Geometry of forward TOF

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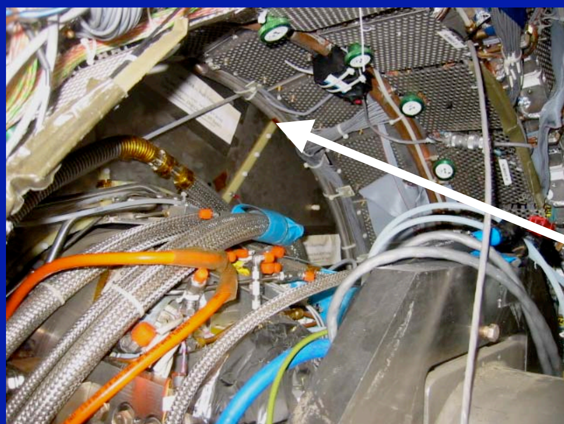
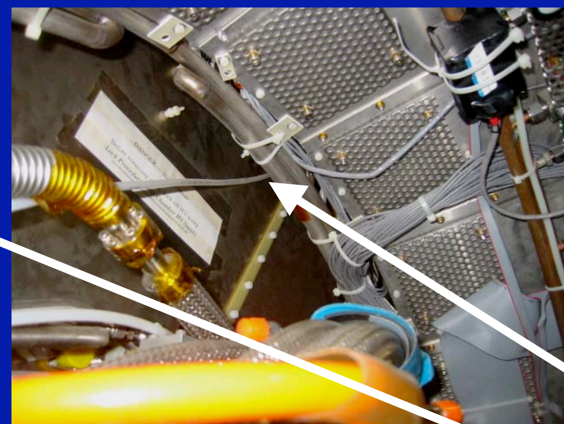
Light travels 300μm in one ps

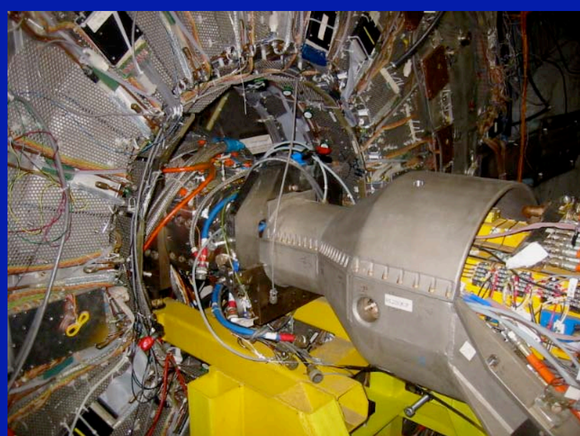
Content of this talk

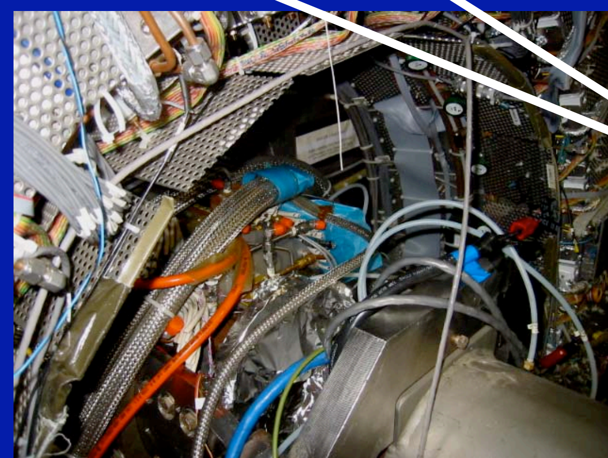
- **Follow upon what I have said in my Orsay talk**
  - **- DIRC-like TOF**
  - **- TOF with cube radiators (run very low gain)**

Changed my mind after inspecting the BaBar forward region a week ago









Space for a TOF detector, or any other one, is VERY tight !!!

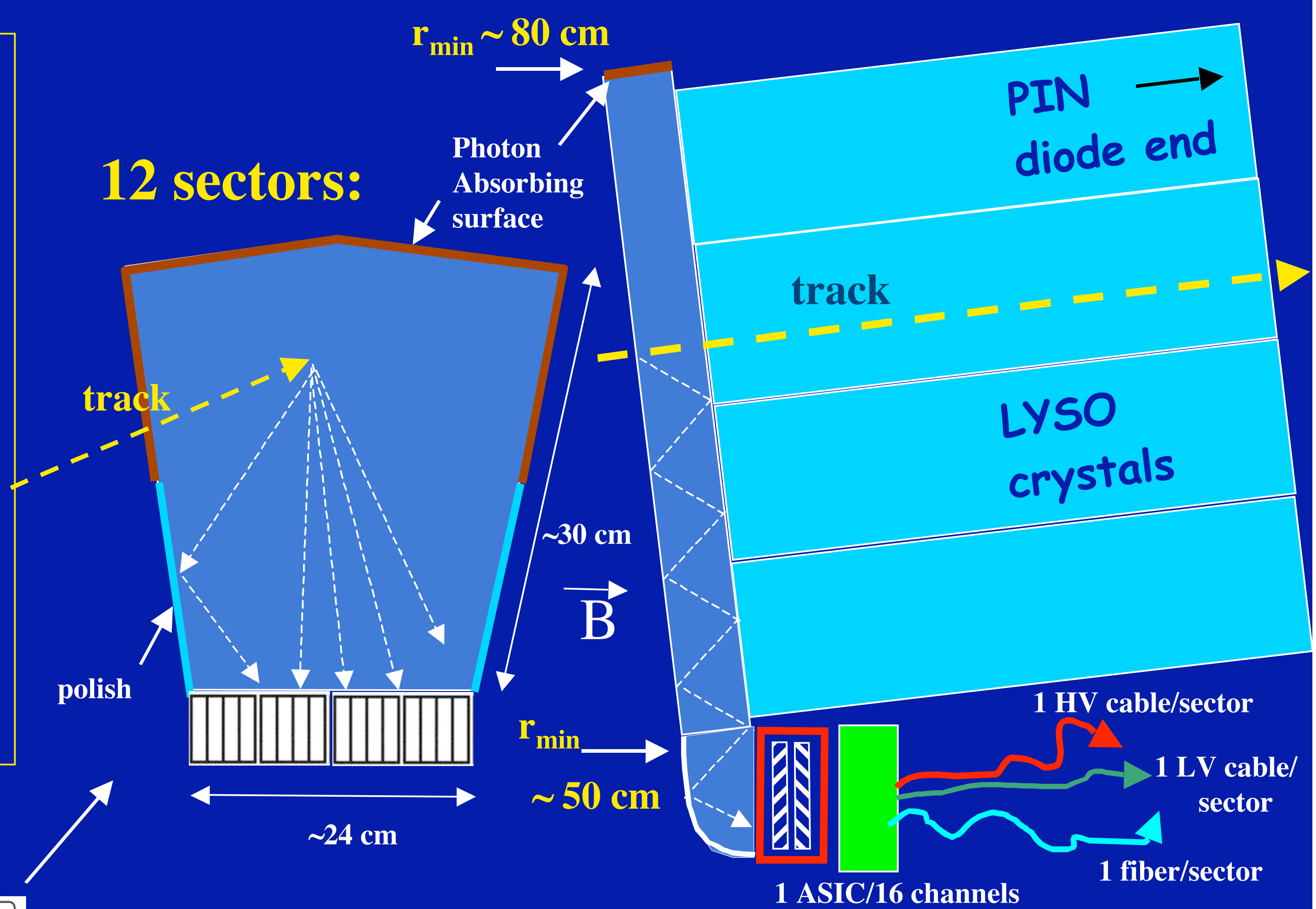
"DIRC-like" Forward TOF detector ?

Sector:

12 mm thick quartz bar
Ave. photon path: ~15 cm
2 MCP tubes /sector
1 ASIC chips / sector
16 pixels / sector
1 fiber/ sector
1 HV cable / sector

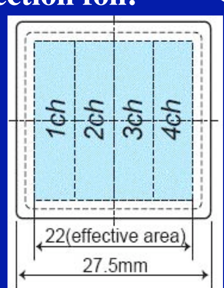
Total:

12 sectors - total
48 MCP-PMTs - total !!!
Req.pos. accuracy: ~0.5 mm
Hang it off EMC support ?
r_{min} ~ 50 cm (θ ~ 15-16^o)
r_{max} ~ 80 cm (θ ~ 25^o)
Δ r ~ 30 cm



Hamamatsu MCP-PMT with strips and a protection foil:

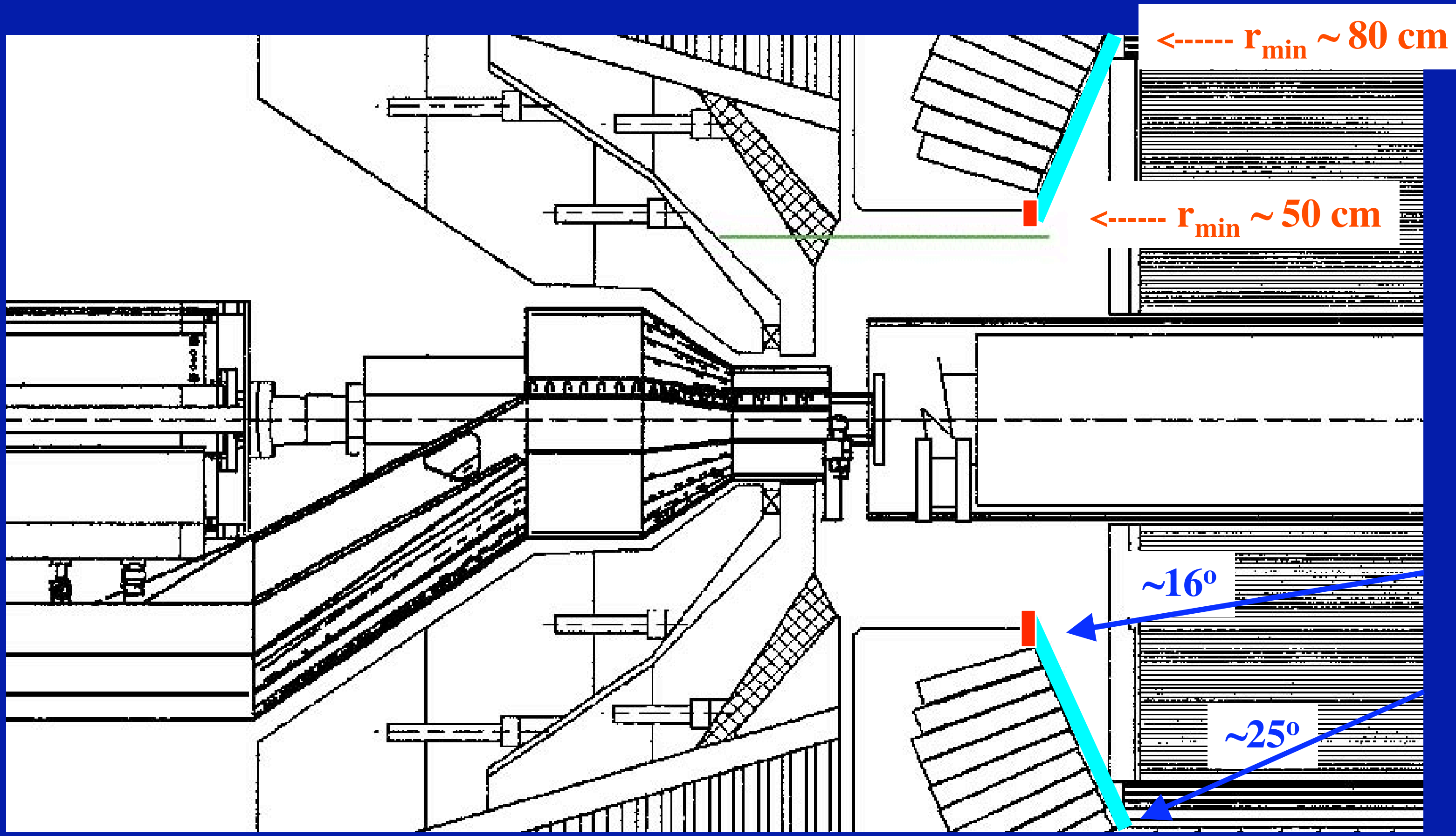
ϕ 10 μm holes



A photon is accepted if:
$\Sigma(TOP_i^{measured} - TOP_i^{expected}) < Cut$

This design requires a high gain operation to detect single photons !!!

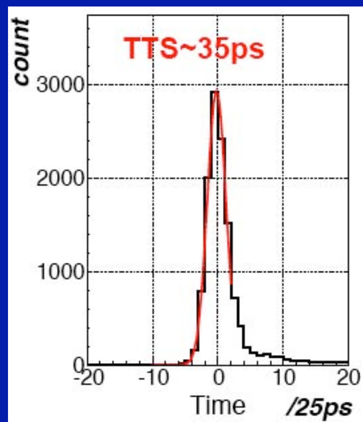
Forward geometry with a DIRC-likeTOF counter

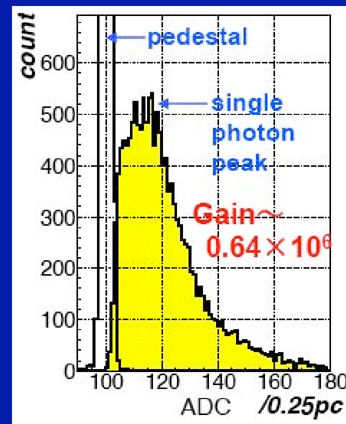


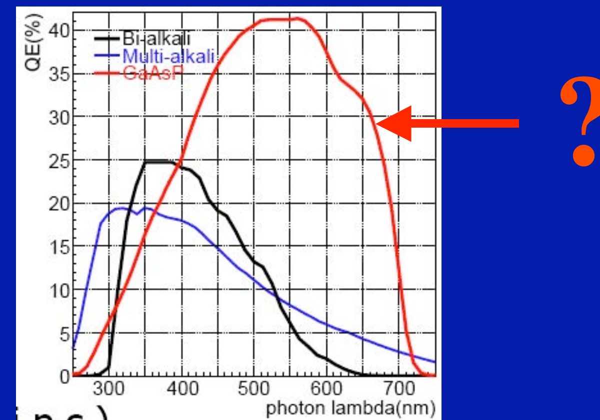
- What is the expected rate fin this location ?

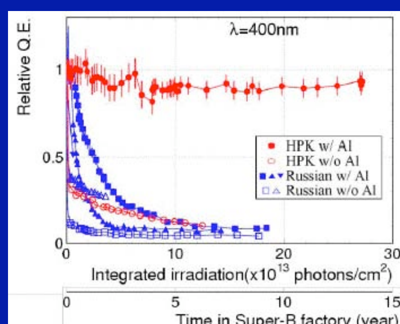
“DIRC-like” Forward TOF detector is using the same photon detector as the TOP counter

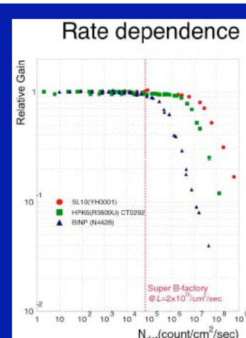
(plots taken from K. Inami’s talk about TOP counter at RICH 2007, Trieste & NIM A595(2008)96-99)

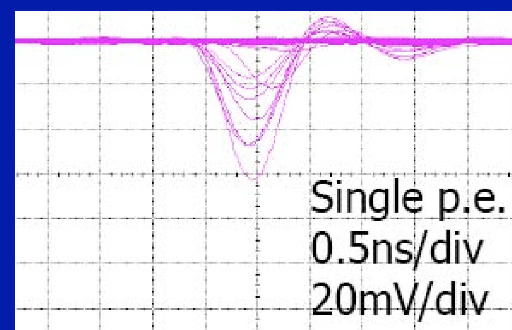












- **Excellent TTS resolution**
- **Maximum rate: ~ 1 MHz/cm² with a 10μm hole MCP**
- **Protective foil does prevent the aging considerably, but Npe loss is a factor of 2**
- **GaAsP photocathode has much higher QE and in the “red” region**
  -> smaller chromatic effects -> better timing resolution

Expected performance

A photon is accepted if: $TOP_i^{measured} - TOP_i^{expected} < Cut$

$\sigma \sim \sigma_{Electronics} \otimes \sigma_{Chromatic} / \sqrt{Npe} \otimes \sigma_{TTS} / \sqrt{Npe} \otimes \sigma_{T0}$

Npe ~ 40-50/cm * 1/2 * 1/3 * 1.2 cm ~ 9

(Bialkali QE) (foil) (acceptance) (radiator thickness)

Assume:

$\sigma_{TTS} \sim 35$ ps , $\sigma_{Electronics} \sim 10$ ps , $\sigma_{Chromatic} \sim 20$ ps , $\sigma_{T0} \sim 15$ ps

=> Expect: $\sigma \sim \sqrt{(10^2 + (20/3)^2 + (35/3)^2 + 15^2)} \sim 20$ ps

Expected rates

SuperB expectation:

Track rate in the forward region: ~ 2 kHz / cm^2 ~ 6.3x10^9/mm^2/10 years

=> Expected pixel rate:

~ 2 kHz /cm^2 x 24 cm x 30 cm x (1/2) x (1/3x50) pe/track x (1/16) ~ 0.75 MHz/pixel

This may be pushing the MCP-PMT rate limit.

=> One may have to use pixilated approach

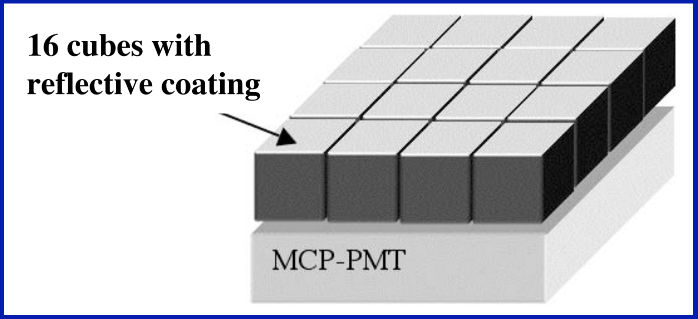
At the end, the only design which might work reliably is a highly pixilated type

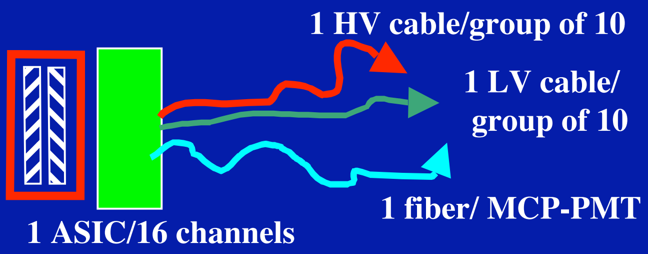
"Pixilated" TOF counter running at low gain

Numbers:

10mm thick qtz radiator
~ 7200 quartz cubes - total
~ 7200 pixels - total
~ 450 MCP-PMTs - total
1 ASIC chips/MCP-PMT
~ 450 ASIC chips - total
16 pixels/MCP-PMT
1 fiber cable/ASIC
~ 450 fiber cables - total
1 HV cable/5 MCPs
~90 HV cables - total
r_{min} ~ 50 cm (θ ~ 15-16^o)
r_{max} ~ 80 cm (θ ~ 25^o)
Δr ~ 30 cm
Total area: ~12,300 cm^2
Req.pos. accuracy: ~0.5 mm
Hang it off EMC support ?
~$3k/MCP-PMT ?
~1.35 M$ - total detectors

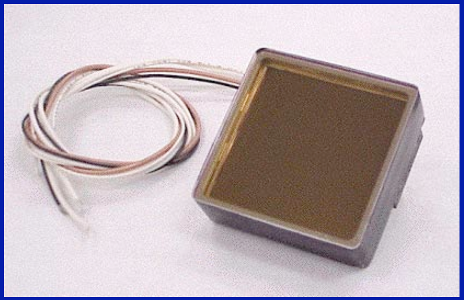
Quartz cubes radiators:





Total cable plant:
- 450 fibers
- 50 HV & LV cables

Photonis MCP-PMT with 64 pixels



Arguments for it:
- very low gain of ~$2x10^4$.
- smaller aging rate ?
- good results in beam
- use all photons
- less complicated analysis

Arguments against it:
- more channels.
- Not sure that we can get cables out