TOP reconstruction software: status and plans

Marko Starič


Jožef Stefan Institute
Ljubljana

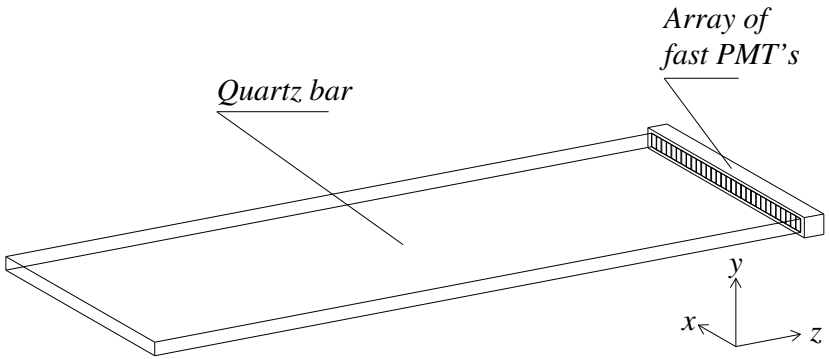
Belle II Computing Workshop

Outline

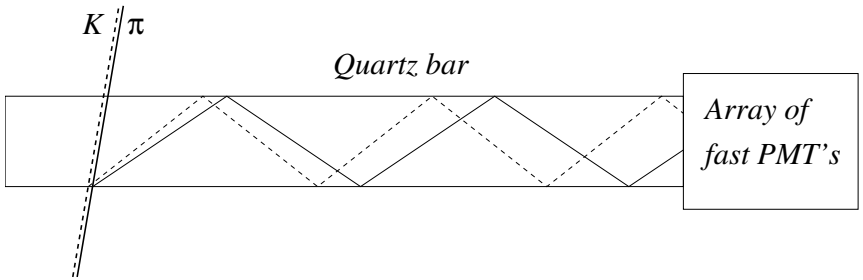
- TOP counter principles
- Short about reconstruction
- TOPsimrec: existing stand-alone reconstruction code
- Plans

Time-of-propagation (TOP) counter

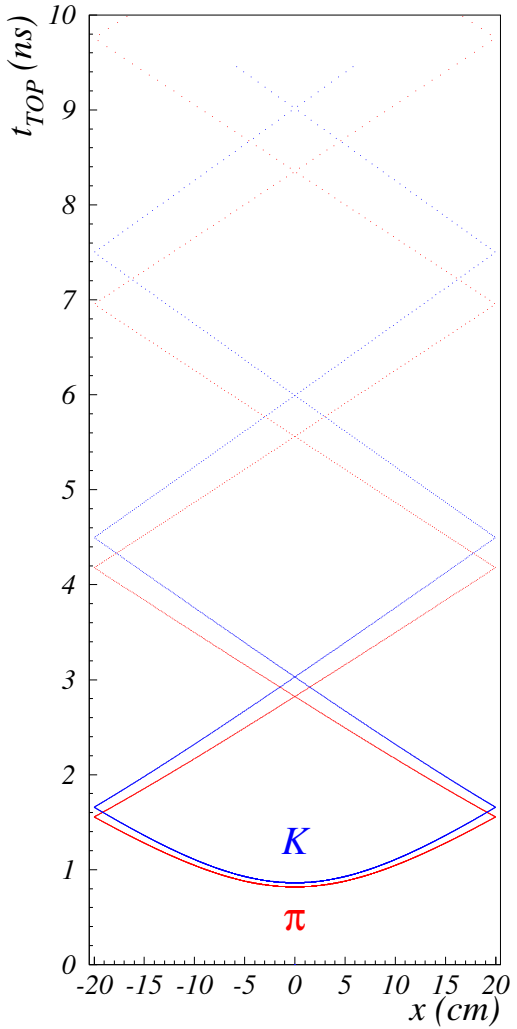
- schematic view of a module



- principle of operation

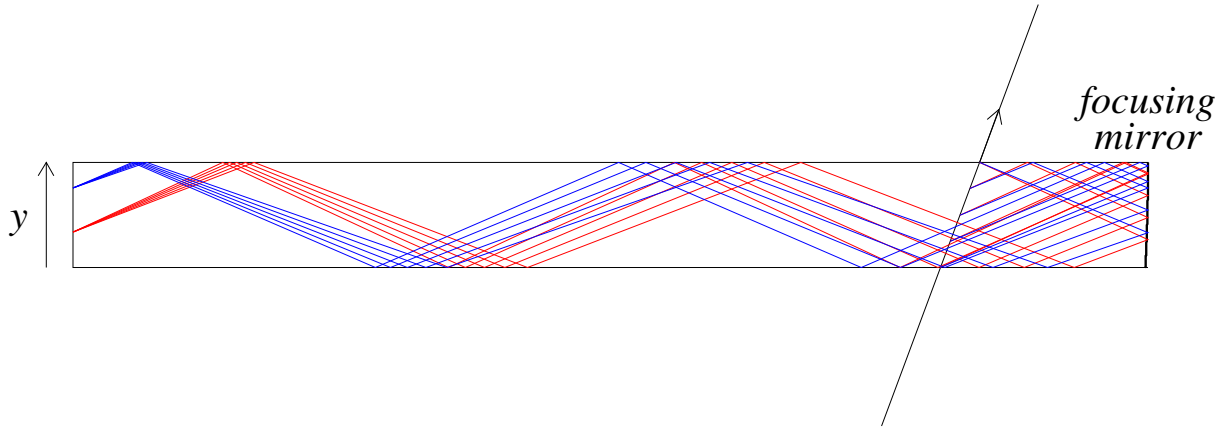


- example of ring images

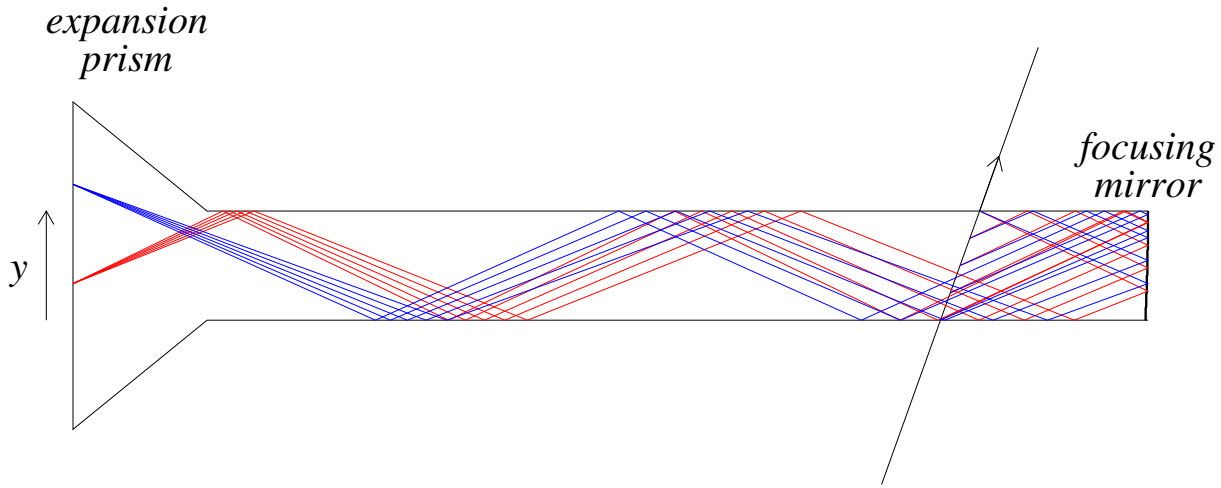


f-TOP and i-TOP

- focusing TOP $\longrightarrow$ chromatic error correction



- focusing TOP with expansion prism = imaging TOP



Extended Likelihood probability

For a given mass hypothesis $h = e, \mu, \pi, K, p$:

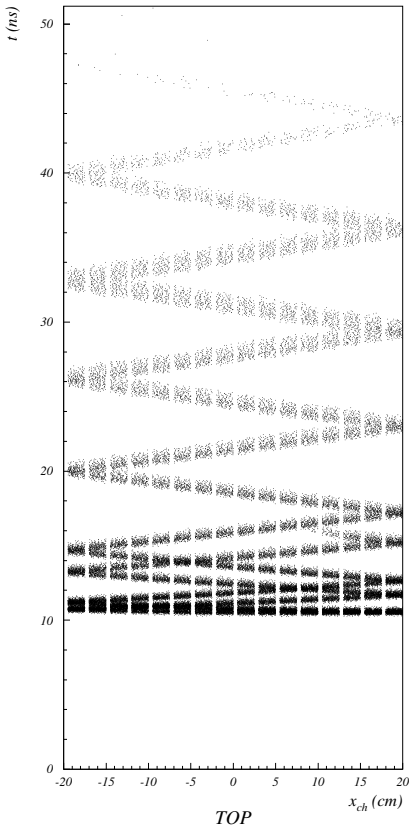
$$\log \mathcal{L}_h = \sum_{i=1}^{N} \log\left(\frac{S_h(x_i, t_i) + B(x_i, t_i)}{N_e}\right) + \log P_N(N_e)$$

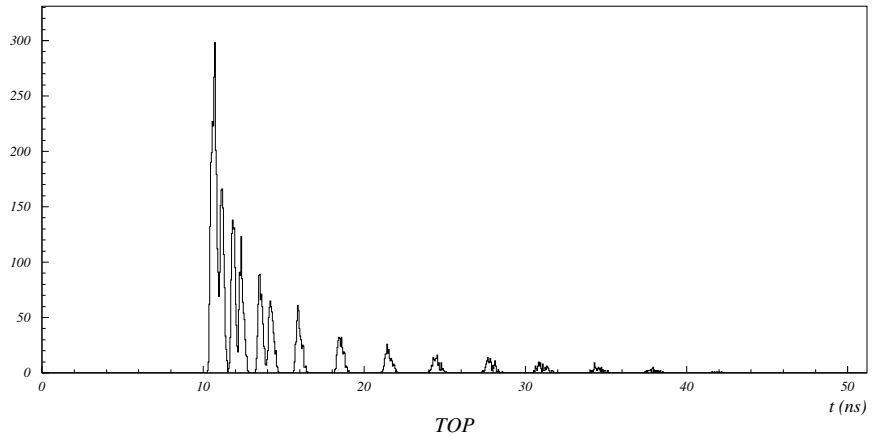
- N ... number of detected photons
- $N_e = N_h + N_B$ ... expected number of photons
- $S_h(x, t)$ ... signal distribution for mass hypothesis h
- $B(x, t)$ ... distribution of background photons
- $P_N(N_e)$ ... Poisson probability of mean N_e to obtain N photons

Distributions normalized as:

$$\sum_{j=1}^{n_{ch}} \int_0^{t_m} S(x_j, t)dt = N_h, \qquad \sum_{j=1}^{n_{ch}} \int_0^{t_m} B(x_j, t)dt = N_B$$

Parametrization of signal distribution





$$S_h(x_j, t) = \sum_{k=1}^{m_j} n_{kj} g(t - t_{kj}; \sigma_{kj})$$

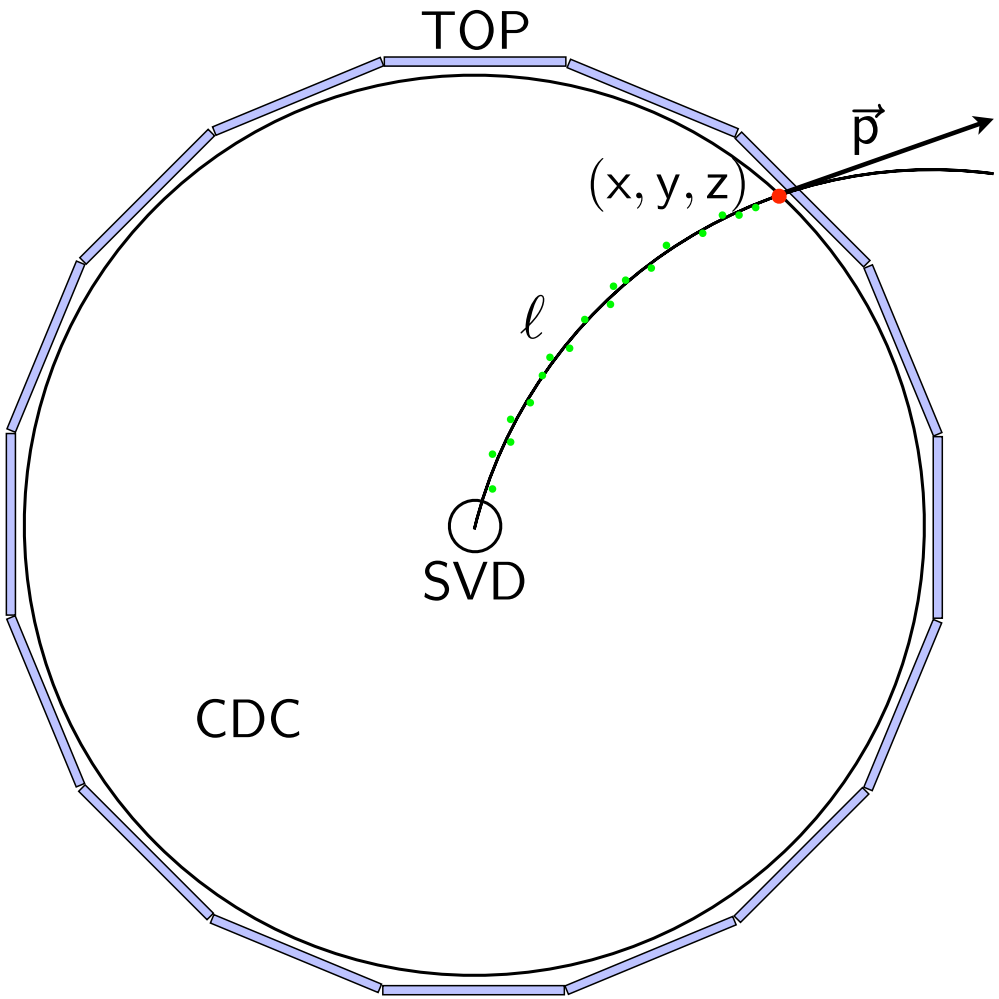
- n_{kj} ... number of photons in the k-th peak
- t_{kj} ... position of the k-th peak
- σ_{kj} ... width of the k-th peak
- $g(t - t_{kj}; \sigma_{kj})$ ... normalized Gaussian

Signal distribution: analytical construction

NIM A 595 (2008) 252-255

- Find analytical expressions for n_{kj}, t_{kj} and σ_{kj}
- Input:
  - track impact position (x_0, z_0) and impact angles (θ, ϕ)
  - Cerenkov angle θ_c for given mass hypothesis
  - photon detection coordinate x_j
- Solve for unknown $\phi_c \Rightarrow$ photon direction vector fully determined
- Geometric view: intersection of Cerenkov cone with a plane
  - well known, quadratic equations
- Total reflections: act as folding the detector plane at bar boundaries
- Method now successfully extended to f-TOP and i-TOP
  - iterations needed to solve for ϕ_c
  - then t_{kj}, σ_{kj}, n_{kj} obtained by raytracing

What we need from tracking



Track parameters as close to TOP as possible:

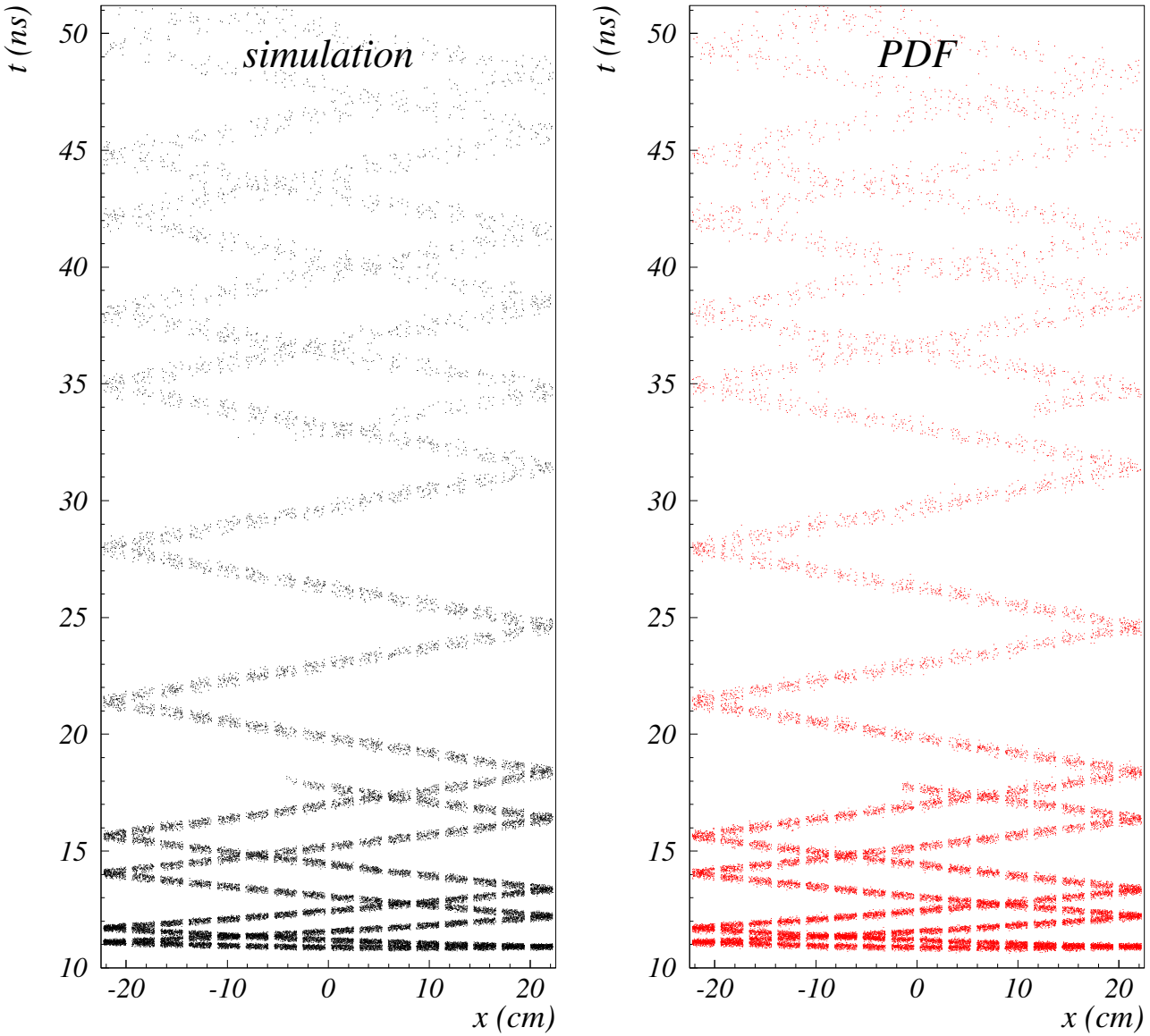
- point (x, y, z)
- momentum $\vec{p}$
- track length ℓ

TOPsimrec

- Stand-alone code exists since last year
  - Based on F77 code
  - C++ user interface provided
- Can be downloaded from http://www-f9.ijs.si/ staric/TOP/
- Possible to use it for virtually any TOP configuration
- Includes also non-Geant simulation
- Already used for many design/performance studies
- CPU and memory consumption (tested on B computers):

configuration	CPU/track/hypothesis	max MEM
1-bar option	18 ms	15 MB
2-bar option	3.3 ms	10 MB

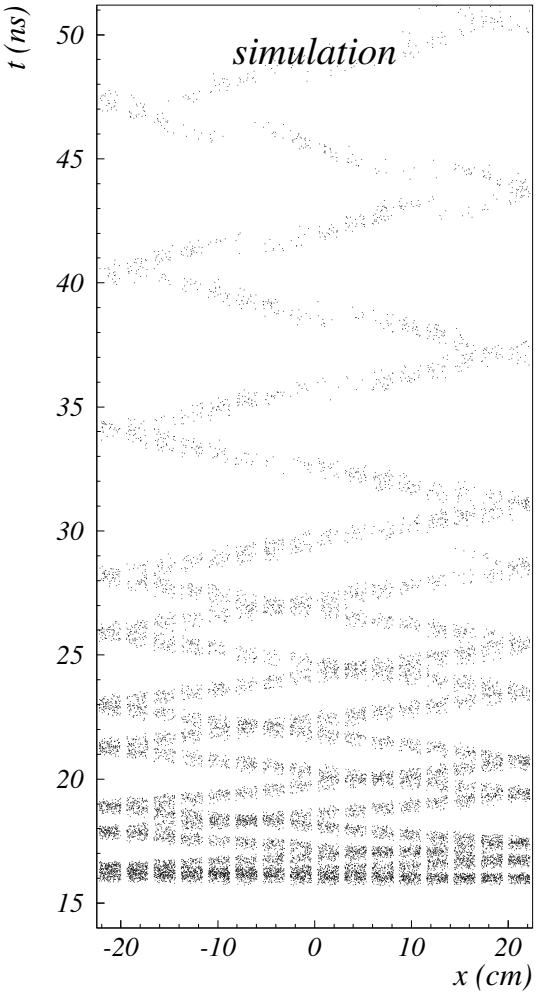
Comparison: simulated vs. analytic $S_h(x, t)$

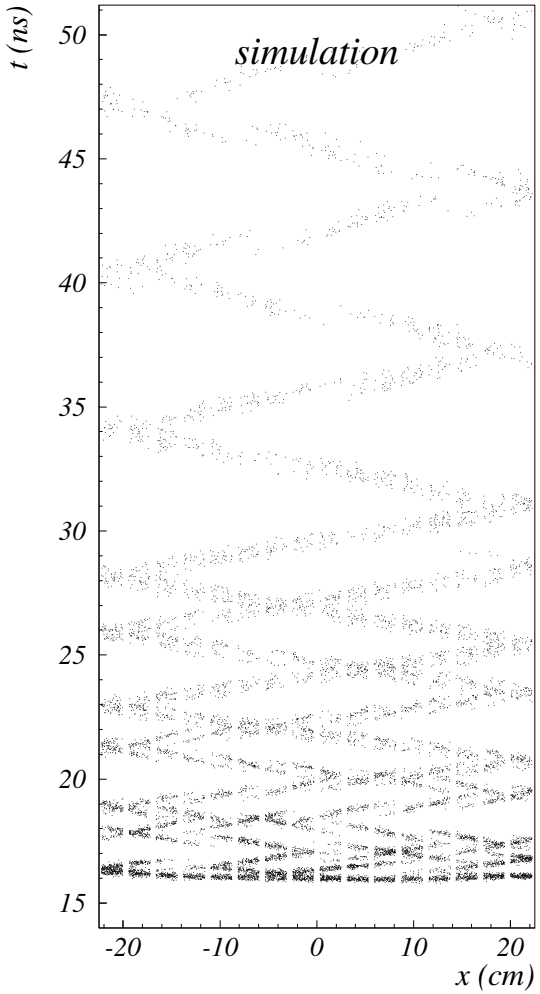


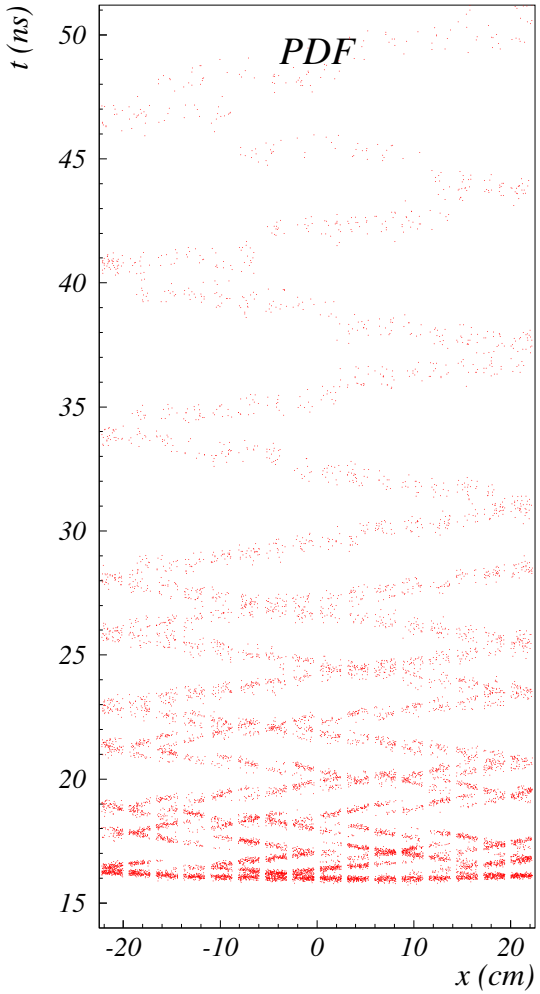
f-TOP with cylindrical mirror

all channels

one row of channels (out of 4)

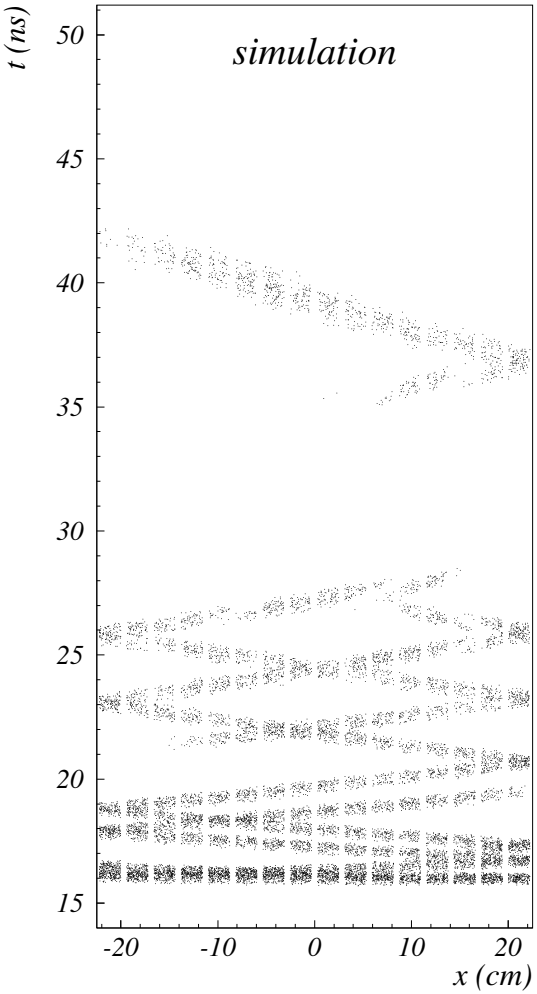




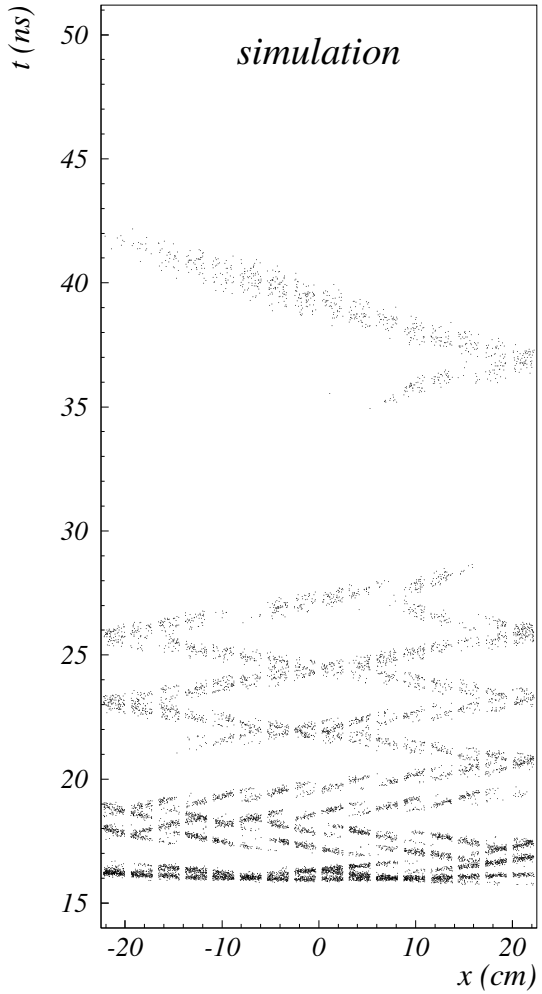


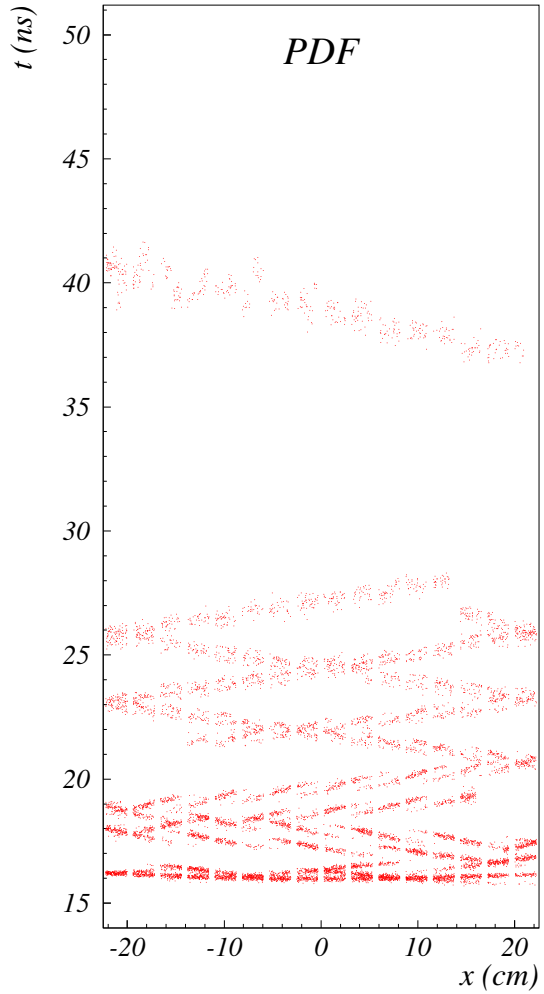
f-TOP with spherical mirror

all channels



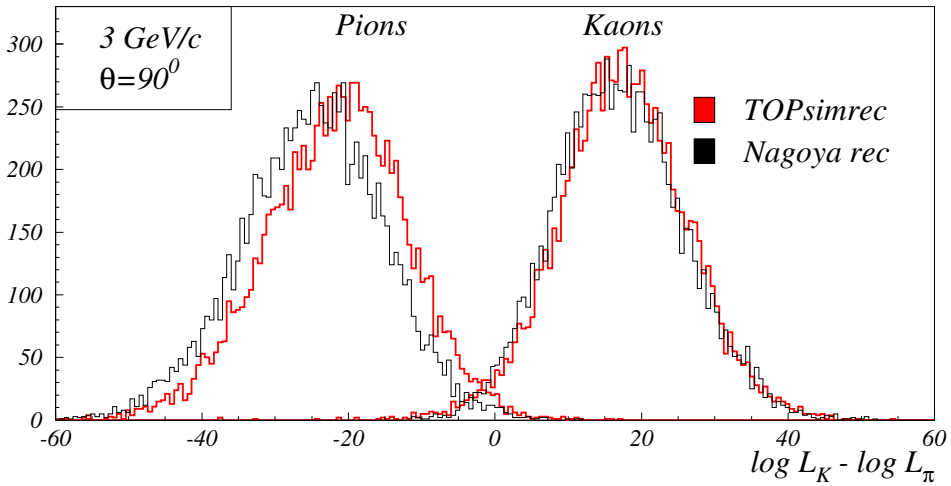
one row of channels (out of 4)

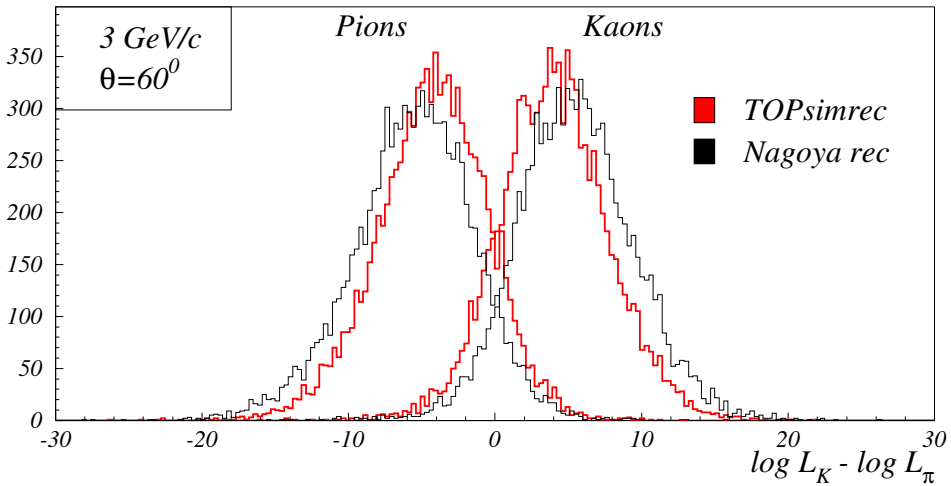




Reconstruction of Geant3 simulation

- analytical PDF
- PDF constructed with MC simulation (5000000 photons)





Kaon selection:

$$\log \mathcal{L}_{\mathcal{K}} > \log \mathcal{L}_{\pi}$$

efficiency

θ	MC PDF	anal.PDF
90^0	97.9%	97.2%
60^0	92.8%	86.6%

fake

θ	MC PDF	anal.PDF
90^0	0.5%	0.9%
60^0	7.5%	11.9%

Plans

- Reconstruction code is mainly in F77 $\longrightarrow$ rewrite to C++
- Implement into Belle II software
- To be ready: end of this year
- Improvements in PDF $\longrightarrow$ need full Geant 4 simulation