Possible designs for a Liquid-Scintillator based Surround Background Tagger for the He-bag option

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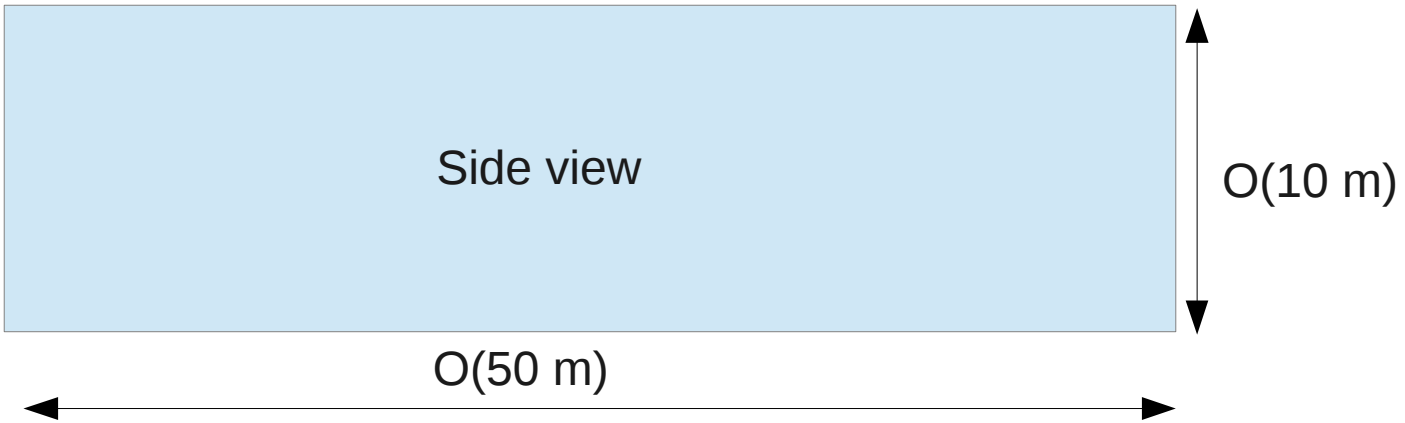
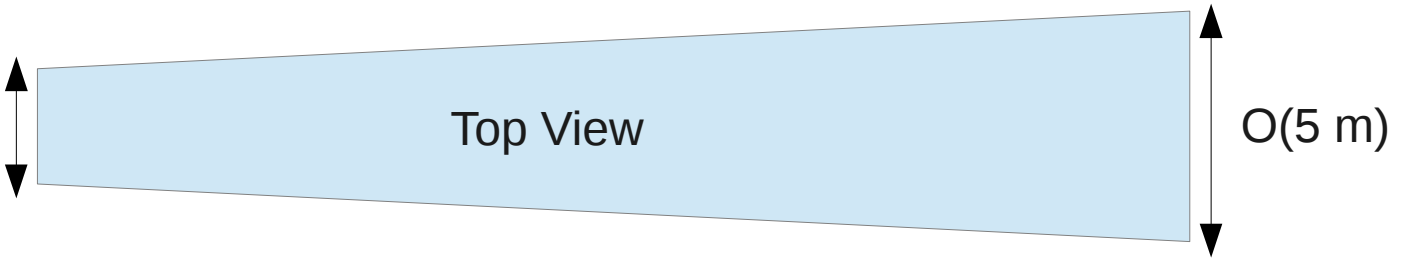
Geometry

Conical SBT:



Dimensions depend on final muon filter



Since optimized geometry not yet defined, use conservative dimensions:

5 m x 10 m x 50 m

SBT: built from rectangular boxes filled with LS

Liquid Scintillator costs/weight/handling

- **Dimensions larger than elliptical shape in TP → increase in LS volume**

  30 cm layer of LS: 450 m^3 → 387 tons LAB + PPO (1.5 g/l) → 538 kEuro

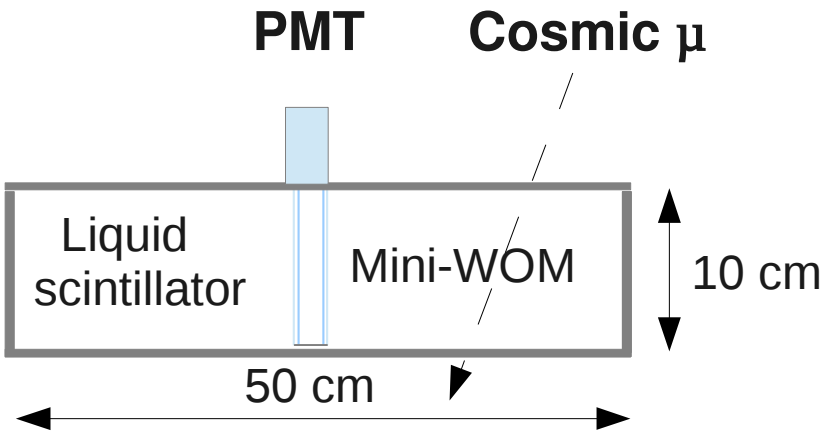
- **Handling, storage, purification, detector mantling efforts scale with LS volume**

  → Would like to minimize the amount of LS as much as possible!

Reduction of LS thickness ?

- **Can we reduce the LS layer thickness without significant loss in efficiency?**

  ε>95% with 10 x 40 x 50 cm³ boxes with low-quality LS (μ_{abs}~5 cm @ λ< 380 nm) viewed by one Mini-WOM+PMT (with mirror on other side)



Efficiency will significantly increase with
1. High-quality LS
2. Large-area WOM

For high-quality LS:
Can increase the efficiency further with PMMA-mirror plates as inner box walls

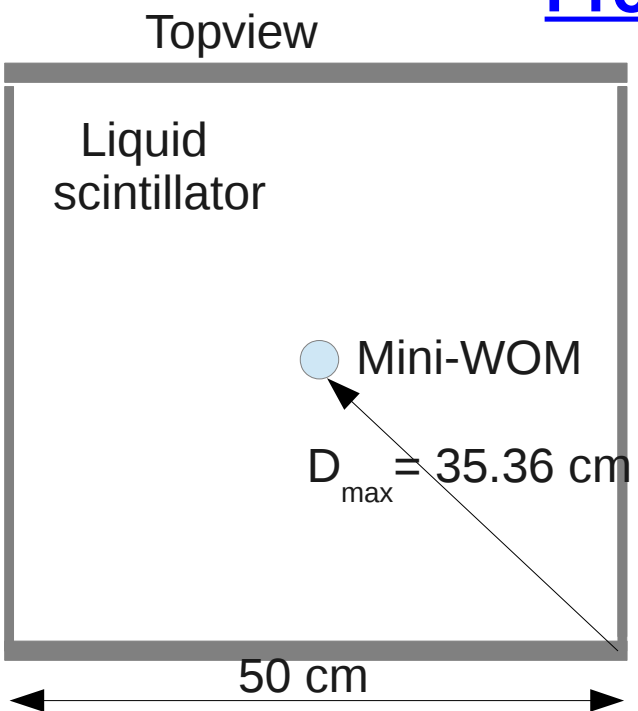
Reduced thickness & “high” granularity

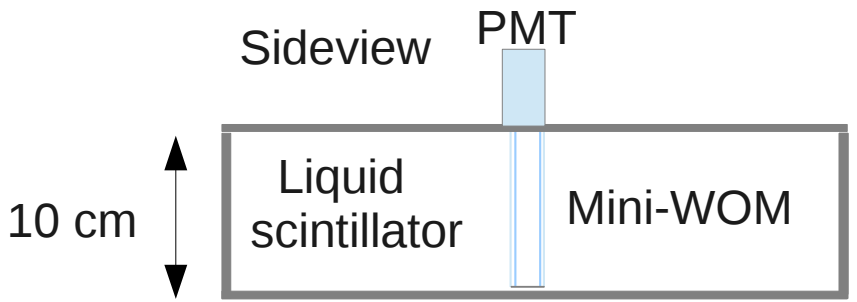
- **Assume: 10 cm thick LS layer → 150 m³ → 129 tons LAB+PPO → 179 k€**
- **Plastic scint. option: quite high granularity! LS option with high granularity?**
- **Assume 10 x 50 x 50 cm³ LS-filled boxes (~ prototype @ HU Berlin)**

  → 6000 boxes → 6000 WOMs/PMTs → 1900 k€ (w/o HV and electronics)

  + PMMA-mirror walls (if needed): 300 k€

Prototype design 0

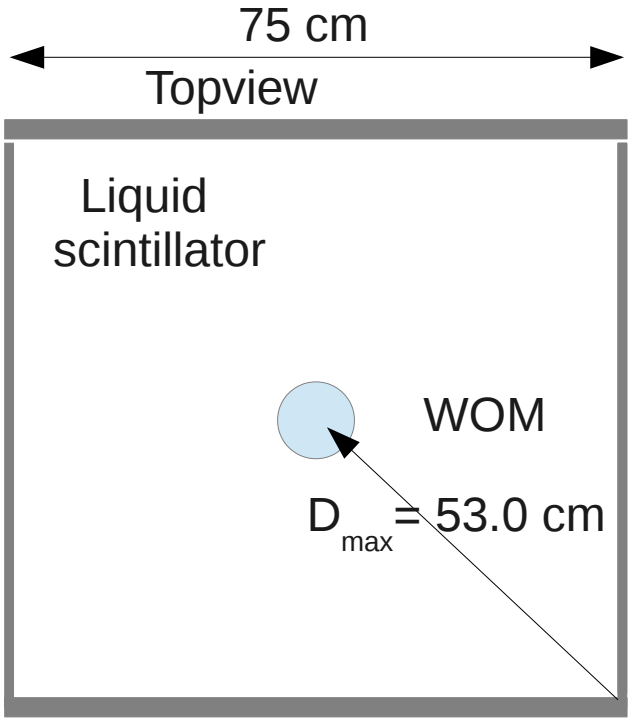


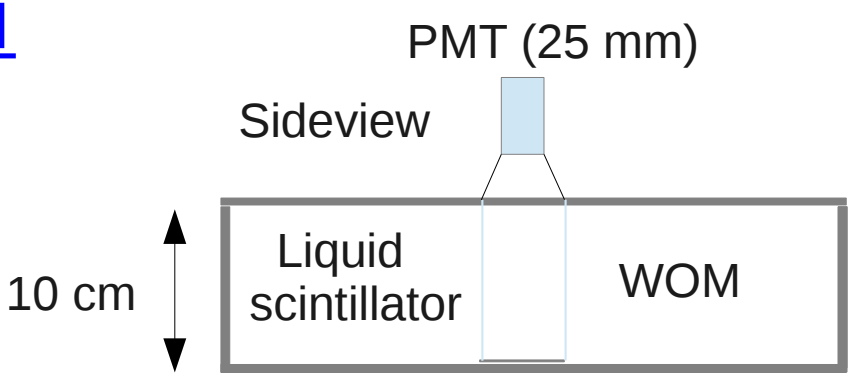


WOM area:
100 (length) x 20 (diam.) mm²
= 2000 mm²

WOM diameter/D_{max} =0.056

Design 1





WOM area:
100 (length) x 50 (diam.) mm²
= 5000 mm²

WOM diameter/D_{max}=0.094

Some efficiency drop @ WOM loc.

- **LS: 179 kEuro**
- **2667 boxes (10 x 75 x 75 cm³) → 2667 WOMs → 2667 PMTs**

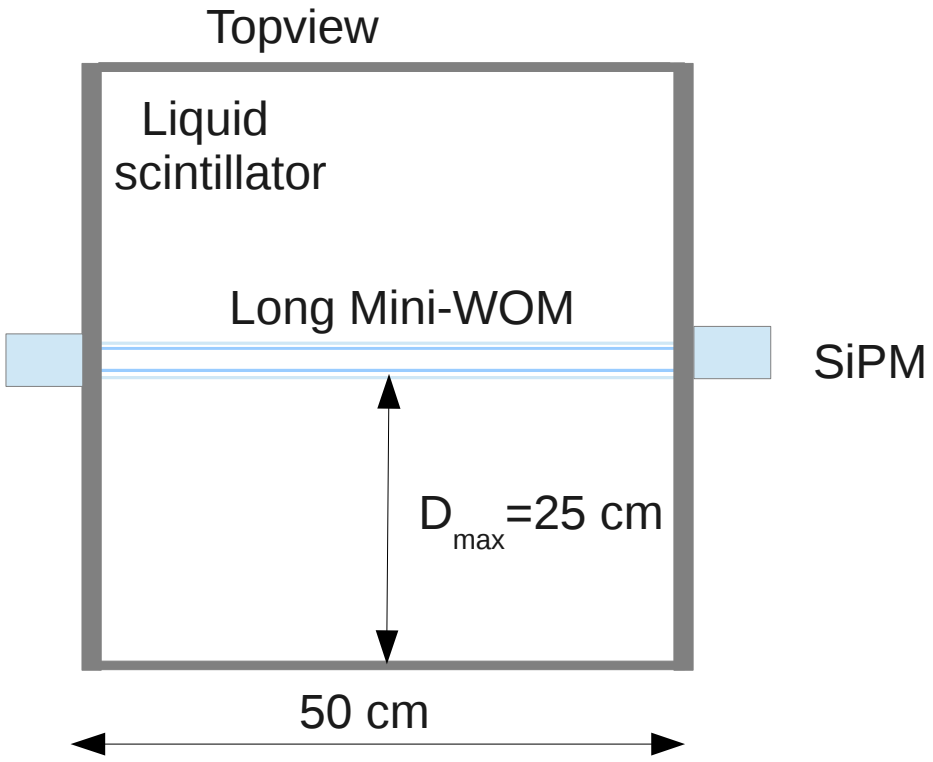
  320 € x 2667 (PMT) = 853 k€
- **PMMA-mirror inner box walls: 100 € x 2667 = 267 k€**
- **Costs (w/o HV, electronics and cabling) in k€:**

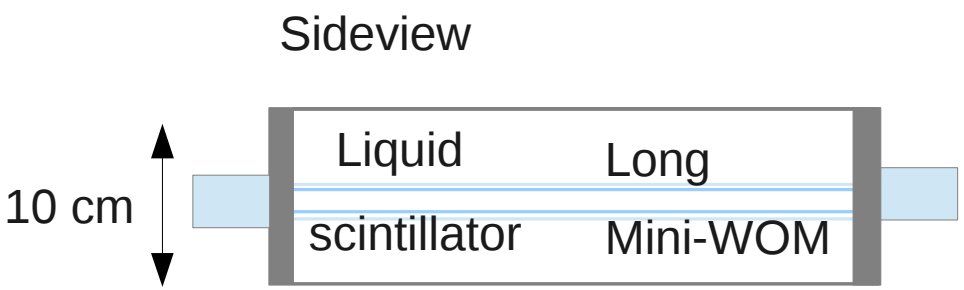
LS thickness	10 cm	20 cm
with mirror box walls	1299	1478
w/o mirror box walls	1032	1211

Design 2

- **Photo-sensor alternative: e.g. Hamamatsu S13360-6075PE SiPM (6 x 6 mm² area) (ε=50% @ 450 nm)**
  Further studies needed, e.g. concerning dark count rate
- **Costs: 35 € (SiPM) + 40 € (power supply) for several thousand SiPM**

→ Need to reduce WOM diameter →Loss in efficiency → Use long Mini-WOM





WOM area:
500 (length) x 6 (diam.) mm²
= 3000 mm²

WOM diameter/D_{max}=0.024

Two-sided read-out!
→ relative efficiency gain of 2
(if transport losses are small)

Costs for Design 2

- **LS: 179 k€**

- **6000 LS-filled boxes (10 x 50 x 50 cm^3) → 6000 WOMs → 12000 SiPM**

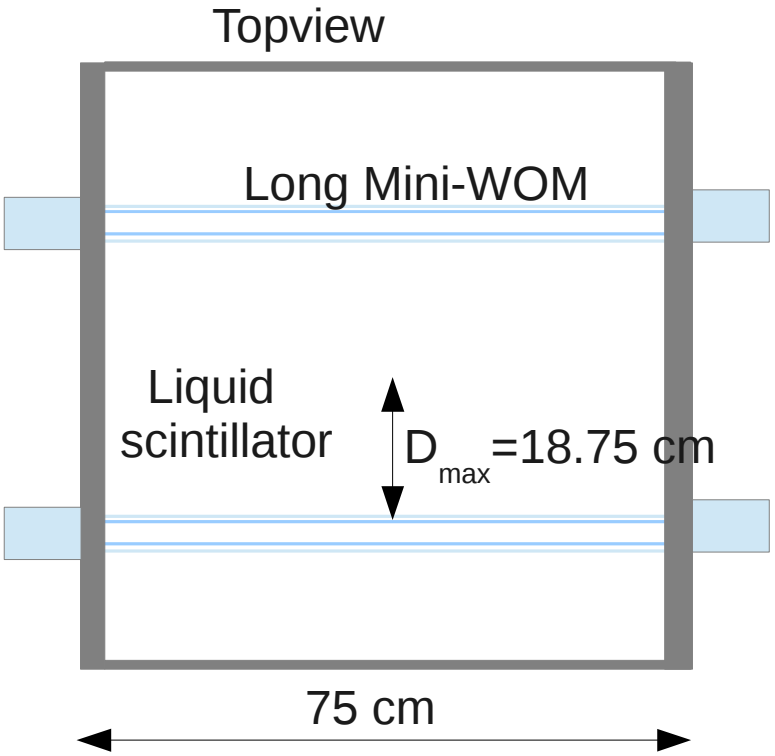
  Costs: 30 € x 12000 (SiPM) + 38 € x 12000 (power supply) = 816 k€

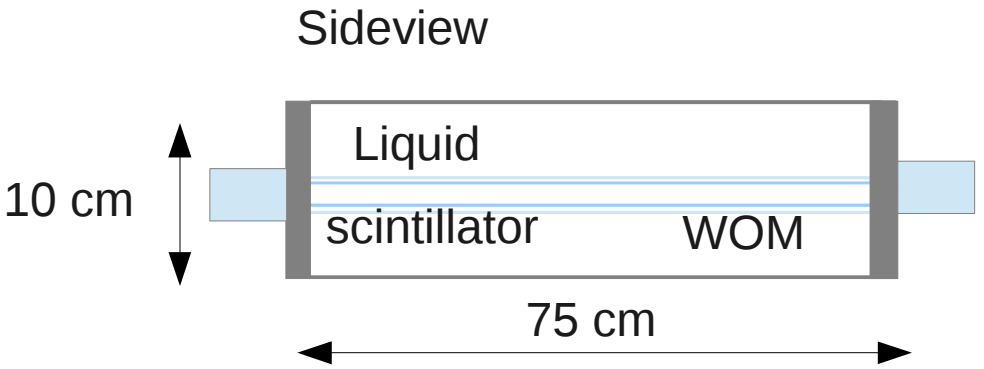
- **PMMA-mirror box walls: 50 € x 6000 boxes = 300 k€**

- **Costs (w/o electronics and cabling) in k€:**

LS thickness	10 cm	20 cm
with mirror box walls	1295	1374
w/o mirror box walls	1028	1295

Design 3





WOM diameter/D_{max}=0.032

Two-sided read-out!
→ relative efficiency gain of 2
(if transport losses are small)

Two WOMs!
→ relative efficiency gain

About same efficiency as Design 1

Simpler WOM construction and their deployment in the SBT wrt Design 1

Increase in box area wrt Design 2: **$75^2/50^2$ → Reduction in box numbers: 1/2.25**

Increase in number of photosensors/box: 2/1

→ Reduction in number of photo sensors: 11%

Costs for Design 3

- **LS: 179 kEuro**

- **2667 LS-filled boxes (10 x 75 x 75 cm^3) → 5333 WOMs → 10666 SiPM**

  30 € x 10666 (SiPM) + 38 € x 10666 (power supply) = 725 k€

- **PMMA-mirror inner box walls: 100 € x 2667 = 267 k€**

- **Costs (w/o electronics and cabling) in k€:**

LS thickness	10 cm	20 cm
with mirror box walls	1171	1350
w/o mirror box walls	905	1083

Plans & ManPower (for Comprehensive Design Report)

- **Purchase 1 ton of high-quality LAB + 1 kg PPO**

  Contruct boxes with and w/o PMMA mirror walls (or mirror foils?)

  Build different WOM types (also for vacuum tank solution → TP)

  Test different photo sensors (PMT R1924, SiPM S13360-6075PE)

  Test designs 0, 1, 2, and 3: efficiency, time resolution, light yield

  Simulation studies of SBT veto performance in offline analysis

- **ManPower (@ HU Berlin):**

  H. Lacker (0.25 FTE)

  Ievgen Korol (Postdoc, 1 FTE, Starting date: 01/09/2016)

  Plamenna Venkova (PhD student, 1 FTE, Starting date: 01/09/2016)

  Maik Daniels/O. Epler (Technicians, 0.25 FTE)