Current status of the TITUS sensitivity studies

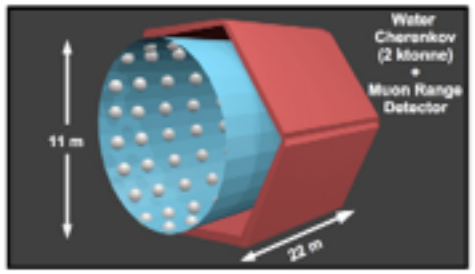
Sam Short
28 January 2015

Sam Short

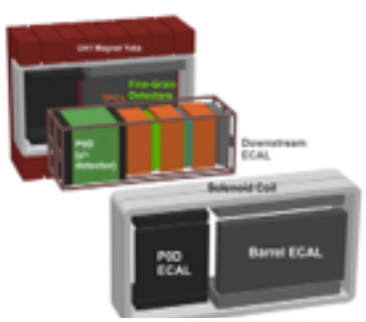
Raj Shah

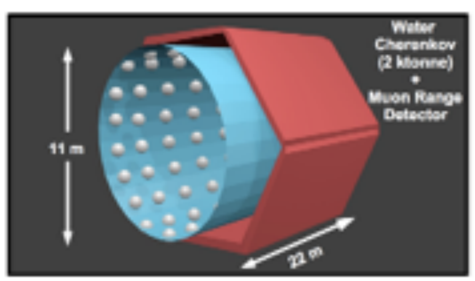
Nick Prouse

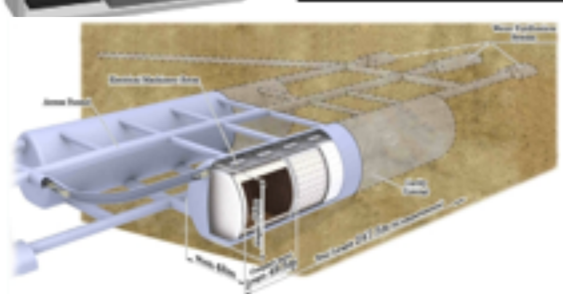
The Plan to Date



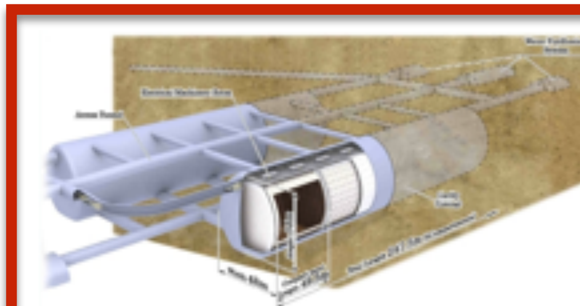
TITUS samples + covariance







"BANFF"–type fit result



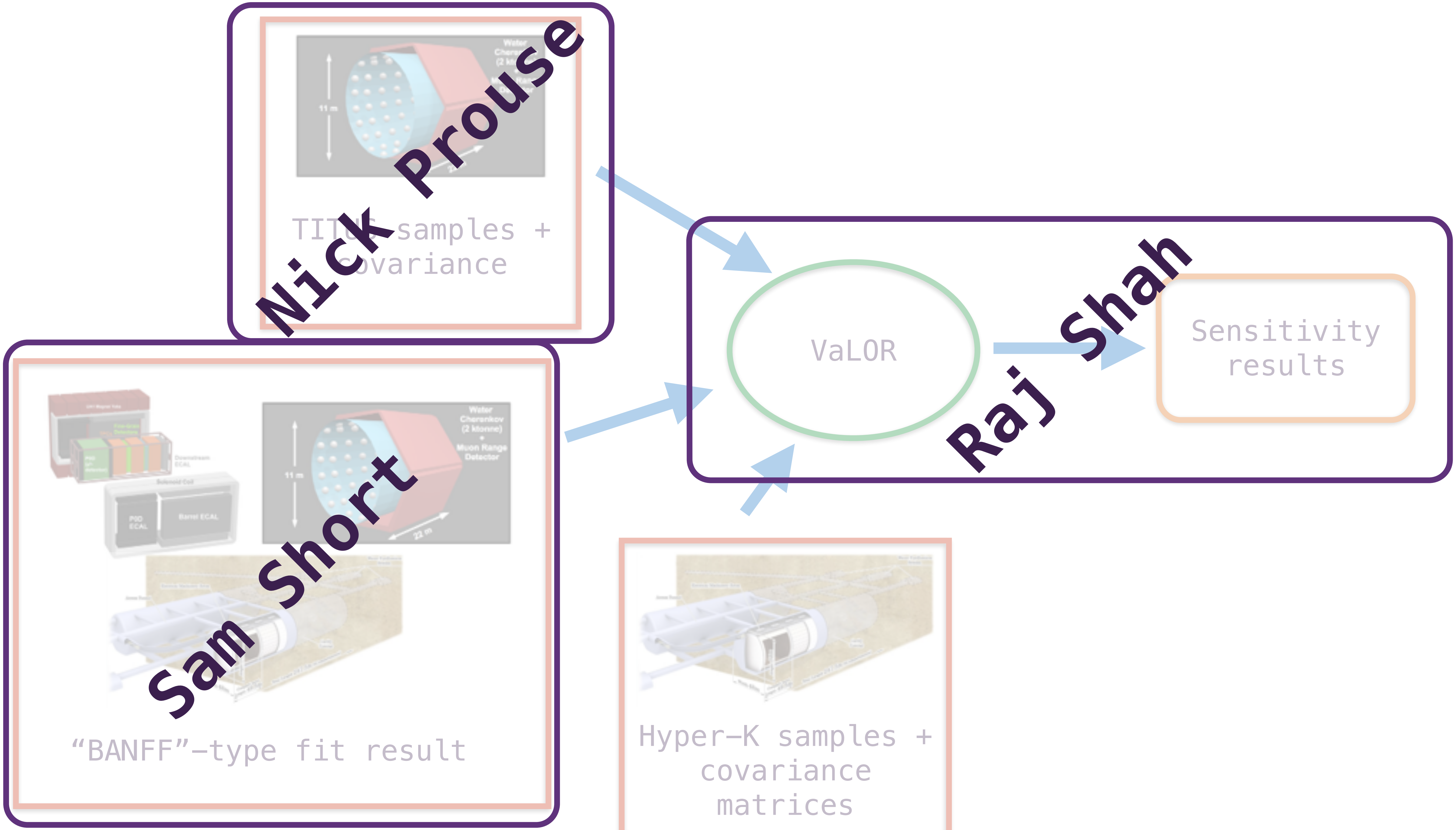
Hyper–K samples + covariance matrices

VaLOR

Sensitivity results

Aside:
- Sam will take over the SimpleFitter from Linda once the MaCh3 inputs are OK (possibly after the collaboration meeting).
- We aim to always run both the SimpleFitter and VaLOR as they have different features.

The Plan to Date



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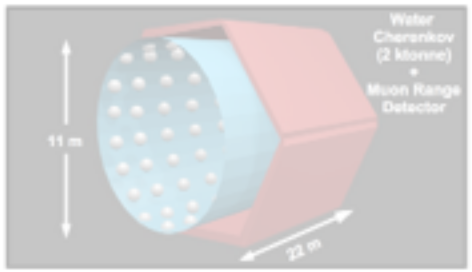

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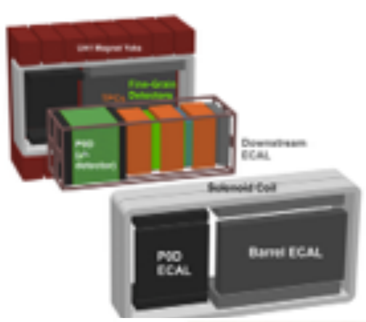
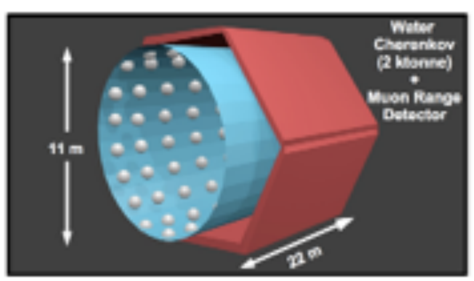
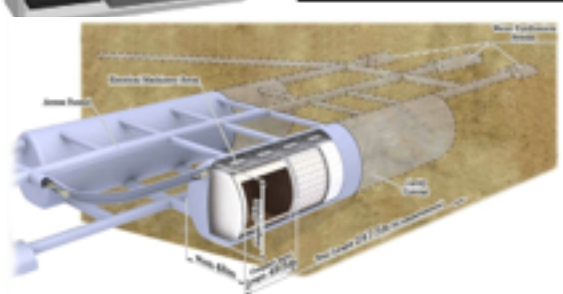
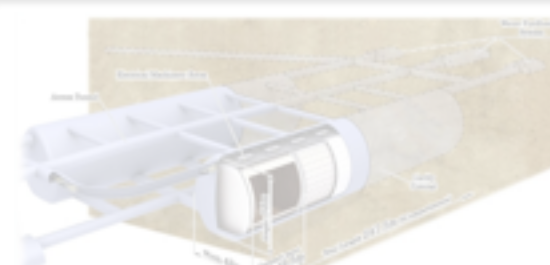
Sensitivity results







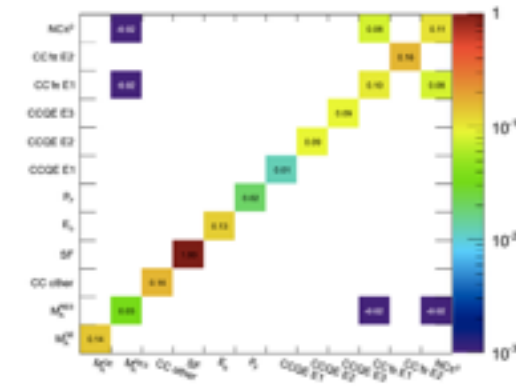
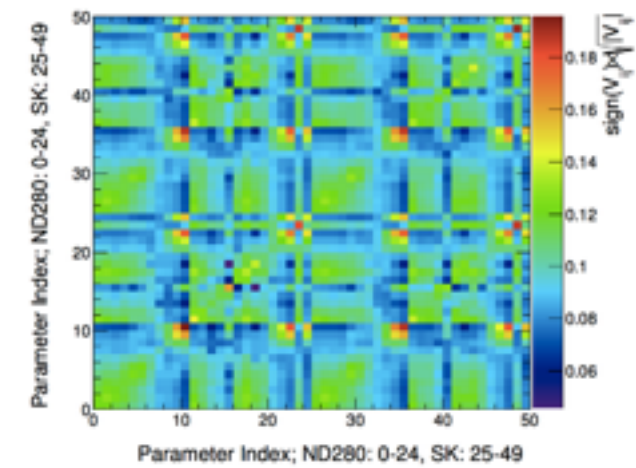
“BANFF”-type fit result

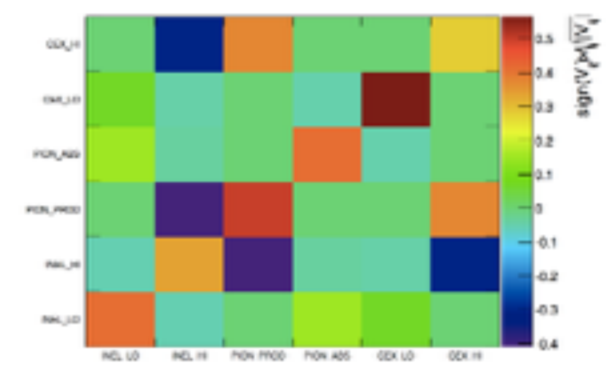
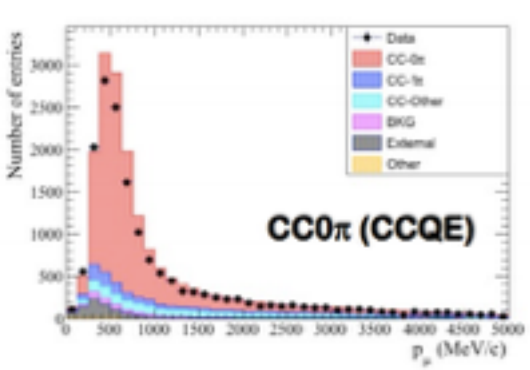


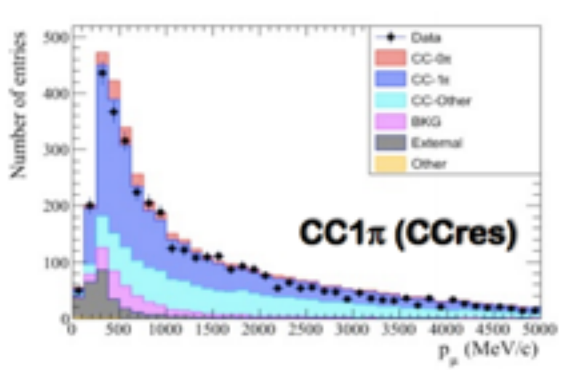
Hyper-K samples + covariance matrices

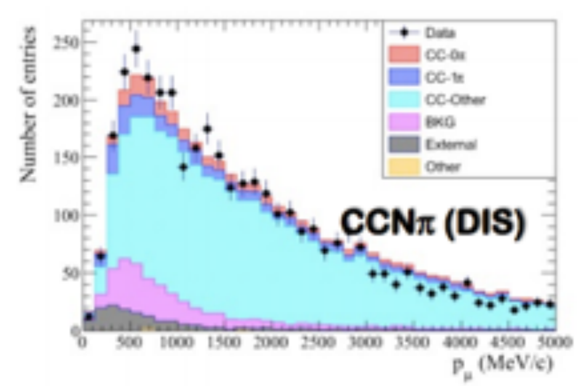
What the BANFF does

- Inputs matrices of systematics:
  - Flux (ND280 + SK)
  - Cross-section
  - Final state interaction (FSI)
  - Detector
- Inputs numu samples from ND280





What the BANFF does

- Outputs:
  - Best fit values for ND280 flux and cross-section parameters
  - A covariance matrix with **correlations** for flux and xsec parameters

What we want

- To input matrices of systematics
  - ND280 flux + SK/HK flux + **TITUS flux**
  - Cross-section
  - FSI
  - Detector
- To input ND280 numu samples
- To output:
  - Best fit of ND280 flux + cross-section parameters
  - A covariance matrix with **correlations** between flux (including **TITUS flux**) and xsec parameters
- This output will go into VaLOR (Raj is working on this) and be used in TITUS sensitivity studies

Machinery: MaCh3

(GlobalAnalysisTools/GlobalFitters/MaCh3/src/ND280_2013)

- Relatively easy to modify
- Asher wrote a lot of MaCh3 and works in London – easy to get help
- Downside: takes a long time to run
  Took 9 days to process 2 million steps
  (this is the case with any fitter)

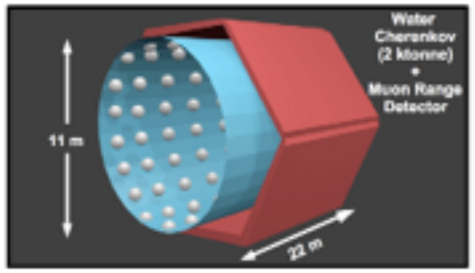
Inputs to MaCh3

- ☑ ND280 numu samples
- ☑ Cross-section covariance matrix
- ☑ ND280 detector systematics + FSI
- ☑ ND280 + TITUS + SK/HK flux covariance matrix

Reproducing 2012 BANFF

- Achieve agreement for flux parameters to within 5% (apart from the high energy / low statistics bins which was ~10% agreement)
- Having issues with the cross-section parameters – this is a known issue that Asher and I are looking into
- Optimistic that can just use the 2015 framework soon, as it is nearing completion

The Plan to Date



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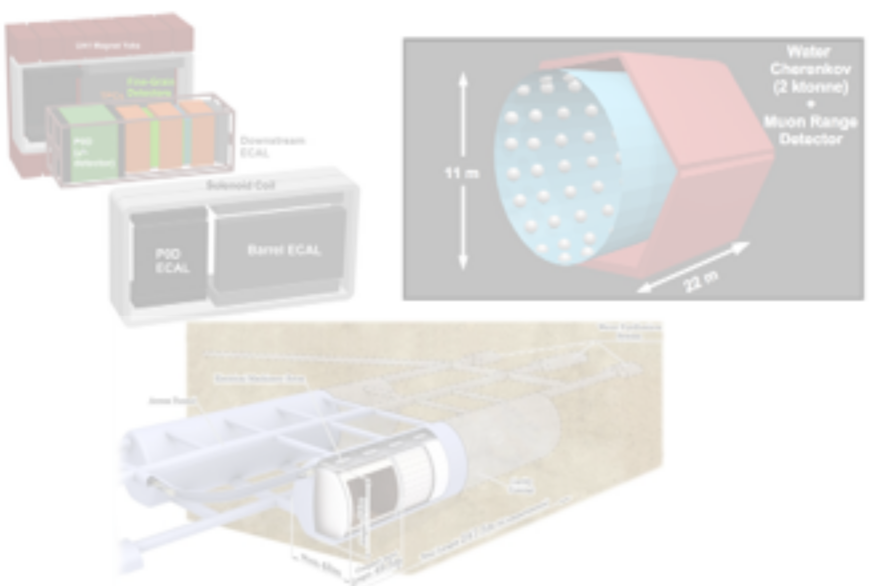
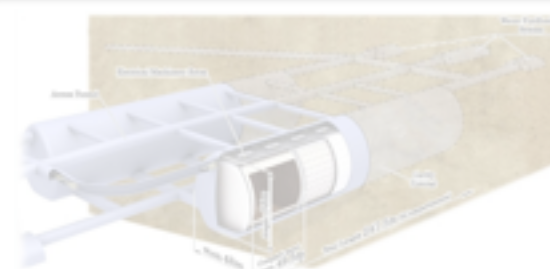


“BANFF”–type fit result



Hyper–K samples + covariance matrices

TITUS Inputs

Considering the following samples as a first approach (further investigation required):

1. 1 ring, e-like, 0 neutrons (high purity ν_e CCQE-like sample)
2. 1 ring, e-like, 1 neutron
3. 1 ring, e-like, 2+ neutrons (high purity $\bar{\nu}_e$ MEC-like sample)
4. 1 ring, mu-like, 0 neutrons (high purity ν_μ CCQE-like sample)
5. 1 ring, mu-like, 1 neutron
6. 1 ring, mu-like, 2+ neutrons (high purity $\bar{\nu}_\mu$ MEC-like sample)

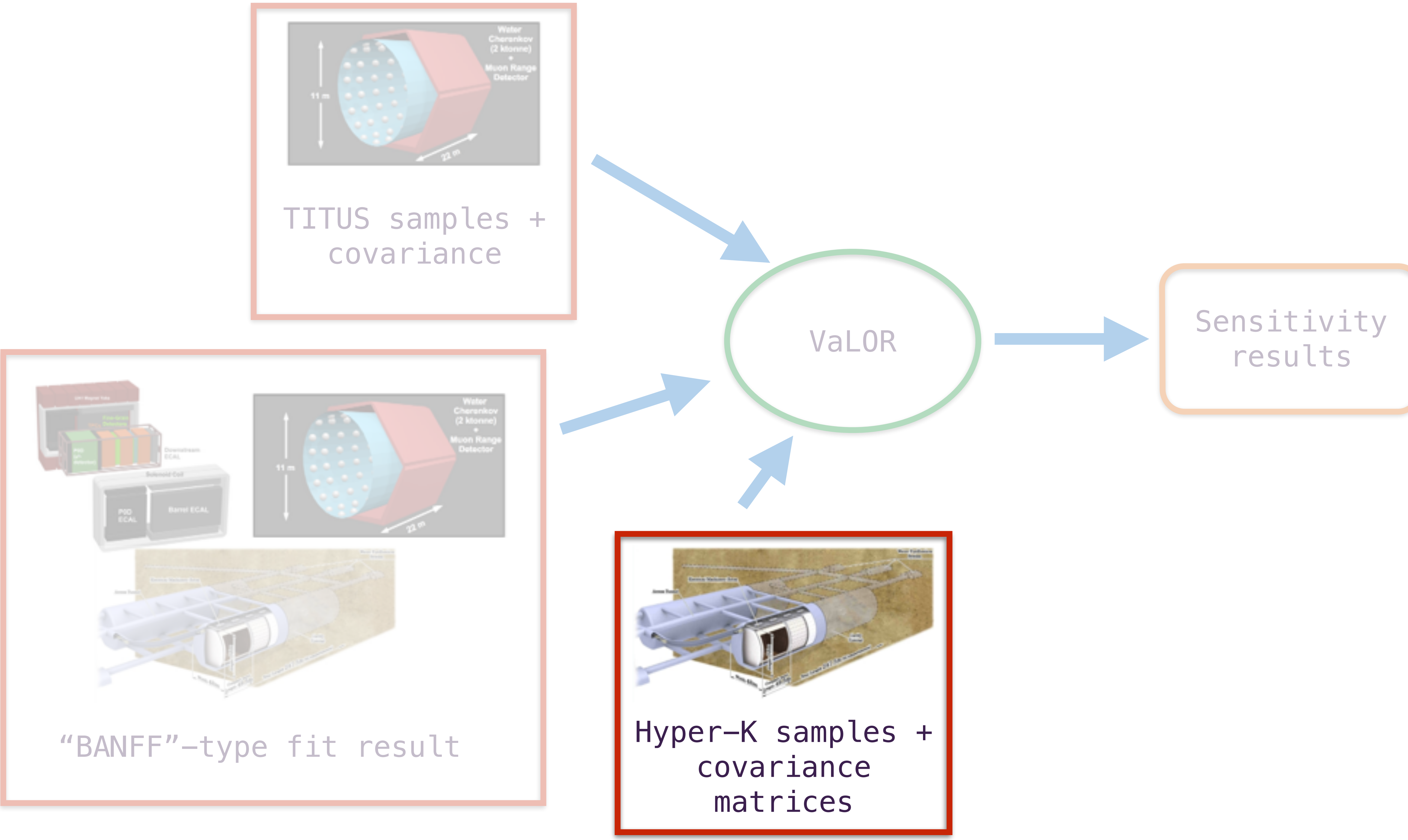
- First pass at sensitivity will only contain 1Re and 1Rmu samples
- Currently:
  Use WCSim + fiTQun
  Does not model Gd
- Future:
  Use WChSandBox + reconstruction
  Will model Gd

Selections in development:
Nick Prouse, QMUL

TITUS Inputs

- Samples (Nick Prouse)
- Output of “BANFF”–like fit (Sam Short)
- Use NIWG official 2013 → cross–section splines (Raj Shah)
- Detector systematics (use SK*√10)
- FSI covariance matrix (use SK)

The Plan to Date



Hyper–K Inputs

- Super–K samples and covariance matrices appropriately scaled
  - Scale SK MC with the POT to make 10 years of HK data
  - Take this HK POT and multiply it by 25 to account for the ratio of fiducial volumes
  - Use 1:3 $\nu:\bar{\nu}$ running
  - Scale the SK errors by $1/\sqrt{20}$

Summary

- Framework for sensitivity studies is in place
- Expecting first results soon

Supplementary slides

Inputs: MC

- Run 2 air

MC_air_beamB_5F_aa_BANFF_Sep_accum3_fcf_spline.root
MC_air_beamB_5F_ab_BANFF_Sep_accum3_fcf_spline.root
→ 6e20 POT

- Run 2 water

MC_water_beamB_5F_aa_BANFF_Sep_accum3_fcf_spline.root
MC_water_beamB_5F_ab_BANFF_Sep_accum3_fcf_spline.root
→ 6e20 POT

- Run 3c

MC_air_beamC_5F_ab_BANFF_Sep_accum3_fcf_spline.root
MC_air_beamC_5F_ac_BANFF_Sep_accum3_fcf_spline.root
MC_air_beamC_5F_ad_BANFF_Sep_accum3_fcf_spline.root
MC_air_beamC_5F_ae_BANFF_Sep_accum3_fcf_spline.root
MC_air_beamC_5F_af_BANFF_Sep_accum3_fcf_spline.root
→ 1.5e21 POT

Total = 6.113e21 POT
(not inc sand)

- Run 4 water

MC_water_beamC_5F_ac_BANFF_Sep_accum3_fcf_spline.root
MC_water_beamC_5F_ad_BANFF_Sep_accum3_fcf_spline.root
MC_water_beamC_5F_ae_BANFF_Sep_accum3_fcf_spline.root
MC_water_beamC_5F_af_BANFF_Sep_accum3_fcf_spline.root
MC_water_beamC_5F_ag_BANFF_Sep_accum3_fcf_spline.root
MC_water_beamC_5F_ah_BANFF_Sep_accum3_fcf_spline.root
→ 1.8e21 POT

- Run 4 air

MC_air_beamC_5F_ag_BANFF_Sep_accum3_fcf_spline.root
MC_air_beamC_5F_ah_BANFF_Sep_accum3_fcf_spline.root
MC_air_beamC_5F_ai_BANFF_Sep_accum3_fcf_spline.root
MC_air_beamC_5F_aj_BANFF_Sep_accum3_fcf_spline.root
MC_water_beamC_5F_aa_BANFF_Sep_accum3_fcf_spline.root
MC_water_beamC_5F_ab_BANFF_Sep_accum3_fcf_spline.root
→ 1.613e21 POT

- Sand

Sand_air_beamC_5F_aa_BANFF_Sep_accum3_fcf_spline.root
Sand_air_beamC_5F_ab_BANFF_Sep_accum3_fcf_spline.root
Sand_air_beamC_5F_ac_BANFF_Sep_accum3_fcf_spline.root
Sand_air_beamC_5F_ad_BANFF_Sep_accum3_fcf_spline.root
Sand_air_beamC_5F_ae_BANFF_Sep_accum3_fcf_spline.root
Sand_water_beamC_5F_aa_BANFF_Sep_accum3_fcf_spline.root
Sand_water_beamC_5F_ab_BANFF_Sep_accum3_fcf_spline.root
→ 5.51932e20 POT

Inputs: Data

- Run 2 air

DataRun2_WaterOut_BANFF_Oct_fctcf.root
→ 3.55196e19 POT

- Run 2 water

DataRun2_WaterIn_BANFF_Oct_fctcf.root
→ 4.2858e19 POT

- Run 3c

DataRun3c_part1_WaterOut_BANFF_Oct_fctcf.root
DataRun3c_part2_WaterOut_BANFF_Oct_fctcf.root
→ 1.34821e20 POT

- Run 4 water

DataRun4_WaterIn_aa_BANFF_Oct_fctcf.root
DataRun4_WaterIn_ab_BANFF_Oct_fctcf.root
→ 1.62488e20 POT

- Run 4 air

DataRun4_WaterOut_aa_BANFF_Oct_fctcf.root
DataRun4_WaterOut_ab_BANFF_Oct_fctcf.root
DataRun4_WaterOut_ac_BANFF_Oct_fctcf.root
→ 1.76246e20 POT

Total = 5.51932e20 POT