SPS Σ^+ studies at the SPS with double crystal

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Outline

To support EDM/MDM measurements in the LHC, the SPS can be used as test-bench to investigate the feasibility to identify secondary particles channeled in a double-crystal setup.

To be studied:

- Σ^+ Production
  - Find optimal condition for Σ^+ tagging: energy, angular distribution, background
  - These are prerequisites for the choice of the precession crystal deflection and length
- Optics layout
  - Evaluate post-LS2 space availability in LSS5 (for a detector)
  - Investigate the necessity for a new absorber for deflected particles
- Detection

Σ^+ Production

Σ^+ Simulation setup

Beam:

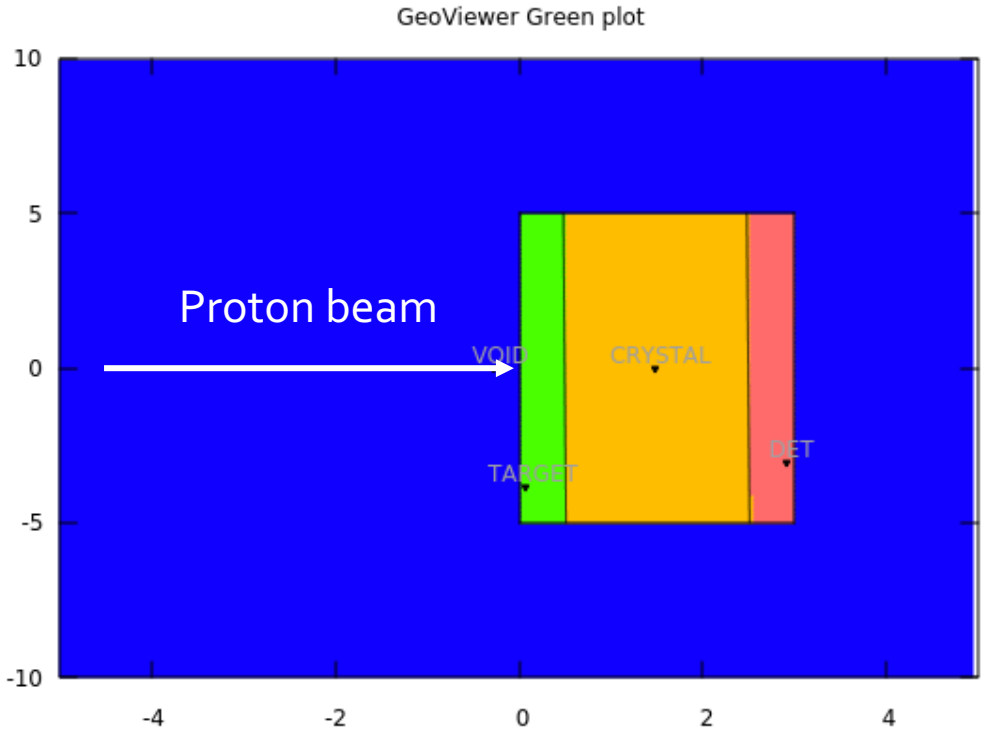
SPS COAST p beams @ 270 GeV

Target:

W – 50 mm and 10 cm*

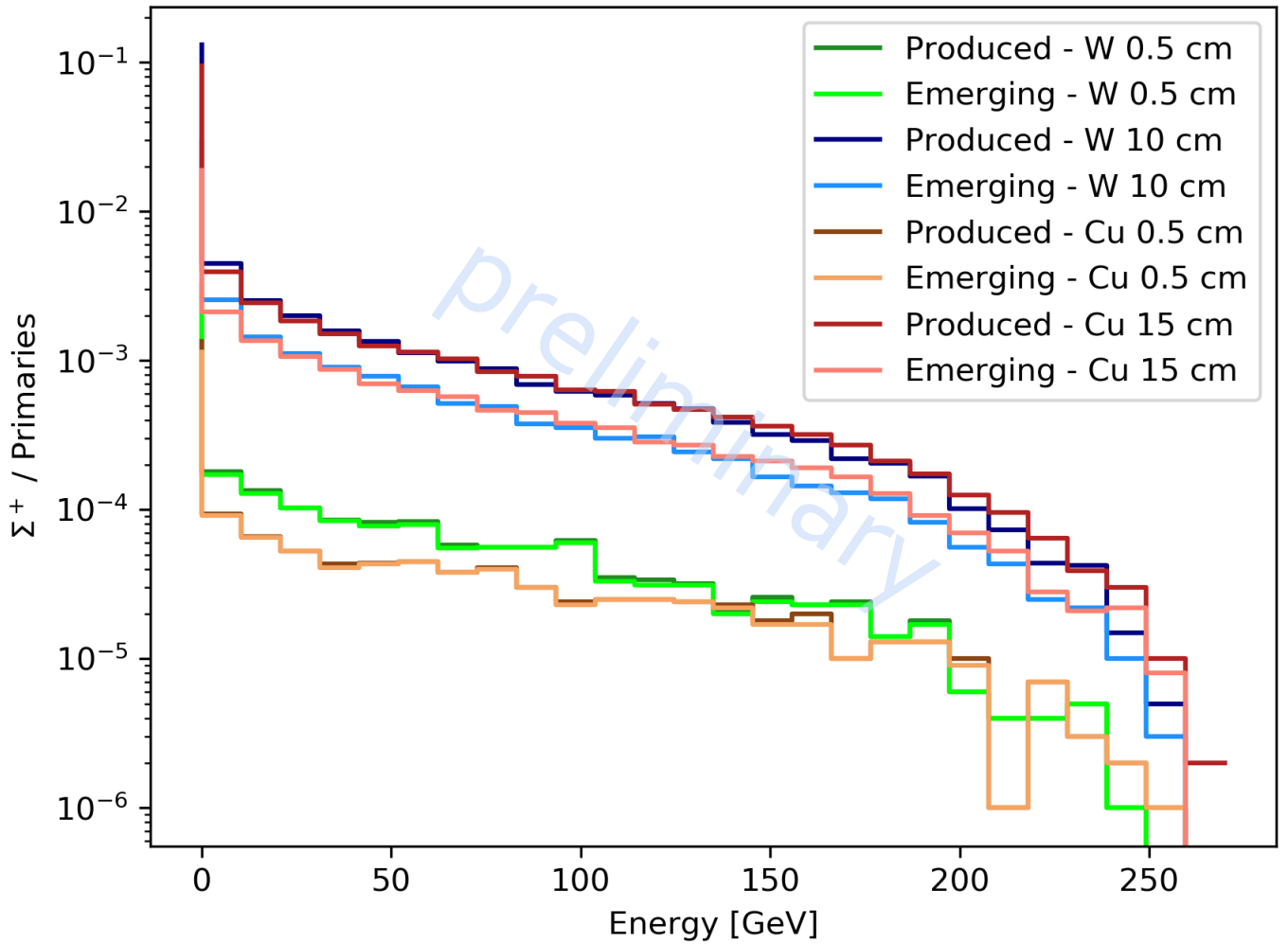
Cu – 50 mm and 15 cm*

*corresponding to 1 interaction length



Σ^+ Production energy

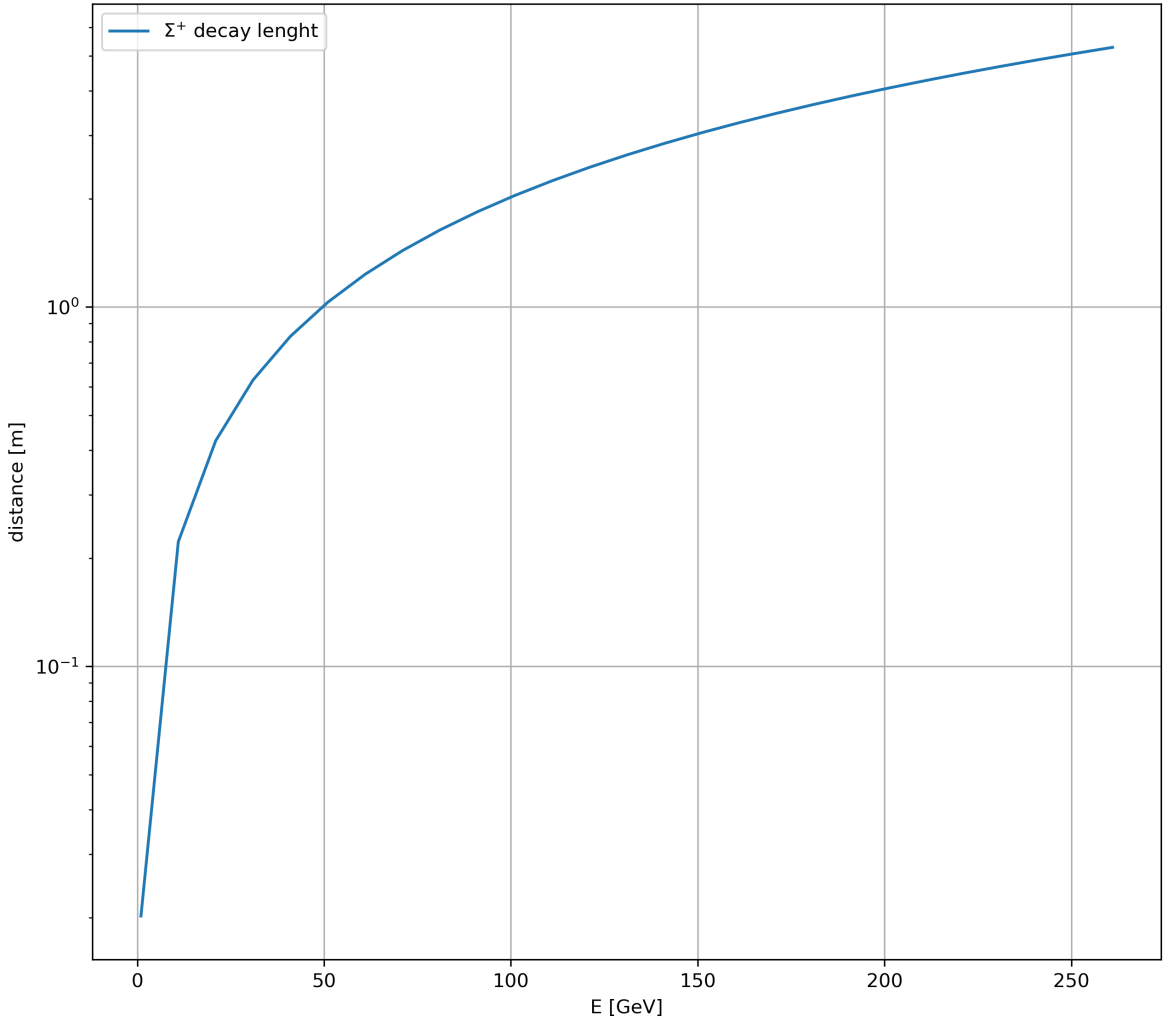
Highest Σ^+ flux emerging with target 1 interaction length long.



Σ^+ Decay Length

For Σ^+ with energies < 10 GeV, the decay length is < 20 cm.

For Σ^+ @ 50 GeV, the decay length increase to a more reasonable 1 m



Σ^+ production estimation

The number of Σ^+ produced by the interactions of a deflected beam with a target can be evaluated with 2018 SPS COAST proton beam @ 270 GeV

No ADT

- Flux of protons lost from the machine in single channeling setup : ~1.5e7 p/s
- Assuming 90% of single channeling multi-turn efficiency
- A production on target (1 interaction length) 1e-4 Σ^+ @~200 GeV per primary

Thus, ~1.3e3 Σ^+ /s @ 200 GeV will emerge from target and interact with the second crystal

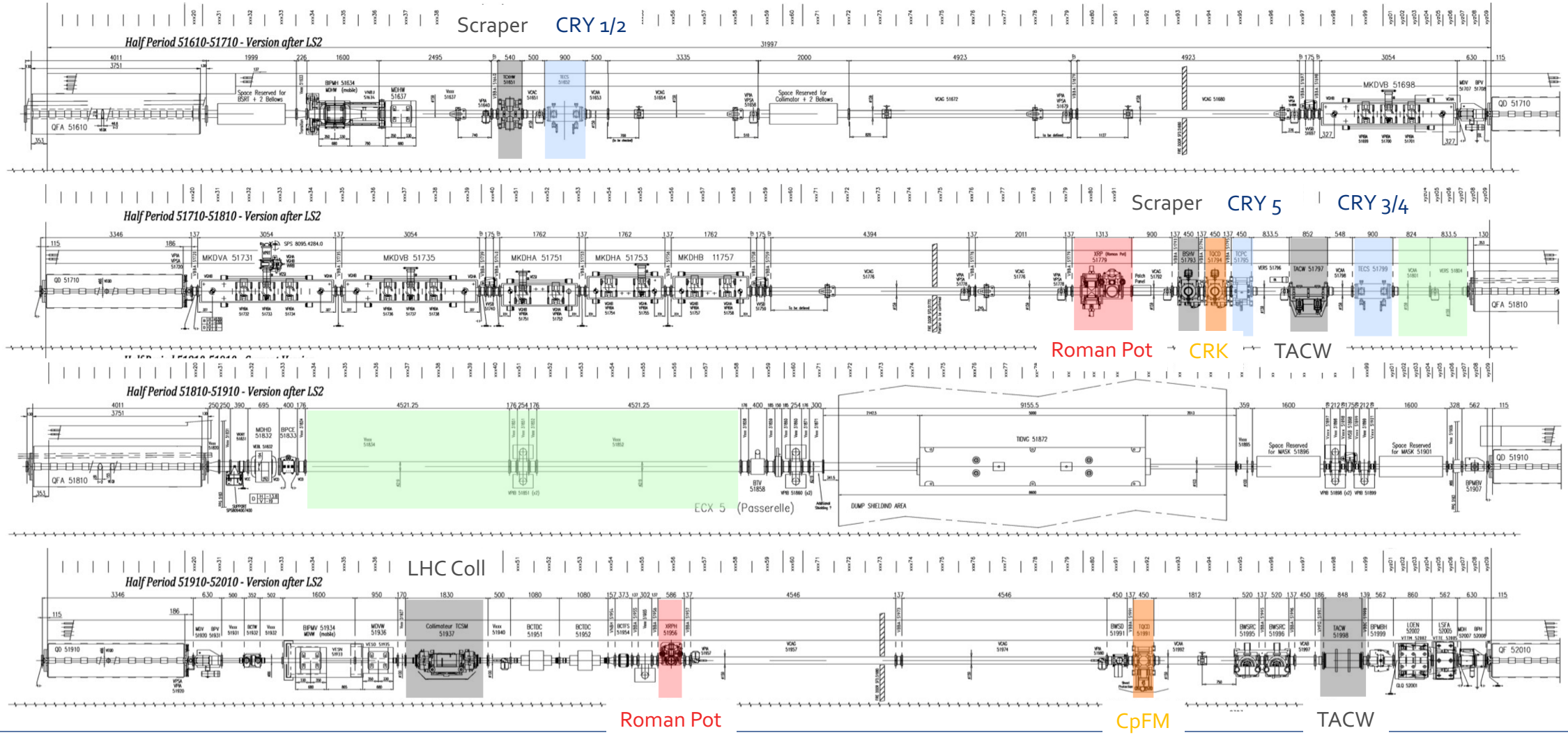
With ADT @ 30%

- the flux of protons lost from the machine with single channeling configuration is ~6.5e7 p/s, i.e. the production rate is increase by a factor of 4.

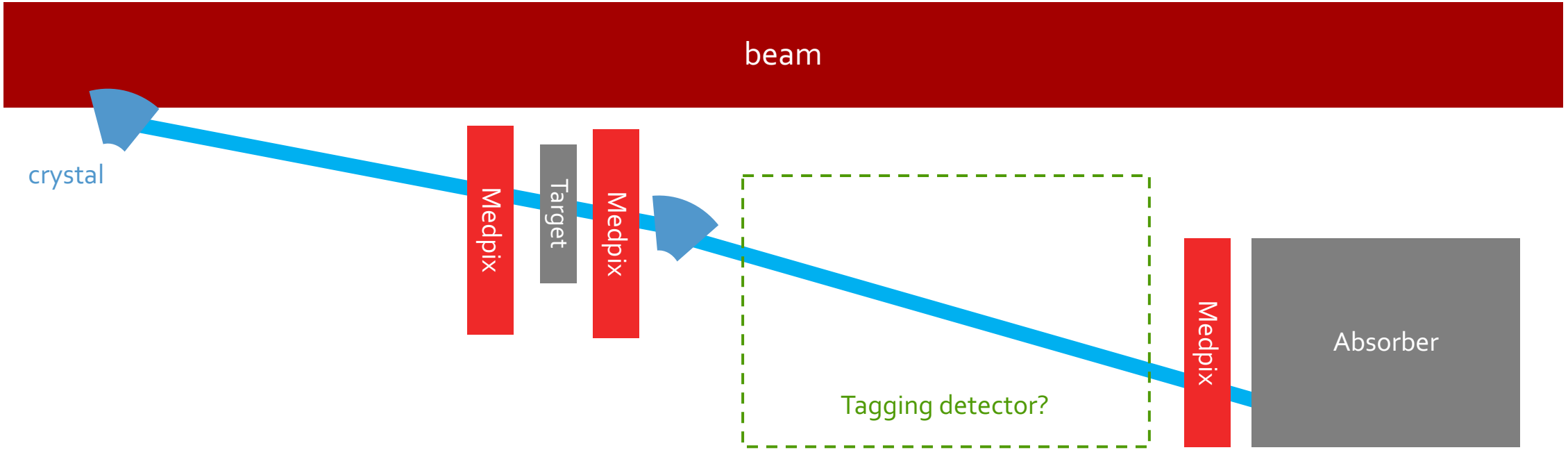
NB. The **transmission factor** of the right energy Σ^+, that emerge from the target with the right angle to be channeled is being studied by means of FLUKA simulations

SPS LSS5 Layout

Overview LSS5 layout

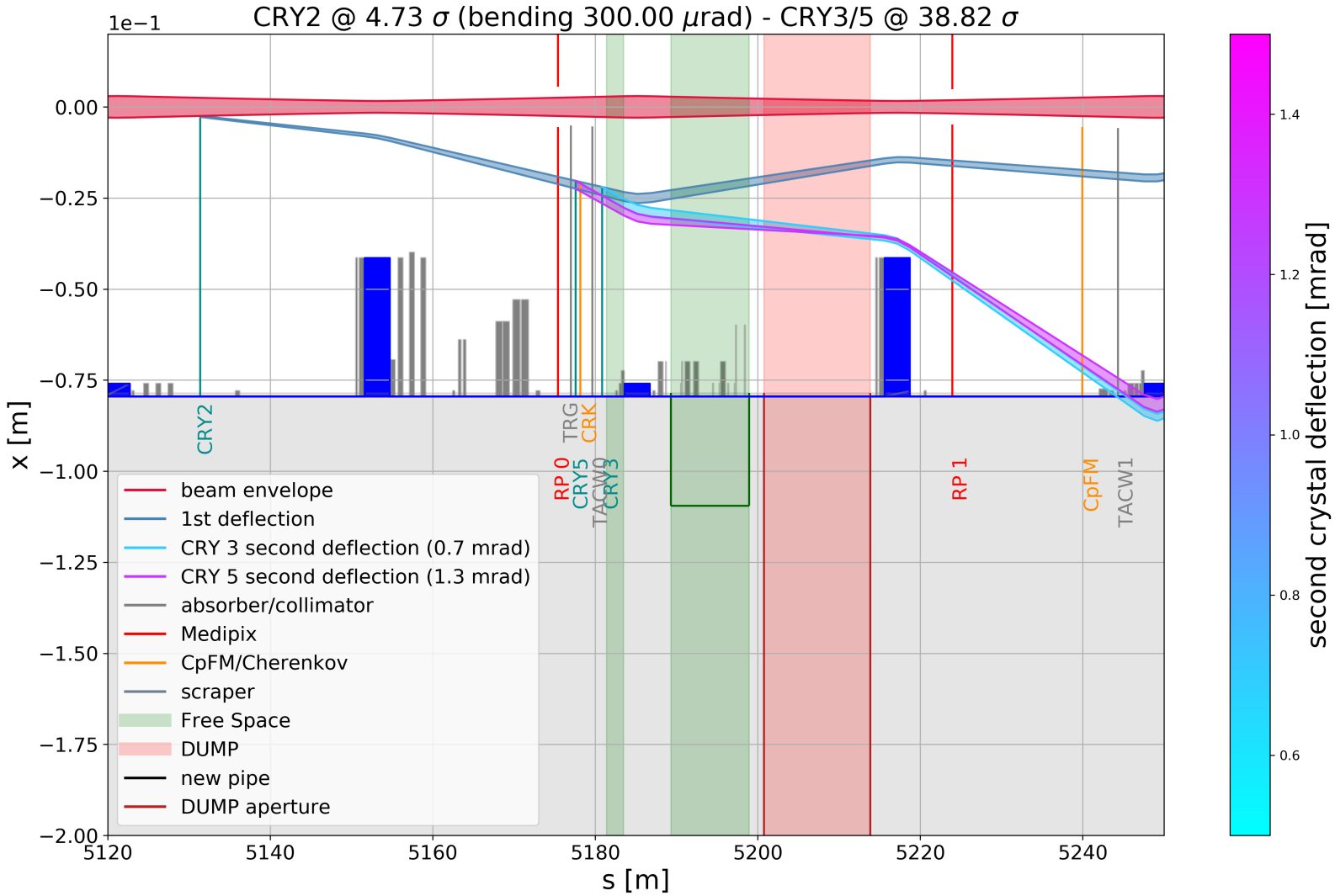


Scenarios – Double Channeling w/ Tagging



The schematic shows a conceptual layout of a double crystal setup for a particles tagging experiment.
MediPixes can be used, but we might also have space for other detectors.

Scenarios – Double Channeling w/ Tagging



In LSS5, according to post-LS2 drawings, we could have **1 m** upstream the QF.51710. and **9 m** downstream

The downstream space is just in front of the new SPS Dump (!)

Second Crystal Angle

In FNAL, a 4.5 cm long crystals with a bending angle of 1.6 mrad was used for Σ^+ @ 375 GeV

This means that a crystal with ~10 mrad bending angle would be necessary to select Σ^+ @ 50 GeV

For tagging only purpose, it is not needed such a large deflection angle.

Bending angles of about 1 mrad are well contained inside the aperture, and will be easily absorbed by present UA9 installations.

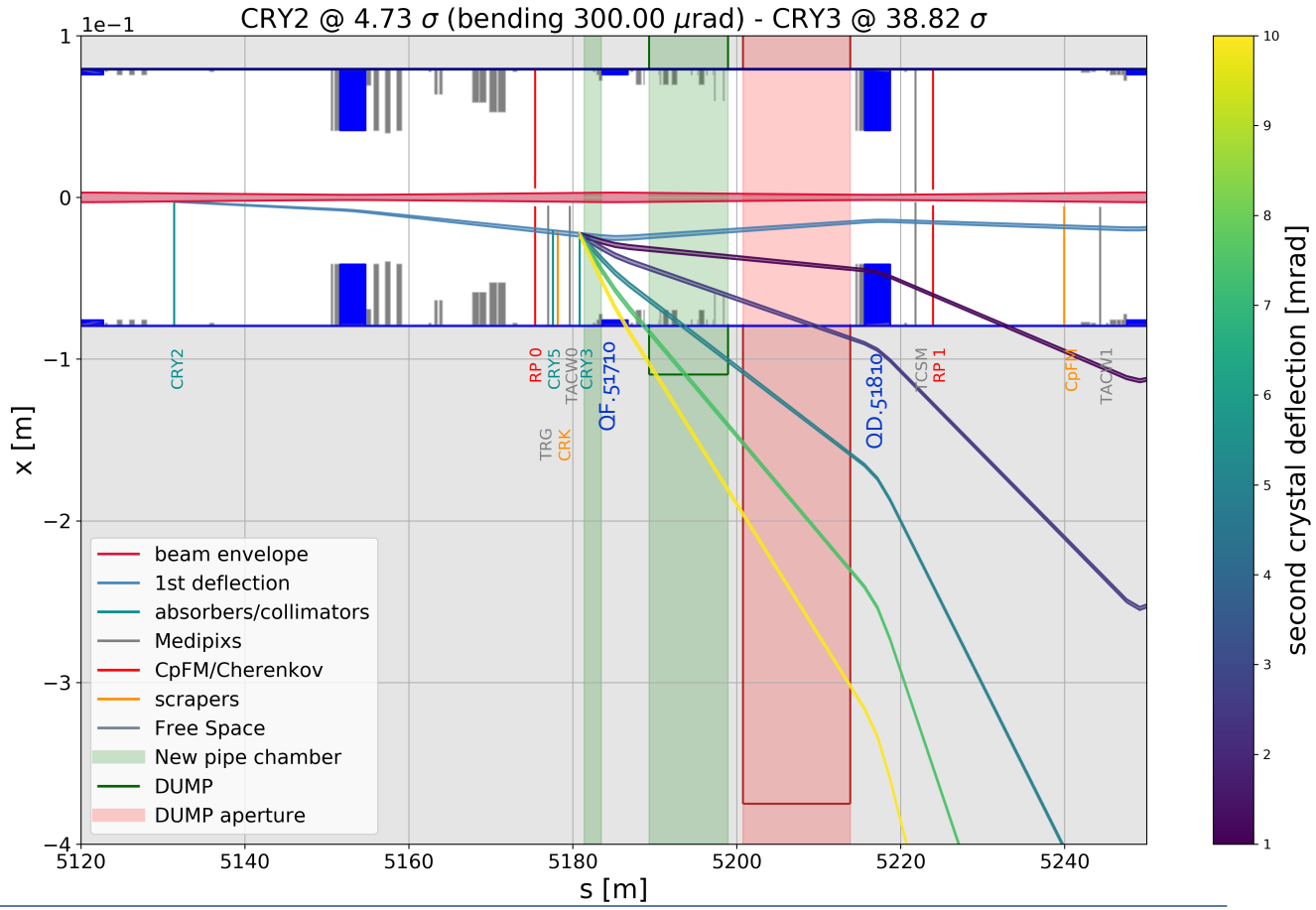
Layout limitations with large bending angle

For a 2nd crystal bending angle of about

- 10 mrad, the beamlet hits the QF.51710 in the present configuration.
- 9 to 7 mrad, the beamlet exits the larger pipe (green box) in the free zone, but it does not hit the dump aperture (red box), where it would be absorbed.

A new absorber would be needed to intercept all the beamlets deflected more than 1 mrad, before it hits the QD.51810 aperture.

Using present configuration for machine optics and 1st crystal

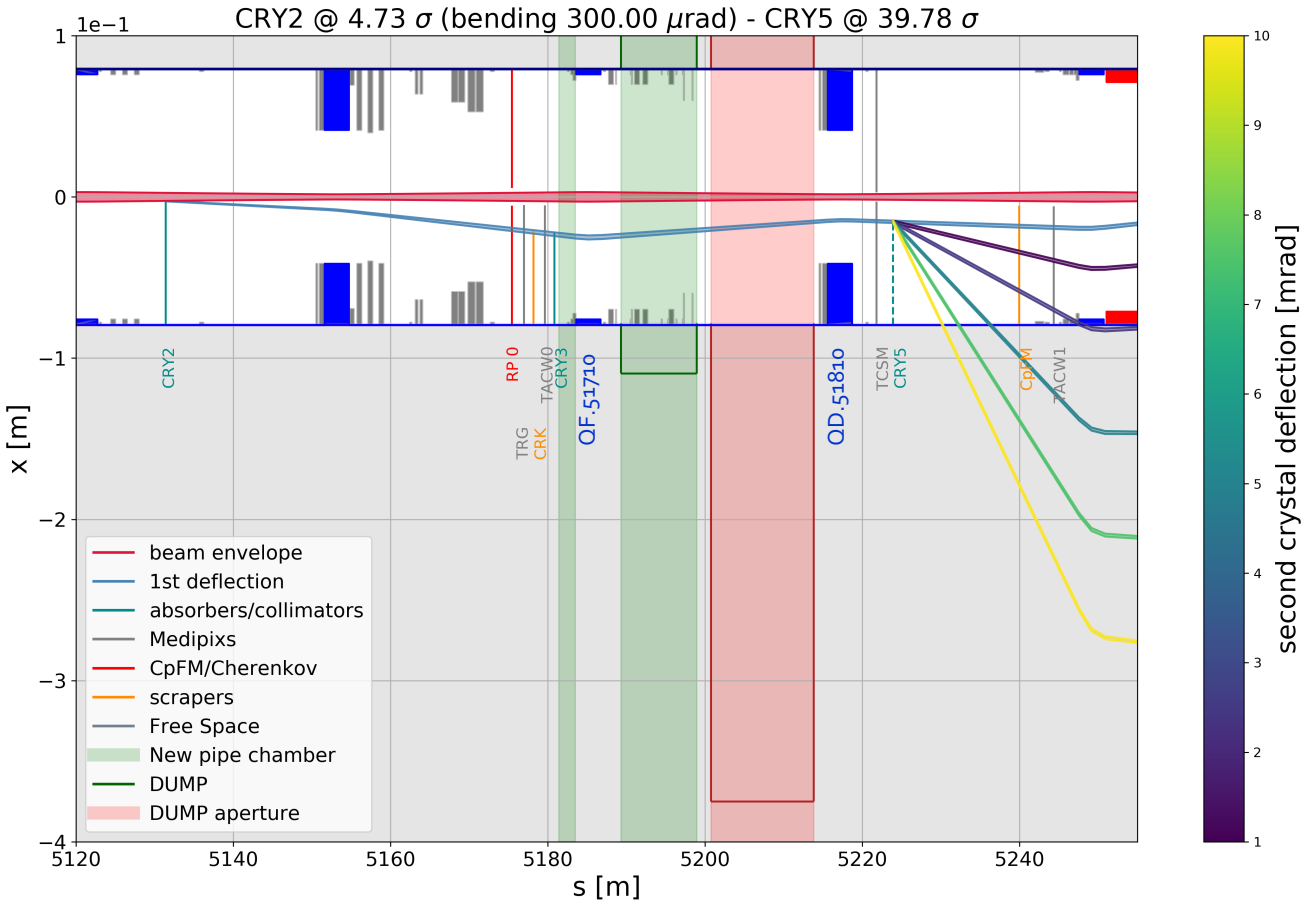


Possible layout to be investigated

To avoid problems on controlling the deflected beams, a solution is to move the CRY5 after QD.51810.

This half period is occupied only by UA9 installations and would be relatively free to use.

TO BE VERIFIED



Conclusions

- The highest flux of Σ^+ is achieved using a 1 interaction length long target
  - Might be an operation issue the handling of such an object
- Decay length is very short (~1 m for Σ^+ @ 50 GeV)
  - Channeling is still possible if the second crystal is very close to the target
- Few Σ^+ are produced per primary proton and deflected by the second crystal
  - The SPS high flux, and ADT might help to gain statistics
- The space available in the present layout is still limited
  - A detector(s) has to be investigated for the tagging purpose
  - Large bending angle for second crystal will require modification to the present layout
    - Deflections of [1,9] mrad would clear the restriction of QF.51710, still a dedicated absorber must be installed in front of the new dump
    - Deflections of [7,9] mrad would exit the beam pipe before the new dump

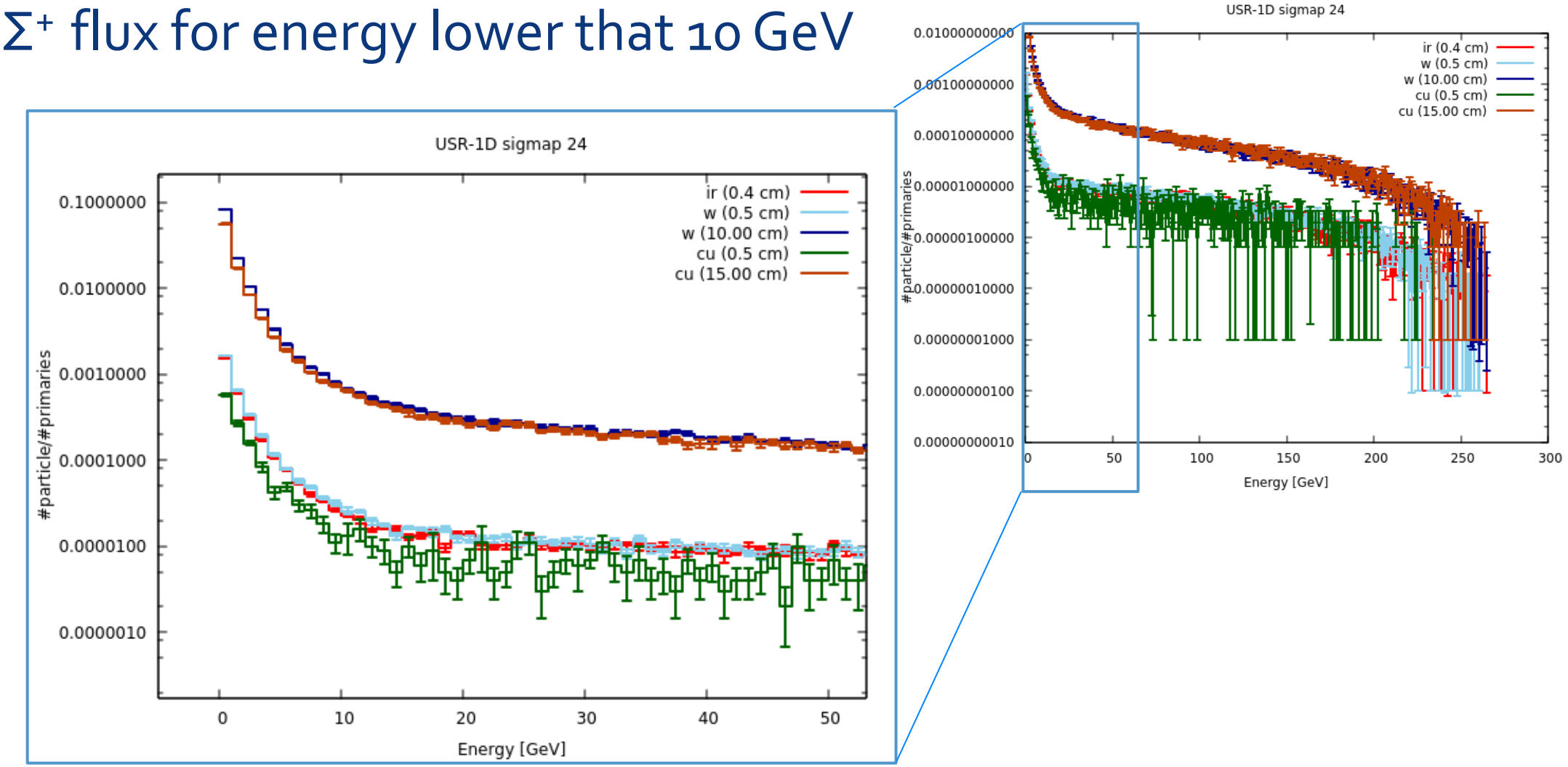
Future Studies

- ❑ Finalizing studies on angular distribution of emerging Σ^+
- ❑ Investigate further aperture restriction an layout availability
- ❑ Open investigation on possible detectors and tagging strategies

Backup

Σ^+ Production energy

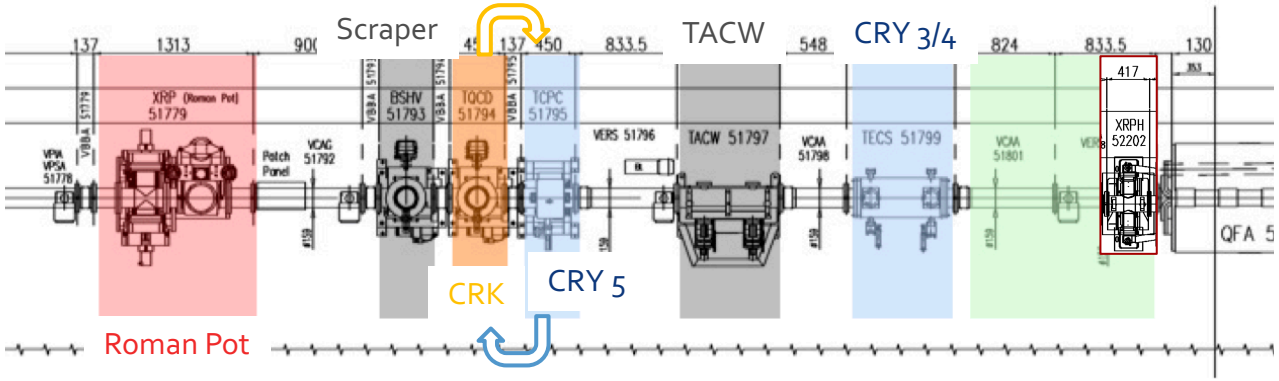
Highest Σ^+ flux for energy lower that 10 GeV



Preliminary

First proposal is to swap crystal 5 (TCPC.51795) with Russian Cherenkov (TQCD.51794)
This will allow to have a new independent target (BSHV.51793) + crystal configuration, and an extra Cherenkov radiator behind the crystal.
Also moving the XRP from dispersive area to the available slot downstream CRY3/4 (TECS.51799), could be an interesting change for new measurements.

NB. Piezo-Gonio TCPC.51795 has a limit for the crystal weight (has for LHC crystals).
At moment a QM LHC-type crystal is installed, but with a larger bending angle (~150 µrad)



Overview LSS5 layout with modifications