Focusing Aerogel RICH with SiPM Photodetectors

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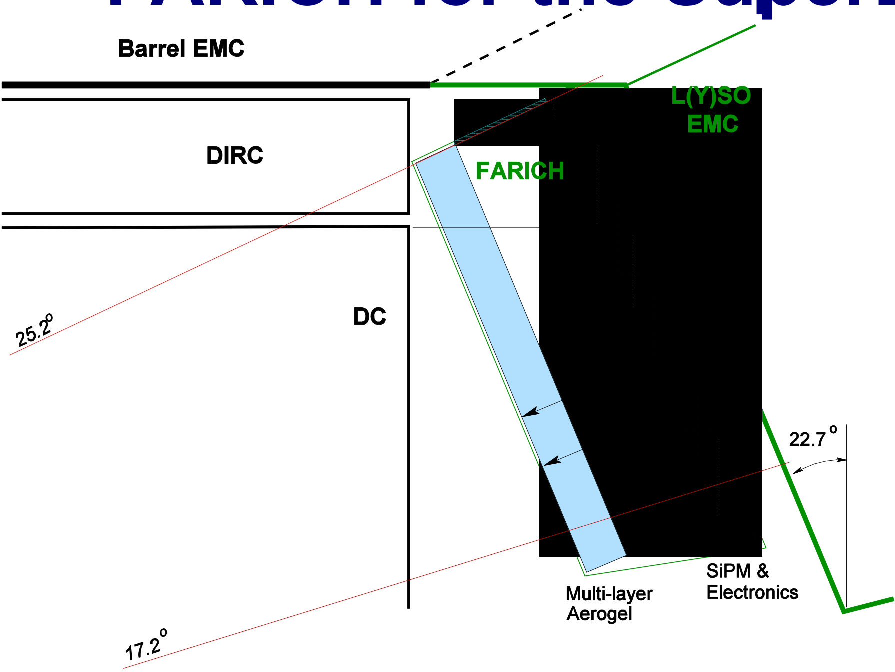
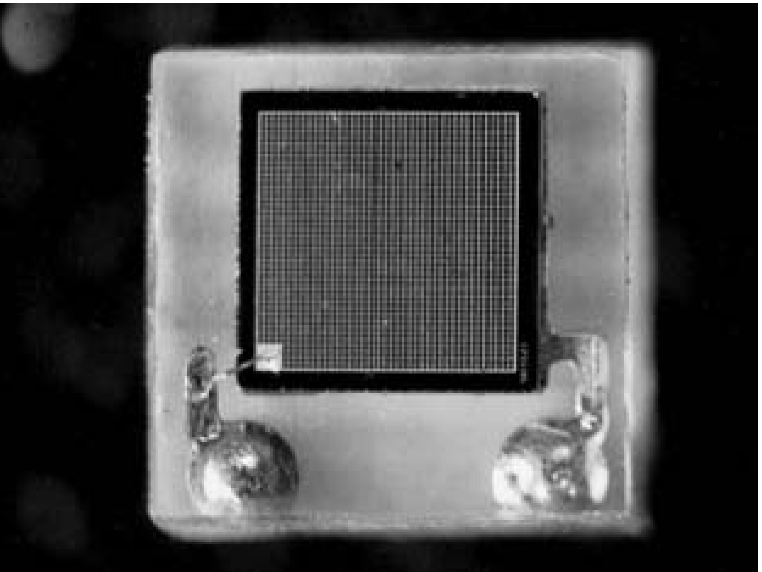
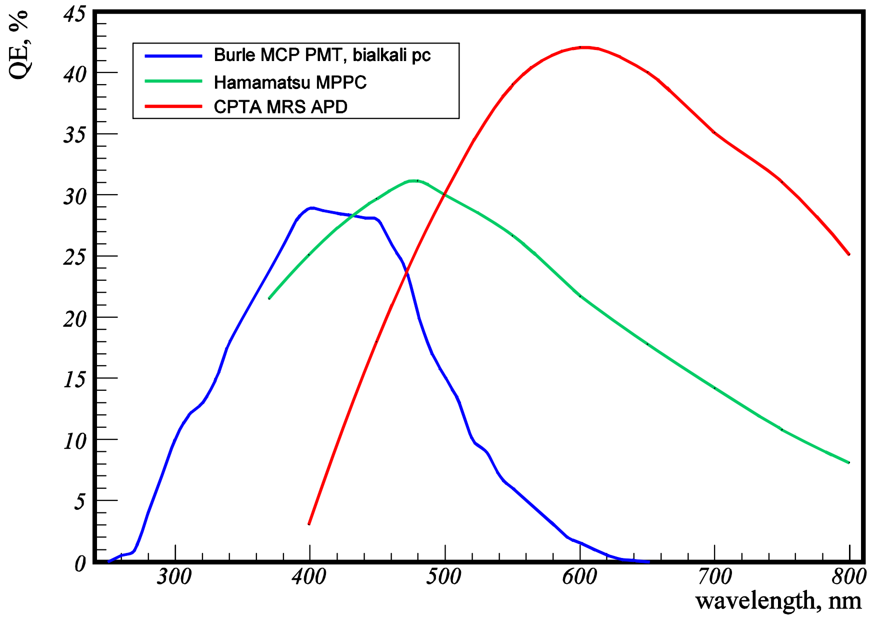
FARICH for the SuperB detector (MRS APD)

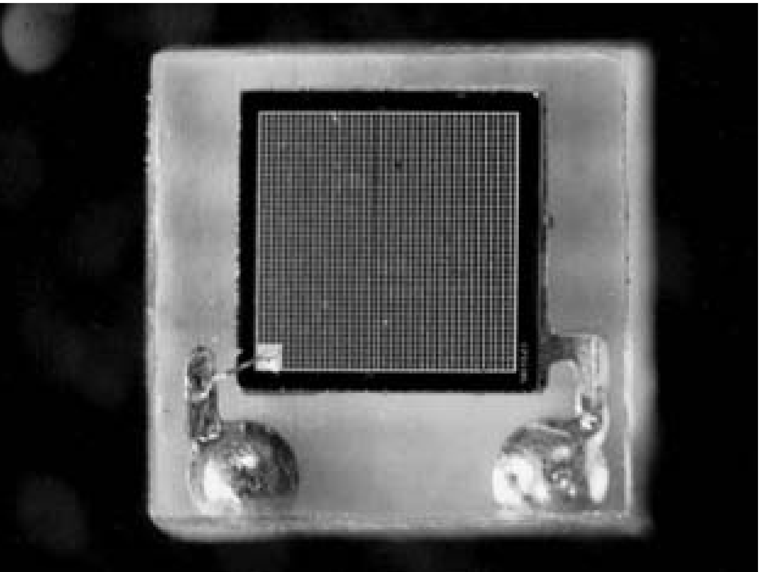




- CPTA MRS APD (Moscow) --- silicon photomultiplier
  - 2.1x2.1 mm sensor
  - 3x3 mm case size (50% active/total area)
  - PDE=40% @ 600 nm
- 3-layer focusing aerogel, n_{max}=1.07, total thickness 25 mm
- Number of channels – 160000
- Amount of material, (X_0) = 3%(aerogel) + 1%(SiPM) + 6% (electronics,cooling, support, cables) = 10% !

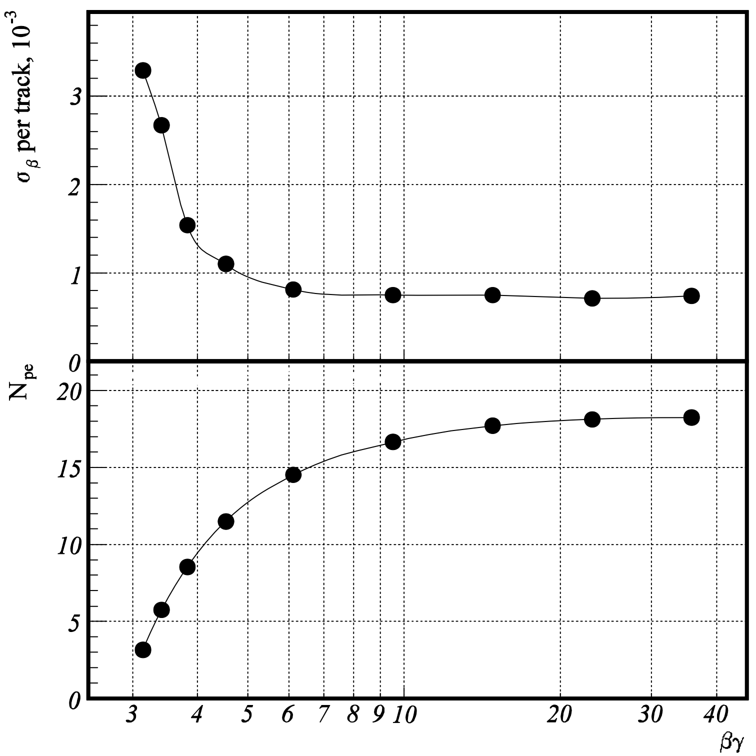
MRS APD parameters

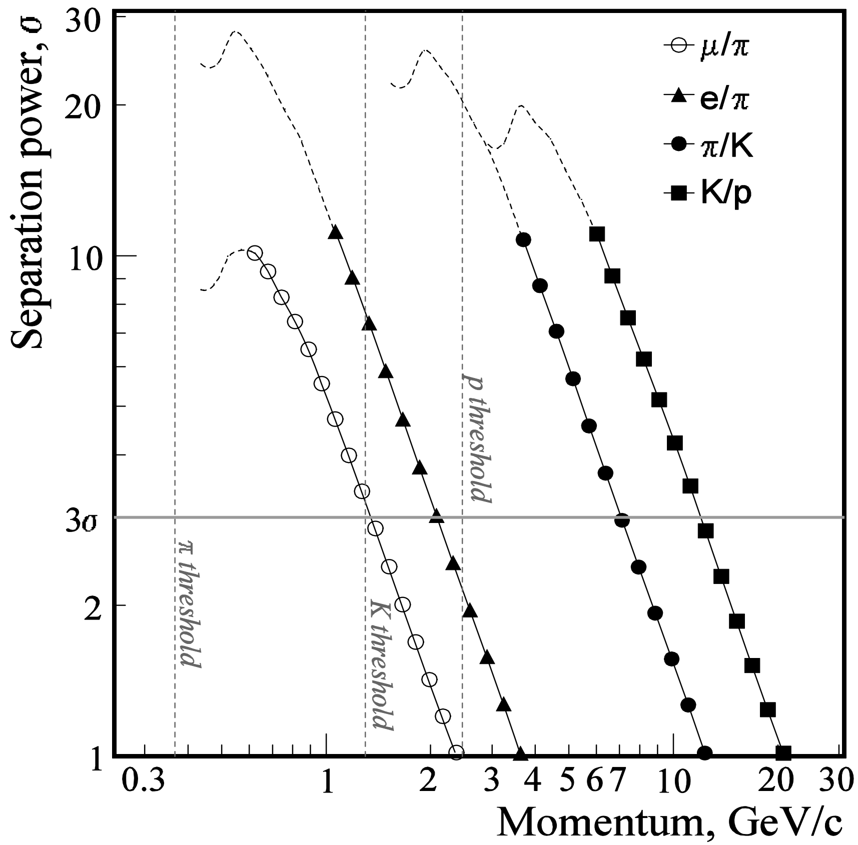




- Producer - Center of Perspective Technology and Apparatus – CPTA, Moscow http://www.spta-apd.ru/
- Genuine name - MRS APD (other names:SiPM, PPD, MPPC…)
- 2.1x2.1 mm sensor
- 4x4 mm case size (could be reduced to 3x3 mm)
- PDE=40% @ 600 nm
- Gain ~ $4 \cdot 10^5$
- Time resolution ~100 ps
- Dark counts ~10 MHz (0.5pe threshold, room temperature)

FARICH expected performance, Monte Carlo results



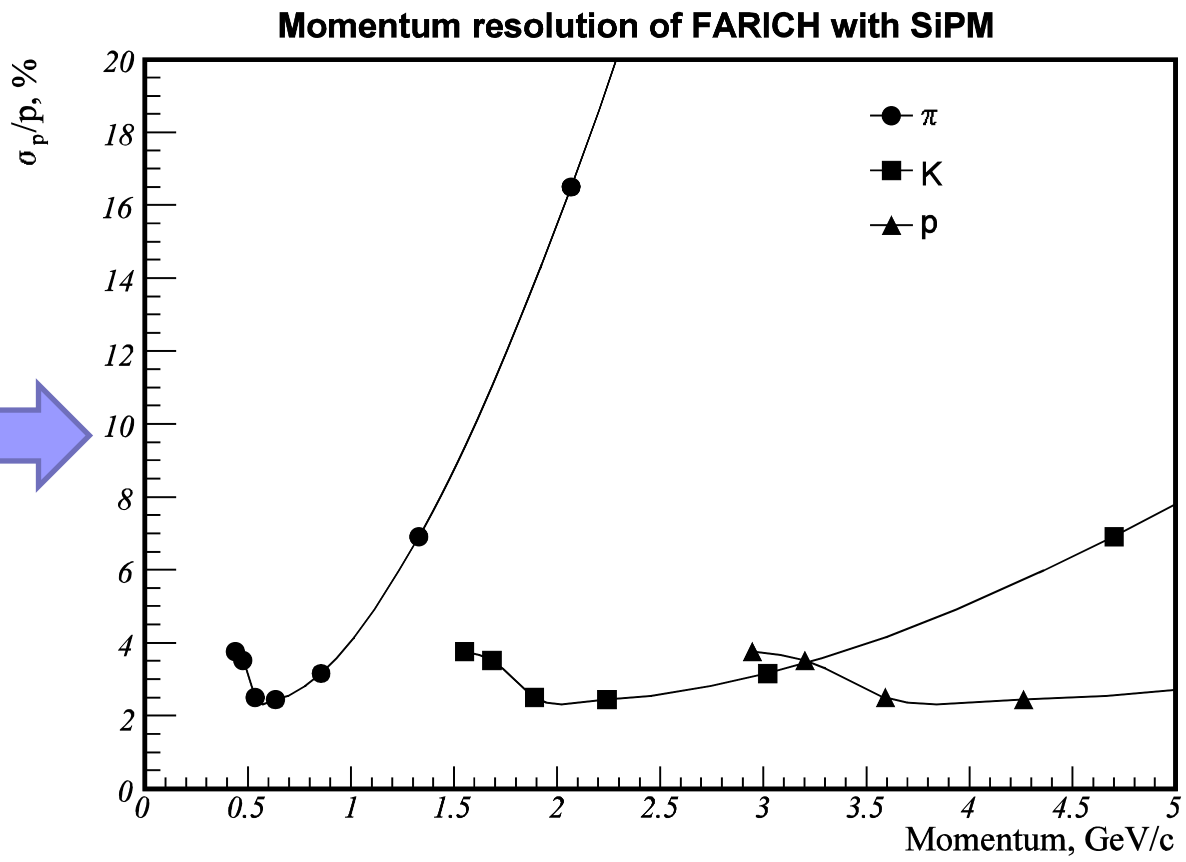


- N_{pe} = 18
- $\sigma\beta/\beta = 8\cdot10^{-4}$

FARICH momentum resolution

$\sigma\beta/\beta = 8 \cdot 10^{-4}$

$\sigma P/P = \gamma^2 \cdot \sigma\beta/\beta$



Potentially this could be the very strong argument for Forward PID

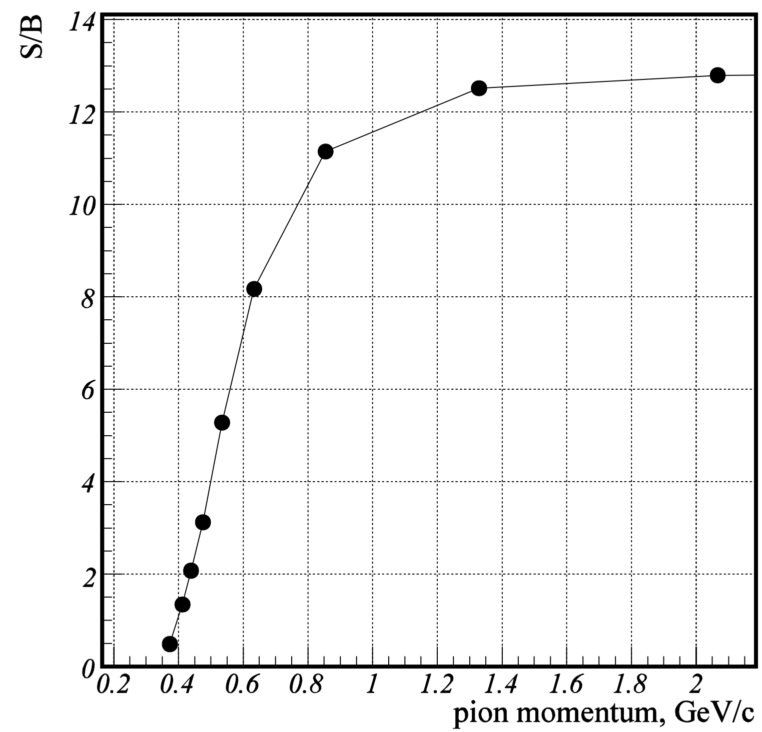
What about noise?

Estimation

$S/N=N_{pe}/(N_{px}\cdot f_n\cdot \tau)$,

where :

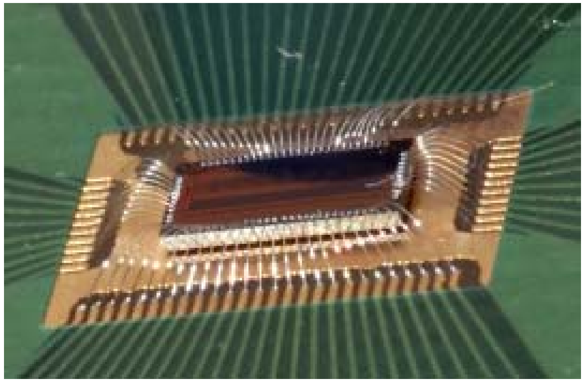
- N_{pe} – number of Cherenkov photons,
- N_{px}= ring area/(pixel size)^2 – number of pixels in the ring of the width $\pm 3\sigma_r$,
- f_n – noise rate,
- τ – time window.

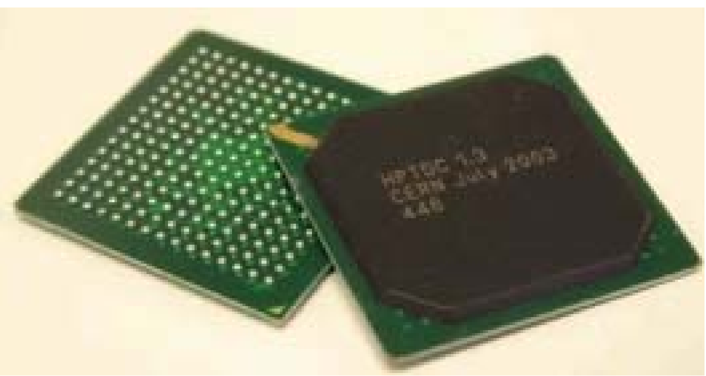


f_n = 10 MHz

τ = 1 ns

Suggestion for the read-out electronics





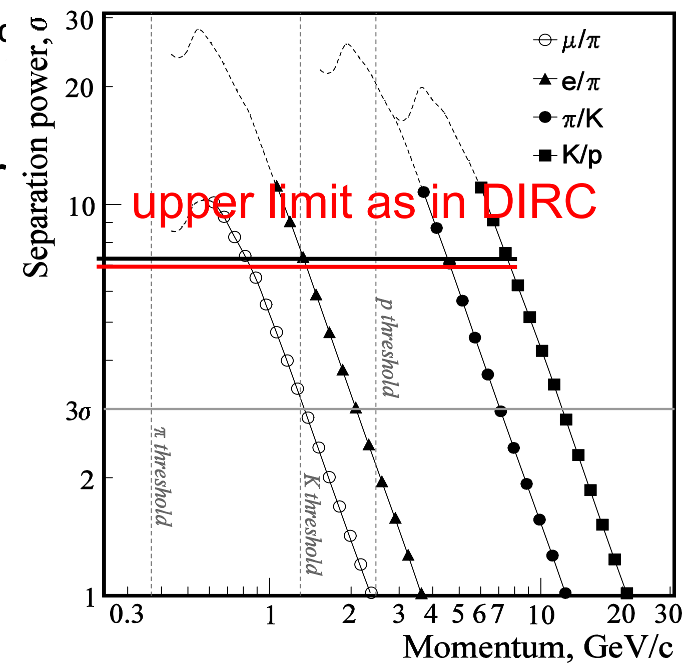
CERN has developed for ALICE TOF high performance chips (high rate, small dead time):

- 8-channel NINO ASIC chip (very high rate >10MHz, low power front-end amplifier discriminator)
- 32-channel HPTDC ASIC chip (programmable TDC with clock period between 25ps to 800ps, 5 ns dead time, up to 16MHz)

Work on Fast MC simulation

Results of Alexey Berdyugin visit to Padova.

- Geometry description is done:
  - Aerogel – 3 cm, 3% X_0
  - 7 cm gap
  - 5 cm for photodetector block, (NEMA G10 – 4
    3% X_0)
- Hit information is prepared (particle type, coor



Tasks for the second visit (March):

- To add the identification
- To add the momentum measurement

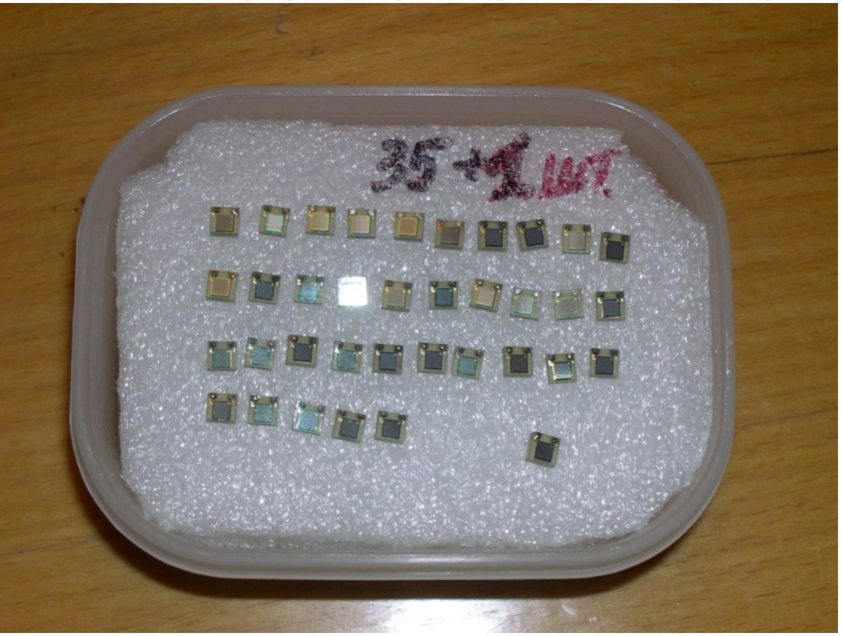
We are planning the second visit of Alexey to Padova in March.

The Fast MC with Forward PID option will be ready for the

SiPM radiation hardness

- Need to be carefully investigated:
  - What will be the neutron flax in SuperB? MC simulation of background conditions is needed.
  - Is it possible to use shielding?
- It is known that the main effect from the irradiation is the increase of dark noise rate:
  - We need fast, small dead time electronics.
  - Cooling will help
  - Optical collection devices could increase signal to noise ratio.

What we have for the test beam and prototype



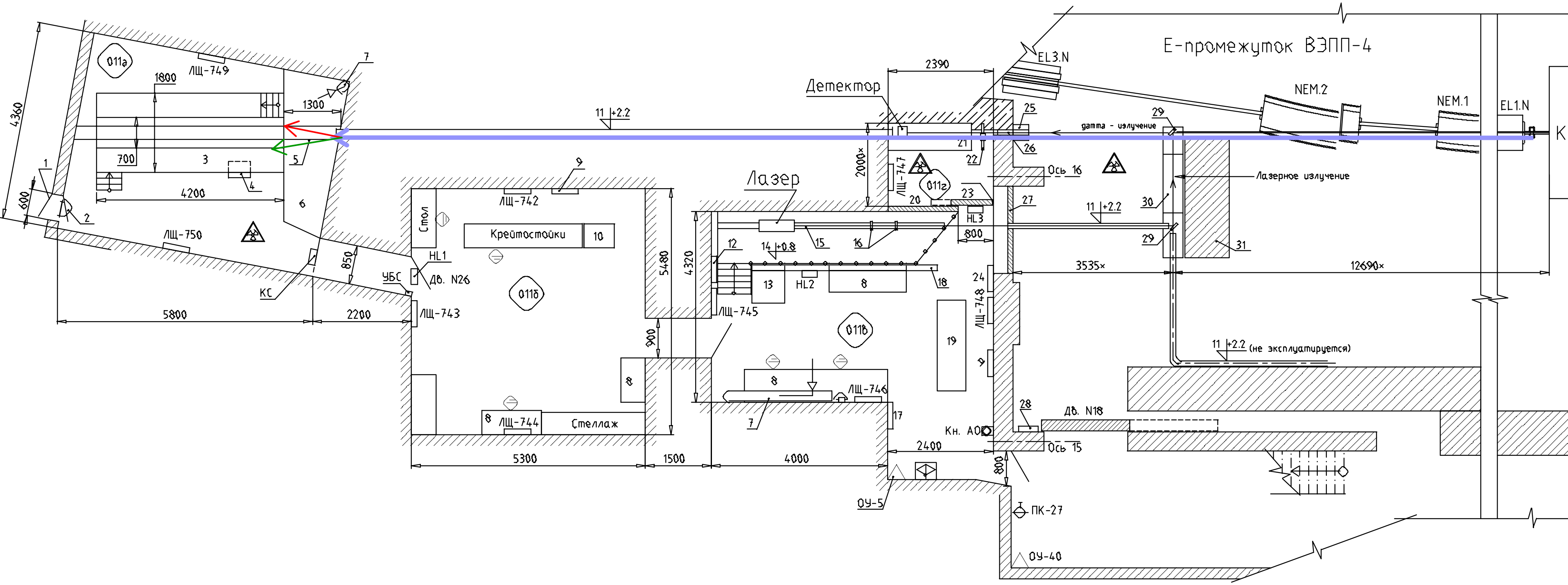
- 35 MRS APD for the first stage

64 channel TDC
CAEN - V1190B
Based on 2 HPTDC chips

Our plans

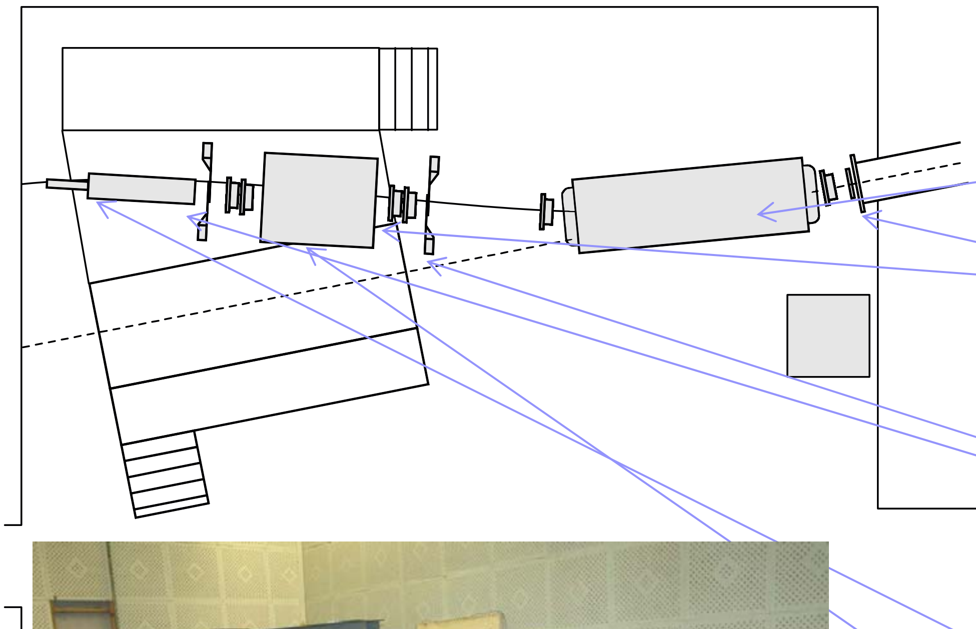
- Prototype – to make the first test with the beam at the end of 2009
- Fast MC – Forward PID description will be ready for use in April

Test beam at VEPP-4M, Novosibirsk



- E_{max}beam = 5.5 GeV
- We insert the converter in the beam halo to receive bremstrahlung gammas
- We convert gamma-quants to electron-positron pairs in the target.
- To select electrons (positrons) with the required energy we use the magnet

Test beam apparatus



- Magnet
- Coordinate chambers
- Veto and trigger counters
- NaI calorimeter
- FARICH prototype

What we have for the test beam and prototype

- Experimental hall reconstruction is n progress.
- Magnet+power supply (B = 1.5 Tesla)

Our plans for the test beam

- Magnet will be ready in April-May
- Prototype will be ready at June-July
- The first experiment – November-December 2009
- MRS-APD tests and characterization we are planning to do together with Padova group

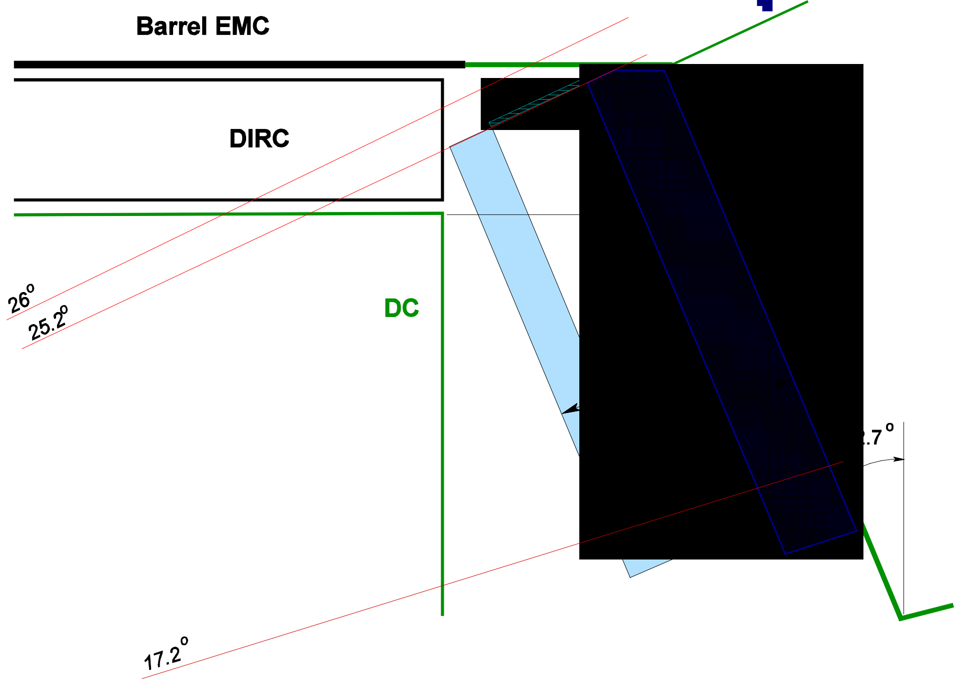
Plans on forward PID fast simulation

o Alexey Berdyugin will come to Padova next week (Visit is supported by Padova group).

- Geometry and material description
- PID performance according to MC simulation

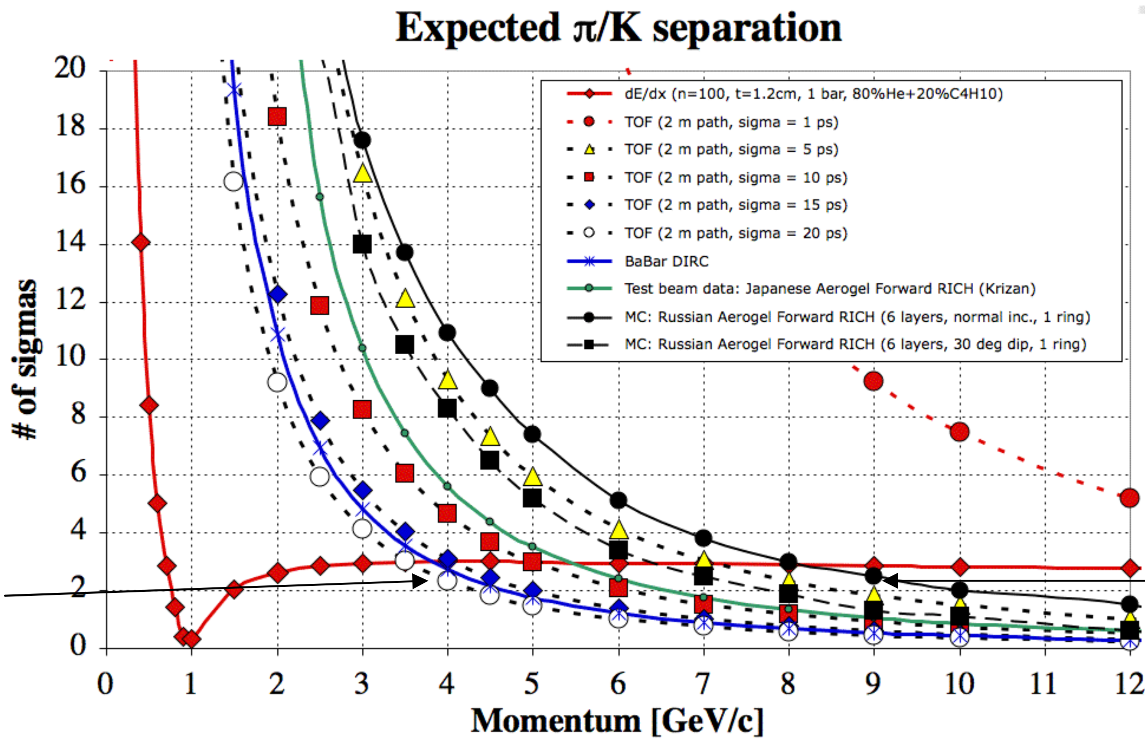
Additional slides

FARICH for the SuperB detector (MCP PMT)



- Burle MCP PMT with 3x3 mm pixels (16x16 matrix), photoelectron collection efficiency 70%, geometrical factor 85%
- 3-layer focusing aerogel, n_{max}=1.07, total thickness 30 mm
- Number of PMTs - 550
- Number of channels – 140000
- Amount of material, (X_0) = 3.5%(aerogel)+14%(MCP PMT)+5÷10% (support, electronics, cables) > 23÷28% !

Forward TOF and FARICH comparison



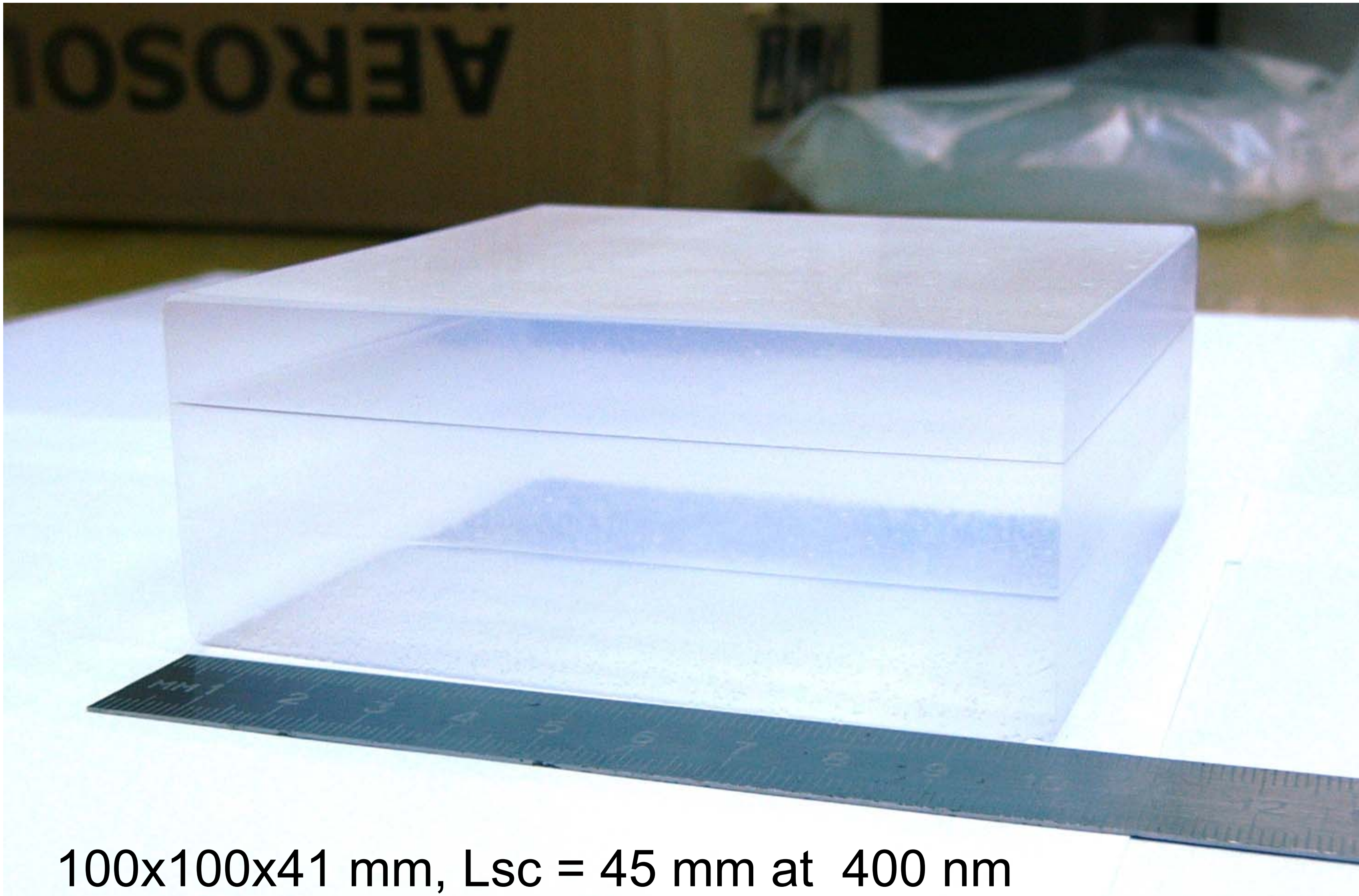
TOF

FARICH

Pro	Contra
■Much better π/K,μ/π,e/π identification ■Momentum measurement improvement in the forward ■Better background endurance	■15 cm of additional space ■10 times more channels ■Price (?)

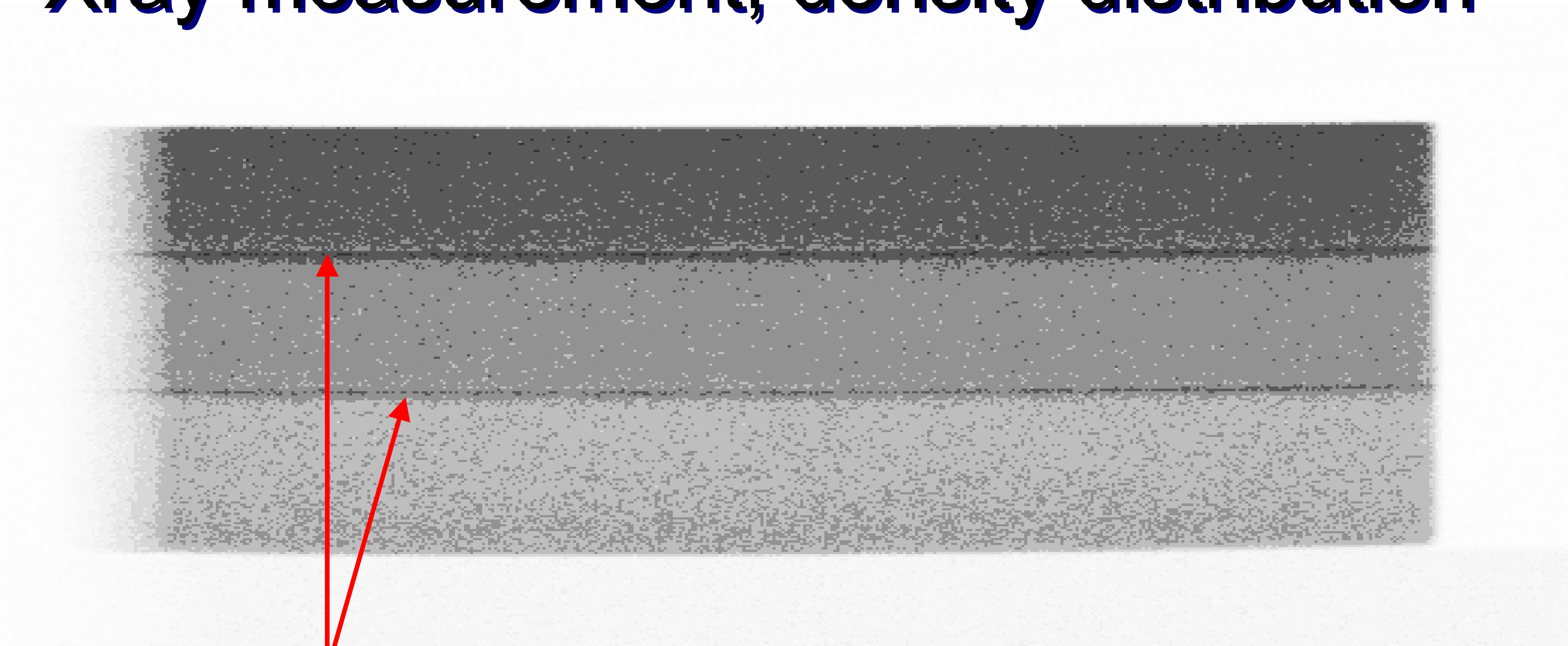
The amount of material is almost the same

Multilayer aerogel characterization



100x100x41 mm, Lsc = 45 mm at 400 nm

Xray measurement, density distribution



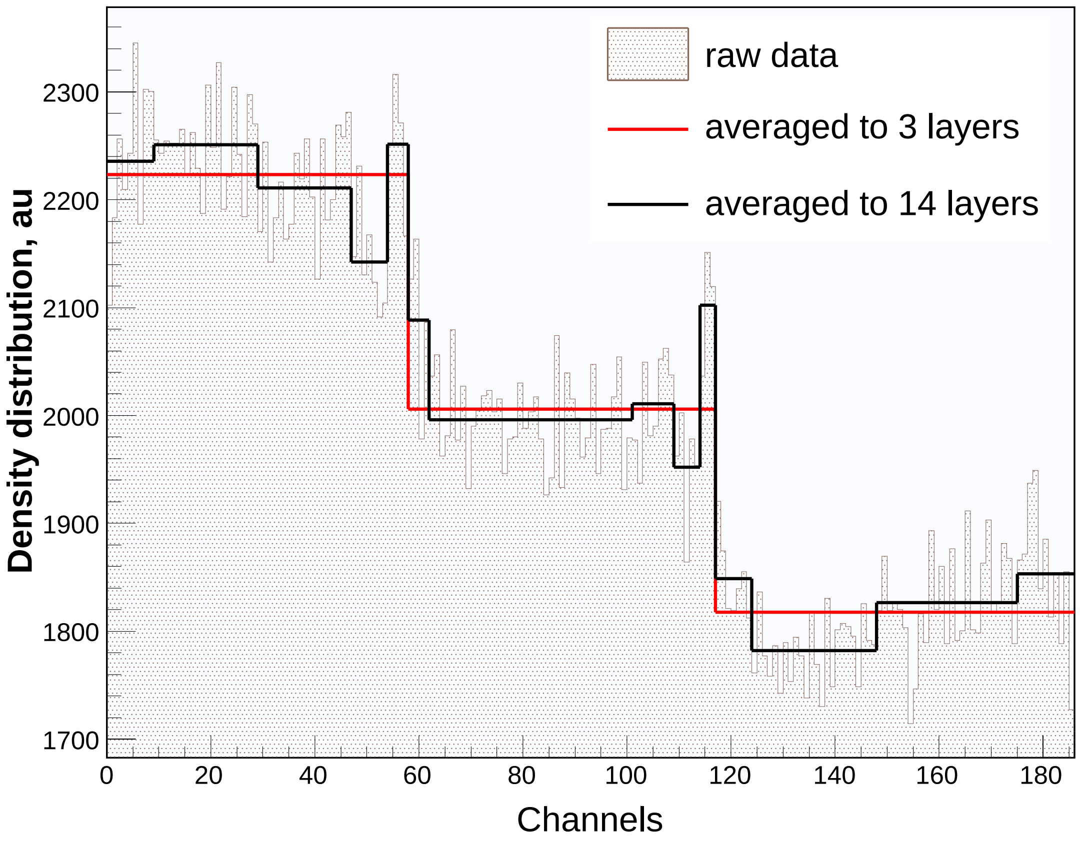
The increase in density at the internal borders is the result of the production procedure (diffusion).

Does it effect the performance?

Layer	<n>	n, (optimal)	n, (design)	h, mm	h, mm (design)
1	1.046	1.046	1.050	12.6	12.5
2	1.041	1.040	1.044	13.2	13.3
3	1.037	1.035	1.039	15.2	14.2

Monte Carlo simulation of longitudinal refractive index fluctuations

- 200 mm expansion gap
- 3 types of radiators
  - 3layer as designed (ideal)
  - Xray data avereged to 3 layers
  - Xray data avereged to 14 layers



Simulation results, π/K separation

- Npe =14
- σ_β = $5 \cdot 10^{-4}$
  - 'optimal' radiator → best resolution for 4 GeV/c pions
  - 'real' experimental radiator → best resolution for 3.5 GeV/c kaons
- π/K separation up to 8 GeV/c (>3σ)