

J-PARC KOTO実験における横方向光子検出器の性能向上

Main Barrel upgrade for J-PARC KOTO exp.

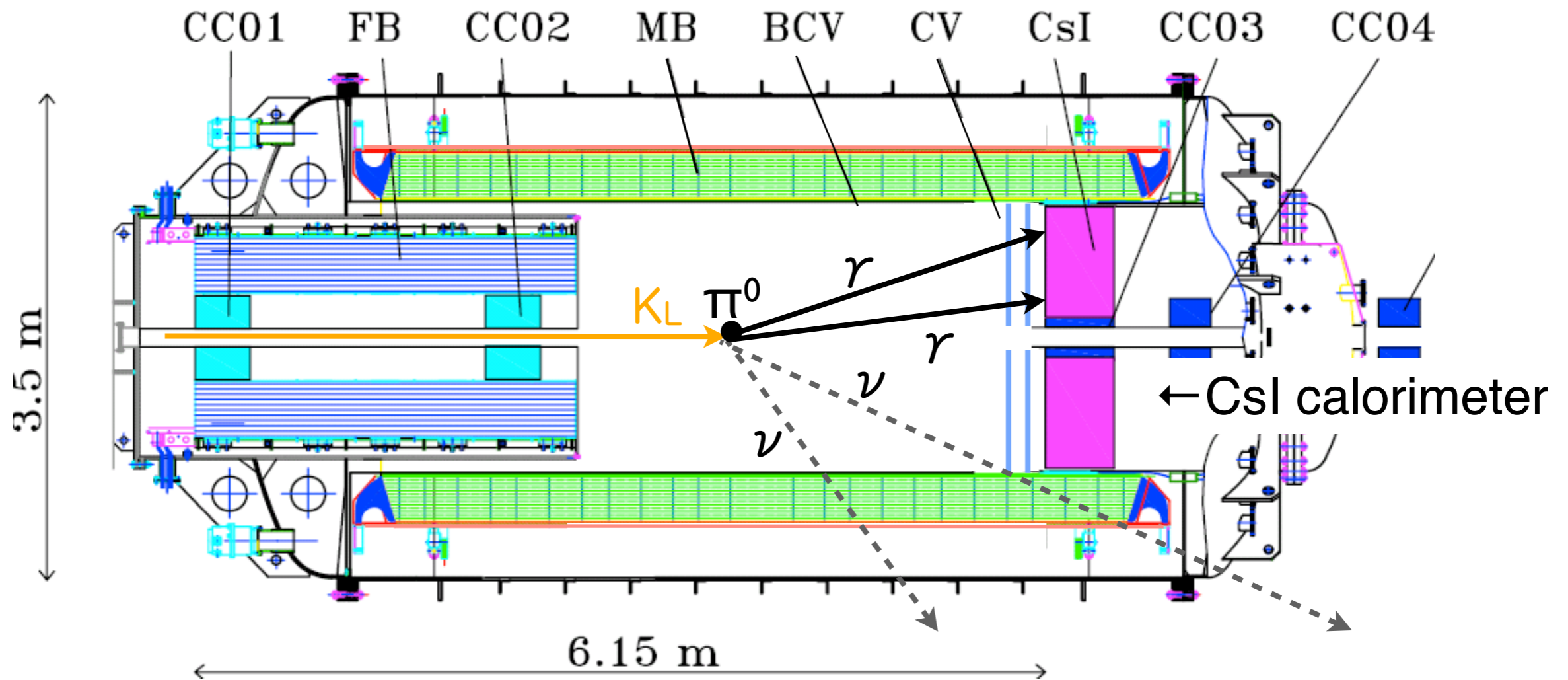
Dec. 25. 2015

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Rie MURAYAMA

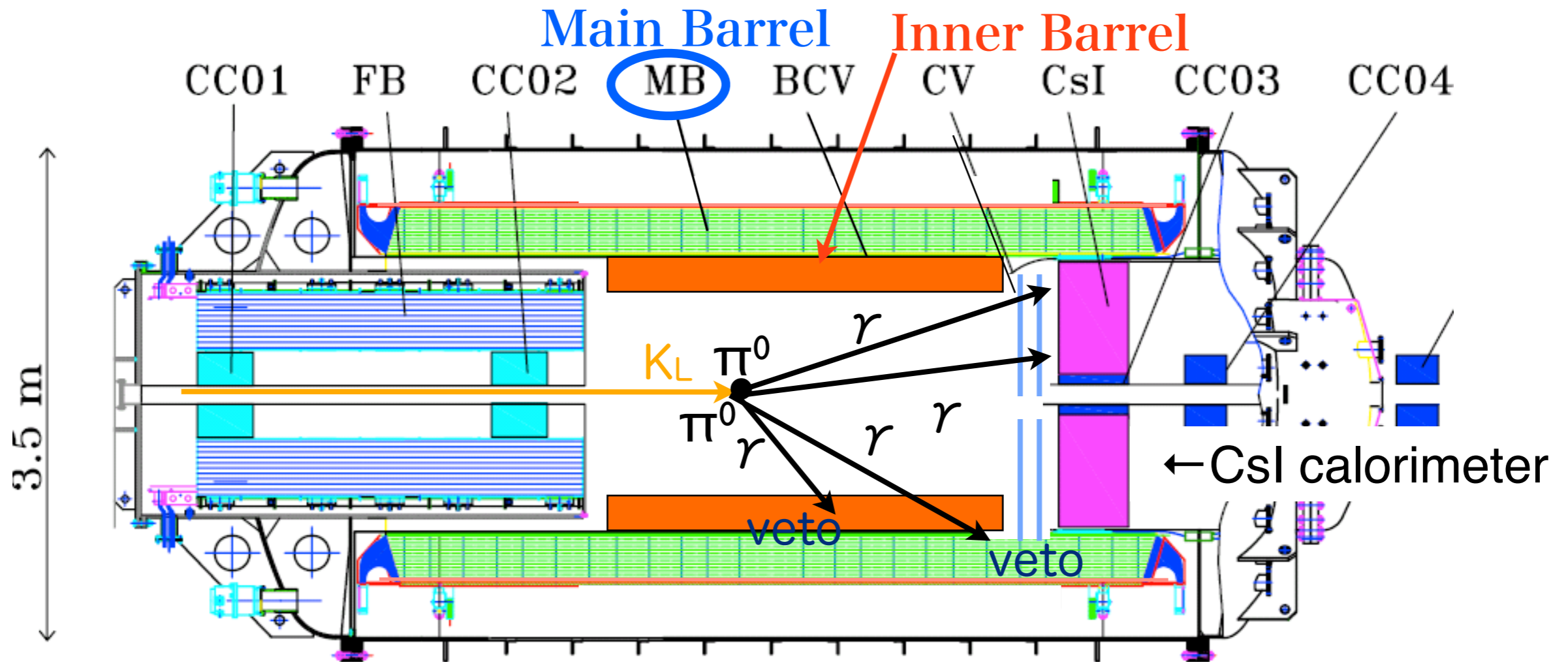
KOTO experiment

- KOTO measures the branching ratio of $K_L \rightarrow \pi^0 \nu \nu$ estimated 2.4×10^{-11} by SM.



- CsI calorimeter detects 2γ from π^0 in $2K_L \rightarrow \pi^0 \nu \nu$.
- All detectors surrounding decay region veto other particle in other decay mode.

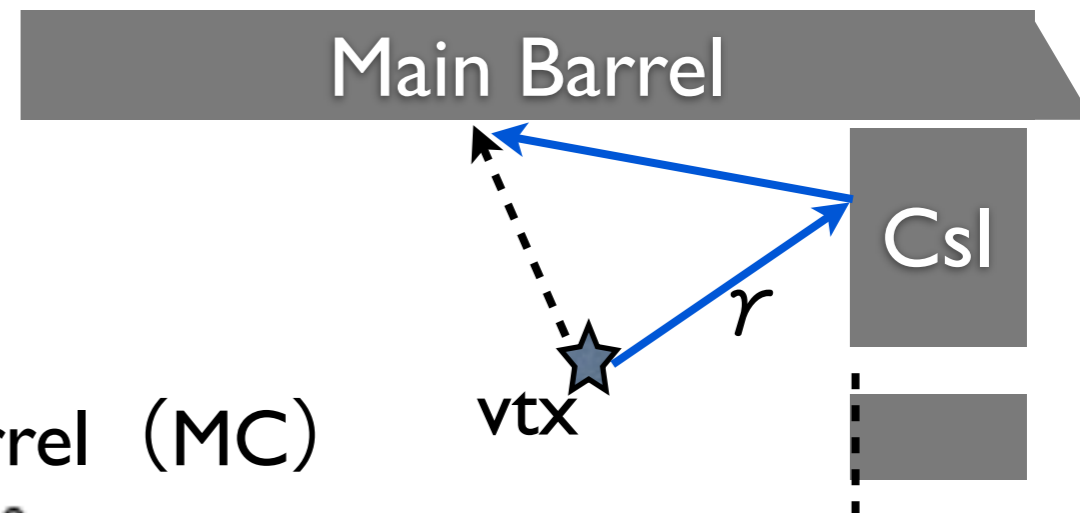
Issues of Main Barrel region and new detector



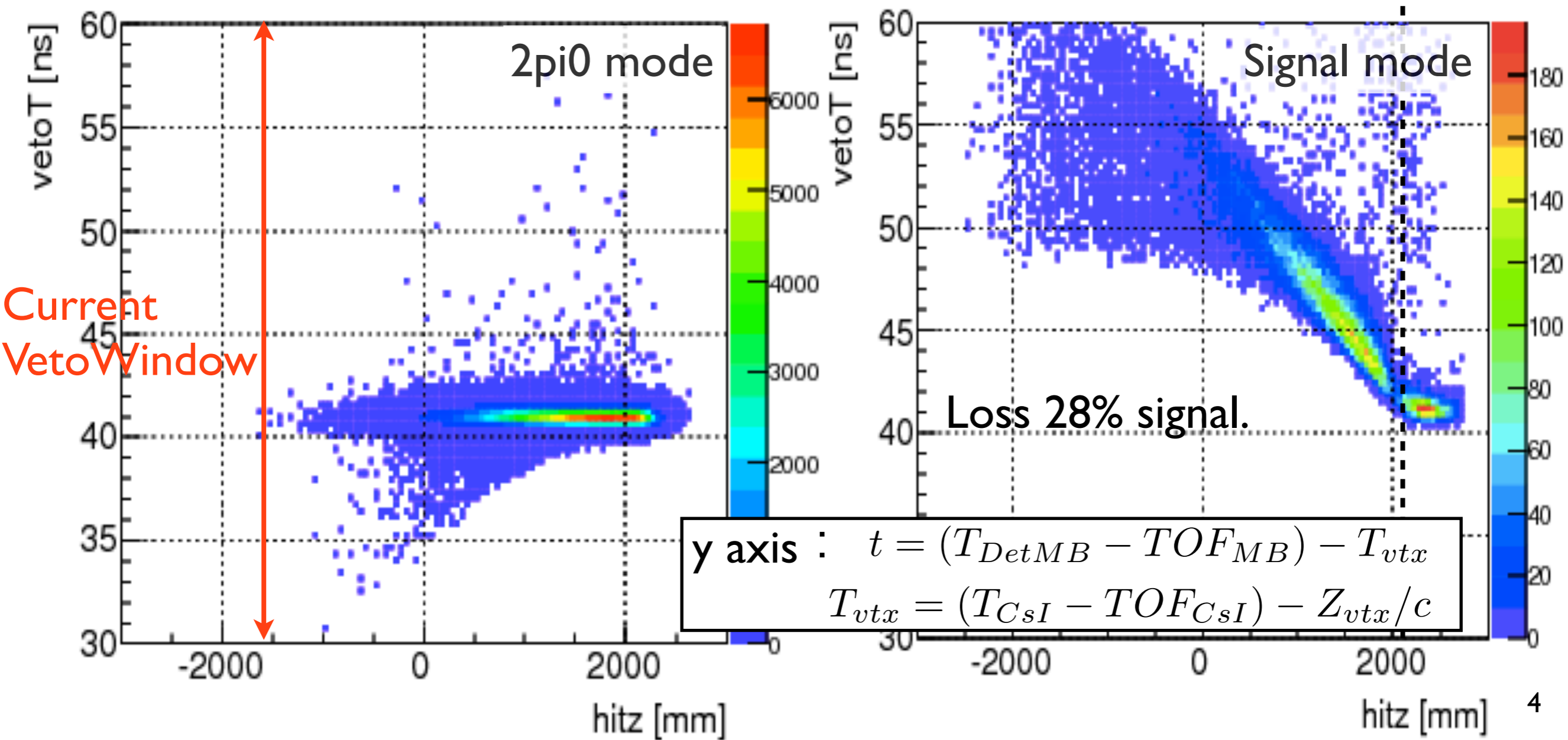
- γ missing in main background $K_L \rightarrow \pi^0 \pi^0$.
 → Additional detector thickness makes # $2\pi^0$ 2.0 → 0.6, S/N 1.0 → 1.7. (same condition about signal loss)
- Signal loss due to over veto of accidental event.
 → High resolution fiber of Inner Barrel makes good **timing resolution**.

Signal loss case 1) Back splash

- Back splash ... Electromagnetic shower leakage from CsI calorimeter



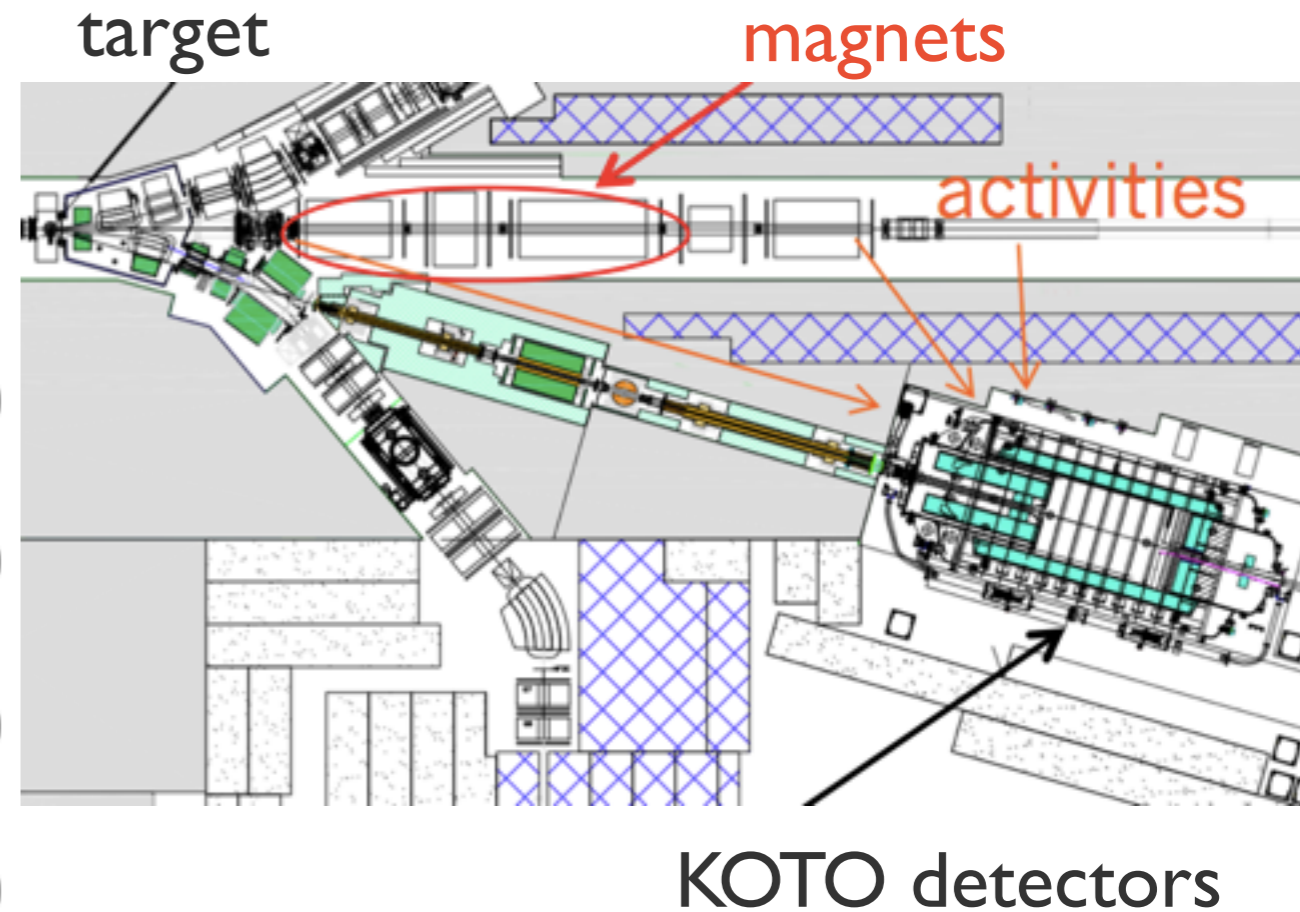
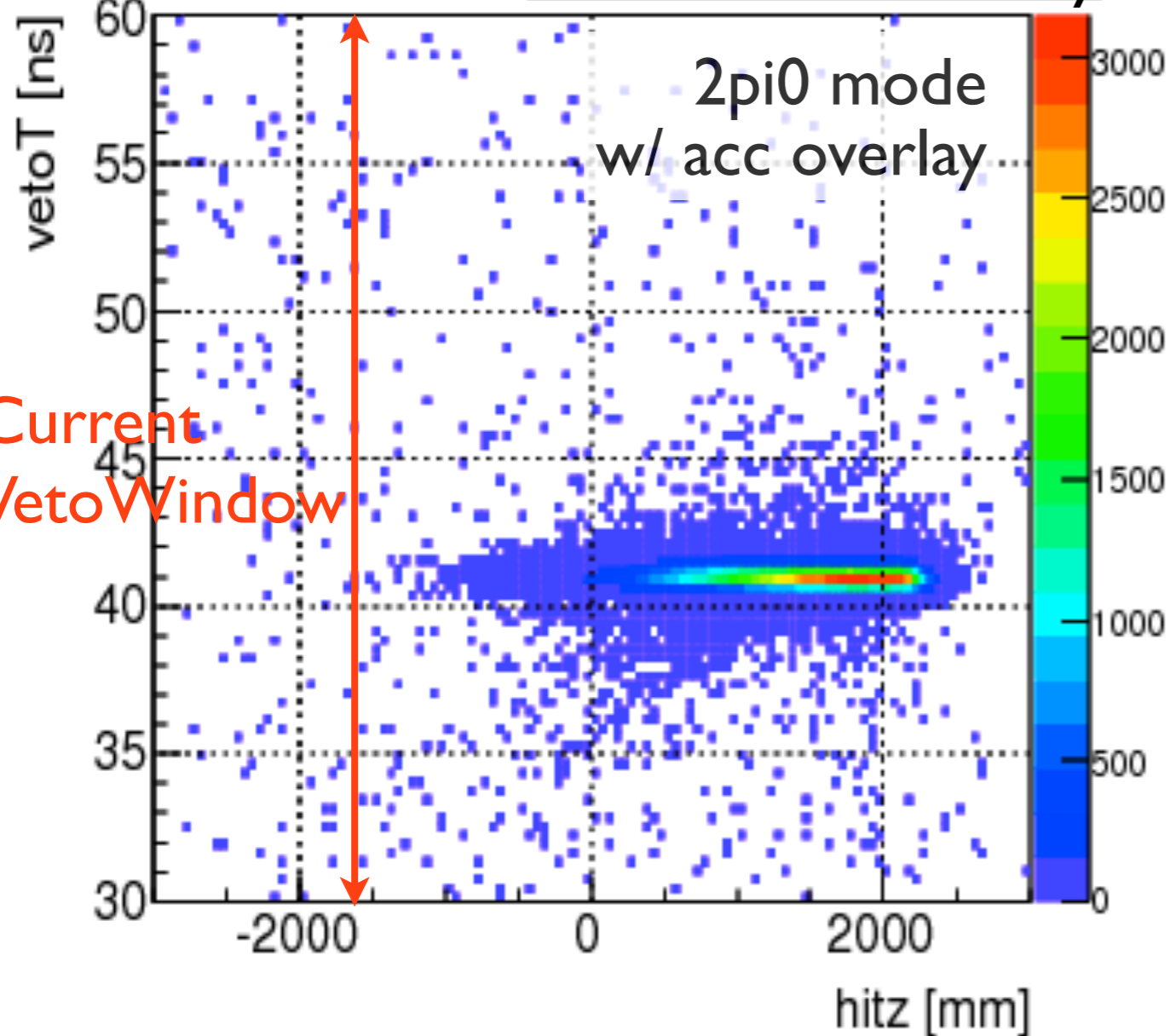
- Detect position z and timing at Main Barrel (MC)



Signal loss case 2) Primary beam origin

- Activities from primary beam line make high accidental counting rate. Magnet tuning is on trial.

- Detect position z and timing at Main Barrel (MC w/ accidental overlay)



Timing resolution at Barrel

- Timing / z position is important for long veto Barrel detector.

Z position resolution is in proportion to timing resolution.

※ Resolution caused by Csl is already included.

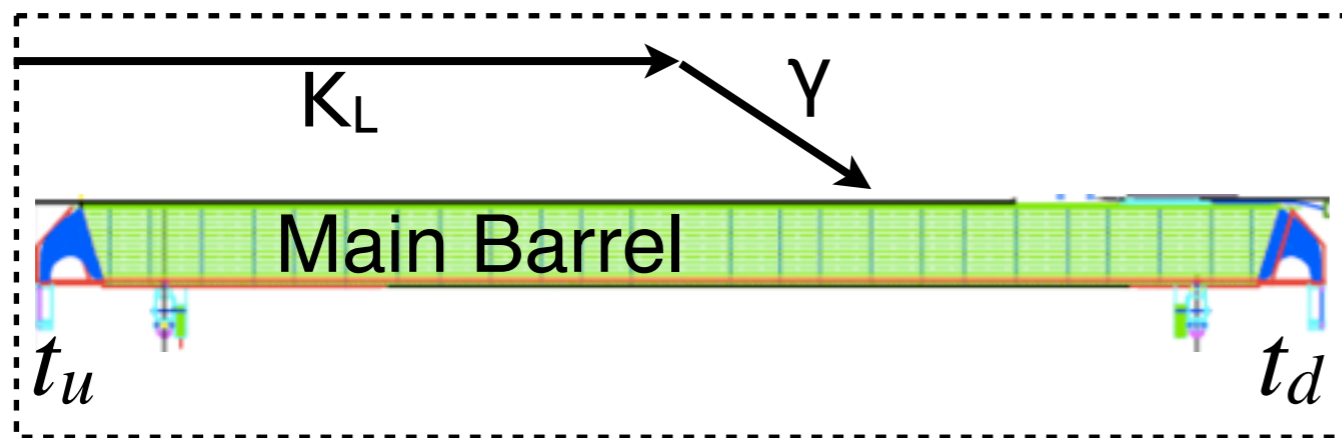
< Timing / z position at Barrel >

$$t_{MB} = (\underline{T_{DetMB}} - \underline{TOF_{MB}}) - \underline{T_{vtx}}$$

$$\underline{T_{DetMB}} = (t_u + t_d)/2$$

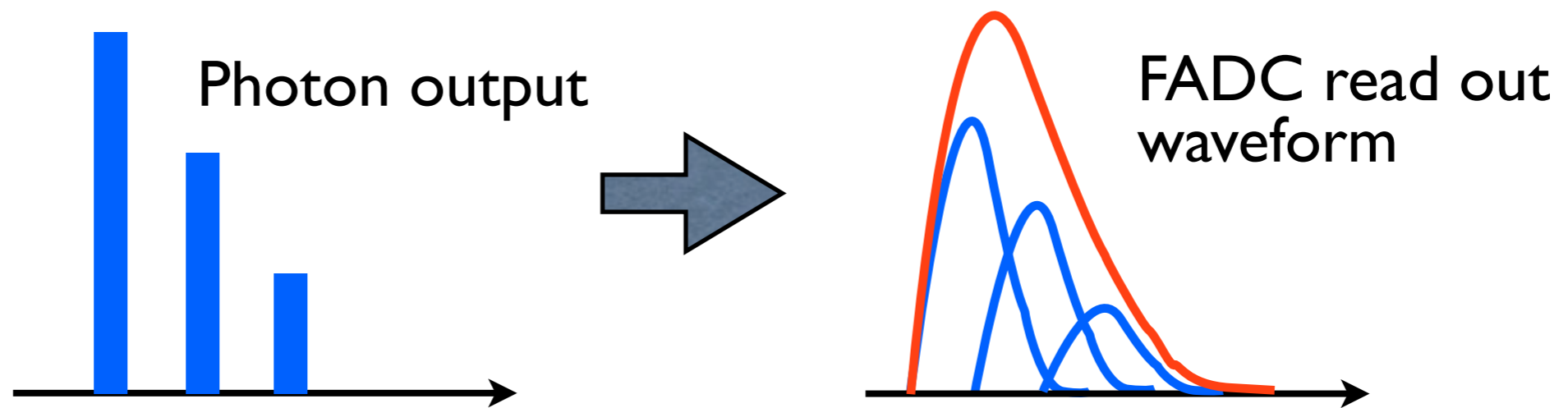
$$z_{MB} = v(t_u - t_d)/2$$


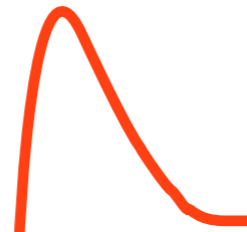

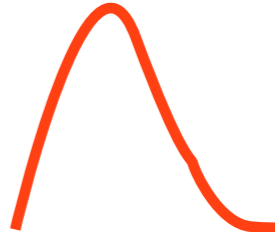




$$\sigma_z = v\sigma_t$$



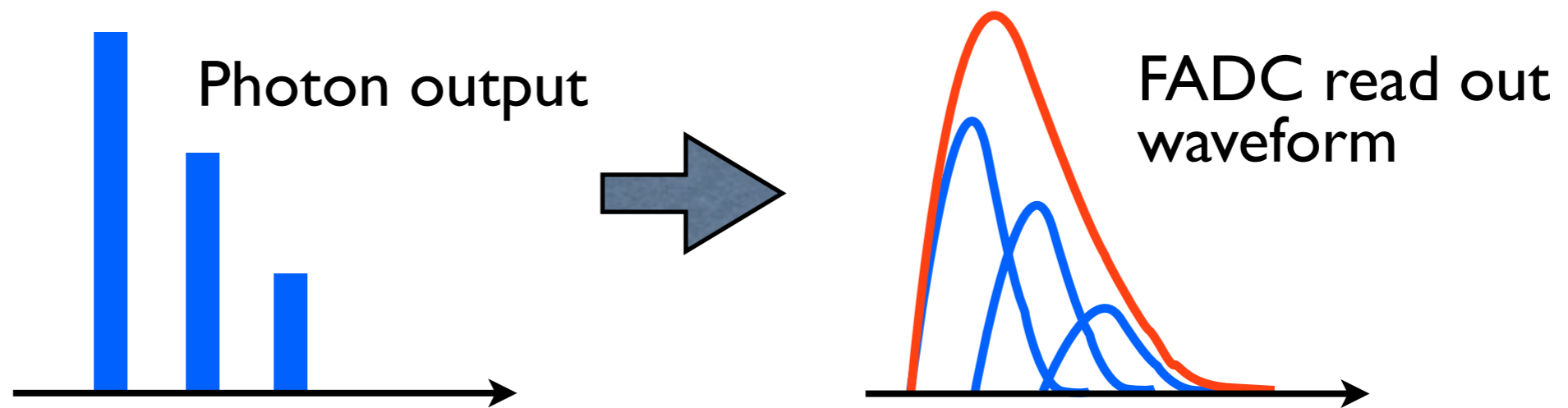
- Timing is decided by waveform taken by FADC.

Waveform of Barrel detectors



	scinti.	fiber (catalog decay time)	PMT	FADC w/ or w/o filter	
MB	MS-resin 15+30 layers 	Y11 (8.8 ns) 	R329EGP 	125 MHz w/ Bessel filter 	→ total waveform
IB	MS-resin 25 layers 	BCF92 (2.7 ns) 	R329EGP (up) R7724 (down) 	500MHz w/o filter 	→ total waveform

Waveform of Barrel detectors



	scinti.	fiber (catalog decay time)	PMT	FADC w/ or w/o filter
MB	MS-resin 15+30 layers	Y11 (8.8 ns)	R329EGP	125 MHz w/ Bessel filter
	Cosmic ray by Oscillo. → timing PDF		p.e. counting by Oscillo.	
IB	MS-resin 25 layers	BCF92 (2.7 ns)	R329EGP (up) R7724 (down)	500MHz w/o filter

p.e. counting by FADC

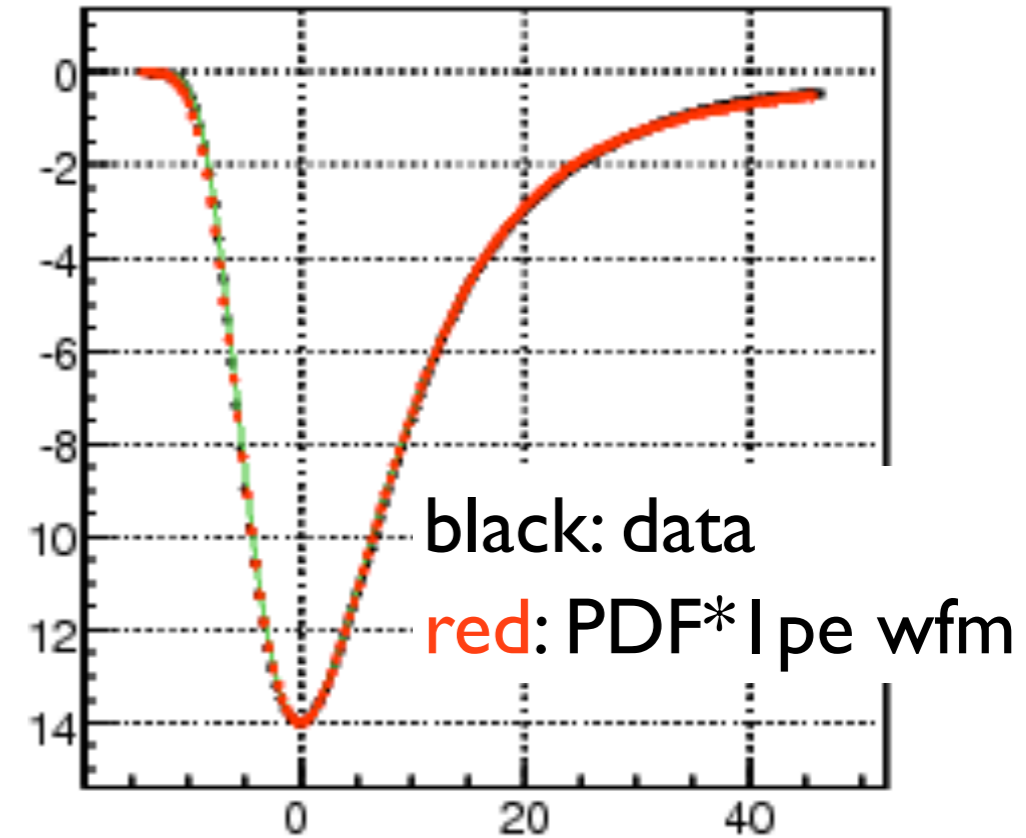
Timing PDF finding

- Pile up cosmic ray data on assumed timing PDF * l.p.e. waveform at PMT.

Timing PDF

$$f = A \exp \left[- \left(\frac{t - \mu}{a(t - \mu) + \sigma} \right)^2 \right] + C$$

Fitting waveform at minimum chi2 →

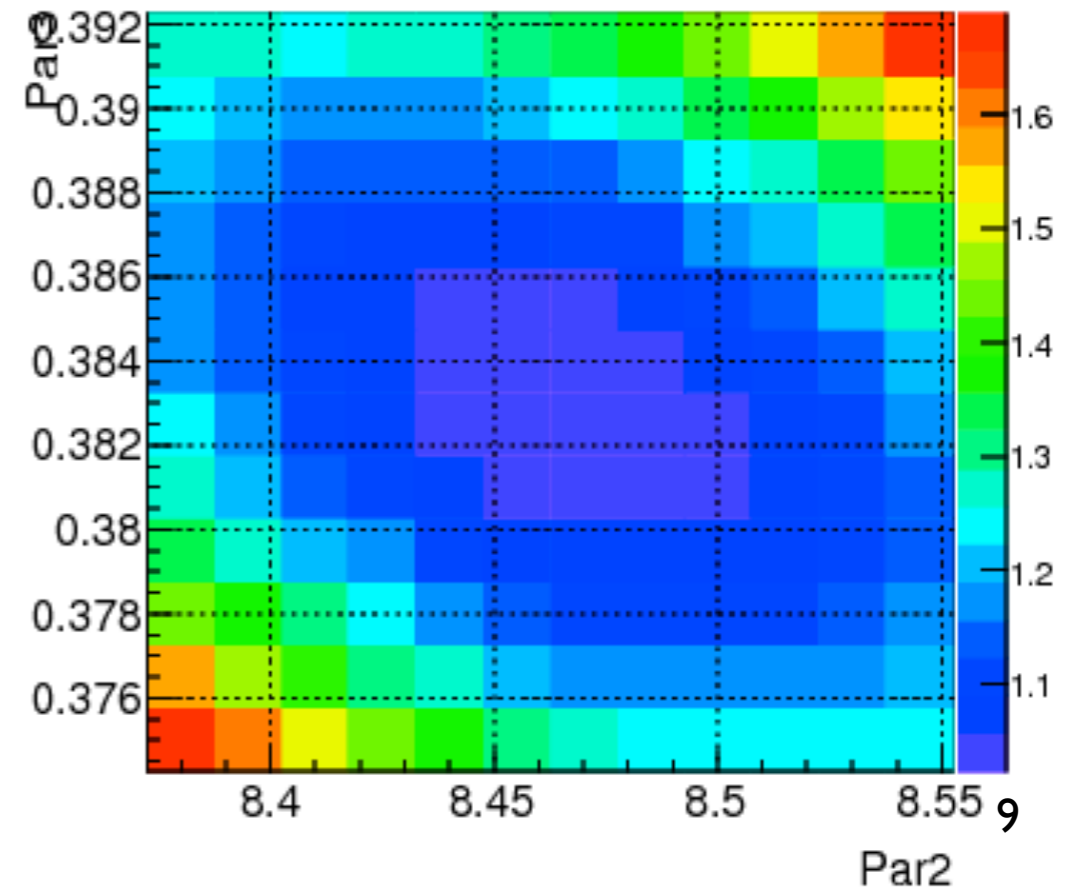


- Search minimum chi2.

$$\frac{\chi^2}{NDF} = \frac{1}{N-2} \sum_i^N \frac{\left(H_i^{cos} - H_i^{pdf} \right)^2}{\alpha_{min} \sigma_i \left(H_i^{cos} \right)^2 + \sigma_i^{pe} \left(H_i^{pdf} \right)^2}$$

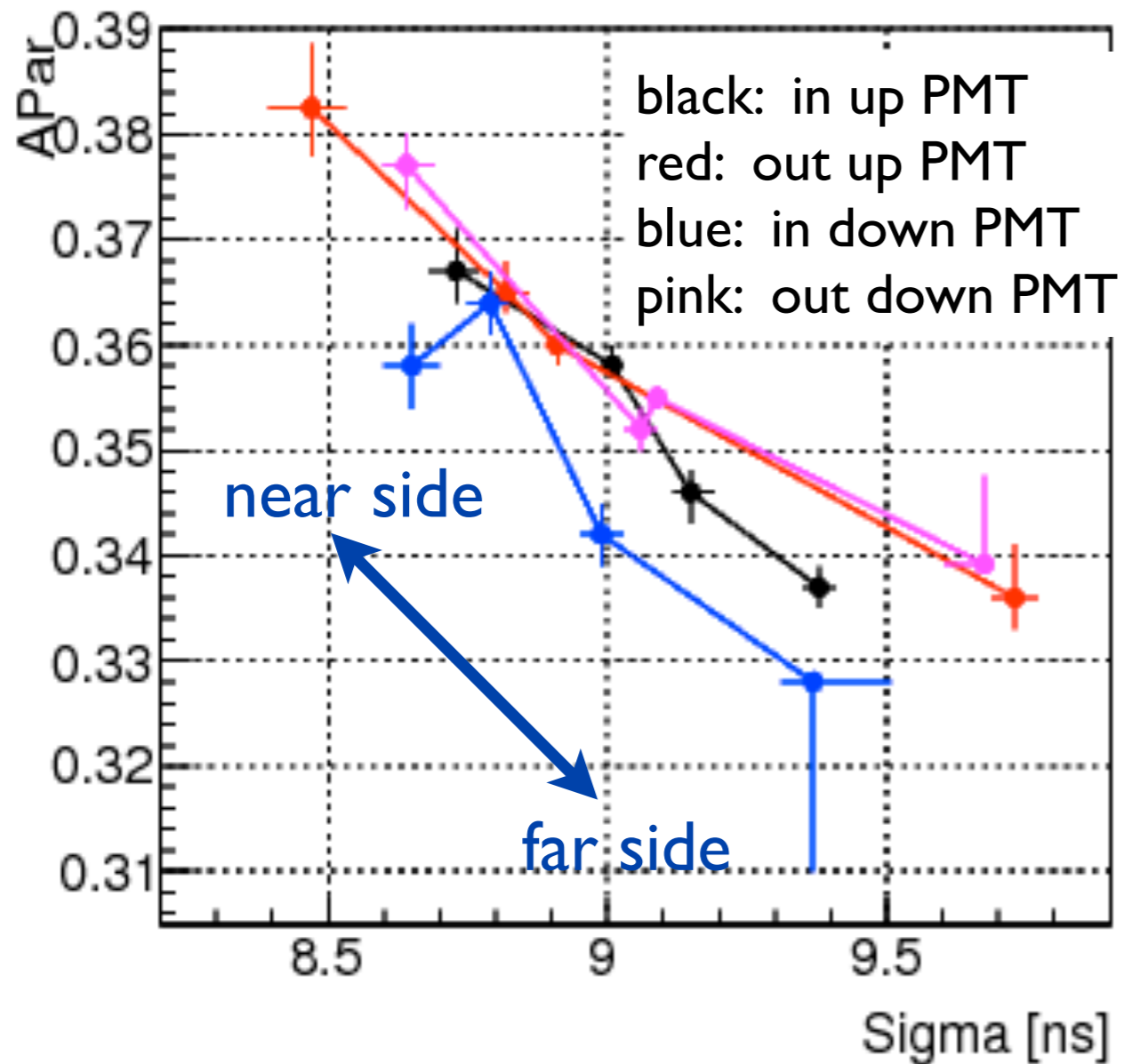
$$\alpha \sim \frac{1}{N-2} \sum_i^N \frac{\left(H_i^{cos} - H_i^{pdf} \right)^2}{\sigma_i \left(H_i^{cos} \right)^2 + \sigma_i^{pe} \left(H_i^{pdf} \right)^2}$$

Chi2 value at each σ and a →

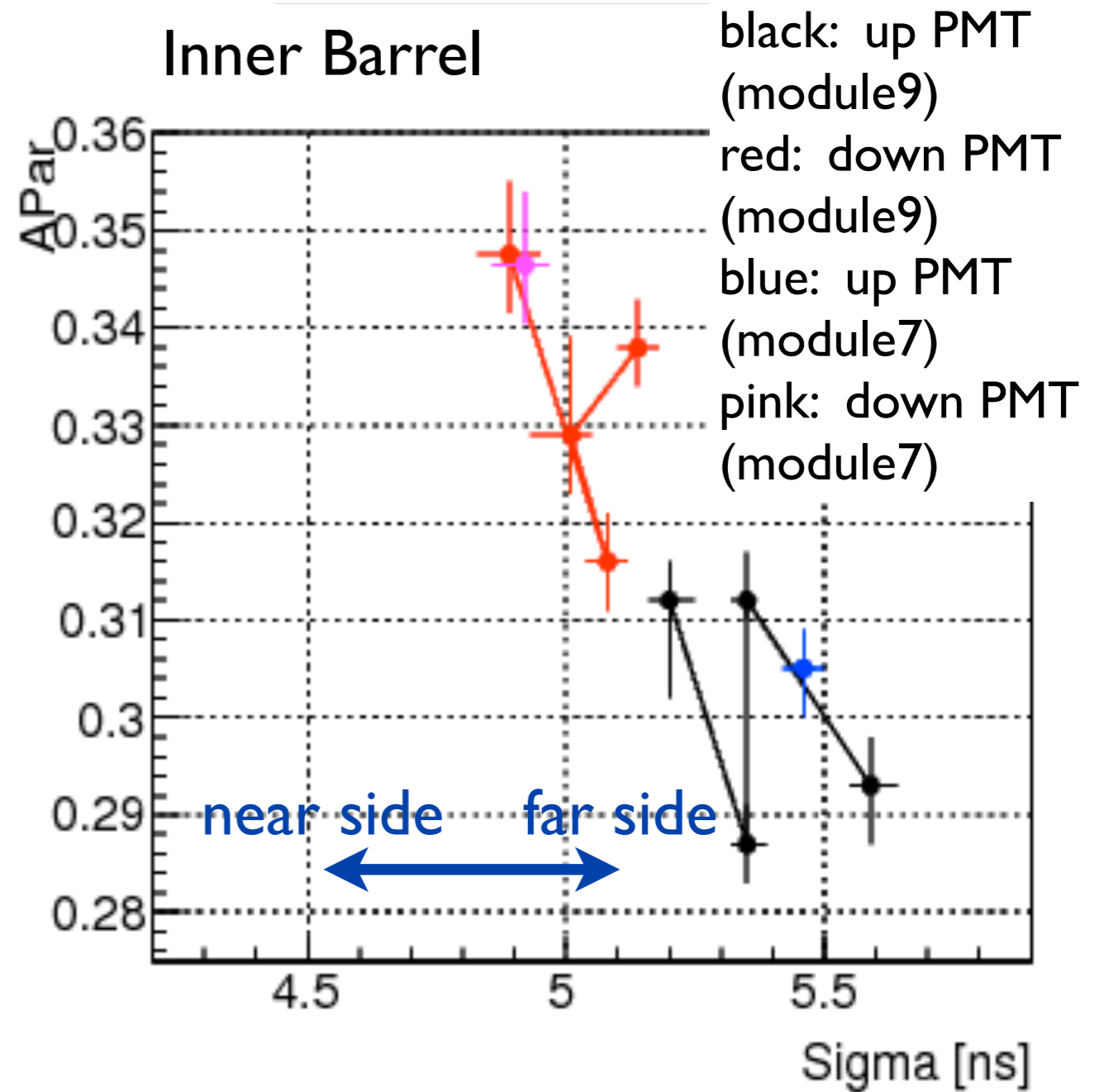


Parameters of timing PDF

Main Barrel

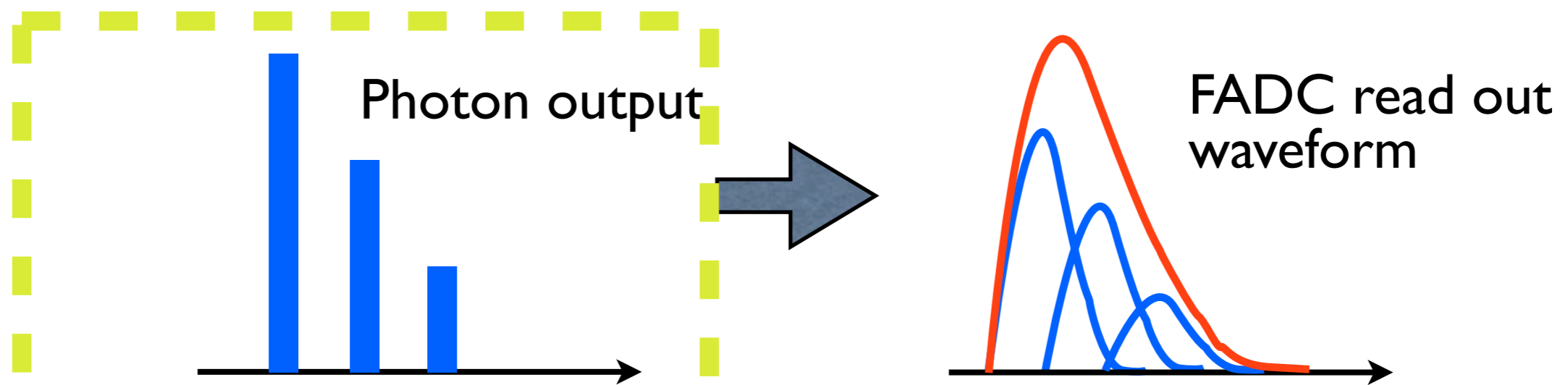



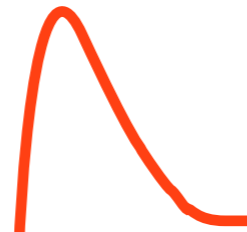

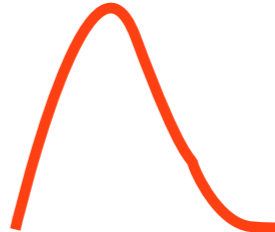




Inner Barrel



- Error bar is set reduced $\chi^2 < 1.1$.

Waveform of Barrel detectors



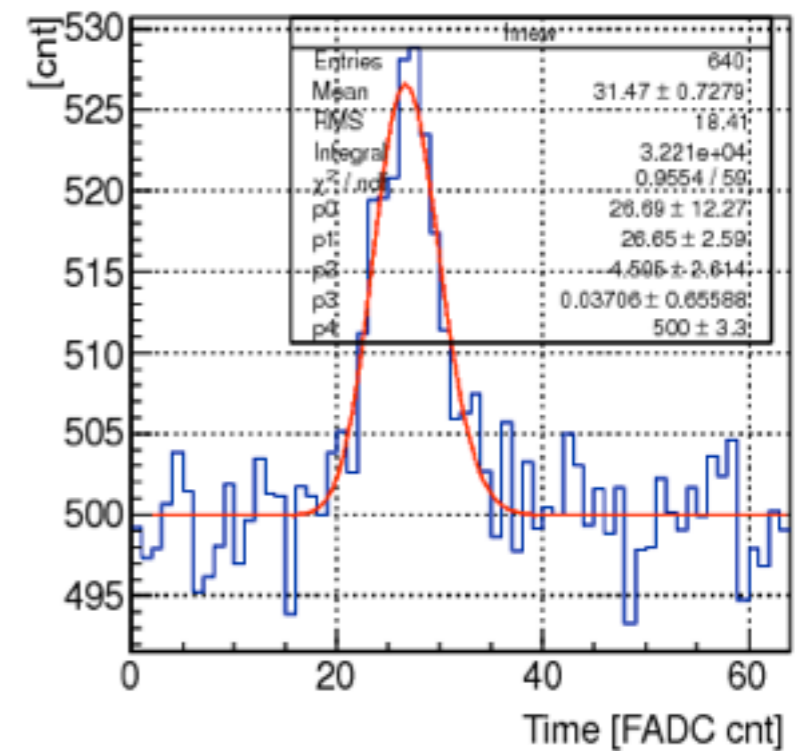
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Timing resolution definition

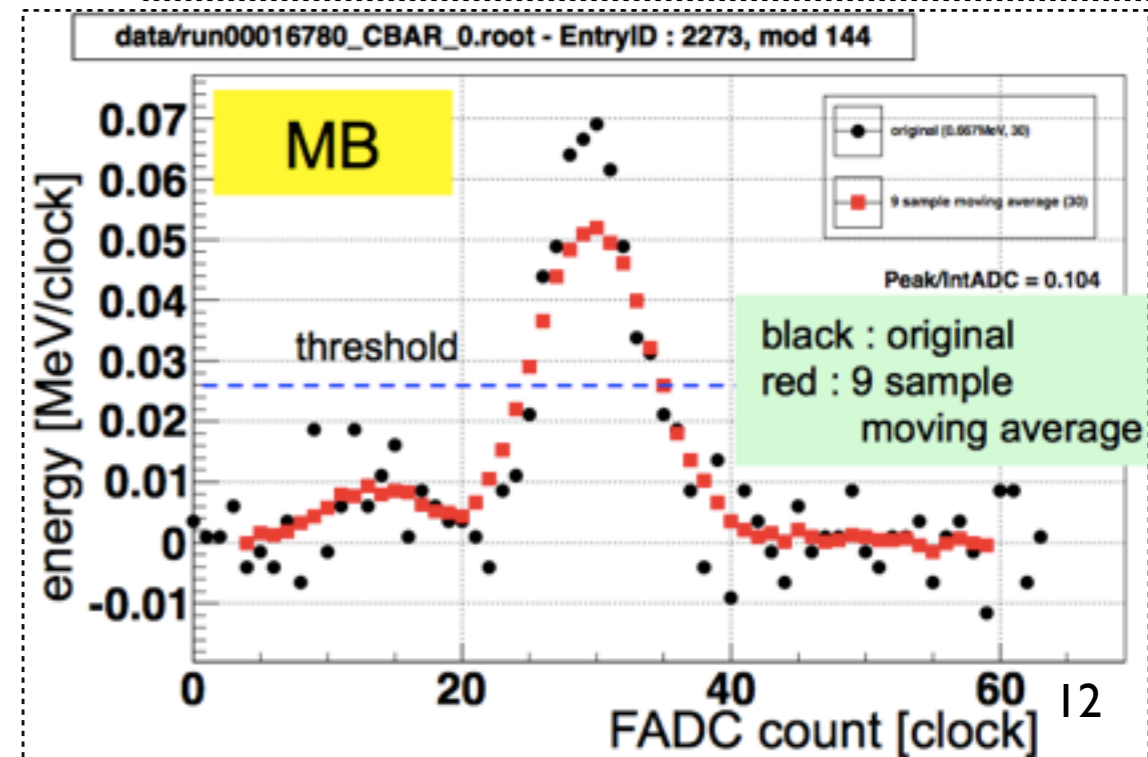
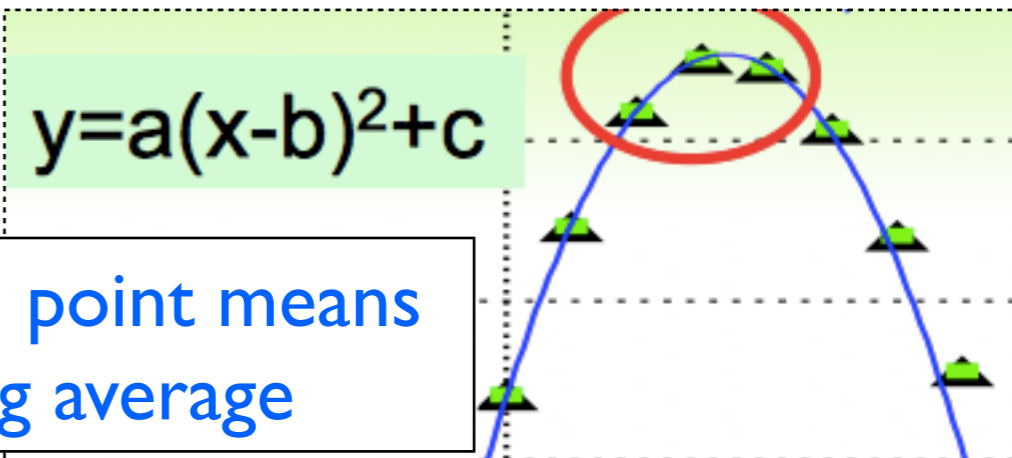
- Method 1) Peak of asymmetric gaus fitting →

Fit function

$$f = A \exp \left[- \left(\frac{t - \mu}{a(t - \mu) + \sigma} \right)^2 \right] + C$$

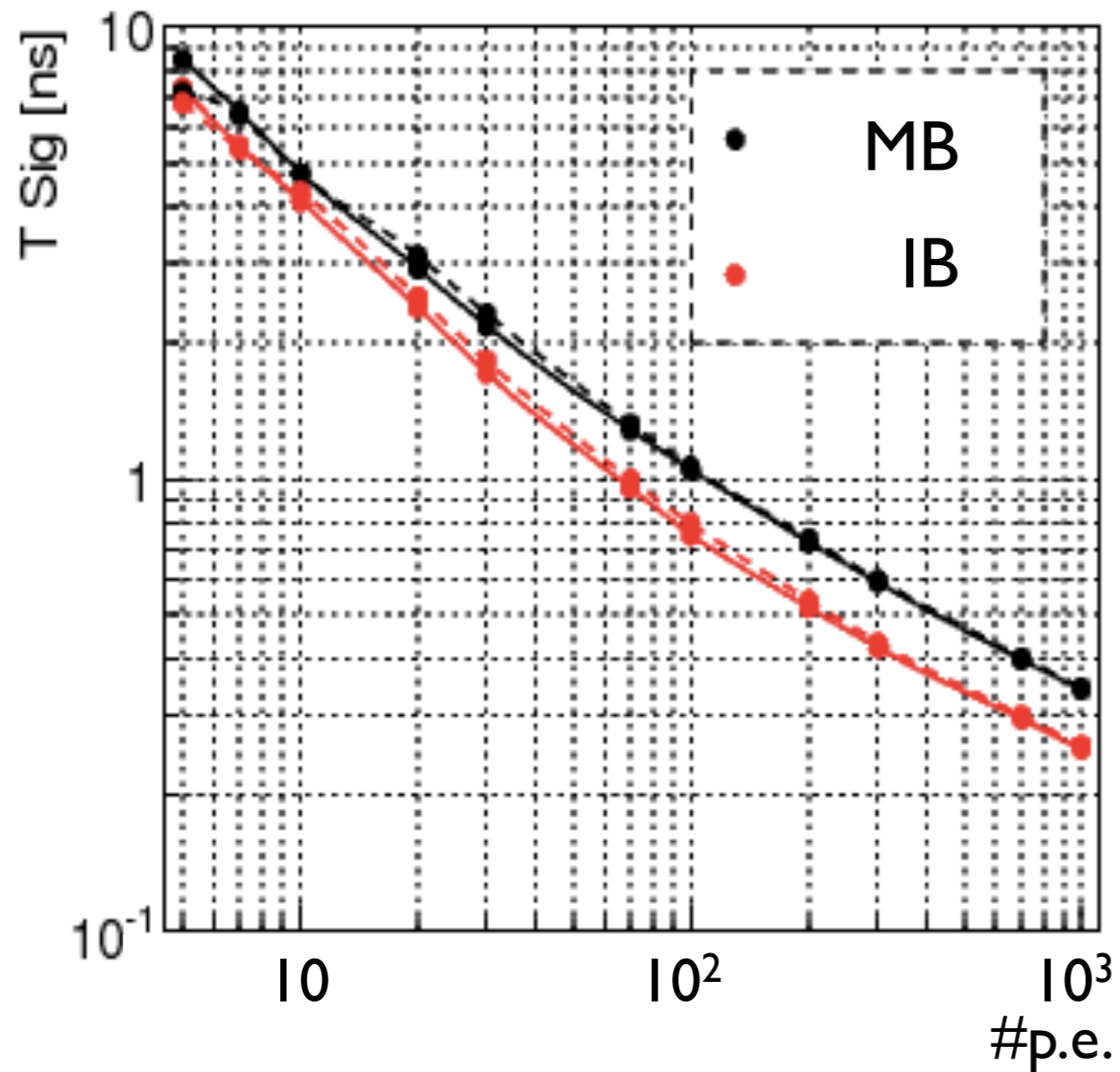


- Method 2) Parabola fitting
 - Parabola peak of moving average.
 - Nearest peak to “Nominal time”.
 - Bias to suppress background enough and avoid event masking.

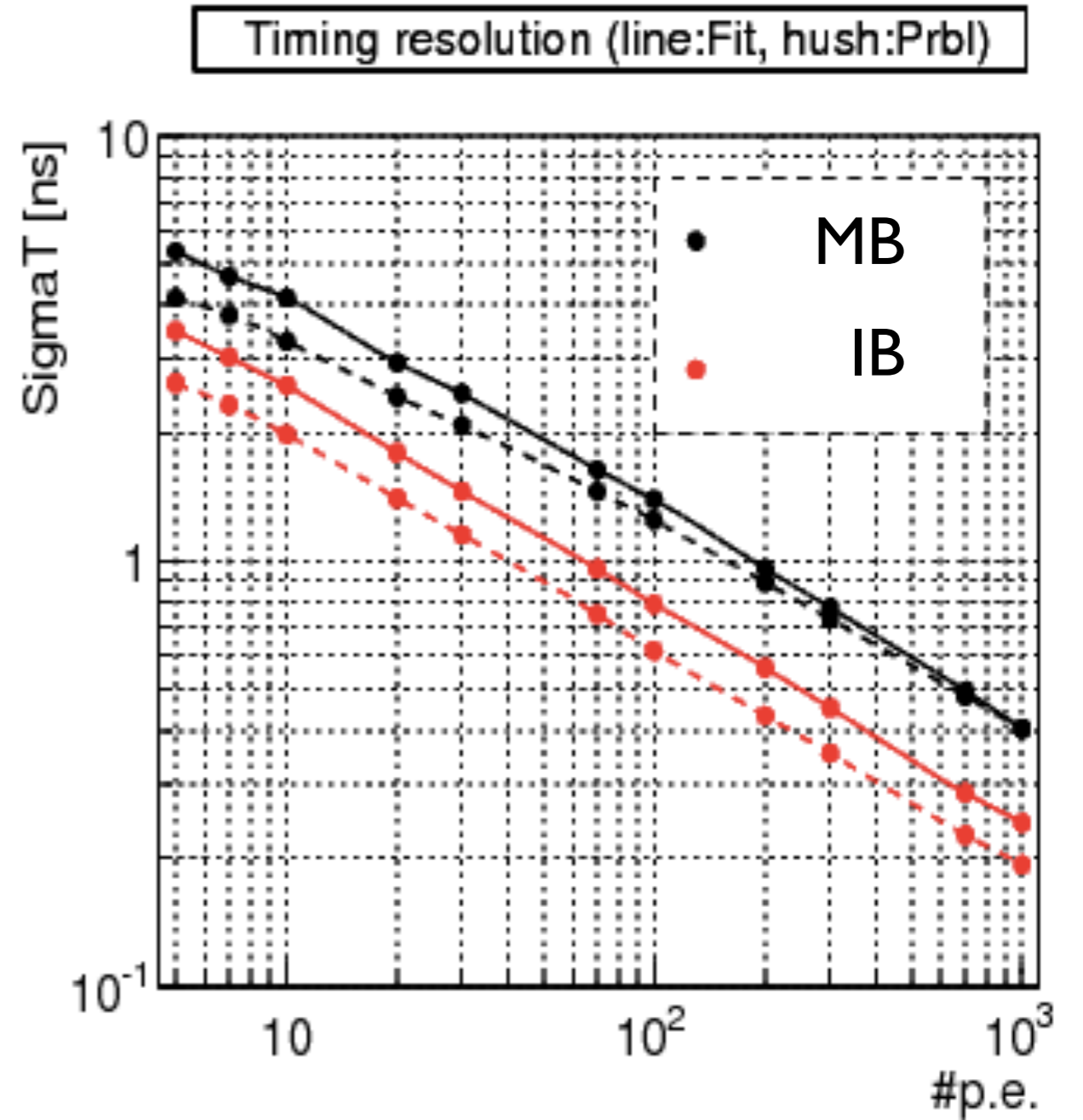


Timing resolution

125 MHz FADC



500 MHz FADC



Summary

- Timing resolution for 125 MHz FADC and 500 MHz FADC is estimated.
- Things to do...
- Check parabola method about peak selection bias.
- Check wfm dependence of timing resolution of 500 MHz FADC.
- Estimate the effect on veto timing condition.