SuperB Detector Status

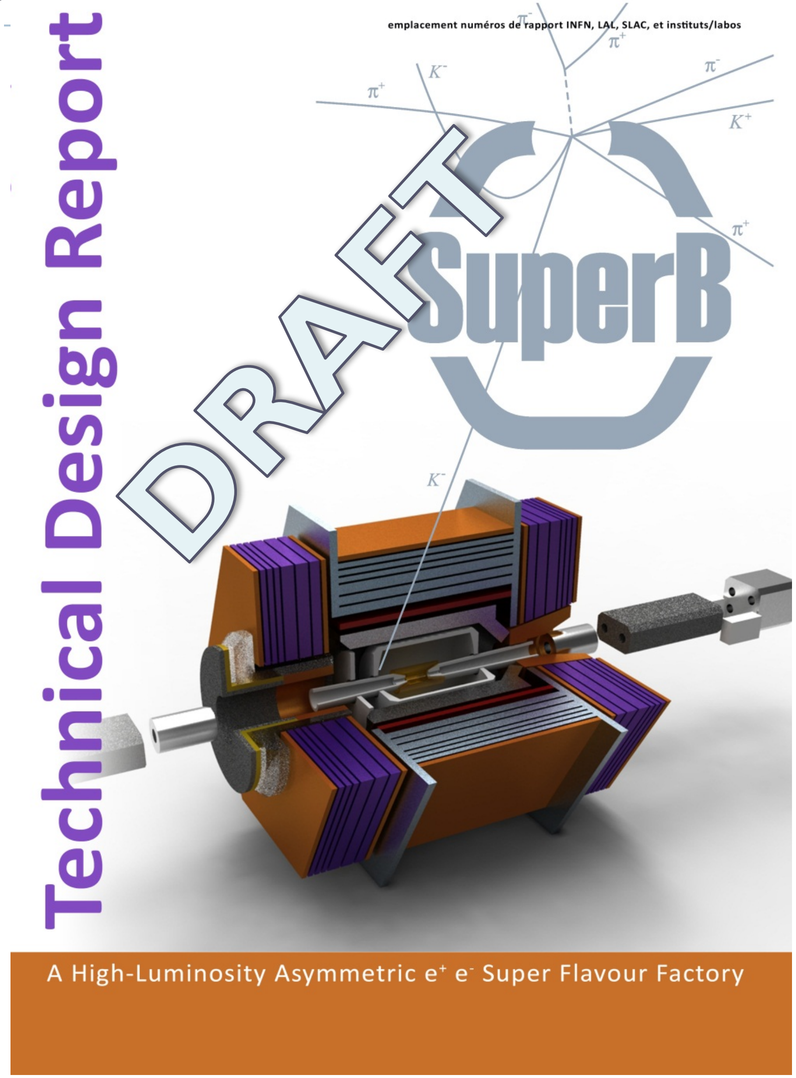
F.Forti, INFN and University, Pisa

Outline

- SuperB Detector Status
  - TDR
  - Subsystem progress
- Super TauCharm Detector Issue
  - List of detector issue for a TauCharm machine
- Conclusions

Technical Design Report

- The SuperB Detector TDR is nearly ready
  - We had planned to have copies distributed today, but we didn't quite get there.
- About 500 pages
- Fixing last typos and figures
  - Completed in a few weeks
- Authors
  - Input has been requested from institutions and systems
  - Final list will be distributed soon: please check and react rapidly !
- Current version available in alfresco repository.
  - There will be circulation to the entire collaboration before publication



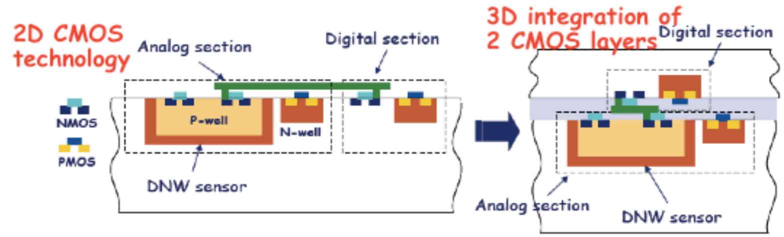
Subsystems

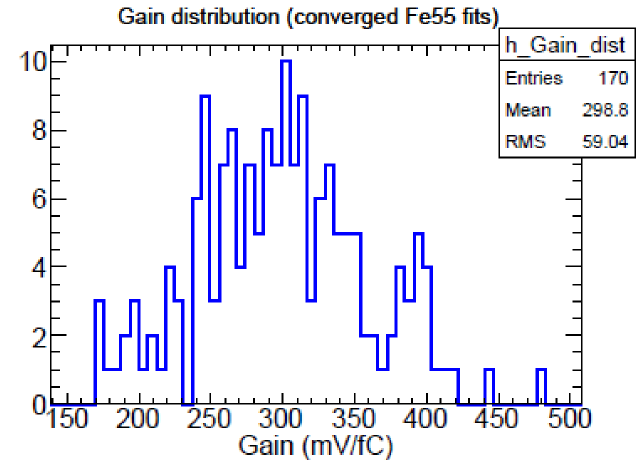
- Al subsystems have been focused on the TDR writing
- Lots of ongoing activities for conclusion of R&D in the subsystems
- Several beam tests
  - SVT – test of CMOS MAPS @ CERN
  - DCH – test of full length prototype @ TRIUMF
  - PID – Cosmic Ray Test of FDIRC prototype @ SLAC
  - EMC – Study of pure CsI @ LNF
  - IFR – Beam test of prototype @ FNAL & GELINA

SVT – Update on CMOS MAPS R&D

- After a long delay, 3D MAPS (2 CMOS layers) received and tested:
  - ✓ 8x32 digital matrix works as expected
  - ✓ Low noise ENC= 40e- & low threshold dispersion ~ 2xNoise
  - ✓ Good S/N = 25
  - ➢ Gain dispersion definitely too large

    ~ 20%, not acceptable to operate the chip with a single threshold; analog design already improved for next submission (~ April 2013)
  - ➢ Dead pixels < 1 % on 2 chips tested, 10% in the third one. Still due to bad interconnections between 2 CMOS layers?

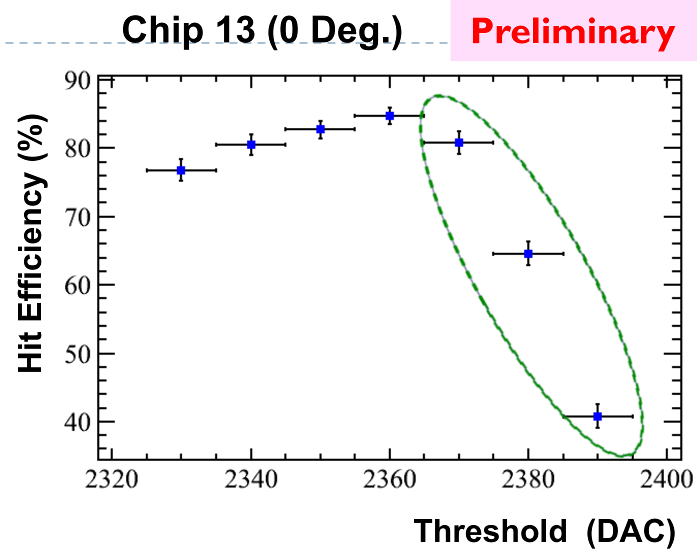


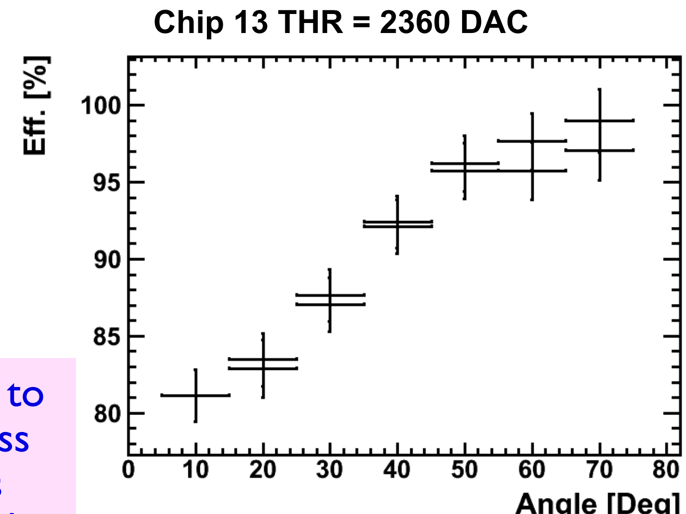


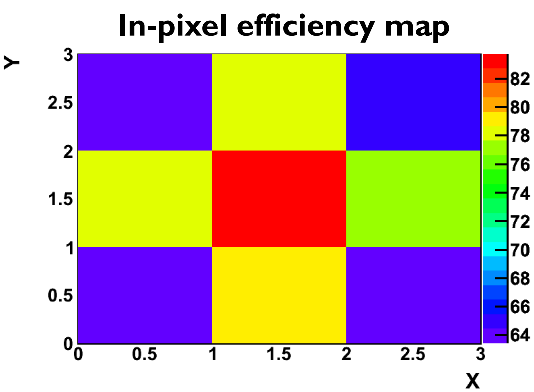
SVT – Update on CMOS MAPS R&D

Preliminary INMAPS results from testbeam @ CERN (Mid Nov.)

1. Hit Efficiency vs threshold for 32x32 digital matrix:
   - max hit effi only ~ 85% & drop of efficiency measured at lower thr: probably due to some "induction" effects discovered during data taking & now under investigation:
     - pixel might become inefficient on track if it fired already before on some induced signal.
2. In MAPS (only 12 um active thickness and 50 um pitch) increasing the track angle can boost the charge released per pixel & hit efficiency → Measured efficiency > 98% with large incidence angle.
3. Study of the efficiency map inside the pixel cell ongoing (not uniform!) to improve the collecting electrodes design.



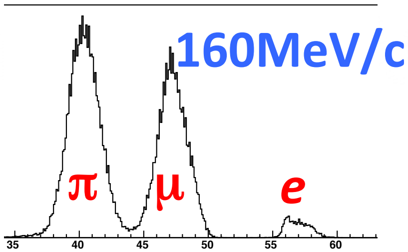


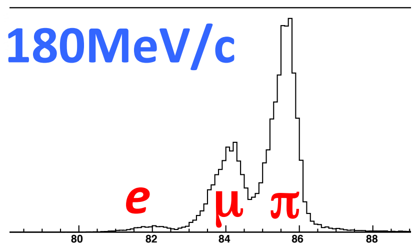


Data from 3x3 analog matrix, still to be analyzed, are an important cross check, since no digital induction is present there and lower threshold could be set.

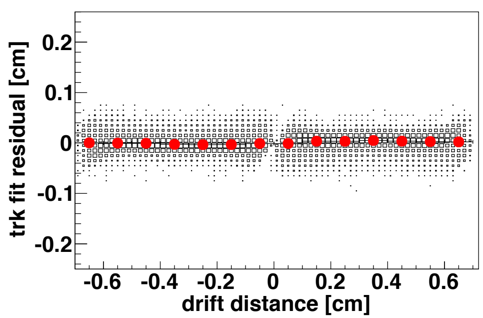
Test of the full-length 28 channels prototype on the M11 Beam at TRIUMF

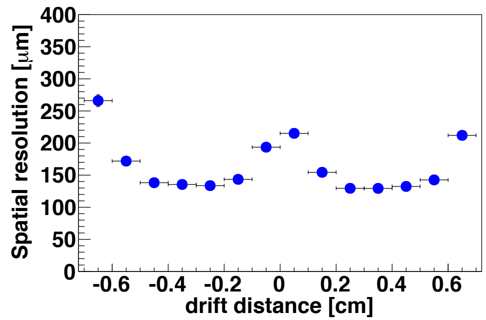
- Nov 22nd – Dec 3rd
- Good external particle separation from TOF system for momenta up to 160MeV/c, not as good above





- First results on spatial resolution in *90%He-10%i*C_4H_{10}

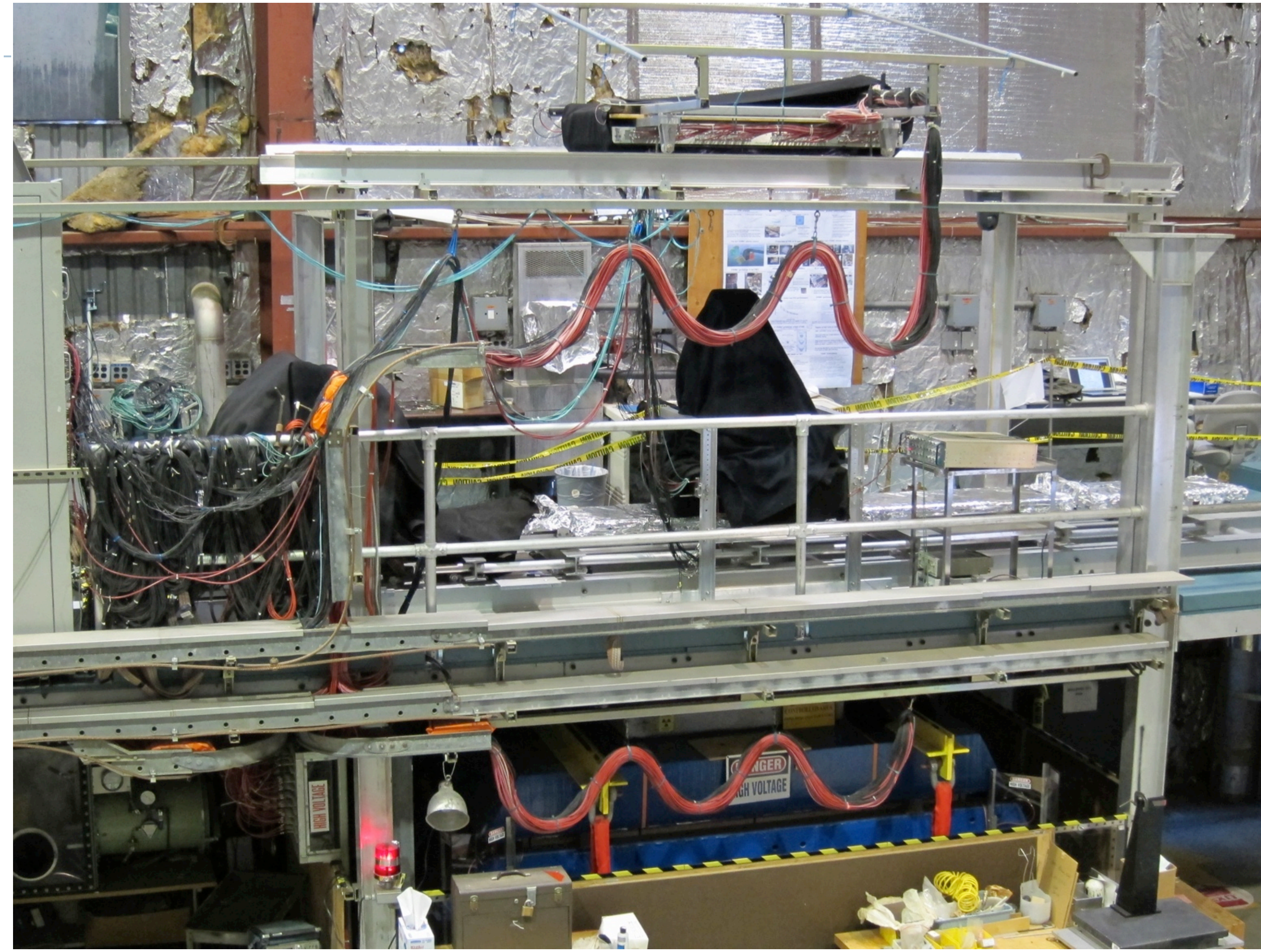




- dE/dx & cluster counting analysis in progress
  - including counting clusters in a limited set of cells using "analogic derivative"

- Several million triggers collected at different:
  - momenta (120÷210MeV/c)
  - HV settings
  - *z* positions
  - DIP angles (0º-10º-30º-40º)
  - ϕ angle 0,±22º
- and another, faster gas mixture
  - *(80%He-7%i*C_4H_{10}*-13%i*CH_4*)*

FDIRC prototype in CRT



The FDIRC prototype in CRT, taking data.

Status

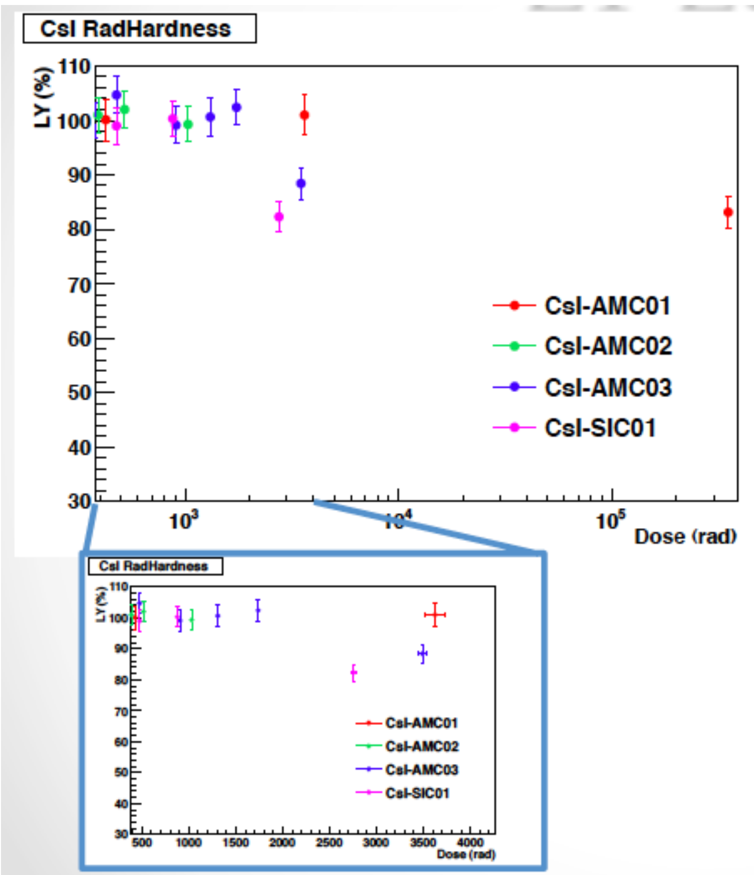
- The prototype is finally taking data after a long period of debugging of Hawaii IRS-2 electronics, and other issues.
- System has now 8 H-8500 instrumented tubes; expect to add 4 more tubes by the end of this year. This will complete the system for total of 768 pixels.
- A clear progress in MC studies. Have now two independent verifications of pixel constants.
- There is also a progress in the data analysis. Big effort as we now have 12 bars to deal with, a full 3D tracking geometry. One analysis is well under way, two more are starting.
- Work on the Cherenkov angle resolution in progress. It is more complex than previous prototype as we have to deal with 4-10 ambiguities.
- We will also push a PDF-based PID analysis.
- People working on this: Kurtis Nishimura, Jerry Va'vra, Martino Borsato, Doug Roberts, Biplab Day and Matt Andrew (Hawaii tech.).
- Hope to make a major push in coming 3-4 months.

Plans for next year

- There is a discussion to add French electronics in spring.
- There was also a talk to add a TOP counter on top of FDIRC prototype. In this way we would compare FDIRC & TOP.
- SLAC will support this R&D project “nominally” until September 2013.

EMC STATUS

R&D on LYSO is completed discuss one or more publications in the parallel session
We may add information from a BT@BTF in 2013 with SiPM readout (in collaboration with people from Insubria University)



Expected dose at SuperB 350Krad/year
(3 Krad 10 years)
Less than 20% loss at the end of the experiment.

R&D will continue in 2013 with a test beam on a pure CsI matrix of 25 crystals at the BTF

IFR Activities Since the Sept. Pisa Meeting

- The main activity, since the last meeting, has been the completion of the TDR
- Analysis of the GELINA irradiation test data is ongoing, to study in particular the annealing effect after ~ 4 months since the data taking (FE + Krakow)
- More simulations of Scintillator-WLS-SiPM and comparison with cosmic data has been done (BO)

Activities to be completed:

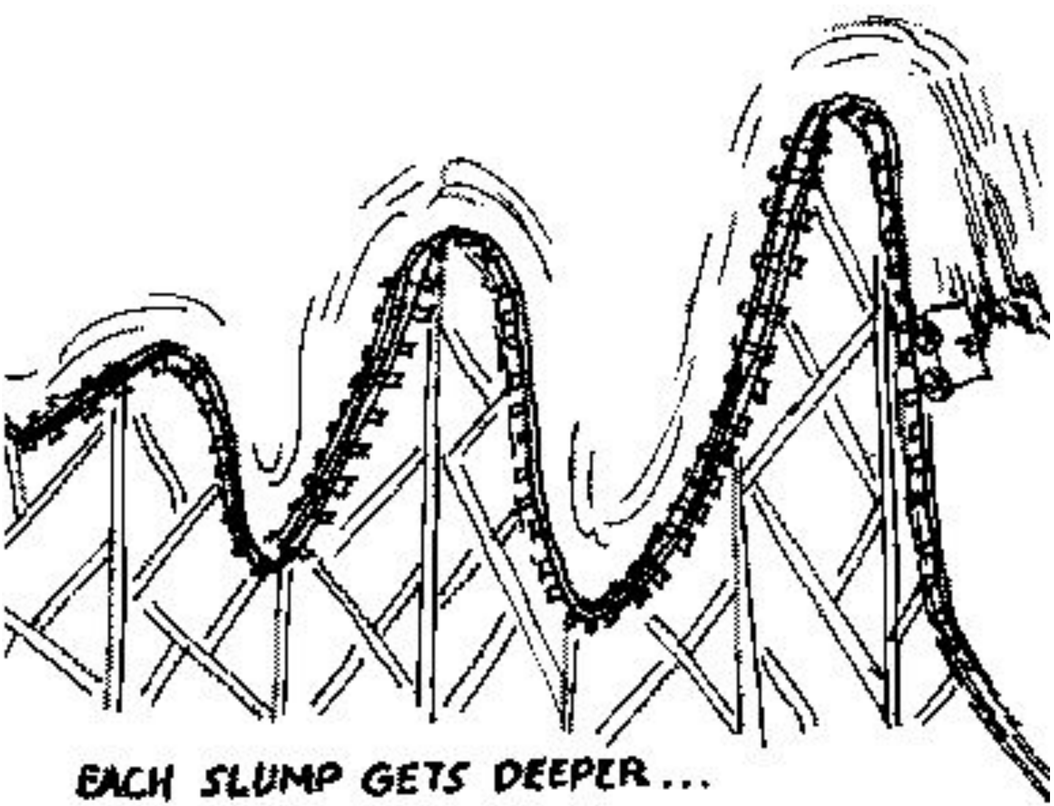
- Irradiation test data analysis
- Test to complete the SiPMs irradiation program (high energy neutrons)…

ETD

- Within the last months, ETD activities have been concentrated on the TDR writing
  - Except editorial details (agreed yesterday at the TB), the two chapters are complete
  - All subdetectors have updated their budget (SVT still needs to do it on Smartsheet)
  - There was less motivation for the schedule …
- We are now waiting for the new numbers linked to the new machine and detector to adapt our design
- ETD/Online is completely driven by backgrounds, rates in the subdetectors and radiation levels
  - ETD architecture is very flexible
  - Changes should however be very limited
- The ETD design rules document (section 12.A from the TDR) is the best basis for updating the important numbers
  - We'll be able to give rapid answers about the adpatation of the design as soon as this document will have been updated

SuperB Detector Conclusions

- Very good work done, finishing R&D
- On a rollercoaster for some time



Detector issues for TauCharm running

Outline

- Symmetry
- Hermeticity
- Magnetic field
- SVT
- DCH
- PID
- EMC
- IFR
- Electronics
- Trigger
- DAQ

- Working hypothesis
  - Start from SuperB Detector

- Disclaimer:
  - Mainly questions, no anwers
  - Not in-depth thought
  - Many things are obvious

- Some documents:
  - Cleo-C - CLNS 01/1742

    http://www.lns.cornell.edu/public/CLNS/2001/CLNS01-1742/cleocyb.pdf

  - BES-III:

    http://arxiv.org/abs/0809.1869v1

Changes from SuperB

- What changes in the events
  - Smaller backgrounds,
  - Softer particle spectrum
- What needs to be changed in the detector
  - Smaller magnetic field
  - Need to be lighter to retain momentum resolution
  - SVT may not be beneficial if symmetric machine
    - Even if asymmetric SVT design needs to be reoptimized
  - Need PID at smaller p. Also would like to have pi/mu separation at small momentum for $\tau \rightarrow \mu\gamma$ analysis

Symmetric or asymmetric machine ?

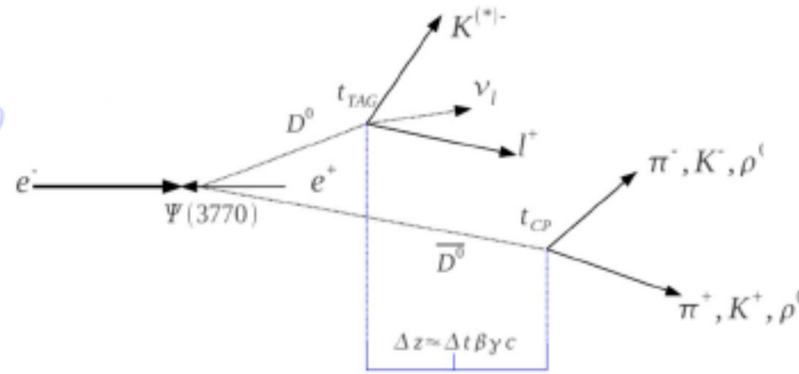
Item	Symmetric	Asymmetric
TD CPV in charm	NO	YES
Vertexing for background regjection	NO	YES
Hermeticity → Signal efficiency, invisibles veto	Better	Like Babar
Backgrounds	?	?
Machine cost	Cheaper	Expensive
Vertex detector	Probably no	Yes

- The choice of asymmetric or symmetric machine is one with major implications.
- Backgrounds could be significantly lower for a symmetric machine if final focus is shared and/or further away from IP
  - To be understood quantitatively

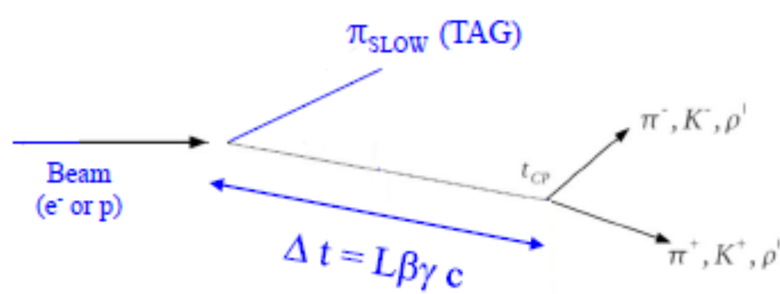
Asymmetric machine

Tagging

- At the $\psi(3770)$ can use a semi-leptonic decay on other side to ensure that "signal" is either D^0 or D^0.



- At $\Upsilon(4S)$ (e beam) or at LHCb (p beam) tag uses slow pion from D^* decay
  - This has inherent mis-tag probability ω~1% for Υ(4S) and at present, 6%at LHCb
  - Also has CP asymmetry $\Delta\omega$ in ω.



Boost vs polarization

- If asymmetric machine, boost optimization needs to be studied
- There is a compromise between boost and polarization

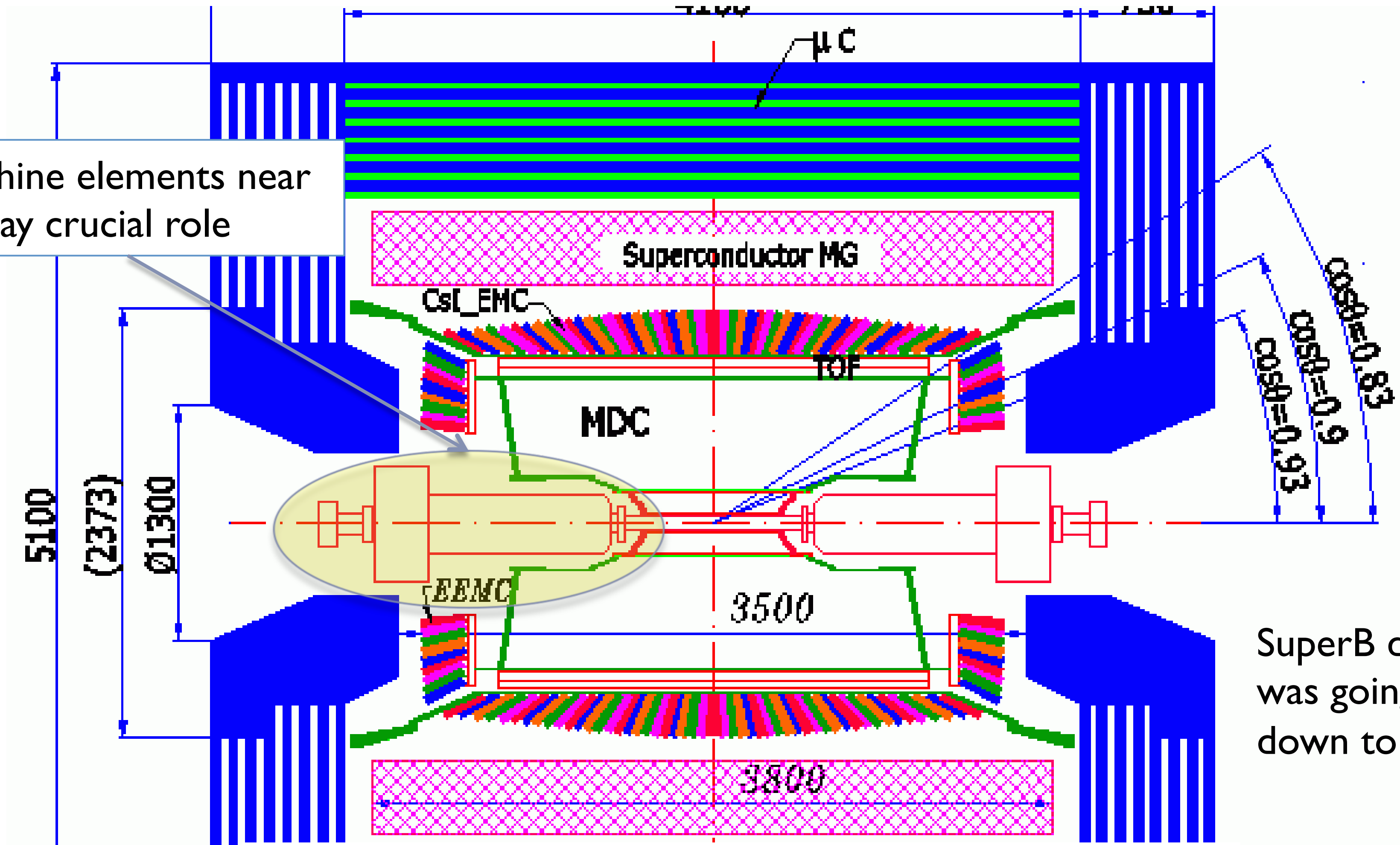
- Time difference resolution
  - $c\tau$ (D0) = 122um → $\beta\gamma c\tau$ order of 60 um or less.
  - What is the required vertex resolution ?

		Pol beam	in red					
E_{cm}	Resonance	E_LER	E_HER	Boost	Notes			
10,58	Υ(4S)	4,18	6,700	0,24	SuperB			
3,686	Tau	1,3	2,613	0,36	Larger boost but no polarization			
		1,405	2,417	0,27				
		1,536	2,211	0,18				
3,770	Charm	1,3	2,733	0,38	Larger boost but no polarization			
		1,470	2,417	0,25				
		1,536	2,313	0,21				
4,400	Max E	1,3	3,723	0,55	Larger boost but no polarization			
		1,536	2,211	0,18				
		2,002	2,417	0,09				

M.Biagini

BES-III detector and hemerticity

Machine elements near IP play crucial role



SuperB det was going down to 0.95

Hermeticity of symmetric detector not necessarily better

Why hermeticity

- If ε is the uncovered solid angle fraction
- Efficiency goes with $(1-\varepsilon)^n \approx 1-n\varepsilon$
  - Relevant for signal high multiplicity modes
  - Important for background rejection especially with neutrinos

$$D \to \nu\overline{\nu}(+\gamma) \qquad D \to X_u \nu\overline{\nu}$$

$$D^+_{(s)} \to \ell^+ \nu_\ell$$

- Study possibility to instrument with veto-like detectors down to very small angle if backgrounds are manageable
- For a symmetric machine the backward region becomes more important.

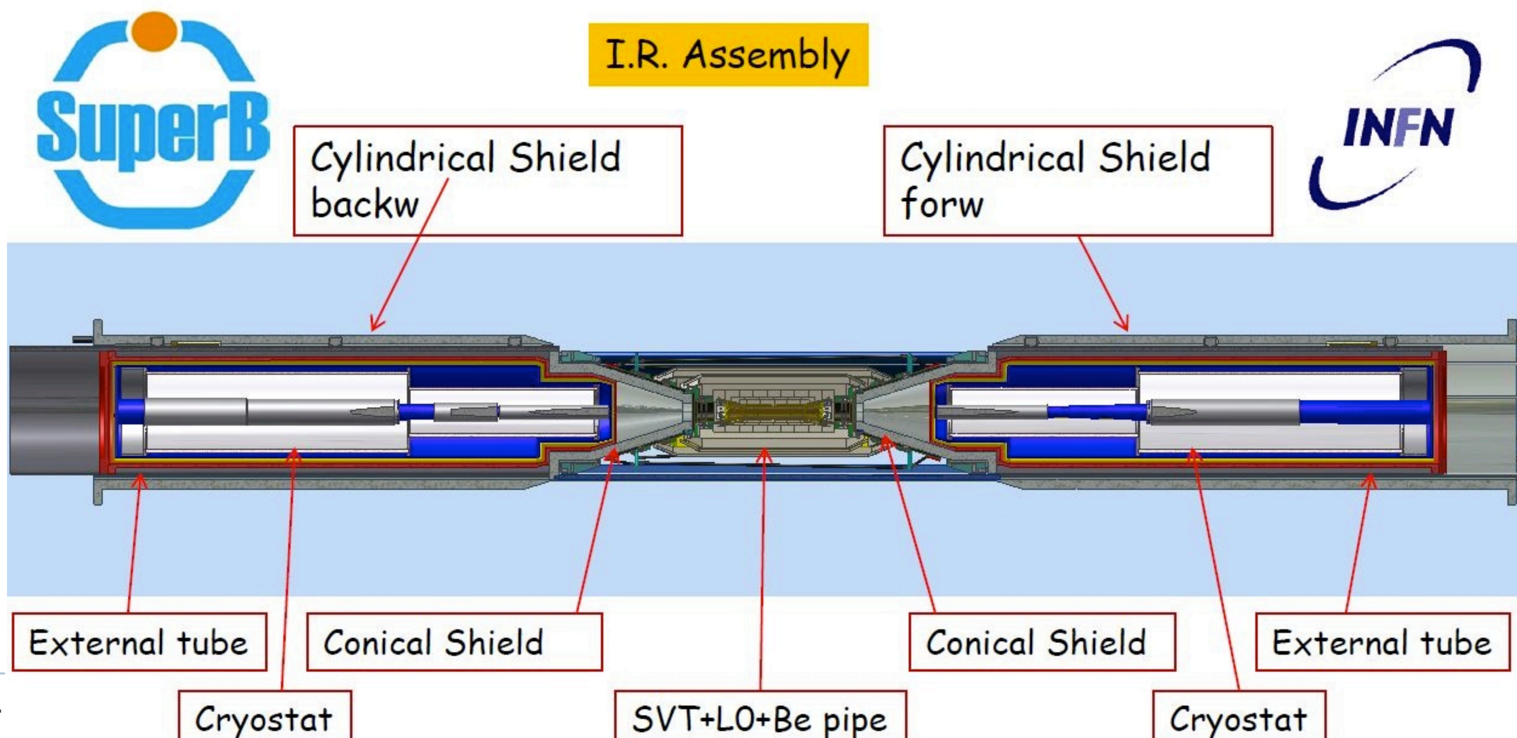
Magnetic field

- The B field for a tau-charm threshold machine is something that has been optimised elsewhere:
  - CLEO changed the field strength from 1.5T to 1.0T for physics reasons.
  - BES III adopted the 1.0T field as well.
  - There is D mass resolution degradation of 15% in going from a 1.5 to a 1.0T B field [O'Hanlon, 2011].
  - Efficiency for soft tracks important:
    - if we want to do multi-body charm physics (with soft tracks), we need to run with ~1.0T field to make sure we don't loose efficiency through loopers (based on CLEO-c and BES III studies).
  - → use 1.0T as a baseline B field to start optimisation from.
- How well does the Babar magnet run at 1.0 T ?
  - Uniformity ?

MDI

Many MDI questions

- How close and how large are the cryostats ?
- Are the tungsten shields still needed ?
- Can the DCH get at smaller radius if no SVT ?

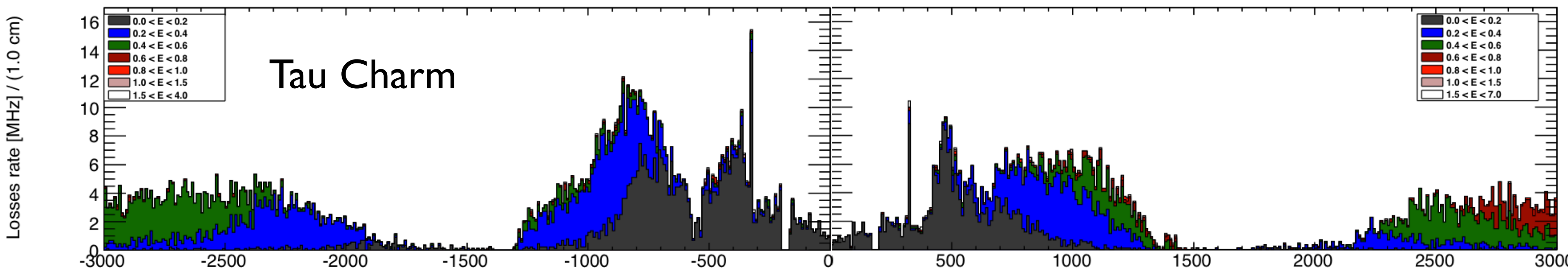


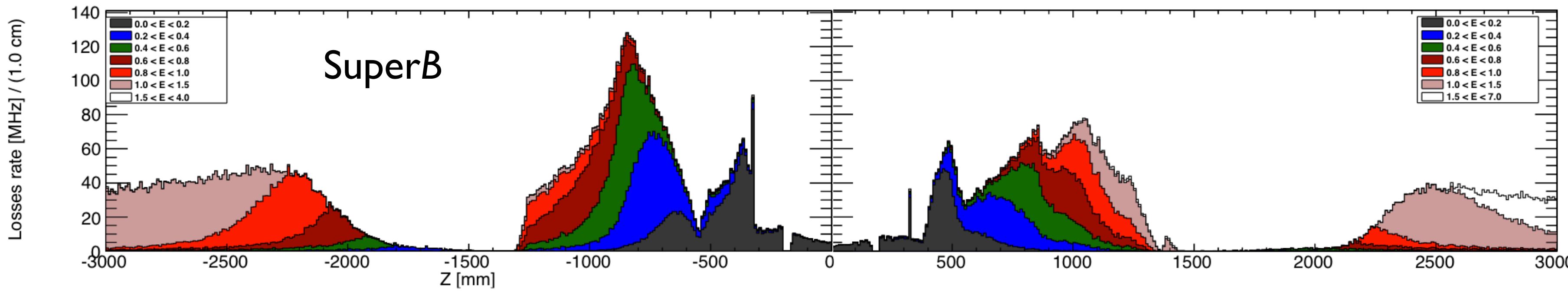
Luminosity Scaling Terms

- Assumptions (quite realistic for an asymmetric machine)
  - IP geometric layout: same as in SuperB
  - B Field in the final focus magnets scaled with the beam magnetic rigidity
  - Twiss & beam parameters from the blue book
- Rad Bhabha Near to the IP loss Cross section ~ 49 mbarn (-2% w.r.t Y(4S))
  - Luminosity will reduce the losses by a factor 10
  - Softer energy spectrum
  - Significant impact on the tungsten shield
- Pairs Production cross section @ 4.4 GeV ~ 5 mBarn (to be compared with 7.3 mBarn)
  - Scaling factors : luminosity (factor:10%) / Magnetic field of the detector
  - The main question is: what will be the solenoid magnetic field, anyway even 0.5T at 10^35 doesn't seems worst than 1.5 T @ Y(4S) (jobs pending…)

E.Paoloni

Rad Bhabha losses





- Losses at the IP reduced by a factor 10 (as expected)
- Softer spectrum: energy <400 MeV inside the detector vs 1GeV in SuperB
- Energy flux from the shields and neutron flux are also way smaller. Touschek and Beam gas have still to be evaluated

E.Paoloni

Beam Lifetimes for the Tau/Charm factory

- **Touschek effect is expected to be the dominant effect for lifetime and backgrounds source**
- Lattice is needed for a correct estimate
- However, a rough rescaling from SuperB LER parameters has been done, but estimates to be taken *cum grano salis*

Touschek lifetime goes like $$\frac{1}{\tau} \propto \frac{N}{\gamma^3 \sigma_x \sigma_y \sigma_l \sigma_{x'}}$$

	Lifetime (minutes)	IR Losses (GHz)
LER E= 1.4 GeV	4	41
LER E=1.735 GeV	7.5	21
HER E= 2.538 GeV	28	5.9
HER E=2.79 GeV	37	4.3

Rescaling done from lifetime (LER)= 10 min without collimators inserted and IBS included

M.Boscolo

SVT

- If symmetric machine probably no vertex detector is required
  - CLEO-C decided to remove the vertex detector
  - BES-III has none → talk by Gradl tomorrow to discuss tracking issues
- If asymmetric machine
  - Z Vertex resolution
    - Back of the envelope calculation: for 500 MeV pion, with 0.5%X0 in B.P. +L0 @ 1.5cm, single particle z resolution is about 30um
    - It should be possible to obtain a good resolution for TDCPV in charm
  - Need as light as possible SVT
    - Impact on momentum resolution
  - SVT will need to measure loopers and low momentum particles
  - Probably dE/dx useful for PID at small momentum

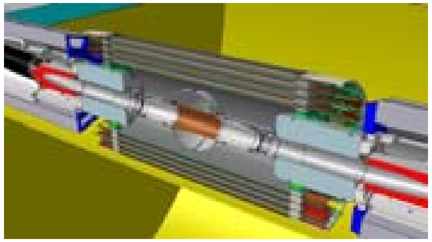
Vertex detector tecnology

- Need to have a broad look at possible vertex detector tecnologies
  - Need to know backgrounds to evaluate
  - Silicon strip / striplets – proven and safe, but relatively high material content
  - Gas based detectors like GEMs like KLOE-2 might be alternatives, although the resolution is not quite enough (arxiv.org/abs/1002.2572)
- To be studied

KLOE-2 upgrade: Inner Tracker[3]

For fine vertex reconstruction of K_s, η and η' rare decays and K_s- K_L interference measurements :

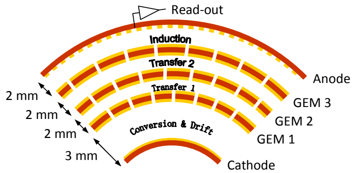
- $\sigma_{r\phi} \sim 200\ \mu m$ and $\sigma_z \sim 500 \mu m$
- low material budget: $<2\% X_0$
- 5 kHz/cm² rate capability



Cylindrical GEM technology

- 4 CGEM layers with radii from 13 to 23 cm from IP and before DC Inner Wall
- 700 mm active length
- XV strips-pads readout (40° stereo angle)
- 1.5% X_0 total radiation length in the active region with Carbon Fiber supports

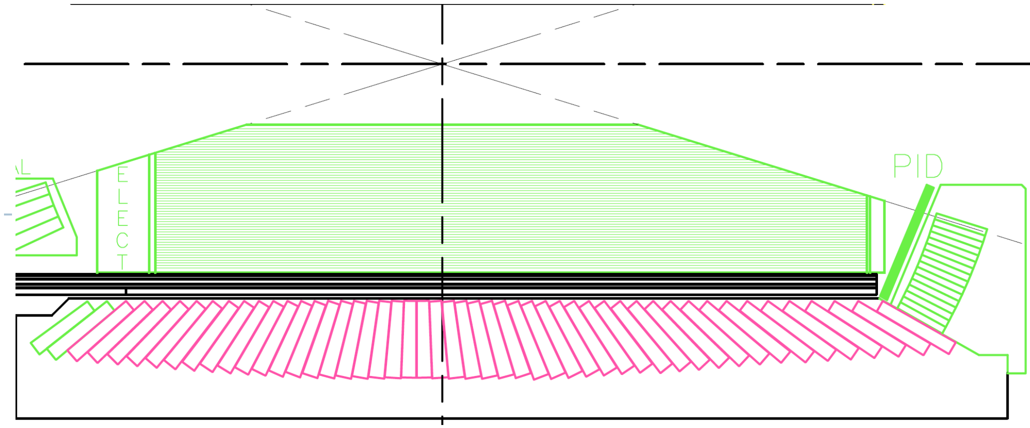
Cylindrical Triple GEM



$K_S \rightarrow \pi\pi$ vertex resolution will improve of a factor 3 from present 6mm

DCH

- Inner radius needs to be reoptimized depending on cryostat dimensions
- Possibility of graded geometry, especially if no SVT
- Need to reexamine question of gas mixture
- Re-examine dE/dx performance for low p.
  - Is cluster counting becoming more useful ?
- To close in the back we need to redesign the electronics so that there is less material



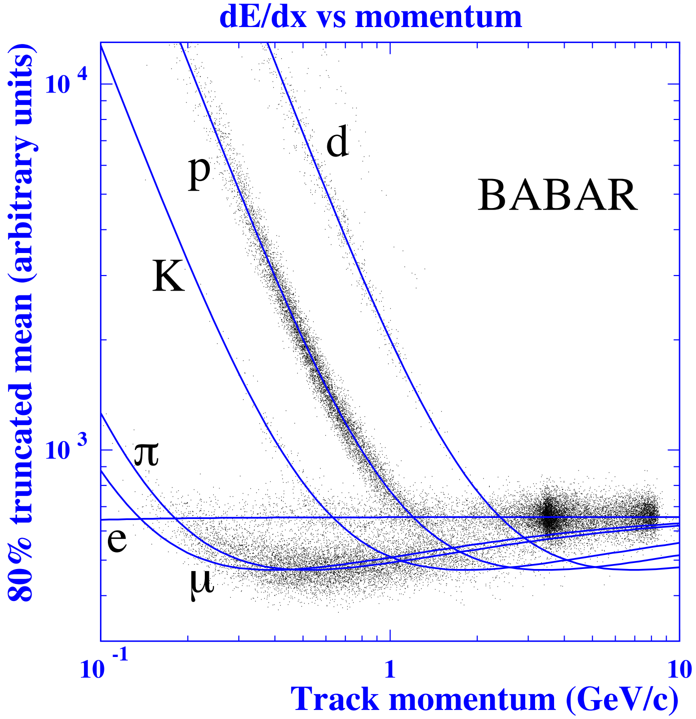
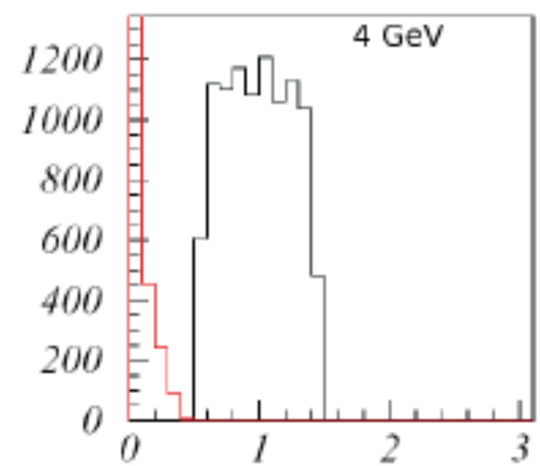


Figure 4-23. *BABAR relative dE/dx vs. momentum for inclusive tracks.*

PID

- Probably no significant changes on DIRC….
- …unless one decides to completely revise the PID concept
- Since we are now below 2 GeV, a TOF system might sufficient, like in BES-III, even for the barrel
- CLEO-C used instead a RICH
- Need to do a full cost/benefit analysis of the DIRC system for the tau charm running
  - Forward PID is probably an easier problem at smaller momentum and smaller backgrounds
  - Backward PID might become possible and/or necessary
- Can something be done for pi/mu separation in the energy range of $\tau \rightarrow \mu\gamma$?



From the CDR

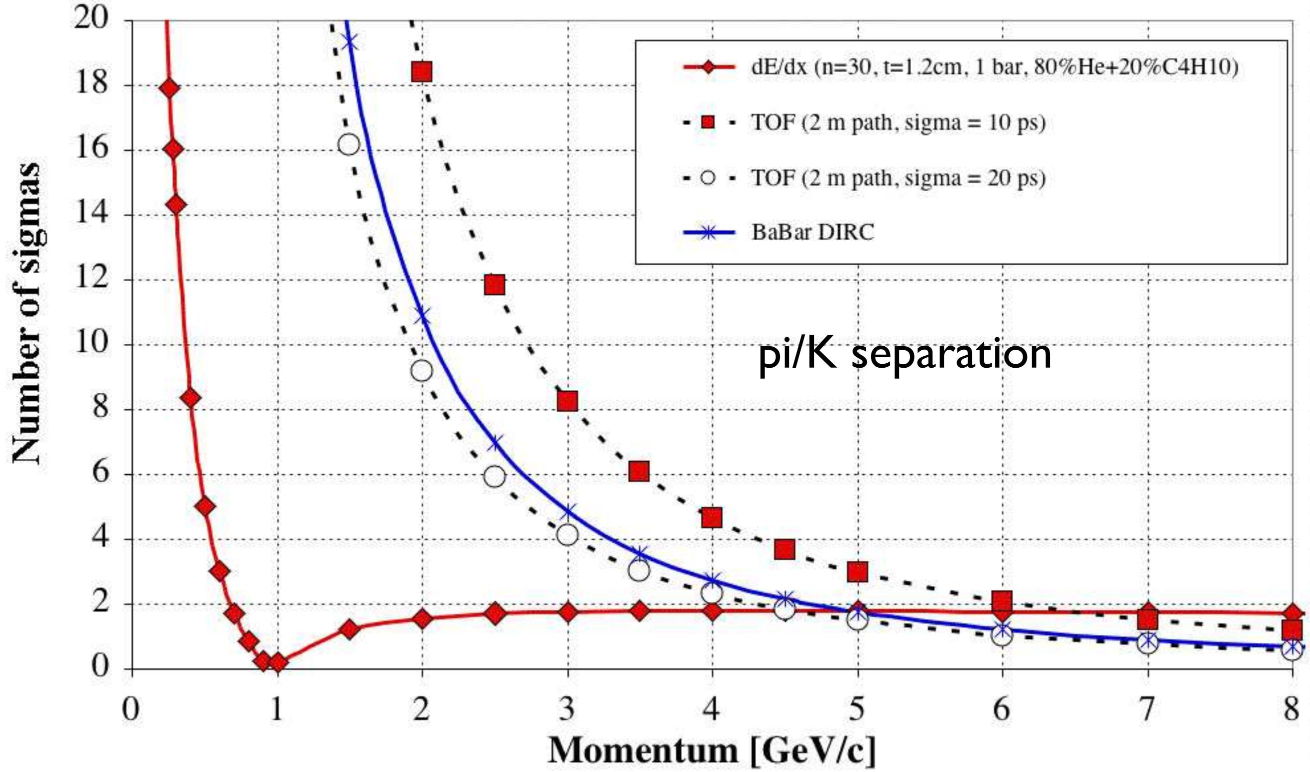


Figure 4-30. *Expected PID performance as a function of momentum for the barrel BABAR* DIRC *(the Focusing* DIRC *option would be similar), the forward end cap TOF option, and the* $\mathrm{d}E/\mathrm{d}x$ *method in the drift chamber. A TOF resolution at a level of* $\sigma{\sim}20$ *ps with a path length of* $\sim$*2 meters yields a performance equivalent to present BABAR* DIRC, *and is far superior to the* $\mathrm{d}E/\mathrm{d}x$ *method.*

EMC

- Lower backgrounds and rates simplify life for EMC
- Barrel
  - Need to re-examine the refurbishing strategy.
  - Would it be possible to live with Babar electronics ?
- Forward
  - Given the smaller rates, could we use the Babar forward endcap ?
  - If not, can we reduce the calorimeter thickness and cost, given the smaller momentum spectrum ?
- Backward
  - Hermeticity would require a better backward calorimetric coverage, but DCH electronics is in the way.
    - Move out some of the DCH electronics to reduce materiale
  - The backward are needs to completely re-examined for a symmetric machine

IFR

- Basic tecnology is OK
- Need the revisit the steel segmentation and the number of active layers
- No need to ad extra steel outside because of the softer momentum

ETD

- ETD general architecture seems OK
- Front-end electronics is likely to stay the same
  - Need to re-evaluate data rates, shaping times, buffer lengths
- Need to re-evaluate the trigger rate.
- Is trigger latency staying the same as SuperB ?
- Are the less demanding needs on data rate change perspective on possible tecnologies ?
  - e.g. data links
- For DAQ, performance can be scaled down (with savings) as the rate is reduced

Conclusion

- A detector optimized for tau-charm running can be derived from the SuperB detector
- A number of significant issues need to be examined to optimize the performance and implement possible cost savings
- The choice of symmetric vs asymmetric machine has many ramifications and should be made as soon as possible.

Collaboration issues

- The collaboration has been shocked by the news of the cancellation of SuperB
  - The fact itself
  - The lack of information and planning
- Things have been moving so fast that it was very difficult to inform the collaboration
  - The situation and perspective are still not clear
- Still, there is a chance to redefine SuperB as a Super Tau-Charm factory and do very good physics
- The collaboration is undergoing a lot of reshaping
  - People going, people coming
  - Need some time to settle down
  - Execboard today, Council tomorrow to discuss and manage the transition.

A truly remarkable collaboration

Conclusions

- To say with the words of INFN president
  - "Anche il nostro progetto bandiera SuperB è stato vittima della crisi economica. La salvezza qui non dipende però dall'intervento di forze esterne ma dalla nostra volontà di saper utilizzare il finanziamento inizialmente promesso nel modo più efficace possibile. Da una crisi nasce una opportunità."
  - "Also our flagship project has been a victim of the economical crisi. But salvation does not depend on the intervention of external forces but by our will to know how to use the initially promised funding in the most effective way possible. From a crisis an opportunity is born"
- And indeed it is an opportunity for young and motivated people to jump on the ship and manage the "gybe"
  - Personally I have informed the executive board that I will step down as detector coordinator as soon as the TDR is published


That's all Folks!