Overview on

FDD frontend electronics

for the DAQ workshop
in Bodenmais @ 2009-04-22

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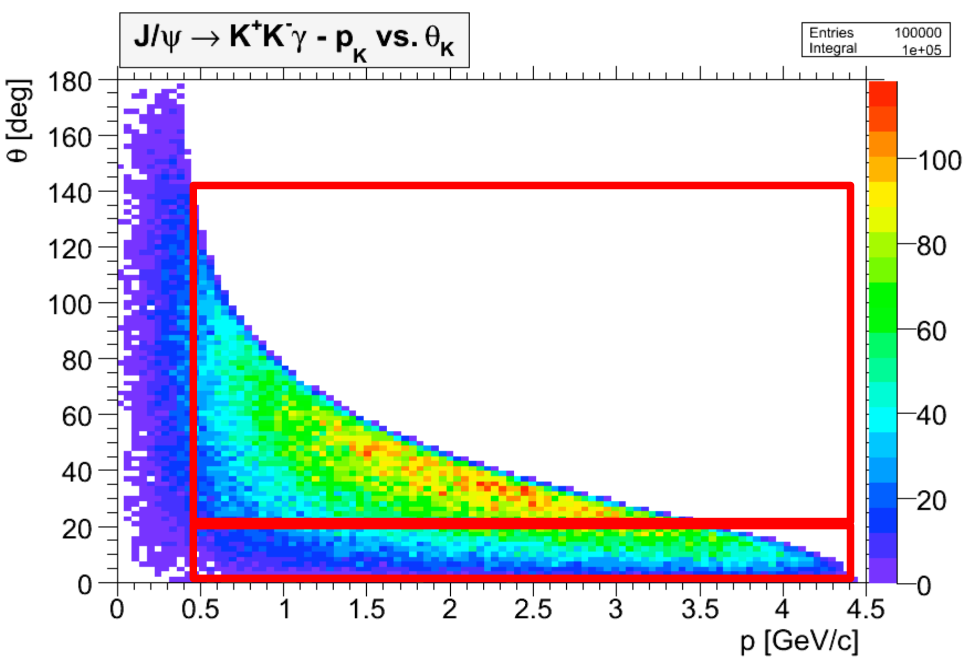
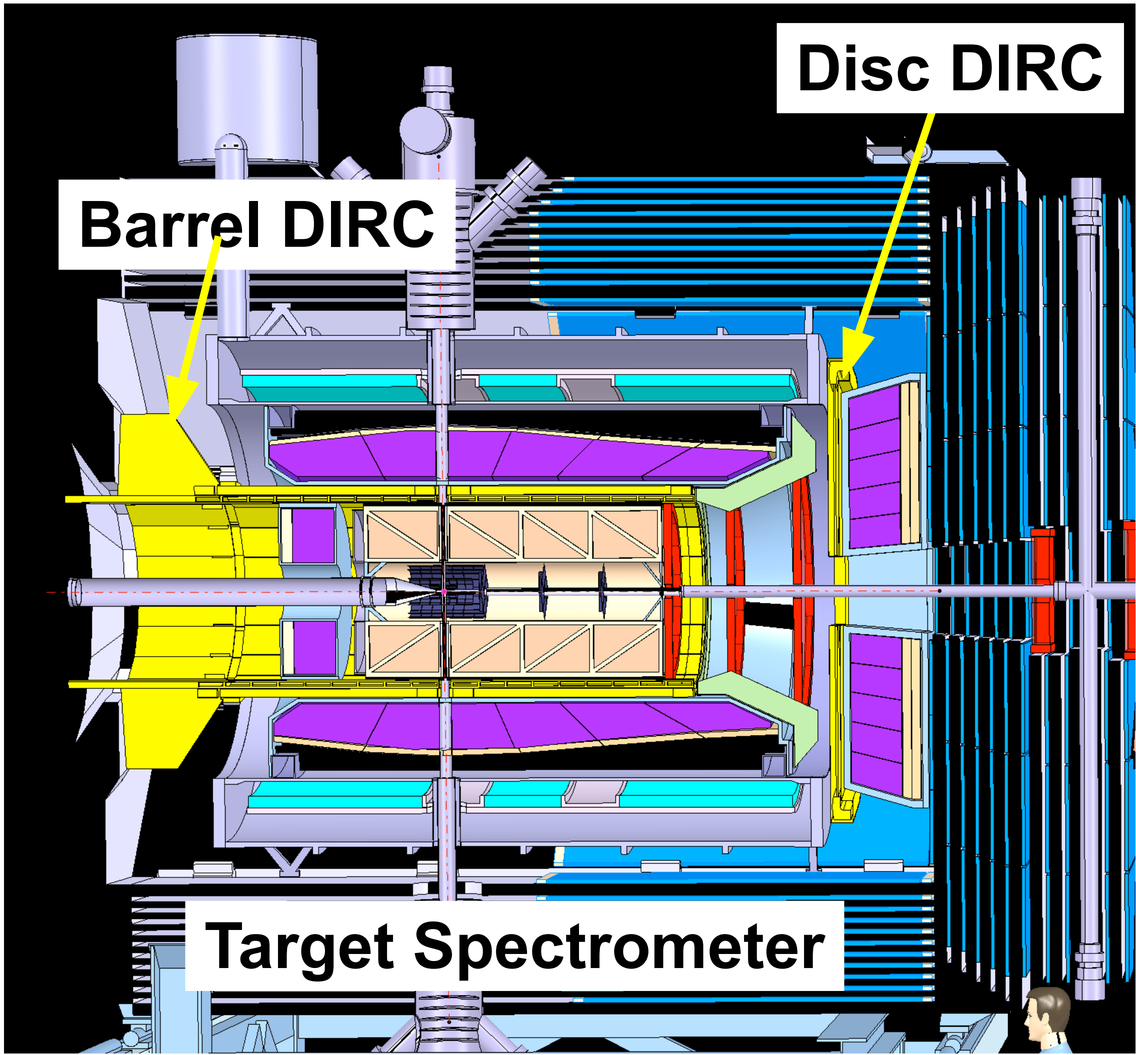
Outline

- Detector Design Requirements
- FDD solution
- Frontend electronics
  - Photon Detector
  - Frontend
  - Backend
- Outlook

Detector Requirements

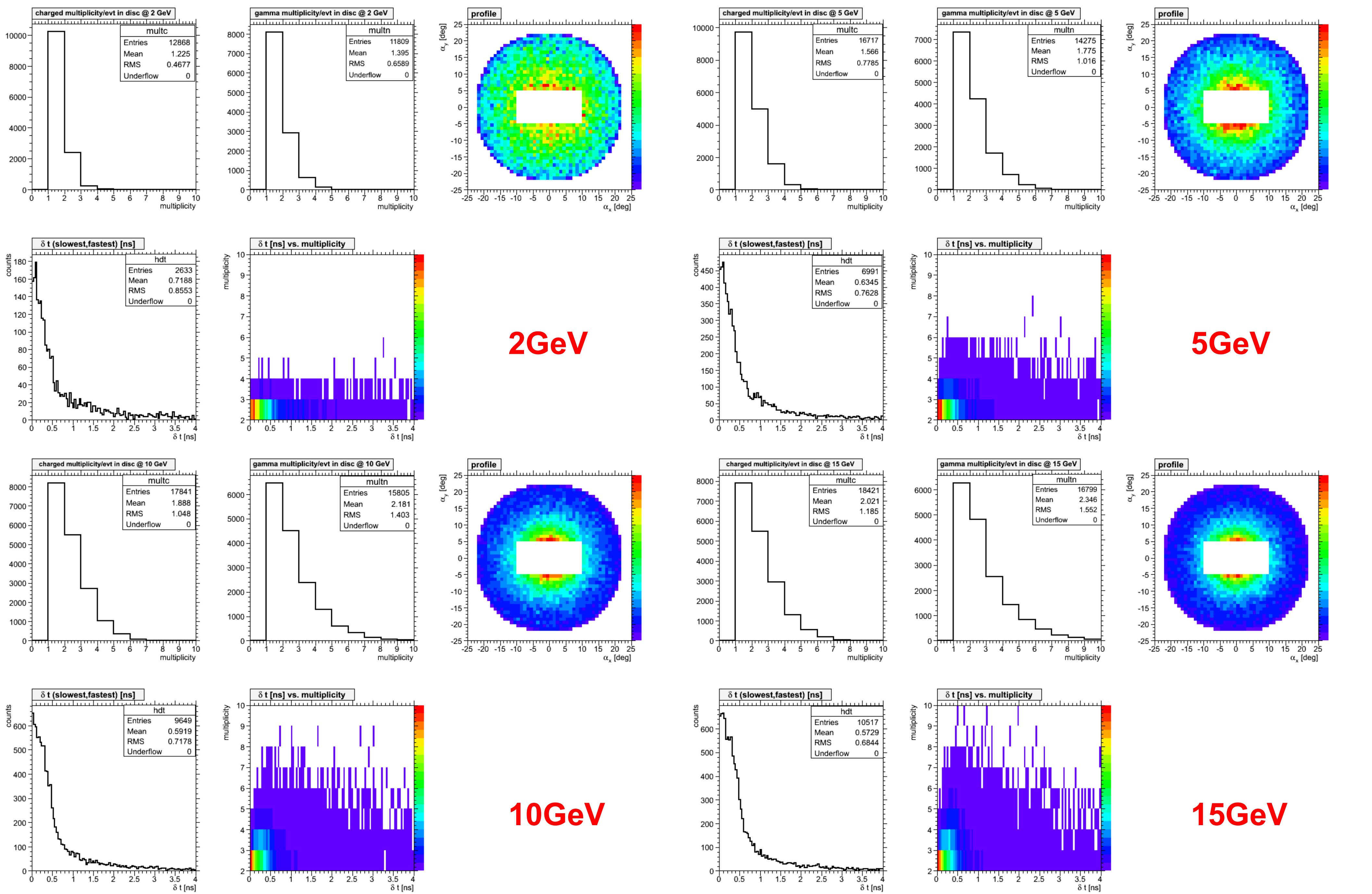
- PANDA anti-proton annihilation experiment at $\sqrt{s} \leqslant 5.5 \mathrm{GeV}/c$
- Full angular coverage and very good PID mandatory
- 20MHz interaction rate with continuous beam and quasi-fixed target
  - Radiation hard (>100krad)
  - High count rates (>2MHz/cm^2)
  - Excellent time resolution (<100ps)
- Magnetic field up to 2.0T
- Small radiation length





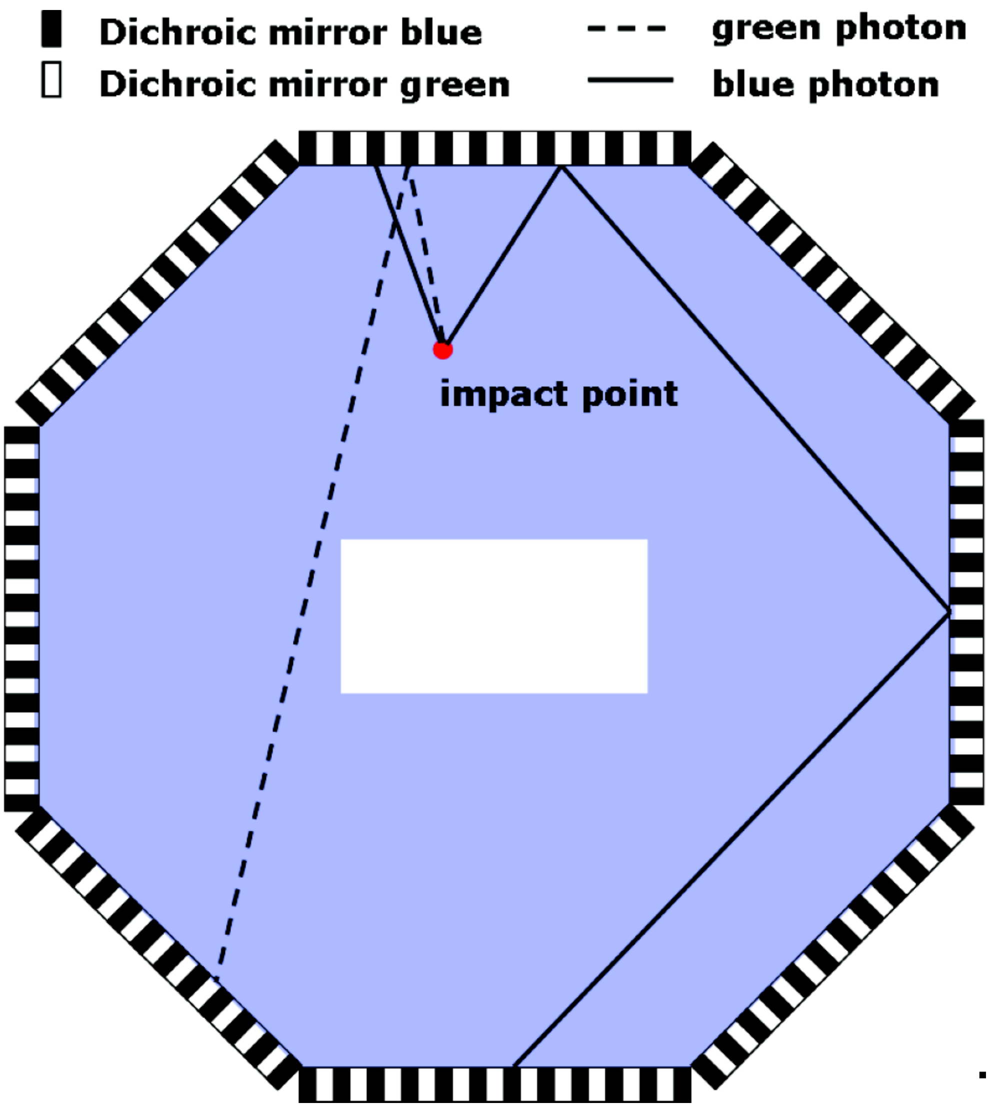
Physics characteristics

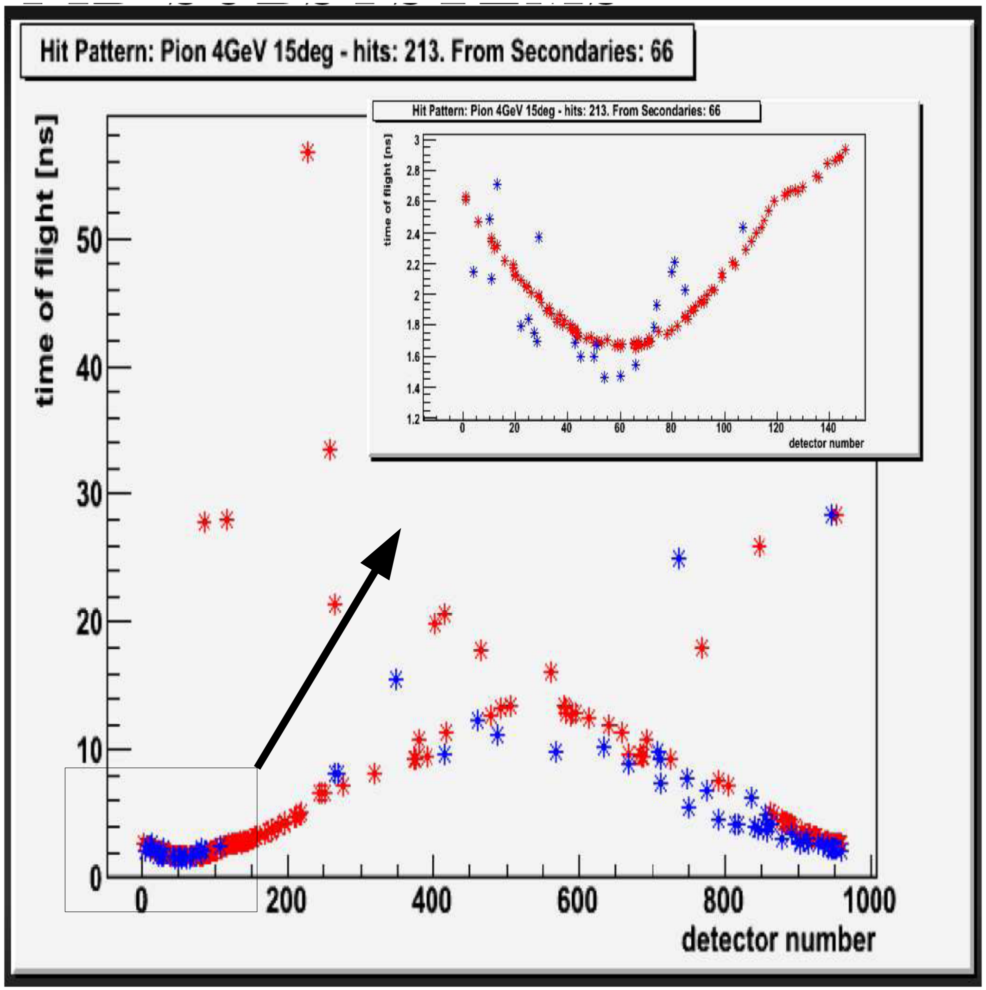
10k events @ http://panda-wiki.gsi.de/cgi-bin/view/Computing/DpmGen



PID detector solutions

- TDD (Time of propagation Disc DIRC) by 1D+1t
  - time resolution<~50ps; ~1k readout channels
  - dichroic mirror for dispersion correction & light path enhancement

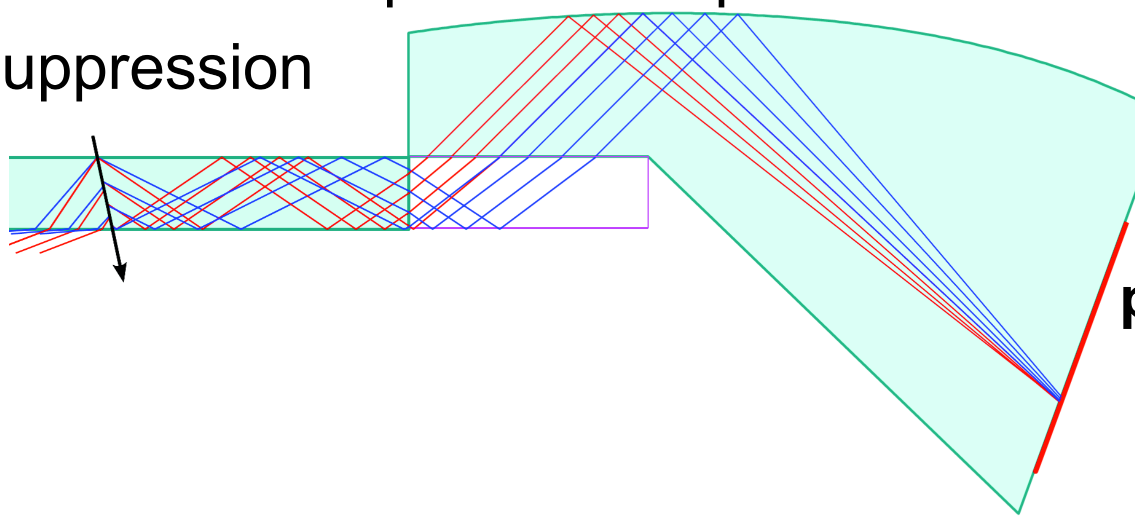


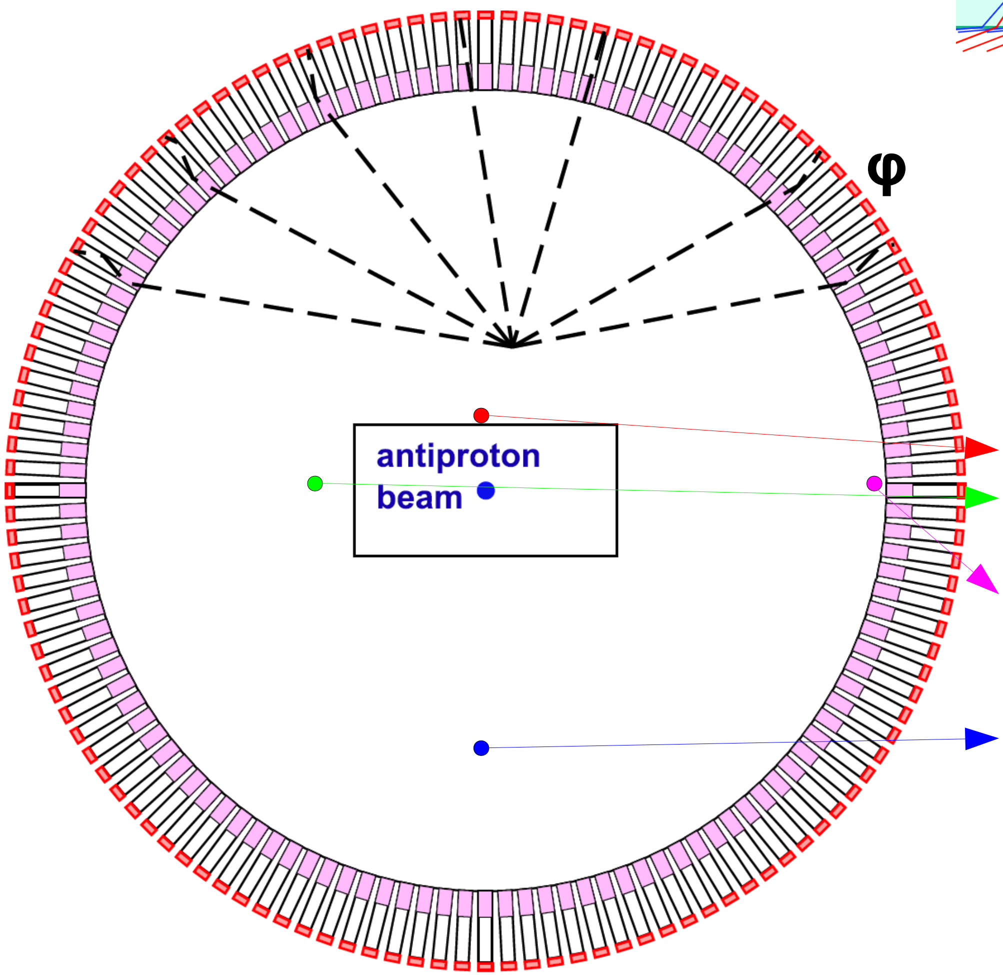


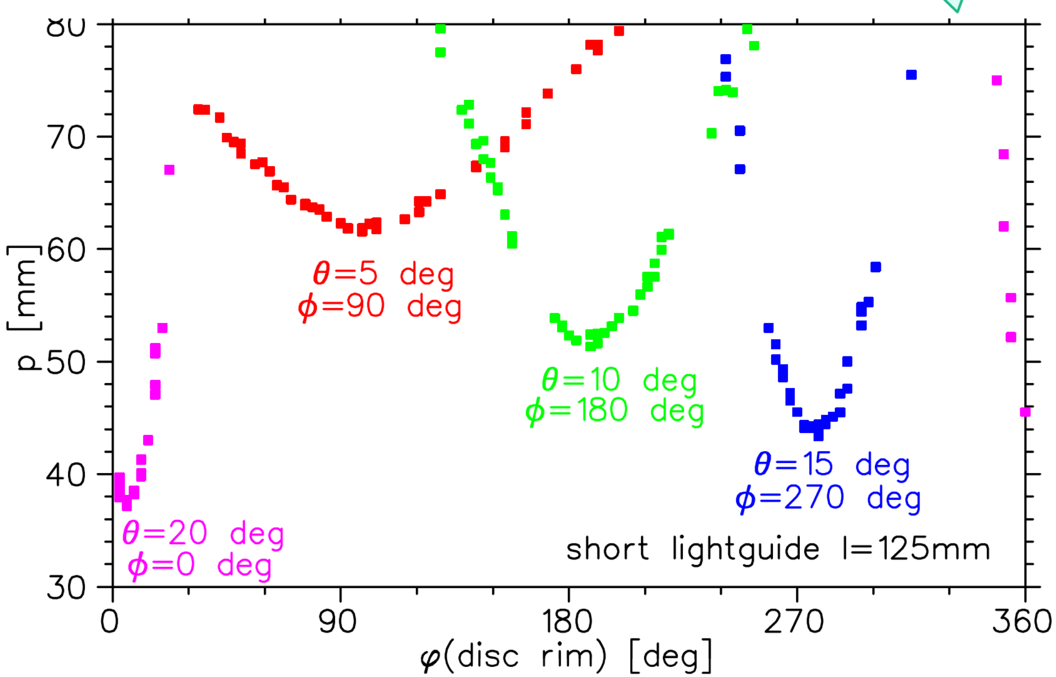
... soon more by Klaus Foehl ...

PID detector solution by FDD

- FDD (Focusing light guide Disc DIRC) by 2D (+1t)
  - Time resolution<~100ps;~128Light guides;~4k readout channels
  - LiF for dispersion correction and acceptance compression
  - Timing for background suppression and event separation

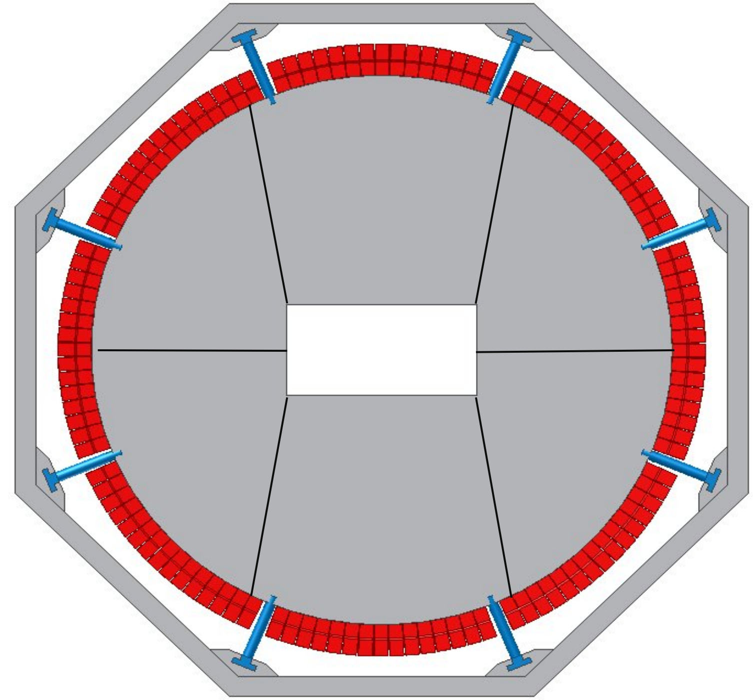


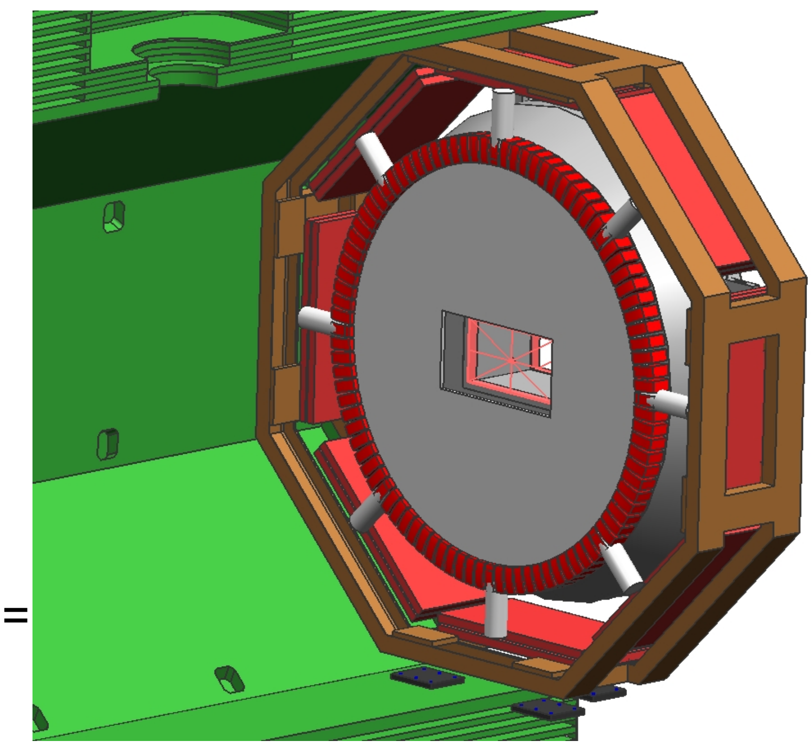




FDD (Focusing light guide Disc DIRC)

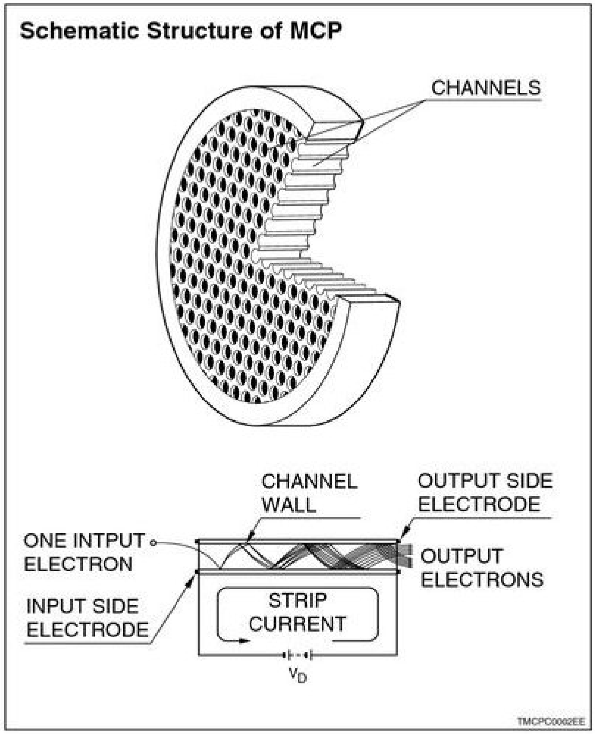
- Disc
  - Fused Silica (SiO_2)
    Suprasil 311
  - 4+2 pieces
  - Radius 1100mm
  - Thickness 20mm
- LiF-Crystal Block
  - Dispersion correction and acceptance enhancement
  - $50x50x20mm^3$
- Focusing Light guide
  - Focusing Cherenkov angles to focal points
- Converter
  - 128 MCP-PMT
    Burle 85011
  - $51x51mm^2$ active area
  - 15mm Thickness
  - 1x32 Channels (tunable)
  - 4096 channels total
- Space in mm behind MCP-PMT:
  1202(inner)+~17(tilt)+~15(PMT)+~15(electronics)=1250(outer)





Photondetector

- Photonis Burle 85001-502 (current candidate)



GENERAL

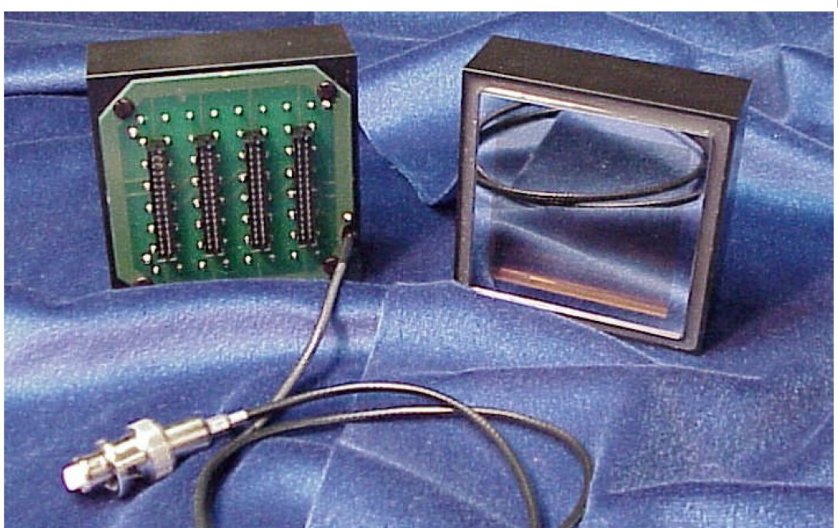
Parameter		Value	Unit
Spectral Response		185 to 660	nm
Wavelength of Maximum Response		400	nm
Active Area		51 × 51	mm
Photocathode Material		Bialkali	--
Window	Material	UV Grade Fused Silica	--
	Thickness	2.0	mm
Multiplier	Structure	MCP (25µm pore, 40:1 L:D)	--
	Number of Stages	2	--
Anodes	Number	64 (8 × 8)	
	Size / Pitch	5.9 / 6.5	mm
Voltage Divider Resistance		13	MΩ

Maximum Ratings (Absolute Maximum Values)

Parameter	Value	Unit
Supply Voltage	-2600	VDC
Average Anode Current, sum of all anodes	3	µA
Ambient Temperature	- 15 to + 50	°C

Characteristics (at 25 °C)

Parameter		Min.	Typ.	Max.	Unit
Cathode Sensitivity	Luminous		55	--	µA/Lm
	Blue (with CS-5-58 filter)	6.0	8.0	--	µA/lm-b
Anode Sensitivity	Blue (with CS-5-58 filter)		5.5	--	A/lm-b
Gain		1×10^5	7×10^5	--	--
Anode Dark Current, Total (@ 10^5 Gain)		--	1	5	nA
Time Response	Anode Pulse Rise Time	--	0.3	--	ns
	Anode Pulse Width (FWHM)	--	1.8	--	ns
Pulse Linearity at 5% Deviation		--	300	--	mA
Anode Uniformity		--	1:1.5	--	--



~3KV for the MCP-PMT ; FWHM time of PMT signals ~few ns

Timing resolution ~100ps should be more than fine

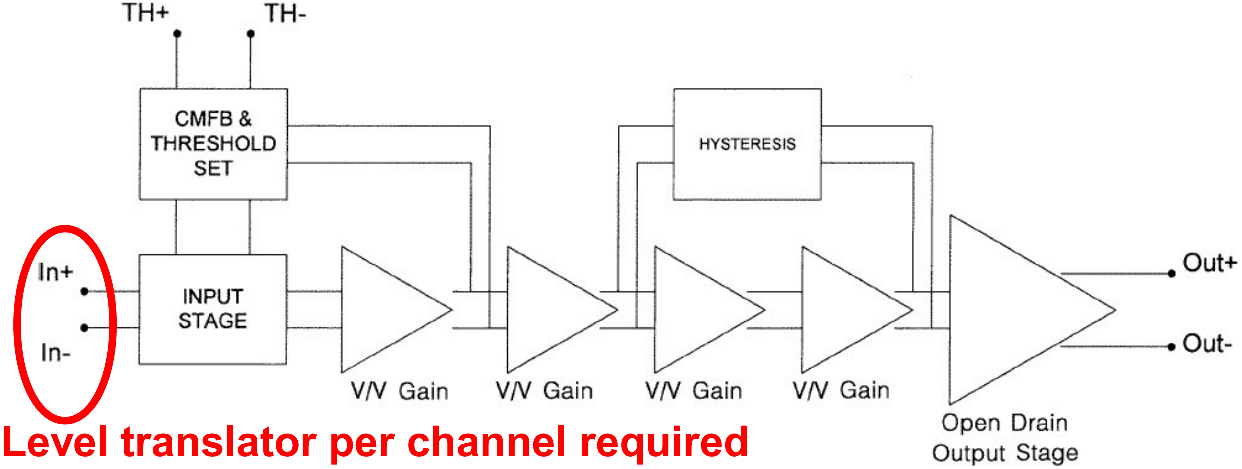
~4k channels by 128MCP-PMT with 32Channels

4 times 8channel Connector with 2mm pin-distance

Some numbers........

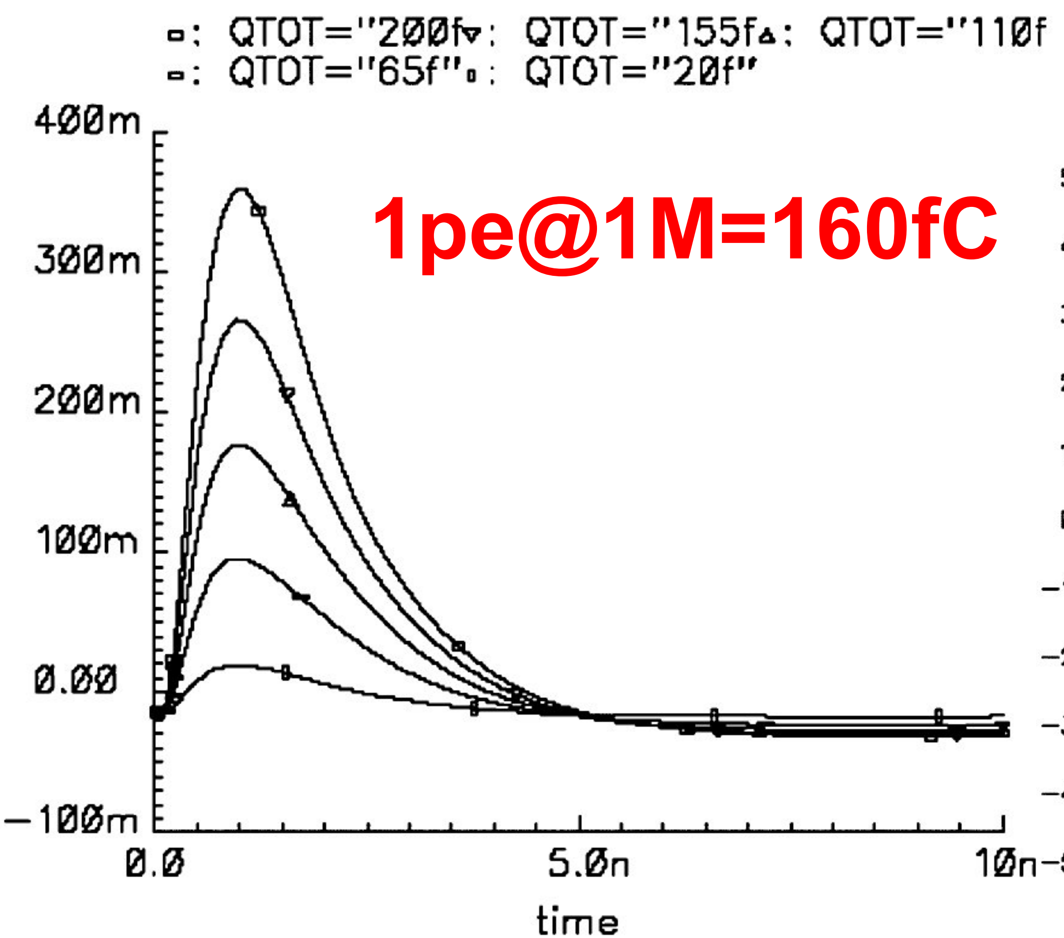
- Rough data assumptions in normal readout mode
  - 20M : intersections per seconds
  - 8 : peak charged Multiplicity
  - 32 : Number of generated Photons
  - 128 : MCP-PMT
  - 32 : Channels per MCP-PMT
  - yields
    - ~40MHz hits per MCP-PMT
    - ~1.3MHz per MPC-PMT-channel
    - 7 Bytes per hit
      - 2 for location
      - 3 time stamping
      - 1 for status
      - 1 spare
    - ~300 MBytes per second per MCP-PMT
    - ~3 GBit per second per MCP-PMT
    - Background NOT included yet

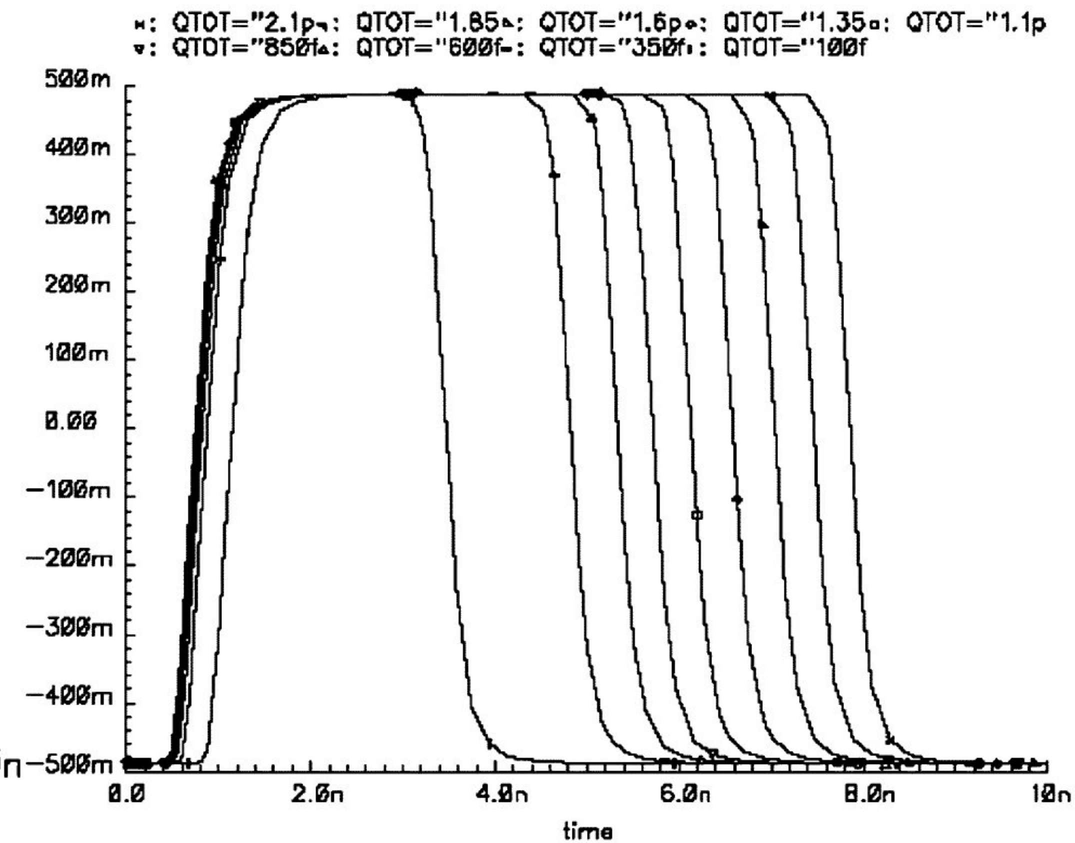
Analog Readout via NINO-chip



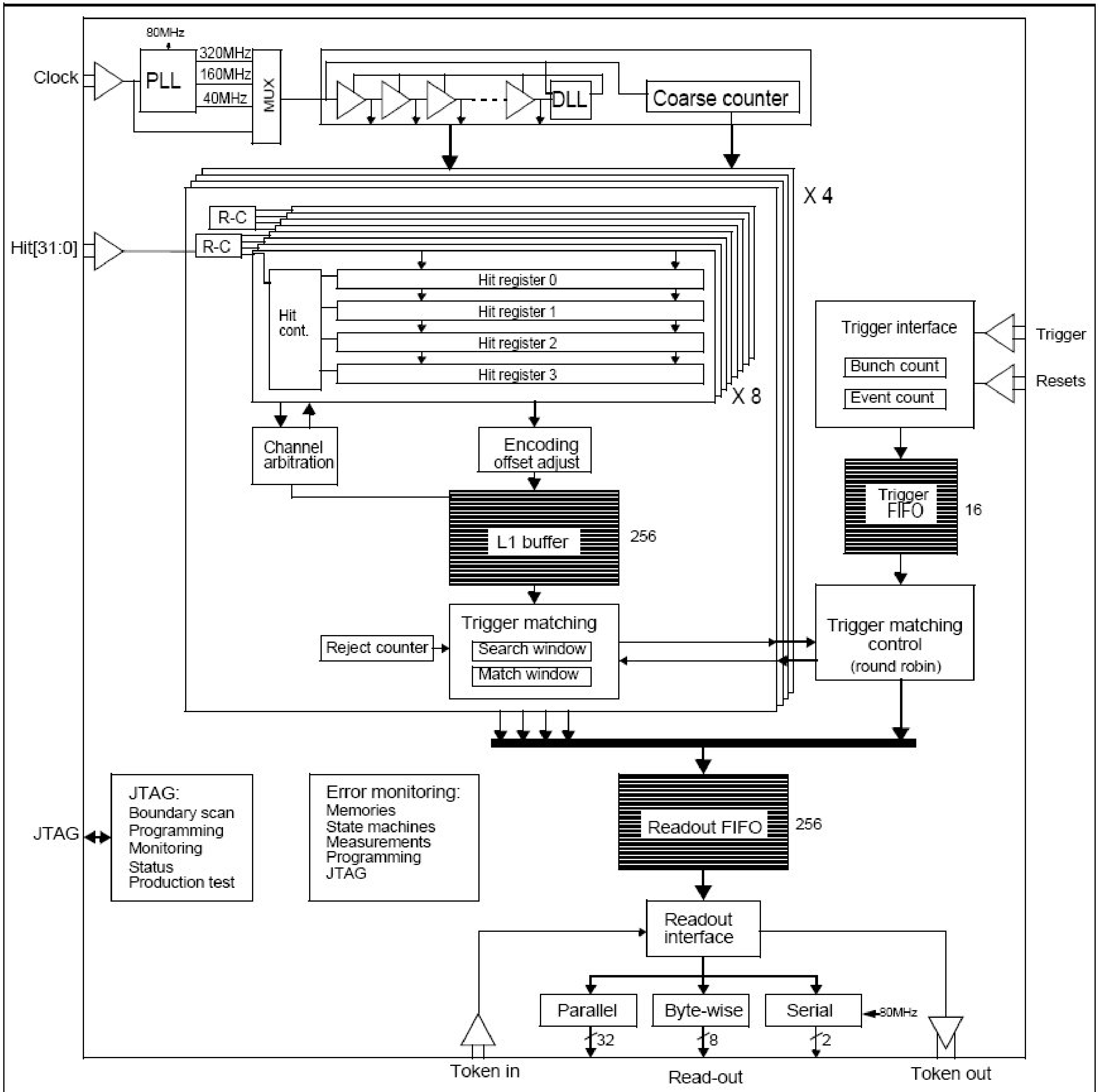
Level translator per channel required

Parameter	Value
Peaking time	1ns
Signal range	100fC-2pC
Noise (with detector)	< 5000 e- rms
Front edge time jitter	< 25ps rms
Power consumption	30 mW/ch
Discriminator threshold	10fC to 100fC
Differential Input impedance	40Ω< Zin < 75Ω
Output interface	LVDS





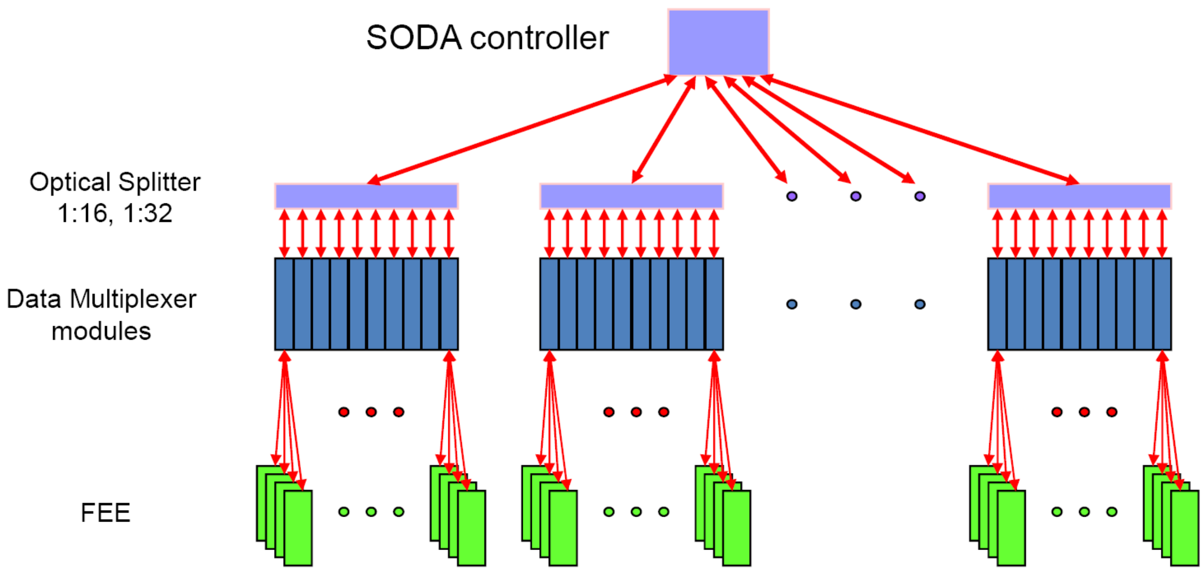
Digital Readout via HPTDC-chip



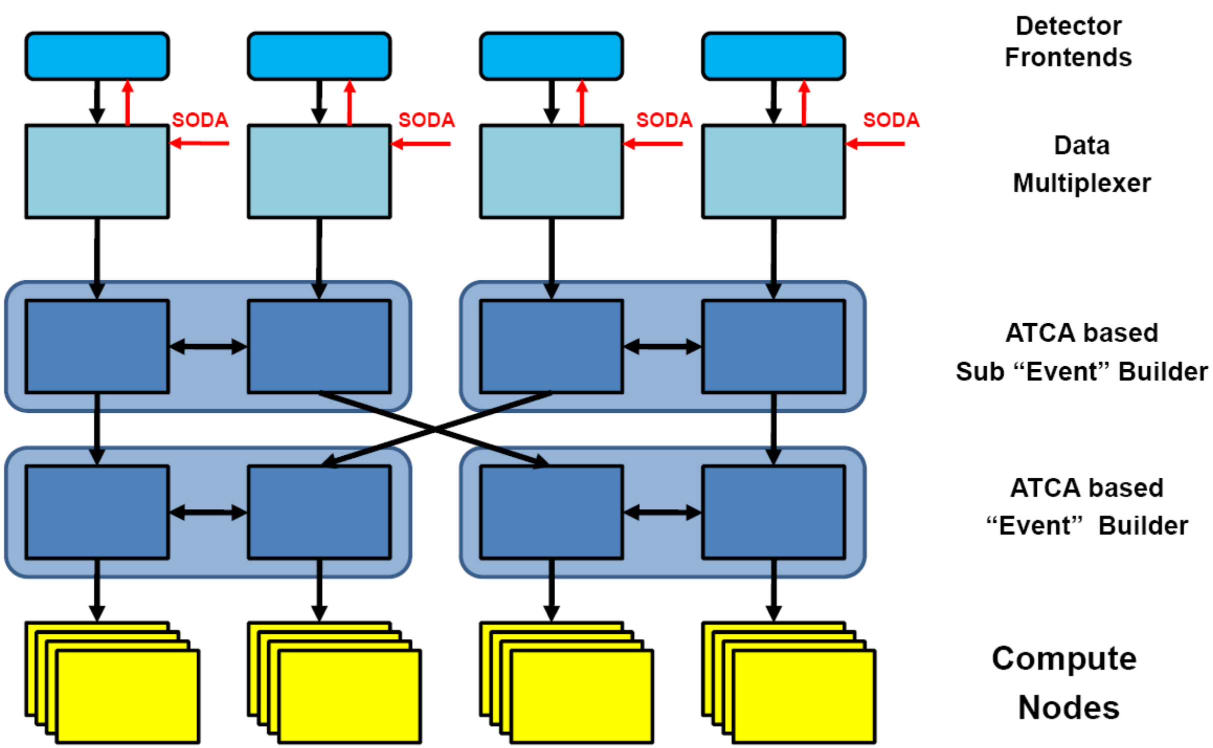
Mode	Resolution (RMS)
Low resolution	0.34 bin (265 ps)
Medium resolution	0.44 bin (86ps)
High resolution	0.65 bin (64ps)
High resolution DLL tap adjust INL table correction	0.35 bin (34ps)
Very high resolution	2.4 bin (58ps)
Very high resolution DLL tap adjust INL table correction	0.72 bin (17 ps)

- **HPTDC chips @ CERN**
- **32ch in “slow mode”**
  - ~100ps RMS
  - CAEN TDC v1190
- **8ch in “fast mode”**
  - ~25ps RMS
  - CAEN TDC V1290
- **Care about hitrate**

Interfacing for timestamping / readout



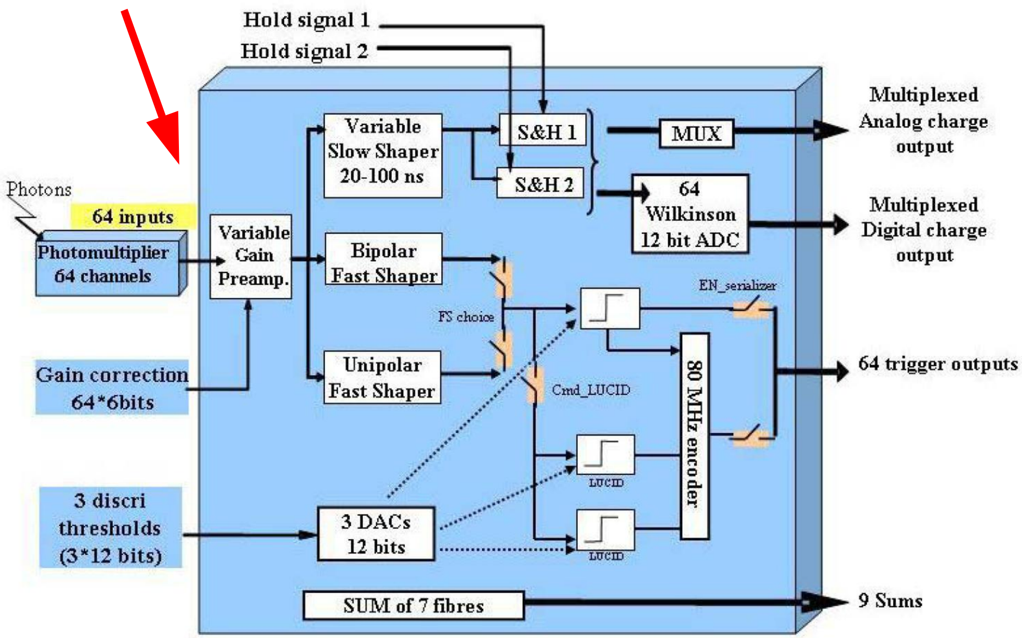
- No central trigger
  - Timestamping via Optical interface with ~15ps RMS before FEE
- Individual FEE for each Detector
- FDD : 16x8 splitter
- DAQ readout
  - Data Multiplexer
  - Multi level event builder
  - Massive parallel Computer nodes for data analysis



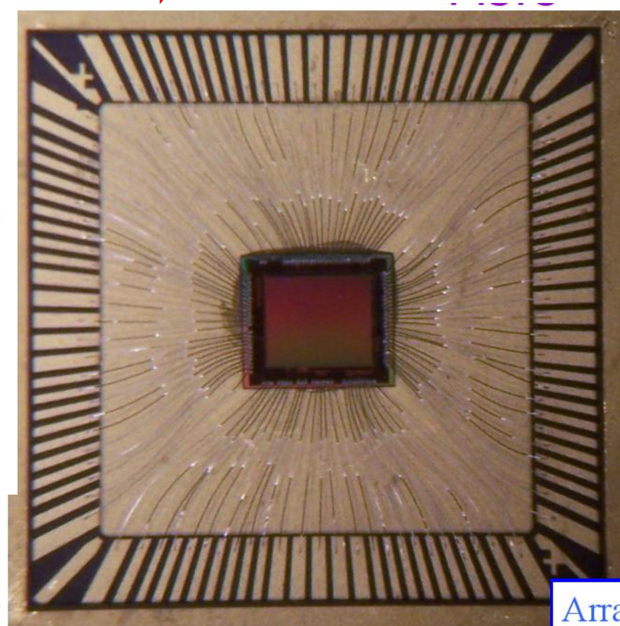
→learn more next days

Alternatives to mainstream

MAROC-style @ **http://omega.in2p3.fr/index.php/omega/talks-a-publications/doc_download/85-paper-maroc2-nss-2007**



BLAB sampling chip



3mm x 2.8mm, TSMC 0.25um

arXiv:0802.2278, NIM **A** (2008) in press

- Single channel
- 64k samples deep, same SCA technique as LAB, no ripple pointer
- Multi-MSa/s to Multi-GSa/s
- 12-64us to form Global trigger

Arranged as 128 x 512 samples
Simultaneous Write/Read

•Calibration / monitoring measurements with extended data
•Normal data taking with core data informations like start and integral / time over threshold
•Gain adjusting on the fly
•Signal resonstruction on the fly
•Cross linking of MCP-PMT inside detector via Xilinx-Rocket-IO-channels

- Currently under investigation................

Other features to merge and attend

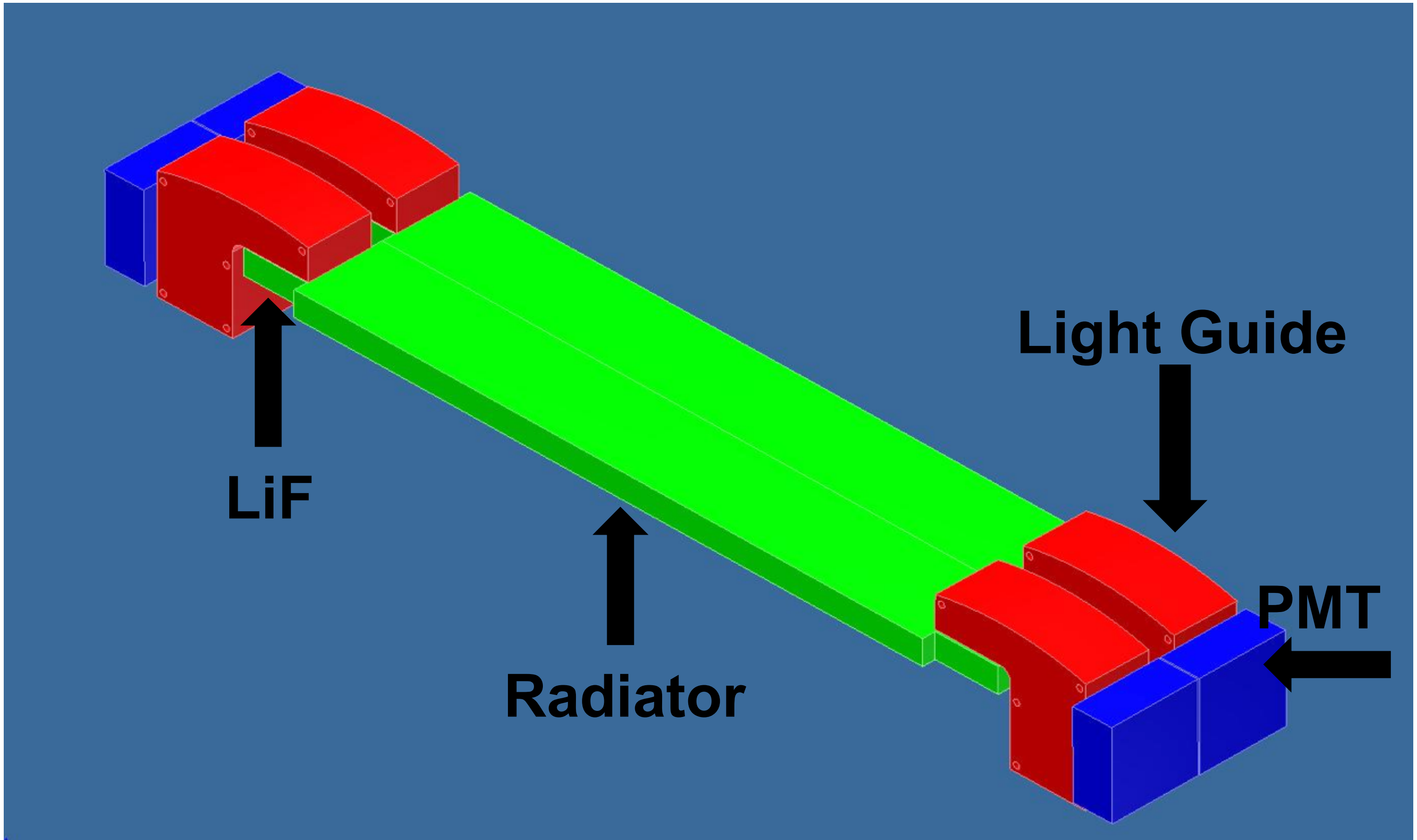
- **Temperature sensors**
- **Radiation sensors**
- **Calibration measurements within beam profile**
- **Adjusting individual gain of MCP-PMT**
- **Preamplifier to increase MCP-PMT life-time**
- **Monitoring of**
  - HV @ ~3kV; LV
  - Currents
  - Timing
  - Temperature
  - Radiation
  - Alignment
- **Gain monitoring system**
- **Wire-, Cooling-lines**
- **Bootstrapping of Xilinx / PowerPC**
- **Timestamping interface to SODA**
- **For sure some more will come / forgotten ....**

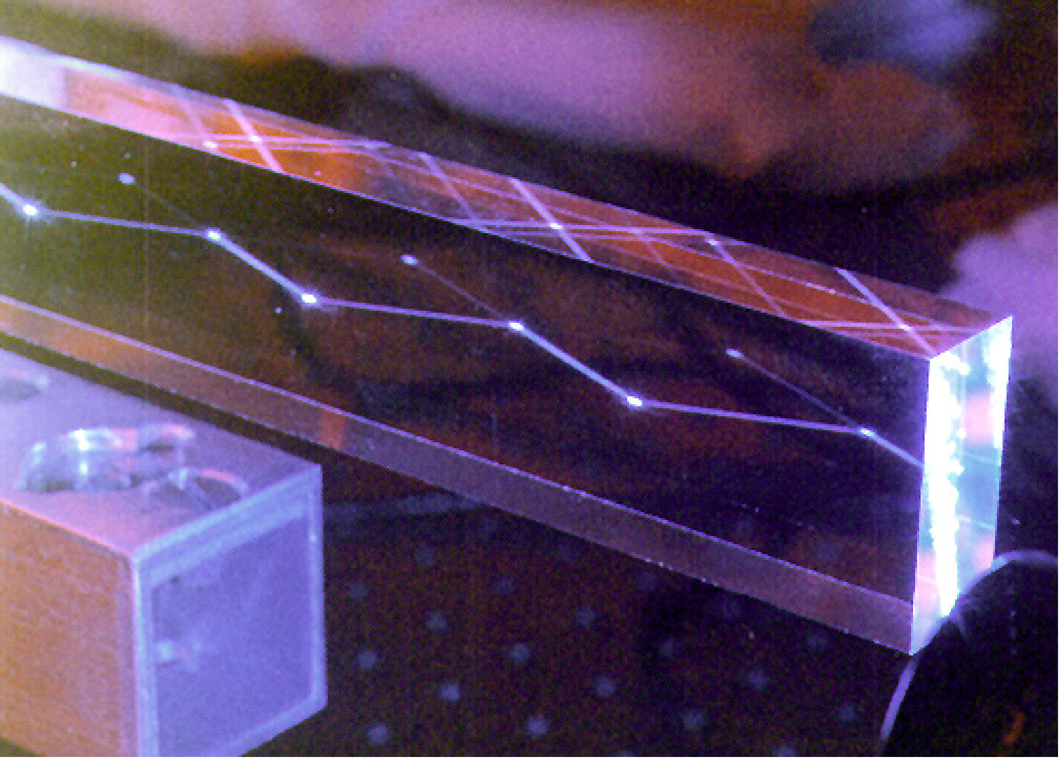
current solution via PCB-tuning with available chips

Outlook (Testbeam prototype in summer)

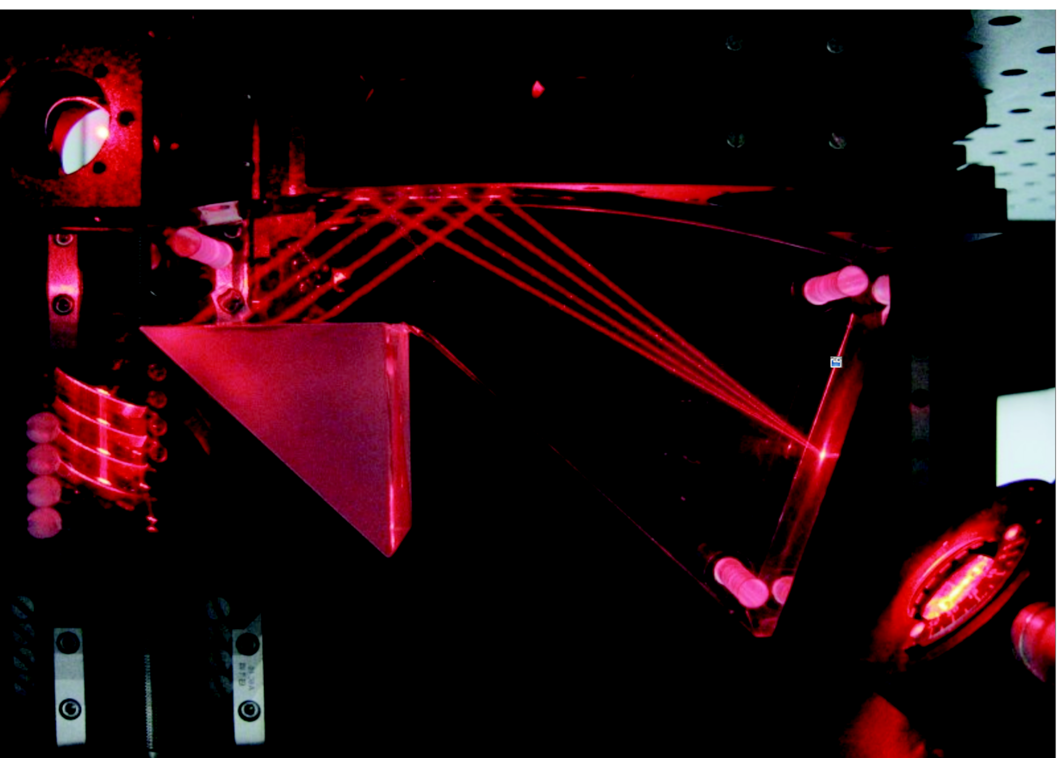
- Two fused Silica Bars (500mm x 70mm x 20mm)
- Four plates Lithium Fluoride (50mm x 50mm x 15mm)
- Four light guides optimized for MCP-PMT candidate
- Use commercial electronics and self-made DAQ
- Testbeam together with other subdetectors

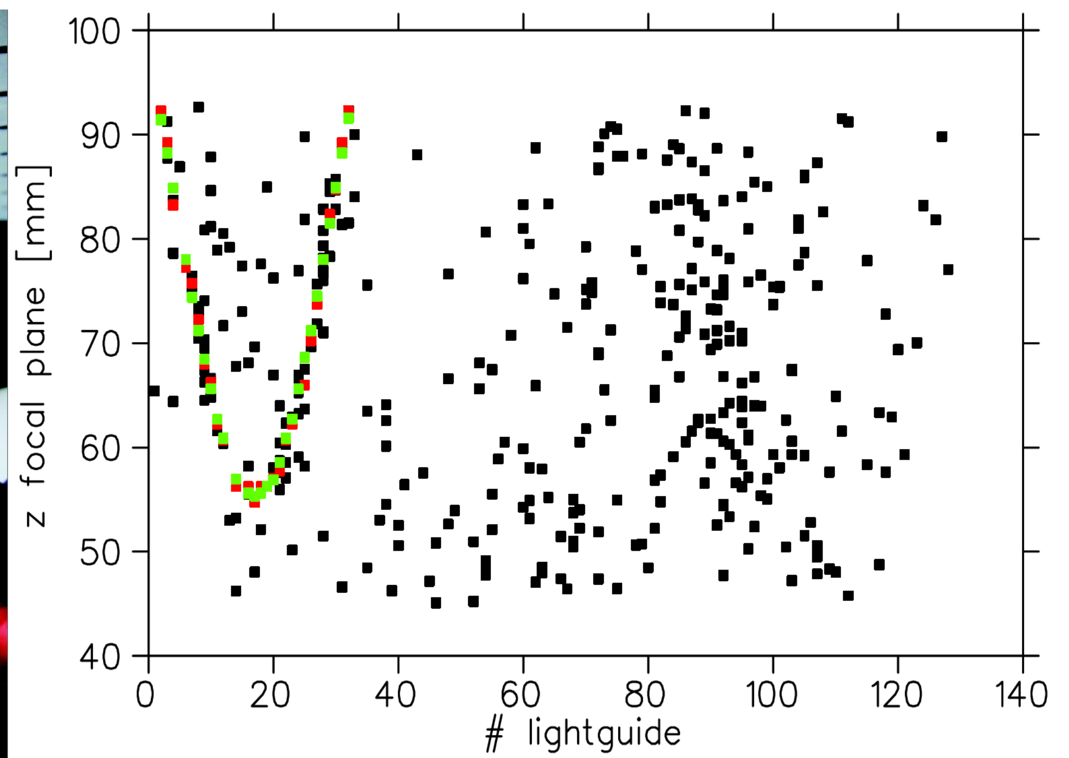
- Studies
  - Particle(K,pi,p) response
  - Photon propagation
  - Hit pattern
  - Mechanical designs
  - **Check for unforeseen challenges**





Thank you very much for your attention :)





BACKUP slides

Physics characteristics (backup)

http://panda-wiki.gsi.de/cgi-bin/view/Computing/DpmGen

Das sind für jeweils 10k DPM events (nur inelastisch, keine elastische pbar p Streuung; keine stabilen Resonanzen wie K_S, pi0, Lambda, d.h. im wesentlichen p, pi, K, gamma) die Multiplizität der geladenen und gammas, welche durch die Scheibe gehen. Dann einmal zur Kontrolle das 2dim Winkelprofil oben rechts. Unten dann das Energiespektrum aller gammas in GeV, welche durch die Scheibe gehen sowie die theta-Verteilung für alle Teilchen. Da kann man dann grob ablesen für 0.087 = 5/180*pi < theta < 0.384 = 22/180*pi gehen die Teilchen durch den Disc-DIRC.