Step IV Run planning – First pass

(V. Blackmore / S. Boyd)

- We need to start planning the data campaign.
- This is the first pass at putting together a data-taking plan.
- The numbers and schedules given here flexible – there are many blank periods
- Intended to start the discussion
- Priority is to complete the essential program necessary to allow setting up of Step V to start on time.

ISIS Run Plan

Not the official schedule – an indicator for planning purposes

	Monday	25-Aug-14	Sunday	08-Feb-15	168			
	Monday	09-Feb-15	Sunday	15-Mar-15	35			
	Monday	16-Mar-15	Monday	16-Mar-15	1			
2014/03	Tuesday	**17-Mar-15**	Friday	**24-Apr-15**	38	37.0	**124.0**	33 days (24 hr)
	Friday	24-Apr-15	Sunday	26-Apr-15	3			
	Monday	27-Apr-15	Sunday	17-May-15	21			
	Monday	18-May-15	Sunday	31-May-15	14			
	Monday	01-Jun-15	Monday	01-Jun-15	1			
2015/01	Tuesday	**02-Jun-15**	Friday	**24-Jul-15**	52	50.0	50.0	54 days (24 hr)
	Friday	24-Jul-15	Sunday	26-Jul-15	3			
	Monday	27-Jul-15	Sunday	23-Aug-15	28			
	Monday	24-Aug-15	Sunday	06-Sep-15	14			
	Monday	07-Sep-15	Monday	07-Sep-15	1			
2015/02	Tuesday	**08-Sep-15**	Friday	**16-Oct-15**	38	37.0	87.0	38 days (24 hr)
	Friday	16-Oct-15	Sunday	18-Oct-15	3			
	Monday	19-Oct-15	Sunday	25-Oct-15	7			
	Monday	26-Oct-15	Sunday	01-Nov-15	7			
	Monday	02-Nov-15	Monday	02-Nov-15	1			
2015/03	Tuesday	**03-Nov-15**	Friday	**18-Dec-15**	45	44.0	**131.0**	45 days (24 hr)
	Cycle							
	Shutdown and/or moderator change							

User run period 1

Reserved for commissioning, calibration and alignment

Commissioning plans in development (P. Soler / J. Pasternak)

- Magnet and detector commissioning w/o field
- Tracker commissioning with field
- Beam line commissioning with field
- Cooling cell optics commissioning

Measurement runs

Physics run plan : prioritise core measurements

- 9 nominal matrix settings
- Empty/H2/LiH absorber
- Flip/Solenoid mode
- Positive (negative?) beam

(3, 140)	(3, 200)	(3, 240)
(6, 140)	(6, 200)	(6, 240)
(10, 140)	(10, 200)	(10, 240)

Core program : 52 measurement points (108 with negative beam)

How long would one measurement take?

How long would a measurement point take?

(Victoria)

(6,200) Step 1 μ+

From CM32 studies

For 0.3% stat. error

# TOF Triggers / hour	150,000
# muons / TOF Trigger	0.71
NF-like momentum spectrum @ TOF 1	0.27
Muon matched to US Tracker	0.46
Total # Useful triggers / hour	13,300
# TOF Triggers needed	100,000
Time for one point	~ (8+4) = 12 hours
Time for full matrix	4.5 (7) days for 3 (2) shift running

* Assumes current dip rate of 0.4 Hz

User run periods 2-4

Contingency for commissioning in User run period 2 : 2 weeks

Basic Run Block Format

Run Type	Duration
Calibration & Monitoring	?
Reference run	few hours
Physics grid	7 days
Additional configs	2 days

Depends on duration and frequency of monitoring and calibration runs, and on actual time to do the physics grid

Data taking schedule v 0.0

*Only single polarity

User Run Period	Run Type	Absorber	Magnet Mode	Time (days) : 16 hour running
1	Commissioning			30
2	Contingency / Setup			14
	Physics	Empty	Flip	9
			Solenoid	9
	LH2 Fill			2
		LH2	Solenoid	9
			Flip	9
3	Calibration / Setup			7
		LiH	Flip	9
			Solenoid	9
	Additional config / repeats			13
4	Calibration / Setup			7
	Additional configs / repeats			45

Data taking schedule v 0.0

*pos + neg beam

User Run Period	Run Type	Absorber	Magnet Mode	Time (days) : 16 hour running
1	Commissioning			30
2	Contingency / Setup			14
	Physics	Empty	Flip	18
			Solenoid	18
MP	LH2 Fill			2
	Calibration / setup			7
		LH2	Solenoid	18
			Flip	13
MP	LiH Installation			
4	Calibration / Setup			7
		LiH	Flip	18
			Solenoid	18
	Additional config / repeats			3

Data taking schedule v 0.0

*pos + neg beam

User Run Period	Run Type	Absorber	Magnet Mode	Time (days) : 24 hour running
1	Commissioning			30
2	Contingency / Setup			14
	Physics	Empty	Flip	12
			Solenoid	12
	LH2 Fill			2
		LH2	Solenoid	12
3	Calibration / Setup			7
		LH2	Flip	12
	LiH Installation			?
		LiH	Flip	12
4	Calibration / Setup			7
		LiH	Solenoid	12
	Additional config / repeats			29

Summary

- Assuming 2 shifts / day and that a grid point takes about 12 hours (& other assumptions which can, and probably will, be argued with)
    - Can take core physics data with one polarity and have time left to explore other configurations.
    - Can (just) take core physics data with both polarities, but very little time (if any) to explore other configurations
    - 24 hour running allows extra studies to be performed.
- The start of the run plan discussion
- Discuss.

Backup

Run Statistics*

- Consider the runs that made up the (6, 200) mu+ Step I data set:
  - 2396, 2398, 2423, 2444, 2446, 2462, 2466, 2482, 2534, 2538—9, 2553—8, 2561—2, 2616, 2702, 2714—5, 2726, 2734—2741, 2743, 2767, 2803, 2846, 2873—2884, 2887—2891, 2893—5.

possible gain here

  - Total number of target pulses: **19’464**
  - Mean triggers/spill: **38.8** DS is **on**, but mean beam loss = 1.3V
  - Total number of particle triggers at TOF1: **800’013**
  - 1 target pulse per second, so 19’464 pulses = 324.4 min = **5.4 hrs**
  - **Approximate TOF triggers per hour = 148’151**

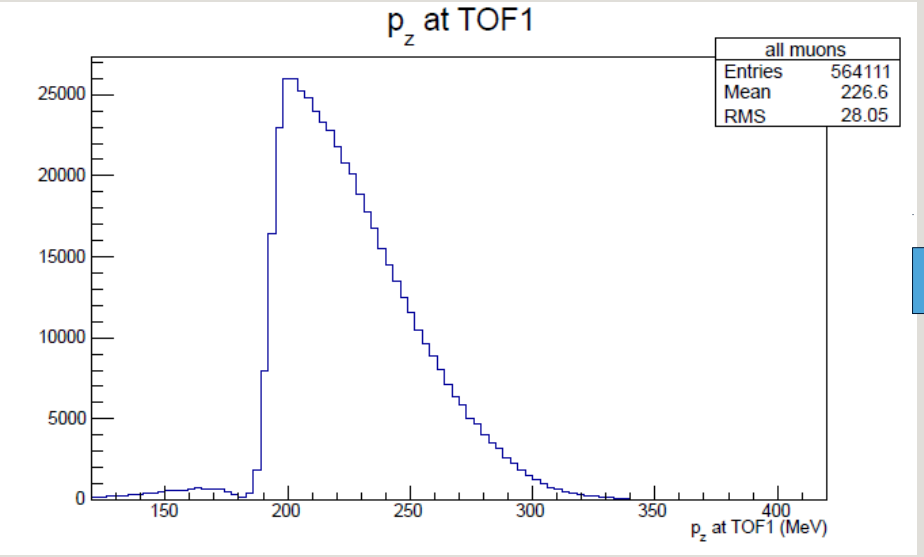
* According to the Run Conditions Summary spread sheet

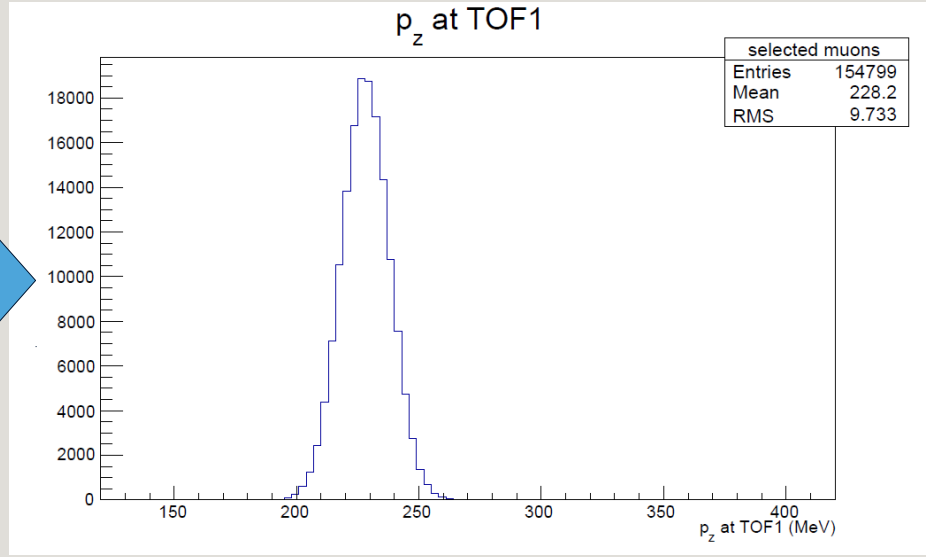
TOF triggers → N_μ?

- 1TOF trigger ≠ 1μ (could be e or π)
- In Step I data, accept as a muon **if**:
  - Time-of-flight is within 26.5—40.0ns (for "200 MeV" beam)
  - Particle crossed **calibrated** TOF strips
    - Assume similar portion of TOFs will be calibrated ("similar" beam at TOF0 and TOF1, but probably poorer statistics at TOF2…)
- 800'012 TOF triggers → 564'111 "muons".

- **70.5% of Step I data is (so far) potentially useful**

NF-like momentum selection





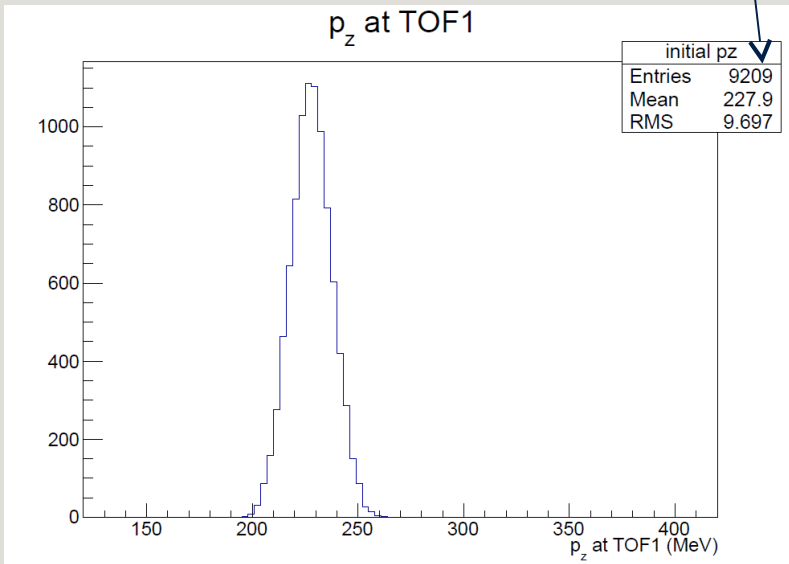
- Selected central $p_z = 230$ MeV, $\sigma_{pz} = 10$ MeV at TOF1
- Used entire Step I "6, 200" mu+ muon data set
- **154'799** of 564'111 muons made the cut

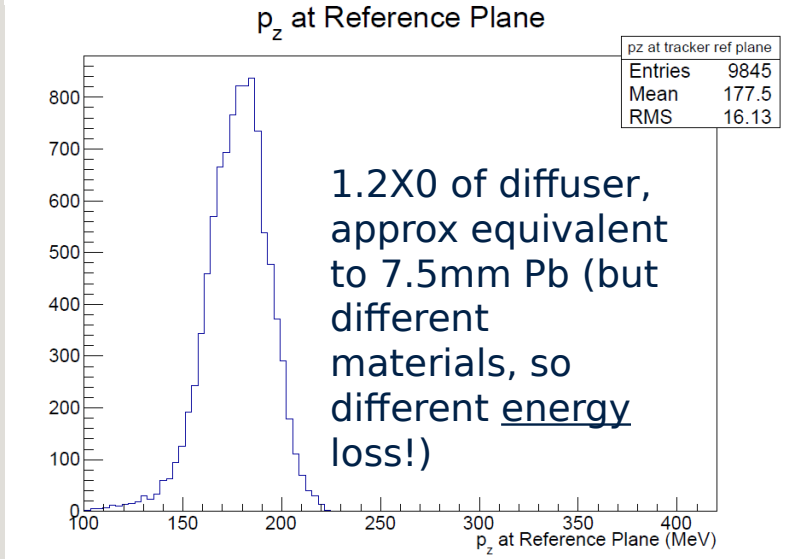
27% of muons could be useful in this scenario

Now using ~10k muon simulations

Selection at the tracker reference plane

- CM32 simulations used ~10k Step I muons, selected only by their longitudinal momentum
  - Meant to study Pb diffuser
  - Beams were meant for Pb diffuser
  - Therefore, lose the "wrong" amount of momentum going through the new design (new materials!)
  - But, assuming that we can correct for that, we can use these simulations to make an estimate of the number of "useful" muons in the beam at the tracker reference plane
    - *I.e.* muons that we would select for our analyses.

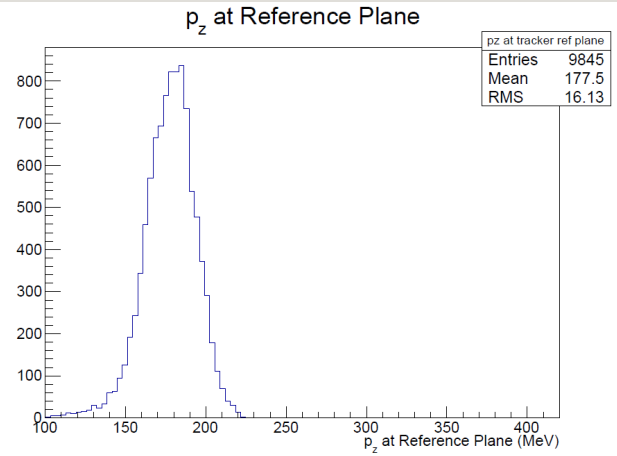


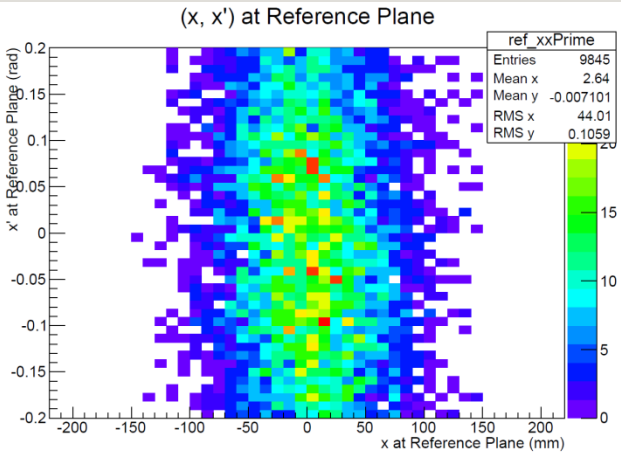


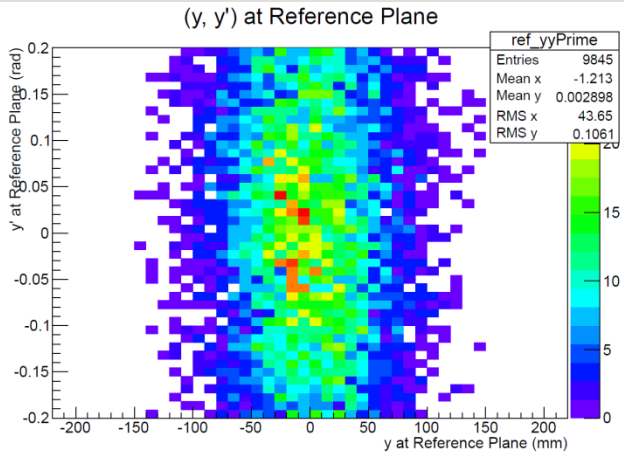
$100 \times 0.705 \times 0.27 = 19\%$ useful particles…

NB: Ignored canonical angular momentum picked up in diffuser

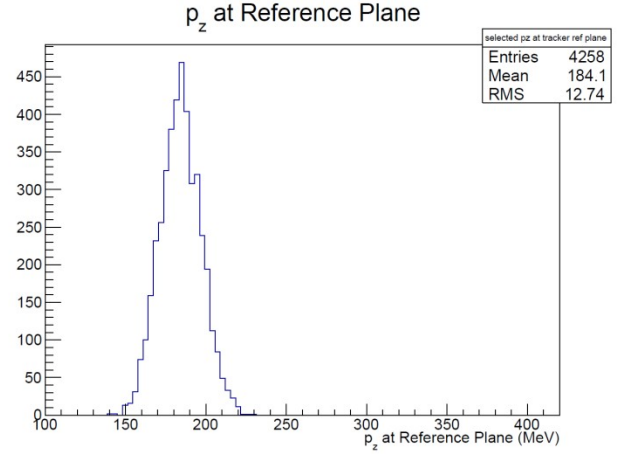
Picking a “matched” beam

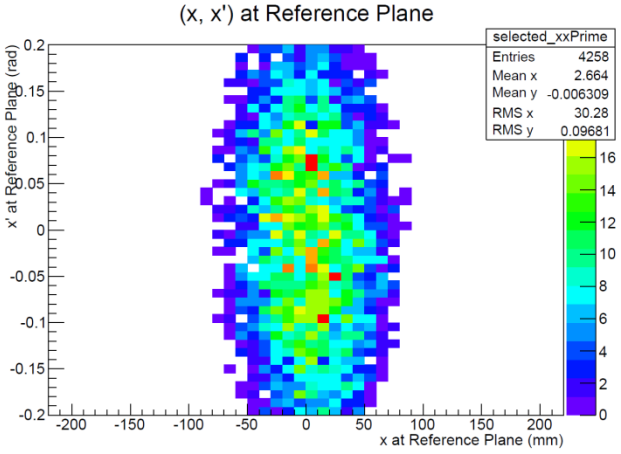


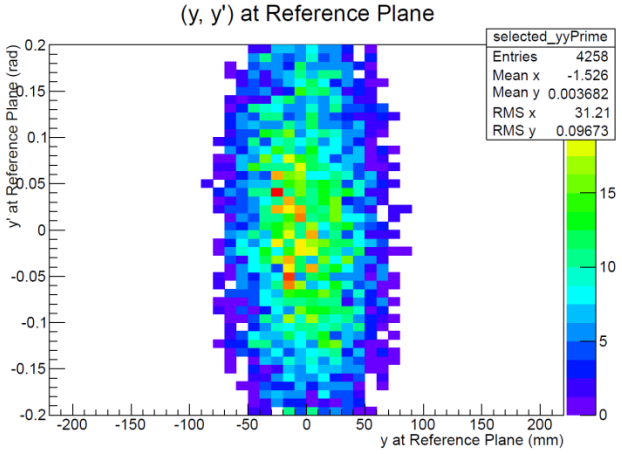




if $\gamma_m(x^2 + y^2) + \beta_m(x'^2 + y'^2) + 2\alpha_m(xx' + yy') \leq 4\varepsilon_n$, accept muon







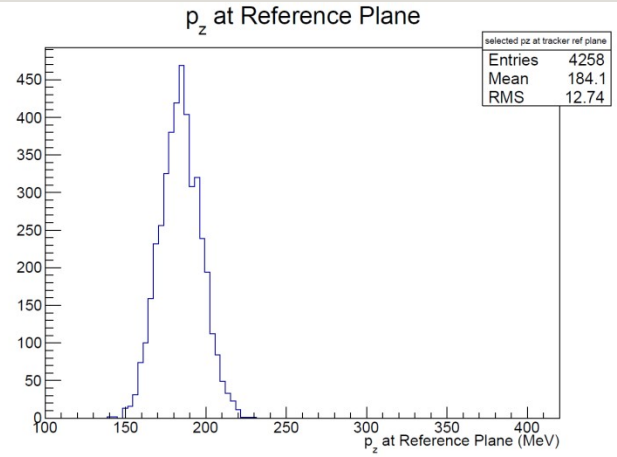
NB: Ignored canonical angular momentum picked up in diffuser

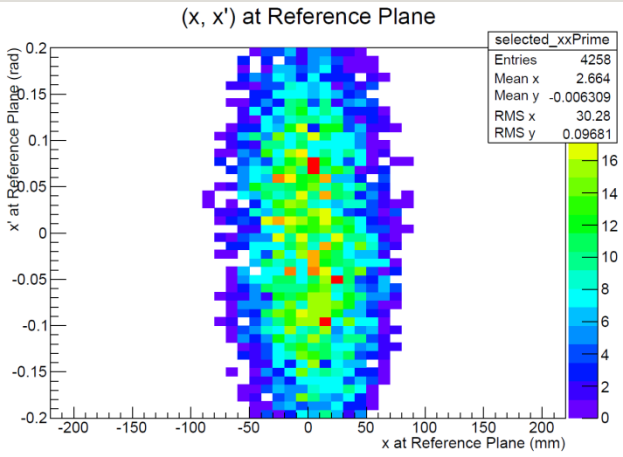
Picking a "matched" beam

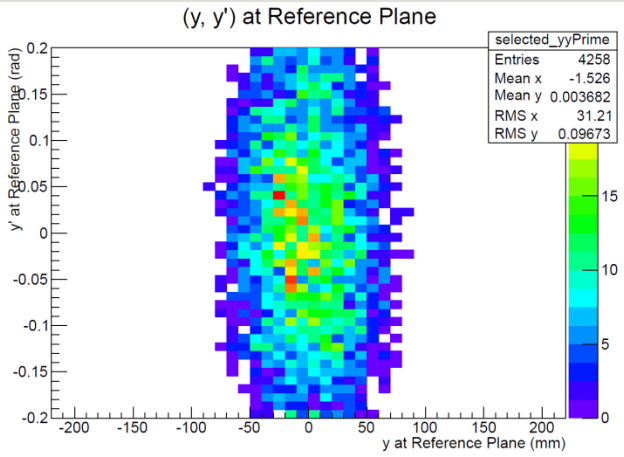
- Selected beam has σ_{pz} a 10 MeV
- Then matched beam at tracker reference plane has the properties:

$\varepsilon_n = 5.32$ mm
$\beta_t = 301.9$ mm
$\alpha_t = 0.09$
$\gamma_t = 0.0037$ mm^{-1}

- Good enough for an estimate
- Start with 9,209 muons at TOF1
- After matching, left with 4,258 at reference place
- **46.2 %** muons are useful for analysis







Conclusions

- Just an estimate, but…
  - If 8.8% of our TOF triggers are useful particles
  - Say we get 150'000 TOF triggers per hour (dependent on allowed beam loss)
  - ~100k muons for a 0.3% statistical error on emittance

  - Therefore, useful muons per hour: $150'000 \times 0.088 = 13'200$
  - Approx 8 hours for 100k "useful muons"
  - → Call it 10 hours per data point as a "rough estimate"

(*c.f.*: 10'000 muons = 1 hour per point, 1'000'000 muons = 76 hours per point!)