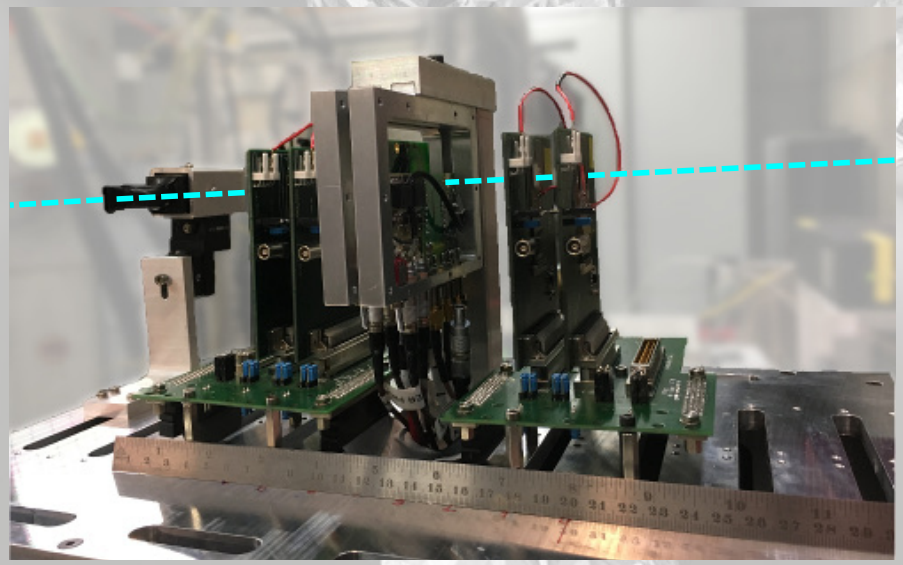
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich



Overview of the Rate Pad Results at PSI

PSI Analysis Meeting

Michael Reichmann

28th February 2019

Table of Contents

Section 1

Introduction

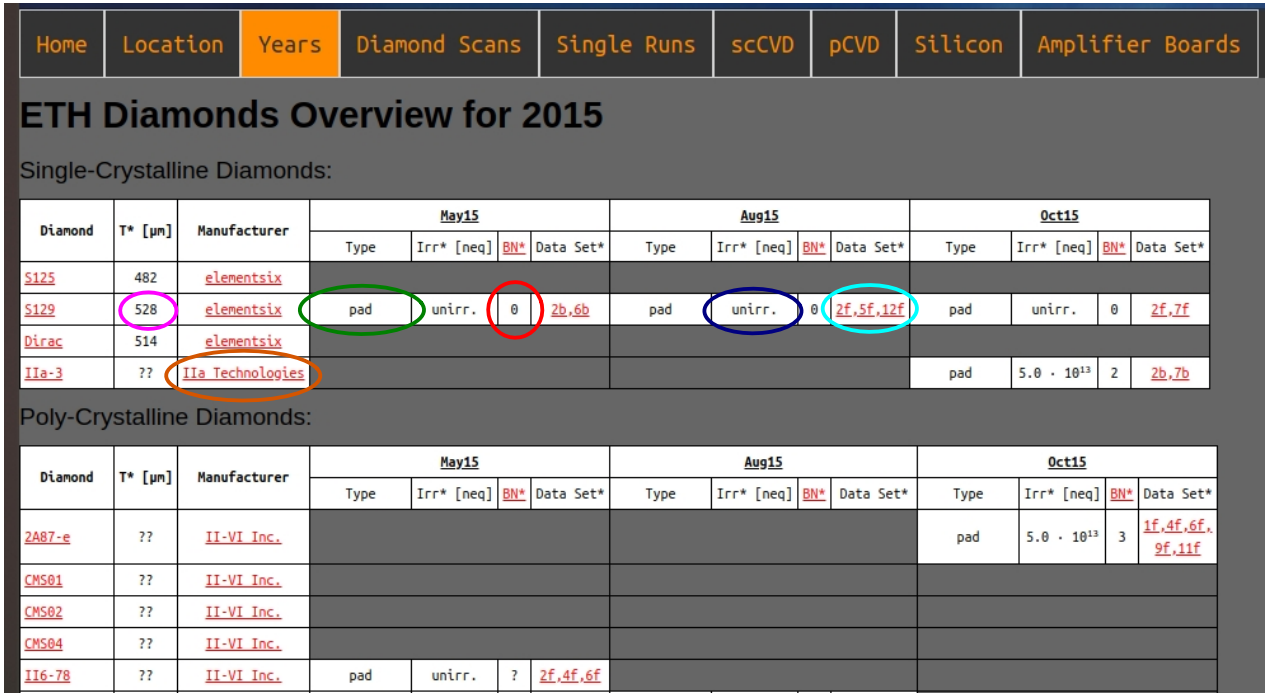
Introduction

- finished analysis of all the pad data taken at PSI starting from October 2015
- uploaded the most important results to the website (https://diamond.ethz.ch/psi)
- need to finish plot overview page for single runs and scans

Section 2

Website

Year Overview



Home | Location | Years | Diamond Scans | Single Runs | scCVD | pCVD | Silicon | Amplifier Boards

ETH Diamonds Overview for 2015

Single-Crystalline Diamonds:

Diamond	T* [µm]	Manufacturer	May15				Aug15				Oct15			
			Type	Irr* [neq]	BN*	Data Set*	Type	Irr* [neq]	BN*	Data Set*	Type	Irr* [neq]	BN*	Data Set*
S125	482	elementsix												
S129	528	elementsix	pad	unirr.	0	2b,6b	pad	unirr.	0	2f,5f,12f	pad	unirr.	0	2f,7f
Dirac	514	elementsix												
IIa-3	??	IIa Technologies									pad	$5.0 \cdot 10^{13}$	2	2b,7b

Poly-Crystalline Diamonds:

Diamond	T* [µm]	Manufacturer	May15				Aug15				Oct15			
			Type	Irr* [neq]	BN*	Data Set*	Type	Irr* [neq]	BN*	Data Set*	Type	Irr* [neq]	BN*	Data Set*
2A87-e	??	II-VI Inc.									pad	$5.0 \cdot 10^{13}$	3	1f,4f,6f, 9f,11f
CMS01	??	II-VI Inc.												
CMS02	??	II-VI Inc.												
CMS04	??	II-VI Inc.												
II6-78	??	II-VI Inc.	pad	unirr.	?	2f,4f,6f								

- **Thickness**
- **Manufacturer**
- **Type** of the detector
- **Boardnumber**: Amplifier Board the detector was mounted on
- **Irradiation**
- **Data Set**: “4f” front diamond of the fourth scan

Diamond Scans

- general overview of all scans taken at a single beam test

Home | Location | Years | Diamond Scans | Single Runs | scCVD | pCVD | Silicon | Amplifier Boards

Run Plan Overview for the Test Campaign in August 2017-2

Run Plan	Digitiser	Amplifier	Sub Plan	Run Type	Runs	Events	Front				Middle				Back			
							Info	Diamond	Detector	Bias [V]	Info	Diamond	Detector	Bias [V]	Info	Diamond	Detector	Bias [V]
01	ROC	ROC	1	angle scan	001 - 011	2.9M	Runs	II6-B6	3D-pixel	-50	Runs	II6-A2	3D-pixel	-50	Runs	Si352	pixel	-150
02	DRS4	OSU1	2	rate scan	019 - 040	7.5M	Runs	II6-B2	pad	-1000	-				Runs	II6-97	pad	-1000
			2.1	up scan	029 - 035	2.0M	Runs								Runs			
			2.2	rate scan	024 - 040	5.5M	Runs								Runs			
03	DRS4	OSU1	3	rate scan	042 - 065	8.2M	Runs	II6-B2	pad	+1000	-				Runs	II6-97	pad	+1000
			3.1	up scan	053 - 059	2.4M	Runs								Runs			
			3.2	rate scan	042 - 053	4.1M	Runs								Runs			
04	DRS4	OSU1	4	rate scan	087 - 097	1.8M	Runs	SiD2	pad	+150	-				Runs	S129	pad	-500
			4.1	up scan	087 - 092	1.0M	Runs								Runs			
05	CAEN	OSU1	5	rate scan	155 - 164	1.5M	Runs	SiD2	pad	+150	-				Runs	S129	pad	-500
06	OSCI	OSU1	6	rate scan	170 - 176	?	Runs	SiD2	pad	+150	-				Runs	S129	pad	-500
07	DRS4	C6_1, Cx_2	7	voltage scan	179 - 187	7.0M	Runs	SiD6	pad	-500	-				Runs	II6-A7	3D-multi	-30 ... -100
08	DRS4	Cx_2, C6_1	8	digitiser test	188 - 202	6.0M	Runs	SiD6	pad	-500	-				Runs	II6-A7	3D-multi	+100 → -100
09	DRS4	Cx_2, C6_2	9	rate scan	265 - 271	1.9M	Runs	L100	pad	+1000	-				Runs	CMS04	pad	+350
10	DRS4	C6_1, C6_2	10	rate scan	274 - 280	2.0M	Runs	L100	pad	-1000	-				Runs	CMS04	pad	-800
11	DRS4	Cx_2, C6_2	11	digitiser test	281 - 281	0.6M	Runs	L100	pad	-1000	-				Runs	CMS04	pad	-800
12	DRS4	C6_2, Cx_2	12	digitiser test	282 - 282	0.6M	Runs	L100	pad	-1000	-				Runs	CMS04	pad	-800

Diamond Overview

- full overview of all scans for every scCVD, pCVD and silicon detector

Home | Location | Years | Diamond Scans | Single Runs | scCVD | pCVD | Silicon | Amplifier Boards

Overview of all RunPlans for II6-79

Beam Test	Irradiation [n/cm²]	Nr.	Type	Digitiser	Amplifier	Position	Runs	Attenuators		Bias [V]	Flux [kHz/cm²]	Leakage Current	Pulser				Signal				Events	Start	Duration
								Diamond	Pulser				Type	Mean	Corr.	Ped.	Pulse Height	Corr	Ped.	Noise [σ]			
201505	unirr.	2	rate scan	DRS4	OSU_?	Front	239-265	None	None	-600	10 ... 54682			?	-		?	-		?	?	May 28th 20:58:58	10:04:15
		3	rate scan	DRS4	OSU_?	Front	272-299	None	None	-1000	10 ... 43673			?	-		?	-		?	?	May 29th 09:19:35	11:52:53
		6	rate scan	DRS4	OSU_?	Front	373-393	None	None	+600	10 ... 13943			?	-		?	-		?	?	May 31th 01:03:24	7:37:49
		7	rate scan	DRS4	OSU_?	Front	395-408	None	None	+1000 → +0	60 ... 5362			?	-		?	-		?	?	May 31th 09:11:39	6:40:18
201508	unirr.	1	rate scan	DRS4	OSU_?	Front	069-088	None	?	+750	8 ... 12155	Plot	extern	76.66 (1.81)	?	Plot	36.50 (26.71)	-	Plot	4.71 (0.05)	20.5M	Aug 13th 01:06:16	20:43:00
		1.1	up scan	DRS4	OSU_?	Front	082-088	None	?	+750	8 ... 12155	Plot	extern	76.59 (1.72)	?	Plot	42.20 (30.35)	-	Plot	4.71 (0.06)	7.9M	Aug 13th 12:05:26	9:43:50
		1.2	up scan	DRS4	OSU_?	Front	069-077	None	None	+750	8 ... 11906		extern	75.94 (1.76)	-		34.75 (25.83)	-		4.71 (0.03)	7.5M	Aug 13th 01:06:16	6:42:54
		2	rate scan	DRS4	OSU_?	Front	091-112	None	?	+1000	7 ... 15287	Plot	extern	74.47 (18.67)	?	Plot	44.29 (34.81)	-	Plot	4.72 (0.05)	18.7M	Aug 13th 22:58:25	6:27:11
		2.1	up scan	DRS4	OSU_?	Front	107-112	None	?	+1000	7 ... 10965	Plot	extern	67.99 (30.14)	?	Plot	42.18 (36.94)	-	Plot	4.73 (0.04)	7.4M	Aug 14th 12:08:31	6:36:41
		2.2	up scan	DRS4	OSU_?	Front	091-096	None	?	+1000	7 ... 15287	Plot	extern	77.95 (0.18)	?	Plot	44.37 (37.21)	-	Plot	4.71 (0.06)	6.8M	Aug 13th 22:58:25	6:27:11
		2.3	rate scan	DRS4	OSU_?	Front	096-111	None	?	+1000	7 ... 15287	Plot	extern	78.41 (0.17)	?	Plot	45.86 (33.14)	-	Plot	4.72 (0.04)	11.8M	Aug 14th 04:24:42	1:00:54
		4	rate scan	DRS4	OSU_?	Back	133-151	None	?	-600	6 ... 10553	Plot	extern	74.13 (0.19)	?	Plot	71.74 (9.36)	-	Plot	4.70 (0.06)	20.5M	Aug 15th 15:20:30	22:00:43
		4.1	up scan	DRS4	OSU_?	Back	146-151	None	?	-600	6 ... 10528	Plot	extern	74.12 (0.23)	?	Plot	73.15 (11.10)	-	Plot	4.71 (0.06)	6.7M	Aug 16th 07:08:29	6:12:44
		5	rate scan	DRS4	OSU_?	Back	153-173	None	?	-1000	6 ... 10572	Plot	extern	74.04 (0.26)	?	Plot	116.32 (2.80)	-	Plot	4.70 (0.05)	19.1M	Aug 16th 14:49:09	21:47:51
		5.1	up scan	DRS4	OSU_?	Back	153-163	None	?	-1000	6 ... 10572	Plot	extern	73.77 (0.12)	?	Plot	115.20 (2.96)	-	Plot	4.70 (0.08)	8.1M	Aug 16th 14:49:09	11:01:04
201707-2	unirr.	6	rate scan	DRS4	OSU_2	Front	112-135	None	6dB_3	-1000	12 ... 11950	Plot	extern	234.47 (0.80)	467.82 (3.60)	Plot	131.95 (2.38)	-	Plot	5.72 (0.12)	8.1M	Jul 30th 03:33:29	8:43:53
		7	rate scan	DRS4	OSU_2	Front	139-143	None	6dB_3	+900	104 ... 13401	Plot	extern	329.82 (8.18)	658.08 (16.93)	Plot	141.68 (1.50)	-	Plot	3.05 (2.77)	1.9M	Jul 30th 14:52:44	1:44:45

Section 3

Timeline

Final Setup

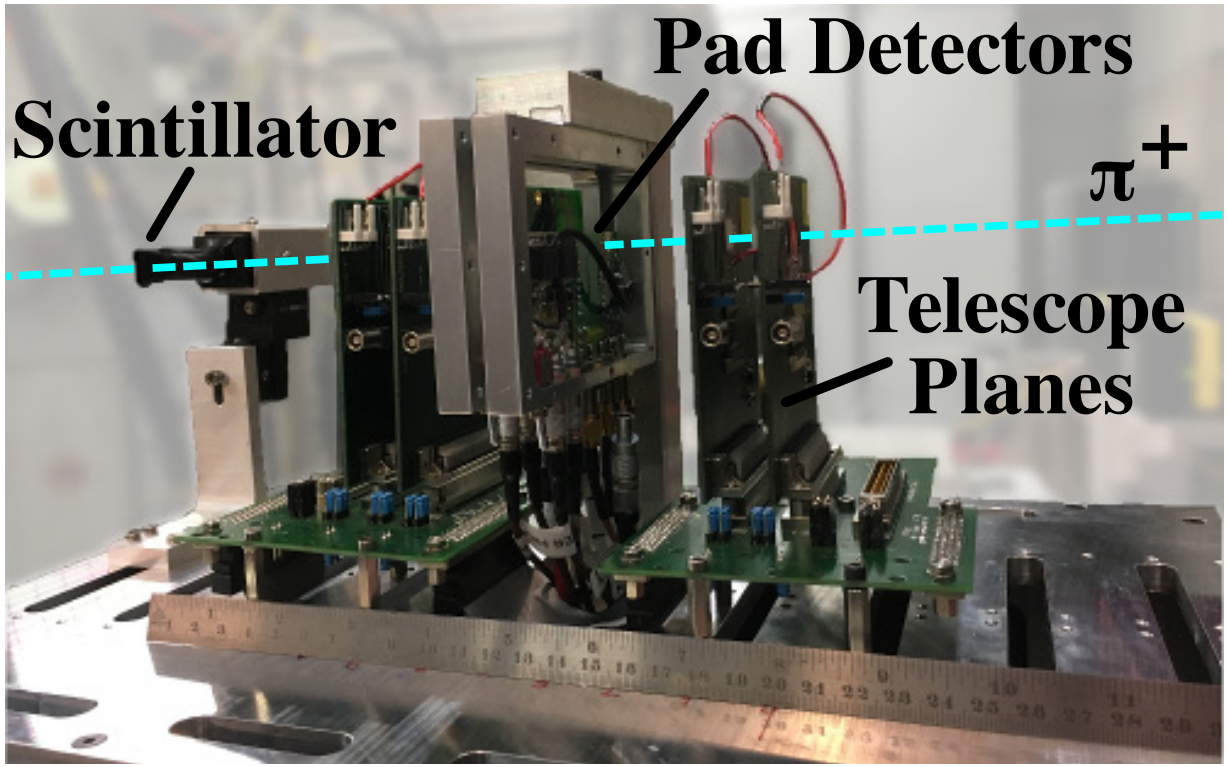


Figure: Modular Beam Telescope

- 4 tracking planes $\rightarrow$ trigger (fast-OR) with adjustable effective area
- diamond pad detectors in between tracking planes
- fast scintillator

Setup Development

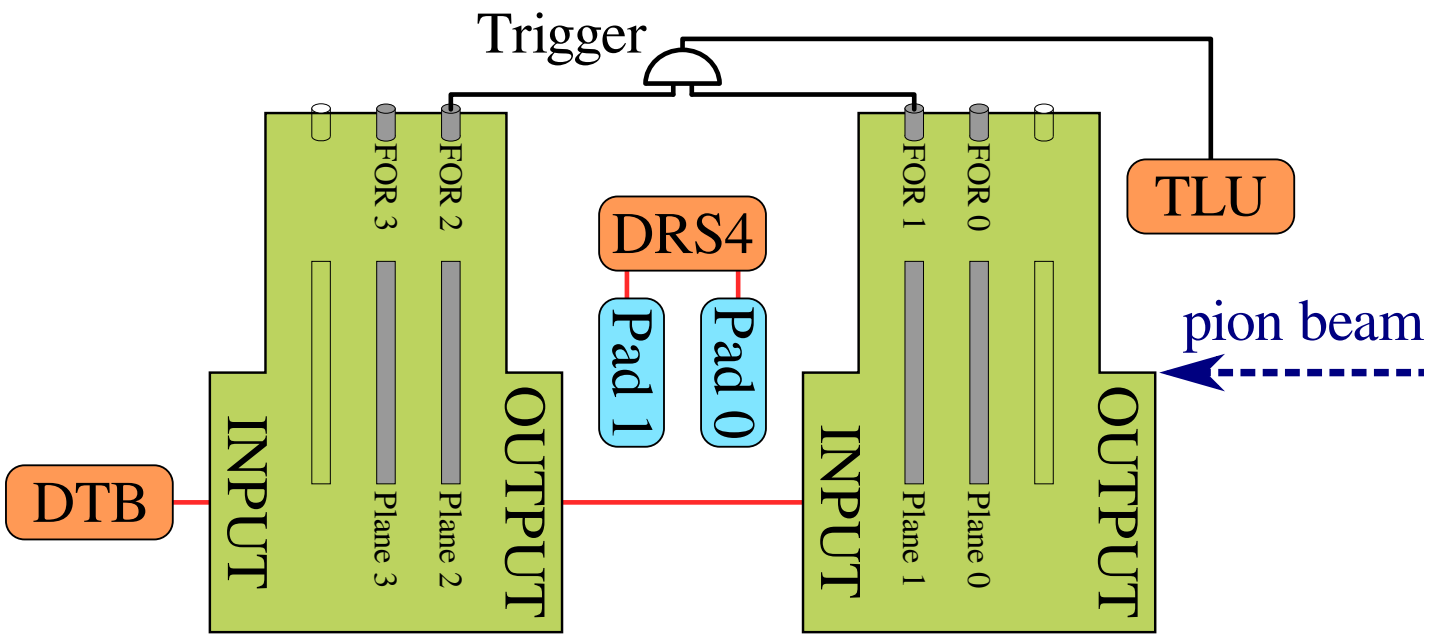


Figure: Setup May15

- May15

Setup Development

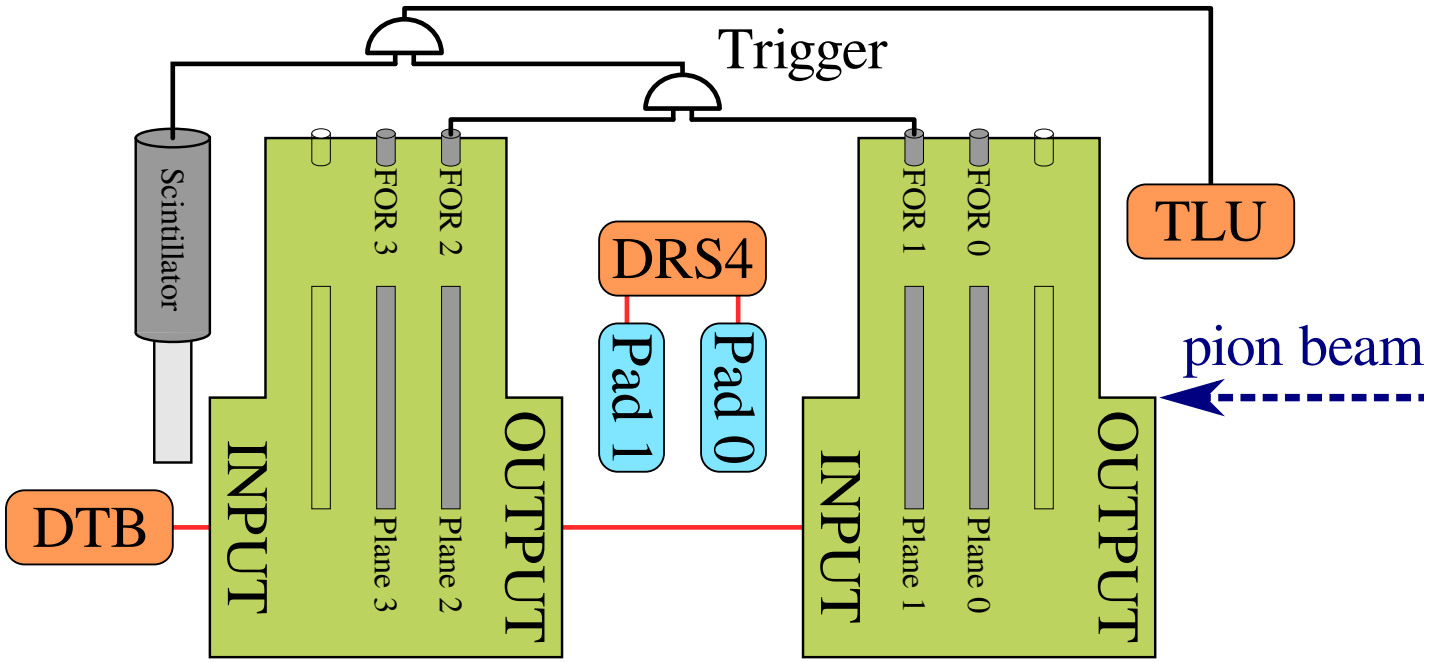


Figure: Setup Aug15 - Oct15

- May15 → **adding scintillator** → Aug15, Oct15
- gaining precise trigger timing of $\mathcal{O}(1\,\text{ns})$

Setup Development

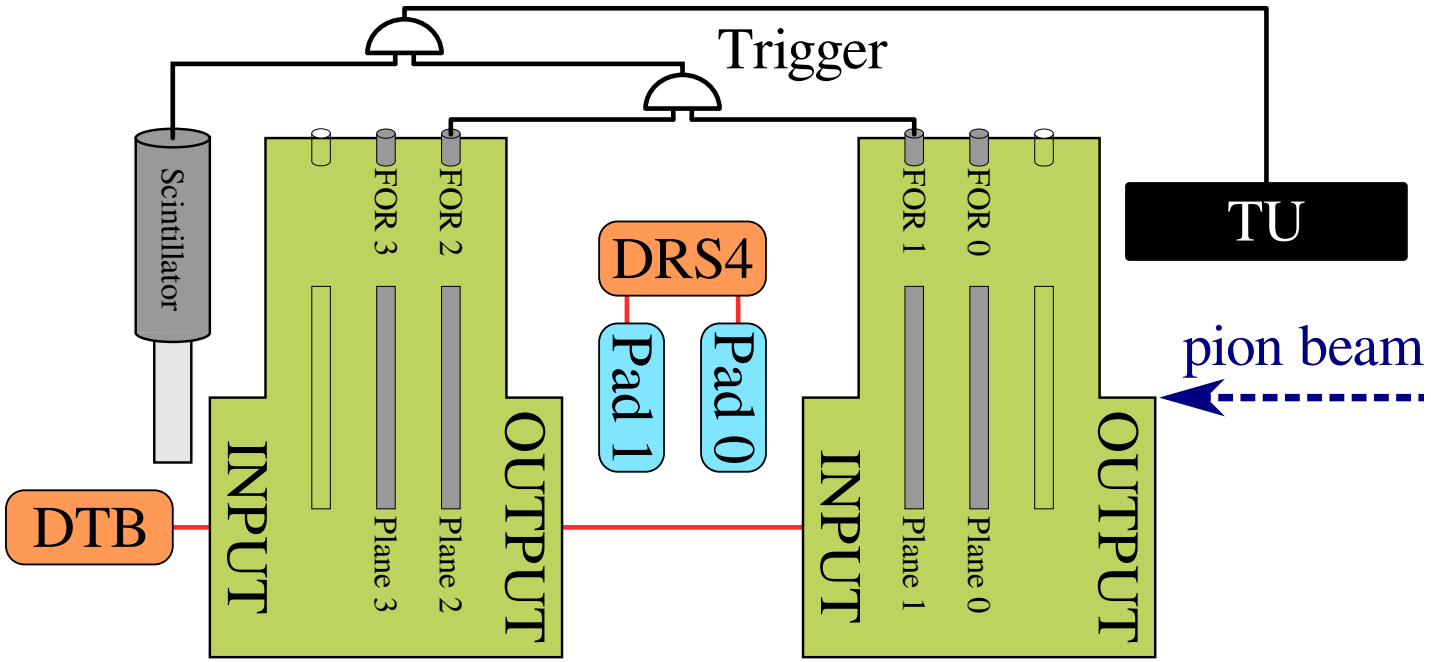


Figure: Setup Aug16 - Oct18

- May15 → adding scintillator → Aug15, Oct15 → **using OSU-TU** → May17 ...
- gaining precise trigger timing of $\mathcal{O}(1\,\text{ns})$
- strongly simplifying setup, slightly worsening trigger timing (400 MHz clock)

Procedure Development

- until October 2015: closing beam shutter before every run
  - found out it makes no difference and always left it open afterwards

- until October 2016: pumping every diamond pad detector with a Sr-source
  - found out that pumping with the beam is much faster and reliable

Tested Detectors

Name	Nick	Producer	Type	T [µm]	$\mathbf{Irr_{max}}$	Comments
S129	S129	e6	scCVD	528	0	reference
IIa-3	IIa-3	IIa	scCVD	?	$5 \cdot 10^{13}$	
SiD1	SiD1	PSI	Si-Diode	300	0	calibration
SiD2	SiD2	IJS	Si-Diode	100	0	calibration
2A87-e	2A87-e	II-VI	pCVD	?	$5 \cdot 10^{13}$	
II6-78	poly-A	II-VI	pCVD	?	0	
II6-79	poly-B	II-VI	pCVD	?	0	fixed surface
II6-81	poly-D	II-VI	pCVD	?	$1 \cdot 10^{14}$	
II6-94	94	II-VI	pCVD	?	0	also as pixel
II6-95	95	II-VI	pCVD	?	$5 \cdot 10^{14}$	also as pixel
II6-96	96	II-VI	pCVD	?	0	
II6-97	97	II-VI	pCVD	?	$3.5 \cdot 10^{15}$	irradiation studies
II6-B2	B2	II-VI	pCVD	455	$8 \cdot 10^{15}$	irradiation studies
II6-E5	E5	II-VI	pCVD	?	0	bcm prime test
II6-H0	H0	II-VI	pCVD	?	0	bcm prime test
II6-H8	H8	II-VI	pCVD	?	0	bcm prime test

Table: Pad Detector Information.

2015 - 2016

Diamond	May15	Aug15	Oct15	Aug16	Oct16
S129	✓(0)	✓(0)	✓(0)	✓(0)	✓(0)
IIa-3	✗	✗	✓($5 \cdot 10^{13}$)	✗	✗
SiD1	✗	✗	✗	✓(0)	✓(0)
SiD2	✗	✗	✗	✗	✓(0)
2A87-e	✗	✗	✓($5 \cdot 10^{13}$)	✗	✗
II6-78	✓(0)	✗	✗	✗	✗
II6-79	✓(0)	✓(0)	✗	✗	✗
II6-81	✓($1 \cdot 10^{14}$)	✗	✓($1 \cdot 10^{14}$)	✗	✗
II6-94	✓(0)	✗	✗	✓(0)	✗
II6-95	✓(0)	✗	✗	✓($5 \cdot 10^{14}$)	✗
II6-96	✓(0)	✗	✗	✗	✗
II6-97	✗	✓(0)	✓(0)	✓($5 \cdot 10^{14}$)	✓($1.5 \cdot 10^{15}$)
II6-B2	✗	✓(0)	✓($5 \cdot 10^{14}$)	✓($1 \cdot 10^{15}$)	✓($2 \cdot 10^{15}$)
II6-E5	✗	✗	✗	✗	✗
II6-H0	✗	✗	✗	✗	✗
II6-H8	✗	✗	✗	✗	✗

Table: Pad Detector Timeline. Irradiation in n/cm^2 in parenthesis.

2017 - 2018

Diamond	May17	Jul17	Aug17	Aug18	Oct18
S129	✓(0)	✓(0)	✓(0)	✓(0)	✗
IIa-3	✗	✗	✗	✗	✗
SiD1	✗	✗	✗	✗	✗
SiD2	✓(0)	✓(0)	✓(0)	✓(0)	✗
2A87-e	✗	✗	✗	✗	✗
II6-78	✗	✗	✗	✗	✗
II6-79	✗	✓(0)	✗	✗	✗
II6-81	✗	✗	✗	✗	✗
II6-94	✗	✗	✗	✗	✗
II6-95	✗	✗	✗	✗	✗
II6-96	✗	✗	✗	✗	✗
II6-97	✗	✓($1.5 \cdot 10^{15}$)	✓($3.5 \cdot 10^{15}$)	✗	✗
II6-B2	✗	✓($2 \cdot 10^{15}$)	✓($4 \cdot 10^{15}$)	✓($8 \cdot 10^{15}$)	✗
II6-E5	✗	✓*(0)	✗	✗	✗
II6-H0	✓*(0)	✓*(0)	✗	✗	✗
II6-H8	✗	✗	✗	✓(0)	✓*(0)

Table: Pad Detector Timeline. Irradiation in n/cm^2 in parenthesis. * - BCMPrime devices.

Scan Types

Diamond	Rate Scan	Voltage Scan	Random Scan
S129	✓	✓	✗
IIa-3	✓	✗	✗
SiD1	✓	✓	✗
SiD2	✓	✓	✗
2A87-e	✓	✗	✗
II6-78	✓	✗	✗
II6-79	✓	✗	✗
II6-81	✓	✓	✗
II6-94	✓	✓	✓
II6-95	✓	✓	✓
II6-96	✓	✗	✗
II6-97	✓	✗	✓
II6-B2	✓	✓	✓
II6-E5	✓	✗	✗
II6-H0	✓	✗	✗
II6-H8	✓	✗	✗

Table: Pad Detector Scan Types.

Section 4

Conclusion

Conclusion

- improved setup
  - adding scintillator for precise timing
  - using OSU Trigger Unit
- simplified data-taking
  - leaving beam shutter open
  - pumping with the beam
- using scCVD and SiD1 as reference and calibration
- tested 12 pCVD diamond for rate dependence
- irradiation studies of two pCVD diamonds

Del Fin