Beam windows 18-12-2015

The CERN Neutrino Platform team

Requirements for material budget

- From proposal requirement table:
- Protons from 0.7 GeV/c
- Pions+- from 0.2 GeV/c
- Electrons from 0.2 GeV/c
- Kaons+ from 1 GeV/c

- Absolute momentum scale : <= 1% How to quantify?
- What on angular resolution? Assume 10 or 20 mrad? Needed at all energies, or enough to measure at high E?

Materials in the beam line (unavoidable)

- Preliminary guess:
- Position/tof monitors: a total of 10 mm plastic
- Cerenkov : 1-2 m of CO_2 at 0.5-0.8 atm
- Beam windows + cerrenkov mirror: 1mm mylar
- SS membrane and its strengthening (here 1cm plywood, could be something else)

- Kept in all simulations, (although Cherenkov could be eliminated for electron beam)

Configurations

- Possible scenarios

1. Beam line and SS membrane, plug up to active LAr
2. Same, plug up to field cage, 5 cm inactive Lar
3. Same, no plug, 45 cm inactive Lar
4. As 1, keep also secondary membrane and 40 cm foam in between the two membranes

Simulations (FLUKA)

- Energy loss
- Straggling of energy loss (as simulated, systematics uncertainty on materials/ MC not included)
- Angular deflection

For hadrons: only uncollided particles included

For electrons : "still mip" fraction

No plug inside the cryostat: 45cm of inactive LAR

- Electrons loose on average > 35% of their energy at 2 GeV, 65% at 200 MeV
- No electron survives as mip
- Electron energy loss spread : from 10 to 20%
- ➔ The "no plug"condition does not allow to measure electrons

- Protons survive only if p>1 GeV/c
- Pions, kaons Energy loss >15% for p<1 GeV/c
- Deflections > 30 mrad rms for p<1 GeV/c

- ➔ The "no plug"condition does not allow to measure hadrons below 1 GeV/c or more, unless one relies on tagging /simulations

Tables..

- In the following, you'll find two tables for each of the configurations
- The first table collects information for the various particles at the momentum corresponding to the requirements in the proposal
- The second table tries to guess what could be a minimum "measurable" momentum according to some (rather arbitrary) guess on the required precision, namely :
  - *energy loss smaller than 15% of original energy ,*
  - *spread of this energy loss < 2% of original energy,*
  - *Angular deflection rms <20 mrad*
  - *Fraction of electrons still visible as mip > 50%*
- The entry "Not interacting / stopping/decay' measures how many primaries survive with respect to those arriving at the secondary membrane (40 cm before the primary one)
- For pion/kaons "nearby"decays are a source of (muon) background, even in absence of dead materials

Total plug : no inactive LAr

At lower wished momentum	Eloss/e	Deloss/E	Theta rms mrad	Non-int/ Stop/decay	mip
Proton (0.7)	4.5%	0.25%	6	0.98	
Pion (0.2)	5.8%	0.7%	28	0.88	
Kaon (1.0)	.8%	0.14%	5	0.83	
Electron (0.2)	1.3 %	0.4%			90%

Minimum measurable p?	Eloss/E < 15%	Deloss/E <2%	Theta rms< 20mrad	Mip >50%
proton	.5	0.4	0.7	
pion	.2	0.2	0.4	
kaon	.4	0.4	0.4	
electron	.2	0.2		.2

Only concern: deflection of low energy pions

Partial plug (no field cage penetration)

At lower wished momentum	Eloss/e	Deloss/E	Theta rms mrad	Non-int/ Stop/decay	mip
proton	14%	0.5%	25	0.93	
pion	18%	1.3%	65	0.81	
kaon	2.5%	0.5%	10	0.84	
electron	8 %	3%			70%

Minimum measurable p?	Eloss/E < 15%	Deloss/E <2%	Theta rms < 20mrad	Mip >50%
proton	.7	0.7	1	
pion	.4	0.2	0.7	
kaon	.5	0.4	0.7	
electron	.2	0.4		.2

Questionable at low energies: high energy loss and deflection.
Also, would need more insight on the residual ability to reconstruct "mip"electrons
Also: first part of the tracks in non-uniform Efield. Backscatter to be assessed

Total plug, +secondary membrane and foam

At lower wished momentum	Eloss/E	Deloss/E	Theta rms mrad	Non-int/ Stop/decay	mip
proton	10%	0.4%	15	0.95	
pion	13%	1.0%	36	0.79	
kaon	1.9%	0.2%	6		
electron	4.8 %	1.1%			87%

Minimum measurable p ?	Eloss/E < 15%	Deloss/E <2%	Theta rms< 20mrad	Mip >50%
proton	.7	0.5	0.7	
pion	.2	0.2	0.4	
kaon	.5	0.4	0.5	
electron	.2	0.2		.2

Some concern at low energies

Summary on materials in the beam window

- The full 45 cm LAr (no plug) would kill the measurement for all electrons. Same for all hadrons <1 GeV , unless one relies heavily on MC and/or reconstruction
- Plug ending before field cage (5 cm inactive Lar): Questionable at low energies: high energy loss and deflection. Also, would need more insight on the residual ability to reconstruct "mip"electrons. Also: first part of the tracks in non-uniform Efield. Backscatter to be assessed
- Full plug, no inactive Lar, always keeping the SS membrane: GOOD. The only concern might be the deflection of very low energy pions
- Full plug, no inactive Lar, always keeping both primary and secondary membrane, 40 cm of foam: some concern at low energies, better than 5~cm LAr . To be considered only if really needed (seems not the case)
- **Baseline design is a beam window up to the primary membrane, followed by a plug displacing the LAr ..possibly through the field cage.**

Requirements for the beam angles/positions

- Vertical angle not too far from the 6^0 angle of the beam in DUNE far
- Three beam windows to check
  1. Full containment in full drift volume
  2. Crossing of the cathode
  3. Containment in the second volume with option on reduced drift distance
- No interference with support structure I-Beams
- Check (later?) to fall on flat part of the inner membrane
- And of course compatibility with the beam line optics and the occupancy of the Nord Area extension.

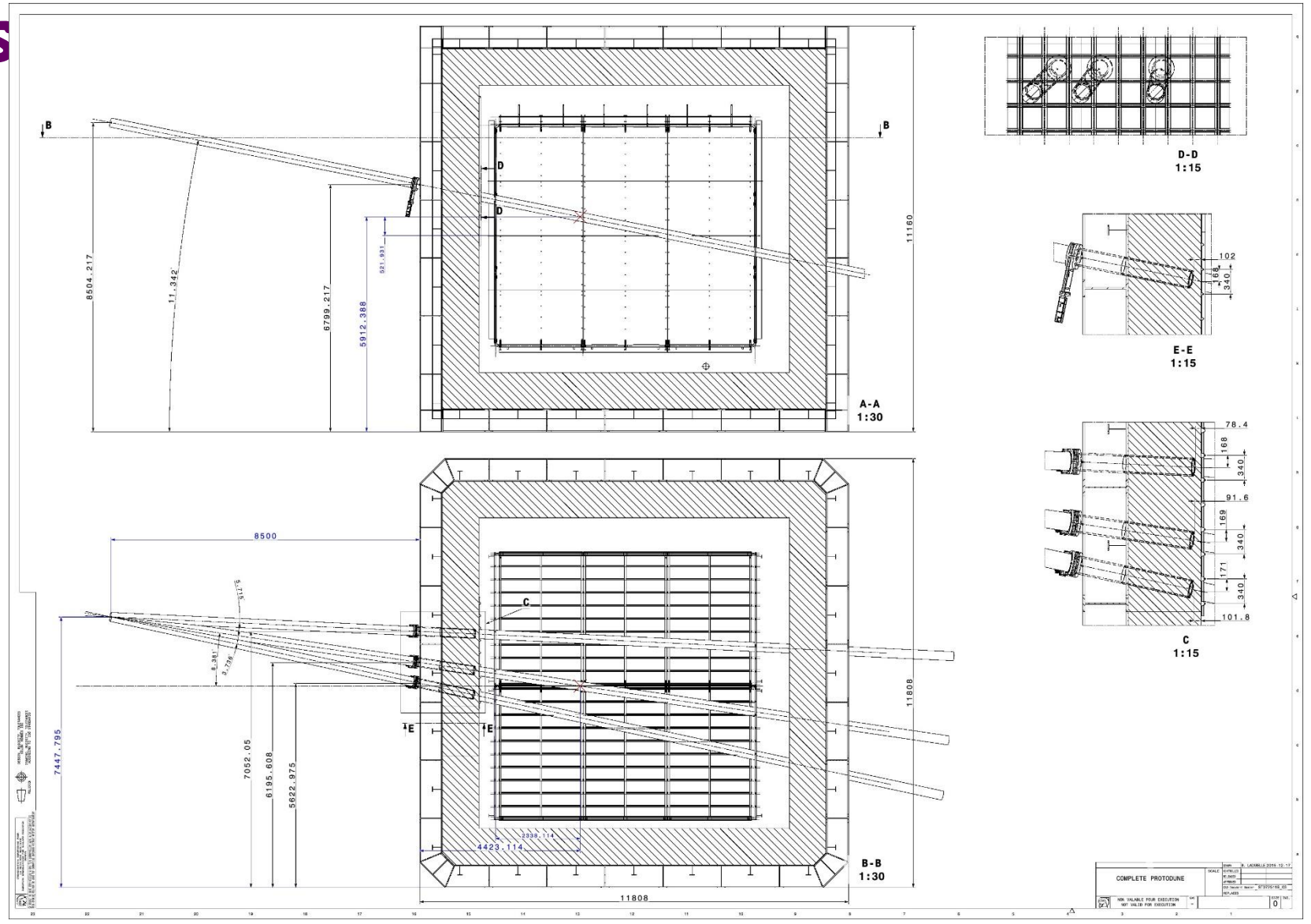
Parameters for the latest beam layout

- New layout optimized together with beam line people
- Vertical angle 11.342^0
- Horizontal : 2.67^0, 8.38^0, 12.11^0 (first one at the limit of the required range, should be acceptable)
- Note that horizontal and vertical angles are not completely independent due to the tilt of the magnets
- No interference with the I-beams
- Correct spacing for membrane corrugation (meaning that in the PRESENT design all beam windows arrive to the membrane in a flat part)
- Compatible with WA105 cryo in the pit.

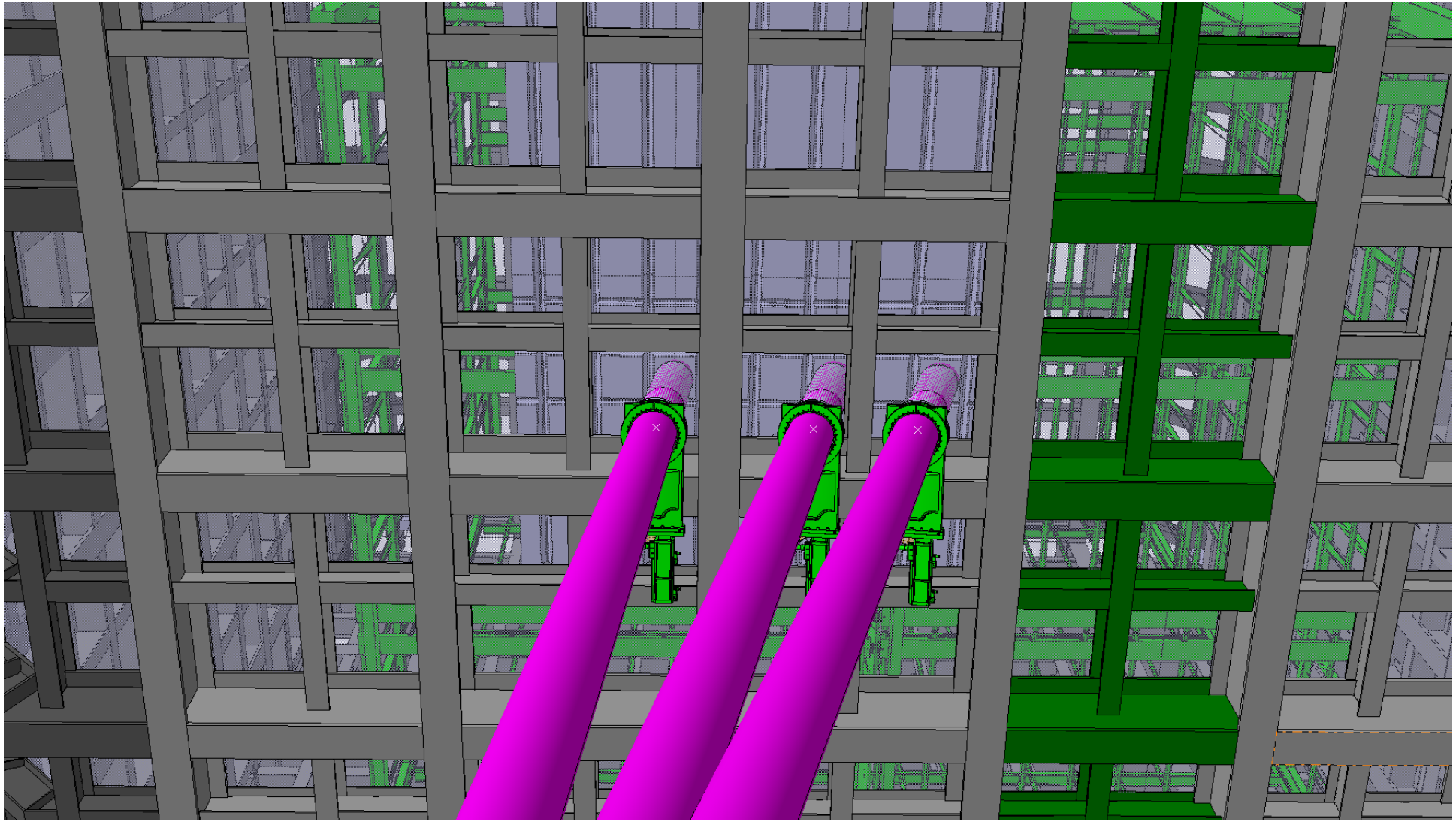
Layout of the beam penetrations

Lateral view

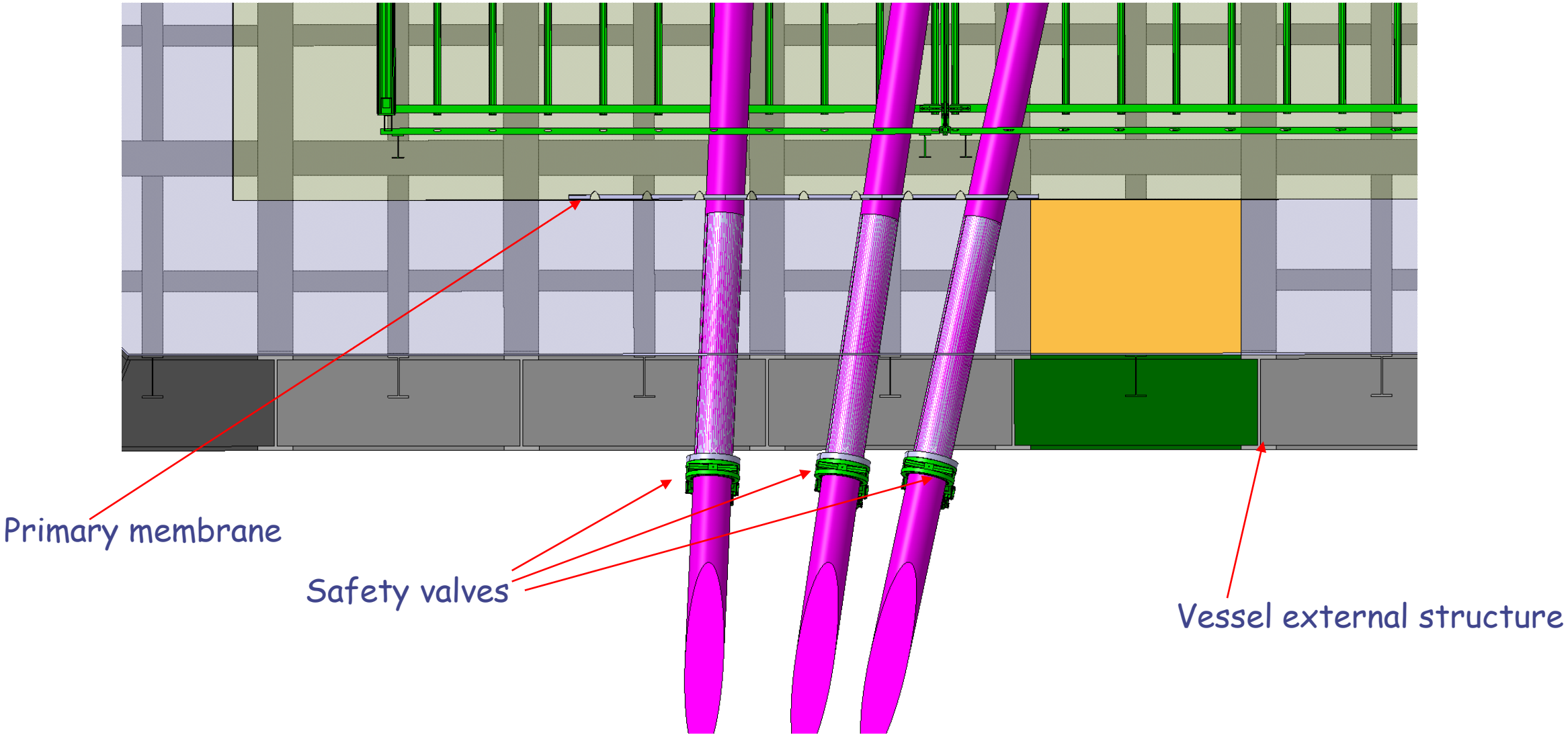
Top view



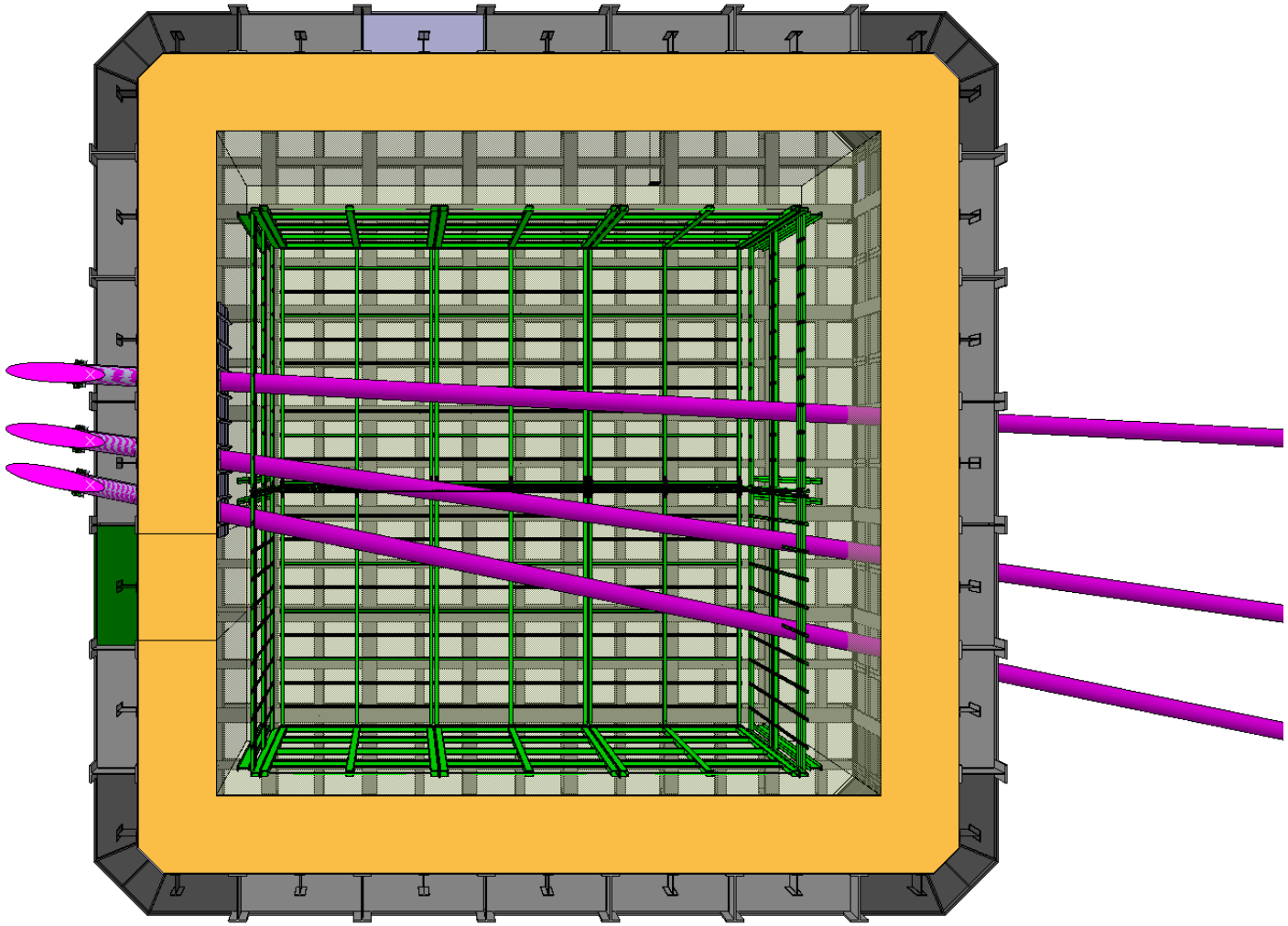
Entrance in the vessel support structure



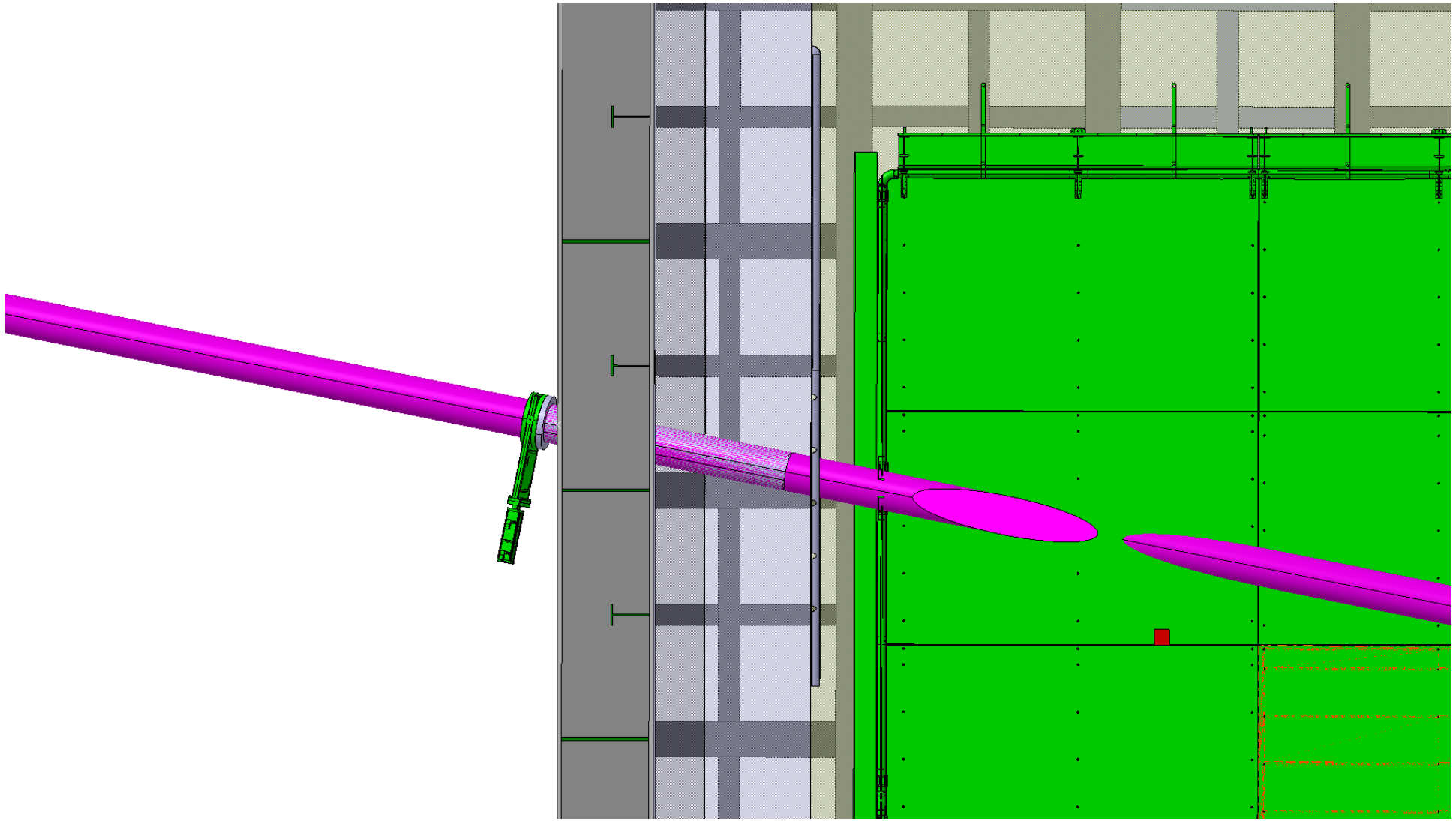
Propagation in the various layers



Full beam paths, seen from top



Detail



Possible beam window layout, vacuum insulated