Prototype Pipeline Code
Overview

- **Uses data simulator output as observations**
- **Implements a piece of support structure for the global reduction section of the pipeline**

  (A pipe, not a pipeline!)
- **Uses apparent directions of photons from stars — no centroiding (yet) of CCD charge distributions**

  Apparent places of stars as viewed from FAME computed from slightly modified NOVAS/Fortran
- **Geometric algorithms for sky ® focal plane mapping based on those in "Rapidly Computing" memo**
- **IDL Executive** **(Olling, Hennessy)**
- **Modules written in IDL, Fortran, C, C++**

  (Hennessy, Lee, Makarov, Murison, Kaplan)

Prototype Pipeline Code
Testing Strategy

- **Look at pipeline-simulator O-C plots**
- **Figure out what's wrong**
- **Fix it**

Prototype Pipeline Code

Test Plan — Spring/Summer 01

Note: No e^- distribution centroiding; based on apparent directions of stellar photons

- **Evaluate O-C stats, using SC rotation from simulator**
  - Constant SC spin around celestial pole
  - ~~Move rotation axis off pole~~
  - Add precession (separates **z** and **w** axes) ¬ in progress
  - Perturb pipeline rotation, see perturbations properly reflected in O-Cs
- **Add WLS estimator for some rotation-related and astrometric parameters**
  - Initially: test astrometric parameters for position only (2 per star)
  - Later: test SC rotation parameters
  - Still later: test basic angle variations
- **Add independent rotation model**
  - Match initial conditions, attempt to understand differences

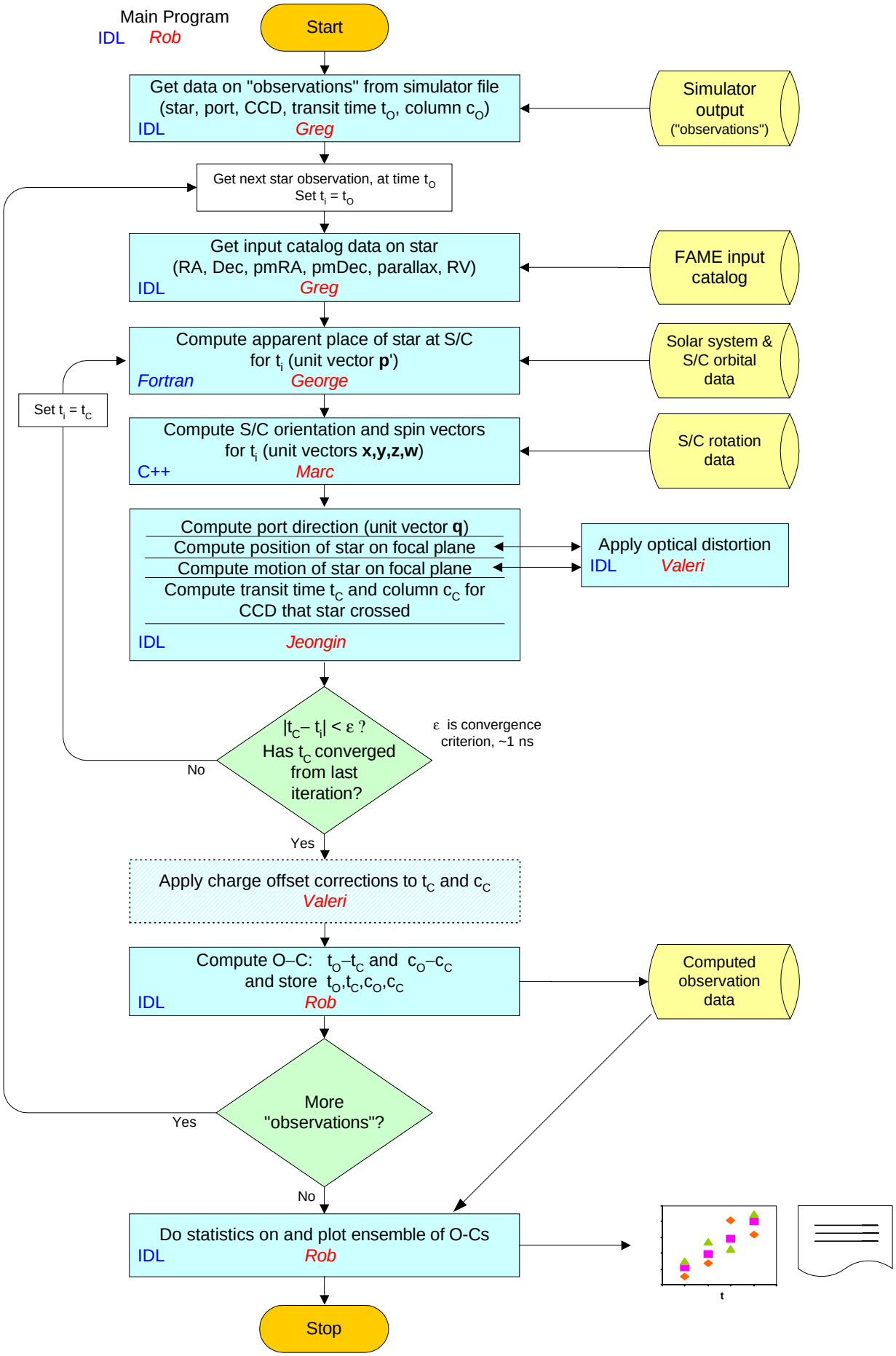
continued...

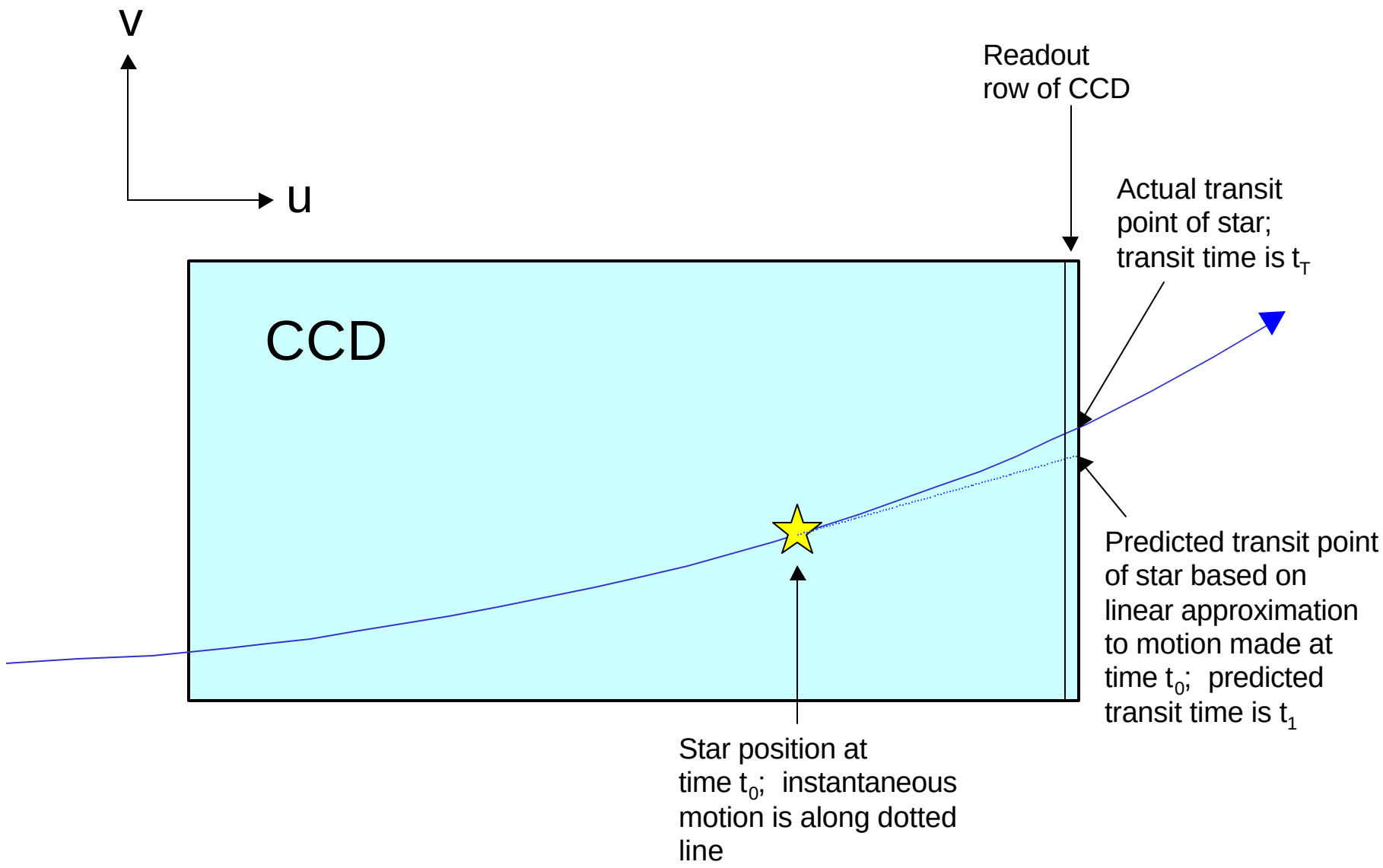
Prototype Pipeline Code
Test Plan (continued)

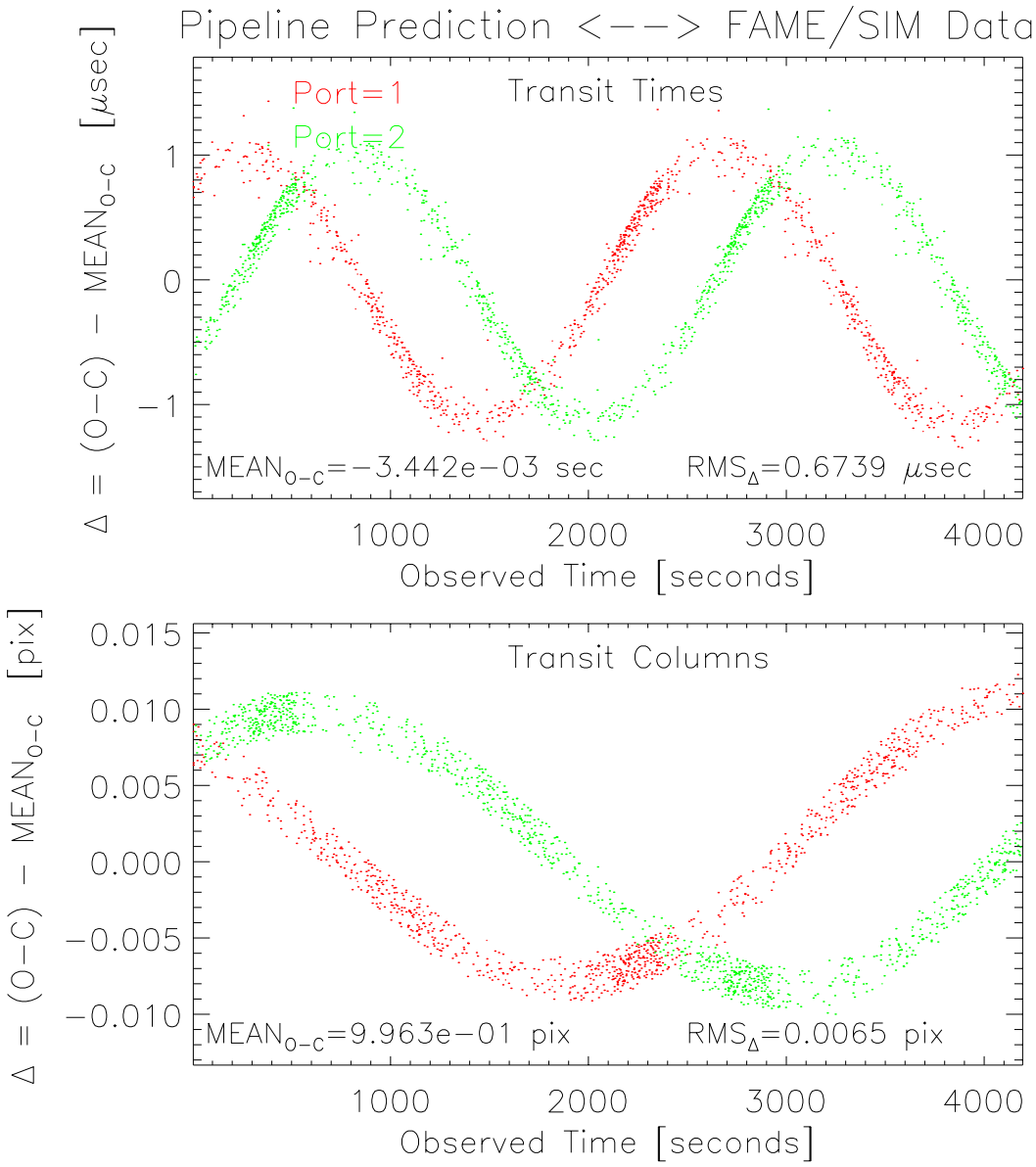
e^- distribution centroiding

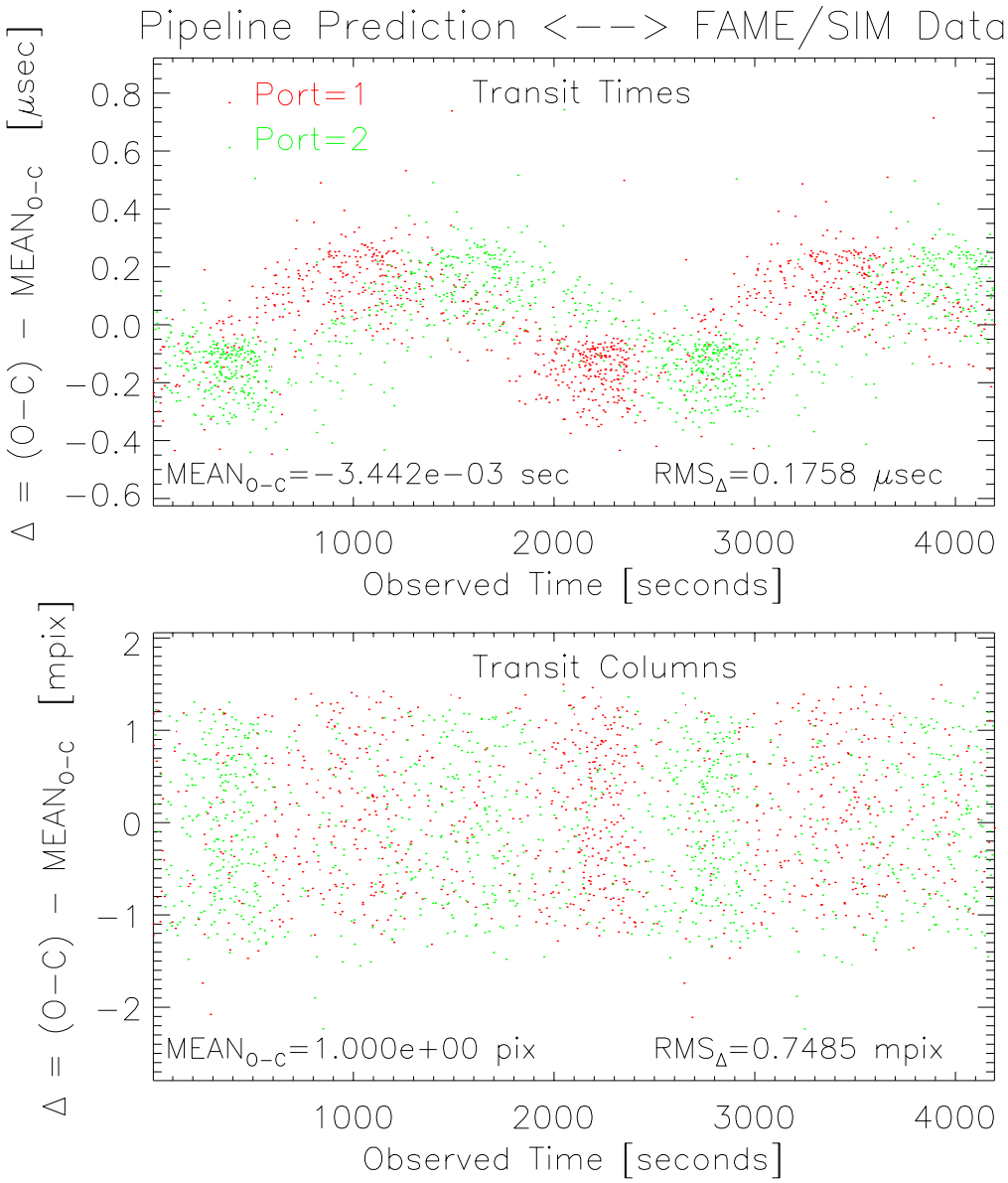
- **Centroiding tests**
  - Develop ensemble of representative observation profiles from known PSFs (“parameter space grid”)

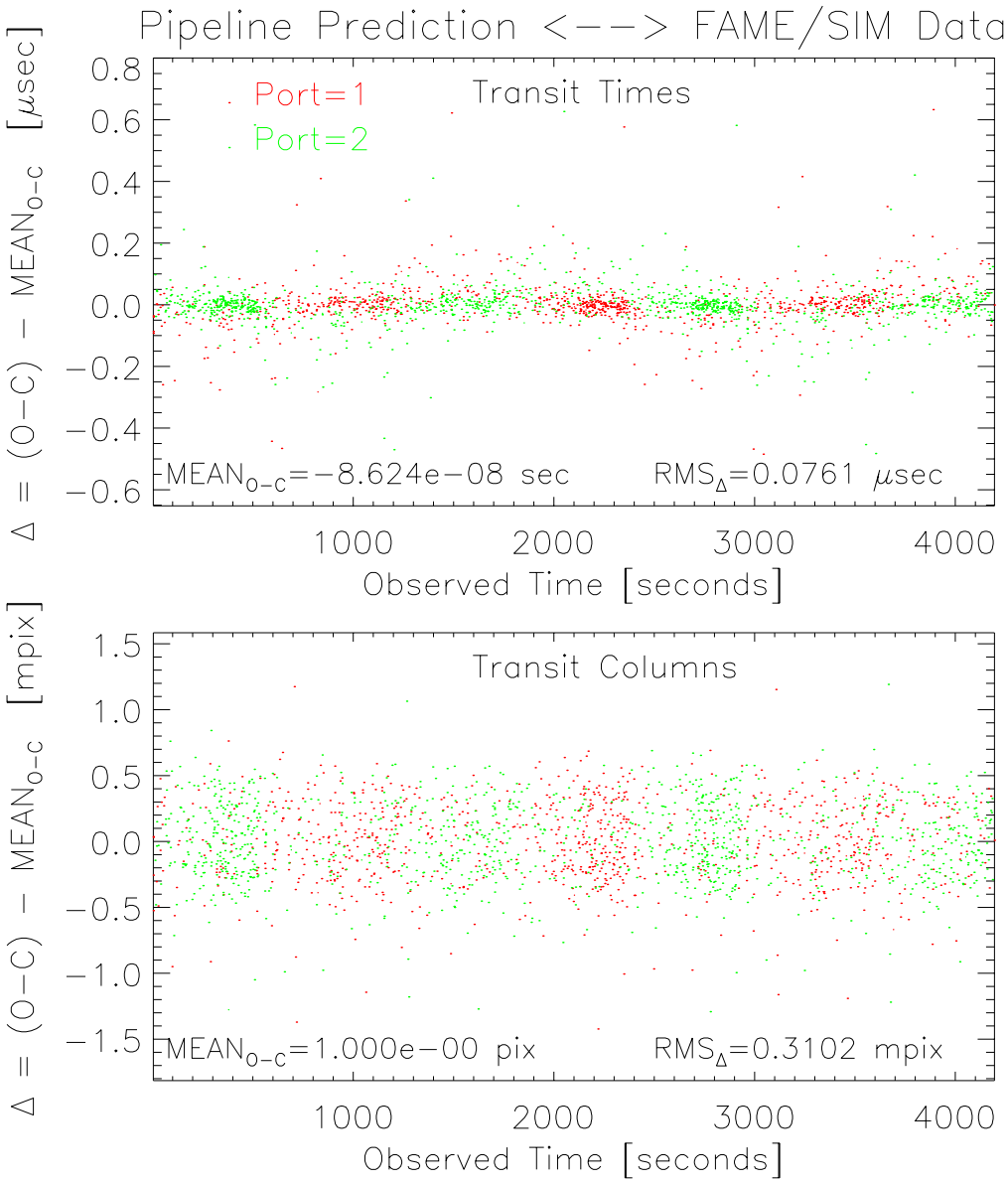
    for various spectral types, smearing, position in focal plane, optical tolerance, etc.
  - Perform simple fits to determine span of variation in centroid bias
  - Develop more sophisticated fitting functions
    - lookup table of functions, each for a region of parameter space
    - analytic development of functions
    - some combination of the two

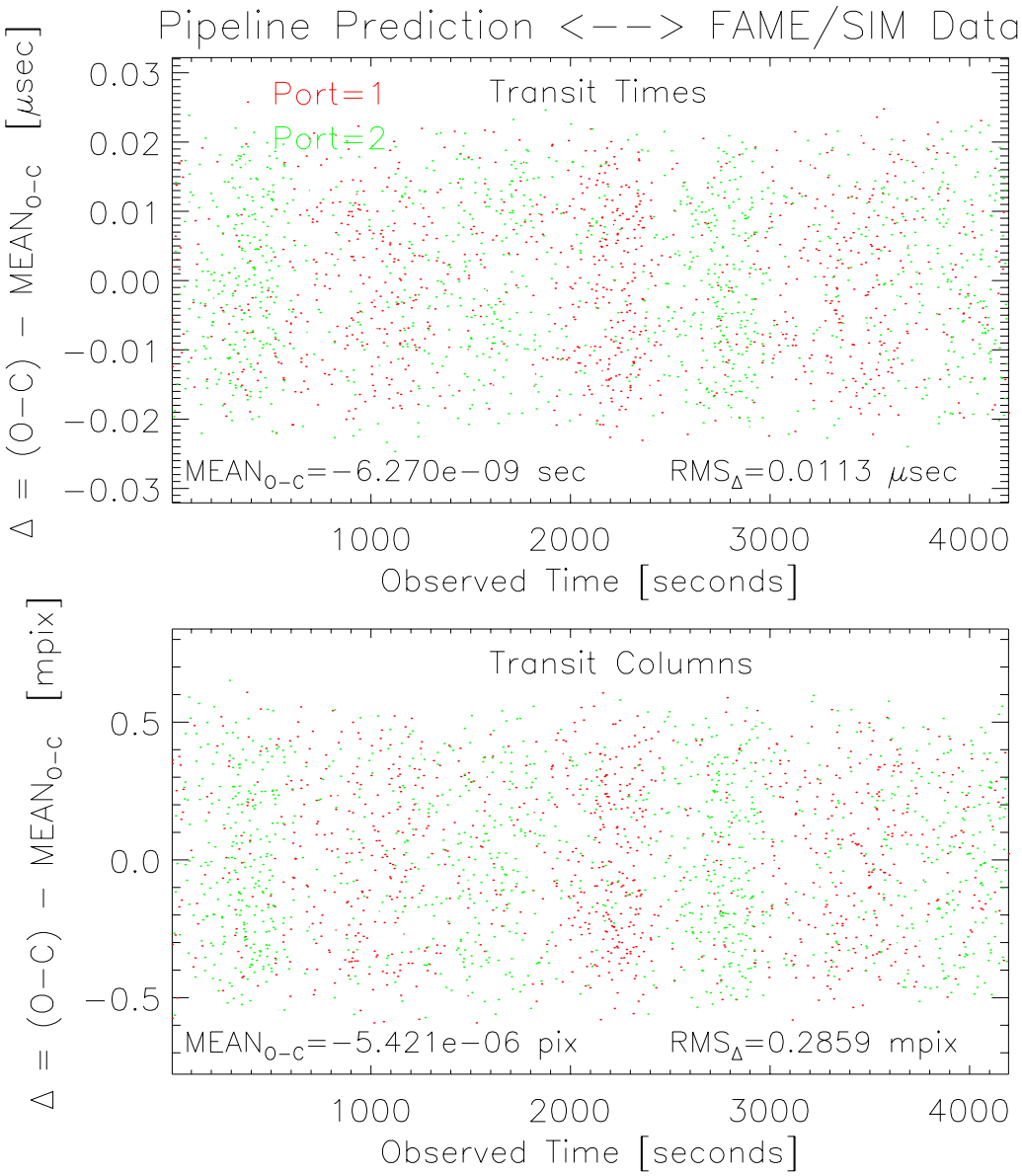

Main Program
IDL Rob
Start
Get data on "observations" from simulator file (star, port, CCD, transit time t_O, column c_O)
IDL Greg
Simulator output ("observations")
Get next star observation, at time t_O
Set $t_i = t_O$
Get input catalog data on star (RA, Dec, pmRA, pmDec, parallax, RV)
IDL Greg
FAME input catalog
Compute apparent place of star at S/C for t_i (unit vector **p**')
Fortran George
Solar system & S/C orbital data
Set $t_i = t_C$
Compute S/C orientation and spin vectors for t_i (unit vectors **x,y,z,w**)
C++ Marc
S/C rotation data
Compute port direction (unit vector **q**)
Compute position of star on focal plane
Compute motion of star on focal plane
Compute transit time t_C and column c_C for CCD that star crossed
IDL Jeongin
Apply optical distortion
IDL Valeri
$|t_C - t_i| < \varepsilon$?
Has t_C converged from last iteration?
ε is convergence criterion, ~1 ns
No
Yes
Apply charge offset corrections to t_C and c_C
Valeri
Compute O–C: $t_O - t_C$ and $c_O - c_C$ and store t_O, t_C, c_O, c_C
IDL Rob
Computed observation data
More "observations"?
Yes
No
Do statistics on and plot ensemble of O-Cs
IDL Rob
t
Stop

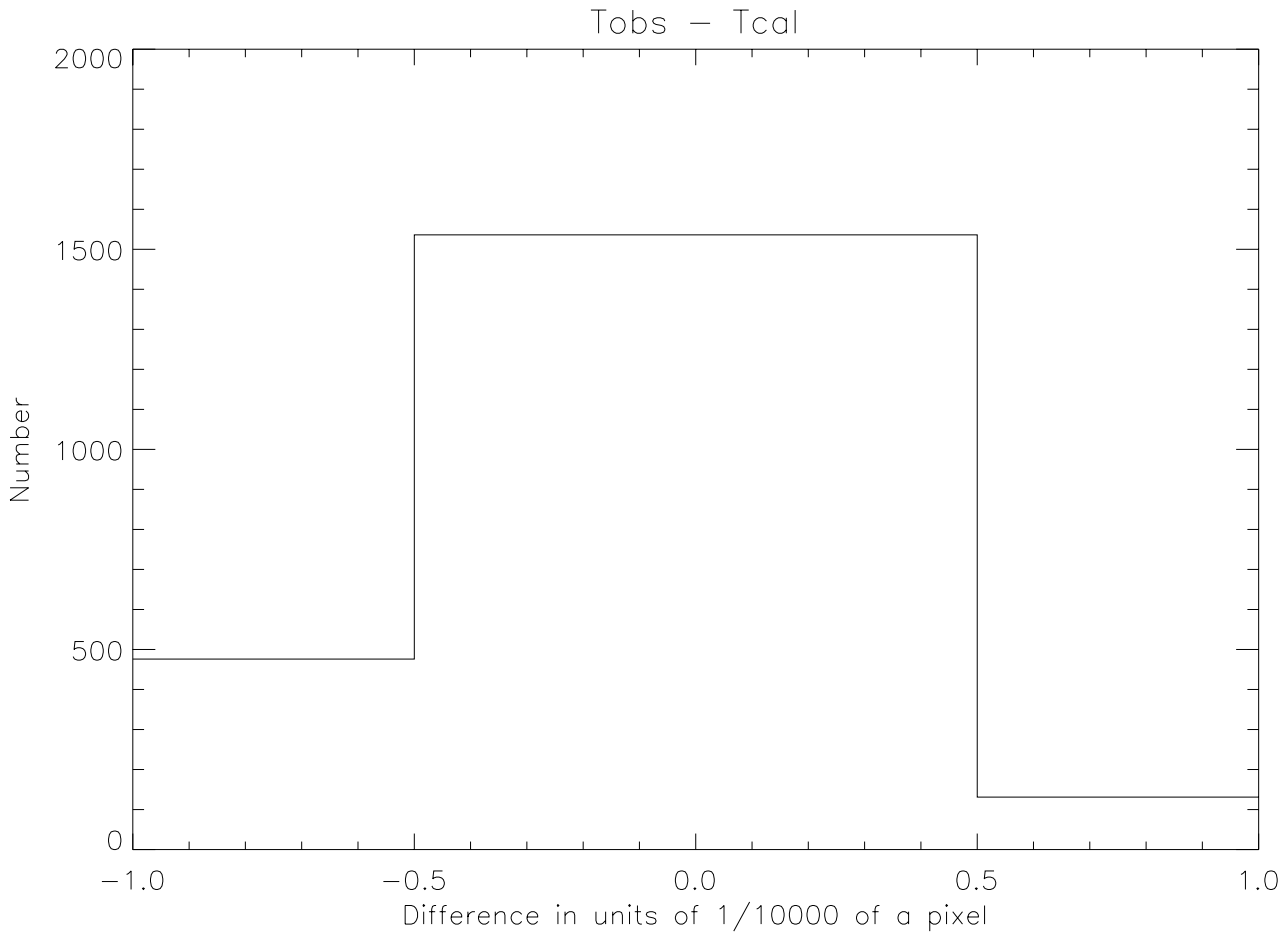

v
u
Readout
row of CCD
Actual transit
point of star;
transit time is t_T
CCD
Predicted transit point
of star based on
linear approximation
to motion made at
time t_0; predicted
transit time is t_1
Star position at
time t_0; instantaneous
motion is along dotted
line

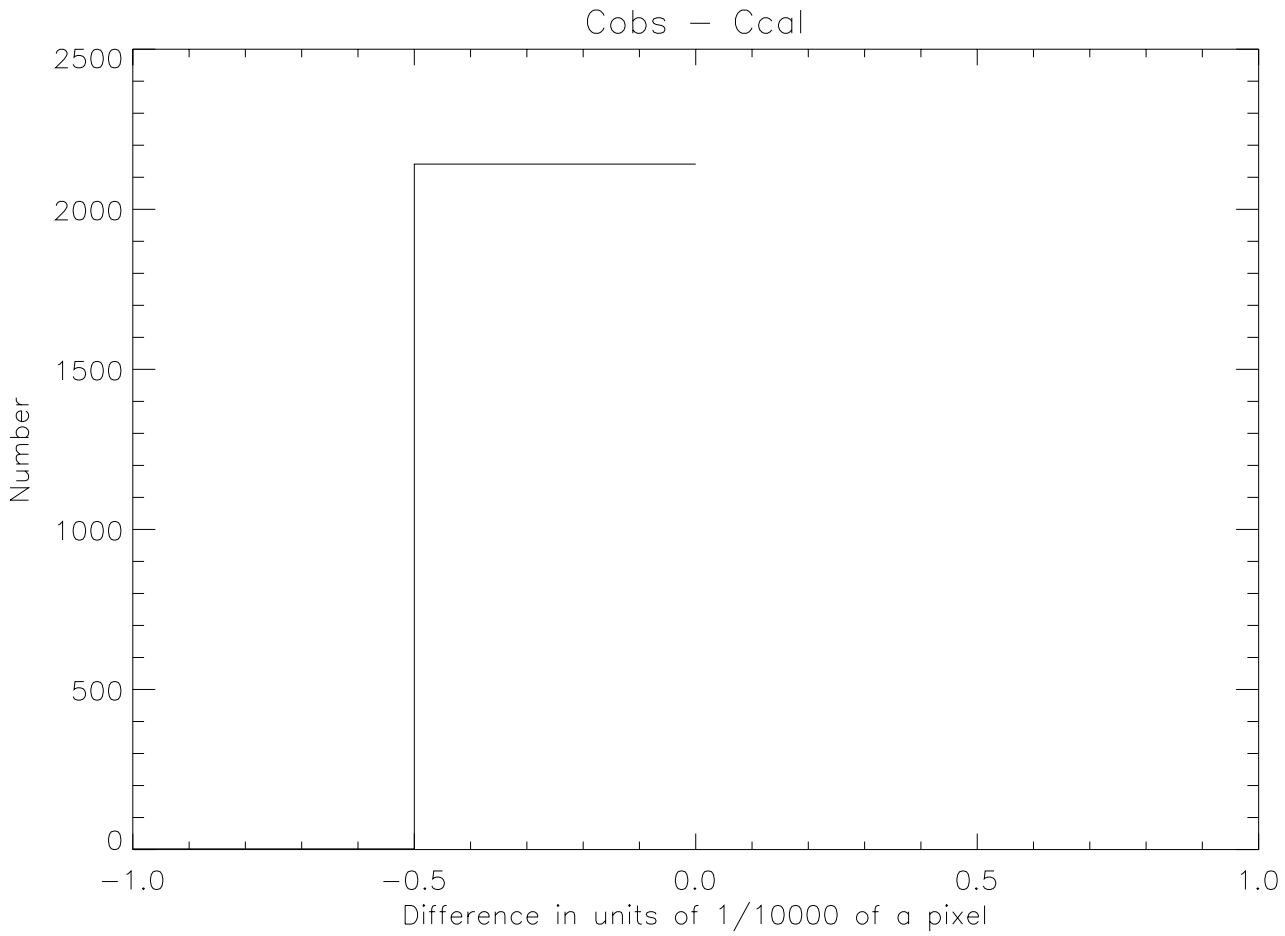

Pipeline Prediction <--> FAME/SIM Data
Transit Times
Port=1
Port=2
Δ = (O−C) − MEAN$_{O-C}$ [μsec]
1
0
−1
MEAN$_{O-C}$=−3.442e−03 sec
RMS$_{\Delta}$=0.6739 μsec
1000
2000
3000
4000
Observed Time [seconds]
Transit Columns
Δ = (O−C) − MEAN$_{O-C}$ [pix]
0.015
0.010
0.005
0.000
−0.005
−0.010
MEAN$_{O-C}$=9.963e−01 pix
RMS$_{\Delta}$=0.0065 pix
1000
2000
3000
4000
Observed Time [seconds]

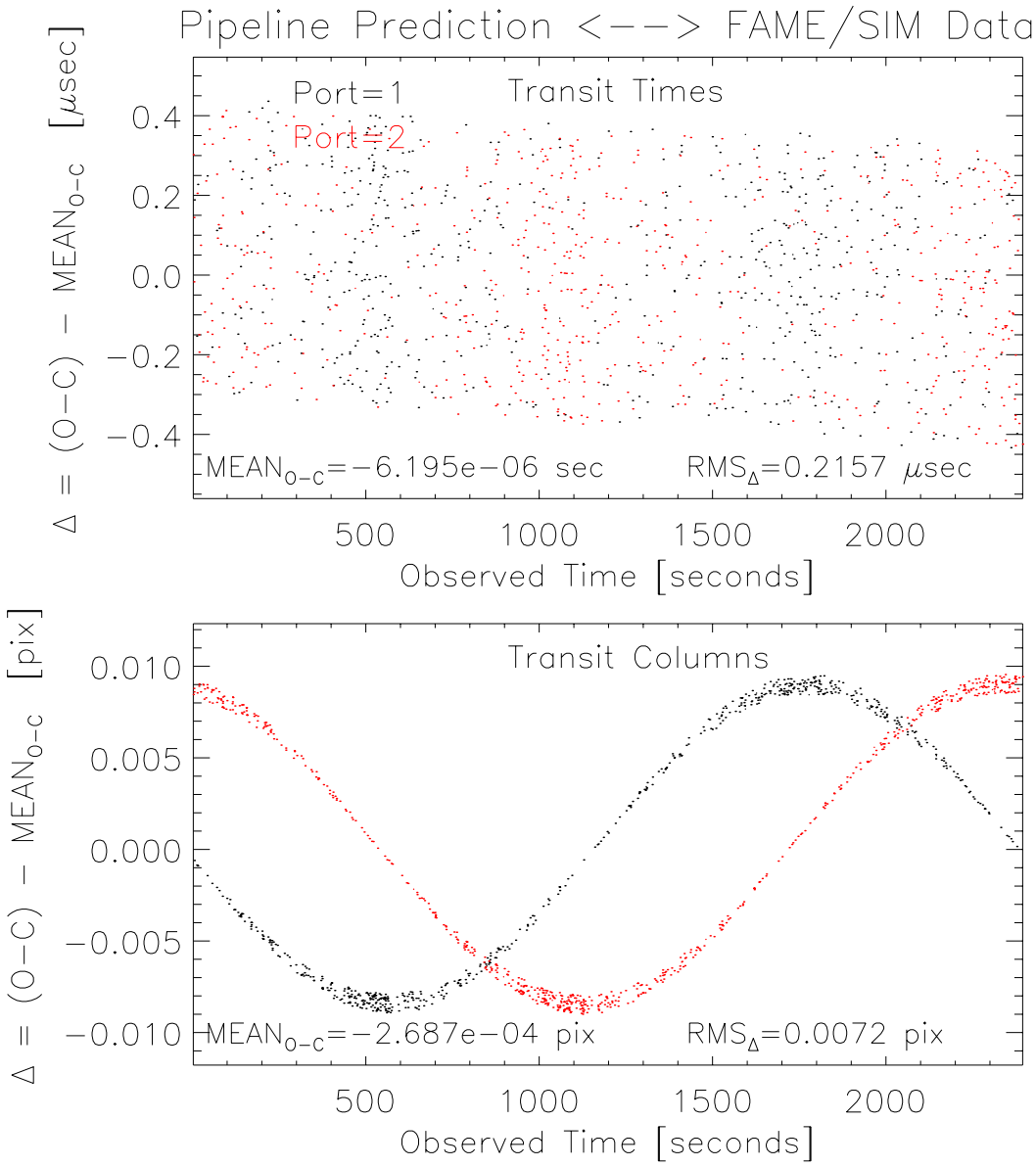

Pipeline Prediction <--> FAME/SIM Data
Transit Times
Port=1
Port=2
Δ = (O−C) − MEAN$_{O-C}$ [μsec]
0.8
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
MEAN$_{O-C}$=−3.442e−03 sec
RMS$_{\Delta}$=0.1758 μsec
1000
2000
3000
4000
Observed Time [seconds]
Transit Columns
Δ = (O−C) − MEAN$_{O-C}$ [mpix]
2
1
0
−1
−2
MEAN$_{O-C}$=1.000e+00 pix
RMS$_{\Delta}$=0.7485 mpix
1000
2000
3000
4000
Observed Time [seconds]


Pipeline Prediction <--> FAME/SIM Data
Transit Times
Port=1
Port=2
MEAN$_{O-C}$=−8.624e−08 sec
RMS$_{\Delta}$=0.0761 μsec
Δ = (O−C) − MEAN$_{O-C}$ [μsec]
Observed Time [seconds]
Transit Columns
MEAN$_{O-C}$=1.000e−00 pix
RMS$_{\Delta}$=0.3102 mpix
Δ = (O−C) − MEAN$_{O-C}$ [mpix]
Observed Time [seconds]


Pipeline Prediction <--> FAME/SIM Data
Transit Times
Port=1
Port=2
MEAN$_{O-C}$=−6.270e−09 sec
RMS$_{\Delta}$=0.0113 μsec
Δ = (O−C) − MEAN$_{O-C}$ [μsec]
0.03
0.02
0.01
0.00
−0.01
−0.02
−0.03
1000
2000
3000
4000
Observed Time [seconds]
Transit Columns
MEAN$_{O-C}$=−5.421e−06 pix
RMS$_{\Delta}$=0.2859 mpix
Δ = (O−C) − MEAN$_{O-C}$ [mpix]
0.5
0.0
−0.5
1000
2000
3000
4000
Observed Time [seconds]


Tobs − Tcal
2000
1500
1000
500
0
Number
−1.0
−0.5
0.0
0.5
1.0
Difference in units of 1/10000 of a pixel


Cobs − Ccal
2500
2000
1500
1000
500
0
Number
−1.0
−0.5
0.0
0.5
1.0
Difference in units of 1/10000 of a pixel


Pipeline Prediction <--> FAME/SIM Data
Port=1
Port=2
Transit Times
0.4
0.2
0.0
−0.2
−0.4
Δ = (O−C) − MEAN$_{O-C}$ [μsec]
MEAN$_{O-C}$=−6.195e−06 sec
RMS$_{\Delta}$=0.2157 μsec
500
1000
1500
2000
Observed Time [seconds]
Transit Columns
0.010
0.005
0.000
−0.005
−0.010
Δ = (O−C) − MEAN$_{O-C}$ [pix]
MEAN$_{O-C}$=−2.687e−04 pix
RMS$_{\Delta}$=0.0072 pix
500
1000
1500
2000
Observed Time [seconds]