PID Summary

Elba SuperB Meeting, June 4th 2012

Nicolas Arnaud, for the SuperB PID group

- 3 parallel sessions
  - S1: FDIRC: CRT test, background, PMT tests, electronics
  - S2: FDIRC G4 simulation, FTOF update
  - S3: TDR

PID Parallel Sessions

- Three PID parallel sessions

Friday, 01 June 2012

[75] **FDIRC prototype construction**
by Dr. Jerry VAVRA (SLAC)
(Sala Bonaparte 1: 16:00 - 16:20)

[76] **FDIRC background estimates**
by Luis Alejandro PEREZ PEREZ (PI)
(Sala Bonaparte 1: 16:20 - 16:35)

[77] **Update on the Bari H-8500 tests**
by Fabio GARGANO (BA)
(Sala Bonaparte 1: 16:35 - 16:50)

[78] **Maryland phototube testing**
by Prof. Douglas ROBERTS (University of Maryland)
(Sala Bonaparte 1: 16:50 - 17:05)

[79] **PIF chip status update**
by Ms. Vanessa TOCUT (LAL/IN2P3/CNRS)
(Sala Bonaparte 1: 17:05 - 17:20)

[80] **Bandwidth, what do we need?**
by Dr. Jerry VAVRA (SLAC)
(Sala Bonaparte 1: 17:20 - 17:30)

Friday, 01 June 2012

[81] **FTOF update**
by Mr. leonid BURMISTROV (LaL)
(Sala Bonaparte 1: 18:00 - 18:20)

[82] **Simulation with background**
by Prof. Douglas ROBERTS (University of Maryland)
(Sala Bonaparte 1: 18:20 - 18:35)

[83] **FDIRC G4 simulation**
by Mr. martino BORSATO (LAL Orsay)
(Sala Bonaparte 1: 18:35 - 18:50)

[84] **TDR status and discussion (1/2)**
(Sala Bonaparte 1: 18:50 - 19:30)

Saturday, 02 June 2012

[85] **Mechanical design of the PMT motherboard**
by Massimo BENETTONI (PD)
(Sala Bonaparte 1: 08:30 - 08:50)

[86] **FDIRC electronics: status update & TDR**
by Mr. Christophe BEIGBEDER (LAL)
(Sala Bonaparte 1: 08:50 - 09:10)

[87] **TDR status and discussion (2/2)**
(Sala Bonaparte 1: 09:10 - 10:30)

Contents

- TDR
- FDIRC test at SLAC Cosmic Ray Telescope (CRT)
- Electronics
- Background
- Simulation
- H-8500 Photomultiplier Tests
- FTOF status update

TDR Status

- Chapter in pretty good shape

- Currently 46 pages long
  - Most of the FDIRC sections are in SVN
    → Some still need some work – text tuning, figure updates, etc.
  - A few well-identified sections are missing
    → To be added soon
  - Electronics part needs to be moved to ETD chapter
  - FTOF section still to be written – should be short

- Latest version of the PID chapter:
  http://www.slac.stanford.edu/~narnaud/SuperB/DTDR/dtdr-PID.pdf
  → Updated daily by a cronjob – when the compilation isn't broken ☺
  - Also available through the SuperB wiki

A few samples

Contents

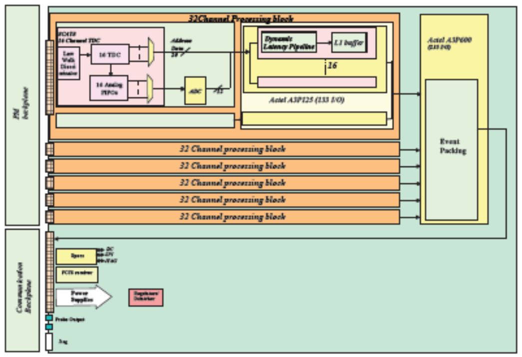
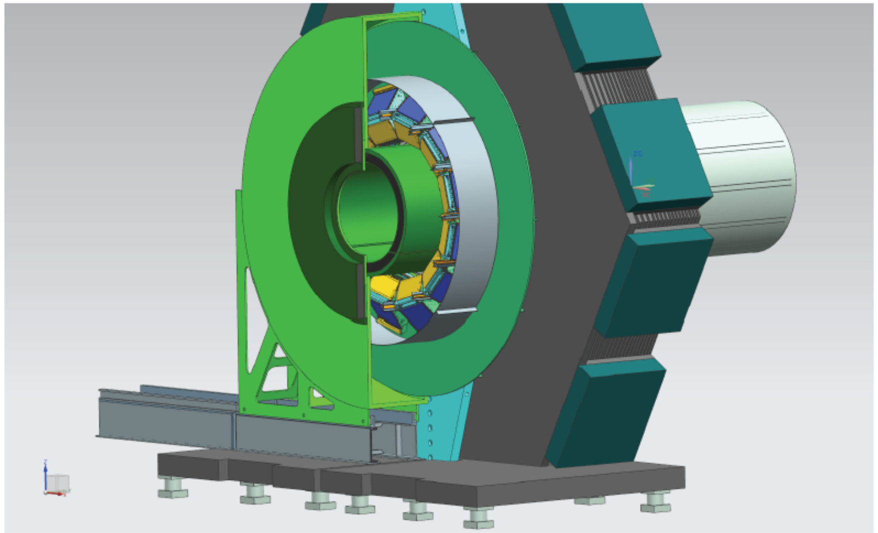


Figure 1.55: Front-end board connected to backplanes.



(a) A 3D view showing the new magnetic shield and background shields, and Fboxes.

(a) Fbox and bar box in the CRT setup. (b) Details of coupling of new Wedge to FBLOCK.

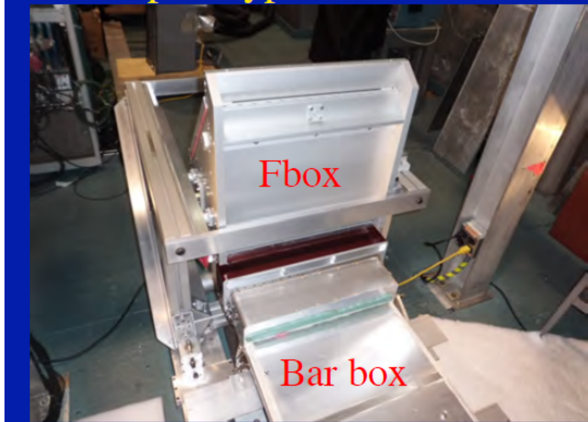
Figure 1.44: Fbox coupling to bar box in the CRT setup.

FDIRC test @ SLAC CRT

- The prototype has been successfully built!
- Preparation of the data taking
- Test planning and goals

→ See Jerry's opening talk in the 1^{rst} PID parallel session for more details.

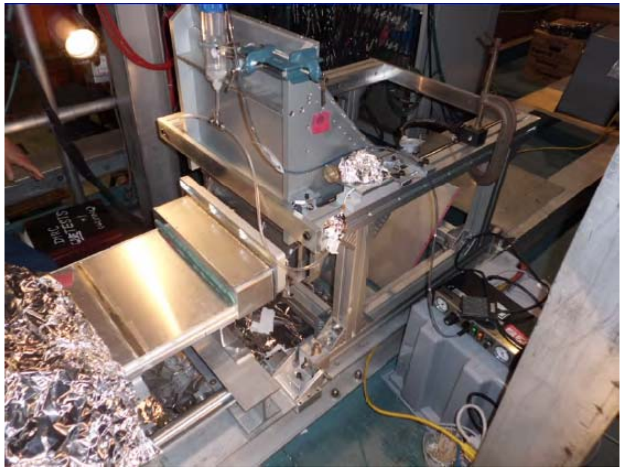
FDIRC prototype located in CRT:



Fabrication of the FDIRC prototype optics and mechanics successfully finished !!!

Completing the FDIRC prototype

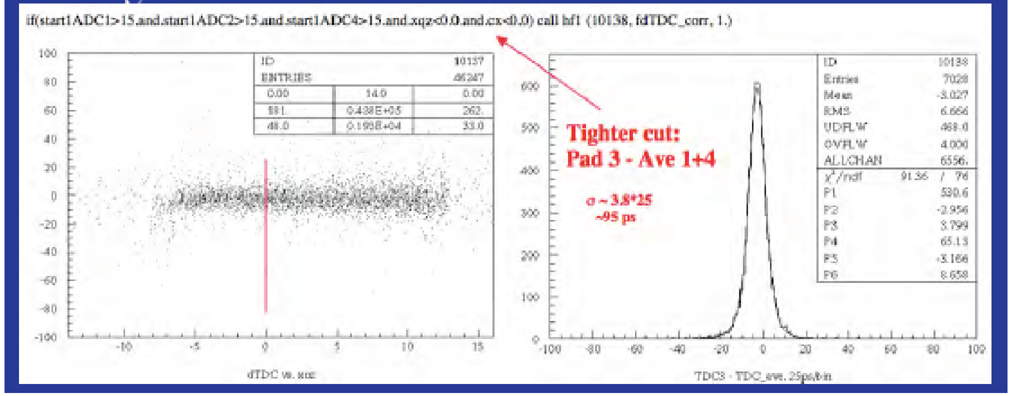
- Photon camera assembly and move to CRT
- Bar box move to CRT
- FBLOCK alignment
- FBLOCK & bar box gluing
  → Alignment detailled survey all OK!



Cosmic Ray Telescope

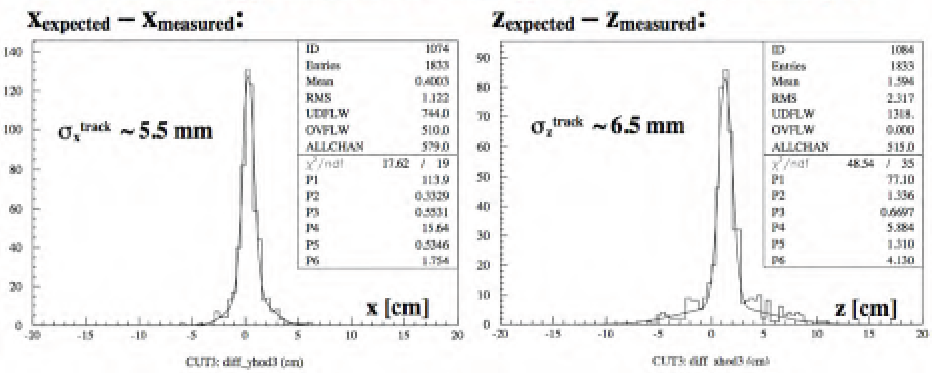
- Resolution measurements
  - Timing & tracking

Timing resolution:



CRT tracking resolution:

CRT tracking resolution using the 3-rd hodoscope:



SLAC Cosmic Ray Telescope (CRT):

- ~1.5 mrads track resolution
- > 1.6 GeV muon energy
- 3D tracking
- 46” thick iron absorber, ~ 55” x 90” size

Planning & data taking goals

- Short term: running preparation
- Longer term: data taking – 1 bar per run

- Detector placement, HV connections: June 7-10, 2012.
- Monitor tube setup with a laser: June 10-15, 2012.
- Hawaii electronics: June 20-22, 2012.
- Initial tests of DAQ and data format: June 25-30, 2012.
- The first dst file for software development: July 15-30, 2012.
- The 1st run on bar #6: August – Sept., 2012.
- The 2nd run on bar #1: Sept. – October, 2012.
- The 3rd run on bar #12: October – Nov., 2012.
- The 4th run on bar #6 (add assynchronours bckg.): Nov. – Feb., 2012.
- French electronics: March 2013 ?

Monitoring and
ascii → ROOT conversion

- Study bars #6 and #1 in position #3 initially.
- Verify that the new FDIRC optics works by measuring the Cherenkov angle resolution and its tail, comparing it with the 1-st FDIRC prototype results.
- Study an effect of ambiguities on the Cherenkov angle tails.
- Study the chromatic error correction by timing using 3D tracks.
- Study of several new detector options.
- Study effect of background rates on FDIRC Cherenkov angle resolution and its tails by adding a random light noise while taking normal CRT data.

Electronics

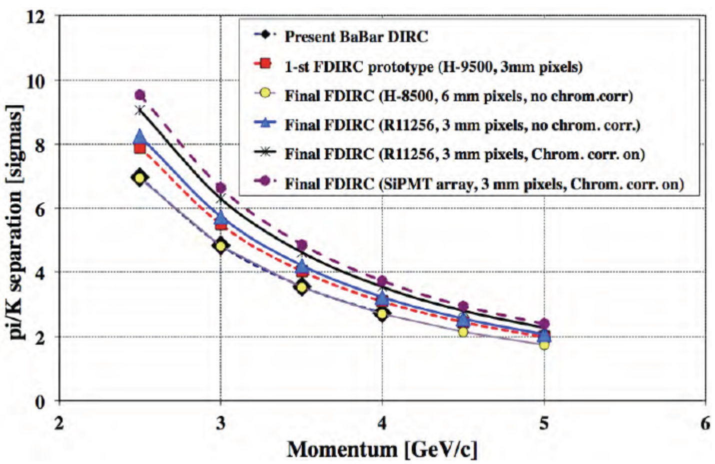
- Preparation of the CRT test
- Status update of the analog front-end chip
- Bandwidth discussion
- Motherboard design

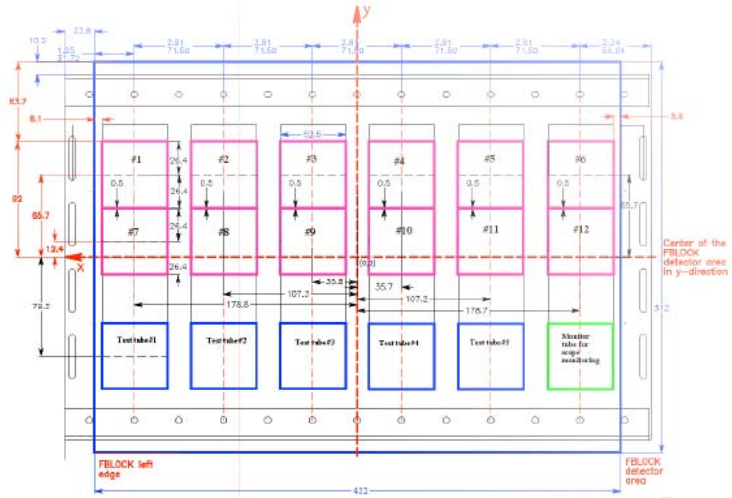
Electronics & MaPMTs for the CRT test

- New SLAC amplifiers designed to fit with the BLAB2 Hawaii electronics
  - 64 boards ordered
  - Tests ongoing (SLAC + Hawaii)
  - Installation in the CRT foreseen in the second half of June

- MaPMT locations defined

- H-8500 still the baseline option
  - Other possible MaPMT candidates under study

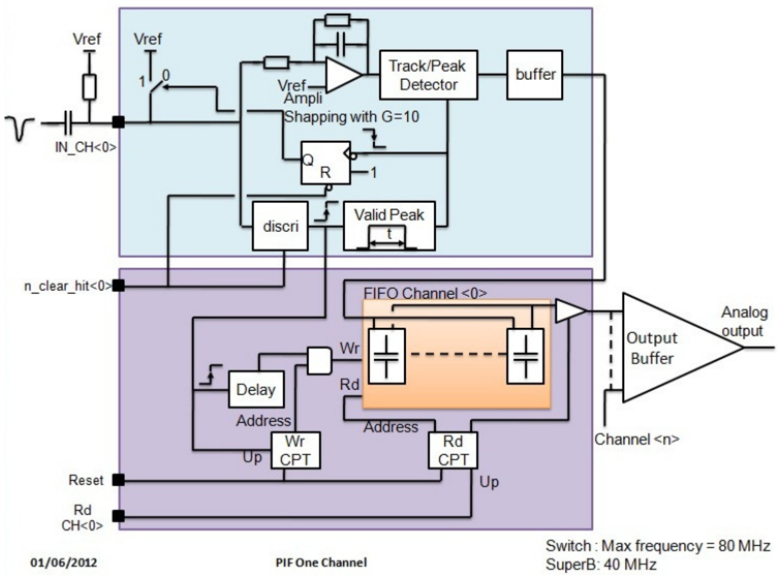


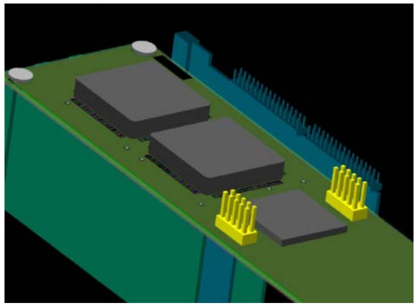


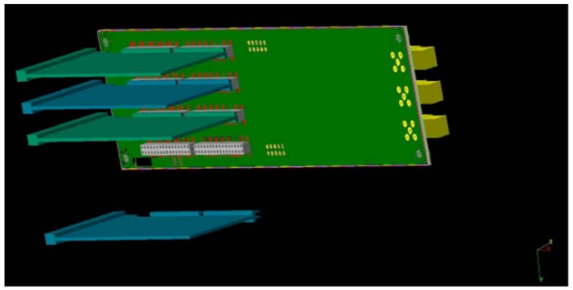
Status update of the analog FE chip – 'PIF'

- PIF is an analog chip doing CFD-like and charge measurements
- PMT signal characteristics – as measured by SLAC and Bari – taken into account
- Design and simulation ongoing
  - CMOS AMS 0.35 μm technology
    → Compatibility with the TDC chip,
    the 'SCATS'
- Chip to be submitted in December
  → Available for tests around end of Feb. 2013
- LAL CRT test bench operational
  → Work in common with LPNHE Paris
  - CRT test board being designed,
    first for SCATS, PIF to be included later

PIF (inside SCATS) final architecture







4 analog boards with the SCATS CRT (bottom view)

Bandwidth

- Just giving the conclusion of Jerry's study
  - Amplifier bandwidth is of course important but S/N also matters!

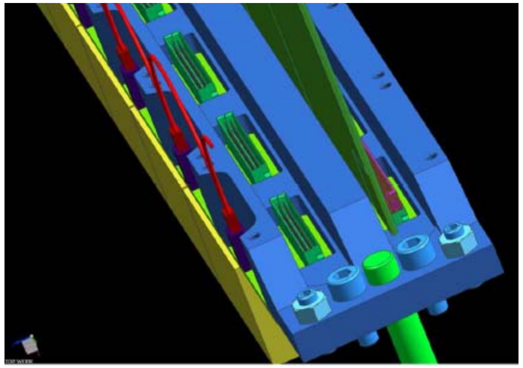
  → See slides for details

Conclusion

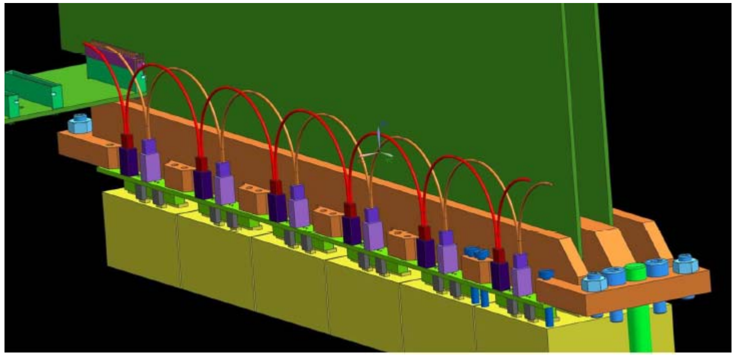
- In the "30ps timing resolution domain" the amplifier BW is not that important. It starts to be important in the "10ps timing resolution domain".
- For FDIRC, it is important to match the speed of the amplifier to the speed of the tube (you do not want to be much faster that the tube). In my opinion an amplifier with ~0.5GHz BW and good S/N ration is just fine for H-8500 tube.

Motherboard

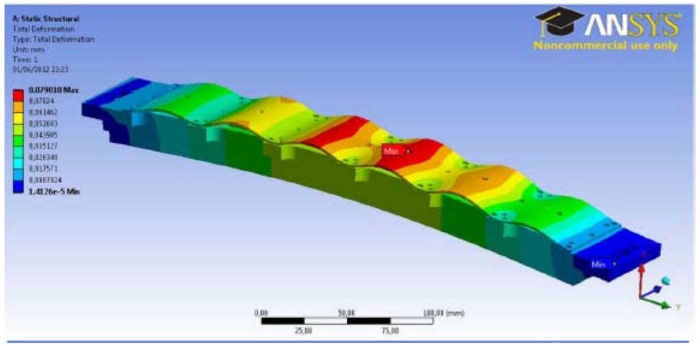
- 8 motherboards per sector, connected to 6 MaPMTs each
  - Support PMTs in precise position
  - Allow FE board insertion
  - Transmit signals to FE boards



- Design
  - Baseline exists
    → Assumes type-D PMT for HV distribution
    Backup: type-C
  - Assembly procedure being defined
  - Going to prototype
    → Some additional information needed
    - Also: design for CRT test or final setup?



- Study of deformation / coupling to structure
  → Leads to clearance definition



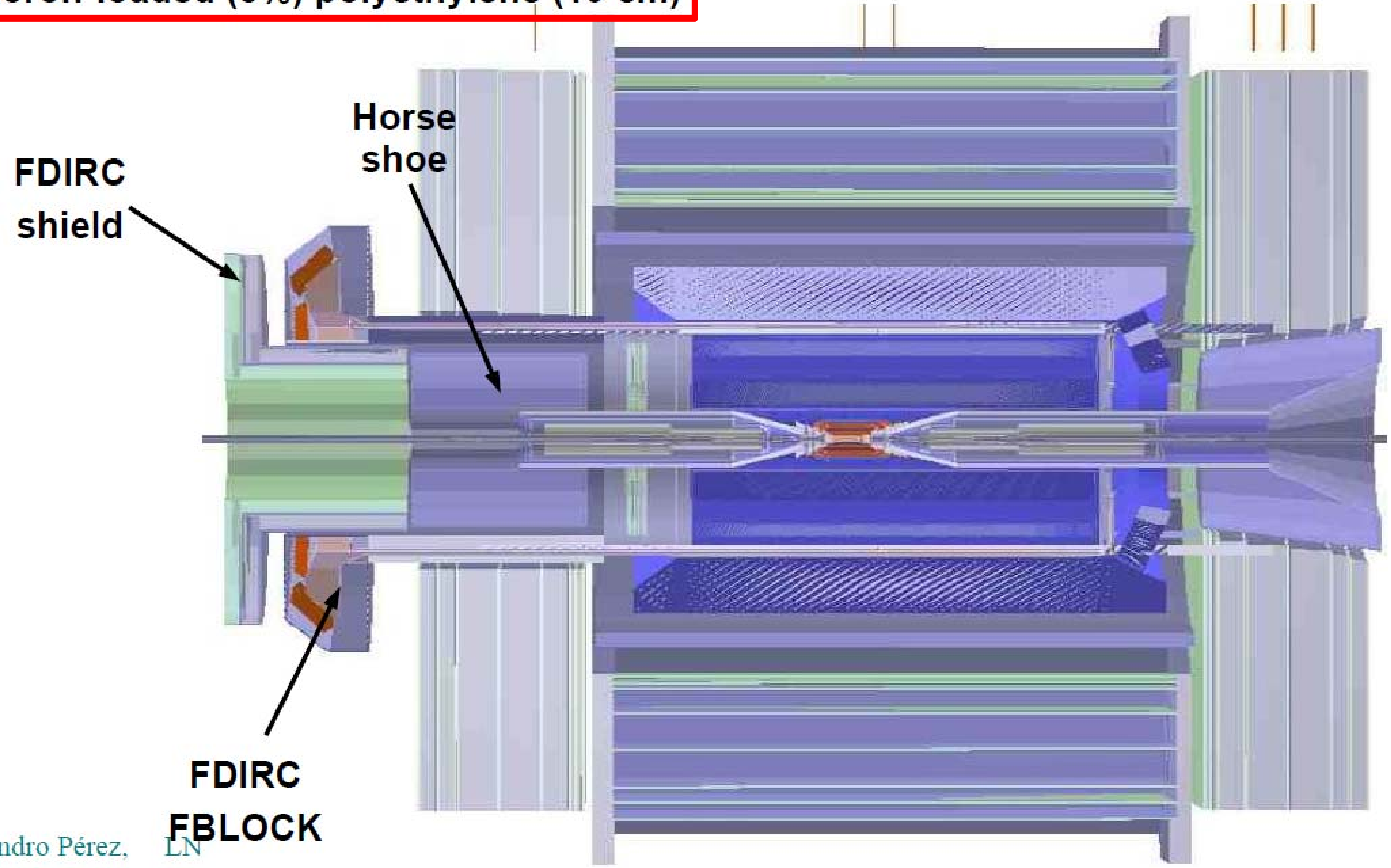
Background

- Results from the last BRN production
  $\rightarrow$ Includes new shieldings (Tungsten + FBLOCK + neutron)

- Estimation of integrated charge and anode current

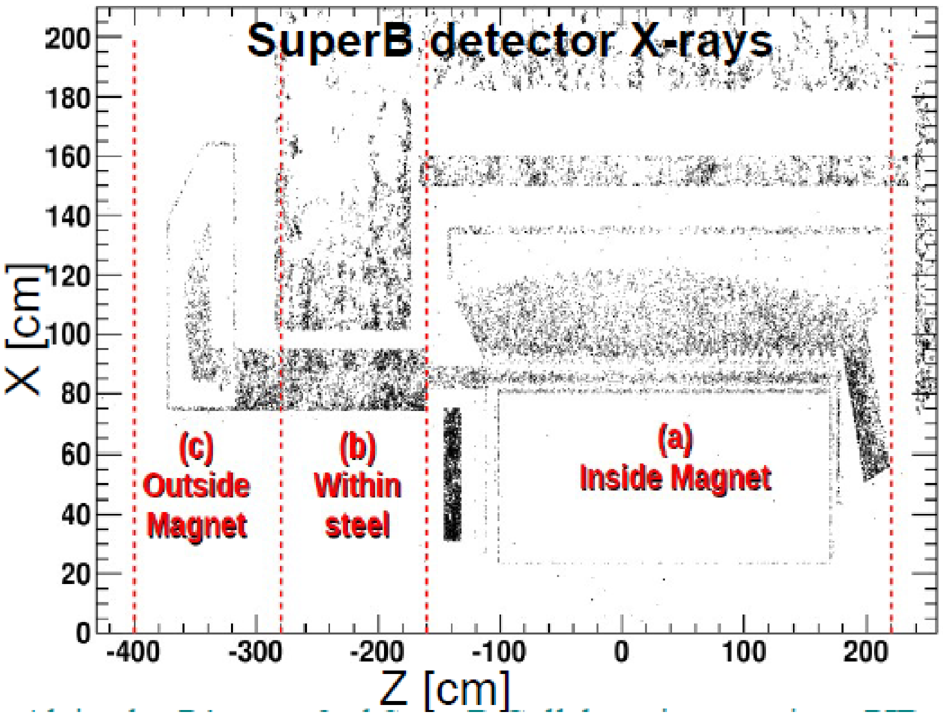
FDIRC Shielding

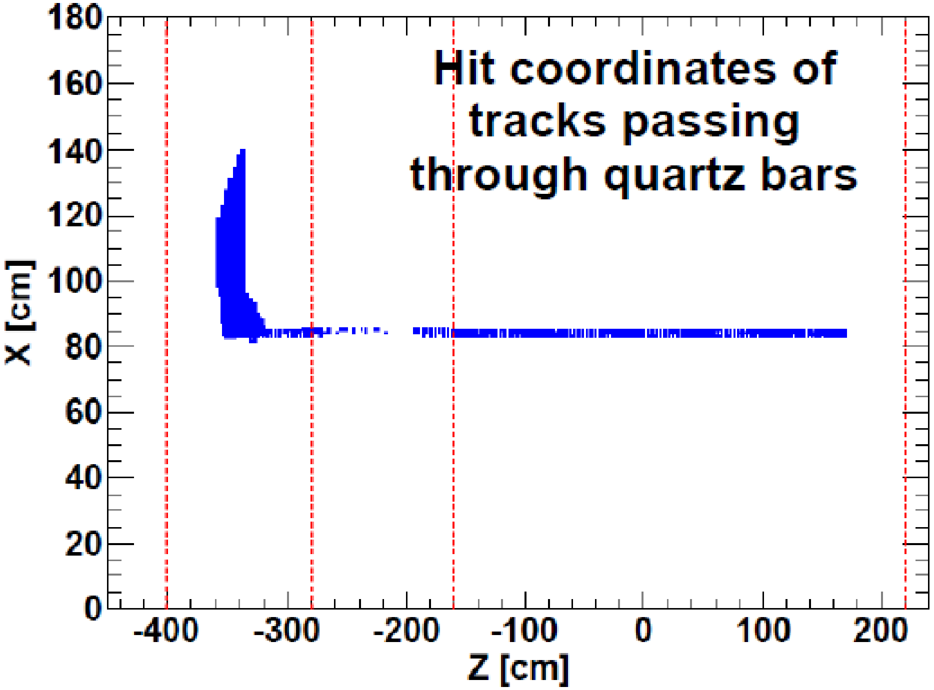
- Steel-lead-steel sandwich (2.5-10-2.5 cm)
- Boron-loaded (5%) polyethylene (10 cm)



Background analysis

- April 2012 production
- Three different z-regions analyzed separately



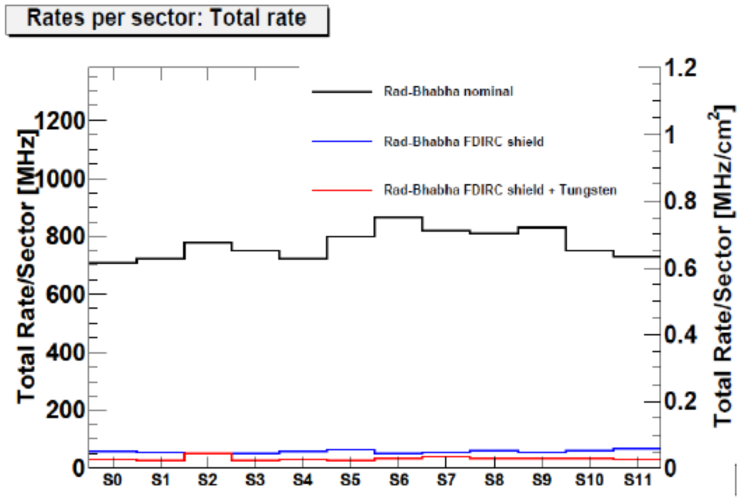


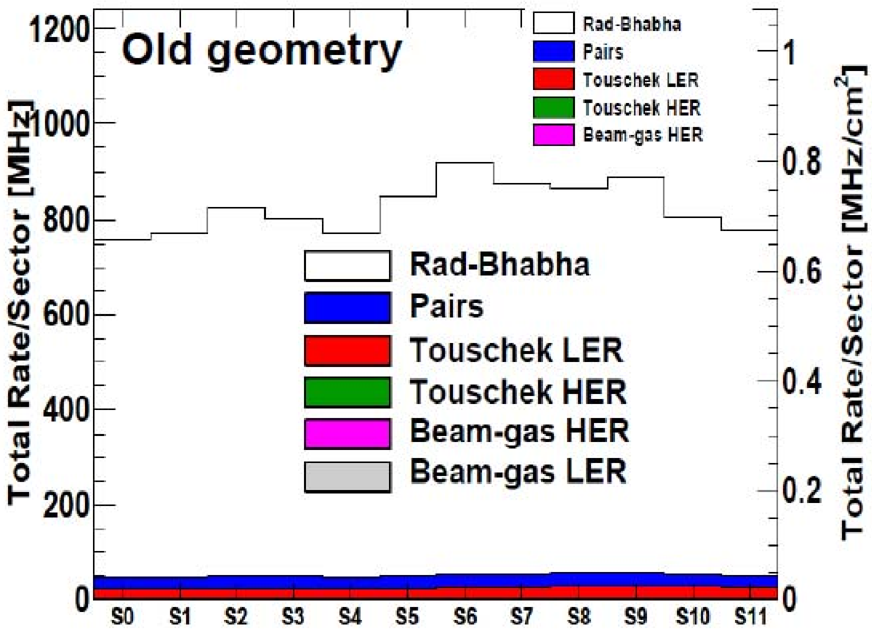
- Nominal FDIRC configuration
  - 48 H-8500 MaPMTs per sector
  - 32 pixels each

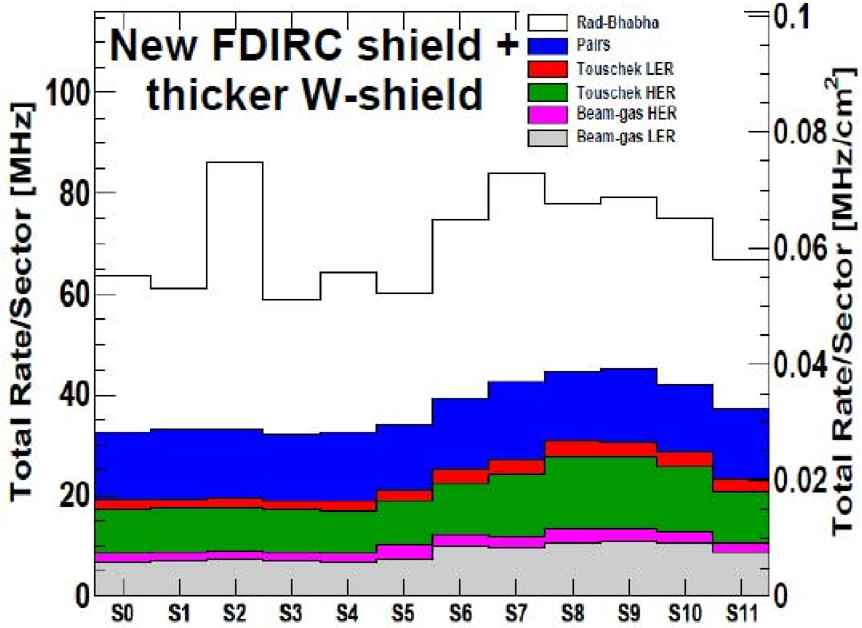
Main results

- Radiative Bhabha contribution reduced by a factor ~10
- All bkg sources of similar magnitudes

+ first look at FEE dose & fluency
  → See Alejandro's slides for details

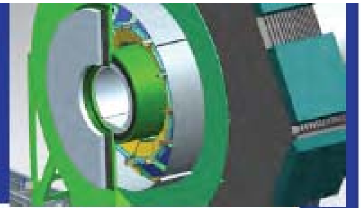






FDIRC background estimation: summary

FDIRC Expected rates



J. Va'vra (based on simulation results of Alejandro Perez)

1) Contribution from active volume (with & without shielding):

	Lumi	H-8500 MaPMT rate	One single Double-pixel rate	Total dose (after 50 ab^{-1}) (~ 10 years)	Expected anode current at a gain of ~2×10^6	Maximum allowed current for 10 years of operation
without	10^{36}	~ 3.84 MHz	~ 120 kHz	~ 1.3 C/cm²/50 ab^{-1}	~ 1.2 μA /PMT	~ 10 μA /PMT
with	10^{36}	~ 1.5 MHz	~ 50 kHz	~ 0.5 C/cm²/50 ab^{-1}	~ 0.5 μA /PMT	~ 10 μA /PMT

2) Contribution from FDIRC photon camera (with & without shielding):

	Lumi	H-8500 MaPMT rate	One single Double-pixel rate	Total dose (after 50 ab^{-1}) (~ 10 years)	Expected anode current at a gain of ~2×10^6	Maximum allowed current for 10 years of operation
without	10^{36}	~ 17.6 MHz	~ 550 kHz	~ 5.9 C/cm²/50 ab^{-1}	~ 5.6 μA /PMT	~ 10 μA /PMT
with	10^{36}	~ 1.92 kHz	~ 60 kHz	~ 0.6 C/cm²/50 ab^{-1}	~ 0.6 μA /PMT	~ 10 μA /PMT

- A safety factor of less than ~2 only !!!! => need to shield photon camera:
- New shielding: 10 cm Polyethylene + 10 cm lead + 2 x 2.5 cm steel + thicker tungsten.
- With the shielding we have a safety factor of ~10x, without less than a factor of 2x !!!

Simulation

- Recent developments and studies
- First look at background impact on single photon resolution

G4 standalone simulation

- FDIRC/fDircG4 package in SVN
  - https://sbrepo.pd.infn.it:8911/projects/FDIRC/browser/fDircG4

- Wiki pages have been written to guide new users and store common information
  - http://mailman.fe.infn.it/superbwiki/index.php/Simulation_of_the_SuperB_Focusing_DIRC

- Ongoing discussion to design interface classes allowing users to easily access relevant information (e.g. pixel hit by a given photon) w/o knowing the internal code
  → For instance this will allow to test different PMTs / pixel grouping schemes

- Preparation of a 'FDIRC numerology document'
  - Frames, numbering & naming conventions, etc.

  → Should avoid (minimize) misunderstandings in the future

- Simulation ran successfully at CC-IN2P3
  - Batch system could be used for time-consuming simulations

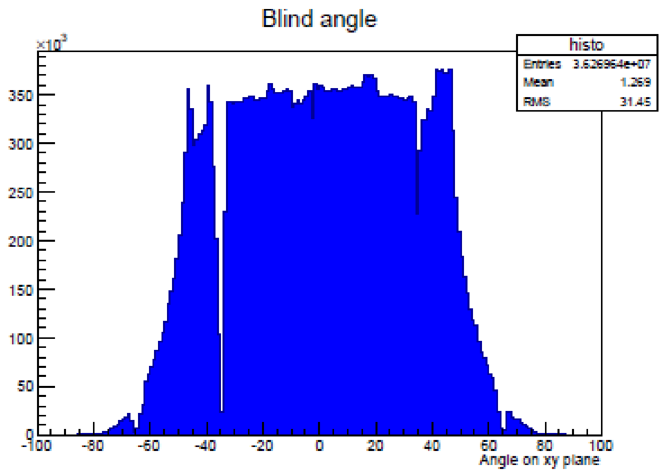
  → E.g. computation of a photon dictionnary

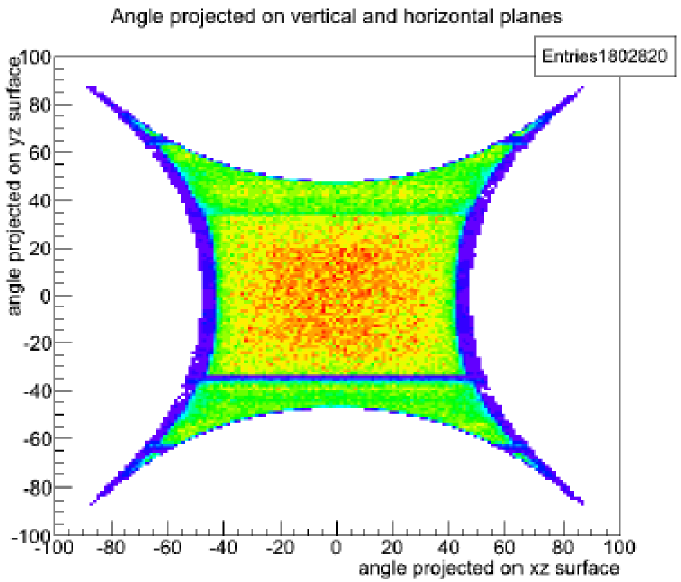
Example of a recent study

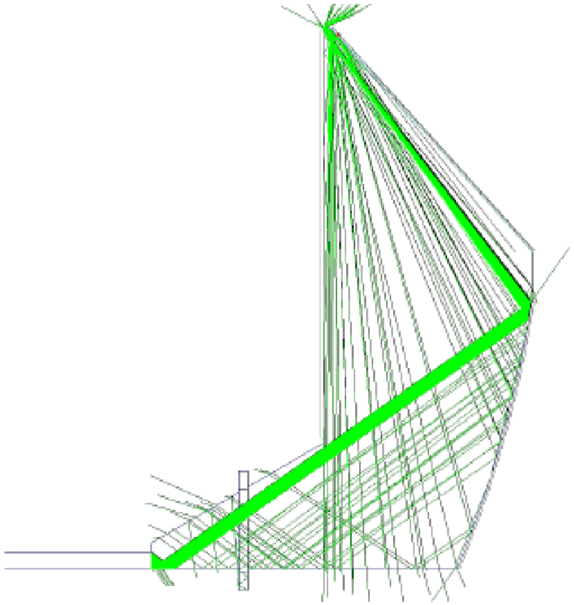
- Code ran at LAL and Maryland; discussions with Jerry

Found little blind angle

- 35 deg ⇒ missing focal plane
- solution could be a longer wedge (Jerry)
- actually missing just 2%







First simulations with background

- Goal is to look at effects on the single photon resolution

- ‘Salt and pepper’ background
  - Using latest rates computed from BRN simulation
    $\rightarrow$ Various tests up to 20$\times$ the simulated background rate
  - Uniform in space and time (window about 500 ns width)
    $\rightarrow$ More investigation needed on the background structure (burst-like!?)

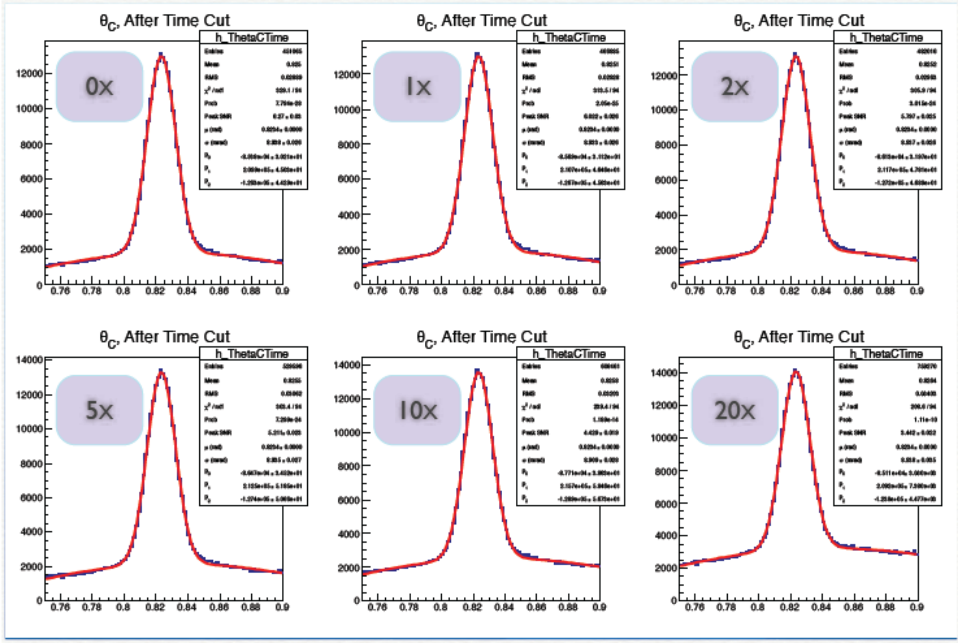
- Use of cosmic muons
  $\rightarrow$ CRT-like simulation

- Time cut used to remove some ambiguities

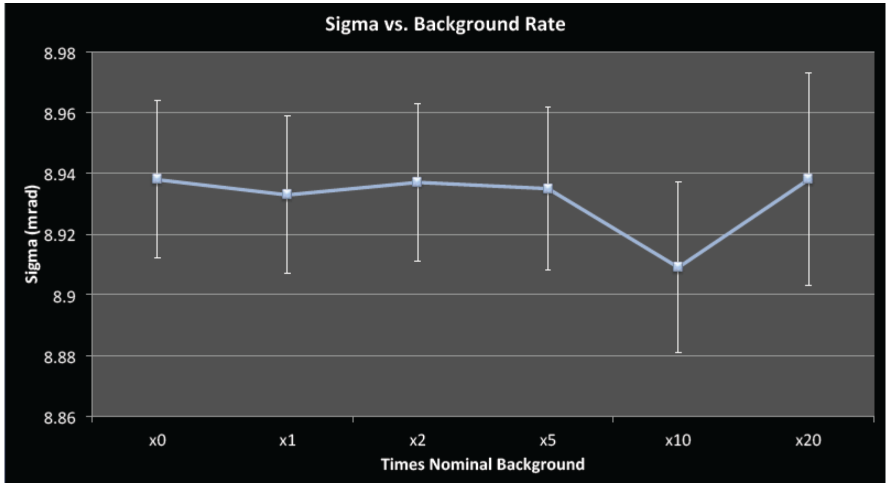
- Background impact on various quantities studied
  - θ_C resolution, peak signal-to-noise ratio, etc.

- More studies in the future
  - Reconstruction will be needed to really assess the effect of background

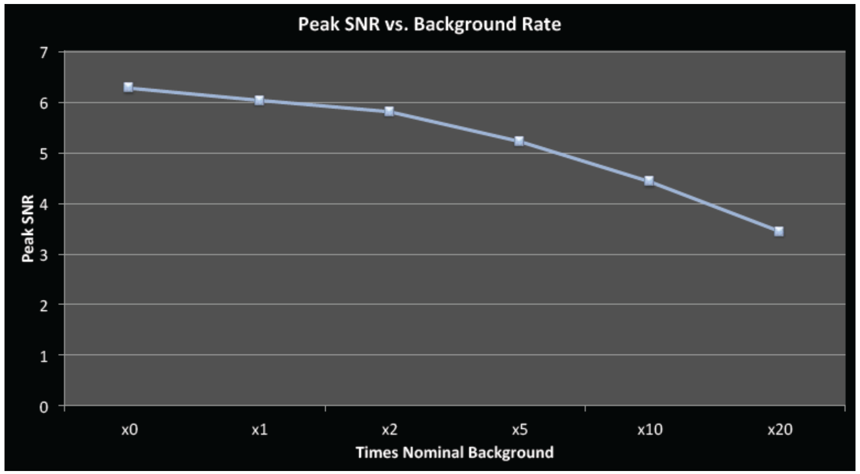
Results



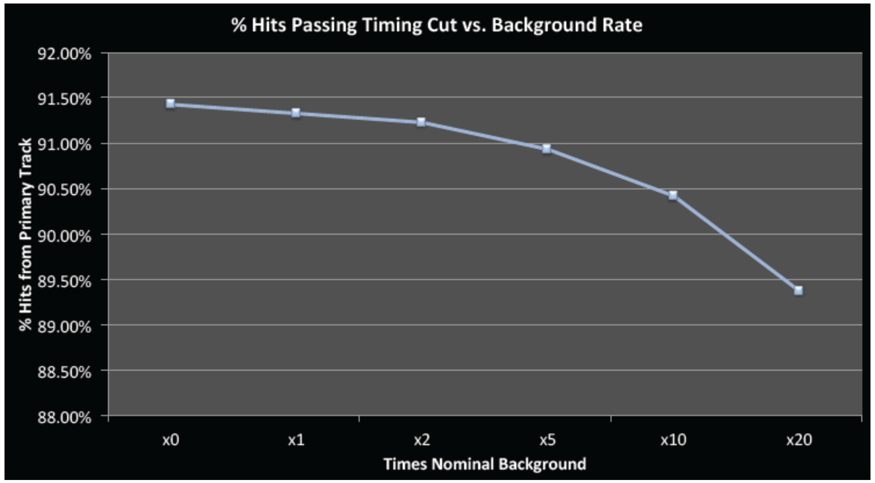
- Resolution unchanged



- Peak SNR goes down – tails increase



- ~2% hit shadowing at highest bkg

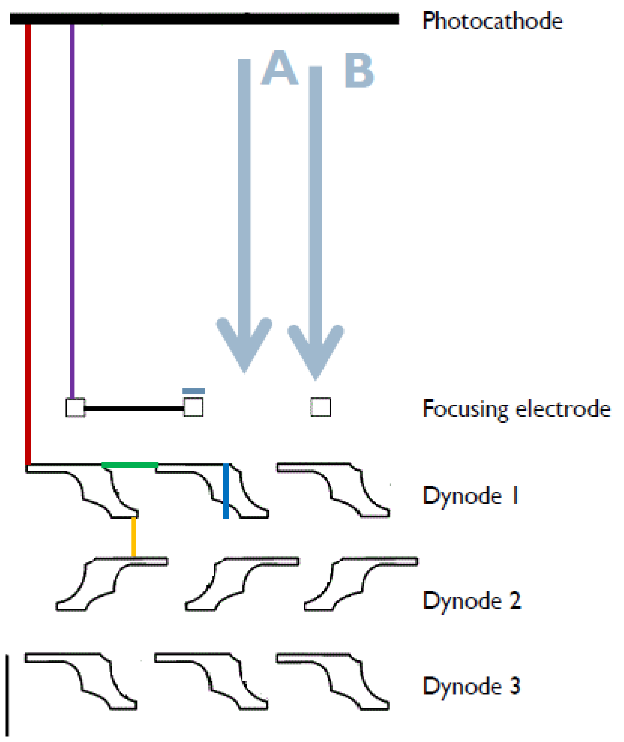


H-8500 MaPMT tests

- Intra-pixel studies
- Various scans

H-8500 inner structure studies

- Comparison of the MaPMT response at two different locations inside a given pixel
  - Position A: between two focusing electrodes
  - Position B: on the focusing electrode



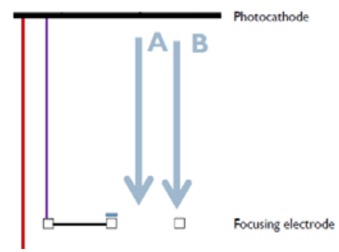
- Laser beam
  - 50 mm size
  - 1 p.e. intensity
  - Close to center of a corner pixel
- Studies
  - Charge distribution
  - Transit Time (TT) distribution
- Also
  - Efficiency inside pixel
  - TT peak not Gaussian

  → See slides for details

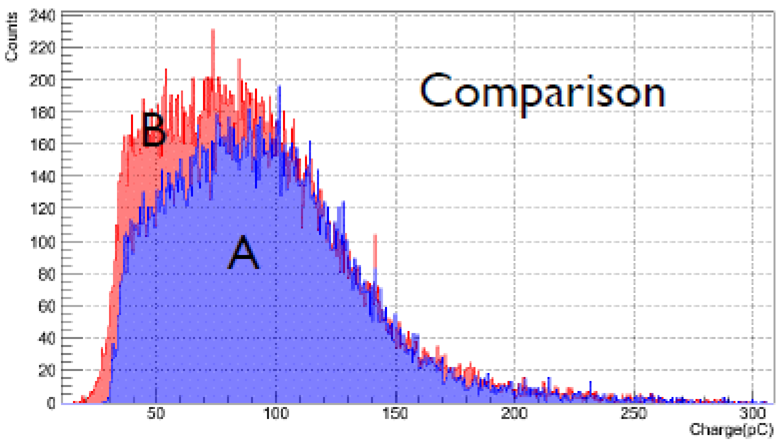
  → More studies planned

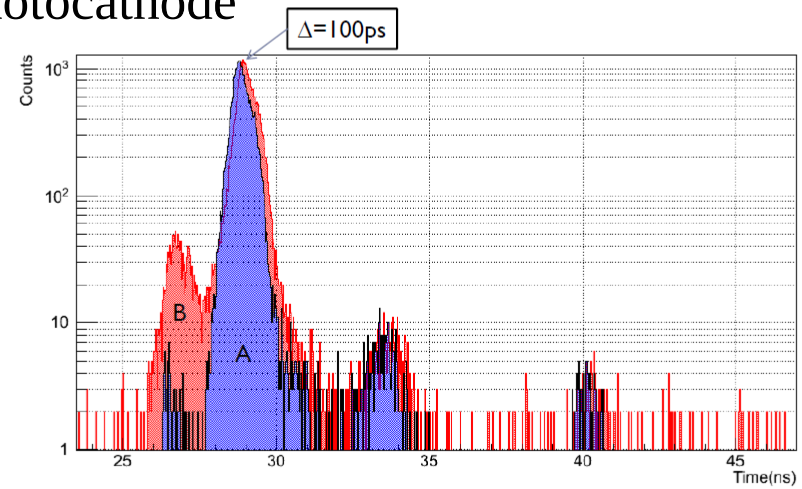
1) **red** line (distance between photocathode and first dynode): **3 mm**
2) **black** line (distance between two adjacent focusing electrode): **0.5 mm**
3) **green** line (distance between two adjacent dynodes): **0.2 mm**
4) **blue** line (dynode thickness): **0.2 mm**
5) **orange** line (distance between first dynode and second dynode): **0.2 mm**
6) **purple** line (distance between photocathode and focusing electrode): **2.75 mm**
7) **light blue** line (focusing electrode thickness): **0.05 mm**

H-8500 inner structure studies



- The main difference between the two positions is due to events that miss the conversion on the photocathode



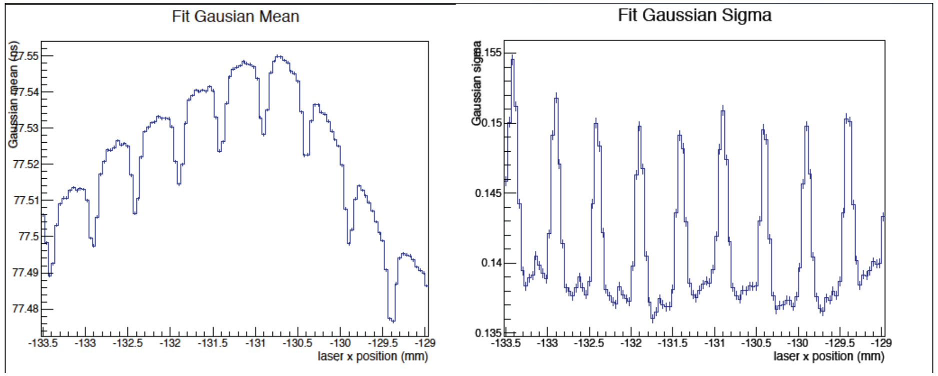


- Position A
- Charge Distribution
  - No clear evidence of the low charge events (conversion on the 1st dynode)
- Time Distribution
  - Only few pre pulses i.e. only few detected events that have converted on the 1st dynode

- Position B
- Charge Distribution
  - Clear peak of low charge events (conversion on the 1st dynode) with a charge of almost 1/3 p.e.
- Time Distribution
  - 5% of pre pulses

More H-8500 scans & studies

- Timing
  - Above 1 p.e., mean and sigma depend on location on the pad (both in x and y)
  - Size of effect depends on signal peak
  - Almost no effect in single p.e. regime



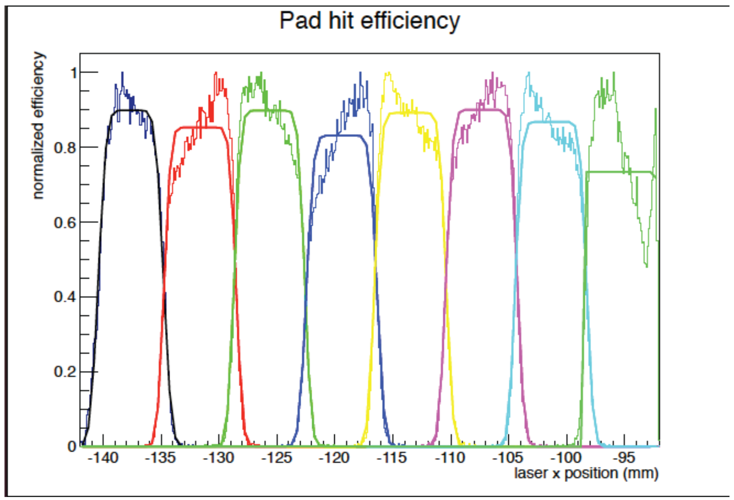
- Position
  - Pad ‘effective size’ is not constant!

    → The simulation will have to account for this effect

FIT TO BOX CONVOLUTED WITH A GAUSSIAN
GAUSSIAN SIGMA FOR INTERNAL PADS ~450 μM
FOR EDGE PADS, ~540 μM
(4σ BEAM SPOT ~50 μM)

- Capacitive cross-talk identified in pre-amp boards for a subset of channels
  - Seem to come from the board layout

    → Channels that pick up induced signals have a long trace that passes very close to output pins that induce signal

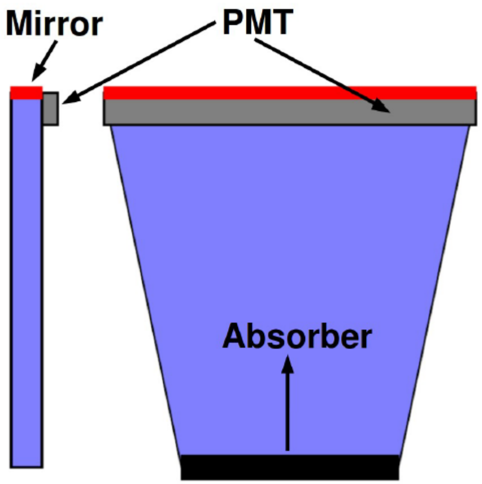


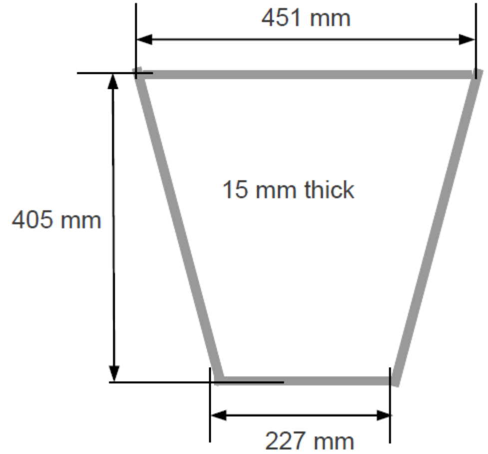
FTOF status update

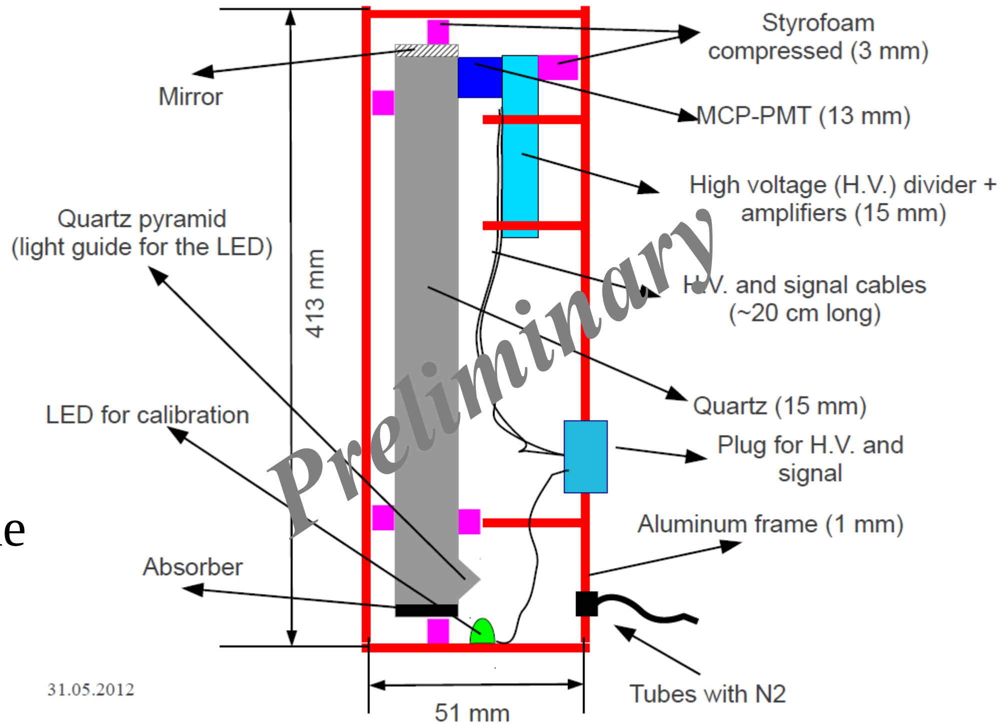
- Summarize current design
  - Geometry, orientation
- ‘Official’ drawing of the SuperB forward side needed to move forward
- Report of LPSC Grenoble ongoing activities
- Background
  - Rate from latest production around 115 kHz / cm^2
  - Reduction by a factor 3 with the thicker tungsten shield
  - Results based directly on BRN now
    $\rightarrow$ Cherenkov physics and optical photons implemented in BRN

Geometry and orientation

- Optimized layout
  - Maximize photon yield
  - Minimize time jitter
- Interested in direct photons
  - The more forward-tilted the FTOF, the better
- Dimensions and weight
  - 5 cm in z (quartz: 1.5 cm thick)
  - ~12 kg by sector (~ 150 kg total)
  - Awaiting official forward design
  - → will use best the available space
- Electronics boards outside the detector
  - Just HV dividers and amplifiers inside
- MCP-PMTs on the outer radius

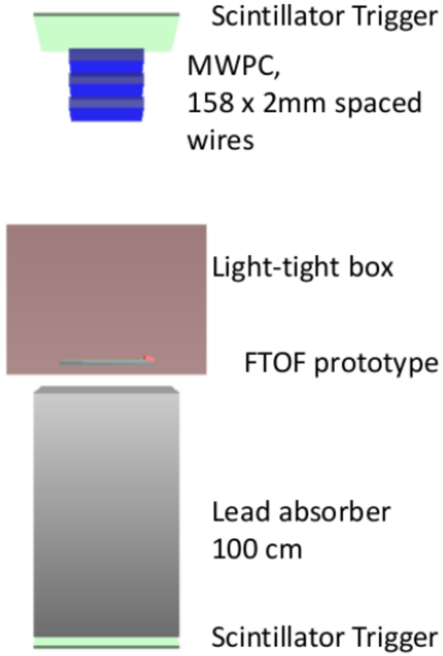


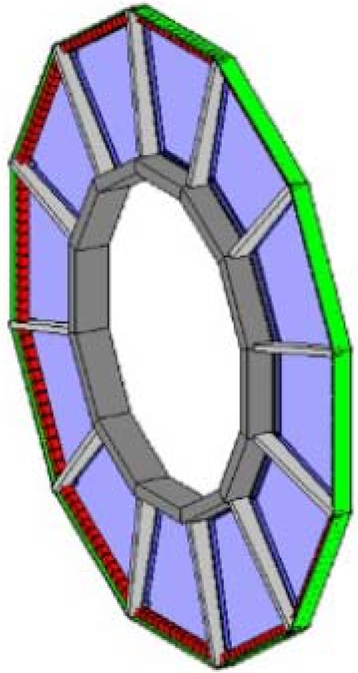


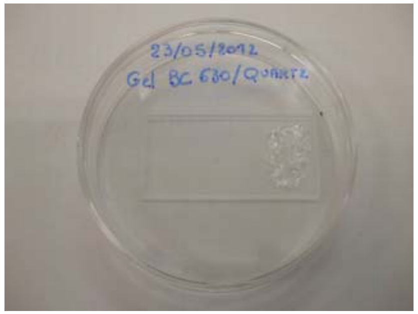


FTOF-related studies at LPSC Grenoble

- Cosmic ray telescope
  - > 1.5 GeV/c muons
  - Designed for FTOF geometry
  - Good position and angle precisions
- Quartz tile ordered
  - Spectrosil 2000 from Heraeus
- Goal: study photon collection
  - Efficiency; timing (with USBWC)
  - Data/MC crosscheck
- Initial mechanical studies







Conclusions

PID Outlook

- The FDIRC prototype is real
  - Great achievement – SLAC + Padova + Bari
  - Next step: get ready for data taking

- Many related activities
  - Electronics
  - Background
  - Simulation
  - H-8500 tests

- FTOF
  - Updated design summarizing & motivating all relevant FTOF parameters
  - Awaiting a drawing zooming on the forward region

    → Help defining the FTOF envelope – design quite flexible

- TDR chapter in good shape
  - Missing text to be added in the coming weeks
  - Then internal review – in each PID group + by at least one native speaker