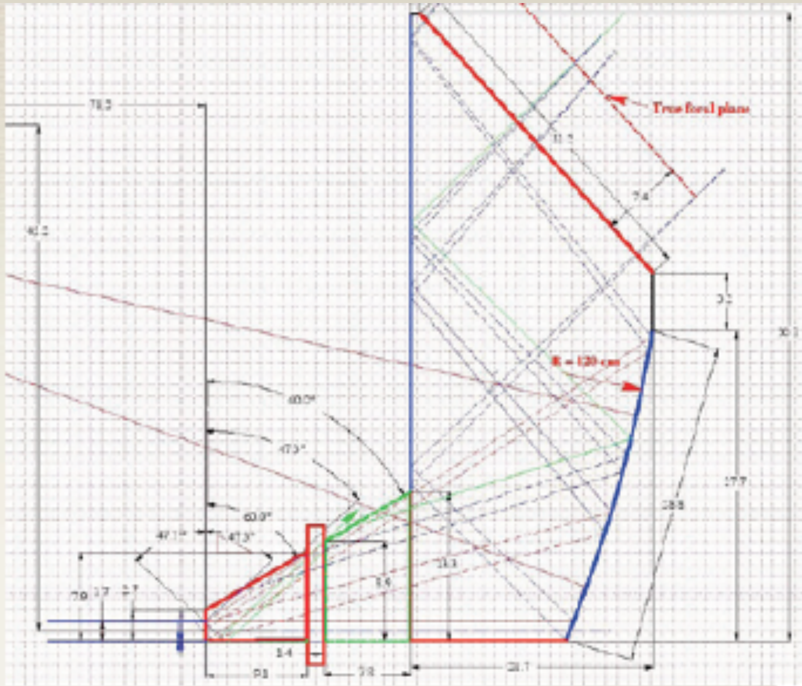
- Scelta da ottimizzare con gli studi sul background

Particle IDentification

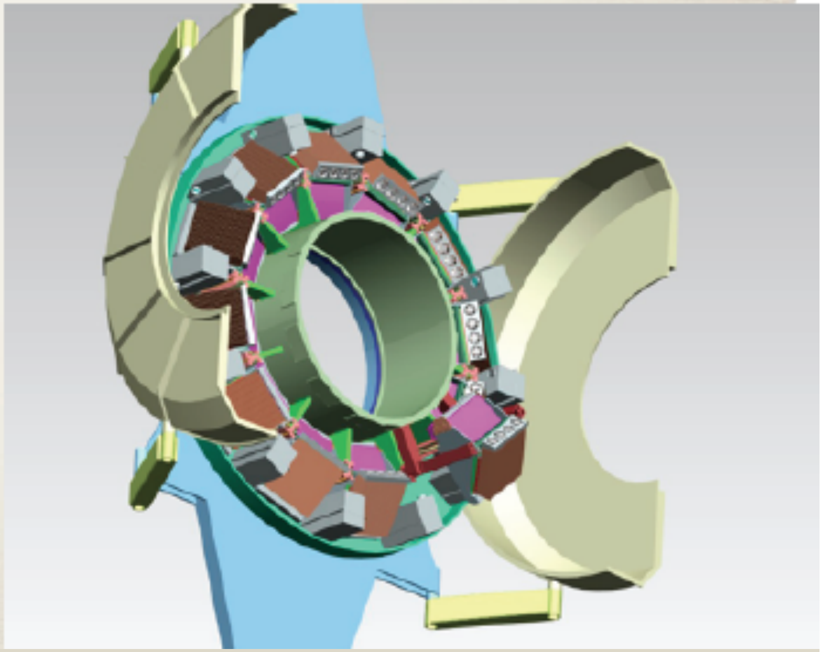
- Barrel: Focusing DIRC
  - Sistema basato sul DIRC di BaBar
  - Riutilizzo barre di quarzo
  - Disegno nuovo Stand Off Box
  - Istituzioni coinvolte
    - SLAC: progetto generale
    - Cincinnati, Maryland: simulazioni
    - Univ. Hawaii: elettronica
    - LAL: elettronica
    - Padova: meccanica SOB, meccanica test
    - Bari: photon detector, test prototipo
- Forward: tre ipotesi in esame
  - FARICH (Budker): focusing aerogel RICH
  - DIRC-like TOF (SLAC, LAL): TOF con barre di quarzo
  - Pixelated TOF (SLAC, Padova)



FDIRC



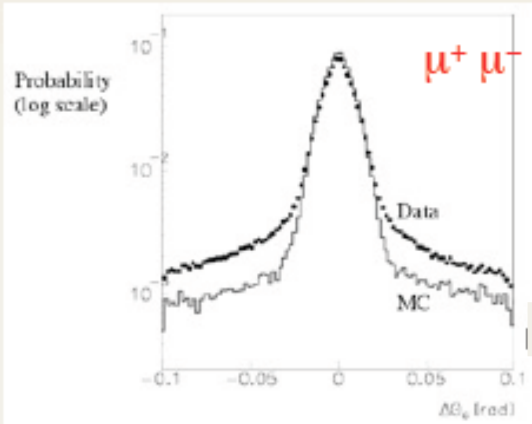
- Blocco di quarzo e specchio cilindrico
- MAPMT come photon detector
- Test di un prototipo FDIRC nel 2011 con i cosmici a SLAC
- Partecipazione italiana per il TDR e per il test con i cosmici:
  - Padova:
    - Progettazione e costruzione della meccanica
  - Bari:
    - Test dei MAPMT
    - Studio dell'elettronica di readout



Barrel PID

- **FBLOCK** [SLAC]
  - Raw block has been produced by Corning and is ready to be shipped.
  - Had to make a new quote request for the FBLOCK machining operation because a buyer made a silly mistake in the first round. The search has 10 companies involved.

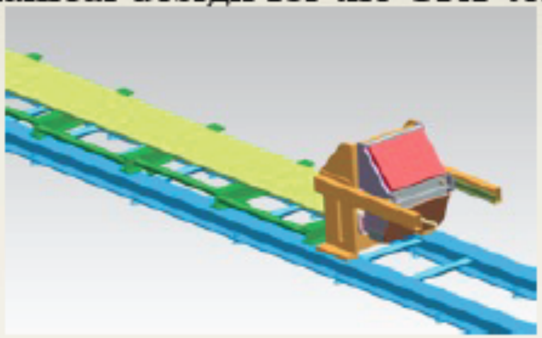
- **FDIRC prototype studies in CRT** [SLAC]
  - FDIRC prototype is now being used to study Cherenkov ring resolution & its tails.
  - BaBar DIRC:

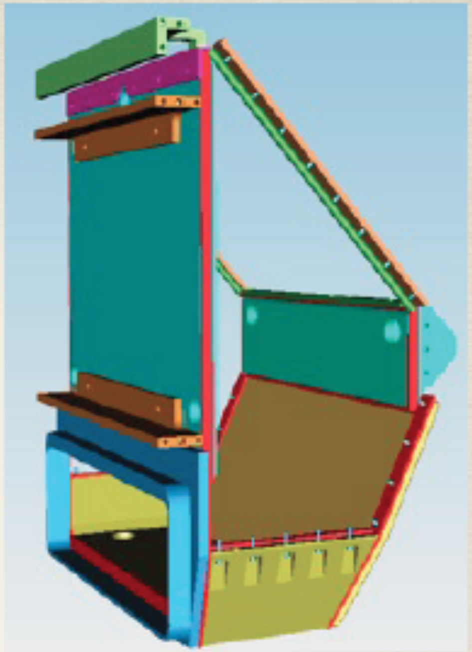


- **Bar boxes removed from BaBar** [SLAC + LAL + Saclay]
  - And safely stored. Bars look good to visual inspection.
  - Some PMT studies performed.

Barrel PID

- **Mechanics** [Padova + SLAC]
  - Ongoing work on the mechanical design for the CRT test.





- **MaPMTs** [Maryland + SLAC]
  - Modified SLAC PC board for MaPMT amplifiers ready.

- **Electronics** [LAL-Orsay + LPNHE-Paris]
  - Front-end chip architecture still being discussed

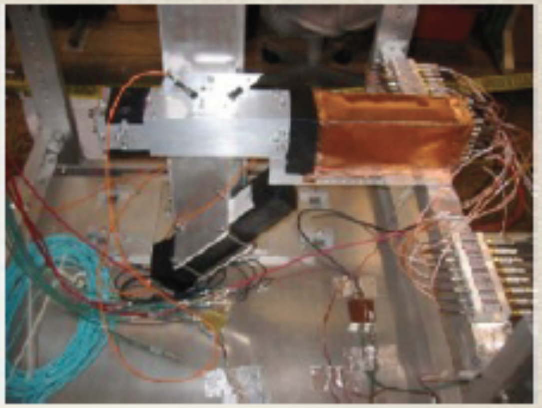
  → Need to match the background requirements and the TDC readout
  - SCAT (100 ps TDC) architecture completely defined (behavioral simulations done)

  → Layout of the chip from part almost done; readout design ongoing

- **Background** [SLAC]
  - Simple rate estimates updated after a recent visit to Belle-II collaboration meeting.

Forward PID

- **FARICH** [Novosibirsk]
  - Test beam in progress

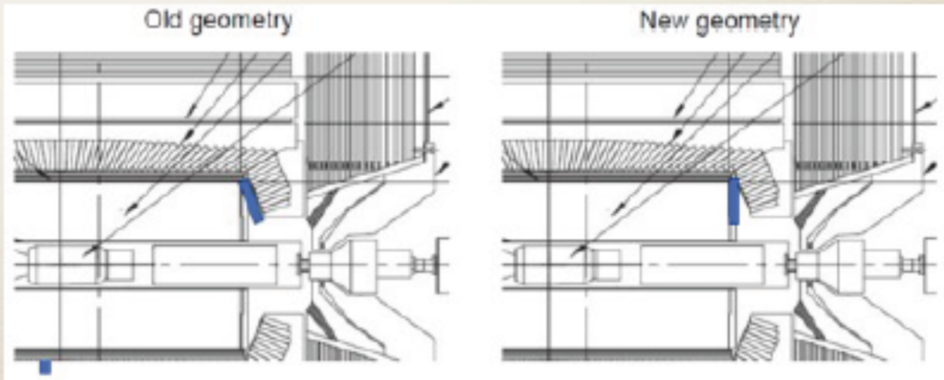


- **DIRC-like TOF** [LAL-Orsay + SLAC]
  - Large data sample collected in CRT telescope.
  - Analysis in progress

- **A simple pixilated TOF using a LYSO crystal** [SLAC]
  - Caltech provided a full size LYSO crystal. SLAC prepared a detector setup.
  - The prototype with **4x4 G-APD array** readout is now being tested in CRT.
  - More simple version with **single 3mm x 3mm G-APD** will be tested in January.
  - Data taking in progress.

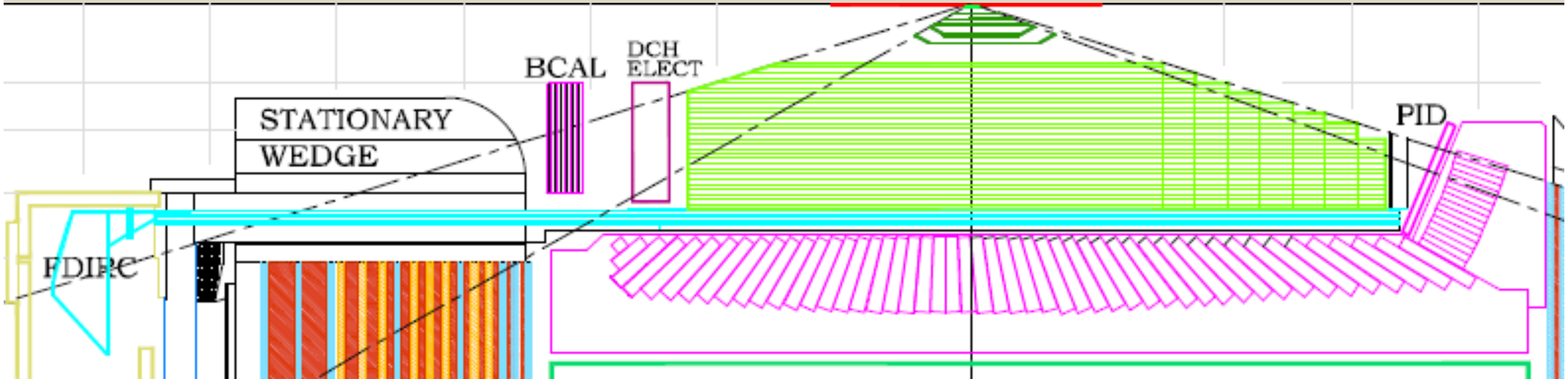
- **Electronics** [LAL-Orsay]
  - Ongoing work on ASICS and system sides
  - Design of a 16 channel board

→ One step further towards a demonstration that 10 ps precision can be achieved with 100+ channels



EMC

- Barrel: CsI(Tl) crystals read by Pin Diodes
  - reusing BaBar
  - optimization of readout needed
- Forward: baseline option LYSO with APDs
  - fast and with high LY
  - expensive, discussing alternatives
- Backward: lead+scintillator (groove geometry)
  - cost-benefit discussion ongoing

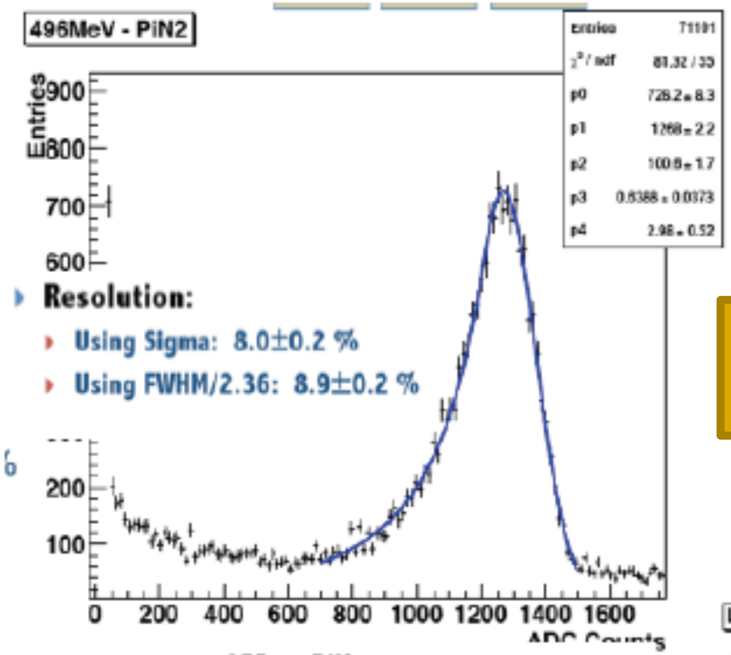


Bergen, CalTech, Perugia, Roma1, Roma3

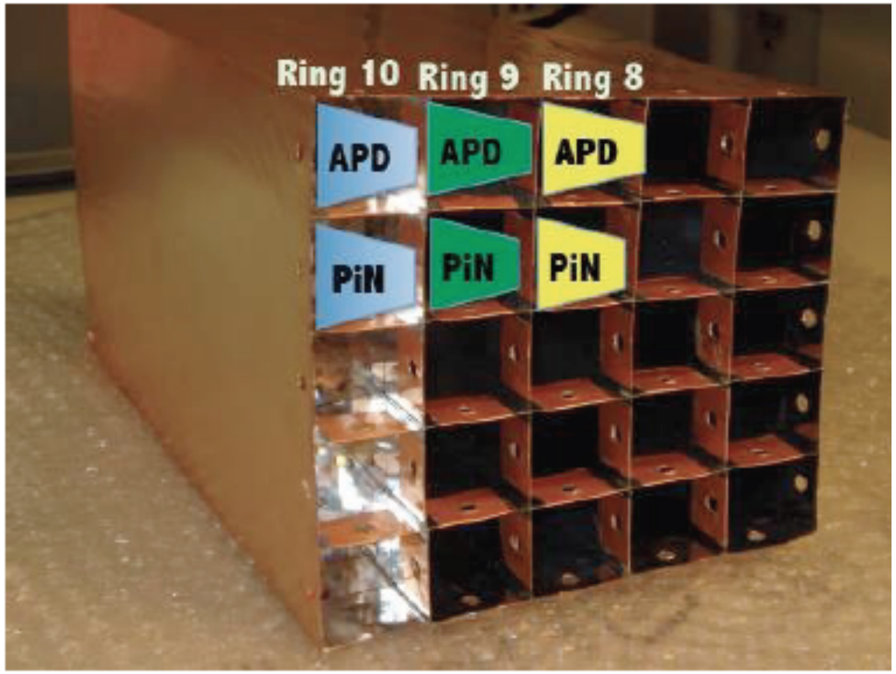
Ongoing activities

- Design of electronics / trigger --> See talk from Valerio
- 25 crystals LYSO prototype
  - Test Beams for electronics and crystals → See talk from Davide
- Mechanical design

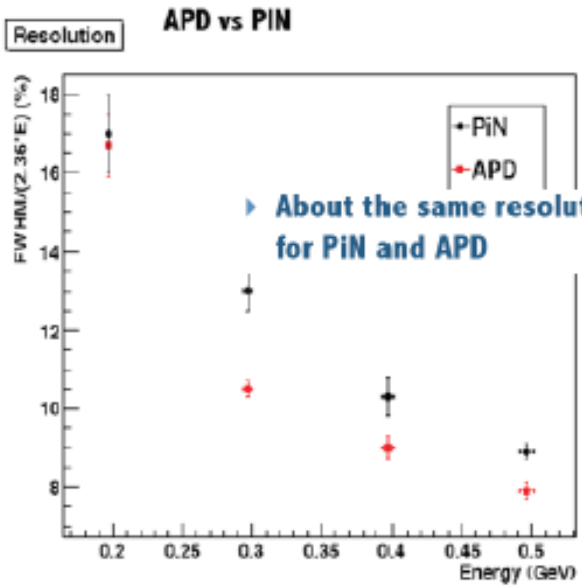
Test alla BTF
21-25 Giugno



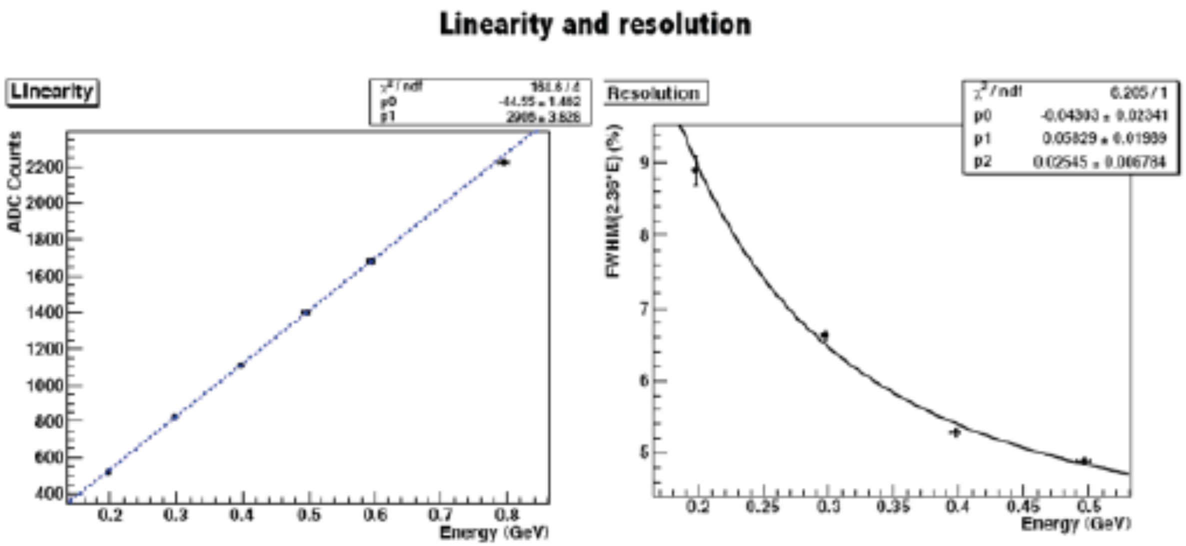
- **Resolution:**
  - **Using Sigma: 8.0±0.2 %**
  - **Using FWHM/2.36: 8.9±0.2 %**



6 crystals only



- **About the same resolution for PiN and APD**



EMC: Test Beam at CERN October 11th – 31st

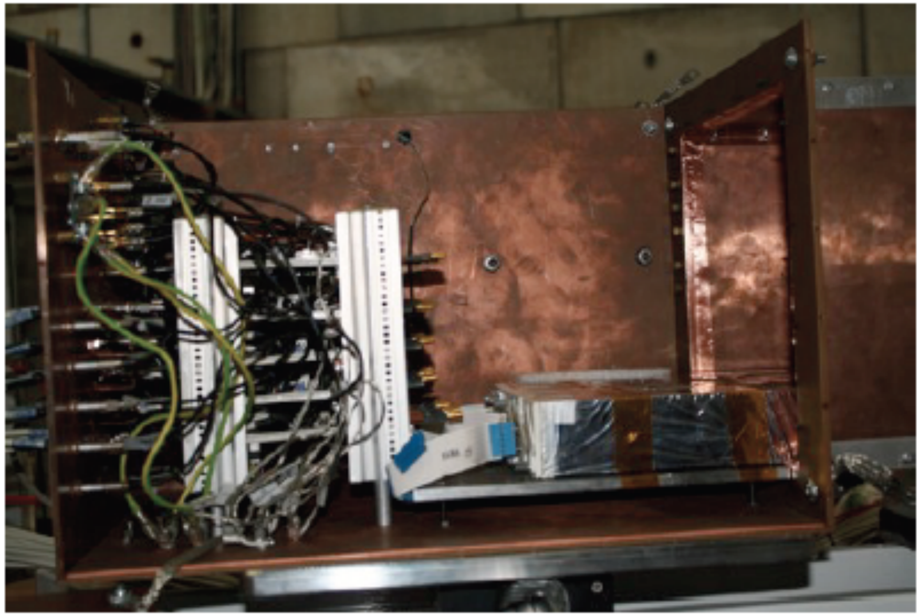
SETUP

20 APD + 5 PD

	Ring 6	Ring 7	Ring 8	Ring 9	Ring 10
Shaper 0 PIN	Sipat 13	Sipat 7-4	Sipat 12	SG X	SG X
Shaper 1 APD	Sipat 14	Sipat 7-3	SG 005-3	SG X	SG X
Shaper 2 APD	Sipat 17	Sipat 18	Sipat 11	SG X	SG X
Shaper 3 APD	Sipat 15	Sipat 19	SG 005-4	SG X	SG X
Shaper 4 APD	Sipat 16	Sipat 7-5	Sipat L9	SG X	SG X

	Temperature 1
	Temperature 2
	Temperature 3
	Temperature 4
	Temperature 5

	Ring 6	Ring 7	Ring 8	Ring 9	Ring 10
Shaper 0 PIN	Ch5	Ch4	Ch3	Ch2	Ch1
Shaper 1 APD	Ch10	Ch9	Ch8	Ch7	Ch6
Shaper 2 APD	Ch15	Ch14	Ch13	Ch12	Ch11
Shaper 3 APD	Ch20	Ch19	Ch18	Ch17	Ch16
Shaper 4 APD	Ch25	Ch24	Ch23	Ch22	Ch21



Data collected at energies of:

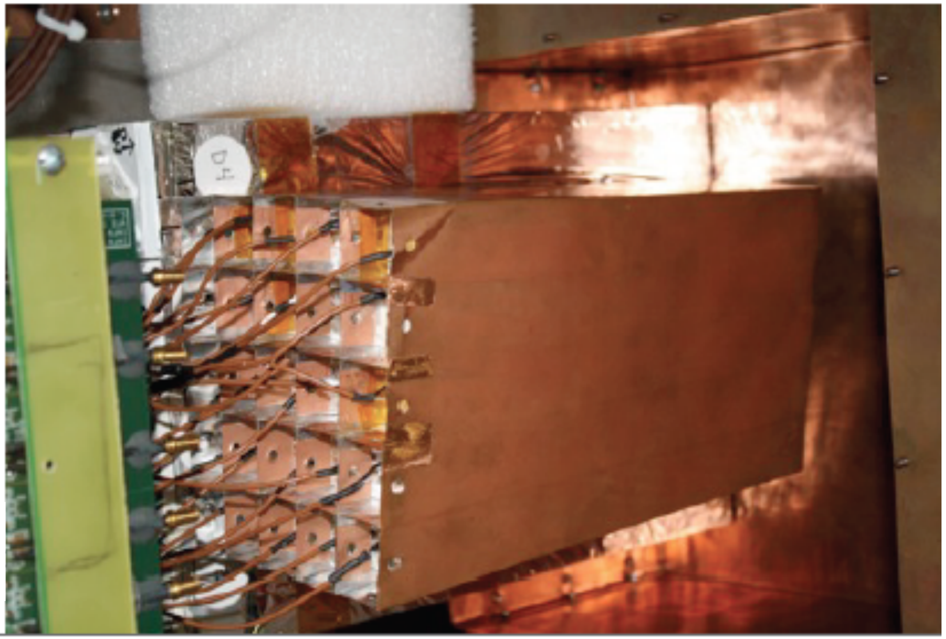
1GeV : ~ 95000 - 64% e-

1.5GeV: ~ 20000 - 60% e-

2GeV: ~ 40000 - 48% e-

3GeV: ~9500 - 30% e-

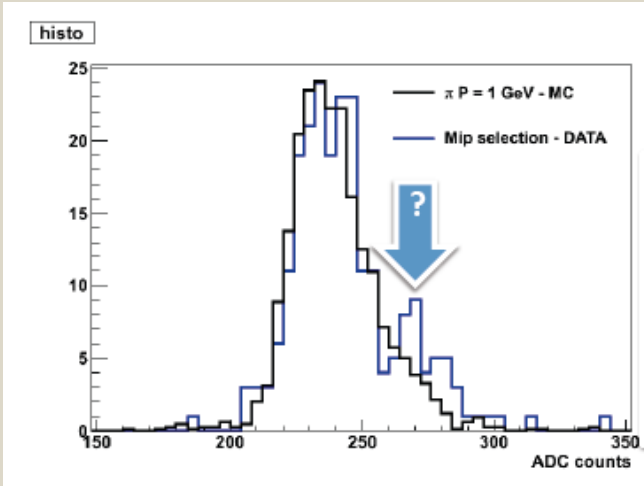
4GeV: ~ 650 - 25% e-

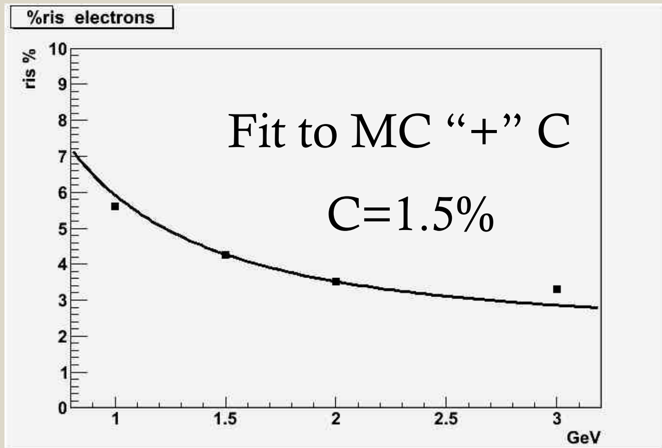


Test Beam results

- Good data-MC agreement on MIPS
- HV and temperature stability under control
- Electronic noise ~7mV → need to increase shaping time
- Resolution missing a ~2% effect (beam resolution?)

➔ Need to redo test at BTF with same setup as CERN





EMC: future activities

- Non-satisfactory LYSO performances at TB: due to beam quality? New test at BTF in May
- Decision on crystal choice (FWD)
- Decision on readout device (APD?) and electronics
- Trigger primitives
- Optimize the Barrel electronics to match new environment

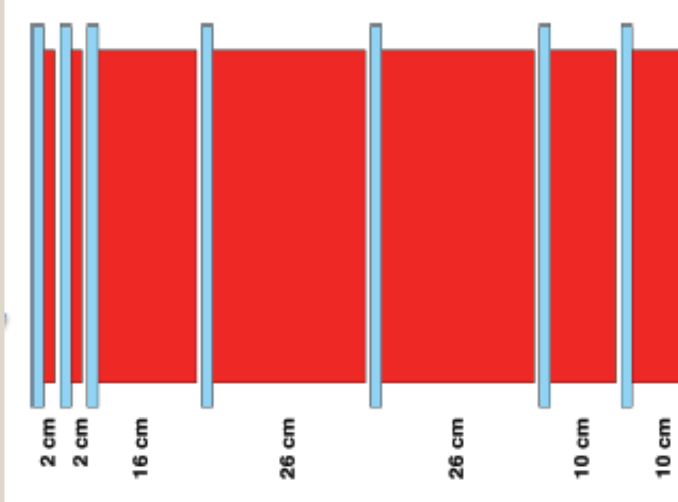
IFR

- Instrument the flux return of the magnet to identify muons

- Reuse iron and magnetic coil from BaBar, but:
  - reoptimize the number and position of active layers after BaBar's experience
    - 8 layers instead of 21
  - Extruded scintillators instead

of RPC/LST

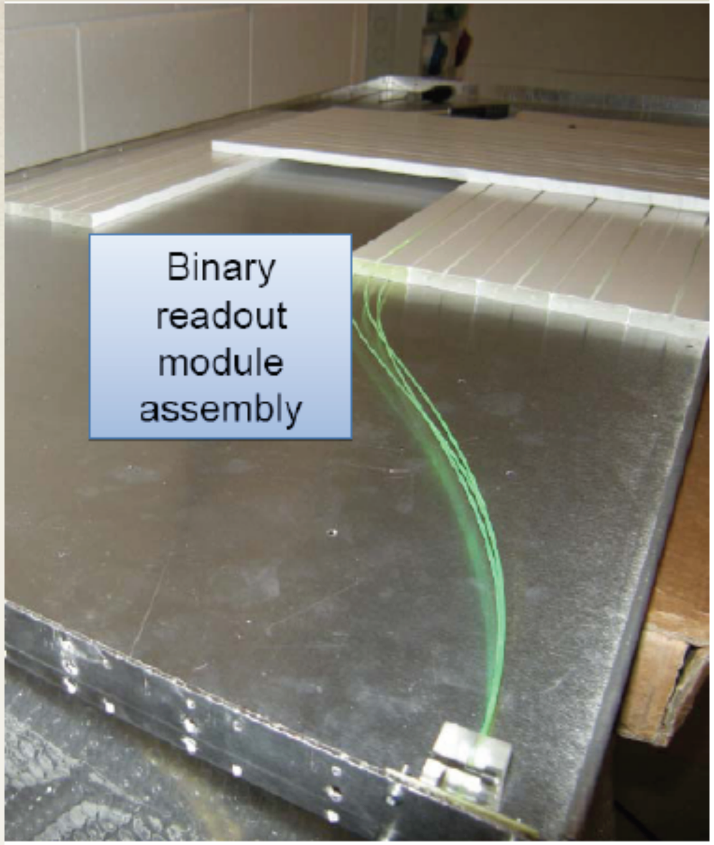
- costs/efficiency balance

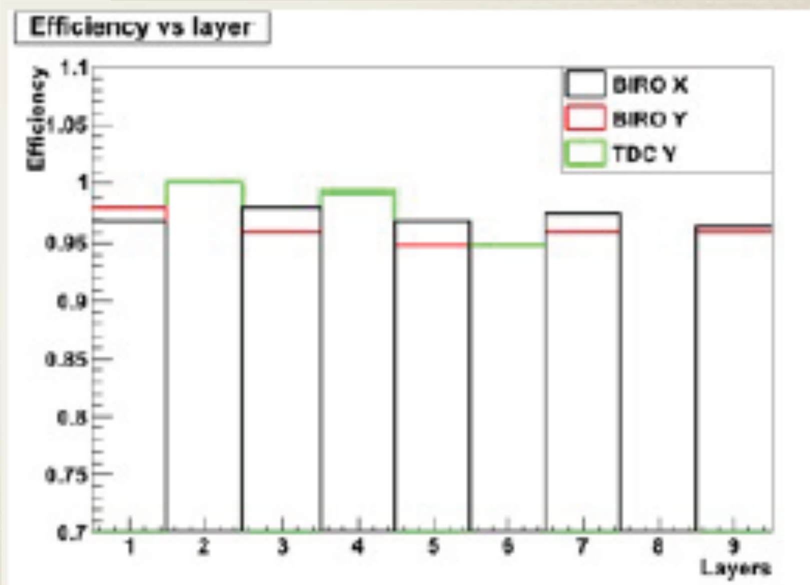


Ferrara, Padova

IFR Beam Test

- All needed SiPM received and characterized
- Prototype completed, tested with cosmic and shipped to FNAL
- Prototype tested (1-7 Dec 2010) at Fermilab Meson Area
- Energy vary from 0.5 to 5 GeV.
- 9 layer configuration tested with different readout schemes
- (5 BiRO layers and 4 TDC layers)





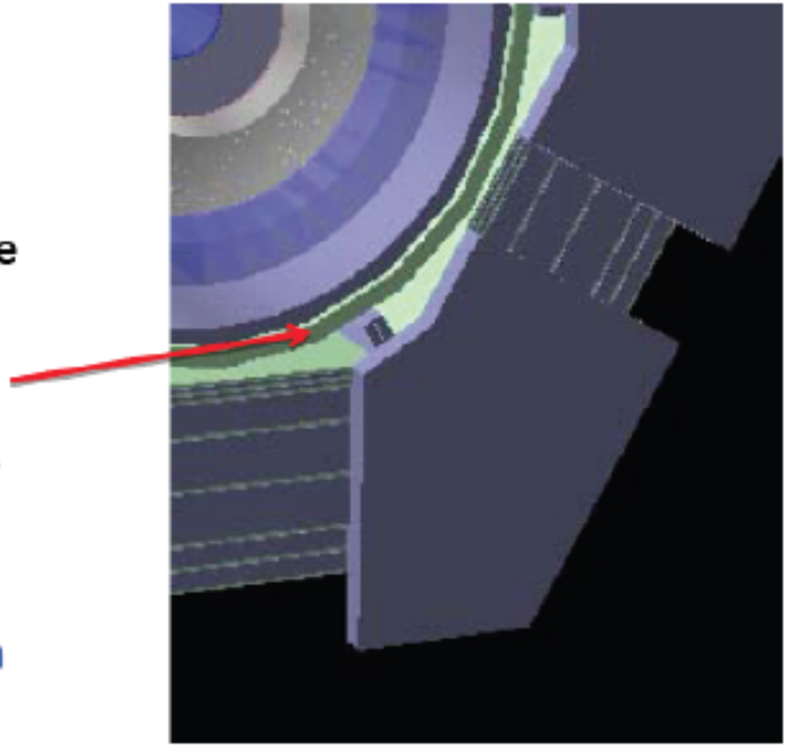
Background studies

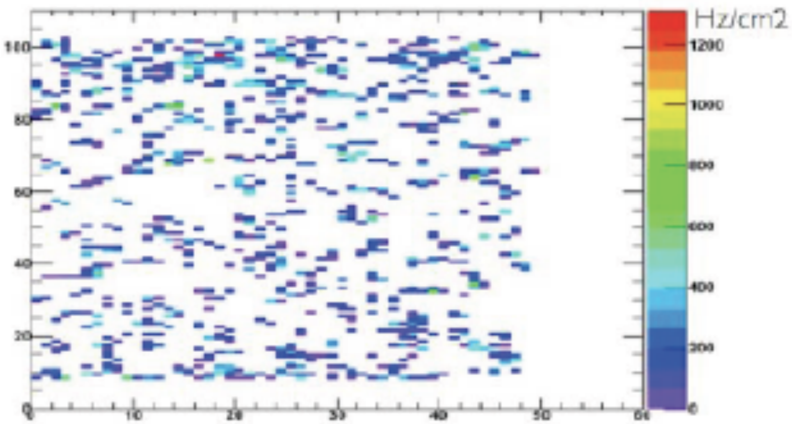
Neutron background is the main concern for SiPM damage.
The present rate is too high for SiPM life.

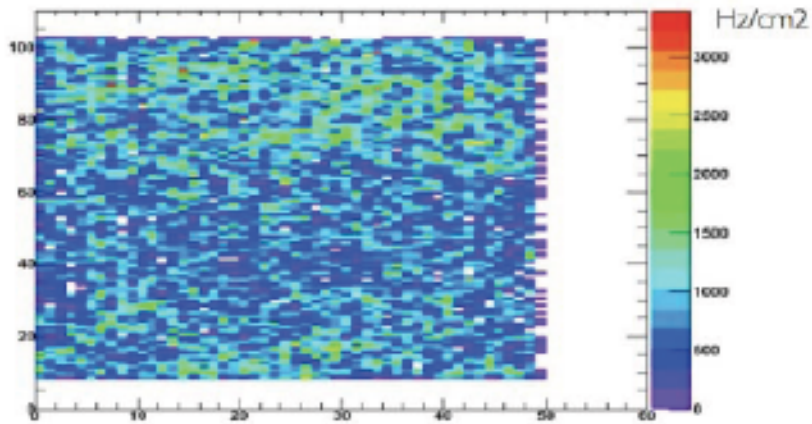
A polyethylene shield has been inserted between the solenoid magnet and the barrel to study possible reduction.

Preliminary results show a reduction of one order of magnitude with 10cm of shielding.

Promising, but need more study and more reduction

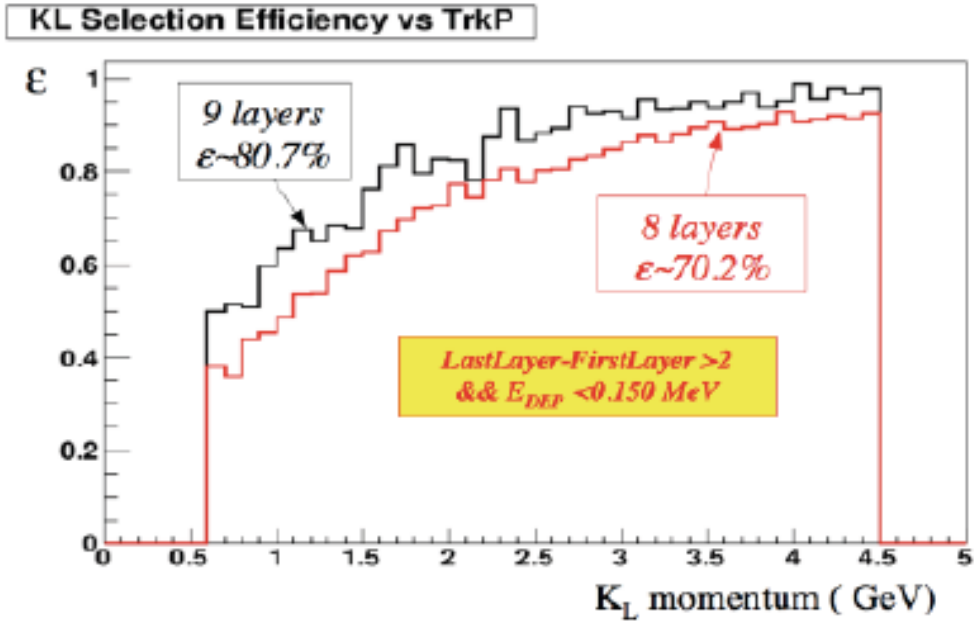






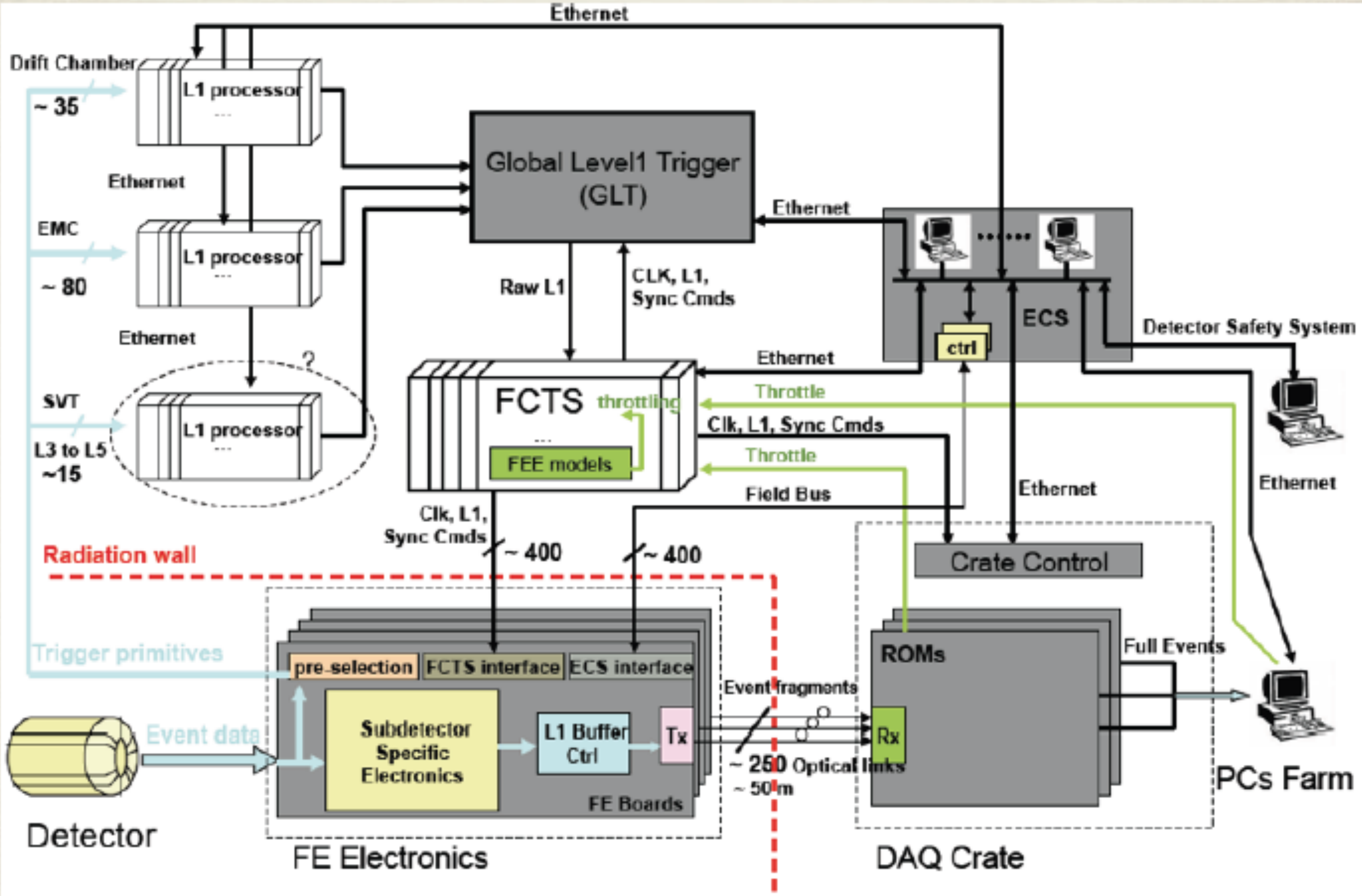
First look at K_L identification

-Simulated 110k of single K_L using baseline configuration and 10k using a 9 layers configurations;
-Momentum: range from 0.6 GeV/c to 4.5 GeV/c
-Distinguish K_L interacting in the EMC from K_L interacting in the IFR volume
-Use the energy deposited in the EMC to distinguish these K_L categories



Performed a Very Loose K_L selector to compare configuration with 8 and 9 active layers → Configuration with 9 layer gives better K_L efficiency
-Need to simulate background samples to have meaningful results, but it's a good start

Electronics, Trigger, DAQ/Online



SLAC, Caltech, Napoli, Bologna, LAL, Padova, Roma3, Roma 1

Architettura

- Sistema sincrono, con latenza costante.
- Trasferimento dati dal Front-end al Readout solo in caso di trigger.
  - Frequenza di trigger attesa dell'ordine di 150 kHz.
  - Event size 100 kB, ~ 500 kB per l'evento RAW.
- Trigger di attività del rivelatore, basato su segnali del calorimetro e Drift Chamber.
  - Latenza fissata a 6 μs.
  - Richiesta di tempo morto inferiore all'1% (<70 ns).

- Elementi principali
  - Link ottici:
    - Per la trasmissione del clock e dei comandi.
      - link con tempo di connessione deterministico.
    - Per la trasmissione dati.
  - Schede di read out (ROM).
  - Sistema di trigger.
  - Sistema di controllo e configurazione
  -

Dettagli nel talk di Valerio

Computing

* Calcolo distribuito su GRID
* Calcolo parallelo per Lattice QCD
* Network dati locale e geografico alta velocità
* Sviluppo di tecnologie software per lo sfruttamento di architetture CPU a elevato numero di core computazionali
* Sistemi di accesso ai dati ad elevatissime prestazioni basati sull'impiego di cache a stato solido
* Impiego di tecnologie di virtualizzazione per l'uso condiviso di risorse di calcolo distribuite (cloud computing)
* Tecnologie di progetto di centri di calcolo a bassissimo impatto ambientale

Padova, Ferrara, Torino, Bologna, Rome2, Pisa, Perugia, LNF, LBNL, Napoli, SLAC

Opzioni sul rivelatore

6 Layer SVT	LO Striplets @ 1.6cm if background is acceptable as default. MAPS Option. Retain 5 Layer outer detector.
SVT – DCH transition radius	~> than 20 cm determined by beam element cryostats to allow easy installation
Backward EMC	Inexpensive Veto device bringing 8-10% sensitivity improvements for $B \rightarrow \tau \nu$. Low momentum PID via TOF? Technical Issues?
Forward PID	Physics gains about 5% in $B \rightarrow K(*)\nu\nu$. Somewhat larger gains for higher multiplicities Open technical options/interactions with EMC
Absorber in IFR	Optimized layout. Plan to reuse yoke. Still need to resolve engineering questions.

Geometry Selection Task Force

Decision mid 2011

Bill Wisniewsky

Hassan Jawahery

R&D and Engineeering Summary

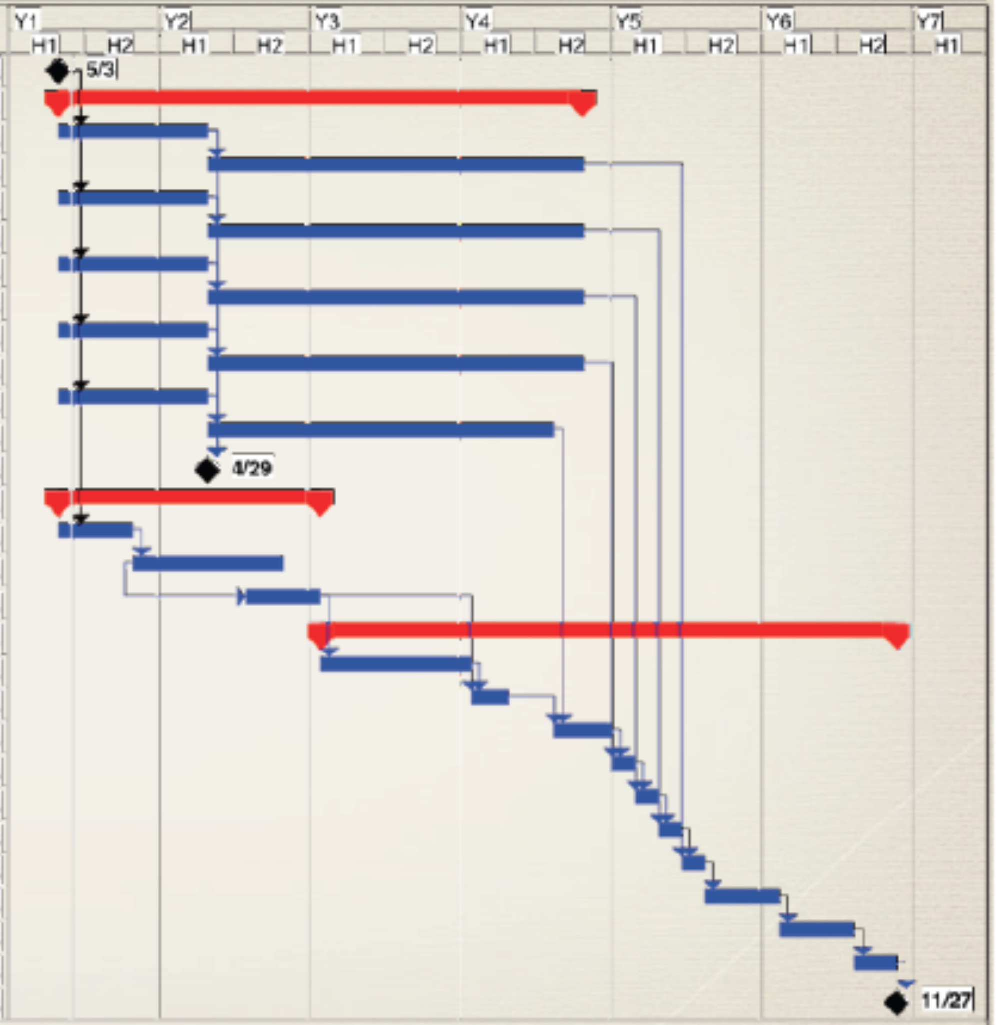
Sys	R&D	Engineering
SVT	Layer 0 thin pixels Low mass mechanical support	Silicon strip layers Readout architecture
DCH	High speed waveform digitizing Cluster counting	CF mechanical structure Gas speed, cell size
Barrel PID	Photon detection for quartz bars	Standoff box replacement
Forw PID	Time of flight option Focusing RICH option	Mechanical integration. Electronics
EMC	LYSO characterization Light detection, Other crystals Prototype Module Test	Readout electronics Forward EMC mechanical support
IFR	SiPM performance Prototype Module Test	Location of photo-detectors Absorber thickness definition
ETD	High speed data link Radiation hard devices	Trigger strategy Bhabha rejection

Documenti

* The Discovery Potential of a Super B Factory
  Slac-R-709
* Physics at Super B Factory: hep-ex/0406071
* SuperB report: hep-ex/0512235
* SuperB Conceptual Design Report
  arxiv.org/abs/0709.0451
* New Physics at the Super Flavor Factory
  arxiv.org/abs/0810.1312
* Detector Progress Report: arxiv.org/abs/1007.4241
* Physics Progress Report: arxiv.org/abs/1008.1541
* Accelerator Progress Report: arxiv.org/abs/1009.6178
* See http://web.infn.it/superb/

Detector Schedule Piano Triennale

ID	Task Name	Duration
1	Approval	0 wks
2	**Detector Design & Construction**	182 wks
3	Design SVT	52 wks
4	Construct SVT	130 wks
5	Design DCH	52 wks
6	Construct DCH	130 wks
7	Design PID	52 wks
8	Construct PID	130 wks
9	Design forward EMC	52 wks
10	Construct forward EMC	130 wks
11	Design IFR	52 wks
12	Construct IFR	120 wks
13	Detector Technical Design Report	0 wks
14	**Dismantle & Move Babar**	91 wks
15	Design Tooling	26 wks
16	Dismantle Babar	52 wks
17	Component transportation	26 wks
18	**Detector Installation & Commissioning**	200 wks
19	Installation steel	52 wks
20	Installation magnet	13 wks
21	Installation IFR	20 wks
22	Installation EMC	8 wks
23	Installation PID	8 wks
24	Installation DCH	8 wks
25	Installation SVT	8 wks
26	Commissioning	26 wks
27	Cosmic Ray test	26 wks
28	Commissioning on beam	15 wks
29	**Detector ready for collision**	0 wks



Project: SBF_schedule_v1.2
Date: Fri 6/4/10

Task | Split | Milestone | Summary | External Tasks | External Milestone

Outlook

- R&D before construction still ongoing
  - expanding collaboration: lots of opportunities for involvement
- May 28 - June 2: Foundation Collaboration Meeting:
  - site decision should have been taken
- Technical Design Report to be written (at 90%) by end of the year
  - hottest point in annex
- Physics book within 2013
- 2012: first construction year