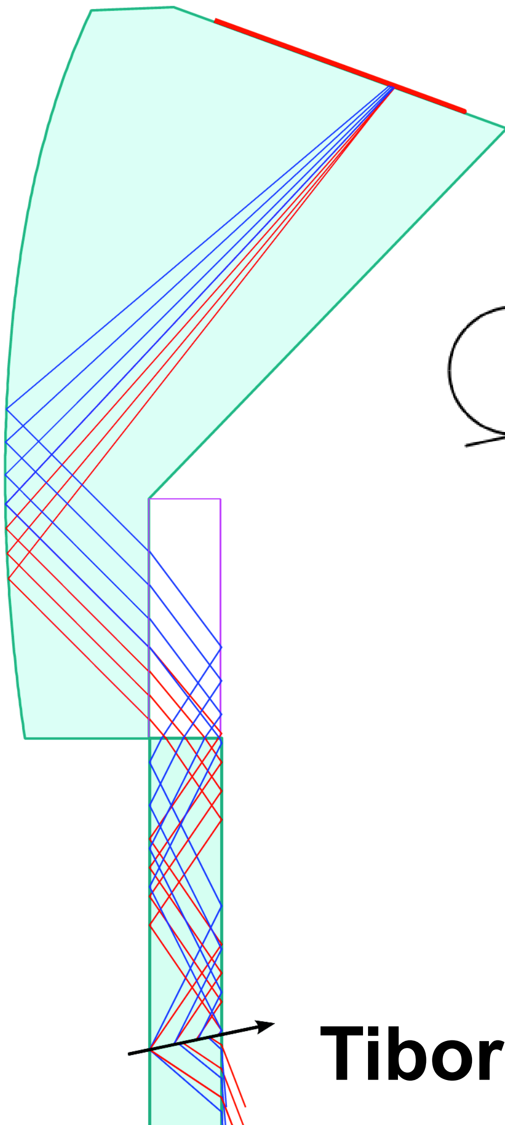
Focusing Disc DIRC

Front-End Electronics



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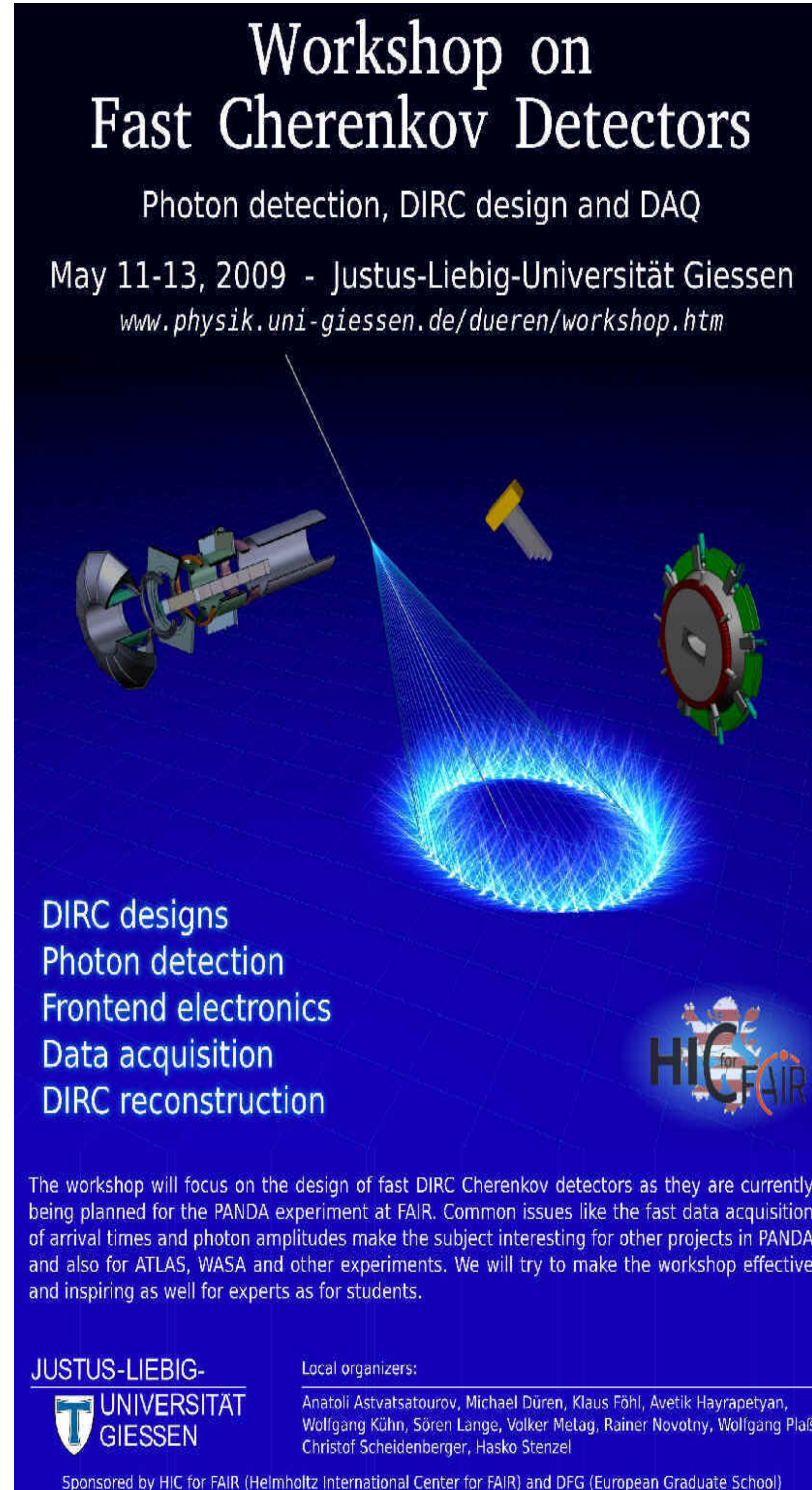
for the

Tibor Keri



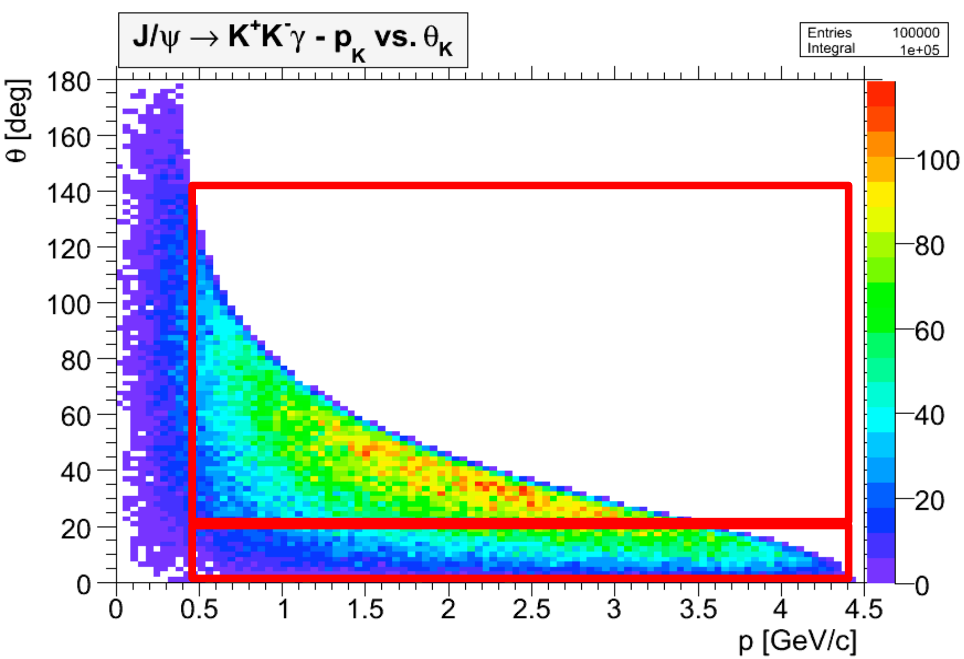
Outline

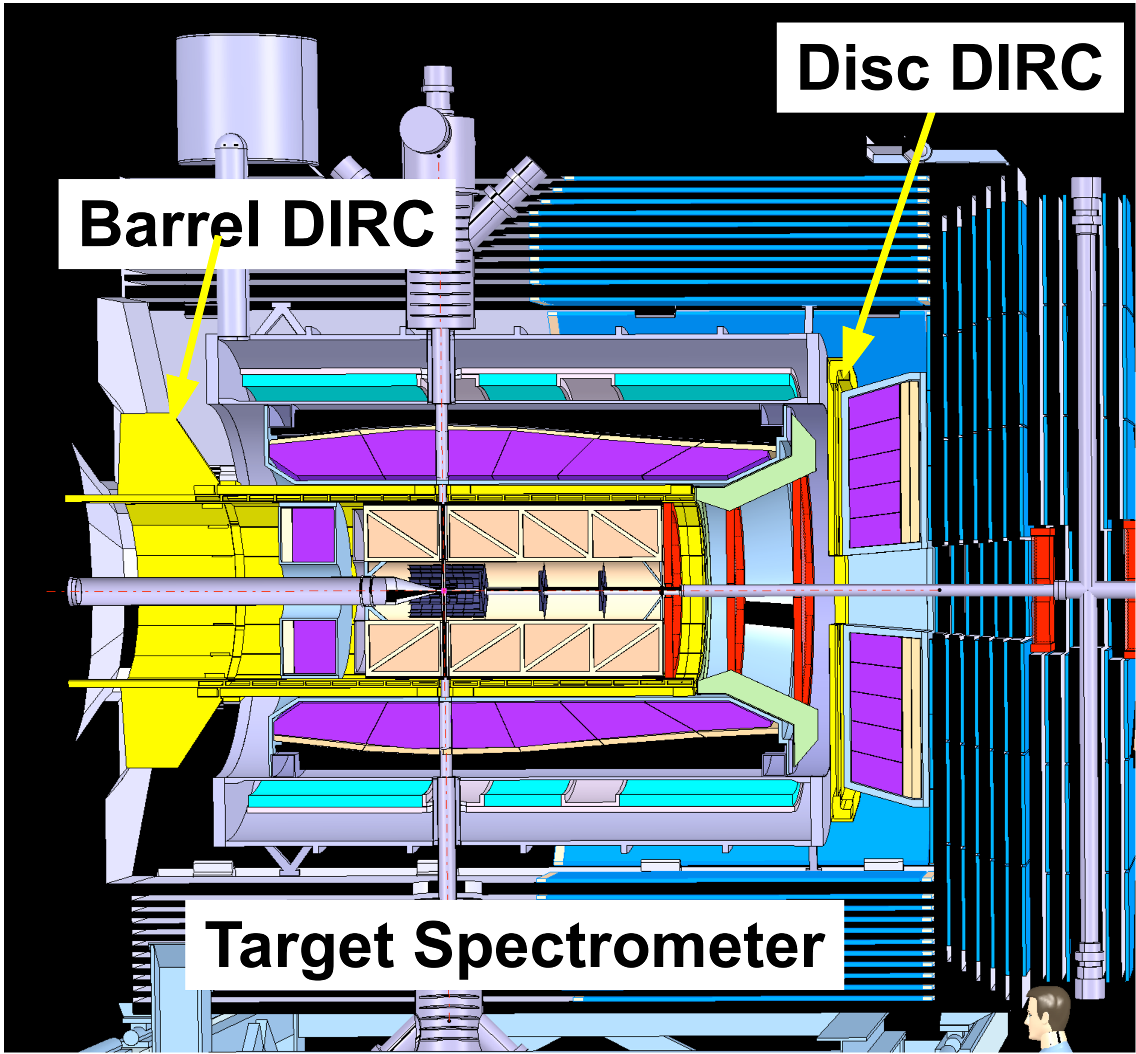
- Detector Design Requirements
- FDD solution
- Front End Electronics
  - Photon Detector
  - Front End
  - Back End
- Summary and Outlook

Detector Design Requirements

Matthias Hoek
Tuesday

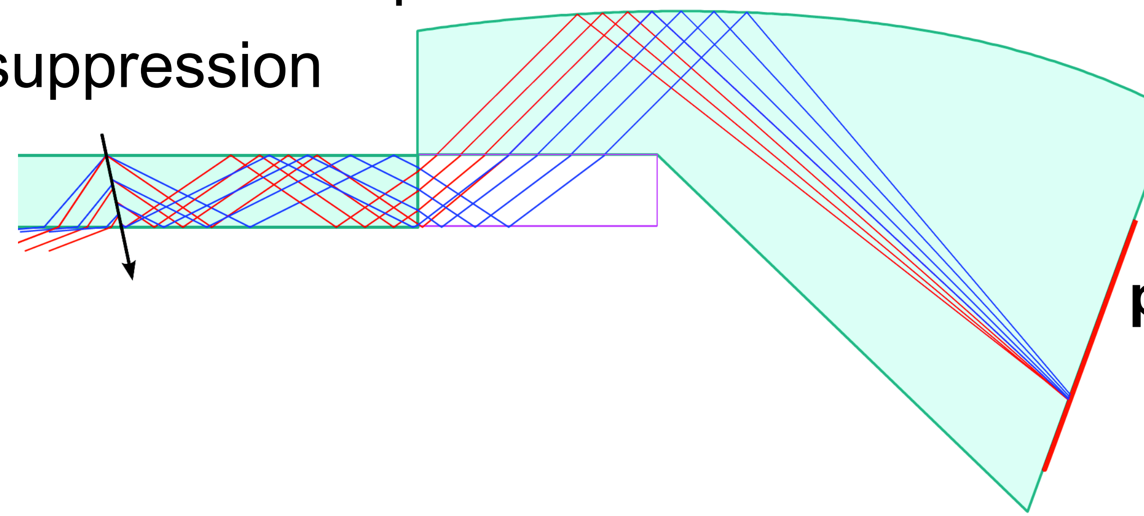
- PANDA anti-proton annihilation experiment at $\sqrt{s} \leqslant 5.5 \mathrm{GeV}/c$
- Full angular coverage and very good PID mandatory required for physics program
- 20MHz average interaction rate with continuous beam and quasi-fixed flexible target
  - 2000ns beam on and 400ns beam off
  - Radiation hard (~100krad for PANDA lifetime ~10y)
  - High count rates (~2MHz/cm^2)
  - Moderate time resolution (~300ps)
- Magnetic field up to 1.5 T
- Small radiation length

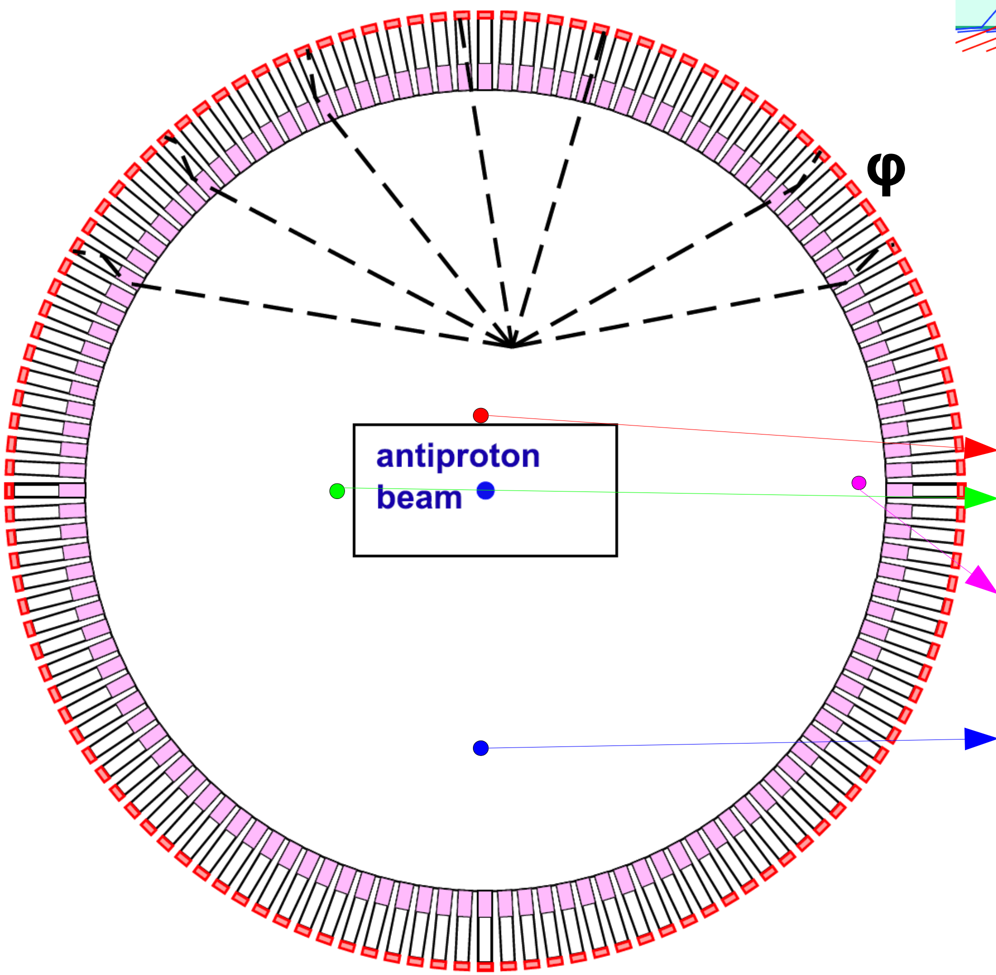


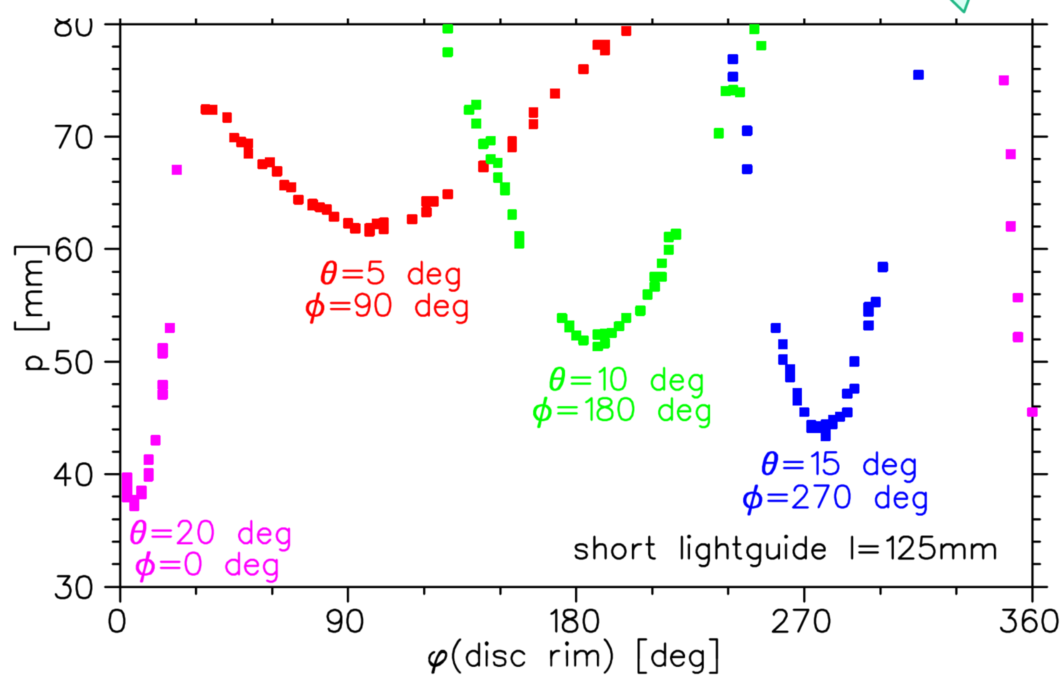


PID detector solution by FDD

- FDD (Focusing light guide Disc DIRC) by 2D (+1t)
  - Time resolution ~300ps;~128Light guides;~4k readout channels
  - LiF for dispersion correction and acceptance enhancement
  - Timing for background suppression and event separation

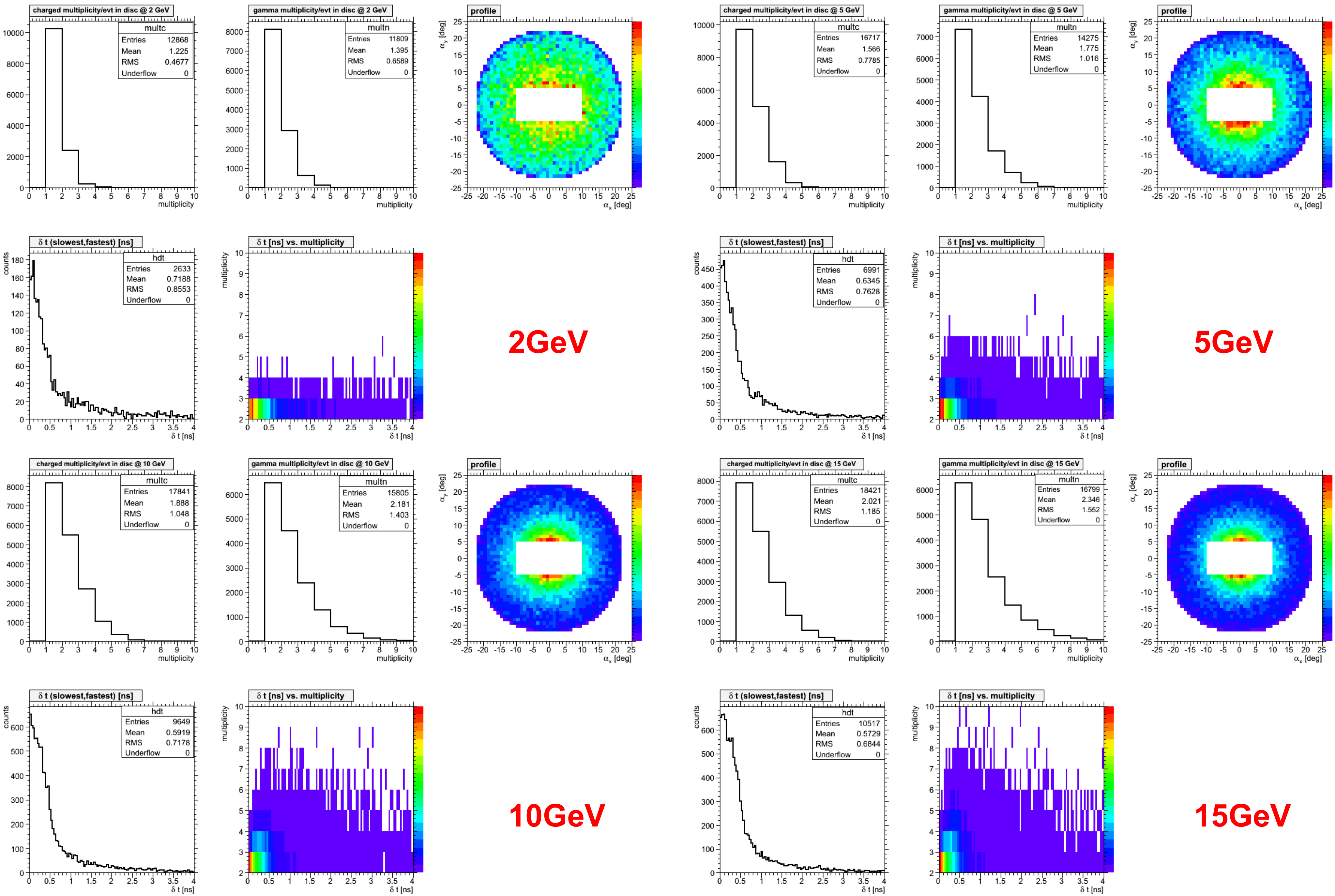






Physics characteristics

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



Design Requirement for readout

- Average data assumptions in readout mode
  - 20MHz : average intersection rate
  - 4 : average charged multiplicity per intersection
  - 64 : number of detected Photons per charged particle

    - 128 : number of MCP-Photomultiplier for photon detection
    - 32 : number channels per MCP-Photomultiplier

      - ~40MHz hits per MCP-Photomultiplier
      - ~1.25MHz per MPC-Photomultiplier-channel

        - 6 Bytes per hit
          - 2 for location
          - 3 time stamping
          - 1 for status

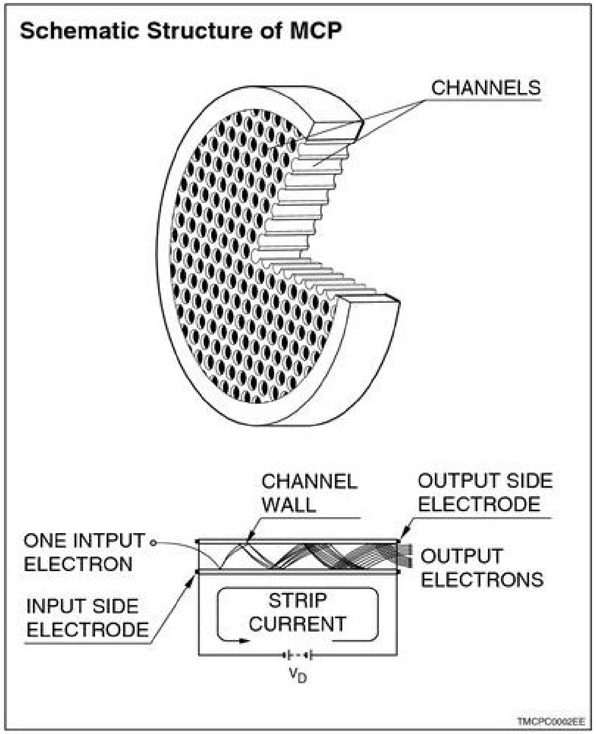
        - ~250 MBytes per second per MCP-Photomultiplier
        - ~2.5 GBit per second per MCP-Photomultiplier
          - Optical Rocket-IO-links 6GBit/sec

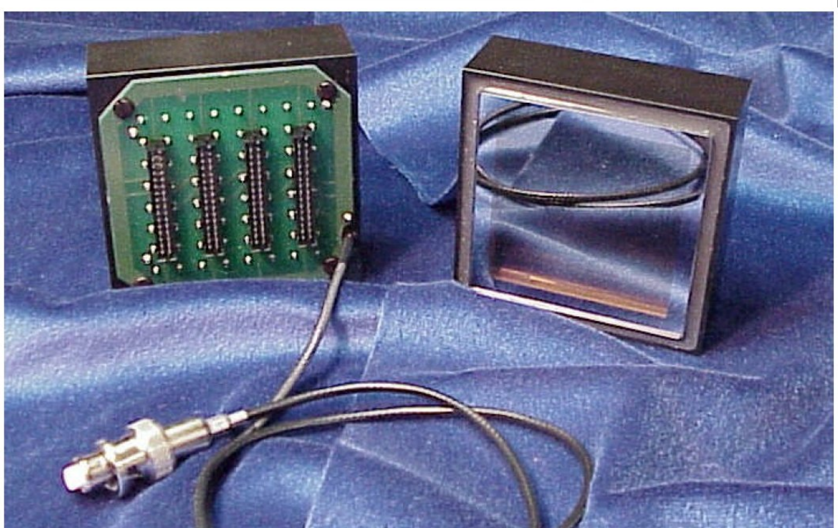
        - Background NOT included yet
          - Showers, Backscattering, Dark current
          - Events for calibration, monitoring, tuning
          - A lot more ...

Photondetector

Albert Lehmann
Monday

- 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 response resolution ~300ps should be more than fine

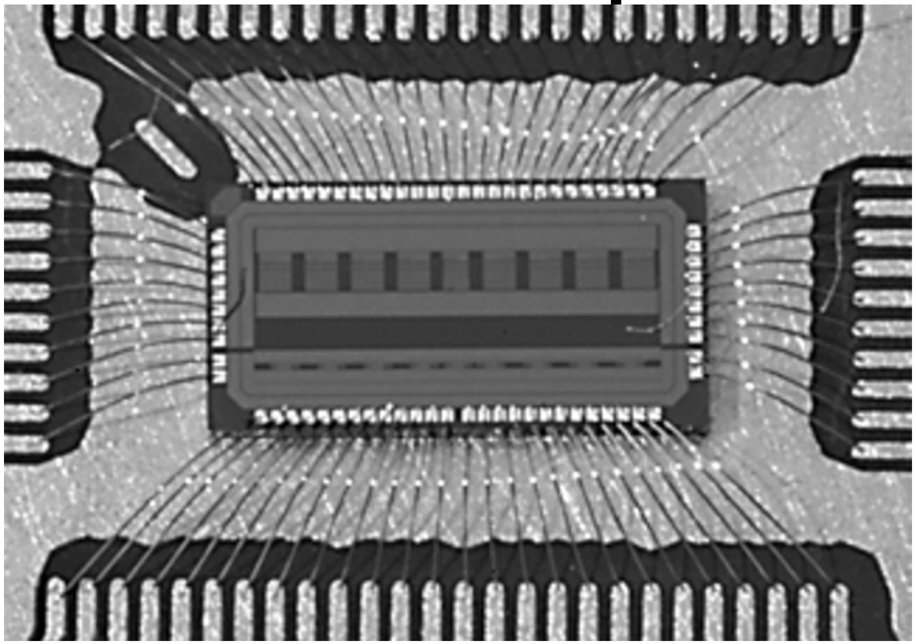
~4k channels by 128 MCP-PMT with 32 Channels / Strips

4 times 8channel Connector with 2mm pin-distance

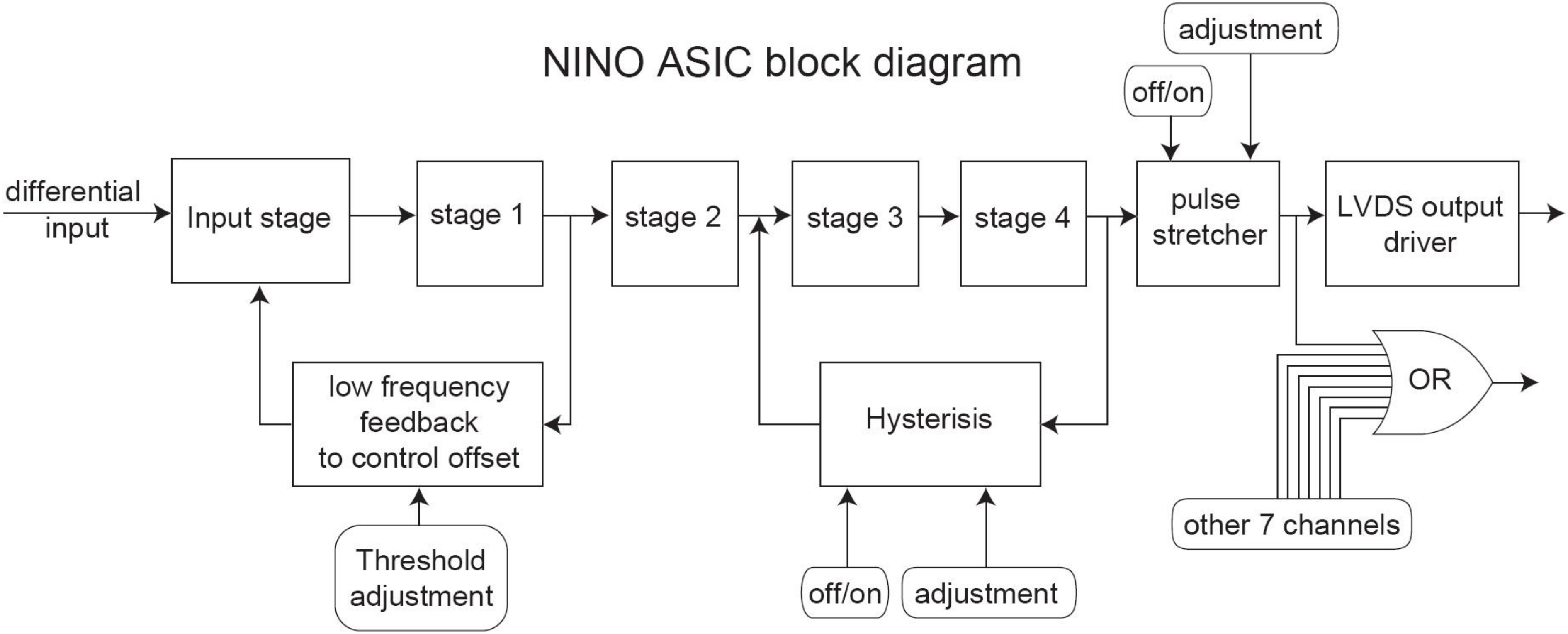
Analog Readout via NINO-chip 1/3

NINO
An ultrafast low-power front-end amplifier discriminator for the Time-of-Flight Detector in the ALICE Experiment

- NIMA 533(2004) 184-187
- IEEE Vol. 51, No. 5 Oct 2004

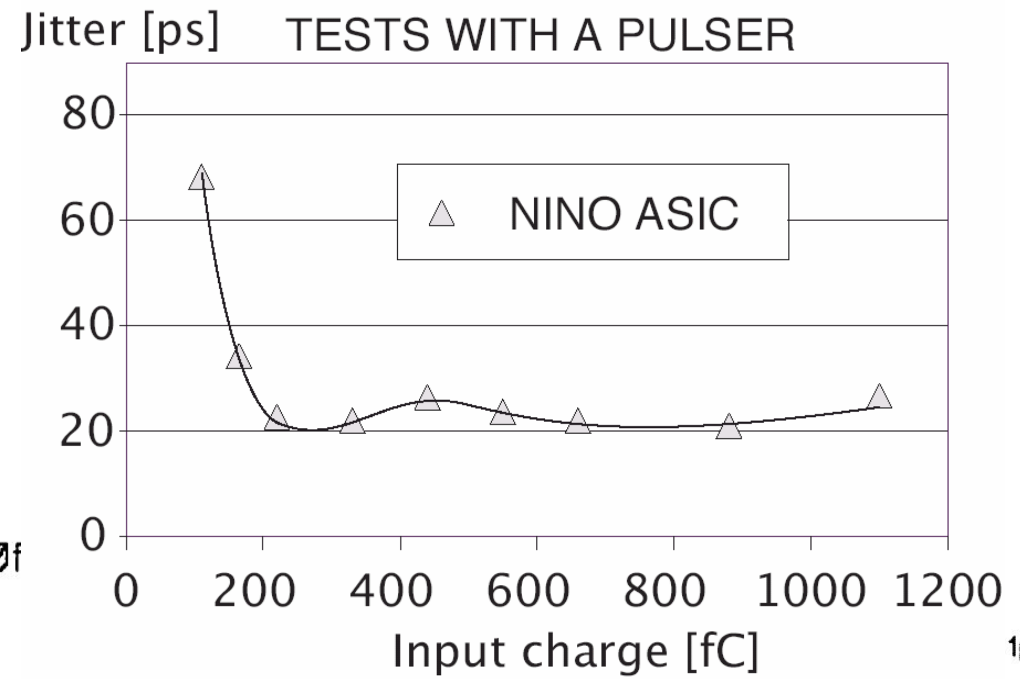


2mm X 4mm

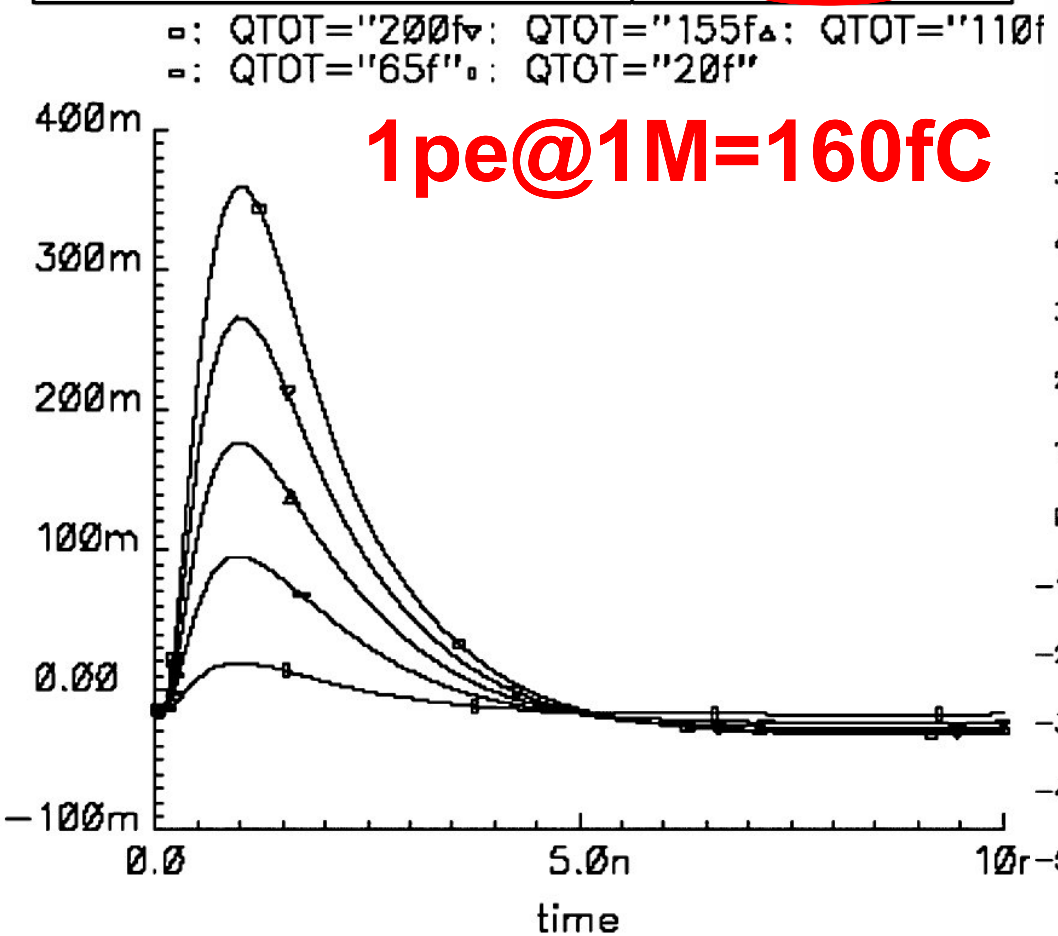


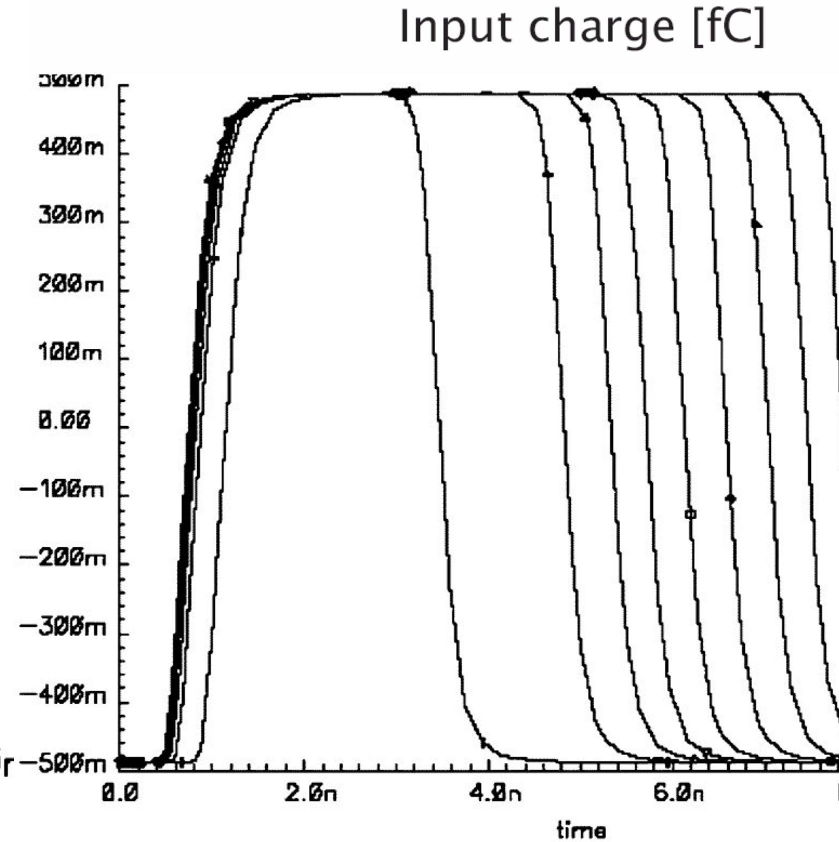
Analog Readout via NINO-chip 2/3

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



1pe@1M=160fC

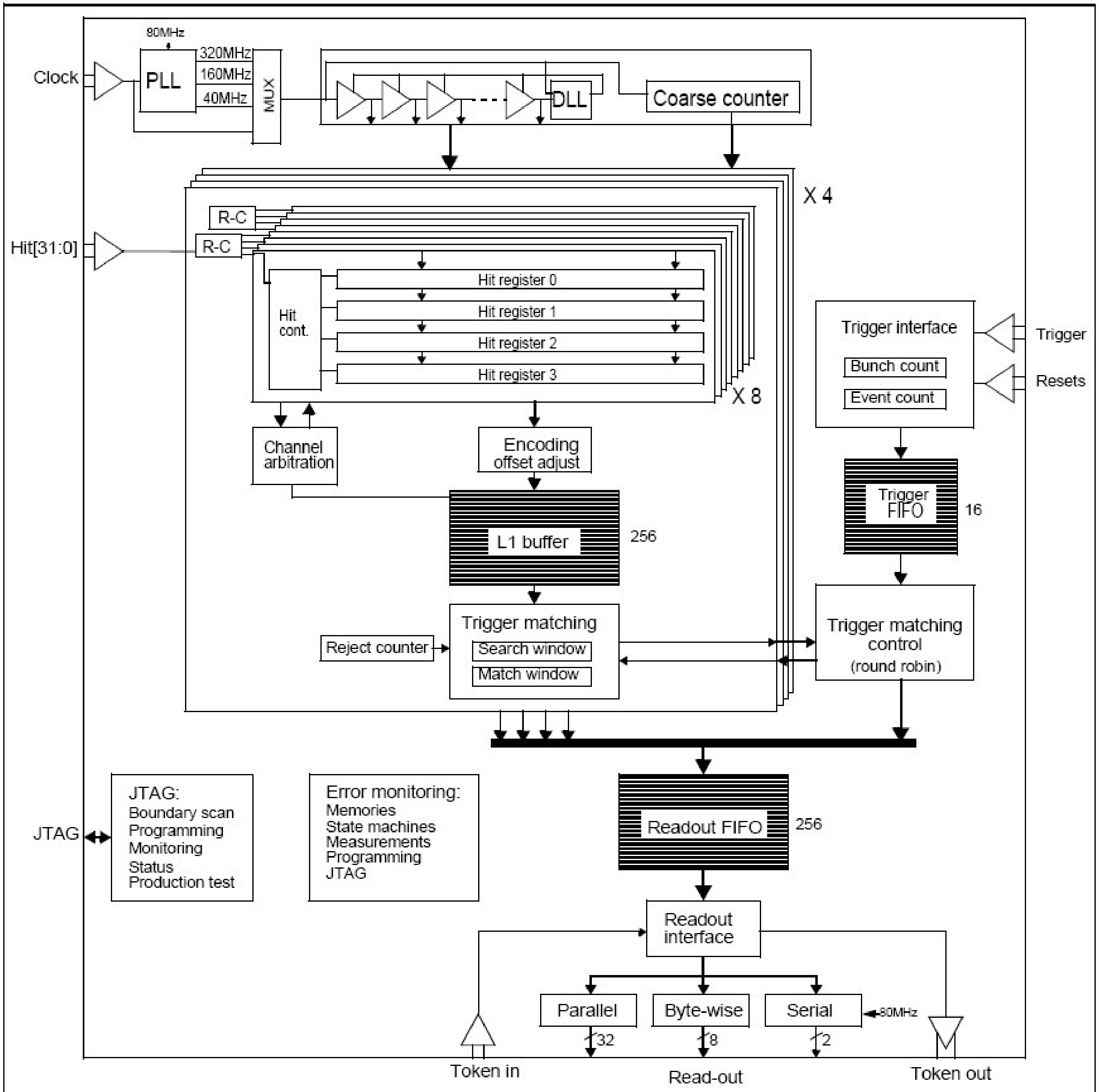




+10ns deadtime due to HPTDC double hit detection >6ns

Digital Readout via HPTDC-chip

J.Christiansen @ CERN/EP-MIC



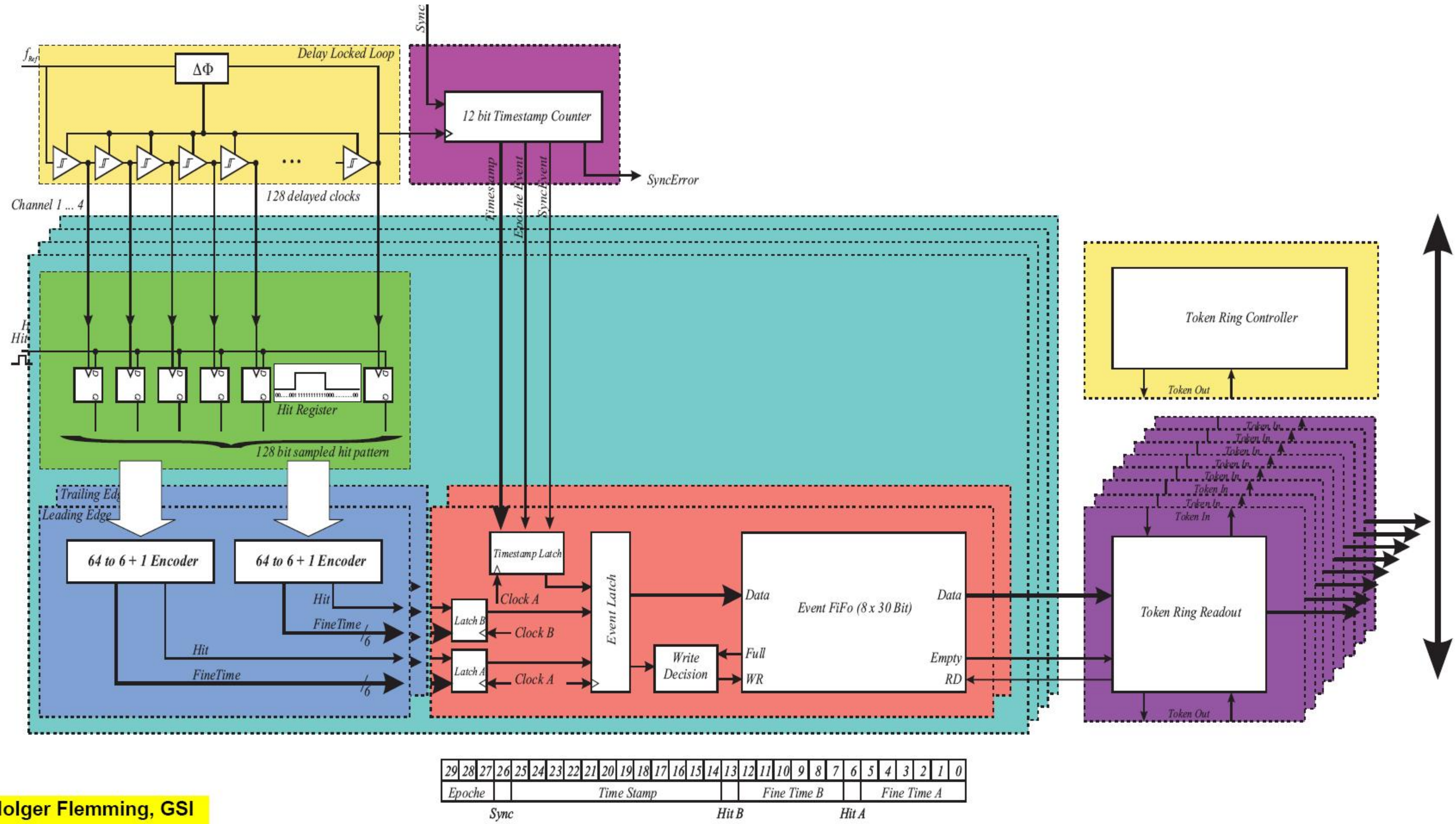
Mode	Resolution (RMS)
Low resolution	0.34 bin (265 ps)
Medium resolution	0.44 bin (86ps)
High resolution	0.65 bin (64ps)
High resolution DLL tap adjust INL table correction	0.35 bin (34ps)
Very high resolution	2.4 bin (58ps)
Very high resolution DLL tap adjust INL table correction	0.72 bin (17 ps)

- **HPTDC chips @ CERN**
- **32ch in “medium mode”**
  - ~100ps RMS
  - CAEN TDC v1190
- **8ch in “(very) high mode”**
  - ~25ps RMS
  - CAEN TDC V1290
- **Care about hit-rate in L1-buffer**

GET4-chip

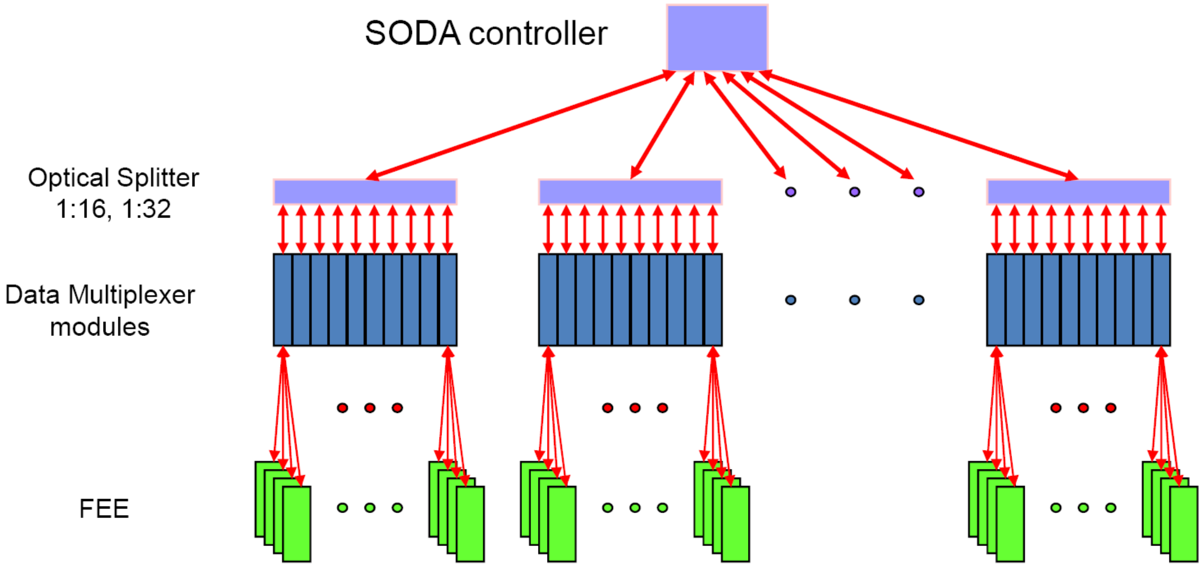
GSI Event-DrivenTDC with 4 Channels

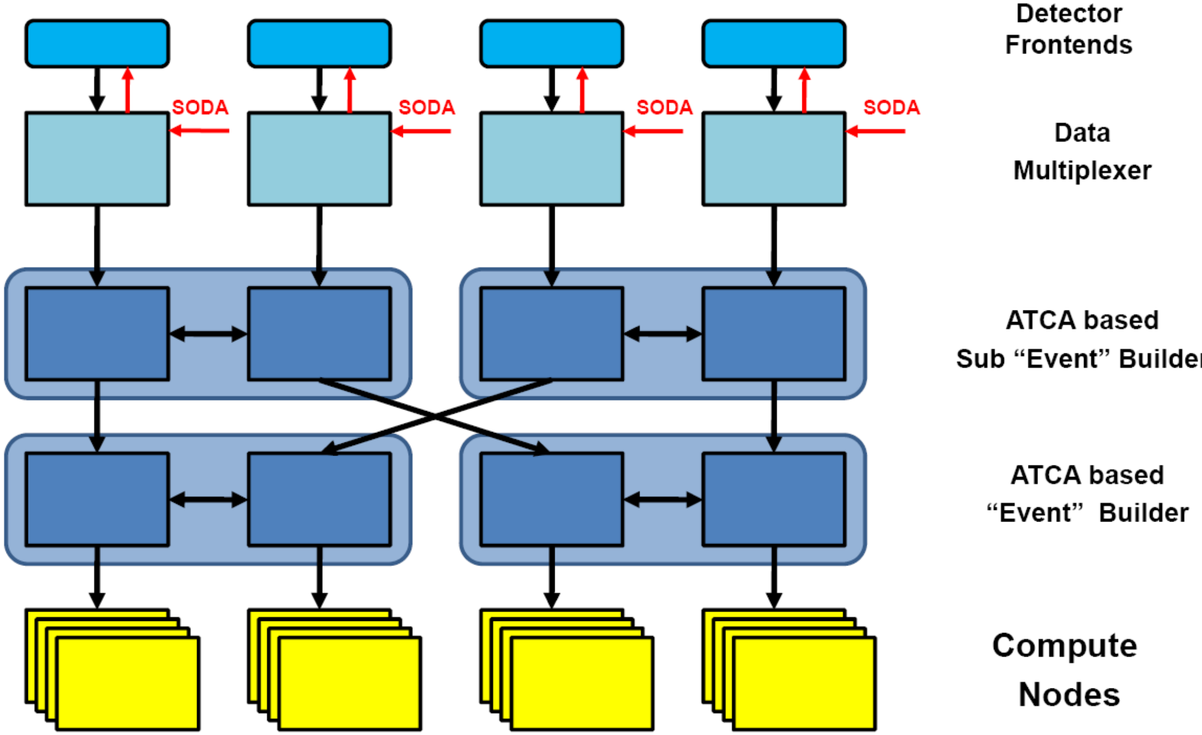
Harald Deppe
Holger Fleming
EE-ASIC @ GSI



Holger Flemming, GSI
Bodenmais, 2009

Interfacing for timestamping / readout



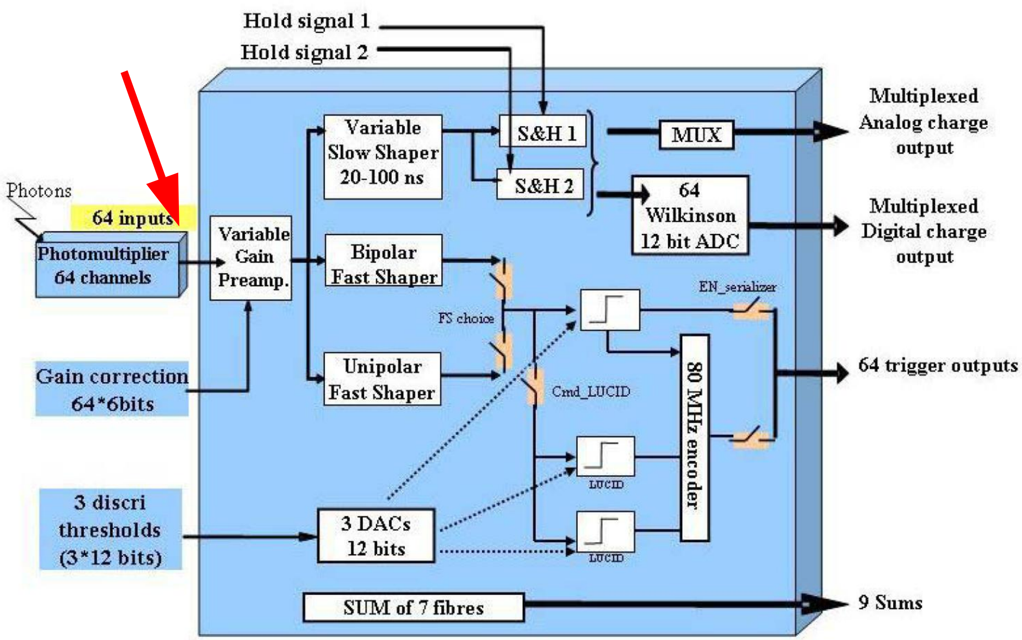


- No hardware trigger
  - Timestamping via Optical interface with ~15ps RMS

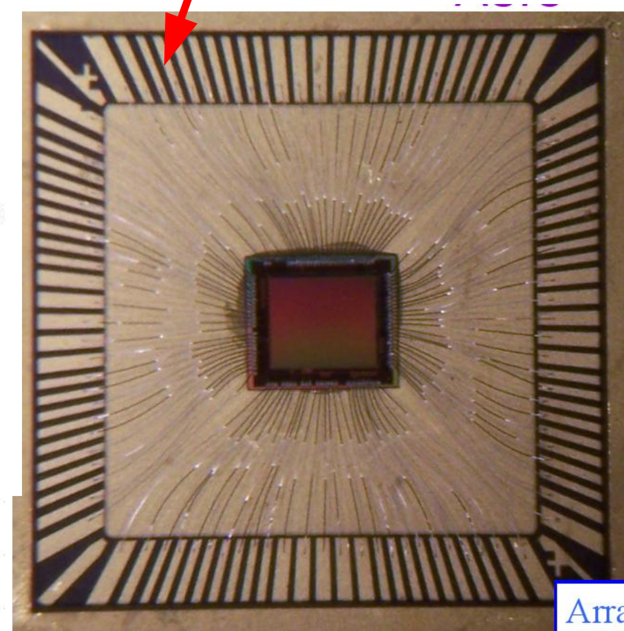
    right before FEE
- Individual FEE for each Detector
- FDD : 128PMT
  → 16x8 or 8x16
  optical splitter
- DAQ readout
  - Data Multiplexer
  - Multi level event builder
  - Massive parallel Computer nodes for data analysis

Alternatives to mainstream solution

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

- Online signal reconstruction to studies FDD with PANDA detector
- Online calibration / monitoring measurements with extended data stream
- Data taking with core data informations like hit timestamp and integral / time over threshold
- In situ PMT gain correction for improved pattern recognition and noise reduction
- Reduction of power consumption and required space for readout elektronik

- Cross linking of MCP-PMT inside detector via Xilinx-Rocket-IO-channels for preprocessing

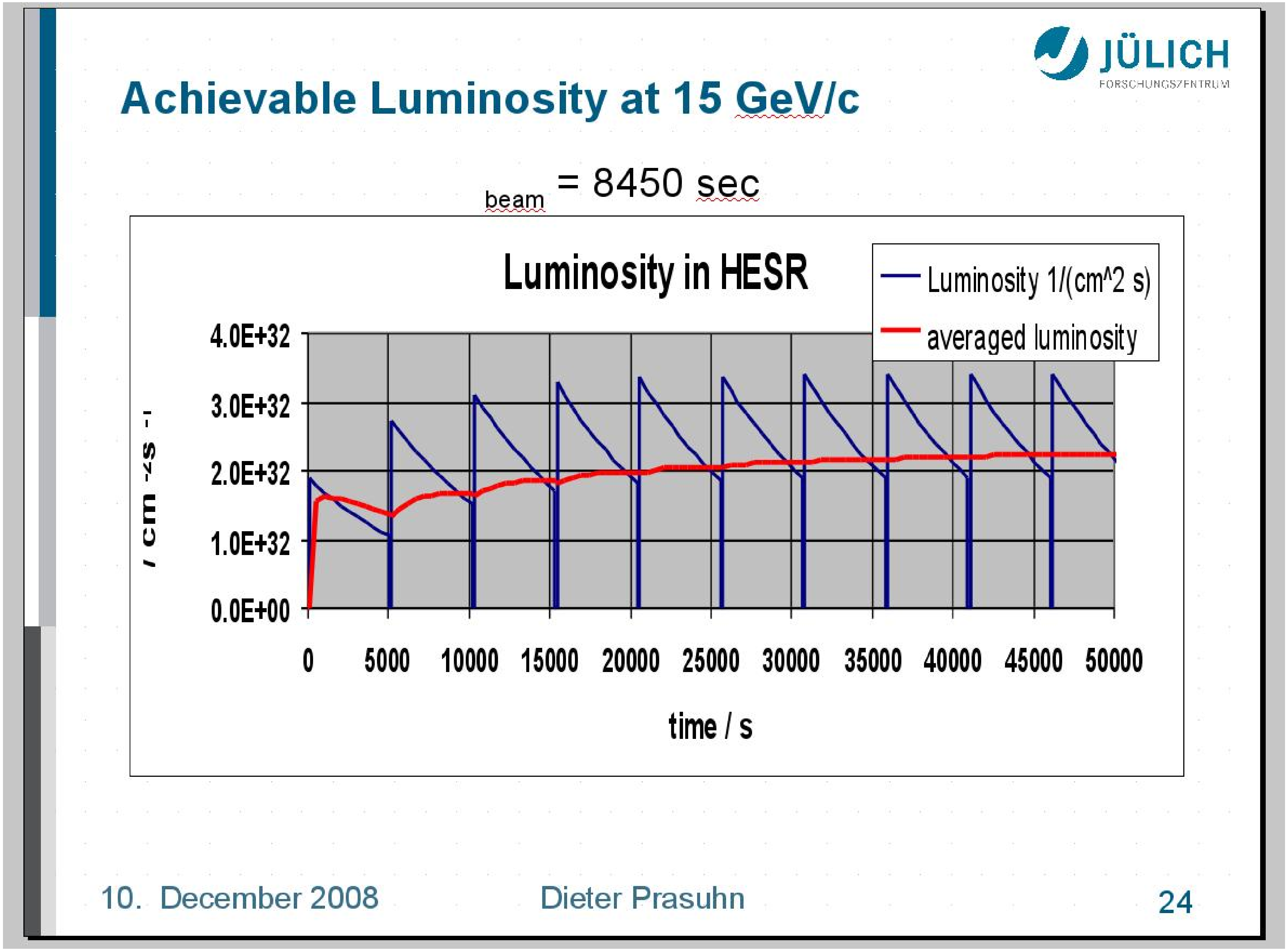
  - Such optional solutions are currently under investigation.................

unsorted 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**
- **Layout Power-, 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

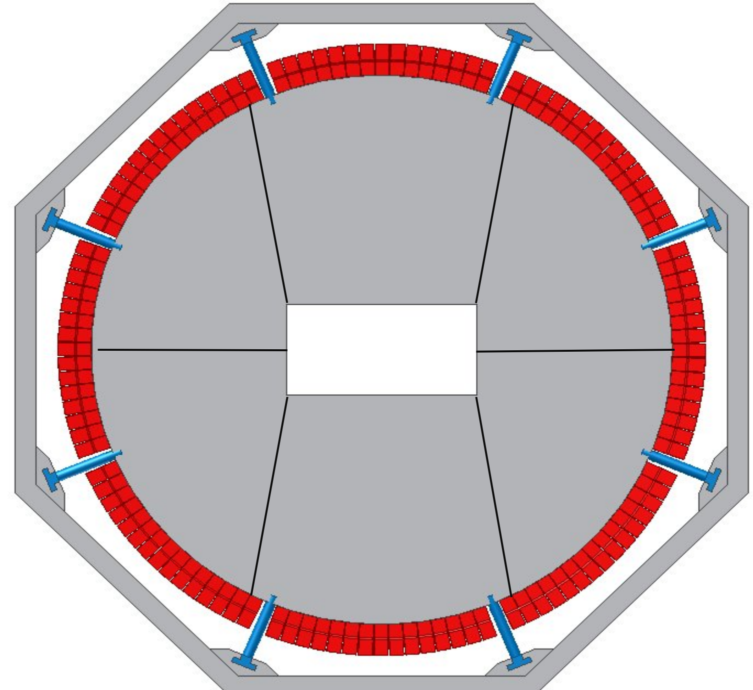
Wishlist for readout for physics stuff

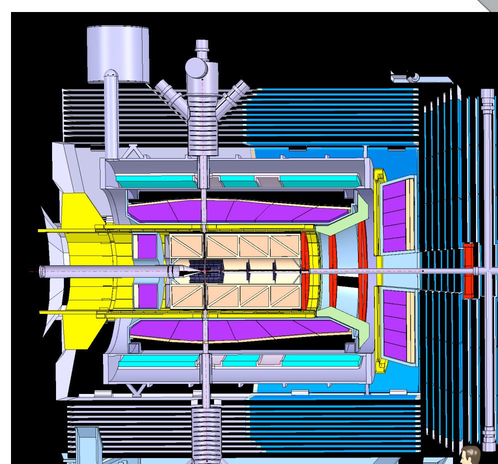


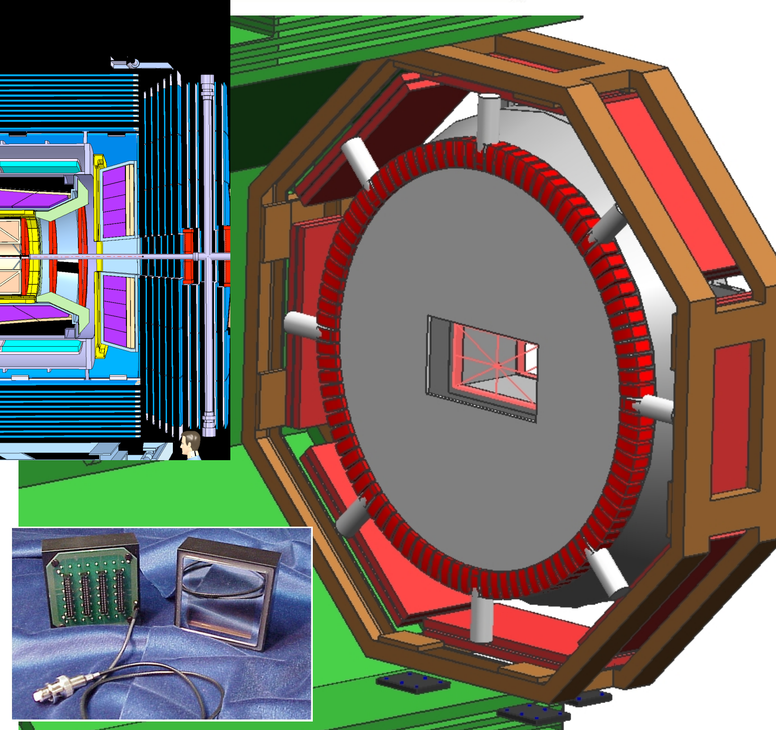
Average Interaction rate 20 Mhz ????

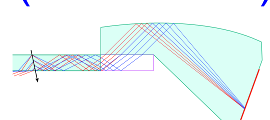
FDD (Focusing light guide Disc DIRC)

- 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 available:
  1202(inner)+~17(~70^{0} tilt)+~15(PMT)+~15(electronics)=
  1250(outer)





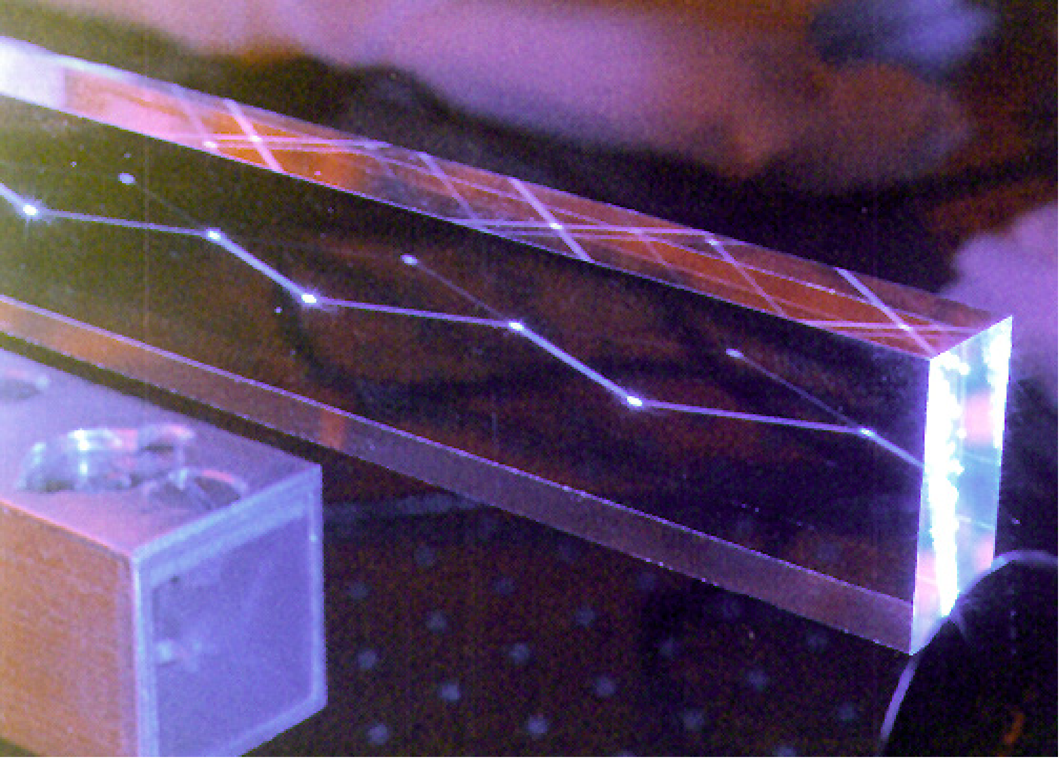




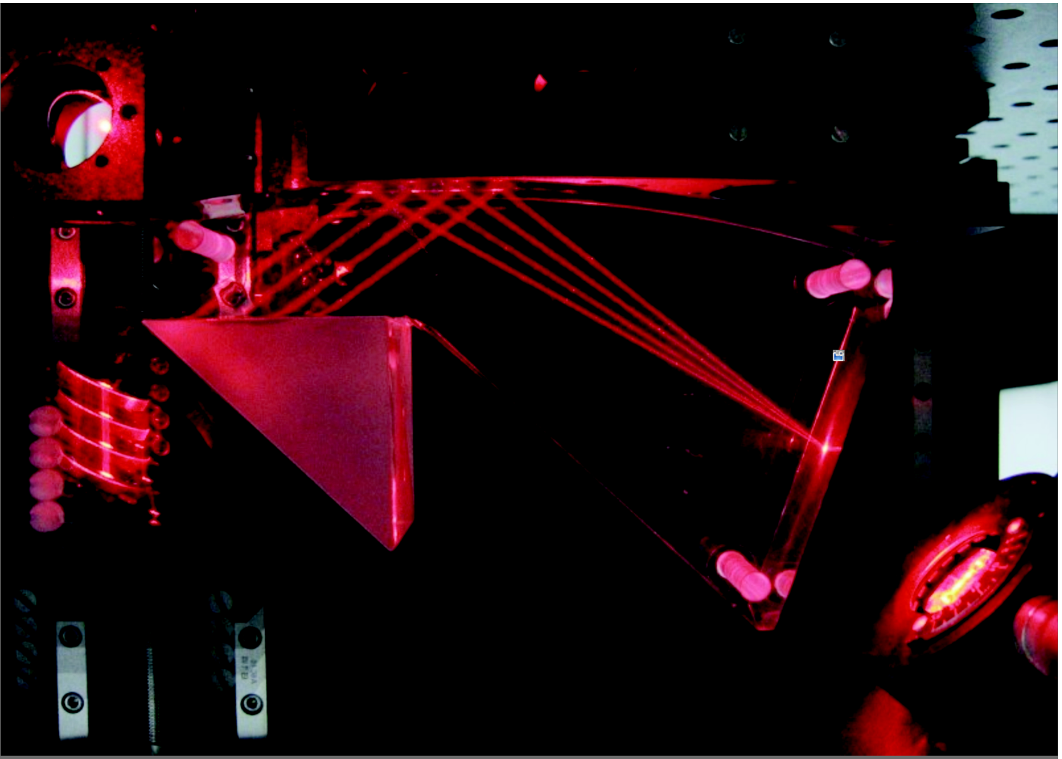
Summary and Outlook

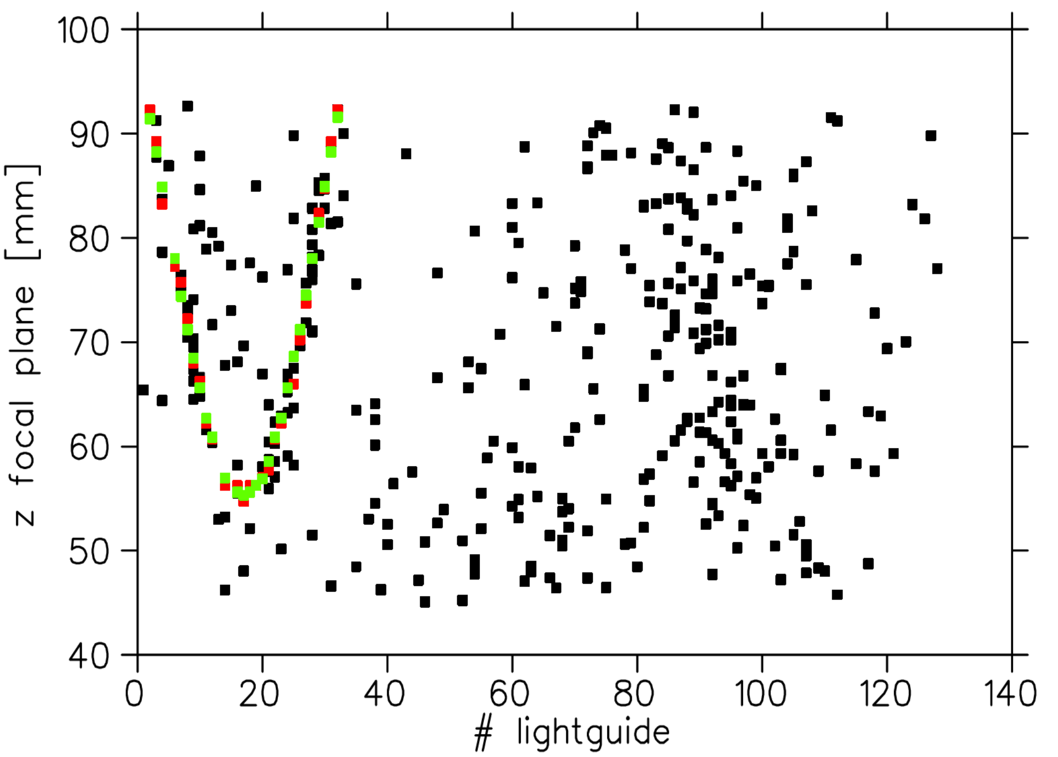
- FDD is compact PID-detector
- Main aspects studied individually
  - Photon generation, transportation and detection known
  - Readout requirements formulated
  - Solution available, looking for extension
- Testbeams in pipeline to study further attentions
  - Particle correlation
  - Hit pattern
  - Mechanical design
- Readout capability wishlist to be formulated
- Data-rate reduction to be implemented
- Slow-control and Monitoring facility in preparation

Thanks to a lot of people for help, pictures and discussions



Thank you very much for your attention :)





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.

Datasheets for SiO2/LiF and QE(Burle85001-511