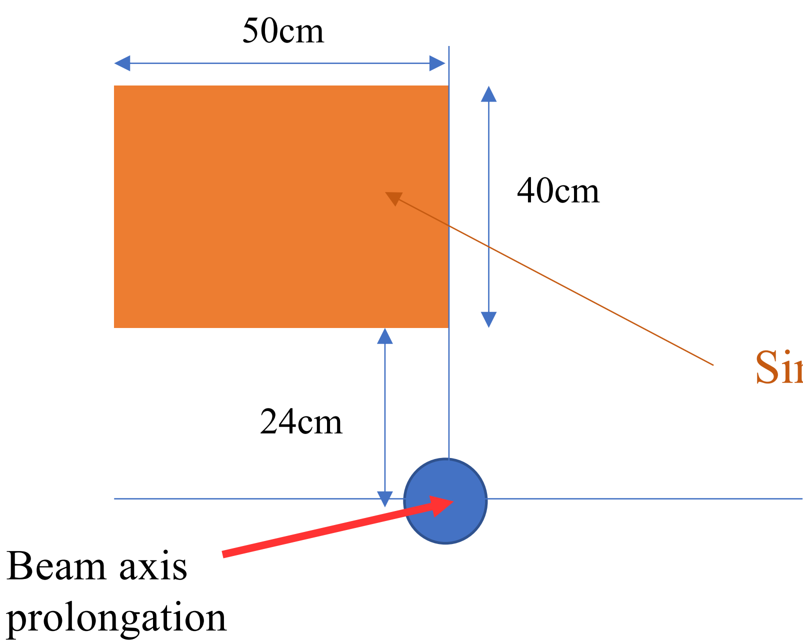
Scattering and Neutrino Detector in TI18

Giovanni De Lellis

Detector configuration



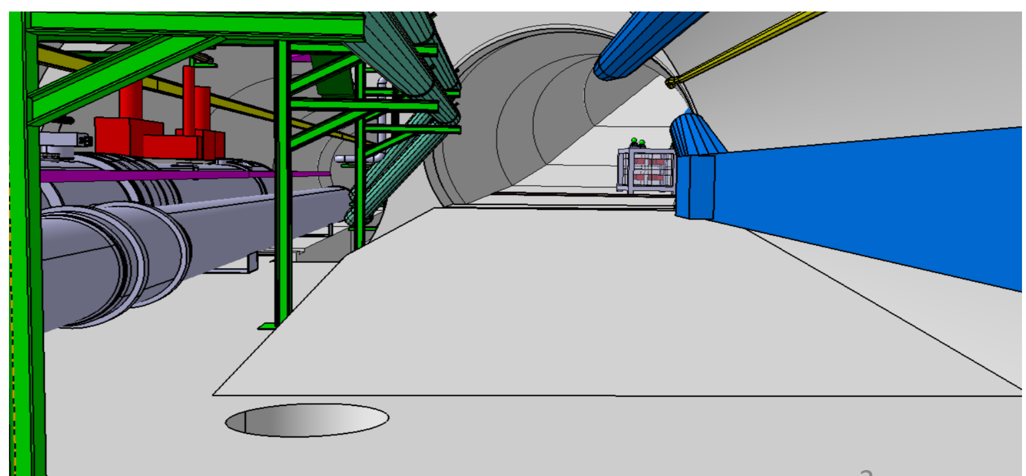
$7.1 < \eta < 8.3$

η	Distance (m)
9.86	0.05
7.38	0.6
6.5	1.4
6	2.4

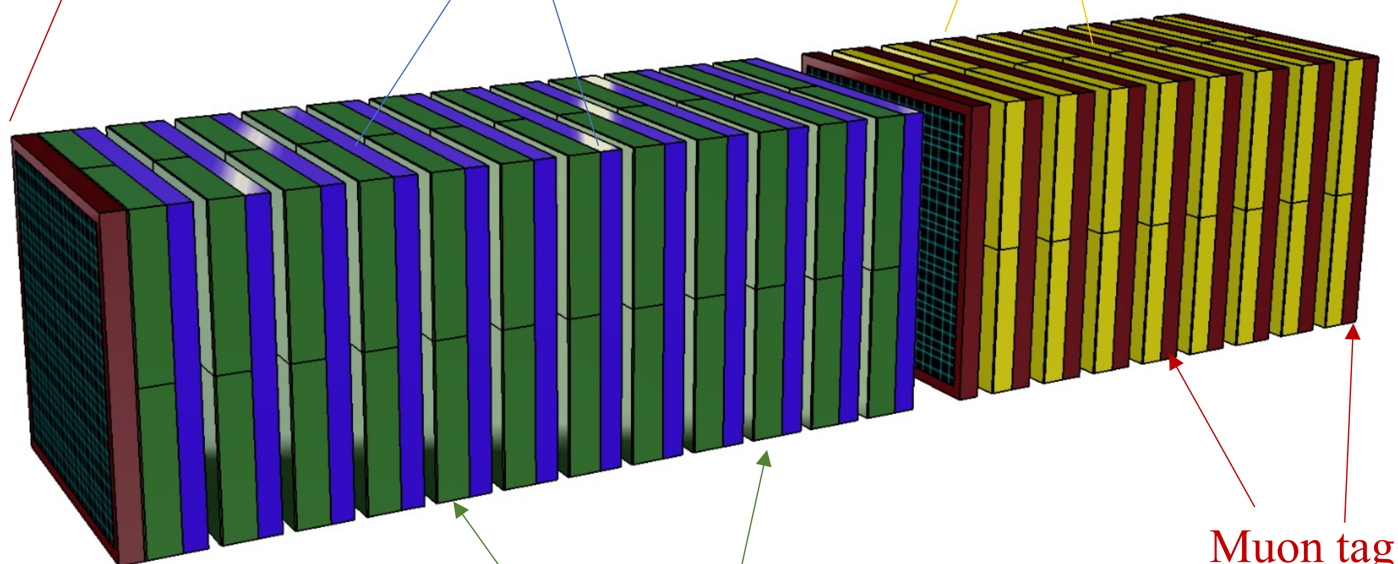
Simulation refers to this area

5.8 cm above the l.o.s. due to crossing angle

TI18, Pablo Santos Diaz, EN

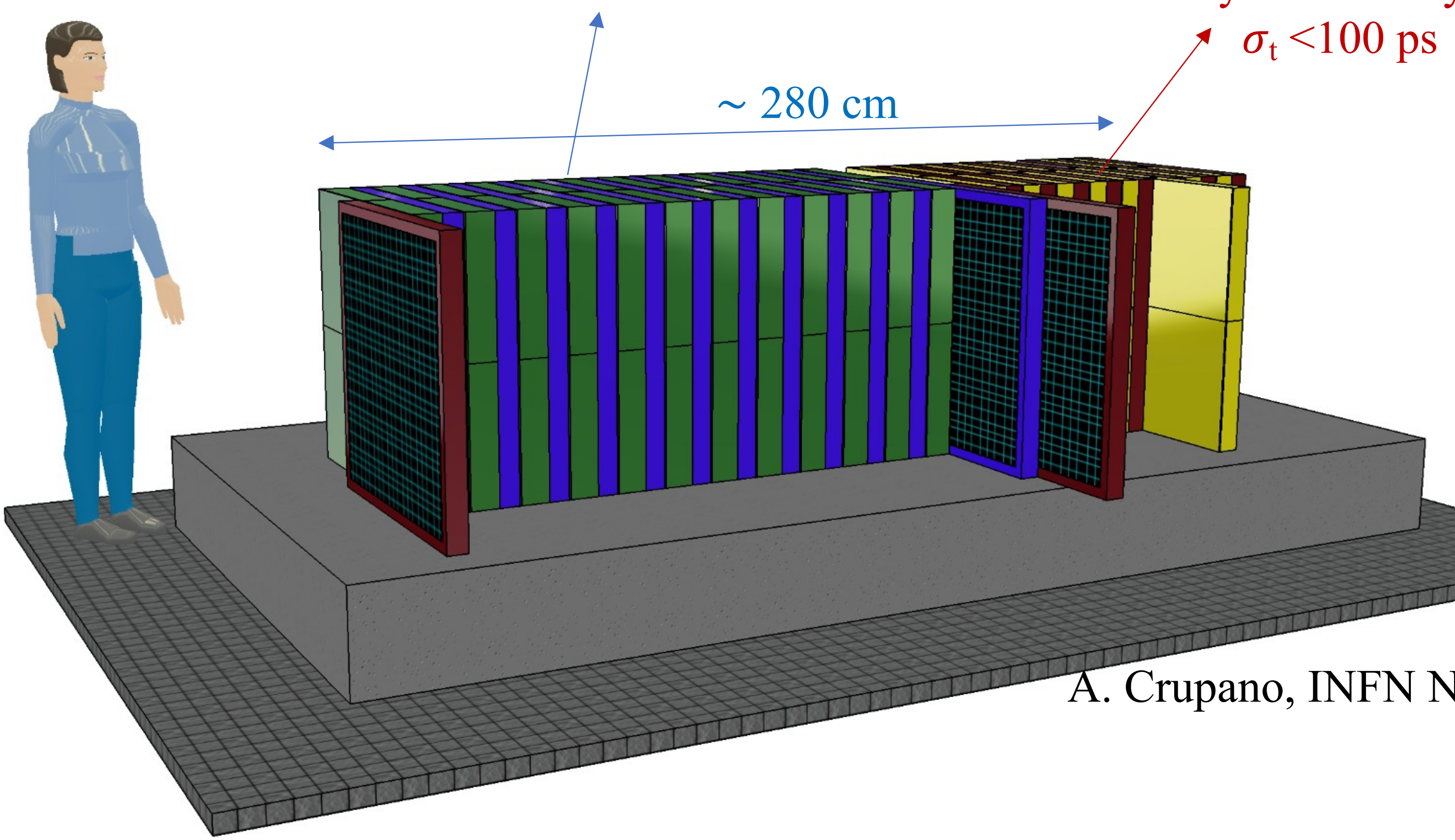


SND detector setup



SND detector setup

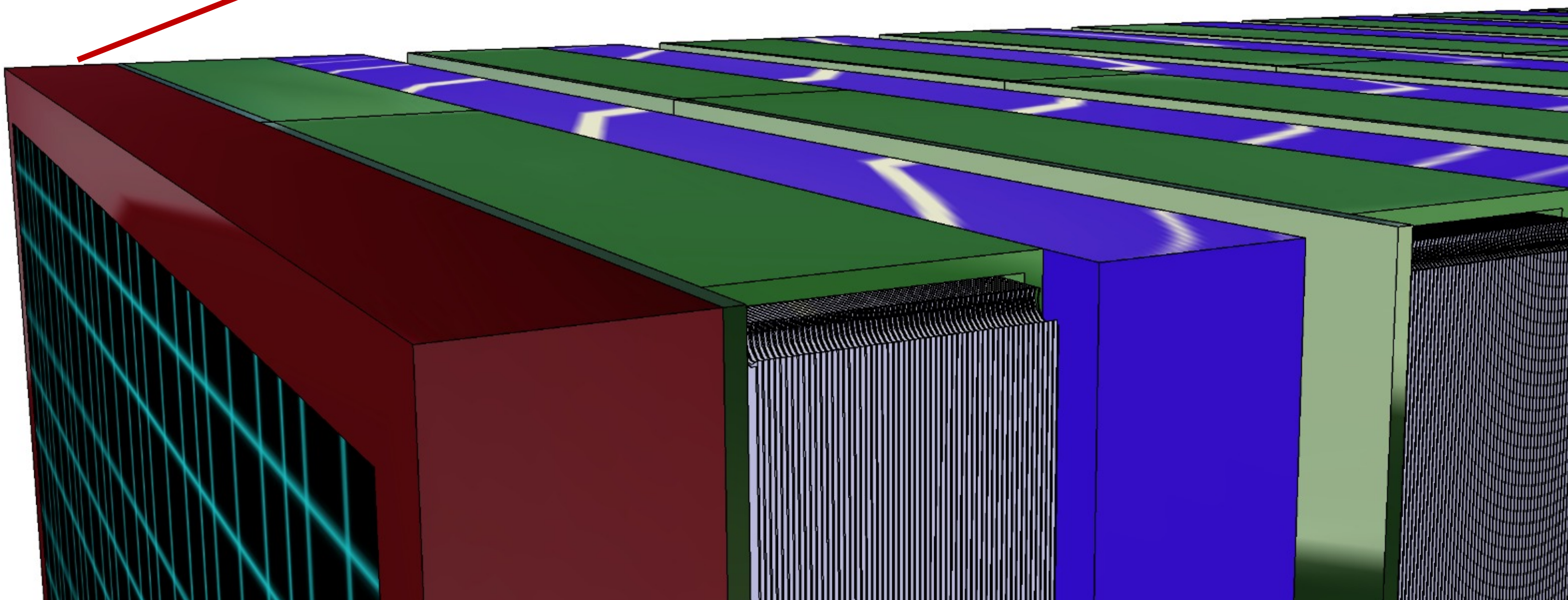
ν target: 1.5 tons
135 m^2 of emulsion films



Veto plane to discriminate between neutrino-induced and penetrating muons
Fast timing required to distinguish between neutrinos and heavier particles

SND detector setup

Bar dimension: $50\times1\times1 cm^3$ (X and Y arrangement)
In SHIP 168 x 6 cm2 → better timing in this configuration



Emulsion Cloud Chamber
57 emulsion films interleaved
by 56 1mm lead plates ($10 X^0$)

Detector considerations

- Emulsion as a vertex detector, with optimal e/π^0 separation
- Hybrid detector for all 3 neutrino flavours
- Muon identification with a muon filter (scintillator bars): muon neutrinos and $\tau \rightarrow \mu$ decays
- Energy measurement with SciFi (and scintillator bars) in combination with emulsions
- SciFi is a good option for several reasons:
  - The high intensity flux of muons is similar to the SHiP conditions (10^5/cm2)
  - Hence, matching with emulsion tracks requires high position accuracy (< 100 um)
  - Very light infrastructure required (low radiation rate, < 1Hz/cm^2 → no cooling needed)
  - It complies with the difficulty to make sizeable infrastructure work for Run3 in TI18
- A scintillator station upstream as a veto. Same technology used for the muon filter
- Time stamp with good timing resolution (<100 ps) required to separate neutrinos from DM at 480m distance

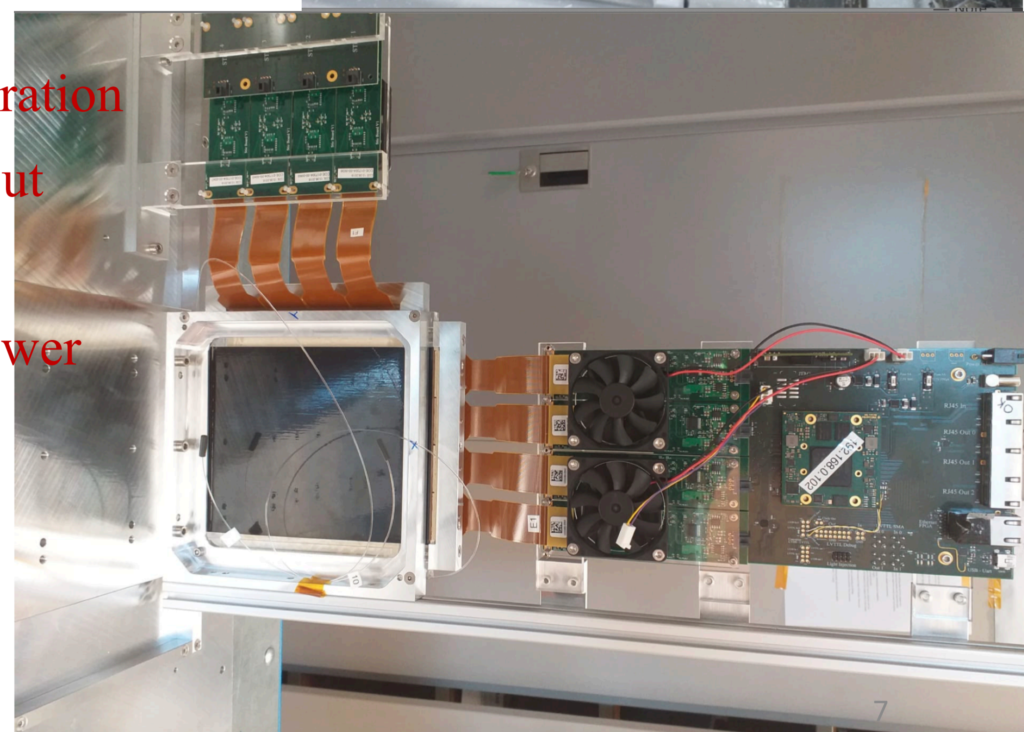
SciFi in TI18 (EPFL)

Current status:

- 8 planes (or 4xy) available with the size of (400mm)^2
- possible to double this number by 2021
- power consumption ~ 125 W/plane
- cooling power required ~125 W/plane, --> 250 W/plane effectively
- one socket of 220 V is enough for operation
- Ethernet connection for the data readout

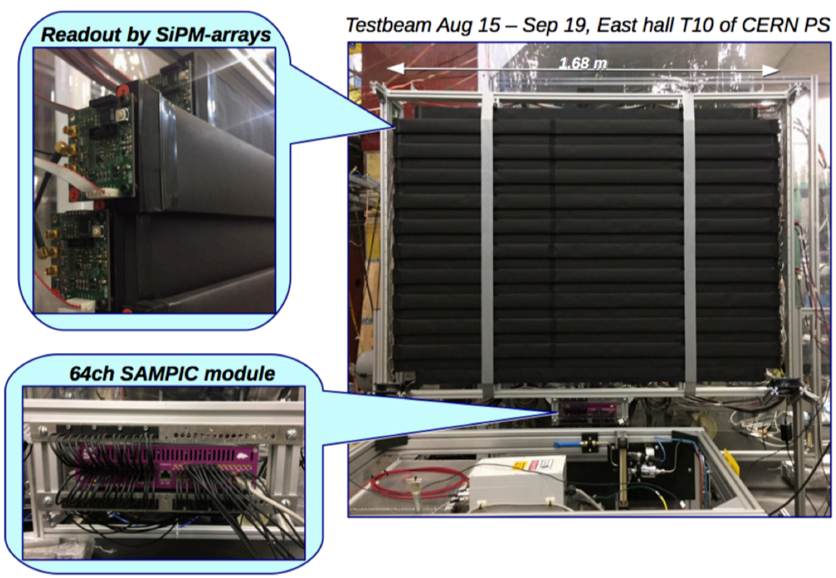
Possible developments:

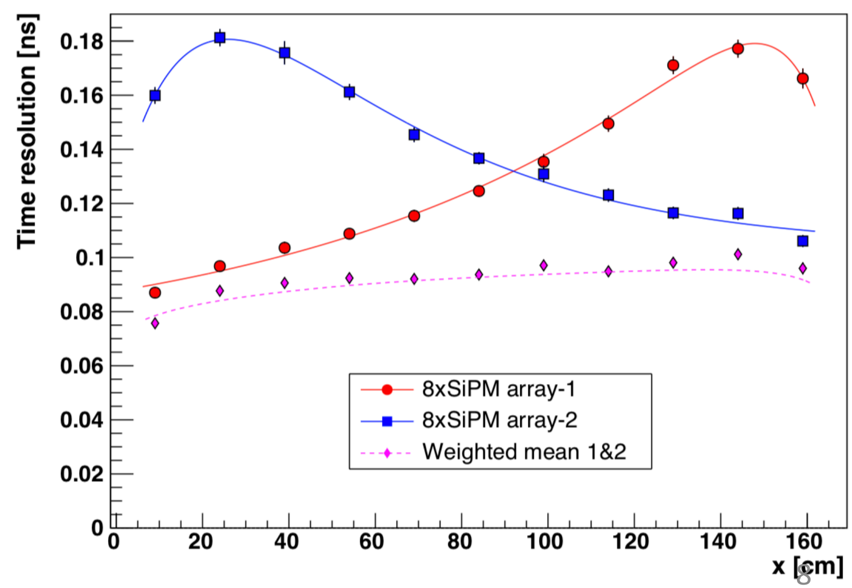
- conceivable to have new chips with lower power consumption, ~ 15 W/plane



Scintillating bars with high timing performance (Zurich)

- Length to be shortened (50-60 cm)
- Smaller width (~cm)





Gel Production Facility at Nagoya Univ.
for all emulsion projects

2010-(x1)

2014-(x3)

Next
2020-(x30)

1st Machine
0.3m^2/Operation

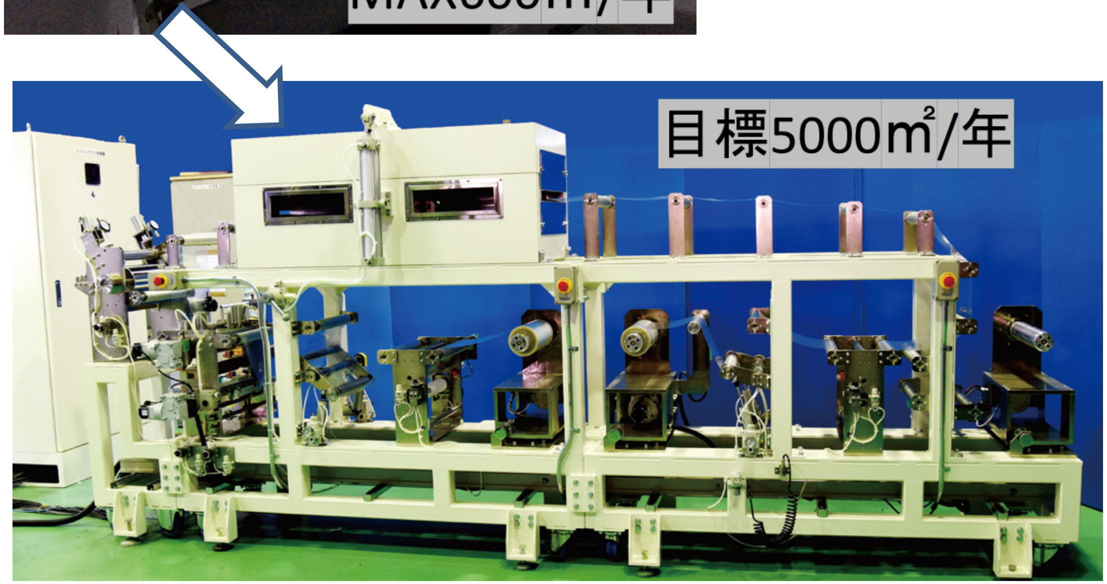
2nd Machine
1 m^2/Operation

3rd Machine
(under construction)
10 m^2/Operation
→2000-3000m^2/year

Automation of film production

Production by hand limited to 600m^2/year

Aiming at 5000m^2/year by a roll to roll pouring system



135 m^2 per 1.5 ton detector
Assume to replace emulsions
every ~ 20 fb^{-1}, 7-8 times in Run3
~1000 m2

Emulsion production at Slavich

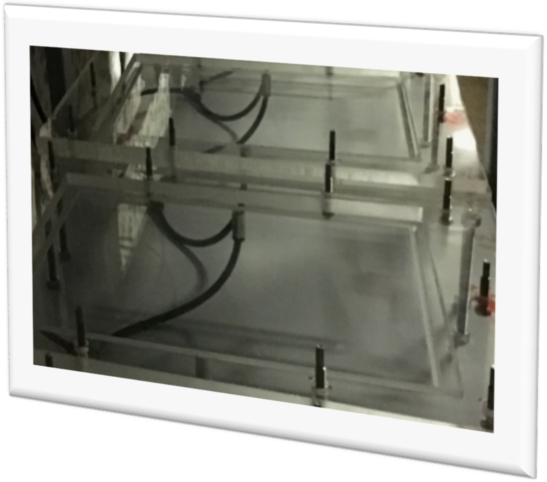
- Emulsion production by SLAVICH company started in 2009, since 2012 pilot batches manufactured
- Production scale today is about 190kg/year
- Emulsion production could be as large as ~600 kg/year



Emulsion production at Slavich

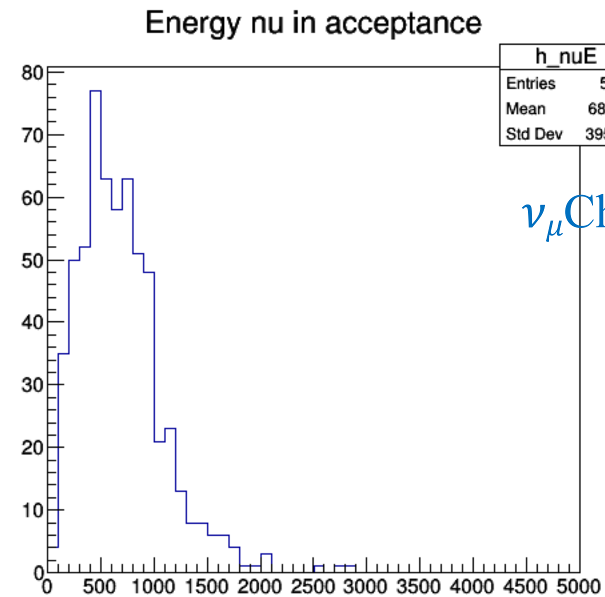
- Currently, films are produced by hand pouring with 18 vacuum tables

- Speed production by hand pouring now is 80 m^2 per year

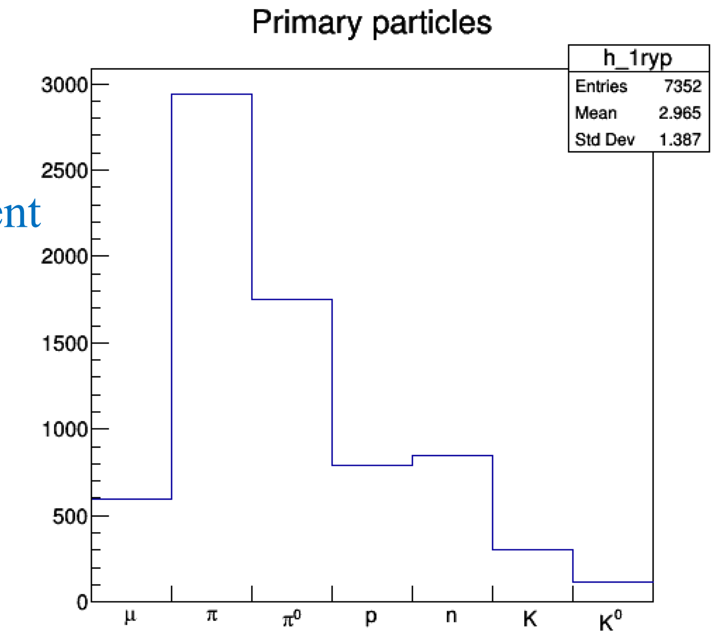


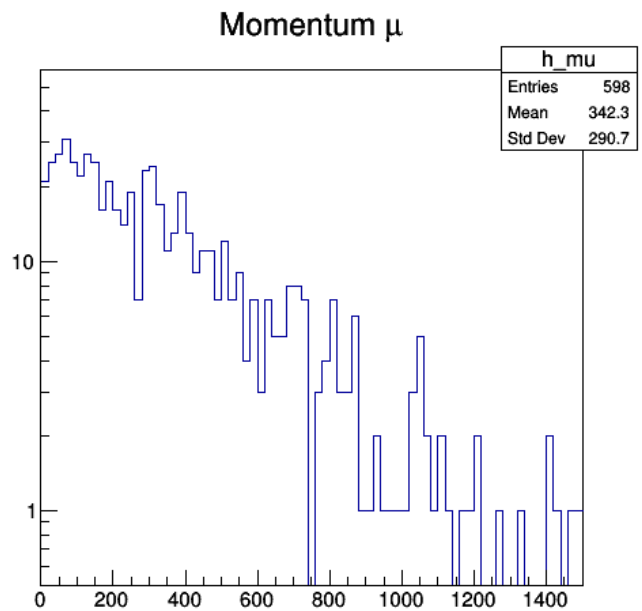
For a large production, an automated chain could be used
Capacity of pilot automated pouring machine is 480 m^2 per year

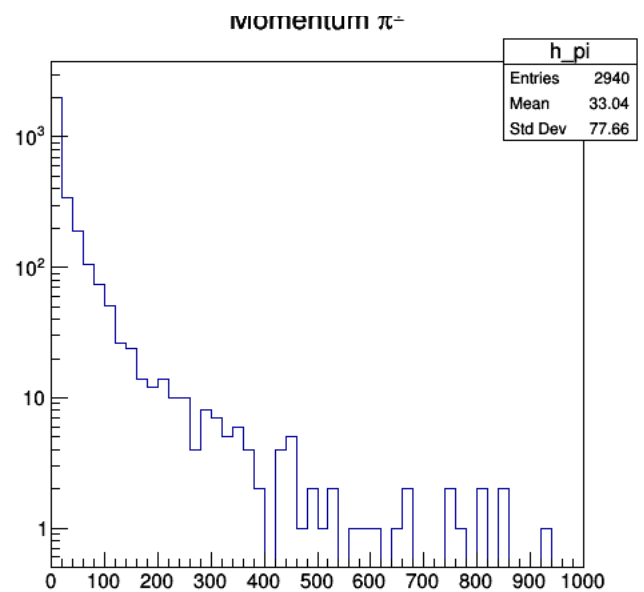
Energy spectra of produced particles: ν flux Pythia (Luca) + ν int Genie (Annarita)



ν_μ Charged-Current





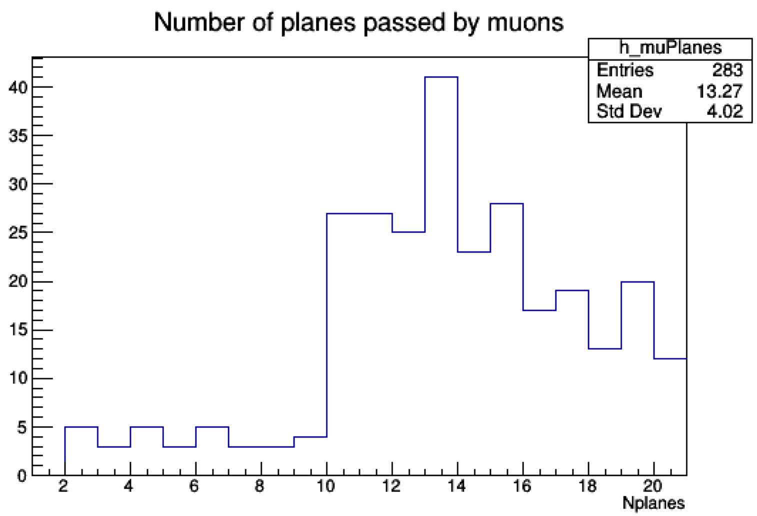


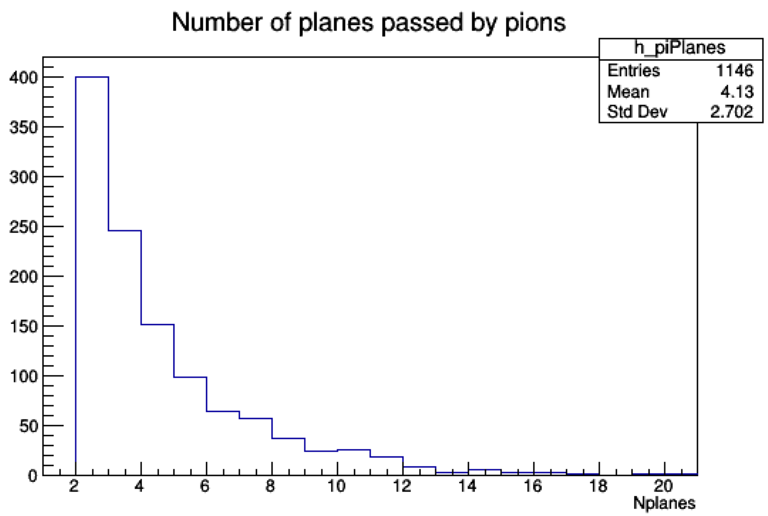
Penetrating power in terms of walls

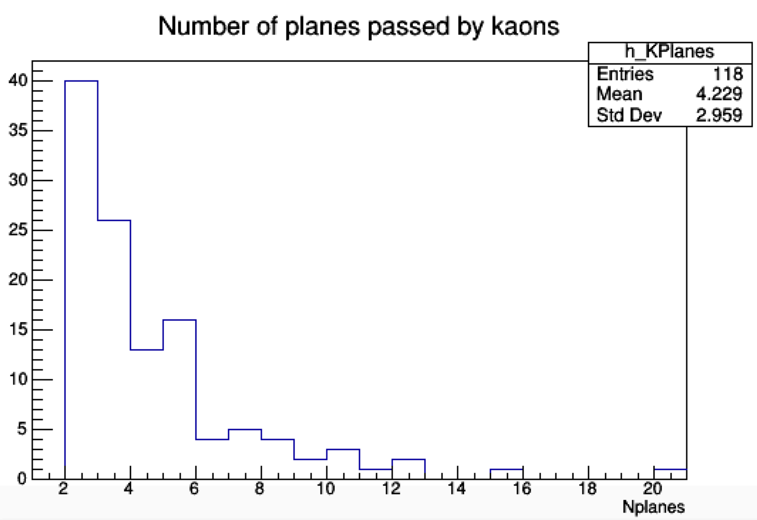
Fairship simulation by Annarita

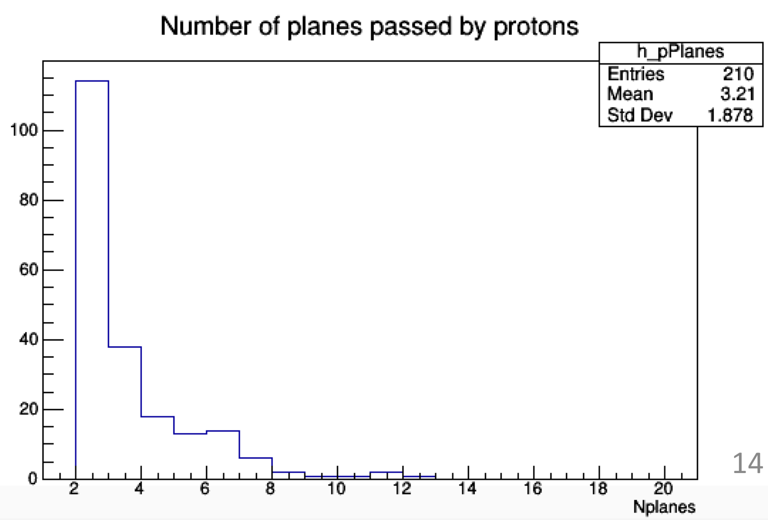
15000 events simulated, 288 in acceptance

Interacting in the first 12 walls



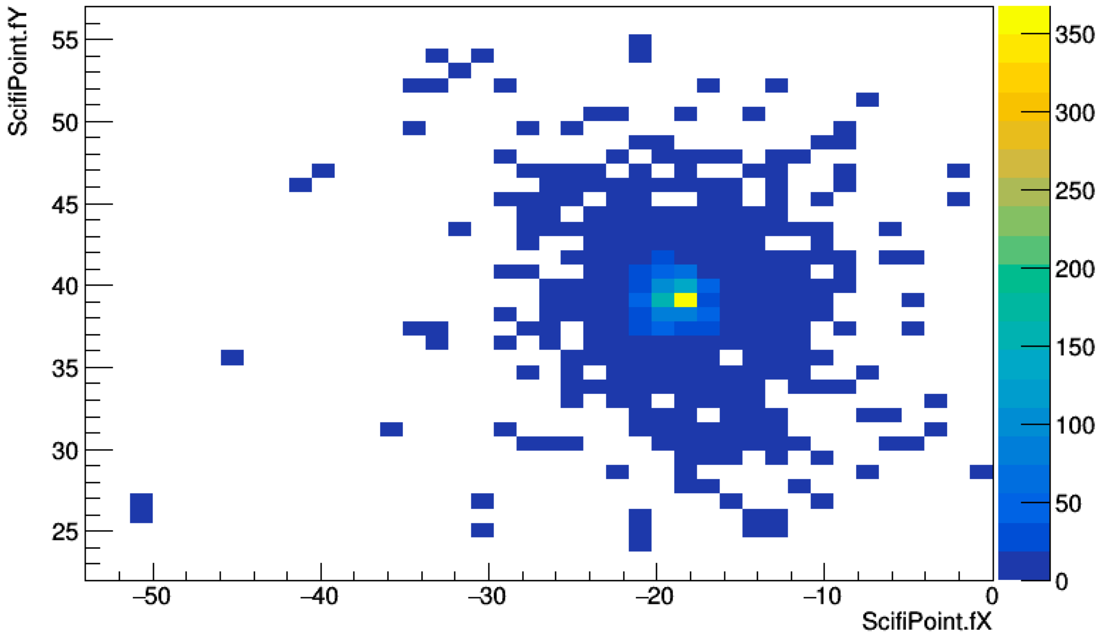


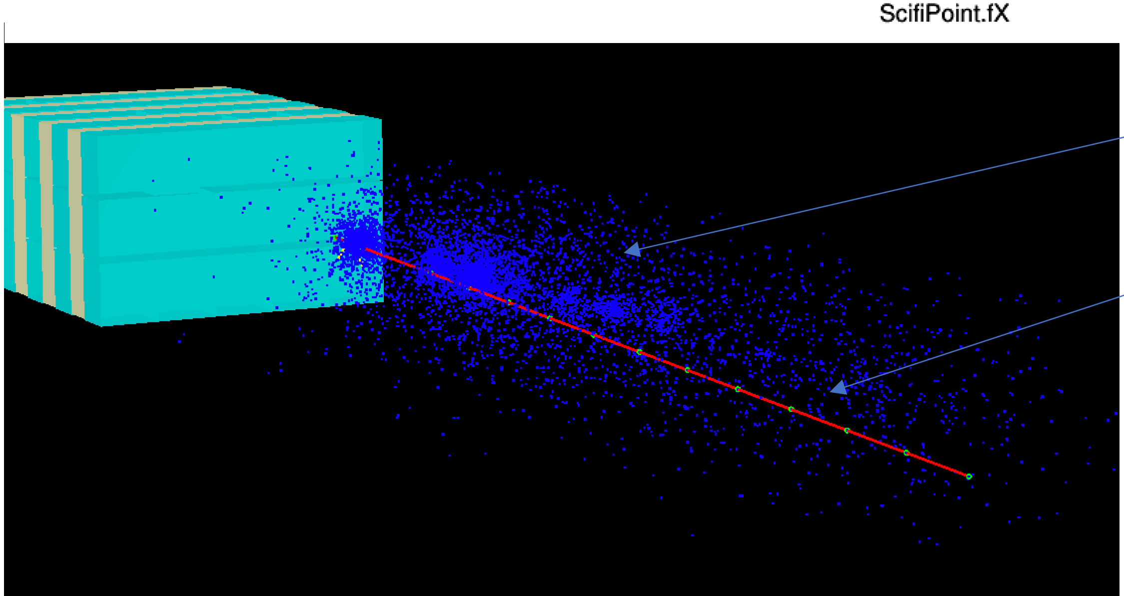




One event as an example

Hits in the first electronic detector



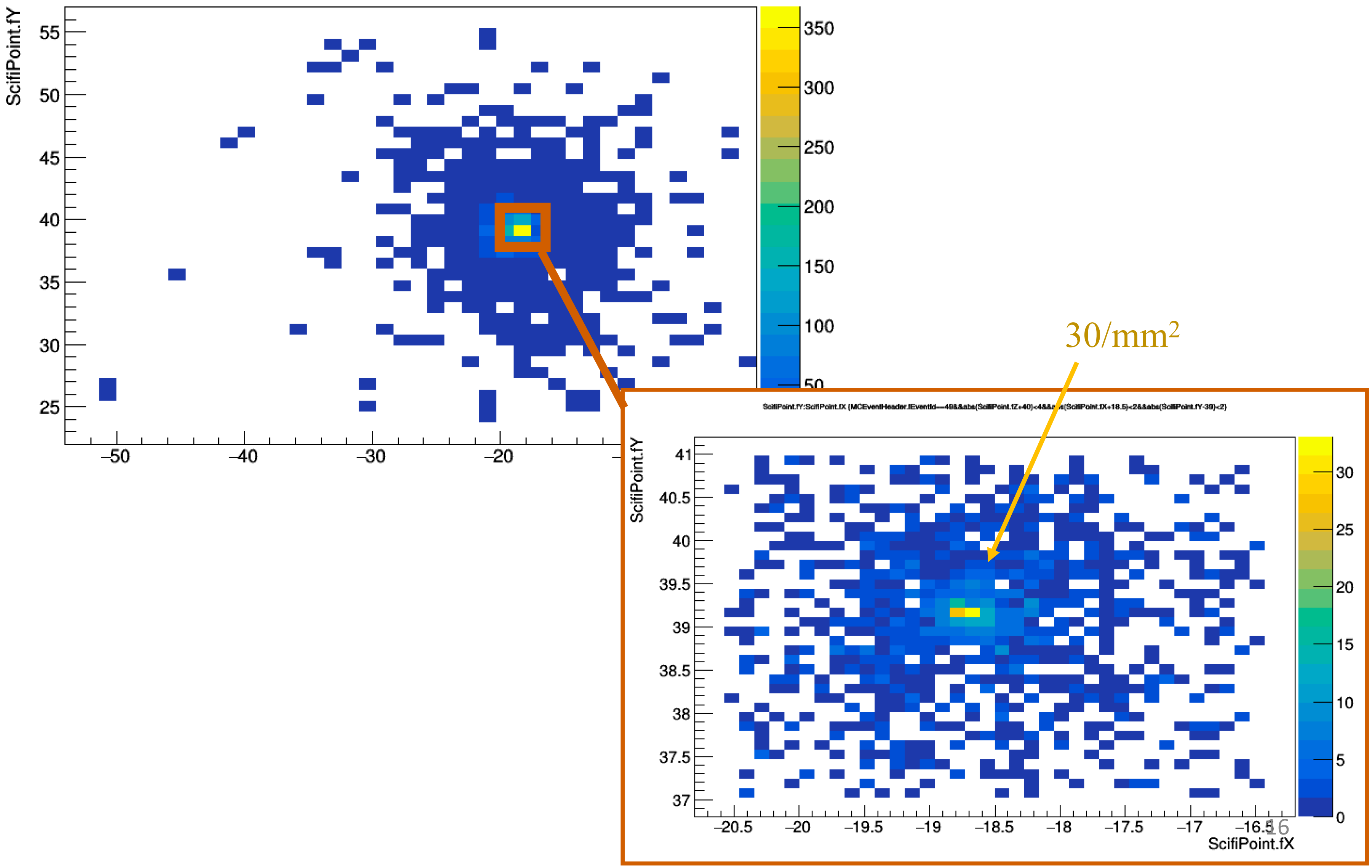


Particle hits

Muon track

One event as an example

Hits in the first electronic detector



Event classification

Npl cut	N 0μ	N 1μ	N 2μ	N 3μ	N > 3μ
> 12	109	168	9	2	0

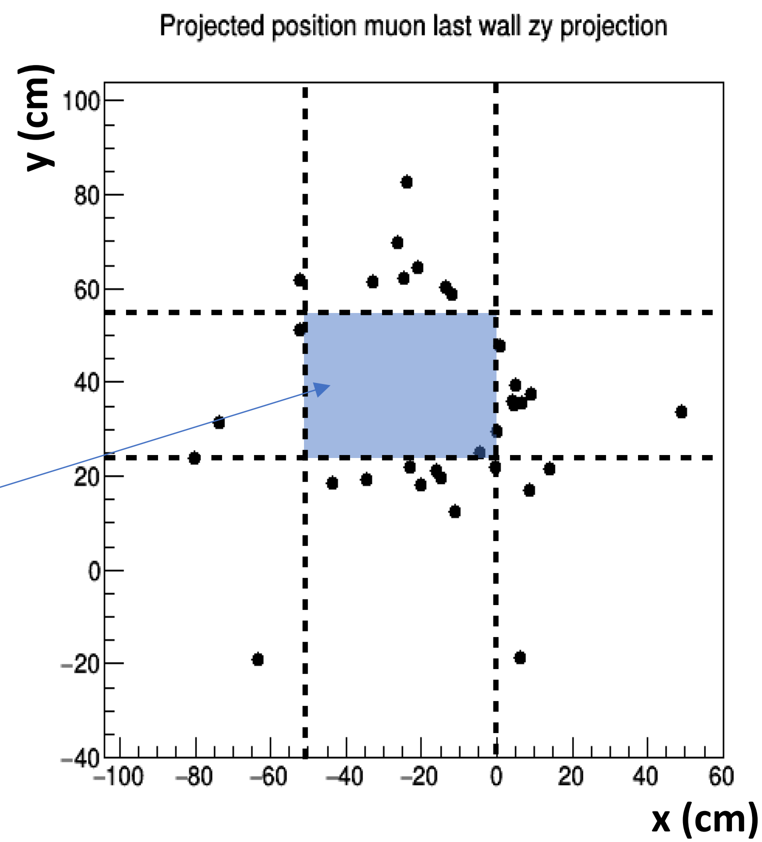
Purity = (N $\mu \rightarrow \mu$) /N 1μ = 162/168 = 0.96

ε~60%

Main reason is insufficient thickness
Currently 8 walls (~50 cm Fe equivalent)
To be increased → 80 cm Fe

Muon identification efficiency
Can be largely optimised
Also by increasing the size (~10cm)

Interactions sufficiently upstream
With unidentified muon



Remarks

- Optimise the geometry (more passive material at the end)
- Fix the number of muon stations in the downstream part (3 sufficient)
- Consider the infrastructure required (Pablo)