Status of FARICH

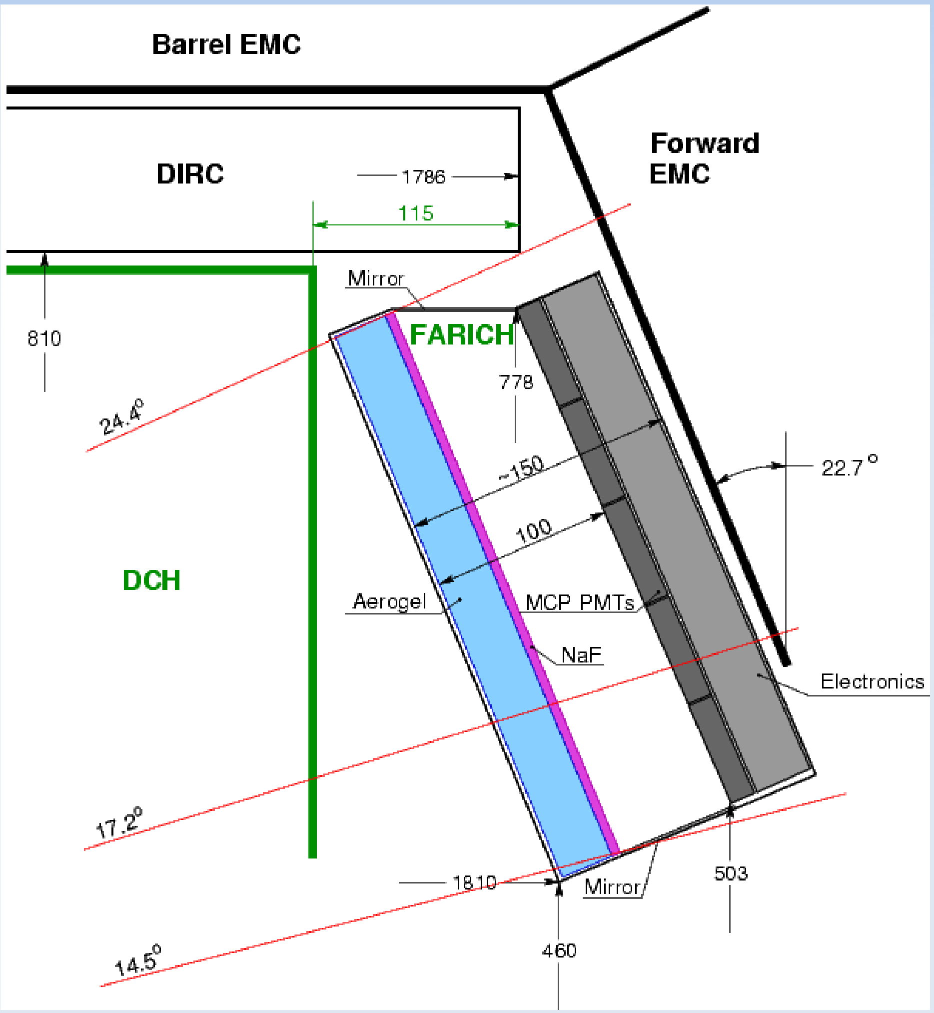
A.Yu.Barnyakov, M.Yu.Barnyakov, V.E.Blinov, V.S.Bobrovnikov, A.A.Borodenko, A.R.Buzykaev, A.F.Danilyuk, V.V.Gulevich, S.A.Kononov, E.A.Kravchenko, I.A.Kuyanov, A.P.Onuchin, I.V.Ovtin, A.A.Talyshev

Budker Institute of Nuclear Physics, Novosibirsk
Boreskov Institute of Catalysis, Novosibirsk

Outline

- FARICH overview
- Electronics layout
- Start of test beam experiments
- Conclusion

FARICH layout

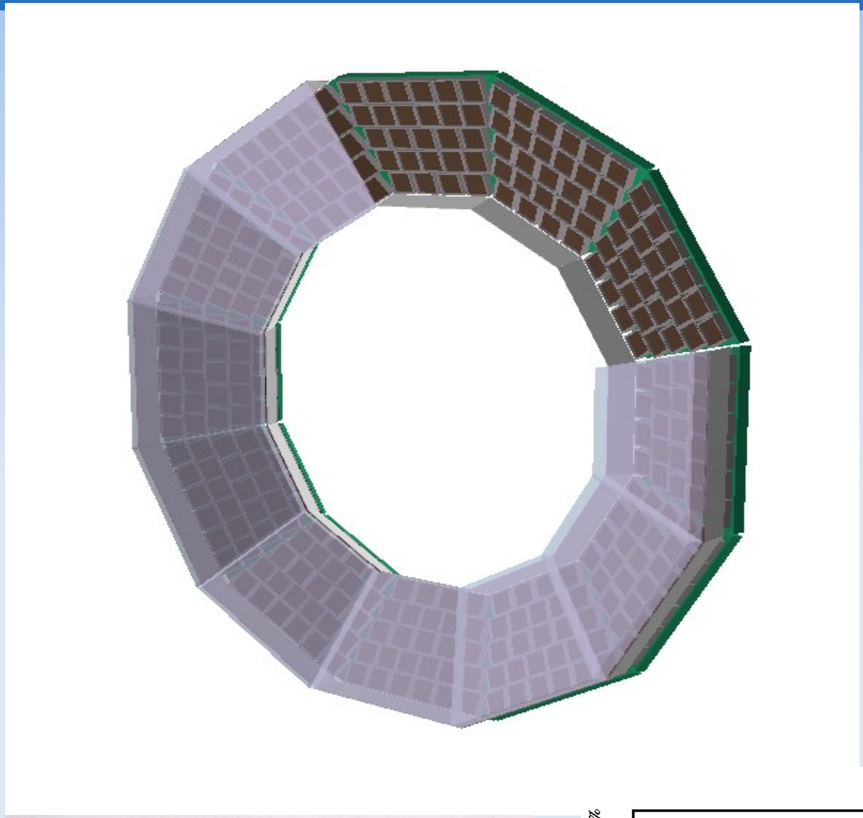


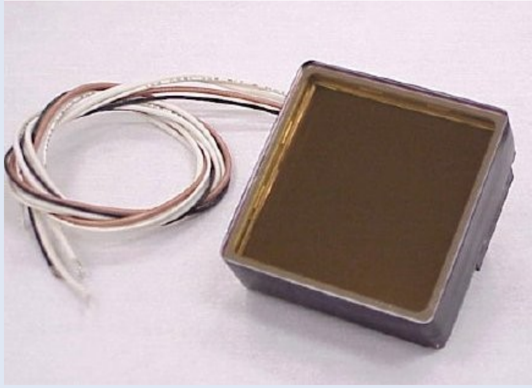
- MCP PMT photodetectors - Photonis XP85012
- Radiator - Focusing Aerogel + NaF

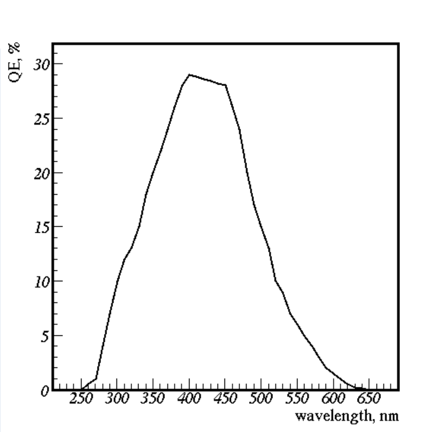
layer	marerial	n(400nm)	t, mm
1	aerogel	1.039	16.2
2	aerogel	1.050	13.8
3	NaF	1.332	5.0

- X/X0 = 2.4%(aerogel) + 4.3%(NaF) + 10%(PMT) + ~ 8% (support,FEE,cooling) ≈ 25%

Photodetector

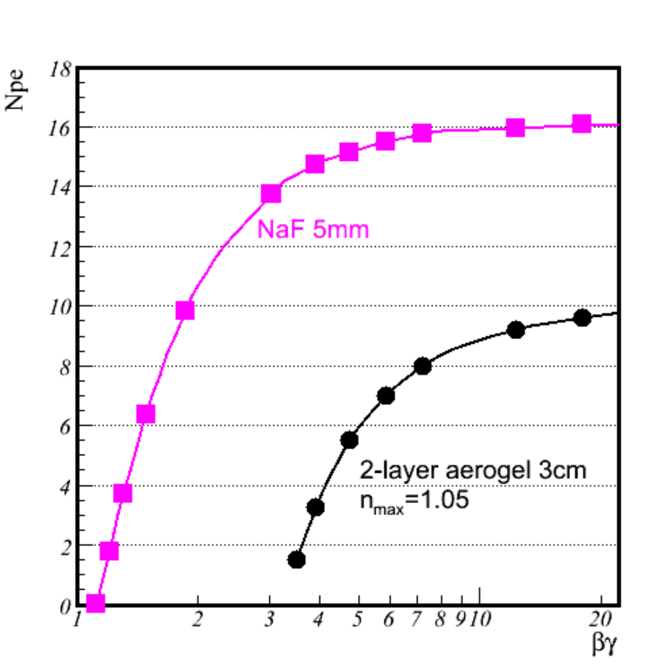




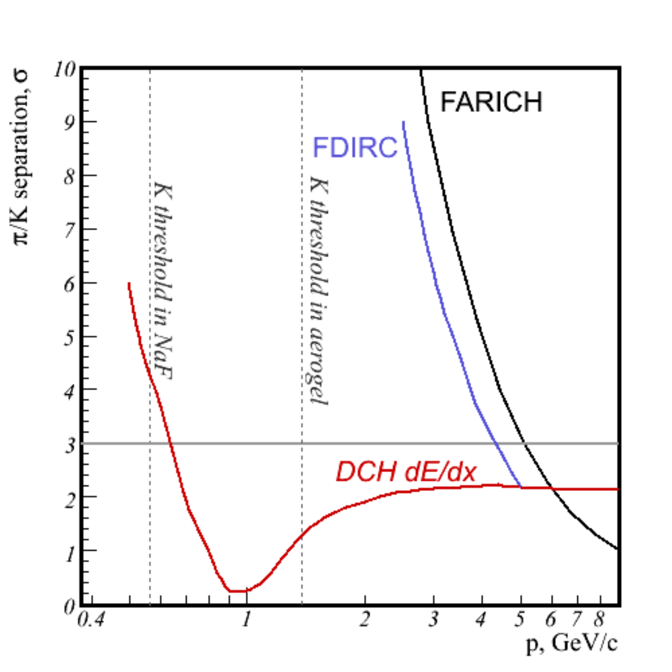


- Number of PMTs: 312
- Number of anodes: 8×8
- 6×6 mm anode size
- 59×59×13 mm case dimensions
- 81% active area fraction
- 70% MCP photoelectron collection
- QE(400nm)=29%
- Gain ~ $5 \cdot 10^5$;
- Time resolution ~ 40 ps;

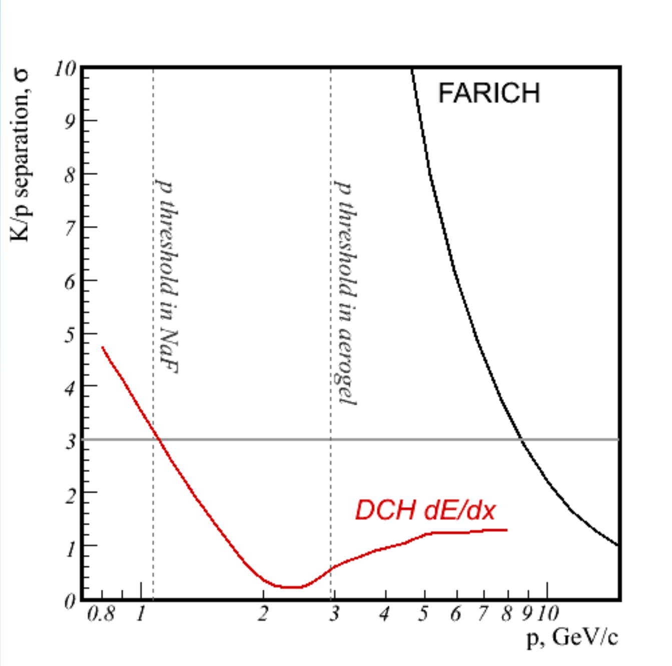
Monte Carlo Simulation



Number of photoelectrons



π/K separation of FARICH in comparison with FDIRC and DCH



K/p separation of FARICH in Comparison with DCH

Cost estimation

Component	**Unit price, kEuro**	**Cost, kEuro**
Photonis MCP PMT*	6.5	2300
2-layer aerogel	3.0	400
NaF	2.0	200
Electronics		300
Mechanics		100
R&D		100
Total		3400

(*) - based on price of PMTs with 25mkm MCPs

Background consideration

Preliminary estimations of FTOF backgrounds gave 8 low-momentum electrons in forward for each bunch crossing. We estimated the response of FARICH to those electrons with given momentum distribution. That gives us 0.7 hits in average per electron or 6 hits per bunch crossing.

- **Pile-up noise**
  - Time resolution < 1 ns
  - Occupancy: 6 hits / 20000 ch = **$3 \cdot 10^{-4}$** → less than one background hit within area of the rings — negligible for the ring reconstruction.
- **MCP PMT aging**
  - Gain: 10^5
  - Bunch crossing rate: $200 \cdot 10^6$ Hz
  - Integrated anode charge:
  - $6 \times 200 \cdot 10^6 \times 10^5 \times 3 \cdot 10^7 \times 1.6 \cdot 10^{-19} /(312 \times 5.3^2) =$ **0.07 C/cm^2 /year**

    P. Krizan et al. poster at RICH2010:

    10% QE drop at 400mC/cm^2 (25 μm version) → ***6 years of SuperB***
- **MCP PMT gain stability**
  - Rate: $6 \times 200 \cdot 106 /(312 \times 5.3^2) =$ **140 kHz/cm^2** — no gain drop expected.

Electronics

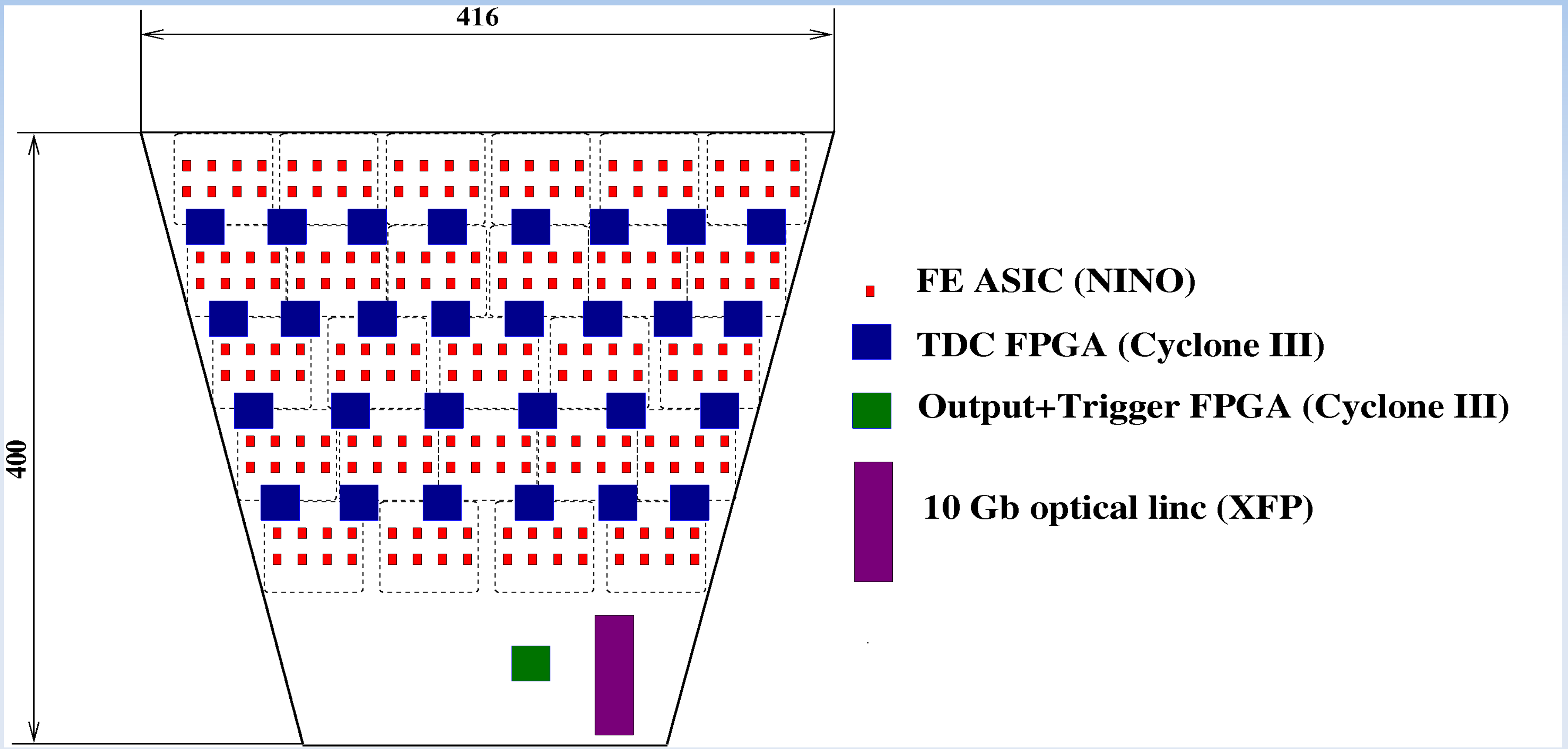
- Fast FPGA are used as TDC:
  - Smaller number of components – it is easier to fit FARICH electronics into available space
  - zero dead time
  - Flexible logic
  - Commercially available
  - Low cost (~0.5 Euro/channel)
- FE ASIC – several candidates:
  - DIRC ASIC
  - NINO

Electronics layout 1

One sector:

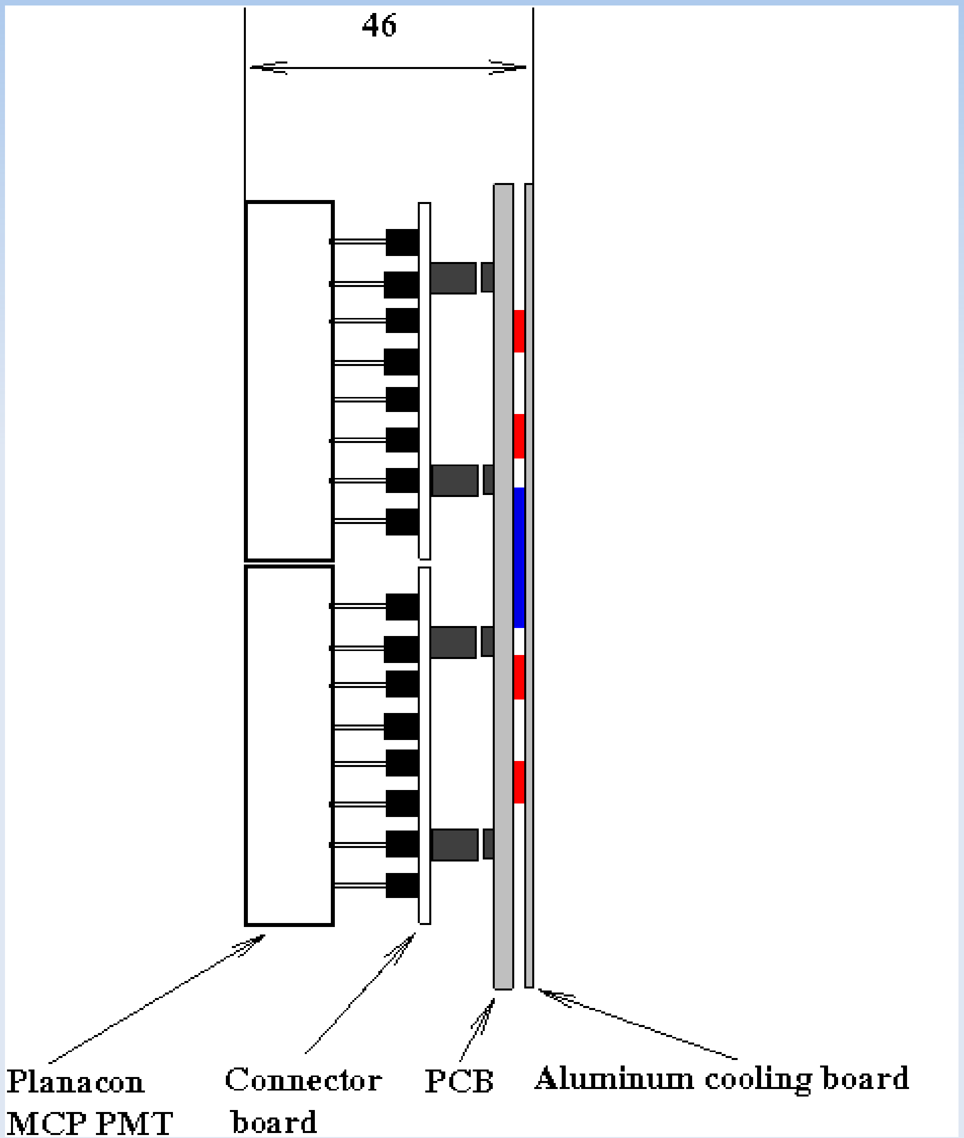
- 26 PMTs with 64 channels = 1664 channels
- FE ASIC (NINO type) – 5x7 mm frame, 8 channels, 1664/8= 208 chips on board
- FPGA TDC (Cyclone III) – 23x23 mm frame, 60 channels, 1664/60 – 28 chips on board
- 10 Gb optical link(XFP)

Electronics layout 2



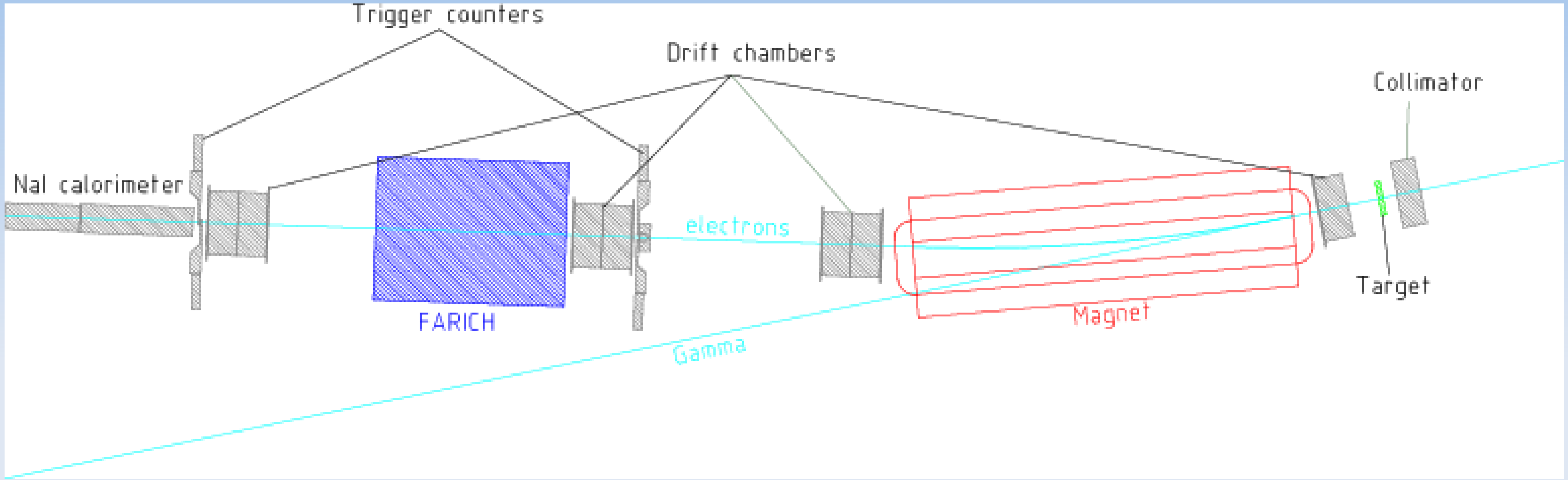
- 100 W heat dissipation per PCB ⇨ water cooling

Electronics layout 3



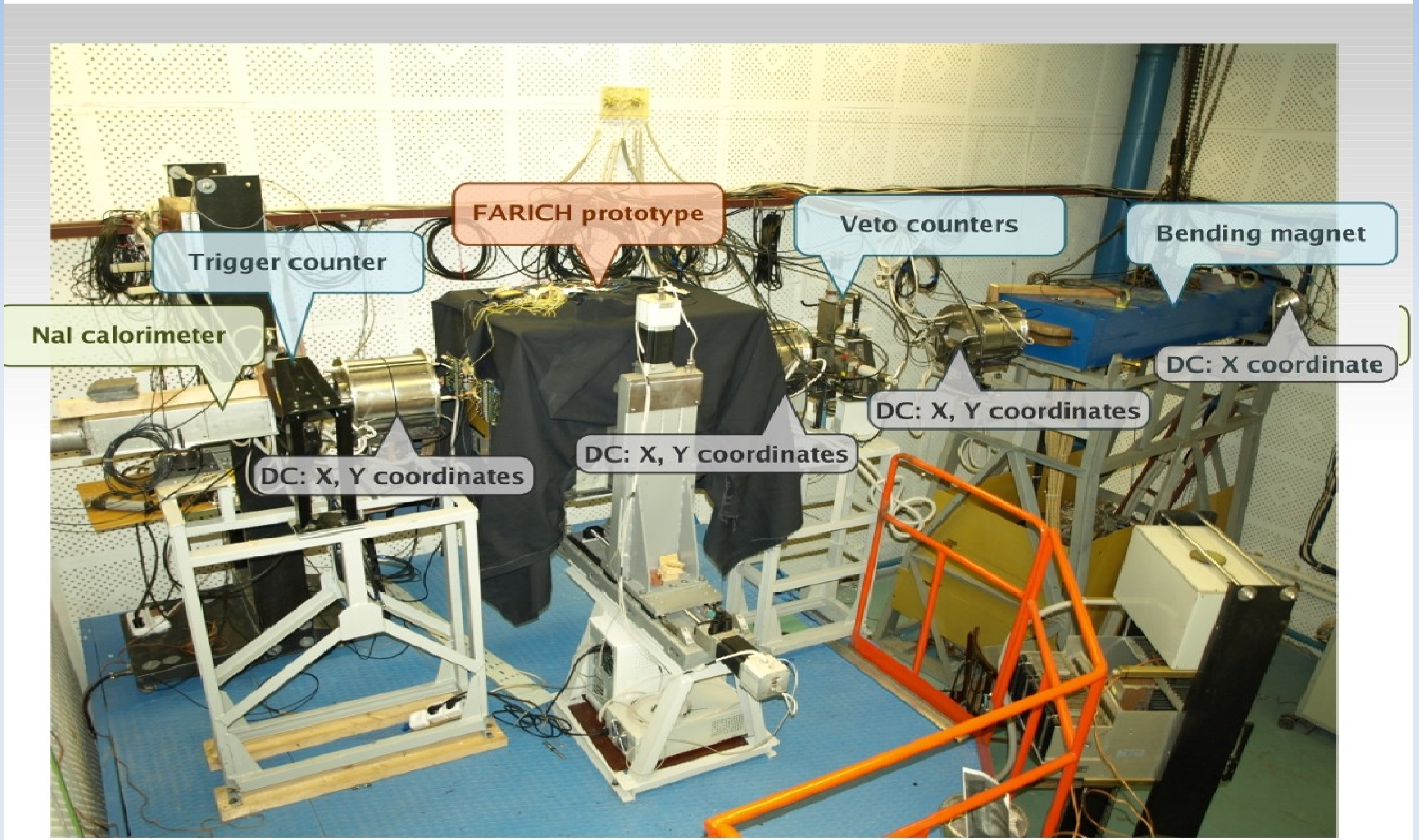
- We need only one PCB for signal digitization and readout
- Aluminum cooling board with water channels is coupled to PCB. 1 mm thickness (1% of X0)
- Separate connector board for each PMT is foreseen. It is used also to arrange HV divider.
- 46 mm total thickness

Start of test beam experiment



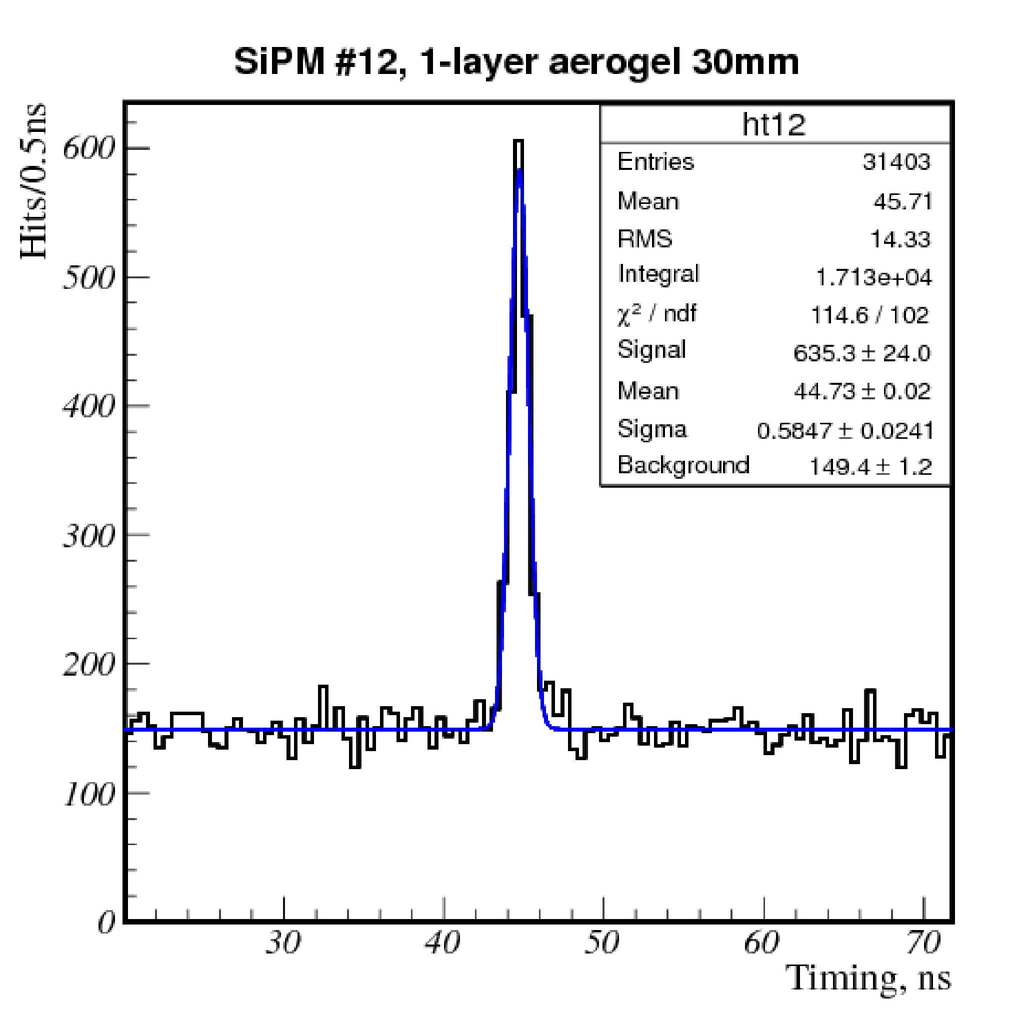
- About 10 shifts for 12 hours were used for beam apparatus tuning and FARICH measurement in April:
  - ”Luminocity mode”, 3.5 GeV beams in VEPP-4M, L~2*10^{30}, ~20000 s beam life time – up to 30 Hz of 650 MeV secondary electrons
  - ”Converter mode”, 1.85 GeV, 10 mA current beam in VEPP-4M, ~4000 s beam life time – up to 10 Hz of 650 MeV secondary electrons

Test beam line



FARICH prototype experiment

- We see Cherenkov light!:
  - 550 to 900 ps timing resolution (as expected)
  - Good signal to noise ratio
- > 100000 events were written:
  - single layer h=20 mm, n=1.055
  - single layer h=30 mm, n=1.05
  - 4-layer, 100 mm focal length, h=30 mm, n=1.03-1.05
  - Direct hit of particles on G-APD (coordinate calibration)



Test beam plans for April

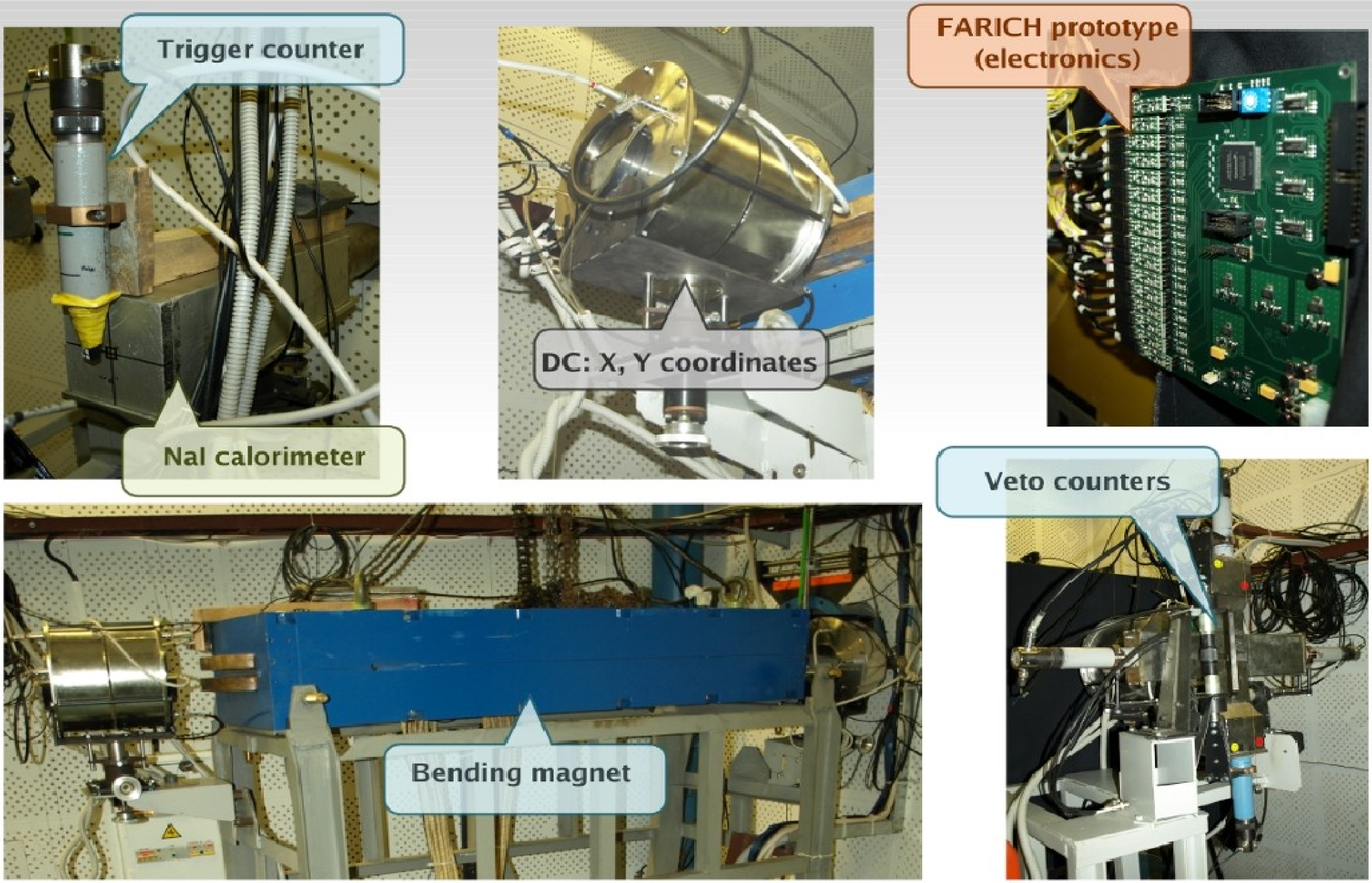
- 15 shifts for 12 hours are scheduled in April:
  - Tune drift chambers coordinate reconstruction
  - To measure two 4-layer samples with 100 mm focal length at 3 distances (SuperB FARICH type)
  - To measure this 4-layer samples in defocusing mode to check refractive index measurements
  - To collect statistics with single layer blocks (h=20 and 30 mm)
  - 4 additional focusing aerogel radiators (2-3-4 layers, focal length 150-200-500 mm)
- To work on data analysis:
  - number of photoelectrons
  - Cherenkov angle resolution

Conclusion

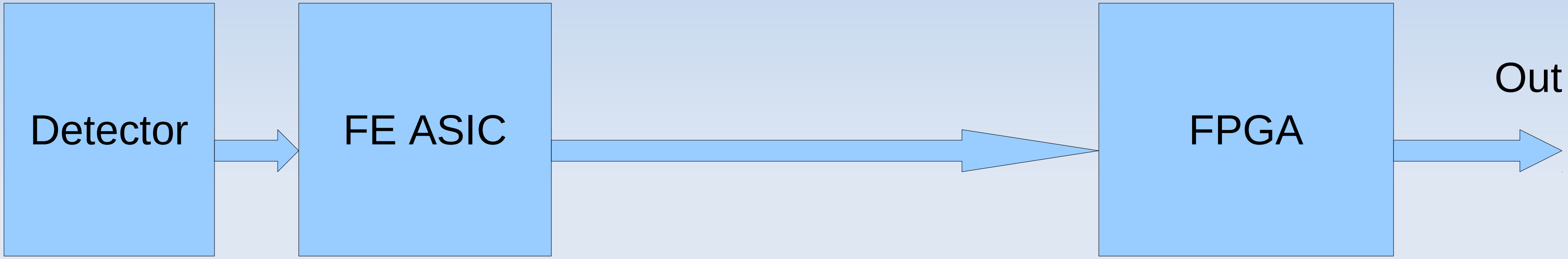
- FARICH with total thickness of 150 mm could provide accelent PID in the forward region of SuperB detector
- Readout electronics is suggested. Total thickness with PMTs is 46 mm. Total heat dissipation is about 1 kW
- Test beam experiment with FARICH prototype has started. >100000 events is collected. Test will continue in April.

Additional slides

Test beam apparatus



Suggested electronics



- ~1 ns time resolution is enough for FARICH
- Large progress in FPGA (Flexible Programmable Gate Array) technology during last years - 1 Ghz and more operational rate, large number of input channels, high channels density.
- We suggest to use FPGA fast counters for time measurement

FPGA examples

- Cyclone III (Altera) :ep3c16f484c-6 – 484 pin body
  - 840 MHz working rate (DDR mode) → $\sigma_\tau = 1.2/\sqrt{12}$ ns ~ 400 ps
  - 60 differencial LVDS inputs
  - 23x23 mm frame
  - ~70 USD (one chip)
- Cyclone III (Altera) – 780 pin body
  - 840 MHz working rate (DDR mode) →
  - ~100 differencial LVDS inputs
  - 29x29 mm frame
  - ~700 USD (one chip)