IceCube results on magnetic monopoles

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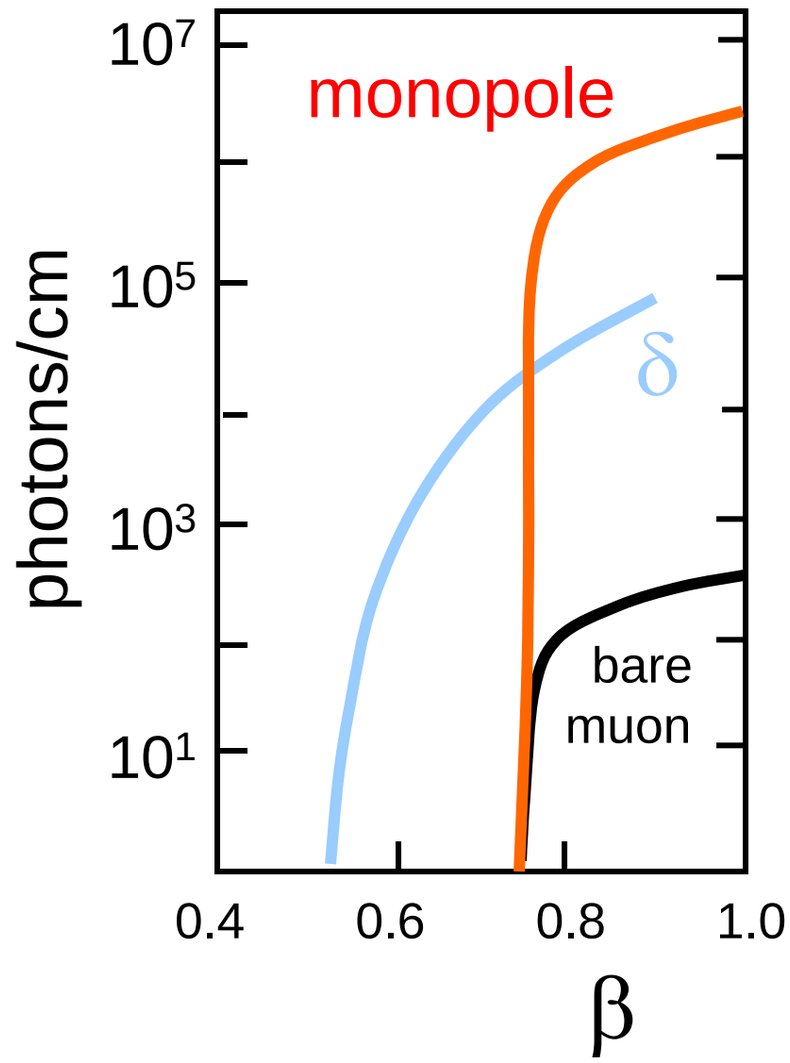
Dubna, VLVNT 2018

Using material of Anna Pollmann

Basics

- elemental magnetic charge (Dirac) $g_D = 68.5\ e$
- Ionisation: ~4700 of that of a bare muon
- Cherenkov light: ~8300 of that of a bare muon



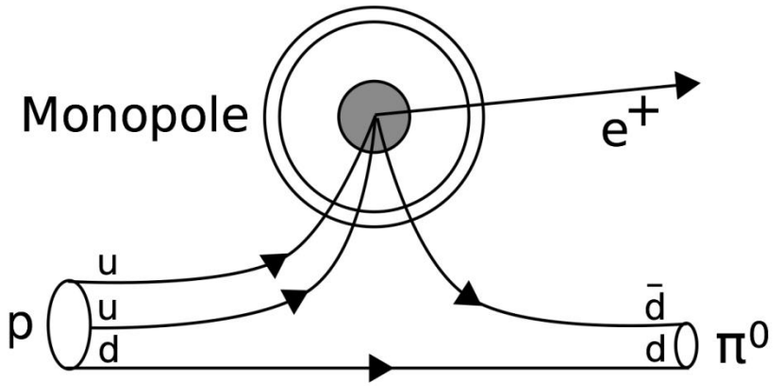
- With huge mass created
  - shortly after the Big Bang (GUT)

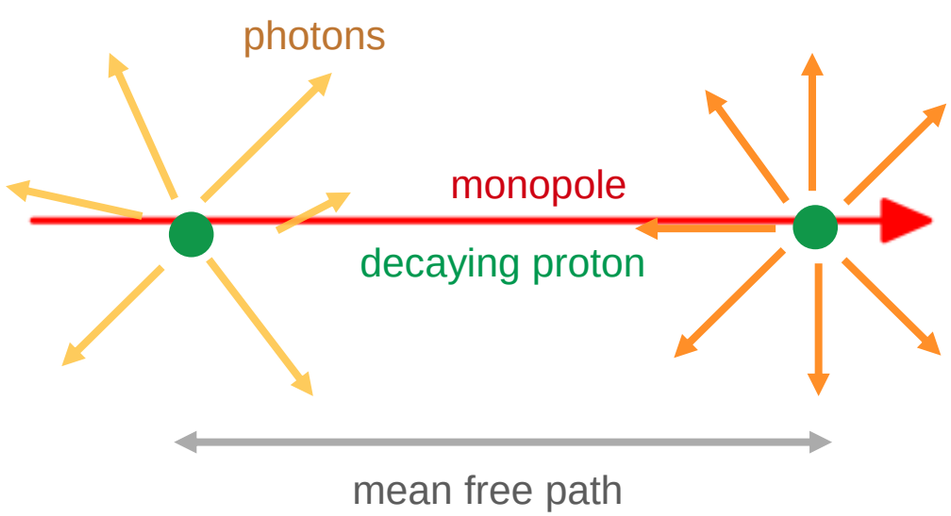
    $10^{13}\ \text{GeV} \leqq M_{MM} \leqq 10^{19}\ \text{GeV}$
  - in intermediate stages of symmetry breaking (IMM)

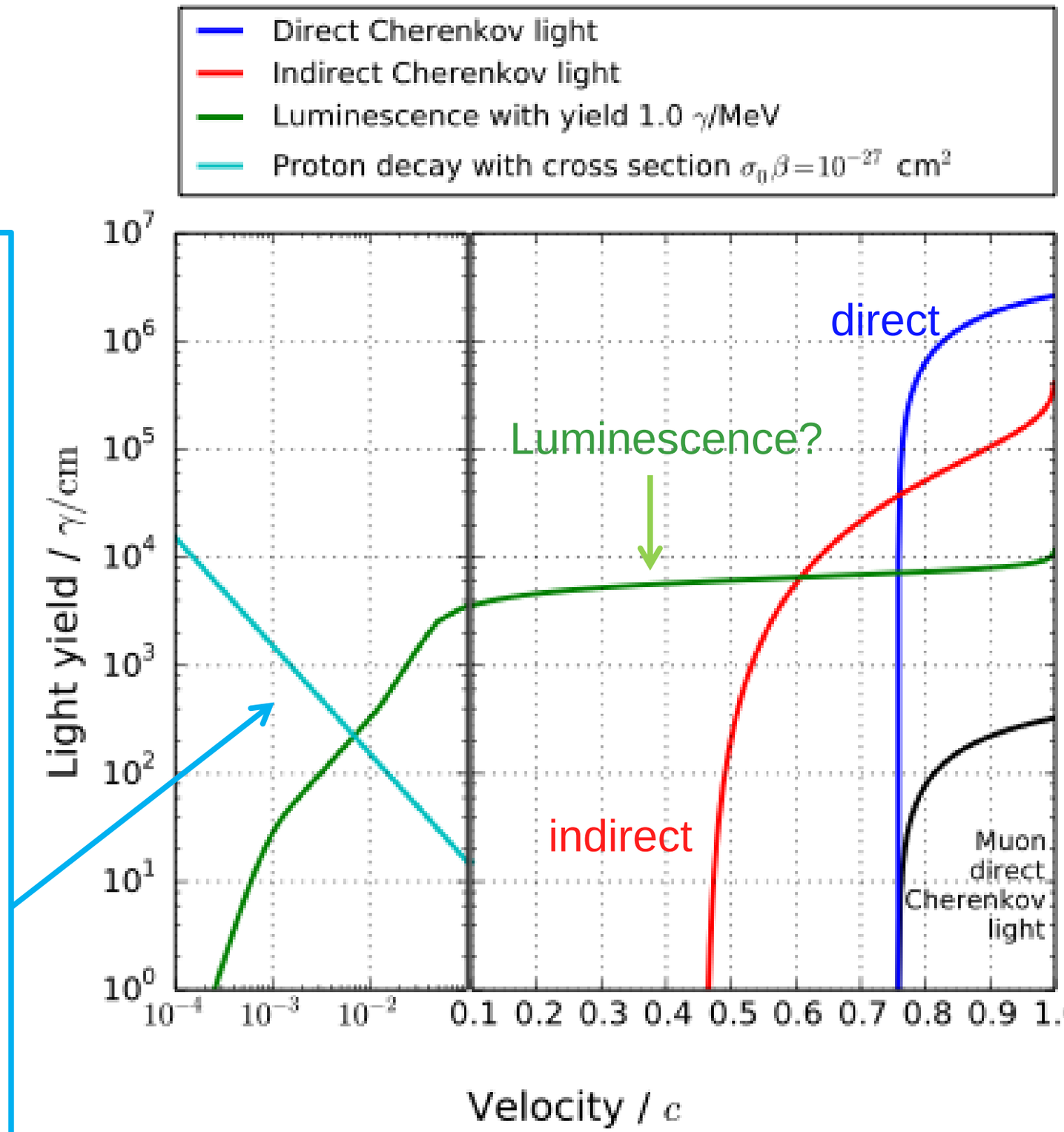
    $10^{7}\ \text{GeV} \leqq M_{MM} \leqq 10^{13}\ \text{GeV}$
- Acceleration in magnetic fields for $M_{MM} \leqq 10^{14}$ GeV: up to $E_{kin} \sim 10^{15}$ GeV
- Trapping in Galaxy, around Sun, Earth for $v \sim 10^{-5}$ -- 10^{-2} c

Monopole light yield

Rubakov-Callen Effekt (catalysis of proton decay)







New results on GUT monopoles

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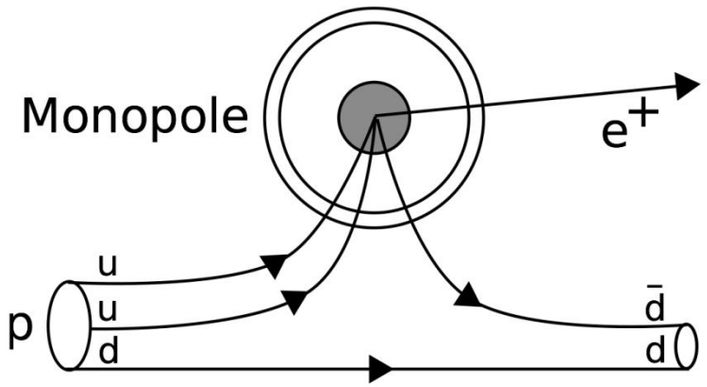

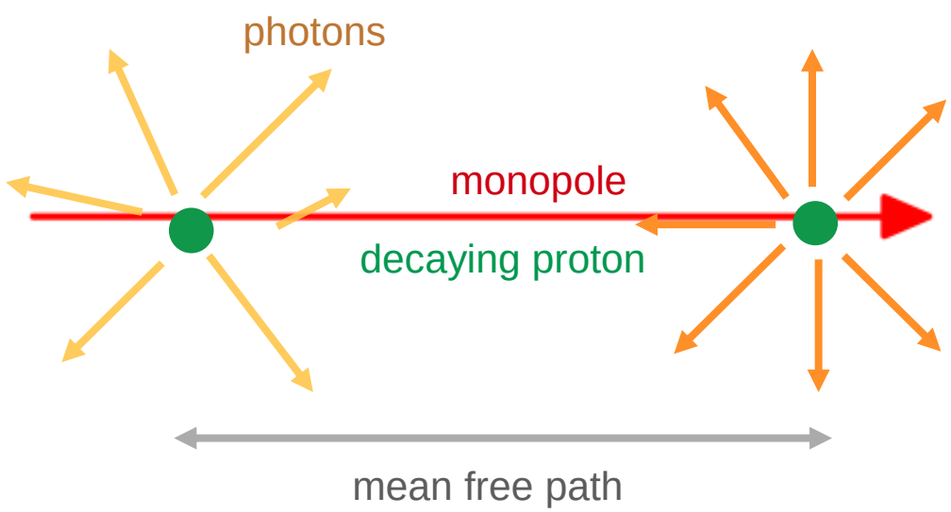

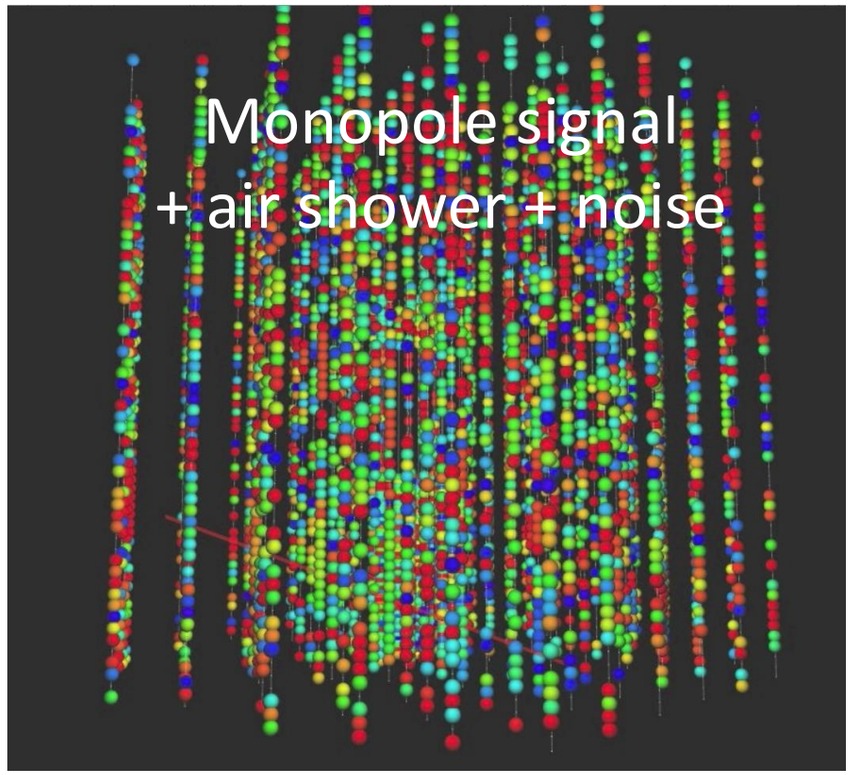

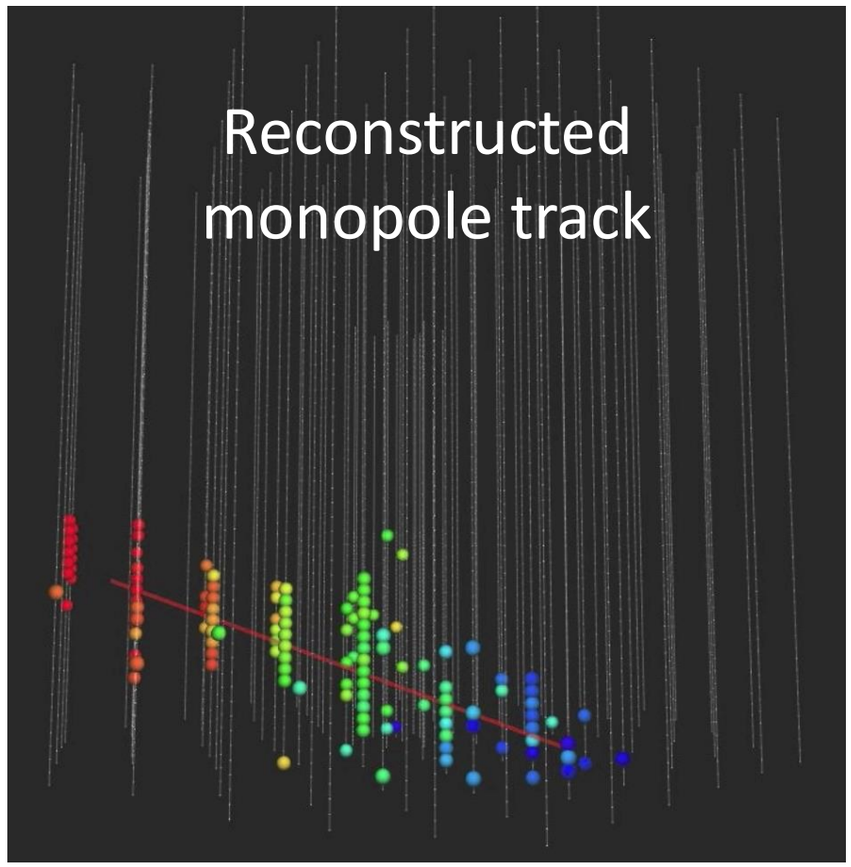

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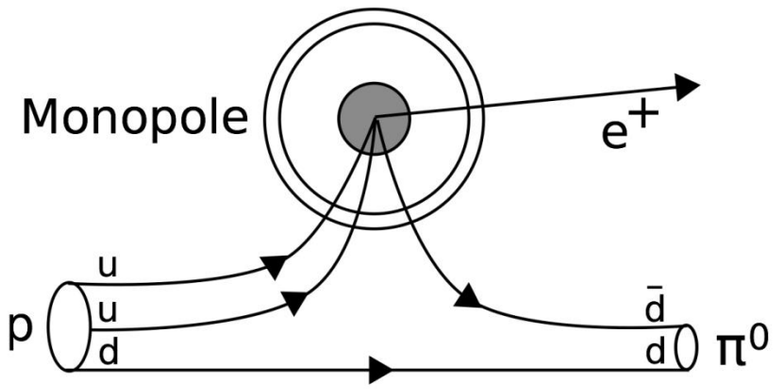

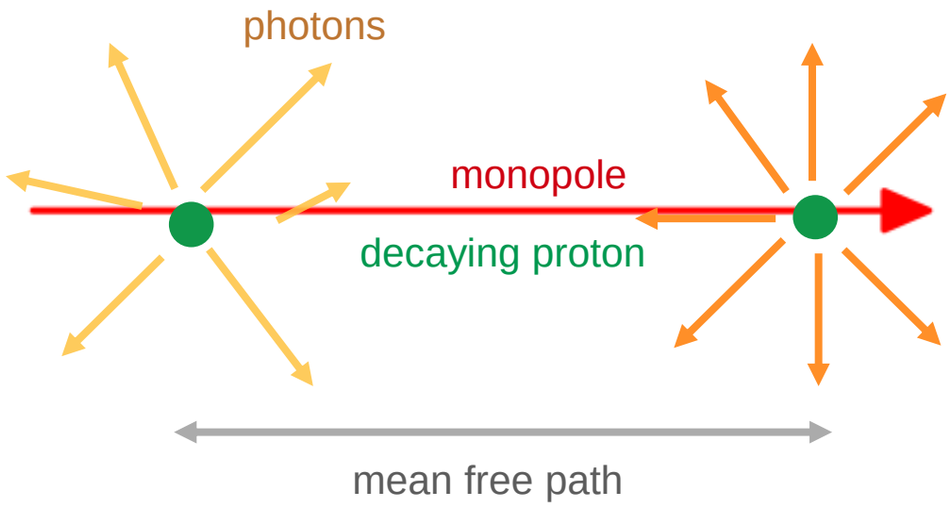

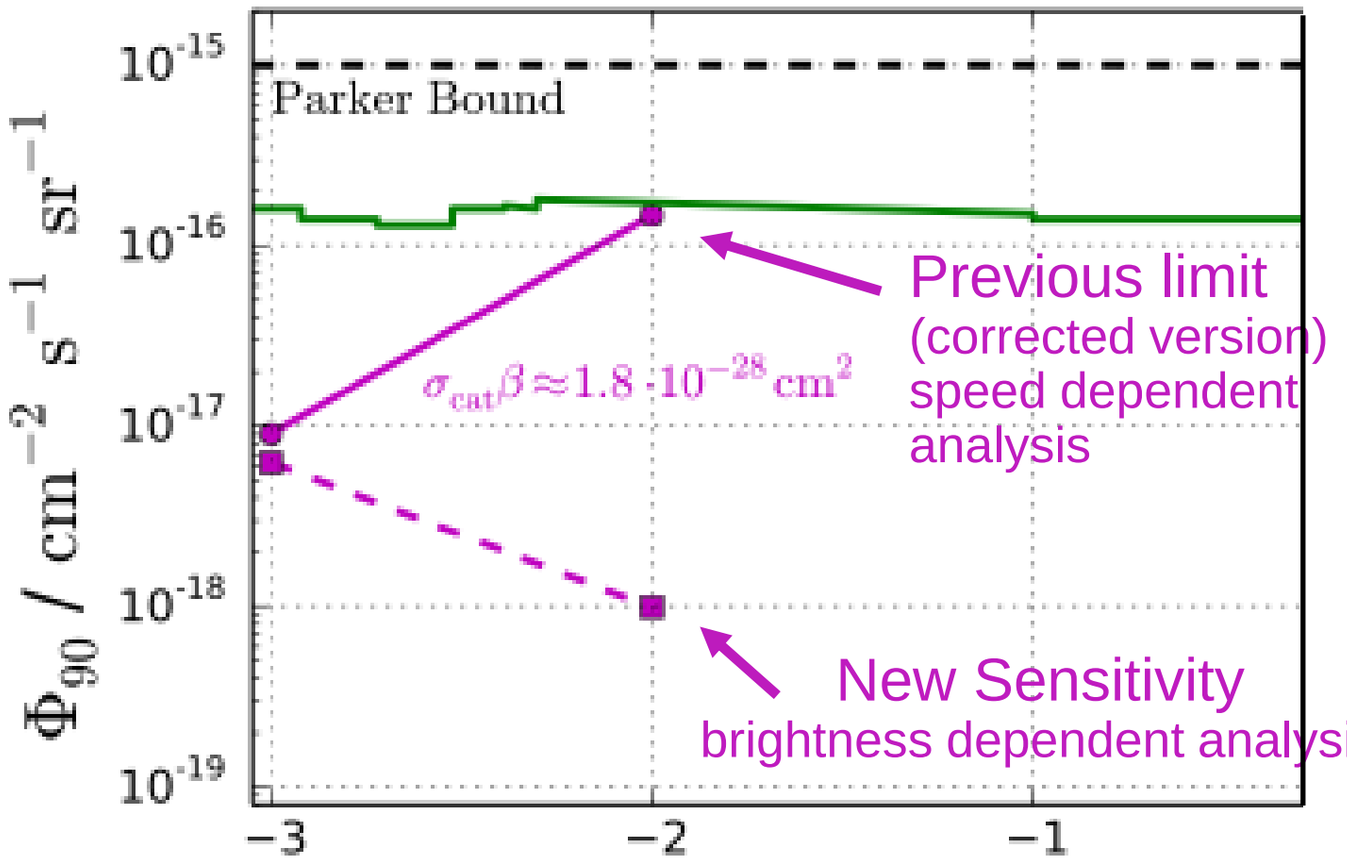

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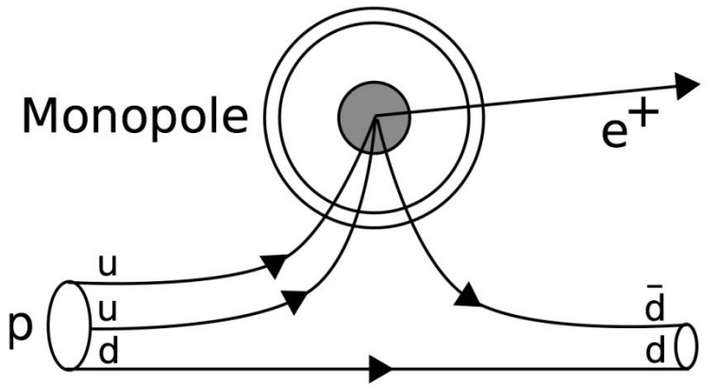
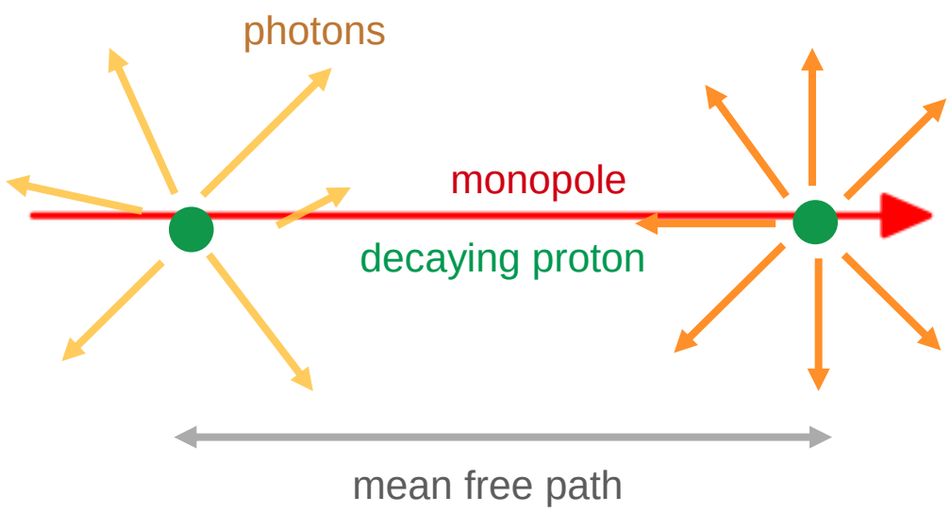
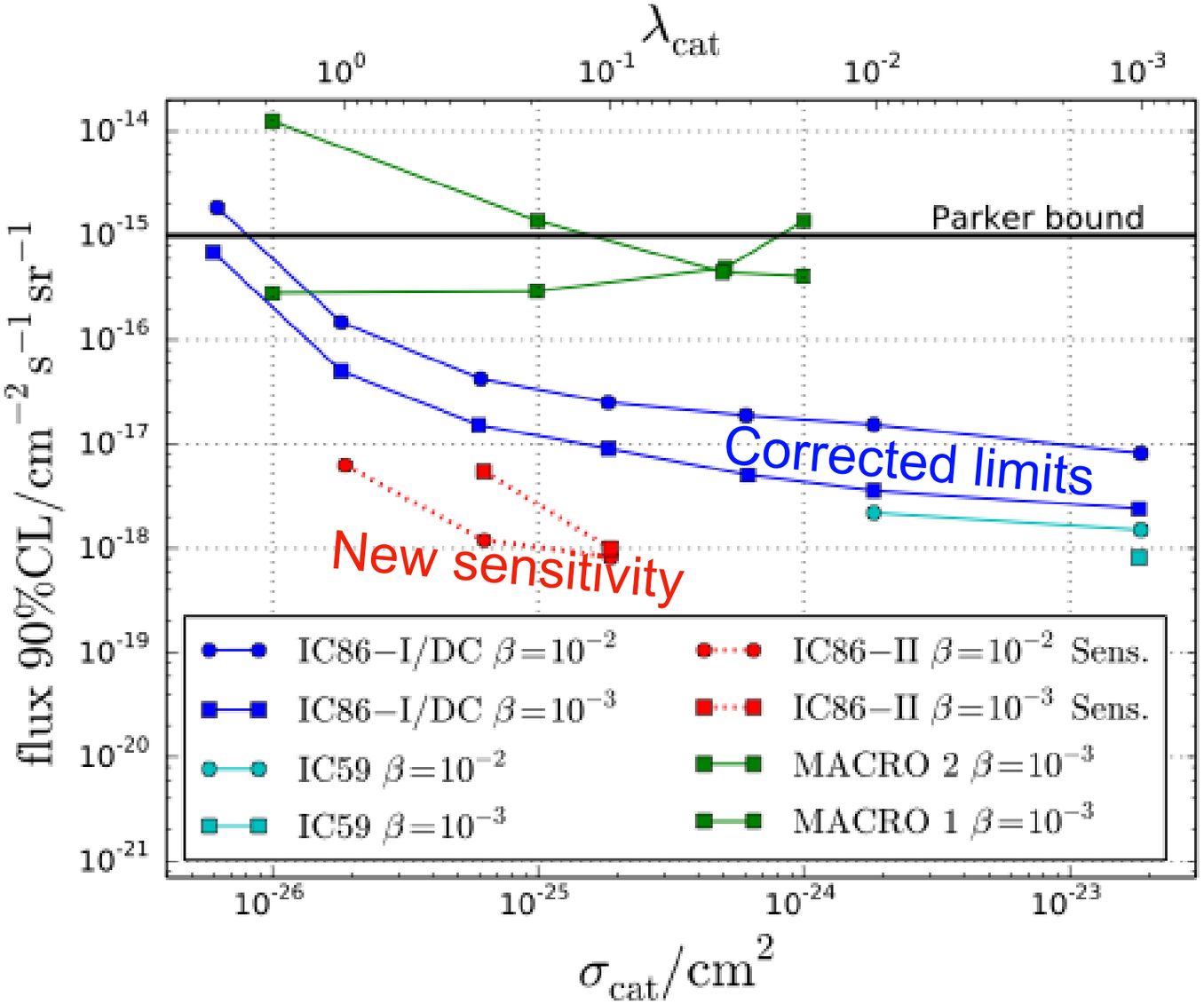


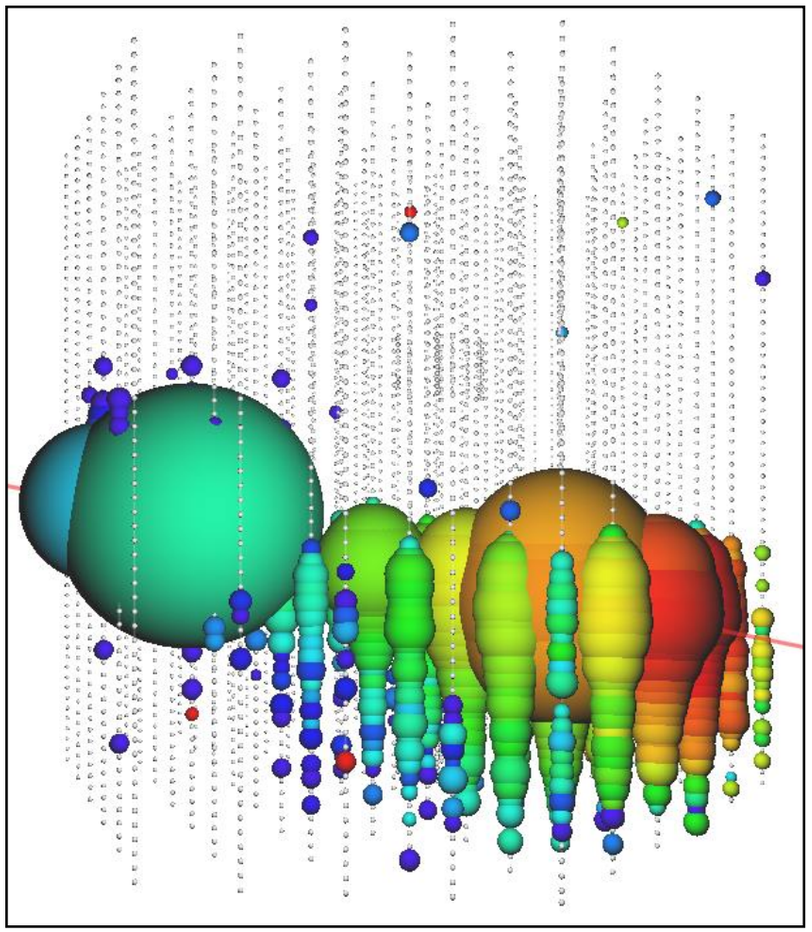




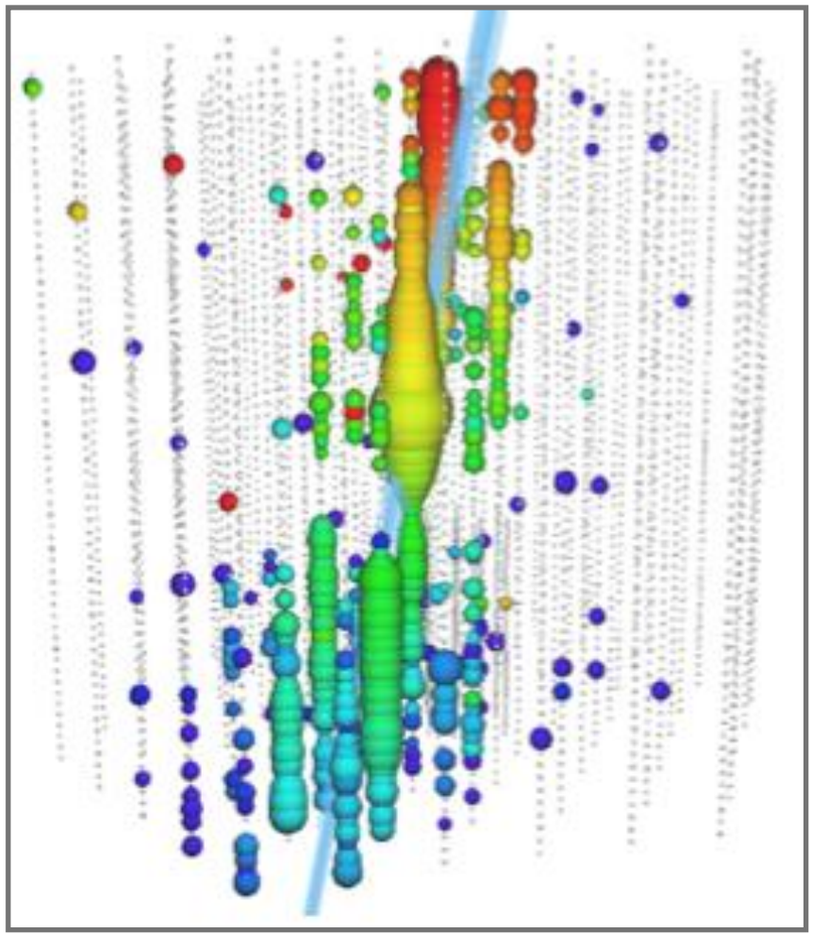
Erratum in preparation:
IceCube limits shift factor 9 to the left, previously the contribution of oxygen to cross section was neglected

Event signature of highly relativistic monopoles

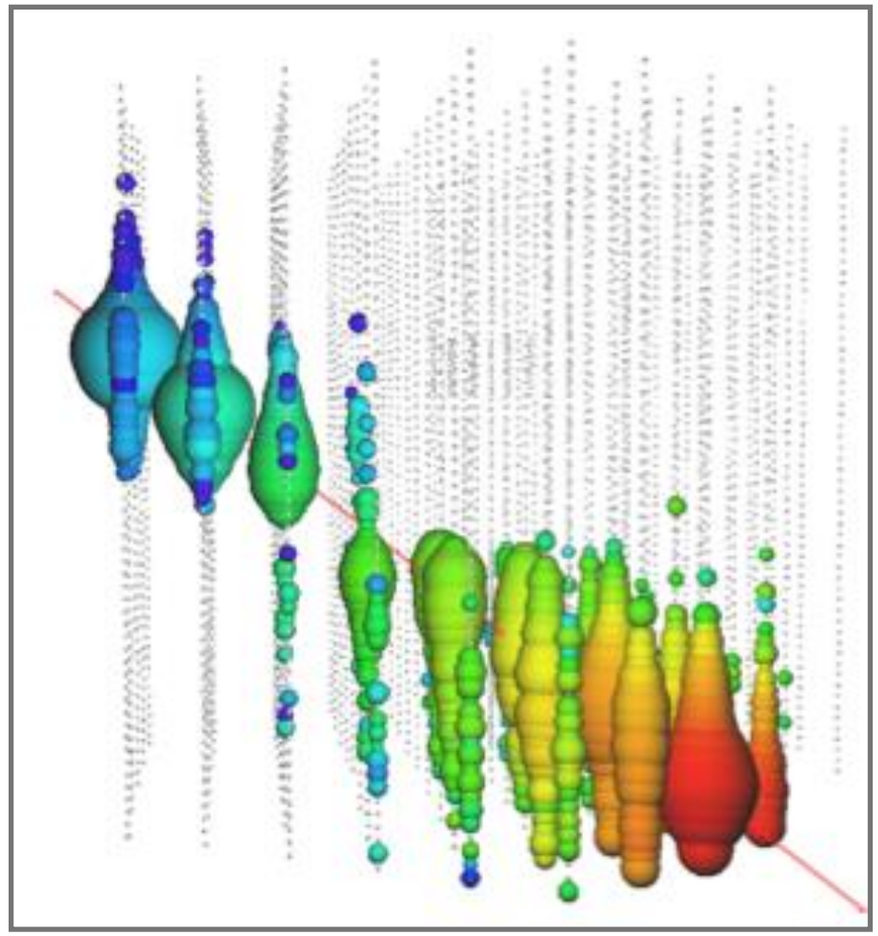
μ-neutrino
2.6 ± 0.3 PeV



μ-bundle
from cosmic rays

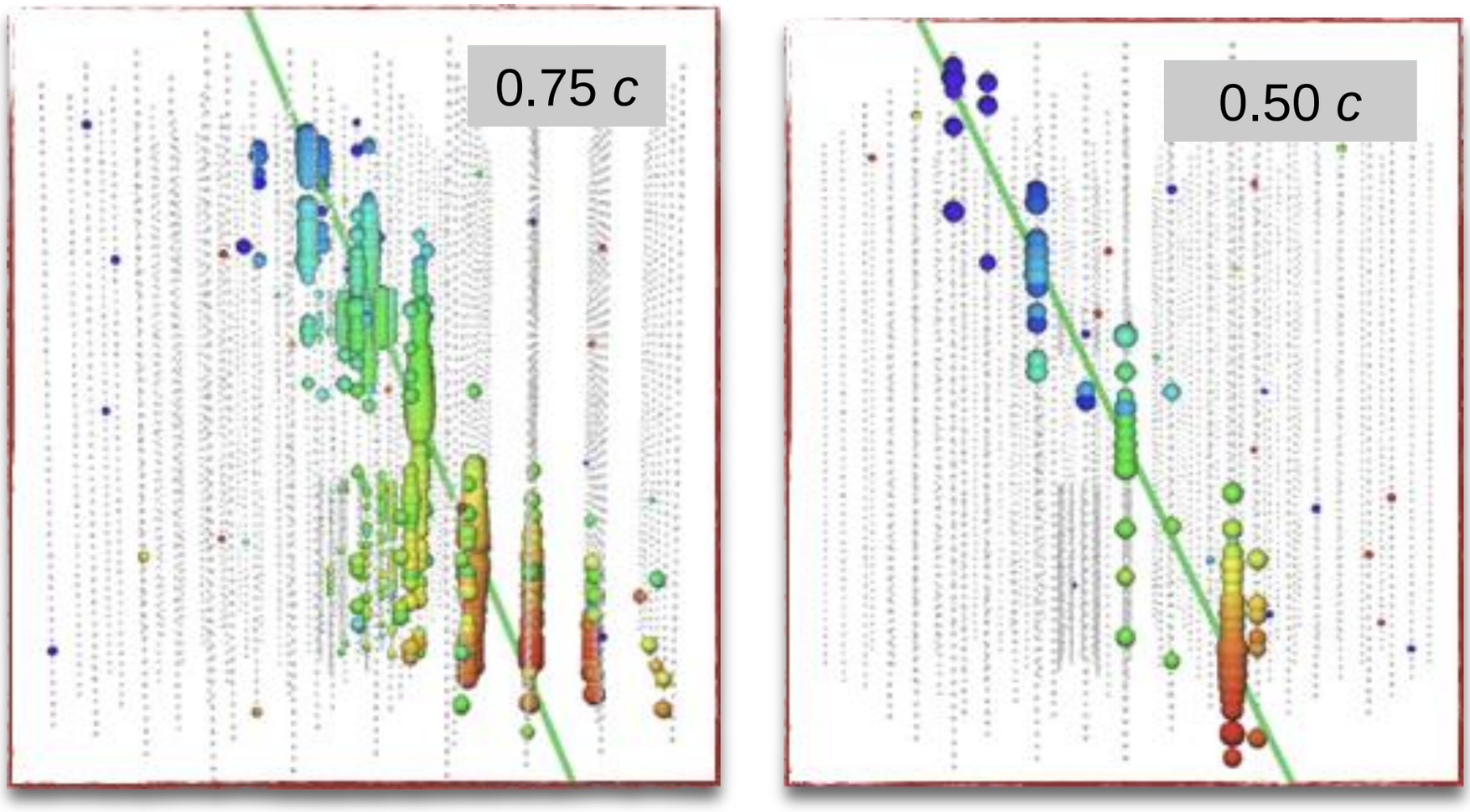


Simulation of a monopole
with 0.99 *c*



- ***High*** **energy deposition**
- ***Smooth*** **energy deposition along the track (different to h.e. neutrinos)**

Event signature of mildly relativistic monopoles

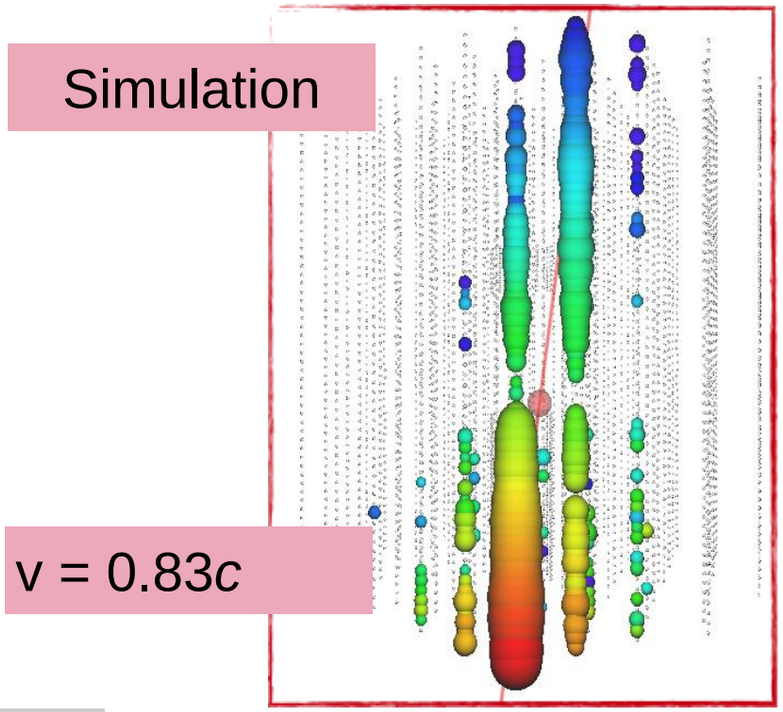


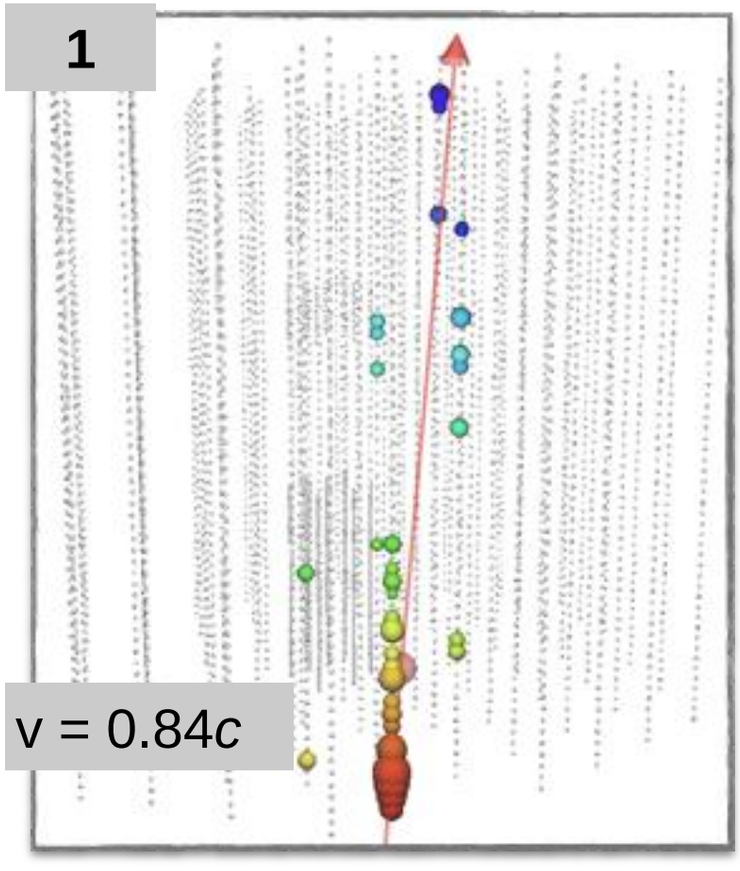
- ***High*** **energy deposition**
- ***Smooth*** **energy deposition along the track (different to h.e. neutrinos)**
- ***Lower*** **velocity**

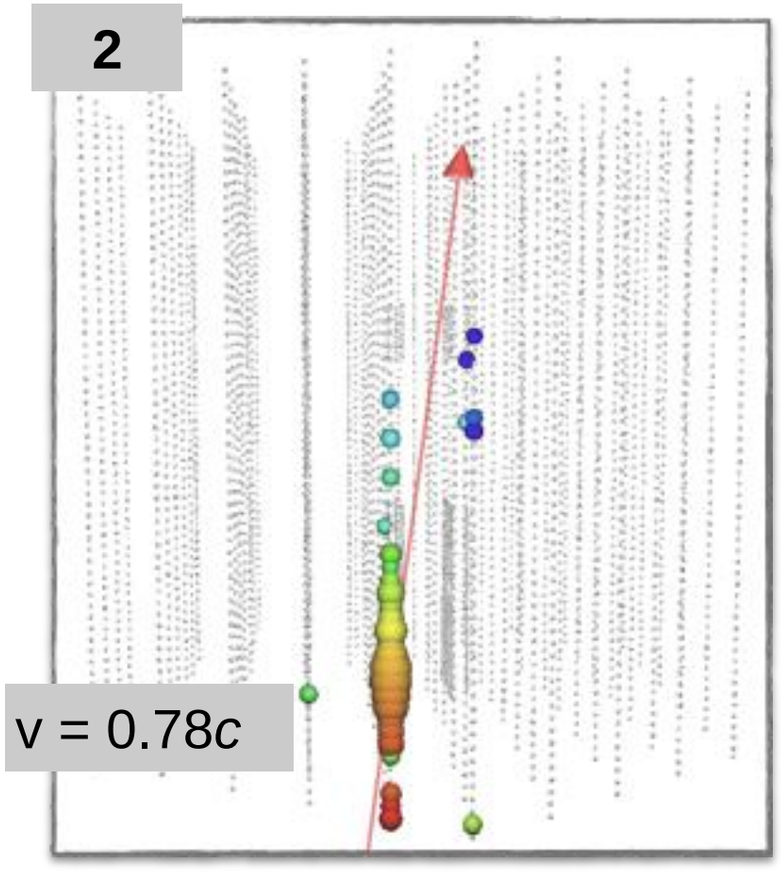
Results for mildly relativistic monopoles, 1 year of data

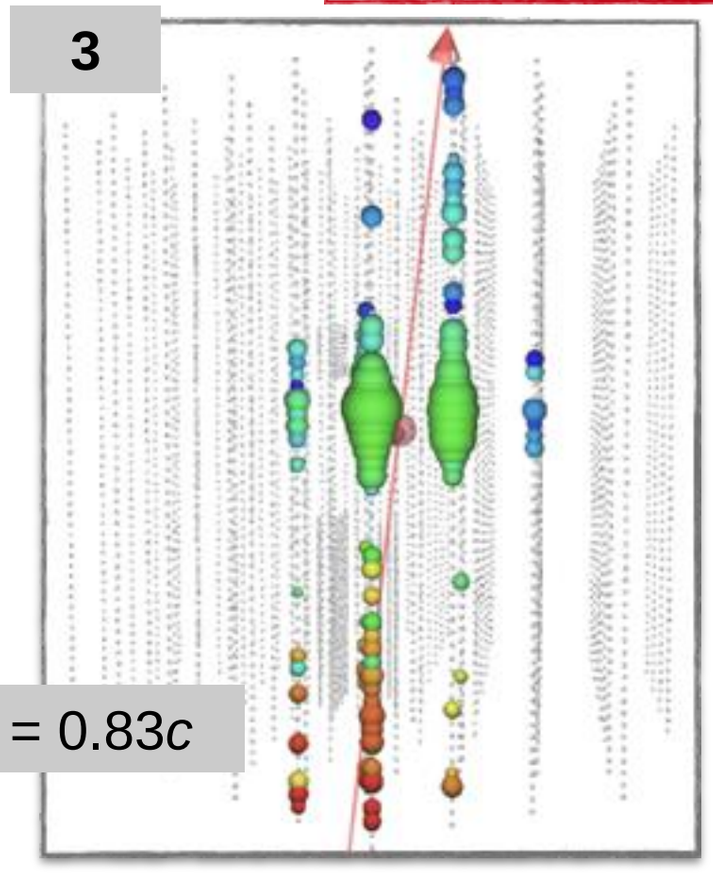
3 events after unblinding

- 1 & 2: obvious background shape → muon
- all: too dim for that velocity

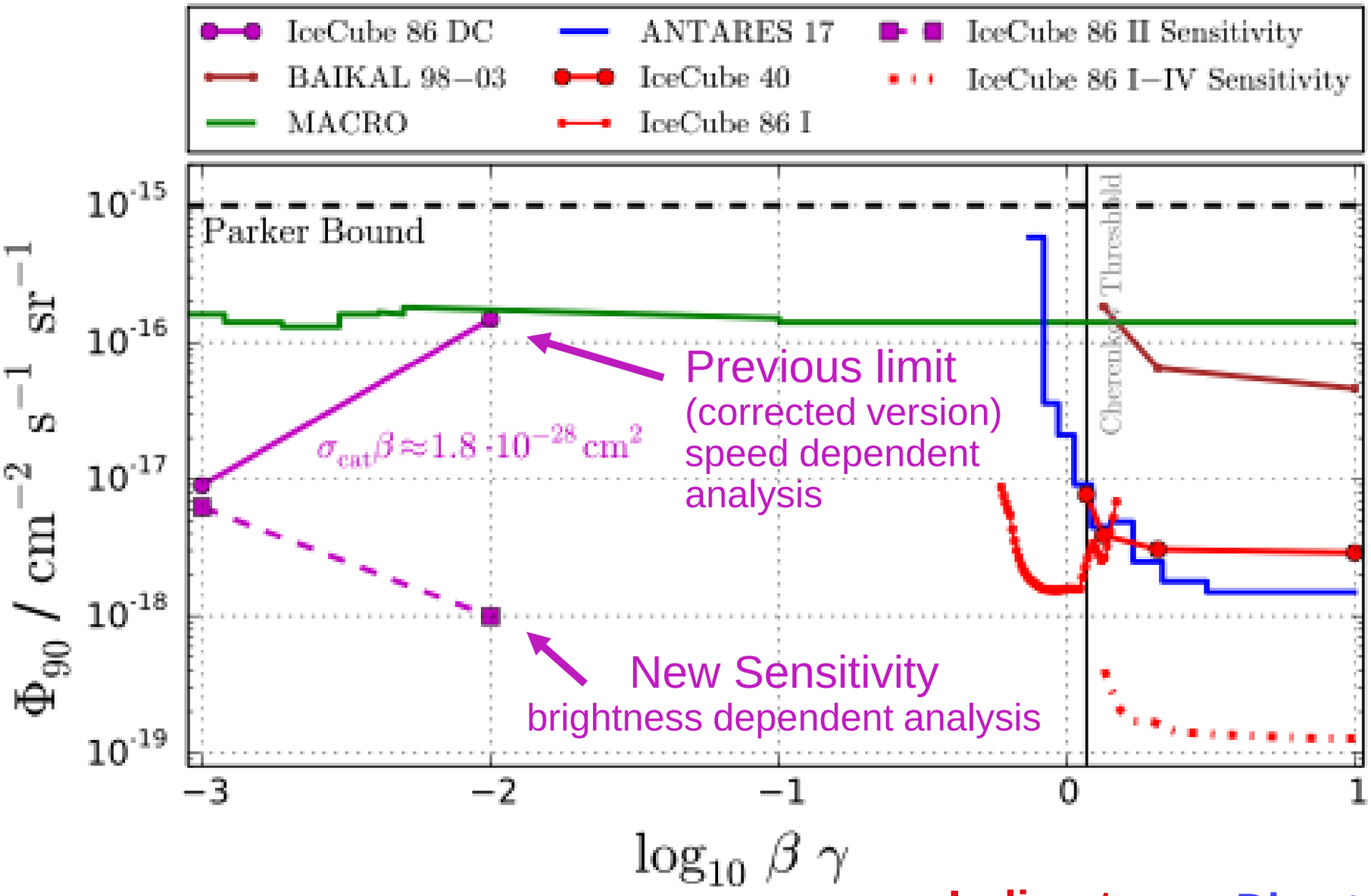








Limits on non relativistic magnetic monopoles



Estimated new densitivity

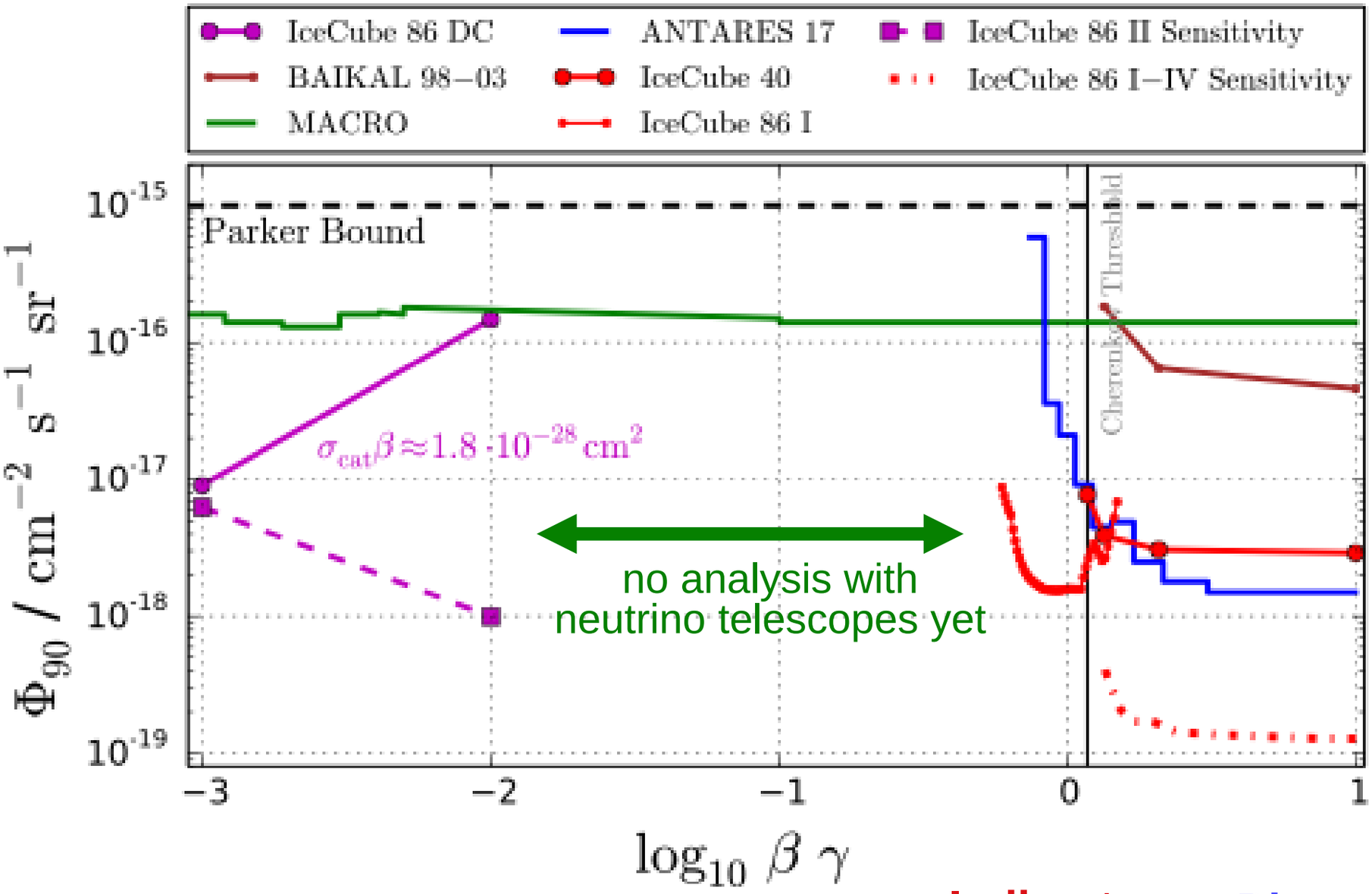
Catalysis of proton decay

Luminescence

Indirect Cherenkov radiation

Direct Cherenkov radiation

… but there is a gap:



Estimated
new densitivity

Catalysis of proton decay

Luminescence

Indirect Cherenkov radiation

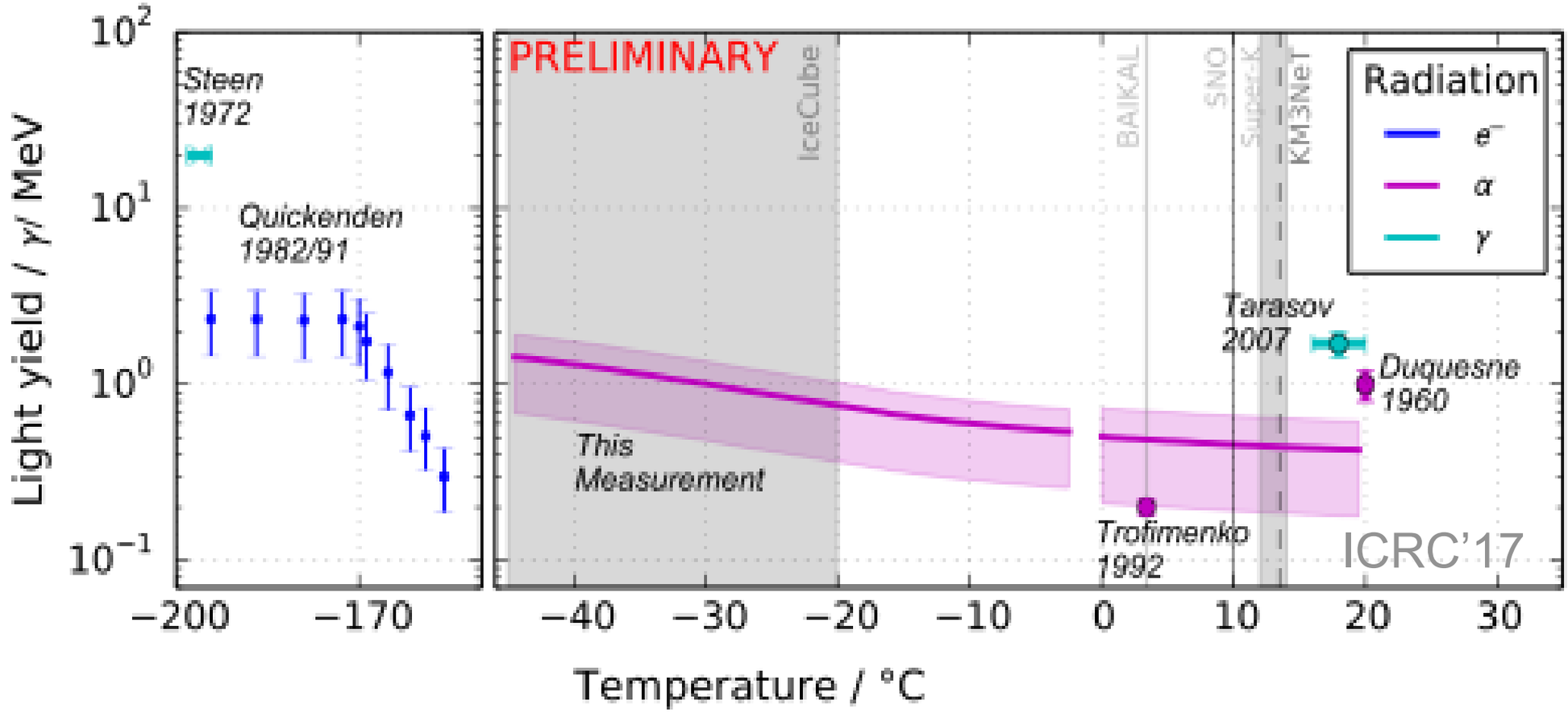
Direct Cherenkov radiation

Luminescence light measurement

Light yield depends on:

- temperature
- impurities / solubles
- radiation type
- Pressure

First measurement at temperatures of neutrino telescopes



Measurement with ^{241}Am α-source,
E(α) = 5.486 MeV (4.4$\pm$0.4) after passing of gold foil coverage

arxiv:1710.01197

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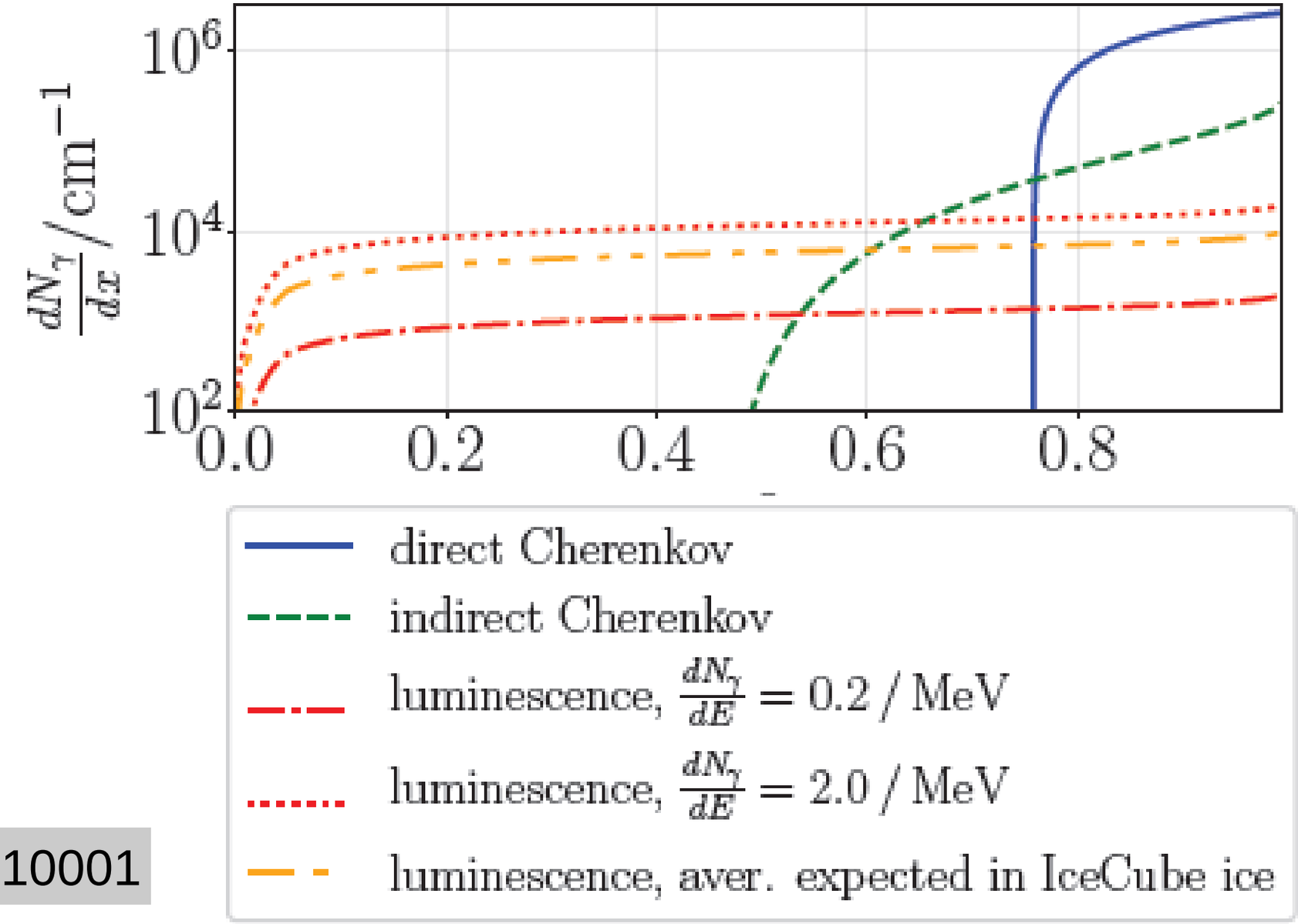

arxiv:1807.10001

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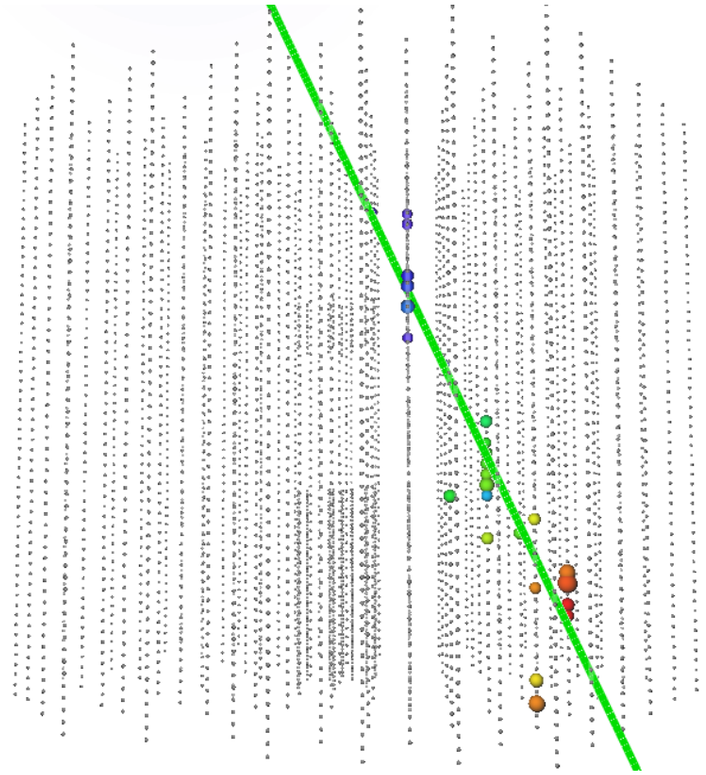
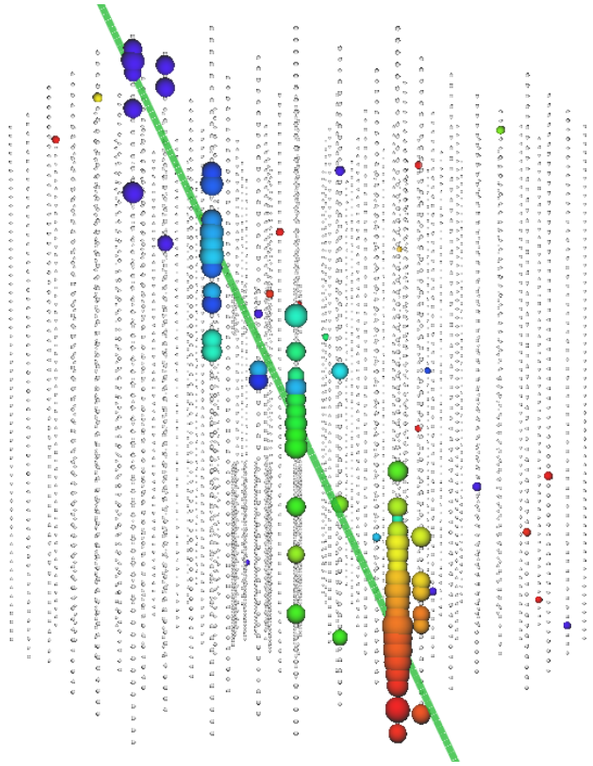
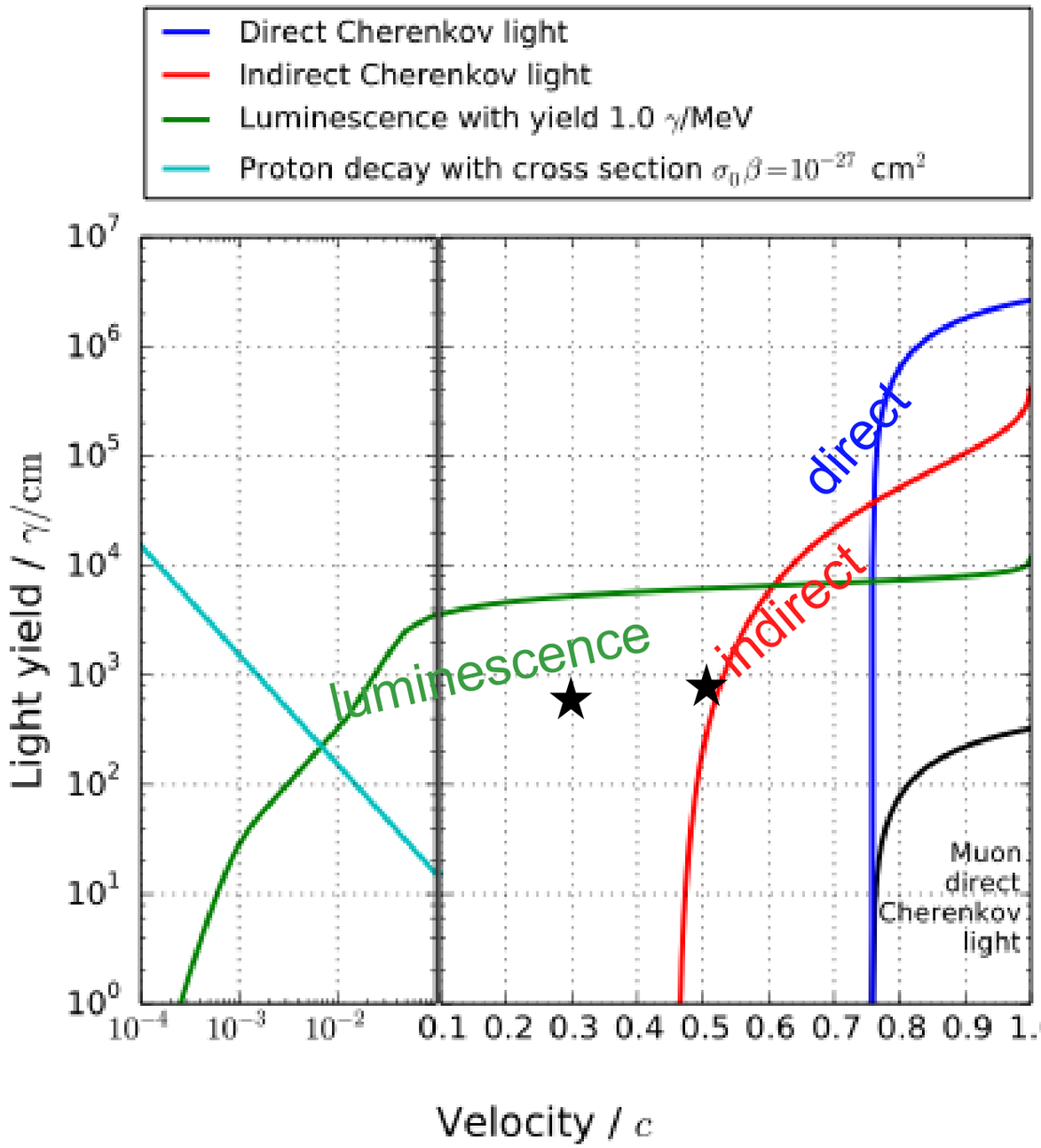
Monopole detection via luminescence



0.30 *c*



0.50 *c*



Summary

- **IceCube's large volume provides best sensitivities to intermediate / high mass magnetic monopoles**

- **non-relativisitic searches 10^{13} GeV $\leqq M_{MM} \leqq 10^{19}$ GeV**

- **relativistic searches 10^{8} GeV $\leqq M_{MM} \leqq 10^{14}$ GeV**

- **ongoing analyses at all channels**

- **unblinding (results) expected soon**