Status of the Forward RICH development in Novosibirsk

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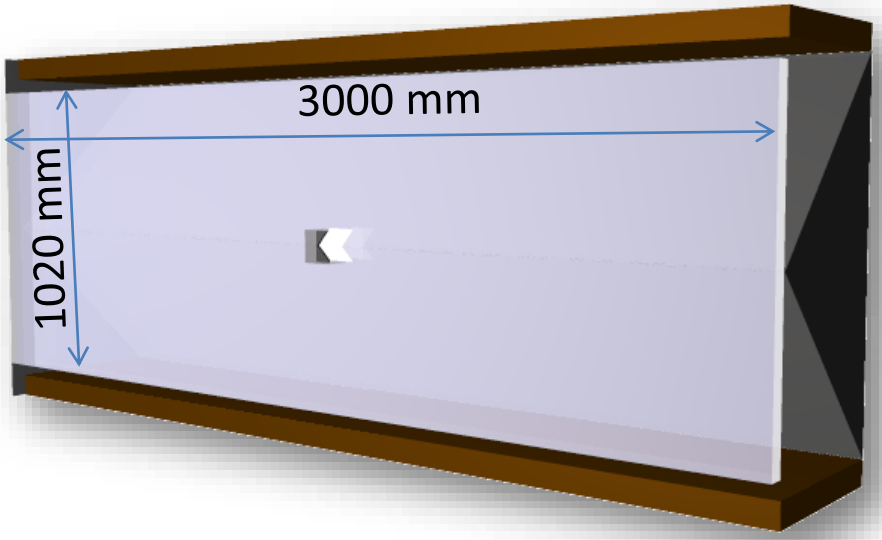
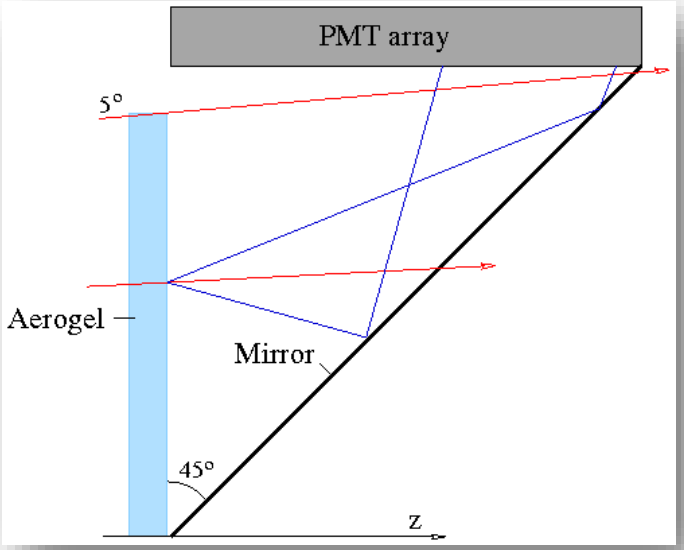
Conceptual design based on FARICH 2010





Hamamatsu H8500 MaPMT

- flat panel,
- 8x8 anode pixels of 6mm size
- 89% active area ratio
- Bialkali photocathode
- Gain: $1.5 \cdot 10^6$
- Relatively cheap (≈€1800 / unit)
- Robust
- Long lifetime

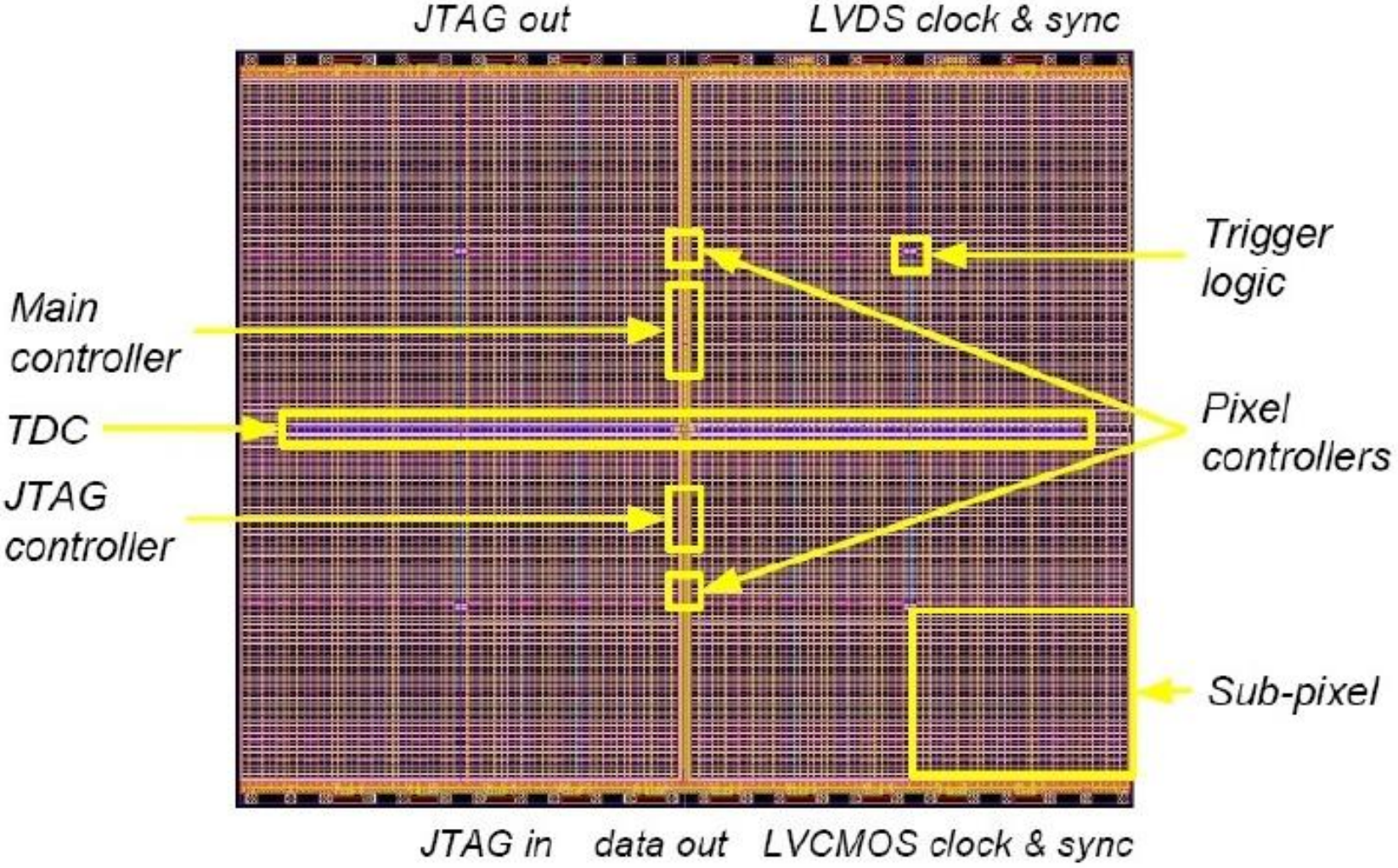
- 2-layer aerogel n_1=1.050, n_2=1.047 (no gas)
- Flat mirrors only
- MaPMT readout
- MC simulated PID performance:
  - π/K up to P = 10 GeV/c
  - μ/π up to P = 2 GeV/c

Detection&readout options presently considered

Baseline option
H12700B price: 1600 € per tube
Total MaPMT cost with spares: 2.2 M€

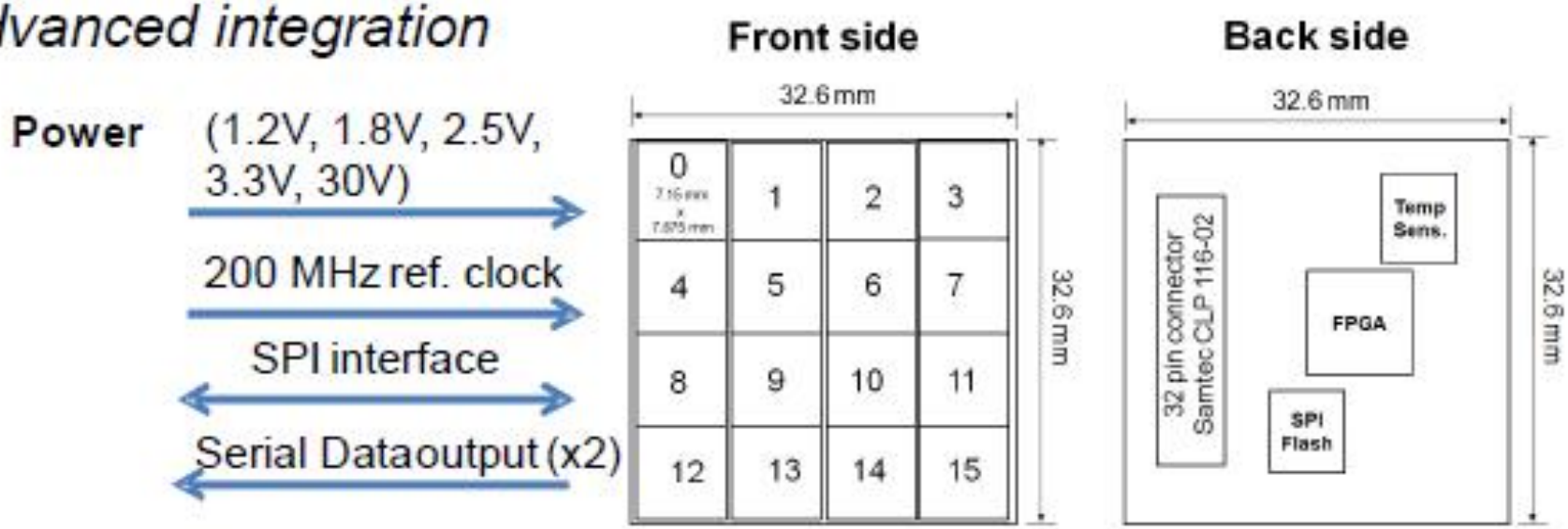
Dare-to-try option
Total modules cost with spares: 2 M€
Needs liquid cooling.

PDPC Digital SiPM: architecture of one die (die = 2x2 pixels)



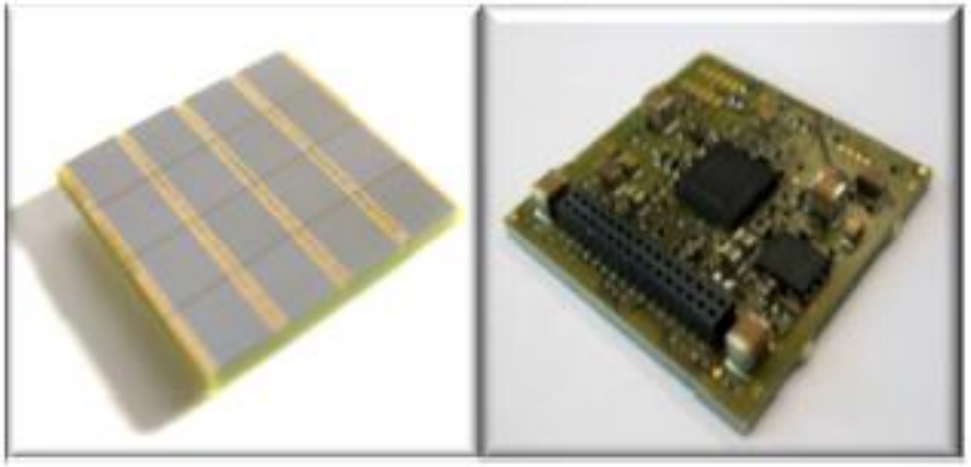
DPC 4x4 array – Tile

advanced integration



FPGA/Flash:

- tile firmware
- data collection/concentration
- skew correction
- saturation correction
- configuration
- temperature measurement
- dark count maps

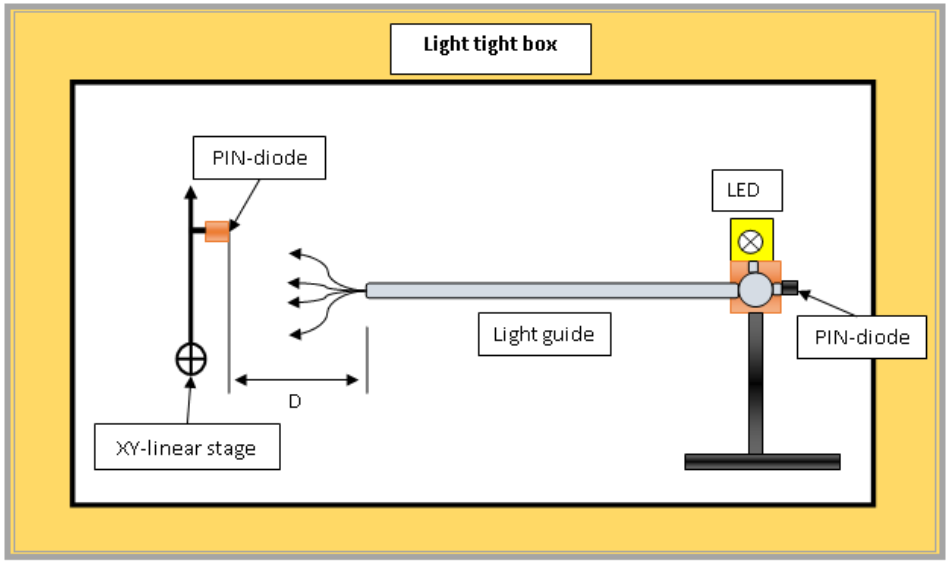


R&D of Digital Photon Counter (DPC)

- Promising option for photon detection despite of high DCR and a need for cooling (for present design - down to -40°C).
- Previous beam tests and preliminary measurements have shown PDE deficiency: about 1.7-1.9 times less than producer's value. We have to address this issue by
  - measuring PDE of 36 DPC tiles of the FARICH prototype.
  - understanding differences in our and PDPC calibration procedures.
- Possible radiation aging/damage:
  - Beam tests
  - MC sim to evaluate expected dose for the PANDA FRICH.

DPC PDE measurement (1)

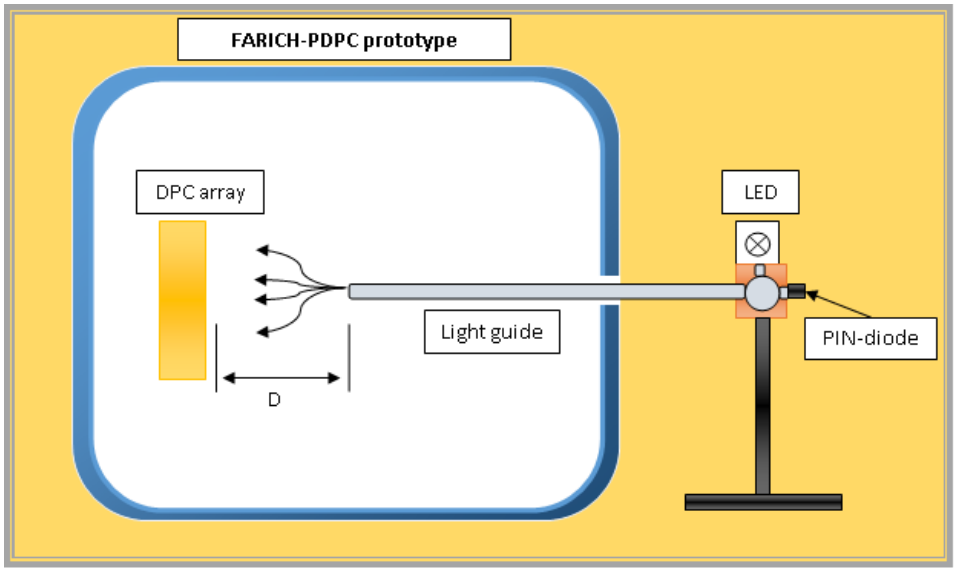
Scheme of wide-angle light source calibration by scanning setup



Custom-made scanning setup

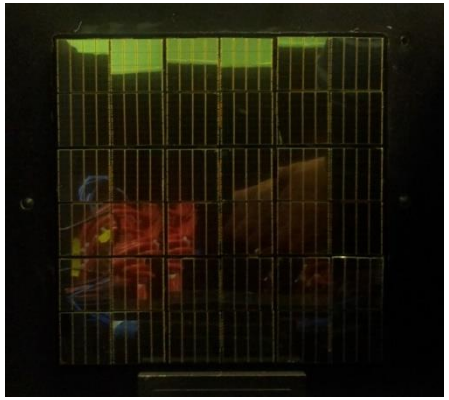
DPC PDE measurement (2)

Use wide-angle light source to illuminate DPC array



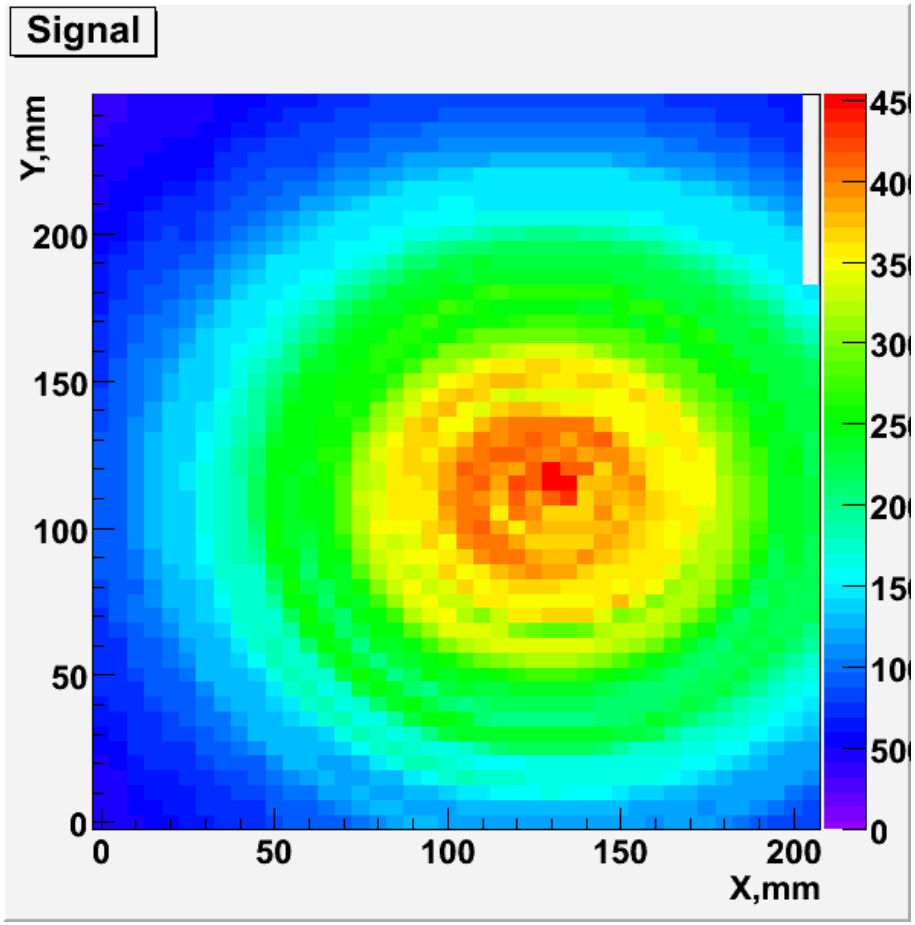
FARICH setup

DPC array 6x6 tiles

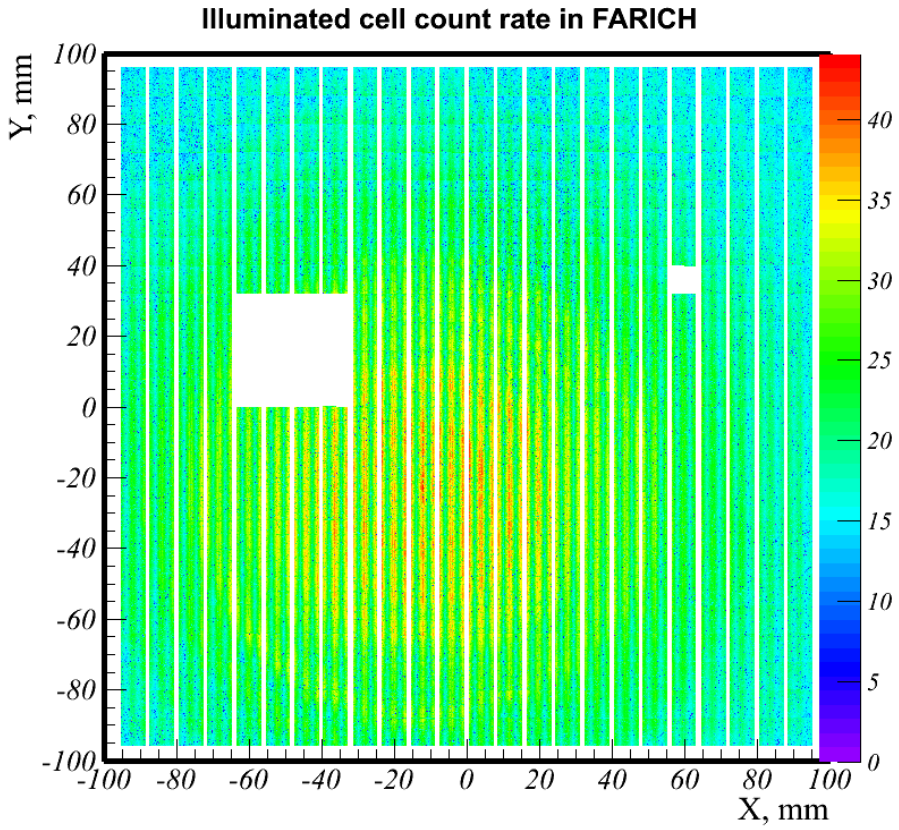


DPC PDE measurement (3)

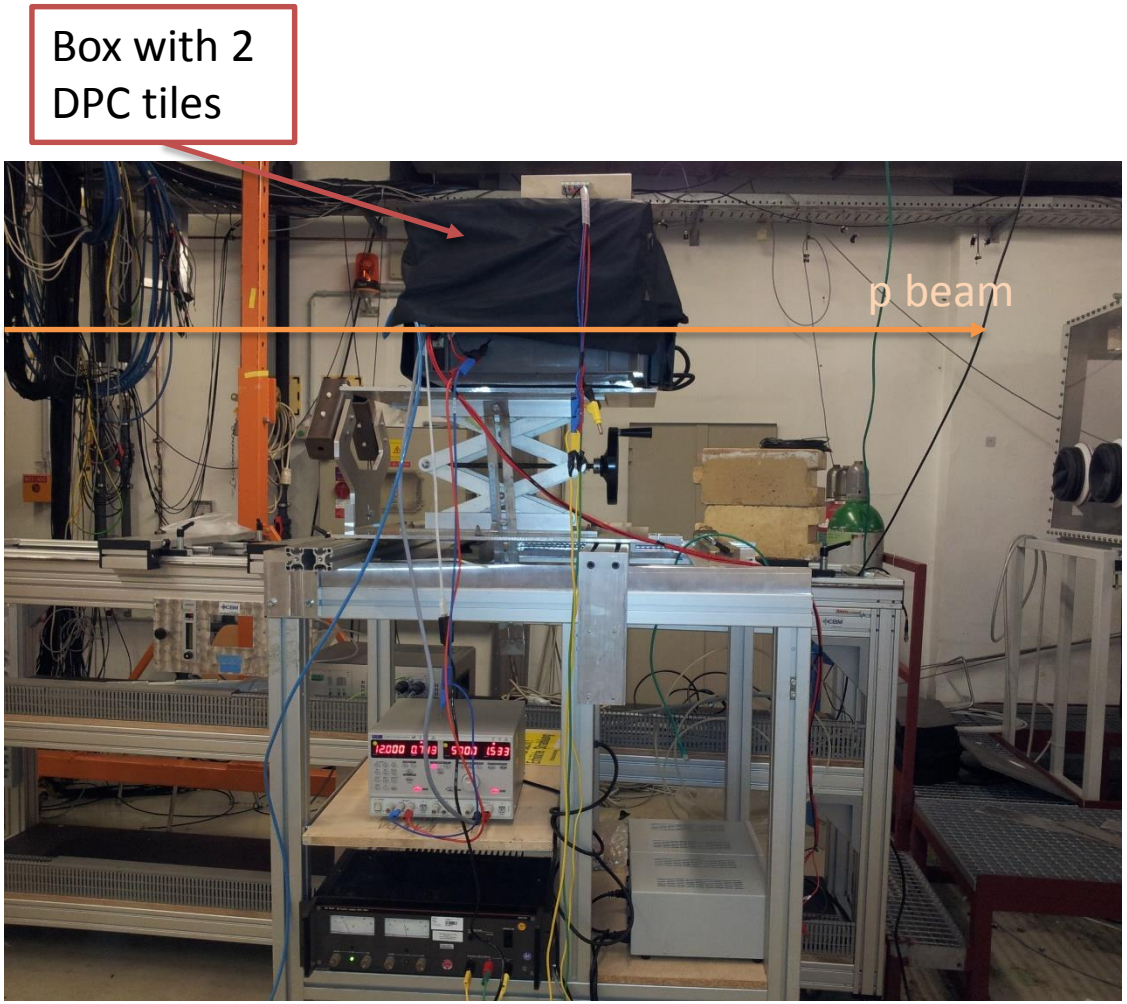
Relative intensity map by scanning setup (5 mm step)



Count rate map for DPC array 2400x3072 cells



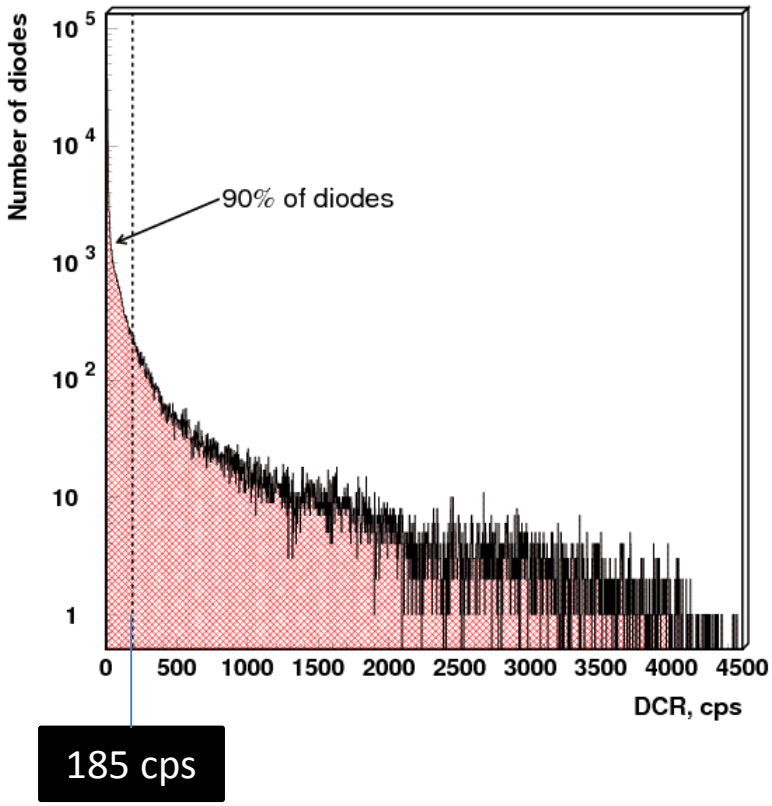
DPC radiation hardness test at COSY
August 1-4, 2014



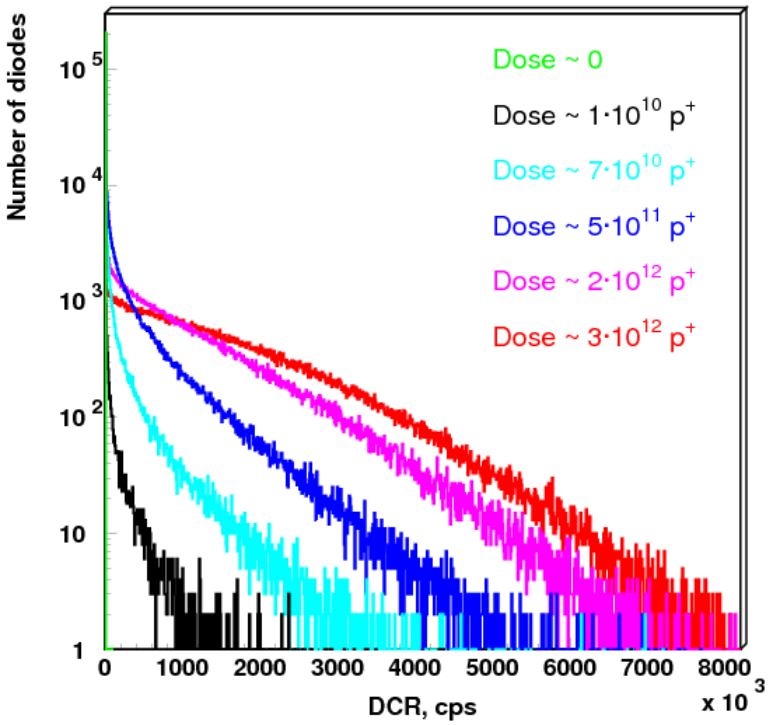
- Protons with 800 MeV/c momentum
- Maximum fluence ~$4 \cdot 10^{11}$ p/cm^2 accumulated in 9 steps
- Tiles were at -18°C
- DCR scan of cells was done in beam stops
- Total dose is measured by ionization chamber provided by COSY team
- Beam profile is measured by MWPC ~1 m upstream of the detector

DPC irradiation (1)

Initial dark count rate (DCR) distribution of cells

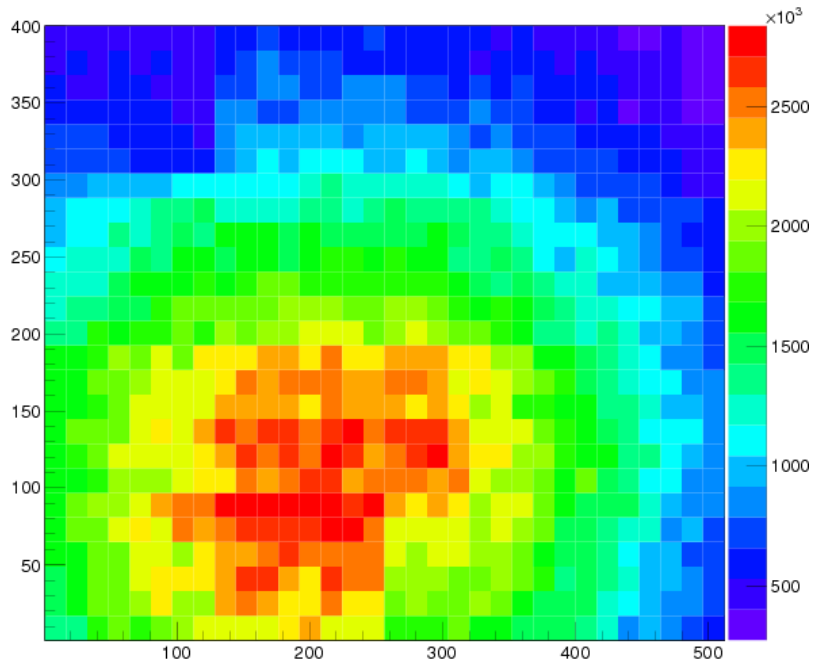


DCR distribution of cells for several total doses



DPC irradiation (2)

Dark count rate map after final dose

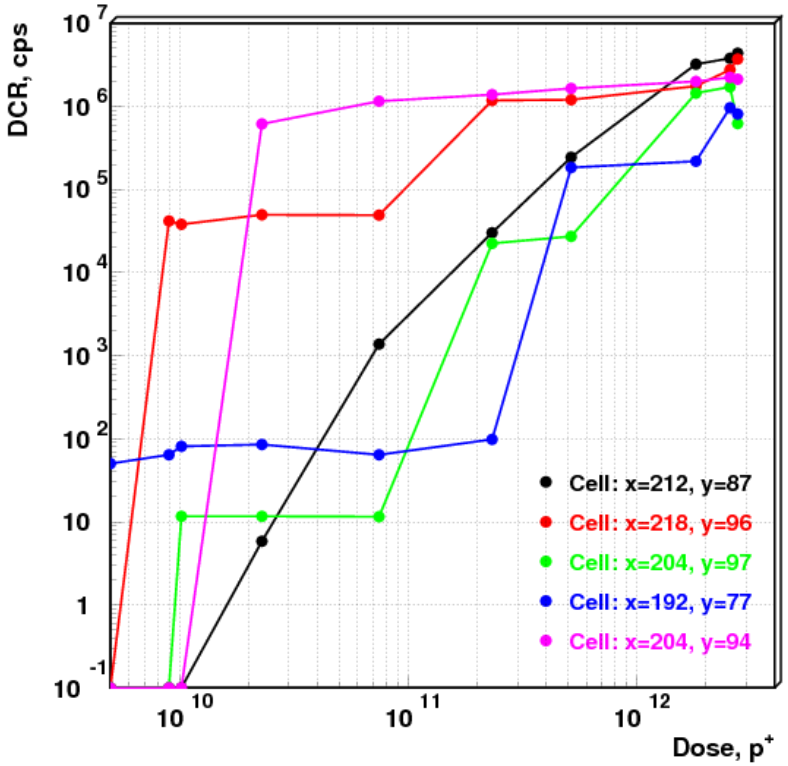


DCR of individual cells vs total dose

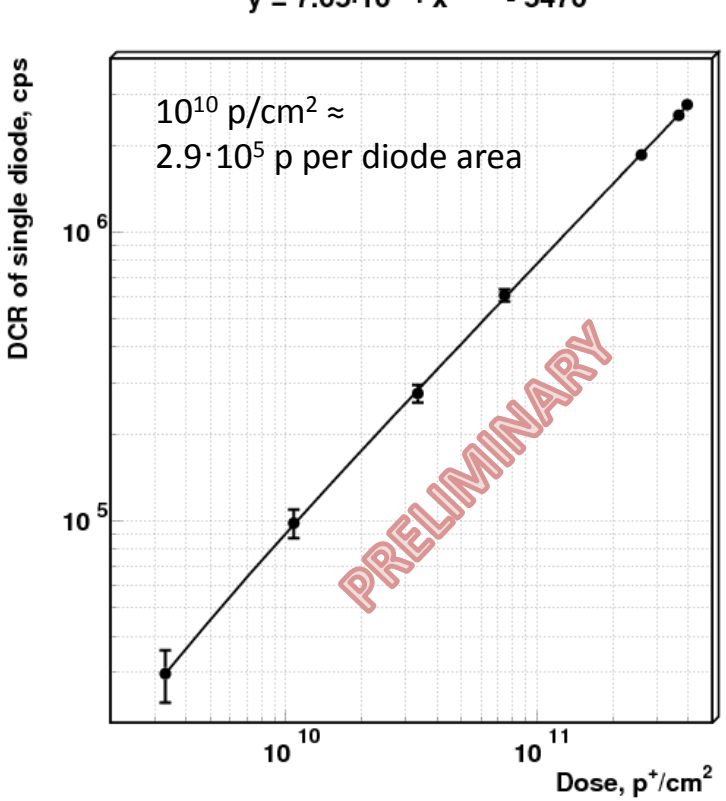
- Beam profile at the tile position is not precisely determined due to multiple scattering of protons in ~1m of air
- We had to use DCR data to fit beam profile and determine fluence distribution

DPC irradiation (3)

DCR vs dose for several cells



Mean cell DCR in the central part of the tile vs fluence



Calibration of fluence: cell DCR is changed mostly not continuously but by jumps – effect of damage by single protons. Density of noisy cells should be proportional to proton fluence. It is fitted by a Gaussian to get fluence distribution.

DPC radiation hardness

- DCR vs fluence measured.
- Observed single event effects: tile and TEK FPGA failures, bit upsets in SAM on-chip memory. Can be recovered by FW reload. Special runs were acquired to evaluate frequency of such events, that are to be analyzed.
- Also we did several temperature scans to compare DCR vs temperature behavior before and after irradiation. To be analyzed.
- We should evaluate total fluence expected in PANDA FRICH for the experiment lifetime. MC simulation is in preparation. Help and advices are welcome.

Name	Status	Task	FTE
Sergey Kononov	PI	Project lead, MC sim., beam test data analysis	0.8
Mikhail Barnyakov	PI	PMT studies	0.6
Ivan Kuyanov	PhD student	DPC studies	0.8
Dmitriy Korda	Master student	Aerogel R&D, MC sim.	0.6
Nikolay Podgornov	Undergraduate	beam test data analysis	0.4
Pavel Kirilenko	Undergraduate	Aerogel R&D	0.4
Evgeniy Kravchenko	PI	FEE, aerogel	0.2
Alexander Barnyakov	PI	aerogel, prototyping	0.2
Alexander Katcin	PI	prototyping	0.6
Vyacheslav Prisekin	PI	DPC radiation tests	0.2
Konstantin Beloborodov	PI	MC sim.	0.2
Alexei Onuchin	Prof.	Advisory	
Karina Martin	PI	Mirror R&D	assigned
Viktor Bobrovnikov	PI	test beam at BINP	assigned
Alexander Blinov	PI	Physics cases studies	assigned
Andrey Bykov	Eng.	Design & integration	assigned
Valery Tayurskiy	PI	MC sim.	assigned
Pavel Kasyanenko	El. eng.	FEE R&D	assigned
Alexey Talyshev	El. eng.	FEE R&D	assigned

R&D funding

Agencies	Sum per year, kEuro	Period	Status
Helmholtz Ass. & Rosatom through ITEP/FRRC	78	2014-2017	approved
Russian Fund for Basic Research (on FARICH)	10	2014-2016	approved
Novosibirsk State University (PANDA lab is founded)	31	2014-2016	approved
Russian Fund for Basic Research (on PANDA FRICH)	10	2015-2017	to be applied

Project status

- Funding up to 2017 has been secured (~105 k€/year)
- Core team has been formed (~5 FTE), 5 new persons joined since March.
- PANDAroot has been set up.
- Direct DPC PDE measurement is in progress.
- DPC radiation hardness test at COSY in August.

Current problems

- Lack of qualified resources for MC simulation. Long period of learning needed.
- Time management problem. Most of group members are involved in other projects.
- A half-year delay with purchases on FRRC grant.