Project-ANR-19-CE31-0009

Long-baseline **tagged** neutrino experiments with Megaton scale water Cerenkov detectors

XIX International Workshop on Neutrino Telescopes

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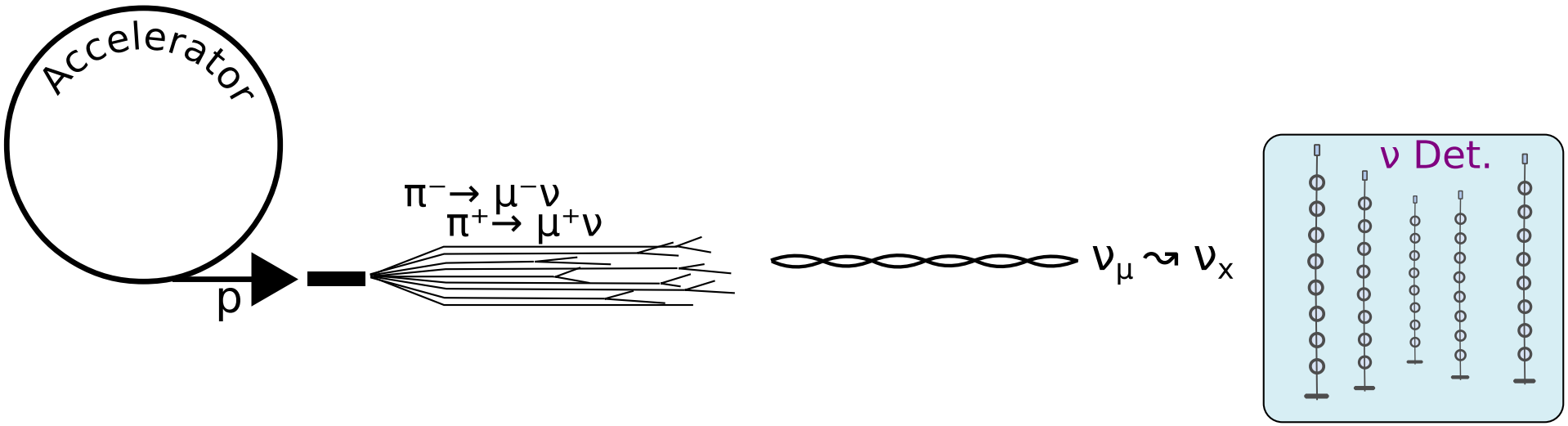
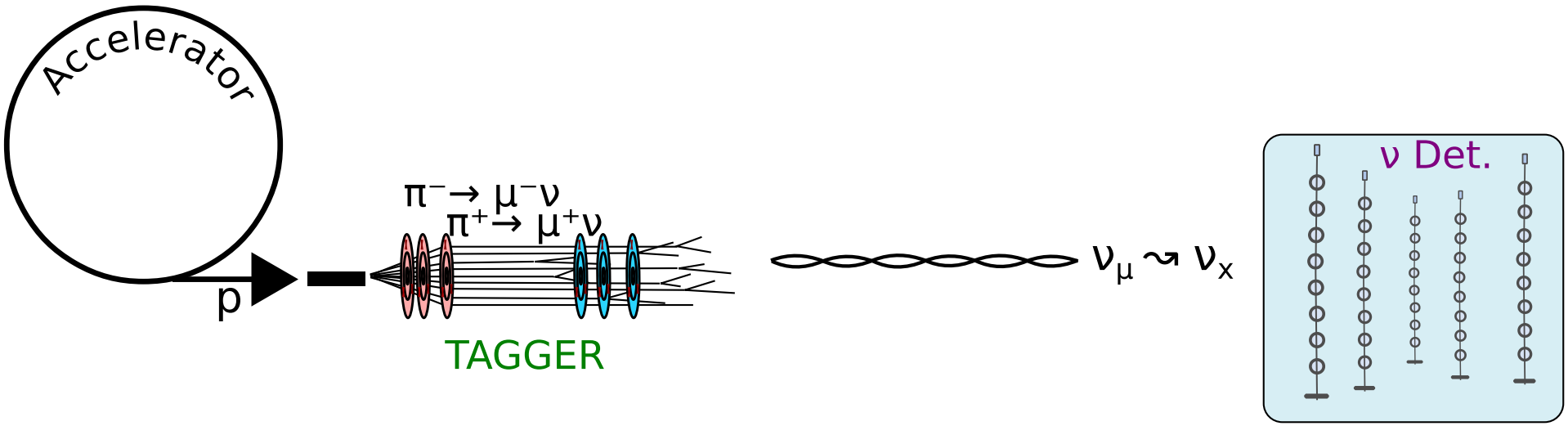
Standard LBNE

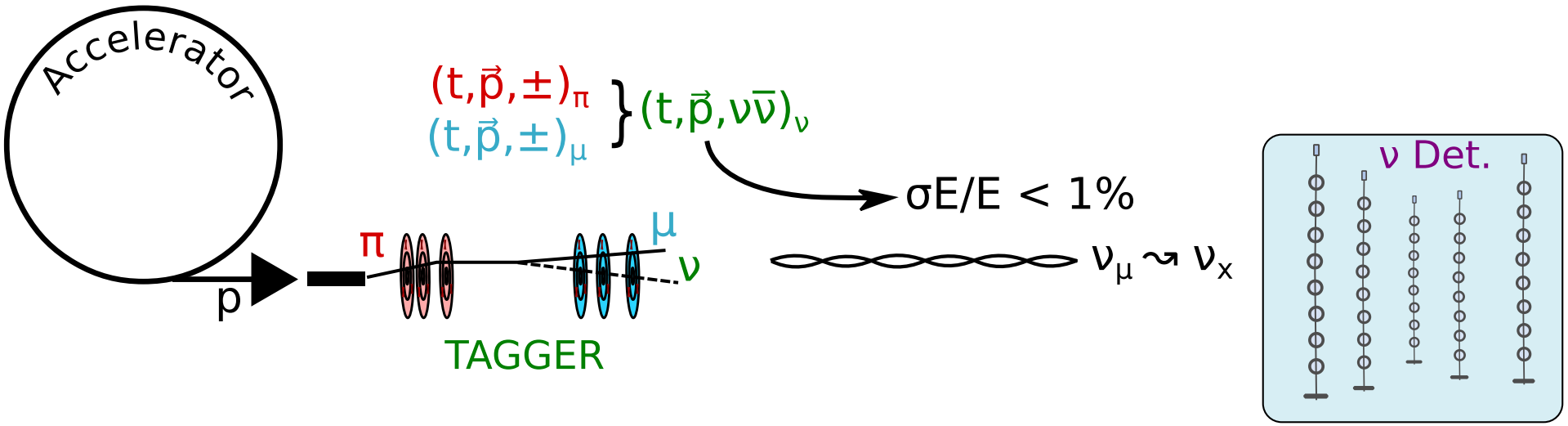


- **MegaTon scale** ν detectors allows to run at **modest beam intensities**
- At these intensity it is possible to **instrument the beam line** with silicon trackers!

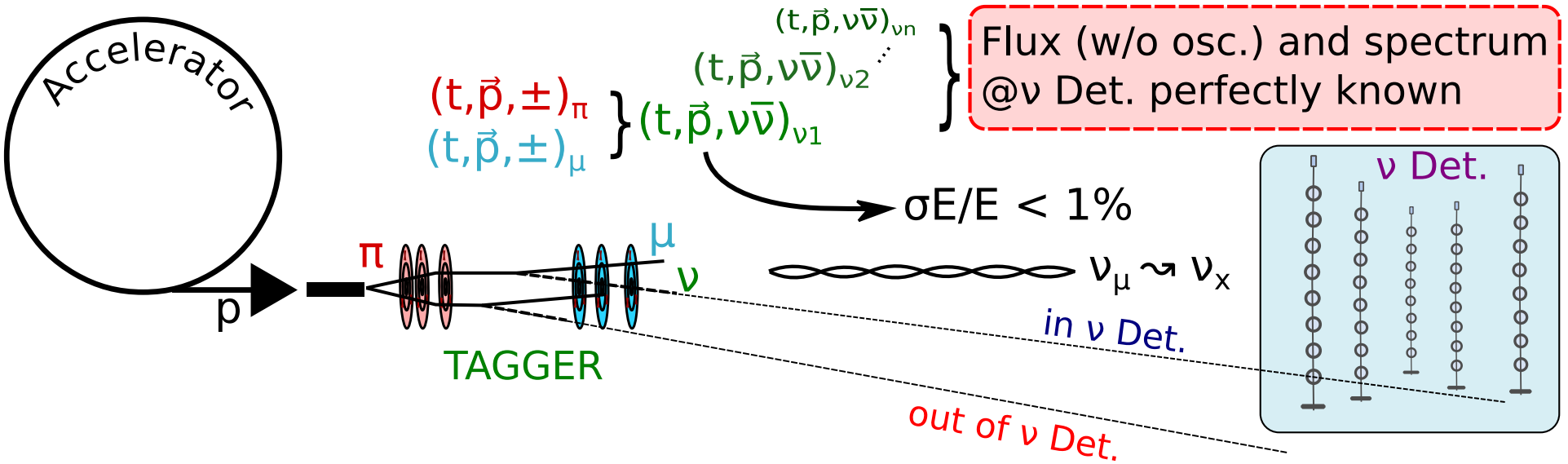
Tagged LBNE – Concept



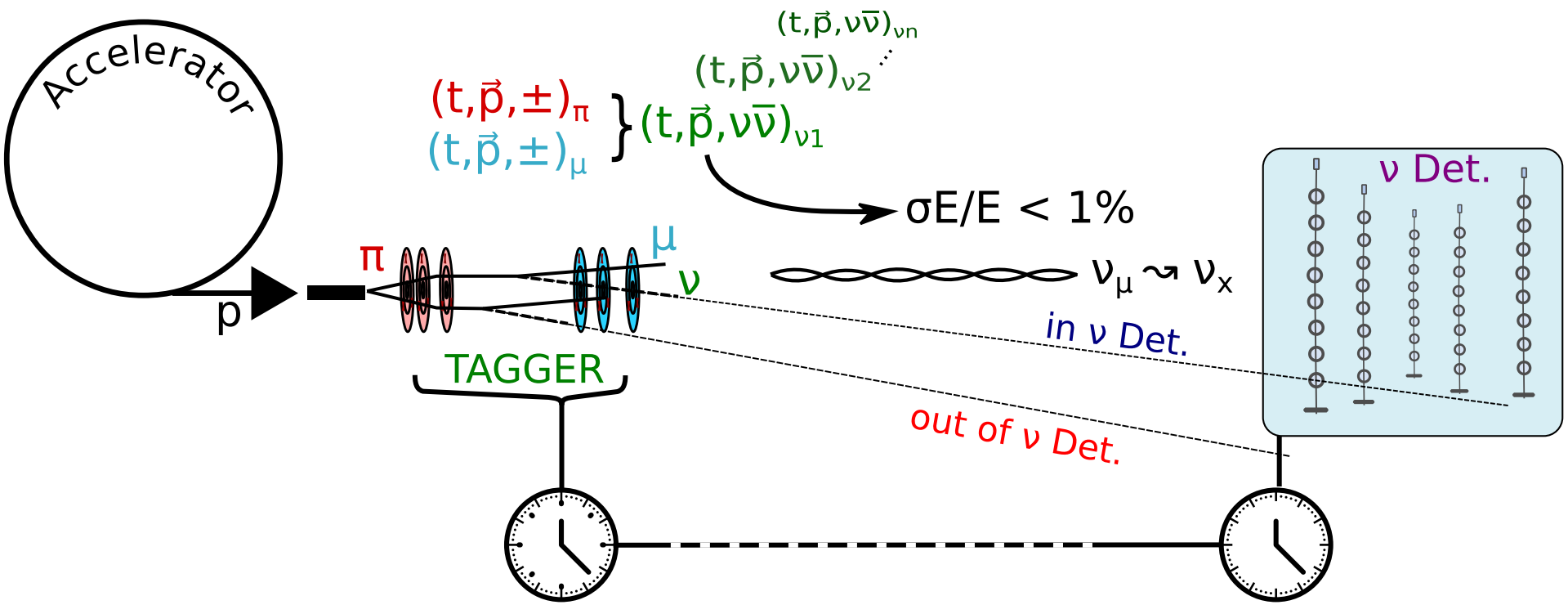
Tagged LBNE – Concept



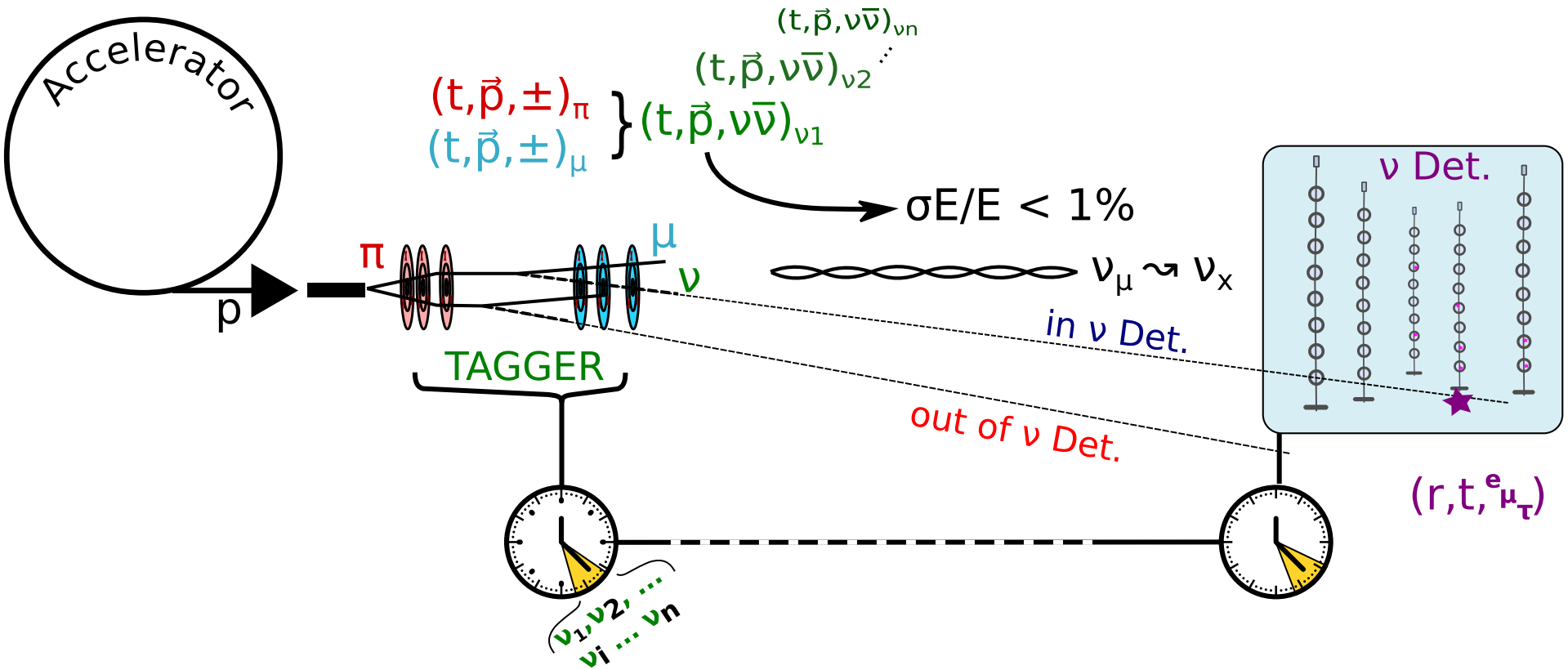
Tagged LBNE – 1



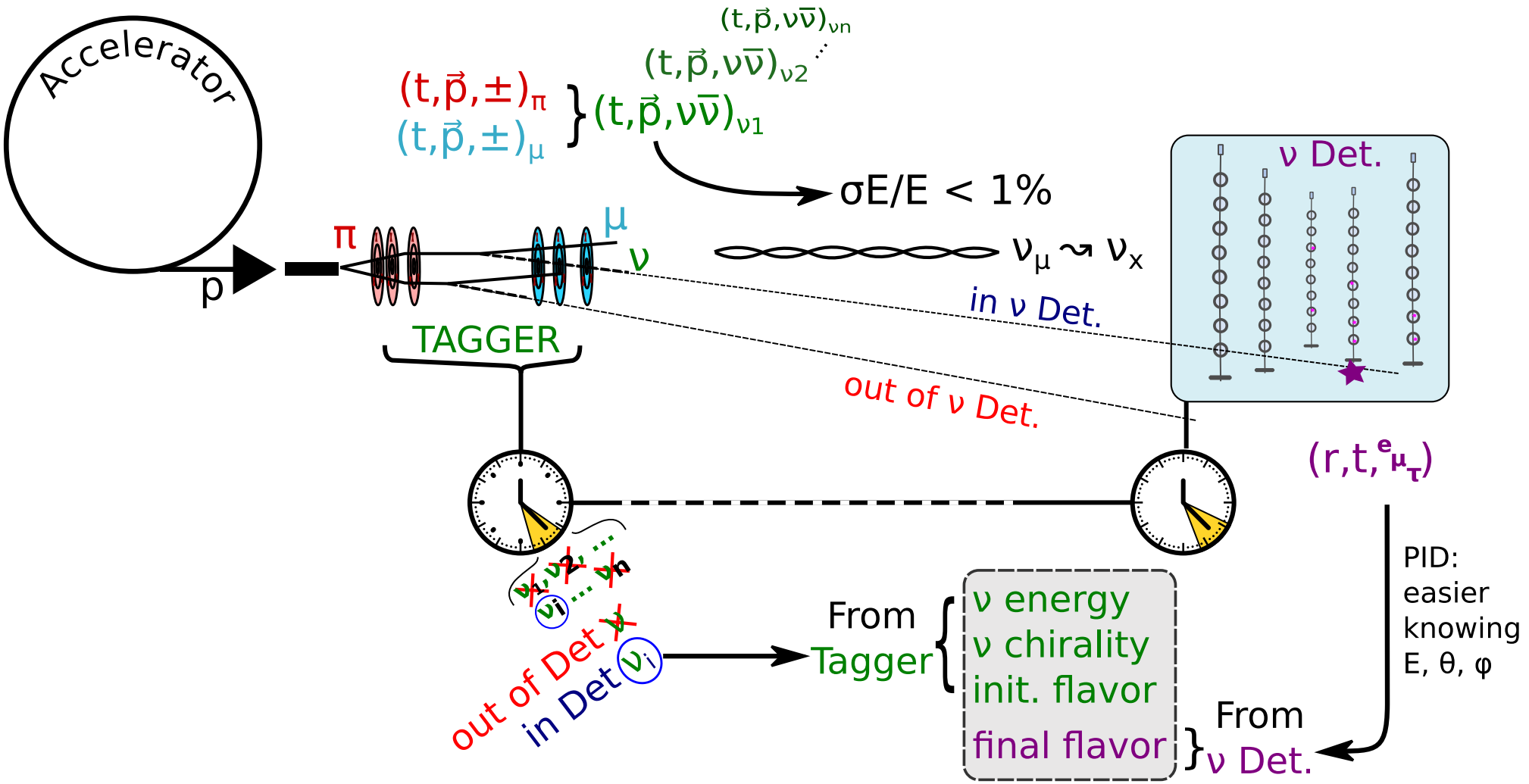
Tagged LBNE – 2



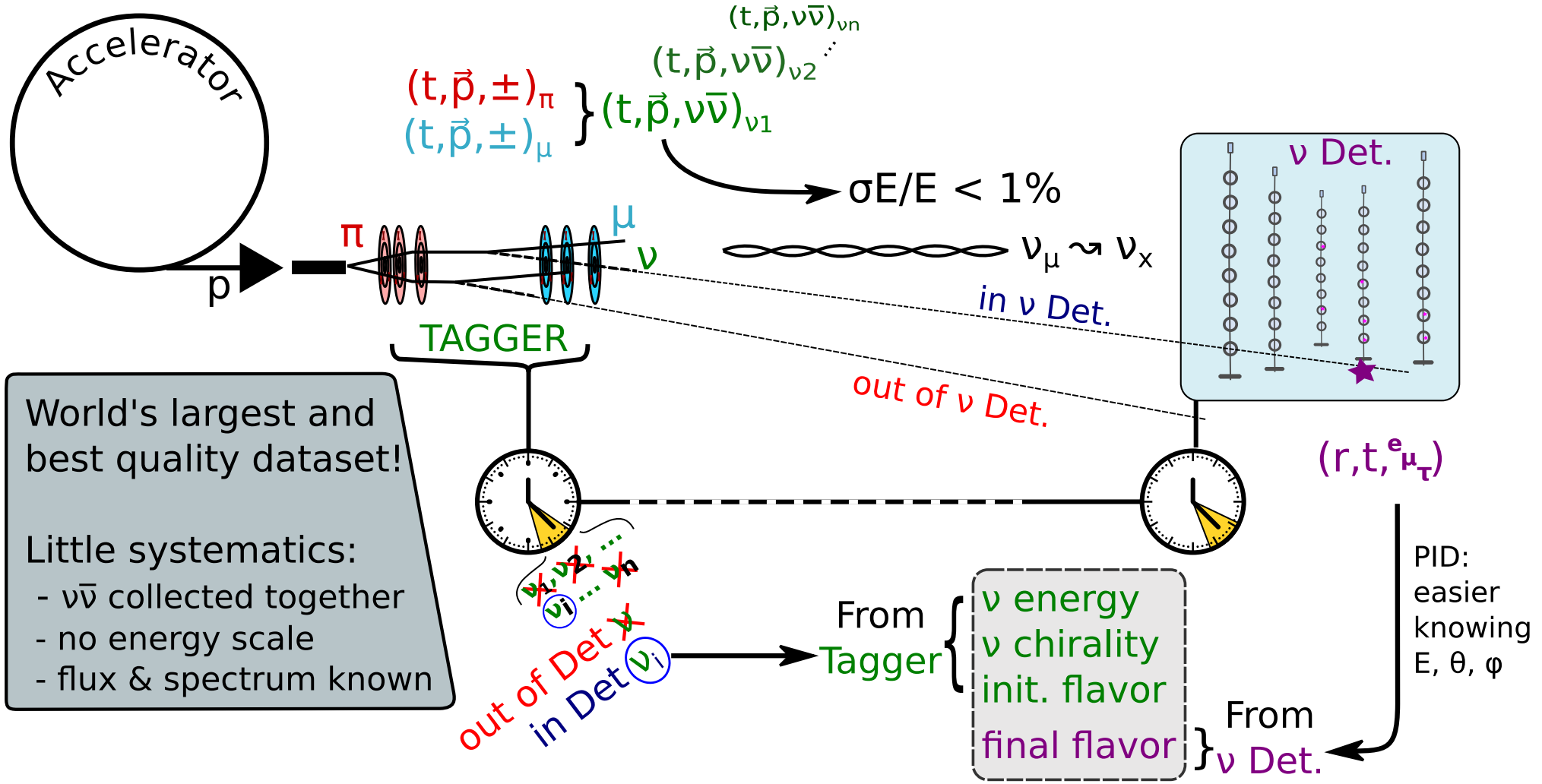
Tagged LBNE – 2



Tagged LBNE – 2



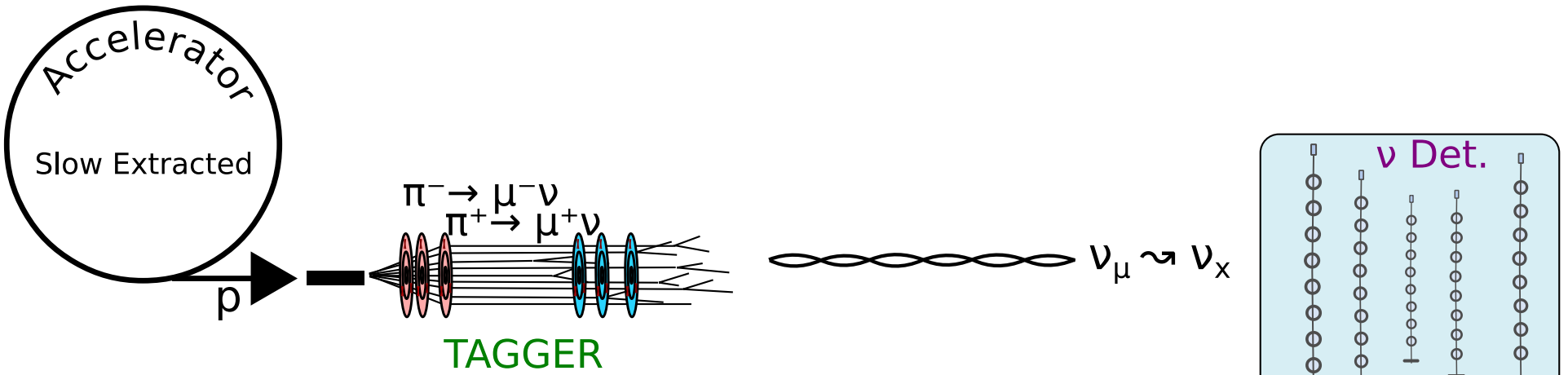
Tagged LBNE – 2



World's largest and best quality dataset!

Little systematics:
- νν̄ collected together
- no energy scale
- flux & spectrum known

Tagged LBNE – Feasibilty

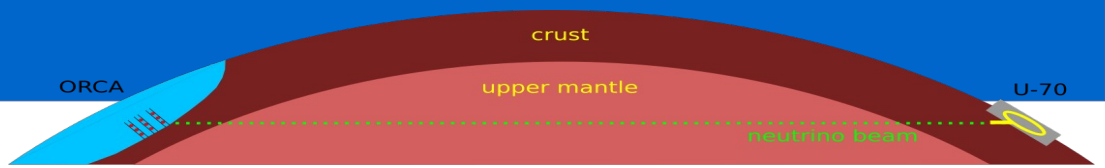


Max Radiation for
Silicon Tracker (LHC)
$10^{16} n_{eq}/cm2$ → ($30x30cm^2$ beam spot) → $10^{19}\pi$ → (decay) $10^{18}\nu_\mu$ → (divergence) $10^{14}\nu_x$ in acceptance

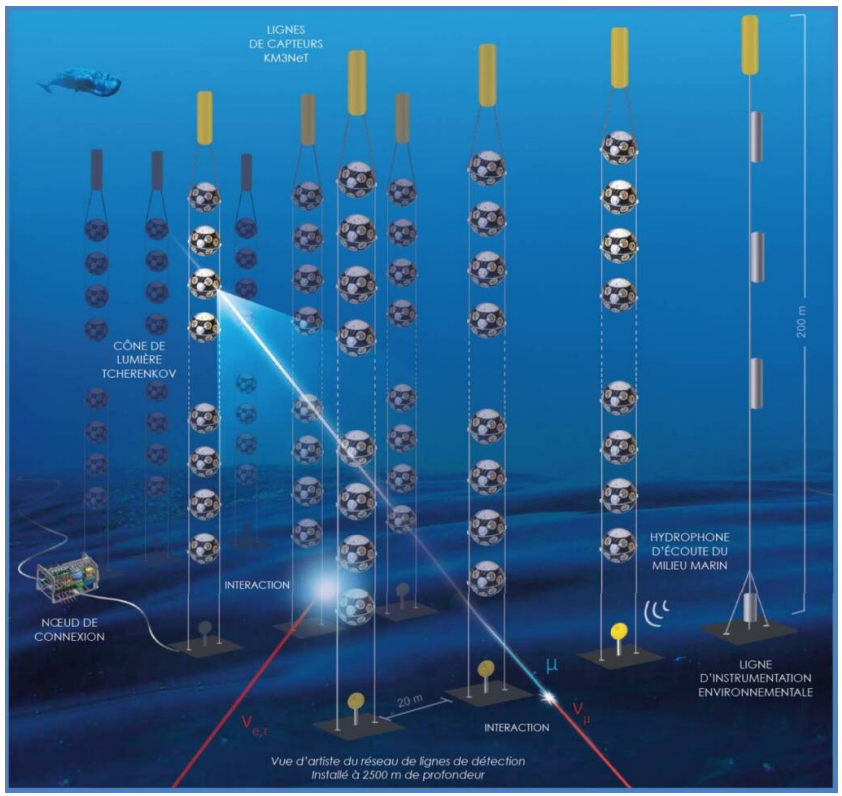
1Megaton

$10^4\nu_x$ detected

A case study P2O



- LBLNE from **U70-Protvino** (Russia) **to KM3NeT-ORCA [1]**



[1] Letter of Interest (EPJ-C)

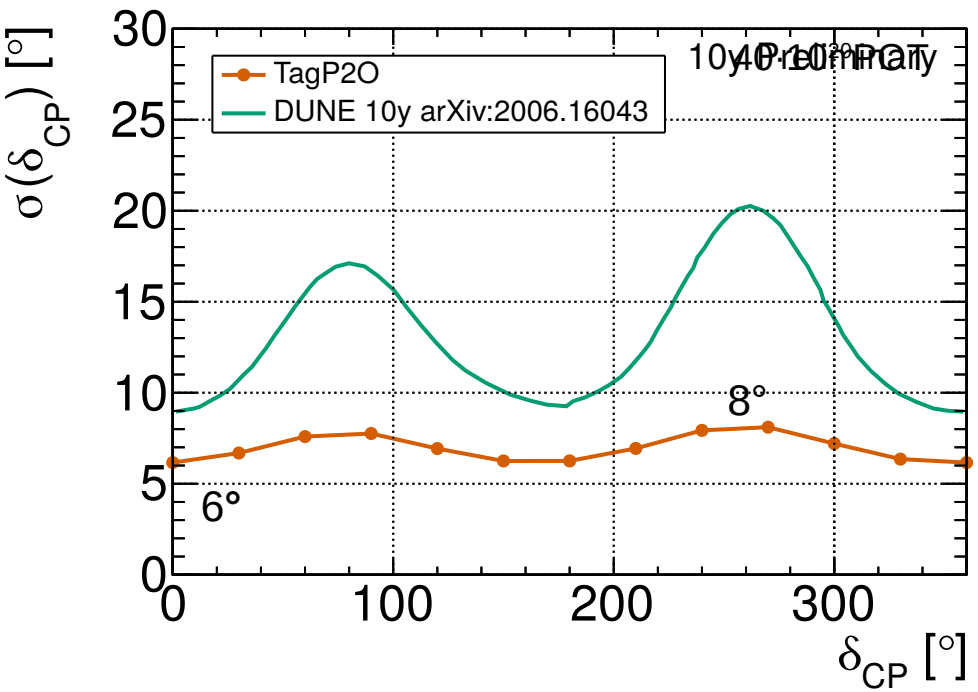
- U70 could provide 450kW beam
- ORCA will instrument 5Mton of sea water

Precision to δ_{CP}

- **Systematics** on oscillation parameters, cross section & normalisation (free)

θ13 ± 0.15°	ντ ± 10%
θ23 ± 2°	NC ± 5%
Δm²31 ± 5e-3eV²	νe=νμ ± 5%

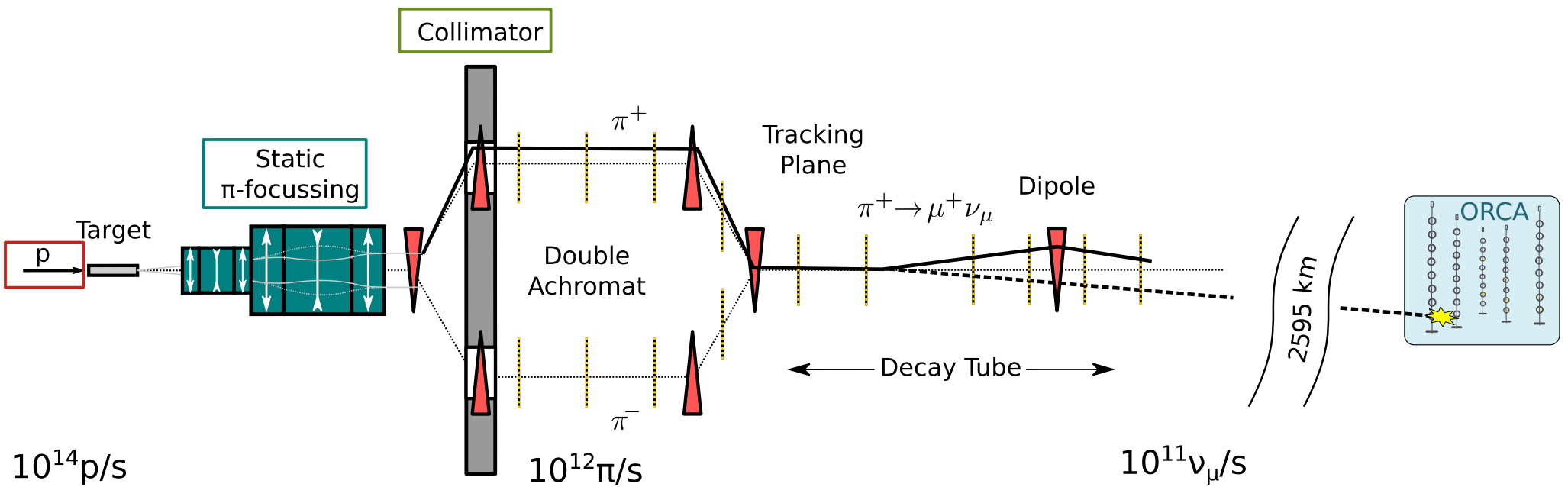
- **Conservative** estimates:
  no PID improvement was considered
- δ_{CP} precision **stable** over all values
- **<8° precision** can be achieved!



Thank you for you attention

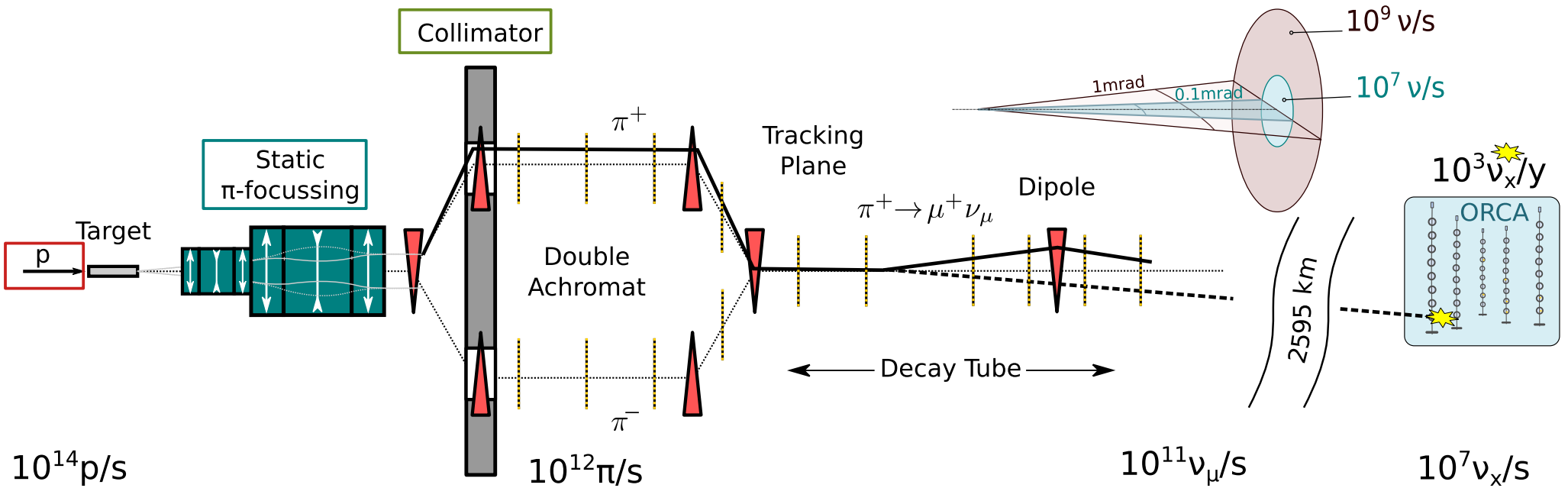
Beam Line Sketch

- **Slow extraction** & **beam cleaning** to reduce π rate
- **Static π+ and π- Focussing Devices** replace conventional horns



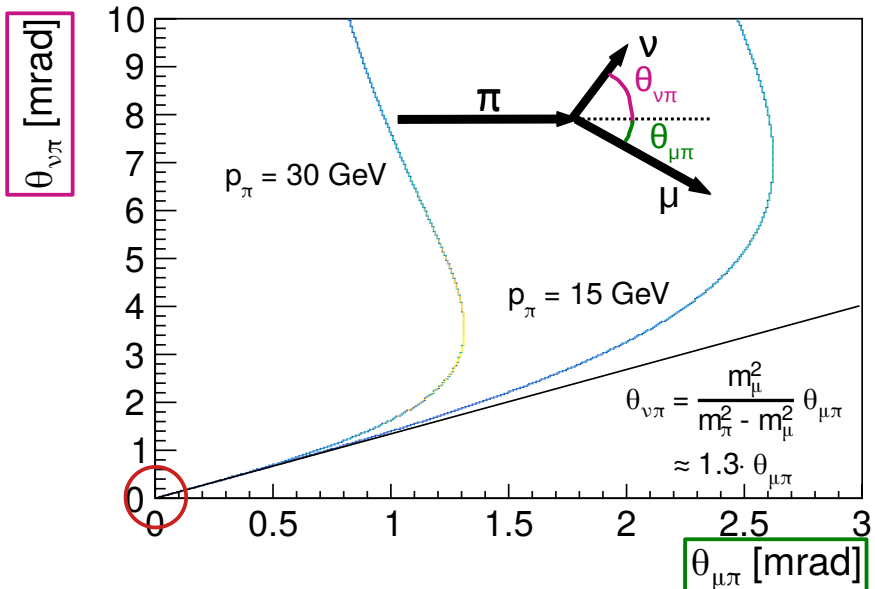
Rate and Synchronisation

- **Rates** shown for a LBLNE like P2O
- **Association $\nu_\mu \leftrightarrow \nu_X$** relies on **time** and **direction** matching
  - with **1ns time** resolution and no ang. reso: ~100 ν_μ are in-time with νX
  - with **1ns & 1mrad** ν_μ ang. reso (10x det. accep): $\nu_\mu \leftrightarrow \nu_X$ is done w/o ambiguity

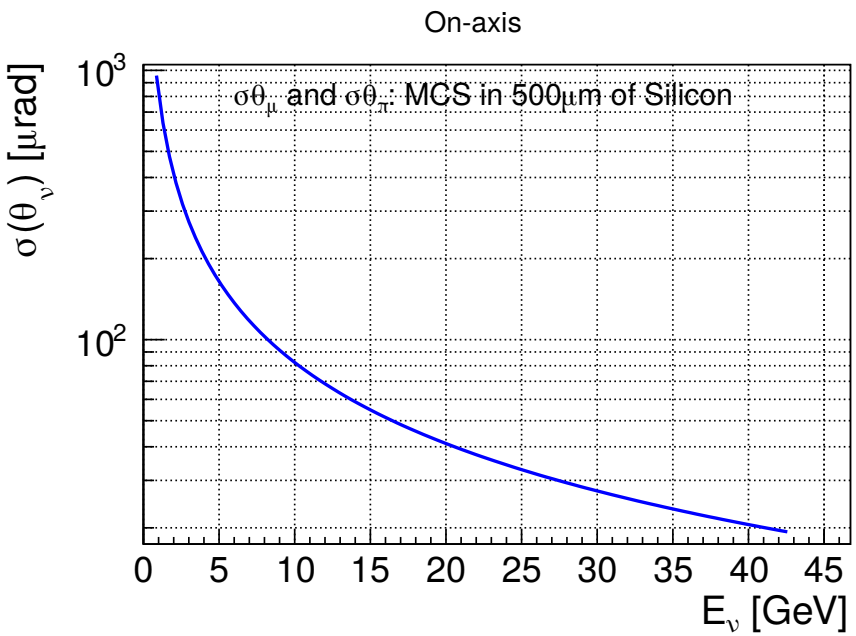


Angular Resolution

- For $\theta_\nu \to 0$ (on-axis) the most precise estimate for θ_ν is obtained using θ_μ.
- Assuming $\theta_{\pi,\mu}$ prec. is dominated by MCS (0.5%X_0 as for NA62), sub-mrad prec. on θ_ν can be achieved

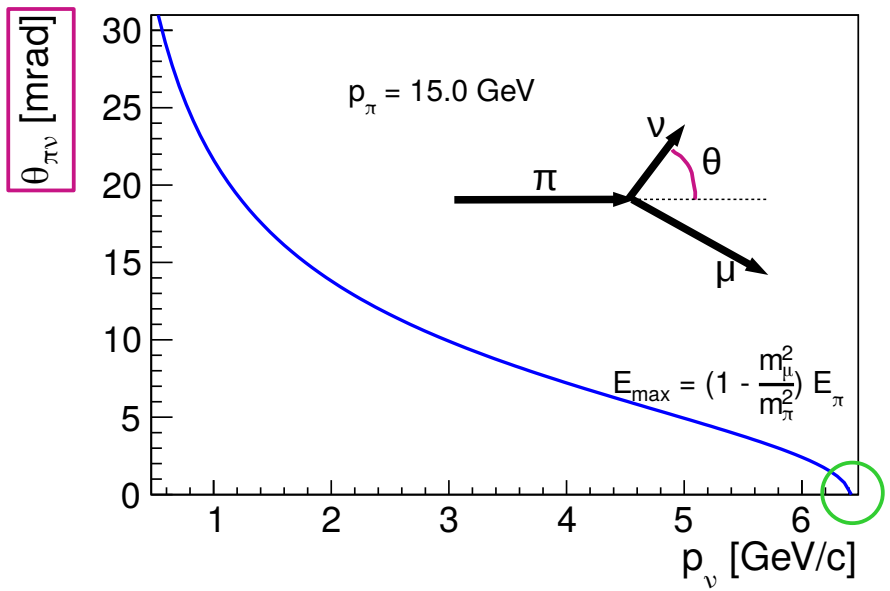


Asymptotically: $\theta_\nu = 1.3\ \theta_\mu$



Energy Resolution

- Only ν at max. energy (0.43 p_π) reach an on-axis detector

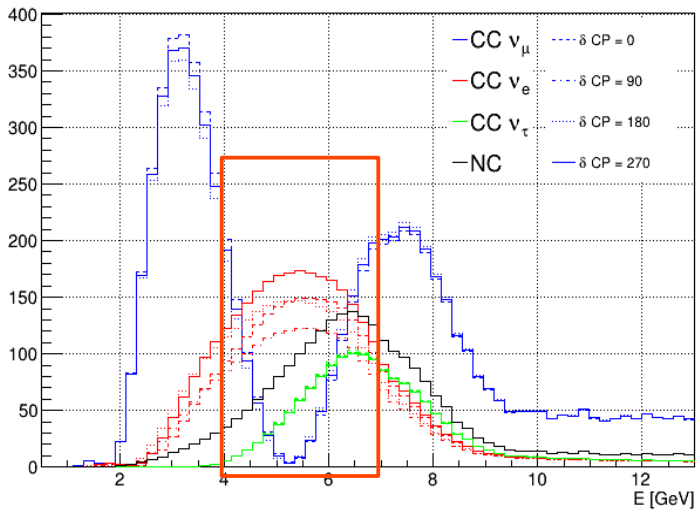


For ~on-axis beam Eν = Emax

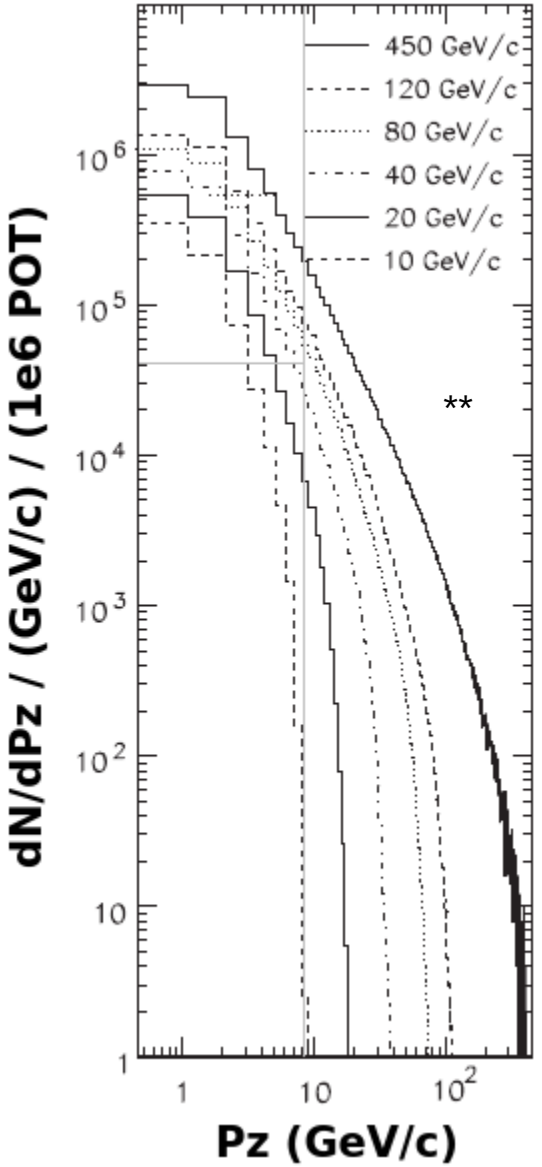
= 0.43 Eπ so $\frac{\delta E_\nu}{E_\nu} = \frac{\delta p_\pi}{p_\pi} < 1\%$

Beam Cleaning

- U70 could deliver **2.25e14 POT per flat-top** (2.2s)* amounting to **4e20 POT/y** (i.e. 2e6 flat-tops/y)
- Relevant ν **energy range** for δcp is **4-6 GeV**



- Neutrino energy is **$0.43 \cdot E_\pi$**
- **π below 9 GeV/c** can safely be removed, <u>reducing the rate by a **factor 50**</u> giving a rate of **O(1e12) π/s**



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