Exotics in photon propagator

… or rather PPC

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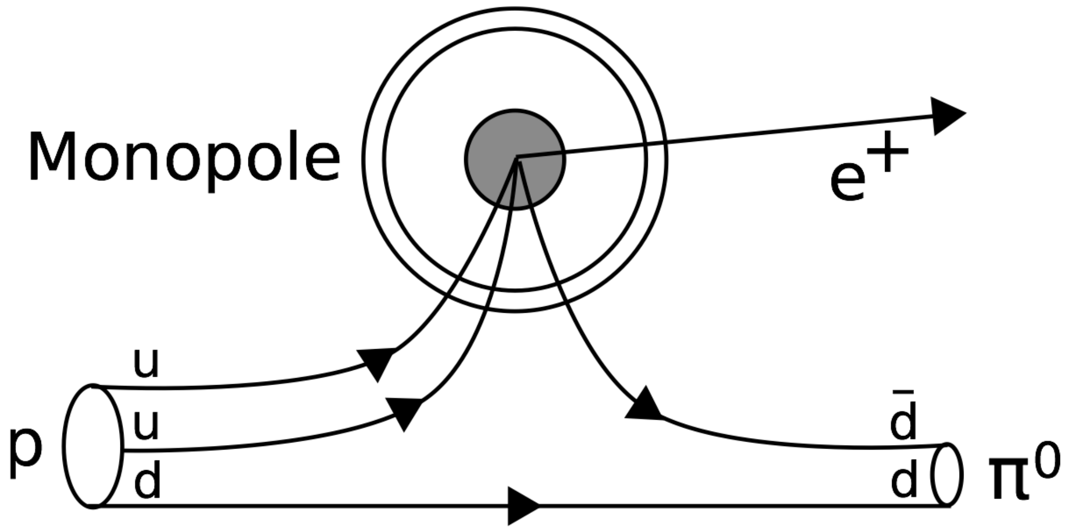
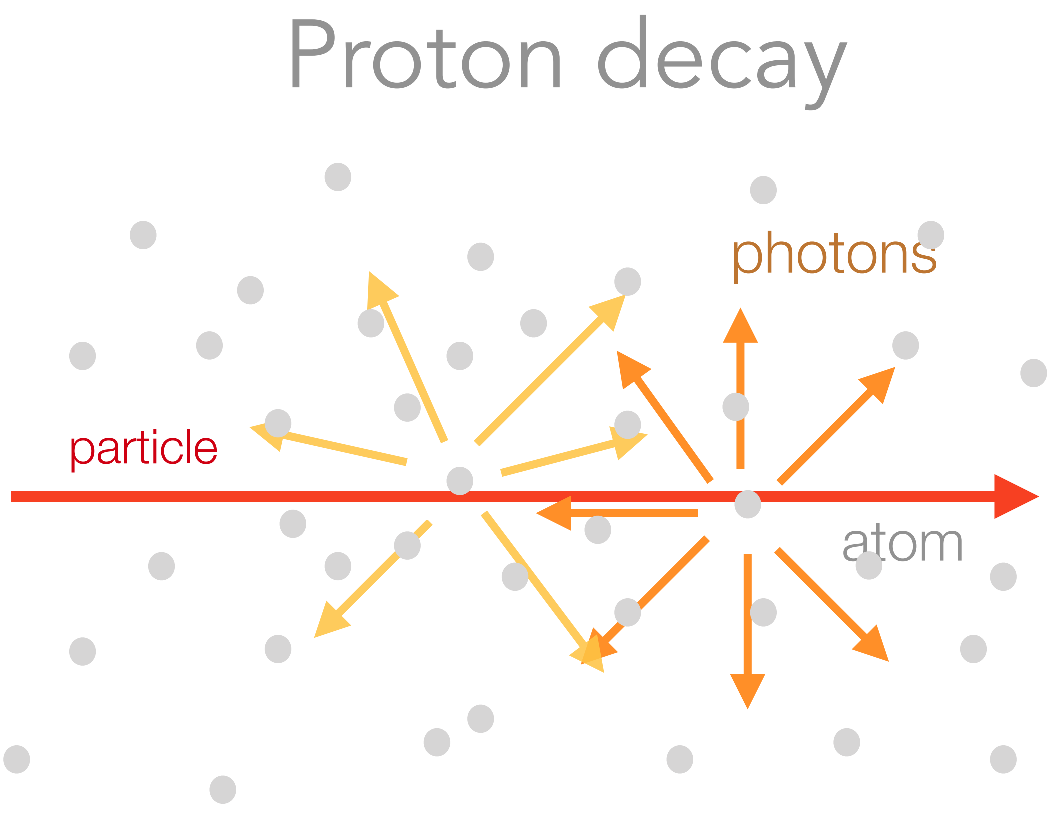
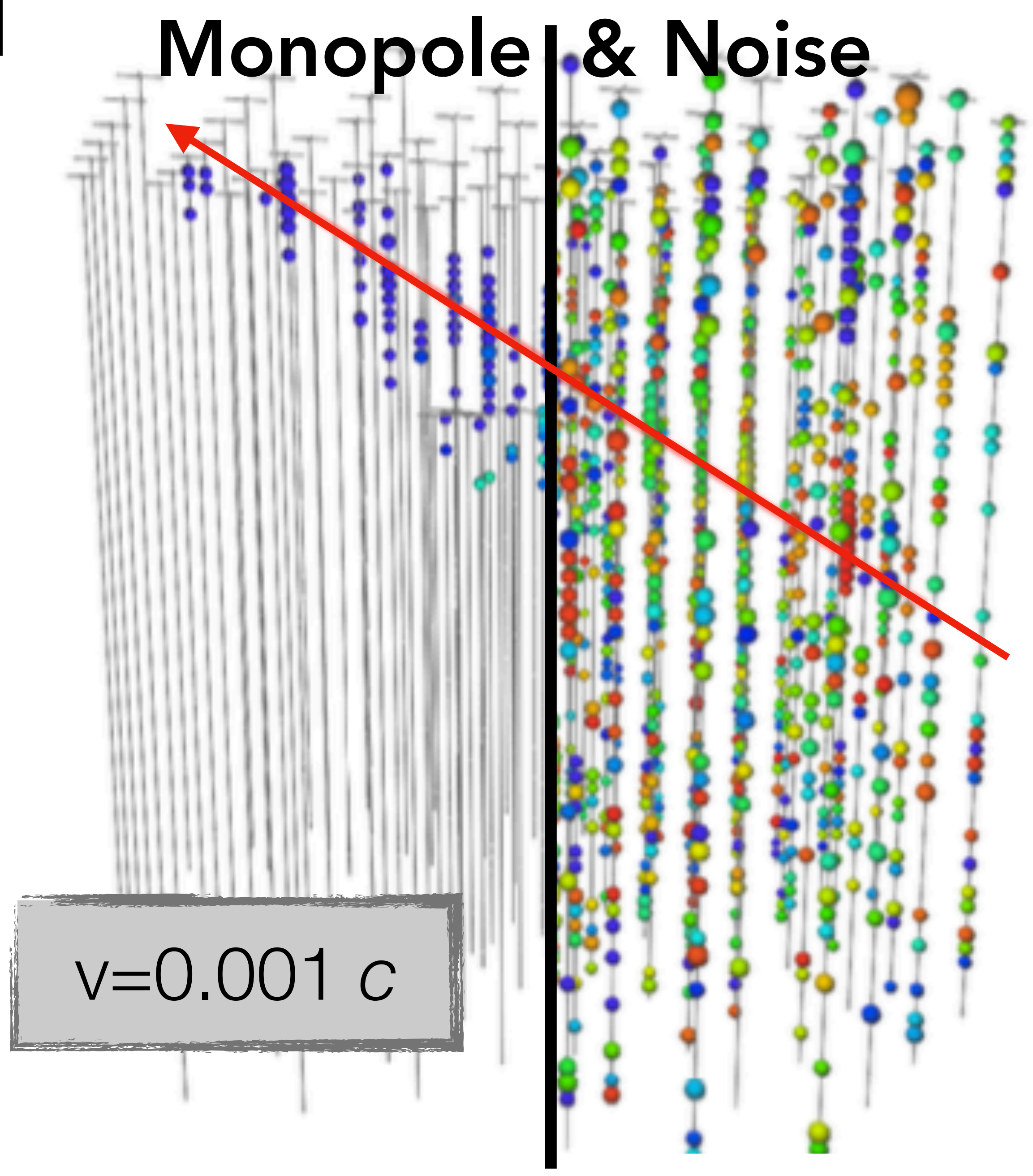
Categories of exotics

1. final states are Standard Model particles, e.g. slow monopoles/Q-balls (< 0.1c)
   - catalysis of proton decay
   - pion cascades along a track
   - fully handled by propagator
2. Minor change in light output, e.g.
   - fractionally charged particles: Cherenkov light proportional to charge squared
   - fast monopoles: Cherenkov light varies with speed (along track)
3. Major change in light output, e.g. mildly relativistic monopoles (> 0.5c)
   - indirect Cherenkov light varies with speed:
     - photon number and
     - photon emission angle
4. New kind of light output: e.g. luminescence / thermal shock waves
   - changes photon number, emission angle, wavelength, and emission time







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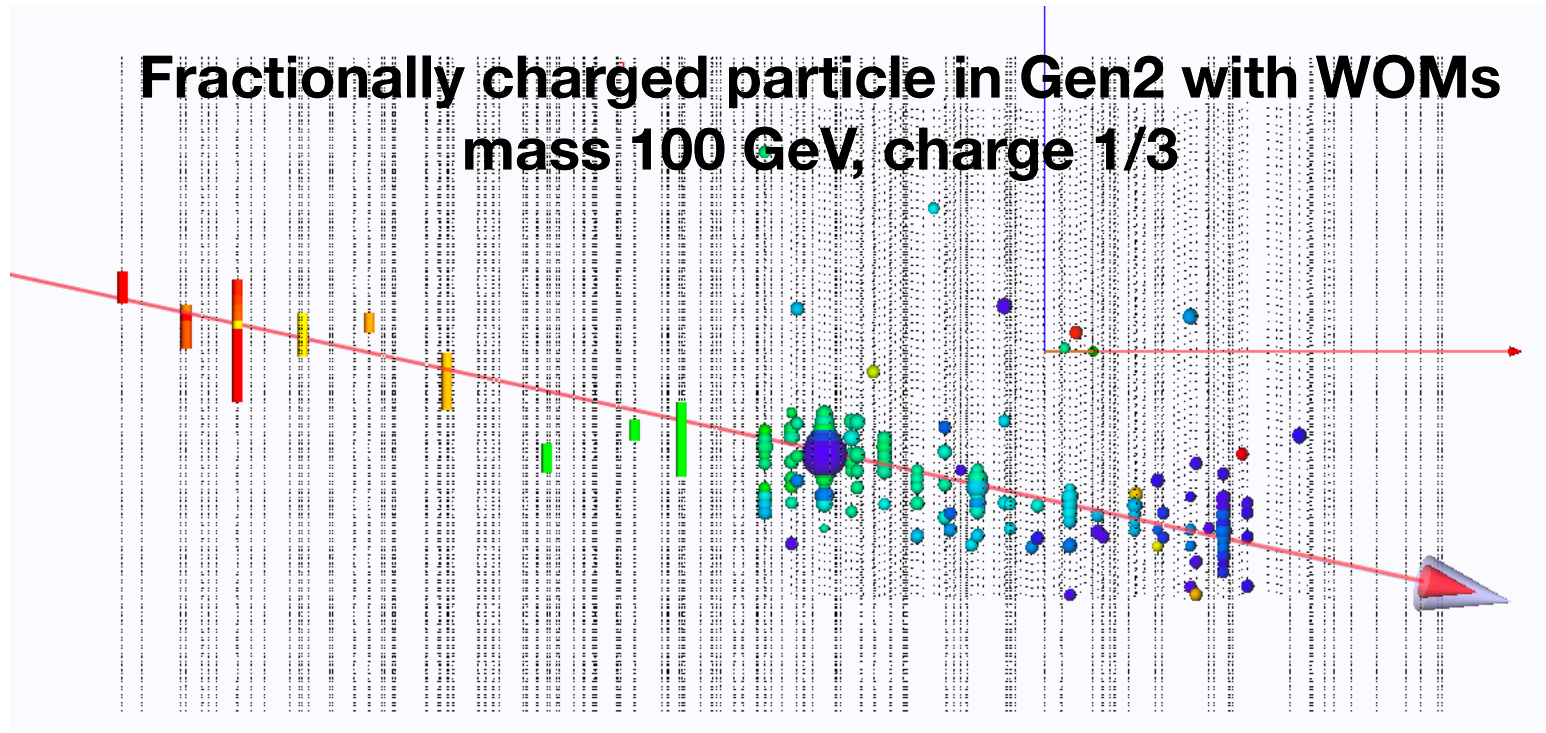

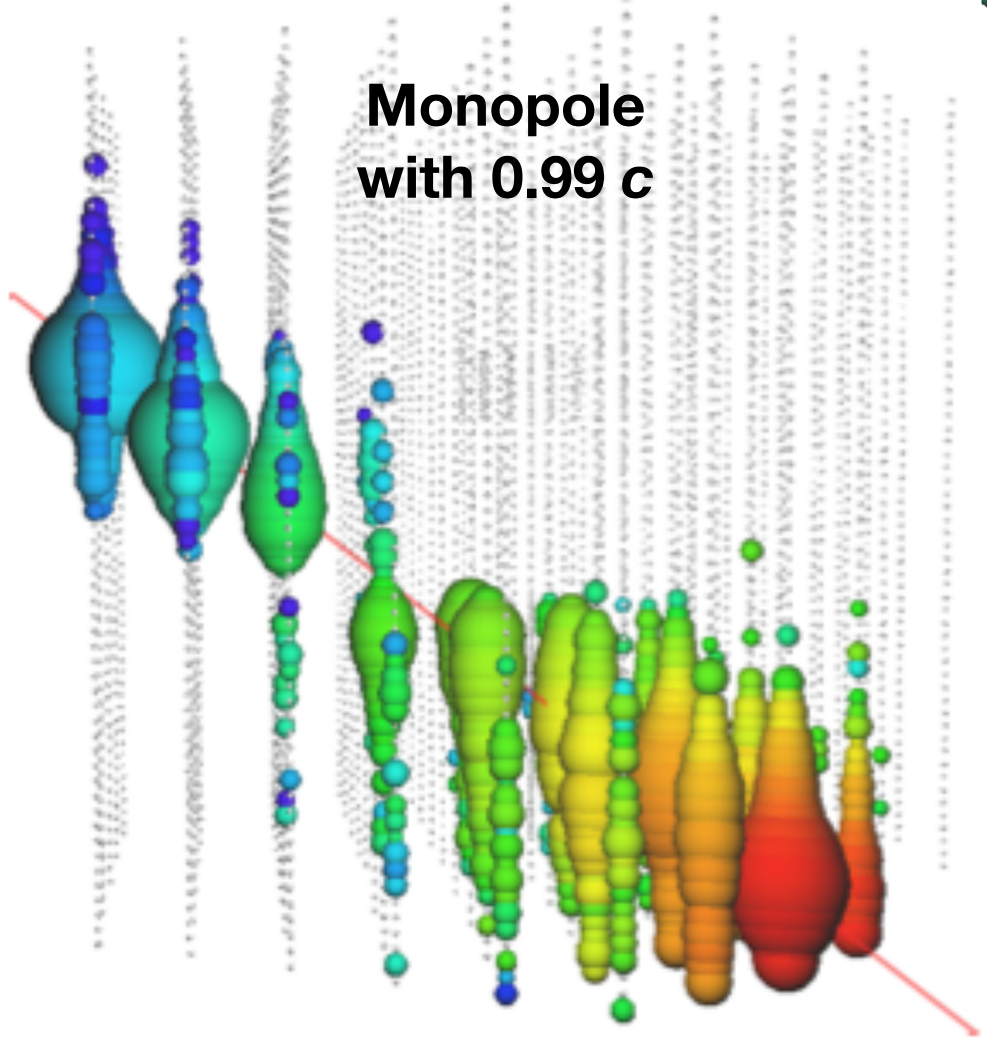

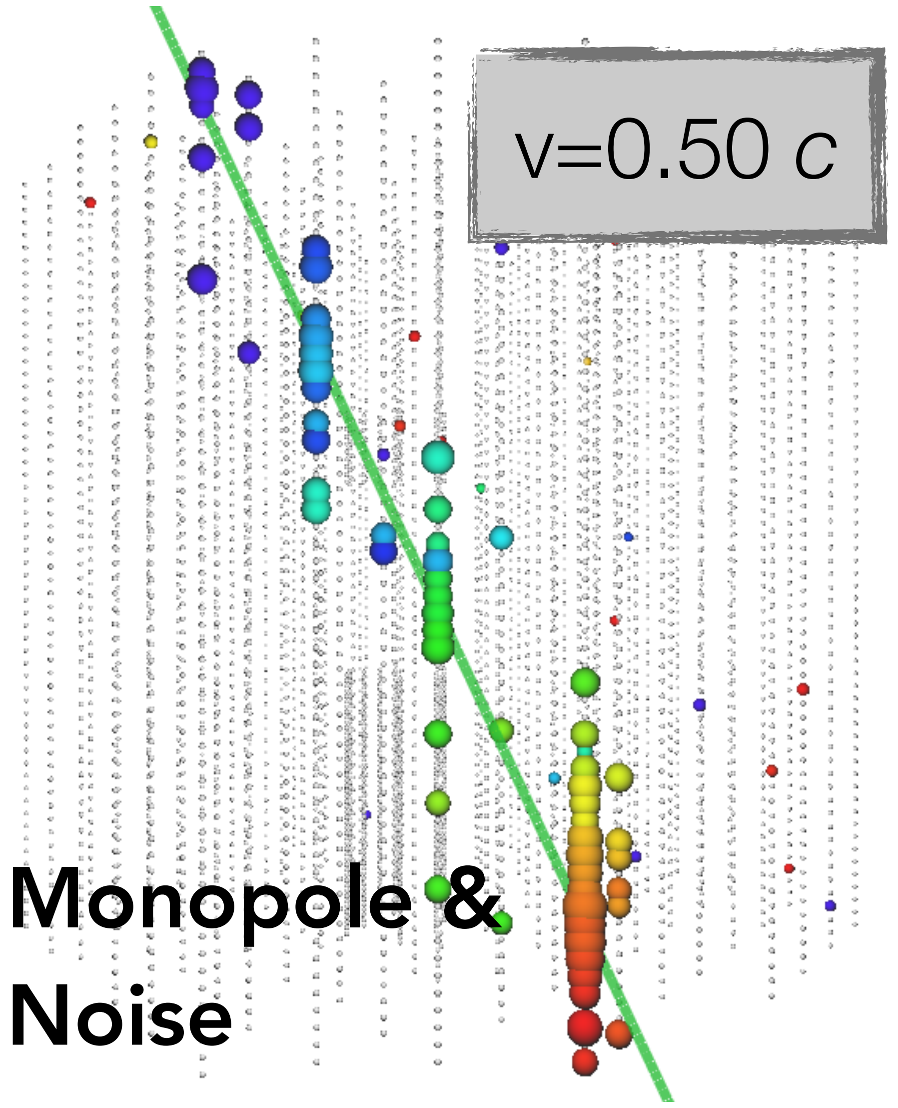

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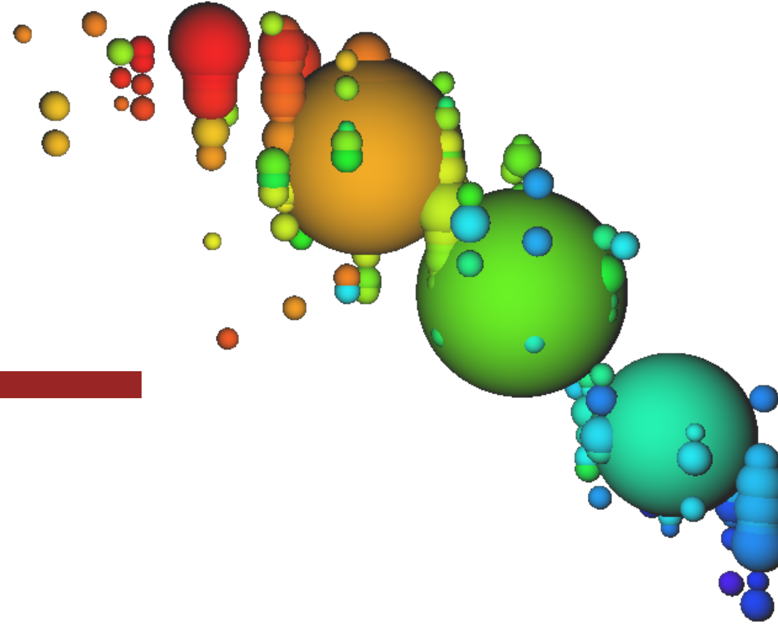

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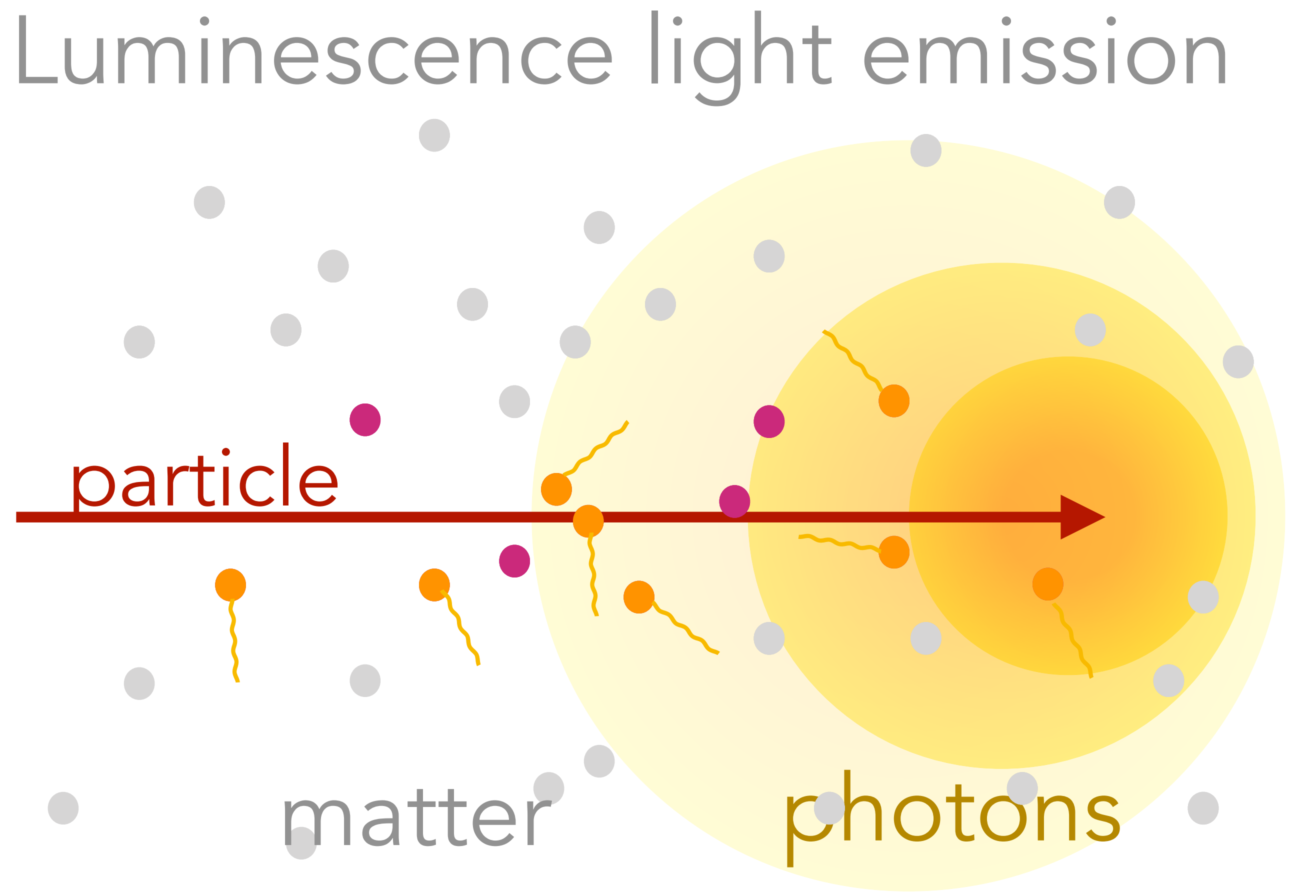
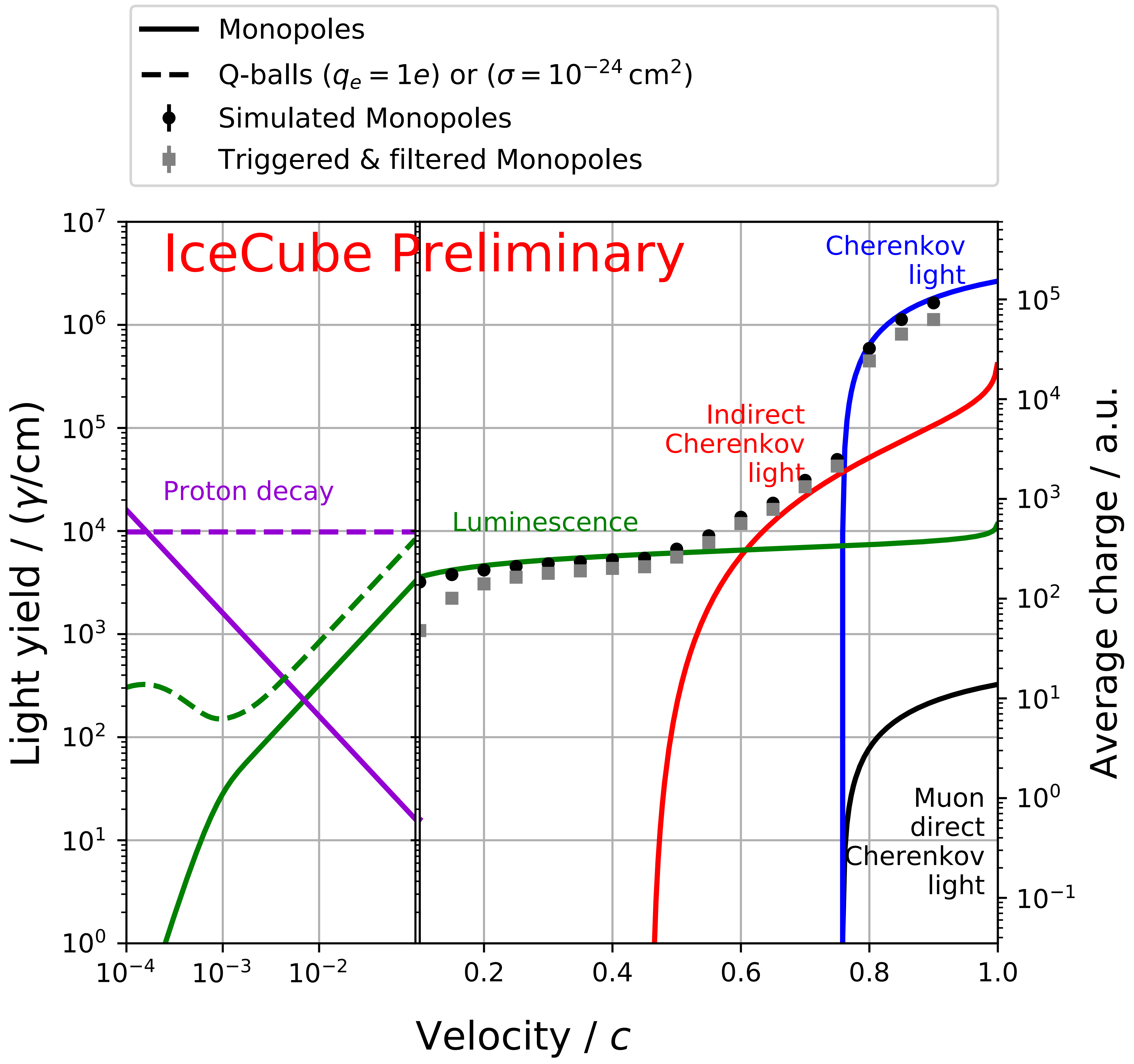


Exotics in PPC - the history

- started with fast monopoles and used these software for all other exotics due to
  - familiarity and
  - existing starting points
- all light emissions are in the trunk version -> knowledge won't get lost
  - exceptions:
    - wavelength dependence of luminescence (soon)
    - thermal shock waves

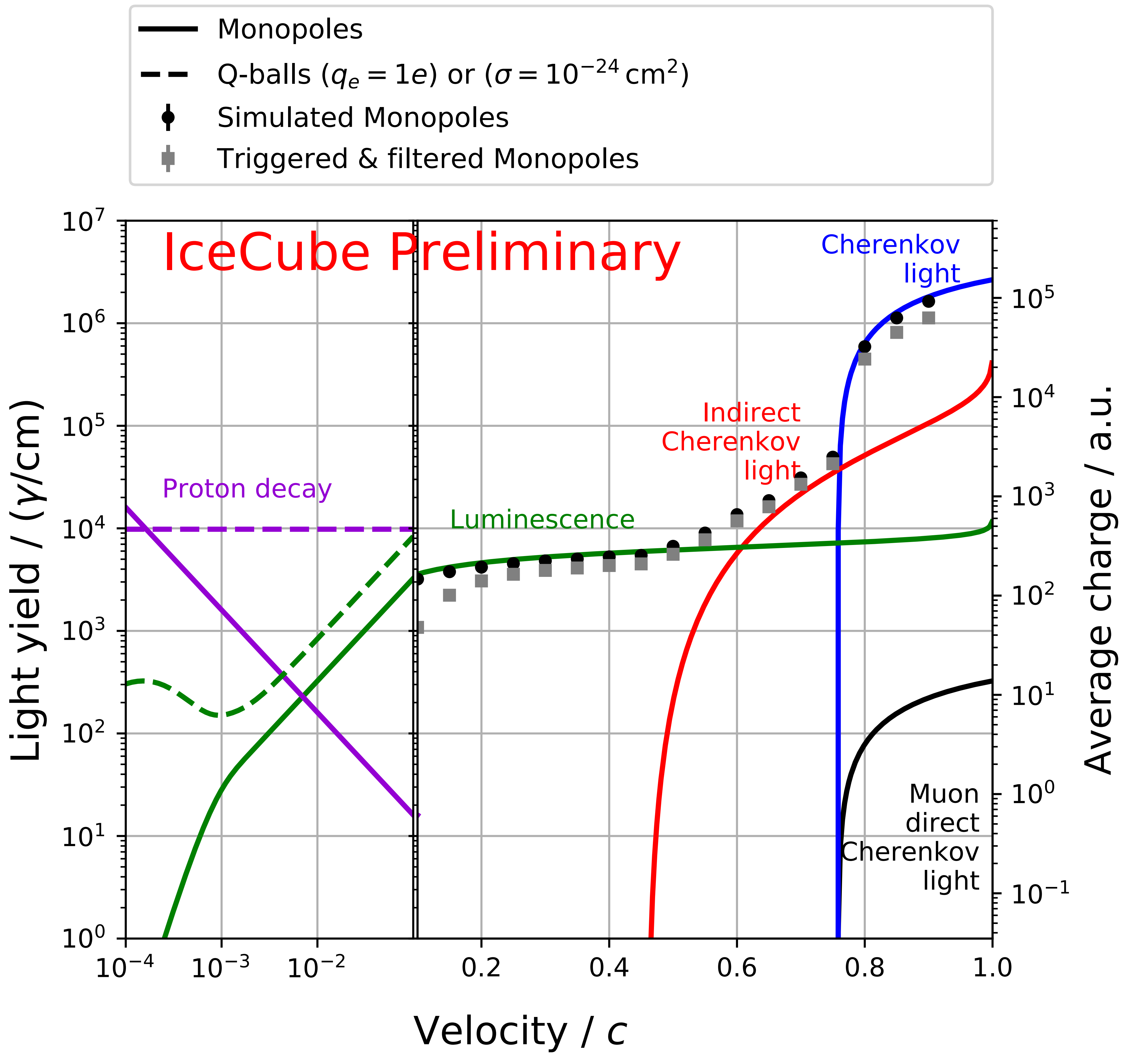
Implementation in PPC - light yield

- fractional charges:
  - charge is given as module parameter
  - treatment as a muon track, but if
  - particle type is found in MCTree => number of photons (yield) is scaled with charge squared [f2k]
- direct Cherenkov light, fast monopoles (first exotics in ppc)
  - copies handling of muon tracks
  - no module parameter needed, reads particle type from MCTree
  - scales photon number [i3ppc, f2k] (Frank-Tamm devided by muon ppm, see Dima's talk)



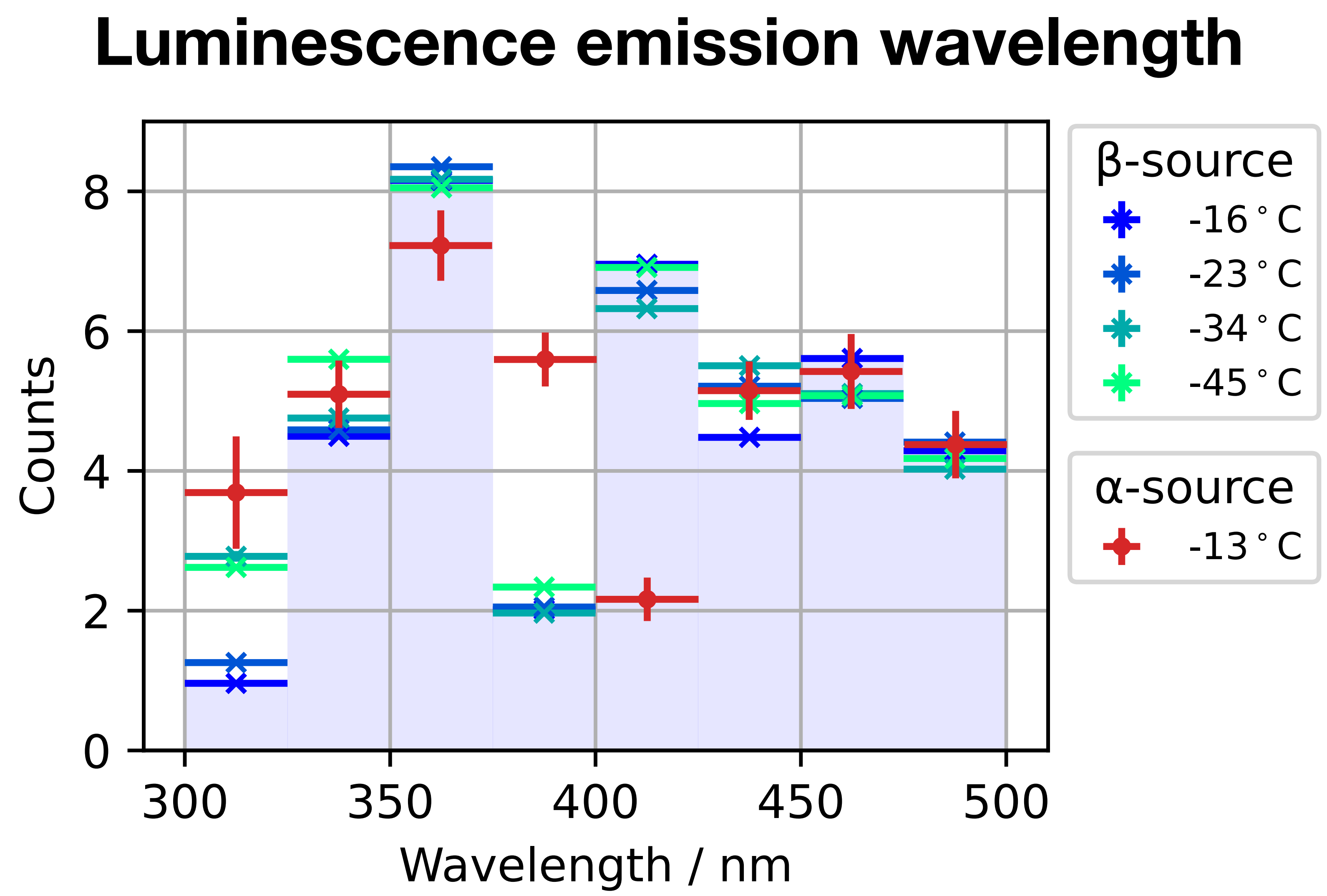
Implementation in PPC - light yield

- indirect Cherenkov light:
  - spline fit of light yield is used for calculation in dependence of speed (includes Dima's muon ppm) [i3ppc]
  - amount of indirect Cherenkov light is given as fraction to direct light [i3ppc]
- luminescence light:
  - yield per energy loss and decay kinetics are given as vector as module parameters
  - yield depends on energy loss which is calculated here [i3ppc]
  - photons added on top of direct and indirect Cherenkov light [i3ppc]



Implementation in PPC - emission angle/time

- direct Cherenkov light
  - photons on GPU know particle speed,
  - if speed < 1: cone is sampled with varying angle [pro.cu]
- indirect Cherenkov light
  - angle chosen as if indirect contribution to muon track: cascade [pro.cu l.470]
  - theoretical emission from predicted cross sections in older branch
- luminescence
  - angle sampled as isotropic emission [pro.cu 463]
  - time sampled from several exponentials
  - wavelength - TBD



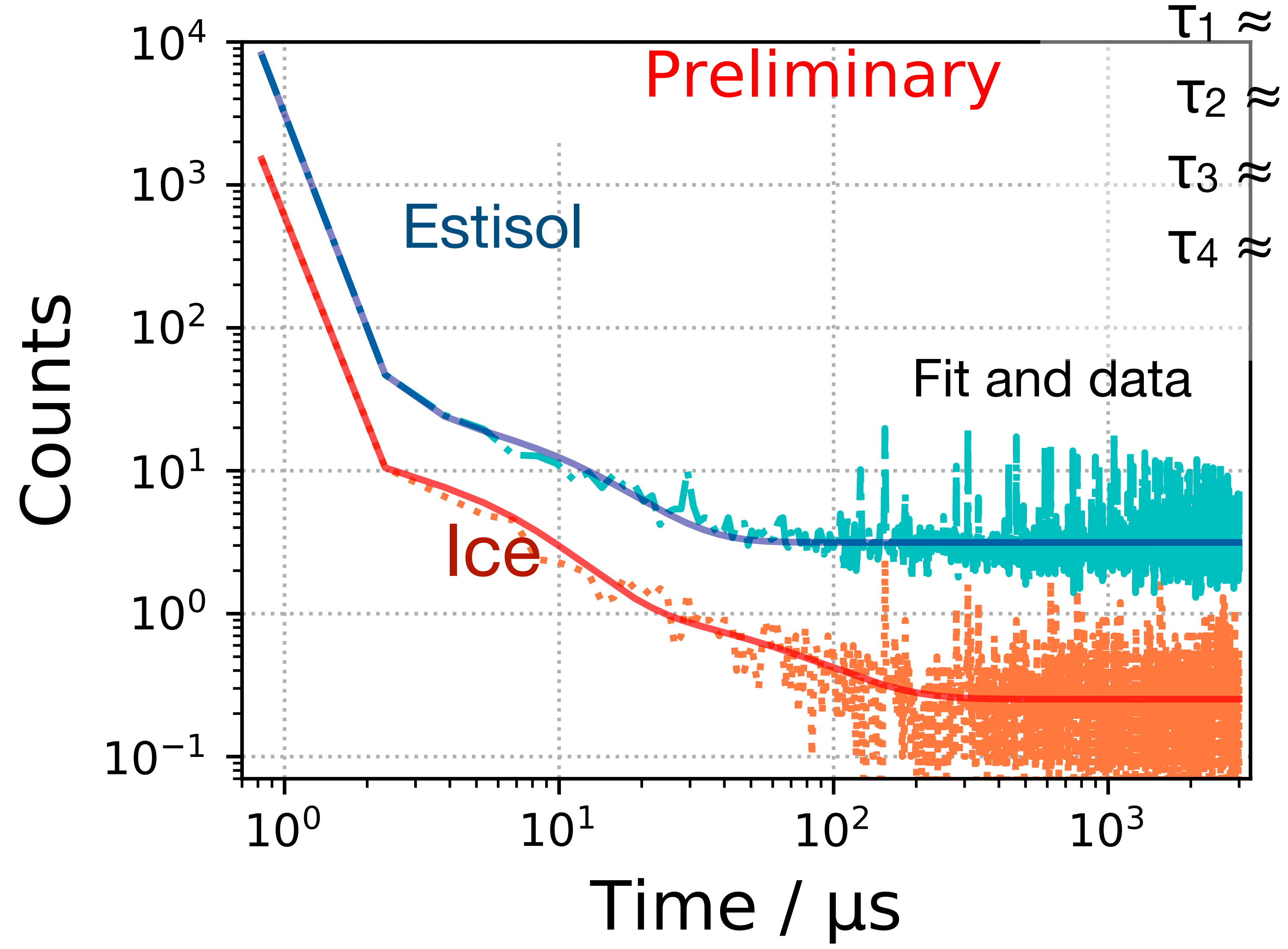
Decay times of ice

$\tau_1 \approx 2.44$ ns

$\tau_2 \approx 196$ ns

$\tau_3 \approx 5.03$ μs

$\tau_4 \approx 56.1$ μs



Exotics in CLSIM

- no idea!
- best guess on the work load:
  - GEANT knows fast monopoles, but likely with wrong cross-section
  - GEANT does not know new light channels
  - implementation of some channels could be easy, of other channels it requires lots of work

General remarks

- exotics code "weakens" the efficiency of less diverse code
- analysers searching for exotics have tasks on top of usual analysis work:
  - write your own generator, propagator, photon emission parameters
  - important to keep knowledge in order to improve instead of re-invent the wheel