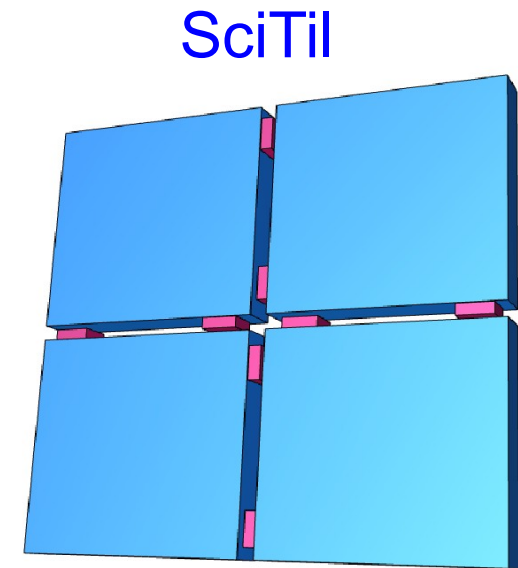


The Scintillation Tile Hodoscope (SciTil)

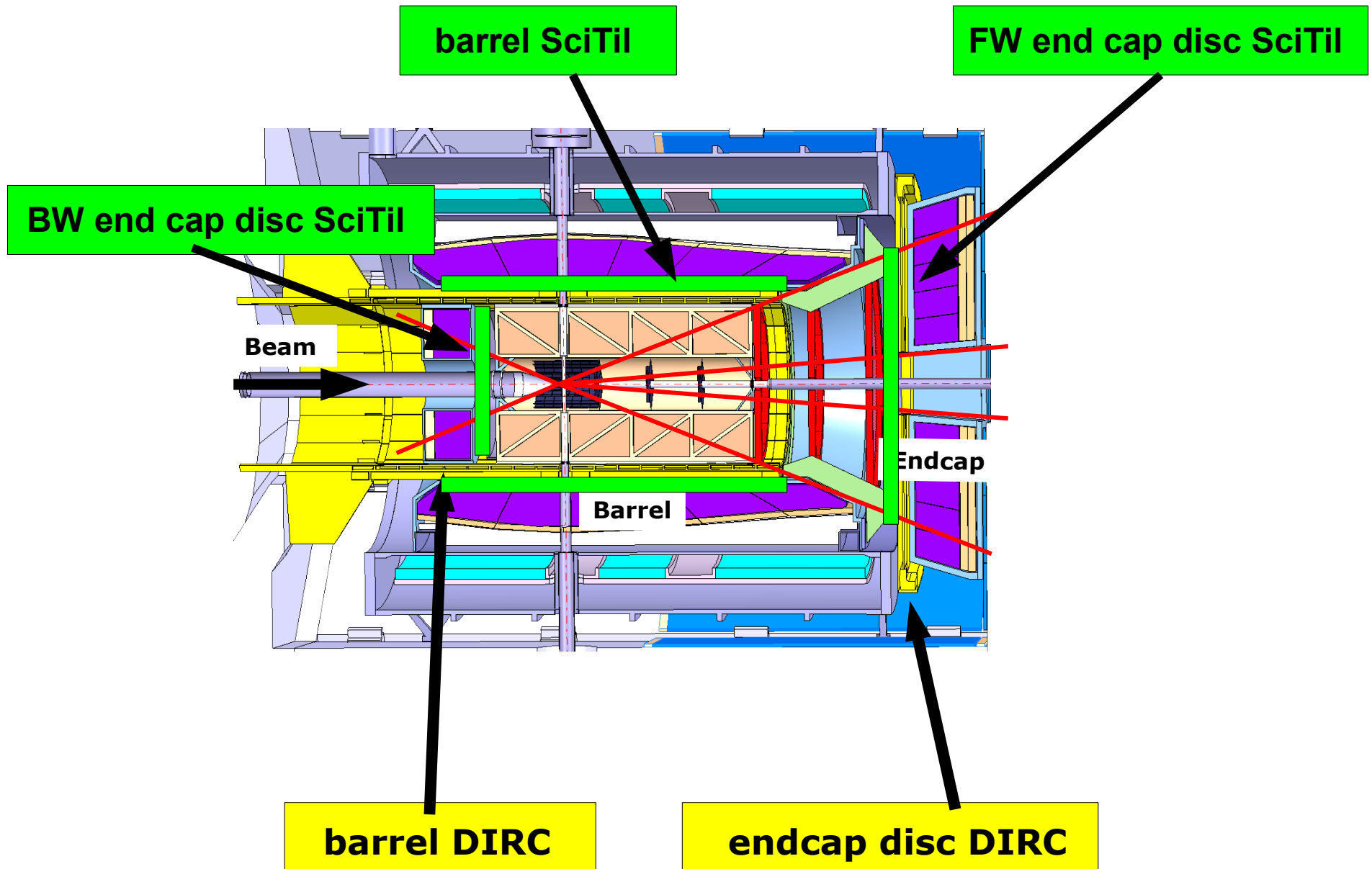
C.Schwarz, GSI

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



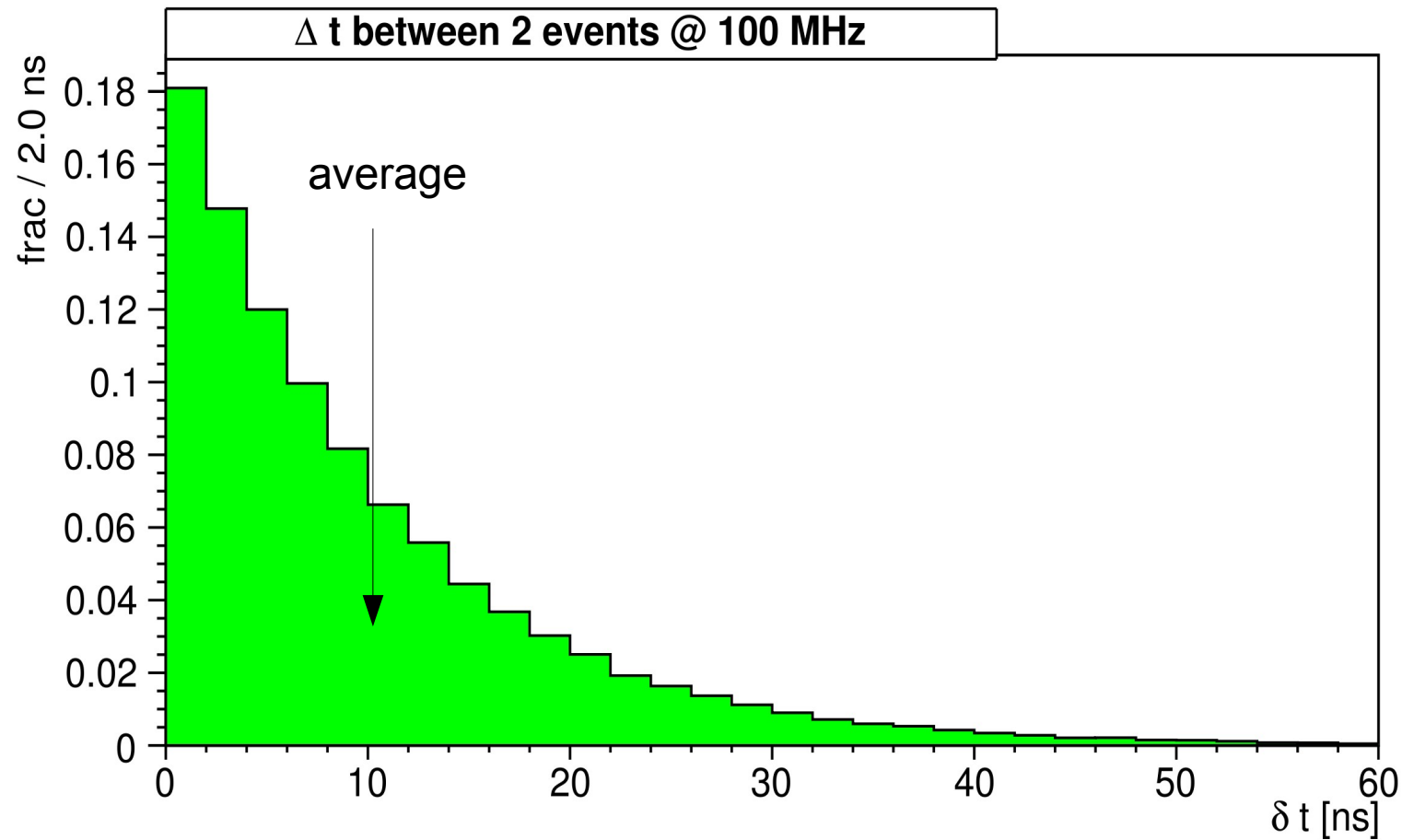
Panda Detector

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



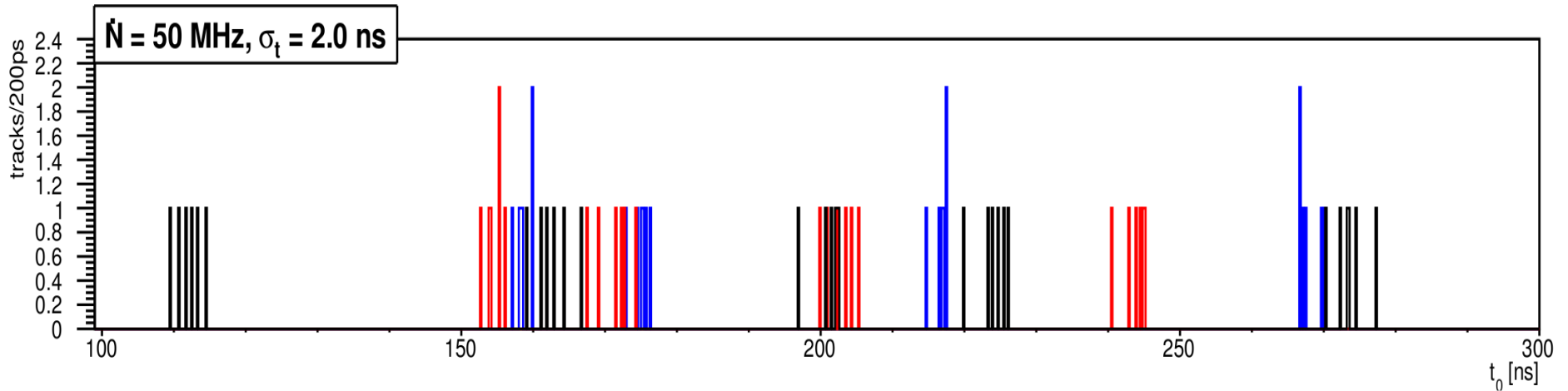
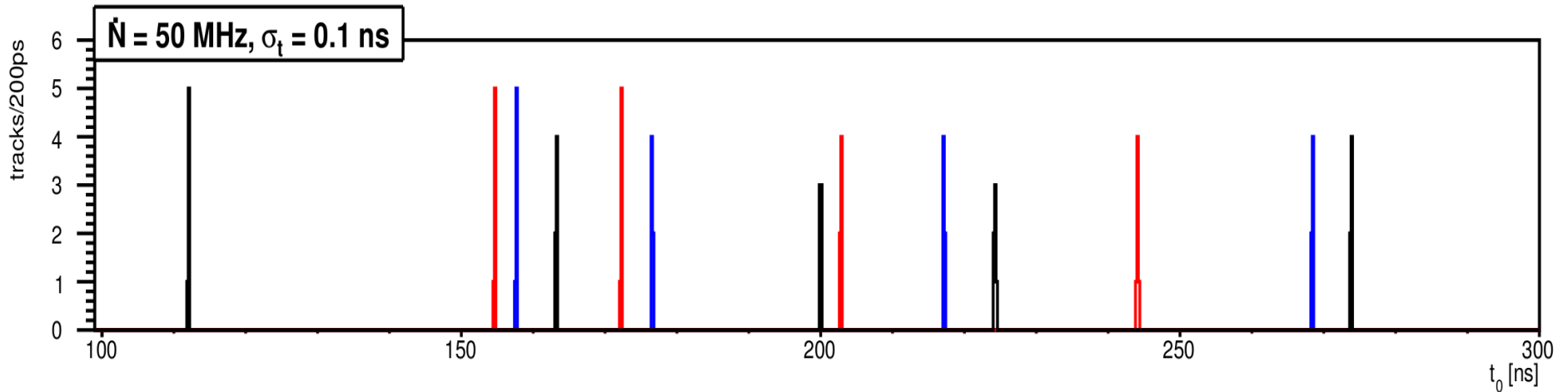
Event timing

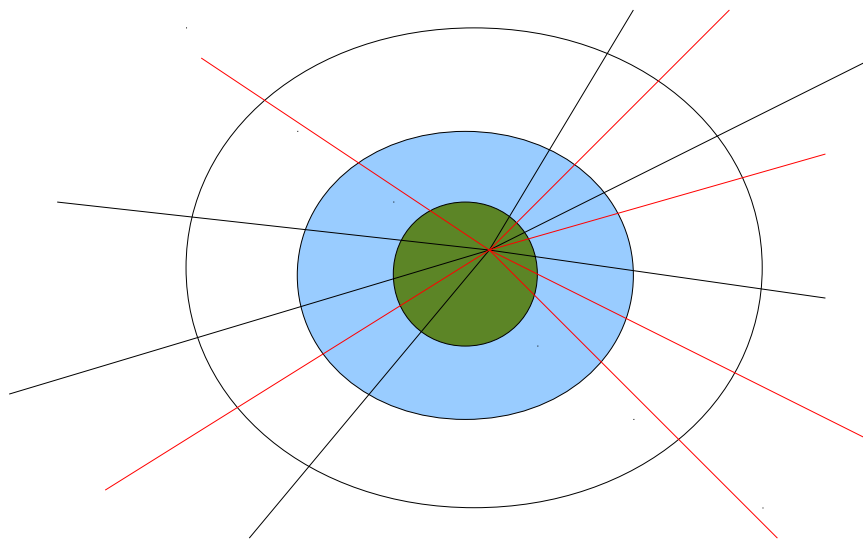
Time between successive events are **not equally spaced** but follow a **exponential distribution**



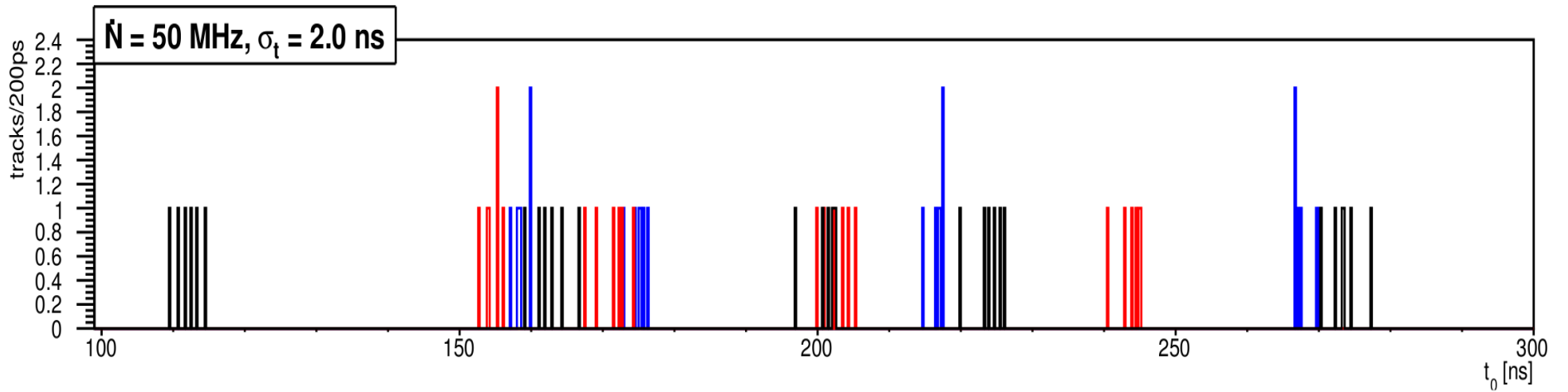
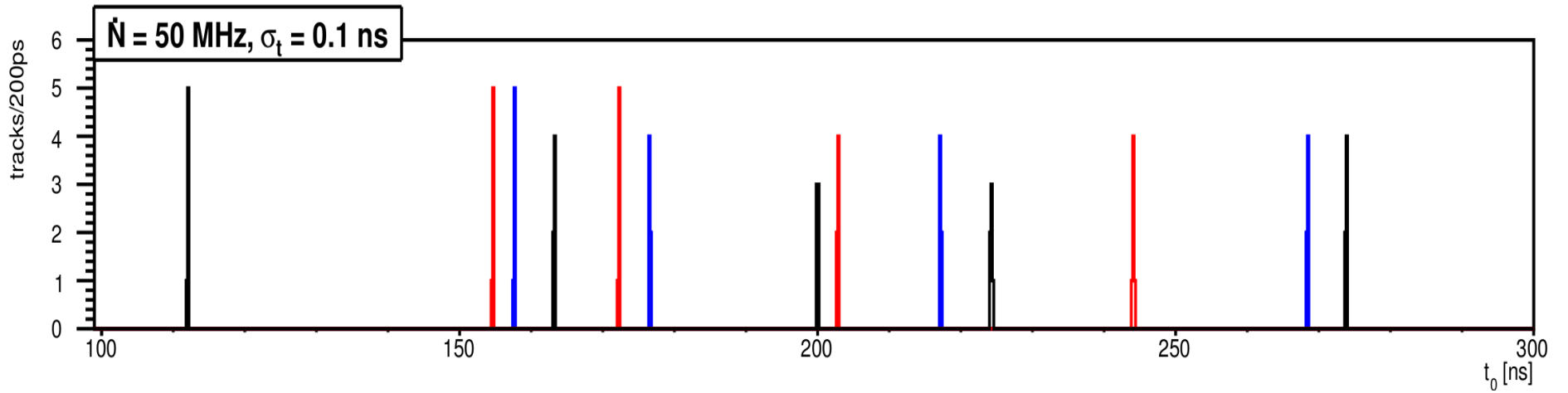
Event timing

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

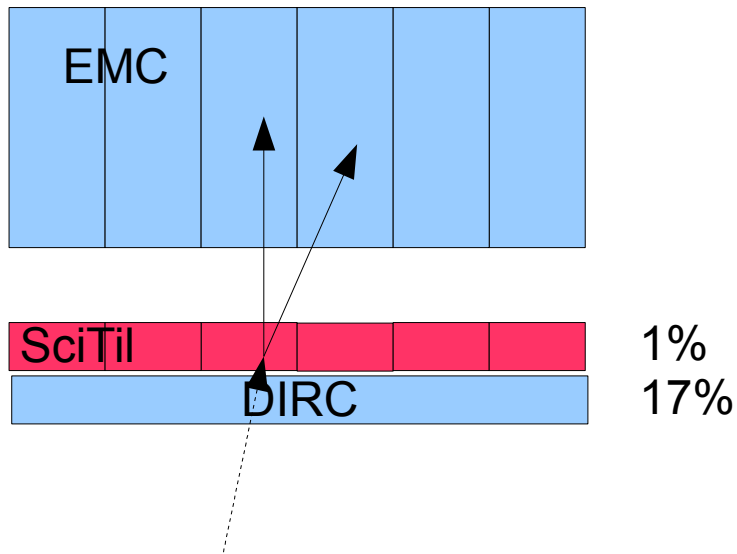




Fast detector assigns accurate time stamps to tracks.

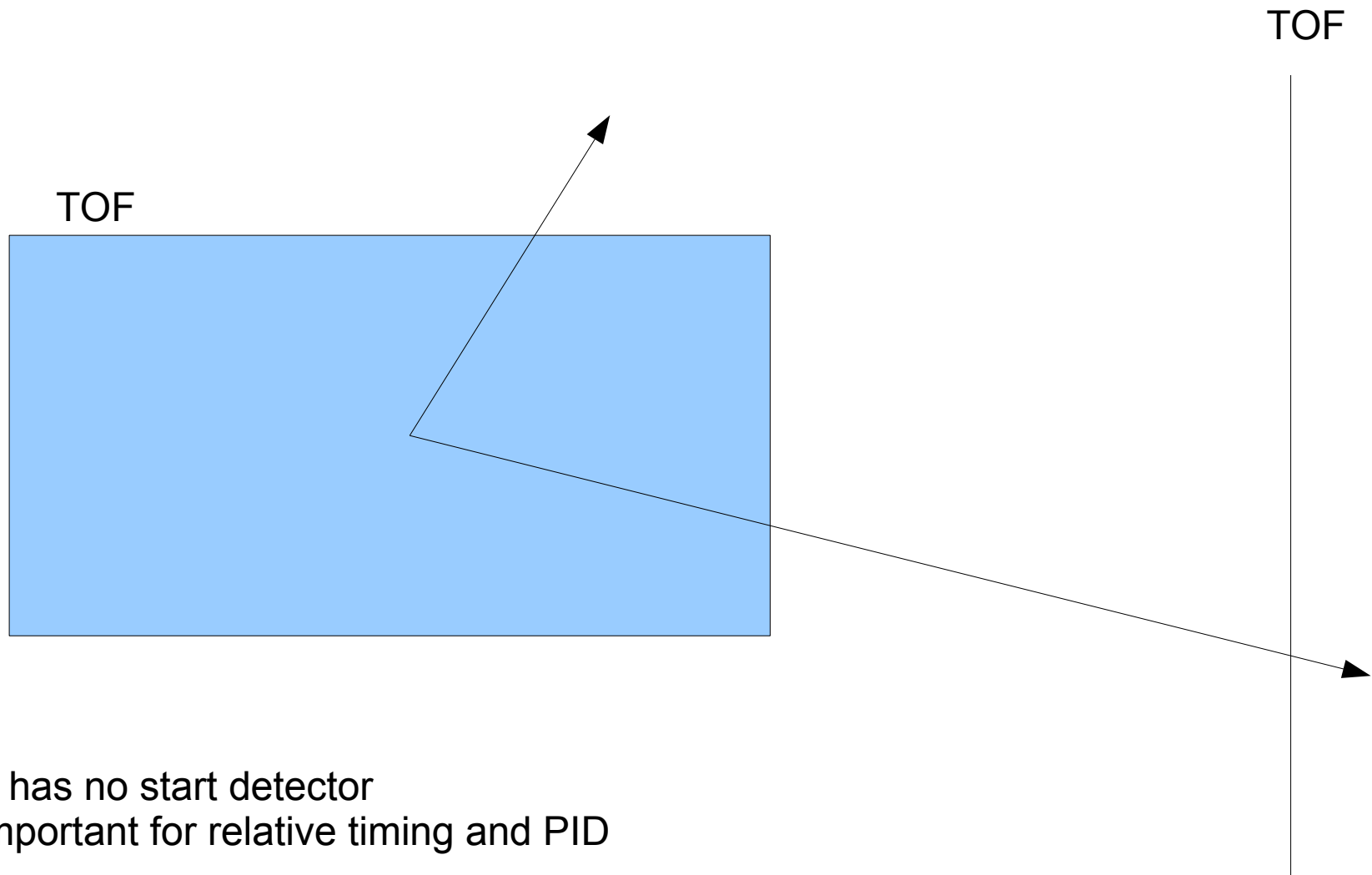


Conversion detection



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

Relative timing

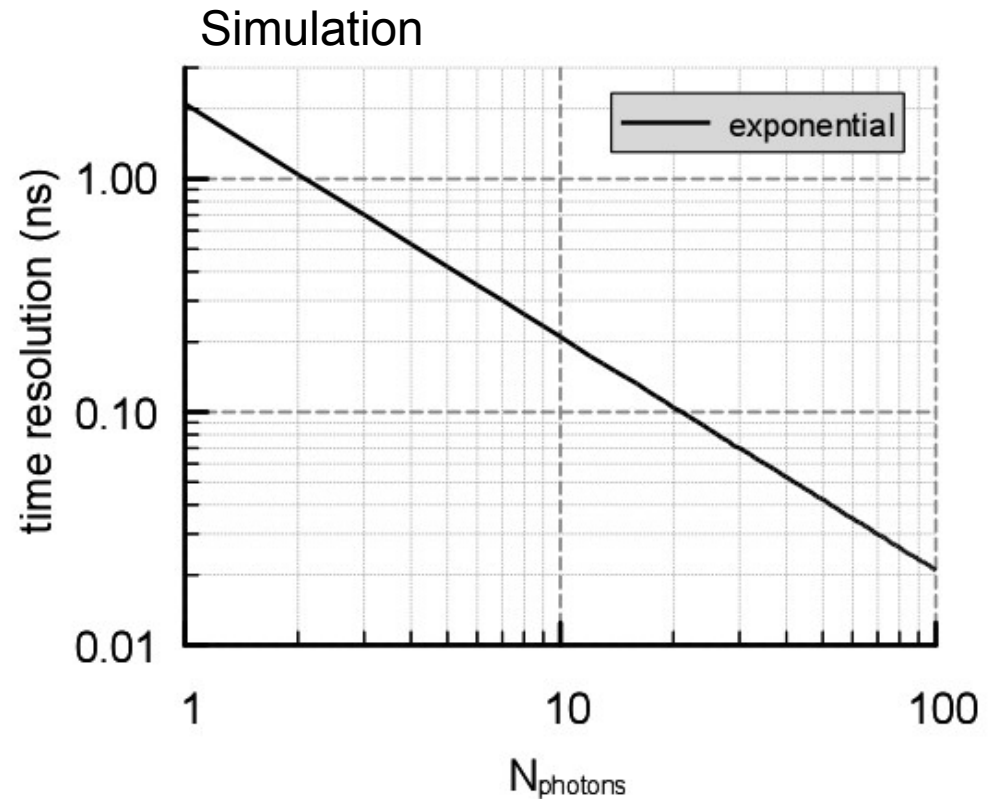
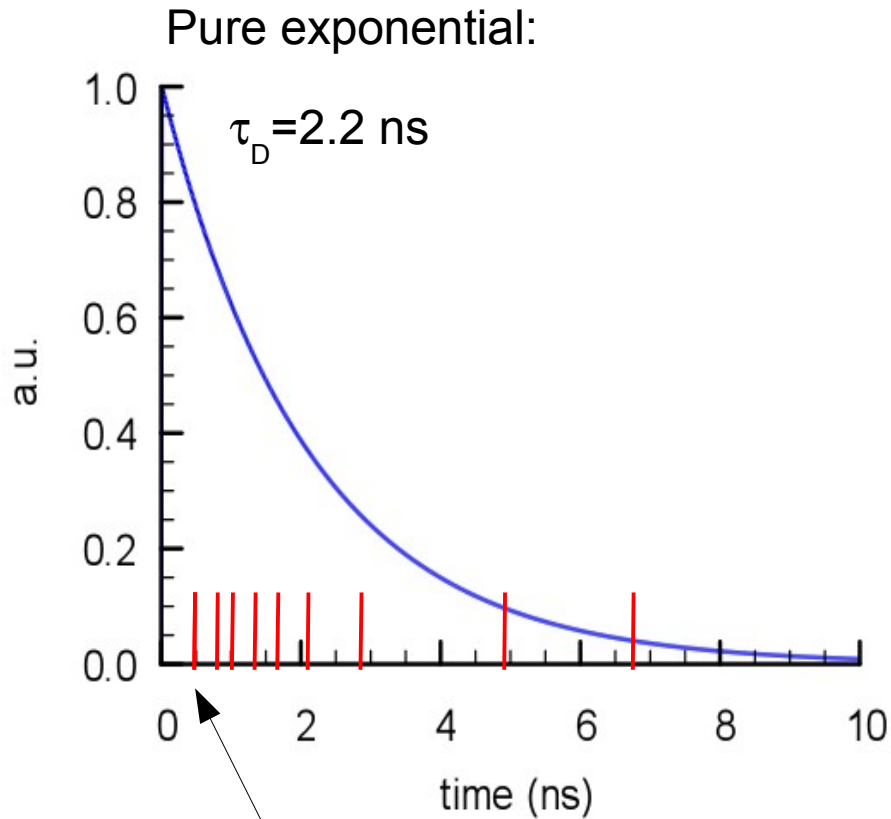


PANDA has no start detector
SciTil important for relative timing and PID

Scintillator Material

For subnanosecond timing: timing on first arriving photon

→ Time resolution depends on number of photons.

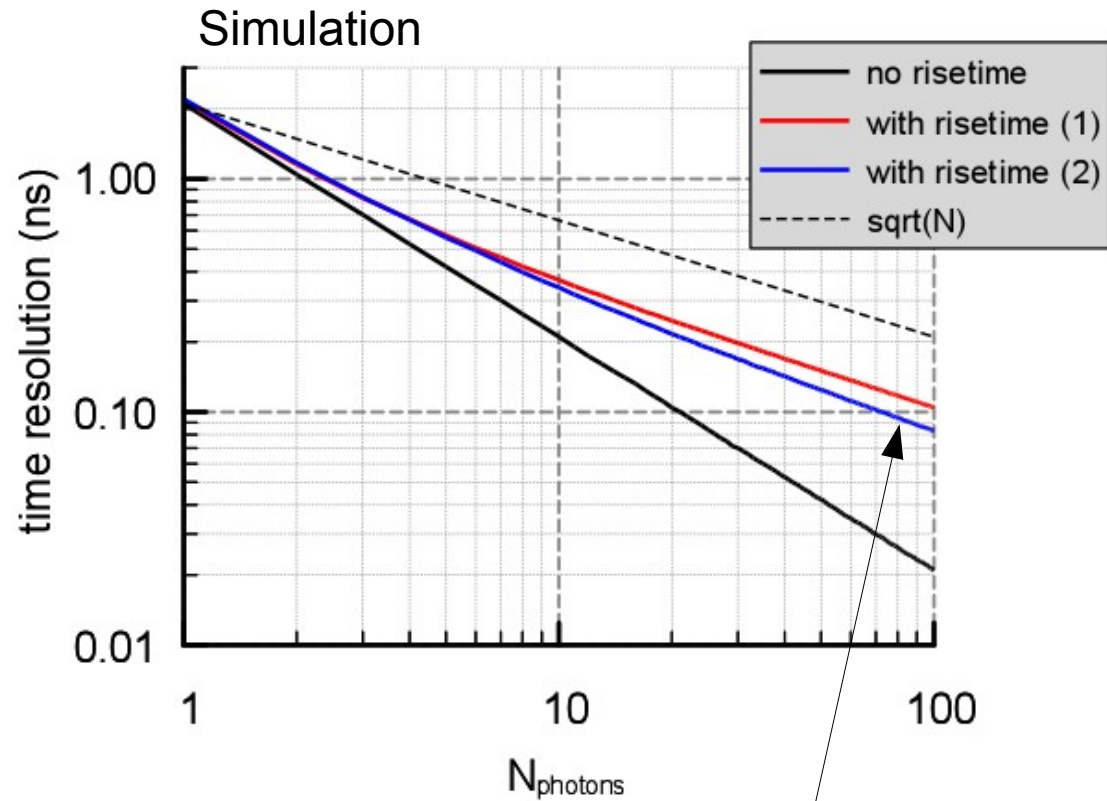
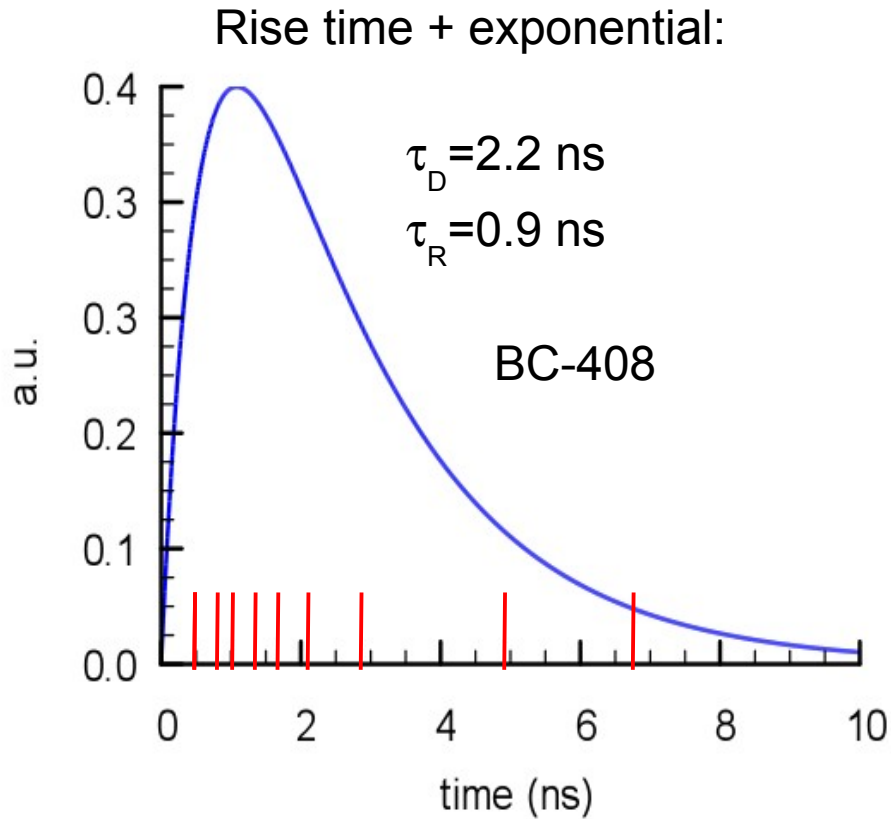


Time spread of first photon (RMS) for many events $\sim 1/N$

Unfortunately
→ not so simple...

Rise time comparable to wanted time resolution

→ Additional smearing of first photon

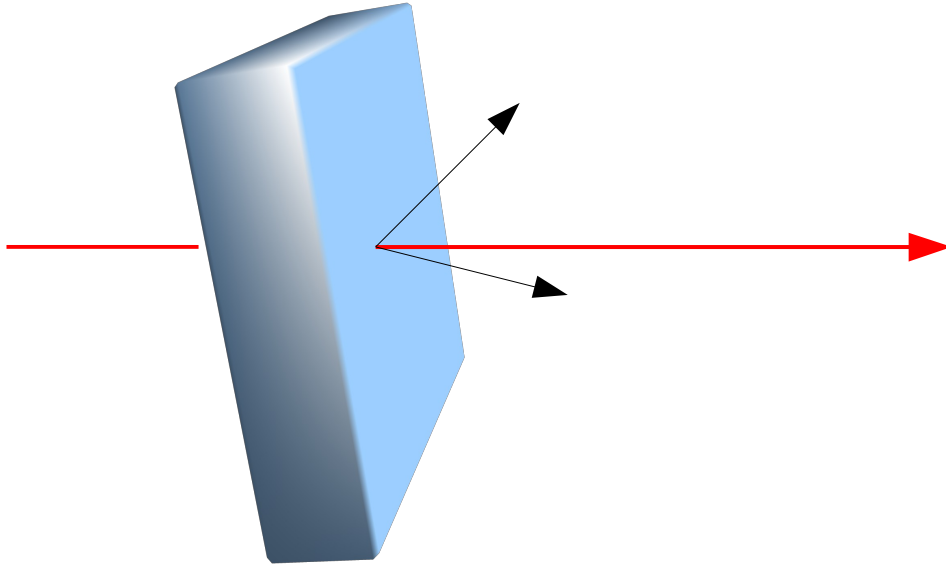


Time spread of first photon (RMS) for many events $\sim 1/\sqrt{N}$

BC-408: 100 ps
100 photons

Photon number

Tile 30 x 30 x 5 mm³



Minimum ionizing particle

$$\begin{aligned}\Delta E &= 1 \text{ MeV} \\ &= 10^4 \text{ photons}\end{aligned}$$

generated

$$\begin{aligned}70\% \text{ hit rim} \\ &= 7000 \text{ photons}\end{aligned}$$

on rim

$$\begin{aligned}\text{PD area} &= 18 \text{ mm}^2 \\ \text{rim area} &= 600 \text{ mm}^2\end{aligned}$$

$$= 210 \text{ photons}$$

geometry

$$55\% \text{ PD efficiency}$$

PDE

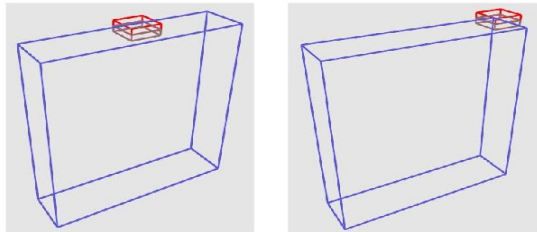
$$= 115 \text{ photons}$$

$$\begin{aligned}30 \times 30 \times 5 \text{ mm}^3 &\rightarrow 115 \text{ photons} \\ 20 \times 20 \times 5 \text{ mm}^3 &\rightarrow 180 \text{ photons}\end{aligned}$$

20 x 20 x 5mm³

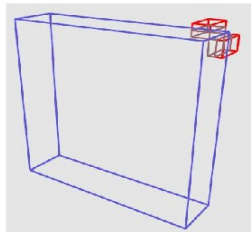
Slitroni simulations

Stefano Casasso, University of Turin
Summerstudent program GSI 2010

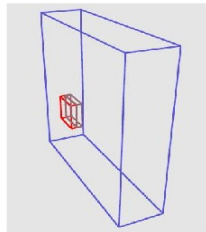


(a) Geo1

(b) Geo2



(a) Geo3



(b) Geo4

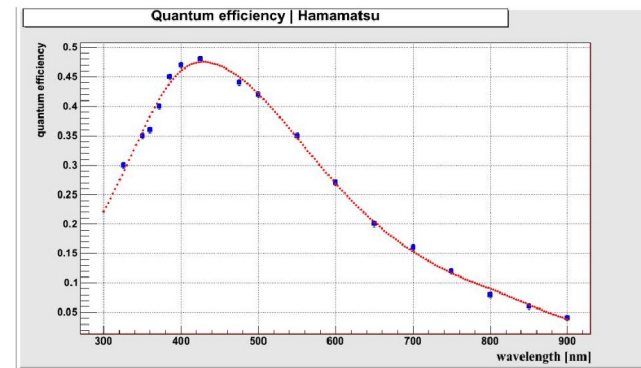


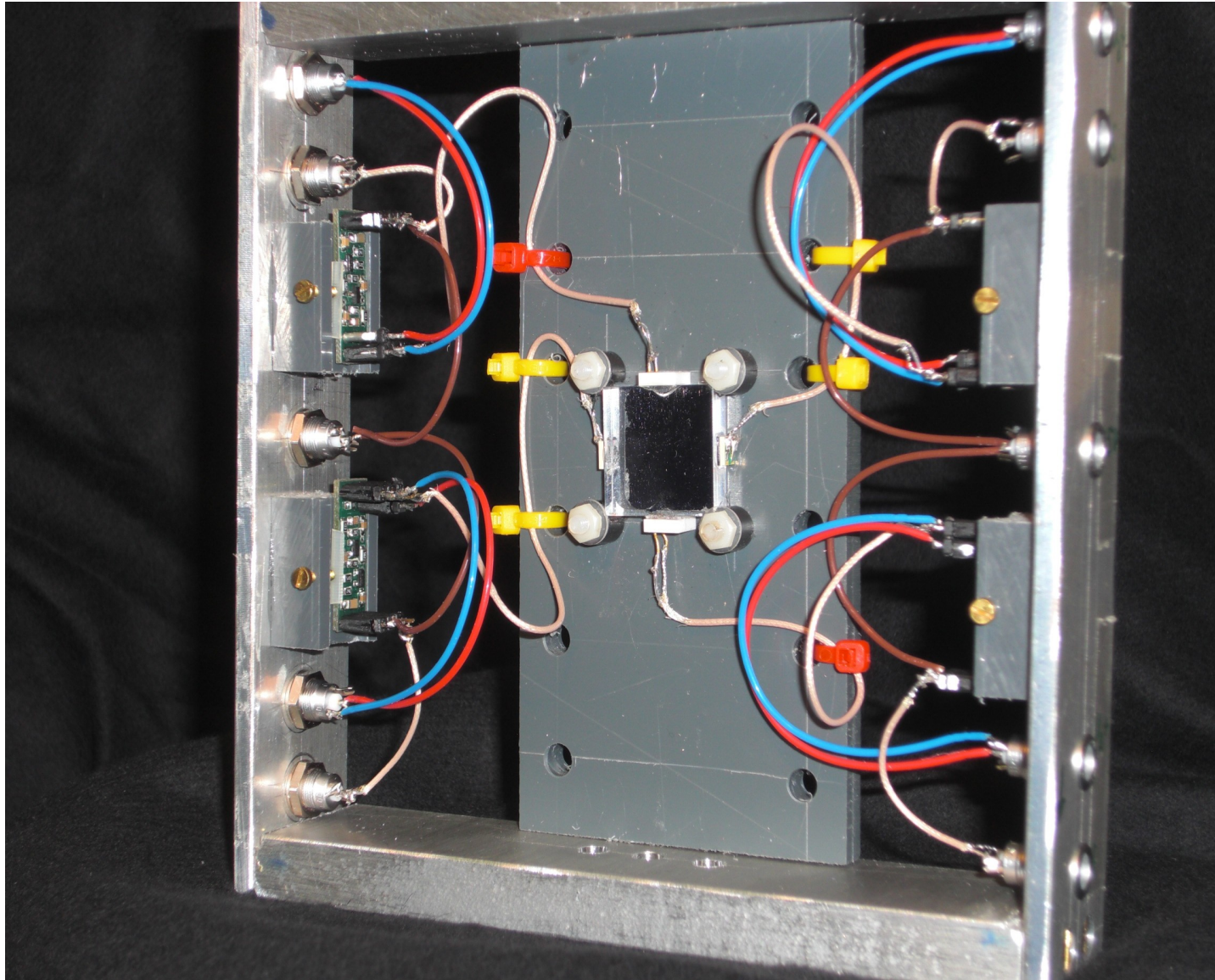
Fig. 4: Plot showing the Quantum Efficiency of Hamamatsu SiPMs vs. wavelength

	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 analysis for the four geometries

Simulations agree
with above rough estimates

Prototype



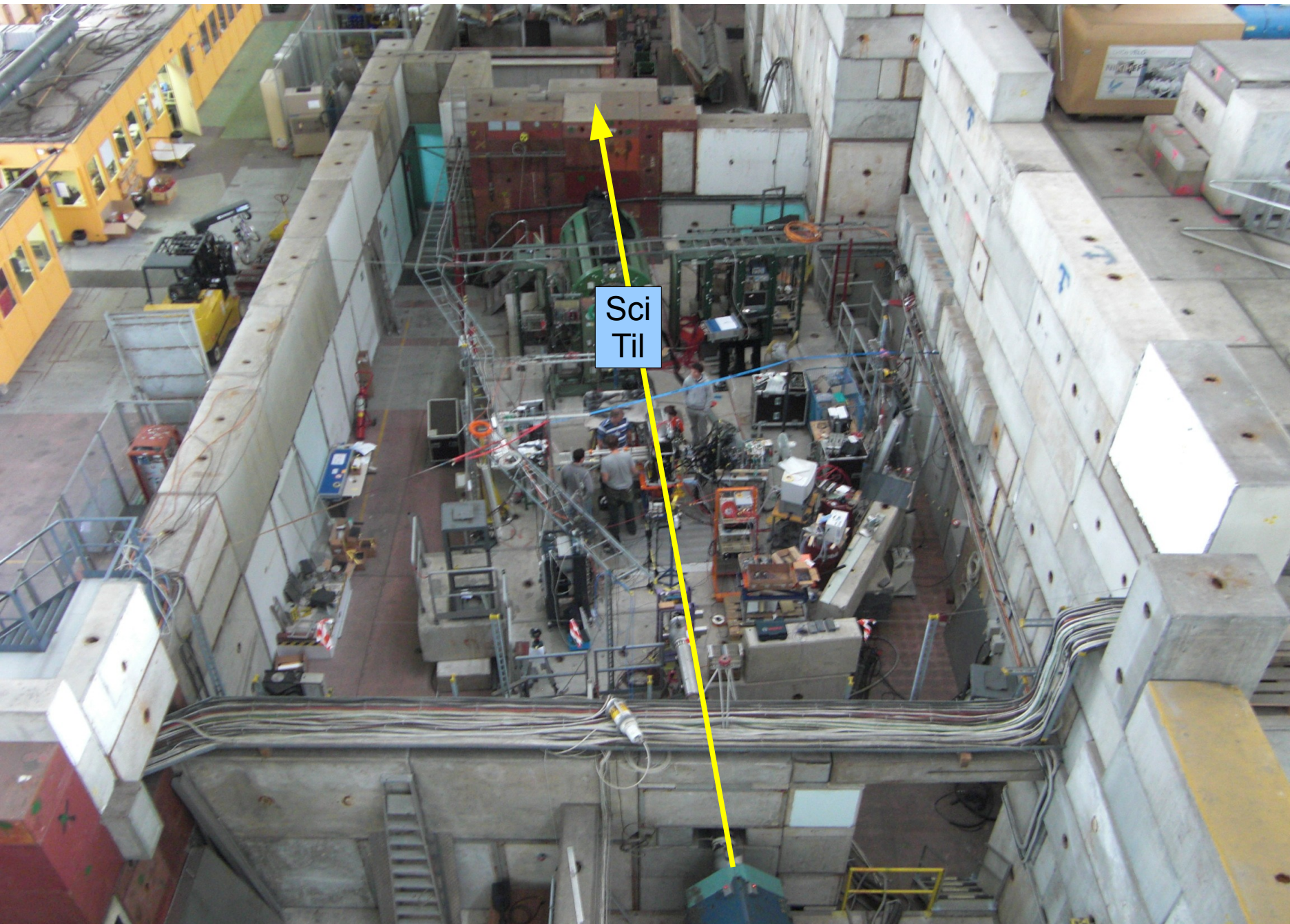
BC408
20 x 20 x 5 mm³

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

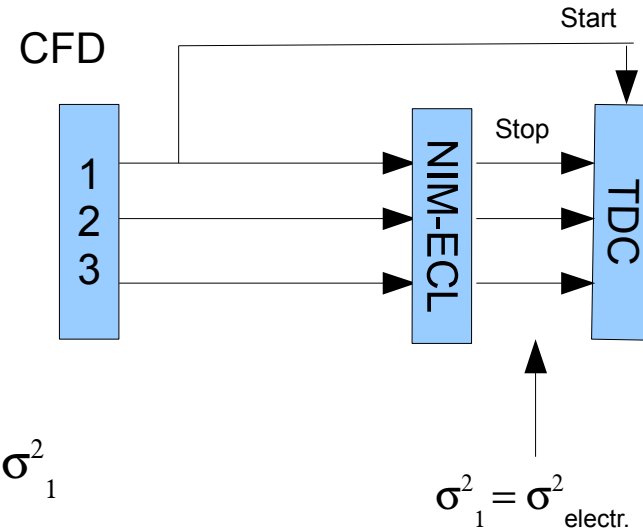
Photonique
Fast amplifier 611

Readout
NINO + HADES TRB

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



Timing resolution of 3 detectors



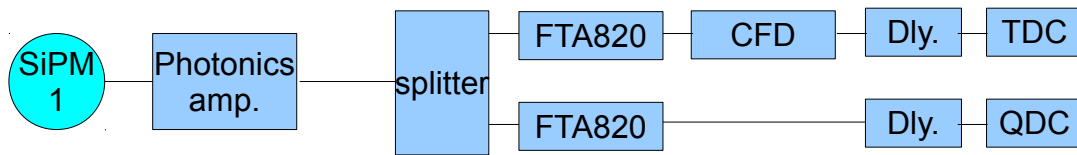
Measure $t_1 - t_2, t_1 - t_3, t_2 - t_3, t_1 \rightarrow \sigma_{12}^2 \sigma_{13}^2 \sigma_{23}^2 \sigma_1^2$

And subtract $2\sigma_{\text{electr.}}^2 \rightarrow \sigma_{12}^{2'} \sigma_{13}^{2'} \sigma_{23}^{2'}$

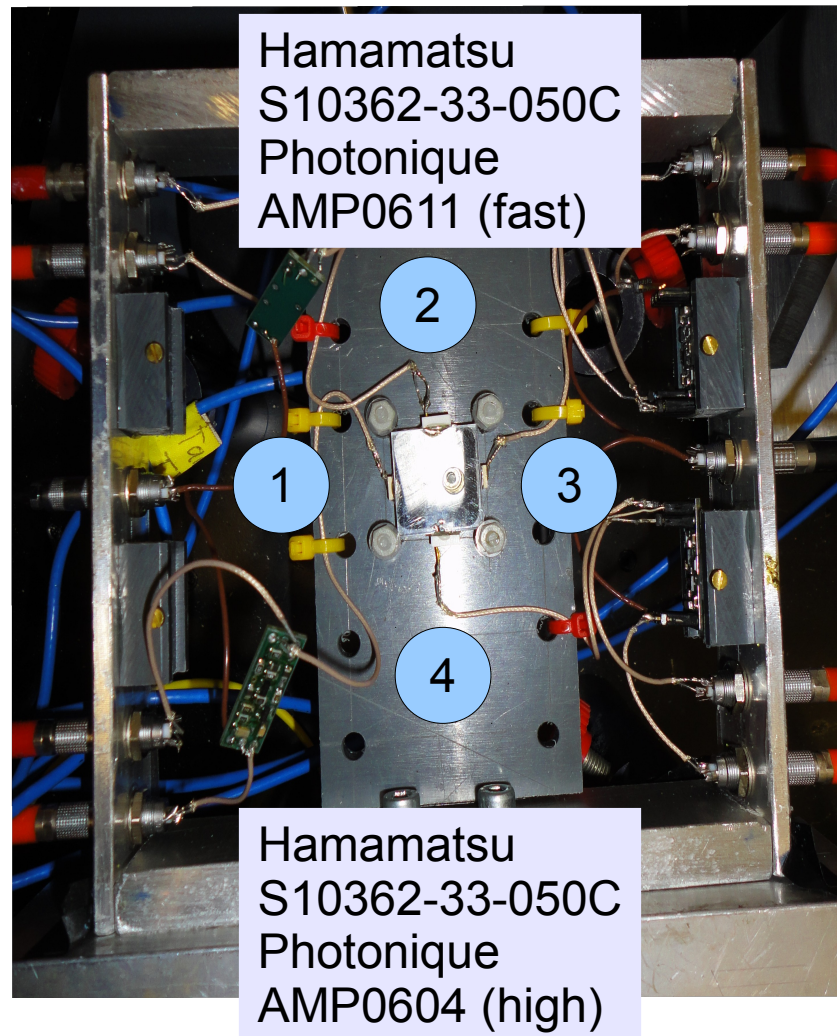
$$\begin{aligned} \sigma_{12}^{2'} + \sigma_{13}^{2'} - \sigma_{23}^{2'} &= (\sigma_1^2 + \sigma_2^2) + (\sigma_1^2 + \sigma_3^2) - (\sigma_2^2 + \sigma_3^2) \\ &= 2\sigma_1^2 \end{aligned}$$

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

GSI Summerstudent program 2011: Stefan Diehl, Giessen
→ more systematic search for missing time resolution



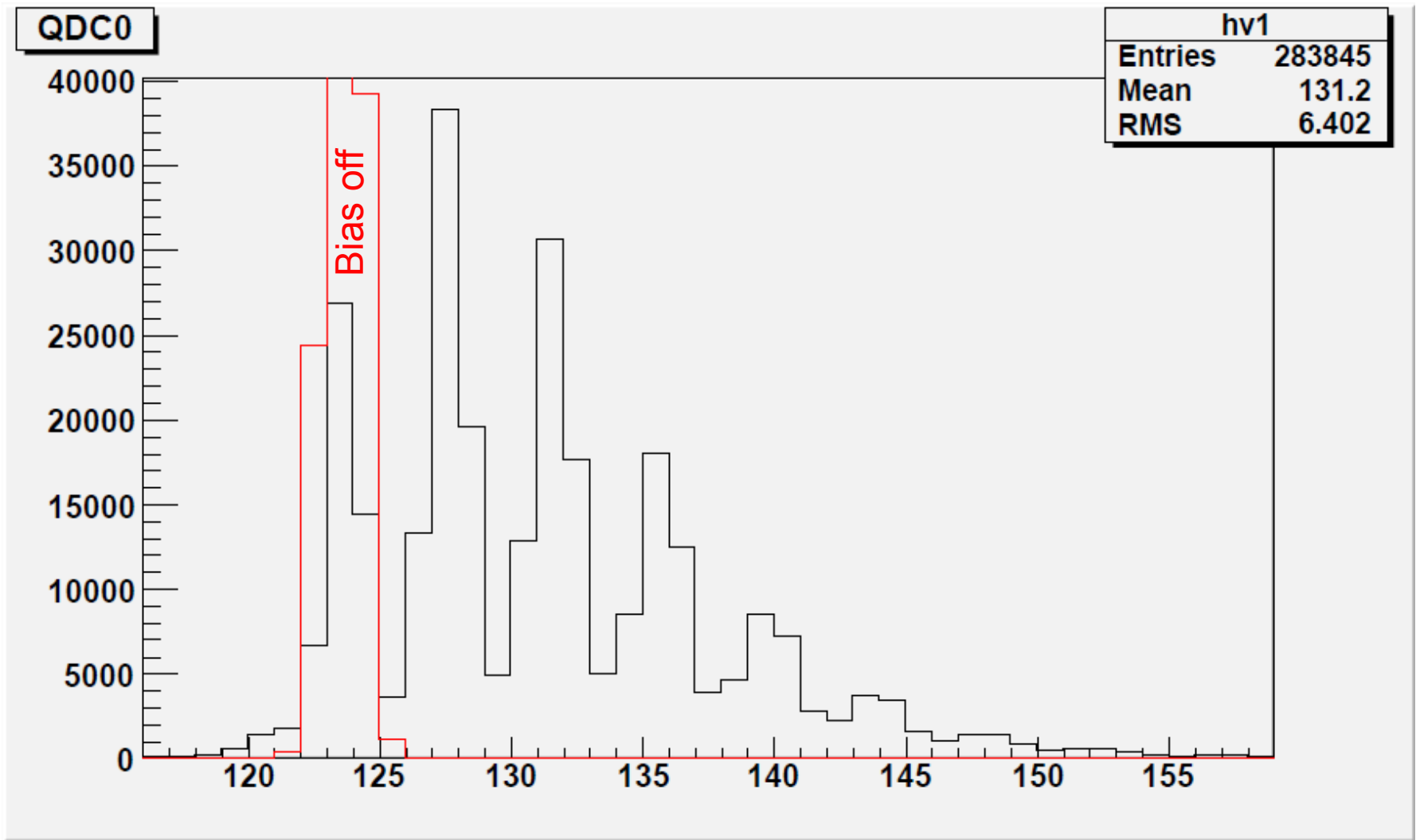
Trigger done by majority coincidence (=4)
CFD set to 1 photon



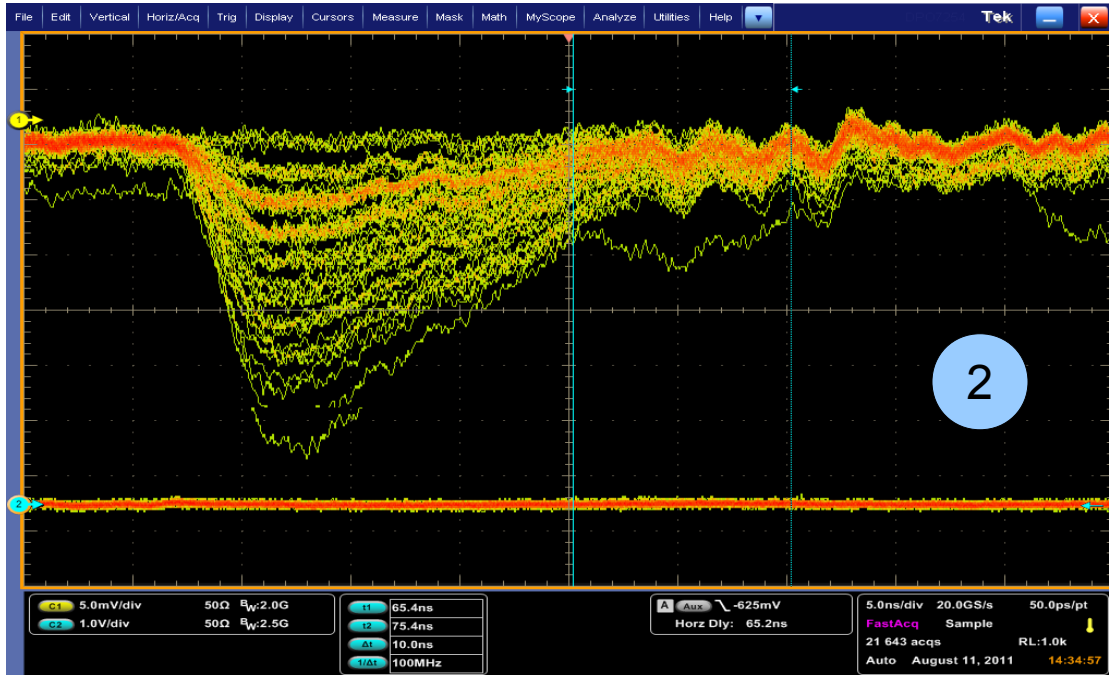
Hamamatsu S10931-050P
Photonique AMP0611 (fast)

Hamamatsu S10931-050P
Photonique AMP0604 (high)

Shielded bias/5V

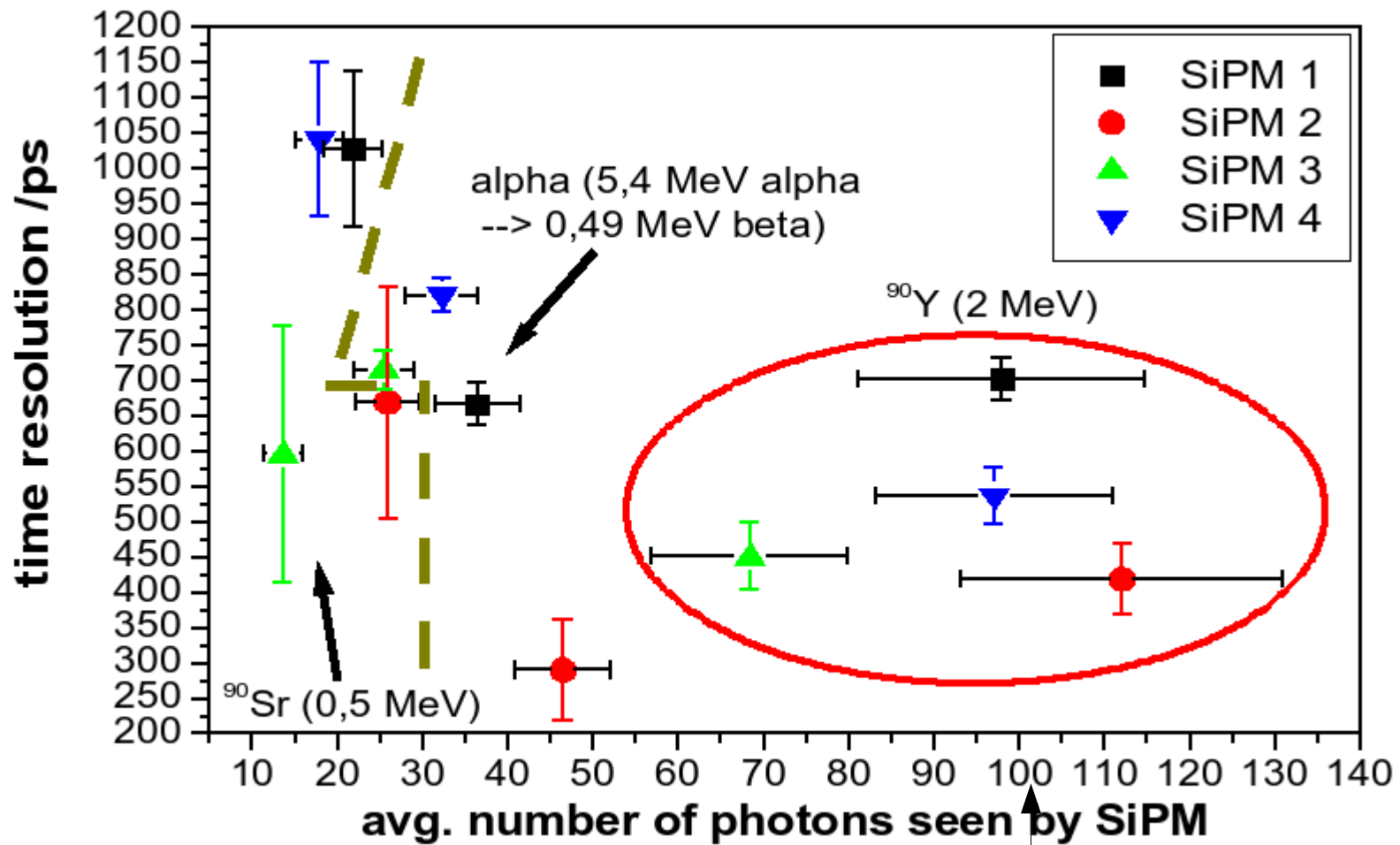


Calibration of QDC spectra with PicoQuant laser to count photons



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



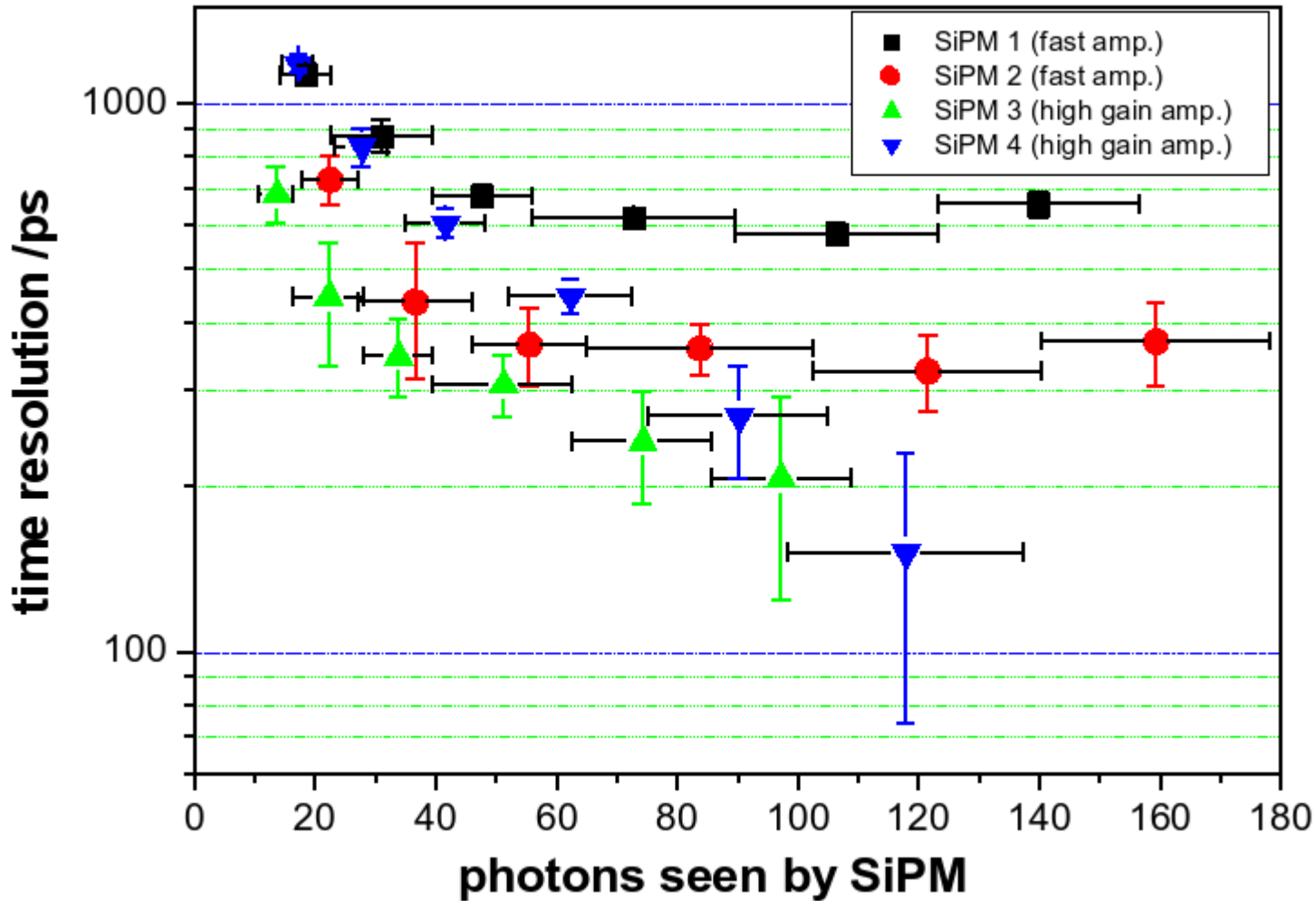
Time resolution including electronic time jitter

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

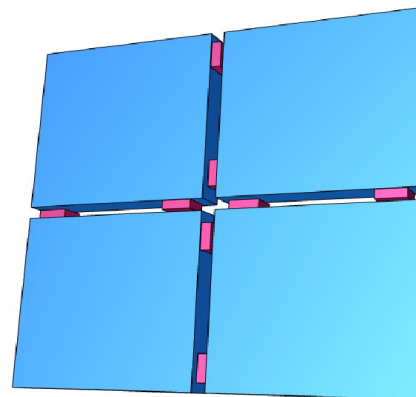
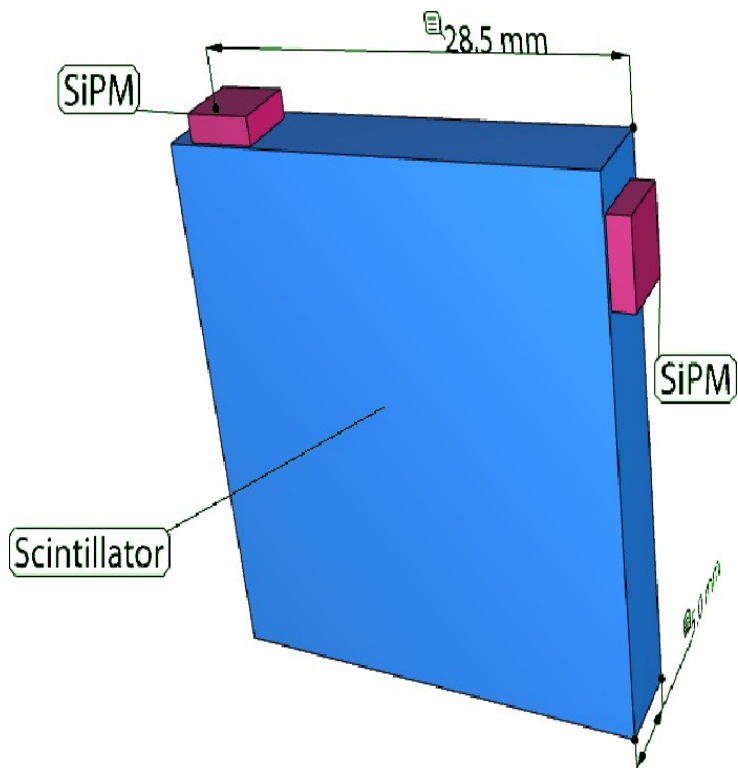
Electronic time
Resolution
(FTA820/CFD/ NIM-ECL converter)

⁹⁰Sr source, results corrected for electronic time resolution

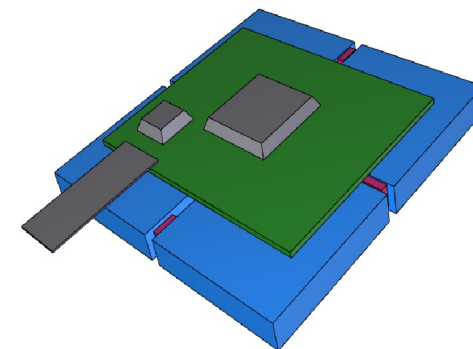


High gain
AMP604
most promising

Mechanics



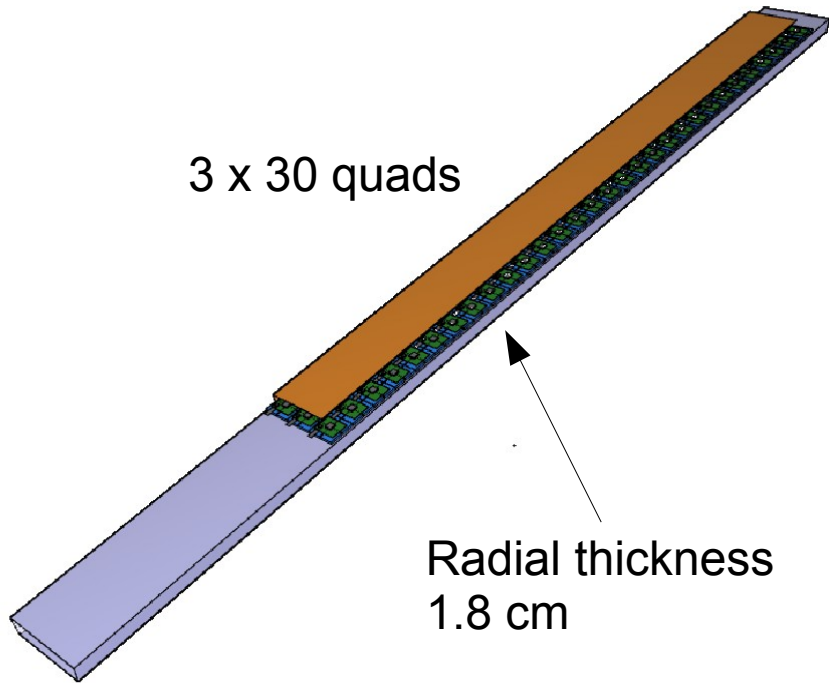
Quad module



With electronics
8 ch. ASIC
data transfer IC

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

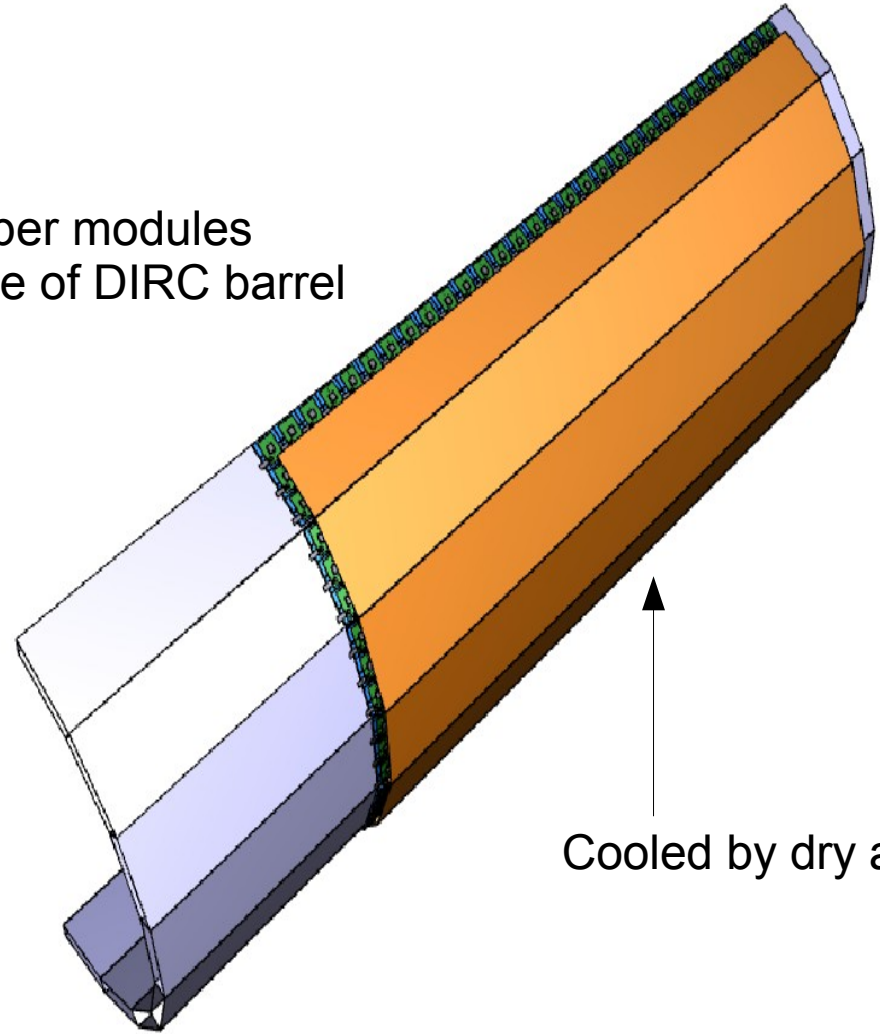
Super-module = 90 quad modules



3 x 30 quads

Radial thickness
1.8 cm

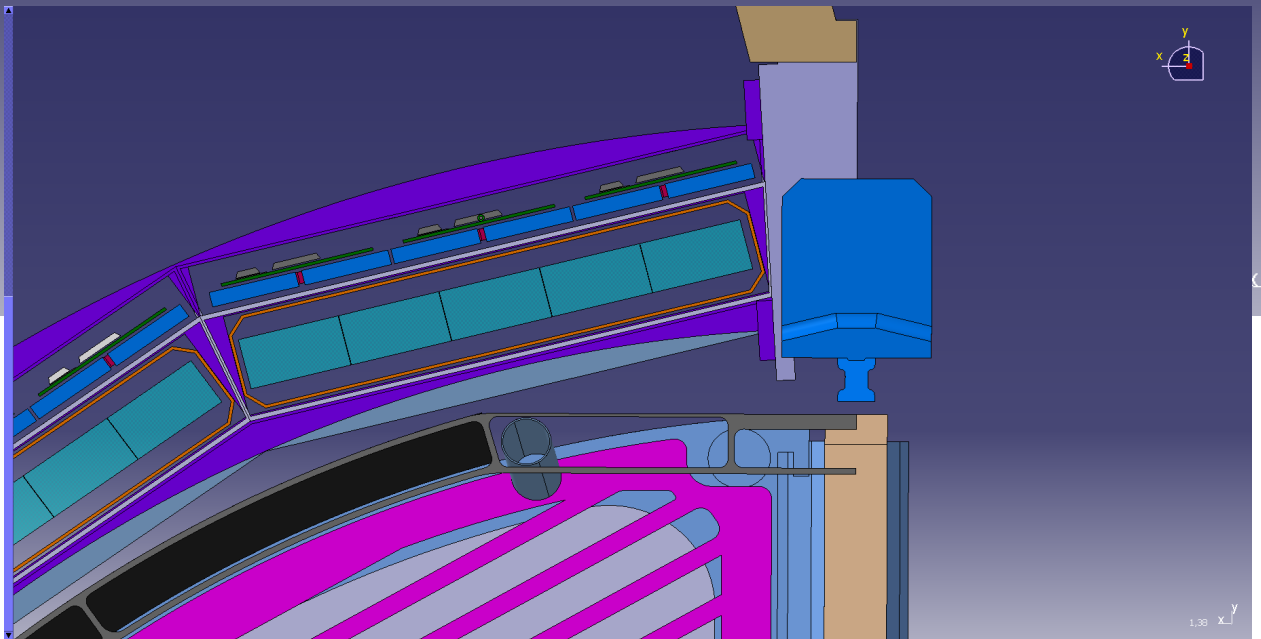
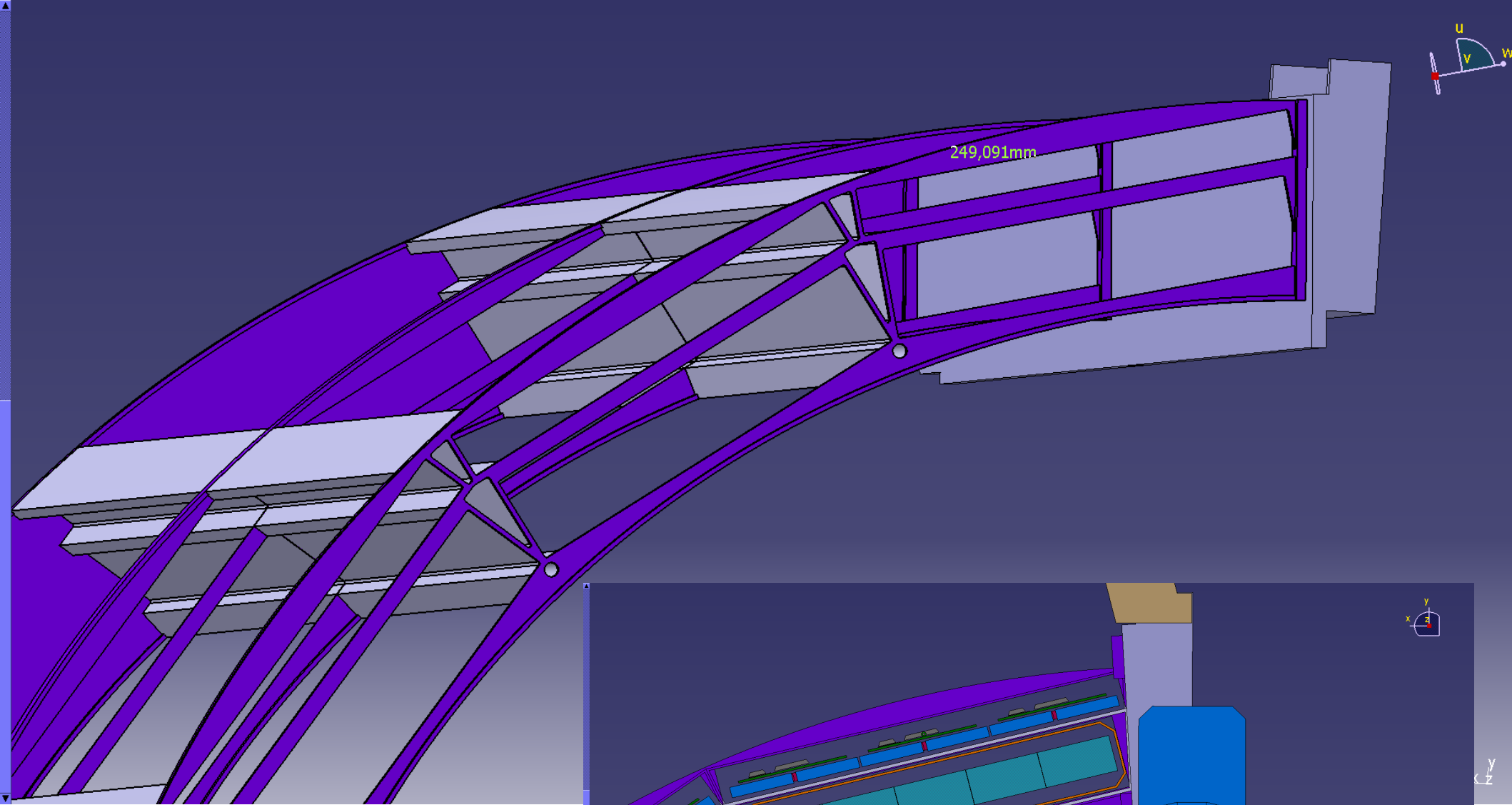
16 super modules
outside of DIRC barrel



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
 - AMP604 pre-amps give right time resolution
 - Number of photons agrees with estimates
- Groups need to be identified for
 - Electronic development
 - Mechanical development...