PID Summary

Frascati SuperB Meeting, December 4th 2009

Nicolas Arnaud, for the SuperB PID group

- Two parallel sessions
- Updates on Barrel PID
- Updates on Forward PID
- Outlook

Two PID Parallel Sessions

- Full sessions
  - 1rst one dedicated to barrel PID
  - 2nd dedicated to forward PID
- Detector design updates
- Simulation updates
- Electronics updates
- SiPM studies

16:30->*18:00* Parallel - PID I (Barrel FDIRC) (Convener: NICOLAS ARNAUD (*LAL ORSAY CNRS-IN2P3*) , Jerry Vavra (*SLAC*))
Description:
Location: Aula A-1
Phone number: +39 06 6228 8548
or http://server10.infn.it/video/index.php?page=telephone_numbers
Meeting ID: 1552

16:30	FDIRC Design Update (15') (Slides)	Jerry Vavra (*SLAC*)
16:45	Update on FBLOCK simulation studies (15') (Slides)	Douglas Roberts (*University of Maryland*)
17:00	ADC/TDC vs. analog memories for the barrel electronics (10') (Slides)	Dominique Breton (*LAL ORSAY*)
17:10	First estimation of the number of links needed for PID readout (10') (Slides)	Dominique Breton (*LAL ORSAY*)
17:20	TDC based electronics for the CRT (10') (Slides)	Christophe Beigbeder (*LAL*)
17:30	Padova activities on SiPM (15') (Slides)	Flavio Dal Corso (*PD*)
17:45	SiPM characterization at LAL-Orsay (15') (Slides)	Véronique PUILL (*CNRS IN2P3 LAL*)

14:30->*16:15* Parallel - PID II (Forward PID Detector)
(Convener: NICOLAS ARNAUD (*LAL ORSAY CNRS-IN2P3*) , Jerry Vavra (*SLAC*))
Description:
Location: Aula A-1
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Meeting ID: 1552

14:30	Simulation of the DIRC-like TOF (15') (Slides)	Ieonid Burmistrov (*LaL*)
14:45	Summary of last Friday joint PID-EMC meeting (mechanical integration on forward side) (15') (Slides)	NICOLAS ARNAUD (*LAL ORSAY CNRS-IN2P3*)
15:00	First results of the WaveCatcher board with MCPPMTs (15') (Slides)	Dominique Breton (*LAL ORSAY*) , Jihane Maalmi (*cNRS-LAL*)
15:15	Pixilated TOF update (15') (Slides)	Jerry Vavra (*SLAC*)
15:30	Status of FARICH (15') (Slides)	Evgeniy Kravchenko (*Budker INP*)
15:45	Comparison of overall performances for various forward PID detectors (15') (Slides)	Jerry Vavra (*SLAC*)

Many other Sessions relevant for PID

- DGWG
- FastSim
- ETD
- Background

→ Analysis, comparison of different configurations, PID selectors, etc.

→ See session talks & summaries for details

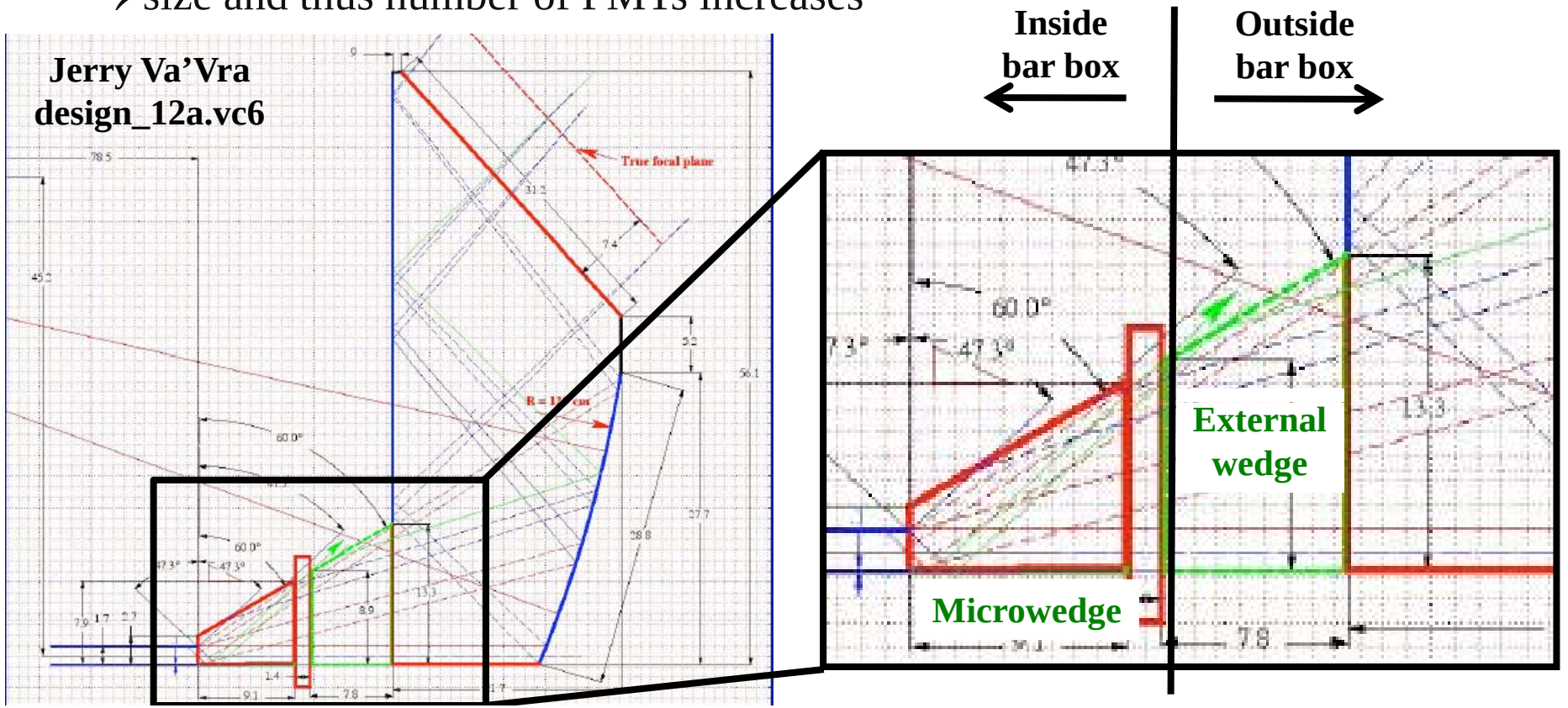
Summary in 1 Slide

- Manpower- and money-wise, the group is still not healthy but we're making progress
  → Welcome to LPNHE-Paris (1 physicist + 1 engineer, part-time involvement)
- Barrel PID
  - Updated design for the FBLOCK and its interface to the quartz bars
    → Geant4 simulation to compare designs and start estimating performances
  - Mechanical design studies in progress
  - Electronics: discussion about the technology (TDC/ADC vs. analog memories)
    first estimation of the number of links between detector and barracks
- SiPM tests
- Forward PID
  - Status of Novosibirsk FARICH
  - Summary of Orsay-Perugia meeting about mechanical interface on the forward side
  - First results of the 'DIRC-like' TOF simulation in Geant4
  - SLAC test of the Orsay electronics (analog memories) for ps-measurements
- Comparison of the overall performances of various PID detectors
  → Preparation for the White Paper

Barrel PID

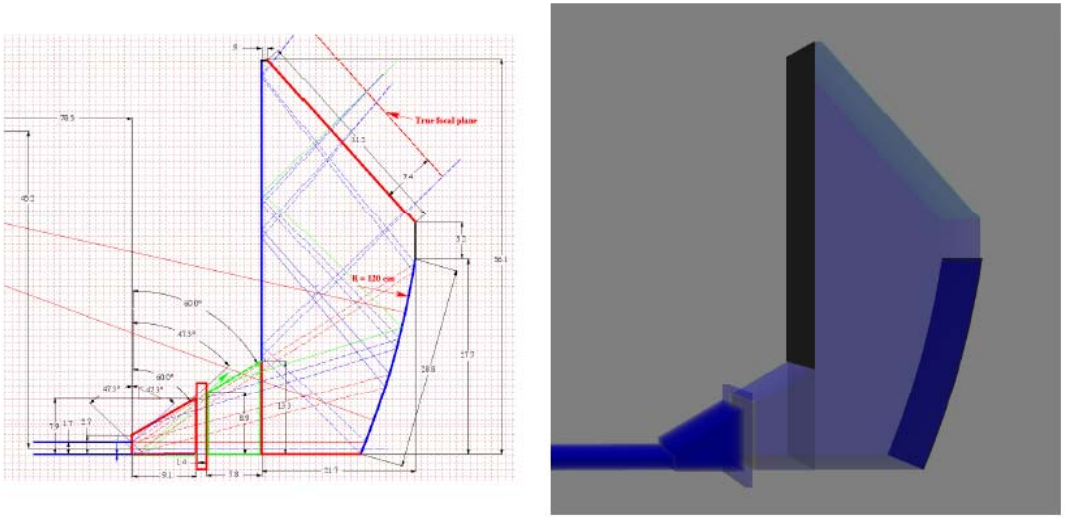
FBLOCK Design and Simulation

- New design presented by J. Va'Vra (SLAC)
  - Wedge too short in previous iteration
    → Not all rays reflected to good mirror area: unfocus rings, spurious reflexions, etc.
  - New design has an external wedge
    + a micro-wedge glued at the bottom (to remove a 6 mrad angle)
    → size and thus number of PMTs increases



FBLOCK Design and Simulation

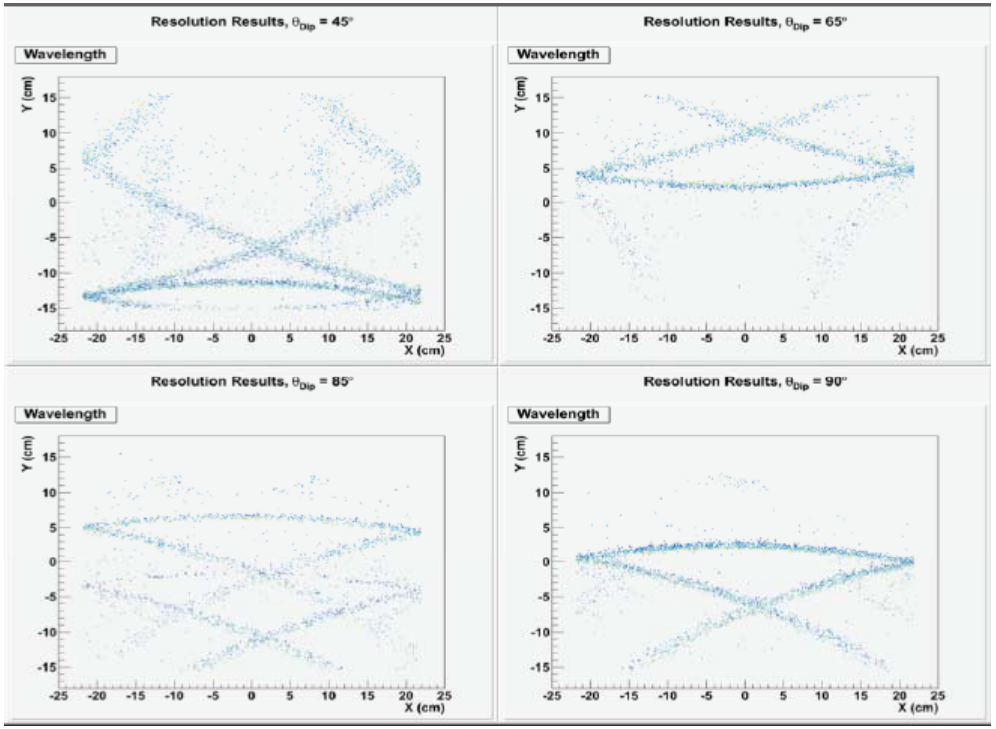
- New design implemented in Geant 4 simulation (D. Roberts, Maryland)



- Tests of the micro-wedge (any work inside the barbox will need strong justification) and of the glue joints (extra-reflections)
- Test whether photons reflecting of FBLOCK side should be kept
  → More photons but also more ambiguities
- Analysis in progress
  - No background
  - Procedure still being optimized
  - Timing information not optimally used yet

FBLOCK Design and Simulation

- Preliminary results
  - Better to keep photons reflecting on the FBLOCK sides
  - Glue joint effect is at ~8% (unavoidable)
  - Single photon resolution around 8.2 mrad for π (BaBar: 9.6 mrad for $\mu^+\mu^-$ events)
    $\rightarrow$ including 0.5 mrad gain from the micro wedge
  - θ_C resolution / track around 2.5 – 3.5 mrad depending on dip angle
    $\rightarrow$ 2.2 mrad required for a '3σ'-separation at 3 GeV/c



Examples of 'rings' for tracks at different dip angles

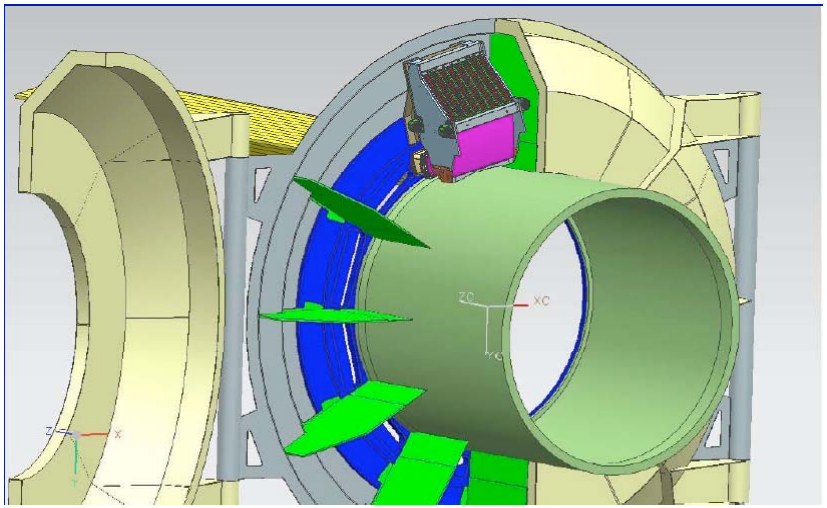
2000 events per plot, 4 GeV/c π

FBLOCK Design and Simulation

- One substrate candidate identified: Corning fused silica 7980
  → Potential issue: (in)homogeneity of the refraction index n

- 13 optical companies contacted for shaping and polishing
  - 2 did not reply; 4 rejected the offer
  - 1 offer consistent with budget
    → From the company which manufactured the DIRC bars
  - 2 more bids expected soon; 4 other companies still in the loop

- Work ongoing on the mechanical design of the FBLOCKs (M. Bennetoni, Padova)



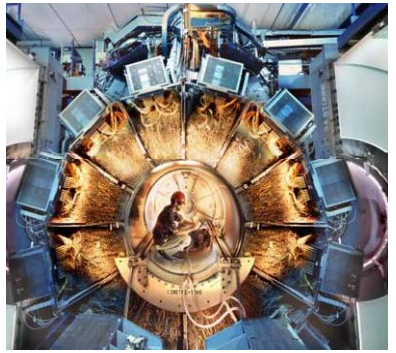
Updated design to be presented in March 2010 meeting

Barrel Electronics

- Two options: TDC (+ ADC) 'à la BaBar' / Analog memories
  → Comparison during the parallel session: inputs from D. Breton (LAL), J. Va'Vra (SLAC), G. Varner (Hawaii)
- Constraints:
  - ~ 30 000 channels / limited physical space to install electronics
  - ~ 150 kHz trigger rate
  - ~ 200 ns readout window
  - ~ 100 kHz PMT rate (preliminary)
- TDC (+ ADC) is the baseline solution; can we afford to use analog memories?
  → Choice has strong consequences on the number of DAQ links
- Analog memories provide a lot of information
  but: implementation not trivial, more computing needed, higher power consumption
- One potential issue with the TDC: the discriminator
  → Power consumption, random walk (may require charge to correct)

Barrel Electronics

- DAQ links
  → Based on ETD spreadsheet and the constraints listed in previous slide



- 1.5 – 2 links for TDC solution (~32 bits/hit w/o charge, ~ 48 with)
  → Barrel PID would be topology-driven just like the BaBar DIRC
  → The segmentation in 12 sectors provides a nice safety margin

- Different picture for analog memories: ~ 40× more bits/hit
  → Number of links scaling by the same factor!

⇒ Choosing analog memories would be a challenge; option not ruled out yet

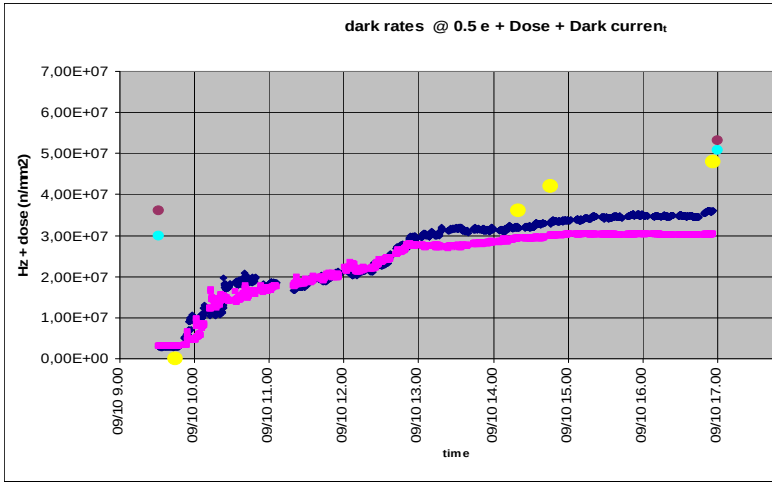
⇒ Important point is to get a better estimate of the PMT rate and to choose a conservative-enough safety factor (×5 – 10 ?)

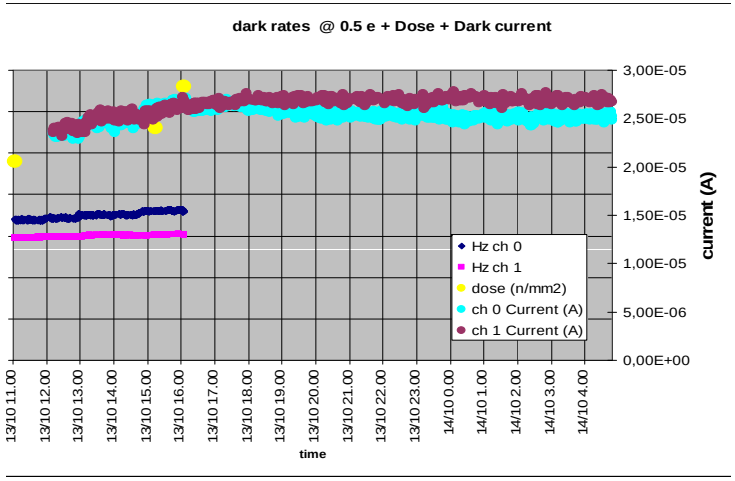
- Chip based on existing LAL 100 ps TDC will be tested in SLAC CRT
  - Two possible designs: include chip in existing module or develop a new module
    → Both solutions have pros and cons
  - Decision to be taken soon as these tests are targeted for next year

SiPM Tests

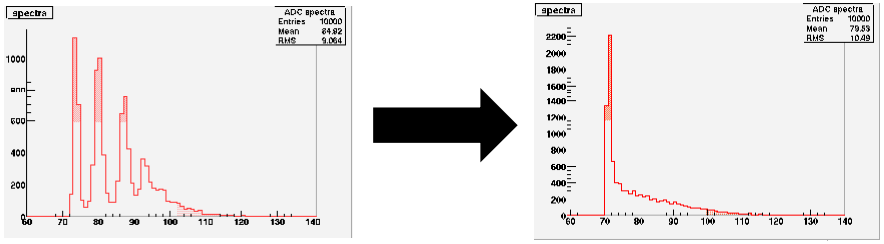
SiPM Tests

- Irradiation of 2 FBK 1 mm^2 SiPMs by neutrons @ Legnaro (F. Dal Corso, Padova)
- Dose ~ 6.8 10^9 n/cm^2
  → Small w.r.t. SuperB expectation ~ 10^{11} n/cm^2 /year [tbc]
- Most of the damages occur at low dose
  → New tests foreseen with a smaller dose rate

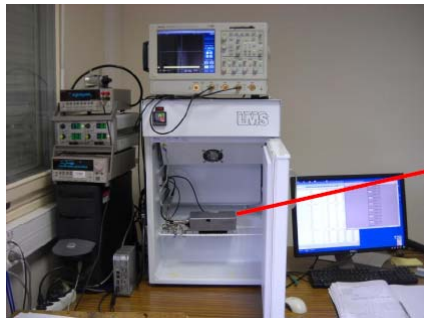




- Resolution gets strongly degraded as well
- No final conclusion yet: tests in progress



SiPM Tests

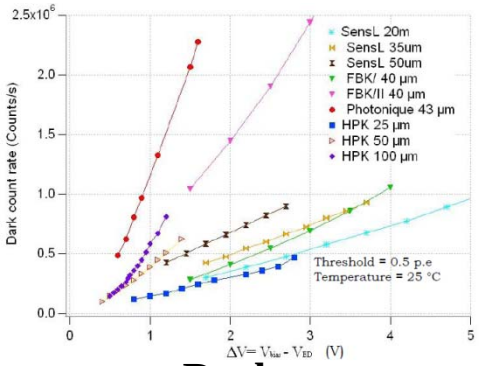


- Status of SiPM characterization @ LAL-Orsay (V. Puill)

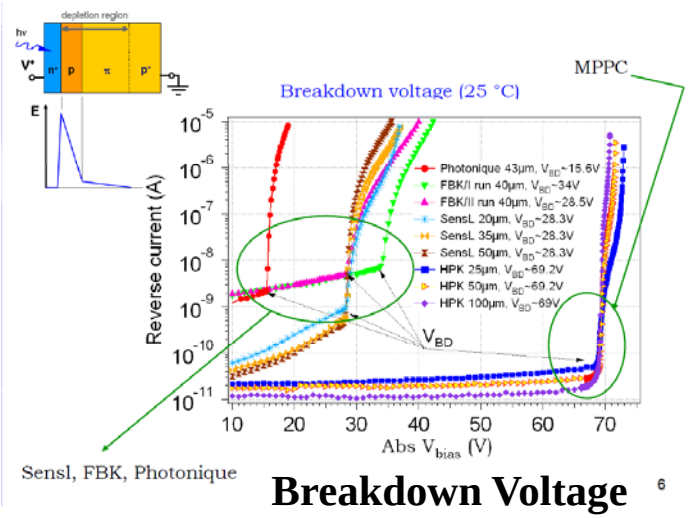
- Two test benches developed in the past
  - Dark Monitored Temperature test bench
    - → Operational voltage range (breakdown voltage + dark noise)
    - → Noise contributions: dark current, after-pulse, cross-talk
  - Optical test bench
    - → Dynamic range
    - → Photon detection efficiency = QE × Prob(avalanche) × fraction of sensitive area

      Measurements with continuous light or pulsed light (ongoing)

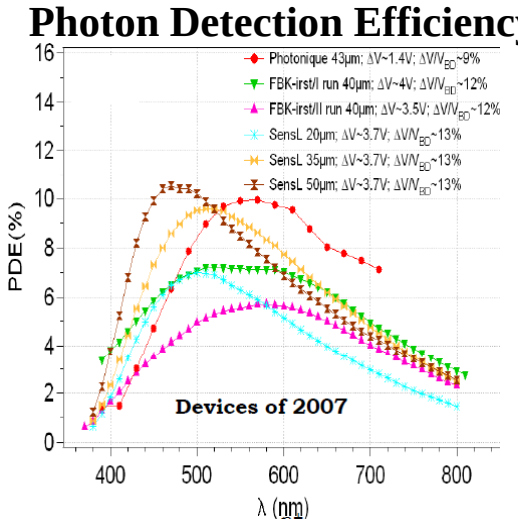
- Various SiPMs tested



Dark rate



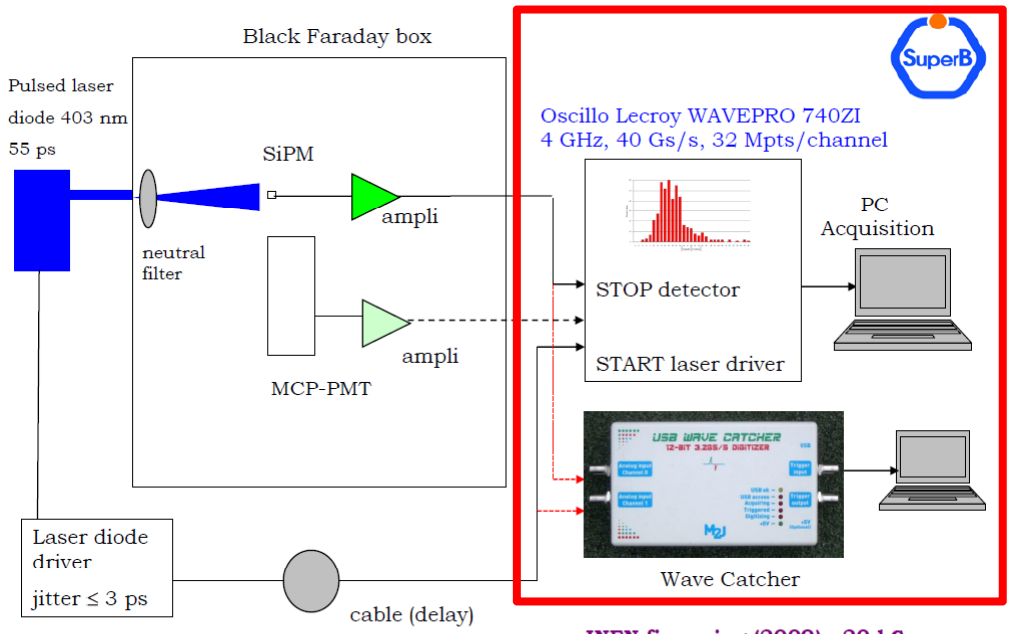
Breakdown Voltage



SiPM Tests

Double measurement in parallel

- New bench for timing studies
- Various detectors to be delivered in January: FBK, Hamamatsu, Photonique and Sensl SiPMTs; Burle MCP-PMT
  → Used for comparison
- SiPM timing measured versus
  - over voltage
  - wavelength (403 and 633 nm)
  - incident number of photons
  - light spot size and position
  - temperature
- IN2P3 & INFN co-funding at work ☺
- First results next year



INFN financing (2009) : 20 k€
+ IN2P3 financing 2009) : 50 k€

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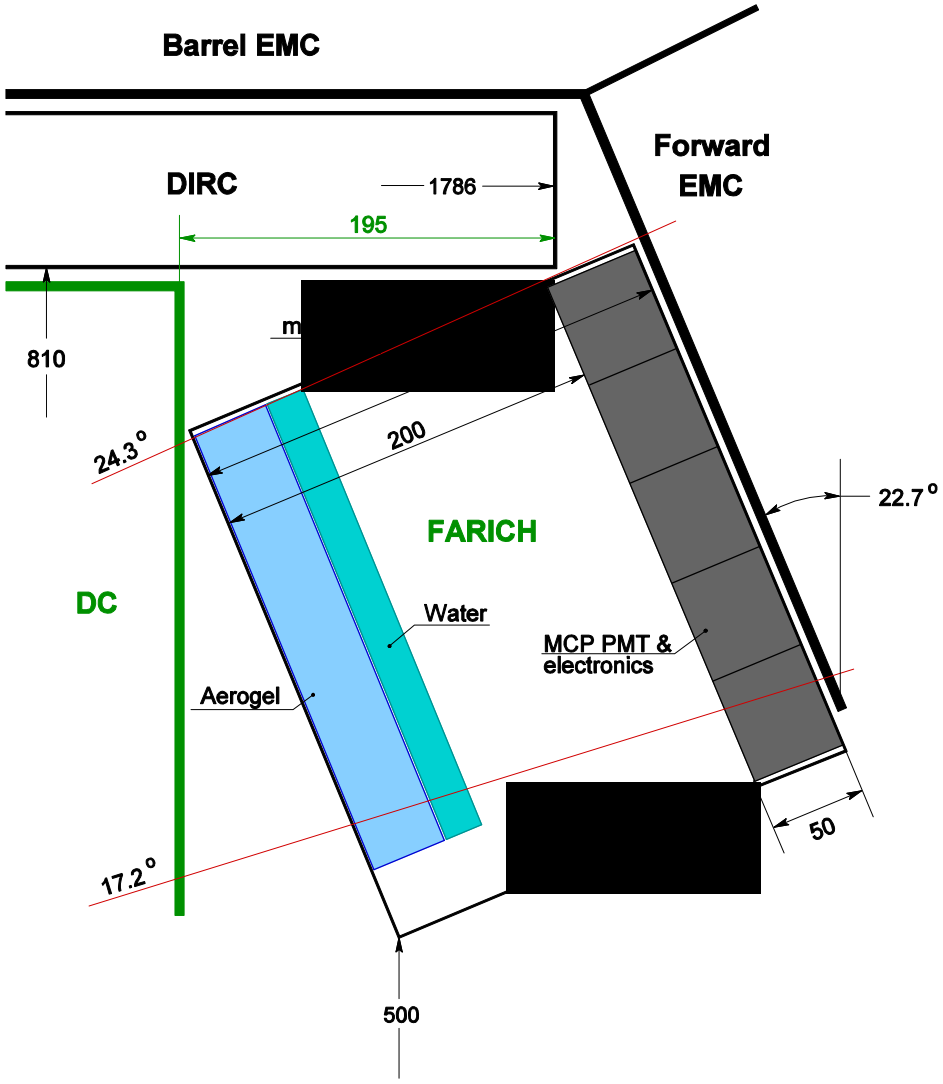
Forward PID

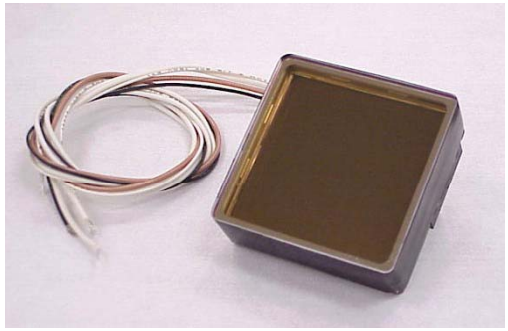
FARICH

- Update from E. Kravchenko (Novossibirsk)



- Requires a DCH shorter by ~20cm
- ~450 MCP-PMT
  → ~ 115 000 electronics channels
- ~28% X_0
- Excellent π-K separation > 0.6 GeV/c
- Momentum measurement at ~% level
- Study in standalone MC
  → FastSim implementation asap
- Cost and number of electronics links are being estimated

FARICH



- Update on MCP-PMT ageing test (from P. Krizan):
  10% drop in efficiency after 400 mC/cm^2

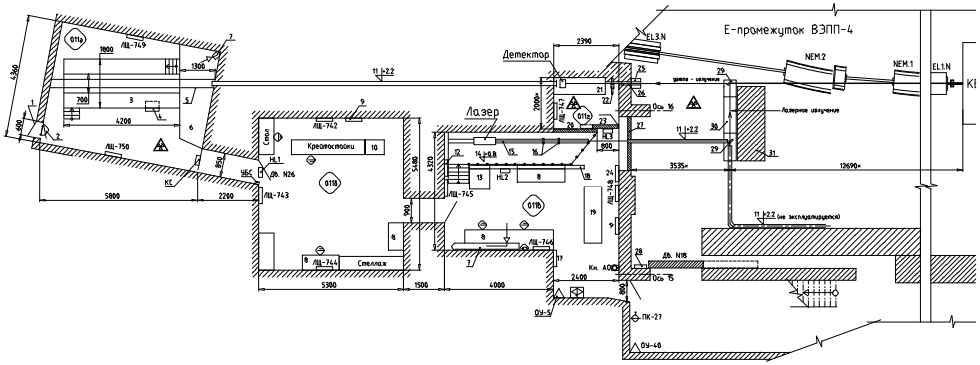
→ What is the expected SuperB rate?

Back of the envelope calculation:
2 kHz/cm^2 (charged tracks) × 60 photons (FARICH) × 5 10^5 (gain) × 10^8 s (10 years)
⇒ integrated charge ~ 1 C/cm^2 [to be updated when bkg estimates get updated]

- Burle is aiming at delaying this effect by a factor 5
- Dose integrated much quicker for this test than in real life
- Actual conditions of the test?

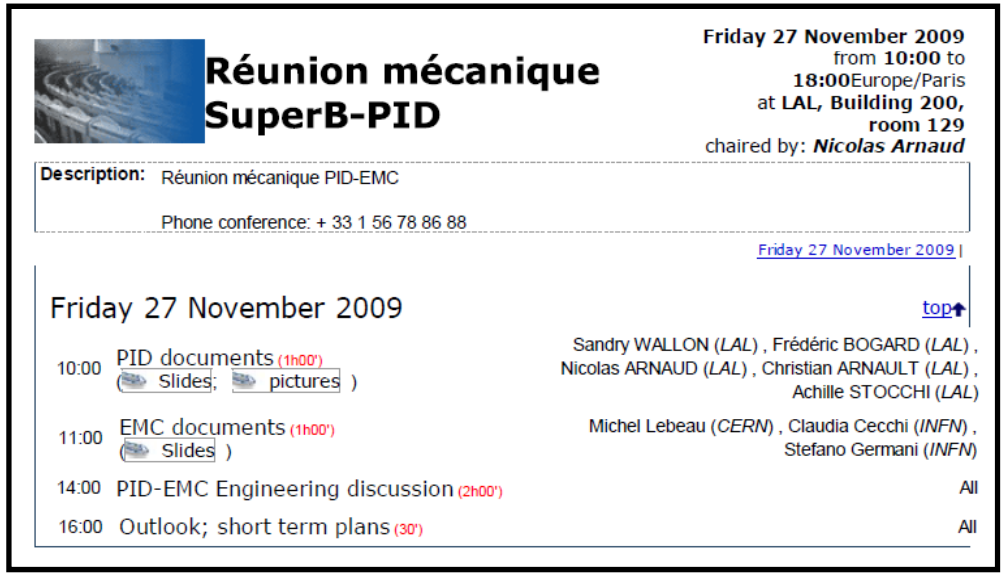
} **To be followed**

- Preparation of test beam at VEPP-4M
  → Tests with pulsed laser and SiPM will start early next year while the experiment gets assembled



Orsay-Perugia Engineering Meeting

- Fruitful meeting between Orsay engineers (F. Bogard, S. Wallon) and Perugia experts (M. Lebeau, S. Germano)
- Indico webpage: http://indico.lal.in2p3.fr/conferenceDisplay.py?confId=926



Réunion mécanique SuperB-PID

Friday 27 November 2009
from **10:00** to **18:00**Europe/Paris
at **LAL, Building 200, room 129**
chaired by: ***Nicolas Arnaud***

Description: Réunion mécanique PID-EMC

Phone conference: + 33 1 56 78 86 88

Friday 27 November 2009 |

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10:00	PID documents (1h00') (Slides; pictures)	Sandry WALLON (*LAL*) , Frédéric BOGARD (*LAL*) , Nicolas ARNAUD (*LAL*) , Christian ARNAULT (*LAL*) , Achille STOCCHI (*LAL*)
11:00	EMC documents (1h00') (Slides)	Michel Lebeau (*CERN*) , Claudia Cecchi (*INFN*) , Stefano Germani (*INFN*)
14:00	PID-EMC Engineering discussion (2h00')	All
16:00	Outlook; short term plans (30')	All

- Outcome: definition of a common mechanical interface
  → Orsay design to be updated accordingly
  → Basis for future designs more accurate & realistic
- Limited manpower on both sides
  → Mandatory collaboration

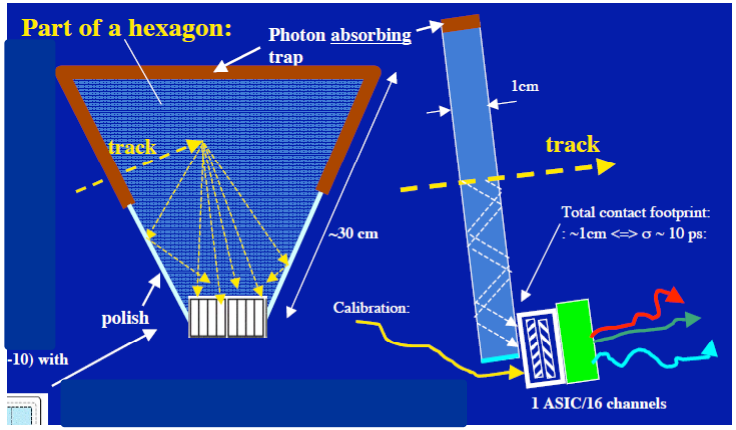
‘DIRC’-like TOF Geant4 Simulation

- First results shown by L. Burmistrov (LAL-Orsay)
  → Collaboration with Taras Shevchenko University (Kiev, Ukraine)
  → Starting point: D. Roberts G4 simulation code for the FBLOCKs, inherited from SLAC fDIRC prototype

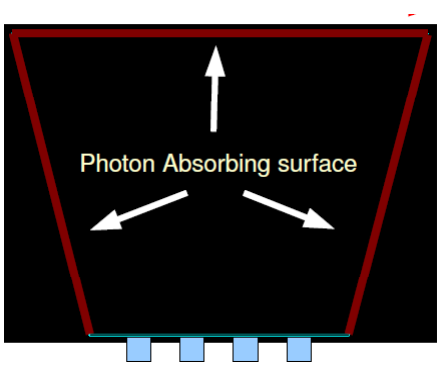
- Use time of flight to separate charged particle species
  ~ 25 ps resolution for ‘3σ’ separation @ 3 GeV/c [L ~ 2 m]

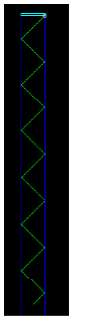
$$\Delta t = \frac{Lc}{2p^2}\Delta m^2$$

- Jerry’s design (Perugia; update @ SLAC)



- Design simulated so far:





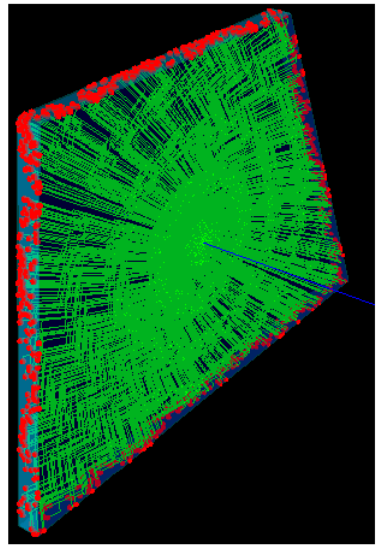
12 mm width

→ Different geometries & configurations to be studied in the near future

‘DIRC’-like TOF Geant4 Simulation

- $\Delta t = t_{stop} - \boxed{t_{start}}$

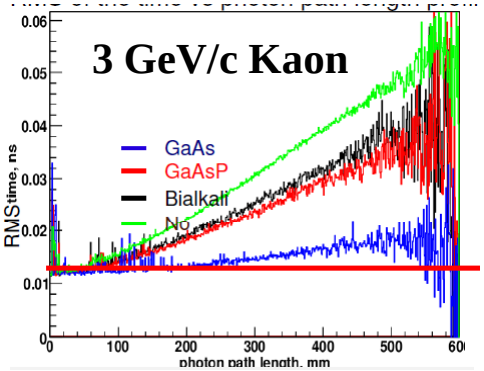
Driven by T_0 accuracy: σ_{T0} ~ 15-25 ps

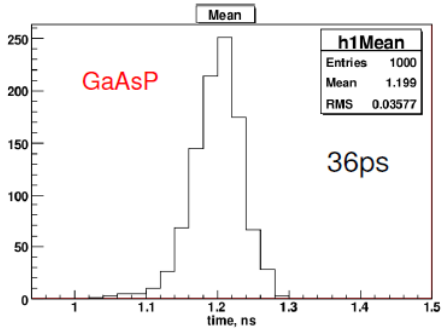


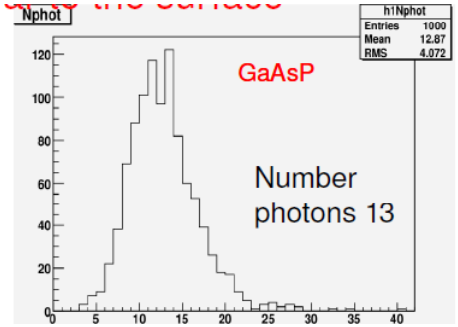
→ Study focusing on t_{stop}, ‘time of photons arrival in PMT’

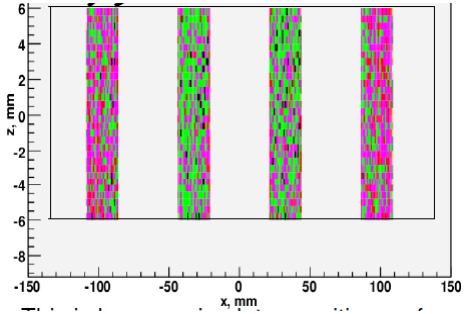
- Various effects impact the accuracy on t_{stop}:
  - Electronics
  - PMT TTS
  - Photon ‘collection efficiency’ (QE, active area fraction, photocathode)
  - Chromaticity (photon propagation speed depends on wavelength)
  - Quartz thickness

    → N_{phot} + time spread coming from the track transit in the bar (up to tens of ps!)









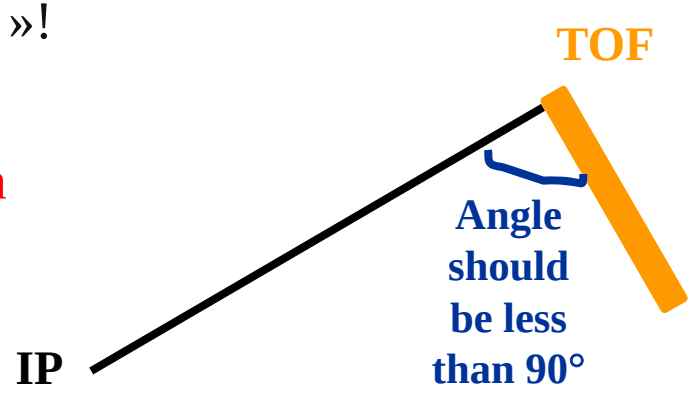
New 'DIRC'-like TOF Geant4 Simulation New

- 'Kravchenko effect': light emitted by low-momentum kaons (up to ~1.2 GeV/c) perpendicular to the quartz surface is transmitted instead of reflected
  → Obvious (but unexpected) effect, confirmed in simulation

- Possible fixes:
  - add a mirror behind the quartz
    → reflectivity ~92%, so part of the photons still lost
  - tilt more the quartz surface
    → Take more space in z, potential impact on EMC (gap between detectors would depend on radius)
  - others!?

- Quartz surface orientation is clearly a key parameter for this detector
  - There must always be photons going « downward »!
  - Consequences for the PID-EMC interface

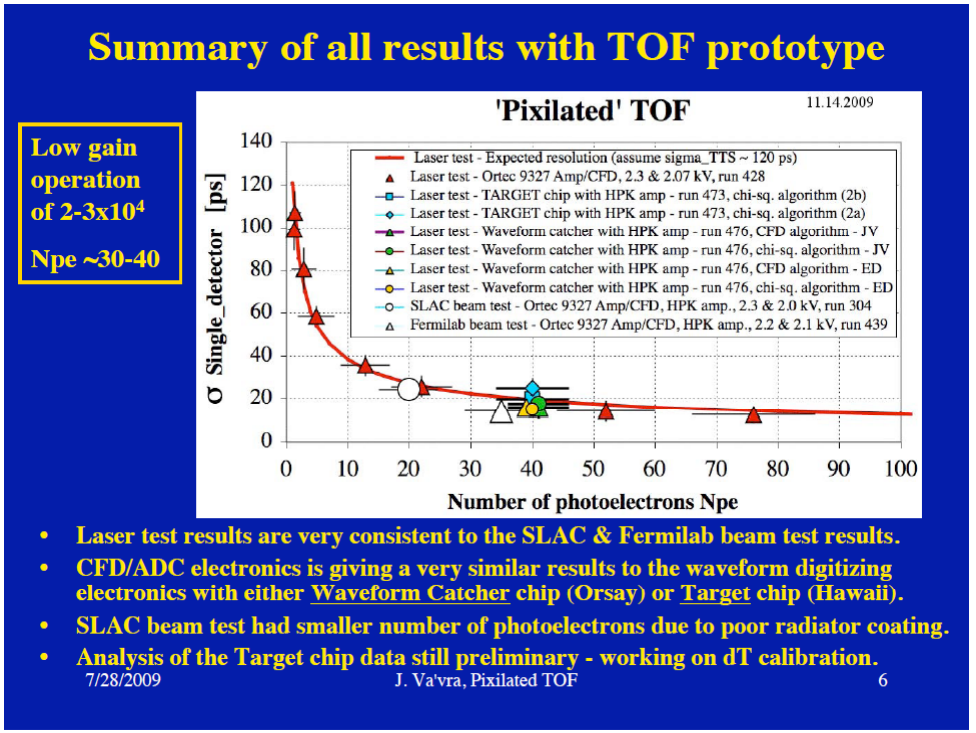
⇒ To be studied in simulation, updates expected soon



Orsay Electronics Tests at SLAC

- Orsay USB_WaveCatcher prototype board given to Jerry in October
  → Tested in the same setup as Hawaii and commercial electronics (Ortec)
  → Software (board control + acquisition system) running on Jerry's computer
- Data collected and analysed both at SLAC and in France
  → Different methods used; consistent results achieved (see Jihane's and Jerry's talks)
- Analog memories suited for ps timing

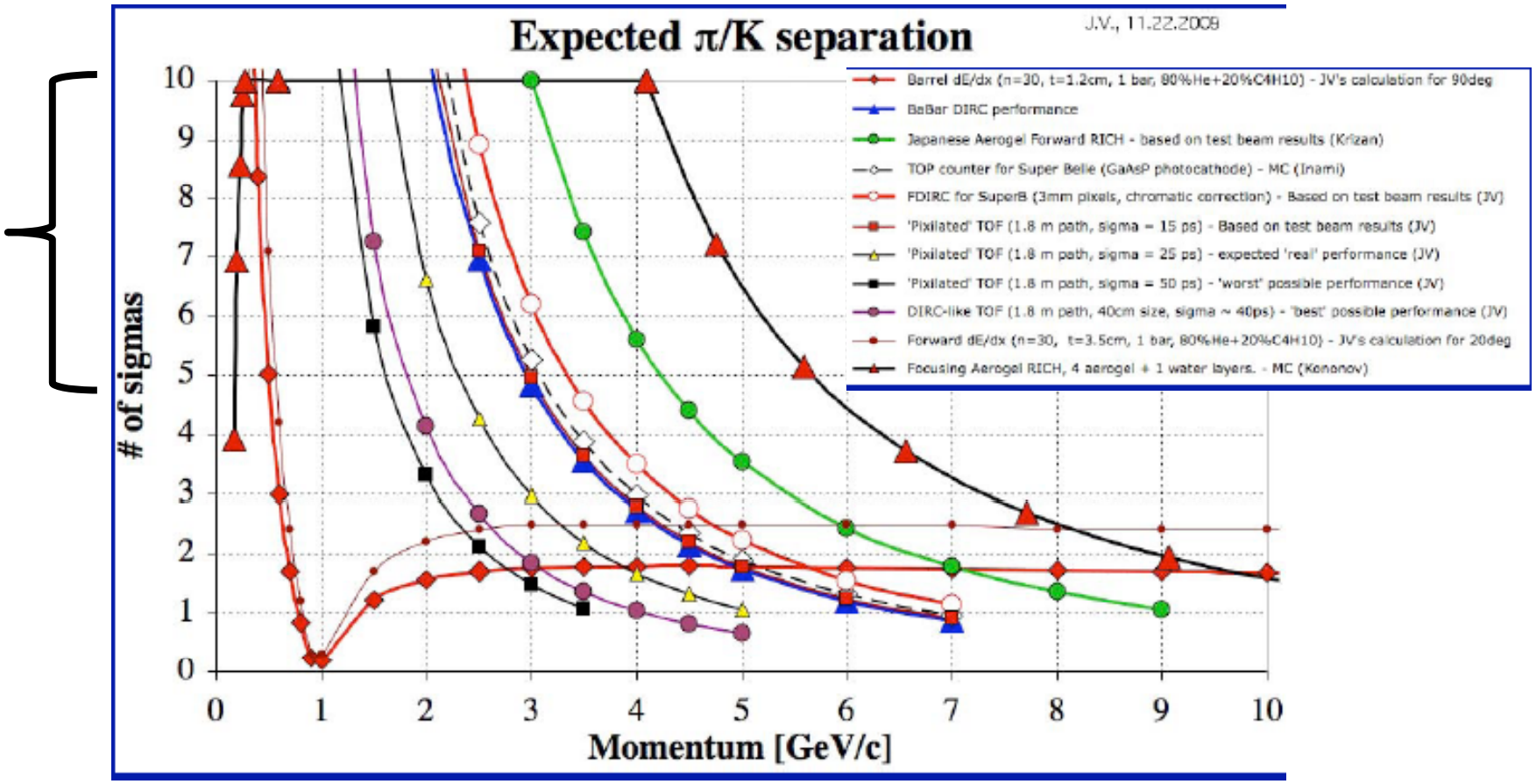
Jihane & Dominique @ SLAC



PID Detector Performances

Comparison of overall PID detector performances

- Jerry's compilation of results using various sources



- Caveats: 'simple' calculations less accurate than full MC simulations
  real world not Gaussian ⇒ 'sigmas' don't translate simply to performances

  → Yet, a way to get an idea of the differences between technologies

Conclusions

Outlook

- Significant progresses on the detector side
  - Interplay between designs and Geant4 simulations
  - Mechanical designs

- Mature and high-level discussions on electronics
  - Narrowing down the technology options for barrel and forward
  - Test of existing devices in CRT at SLAC
  - New prototypes to be available next year

- PMT tests in progress
  → New test benches (Maryland, LAL) available soon

- Still far from closing on the forward PID (yes/no, geometry choice)
  - Large amount of valuable work already completed
  → Manpower was/is/will remain the main limiting factor
  - Updated results expected for the March meeting in Annecy