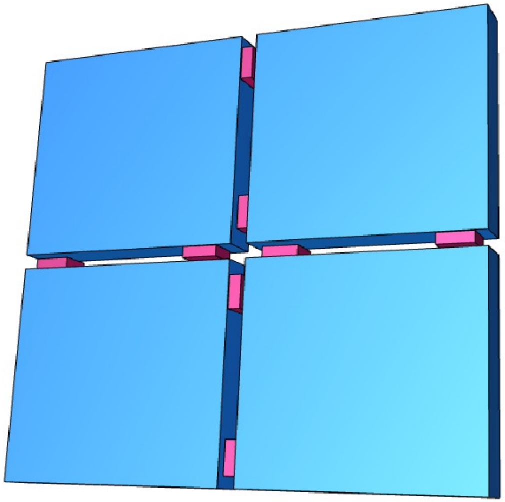
The Scintillation Tile Hodoscope (SciTil)

SciTil



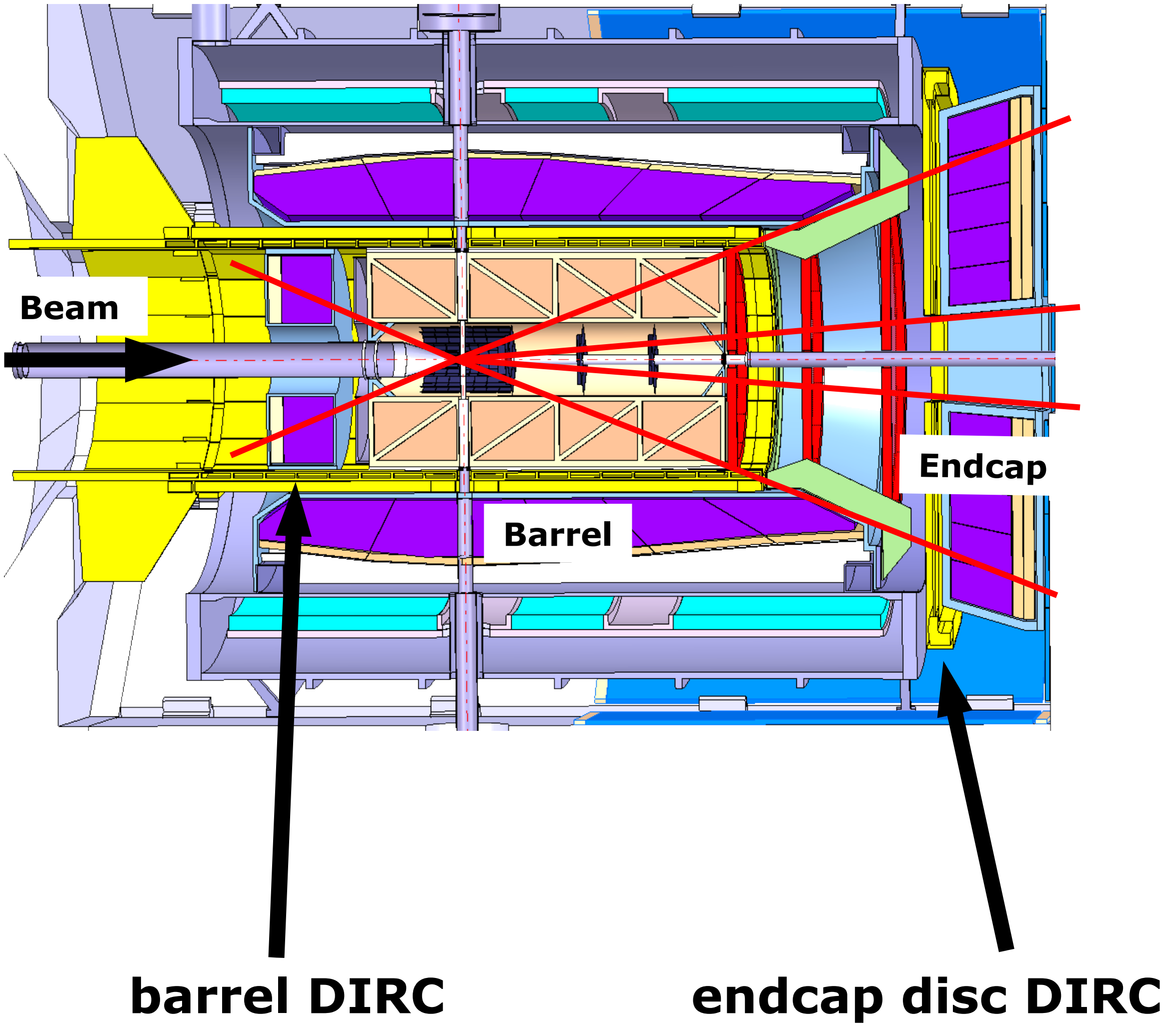
C.Schwarz, GSI

- Motivation
  - Event timing
  - Conversion detection
  - Charged particle TOF (relative timing)
- Requirements, Simulations
- Prototype
- Mechanics
- Work packages

SiPM workshop 6-7 Oct. 2011, GSI

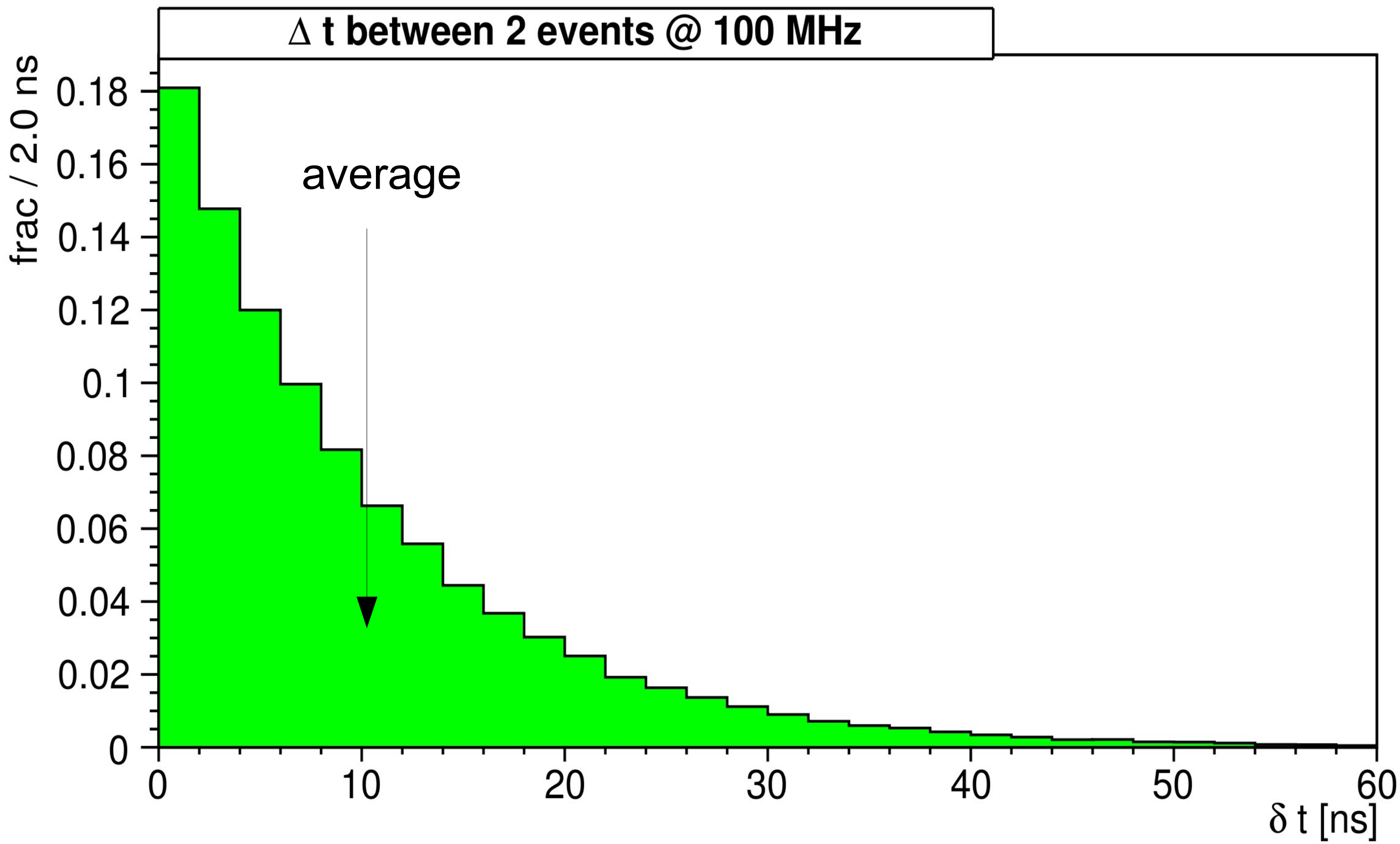
Panda Detector

PANDA interaction rate:
Average 20MHz
Peak 50-100MHz



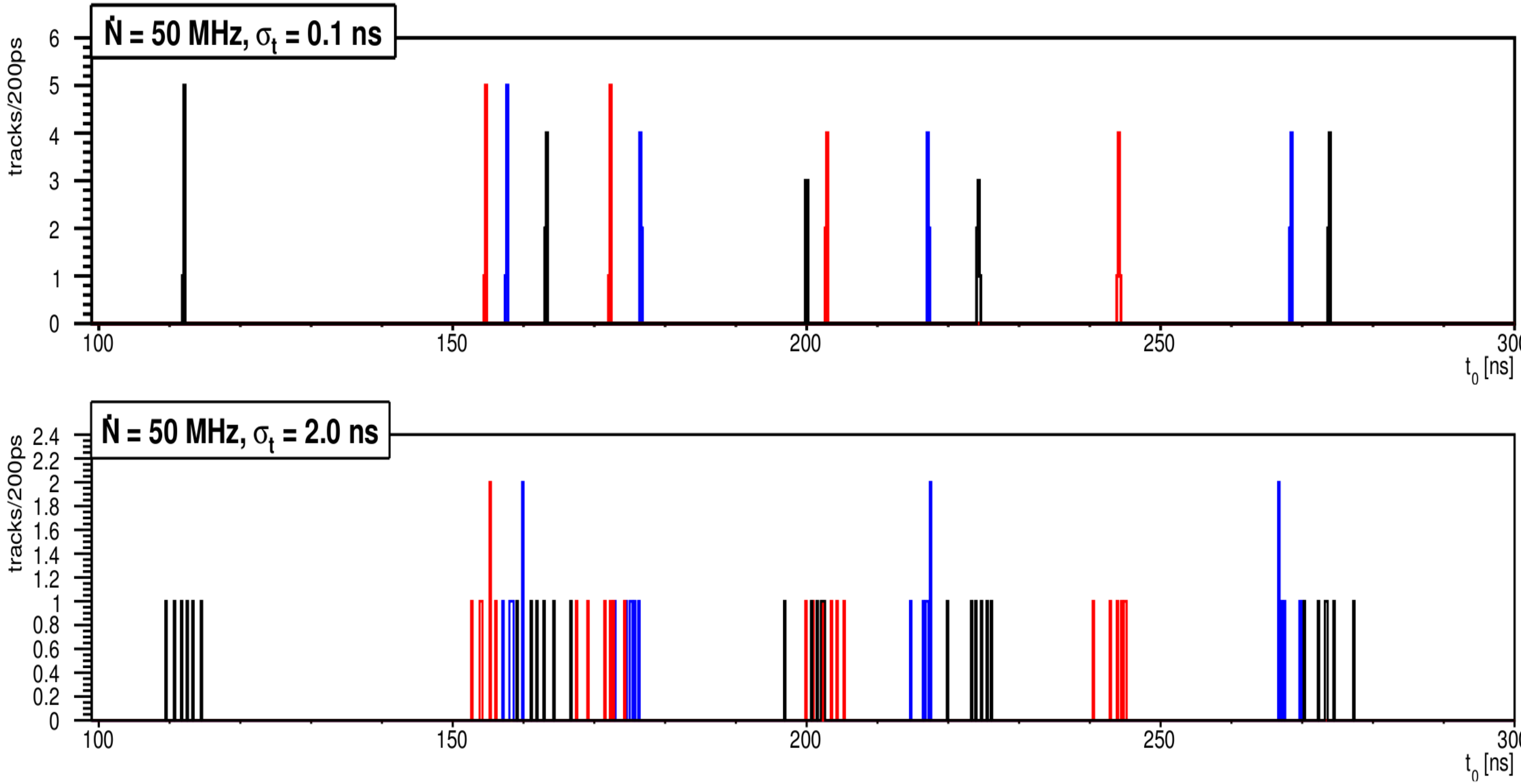
Event timing

Time between successive events are **not equally spaced** but follow a **exponential distribution**

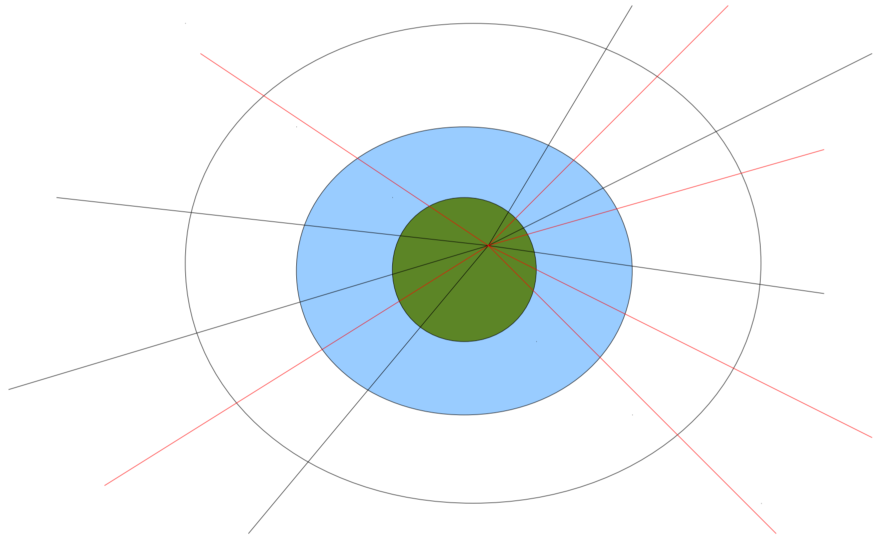


Event timing

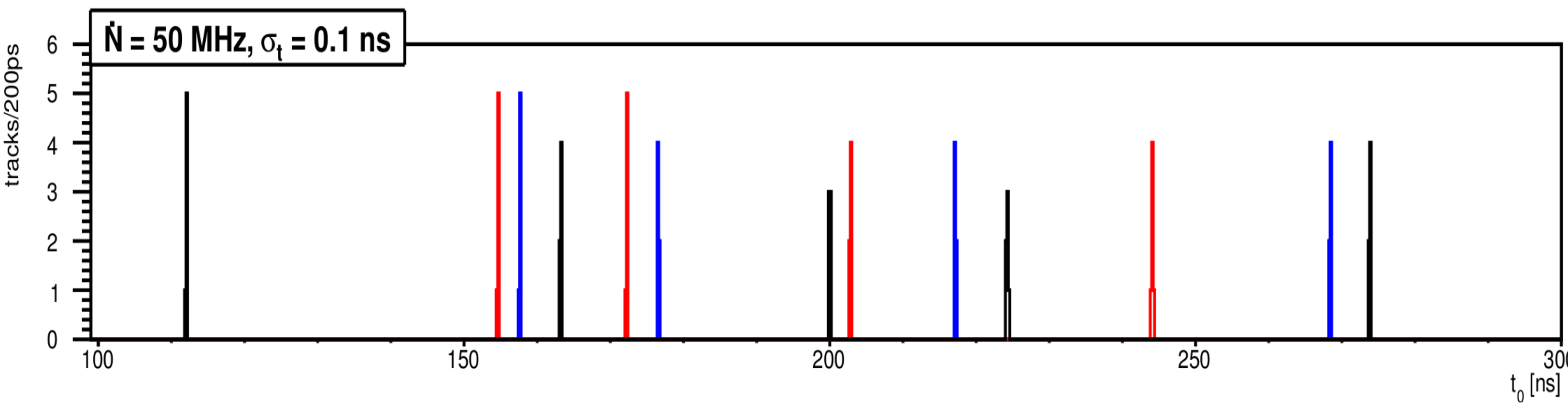
Events 1,2,3,4,5,6,7,8... for 50Mhz interaction rate with 6 tracks

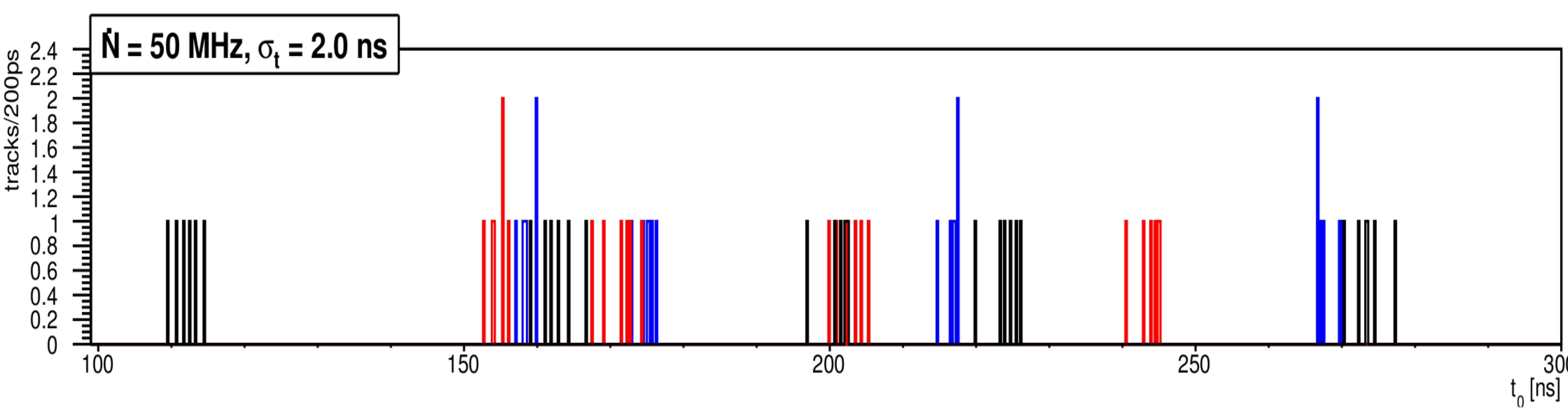


Klaus Götzen,Influence of Particle Timing on Event Building
PANDA collaboration meeting March 2011, GSI

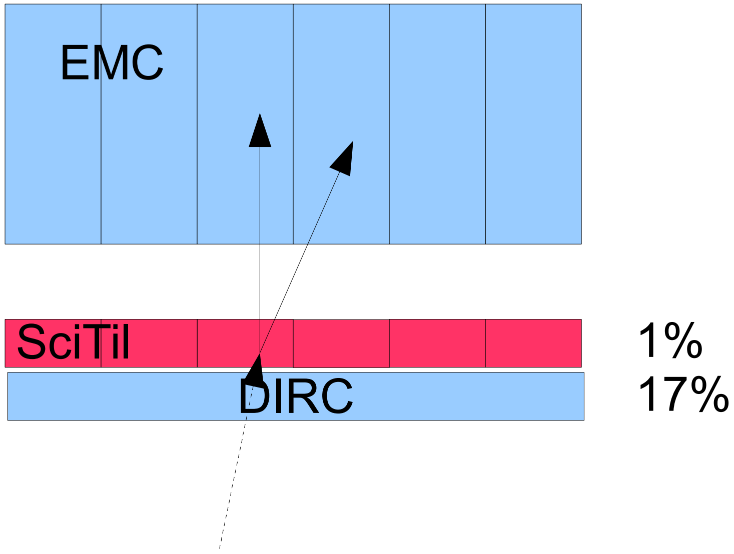


Fast detector assigns accurate time stamps to tracks.



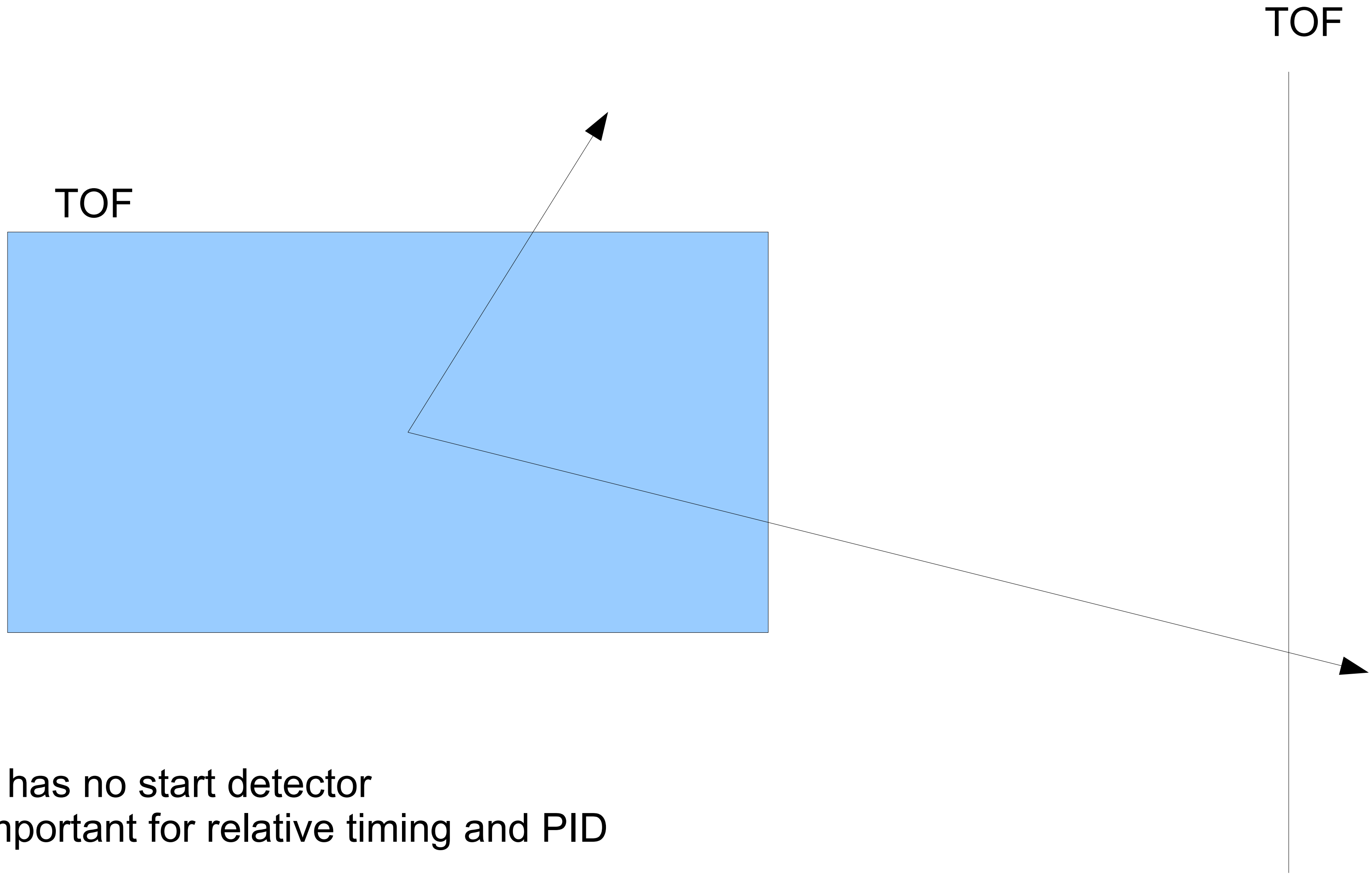


Conversion detection



Conversion of gammas within the DIRC can be detected with the SciTil

Relative timing



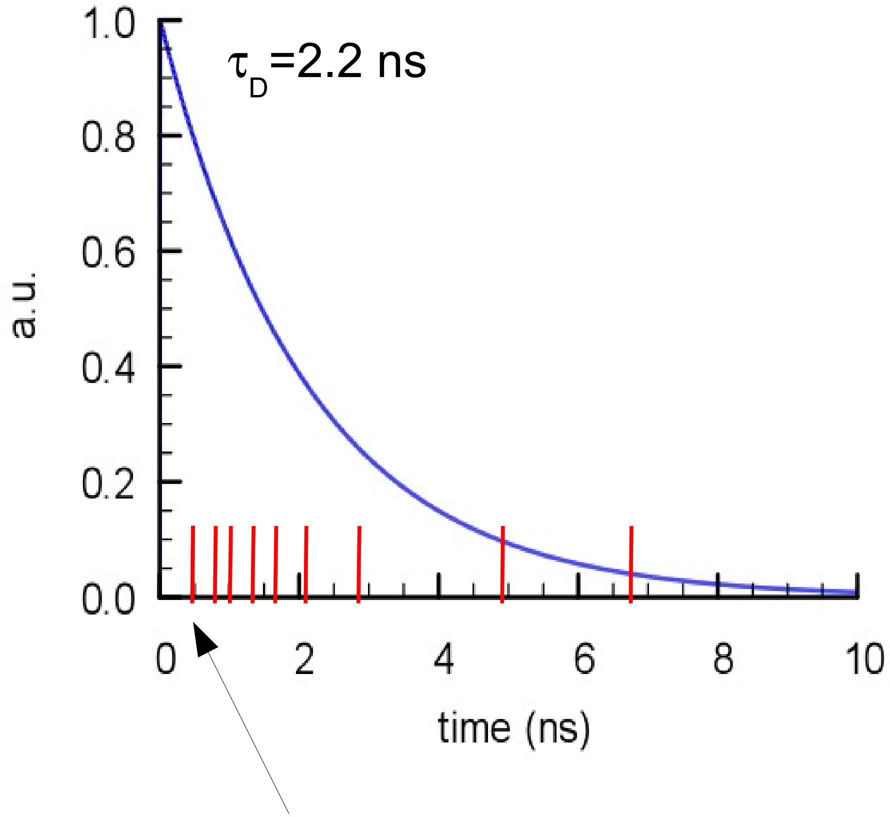
PANDA has no start detector
SciTil important for relative timing and PID

Scintillator Material

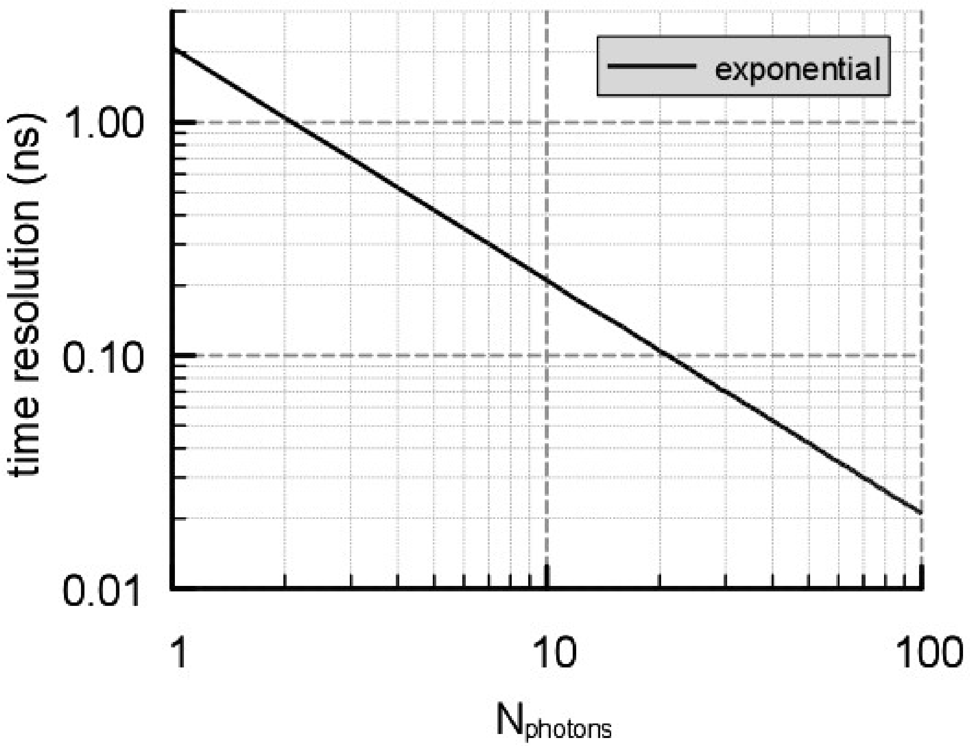
For subnanosecond timing: timing on first arriving photon

→ Time resolution depends on number of photons.

Pure exponential:



Simulation



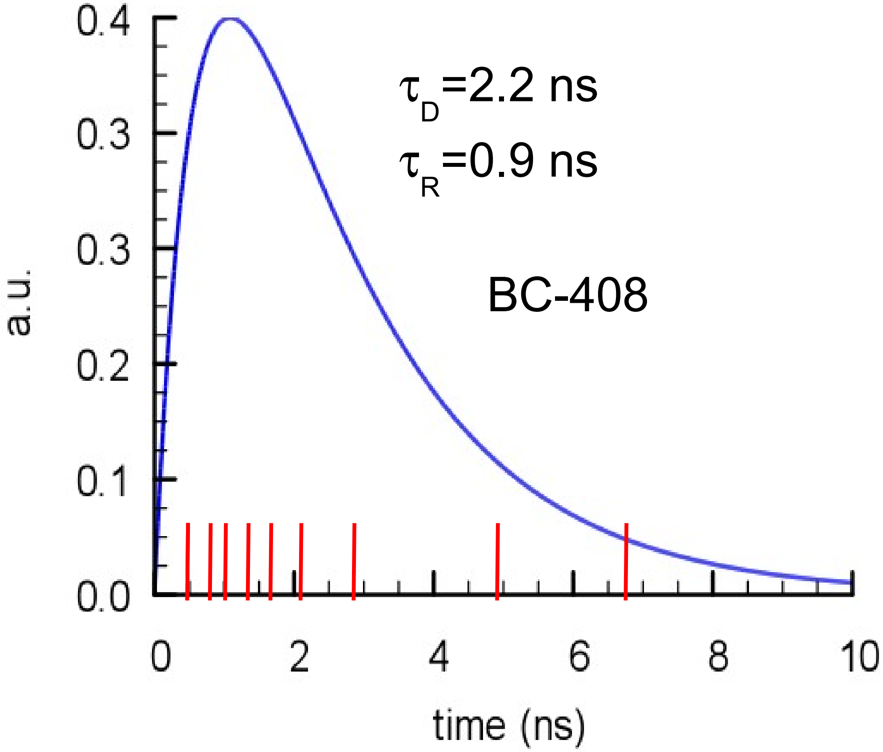
Time spread of first photon (RMS) for many events ~1/N

Unfortunately
→ not so simple...

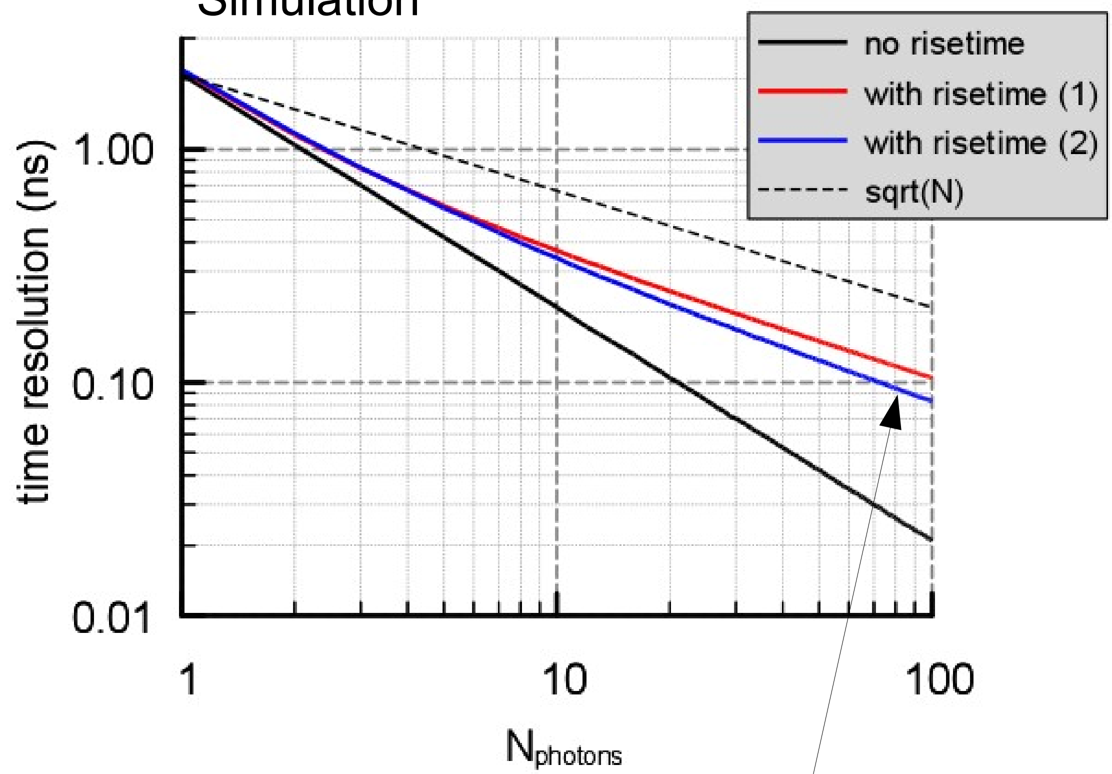
Rise time comparable to wanted time resolution

→ Additional smearing of first photon

Rise time + exponential:



Simulation

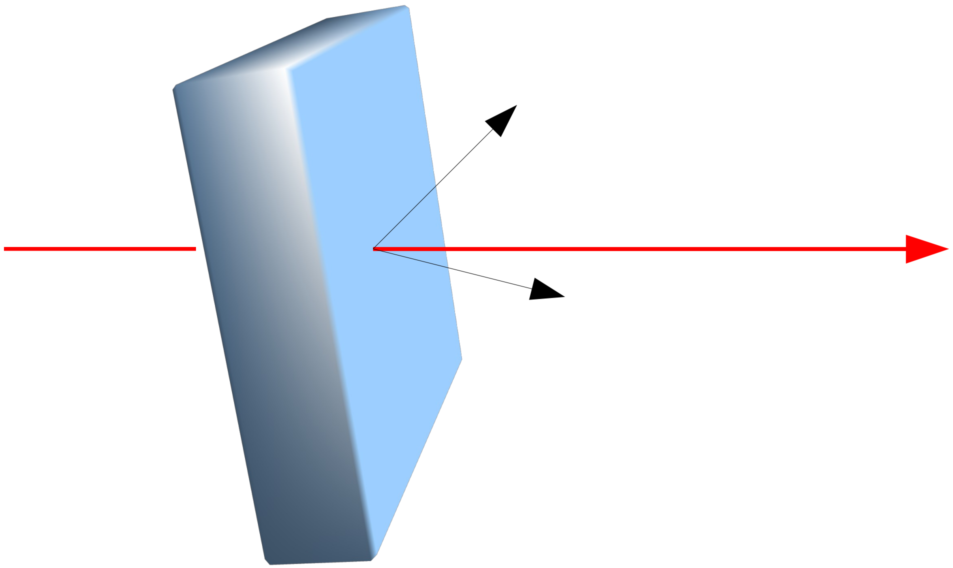


Time spread of first photon (RMS) for many events ~1/sqrt(N)

BC-408: 100 ps
100 photons

Photon number

Tile 30 x 30 x 5 mm^3



Minimum ionizing particle

ΔE = 1 MeV
= 10^4 photons — generated

70% hit rim
= 7000 photons — on rim

PD area = 18 mm^2
rim area = 600 mm^2

= 210 photons — geometry

55% PD efficiency — PDE

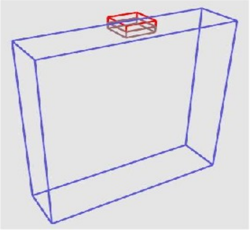
= 115 photons

30 x 30 x 5 mm^3 → 115 photons
20 x 20 x 5 mm^3 → 180 photons

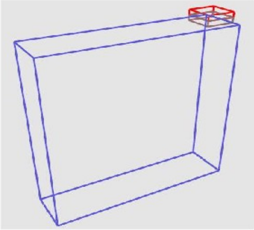
Slitrani simulations

20 x 20 x 5mm^3

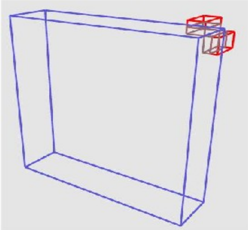
Stefano Casasso, University of Turin
Summerstudent program GSI 2010



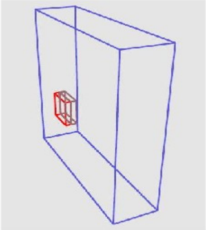
(a) Geo1



(b) Geo2



(a) Geo3



(b) Geo4

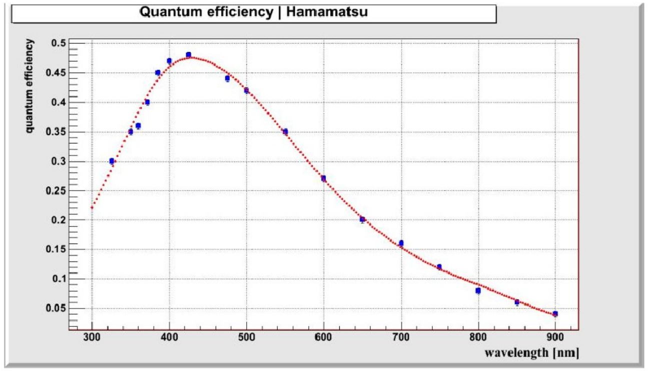


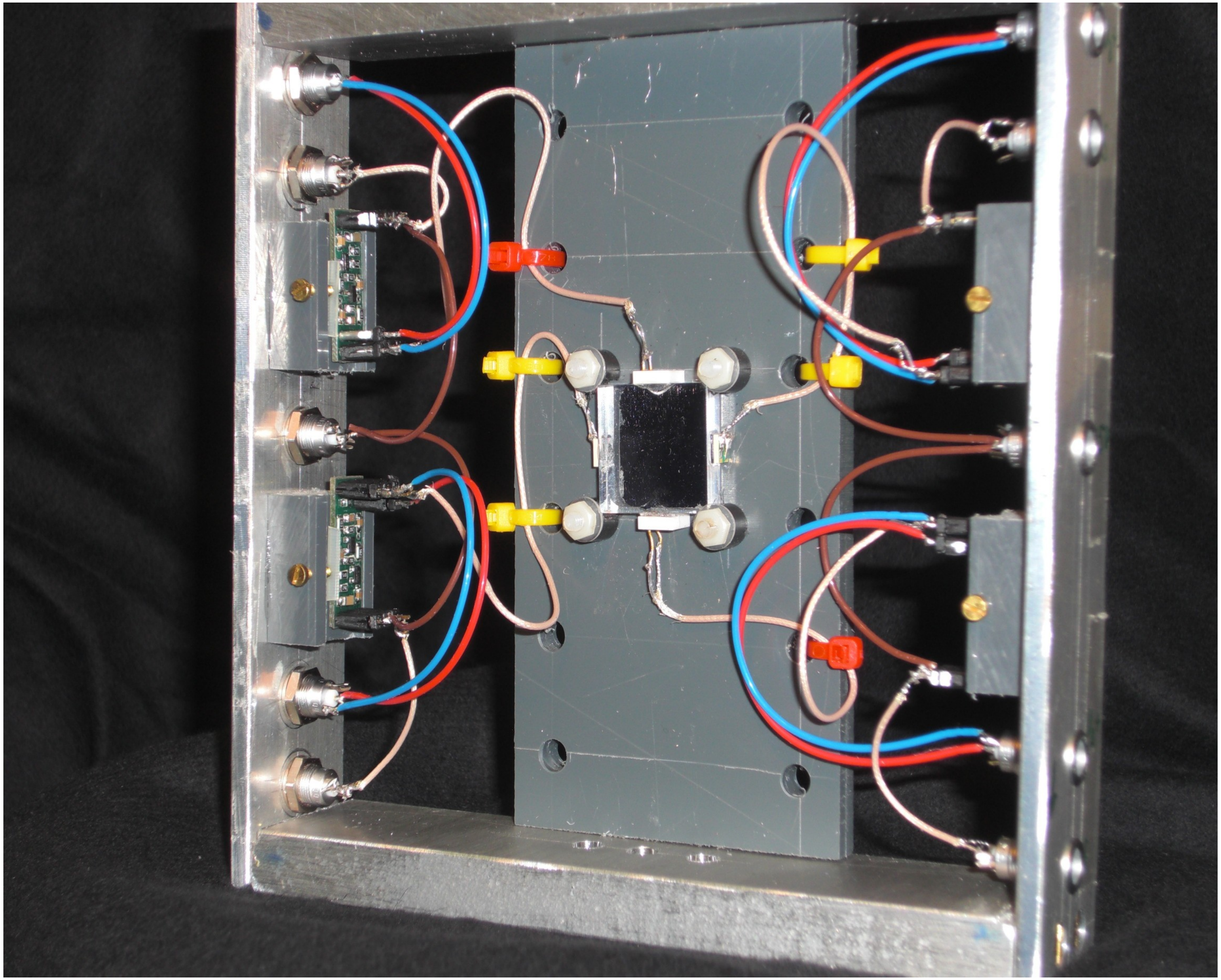
Fig. 4: Plot showing the Quantum Efficiency of Hamamatsu SiPMs vs. wavelength

	Time of arrival τ (ps)	RMS σ (ps)
Geo1	510 ± 20	111 ± 16
Geo2	590 ± 20	118 ± 17
Geo3	403 ± 13	66 ± 9
Geo4	470 ± 20	115 ± 16

Tab. 2: Time-response analisys for the four geometries

Simulations agree
with above rough estimates

Prototype



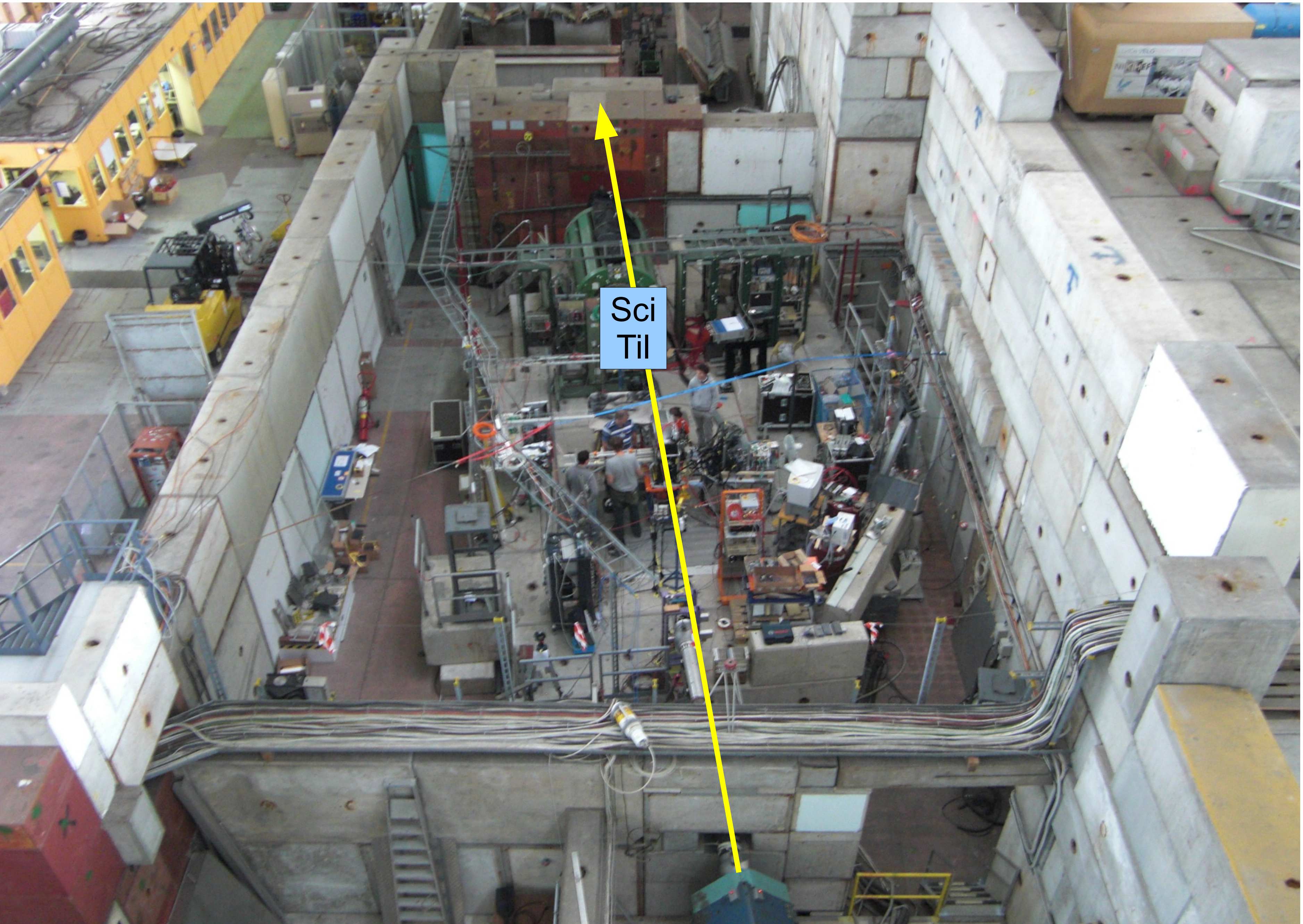
BC408
20 x 20 x 5 mm3

Hamamatsu SiPM
S10931-050P
S10362-33-050C

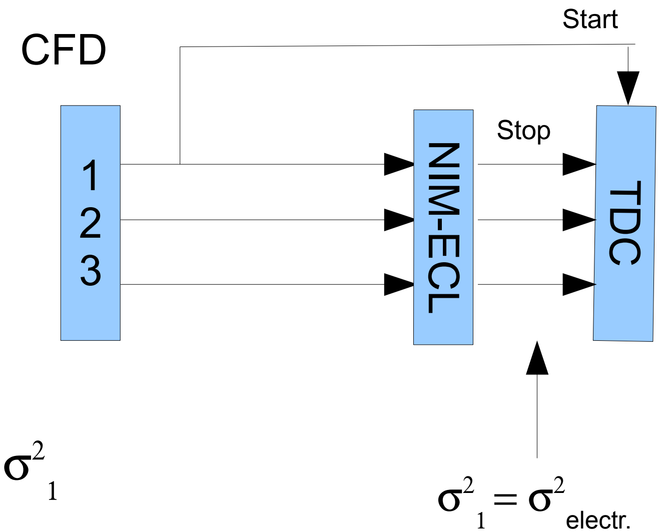
Photonique
Fast amplifier 611

Readout
NINO + HADES TRB

GSI, CERN DIRC prototype beam times
---> SciTil time resolution of 600ps :(



Timing resolution of 3 detectors



Measure t_1-t_2, t_1-t_3, t_2-t_3 , t_1 → σ^2_{12} σ^2_{13} σ^2_{23} σ^2_1

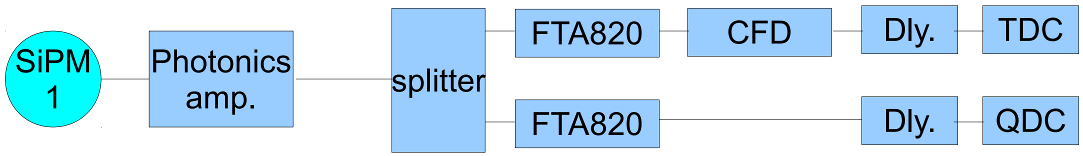
And subtract $2\sigma^2_{electr.}$ → $\sigma^{2'}_{12}$ $\sigma^{2'}_{13}$ $\sigma^{2'}_{23}$

$$\sigma^{2'}_{12} + \sigma^{2'}_{13} - \sigma^{2'}_{23} = (\sigma^2_1 + \sigma^2_2) + (\sigma^2_1 + \sigma^2_3) - (\sigma^2_2 + \sigma^2_3) = 2\,\sigma^2_1$$

For 4 detectors each σ^2 can be determined several times
→ error bars

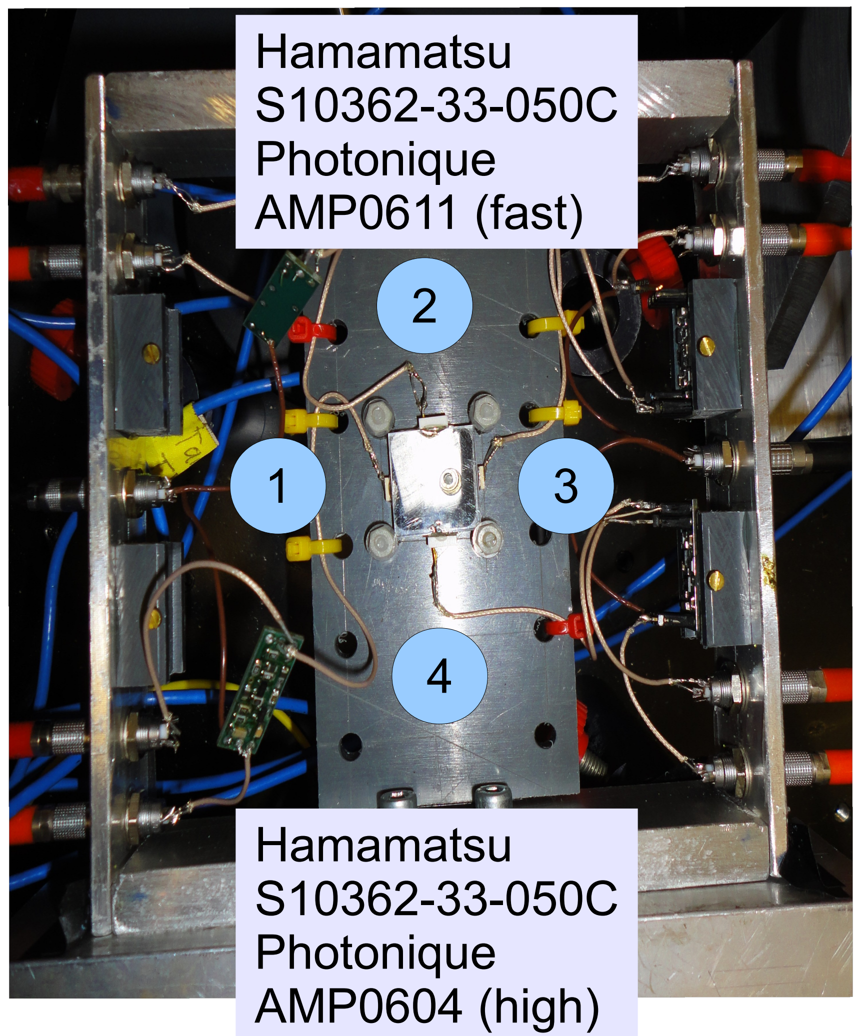
GSI Summerstudent program 2011: Stefan Diehl, Giessen

→ more systematic search for missing time resolution



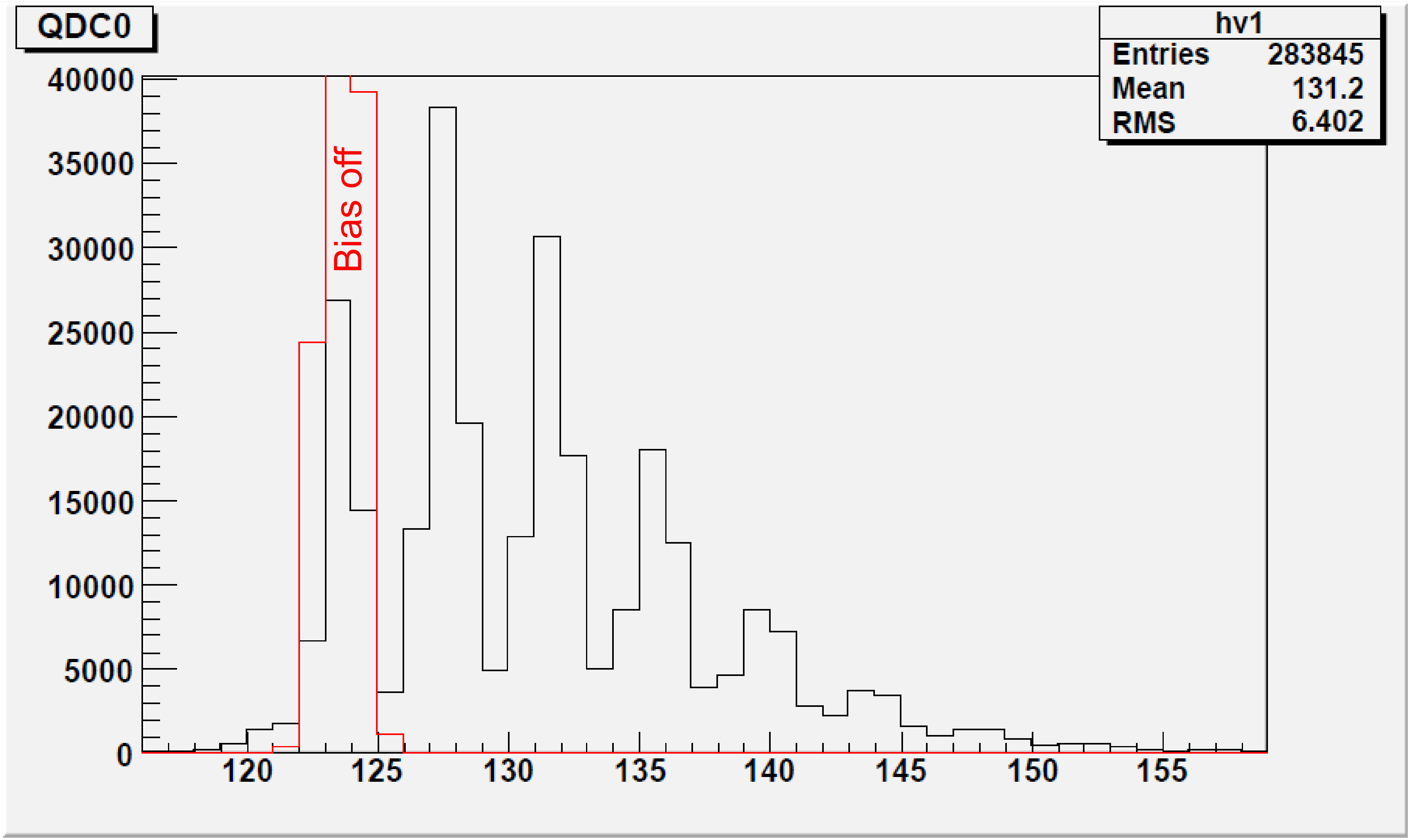
Trigger done by
majority coincidence (=4)
CFD set to 1 photon

Hamamatsu
S10931-050P
Photonique
AMP0611 (fast)

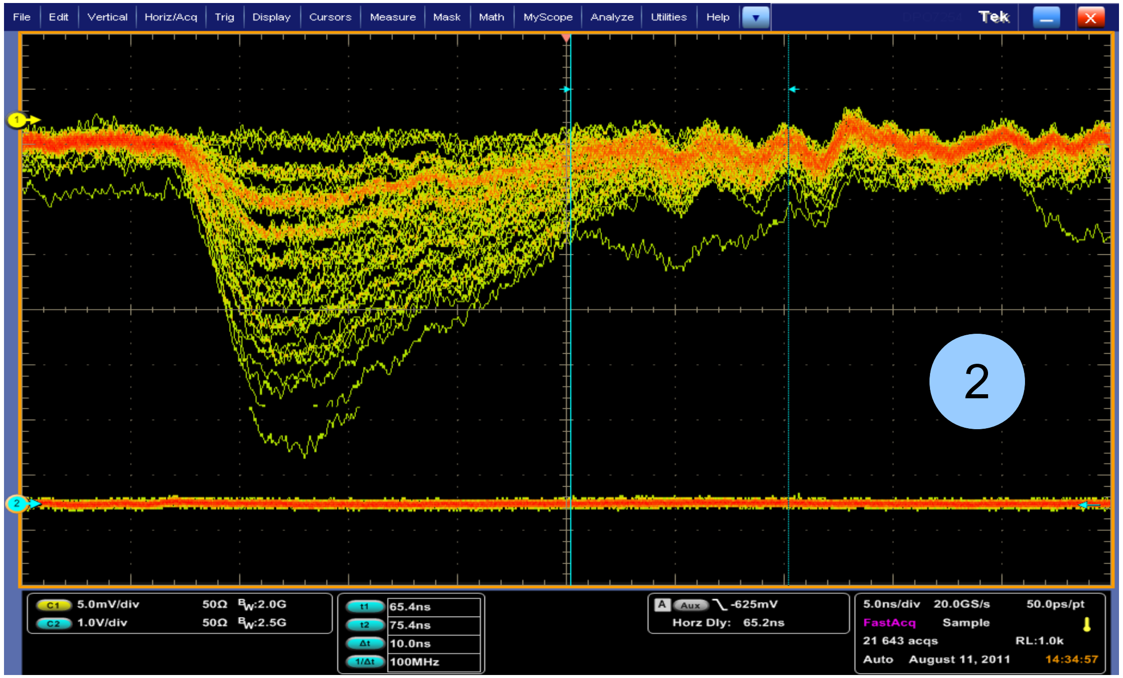


Hamamatsu
S10931-050P
Photonique
AMP0604 (high)

Shielded bias/5V

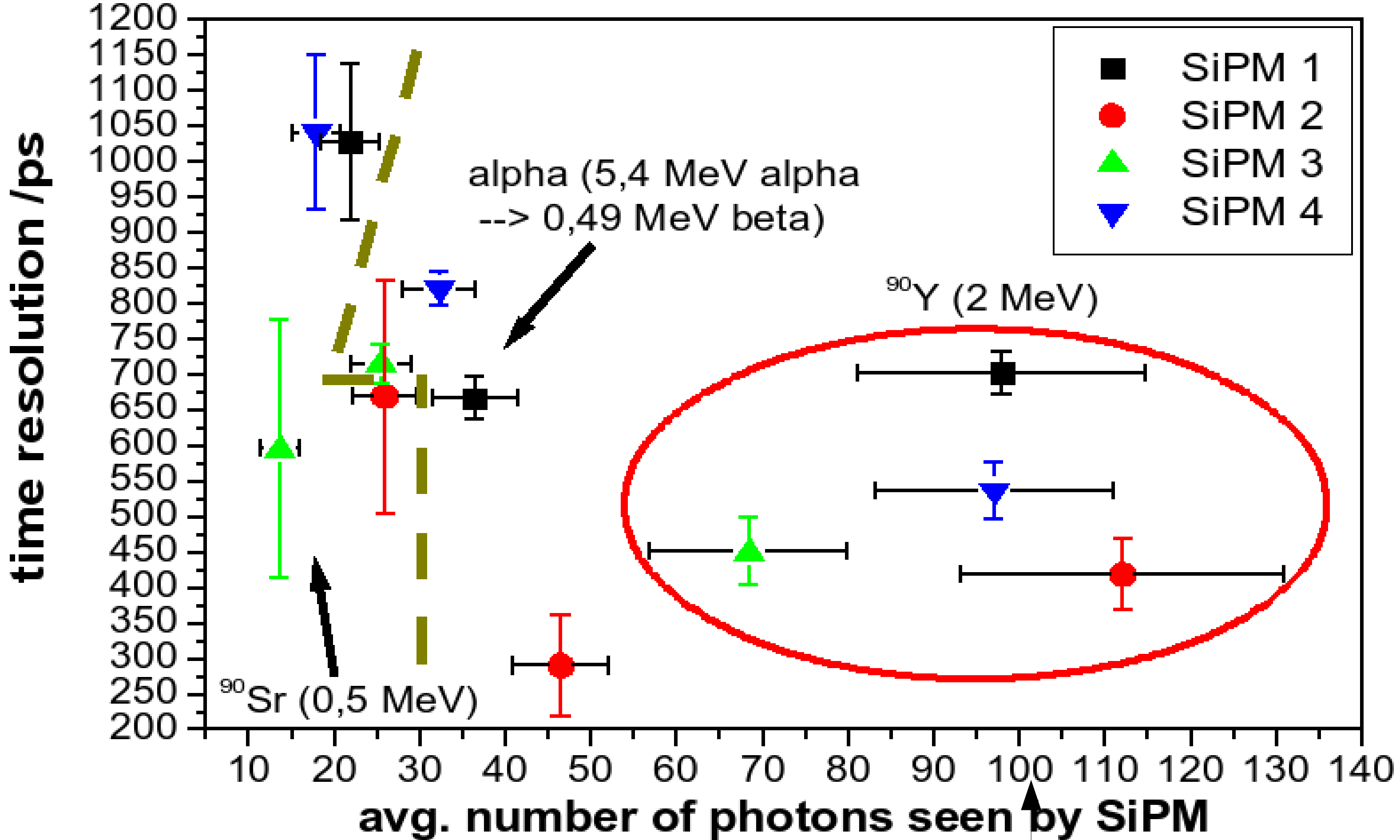


Calibration of QDC spectra with PicoQuant laser to count photons



Fast
AMP611

SiPM	Rise-time [ns]	Decay-time [ns]
1 (fast amp.)	1,1 +- 0,05	11,1 +- 0,5
2 (fast amp.)	1,1 +- 0,5	10,8 +- 0,5
3 (high gain amp.)	1,2 +- 0,05	18,4 +- 1,0
4 (high gain amp.)	1,3 +- 0,3	23,9 +- 3,0



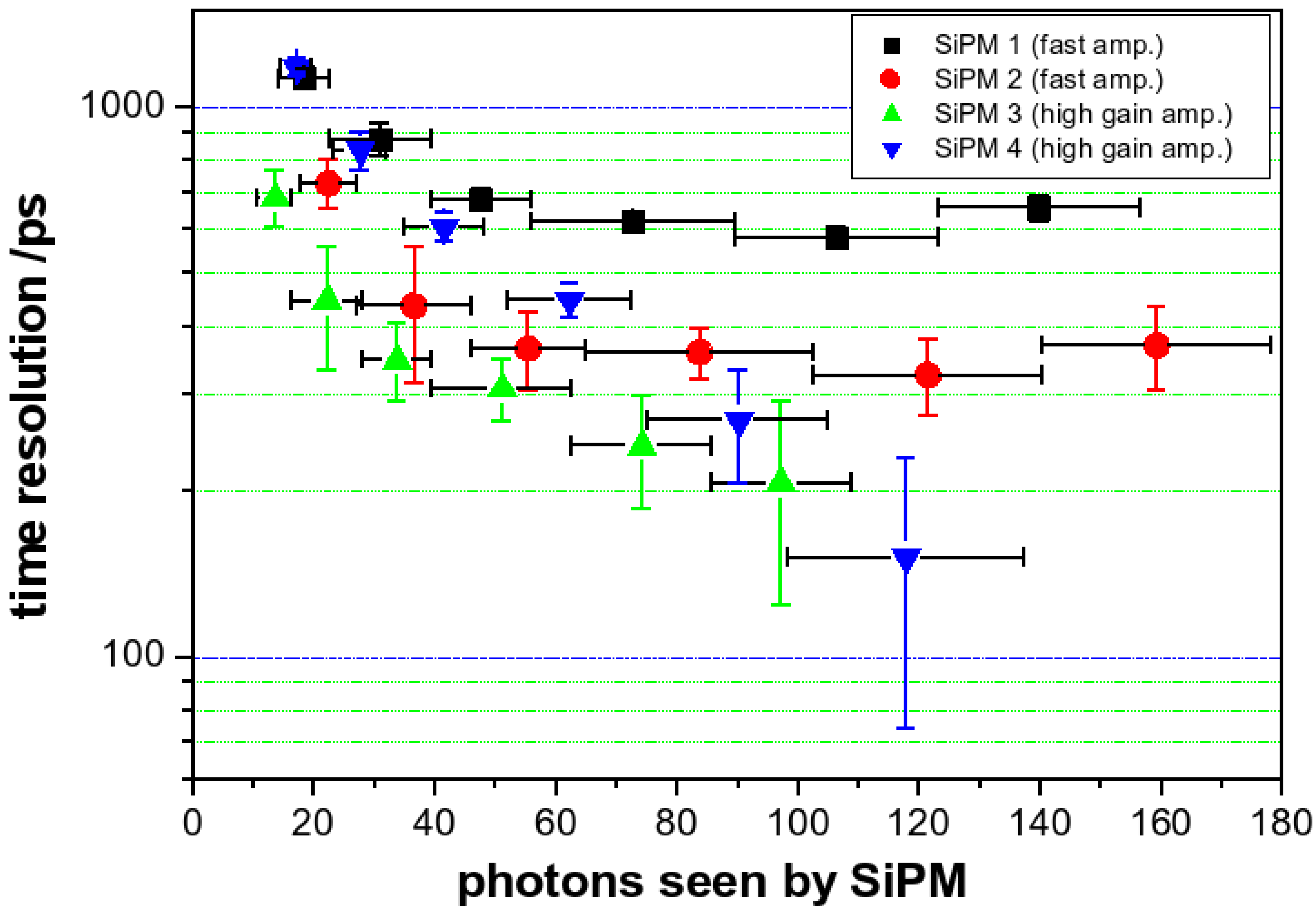
Time resolution including electronic time jitter

We see the right number of photons

σ_{i-el}	time resolution /ps
σ_{1-el}	368 ± 29
σ_{2-el}	135 ± 30
σ_{3-el}	210 ± 54
σ_{4-el}	115 ± 30

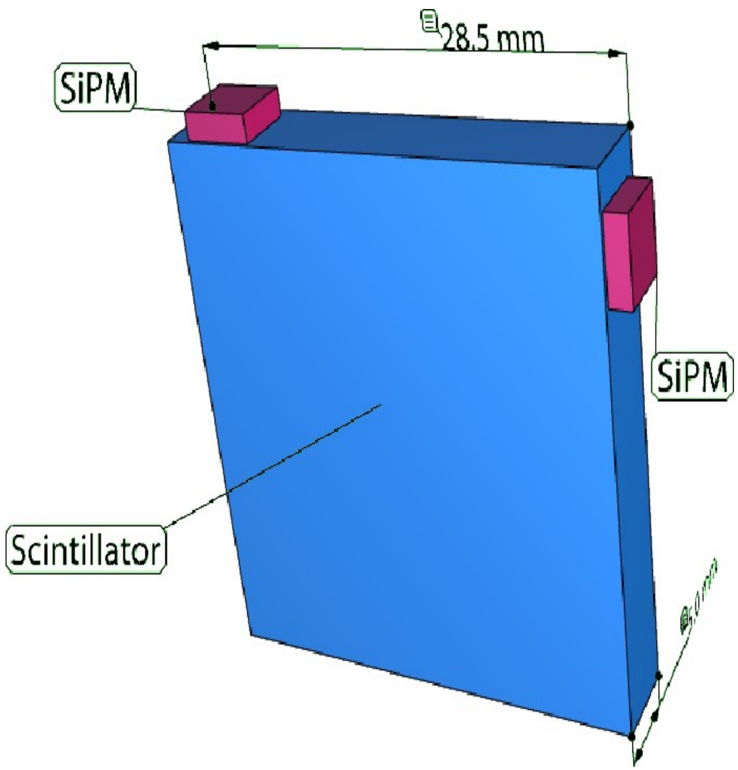
Electronic time Resolution (FTA820/CFD/ NIM-ECL converter)

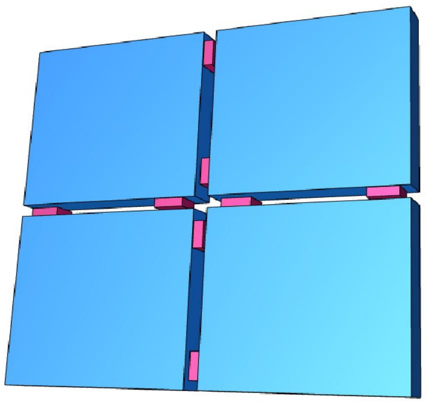
^{90}Sr source, results corrected for electronic time resolution



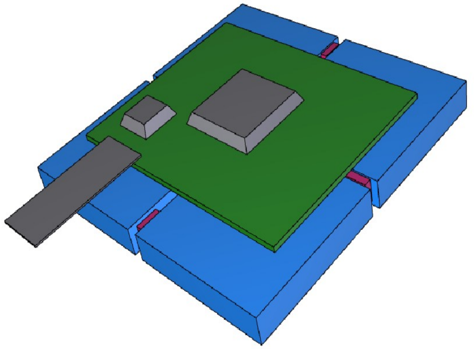
High gain AMP604 most promising

Mechanics





Quad module

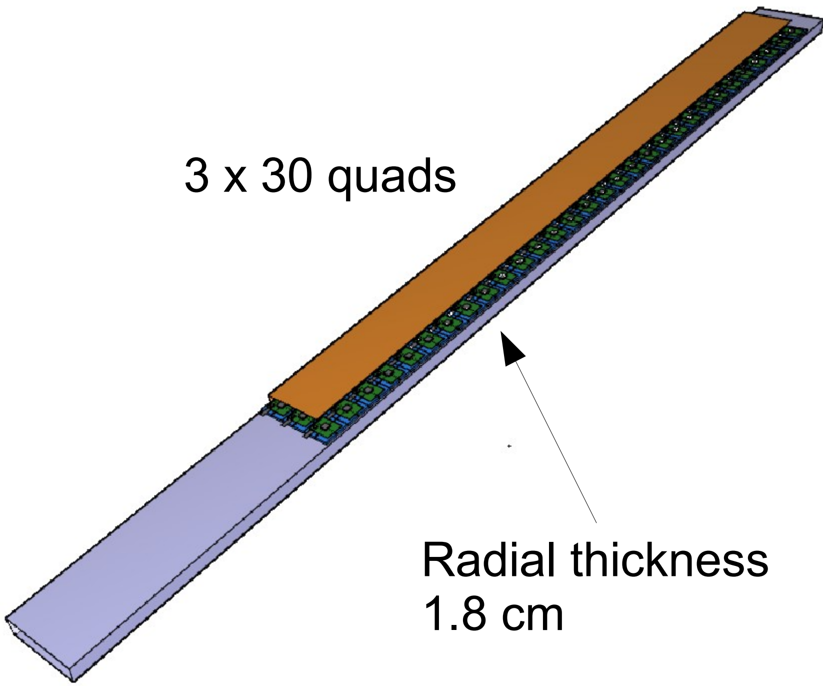


With electronics
8 ch. ASIC
data transfer IC

Readout at two positions
- more photons
- less light path fluctuations
- larger detection efficiency

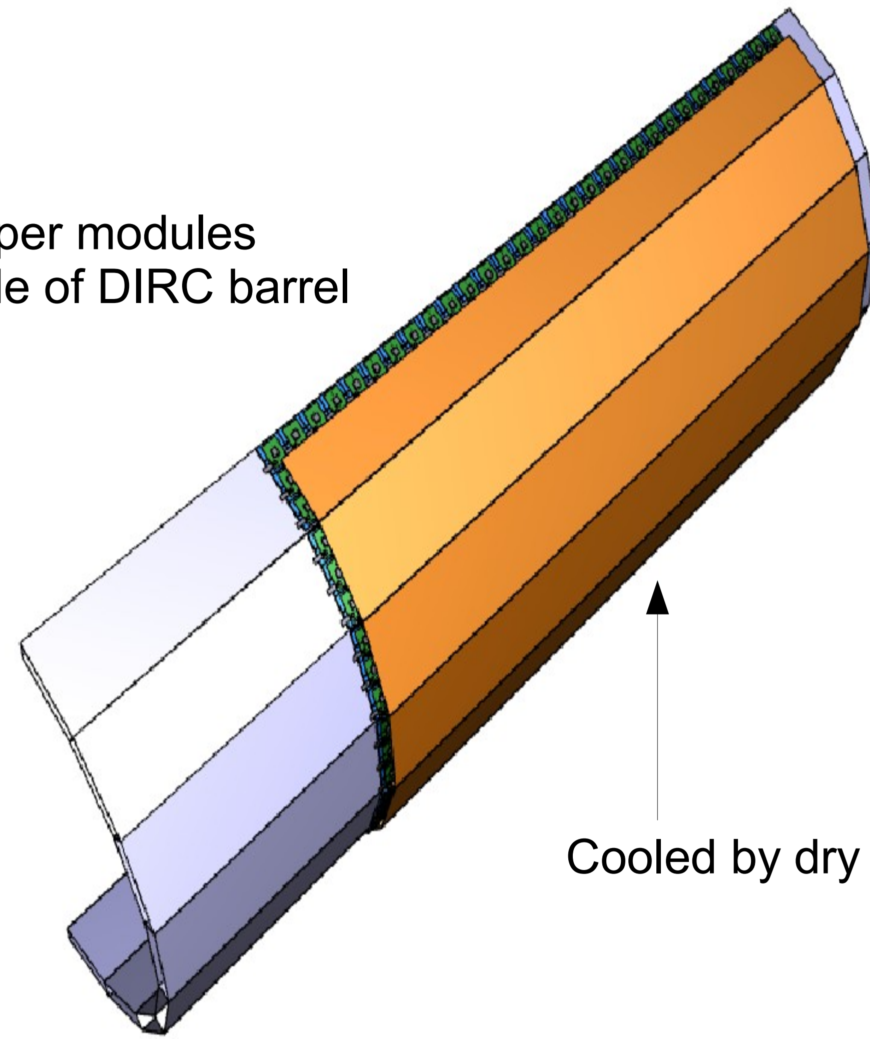
Super-module = 90 quad modules

3 x 30 quads



Radial thickness
1.8 cm

16 super modules
outside of DIRC barrel



Cooled by dry air

Total

5760 SciTils

Work Packages

Work package	Interested institutes
Simulation	BARC
Module design	GSI, BARC
Scintillator	Dubna, Gatchina
Silicon PM	EU HP3, BARC, Dubna, Gatchina
Readout design	EU HP3, BARC
Mechanical design	GSI
Prototype production	BARC

Summary

- SciTil for
  - Event timing/ conversion detection/ relative time
- Prototype works well
  - AMP604 pre-amps give right time resolution
  - Number of photons agrees with estimates
- Groups need to be identified for
  - Electronic development
  - Mechanical development...