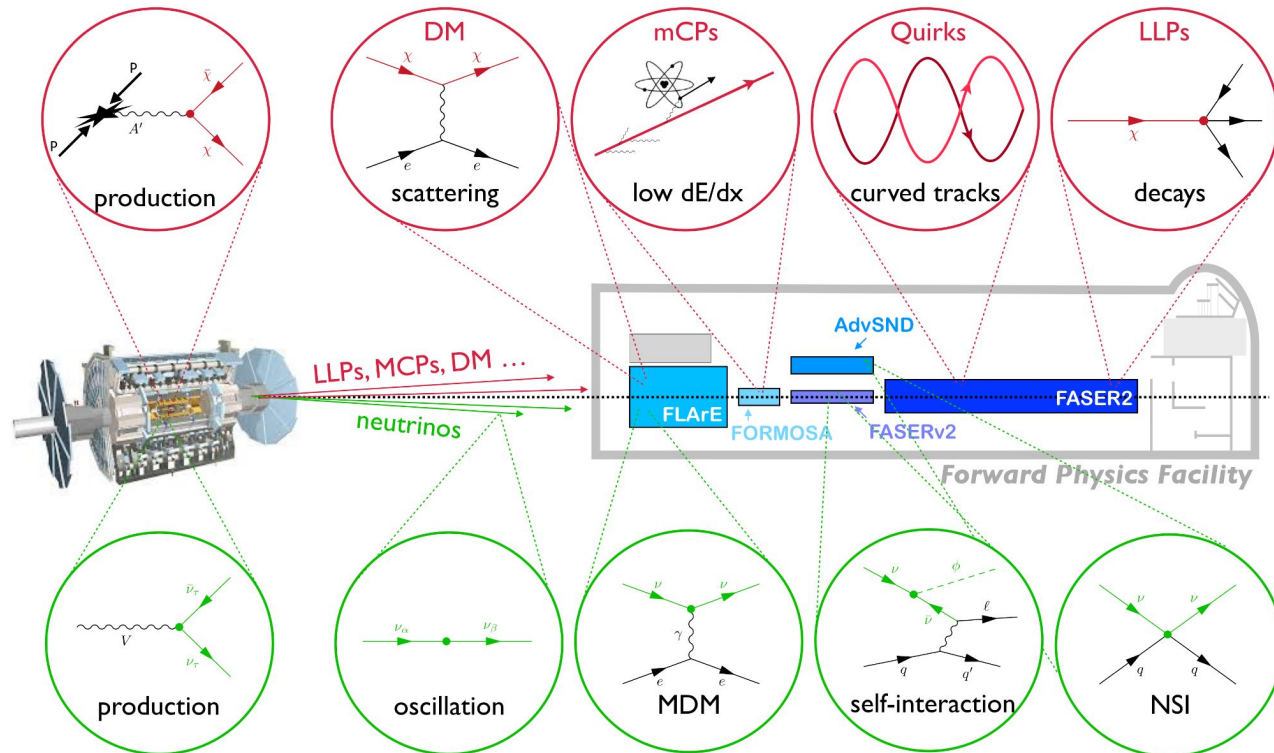


Updates on FORMOSA:



THE OHIO STATE UNIVERSITY

Cost, Schedule, Performance & Points for Discussion

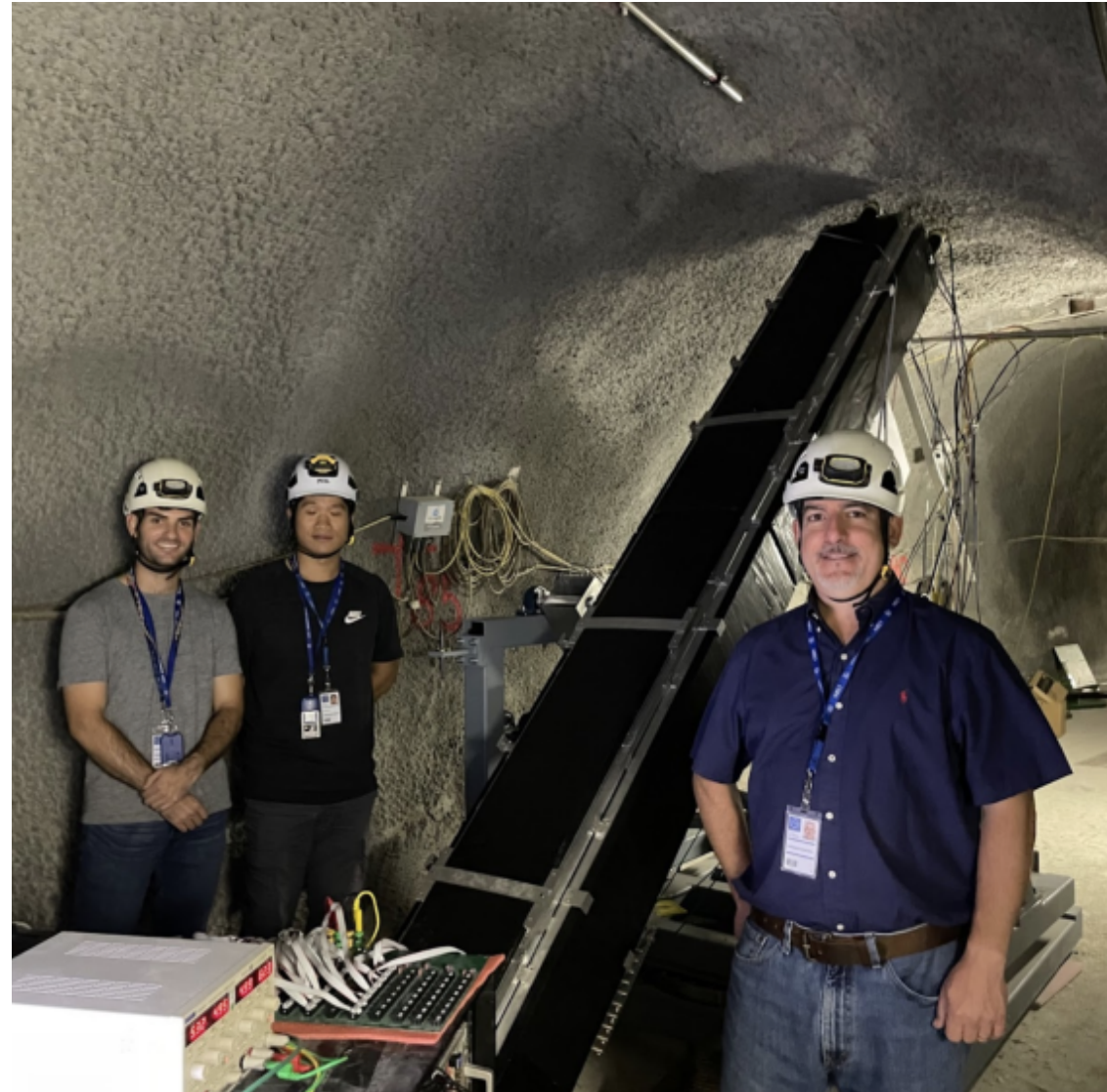


FPF “in-person” meeting

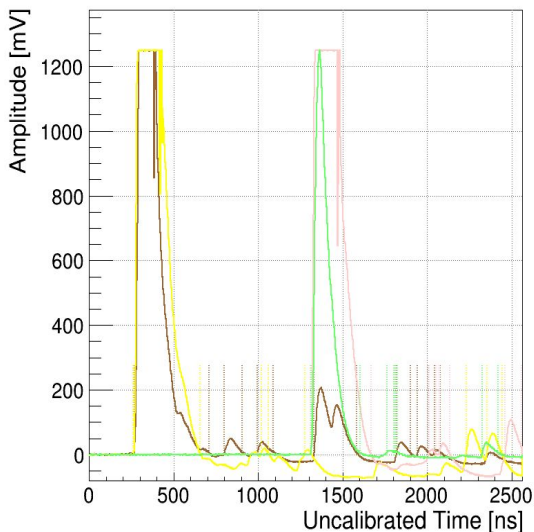
Christopher S. Hill
 The Ohio State University
 11/15/22

milliQan Run 3 “Bar” Detector Taking Data

- Run 3 bar detector installed over last few months
- Taking collision, cosmic, source data
 - *commissioning*
 - *calibration*
- Install “slab” detector over shutdown, and have full detector ready by end of YETS



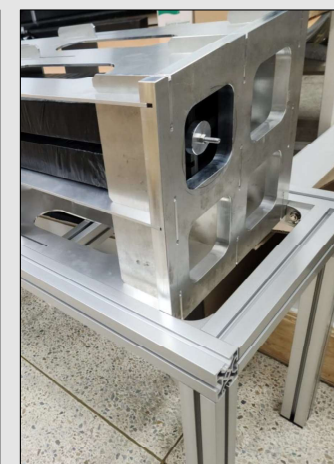
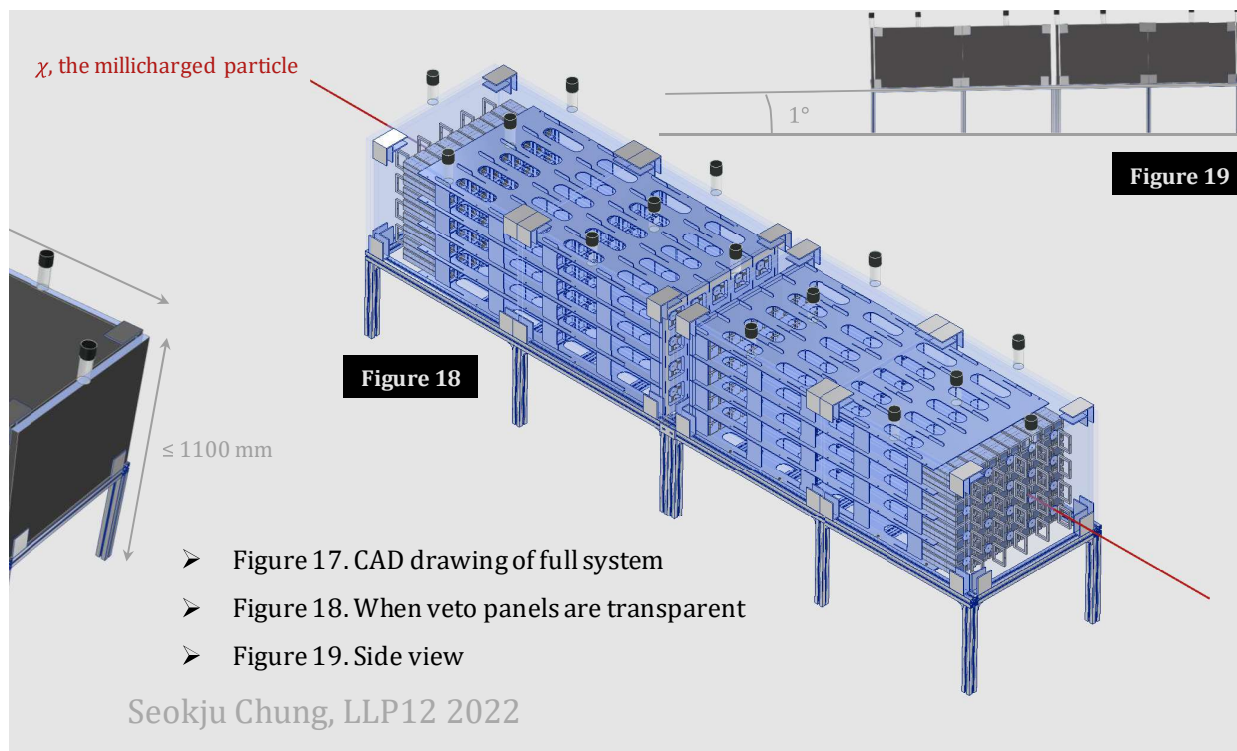
Run 494, File 1, Event 94



Channel 8, $V_{\max} = 1250$, $N_{\text{pulses}} = 7$
 Channel 9, $V_{\max} = 1249$, $N_{\text{pulses}} = 5$
 Channel 17, $V_{\max} = 1249$, $N_{\text{pulses}} = 4$
 Channel 22, $V_{\max} = 1248$, $N_{\text{pulses}} = 4$

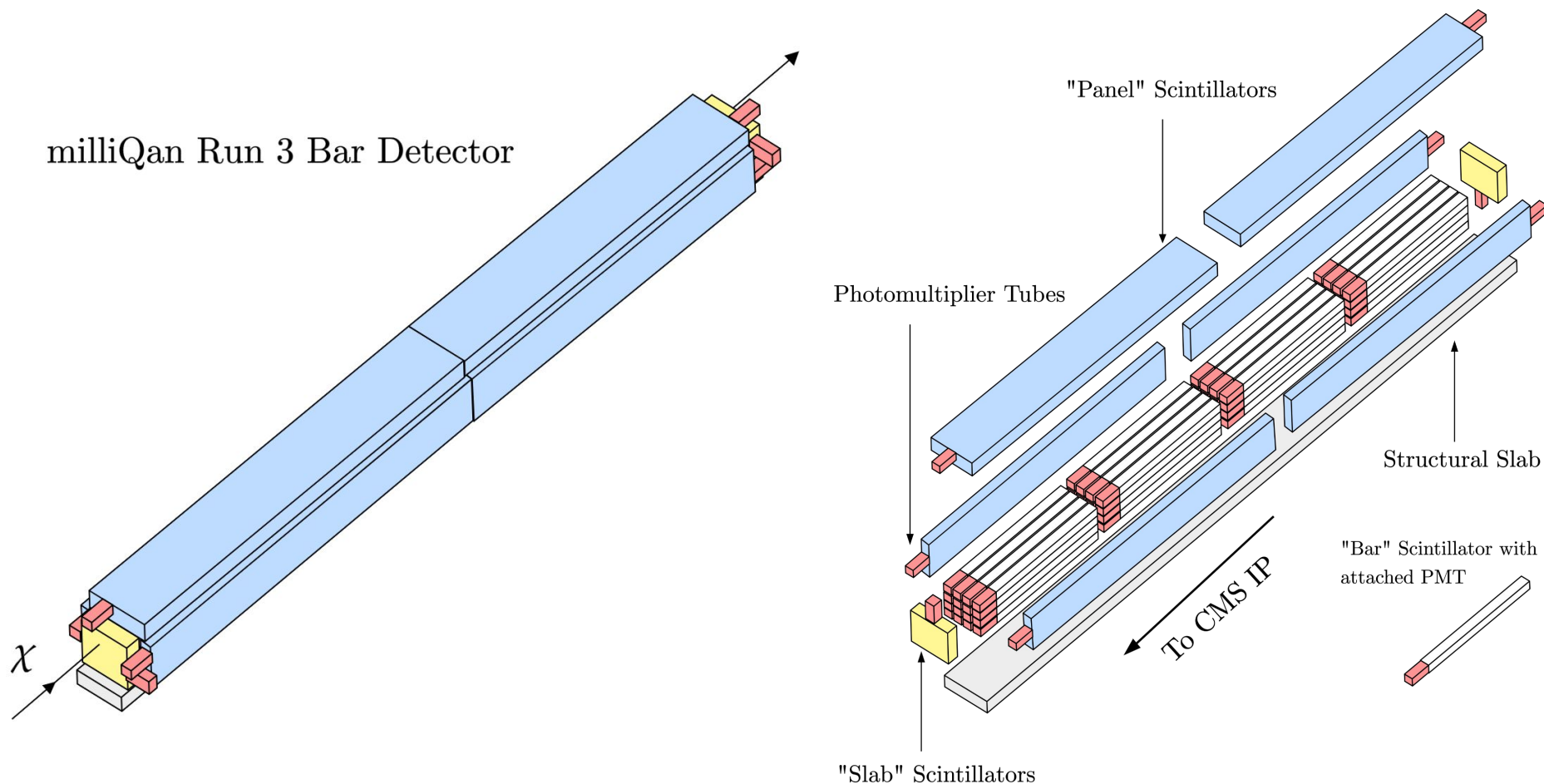
Also SUBMET, under construction in Korea

- A 3rd scintillator array will be deployed at JPARC (pending final PAC approval)
- Experience building/ commissioning/ operating milliQan Run 2 demonstrator, milliQan Run 3 detector, and SUBMET
 - *Makes cost & schedule estimates reliable*



FORMOSA is “just” a scaled up milliQan/SUBMET

- Modular, array can be as big/small as we want
 - $5 \times 5 \text{ cm}^2$ scintillator bars + PMTs, grouped in mechanical super-modules, + veto panels
 - 4 layers of supermodules for coincidence
 - Plastic is be EJ-200 or BC-408 (or similar)



Q/e sensitivity proportional to length of bars, L

- Will make as long as longitudinal space allows
 - *Are these dimensions fixed?*

FASER2

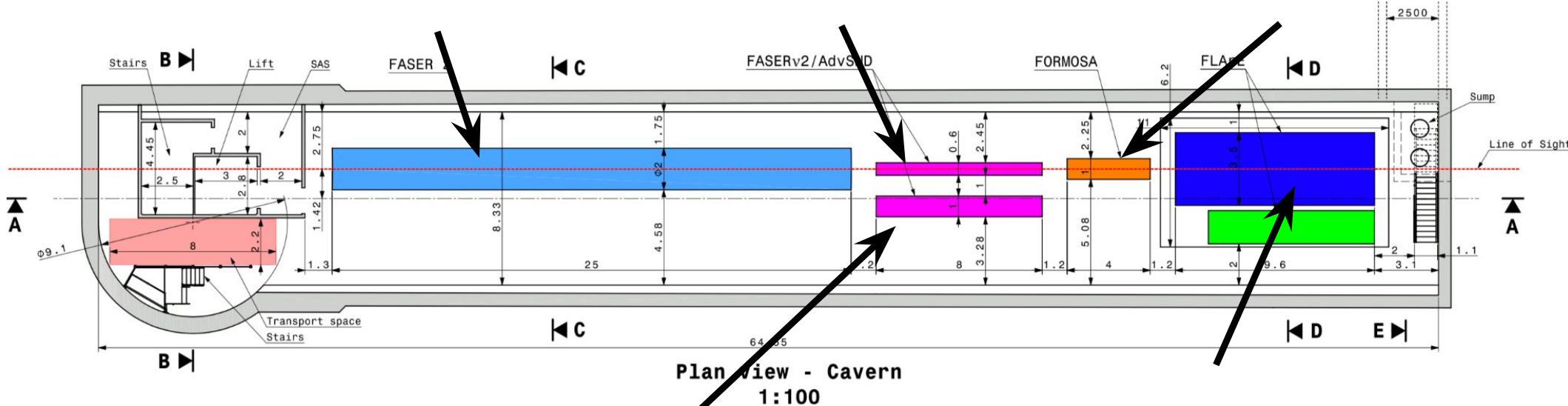
magnetized spectrometer
for BSM searches

FASERv2

emulsion-based
neutrino detector

FORMOSA

plastic scintillator array
for BSM searches



AdvSND

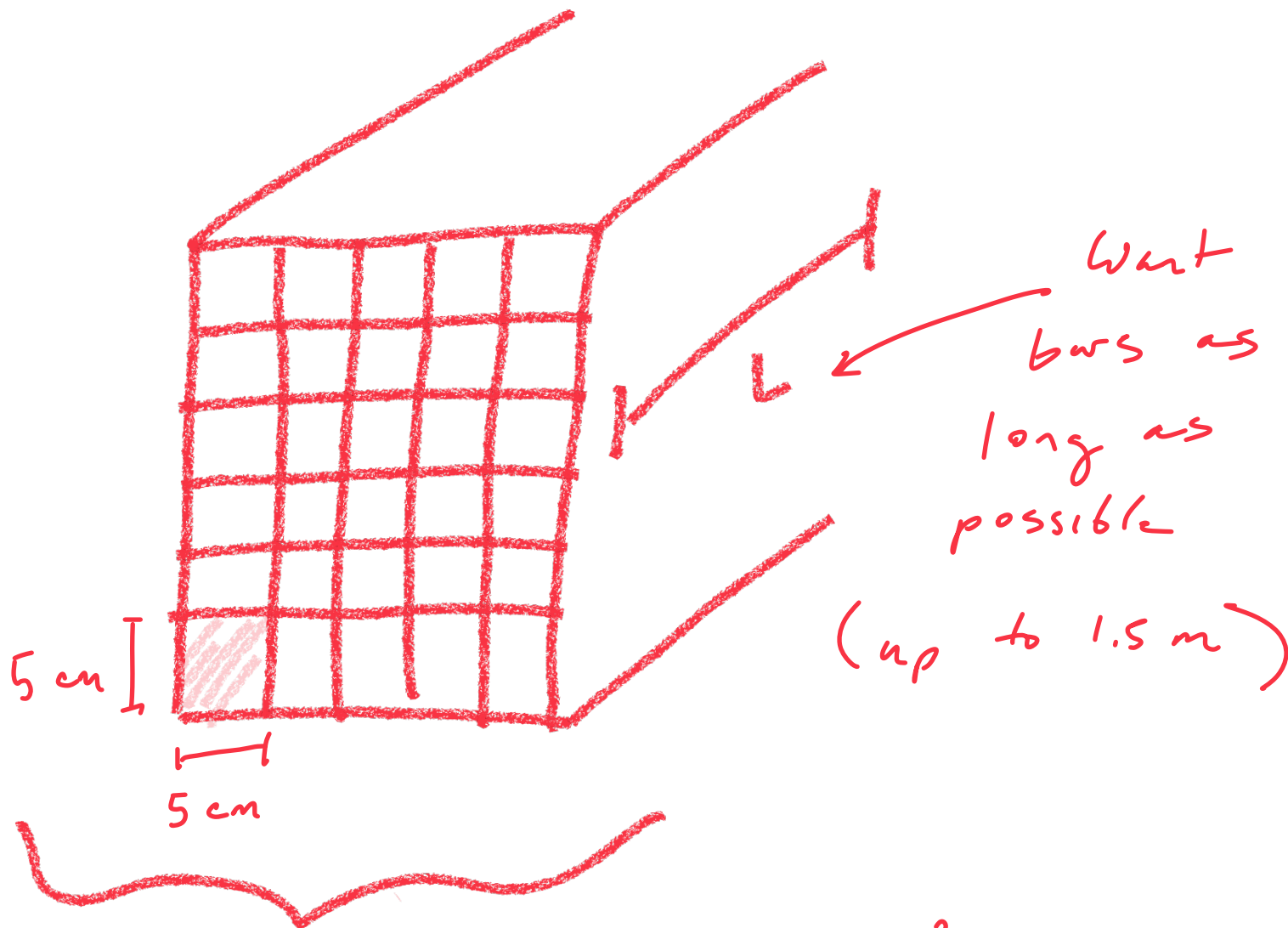
electronic
neutrino detector

FLArE

LAr based
neutrino detector

Also (less) sensitive to transverse area, A

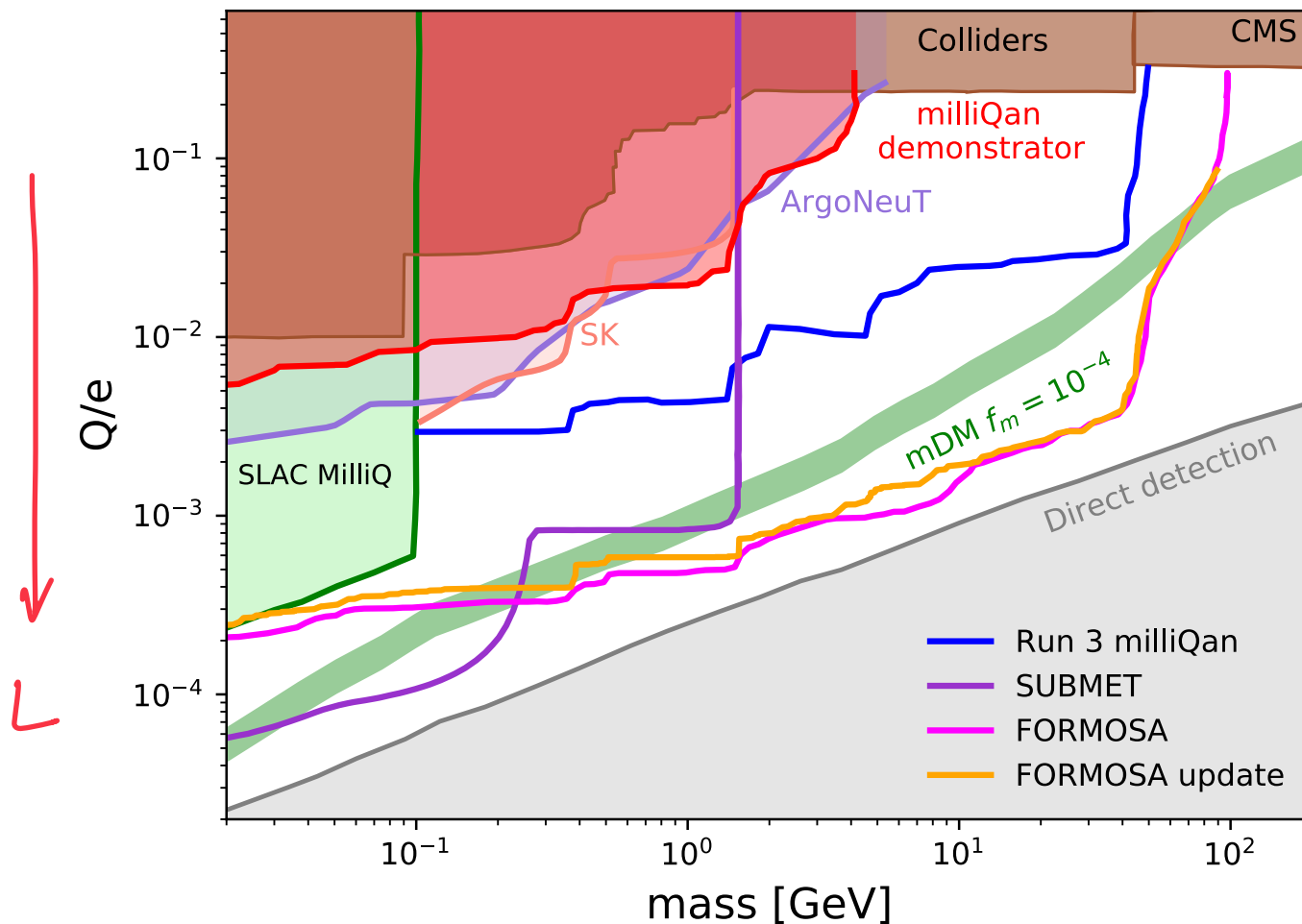
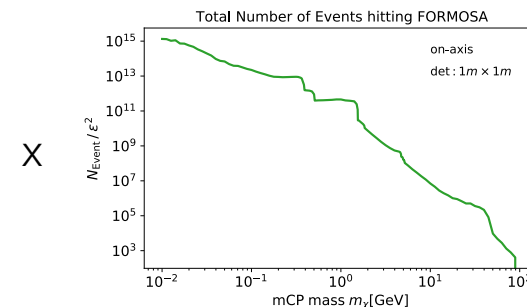
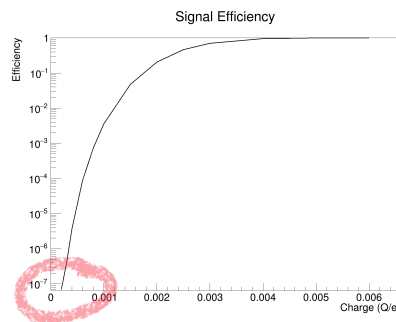
- Will make A as large as *space and money* allow
 - *milliQan Run 3 slab detector was "cheap" way to extend A*
- FORMOSA Will not see much ROI going beyond current 20 x 20 x 4 design



Can increase A by adding more $5 \times 5 \text{ cm}^2$ bars

Physics reach, 20x20x4 nominal design

- Physics sensitivity updated from that in original FORMOSA paper
- Now includes full GEANT simulation, calibrated by milliQan data
 - *No significant change to projected reach*
- Still don't have integration with simulation from ATLAS IP



Construction (based on milliQan experience)

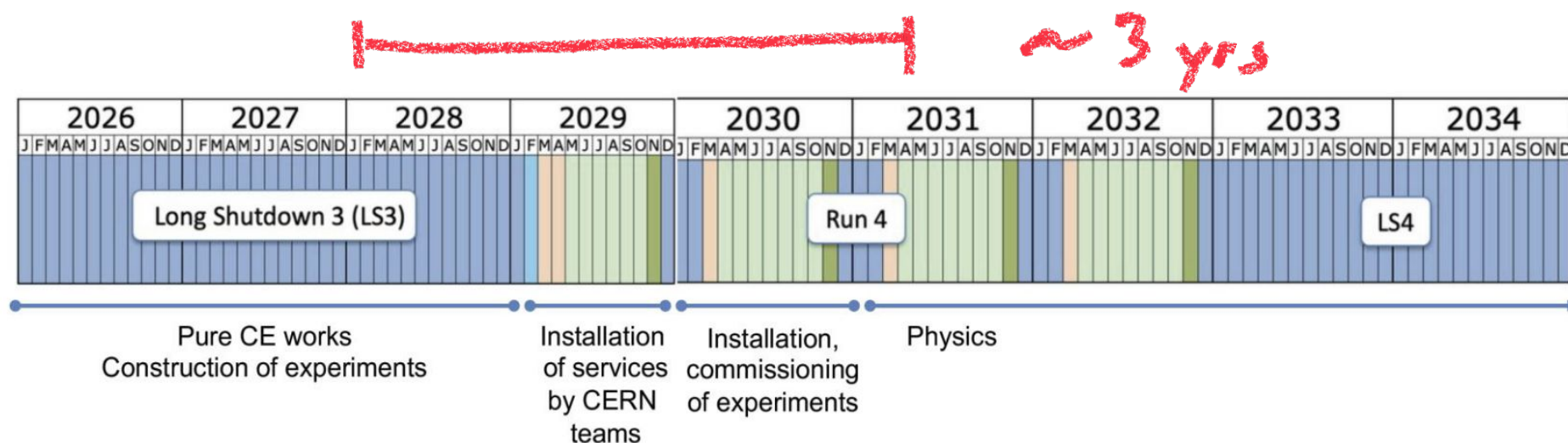
- Construction breaks down to following tasks:

- | | |
|---|---|
| <ul style="list-style-type: none"> • Finalize design <i>~ now</i> • PMT testing • Bar wrapping • PMT mounting • SPE calibration in lab • Mechanics - support • Mechanics - supermodules • Infrastructure at CERN • Shipping to CERN <i>~ 6 mo.</i> | <ul style="list-style-type: none"> • DAQ system development • Trigger system development • HV system development • Installation <i>~ 6 mo.</i> • In situ calibrations • Commissioning • Simulation • Offline • Ready for physics <i>~ 2031</i> |
|---|---|
- Handwritten annotations in red:*
- A large bracket on the left side groups the first six items (Finalize design to SPE calibration) with the label *~ 1 yr*.
 - A large bracket on the right side groups the first three items (DAQ system development to HV system development) with the label *1 yr*.
 - A large bracket on the left side groups the last three items (Mechanics - support to Shipping to CERN) with the label *~ 1 yr*.
 - A large bracket on the right side groups the last three items (In situ calibrations to Commissioning) with the label *~ 3 mo.*
 - A large bracket on the right side groups the last two items (Simulation to Offline) with the label *1 yr*.

** Most can/will proceed in parallel*

Schedule (based on milliQan experience)

- whole project should take < 3 yrs, with plenty of float (could start late as ~ 2028)
- Could go earlier
- Questions of infrastructure, shared FPF resources



conceptual designs for the FPF and its 5 experiments by mid-2023

Institutes that have expressed interest, so far

- Schedule will depend on person power available ... probably have (almost) enough but certainly welcome to new collaborators!



Material Cost (based on milliQan experience)

Item	Cost per unit	N required	Cost
Scintillator Bars	\$150	1600	\$240k
PMTs + bases*	\$800	1600	\$1280k
HV and readout cables	\$40	3216	\$129k
Readout (CAEN)	\$8k	102	\$816k
Readout (no CAEN)	\$40	1608	\$129k
Panels	\$6.1k	6	\$37k
Slabs	\$11k	2	\$22k
Mechanics	\$25k	1	\$25k
Amplifiers	\$3	1.6k	\$5k
Total No CAEN			\$1.9M
Total CAEN			\$2.6M

Custom
DAQ
(as in
SUBMET)

Labor costs (based on milliQan experience)

Person	Salary + fringe	FTE/yr	Yrs	Cost (k\$)
Mechanical Engineer	\$150k	0.25	5	187.5
Electrical Engineer	\$200k	0.10	5	100
Technicians	\$75k	0.2	5	75
Postdocs	\$100k	4.0	5	2000
Students	\$50k	6.0	5	1500
PIs	0*	1.0	5	-
Total				\$3.9M

* For U.S. PIs - summer salary?

Infrastructure cost (based on milliQan experience)

- How much of these will CERN pay for?

Item	N required	Cost
FPS	1	\$25k
DSS	1	\$25k
DCS	1	\$25k
Crates, Racks, etc	4,2	\$7.5k
Misc	-	\$5k
Total CAEN		~\$0.1M

“Total” Cost

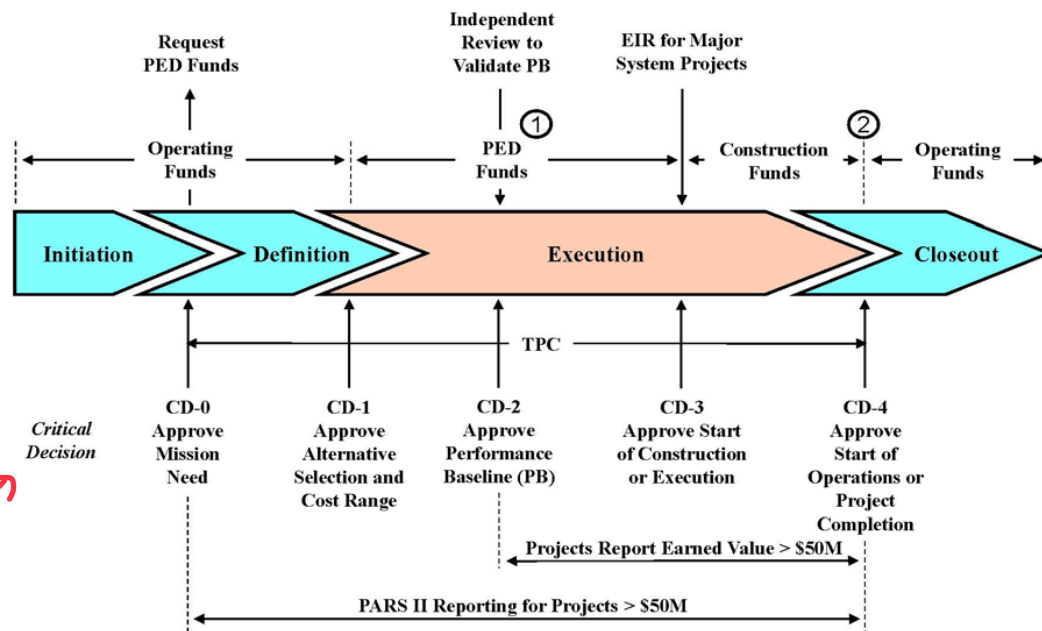
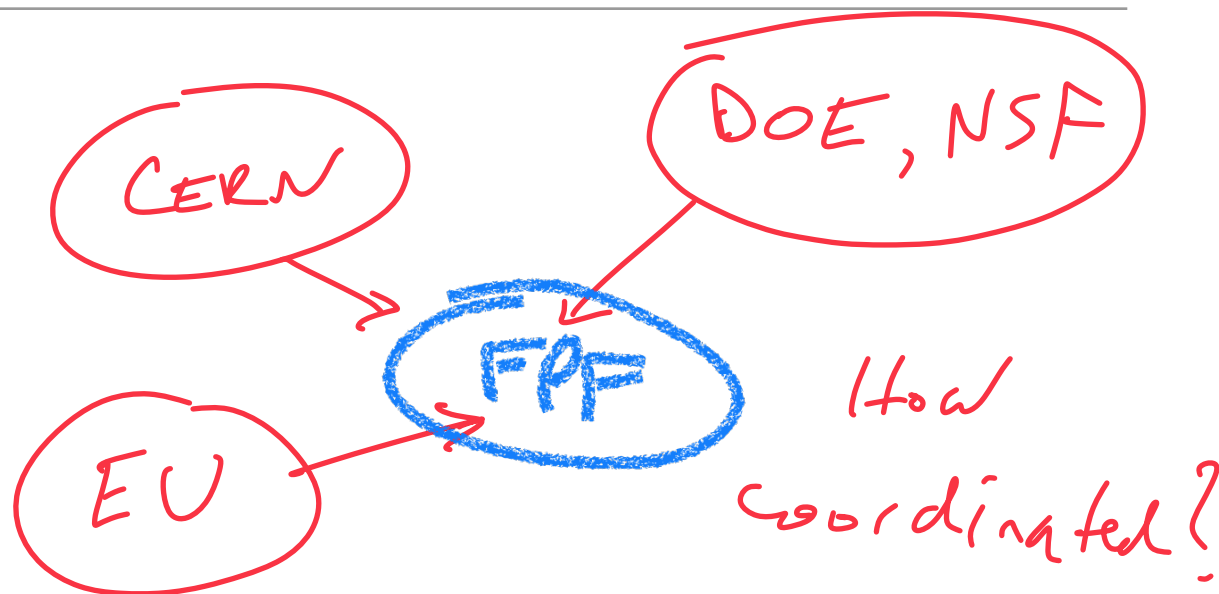
- What total are we talking about?
- If add labor, project cost can easily double
 - *And this doesn't include “contingency,” which can add another large factor*
- To have meaningful cost comparisons, have to agree on what we are costing (and how)

Type	Cost
Materials	\$1.9 — 2.6M
Labor	\$3.9M
Infrastructure	\$0.1M
“Total”	\$5.9 — 6.6M

* with cost/schedule uncertainty could be ~\$10M in DOE/NSF accounting

Funding Model, CERN oversight, etc

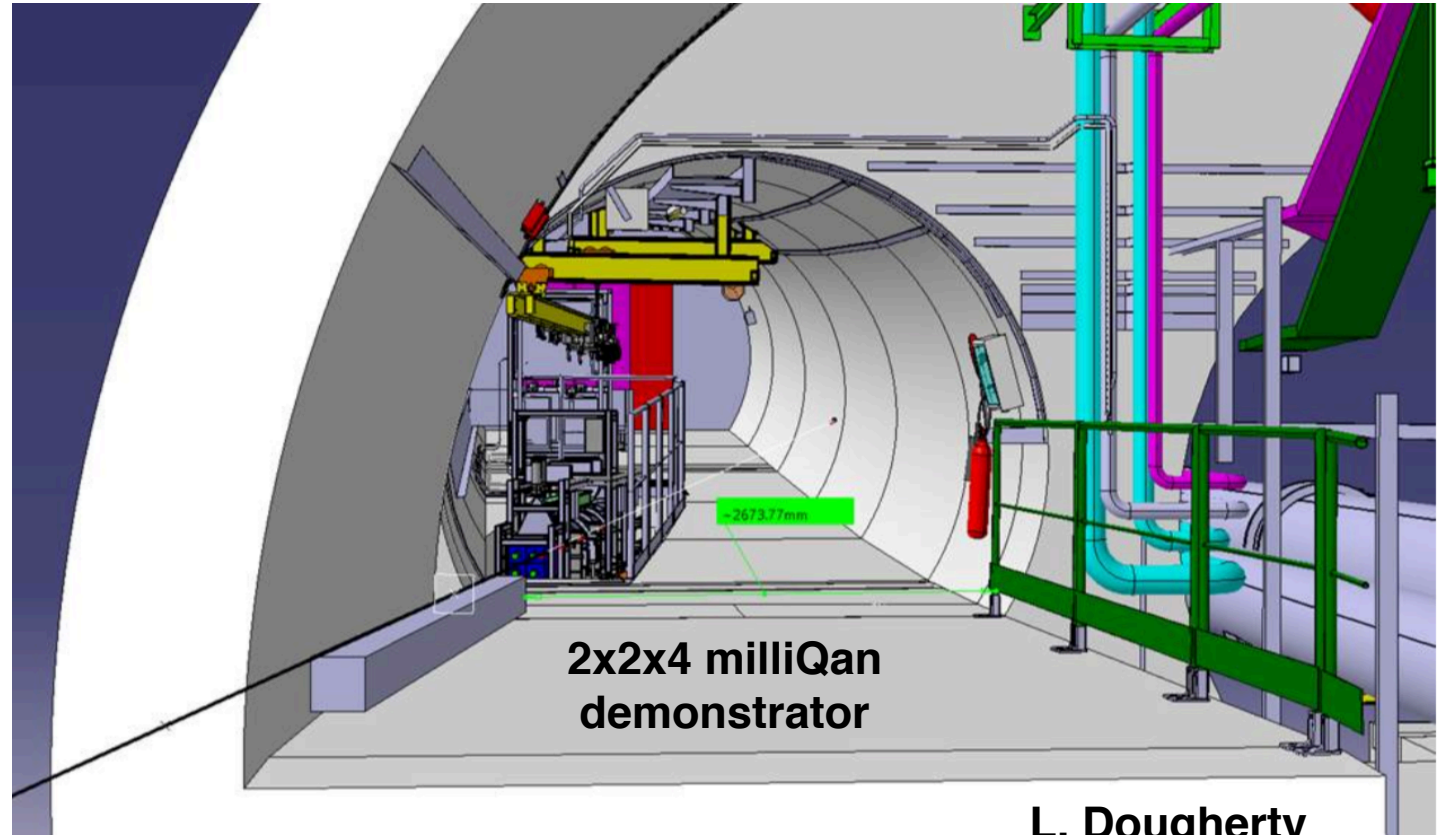
- How do we envision funding the FPF + experiments?
 - CERN pays for FPF facility?
 - **What about infrastructure, services, operating costs?**
 - Each FPF experiment finds separate funding?
 - **From one or more FA?**
 - Combined proposal(s)?
- FPF will be proposed to LHCC — presumably experiments part of this?
 - Cost & Schedule overseen by UCG? Experiments separately or whole FPF?



Want to avoid, if can

Demonstrator in FASER experimental area

- We still plan on putting the Milan demonstrator near FASER to get some in situ data
 - *With Run 3 detector installed, demonstrator has been decommissioned and this can proceed*
 - *Funds secured & discussions with CERN underway*



← Contact M. Citron

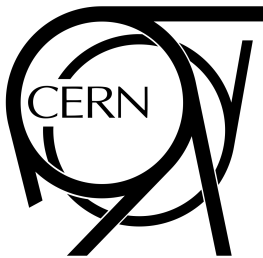
Summary & Further Discussion

- FORMOSA will cost between \$2M and \$6M (or more) depending how you count costs (and if you include cost/schedule uncertainty, i.e. contingency).
 - *At some point should discuss and agree on funding model*
- From time of design finalization, first funding available:
 - *Should take << 3 yrs to build, install, commission FORMOSA*
 - **Depending on eventual size of collaboration, could be done more quickly**
 - *Starting during LS3 as envisioned should work*
 - **Could be as late as ~2028 with plenty of float**
 - **Or should we aim earlier? when?**
 - *Logistically, is there a necessary serialization for installation in FPF? Or experiments can proceed in parallel?*

Additional Information

milliQan consists of ~30 people, 10 institutes

The MilliQan collaboration



SUBMET Collaboration a bit smaller, so far



Sungwoong Cho
Suyong Choi
Seokju Chung
Hoyong Jeong
Hyunki Moon
Eunil Won
Jae Hyeok Yoo



Claudio Campagnari
Matthew Citron
Jeong Hwa Kim
David Stuart
Ryan Schmitz



Christopher S. Hill



Andy Haas



Jihad Sahili
Ayman Youssef
Ahmad Zaraket
Haitham Zaraket



Albert De Roeck
Martin Gastal