R-SIDIS Analysis

February 17, 2025

Topics:

1. Github stuff
2. SIMC overview
3. Setting up input files and running
4. Single arm MC overview
5. Input files and running

Getting SIMC and mc-single-arm from Github

- R-SIDIS wiki:
  - https://hallcweb.jlab.org/wiki/index.php?title=R-SIDIS

- SIMC:
  - https://hallcweb.jlab.org/wiki/index.php?title=Setting_up_SIMC

- mc-single-arm:
  - https://hallcweb.jlab.org/wiki/index.php?title=Mc-single-arm_(R-SIDIS_version)

SIMC Overview

- More details in talk from NPS collaboration meeting:
  - https://indico.jlab.org/event/866/contributions/14917/subcontributions/228/attachments/11515/17826/simc_nps.pdf
- Excerpts follow

What is SIMC?

SIMC is the standard Hall C Monte Carlo for coincidence reactions (similar to MCEEP) → written in FORTRAN (now gfortran compatible …)

Features:

→ Optics (COSY) and "aperture checking" Monte Carlos of spectrometers

[HMS, SOS, SHMS, HRS's, BigCal,…]

→ Includes radiative effects, multiple scattering, ionization energy loss, particle decay

→ Simple prescriptions available for FSIs, Coulomb Corrections, etc.

Reactions implemented:

1. Elastic and quasielastic → H(e,e'p), A(e,e'p)
2. Exclusive pion production
   → H(e,e'π^+)n, A(e,e'$\pi^{+/-}$) [quasifree or coherent]
3. Kaon electroproduction → H(e,e'K^+)Λ,Σ, A(e,e'$K^{+/-}$)
4. H(e,e'$\pi^{+/-}$)X, D(e,e'$\pi^{+/-}$)X [semi-inclusive]
5. H(e,e'$K^{+/-}$)X, D(e,e'$K^{+/-}$)X [semi-inclusive]
6. H(e,e'$\rho \rightarrow \pi^+\pi^-$)p, D(e,e'$\rho \rightarrow \pi^+\pi^-$) [diffractive ρ]
7. *H(e,e'π^0)p, D(e,e'π^0)p/n, (e,e'π^0)X* ← **Peter's updates underway**

What SIMC is NOT…

SIMC is NOT a full detector response simulation a la GEANT

SIMC does NOT simulate a large class of processes simultaneously to generate backgrounds (like Pythia for example)

SIMC is not a generic event generator → processes are generated over a limited phase space with the specific purpose of being “thrown” into a spectrometer

SIMC is not hard to modify → if you want it to do something else (different cross section model, add new spectrometer, etc.) it is pretty easy to update + I can help

SIMC program flow

- Initialization
  - Choose reaction, final state (if appropriate)
  - Disable/enable implementation of (or correction for) raster, eloss …
- Event generation
  - Select vertex based on target size, position, raster size, beam spot size
  - Determine energy, angle generation that will populate 100% of the acceptance (accounting for radiation, energy loss, …)
- Physics Processes
  - Event-by-event multiple scattering, radiative corrections, particle decay, coulomb corrections
- Acceptance
  - Can apply geometric cuts or spectrometer model. Default spec. models include target/spec. offsets, model of magnetic elements, apertures at front, back, middle of magnets, collimators, detector active area
- Event Reconstruction
  - Tracks are fitted in the focal plane and reconstructed to the target. Apply (average) energy loss, fast raster corrections. Calculate physics quantities for Ntuple/Root tree

Simulating SIDIS Process

- Kinematics: SIDIS18 settings from last week's discussion
  - Q^2=3.9 GeV^2, x_B=0.45, z=0.5, LH2
  - Ebeam=10.6 GeV
  - Electrons (HMS): P=5.898 GeV, theta=14.24 deg.
  - Pions (SHMS): P=2.304 GeV, theta=17.04 GeV

- See input file here:
  - /group/c-rsidis/gaskelld/simc_gfortran/infiles/sidis18_q23p9_x0p45_z0p5_pip_lh2.inp

Make some plots and get some yields

Mate Terminal

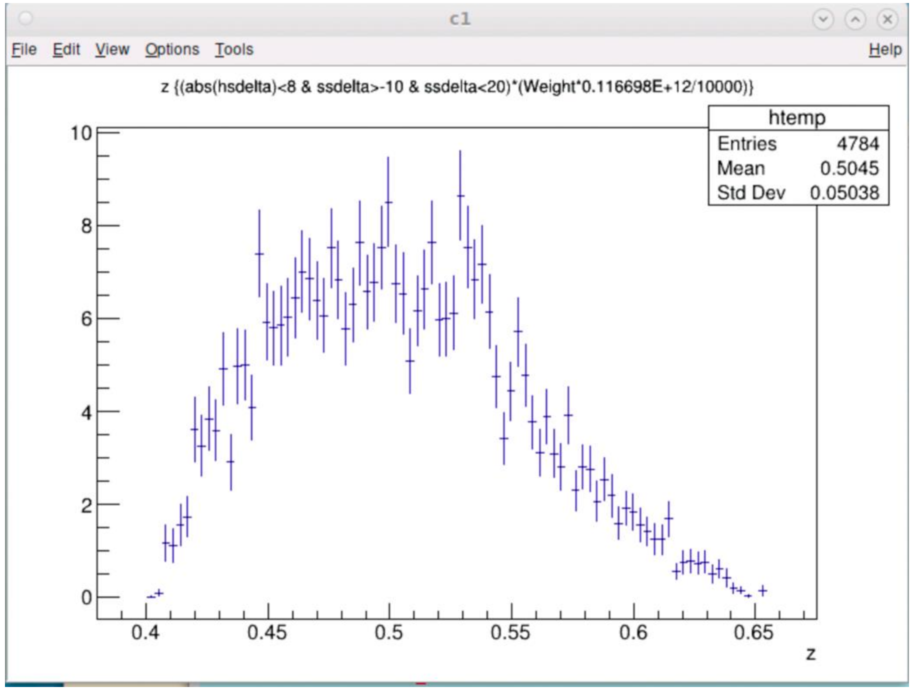
File Edit View Search Terminal Help

```
[gaskelld@ifarm2402 simc_gfortran]$ root worksim/sidis18_q23p9_x0p45_z0p5_pip_lh2.root
   ------------------------------------------------------------------
  | Welcome to ROOT 6.30/04                        https://root.cern |
  | (c) 1995-2024, The ROOT Team; conception: R. Brun, F. Rademakers |
  | Built for linuxx8664gcc on Jun 17 2024, 14:01:44                 |
  | From heads/master@tags/v6-30-04                                  |
  | With g++ (GCC) 11.4.0                                            |
  | Try '.help'/'.?', '.demo', '.license', '.credits', '.quit'/'.q'  |
   ------------------------------------------------------------------

root [0]
Attaching file worksim/sidis18_q23p9_x0p45_z0p5_pip_lh2.root as _file0...
(TFile *) 0x24c32f0
root [1] TCut icut="abs(hsdelta)<8 & ssdelta>-10 & ssdelta<20"
(TCut &) Name: CUT Title: abs(hsdelta)<8 & ssdelta>-10 & ssdelta<20
root [2] h10->Draw("z",(icut)*"Weight*0.116698E+12/10000")
Info in <TCanvas::MakeDefCanvas>:  created default TCanvas with name c1
(long long) 4784
root [3] htemp->Integral()
(double) 338.19834
root [4]
```

→ Also need to divide by number of events in tree

Result from this simulation (with these cuts) was:
Yield = 338.2 counts/mC



Get normalized yield by applying "Weight" from tree
→ Includes cross section, radiative corrections, small jacobian
→ Also need "normfac" (0.116698E+12)
  → Found in: outfiles/sidis18_q23p9_x0p45_pip_lh2.hist file
  → Includes target thickness, simulated charge, generation volume

Jefferson Lab

π+ from Exclusive, Δ, and ρ^0 production

- Each process needs to be simulated separately
- Example input files in /group/c-rsidis/gaskelld/simc_gfortran/infiles
  - Exclusive π+, H(e,e'π+)n: exclusive_q23p9_x0p45_z0p5_pip_lh2.inp
  - Delta, H(e,e'π+)Δ^0: delta_q23p9_x0p45_z0p5_pip_lh2.inp
  - ρ^0 production, H(e,e' $\rho^0 \rightarrow \pi+\pi-$)p: rho_q23p9_x0p45_z0p5_pip_lh2.inp

mc-single-arm

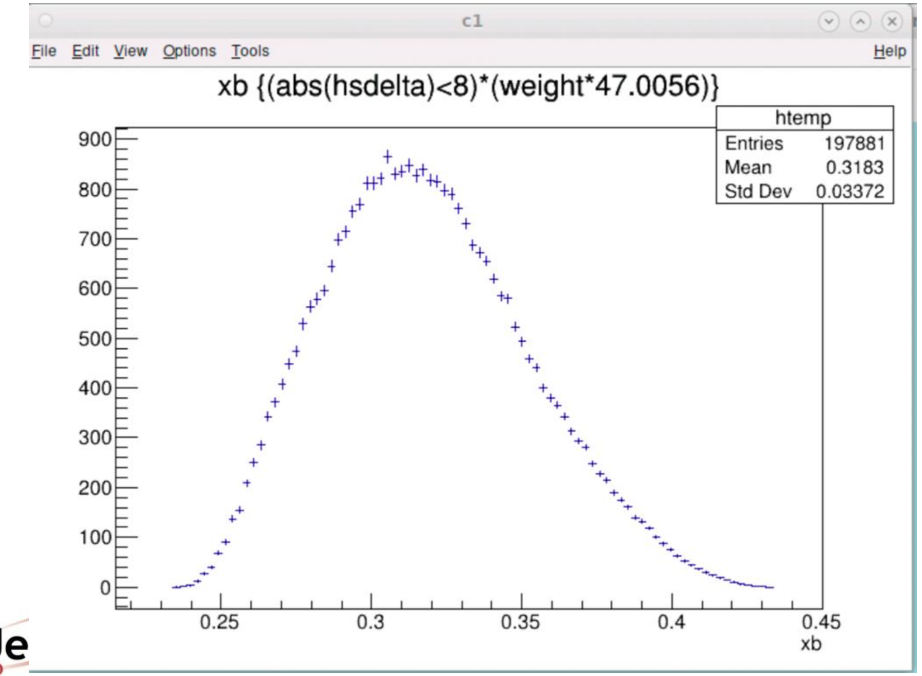
- Single are Monte Carlo works very differently than SIMC
  - No cross-section model or radiative corrections built in – just simulation of spectrometer phase space and acceptance
  - Includes multiple scattering – nothing else
- Typically, Monte Carlo yield requires combining events from mc-single-arm with radiative corrections (written to table) from separate, stand-along program
- Made new branch of mc-single-arm (rctables)
  - Reads in RC tables from “rctables” directory → needs to be generated ahead of time
  - Specify filename and number of momentum and angle entries in input file

mc-single-arm example from XEM2

Example from XEM2 run period
Ebeam=10.55 GeV
HMS: theta=20.0 deg, P=3.40 GeV
LH2

```
*Entries :   244933 : Total  Size=    1963877 bytes  File Size  =    1238095 *
*Baskets :       41 : Basket Size=    1311744 bytes  Compression=   1.06     *
*............................................................................*
[gaskelld@ifarm2402 mc-single-arm]$ root worksim/hms_20deg_3p40gev_hyd_XEM.root
   ------------------------------------------------------------------
  | Welcome to ROOT 6.30/04                        https://root.cern |
  | (c) 1995-2024, The ROOT Team; conception: R. Brun, F. Rademakers |
  | Built for linuxx8664gcc on Jun 17 2024, 14:01:44                 |
  | From heads/master@tags/v6-30-04                                  |
  | With g++ (GCC) 11.4.0                                            |
  | Try '.help'/'.?', '.demo', '.license', '.credits', '.quit'/'.q'  |
   ------------------------------------------------------------------

root [0]
Attaching file worksim/hms_20deg_3p40gev_hyd_XEM.root as _file0...
(TFile *) 0x2e6b100
root [1] TCut icut="abs(hsdelta)<8"
(TCut &) Name: CUT Title: abs(hsdelta)<8
root [2] h10->Draw("xb",(icut)*"weight*47.0056")
Info in <TCanvas::MakeDefCanvas>:  created default TCanvas with name c1
(long long) 197881
root [3] htemp->Integral()
(double) 31626.440
root [4]
```



“normfac” in outfiles/hms_20deg_3p40gev_hyd_XEM.out

Added single-arm data/dummy/report files to example output directory for comparisons

Things to try/work on

- Determine total background (exclusive, delta, rho) for pi+
  - Contribution from each channel
  - Plots vs. pion momentum or missing mass
- Simulate SIDIS pi- yield for same setting
  - Determine total background (hint: no exclusive contribution for pi- from proton)
- Estimate SIDIS rates for one of the R-SIDIS settings – compare to Peter's estimates (see following slides)
- Compare yield from mc-single-arm to inclusive data (runs 4919 and 4920)

Draft R-SIDIS Run plan – pi+

```
e = beam energy (GeV)
wpsq is double arm missing mass squared (GeV**2)
eps is epsilon
ep = HMS momentum (GeV)
the = HMS angle in degrees.
thpq = angle between pion and q-vector.
thpi = SHMS angle in degrees.
ppi is SHMS momentum in GeV
cur is current in muA
crate is coincidence rate in kilo-counts/hour
a/r is predicted accidental/real ratio
hrs is nominal PAC hours
counts is total number of coincidences in kilo-counts
3/4 is single particle rate in SHMS in kHz
```

https://hallcweb.jlab.org/elogs/R-SIDIS+Experiment/4

e	x	q2	z	wpsq	eps	ep	the	thpq	thpi	ppi	cur	crate	a/r	hrs	counts	3/4
6.5	0.16	1.6	0.50	4.9	0.32	1.2	26.5	2.0	7.5	2.7	11.8	5.	0.7	6.5	35.	900.
8.6	0.16	1.6	0.50	4.9	0.65	3.3	13.7	2.0	10.1	2.7	16.6	90.	0.6	2.0	179.	900.
6.5	0.22	2.2	0.50	4.6	0.31	1.1	31.6	2.0	8.2	2.8	14.9	3.	0.7	8.3	27.	900.
8.6	0.22	2.2	0.50	4.6	0.64	3.3	16.1	2.0	11.4	2.8	24.5	66.	0.6	2.0	133.	900.
8.6	0.25	3.3	0.36	7.0	0.32	1.6	28.7	2.0	7.9	2.6	8.4	2.	0.6	10.0	17.	900.
10.7	0.25	3.3	0.36	7.0	0.59	3.7	16.7	2.0	10.3	2.6	12.5	20.	0.5	3.4	67.	900.
8.6	0.25	3.3	0.50	5.6	0.32	1.6	28.7	2.0	7.9	3.6	19.9	6.	0.4	6.4	35.	900.
10.7	0.25	3.3	0.50	5.6	0.59	3.7	16.7	2.0	10.3	3.6	34.0	72.	0.4	2.0	145.	878.
8.6	0.25	3.3	0.67	3.8	0.32	1.6	28.7	2.0	7.9	4.9	42.0	11.	0.2	4.5	50.	518.
10.7	0.25	3.3	0.67	3.8	0.59	3.7	16.7	2.0	10.3	4.9	34.0	68.	0.1	2.0	137.	201.
8.6	0.25	3.3	0.50	5.4	0.32	1.6	28.7	5.2	11.1	3.6	42.0	7.	0.3	5.5	41.	568.
10.7	0.25	3.3	0.50	5.4	0.59	3.7	16.7	5.2	13.5	3.6	34.0	46.	0.1	2.2	102.	248.
8.6	0.25	3.3	0.50	5.0	0.32	1.6	28.7	8.5	14.4	3.6	42.0	3.	0.2	8.2	27.	149.
10.7	0.25	3.3	0.50	5.0	0.59	3.7	16.7	8.5	16.8	3.6	34.0	21.	0.1	3.3	68.	62.
8.6	0.25	3.3	0.50	4.5	0.32	1.6	28.7	11.7	17.6	3.6	42.0	1.	0.2	10.0	8.	37.
10.7	0.25	3.3	0.50	4.5	0.59	3.7	16.7	11.7	20.0	3.6	34.0	5.	0.1	6.7	34.	15.
10.7	0.25	3.3	0.50	5.6	0.59	3.7	16.7	-0.8	7.5	3.6	12.4	29.	0.4	2.8	81.	900.
10.7	0.25	3.3	0.67	3.9	0.59	3.7	16.7	-0.8	7.5	4.9	34.0	78.	0.3	2.0	157.	865.
6.5	0.31	3.1	0.50	4.1	0.30	1.1	37.7	2.0	9.2	2.8	20.1	2.	0.6	10.0	19.	900.
8.6	0.31	3.1	0.50	4.1	0.63	3.3	19.2	2.0	13.0	2.8	40.8	48.	0.6	2.2	104.	900.
10.7	0.31	3.1	0.50	4.1	0.78	5.4	13.4	2.0	14.7	2.8	34.0	150.	0.3	2.0	300.	561.
10.7	0.31	3.1	0.50	4.1	0.78	5.4	13.4	-1.0	11.7	2.8	22.3	101.	0.6	2.0	203.	900.
6.5	0.44	4.4	0.40	4.0	0.28	1.2	44.7	2.0	10.3	2.3	14.8	0.	0.7	10.0	4.	900.
8.6	0.44	4.4	0.40	4.0	0.62	3.3	22.8	2.0	14.8	2.3	31.8	10.	0.6	4.7	48.	900.
10.7	0.44	4.4	0.40	4.0	0.77	5.4	15.9	2.0	16.9	2.3	34.0	41.	0.5	2.3	96.	697.
6.5	0.44	4.4	0.52	3.2	0.28	1.2	44.7	2.0	10.3	3.0	33.8	1.	0.6	10.0	11.	900.
8.6	0.44	4.4	0.52	3.2	0.62	3.3	22.8	2.0	14.8	3.0	42.0	16.	0.2	3.7	60.	404.
10.7	0.44	4.4	0.52	3.2	0.77	5.4	15.9	2.0	16.9	3.0	34.0	49.	0.1	2.1	105.	212.
6.5	0.44	4.4	0.67	2.3	0.28	1.2	44.7	2.0	10.3	3.8	56.0	2.	0.3	10.0	18.	434.
8.6	0.44	4.4	0.67	2.3	0.62	3.3	22.8	2.0	14.8	3.8	42.0	16.	0.0	3.7	60.	87.
10.7	0.44	4.4	0.67	2.3	0.77	5.4	15.9	2.0	16.9	3.8	34.0	49.	0.0	2.1	105.	40.
10.7	0.44	4.4	0.40	4.0	0.77	5.4	15.9	-2.0	12.9	2.3	16.8	20.	0.7	3.3	67.	900.
10.7	0.44	4.4	0.40	4.0	0.77	5.4	15.9	0.0	14.9	2.3	27.0	34.	0.6	2.6	87.	900.
10.7	0.44	4.4	0.52	3.2	0.77	5.4	15.9	0.0	14.9	3.0	34.0	53.	0.2	2.1	109.	413.
10.7	0.44	4.4	0.52	3.2	0.77	5.4	15.9	-2.0	12.9	3.0	34.0	49.	0.5	2.1	105.	786.
10.7	0.44	4.4	0.67	2.3	0.77	5.4	15.9	0.0	14.9	3.8	34.0	54.	0.0	2.0	110.	99.
10.7	0.44	4.4	0.67	2.3	0.77	5.4	15.9	-2.0	12.9	3.8	34.0	49.	0.1	2.1	105.	239.

	all	3-pass	4-pass	5-pass
total time pi+ (day)=	8.439	2.286	2.622	2.055

Draft R-SIDIS Run plan – pi-

e	x	q2	z	wpsq	eps	ep	the	thpq	thpi	ppi	cur	crate	a/r	hrs	counts	3/4
6.5	0.16	1.6	0.50	4.9	0.32	1.2	26.5	2.0	7.5	2.7	22.8	4.	1.8	7.2	31.	900.
8.6	0.16	1.6	0.50	4.9	0.65	3.3	13.7	2.0	10.1	2.7	34.9	81.	2.0	2.0	162.	900.
6.5	0.22	2.2	0.50	4.6	0.31	1.1	31.6	2.0	8.2	2.8	29.3	3.	1.8	9.1	25.	900.
8.6	0.22	2.2	0.50	4.6	0.64	3.3	16.1	2.0	11.4	2.8	42.0	49.	1.5	2.1	105.	710.
8.6	0.25	3.3	0.36	7.0	0.32	1.6	28.7	2.0	7.9	2.6	16.9	2.	1.3	10.0	18.	900.
10.7	0.25	3.3	0.36	7.0	0.59	3.7	16.7	2.0	10.3	2.6	25.8	21.	1.4	3.2	69.	900.
8.6	0.25	3.3	0.50	5.6	0.32	1.6	28.7	2.0	7.9	3.6	37.0	4.	1.1	7.1	31.	900.
10.7	0.25	3.3	0.50	5.6	0.59	3.7	16.7	2.0	10.3	3.6	34.0	31.	0.6	2.7	84.	438.
8.6	0.25	3.3	0.67	3.8	0.32	1.6	28.7	2.0	7.9	4.9	42.0	4.	0.4	7.7	29.	451.
10.7	0.25	3.3	0.67	3.8	0.59	3.7	16.7	2.0	10.3	4.9	34.0	24.	0.2	3.1	73.	123.
8.6	0.25	3.3	0.50	5.4	0.32	1.6	28.7	5.2	11.1	3.6	42.0	3.	0.5	8.4	27.	285.
10.7	0.25	3.3	0.50	5.4	0.59	3.7	16.7	5.2	13.5	3.6	34.0	20.	0.2	3.4	67.	116.
8.6	0.25	3.3	0.50	5.0	0.32	1.6	28.7	8.5	14.4	3.6	42.0	1.	0.3	10.0	15.	72.
10.7	0.25	3.3	0.50	5.0	0.59	3.7	16.7	8.5	16.8	3.6	34.0	9.	0.1	5.0	45.	27.
8.6	0.25	3.3	0.50	4.5	0.32	1.6	28.7	11.7	17.6	3.6	42.0	0.	0.2	10.0	4.	18.
10.7	0.25	3.3	0.50	4.5	0.59	3.7	16.7	11.7	20.0	3.6	34.0	2.	0.1	10.0	22.	6.
10.7	0.25	3.3	0.50	5.6	0.59	3.7	16.7	-0.8	7.5	3.6	23.4	23.	1.1	3.1	73.	900.
10.7	0.25	3.3	0.67	3.9	0.59	3.7	16.7	-0.8	7.5	4.9	34.0	27.	0.6	2.9	78.	523.
6.5	0.31	3.1	0.50	4.1	0.30	1.1	37.7	2.0	9.2	2.8	40.4	2.	1.7	10.0	16.	900.
8.6	0.31	3.1	0.50	4.1	0.63	3.3	19.2	2.0	13.0	2.8	42.0	21.	0.9	3.3	69.	409.
10.7	0.31	3.1	0.50	4.1	0.78	5.4	13.4	2.0	14.7	2.8	34.0	64.	0.5	2.0	129.	243.
10.7	0.31	3.1	0.50	4.1	0.78	5.4	13.4	-1.0	11.7	2.8	34.0	66.	1.3	2.0	132.	643.
6.5	0.44	4.4	0.40	4.0	0.28	1.2	44.7	2.0	10.3	2.3	32.6	0.	2.0	10.0	4.	900.
8.6	0.44	4.4	0.40	4.0	0.62	3.3	22.8	2.0	14.8	2.3	42.0	7.	1.1	5.8	39.	494.
10.7	0.44	4.4	0.40	4.0	0.77	5.4	15.9	2.0	16.9	2.3	34.0	20.	0.6	3.3	67.	281.
6.5	0.44	4.4	0.52	3.2	0.28	1.2	44.7	2.0	10.3	3.0	56.0	1.	1.4	10.0	8.	744.
8.6	0.44	4.4	0.52	3.2	0.62	3.3	22.8	2.0	14.8	3.0	42.0	7.	0.4	5.8	39.	172.
10.7	0.44	4.4	0.52	3.2	0.77	5.4	15.9	2.0	16.9	3.0	34.0	21.	0.2	3.3	68.	86.
6.5	0.44	4.4	0.67	2.3	0.28	1.2	44.7	2.0	10.3	3.8	56.0	1.	0.4	10.0	6.	370.
8.6	0.44	4.4	0.67	2.3	0.62	3.3	22.8	2.0	14.8	3.8	42.0	6.	0.1	6.3	36.	46.
10.7	0.44	4.4	0.67	2.3	0.77	5.4	15.9	2.0	16.9	3.8	34.0	17.	0.0	3.6	62.	18.
10.7	0.44	4.4	0.40	4.0	0.77	5.4	15.9	-2.0	12.9	2.3	34.0	20.	1.8	3.3	67.	822.
10.7	0.44	4.4	0.40	4.0	0.77	5.4	15.9	0.0	14.9	2.3	34.0	21.	1.0	3.3	69.	485.
10.7	0.44	4.4	0.52	3.2	0.77	5.4	15.9	0.0	14.9	3.0	34.0	22.	0.4	3.2	70.	178.
10.7	0.44	4.4	0.52	3.2	0.77	5.4	15.9	-2.0	12.9	3.0	34.0	21.	0.8	3.3	68.	360.
10.7	0.44	4.4	0.67	2.3	0.77	5.4	15.9	0.0	14.9	3.8	34.0	19.	0.1	3.5	65.	46.
10.7	0.44	4.4	0.67	2.3	0.77	5.4	15.9	-2.0	12.9	3.8	34.0	17.	0.3	3.6	62.	115.

total time pi- (day)= 8.439 2.343 3.269 2.827
all 3-pass 4-pass 5-pass